

the Advantage

Faster, More Accurate Volatile Analysis

Using 0.45mm ID Rtx®-624 & Rtx®-1 Capillary GC Columns

by Christopher English

There are over a dozen acceptable gas chromatographic (GC) columns for volatile compound analyses on the market today. Selecting a column that truly meets your needs can be difficult and frustrating. Restek has been in the process of developing new stationary phases to resolve a broad range of volatile compounds. During the development, however, it became apparent that existing volatile columns could be optimized for faster analyses and better resolution. By reducing the column ID of our

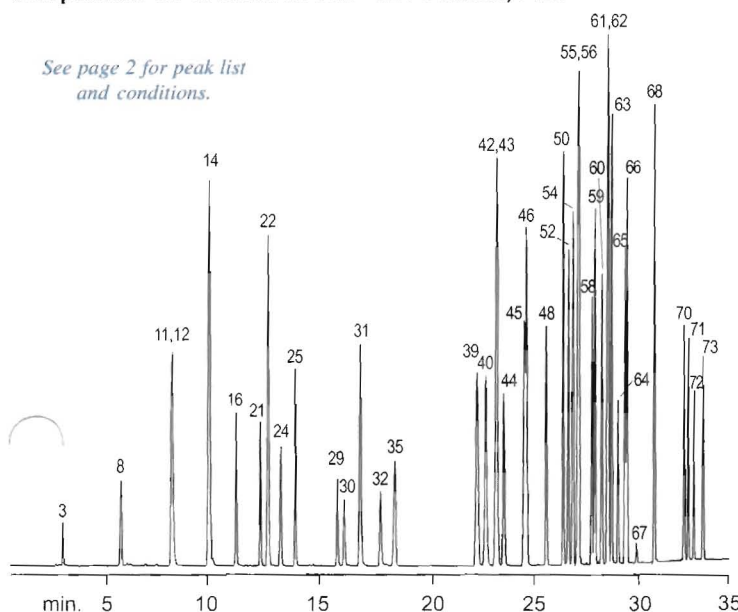
Rtx®-624 and Rtx®-1 capillary GC columns to 0.45mm, we can decrease analysis time and improve resolution of traditionally coeluting compounds, without sacrificing capacity and carrier gas flow requirements.

The Importance of Resolution
Volatile analysis methods such as US Environmental Protection Agency (EPA) Method 8021 require use of a photoionization detector (PID) and an electrolytic conductivity detector (ELCD) in series. The most problematic of these two detectors is the ELCD because of the characteristic tailing peaks. Sensitivity can be increased, but not without a sacrifice in peak shape, and the ELCD can exaggerate poor resolution for some compounds of interest.

Most environmental laboratories follow US Environmental Protection Agency (EPA) Method 502.2 for GC analysis of drinking water. The best column must address the compounds that are most commonly found in your samples. For example, water that has been disinfected will have measurable amounts of trihalomethanes (THMs). The four THMs are chloroform, bromodichloromethane,

Figure 1:

Faster analysis and better resolution of volatile organic compounds on 0.45mm ID Rtx®-624 column, PID.



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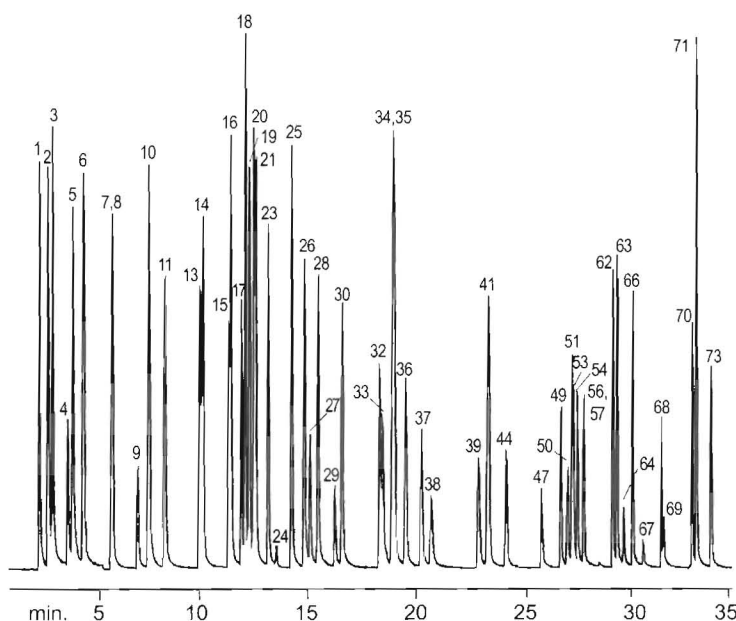
Faster, More Accurate Volatile Analysis (continued from page 1)

dibromochloromethane, and bromoform (listed in descending order of concentrations typically found in municipal drinking water). For quantitation, these compounds must be well resolved from the other 60 analytes listed in US EPA Method 502.2.

Most states in the US require the analysis of a performance evaluation (PE) sample prior to running drinking water samples for regulatory purposes. Columns that cannot resolve THMs from other target compounds in the calibration will produce poor quantitation and ultimately result in failure of the PE. Acceptable resolution for THMs is obtained when the valley between a pair of peaks is at least 25% of the average of the two peak heights. Quantitative analysis must be done using a column that can meet this criteria. Laboratories should test their own proficiency by analyzing a check standard with the surrogates and THMs, following a passing calibration with the full target list. Values for the check standard calculated from the curve must be within 20% of their "true" value. Currently, there are no GC columns that can offer a 25% valley separation for all compounds in US EPA Methods 8021A, 8021B, and 502.2, however, finding a column that addresses the target compounds most common in your real-world samples is the key to obtaining accurate data.

Figure 2:

Good selectivity for THMs using an 0.45mm ID Rtx®-624 Column, ELCD.



Run Conditions for Figures 1-3

Concentrator:	Tekmar® LSC-3000 Purge and Trap
Trap:	VOCARB™ 3000
Purge:	11 min. @ 40mL/min.
Dry purge:	1 min. @ 40mL/min. (Moisture Control System OFF)
Desorb preheat:	245°C
Desorb:	250°C for 2 min.
Bake:	260°C for 8 min.
Interface:	direct
Transfer line:	0.45mm ID fused silica (5-Meter Length, cat.# 10071, \$60; 10-Meter Length, cat.# 10072, \$120)
GC:	Finnigan 9001
Oven temp:	35°C (hold 9 min.) to 90°C @ 17°C/min. (hold 10 min.), 220°C @ 14°C/min. (hold 5 min.)
Carrier gas:	helium
Flow rate:	9mL/min.
µGold Tandem PID:	Makeup: 7mL/min.; Purge: 7mL/min., set @ 0.35mV base temp 200°C.
Hall 2000 ELCD:	Reaction gas: hydrogen, 25mL/min.;
Reactor temp.:	940°C; Propanol flow: 470µL/min.

The New 0.45mm ID Columns Improve Resolution and Save Time for Volatiles Analyses

At Restek, we have optimized dimensions and analysis conditions for columns currently used for volatile analysis: the Rtx®-624 and the Rtx®-1 capillary GC columns. In Figures 1 through 3 you will find chromatograms using optimized analysis conditions and column parameters. The 0.45mm internal diameter (ID) of these columns enhances resolution and decreases the analysis time. Desorb flow rates of 9mL/min. effectively sweep the volatile compounds off of the trap, and help maintain tight bands for the gases and other early eluting compounds. Analysis time has been decreased by almost 20 minutes compared to using the same stationary phase on a 0.53mm ID column.

The PID and the ELCD were run in series to obtain two chromatograms (Figures 1 and 2). Figure 1 shows an analysis on the Rtx®-624 column (75m, 0.45mm ID, 2.55µm) using a PID. The greatest disadvantage of the 624 phase has been the coelution of o-xylene and styrene. Using the conditions and column dimensions shown for Figures 1-3, resolution is possible between these compounds (Figure 1, peaks 45 and 46). This 0.45mm ID column offers an excellent alternative to other GC phases for volatile analysis. Figure 2 demonstrates good selectivity using an ELCD for the THMs in EPA Method 8021A, as well as the compounds listed in the 8021B.

Volatile compounds also can be found as subsets of Method

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38021 in the following EPA Methods: 501, 504, 502.2, 601, 602, 8010, and 8020. The five surrogates suggested by these methods were added to the compound list. The best surrogate compounds under the conditions shown are fluorobenzene, 1-chloro-2-fluorobenzene, and 1,4-dichlorobutane. Customer feedback resulted in the addition of Freon® 113 and methyl-tert-butyl-ether (MTBE). These compounds are commonly analyzed in addition to the method-specific target analytes. Figure 3 shows confirmation analysis on the Rtx®-1 column (75m, 0.45mm ID, 2.55µm), which provides a different selectivity, using PID/ELCD under the same conditions as the Rtx®-624 chromatograms in Figures 1 and 2. The recently optimized column dimensions and GC conditions for the Rtx®-624 and Rtx®-1 capillary GC columns achieve decreased analysis time and improved resolution for volatile compound analyses.

Product Listing:

Column Description

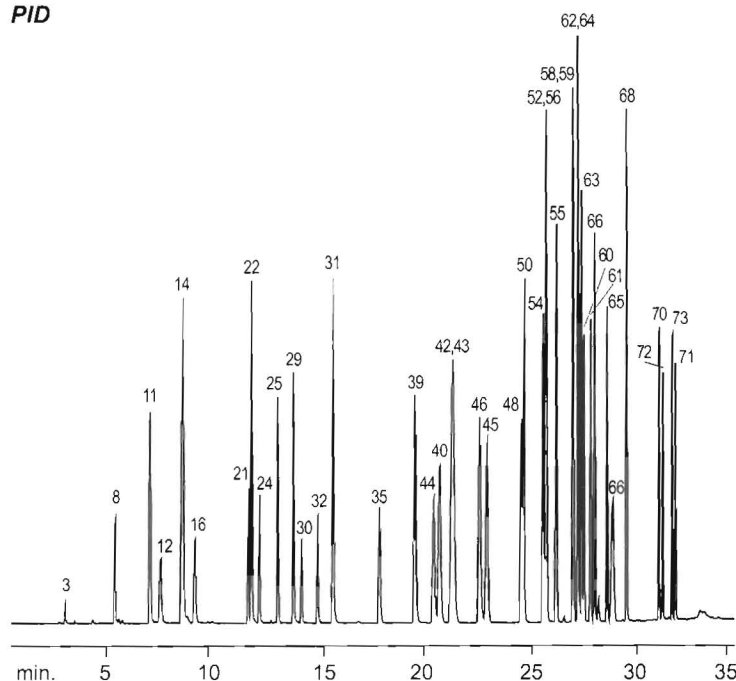
cat.#	price
Rtx®-624	
75m, 0.45mm ID, 2.55µm	
cat #10982	\$900
Rtx®-1	
75m, 0.45mm ID, 2.55µm	
cat #10992	\$900
Transfer Line	
cat.#	price
5m, 0.45mm ID	
cat #10071	\$60
10m, 0.45mm ID	
cat #10072	\$60

Restek also offers a full line of volatile component standards, and custom mixes are available. Please contact our Technical Service chromatographers.

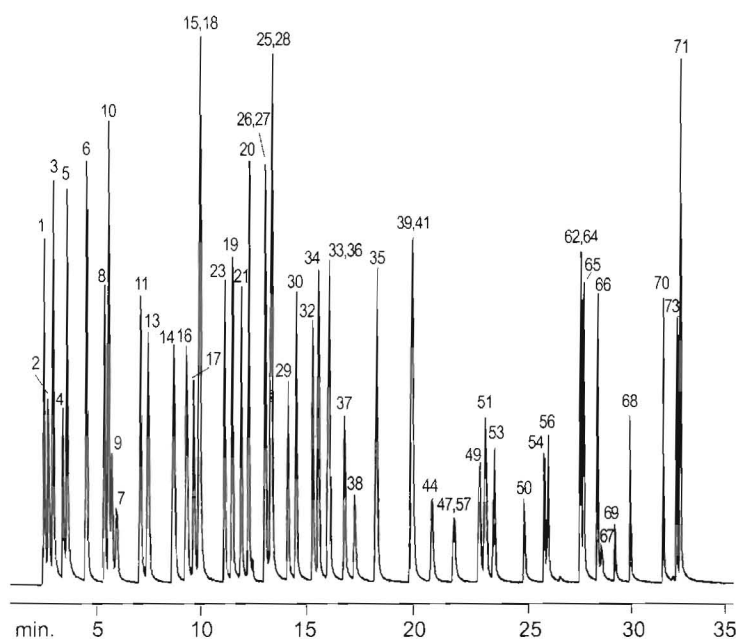
Figure 3:

The different selectivity provided by the Rtx®-1 column makes it an excellent confirmation to the Rtx®-624 column.

PID



ELCD



Peak List for Figures 1-3

1. dichlorodifluoromethane
2. chloromethane
3. vinyl chloride
4. bromomethane
5. chloroethane
6. trichlorofluoromethane
7. Freon® 113
8. 1,1-dichloroethene
9. allyl chloride
10. methylene chloride
11. trans-1,2-dichloroethene
12. methyl-tert-butyl-ether
13. 1,1-dichloroethane
14. chloroprene
15. 2,2-dichloropropane
16. cis-1,2-dichloroethene
17. bromochloromethane
18. chloroform
19. 1,1,1-trichloroethane
20. carbon tetrachloride
21. 1,1-dichloropropene
22. benzene
23. 1,2-dichloroethane
24. fluorobenzene
25. trichloroethene
26. 1,2-dichloropropane
27. dibromomethane
28. bromodichloromethane
29. 2-chloroethylvinyl ether
30. cis-1,3-dichloropropene
31. toluene
32. trans-1,3-dichloropropene
33. 2-bromo-1-chloropropane
34. 1,1,2-trichloroethane
35. tetrachloroethene
36. 1,3-dichloropropane
37. dibromochloromethane
38. 1,2-dibromoethane
39. chlorobenzene
40. ethyl benzene
41. 1,1,1,2-tetrachloroethane
42. m-xylene
43. p-xylene
44. 1-chloro-2-fluorobenzene
45. o-xylene
46. styrene
47. bromoform
48. isopropyl benzene
49. 1,4-dichlorobutane
50. bromobenzene
51. 1,1,2,2-tetrachloroethane
52. n-propyl benzene
53. 1,2,3-trichloropropane
54. 2-chlorotoluene
55. 1,3,5-trimethylbenzene
56. 4-chlorotoluene
57. 1,3-dichloro-2-propanol (40ppb)
58. tert-butylbenzene
59. 1,2,4-trimethylbenzene
60. sec-butylbenzene
61. p-isopropyl toluene
62. 1,3-dichlorobenzene
63. 1,4-dichlorobenzene
64. benzyl chloride
65. n-butylbenzene
66. 1,2-dichlorobenzene
67. bis-(2-chloroisopropyl) ether (40ppb)
68. 4-bromo-1-chlorobenzene
69. 1,2-dibromo-3-chloropropane
70. 1,2,4-trichlorobenzene
71. hexachlorobutadiene
72. naphthalene
73. 1,2,3-trichlorobenzene

Acknowledgement

Finnigan 9001 GC, µGold Tandem Photoionization Detector and Hall 2000 Detector provided through courtesy of ThermoQuest/CE Instruments, 2215 Grand Avenue Parkway, Austin Texas 78728.

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Optimizing the Massachusetts Extractable Petroleum Hydrocarbon Method

by Christopher English

Soil and water contamination as a result of petroleum spills are the primary sources of environmental pollution in the United States. Measures to identify and cleanup these sites have proven difficult. Massachusetts is one of the leading states in total petroleum hydrocarbon (TPH) regulation with their recent publication of two methods for the identification of gasoline contamination: extractable petroleum hydrocarbons (EPH) and volatile petroleum hydrocarbons (VPH). The EPH method focuses on areas that early methods have failed to address such as weathering of the sample, identifying specific compounds, and allowing estimates of overall toxicity of diesel range organics (DRO).

Sample Preparation and Analysis

EPH samples are extracted in methylene chloride, dried with sodium sulfate, and solvent-exchanged into hexane. A Kuderna-Danish (KD) apparatus is used to concentrate the sample

prior to cleanup. Silica gel tubes are used for cleanup, and the sample is fractionated into aliphatic and aromatic extracts. These two extracts then are analyzed using a flame ionization detector (FID). The aliphatic range of compounds are collectively calculated between the ranges of C9 to C18 and C19 to C36 (Figure 1), while the aromatic range is from C11 to C36 and allows the identification of specific polyaromatic hydrocarbons (Figure 2).

Samples are fractionated using solid phase extraction (SPE) silica gel tubes. In this method, silica gel is used to separate petroleum fractions into aliphatic and aromatic extracts. The most difficult part of EPH analysis is consistency and attention to detail during this fractionation step. Surrogates are added prior to extraction to monitor the efficiency of the fractionation procedure (Figure 3). The method recommends using a commercially prepared tube to avoid introducing

variables to the extraction procedure. Contamination (i.e., moisture in the tubes) will adversely effect the fractionation of the two extracts. Other factors that may prevent proper quantitation of field samples include: sample matrixes, amount of hexane used, variability of lab-packed columns, inconsistent pre-rinsing, silica gel variability, and phthalate contamination.

Contamination

To prevent phthalate contamination, rinse glassware thoroughly and install carbon traps at the end of gas lines. Silica gel tubes suspected of having contaminants should be rinsed with methylene chloride, followed by hexane, prior to the addition of the extract. Restek offers SPE tubes specifically designed for the EPH section of the method. These tubes have exceptionally low background and provide excellent reproducibility.

Column Selection

The EPH method recommends using the Restek Rtx®-5 column

(30m, 0.32mm ID, 0.25µm). Because the method can be used to identify specific polyaromatic hydrocarbons (PAHs), compound separation is critical. Closely eluting compound pairs such as benzo(b)fluoranthene/benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene/dibenzo(a,h)anthracene must have 50% to baseline separation in order to meet the criteria set by the method. When using optimized flows, Restek's Rtx®-5 column provides better than 80% resolution of the benzo(b)fluoranthene/benzo(k)fluoranthene pair—the most difficult separation for the EPH method (Figure 4). Column bleed is minimal, resulting in excellent quantitation of the late eluting compounds. Using the appropriate sample preparation procedure and optimized analysis conditions described here, combined with using an Rtx®-5 column, will ensure a trouble-free EPH analysis and result in a high degree of accuracy.

Figure 1:

The Rtx®-5 column provides excellent separation of the EPH aliphatic compounds and minimal bleed.

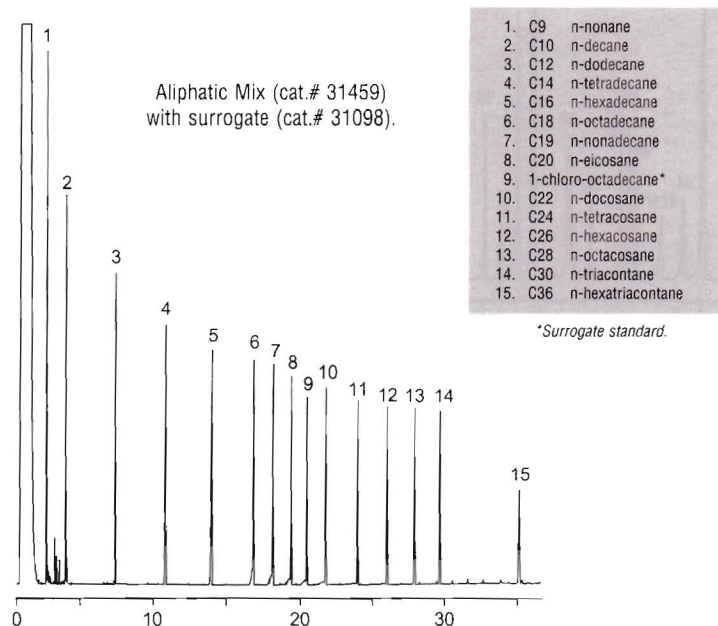
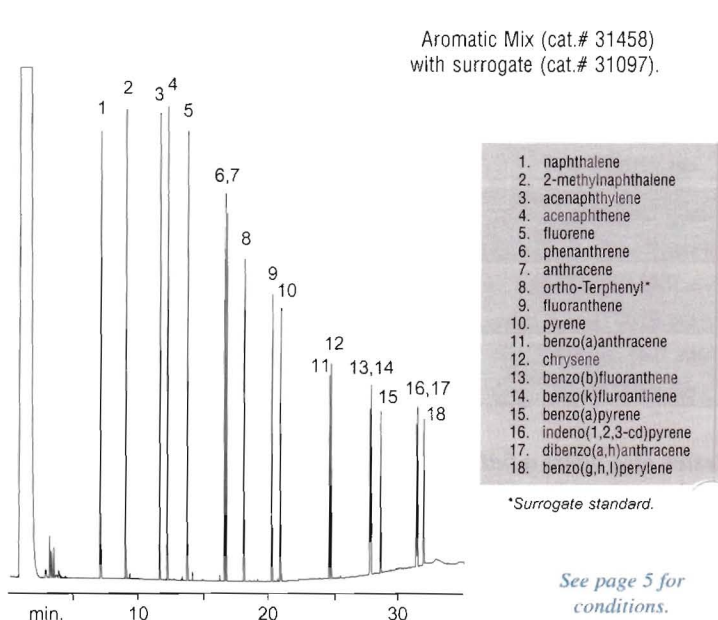


Figure 2:

The Rtx®-5 column provides good resolution of the aromatic calibration compounds.



See page 5 for conditions.

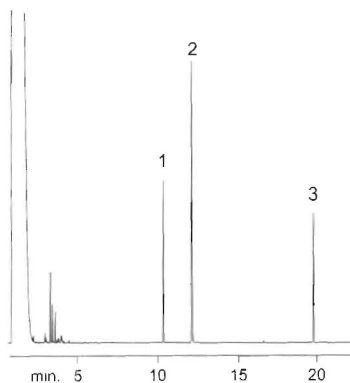
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5 Figure 3:

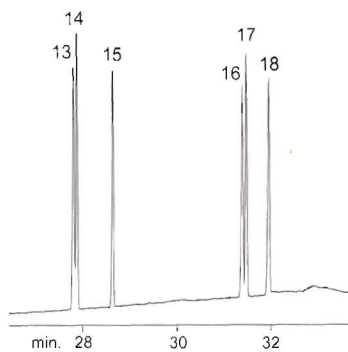
Efficiency of the fractionation standards (cat.# 31480) are monitored using an internal standard (cat.# 31065).



1. 2-fluorobiphenyl
2. 2-bromonaphthalene
3. 5-alpha-androstane

Figure 4:

The Rtx®-5 column provides better than 80% resolution of benzo(b) and benzo(k).



For peak IDs, see Figure 2.

Conditions for Figures 1-4

30m, 0.32mm ID, 0.25µm Rtx®-5 (cat.# 10224). **Concentration:** 100ng/µL on-column; **Injection:** manual, solvent flush technique, 1µL, direct. **Oven temp:** 60°C (hold 1 min.) to 305°C @ 8°C/min. (hold 4 min.); **Inj./det. temp.:** 285°C/315°C; **Carrier gas:** helium; **FID sensitivity:** 2.56 x 10E-10 AFS; **Linear velocity:** 76.9cm/sec. @ 60°C.

Product Listing:

Rtx®-5 Capillary GC Columns	cat. #	price
30m, 0.25mm ID, 0.25µm	10223	\$385
30m, 0.32mm ID, 0.25µm	10224	\$415
30m, 0.53mm ID, 0.50µm	10240	\$465
Uniliner® Direct Injection Sleeve for HP GCs*		
Fits 0.32-0.53mm ID, each	20335	\$54
Fits 0.32-0.53mm ID, 5-pk.	20336	\$198
MA TPH SPE Tubes		
20mL, 5g Silica, 20-pk.	26065	\$95
MA Fractionation Check Mix		
each	5-pk.	10-pk.
31481 \$40	31481-510 \$180	----
w/data pack 31481-500 \$50	31481-520 \$200	31481 \$360

*For a complete list of Uniliner® inlet sleeves, see the annual Product Guide.

For a complete list of standards for underground storage tank (UST) analyses, please request Lit. Cat. #59617.

Specialized SPE Products for Environmental Wastewater Extractions

Resprep™ Oil & Grease Extraction Disks

by Lydia Nolan

- Reduce the use of dangerous & expensive CFCs
- Faster and cleaner sample preparation using filter disks, prefilters, and manifolds
- Reproducible method for better gravimetric oil and grease extractions

Increasing environmental concerns about the effects of released chlorofluorocarbons (CFCs) in the atmosphere, and in an effort to reduce discharges during routine laboratory procedures, the US Environmental Protection Agency (EPA) has mandated the elimination of Freon® (CFC-113) extraction solvent for industrial waste samples. This has recently resulted in the release of an alternative procedure for US EPA Method 413.1—the US EPA Method 1664, Oil and Grease Analysis in Wastewater. The updated 1664 method describes an n-hexane liquid-liquid extraction and allows use of alternative extraction and concentration

techniques such as SPE if the performance specifications of the method are not met.

The n-hexane extraction process described in the method has several difficulties. As with all liquid-liquid extractions, emulsions are problematic, but with industrial discharge samples this problem may become extreme, resulting in poor partitioning or samples too viscous to process at all. In addition, the n-hexane is lighter than water, making routine separatory funnel processes difficult to manage. Some of these difficulties may be overcome using an SPE procedure.

By decanting the supernatant from the sample first and using an appropriate prefilter, most complex samples can be extracted in less than an hour. The SPE system also can be automated using vacuum manifolds, which allow simulta-

neous processing of up to six samples, thereby improving sample throughput and lab efficiency.

For a complete description of the SPE extraction method, please request lit. cat.# 59800.

Product Listing:

Description	cat. #	price
Oil & Grease SPE Disk, 47mm (20-pk.)	26022	\$75
Flow Filter, 47mm (20-pk.)	26024	\$14
Maxi-Manifold		
Complete Manifold (6 positions)	26026	\$3250
1 Station (1 position)	26025	\$1045
Individual Stations (add-on)	26027	\$500
Dry Prep, Sodium Sulfate Drying Tube		
Dry Prep I, small (50-pk.)	26075	\$80
Dry Prep II, large (50-pk.)	26076	\$85
25mm Syringe Tip Filter, PTFE, 0.45µm (50-pk.)	26073	\$120
US EPA Method 1664 Oil & Grease Mix	31457	\$25
w/Data Packet (5-pk.)	31457-510	\$112.50

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6 GC/MS Analysis of Phthalate Ester Endocrine Disrupters*

by Frank Dorman, Ph.D., & Christopher Cox

**Part of a series on endocrine disrupters. See the Fall 1997 Restek Advantage for analysis of organo tin compounds, and the Fall 1998 Restek Advantage for analysis of alkyl phenols and bisphenol A compounds.^{1,2}*

This article will address the analysis of a series of phthalate ester endocrine disrupters using gas chromatography/mass spectrometry (GC/MS) and a benchtop quadrupole detector. We can achieve the lowest reasonable detection limit using common instrumentation.

Several countries are actively investigating the effects of endocrine disrupters, and beginning to research potential methods of preparation and analysis.^{3,4} In addition, these compounds have become a focal point of several recent chemistry conventions, including the 1998 American Chemical Society national meeting. However, there are no accepted or standard methods of analysis, and there is still considerable disagreement as to which specific compounds should be studied and in what order they should be prioritized.

Phthalate compounds have long been used in the plastics industry and, until very recently, were not monitored except in a very few cases. Since the discovery that these compounds can exhibit estrogenic activity, they have become of great interest. Additionally, because some of these compounds were not regulated, they often are found in the environment, which helps to further intensify the interest with the public.⁵ We will demonstrate a method for the analysis of phthalate esters

that achieves a reasonably low limit of detection, and is adaptable to common laboratory instrumentation and preparation techniques.

Although no US Environmental Protection Agency (EPA) method exists for phthalate esters at these detection limits, it is possible to perform the preparation and analysis with equipment commonly found in an environmental laboratory. The compounds can be extracted under neutral conditions using US EPA Method 3510 (separatory funnel) or 3520 (liquid-liquid) for water samples, and US EPA Method 3540 (soxhlet) or 3550 (sonication) for solid matrices. These methods produce a methylene chloride extract, which is dried using granular sodium sulfate and then concentrated to a final volume. For biota or soil samples with lipid or other high molecular weight contaminants, gel permeation chromatography (GPC) should be used to clean the extracts prior to final concentration.

Because all of the phthalate compounds share a common mass-to-charge ion of 149, except dimethyl phthalate at 163, the best detection limit will be obtained by operating the MS in single ion monitoring (SIM) mode. This will typically yield a 10-fold or greater increase in sensitivity over a full scan acquisition.

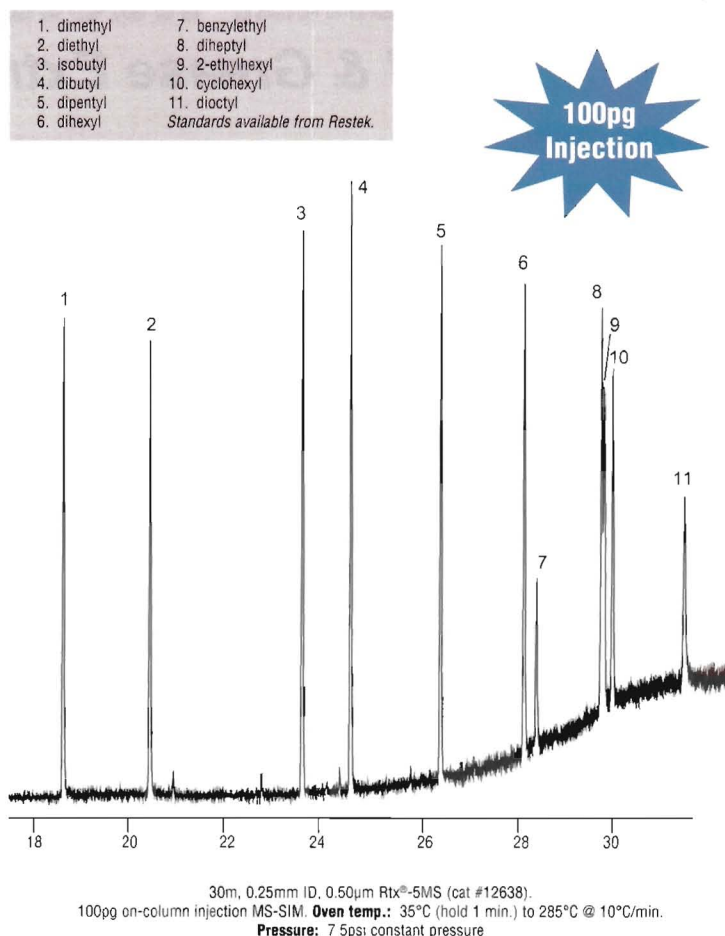
Figure 1 shows the GC/MS analysis obtained from a 100pg injection of the phthalate esters. Mass-to-charge ion 163 is monitored until 19 minutes, after which mass-to-charge 149 is monitored for the duration of the run. It should be noted that this represents a factor of 200 lower concentration than would typically be analyzed by US EPA Method 8270.

Figure 2 shows a GC/MS analysis obtained from a 20pg

injection of the same compounds. This represents nearly a 1000-fold lower concentration than US EPA Method 8270! This concentration level was used to obtain method detection limits (MDLs) for these compounds. Seven replicate analyses are performed, and the resulting MDL was calculated to be less than 10pg for each compound, with the later-eluting compounds producing a higher MDL due to splitless injection port discrimination. These analyses were

Figure 1:

Rtx®-5MS column and optimized conditions analyze a concentration 200-times lower than typical US EPA Method 8270.



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performed using an HP 5890 GC and a 5971A MS. Limits of detection should improve with a 5973 MS or an ion-trap, because these newer detectors offer increased sensitivity.

For additional information, please contact Restek's

technical service at 1-800-356-1688, ext 4. Restek also offers the analytical standards for these compounds at concentrations to suit your application. For information, please ask for our chemical standards group.

Product Listing:

Description	cat. #	price
Rtx®-5MS (30m, 0.25mm ID, 0.50µm)	12638	\$415

For custom standards, please call 800-356-1688, ext. 3, or contact your local Restek representative.

References

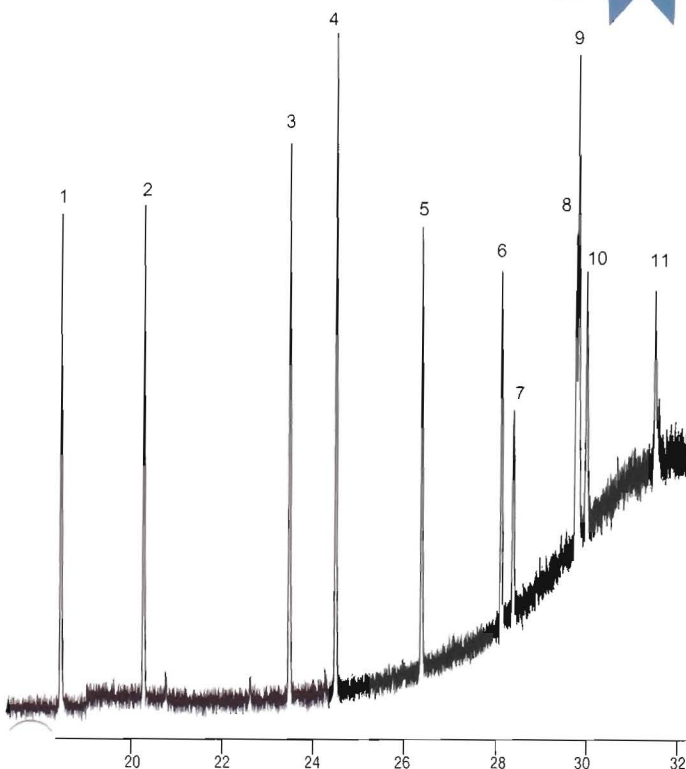
1. *The Restek Advantage*, Fall 1997.
 2. *The Restek Advantage*, Fall 1998.
 3. Special Report on Environmental Endocrine Disruption: An Effects Assessment and Analysis, EPA/630/R-96/012, Feb. 1997.
 4. JAIMA 1998, Tokyo, Japan.
 5. *The Boston Globe*, Vol. 255, # 58, p. 1, 1998.
- References 3, 4, and 5 not available from Restek.

Figure 2:

Rtx®-5MS column and optimized conditions analyze a concentration 1000-times lower than typical US EPA Method 8270.

1. dimethyl	7. butylbenzyl
2. diethyl	8. diheptyl
3. diisobutyl	9. bis-2-ethylhexyl
4. dibutyl	10. dicyclohexyl
5. dipentyl	11. dioctyl
6. dihexyl	

Standards available from Restek



30m, 0.25mm ID, 0.50µm Rtx®-5MS (cat #12638). 20pg on-column injection MS-SIM
Oven temp.: 35°C (hold 1 min.) to 285°C @ 10°C/min.
Pressure: 7.5psi constant pressure

Instrument-Grade Stainless Steel and Copper Tubing

Meets or exceeds oxygen service cleanliness guidelines for CGA Method G-4.1

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We know how important clean tubing for plumbing is to the successful delivery of pure gas to your instrument. We also know that we have a responsibility to protect the environment and our employees. For those reasons, Restek has developed a new cleaning process that uses biodegradable detergents, solubilizers, penetrants, organic acids, and non-toxic solvents for superior surface cleaning—leaving no film or residue. The cleaning performance of this process equals that of chlorinated solvents without the well-publicized hazards to our environment.

When you want the cleanest tubing for plumbing your analytical instrument system, and you also are concerned about the quality of the environment and worker safety, choose Restek Instrument-Grade Tubing.



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Two chromatographers put Restek's Rtx®-CLPesticides

A Low-Cost, High-Resolution Solution for Chlorinated Pesticides Analysis.

Jeff Westerlund, Sound Analytical Services, Tacoma, WA

Jeff Westerlund recently has begun using Restek's Rtx®-CLPesticides and Rtx®-CLPesticides2 columns for US Environmental Protection Agency (EPA) Method 8081 chlorinated pesticide analysis. He also set up his gas chromatograph (GC) using nitrogen as a carrier gas. He chose nitrogen because it is available at high-purity levels, but is much less expensive than helium. Nitrogen is not typically recommended as a carrier for GCs because of its low efficiency. Because the Rtx®-CLPesticides stationary phases were designed with a high selectivity for chlorinated pesticides, carrier gas efficiency may be sacrificed without greatly affecting separation.

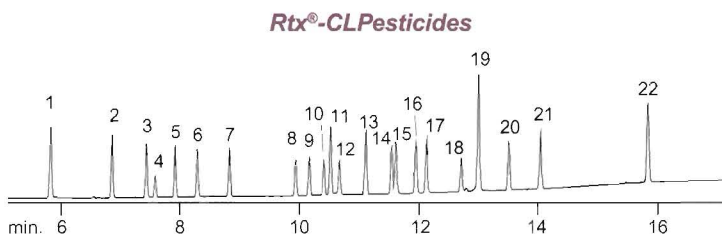
"In my 11 years of experience as a chromatographer working in the environmental industry, I have concentrated on method improvements while keeping a focus on controlling or lowering costs. It is important that in the process of lowering costs, you get approval from auditing agencies, or in other words, you don't sacrifice data quality. I have been interested in the use of nitrogen as a carrier gas for some time because it is available at low cost and high purity, but the sacrifice in separation using previous columns limited its use.

When I found the Rtx®-CLPesticides and Rtx®-CLPesticides2 columns from Restek, I was excited to learn that they had been designed specifically for the selectivity of chlorinated pesticides. I tried the columns and immediately thought they might show promise for use with nitrogen carrier gas. I plumbed my GC (Varian 3400) with nitrogen and, after some development work, produced the following chromatograms (Figure 1).

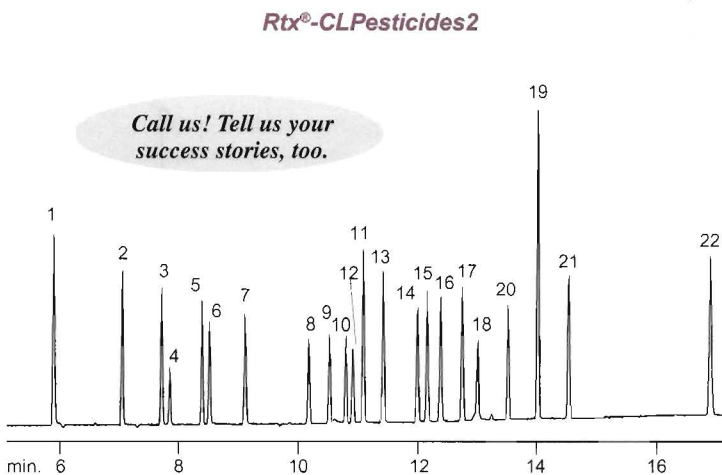
These chromatograms show that my total run time was less than 17 minutes for decachlorobiphenyl to elute on

Figure 1:

Fast, high resolution of chlorinated pesticides on 0.32mm ID Rtx®-CLPesticides and Rtx®-CLPesticides2 columns.



- | | | |
|---------------------------------|-----------------------|------------------------|
| 1. 2,4,5,6-tetrachloro-m-xylene | 8. heptachlor epoxide | 16. endosulfan II |
| 2. α-BHC (α-HCH) | 9. γ-chlordane | 17. 4,4'-DDT |
| 3. γ-BHC (lindane) | 10. α-chlordane | 18. endrin aldehyde |
| 4. β-BHC (β-HCH) | 11. 4,4'-DDE | 19. methoxychlor |
| 5. δ-BHC (δ-HCH) | 12. endosulfan I | 20. endosulfan sulfate |
| 6. heptachlor | 13. dieldrin | 21. endrin ketone |
| 7. aldrin | 14. endrin | 22. decachlorobiphenyl |
| | 15. 4,4'-DDD | |



Chromatogram courtesy of Sound Analytical Services.
Conditions are proprietary.

both columns. Also, baseline separation of all the target compounds was maintained with the exception of greater than 80% between endrin and DDD on the Rtx®-CLPesticides column. We currently are using this instrumental setup for the analysis of samples for US EPA Methods 8081 and 8082, and

have been very happy with the performance of this system. This analysis also would have advantages for application to field GC instruments, as you would only have to carry nitrogen for the instrument. This would eliminate at least one tank or generator, while minimizing cost."



Jeff Westerlund, Sound Analytical

www.restekcorp.com

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9 s into Reality

Columns & Rtx[®]-CLPesticides2 columns to the test!

The Dioxin & Toxic Organics Section of the Ontario Ministry of the Environment (MOE) has been investigating decreasing analysis time by fast gas chromatography (GC) through the use of narrow bore columns (0.18 and 0.10 mm ID). Reducing analysis time increases sample throughput and decreases costs. The limiting factor in reducing analytical run times is maintaining good analyte separation. Conventional organochlorine pesticide analysis uses 5% phenyl/50% phenyl columns and the separation requires an analysis time of about one hour.

MOE has developed a fast GC method for organochlorine pesticides using the Rtx[®]-CLPesticides and Rtx[®]-CLPesticides2 columns. The previous analysis that took 55 minutes is now completed in just over 10 minutes, with an improvement in resolution of the target compounds. Another advantage of the Rtx[®]-CLPesticides and Rtx[®]-CLPesticides2 columns is their thermal stability.

Higher thermal stability allows use of higher final oven temperatures, which drives off any high-boiling contaminants that may make it through our rigorous cleanup process. There also is virtually no column bleed. This, along with the thermal stability, indicate the lifetime of these columns are longer than those used previously. Over 2000 soil, biota, and vegetation samples have been analyzed on these columns without a reduction in performance.

The use of Fast GC and analyte-specific columns has reduced analysis times for organochlorine pesticides to about 10 minutes, or a factor of 5 in time savings. This also translates into an increase in sample throughput by 5-fold, without adding any additional instrumentation to the lab.

If you would like additional information on the Restek Rtx[®]-CLPesticides and Rtx[®]-CLPesticides2 columns, please contact Restek's Technical Service Department or your local Restek Distributor; or visit our web site at www.restekcorp.com.

Request the new 24-page "Guide to Preparing and Analyzing Chlorinated Pesticides" (Lit. Cat.# 59892).

Fast GC Analysis of Organochlorine Pesticides Using Analyte-Specific Columns

Eric Reiner, Ontario Ministry of the Environment, Ontario, Canada

Product Listing:

Rtx [®] -CLPesticides Columns	15-Meter cat.#/price	30-Meter cat.#/price
0.18mm ID, 0.18µm	42101*/\$265	42102**/\$385
0.25mm ID, 0.25µm	11120/\$290	11123/\$445
0.32mm ID, 0.50µm	11136/\$310	11139/\$475
0.53mm ID, 0.50µm	11137/\$325	11140/\$525
Rtx [®] -CLPesticides2 Columns	15-Meter cat.#/price	30-Meter cat.#/price
0.18mm ID, 0.18µm	42301*/\$265	42302**/\$385
0.25mm ID, 0.20µm	11320/\$290	11323/\$445
0.32mm ID, 0.25µm	11321/\$310	11324/\$475
0.53mm ID, 0.42µm	11337/\$325	11340/\$525

*0.18mm ID Columns are 10 meters in length.

**0.18mm ID Columns are 20 meters in length.

CLP Pesticide Standards

Organochlorine Pesticide Mix AB #2

aldrin	8µg/mL	dieldrin	16µg/mL
α-BHC	8	endosulfan I	8
β-BHC	8	endosulfan II	16
δ-BHC	8	endosulfan sulfate	16
γ-BHC (lindane)	8	endrin	16
α-chlordane	8	endrin aldehyde	16
γ-chlordane	8	endrin ketone	16
4,4'-DDD	16	heptachlor	8
4,4'-DDE	16	heptachlor epoxide (B)	8
4,4'-DDT	16	methoxychlor	80

At concentration listed in hexane/toluene (1:1), 1mL/ampul

	Each	5-pk.	10-pk.
	32292 \$25	32292-510 \$112.50	—
w/data pack	32292-500 \$35	32292-520 \$125	32392 \$225



Eric Reiner, Ontario Ministry of the Environment

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OPN Res-Sil™ C Packing

Restek's Newest Bonded Phase for Packed Column GC

by Barry Burger

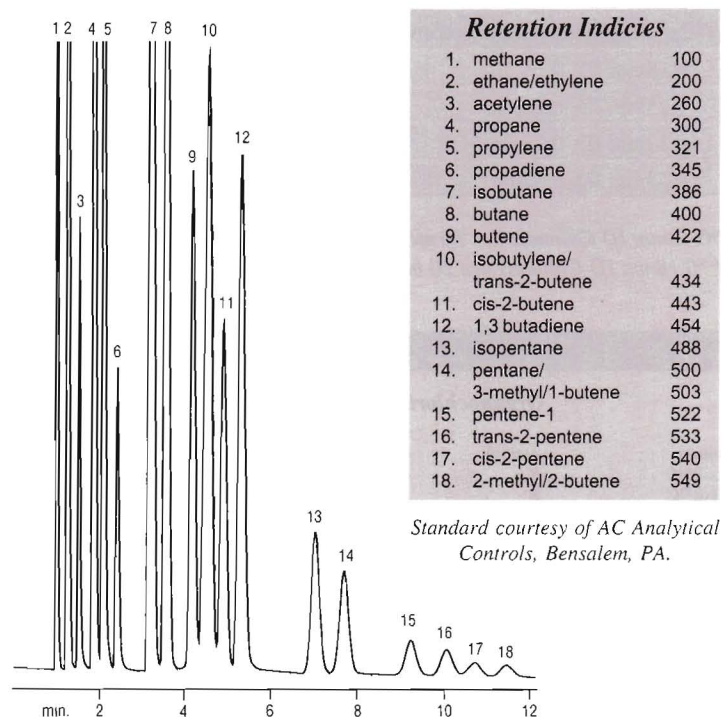
- Unique separation of saturated and unsaturated hydrocarbons
- Innovative bonding chemistry for batch-to-batch reproducibility, excellent thermal stability, and long life
- Wide range of bonded phases available
- Equivalent to Waters Durapak® packings

For over 25 years the process GC and petrochemical industries have used bonded silica packings such as Waters Durapak® packing for analysis of C1 to C4 hydrocarbons. These phases provide unique selectivity by modifying silica with a covalent attachment of either n-octane or cyano-propyl (OPN) functional groups. These phases have many advantages over conventional gas liquid chromatography packings because they

yield faster separations, higher thermal stability, shorter conditioning times, and longer lifetimes. In the past, these packings had inconsistent reproducibility and limited availability. Restek's research team has solved these age old problems by developing new Res-Sil™ C packings for consistent batch-to-batch performance and immediate delivery.

Figure 1:

OPN on Res-Sil™ C packing demonstrates unique selectivity for cis-2-butene and 1,3-butadiene.



Standard courtesy of AC Analytical Controls, Bensalem, PA.

12' x 2mm ID x 1/8" OD Silcosteel® column packed with OPN on Res-Sil™ C 80/100 mesh.
20µL on-column injection of refinery gas

Oven Temp.: 50°C Inj. temp.: 200°C Det. temp.: 200°C Flow rate: 30mL/min., He

Unique Selectivity for Process GC and High-Speed Analysis of Petrochemicals

Speed of analysis is crucial for process GC, and in laboratory gas analyzers using multiple columns and valve switching for separation of complex gas mixtures. The Res-Sil™ C bonded packings are ideal for resolution of the saturated and unsaturated C4 hydrocarbons that are difficult to separate. The chromatogram in Figure 1 demonstrates the unique selectivity for separation of cis-2-butene before 1,3-butadiene using the OPN on Res-Sil™ C packing. This unique selectivity, when combined with other columns in series, provides petroleum and petrochemical method developers with a powerful tool for fast determination of C1 to C5 hydrocarbons.¹

Innovative Research and Stringent QA Provide Batch-to-Batch Consistency

Historically, one of the problems with bonded phases such as Carbowax®, n-octane, and OPN on Porasil® packing has been batch-to-batch variations in the amount of liquid stationary phase added to solid silica support. Restek's product development team pulled together chemists with experience in GC packings and HPLC phase development to innovate a new synthesis procedure.

Utilizing new synthesis pathways, the amount of bonded liquid phase is precisely

controlled in every batch, resulting in reproducible retention times and separations. Each production batch of Res-Sil™ C packing is quality assurance tested with a complex hydrocarbon mixture to meet demanding retention time and retention index specifications. Column bleed also is evaluated at the recommended maximum temperature of 150°C, as part of the QA test to ensure that retention shifts and high baselines are not observed.

OPN on Res-Sil™ C Packing is the Latest of a Full Line of Bonded GC Phases

Restek now offers a wide range of bonded packings for packed GC columns, including Rtx®-1 and Stabilwax® phases, Carbowax® and n-octane phases on Res-Sil™ C packing, and the new OPN on Res-Sil™ C packing. Each of these packings have low bleed, conditioning times of less than 30 minutes, long lifetime, and consistent batch-to-batch reproducibility. Every batch of Restek's bonded phases is tested for bleed, efficiency, retention index and retention time reproducibility. In addition, Restek offers a full range of packed and micro-packed GC columns, available with specially-deactivated Silcosteel® tubing for improved inertness and efficiency.

1. N.C Saha, S.K. Jain, and R.K. Dua. *J. of Chromat. Sci.* 1978: 16, pp.323-328.

Reference not available from Restek.

Product Listing:

Description	cat. #	price/g*
n-Octane on Res-Sil™ C, 80/100 Mesh	25030	\$30/g*
OPN on Res-Sil™ C, 80/100 Mesh	25042	\$30/g*
Res-Sil™ C, 80/100 Mesh	25028	\$24/g
2 % Carbowax 1540 on Res-Sil™ C, 80/100 Mesh	25044	\$30/g*

*Minimum order 10g

Analysis and Stability of Low-Level Sulfur-Containing Samples Using Silcosteel®-Treated Products

by Gary Stidsen and Jingzhen Xu

Low-level air analyses of reduced sulfur compounds, such as hydrogen sulfide and methyl mercaptan, have been very difficult to perform due to adsorption of the compounds on metal surfaces. These difficulties are compounded by the short holding times of collected air samples. Restek has conducted research to improve sulfur analysis and has developed an analytical technique to allow for low concentration (ppbv) analysis of reduced sulfur compounds using a Silcosteel®-treated stainless steel system.

Restek's Silcosteel® passivation technique bonds an inert silica layer to the surface of stainless steel. The Silcosteel®-treated surface acts as a barrier to active compounds that can react or be adsorbed on stainless steel. This provides a very inert surface for the storage and transfer of reactive sulfur compounds. Most stainless steel products, including tubing, can be treated with the Silcosteel® process. Because the Silcosteel® layer is incorporated into the structure of the stainless steel, it is highly flexible. Therefore, Silcosteel®

tubing can be bent without affecting the inertness characteristics.

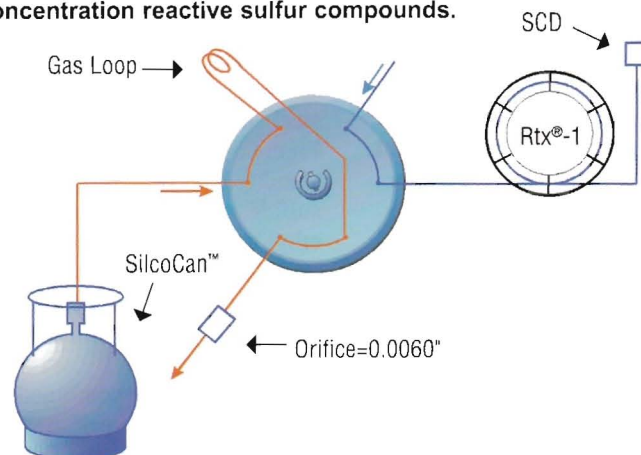
Holding time data of sulfur compounds using Silcosteel®-treated sample canisters with low ppmv concentrations were previously published in *The Restek Advantage*, Fall 1997. As an expansion of this project and to assist chemists in the field of sulfur analysis, we developed an analytical technique to demonstrate the effects of using Silcosteel®-treated transfer lines, sample loops, and sample storage canisters to work with low ppbv concentration of reactive sulfur compounds.

The research process was completed in three steps:

The **first step** was to select a mix of sulfur compounds for the stability tests (Table I). Some of these compounds will react with stainless steel surfaces and some will not. The reactive compounds include hydrogen sulfide, methyl mercaptan, and ethyl mercaptan. Carbonyl sulfide, dimethyl sulfide, and dimethyl disulfide are typically stable and do not

Figure 1:

Silcosteel®-treated system ensures excellent analysis of low-concentration reactive sulfur compounds.



react with stainless steel. Therefore, dimethyl sulfide was chosen as an internal standard.

The **second step** was to configure the analytical system so that the 60ppbv standard could be detected with enough of a signal-to-noise ratio so adsorption of compounds could be detected up to 80% loss. The analytical system was designed with a 1mL Silcosteel®-treated sample loop, Silcosteel®-treated Valco® valve, and 1/16" Silcosteel®-treated transfer lines (Figure 1). The analytical column was directly connected to the Valco® valve.

In order to consistently purge the 1mL sample loop with the sample, an orifice was attached to the exit of the sample loop allowing 60-90mL/min. of sample to flow through the gas loop during sample loading. The analytical column was an Rtx®-1 column (60m x 0.53mm ID, 7.0µm) and the detector was a Sievers Model 355 sulfur

chemiluminescence detector (SCD).

To introduce the sample to the GC column, the Silcosteel®-treated canister was pressurized to 26psig, and the sample loop was flushed with the sample for 90 seconds. After 90 seconds, the canister valve was closed and the pressurized sample loop was vented to atmospheric pressure. Once the sample loop was equilibrated to atmospheric pressure, the Valco® valve was switched to introduce the sample from the loop to the analytical column, then the GC analysis was initiated.

The SCD is very sensitive to sulfur-containing compounds, with a detection limit of about 5ppbv for a 1mL injection. The compounds first enter the burner, where they are combusted to SO* and other products. The compounds then are transferred to a reaction cell, where the SO reacts with ozone resulting in SO₂ + O₂. This chemiluminescence

Table I—Sulfur Compounds

Compound	Formula	Stock Conc. (ppmv)	Standard Conc. (ppbv)	Standard Conc. as S (ppbv)
Hydrogen sulfide	H ₂ S	100	60	56
Carbonyl sulfide	COS	100	60	30
Methyl mercaptan	CH ₃ SH	100	60	40
Ethyl mercaptan	CH ₃ CH ₂ SH	100	60	20
Dimethyl sulfide	CH ₃ SCH ₃	100	60	30
Dimethyl disulfide	CH ₃ SSCH ₃	100	60	40

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reaction is detected at 300-400nm. Figure 2 shows a chromatogram of the 60ppb sulfur standard acquired using the gas loop setup. The standard exhibited very good signal-to-noise ratio without using sample focusing.

The **last step** was to test the stability of the sulfur compounds in the Silcosteel®-treated canisters over a three day period. The test compared the stability of the sulfur compounds in four Silcosteel®-treated canisters to a stainless steel canister. The standards were prepared by adding 10mL (gas) of 1000ppbv to a 6-liter canister, which then was pressurized to 26psig using nitrogen. The standards were made "dry," meaning no water was added to the canisters during preparation. A dry standard prevents any possible reaction with water and allows the effects of the sulfur compounds to appear directly on the Silcosteel®-treated surface. Dimethyl sulfide was used as the internal standard to ensure accuracy over the 74-hour testing period.

Results

The results of the analysis indicated that the stability of sulfur compounds was very good over the 74-hour test period. The Silcosteel®-treated canisters showed excellent stability, with greater than 80% recovery of all sulfur compounds. The stainless steel canister showed significant decrease in recovery of hydrogen sulfide, methyl mercaptan, and ethyl mercaptan as time elapsed. Carbonyl sulfide and dimethyl disulfide showed no loss in the stainless steel canister. The graphs in Figure 3 show the results of the stability tests of hydrogen sulfide, methyl mercaptan, and ethyl mercaptan. Notice how quickly the drop in recovery of the sulfur compounds occurs in the stainless steel cylinder.

In conclusion, the combined usage of the Silcosteel®-treated transfer lines, gas loops, Valco® valve, and canisters provides excellent inert surfaces for analyzing reactive sulfur compounds down to 60ppbv.

Figure 2:

Excellent signal-to-noise ratio achieved without sample focusing.

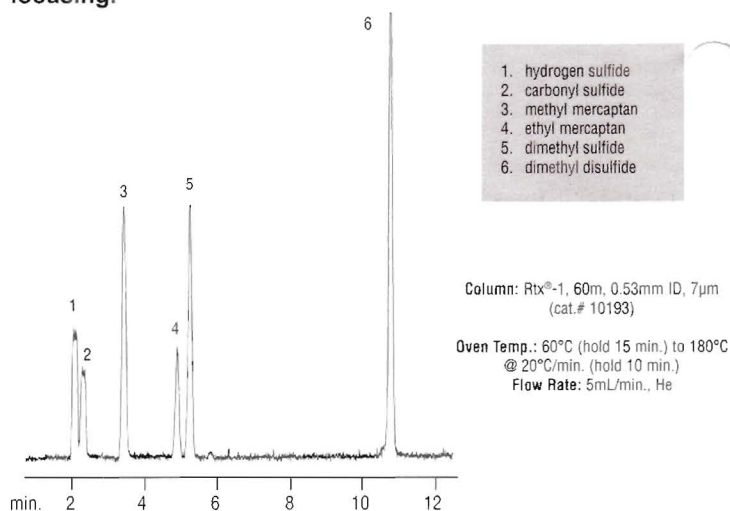
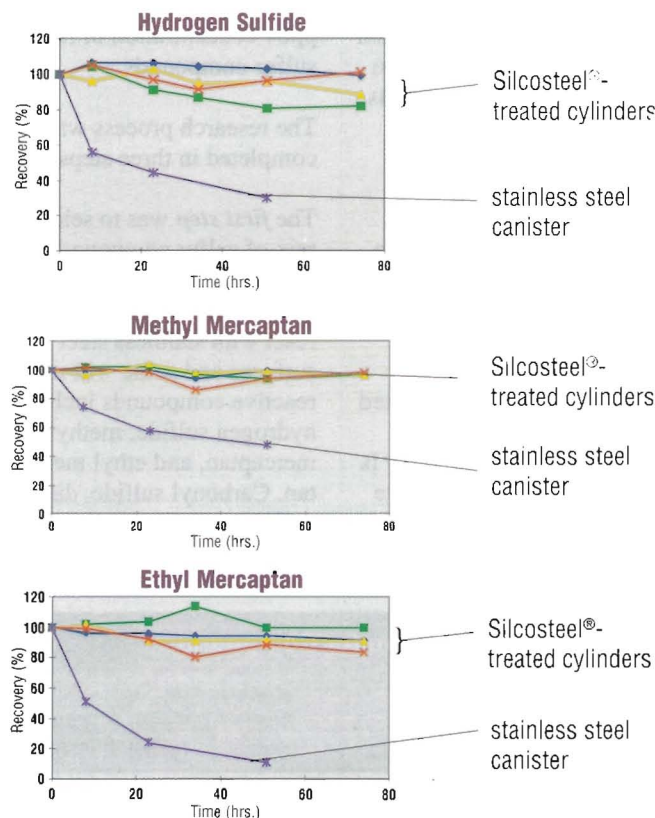


Figure 3:

Final results proved stability of sulfur compounds.



Product Listing:

SilcoCan™ Canisters, with a Silcosteel®-Treated Valve*					
	cat.#	price			
6.0 Liter	24200-650	\$550			
Silcosteel®-Treated Sample Canisters					
75cc	24271	\$125			
150cc	24272	\$140			
300cc	24273	\$150			
500cc	24274	\$180			
1000cc	24275	\$320			
Silcosteel®-Treated Hoke Sample Cylinder Valves					
KEL-F® stem tip, 1/4" male NPT exit	24278	\$130			
KEL-F® stem tip, 1/4" compression exit	24279	\$130			
Silcosteel® Sample Loops for GC			Silcosteel®-Treated Transfer Lines		
size	cat.#	price	6-ft. Lengths	cat.#	price
250µL	22803	\$80	1/16" OD x 0.010" ID	20550	\$50
500µL	22804	\$82	1/16" OD x 0.020" ID	20524	\$50
1mL	22801	\$86	1/16" OD x 0.030" ID	20530	\$50
5mL	22802	\$86	1/16" OD x 0.040" ID	20538	\$50

*Please call Restek's Customer Service at 800-356-1688 or 814-353-1300, ext. 3 for availability of SilcoCan™ canisters.

If you are wondering if Silcosteel® coating is right for your application, call us at 800-356-1688, ext. 4, or contact your local Restek Representative for a custom Silcosteel® information survey.

800-356-1688

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New Flexible Graphite Ferrule Technology

by Doug Elliott and Brad Righnour

- **Conforms to challenging spaces with virtually no ferrule creep.**
- **Purer graphite eliminates detector interferences.**
- **Smoother surface and cleaner edges.**



Restek has been searching for a superior graphite ferrule, and we have found it! This new ferrule has been made from material developed by UCAR Carbon Co., who for over 100 years has dedicated research to developing graphite products that are in the forefront of fluid sealing technology. The finished product now offered by Restek has preferred performance characteristics including heat resistance, natural lubricity, chemical inertness, and high thermal conductivity.

The finest ferrule now available, Restek's New Flexible Graphite Ferrule starts with the most pure, natural graphite. The flexibility of the new ferrule is apparent by the ease with which the ferrule conforms to challenging spaces while maintaining its superior resilience. Pits, gouges, and even microscopic irregularities are filled under only moderate fitting tightening, to create leak-tight seals. In addition, this high-purity graphite exhibits virtually no ferrule creep relaxation for long-term fitting tightness.

These ferrules are manufactured by a process that eliminates the need for organic or inorganic binders, fillers, or other potentially off-gassing or absorptive ingredients. The resulting material is over 98% pure carbon, with the remainder being inert inorganic material. Sulfur and chloride-containing components are reduced to trace amounts in the ferrule composition to eliminate detector interference.

The unique flexibility properties are evident when the fitting is loosened—the ferrule will recover or spring back to an intermediate thickness with proportional reduction of density from the under-load conditions. This means that these ferrules may be resealed several times before they need to be replaced.

Even more amazing is that these new flexible graphite ferrules can be run continuously at up to 400°C gas chromatography (GC) tempera-

tures with no degradation of their sealing ability.

Restek offers both flexible graphite and VESPEL®/graphite ferrules to use with capillary columns. We have found that 60% VESPEL®/40% graphite give the best combination of sealing performance with ease of workability. They seal with minimal torque, are reusable, and are preferred for vacuum and high-pressure uses. Both ferrule types are stable to 400°C.

For a complete listing of ferrules, please see the Restek 1999 Product Guide.

Capillary Ferrules (for 1/16" compression-type fittings)					
Ferrule ID	Fits Column ID	Graphite		VESPEL®/Graphite	
10-pack					
0.3mm	0.20mm	20233	\$30	—	—
0.4mm	0.25mm	20200	\$25	20211	\$30
0.5mm	0.32mm	20201	\$25	20212	\$30
0.6mm	0.28mm	—	—	20232	\$40
0.8mm	0.53mm	2020	\$25	20213	\$30
50-pack					
0.4mm	0.25mm	20227	\$100	20229	\$120
0.5mm	0.32mm	20228	\$100	20231	\$120
0.8mm	0.53mm	20224	\$100	20230	\$120
Compact Graphite Ferrules for HP GCs (for capillary injection ports)					
Ferrule ID	Fits Column ID	Graphite 10-pk.		Graphite 50-pk.	
0.4/0.5mm	0.25–0.32mm	20250	\$25	20251	\$100
0.8mm	0.53mm	20252	\$25	20253	\$100
Compact VESPEL®/Graphite Ferrules for HP GCs					
Ferrule ID	Fits Column ID	VESPEL®/Graphite 10-pack		VESPEL®/Graphite 50-pack	
0.4mm	0.25mm	20238	\$45	20239	\$180
0.5mm	0.32mm	20248	\$45	20249	\$180
0.8mm	0.53mm	20263	\$45	20264	\$180

Hey HP Users!

Restek has produced a new 32-page catalog, *Genuine Restek Replacement Parts for HP GCs*, detailing our full line of products for HP GCs. It covers everything from the injector to the detector and includes tech tips and useful reference materials.




To request your copy, call our literature request hotline at 800-356-1688, ext. 5, or contact your local Restek representative.

Peak Performers

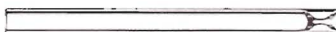
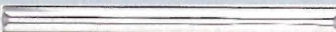

New Inlet Liners from Restek

All of Restek's Liners
are Deactivated


for HP GCs with Gerstel injectors

Liners for HP CIS4 and PTV GCs	Benefits/Uses:	ID**/OD & Length (mm)	cat.#/price 10-pk.	Similar to HP part #
 Single Glass Inlet Liner	general use	2.0 ID 3.0 OD x 71	21157 \$71	5181-2036
 Baffled Glass Inlet Liner	active compounds, drugs, pesticides	1.5 ID 3.0 OD x 71	21704 \$149	5183-2037
 Glass Inlet Liner with Wool*	large volume injections	2.0 ID 3.0 OD x 71	21156 \$173	5183-2039


for Varian GCs

Liners for Varian 1078/1079 GCs	Benefits/Uses:	ID**/OD & length (mm)	ea.	cat.#/price 5-pk.	25-pk.	Similar to Varian Part #
 1078/1079 Split—No Frit	active samples	3.4 ID 5.0 OD x 54	20859 \$32	20901 \$140	— —	03-918464-00
 Open 0.75mm ID	trace, low volume samples	0.75 ID 5.0 OD x 54	21714 \$22	21715 \$91	21716 \$370	03-925330-00
 1078/1079 Split/Splitless SilcoSleeve™	universal, unbreakable	3.8 ID 5.0 OD x 54	— —	20711 \$88	— —	—

for Perkin-Elmer GCs

Splitless Liners for Perkin-Elmer GCs	Benefits/Uses:	ID**/OD & Length (mm)	ea.	cat.#/price 5-pk.	Similar to PE Part #
 Auto SYS XL Split/Splitless	most common analyses	2.0 ID 4.0 OD x 81.2	21717 \$37	21718 \$148	N612-1004

for Shimadzu GCs

Direct Injection Liners for Shimadzu GCs (0.32/0.53mm ID)	Benefits/Uses:	ID**/OD & Length (mm)	ea.	cat.#/price 5-pk.	Similar to Shimadzu Part #
 94mm Uniliner® with Wool*	trace, dirty, high MW active samples, high recovery & linearity	3.0 ID 5.0 OD x 94	21713 \$45	21719 \$180	—

*This sleeve is prepacked with fused silica wool. To order glass wool instead, add the suffix "-202" to the sleeve's catalog number.

** Nominal ID at syringe needle expulsion point.

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15 Direct Replacement Parts for HP GCs

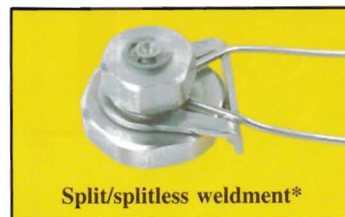
Direct Replacement Split/Splitless Injection Port for HP 5890 GCs

Restek now offers a **direct replacement** split/splitless injector for the HP 5890 GC. The injector is manufactured from high-quality stainless steel and meets or exceeds HP original equipment specifications.

Would you like even better performance from your injector? Restek's proprietary Silcosteel®-coated version of the split/splitless injector is what you are looking for. Silcosteel® treatment passivates the metal surface to ensure an inert pathway for the sample, delivering increased performance.

* Septum nut not included. Order separately.

Replacement Split/Splitless Injection Port for HP 5890 GCs			
Product	cat.#	price	
Replacement Split/Splitless Weldment Similar to HP part# 19251-60575	20265	\$200	
Replacement Shell Weldment Similar to HP part# 19251-80570	20266	\$178	
Septum Nut	21309	\$39	
Silcosteel®-Treated Split/Splitless Weldment	20267	\$272	
Silcosteel®-Treated Shell Weldment	20268	\$250	



SILCOSTEEL®
version available



Replacement Chemical Trap for HP 5880 GCs

(Similar to HP part #19362-60500.): cat.# 21158, \$82



1/4" CD Adaptor Fitting

(Similar to HP part #19802-80020.): cat.# 20269, \$99



Gerstel GRAPHPACK® Conectors

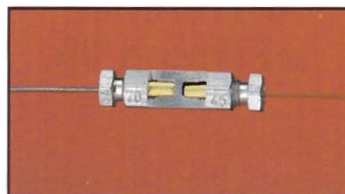
GRAPHPACK® technology results in a complete system that quickly and reliably makes truly leak-free, low-dead-volume connections. The central component is a metal-jacketed graphite ferrule—the ideal sealant for gas chromatography applications. These GRAPHPACK® ferrules eliminate all the disadvantages and shortcomings associated with connecting MXT® tubing to fused silica tubing.

GRAPHPACK® 3D/2 Connector*: (0.25mm to 0.32 mm); cat.# 20272 (ea.), \$97

GRAPHPACK® 3D/2 Connector*: (0.7mm to 0.45 mm); cat.# 20273 (ea.), \$97

*Use only with GRAPHPACK® 3D/2 ferrules.

GRAPHPACK® 3D/2 Ferrules			
Ferrule ID	Fits Column ID	cat.# (10-pk.)	
0.4mm	0.25mm	20271	\$139
0.5mm	0.32mm	20270	\$139
0.8mm	0.53mm	20274	\$139



Replacement 0.8mm ID Cross Disk Inlet Seal for HP 6890 GCs

(Similar to HP part #5182-9652.)

0.8mm ID Cross Disk Inlet Seal for HP GCs				
Inlet Seal Type	2-pk.		10-pk.	
Gold-Plated	20477	\$62	20476	\$280
Silcosteel®-Treated	20475	\$62	20474	\$280

New
CROSS DISKS

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15 (of 16) 1999 Winter

RESTEK

Behind the Scenes

Innovators of
High Resolution
Chromatography
Products



For every customer profile
completed at Pittcon this year,
Restek will donate
\$1 to the American Cancer
Society and give you a free
tote bag.

Because at Restek, we feel
that it's as important
to give as it is to receive.



Making a
Difference
at Pittcon '99

Will you be in Orlando March 7-12? Check out Booth #6348 – The Hottest Booth at PittCon '99.

Restek Corporation, innovators in chromatography products, will be offering several technical presentations at this year's Pittsburgh Conference. Visit our booth (#6348) for up-to-date information on these presentations, new products, what's "hot" in the industry, and employment opportunities. See you there—stop by for your free gift!

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