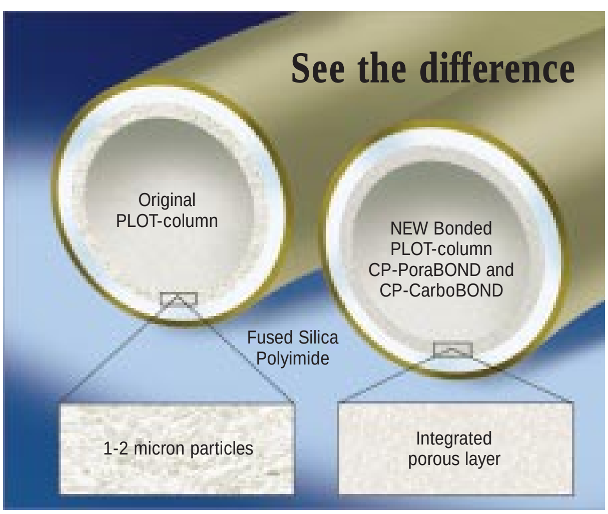
Chrompack PLOT Columns

Chrompack PLOT Columns: the best choice for analyzing gases and volatiles

Analyzing gases and volatiles has long been one of the most difficult tasks in gas chromatography. The challenge to maintain resolution for very volatile compounds has meant that many methods are still based on traditional packed columns. This is very limiting, since packed columns offer low resolution and are often dedicated to one specific analysis. When Wall Coated Open Tubular (WCOT) capillary columns are used, it has been necessary to operate at very low temperatures requiring liquid nitrogen or CO2 coolants. Other problems arise when using columns with very thick films, which aren't very efficient and offer poor resolution.

The Original PLOT Column

The introduction of the first Porous Layer Open Tubular (PLOT) column by Chrompack in 1988 finally allowed users to experience the benefits of high-resolution capillary gas chromatography when analyzing a wide range of gases and volatiles. In comparison to packed WCOT columns, the PLOT columns were more versatile, offered higher resolution, and delivered faster analysis.



A Technological Revolution

Recent technical breakthroughs by our research laboratories in the Netherlands have allowed Varian to introduce a new line of bonded PLOT columns. Varian's PLOT columns deliver superior mechanical and temperature stability and allow for increasingly fast methods. These columns are ideal for use in the chemical, petrochemical, pharmaceutical, and environmental applications.

In comparison to their non-bonded predecessors, bonded PLOT columns contain significant improvements in column stability. New technology has led to the development of "in-situ" column manufacturing techniques, process that enable adsorbents to be grown in-situ within a column. The result is a layer that cross links to produce a column with significantly higher mechanical and temperature stability. This is drastically different than earlier techniques in which pre-formed particles were coated in the column.

Some of the advantages of bonded PLOT columns include:

- **High Tmax**. The new CP-PoraBOND Q has a Tmax of 320 °C and offers increased flexibility and versatility. PLOT columns can now be used for analyzing a wide range of volatile and semi-volatile applications; cycle times can be shortened by temperature ramping to higher temperatures. Plus, using different columns in the same oven (e.g. CP-PoraBOND and CP-Molsieve) increases system flexibility.
- **Lower bleed**. The bonding process means lower bleed, by a factor of >5. This results in improved sensitivity and reduced detector fouling.
- **No particle loss**. High mechanical stability means that columns can be interfaced to MS detectors and valve switching systems. Particle traps are no longer required, eliminating column blockage and increasing column lifetimes.
- **High inertness**. Superior synthesis and column manufacturing techniques ensure columns are suitable for accurately analyzing a wide range of compounds, including solvents, sulfur compounds, and CFCs at trace levels.

The Chrompack PLOT Advantage

The Original PLOT Manufacturer

The Chrompack brand name is synonymous with PLOT columns. The innovations that began more than 15 years ago with the PLOT column still continues, with constant product development and continual improvements. By working closely with laboratories in a variety of industries, Varian is able to offer practical solutions to your analytical and productivity challenges. Our newest innovations are designed for the online process and field portable GCs, as well as applications requiring value switching and systems interfaced to MS detectors.

The widest range of columns to optimize your analysis

• Stationary phases

Varian's Chrompack line of PLOT columns now includes 6 different types of columns, making unique separations possible for a wide range of compounds.

• Tubing materials

Our columns are available in fused silica for general-purpose laboratory work and Ultimetal, for online processes and field portable instruments.

• Tubing diameters

Varian's columns are available in many different lengths, internal diameters, and coil diameters. This allows you the flexibility to select the right column to suit your sample, GC, and laboratory.

Application support

We're pleased to offer you more than 15 years of application knowledge. In addition to Help Desks in Europe and the United States, we have an applications database on CD-ROM as well as a wide range of posters and technical publications. Challenge us with your application today!

Highest Quality

Varian combines the highest quality materials with the latest manufacturing techniques to produce high-quality, high-performance PLOT columns.

Bonded

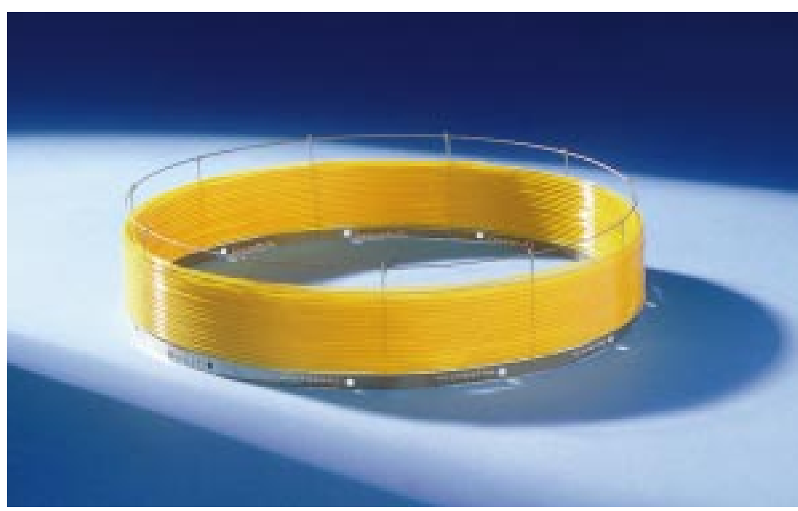
Bonded columns offer increased method reliability and are ideal for labs in which high throughput and low maintenance are essential. Instead of coating the column with particles, Varian builds a homogeneous layer within the column. This process eliminates particle traps and ensures that column and valve blockage are a thing of the past.

Inertness

In attempting to lower detection levels, the purity of materials and deactivation procedures become essential to achieving symmetrical peaks and accurate measurements. CP-PoraBOND Q is the only "PLOT Q" column available that is designed to provide accurate analysis of a wide range of polar solvents at trace levels.

Highest Price Performance Ratio

Varian is committed to providing high quality products at competitive prices. Contact your local office for more details.



Ordering information Chrompack PLOT and Bonded PLOT Columns

CP-PoraBOND Q

Tubing material	ID (mm)	Length (m)	Df (µm)	Tmax °C Iso/prog	Cat. No
Fused Silica	0,25	10	3	300/320	CP7347
Fused Silica	0,25	25	3	300/320	CP7348
Fused Silica	0,32	10	5	300/320	CP7350
Fused Silica	0,32	25	5	300/320	CP7351
Fused Silica	0,32	50	5	300/320	CP7352
Fused Silica	0,53	10	10	300/320	CP7353
Fused Silica	0,53	25	10	300/320	CP7354
Fused Silica	0,53	50	10	300/320	CP7355

CP-PoraBOND Q replaces CP-PoraPLOT Q in >95% of applications offering higher column performance.

CP-PoraPLOT Q

Tubing material	ID (mm)	Length (m)	Df (µm)	Tmax °C Iso/prog	Cat. No
Fused silica	0,25	10	8	250/250	CP7548
Fused silica	0,25	25	8	250/250	CP7549
Fused silica	0,32	10	10	250/250	CP7550
Fused silica	0,32	25	10	250/250	CP7551
Fused silica	0,32	50	10	250/250	CP7552
Fused silica	0,53	10	20	250/250	CP7553
Fused silica	0,53	25	20	250/250	CP7554
Fused silica	0,53	50	20	250/250	CP7555
Ultimetal	0,53	10	20	250/250	CP6953
Ultimetal	0,53	25	20	250/250	CP6954
Ultimetal	0,53	50	20	250/250	CP6955

CP-PoraBOND Q replaces CP-PoraPLOT Q in >95% of applications offering higher column performance.

CP-PoraPLOT Q-HT

Tubing material	ID (mm)	Length (m)	Df (µm)	Tmax °C Iso/prog	Cat. No
Fused Silica	0,32	10	10	290/290	CP7556
Fused Silica	0,32	25	10	290/290	CP7557
Fused Silica	0,53	10	20	290/290	CP7558
Fused Silica	0,53	25	20	290/290	CP7559

CP-PoraPLOT S

Tubing material	ID (mm)	Length (m)	Df (µm)	Tmax °C Iso/prog	Cat. No
Fused Silica	0,53	10	20	250/250	CP7573
Fused Silica	0,53	25	20	250/250	CP7574

CP-PoraPLOT U

Tubing material	ID (mm)	Length (m)	Df (µm)	Tmax °C Iso/prog	Cat. No
Fused Silica	0,25	10	8	190/190	CP7578
Fused Silica	0,25	25	8	190/190	CP7579
Fused Silica	0,32	10	10	190/190	CP7580
Fused Silica	0,32	25	10	190/190	CP7581
Fused Silica	0,53	10	20	190/190	CP7583
Fused Silica	0,53	25	20	190/190	CP7584

CP-PoraPLOT Amines

Tubing material	ID (mm)	Length (m)	Df (µm)	Tmax °C Iso/prog	Cat. No
Fused Silica	0,32	25	10	220/220	CP7591
Fused Silica	0,53	25	20	220/220	CP7594

CP-Al_2O_3/KCL

Tubing material	ID (mm)	Length (m)	Df (µm)	Tmax °C Iso/prog	Cat. No
Fused Silica	0,25	10	4	200/200	CP7575
Fused Silica	0,25	25	4	200/200	CP7576
Fused Silica	0,25	50	4	200/200	CP7577
Fused Silica	0,32	10	5	200/200	CP7511
Fused Silica	0,32	25	5	200/200	CP7519
Fused Silica	0,32	50	5	200/200	CP7515
Fused Silica	0,53	10	10	200/200	CP7516
Fused Silica	0,53	25	10	200/200	CP7517
Fused Silica	0,53	50	10	200/200	CP7518
Ultimetal	0,53	50	10	200/200	CP6918

CP-Al_2O_3/Na_2SO_4

Tubing material	ID (mm)	Length (m)	Df (µm)	Tmax °C Iso/prog	Cat. No
Fused Silica	0,25	10	4	200/200	CP7585
Fused Silica	0,25	25	4	200/200	CP7586
Fused Silica	0,25	50	4	200/200	CP7587
Fused Silica	0,32	10	5	200/200	CP7561
Fused Silica	0,32	50	5	200/200	CP7565
Fused Silica	0,53	25	10	200/200	CP7567
Fused Silica	0,53	50	10	200/200	CP7568
Ultimetal	0,53	50	10	200/200	CP6968

CP-SilicaPLOT

Tubing material	ID (mm)	Length (m)	Df (µm)	Tmax °C Iso/prog	Cat. No
Fused Silica	0,25	15	3	225/225	CP8563
Fused Silica	0,25	30	3	225/225	CP8564
Fused Silica	0,25	60	3	225/225	CP8565
Fused Silica	0,32	15	4	225/225	CP8566
Fused Silica	0,32	30	4	225/225	CP8567
Fused Silica	0,32	60	4	225/225	CP8568
Fused Silica	0,53	15	6	225/225	CP8569
Fused Silica	0,53	30	6	225/225	CP8570
Fused Silica	0,53	60	6	225/225	CP8571

CP-Lowox

Tubing material	ID (mm)	Length (m)	Df (µm)	Tmax °C Iso/prog	Cat. No
Fused Silica	0,53	10	10	350/350	CP8587

CP-CarboBOND

Tubing material	ID (mm)	Length (m)	Df (µm)	Tmax °C Iso/prog	Cat. No
Fused Silica	0,53	25	5	200/300	CP7371
Fused Silica	0,53	25	10	200/300	CP7374
Fused Silica	0,53	50	5	200/300	CP7372
Fused Silica	0,53	50	10	200/300	CP7375

CP-CarboPLOT P7

Tubing material	ID (mm)	Length (m)	Df (µm)	Tmax °C Iso/prog	Cat. No
Fused Silica	0,53	10	25	115/115	CP7513
Fused Silica	0,53	25	25	115/115	CP7514

CP-Molsieve 5Å

Tubing material	ID (mm)	Length (m)	Df (µm)	Tmax °C Iso/prog	Cat. No
Fused Silica	0,32	10	30	350/350	CP7535
Fused Silica	0,32	25	30	350/350	CP7536
Fused Silica	0,32	30	10	350/350	CP7534
Fused Silica	0,32	50	30	350/350	CP7540
Fused Silica	0,53	10	50	350/350	CP7537
Fused Silica	0,53	15	15	350/350	CP7543
Fused Silica	0,53	25	50	350/350	CP7538
Fused Silica	0,53	30	15	350/350	CP7544
Fused Silica	0,53	50	50	350/350	CP7539
Ultimetal	0,53	10	50	350/350	CP6937
Ultimetal	0,53	25	50	350/350	CP6938

Varian Analytical Instruments, serving worldwide markets in:

Agriculture
Basic Chemical
Biotechnology
Clinical
Electronics
Environmental
Photonics
Toxicology
Pharmaceutical
Food and Beverage
Metals and Mining
Petroleum and Petrochemical

• Varian Sales Offices

Varian is committed to a process of continuous improvement which demands that we understand and then meet or exceed the needs and expectations of our customers — both inside and outside the company — in everything we do.

ISO 9001 REGISTERED

VARIAN

Varian Analytical Instruments • **www.varianinc.com**
• **North America**: 800.926.3000, 925.939.2400
• **Europe** The Netherlands: 31.118.67.1000
• **Asia Pacific** Australia: 613.9560.7133
• **Latin America** Brazil: 55.11.3845.0444
• **Other sales offices and dealers throughout the world**

GC • GC/MS • HPLC • AAS • ICP • ICP-MS • UV-Vis-NIR • Fluorescence • NMR • Analytical Supplies

MDL0001R0GU040005M

The Original PLOT Manufacturer

Chrompack PLOT Columns

Technical information

Selecting the Right Chrompack PLOT Column for your Analysis

Table of Contents

CP-PoraBOND and CP-PoraPLOT

Styrene-divinylbenzene-based porous polymer columns are ideal for the analysis of solvents and volatile compounds in the chemical, petrochemical, environmental, and pharmaceutical industries. A porous polymer exhibits unique retention characteristics, including the perfect elution of polar and apolar volatile compounds, as well as hydrocarbons, alcohols, esters, and ketones.

Polar compounds such as methanol, acetaldehyde and ethylene oxide have very short retention times in gas-liquid chromatography but do not elute from alumina or molecular sieve adsorbents. The CP-PoraBOND and PoraPLOT range of columns elute these polar compounds as perfectly symmetrical peaks, allowing them to be analyzed together with light hydrocarbons or permanent gases.

Since the retention is not influenced by water in the sample, retention times are repeatable.

PoraBOND/PoraPLOT Application fields

Q	alcohols and water, polar solvents, hydrocarbons, gases
S	ketones, esters, halogenated compounds, hydrocarbons
U	all polar volatiles, nitriles/nitro-compounds, alcohols/aldehydes, ethane/ ethylene, sulfur gases, oxygen in air, ppm water in gases
Amines	ammonia, very volatile amines

Fast separation of commonly used residual solvents

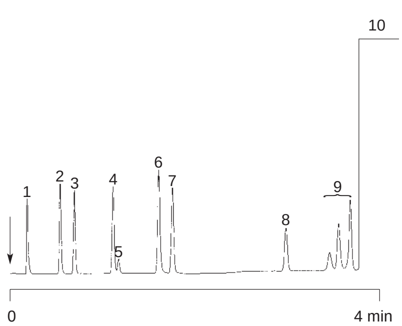
Application 1457 - GC

residual solvents

In addition to a CP-Select 624 CB column (see Application notes 1282 - 1286), which phase is prescribed in the USP for the analysis of residual solvents in pharmaceutical products, a second column often is used for confirmation or special solvents analysis. In many cases this column is a PLOT column. The CP-PoraBOND Q column, with a bonded layer of the very hydrophobic styrene-divinylbenzene copolymer phase, is an improved version of this type of column.
The CP-PoraBOND Q column provides a good selectivity, peakshape, signal/noise ratio and stable baseline, even at high flow rates due to the bonded character of the stationary phase.

Technique:	GC - capillary
Column:	CP-PoraBOND Q fused silica PLOT 10 m x 0.32 mm, df = 5 µm Cat. no. 7350
Temperature:	150 °C → 220 °C, 10 °C/min; 220 °C (5 min)
Carrier gas:	N_2, 1 ml/min
Injector:	Splitter, 20 ml/min, T = 150 °C
Detector:	FID, T = 280 °C
Sample size:	1.0 µl
Concentration range:	0.05 mg/ml
Solvent sample:	pyridine
Courtesy:	Mr. J. Vloet, Organon, Oss, The Netherlands

Peak identification:
1. methanol
2. ethanol
3. acetonitrile
4. acetone
5. dichloromethane
6. diethyl ether
7. 1,2-dichloroethane (Internal Standard)
8. ethyl acetate
9. hydrocarbons C_6
10. pyridine (sample solvent)



Headspace analysis of cyanides in blood.

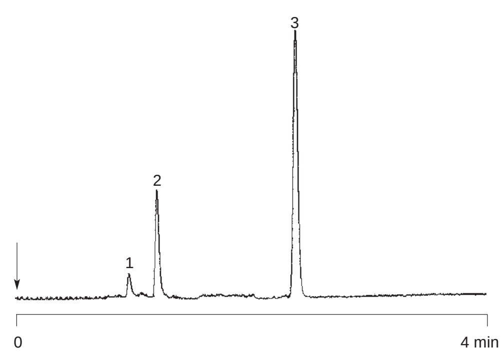
Application 1529 - GC

Gases

Blood samples of 500 µl are spiked with acetonitrile (Internal Standard) and with 100 µl phosphoric acid. After homogenization they are heated in a closed vial at 60 °C for 30 minutes. A 250 µl headspace sample is injected and analyzed.
The PoraBOND Q column gives an excellent separation, peakshape and quantitative results.

Analysis technique:	GC - wide-bore
Column:	CP-PoraBOND Q, 25 m x 0.53 mm, df = 10 µm Cat. no. CP7354
Temperature:	120 °C
Carrier gas:	He, 40 kPa
Injector:	headspace/split, 200 °C
Detector:	NPD, 230 °C
Sample size:	250 µl headspace
Concentration range:	20 - 4800 ng/ml
Sample solvent:	body fluid / water
Courtesy:	P. Visinoni, Lab. de Police Scientifique, Toulouse, France

Peak identification:
1. nitrogen (air)
2. hydrocyanic acid (HCN) 0.47 mg/l
3. acetonitrile (IS) 1.0 mg/l



CP-PoraBOND Q

- New bonded column which replaces CP-PoraPLOT Q and CP-PoraPLOT Q-HT
- Applicable on a wide range of non-polar volatiles/semi-volatiles
- No effect of water on retention times
- High column stability with Tmax of 320 °C
- The "lowbleed" PLOT Q Column
- Suitable for valve switching, high flow rates, and EPC pressure/flow programming
- No need for particle traps

Styrene-divinylbenzene polymer

Replaces: Porapak Q, HayeSep Q, Chromosorb 102, 105, 106, GS-Q, HP-PLOT Q; CP-PoraPLOT Q; CP-PoraPLOT Q-HT

Trace analysis of sulfur compounds

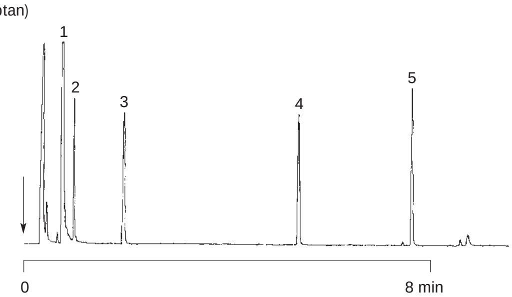
Application 1458 - GC

sulfur compounds

The inertness of the CP-PoraBOND Q column allows the separation of volatile sulfur compounds at low levels with an excellent peak shape. Together with the high sensitivity of the Pulsed Discharge Detector, linear quantification down to the sub-ppm level is possible under these conditions. Also water can be detected.

Technique:	GC - capillary
Column:	CP-PoraBOND Q fused silica PLOT 15 m x 0.32 mm, df = 5 µm Cat. no. 7351 (as 25 m column)
Temperature:	35 °C (3 min) → 250 °C, 20 °C/min
Carrier gas:	He, 50 kPa (0.5 bar, 7.2 psi)
Injector:	Valve/Split
Detector:	VICI Pulsed Discharge Detector, T = 300 °C
Sample size:	100 µl
Concentration range:	100 ppm
Courtesy:	Jim Luong, Analytical Sciences, Dow Western Canada Operations

Peak identification:
1. water
2. hydrogen sulfide
3. carbonyl sulfide
4. methanethiol (methyl mercaptan)
5. ethanethiol (ethyl mercaptan)



Analysis of trace of polar solvents in water via splitless injection

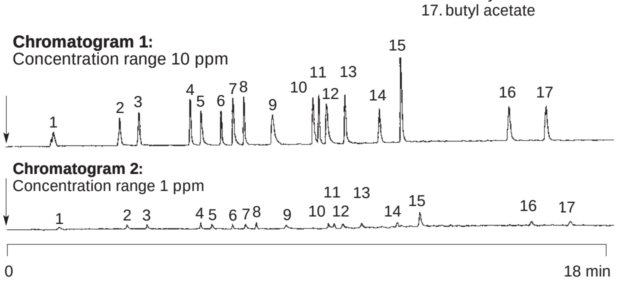
Application 1428 - GC
REV: 02

Solvents

The CP-PoraBOND Q column allows direct water injections via direct or splitless sample introduction without extra peak broadening for quick-eluting compounds, and avoiding difficult techniques like purge and trap analysis. Especially the splitless injection of water results in good chromatography, even for volatile polar compounds like ethanol, acetonitrile and acetone. The water peak elutes very early and will coelute with the methanol. This peak is also somewhat broadened due to the water matrix effect. All other components elute with good symmetry at levels of 10 ppm.
Even at 1 ppm level all components can be quantified. The inertness of the CP-PoraBOND Q porous polymer in combination with the stability of the bonded phase, form a base for a long lifetime. See also application 1423.

Technique:	GC - capillary
Column:	CP-PoraBOND Q fused silica PLOT 25 m x 0.32 mm, df = 5 µm, Cat. no. 7351
Temperature:	90 °C (2 min) → 200 °C, 10 °C/min
Carrier gas:	He, 160 kPa (1.6 bar, 22 psi)
Injector:	Splitless, T = 225 °C
Detector:	FID, T = 250 °C
Sample size:	1 µl
Concentration range:	10 ppm and 1 ppm
Solvent sample:	water
Courtesy:	E. Houben, Pro Analyse, Environmental Laboratory, Barneveld, the Netherlands

Peak identification:
1. methanol
2. ethanol
3. acetonitrile
4. acetone
5. 2-propanol (isopropanol)
6. methyl acetate
7. 1-propanol
8. diethyl ether
9. 2-methyl-2-propanol (t-butanol)
10. 2-butanol
11. ethyl acetate
12. isobutanol
13. butanol
14. 1,4-dioxane
15. pyridine
16. isobutyl acetate
17. butyl acetate



Separation of CFCs

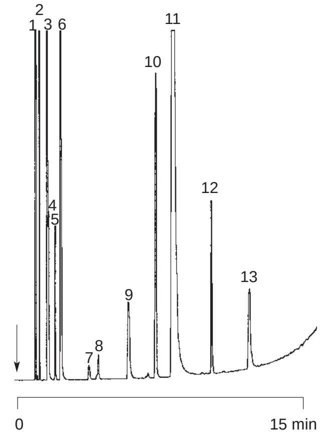
Application 1429 - GC

Halogenated hydrocarbons C1 - C2, hydrocarbons C1 - C6

Porous polymers are generally preferred for CFC separations as the high retention allows the volatile CFCs to be measured at low levels. However, if the porous polymer has no homogeneous pore size distribution, several molecules will show extra peak broadening resulting in poor detection limits. A CFC that shows this behavior is the CFC 113 or its isomer 113a.
The CP-PoraBOND Q, with its well defined pore size distribution, elutes CFC 113 as a sharp peak. Due to the inertness of the CP-PoraBOND Q porous polymer a wide range of CFCs will elute at low concentrations. Conditioning the column at 300 °C removes any heavy material which might be in the sample as an impurity. Valve injections that include pressure pulses can be done as the CP-PoraBOND Q has a chemically bonded integrated adsorption layer, that does not contain particles.

Technique:	GC - wide-bore
Column:	CP-PoraBOND Q fused silica PLOT 25 m x 0.53 mm, df = 10 µm Cat. no. 7354
Temperature:	100 °C (2 min) → 250 °C, 10 °C/min
Carrier gas:	He, 40 kPa (0.4 bar, 6 psi)
Injector:	Split, T = 250 °C
Detector:	FID, T = 250 °C
Sample size:	50 µl
Concentration range:	0.1% in N_2

Peak identification:
1. methane
2. ethane
3. CFC 134a
4. CFC 22
5. propane
6. CFC 12
7. isobutane
8. butane
9. CFC 11
10. pentane
11. CFC 113 + CFC 113a
12. hexane
13. CFC 112 + CFC 112a



CP-PoraPLOT U

- Most polar Porous polymer PLOT
- Symmetrical peaks for polar and non-polar volatiles
- No effect of water on retention times
- Separates CO_2 from bulk air

Divinylbenzene-ethyleneglycol-dimethacrylate polymer

Replaces: Porapak N, T; Hayesep N, T, C; Chromosorb 104, HP-PLOT U

CP-PoraPLOT S

- Analysis of medium-polarity volatiles

Divinylbenzene-vinylpyridine polymer

Replaces: Porapak S, R, HayeSep S, R, Chromosorb 107

CP-PoraPLOT Amines

- High retention for very volatile amines

Tmax	iso/prog (ºC)
CP-PoraPLOT Q	250/250
CP-PoraPLOT Q-HT	290/290
CP-PoraBOND Q	300/300
CP-PoraPLOT S	250/250
CP-PoraPLOT U	190/190
CP-Pora PLOT amines	220/220

Impurities in polymer

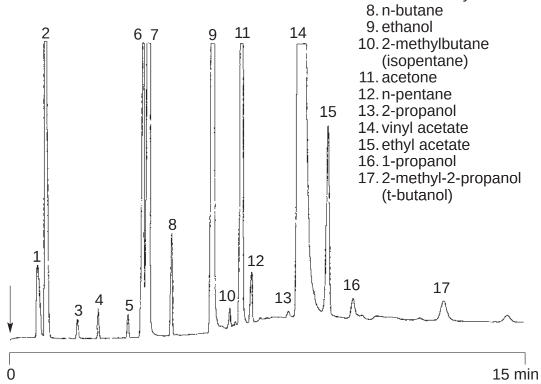
Application 1338 - GC

Vinyl chloride, vinyl acetate and volatiles in polymeric dispersion

Headspace sampling makes the analysis possible of volatile compounds at low levels in a complex, “dirty” matrix.
The unique selectivity of the CP-PoraPLOT U column separates vinyl chloride, vinyl acetate and many other hydrocarbons and oxygenates.

Technique:	GC - wide-bore
Column:	CP-PoraPLOT U fused silica PLOT 10 m x 0.53 mm, df = 20 µm, Cat. no. 7583
Temperature:	65 °C (0.1 min) → 150 °C, 10 °C/min
Carrier gas:	He, 50 kPa (0.5 bar, 7.2 psi), 6 ml/min
Sampler:	CP-9020 headspace sampler; incubation temperature and time: 40 °C for 30 min
Injector:	direct, T = 90 °C
Detector:	FID, T = 200 °C
Sample size:	250 µl headspace
Concentration range:	2 ppm (vinyl chloride)
Solvent sample:	polymeric dispersion
Courtesy:	J. Appeldoorn, Vinamul BV, Geleen, the Netherlands

Peak identification:
1. methane
2. ethylene
3. propylene
4. propane
5. vinyl chloride
6. isobutane
7. methanol + acetaldehyde
8. n-butane
9. ethanol
10. 2-methylbutane (isopentane)
11. acetone
12. n-pentane
13. 2-propanol
14. vinyl acetate
15. ethyl acetate
16. 1-propanol
17. 2-methyl-2-propanol (t-butanol)



Analysis of trace amines

Application 1397 - GC

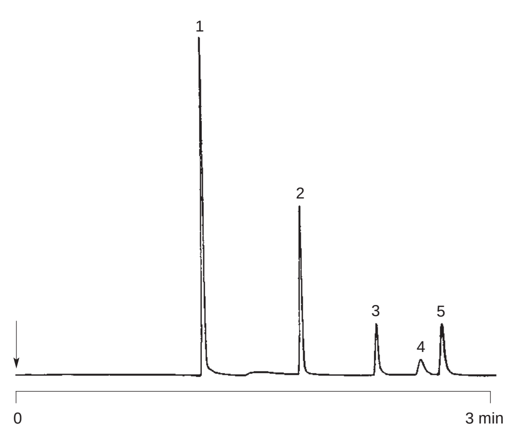
Amines C1 - C2

Amines are difficult to analyze due to their strong basic nature. Capillary columns must be base-modified to elute amines with acceptable recovery. For highly volatile amines including ammonia, the siloxane-based phases do not provide enough retention.
The CP-PoraPLOT Amines porous polymer provides a high retention combined with a high inertness for amines. Volatile amines elute at low levels as shown in this application. Also ammonia elutes as a sharp peak at nanogram levels.
If besides these amines also alcohols and/or water must be measured, a 5 µm film CP-Sil 5 CB is recommended, operated at temperatures around 30 °C.

Technique:	GC - capillary
Column:	CP-PoraPLOT amines fused silica PLOT 25 m x 0.32 mm, df = 10 µm Cat. no. 7591
Temperature:	140 °C (2 min) → 250 °C, 10 °C/min
Carrier gas:	H_2, 95 kPa (0.95 bar, 13 psi)
Injector:	on-column
Detector:	ELD
Sample size:	0.1 µl

Peak identification:

1. ammonia	1.8 ng
2. methylamine	3.4 ng
3. dimethylamine	2.9 ng
4. trimethylamine	2.9 ng
5. ethylamine	3.4 ng



CP-Al_2O_3

- High resolution for C1-C5 hydrocarbon isomers
- Suitable for measuring hydrocarbon impurities in ethylene/propylene/butene streams
- No need for sub-ambient cooling
- Two unique selectivities
- Available in both fused silica and Ultimetal

Aluminum oxide PLOT columns offer high selectivity for analyzing ppm levels of C1-C5 hydrocarbon in a main stream of C1-C5 hydrocarbons. These columns are able to analyze more compounds in a single run than packed columns, while still delivering higher resolution and faster analysis times. When compared to liquid stationary phases, the Al_20_3 PLOT column offers increased selectivity and allows all Cl-C5 hydrocarbon isomers to be separated.

In the presence of moisture, the retention times on Al_2O_3 PLOT columns may vary from analysis to analysis. This can be prevented by temperature programming up to 200 °C, which elutes the water.

KCl or Na_2SO_4 deactivation

The aluminum oxide PLOT columns are deactivated using very small salt crystals, providing a reproducible and stable deactivation up to 200 °C. Depending on the type of deactivation salt, the CP-Al_2O_3 column will show a certain selectivity. KCl salt results in a relatively apolar Al_2O_3 surface, while Na_2SO_4 deactivation results in a polar surface. Unsaturated compounds like ethylene and acetylene (ethyne) are retained longer.

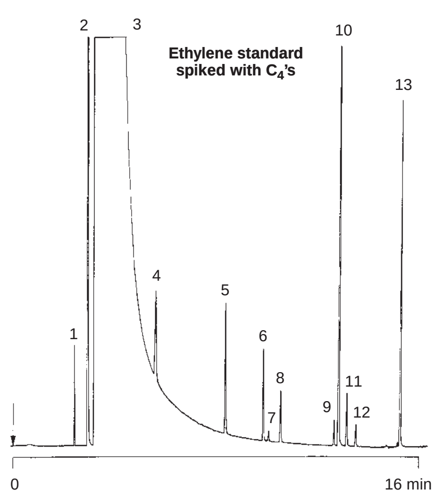
Analysis of high-purity ethylene

Application 671 - GC

Hydrocarbons C1 - C4

Technique:	GC-capillary
Column:	Al_2O_3/KCl fused silica PLOT 50 m x 0.53 mm; df = 10 µm Cat.no. 7518
Temperature:	35 ˚C (3 min) - 150 ˚C, 8 ˚C/min; 150 ˚C (30 min)
Carrier gas:	He, 6 ml/min
Injector:	Valco 6 port valve
Detector:	FID, 2⁴ Afs T = 300 ˚C
Sample:	120 µl
Courtesy:	A. Tailor Chevron Chemical Company, Cedar Bayou Plant, Baytown, Texas, USA

Peak identification:	**Concentration range**	
1. methane	4.5	ppm
2. ethane	316	ppm
3. ethylene		
4. propane	4.5	ppm
5. propylene	5.2	ppm
6. acetylene	4.7	ppm
7. isobutene		
8. n-butane		
9. trans-2-butene		
10. 1-butene		
11. isobutene		
12. cis-2-butene		
13. 1,3-butadiene		



Separation of impurities in high purity propylene acc to proposed ASTM method

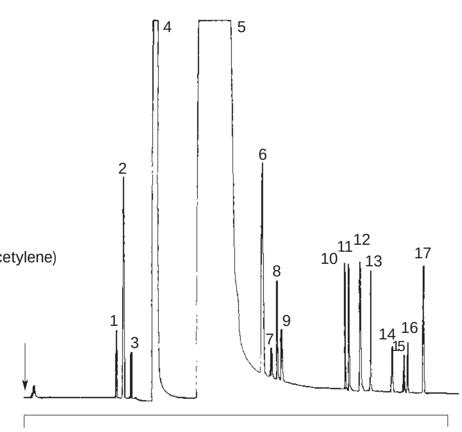
Application 1312 - GC

Hydrocarbons C1 -C4

Because of the low polarity the Al2O3/KCl deactivated PLOT column provides highest separation factor between propylene and butanes making quantification possible at ppm levels. Also pentanes do not interfere with cis-2-butene which may happen on more polar Al2O3 PLOT columns.
Moisture present in the sample will cause a shift of retention times. Retention times will be highly reproducible when a temperature programmed analysis is used. Usually a final temperature of 200 °C is used; for high purity samples like high purity propylene, 160 °C will be sufficient.

Technique:	GC - wide-bore
Column:	CP-Al2O3/KCl fused silica PLOT 50 m x 0.53 mm, df = 10 µm Cat. no. 7518
Temperature:	40 °C (10 min) Æ 160 °C, 5 °C/min
Carrier gas:	He, 80 kPa (0.8 bar, 12 psi),
Injector:	Valve into splitter, 20:1, T = 200 °C
Detector:	FID, T = 200 °C
Sample size:	0.2 µl (liquid)
Concentration range:	10 - 20 ppm

Peak identification:
1. methane
2. ethane
3. ethylene
4. propane
5. propylene
6. isobutane
7. acetylene
8. butane
9. propadiene
10. trans-2-butene
11. 1-butene
12. isobutene
13. cis-2-butene
14. isopentane
15. propyne (methylacetylene)
16. pentane
17. 1,3-butadiene



CP-Al_2O_3/KCL

Replaces: Alumina

CP-Al_2O_3/Na_2SO_4

Replaces: GS-Alumina, HP-PLOT m/s

Tmax	iso/prog (ºC)
Al_2O_3/KCl	200ºC/200ºC
Al_2O_3/Na_2SO_4	200ºC/200ºC

Impurities in 1,2-butadiene

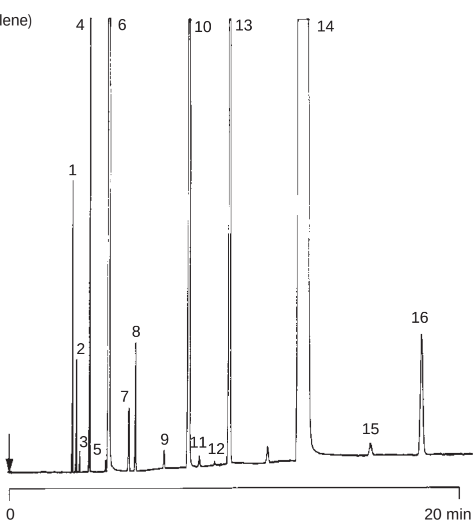
Application 594 - GC

Hydrocarbons C1 - C4

Technique:	GC-capillary
Column:	50 m x 0.32 mm fused silica WCOT Al_2O_3/Na_2SO_4 (df = 5 µm) (Cat.no. 7565)
Temperature:	110 ˚C
Carrier gas:	N_2' 110 kPa (1.1 bar, 16 psi)
Injector:	Splitter, 20 ml/min T = 150 ˚C
Detector:	FID, 4 x 10^{-12} Afs. T = 200 ˚C
Sample size:	100 µl
Concentration range:	5 - 1000 ppm

Peak identification:

1. methane
2. ethane
3. ethene (ethylene)
4. propane
5. cyclopropane
6. propene (propylene)
7. isobutane
8. n-butane
9. cyclobutane
10. trans-2-butene
11. 1-butene
12. isobutene
13. cis-2-butene
14. 1,2-butadiene
15. 1,3-butadiene
16. propyne



Seperation og C1 - C5 hydrocarbons on Al_2O_3/Na_2SO_4 PLOT

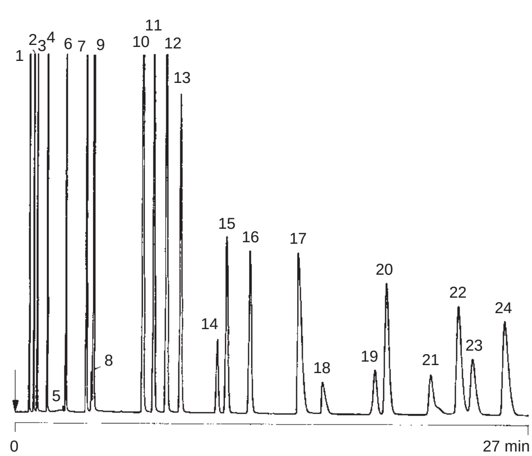
Application 611 - GC

Hydrocarbons C1 - C4

Technique:	GC-capillary
Column:	Al_2O_3/Na_2SO_4fused silica PLOT 50 m x 0.53 mm; df = 10 µm, Cat.no. 7568
Temperature:	120 ˚C
Carrier gas:	He, 50 kPa (0.5 bar, 7 psi), 23 cm/s
Injector:	Splitter, T = 225 ˚C
Detector:	FID, T = 250 ˚C

Peak identification:

1. methane
2. ethane
3. ethylene
4. propane
5. cyclopropane
6. propylene
7. isobutane
8. propadiene
9. n-butane
10. trans-2-butene
11. 1-butene
12. isobutene
13. cis-2-butene
14. cyclopentane
15. isopentane
16. n-pentane
17. 1,3-butadiene
18. propyne
19. cyclopentene
20. trans-2-pentene
21. 2-methyl-2-butene
22. 1-pentene
23. 2-methyl-1-butene
24. cis-2-pentene



CP-SilicaPLOT

- High selectivity for C1-C4 isomers in the presence of water
- Water does not influence retention times
- Elution of CO2 and sulfur gases at ppm levels
- Separates cyclopropane from propylene
- No decomposition of pentadienes
- High selectivity for CFCs without decomposition
- Bonded column ensures no particle loss

The CP-SilicaPLOT is a bonded silica-based column that offers unique selectivity for a wide range of compounds including light hydrocarbons, sulfur compounds, and CFCs. Its stable retention time even in the presence of water and other polar compounds makes the column ideal for high-throughput lab and online process applications.

This robust column offers high mechanical stability, making it suitable for valve-switching applications.

Replaces: GS-Gaspro, Silicagel, Porasil-C.

Tmax: 225/225 (ºC) iso/prog

Separation of halogenated hydrocarbons and C2 hydrocarbons

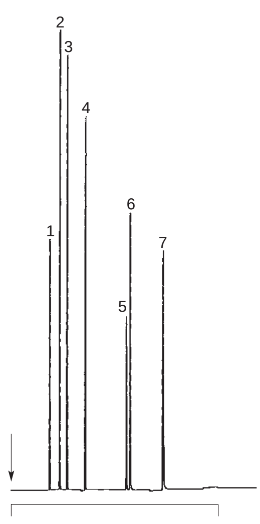
Application 1356 - GC

Halogenated hydrocarbons

The CP-SilicaPLOT separates all C2 isomers with high resolution. Besides this, the column is highly selective and inert for halogenated compounds. Volatile compounds like chloromethane, vinyl chloride and chloroethane elute as sharp peaks, well separated from the C2 isomers. Typical separations can be done at temperatures above ambient. Traces of water will not change retention time.

Technique:	GC - capillary
Column:	CP-SilicaPLOT fused silica PLOT 30 m x 0.32 mm, df = 4 µm Cat. no. 8567
Temperature:	40 °C (2 min) Æ 200 °C, 20 °C/min
Carrier gas:	N2, 50 kPa (0.5 bar, 7 psi)
Injector:	Split 50 ml/min,T = 200 °C
Detector:	FID, T = 200 °C
Sample size:	1 ml
Concentration range:	% level
Sample matrix:	nitrogen
Courtesy:	H. Erlemeier, Zentrale Analytik, Hoechst AG, Germany

Peak identification:	as v/v ppm
1. methane	1000 ppm
2. ethane	980 ppm
3. ethylene	980 ppm
4. acetylene	960 ppm
5. chloromethane	1020 ppm
6. vinyl chloride	880 ppm
7. chloroethane	960 ppm



Sulfur and hydrocarbons by GC-AED

Application 1292 - GC

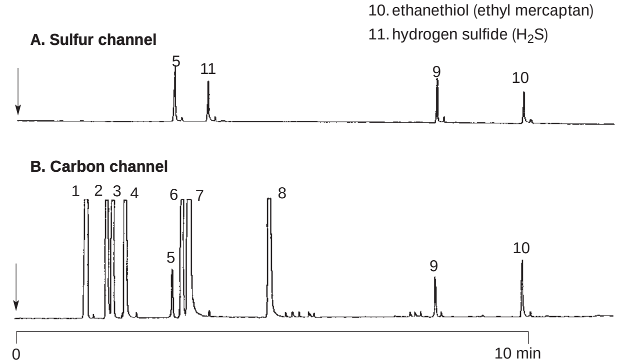
Sulfur gases and hydrocarbons C1 - C3

Elution of sulfur gases in relation with hydrocarbons
COS and H_2S elute without interference from light hydrocarbons making quantification possible with universal detection devices and avoids quenching effects with selective detectors

Technique:	GC - capillary
Column:	CP-SilicaPLOT fused silica PLOT 30 m x 0.32 mm, df = 4 µm Cat. no. 8567
Temperature:	40 °C (2 min) Æ 250 °C, 20 °C/min
Carrier gas:	He, 210 kPa (2.1 bar, 30 psi)
Injector:	Split, 1:100 T = 200 °C
Detector:	AED, Carbon channel, C 193; Sulfur channel, S 181 T = 250 °C
Sample size:	1.0 ml
Concentration range:	sulfur compounds: 50 ppm hydrocarbons: 500 ppm
Courtesy:	Jim Luong, The Dow Chemical Company,Canada

Peak identification:

1. methane + carbon monoxide
2. ethane
3. carbon dioxide
4. ethylene
5. carbonyl sulfide (COS)
6. acetylene
7. propane
8. propylene
9. methanethiol (methyl mercaptan)
10. ethanethiol (ethyl mercaptan)
11. hydrogen sulfide (H_2S)



CP-Lowox

- Designed for measuring ppm/ppb level oxygenates in C1-C10
- Separates a wide range of oxygenates from methanol to butyl alcohols
- Suitable for laboratory and on-line process applications
- High column stability Tmax 350 °C
- No particle loss

The new CP-Lowox offers a unique solution for the chemical and petrochemical industries, making it finally possible to analyze trace level oxygenate impurities in gas and liquid hydrocarbon streams. A unique "multi-layer" column coating process results in a highly polar column that exhibits unique characteristics for the analysis of trace level oxygenate impurities in hydrocarbon matrices.

Our multi-layer PLOT technology also delivers very high column stability, making Varian's CP-Lowox ideal for valve switching and online process applications.

Tmax: 350ºC/350ºC (iso/prog)

Separation of oxygenates in C1 - C5 hydrocarbon matrix

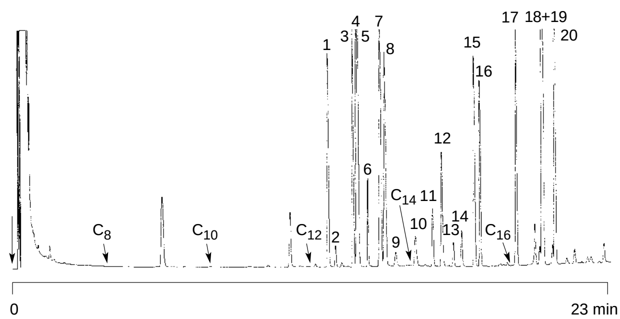
Application 1362 - GC

Oxygenates

For the separation of oxygenates in light hydrocarbons a highly polar stationary phase has to be used. TCEP is used widely but has a limited temperature stability. A new phase with an exceptional high polarity was introduced recently. The CP-Lowox adsorbent provides very high retention for oxygenated compounds. The methanol elutes after n-C_{14} allowing this component to be measured at low levels in a range of hydrocarbon streams (see Application note 1363). To demonstrate the unique selectivity of the CP-Lowox phase, a mixture of a wide range of oxygenates was analyzed.
All oxygenates, including the highly volatile aldehydes and ethers, are well separated and elute as sharp symmetrical peaks. Typical applications of trace methanol in hydrocarbons are shown in Application notes 1360 and 1361. The high maximum temperature of 350 °C with virtually no bleed makes the CP-Lowox column widely applicable for long term reliable analysis.

Technique:	GC - wide-bore
Column:	CP-Lowox 0.53 mm fused silica PLOT Cat. no. 8587
Temperature:	50 °C (5 min) → 240 °C, 10 °C/min
Carrier gas:	He, 28.8 kPa (0.288 bar, 4.1 psi)
Injector:	Split, T = 250 °C
Detector:	FID, T = 250 °C
Sample size:	1 µl
Concentration range:	0.01 %
Solvent sample:	cyclohexane

Peak identification:
1. acetaldehyde
2. diethyl ether
3. ethyl tert-butyl ether
4. methyl tert-butyl ether
5. diisopropyl ether
6. propionaldehyde (propanal)
7. tert-amyl methyl ether
8. dipropyl ether
9. isobutyraldehyde
10. butyraldehyde
11. methanol
12. acetone
13. isovaleraldehyde
14. valeraldehyde
15. 2-butanone
16. ethanol
17. 1-propanol
18. 2-methyl-1-propanol (isobutanol)
19. 2-methyl-2-propanol (t-butanol)
20. 1-butanol



Analysis of trace methanol in 1,3-butadiene

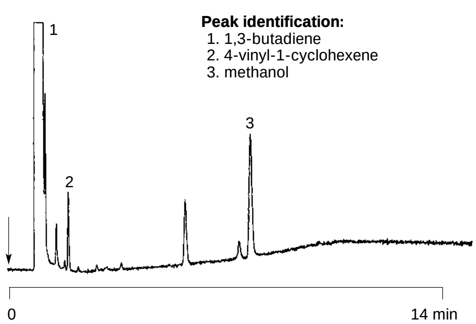
Application 1361 - GC
REV: 02

Oxygenates

The CP-Lowox adsorbent provides very high retention for oxygenated compounds. The methanol elutes after n-C_{14} allowing this component to be measured at low levels in a range of hydrocarbon streams. A typical application of trace methanol in 1,3-butadiene is shown here. Methanol has to be measured usually at specs as low as 5 ppm. Normally this application is run on a CP-TCEP column, but on CP-TCEP the methanol co-elutes with the 4-vinylcyclohexene. With the CP-Lowox column, the methanol is retained much more and is well separated from the 4-vinylcyclohexene, as shown in the chromatogram.
The reproducibility on quantification of this method is within 5%.
Besides in butadiene, methanol can also be measured in ethylene and propylene.
The high maximum temperature of 350 °C with virtually no bleed makes the CP-Lowox column widely applicable. Other C_1 - C_5 oxygenated compounds can also be separated as the selectivity of the CP-Lowox is also very high, see Application note 1362.
If lower levels have to be measured, a pre-separation on a CP-Sil 5 CB precolumn is advised. Oxygenates can be quantified at ppb level in complex hydrocarbon ranges.
To obtain a small injection band a 50 cm x 0.1 mm deactivated fused silica was placed before the CP-Lowox column.

Technique:	GC - wide-bore
Column:	CP-Lowox 0.53 mm fused silica PLOT, Cat. no. 8587
Temperature:	175 °C (2 min) → 275 °C, 10 °C/min
Carrier gas:	He, 420 kPa (4.2 bar, 60 psi)
Injector:	Split via Valco valve
Detector:	MSD
Sample size:	ca 0.1 µl liquid commercial 1,3-butadiene
Concentration range:	ca. 20 ppm
Courtesy:	The Dow Chemical Company, Fort Saskatewan, Canada

Peak identification:
1. 1,3-butadiene
2. 4-vinyl-1-cyclohexene
3. methanol



Analysis of trace methanol in propylene

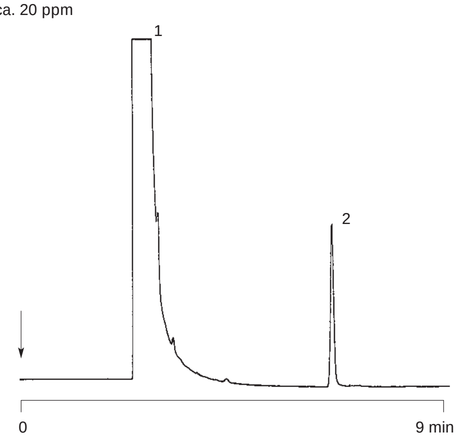
Application 1360 - GC

Oxygenates

The CP-Lowox adsorbent provides very high retention for oxygenated compounds. The methanol elutes after n-C14 allowing this component to be measured at low levels in a range of hydrocarbon streams, see Application note 1363.
A typical application of trace methanol in propylene is shown here. Methanol has to be measured usually at specs as low as
5 ppm. With the CP-Lowox column the methanol can be quantified down to sub-ppm levels. The reproducibility of this method is within 5%.
Besides propylene, also the measurement of methanol in ethylene and butadiene is possible. The high maximum temperature of 350 °C with virtually no bleed makes the CP-Lowox column widely applicable. Other C1 - C5 oxygenated compounds can also be separated as the selectivity of the CP-Lowox column is also very high, see Application 1362.

Technique:	GC - wide-bore
Column:	CP-Lowox 0.53 mm fused silica PLOT Cat. no. 8587
Temperature:	150 °C (2 min) Æ 200 °C, 10 °C/min
Carrier gas:	He, 10 kPa (0.1 bar, 1.4 psi)
Injector:	Direct
Detector:	FID, T = 200 °C
Sample size:	50 µl
Concentration range:	ca. 20 ppm

Peak identification:
1. propylene
2. methanol



CP-CarboBOND and CP-CarboPLOT P7

CP-CarboBOND

- New Bonded Carbon PLOT column for analyzing CO and CO2 in C2/C3 streams
- ppm acetylene in ethylene streams using a single column
- High Tmax 300 °C for elution of high boiling components and fast cycle times
- Single column replacement for ASTM D2505
- No need for particle traps
- Repeatable retention times (no influence of moisture on retention)

CP-CarboPLOT P7

- Separates O2 and N2 together with CO and CO2 in C2/C3 streams

CP-CarboBOND and CP-CarboPLOT P7 are carbon-based Porous Layer Open Tubular (PLOT) columns. Both columns offer a simplified solution for ASTM D2505, which describes the measurement of ppm CO and CO2 in ethylene and propylene streams. Compared to a multi-packed column system, the analysis is performed on a single column, providing higher sample throughputs and reduced system maintenance. The new bonded CP-CarboBOND offers significant improvement in column stability with a Tmax of 300 °C. This means that cycle times can be reduced by speeding up the elution of high boiling contaminants. The high stability of this bonded PLOT column means that it's equally suited for both laboratory and online applications.

CP-CarboPLOT is recommended in cases where air/oxygen are present

Replaces: Carbosieve, Carbosphere
GS- CarbonPLOT, Carboxene

Tmax	iso/prog (ºC)
CP-CarboPLOT	115/115
CP-CarboBOND	200/300

Fast analysis of acetylene in ethylene

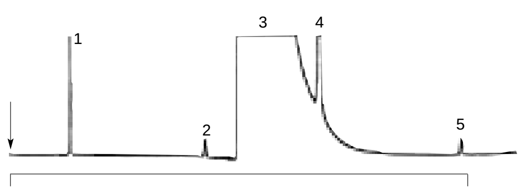
Application 1433 - GC

Gases, hydrocarbons C1 - C3

CP-CarboBOND elutes acetylene in front of the ethylene alowing acurate quantification of ppm levels of acetylene in high-purity ethylene. This analysis is usually done by a multi-valve packed system, see ASTM D 2505. The acetylene peak, however, is broad and detection limits are depending strongly on the quality of the system, but are typically around 1 ppm. With the CP-CarboBOND, the analysis can be done on one column while improving the detection limit significantly.
If the interest is mainly in traces acetylene and the separation of CO from air is not important, a 25 m column can be chosen with a 10 µm coating. This column allows acetylene measurements below 100 ppb within 7-8 minutes analysis times.
The large injection volume will make trace analysis of acetylene possible, but will also cause a coelution between air and CO. If CO and acetylene have to be measured at lowest level, a 50 m x 0.53 mm CP-CarboBOND with a 10 µm layer is recommended (Cat. no. 7375).
All the CP-CarboBOND columns can be conditioned at 300 °C for quick bake-out. Due to the bonded layer, the CP-CarboBOND can be used with switching systems.

Technique:	GC - wide-bore
Column:	CP-CarboBOND fused silica PLOT 25 m x 0.53 mm, df = 10 µm Cat. no. 7374
Temperature:	35 °C (4 min) → 180 °C, 30 °C/min
Carrier gas:	He, 40 kPa 0.4 bar, 6.6 psi)
Injector:	Valve into split, split 1:5, T = 30 °C
Detector:	FID,T = 250 °C
Sample size:	1000 µl
Concentration range:	3 ppm acetylene in ethylene synthetic standard
Courtesy:	Jim Luong and Lyndon Sieben, Dow Chemical Canada, Western Canada Operations

Peak identification:
1. methane
2. acetylene 3 ppm
3. ethylene bulk
4. ethane
5. propane



Analysis of carbon monoxide and carbon dioxide in hydrocarbon streams

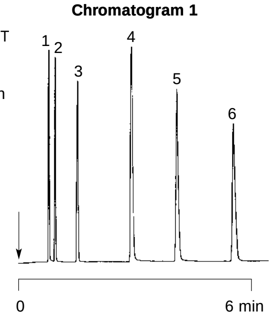
Application 1431 - GC
REV: 02

Gases, hydrocarbons C1 - C2

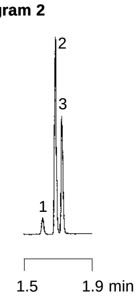
The CP-CarboBOND column has a high retention for CO and CO_2. The CO is separated from the air peak, but only if the air peak is not too big.
Separation between CO and oxygen (air) is sufficient (Chromatogram 2) to measure CO and CO_2 at low ppm levels by converting them to methane and detection with FID (Chromatogram 1). If there were coelution, response would be non-linear. Therefore, this can only be done if the oxygen concentration is of the same order as CO. Here we were able to inject up to 100 µl of ethylene, keeping the response on carbon monoxide reproducible. When using shorter columns, the sample size has to be much smaller to get the separation. A 50 m x 0.53 mm CP-CarboBOND with a 10 µm film will improve capacity, but will also require more time for higher boiling material to elute.
To elute any high boiling material, the CP-CarboBOND column can be conditioned at 300 °C for quick bake-out. Due to the bonded layer, the CP-CarboBOND can be used with switching systems.

Technique:	GC - wide-bore
Column:	CP- CarboBOND fused silica PLOT 50 m x 0.53 mm, df = 5 µm Cat. no. 7372
Temperature:	35 °C (7 min) → 180 °C, 30 °C/min
Carrier gas:	H_2, 60 kPa (0.6 bar, 7.2 psi)
Injector:	Valve via split, 1:5, T = 30 °C
Detector:	Chromatogram 1: FID, with a Ni-catalyst methanizer Chromatogram 2: TCD T = 250 °C
Sample size:	100 µl
Courtesy:	Jim Luong and Lyndon Sieben, Dow Chemical Canada, Western Canada Operations

Chromatogram 1



Chromatogram 2



Peak identification: chromatogram 1
Concentration range: 100 ppm in N_2
1. carbon monoxide
2. methane
3. carbon dioxide
4. acetylene
5. ethylene
6. ethane

Peak identification: chromatogram 2
Concentration range: equal concentrations
1. helium
2. air
3. carbon monoxide

CP-Molsieve 5Å

- High-resolution analysis of permanent gases
- New, thin-layer dimensions for fast elution of CO
- Symmetrical peaks (even for CO)
- Available in both fused silica and Ultimetal

The molecular-sieve coated capillary column is especially valuable when separating permanent gases. These columns deliver analysis times that are one quarter of those achieved with packed columns. The CP-Molsieve 5Å delivers baseline separation of Ar/O2 at ambient temperatures. Columns are available in fused silica and in Ultimetal.
A special thin-film CP-Molsieve 5Å is available for the fast elution of CO.

Gases separated by Molsieve 5 PLOT

He	H2	O2	CO
Ne	HD	N2	N2O
Ar	D2	CH4	
Kr	HT	C2H6	
Xe	DT	CD4	
Rn	T2	C2D6	

Replaces: Molsieve 5
GS-Molsieve; HP-PLOT Molsieve

Tmax: 350/350 (ºC) iso/prog

High resolution chromatography of permanent gases

Application 764 - GC

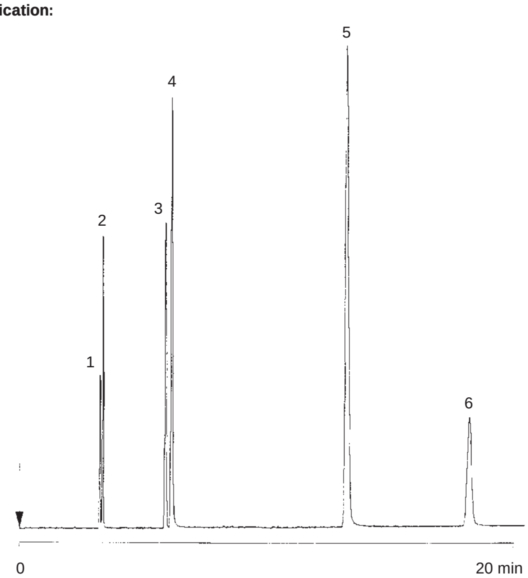
Permanent gases

Technique: GC - wide-bore

Column: Molsieve 5Å fused silica PLOT
50 m x 0.53 mm; df = 50 µm
Cat. no. 7539

Temperature: 30 ˚C
Carrier gas: H2’ 55 kPa (0.55 bar, 8 psi), 25.6 cm/s
Injector: Splitter, 200 ml/min
T = 30 ˚C
Detector: TCD
T = 180 ˚C
Concentration range: 5 - 10%

Peak identification:
1. helium
2. neon
3. argon
4. oxygen
5. nitrogen
6. methane



Permanent gases on a thin film Molsieve column

Application 1246 - GC

Gases

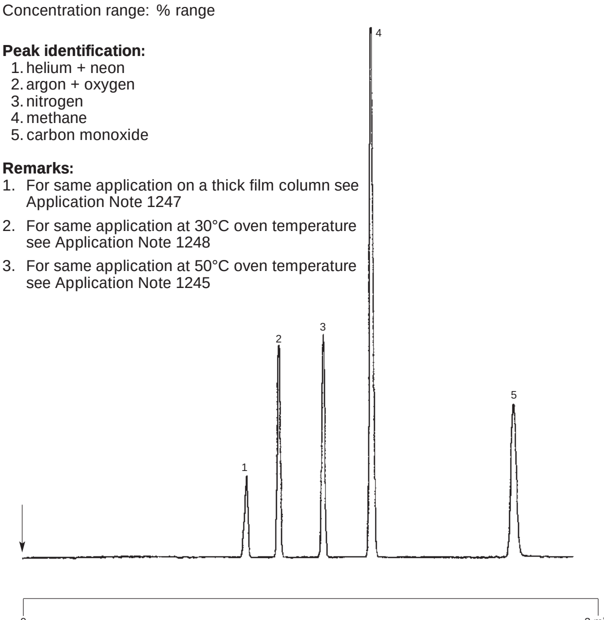
Technique: GC - wide-bore

Column: CP-Molsieve 5Å fused silica PLOT
30 m x 0.53 mm; df = 15 mm
Cat. no. 7544

Temperature: 100°C
Carrier gas: H2
Injector: Split, 100 ml/min
Detector: TCD
Sample size: 10 ml
Concentration range: % range

Peak identification:
1. helium + neon
2. argon + oxygen
3. nitrogen
4. methane
5. carbon monoxide

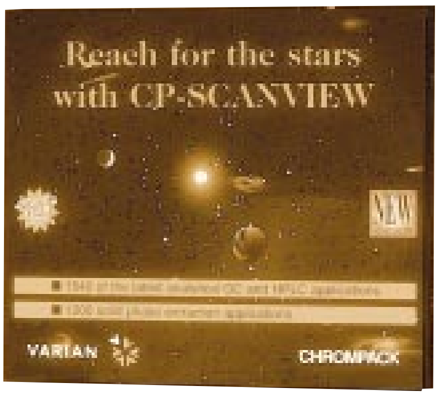
Remarks:
1. For same application on a thick film column see Application Note 1247
2. For same application at 30°C oven temperature see Application Note 1248
3. For same application at 50°C oven temperature see Application Note 1245



Further application help

CP-Scanview CD-ROM

Expand your application possibilities with CP-Scanview, our FREE applications database. CP-Scanview is an easily searchable CD-ROM that contains over 1540 GC and HPLC applications, as well as 1200 sample preparation methods. This CD-ROM is an invaluable tool for all chromatographers; contact your Varian office today for your free copy.



Help Desk

For responsive customer support, you can always rely on our Technical Help Desks in the USA and Europe. Help Desks associates are a dedicated group of chemists, all with Ph.D or Master of Science in Chemistry degrees. Many have over ten years of experience with SPE, LC and, GC method development. Varian's Help Desk team is always available to answer customers' toughest application questions.
Call the US Help Desk toll-free at 800.421.2825, send a fax at 310.539.1449, or e-mail us at helpdesk.us@varianinc.com.
Call your local Varian office for the European Help Desk nearest you, we'll connect you at no cost. Or, e-mail us at helpdesk.eu@varianinc.com.

Additional Reading

For further information, please ask for our additional documentation, mentioned below.

P-126	Application of in-situ prepared PLOT columns for gas chromatograph (**CP-PoraBOND**; **CP-CarboBOND**; **CP-SilicaPLOT**)
P-121	CP-PoraBOND, a 100% bonded porous polymer coated capillary column (**CP-PoraBOND Q**)
P-120	Separation of impurities in light hydrocarbons using a highly stable carbon-coated capillary column (**CP-CarboBOND**)
P-119	Analysis of ppm-ppb levels of oxygenates in C1-C5 hydrocarbons by using a highly selective PLOT column (**CP-Lowox**)
P-115	Separation of chlorofluorocarbons (CFC) on PLOT columns coated with an inert adsorbent based on silica (**CP-SilicaPLOT**, **CP-PoraPLOT Q,S&U**)
P-112	New silica-based adsorbent for analyzing volatile compounds (**CP-SilicaPLOT**)
P-134	Moving from packed to wide bore: a simple step for significantly improve your packed GC method. (**0.53 mm ID capillary columns**)
P-97	CP-Al2O3 and CP-Molsieve 5Å, separation of light hydrocarbons and permanent gases using PLOT columns (**CP-Al_2O_3** and **CP-Molsieve 5Å**)

MDL0001R0GU040005M