

Millipore  
SIGMA

# FUEL THE FUTURE

ANALYTICAL SOLUTIONS FOR  
THE PETROCHEMICAL INDUSTRY



The life science business of Merck KGaA,  
Darmstadt, Germany operates as  
MilliporeSigma in the U.S. and Canada.

## EMD MILLIPORE + SIGMA-ALDRICH = MILLIPORESIGMA

The life science business of Merck KGaA, Darmstadt, Germany brings together the world-class products and services, innovative capabilities and exceptional talent of EMD Millipore and Sigma-Aldrich to create a global leader in the life science industry.

### WE ARE A LEADER IN LIFE SCIENCE

**We aim** to solve the toughest problems in the industry by collaborating with the global scientific community

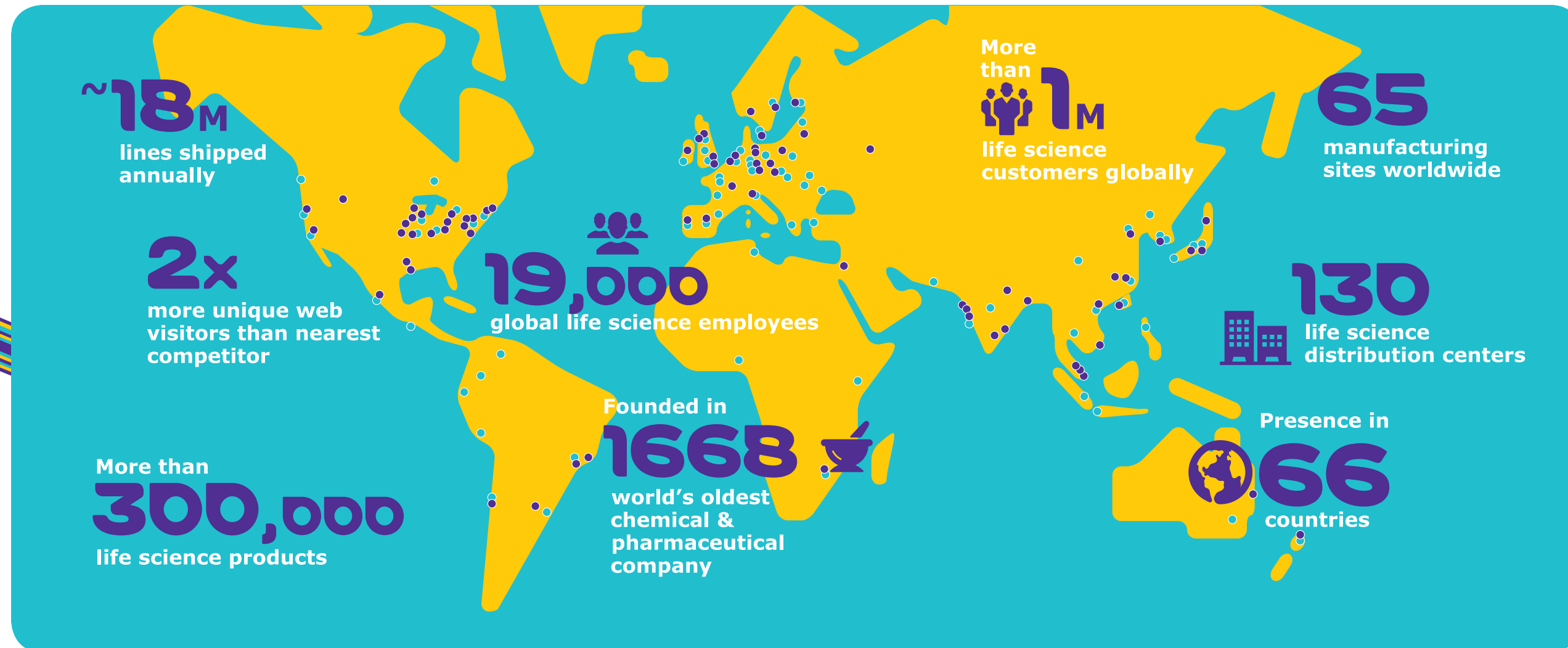
**We provide** scientists and engineers with best-in-class lab materials, technologies and services

**We are dedicated** to making research and production simpler, faster and more successful

Our life science business areas are designed to best address our customers' needs:

- **Applied solutions**  
Customer-centric workflow solutions across industrial and diagnostic applications
- **Research solutions**  
Most complete portfolio of solutions that enable scientific discovery
- **Process solutions**  
End-to-end portfolio in manufacturing—products that meet the highest quality and purity standards with services to ensure regulatory compliance

## Life science – view at a glance



### Our core strengths:

- Portfolio and customer-focused innovation
- Balanced geographic reach
- Well-differentiated and industry-leading capabilities

# YOUR PARTNER FOR HIGH-QUALITY ANALYTICAL PRODUCTS

The oil industry fuels the global economy by meeting the demand for petroleum, natural gas, and petrochemicals. Its success depends upon safe, reliable, and efficient processes to ensure that consumers receive a consistent flow of dependable products.

For decades, Sigma-Aldrich has provided the highest quality of reliable analytical solutions to help researchers, process managers, and quality analysts meet their measurement challenges. From characterizing raw crude oil and natural gas, to monitoring the production of refined chemicals, now as MilliporeSigma, an even broader range of analytical products is available to the energy and chemical industries.

Here we focus our analytical capabilities in two areas; the downstream R&D workflow (chemical synthesis, reaction monitoring, purification, and characterization steps), and the quality control of raw materials and production batches.

- **Chemical Analysis of Petrochemicals** – includes the “reaction monitoring” and “characterization” steps of the downstream R&D workflow area, and the quality control area
- **Purification of Petrochemicals** – comprises of the “purification” step of the downstream R&D workflow area

As a leading solutions provider to the petrochemical industry, we understand the challenges customers face. We offer innovative product solutions to monitor the quality of petrochemical products and to comply with industry standards – in the laboratory and on-line in the process environment. For more information, visit [sigma-aldrich.com/petro](http://sigma-aldrich.com/petro)

## products for R&D and QC

Chemical Synthesis	Purification	Reaction Monitoring & Characterization	QC Specialties
Building Blocks	Specialty Carbon Adsorbents	GC Ionic Liquid Columns	Petrochemical Columns
Solvents	Resins/Media	HPLC Ascentis Express Columns	Water Determination with GC
Catalysts	Resins Processing Capabilities	UHPLC Titan™ Columns	Physical Properties CRM (Paragon)
Reagents	Glassware Repair Service	Custom Analytical Standards	Analytical Reagents
Organometallics	Custom Carbon Adsorbents		
Labware			

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# CHEMICAL ANALYSIS OF PETROCHEMICALS

From reaction monitoring to analytical characterization we've got you covered. We have all the consumables and accessories to keep your instruments running.

## GAS CHROMATOGRAPHY (GC) DID YOU KNOW?

The main analytical instrument used in the petrochemical industry is GC. This is due to the fact that samples are already in an organic matrix, or in a gaseous state. This mature analytical technique was actually invented by and for the petrochemical industry, back in 1952.

### Columns

We offer a full-line of capillary columns for GC, GC-MS, and GCxGC applications. Our columns can be used for analyses such as measuring purity and boiling point composition, plus the determination of aliphatic, aromatic, oxygen-containing, basic, halogen-containing, and sulfur-containing compounds in various refined petroleum products and downstream chemical products. Highlights of our offering include:

- **Watercol™ 1910** – contain an innovative ionic liquid stationary phase that allows the convenient measurement of water by GC

- **SLB®-IL60i, SLB®-IL76i, and SLB®-IL111i** – ionic liquid columns that combine high selectivity and high inertness towards polar analytes

- **SLB®-ILPAH** – ionic liquid column for unsurpassed resolution of PAHs

- **SLB®-ILD3606** – ionic liquid column for separations involving benzene (and other aromatics) and oxygenates in petroleum products, such as gasoline

- **Petrocol® series** – non-polar columns with considerable theoretical plate numbers for detailed analyses of petroleum products for PIANO, PONA, and PNA-type analyses

- **MS-grade** – achieve low detection limits, easy mass spectral identification, less instrument downtime, great resolution, short analysis times, and long column life

- **SPB®-1 SULFUR** – for analyses of sulfur gases and other volatile sulfur compounds

- **PTA-5 and Carbowax® Amine** – base-deactivated columns for analyses of amines and other volatile basic compounds

- **SPB®-1000 and Nukol™** – incorporation of acid functional groups for analyses of volatile acidic compounds, such as glycols

- **PLOT** – choose from four adsorbent types for separations of small molecules, such as permanent gases, light hydrocarbons, and volatile sulfur compounds

- **SCOT** – the sensitivity and excellent sample resolution of capillary GC combined with the extensive stationary phase library of packed GC

- **Packed** – complete line of packed GC columns and components

Detailed hydrocarbon analysis (DHA) is performed on long non-polar columns. Elution occurs in order of lowest boiling point to highest. Figure 1 shows a chromatogram of a gasoline sample

using a 100 m Petrocol® DH column. The long column length and 60 °C isothermal oven temperature allow the separation of many components in this complex sample. Compounds identified range from propane

(peak 1) to 1-methylnaphthalene (peak 96). Retention index libraries exist for this column, adding to its usefulness.

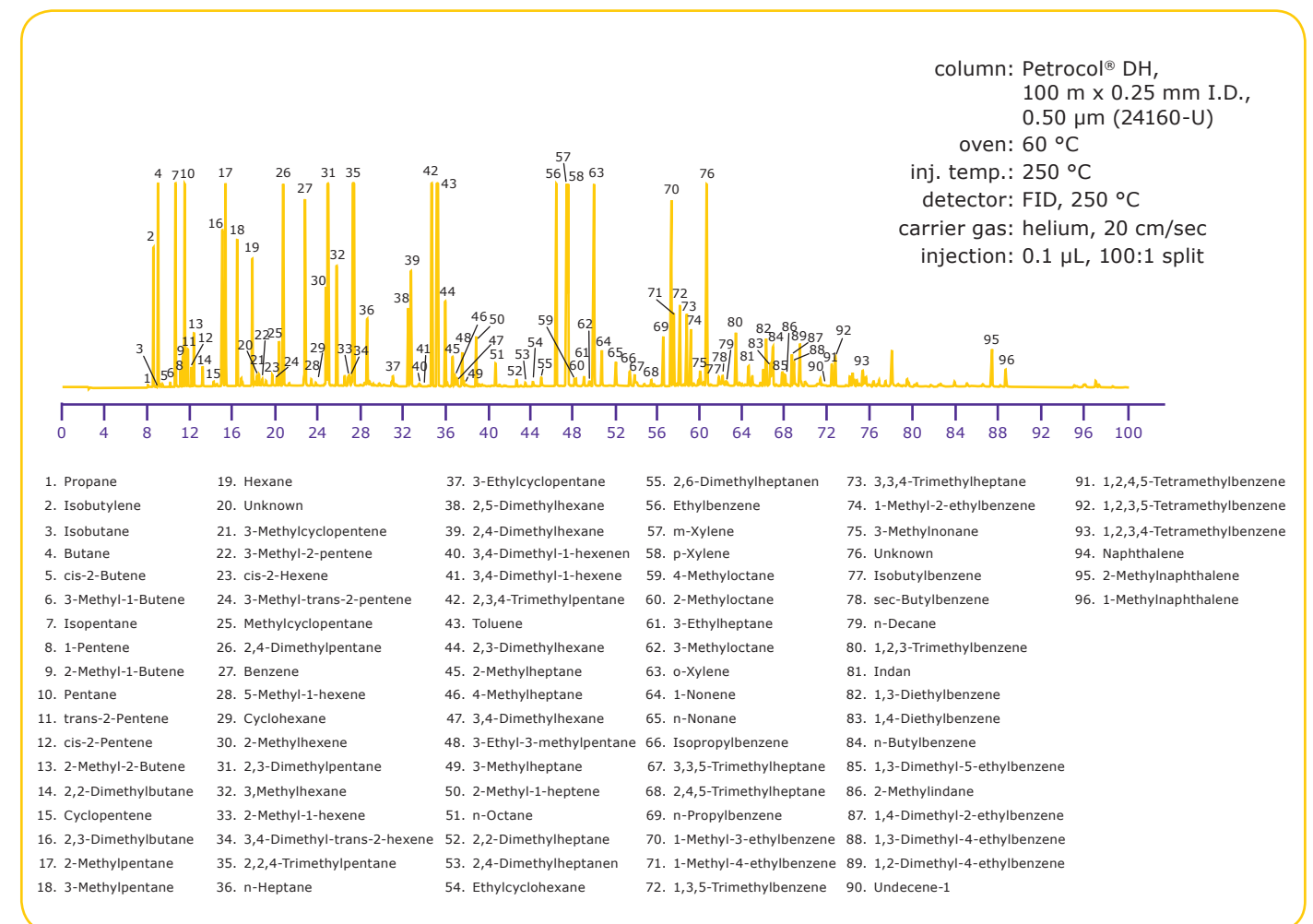


Figure 1. Detailed Hydrocarbon Analysis (DHA)



## Sharp peaks for water

Residual moisture in fuel is very undesirable – it reduces the heat of combustion which increases engine stress, corrodes fuel system components, allows gelling of fuel in cold temperatures through ice crystal formation and nucleation, and accelerates the growth of microbial colonies which can clog fuel systems. The Watercol™ series of ionic liquid capillary GC columns

are characterized by their ability to produce a sharp peak shape for water, sharp enough so that water can be integrated and quantified.

Figure 2 illustrates the suitability of Watercol™ 1910 for the analysis of water in gasoline. In addition to identification of water, the column's selectivity allowed for the identification of the BTEX

analytes. The water and ethanol peaks were confirmed by injecting a series of standards (water in ethanol). The BTEX peaks were confirmed by analysis of neat materials. The unique combination of stationary phase: analyte interactions also allowed the elution of the heavy components (e.g. methylnaphthalenes) in a reasonable time (<19 minutes)

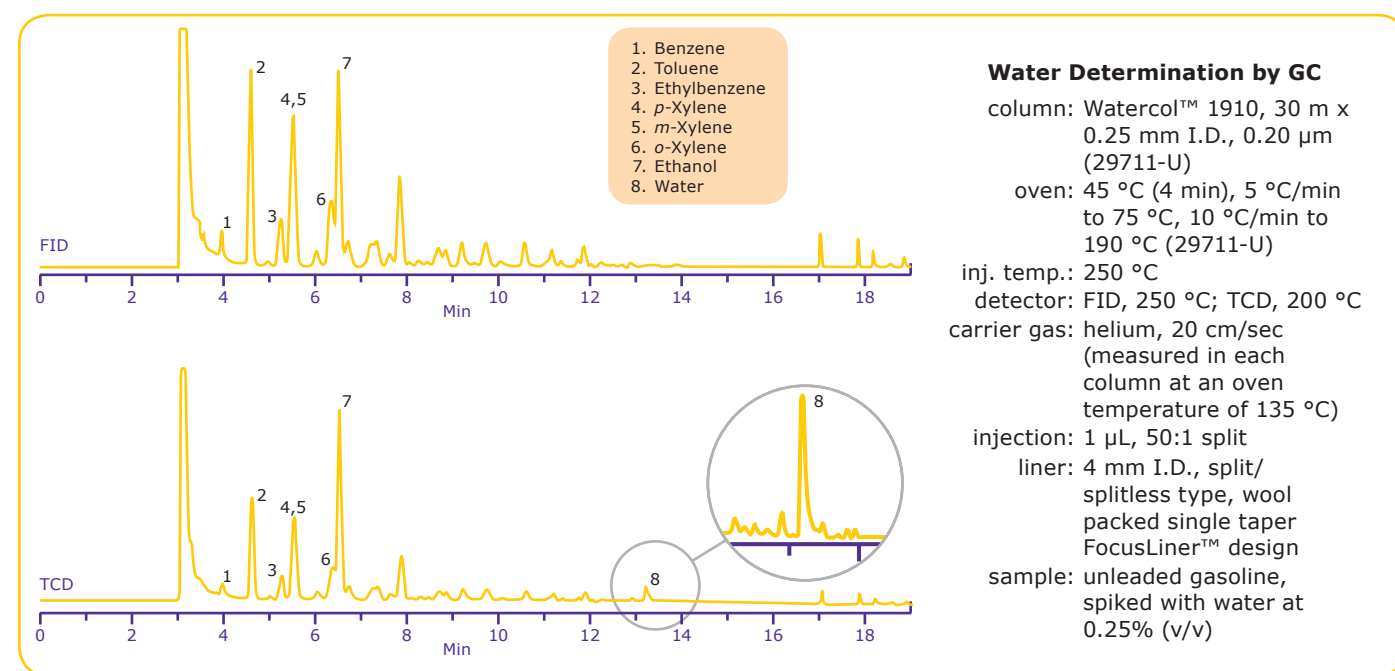


Figure 2. Water Determination by GC

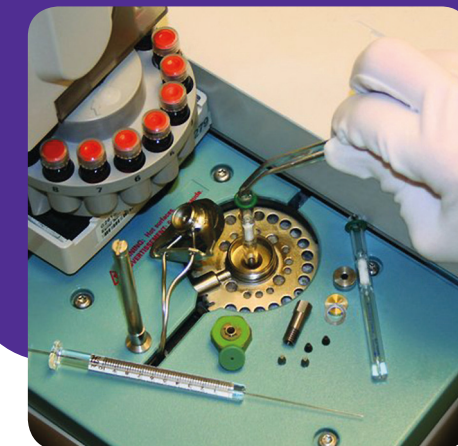


For additional product information, real-time availability, and ordering information, visit [sigma-aldrich.com/gc-petro](http://sigma-aldrich.com/gc-petro) (petroleum refining industry), [sigma-aldrich.com/gc-chem](http://sigma-aldrich.com/gc-chem) (downstream petrochemical industry), [sigma-aldrich.com/il-gc](http://sigma-aldrich.com/il-gc) (ionic liquid columns), and [sigma-aldrich.com/gcpacked](http://sigma-aldrich.com/gcpacked) (packed columns)

## GC Accessories

In addition to high-quality GC columns, we also offer the most commonly needed accessories. This includes GC septa, inlet liners, inlet seals, ferrules, nuts, guard columns, connectors, flowmeters, hand tools, syringes, vials, and PID lamps. Highlights of our offering include:

- **Molded Thermogreen® LB-2 GC septa** – the perfect combination of low bleed, thermal stability, and easy puncturability
- **FocusLiner™ inlet liners** – enhance sample vaporization and increase precision, accuracy, and reliability
- **Low Adsorption (LA) vials** – maintain sample integrity during storage by minimizing pH shifts and metal contamination
- **Inlet liner o-ring and inlet seals** – commonly replaced items in Agilent capillary injection ports
- **Capseal Bullet® ferrules (for capillary)** – design keeps the graphite from adhering to the fitting, making them easy to remove and reusable
- **Supeltex® ferrules** – form leaktight seals without sticking to columns
- **Flowmeters** – four models of digital flowmeters, including choices for volumetric or mass measurement



Example of GC Accessories



For additional product information, real-time availability, and ordering information, visit [sigma-aldrich.com/gc-accessories](http://sigma-aldrich.com/gc-accessories)

## PURITY UNDER PRESSURE

### Gas Purification

It is critical that a gas delivery system provides gas at the proper purity level, and at the correct pressure, based on its intended use. We offer many products that enable the GC user to purify and manage their gas streams (such as helium, hydrogen, nitrogen, argon, 5% methane in argon, and air). Highlights of our offering include:

- **OMI® (oxygen moisture indicating) polishing purifiers** – removes many contaminants that other upstream purifiers miss
- **High capacity gas purifiers** – best purifier choice for removing moisture and oxygen from carrier gas streams
- **Tubing** – specially cleaned to ensure inertness
- **Swagelok® tubing fittings** – combine superior design principles with close manufacturing tolerances and rigid quality assurance programs
- **Gas cylinder pressure regulators** – designed with features meaningful to chromatographers
- **Gas generators and air compressors** – generating gas on-site is often a less expensive option to gas cylinders



High capacity gas purifier



For additional product information, real-time availability, and ordering information, visit [sigma-aldrich.com/gaspurifiers](http://sigma-aldrich.com/gaspurifiers)

# TAME THE UNSTABLE HIGH PERFORMANCE LIQUID CHROMATOGRAPHY (HPLC)

HPLC is a very versatile analytical technique that can be configured for the separation of small molecules, such as small polar additive, to large industrial polymers. This technique is most commonly used for analytes that are either thermally unstable or non-volatile, neither of which can be analyzed using GC.

## Columns

We offer a wide-range of columns for HPLC, LC-MS, and UHPLC use, including those suitable for reversed phase, normal phase, large molecules, and chiral applications. The column lines most suitable for the petrochemical industry are:

- **Ascentis® Express** – for small molecules (fast HPLC, UHPLC, and high resolution applications)
- **TSKgel®** – for industrial polymers (size exclusion, gel permeation, and gel filtration techniques)

Based on Fused-Core® particle technology, Ascentis® Express HPLC columns represent a breakthrough in HPLC column performance compared to columns based on traditional porous particles. Specifically, they provide improved efficiency without increased backpressure, resulting in faster analysis on any system. The Fused-Core® particle has three distinct features:

- narrow particle size distribution
- more consistent bed
- shorter diffusion path.

As shown in Figure 3, a narrow particle size distribution allows for the use of large porosity frits that resist clogging, resulting in a more rugged column.



For additional product information, real-time availability, and ordering information, visit [sigma-aldrich.com/express](http://sigma-aldrich.com/express)

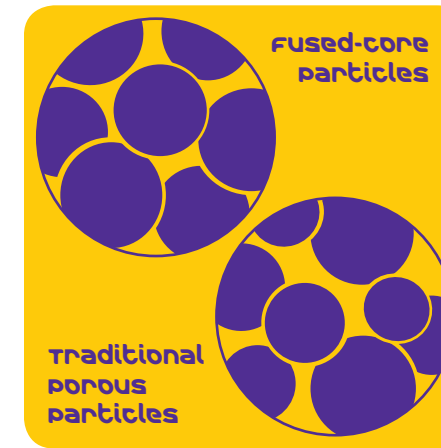


Figure 3. Narrow Particle Size Distribution

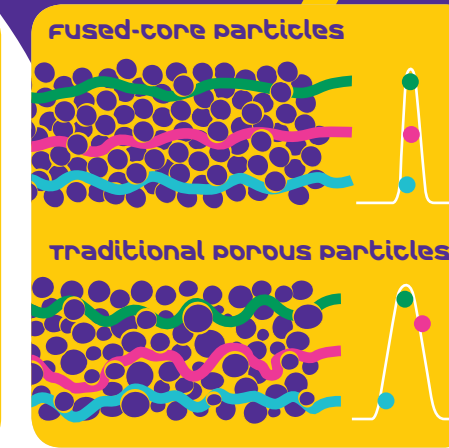


Figure 4. More Consistent Bed

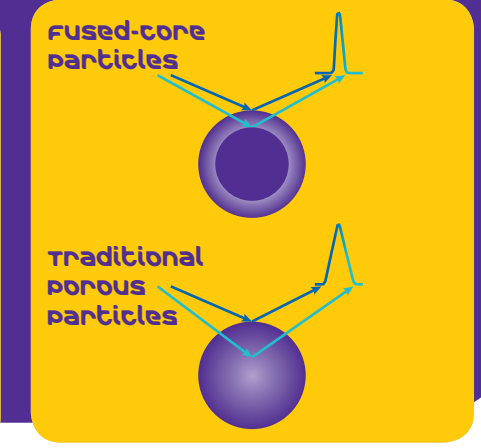


Figure 5. Shorter Diffusion Path

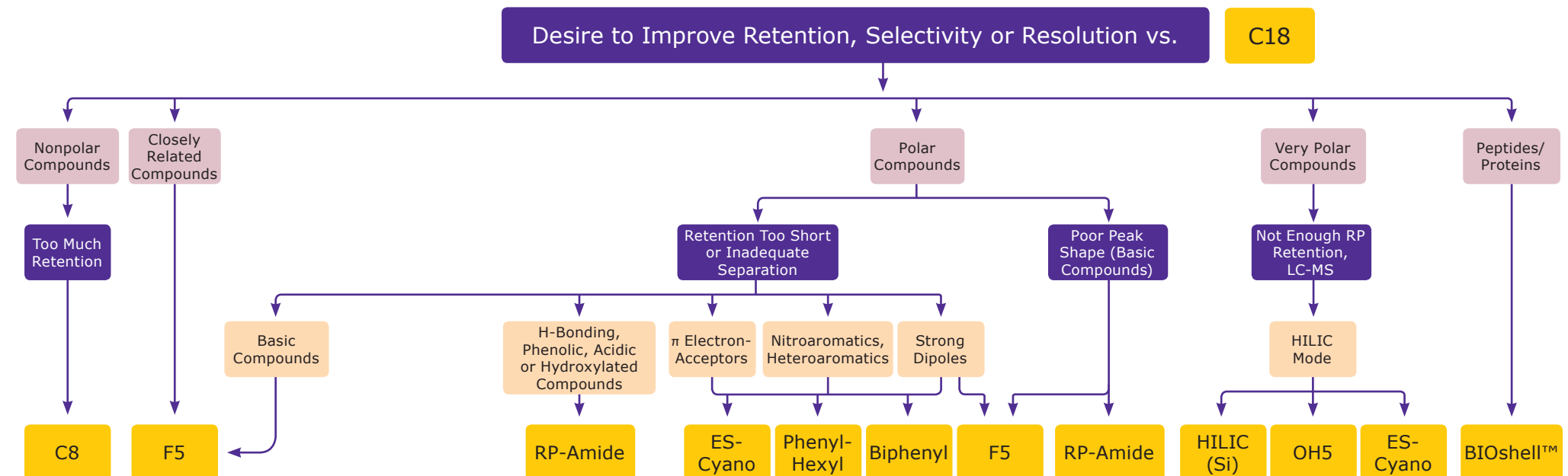
van Deemter Equation:  
 $HETP = A + B/u + (C_s + C_m) \cdot u$

A = Eddy-diffusion parameter, related to channeling through a non-ideal packing

C = Resistance to mass transfer coefficient of the analyte between mobile and stationary phase

As shown in Figure 4, a narrow particle size distribution forms a more consistent packed bed which minimizes analyte diffusion through the column. This eddy-diffusion is effectively independent of mobile phase velocity.

As shown in Figure 5, the shorter diffusion path of the Fused-Core® particle provides sharper peaks than traditional porous particles.



## Size Exclusion Chromatography

TSKgel® columns are considered the leading columns for size exclusion chromatography (SEC), a technique suitable for the analysis of industrial polymers. The mechanism of SEC is based on differences in the sizes of the analytes, and whether they can fit into the pores of the particles. Small molecules can enter all or many pores, whereas large molecules can enter few or none. Large molecules elute first with SEC, and small molecules elute last. An example is shown in Figure 6.

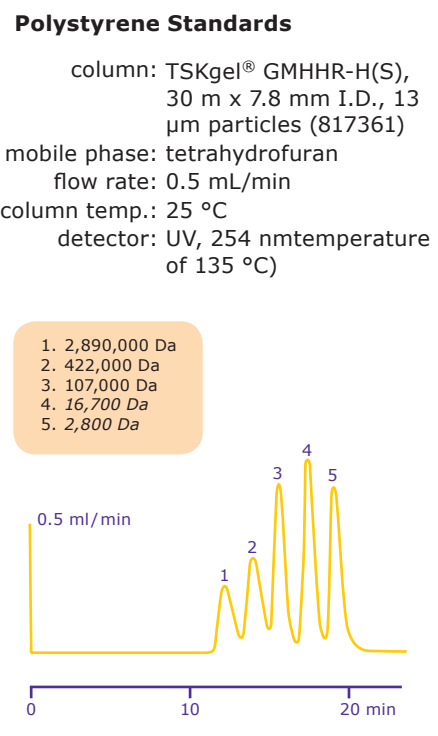


Figure 6. Polystyrene Standards



For additional product information, real-time availability, and ordering information, visit [sigma-aldrich.com/tsk](https://sigma-aldrich.com/tsk)

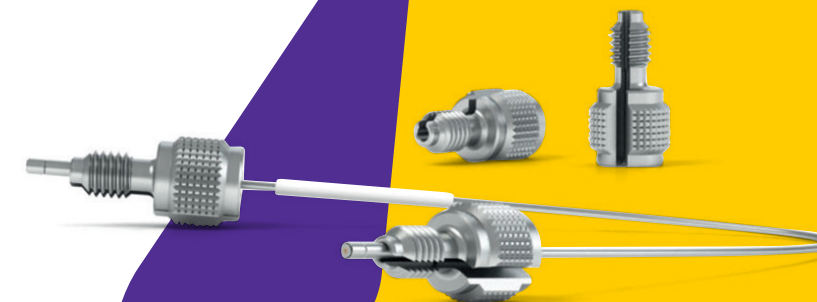
\* NOTE: We do not offer TSKgel® columns in India or Japan.

## PROTECT THE COLUMN, PROTECT YOUR RESULTS.

### HPLC Accessories

The quality of an HPLC separation can be influenced by the system having components designed to minimize instrument bandwidth and adsorption. To serve this need, we offer products that maximize efficiency and response while protecting the column investment. Highlights of our offering include:

- **MarvelIX™ connectors** – unique next-generation technology auto-adjusts to various port depths, ensuring zero dead volume
- **Upchurch-brand fittings** – stainless steel and fingertight PEEK designed for various ports geometries
- **OPTI-SOLV® EXP® pre-column filter** – hand-tight, auto-adjusting, zero dead volume connection employing low volume, low dispersion disposable cartridges
- **Rheodyne® injectors and sample loops** – advanced fluid-handling solutions for a wide range of analytical instrumentation
- **Tubing** – various inner diameters and lengths with stainless steel, PEEK, PEEKsil, and PTFE options
- **Low Adsorption (LA) vials** – maintain sample integrity during storage by minimizing pH shifts and metal contamination



For additional product information, real-time availability, and ordering information, visit [sigma-aldrich.com/hplc-accessories](https://sigma-aldrich.com/hplc-accessories)



# JUST PROVE IT!

## Bench-Top Instruments

Regardless of your application, the three most important requirements of a spectrophotometer are simplicity, security, and durability. We offer Spectroquant® Prove, a new class of spectrophotometers that perfectly unite all these features. Intuitive, innovative, and preprogrammed for the broadest range of test kits, Spectroquant® Prove instruments make UV/Vis analysis smoother than ever. Three versions are available to meet a wide range of testing need:

- **Prove 100** – for routine VIS applications
- **Prove 300** – for sensitive UV/VIS measurements
- **Prove 600** – for complex UV/VIS analyses, plus long cell size option for maximum sensitivity
- Storage of data with each measurement
- Removable cell holder for easy cleaning
- Preprogrammed methods for all Spectroquant® cell and reagent tests
- Room for 99 user defined methods and 20 profiles for kinetics and absorbance scans
- Free software updates
- 28 built in languages
- 2 USB ports for printers, memory devices, keyboard, and bar code readers
- 1 USB port for Ethernet/LAN connection

All Spectroquant® Prove spectrophotometers have the following features:

- Reference beam technology
- Ambient light protection (allows open door measurements)
- Live ID system provides 2D barcode recognition for cell tests and reagent tests (barcode contains lot number, expiration date, and calibration data)



Prove 100

# FIND THE PROVE FOR YOU

## Instrument Comparison

Feature	Prove 100	Prove 300	Prove 600
<b>Wavelength Range</b>	VIS (320 – 1100nm)	VIS (320 – 1100nm) UV (190 – 320 nm)	VIS (320 – 1100nm) UV (190 – 320 nm)
<b>Lamp Type</b>	Tungsten halogen lamp	Xenon flash lamp	Xenon flash lamp
<b>Spectral Bandwidth</b>	4 nm	4 nm	1.8 nm
<b>Smart Screen Display</b>	Resistive touch screen	Resistive touch screen	P-cap glass touch screen
<b>Cell Size</b>	16 mm round cells, 10, 20, and 50 mm rectangular cells with automatic recognition	16 mm round cells, 10, 20, and 50 mm rectangular cells with automatic recognition	16 mm round cells, 10, 20, 50, and 100 mm rectangular cells with automatic recognition

## Test Kits

The Spectroquant® product line also includes over 180 kits for quantitative analysis, for parameters such as those shown here. All kits utilize the Live ID system, a 2D barcode recognition for cell tests and reagent tests. Barcodes contain the lot number, expiration date, and calibration data. The cell test kits contain all necessary analysis reagents in a prepared cell for immediate analysis. The reagent test kits provide the ability to use the cell size of choice. All kits are compatible with the Spectroquant® Prove family of instruments.

Acid Capacity (Total Alkalinity)	Crack Set 10	Magnesium	Residual Hardness
Ammonium	Crack Set 10C	Molybdenum	Silicate (Silicic Acid)
Arsenic	Crack Set 20	Monochloramine	Sulfate
BOD	Cyanide	Nickel	Sulfide
Boron	Cyanuric Acid	Nitrogen (total)	Sulfite
Cadmium	Fluoride	Oxygen	Surfactants (cation)
Calcium	Formaldehyde	Oxygen Scavengers	Tin
Chromate	Gold	pH	TOC
COD	Hydrogen Peroxide	Phenol	Total Hardness
COD (Hg-free)	Iodine	Potassium	Zinc
Copper	Lead		



For additional product information, real-time availability, and ordering information, visit [sigma-aldrich.com/spectroquant](https://sigma-aldrich.com/spectroquant)

## A LITTLE MORE SENSITIVE...

### Thin Layer Chromatography (TLC)

We offer a complete line of products for TLC, including plates, sorbents, reagents, and accessories. Our TLC products are designed for quick and convenient analysis of a broad spectrum of substances.

Benefit from unsurpassed separations with TLC plates that offer excellent adherence, hardness, and surface homogeneity. As the leading supplier of TLC plates, we offer an extensive portfolio, which includes conventional TLC plates for manual use, high performance TLC (HPTLC) plates for maximum sensitivity, and preparative liquid chromatography (PLC) plates for scale-up applications. To meet your individual application requirements, we offer multiple plate options, including:

- Three different types of supports/backings: glass, aluminum foil, and plastic (polyester – PET)
- A variety of matrices: silica gel (unmodified, modified/bonded, chiral, and high purity), aluminum oxide, cellulose, and polyamide
- Three binder choices: polymeric (organic), inorganic, or gypsum
- With or without indicators

We also provide a variety of sorbents for the preparation of TLC plates. These include silica, alumina, aluminum hydroxide, cellulose, cellulose ion-exchange, polyamide 6 (nylon 6), and Florisil® (magnesium silicate). Reagents, such as those for derivatization and visualization (staining), are also conveniently offered. Our offering also includes a comprehensive offering of accessories, including items such as adsorbent scrapers, aerosol accessories, cutting tools, developing tanks/chambers, pipettes, plate racks, UV-viewing cabinets, saturation pads, and sprayers.



For additional product information, real-time availability, and ordering information, visit [sigma-aldrich.com/tlc](http://sigma-aldrich.com/tlc)

## SOLVENT-FREE SAMPLE PREP!

### Solid Phase Microextraction (SPME)

SPME is an innovative, solvent-free sample preparation technology that is fast, economic, and versatile. This technique uses a fiber coated with a liquid (polymer), or a combination of liquid (polymer) and solid (sorbent). The fiber coating extracts analytes from the sample by absorption (using liquid coatings) or adsorption (using solid coatings). The SPME fiber is then inserted directly into the GC injection port for desorption and subsequent analysis.

Chromatographic evidence is best able to fully illustrate the benefit of SPME. The example presented in Figure 7 depicts the analysis of several oxygenates in gasoline, and compares SPME to direct injection.

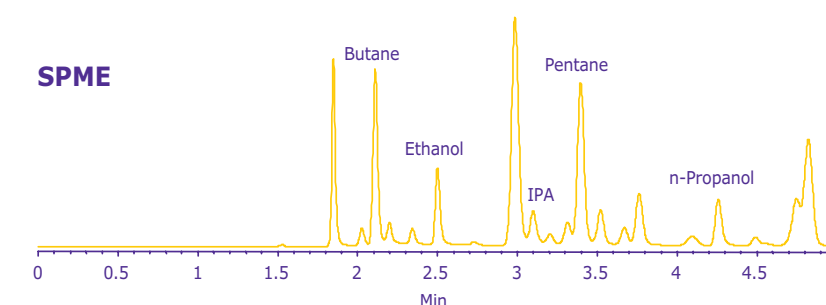


For additional product information, real-time availability, and ordering information, visit [sigma-aldrich.com/spme](http://sigma-aldrich.com/spme)

#### Conditions (SPME):

sample/matrix: three oxygenates, each at 400 ppm, in gasoline;  
3.5 mL in 4mL vial  
SPME fiber: 60 µm PEG on metal alloy, 23 gauge needle (57355-U)  
extraction: direct immersion for 15 min  
desorption process: 240 °C for 5 min  
column: SPB®-1 SULFUR, 30 m x 0.32 mm I.D., 4.0 µm (24158)  
oven: 40 °C (1.5 min), 8 °C/min to 80 °C,  
20 °C/min to 260 °C (10 min)  
inj. temp.: 240 °C  
detector: FID, 300 °C  
carrier gas: helium, 13 psi constant pressure (40 cm/sec), set at 40 °C  
injection: 50:1 split  
liner: 0.75 mm I.D., direct (SPME) type, straight design

#### SPME



#### Conditions (direct injection):

column: SPB®-1 SULFUR, 30 m x 0.32 mm I.D., 4.0 µm (24158)  
oven: 40 °C (1.5 min), 8 °C/min to 80 °C,  
20 °C/min to 260 °C (10 min)  
inj. temp.: 240 °C  
detector: FID, 300 °C  
carrier gas: helium, 13 psi constant pressure (40 cm/sec),  
set at 40 °C  
injection: 0.2 µL, 50:1 split  
liner: 0.75 mm I.D., direct (SPME) type, straight design  
sample: three oxygenates, each at 400 ppm, in gasoline

#### Direct Injection

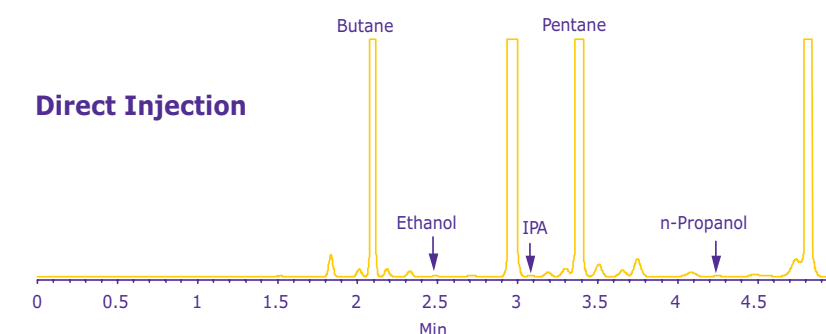


Figure 7. Oxygenates in Gasoline

# YOU SET THE STANDARD

## ANALYTICAL STANDARDS

We offer a comprehensive line of certified reference materials (CRMs), reference materials, and analytical standards for many of the analytical techniques used in the petrochemical industry, including those for GC, HPLC, UV/Vis, IR, NMR, XRF, IC, titration, ICP, AAS, and many more. Many of our analytical standards are formulated for use with specific methods promulgated by appropriate regulatory agencies. We also boast excellent custom capabilities if you need a specific solution or mixture.

### For Chemical Analysis

Our offering includes pure (neat) materials, single-component solutions, and multi-component mixes. Many of our mixes are formulated to meet the prescribed recommendations of international organizations/bodies, such as ASTM®, DIN, EN, and ISO®. Our analytical standards are manufactured under several brands.

All analytical standards are tested for purity and supported by a certificate of analysis. The quality and consistency of our products are also supported by our ISO 9001:2000 certification. All standards manufacturing sites are at a minimum double accredited to ISO/IEC 17025 and ISO Guide 34, which is the highest achievable quality level ("Gold Standard") for reference material producers. Highlights of our offering include standards for:

- GPA methods
- Hydrocarbons
- Inorganic analysis by ICP, AAS, and XRF
- Jet fuel
- Olefins
- Organometallic oil solutions
- Paraffins
- Petroleum refinery reformates
- PIANO/PONA/PNA
- Sulfur compounds
- Underground storage tank (UST)
- Wear metal

- ASTM® methods
- Biodiesel
- Bioethanol
- BTEX
- Diesel range organics (DRO)
- DIN / EN / ISO methods
- Fuel oil
- Gas calibration
- Gasoline range organics (GRO)



For additional product information, real-time availability, and ordering information, visit [sigma-aldrich.com/standardspetrochemistry](http://sigma-aldrich.com/standardspetrochemistry)

### For Physical Properties

With over 20 years of experience in production and certification, Paragon Scientific® has become a leading producer of quality analytical standards in accordance with the requirements of ISO/IEC 17025 and ISO Guide 34. They have developed an international reputation synonymous with quality, affordability, and first-class customer service. Their product offering relevant to the petrochemical industry includes:

- Cloud point standards
- Cold filter plugging point standards
- Colour standards
- Density standards
- Distillation standards
- Element / chemical standards
- Flash point standards
- Freezing point standards
- Fuels testing standards
- Lithium chloride solutions
- Multi parameter CRMs
- Pour point standards
- Synthetic sea water
- Total acid number standards
- Total base number standards
- Viscometers
- Viscosity bath media
- Viscosity standards

The combination of advanced manufacturing techniques with the use of primary laboratory test equipment and methodology, plus an acute attention to detail, enables Paragon Scientific® to produce reference materials with some of the lowest levels of uncertainty of measurement available. We offer their full-line of products worldwide. All products ship in the original packaging



For additional information, or to request a quotation, contact [sigma-aldrich.com/paragon](http://sigma-aldrich.com/paragon)



# PURIFICATION OF PETROCHEMICALS

We understand that your purification challenges are unique. That's why we have a variety of options to help solve them. Our portfolio includes bulk media, empty columns, and pre-packed hardware. Products for low pressure liquid chromatography (LPLC) and preparative HPLC techniques are offered.

## BULK MEDIA

Selecting the proper media is a vital step in the development of a successful purification method. We offer a wide range of organic resins, inorganic adsorbents, and specialty carbon adsorbents. We also offer several custom resin services.

## NO DRUM REQUIRED

### Organic Resins

The vast array of organic resins that we offer includes those from many leading manufacturers, such as Dow, GE Healthcare, Lanxess, Mitsubishi, Rohm & Haas, Sigma-Aldrich, and Tosoh.

We offer package sizes from 100 g to 25 Kg, which are appropriate for bench-top to mid-scale applications, and allow end-users to gain access to high quality products without the requirement to purchase full drums. The types of organic resins that we offer include:

- **Organic adsorbents** – comprise many different polymer formulations; are stable at virtually all pH levels, which permits operation in conditions under which silica based materials are unsuitable

- **Anion and cation exchange** – utilize the reversible interchange of ions between a solid (the polymeric resin) and a liquid (the mobile phase); function as 'chemical sponges'

- **Mixed bed ion exchange** – contain a mixture of two resin components, typically a strong acid (cation) and a strong base (anion) resin

- **Chelating ion exchange** – have special functionalities incorporated in the copolymer; are useful for metal recovery



- **Nuclear ion exchange** – a minimum of 95% of the available exchange sites are in the hydroxide form

- **Gel filtration** – separation is based on differences in the size and/or shape of the molecules, which govern their access to the area inside the pores; typically used for large molecules

- **Hydrophobic interaction** – exploit hydrophobic properties of large molecules, utilizing more polar elution conditions; can be used in combination with ion exchange or gel filtration

### Custom Resin Services

We provide a wide range of custom resin services to meet the unique demands associated with both bench-top and mid-scale purification. Processing, testing, and packaging are all strengths we demonstrate. Our access to multiple resins, combined with the necessary facilities, expertise, and documented processes, allows us to meet any project requirement.

Outsourcing your resin processing will allow you to save time and reduce operating costs, all while gaining access to our resins experts. Our worldwide delivery capability means you can have the resin arrive where and when it is needed. Custom resin services that we offer include:

#### Processing

- Cleaning
- Pre-wetting
- Blending
- Ion exchange
- Sanitizing/sterilizing

#### Testing

- QC analysis
- Certificate of analysis generation

#### Packaging (clean room conditions)

- Customer-specified containers
- Amounts from 100 g to 25 Kg



Resin Processing



For additional product information, real-time availability, and ordering information, visit [sigma-aldrich.com/resins](http://sigma-aldrich.com/resins)



For additional information, or to request a quotation, contact [supelco\\_quotes@sial.com](mailto:supelco_quotes@sial.com)

## Inorganic Adsorbents

We offer several high quality inorganic adsorbents, including products from Davisil, Imerys Minerals, Merck KGaA Darmstadt, Germany, Sigma-Aldrich, and US Silica. These adsorbents are based on silica, calcium silicate, diatomite, magnesium silicate, or alumina. Silica gel is the most popular. It is available bare or with functionality bonded to it.

Package sizes from 100 g to 25 Kg are appropriate for bench-top to mid-scale applications, and allow end-users to gain access to high quality products, without the requirement to purchase full drums. The types of inorganic adsorbents that we offer include:

- **Bare silica** – widely used; available in various particle and pore sizes; high-quality options are processed to minimize or eliminate impurities; also offer economic options that provide excellent performance at a lower cost

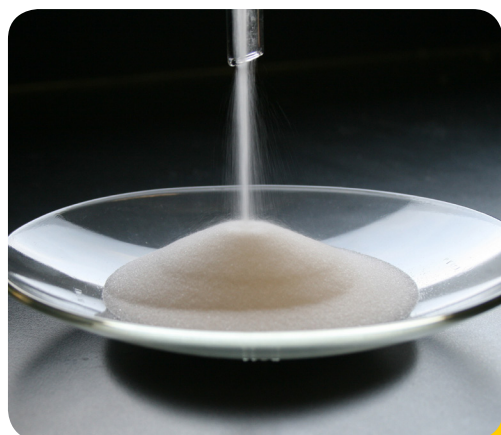
- **Modified/bonded silica** – surface polarity dramatically modified by chemically bonding it with organosilane groups, producing media with unique properties

- **Lipid removal agent (LRA)** – synthetic calcium silicate hydrate (32% calcium oxide and 48% silicon dioxide, plus residual levels of sodium, magnesium, and iron)

- **Celite®** – an acid washed, high purity flux calcined diatomaceous silica specially produced as a filter aid for chromatographic and other laboratory applications

- **Florisil®** – activated magnesium silicate; available in powdered and granular forms

- **Activated alumina** – highly porous aluminum oxide; four activation options (acidic, weakly acidic, basic, and neutral)



Silica Gel



For additional product information, real-time availability, and ordering information, visit [sigma-aldrich.com/resins](https://sigma-aldrich.com/resins)

## Specialty Carbon Adsorbents

We have committed several decades to carbon adsorbent research and product development, with an emphasis on understanding how thermodynamic and kinetic properties affect performance characteristics. A graphic depicting a spherical particle which includes macropores (>500 Å diameter), mesopores (20–500 Å diameter), and micropores (<20 Å diameter) is shown in Figure 8. Controlling pore composition is very important, as it determines the adsorption and desorption characteristics of the particle. Our specialty carbon adsorbents are highly engineered materials, many manufactured from highly pure synthetic polymers. They can be designed with

- The shape we want, either spherical or granular

- No pores, or more/less of any pore type to serve a specific purpose

- Tapered pores (from macro- to meso- to micro-) which increases thermodynamic and kinetic efficiency

- A through-pore or closed-pore structure, which influences microporous strength and kinetic effectiveness

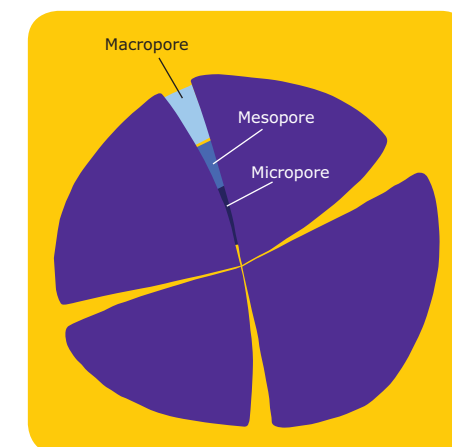


Figure 8. Spherical Particle

Today, we make over 30 different specialty carbon adsorbents ranging in particle size from <0.2 to 850 µm and surface areas from 5 to 1,500 m<sup>2</sup>/g. Any modifications (activation, oxidation, graphitization, surface pH adjustment, etc.) are accomplished through physical means, not chemical means. Our offering includes:

- **Carbon Adsorbent Sampler Kits** – a cost-effective way to evaluate several of our specialty carbon adsorbents

- **Carbon Molecular Sieve (CMS) Adsorbents** – the porous carbon skeletal framework that remains after pyrolysis of a polymeric precursor; includes the Carboxen® (have tapered pores) and Carbosieve® (have non-tapered pores) product lines

- **Spherical Graphitized Polymer Carbon (SGPC) Adsorbents** – a porous or non-porous core plus a graphitized shell of a controlled thickness; includes the Graphsphere™ product line

- **Graphitized Carbon Black (GCB) Adsorbents** – generally are non-porous carbons; includes the Carbotrap® (particles are 20/40 mesh), Carbopack™ (particles are smaller than 40 mesh), and Small Particle GCB (for electrochemical applications) product lines

Sixteen of our specialty carbon adsorbents are scalable, signifying that we can produce large amounts (>1,000 Kg annually) of these adsorbents in 20/40, 20/45, or 30/45 mesh. If you are investigating a specialty carbon adsorbent for a purification or recovery application, we recommend that you focus on the sixteen that are scalable to ensure we can meet your demand if you require a large quantity. Suitable uses in the petrochemical industry include:

- **Purification applications** – an interference removal technique is used to remove an impurity or impurities from a liquid or gas stream

- **Recovery applications** – a bind and elute technique is employed to first capture a compound or compounds from a liquid or gas, and then to recover (through solvent or thermal desorption) the compound or compounds



For additional product information, real-time availability, and ordering information, visit [sigma-aldrich.com/carbon](https://sigma-aldrich.com/carbon)

## EMPTY COLUMNS

Consider packing your own columns to take advantage of up-front cost savings and flexibility:

- Economical – glass columns can be reused again and again
- Versatile – limitless media and packing configurations

We offer several brands of empty columns, a comparison of which is shown in Table 1. Options include polypropylene or glass bodies, ball or threaded joints, and gravity or pump operation.

Column Type	Pressure Range	Features
Omnifit®	Low/Medium	Designed for 20-200 µm media; can be operated at medium pressures
Sigma®	Low	Available jacketed and non-jacketed with various end types
Michel-Miller	Low	Special column end geometries allow for LPLC
Aldrich®	Gravity/Low	Ball or threaded joints available
Ace	Gravity	Threads on ends are compatible with a wide variety of adapters
PD-10	Gravity	Open end, polypropylene column

Table 1. Comparison of Empty Columns

In addition to columns, we also offer a full-line of accessories, such as tubing, fittings, column unions, adapters, flow controllers, valves, solvent reservoirs, and tube flanging tools.



For additional product information, real-time availability, and ordering information, visit [sigma-aldrich.com/purification](https://sigma-aldrich.com/purification)

## PRE-PACKED HARDWARE

If consistent quality and time savings are of significant importance, choose pre-packed configurations.

### Flash Cartridges

Supel™ Flash cartridges are pre-compressed, disposable flash columns containing ultrapure silica, and are designed to meet stringent flash purification requirements. Multiple dimensions are offered. These are suitable for use with organic mobile phases.

Cartridge pre-compression reduces particle interstitial spacing, resulting in even mass transfer and balanced chemical interaction. Other features and benefits include:

- 40-63 µm irregular silica
- 8 bed weights, from 4 grams to 330 grams
- Female luer lock inlet and male slip luer outlet
- Compatible with popular automated flash systems
- High efficiency, leading to sharp, symmetric peaks
- High yield
- High sample loading capacity
- Reliable, consistent performance



Variety of Flash Cartridge Dimensions



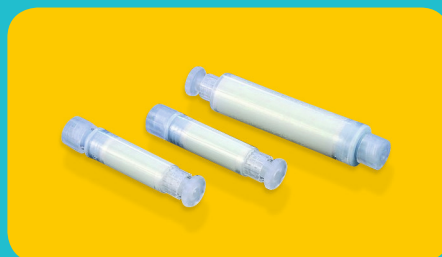
For additional product information, real-time availability, and ordering information, visit [sigma-aldrich.com/purification](https://sigma-aldrich.com/purification)



## LPLC Cartridges

Single-use luer lock syringe tip Rezorian™ cartridges offer convenience for isolating, purifying, and concentrating large molecules. Two pre-packed options are available, employing anion exchange or adsorption retention mechanisms:

- **Polymer SAX Rezorian™ cartridges** contain 200/400 mesh Dowex® 1x8, a quaternary amine functional group bonded to styrene gel, for use with organic mobile phases
- **Rezorian™ A161 cartridges** are packed with styrene-divinylbenzene (reagent grade), a high performance, macroreticular, hydrophobic adsorbent resin for use with aqueous mobile phases



Rezorian™ Cartridges

Ready-to-use Porozorb™ cartridges, are effective for the removal of non-polar, hydrophobic materials from aqueous matrices. Three cartridge sizes are available (250,

1000, and 4000 mL), packed with an Amberlite® XAD-4 resin that is first specially cleaned. Features include:

- 500 µm mean particle size
- Clear polycarbonate shell
- 50 × 250 mesh stainless steel screens
- Medical grade gaskets
- 3/16 inch I.D. x 1/4 inch O.D. nipple connection
- 30 psi (2.1 Kg/cm<sup>2</sup>) maximum pressure



Porozorb™ Cartridges

## PURIFY MORE

### Preparative HPLC Columns

HPLC is a versatile technique which can be scaled from trace analytical to preparative applications. Preparative HPLC columns, utilize wider bores (10-50 mm I.D.) and larger particles compared to columns suitable for analytical applications. Bigger bores have more sample capacity, so can purify greater amounts of synthesized compound per given time. 5 µm particles are appropriate when resolution is required for closely eluting peaks, whereas economical

10 µm particles should be used when peaks are well separated, or when higher throughput and/or lower back pressure is desired.



Preparative HPLC Column

Our offering of preparative HPLC columns encompasses multiple phase chemistries in numerous particle configurations, and includes:

- **Ascentis® columns** (5 and 10 µm Type B silica particles; 100 Å pores; C18, C8, RP-Amide, Phenyl, and Si ligands) – for small molecules; high surface area and ligand coverage allows use at high organic solvent composition
- **Kromasil® Eternity™ and EternityXT columns** (5 and 10 µm silica particles; 100 Å pores; C18 and PhenylHexyl ligands) – for small molecules; produced with a narrow particle size distribution for high efficiency, low pressure-drop, and best total economy in chromatographic purifications
- **Discovery® HS columns** (5 and 10 µm Type B silica particles; 120 Å pores; C18, F5, and PEG ligands) – for small molecules; high stability and low bleed; excellent for LC/MS applications
- **Discovery® columns** (5 µm Type B silica particles; 180 Å pores; C18 and RP-AmideC16 ligands) – intermediate pore size for a wide range of analyte sizes
- **Discovery® BIO Wide Pore columns** (5 and 10 µm Type B silica particles; 300 Å pores; C18, C8, and C5 ligands) – for large molecules
- **Supelcosil™ columns** (5 and 12 µm Type A silica particles; 120 Å pores; C18, C8, ABZ, and Si ligands) – for small molecules
- **Astec® chiral columns** (5 µm silica particles; 100 Å pores; includes Cellulose, CHIROBIOTIC®, CYCLOBOND®, and P-CAP™ product lines) – for small enantiomeric molecules
- **Kromasil® chiral columns** (5 and 10 µm silica particles; >1000 Å pores; includes AmyCoat® and CelluCoat® product lines) – for large enantiomeric molecules



For additional product information, real-time availability, and ordering information, visit [sigma-aldrich.com/purification](http://sigma-aldrich.com/purification)



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\* NOTE: We only offer Kromasil® columns in the USA, Canada, and Puerto Rico

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