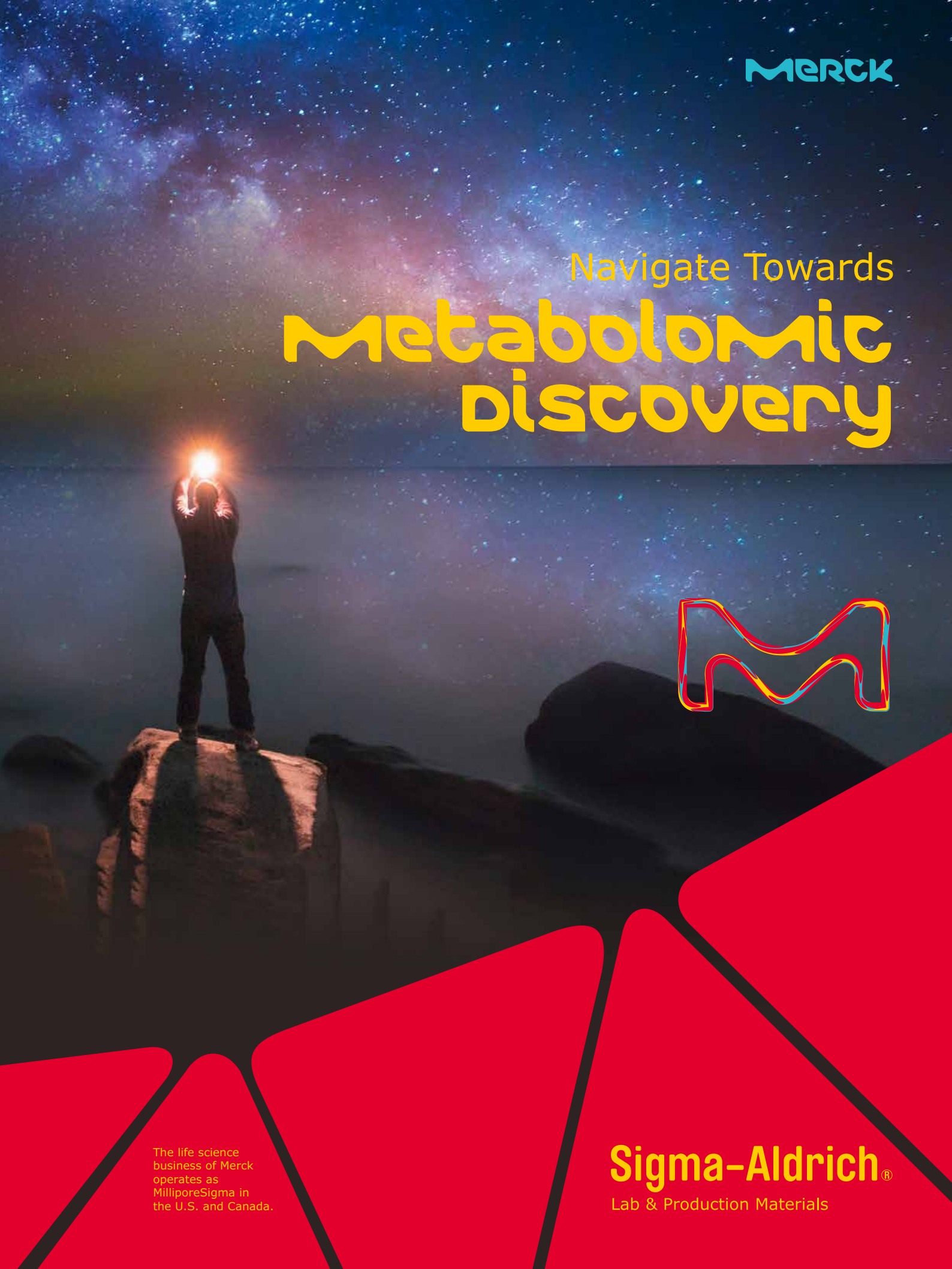
MERCK

Navigate Towards

Metabolomic Discovery



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

Sigma-Aldrich®

Lab & Production Materials

Navigate Towards

Metabolomic Discovery

The renaissance of metabolism from molecular physiology to systems medicine requires tools and workflows for obtaining a snapshot of the amount of small molecules present. These low-molecular weight biochemical compounds have been the subject of much classical biochemistry research in the 20th century. The identification of natural substrates and products of enzymatic reactions laid the foundation of metabolic pathway discovery.

Changes in the levels of specific metabolites have been used in routine analysis of healthy and pathological states of humans and animals, but microbial and plant systems benefit as well from the quantification of metabolites. The quantitative and qualitative determination of a larger number of metabolites from a group of related compounds have become possible, primarily through breakthroughs in separation and detection technologies together with the availability of a large number of metabolites. A rapid global analysis can be used as a metabolic fingerprint for phenotype or sample classification. On a more detailed level, workflows for the analysis of specific metabolic pathways and their changes under different experimental conditions are useful for metabolic profiling, with complementary information to genomic and proteomic studies. In 1947, Sigma-Aldrich produced the first commercially available form of ATP. Since then, Sigma-Aldrich has consistently expanded its product portfolio to maintain the most comprehensive line of organic metabolites, enzymes, and analytical tools in the world.

Sigma-Aldrich metabolites, enzymes, separation tools and technologies help you navigate the metabolic pathways to biomarker discovery.

The Sigma-Aldrich Metabolomics Resource gives you:

- Nicholson/IUBMB Metabolic Pathways Chart with over 500 links to metabolite, cofactor, and enzyme listings
- High resolution tandem mass spectrometry analysis of select Sigma-Aldrich metabolites from Scripps METLIN Database
- Direct access to 35 Nicholson Metabolic mini-maps
- Animated pathways for teaching and illustration

To get started, visit the Metabolomics Resource at **SigmaAldrich.com/metabolomics**

Table of Contents


Sigma-IUBMB Interactive Metabolic Pathway Tool
Metabolites, Standards, and Enzymes
Metabolomics Workflow
Metabolite Analysis and Labeling
Metabolomics Applications

IUBMB-Sigma-Nicholson Interactive Metabolic Pathways Chart

As your partner in discovery, we are here to provide you the products and information that you need to stay on the leading edge of research in metabolomics. This new edition of the iconic IUBMB-Sigma-Nicholson Metabolic Pathways Chart brings increased functionality to a canonical tool. Now, all metabolites, enzymes, and selected pathways are searchable and interactive.

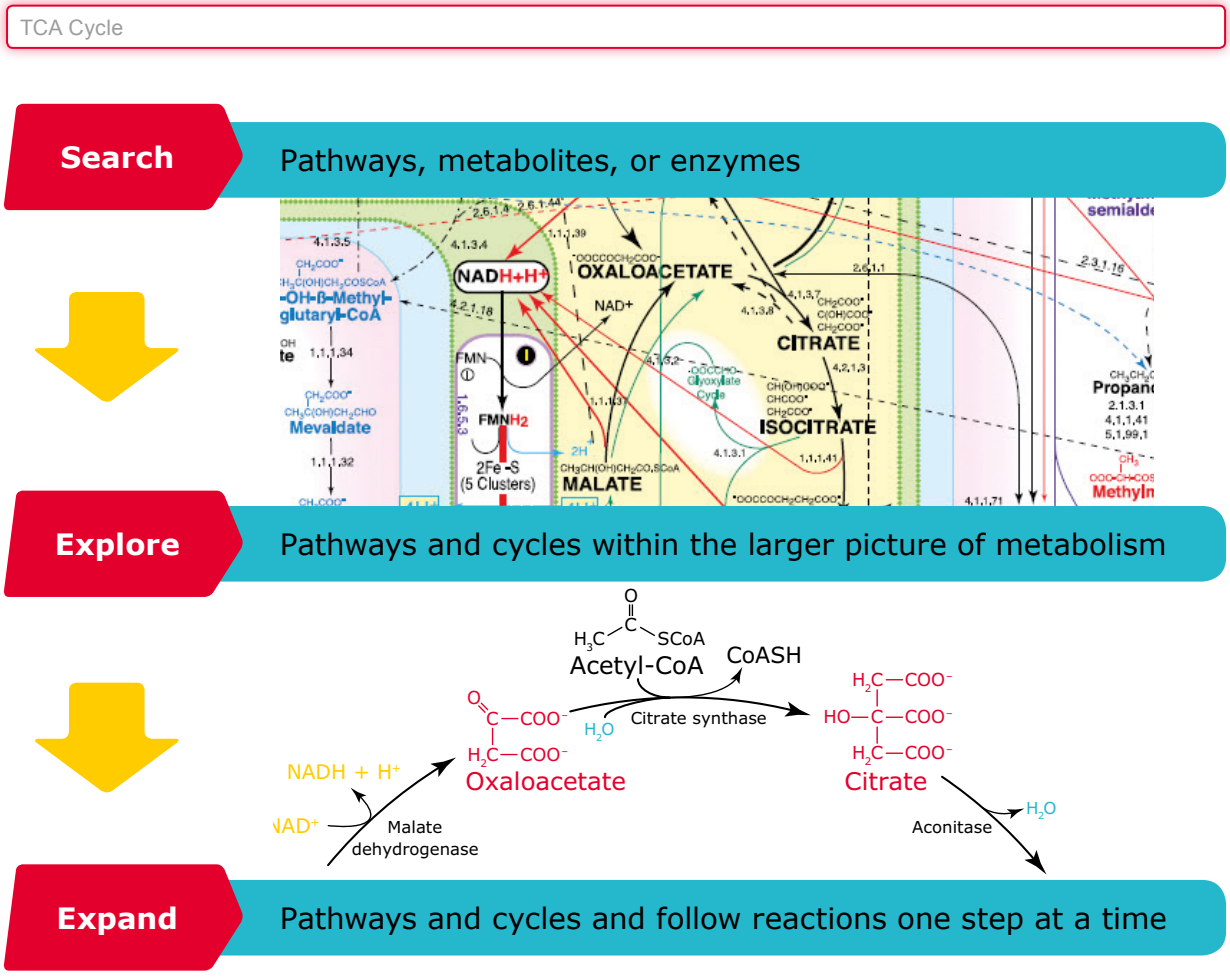
Navigating the Interactive Chart

Colored pins are used to differentiate metabolites from enzymes, red representing metabolites and blue representing enzymes. The pins drop upon searching any of the 1,100 metabolites and enzymes, or their associated pathways. Click the pins to view more information and to see our related products. We hope you enjoy your experience with our new interactive tool.

Key Features and Benefits

- Search any metabolite or enzyme
- Explore the pathways and cycles within the larger picture of metabolism
- Expand pathways and cycles and follow reactions one step at a time

Discover your pathway at
SigmaAldrich.com/metpath



Search the Metabolic Pathway Map …

Search

- Metabolites by CAS number, name, or chemical class
- Enzymes by EC number, name, or enzyme class
- Pathways and cycles including: glycolysis, gluconeogenesis, TCA cycle, pentose phosphate, urea cycle, ketogenesis, and ketolysis

Explore

- New metabolite and enzyme descriptions
- Relevant pathways and related products
- Additional information on the product detail page by clicking on the Sigma-Aldrich Product No.

Acetyl-Coa

Classication: Acyl CoAs

Pathways(s): Glycolysis, TCA Cycle, Lipid metabolism, Glyoxylate Cycle, Ketogenesis, Ketolysis
Synonyms: Acetyl-S-Coa, Acetyl CoA

Acetyl-Coa is an essential cofactor and carrier of acyl groups in enzymatic acetyl transfer reactions. It is formed either by the oxidative decarboxylation of pyruvate in mitochondria, by the oxidation of long-chain fatty acids, or by the oxidative degradation of certain amino acids. Acetyl-Coa is the starting compound for the citric acid cycle (Kreb's cycle). It is also key precursor in lipid biosynthesis, and the source of all fatty acid carbons.

Product Name: Acetyl coenzyme A sodium salt

Product No: A2056

Inborn Errors of Metabolism Chart

Every characteristic of human anatomy and physiology is determined by biochemical reactions catalyzed by enzymes. These in turn are determined by our genetic make-up. If a gene is defective or missing it will result in a defective or missing enzyme, a so-called “inborn error of metabolism.” The Inborn Errors of Metabolism Map includes:

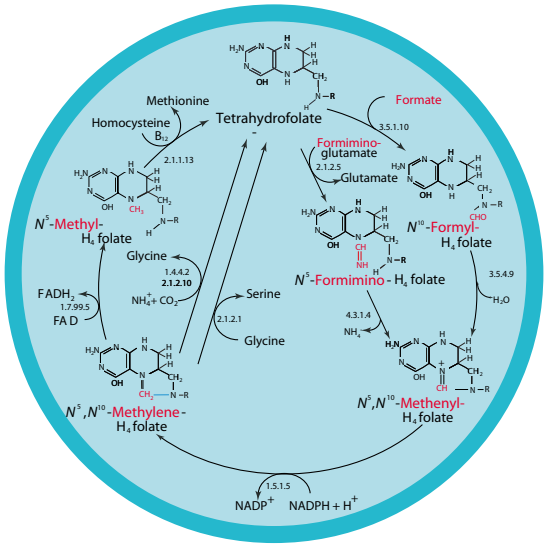
- Over 100 metabolic deficiency diseases which are named on the map

Description	Cat. No.
Inborn Errors of Metabolism, 21st ed. Poster, 22 × 27 in.	**I8014**
Metabolic Pathways, 22nd Ed. Chart, 12.5 × 19 in.	**M3782**
Metabolic Pathways, 22nd Ed. Poster, 33 × 50 in.	**M3907**

IUBMB-Nicholson Minimaps

Selected individual pathways enlarged to illustrate aspects of metabolism, such as compartmentalization and regulation, expand the information provided by the Metabolic Pathways Chart.

Find the interactive Metabolic Pathways Chart, Minimaps and Animaps at **SigmaAldrich.com/metpath**



ENZYMES

1.4.4.2	Glycine dehydrogenase (decarboxylating)
1.5.1.3	Dihydrofolate reductase
1.5.1.5	Methylene-THF dehydrogenase (NADP$^+$)
1.7.99.5	5, 10-Methylene-THF reductase ($FADH_2$)
2.1.1.13	5-Methyl-THF–homocysteine S-methyltransferase
2.1.1.45	Thymidylate synthase
2.1.2.2	Phosphoribosylglycinamide formyltransferase
2.1.2.3	Phosphoribosylamidoimidazole-carboxamide formyltransferase
2.1.2.5	Glutamate formiminotransferase
2.1.2.10	Aminomethyltransferase
3.5.1.10	Formyl-THF deformylase
3.5.4.9	Methenyl-THF cyclohydrolase
4.3.1.4	Formimino-THF cyclodeaminase
6.3.3.2	5-Formyl-THF cyclo-ligase
6.3.4.3	Formate-tetrahydofolate ligase

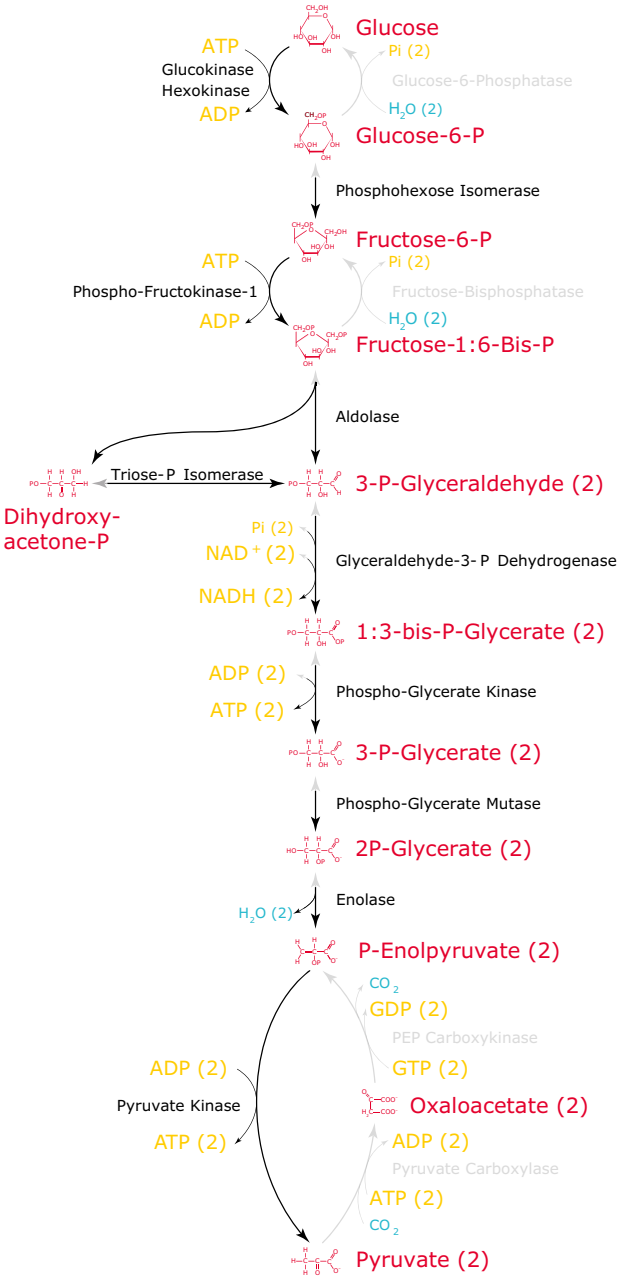
Metabolites, Standards, and Enzymes

Glycolysis Pathway

Glycolysis is the primary pathway that converts glucose into pyruvate. The glycolytic pathway is highly up regulated in rapidly-growing malignant tumor cells, a phenomenon first described by Otto Warburg in 1930. This phenomenon, commonly referred to as the Warburg effect, is a preference for highly proliferatively active cells to shift to aerobic glycolysis even in the presence of adequate oxygen. In aerobic glycolysis, NADH is regenerated through the reduction of pyruvate to lactic acid by lactate dehydrogenase. Enzymes of the glycolytic pathway are potential therapeutic targets for the treatment of cancer.

Glycolysis Metabolites

Description	Cat. No.
2,3-Diphospho-D-glyceric acid pentasodium salt glycolysis metabolite	D5764
D-(−)-3-Phosphoglyceric acid disodium salt ≥93%, powder	P8877
D-(+)-Glucose ≥99.5% (GC)	G8270
D-(+)-Glucose BioXtra, ≥99.5% (GC)	G7528
D-Fructose 1,6-bisphosphate trisodium salt hydrate ≥98% (TLC)	F6803
D-Fructose 6-phosphate disodium salt hydrate ≥98%, amorphous powder	F3627
D-Glucose 6-phosphate dipotassium salt hydrate Sigma Grade, 98–100%	G7375
D-Glucose 6-phosphate disodium salt hydrate Sigma Grade, ≥98%	G7250
D-Glucose 6-phosphate potassium salt ≥95%	G6526
D-Glucose 6-phosphate sodium salt Sigma Grade, crystalline	G7879
D-Glyceraldehyde 3-phosphate solution 8–13 mg/mL in H_2O	39705
DL-Glyceraldehyde 3-phosphate solution 45–55 mg/mL in H_2O	G5251
D(+)2-Phosphoglyceric acid sodium salt hydrate ≥75% (calc. on dry substance, enzymatic)	79470
Phospho(enol)pyruvic acid monopotassium salt ≥97% (enzymatic)	P7127
Phospho(enol)pyruvic acid tri(cyclohexylammonium) salt ≥98% (enzymatic)	P7252
Phospho(enol)pyruvic acid trisodium salt hydrate ≥97% (enzymatic)	P7002
Sodium pyruvate ReagentPlus®, ≥99% (Sigma-Aldrich)	P2256
α-D-Glucose 1-phosphate dipotassium salt hydrate ≥97%	G6875
α-D-Glucose 1-phosphate dipotassium salt hydrate BioXtra, ≥98%	G6750
α-D-Glucose 1-phosphate disodium salt hydrate ≥95%	G1259
α-D-Glucose 1-phosphate disodium salt hydrate ≥97%	G7000
α-D-Glucose 1-phosphate disodium salt hydrate ≥98%, BioXtra, lyophilized powder	G7018
α-D-Glucose 1-phosphate disodium salt hydrate 98–99%	G9380
β-D-Glucose 1-phosphate bis(cyclohexylammonium) salt	G7920



Key Glycolytic Enzymes

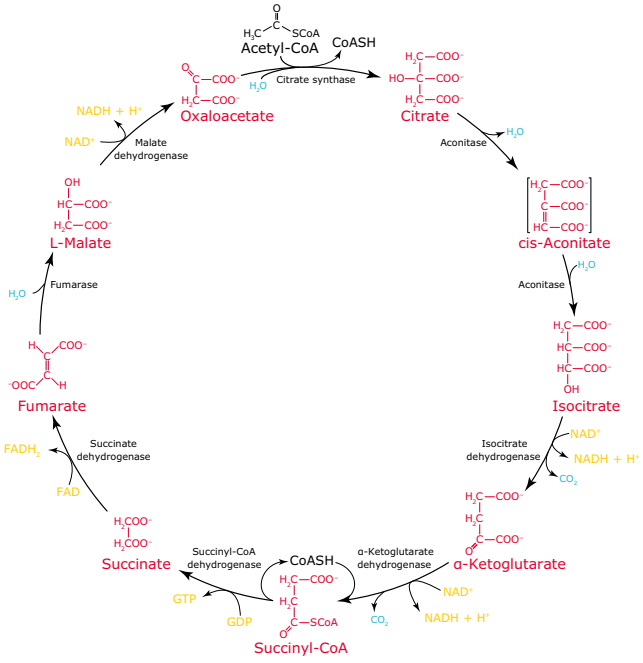
Description	Cat. No.
Aldolase from rabbit muscle ammonium sulfate suspension, 10 – 20 units/mg protein	**A8811**
Creatine Phosphokinase from rabbit muscle Type I, salt-free, lyophilized powder, ≥ 150 units/mg protein	**C3755**
Enolase from baker's yeast (S. cerevisiae) lyophilized powder, ≥ 50 units/mg protein	**E6126**
Fructose-6-phosphate Kinase from Bacillus stearothermophilus Type VII, lyophilized powder, ≥ 50 units/mg protein	**F0137**
Glyceraldehyde-3-phosphate Dehydrogenase from rabbit muscle lyophilized powder, ≥ 75 units/mg protein	**G2267**
α-Glycerophosphate Dehydrogenase-Triosephosphate Isomerase from rabbit muscle Type III, ammonium sulfate suspension, TPI 750 – 2,000 units/mg protein, GDH 75 – 200 units/mg protein (biuret)	**G1881**
Hexokinase from Saccharomyces cerevisiae Type F-300, lyophilized powder, ≥ 130 units/mg protein (biuret)	**H4502**
Invertase from baker's yeast (S. cerevisiae) Grade VII, ≥ 300 units/mg solid	**I4504**
L-Lactic Dehydrogenase from rabbit muscle Type II, ammonium sulfate suspension, 800 – 1,200 units/mg protein	**L2500**
L-Lactic Dehydrogenase from rabbit muscle Type XI, lyophilized powder, 600 – 1,200 units/mg protein	**L1254**
Phosphoglucose Isomerase from baker's yeast (S. cerevisiae) Type III, ammonium sulfate suspension, ≥ 400 units/mg protein (biuret)	**P5381**
3-Phosphoglyceric Phosphokinase from baker's yeast (S. cerevisiae) ammonium sulfate suspension, ≥ 1,000 units/mg protein	**P7634**
Pyruvate Kinase from rabbit muscle Type III, lyophilized powder, 350 – 600 units/mg protein	**P9136**
Triosephosphate Isomerase from rabbit muscle Type X, lyophilized powder, ≥ 3,500 units/mg protein	**T6258**

Tricarboxylic acid (TCA) Cycle

The Citric acid (TCA or Krebs) Cycle is the origin and the termination of many Metabolic Pathways. It harnesses the potential energy of Acetyl-CoA into the reducing power of NADH.

TCA Cycle Metabolites

Description	Cat. No.
TCA Cycle Metabolite Library	**ML0010**
Acetyl coenzyme A sodium salt, ≥ 93 % (HPLC)	**A2056**
Citric acid monohydrate, reagent grade, ≥ 98 % (GC/titration)	**C7129**
Sodium fumarate dibasic, ≥ 99 %	**F1506**
DL-Isocitric acid trisodium salt hydrate, ≥ 93 %	**I1252**
L-(−)-Malic acid, 95 – 100 % (enzymatic)	**M1000**
Oxaloacetic acid, ≥ 97 %	**O4126**
Sodium pyruvate, ReagentPlus®, ≥ 99 %	**P2256**
Succinyl coenzyme A sodium salt, ≥ 85 %	**S1129**
Sodium succinate dibasic hexahydrate, ReagentPlus®, ≥ 99 %	**S2378**
α-Ketoglutaric acid disodium salt hydrate, analytical standard	**K3752**



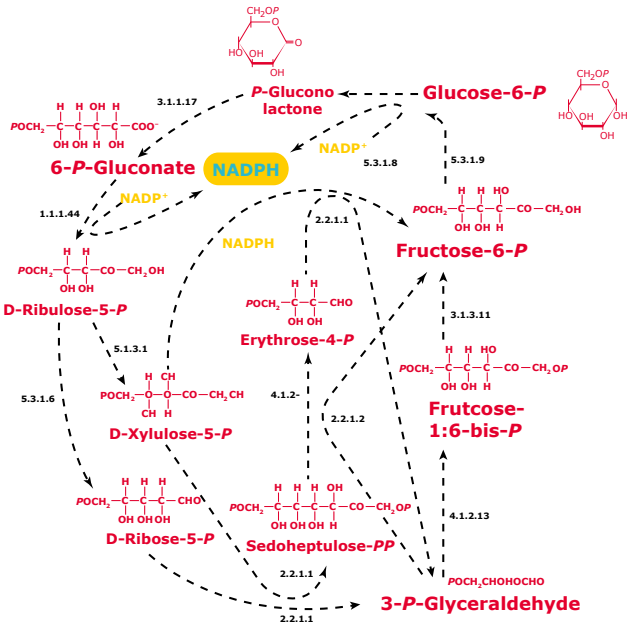
Key TCA Cycle Enzymes

Description	Cat. No.
Malic Dehydrogenase from porcine heart buffered aqueous glycerol solution, 600 – 1,000 units/mg protein (biuret)	**M2634**
α-Ketoglutarate Dehydrogenase from porcine heart buffered aqueous glycerol solution, 0.1 – 1.0 units/mg protein (Lowry)	**K1502**
Citrate Synthase from porcine heart ammonium sulfate suspension, ≥ 100 units/mg protein	**C3260**
Fumarase from porcine heart ammonium sulfate suspension, 300 – 500 units/mg protein (biuret)	**F1757**
Aconitase from porcine heart	**A5384**

Pentose Phosphate Pathway

While glucose metabolism by glycolysis occurs where energy is needed quickly, e.g. in brain and muscle cells, a second pathway for glucose metabolism, called pentose phosphate pathway, operates in tissues that synthesize fatty acids and steroids.

Description	Cat. No.
D-Glyceraldehyde 3-phosphate solution	39705
D-Sedoheptulose 7-phosphate lithium salt	78832
Adenosine 5'-triphosphate disodium salt hydrate	A2383
Adenosine 5'-diphosphate sodium salt	A2754
Dihydroxyacetone phosphate dilithium salt	D7137
D-Erythrose 4-phosphate sodium salt	E0377
D-Fructose 6-phosphate disodium salt hydrate	F3627
D-Fructose 1,6-bisphosphate trisodium salt hydrate	F6803
D-Glucose 6-phosphate sodium salt	G7879
β-Nicotinamide adenine dinucleotide phosphate sodium salt hydrate	N0505
β-Nicotinamide adenine dinucleotide 2'-phosphate reduced tetrasodium salt hydrate	N7505
6-Phosphogluconic acid trisodium salt	P7877
5-Phospho-D-ribose 1-diphosphate pentasodium salt	P8296
D-(–)-Ribose	R7500
D-Ribose 5-phosphate disodium salt hydrate	R7750
D-Ribulose 5-phosphate sodium salt	R9875
D-Xylulose 5-phosphate sodium salt	X0754



Key Pentose Phosphate Pathway Enzymes

Description	Cat. No.
6-Phosphogluconic Dehydrogenase from yeast lyophilized powder, 3.0 – 6.0 units/mg solid	P4553
Glucose-6-phosphate Dehydrogenase from baker's yeast (S. cerevisiae) Type XV, lyophilized powder, 200 – 400 units/mg protein (modified Warburg-Christian)	G6378
Transketolase from E. coli ≥ 0.1 units/mg	68138
Transaldolase from baker's yeast (S. cerevisiae) lyophilized powder, 10 – 30 units/mg protein (biuret)	T6008
Hexokinase from Saccharomyces cerevisiae Type F-300, lyophilized powder, ≥ 130 units/mg protein (biuret)	H4502
Aldolase from rabbit muscle ammonium sulfate suspension, 10 – 20 units/mg protein	A8811
D-Ribulose-5-phosphate 3-Epimerase from baker's yeast (S. cerevisiae) lyophilized powder, 50 – 100 units/mg protein (modified Warburg-Christian)	R3251
Triose-phosphate isomeraseTriosephosphate Isomerase from rabbit muscle Type X, lyophilized powder, ≥ 3,500 units/mg protein	T6258
Phosphoriboisomerase from spinach Type I, partially purified powder, ≥ 75 units/mg protein (biuret)	P9752
Phosphoglucose Isomerase from baker's yeast (S. cerevisiae) Type III, ammonium sulfate suspension, ≥ 400 units/mg protein (biuret)	P5381

For a comprehensive list of pathway metabolites, visit **SigmaAldrich.com/metpath**

Metabolite Libraries and Kits

The **ML0100 TCA Cycle Metabolite Library** provides all 10 components of the Kreb's Cycle in one convenient format.

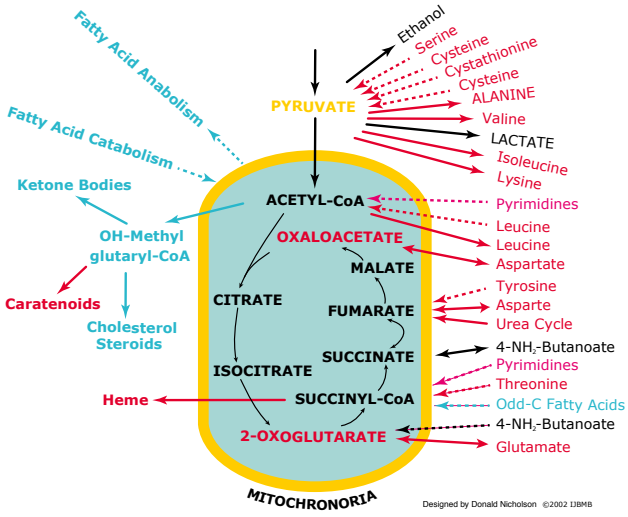
TCA Cycle Metabolite Library

All components are directly water soluble at ≥ 50 mg/mL.

Components

Acetyl coenzyme A (Sigma A2056) 10 mg
Citric acid (Sial C7129) 10 mg
Sodium fumarate dibasic (Sigma F1506) 10 mg
DL-Isocitric acid (Sigma I1252) 10 mg
L-(–)-Malic acid (Sigma M1000) 10 mg
Oxaloacetic acid (Sigma O4126) 10 mg
Sodium pyruvate (Sial P2256) 10 mg
Succinyl coenzyme A (Sigma S1129) 10 mg
Sodium succinate (Sial S2378) 10 mg
store at: –20 °C

ML0100-1KT	1 kit



Name	Description	Cat. No.
Vitamins Kit ~98% (Components, TLC)	11 Vitamins in quantities as indicated: p-Aminobenzoic acid, 5 g; d-Biotin, 100 mg; Folic acid, 1 g; Niacinamide, 100 g; D-Pantothenic acid, hemicalcium salt, 5 g; Pyridoxal hydrochloride, 500 mg; Pyridoxamine dihydrochloride, 250 mg; Pyridoxine hydrochloride, 5 g; Riboflavin, 5 g; Thiamine hydrochloride, 5 g; DL-6,8-Thioctic acid, 500 mg	**V1**

Carbohydrate Metabolite Kits

Name	Description	Cat. No.
Carbohydrates Kit	Ten carbohydrates, 5 g of each, contains: Arabinose, Fructose, Galactose, Glucose, α-Lactose, Maltose, Mannose, Ribose, Sucrose and Xylose	**CAR10**
Sugar Alcohol Kit	Nine sugar alcohols, 500 mg of each, contains: D-(+)Arabitol, Dulcitol (Galactitol), iso-Erythritol, Glycerol, Maltitol, D-Mannitol, Ribitol (Adonitol), D-Sorbitol, and Xylitol	**47266**
Monosaccharides Kit	Seven monosaccharides, 500 mg of each, contains: D-(+)Glucose, mixed anomers, D-(–)Arabinose, Fructose, D-(+)Galactose, D-(+)Mannose (mixed anomers), D-(–)Ribose, and D-(+)Xylose	**47267**
Disaccharides Kit	Contains disaccharides in quantities indicated: Maltose 500 mg, Sucrose 500 mg, Isomaltose (mixed anomers) 100 mg, and α-Lactose 500 mg	**47268-U**

Amino Acids Kits

Name	Description	Cat. No.
L-Amino Acids analytical standard	Contains 21 L-Amino Acids plus glycine, 1 g of each	**LAA21**
L-Amino Acids analytical standard	Contains the 10 Essential Amino Acids, 1 g of each	**LAA10**
Amino acid Standard analytical standard	Amino Acids in this standard are 2.5 µmoles per mL in 0.1 N HCl, except L-cystine at 1.25 µmoles per mL	**AAS18**
Amino acid standards, physiological analytical standard, acidics and neutrals	Amino Acids in this standard are 2.5 µmoles per mL except L-cystine at 1.25 µmoles per mL	**A6407**
Amino acid standards, physiological analytical standard, acidics, neutrals, and basics	Amino Acids and related compounds are 0.5 µmole/mL in 0.2 N lithium citrate, pH 2.2 containing 0.1% phenol and 2% thiodiglycol	**A9906**
Amino acid standards, physiological analytical standard, basics	This solution contains physiological, basic Amino Acids and related compounds for calibration of amino acid analyzers. Amino Acids and related compounds are at 2.5 mmoles/mL ±4% in 0.1 N HCl	**A6282**

Fatty Acids & Lipid Metabolite Kits

Name	Cat. No.
Fatty Acid Kit (individually packaged, quantities indicated), analytical standard	**EC10A-1KT**
Fatty Acids, Odd Carbon Straight Chains Kit (individually packaged in quantities indicated), analytical standard	**OC9-1KT**
Fatty Acids Unsaturated Kit (individualy packaged in quantities indicated), analytical standard	**UN10-1KT**
Triglycerides Kit (individually packaged in quantities indicated), analytical standard	**TRI19-1KT**
Triglycerides, Saturated, Even Carbon Kit (individually packaged in quantities indicated), analytical standard	**TRI11-1KT**

LC-MS Certified Spiking Solutions and Reference Materials

Single and multi-component solution standards (both stable-labeled and unlabeled) designed, manufactured and tested specifically for use as reference standards for laboratories performing bioanalysis, therapeutic drug monitoring, diagnostic and toxicology testing.

Cerilliant®'s products address the stringent and complex requirements of forensic toxicology, clinical toxicology, clinical chemistry/immunoassay, therapeutic drug monitoring, pain management and pharmaceutical analysis. Products manufactured at Cerilliant® are fully documented through the use of batch records to provide traceability of materials used, traceability of equipment utilized, calibration records, and detail of all work performed and staff utilized, all backed by a comprehensive Certificate of Analysis. Cerilliant®'s quality credentials include accreditations to ISO Guide 34, ISO/IEC 17025 and certification to ISO 13485 and ISO 9001. Cerilliant®'s quality system incorporates cGMP and GLP requirements.

Cerilliant® CRM portfolio includes:

Catalog and Custom

- Metabolites including P450 and Glucuronides
- Impurities/Degradants
- Internal Standards
- Many analyte classes, including
  - Drugs/Drugs of Abuse
  - TDM Drugs/Immunosuppressants/Catecholamines
  - Hormones including Thyroid/Steroids – Alcohol/Ethanol
  - Vitamins (A, B, D and E)
  - Natural Products/Phytochemicals

For a complete listing of Cerilliant® certified standards, visit **SigmaAldrich.com/cerilliant**

Mass Spectrometry Metabolite Library

Supplied by IROA Technologies

MSMLS™ (Mass Spectrometry Metabolite Library of Standards) and LSMLS™ (Large Scale Metabolite Library of Standards) are a collection of high quality small biochemical molecules that span a broad range of primary metabolism. These are high purity (>95%) compounds supplied in an economical, ready-to-use format. The library of standards are most commonly used to provide retention times and spectra for key metabolic compounds, help optimize mass spectrometry analytical protocols, qualify and quantify mass spectrometry sensitivity and NMR, functional cellular assays, phenotypic screening and limit of detection.

Features and Benefits

Compounds

Unique small molecule metabolites organized in a 96-well format according to solubility. Broad metabolite spectrum, key primary metabolites and intermediates covering key metabolic pathways, including the following classes of compounds:

- Carboxylic acids, amino acids
- Biogenic amines, polyamines
- Nucleotides, coenzymes and vitamins
- Mono- and disaccharides
- Fatty acids, lipids, steroids, and hormones

MSMLS™ features 619 unique metabolites as 5 µg dried weight

LSMLS™ features 504 unique metabolites as 1 mg dried weight

Convenient

- High purity metabolites, pre-weighed, solubilized in either water, 40 % aqueous methanol or 100 % ethanol and supplied dried
- The library is intended to be used for mass spectrometry metabolomics applications and provides a broad representation of primary metabolites
- Suitable for manual and automated work flow

MSMLSDiscovery™ software tool is provided to support the extraction, manipulation, and storage of the data generated when using the MSMLS™ and LSMLS™ Library of Metabolite Standards.

Ordering Information

Description	Cat. No.
Mass Spectrometry Metabolite Library	**MSMLS-1EA**
Large Scale Metabolite Library	**LSMLS-1EA**

For more information, visit
SigmaAldrich.com/MSMLS

IROA TECHNOLOGIES
...making metabolic profiling easy®

Lipid Sample Preparation Kits

Isolate, Methylate, and Purify

Lipid and Sterol Extraction Kits

The Folch method of lipid and sterol extraction is an effective but time-consuming procedure. Our Lipid Extraction Kit and Sterol Extraction Kit provide an isolation method that is high-throughput, simpler, faster, and less costly than conventional techniques, such as the Folch method, but still yield the same high-quality results.

Features and Benefits

- **No centrifugation or pipetting required** – Extract compounds in two steps: Pour and Push
- **Solvents and internal standards come pre-mixed** – Eliminate the need to prepare solvents and standards
- **Less than 30 seconds per sample** – Reduce your labor costs and save your valuable time
- **High-throughput** – Cut cost and time without sacrificing yield

Ordering Information

Description	Cat. No.
Fatty acid Extraction Kit	**MAK174-1KT**
Sterol Extraction Kit	**MAK175-1KT**

Get the Same High-quality Results in Less Time

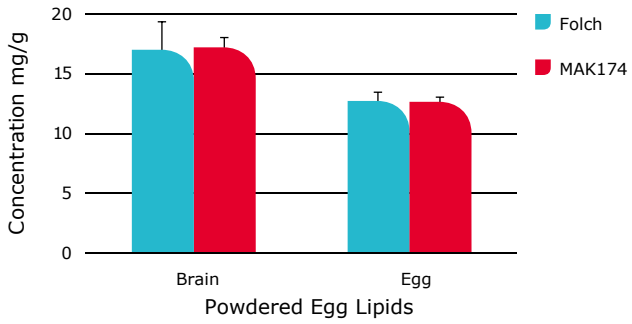


Figure 1: Rat brain fatty acid concentrations (mg/g)

Lipids were extracted from rat brain with the Folch or MAK174 kit method, transesterified, and quantified with GC-FID.

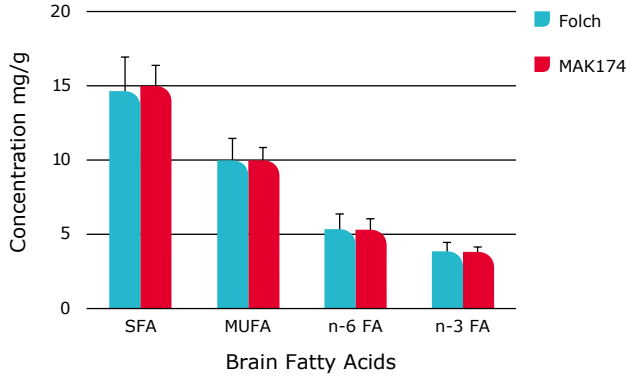


Figure 2: Rat brain and powdered egg cholesterol concentrations (mg/g)

Lipids were extracted with the Folch or MAK175 kit method, saponified, derivitized, and quantified with GC-FID.

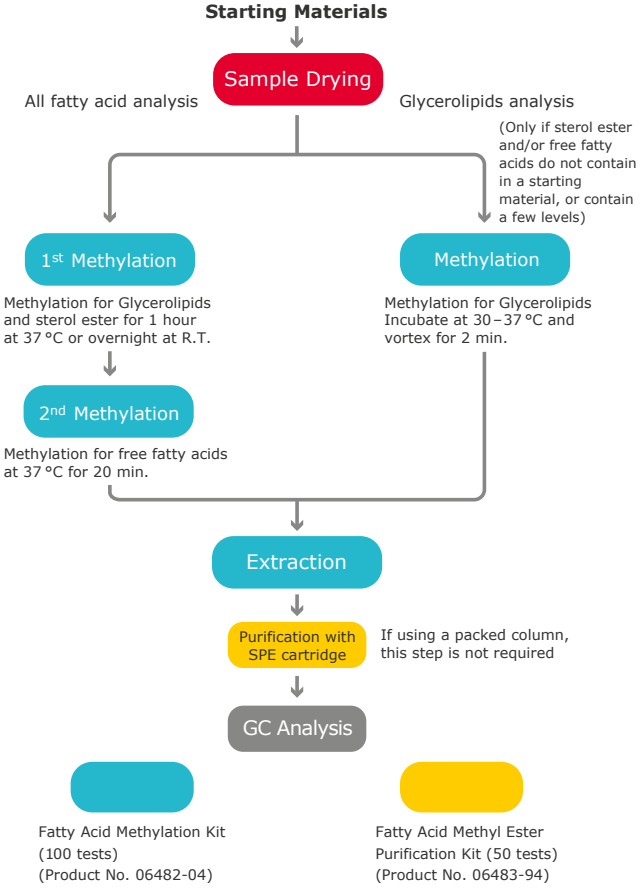
Fatty acid Methylation and Purification Kits

Manufactured by Nacalai Tesque, Inc.

Methyl esterification of fatty acids is commonly performed prior to gas chromatography analysis to prevent peak tailing and to increase sample volatility. However, the conventional esterification procedure requires specialized equipment and high technical skill. Preparation of methyl ester derivatives is often poorly understood and unnecessarily vigorous reaction conditions are often employed.

By using the Fatty acid Methylation Kit (MAK224) that utilizes a new reaction technique, followed by the Fatty acid Methyl Ester Purification Kit (MAK225), fatty acid methyl esterification is greatly simplified.

General Procedure



Features and Benefits

No excessive heating – Can be performed safely and easily

Reaction is conducted at 37 °C

Detects long-chain and short-chain fatty acids

Applicable for free fatty acids and glycerolipids, such as triglycerides, phospholipids, glycolipids and sterol esters

Ordering Information

Description	Cat. No.
Fatty acid Methylation Kit	**MAK224-1KT**
Fatty acid Methyl Ester Purification Kit	**MAK225-1KT**

Comparison of Methylation Efficiency Rate

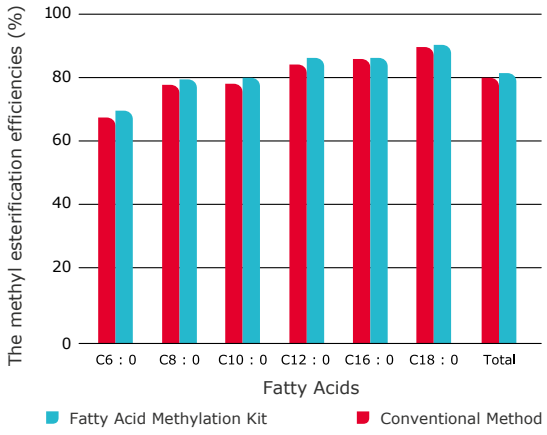


Figure 1: The methyl esterification efficiencies between the Fatty acid Methylation Kit and a conventional method using different fatty acid side-chains.

Supel™ Select Polymeric SPE Products

Key Features and Benefits

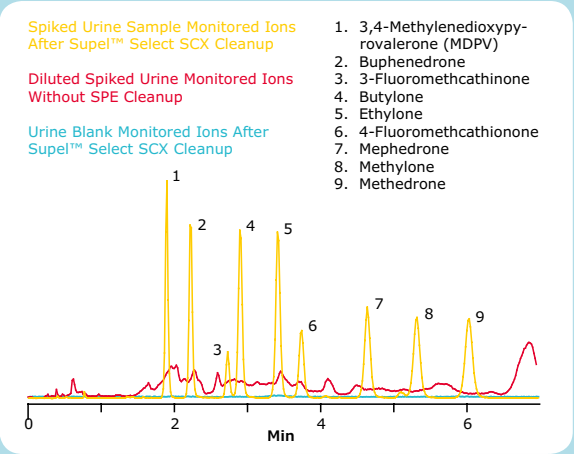
- Hydrophilic-modified styrene resin extracts and recovers a broad range of analytes (polar to nonpolar, acidic to basic) using a single sorbent
- Generic methodology saves time, money, and headaches during method development
- Greater capacity allows for smaller bed weights = smaller elution volumes = time savings in sample processing
- Resistant to over-drying allowing for more robust methodology

Versatile and Simple Sample Cleanup by SPE

Supel™ Select SPE phases are ideal for the solid phase extraction (SPE) of a broad range of compounds from aqueous samples. While reversed-phase interactions dominate retention on the Supel™ Select HLB, and the retention mechanisms of the Supel™ Select SAX and SCX are predominately based on ion-exchange, the hydrophilic modifications of the styrene-based polymer backbone allow for retention and recovery of more polar compounds.

LC-MS Analysis of Illicit Bath Salts in Urine on Ascentis® Express HILIC with and without Supel™ Select SCX SPE Cleanup

SPE tube:	Supel™ Select SCX, 30 mg/1 mL (54240-U)
column:	Ascentis® Express HILIC, 10 cm × 2.1 mm I.D., 2.7 µm (53939-U)
mobile phase:	(A) 5 mM ammonium formate acetonitrile; (B) 5 mM ammonium formate water; (98:2, A:B) (solvents and additives LC-MS Ultra CHROMASOLV® grade)
flow rate:	0.6 mL/min
pressure:	127 bar
column temp:	35 °C
detector:	MS, ESI+, 100 – 1,000 m/z
injection:	1 µL
sample:	200 ng/mL in acetonitrile (standards from Cerilliant®)



Supel™ Select Properties	
HLB Phase Chemistry	Hydrophilic-modified styrene polymer
SAX Phase Chemistry	Quanternary amine-functionalized hydrophilic-modified styrene polymer
SCX Phase Chemistry	Sulfonic acid-functionalized hydrophilic modified styrene polymer
Suitable for MS Detection?	Yes
pH Compatibility	0 – 14
Particle Size	50 – 70 µm
Surface Area	160 – 420 m²/g
Pore Volume	0.8 – 1.2 mL/g
Pore Size	80 – 200 Å

Name	Description	Quantity	Cat. No.
Supel™ Select HLB 96-well SPE	10 mg/well	1	**Inquire**
	30 mg/well	1	**575661-U**
	60 mg/well	1	**575662-U**
Supel™ Select SAX 96-well SPE	10 mg/well	1	**Inquire**
	30 mg/well	1	**575660-U**
	60 mg/well	1	**575663-U**
Supel™ Select SCX 96-well SPE	10 mg/well	1	**Inquire**
	30 mg/well	1	**575664-U**
	60 mg/well	1	**575665-U**

Name	Description	Quantity	Cat. No.
Supel™ Select HLB SPE	30 mg/1 mL	100	**54181-U**
	60 mg/3 mL	50	**54182-U**
	200 mg/6 mL	30	**54183-U**
	500 mg/12 mL	20	**54184-U**
	1 g/20 mL	20	**54186-U**
Supel™ Select SAX SPE	30 mg/1 mL	100	**54231-U**
	60 mg/3 mL	50	**54233-U**
	200 mg/6 mL	30	**54235-U**
	500 mg/12 mL	20	**54236-U**
	1 g/20 mL	20	**54237-U**
Supel™ Select SCX SPE	30 mg/1 mL	100	**54240-U**
	60 mg/3 mL	50	**54241-U**
	200 mg/6 mL	30	**54242-U**
	500 mg/12 mL	20	**54243-U**
	1 g/20 mL	20	**54245-U**

For more information, visit **SigmaAldrich.com/supel-select**

HybridSPE®-Phospholipid Products for Consistent LC-MS Ionization

Key Features and Benefits

- Maximize sensitivity by minimizing ion-suppression
- 100 % removal of phospholipids and precipitated proteins
- 2 – 3 step generic procedure
- Ideal for high-throughput pre-clinical and clinical studies

Ion-Suppression and Phospholipid Contamination

When analyzing a compound and its metabolites in biological fluids, such as plasma or serum, one frequently deals with interference from the complex sample matrix. Ion-suppression of the mass spec signal due to contaminants in the matrix often limits our ability to properly identify and quantify the analytes of interest. The presence of phospholipids in biological fluids is one of the major causes of ion-suppression in LC-MS when using positive ion electrospray mode (+ESI). Removing phospholipids with HybridSPE®-Phospholipid is a rapid and reliable means to improve identification and quantification of compounds in biological matrices using LC-MS.

How Does HybridSPE®-Phospholipid Work?

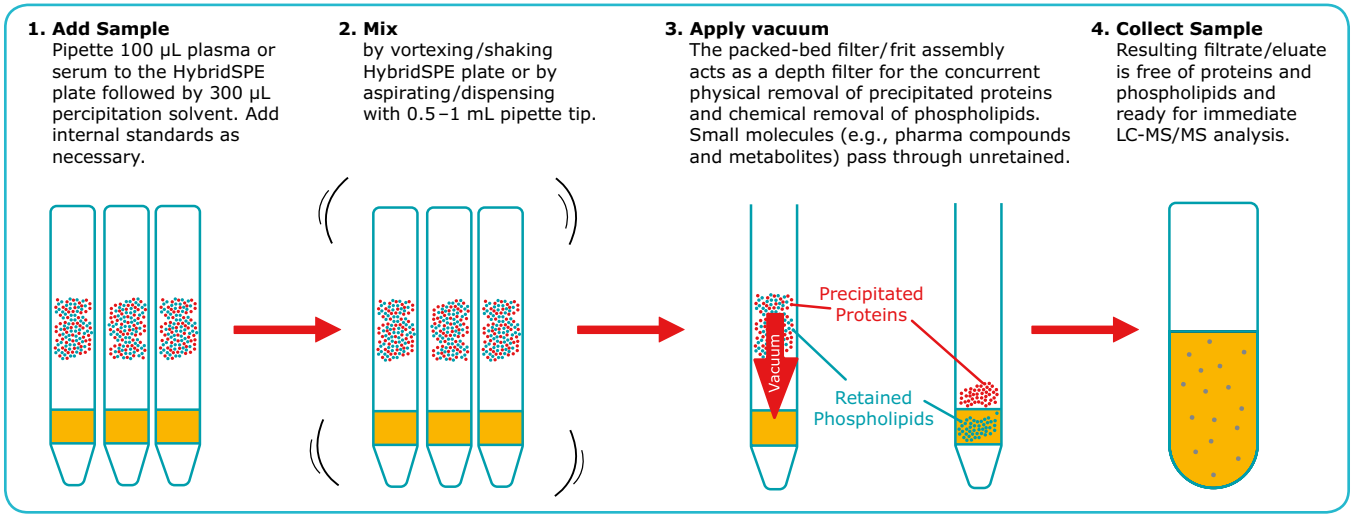
Sample preparation with HybridSPE®-Phospholipid is a very rapid and simple procedure. Proteins in the sample are precipitated by addition of acetonitrile containing 1 % formic acid. The sample is then added to the HybridSPE®-Phospholipid packed bed, either well plate or tube format. As shown in the accompanying figure, the bed consists of proprietary zirconia-coated silica particles. The zirconia sites exhibit Lewis acid (electron acceptor) properties that will interact strongly with Lewis bases (electron donors).

Phospholipids structurally consist of a polar head group (zwitterionic phosphonate moiety) and a large hydrophobic tail (two hydrophobic fatty acyl groups). The phosphonate group acts as a very strong Lewis base that interacts strongly with zirconia. Formic acid in the precipitation solvent is a critical modifier used to improve the recovery of many analytes of interest (particularly acidic compounds) by preventing analyte retention, while not affecting phospholipid removal.

The HybridSPE®-Phospholipid sample preparation products are available in several configurations.

- Two 96-well plate formats for sample volumes of ~100 µL and 20 – 40 µL. Both formats allow for in-well precipitation.
- Three SPE tube formats; the ultra version allows for in-tube protein precipitation.

For more information and to view a video of HybridSPE®-Phospholipid in operation, visit **SigmaAldrich.com/hybridspe**

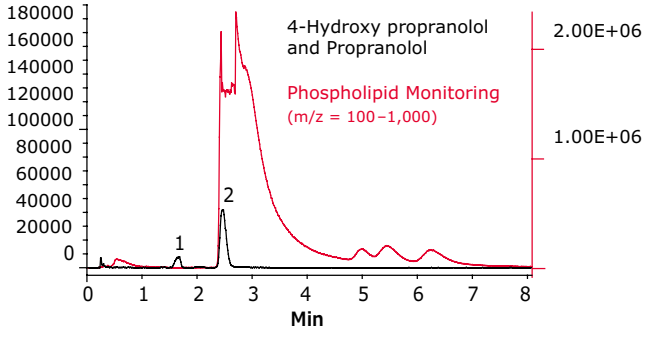


Ion-Suppression from Phospholipids: Standard Protein Precipitation vs. HybridSPE®-Phospholipid

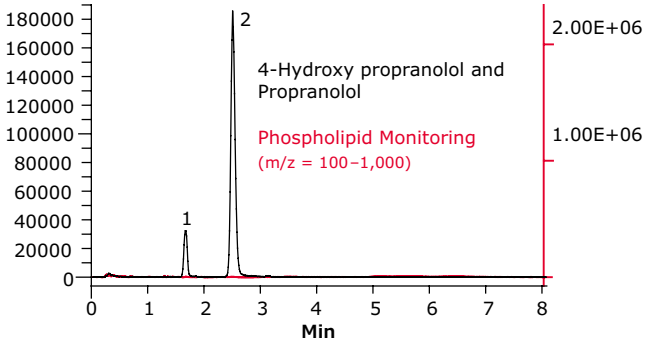
Samople prep	standard protein precipitation or HybridSPE®-Phospholipid (575656-U)
Column	Ascentis® Express F5, 5 cm × 2.1 mm I.D., 2.7 µm (53567-U)
Mobile phase	(A) 2 mM ammonium formate in acetonitrile; (B) 2 mM ammonium formate in water; (90:10, A:B)
Flow rate	0.4 mL/min
Pressure	1073 psi
Column temp	35 °C
Detector	MS, ESI(+) TOF, m/z = 100 – 1,000
Injection	2 µL
Sample	Agilent® 1200SL Rapid Resolution; 6210 Time of Flight (TOF) MS
System	Agilent® 1200SL Rapid Resolution; 6210 Time of Flight (TOF) MS

Standard Protein Precipitation Technique

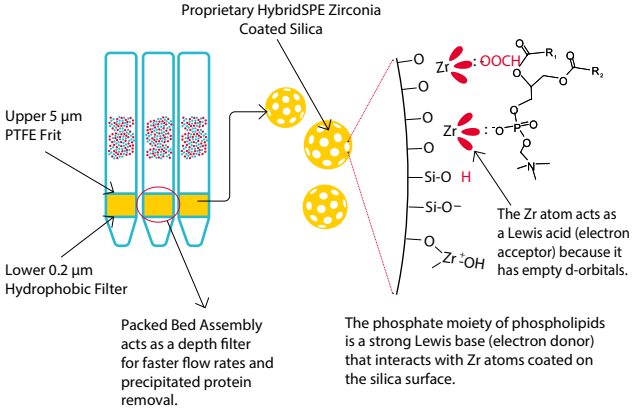
(Note suppression of propranolol signal)



HybridSPE®-Phospholipid Technique



Interaction of Phospholipids with HybridSPE®-Phospholipid



Featured Products

Name	Qty.	Cat. No.
HybridSPE®-PLus Plate Essentials Kit		
Includes HybridSPE®-PLus 96-well plate (575659-U), plate cap mat (as in 575680-U), sealing film (as in Z721581) and collection plate (as in Z717266)	1	**52818-U**
HybridSPE®-PLus 96-Well Plates		
50 mg/well	1	**575659-U**
	20	**575673-U**
HybridSPE®-Phospholipid Small Volume 96-Well Plates		
5 mg/well	1	**52794-U**
	20	**52798-U**
HybridSPE®-Phospholipid Cartridges		
HybridSPE®-Phospholipid Ultra Cartridge, 30 mg/1 mL	100	**55269-U**
HybridSPE®-Phospholipid Cartridge, 500 mg/6 mL	30	**55267-U**
HybridSPE®-Phospholipid Cartridge, 30 mg/1 mL	100	**55261-U**
	200	**55276-U**

Protein Precipitation

96-Well Protein Precipitation Filter Plate The 96-well protein precipitation filter plate is ideal for removing precipitated proteins from biological plasma/serum. The plate consists of a 0.2 µm hydrophobic graded filter/frit. Biological plasma is first added to the 96-well plate followed by a protein precipitating agent (e.g., acetonitrile). After a brief mixing step, vacuum is applied to the plate, and the filter/frit removes precipitated proteins from the sample. The resulting filtrate is ready for further processing and/or analysis.

Description	Qty.	Cat. No.
2 mL	1 ea.	**55263-U**

SupelMIP® Molecularly Imprinted Polymers

Key Features and Benefits

- Achieve lower detection limits through superior selectivity
- Reduce ion-suppression
- Save time and reduce cost via robust and rapid sample prep methodology
- Minimal to no method development required

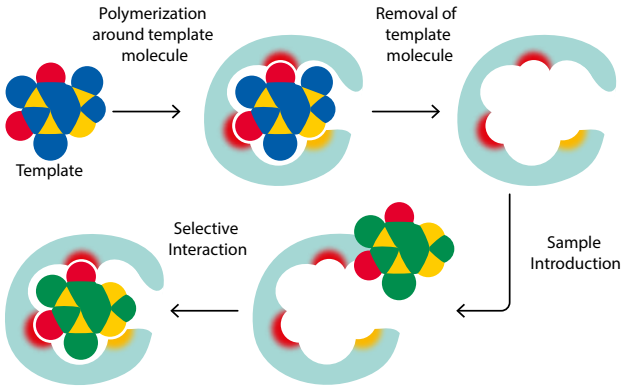
Highly Selective Extraction of Trace Analytes from Complex Matrices

Molecularly imprinted polymers (MIPs) are a class of highly crosslinked polymer-based molecular recognition elements engineered to bind one target compound or a class of structurally related target compounds with high selectivity. Selectivity is introduced during MIP synthesis in which a template molecule, designed to mimic the analyte, guides the formation of specific cavities or imprints that are sterically and chemically complementary to the target analyte.

SupelMIPs® are available for these analyte and matrix combinations

Analytes	Matrix
Chloramphenicol	Milk, plasma, honey, urine, and shrimp/prawns
Clenbuterol	Urine
Fluoroquinolones	Bovine kidney, honey, and milk
PAHs	Edible oils
Riboflavin (Vitamin B2)	Milk
β-Agonists and/or β-Blockers	Tissue, urine and wastewater
TSNAs (4 Different Tobacco-Specific Nitrosamines: NNK, NNN, NAB, NAT)	Urine and tobacco
NNAL (4-(Methylnitrosamino)-1-(3-pyridyl)-1-butanol)	Urine

Formation of MIPs



SupelMIP® Molecularly Imprinted Polymer SPE Tubes

Description	Pack Sizes	Cat. No.
SupelMIP® SPE – β-agonists, bed wt. 25 mg, volume 3 mL	50	**53225-U**
SupelMIP® SPE – β-agonists, bed wt. 25 mg, volume 10 mL	50	**53202-U**
SupelMIP® SPE – Chloramphenicol, bed wt. 25 mg, volume 3 mL	50	**53209-U**
SupelMIP® SPE – Chloramphenicol, bed wt. 25 mg, volume 10 mL	50	**53210-U**
SupelMIP® SPE – Clenbuterol, bed wt. 25 mg, volume 10 mL	50	**53201-U**
SupelMIP® SPE – Fluoroquinolones, bed wt. 25 mg, volume 3 mL	50	**53269-U**
SupelMIP® SPE – Full β-receptor (β-blockers and β-agonists), bed wt. 25 mg, volume 3 mL	50	**53224-U**
SupelMIP® SPE – Full β-receptor (β-blockers and β-agonists), bed wt. 25 mg, volume 10 mL	50	**53223-U**
SupelMIP® SPE – Riboflavin (vitamin B_2), bed wt. 25 mg, volume 10 mL	50	**53207-U**
SupelMIP® SPE – TSNAs, bed wt. 50 mg, volume 3 mL	50	**53222-U**
SupelMIP® SPE – TSNAs, bed wt. 50 mg, volume 10 mL	50	**53221-U**
SupelMIP® SPE – NNAL, bed wt. 25 mg, volume 3 mL	50	**53203-U**

ZipTip® Pipette Tips: Proteomics Sample Prep in Seconds

A staple of every mass spectrometry lab, ZipTip® is a 10 µL pipette tip with a 0.6 or 0.2 µL bed of chromatography media fixed at its end with no dead volume. It is ideal for concentrating and purifying peptides or proteins in seconds prior to mass spectrometry, HPLC, and capillary electrophoresis. The ZipTip® pipette tip provides a reproducible, high recovery method for concentrating, purifying or even fractionating femtomoles to picomoles of peptides, proteins and oligonucleotides for improved data quality.

ZipTip® Advantages:

- Single-step desalting, concentration, and purification
- Fractionate complex samples for more meaningful data
- Ideal for peptides, proteins, nucleic acids, and more
- No dead volume for maximum recovery
- Eliminates time-consuming chromatography

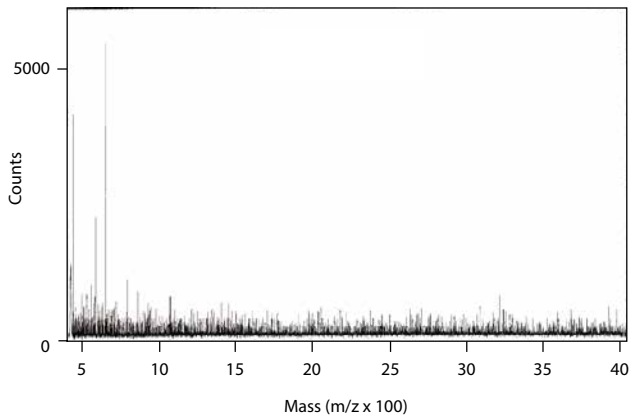
The ZipTip® pipette tip is simple and easy to use

- Place the tip on a single- or multi-channel pipettor, standard 22-gauge blunt-end HPLC needle, or compatible automated liquid handling/sample preparation station
- For sample binding, aspirate and dispense through the media several times
- Similarly, aspirate and dispense appropriate wash solvent to remove contaminants
- The concentrated, purified sample is eluted in 1–4 µL of compatible solvent with direct transfer to a mass spectrometer target, vial, or other analysis step

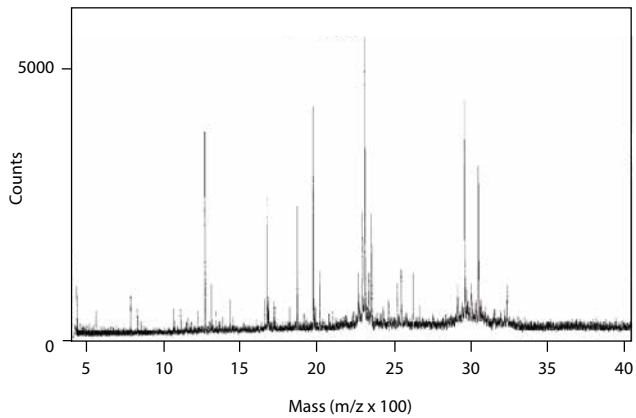
For applications requiring smaller elution volumes (e.g., < 1 µL), a micro-bed format containing 0.2 µL of media is available

Description	Qty / Pkg	Cat. No.
ZipTip® Pipette Tips		
ZipTip® with 0.6 mL strong cation resin	8	**ZTSCXS008**
ZipTip® with 0.6 mL strong cation resin	96	**ZTSCXS096**
ZipTip® with 0.6 mL C4 resin	8	**ZTC04S008**
ZipTip® with 0.6 mL C4 resin	96	**ZTC04S096**
ZipTip® with 0.6 mL C4 resin	960	**ZTC04S960**
ZipTip® with 0.6 mL C18 resin	8	**ZTC18S008**
ZipTip® with 0.6 mL C18 resin	96	**ZTC18S096**
ZipTip® with 0.6 mL C18 resin	960	**ZTC18S960**
ZipTip® with 0.2 mL C18 resin	8	**ZTC18M008**
ZipTip® with 0.2 mL C18 resin	96	**ZTC18M096**
ZipTip® with 0.2 mL C18 resin	960	**ZTC18M960**

A. Direct Spotting



B. After ZipTip®µ-C18



ZipTips® increase sensitivity of mass spectrometric analysis. MALDI MS spectra of a tryptic peptide digest from an in-gel 2D digest. The top spectrum represents a contaminated sample prior to sample clean-up. The lower spectrum represents the sample after treatment with a ZipTip®C18 prior to MALDI-ToF MS analysis.

MS-Compatible Millex® LCR Syringe Filters

Obtain immaculate, particle-free samples for LCMS with the peace of mind that you will have minimum interference from impurities introduced from your sample preparation device. Our MS-compatible Hydrophilic polytetrafluoroethylene (PTFE) Millex® LCR Filters have been shown to minimize extractable impurities in mass spectrometry, as shown in Table 1.

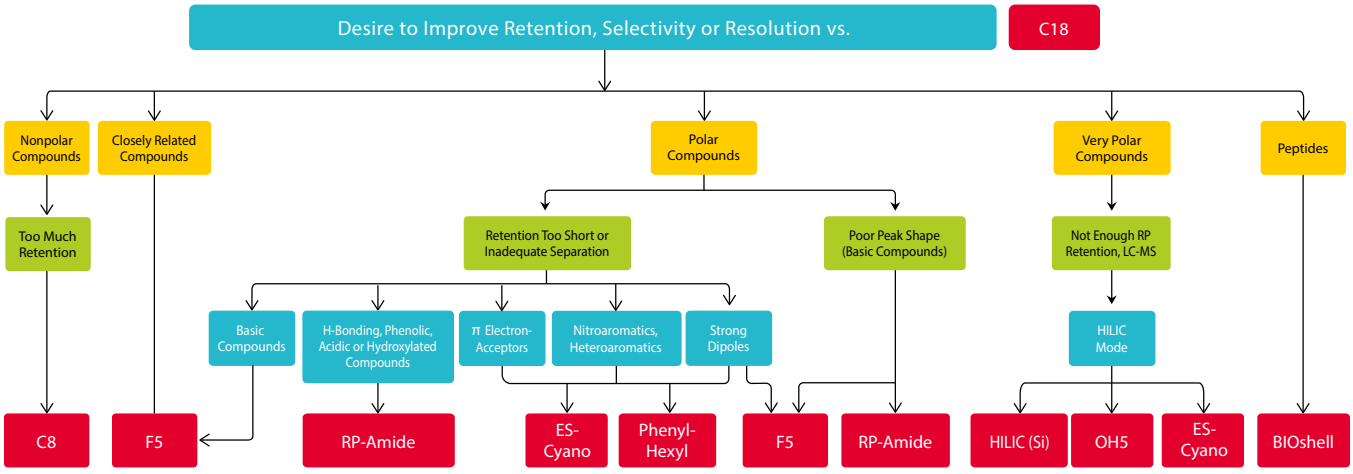
Description	Cat. No.
Millex®-LCR Filter, 13 mm, Hydrophilic PTFE, 0.45 µm, 100/pk	**SLCR013NL**
Millex®-LCR Filter, 13 mm, Hydrophilic PTFE, 0.45 µm, 1,000/pk	**SLCR013NK**
Millex®-LCR Filter, 25 mm, Hydrophilic PTFE, 0.45 µm, 250/pk	**SLCR025NB**
Millex®-LCR Filter, 25 mm, Hydrophilic PTFE, 0.45 µm, 1,000/pk	**SLCR025NK**

	Millex® Hydrophilic PTFE	Polypropylene (Vendor A)	Polypropylene (Vendor B)	Nylon (Vendor A)	Nylon (Vendor B)
Reproducibility	Good	Medium	Good	Poor	Poor
Extractable Level	Low	High	Medium	High	High
Nature of Extractables	100–400	Polymeric	Variable	Polymeric – Variable	Polymeric – Variable

Table 1. Across all solvents tested, Millex® Hydrophilic PTFE Filters outperformed syringe filters from other suppliers. We tested our filters with eight commonly used mobile phase solvents, such as water, methanol, acetonitrile, tetrahydrofuran in water, and isopropanol in water. After collecting 1st and 2nd mL filtrates, we analyzed them using infusion mass spectrometry (electrospray positive ion mode, 15-minute runs on average).

Selecting The Right HPLC Phase Chemistry for Your Application

C18 column is the standard first choice when starting a new LC-MS method. You can consider selecting another stationary phase when C18 doesn't give the desired separation, or the sample contains compounds difficult to retain or resolve on C18. The Ascentis® Express and BIOshell™ product lines offer a wide range of selectivities for making an effective choice. This decision tree will help you to select an alternative phase based on the particular compound type or separation challenge. All options displayed are relative to the C18 column that started your separation journey.



Key product features for LC-MS and (U)HPLC applictions

Primary Application	Product Line	Particle Size (µm)	Pore Size (A)	Surface Area (m^2/g)	Max Temperature	Pressure (bar)
Small molecules, metabolites and low molecular weight peptides	Titan	1.9	80	410	60	1,000
	Ascentis® Express	2.0	90	120	60	1,000
		2.7	90	150	60	600
		5.0	90	100	60	600
Proteins, Peptides and large Biomolecules	BIOshell™	2.7	160	90	90	600
		3.4	400	15	90	600
		5.0	160	60	60	600

For a complete listing of LC-MS columns, visit **SigmaAldrich.com/hplc**

Available in a variety of analytical and capillary column dimensions

	Column Length (cm)						
Column I.D	**2**	**3**	**5**	**7.5**	**10**	**15**	**25**
75 µm			•			•	
100 µm			•			•	
200 µm			•			•	
2.1 mm	•	•	•	•	•	•	•
3 mm	•	•	•	•	•	•	•
4.6 mm	•	•	•	•	•	•	•

For Part Numbers, visit **SigmaAldrich.com/hplc**

LC-MS & (U)HPLC Columns

Ascentis® Express & BIOshell™ Fused-Core® U/HPLC & LC-MS Columns

Key Features and Benefits

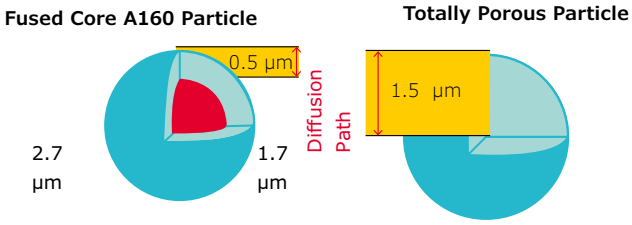
- Maximize speed with sharp peaks even at ultra-high flow rates
- Stable low-bleed for LC-MS and LC-UV
- Suitable for any HPLC, UHPLC, and LC-MS instruments
- Achieve UHPLC performance on a traditional HPLC system
- Available in both 2.0, 2.7 and 5 µm particles
- Wide variety of pore sizes, ranging from 90 – 1,000 Å, for small to large molecules

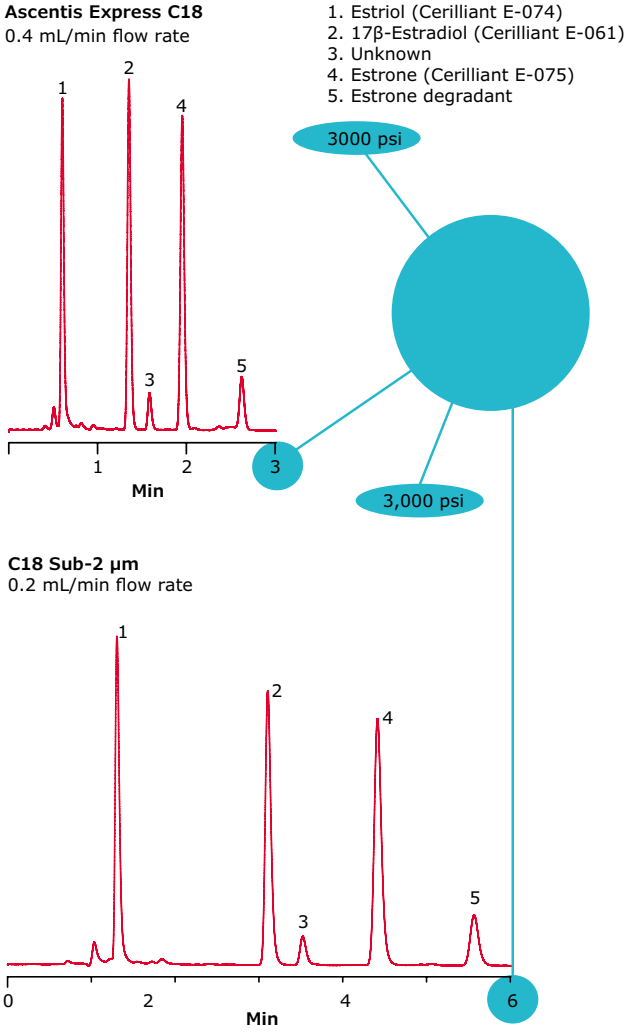
Ascentis® Express Fused-Core® Columns

Ascentis® Express columns provide a breakthrough in (U)HPLC and LC-MS column performance. Based on Fused-Core® particle technology, Ascentis® Express columns provide the benefits of high speed and high efficiency. The Fused-Core® particle consists of a solid core and a porous shell, allowing for a shorter diffusion path compared to conventional fully porous particles. Compared to totally porous particles typically used in HPLC, Ascentis® Express Fused-Core® particles generate approximately half the backpressure without loss of resolution. This permits for more resolving power, and faster flow rates, for higher throughput. Ascentis® Express Fused Core Columns are now available in 2.0, 2.7 and 5 µm particle sizes with 8 different phase chemistries. Available in pore size of 90 Å, Ascentis® Express are ideal for LC-MS and (U)HPLC separations of small molecules, metabolites and low molecular weight peptides.

For more information, visit
SigmaAldrich.com/express

Comparison of Fused-Core® and Standard HPLC Particle





Particle Size	I.D.	Length	C18	C8	OH5
Capillary Dimensions Columns					
2.7 µm	75 µm	5 cm	**53982-U**	**53983-U**	–
2.7 µm	75 µm	15 cm	**54219-U**	**54229-U**	–
2.7 µm	100 µm	5 cm	**53985-U**	**53987-U**	–
2.7 µm	100 µm	15 cm	**54256-U**	**54260-U**	–
2.7 µm	200 µm	5 cm	**53989-U**	**53991-U**	–
Ascentis® Express Columns					
2.0 µm	2.1 mm	2 cm	**50805-U**	**51652-U**	**50951-U**
2.0 µm	2.1 mm	3 cm	**50809-U**	**51654-U**	**50952-U**
2.0 µm	2.1 mm	5 cm	**50811-U**	**51656-U**	**50957-U**
2.0 µm	2.1 mm	7.5 cm	**50812-U**	**51657-U**	**50958-U**
2.0 µm	2.1 mm	10 cm	**50813-U**	**51658-U**	**50959-U**
2.0 µm	2.1 mm	15 cm	**50814-U**	**51661-U**	**50962-U**
2.0 µm	3.0 mm	3 cm	**50815-U**	**51663-U**	**50963-U**
2.0 µm	3.0 mm	5 cm	**50816-U**	**51664-U**	**50964-U**
2.0 µm	3.0mm	7.5 cm	**50817-U**	**51672-U**	**50965-U**
2.0 µm	3.0 mm	10 cm	**50819-U**	**51673-U**	**50967-U**
2.0 µm	3.0 mm	15 cm	**50821-U**	**51674-U**	**50968-U**
2.7 µm	2.1 mm	2 cm	**53799-U**	**53795-U**	**53779-U**
2.7 µm	2.1 mm	3 cm	**53802-U**	**53839-U**	**53748-U**
2.7 µm	2.1 mm	5 cm	**53822-U**	**53831-U**	**53749-U**
2.7 µm	2.1 mm	7.5 cm	**53804-U**	**53843-U**	**53755-U**
2.7 µm	2.1 mm	10 cm	**53823-U**	**53832-U**	**53757-U**
2.7 µm	2.1 mm	15 cm	**53825-U**	**53834-U**	**53764-U**
2.7 µm	3.0 mm	3 cm	**53805-U**	**53844-U**	**53766-U**
2.7 µm	3.0 mm	5 cm	**53811-U**	**53848-U**	**53767-U**
2.7 µm	3.0 mm	7.5 cm	**53812-U**	**53849-U**	**53768-U**
2.7 µm	3.0 mm	10 cm	**53814-U**	**53852-U**	**53769-U**
2.7 µm	3.0 mm	15 cm	**53816-U**	**53853-U**	**53771-U**
2.7 µm	4.6 mm	3 cm	**53818-U**	**53857-U**	**53772-U**
2.7 µm	4.6 mm	5 cm	**53826-U**	**53836-U**	**53774-U**
2.7 µm	4.6 mm	7.5 cm	**53819-U**	**53858-U**	**53775-U**
2.7 µm	4.6 mm	10 cm	**53827-U**	**53837-U**	**53776-U**
2.7 µm	4.6 mm	15 cm	**53829-U**	**53838-U**	**53778-U**
5 µm	2.1 mm	10 cm	**50517-U**	**50368-U**	**50322-U**
5 µm	2.1 mm	15 cm	**50518-U**	**50372-U**	**50327-U**
5 µm	2.1 mm	2 cm	**50507-U**	**50362-U**	**50313-U**
5 µm	2.1 mm	25 cm	**50521-U**	**50373-U**	**50328-U**
5 µm	2.1 mm	3 cm	**50508-U**	**50363-U**	**50314-U**
5 µm	2.1 mm	5 cm	**50509-U**	**50364-Y\U**	**50317-U**
5 µm	2.1 mm	7.5 cm	**50511-U**	**50367-U**	**50321-U**
5 µm	3.0 mm	10 cm	**50526-U**	**50381-U**	**50338-U**
5 µm	3.0 mm	15 cm	**50527-U**	**50382-U**	**50339-U**
5 µm	3.0 mm	25 cm	**50528-U**	**50385-U**	**50341-U**
5 µm	3.0 mm	3 cm	**50522-U**	**50376-U**	**50329-U**

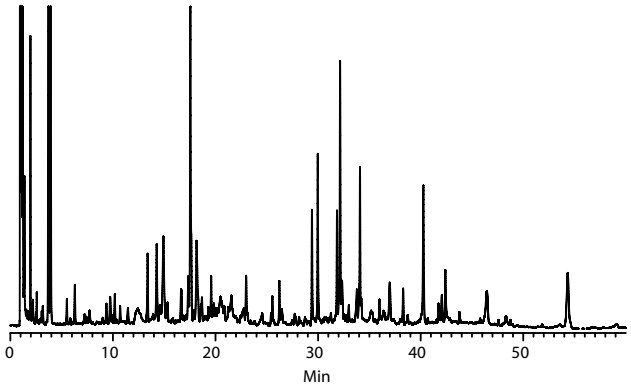
Particle Size	I.D.	Length	C18	C8	OH5
5 µm	3.0 mm	5 cm	**50523-U**	**50377-U**	**50335-U**
5 µm	3.0 mm	7.5 cm	**50525-U**	**50378-U**	**50336-U**
5 µm	4.6 mm	10 cm	**50536-U**	**50391-U**	**50346-U**
5 µm	4.6 mm	15 cm	**50537-U**	**50392-U**	**50347-U**
5 µm	4.6 mm	25 cm	**50538-U**	**50394-U**	**50348-U**
5 µm	4.6 mm	3 cm	**50529-U**	**50386-U**	**50343-U**
5 µm	4.6 mm	5 cm	**50530-U**	**50389-U**	**50344-U**
5 µm	4.6 mm	7.5 cm	**50533-U**	**50390-U**	**50345-U**
Ascentis® Express Guard Cartridges, Package of 3					
2.0 µm	2.1 mm	0.5 cm	**50822-U**	**51676-U**	–
2.0 µm	3.0 mm	0.5 cm	**50823-U**	**51679-U**	–
2.7 µm	2.1 mm	–	**53501-U**	**53509-U**	**53780-U**
2.7 µm	3.0 mm	–	**53504-U**	**53511-U**	**53781-U**
2.7 µm	4.6 mm	–	**53508-U**	**53512-U**	**53782-U**
5 µm	2.1 mm	–	**50539-U**	–	–
5 µm	3.0 mm	–	**50541-U**	–	–
5 µm	4.6 mm	–	**50542-U**	–	–
Titan U/HPLC columns					
1.9 µm	2.1 mm	2 cm	**577120-U**	–	–
1.9 µm	2.1 mm	3 cm	**577121-U**	–	–
1.9 µm	2.1 mm	5 cm	**577122-U**	–	–
1.9 µm	2.1 mm	7.5 cm	**577123-U**	–	–
1.9 µm	2.1 mm	10 cm	**577124-U**	–	–
1.9 µm	3.0 mm	3 cm	**577125-U**	–	–
1.9 µm	3.0 mm	5 cm	**577126-U**	–	–
Titan U/HPLC columns					
1.9 µm	2.1 mm	–	**577127-U**	–	–
1.9 µm	3.0 mm	–	**577128-U**	–	–

Guard Cartridge Holder

Description	Pack Sizes	Cat. No.
Universal Guard Holder		
Holder w/EXP Titanium Hybrid Ferrule (cartridge not included)	1	**53500-U**

Analysis of Tryptic Digests on BIOshell™ A160 Peptide ES-C18

Column	BIOshell™ A160 Peptide C18, 10 cm × 4.6 mm I.D.
(66915-U)	
Mobile phase	A 0.1% (w/v) TFA in water
Mobile phase	B 0.1% TFA (w/v) in 40:60
Water	acetonitrile
Gradient	initial = 3% B to 100% B in 53 min.
Flow	rate 1.0 mL/min
Temp.	30 °C
Det.	UV at 215 nm
Injection	20 µL



Titan UHPLC Columns

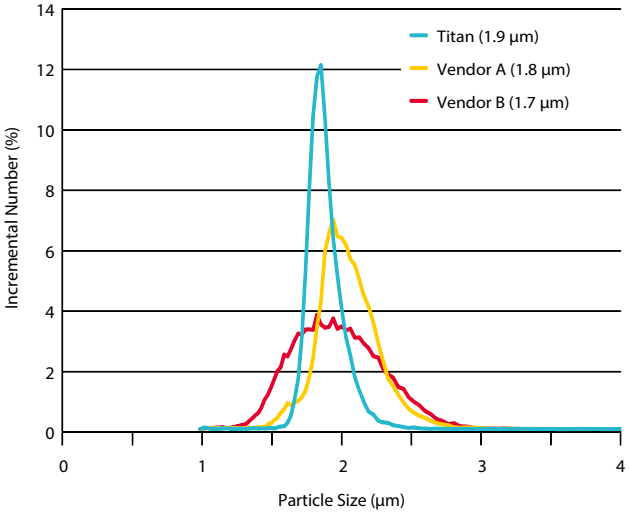
Titan C18 is based on a silica particle platform that has the narrowest particle size distribution available of any totally porous particles. This provides performance advantages in the A-term of the van Deemter equation and in the elimination of fines associated with broader particle size distributions. Monodisperse particles, owing to their narrow particle size distributions, are one of the key reasons that core-type particles achieve higher efficiencies than comparative porous particles.

Key Features

These monodisperse particles offer:

- Minimized voiding and channeling in silica bed compared to higher PSD particles
- A positive influence on column permeability, as evident from a Titan UHPLC column's low pressure drop compared to other traditional porous particle columns
- A profound affect on separation impedance or kinetic performance, resulting in more robust and rugged LC-MS columns

Particle Size Distribution (PSD) Comparison for Different Silica



Poor Retention of Polar Compounds?

SeQuant® ZIC®-HILIC Columns solve your problem

From small peptides to ions, complex carbohydrates and metabolites — all types of hydrophilic compounds can be separated with ZIC®-HILIC Columns.

What is HILIC?

HILIC or Hydrophilic Interaction Liquid Chromatography is a straight-forward chromatographic technique for separation of many types of polar and hydrophilic compounds. To put it simply, one can say that HILIC is a normal-phase (NPLC) type of separation but uses reversed-phase (RPLC) type eluents.

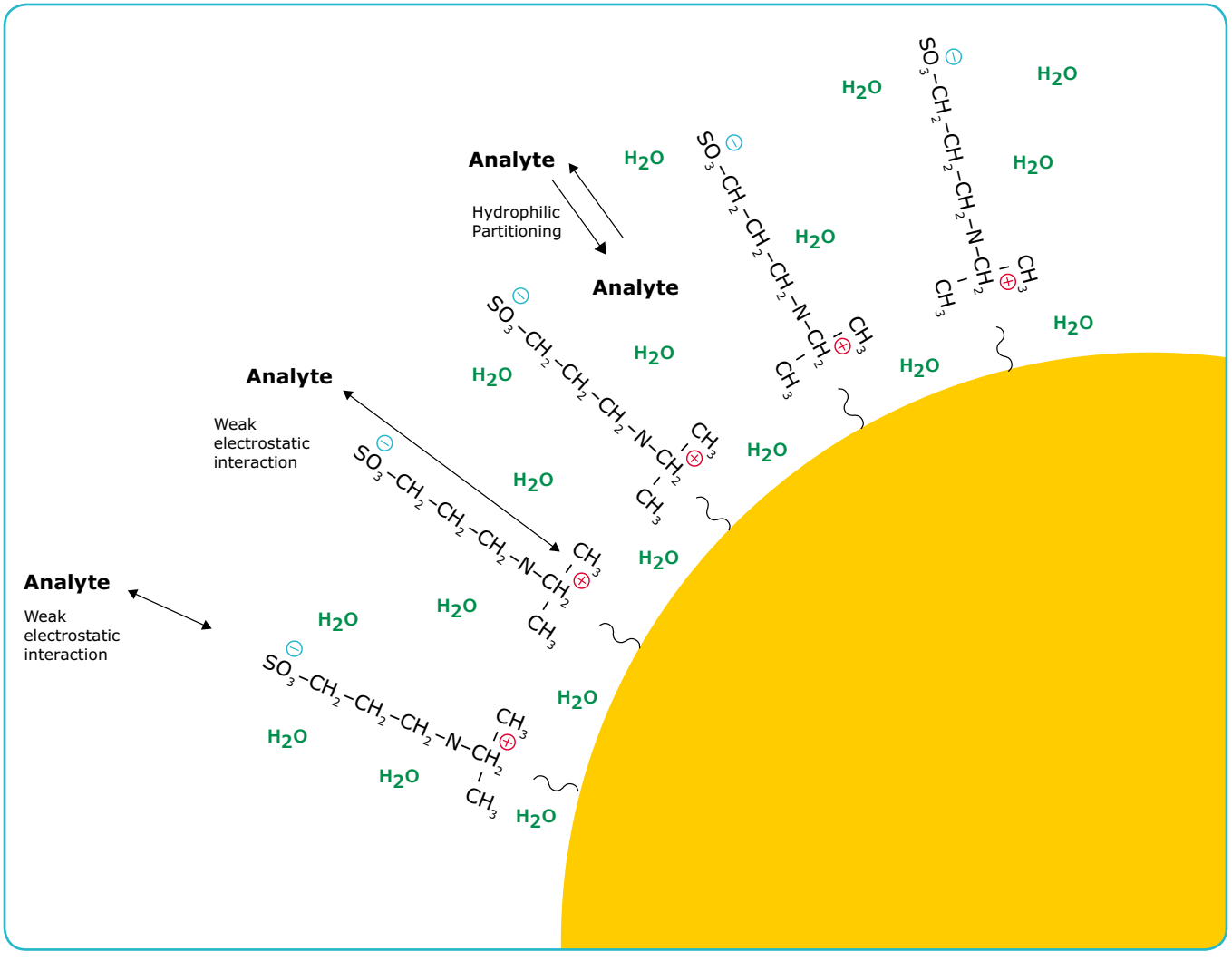
HILIC provides:

- A column with a hydrophilic stationary phase
- An eluent with water, buffer and a high concentration of water-miscible organic solvent

A typical HILIC application uses an eluent with 50-85% organic solvent in an aqueous buffer that has a high solubility in the solvent, for example acetonitrile in ammonium acetate.

The elution order in HILIC is roughly the opposite of that in RPLC and retention increases with hydrophilicity and charge of the analyte. This enables straightforward separation of compounds that would otherwise elute in the void volume on RPLC columns.

Retention of the ZIC®-HILIC Column increases with hydrophilicity and charge of the analyte.



Chiral LC-MS Columns

Astec® CHIROBIOTIC® CSPs

Key Features and Benefits

- Versatile, robust chiral HPLC and LC-MS separations
- Amenable to aqueous samples and mobile phases
- Wide applicability, especially suited to polar and ionizable compounds
- Covalently bonded chiral selector for rugged operation

Ideally Suited for LC-MS of Polar, Ionizable and Neutral Drugs and Biomolecules

Highly enantioselective Astec® CHIROBIOTIC® CSPs (chiral stationary phases) are based on macrocyclic glycopeptides that have been bonded through multiple covalent linkages to high-purity silica particles. CHIROBIOTIC® columns separate the enantiomers of many drugs and biochemical compounds, like amino acids, that cannot be separated by other CSPs. Their most relevant attribute to bioanalysis is the presence of ionic interactions. This allows CHIROBIOTIC® columns to be used with polar ionic (polar organic solvents containing salts) and reversed-phase mobile phases for sensitive LC-MS operation, where analyte ionization and detection sensitivity are of critical concern. Due to the fact that the stationary phase is covalently bonded to the silica surface means CHIROBIOTIC® columns have exceptional stability and long column life, even with repeated injections of biological samples.

Astec® CHIROBIOTIC® Application Areas

- **Drug Discovery** – High enantioselectivity, fast screening protocols, scalability to prep, reproducibility for reliable methods, effective for both polar and nonpolar analytes
- **Clinical, Bioanalytical, Drug Metabolism** – High throughput, MS-compatibility, aqueous samples, short run times, rugged columns
- **Amino Acid and Peptide Analysis** – Resolves underivatized natural and synthetic chiral amino acids and peptides

Chiral Column Selection

Astec® CHIROBIOTIC® CSPs are based on 5, 10 or 16 µm, high purity, porous silica gel. They differ in the nature of the bonded macrocyclic glycopeptide and resulting enantioselectivity.

- Astec® CHIROBIOTIC® V and V2 – Vancomycin
- Astec® CHIROBIOTIC® T and T2 – Teicoplanin
- Astec® CHIROBIOTIC® R – Ristocetin
- Astec® CHIROBIOTIC® TAG – Teicoplanin Aglycone

For additional information, request our "Chiral Method Development Wall Chart" at **SigmaAldrich.com/chiral**

Astec® CHIROBIOTIC® Columns

Many more dimensions are available. Please call or consult our website SigmaAldrich.com/chiral

Particle Size	I.D. (mm)	Length (cm)	V	V2	T	T2	TAG	R
5 µm	2.1	10	**11018AST**	**15018AST**	**12018AST**	**16018AST**	**14018AST**	**13018AST**
5 µm	2.1	15	**11019AST**	**15019AST**	**12019AST**	**16019AST**	**14019AST**	**13019AST**
5 µm	2.1	25	**11020AST**	**15020AST**	**12020AST**	**16020AST**	**14020AST**	**13020AST**
5 µm	4.6	10	**11022AST**	**15022AST**	**12022AST**	**16022AST**	**14022AST**	**13022AST**
5 µm	4.6	25	**11024AST**	**15024AST**	**12024AST**	**16024AST**	**14024AST**	**13024AST**

Method Development Kit

Contains one column each of Astec® CHIROBIOTIC® V2, T, TAG and R

Particle Size	I.D.	Length	Cat. No.
5 µm	4.6	10	**10300AST**
5 µm	4.6	25	**10305AST**

Chemical Derivatization Reagents for LC-MS

Modern mass spectrometry techniques such as APCI or ESI are highly successful in providing valuable structural information and allow the detection of very low analyte concentrations in various sample matrices. However, in today's advanced research and analytical areas, such as metabolomics, clinical and forensics analytics, such methods are sometimes insufficiently sensitive to deliver the solution to a particular analytical problem[1]. Therefore, derivatization is used in mass spectrometry to increase ionization efficiency, and thus enhance the sensitivity of the ionization used, to result in lower analyte detectability[2]. The derivatization reagents have functional groups with high proton (cation) affinity that stabilize positive charge. Of similar importance in derivatization is the improvement of qualitative analysis by modifying fragmentation behavior to form unique product ions, and shifting them to a specific, unique mass ("fingerprinting"), as well as precise quantitative analysis to profile comparatively small analyte molecules, particularly in metabolomics.

For more information, visit
SigmaAldrich.com/derivatization

References:

1. D. Weibel, Analytix 2014, 2, 6-7.
2. (a) A Handbook of Derivatives for Mass Spectrometry, V. Zaikin, J: Halket, IM Publications LLP, 2009, Chichester; (b) T. Santa, Drug Discov. Ther. 2013, 7, 9-17; (c) T. Santa, Biomed. Chromatogr. 2011, 25, 1-10; (d) T. Santa, et al., Drug Discov. Ther. 2007, 1, 108-118.
3. Y. Suzuki, et al., Anal. Sci. 2004, 20, 475-482.
4. K.A. Zemski Berry, et al., Anal. Chem. 2009, 81, 6633-6640.
5. F. Huo, et al., Talanta 2012, 99, 420-425.
6. T. Higashi, et al., Steroids 2007, 72, 865-874.
7. F. Sachet, et al., J. Chromatogr. A 1997, 764, 85-93.
8. (a) G. Li, et al., Food Chem. 2011, 125, 1365-1372; b) J. You, et al., Chromatographia 2004, 60, 527-535.
9. (a) O.Y. Al-Dirbashi, et al., J. Lipid Res. 2008, 49, 1855-1862; b) Y. Tsukamoto, et al., Biomed. Chromatogr. 2005, 19, 802-808.
10. E. Lattova, H. Perreault, Mass Spectrom. Rev. 2013, 32, 366-385.
11. X. Jiang, et al., J. Lipid Res. 2011, 52,1435-1445.
12. R. Rebane, et al., J. Chromatogr. B 2012, 904, 99-106.
13. J. Han, et al., Anal. Chem. 2013, 85, 5965-5973.
14. I. Athanasiadou, et al., Trends Anal. Chem. 2013, 42, 137-156.
15. Z. H. Huang, et al., Anal. Biochem. 1999, 268, 305-17.
16. J. Adamec, et al., J. Sep. Sci. 2011, 34, 11-20.
17. R. Schiewek, et al., Angew. Chem. Int. Ed. 2008, 47, 9989-9992.
18. H. Hong, Y. Wang, Anal. Chem. 2007, 79, 322-326.
19. C. O. Miles, et al., Environ. Sci. Technol. 2013, 47, 4080-4087.

Description	Analyte Functional Group	Typical Application	Reference	Cat. No.
4-(Dimethyl-d_6-amino)benzoyl chloride	Hydroxy	Deuterium mass shift	3	**00721**
Dansylhydrazine	Carbonyl	–	2c	**03334**
Dansyl chloride	Hydroxy	–	2c	**03641**
N,N-Dimethylglycine	Hydroxy	Cholesterol	11	**05022**
Diethyl ethoxymethylenemalonate	Amine	Amino acids	12	**05689**
3-Amino-9-ethylcarbazole	Hydroxy	Sugars	13	**06696**
4-(Diethylamino)benzhydrazide	Carbonyl	–	3	**06963**
2-Hydrazinopyridine	Carbonyl	Steroids	14	**08843**
(*N*-Succinimidyloxycarbonylmethyl) tris (2,4,6-trimethoxyphenyl) phosphonium bromide	Amine	Protein sequence analysis	15	**29208**
4-Phenyl-1,2,4-triazoline-3,5-dione	Diene	Vitamin D	16	**42579**
4-(Diethylaminomethyl) benzhydrazide	Carbonyl	–	3	**59799**
N-Succinimidyl 4-(dimethylamino) benzoate	Amine	Glycerophosphoethanol-amine lipids	4	**61224**
2-Picolylamine	Carbonyl	Steroids	14	**65562**
4-(Dimethylamino) benzoyl chloride	Hydroxy	17β-Estradiol	3	**67954**
6-Bromo-3-pyridinylboronic acid	1,2-Dihydroxy	Brassinosteroids	5	**69706**
3,5-Dinitrobenzoyl chloride	Hydroxy	Tetrahydrocorticosterones	6	**72702**
1-Fluoro-2,4-dinitrobenzene	Amine	Prim./sec. aliphatic amines	7	**73177**
9-Anthracenemethanol	Carboxylic acid, amine, alcohol	–	17	**74905**
1,2-Benzo-3,4-dihydrocarbazole-9-ethyl-ptoluenesulfonate	Carboxylic acid	Fatty-/bile acids	8	**75821**
4-[2-(N,N-Dimethylamino)ethylaminosulfonyl]-7-(2-aminoethylamino)-2,1,3-benzoxadiazole	Carboxylic acid	Fatty acids	9	**79291**
Girard's reagent T	Carbonyl	Nucleosides	18	**89397**
4-(Dimethylamino)benzohydrazide	Carbonyl	–	3	**92989**

Description	Analyte Functional Group	Typical Application	Reference	Cat. No.
Pentafluorophenylhydrazine	Carbonyl	Oligosaccharides	10	**93742**
{1-[2-(Diethylamino)ethoxy]-2-isothiocyanatoethyl} benzene	Amine	–	3	**94076**
2-Mercaptoethanol	Double bond	Microcystins	19	**97622**

N-Methyl-N-trimethylsilylfluoroacetamide (MSTFA) is also an important TMS reagent. It has similar reactivity as BSA and BSTFA. However, because the reaction byproducts are more volatile, MSTFA is particularly useful for GC analysis of early-eluting compounds that would otherwise be obscured in the chromatogram. Silylation is also valuable for MS applications where introducing the silyl group produces either more interesting diagnostic fragments or particular characteristic ions used for SIM (Selected Ion Monitoring). The product table below features selected silylation reagents for GC derivatization. To request the 100 page guide "Derivatization Reagents for Selective Response and Detection in Complex Matrices", you can search for T407138.

To learn more, visit **SigmaAldrich.com/derivatization**

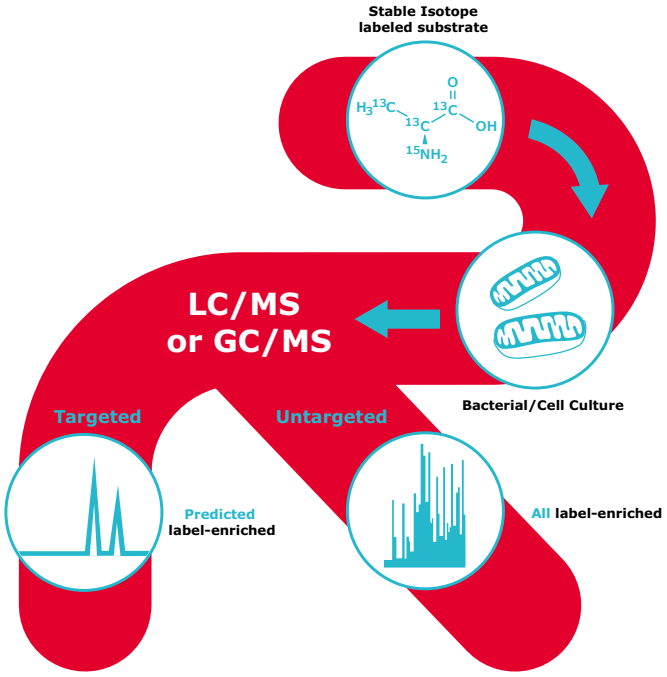
Description	Cat. No.
1,1,3,3-Tetramethyl-1,3-diphenyldisilazane	**43340**
4-(Trimethylsiloxy)-3-penten-2-one	**69649**
Bis(dimethylamino)dimethylsilane	**14755**
BSA + TMCS	**15256**
Chlorodimethyl(pentafluorophenyl)silane	**76750**
Chlorotriethylsilane	**90383**
Chlorotrimethylsilane	**89595**
Hexamethyldisilazane	**52619**
Hexamethyldisiloxane	**01565**
N-(Trimethylsilyl)acetamide	**91566**
N,N-Bis(trimethylsilyl)methylamine	**15235**
N,O-Bis(tert-butyldimethylsilyl)trifluoroacetamide	**89539**
N,O-Bis(trimethylsilyl)acetamide	**15269**
N,O-Bis(trimethylsilyl)trifluoroacetamide	**15222**
N,O-Bis(trimethylsilyl)trifluoroacetamide with trimethylchlorosilane	**15209, 15238**
N-Methyl-*N*-(trimethylsilyl)trifluoroacetamide	**69479**
N-Methyl-*N*-(trimethylsilyl)trifluoroacetamide with 1% trimethylchlorosilane	**69478**
N-*tert*-Butyldimethylsilyl-*N*-methyltrifluoroacetamide with 1% tert-Butyldimethylchlorosilane	**00942**
BSA Derivatization Grade	**33036, 33035-U, 33037-U**
BSA + TMCS + TMSI	**33030, 33151, 33031-U**
BSTFA + TMCS	**33149-U, 33154-U, 33155-U, 33148**
BSTFA, Derivatization Grade	**33024, 33027, 33084**
Chlorotrimethylsilane	**33014**
HMDS, Derivatization Grade	**33350-U**
HMDS + TMCS + Pyridine	**33038, 33039**
Silica Column Regeneration Solution	**33175**
Silylation Sampler Kit	**505846**
Sylon CT	**33065-U**
tert-Butyldimethylsilylimidazole solution	**33092-U**
TMSI, Derivatization Grade	**33068-U**
TMSI + Pyridine	**33156-U, 33159-U**

Metabolic Labeling with Stable Isotopes

Introducing heavy isotopologs into the metabolome enables detection of resulting metabolites by mass spectrometry. Growing cells or bacteria with labeled substrates allows for incorporation of heavy isotopes, such as deuterium, ^{13}C, and ^{15}N, into metabolites, assisting in the understanding of metabolic pathways and identification of metabolites of interest. Both steady-state and flux analysis benefit from the use of heavy isotope labeled compounds.

Specifically-labeled nutrients and metabolites allow for a detailed understanding of mechanistic features. Refer to **SigmaAldrich.com/isotec** for a complete list stable isotope labeled metabolic labeling compounds.

Amino Acids	Cat. No.
L-Alanine-2,3,3,3-d_4	**485845**
L-Alanine-2-^{13}C	**486779**
L-Alanine-1-^{13}C	**489867**
L-Alanine-$^{13}C_3$	**489875**
L-Alanine-3,3,3-d_3	**489921**
L-Alanine-3-^{13}C	**489948**
L-Alanine-2,3-$^{13}C_2$	**604682**
DL-Alanine-2,3,3,3-d_4	**488917**
L-Alanine-^{15}N	**332127**
L-Alanine-d_7	**774820**
L-Arginine-(*guanidineimino*-$^{15}N_2$) hydrochloride	**609080**
L-Arginine-$^{15}N_4$ hydrochloride	**600113**
L-Asparagine-$^{15}N_2$	**641960**
L-Asparagine-4-^{13}C monohydrate	**579866**
L-Asparagine-$^{15}N_2$ monohydrate	**485918**
L-Asparagine-1-^{13}C	**750824**
L-Aspartic acid-2,3,3-d_3	**489980**
L-Aspartic acid-1,2-$^{13}C_2$	**579793**
L-Aspartic-3,4-$^{13}C_2$ acid	**586161**
L-Aspartic-2-^{13}C acid	**604895**
L-Aspartic-3-^{13}C acid	**617539**
L-Aspartic acid-d_7	**673021**
L-Aspartic-^{15}N acid	**332135**
L-Cysteine-1-^{13}C	**676128**
L-Cystine-1,1'-$^{13}C_2$	**676136**
L-Glutamic-4-^{13}C acid	**587672**
D-Glutamic-5-^{13}C acid	**605255**
DL-Glutamic-2,3,3,4,4-d_5 acid	**631973**
L-Glutamic-2-^{13}C acid	**605123**
L-Glutamic-^{15}N acid	**332143**
L-Glutamine-2,3,3,4,4-d_5	**616303**
L-Glutamine-2-^{13}C	**605085**
L-Glutamine-4-^{13}C	**750506**
L-Glutamine-$^{15}N_2$	**490032**
Glycine-1-^{13}C	**279420**
Glycine-2-^{13}C	**279439**
Glycine-$^{13}C_2$	**283827**
Glycine-^{15}N, 98+ ATOM % ^{15}N	**299294**
Glycine-2,2-d_2	**336459**
L-Isoleucine-1-^{13}C	**604771**
L-Leucine-^{15}N	**340960**



Amino Acids	Cat. No.
L-Leucine-2-^{13}C	**486817**
L-Leucine-5,5,5-d_3	**486825**
L-Leucine-1-^{13}C	**490059**
L-Leucine-2,3,3,4,5,5,5,5',5',5'-d_{10}	**492949**
L-Leucine-3-^{13}C	**604828**
L-Leucine-4-d	**615978**
L-Leucine-(*isopropyl*-d_7)	**615986**
L-Leucine-2-d	**704504**
L-Lysine-2-^{15}N dihydrochloride	**592900**
L-Lysine-1-^{13}C hydrochloride	**604704**
L-Lysine-2-^{15}N hydrochloride	**608963**
L-Lysine-ε-^{15}N hydrochloride	**608971**
L-Lysine-$^{15}N_2$ hydrochloride	**609021**
L-Methionine-1-^{13}C	**490083**
L-Methionine-(*methyl*-^{13}C)	**299146**
L-Methionine-(*methyl*-d_3)	**300616**

Amino Acids	Cat. No.
D-Methionine-(*methyl*-^{13}C)	**589780**
L-Methionine-2-d	**589802**
L-Methionine-^{15}N	**609242**
L-Phenylalanine-1-^{13}C	**490091**
L-Phenylalanine-^{15}N	**490105**
L-Phenylalanine-2-^{13}C	**490113**
L-Phenylalanine-3-^{13}C	**490121**
L-Phenylalanine-2,3,3-d_3	**490148**
L-Phenyl-$^{13}C_6$-alanine	**604879**
L-Phenyl-1-^{13}C-alanine	**605042**
L-Phenyl-d_5-alanine	**615870**
L-Phenylalanine-3,3-d_2	**615889**
L-Phenylalanine-$^{13}C_9$	**795844**
L-Phenylalanine-2-d	**589438**
L-Proline-1-^{13}C	**589497**
L-Proline-2,5,5-d_3	**791261**
L-Proline-^{15}N	**608998**
L-Selenomethionine-(*methyl*-^{13}C)	**634093**
L-Serine-1-^{13}C, 99 ATOM % ^{13}C	**490156**
L-Serine-2-^{13}C	**604712**
L-Serine-3-^{13}C	**604720**
L-Serine-2,3-$^{13}C_2$	**605174**
L-Serine-^{15}N	**609005**
L-Threonine-1-^{13}C	**605034**
L-Threonine-$^{13}C_4$	**677604**
L-Threonine-1,2-$^{13}C_2$	**668060**
L-Tryptophan-1-^{13}C	**604836**
L-Tryptophan-(*indole ring*-2-^{13}C)	**604844**
L-Tryptophan-(*indole*-d_5)	**615862**
L-Tyrosine-2,6-d_2	**485829**
L-Tyrosine-(*phenyl*-$^{13}C_6$)	**489794**
L-Tyrosine-(*phenyl*-d_4)	**489808**
L-Tyrosine-(*phenyl*-3,5-d_2)	**489816**
L-Tyrosine-1-^{13}C	**489824**
L-Tyrosine-3-^{13}C	**489859**
L-Tyrosine-(*phenyl*-4-^{13}C)	**605093**
L-Tyrosine-2-^{13}C	**605107**
L-Tyrosine-(4-*hydroxy*-^{18}O)	**609919**
L-Tyrosine-^{15}N	**332151**
L-Tyrosine-3,3-d_2	**489840**
L-Valine-1-^{13}C, 99 ATOM % ^{13}C	**490164**
L-Valine-2-^{13}C	**604917**
L-Valine-^{15}N	**490172**

Carbohydrates	Cat. No.
D-Arabinose-1-^{13}C	**426415**
D-Arabinose-$^{13}C_5$	**763802**
Cellulose-^{13}C from maize	**696498**
D-Fructose-1,1,3,4,5,6,6-d_7	**729051**
D-Fructose-1-^{13}C	**415553**

Carbohydrates	Cat. No.
D-Fructose-2-^{13}C	**492140**
D-Fructose-1,6-$^{13}C_2$	**587613**
D-Fructose-$^{13}C_6$	**587621**
D-Fructose-6-^{13}C	**605395**
D-Fructose-6,6-d_2	**488720**
D-Fructose-d_{12}	**723908**
L-Fucose-1-^{13}C	**605425**
D-Galactose-1-^{13}C	**415545**
D-Galactose-2-^{13}C	**454621**
D-Galactose-$^{13}C_6$	**605379**
D-Galactose-1-d	**495077**
D-Glucose-1-^{13}C	**297046**
D-Glucose-4-^{13}C	**668648**
D-Glucose-1,6-$^{13}C_2$	**453196**
D-Glucose-2-^{13}C	**310794**
D-Glucose-1,2-$^{13}C_2$	**453188**
D-Glucose-3-^{13}C	**605409**
D-Glucose-1,2,3-$^{13}C_3$	**720127**
D-Glucose -4,5,6-$^{13}C_3$	**731501**
D-Glucose-4,5-$^{13}C_2$	**605468**
D-Glucose-5-^{13}C	**717355**
D-Glucose -5,6-$^{13}C_2$	**755893**
D-Glucose-$^{13}C_6$	**389374**
D-Glucose-6-^{13}C	**310808**
D-Glucose-1-d	**310816**
D-Glucose-2-d	**310824**
D-Glucose-3-d	**615498**
D-Glucose -6-^{13}C,6,6-d_2	**734403**
D-Glucose-6,6-d_2	**282650**
D-Glucose-d_{12}	**616338**
D-Glucose-1,2,3,4,5,6,6-d_7	**552003**
Inulin-^{13}C	**900388**
D-Mannose-1-^{13}C	**415537**
D-Mannose-2-^{13}C	**605344**
D-Mannose-3-^{13}C	**749419**
D-Mannose-4-^{13}C	**733733**
D-Mannose-5-^{13}C	**749400**
D-Mannose-6-^{13}C	**605387**
D-(+)-Mannose-$^{13}C_6$	**592994**
D-Ribose-1-^{13}C	**605352**
D-Ribose-2-^{13}C	**310840**
D-Ribose-1,2-$^{13}C_2$	**605476**
D-Ribose-2,3,4,5-$^{13}C_4$	**605484**
D-Ribose-$^{13}C_5$	**798258**
Starch-^{13}C from algae	**605336**
Sucrose-$^{13}C_{12}$	**605417**
Sucrose-^{13}C-(*glucose*-1-^{13}C)	**705136**
Sucrose-(*glucose*-$^{13}C_6$)	**738786**
D-Xylose-$^{13}C_5$	**666378**
D-Xylose-1-^{13}C	**331104**

Fatty Acids and Lipids	Cat. No.
Behenic-d_{43} acid	**586064**
Butyric acid-$^{13}C_4$	**723894**
Sodium butyrate-2-^{13}C	**485357**
Sodium butyrate-$^{13}C_4$	**488380**
Sodium butyrate-2,4-$^{13}C_2$	**492000**
Sodium butyrate-4-^{13}C	**492019**
Decanoic-d_{19} acid	**488666**
Decanoic acid-1-^{13}C	**488658**
Decanoic acid-1,2-$^{13}C_2$	**587818**
1,12-Dodecanedioic acid-$^{13}C_{12}$	**659525**
Glyceryl tri(oleate-1,2,3,7,8-$^{13}C_5$)	**772941**
Glyceryl-$^{13}C_3$ trioleate	**605638**
Glyceryl tri(palmitate-d_{31})	**616966**
Glyceryl tri(octanoate-d_{15})	**617121**
Glyceryl tri(palmitate-1,2,3,4-$^{13}C_4$)	**777862**
Glyceryl tri(octanoate-1,2,3,4-$^{13}C_4$)	**808563**
Glyceryl tri(oleate-2,3,7,8-$^{13}C_4$)	**722960**
Methyl heptadecanoate-d_{33}	**733148**
Heptadecanoic-d_{33} acid	**807907**
2-Ethylhexanoic-d_{15} acid	**710709**
Isovaleric-d_9 acid	**808997**
Lauric-d_{23} acid	**451401**
Lauric acid-12-^{13}C	**486639**
Linoleic acid-$^{13}C_{18}$	**605735**
Linoleic acid-d_{32}	**735124**
Potassium linoleate-$^{13}C_{18}$	**605816**
Linolenic acid-$^{13}C_{18}$	**605743**
Algal fatty acid mixture-^{13}C	**487937**
Myristic-d_{27} acid	**366889**
Myristic acid-$^{13}C_{14}$	**605689**
Sodium octanoate-2,4,6,8-$^{13}C_4$	**657204**
Octanoic-d_{15} acid	**448214**
Octanoic acid-1,2,3,4-$^{13}C_4$	**493163**
Octanoic acid-$^{13}C_8$	**605727**
Oleic acid-1,2,3,7,8-$^{13}C_5$	**749079**
Oleic acid-$^{13}C_{18}$	**490431**
Oleic acid-1,2,3,7,8,9,10-$^{13}C_7$	**646458**
Oleic acid-d_{34}	**683582**
Oleic acid-d	**900336**
Potassium oleate-$^{13}C_{18}$	**714313**
Sodium oleate-$^{13}C_{18}$	**798479**
Potassium oleate-d_{33}	**736155**
Potassium oleate-1,2,3,7,8-$^{13}C_5$	**739693**
Potassium oleate-15,15,16,16,17,17,18,18,18-d_9	**772399**

Fatty Acids and Lipids	Cat. No.
Palmitoleic acid-$^{13}C_{16}$	**724173**
Palmitic acid-d_{31}	**366897**
Palmitic acid-$^{13}C_{16}$	**605573**
Palmitic acid-1-^{13}C	**292125**
Palmitic acid-1,2-$^{13}C_2$	**485802**
Palmitic acid-1,2,3,4-$^{13}C_4$	**489611**
Potassium palmitate-$^{13}C_{16}$	**605751**
Potassium palmitate-d_{31}	**614378**
Potassium palmitate-1-^{13}C	**489646**
Sodium palmitate-$^{13}C_{16}$	**700258**
Sodium pyruvate-$^{18}O_3$	**700274**
Stearic-d_{35} acid	**448249**
Stearic acid-$^{13}C_{18}$	**605581**
Stearic acid-d	**900337**
Valeric acid-1-^{13}C	**596442**
Valeric acid-5-^{13}C	**605662**
4-Methylvaleric-d_{11} acid	**809004**

Isotopically-Labeled Water	Cat. No.
Deuterium oxide-^{18}O, 98 atom % D, 50 atom % ^{18}O	**608548**
Deuterium oxide-^{18}O, 5 atom % D, 5 atom % ^{18}O	**608556**
Deuterium oxide-^{18}O, 99 atom % D, 95 atom % ^{18}O	**608572**
Deuterium oxide-^{18}O 99 atom % D, 75 atom % ^{18}O	**609757**
Water-^{18}O, 99 atom % ^{18}O	**487090**
Water-^{18}O, 98 atom % ^{18}O	**603112**
Water-^{18}O, 97 atom % ^{18}O	**329878**
Water-^{18}O, 10 atom % ^{18}O	**332089**
Deuterium oxide, filtered, 99.9 atom % D	**756822**

Other Isotopically-Labeled Products for Metabolic Labeling	Cat. No.
Ammonium-^{15}N chloride	**299251**
Ammonium-^{15}N,d_4 chloride	**366501**
Ammonium-$^{15}N_2$ sulfate	**299286**
Ammonium-$^{15}N_2$,d_8 sulfate	**593990**
ISOGRO®-^{13}C powder growth medium	**606863**
ISOGRO®-^{13}C,^{15}N growth medium	**606839**
ISOGRO®-^{15}N growth medium	**606871**
ISOGRO®-^{13}C,^{15}N,D growth medium	**608297**
ISOGRO®-^{15}N,D growth medium	**608300**
ISOGRO®-D growth medium	**616729**

Solvents and Blends for LC-MS

LC-MS has become an important tool in today's analytical labs. In order to obtain accurate and reproducible results, high demands are made on the purity of chemicals. We offer high purity solvents specifically to meet the stringent requirements of LC-MS applications, ensuring high UV transmittance, baseline stability and lowest impurity levels. We have developed and introduced high purity solvents pre-blended with acetic acid (HA), formic acid (FA) or trifluoroacetic acid (TFA) to provide ready-to-use mobile phases for LC-MS. With this comprehensive portfolio, we set the standard for accurate, reproducible and high-resolution analytical separations.

Features:

- Ready-to-use
- LC-MS suitability
- Minimal metal adduct formation
- Minimal ionization suppression
- Batch to batch consistency
- Filtered through 0.2 µm

Benefits:

- Time- & cost-saving
- Reliable LC-MS application
- Less laborious mixing procedure
- Reduced contamination danger
- Safer – less exposure to hazardous chemicals
- No glassware cleaning
- Reduced solvent/acid excess
- Less storage room needed

Name	Description	Pack Sizes	Cat. No.
Acetonitrile + 0.1 % Acetic acid (v/v)	Hypergrade for LC-MS LiChrosolv®	2.5 L	**1.59004.2500**
Acetonitrile + 0.1 % Formic acid (v/v)	Hypergrade for LC-MS LiChrosolv®	2.5 L	**1.59002.2500**
Acetonitrile + 0.1 % Trifluoroacetic acid (v/v)	Hypergrade for LC-MS LiChrosolv®	2.5 L	**1.59014.2500**
		4 L	**1.59014.4000**
Water + 0.1 % Acetic acid (v/v)	Hypergrade for LC-MS LiChrosolv®	2.5 L	**1.59007.2500**
Water + 0.1 % Formic acid (v/v)	Hypergrade for LC-MS LiChrosolv®	2.5 L	**1.59013.2500**
Water + 0.1 % Trifluoroacetic acid (v/v)	Hypergrade for LC-MS LiChrosolv®	2.5 L	**4.80112.2500**
		4 L	**4.80112.4000**
Acetonitrile	Hypergrade for LC-MS LiChrosolv®	1 L GL*	**1.00029.1000**
		2.5 L GL*	**1.00029.2500**
		10 L ST	**1.00029.9010**
		30 L ST	**1.00029.9030**
Methanol	Hypergrade for LC-MS LiChrosolv®	1 L GL*	**1.06035.1000**
		2.5 L GL*	**1.06035.2500**
Water	Hypergrade for LC-MS LiChrosolv®	1 L GL*	**1.15333.1000**
		2.5 L GL*	**1.15333.2500**
		4 L GL*	**1.15333.4000**
		10 L ST	**1.15333.9010**
		30 L ST	**1.15333.9030**
Ethyl acetate	Hypergrade for LC-MS LiChrosolv®	1 L	**1.03649.1000**
		2.5 L	**1.03649.2500**
Hexane	Hypergrade for LC-MS LiChrosolv®	1 L	**1.03701.1000**
		2.5 L	**1.03701.2500**
Heptane	Hypergrade for LC-MS LiChrosolv®	1 L	**1.03654.1000**
		2.5 L	**1.03654.2500**
2-Propanol	Hypergrade for LC-MS LiChrosolv®	1 L	**1.02781.1000**
		2.5 L	**1.02781.2500**

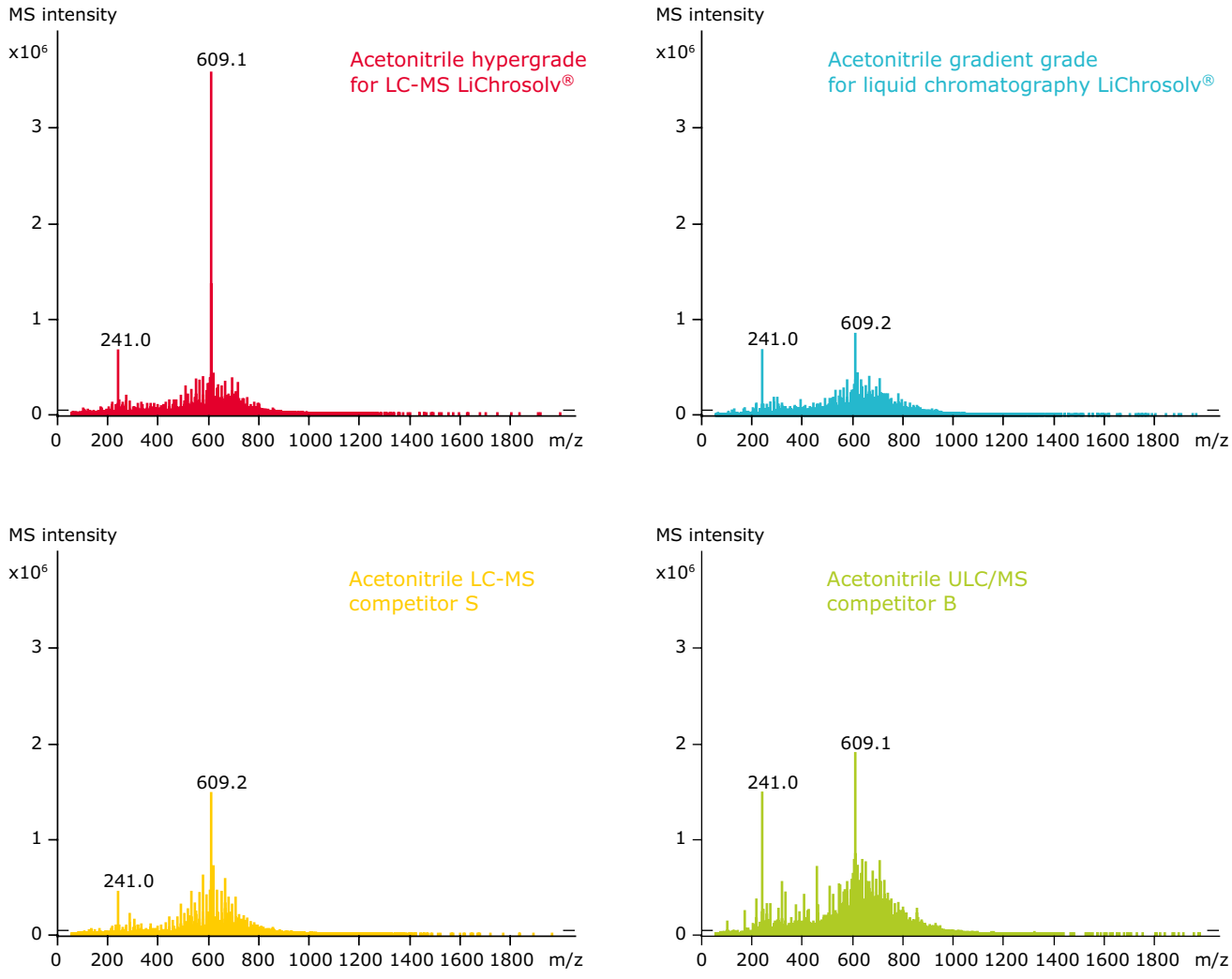
*special treated amber glass bottle

All solvents are filtered through 0.2 µm | GL = glass bottle | ST = stainless steel returnable barrel

MS conditions

System	Bruker Esquire 3,000+ ion trap MS
Detection	Pos. ESI-MS, m/z range 50 – 2,000
Flow rate	0.2 mL/min via syringe pump
Temperature	25 °C
Sample	Reserpine (m/z 609.1), internal standard (m/z 241.0)

The mass spectra of four different acetonitrile grades clearly show the variation in the intensity of the reserpine signal ([M+H]+ = 609) as well as the extent of the background signals. The differences in the intensity of the reserpine signal are caused by ion suppression. This effect occurs due to interfering trace contaminants that can be present in acetonitrile.



Mass spectra displaying the results of the reserpine test of different acetonitrile qualities from Merck and two alternative competitors.

LiChropur® LC-MS Reagents

It is common practice in LC-MS to add certain chemicals to the mobile phase or introduce them post-column prior to the interface to influence analyte ionization. Most often, an improvement in the analyte signal is the goal. However, some additives may be used to suppress unwanted signals or selectively enhance the signal of particular compounds in a mixture, for example glycosidic species in a mixture of peptides.

We offer a wide range of high purity mobile phase additives for LC-MS applications. Our offer includes the most commonly used acids, bases and volatile salts. All are of high purity and are rigorously tested for LC-MS application suitability, offering many advantages for both small and large molecule analysis.

Impurities, such as alkali ions, plasticizers and surfactants, found in lower-grade reagents are particularly problematic as they interfere strongly with LC-MS, resulting in higher background noise and formation of adducts. Only highly pure reagents allow high signal-to-noise ratios.

Features:

- LC-MS application tested for consistent quality
- Improves ionization and resolution
- Extremely low levels of inorganic and organic impurities
- Manufactured specifically for accurate and fast LC-MS
- Highest quality acids, bases & salts

For more information, visit
SigmaAldrich.com/lcms-reagents

Product Name	Description	Pack Sizes	Cat. No.
Acetic acid	100 % for LC-MS LiChropur®	50 mL	**5.33001.0050**
Formic acid	98 – 100 % for LC-MS LiChropur®	50 mL	**5.33002.0050**
Ammonia solution	25 % for LC-MS LiChropur®	50 mL	**5.33003.0050**
Ammonium acetate	for LC-MS LiChropur®	50 mL	**5.33004.0050**
Ammonium hydrogen carbonate	for LC-MS LiChropur®	50 mL	**5.33005.0050**

Tools for Metabolite Analysis by GC-MS

Strategies to analyze small biological compounds in a metabolome range from analyzing a particular class of metabolites (targeted analysis) to separating and detecting as many metabolites as possible of a particular developmental stage (metabolite profiling or metabonomics). When gas chromatography (GC) is used as the separation technique, the analyst benefits from the high resolving power of capillary GC, but the task is complex, as not all compounds are volatile and therefore need to be derivatized before analysis. This and other pages in this publication list selected product options for the analysis of volatile and semivolatile metabolites, including metabolite standards, derivatization reagents, solid-phase microextraction (SPME), and selected GC columns and accessories. For detailed information, references 1 and 2 look at the role of GC and MS in metabolite analysis, while references 3 and 4 discuss compound identification and sample throughput, respectively.

References

1. D. Wishart, Chapter 10, “Metabolomics in Humans and Other Mammals”, in Metabolome Analysis: An Introduction, SG Villas-Boas, J. Nielsen, J. Smedsgaard, M. Hansen, U. Roessner-Tunali, eds., John Wiley & Sons, 2007.
2. Villas-Bôas S.G., et al., Mass Spectrom Rev. 2005, 24 (5):613-46.
3. Applying In-Silico Retention Index and Mass Spectra Matching for Identification of Unknown Metabolites in Accurate Mass GC-TOF Mass Spectrometry, Kumari, S., et al., Anal. Chem. 2011, 83, 5895-5902.
4. Fast, High Peak Capacity Separations in Gas Chromatography–Timeof- Flight Mass Spectrometry, Wilson, R.B., et al., Anal. Chem. 2012, 84, 4167-4173.

SLB®-5ms
An MS-Grade Capillary GC Column for Metabolomics Research

The 5% phenyl equivalent phase provides a boiling point elution order with a slight increase in selectivity, especially for aromatic compounds. The low bleed characteristics, inertness, and durable nature make it the column of choice for the analysis of semivolatiles or, in general, any application that requires a low bleed non-polar column. Temp. Limits for ≤0.25 mm I.D. are -60 °C to 340 °C (isothermal) or 360 °C (programmed).

I.D. (mm)	df (µm)	Length (m)	Beta Value	Qty.	Cat. No.
0.10	0.10	10	250	1 ea.	**28465-U**
–	0.10	15	250	1 ea.	**28466-U**
0.18	0.18	20	250	1 ea.	**28564-U**
–	0.30	12	150	1 ea.	**28566-U**
–	0.30	30	150	1 ea.	**28575-U**
–	0.36	20	125	1 ea.	**28576-U**
0.20	0.20	30	250	1 ea.	**28513-U**
0.25	0.10	30	625	1 ea.	**28467-U**
–	0.25	15	250	1 ea.	**28469-U**
–	0.25	30	250	1 ea.	**28471-U**
–	0.25	60	250	1 ea.	**28472-U**
–	0.50	15	125	1 ea.	**28577-U**
–	0.50	30	125	1 ea.	**28473-U**
–	0.50	60	125	1 ea.	**28474-U**
–	1.00	30	63	1 ea.	**28476-U**

Extend the Lifetime of Your Capillary Column

A guard column/retention gap is a short (1 – 5 m) piece of uncoated deactivated fused silica tubing which is placed in-line between the GC injection port and the capillary column. A guard column/retention gap consists of two parts: a short length of fused silica tubing and a connector. Match the deactivation of the fused silica tubing with the polarity of the injection solvent. In most cases, it is also recommended to match the I.D. of the capillary column.

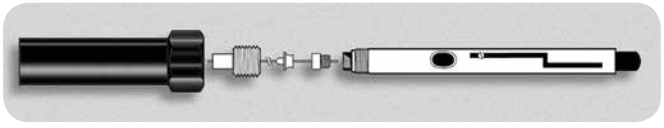
For more information about guard column selection, visit **SigmaAldrich.com/gc-guard**

SPME
A Unique Sample Preparation Technique

Solid Phase Microextraction is the sample preparation technique of choice for analyzing volatile and semi-volatile metabolites by GC-MS. SPME eliminates most drawbacks to extracting organics by more traditional methods. It requires no solvents or complicated apparatus, and can concentrate volatile and nonvolatile compounds, in both liquid and gaseous samples, for analysis by GC and GC-MS. SPME reduces sample preparation time by 70%, minimizes the use of solvents and their disposal, is cost-effective, can be used with any GC system, and can be automated. An SPME fiber assembly consists of a length of fused silica fiber coated with a polymer material, in some cases mixed with a solid adsorbent. The fiber is attached to a stainless steel plunger sheathed by a protective needle. Fiber holders are available for manual injection as well as for use with autosamplers. The holder protects the coated fiber, and controls exposure of the fiber during analyte adsorption and desorption. The holder is reusable indefinitely and accepts the replaceable fiber assembly. First time users must order both a holder and a fiber assembly. Fiber holders for use with an autosampler are also available.

Fiber Holder for Manual Sampling

An adjustable depth guide positions the fiber for sampling and for correct placement in the heated zone of the GC injection port. The fiber can be locked in the exposed position.



Description	Qty.	Cat. No.
SPME Fiber Holder, for use with manual sampling	1 ea.	**57330-U**

SPME Fiber Assemblies

SPME fiber assemblies can be reused for ≥100 analyses, depending on the application and the care they are given. For reuse, simply condition with heat before and after every analysis. Each assembly has a color-coded or notched hub indicating the type of coating on the fiber. Choose the appropriate assembly for the holder: manual or autosampler. The key to proper SPME performance is fiber selection.

For information on how to select a fiber, visit **SigmaAldrich.com/spme**

SPME Fiber Assortment Kit for Volatiles and Semivolatiles

Recommended starter kit for the extraction of volatile and semivolatile metabolites contains one fiber each of 85 µm polyacrylate coating, 100 µm polydimethylsiloxane coating, and 7 µm polydimethylsiloxane coating.

Description	Qty.	Cat. No.
Manual holder 24 ga	1 kit	**57306**
Autosampler 24 ga	1 kit	**57307**
Autosampler 23 ga	1 kit	**57285-U**

Achieve Sharper Peaks with SPME-GC Analyses Using Supelco® Inlet Liners

GC injection port liners are designed for optimal sample introduction for specific injection techniques. When using SPME, a 0.75 mm I.D. inlet liner increases linear velocity, compared to a conventional, larger volume 2 mm I.D. liner, and rapidly introduces analytes onto the column in a narrow band. To minimize sample loss or peak tailing, the inlet liner must be inert to minimize adsorption of active sample components. An inlet liner, in conjunction with efficient, solvent-free, SPME sample introduction, helps to achieve excellent chromatographic results. An inlet liner for several Agilent® GC systems is available.

For Agilent® (5890, 6890, and 7890)

Inlet Liner, Direct (SPME) Type, Straight Design (unpacked)

L × O.D. × I.D. _____ 785 mm × 65 mm × 0.75 mm

Qty.	Cat. No.
1 ea.	**2637501**

To select the appropriate inlet liner for your GC, visit **SigmaAldrich.com/inletliners**

GC Derivatization Reagents

A large number of reagents are used to prepare derivatives for gas chromatography. Derivatives are used for the following reasons:

- To improve resolution and reduce tailing of polar compounds (-OH, -COOH, =NH, -NH2, -SH, and other functional groups)
- To analyze relatively nonvolatile compounds
- To improve analytical efficiency and increase detectability
- To improve stability of compounds

The following table lists the silylation reagents most commonly used together with acylation and alkylations.

Description	Cat. No.
1,1,3,3-Tetramethyl-1,3-diphenyldisilazane	**43340**
4-(Trimethylsiloxy)-3-penten-2-one	**69649**
Bis(dimethylamino)dimethylsilane	**14755**
BSA + TMCS	**15256**
Chlorodimethyl(pentafluorophenyl)silane	**76750**
Chlorotriethylsilane	**90383**
Chlorotrimethylsilane	**89595**
Hexamethyldisilazane	**52619**
Hexamethyldisiloxane	**01565**
N-(Trimethylsilyl)acetamide	**91566**
N,N-Bis(trimethylsilyl)methylamine	**15235**
N,O-Bis(tert-butyldimethylsilyl)trifluoroacetamide	**89539**
N,O-Bis(trimethylsilyl)acetamide	**15269**
N,O-Bis(trimethylsilyl)trifluoroacetamide	**15222**
N,O-Bis(trimethylsilyl)trifluoroacetamide with trimethylchlorosilane	**15209** **15238**
N-Methyl-*N*-(trimethylsilyl)trifluoroacetamide	**69479**
N-Methyl-*N*-(trimethylsilyl)trifluoroacetamide with 1% trimethylchlorosilane	**69478**
N-*tert*-Butyldimethylsilyl-*N*-methyltrifluoroacetamide with 1% *tert*-Butyldimethylchlorosilane	**00942**
BSA Derivatization Grade	**33036** **33035-U** **33037-U**
BSA + TMCS + TMSI	**33030** **33151** **33031-U**
BSTFA + TMCS	**33149-U** **33154-U** **33155-U** **33148**
BSTFA, Derivatization Grade	**33024** **33027** **33084**
Chlorotrimethylsilane	**33014**
HMDS, Derivatization Grade	**33350-U**
HMDS+TMCS+Pyridine	**33038** **33039**
Silica Column Regeneration Solution	**33175**
Silylation Sampler Kit	**505846**
Sylon CT	**33065-U**
tert-Butyldimethylsilylimidazole solution	**33092-U**
TMSI, Derivatization Grade	**33068-U**
TMSI + Pyridine	**33156-U** **33159-U**

To learn more, view the Derivatization Reagents for Selective Responses Guide at **SigmaAldrich.com/derivatization**

MALDI Matrices Selection Table

Matrix-assisted laser desorption/ionization (MALDI) has expanded MS into the analysis of high molecular mass, non-volatile, and thermally labile compounds, such as intact proteins and oligonucleotides. Moreover, it has become an important technique in proteomics research.[1–3] Further significant applications of MALDI-MS include the analysis of polymers, glycans, lipids, and metabolites.

A typical MALDI matrix substance is an aromatic acid with a chromophore that absorbs strongly at the wavelength of the incident laser. The MALDI technique generally involves mixing the sample with a matrix substance, followed by crystallization by different techniques on the MALDI sample plate. The crystallized sample-matrix mixture is irradiated by laser light, usually UV. As the matrix absorbs the light energy, it vaporizes into the gas phase, resulting in an indirect ionization of the sample molecules.[4–6]

Choosing a suitable matrix of high quality is the key to the success of a MALDI-MS experiment. Organic impurities can lead to extraneous peaks, especially in the low mass range. Trace levels of ions, especially Na^+ and K^+, form adducts with sample molecules. These adducts differ in mass according to the number of positive ions and complicate the MS spectrum. Since the matrix substance is generally applied in large excess to the sample, a very high purity is even more crucial. The MALDI Matrices Selection Table below facilitates choosing the appropriate matrix for the use in proteomics and metabolomics.

Features and Benefits

- High chemical purity
- Low trace metal content to minimize adduct formation and simplify the resulting MS spectrum
- Ultra pure grades of the most popular matrix substances with extremely strict specifications concerning purity, trace metal content, appearance, and solubility

References

1. Karas, M., et al., Matrix-assisted ultraviolet laser desorption of nonvolatile compounds. Int. J. Mass Spectrom. Ion Proc., 78, 53-68 (1987).
2. Hillenkamp, F., and Peter-Katalinic, J. (eds.), MALDI MS. A Practical Guide to Instrumentation, Methods and Applications, Wiley-VCH (2007).
3. Aebersold, R., and Mann, M., Mass spectrometry-based proteomics. Nature, 422, 198-207 (2003).
4. Dreisewerd, K., The desorption process in MALDI. Chem. Rev., 103, 395-425 (2003).
5. Karas, M., and Krüger, R., Ion formation in MALDI. Chem. Rev., 103, 427-439 (2003).
6. Knochenmuss, R., and Zenobi, R., MALDI ionization: The role of in-plume processes. Chem. Rev., 103, 441-452 (2003).

Description	Purity	Abbreviation	Proteins	Peptides	Glycans	Oligonucleotides	Polymers	Lipids	Other Analytes	Note	Pack Sizes	Cat. No.
9-Aminoacridine	≥99.5%	9-AA						•	Metabolites		1 g	**92817**
4-Bromo-α-cyanocinnamic acid	≥95%	BrCCA		•				•	Phosphopeptides, phospholipids, chlorinated lipids, drugs, fragile analytes, ionic liquids (quantification), ME-SIMS, CID-MS/MS		100 mg	**89063**
4-Bromo-α-cyanocinnamic acid-4-Chloro-α-cyanocinnamic acid mixture	≥95%	BrCCA:ClCCA		•				•	Phosphopeptides, phospholipids, chlorinated lipids, drugs, fragile analytes, ionic liquids (quantification), ME-SIMS, CID-MS/MS		100 mg	**68914**
4-Aminoquinaldine	≥99.0%					•			amino acids		1 g	**05851**
9-Nitroanthracene	≥98.5%	9-NA					•		fullerenes, humic acids		100 mg 1 g	**56229**
4-Phenyl-acyanocinnamamide	≥98.5%							•	MALDI imaging		100 mg	**69028**
Anthranilamide	≥99.0%		•	•	•						1 g	**76884**
Curcumin	≥99.5%							•	pharmaceuticals, drugs, MALDI imaging		100 mg	**78246**
(2E)-3-(9-Anthryl)-2-cyanoacrylic acid	≥97.0%								low molecular weight compounds		100 mg	**83788**
trans-2-[3-(4-tert-Butylphenyl)-2-methyl-2-propenylidene] malononitrile	≥99.0%				•		•		Gold nanoparticles, fullerenes, organometallics, macrocycles		250 mg 1 g	**87884**
(*E*)-2-Cyano-3-(2-naphthyl) acrylic acid	≥98.0%								low molecular weight compounds		100 mg	**94477**

Description	Purity	Abbreviation	Proteins	Peptides	Glycans	Oligonucleotides	Polymers	Lipids	Other Analytes	Note	Pack Sizes	Cat. No.
4-Bromo-α-cyanocinnamic acid – α-Cyano-2,4-difluorocinnamic acid mixture	≥95%	BrCCA:DiFCCA		•				•	Phosphopeptides, phospholipids, chlorinated lipids, drugs, fragile analytes, ionic liquids (quantification), ME-SIMS, CID-MS/MS		100 mg	**55841**
Caffeic acid	≥99.0%		•	•							1 g 5 g	**60018**
4-Chloro-α-cyanocinnamic acid	≥95%	ClCCA		•				•	Phosphopeptides, phospholipids, chlorinated lipids, drugs, fragile analytes, ionic liquids (quantification), ME-SIMS, CID-MS/MS		100 mg	**94141**
4-Chloro-α-cyanocinnamic acid – α-Cyano-2,4-difluorocinnamic acid mixture	≥95%	ClCCA:DiFCCA		•				•			100 mg	**39379**
α-Cyano-2, 4-difluorocinnamic acid	≥95%	DiFCCA		•					Phosphopeptides, phospholipids, chlorinated lipids, drugs, fragile analytes, ionic liquids (quantification), ME-SIMS, CID-MS/MS		100 mg	**77646**
α-Cyano-4-fluorocinnamic acid	≥95%	FCCA		•					Phosphopeptides, phospholipids, chlorinated lipids, drugs, fragile analytes, ionic liquids (quantification), ME-SIMS, CID-MS/MS		100 mg	**77081**
α-Cyano-4-hydroxycinnamic acid	≥99.0%	CHCA	•	•	•						250 mg 1 g	**70990**
α-Cyano-4-hydroxycinnamic acid	≥99.5%, Ultra pure	CHCA	•	•	•						10 × 10 mg	**39468**
α-Cyano-4-hydroxycinnamic acid – α-Cyano-2, 4-difluorocinnamic acid – α-Cyano-2, 3, 4, 5, 6-pentafluorocinnamic acid mixture	≥95%	CHCA:DiFCCA:PentaFCCA		•					Phosphopeptides, phospholipids, chlorinated lipids, drugs, fragile analytes, ionic liquids (quantification), ME-SIMS, CID-MS/MS		100 mg	**03841**
α-Cyano-2, 3, 4, 5, 6-pentafluorocinnamic acid	≥95%	PentawFCCA		•					Phosphopeptides, phospholipids, chlorinated lipids, drugs, fragile analytes, ionic liquids (quantification), ME-SIMS, CID-MS/MS		100 mg	**38419**
1,5-Diamino naphthalene	≥99.0%			•		•			1,5-DAN In-Source-Decay		250 mg	**56451**
2', 6'-Dihydroxy acetophenone	≥99.5%	2,6-DHAP	•	•	•			•			1 g 5 g	**37468**
2, 5-Dihydroxybenzoic acid	≥99.0%	DHB	•	•	•		•	•	Organic molecules		10 mg 250 mg 1 g	**85707**
2, 5-Dihydroxybenzoic acid	≥99.5%, Ultra pure	DHB	•	•	•		•	•	Organic molecules		10 × 10 mg	**39319**
trans-Ferulic acid	≥99.0%	FA	•	•							1 g 5 g	**46278**
2-(4-Hydroxy phenylazo) benzoic acid	≥99.5%	HABA	•	•	•		•				1 g 5 g	**54793**
3-Hydroxypicolinic acid	≥99.0%	3-HPA				•			Oligosaccharides		250 mg 1 g	**56197**
3-Nitrobenzyl alcohol	≥99.5%										5 g	**73148**
3-Nitrobenzonitrile	≥99.0%	3-NBN							Tissues via MAIV		1 g	**80362**
Salicylamide	≥99.0%					•					1 g	**84228**
Sinapic acid	≥99.0%	SA	•	•					Dendrimers, Fullerenes		1 g 5 g	**85429**
Sinapic acid	≥99.5%	SA	•	•					Dendrimers, Fullerenes		10 × 10 mg	**49508**
Super-DHB BioReagent		Super-DHB	•	•	•						10 × 10 mg 1 g 5 g	**50862**
2', 4', 6'-Trihydroxy acetophenone monohydrate	≥99.5%	THAP	•	•	•	•					1 g 5 g	**91928**

Stable Isotope Labeled Bioactive Compounds

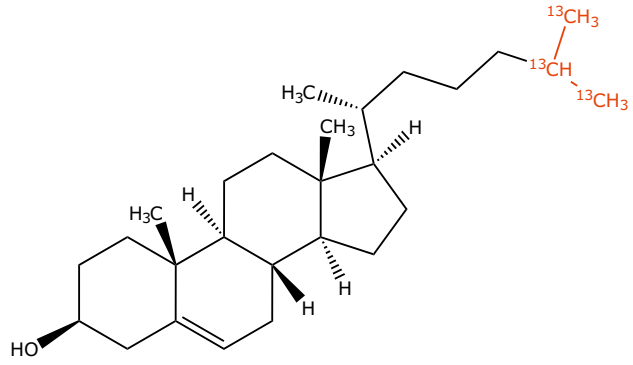
ISOTEC® Products for Use as Internal Standards

Stable isotope labeled compounds are used as internal standards for various MS techniques and within many applications. With chemical and ionization properties nearly identical to their unlabeled counterparts, stable isotope labeled compounds are often considered the top choice for an internal standard. Furthermore, the labeled standard and the analyte of interest can be easily differentiated by the mass shift between the two compounds, which is ideally three or more units.[1]

ISOTEC® Stable Isotopes offers a large selection of labeled products suitable for this purpose. Labeled standards have been utilized within numerous applications, including quantification of cholesterol in a clinical setting,[2] vitamin D within baby formula,[3] and B vitamins in human milk.[4] Labeled internal standards have also been employed in research on the diagnosis of Graves disease[5] and hypertension,[6] the study of fatty acid oxidation,[7] and the analysis of androgenic steroids in wastewater.[8]

MS standards from ISOTEC® have high chemical and isotopic purities with labeling patterns including ^{13}C, ^{15}N, and deuterium. The ^{13}C and/or ^{15}N labels do not exchange within the mass spectrometer source, providing further advantage.[9]

ISOTEC® is also able to custom-synthesize labeled compounds upon request. Custom compounds can be designed with specific isotopes in specific locations. Whether a fully labeled or specifically labeled compound is of interest, let our expert team evaluate your needs.



Amino acids

Description	Cat. No.
DL-Alanine-2,3-$^{13}C_2$	**485578**
L-Arginine-2,3,3,4,4,5,5-d_7 hydrochloride	**776408**
L-Arginine-$^{13}C_6$ hydrochloride	**643440**
DL-aspartic acid-2-^{13}C,^{15}N	**492353**
L-Citrulline-5-^{13}C,4,4,5,5-d_4	**748935**
L-Citrulline-4,4,5,5-d_4	**578886**
L-Citrulline-5,5-d_2	**741833**
DL-Cysteine-3,3-d_2	**900206**
DL-Glutamic acid-$^{13}C_5$	**604984**
DL-Histidine-1-^{13}C	**588644**
L-Leucine-$^{13}C_6$	**605239**
L-Lysine-$^{13}C_6$ hydrochloride	**643459**
L-Ornithine-3,3,4,4,5,5-d_6 hydrochloride	**749443**
DL-Serine-1-^{13}C	**489107**
DL-Valine-2-^{13}C amine	**592048**

Additional products and labeling patterns are available.

References

1. Vogeser, M. and Seger, C., Pitfalls associated with the use of liquid chromatography-tandem mass spectrometry in the clinical laboratory. Clin. Chem., 56, 1234-1244 (2010).
2. Edwards, S.H., et al., Proposed serum cholesterol reference measurement procedure by gas chromatography-isotope dilution mass spectrometry. Clin. Chem., 57, 614-622 (2011).
3. Sullivan, D., Infant formula and adult/pediatric nutritional methods approved First Action using the AOAC voluntary consensus standards process. J. AOAC Int., 95, 1-4 (2012).
4. Hampel, D., et al., Ultra-performance liquid chromatography tandem mass-spectrometry (UPLC-MS/MS) for rapid, simultaneous analysis of thiamin, riboflavin, flavin adenine dinucleotide, nicotinamide and pyridoxal in human milk. J. Chromatogr. B, 903, 7-13 (2012).
5. Higashi, T., et al., Stable isotope-dilution liquid chromatography/tandem mass spectrometry method for determination of thyroxine in saliva. J. Chromatogr. B, 879, 1013-1017 (2011).
6. Taylor, P.J., et al., Measurement of aldosterone in human plasma by semiautomated HPLC-tandem mass spectrometry. Clin. Chem., 55, 1155-1162 (2009).
7. Mohammad, M.A., et al., Galactose promotes fat mobilization in obese lactating and nonlactating women. Am. J. Clin. Nutr., 93, 374-381 (2011).
8. Backe, W.J., et al., Analysis of androgenic steroids in environmental waters by large-volume injection liquid chromatography tandem mass spectrometry. Anal. Chem., 83, 2622-2630 (2011).
9. Ciccimaro, E. and Blair, I.A. Stable-isotope dilution LC-MS for quantitative biomarker analysis. Bioanalysis, 2(2), 311-341(2010).

To find addional stable isotope labeled standards, visit **SigmaAldrich.com/isotec**

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Fatty acids

Description	Cat. No.
Arachidonic-5,6,8,9,11,12,14,15-d_8 acid	**735000**
Decanoic-10,10,10-d_3 acid	**616125**
cis-4,7,10,13,16,19-Docosahexaenoic-21,21,22,22,22-d_5 acid	**733326**
cis-5,8,11,14,17-Eicosapentaenoic acid-19,19,20,20,20-d_5	**734322**
Heptanoic-d_{13} acid	**617040**
trans-9-Hexadecenoic acid-1,2,3,7,8-$^{13}C_5$	**722774**
Lauric-d_{23} acid	**451401**
Linoleic acid-$^{13}C_{18}$	**605735**
Methyl heptadecanoate-d_{33}	**733148**
Myristic acid-1,2-$^{13}C_2$	**490865**
Myristic acid-13,13,14,14,14-d_5	**614165**
trans-6-Octadecenoic acid-1,2,3,4,5-$^{13}C_5$	**722847**
trans-9-Octadecenoic acid-1,2,3,7,8-$^{13}C_5$	**722790**
trans-11-Octadecenoic acid-1,2,3,9,10-$^{13}C_5$	**722855**
Octanoic acid-$^{13}C_8$	**605727**
Octanoic-d_{15} acid	**448214**
Oleic acid-$^{13}C_{18}$	**490431**
Palmitic acid-$^{13}C_{16}$	**605573**
Palmitic acid-d_{31}	**366897**

Additional products and labeling patterns are available.

Glycerides & Lipids

Description	Cat. No.
Cholesteryl linoleate-$^{13}C_{18}$	**729663**
Cholesteryl-26,26,26,27,27,27-d_6 oleate-1,2,3,7,8,9,10-$^{13}C_7$	**729671**
Glyceryl tri(palmitate-d_{31})	**616966**
Glyceryl tri(octanoate-d_{15})	**617121**
Glyceryl-$^{13}C_3$ trioleate	**605638**
Cholesteryl oleate-$^{13}C_{18}$	**729523**
Glyceryl tri(palmitate-1,2,3,4-$^{13}C_4$)	**777862**
2-Oleoyl-1-palmitoyl-rac-glycero-3-phosphocholine-(trimethyl-d_9)	**730041**
Glyceryl-d_5 trilinoleate	**729507**
Cholesteryl-26,26,26,27,27,27-d_6 linoleate	**729515**
rac-Glyceryl-1,1,2,3,3-d_5-1,2-dioleate	**723703**
Glyceryl tri(oleate-1,2,3,7,8,9,10-$^{13}C_7$	**646253**
1-Palmitoyl-rac-glycero-3-phosphocholine-(trimethyl-d_9)	**757438**
Glyceryl tri(oleate-1-^{13}C)	**489514**
Glyceryl tri(oleate-9,10-$^{13}C_2$)	**646245**
1-Palmitoyl-rac-glycero-3-phosphocholine-(trimethyl-d_9)	**757438**
Glyceryl tri(stearate-1-^{13}C)	**492663**

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Steroids and Hormones

Description	Cat. No.
Aldosterone-2, 2, 4, 6, 6, 21, 21-d_7	**706035**
Aldosterone-9,11,12,12-d_4 solution	**802883**
4-Androstene-3, 17-dione-2, 3, 4-$^{13}C_3$ solution	**730645**
Cholesterol-2,3,4-$^{13}C_3$	**749478**
Cholesterol-2, 2, 3, 4, 4, 6-d_6	**488577**
Cholesterol-25, 26, 27-$^{13}C_3$	**707678**
Corticosterone-9,11,12,12-d_4	**802905**
Hydrocortisone-2,3,4-$^{13}C_3$ solution	**803146**
Cortisone-2, 3, 4-$^{13}C_3$ solution	**803154**
Dehydroepiandrosterone-2, 2, 3, 4, 4, 6-d_6	**709549**
Dehydroepiandrosterone-2, 2, 3, 4, 4, 6-d_6 sulfate sodium salt	**723266**
11-Deoxycortisol-2, 2, 4, 6, 6-d_5	**710784**
Dihydrotestosterone-2, 3, 4-$^{13}C_3$ solution, 0.1 mg/mL	**730637**
17β-Estradiol-2, 3, 4-$^{13}C_3$	**719552**
17β-Estradiol-2, 4, 16, 16, 17-d_5	**613967**
Estriol-2, 3, 4-$^{13}C_3$	**731668**
Estrone-2, 3, 4-$^{13}C_3$	**719544**
Estrone-2,3,4-$^{13}C_3$ solution	**802921**
18-Hydroxycorticosterone	**710806**
Hydrocortisone-9, 11, 12, 12-d_4	**705594**
17-α-Hydroxypregnenolone-20, 21-$^{13}C_2$-16,16-d_2	**803081**
Pregnenolone-20, 21-$^{13}C_2$-16, 16-d_2	**739545**
Pregnenolone-20, 21-$^{13}C_2$-16, 16-d_2 sulfate sodium salt	**740985**
Progesterone-2, 3, 4-$^{13}C_3$	**737143**
Progesterone-2, 3, 4-$^{13}C_3$ solution	**803065**
Testosterone-2, 3, 4-$^{13}C_3$ solution	**730610**
3α, 5β-Tetrahydroaldosterone	**750026**
3, 3', 5'-Triiodothyronine-(diiodophenyl-$^{13}C_6$) hydrochloride	**709719**
3, 3', 5'-Triiodothyronine-(tyrosine ring-$^{13}C_6$) hydrochloride	**709611**
Chenodeoxycholic-2,2,3,4,4,6,6,7,8-d_9 acid	**809667**
Cholesterol-23,24,25,26,27-$^{13}C_5$	**809837**
Pregnenolone-2,2,4,4-d_4	**809845**
Allopregnanolone-2,2,3,4,4-d_5 solution	**809853**
Etiocholanolone-2,2,3,4,4-d_5 solution	**809861**
Cortisone-2,3,4-$^{13}C_3$ 21-sulfate sodium salt solution	**900079**
Hydrocortisone-9,11,12,12-d_4 21-sulfate sodium salt	**900080**
L-Thyroxine-1",1",2,2",6-d_5 hydrochloride solution	**900067**
Cortisone-2,2,4,6,6,9,12,12-d_8	**900170**
Tetrahydrocortisol-2,2,3,4,4-d_5	**900182**
Tetrahydrocortisone-2,2,3,4,4-d_5	**900183**

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Vitamins

Description	Cat. No.
Biotin-(*ring*-6, 6-d_2)	**705268**
Coenzyme Q10-(*ring*-d_9)	**802891**
Folic acid-(*glutamic acid*-$^{13}C_5$,^{15}N)	**803162**
Folic acid-(*glutamic acid*-$^{13}C_5$)	**803049**
25-Hydroxyvitamin D3-(26,26,26,27,27,27-d_6)	**803030**
(24*R*), 24,25-Dihydroxyvitamin D_3-26,26,26,27,27,27-d_6 solution	**802913**
25-Hydroxyvitamin D_3-(23-24-25-26-27-$^{13}C_5$) solution	**803103**
25-Hydroxyvitamin D_2 solution	**740217**
25-Hydroxyvitamin D_2 (6, 19, 19-d_3) solution	**740071**
25-Hydroxyvitamin D_2 (6, 19, 19-d_3)	**705497**
25-Hydroxyvitamin D_3 solution	**739650**
25-Hydroxyvitamin D_3 (6, 19, 19-d_3)	**705888**
Nicotinamide-2, 4, 5, 6-d_4	**762970**
Pyridoxal-(*methyl*-d_3) hydrochloride	**705187**
Pyridoxamine-(*methyl*-d_3) dihydrochloride	**705322**
Riboflavin-dioxopyrimidine-$^{13}C_4$, $^{15}N_2$	**705292**
Thiamine-(*4-methyl-*^{13}*C-thiazol-5-yl-*$^{13}C_3$) hydrochloride	**731188**
α-Tocopherol-(ring-5, 7-dimethyl-d_6)	**731234**
Vitamin B_5 (di-β-alanine-$^{13}C_6$, $^{15}N_2$) calcium salt	**705837**
Vitamin B_{12}-(dimethylbenzimidazole-$^{13}C_7$) solution	**803170**
Vitamin D_2 (6,19,19-d_3)	**705489**
Vitamin D_2 (6,19,19-d_3) solution	**739839**
Vitamin D_3 (6,19,19-d_3) solution	**740284**
	731285
Vitamin E acetate-(*trimethyl*-d_9)	**615366**
Vitamin K-d_7(5,6,7,8-d_4, 2-*methyl*-d_3)	**705470**
Vitamin K_3-d_8	**737836**
Biotin-2′,2′,3′,3′-d_4	**809608**
Pyridoxine-(methyl-d_3) hydrochloride	**809659**
1α,25-Dihydroxyvitamin D_3-26,26,26,27,27,27-d_6 solution	**809926**
(24R)-24,25-Dihydroxyvitamin D_3 solution	**809748**
Vitamin D_3-25,26,27-$^{13}C_3$ solution	**809756**
Vitamin D_3-23,24,25,26,27-$^{13}C_5$ solution	**900234**
Vitamin D_3-23,24,25,26,27-$^{13}C_5$ solution	**809772**
Nicotinamide-2,6,7-$^{13}C_3$-(pyridyl-^{15}N)	**809799**
Vitamin K_1-4a,5,6,7,8,8a-$^{13}C_6$	**809888**
Vitamin K_2 (MK-4)-(5,6,7,8-d_4,2-methyl-d_3)	**809896**
Vitamin K_2 (MK-4)-4′,5,6,7,8,8′-$^{13}C_6$	**809918**
Vitamin K_2 (MK-7)-(5,6,7,8-d_4,2-methyl-d_3)	**900074**
Vitamin K2 (MK-9)-(5,6,7,8-d_4,2-methyl-d_3)	**900076**
Vitamin K_2 (MK-7)-4′,5,6,7,8,8′-$^{13}C_6$	**900075**
Vitamin K_2 (MK-9)-4′,5,6,7,8,8′-$^{13}C_6$	**900077**

Metabolites

Description	Cat. No.
5-Hydroxyindole-3a,4,5,6,7,7a-$^{13}C_6$-3-acetic acid	**809616**
Sodium taurochenodeoxycholate-2,2,4,4-d_4	**809683**
Sodium taurochenodeoxycholate-2,2,3,4,4,6,6,7,8-d_9	**809691**
Sodium taurocholate-2,2,4,4-d_4	**900036**
Sodium taurodeoxycholate-2,2,4,4,11,11-d_6	**900078**
Sodium taurodeoxycholate-2,2,4,4-d_4	**900073**
Sodium taurolithocholate-2,2,4,4-d_4	**809713**
Sodium tauroursodeoxycholate-2,2,4,4-d_4	**809721**
Indoxyl-3a,4,5,6,7,7a-$^{13}C_6$ sulfate potassium salt	**809780**

Other Bioactive Compounds

Description	Cat. No.
L-Arbrine-(*methyl*-d_3)	**750913**
Aldicarb-(*N-methyl*-^{13}C,d_3, *carbomoyl*-^{13}C)	**733865**
Aldicarb-(*N-methyl*-^{13}C,d_3, *carbomoyl*-^{13}C) sulfone	**733873**
(±)-Catechin-2,3,4-$^{13}C_3$	**719579**
Chenodeoxycholic acid-2,2,4,4-d_4	**614122**
Cholic acid-2,2,4,4-d_4	**614149**
Deoxycholic acid-2,2,4,4-d_4	**614130**
Desethylamodiaquine-(*ethyl*-d_5)	**705349**
3, 3'-Diiodo-L-thyronine-(phenoxy-$^{13}C_6$) (T2)	**719528**
3, 3'-Diiodo-L-thyronine (T2)	**719536**
4, 6-Dioxoheptanoic acid-3,4,5,6,7-$^{13}C_5$	**749001**
Ferulic acid-1,2,3-$^{13}C_3$	**722820**
Glycocholic-2,2,4,4-d_4 acid	**739723**
Histamine-α, α,β, β-d_4 dihydrochloride	**762962**
Kynurenic acid-3,5,6,7,8-d_5	**793477**
Spermidine-(*butane*-d_8) trihydrochloride	**709891**
Spermidine-(*butane*-$^{13}C_4$) trihydrochloride	**740780**
Spermine-(*butane*-d_8) tetrahydrochloride	**705330**
Vinblastine-^{13}C,d_3	**746274**
Yohimbine-(*methyl*-^{13}C,d_3 ester)	**731242**
(±)-Epicatechin-2,3,4-$^{13}C_3$ gallate	**900368**
(±)-Epigallocatechin-2,3,4-$^{13}C_3$	**900369**
(±)-Epigallocatechin-2,3,4-$^{13}C_3$ gallate	**900376**
(±)-Catechin-2,3,4-$^{13}C_3$ gallate	**900370**
(±)-Gallocatechin-2,3,4-$^{13}C_3$	**900371**
(±)-Gallocatechin-2,3,4-$^{13}C_3$ gallate	**900372**
α-Tocopherol-(phenyl-$^{13}C_6$)	**900374**
11-Deoxycortisol-2,3,4-$^{13}C_3$ solution	**809594**
11-Deoxycorticosterone-2,3,4-$^{13}C_3$ solution	**809586**
Dehydroepiandrosterone-2,2,3,4,4-d_5	**809640**
Exemestane-(3,4-$^{13}C_2$-6-methylidene-^{13}C)	**809802**
Clodinafop-propargyl-(phenoxy-$^{13}C_6$)	**809810**
Atrazine-(triazyl-$^{13}C_3$,$^{15}N_3$)	**809829**

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Features and Benefits

- Convenient, simple and highly-dependable assays for monitoring metabolic pathways
- Assay kits utilize spectrophotometric, fluorometric, and/or gravimetric detection methods
- Kits contain all necessary components and reagents for analysis
- Most assay kits are suitable for high-throughput assays

General Assay Design

For more information, visit **SigmaAldrich.com/assaykits**

BIOshell™ Glycan HPLC Columns

Empowering the Analysis of Glycoproteins with Exceptional Reproducibility

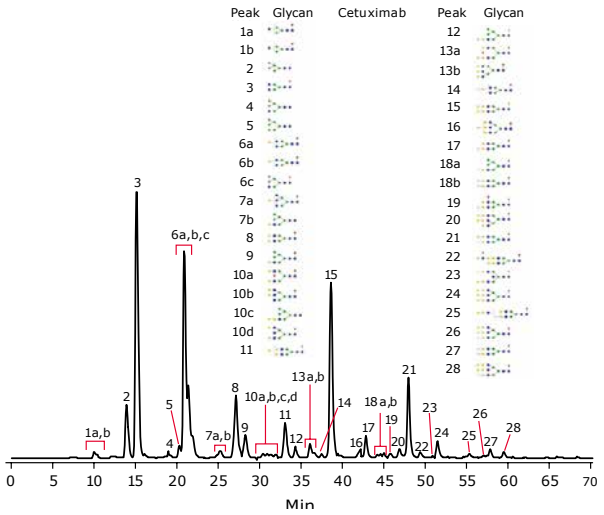
Characterizing and monitoring the glycosylation pattern of a biotherapeutic protein is required by regulatory authorities due to the fact that safety, efficacy and the serum half-life of therapeutic proteins can be affected by differences in their glycosylation pattern. Analysis and identification of glycoproteins can be challenging, however, because of the structural complexity of N-linked and O-linked sugar molecules. Hydrophilic interaction liquid chromatography (HILIC) is a proven technique for the separation and quantitation of isolated glycans under native conditions or after their derivatization with fluorescent labels.

BIOshell™ Glycan HPLC columns are specifically engineered to deliver fast, high resolution, reproducible glycan separation using HILIC chromatography. There are many advantages to using Fused-Core® BIOshell™ Glycan HPLC columns for glycoprotein analysis:

- Increased resolution, faster separations, and lower back pressure – BIOshell™ HPLC columns utilize Fused-Core® particle technology which offers significant performance benefits over traditional columns based on totally porous particles
- Excellent reproducibility – Quality control testing requires tight retention time and peak width specifications ensuring lot-to-lot reproducibility
- Complimentary Sigma-Aldrich products – Sigma-Aldrich® supplies reagents and consumables needed for each step in glycoprotein analysis as indicated in Table 1.

Steps in Glycoprotein Analysis

Figure 1. BIOshell™ Glycan Column Separation of Procainamide Labeled Cetuximab Glycans

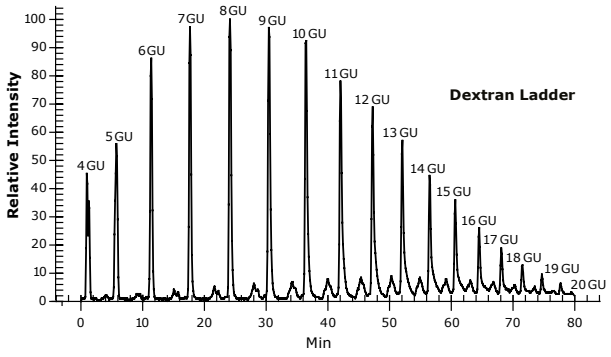


Cetuximab is a chimeric mouse-human IgG1 monoclonal antibody against the epidermal growth factor receptor. It is used to treat head, neck, and colorectal cancers. The antibody is N-glycosylated both in the Fc and Fab regions, which have been shown to impact safety and quality of the drug. Thus, characterizing its glycosylation pattern is exceptionally important. As shown in this application, the BIOshell™ Glycan column is able to elucidate the complex glycosylation of this biotherapeutic, allowing a better understanding of the drug's efficacy.

For a complete protocol detailing glycoprotein analysis, including testing conditions, visit **SigmaAldrich.com/BIOshell**

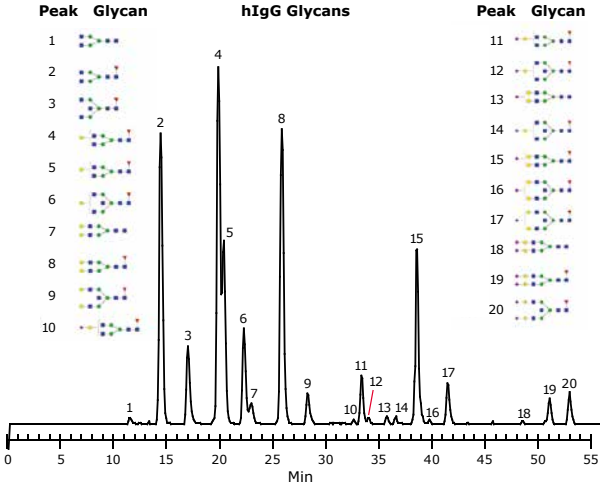
BIOshell™ Glycan Applications

Figure 2. BIOshell™ Glycan Column Separation of a Procainamide Labeled Dextran Ladder



The dextran ladder is used as an external standard for the analysis of glycans by HILIC mode HPLC after fluorescent labeling. When analyzed on the BIOshell™ Glycan HPLC column, this standard gives a characteristic ladder profile from monomeric glucose to a 20-mer glucose oligosaccharide. This ladder provides calibration reference points that can aid in identifying more complex glycans based upon retention characteristics.

Figure 3. BIOshell™ Glycan Column Separation of Procainamide Labeled Human IgG Glycans



A sample of human IgG glycans was analyzed on a BIOshell™ Glycan HPLC column resulting in the identification of 20 distinct peaks. Glycans were identified by mass spectrometry, which was coupled in line with the HPLC-fluorescence detector system. Excellent separation as well as symmetrical peak shape can be observed in the chromatogram.

Get Started

Additional resources are available for helping you implement BIOshell™ Glycan columns into your laboratory.

For product information, webinars, ordering and real time availability information, visit **SigmaAldrich.com/BIOshell**

Table 1. Sigma-Aldrich Reagents and Consumables for Glycoprotein Analysis

Description	Cat. No.
Step 1: Glycan release	
IgG from human serum	**I4506**
Trizma® HCl	**T5941**
Urea	**U0631**
Ammonium bicarbonate	**9830**
PNGase F	**7367**
Step 2: Procainamide labeling	
Sodium cyanoborohydride	**156159**
Procainamide hydrochloride	**P9391**
Dimethyl sulfoxide	**D8418**
Acetic acid	**320099**
Water	**39253**
Dextran hydrolysate	**31417**
Step 3: Cleanup	
Acetonitrile	**34851**
DPA-6S 50 mg cartridges	**52624-U**
Step 4: LC-MS analysis	
BIOshell™ glycan, 15 cm × 2.1 mm I.D., 2.7 µm	**50994-U**
Ammonium formate	**17843**
Formic acid	**94318**

BIOshell™ Glycan Fused-Core® Silica Characteristics

- Pore Size – 90 Å
- Max Temp. – 65 °C
- Pressure – 1,000 bar (14,500 psi)
- Operating pH Range – 2–9
- Surface Area – 135 m^2/g

BIOshell™ Glycan Fused-Core® HPLC Columns

Particle Size	I.D.	Length	Cat. No.
2.7 µm	2.1 mm	10 cm	**50993-U**
2.7 µm	4.6 mm	10 cm	**50998-U**
2.7 µm	2.1 mm	15 cm	**50994-U**
2.7 µm	4.6 mm	15 cm	**50999-U**
2.7 µm	2.1 mm	5 cm	**50991-U**
2.7 µm	4.6 mm	5 cm	**50997-U**

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A technical seminar can be arranged on-site or via the web. Request via seminars@sial.com

Translation to Clinical Applications

The understanding of the genetic and environmental factors influencing health and disease remains a major challenge in the 21st century. The increasing utilization of molecular tools in medicine to analyze samples of body fluids or tissues, in vitro or in-vivo, requires new global standards relevant to patient biology at the individual and population level. Although metabolites have been used for diagnoses and treatments for centuries, the elucidation of biochemical pathways and the development of new analytical technologies have moved the frontiers to define variations of a person's physiological and pathological states. From its foundation Sigma-Aldrich's aim was to enable researchers to expand the frontiers of metabolic pathways to elucidate biomarkers for drug development or clinical diagnostics.

The search for disease biomarkers in urine, breath or blood is highly attractive due to established metabolite analysis in routine clinical chemistry analysis. The focus has however been restricted to a small number of metabolites for which the corresponding rapid analytical methods have been highly automated. New methodologies in metabolomics research allowing the simultaneous analysis of a large number of metabolites enable new discoveries of disease-related metabolites.

Inborn Errors of Metabolism of Amino acids

Characteristic Metabolites for Inborn Errors of Amino acid Metabolism

Inborn errors of metabolism are caused by changes in specific enzymatic reactions and hundreds of different such alterations, which affect about 1 of every 5,000 new-borns, have been characterized thus far. The first inborn errors of metabolism, described in the beginning of the 20th century by Sir Archibald Garrod, dealt with alkaptonuria, pentosuria, cystinuria and albinism. Infants and children with treatable errors of metabolism can be identified by screening newborns for meaningful metabolite biomarkers. Several classic inborn errors of metabolism can be detected by the accumulation of certain amino acids in body-fluids like serum and urine. Phenylketonuria (PKU) is an inherited metabolic disorder in which individuals do not have the ability to further metabolize phenylalanine. Fortunately, this metabolic disorder can be analyzed by the urinary excretion of phenylalanine and successfully treated by dietary restriction.

Urinary excretion of the branched chain amino acids leucine, valine and isoleucine is an indicator for maple syrup urine disease, N-acetylaspartic acid for Canavan disease and tyrosine and N-acetyltyrosine for tyrosinemia type I. The identification of new amino-acid biomarkers for amino-acid-related metabolic disorders is of major importance to biomedical research.

Newborns are not typically screened for other metabolic disorders and as a result, these disorders are often only detected in infants and children after damage has occurred and effects such as developmental delay and mental retardation become apparent. Early detection involving a blood sample analysis for a metabolic marker can reduce such consequences by nutritional adaptations and dietary restriction. Simultaneous enzyme and metabolite tests from a single patient sample are needed for the efficient diagnosis of inborn errors of metabolism in an individual.

Description	Cat. No.
N-Acetyl-l-aspartic acid, puriss., ≥99.0% (T)	**00920**
N-Acetyl-l-tyrosine, ≥98.0% (T)	**01527**
γ-Aminobutyric acid, SigmaUltra, ≥99%	**A5835**
Argininosuccinic acid disodium salt hydrate, ≥80%	**A5707**
l-Citrulline, ≥98% (TLC)	**C7629**
l-Cystathionine, ~90% (TLC)	**C7505**
Fumaric acid, purum, ≥99.0% (T)	**47910**
Glutaric acid, 99%	**G3407**
dl-Homocysteine, ≥95% (titration)	**H4628**
l-Homocystine, ≥98% (TLC)	**H6010**

Description	Cat. No.
Homogentisic acid	**H0751**
3-Hydroxy-3-methylglutaric acid, ≥95%	**H4392**
l-Isoleucine, ≥99.5% (NT)	**58879**
Isovaleric acid, 99%	**129542**
l-Leucine, ≥99.5% (NT)	**61819**
Melanin	**M8631**
Methylmalonic acid, 99%	**M54058**
l-Phenylalanine, ≥99.0% (NT)	**78019**
l-Tyrosine, ≥99.0% (NT)	**93829**
l-Valine, ≥99.5% (NT)	**94619**

Genotype-Phenotype Relationships in Inborn Errors of Metabolism

More than a century has passed since Archibald Garrod connected the excretion of homogentisic acid in normal and alkaptonuric members of families with an alternative course of metabolism and entitled his report specifically as a study in chemical individuality.[1] This concept was later generalized in his book on "Inborn Factors of Disease".[2] The tremendous work on the knowledgebase in human genetic disorders in "Mendelian Inheritance in Man" (MIM) by Victor A. McCusick published first in book form in twelve printed editions and various translations and subsequently in its online version OMIM, is a great resource for the relationships between phenotype and genotype in teaching, research, applications and the clinic.[3,4]

From the early days of the analysis of inborn errors of metabolism up to the present we are offering an ever increasing range of metabolites for research and applications in order to support the establishment of genotype-phenotype relationships and to decrease the gap between the known and the available metabolites.

Selected Metabolites for Genotype-Phenotype-Relationships in Inborn Errors of Metabolism

Genotypes			Phenotypes		Metabolites	
Chromosome	**Gene/Locus**	**MIM No.**	**Phenotype**	**MIM No.**	**Description**	**Cat. No.**
17q21.31	G6PC	613742	Glycogen storage disease (von Gierke Disease)	232200	D-Glucose 6-phosphate disodium salt hydrate	**G7250**
13q32.3	PCCA	606054	Propionic acidemia	232000	Trisodium (2RS,3RS)-2-methylcitrate	**59464**
3q22.3	PCCB	606054	Propionic acidemia	232050	Trisodium (2RS,3RS)-2-methylcitrate	**59464**
21q22.3	CBS		Homocystinuria (CBS deficiency)	236200	L-Homocystine	**H6010**
					L-Homocysteine	**69453**
2q37.3	D2HGDH	609186	D-2-Hydroxyglutaric aciduria 1	600721	D-α-Hydroxyglutaric acid disodium salt	**H8378**
15q26.1	IDH2	147650	D-2-Hydroxyglutaric aciduria 1	613657	D-α-Hydroxyglutaric acid disodium salt	**H8378**
14q21.3	L2HGDH	609584	L-2-Hydroxyglutaric aciduria	236792	L-α-Hydroxyglutaric acid disodium salt	**90790**

1. A.E.Garrod, The incidence of alkaptonuria: a study in chemical individuality, Lancet 2,1616-1620 (1902).
2. A.E.Garrod, The inborn factors in disease: an essay, Clarendon Press, Oxford, United Kingdom (1931).
3. V.A.McKusick, A 60-year tale of spots, maps, and genes, Annual Review Genomics Human Genetics 7, 1–27 (2006).
4. V.A.McKusick, Mendelian Inheritance in Man and Its Online Version OMIM, The American Journal of Human Genetics, 80, 588-604 (2007).

Characteristic Metabolites for Inborn Errors of Lipid Metabolism

Hereditary disorders in lipid metabolism include Tay-Sachs disease, Gaucher disease, Niemann-Pick disease, metachromatic leucodystrophy, Fabry disease, Refsum disease, and Tangier disease. These lipidoses are characterized by dysfunctional lipid metabolism and result in abnormal metabolite accumulations. One of the first disorders recognized as an inborn error of lipid metabolism was Refsum disease, which produces toxic levels of phytanic acid if untreated.

Gaucher disease is a progressive sphingolipid-degradation disease characterized by genetic mutations in the lysosomal enzyme glucocerebrosidase, which leads to decreased enzymatic activity. Measurements of the metabolites methylcholine, phosphatidylcholine, and sphingomyelin are important for studying the pathophysiology of Gaucher disease. The main therapy used to treat Gaucher disease is enzyme-replacement therapy in order to normalize sphingolipid degradation and to prevent tissue damage caused by sphingolipid accumulation. Another promising therapeutic approach to Gaucher disease is to decrease the tissue glucocerebrosidase level to a concentration which can be cleared by the existing glucocerebrosidase. A deficiency of the lysosomal enzyme α-galactosidase A results in the progressive accumulation of the glycosphingolipids globotriaosylceramide Gb3 and digalactosyl-ceramide in Fabry disease, which can cause early death from cardiac, renal, and cerebrovascular events.

Dimethylglycine dehydrogenase (DMGDH) deficiency is an inborn error of choline metabolism caused by a mutation in the gene hDMGDH and results in increased N,N-dimethylglycine concentrations of 100-fold in serum and 20-fold in urine.

Nine inborn errors of bile acid metabolism have been identified that result in enzyme deficiencies and damaged bile acid biosynthesis in infants, children, and adults. Since bile acids have several important physiological functions, such as emulsifying fats and fat-soluble vitamins, and involvement in cholesterol, bilirubin, xenobiotics, and drug metabolites elimination, a failure in the multistep enzymatic conversion of cholesterol to bile acids will accumulate unusual bile acids and metabolic intermediates.

Description	Cat. No.
O-Acetyl-l-carnitine hydrochloride	**A6706**
N,N-Dimethylglycine	**D1156**
N,N-Dimethylglycine hydrochloride	**D6382**
Globotriaosylsphingosine from porcine blood	**G9534**
dl-Hexanoylcarnitine chloride	**H2132**
3-Hydroxy-3-methylglutaric acid	**H4392**
Palmitoyl-l-carnitine chloride	**P1645**
Palmitoyl-dl-carnitine chloride	**P4509**
Phytanic acid, mixture of isomers	**P4060**
Pristanic acid solution, mixture of isomers	**P6617**

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