Laboratory Products and Services for Chiral Analysis and Separation

2006 Edition

CHIRAL
TECHNOLOGIES INC

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CHIRAL
TECHNOLOGIES INC

Welcome

All of us at CHIRAL TECHNOLOGIES, INC. are pleased to present this new, expanded catalog to our customers in North and South America.

The core of our product line and our business is our range of immobilized and coated polysaccharide chiral stationary phases (CSPs). These phases, based on derivatized cellulose and amylose, were invented by Professor Yoshio Okamoto of Nagoya University and were the foundation for the establishment of CHIRAL TECHNOLOGIES in the early 1990s. They are the most general CSPs available today, and it is our intention to continually add to our polysaccharide line-up with new immobilized columns and bulk CSPs for use with HPLC, SFC, and SMB equipment.

The most important development in the field of chiral chromatography in recent times is the expanded use of supercritical fluid chromatography (SFC). We now offer a complete line of SFC columns ranging from analytical to preparative size that are designed for use with the latest SFC equipment. These higher pressure-rated SFC columns can be identified by a black coating on the column exterior.

We are also introducing in this catalog a line of columns based on our licensing of technology invented by Professor Wolfgang Lindner and his co-workers at the University of Vienna. These columns and CSPs are intended specifically for the separation of chiral acids. They complement our polysaccharide-based columns and expand the overall chiral chromatography product offering that we provide to the industry.

Tom Lewis, President; **David Ellis,** Vice President & General Manager, Lab Products; **James Lee,** Director, Separation Services; **Geoff Cox,** Vice President & General Manager, Separation Solutions; **Kathleen Berry,** Vice President, Finance & Administration; **Rodger Stringham,** Director, Technology.

As the pharmaceutical industry continues to seek ways to analyze compounds more quickly using smaller quantities, we are introducing in 2006 HPLC Microflow capillary columns of 0.3 mm ID that reduce sample requirements by 99% and analysis times by 50 to 75%. These columns are designed for use on Microfluidic HPLC systems recently introduced in the U.S.

Our Technical Center in West Chester, PA (suburb of Philadelphia) provides technical support for all of our products, and in addition offers an Outsourcing Separation Service for chiral resolutions. This facility utilizes state-of-the art HPLC, SFC, and SMB equipment for projects ranging from a gram to 50 kilograms.

Since the late 1990s over a half dozen commercial pharmaceutical products began production with large-scale simulated moving bed (SMB) equipment packed with our bulk CSPs. During this period over 200 metric tons of chiral separation capacity was installed in the three major world areas: America, Europe, and Japan. In 2006 our parent company, Daicel Chemical Industries, Ltd., will install additional manufacturing capacity for bulk CSP at its cGMP operation in Arai, Japan to match this growing demand.

The senior management (at left) along with the rest of the CHIRAL TECHNOLOGIES team believes this catalog contains the most useful and important chiral chromatography products to support our American customers in their work to develop and manufacture chiral therapeutics. On behalf of all of us at CHIRAL TECHNOLOGIES, we want to thank our customers for their continued support and trust in making us their preferred supplier of chiral chromatography products and services.

PROMISE OF QUALITY

As our business grows, our commitment to quality never wavers. Our promise to quality encompasses all areas of our operations.

*The **Quality Services Group** at Chiral Technologies, Inc. assures our customers that columns and services meet our high, well-established standards and criteria.*

***Laboratory Products:** Each column produced at a Daicel Group facility is individually tested against stringent specifications and shipped with its own test chromatogram, guaranteeing performance every time.*

***Contract Separation Services:** Pure enantiomers generated during contract separation projects are analyzed for enantiomeric purity, achiral purity, achiral assay, and residual solvent content before release. A Certificate of Analysis is provided for every product. cGMP separation projects are carried out under the ICH Q7 paragraph 19 guidelines.*

Growth Through Technology and Customer Focus

CHIRAL TECHNOLOGIES is the leading supplier of chiral chromatography products and services in North America. We are committed to further strengthening that position by continually offering advancements in technology, products, services, and support that meet the fast-changing needs of our customers.

Since the founding of CHIRAL TECHNOLOGIES, INC., applications for chiral chromatography have grown significantly. We have seen a dramatic increase in demand for chiral columns, bulk CSPs, and outsourcing services to rapidly obtain pure enantiomers through chromatography. Pharmaceutical industry customers, particularly those involved in early-stage discovery and chemical development, have come to rely on chromatographic resolution technology for the fastest separation of racemic compounds and as a viable and economical route to commercial production.

CHIRAL TECHNOLOGIES has responded to this growing need with expanded facilities, product lines, and services.

HEADQUARTERS AND TECHNICAL CENTER

Built in 2004, our new Headquarters and Technical Center in West Chester, Pennsylvania reflects our commitment to advancing the field of chiral chromatography. The 23,000-square-foot facility includes a business center and laboratories with a state-of-the-art cGMP Separations Center featuring new SMB, preparative-scale HPLC, and SFC chromatography equipment. This facility enables us to separate chiral compounds for pharmaceutical companies in quantities ranging from less than one gram up to 50 kilograms. In addition, our Methods Development Laboratory gives us the ability to screen clients' compounds under confidentiality for analytical applications or for potential large-scale applications with a library of over 50 proprietary CSPs.

CORE TECHNOLOGY DEVELOPMENT

The technologies that have propelled CHIRAL TECHNOLOGIES and chiral chromatography into the twenty-first century began in the early 1980s with Professor Yoshio Okamoto while he served on the Faculty of Science at Osaka University. His discovery of coated polysaccharide CSPs has proven to be the foundation for the growth and development of our chiral chromatography products and separations.

The polysaccharide columns are recognized worldwide as the most widely used phases for chiral HPLC separations due to their broad range of application—including analytical, preparative, and pilot- and commercial-scale separations. Over 85% of compounds submitted to our laboratories and over 85% of literature-reported chiral separations are achieved on these polysaccharide phases.

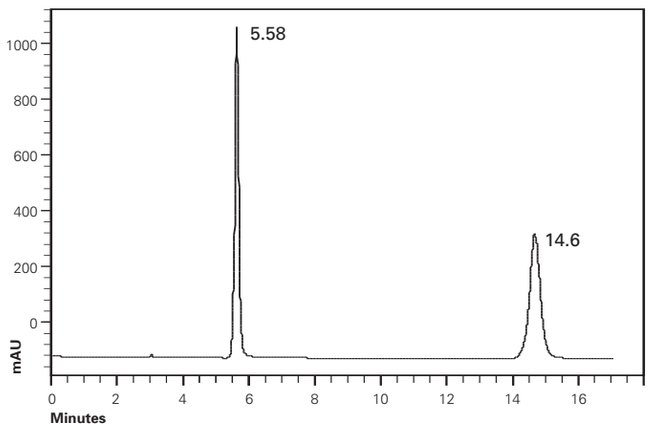
Daicel Chemical Industries, Ltd., the parent of CHIRAL TECHNOLOGIES, developed the derivatization, coating, and quality control procedures to turn Professor Okamoto's discoveries into reproducible and world-renowned commercial CSPs. These CSPs have served as the basis for our immobilized phases, representing the next generation of chiral stationary phases.

IMMOBILIZED POLYSACCHARIDE CSPs

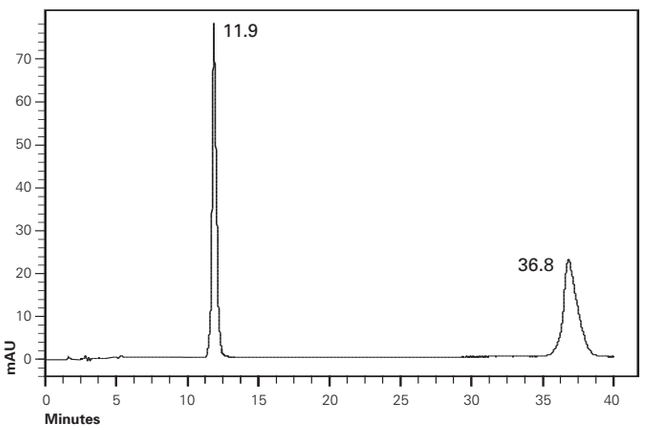
Despite a very broad range of application, the coated polysaccharide CSPs are limited somewhat in the solvents that may be used in the mobile phase and as sample diluents. New immobilized polysaccharide CSPs (CHIRALPAK® IA and CHIRALPAK® IB) overcome this limitation. IA utilizes the same chiral polymer as CHIRALPAK AD while IB is similar to CHIRALCEL OD. Both are based on high efficiency 5-micron diameter spherical silica. These phases have proven extremely stable to a broad range of mobile phases and diluents, as well as elevated temperatures.

The CHIRALPAK AD and CHIRALCEL OD phases separate an extremely broad range of analytes. Their immobilized counterparts not only perform the same separations with conventional mobile phases, but the expanded range of usable mobile phase solvents gives additional separations not obtainable on the coated CSPs. Additional immobilized polysaccharide CSPs are under development. Chromatograms below illustrate the utility of these exciting new columns.

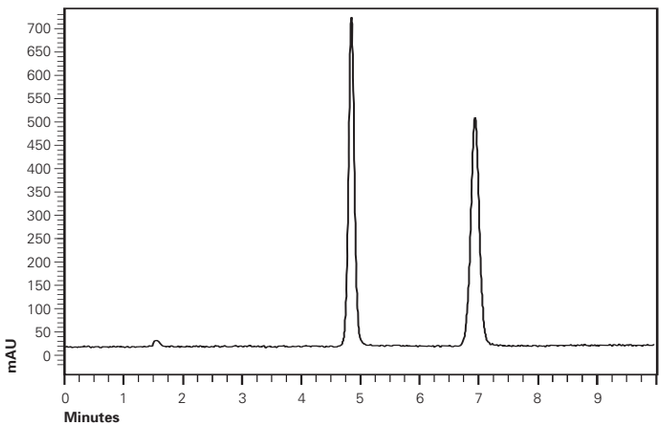
Benzoin
Column: CHIRALPAK® IA
Mobile Phase: 100% MTBE



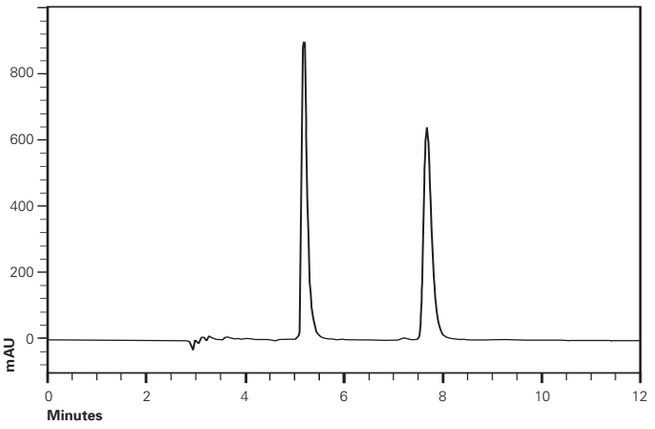
α-Methyl-α-phenyl succinimide
Column: CHIRALPAK® IA
Mobile Phase: 100% $CHCl_3$



Warfarin
Column: CHIRALPAK® IB
Mobile Phase: methanol/CO_2



Aminoglutethimide
Column: CHIRALPAK® IB
Mobile Phase: hexane/$CHCl_3$/PM/DEA



DAICEL POLYSACCHARIDE COATED PHASE COLUMNS

Originally produced on 10-micron diameter silica, our most successful chiral phases (CHIRALPAK® AD®, CHIRALPAK® AS®, CHIRALCEL® OD®, CHIRALCEL® OJ®, CHIRALCEL® OB®, and CHIRALCEL® OC®) have now been coated onto higher efficiency 5-micron particles. These CSPs have proven to have an extremely wide range of applicability with over 85% of literature-reported chiral separations achieved on them. The key to this success is the number of different stationary phases available and the dramatic effect of changing mobile phases.

Compounds form hydrogen bonds with the carbamate linkages between the side-chains and the polysaccharide backbone. A compound can form multiple hydrogen bonds with the linkages of different side chains, greatly expanding the possible interactions. The polysaccharide backbone exists in a helical conformation, giving rise to steric restrictions that may inhibit access of one enantiomer to hydrogen-bonding sites. This can result in numerous potential enantioselective interactions and large selectivity values.

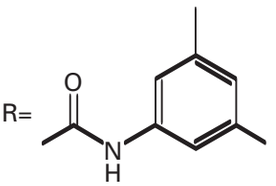
The composition of the mobile phase may also have dramatic effects on chiral separations using these CSPs. Different solvents can alter the three-dimensional structure of the polysaccharide backbone and binding sites, giving a valuable tool for controlling selectivity. Polysaccharide CSPs have been used successfully with normal, polar organic, and reversed-phase mobile phases.

KEY FEATURES OF DAICEL CHIRAL COLUMNS

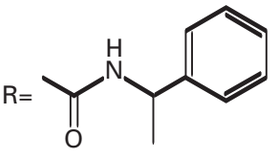
- *Excellent resolution of racemates*
- *Fast, easy method development*
- *Columns are durable and long lasting*
- *Smooth transition from laboratory to development, pilot- to commercial-scale production*

Structures of Commercially Available Polysaccharide CSPs

AMYLOSE-O-R

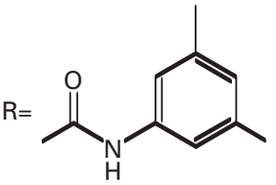


CHIRALPAK® IA
CHIRALPAK® AD-H
CHIRALPAK® AD

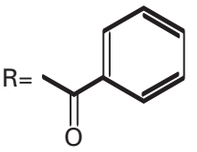


CHIRALPAK® AS-H
CHIRALPAK® AS

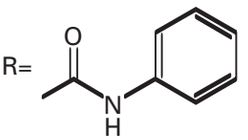
CELLULOSE-O-R



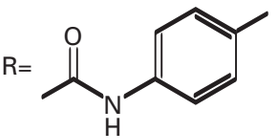
CHIRALPAK® IB
CHIRALCEL® OD-H
CHIRALCEL® OD



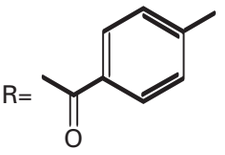
CHIRALCEL® OB-H
CHIRALCEL® OB



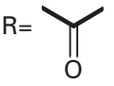
CHIRALCEL® OC-H
CHIRALCEL® OC



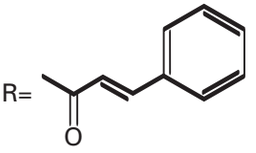
CHIRALCEL® OG



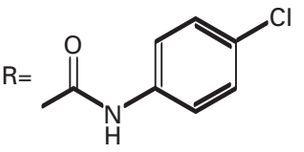
CHIRALCEL® OJ-H
CHIRALCEL® OJ



CHIRALCEL® OA



CHIRALCEL® OK



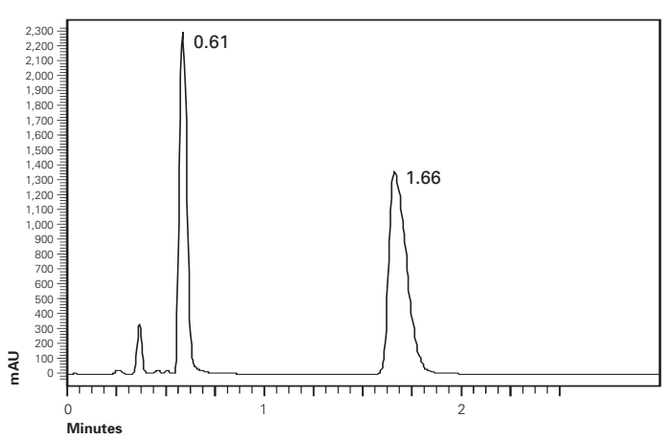
CHIRALCEL® OF

SUPERCRITICAL FLUID CHROMATOGRAPHY COLUMNS

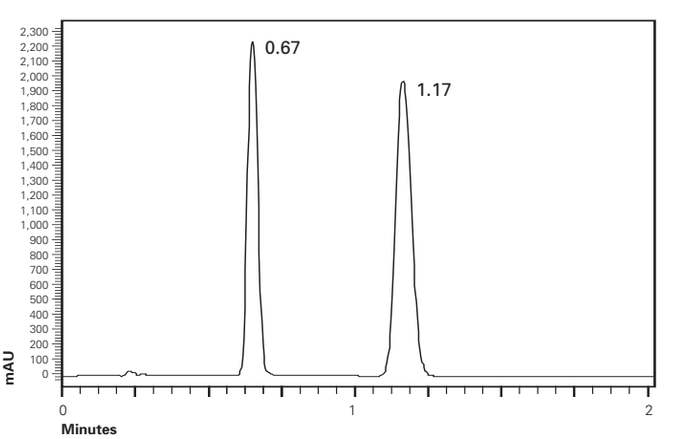
Supercritical fluid chromatography (SFC) offers significant benefits to those performing chiral separations. These benefits include speed of separation, speed of method development, and improved column efficiency. Polysaccharide CSPs marketed by CHIRAL TECHNOLOGIES have long been the most popular columns in SFC separations of enantiomers. Although our analytical HPLC columns may be used in SFC applications, we have introduced short analytical columns (4.6 mm x 100 mm) which are specifically designed for the high speed and high efficiency of SFC. These columns are used for rapid analytical separations and fast screening during method development.

For preparative applications, there are benefits beyond the speed offered by SFC. Use of liquid carbon dioxide is considered a green technology, as there is no net addition to the atmosphere and large quantities of organic solvent are replaced. Recovery of separated product is much faster, as isolated fractions are collected in much smaller volumes of liquid. The marked advantages of this technique in preparative applications led us to manufacture a complete line of preparative columns designed to withstand the elevated pressures used in SFC. Recently we have introduced 5-cm ID columns packed with 5-micron particle stationary phases.

3-Oxo-1-indane carboxylic acid
Column: CHIRALPAK® AD-H (4.6 mm x 100 mm)
Mobile Phase: 20% methanol at 5 mL/min



1-Naphthylethanol
Column: CHIRALPAK® AD-H (4.6 mm x 100 mm)
Mobile Phase: 20% methanol at 5 mL/min

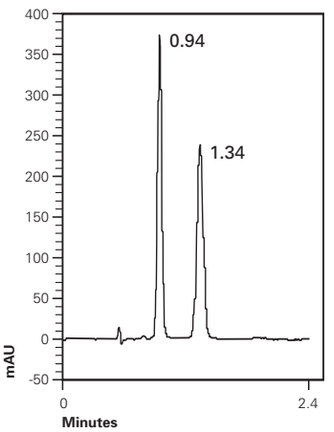


HPLC MICROFLOW CAPILLARY COLUMNS

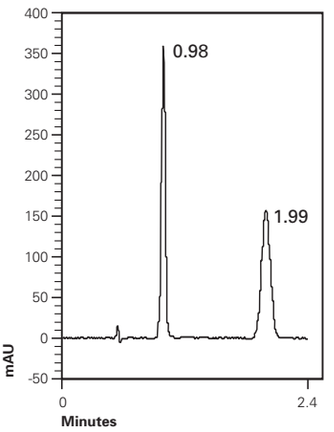
HPLC capillary chiral columns are the newest additions to our laboratory product line. These columns were developed for use with the recently introduced HPLC instruments with microscale liquid pumping and flow control in the 2-20 µL/minute range.

The key advantages for these chiral columns are significant: a 99% reduction in sample amount and mobile phase consumption when compared to standard 4.6 mm ID analytical columns and faster analysis with chiral assays running up to four times faster than conventional HPLC. The impressive reduction in analysis time is due to a very flat Van Deemter curve compared to conventional HPLC. The columns are available with 0.3 mm ID and 150 mm length.

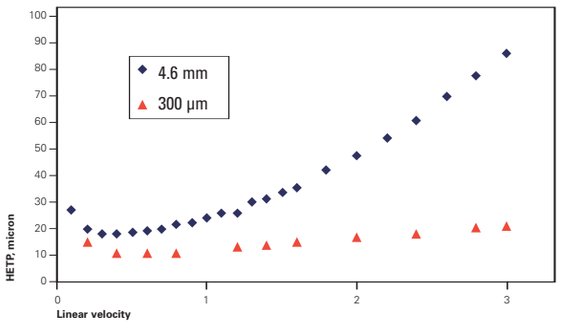
Troger's Base
Column: CHIRALPAK® AD-H® microflow
Mobile Phase: 9/1 hexane/isopropanol
Flow Rate: 17.12 µL/min



Trans-Stilbene Oxide
Column: CHIRALPAK® AD-H® microflow
Mobile Phase: 9/1 hexane/isopropanol
Flow Rate: 17.12 µL/min



ADH: van Deemter
4.6 mm vs. 300 µm



LINDNER PHASE COLUMNS

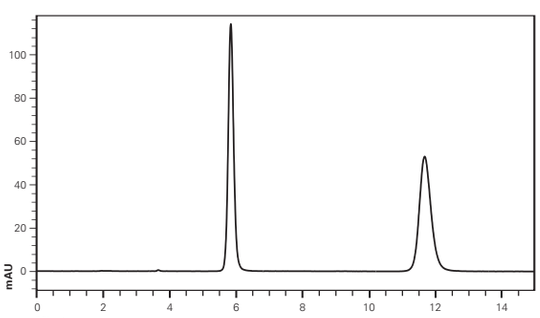
The Daicel Group entered into an exclusive licensing agreement for the chiral chromatography columns invented and developed by Professor Wolfgang Lindner and his colleagues at the University of Vienna.

The chiral selectors for the CHIRALPAK® QD-AX and CHIRALPAK® QN-AX columns are based on complementary quinine (QN) and quinidine (QD) derivative selectors bonded to high-efficiency 5-micron diameter spherical silica. The structure of these selectors is such that a tertiary amine is located in a three-dimensional cleft surrounded by additional hydrogen binding sites and a large aromatic group. This combination provides excellent separations of chiral acids. Reversed-phase, polar organic, normal, and supercritical mobile phases may be used with these columns.

N-Benzoyl-phenylalanine
Column: CHIRALPAK® QD-AX
Mobile Phase: 98/2/0.5 methanol/acetic acid/ammonium acetate

1 ml/min
25°C

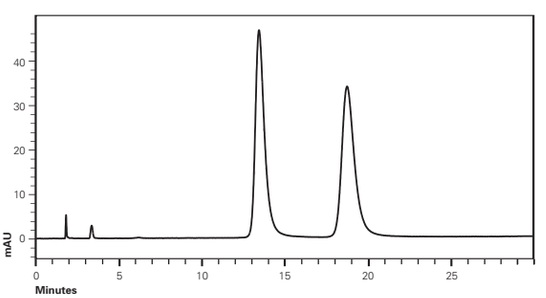
k'_1 = 2.25
k'_2 = 5.49
α = 2.454

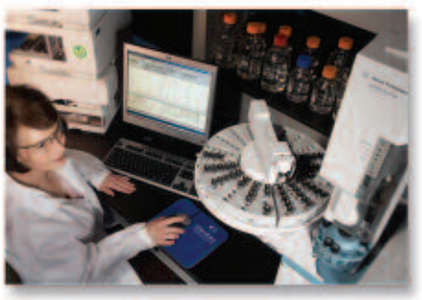


BiNap
Column: CHIRALPAK® QN-AX
Mobile Phase: 98/2/0.5 methanol/acetic acid/ammonium acetate

1 ml/min
25°C

k'_1 = 6.46
k'_2 = 9.41
α = 1.46





ANALYTICAL METHOD DEVELOPMENT

The key to effective chiral separations is the CSP. CHIRAL TECHNOLOGIES offers the products and the services to assist customers in selecting the optimum columns and phases for their chiral separations.

Through our fee-based Application Service, we assist customers in identifying the column that offers optimum resolution for analysis. This service is performed under strict confidentiality.

DAICEL BULK CHIRAL STATIONARY PHASES

Chiral Technologies is pleased to announce the introduction of two immobilized preparative CSPs, CHIRALPAK IA and CHIRALCEL OD-I. These have the same chiral selectors as the 5-micron CHIRALPAK IA and IB CSPs but are available in 20-micron particle size. These immobilized preparative media, allowing the use of a wide range of solvents, will bring new selectivity and higher sample solubility relative to the conventional coated CSPs.

Daicel's Arai (Japan) cGMP production facility can produce these and our traditional coated CSPs in quantities up to the metric ton scale, ensuring adequate quantities of media are available no matter what the scale of the separation.

SEPARATION SERVICES

The Separation Services Group at CHIRAL TECHNOLOGIES offers rapid isolation of pure enantiomers from racemic mixtures at scales from less than one gram to 50 kilograms using preparative-scale SFC, HPLC, and SMB. Our expertise in both HPLC and SFC techniques allows us to develop the fastest and most economic process for a separation project. Our bench-scale SMB unit is used to develop the methodology and associated costs for projects to be carried out in our in-house 5-cm SMB unit or for larger scale production at our customer's facility, at Daicel's Arai Plant, or with a suitable partner.

Separation Services projects start by our developing, free of charge, a suitable preparative separation process for the customer sample. The results from this screening are used to prepare a cost estimate for the requested separation. Upon approval of the estimate, the customer sample passes first through incoming Quality Control (QC). After the separation is completed the enantiomers are analyzed by the QC Group to determine their enantiomeric and achiral purity, the assay for the sample, and residual solvent content. The final products are returned to the customer accompanied by a Certificate of Analysis. For cGMP projects, CHIRAL TECHNOLOGIES adheres to the ICH Q7, paragraph 19 guidelines.

TECHNICAL SUPPORT

CHIRAL TECHNOLOGIES, INC. backs our products and services with full technical support. With access to an extensive database of chiral separations, we can provide guidance on questions related to the separation of a specific compound. Our technical support team assists customers with issues related to the use of our chiral analytical columns, preparative separations using semi-preparative and preparative columns, and questions regarding bulk CSPs and the availability of our outsourcing services.

We provide several ways for customers to obtain rapid and accurate technical support:

- Visit the Frequently Asked Questions (FAQs) area on our company website, www.chiraltech.com. The FAQs are regularly updated to reflect customers' most common and immediate concerns.
- Send an email to questions@chiraltech.com for a rapid response from our team of experts in all areas of chiral chromatography.
- Call our toll-free number, 1-800-6CHIRAL, for those issues that require immediate response.

Clint Amoss, Ph.D., Senior Chemist, Lab Products and Technical Support

Send your email to:
questions@chiraltech.com

PROFESSOR YOSHIO OKAMOTO

The discoveries of Professor Yoshio Okamoto are the basis of the Daicel polysaccharide chiral columns and CSPs. CHIRAL TECHNOLOGIES would like to acknowledge Professor Okamoto's contributions and express our sincere appreciation for inventing the products that are the core of our business.

Professor Okamoto is a native of Osaka, Japan and received his Bachelor's (1964), Master's (1966), and Doctorate (1969) degrees from the Faculty of Osaka University. After receiving his Ph.D., he started his professional career at Osaka University and remained there until joining the Faculty at Nagoya University as a Full Professor in 1990. He continues his scientific research there today as a member of the EcoTopia Science Institute. He is active in numerous professional organizations and in May 2004 was elected President of the Society of Polymer Science in Japan.

His research interests span the areas of stereocontrol in polymerization reactions, asymmetric polymerization, optically active polymers, and enantioseparation by HPLC.

Professor Okamoto's scientific accomplishments have been widely acclaimed. Among his most recent awards are:

- *Fujiwara Prize (2005)*
- *Medal w/Purple Ribbon from Japanese Government (2002)*
- *Chirality Medal (2001)*
- *The Award of the Chemical Society of Japan (1999)*

HPLC Immobilized Analytical Columns

New

CHIRALPAK® IA and IB are the first in a series of immobilized polysaccharide columns. Immobilization provides the column with outstanding solvent tolerance.

PRODUCT NAME	PARTICLE SIZE (µ)	INTERNAL DIAMETER (mm)	COLUMN LENGTH (mm)	PRODUCT TYPE	PART NUMBER
CHIRALPAK IA	5	4.6	150	Analytical	80324
CHIRALPAK IA	5	4.6	250	Analytical	80325
CHIRALPAK IA	5	2.1	150	Analytical	80394
CHIRALPAK IB	5	4.6	150	Analytical	81324
CHIRALPAK IB	5	4.6	250	Analytical	81325
CHIRALPAK IB	5	2.1	150	Analytical	81394

HPLC Analytical Columns — H Series

Our most popular coated phases have been manufactured on high-efficiency 5-micron particles. These columns provide excellent resolution of a broad range of analytes.

PRODUCT NAME	PARTICLE SIZE (µ)	INTERNAL DIAMETER (mm)	COLUMN LENGTH (mm)	PRODUCT TYPE	PART NUMBER
CHIRALPAK AD-H	5	4.6	150	Analytical	19324
CHIRALPAK AD-H	5	4.6	250	Analytical	19325
CHIRALPAK AD-H	5	2.1	150	Analytical	19394
CHIRALPAK AS-H	5	4.6	150	Analytical	20324
CHIRALPAK AS-H	5	4.6	250	Analytical	20325
CHIRALPAK AS-H	5	2.1	150	Analytical	20394
CHIRALCEL OB-H	5	4.6	150	Analytical	12324
CHIRALCEL OB-H	5	4.6	250	Analytical	12325
CHIRALCEL OC-H	5	4.6	250	Analytical	13325
CHIRALCEL OD-H	5	4.6	150	Analytical	14324
CHIRALCEL OD-H	5	4.6	250	Analytical	14325
CHIRALCEL OD-H	5	2.1	150	Analytical	14394
CHIRALCEL OJ-H	5	4.6	150	Analytical	17324
CHIRALCEL OJ-H	5	4.6	250	Analytical	17325
CHIRALCEL OJ-H	5	2.1	150	Analytical	17394

HPLC Analytical Columns

We continue to offer our 10-micron columns to serve the needs of users with established methods based on them. Several CSPs are currently only available in this particle size.

PRODUCT NAME	PARTICLE SIZE (µ)	INTERNAL DIAMETER (mm)	COLUMN LENGTH (mm)	PRODUCT TYPE	PART NUMBER
CHIRALPAK AD	10	4.6	250	Analytical	19025
CHIRALPAK AD	10	2.1	150	Analytical	19094
CHIRALPAK AS	10	4.6	250	Analytical	20025
CHIRALCEL OB	10	4.6	250	Analytical	12025
CHIRALCEL OC	10	4.6	250	Analytical	13025
CHIRALCEL OD	10	4.6	250	Analytical	14025
CHIRALCEL OF	10	4.6	250	Analytical	15025
CHIRALCEL OG	10	4.6	250	Analytical	16025
CHIRALCEL OJ	10	4.6	250	Analytical	17025
CHIRALCEL OK	10	4.6	250	Analytical	18025

Preparative Method Development Columns

Method development columns are packed with 20-µ CSP and match the performance of larger preparative columns. The loading data on these columns yield accurate projections of the full-size separations. The CHIRALPAK IA and CHIRALCEL OD-I columns are packed with the 20-micron equivalents of the analytical immobilized CHIRALPAK IA and IB phases.

PRODUCT NAME	PARTICLE SIZE (µ)	INTERNAL DIAMETER (mm)	COLUMN LENGTH (mm)	PRODUCT TYPE	PART NUMBER
CHIRALPAK IA	20	4.6	250	Method Development	80225
CHIRALPAK AD	20	4.6	250	Method Development	19225
CHIRALPAK AS	20	4.6	250	Method Development	20225
CHIRALCEL OD-I	20	4.6	250	Method Development	82225
CHIRALCEL OD	20	4.6	250	Method Development	14225
CHIRALCEL OJ	20	4.6	250	Method Development	17225

HPLC Microflow Capillary Columns

New

These microbore columns allow assays to run up to 4 times faster than a conventional HPLC while reducing solvent usage by 99%. Ideal for applications requiring speed, high-quality quantitative data, and separation efficiency.

PRODUCT NAME	PARTICLE SIZE (µ)	INTERNAL DIAMETER (mm)	COLUMN LENGTH (mm)	PRODUCT TYPE	PART NUMBER
CHIRALPAK IA	5	0.3	150	Microflow	803C4
CHIRALPAK IB	5	0.3	150	Microflow	813C4
CHIRALPAK AD-H	5	0.3	150	Microflow	193C4
CHIRALPAK AS-H	5	0.3	150	Microflow	203C4
CHIRALCEL OD-H	5	0.3	150	Microflow	143C4
CHIRALCEL OJ-H	5	0.3	150	Microflow	173C4

HPLC Analytical Reversed-Phase Columns

Reversed-phase analytical columns are produced specifically for use with aqueous-organic mobile phases. They are suited for applications involving aqueous samples and are frequently used in LC/MS applications.

PRODUCT NAME	PARTICLE SIZE (µ)	INTERNAL DIAMETER (mm)	COLUMN LENGTH (mm)	PRODUCT TYPE	PART NUMBER
CHIRALPAK AD-RH	5	4.6	150	Analytical Rev Ph	19724
CHIRALPAK AD-RH	5	2.1	150	Analytical Rev Ph	19794
CHIRALPAK AS-RH	5	4.6	150	Analytical Rev Ph	20724
CHIRALPAK AS-RH	5	2.1	150	Analytical Rev Ph	20794
CHIRALCEL OD-R	10	4.6	250	Analytical Rev Ph	14625
CHIRALCEL OD-RH	5	4.6	150	Analytical Rev Ph	14724
CHIRALCEL OD-RH	5	2.1	150	Analytical Rev Ph	14794
CHIRALCEL OJ-RH	5	4.6	150	Analytical Rev Ph	17724
CHIRALCEL OJ-RH	5	2.1	150	Analytical Rev Ph	17794

HPLC Analytical Crown Ether Columns

Crown ether columns are especially effective for compounds with a primary amino group adjacent to the chiral center, as in the resolution of amino acids.

PRODUCT NAME	PARTICLE SIZE (µ)	INTERNAL DIAMETER (mm)	COLUMN LENGTH (mm)	PRODUCT TYPE	PART NUMBER
CROWNPAK CR (+)	5	4.0	150	Analytical	27714
CROWNPAK CR (–)	5	4.0	150	Analytical	28714

HPLC Analytical Ligand Exchange Columns

These columns resolve compounds which form bidentate ligands with copper, such as amino and hydroxyl acids.

PRODUCT NAME	PARTICLE SIZE (µ)	INTERNAL DIAMETER (mm)	COLUMN LENGTH (mm)	PRODUCT TYPE	PART NUMBER
CHIRALPAK MA (+)	3	4.6	50	Analytical	21822
CHIRALPAK WH	10	4.6	250	Analytical	25625

HPLC Analytical Guard Cartridges for Use with Cartridge Holder

For maximum lifetime, analytical columns should be used in series with an appropriate guard cartridge or column. Both formats are available with the packing material to match the protected column. Guard cartridges are mounted in a cartridge holder and utilize the 5-µ material.

Available in packs of 3.

PRODUCT NAME	PARTICLE SIZE (µ)	INTERNAL DIAMETER (mm)	COLUMN LENGTH (mm)	PRODUCT TYPE	PART NUMBER
CHIRALPAK IA	5	4.0	10	Guard Cartridges	80311
CHIRALPAK IB	5	4.0	10	Guard Cartridges	81311
CHIRALPAK AD-H	5	4.0	10	Guard Cartridges	19311
CHIRALPAK AD-RH	5	4.0	10	Guard Cartridges	19711
CHIRALPAK AS-H	5	4.0	10	Guard Cartridges	20311
CHIRALPAK AS-RH	5	4.0	10	Guard Cartridges	20711
CHIRALCEL OB-H	5	4.0	10	Guard Cartridges	12311
CHIRALCEL OD-H	5	4.0	10	Guard Cartridges	14311
CHIRALCEL OD-RH	5	4.0	10	Guard Cartridges	14711
CHIRALCEL OJ-H	5	4.0	10	Guard Cartridges	17311
CHIRALCEL OJ-RH	5	4.0	10	Guard Cartridges	17711

HPLC Analytical Guard Columns

These are stand-alone guard columns which do not require a cartridge holder.

PRODUCT NAME	PARTICLE SIZE (µ)	INTERNAL DIAMETER (mm)	COLUMN LENGTH (mm)	PRODUCT TYPE	PART NUMBER
CHIRALPAK AD	10	4.6	50	Guard Column	19022
CHIRALPAK AS	10	4.6	50	Guard Column	20022
CHIRALCEL OB	10	4.6	50	Guard Column	12022
CHIRALCEL OC	10	4.6	50	Guard Column	13022
CHIRALCEL OD	10	4.6	50	Guard Column	14022
CHIRALCEL OF	10	4.6	50	Guard Column	15022
CHIRALCEL OG	10	4.6	50	Guard Column	16022
CHIRALCEL OJ	10	4.6	50	Guard Column	17022
CHIRALCEL OK	10	4.6	50	Guard Column	18022
CROWNPAK CR	5	4.0	10	Guard Column	27711
CHIRALPAK WH	10	4.6	50	Guard Column	25622

Analytical Chromatography Accessories

Cartridge holders are needed when installing a guard cartridge. Column jackets allow operating temperatures of analytical columns to be controlled with a circulating water bath.

PRODUCT NAME	PARTICLE SIZE (µ)	INTERNAL DIAMETER (mm)	COLUMN LENGTH (mm)	PRODUCT TYPE	PART NUMBER
CARTRIDGE HOLDER	–	4.0	10	Holder	00011
COLUMN JACKET (15 cm)	–	4.6	150	Jacket	00024
COLUMN JACKET (25 cm)	–	4.6	250	Jacket	00025

HPLC Semi-Preparative Columns

Semi-preparative columns permit easy scale-up of a chiral separation using the same CSP as in the analytical columns.

These HPLC semi-preparative columns cannot be used in SFC applications due to the customized hardware that high-pressure SFC requires.

CHIRALCEL OB, OC, OF, OG, and OK semi-preparative columns are available upon request.

PRODUCT NAME	PARTICLE SIZE (µ)	INTERNAL DIAMETER (mm)	COLUMN LENGTH (mm)	PRODUCT TYPE	PART NUMBER
CHIRALPAK IA	5	10	250	Semi-Prep	80335
CHIRALPAK IA	5	20	250	Semi-Prep	80345
CHIRALPAK IA	5	30	250	Semi-Prep	80375
CHIRALPAK IA	20	21	250	Semi-Prep	80275
CHIRALPAK IB	5	10	250	Semi-Prep	81335
CHIRALPAK IB	5	20	250	Semi-Prep	81345
CHIRALPAK IB	5	30	250	Semi-Prep	81375
CHIRALPAK AD	10	10	250	Semi-Prep	19035
CHIRALPAK AD	10	20	250	Semi-Prep	19045
CHIRALPAK AD	20	21	250	Semi-Prep	19245
CHIRALPAK AD-H	5	10	250	Semi-Prep	19335
CHIRALPAK AD-H	5	20	250	Semi-Prep	19345
CHIRALPAK AD-H	5	30	250	Semi-Prep	19375
CHIRALPAK AS	10	10	250	Semi-Prep	20035
CHIRALPAK AS	10	20	250	Semi-Prep	20045
CHIRALPAK AS	20	21	250	Semi-Prep	20245
CHIRALPAK AS-H	5	10	250	Semi-Prep	20335
CHIRALPAK AS-H	5	20	250	Semi-Prep	20345
CHIRALPAK AS-H	5	30	250	Semi-Prep	20375
CHIRALCEL OD	10	10	250	Semi-Prep	14035
CHIRALCEL OD	10	20	250	Semi-Prep	14045
CHIRALCEL OD	20	21	250	Semi-Prep	14245
CHIRALCEL OD-H	5	10	250	Semi-Prep	14335
CHIRALCEL OD-H	5	20	250	Semi-Prep	14345
CHIRALCEL OD-H	5	30	250	Semi-Prep	14375
CHIRALCEL OJ	10	10	250	Semi-Prep	17035
CHIRALCEL OJ	10	20	250	Semi-Prep	17045
CHIRALCEL OJ	20	21	250	Semi-Prep	17245
CHIRALCEL OJ-H	5	10	250	Semi-Prep	17335
CHIRALCEL OJ-H	5	20	250	Semi-Prep	17345
CHIRALCEL OJ-H	5	30	250	Semi-Prep	17375

HPLC Semi-Preparative Reversed-Phase Columns

Reversed-phase columns are suited for applications where the sample is presented in aqueous media.

Perchlorate acids and buffers must be avoided in preparative applications as they pose an explosion hazard during product isolation!

PRODUCT NAME	PARTICLE SIZE (µ)	INTERNAL DIAMETER (mm)	COLUMN LENGTH (mm)	PRODUCT TYPE	PART NUMBER
CHIRALPAK AD-RH	5	20	250	Semi-Prep Rev Ph	19745
CHIRALPAK AS-RH	5	20	250	Semi-Prep Rev Ph	20745
CHIRALCEL OD-RH	5	21	250	Semi-Prep Rev Ph	14745
CHIRALCEL OJ-RH	5	20	250	Semi-Prep Rev Ph	17745

HPLC Semi-Preparative Guard Columns

For extended lifetime, semi-preparative columns should be used in series with an appropriate guard column. Semi-preparative guard columns contain 20-µ material for minimum pressure drop and maxiumum flow.

PRODUCT NAME	PARTICLE SIZE (µ)	INTERNAL DIAMETER (mm)	COLUMN LENGTH (mm)	PRODUCT TYPE	PART NUMBER
CHIRALPAK IA	20	21	50	Semi-Prep Guard	80242
CHIRALPAK AD	20	21	50	Semi-Prep Guard	19242
CHIRALPAK AS	20	21	50	Semi-Prep Guard	20242
CHIRALCEL OD	20	21	50	Semi-Prep Guard	14242
CHIRALCEL OJ	20	21	50	Semi-Prep Guard	17242

HPLC Preparative Columns

Preparative columns are packed with 20-µ CSP. These columns are water-jacketed and come with their own wheeled stand. Installation and on-site testing included.

These HPLC preparative columns cannot be used in SFC applications due to the customized hardware that high-pressure SFC requires.

PRODUCT NAME	PARTICLE SIZE (µ)	INTERNAL DIAMETER (mm)	COLUMN LENGTH (mm)	PRODUCT TYPE	PART NUMBER
CHIRALPAK IA	20	50	500	Preparative	80256
CHIRALPAK IA	20	100	500	Preparative	80266
CHIRALPAK AD	20	50	500	Preparative	19256
CHIRALPAK AD	20	100	500	Preparative	19266
CHIRALPAK AS	20	50	500	Preparative	20256
CHIRALPAK AS	20	100	500	Preparative	20266
CHIRALCEL OD	20	50	500	Preparative	14256
CHIRALCEL OD	20	100	500	Preparative	14266
CHIRALCEL OF	20	50	500	Preparative	15256
CHIRALCEL OF	20	100	500	Preparative	15266
CHIRALCEL OJ	20	50	500	Preparative	17256
CHIRALCEL OJ	20	100	500	Preparative	17266

SMB Column Sets

SMB technology is a continuous, efficient process suitable for production of metric tons per year of pure chiral material. SMB method development columns are manufactured, tested, and sold as a matched set of 8 to perform lab studies for development and optimization of large-scale SMB separations.

PRODUCT NAME	PARTICLE SIZE (µ)	INTERNAL DIAMETER (mm)	COLUMN LENGTH (mm)	PRODUCT TYPE	PART NUMBER
CHIRALPAK IA	20	10	100	SMB (set of 8)	80233
CHIRALPAK AD	20	10	100	SMB (set of 8)	19233
CHIRALPAK AS	20	10	100	SMB (set of 8)	20233
CHIRALCEL OD-I	20	10	100	SMB (set of 8)	82233
CHIRALCEL OD	20	10	100	SMB (set of 8)	14233
CHIRALCEL OJ	20	10	100	SMB (set of 8)	17233

SFC Analytical Screening Columns

New

These columns were developed for rapid screening by SFC. Use of the short length allows higher flow rates with less sacrifice of column efficiency than with HPLC. They may also be used for fast analysis and for routine analysis where the separation is sufficient.

PRODUCT NAME	PARTICLE SIZE (µ)	INTERNAL DIAMETER (mm)	COLUMN LENGTH (mm)	PRODUCT TYPE	PART NUMBER
CHIRALPAK IA	5	4.6	100	Screening	80423
CHIRALPAK IB	5	4.6	100	Screening	81423
CHIRALPAK AD-H	5	4.6	100	Screening	19423
CHIRALPAK AS-H	5	4.6	100	Screening	20423
CHIRALCEL OD-H	5	4.6	100	Screening	14423
CHIRALCEL OJ-H	5	4.6	100	Screening	17423

SFC Semi-Preparative Columns

The speed of separation coupled with the ease of isolating product from mobile phase makes SFC an ideal choice for preparative resolution. Semi-preparative columns are offered in 1-, 2.1-, and 3-cm IDs.

Note: HPLC semi-preparative columns cannot be used in SFC applications due to the customized hardware that high-pressure SFC requires.

PRODUCT NAME	PARTICLE SIZE (µ)	INTERNAL DIAMETER (mm)	COLUMN LENGTH (mm)	PRODUCT TYPE	PART NUMBER
CHIRALPAK IA	5	10	250	Semi-Prep	80435
CHIRALPAK IA	5	21	250	Semi-Prep	80445
CHIRALPAK IA	5	30	250	Semi-Prep	80475
CHIRALPAK IB	5	10	250	Semi-Prep	81435
CHIRALPAK IB	5	21	250	Semi-Prep	81445
CHIRALPAK IB	5	30	250	Semi-Prep	81475
CHIRALPAK AD-H	5	10	250	Semi-Prep	19435
CHIRALPAK AD-H	5	21	250	Semi-Prep	19445
CHIRALPAK AD-H	5	30	250	Semi-Prep	19475
CHIRALPAK AS-H	5	10	250	Semi-Prep	20435
CHIRALPAK AS-H	5	21	250	Semi-Prep	20445
CHIRALPAK AS-H	5	30	250	Semi-Prep	20475
CHIRALCEL OD-H	5	10	250	Semi-Prep	14435
CHIRALCEL OD-H	5	21	250	Semi-Prep	14445
CHIRALCEL OD-H	5	30	250	Semi-Prep	14475
CHIRALCEL OJ-H	5	10	250	Semi-Prep	17435
CHIRALCEL OJ-H	5	21	250	Semi-Prep	17445
CHIRALCEL OJ-H	5	30	250	Semi-Prep	17475
CHIRALCEL OF	10	10	250	Semi-Prep	15135
CHIRALCEL OF	10	21	250	Semi-Prep	15145
CHIRALCEL OF	10	30	250	Semi-Prep	15175
CHIRALCEL OG	10	10	250	Semi-Prep	16135
CHIRALCEL OG	10	21	250	Semi-Prep	16145
CHIRALCEL OG	10	30	250	Semi-Prep	16175

5-cm SFC Preparative Columns *New*

The recent success of semi-preparative SFC has led to our introduction of 5-cm ID columns. These columns are packed with high-efficiency 5-µ particles.

PRODUCT NAME	PARTICLE SIZE (µ)	INTERNAL DIAMETER (mm)	COLUMN LENGTH (mm)	PRODUCT TYPE	PART NUMBER
CHIRALPAK IA	5	50	250	Preparative	80455
CHIRALPAK IB	5	50	250	Preparative	81455
CHIRALPAK AD-H	5	50	250	Preparative	19455
CHIRALPAK AS-H	5	50	250	Preparative	20455
CHIRALCEL OD-H	5	50	250	Preparative	14455
CHIRALCEL OJ-H	5	50	250	Preparative	17455

Bulk CSP

Bulk CSP is supplied for large-scale SMB as well as single-column HPLC applications. Material is readily available in kilogram quantities. Larger quantities are available upon request.

PRODUCT NAME	PARTICLE SIZE (µ)	QUANTITY	COLUMN LENGTH (mm)	PRODUCT TYPE	PART NUMBER
CHIRALPAK IA	20	1 kg	–	CSP	80220
CHIRALPAK AD	20	1 kg	–	CSP	19020
CHIRALPAK AS	20	1 kg	–	CSP	20020
CHIRALCEL OD-I	20	1 kg	–	CSP	82020
CHIRALCEL OD	20	1 kg	–	CSP	14020
CHIRALCEL OF	20	1 kg	–	CSP	15020
CHIRALCEL OJ	20	1 kg	–	CSP	17020

The Lindner columns are designed specifically for enantioselective resolution of chiral acids by HPLC.

PRODUCT NAME	PARTICLE SIZE (µ)	INTERNAL DIAMETER (mm)	COLUMN LENGTH (mm)	PRODUCT TYPE	PART NUMBER
QUINIDINE					
CHIRALPAK QD-AX	5	4.6	150	Analytical	31324
CHIRALPAK QD-AX	5	2.1	150	Analytical	31394
CHIRALPAK QD-AX	5	20	150	HPLC Semi-Prep	31344
CHIRALPAK QD-AX	5	4.0	10	Guard Cartridge	31311
QUININE					
CHIRALPAK QN-AX	5	4.6	150	Analytical	32324
CHIRALPAK QN-AX	5	2.1	150	Analytical	32394
CHIRALPAK QN-AX	5	20	150	HPLC Semi-Prep	32344
CHIRALPAK QN-AX	5	4.0	10	Guard Cartridge	32311

PROFESSOR WOLFGANG LINDNER AND COLLEAGUES

The most recent chiral chromatography products licensed by the Daicel Group are the cinchona-based chiral stationary phases (CSPs) invented in the laboratory of Professor Wolfgang Lindner (center) of the University of Vienna, along with two colleagues, Associate Professors Michael Lammerhofer (right) and Norbert M. Maier (left). Their work focused on cinchona alkaloids as chiral selector scaffolds and established a detailed mechanistic understanding of enantioselective binding for acidic analytes with cinchona carbamates. This in turn led to the identification of tert.-butyl carbamate derivatives of quinine and quinidine as the preferred selectors for the separation of acidic analytes using reversed-phase and polar organic mobile phases.

- *Prof. Lindner was born in Bavaria, grew up in Austria, and was educated at the University of Vienna and University of Graz (Austria). Upon receiving his doctorate in chemistry he joined the Institute of Pharmaceutical Chemistry at the University of Graz. In 1996 he moved to the University of Vienna as the Chair for Analytical Chemistry. He currently heads the Department of Analytical Chemistry and Food Chemistry at the University of Vienna.*
- *Prof. Lammerhofer is a native of Austria and did his Ph.D. studies with Professor Lindner in Graz before joining the Faculty of Chemistry at the University of Vienna. He remains active in the field of chiral separations with particular interest in miniaturized enantiomer separation techniques.*
- *Dr. Maier is also from Austria and joined the Lindner Group at the University of Vienna in 1997 after working with Professor Georg Uray at the University of Graz on donor-acceptor type CSPs. His current research interests are mainly in the area of molecular recognition.*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