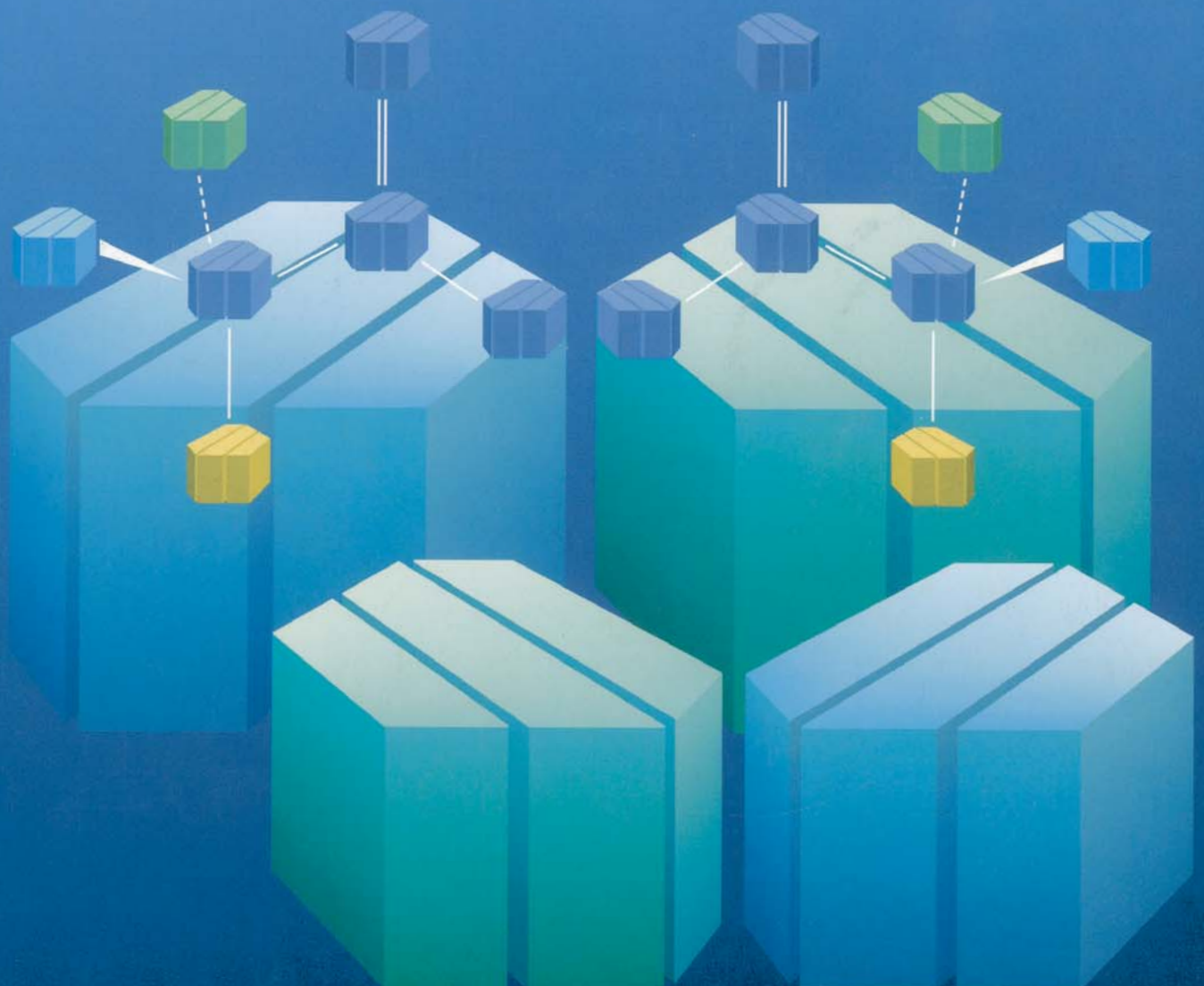
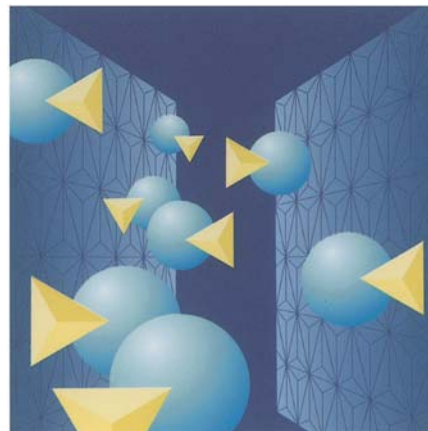




Chiral Compounds Chemistry

Your $\Delta\Delta G^\ddagger$:
Analytical Reagents
Preparative Compounds





Fluka Chemie AG, domiciled in Buchs, Switzerland, was founded in 1950. The company has become one of the world's leading suppliers of fine chemicals, biochemicals and analytical reagents.

We develop, produce, analyze and market a very wide range of products. These 16 000 items are used primarily in research and development and as intermediates for industrial manufacturing. The full range is described in the main catalogue, or on a computer disk, backed by a wealth of extensive scientific and technical information.

Fluka – Committed to Reliability

Fluka's reliability consists of three elements:

- quality
- service
- competence

Fluka – Committed to Quality

Well-motivated employees, used to dealing with your requirements, as well as with all aspects of modern chemistry, and a powerful and flexible state-of-the-art production plant are the prerequisites for the quality you need.

The quality assurance system guarantees that each product

- is specified for identity, purity and specific application-oriented quality criteria,
- is only released after careful analysis of each batch and subsequent validation by the analytical product manager,
- is thoroughly described with technical information, risk, safety, toxicological and ecological data, application hints and literature if required,
- is packed carefully and in a user-friendly way to maintain the high quality of the product.

Fluka – Committed to Service

An excellent and reliable service can be guaranteed through the Fluka subsidiaries and the worldwide Sigma-Aldrich distribution network.

The elements of that highly sophisticated logistics are

- local sales organisations and stocks to provide the shortest delivery times for goods,
- a computer network, enabling us to inform customers immediately about delivery, costs, quality and legal aspects,
- performance control of service parameters for a continuous improvement of service levels.

Fluka – Competence in Chiral Compounds

Chirality has become a very important and omnipresent aspect in the reflections of chemists, and this trend will surely continue to grow.

These compounds have contributed prominently to the Fluka Prize winning reagents. The following list shows the Fluka Prizes granted so far in this field:

1987:

Prof. Dr. D. Seebach for a versatile, chiral acetoacetic acid derivative

1989:

Prof. Dr. R. Noyori and Prof. Dr. H. Takaya for the BINAP-Ru(II)acetate complexes

1994:

Prof. Dr. E. N. Jacobsen for his catalytically active Salen-Mn complexes.

The third edition of our «Chiral Compounds» brochure contains many new and several novel user-friendly features, such as the arrangement of products in chapters according to application types, and the listing of entries according to functional groups. We hope this brochure will support our customers in their work in chiral compounds chemistry.

Chiral Compounds Chemistry

Your $\Delta\Delta G^\ddagger$:
Analytical Reagents
Preparative Compounds

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Introduction

In response to a general request expressed by our customers, and to the feeling that the community of organic chemists should be informed of the rapidly growing number of chiral compounds in the Fluka range, we have decided to publish this new edition of the Fluka Chiral Compounds brochure.

Competence and Ability

Many years of experience in the *production* and *quality assurance* of chiral compounds have made Fluka a leading chiral fine chemicals supplier.

Fluka was first to analyze, specify and guarantee the enantiomeric purity (also called enantiomeric ratio, optical purity, "ee", etc.) of the more important chiral reagents used to assay the enantiomeric purity of compounds.

Structure and Content of this Brochure

This brochure is divided into two main parts, "Analytical Reagents" and "Preparative Compounds". The latter is further subdivided into groups such as "Catalysts and Ligands", "Enzymes", "Auxiliaries", "Building Blocks", "Resolving Agents" and "Natural Products". Chiral compounds are entered in these chapters of the brochure according to important applications. Certain compounds can thus appear in more than one chapter. At the end of the brochure, you will find a complete alphabetical index of all the entries.

Bulk Quantities, Custom Synthesis, GMP Production

Bulk Quantities

Most of the chemicals listed in this brochure can be supplied in larger quantities. Contact us for a prompt quotation on price and delivery!

Custom Synthesis

Feel free to ask for an offer if you would like to buy – on a customer synthesis base – a substance we do not list in the catalogue.

GMP Production

We would like to point out that we are able to produce many of the compounds according to GMP rules.

$\Delta\Delta G^\ddagger$ is the active principle steering an asymmetric reaction in the right direction.

$\Delta\Delta G^\ddagger$ seems to us a very fitting symbol for our range of chiral compounds: our quality, our reliability and our service will make all the difference for you:

Fluka Chiral Compounds

It's that certain $\Delta\Delta G^\ddagger$ that makes all the difference.

Abbreviations and Symbols

D-, L-	Designation given to carbohydrates, amino acids, lipids and those compounds whose stereochemistry is derived from carbohydrates and amino acids, according to the corresponding conventions.	sn-	Stereospecific numbering, applied to chiral lipids (glycerol derivatives). In the Fischer projection the central hydroxyl group is positioned to the left and the C atoms are numbered 1–3 starting from above.
D(+)-	Specifically indicates the direction of optical rotation in addition to the D- (or L-) affix, hence providing a more accurate characterization.	rac.	is only used in the synonym for racemic lipids.
DL-	Denotes the racemate of a compound whose enantiomers have the designation D- or L-.	ee	Enantiomeric excess, specifies the excess of the predominant enantiomer over the racemic part in a mixture as a percentage. $ee = \frac{A-B}{A+B} \cdot 100$
(+)- or (-)-... D- or L-	Derivatives of compounds designated with D- or L-; the direction of rotation refers to the derivative.		A: predominant enantiomer B: its antipode
d, l	Rare designations used for compounds derived from a natural product with a positive (d-) or negative (l-) optical rotation.	er	Enantiomeric ratio, specifies the proportion of both enantiomers in the product, e.g., er: (R):(S) > 99.5:0.5.
erythro- threo-	Compounds with two vicinal asymmetric centres. erythro: in the Fischer projection the two similar substituents point to the same side; threo: in the Fischer projection the two similar substituents point to different sides.		
(R)-, (S)-	Indicates compounds with one asymmetric centre which is systematically designated according to the CIP sequence rule procedure.		
R(+)-, S(-)-	Indicates in addition the direction of rotation.		
(aR, bR,...)	Indicates compounds with two or more asymmetric centres, classified systematically according to the sequence rule (a and b define the positions).		
(+)-(aR, bR...)-	Analogous with the above.		
(±)-	Indicates a racemate whose enantiomers have been designated according to the sequence rule procedure; this symbol is stated only when the (R)- and/or (S)- enantiomers are present in the catalogue.		
(+)-, (-)-	Some natural products have adopted this designation (e.g. camphor); the systematic nomenclature of the synonym is in accordance with the sequence rule.		

Enantiomeric Purity Determinations

The results of one of the most spectacular areas in organic chemistry in the last 25 years, namely the synthesis of enantiomerically pure compounds (EPC synthesis) [1] are still largely dependent on reliable enantiomeric purity determinations. This concerns basic research as well as the industrial production of chiral compounds, especially pharmaceutical agents. The importance of exact specifications including enantiomeric purity will increase, chiefly as a consequence of legislative guidelines.

- Polarimetry* [2 a], the classical method of enantiomeric purity determination, suffers from several drawbacks, such as
- a possible non-linearity between substrate concentration and the measured optical rotation,
 - the necessity to know the optical rotation of the enantiomerically pure substrate under the exact measuring conditions,
 - (frequently) a limit of accuracy that is not below 2–3 % [3].

Ever since the late 1960s, *NMR spectroscopic methods* have become very popular [4, 5]. These methods are not hampered by the above-mentioned disadvantages of the chiroptical methods, except that their accuracy is not sufficient for specifying enantiomeric excesses (ee's) above 98 %, either. ^1H , ^{19}F and ^{13}P -NMR spectroscopy has been used. Since NMR spectra of enantiomers in an achiral environment are identical, ee determination has to follow one of two courses. Either you measure a sample of chiral material in a chiral environment (chiral solvent or additive [2b] or chiral shift reagent [2c, 9], which constitutes the "direct method", or you derivatise a sample of chiral material with a chiral, optically pure reagent [2d] to form a pair of diastereoisomers, which in principle differ in a "normal" NMR spectrum; this latter procedure is called the "indirect method" (\rightarrow ChiraSelect).

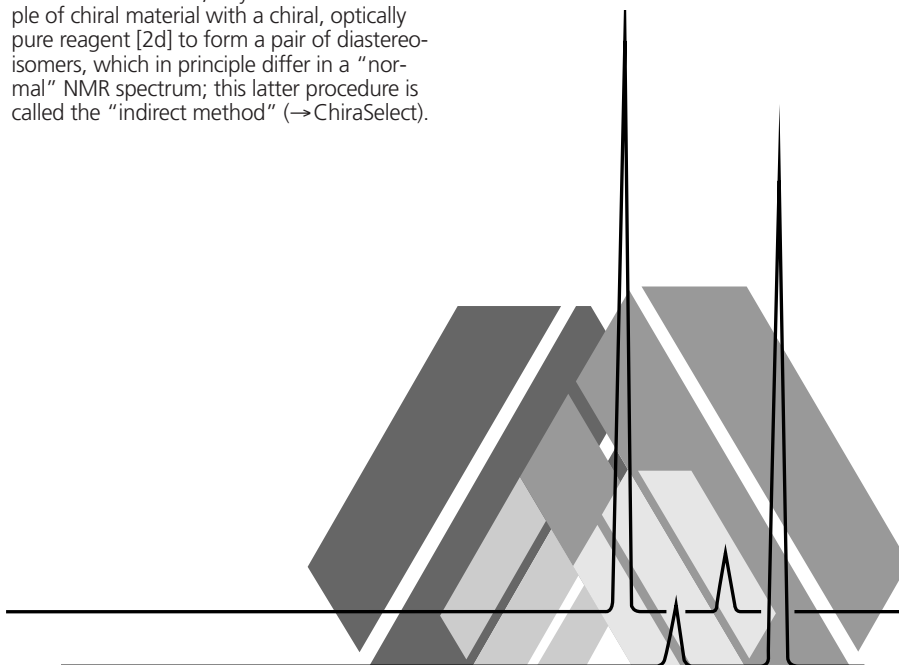
The *chromatographic methods* [2f, 3, 6, 7] have turned out to be most important. They have the essential advantage of a high accuracy with ee's approaching 100 %. GC [2e, 3b, 6, 8a, 9], HPLC [2f, 3c, 8b] and TLC [8c] methods have been employed. Again, a distinction can be made between "direct" methods, i.e. enantiomer separation on chiral phases (CSPs) and "indirect" methods, i.e. derivatisation of enantiomers with an optically pure reagent (\rightarrow ChiraSelect) and separation of the resulting diastereoisomers on conventional achiral phases.

The development of new chiral phases has been extended in the last few years, and CSPs have become commercially available. Whereas the current literature is dominated by this approach, the "indirect" methods are still very popular in application-oriented analytical laboratories, since they show the following advantages:

- cheap, well standardized chromatography columns can be used,
- a large variety of eluents (HPLC) is possible,
- large substrate spectrum with today's commercially available derivatising agents

Please note that in the case of the "indirect" methods only derivatising agents with the highest optical purity can furnish accurate results.

Many of these reagents are routinely used at Fluka in the quality control of chiral compounds. In case of application-oriented questions benefit from our know-how and contact the Fluka technical service!



Fluka Chiral Compounds.

It's that certain $\Delta\Delta G^\ddagger$
that makes all the difference.

ChiraSelect Quality Grade

ChiraSelect – a unique Fluka quality set of the most useful chiral derivatisation reagents, carefully produced and rigorously analysed in our laboratories for all your analytical applications in the chiral field.

ChiraSelect reagents are specially selected to meet the requirements for derivatisation reagents for ee determinations.

To meet any analytical situation, the

Chira-Select line provides pairs of reagents, each respective enantiomer exhibiting an enantiomeric ratio of 99.5:0.5 at least. As a rule, the actual value is distinctly higher in most cases.

For application methods and procedures, as well as literature references, see our ChiraSelect Info Sheet which is available on request.

The ChiraSelect Programm


15226 (+)-Diisopropyl 0,0'-bis(trimethylsilyl)-L-tartrate	65363 R(-)- α -Methoxy- α -trifluoromethylphenylacetic acid chloride [(-)-MTPA-Cl, Mosher's acid chloride]
15223 (-)-Diisopropyl 0,0'-bis(trimethylsilyl)-D-tartrate	65365 S(+)- α -Methoxy- α -trifluoromethylphenylacetic acid chloride [(+)-MTPA-Cl, Mosher's acid chloride]
21286 (+)-Camphanic acid chloride	70710 R(+)-1-(1-Naphthyl)ethylamine [(+)-NEA]
21287 (-)-Camphanic acid chloride	70712 S(-)-1-(1-Naphthyl)ethylamine [(-)-NEA]
23182 (+)-FLEC, 50 mg, acetone solution	70725 R(-)-1-(1-Naphthyl)ethyl isocyanate stab. [(-)-NEIC]
23183 (-)-FLEC, 50 mg, acetone solution	70726 S(+)-1-(1-Naphthyl)ethyl isocyanate stab. [(+)-NEIC]
39145 (3aR,7aR)-2-Dimethylamino-1,3-dimethyloctahydro-1H-1,3,2-benzodiazaphosphole solution	74865 R(-)-2-Octanol
39155 (3aS,7aS)-2-Dimethylamino-1,3-dimethyloctahydro-1H-1,3,2-benzodiazaphosphole solution	74863 S(+)-2-Octanol
40764 (R)-2,8-Dimethyl-5, 11-methanodibenzo-[b, f] [1,5]diazocine, [(+)-Tröger's base]	76744 R(+)-1-(Pentafluorophenyl)ethanol
40765 (S)-2,8-Dimethyl-5, 11-methanodibenzo-[b, f] [1,5]diazocine, [(-)-Tröger's base]	76746 S(-)-1-(Pentafluorophenyl)ethanol
42100 N α -(2,4-Dinitro-5-fluorophenyl)-D-valinamide	77848 R(+)-1-Phenylethanol
42102 N α -(2,4-Dinitro-5-fluorophenyl)-L-valinamide	77849 S(-)-1-Phenylethanol
42197 R(-)-3,5-Dinitro-N-(1-phenylethyl)benzamide	77879 D(+)- α -Methylbenzylamine [R(+)-1-Phenylethylamine, (+)-PEA]
42198 S(+)-3,5-Dinitro-N-(1-phenylethyl)benzamide	77869 L(-)- α -Methylbenzylamine [S(-)-1-Phenylethylamine (-)-PEA]
58689 N-Isobutyryl-D-cysteine	77968 R(+)-1-Phenylethyl isocyanate stab. [(+)-PEIC]
58698 N-Isobutyryl-L-cysteine	77970 S(-)-1-Phenylethyl isocyanate stab. [(-)-PEIC]
65209 R(-)- α -Methoxyphenylacetic acid	
65208 S(+)- α -Methoxyphenylacetic acid	
65361 R(+)- α -Methoxy- α -trifluoromethylphenylacetic acid [(+)-MTPA, Mosher's acid]	
65369 S(-)- α -Methoxy- α -trifluoromethylphenylacetic acid [(-)-MTPA, Mosher's acid]	

86550
2,3,4,6-Tetra-O-acetyl- β -D-glucopyranosyl isothiocyanate (GITC)
86729
2,3,4,6-Tetra-O-benzoyl- β -D-glucopyranosyl isothiocyanate
88102
2,3,4,6-Tetra-O-pivaloyl- β -D-galactopyranosyl isothiocyanate
90245
2,3,4-Tri-O-acetyl- α -D-arabinopyranosyl isothiocyanate (AITC)
93510
(S)-Trolox TM methyl ether

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Typical Product Entry

①
 ②
 ③ **D(+)- α -Methylbenzylamine** ●●● [R(+)-1-Phenylethylamine]
 ④ ●●● C₈H₁₁N M_r 121.18 [3886-69-9] BRN 2410916 EEC No.: 2234234
 ⑤
 ⑥
 ⑦
 ⑧
 ⑨
 ⑩ 77879 ChiraSelect; >99% (GC); bp 187–189°; d₄²⁰ 0.952; n_D²⁰ 1.528; 1l ≈ 0.95 kg 5 ml
 0–4° [α]_D²⁰ +36 ± 1°; [α]_D²⁰ +30 ± 1° (c=10 in ethanol); er: R:S 25 ml
 ⑪ >99.5:0.5 (GC)
 ⑫
 ⑮ ●●●
 ⑬ Chiral amine used for the determination of the enantiomeric purity of acids: W. H. Pirkle, J. Finn, in
 Asymmetric Synthesis, vol. 1, J. D. Morrison, ed., Academic Press, New York, 1983, p. 87; R. W. Souter,
 Chromatographic Separations of Stereoisomers, CRC Press, Boca Raton, 1985
 ⑭ ●●● Beil. 12, IV, 2424, Fieser 1, 838, 2, 271, 3, 199, 5, 441, 6, 457, 11, 411, 12, 319, 13, 185 ⑯
 ⑰
 ⑱  R: 34; S: 23–28; F: 3–10–23
 RID/ADR 8/53c Flpt. 70° CH-Giftkl. 4 ●●● ⑰
 ⑲
 ⑳
 ㉑
 ㉒
 ㉓
 ㉔
 ㉕

- ① Synonyms
- ② Usual Abbreviations
- ③ Product Name
- ④ Extended Formula
- ⑤ Empirical Formula
- ⑥ Molecular Mass
- ⑦ CAS-No. (Chemical Abstract Registry Number)
- ⑧ BRN: Beilstein Registry Number; for research with the Beilstein data base
- ⑨ EEC No: corresponds with the EINECS (European Inventory of Existing Commercial Chemical Substances) or ELINCS (European List of Notified Chemical Substances) number.
- ⑩ Product Number (please state product number when ordering)
- ⑪ Storage Temperature
- ⑫ Special Quality (description see page 4, Fluka Catalogue 1995/96)
- ⑬ Literature references about applications etc.
- ⑭ Merck Index reference to "The Merck Index"
 e.g. Merck Index 11, 453 ————— index
 ————— volume
- ⑮ Beilstein reference to "Beilsteins Handbuch der Organischen Chemie"
 e.g. Beil. 4, IV, 4008 ————— page
 ————— supplement
 ————— volume
 alternative example for a citation from the 5th supplement
 e.g. Beil. 23, 7, V, 144 ————— page
 ————— supplement
 ————— part
 ————— volume
- ⑯ Fieser reference to "Reagents for Organic Synthesis", L.F. Fieser & M. Fieser
 e.g. Fieser 1, 838, 2, 271, 3, 199, 5, 441, 6, 457, 11, 411, 12, 319, 13, 185
 ————— page
 ————— volume
- ⑰ F phrases: Information on properties and handling (see page 9, Fluka Catalogue 1995/96)
- ⑱ Hazard Symbols (acc. EEC-directions; see page 10, Fluka Catalogue 1995/96)
- ⑲ RTECS-No. ["Registry of Toxic Effects of Chemical Substances", NIOSH (National Institute for Occupational Safety and Health)]
- ⑳ Risks and Safety Phrases R: Nature of the special risks attaching to dangerous substances (see page 11, Fluka Catalogue 1995/96)
 S: Safety advice concerning dangerous chemical substances (see page 12, Fluka Catalogue 1995/96)
- ㉑ RID/ADR-European agreement on the international transport of dangerous goods on the road (see also page 12, Fluka Catalogue 1995/96)
- ㉒ Flash Point in °C
- ㉓ CH-Giftkl.: Swiss toxicity classification (CH)
- ㉔ WGK: German water hazard classification
- ㉕ Guaranteed specifications

Preparative Compounds

Chiral compounds employed for synthetic applications are presented in this part of the brochure. In order to make this section more transparent, it has been subdivided into six chapters, briefly characterized as follows:

Catalysts and Ligands

Catalysts and ligands, as well as their direct precursors, are treated in this chapter. These compounds foster reactions *catalytically*. Classifying compounds for the chapters "Catalysts and Ligands" and "Auxiliaries" (see below) proved to be a difficult task because several of them can either be employed catalytically or stoichiometrically in some reactions. The importance of catalytic processes and their potential for future applications in medium and large scale syntheses have prompted us to create this separate chapter.

Enzymes

Enzymes are becoming increasingly more important as catalysts for chemical reactions and processes. Those enzymes which are of value to the organic chemist in enantioselective synthesis are included in this brochure. Many other enzymes can be found in our main catalogue and in our recent special brochure, "Enzymes".

Auxiliaries

Chiral compounds which are used as auxiliary compounds in asymmetric reactions and which act *stoichiometrically* can be found here. Resolving agents, a special group of auxiliary compounds, have been assigned a separate chapter.

Building Blocks

Chiral compounds which are fully or partly incorporated into the target molecule during a synthesis carry the label "chiral building block".

Most N-protected amino acids and amino acid esters, for instance, are not included in this brochure because their main application, peptide synthesis, is not topical here.

Resolving Agents

Reagents employed for the preparative resolution of racemates are treated in this chapter. Analytical applications, such as the determination of enantiomeric purity of chiral compounds, which are also often termed "resolution", are detailed in the first part "Analytical Reagents" of this brochure.

Natural Products (Alkaloids, Amino Acids, Carbohydrates, Terpenes)

A selection from our range of natural products, being of value to the scientist interested in the analysis and the synthesis of enantiomerically pure compounds, is presented here.

Compounds which apply to more than one of the above sections will also appear in the respective chapters.

Other less frequently used preparative chiral compounds not mentioned in one of the above chapters can be found in our main catalogue.

Catalysts and Ligands

Enantioselective catalysis [1] in which a small amount of chiral, enantiomerically pure or enriched material can transmit chirality information to a large amount of substrate, is the most efficient way of enantioselective synthesis. Two kinds of catalysts have proved to be most widely used so far: enzymes (see chapter below) and *transition metal complexes* for *homogeneous* reaction conditions.

Using chiral types of Wilkinson catalysts, Horner and coworkers [2] and Knowles and Sabacky [3] reported the first successful results of homogeneous catalysis in enantioselective synthesis in 1968. Since that time, chemists have got increasingly better at the "game with non-covalent bonding and steric hindrance" [4], and almost every reaction generating chirality has been performed with moderate to good enantioselectivity. Several excellent literature reviews concerning scope and limitation, reactivity, selectivity and mechanism of enantioselective catalysis have appeared [5, 6] (up to 1984), [7–16].

Catalysts and ligands linked to the most outstanding achievements in this field have been united under the *Chiralysts* label.

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The Chiralysts Label

Selected chiral non racemic catalysts, ligands and enzymes for enantioselective and diastereoselective catalysis in synthetic organic chemistry.

Both enantiomers available.

Highest enantiomeric purity, determined and guaranteed.

er >99.5 : 0.5 minimum.

Chiralysts – this new Fluka series is a tribute to what is one of the most exciting fields in organic chemistry today: the enantioselective synthesis of chiral non racemic compounds via catalytic processes.

Ingenious research concentrates on the design, tailoring, and tuning of catalytically active transition metal / ligand complexes. Simultaneously, the powerful stereodifferentiating capabilities and catalytic activities of nature's own chiral non racemic catalysts are exploited extensively and no less skilfully. Both approaches to introducing chirality into achiral substrates are being developed vigorously side by side in a fascinating style. Some of the truly most spectacular achievements are reflected in the chiral non racemic ligands and in the enzymes we selected.

The *Chiralysts* series provides pairs of ligands, each enantiomer exhibiting an enantiomeric ratio of >99.5:0.5 at least. The actual value is distinctly higher in most cases and coincides with detection limits. The series is being supplemented continuously as the field evolves.

Fluka Chiral Compounds.
It's that certain $\Delta\Delta G^\#$
that makes all the difference.

The Chiralysts Series

14797 R(+)-2,2'-Bis-(diphenylphosphino)- 1,1'-binaphtalene, R(+)-BINAP	59488 (+)-2,3-O-Isopropylidene-1,1,4,4-tetra- (2-naphtyl)-D-threit, (+)-DINOL
14798 S(-)-2,2'-Bis-(diphenylphosphino)- 1,1'-binaphtalene, S(-)-BINAP	59490 (-)-2,3-O-Isopropylidene-1,1,4,4-tetra- (2-naphtyl)-L-threit, (-)-DINOL
29170 Cyclohexanone-Monooxygenase from Acinetobacter sp., 0.5 U/mg	62312 Lipase from Pseudomonas fluorescens, SAM-2, 42 U/mg
43179 α,α -Diphenyl-D-prolinol	95340 (-)-Diethyl-D-tartrate
43182 α,α -Diphenyl-L-prolinol	95355 (+)-Diethyl-L-tartrate
46063 Esterase from hog liver, PLE, 130 U/mg	
46064 Esterase from hog liver, immobilized, PLE, 2300 U/g	

Catalysts and Ligands listed according to type of reaction

1,2-Addition Reactions

34778
N,N-Dibutyl-D-norephedrine
34779
N,N-Dibutyl-L-norephedrine
14383
R(+)-1,1'-Bi(2-naphthol)
14384
S(-)-1,1'-Bi(2-naphthol)
14970
(S,S)-2,6-Bis(4-isopropyl-2-oxazolin-2-yl)pyridine
33691
(S,S)-4,4'-Dibenzyl-2,2'-bi(2-oxazoline)
95364
(+)-Diisopropyl L-tartrate
95367
(-)-Diisopropyl D-tartrate
43118
α,α -Diphenyl-N-methyl-D-prolinol
43119
α,α -Diphenyl-N-methyl-L-prolinol
59488
(+)-2,3-O-Isopropylidene-1,1,4,4-tetra-(2-naphthyl)-D-threitol
59490
(-)-2,3-O-Isopropylidene-1,1,4,4-tetra-(2-naphthyl)-L-threitol
59534
(+)-2,3-O-Isopropylidene-1,1,4,4-tetraphenyl-D-threitol
59532
(-)-2,3-O-Isopropylidene-1,1,4,4-tetraphenyl-L-threitol
66705
(S,S)-2,2'-Methylene-bis(4-phenyl-2-oxazoline)
78911
(S,S)-(+)-4-Phenyl- α -(4-phenyloxazolidin-2-ylidene)-2-oxazoline-2-acetonitrile

Alkylation Reactions

13285
N-Benzylcinchonidinium chloride
13265
N-Benzylquininium chloride
13288
N-Benzylcinchoninium chloride
13593
(-)-N-Benzyl-N-methylephedrinium bromide
40235
(-)-N,N-Dimethylephedrinium bromide
44220
(-)-N-Dodecyl-N-methylephedrinium bromide
91851
N-(4-Trifluoromethylbenzyl)cinchoninium bromide
14802
(2R,3R)-(+)-2,3-Bis(diphenylphosphino) butane [(R,R)-Chiraphos]
14803
(2S,3S)-(+)-2,3-Bis(diphenylphosphino)butane [(S,S)-Chiraphos]

Aryl-(Alkyl)-ation of Olefins

14797
R(+)-2,2'-Bis(diphenylphosphino)-1,1'-binaphthalene, R(+)-BINAP
14798
S(-)-2,2'-Bis(diphenylphosphino)-1,1'-binaphthalene, S(-)-BINAP

Cycloaddition Reactions (Diels-Alder and 2+2)

14383
R(+)-1,1'-Bi(2-naphthol)
14384
S(-)-1,1'-Bi(2-naphthol)
59429
(S,S)-2,2'-Isopropylidene-bis(4-phenyl-2-oxazoline)
59534
(+)-2,3-O-Isopropylidene-1,1,4,4-tetraphenyl-D-threitol
59532
(-)-2,3-O-Isopropylidene-1,1,4,4-tetraphenyl-L-threitol

Cyclopropanation Reactions

14556
(1S,9S)-1,9-[Bis(tertbutyldimethylsiloxy)methyl]-5-cyanosemicorrin
28600
Dimethyl (1S,9S)-5-cyanosemicorrin-1,9-dicarboxylate
66680
(S,S)-2,2'-Methylene-bis(4-tert.-butyl-2-oxazoline)
66685
(4R,5S,4'R,5'S)-2,2'-Methylene-bis(4,5-diphenyl-2-oxazoline)

Dihydroxylation Reactions

23758
O-(4-Chlorobenzoyl)hydroquinidine
23762
O-(4-Chlorobenzoyl)hydroquinine
53956
Hydroquinine(2,5-diphenyl-4,6-pyrimidinediyl)diether
53952
Hydroquinidine 4-methyl-2-quinolyl ether
53957
Hydroquinine 4-methyl-2-quinolyl ether
53953
Hydroquinidine 9-phenanthryl ether
53958
Hydroquinine 9-phenanthryl ether
53954
Hydroquinidine 1,4-phthalazinediyl diether
53959
Hydroquinine 1,4-phthalazinediyl diether

Ene-Reactions

14383
R(+)-1,1'-Bi(2-naphthol)
14384
S(-)-1,1'-Bi(2-naphthol)

Epoxidations

14713
(R,R)-(-)-N,N'-Bis(3,5-di-tert-butylsalicylidene)-1,2-cyclohexanediamine

14715
(R,R)-(-)-N,N'-Bis(3,5-di-tert-butylsalicylidene)-1,2-cyclohexane diaminomanganese chloride

14717
(S,S)-(+)-N,N'-Bis(3,5-di-tert-butylsalicylidene)-1,2-cyclohexane diaminomanganese chloride

95355
(+)-Diethyl L-tartrate

95340
(-)-Diethyl D-tartrate

95364
(+)-Diisopropyl L-tartrate

95367
(-)-Diisopropyl D-tartrate

95365
(+)-Dimethyl L-tartrate

95366
(-)-Dimethyl D-tartrate

Hydroformylation Reactions

20424
(2S,4S)-1-tert-Butoxycarbonyl-4-diphenylphosphino-2-(diphenylphosphinomethyl)pyrrolidine, BPPM

14821
(+)-DIOP

14822
(-)-DIOP

43156
(2S,4S)-4-Diphenylphosphino-2-(diphenylphosphinomethyl)pyrrolidine, PPM

Hydrogenation Reactions

14797
R(+)-2,2'-Bis(diphenylphosphino)-1,1'-binaphthalene, R(+)-BINAP

14798
S(-)-2,2'-Bis(diphenylphosphino)-1,1'-binaphthalene, S(-)-BINAP

14800
[R(+)-2,2'-Bis(diphenylphosphino)-1,1'-binaphthalene]chloro(p-cumene)-ruthenium chloride, R(+)-BINAP-chloro(p-cumene)ruthenium chloride

14801
[S(-)-2,2'-Bis(diphenylphosphino)-1,1'-binaphthalene]chloro(p-cumene)-ruthenium chloride, S(-)-BINAP-chloro(p-cumene)ruthenium chloride

14802
(2R,3R)-(+)-2,3-Bis(diphenylphosphino) butane [(R,R)-Chiraphos]

14803
(2S,3S)-(+)-2,3-Bis(diphenylphosphino)butane [(S,S)-Chiraphos]

14821
(+)-DIOP

14822
(-)-DIOP

20424
(2S,4S)-1-tert-Butoxycarbonyl-4-diphenylphosphino-2-(diphenylphosphinomethyl)pyrrolidine, BPPM

43156
(2S,4S)-4-Diphenylphosphino-2-(diphenylphosphinomethyl)pyrrolidine, PPM

Hydroxylation Reactions

14797
R(+)-2,2'-Bis(diphenylphosphino)-1,1'-binaphthalene, R(+)-BINAP

14798
S(-)-2,2'-Bis(diphenylphosphino)-1,1'-binaphthalene, S(-)-BINAP

91851
N-(4-Trifluoromethylbenzyl)cinchoninium bromide

Reduction Reactions

14556
(1S,9S)-1,9-[Bis(tert-butyl)dimethylsiloxy)methyl]-5-cyanosemicorrin

28600
Dimethyl (1S,9S)-5-cyanosemicorrin-1,9-dicarboxylate

43179
 α,α -Diphenyl-D-prolinol

43182
 α,α -Diphenyl-L-prolinol

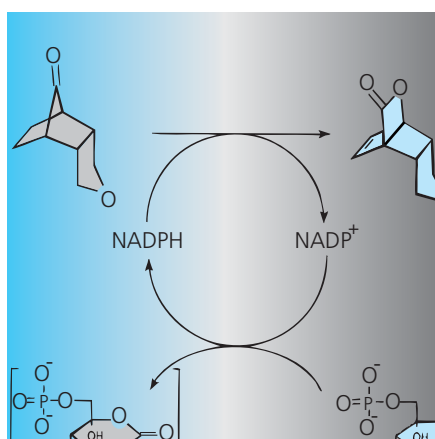
44220
(-)-N-Dodecyl-N-methylephedrinium bromide

Enzymes

Although several enzymatically catalysed, organic transformations have been described and used for a long time, these enzymatic methods have come into their own only in about the last fifteen years and thus have become real alternatives to the classical chemical methods in many cases [1, 2]. Several reasons contributed to this, i.e. the discovery that many enzymes work at least as well in organic media, as in water [3], the growing need for stereoselective transforma-

tions and the increasing urge to use mild reaction conditions and reagents. Molecular biology methods make their contribution to boosting the enzymatic "wave" in organic synthesis by the possibility to over-express natural enzymes [4] or by the design of completely new protein catalysts specifically for predetermined reactions and available through the catalytic antibody approach [5].

Oxidoreductases



Oxidoreductases used in preparing chiral compounds and functioning *without* added cofactor predominantly belong to the groups of oxidases and oxygenases. Examples are *amino acid oxidases*, which *enantiospecifically* catalyse the oxidative deamination of either D- or L-amino acids [6a], and *soybean lipoxidase* (SBL), which mediates the stereoselective oxygenation of (poly-)unsaturated fatty acids [6b].

The highly promising NADPH-dependent flavoenzymes *Cyclohexanone-monooxygenase from Acinetobacter sp.* and *Cyclopentanone-monooxygenase from Pseudomonas sp.* permit stereoselective Bayer-Villiger oxidations [6d, e].

The most useful and most thoroughly investigated are the NAD(P)H-dependent *alcohol dehydrogenases* [6 c]. Only some of them are capable of reducing a reasonably wide spectrum of ketones to the corresponding alcohols (or the reverse of that reaction). Others have been used to recycle the rather expensive cofactors.

Enzymes for Main Substrate Conversion

05645/05646/05648	Alcohol Dehydrogenase from horse liver, HLADH
05643	Alcohol Dehydrogenase from Lactobacillus kefir, ADH
05655	Alcohol Dehydrogenase from Thermoanaerobium brockii, TBADH
05635/05640	Alcohol Dehydrogenase from yeast, ADH
09414	L-Amino acid Oxidase from Agkistrodon halys, LAAO
09417	L-Amino acid Oxidase from Crotalus adamanteus, LAAO
09419	L-Amino acid Oxidase from Crotalus atrox, LAAO
25810	Chloride Peroxidase
25810	Chloroperoxidase from Caldariomyces fumago

29170	Cyclohexanone Monooxygenase from Acinetobacter sp.
29800	Cyclopentanone Monooxygenase from Pseudomonas sp.
49860	Glycerol Dehydrogenase from Geotrichum candidum
56460	3 α -Hydroxysteroid Dehydrogenase from Pseudomonas testosteroni
61306	D-Lactate Dehydrogenase from Lactobacillus leichmanii, D-LDH
61309/61311	L-Lactate Dehydrogenase from rabbit muscle, L-LDH
61310	Lactate Dehydrogenase from bovine heart, LDH

Cofactors

43404/43405/43406	Diphosphopyridine nucleotide
43420/43423	Diphosphopyridine nucleotide reduced
43404/43405/43406	β -Nicotinamide adenine dinucleotide Dihydrate from yeast, NAD ⁺
43407	β -Nicotinamide adenine dinucleotide Monohydrate from yeast, NAD ⁺
43410	β -Nicotinamide adenine dinucleotide Monohydrate, NAD ⁺
43409	β -Nicotinamide adenine dinucleotide Dihydrate, NAD ⁺
43420/43423	β -Nicotinamide adenine dinucleotide reduced Disodium salt Trihydrat, NADH
93205	β -Nicotinamide adenine dinucleotide phosphate Disodium salt, NADP
93208/93210	β -Nicotinamide adenine dinucleotide phosphate Sodium salt, NADP

93219/93220
 β -Nicotinamide adenine dinucleotide phosphate reduced Tetrasodium salt, NADPH

93200
 β -Nicotinamide adenine dinucleotide phosphoric acid, NADP

93205
Triphosphopyridine nucleotide

93219/93220
Triphosphopyridine nucleotide reduced

Auxiliary Enzymes

47709
Formate Dehydrogenase from *Candida boidini*

47711
Formate Dehydrogenase from yeast, FDH

49165
Glucose Dehydrogenase from *Bacterium megaterium*

49271/49272
Glucose-6-phosphate Dehydrogenase from baker's yeast, G-6-P-DH

49275/49276
Glucose-6-phosphate Dehydrogenase from *Leuconostoc mesenteroides*, G-6-P-DH

49278/49279
Glucose-6-phosphate Dehydrogenase from torula yeast, G-6-P-DH

49270/49273
Glucose-6-phosphate Dehydrogenase from yeast, G-6-P-DH

49390/49392
Glutamate Dehydrogenase from bovine liver, L-GLDH

Transferases

Three groups of transferases reached practical potential in the syntheses of chiral compounds, namely glycosyl transferases, amino-transferases and kinases. Examples are *galactosyltransferase* used in oligosaccharide synthesis [7a, b] and *hexokinase* [7b], *nucleoside phosphorylase* [7c] and *glycerokinases* [7d] for various phosphorylations. They are usually dependent on ATP as a phosphate donor, a cofactor which needs to be recycled in large-scale reactions because of its relatively high price. The most convenient recycling system is *pyruvate kinase/ phosphoenolpyruvate* (PEP) [8].

Enzymes for Main Substrate Conversion

48279
Galactosyl Transferase from bovine milk

49950
Glycerol Kinase from *Arthrobacter* sp.

49953
Glycerol Kinase from *Candida mycoderma*

49955
Glycerol Kinase from *E. coli*

53110/53115
Hexokinase from yeast

48279
Lactose Synthase from bovine milk

74678
Nucleoside Phosphorylase from calf spleen

Cofactors

01930
Adenosine-5'-monophosphate Disodium salt, 5'-AMP

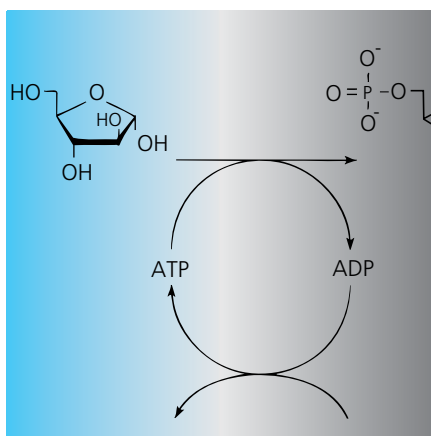
01970
Adenosine 5'-monophosphoric acid Monohydrate, 5'-AMP

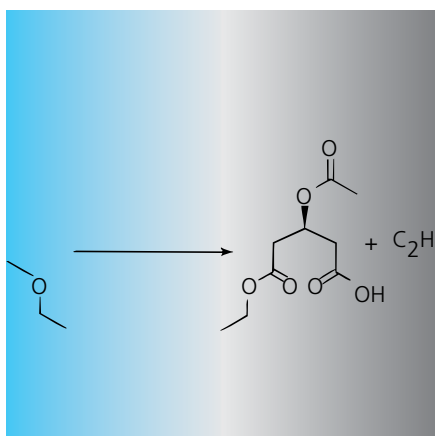
02055/02060
Adenosine-5'-triphosphate Disodium salt Hydrate, 5'-ATP

Auxiliary Enzymes

83328/83330
Phosphoenolpyruvate Kinase from rabbit muscle

83328/83330
Pyruvate Kinase from rabbit muscle





Hydrolases

Hydrolases provided the main contribution to the breakthrough of enzymatic methods in organic chemistry [9] and at present constitute the largest group of synthetically useful enzymes for the following reasons:

- relative high stability under non-natural conditions,
- often wide substrate spectra,
- no cofactors necessary.

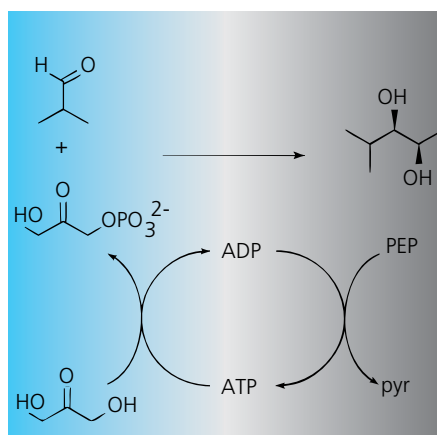
The Fluka hydrolases are covered in a special Info sheet entitled "Hydrolyses and Condensations". It includes almost one hundred application references and experimental details of large-scale transformations done routinely in Fluka laboratories. Please ask for a free copy.

Enzymes

01022/01023 Acetylcholine Esterase from Electrophorus electricus
81750 Actinase
01818 Acyase I from Aspergillus melleus
01824 Acyase I from Aspergillus immobilized on Eupergit C
01821/01831/01833 Acyase I from hog kidney
10065 α -Amylase from Aspergillus oryzae
10067 α -Amylase from Bacillus licheniformis
10069/10070 α -Amylase from Bacillus subtilis
10094 α -Amylase from hog pancreas
16990 Bromelain from pineapple stem
20777 Butyrylcholine Esterase from horse serum
21937/21938 Carboxypeptidase A from bovine pancreas
21943/21945 Carboxypeptidase Y from baker's yeast
26745 Cholesterol Esterase from hog pancreas
20777 Choline Esterase, butyryl
27270/27272 α -Chymotrypsin from bovine pancreas
45122/45123/45124/45125/45127 Elastase from hog pancreas
46062 Esterase from Bacillus sp.
46063 Esterase from hog liver, PLE

46064 Esterase from hog liver, immobilized on Eupergit® C
46059 Esterase from Mucor miehei
46061 Esterase from Thermoanaerobium brockii
57629 β -D-Fructofuranosidase
48274/48275 β -Galactosidase from E. coli
63412 α -Glucosidase from yeast
49289/49290 β -Glucosidase from almonds
57629 Invertase from bakers yeast
48274/48275 Lactase
62322 Lipase, immobilized on carrier from micro organisms
62294/62301 Lipase from Aspergillus niger
62285 Lipase from Aspergillus oryzae
62286 Lipase, recombinant from Aspergillus oryzae
62299 Lipase from Candida antarctica
62302/62316 Lipase from Candida cylindracea
62303 Lipase from Candida lipolytica
62307 Lipase from Candida utilis
62300/62313 Lipase from hog pancreas, PPL
62304 Lipase from Mucor javanicus
62298 Lipase from Mucor miehei
62289 Lipase, recombinant from Mucor miehei
62308 Lipase from Penicillium roqueforti
62312 Lipase from Pseudomonas fluorescens, SAM-2
62319 Lipase, immobilized on Eupergit C from Pseudomonas fluorescens
62321 Lipase from Pseudomonas fluorescens
62291 Lipase from Rhizomucor miehei

62305 Lipase from <i>Rhizopus arrhizus</i>	46064 Pig liver esterase immobilized on Eupergit® C
62311 Lipase from <i>Rhizopus delemar</i>	01824 Plexazyme® AC
62310 Lipase from <i>Rhizopus niveus</i>	62300/62313 PPL
62293 Lipase from <i>Thermus aquaticus</i>	81706 Prolidase from <i>Lactococcus lactis</i>
62295 Lipase from <i>Thermus flavus</i>	81706 Proline Dipeptidase
62296 Lipase from <i>Thermus thermophilus</i>	81748 Pronase from <i>Streptomyces griseus</i>
62306 Lipase from wheat germ	81750 Pronase E from <i>Streptomyces griseus</i>
62287 Lipase A, recombinant from <i>Candida antarctica</i>	82459 Proteinase from <i>Bacillus licheniformis</i>
62294/62301 Lipase AP6	82462/82464 Proteinase from <i>Bacillus subtilis</i>
62288 Lipase B, recombinant from <i>Candida antarctica</i>	82490 Proteinase from <i>Bacillus subtilis</i> var. biotecus A
62303 Lipase L	82518 Proteinase, bacterial (Nagarse, Subtilisin BPN)
62304 Lipase M10	82528 Proteinase, bacterial (Subtilisin Carlsberg, bacterial)
62310 Lipase N	62312 SAM-2
62308 Lipase R	85967/85968 Subtilisin from <i>Bacillus licheniformis</i>
62333 Lipoprotein Lipase from <i>Chromobacterium viscosum</i>	82459 Subtilisin A
62335 Lipoprotein Lipase from <i>Pseudomonas</i> sp.	82490 Subtilisin Carlsberg from <i>Bacillus subtilis</i> var. biotecus A
62970/62971 Lysozyme from hen egg white	82528 Subtilisin Carlsberg, bacterial
63412 Maltase from yeast	82518 Subtilisin BPN
62970/62971 Muramidase	86247/86250 Taka-Diastase from <i>Aspergillus oryzae</i>
82518 Nagarse	86247/86250 Taka-Amylase
76190 Pancreatin from hog pancreas	88303 Thermolysin from <i>Bacillus thermoproteolyticus</i>
76220/76222 Papain from <i>Carica papaya</i>	93610/93612 Trypsin from bovine pancreas
76221 Papain, immobilized on Eupergit® CA. from <i>Carica papaya</i>	93613/93614/93615 Trypsin from hog pancreas
76428 Penicillin G-amidase, immobilized from <i>E. coli</i>	94278/94280/94282/94285 Urease from jack beans
77151/77152/77160/77163 Pepsin from hog stomach	94287 Urease, immobilized on Eupergit® C from jack beans
46063 Pig liver esterase	



Lyases

Mainly two kinds of lyases have been used in organic syntheses: aldolases and oxynitrilases. Aldolases are powerful enzymes used to make highly functionalised compounds with one or more newly created stereogenic centres, i.e. sugars or branched chained sugars [10]. The most prominent member of this group of enzymes is *Aldolase from rabbit muscle* (FDP aldolase, RAMA). It condensates dihydroxy acetone phosphate (DHAP, from Fluka 37435) with a wide variety of aldehydes [2].

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Enzymes

01402	N-Acetylneuraminic acid Aldolase from <i>E. coli</i>
05515	Aldolase from trout muscle
05518/05520	Aldolase from rabbit muscle
01402	NANA Aldolase
05522	Aldolase from <i>Staphylococcus aureus</i>

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Auxiliaries

In this section, compounds will be treated which act stoichiometrically either as chiral auxiliary substances (e.g. Evans' oxazolidinones) or as chiral reagents (e.g. chiral boranes). Compounds which induce stereoselectivity catalytically are treated in the separate section "Chiral Catalysts and Ligands". Many reactions which use achiral building blocks can now be run stereoselectively with the aid of a chiral auxiliary to give the target molecule in enantiomerically pure form. In most cases, the auxiliary can be regenerated.

The important aldol reaction leads to chiral β -hydroxy carbonyl compounds when diastereofacial selectivity is imparted by a chiral auxiliary [1]. Many auxiliaries have been proposed to run the aldol reaction diastereoselectively. Evans' auxiliaries, a group of chiral oxazolidinones, are just a versatile example of auxiliaries for the aldol reaction and also for other reactions [2].

Alkylation of chiral enolates and related compounds provides another access to enantiomerically pure compounds. Many processes have been devised which use chiral auxiliaries to induce diastereofacial selectivity in alkylation reactions [3,4,5]. Chiral auxiliaries are also useful for asymmetric cycloaddition reactions [6].

Chiral borane reagents are very useful reagents for asymmetric hydroborations, reductions, and other transformations [7–12]. Asymmetric reductions can also be performed with modified LAH [13]; alcohols, glycols, mono- and diamines, and amino alcohols have mainly been employed as chiral auxiliary modifiers. Enantiomerically pure compounds have also been prepared via chiral acetals and enamines of achiral ketones [14].

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Auxiliaries listed according to functional group

Alcohols

15597
(+)-Borneol
15598
(-)-Borneol
63658
(+)-Menthol
63660
(-)-Menthol
70692
R(+)-1-(1-Naphthyl)ethanol
70693
S(-)-1-(1-Naphthyl)ethanol
78322
(1R,2S)-trans-2-Phenyl-1-cyclohexanol
78323
(1S,2R)-trans-2-Phenyl-1-cyclohexanol
78805
(-)-8-Phenylmenthol
79231
R(-)-1-Phenyl-2,2,2-trifluoroethanol
79233
S(+)-1-Phenyl-2,2,2-trifluoroethanol

Amines

08394
(R)-1-Amino-2-(methoxymethyl)pyrrolidine
08396
(S)-1-Amino-2-(methoxymethyl)pyrrolidine
08399
S(+)-2-Amino-1-methoxy-3-phenylpropane hydrochloride
40239
R(+)-N,N-Dimethyl-1-ferrocenylethylamine
40241
S(-)-N,N-Dimethyl-1-ferrocenylethylamine
65090
(S)-2-(Methoxymethyl)pyrrolidine
77880
D(+)- α -Methylbenzylamine
77870
L(-)- α -Methylbenzylamine
70711
R(+)-1-(1-Naphthyl)ethylamine
70713
S(-)-1-(1-Naphthyl)ethylamine
88101
2,3,4,6-Tetra-O-pivaloyl- β -D-galactopyranosylamine

Amino Alcohols

07930
(1R,2S)-2-Amino-1,2-diphenyl ethanol
07932
(1S,2R)-2-Amino-1,2-diphenyl ethanol
07950
(S)-2-Amino-1,1-diphenyl-1-propanol
09235
L(+)-threo-2-Amino-1-phenyl-1,3-propanediol
13839
N-Benzyl-L-prolinol

39180
(+)-(2S,3R)-4-Dimethylamino-3-methyl-1,2-diphenyl-2-butanol
55720
(-)-2-Hydroxymethyl-1-(1-methylpyrrolidin-2-ylmethyl)pyrrolidine
61925
L-tert-Leucinol
61930
L-tert-Leucinol hydrochloride
68890
N-Methyl-L-prolinol
81744
D-Prolinol
81745
L-Prolinol
94674
D-Valinol
94672
L-Valinol

Boranes

24295
(+)-B-Chlorodiisopinocampheylborane
24300
(-)-B-Chlorodiisopinocampheylborane
38488
Dilongifolylborane
59234
(+)-Isopinocampheylborane TMEDA Complex
59235
(-)-Isopinocampheylborane TMEDA Complex

Glycols

14383
R(+)-1,1'-Bi(2-naphthol)
14384
S(-)-1,1'-Bi(2-naphthol)
18937
R(-)-1,3-Butanediol
18938
S(+)-1,3-Butanediol
18965
D(-)-2,3-Butanediol
18967
L(+)-2,3-Butanediol
29722
(1R,2R)-trans-1,2-Cyclopentanediol
29723
(1S,2S)-trans-1,2-Cyclopentanediol
33860
(-)-N,N'-Dibenzyl-D-tartaric diamide
33840
(+)-1,4-Di-O-benzyl-D-threitol
33845
(-)-1,4-Di-O-benzyl-L-threitol
95359
(+)-Di-tert-butyl L-tartrate
95358
(-)-Di-tert-butyl D-tartrate

95355
(+)-Diethyl L-tartrate
95340
(-)-Diethyl D-tartrate
95364
(+)-Diisopropyl L-tartrate
95367
(-)-Diisopropyl D-tartrate
38710
(R,R)-(+)-1,4-Dimethoxy-2,3-butanediol
38715
(S,S)-(-)-1,4-Dimethoxy-2,3-butanediol
95365
(+)-Dimethyl L-tartrate
95366
(-)-Dimethyl D-tartrate
43185
S(-)-1,1-Diphenyl-1,2-propanediol
53947
(S,S)-(-)-Hydrobenzoin [(S,S)-(-)-1,2-Diphenyl-ethylene glycol]
59488
(+)-2,3-O-Isopropylidene-1,1,4,4-tetra (2-naphthyl)-D-threitol
59490
(-)-2,3-O-Isopropylidene-1,1,4,4-tetra (2-naphthyl)-L-threitol
59534
(+)-2,3-O-Isopropylidene-1,1,4,4-tetraphenyl-D-threitol
59532
(-)-2,3-O-Isopropylidene-1,1,4,4-tetraphenyl-L-threitol
76897
(R,R)-(+)-2,4-Pentanediol
76898
(S,S)-(+)-2,4-Pentanediol
80594
(1R,2R,3S,5R)-2,3-Pinanediol
80596
(1S,2S,3R,5S)-2,3-Pinanediol
87953
(+)-N,N,N',N'-Tetramethyl-L-tartaric acid diamide
87950
(-)-N,N,N',N'-Tetramethyl-D-tartaric acid diamide
92923
R(+)-1,1,2-Triphenyl-1,2-ethanediol
93030
S(-)-1,1,2-Triphenyl-1,2-ethanediol
Carboxylic acids and Esters
43456
(+)-Di-O,O'-pivaloyl-D-tartaric acid
43457
(-)-Di-O,O'-pivaloyl-L-tartaric acid
52550
R(-)-Hexahydromandelic acid
52545
S(+)-Hexahydromandelic acid

89115
(-)-Methyl (R)-2-thioxothiazolidine-4-carboxylate
89113
R(-)-2-Thioxothiazolidine-4-carboxylic acid
Diamines
10418
(S)-2-(Anilinomethyl)pyrrolidine
32787
R(+)-2,2'-Diamino-1,1'-binaphthalene
32788
S(-)-2,2'-Diamino-1,1'-binaphthalene
32846
(1R,2R)-(-)-1,2-Diaminocyclohexane
32848
(1S,2S)-(+)-1,2-Diaminocyclohexane
42745
(1R,2R)-(+)-1,2-Diphenylethylenediamine
42743
(1S,2S)-(-)-1,2-Diphenylethylenediamine
68870
(S)-1-Methyl-2-(piperidinomethyl)pyrrolidine
Ketones
51695
3-(Heptafluorobutyl)-d-camphor
56205
(1S,2S,5S)-(-)-2-Hydroxy-3-pinanone
91695
3-(Trifluoroacetyl)-d-camphor
91689
3-(Trifluoroacetyl)-l-camphor
Oxazolidinones and related cyclic amides
13615
(R)-4-Benzyl-2-oxazolidinone
13616
(S)-4-Benzyl-2-oxazolidinone
20280
(R)-4-tert-Butyl-2-methyl-2-oxazoline
20282
(S)-4-tert-Butyl-2-methyl-2-oxazoline
20380
(S)-4-tert-Butyl-2-oxazolidinone
20550
(S)-3-tert-Butyl-2,5-piperazinedione
37308
(4S,5S)-(-)-4,5-Dihydro-4-methoxymethyl-2-methyl-5-phenyl-oxazole
41412
(4R,5S)-(-)-1,5-Dimethyl-4-phenyl-2-imidazolidinone
41414
(4S,5R)-(+)-1,5-Dimethyl-4-phenyl-2-imidazolidinone
59658
(R)-4-Isopropyl-2-oxazolidinone
59660
(S)-4-Isopropyl-2-oxazolidinone
59731
(R)-3-Isopropyl-2,5-piperazinedione

59732 (S)-3-Isopropyl-2,5-piperazinedione	32846 (1R,2R)-(-)-1,2-Diaminocyclohexane
68700 (4R,5S)-4-Methyl-5-phenyl-2-oxazolidinone	32848 (1S,2S)-(+)-1,2-Diaminocyclohexane
78875 (S)-4-Phenyl-2-oxazolidinone	95355 (+)-Diethyl L-tartrate
Various Compounds	95340 (-)-Diethyl D-tartrate
15148 (S,S)-(-)-N,N'-Bis(α -methylbenzyl)sulfamide	95364 (+)-Diisopropyl L-tartrate
21371 (+)-10,2-Camphorsultam	95367 (-)-Diisopropyl D-tartrate
21372 (-)-10,2-Camphorsultam	38710 (R,R)-(+)-1,4-Dimethoxy-2,3-butanediol
21374 (1R)-(+)-Camphorsulfonylimine	38715 (S,S)-(-)-1,4-Dimethoxy-2,3-butanediol
21373 (1S)-(-)-Camphorsulfonylimine	40180 (R,R)-2,2-Dimethyl-1,3-dioxolane-4,5-bis(diphenylmethoxy)-cyclopentadienyl-chlorotitanium
33562 N,N'-Dibenzoyl-L-cystine	40182 (S,S)-2,2-Dimethyl-1,3-dioxolane-4,5-bis(diphenylmethoxy)-cyclopentadienyl-chlorotitanium
35603 (+)-(8,8-Dichlorocamphorylsulfonyl)oxaziridine	42745 (1R,2R)-(+)-1,2-Diphenylethylenediamine
35605 (-)-(8,8-Dichlorocamphorylsulfonyl)oxaziridine	42743 (1S,2S)-(-)-1,2-Diphenylethylenediamine
36657 (+)-N,N-Dicyclohexyl-(1R)-isoborneol-10-sulfonamide	53947 (S,S)-(-)-Hydrobenzoin [(S,S)-(-)-1,2-Diphenylethylene glycol]
36659 (-)-N,N-Dicyclohexyl-(1S)-isoborneol-10-sulfonamide	55720 (-)-2-Hydroxymethyl-1-(1-methylpyrrolidin-2-ylmethyl)pyrrolidine
40180 (R,R)-2,2-Dimethyl-1,3-dioxolane-4,5-bis(diphenylmethoxy)-cyclopentadienyl-chlorotitanium	59488 (+)-2,3-O-Isopropylidene-1,1,4,4-tetra(2-naphthyl)-D-threitol
40182 (S,S)-2,2-Dimethyl-1,3-dioxolane-4,5-bis(diphenylmethoxy)-cyclopentadienyl-chlorotitanium	59490 (-)-2,3-O-Isopropylidene-1,1,4,4-tetra(2-naphthyl)-L-threitol
41390 (1R)-3-[N-(3,5-Dimethylphenyl)benzenesulfonamido]isoborneol	59534 (+)-2,3-O-Isopropylidene-1,1,4,4-tetraphenyl-D-threitol
47731 S(-)-1-Formyl-2-(methoxymethyl)pyrrolidine	59532 (-)-2,3-O-Isopropylidene-1,1,4,4-tetraphenyl-L-threitol
89714 (+)-(1S)-Menthyl (R)-toluene-4-sulfinate	65090 (S)-2-(Methoxymethyl)pyrrolidine
89715 (-)-(1R)-Menthyl (S)-toluene-4-sulfinate	68870 (S)-1-Methyl-2-(piperidinomethyl)pyrrolidine
	76897 (R,R)-(+)-2,4-Pentanediol
	76898 (S,S)-(+)-2,4-Pentanediol
1,2-Addition Reactions	1,4-Addition Reactions
10418 (S)-2-(Anilinomethyl)pyrrolidine	08394 (R)-1-Amino-2-(methoxymethyl)pyrrolidine, RAMP
14383 R(+)-1,1'-Bi(2-naphthol)	08396 (S)-1-Amino-2-(methoxymethyl)pyrrolidine, SAMP
14384 S(-)-1,1'-Bi(2-naphthol)	
18937 R(-)-1,3-Butanediol	
18938 S(+)-1,3-Butanediol	

Auxiliaries listed according to type of reaction

13615 (R)-4-Benzyl-2-oxazolidinone	Alkylation Reactions
13616 (S)-4-Benzyl-2-oxazolidinone	08394 (R)-1-Amino-2-(methoxymethyl)pyrrolidine, RAMP
18965 D(-)-2,3-Butanediol	08396 (S)-1-Amino-2-(methoxymethyl)pyrrolidine, SAMP
18967 L(+)-2,3-Butanediol	08399 S(+)-2-Amino-1-methoxy-3-phenylpropane hydrochloride
20280 (R)-4-tert-Butyl-2-methyl-2-oxazoline	09235 L(+)-threo-2-Amino-1-phenyl-1,3-propane- diol
20282 (S)-4-tert-Butyl-2-methyl-2-oxazoline	13615 (R)-4-Benzyl-2-oxazolidinone
21371 (+)-10,2-Camphorsultam	13616 (S)-4-Benzyl-2-oxazolidinone
21372 (-)-10,2-Camphorsultam	20380 (S)-4-tert-Butyl-2-oxazolidinone
33840 (+)-1,4-Di-O-benzyl-D-threitol	20550 (S)-3-tert-Butyl-2,5-piperazinedione
33845 (-)-1,4-Di-O-benzyl-L-threitol	37308 (4S,5S)-(-)-4,5-Dihydro-4-methoxymethyl-2- methyl-5-phenyloxazol
36657 (+)-N,N-Dicyclohexyl-(1R)-isoborneol-10-sul- fonamide	41390 (1R)-3-[N-(3,5-Dimethylphenyl)benzene- sulfonamido]isoborneol
36659 (-)-N,N-Dicyclohexyl-(1S)-isoborneol-10-sul- fonamide	47731 S(-)-1-Formyl-2-(methoxymethyl)pyrrolidine
41390 (1R)-3-[N-(3,5-Dimethylphenyl)benzene- sulfonamido]isoborneol	56205 (1S,2S,5S)-(-)-2-Hydroxy-3-pinanone
41412 (4R,5S)-(-)-1,5-Dimethyl-4-phenyl-2-imi- dazolidinone	59658 (R)-4-Isopropyl-2-oxazolidinone
41414 (4S,5R)-(+)-1,5-Dimethyl-4-phenyl-2-imi- dazolidinone	59660 (S)-4-Isopropyl-2-oxazolidinone
42745 (1R,2R)-(+)-1,2-Diphenylethylenediamine	59732 (S)-3-Isopropyl-2,5-piperazinedione
42743 (1S,2S)-(-)-1,2-Diphenylethylenediamine	61925 L-tert-Leucinol
89714 (+)-(1S)-Menthyl (R)-toluene-4-sulfinate	61930 L-tert-Leucinol
89715 (-)-(1R)-Menthyl (S)-toluene-4-sulfinate	65090 (S)-2-(Methoxymethyl)pyrrolidine
65090 (S)-2-(Methoxymethyl)pyrrolidine	68700 (4R,5S)-4-Methyl-5-phenyl-2-oxazolidinone
77880 D(+)- α -Methylbenzylamine	81744 D-Prolinol
77870 L(-)- α -Methylbenzylamine	81745 L-Prolinol
68890 N-Methyl-L-prolinol	94674 D-Valinol
78805 (-)-8-Phenylmenthol	94672 L-Valinol
87953 (+)-N,N,N',N'-Tetramethyl-L-tartaric acid diamide	Aldol Condensation Reactions
87950 (-)-N,N,N',N'-Tetramethyl-D-tartaric acid diamide	08394 (R)-1-Amino-2-(methoxymethyl)pyrrolidine, RAMP
	08396 (S)-1-Amino-2-(methoxymethyl)pyrrolidine, SAMP

13615
(R)-4-Benzyl-2-oxazolidinone
13616
(S)-4-Benzyl-2-oxazolidinone
18937
R(-)-1,3-Butanediol
18938
S(+)-1,3-Butanediol
36657
(+)-N,N-Dicyclohexyl-(1R)-isoborneol-10-sulfonamide
36659
(-)-N,N-Dicyclohexyl-(1S)-isoborneol-10-sulfonamide
95355
(+)-Diethyl L-tartrate
95340
(-)-Diethyl D-tartrate
38710
(R,R)-(+)-1,4-Dimethoxy-2,3-butanediol
38715
(S,S)-(-)-1,4-Dimethoxy-2,3-butanediol
41412
(4R,5S)-(-)-1,5-Dimethyl-4-phenyl-2-imidazolidinone
41414
(4S,5R)-(+)-1,5-Dimethyl-4-phenyl-2-imidazolidinone
42745
(1R,2R)-(+)-1,2-Diphenylethylenediamine
42743
(1S,2S)-(-)-1,2-Diphenylethylenediamine
52550
R(-)-Hexahydromandelic acid
52545
S(+)-Hexahydromandelic acid
59658
(R)-4-Isopropyl-2-oxazolidinone
59660
(S)-4-Isopropyl-2-oxazolidinone
89714
(+)-(1S)-Menthyl (R)-toluene-4-sulfinate
89715
(-)-(1R)-Menthyl (S)-toluene-4-sulfinate
68700
(4R,5S)-4-Methyl-5-phenyl-2-oxazolidinone
68870
(S)-1-Methyl-2-(piperidinomethyl)pyrrolidine
88101
2,3,4,6-Tetra-O-pivaloyl- β -D-galactopyranosylamine
92923
R(+)-1,1,2-Triphenyl-1,2-ethanediol
93030
S(-)-1,1,2-Triphenyl-1,2-ethanediol

Claisen-Rearrangement Reactions

61925
L-tert-Leucinol
61930
L-tert-Leucinol hydrochloride
94674
D-Valinol
94672
L-Valinol

Coupling Reactions

07930
(1R,2S)-2-Amino-1,2-diphenylethanol
07932
(1S,2R)-2-Amino-1,2-diphenylethanol
14383
R(+)-1,1'-Bi(2-naphthol)
14384
S(-)-1,1'-Bi(2-naphthol)

Cycloaddition Reactions

(Diels-Alder and 2+2)
14383
R(+)-1,1'-Bi(2-naphthol)
14384
S(-)-1,1'-Bi(2-naphthol)
20380
(S)-4-tert-Butyl-2-oxazolidinone
21371
(+)-10,2-Camphorsultam
21372
(-)-10,2-Camphorsultam
33860
(-)-N,N'-Dibenzyl-D-tartaric diamide
33840
(+)-1,4-Di-O-benzyl-D-threitol
33845
(-)-1,4-Di-O-benzyl-L-threitol
36657
(+)-N,N-Dicyclohexyl-(1R)-isoborneol-10-sulfonamide
36659
(-)-N,N-Dicyclohexyl-(1S)-isoborneol-10-sulfonamide
38710
(R,R)-(+)-1,4-Dimethoxy-2,3-butanediol
38715
(S,S)-(-)-1,4-Dimethoxy-2,3-butanediol
42745
(1R,2R)-(+)-1,2-Diphenylethylenediamine
42743
(1S,2S)-(-)-1,2-Diphenylethylenediamine
53947
(S,S)-(-)-Hydrobenzoin [(S,S)-(-)-1,2-Diphenylethylene glycol]
59534
(+)-2,3-O-Isopropylidene-1,1,4,4-tetraphenyl-D-threitol
59532
(-)-2,3-O-Isopropylidene-1,1,4,4-tetraphenyl-L-threitol

78322
(1R,2S)-trans-2-Phenyl-1-cyclohexanol

78323
(1S,2R)-trans-2-Phenyl-1-cyclohexanol

78805
(-)-8-Phenylmenthol

78875
(S)-4-Phenyl-2-oxazolidinone

Cyclopropanation Reactions

33840
(+)-1,4-Di-O-benzyl-D-threitol

33845
(-)-1,4-Di-O-benzyl-L-threitol

18965
D(-)-2,3-Butanediol

18967
L(+)-2,3-Butanediol

53947
(S,S)-(-)-Hydrobenzoin [(S,S)-(-)-1,2-Diphenyl-ethylene glycol]

Dihydroxylation Reactions

21371
(+)-10,2-Camphorsultam

21372
(-)-10,2-Camphorsultam

32846
(1R,2R)-(-)-1,2-Diaminocyclohexane

32848
(1S,2S)-(+)-1,2-Diaminocyclohexane

42745
(1R,2R)-(+)-1,2-Diphenylethylenediamine

42743
(1S,2S)-(-)-1,2-Diphenylethylenediamine

Ene-Reactions

14383
R(+)-1,1'-Bi(2-naphthol)

14384
S(-)-1,1'-Bi(2-naphthol)

78322
(1R,2S)-trans-2-Phenyl-1-cyclohexanol

78323
(1S,2R)-trans-2-Phenyl-1-cyclohexanol

78805
(-)-8-Phenylmenthol

Epoxidations

95355
(+)-Diethyl L-tartrate

95340
(-)-Diethyl D-tartrate

95364
(+)-Diisopropyl L-tartrate

95367
(-)-Diisopropyl D-tartrate

95365
(+)-Dimethyl L-tartrate

95366
(-)-Dimethyl D-tartrate

87953
(+)-N,N,N',N'-Tetramethyl-L-tartaric acid diamide

87950
(-)-N,N,N',N'-Tetramethyl-D-tartaric acid diamide

Halogenation Reactions

95365
(+)-Dimethyl L-tartrate

95366
(-)-Dimethyl D-tartrate

79231
R(-)-1-Phenyl-2,2,2-trifluoroethanol

79233
S(+)-1-Phenyl-2,2,2-trifluoroethanol

87953
(+)-N,N,N',N'-Tetramethyl-L-tartaric acid diamide

87950
(-)-N,N,N',N'-Tetramethyl-D-tartaric acid diamide

Hydroxylation and Amination Reactions

21374
(1R)-(+)-Camphorsulfonylimine

21373
(1S)-(-)-Camphorsulfonylimine

35603
(+)-(8,8-Dichlorocamphorylsulfonyl) oxaziridine

35605
(-)-(8,8-Dichlorocamphorylsulfonyl) oxaziridine

36657
(+)-N,N-Dicyclohexyl-(1R)-isoborneol-10-sulfonamide

36659
(-)-N,N-Dicyclohexyl-(1S)-isoborneol-10-sulfonamide

38488
Dilongifolylborane

41390
(1R)-3-[N-(3,5-Dimethylphenyl)benzene-sulfonamido]isoborneol

59234
(+)-Isopinocampheylborane TMEDA Complex

59235
(-)-Isopinocampheylborane TMEDA Complex

Oxidation Reactions

21374
(1R)-(+)-Camphorsulfonylimine

21373
(1S)-(-)-Camphorsulfonylimine

35603
(+)-(8,8-Dichlorocamphorylsulfonyl) oxaziridine

35605
(-)-(8,8-Dichlorocamphorylsulfonyl)oxaziridine

Reduction Reactions

07950
(S)-2-Amino-1,1-diphenyl-1-propanol
10418
(S)-2-(Anilinomethyl)pyrrolidine
13839
N-Benzyl-L-prolinol
14383
R(+)-1,1'-Bi(2-naphthol)
14384
S(-)-1,1'-Bi(2-naphthol)
15148
(S,S)-(-)-N,N'-Bis(a-methylbenzyl)sulfamide
21371
(+)-10,2-Camphorsultam
21372
(-)-10,2-Camphorsultam
24295
(+)-B-Chlorodiisopinocampheylborane
24300
(-)-B-Chlorodiisopinocampheylborane
32787
R(+)-2,2'-Diamino-1,1'-binaphthalene
32788
S(-)-2,2'-Diamino-1,1'-binaphthalene
33562
N,N'-Dibenzoyl-L-cystine
38710
(R,R)-(+)-1,4-Dimethoxy-2,3-butanediol
38715
(S,S)-(-)-1,4-Dimethoxy-2,3-butanediol
39180
(+)-(2S,3R)-4-Dimethylamino-3-methyl-1,2-diphenyl-2-butanol
89714
(+)-(1S)-Menthyl (R)-toluene-4-sulfinate
89715
(-)-(1R)-Menthyl (S)-toluene-4-sulfinate
77880
D(+)- α -Methylbenzylamine
77870
L(-)- α -Methylbenzylamine
68870
(S)-1-Methyl-2-(piperidinomethyl)pyrrolidine
70711
R(+)-1-(1-Naphthyl)ethylamine
70713
S(-)-1-(1-Naphthyl)ethylamine
76897
(R,R)-(+)-2,4-Pentanediol
76898
(S,S)-(+)-2,4-Pentanediol
81744
D-Prolinol
81745
L-Prolinol

Various Reactions

15597
(+)-Borneol
15598
(-)-Borneol
32787
R(+)-2,2'-Diamino-1,1'-binaphthalene
32788
S(-)-2,2'-Diamino-1,1'-binaphthalene
95359
(+)-Di-tert-butyl L-tartrate
95358
(-)-Di-tert-butyl D-tartrate
40239
R(+)-N,N-Dimethyl-1-ferrocenylethylamine
40241
S(-)-N,N-Dimethyl-1-ferrocenylethylamine
43185
S(-)-1,1-Diphenyl-1,2-propanediol
43456
(+)-Di-O,O'-pivaloyl-D-tartaric acid
43457
(-)-Di-O,O'-pivaloyl-L-tartaric acid
63658
(+)-Menthol
63660
(-)-Menthol
70692
R(+)-1-(1-Naphthyl)ethanol
70693
S(-)-1-(1-Naphthyl)ethanol
80594
(1R,2R,3S,5R)-2,3-Pinanediol
80596
(1S,2S,3R,5S)-2,3-Pinanediol

Building Blocks

A. Introduction

Readily available chiral natural products such as hydroxy acids, amino acids, carbohydrates, and terpenes provide a pool of versatile chiral starting materials for synthesis: the "chiral pool" [1]. Although easy to get, many of these compounds either have too many functional groups and too many chiral centres or lack selective protection to be really useful for the synthetic chemist. Selectively protected small compounds with few functional groups and one or two chiral centres are the ideal compounds modern synthetic chemists like to use as *chiral building blocks*.

Fluka offers a large selection of these building blocks, and the more important ones are available in both enantiomeric forms. About 330 chiral building blocks are presented in this section. Other chiral compounds less often employed as building blocks can either be found in other sections of this brochure or in our main catalogue. N-Protected amino acids and amino acid esters, for instance, are not included in this brochure because their main application, peptide synthesis, is not a topic here. As an exception, BOC-L-serine and Z-L-serine (N-Carbobenzyloxy-L-serine) are listed in the section "Amino Acids". Both compounds have recently been shown to be ideal starting materials for the synthesis of protected α -amino- β -lactones in a checked procedure by J. C. Vederas and coworkers [2]. α -Amino- β -lactones are important intermediates for preparing β -substituted α -amino acids.

Several books and review articles have appeared covering the use of chiral building blocks for the synthesis of enantiomerically pure compounds [3–7]. Some important groups of building blocks have received special attention and have been treated in separate reviews: building blocks derived from tartaric acid [1], from carbohydrates [4, 8], from amino acids [5, 12], and building blocks related to isopropylidene-glycerol [9, 10]. A perspective of the large scale synthesis of enantiomerically pure compounds is given in references [11, 13]. Further literature on applications of individual building blocks can be found in the catalogue entries below.

References

- [1] D. Seebach, E. Hungerbühler, Synthesis of Enantiomerically Pure Compounds, Tartaric Acid in Modern Synthetic Methods, R. Scheffold, ed., Springer-Verlag, Berlin, vol. 2, 1980 p. 91
- [2] S.V. Pansare et al., Org. Synth. 70, 1, 10 (1992)
- [3] J.W. Scott in Asymmetric Synthesis, J.D. Morrison ed., Academic Press, vol. 4, 1983
- [4] S. Hanessian, Total Synthesis of Natural Products: the Chiron Approach, Pergamon Press, Oxford, 1983
- [5] G. Coppola, H.F. Schuster, eds., Asymmetric Synthesis: Construction of Chiral Molecules Using Amino Acids, Wiley, New York 1987
- [6] M. Nogradi, Stereoselective Synthesis, Verlag Chemie, Weinheim 1987
- [7] Atta-ur-Rahman, ed., Studies in Natural Products Chemistry, Stereoselective Synthesis, part A, B, C, D, E, Elsevier, Amsterdam, 1988-
- [8] A. Vasella, Chiral Building Blocks in Enantiomer Synthesis, ex Sugars, in Modern Synthetic Methods, R. Scheffold, ed., Springer-Verlag, Berlin, vol. 2, 1980 p. 173
- [9] J. Jurczak et al., Tetrahedron 42, 447 (1986) S. Takano, Pure Appl. Chem. 59, 353 (1987)
- [10] H. Eibl, Chem. Phys. Lipids 26, 405 (1980)
- [11] J. Crosby, Tetrahedron 47, 4789 (1991) R.A. Sheldon, Chirotechnology: Industrial Synthesis of Optically Active Compounds, Marcek Dekker, New York 1993
- [12] J. Jurczak, A. Golebiowski. Chem. Rev. 89, 149 (1989)
- [13] S. Kotha, Tetrahedron 50, 3639 (1994)

B. Presentation of Building Blocks

Chiral building blocks which permit the introduction of fragments ranging from C1 to C5 into chiral target molecules are arranged in tables. The building blocks are tabulated according to:

1. increasing number of skeletal carbon atoms (without counting protecting groups).
 2. decreasing chainlength (straight-chain before branched compounds),
 3. increasing number and position of functionalization,
 4. increasing oxidation state
- and, finally, by:
5. increasing protection.

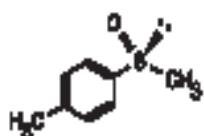
The tables provide the chemist with the opportunity to recognize the stereochemical

relationship of the building blocks at a glance. This will greatly facilitate the job of choosing the building block most suited for a particular synthesis.

Larger building blocks which transfer fragments ranging from C6 to C15 are compiled in lists.

Some building blocks are composed of an achiral part and a chiral auxiliary ("chiral acetate", "chiral glycine", "chiral propionate", etc.). Carbon atoms of the achiral part are incorporated into the target molecule. In this manner, the chiral information is only transferred during the reaction from the auxiliary to the target molecule being built up. These building blocks are also included in these tables although the chirality which is created during a reaction is not directly evident from the structure formula.

C₁-Building Blocks

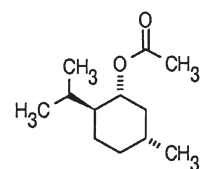


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R(+)-Methyl p-tolyl
sulfoxide

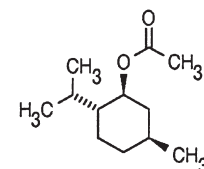


69425
S(-)-Methyl p-tolyl
sulfoxide

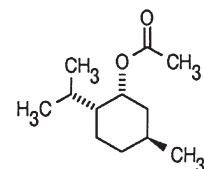
C₂-Building Blocks



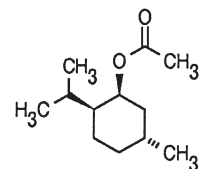
45985
(-)-(1R)-Menthyl
acetate



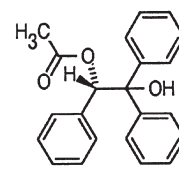
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(+)-(1S)-Menthyl
acetate



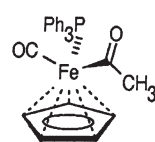
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(-)-(1R)-Neomenthyl
acetate



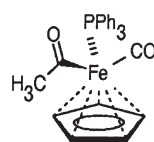
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(+)-(1S)-Neomenthyl
acetate



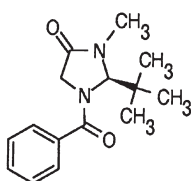
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S(-)-2-Acetoxy-1,1,2-triphenylethanol



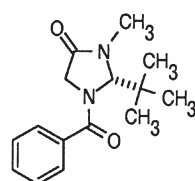
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R(-)-Acetyl-cyclopentadienyliron
carbonyl
Triphenylphosphine
Complex



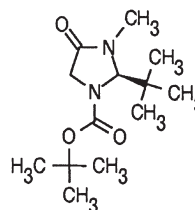
01037
S(+)-Acetyl-cyclopentadienyliron
carbonyl
Triphenylphosphine
Complex



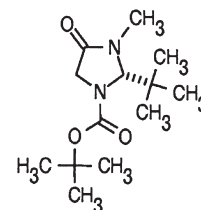
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3-methyl-4-imidazoli-
dinone



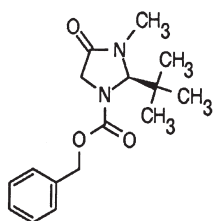
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dinone



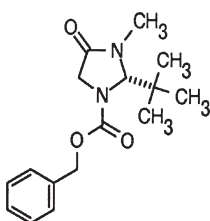
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3-methyl-4-
imidazolidinone



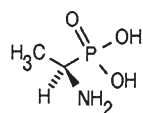
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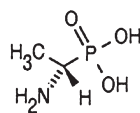
96022
(R)-1-Z-2-tert-butyl-3-
methyl-4-imidazolidinone



96024
(S)-1-Z-2-tert-butyl-3-
methyl-4-imidazolidinone

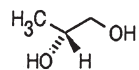


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R(-)-1-Aminoethylphos-
phonic acid

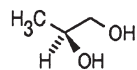


06657
S(+)-1-Aminoethylphos-
phonic acid

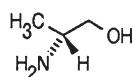
C₃-Building Blocks



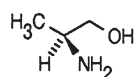
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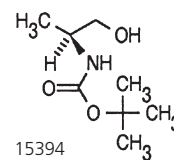
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S(+)-Propylene glycol



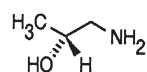
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D-Alaninol



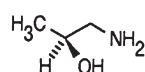
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L-Alaninol



15394
BOC-L-alaninol



09281
R(-)-1-Amino-2-propanol



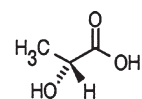
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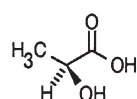
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R(+)-Propylene oxide



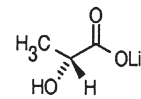
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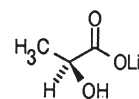
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D(-)-Lactic acid



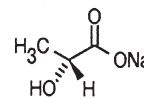
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L(+)-Lactic acid



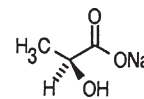
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Lithium D-lactate



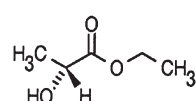
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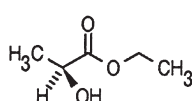
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D-Lactic acid
Sodium salt



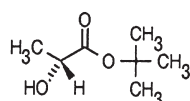
71718
L-Lactic acid
Sodium salt



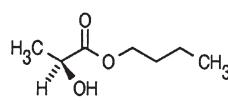
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(+)-Ethyl D-lactate



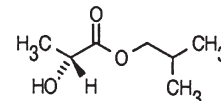
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(-)-Ethyl L-lactate



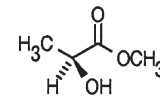
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(+)-tert-Butyl D-lactate



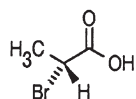
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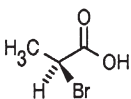
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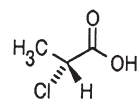
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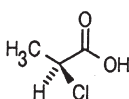
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R(+)-2-Bromopropionic
acid



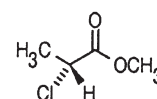
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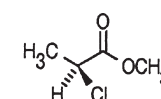
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R(+)-2-Chloropropionic
acid



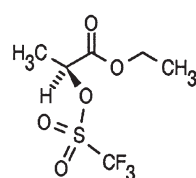
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acid



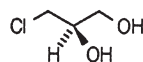
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propionate



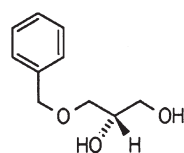
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propionate



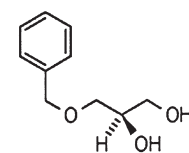
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Ethyl O-(trifluoro-
methanesulfonyl)-
L-lactate



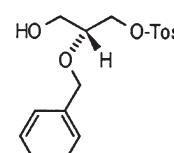
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propanediol



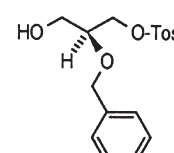
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propanediol



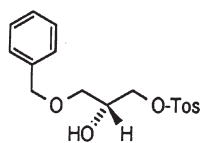
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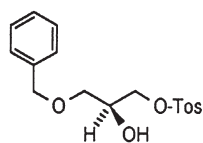
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propanediol 1-tosylate



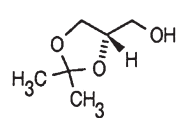
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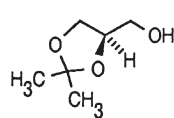
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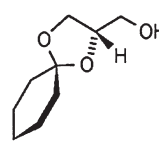
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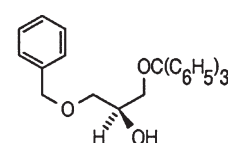
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D-α,β-Isopropylidene-glycerol



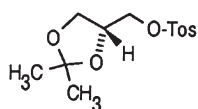
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L-α,β-Isopropylidene-glycerol



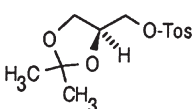
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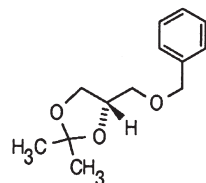
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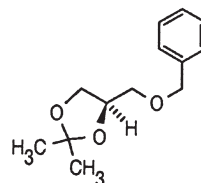
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D-α,β-Isopropylidene-glycerol γ -tosylate



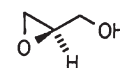
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L-α,β-Isopropylidene-glycerol γ -tosylate



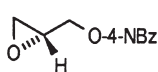
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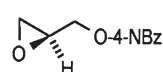
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L-α,β-Isopropylidene-glycerol γ -benzyl ether



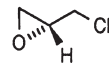
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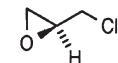
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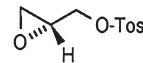
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S(+)-Glycidyl 4-nitrobenzoate



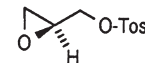
45325
R(-)-Epichlorohydrin



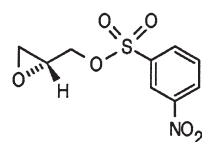
45327
S(+)-Epichlorohydrin



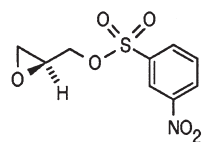
50041
R(-)-Glycidyl tosylate



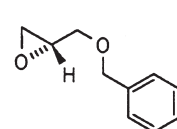
50044
S(+)-Glycidyl tosylate



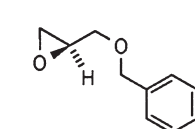
50047
R(-)-Glycidyl 3-nitrobenzenesulfonate



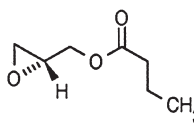
50048
S(+)-Glycidyl 3-nitrobenzenesulfonate



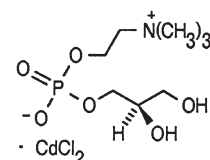
13425
(-)-Benzyl (R)-glycidyl ether



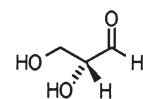
13423
(+)-Benzyl (S)-glycidyl ether



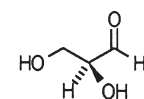
50038
R(-)-Glycidyl butyrate



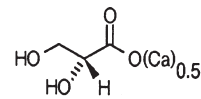
50035
L-α-Glycerol-phosphorylcholine Cadmium chloride Complex



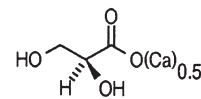
49800
D(+)-Glyceraldehyde



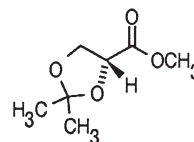
49790
L(-)-Glyceraldehyde



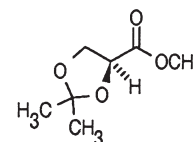
50031
D-Glyceric acid Hemicalcium salt



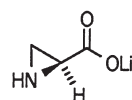
50032
L-Glyceric acid Hemicalcium salt



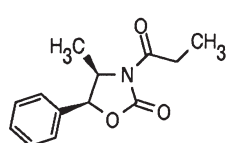
59449
Methyl α , β -isopropylidene D-glycerate



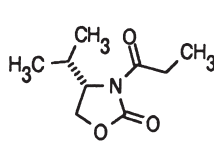
59448
Methyl α , β -isopropylidene L-glycerate



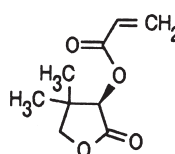
11558
L-Aziridine-2-carboxylic acid Lithium salt



68730
(4R, 5S)-4-Methyl-5-phenyl-3-propionyl-2-oxazolidinone

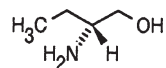


59735
(S)-4-Isopropyl-3-propionyl-2-oxazolidinone

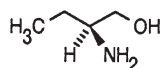


01728
(R)- α -Acryloxy- β , β -dimethyl- γ -butyrolactone

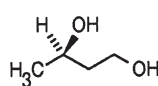
C₄-Building Blocks



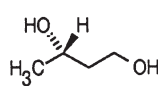
07180
R(-)-2-Amino-1-butanol



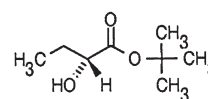
07178
S(+)-2-Amino-1-butanol



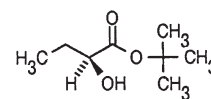
18937
R(-)-1,3-Butanediol



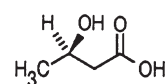
18938
S(+)-1,3-Butanediol



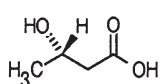
54956
tert-Butyl (R)-2-hydroxybutyrate



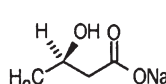
54954
tert-Butyl (S)-2-hydroxybutyrate



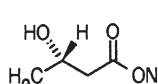
54920
(R)-3-Hydroxybutyric acid



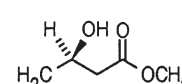
54925
(S)-3-Hydroxybutyric acid



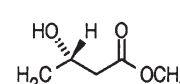
54963
(R)-3-Hydroxybutyric acid Sodium salt



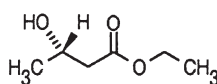
54964
(S)-3-Hydroxybutyric acid Sodium salt



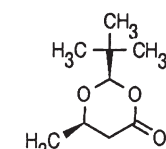
54957
Methyl (R)-3-hydroxybutyrate



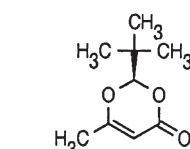
54958
Methyl (S)-3-hydroxybutyrate



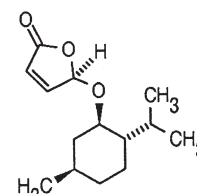
54955
Ethyl (S)-3-hydroxybutyrate



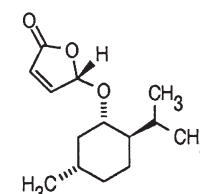
20260
(2R, 6R)-2-tert-Butyl-6-methyl-1,3-dioxan-4-one



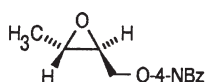
20264
(R)-2-tert-Butyl-6-methyl-1,3-dioxin-4-one



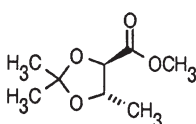
63687
(R)-5-[(1R)-Menthyl]-2-(5H)-furanone



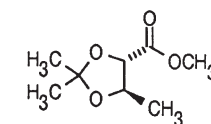
63688
(S)-5-[(1S)-Menthyl]-2-(5H)-furanone



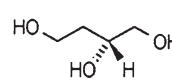
68249
(2S, 3S)-trans-3-Methyloxirane-2-methyl 4-nitrobenzoate



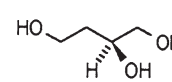
59436
Methyl (2R, 3S)-2,2-O-isopropylidene-2,3-dihydroxybutyrate



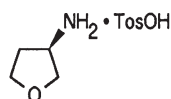
59437
Methyl (2S, 3R)-2,2-O-isopropylidene-2,3-dihydroxybutyrate



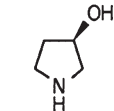
19043
(R)-1,2,4-Butanetriol



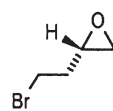
19045
(S)-1,2,4-Butanetriol



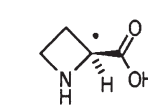
09440
R(+)-3-Aminotetrahydrofuran toluene-4-sulfonate



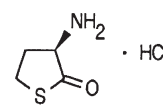
56435
(R)-3-Hydroxypyrrolidine



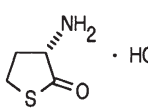
16995
S(-)-4-Bromo-1,2-epoxybutane



11542
L-Azetidine-2-carboxylic acid



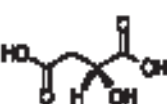
53525
D-Homocysteine thio-lactone hydrochloride



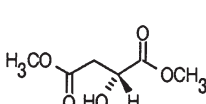
53527
L-Homocysteine thio-lactone hydrochloride



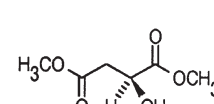
02300
D(+)-Malic acid



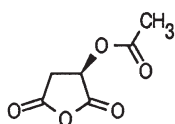
02290
L(-)-Malic acid



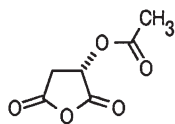
02318
Dimethyl D-malate



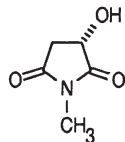
02315
Dimethyl L-malate



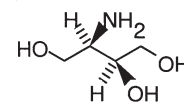
00822
(R)-2-Acetoxy succinic
anhydride



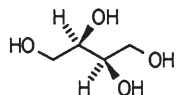
00823
(S)-2-Acetoxy succinic
anhydride



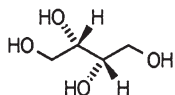
55860
(S)-2-Hydroxy-N-methyl-
succinimide



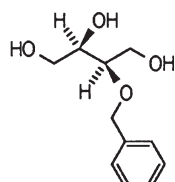
89212
L-Threoninol



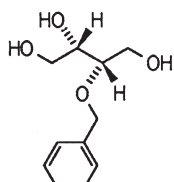
89173
D-Threitol



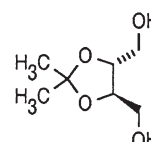
89175
L-Threitol



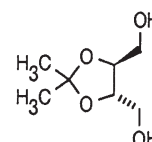
13624
(2R, 3R)-(-)-2-Benzyloxy-
1,3,4,-butanetriol



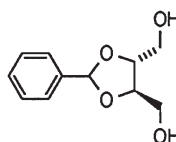
13623
(2S, 3S)-(+)-2-Benzyloxy-
1,3,4,-butanetriol



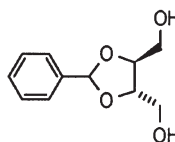
59535
(-)-2,3-O-Isopropylidene-
D-threitol



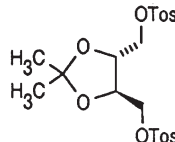
59539
(+)-2,3-O-Isopropylidene-
L-threitol



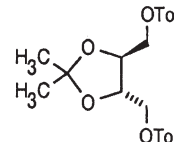
13473
(+)-2,3-O-Benzylidene-
L-threitol



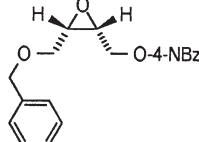
13474
(-)-2,3-O-Benzylidene-
L-threitol



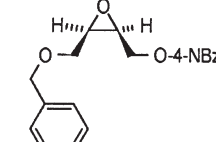
43875
(+)-1,4-Di-O-tosyl-2,3-
O-isopropylidene-
D-threitol



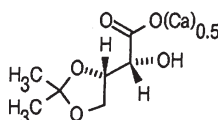
43880
(-)-1,4-Di-O-tosyl-2,3-
O-isopropylidene-
L-threitol



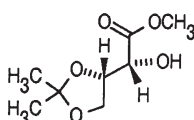
13730
(2R, 3S)-3-(Benzyl-
oxymethyl) oxirane-
2-methanol 4-
nitrobenzoate



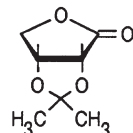
13732
(2S, 3R)-3-(Benzyl-
oxymethyl) oxirane-
2-methanol 4-
nitrobenzoate



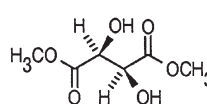
59546
3,4-O-Isopropylidene-
L-threonic acid
Hemicalcium salt



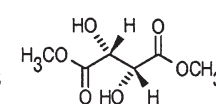
59544
Methyl 3,4-O Isopropylidene-
L-threonate



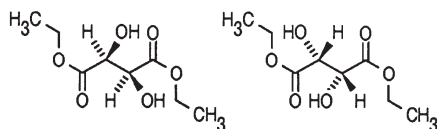
59430
(-)-2,3-O-Isopropylidene
D-erythronolactone



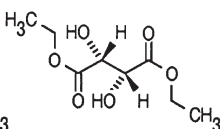
95366
(-)-Dimethyl D-tartrate



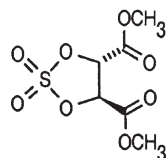
95365
(+)-Dimethyl L-tartrate



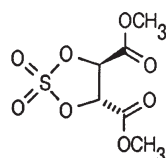
95340
(-)-Diethyl D-tartrate



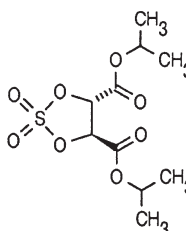
95355
(+)-Diethyl L-tartrate



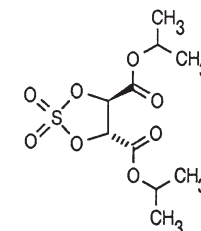
42544
Dimethyl (4S, 5S)-1,3,2-
dioxathiolane-4,5-
dicarboxylate 2,2-dioxide



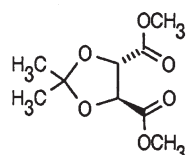
42543
Dimethyl (4R, 5R)-1,3,2-
dioxathiolane-4,5-
dicarboxylate 2,2-dioxide



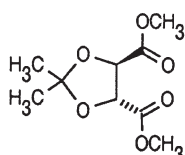
42542
Diisopropyl (4S, 5S)-
1,3,2-dioxathiolane-
4,5-dicarboxylate
2,2-dioxide



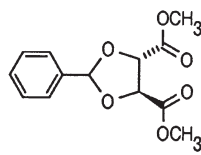
42541
Diisopropyl (4R, 5R)-
1,3,2-dioxathiolane-
4,5-dicarboxylate
2,2-dioxide



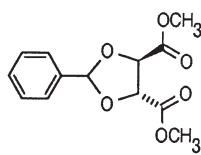
59543
(+)-Dimethyl 2,3-O-
isopropylidene D-tartrate



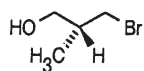
59542
(-)-Dimethyl 2,3-O-
isopropylidene L-tartrate



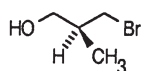
13476
(+)-Dimethyl 2,3-O-
benzylidene D-tartrate



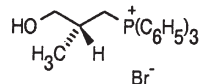
13478
(-)-Dimethyl 2,3-O-
benzylidene L-tartrate



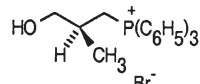
17619
R(-)-3-Bromo-2-methyl-1-propanol



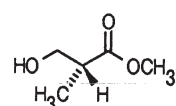
17620
S(+)-3-Bromo-2-methyl-1-propanol



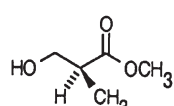
55764
R(+)-(3-Hydroxy-2-methylpropyl)triphenylphosphonium bromide



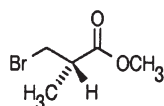
55766
S(-)-(3-Hydroxy-2-methylpropyl)triphenylphosphonium bromide



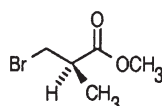
55415
(-)-Methyl D- β -hydroxyisobutyrate



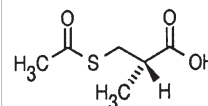
55412
(+)-Methyl L- β -hydroxyisobutyrate



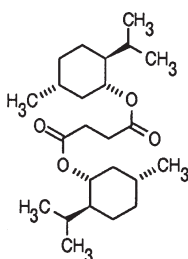
17621
(-)-Methyl (S)-3-bromo-2-methylpropionate



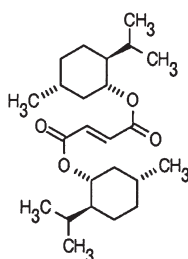
17616
(+)-Methyl (R)-3-bromo-2-methylpropionate



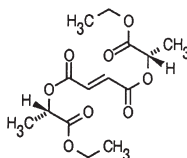
01280
(S)-B-(Acetylmercapto)isobutyric acid



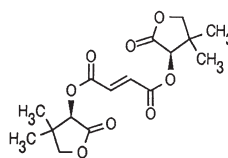
14145
(-)-Di [(1R)-menthyl]succinate



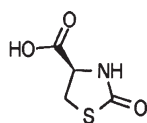
47965
(-)-Di [(1R)-menthyl]fumarate



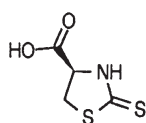
47915
(-)-Bis [(S)-1-(ethoxycarbonyl)ethyl]fumarate



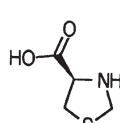
47920
(+)-Bis [(R)-4,4-dimethyl-2-oxotetrahydro-3-furyl]fumarate



75951
R(-)-2-Oxothiazolidine-4-carboxylic acid

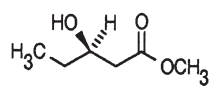


89113
R(-)-2-Thioxothiazolidine-4-carboxylic acid

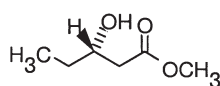


88400
L-Thiazolidine-4-carboxylic acid

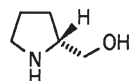
C₅-Building Blocks



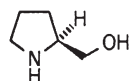
56655
Methyl (R)-3-hydroxyvalerate



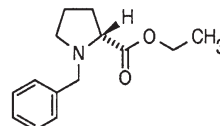
56657
Methyl (S)-3-hydroxyvalerate



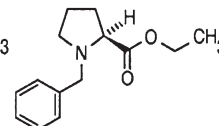
81744
D-Prolinol



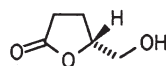
81745
L-Prolinol



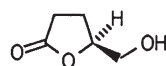
13836
N-Benzyl-D-proline ethyl ester



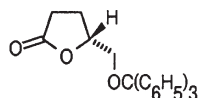
13838
N-Benzyl-L-proline ethyl ester



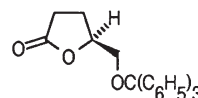
55621
(R)- γ -Hydroxymethyl- γ -butyrolactone



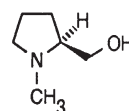
55620
(S)- γ -Hydroxymethyl- γ -butyrolactone



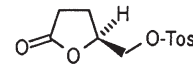
93461
(R)- γ -Trityloxymethyl- γ -butyrolactone



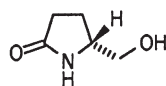
93463
(S)- γ -Trityloxymethyl- γ -butyrolactone



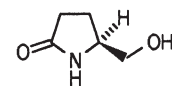
68890
N-Methyl-L-prolinol



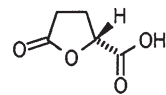
90183
S(+)- γ -Tosyloxymethyl- γ -butyrolactone



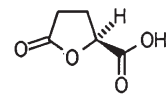
55820
(R)-5-(Hydroxymethyl)-2-pyrrolidinone



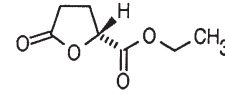
55830
(S)-5-(Hydroxymethyl)-2-pyrrolidinone



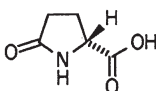
75946
(R)-5-Oxotetrahydrofuran-2-carboxylic acid



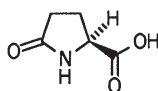
75947
(S)-5-Oxotetrahydrofuran-2-carboxylic acid



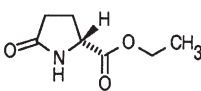
75952
(-)-Ethyl (R)-5-oxotetrahydrofuran-2-carboxylate



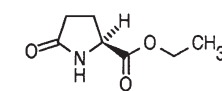
83165
D-Pyroglutamic acid



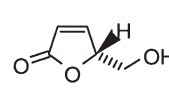
83160
L-Pyroglutamic acid



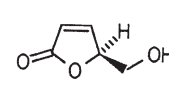
83173
D-Pyroglutamic acid ethyl ester



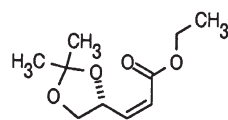
83175
L-Pyroglutamic acid ethyl ester



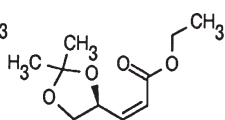
55673
R(+)-5-Hydroxymethyl-2(5H)-furanone



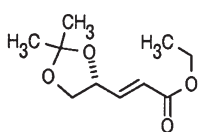
55675
S(-)-5-Hydroxymethyl-2(5H)-furanone



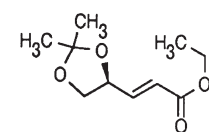
59431
Ethyl (R)-cis-4,5-O-isopropylidene-4,5-dihydroxy-2-pentenoate



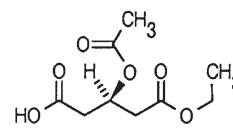
59432
Ethyl (S)-cis-4,5-O-isopropylidene-4,5-dihydroxy-2-pentenoate



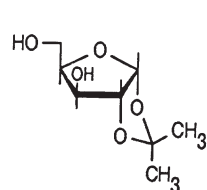
59433
Ethyl (R)-trans-4,5-O-isopropylidene-4,5-dihydroxy-2-pentenoate



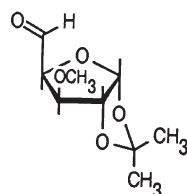
59434
Ethyl (S)-trans-4,5-O-isopropylidene-4,5-dihydroxy-2-pentenoate



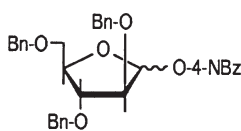
00852
mono-Ethyl (R)-3-acetoxyglutarate



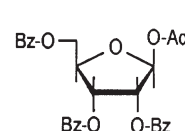
59545
1,2-O-Isopropylidene- α -D-xylofuranose



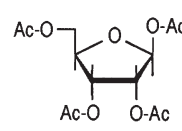
59538
1,2-O-Isopropylidene-3-O-methyl- α -D-xylopentodialdo-furanose



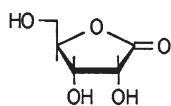
90675
2,3,5-Tri-O-benzyl-1-O-(4-nitrobenzoyl)-D-arabinofuranose



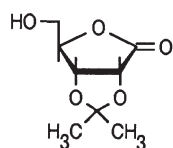
01510
1-O-Acetyl-2,3,5-tri-O-benzoyl- β -D-ribofuranose



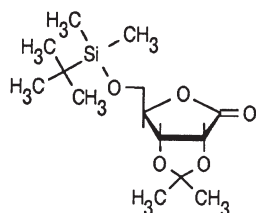
86560
1,2,3,5-Tetra-O-acetyl- β -D-ribofuranose



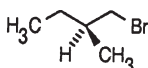
83820
D(+)-Ribonic acid γ -lactone



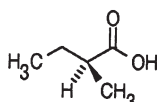
59485
2,3-O-Isopropylidene
D-ribono-1,4-lactone



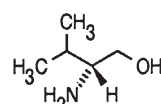
19917
5-O-(tert-Butyldimethylsilyl)-2,3-O-isopropylidene-D-ribo-1,4-lactone



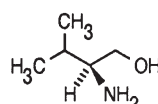
17605
S(+)-1-Bromo-2-methylbutane



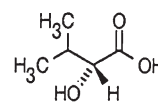
66127
S(+)-2-Methylbutyric acid



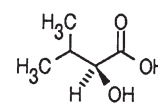
94674
D-Valinol



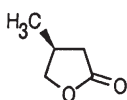
94672
L-Valinol



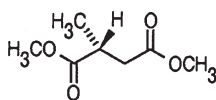
55452
D- α -Hydroxyisovaleric acid



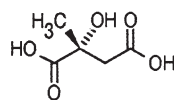
55454
L- α -Hydroxyisovaleric acid



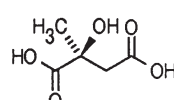
66145
S- β -Methyl- γ -butyrolactone



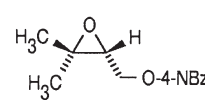
65920
(+)-Dimethyl (R)-methylsuccinate



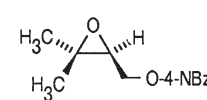
27454
D(-)-Citramalic acid



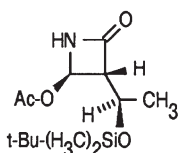
27453
L(+)-Citramalic acid



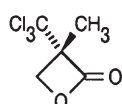
41033
R(+)-3,3-Dimethylxirane-2-methyl 4-nitrobenzoate



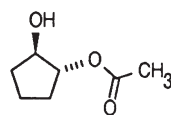
41032
S(-)-3,3-Dimethylxirane-2-methyl 4-nitrobenzoate



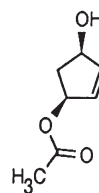
00828
[3R(1'R), 4R]-4-Acetoxy-3-[1-(tert-butyl-dimethylsilyloxy)ethyl]-2-azetidinone



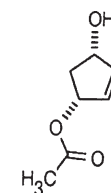
69446
S(-)-4-Methyl-4-(trichloromethyl)-2-oxetanone



00846
(1R, 2R)-trans-2-Acetoxy-1-cyclopentanol



00848
(1R, 4S)-cis-4-Acetoxy-2-cyclopenten-1-ol



00850
(1S, 4R)-cis-4-Acetoxy-2-cyclopenten-1-ol

C₆ Building Blocks

00525	Acetobromo- α -D-galactose	49210	β -D-Glucose pentaacetate
00530	Acetobromo- α -D-glucose	51190	D-Gulonic acid γ -lactone
00851	(R)-2-Acetoxy-3,3-dimethylbutyronitrile	51195	L-Gulonic acid γ -lactone
10390	1,6-Anhydro- β -D-glucopyranose (Levo-glucosan)	52793	(2S,5S)-2,5-Hexanediol
13145	Benzyl-2-acetamido-4,6-O-benzylidene-2-deoxy- α -D-glucopyranoside	53400	L-Histidinol dihydrochloride
15015	1,3:4,6-Bis-O-(4-methoxybenzylidene)-D-mannitol	55200	D(-)-2-Hydroxy-3,3-dimethyl- γ -butyrolactone
15409	N-BOC-D-glucosamine	59435	(+)-5,6-O-Isopropylidene-L-ascorbic acid
29002	(1R,2R)-trans-1,2-Cyclohexanediol	59439	1,2-O-Isopropylidene- α -D-glucofuranose
29003	(1S,2S)-trans-1,2-Cyclohexanediol	59465	5,6-O-Isopropylidene-D-gulonic acid
29397	(+)-5,6-O-Cyclohexylidene-L-ascorbic acid	59470	5,6-O-Isopropylidene-L-gulonic acid
29415	(-)-5,6-O-Cyclohexylidene-D-isoascorbic acid	59480	1,2-O-Isopropylidene- β -L-idofuranose
31460	Diacetone-D-glucose	59531	1,2-O-Isopropylidene-D-mannitol
31542	3,4-Di-O-acetyl-6-deoxy-L-glucal	59533	3,4-O-Isopropylidene-D-mannitol
33427	1,4:3,6-Dianhydro-D-mannitol	61835	D-tert-Leucine
33750	1,3:4,6-Di-O-benzylidene-D-mannitol	61825	L-tert-Leucine
36655	1,2:5,6-Di-O-cyclohexylidene-D-mannitol	61915	D-Leucinol
38406	1,2:3,4-Di-O-isopropylidene- α -D-galactopyranose	61920	L-Leucinol
38410	1,2:5,6-Di-O-isopropylidene-D-mannitol	65898	Methyl-4,6-O-benzylidene-2,3-di-O-(p-toluenesulfonyl)- α -D-galactopyranose
38415	1,2:5,6-Di-O-isopropylidene- α -D-ribo-3-hexofuranosulose	65895	Methyl-4,6-O-benzylidene- α -D-glucopyranose
03400	Ethyl-4,6-di-O-acetyl-2,3-dideoxy- α -D-erythro-hex-2-enopyranoside	66885	2,5-O-Methylene-D-mannitol
67000	(R)-1-Ethyl hydrogen 3-methylglutarate	66930	N-Methyl-D-glucamine
48186	R(+)-1-(2-Furyl)ethanol	67024	(R)-1-Methyl hydrogen 3-methylglutarate
48188	S(-)-1-(2-Furyl)ethanol	68336	R(-)-2-Methyl-2,4-pentanediol
48225	D-Galactal	86555	1,3,4,6-Tetra-O-acetyl- β -D-mannopyranose
48240	D(-)-Galactonic acid γ -lactone	86566	1,3,4,6-Tetra-O-acetyl-2-O-(trifluoromethanesulfonyl)- β -D-mannopyranose
48245	L(+)-Galactonic acid γ -lactone	86730	2,3,4,6-Tetra-O-benzyl-D-glucopyranose
49200	α -D-Glucose pentaacetate	90260	Tri-O-acetyl-D-glucal
		90672	Tri-O-benzyl-D-glucal

C₇ Building Blocks

65510
R(+)-3-Methyladipic acid
75650
(1R,5S)-2-Oxabicyclo[3.3.0]oct-6-en-3-one
75651
(1S,5R)-2-Oxabicyclo[3.3.0]oct-6-en-3-one

C₈ Building Blocks

00873
(R)-α-Acetoxyphenylacetonitrile
56065
tert-Butyl (R)-2-hydroxyoctanoate
25903
R(-)-2-Chloro-1-phenylethanol
25905
S(+)-2-Chloro-1-phenylethanol
52535
(-)-Corey lactone 5-(-phenylbenzoate)
63466
(+)-Methyl L-mandelate
63456
(-)-Methyl D-mandelate
87462
(1S,2R)-1-Methyl cis-1,2,3,4-tetrahydro-phthalate
87463
(1S,2R)-1-Methyl cis-1,2,3,4-tetrahydro-phthalate Dicyclohexylamine salt
77847
R(-)-1-Phenyl-1,2-ethanediol
77845
S(+)-1-Phenyl-1,2-ethanediol
78583
D(-)-α-Phenylglycine chloride hydrochloride
78590
D(-)-Phenylglycinol
78585
L(+)-Phenylglycinol
78880
R(-)-Phenyloxirane
78885
S(+)-Phenyloxirane

C₉ Building Blocks

07624
(S)-2-Amino-3-cyclohexyl-1-propanol hydrochloride
15486
BOC-D-phenylalaninol
15489
BOC-L-phenylalaninol
56187
(+)-Ethyl (R)-3-hydroxy-3-phenylpropionate
56188
(-)-Ethyl (S)-3-hydroxy-3-phenylpropionate
56862
R(-)-1-Indanol
56864
S(+)-1-Indanol
78115
D-Phenylalaninol

78100
L-Phenylalaninol
78395
R(+)-4-Phenyl-1,3-dioxane
78397
S(-)-4-Phenyl-1,3-dioxane
78888
(2R,3R)-trans-3-Phenyloxirane-2-methanol
78890
(2S,3S)-trans-3-Phenyloxirane-2-methanol
78917
R(+)-1-Phenyl-1,3-propanediol
78918
S(-)-1-Phenyl-1,3-propanediol
78972
(R)-1-Phenyl-2-propen-1-ol
78974
(S)-1-Phenyl-2-propen-1-ol
79005
(R)-2-Phenyl-1-propylamine
79007
(S)-2-Phenyl-1-propylamine
78976
(R)-1-Phenyl-2-propyn-1-ol
78978
(S)-1-Phenyl-2-propyn-1-ol
92398
(R)-2,2,6-Trimethyl-1,4-cyclohexanedione
97025
Z-D-phenylalaninol
97027
Z-L-phenylalaninol

C₁₀ Building Blocks

00873
(R)-α-Acetoxyphenylacetonitrile
00874
(R)-2-Acetoxy-4-phenylbutyronitrile
16571
(+)-3-Bromocamphor
21300
(+)-Camphor
21295
(-)-Camphor
21335
(1R)-(-)-Camphor oxime
21322
(1R)-(-)-Camphorquinone
21323
(1S)-(+)-Camphorquinone
21327
(1R,E)-(+)-Camphorquinone 3-oxime
21328
(1S,E)-(-)-Camphorquinone 3-oxime
21984
(+)-2-Carene
21986
(+)-3-Carene
22060
(+)-Carvone

22070 (-)-Carvone	78239 (R)-3-Phenylbutyric acid
27467 (+)-Citronellal	78240 (S)-3-Phenylbutyric acid
27468 (-)-Citronellal	78172 R(-)-Phenylsuccinic acid
27475 (+)- β -Citronellene	78173 S(+)-Phenylsuccinic acid
27477 (-)- β -Citronellene	80605 (+)- α -Pinene
27478 (+)- β -Citronellol	80599 (-)- α -Pinene
27483 (-)- β -Citronellol	80607 (+)- β -Pinene
40960 R(+)-5,7-Dimethyl-1,6-octadiene	80609 (-)- β -Pinene
56114 Ethyl (R)-2-hydroxy-4-phenylbutyrate	82569 (+)-Pulegone
46199 (+)-Fenchol	82579 (-)-Pulegone
46210 (+)-Fenchone	86477 (+)-Terpinen-4-ol
46200 (-)-Fenchone	94881 (1R)-cis-Verbenol
56112 (R)-2-Hydroxy-4-phenylbutyric acid	94879 (1S)-cis-Verbenol
59765 (+)-Isopulegol	94882 (1S)-(-)-Verbenone
59770 (-)-Isopulegol	
62118 R(+)-Limonene	C₁₁ Building Blocks
62128 S(-)-Limonene	52560 R(-)-4,4a,5,6,7,8-Hexahydro-4a-methyl-2(3H)-naphthalenone
63655 (+)-p-Menth-1-ene	52562 S(+)-4,4a,5,6,7,8-Hexahydro-4a-methyl-2(3H)-naphthalenone
63675 (+)-Menthone	68167 S(+)-8a-Methyl-3,4,8,8a-tetrahydro-1,6(2H,7H)-naphthalenedione
68262 (+)-Methyl (R)-3-(1-methyl-2-oxocyclohexyl)propionate	68169 R(-)-8a-Methyl-3,4,8,8a-tetrahydro-1,6(2H,7H)-naphthalenedione
68261 (-)-Methyl (S)-3-(1-methyl-2-oxocyclohexyl)propionate	
78275 Methyl (R)-3-phenylbutyrate	C₁₂ Building Blocks
68704 (2S,3S)-trans-2-Methyl-3-phenyloxirane-2-methanol	74440 (-)-Nopol
70125 (-)-Myrtenal	
70158 (-)-Myrtenol	C₁₅ Building Blocks
77301 (+)-Perillaaldehyde	00010 Abietic acid
77302 (-)-Perillaaldehyde	
77304 (-)-Perillyl alcohol	
77303 (+)-Perillyl alcohol	

Resolving Agents

Despite its age, resolution is still a widely used technique for preparing enantiomerically pure compounds both in the laboratory and in industry. The separation of a pair of diastereoisomers (salts, esters, amides, etc.) formed from a racemate with a resolving agent can either be performed by crystallisation or also by chromatography. In the latter case, the amount of racemate to be resolved should not be too large. Separation by crystallization is in most cases an empirical matter needing much "trial and error" when no procedure has been published for the specific racemate to be resolved. Besides a large body of examples which have been compiled over more than a century [1], a rational approach to separation developed by Wilen et al. [2] provides guidelines for the successful resolution of new compounds.

In some special cases, the unwanted enantiomer is transformed during the resolution via racemization into the other enantiomer. In a crystallization-induced asymmetric transformation, nearly complete conversion was achieved [3]; several "deracemization" procedures lead to enantiomeric enrichment [4].

The more important resolving agents are collected in this section of the brochure. The reagents are grouped in 9 lists according to functional groups providing a quick overview. Other compounds useful as resolving agents which are not listed here can be found in other sections of this brochure or in our main catalogue.

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- [1] S. H. Wilen, *Tables of Resolving Agents and Optical Resolutions*, University of Notre Dame Press, Notre Dame, 1972
S. H. Wilen, *Resolving Agents and Resolutions in Organic Chemistry*, in *Topics in Stereochemistry*, vol. 6, 1971, p. 107
P. Newman, *Optical Resolution Procedures for Chemical Compounds*; Optical Resolution Information Center, New York; vol. 1: Amines and Related Compounds, 1978; vol. 2: Acids, 1981; vol. 3: Alcohols, Phenols, Thiols, Aldehydes and Ketones, 1984; vol. 4: to be published
- [2] S. H. Wilen, A. Collet, J. Jacques, *Tetrahedron* **33**, 2725 (1977)

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- [3] P. J. Reider et al., *J. Org. Chem.* **52**, 955 (1987)
- [4] L. Duhamel, J. C. Plaquevent, *Bull. Soc. Chim. Fr.* **75** (1982)
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Lists of resolving agents according to type of reagent

Acids, useful for the resolution of bases and alcohols

00805
(-)-3 β -Acetoxy-5-etienic acid
14380
R(-)-1,1'-Binaphthalene-2,2'-diyl hydrogen phosphate
14375
S(+)-1,1'-Binaphthalene-2,2'-diyl hydrogen phosphate
16579
(-)-3-Bromocamphor-8-sulfonic acid Ammonium salt
16575
(+)-3-Bromocamphor-10-sulfonic acid
21282
(+)-Camphanic acid
21284
(-)-Camphanic acid
21340
(+)-Camphoric acid
21345
(-)-Camphoric acid
21360
(+)-Camphor-10-sulfonic acid
21365
(-)-Camphor-10-sulfonic acid
33624
(-)-Di-O,O'-benzoyl-L-tartaric acid mono(dimethyl)amide
33610
(+)-Di-O,O'-benzoyl-D-tartaric acid
33620
(-)-Di-O,O'-benzoyl-L-tartaric acid
33622
(-)-Di-O,O'-benzoyl-L-tartaric acid Monohydrate
33624
(-)-Di-O,O'-benzoyl-L-tartaric acid mono(dimethylamide)
31462
(-)-2,3:4,6-Di-O-isopropylidene-2-keto-L-gulonic acid
43822
(+)-Di-O,O'-p-toluyll-D-tartaric acid
43821
(-)-Di-O,O'-p-toluyll-L-tartaric acid
02300
D(+)-Malic acid
02290
L(-)-Malic acid
63450
D(-)-Mandelic acid
63460
L(+)-Mandelic acid
63683
(+)-Menthylloxyacetic acid
63685
(-)-Menthylloxyacetic acid
80155
(+)-mono-(1S)-Menthyl phthalate
80157
(-)-mono-(1R)-Menthyl phthalate

65212
R(-)- α -Methoxyphenylacetic acid
65211
S(+)- α -Methoxyphenylacetic acid
65362
R(+)- α -Methoxy- α -trifluoromethylphenylacetic acid puriss.
65364
S(-)- α -Methoxy- α -trifluoromethylphenylacetic acid puriss.
65901
R(+)-N-(α -Methylbenzyl)phthalic acid monoamide
65902
S(-)-N-(α -Methylbenzyl)phthalic acid monoamide
75946
(R)-5-Oxotetrahydrofuran-2-carboxylic acid
75947
(S)-5-Oxotetrahydrofuran-2-carboxylic acid
78135
S(-)-2-(Phenylaminocarbonyloxy)propionic acid
78990
R(-)-2-Phenylpropionic acid
78992
S(+)-2-Phenylpropionic acid
22580
D(-)-Quinic acid
95320
D(-)-Tartaric acid
95309
L(+)-Tartaric acid

Acid chlorides (or anhydrides), useful for the resolution of alcohols and amines via covalent derivatives

21380
(+)-Camphor-10-sulfonyl chloride
21382
(-)-Camphor-10-sulfonyl chloride
31587
Di-O-acetyl-L-tartaric anhydride
23197
(+)-(1S)-Menthyl chloroformate
23200
(-)-(1R)-Menthyl chloroformate

Alcohols, useful for the resolution of acids via esters

63658
(+)-Menthol
63660
(-)-Menthol
63466
(+)-Methyl L-mandelate
63456
(-)-Methyl D-mandelate
82902
R(+)-1-(4-Pyridyl)ethanol
82903
S(-)-1-(4-Pyridyl)ethanol

Glycols, useful for the resolution of carbonyls

14635
(+)-1,4-Bis-O-(4-chlorobenzyl)-D-threitol
14630
(-)-1,4-Bis-O-(4-chlorobenzyl)-L-threitol
18965
D(-)-2,3-Butanediol
18967
L(+)-2,3-Butanediol
95360
Dibutyl L-tartrate

Bases, useful for the resolution of acids

09235
L(+)-threo-2-Amino-1-phenyl-1,3-propanediol
13202
(1R,2S)-(+)-cis-[2-(Benzylamino)-cyclohexyl]-methanol
13203
(1S,2R)-(+)-cis-[2-(Benzylamino)-cyclohexyl]-methanol
13595
(R)-N-Benzyl-1-(1-naphthyl)-ethylamine-hydrochloride
13597
(S)-N-Benzyl-1-(1-naphthyl)-ethylamine-hydrochloride
13765
R(+)-N-Benzyl-1-phenylethylamine
13767
S(-)-N-Benzyl-1-phenylethylamine
15145
(-)-Bis-[(S)-1-phenylethyl]-amine-hydrochloride
15147
(+)-Bis-[(R)-1-phenylethyl]-amine-hydrochloride
18800
Brucine
18810
Brucine sulfate Hydrate
27350
Cinchonidine
27370
Cinchonine
30752
(+)-Dehydroabietylamine
41385
R(+)-N,N-Dimethyl-1-phenylethylamine
41387
S(-)-N,N-Dimethyl-1-phenylethylamine
45261
(-)-Ephedrine
45280
(+)-Ephedrine hydrochloride
77880
D(+)- α -Methylbenzylamine purum
77870
L(-)- α -Methylbenzylamine purum
68620
R(+)-N-Methyl-1-phenylethylamine

68622
S(-)-N-Methyl-1-phenylethylamine
70711
R(+)-1-(1-Naphthyl)ethylamine purum
70713
S(-)-1-(1-Naphthyl)ethylamine purum
73612
(R)-1-(4-Nitrophenyl)ethylamine hydrochloride
73613
(S)-1-(4-Nitrophenyl)ethylamine hydrochloride

22600
Quinidine

22620
Quinine

85920
Strychnine

Isocyanates, useful for the resolution of alcohols and amines

77973
R(+)-1-Phenylethyl isocyanate
77971
S(-)-1-Phenylethyl isocyanate

Various compounds

93915
L-Tyrosine hydrazide

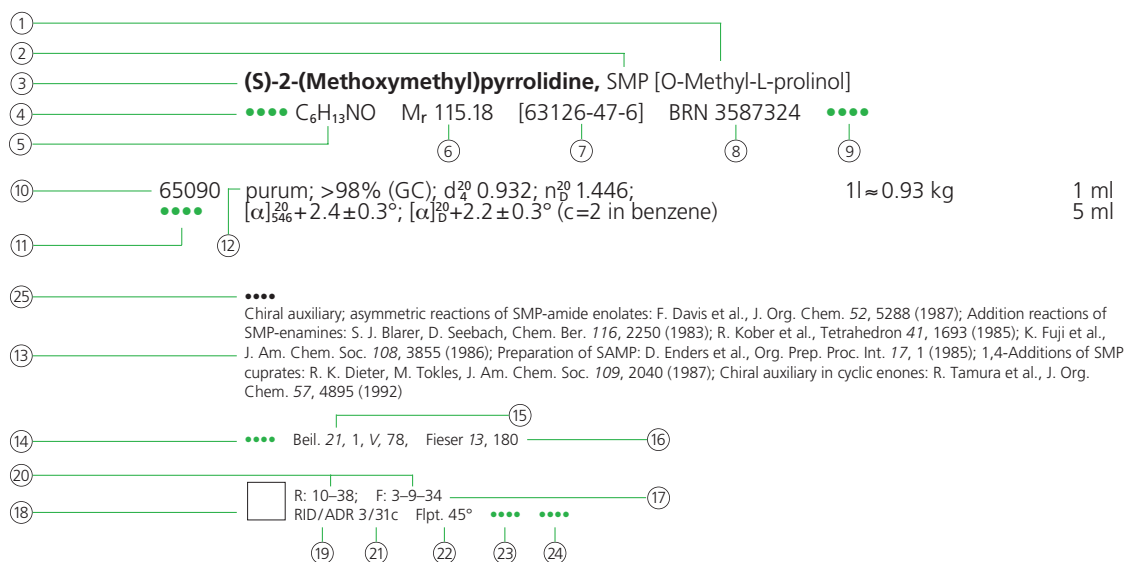
Reagents for the formation of clathrates

14662
(+)-1,6-Bis(2-chlorophenyl)-1,6-diphenyl-2,4-hexadiyne-1,6-diol
14663
(-)-1,6-Bis(2-chlorophenyl)-1,6-diphenyl-2,4-hexadiyne-1,6-diol
38819
(R,R)-(+)-2,3-Dimethoxy-N,N,N',N'-tetramethylsuccinic diamide
38820
(S,S)-(-)-2,3-Dimethoxy-N,N,N',N'-tetramethylsuccinic diamide
43185
S(-)-1,1-Diphenyl-1,2-propanediol
59532
(-)-2,3,0-Isopropyliden-1,1,4,4-tetraphenyl-L-threitol
59534
(-)-2,3,0-Isopropyliden-1,1,4,4-tetraphenyl-D-threitol

Special compounds, e.g. for chiral stationary phases for HPLC

28127
(+)-(18-Crown-6)-2,3,11,12-tetracarboxylic acid
42032
N-(3,5-Dinitrobenzoyl)-D-phenylglycine
42033
N-(3,5-Dinitrobenzoyl)-L-phenylglycine

Typical Product Entry



- ① Synonyms
- ② Usual Abbreviations
- ③ Product Name
- ④ Extended Formula
- ⑤ Empirical Formula
- ⑥ Molecular Mass
- ⑦ CAS-No. (Chemical Abstract Registry Number)
- ⑧ BRN: Beilstein Registry Number; for research with the Beilstein data base
- ⑨ EEC No: corresponds with the EINECS (European Inventory of Existing Commercial Chemical Substances) or ELINCS (European List of Notified Chemical Substances) number.
- ⑩ Product Number (please state product number when ordering)
- ⑪ Storage Temperature
- ⑫ Special Quality (description see page 4, Fluka Catalogue 1995/96)
- ⑬ Literature references about applications etc.
- ⑭ Merck Index reference to "The Merck Index"
 e.g. Merck Index 11, 453 _____ index
 _____ volume
- ⑮ Beilstein reference to "Beilsteins Handbuch der Organischen Chemie"
 e.g. Beil. 4, IV, 4008 _____ page
 _____ supplement
 _____ volume
- alternative example for a citation from the 5th supplement
 e.g. Beil. 23, 7, V, 144 _____ page
 _____ supplement
 _____ part
 _____ volume
- ⑯ Fieser reference to "Reagents for Organic Synthesis", L.F. Fieser & M. Fieser
 e.g. Fieser 1, 838, 2, 271, 3, 199, 5, 441, 6, 457, 11, 411, 12, 319, 13, 185
 _____ page
 _____ volume
- ⑰ F phrases: Information on properties and handling (see page 9, Fluka Catalogue 1995/96)
- ⑱ Hazard Symbols (acc. EEC-directions; see page 10, Fluka Catalogue 1995/96)
- ⑲ RTECS-No. ["Registry of Toxic Effects of Chemical Substances", NIOSH (National Institute for Occupational Safety and Health)]
- ⑳ Risks and Safety Phrases R: Nature of the special risks attaching to dangerous substances (see page 11, Fluka Catalogue 1995/96)
 S: Safety advice concerning dangerous chemical substances (see page 12, Fluka Catalogue 1995/96)
- ㉑ RID/ADR-European agreement on the international transport of dangerous goods on the road (see also page 12, Fluka Catalogue 1995/96)
- ㉒ Flash Point in °C
- ㉓ CH-Giftkl.: Swiss toxicity classification (CH)
- ㉔ WGK: German water hazard classification
- ㉕ Guaranteed specifications