CHIRAL
TECHNOLOGIES INC

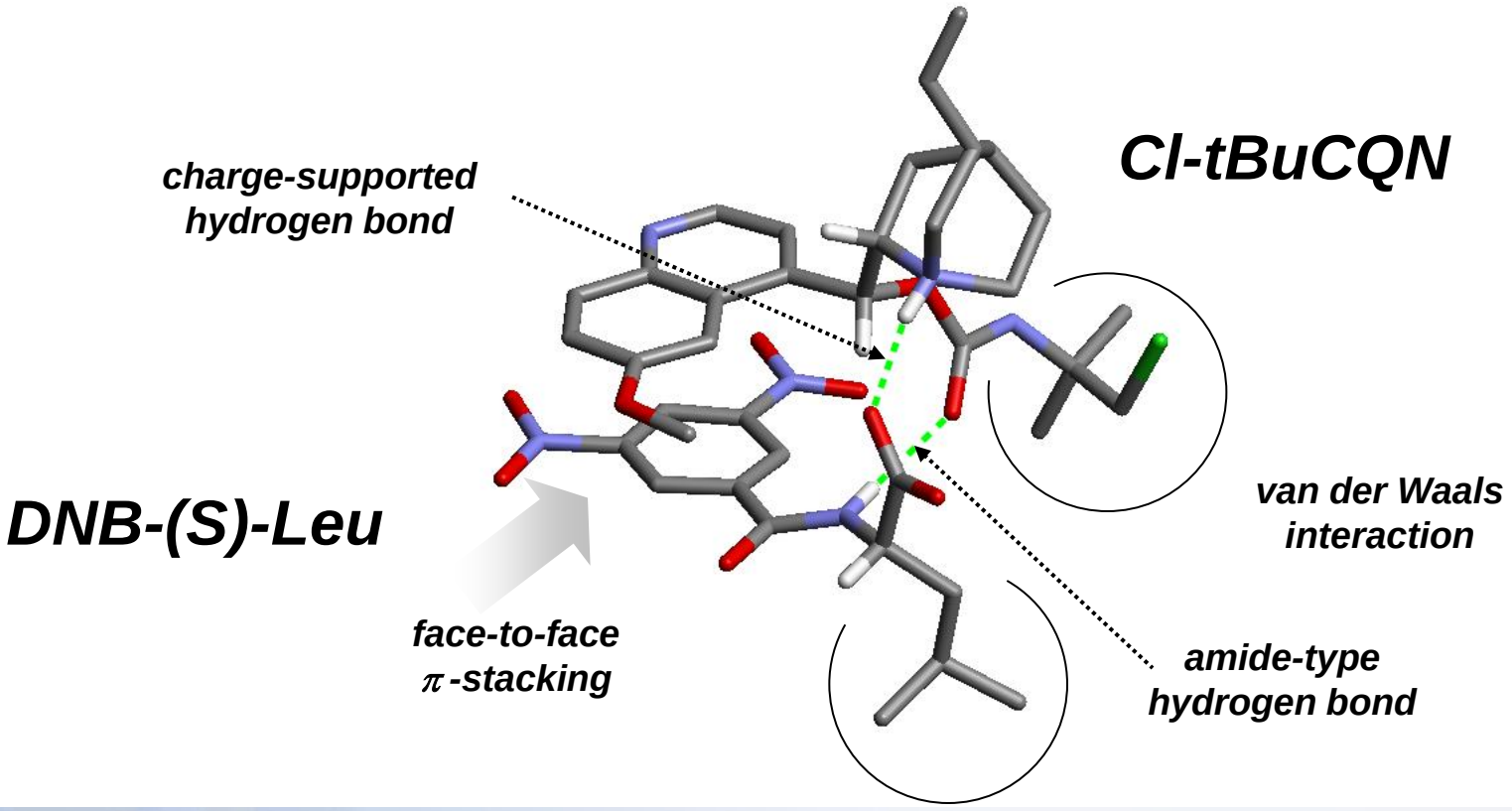
SUBSIDIARY OF  DAICEL CHEMICAL INDUSTRIES, LTD.

YOUR CHIRAL PROCESS PARTNER

Enantiomer Separation of Chiral Acids on CHIRALPAK® AX-QN and CHIRALPAK® AX QD

Chiral Recognition Mechanism

Non-covalent Interactions Stabilizing the Quinine tert-butylcarbamate / 3,5-dinitrobenzoyl leucine complex
(X-Ray Crystal Structure)



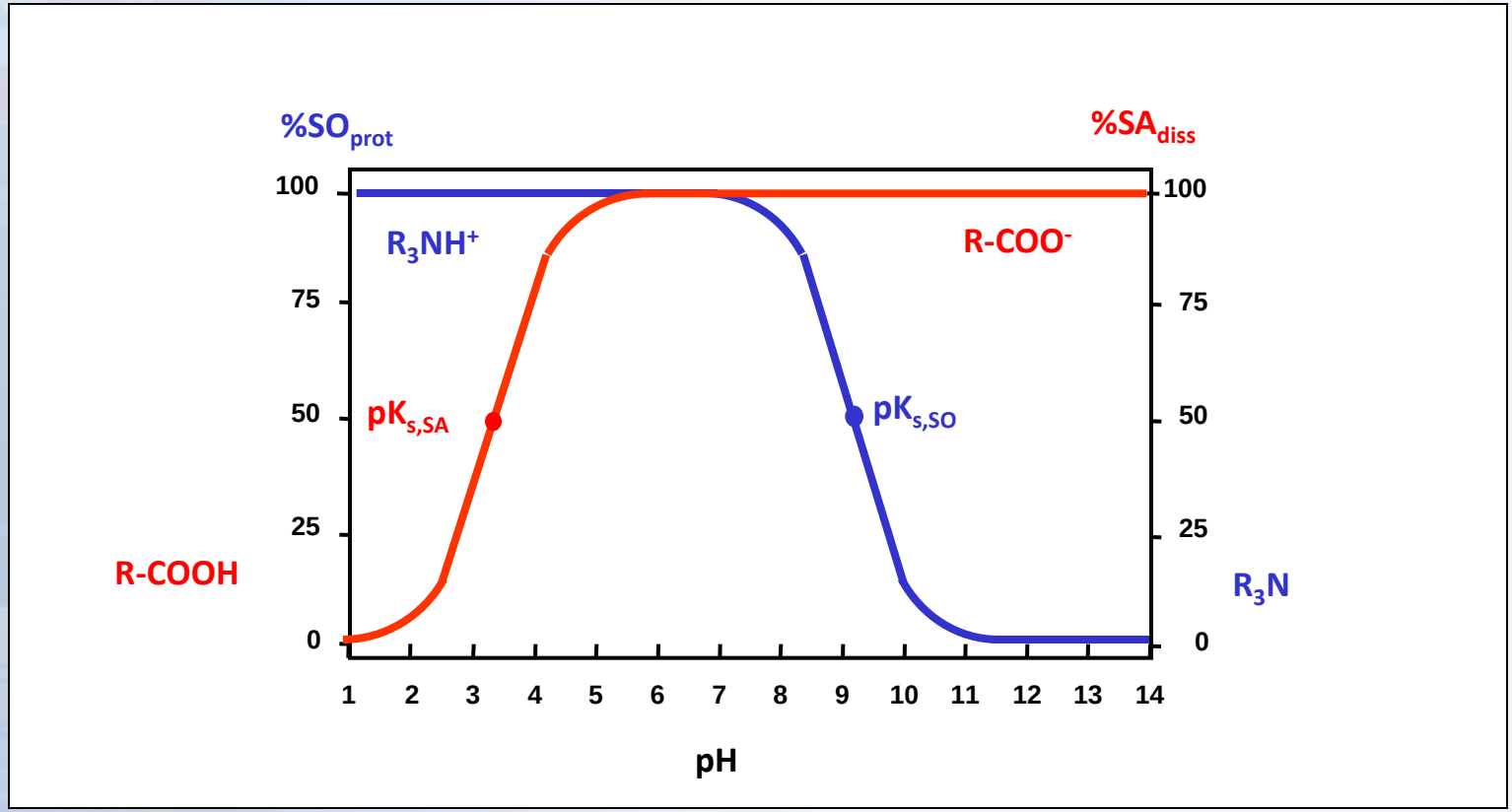
N.M. Maier et al. *Chirality* (1999)
N.M. Maier et al. *JACS* (2001)

Principles of Analyte Retention on CHIRALPAK® AX Columns: Weak Anion Exchange

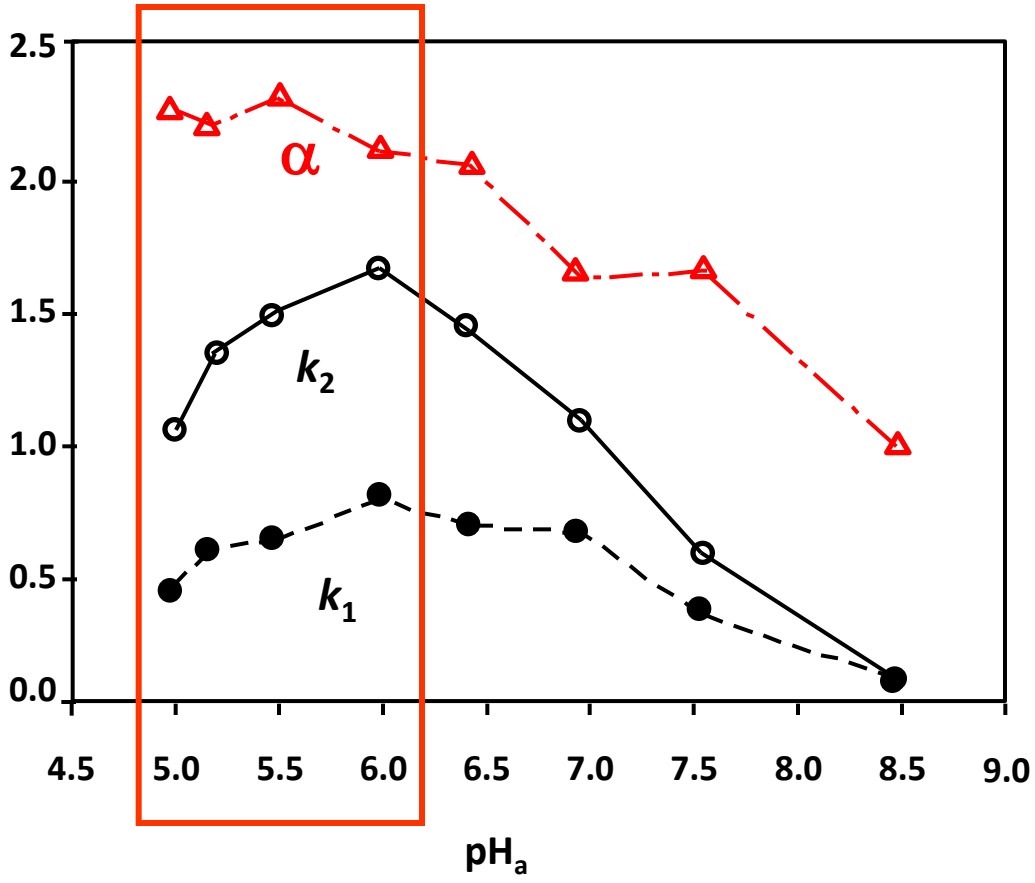
$$k \approx K \times \phi \times [SO]_{tot} \times \frac{1}{[X^-]} \times \alpha_{prot,SO} \times \alpha_{diss,SA}$$

k	retention factor
K	association constant
ϕ	phase ratio
$[SO]_{tot}$	total selector concentration
$[X^-]$	counterion concentration
$\alpha_{prot,SO}$	degree of protonation of selector
$\alpha_{diss,\ SA}$	degree of dissociation of analyte

Impact of pH on Retention Enantioselectivity



Impact of Mobile Phase pH on Retention & Enantioselectivity

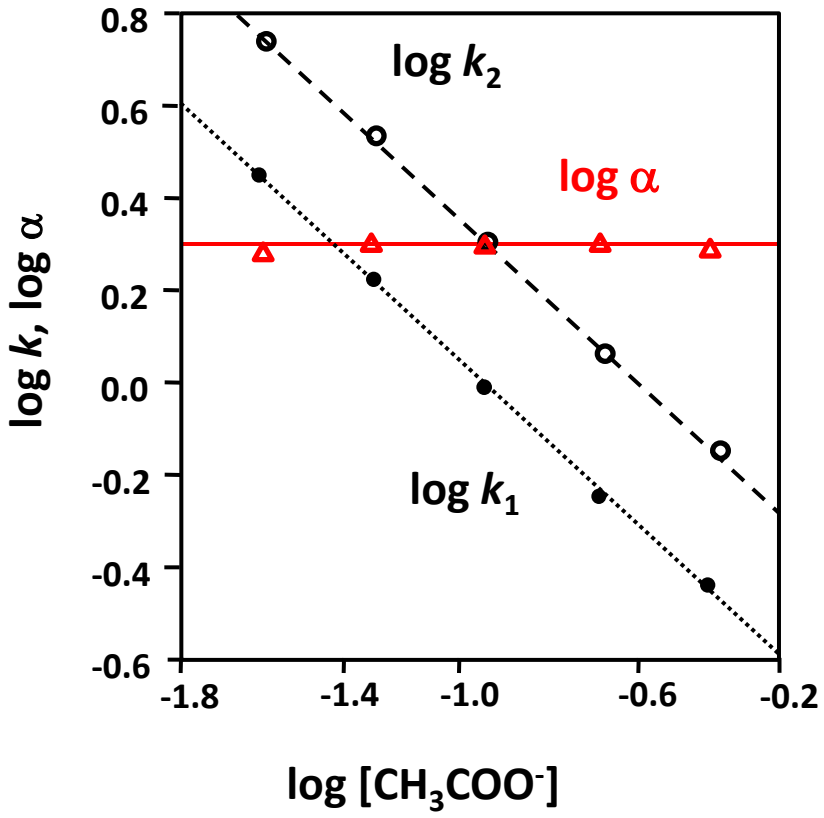


CHIRALPAK AX-QN (150 x 4 mm I.D.);
MeOH-aqu. 0.2 M NH_4OAc (80:20, v/v);
1.0 mL/min; 254 nm; T 25 °C
Analyte: *N*-benzoyl leucine

Retention and enantioselectivity can be optimized by appropriate adjustment of the pH_a of the mobile phase.

M. Lämmerhofer et al., *Am.Lab.* (2002)

Impact of Counterion Concentration on Retention & Enantioselectivity



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MeOH-aqu. 0.2 M NH_4OAc (80:20, v/v);
1.0 mL/min; 254 nm; T 25 °C
Analyte: *N*-benzoyl leucine

Retention adjustable via counterion concentration without significant loss in enantioselectivity.

M. Lämmerhofer et al., *Am.Lab.* (2002)

Method Development Strategy: Optimization Parameter

pH (pH profile of k and alpha)

Counterions (nature, concentration)

Organic modifier (nature, relative amounts)

Lower flow rates: Strongly electrostatic SO-SA interaction – slow mass transfer.

Low temperature: Chiral recognition process enthalpically driven – low temperature favor enantioselectivity.

Polar Organic Conditions

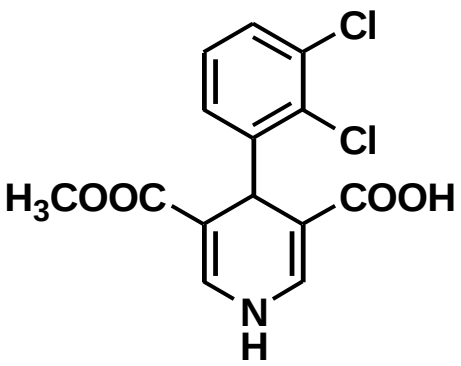
Preferred due to enhanced enantioselectivity, generality, low viscosity, solubility of most analyte
Little non-specific retention of lipophilic compounds
MS-compatible

Methanol - ammonium acetate - acetic acid (98:2:0.5 to 95:5:2)
Methanol - triethylamine - acetic acid
Methanol - ammonium format - formic acid

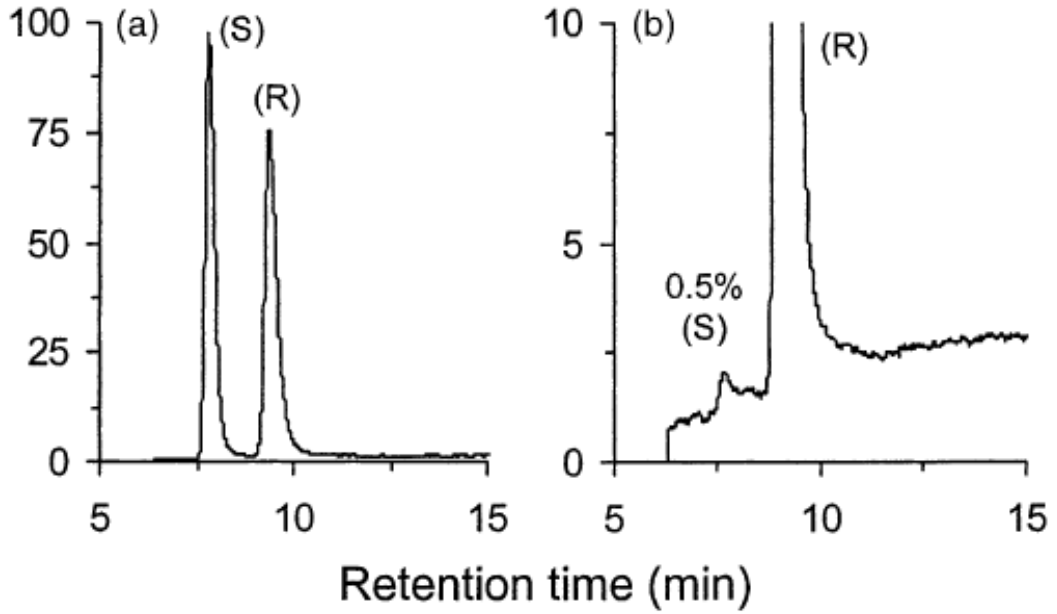
Methanol - acetic acid
Acetonitrile - acetic acid

POM works for most N-acylated amino acids, N-blocked peptides, carboxylic acid and drug compounds with pK_a 3 to 5.

Polar Organic Conditions:
Dihydropyrimidine Carboxylic Acid



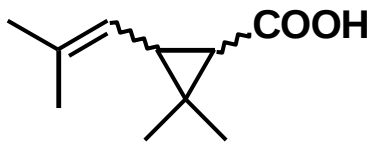
Ca^{2+}-Channel Blocker Intermediate



CHIRALPAK AX-QN (150 x 4.6 mm ID), 0.124 % AcOH in acetonitrile; 1.0 mL/min; 250 nm; 25°C.

M. Lämmerhofer et al., *J. Pharm. Biomed. Anal.* (2004)

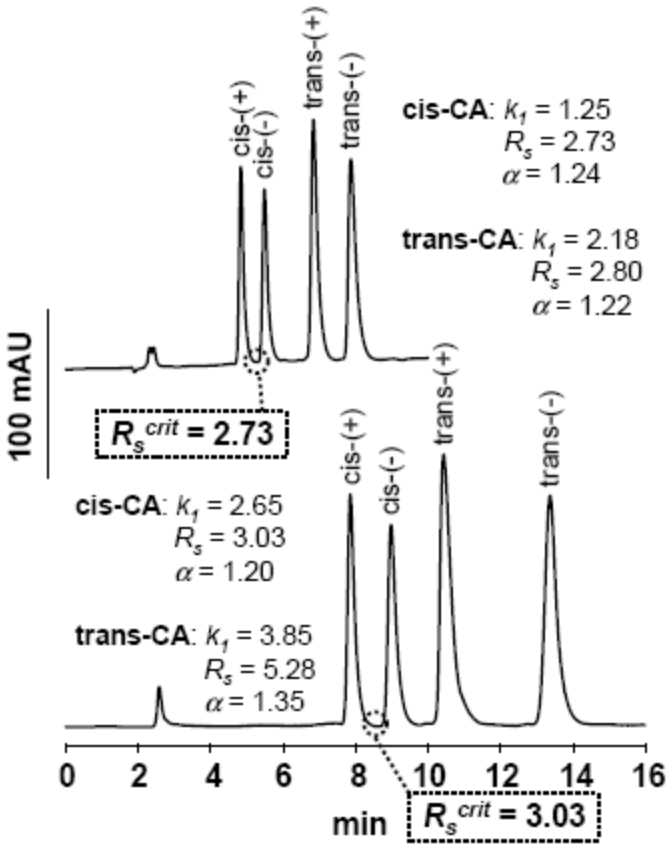
Polar Organic Conditions: Pyrethroic Acids



***cis/trans*-Chrysanthemic acid**
(Pesticide Intermediate)

a) Polar-organic conditions:
0.06% AcOH in acetonitrile-methanol 95:5 (v/v); 0.65 mL/min; 25°C.

b) Reversed-phase conditions:
10mM AcOH in acetonitrile-water 90:10 (v/v), pHa 6.0 (NH3 aq.), 0.65 mL/min; 25°C.



W. Bicker et al., *J.Chromatogr. A* (2004)

Reversed Phase Conditions

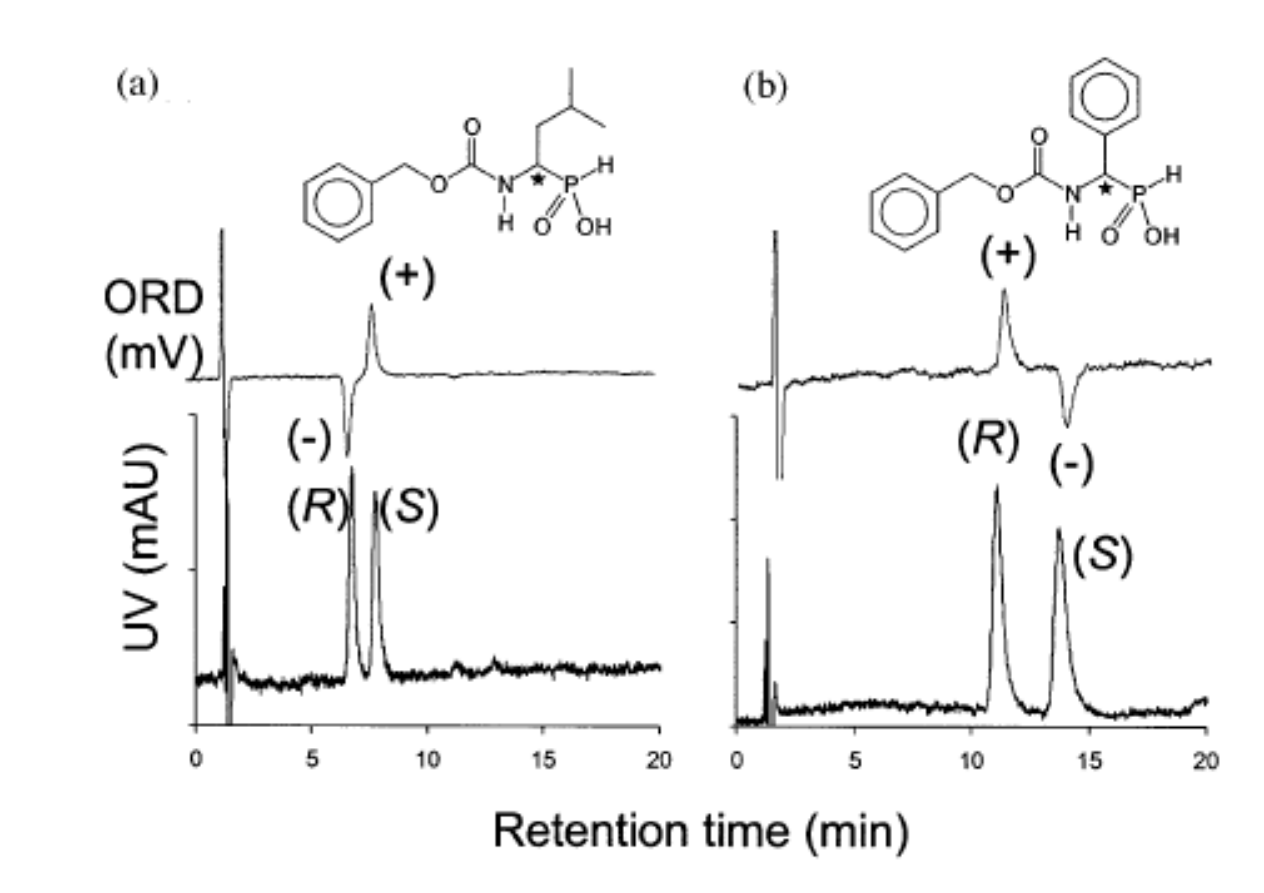
Exploits mixed reversed phase/anion exchange mechanisms

For analytes poorly soluble/retained under polar organic conditions:
Phosphoric acids, sulfonic, phosphonic, phosphinic acids, poly-carboxylic acids

Aqueous ammonium acetate – methanol (pHa 4.5 to 7.0)
Aqueous sodium phosphate – methanol/acetonitrile (pHa 4.5 to 7.0)
Other buffers: Citrate >> phosphate > format > acetate

Column life time may be shortened due to exposure to strong buffers. Column may need regeneration after use of citrate.

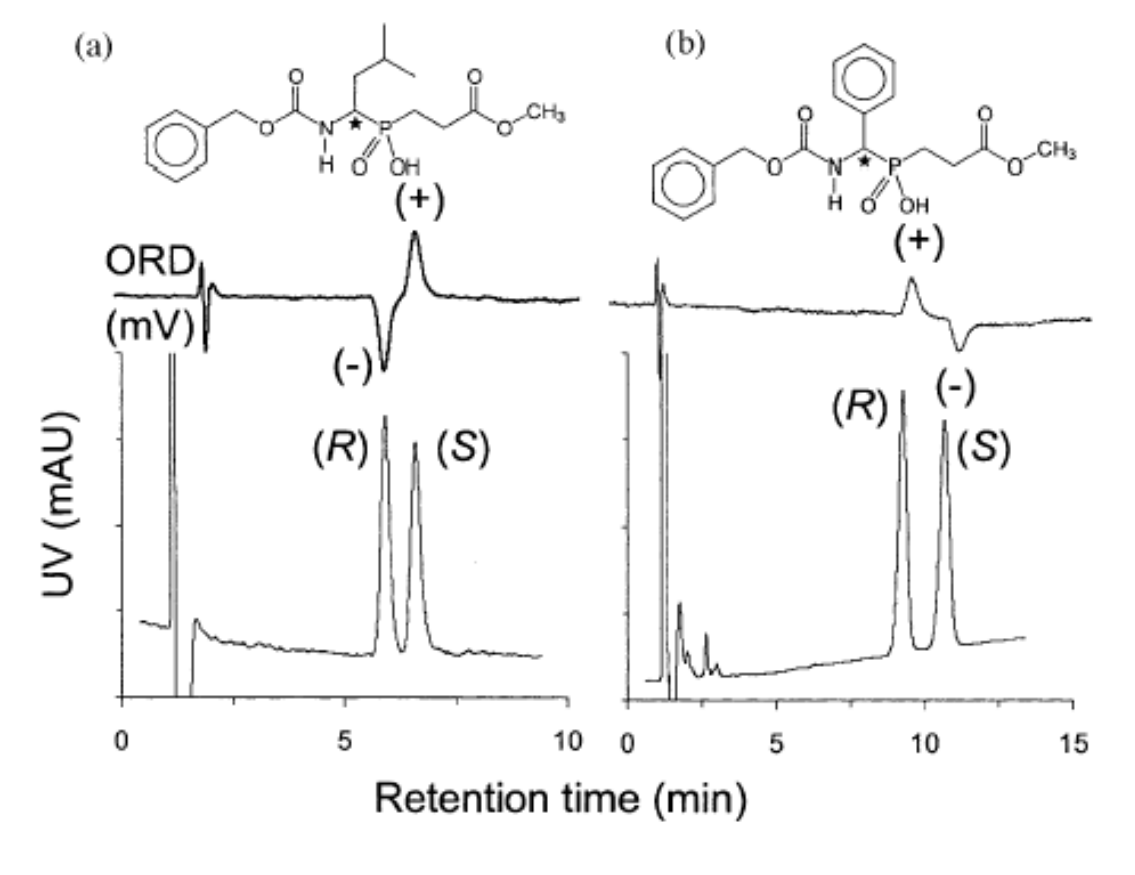
Reversed Phase Conditions: Phosphinic Acids



CHIRALPAK AX-QN (150 x 4.6 mm ID), methanol-50 mM sodium phosphate buffer (80:20, v/v), pHa 5.6; 1.0 mL/min; 250 nm; 40°C.

W. Bicker et al., *J.Chromatogr. A* (2004)

Reversed Phase Conditions: Phosphinic Acid Derivatives



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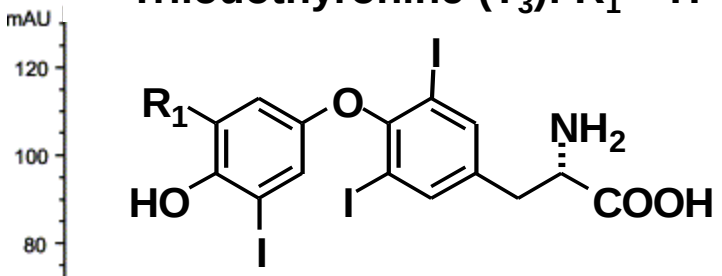
Lämmerhofer et al., *Tetrahedron Asym.* (2003)

Reversed Phase Conditions: Amino Acid - Thyroxine

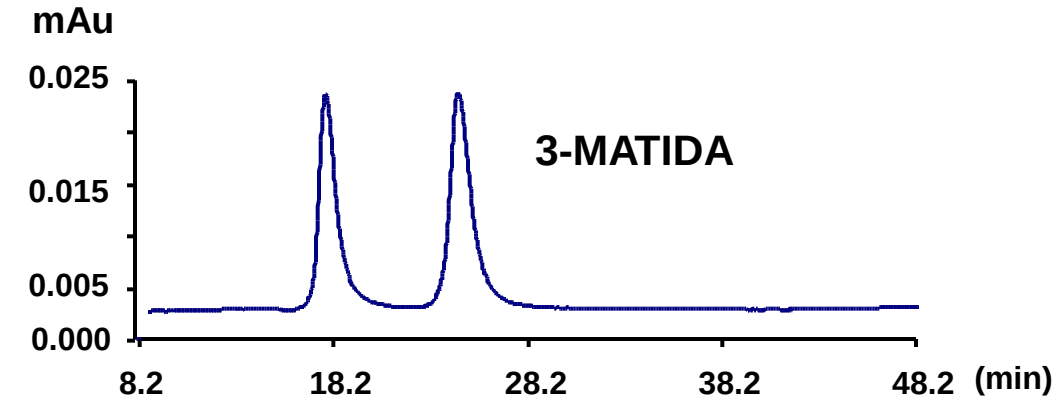
Thyroxine (T_4): R_1 = I
Triiodothyronine (T_3): R_1 = H

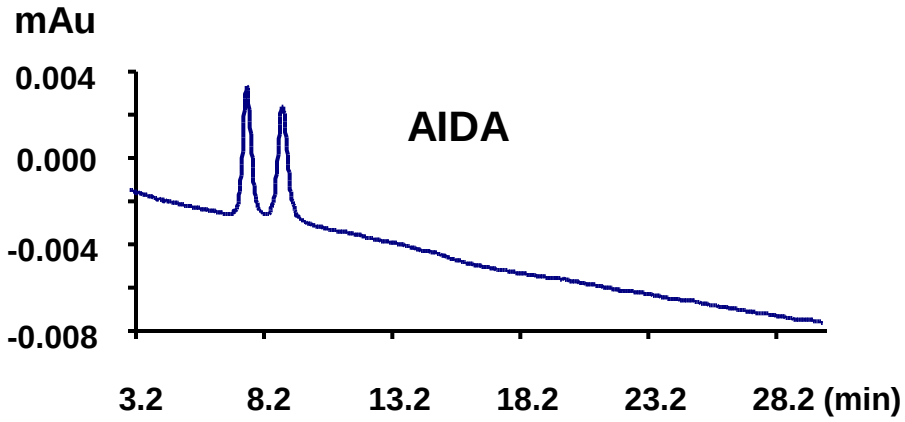


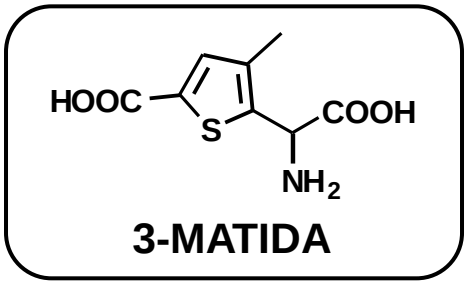
Chiralpak®QN-AX (150 x 4.6 mm ID), ACN-0.05 NH_4OAc (60:40 v/v); 0.7 mL/min; 240 nm; 25°C

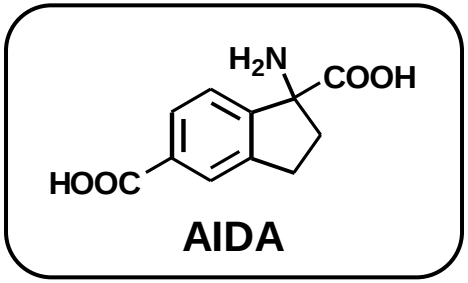
H. Gika et al., *J. Chromatogr. B* (2004)

Reversed Phase Conditions: Amino Dicarboxylic Acids







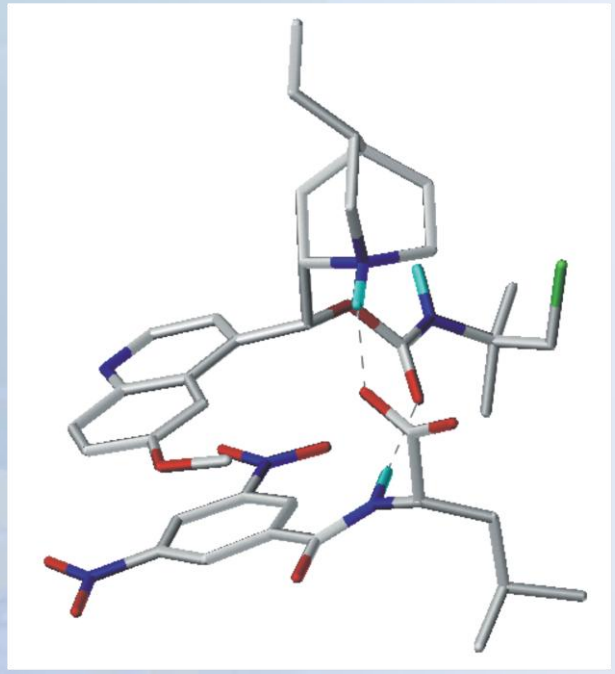


Potential mGluR1 Subtype Selective Antagonist

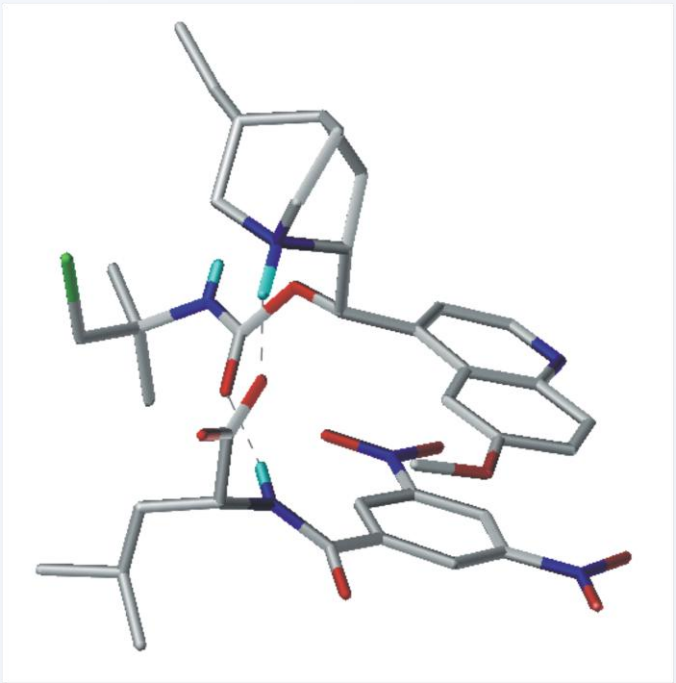
Chiralpak QN-AX (150 x 4 mm ID); MeOH-0.1 M NH4OAc (80: 20, v/v) pH_a 5.5; 1.0 mL/min; UV 254 nm; 25°C.

CHIRALPAK® AX-QN and AX-QD: Pseudoenantiomeric CSPs

X-Ray Crystal Structures



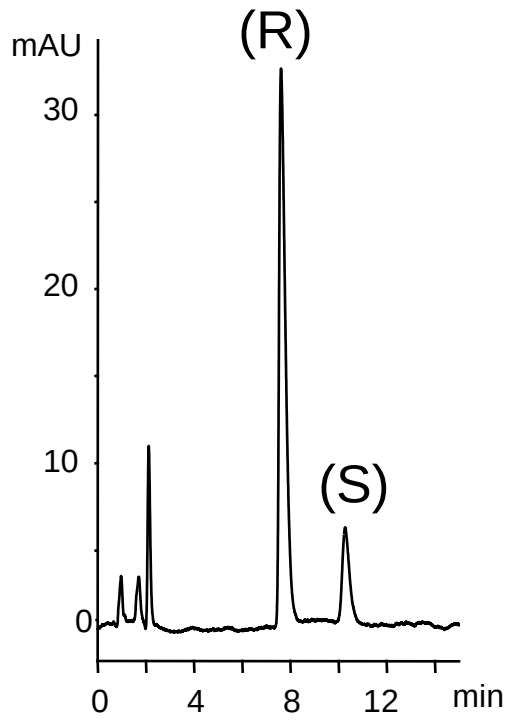
CHIRALPAK AX-QN Selector
Co-crystallized
with DNB-(S)-leucine

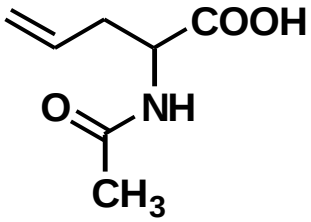


CHIRALPAK AX-QD Selector
Co-Crystallized
with DNB-(R)-leucine

Control of Elution Order by Combined Use of CHIRALPAK® AX-QN and AX-QD

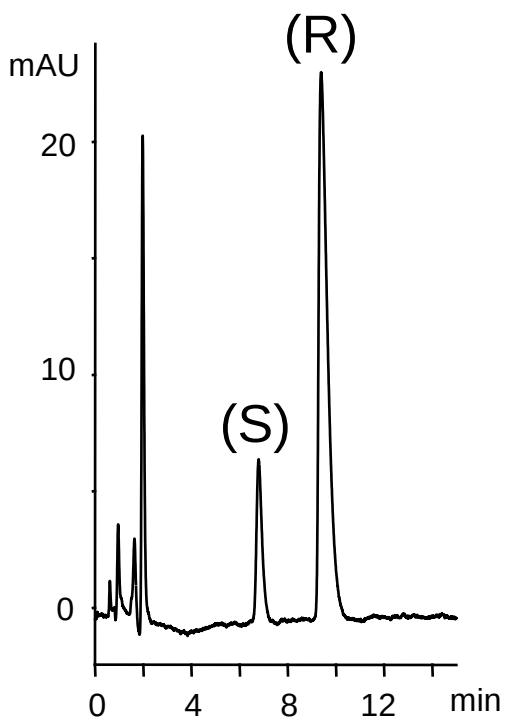
CHIRALPAK AX-QN





$\alpha = 1.5$

CHIRALPAK AX-QD



Columns (150 x 4 mm ID); 1% (v/v) AcOH in MeOH; 1 mL/min, 25°C; UV 230 nm.

Prep Application

Employing volatile mobile phases to facilitate product recovery

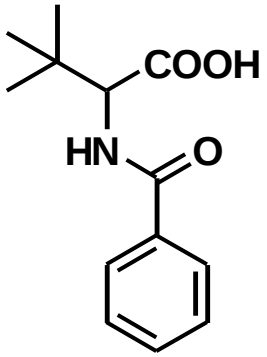
Acetonitrile - Methanol – acetic acid (99:1 to 97:3, v/v)

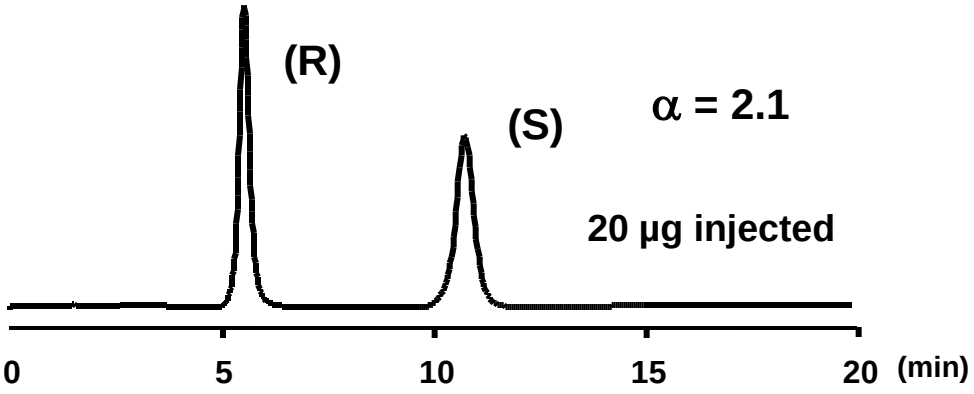
Acetonitrile / Methanol – formic acid (99:1 to 98:2, v/v)

SFC: CO2 – Methanol

Added acids concentrate upon solvent evaporation – chemical stability and stereochemical integrity of the target compounds need to be established.

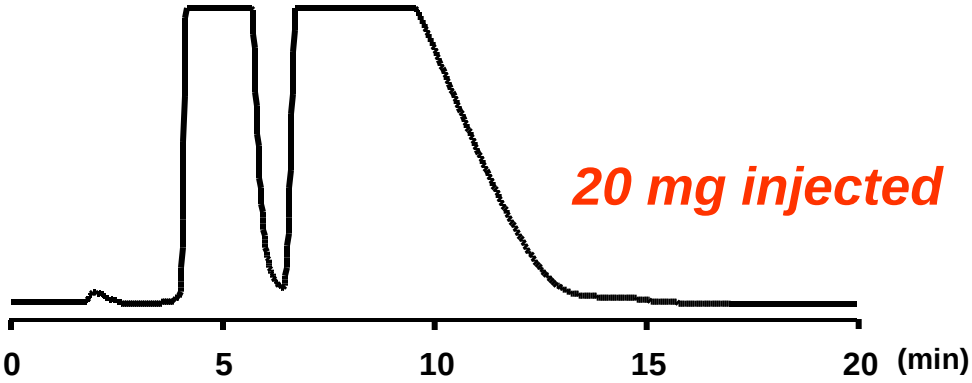
Semiprep Separation of N-benzoyl tert.-leucine





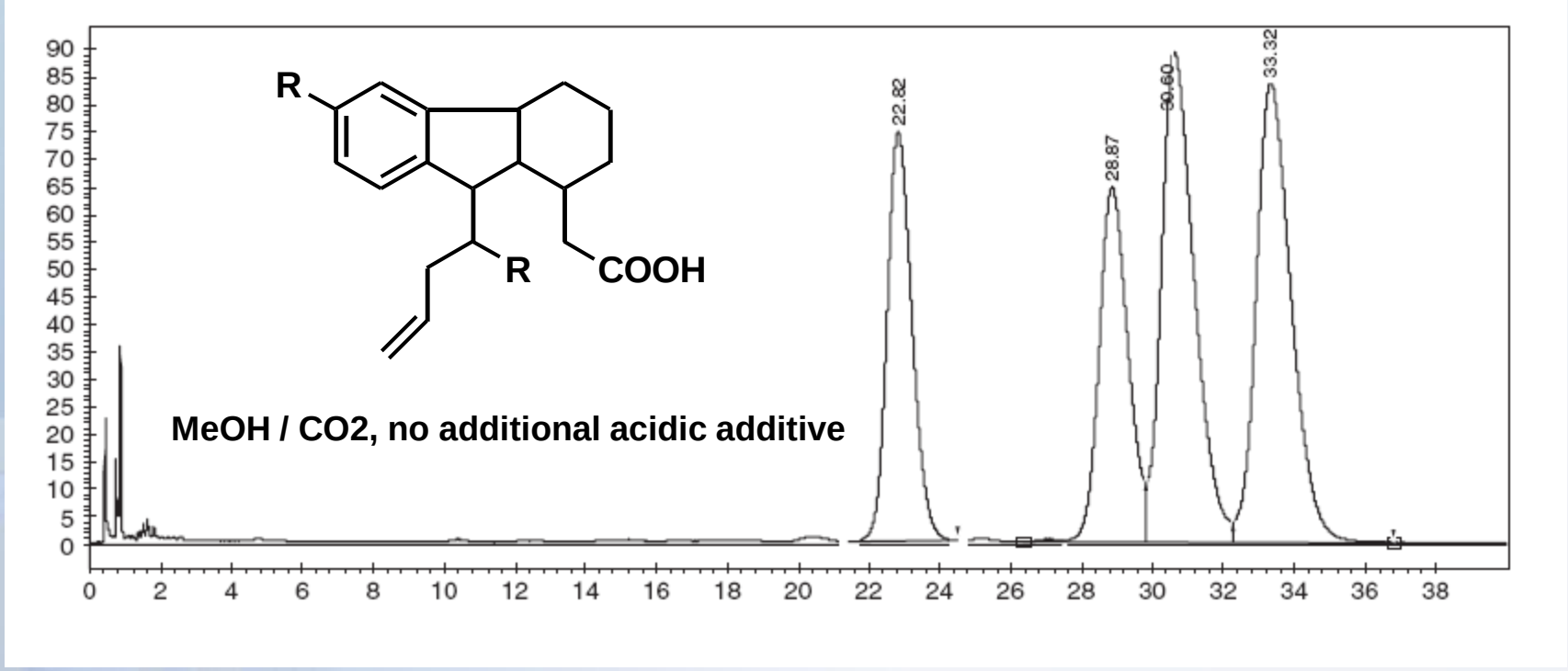
Inherently favorable saturation capacity of ion-exchangers

Possibly displacement effects (high affinity enantiomer sharpens front of low affinity enantiomer



Chiralpak AX-QN (150 x 4.6 mm I.D.); 10 mM ammonium acetate + 30 mM acetic acid in methanol (pH_a = 6.0); flow rate: 1 mL/min; UV 254 nm, 320 nm; 25°C.

SFC Separation of Diastereomeric Mixture of an Acidic Drug Candidate



S. Staskiewicz et al., *J. Label Compd Radiopharm* (2007)

CHIRALPAK® AX-QN & CHIRALPAK® AX-QD

Enantioselectivity for a broad range of chiral acidic compounds

Compatibility with all common HPLC solvents and modes (non-polar, polar-organic, reversed-phase and SFC)

Stable in pH range 2 to 8

Control of elution order via pseudoenantiomeric chiral recognition properties

Straightforward method development

Suitable for bio-analytical and MS applications

Manufacture and technical support by DAICEL

Thanks

Michael Lämmerhofer and Wolfgang Lindner
University of Vienna, Austria

All former coworkers at the Department of Analytical Chemsitry, University of Vienna, Austria

Pilar Franco and Tong Zhang
Chiral Technologies Europe, France