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Supporting Information

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Zn-Catalyzed Enantiospecific sp^3-sp^3 Cross-Couplings of α-Hydroxy Ester Triflates with Grignard Reagents

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Supporting Information

I General

All reactions were carried out in oven-dried glassware under an atmosphere of argon (Argon 5.0 from Sauerstoffwerke Friedrichshafen). All reagents were obtained commercially unless otherwise noted. MeMgCl (22 wt% in THF) and EtMgCl (2.0 M in THF) were purchased from Acros, all other Grignard reagents were prepared from activated magnesium[1] and freshly distilled alkyl halides in THF and titrated with salicylaldehyde phenylhydrazone[2] before use. All solvents were dried and distilled by standard procedures. Chromatographic purification of products was accomplished using flash chromatography[3] on Macherey-Nagel silica gel 60® (230-400 mesh).

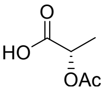
Melting points were measured on a Büchi melting point apparatus using open glass capillaries, and the values are uncorrected. Optical rotations were measured on a Perkin-Elmer 241 polarimeter in 1.0 dm, 1.0 mL cells. The concentration in g/100 mL and the solvent are given in parentheses.

Achiral GC analyses were performed on an Agilent 6890N apparatus equipped with a DB-WAX column (30 m x 0.25 mm ID x 0.25 μm film). Chiral GC analyses were carried out on a CE Instruments GC 8000 apparatus equipped with a Chiraldex™ G-TA column (30 m x 0.25 mm ID x 0.25 μm film) or an Agilent 6890N apparatus equipped with a Hydrodex β-TBDAc column (25 m x 0.25 mm ID x 0.25 μm film). Chiral HPLC analyses were performed on Merck-Hitachi systems with Daicel Chiralpak AD-H (25 cm x 4.6 mm ID), Chiralcel OD-H (25 cm x 4.6 mm ID) or Chiralcel OJ-R (15 cm x 4.6 mm ID) columns in *n*-heptane/*iso*-propanol or acetonitrile/water (reverse phase) mixtures.

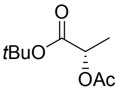
Nuclear magnetic resonance spectra were acquired on a Bruker Avance 400 spectrometer (400 MHz, 235 MHz and 100 MHz for ^{1}H, ^{19}F and ^{13}C respectively) and referenced internally for ^{1}H- and ^{13}C-NMR according to residual protio solvent signals [CDCl$_3$: 7.26 ppm (^{1}H). 77.10 ppm (^{13}C)] and externally for ^{19}F-NMR (CCl$_3$F: 0.00 ppm).[4] Data for ^{1}H-NMR are reported as follows: chemical shift (δ in ppm), multiplicity (s, singlet; d, doublet; t, triplet; q, quartet; quint, quintet; sext, sextet; hept, heptet; oct, octet; m, multiplet; m$_c$, symmetrical multiplet; br, broad signal; *p*, pseudo), integration, coupling constant (Hz). Data for ^{13}C-NMR and ^{19}F-NMR are reported in terms of chemical shift, integration, coupling constant (Hz). Low resolution mass spectra were recorded on Thermo Finnigan MAT 8200 and TSQ 7000 spectrometers (EI: 70 eV; CI,NH$_3$: 110 eV). High-resolution mass spectra were obtained on a Finnigan MAT 8200 instrument (EI: 70 eV; CI/NH$_3$: 110 eV).

II Experimental procedures and characterizations

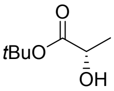
General Procedure for the synthesis of α-hydroxy acids from α-amino acids.[5] To α-amino acids (−)-**7a**-**f** dissolved in 4:1 mixtures of water and acetic acid (v/v; 0.1 M) were slowly added aqueous solutions of sodium nitrite (1 M; 2.0 equiv) using a syringe pump (8 mL/h) at −5 °C to 0 °C. The reaction mixtures were allowed to stir at the same temperature for 3 h and then stirring was continued at ambient temperature overnight. After quenching the reactions with aqueous solutions of methylamine (12 M), the reaction mixtures were acidified with 1N HCl to pH 2 and then extracted with ethyl acetate (3×). Subsequent purification via crystallization or column chromatography on silica gel gave the enantiopure α-hydroxy acids **8a**-**f**.[6]



Representative Procedure for the synthesis of α-acetoxy acids.[7] To a solution of (L)-lactic acid (90w% in H$_2$O; 9.00 g, 7.50 mL, 100 mmol) in acetic acid (30 g, 29.0 mL, 500 mmol, 5.0 equiv) was slowly added acetic chloride (23.6 g, 21.4 mL, 300 mmol, 3.0 equiv) at 0 °C. After the reaction mixture was allowed to stir at ambient temperature overnight, remaining acetic chloride and acetic acid were distilled off at atmospheric pressure and the residue was distilled in vacuo (117-120 °C/11 mbar) to give (−)-(2*S*)-acetoxy propionic acid (8.93 g, 67.6 mmol, 68%) as a colorless oil. $[\alpha]_D^{21}$ = –47.5 (c = 2.28, CHCl$_3$).[8] ^{1}H-NMR (400 MHz, CDCl$_3$): δ = 1.52 (d, 3H, J = 7.3 Hz, CH$_3$), 2.12 (s, 3H, CH$_3$), 5.10 (q, 1H, J = 7.2 Hz, CH), 11.2 (br s, 1H, COOH). ^{13}C-NMR (100 MHz, CDCl$_3$): δ = 16.8, 20.6, 68.2, 170.6, 176.7. The analytical data correspond to those reported previously.[7]

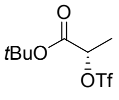


Representative Procedure for the synthesis of α-acetoxy *tert*-butyl esters.[9] To a solution of (–)-(2*S*)-acetoxy propionic acid (5.71 g, 43.2 mmol), *tert*-butanol (7.05 g, 9.15 mL, 95.1 mmol, 2.2 equiv) and 4-dimethylaminopyridine (1.74 g, 14.3 mmol, 0.33 equiv) in CH_2Cl_2 (110 mL) was added *N,N'*-dicyclohexylcarbodiimide (11.6 g, 56.2 mmol, 1.3 equiv) in CH_2Cl_2 (36 mL) at 0 °C. After the reaction mixture was allowed to stir at ambient temperature overnight, it was filtered through a pad of celite. The organic phase was washed with water, dried over $MgSO_4$, concentrated and distilled in vacuo (74-78 °C/11 mbar) to afford (–)-(2*S*)-acetoxy propionic acid *tert*-butyl ester (7.59 g, 40.3 mmol, 93%) as a colorless oil. $[\alpha]_D^{20} = -50.4$ ($c = 2.05$, $CHCl_3$).[10] ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 1.43 (d, 3H, J = 6.9 Hz, CH_3), 1.45 (s, 9H, 3×CH_3), 2.10 (s, 3H, CH_3), 4.93 (q, 1H, J = 7.2 Hz, CH). ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 16.9, 20.8, 28.0 (3C), 69.2, 82.0, 170.0, 170.4. The analytical data correspond to those reported previously.[11]

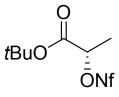


Representative Procedure for the synthesis of α-hydroxy *tert*-butyl esters.[12] A solution of (–)-(2*S*)-acetoxy propionic acid *tert*-butyl ester (9.60 g, 51.0 mmol) and ethylenediamine (1.56 g, 1.74 mL, 26.0 mmol, 5.0 equiv) in cyclohexane (100 mL) was refluxed for 18 h (TLC control) at 90 °C. The solution was cooled down to room temperature, diluted with diethyl ether and washed with water. The organic phase was washed successively with saturated sodium bicarbonate solution, an aqueous solution of citric acid (15w%) and water (4×) and dried over Na_2SO_4. Removal of the solvent at atmospheric pressure and cristallization from *n*-pentane at –20 °C afforded (–)-(2*S*)-hydroxy propionic acid *tert*-butyl ester (4.62 g, 31.6 mmol, 62%, >99% *ee*) as colorless needles. The *ee* of the corresponding α-hydroxy acetate was determined by GC on a chiral phase (G-TA, 1.3 bar, isothermal 85 °C) with t_R = 10.2 min (major *S* enantiomer), t_R = 11.1 min (minor *R* enantiomer). $[\alpha]_D^{21} = -5.2$ ($c = 2.05$, $CHCl_3$).[10] Mp.: 37-39 °C.[12] ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 1.36 (d, 3H, J = 6.9 Hz, CH_3), 1.49 (s, 9H, 3×CH_3), 2.85 (d, 1H, J = 5.6 Hz, OH), 4.12 (qd, 1H, J = 6.9, 5.6 Hz, CH). ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 20.6, 28.1 (3C), 67.0, 82.3, 175.2. The analytical data correspond to those reported previously.[11]

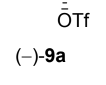
General Procedure for the synthesis of α-hydroxy ester triflates/nonaflates.[13] To a stirred solution of α-hydroxy ester in CH_2Cl_2 (0.25 M) is first added 2,6-lutidine (1.5 equiv) and then slowly via a syringe pump (4 mL/h) triflic/nonaflic anhydride (1.4 equiv) at 0 °C. After the mixture was allowed to stir at the same temperature for 50 min it was diluted with petroleum ether (PE, 40-65; 20 mL/mmol), washed with a 3:1 mixture of brine and 1N HCl (3×10 mL/mmol), dried over $MgSO_4$, filtered and concentrated (water bath: >35 °C) to afford a yellowish-brown residue. Purification by silica gel flash chromatography (1:1 PE:CH_2Cl_2) gave the α-hydroxy ester triflates/nonaflates as colorless oils or solids.


(–)-**1a**

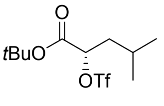
(–)-(2*S*)-Trifluoromethanesulfonyloxy-propionic acid *tert*-butyl ester [(–)-1a] was isolated as a colorless oil (5.41 g, 19.4 mmol, 95% yield, >99% *ee*). $[\alpha]_D^{20}$ = –43.6 (c = 2.45, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 1.51 (s, 9H, 3×CH_3), 1.66 (d, 3H, J = 7.0 Hz, CH_3), 5.09 (qq, 1H, J = 7.0 Hz, $^5J_{H,F}$ = 0.4 Hz, CH). ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 18.1, 27.8 (3C), 80.7, 84.4, 118.6 (q, $J_{C,F}$ = 319 Hz), 166.5. ^{19}F-NMR (235 MHz, $CDCl_3$): δ = –75.4 (3F, CF_3).


(–)-**1b**

(–)-(2*S*)-(Nonaflourobutane-1-sulfonyloxy)-propionic acid *tert*-butyl ester [(–)-1b] was isolated as a slightly yellow oil (701 mg, 1.64 mmol, 82% yield, >99% *ee*). $[\alpha]_D^{20}$ = –40.7 (c = 1.16, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 1.51 (s, 9H, 3×CH_3), 1.66 (d, 3H, J = 7.1 Hz, CH_3), 5.12 (q, 1H, J = 7.0 Hz, CH). ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 17.9, 27.8 (3C), 81.2, 84.5, 107.3-118.9 (m, 4C), 166.6. ^{19}F-NMR (235 MHz, $CDCl_3$): δ = –125.95 (m_c, 2F, CF_2), –121.26 (m_c, 2F, CF_2), –111.44 (m_c, 2F, CF_2), –80.73 (tt, 3F, ^3J = 9.5 Hz, ^4J = 2.2 Hz, CF_3).

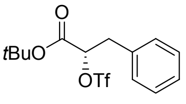

(–)-**9a**

(–)-(2*S*)-Trifluoromethanesulfonyloxy-hexanoic acid *tert*-butyl ester [(–)-9a] was isolated as a colorless oil (3.02 g, 9.43 mmol, 90% yield, 99% *ee*). $[\alpha]_D^{20}$ = –45.6 (c = 0.96, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 0.92 (t, 3H, J = 7.2 Hz, CH_3), 1.33-1.48 (m, 4H, 2×CH_2), 1.51 (s, 9H, 3×CH_3), 1.93-1.99 (m, 2H, CH_2), 4.98 (t, 1H, J = 6.1 Hz, CH). ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 13.7, 22.0, 26.6, 27.9 (3C), 31.7, 84.36, 84.38, 118.6 (q, $J_{C,F}$ = 319 Hz), 166.3. ^{19}F-NMR (235 MHz, $CDCl_3$): δ = –75.1 (3F, CF_3).



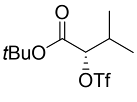
(–)-**9b**

(–)-(2*S*)-Trifluoromethanesulfonyloxy-4-methyl-pentanoic acid *tert*-butyl ester [(–)-9b] was isolated as a colorless oil (1.87 g, 5.84 mmol, 94% yield, >99% *ee*). $[\alpha]_D^{20}$ = –57.2 (*c* = 2.14, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 0.98 (d, 3H, *J* = 6.5 Hz, CH_3), 0.99 (d, 3H, *J* = 6.5 Hz, CH_3), 1.51 (s, 9H, 3×CH_3), 1.73 (ddd, 1H, *J* = 13.8, 9.0, 3.9 Hz, CH_2), 1.79 (m_c, 1H, CH), 1.92 (ddd, 1H, *J* = 13.7, 9.4, 4.2 Hz, CH_2), 5.01 (dd, 1H, *J* = 9.4, 3.8 Hz, CH). ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 21.2, 23.0, 24.3, 27.9 (3C), 40.8, 83.1, 84.4, 118.6 (q, $J_{C,F}$ = 319 Hz), 166.7. ^{19}F-NMR (235 MHz, $CDCl_3$): δ = –75.1 (3F, CF_3).



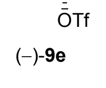
(–)-**9c**

(–)-(2*S*)-Trifluoromethanesulfonyloxy-3-phenyl-propionic acid *tert*-butyl ester [(–)-9c] was isolated as a colorless oil that solidified upon standing (1.82 g, 5.14 mmol, 94% yield, 98% *ee*). $[\alpha]_D^{20}$ = –57.2 (*c* = 2.14, $CHCl_3$). Mp.: 33-35 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 1.46 (s, 9H, 3×CH_3), 3.19 (dd, 1H, *J* = 14.6, 8.4 Hz, CH_2), 3.32 (dd, 1H, *J* = 14.6, 4.4 Hz, CH_2), 5.13 (dd, 1H, *J* = 8.5, 4.3 Hz, CH), 7.21-7.25 (m, 2H, ArH), 7.27-7.36 (m, 3H, ArH). ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 27.8 (3C), 38.3, 83.4, 84.7, 118.3 (q, $J_{C,F}$ = 319 Hz), 127.8, 128.8 (2C), 129.6 (2C), 133.7, 165.6. ^{19}F-NMR (235 MHz, $CDCl_3$): δ = –75.3 (3F, CF_3).



(–)-**9d**

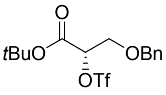
(–)-(2*S*)-Trifluoromethanesulfonyloxy-3-methyl-butyric acid *tert*-butyl ester [(–)-9d] was isolated as a colorless oil (2.20 g, 7.18 mmol, 89% yield, >99% *ee*). $[\alpha]_D^{20}$ = –47.2 (*c* = 1.62, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 1.01 (d, 3H, *J* = 6.9 Hz, CH_3), 1.08 (d, 3H, *J* = 6.9 Hz, CH_3), 1.51 (s, 9H, 3×CH_3), 2.37 (heptd, 1H, *J* = 6.9, 4.0 Hz, CH), 4.83 (d, 1H, *J* = 4.0 Hz, CH). ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 16.3, 18.5, 27.9 (3C), 31.2, 84.3, 88.6, 118.6 (q, $J_{C,F}$ = 319 Hz), 165.8. ^{19}F-NMR (235 MHz, $CDCl_3$): δ = –74.9 (3F, CF_3).



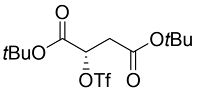
(–)-**9e**

(–)-(2*S*)-Trifluoromethanesulfonyloxy-(3*S*)-methyl-pentanoic acid *tert*-butyl ester [(–)-9e] was isolated as a colorless oil (2.73 g, 8.52 mmol, 83% yield, 99% *de*, >99% *ee*). $[\alpha]_D^{20}$ = –43.0 (*c* = 2.14, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 0.95 (t, 3H, *J* = 7.5 Hz, CH_3), 1.05 (d, 3H, *J* = 7.0 Hz, CH_3), 1.26-1.39 (m, 1H, CH_2), 1.44-1.59 (m, 1H, CH_2), 1.51 (s, 9H, 3×CH_3), 2.11 (m_c, 1H, CH), 4.88 (d, 1H,

J = 4.1 Hz, CH). ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 11.5, 15.1, 24.0, 27.9 (3C), 37.7, 84.3, 88.2, 118.6 (q, $J_{C,F}$ = 319 Hz), 165.8. ^{19}F-NMR (235 MHz, $CDCl_3$): δ = –75.0 (3F, CF_3).

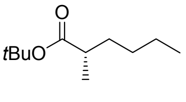

(–)-**9f**

(–)-(2*S*)-Trifluoromethanesulfonyloxy-3-benzyloxy-propionic acid *tert*-butyl ester [(–)-9f] was isolated as a colorless oil (2.08 g, 5.41 mmol, 92% yield, 97% *ee*). $[\alpha]_D^{20}$ = –34.2 (c = 1.06, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 1.50 (s, 9H, 3×CH_3), 3.88 (dd, 1H, J = 11.6, 3.0 Hz, CH_2), 3.92 (dd, 1H, J = 11.6, 5.8 Hz, CH_2), 4.57 (d, 1H, J = 12.1, CH_2), 4.64 (d, 1H, J = 12.1, CH_2), 5.17 (ddd, 1H, J = 5.8, 3.0 Hz, $^5J_{H,F}$ = 0.3 Hz, CH), 7.28-7.39 (m, 5H, ArH). ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 27.9 (3C), 68.6, 73.6, 82.8, 85.0, 118.3 (q, $J_{C,F}$ = 319 Hz), 127.8 (2C), 128.1, 128.6 (2C), 137.0, 163.9. ^{19}F-NMR (235 MHz, $CDCl_3$): δ = –74.9 (3F, CF_3).


(–)-**9g**

(–)-(2*S*)-Trifluoromethanesulfonyloxy-succinic acid di-*tert*-butyl ester [(–)-9g] was isolated as a colorless solid (3.35 g, 8.85 mmol, 89% yield, >99% *ee*). $[\alpha]_D^{20}$ = –42.9 (c = 1.02, $CHCl_3$). Mp.: 53-54 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 1.46 (s, 9H, 3×CH_3), 1.51 (s, 9H, 3×CH_3), 2.88 (dd, 1H, J = 16.9, 7.2 Hz, CH_2), 2.93 (dd, 1H, J = 16.9, 4.9 Hz, CH_2), 5.34 (dd, 1H, J = 7.1, 4.9 Hz, CH). ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 27.8 (3C), 28.0 (3C), 38.0, 79.8, 82.8, 85.0, 118.5 (q, $J_{C,F}$ = 319 Hz), 165.2, 166.8. ^{19}F-NMR (235 MHz, $CDCl_3$): δ = –74.8 (3F, CF_3).

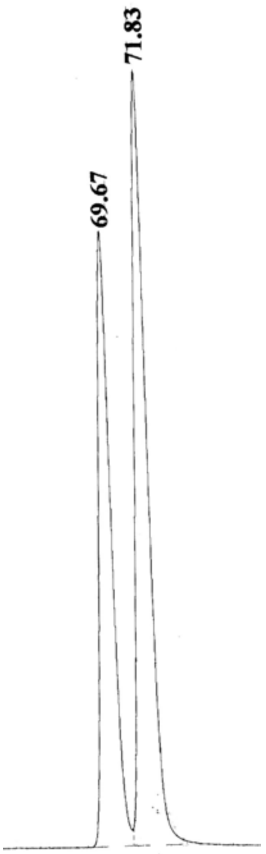
General Procedure for the synthesis of α-alkyl esters. To a solution of anhydrous $ZnCl_2$[14] (5-20 mol%) in dry THF (0.3 M) at 0 °C was added successively triflate and RMgCl (0.8-2.4 M, 1.4 equiv) in an argon atmosphere. After stirring the reaction for 3 h at this temperature it was diluted with *n*-pentane and quenched by the addition of an aqueous saturated NH_4Cl solution. The reaction mixture was then extracted with *n*-pentane (3×) and the combined organic layers were directly added onto a pad of silica-gel. After rinsing the filter with *n*-pentane, the product was either eluted from the silica-gel with a mixture of *n*-pentane/Et_2O (10:1) or purified by silica gel flash chromatography (20:1 *n*-pentane/Et_2O). The solvent was distilled off at atmospheric pressure to give the α-alkyl esters as colorless liquids.

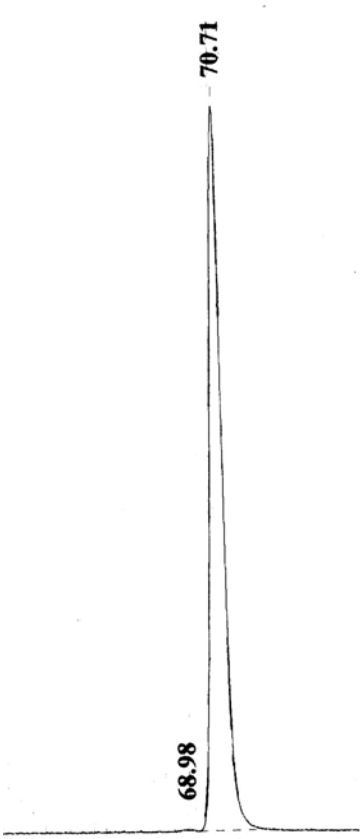


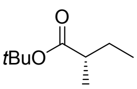
(+)-**2a**

(+)-(2*S*)-Methyl-hexanoic acid *tert*-butyl ester [(+)-2a] The compound was prepared according to the General Procedure with (−)-**1a** (278 mg, 1.00 mmol, >99% *ee*), $ZnCl_2$ (3.4 mg, 2.5 mol%) and *n*BuMgCl (2.0 M in THF; 0.70 mL, 1.4 mmol). After filtration over silica gel, (+)-**2a** was isolated as a colorless liquid (186 mg, 1.00 mmol, >99% yield, >99% *ee*). The *ee* was determined by GC on a chiral phase (G-TA, 1.2 bar, isothermal 40 °C) with t_R = 69.0 min (minor *R* enantiomer), t_R = 70.7 min (major *S* enantiomer). $[\alpha]_D^{20}$ = +11.5 (*c* = 0.83, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 0.88 (t, 3H, *J* = 7.1 Hz, CH_3), 1.08 (d, 3H, *J* = 7.0 Hz, CH_3), 1.21-1.39 (m, 5H, 3×CH_2), 1.43 (s, 9H, 3×CH_3), 1.55-1.64 (m, 1H, CH_2), 2.28 (qdd, 1H, *J* = 7.1, 6.4, 6.1 Hz, CH). ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 14.0, 17.2, 22.7, 28.2 (3C), 29.5, 33.7, 40.5, 79.7, 176.5. MS (CI/NH_3, M = 186.2 g/mol, 110 eV): *m*/*z* (%) = 204 ($[M+NH_4]^+$, 82), 187 ($[M+H]^+$, 100), 148 (90), 131 (14), 113 (11), 74 (23). HRMS (EI, 70 eV, $[M-CH_3]^+$): *m*/*z* calcd. for $C_{10}H_{19}O_2$: 171.1383; found: 171.1385.

The absolute configuration of the product was assigned by converting (+)-**2a** with TFA in CH_2Cl_2 quantitatively to the corresponding acid (+)-**6** $[\alpha]_D^{20}$ = + 18.1 (*c* = 0.84, $CHCl_3$) and comparing the optical rotation with reported data: $[\alpha]_D^{20}$ = + 15.8 (*c* = 1.0, $CHCl_3$).[15]

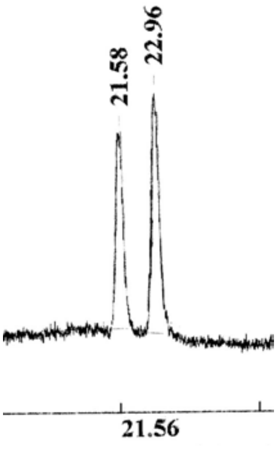


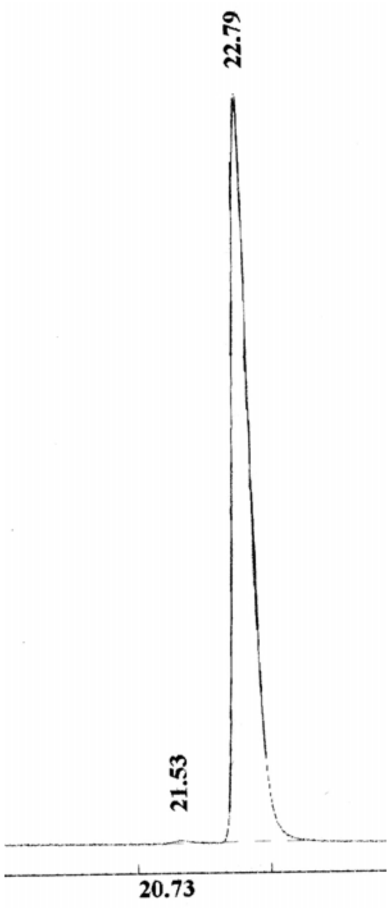


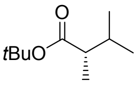


(+)-**2b**

(+)-(2*S*)-Methyl-butyric acid *tert*-butyl ester [(+)-2b] The compound was prepared according to the General Procedure with (–)-**1a** (278 mg, 1.00 mmol, >99% *ee*), $ZnCl_2$ (6.8 mg, 5 mol%) and EtMgCl (1.5 M in THF; 0.93 mL, 1.4 mmol). After filtration over silica gel, (+)-**2b** was isolated as a colorless liquid (158 mg, 1.00 mmol, >99% yield, >99% *ee*). The *ee* was determined by GC on a chiral phase (G-TA, 1.2 bar, isothermal 45 °C) with t_R = 21.5 min (minor *R* enantiomer), t_R = 22.8 min (major *S* enantiomer). $[\alpha]_D^{20}$ = +16.0 (*c* = 0.80, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 0.90 (t, 3H, *J* = 7.4 Hz, CH_3), 1.09 (d, 3H, *J* = 7.0 Hz, CH_3), 1.36-1.47 (m, 1H, CH_2), 1.44 (s, 9H, 3×CH_3), 1.56-1.68 (m, 1H, CH_2), 2.24 (*p*sext, 1H, *J* = 7.0 Hz, CH). ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 11.7, 16.8, 27.0, 28.2 (3C), 42.1, 79.8, 176.3. MS (CI/NH_3, M = 158.1 g/mol, 110 eV): *m/z* (%) = 176 $[M+NH_4]^+$, 100), 159 ($[M+H]^+$, 38), 120 (21), 74 (9). HRMS (EI, 70 eV, $[M-CH_3]^+$): *m/z* calcd. for $C_8H_{15}O_2$: 143.1074; found: 143.1072.

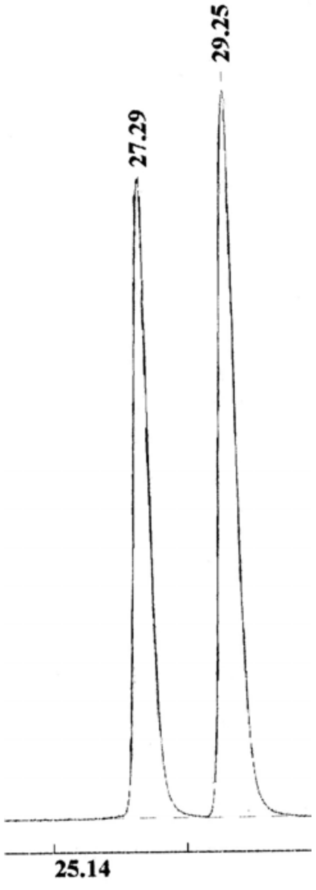


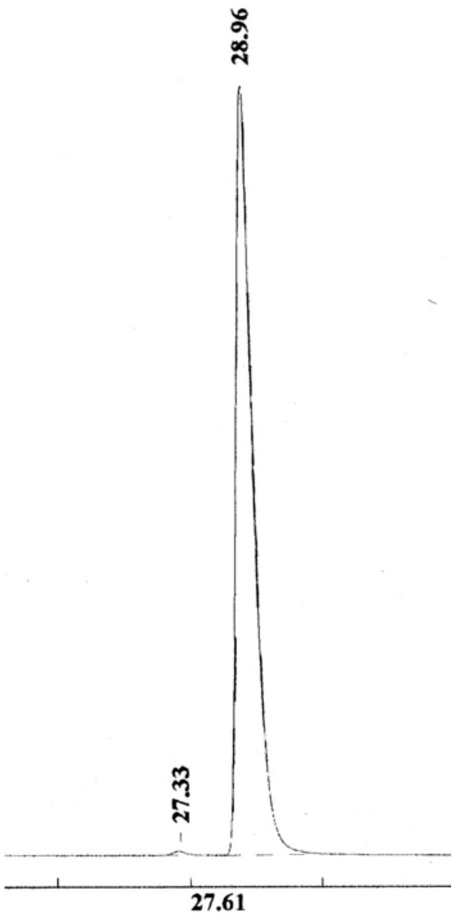


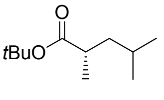


(+)-**2c**

(+)-(2*S*,3)-Dimethyl-butyric acid *tert*-butyl ester [(+)-2c] The compound was prepared according to the General Procedure with (–)-**1a** (278 mg, 1.00 mmol, >99% *ee*), $ZnCl_2$ (6.8 mg, 5 mol%) and *i*PrMgCl (1.7 M in THF; 0.82 mL, 1.4 mmol). After flash chromatography on silica gel (20:1 *n*-pentane/Et_2O), (+)-**2c** was isolated as a colorless liquid (168 mg, 0.98 mmol, 98% yield, >99% *ee*). The *ee* was determined by GC on a chiral phase (G-TA, 1.2 bar, isothermal 45 °C) with t_R = 27.3 min (minor *R* enantiomer), t_R = 29.0 min (major *S* enantiomer). $[\alpha]_D^{20}$ = +16.2 (*c* = 0.75, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 0.88 (d, 3H, *J* = 6.8 Hz, CH_3), 0.91 (d, 3H, *J* = 6.7 Hz, CH_3), 1.04 (d, 3H, *J* = 7.0 Hz, CH_3), 1.43 (s, 9H, 3×CH_3), 1.85 (*p*oct, 1H, *J* = 6.8 Hz, CH), 2.08 (*p*quint, 1H, *J* = 7.0 Hz, CH). ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 13.9, 19.2, 20.7, 28.2 (3C), 31.1, 47.2, 79.7, 175.4. MS (CI/NH_3, M = 172.1 g/mol, 110 eV): *m*/*z* (%) = 190 ($[M+NH_4]^+$, 100), 173 ($[M+H]^+$, 46), 134 (18). HRMS (EI, 70 eV, $[M-CH_3]^+$): *m*/*z* calcd. for $C_9H_{17}O_2$: 157.1232; found: 157.1229.

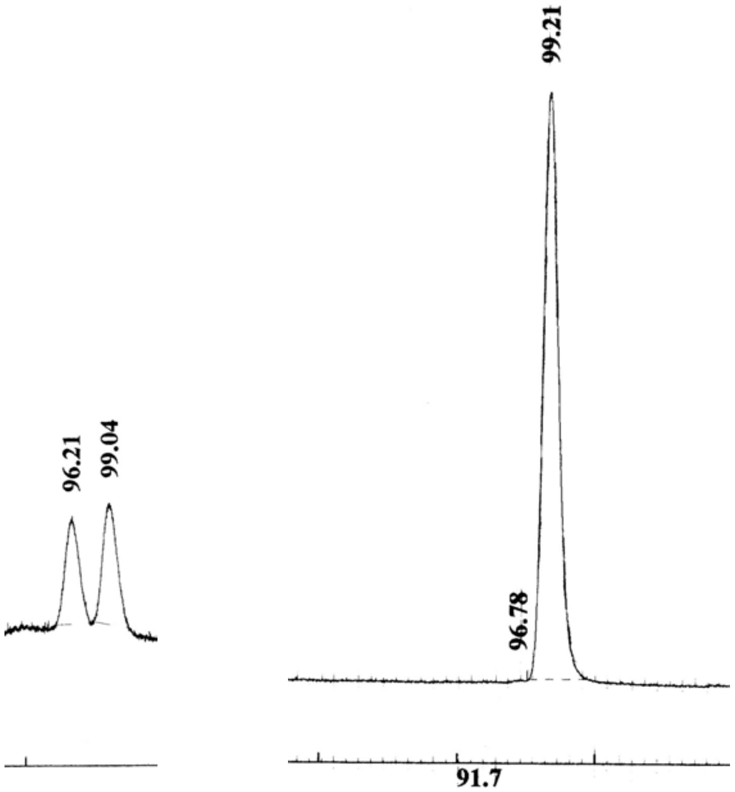


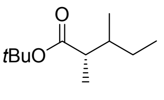




(+)-**2d**

(+)-(2*S*,4)-Dimethyl-pentanoic acid *tert*-butyl ester [(+)-2d] The compound was prepared according to the General Procedure with (−)-**1a** (278 mg, 1.00 mmol, >99% *ee*), $ZnCl_2$ (27.3 mg, 20 mol%) and *i*BuMgCl (2.2 M in THF; 0.64 mL, 1.4 mmol). After filtration over silica gel, (+)-**2d** was isolated as a colorless liquid (186 mg, 1.00 mmol, >99% yield, >99% *ee*). The *ee* was determined by GC on a chiral phase (G-TA, 1.0 bar, isothermal 30 °C) with t_R = 96.4 min (minor *R* enantiomer), t_R = 99.2 min (major *S* enantiomer). $[\alpha]_D^{20}$ = +15.9 (*c* = 0.99, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 0.87 (d, 3H, *J* = 6.4 Hz, CH_3), 0.90 (d, 3H, *J* = 6.5 Hz, CH_3), 1.08 (d, 3H, *J* = 7.0 Hz, CH_3), 1.16 (*p*quint, 1H, *J* = 6.2 Hz, CH_2), 1.43 (s, 9H, 3×CH_3), 1.53 (dt, 1H, *J* = 8.3, 6.7 Hz, CH_2), 1.58 (m_c, 1H, CH), 2.38 (dq, 1H, *J* = 8.1, 6.9 Hz, CH). ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 17.7, 22.5, 22.7, 26.0, 28.2 (3C), 38.6, 43.2, 79.7, 176.7. MS (CI/NH_3, M = 186.2 g/mol, 110 eV): *m*/*z* (%) = 204 ($[M+NH_4]^+$, 100), 187 ($[M+H]^+$, 40), 148 (18). HRMS (EI, 70 eV, $[M-CH_3]^+$): *m*/*z* calcd. for $C_{10}H_{19}O_2$: 171.1387; found: 171.1385.

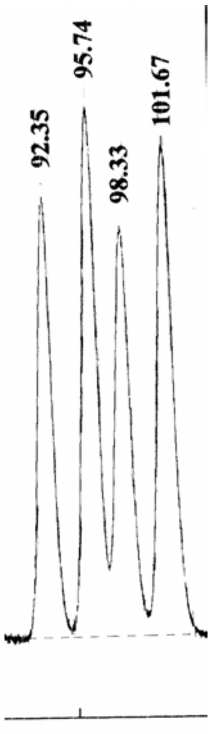


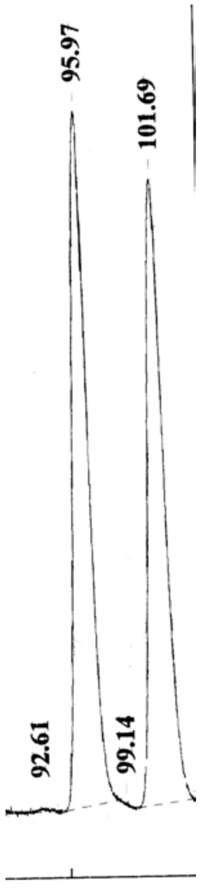


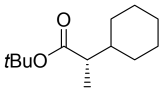
(+)-**2e**

(+)-(2*S*,3)-Dimethyl-pentanoic acid *tert*-butyl ester [(+)-2e] The compound was prepared according to the General Procedure with (−)-**1a** (278 mg, 1.00 mmol, >99% *ee*), $ZnCl_2$ (6.8 mg, 5 mol%) and *s*BuMgCl (2.3 M in THF; 0.61 mL, 1.4 mmol). After flash chromatography on silica gel (20:1 *n*-pentane/Et_2O), (+)-**2e**

was isolated as a 1:1 diastereomeric mixture (178 mg, 0.96 mmol, 96% yield, *dr* = 1:1, *SR* diasteromer: >99% *ee*, [*SS* diastereomer: >99% *ee*]). The *ee* of each diastereomer was determined by GC on a chiral phase (G-TA, 1.2 bar, isothermal 35 °C) with t_R = 92.4 min (minor *RS* isomer), t_R = 96.0 min (major *SR* isomer), t_R = 98.3 min (minor *RR* isomer), t_R = 101.7 min (major *SS* isomer). $[\alpha]_D^{20}$ = +16.6 (*c* = 1.80, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 0.84 (d, 3H, *J* = 6.8 Hz, CH_3), [0.87 (t, 3H, *J* = 7.4 Hz, CH_3)][16], 0.88 (t, 3H, *J* = 7.4 Hz, CH_3), [0.89 (d, 3H, *J* = 6.7 Hz, CH_3)], 1.01 (d, 3H, *J* = 7.0 Hz, CH_3), [1.05 (d, 3H, *J* = 7.0 Hz, CH_3)], 1.07-1.50 (m, 2H, CH_2), [1.07-1.50 (m, 2H, CH_2)], 1.43 (s, 9H, 3×CH_3), [1.43 (s, 9H, 3×CH_3)], [1.60 (d*p*quintd, 1H, *J* = 8.7, 6.7, 4.3 Hz, CH)], 1.70 (d*p*quintd, 1H, *J* = 8.3, 6.7, 5.1 Hz, CH), [2.21 (*p*quint, 1H, *J* = 6.9 Hz, CH)], 2.25 (*p*quint, 1H, *J* = 6.9 Hz, CH). ^{13}C-NMR (100 MHz, $CDCl_3$): δ = [11.4][16], 11.7, 12.5, [14.3], 15.2, [16.7], [26.1], 27.5, 28.2 (3C), [28.2 (3C)], 37.2, [37.8], 44.9, [45.4], 79.7, [79.7], [175.8], 176.1. MS (CI/NH_3, M = 186.2 g/mol, 110 eV): *m*/*z* (%) = 204 ($[M+NH_4]^+$, 100), 187 ($[M+H]^+$, 57), 148 (20). HRMS (EI, 70 eV, $[M-CH_3]^+$): *m*/*z* calcd. for $C_{10}H_{19}O_2$: 171.1385; found: 171.1385.

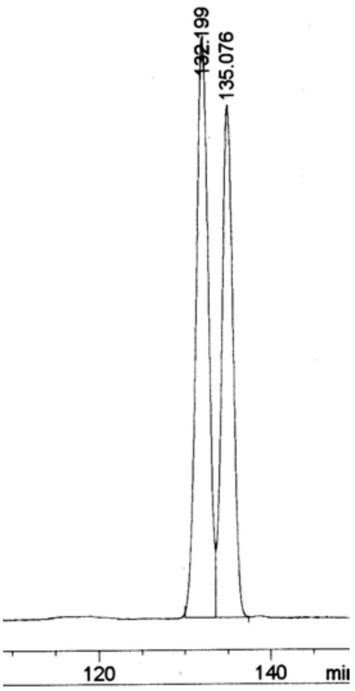


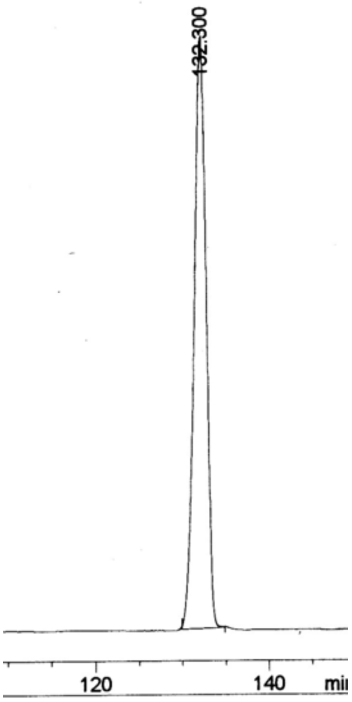


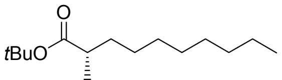


(+)-**2f**

(+)-(2*S*)-Cyclohexyl-propionic acid *tert*-butyl ester [(+)-2f] The compound was prepared according to the General Procedure with (−)-**1a** (278 mg, 1.00 mmol, >99% *ee*), $ZnCl_2$ (13.6 mg, 10 mol%) and CyMgCl (2.1 M in THF; 0.67 mL, 1.4 mmol). After flash chromatography on silica gel (20:1 *n*-pentane/Et_2O), (+)-**2f** was isolated as a colorless liquid (191 mg, 0.90 mmol, 90% yield, >99% *ee*). The *ee* was determined by GC on a chiral phase (Hydrodex β-TBDAc, 1.3 bar, isothermal 60 °C) with t_R = 132.3 min (major *S* enantiomer), t_R = 135.1 min (minor *R* enantiomer). $[\alpha]_D^{20}$ = +10.4 (*c* = 1.92, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 0.87-1.30 (m, 5H, CH_2), 1.05 (d, 3H, *J* = 7.1 Hz, CH_3), 1.44 (s, 9H, 3×CH_3), 1.43-1.54 (m, 1H, CH_2), 1.59-1.76 (m, 5H, CH, 2×CH_2), 2.10 (*p*quint, 1H, *J* = 7.2 Hz, CH). ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 14.2, 26.41, 26.44, 26.5, 28.2 (3C), 29.7, 31.2, 40.9, 46.4, 79.8, 176.1. MS (CI/NH_3, M = 212.2 g/mol, 110 eV): *m*/*z* (%) = 230 ($[M+NH_4]^+$, 100), 214 ($[M+H]^+$, 70), 174 (32). HRMS (EI, 70 eV, $[M-C_4H_7]^+$): *m*/*z* calcd. for $C_9H_{17}O_2$: 157.1227; found: 157.1229.

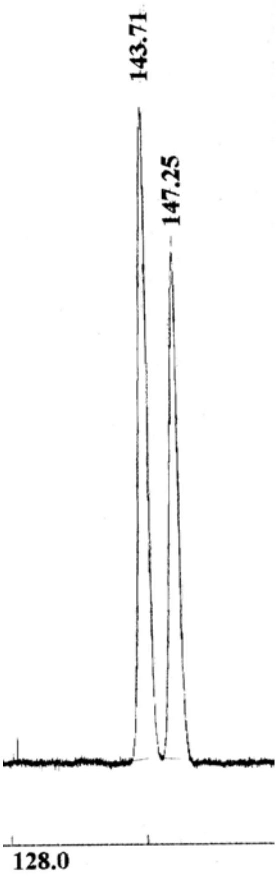


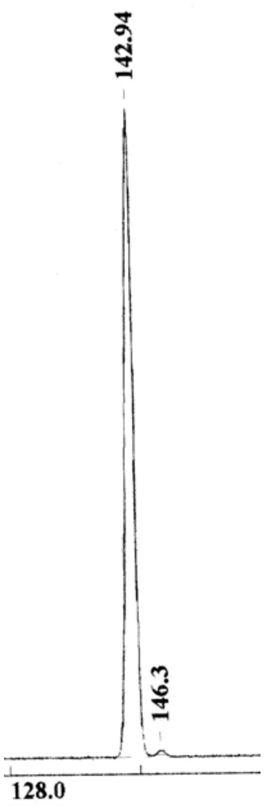


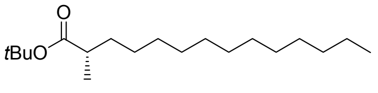


(+)-**2g**

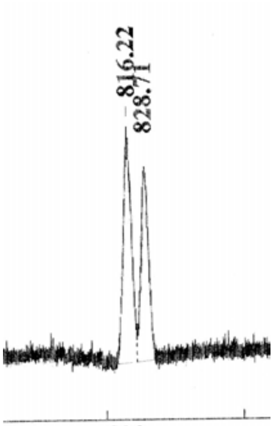
(+)-(2*S*)-Methyl-decanoic acid *tert*-butyl ester [(+)-2g] The compound was prepared according to the General Procedure with (−)-**1a** (278 mg, 1.00 mmol, >99% *ee*), $ZnCl_2$ (6.8 mg, 5 mol%) and *n*OctMgCl (1.8 M in THF; 0.78 mL, 1.4 mmol). After filtration over silica gel, (+)-**2g** was isolated as a colorless liquid (242 mg, 1.00 mmol, >99% yield, >99% *ee*). The *ee* was determined after converting the reduced ester to the acetate by GC on a chiral phase (G-TA, 1.3 bar, isothermal 80 °C) with t_R = 142.9 min (major *S* enantiomer), t_R = 146.3 min (minor *R* enantiomer). $[\alpha]_D^{20}$ = +10.9 (*c* = 1.90, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 0.87 (t, 3H, *J* = 7.0 Hz, CH_3), 1.08 (d, 3H, *J* = 7.0 Hz, CH_3), 1.19-1.39 (m, 13H, 7×CH_2), 1.43 (s, 9H, 3×CH_3), 1.52-1.65 (m, 1H, CH_2), 2.29 (qdd, 1H, *J* = 7.0, 6.3, 6.0 Hz, CH). ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 14.2, 17.2, 22.7, 27.3, 28.2 (3C), 29.3, 29.6, 29.7, 32.0, 34.0, 40.5, 79.7, 176.5. MS (CI/NH_3, M = 242.2 g/mol, 110 eV): *m*/*z* (%) = 260 ($[M+NH_4]^+$, 100), 243 ($[M+H]^+$, 24), 204 (17). HRMS (EI, 70 eV, $[M-C_4H_7]^+$): *m*/*z* calcd. for $C_{11}H_{23}O_2$: 187.1702; found: 187.1698.

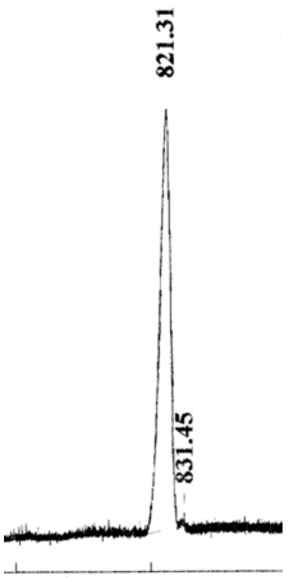


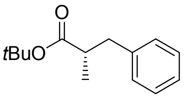



(+)-**2h**

(+)-(2*S*)-Methyl-tetradecanoic acid *tert*-butyl ester [(+)-2h] The compound was prepared according to the General Procedure with (−)-**1a** (278 mg, 1.00 mmol, >99% *ee*), $ZnCl_2$ (6.8 mg, 5 mol%) and LaurylMgCl (0.88 M in THF; 1.56 mL, 1.4 mmol). After filtration over silica gel, (+)-**2h** was isolated as a colorless liquid (298 mg, 1.00 mmol, >99% yield, >99% *ee*). The *ee* was determined after converting the reduced ester to the acetate by GC on a chiral phase (G-TA, 1.3 bar, isothermal 95 °C) with t_R = 821.3 min (major *S* enantiomer), t_R = 831.5 min (minor *R* enantiomer). $[\alpha]_D^{20}$ = +10.7 (*c* = 1.63, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 0.87 (t, 3H, *J* = 7.0 Hz, CH_3), 1.08 (d, 3H, *J* = 7.0 Hz, CH_3), 1.20-1.38 (m, 21H, 11×CH_2), 1.43 (s, 9H, 3×CH_3), 1.54-1.64 (m, 1H, CH_2), 2.29 (qdd, 1H, *J* = 7.0, 6.2, 5.9 Hz, CH). ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 14.2, 17.2, 22.8, 27.3, 28.2 (3C), 29.4, 29.6, 29.65, 29.7, 29.75 (2C), 29.8, 32.0, 34.0, 40.6, 79.7, 176.5. MS (CI/NH_3, M = 298.3 g/mol, 110 eV): *m*/*z* (%) = 316 ($[M+NH_4]^+$, 100), 299 ($[M+H]^+$, 24), 260 (17). HRMS (EI, 70 eV, $[M-C_4H_7]^+$): *m*/*z* calcd. for $C_{15}H_{31}O_2$: 243.2329; found: 243.2324.

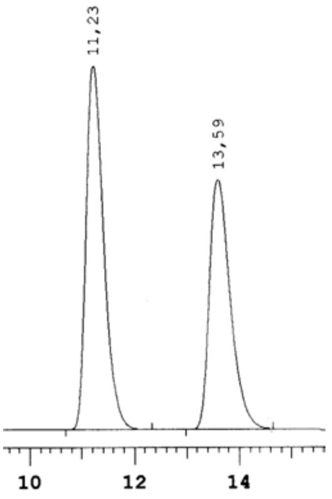


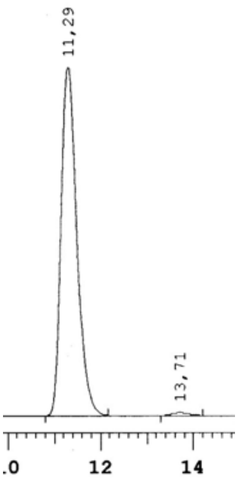


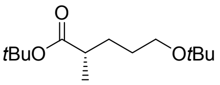


(+)-**2i**

(+)-(2*S*)-Methyl-3-phenyl-propionic acid *tert*-butyl ester [(+)-2i] The compound was prepared according to the General Procedure with (−)-**1a** (278 mg, 1.00 mmol, >99% *ee*), $ZnCl_2$ (6.8 mg, 5 mol%) and BnMgCl (0.83 M in THF; 1.69 mL, 1.4 mmol). After filtration over silica gel, (+)-**2i** was isolated as a colorless liquid (220 mg, 1.00 mmol, >99% yield, >99% *ee*). The *ee* was determined by HPLC on a chiral phase (OJ-R, AcCN/H_2O 50:50, flow 0.8 mL/min) with t_R = 11.3 min (major *S* enantiomer), t_R = 13.7 min (minor *R* enantiomer). $[\alpha]_D^{20}$ = +28.2 (c = 1.32, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 1.13 (d, 3H, J = 6.7 Hz, CH_3), 1.38 (s, 9H, 3×CH_3), 2.64 (m_c, 2H, CH, CH_2), 2.97 (m_c, 1H, CH_2), 7.16-7.22 (m, 3H, ArH), 7.25-7.30 (m, 2H, ArH). ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 17.0, 28.1 (3C), 39.9, 42.3, 80.1, 126.2, 128.3 (2C), 129.1 (2C), 139.8, 175.6. MS (CI/NH_3, M = 220.2 g/mol, 110 eV): m/z (%) = 238 ($[M+NH_4]^+$, 100), 221 ($[M+H]^+$, 15), 182 (42). HRMS (EI, 70 eV, $[M^+]$): m/z calcd. for $C_{14}H_{20}O_2$: 220.1467; found: 220.1463.

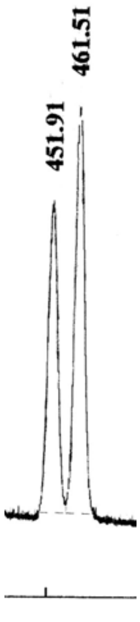


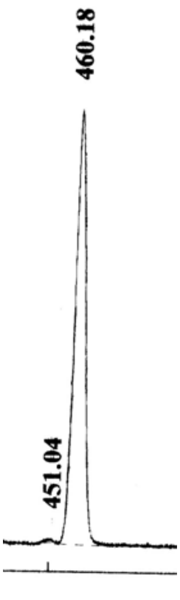


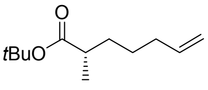


(+)-**2j**

(+)-(2*S*)-Methyl-5-*tert*-butoxy-pentanoic acid *tert*-butyl ester [(+)-2j] The compound was prepared according to the General Procedure with (−)-**1a** (278 mg, 1.00 mmol, >99% *ee*), $ZnCl_2$ (6.8 mg, 5 mol%) and tBuO(CH_2)$_3$MgCl (1.2 M in THF; 1.17 mL, 1.4 mmol). After flash chromatography on silica gel (20:1 *n*-pentane/Et_2O), (+)-**2j** was isolated as a colorless liquid (229 mg, 0.94 mmol, 94% yield, >99% *ee*). The *ee* was determined by GC on a chiral phase (G-TA, 1.2 bar, isothermal 50 °C) with t_R = 451.0 min (minor *R* enantiomer), t_R = 460.2 min (major *S* enantiomer). $[\alpha]_D^{20}$ = +9.2 (c = 1.54, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 1.10 (d, 3H, J = 7.0 Hz, CH_3), 1.17 (s, 9H, 3×CH_3), 1.39-1.56 (m, 3H, 2×CH_2), 1.43 (s, 9H, 3×CH_3), 1.61-1.68 (m, 1H, CH_2), 2.31 (qdd, 1H, J = 7.0, 6.4, 5.8 Hz, CH), 3.32 (m$_c$, 2H, CH_2). ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 17.3, 27.7 (3C), 28.2 (3C), 28.5, 30.6, 40.4, 61.5, 72.6, 79.8, 176.3. MS (CI/NH_3, M = 244.2 g/mol, 110 eV): m/z (%) = 262 ([M+NH$_4$]$^+$, 53), 245 ([M+H]$^+$, 100), 189 (10). HRMS (CI/NH_3, 110 eV, ref.: benzil, [M+H]$^+$): m/z calcd. for $C_{14}H_{29}O_3$: 245.2123; found: 245.2117.

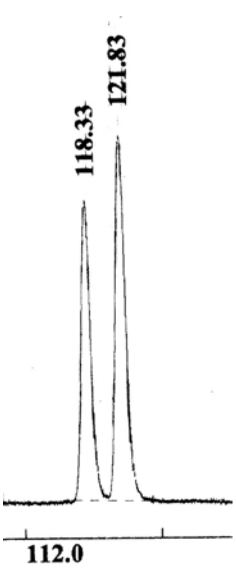


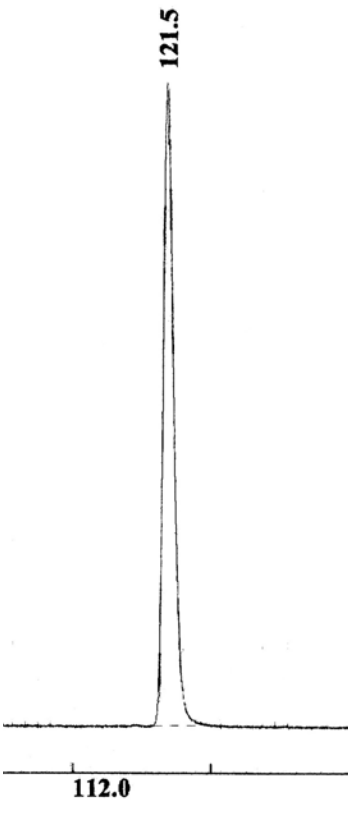


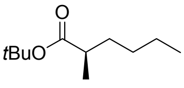


(+)-**2k**

(+)-(2*S*)-Methyl-hept-6-enoic acid *tert*-butyl ester [(+)-2k] The compound was prepared according to the General Procedure with (–)-**1a** (278 mg, 1.00 mmol, >99% *ee*), $ZnCl_2$ (6.8 mg, 5 mol%) and $H_2C{=}CH(CH_2)_3MgCl$ (1.5 M in THF; 0.93 mL, 1.4 mmol). After filtration over silica gel, (+)-**2k** was isolated as a colorless liquid (198 mg, 1.00 mmol, >99% yield, >99% *ee*). The *ee* was determined by GC on a chiral phase (G-TA, 1.2 bar, isothermal 45 °C) with t_R = 118.0 min (minor *R* enantiomer), t_R = 121.5 min (major *S* enantiomer). $[\alpha]_D^{20}$ = +15.1 (*c* = 1.31, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 1.09 (d, 3H, J = 7.0 Hz, CH_3), 1.33-1.42 (m, 3H, 2×CH_2), 1.43 (s, 9H, 3×CH_3), 1.56-1.67 (m, 1H, CH_2), 2.04 (m_c, 2H, CH_2), 2.30 (m_c, 1H, CH), 4.93 (ddt, 1H, J = 10.2, 2.2 Hz, ^4J = 1.2 Hz, CH_2), 4.99 (ddt, 1H, J = 17.1, 2.0 Hz, ^4J = 1.6 Hz, CH_2), 5.78 (ddt, 1H, J = 17.1, 10.2, 6.7 Hz, CH). ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 17.2, 26.6, 28.2 (3C), 33.4, 33.7, 40.4, 79.8, 114.6, 138.7, 176.3. MS (CI/NH_3, M = 198.2 g/mol, 110 eV): *m*/*z* (%) = 216 ($[M+NH_4]^+$, 100), 212 (19), 199 ($[M+H]^+$, 15), 195 (70), 160 (39). HRMS (CI/NH_3, 110 eV, ref.: bezophenone, $[M+NH_4]^+$): *m*/*z* calcd. for $C_{12}H_{26}NO_2$: 216.1963; found: 216.1963.

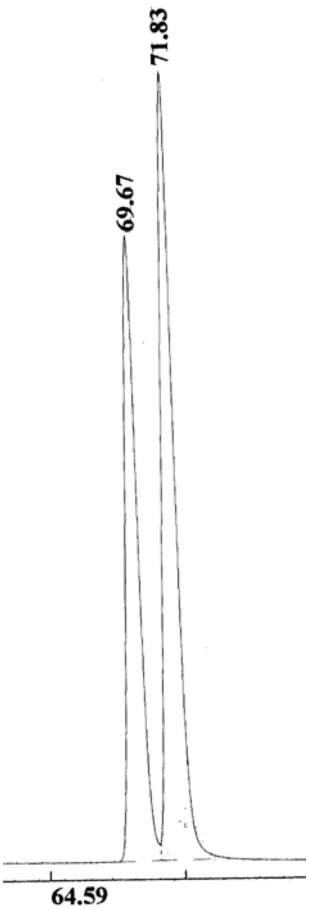


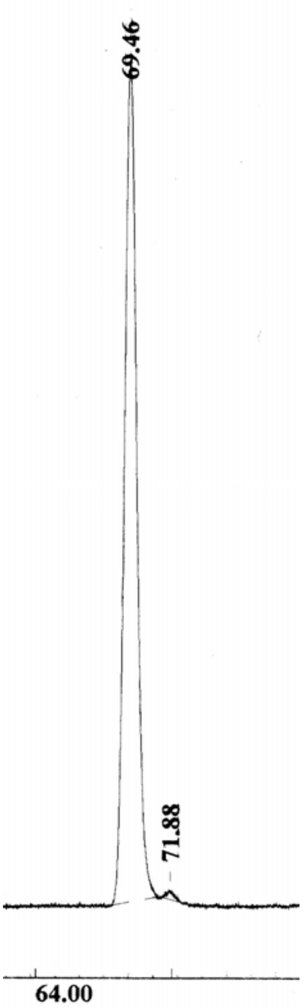


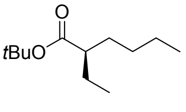


(−)-**2a**

(−)-(2*R*)-Methyl-hexanoic acid *tert*-butyl ester [(−)-2a] The compound was prepared according to the General Procedure with (−)-**9a** (320 mg, 1.00 mmol, 99% *ee*), $ZnCl_2$ (27.3 mg, 20 mol%) and MeMgCl (2.4 M in THF; 0.96 mL, 2.3 mmol). After flash chromatography on silica gel (20:1 *n*-pentane/Et_2O), (−)-**2a** was isolated as a colorless liquid (171 mg, 0.92 mmol, 92% yield, 99% *ee*). The *ee* was determined by GC on a chiral phase (G-TA, 1.2 bar, isothermal 40 °C) with t_R = 69.5 min (major *R* enantiomer), t_R = 71.9 min (minor *S* enantiomer). $[\alpha]_D^{20} = -11.2$ (c = 0.55, $CHCl_3$). The spectroscopic and mass data were identical to those of (+)-**2a**.

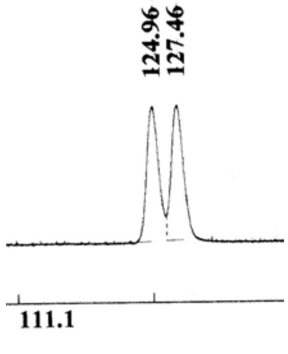


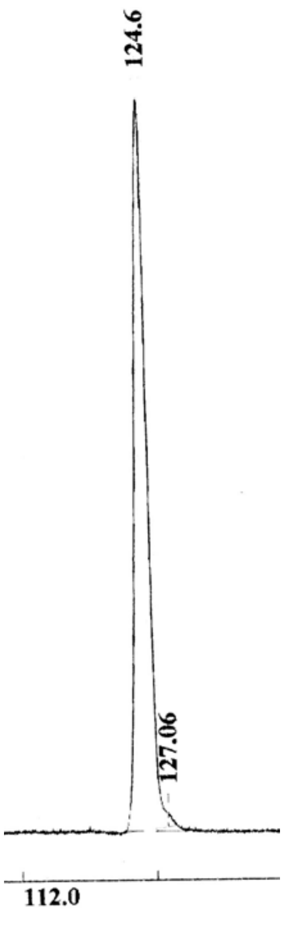


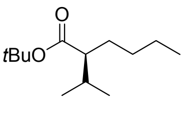


(–)-**10a**

(–)-(2*R*)-Ethyl-hexanoic acid *tert*-butyl ester [(–)-10a] The compound was prepared according to the General Procedure with (–)-**9a** (320 mg, 1.00 mmol, 99% *ee*), $ZnCl_2$ (6.8 mg, 5 mol%) and EtMgCl (1.5 M in THF; 0.93 mL, 1.4 mmol). After filtration over silica gel, (–)-**10a** was isolated as a colorless liquid (200 mg, 1.00 mmol, >99% yield, 99% *ee*). The *ee* was determined by GC on a chiral phase (G-TA, 1.0 bar, isothermal 30 °C) with t_R = 124.6 min (major *R* enantiomer), t_R = 127.1 min (minor *S* enantiomer). $[\alpha]_D^{20} = -5.4$ (c = 1.03, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 0.87 (t, 3H, J = 7.1 Hz, CH_3), 0.88 (t, 3H, J = 7.4 Hz, CH_3), 1.20-1.49 (m, 6H, 4×CH_2), 1.44 (s, 9H, 3×CH_3), 1.55 (m, 2H, 2×CH_2), 2.11 (tt, 1H, J = 8.9, 5.3 Hz, CH). ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 11.9, 14.0, 22.7, 25.8, 28.2 (3C), 29.7, 32.0, 48.3, 79.8, 175.9. MS (CI/NH_3, M = 200.2 g/mol, 110 eV): m/z (%) = 218 ($[M+NH_4]^+$, 100), 201 ($[M+H]^+$, 52), 162 (22). HRMS (EI, 70 eV, $[M-C_4H_7]^+$): m/z calcd. for $C_8H_{17}O_2$: 145.1226; found: 145.1229.

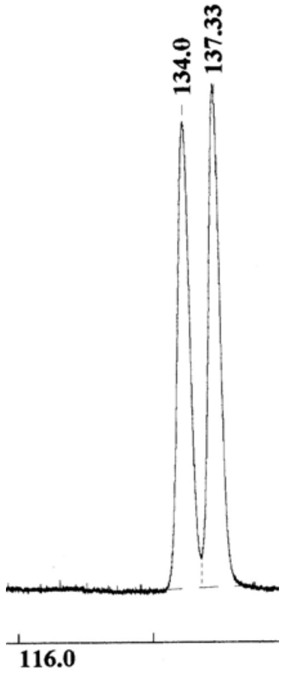


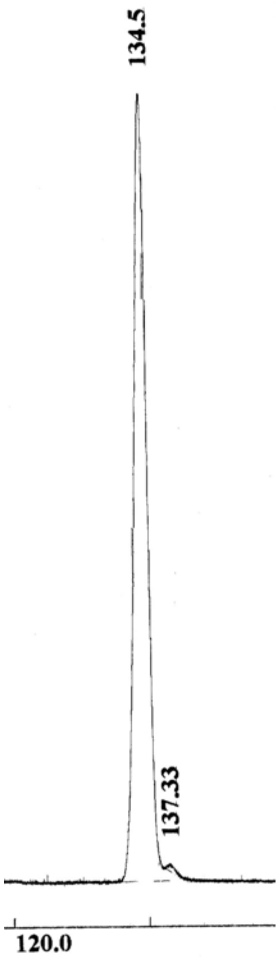


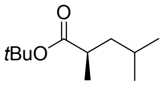


(−)-**10b**

(−)-(2*S*)-Isopropyl-hexanoic acid *tert*-butyl ester [(−)-10b] The compound was prepared according to the General Procedure with (−)-**9a** (320 mg, 1.00 mmol, 99% *ee*), $ZnCl_2$ (20.4 mg, 15 mol%) and *i*PrMgCl (1.7 M in THF; 0.82 mL, 1.4 mmol). After flash chromatography on silica gel (20:1 *n*-pentane/Et_2O), (−)-**10b** was isolated as a colorless liquid (188 mg, 0.88 mmol, 88% yield, 99% *ee*). The *ee* was determined by GC on a chiral phase (G-TA, 1.2 bar, isothermal 45 °C) with t_R = 134.5 min (major *S* enantiomer), t_R = 137.3 min (minor *R* enantiomer). $[\alpha]_D^{20}$ = −6.3 (*c* = 1.10, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 0.87 (t, 3H, *J* = 7.1 Hz, CH_3), 0.91 (d, 6H, *J* = 6.8 Hz, 2×CH_3), 1.15-1.37 (m, 5H, 3×CH_2), 1.44 (s, 9H, 3×CH_3), 1.47-1.61 (m, 1H, CH_2), 1.78 (dhept, 1H, *J* = 7.6, 6.7 Hz, CH), 1.94 (ddd, 1H, *J* = 10.5, 7.7, 4.1 Hz, CH). ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 14.0, 20.3, 20.6, 22.8, 28.3 (3C), 29.7, 30.0, 30.8, 53.7, 79.8, 175.4. MS (CI/NH_3, M = 214.2 g/mol, 110 eV): *m*/*z* (%) = 232 ($[M+NH_4]^+$, 100), 215 ($[M+H]^+$, 70), 176 (32). HRMS (EI, 70 eV, $[M-C_4H_7]^+$): *m*/*z* calcd. for $C_9H_{19}O_2$: 159.1383; found: 159.1385.

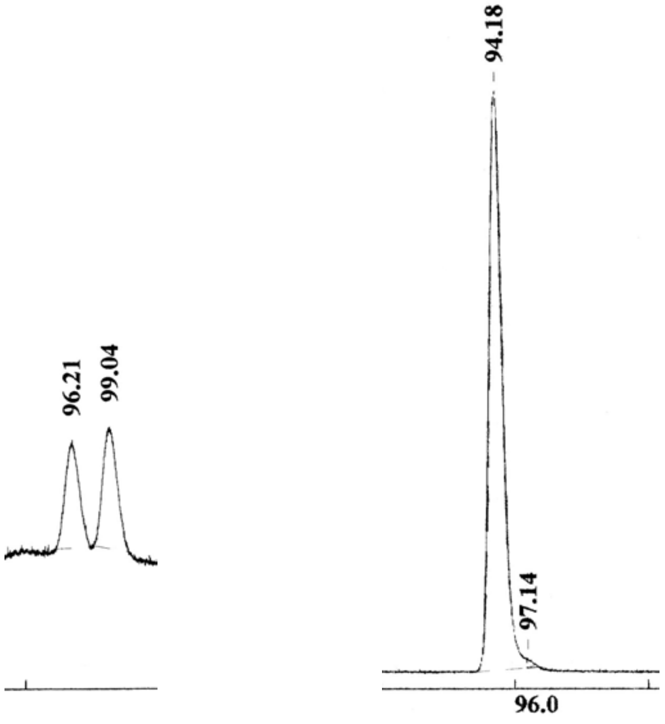


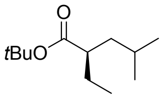




(−)-**2d**

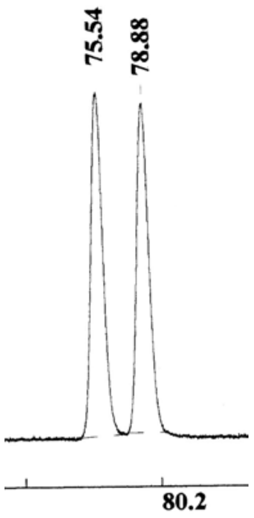
(−)-(2*R*,4)-Dimethyl-pentanoic acid *tert*-butyl ester [(−)-2d] The compound was prepared according to the General Procedure with (−)-**9b** (320 mg, 1.00 mmol, >99% *ee*), $ZnCl_2$ (27.3 mg, 20 mol%) and MeMgCl (2.4 M in THF; 0.96 mL, 2.3 mmol). After flash chromatography on silica gel (20:1 *n*-pentane/Et_2O), (−)-**2d** was isolated as a colorless liquid (150 mg, 0.81 mmol, 81% yield, >99% *ee*). The *ee* was determined by GC on a chiral phase (G-TA, 1.0 bar, isothermal 30 °C) with t_R = 94.2 min (major *R* enantiomer), t_R = 97.1 min (minor *S* enantiomer). $[\alpha]_D^{20}$ = −16.1 (c = 1.37, $CHCl_3$). The spectroscopic and mass data were identical to those of (+)-**2d**.

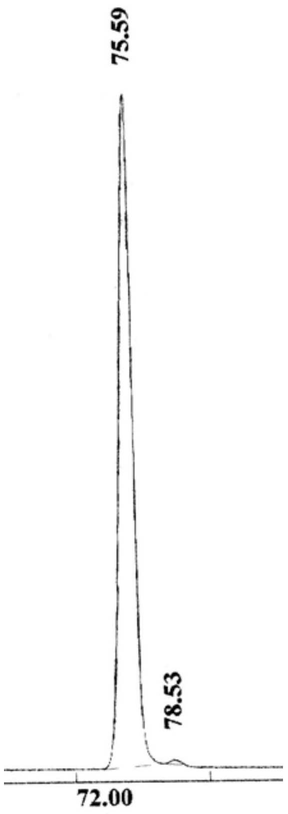


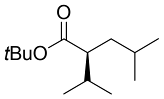


(−)-**11a**

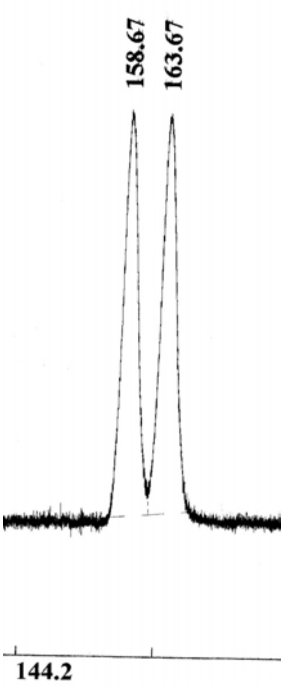
(−)-(2*R*)-Ethyl-4-methyl-pentanoic acid *tert*-butyl ester [(−)-11a] The compound was prepared according to the General Procedure with (−)-**9b** (320 mg, 1.00 mmol, >99% *ee*), $ZnCl_2$ (13.6 mg, 10 mol%) and EtMgCl (1.5 M in THF; 0.93 mL, 1.4 mmol). After filtration over silica gel, (−)-**11a** was isolated as a colorless liquid (200 mg, 1.00 mmol, >99% yield, >99% *ee*). The *ee* was determined by GC on a chiral phase (G-TA, 1.2 bar, isothermal 40 °C) with t_R = 75.6 min (major *R* enantiomer), t_R = 78.5 min (minor *S* enantiomer). $[\alpha]_D^{20}$ = −9.8 (c = 2.78, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 0.87 (d, 3H, J = 6.4 Hz, CH_3), 0.88 (t, 3H, J = 7.4 Hz, CH_3), 0.89 (d, 3H, J = 6.4 Hz, CH_3), 1.16 (*p*quint, 1H, J = 5.0 Hz, CH_2), 1.44 (s, 9H, 3×CH_3), 1.37-1.61 (m, 4H, CH, 2×CH_2), 2.38 (tt, 1H, J = 9.2, 5.2 Hz, CH). ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 11.9, 22.2, 23.3, 26.3, 26.33, 28.2 (3C), 41.7, 46.3, 79.8, 176.1. MS (CI/NH_3, M = 200.2 g/mol, 110 eV): *m/z* (%) = 218 ($[M+NH_4]^+$, 100), 201 ($[M+H]^+$, 53), 162 (21). HRMS (EI, 70 eV, $[M-C_4H_7]^+$): *m/z* calcd. for $C_8H_{17}O_2$: 145.1231; found: 145.1229.

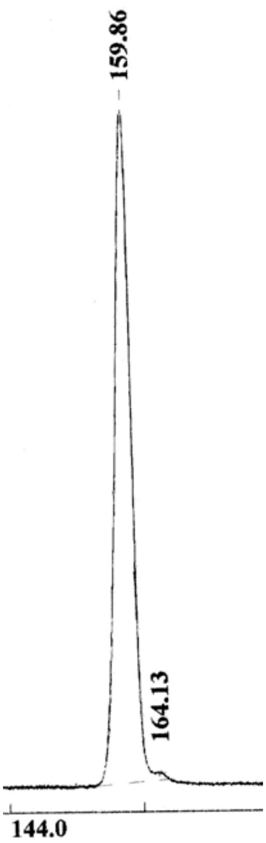


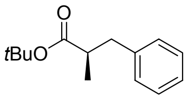



(–)-11b

(–)-(2*S*)-Isopropyl-4-methyl-pentanoic acid *tert*-butyl ester [(–)-11b] The compound was prepared according to the General Procedure with (–)-**9b** (320 mg, 1.00 mmol, >99% *ee*), $ZnCl_2$ (20.4 mg, 15 mol%) and *i*PrMgCl (1.7 M in THF; 0.82 mL, 1.4 mmol). After flash chromatography on silica gel (20:1 *n*-pentane/Et_2O), (–)-**11b** was isolated as a colorless liquid (169 mg, 0.79 mmol, 79% yield, >99% *ee*). The *ee* was determined by GC on a chiral phase (G-TA, 1.2 bar, isothermal 35 °C) with t_R = 159.9 min (major *S* enantiomer), t_R = 164.1 min (minor *R* enantiomer). $[\alpha]_D^{20}$ = −12.5 (*c* = 2.10, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 0.88 (d, 3H, J = 6.6 Hz, CH_3), 0.89 (d, 3H, J = 6.6 Hz, CH_3), 0.90 (d, 3H, J = 6.8 Hz, CH_3), 0.91 (d, 3H, J = 6.8 Hz, CH_3), 1.17 (ddd, 1H, J = 13.0, 9.4, 3.7 Hz, CH_2), 1.44 (s, 9H, 3×CH_3), 1.44-1.60 (m, 2H, CH, CH_2), 1.76 (*p*oct, 1H, J = 6.8 Hz, CH), 2.05 (ddd, 1H, J = 11.0, 7.5, 3.6 Hz, CH). ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 20.4, 20.5, 21.7, 23.9, 26.6, 28.2 (3C), 31.2, 39.3, 51.6, 79.8, 175.5. MS (CI/NH_3, M = 214.2 g/mol, 110 eV): *m/z* (%) = 232 ($[M+NH_4]^+$, 100), 215 ($[M+H]^+$, 74), 176 (30). HRMS (EI, 70 eV, $[M-C_4H_7]^+$): *m/z* calcd. for $C_9H_{19}O_2$: 159.1388; found: 159.1385.

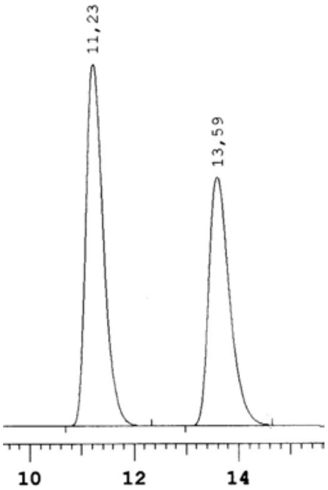


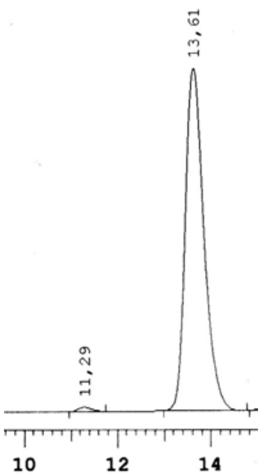


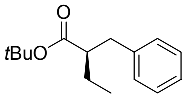


(−)-**2i**

(−)-(2*R*)-Methyl-3-phenyl-propionic acid *tert*-butyl ester [(−)-2i] The compound was prepared according to the General Procedure with (−)-**9c** (354 mg, 1.00 mmol, 98% *ee*), $ZnCl_2$ (27.3 mg, 20 mol%) and MeMgCl (2.4 M in THF; 0.96 mL, 2.3 mmol). After flash chromatography on silica gel (20:1 *n*-pentane/Et_2O), (−)-**2i** was isolated as a colorless liquid (158 mg, 0.72 mmol, 72% yield, 98% *ee*). The *ee* was determined by HPLC on a chiral phase (OJ-R, AcCN/H_2O 50:50, flow 0.8 mL/min) with t_R = 11.3 min (minor *S* enantiomer), t_R = 13.6 min (major *R* enantiomer). $[\alpha]_D^{20}$ = −27.6 (*c* = 0.72, $CHCl_3$). The spectroscopic and mass data were identical to those of (+)-**2i**.

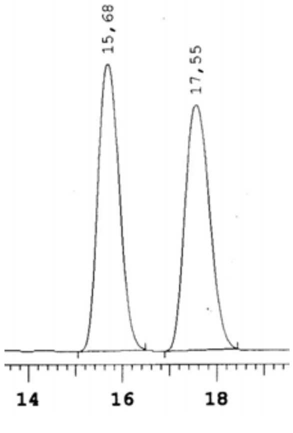


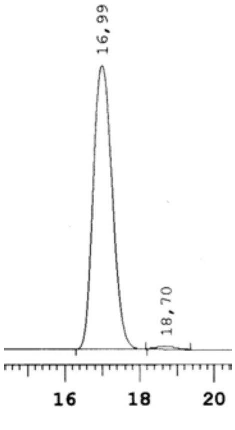


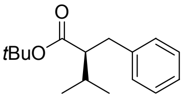


(–)-**12a**

(–)-(2*R*)-Benzyl-butyric acid *tert*-butyl ester [(–)-12a] The compound was prepared according to the General Procedure with (–)-**9c** (354 mg, 1.00 mmol, 98% *ee*), $ZnCl_2$ (6.8 mg, 5 mol%) and EtMgCl (1.5 M in THF; 0.93 mL, 1.4 mmol). After filtration over silica gel, (–)-**12a** was isolated as a colorless liquid (234 mg, 1.00 mmol, >99% yield, 98% *ee*). The *ee* was determined by HPLC on a chiral phase (OD-H, *n*-heptane, flow 0.8 mL/min) with t_R = 17.0 min (major *R* enantiomer), t_R = 18.7 min (minor *S* enantiomer). $[\alpha]_D^{20}$ = –34.6 (c = 1.24, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 0.93 (t, 3H, *J* = 7.5 Hz, CH_3), 1.35 (s, 9H, 3×CH_3), 1.54 (dqd, 1H, *J* = 13.6, 8.9, 7.4 Hz, CH_2), 1.62 (ddq, 1H, *J* = 13.6, 7.5, 5.1 Hz, CH_2), 2.49 (tdd, 1H, *J* = 8.8, 6.5, 5.1 Hz, CH), 2.71 (dd, 1H, *J* = 13.7, 6.5 Hz), 2.88 (dd, 1H, *J* = 13.7, 8.8 Hz), 7.16-7.21 (m, 3H, ArH), 7.24-7.30 (m, 2H, ArH). ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 11.8, 25.5, 28.1 (3C), 38.4, 50.0, 80.1, 126.2, 128.3 (2C), 129.1 (2C), 139.8, 175.0. MS (CI/NH_3, M = 234.2 g/mol, 110 eV): *m*/*z* (%) = 252 ($[M+NH_4]^+$, 100), 235 ($[M+H]^+$, 15), 196 (83). HRMS (EI, 70 eV, $[M^+]$): *m*/*z* calcd. for $C_{15}H_{22}O_2$: 234.1625; found: 234.1620.

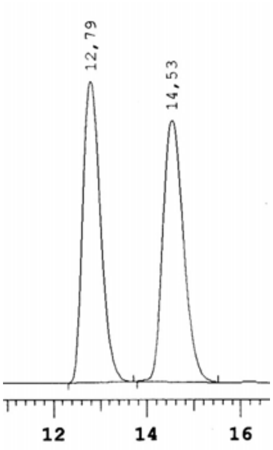


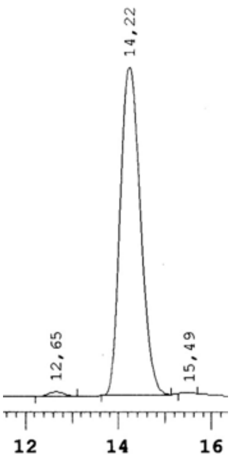


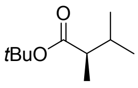


(–)-**12b**

(–)-(2*S*)-Benzyl-3-methyl-butyric acid *tert*-butyl ester [(–)-12b] The compound was prepared according to the General Procedure with (–)-**9c** (354 mg, 1.00 mmol, 98% *ee*), $ZnCl_2$ (27.3 mg, 20 mol%) and *i*PrMgCl (1.7 M in THF; 0.82 mL, 1.4 mmol). After flash chromatography on silica gel (20:1 *n*-pentane/Et_2O), (–)-**12b** was isolated as a colorless liquid (208 mg, 0.84 mmol, 84% yield, 98% *ee*). The *ee* was determined by HPLC on a chiral phase (OD-H, *n*-heptane, flow 0.8 mL/min) with t_R = 12.7 min (minor *R* enantiomer), t_R = 14.2 min (major *S* enantiomer). $[\alpha]_D^{20}$ = –51.2 (*c* = 1.14, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 1.00 (d, 3H, *J* = 6.8 Hz, CH_3), 1.03 (d, 3H, *J* = 6.8 Hz, CH_3), 1.28 (s, 9H, 3×CH_3), 1.91 (*p*oct, 1H, CH), 2.36 (ddd, 1H, *J* = 10.2, 7.3, 5.4 Hz, CH), 2.79 (dd, 1H, *J* = 13.6, 10.3 Hz, CH_2), 2.84 (dd, 1H, *J* = 13.6, 5.4 Hz, CH_2), 7.16-7.22 (m, 3H, ArH), 7.23-7.29 (m, 2H, ArH). ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 20.3, 20.6, 28.0 (3C), 31.0, 36.2, 55.3, 80.0, 126.1, 128.2 (2C), 129.1 (2C), 140.2, 174.2. MS (CI/NH_3, M = 248.2 g/mol, 110 eV): *m*/*z* (%) = 266 ($[M+NH_4]^+$, 100), 249 ($[M+H]^+$, 15), 210 (80). HRMS (EI, 70 eV, [M^+]): *m*/*z* calcd. for $C_{14}H_{20}O_2$: 248.1780; found: 248.1776.

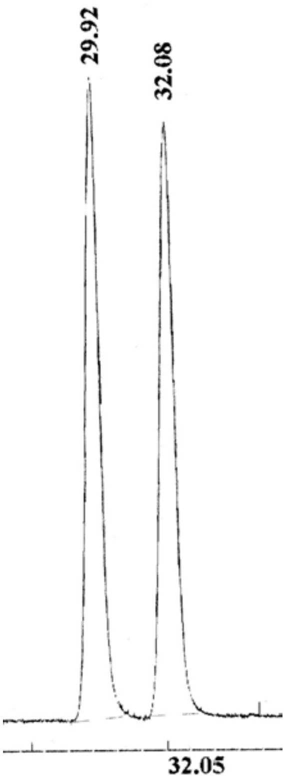


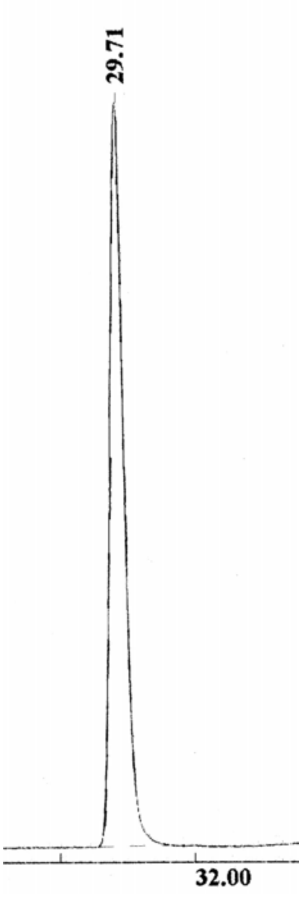


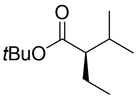


(–)-**2c**

(–)-(2*R*,3)-Dimethyl-butyric acid *tert*-butyl ester [(–)-2c] The compound was prepared according to a slightly modified General Procedure with (–)-**9d** (306 mg, 1.00 mmol, >99% *ee*), $ZnCl_2$ (68.2 mg, 50 mol%) and the slow addition of MeMgCl (2.4 M in THF; 2.08 mL, 5.0 mmol) via syringe pump (3 mL/h) at 20 °C. After flash chromatography on silica gel (20:1 *n*-pentane/Et_2O), (–)-**2c** was isolated as a colorless liquid (131 mg, 0.76 mmol, 76% yield, >99% *ee*). The *ee* was determined by GC on a chiral phase (G-TA, 1.2 bar, isothermal 45 °C) with t_R = 29.7 min (major *R* enantiomer), t_R = 32.0 min (minor *S* enantiomer). $[\alpha]_D^{20}$ = –16.7 (*c* = 0.90, $CHCl_3$). The spectroscopic and mass data were identical to those of (+)-**2c**.

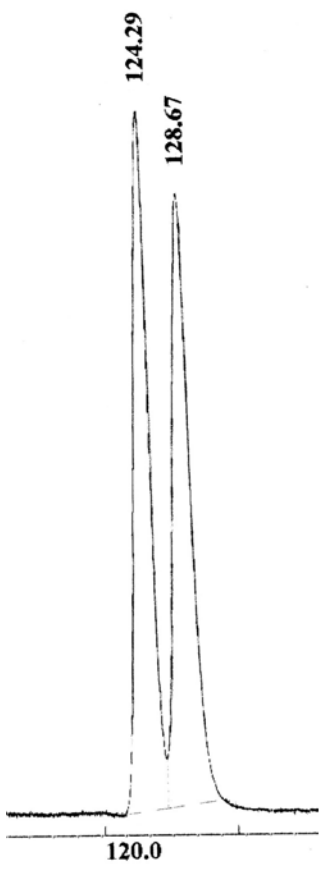


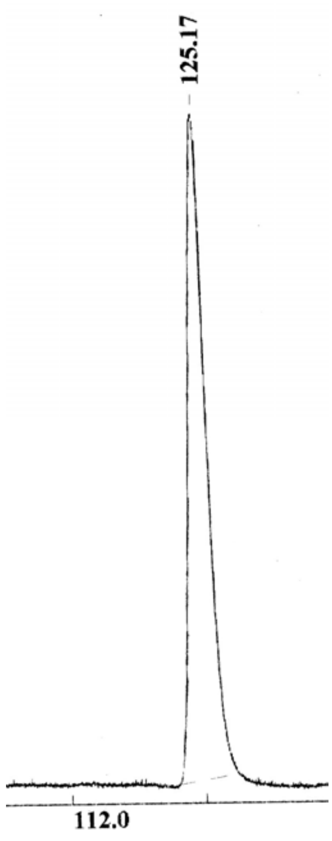


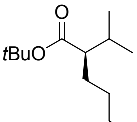


(−)-13a

(−)-(2*R*)-Ethyl-3-methyl-butyric acid *tert*-butyl ester [(−)-13a] The compound was prepared according to the General Procedure with (−)-**9d** (306 mg, 1.00 mmol, >99% *ee*), $ZnCl_2$ (20.4 mg, 15 mol%) and EtMgCl (1.5 M in THF; 0.93 mL, 1.4 mmol). After filtration over silica gel, (−)-**13a** was isolated as a colorless liquid (186 mg, 1.00 mmol, >99% yield, >99% *ee*). The *ee* was determined by GC on a chiral phase (G-TA, 1.0 bar, isothermal 30 °C) with t_R = 125.2 min (major *R* enantiomer), t_R = 129.6 min (minor *S* enantiomer). $[\alpha]_D^{20} = -1.5$ (c = 1.56, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 0.88 (t, 3H, J = 7.5 Hz, CH_3), 0.92 (d, 6H, J = 6.6 Hz, $2\times CH_3$), 1.45 (s, 9H, $3\times CH_3$), 1.53 (*p*quint, 2H, J = 7.5 Hz, CH_2), 1.80 (*p*oct, 1H, J = 6.6 Hz, CH), 1.88 (td, 1H, J = 7.8, 6.6 Hz, CH). ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 12.2, 20.4, 20.6, 23.1, 28.3 (3C), 30.6, 55.6, 79.9, 175.3. MS (CI/NH_3, M = 186.2 g/mol, 110 eV): m/z (%) = 204 ($[M+NH_4]^+$, 100), 187 ($[M+H]^+$, 64), 148 (23). HRMS (EI, 70 eV, $[M-CH_3]^+$): m/z calcd. for $C_{10}H_{19}O_2$: 171.1389; found: 171.1385.

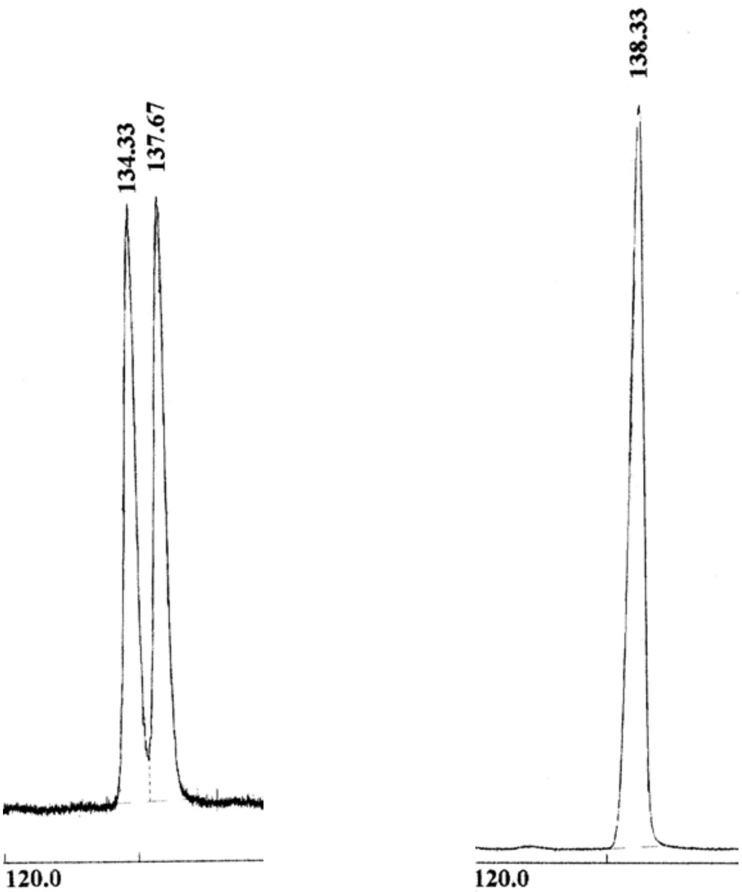


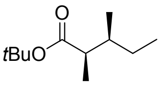




(+)-**10b**

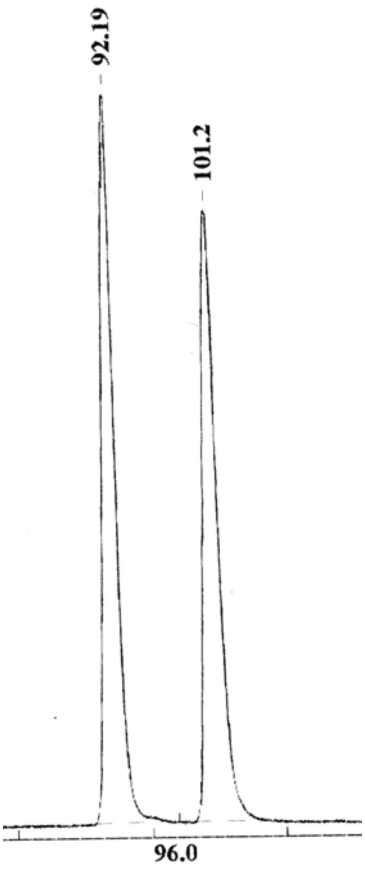
(+)-(2*R*)-Isopropyl-hexanoic acid *tert*-butyl ester [(+)-10b] The compound was prepared according to the General Procedure with (–)-**9d** (306 mg, 1.00 mmol, >99% *ee*), $ZnCl_2$ (27.3 mg, 20 mol%) and *n*BuMgCl (2.0 M in THF; 2.25 mL, 4.5 mmol). After filtration over silica gel, (+)-**10b** was isolated as a colorless liquid (214 mg, 1.00 mmol, >99% yield, >99% *ee*). The *ee* was determined by GC on a chiral phase (G-TA, 1.2 bar, isothermal 45 °C) with t_R = 134.9 min (minor *S* enantiomer), t_R = 138.3 min (major *R* enantiomer). $[\alpha]_D^{20}$ = +6.5 (*c* = 1.86, $CHCl_3$). The spectroscopic and mass data were identical to those of (–)-**10b**.

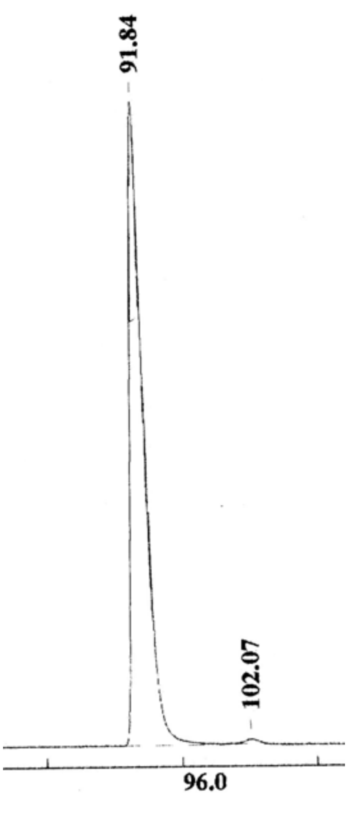


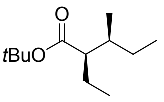


(–)-**2e**

(–)-(2*R*,3*S*)-Dimethyl-pentanoic acid *tert*-butyl ester [(–)-2e] The compound was prepared according to a slightly modified General Procedure with (–)-**9e** (320 mg, 1.00 mmol, 99% *de*, >99% *ee*), $ZnCl_2$ (68.2 mg, 50 mol%) and the slow addition of MeMgCl (2.4 M in THF; 2.08 mL, 5.0 mmol) via syringe pump (3 mL/h) at 20 °C. After flash chromatography on silica gel (20:1 *n*-pentane/Et_2O), (–)-**2e** was isolated as a colorless liquid (136 mg, 0.73 mmol, 73% yield, 99% *de*, >99% *ee*). The *de* and *ee* were determined by GC on a chiral phase (G-TA, 1.2 bar, isothermal 35 °C) with t_R = 91.8 min (major *RS* isomer), t_R = 96.3 min (minor *SR* isomer), t_R = 98.7 min (minor *RR* isomer), t_R = 102.1 min (minor *SS* isomer). $[\alpha]_D^{20} = -13.1$ (c = 0.42, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 0.84 (d, 3H, J = 6.8 Hz, CH_3), 0.89 (t, 3H, J = 7.4 Hz, CH_3), 1.01 (d, 3H, J = 7.0 Hz, CH_3), 1.18 (ddq, 1H, J = 13.6, 8.3, 7.3 Hz, CH_2), 1.37 (dqd, 1H, J = 13.6, 7.5, 5.1 Hz, CH_2), 1.44 (s, 9H, 3×CH_3), 1.71 (d*p*quintd, 1H, J = 8.3, 6.7, 5.1 Hz, CH), 2.26 (*p*quint, 1H, J = 6.9 Hz, CH). ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 11.7, 12.5, 15.3, 27.6, 28.2 (3C), 37.2, 44.9, 79.7, 176.1. The mass data were identical to those of (+)-**2a**.

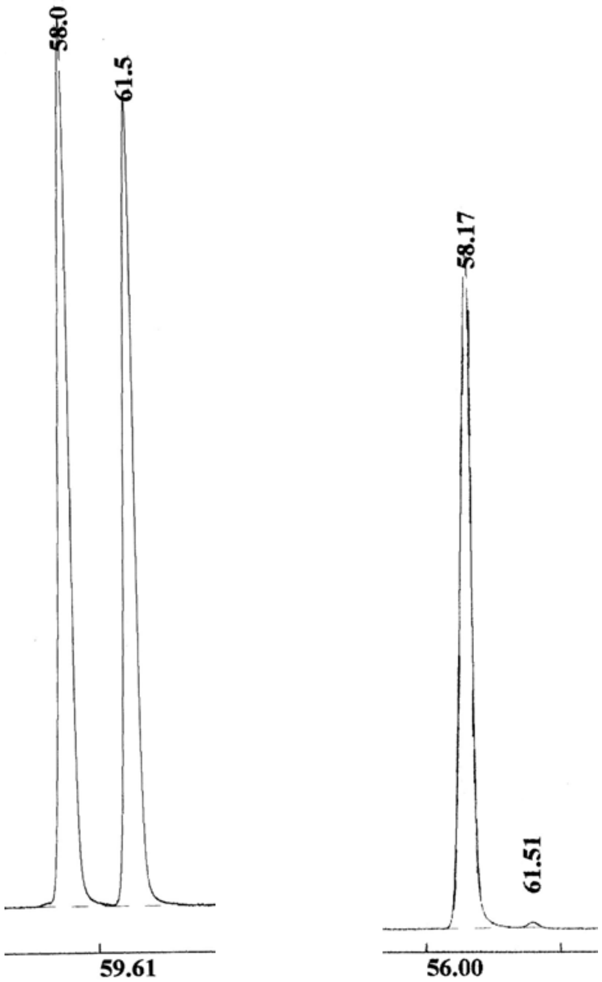


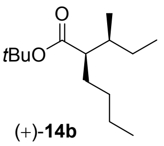




(−)-**14a**

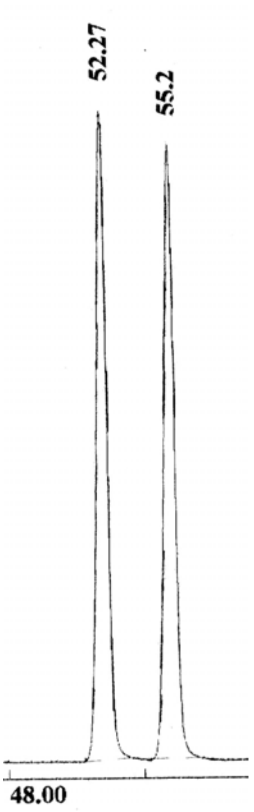
(−)-(2*R*)-Ethyl-(3*S*)-methyl-pentanoic acid *tert*-butyl ester [(−)-14a] The compound was prepared according to the General Procedure with (−)-**9e** (320 mg, 1.00 mmol, 99% *de*, >99% *ee*), $ZnCl_2$ (27.3 mg, 20 mol%) and EtMgCl (1.5 M in THF; 0.93 mL, 1.4 mmol). After filtration over silica gel, (−)-**14a** was isolated as a colorless liquid (200 mg, 1.00 mmol, >99% yield, 99% *de*, >99% *ee*). The *de* was determined by GC on a chiral phase (G-TA, 1.2 bar, isothermal 50 °C) with t_R = 58.2 min (major *RS* isomer), t_R = 61.5 min (minor *SS* isomer). $[\alpha]_D^{20}$ = −6.7 (*c* = 0.90, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 0.87 (d, 3H, *J* = 6.7 Hz, CH_3), 0.878 (t, 3H, *J* = 7.4 Hz, CH_3), 0.881 (t, 3H, *J* = 7.2 Hz, CH_3), 1.15 (ddq, 1H, *J* = 13.6, 8.7, 7.2 Hz, CH_2), 1.36-1.66 (m, 4H, CH, 2×CH_2), 1.45 (s, 9H, 3×CH_3), 2.00 (ddd, 1H, *J* = 10.0, 7.4, 4.6 Hz, CH). ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 11.5, 12.3, 16.2, 22.2, 27.4, 28.3 (3C), 37.0, 53.8, 79.8, 175.4. MS (CI/NH_3, M = 200.2 g/mol, 110 eV): *m*/*z* (%) = 218 ($[M+NH_4]^+$, 100), 201 ($[M+H]^+$, 69), 162 (24). HRMS (EI, 70 eV, $[M-C_4H_7]^+$): *m*/*z* calcd. for $C_8H_{17}O_2$: 145.1228; found: 145.1229.

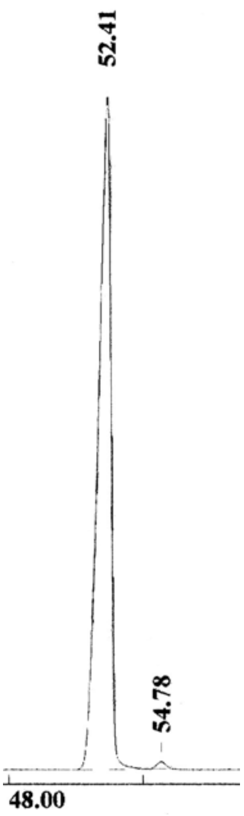


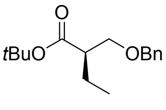


(+)-**14b**

(+)-(2*R*)-[Propyl-(1'*S*)-methyl]-hexanoic acid *tert*-butyl ester [(+)-14b] The compound was prepared according to the General Procedure with (−)-**9e** (320 mg, 1.00 mmol, 99% *de*, >99% *ee*), $ZnCl_2$ (27.3 mg, 20 mol%) and *n*BuMgCl (2.0 M in THF; 1.25 mL, 2.5 mmol). After filtration over silica gel, (+)-**14b** was isolated as a colorless liquid (228 mg, 1.00 mmol, >99% yield, 99% *de*, >99% *ee*). The *de* was determined by GC on a chiral phase (G-TA, 1.3 bar, isothermal 70 °C) with t_R = 52.4 min (major *RS* isomer), t_R = 54.8 min (minor *SS* isomer). $[\alpha]_D^{20}$ = +0.6 (*c* = 1.50, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 0.869 (d, 3H, *J* = 6.8 Hz, CH_3), 0.873 (t, 3H, *J* = 7.4 Hz, CH_3), 0.877 (t, 3H, *J* = 7.0 Hz, CH_3), 1.15 (ddq, 1H, *J* = 13.6, 8.7, 7.4 Hz, CH_2), 1.20-1.66 (m, 8H, CH, 4×CH_2), 1.44 (s, 9H, 3×CH_3), 2.07 (ddd, 1H, *J* = 10.9, 7.2, 3.8 Hz, CH). ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 11.6, 14.1, 16.2, 22.8, 27.3, 28.2 (3C), 28.7, 30.1, 37.2, 52.0, 79.8, 175.6. MS (CI/NH_3, M = 228.2 g/mol, 110 eV): *m*/*z* (%) = 246 ($[M+NH_4]^+$, 100), 229 ($[M+H]^+$, 84), 206 (24), 190 (33). HRMS (CI/NH_3, 110 eV, ref.: benzil, $[M+NH_4]^+$): *m*/*z* calcd. for $C_{14}H_{32}NO_2$: 246.2439; found: 246.2433.



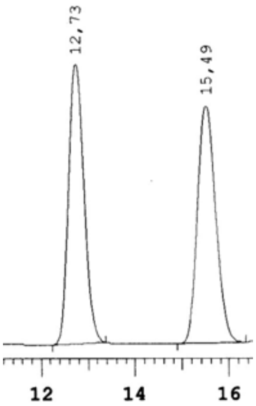


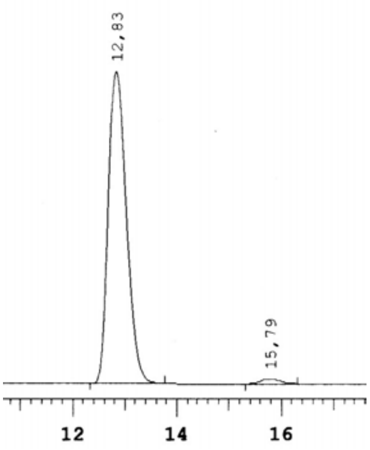


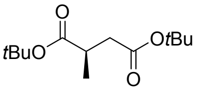
(−)-**15**

(−)-(2*R*)-Benzyloxymethyl-butyric acid *tert*-butyl ester [(−)-15] The compound was prepared according to the General Procedure with (−)-**9f** (384 mg, 1.00 mmol, 97% *ee*), $ZnCl_2$ (27.3 mg, 20 mol%) and EtMgCl (1.5 M in THF; 1.33 mL, 2.0 mmol). After flash chromatography on silica gel (20:1 *n*-pentane/Et_2O), (−)-**15** was isolated as a colorless liquid (251 mg, 0.95 mmol, 95% yield, 97% *ee*). The *ee* was determined by HPLC on a chiral phase (OD-H, *n*-heptane/*iso*-propanol 400:1, flow 0.8 mL/min) with t_R = 12.8 min (major *R* enantiomer), t_R = 15.8 min (minor *S* enantiomer).

$[\alpha]_D^{20}$ = −3.1 (c = 1.35, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 0.92 (t, 3H, J = 7.5 Hz, CH_3), 1.46 (s, 9H, 3×CH_3), 1.49-1.66 (m, 2H, CH_2), 2.54 (tt, 1H, J = 8.2, 5.7 Hz, CH), 3.50 (dd, 1H, J = 9.2, 5.7 Hz, CH_2), 3.64 (dd, 1H, J = 9.2, 8.0 Hz, CH_2), 4.51 (s, 2H, CH_2), 7.24-7.36 (m, 5H, ArH). ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 11.6, 22.3, 28.2 (3C), 48.6, 71.2, 73.2, 80.3, 127.58, 127.63 (2C), 128.4 (2C), 138.5, 173.9. MS (CI/NH_3, M = 264.2 g/mol, 110 eV): *m*/*z* (%) = 282 ($[M+NH_4]^+$, 14), 265 ($[M+H]^+$, 8), 226 (100), 209 (9), 207 (8). HRMS (EI, 70 eV, $[M-t\text{Bu}]^+$): *m*/*z* calcd. for $C_{12}H_{15}O_3$: 207.1019; found: 207.1021.

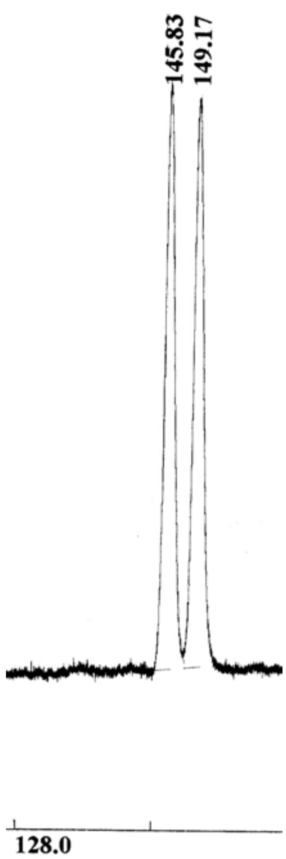


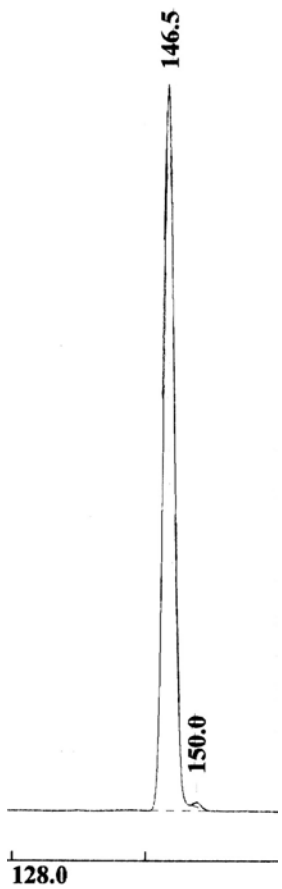




(−)-**16**

(−)-(2*R*)-Methyl-succinic acid di-*tert*-butyl ester [(−)-16] The compound was prepared according to the General Procedure with (−)-**9g** (378 mg, 1.00 mmol, >99% *ee*), $ZnCl_2$ (27.3 mg, 20 mol%) and MeMgCl (2.4 M in THF; 0.96 mL, 2.3 mmol). After flash chromatography on silica gel (20:1 *n*-pentane/Et_2O), (−)-**16** was isolated as a colorless liquid (180 mg, 0.74 mmol, 74% yield, >99% *ee*). The *ee* was determined by GC on a chiral phase (G-TA, 1.3 bar, isothermal 65 °C) with t_R = 146.5 min (major *R* enantiomer), t_R = 150.0 min (minor *S* enantiomer). $[\alpha]_D^{20}$ = −3.7 (c = 0.43, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 1.15 (d, 3H, J = 7.1 Hz, CH_3), 1.43 (s, 18H, 6×CH_3), 2.25 (dd, 1H, J = 16.2, 6.3 Hz, CH_2), 2.58 (dd, 1H, J = 16.2, 8.0 Hz, CH_2), 2.74 (dqd, 1H, J = 8.0, 7.1, 6.3 Hz, CH). ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 17.1, 28.1 (3C), 28.2 (3C), 37.0, 39.1, 80.4, 80.6, 171.4, 174.8. MS (CI/NH_3, M = 244.2 g/mol, 110 eV): *m*/*z* (%) = 262 ($[M+NH_4]^+$, 9), 245 ($[M+H]^+$, 34), 206 (100), 189 (35), 150 (25). HRMS (EI, 70 eV, $[M-Ot\text{Bu}]^+$): *m*/*z* calcd. for $C_9H_{15}O_3$: 171.1024; found: 171.1021.





3 Literature

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[6] α-Hydroxy acids **8e-g**, which were susceptible to racemization, were converted directly to the corresponding α-hydroxy *tert*-butyl esters with *N,N'*-diisopropyl-*O*-*tert*-butylisourea in DCM at rt overnight, see: K. R. West, K. D. Bake, S. Otto, *Org. Lett.* **2005**, *7*, 2615-2618.
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[13] Slightly modified procedure reported by: R. W. Feenstra, E. H. M. Stokkingreef, R. J. F. Nivard, H. C. J. Ottenheijm, *Tetrahedron* **1988**, *44*, 5583-5595.

[14] Anhydrous $ZnCl_2$ was used as obtained and weighed in a glove box.

[15] H. Iwamoto, N. Inukai, I. Yanagisawa, Y. Ishii, T. Tamura, T. Shiozaki, T. Takagi, K.-I. Tomoika, M. Murakami, *Chem. Pharm. Bull.* 1980, *28*, 1422-1431.

[16] The ^{1}H- and ^{13}C-NMR data for the *SS* isomer are reported in parentheses.