*Electronic supplementary information for:*

# Asymmetric Autocatalysis Induced by Meteoritic Amino Acids with Hydrogen Isotope Chirality

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## I. General method

All reactions were carried out under an argon atmosphere, unless otherwise noted. Reactions and purifications were monitored by thin layer chromatography using Silica gel 60 $F_{254}$ (pre-coated on aluminum sheet, 0.2 mm thickness, Merck). Chromatographic purification was performed with Silica gel 60 (230–400 mesh, Merck). NMR spectra were recorded on a BRUKER AV600 spectrometer (operating at 600 MHz for $^{1}H$ and 150 MHz for $^{13}C$ acquisitions). Chemical shifts *d* are reported in ppm with the solvent resonance as the internal standard (Chloroform-*d*: 7.26 ($^{1}H$-NMR), 77.0 ($^{13}C$-NMR); THF-$d_8$: 1.73 ($^{1}H$-NMR); $D_2O$: 4.75 ($^{1}H$-NMR)). Coupling constants *J* are given in Hertz (Hz). Multiplicities are classified by the following abbreviations: s = singlet, d = doublet, t = triplet, q = quartett, m = multiplet or unresolved, br = broad signal. Infrared (IR) data were recorded on a Horiba FT-200 FT-IR spectrometer as thin film using sodium chloride plates for oily compounds or as KBr disk for crystalline compounds. Absorbance frequencies are reported in reciprocal centimeters ($cm^{-1}$). Optical rotations were measured using a Jasco P-1030 digital polarimeter using 5 cm cells. Elementary analyses were performed using a Yanako MT-6 analyzer. High-resolution mass spectra were recorded using a ESI-TOF mass spectrometers (Bruker Daltonics micrOTOF focus).

## II. Asymmetric autocatalysis in the presence of 1 and 2

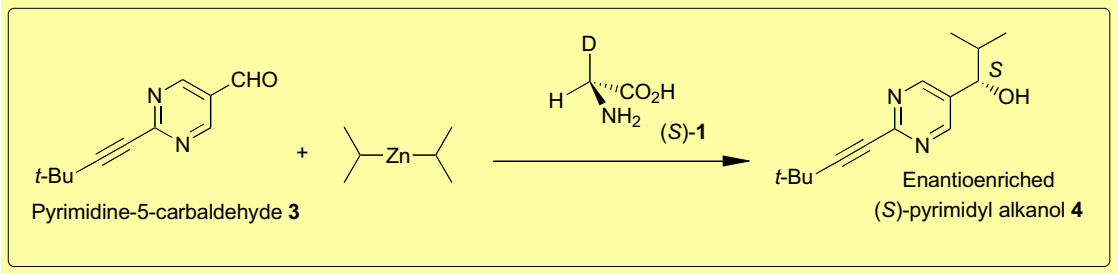



***Figure S1***: Asymmetric autocatalysis in the presence of (*S*)-glycine-α-*d* **1**

**Table 1, series I, entry 1**: A diisopropylzinc (0.15 mL of 1 M methylcyclohexane (MCH) solution, 0.15 mmol) was added to (*S*)-glycine-α-*d* (**1**) (3.8 mg, 0.05 mmol) and the mixture was stirred for 12 h at room temperature. After the addition of diisopropylzinc (0.5 mL of 1 M MCH solution, 0.5 mmol,) at 0 °C, MCH (2.0 mL) solution of pyrimidine-5-carbaldehyde **3** (9.4 mg, 0.05 mmol) was added over a period of 1 h and the mixture was stirred for 6 h at 0 °C. After a toluene (3.2 mL) and diisopropylzinc (0.4 mL of 1 M toluene solution, 0.4 mmol) were added, the reaction mixture was stirred for 10 min. Then, toluene (1.5 mL) solution of aldehyde **3** (37.6 mg, 0.2 mmol) was added over a period of 1 h at 0 °C, and the mixture was stirred for 2 h. Moreover, after toluene (14.4 mL) and *diisopropylzinc* (1.6 mL of 1 M toluene solution) were added and the mixture was stirred for 10 min. Then, toluene (4.0 mL) solution of **3** (150.6 mg, 0.8 mmol) was added over a period of 1 h. After stirring for 1 h, the reaction was quenched with 1 M aqueous hydrochloric acid (5 mL) at 0 °C. After the neutralization with saturated aqueous solution of sodium hydrogen carbonate (15 mL), the mixture was filtered through Celite, and the filtrate was extracted with ethyl acetate. The combined organic fractions were dried over anhydrous sodium sulfate and evaporated in *vacuo*. Purification of the residue using silica gel thin layer chromatography (hexane / ethyl acetate = 2/1, *v*/*v*) gave the (*S*)-5-pyrimidyl alkanol **4** (229 mg, 0.9849 mmol) in 94% yield. The enantiomeric purity was determined to be 96% ee by HPLC using a chiral stationary phase.

HPLC conditions: column: Daicel Chiralcel OD-H; room temperature; eluent: 5% 2-propanol in hexane (*v*/*v*); flow rate: 1.0 mL $min^{-1}$; UV detector: 254 nm; retention time: 13.4 min for (*S*)-**4**, 20.1 min for (*R*)-**4**.

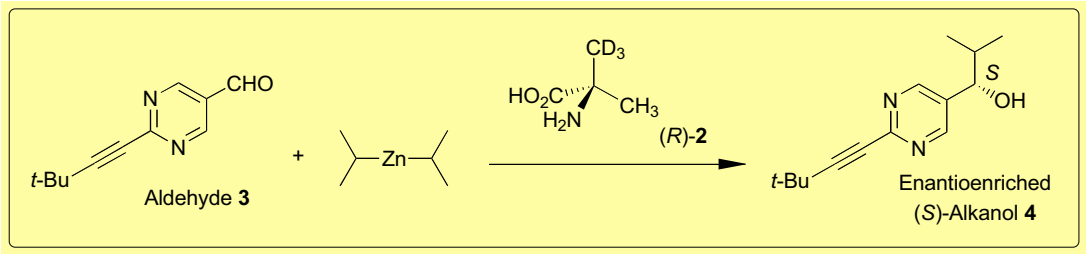



***Figure S2***: Asymmetric autocatalysis in the presence of (*R*)-α-methyl-$d_3$-alanine (**2**)

**Table 1, series II, entry 9**: To a mixture of (*R*)-**2** (8.0 mg, 0.075 mmol, 81% ee), aldehyde **3** (4.7 mg, 0.025 mmol) and toluene (0.03 mL), was added diisopropylzinc (0.15 mL of 1 M toluene solution, 0.15 mmol) over a period of 1 h at 0 °C, and the reaction mixture was stirred for 6 h. After the addition of toluene (1.1 mL), diisopropylzinc (0.2 mL of 1 M toluene solution, 0.2 mmol) and a toluene (0.5 mL) solution of aldehyde **3** (18.8 mg, 0.1 mmol) was added dropwise over a period of 1 h at 0 °C, and the mixture was stirred for 3 h. A part of the reaction mixture (*ca*. 0.4 mL) was transferred to another reaction vessel by syringe, and toluene (1.1 mL) was added. A toluene (0.5 mL) solution of **3** (18.8 mg, 0.1 mmol) and diisopropylzinc (0.2 mL of 1 M toluene solution) were added over a period of 1 h at 0 °C, and the reaction mixture was stirred for 3 h. Moreover, after the addition of toluene (7.2 mL), diisopropylzinc (0.8 mL of 1 M toluene solution, 0.8 mmol) and toluene (4.0 mL) solution of aldehdey **3** (75.3 mg, 0.4 mmol) were added over a period of 1 h at 0 °C, and the mixture was stirred for 1.5 h. The reaction was quenched with a mixture of 30% aqueous ammonia and saturated aqueous ammonium chloride (2/1, *v*/*v*) solution (10 mL). The mixture was extracted using ethyl acetate three times. The combined organic layers were dried over anhydrous sodium sulfate and evaporated *in vacuo*. Purification of the residue using silica gel column chromatography (hexane / ethyl acetate = 3/1, *v*/*v*) gave (*S*)-5-pyrimidyl alkanol **4** (120.4 mg, 0.518 mmol) with 99% ee in 95% yield.

HPLC conditions: column: Daicel Chiralcel IB column (4 x 250 mm); room temperature; eluent: 5% 2-propanol in hexane (*v*/*v*); flow rate: 1.0 mL $min^{-1}$; UV detector: 254 nm; retention time: 10.7 min for (*S*)-**4**, 15.5 min for (*R*)-**4**.

## III. Synthetic method for the compounds 1[1] and 2[2]

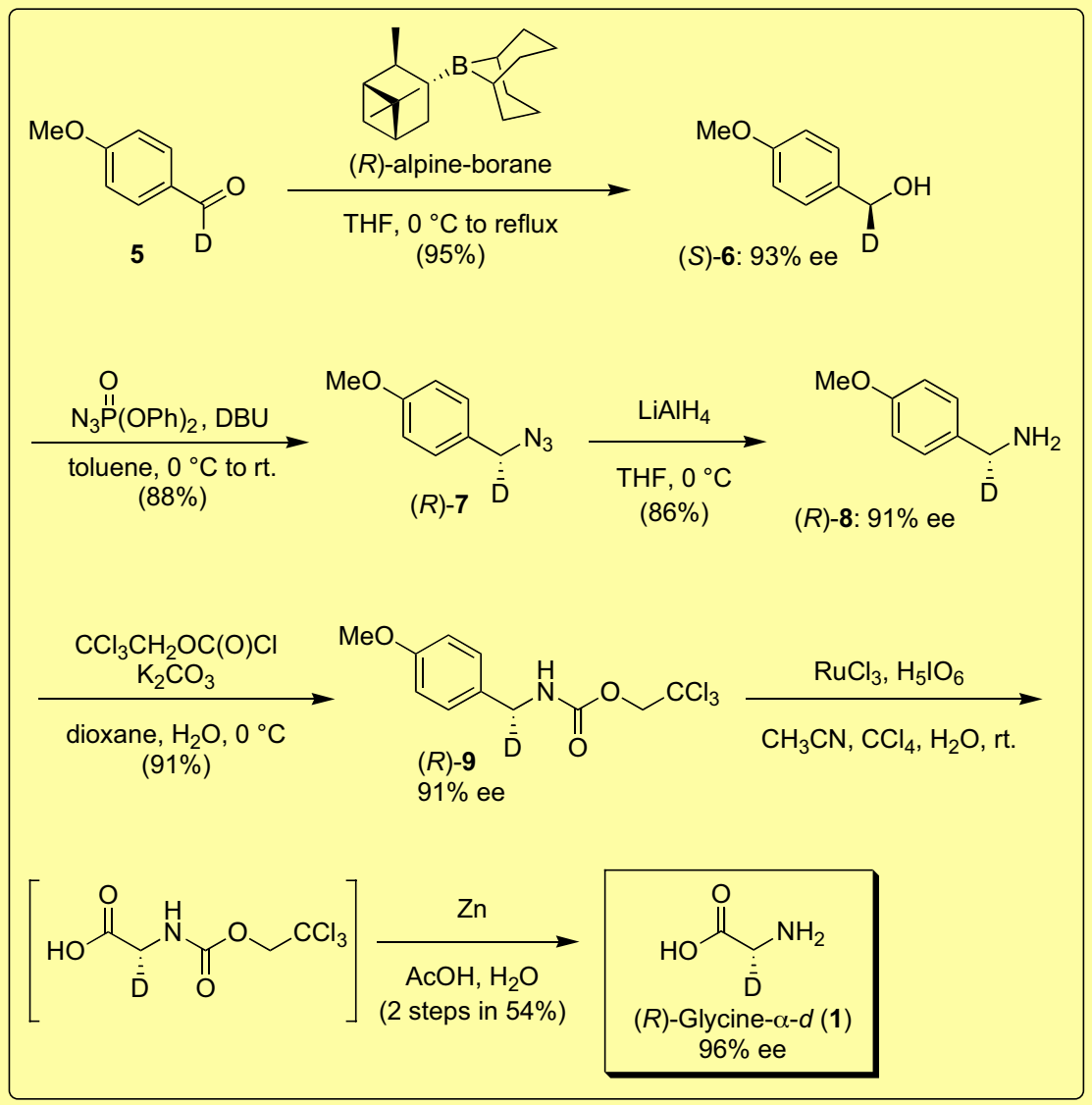
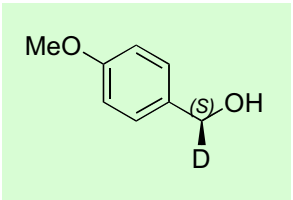



*Figure S3*: Asymmetric synthesis of (*R*)-glycine-α-*d* (**1**).

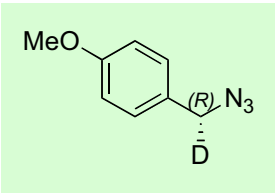



**(*S*)-4-Methoxybenzyl-α-*d* alcohol (6):** To a solution of (*R*)-alpine-borane (28.2 mmol, 56.5 mL, 0.5 M in THF) was slowly added a solution of 4-methoxybenzaldehyde-1-*d* (**5**)[1] (2.32 g, 16.9 mmol) in THF (10 mL) at 0 °C and the reaction mixture was stirred for 1 h. After stirring for 19 h at room temperature,

1 Walker, J. R.; Curley, W. Jr. *Tetrahedron* **2001**, *57*, 6695–6701 and references cited therein.
2 Seebach, D.; Fadel, A. *Helv. Chem. Acta* **1985**, *68*, 1243 and references cited therein.

the mixture was refluxed for 1.5 h. After cooling to room temperature, the reaction was quenched with acetaldehyde (1.6 mL, 28.2 mmol) and the mixture was stirred for 1 h. The resulting residue was dissolved in diethyl ether (30 mL) and cooled to 0 °C. And then, aminoethanol (1.7 mL, 28.2 mmol) was added and the mixture was stirred at room temperature for 1 h. The mixture was filtered through Celite and the precipitate was washed with diethyl ether. The combined organic layer was washed with water and concentration in *vacuo*. Resulting residue was purified by the two-phase partition between octane and 10% aqueous methanol (*v*/*v*). The product was extracted in aqueous methanol phase. After the evaporation of methanol, the residue was extracted with ethyl acetate. The combined organic layer was dried over anhydrous sodium sulfate and evaporated in *vacuo*. Purification of the residue by silica gel column chromatography (hexane / ethyl acetate (9/1) to hexane / ethyl acetate / methanol (10/2/1), *v*/*v*) gave (*S*)-4-methoxybenzyl-α-*d* alcohol (**6**) (2.23 g, 16.1 mmol) in 95% yield as a colorless oil.

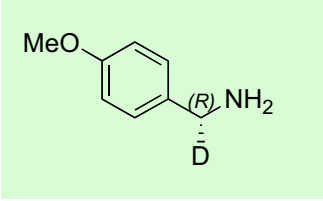
**(S)-6:** $[\alpha]_D^{26}$ +0.79 (c 3.11, $CHCl_3$), 93% ee; IR *ν* (film) 3359, 2906, 2139, 1614, 1512, 1246, 1034, 812; $^1$H-NMR ($CDCl_3$) *δ* 1.54–1.55 (d, 1H, *J*=5.6), 3.81 (s, 3H), 4.60 (d, 1H, *J*=5.2), 6.89–6.90 (d, 2H, *J*=8.5), 7.29-7.31 (d, 2H, *J*=8.6); $^{13}$C-NMR ($CDCl_3$) *δ* 55.3, 64.6–64.9 (t, *J*=21.8 Hz), 114.0, 128.7, 133.0, 159.2; Anal. calcd. for $C_8H_9DO_2$: C, 69.04; H(D), 7.97, found: C, 69.15; H(D), 8.07.
**(*R*)-6**: $[\alpha]_D^{26}$ –0.79 (c 3.13, $CHCl_3$), 95% ee.




**(*R*)-4-Methoxybenzyl-α-*d* azide (7):** To a solution of (*S*)-**6** (2.2 g, 15.9 mmol) and diphenylphosphoryl azide[3] (4.1 mL, 19.1 mmol) in toluene (28 mL) was added 1,8-diazabicyclo-[5,4,0]-7-undecene (2.8 mL, 19.1 mmol) and the mixture was stirred at 0 °C for 2 h and then at room temperature for 16 h. After the addition of 1 M aqueous hydrochloric acid (25 mL), the reaction mixture was extracted with ethyl acetate. The organic layer was washed with water and brine, dried over anhydrous sodium sulfate and concentrated under reduced pressure. The residue was purified using silica gel column chromatography (hexane / ethyl acetate = 2/1, *v*/*v*) to give (*R*)-**7** (2.28 g, 13.9 mmol) in 88% yield as a colorless oil.

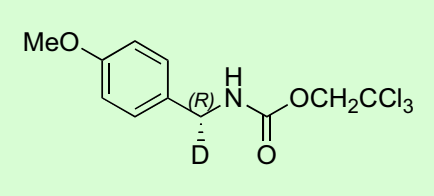
3 Thompson, A. S.; Humphrey, G. R.; DeMarco, A. M.; Mathre, D. J.; Grabowski, E. J. J. *J. Org. Chem*. **1993**, *58*, 5886–5888.

**(*R*)-7**: $[\alpha]_D^{25}$ +5.39 (c 3.05, $CHCl_3$); IR (film) $\nu$ 2951, 2098, 1612, 1512, 1246, 1034, 812; $^1$H-NMR ($CDCl_3$) $\delta$ 3.82 (s, 3H), 4.26 (s, 1H), 6.91–6.92 (d, 2H, *J*=8.5), 7.24–7.26 (d, 2H, *J*=8.6); $^{13}$C-NMR ($CDCl_3$) $\delta$ 53.9–54.2 (t, *J*=21.8), 55.3, 114.2, 127.3, 129.8, 159.6; Anal. calcd. for $C_8H_8DN_3O$: C, 58.52; H(D), 6.14; N, 25.59, found: C, 58.62; H(D), 6.18; N, 25.64.
**(*S*)-7**: $[\alpha]_D^{25}$ –4.51 (c 2.98, $CHCl_3$).




**(*R*)-4-Methoxybenzyl-α-*d*-amine (8):** To a suspension of lithium aluminum hydride[4] (0.5419 g, 14.3 mmol) in THF (40 mL) was added the solution of (*R*)-**7** (2.28 g, 14.0 mmol) in THF (10 mL) at 0 °C, and the mixture was stirred at room temperature for 1.5 h. The reaction was quenched successively with water (0.54 mL), 2.5 M aqueous solution of sodium hydroxide (0.54 mL, 2.5 M) and water (1.62 mL) at 0 °C. The precipitate was filtered off on Celite and washed with THF. The filtrate was concentrated under reduced pressure to give (*R*)-**8** (1.65 g, 11.9 mmol) as a colorless oil in 86% yield.

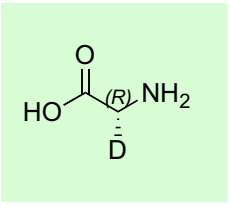
**(*R*)-8:** $[\alpha]_D^{25}$ –0.73 (c 3.14, $CHCl_3$), 91% ee; IR (film) $\nu$ 3369, 2951, 1610, 1512, 1246, 1034, 833; $^1$H-NMR ($CDCl_3$) $\delta$ 1.42 (br, 2H), 3.79 (t, 1H, *J*=1.8), 3.82 (s, 3H), 6.85–6.86 (d, 2H, *J*=7.8), 7.22–7.23 (d, 2H, *J*=7.8); $^{13}$C-NMR ($CDCl_3$) $\delta$ 45.4–45.7 (t, *J*=20.7), 55.3, 113.9, 128.3, 135.6, 158.5; Anal. calcd for $C_8H_{10}DNO$: C, 69.53; H(D), 8.75; N, 10.14, found: C, 69.43; H(D), 8.72; N, 10.08.
**(*S*)-8:** $[\alpha]_D^{25}$ +0.58 (c 3.43, $CHCl_3$), 94% ee.




**(*R*)-2,2,2-Trichloroethyl 4-methoxybenzyl-α-*d* carbamate (9)**: To a solution of (*R*)-**8** (1.64 g, 11.9 mmol) and potassium carbonate (6.9 g, 50.0 mmol) in a mixed solvent of 1,4-dioxane / water (50 mL , 2/1, *v*/*v*) was slowly added the solution of 2,2,2-trichloroethyl chloroformate (2.4 mL, 17.9 mmol) in a mixed solvent of 1,4-dioxane / water (50 mL , 2/1, *v*/*v*) at 0 °C and the reaction mixture was stirred for 1 h. After neutralization of the reaction using 1 M aqueous hydrochloric acid, the solvent was removed under reduced pressure. The resulting mixture was extracted with diethyl ether. The organic extracts were combined and dried over anhydrous sodium sulfate and evaporated in *vacuo*. The residue was purified using silica gel column chromatography (hexane / ethyl acetate = 2/1, *v*/*v*) to give product (*R*)-**9** (3.40 g, 10.8 mmol) in 91% yield as a colorless crystal.

4 Boyer, J. H. *J. Am. Chem. Soc*. **1951**, *73*, 5865-5866.

**(*R*)-9**: m.p. 61-62 °C; $[\alpha]_D^{25}$ –0.73 (c 3.17, $CHCl_3$); IR (KBr) $\nu$ 3305, 1703, 1522, 1240, 1032, 814, 717; $^1$H-NMR ($CDCl_3$) $\delta$ 3.80 (s, 3H), 4.34–4.35 (d, 1H, *J*=5.6), 4.75 (s, 2H), 5.22 (br, 1H), 6.87–6.88 (d, 2H, *J*=8.6), 7.22–7.24 (d, 2H, *J*=8.6); $^{13}$C-NMR ($CDCl_3$) $\delta$ 44.4–44.7 (t, *J*=21.2), 55.3, 74.6, 95.6, 114. 1, 129.0, 129.7, 154.5, 159.2;
**(*S*)-9**: m.p. 61-62 °C; $[\alpha]_D^{25.4}$ +0.58 (c 3.23, $CHCl_3$). Anal. calcd. for $C_{11}H_{11}DCl_3NO_3$: C, 42.13; H(D), 4.18; N, 4.47, found: C, 42.15; H(D), 4.32; N, 4.41.




**(*R*)-Glycine-α-*d* (1):** To a solution of (*R*)-**9** (3.40 g, 10.8 mmol) and periodic acid (34.6 g, 151.7 mmol) in a mixed solvent of acetonitrile, carbon tetrachloride and water (76 mL, 2/2/3, *v*/*v*) was added ruthenium(III) chloride (47.4 mg, 0.229 mmol) and the mixture was stirred at room temperature for 2 h. The reaction mixture was diluted with diethyl ether and stirred at 0 °C for 10 min. The mixture was extracted with diethyl ether and combined extract was washed with brine, dried over anhydrous sodium sulfate and evaporated in *vacuo*. The resulting residue made alkaline (pH *ca*. 8) by the addition of 1 M aqueous solution of sodium hydroxide. The mixture was washed with diethyl ether, made acidic by the addition of aqueous hydrochloric acid (pH *ca*. 2) and extracted with diethyl ether. The combined organic layer was washed with brine, dried over anhydrous sodium sulfate and evaporated in *vacuo*.

To a solution of the concentrated residue in a mixed solvent of acetic acid and water (78 mL, 6/7, *v*/*v*) was slowly added zinc powder (6.02 g, 92.1 mmol) at room temperature and the mixture was stirred for 5 min. After the addition of water (30 mL), the reaction mixture was stirred for 20 min and filtered through Celite. The precipitate was washed with dichloromethane. The combined filtrate was concentrated under reduced pressure. The resulting solid was purified using anion exchange resin chromatography (Bio-Rad AG 1-X8, 200–400 mesh, $OH^-$ form, eluent: 1 M aqueous hydrochloric acid) followed by cation exchange resin chromatography (Bio-Rad AG 50W-X8, 200–400 mesh, $H^+$ form, eluent: 1.3 M aqueous ammonia). Sublimation under reduced pressure gave (*R*)-**1** (0.45 g, 5.88 mmol) in 54% yield as a colorless solid.

**(*R*)-1**: m.p. 229–231 °C; $[\alpha]_D^{25}$ +0.70 (c 2.99, $H_2O$); IR (KBr) $\nu$ 3163, 2920, 2613, 2123, 1589, 1523, 1412, 1335; $^1$H-NMR ($D_2O$) $\delta$ 3.53 (q, 1H, *J*=1.2). $^{13}$C-NMR ($D_2O$) $\delta$ 41.1–41.4 (t, *J*=21.8), 172.43.
**(*S*)-1:** m.p. 229–231 °C; $[\alpha]_D^{25}$ –0.90 (c 1.80, $H_2O$); Anal. calcd. for $C_2H_4DNO_2$: C, 31.58; H(D), 7.95; N, 18.41, found: C, 31.67; H(D), 8.05; N, 18.56.

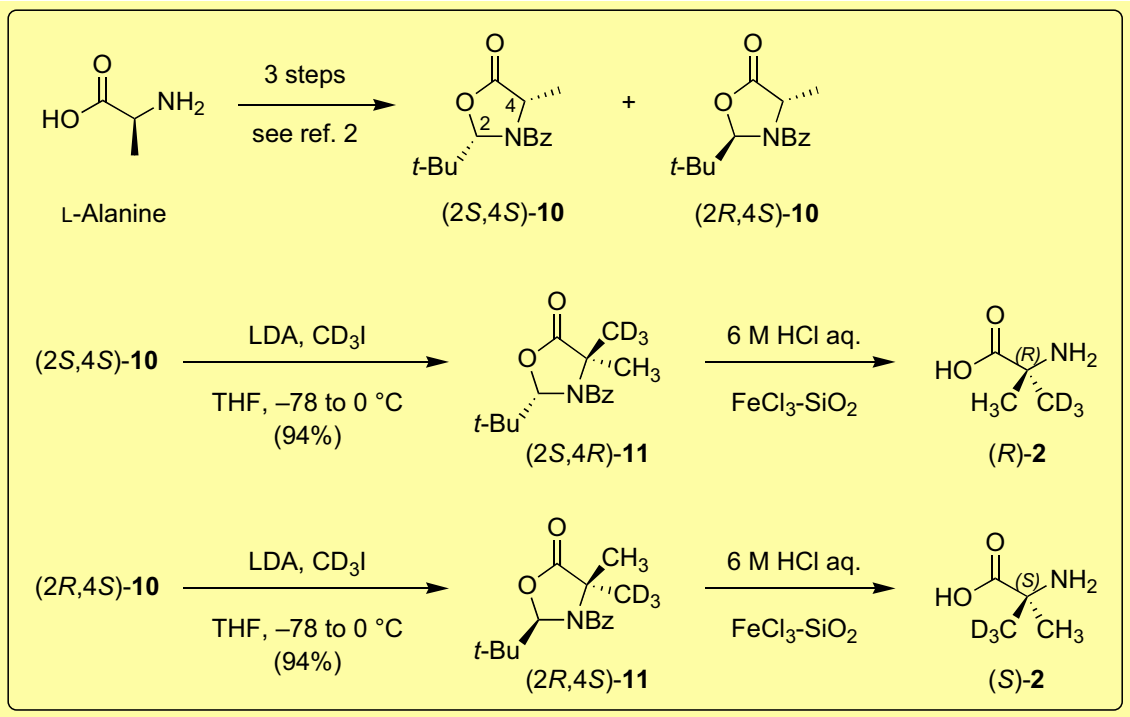
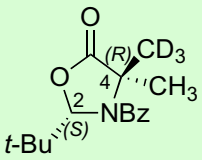
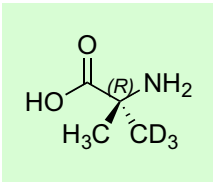



***Figure S4***: Asymmetric synthesis of α-methyl-$d_3$-alanine (**2**).



**(2*S*,4*R*)-*N*-Benzoyl-2-*tert*-butyl-4-methyl-$d_3$-4-methyloxazolidine-5-one (11):** To a solution of diisopropylamine (0.84 mL, 6.0 mmol) in THF (80 mL) was slowly added a solution of *n*-butyl lithium (3.77 mL, 6.0 mmol, 1.59 M in hexane) at 0 °C and the solution was stirred for 30 min at 0 °C. After the solution was cooled to –78 °C, the solution of (2*S*,4*S*)-**10**[2] (1.31 g, 5.0 mmol) in THF (5 mL) was slowly added to the solution and the reaction mixture was stirred for 40 min at –78 °C. To this solution was added the iodomethane-$d_3$ (1.31 g, 5.0 mmol) and the mixture was allowed to warm gradually to room temperature and stirred for 12 h at room temperature. The reaction was quenched with the aqueous solution (200 mL) of ammonium chloride (saturated aqueous solution of ammonium chloride / water = 1/1, *v*/*v*) at 0 °C. The mixture was extracted with diethyl ether and the combined organic layer was washed with water, dried with anhydrous magnesium sulfate and evaporated in *vacuo*. The resulting residue was purified using silica gel column chromatography (hexane / ethyl acetate = 6/1, *v*/*v*) to give product (2*S*,4*R*)-**11** (1.29 g, 4.63 mmol) in 93% yield as a colorless oil.

**(2*S*,4*R*)-11:** $[\alpha]_D^{25}$ –6.04 (c 3.00, $CHCl_3$); IR (film) $\nu$ 3562, 3299, 2968, 2239, 1790, 1658, 1479, 1335, 1255, 1055, 931, 858; $^1$H-NMR ($CDCl_3$) $\delta$ 1.02 (s, 9H), 1.59 (s, 3H), 6.24 (s, 1H), 7.44–7.46 (t, 2H, *J*=7.5), 7.52–7.53 (d, 3H, *J*=8.4); $^{13}$C-NMR ($CDCl_3$) $\delta$ 25.10, 38.05, 60.17, 93.99, 128.09, 128.40, 131.44, 137.10, 176.22; Anal. calcd. for $C_{16}H_{18}D_3NO_3$: C, 69.04; H(D), 8.69; N, 5.03, found: C, 69.23; H(D), 8.42; N, 5.03.
**(2*R*,4*S*)-11:** Colorless oil; yield: quant.; $[\alpha]_D^{25}$ +6.59 (c 3.01, $CHCl_3$); IR (film) $\nu$ 3562, 3298, 2966, 2241, 1790, 1658, 1479, 1335, 1255, 1055, 931, 858; $^1$H-NMR ($CDCl_3$) $\delta$ 1.03 (s, 9H), 1.57 (s, 3H), 6.25 (s, 1H), 7.44–7.46 (t, 2H, *J*=7.2), 7.52–7.53 (d, 3H, *J*=7.8); $^{13}$C-NMR($CDCl_3$) $\delta$ 25.1, 38.1, 60.2, 94.0, 128.1, 128.4, 131.4, 137.1, 176.2; Anal. calcd. for $C_{16}H_{18}D_3NO_3$: C, 69.04; H, 8.69; N, 5.03, found: C, 69.34; H(D), 8.32; N, 5.15.




**(*R*)-α-Methyl-$d_3$-alanine (2):** To the mixture of (2*S*,4*R*)-**11** (1.31 g, 4.7 mmol) and ferric chloride/silica gel reagent (2/25, 10 g) was added 6 M aqueous hydrochloric acid (50 mL) and the reaction mixture was refluxed for 3 h. The mixture was filtered through Celite and the precipitate was washed with dichloromethane. After the solvent was removed under reduced pressure, the residue was purified using cation exchange resin chromatography (Bio-Rad AG 50W-X8, 200–400 mesh, $H^+$ form, eluent: 1.3 M aqueous solution of ammonia). Sublimation under reduced pressure gave (*R*)-**2** (486 mg, 4.58 mmol) in 97% yield as a colorless solid.

**(*R*)-2**: m.p. 280 °C (decomp.); $[\alpha]_D^{25}$ +0.38 (c 3.00, $H_2O$); IR (KBr) $\nu$ 3043, 2856, 2602, 2457, 2318, 2098, 1637, 1456, 1405, 1261; $^1$H-NMR ($D_2O$) $\delta$ 1.40 (s, 3H); $^{13}$C-NMR ($D_2O$) $\delta$ 23.5, 58.1, 178.0; Anal. calcd for $C_4H_6D_3NO_2$: C, 45.26; H(D), 11.39; N, 13.20, found: C, 45.47; H(D), 11.30; N, 13.16.
**(*S*)-2**: Colorless solid; yield: 94%; m.p. 280 °C (decomp.); $[\alpha]_D^{25}$ –0.24 (c 2.98, $H_2O$); IR (KBr) $\nu$ 3035, 2856, 2602, 2457, 2320, 2094, 1635, 1456, 1406, 1259; $^1$H-NMR ($D_2O$) $\delta$ 1.40 (s, 3H); $^{13}$C-NMR ($D_2O$) $\delta$ 23.5, 58.1, 177.9; Anal. calcd for $C_4H_6D_3NO_2$: C, 45.26; H(D), 11.39; N, 13.20, found: C, 45.37; H(D), 11.65; N,13.09.

## V. Determination of enantiomeric purity of hydrogen isotope enantiomers

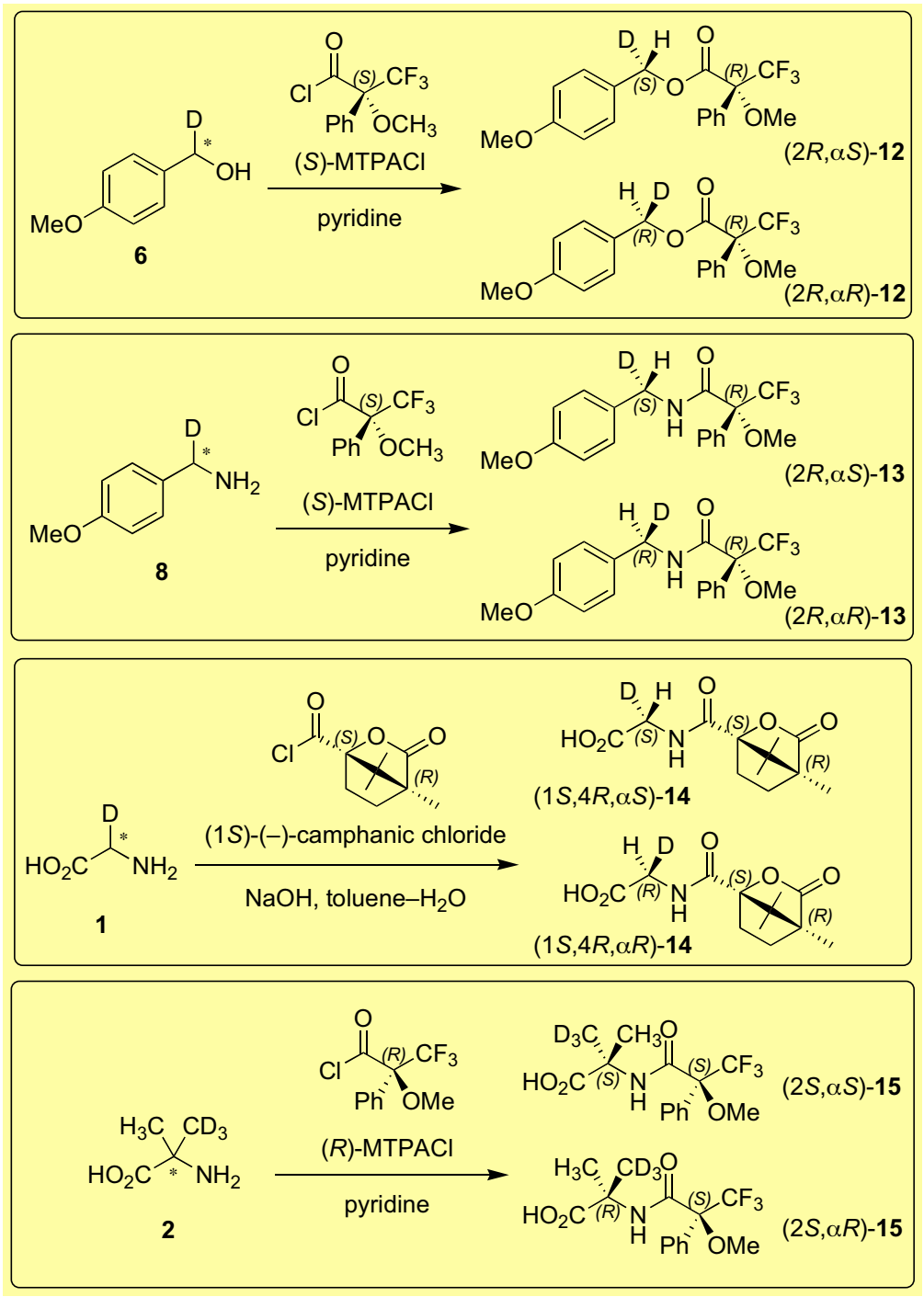
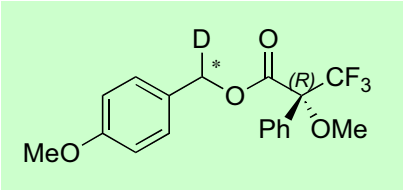
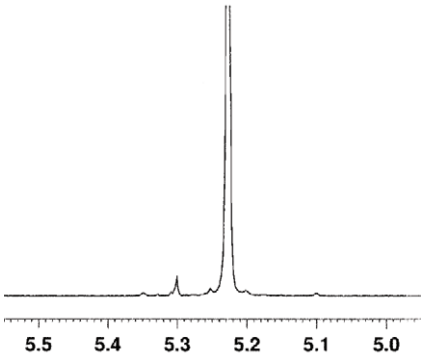
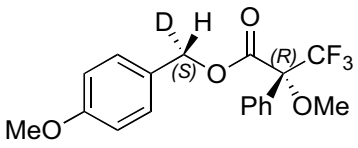



***Figure S5*:** Synthesis of hydrogen isotope diastereomers **12–15**



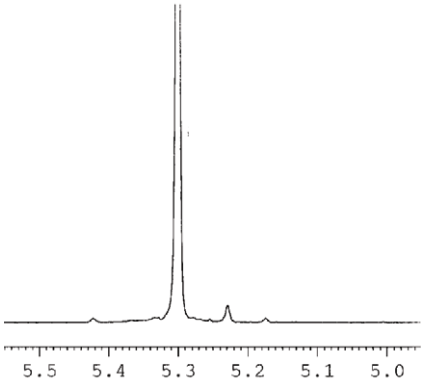

**(*R*)-MTPA ester ((*R*)-α-methoxy-α-(trifluoro methyl)phenylacetate) 12**: To a solution of alcohol **6** (4.0 mg, 0.0287 mmol) in pyridine (0.7 mL) was added (*S*)-(+)-α-methoxy-α-(trifluoro methyl) phenylacetyl chloride ((*S*)-MTPACl, 0.0161 mL, 0.0861 mmol) and the solution was stirred for 2 h at room temperature. The solvent was removed under reduced pressure and the resulting residue was purified by preparative thin-layer chromatography using silica gel (hexane / ethyl acetate = 2/1, *v*/*v*) to give (*R*)-MTPA ester **12**. [1,5]

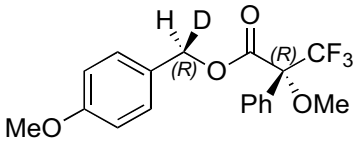



(2*R*,α*S*)-**12**

93% de

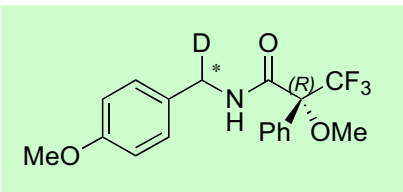



(2*R*,α*R*)-**12**

95% de

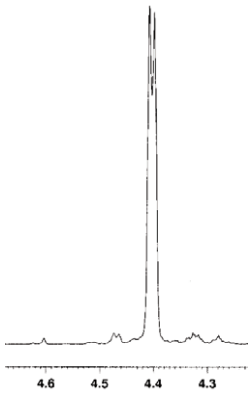
***Figure S6***: $^{1}$H-NMR spectra of (*R*)-MTPA ester **12**.

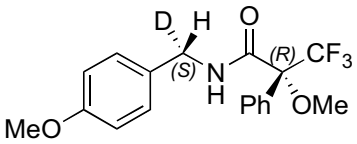



**(*R*)-MTPA amide 13**: To a pyridine (0.7 mL) solution of amine **8** (4.0 mg, 0.0289 mmol) was added (*S*)-MTPACl (0.016 mL, 0.0867 mmol) and the solution was stirred for 2 h at room

5 Takeuchi, Y.; Fujisawa, H.; Noyori, R. *Org. Lett*. **2004**, *6*, 4607–4610.

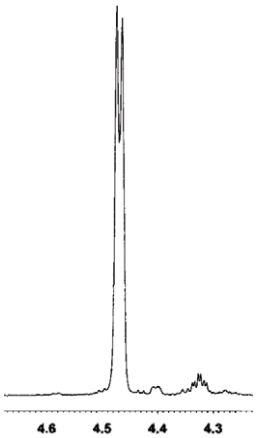
temperature. The solvent was removed under reduced pressure. The residue was purified by preparative thin-layer chromatography using silica gel (hexane / ethyl acetate = 2/1, *v*/*v*) to give (*R*)-MTPA amide **13**.

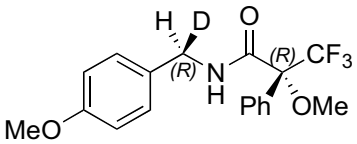



(2*R*,α*S*)-**13**

94% de

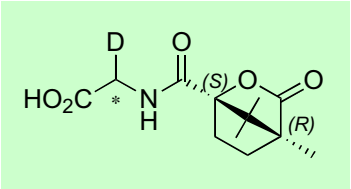



(2*R*,α*R*)-**13**

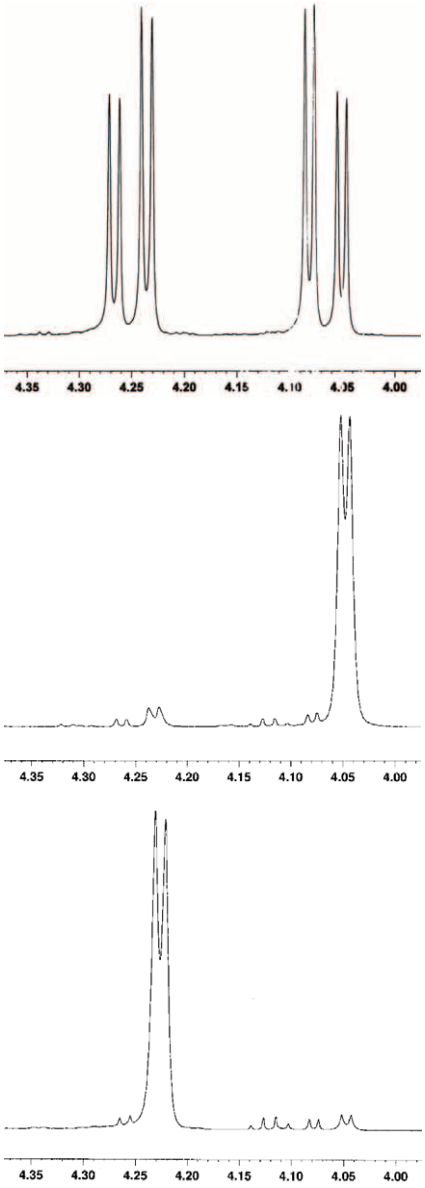
91% de

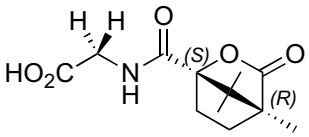
***Figure S7***: $^{1}$H-NMR spectra of (*R*)-MTPA amide **13**.



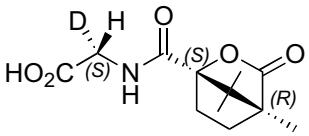

**(1*S*)-Camphanic amide 14**[6]: To a toluene (2.0 mL) solution of (1*S*)-(–)-camphanic chloride (39.3 mg, 0.184 mmol), was added the glycine-α-*d* (**1**) (6.9 mg, 0.0907 mmol) dissolved in 0.1 M aqueous solution of sodium hydroxide (3.2 mL) at 0 °C, and the mixture was stirred for 30 min. After stirring for 2 h at room temperature, the reaction mixture was washed with chloroform and acidified with 1 M aqueous hydrochloric acid. The mixture was extracted with dichloromethane and combined organic fractions were dried over anhydrous sodium sulfate and evaporated in *vacuo*.

6 Williams, R. M.; Zhai, D. Peter J. Sinclair *J. Org. Chem*. **1986**, *51*, 5021-5022.



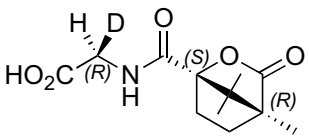



**14**



(1*S*,4*R*,α*S*)-**14**

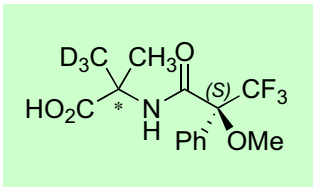
95% de



(1*S*,4*R*,α*R*)-**14**

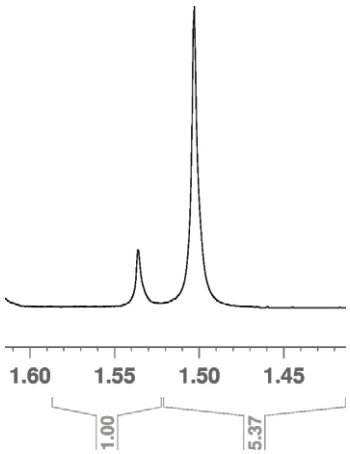
93% de

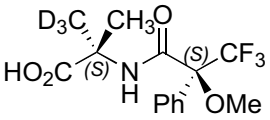
***Figure S8***: $^{1}$H-NMR spectra of (1*S*)-camphanic amide **14**



**(*S*)-MTPA amide 15**: To a solution of α-methyl-$d_3$-alanine (**2**) (5.9 mg, 0.05 mmol) and *N*,*N*-dimethylaminopyridine (DMAP, 6.1 mg, 0.05 mmol) was added (*R*)-MTPACl (0.047 mL, 0.25 mmol) and the solution was stirred for 3 h at room temperature. The reaction was quenched with water (1 mL) and the mixture was extracted with diethyl ether. The combined organic extract was dried over anhydrous sodium sulfate and concentrated in *vacuo*. The residue was purified by preparative thin-layer chromatography using silica gel (hexane / ethyl acetate = 2/1, *v*/*v*) to give

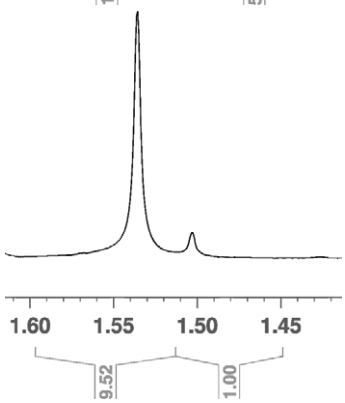
(*S*)-MTPA amide **15**.

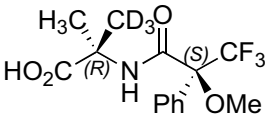



(2*S*,α*S*)-**15**

69% de




(2*S*,α*R*)-**15**

81% de

***Figure S9***: $^{1}$H-NMR spectra of (*S*)-MTPA amide **15** (600 MHz, in THF).