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Supporting Information for:

γ-Selective Directed Catalytic Asymmetric Hydroboration of 1,1-Disubstituted Alkenes.

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DFT calculations of possible octahedral intermediates (Figure S1)

The geometry optimizations of intermediates **A**–**F** were performed at the B3LYP density functional level[1] using Gaussian09. [2] The Hay-Wadt relativistic effective core potential (ECP) replaced the 28 core electrons of Rh.[3] The basis set for Rh was that associated with the ECP, with a double- ζvalence basis set (LANL2DZ). All other atoms were represented by means of the 6-31+G(d,p) basis set.[4] Stationary points located at the potential energy hypersurface were characterized as true minima through vibrational analysis at the same level of theory.

Intermediates **A** (pro-gamma) and **B** (pro-beta) (0 kcal/mol and +1.9 kcal/mol, respectively) are discussed in the main text. Other possible intermediates **C** and **D** (+1.8 and +1.9 kcal/mol, respectively) have energies comparable to **B**. Intermediates **E** and **F** consist of (pin)B in the axial position and are considerably higher in energy (+11.2 and +7.0 kcal/mol, respectively) relative to **A**.

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[1] a) A. D. Becke *J. Chem. Phys.* **1993**, *98*, 5648–5652; b) B. Miehlich, A. Savin, H. Stoll, H. Preuss *Chem. Phys. Lett.* **1989**, *157*, 200–206; c) C. Lee, W. Yang, G. Parr, *Phys. Rev. B* 1988, 37, 785–789; d) P. J. Stephens, F. J. Devlin, C. F. Chabalowski *J. Phys. Chem.* **1994**, *98*, 11623–11627.

[2] Gaussian 09, Revision A.02, M. J. Frisch, G.W. Trucks, H. B. Schlegel, G. E. Scuseria, M. A. Robb, J. R. Cheeseman, G. Scalmani, V. Barone, B. Mennucci, G. A. Petersson, H. Nakatsuji, M. Caricato, X. Li, H. P. Hratchian, A. F. Izmaylov, J. Bloino, G. Zheng, J. L. Sonnenberg, M. Hada, M. Ehara, K. Toyota, R. Fukuda, J. Hasegawa, M. Ishida, T. Nakajima, Y. Honda, O. Kitao, H. Nakai, T. Vreven, J. A., Jr., Montgomery, J. E. Peralta, F. Ogliaro, M. Bearpark, J. J. Heyd, E. Brothers, K. N. Kudin, V. N. Staroverov, R. Kobayashi, J. Normand, K. Raghavachari, A. Rendell, J. C. Burant, S. S. Iyengar, J. Tomasi, M. Cossi, N. Rega, J. M. Millam, M. Klene, J. E. Knox, J. B. Cross, V. Bakken, C. Adamo, J. Jaramillo, R. Gomperts, R. E. Stratmann, O. Yazyev, A. J. Austin, R. Cammi, C. Pomelli, J. W. Ochterski, R. L. Martin, K. Morokuma, V. G. Zakrzewski, G. A. Voth, P. Salvador, J. J. Dannenberg, S. Dapprich, A. D. Daniels, O. Farkas, J. B. Foresman, J. V. Ortiz, J. Cioslowski, D. J. Fox, ; Gaussian, Inc., Wallingford CT, **2009**.

[3] P. J. Hay, W. R. Wadt *J. Chem. Phys.* **1985**, *82*, 299–310.

[4]a) V. A. Rassolov, M. A. Ratner, J. A. Pople, P. C. Redfern, L. A. Curtiss, *J. Comput. Chem.* **2001**, *22*, 976–984; b) M. J. Frisch, J. A. Pople, J. S. Binkley, *J. Chem. Phys.* **1984**, *80*, 3265–3269.

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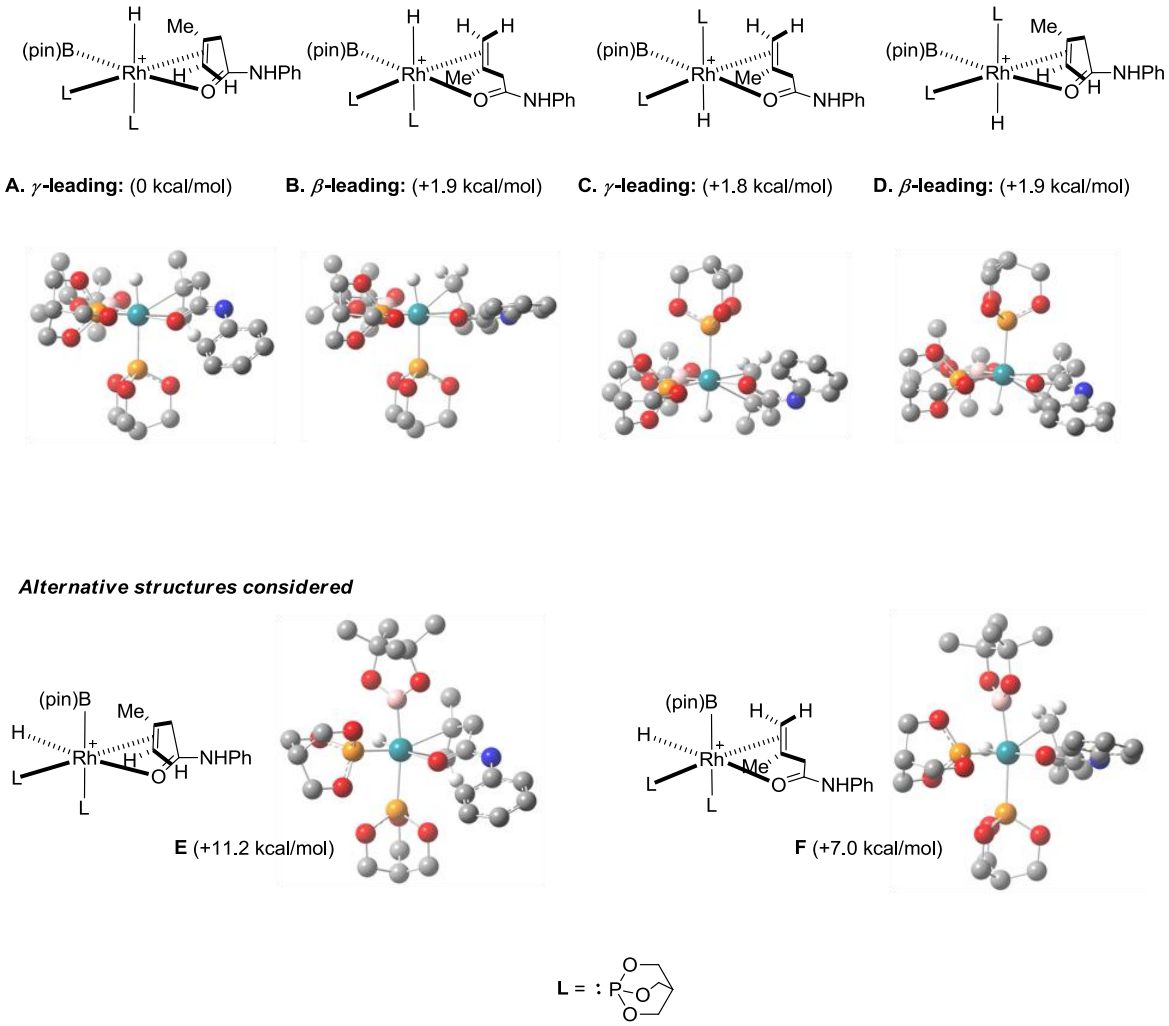

Figure S1. Relative energies of proposed octahedral intermediates **A** and **B** (Figure 3 from the main text), conformational isomers **C** and **D**, and alternative structures **E** and **F**. For clarity, only the Rh-H and methylidene hydrogens are shown.

General procedures. Reactions were carried out in a dry nitrogen atmosphere. Dichloromethane (DCM) and tetrahydrofuran (THF) were freshly distilled under the following conditions: THF from sodium metal and benzophenone, and DCM from calcium hydride. HPLC solvents were filtered through Millipore filter paper. When indicated in the following procedures, solvents were degassed by freezing under reduced pressure followed by a dry nitrogen atmosphere thaw (3–4 times). 4,4,6-Trimethyl-1,3,2-dioxaborinane (tmdBH) was distilled immediately before use. All synthesized compounds were purified with flash chromatography using EMD Silica Gel 60 Geduran®, distilled via short path distillation, or triturated. Thin Layer Chromatography analyses were performed on Analtech Silica Gel HLF (0.25 mm) precoated analytical plates and visualized with use of handheld short wavelength UV light, Iodine stain (I_2 and EMD Silica Gel 60 Geduran®) and Vanillin stain (Ethanol, H_2SO_4, and vanillin). HPLC analyses were performed with use of an ISCO model 2360 HPLC and Chiral Technologies, Inc. chiral HPLC columns (Chiralcel OD; column: 250 x 4.6 mm, Chiralpak-AD; column: 250 x 4.6 mm, Chiralpak-IC; column: 4.6 x 250 mm). Data were recorded and analyzed with ChromPerfect chromatography

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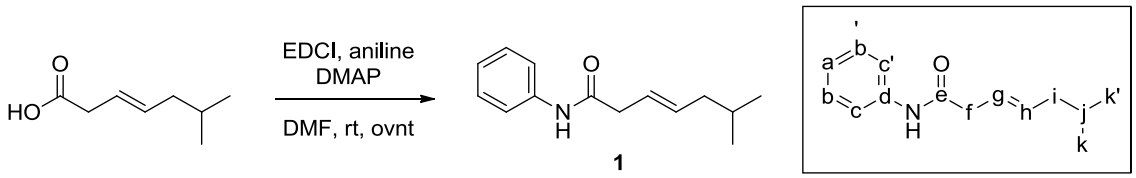
software (version 5.1.0). NMR spectra were recorded on 400, and 300 MHz Bruker Advance NMR spectrometers using residue $CHCl_3$ (δ 7.27 ppm) or $CDCl_3$ (δ 77.0 ppm) for reference unless otherwise specified. Peaks are expressed as m (unresolved multiplet), q (quartet), t (triplet), d (doublet) or s (singlet). IR spectra were recorded using an Avatar 360 FT-IR. Optical rotations were measured as solutions, 1.0 g/100 mL in chloroform unless indicated otherwise, and recorded using an Autopol III automatic polarimeter. HRMS analyses were performed by the Nebraska Center for Mass Spectrometry.

Assignment of Absolute Configuration. The absolute stereochemistry of the γ-hydroxy esters were assigned based on conversions to the known lactones, (S)-**20**, (*R*)-**22a**, (*R*)-**22b** and (*S*)-**22c**. [Literature for (*S*)-**20**: Reference 14 from the supporting information (T. Ok, A. Jeon, J. Lee, J. H. Lim, C. S. Hong, H. –S. Lee, *J. Org. Chem.* **2007**, *72*, 7390–7393); for (*R*)-**22a**: Reference 16 from the supporting information (G. Hughes, M. Kimura, S. L. Buchwald, *J. Am. Chem. Soc.* **2003**, *125*, 11253–11258); for (*R*)-**22b** and (*S*)-**22c**: Reference 17 from the supporting information (J. W. Bode, M. P. Doyle, M. N. Protopopova, Q. –L. Zhou, *J. Org. Chem.* **1996**, *61*, 9146–9155)]. Other γ-hydroxyesters were assigned in analogy. The $AlMe_3$-mediated amidation of (*S*)-**20** proved a sample of (*S*)-**17** permitting the unambiguous assignment of γ-hydroxyamide (*R*)-**17**; other γ-hydroxyamides were assigned in analogy.



Procedure for the preparation of (*E*)-6-methyl-3-heptenoic acid phenyl amide (1):[5] To a cooled (0 °C) degassed solution of (*E*)-6-Methyhept-3-enoic acid (2.49 g, 17.5 mmol) in *N*,*N*-dimethylformamide (DMF, 50 mL) was slowly added aniline (1.63 g, 17.5 mmol). The resulting solution was stirred (0.5 h, 0 °C) and then *N*-(3-dimethylaminopropyl)-*N*'-ethylcarbodiimide hydrochloride (3.35 g, 17.5 mmol) and 4-(dimethylamino)pyridine (DMAP, 1.07 g, 17.5 mmol) were added. The resulting mixture was allowed to slowly warm to room temperature and stirred overnight. The reaction mixture was quenched by the addition of satd. aq. sodium bicarbonate (50 mL) and extracted with diethyl ether (2 x 50 mL). The combined ether extracts were dried (anhyd. $MgSO_4$) and concentrated under reduced pressure. Flash chromatography on silica gel (90:10 hexanes:ethyl acetate) affords the title compound (2.66 g, 70%) as a light brown solid: mp 87–88.5 °C; TLC analysis R_f 0.5 (75:25 hexanes:ethyl acetate); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.52 (2H, d, *J* = 8.3 Hz, c,c') 7.44 (1H, br s, NH), 7.34 (2H, t, *J* = 7.7 Hz, b,b'), 7.13 (1H, t, *J* = 7.4 Hz, a), 5.80-5.55 (2H, m, g,h), 3.15 (2H, d, *J* = 6.9 Hz, f), 2.04 (2H, t, *J* = 6.8 Hz, i), 1.80-1.60 (1H, m, j), 0.96 (6H, d, *J* = 6.6 Hz, k,k'); ^{13}C NMR (100 MHz, $CDCl_3$) δ 169.39 (e), 137.79 (d), 136.53 (g), 129.02 (b,b'), 124.31 (a), 123.41 (h), 119.61 (c,c'), 41.93 (f), 41.73 (i), 28.25 (j), 22.35 (k,k'); IR (neat) 3244 (N-H stretch), 2952, 1654 (C=O stretch), 1595, 1544 (N-H bend), 1443, 1247 (C-N stretch), 1187, 967, 843, 756 cm^{-1}; HRMS (FAB) calcd. for $C_{14}H_{20}NO$ (M+H): 218.1545, found 218.1541 *m/z*.

[5] S. M. Smith, N. C. Thacker, J. M. Takacs, *J. Am. Chem. Soc.* **2008**, *130*, 3734–3735.

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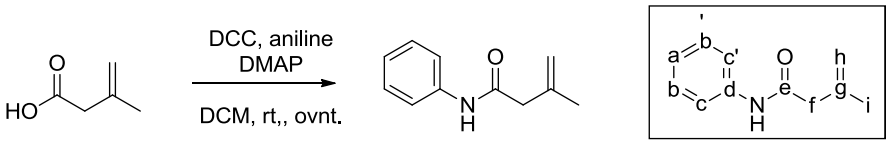
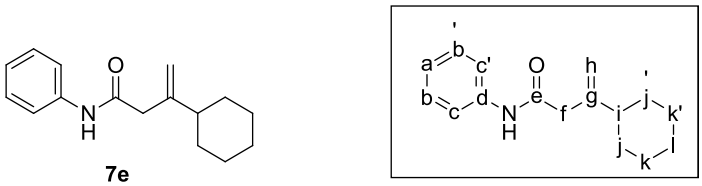
General procedure for the preparation of *β,γ*-unsaturated phenyl amides via DCC-mediated condensation.



7a

Preparation of 3-methyl-3-butenoic acid phenyl amide (7a):[6] To a cooled (0 °C) solution of 3-methyl-3-butenoic acid (501 mg, 5.0 mmol) in dichloromethane (DCM, 10 mL) was added aniline (560 mg, 6.0 mmol) and *N*,*N*-dimethylamino pyridine (DMAP, 61 mg, 0.50 mmol). After the resulting mixture was allowed to stir for 0.5 h at the same temperature, *N*,*N*-dicyclohexylcarbodiimide (DCC, 1.14 g, 5.5 mmol) was added in one portion and allowed to warm to room temperature. After an overnight stir, the reaction mixture was filtered and the filtrate was washed with dilute HCl (2 x 15 mL, 1M). The organic layer was dried (anhyd. Na_2SO_4) and concentrated under reduced pressure. Flash chromatography on silica gel (85–75:15–25 hexanes:ethyl acetate) affords the title compound (570 mg, 65%) as a white solid: mp 97.5–99.5 ºC; TLC analysis R_f 0.3 (75:25 hexanes:ethyl acetate); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65 (1H, br s, NH), 7.53 (2H, d, J = 8.0 Hz, c,c'), 7.33 (2H, t, J = 7.6 Hz, b,b'), 7.13 (1H, t, J = 7.2 Hz, a), 5.09 and 5.02 (2H, s's, h), 3.15 (2H, s, f), 1.88 (3H, s, i); ^{13}C NMR (100 MHz, $CDCl_3$) δ 168.58 (e), 140.35 (d), 137.80 (g), 128.98 (b,b'), 124.36 (a), 119.79 (c,c'), 116.09 (h), 47.41 (f), 22.46 (i); IR (neat) 3291 (N-H stretch), 3060, 2953, 2921, 2865, 1657 (C=O stretch), 1638, 1595, 1525 (N-H bend), 1440, 1307, 1251 (C-N stretch), 1162, 869, 738, 688, 617 cm^{-1}.

General procedure for the preparation of *β,γ*-unsaturated amides via carbonylation[7]-hydrolysis sequence followed by DCC-mediated condensation.



7e

Preparation of 3-Cyclohexyl-3-butenoic acid phenyl amide (7e): A mixture of 2-cyclohexylallyl ethyl carbonate (1.06 mg, 5.0 mmol) and palladium tetrakis (116 mg, 0.10 mmol) was placed under a pressurized (70 psi) atmosphere of carbon monoxide. The mixture was heated (50 °C) for 16 h and then allowed to cool to room temperature and ambient pressure. The resultant black mixture was run over a silica plug to afford the crude *β,γ*-unsaturated ethyl ester. The crude residue was taken up in a mixture of ethanol (5 mL) and aqueous 2 M sodium hydroxide (50 mL) and stirred overnight at room temperature. The resultant basic solution was extracted with dichloromethane (2 x 15 mL) and then acidified. The acidic aqueous layer was extracted with dichloromethane (3 x 30 mL) and the combined organic extracts were dried (anhyd. Na_2SO_4) and concentrated under reduced pressure. The crude *β,γ*-unsaturated acid (537 mg, 3.2 mmol) was used in the next step without further purification.

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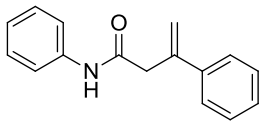
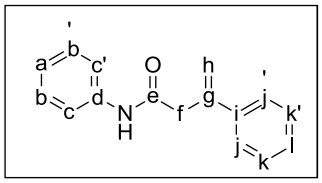
[6] J. F. Wolfe, G. B. Trimitsis, D. R. Morris, *J. Org. Chem.* **1969**, *34*, 3263–3268.
[7] J. Tsuji, K. Sato, H. Okumoto, *J. Org. Chem.* **1984**, *49*, 1341–1344

Following the general condensation procedure with DCC, the crude *β,γ*-unsaturated acid affords, after flash chromatography on silica gel (85–75:15–25 hexanes:ethyl acetate), the title compound (469 mg, 39%, 3 steps) as a white solid: mp 81–83 ºC; TLC analysis R_f 0.5 (75:25 hexanes:ethyl acetate); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.62 (1H, br s, NH), 7.51 (2H, d, J = 7.8 Hz, c,c'), 7.34 (2H, t, J = 8.1 Hz, b,b'), 7.12 (1H, t, J = 7.5 Hz, a), 5.15 and 5.06 (2H, s's, h), 3.19 (2H, s, f), 2.05–1.95 (1H, m, i), 1.90–1.75 (4H, m, k,k',l,j), 1.75–1.65 (1H, m, j'), 1.30–1.10 (5H, m, j,j',k,k',l); ^{13}C NMR (75 MHz, $CDCl_3$) δ 168.85 (e), 150.39 (d), 137.72 (g), 129.00 (b,b'), 124.31 (a), 119.65 (c,c'), 113.79 (h), 44.06 (i), 44.42 (f), 32.18 (j,j'), 26.48 (k,k'), 26.09 (l); IR (neat) 3330 (N-H stretch), 2921, 2848, 1665 (C=O stretch), 1596, 1514 (N-H bend), 1436, 1346, 1245 (C-N stretch), 1167, 956, 905, 749, 691, 586 cm^{-1}; HRMS (ESI) calcd. for $C_{16}H_{21}NaNO$ (M+Na): 266.1521, found 266.1526 *m/z*.

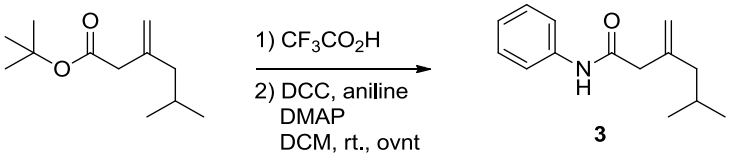


7f

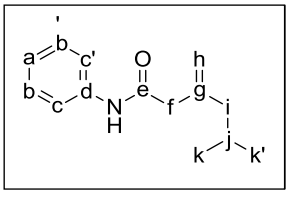


3-Phenyl-3-butenoic acid phenyl amide (7f):[6] Following the general procedure, 2-phenylallyl ethyl carbonate (1.03 g, 5.0 mmol) affords, after flash chromatography on silica gel (85–75:15–25 hexanes:ethyl acetate), the title compound (215 mg, 18%, 3 steps) as a white solid: mp 90.5–93.5 ºC; TLC analysis R_f 0.4 (75:25 hexanes:ethyl acetate); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.60–7.50 (3H, m, j,j',NH), 7.45–7.35 (5H, m, c,c',k,k',l), 7.35–7.25 (2H, m, b,b'), 7.10 (1H, t, J = 7.5 Hz, a), 5.78 and 5.41 (2H, s's, h), 3.65 (2H, s, f); ^{13}C NMR (75 MHz, $CDCl_3$) δ 168.35 (e), 142.08 (d), 138.76 (i), 137.61 (g), 128.94 (b,b'), 128.82 (j,j'), 128.47 (l), 125.78 (k,k'), 124.43 (a), 119.84 (c,c'), 117.44 (h), 45.14 (f); IR (neat) 3248 (N-H stretch), 3192, 3135, 3085, 2929, 1804, 1656 (C=O stretch), 1597, 1554 (N-H bend), 1484, 1441, 1338, 1232 (C-N stretch), 1162. 896, 770, 752, 688 cm^{-1}.

<u>General procedure for the preparation of *β,γ*-unsaturated phenyl amides via hydrolysis followed by DCC-mediated condensation.</u>



3



Preparation of 5-methyl-3-methylidenehexanoic acid phenyl amide (3): To *tert*-butyl ester **7i** (595 mg, 3.0 mmol) was added trifluoroacetic acid (CF_3CO_2H, 6 mL) followed by a 1 h stir at room temperature. The mixture was concentrated under reduced pressure, taken up in ethyl acetate (15 mL), and washed with dilute sodium hydroxide (3 x 10 mL, 2 M). The basic aqueous layer was acidified and extracted with dichloromethane (3 x 15 mL). The combined organic extracts were dried (anhyd. Na_2SO_4) and concentrated under reduced pressure to afford the crude *β,γ*-unsaturated acid (326 mg, 2.3 mmol) which was used in the next step without further purification.

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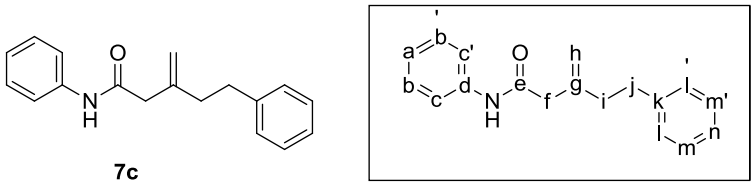
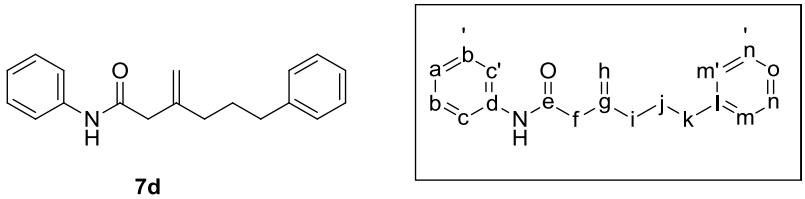
Following the general DCC-mediated condensation procedure, the crude *β,γ*-unsaturated acid affords, after flash chromatography on silica gel (85–75:15–25 hexanes:ethyl acetate), the title compound (411 mg, 63%, 2 steps) as a white solid: mp 91–92.5 ºC; TLC analysis R_f 0.4 (75:25 hexanes:ethyl acetate); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.87 (1H, br s, NH), 7.53 (2H, d, J = 8.1 Hz, c,c'), 7.32 (2H, t, J = 8.1 Hz, b,b'), 7.11 (1H, t, J = 7.5 Hz, a), 5.09 and 5.06 (2H, s's, h), 3.13 (2H, s, f), 2.02 (2H, d, J = 6.9 Hz, i), 1.90–1.75 (1H, m, j), 0.91 (6H, d, J = 6.6 Hz, k,k'); ^{13}C NMR (75 MHz, $CDCl_3$) δ 168.92 (e), 143.29(d), 137.90 (g), 128.94 (b,b'), 124.30 (a), 119.84 (c,c'), 116.17 (h), 45.67 (f), 45.63 (j), 25.96 (i), 22.41 (k,k'); IR (neat) 3290 (N-H stretch), 2953, 2921, 2865, 1657 (C=O stretch), 1638, 1595, 1530 (N-H bend), 1440, 1393, 1307, 1295, 1251 (C-N stretch), 1223, 1162, 1120, 996, 869, 738, 668, 617 cm^{-1}; HRMS (CI) calcd. for $C_{14}H_{20}NO$ (M+H): 218.1545, found 218.1539 *m/z*.



7c

3-Methylidene-5-phenylpentanoic acid phenyl amide (7c): Following the general procedure, 3-methylidene-5-phenylpentanoic acid *tert*-butyl ester (739 mg, 3.0 mmol) affords, after flash chromatography on silica gel (85–75:15–25 hexanes:ethyl acetate), the title compound (484 mg, 61%, 2 steps) as a white solid: mp 79–80 ºC; TLC analysis R_f 0.4 (75:25 hexanes:ethyl acetate); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 (2H, d, J = 8.0 Hz, l,l'), 7.40–7.30 (3H, m, c,c', NH), 7.30–7.25 (2H, m, b,b'), 7.25–7.20 (3H, m, m,m',n), 7.14 (1H, t, J = 6.8 Hz, a), 5.16 and 5.12 (2H, s's, h), 3.19 (2H, s, f), 2.86 (2H, t, J = 8.0 Hz, j), 2.50 (2H, t, J = 8.4 Hz, i); ^{13}C NMR (100 MHz, $CDCl_3$) δ 168.31 (e), 143.69 (d), 141.21 (k), 137.66 (g), 128.99 (b,b'), 128.44 (l,l'), 128.35 (m,m'), 126.06 (n), 124.38 (a), 119.69 (c,c'), 115.75 (h), 46.25 (f), 37.44 (i), 33.91 (j); IR (neat) 3237 (N-H stretch), 3185, 3061, 3025, 1652 (C=O stretch), 1596, 1541 (N-H bend), 1469, 1443, 1398, 1346, 1247 (C-N stretch), 1193, 961, 897, 747, 694, 616 cm^{-1}; HRMS (EI) calcd. for $C_{18}H_{19}NO$: 265.1467, found 265.1475 *m/z*.



7d

3-Methylidene-6-phenylhexanoic acid phenyl amide (7d): Following the general procedure, 3-methylidene-6-phenylhexanoic acid *tert*-butyl ester (781 mg, 3.0 mmol) affords, after flash chromatography on silica gel (90–80:10–20 hexanes:ethyl acetate), the title compound (476 mg, 57%, 2 steps) as a white solid: mp 51–52.5 ºC; TLC analysis R_f 0.5 (75:25 hexanes:ethyl acetate); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60 (1H, br s, NH), 7.52 (2H, d, J = 7.9 Hz, m,m'), 7.40–7.35 (2H, m, c,c'), 7.35–7.25 (2H, m, b,b'), 7.25–7.20 (3H, m, n,n',o), 7.15 (1H, t, J = 7.3 Hz, a), 5.13 and 5.11 (2H, s's, h), 3.18 (2H, s, f), 2.66 (2H, t, J = 7.7 Hz, k), 2.22 (2H, t, J = 7.4 Hz, i), 1.90–1.80 (2H, m, j); ^{13}C NMR (100 MHz, $CDCl_3$) δ 168.71 (e), 144.20 (d), 141.98 (l), 137.71 (g), 129.02 (b,b'), 128.44 (m,m'), 128.37 (n,n'), 125.87 (o), 124.43 (a), 119.83 (c,c'), 115.20 (h), 46.06 (f), 35.52 (i), 35.42 (k), 29.24 (j); IR (neat) 3303 (N-H stretch), 3061, 3028,

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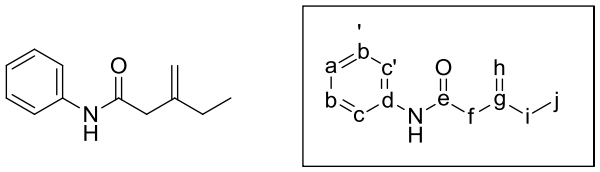
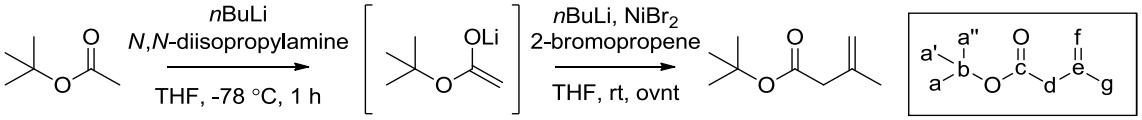
2935, 1659 (C=O stretch), 1598, 1543 (N-H bend), 1497, 1441, 1334, 1245 (C-N stretch), 1155, 899, 749, 690 cm^{-1}; HRMS (EI) calcd. for $C_{19}H_{21}NO$: 279.1623, found 279.1618 *m/z*.



7b

3-Methylidenepentanoic acid phenyl amide (7b): Following the general procedure, *tert*-butyl ester **7h** (511 mg, 3.0 mmol) affords, after flash chromatography on silica gel (85–75:15–25, hexanes:ethyl acetate), the title compound (362 mg, 64%, 2 steps) as a white solid: mp 101–102 ºC; TLC analysis R_f 0.3 (75:25 hexanes:ethyl acetate); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.62 (1H, br s, NH), 7.52 (2H, d, J = 8.0 Hz, c,c'), 7.33 (2H, t, J = 7.6 Hz, b,b'), 7.12 (1H, t, J = 7.6 Hz, a), 5.11 and 5.06 (2H, s's, h), 3.17 (2H, s, f), 2.18 (2H, q, J = 7.2 Hz, i), 1.11 (3H, t, J = 7.2 Hz, j); ^{13}C NMR (100 MHz, $CDCl_3$) δ 168.72 (e), 146.09(d), 137.79 (g), 128.98 (b,b'), 124.33 (a), 119.74 (c,c'), 113.92 (h), 46.23 (f), 28.89 (i), 12.12 (j); IR (neat) 3240 (N-H stretch), 3187, 2955, 2839, 1658 (C=O stretch), 1595, 1544 (N-H bend), 1488, 1444, 1400, 1352, 1297, 1252 (C-N stretch), 1187, 969, 759, 693 cm^{-1}; HRMS (CI) calcd. for $C_{12}H_{16}NO$ (M+H): 190.1232, found 190.1237 *m/z*.

General procedure for the preparation of *β,γ*-unsaturated *tert*-butyl esters via nickel-catalyzed substitution.[8]



7g

Preparation of 3-methyl-3-butenoic acid *tert*-butyl ester (7g):[8] To a cooled (-78 °C) solution of *N*,*N*-diisopropylamine (4.2 mL, 30 mmol) in THF (5 mL) was slowly added *n*-butyllithium (12 mL of a 2.5 M soln. in hexanes, 30 mmol). The resultant mixture was allowed to stir for 0.5 h at the same temperature before the dropwise addition of *tert*-butyl acetate (4.0 mL, 30 mmol). The reaction mixture was allowed to stir for an additional 0.5 h and the generated *tert*-butyl lithioacetate solution was used in the next step.

To a cooled (-78 °C) suspension of nickel bromide (2.76 g, 12.6 mmol) in THF (15 mL) was added *n*-butyllithium (2 mL of a 2.5 M soln. in hexanes, 5 mmol). After the resultant black mixture was allowed to stir for 15 min, 2-bromopropene (2.66 mL, 30 mmol) was added followed by the *tert*-butyl lithioacetate solution prepared in the previous step. The reaction was allowed to slowly rise to room temperature and stirred for an additional 1 h. The reaction mixture was quenched by the addition of dilute HCl (15 mL, 1 M) and then extracted with diethylether (2 x 20 mL). The combined organic extracts were dried (anhyd. Na_2SO_4) and concentrated under reduced pressure. Flash chromatography over silica gel (80–70:20–30, hexanes:dichloromethane) affords the title compound (2.7 g, 59%) as a light yellow oil: TLC analysis R_f 0.5 (50:50

[8] S. G. Alcock, J. E. Baldwin, R. Bohlmann, L. M. Harwood, J. I. Seeman, *J. Org. Chem.* **1985**, *50*, 3526–3535.

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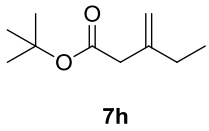
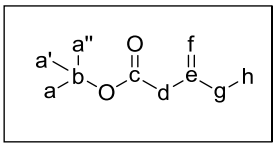
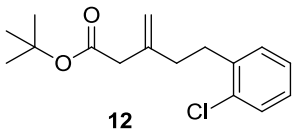
hexanes:dichloromethane); ^{1}H NMR (300 MHz, $CDCl_3$) δ 4.88 and 4.82 (2H, s's, f), 2.93 (2H, s, d), 1.80 (3H, s, g), 1.45 (9H, s, a,a',a"); ^{13}C NMR (75 MHz, $CDCl_3$) δ 170.72 (c), 139.13 (e), 114.09 (f), 80.42 (b), 44.79 (d), 27.99 (a,a',a"), 22.38 (g); IR (neat) 3075, 2976, 2934, 1728 (C=O stretch), 1647, 1455, 1366, 1258 (C-O stretch), 1139, 690, 843 cm^{-1}.



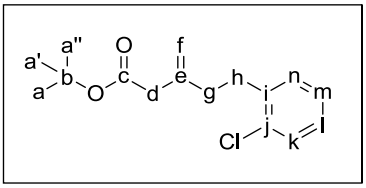
7h



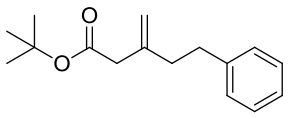
3-Methylidenepentanoic acid *tert*-butyl ester (7h):[8] Following the general procedure, 2-bromobutene (4.1 g, 30 mmol) affords, after flash chromatography on silica gel (80–70:20–30 hexanes:dichloromethane), the title compound (3.1 g, 62%) as a light yellow oil: TLC analysis R_f 0.6 (50:50 hexanes:dichloromethane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 4.91 and 4.88 (2H, s's, f), 2.97 (2H, s, d), 2.12 (2H, q, J = 7.6 Hz, g), 1.46 (9H, s, a,a',a"), 1.06 (3H, t, J = 7.6 Hz, h); ^{13}C NMR (100 MHz, $CDCl_3$) δ 170.99 (c), 144.65 (e), 111.83 (f), 80.40 (b), 43.47 (d), 28.78 (g), 28.01 (a,a',a"), 12.02 (h); IR (neat) 2935, 2848, 1731 (C=O stretch), 1653, 1391, 1252 (C-O stretch), 1145, 1122, 1040, 948, 761, 576 cm^{-1}.

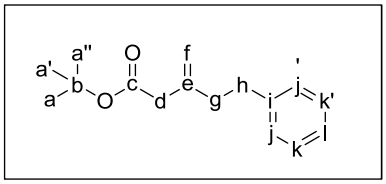


12



5-(2-Chlorophenyl)-3-methylidenepentanoic acid *tert*-butyl ester (12): Following the general procedure, 2-bromo-4-(2-chlorophenyl)butene (3.68 g, 15 mmol) affords, after flash chromatography on silica gel (75–65:25–35 hexanes:dichloromethane), the title compound (1.72 g, 41%) as a light yellow oil: TLC analysis R_f 0.5 (50:50 hexanes:dichloromethane); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.40–7.30 (1H, m, k), 7.30–7.10 (3H, m, n,m,l), 4.98 and 4.97 (2H, s's, f), 3.04 (2H, s, d), 2.91 (2H, t, J = 7.8 Hz, h), 2.43 (2H, t, J = 8.4 Hz, g), 1.48 (9H, s, a,a',a"); ^{13}C NMR (75 MHz, $CDCl_3$) δ 170.76 (c), 142.22 (i), 139.34 (e), 133.91 (j), 130.28 (k), 129.45 (l), 127.38 (m), 126.77 (n), 113.79 (f), 80.61 (b), 43.39 (d), 35.89 (g), 31.91 (h), 28.05 (a,a',a"); IR (neat) 2975, 2931, 1722 (C=O stretch), 1647, 1474, 1443, 1366, 1254 (C-O stretch), 1142, 1052, 1038, 954, 900, 824, 749, 736, 671, 575 cm^{-1}; HRMS (ESI) calcd. for $C_{16}H_{21}ClNaO_2$ (M+Na): 303.1128, found 303.1120 *m/z*.



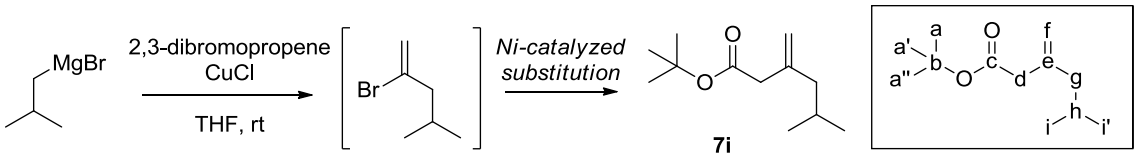


3-Methylidene-5-phenylpentanoic acid *tert*-butyl ester:[9] Following the general procedure, 2-bromo-4-phenylbutene (3.16 g, 15 mmol) affords, after flash chromatography on silica gel (75–

[9] H. Yamashita, S. Tsuyoshi, *Tetrahedron* **2009**, *65*, 613–627.

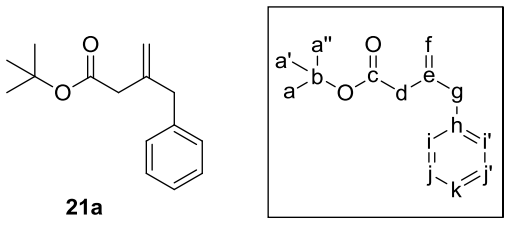
70:25–30 hexanes:dichloromethane), the title compound (1.96 g, 53%) as a light yellow oil: TLC analysis R_f 0.6 (50:50 hexanes:dichloromethane); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.40–7.30 (2H, m, k,k'), 7.30–7.20 (3H, m, j,j',l), 4.99 and 4.97 (2H, s's, f), 3.03 (2H, s, d), 2.83 (2H, t, J = 7.5 Hz, h), 2.46 (2H, t, J = 8.4 Hz, g), 1.51 (9H, s, a,a',a"); ^{13}C NMR (75 MHz, $CDCl_3$) δ 170.80 (c), 142.47 (i), 141.85 (e), 128.35 (j,j',k,k'), 125.88 (l), 113.64 (f), 80.58 (b), 43.49 (d), 37.72 (g), 34.05 (h), 28.08 (a,a',a"); IR (neat) 3028, 2978, 2931, 1726 (C=O stretch), 1647, 1496, 1454, 1366, 1255 (C-O stretch), 1139, 1030, 956, 896, 841, 744, 697 cm^{-1}.

General procedure for the preparation of *tert*-butyl esters via the synthesis of vinyl bromides followed by nickel-catalyzed substitution.[8,10]



Preparation of 3-methylidene-5-methylhexanoic acid *tert*-butyl ester (7i): To a mixture of 2,3-dibromopropene (7.01 g, 35 mmol) and copper chloride (173 mg, 1.8 mmol) in THF (30 mL) was slowly added isobutylmagnesium bromide (40 mmol, 13.8 mL of a 2.9 M solution in THF) at room temperature. After a 5 h stir, the reaction was quenched with satd. aq. ammonium chloride (30 mL) and then extracted with diethyl ether (3 x 30 mL). The combined organic extracts were dried (anhyd. Na_2SO_4) and concentrated under reduced pressure. The crude residue was taken up in hexanes, passed through a short silica plug, and concentrated under reduced pressure. The resultant crude 2-bromo-4-methylpentene (4.25 g, 26 mmol) was used in the next step without further purification.

Following the general procedure for the nickel-catalyzed substitution of vinyl bromides, crude vinyl bromide prepared in the previous step affords, after flash chromatography on silica gel (80–70:20–30, hexanes:dichloromethane), the title compound (3.12 g, 45%, 2 steps) as a light yellow oil: TLC analysis R_f 0.6 (50:50 hexanes:dichloromethane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 4.91 and 4.87 (2H, s's, f), 2.92 (2H, s, d), 1.98 (2H, d, J = 7.2 Hz, g), 1.95–1.85 (1H, m, h,), 1.46 (9H, s, a,a',a"), 0.89 (6H, d, J = 6.6 Hz, i,i'); ^{13}C NMR (100 MHz, $CDCl_3$) δ 170.90 (c), 141.96 (e), 114.33 (f), 80.36 (b), 45.79 (d), 43.03 (g), 28.00 (a,a',a"), 25.75 (h), 22.38 (i,i'); IR (neat) 2969, 2912, 1722 (C=O stretch), 1431, 1376, 1177 (C-O stretch), 1117, 884, 826, 740, 521 cm^{-1}; HRMS (CI) calcd. for $C_{12}H_{23}O_2$ (M+H): 199.1698, found 199.1705 *m/z*.



4-Phenyl-3-methylidenebutanoic acid *tert*-butyl ester (21a): Following the general procedure, crude 2-bromo-3-phenylpropene prepared from 2,3-dibromopropene (7.01 g, 35 mmol) and phenylmagnesium bromide (40 mmol, 40 mL of a 1.0 M solution in THF) affords,

[10] A. Bigot, D. Breuninger, B. Breit, *Org. Lett.* **2008**, *10*, 5321–5324.

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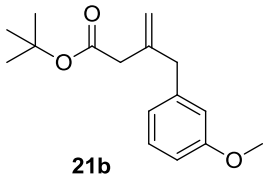
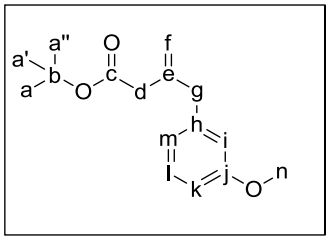
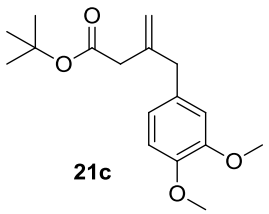
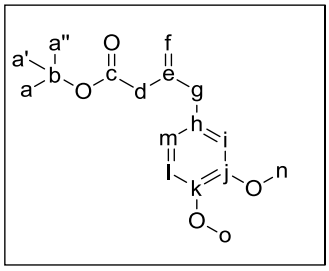
after flash chromatography on silica gel (85–70:15–30, hexanes:dichloromethane), the title compound (4.40 g, 54%, 2 steps) as a light yellow oil: TLC analysis R_f 0.6 (50:50 hexanes:dichloromethane); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.40–7.30 (2H, m, j,j'), 7.30–7.20 (3H, m, i,i',k), 5.01 and 4.95 (2H, s's, f), 3.48 (2H, s, g), 2.92 (2H, s, d), 1.49 (9H, s, a,a',a"); ^{13}C NMR (75 MHz, $CDCl_3$) δ 170.75 (c), 142.43 (h), 138.97 (e), 129.17 (i,i'), 128.39 (j,j'), 126.30 (k), 115.26 (f), 80.59 (b), 42.68 (g), 42.40 (d), 28.06 (a,a',a"); IR (neat) 2978, 1725 (C=O stretch), 1647, 1494, 1366, 1253 (C-O stretch), 1137, 966, 898, 838, 728, 696, 628 cm^{-1}; HRMS (ESI) calcd. for $C_{15}H_{20}NaO_2$ (M+Na): 255.1361, found 255.1371 *m/z*.





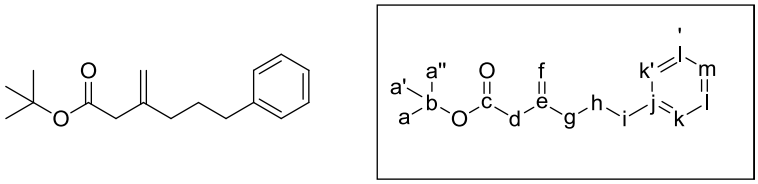
4-(3-methoxyphenyl)-3-methylidenebutanoic acid *tert*-butyl ester (21b): Following the general procedure, crude 2-bromo-3-(3-methoxyphenyl)propene prepared from 2,3-dibromopropene (7.01 g, 35 mmol) and 3-methoxyphenylmagnesium bromide (30 mmol) affords, after flash chromatography on silica gel (80–70:20–30 hexanes:dichloromethane), the title compound (3.31 g, 42%, 2 steps) as a colorless oil: TLC analysis R_f 0.3 (50:50 hexanes:dichloromethane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.30–7.20 (1H, m, i), 6.85–6.75 (3H, m, m,l,k), 5.01 and 4.97 (2H, s's, f), 3.82 (3H, s, n), 3.45 (2H, s, g), 2.92 (2H, s, d), 1.48 (9H, s, a,a',a"); ^{13}C NMR (100 MHz, $CDCl_3$) δ 170.70 (e), 159.70 (j), 142.22 (h), 140.57 (e), 129.32 (l), 121.59 (m), 115.31 (i), 114.78 (f), 111.71 (k), 80.55 (b), 55.12 (n), 42.73 (d), 42.33 (g), 28.05 (a,a',a"); IR (neat) 2977, 1725 (C=O stretch), 1600, 1584, 1488, 1435, 1366, 1257 (C-O stretch), 1140, 1050, 899, 779, 754, 695, 571 cm^{-1}; HRMS (ESI) calcd. for $C_{16}H_{22}NaO_3$ (M+Na): 285.1467, found 285.1479 *m/z*.





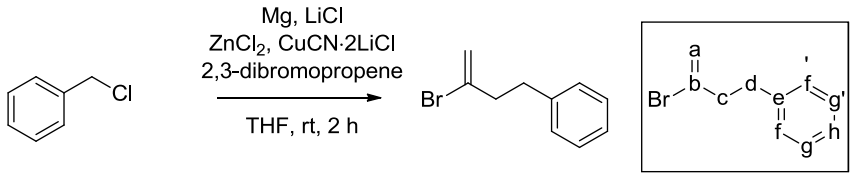
4-(3,4-dimethoxyphenyl)-3-methylidenebutanoic acid *tert*-butyl ester (21c): Following the general procedure, crude 2-bromo-3-(3,4-dimethoxyphenyl)propene prepared from 2,3-dibromopropene (7.01 g, 35 mmol) and 3,4-dimethoxyphenylmagnesium bromide (30 mmol) affords, after flash chromatography on silica gel (75–65:25–35 hexanes:dichloromethane), the title compound (3.16 g, 36%, 2 steps) as a colorless oil: TLC analysis R_f 0.3 (50:50 hexanes:dichloromethane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.85–6.75 (1H, m, i), 6.75–6.65 (2H, m, l,m), 4.97 and 4.93 (2H, s's, f), 3.87 (6H, s, n,o), 3.40 (2H, s, g), 2.90 (2H, s, d), 1.46 (9H, s, a,a',a"); ^{13}C NMR (100 MHz, $CDCl_3$) δ 170.74 (c), 148.85 (k), 147.54 (j), 142.66 (e), 131.51 (h), 121.16 (m), 114.95 (i), 112.29 (l), 111.15 (f), 80.53 (b), 55.90 (o), 55.80 (n), 42.29 (g), 42.25 (d),

28.05 (a,a',a"); IR (neat) 2978, 1725 (C=O stretch), 1647, 1599, 1584, 1488, 1454, 1366, 1256 (C-O stretch), 1139, 1050, 899, 779, 738, 694, 572 cm^{-1}; HRMS (EI) calcd. for $C_{17}H_{24}O_4$: 292.1675, found 292.1684 *m/z*.



3-Methylidene-6-phenylhexanoic acid *tert*-butyl ester: Following the general procedure, crude 2-bromo-5-phenylpentene prepared from 2,3-dibromopropene (4.02 g, 20 mmol) and 2-phenylethylmagnesiumbromide (15 mmol) affords, after flash chromatography on silica gel (75–70:25–30 hexanes:dichloromethane), the title compound (2.23 g, 57%) as a light yellow oil: TLC analysis R_f 0.6 (50:50 hexanes:dichloromethane); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.35–7.25 (2H, m, l,l'), 7.25–7.15 (3H, m, k,k',m), 4.94 and 4.93 (2H, s's, f), 2.97 (2H, s, d), 2.65 (2H, t, J = 7.6 Hz, i), 2.17 (2H, t, J = 7.5 Hz, g), 1.90–1.75 (2H, m, h), 1.46 (9H, s, a,a',a"); ^{13}C NMR (75 MHz, $CDCl_3$) δ 170.93 (c), 142.74 (j), 142.33 (e), 128.45 (k,k'), 128.31 (l,l'), 125.74 (m), 113.30 (f), 80.54 (b), 43.35 (d), 35.50 (g), 35.47 (i), 29.14 (h), 28.03 (a,a',a"); IR (neat) 3026, 2933, 2863, 1726 (C=O stretch), 1645, 1496, 1366, 1255 (C-O stretch), 1140, 897, 839, 744, 695 cm^{-1}; HRMS (ESI) calcd. for $C_{17}H_{24}NaO_2$ (M+Na): 283.1674, found 283.1682 *m/z*.

General procedure for the preparation of vinyl bromides by the direct insertion of magnesium into benzylic chlorides in the presence of LiCl and $ZnCl_2$.[11]



Preparation of 2-bromo-4-phenylbutene:[12] To a mixture of magnesium turnings (1.83 g, 75 mmol) in THF (5 mL) were added lithium chloride (37.5 mmol, 75 mL of a 0.5 M solution in THF) and zinc chloride (33 mmol, 33 mL of a 1.0 M solution in THF). To the resultant mixture was added benzyl chloride (3.80 g, 30 mmol) in one portion. The reaction mixture was allowed to stir for 1 h before transferring to a mixture of 2,3-dibromopropene (7.01 g, 35 mmol) and copper chloride (173 mg, 1.8 mmol) in THF (10 mL). After a 5 h stir, the reaction was quenched with satd. aq. ammonium chloride (30 mL) and then extracted with diethyl ether (3 x 30 mL). The combined organic extracts were dried (anhyd. Na_2SO_4) and concentrated under reduced pressure. Flash chromatography on silica gel (hexanes) affords the title compound (3.48 g, 55%) as a light brown oil: TLC analysis R_f 0.7 (hexanes); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.37 (2H, t, J = 7.9 Hz, g,g'), 7.30–7.20 (3H, m, f,f',h), 5.58 (1H, s, a), 5.47 (1H, s, a), 2.97 (2H, t, J = 6.9 Hz, c), 2.80 (2H, t, J = 8.1 Hz, d); ^{13}C NMR (75 MHz, $CDCl_3$) δ 140.42 (e), 133.62 (b), 128.56 (f,f'), 128.48 (g,g'), 126.26 (h), 117.20 (a), 43.36 (c), 34.44 (d); IR (neat) 3027, 2949,

[11] A. Metzger, F. M. Piller, P. Knochel, *Chem. Commun.* **2008**, 5824–5826.
[12] N. Kutsumura, K. Kubokawa, T. Saito, *Synthesis* **2011**, 2377–2382.

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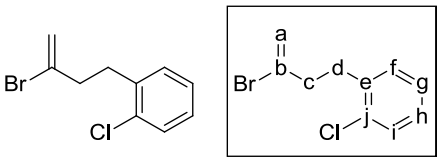
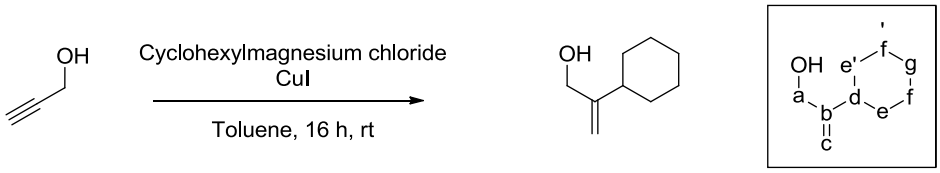
2858, 1756, 1628, 1495, 1428, 1233, 1115, 1071 (C-Br stretch), 886, 766, 747, 696, 646, 559 cm^{-1}.

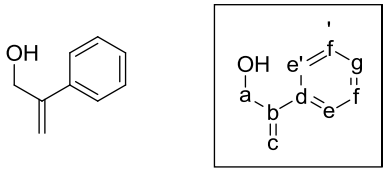


2-Bromo-4-(2-chlorophenyl)butene: Following the general procedure with 1-chloro-2-(chloromethyl)benzene (4.83 g, 30 mmol), flash chromatography on silica gel (hexanes) affords the title compound (4.33 g, 59%) as a colorless oil: TLC analysis R_f 0.7 (hexanes); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.40–7.35 (1H, m, i), 7.30–7.25 (1H, m, g), 7.25–7.15 (2H, m, f,h), 5.56 (1H, s, a), 5.44 (1H, s, a), 3.04 (2H, t, J = 7.2 Hz, c), 2.77 (2H, J = 8.0 Hz, d); ^{13}C NMR (75 MHz, $CDCl_3$) δ 137.89 (e), 133.94 (j), 133.20 (b), 130.74 (i), 129.55 (h), 127.79 (g), 126.80 (f), 117.36 (a), 41.28 (c), 32.39 (d); IR (neat) 3027, 1628, 1474, 1282, 1189 (C-Cl stretch), 1052 (C-Br stretch), 1038, 890, 824, 751, 734, 684, 669, 550, 506 cm^{-1}; HRMS (EI) calcd. for $C_{10}H_{10}BrCl$: 243.9654, found 243.9660 *m/z*.

General procedure for the preparation of allylic alcohols.[13]



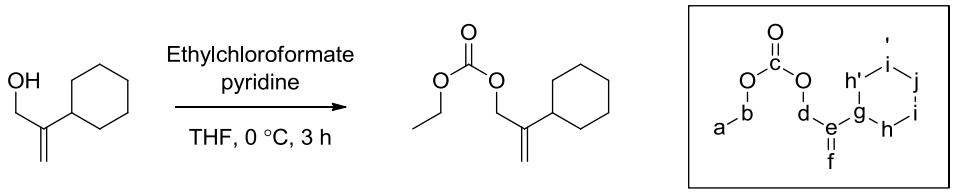
Preparation of 2-cyclohexyl-2-propenol: To a cooled (-78 °C) mixture of 3-propynol (1.68 g, 30 mmol) and copper iodide (2.86 g, 15 mmol) in toluene (40 mL) was added cyclohexylmagnesium chloride (45 mL of a 2.0 M solution in THF, 90 mmol) dropwise. The resultant reaction mixture was allowed to slowly warm to room temperature and stirred for 16 h. The reaction mixture was then cooled (0 °C) and quenched with satd. ammonium chloride (20 mL) and then extracted with diethyl ether (3 x 30 mL). The combined organic extracts were dried (anhyd. Na_2SO_4) and then concentrated under reduced pressure. Flash chromatography over silica gel (80:20 hexanes:ethyl acetate) affords the title compound (3.33 g, 79%) as a colorless oil: TLC analysis R_f 0.4 (75:25 hexanes:ethyl acetate); ^{1}H NMR (300 MHz, $CDCl_3$) δ 5.00 (1H, s, c), 4.86 (1H, s, c), 4.10 (2H, s, a), 2.00–1.85 (2H, m, a,OH), 1.85–1.70 (4H, m, e,e',f,f'), 1.70–1.65 (1H, m, g), 1.30–1.10 (5H, m, e,e',f,f',g); ^{13}C NMR (75 MHz, $CDCl_3$) δ 154.53 (b), 107.40 (c), 65.05 (a), 41.25 (d), 32.43 (e,e'), 26.70 (f,f'), 26.29 (g); IR (neat) 3306 (O-H stretch), 2850, 1649, 1060, 1019 (C-O stretch), 889, 625 cm^{-1}; HRMS (EI) calcd. for $C_9H_{16}O$: 140.1201, found 140.1204 *m/z*.



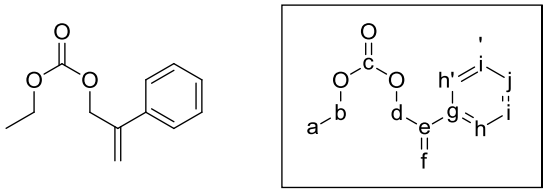
[13] Z. Lu, S. Ma, *J. Org. Chem.* **2006**, *71*, 2655–2660.

2-Phenyl-2-propenol:[13] Using the general procedure, phenylmagnesium bromide (90 mL of a 1.0 M solution in THF, 90 mmol) affords, after flash chromatography on silica gel (80:20 hexanes:ethyl acetate), the title compound (3.08 g, 77%) as a light yellow oil: TLC analysis R_f 0.3 (75:25 hexanes:ethyl acetate); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.55–7.45 (2H, m, e,e'), 7.45–7.30 (3H, m, f,f',g), 5.50 (1H, s, c), 5.39 (1H, s, c), 4.55 (2H, s, a), 2.28 (1H, br s, OH); ^{13}C NMR (75 MHz, $CDCl_3$) δ 147.30 (b), 138.60 (d), 128.53 (f,f'), 127.94 (g), 126.10 (e,e'), 112.55 (c), 64.87 (a); IR (neat) 3370 (O-H stretch), 2945, 2883, 1735, 1632, 1495, 1444, 1372, 1239, 1043 (C-O stretch), 1024, 902, 778, 706, 609 cm^{-1}.

General procedure for the preparation of allylic carbonates.



Preparation of 2-cyclohexylallyl ethyl carbonate: To a cooled (0 °C) mixture of 2-cyclohexyl-2-propenol (2.80 g, 20 mmol) and pyridine (3.16 g, 40 mmol) in THF (30 mL) was slowly added ethyl chloroformate (2.17 g, 20 mmol) over a period of 10 min. The resultant reaction mixture was allowed to stir for 3 h and then diluted with a solution of dilute HCl (15 mL). The mixture was extracted with diethyl ether (3 x mL) and the combined organic extracts were dried (anhyd. Na_2SO_4) and concentrated under reduced pressure. Flash chromatography on silica gel (98–95:2–5 hexanes:ethyl acetate) affords the title compound (3.69 g, 87%) as a colorless oil: TLC analysis R_f 0.8 (95:5 hexanes:ethyl acetate); ^{1}H NMR (300 MHz, $CDCl_3$) δ 5.04 (1H, s, f), 4.96 (1H, s, f), 4.60 (2H, s, d), 4.20 (2H, q, J = 7.1 Hz, b), 2.00–1.90 (1H, m, g), 1.90–1.75 (4H, m, h,h',i,i'), 1.75–1.65 (1H, m, j), 1.31 (3H, t, J = 7.1 Hz, a), 1.30–1.10 (5H, m, h,h',i,i',j); ^{13}C NMR (75 MHz, $CDCl_3$) δ 155.07 (c), 148.66 (e), 111.07 (f), 69.35 (d), 63.92 (b), 41.19 (g), 32.09 (h,h'), 26.56 (i,i'), 26.21 (j), 14.25 (a); IR (neat) 2926, 2853, 1742 (C=O stretch), 1649, 1448, 1374, 1241 (C-O stretch), 1004, 908, 890, 790, 630 cm^{-1}; HRMS (CI) calcd. for $C_{12}H_{21}O_3$ (M+H): 213.1491, found 213.1493 *m/z*.



2-Phenylallyl ethyl carbonate:[13] Using the general procedure, 2-phenyl-2-propenol (2.68 g, 20 mmol) affords, after flash chromatography on silica gel (98–95:2–5 hexanes:ethyl acetate), the title compound (3.46 g, 84%) as a colorless oil: TLC analysis R_f 0.8 (95:5 hexanes:ethyl acetate); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.50–7.45 (2H, m, h,h'), 7.45–7.30 (3H, m, i,i',j), 5.60 (1H, s, f), 5.45 (1H, s, f), 5.06 (2H, s, d), 4.23 (2H, q, J = 7.1 Hz, b), 1.33 (3H, t, J = 7.1 Hz, a); ^{13}C NMR (75 MHz, $CDCl_3$) δ 155.06 (c), 142.15 (e), 137.86 (g), 128.54 (i,i'), 128.14 (j), 126.04 (h,h'), 115.62 (f), 68.87 (d), 64.15 (b), 14.25 (a); IR (neat) 2984, 1740 (C=O stretch), 1634, 1375, 1242 (C-O stretch), 1006, 910, 872, 789, 705, 547 cm^{-1}.

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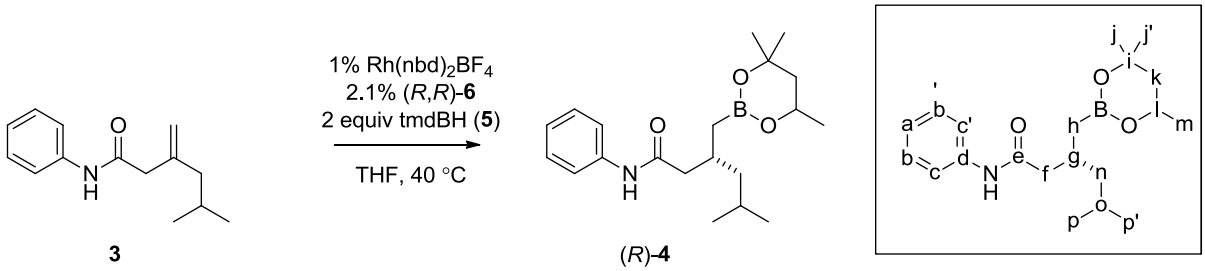
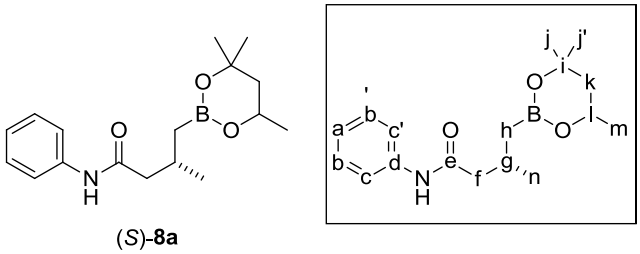
General procedure for the directed catalytic asymmetric hydroboration (CAHB).



3 (*R*)-**4**

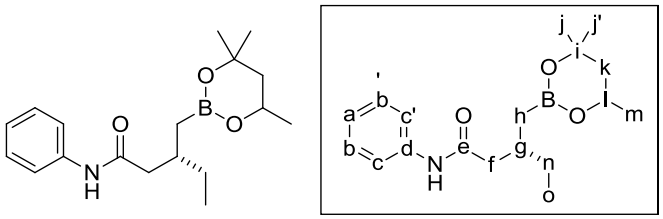
Preparation of (*R*)-5-methyl-3-(4,4,6-trimethyl-1,3,2-dioxaboratomethyl)hexanoic acid phenyl amide ((*R*)-4): A stock solution containing $Rh(nbd)_2BF_4$ (2.6 mM) and (3,5-dimethylphenyl-TADDOL)POPh ((*R*,*R*)-**6**, 5.5 mM) in THF (2.0 mL) was prepared. To the resulting yellow solution [$Rh(nbd)_2BF_4$ (2.0 mg, 0.0053 mmol) and (*R*,*R*)-**6** (7.8 mg, 0.011 mmol)] was added *β,γ*-unsaturated amide **3** (115 mg, 0.53 mmol) as a solution in THF (2.0 mL). To the resulting solution was slowly added (i.e., dropwise over the course of 0.5 h) a solution of 4,4,6-trimethyl-1,3,2-dioxaborinane (tmdBH, **5**, 135 mg, 1.1 mmol) in THF (1 mL). The mixture was then stirred at 40 °C for 24 h. Afterwards, the reaction was concentrated under reduced pressure and purified via flash chromatography on silica gel (80:20 hexanes:ethyl acetate) to afford the title compound (131 mg, 72%) as a yellow oil: TLC analysis R_f 0.7 (60:40 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = -17.9° (*c* 0.5, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.13 (1H, br s, NH), 7.56 (2H, d, *J* = 8.3 Hz, c,c'), 7.33 (2H, t, *J* = 7.9 Hz, b,b'), 7.10 (1H, t, *J* = 7.4 Hz, a), 4.30–4.20 (1H, m, l), 2.40–2.25 (2H, m, f), 2.25–2.15 (1H, m, g), 1.84 (1H, dd, *J* = 13.9 Hz, 2.9 Hz, k), 1.80–1.70 (1H, m, o), 1.53 (1H, dd, *J* = 13.7 Hz, 11.8 Hz, k), 1.35 (6H, s, j,j'), 1.31 (3H, dd, *J* = 6.2 Hz, 2.0 Hz, m), 1.20 (2H, t, *J* = 6.8 Hz, n), 0.95–0.85 (6H, t, *J* = 7.1 Hz, p), 0.90–0.70 (2H, m, h); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.62 (e), 138.45 (d), 128.91 (b,b'), 123.77 (a), 119.61 (c,c'), 71.21 and 71.16 (i), 64.90 (l), 46.75 (n), 45.88 (k), 44.99 (f), 31.40 (h), 30.96 (g), 28.26 and 28.20 (j,j'), 25.14 and 25.11 (o), 23.30 and 23.28 (m), 23.08, 23.06, and 23.34 (p,p'); IR (neat) 3304 (N-H stretch), 2954, 1659 (C=O stretch), 1600, 1544 (N-H bend), 1499, 1442, 1389, 1302 (C-O stretch), 1208 (C-N stretch), 1161, 755 cm^{-1}; HRMS (EI) calcd. for $C_{20}H_{32}BNO_3$: 345.2475, found 345.2486 *m/z*.



(*S*)-**8a**

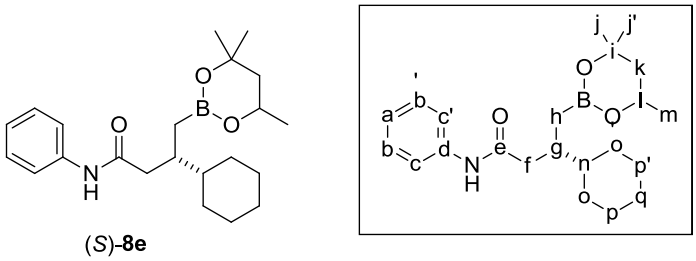
Preparation of (*S*)-3-methyl-4-(4,4,6-trimethyl-1,3,2-dioxaborato)butanoic acid phenyl amide ((*S*)-8a): Using the representative procedure at room temperature, CAHB of *β,γ*-unsaturated amide **7a** (93 mg, 0.53 mmol) affords, after flash chromatography on silica gel (80:20 hexanes:ethyl acetate), the title compound (85 mg, 53 %) as a yellow oil: TLC analysis R_f 0.7 (60:40 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = -18.8° (*c* 0.5, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.82 (1H, br s, NH), 7.56 (2H, d, *J* = 7.9 Hz, c,c'), 7.33 (2H, t, *J* = 7.8 Hz, b,b'), 7.11 (1H, t, *J* = 7.4 Hz, a), 4.30–4.20 (1H, m, l), 2.40–2.20 (3H, m, g,f), 1.82 (1H, dd, *J* = 14.0 Hz, 2.9 Hz, k),

1.51 (1H, dd, *J* = 13.6 Hz, 11.8 Hz, k), 1.33 (6H, s, j,j'), 1.29 (3H, d, *J* = 6.2 Hz, m), 1.05 (3H, d, *J* = 6.2 Hz, n), 0.81 (2H, d, *J* = 5.7 Hz, h) ; ^{13}C NMR (75 MHz, $CDCl_3$) δ 171.38 (e), 138.33 (d), 128.92 (b,b'), 123.85 (a), 119.62 (c,c'), 71.02 (i), 64.79 (l), 46.97 (k), 45.89 (f), 31.35 (h), 28.38 (j,j'), 28.20 (m), 23.24 (n), 22.85 (g); IR (neat) 3301 (N-H stretch), 2972, 1660 (C=O stretch), 1600, 1554 (N-H bend), 1499, 1442, 1390, 1302 (C-O stretch), 1209 (C-N stretch), 1161, 755, 692 cm^{-1}; HRMS (EI) calcd. for $C_{17}H_{26}BNO_3$: 303.2006, found 303.1996 *m/z*.



(*R*)-**8b**

(*R*)-3-(4,4,6-Trimethyl-1,3,2-dioxaboratomethyl)pentanoic acid phenyl amide ((*R*)-8b): Using the representative procedure at room temperature, CAHB of *β,γ*-unsaturated amide **7b** (100 mg, 0.53 mmol) affords, after flash chromatography on silica gel (80:20 hexanes:ethyl acetate), the title compound (100 mg, 60%) as a yellow oil: TLC analysis R_f 0.7 (60:40 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = -22.4^o (*c* 0.5, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.04 (1H, br s, NH), 7.56 (2H, d, *J* = 8.0 Hz, c,c'), 7.33 (2H, t, *J* = 7.9 Hz, b,b'), 7.10 (1H, t, *J* = 7.4 Hz, a), 4.30–4.20 (1H, m, l), 2.40–2.30 (2H, m, f), 2.15–2.00 (1H, m, g), 1.83 (1H, dd, *J* = 14.0 Hz, 2.9 Hz, k), 1.52 (1H, dd, *J* = 13.8 Hz, 11.9 Hz, k), 1.50–1.35 (2H, m, n), 1.35 (6H, s, j,j'), 1.30 (3H, dd, *J* = 6.2 Hz, 1.5 Hz, m), 0.95 (3H, t, *J* = 7.4 Hz, o), 0.95–0.85 (1H, m, h), 0.85–0.75 (1H, m, h); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.73 (e), 138.46 (d), 128.89 (b,b'), 123.77 (a), 119.63 (c,c'), 71.13 and 71.09 (i), 64.86 (l), 45.84 (k), 44.34 (f), 34.88 (g), 31.37 (h), 29.92 (n), 28.22 and 28.18 (j,j'), 23.26 (m), 11.66 (o); IR (neat) 3296 (N-H stretch), 2971, 2926, 1660 (C=O stretch), 1600, 1543 (N-H bend), 1499, 1441, 1389, 1302 (C-O stretch), 1209 (C-N stretch), 755 cm^{-1}; HRMS (EI) calcd. for $C_{18}H_{28}BNO_3$: 317.2162, found 317.2172 *m/z*.



(*S*)-**8e**

(*S*)-3-Cyclohexyl-4-(4,4,6-trimethyl-1,3,2-dioxaborato)butanoic acid phenyl amide ((*S*)-8e): Using the representative procedure, CAHB of *β,γ*-unsaturated amide **7e** (128 mg, 0.53 mmol) affords, after flash chromatography on silica gel (80:20 hexanes:ethyl acetate), the title compound (141 mg, 72%) as a yellow oil: TLC analysis R_f 0.7 (60:40 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = -16.4^o (*c* 0.5, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.03 (1H, br s, NH), 7.56 (2H, d, *J* = 7.9 Hz, c,c'), 7.32 (2H, t, *J* = 7.9 Hz, b,b'), 7.09 (1H, t, *J* = 7.4 Hz, a), 4.30–4.15 (1H, m, l), 2.50–2.30 (2H, m, f), 2.10–2.00 (1H, m, g), 1.80 (1H, dd, *J* = 14.1 Hz, 2.6 Hz, k), 1.80–1.65 (5H, m, n,p,p'), 1.51 (1H, t, *J* = 12.8 Hz, k), 1.32 (6H, s, j,j'), 1.28 (3H, d, *J* = 6.0 Hz, m), 1.25–0.95 (6H, m, o,o',q), 0.87 (1H, dd, *J* = 15.3 Hz, 5.2 Hz, h), 0.80–0.70 (1H, m, h); ^{13}C NMR (100

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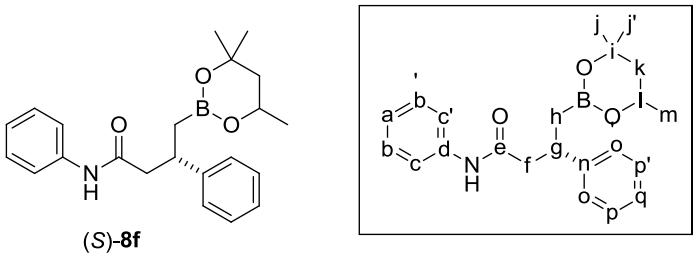
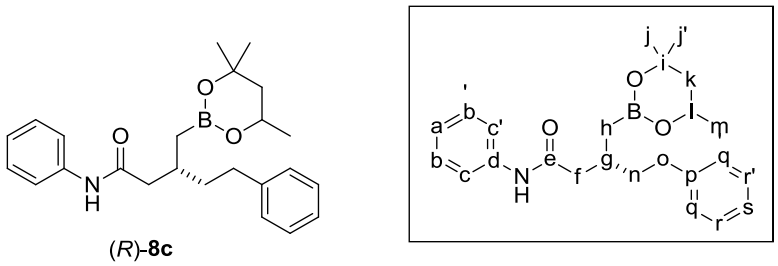
MHz, $CDCl_3$) δ 172.35 (e), 138.48 (d), 128.90 (b,b'), 123.76 (a), 119.64 (c,c'), 71.09 and 71.00 (i), 64.86 and 64.80 (l), 45.78 (k), 43.29 and 43.26 (n), 42.25 and 42.21 (f), 38.48 (g), 31.36 (h), 30.49 (o,o'), 29.81, 29.70, 28.16, and 28.08 (j,j'), 26.73 (p,p'), 26.68 (q), 23.25 (m); IR (neat) 3298 (N-H stretch), 3255, 2928, 1656 (C=O stretch), 1595 (N-H bend), 1414, 1318 (C-O stretch), 1246, 1206 (C-N stretch), 1141, 755 cm^{-1}; HRMS (EI) calcd. for $C_{22}H_{34}BNO_3$: 371.2632, found 371.2627 *m/z*.



(*S*)-4-(4,4,6-trimethyl-1,3,2-dioxaborato)-3-phenylbutanoic acid phenyl amide ((*S*)-8f): Using the representative procedure, CAHB of *β,γ*-unsaturated amide **7f** (125 mg, 0.53 mmol) affords, after flash chromatography on silica gel (80:20 hexanes:ethyl acetate), the title compound (137 mg, 71%) as a yellow oil: TLC analysis R_f 0.7 (60:40 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = -18.8° (*c* 0.5, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.36 (2H, d, *J* = 7.8 Hz, c,c'), 7.35–7.25 (6H, m, b,b',o,o',p,p'), 7.25–7.15 (1H, m, q), 7.07 (1H, t, *J* = 7.2 Hz, a), 4.15–4.00 (1H, m, l), 3.50–3.40 (1H, m, g), 2.80–2.70 (1H, m, f), 2.62 (1H, dd, *J* = 13.6 Hz, 2.8 Hz, f), 1.69 (1H, dd, *J* = 13.9 Hz, 2.8 Hz, k), 1.35–1.25 (1H, m, k), 1.25–1.05 (11H, m, h,j,j',m); ^{13}C NMR (100 MHz, $CDCl_3$) δ 170.56 (e), 146.23 (n), 137.95 (d), 128.84 (b,b'), 128.41 (p,p'), 127.32 and 127.30 (o,o'), 126.29 (q), 123.99 (a), 119.80 (c,c'), 70.80 (i), 64.71 and 64.68 (l), 47.15 and 47.11 (f), 45.70 (k), 39.05 (g), 31.15 and 31.11 (h), 27.97 and 27.90 (j,j'), 23.08 and 23.07 (m); IR (neat) 3299 (N-H stretch), 2973, 1657 (C=O stretching), 1600, 1544 (N-H bend), 1499, 1442, 1392, 1302 (C-O stretch), 1208 (C-N stretch), 1187, 909, 755, 731 cm^{-1}; HRMS (EI) calcd. for $C_{22}H_{28}BNO_3$: 365.2162, found 365.2169 *m/z*.



(*R*)-3-((4,4,6-trimethyl-1,3,2-dioxaborato)methyl)-5-phenylpentanoic acid phenyl amide ((*R*)-8c): Using the representative procedure, CAHB of *β,γ*-unsaturated amide **7c** (140 mg, 0.53 mmol) affords, after flash chromatography on silica gel (80:20 hexanes:ethyl acetate), the title compound (152 mg, 73%) as a yellow oil: TLC analysis R_f 0.7 (60:40 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = -12.6° (*c* 0.5, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.05 (1H, br s, NH), 7.56 (2H, d, *J* = 8.0 Hz, c,c'), 7.40–7.15 (7H, m, b,b',o,o',p,p',q), 7.11 (1H, t, *J* = 7.3 Hz, a), 4.35–4.15 (1H, m, l), 2.85–2.60 (2H, m, o), 2.45–2.35 (2H, m, f), 2.30–2.15 (1H, m, g), 1.85 (1H, dd, *J* = 14.0 Hz, 2.8 Hz, k), 1.80–1.60 (2H, m, n), 1.60–1.45 (1H, m, k), 1.36 (6H, s, j,j'), 1.32 (3H, d, *J* = 6.2 Hz, m), 1.00–0.90 (2H, m, h); ^{13}C NMR (75 MHz, $CDCl_3$) δ 171.35 (e), 142.74 (p), 138.36 (d),

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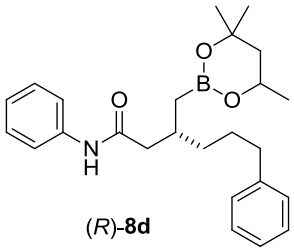
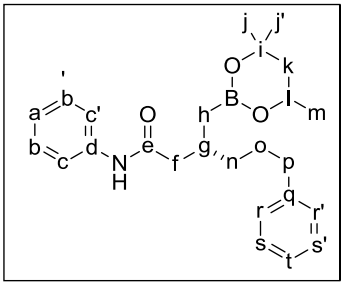
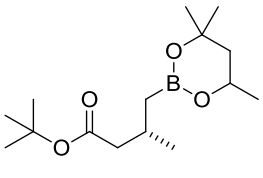
128.93 (b,b'), 128.43 (r,r'), 128.29 (q,q'), 125.62 (s), 123.87 (a), 119.66 (c,c'), 71.28 and 71.24 (i), 64.95 (l), 45.86 (k), 44.63 (f), 39.24 (n), 33.59 (o), 33.09 (g), 31.40 (h), 28.29 and 28.24 (j,j'), 23.29 and 23.27 (m); IR (neat) 3305 (N-H stretch), 2972, 2929, 1659 (C=O stretch), 1600, 1541 (N-H bend), 1498, 1442, 1390, 1303 (C-O stretch), 1209 (C-N stretch), 906, 754 cm^{-1}; HRMS (ESI) calcd. for $C_{24}H_{32}BNaNO_3$ (M+Na): 416.2373, found 416.2379 *m/z*.



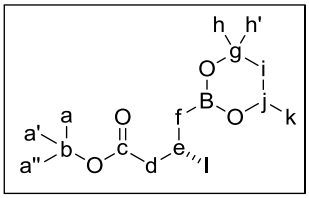
(*R*)-**8d**



(*R*)-3-((4,4,6-Trimethyl-1,3,2-dioxaborato)methyl)-6-phenylhexanoic acid phenyl amide ((*R*)-8d): Using the representative procedure, CAHB of *β,γ*-unsaturated amide **7d** (148 mg, 0.53 mmol) affords, after flash chromatography on silica gel (80:20 hexanes:ethyl acetate), the title compound (151 mg, 70%) as a yellow oil: TLC analysis R_f 0.7 (60:40 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = -14.5° (*c* 0.5, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.99 (1H, br s, NH), 7.55 (2H, d, *J* = 7.8 Hz, c,c'), 7.33 (2H, t, *J* = 7.7 Hz, b,b'), 7.30–7.25 (2H, m, s,s'), 7.25–7.15 (3H, m, r,r',t), 7.11 (1H, t, *J* = 7.3 Hz, a), 4.25–4.15 (1H, m, l), 2.70–2.50 (2H, m, p), 2.40–2.30 (2H, m, f), 2.25–2.10 (1H, m, g), 1.81 (1H, dd, *J* = 14.0 Hz, 2.6 Hz, k), 1.80–1.65 (2H, m, o), 1.55–1.40 (2H, m, k,n), 1.35–1.25 (10H, m, n,j,j',m), 0.95–0.85 (2H, m, h); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.51 (e), 142.71 (q), 138.36 (d), 128.92 (b,b'), 128.42 (s,s'), 128.20 (r,r'), 125.57 (t), 123.84 (a), 119.63 (c,c'), 71.13 (i), 64.86 (l), 45.81 (k), 44.77 (f), 36.82 (n), 36.04 (p), 33.20 (g), 31.35 (h), 29.71 and 29.04 (j,j'), 28.15 (o), and 23.23 (m); IR (neat) 2973 (N-H stretch), 2925, 2854, 1649 (C=O stretch), 1595, 1495 (N-H bend), 1386, 1378, 1307, 1239 (C-N stretch), 1143 (C-O stretch), 1119 (C-O stretch), 966, 868, 772, 749, 698 cm^{-1}; HRMS (CI) calcd. for $C_{25}H_{35}BNO_3$ (M+H): 408.2710, found 408.2711 *m/z*.

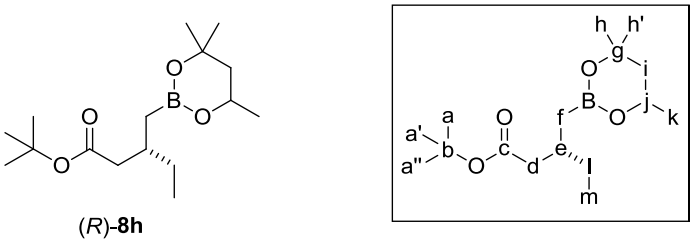


(*S*)-**8g**

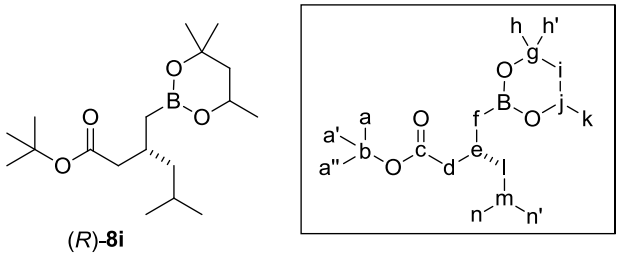


(*S*)-3-Methyl-4-(4,4,6-trimethyl-1,3,2-dioxaborato)butanoic acid *tert*-butyl ester ((*S*)-8g): Using the representative procedure at room temperature, CAHB of *β,γ*-unsaturated ester **7g** (83 mg, 0.53 mmol) affords, after flash chromatography on silica gel (95:5 hexanes:ethyl acetate), the title compound (93 mg, 62 %) as a yellow oil: TLC analysis R_f 0.5 (80:20 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = -4.0° (*c* 0.5, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 4.20–4.05 (1H, m, j), 2.25–2.15 (1H, m, d), 2.15–2.05 (1H, m, e), 2.05–1.95 (1H, m, d), 1.75 (1H, dd, *J* = 13.8 Hz, 2.7 Hz, i), 1.50–1.40 (1H, m, i), 1.43 (9H, s, a,a',a''), 1.26 (6H, s, h,h'), 1.22 (3H, d, *J* = 5.8 Hz, k), 0.93 (3H, d, *J* = 6.3 Hz, l), 0.80–0.70 (1H, m, f), 0.65–0.50 (1H, m, f); ^{13}C NMR (100 MHz, $CDCl_3$) δ 172.96 (c), 79.50 (b), 70.39 (g), 64.44 (j), 45.95 (i), 45.19 (e), 45.15 (d), 31.25 (f), 28.13

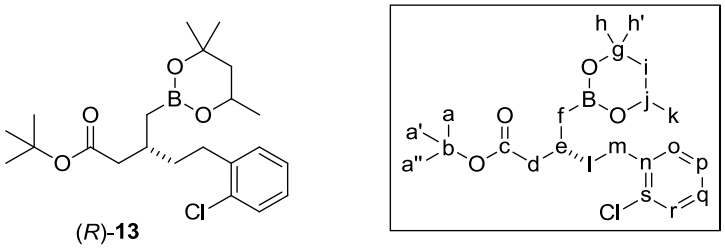
(a,a',a''), 27.24 and 27.21 (h,h'), 23.18 (k), 22.01 and 21.98 (l); IR (neat) 2979, 2930, 1725 (C=O stretch), 1474, 1440, 1366, 1319, 1248, 1141 (C-O stretch), 1051, 968, 917, 846, 750, 733, 681, 667 cm^{-1}; HRMS (CI) calcd. for $C_{15}H_{30}BO_4$ (M+H): 285.2237, found 285.2243 *m/z*.



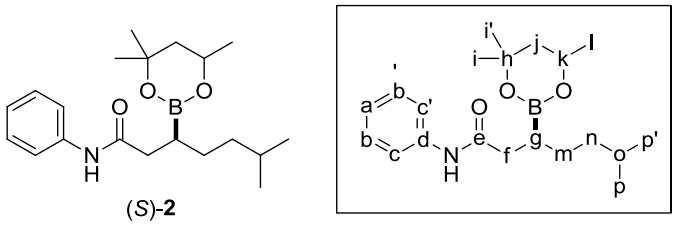
(*R*)-3-((4,4,6-Trimethyl-1,3,2-dioxaborato)methyl)pentanoic acid *tert*-butyl ester ((*R*)-8h): Using the representative procedure at room temperature, CAHB of *β,γ*-unsaturated ester **7h** (90 mg, 0.53 mmol) affords, after flash chromatography on silica gel (95:5 hexanes:ethyl acetate), the title compound (102 mg, 65 %) as a yellow oil: TLC analysis R_f 0.5 (80:20 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = -3.8° (*c* 0.5, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$) δ 4.25–4.10 (1H, m, j), 2.19 (2H, dd, *J* = 6.9 Hz, 2.6 Hz, d), 2.05–1.95 (1H, m, e), 1.77 (1H, dd, *J* = 13.8 Hz, 3.0 Hz, i), 1.50–1.40 (1H, m, i),1.46 (9H, s, a,a',a''), 1.40–1.30 (2H, m, l), 1.28 (6H, s, h,h'), 1.24 (3H, d, *J* = 6.2 Hz, k), 0.88 (3H, t, *J* = 7.4 Hz, m), 0.69 (2H, d, *J* = 6.8 Hz, f); ^{13}C NMR (75 MHz, $CDCl_3$) δ 173.24 (c), 79.51 (b), 70.39 (g), 64.41 (j), 45.96 (i), 42.33 (d), 33.27 (e), 31.28 (f), 28.94 (l), 28.16 (a,a',a''), 28.06 (h,h'), 23.21 (k), 11.19 (m); IR (neat) 2976, 2926, 1726 (C=O stretch), 1456, 1379, 1315, 1246, 1213, 1138 (C-O stretch), 966, 850, 669, 518 cm^{-1}; HRMS (CI) calcd. for $C_{16}H_{32}BO_4$ (M+H): 299.2394, found 299.2397 *m/z*.



(*R*)-5-Methyl-3-((4,4,6-trimethyl-1,3,2-dioxaborato)methyl)hexanoic acid *tert*-butyl ester ((*R*)-8i): Using the representative procedure at room temperature, CAHB of *β,γ*-unsaturated ester **7i** (105 mg, 0.53 mmol) affords, after flash chromatography on silica gel (95:5 hexanes:ethyl acetate), the title compound (134 mg, 78%) as a yellow oil: TLC analysis R_f 0.5 (80:20 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = -2.7° (*c* 0.5, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$) δ 4.20–4.10 (1H, m, j), 2.20–2.05 (3H, m, d,e), 1.77 (1H, dd, *J* = 13.8 Hz, 2.8 Hz, i), 1.70–1.55 (1H, m, m), 1.50–1.40 (1H, m, i), 1.46 (9H, s, a,a',a''), 1.28 (6H, s, h,h'), 1.24 (3H, d, *J* = 6.2 Hz, k), 1.13 (2H, t, *J* = 5.9 Hz, l), 0.90–0.85 (6H, m, n,n'), 0.69 (2H, d, *J* = 5.9 Hz, f); ^{13}C NMR (75 MHz, $CDCl_3$) δ 173.16 (c), 79.51 (b), 70.39 (g), 64.43 (j), 46.21 (l), 45.97 (i), 43.17 (d), 31.30 (f), 29.62 (e), 28.16 (a,a',a''), 28.06 (h,h'), 25.32 (m), 23.21 (k), 23.15, 23.04, 22.83, 22.64 (n,n'); IR (neat) 2971, 2931, 2870, 1725 (C=O stretch), 1456, 1389, 1366, 1300, 1206, 1156 (C-O stretch), 1134 (C-O stretch), 956, 846, 739 cm^{-1}; HRMS (ESI) calcd. for $C_{18}H_{35}NaBO_4$ (M+Na): 349.2526, found 349.2515 *m/z*.



(*R*)-5-(2-Chlorophenyl)-3-(4,4,6-trimethyl-1,3,2-dioxaboratomethyl)pentanoic acid *tert*-butyl ester ((*R*)-13): Using the representative procedure, CAHB of **12** (148 mg, 0.53 mmol) with $Rh(nbd)_2BF_4$ (3.9 mg, 0.011 mmol) and (*R*,*R*)-**6** (15.2 mg, 0.022 mmol) affords, after flash chromatography on silica gel (95:5 hexanes:ethyl acetate), the title compound (160 mg, 74 %) as a yellow oil: TLC analysis R_f 0.5 (80:20 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = -4.5° (*c* 0.5, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.32 (1H, dd, *J* = 7.6 Hz, 1.2 Hz, r), 7.23 (1H, dd, *J* = 7.5 Hz, 1.9 Hz, p), 7.18 (1H, dd, *J* = 7.2 Hz, 1.5 Hz, o), 7.12 (1H, dd, *J* = 7.6 Hz, 2.1 Hz, q), 4.25–4.10 (1H, m, j), 2.80–2.70 (2H, m, m), 2.35–2.25 (2H, m, d), 2.25–2.10 (1H, m, e), 1.77 (1H, dd, *J* = 13.8 Hz, 2.9 Hz, i), 1.70–1.55 (2H, m, l), 1.55–1.40 (1H, m, i), 1.46 (9H, s, a,a',a''), 1.28 (6H, s, h,h'), 1.24 (3H, d, *J* = 6.2 Hz, k), 0.82 (2H, d, *J* = 6.2 Hz, f); ^{13}C NMR (75 MHz, $CDCl_3$) δ 172.90 (c), 140.65 (n), 133.84 (s), 130.29 (r), 129.33 (q), 126.99 (o), 126.67 (p), 79.71 and 79.70 (b), 70.51 (g), 64.52 (j), 45.94 (i), 42.56 (d), 36.45 (l), 31.82 (m), 31.28 (f), 31.08 (e), 28.16 (a,a',a''), 28.11 (h,h'), 23.20 (k); IR (neat) 2978, 2930, 1724 (C=O stretch), 1475, 1443, 1366, 1320, 1240, 1142 (C-O stretch), 1050, 968, 917, 846, 750, 732, 680, 647 cm^{-1}; HRMS (ESI) calcd. for $C_{22}H_{34}NaBClO_4$ (M+Na): 431.2136, found 431.2145 *m/z*.



(*S*)-6-Methyl-3-(4,4,6-trimethyl-1,3,2-dioxaborato)heptanoic acid phenyl amide ((*S*)-2): Using the representative procedure, CAHB of *β,γ*-unsaturated amide **1** (115 mg, 0.53 mmol) affords, after flash chromatography on silica gel (80:20 hexanes:ethyl acetate), the title compound (144 mg, 79%) as a yellow oil: TLC analysis R_f 0.7 (80:20 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = -7.9° (*c* 0.5, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.59 (1H, br s, NH), 7.52 (2H, d, *J* = 7.1 Hz, c,c'), 7.32 (2H, t, *J* = 7.4 Hz, b,b'), 7.09 (1H, t, *J* = 7.2 Hz, a), 4.30–4.15 (1H, m, k), 4.30–4.10 (1H, m, k), 2.55–2.40 (1H, m, f), 2.40–2.20 (4H, m, f,g,m), 1.85–1.65 (2H, m, j,o), 1.60–1.45 (3H, m, j,n), 1.29 (6H, s, j,j'), 1.26 (3H, dd, *J* = 6.2 Hz, 2.1 Hz, l), 0.89 (6H, d, *J* = 6.4 Hz, p,p'); ^{13}C NMR (100 MHz, $CDCl_3$) δ 172.34 (e), 138.39 (d), 128.90 (b,b'), 123.72 (a), 119.60 (c,c'), 70.80 (h), 64.80 and 64.76 (k), 45.93 and 45.89 (j), 39.79 (f), 38.67 (n), 38.11 and 38.05 (g), 31.28 and 27.99 (i,i'), 29.08 (o), 28.20 (m), 23.22 (l), 22.59 (p,p'); IR (neat) 3304 (N-H stretch), 2973, 1660 (C=O stretch), 1600, 1541 (N-H stretch), 1442, 1391, 1369, 1302 (C-O stretch), 1209 (C-N stretch), 1161, 898, 756 cm^{-1}; HRMS (ESI) calcd. for $C_{20}H_{32}NaBNO_3$ (M+Na): 368.2373, found 368.2364 *m/z*.

General procedure for CAHB-oxidation sequence with H_2O_2.

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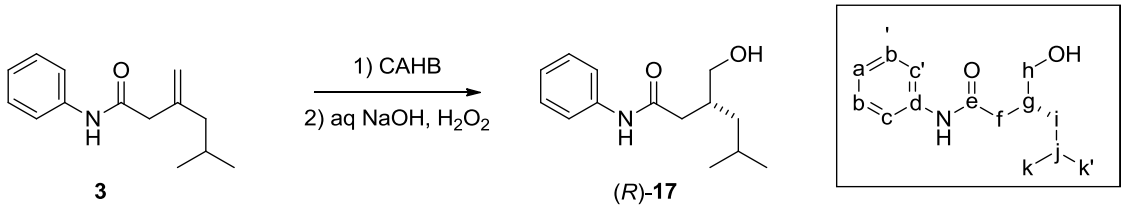
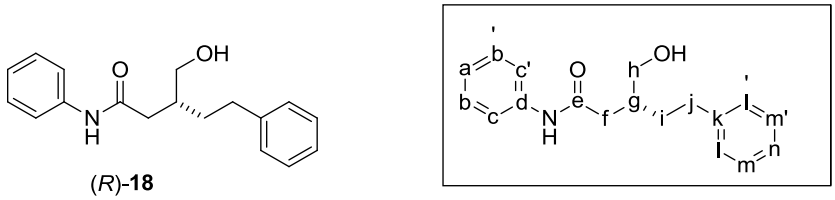


(*R*)-3-Hydroxymethyl-5-methylhexanoic acid phenyl amide ((*R*)-17): After the CAHB of **3**, the resultant mixture was diluted with THF (10 mL). Addition of sodium hydroxide (6 mL of a 3 M soln.) and slow addition of H_2O_2 (0.6 mL of a 30% soln.) afforded a mixture which was allowed to stir for 2 h. After extraction with dichloromethane (3 x 15 mL), the combined organic extracts were dried (anhyd. Na_2SO_4) and concentrated under reduced pressure. Flash chromatography on silica gel (80–40:20–60 hexanes:ethyl acetate) affords the title compound (88 mg, 71%) as a white solid: mp 92.5–94 ºC; TLC analysis R_f 0.4 (30:70 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = +5.1º (*c* 0.5, $CHCl_3$); Chiral HPLC analysis (Chiralpak-IC, 90:10 hexanes:isopropanol) showed peaks at 27 minutes (2.5% (S)) and 30 minutes (97.5% (R)); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.98 (1H, br s, NH), 7.51 (2H, d, *J* = 7.8 Hz, c,c'), 7.32 (2H, t, *J* = 7.6 Hz, b,b'), 7.11 (1H, t, *J* = 7.4 Hz, a), 3.75 (1H, dd, *J* = 10.9 and 3.8 Hz, h), 3.52 (1H, dd, *J* = 10.9 and 6.8 Hz, h), 3.14 (1H, br s, OH), 2.45–2.40 (2H, m, f), 2.30–2.15 (1H, m, g), 1.75–1.60 (1H, m, j), 1.30–1.10 (2H, m, i), 0.92 and 0.91 (6H, overlapping d's, *J* = 6.5 Hz, k,k'); ^{13}C NMR (75 MHz, $CDCl_3$) δ 171.71 (e), 137.85 (d), 128.97 (b,b'), 124.36 (a), 120.06 (c,c'), 65.73 (h), 40.89 (i), 40.72 (f), 35.80 (g), 25.27 (j), 22.78 (k), 22.65 (k'); IR (neat) 3307 (O-H stretch), 3150 (N-H stretch), 2951, 2925, 2856, 1641 (C=O stretch), 1547 (N-H bend), 1452, 1355 (C-O stretch), 1205 (C-N stretch), 1143, 1077, 1032, 878, 735, 695 cm^{-1}; HRMS (CI) calcd. for $C_{14}H_{22}NO_2$ (M+H): 236.1651, found 236.1651 *m/z*.



(*R*)-3-Hydroxymethyl-5-phenylpentanoic acid phenyl amide ((*R*)-18): Using the general procedure, *β*,*γ*-unsaturated amide **7c** (140 mg, 0.53 mmol) affords, after flash chromatography on silica gel (80–40:20–60 hexanes:ethyl acetate), the title compound (106 mg, 71%) as a white solid: mp 92–94 ºC; TLC analysis R_f 0.4 (30:70 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = +4.3º (*c* 0.5, $CHCl_3$); Chiral HPLC analysis (Chiralpak-IC, 85:15 hexanes:isopropanol) showed peaks at 23 minutes (3.0% (S)) and 26 minutes (97.0% (R)); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.75 (1H, br s, NH), 7.50 (2H, d, *J* = 7.8 Hz, c,c'), 7.35–7.25 (4H, m, b,b',l,l'), 7.25–7.15 (3H, m, m,m',n), 7.13 (1H, t, *J* = 7.4 Hz, a), 3.85–3.75 (1H, m, h), 3.70–3.60 (1H, m, h), 2.92 (1H, br s, OH), 2.80–2.65 (2H, m, j), 2.55–2.45 (2H, m, f), 2.20–2.10 (1H, m, g), 1.80–1.65 (2H, m, i); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.32 (e), 141.89 (k), 137.75 (d), 129.01 (l,l'), 128.48 (b,b'), 128.37 (m,m'), 125.98 (n), 124.44 (a), 120.02 (c,c'), 65.36 (h), 40.60 (f), 37.77 (j), 33.41 (g), 33.11 (i); IR (neat) 3679 (O-H stretch), 3150 (N-H stretch), 2993, 2950, 1678 (C=O stretch), 1598, 1498 (N-H bend), 1443, 1322 (C-O stretch), 1304, 1197 (C-N stretch), 1174, 1095, 957, 762 cm^{-1}; HRMS (CI) calcd. for $C_{18}H_{22}NO_2$ (M+H): 284.1651, found 284.1656 *m/z*.

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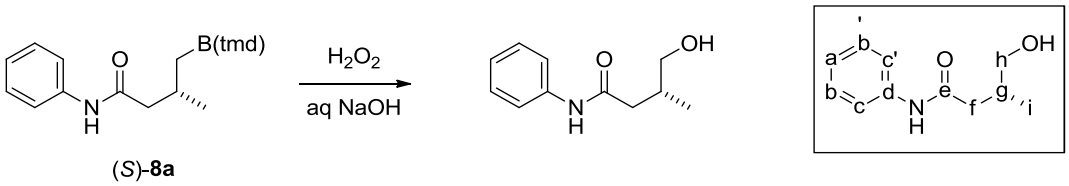
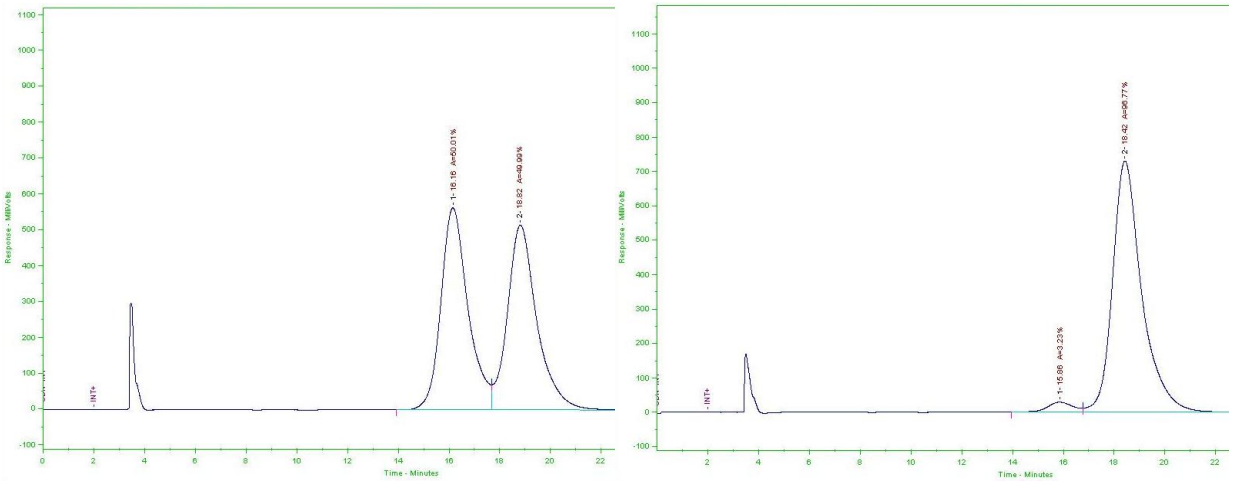
General procedure for small scale oxidation of purified organoboronates with H_2O_2 for chiral HPLC analysis.

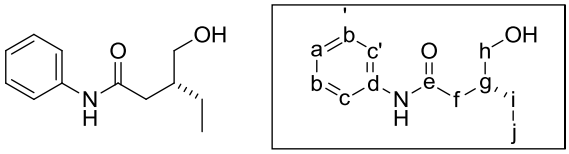


(*S*)-**8a**

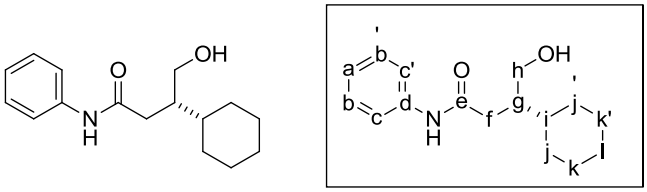
Preparation of (*R*)-4-hydroxy-3-methylbutanoic acid phenyl amide: To a solution of γ-dioxaborato amide (*S*)-**8a** (30 mg, 0.10 mmol) in THF (0.5 mL) was added sodium hydroxide (0.6 mL of a 3 M soln.) and H_2O_2 (0.15 mL of a 30% soln.). After allowing a 2 h stir, the resultant mixture was extracted with dichloromethane (2 x 2 mL) and the combined organic extracts were dried (anhyd. Na_2SO_4) and then concentrated under reduced pressure. Flash chromatography on silica gel (80–40:20–60 hexanes:ethyl acetate) affords the title compound (19 mg, 97%) as a white solid: mp 115–117 ºC; TLC analysis R_f 0.3 (30:70 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = +2.5° (*c* 0.5, $CHCl_3$); Chiral HPLC analysis (Chiralpak-IC, 75:25 hexanes:isopropanol, flow rate = 1.0 mL/min) showed peaks at 16 minutes (3.2% (S)) and 19 minutes (96.8% (R), (see traces for racemate and enriched product below); ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.21 (1H, br s, OH), 7.51 (2H, d, *J* = 7.8 Hz, c,c'), 7.30 (2H, t, *J* = 7.6 Hz, b,b'), 7.10 (1H, t, *J* = 7.4 Hz, a), 3.70–3.55 (1H, m, h), 3.55–3.40 (2H, m, h,OH), 2.52 and 2.29 (2H, overlapping dd's, J_1 = 14.0 Hz, 6.8 Hz, J_2 = 14.0 Hz, 6.00 Hz, f), 2.30–2.20 (1H, m, g), 1.00 (3H, d, *J* = 6.7 Hz, i); ^{13}C NMR (75 MHz, $CDCl_3$) δ 171.71 (e), 137.88 (d), 128.94 (b,b'), 124.40 (a), 120.19 (c,c'), 67.46 (h), 42.16 (f), 33.36 (g), 17.03 (i); IR (neat) 3286 (O-H stretch), 3195 (N-H stretch), 3139, 2957, 2928, 1667 (C=O stretch), 1599, 1549 (N-H bend), 1487, 1444, 1376, 1319 (C-O stretch), 1257, 1231 (C-N stretch), 1132, 1047, 754 cm^{-1}; HRMS (CI) calcd. for $C_{11}H_{16}NO_2$ (M+H): 194.1181, found 194.1180 *m/z*.



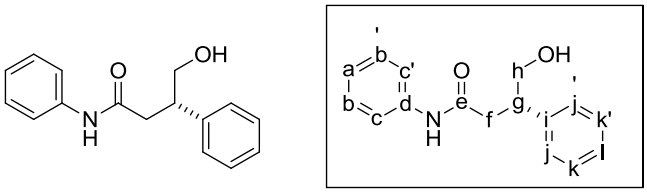
racemate CAHB product



(*R*)-3-(Hydroxymethyl)pentanoic acid phenyl amide: Using the general procedure, *γ*-dioxaborato amide (*R*)-**8b** (32 mg, 0.10 mmol) affords, after flash chromatography on silica gel (80–40:20–60 hexanes:ethyl acetate), the title compound (20 mg, 98%) as a white solid: mp 118–119.5 ºC; TLC analysis R_f 0.3 (30:70 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = +2.1° (*c* 0.5, $CHCl_3$); Chiral HPLC analysis (Chiralpak-IC, 90:10 hexanes:isopropanol) showed peaks at 40 minutes (4.0% (S)) and 46 minutes (96.0% (R)); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83 (1H, br s, NH), 7.52 (2H, d, *J* = 7.9 Hz, c,c'), 7.33 (2H, t, *J* = 7.8 Hz, b,b'), 7.12 (1H, t, *J* = 7.3 Hz, a), 3.78 (1H, dd, J_1 = 10.5 Hz, J_2 = 3.0 Hz, h), 3.59 (1H, dd, J_1 = 10.5 Hz, J_2 = 6.8 Hz, h), 2.87 (1H, br s, OH), 2.55–2.45 (2H, m, f), 2.10–2.00 (1H, g), 1.50–1.35 (2H, m, i), 0.98 (3H, t, *J* = 7.4 Hz, j); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.63 (e), 137.83 (d), 128.99 (c,c'), 124.38 (a), 119.99 (b,b'), 65.32 (h), 40.46 (f), 39.75 (g), 24.36 (i), 11.59 (j); IR (neat) 3349 (O-H stretch), 3253 (N-H stretch), 2959, 1670 (C=O stretch), 1599, 1551 (N-H bend), 1443, 1319 (C-O stretch), 1255 (C-N stretch), 1143, 1074, 758 cm^{-1}; HRMS (CI) calcd. for $C_{12}H_{18}NO_2$ (M+H): 208.1338, found 208.1333 *m/z*.



(*S*)-3-Cyclohexyl-4-hydroxybutanoic acid phenyl amide: Using the general procedure, *γ*-dioxaborato amide (*S*)-**8e** (37 mg, 0.10 mmol) affords, after flash chromatography on silica gel (80–40:20–60 hexanes:ethyl acetate), the title compound (25 mg, 96%) as a white solid: mp 88–89 ºC; TLC analysis R_f 0.4 (30:70 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = +3.1° (*c* 0.5, $CHCl_3$); Chiral HPLC analysis (Chiralpak-IC, 90:10 hexanes:isopropanol) showed peaks at 48 minutes (5.0% (S)) and 52 minutes (95.0% (R)); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.90 (1H, br s, NH), 7.52 (2H, d, *J* = 7.9 Hz, c,c'), 7.33 (2H, t, *J* = 7.9 Hz, b,b'), 7.12 (1H, t, *J* = 7.2 Hz, a), 3.82 (1H, dd, *J* = 10.8 and 4.0 Hz, h), 3.67 (1H, dd, *J* = 10.8 and 7.1 Hz, h), 2.51 (2H, d, *J* = 6.2 Hz, f), 2.00–1.80 (1H, m, g), 1.80–1.60 (5H, m, j,j',k,k',OH), 1.35–1.00 (7H, m, i,j,j',k,k',l); ^{13}C NMR (75 MHz, $CDCl_3$) δ 172.23 (e), 137.94 (d), 128.97 (c,c'), 124.27 (a), 119.92 (b,b'), 64.38 (h), 49.20 (g), 43.41 (f), 39.54 (i), 38.64 (j), 33.93 (j'), 30.36 (l), 26.55 (k), 26.48 (k'); IR (neat) 3292 (O-H stretch), 3100 (N-H stretch), 2957, 2893, 1655 (C=O stretch), 1599, 1540 (N-H bend), 1444, 1327 (C-O stretch), 1268 (C-N stretch), 1121, 1053, 881, 753 cm^{-1}; HRMS (CI) calcd. for $C_{16}H_{24}NO_2$ (M+H): 262.1807, found 262.1808 *m/z*.



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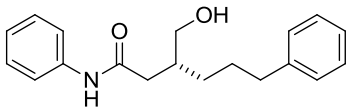
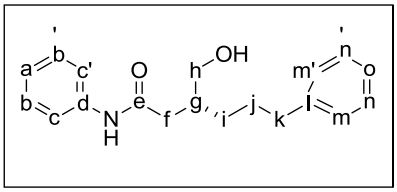
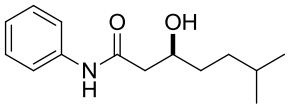
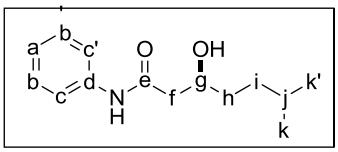
(*S*)-4-Hydroxy-3-phenylbutanoic acid phenyl amide: Using the general procedure, *γ*-dioxaborato amide (*S*)-**8f** (37 mg, 0.10 mmol) affords, after flash chromatography on silica gel (80–40:20–60 hexanes:ethyl acetate), the title compound (25 mg, 98%) as a white solid: mp 95.5–97 ºC; TLC analysis R_f 0.4 (30:70 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = +3.8º (*c* 0.5, $CHCl_3$); Chiral HPLC analysis (Chiralpak-IC, 90:10 hexanes:isopropanol) showed peaks at 56 minutes (3.5% (S)) and 85 minutes (96.5% (R)); ^{1}H NMR (300 MHz, DMSO-d_6) δ 9.86 (1H, br s, NH), 7.51 (2H, d, *J* = 8.0 Hz, c,c'), 7.30–7.10 (7H, m, b,b',j,j',k,k',l), 6.98 (1H, t, *J* = 7.3 Hz, a), 4.79 (1H, t, *J* = 5.2 Hz, OH), 3.65–3.50 (2H, m, h), 3.35–3.20 (1H, m, g), 2.82 and 2.60 (2H, overlapping dd's, J_1 = 14.8 Hz, 5.9 Hz, J_2 = 14.8 Hz, 8.9 Hz, f); ^{13}C NMR (75 MHz, DMSO-d_6) δ 170.55 (e), 143.16 (d), 139.67 (i), 129.06 (j,j'), 128.55 (b,b'), 128.32 (k,k'), 126.64 (l), 123.40 (a), 119.45 (c,c'), 65.84 (h), 44.92(f); IR (neat) 3365 (O-H stretch), 3254, 3191 (N-H stretch), 1667 (C=O stretch), 1607, 1597, 1550 (N-H bend), 1498, 1443, 1316 (C-O stretch), 1254 (C-N stretch), 1189, 1132, 960, 852, 756 cm^{-1}; HRMS (CI) calcd. for $C_{16}H_{18}NO_2$ (M+H): 256.1338, found 256.1337 *m/z*.

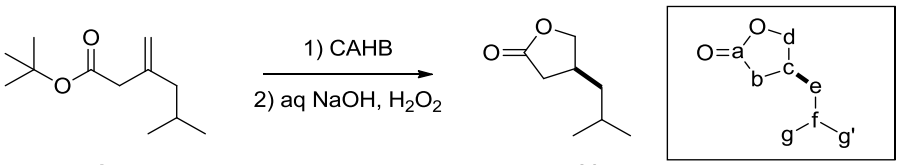
(*R*)-3-(Hydroxymethyl)-6-phenylhexanoic acid phenyl amide: Using the general procedure, *γ*-dioxaborato amide (*R*)-**8d** (41 mg, 0.10 mmol) affords, after flash chromatography on silica gel (80–40:20–60 hexanes:ethyl acetate), the title compound (29 mg, 98%) as a white solid: mp 78.5–80 ºC; TLC analysis R_f 0.5 (30:70 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = +4.1º (*c* 0.5, $CHCl_3$); Chiral HPLC analysis (Chiralpak-IC, 90:10 hexanes:isopropanol) showed peaks at 35 minutes (4.0% (S)) and 37 minutes (96.0% (R)); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.58 (1H, br s, NH), 7.50 (2H, d, *J* = 7.9 Hz, m,m'), 7.40–7.30 (2H, m, c,c'), 7.30–7.25 (2H, m, b,b'), 7.25–7.15 (3H, m, n,n',o), 7.13 (1H, t, *J* = 7.5 Hz, a), 3.77 (1H, dd, *J* = 10.9 and 4.0 Hz, h), 3.58 (1H, dd, *J* = 10.9 and 6.7 Hz, h), 2.64 (2H, t, *J* = 7.3 Hz, k), 2.50–2.40 (2H, m, f), 2.20–2.10 (1H, m, g), 1.80–1.60 (2H, m, i), 1.60–1.40 (2H, m, j); ^{13}C NMR (75 MHz, $CDCl_3$) δ 171.29 (e), 142.18 (d), 137.73 (l), 129.00 (b,b'), 128.39 (m,m'), 128.34 (n,n'), 125.81 (o), 124.41 (a), 119.96 (c,c'), 65.53 (h), 40.65 (f), 38.02 (g), 35.96 (k), 31.06 (i), 28.95 (j); IR (neat) 3714 (O-H stretch), 3040 (N-H stretch), 2890, 1680 (C=O stretch), 1601, 1590, 1545 (N-H bend), 1499, 1451, 1369, 1308 (C-O stretch), 1204 (C-N stretch), 1186, 1100, 1020, 990, 756 cm^{-1}; HRMS (CI) calcd. for $C_{19}H_{24}NO_2$ (M+H): 298.1807, found 298.1800 *m/z*.

(*S*)-3-Hydroxy-6-methylheptanoic acid phenyl amide. Using the general procedure, *γ*-dioxaborato amide (*S*)-**2** (35 mg, 0.10 mmol) affords, after flash chromatography on silica (80:20 hexanes:ethyl acetate), the title compound (23 mg, 98%) as a white solid: mp 130.2-131.7 ºC; TLC analysis R_f 0.4 (50:50 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = +6.8º (*c* 0.5, ethanol); chiral HPLC analysis (Chiralcel-ASH, 90:10 hexanes:isopropanol) showed peaks at 41.1 minutes (2.5% (R))

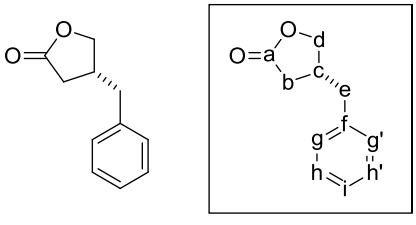
and 48.3 minutes (97.5% (S)); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.89 (1H, br s, NH), 7.52 (2H, d, *J* = 7.7 Hz, c,c'), 7.35 (2H, t, *J* = 7.6 Hz, b,b'), 7.14 (1H, t, *J* = 7.4 Hz, a), 4.15-4.00 (1H, m, g), 3.20 (1H, br s, OH), 2.58 and 2.49 (2H, overlapping dd's, J_1 = 15.5 Hz, 2.7 Hz, J_2 = 15.5 Hz, 8.8 Hz, f) 1.70-1.50 (3H, m, h,i), 1.40-1.30 (1H, m, i), 1.30-1.15 (1H, m, j), 0.92 (3H, d, *J* = 6.6 Hz, k), 0.91 (3H, d, *J* = 6.6 Hz, k'); ^{13}C NMR (100 MHz, $CDCl_3$) δ 170.56 (e), 137.59 (d), 129.04 (b,b'), 124.46 (a), 120.02 (c,c'), 69.15 (g), 43.78 (f), 34.85 (h), 34.59 (i), 28.00 (j), 22.61 (k), 22.52 (k'); IR (neat) 3286 (N-H stretch), 2953, 2869, 1663 (C=O stretch), 1598, 1548, 1442, 1314, 1256, 1079, 716, 692 cm^{-1}; HRMS (FAB) calcd. for $C_{14}H_{22}NO_2$ (M+H): 236.1651, found 236.1645 *m/z*.

General procedure for lactonization via one pot CAHB-oxidation with H_2O_2.



7i (*S*)-**20**

(*S*)-4-isobutylbutyrolactone ((*S*)-20):[14] After the CAHB of **7i** using the general procedure with (*S*,*S*)-**6**, the resultant mixture was diluted with THF (10 mL). Addition of sodium hydroxide (6 mL of a 3 M soln.) and H_2O_2 (0.6 mL of a 30% soln.) afforded a mixture which was allowed to stir for 2 h. Sodium metabisulfite (Na_2SO_5, 4 mL of a 10% soln.) was added and the resultant mixture was acidified (6 M HCl) and extracted with dichloromethane (3 x 15 mL). The combined organic extracts were dried (anhyd. Na_2SO_4) and concentrated under reduced pressure. Flash chromatography on silica gel (75:25 hexanes:ethyl acetate) affords the title compound (58.6 mg, 78%) as a light yellow oil: TLC analysis R_f 0.5 (75:25 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = –1.5° (*c* 0.5, $CHCl_3$); subsequent amidation[15] with $Al(Me)_3$ and aniline affords (*S*)-**17** which was used to determine the enantiomeric purity (91% ee) by chiral HPLC analysis; ^{1}H NMR (400 MHz, $CDCl_3$) δ 4.41 (1H, dd, J_1 = 8.8 Hz, J_2 = 8.1 Hz, d), 3.88 (1H, dd, J_1 = 8.9 Hz, J_2 = 8.6 Hz, d), 2.70–2.55 (2H, m, b), 2.25–2.10 (1H, m, c), 1.65–1.50 (1H, m, f), 1.36 (2H, t, *J* = 7.1 Hz, e), 0.93 (3H, t, *J* = 6.6 Hz, g), 0.90 (3H, t, *J* = 6.6 Hz, g'); ^{13}C NMR (100 MHz, $CDCl_3$) δ 177.22 (a), 73.56 (d), 42.21 (e), 34.76 (b), 33.83 (c), 26.28 (f), 22.64 (g), 22.40 (g'); IR (neat) 2956, 2903, 1773 (C=O stretch), 1469, 1420, 1367, 1216, 1168 (C-O stretch), 1011, 913, 838, 730, 646, 557 cm^{-1}.



(*R*)-**22a**

[14] T. Ok, A. Jeon, J. Lee, J. H. Lim, C. S. Hong, H. –S. Lee, *J. Org. Chem.* **2007**, *72*, 7390–7393.
[15] For the amidation of esters, see reference 1.

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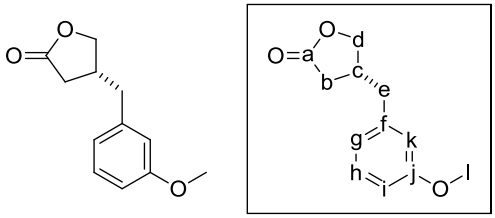
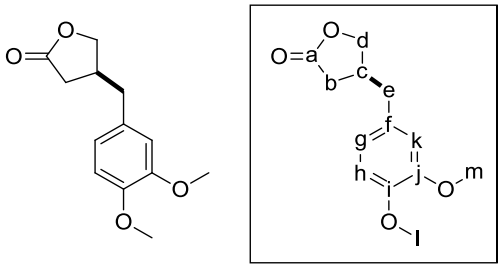
(*R*)-4-benzylbutyrolactone ((*R*)-22a):[16] Following the general procedure, *β*,*γ*-unsaturated ester **21a** (123 mg, 0.528 mmol) affords, after flash chromatography on silica gel (75:25 hexanes:ethyl acetate), the title compound (74.7 mg, 80%) as a light yellow oil: TLC analysis R_f 0.4 (75:25 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = +5.3° (*c* 0.5, $CHCl_3$); Chiral HPLC analysis (Chiralpak-AD, 95:5 hexanes:isopropanol) shows peaks at 36 minutes (97.5% (R)) and 40 minutes (2.5% (S)); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.34 (2H, t, *J* = 7.2 Hz, h,h'), 7.27 (1H, d, *J* = 6.9 Hz, i), 7.17 (2H, d, *J* = 7.3 Hz, g,g'), 4.35 (1H, dd, J_1 = 8.9 Hz, J_2 = 8.9 Hz, d), 4.05 (1H, dd, J_1 = 6.2 Hz, J_2 = 6.1 Hz, d), 2.95–2.85 (1H, m, c), 2.85–2.75 (2H, m, e), 2.62 (1H, dd, J_1 = 17.4 Hz, J_2 = 7.9 Hz, b), 2.31 (1H, dd, J_1 = 17.4 Hz, J_2 = 6.9 Hz, b); ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.84 (a), 138.25 (f), 128.81 (g,g'), 128.67 (h,h'), 126.83 (i), 72.66 (d), 38.95 (e), 37.18 (b), 34.25 (c); IR (neat) 2963, 2909, 1773 (C=O stretch), 1496, 1417, 1257, 1166 (C-O stretch), 1088, 1012, 910, 797, 731, 699, 638, 531 cm^{-1}.



(*R*)-**22b**

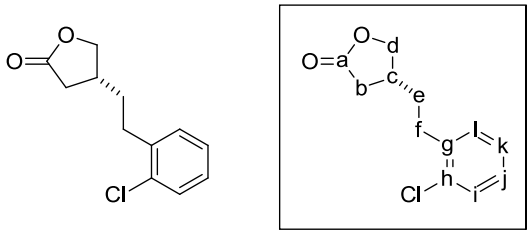
(*R*)-4-(3-Methoxyphenyl)methylbutyrolactone ((*R*)-22b):[17] Following the general procedure, *β*,*γ*-unsaturated ester **21b** (139 mg, 0.528 mmol) affords, after flash chromatography on silica gel (75:25 hexanes:ethyl acetate), the title compound (86.2 mg, 79%) as a light yellow oil: TLC analysis R_f 0.3 (75:25 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = +5.5° (*c* 0.5, $CHCl_3$); Chiral HPLC analysis (Chiralpak-AD, 90:10 hexanes:isopropanol) showed peaks at 31 minutes (97.5% (R)) and 34 minutes (2.5% (S)); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.25 (1H, t, *J* = 8.1 Hz, h), 6.85–6.80 (1H, m, i), 6.75 (1H, d, *J* = 7.5 Hz, g), 7.71 (1H, s, k), 4.35 (1H, dd, J_1 = 9.1 Hz, J_2 = 6.9 Hz, d), 4.05 (1H, dd, J_1 = 9.1 Hz, J_2 = 6.0 Hz, d), 3.82 (3H, s, l), 2.95–2.80 (1H, m, c), 2.80–2.75 (2H, m, e), 2.62 (1H, dd, J_1 = 17.4 Hz, J_2 = 7.9 Hz, b), 2.30 (1H, dd, J_1 = 17.4 Hz, J_2 = 6.9 Hz, b); ^{13}C NMR (75 MHz, $CDCl_3$) δ 176.80 (a), 159.91 (j), 139.81 (f), 129.82 (h), 120.97 (g), 114.64 (k), 111.86 (i), 72.64 (d), 55.20 (l), 38.97 (e), 37.07 (b), 34.26 (c); IR (neat) 2913, 1774 (C=O stretch), 1601, 1584, 1481, 1454, 1261, 1165 (C-O stretch), 1152 (C-O stretch), 1039, 1013, 909, 784, 727, 698, 647 cm^{-1}.



(*S*)-**22c**

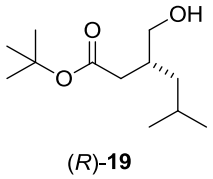
[16] G. Hughes, M. Kimura, S. L. Buchwald, *J. Am. Chem. Soc.* **2003**, *125*, 11253–11258.
[17] J. W. Bode, M. P. Doyle, M. N. Protopopova, Q. –L. Zhou, *J. Org. Chem.* **1996**, *61*, 9146–9155.

(*S*)-4-(3,4-Dimethoxyphenyl)methylbutyrolactone ((*S*)-22c):[17] Following the general procedure with (*S*,*S*)-**6**, *β*,*γ*-unsaturated ester **21c** (154 mg, 0.528 mmol) affords, after flash chromatography on silica gel (75:25 hexanes:ethyl acetate), the title compound (94.6 mg, 75%) as a light yellow oil: TLC analysis R_f 0.3 (75:25 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = –5.8° (*c* 0.5, $CHCl_3$); Chiral HPLC analysis (Chiralpak-AD, 90:10 hexanes:isopropanol) shows peaks at 30 minutes (4.0% (R)) and 34 minutes (96.0% (S)); ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.81 (1H, d, *J* = 8.1 Hz, h), 6.75–6.70 (1H, m, g), 6.67 (1H, s, k), 4.33 (1H, dd, J_1 = 9.0 Hz, J_2 = 7.0 Hz, d), 4.04 (1H, dd, J_1 = 9.0 Hz, J_2 = 6.1 Hz, d), 3.88 (3H, s, m), 3.87 (3H, s, l), 2.90–2.80 (1H, m, c), 2.80–2.65 (2H, m, e), 2.61 (1H, dd, J_1 = 17.5 Hz, J_2 = 8.1 Hz, b), 2.30 (1H, dd, J_1 = 17.5 Hz, J_2 = 6.8 Hz, e); ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.95 (a), 149.10 (j), 147.88 (i), 130.77 (f), 120.65 (g), 111.79 (k), 111.41 (h), 72.66 (d), 55.92 (l), 55.90 (m), 38.57 (e), 37.29 (b), 34.24 (c); IR (neat) 2908, 2836, 2253, 1770 (C=O stretch), 1514, 1464, 1418, 1262, 1234, 1158 (C-O stretch), 1139 (C-O stretch, 1014 (C-O stretch), 912, 805, 725, 646 cm^{-1}.

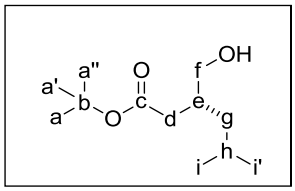


(*R*)-4-(2-(2-chlorophenyl)ethyl)butyrolactone: Following the general procedure, beta,gamma-unsaturated ester **12** (148 mg, 0.53 mmol) affords, after flash chromatography on silica gel (75:25 hexanes:ethyl acetate), the title compound (87 mg, 73%) as a light yellow oil: TLC analysis R_f 0.5 (75:25 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = +4.4° (*c* 0.5, $CHCl_3$); Chiral HPLC analysis (Chiralpak-AD, 90:10 hexanes:isopropanol) shows peaks at 25 minutes (95.0% (R)) and 28 minutes (5.0% (S)); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.40 (1H, m, j), 7.25–7.15 (3H, m, i,k,l), 4.45 (1H, dd, J_1 = 9.0 Hz, J_2 = 7.5 Hz, d), 3.99 (1H, dd, J_1 = 9.0 Hz, J_2 = 7.0 Hz, d), 2.85–2.75 (2H, m, f), 2.75–2.50 (2H, m, b), 2.30–2.20 (1H, m, c), 1.90–1.75 (2H, m, e); ^{13}C NMR (75 MHz, $CDCl_3$) δ 177.06 (a), 138.44 (g), 133.77 (h), 130.30 (i), 129.71 (j), 127.89 (k), 127.07 (l), 73.22 (d), 35.26 (e), 34.46 (b), 33.25 (f), 31.46 (c); IR (neat) 2923, 1771 (C=O stretch), 1474, 1170 (C-O stretch), 1050, 1020, 991, 908, 840, 752, 727, 680 cm^{-1}; HRMS (ESI) calcd. for $C_{12}H_{13}ClO_2$: 224.0604, found 224.0600 *m/z*.

<u>General procedure for one pot CAHB-oxidation of esters with $NaBO_3$.</u>



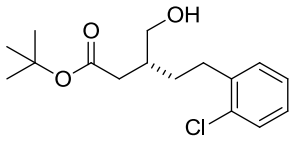
(*R*)-**19**



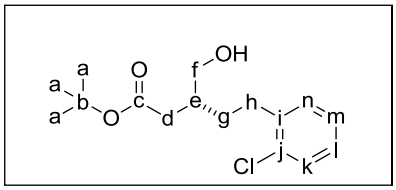
Preparation of (*R*)-3-hydroxymethyl-5-methylhexanoic acid *tert*-butyl ester ((*R*-19):[18] Following the general procedure for the CAHB of *β*,*γ*-unsaturated ester **7i**, the resultant reaction mixture was concentrated under reduced pressure and then taken up in THF (1.5 mL)

[18] A. Reichelt, C. Gaul, R. R. Frey, A. Kennedy, S. F. Martin, *J. Org. Chem.* **2002**, *67*, 4062–4075.

and H_2O (1.5 mL). $NaBO_3$-tetrahydrate (231 mg, 1.5 mmol) was added to the resulting mixture. After a 2 h vigorous stir, the reaction was diluted with H_2O (3 mL) and diethylether (5 mL). After separation of the organic and aqueous layers, the aqueous layer was extracted with diethylether (2 x 3 mL) and the combined organic extracts were dried (anhyd. Na_2SO_4) and concentrated under reduced pressure. The crude residue was purified via flash chromatography on silica gel (80–70:20–30 hexanes:dichloromethane) to afford the title compound (88 mg, 77%) as a light yellow oil: TLC analysis R_f 0.6 (50:50 hexanes:dichloromethane); $[\alpha]_D^{20}$ = +2.3° (*c* 0.5, $CHCl_3$); Subsequent amidation[11] with $Al(Me)_3$ and aniline affords (*R*)-**17** which was used to determine the enantiomeric purity (91% ee) by chiral HPLC analysis; ^{1}H NMR (300 MHz, $CDCl_3$) δ 3.70–3.60 (1H, m, f), 3.60–3.40 (1H, m, f), 2.28 (2H, dd, J_1 = 4.4 Hz, J_2 = 2.5 Hz, d), 2.16 (1H, br s, OH), 2.10–2.00 (1H, m, e), 1.70–1.60 (1H, m, h), 1.47 (9H, s, a,a',a"), 1.30–1.20 (2H, m, g), 0.92 (3H, d, *J* = 4.7 Hz, i), 0.90 (3H, d, *J* = 4.7 Hz, i'); ^{13}C NMR (75 MHz, $CDCl_3$) δ 173.32 (c), 80.62 (b), 66.07 (f), 40.43 (g), 38.46 (d), 35.71 (e), 28.08 (a,a',a"), 25.19 (h), 22.80 (i), 22.67 (i'); IR (neat) 3404 (O-H stretch), 2956, 2930, 1728 (C=O stretch), 1468, 1367, 1311 (C-O stretch), 1254, 1154, 1062, 959, 733 cm^{-1}.

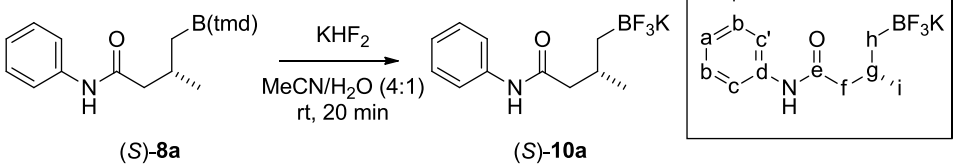


(*R*)-**15**



(*R*)-5-(2-Chlorophenyl)-3-hydroxymethylpentanoic acid *tert*-butyl ester ((*R*)-15): Using the general procedure, *β*,*γ*-unsaturated ester **12** (148 mg, 0.53 mmol) affords, after flash chromatography on silica gel (80–70:20–30 hexanes:dichloromethane), the title compound (115 mg, 73%) as a light yellow oil: TLC analysis R_f 0.6 (50:50 hexanes:dichloromethane); $[\alpha]_D^{20}$ = +4.5° (*c* 0.5, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.40–7.30 (1H, m, k), 7.25–7.10 (3H, m, l,m,n), 3.80–3.65 (1H, m, f), 3.65–3.55 (1H, m, f), 2.78 (2H, t, *J* = 8.2 Hz, h), 2.45–2.35 (2H, m, d), 2.29 (1H, br s, OH), 2.15–2.00 (1H, m, e), 1.80–1.60 (2H, m, g), 1.47 (9H, s, a,a',a"); ^{13}C NMR (75 MHz, $CDCl_3$) δ 173.04 (c), 139.69 (i), 133.79 (j), 130.27 (k), 129.49 (l), 127.38 (m), 126.85 (n), 80.76 (b), 65.49 (f), 38.03 (d), 37.78 (e), 31.30 (h), 31.03 (g), 28.09 (a,a',a"); IR (neat) 3437 (O-H stretch), 2930, 1720 (C=O stretch), 1474, 1456, 1367 (C- O stretch), 1148, 1051, 909, 751, 732 cm^{-1}; HRMS (EI) calcd. for $C_{16}H_{23}ClNaO_3$ (M+Na): 321.1233, found 321.1237 *m/z*.

General procedure for the preparation of trifluoroborate salts.[19]



(*S*)-**8a** (*S*)-**10a**

[19] G. A. Molander, I. Shin, L. Jean-Gérard, *Org. Lett.* **2010**, *12*, 4384–4387.

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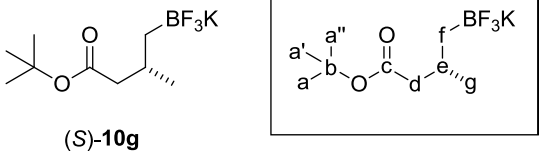
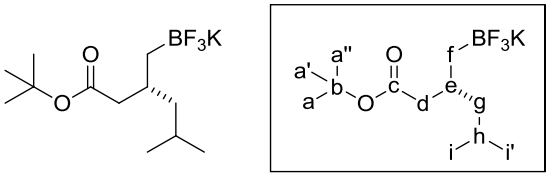
Preparation of (*S*)-4-trifluoroborato-3-methylbutanoic acid phenyl amide potassium salt ((*S*)-10a): To a solution of *γ*-dioxaborato amide (*S*)-**8a** (152 mg, 0.50 mmol, 1.0 equiv) in acetonitrile (MeCN, 1.0 mL) was slowly added a solution of KHF_2 (117 mg, 1.5 mmol, 3.0 equiv) in H_2O (0.3 mL). After a 20 min stir, the reaction mixture was concentrated under reduced pressure and allowed to dry under vacuum overnight. The resultant crude solid was extracted with acetone (2 x 2 mL) and the combined organic extracts were concentrated under reduced pressure. Diethyl ether (3.0 mL) was added to precipitate the product. Filtration affords the title compound (92 mg, 65%) as a white solid: mp 176.5–177.5 ºC; $[\alpha]_D^{20}$ = +5.7º (*c* 0.5, MeOH); ^{1}H NMR (300 MHz, MeOD) δ 7.55 (2H, d, *J* = 7.8 Hz, c,c'),7.29 (2H, t, *J* = 7.6 Hz, b,b'),7.07 (1H, t, *J* = 7.3 Hz, a), 2.55–2.40 (1H, m, f), 2.20–2.00 (2H, m, f,g), 1.01 (3H, d, *J* = 5.7 Hz, i), 0.45–0.20 (2H, m, h); ^{13}C NMR (75 MHz, MeOD) δ 174.37 (e), 138.61 (d), 128.27 (b,b'), 123.51 (a), 119.96 (c,c'), 28.54 (g),25.92 (h), and 22.02 (i); IR (neat) 3129 (N-H bend), 2975, 2898, 1728 (C=O stretch), 1545 (N-H bend), 1390, 1369, 1267 (C-N stretch), 1152, 1086, 960, 777 cm^{-1}; HRMS (CI) calcd. for $C_{11}H_{15}NO$ (M+H-BF_3K): 177.1153, found 177.1148 *m/z*.



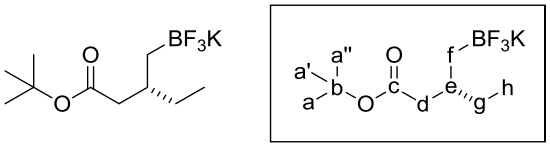
(*S*)-**10g**

(*S*)-4-Trifluoroborato-3-methylbutanoic acid *tert*-butyl ester potassium salt ((*S*)-10g): Using the general procedure, *γ*-dioxaborato ester (*S*)-**8g** (142 mg, 0.50 mmol) affords the title compound (82 mg, 62%) as a white solid: mp 176.0–178.0 ºC; $[\alpha]_D^{20}$ = +6.4º (*c* 0.5, MeOH); ^{1}H NMR (400 MHz, MeOD) δ 2.35 (1H, dd, *J* = 13.7 Hz, 5.2 Hz, d), 2.05–1.95 (1H, m, e), 1.91 (1H, dd, *J* = 13.7 Hz, 8.9 Hz, d), 1.46 (9H, s, a,a',a''), 0.94 (3H, d, *J* = 6.5 Hz, g), 0.35–0.15 (2H, m, f); ^{13}C NMR (100 MHz, MeOD) δ 174.97 (c), 79.46 (b), 45.73 (d), 27.88 (e), 27.05 (a,a',a''), 21.84 (g); IR (neat) 2983, 1727 (C=O stretch), 1457, 1368 (C-O stretch), 1274, 1152, 1099, 956, 918, 842, 769 cm^{-1}; HRMS (CI) calcd. for $C_9H_{17}O_2$ (M-BF_3K): 147.1214, found 147.1215 *m/z*.



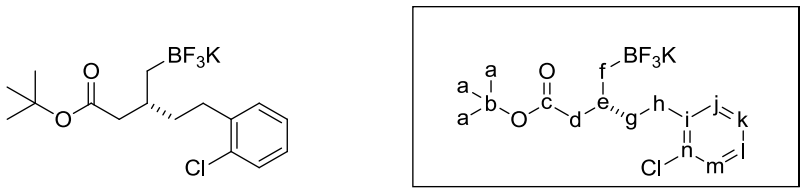
(*R*)-**10i**

(*R*)-5-Methyl-3-trifluoroboratomethylhexanoic acid *tert*-butyl ester potassium salt ((*R*)-10i): Using the general procedure, *γ*-dioxaborato ester (*R*)-**8i** (163 mg, 0.50 mmol) affords the title compound (146 mg, 75%) as a white solid: mp 179.0–179.5 ºC; $[\alpha]_D^{20}$ = +9.7º (*c* 0.5, MeOH); ^{1}H NMR (400 MHz, MeOD) δ 2.50–2.40 (1H, m, d), 2.05–1.95 (2H, m, d,e), 1.75–1.65 (1H, m, h), 1.46 (9H, s, a,a',a''), 1.25–1.15 (1H, m, g), 1.15–1.00 (1H, m, g), 0.88 (6H, t, *J* = 6.1 Hz, i,i'), 0.40–0.35 (1H, m, f), 0.15–0.05 (1H, m, f); ^{13}C NMR (100 MHz, MeOD) δ 175.30 (c), 79.38 (b), 46.83 (g), 43.06 (d), 30.23 (e), 27.07 (a,a',a''), 24.99 (h), 22.41 and 21.64 (i,i'); IR (neat) 2953, 2906, 1728 (C=O stretch), 1392, 1367 (C-O stretch), 1256, 1125, 1069, 974, 908, 759 cm^{-1}; HRMS (CI) calcd. for $C_{12}H_{23}O_2$ (M-BF_3K): 199.1698, found 199.1510 *m/z*.



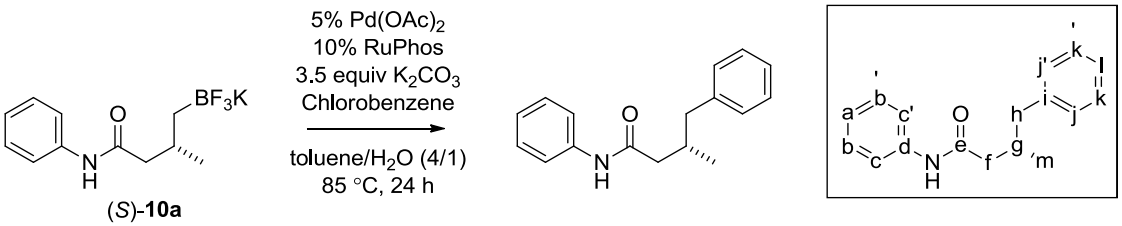
(*R*)-**10h**

(3*R*)-4-Trifluoroboratopentanoic acid *tert*-butyl ester potassium salt ((*R*)-10h): Using the general procedure, *γ*-dioxaborato ester (*R*)-**8h** (149 mg, 0.50 mmol) affords the title compound (86 mg, 62%) as a white solid: mp 174.5–176.0 ºC; $[\alpha]_D^{20}$ = +6.3º (*c* 0.5, MeOH); ^{1}H NMR (300 MHz, MeOD) δ 2.37 (1H, dd, *J* = 14.2 Hz, 5.6 Hz, d), 2.03 (1H, dd, *J* = 14.2 Hz, 8.6 Hz, d), 1.95–1.80 (1H, m, e), 1.45 (9H, s, a,a',a''), 1.34 (2H, t, *J* = 6.9 Hz, g), 0.87 (3H, t, *J* = 7.4 Hz, h), 0.40–0.25 (1H, m, f), 0.20–0.10 (1H, m, f); ^{13}C NMR (75 MHz, MeOD) δ 175.31 (c), 79.39 (b), 42.23 (d), 33.95 (e), 28.79 (g), 27.05 (a,a',a''), 22.69 (f), 9.96 (h); IR (neat) 2983, 1728 (C=O stretch), 1499, 1329 (C-O stretch), 1080, 1029, 966, 915, 751 cm^{-1}; HRMS (CI) calcd. for $C_{10}H_{19}O_2$ (M-BF_3K): 171.1386, found 171.1185 *m/z*.



(*R*)-5-(2-Chlorophenyl)-3-(trifluoroboratomethyl)pentanoic acid *tert*-butyl ester potassium salt: Using the general procedure, *γ*-dioxaborato ester (*R*)-**13** (204 mg, 0.50 mmol) affords the title compound (148 mg, 76%) as a white solid: mp 174.6–175.6 ºC; $[\alpha]_D^{20}$ = +6.9º (*c* 0.5, MeOH); ^{1}H NMR (300 MHz, MeOD) δ 7.35–7.25 (2H, m, l,m), 7.25–7.05 (2H, m, j,k), 2.85–2.60 (2H, m, h), 2.50 (1H, dd, *J* = 13.4 Hz, 4,3 Hz, d), 2.20–1.95 (2H, m, d,e), 1.70–1.50 (2H, m, g), 1.43 (9H, s, a,a',a''), 0.55–0.40 (1H, m, f), 0.35–0.15 (1H, m, f); ^{13}C NMR (75 MHz, MeOD) δ 174.97 (c), 141.01 (i), 133.35 (n), 130.27 (m), 128.81 (l), 126.63 (j), 126.46 (k), 79.48 (b), 42.68 (d), 36.78 (g), 32.50 and 32.47 (e), 30.41 (h), 27.02 (a,a',a''); IR (neat) 2978, 2922, 1703 (C=O stretch), 1474, 1391, 1310 (C-O stretch), 1260, 1030, 967, 953, 841, 777 cm^{-1}; HRMS (CI) calcd. for $C_{16}H_{22}ClO_2$ (M-BF_3K): 281.1308, found 281.1312 *m/z*.

General procedure for palladium-catalyzed C-C cross coupling of aryl- and heteroaryl halides with trifluoroborate salts.[19]



(*S*)-**10a**

Preparation of (*S*)-3-methyl-4-phenylbutanoic acid phenyl amide (Entry 1, Table 2): An 8 mL vial was charged with $Pd(OAc)_2$ (1.2 mg, 0.0050 mmol, 0.050 equiv), RuPhos (4.7 mg, 0.010 mmol, 0.10 equiv), K_2CO_3 (48.4 mg, 0.35 mmol, 3.5 equiv), *γ*-trifluoroborato amide (*S*)-**10a** (28.3 mg, 0.10 mmol, 1.0 equiv), toluene (0.4 mL), and H_2O (0.1 mL). To the resultant

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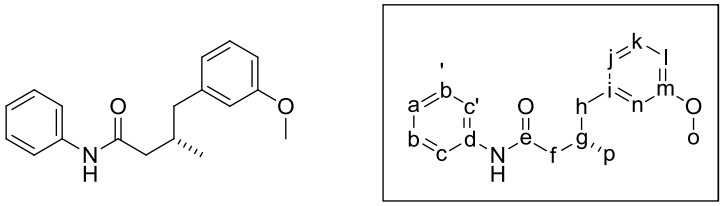
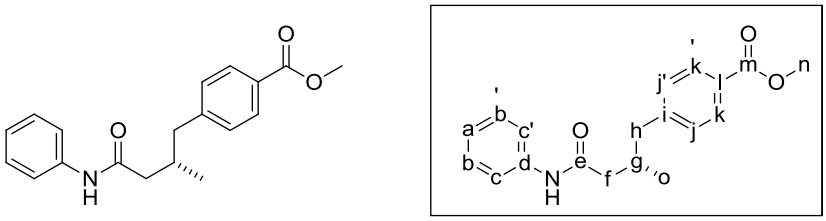
mixture was added chlorobenzene (13.5 mg, 0.12 mmol, 1.2 equiv) and the reaction mixture was raised to 85 °C. After allowing a 24 h stir, H_2O (1 mL) was added to the resultant mixture and extracted with ethyl acetate (2 x 1 mL). The combined organic extracts were dried (anhyd. Na_2SO_4) and concentrated under reduced pressure. Flash chromatography on silica gel (75:25 hexane:ethyl acetate) affords the title compound (20.5 mg, 81%) as a white solid: mp 59–60.5 ºC; TLC analysis R_f 0.4 (80:20 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = +6.5º (*c* 0.5, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.52 (2H, d, *J* = 8.0 Hz, c,c'), 7.40–7.25 (4H, m, j,j',k,k'), 7.25–7.15 (3H, m, b,b',l), 7.12 (1H, t, *J* = 6.9 Hz, a), 2.72 (1H, dd, *J* = 13.2 Hz, 6.4 Hz, h), 2.58 (1H, dd, *J* = 13.2 Hz, 6.8Hz, h), 2.50–2.35 (2H, m, f,g), 2.20–2.05 (1H, m, f), 1.04 (3H, d, *J* = 6.2 Hz, m); ^{13}C NMR (75 MHz, $CDCl_3$) δ 170.54 (e), 140.18 (i), 137.83 (d), 129.27 (b,b'), 129.01 (j,j'), 128.33 (k,k'), 126.11 (l), 124.24 (a), 119.78 (c,c'), 44.50 (h), 43.09 (f), 32.67 (g), 19.69 (m); IR (neat) 3292 (N-H stretch), 3062, 2924, 1657 (C=O stretch), 1600, 1544 (N-H bend), 1498, 1442, 1397, 1097 (C-N stretch), 1050, 754 cm^{-1}; HRMS (EI) calcd. for $C_{17}H_{19}NO$: 253.1467, found 253.1474 *m/z*.

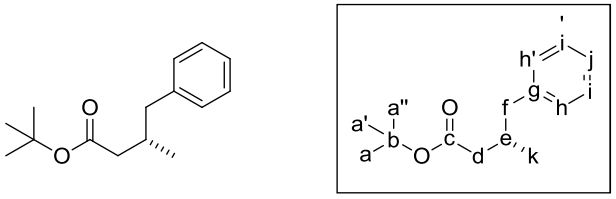


(*S*)-4-(3-Methoxyphenyl)-3-methylbutanoic acid phenyl amide (Entry 2, Table 2): Using the general procedure with SPhos (4.1 mg, 0.010 mmol, 0.10 equiv) and 3-bromoanisole (22.4 mg, 0.12 mmol, 1.2 equiv), *γ*-trifluoroborato amide (*S*)-**10a** (28.3 mg, 0.10 mmol, 1.0 equiv) affords, after flash chromatography on silica gel (75:25 hexanes:ethyl acetate), the title compound (20.1 mg, 71%) as a white solid: mp 65–66 ºC; TLC analysis R_f 0.4 (80:20 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = +2.9º (*c* 0.5, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.52 (2H, d, *J* = 7.9 Hz, c,c'), 7.33 (2H, t, *J* = 7.8 Hz, b,b'), 7.30–7.15 (2H, m, NH,k), 7.12 (1H, t, *J* = 7.5 Hz, a), 6.85–6.70 (3H, m, j,l,n), 3.81 (3H, s, o), 2.67 (1H, dd, *J* = 13.2 Hz, 6.5 Hz, h), 2.56 (1H, dd, *J* = 13.2 Hz, 6.9 Hz, h), 2.50–2.35 (2H, m, f,g), 2.20–2.05 (1H, m, f), 1.04 (3H, d, *J* = 6.2 Hz, m); ^{13}C NMR (75 MHz, $CDCl_3$) δ 170.59 (e), 159.58 (m), 141.83 (i), 137.85 (d), 129.29 (b,b'), 129.00 (k), 124.24 (a), 121.69 (j), 119.80 (c,c'), 114.96 (n), 111.38 (l), 55.11 (o), 44.48 (h), 43.14 (f), 32.58 (g), 19.69 (p); IR (neat) 3308 (N-H stretch), 2927, 1658 (C=O stretch), 1600, 1544 (N-H bend), 1499, 1441, 1322 (C-O stretch), 1260 (C-N stretch), 1153, 1069, 1043, 755 cm^{-1}; HRMS (EI) calcd. for $C_{18}H_{21}NO_2$: 283.1572, found 283.1573 *m/z*.

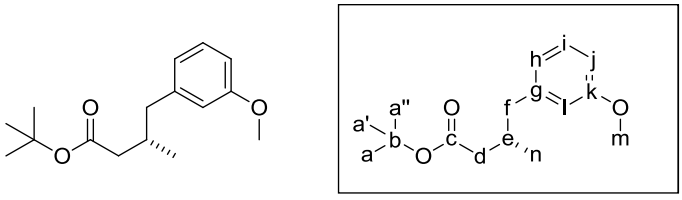


(*S*)-3-Methyl-4-(4-methylcarboxyphenyl)butanoic acid phenyl amide (Entry 3, Table 2): Using the general procedure with methyl-4-bromobenzoate (25.8 mg, 0.12 mmol, 1.2 equiv), *γ*-trifluoroborato amide (*S*)-**10a** (28.3 mg, 0.10 mmol, 1.0 equiv) affords, after flash chromatography on silica gel (75:25 hexanes:ethyl acetate), the title compound (21.8 mg, 70%)

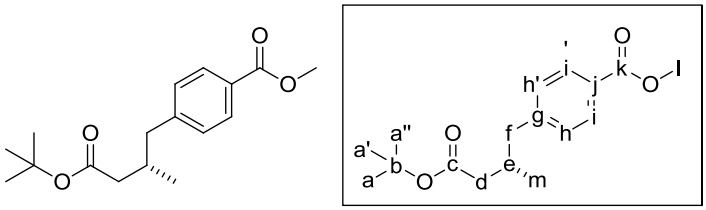
as a white solid: mp 68.5–69.5 ºC; TLC analysis R_f 0.4 (80:20 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = +8.0º (*c* 0.5, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.98 (2H, d, *J* = 7.9 Hz, k,k'), 7.52 (2H, d, *J* = 7.8 Hz, c,c'), 7.40–7.25 (4H, m, b,b',j,j'), 7.12 (1H, t, *J* = 7.3 Hz, a), 3.92 (3H, s, n), 2.81 (1H, dd, *J* = 13.1 Hz, 5.9 Hz, h), 2.60 (1H, dd, *J* = 13.1 Hz, 7.6 Hz, h), 2.55–2.40 (1H, m, g), 2.37 (1H, dd, *J* = 14.2 Hz, 5.9 Hz, f), 2.18 (1H, dd, *J* = 14.1 Hz, 7.7 Hz, f), 1.01 (3H, d, *J* = 6.4 Hz, o); ^{13}C NMR (75 MHz, $CDCl_3$) δ 170.13 (e), 167.13 (m), 145.80 (i), 137.74 (d), 129.70 (k,k'), 129.30 (b,b'), 129.03 (j,j'), 128.12 (l), 124.31 (a), 119.80 (c,c'), 52.02 (n), 44.38 (h), 42.95 (f), 32.43 (g), 19.57 (o); IR (neat) 3311 (N-H stretch), 2923, 1719 (C=O stretch), 1655, 1600, 1530 (N-H stretch), 1444, 1301 (C-O stretch) 1273, 1175 (C-N stretch), 1020, 868, 767 cm^{-1}; HRMS (ESI) calcd. for $C_{19}H_{21}NaNO_3$ (M+Na): 334.1419, found 334.1426 *m/z*.



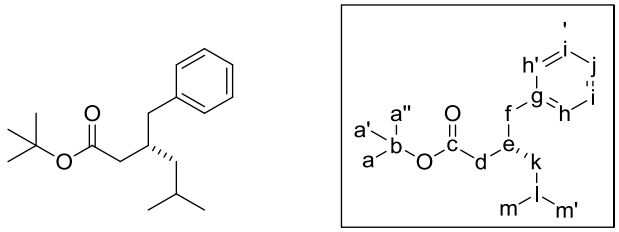
(*S*)-3-Methyl-4-phenylbutanoic acid *tert*-butyl ester (Entry 4, Table 2): Using the general procedure with chlorobenzene (13.5 mg, 0.12 mmol, 1.2 equiv), *γ*-trifluoroborato ester (*S*)-**10g** (26.4 mg, 0.10 mmol, 1.0 equiv) affords, after flash chromatography on silica gel (98:2 hexanes:ethyl acetate), the title compound (19.2 mg, 82%) as a colorless oil: TLC analysis R_f 0.7 (90:10 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = +3.0º (*c* 0.5, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.35–7.25 (2H, m, i,i'), 7.25–7.15 (3H, m, h,h',j), 2.67 (1H, dd, *J* = 13.4 Hz, 6.1 Hz, f), 2.49 (1H, dd, *J* = 13.4 Hz, 7.4 Hz, f), 2.30–2.20 (2H, m, d,e), 2.15–2.00 (1H, m, d), 1.48 (9H, s, a,a',a''), 0.95 (3H, d, *J* = 6.4 Hz, k); ^{13}C NMR (75 MHz, $CDCl_3$) δ 172.46 (c), 140.46 (g), 129.24 (i,i'), 128.22 (h,h'), 125.94 (j), 80.10 (b), 42.96 (f), 42.47 (d), 32.44 (e), 28.15 (a,a',a''), 19.41 (k); IR (neat) 2977, 1725 (C=O stretch), 1454, 1392, 1367 (C-O stretch), 1146, 1051, 755 cm^{-1}; HRMS (ESI) calcd. for $C_{15}H_{22}NaO_2$ (M+Na): 257.1518, found 257.1520 *m/z*.



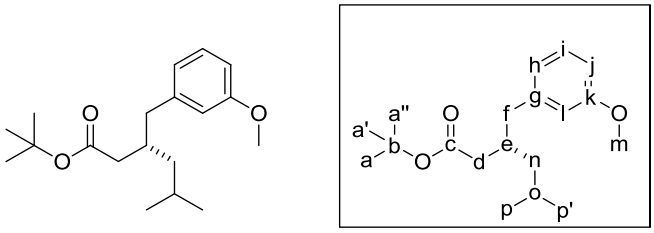
(*S*)-3-Methyl-4-(3-methoxyphenyl)butanoic acid *tert*-butyl ester (Entry 5, Table 2): Using the general procedure with 3-bromoanisole (22.4 mg, 0.12 mmol, 1.2 equiv), *γ*-trifluoroborato ester (*S*)-**10g** (26.4 mg, 0.10 mmol, 1.0 equiv) affords, after flash chromatography on silica gel (98:2 hexanes:ethyl acetate), the title compound (21.6 mg, 82%) as a colorless oil: TLC analysis R_f 0.6 (90:10 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = +3.2º (*c* 0.5, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.22 (1H, t, *J* = 7.8 Hz, i), 6.80–6.70 (3H, m, h,j,l), 3.82 (3H, s, m), 2.64 (1H, dd, *J* = 13.3 Hz, 6.1 Hz, f), 2.46 (1H, dd, *J* = 13.3, 7.4 Hz, f), 2.30–2.20 (2H, m, d,e), 2.15–2.00 (1H, m, d), 1.48 (9H, s, a,a',a''), 0.96 (3H, d, *J* = 6.3 Hz, n); ^{13}C NMR (100 MHz, $CDCl_3$) δ 172.45 (c), 159.54 (k), 142.10 (g), 129.15 (i), 121.70 (h), 114.94 (l), 111.25 (j), 80.11 (b), 55.13 (m), 43.01 (f), 42.48 (d), 32.36 (e), 28.15 (a,a',a''), 19.46 (n); IR (neat) 2929, 1725 (C=O stretch), 1601, 1584, 1455, 1366, 1316 (C-O stretch), 1260, 1044, 779 cm^{-1}; HRMS (EI) calcd. for $C_{16}H_{24}O_3$: 264.1725, found 264.1729 *m/z*.



(*S*)-3-Methyl-4-(4-methylcarboxyphenyl)butanoic acid *tert*-butyl ester (Entry 6, Table 2): Using the general procedure with methyl-4-bromobenzoate (25.8 mg, 0.12 mmol, 1.2 equiv), *γ*-trifluoroborato ester (*S*)-**10g** (26.4 mg, 0.10 mmol, 1.0 equiv) affords, after flash chromatography on silica gel (98:2 hexanes:ethyl acetate), the title compound (25.7 mg, 88%) as a colorless oil: TLC analysis R_f 0.7 (90:10 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = +2.6° (*c* 0.5, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.98 (2H, d, *J* = 8.2 Hz, i,i'), 7.26 (2H, d, *J* = 8.2 Hz, h,h'), 3.92 (3H, s, l), 2.73 (1H, dd, *J* = 13.3 Hz, 6.0 Hz, f), 2.53 (1H, dd, *J* = 13.3 Hz, 7.7 Hz, f), 2.35–2.20 (2H, m, d,e), 2.15–2.05 (1H, m, d), 1.47 (9H, s, a,a',a''), 0.94 (3H, d, *J* = 6.6 Hz, m); ^{13}C NMR (100 MHz, $CDCl_3$) δ 172.19 (c), 167.13 (k), 146.04 (g), 129.60 (i,i'), 129.25 (h,h'), 128.03 (j), 80.28 (b), 52.00 (l), 42.84 (f), 42.34 (d), 32.26 (e), 28.13 (a,a',a''), 19.36 (m); IR (neat) 2931, 1722 (C=O stretch), 1610, 1457, 1415, 1367 (C-O stretch), 1278, 1178, 1148, 1108, 667, 759 cm^{-1}; HRMS (ESI) calcd. for $C_{17}H_{24}NaO_4$ (M+Na): 315.1572, found 315.1566 *m/z*.



(*S*)-5-Methyl-3-phenylmethylhexanoic acid *tert*-butyl ester (Entry 7, Table 2): Using the general procedure with chlorobenzene (13.5 mg, 0.12 mmol, 1.2 equiv), *γ*-trifluoroborato ester (*R*)-**10i** (30.6 mg, 0.10 mmol, 1.0 equiv) affords, after flash chromatography on silica gel (98:2 hexanes:ethyl acetate), the title compound (22.1 mg, 80%) as a colorless oil: TLC analysis R_f 0.6 (90:10 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = +5.6° (*c* 0.5, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35–7.25 (2H, m, i,i'), 7.25–7.15 (3H, m, h,h',j), 2.67 (1H, dd, *J* = 13.5 Hz, 6.1 Hz, f), 2.56 (1H, dd, *J* = 13.5 Hz, 7.2 Hz, f), 2.30–2.15 (1H, m, e), 2.15–2.10 (2H, m, d), 1.80–1.65 (1H, m, l), 1.47 (9H, s, a,a',a''), 1.86 (2H, t, *J* = 6.9 Hz, k), 0.90 (6H, dd, *J* = 19.1 Hz, 6.6 Hz, m,m'); ^{13}C NMR (100 MHz, $CDCl_3$) δ 172.62 (c), 140.46 (g), 129.37 (i,i'), 128.20 (h,h'), 125.87 (j), 80.05 (b), 43.26 (k), 40.52 (f), 39.93 (d), 34.92 (e), 28.15 (a,a',a''), 25.17 (l), 22.79 and 22.65 (m,m'); IR (neat) 2955, 1727 (C=O stretch), 1454, 1391, 1366 (C-O stretch), 1299, 1256, 1146, 747 cm^{-1}; HRMS (ESI) calcd. for $C_{18}H_{28}NaO_2$ (M+Na): 299.1987, found 299.1974 *m/z*.



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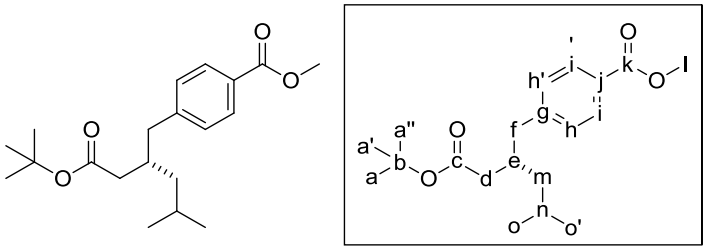
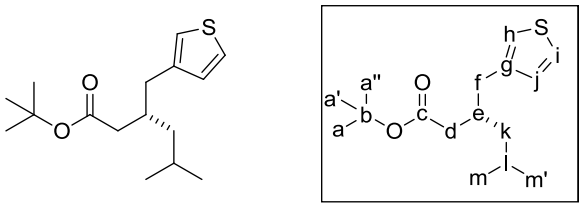
(*S*)-5-Methyl-3-(3-methoxyphenyl)methylhexanoic acid *tert*-butyl ester (Entry 8, Table 2): Using the general procedure with 3-bromoanisole (22.4 mg, 0.12 mmol, 1.2 equiv), *γ*-trifluoroborato ester (*R*)-**10i** (30.6 mg, 0.10 mmol, 1.0 equiv) affords, after flash chromatography on silica gel (98:2 hexanes:ethyl acetate), the title compound (28.2 mg, 92%) as a colorless oil: TLC analysis R_f 0.6 (90:10 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = +2.3° (*c* 0.5, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.22 (1H, t, *J* = 7.5 Hz, i), 6.85–6.70 (3H, m, h,j,l), 3.82 (3H, s, m), 2.65 (1H, dd, *J* = 13.5 Hz, 5.8 Hz, f), 2.53 (1H, dd, *J* = 13.5 Hz, 7.0 Hz, f), 2.30–2.05 (3H, m, d,e), 1.80–1.65 (1H, m, o), 1.47 (9H, s, a,a',a''), 1.19 (2H, t, *J* = 6.8 Hz, n), 0.90 (6H, dd, *J* = 12.7 Hz, 6.5 Hz, p,p'); ^{13}C NMR (75 MHz, $CDCl_3$) δ 172.60 (c), 159.52 (k), 142.11 (g), 129.12 (i), 121.83 (h), 115.11 (l), 111.17 (j), 80.05 (b), 55.12 (m), 43.28 (n), 40.55 (f), 39.94 (d), 34.81 (e), 28.14 (a,a',a''), 25.17 (o), 22.79 and 22.67 (p,p'); IR (neat) 2955, 1726 (C=O stretch), 1600, 1488, 1455, 1366 (C-O stretch), 1260, 1150, 1047, 777 cm^{-1}; HRMS (EI) calcd. for $C_{19}H_{30}O_3$: 306.2195, found 306.2207 *m/z*.



(*S*)-3-(4-Methylcarboxyphenyl)methyl-5-methylhexanoic acid *tert*-butyl ester (Entry 9, Table 2): Using the general procedure with methyl-4-bromobenzoate (25.8 mg, 0.12 mmol, 1.2 equiv), *γ*-trifluoroborato ester (*R*)-**10i** (30.6 mg, 0.10 mmol, 1.0 equiv) affords, after flash chromatography on silica gel (98:2 hexanes:ethyl acetate), the title compound (31.4 mg, 94%) as a colorless oil: TLC analysis R_f 0.7 (90:10 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = +4.1° (*c* 0.5, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97 (2H, d, *J* = 8.1 Hz, i,i'), 7.26 (2H, d, *J* = 8.1 Hz, h,h'), 3.92 (3H, s, l), 2.75–2.60 (2H, m, f), 2.30–2.15 (1H, m, e), 2.15–2.10 (2H, m, d), 1.75–1.60 (1H, m, n), 1.46 (9H, s, a,a',a''), 1.20–1.10 (2H, m, m), 0.88 (6H, dd, *J* = 21.3 Hz, 6.5 Hz, o,o'); ^{13}C NMR (100 MHz, $CDCl_3$) δ 172.35 (c), 167.16 (k), 146.17 (g), 129.57 (i,i'), 129.37 (h,h'), 127.96 (j), 80.24 (b), 51.98 (l), 43.19 (m), 40.58 (f), 39.78 (d), 34.80 (e), 28.13 (a,a',a''), 25.15 (n), 22.82 and 22.51 (o,o'); IR (neat) 2955, 1726 (C=O stretch), 1600, 1584, 1488, 1455, 1366 (C-O stretch), 1260, 1150, 1047, 851, 777 cm^{-1}; HRMS (ESI) calcd. for $C_{20}H_{30}NaO_4$ (M+Na): 357.2042, found 357.2028 *m/z*.



(*S*)-5-Methyl-3-(thiophen-3-yl)methylhexanoic acid *tert*-butyl ester (Entry 10, Table 2): Using the general procedure with 3-chlorothiophene (14.2 mg, 0.12 mmol, 1.2 equiv), *γ*-trifluoroborato ester (*R*)-**10i** (30.6 mg, 0.10 mmol, 1.0 equiv) affords, after flash chromatography on silica gel (98:2 hexanes:ethyl acetate), the title compound (27.7 mg, 98%) as a yellow oil: TLC analysis R_f 0.6 (90:10 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = +1.9° (*c* 0.5, $CHCl_3$); ^{1}H NMR (400

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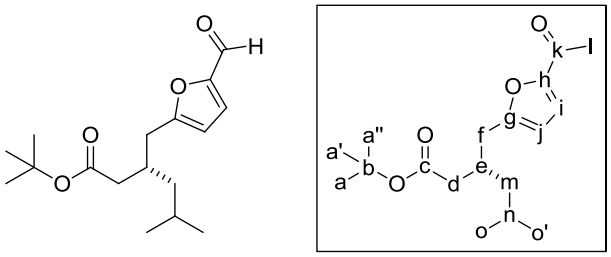
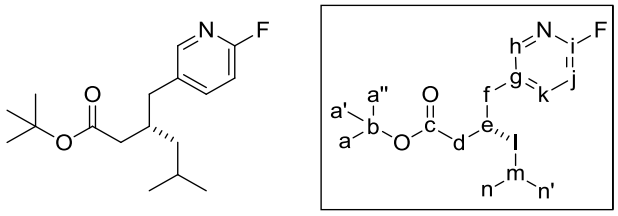
MHz, $CDCl_3$) δ 7.30–7.20 (1H, m, i), 7.00–6.90 (2H, m, h,j), 2.69 (1H, dd, *J* = 14.1 Hz, 5.6 Hz, f), 2.62 (1H, dd, *J* = 14.1 Hz, 6.7 Hz, f), 2.25–2.15 (1H, m, e), 2.15–2.05 (2H, m, d), 1.80–1.65 (1H, m, l), 1.48 (9H, s, a,a',a''), 1.25–1.10 (2H, m, k), 0.91 (6H, dd, *J* = 12.4 Hz, 6.6 Hz, m,m'); ^{13}C NMR (100 MHz, $CDCl_3$) δ 172.61 (c), 140.49 (g), 128.87 (j), 125.09 (i), 121.41 (h), 80.10 (b), 43.30 (k), 40.02 (d), 34.59 (f), 34.22 (e), 25.20 (a,a',a''), 25.20 (l), 22.77 and 22.72 (m,m'); IR (neat) 2956, 2928, 1725 (C=O stretch), 1455, 1391, 1366 (C-O stretch), 1298, 1255, 1146, 851, 772 cm^{-1}; HRMS (EI) calcd. for $C_{16}H_{26}OS$: 282.1653, found 282.1652 *m/z*.



(*S*)-3-(5-Acetylfuran-2-yl)methyl-5-methylhexanoic acid *tert*-butyl ester (Entry 11, Table 2): Using the general procedure with 5-chloro-2-furaldehyde (15.7 mg, 0.12 mmol, 1.2 equiv), *γ*-trifluoroborato ester (*R*)-**10i** (30.6 mg, 0.10 mmol, 1.0 equiv) affords, after flash chromatography on silica gel (94:6 hexanes:ethyl acetate), the title compound (24.7 mg, 84%) as a yellow oil: TLC analysis R_f 0.4 (90:10 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = +4.3° (*c* 0.5, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.55 (1H, s, l), 7.21 (1H, d, *J* = 3.3 Hz, i), 6.31 (1H, d, *J* = 3.3 Hz, j), 2.80–2.70 (2H, m, f), 2.40–2.25 (1H, m, e), 2.25–2.15 (2H, m, d), 1.75–1.60 (1H, m, n), 1.46 (9H, s, a,a',a''), 1.25–1.10 (2H, m, m), 0.90 (6H, dd, *J* = 8.3 Hz, 6.9 Hz, o,o'); ^{13}C NMR (100 MHz, $CDCl_3$) δ 177.17 (k), 172.00 (c), 162.14 (g), 152.04 (h), 110.32 (j), 80.56 (b), 43.28 (m), 39.78 (d), 32.86 (f), 32.43 (e), 28.11 (a,a',a''), 25.17 (l), 22.72 and 22.59 (o,o'); IR (neat) 2956, 1723 (C=O stretch), 1680 (C=O stretch), 1516, 1468, 1368 (C-O stretch), 1255, 1152, 1023, 960, 755 cm^{-1}; HRMS (EI) calcd. for $C_{17}H_{26}NaO_4$ (M+Na): 317.1729, found 317.1735 *m/z*.



(*S*)-3-(6-Fluoropyridin-3-yl)methyl-5-methylhexanoic acid *tert*-butyl ester (Entry 12, Table 2): Using the general procedure with 5-chloro-2-fluoropyridine (15.8 mg, 0.12 mmol, 1.2 equiv), *γ*-trifluoroborato ester (*R*)-**10i** (30.6 mg, 0.10 mmol, 1.0 equiv) affords, after flash chromatography on silica gel (92:8 hexanes:ethyl acetate), the title compound (15.1 mg, 51%) as a colorless oil: TLC analysis R_f 0.6 (90:10 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = +3.8° (*c* 0.5, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.02 (1H, s, k), 7.63 (1H, td, *J* = 8.1 Hz, 2.5 Hz, h), 6.88 (1H, dd, *J* = 8.3 Hz, 2.9 Hz, i), 2.61 (2H, d, *J* = 6.0 Hz, f), 2.20–2.05 (3H, m, d,e), 1.80–1.55 (1H, m, m), 1.46 (9H, s, a,a',a''), 1.20–1.10 (2H, m, l), 0.88 (6H, dd, *J* = 15.9 Hz, 6.5 Hz, n,n'); ^{13}C NMR (75 MHz, $CDCl_3$) δ 172.12 (c), 163.99 (j), 147.88 and 147.69 (k), 141.88 and 141.78 (h), 139.46 (g), 109.27 and 108.78 (i), 80.43 (b), 43.98 (l), 39.42 (d), 36.55 (f), 34.65 (e), 28.12 (a,a',a''), 25.13 (m), 22.88 and 22.38 (n,n'); IR (neat) 2958, 2929, 1724 (C=O stretch), 1593, 1484, 1451,

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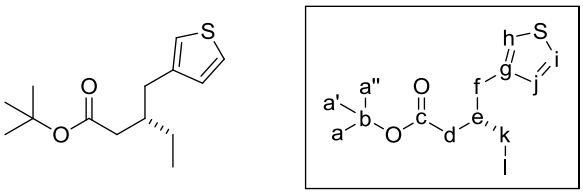
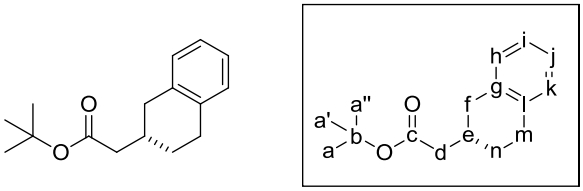
1394, 1367 (C-O stretch), 1249, 1201 (C-N stretch), 1109, 1024, 824, 759 cm^{-1}; HRMS (CI) calcd. for $C_{17}H_{27}FNO_2$ (M+H): 296.2026, found 296.2038 *m/z*.

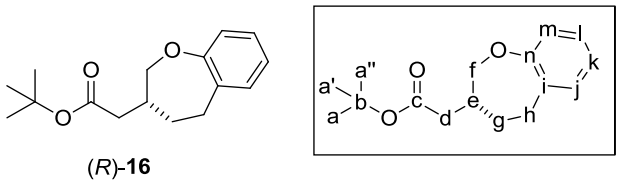


(*S*)-3-(Thiophen-3-yl)methylpentanoic acid *tert*-butyl ester (Entry 13, Table 2): Using the general procedure with 3-chlorothiophene (14.2 mg, 0.12 mmol, 1.2 equiv), *γ*-trifluoroborato ester (*R*)-**10h** (27.8 mg, 0.10 mmol, 1.0 equiv) affords, after flash chromatography on silica gel (98:2 hexanes:ethyl acetate), the title compound (20.4 mg, 80%) as a colorless oil: TLC analysis R_f 0.6 (90:10 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = +1.8° (*c* 0.5, CHCl); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.26 (1H, dd, *J* = 4.7 Hz, 3.2 Hz, i), 7.00–6.90 (2H, m, h,j), 2.75–2.55 (2H, m, f), 2.20–2.15 (2H, m, d), 2.15–2.00 (1H, m, e), 1.47 (9H, s, a,a',a''), 1.45–1.25 (2H, m, k), 0.94 (3H, t, *J* = 7.4 Hz, l); ^{13}C NMR (75 MHz, $CDCl_3$) δ 172.71 (c), 140.64 (g), 128.80 (j), 125.11 (i), 121.31 (h), 80.10 (b), 39.40 (d), 37.95 (e), 34.02 (f), 28.15 (a,a',a''), 26.13 (k), 11.01 (l); IR (neat) 2964, 2929, 1726 (C=O stretch), 1459, 1366 (C-O stretch), 1255, 1144, 1090, 949, 850, 766, 693 cm^{-1}; HRMS (ESI) calcd. for $C_{14}H_{22}NaSO_2$ (M+Na): 277.1238, found 277.1245 *m/z*.



(*S*)-**14**

(*S*)-2-(1,2,3,4-Tetrahydronaphthalen-2-yl)acetic acid *tert*-butyl ester ((*S*)-14): Using the general procedure with (*R*)-5-(2-chlorophenyl)-3-(trifluoroboratomethyl)pentanoic acid *tert*-butyl ester potassium salt (38.9 mg, 0.10 mmol, 1.0 equiv) affords, after flash chromatography on silica gel (97:3 hexanes:ethyl acetate), the title compound (22.4 mg, 91%) as a colorless oil: TLC analysis R_f 0.6 (90:10 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = +1.7° (*c* 0.5, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.20–7.00 (4H, m, h,i,j,k), 2.95–2.80 (3H, m, f,m), 2.53 (1H, dd, *J* = 16.4 Hz, 9.9 Hz, f), 2.35–2.20 (3H, m, d,e), 2.05–1.95 (1H, m, n), 1.55–1.45 (1H, m, n), 1.50 (9H, s, a,a',a''); ^{13}C NMR (100 MHz, $CDCl_3$) δ 172.19 (c), 136.34 (l), 135.99 (g), 129.14 (h), 128.88 (k), 125.66 (i), 125.57 (j), 80.26 (b), 42.41 (d), 35.62 (f), 31.60 (e), 29.16 (n), 28.83 (m), 28.18 (a,a',a''); IR (neat) 2977, 2925, 1728 (C=O stretch), 1495, 1453, 1366 (C-O stretch), 1289, 1255, 1146, 1064, 1039, 744 cm^{-1}; HRMS (CI) calcd. for $C_{16}H_{23}O_2$ (M+H): 247.1698, found 247.1693 *m/z*.



(*R*)-**16**

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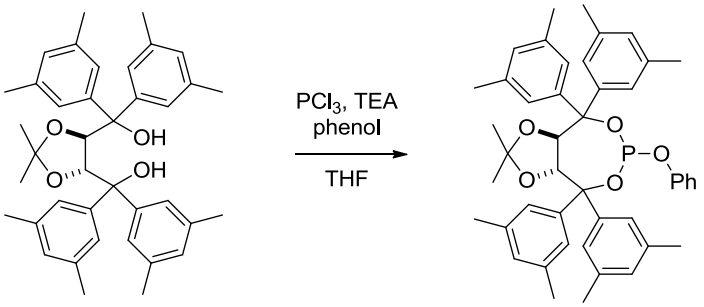
(*R*)-2-(2,3,4,5-Tetrahydrobenzo[*b*]oxepin-3-yl)acetic acid *tert*-butyl ester ((*R*)-16):[20] Using the general procedure with γ-hydroxy ester (*R*)-**15** (29.9 mg, 0.10 mmol) and no aryl halide, flash chromatography on silica gel (95:5 hexanes:ethyl acetate) affords the title compound (20 mg, 75%) as a colorless oil: TLC analysis R_f 0.6 (90:10 hexanes:ethyl acetate); $[\alpha]_D^{20}$ = +3.3° (*c* 0.5, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40–7.25 (3H, m, m,k,j), 7.05–6.95 (1H, m, l), 4.50–4.40 (1H, m, f), 4.05–3.95 (1H, m, f), 2.85–2.75 (2H, m, h), 2.55–2.45 (1H, m, e), 2.20–2.30 (2H, m, d), 1.90–1.80 (2H, m, g), 1.47 (9H, s, a,a',a"); ^{13}C NMR (75 MHz, $CDCl_3$) δ 173.04 (c), 139.69 (i), 133.79 (j), 130.27 (k), 129.49 (l), 127.38 (m), 126.85 (n), 80.76 (b), 65.49 (f), 38.03 (d), 37.78 (e), 31.30 (h), 31.03 (g), 28.09 (a,a',a"); IR (neat) 2954, 1723 (C=O stretch), 1610, 1415, 1367 (C-O stretch), 1277, 1178, 1148, 1110, 1020, 760 cm^{-1}; HRMS (CI) calcd. for $C_{16}H_{23}O_3$ (M+H): 263.1647, found 263.1652 *m/z*.

General procedures for the preparation of TADDOL-derived phosphite (*R*,*R*)-6 and dioxaborinane tmdBH (5).

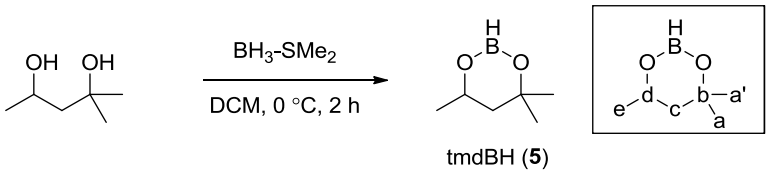


(*R*,*R*)-**6**

Preparation of 3,5-dimethylphenyl-(TADDOL)POPh ((*R*,*R*)-6). 3,5-Dimethylphenyl-(TADDOL) was prepared as previously described.[21] To a cooled solution (dry ice-acetone bath, -78 °C) of 3,5-imethyl-TADDOL (500 mg, 0.864 mmol) and triethylamine (TEA, 0.30 mL, 2.16 mmol) in dry, oxygen-free THF (35 mL) was added PCl_3 (0.07 mL, 0.86 mmol) in one portion. The resulting mixture was allowed to slowly warm to room temperature and stir over a total of ca. 12 h. Afterwards, the reaction mixture was filtered and the volatiles were removed on a vacuum line. The residue was dissolved in THF (5 mL) and the resulting solution added (rapid addition) to a mixture of phenol (105.7 mg, 1.123 mmol) and TEA (0.18 mL, 1.3 mmol) in THF (35 mL). The resulting mixture was allowed to stir at room temperature for ca. 12 h. The resulting mixture was filtered and the volatiles were removed on a vacuum line. Flash chromatography on silica gel (97:3 hexanes:ethyl acetate) affords the title compound (412.0 mg, 68%) as a white foamy solid: mp 97.0-98.2 °C; TLC analysis R_f 0.8 (95:5 hexanes: ethyl acetate); $[\alpha]_D^{20}$ = -120.0° (*c* 0.5, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35-7.20 (6H, m), 7.15-7.05 (5H, m), 6.99 (2H, d, *J* = 10.5 Hz), 6.90 (2H, s), 6.86 (2H, d, *J* = 7.6 Hz), 5.33 (1H, d, *J* = 8.2 Hz), 5.17 (1H, d, *J* = 8.2 Hz), 2.40 (6H, s), 2.37 (6H, s), 2.32 (6H, s), 2.92 (6H, s), 0.99 (3H, s), 0.74 (3H, s); ^{13}C NMR (100 MHz, $CDCl_3$) δ 152.16 (J_{CP} = 2.9 Hz), 146.10 (J_{CP} = 2.0 Hz), 145.83, 141.23 (3.0 Hz), 141.02, 137.37, 136.99, 136.50, 136.29, 129.45, 129.07, 128.94, 128.78, 126.89, 126.84, 125.10, 125.08, 123.33, 120.89, 120.81, 112.65, 85.51 (J_{CP} = 8.1 Hz), 84.64 (J_{CP}

[20] S. –i. Kuwabe, K. E. Torraca, S. L. Buchwald, *J. Am. Chem. Soc.* **2001**, *123*, 12202–12206.
[21] D. Seebach, R. Dahinden, R. E. Marti, A. K. Beck, D. A. Plattner, F. N. M. Kuhnle, *J. Org. Chem.* **1995**, *60*, 1788–1799.

= 4.2 Hz), 82.34 (J_{CP} = 13.8 Hz), 81.28 (J_{CP} = 4.8 Hz), 26.95, 26.48, 21.69, 21.59, 21.48 (overlapping peaks); ^{31}P NMR (162 MHz, $CDCl_3$) δ 129.36; IR (neat) 2916, 2863 (P-O stretching), 1595, 1489, 1455, 1370, 1213 (C-O-C stretch), 1159, 1035, 939, 853, 800, 761, 689 cm^{-1}; HRMS (FAB) calcd. for $C_{45}H_{49}O_5P$ (M+H): 701.3396, found 701.3409 *m/z*.



tmdBH (**5**)

Preparation of 4,4,6-trimethyl-1,3,2-dioxaborinane (tmdBH, 5). To a cooled (0 °C) solution of 2-methyl-2,4-pentanediol (1.54 g, 12 mmol) in dichloromethane (6 mL) was slowly added borane (BH_3, 1 mL of a 10 M solution in dimethylsulfide, 10 mmol) dropwise. After the resulting mixture was stirred for 1.5 h at the same temperature, the ice bath was removed and the reaction was allowed to stir for an additional 0.5 h. Volatiles were carefully removed under reduced pressure (i.e., concentration via rotovap while the mixture was submerged in a room temperature water bath). After complete removal of dichloromethane and dimethylsulfide (SMe_2), the residue was purified via bulb-to-bulb distillation (160–165 °C) to afford the title compound (960 mg, 75%) as a colorless liquid: ^{1}H NMR (300 MHz, $CDCl_3$) δ 4.30–4.15 (1H, m, d), 3.84 (1H, q, *J* = 155.6 Hz, BH), 1.90–1.75 (1H, m, c), 1.60–1.45 (1H, m, c), 1.31 (3H, s, a), 1.29 (3H, s, a'), 1.26 (3H, d, *J* = 6.2 Hz, e); ^{13}C NMR (75 MHz, $CDCl_3$) δ 70.99 (b), 64.73 (d), 46.17 (c), 31.02 (a), 28.14 (a'), 22.93 (e); ^{11}B NMR (193 MHz, THF with residual $CDCl_3$) δ 24.96 (d, *J* = 169.1 Hz); IR (neat) 2976 (CH sp^3 stretch), 2879, 2400, 1495, 1427, 1384, 1291, 1156 (C-O stretch), 1094, 1024, 889, 789, 666 cm^{-1}; HRMS (CI) calcd. for $C_6H_{14}BO_2$ (M+H): 129.1087, found 129.1082 *m/z*.