An Unusual β -Vinyl Effect Leading to High Efficiency and Enantioselectivity of the Amidase, Nitrile Biotransformations for the Preparation of Enantiopure 3- Arylpent-4-enoic Acids and Amides and Their Applications in Synthesis

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1. Preparation and spectroscopic data of racemic nitriles

Racemic nitriles **1** were prepared from the functional group transformations of racemic 3-arylpentonic acids.¹

3-Phenyl-pent-4-ene nitrile **1a**: oil; ¹HNMR (CDCl₃/300MHz) δ 7.37-7.21 (m, 5H), 6.02 (ddd, 1H, *J* = 17.2, 10.4, 6.9 Hz), 5.26-5.17 (m, 2H), 3.69 (app q, 1H, *J* = 7.1 Hz), 2.72 (dd, 1H, *J* = 16.7, 7.3 Hz), 2.69 (dd, 1H, *J* = 16.7, 7.1 Hz); ¹³CNMR (75MHz/CDCl₃) δ 140.4, 137.9, 129.0, 127.6, 127.4, 118.3, 116.9, 45.5, 23.9; IR (KBr) 2249 (CN), 1639 cm⁻¹.

3-(*p*-Methoxyphenyl)-pent-4-ene nitrile **1b**: oil; ¹HNMR (CDCl₃/300MHz) δ 7.15 (d, 2H, *J* = 6.7 Hz), 6.89 (d, 2H, *J* = 5.1 Hz), 6.01 (ddd, 1H, *J* = 17.1, 10.4, 6.8 Hz), 5.25-5.14 (m, 2H), 3.79 (s, 3H), 3.65 (app q, 1H, *J* = 7.1 Hz), 2.70 (dd, 1H, *J* = 16.6, 7.2 Hz), 2.67 (dd, 1H, *J* = 16.6, 7.2 Hz); ¹³CNMR (75MHz/CDCl₃) δ 158.9, 138.2, 132.4, 128.4, 118.4, 116.5, 114.3, 55.3, 44.7, 24.1; IR (KBr) 2249 (CN), 1610 cm⁻¹.

3-(*p*-Methylphenyl)-pent-4-ene nitrile **1c**: oil; ¹HNMR (CDCl₃/300MHz) δ 7.17 (d, 2H, *J* = 8.2 Hz), 7.11 (d, 2H, *J* = 8.2 Hz), 6.02 (ddd, 1H, *J* = 17.2, 10.4, 6.9 Hz), 5.25-5.16 (m, 2H), 3.66 (app q, 1H, *J* = 7.1 Hz), 2.72 (dd, 1H, *J* = 16.7, 7.3 Hz), 2.69 (dd, 1H, *J* = 16.7, 7.1 Hz), 2.33 (s, 3H); ¹³CNMR (75MHz/CDCl₃) δ 138.1, 137.4, 137.3, 129.6, 127.2, 118.3, 116.6, 45.5, 24.0, 21.0; IR (KBr) 2249 (CN), 1639 cm⁻¹.

3-(*p*-Fluorophenyl)-pent-4-ene nitrile **1d**: oil; ¹HNMR (CDCl₃/300MHz) δ 7.26-7.02 (m, 4H), 6.01 (ddd, 1H, *J* = 17.1, 10.4, 6.7 Hz), 5.29-5.16 (m, 2H), 3.70 (app q, 1H, *J* = 7.0 Hz), 2.73 (dd, 1H, *J* = 16.6, 7.1 Hz), 2.69 (dd, 1H, *J* = 16.6, 7.2 Hz); ¹³CNMR (75MHz/CDCl₃) δ 162.1 (d, *J* = 244.8 Hz), 137.6, 136.0 (d, *J* = 3.2 Hz), 129.0 (d, *J* = 8.1 Hz), 118.0, 117.0, 115.9 (d, *J* = 21.3 Hz), 44.7, 24.1; IR (KBr) 2250 (CN), 1640 cm⁻¹.

3-(*p*-Chlorophenyl)-pent-4-ene nitrile **1e**: oil; ¹HNMR (CDCl₃/300MHz) δ 7.33 (d, 2H, *J* = 8.5 Hz), 7.18 (d, 2H, *J* = 8.5 Hz), 6.00 (ddd, 1H, *J* = 17.1, 10.4, 6.8 Hz), 5.29-5.17 (m, 2H), 3.69 (app q, 1H, *J* = 7.0 Hz), 2.73 (dd, 1H, *J* = 16.6, 7.1 Hz), 2.69 (dd, 1H, *J* = 16.6, 7.1 Hz); ¹³CNMR (75MHz/CDCl₃) δ 138.7, 137.3, 133.5, 129.1, 128.8, 117.9, 117.3, 44.8, 23.9; IR (KBr) 2250 (CN), 1640 cm⁻¹.

3-(*m*-Chlorophenyl)-pent-4-ene nitrile **1f**: oil; ^1H NMR (CDCl_3 /300MHz) δ 7.36-7.14 (m, 4H), 6.03 (ddd, 1H, J = 17.2, 10.4, 6.9Hz), 5.34-5.22 (m, 2H), 3.71 (app q, 1H, J = 7.1Hz), 2.77 (dd, 1H, J = 16.6, 7.1 Hz), 2.74 (dd, 1H, J = 16.7, 7.2 Hz); ^{13}C NMR (75MHz/ CDCl_3) δ 142.3, 137.0, 134.8, 130.3, 127.9, 127.6, 125.6, 117.8, 117.5, 45.1, 23.8; IR (KBr) 2250 (CN), 1639 cm^{-1} .

3-(*o*-Chlorophenyl)-pent-4-ene nitrile **1g**: oil; ^1H NMR (CDCl_3 /300MHz) δ 7.42-7.21 (m, 4H), 6.05 (ddd, 1H, J = 17.1, 10.4, 6.6 Hz), 5.35-5.25 (m, 2H), 4.26 (app q, 1H, J = 6.5 Hz), 2.79 (dd, 1H, J = 16.8, 6.2 Hz), 2.76(dd, 1H, J = 16.8, 7.2 Hz); ^{13}C NMR (75MHz/ CDCl_3) δ 137.7, 136.1, 133.6, 130.1, 128.8, 128.4, 127.4, 117.8, 117.7, 41.2, 22.4; IR (KBr) 2250 (CN), 1639 cm^{-1} .

3-(*p*-Bromophenyl)-pent-4-ene nitrile **1h**: oil; ^1H NMR (CDCl_3 /300MHz) δ 7.49 (d, 2H, J = 8.4Hz), 7.12 (d, 2H, J = 8.4 Hz), 5.99 (ddd, 1H, J = 17.1, 10.4, 6.8 Hz), 5.30-5.17 (m, 2H), 3.67 (app q, 1H, J = 7.0 Hz), 2.73 (dd, 1H, J = 16.6, 7.1 Hz), 2.69 (dd, 1H, J = 16.7, 7.2 Hz); ^{13}C NMR (75MHz/ CDCl_3) δ 139.3, 137.2, 132.1, 129.1, 121.6, 117.9, 117.3, 44.9, 23.8; IR (KBr) 2250 (CN), 1640 cm^{-1} .

3-Phenyl-pentane nitrile **4**: oil; ^1H NMR (CDCl_3 /300MHz) δ 7.40-7.23 (m, 5H), 2.88 (q, 1H, J = 8.2 Hz), 2.63 (d, 2H, J = 6.9 Hz), 1.97-1.74 (m, 2H), 0.88 (t, 3H, J = 7.3 Hz); ^{13}C NMR (75MHz/ CDCl_3) δ 141.7, 128.8, 127.4, 127.2, 118.7, 43.9, 28.0, 24.8, 11.8; IR (KBr) 2247 (CN) cm^{-1} .

2. Spectroscopic data of biotransformation products

(S)-(-)-3-Phenyl-4-pentenamide **2a**: mp 77-78°C; $[\alpha]_{\text{D}}^{25}$ = -12.0 (c 2.0, CHCl_3); ee 96.0% (chiral HPLC); ^1H NMR (CDCl_3 /300MHz) δ 7.48-7.20 (m, 5H), 6.02 (ddd, 1H, J = 16.9, 10.8, 6.9 Hz), 5.32 (br s, 2H), 5.13-5.07 (m, 2H), 3.88 (app q, 1H, J = 7.3 Hz), 2.66 (dd, 1H, J = 14.4, 7.6 Hz), 2.60 (dd, 1H, J = 14.4, 7.6 Hz); ^{13}C NMR (75MHz/ CDCl_3) δ 173.3, 142.6, 140.4, 128.7, 127.6, 126.8, 115.1, 45.8, 42.0; IR (KBr) 3406, 3222 (CONH_2), 1635, 1617 cm^{-1} ; MS (EI) m/z 176 ($\text{M}^+ + 1$, 7), 175 (M^+ , 51%), 174 ($\text{M}^+ - 1$, 18) 160 (9), 158 (16), 131 (31), 117 (100), 115 (38), 91(28). Anal. Calcd. for $\text{C}_{11}\text{H}_{13}\text{NO}$: C, 75.40; H, 7.48; N, 7.99. Found: C, 75.19; H, 7.45; N, 8.08.

(R)-(+)-3-Phenyl-4-pentenoic acid (R)-**3a**: oil;² $[\alpha]_{\text{D}}^{25}$ = +18.6 (c 1.1, CHCl_3); ee 97.6% (chiral HPLC); ^1H NMR (CDCl_3 /300MHz) δ 10.43 (br s, 1H), 7.37-7.23 (m, 5H), 6.01 (ddd, 1H, J = 17.3, 9.9, 6.9 Hz), 5.14-5.09 (m, 2H), 3.89 (app q, 1H, J = 7.5 Hz), 2.84 (dd, 1H, J = 15.6, 7.9 Hz), 2.77 (dd, 1H, J = 15.6,

7.9Hz); ^{13}C NMR (75MHz/ CDCl_3) δ 178.4, 142.2, 140.0, 128.7, 127.5, 126.8, 115.1, 45.2, 40.0; IR (KBr) 3040-2545 (br, COOH), 1707 cm^{-1} ; MS (EI) m/z 177 ($\text{M}^+ + 1$, 8), 176 (M^+ , 75%), 158 (10), 131 (17), 130 (51), 117 (100), 115 (80), 91 (25). Anal. Calcd. for $\text{C}_{11}\text{H}_{12}\text{O}_2$: C, 74.98; H, 6.86. Found: C, 74.83; H, 6.87.

(S)-(-)-3-(*p*-Methoxyphenyl)-4-pentenamide **2b**: mp $123\text{ }^\circ\text{C}$ $[\alpha]_{\text{D}}^{25} = -12.0$ (c 2.0, CHCl_3); ee > 99.5% (chiral HPLC); ^1H NMR (CDCl_3 /300MHz) δ 7.17 (d, 2H, $J = 6.6\text{ Hz}$), 6.88 (d, 2H, $J = 6.7\text{ Hz}$), 6.02 (ddd, 1H, $J = 17.1, 10.5, 6.8\text{ Hz}$), 5.30 (br s, 2H, CONH_2), 5.13-5.06 (m, 2H), 3.85 (app q, 1H, $J = 7.3\text{ Hz}$), 3.81 (s, 3H), 2.66 (dd, 1H, $J = 14.4, 7.3\text{ Hz}$), 2.58 (dd, 1H, $J = 14.4, 7.8\text{ Hz}$); ^{13}C NMR (75MHz/ CDCl_3) δ 173.4, 158.4, 140.7, 134.5, 128.6, 114.7, 114.1, 55.3, 44.9, 42.1; IR (KBr) 3404, 3194 (CONH_2), 1652 cm^{-1} ; MS (EI) m/z 206 ($\text{M}^+ + 1$, 7), 205 (M^+ , 58%), 188 (6), 187 (8), 161 (19), 160 (19), 147 (100). Anal. Calcd. for $\text{C}_{12}\text{H}_{15}\text{NO}_2$: C, 70.22; H, 7.37; N, 6.82. Found: C, 70.16; H, 7.34; N, 6.84.

(R)-(+)-3-(*p*-Methoxyphenyl)-4-pentenoic acid **3b**: mp $58\text{-}59\text{ }^\circ\text{C}$; $[\alpha]_{\text{D}}^{25} = +27.0$ (c 2.0, CHCl_3); ee 92.8% (chiral HPLC); ^1H NMR (CDCl_3 /300MHz) δ 10.95 (br s, 1H), 7.13 (d, 2H, $J = 8.7\text{ Hz}$), 6.85 (d, 2H, $J = 8.7\text{ Hz}$), 5.96 (ddd, 1H, $J = 16.5, 10.9, 6.8\text{ Hz}$), 5.09-5.03 (m, 2H), 3.82-3.79 (m, s, 4H, CH and CH_3O), 2.77 (dd, 1H, $J = 15.5, 7.9\text{ Hz}$), 2.71 (dd, 1H, $J = 15.5, 7.5\text{ Hz}$); ^{13}C NMR (75MHz/ CDCl_3) δ 178.3, 158.4, 140.3, 134.2, 128.5, 114.7, 114.0, 55.3, 44.3, 40.1; IR (KBr) 3084-2603 (br, COOH), 1707, 1636 cm^{-1} ; MS (EI) m/z 207 ($\text{M}^+ + 1$, 6), 206 (M^+ , 58%), 147 (100). Anal. Calcd. for $\text{C}_{12}\text{H}_{14}\text{O}_3$: C, 69.88; H, 6.84. Found: C, 69.91; H, 6.90.

(S)-(-)-3-(*p*-Methylphenyl)-4-pentenamide **2c**: mp $101\text{-}102\text{ }^\circ\text{C}$; $[\alpha]_{\text{D}}^{25} = -6.5$ (c 4.0, CHCl_3); ee 94.0% (chiral HPLC); ^1H NMR (CDCl_3 /300MHz) δ 7.11 (s, 5H), 5.98 (ddd, 1H, $J = 16.7, 9.8, 6.9\text{ Hz}$), 6.07-5.50 (br d, 2H, CONH_2), 5.09-5.03 (m, 2H), 3.81 (app q, 1H, $J = 7.5\text{ Hz}$), 2.63 (dd, 1H, $J = 14.5, 7.7\text{ Hz}$), 2.58 (dd, 1H, $J = 14.5, 7.7\text{ Hz}$), 2.31 (s, 3H); ^{13}C NMR (75MHz/ CDCl_3) δ 174.2, 140.5, 139.4, 136.4, 129.4, 127.4, 114.9, 45.4, 41.9, 21.0; IR (KBr) 3392, 3179 (CONH_2), 1654 cm^{-1} ; MS (EI) m/z 190 ($\text{M}^+ + 1$, 10), 189 (M^+ , 90%), 188 ($\text{M}^+ - 1$, 29), 172 (26), 145 (56), 144 (37), 131 (100), 129 (46), 116

(27), 115 (30). Anal. Calcd. for $C_{12}H_{15}NO$: C, 76.16; H, 7.99; N, 7.40. Found: C, 76.36; H, 8.13; N, 7.46.

(R)-(+)-3-(*p*-Methylphenyl)-4-pentenoic acid **3c**: mp 54-55 °C; $[\alpha]_D^{25} = +20.0$ (*c* 2.0, $CHCl_3$); ee > 99.0% (chiral HPLC); 1H NMR ($CDCl_3$ /300MHz) δ 10.55 (br s, 1H), 7.13 (d, 2H, $J = 9.1$ Hz), 7.09(d, 2H, $J = 8.8$ Hz), 5.96 (ddd, 1H, $J = 17.1, 10.0, 6.9$ Hz), 5.10-5.04 (m, 2H), 3.82 (app q, 1H, $J = 7.2$ Hz), 2.77(dd, 1H, $J = 15.4, 7.9$ Hz), 2.72 (dd, 1H, $J = 15.5, 7.4$ Hz), 2.32 (s, 3H); ^{13}C NMR (75MHz/ $CDCl_3$) δ 178.2, 140.2, 139.1, 136.4, 129.4, 127.4, 114.8, 44.8, 40.0, 21.0; IR (KBr) 3076-2600 (br, COOH), 1703 cm^{-1} ; MS (EI) m/z 191 ($M^+ + 1$, 11), 190 (M^+ , 75%), 162 (9), 144 (9), 131 (100), 129(35), 116 (23), 115 (23), 91 (27). Anal. Calcd. for $C_{12}H_{14}O_2$: C, 75.76; H, 7.42. Found: C, 75.59; H, 7.44.

(S)-(-)-3-(*p*-Fluorophenyl)-4-pentenamide **2d**: mp 74-75 °C; $[\alpha]_D^{25} = -17.0$ (*c* 2.0, $CHCl_3$); ee > 99.5% (chiral HPLC); 1H NMR ($CDCl_3$ /300MHz) δ 7.20-6.96 (m, 4H), 5.98 (ddd, 1H, $J = 17.1, 10.4, 6.7$ Hz), 5.81 (br s, 1H, CONH₂), 5.48 (br s, 1H, CONH₂), 5.12-5.03 (m, 2H), 3.87 (app q, 1H, $J = 7.3$ Hz), 2.63 (dd, 1H, $J = 14.5, 7.4$ Hz), 2.54 (dd, 1H, $J = 14.5, 7.7$ Hz); ^{13}C NMR (75MHz/ $CDCl_3$) δ 173.4, 161.6 (d, $J = 243.2$ Hz), 140.2, 138.2 (d, $J = 3.2$ Hz), 129.1 (d, $J = 7.8$ Hz), 115.5 (d, $J = 21.2$ Hz), 115.1, 44.8, 41.9; IR (KBr) 3398, 3196 (CONH₂), 1654 cm^{-1} ; MS (EI) m/z 194 ($M^+ + 1$, 7), 193 (M^+ , 61%), 192 ($M^+ - 1$, 27) 178 (9), 176 (19), 149 (51), 135 (100), 133 (38), 109 (32). Anal. Calcd. for $C_{11}H_{12}FNO$: C, 68.38; H, 6.26; N, 7.25. Found: C, 68.35; H, 6.27; N, 7.15.

(R)-(+)-3-(*p*-Fluorophenyl)-4-pentenoic acid **3d**: mp 58-60 °C; $[\alpha]_D^{25} = +21.0$ (*c* 2.0, $CHCl_3$); ee 90.0% (chiral HPLC); 1H NMR ($CDCl_3$ /300MHz) δ 10.50 (br s, 1H), 7.22-6.99 (m, 4H), 5.98 (ddd, 1H, $J = 17.1, 10.4, 6.7$ Hz), 5.15-5.06 (m, 2H), 3.87 (app q, 1H, $J = 7.0$ Hz), 2.81 (dd, 1H, $J = 15.7, 7.6$ Hz), 2.74 (dd, 1H, $J = 15.6, 7.6$ Hz); ^{13}C NMR (75MHz/ $CDCl_3$) δ 176.8, 161.7(d, 1C, $^1J_{CF}=243.3$ Hz), 139.8, 137.7(d, $J = 3.2$ Hz), 129.0 (d, $J = 7.9$ Hz), 115.5 (d, $J = 21.2$ Hz), 115.2, 44.4, 39.8; IR (KBr) 3065-2607 (br, COOH), 1710 cm^{-1} ; MS (EI) m/z 195 ($M^+ + 1$, 6), 194 (M^+ , 58%), 166 (10), 149 (12), 148 (18), 135 (100), 133 (35), 109 (21). Anal. Calcd. for $C_{11}H_{11}FO_2$: C, 68.03; H, 5.71. Found: C, 67.87; H, 5.72.

(S)-(-)-3-(*p*-Chlorophenyl)-4-pentenamide **2e**: mp 93-94 °C; $[\alpha]_D^{25} = -10.0$ (*c* 2.0, $CHCl_3$); ee 97.4% (chiral HPLC); 1H NMR ($CDCl_3$ /300MHz) δ 7.29 (d, 2H, $J = 8.5$ Hz), 7.17 (d, 2H, $J = 8.5$ Hz), 5.99

(ddd, 1H, $J = 17.1, 10.4, 6.7$ Hz), 5.80 (br s, 1H, CONH₂), 5.49 (br s, 1H, CONH₂), 5.15-5.05 (m, 2H), 3.88 (app q, 1H, $J = 7.3$ Hz), 2.65 (dd, 1H, $J = 14.5, 7.4$ Hz), 2.55 (dd, 1H, $J = 14.5, 7.7$ Hz); ¹³CNMR (75MHz/CDCl₃) δ 173.3, 141.0, 139.9, 132.5, 129.0, 128.8, 115.4, 44.9, 41.7; IR (KBr) 3409, 3196 (CONH₂), 1658 cm⁻¹; MS (EI) m/z 211 (M⁺+2, 26), 209 (M⁺, 80%), 194 (31), 192 (34), 168(12), 167 (23), 166(41), 165 (61), 153 (33), 151 (100), 131 (50), 129 (44), 116 (77), 115 (85). Anal. Calcd. for C₁₁H₁₂ClNO: C, 63.01; H, 5.77; N, 6.68. Found: C, 62.79; H, 5.91; N, 6.59.

(R)-(+)-3-(*p*-Chlorophenyl)-4-pentenoic acid **3e**: mp 57-59 °C [lit.² (S)-**3e** mp 55-60 °C]; [α]_D²⁵ = +19.0 (*c* 2.0, CHCl₃); ee 91.0% (chiral HPLC) [lit.² (S)-**3e** [α]_D²⁵ = -14.4]; ¹HNMR (CDCl₃/300MHz) δ 10.55 (br s, 1H), 7.28 (d, 2H, $J = 8.5$ Hz), 7.14 (d, 2H, $J = 8.5$ Hz), 5.93 (ddd, 1H, $J = 17.1, 10.4, 6.8$ Hz), 5.12-5.03 (m, 2H), 3.83 (app q, 1H, $J = 7.5$ Hz), 2.77 (dd, 1H, $J = 15.7, 7.7$ Hz), 2.71 (dd, 1H, $J = 15.7, 7.7$ Hz); ¹³CNMR (75MHz/CDCl₃) δ 177.8, 140.5, 139.5, 132.6, 129.0, 128.8, 115.4, 44.5, 39.8; IR (KBr) 3088-2604 (br, COOH), 1707 cm⁻¹; MS (EI) m/z 212 (M⁺+2, 26), 210 (M⁺, 80%), 182 (15), 153(28), 151 (100), 129 (45), 125 (14), 116 (67), 115 (77). Anal. Calcd. for C₁₁H₁₁ClO₂: C, 62.72; H, 5.26. Found: C, 62.78; H, 5.50.

(S)-(-)-3-(*m*-Chlorophenyl)-4-pentenamide **2f**: oil; [α]_D²⁵ = -11.3 (*c* 3.0, CHCl₃); ee 93.0% (chiral HPLC); ¹HNMR (CDCl₃/300MHz) δ 7.29-7.12 (m, 4H), 5.98 (ddd, 1H, $J = 17.1, 10.3, 6.8$ Hz), 5.86 (br s, 1H, CONH₂), 5.55 (br s, 1H, CONH₂), 5.16-5.08 (m, 2H), 3.89 (app q, 1H, $J = 6.8$ Hz), 2.65 (dd, 1H, $J = 14.5, 7.5$ Hz), 2.58 (dd, 1H, $J = 14.5, 7.5$ Hz); ¹³CNMR (75MHz/CDCl₃) δ 173.3, 144.7, 139.6, 134.4, 129.9, 127.7, 127.0, 126.0, 115.7, 45.2, 41.6; IR (KBr) 3388, 3198 (CONH₂), 1654 cm⁻¹; MS (EI) m/z 211 (M⁺+2, 24), 209 (M⁺, 100%), 194 (20), 192 (20), 168(11), 167 (13), 166(36), 165 (27), 153 (9), 151(42), 131 (46), 129 (38), 116 (38), 115 (62). Anal. Calcd. for C₁₁H₁₂ClNO: C, 63.01; H, 5.77; N, 6.68. Found: C, 62.88; H, 5.74; N, 6.57.

(R)-(+)-3-(*m*-Chlorophenyl)-4-pentenoic acid **3f**: oil; [α]_D²⁵ = +20.0 (*c* 2.0, CHCl₃); ee 94.2% (chiral HPLC); ¹HNMR (CDCl₃/300MHz) δ 11.18 (br s, 1H), 7.25-7.12 (m, 4H), 5.97 (ddd, 1H, $J = 17.2, 10.4, 6.8$ Hz), 5.17-5.09 (m, 2H), 3.87 (app q, 1H, $J = 7.2$ Hz), 2.82 (dd, 1H, $J = 15.8, 7.8$ Hz), 2.76 (dd, 1H, $J = 15.8, 7.4$ Hz); ¹³CNMR (75MHz/CDCl₃) δ 177.9, 144.1, 139.2, 134.4, 129.9, 127.8, 127.1, 125.8,

115.7, 44.8, 39.7; IR (KBr) 3081-2572 (br, COOH), 1709 cm^{-1} ; MS (EI) m/z 212 ($M^+ + 2$, 26), 210 (M^+ , 96%), 153 (19), 151 (67), 139 (15), 129 (100), 116 (52), 115 (77). Anal. Calcd. for $\text{C}_{11}\text{H}_{11}\text{ClO}_2$: C, 62.72; H, 5.26. Found: C, 62.70; H, 5.18.

(S)-(-)-3-(*o*-Chlorophenyl)-4-pentenamide **2g**: mp 68-69 °C; $[\alpha]_{\text{D}}^{25} = -10.0$ (c 3.0, CHCl_3); ee > 99.5% (chiral HPLC); ^1H NMR ($\text{CDCl}_3/300\text{MHz}$) δ 7.40-7.18 (m, 4H), 6.02 (ddd, 1H, $J = 17.1, 10.4, 6.7$ Hz), 5.99 (br s, 1H, CONH_2), 5.64 (br s, 1H, CONH_2), 5.18-5.04 (m, 2H), 3.39 (app q, 1H, $J = 6.8$ Hz), 2.67 (dd, 1H, $J = 14.8, 6.9$ Hz), 2.64 (dd, 1H, $J = 14.9, 8.1$ Hz); ^{13}C NMR (75MHz/ CDCl_3) δ 173.3, 139.9, 138.6, 133.7, 130.0, 128.5, 127.9, 127.1, 116.0, 41.9, 40.6; IR (KBr) 3401, 3209 (CONH_2), 1659 cm^{-1} ; MS (EI) m/z 211 ($M^+ + 2$, 1.2), 210 ($M^+ + 1$, 2.1), 209 (M^+ , 1.8%), 208 ($M^+ - 1$, 4.2), 174 (100), 153 (6), 151 (18), 116 (12), 115 (14). Anal. Calcd. for $\text{C}_{11}\text{H}_{12}\text{ClNO}$: C, 63.01; H, 5.77; N, 6.68. Found: C, 62.97; H, 6.03; N, 6.61.

(R)-(+)-3-(*o*-Chlorophenyl)-4-pentenoic acid **3g**: mp 41-42 °C; $[\alpha]_{\text{D}}^{25} = +26.0$ (c 2.0, CHCl_3); ee 91.6% (chiral HPLC); ^1H NMR ($\text{CDCl}_3/300\text{MHz}$) δ 11.35 (br s, 1H), 7.39-7.17 (m, 4H), 5.97 (ddd, 1H, $J = 17.1, 10.4, 6.6$ Hz), 5.17-5.07 (m, 2H), 4.41 (app q, 1H, $J = 6.1$ Hz), 2.80 (dd, 1H, $J = 16.0, 6.9$ Hz), 2.77 (dd, 1H, $J = 15.9, 8.2$ Hz); ^{13}C NMR (75MHz/ CDCl_3) δ 177.9, 139.5, 138.1, 133.8, 129.9, 128.3, 128.0, 127.1, 116.0, 41.1, 38.6; IR (KBr) 3129-2557 (br, COOH), 1706 cm^{-1} ; MS (EI) m/z 212 ($M^+ + 2$, 6), 210 (M^+ , 17%), 175 (100), 153 (14), 151 (46), 138 (4), 129 (39), 116 (43), 115 (53). Anal. Calcd. for $\text{C}_{11}\text{H}_{11}\text{ClO}_2$: C, 62.72; H, 5.26. Found: C, 62.47; H, 5.25.

(S)-(-)-3-(*p*-Bromophenyl)-4-pentenamide **2h**: mp 103-104 °C; $[\alpha]_{\text{D}}^{25} = -7.0$ (c 4.0, CHCl_3); ee > 99.0% (chiral HPLC); ^1H NMR ($\text{CDCl}_3/300\text{MHz}$) δ 7.43 (d, 2H, $J = 8.4$ Hz), 7.10 (d, 2H, $J = 8.4$ Hz), 5.97 (ddd, 1H, $J = 17.1, 10.4, 6.7$ Hz), 5.59 (br s, 1H, CONH_2), 5.38 (br s, 1H, CONH_2), 5.14-5.04 (m, 2H), 3.86 (app q, 1H, $J = 7.3$ Hz), 2.64 (dd, 1H, $J = 14.5, 7.4$ Hz), 2.59 (dd, 1H, $J = 14.5, 7.7$ Hz); ^{13}C NMR (75MHz/ CDCl_3) δ 173.0, 141.5, 139.8, 131.8, 129.4, 120.6, 115.5, 45.0, 41.7; IR (KBr) 3410, 3197 (CONH_2), 1657 cm^{-1} ; MS (EI) m/z 255 ($M^+ + 2$, 35), 253 (M^+ , 36%), 238 (21), 236 (14), 212(15), 211 (19), 210(24), 209 (18), 197 (14), 195 (16), 131(23), 130 (25), 129(30), 116 (100), 115 (38). Anal. Calcd. for $\text{C}_{11}\text{H}_{12}\text{BrNO}$: C, 51.99; H, 4.76; N, 5.51. Found: C, 51.79; H, 4.86; N, 5.33.

(R)-(+)-3-(*p*-Bromophenyl)-4-pentenoic acid **3h**: mp 93-94 °C; $[\alpha]_D^{25} = +11.0$ (*c* 2.0, CHCl₃); ee 58.1% (chiral HPLC); ¹HNMR (CDCl₃/300MHz) δ 11.40 (br s, 1H), 7.43 (d, 2H, *J* = 6.6 Hz), 7.08 (d, 2H, *J* = 6.6 Hz), 5.93 (ddd, 1H, *J* = 17.1, 10.4, 6.7 Hz), 5.12-5.03 (m, 2H), 3.81 (app q, 1H, *J* = 7.5 Hz), 2.77 (dd, 1H, *J* = 15.7, 7.7 Hz), 2.71 (dd, 1H, *J* = 15.7, 7.7 Hz); ¹³CNMR (75MHz/CDCl₃) δ 178.0, 141.0, 139.4, 131.8, 129.4, 120.7, 115.5, 44.5, 39.7; IR (KBr) 3082-2602 (br, COOH), 1707 cm⁻¹; MS (EI) *m/z* 256 (M⁺+2, 38), 254 (M⁺, 39%), 228 (10), 226 (9), 197 (15), 195 (16), 129 (34), 116 (100), 115 (35). Anal. Calcd. for C₁₁H₁₁BrO₂: C, 51.79; H, 4.35. Found: C, 51.79; H, 4.42.

(R)-(-)-3-Phenyl-pentanoic acid amide **5**: mp 67-68 °C; $[\alpha]_D^{25} = -41.5$ (*c* 4.0, C₆H₆) ee 87.1% (chiral HPLC); ¹HNMR (CDCl₃/300MHz) δ 7.32-7.17 (m, 5H), 5.84 (br s, 1H, CONH₂), 5.41 (br s, 1H, CONH₂), 2.99-2.95 (m, 1H), 2.55-2.43 (m, 2H), 1.79-1.58 (m, 2H), 0.78 (t, 3H, *J* = 7.3 Hz); ¹³CNMR (75MHz/CDCl₃) δ 174.6, 144.0, 128.6, 127.5, 126.5, 44.3, 43.4, 29.1, 11.9; IR (KBr) 3411, 3168 (CONH₂), 1657 cm⁻¹; MS (EI) *m/z* 178 (M⁺+1, 5), 177 (M⁺, 47%), 160 (7) 159 (11), 119 (25), 105 (54), 91 (100), 59 (46). Anal. Calcd. for C₁₁H₁₅NO: C, 74.54; H, 8.53; N, 7.90. Found: C, 74.47; H, 8.63; N, 7.99.

(S)-(+)-3-Phenyl-pentanoic acid **6**: oil; $[\alpha]_D^{25} = +42.3$ (*c* 8.0, C₆H₆) [lit.³ (R)-**6** $[\alpha]_D^{25} = -48.0$ (*c* 10, C₆H₆)]; ee 83.0% (chiral GC); ¹HNMR (CDCl₃/300MHz) δ 11.23 (br s, 1H), 7.35-7.20 (m, 5H), 3.05-3.00 (m, 1H), 2.69-2.65 (m, 2H), 1.77-1.64 (m, 2H), 0.82 (t, 3H, *J* = 7.4 Hz); ¹³CNMR (75MHz/CDCl₃) δ 179.0, 143.6, 128.5, 127.5, 126.5, 43.5, 41.1, 29.1, 11.9; IR (KBr) 3085-2560 (br, COOH), 1699, 1649 cm⁻¹; MS (EI) *m/z* 179 (M⁺+1, 2), 178 (M⁺, 19%), 160 (2), 132 (2), 119 (18), 118 (26), 107 (100), 91 (28). Anal. Calcd. for C₁₁H₁₅NO: C, 74.13; H, 7.92. Found: C, 73.83; H, 8.23.

3. Chemical hydrolysis of (S)-(-)-3-Phenyl-4-pentenamide **2a**

A mixture of (S)-(-)-3-phenyl-4-pentenamide **2a** (437.5 mg, 2.5 mmol) in hydrochloric acid (6N, 55 ml) was stirred at 60 °C for 22 h. After cooling to room temperature, the solution was extracted with ethyl acetate (40 ml X 4), and the organic phase was combined and dried over with anhydrous Mg₂SO₄. (S)-(-)-3-Phenyl-4-pentenoic acid (S)-**3a**² (422.2 mg, 96%) was obtained after column chromatography using a silica gel column eluted with petroleum ether and ethyl acetate (8:1): oil; $[\alpha]_D^{25} = -15.0$ (*c* 1.1, CHCl₃);

ee 96.4% (chiral HPLC); ^1H NMR (CDCl_3 /300MHz) δ 11.40 (br s, 1H), 7.39-7.25 (m, 5H), 6.03 (ddd, 1H, J = 17.3, 9.9, 6.9 Hz), 5.16-5.11 (m, 2H), 3.90 (app q, 1H, J = 7.4 Hz), 2.83 (dd, 1H, J = 15.5, 7.9 Hz), 2.80 (dd, 1H, J = 15.6, 7.4 Hz); ^{13}C NMR (75MHz/ CDCl_3) δ 178.4, 142.1, 139.9, 128.7, 127.5, 126.8, 115.1, 45.2, 40.0; IR (KBr) 3090-2560 (br, COOH), 1707 cm^{-1} ; MS (EI) m/z 177 ($\text{M}^+ + 1$, 7), 176 (M^+ , 75%), 158 (4), 148 (13), 130 (31), 117 (100), 115 (64), 91 (23). Anal. Calcd. for $\text{C}_{11}\text{H}_{12}\text{O}_2$: C, 74.98; H, 6.86. Found: C, 75.04; H, 6.94.

4. Synthesis and spectroscopic data of compounds 7-13

To a mixture of LiAlH_4 (10.96 mmol) in dry THF (11.2 ml), which was cooled by an ice bath, was added a solution of AlCl_3 (3.52 mmol) in dry THF (11.2 ml). After the mixture was stirred at room temperature for 0.5 h, a solution of (S)-(-)-3-phenyl-4-pentenamide **2a** (4 mmol) in dry THF (11.2 ml) was added, and the resulting mixture was then ewfluxed for 20 h. The reaction was quenched by adding crashed ice followed by aqueous NaOH (10%) solution to adjust the pH to around 12. The white solid was removed by filtration through a pad of Celite and the filtrate was adjusted to pH 2. Extraction of aqueous phase with ether (40 ml X 3) removed unconsumed starting amide (and other by-products). The aqueous solution was then re-adjusted to pH 12 with NaOH solution (10%), extracted with ether (40 ml X 3) and dried over with anhydrous MgSO_4 . After concentration to around 20 ml, Et_3N (630 μl) and benzoyl chloride (525 μl) were added consecutively while cooling with an ice bath. The reaction was quenched after 2 h by the addition of crashed ice followed by NaOH (10%) to basify the mixture to pH 12. Extraction with ether (40 ml X 3), drying over with anhydrous MgSO_4 , and column chromatography of the residue gave pure (S)-(+)-*N*-(pent-3-phenyl-4-enyl)-benzamide **7** (742 mg, 70%): mp 67-68 $^\circ\text{C}$; $[\alpha]_{\text{D}}^{25} = +14.0$ (c 3.0, CHCl_3); ^1H NMR (CDCl_3 /300MHz) δ 7.64 (d, 2H, J = 7.1 Hz), 7.45-7.19 (m, 8H), 6.28 (s, 1H), 5.97 (ddd, 1H, J = 17.1, 10.4, 7.5 Hz), 5.11-5.05 (m, 2H), 3.55-3.46 (m, 1H), 3.40-3.29 (m, 2H), 2.14-1.95 (m, 2H); ^{13}C NMR (75MHz/ CDCl_3) δ 167.4, 143.5, 141.5, 134.7, 131.3, 128.8, 128.5, 127.6, 126.9, 126.6, 114.7, 48.0, 38.7, 34.9; IR (KBr) 3338 (CONH), 1634(CON) cm^{-1} . To a mixture of **7** (0.5 mmol) in CH_2Cl_2 (10 ml) and methanol (10 ml) at -65 $^\circ\text{C}$ was bubbled with O_3 for about 10 min. The mixture turned into a blue solution, and TLC indicated the complete conversion of the starting

material. Argon was then bubbled into the mixture for about 20 min and the temperature was allowed to gradually increase to -40 °C. Dimethyl sulfide (5 ml) was added and the resulting mixture was stirred at room temperature for 6 h. After removal of the solvent under vacuum, the oily residue was dissolved in tert-butyl alcohol (20 ml) and then treated with cyclohexene (2 ml), and the solution of NaClO₂ (5 mmol in 6 ml of water) and KH₂PO₄ (5 mmol in 6 ml of water) under argon protection. After stirring at room temperature for about 12 h, brine (100 ml) and NaOH (2N) were added to basify the mixture to pH 12. After extraction with ether (40 ml X 3), the aqueous solution was re-adjusted to pH 2 using hydrochloric acid (2N). Extraction again with ether (40 ml X 3) gave, after drying, concentration and column chromatography [silica gel eluted with a mixture of petroleum ether and ethyl acetate (3:1-1:3)], pure (R)-(-)-4-benzoylamino-2-phenyl-butyric acid **8** (121.7 mg, 86%): oil; $[\alpha]_D^{25} = -45.3$ (*c* 3.0, CHCl₃); ¹HNMR (DMSO-d₆/300MHz) δ 12.35 (s, 1H), 8.46 (s, 1H), 7.82 (d, 2H, *J* = 8.0 Hz), 7.51-7.42 (m, 3H), 7.37-7.26 (m, 5H), 3.62 (t, 1H, *J* = 7.4 Hz), 3.25-3.14 (m, 2H), 2.31-2.22 (m, 1H), 1.96-1.85 (m, 1H); ¹³CNMR (75MHz/CDCl₃) δ 178.2, 168.0, 138.1, 134.1, 131.6, 129.0, 128.6, 128.0, 127.7, 126.9, 49.5, 38.5, 32.7; IR (KBr) 3264 (CONH), 3083-2547 (br, COOH), 1703 (COO), 1634 (CON) cm⁻¹. **8** (100 mg) was refluxed in hydrochloric acid (6N, 9 ml) for 18 h. Water (20 ml) was added and the mixture was extracted with ethyl acetate (20 ml X 3). The aqueous phase was filtrated, and the water was removed und vacuum to give pure (R)-(-)-4-amino-2-phenyl-butyric acid hydrochloride **9** (71.6 mg, 94%) as pale yellow soild: mp 168-170 °C; $[\alpha]_D^{25} = -14.0$ (*c* 2.0, H₂O); ee > 99.5% (chiral HPLC); ¹HNMR (D₂O/300MHz) δ 7.38-7.27 (m, 5H), 3.70 (t, 1H, *J* = 7.3 Hz), 2.96-2.87 (m, 1H), 2.82-2.76 (m, 1H), 2.36-2.26 (m, 1H); 2.13-2.05 (m, 1H); ¹³CNMR (75MHz/ D₂O) δ 177.2, 137.6, 129.3, 128.1, 127.9, 48.5, 37.5, 29.7; IR (KBr) 3240-2524 (br, COOH), 1719 (COO) cm⁻¹. To a mixture of **9** (10 mg) in ether (0.5 ml) and methanol (0.5 ml) was added CH₂N₂ solution in ether (5 ml). The solvent was then removed at 50 °C under vacuum, and the residue was subjected to silica gel column chromatography using a mixture of petroleum ether and ethyl acetate (1:4) as an eluent to afford pure (R)-3-phenyl-2-pyrrolidinone **10** (5.5 mg, 73%): mp 83-84 °C; (lit.⁴ m.p. 84-85 °C); ¹HNMR (CDCl₃/300MHz) δ 7.38-

7.24 (m, 5H), 5.70 (s, 1H, NH), 3.63 (t, 1H, $J = 9.1$ Hz), 3.54-3.42 (m, 2H), 2.67-2.60 (m, 1H), 2.35-2.25 (m, 1H).

The mixed solution of DCC (3.57 mmol) and DMAP (0.07 mmol) in CH_2Cl_2 (3.6 ml) was added to the solution of (S)-**3a** (528 mg, 3 mmol) in CH_2Cl_2 (3.6 ml) while cooling in an ice bath. *N*-Allyl-*N*-benzylamine **11** (441 mg, 3 mmol) solution in CH_2Cl_2 (1.8 ml) was then added, and the resulting mixture was stirred at room temperature for 1 h. Saturated ammonium chloride solution (60 ml) was added and the organic phase was separated. The aqueous phase was extracted with CH_2Cl_2 (30 ml X 3), and the organic phase was combined and dried over with anhydrous MgSO_4 . After removal of the solvent, the residue was subjected to silica gel column chromatography with a mixture of petroleum ether and ethyl acetate (15:1) as the eluent to give pure (S)-(+)-*N*-allyl-*N*-benzyl-3-phenyl-4-pentenamide (S)-**12** (833 mg, 91%): oil; $[\alpha]_{\text{D}}^{25} = +5.0$ (c 4.0, CHCl_3); ee > 99.5% (chiral HPLC); ^1H NMR (CDCl_3 /300MHz) δ 7.36-7.08 (m, 10H), 6.15-5.99 (m, 1H), 5.79-5.63 (m, 1H), 5.23-4.97 (m, 4H), 4.69 (d, 0.63H, $J = 14.8$ Hz), 4.46 (d, 0.63H, $J = 16.3$ Hz), 4.43 (s, 0.74H), 4.13-3.95 (m, 2H), 3.78-3.70 (m, 1H), 2.86-2.76 (m, 2H); ^{13}C NMR (75MHz/ CDCl_3) δ 171.6, 143.1, 140.9, 140.7, 137.4, 136.7, 132.9, 132.6, 128.9, 128.6, 128.5, 128.1, 127.9, 127.8, 127.5, 127.2, 126.6, 126.3, 117.3, 116.8, 114.7, 50.0, 49.1, 48.4, 48.1, 45.7, 45.6, 38.8, 38.5; IR (KBr) 1648 (CON) cm^{-1} ; MS (ESI) m/z 306.2 ($\text{M}^+ + 1$, 100%), 328.2 ($\text{M}^+ + 23$, 8.2). Anal. Calcd. for $\text{C}_{21}\text{H}_{23}\text{NO}$: C, 82.58; H, 7.59; N, 4.59. Found: C, 82.56; H, 7.58; N, 4.91.

Under argon protection, a solution of (S)-(+)-*N*-allyl-*N*-benzyl-3-phenyl-4-pentenamide (S)-**12** (100 mg, 0.328 mmol) in dry benzene (2 ml) was rapidly added to a solution of the Grubb's catalyst (first generation, 13.94 mg, 0.0164 mmol) in dry benzene (8 ml). After refluxing for 6 h, the solvent was removed under vacuum, and column chromatography of the residue using a silica gel column eluted with a mixture of petroleum ether and ethyl acetate (3:1) afforded pure (S)-(-)-1-benzyl-4-phenyl-1,3,4,7-tetrahydro-azepin-2-one (S)-**13** (84.8 mg, 93%): oil; $[\alpha]_{\text{D}}^{25} = -14.0$ (c 2.0, CHCl_3); ee > 99.5% (chiral HPLC); ^1H NMR (CDCl_3 /300MHz) δ 7.39-7.24 (m, 10H), 5.84-5.75 (m, 2H), 4.70 (s, 2H), 4.30-4.23 (m, 1H), 3.89-3.85 (m, 1H), 3.65-3.57 (m, 1H), 3.19 (t, 1H, $J = 12.2$ Hz), 2.85 (dd, 1H, $J = 12.9$,

3.1 Hz); ^{13}C NMR (75MHz/ CDCl_3) δ 172.9, 143.7, 137.4, 134.8, 128.8, 128.6, 128.0, 127.6, 127.4, 127.0, 124.9, 51.2, 45.2, 42.2, 42.1; IR (KBr) 1649 (CON) cm^{-1} ; MS (ESI) m/z 278.1 ($\text{M}^+ + 1$, 100%). Anal. Calcd. for $\text{C}_{19}\text{H}_{20}\text{NO}$: 278.1539($\text{M} + \text{H}$). Found: 278.1540.

Following the same procedures for the preparation of (S)-**12** and (S)-**13**, (R)-*N*-allyl-*N*-benzyl-3-phenyl-4-pentenamide (R)-**12** and (R)-(+)-1-benzyl-4-phenyl-1,3,4,7-tetrahydro-azepin-2-one (R)-**13** were synthesized when (R)-**3a** was employed as the starting material. (R)-*N*-Allyl-*N*-benzyl-3-phenyl-4-pentenamide (R)-**12**: oil; ee 90.2% (chiral HPLC); ^1H NMR (CDCl_3 /300MHz) δ 7.36-7.08 (m, 10H), 6.15-5.99 (m, 1H), 5.79-5.63 (m, 1H), 5.23-4.97 (m, 4H), 4.69 (d, 0.64H, $J = 14.8$ Hz), 4.46 (d, 0.64H, $J = 16.7$ Hz), 4.43 (s, 0.72H), 4.16-3.95 (m, 2H), 3.78-3.70 (m, 1H), 2.86-2.78 (m, 2H); ^{13}C NMR (75MHz/ CDCl_3) δ 171.6, 171.4, 143.1, 140.9, 140.7, 137.4, 136.7, 132.9, 132.6, 128.9, 128.6, 128.5, 128.1, 127.9, 127.8, 127.5, 127.2, 126.6, 126.3, 117.3, 116.8, 114.7, 50.0, 49.1, 48.4, 48.1, 45.7, 45.6, 38.8, 38.5; IR (KBr) 1648 (CON) cm^{-1} ; MS (ESI) m/z 306.2 ($\text{M}^+ + 1$, 100%), 328.2 ($\text{M}^+ + 23$, 13.7); Anal. Calcd. for $\text{C}_{21}\text{H}_{23}\text{NO}$: C, 82.58; H, 7.59; N, 4.59. Found: C, 82.29; H, 7.66; N, 4.74.

(R)-(+)-1-Benzyl-4-phenyl-1,3,4,7-tetrahydro-azepin-2-one (R)-**13**: oil; $[\alpha]_{\text{D}}^{25} = +14.0$ (c 3.0, CHCl_3); ee 91.2% (chiral HPLC); ^1H NMR (CDCl_3 /300MHz) δ 7.39-7.24 (m, 10H), 5.84-5.75 (m, 2H), 4.70 (s, 2H), 4.30-4.24 (m, 1H), 3.89-3.85 (m, 1H), 3.65-3.57 (m, 1H), 3.19 (t, 1H, $J = 12.2$ Hz), 2.85 (dd, 1H, $J = 12.9, 3.1$ Hz); ^{13}C NMR (75MHz/ CDCl_3) δ 172.9, 143.7, 137.4, 134.8, 128.8, 128.6, 128.0, 127.6, 127.4, 127.0, 124.9, 51.3, 45.2, 42.2, 42.1; IR (KBr) 1649 (CON) cm^{-1} ; MS (ESI) m/z 278.1 ($\text{M}^+ + 1$, 100%), 300.1 ($\text{M}^+ + 23$, 15.4), 316.1 ($\text{M}^+ + 39$, 6.0). Anal. Calcd. for $\text{C}_{19}\text{H}_{20}\text{NO}$: 278.1539($\text{M} + \text{H}$). Found: 278.1535.

5. ^1H and ^{13}C NMR spectra of compounds S-2a, R-3a, R-10 and S-13

S-2a

Bb-040426

Current Data Parameters
 NAME gm-Bb-040426
 EXPNO 10
 PROCNO 1

F2 - Acquisition Parameters
 Date_ 20040427
 Time 4.17
 INSTRUM av300
 PROBHD 5 mm DUL 13C-1
 PULPROG zg30
 TD 65536
 SOLVENT CDC13
 NS 16
 DS 2
 SWH 6172.839 Hz
 FIDRES 0.094190 Hz
 AQ 5.3084660 sec
 RG 322.5
 DW 81.000 usec
 DE 6.00 usec
 TE 296.1 K
 D1 2.00000000 sec

===== CHANNEL f1 =====
 NUC1 1H
 P1 9.30 usec
 PL1 -1.00 dB
 SF01 300.1318534 MHz

F2 - Processing parameters
 SI 32768
 SF 300.1300056 MHz
 WDW EM
 SSB 0
 LB 0.30 Hz
 GB 0
 PC 1.00

1D NMR plot parameters
 CX 21.00 cm
 CY 5.00 cm
 F1P 9.500 ppm
 F1 2851.24 Hz
 F2P -0.500 ppm
 F2 -150.06 Hz
 PPMCM 0.47619 ppm/cm
 HZCM 142.91905 Hz/cm

S-2a

R-3a

Bc-040813

Current Data Parameters
 NAME gm-Bc-040813
 EXPNO 10
 PROCNO 1

F2 - Acquisition Parameters
 Date_ 20040813
 Time 22.04
 INSTRUM av300
 PROBHD 5 mm DUL 13C-1
 PULPROG zg30
 TD 65536
 SOLVENT CDC13
 NS 16
 DS 2
 SWH 6172.839 Hz
 FIDRES 0.094190 Hz
 AQ 5.3084660 sec
 RG 90.5
 DW 81.000 usec
 DE 6.00 usec
 TE 300.3 K
 D1 2.00000000 sec

===== CHANNEL f1 =====
 NUC1 1H
 P1 9.30 usec
 PL1 -1.00 dB
 SFO1 300.1318534 MHz

F2 - Processing parameters
 SI 32768
 SF 300.1300187 MHz
 WDW EM
 SSB 0
 LB 0.30 Hz
 GB 0
 PC 1.00

1D NMR plot parameters
 CX 21.00 cm
 CY 3.00 cm
 F1P 13.000 ppm
 F1 3901.69 Hz
 F2P -0.500 ppm
 F2 -150.07 Hz
 PPMCM 0.64286 ppm/cm
 HZCM 192.94072 Hz/cm

R-3a

Bc-040813

Current Data Parameters
NAME gm-Bc-040813
EXPNO 20
PROCNO 1

F2 - Acquisition Parameters
Date_ 20040813
Time 22.53
INSTRUM av300
PROBHD 5 mm DUL 13C-1
PULPROG zgpg30
TD 65536
SOLVENT CDC13
NS 364
DS 4
SWH 17985.611 Hz
FIDRES 0.274439 Hz
AQ 1.8219508 sec
RG 3649.1
DW 27.800 usec
DE 6.00 usec
TE 300.9 K
D1 2.0000000 sec
d11 0.0300000 sec
d12 0.0002000 sec

===== CHANNEL f1 =====
NUC1 13C
P1 9.40 usec
PL1 -1.00 dB
SF01 75.4752953 MHz

===== CHANNEL f2 =====
CPDPRG2 waltz16
NUC2 1H
PCPD2 80.00 usec
PL2 -1.00 dB
PL12 18.00 dB
PL13 18.00 dB
SF02 300.1312005 MHz

F2 - Processing parameters
SI 32768
SF 75.4677490 MHz
WDW EM
SSB 0
LB 1.00 Hz
GB 0
PC 1.40

1D NMR plot parameters
CX 20.00 cm
CY 10.00 cm
F1P 200.000 ppm
F1 15093.55 Hz
F2P -5.000 ppm
F2 -377.34 Hz
PPMCM 10.25000 ppm/cm
H7CM 773.64449 Hz/cm

lactam7R060217

Current Data Parameters

NAME gm-lactam706021
EXPNO 8
PROCNO 1

F2 - Acquisition Parameters

Date_ 20060217
Time 16.22
INSTRUM av300
PROBHD 5 mm DUL 13C-1
PULPROG zg30
TD 65536
SOLVENT CDCl3
NS 16
DS 2
SWH 6172.839 Hz
FIDRES 0.094190 Hz
AQ 5.3084660 sec
RG 362
DW 81.000 usec
DE 6.00 usec
TE 296.2 K
D1 2.00000000 sec

===== CHANNEL f1 =====

NUC1 1H
P1 9.30 usec
PL1 -1.00 dB
SF01 300.1318534 MHz

F2 - Processing parameters

SI 32768
SF 300.1299982 MHz
WDW EM
SSB 0
LB 0.30 Hz
GB 0
PC 1.00

1D NMR plot parameters

CX 22.00 cm
CY 3.00 cm
F1P 9.000 ppm
F1 2701.17 Hz
F2P -0.500 ppm
F2 -150.07 Hz
PPMCM 0.43182 ppm/cm
HZCM 129.60159 Hz/cm

S-13

Current Data Parameters
 NAME gm-lactam75051202
 EXPNO 11
 PROCNO 1

F2 - Acquisition Parameters
 Date_ 20051202
 Time 16.51
 INSTRUM av300
 PROBHD 5 mm DUL 13C-1
 PULPROG zgpg30
 TD 65536
 SOLVENT CDCl3
 NS 117
 DS 4
 SWH 17985.611 Hz
 FIDRES 0.274439 Hz
 AQ 1.8219508 sec
 RG 5160.6
 DW 27.800 usec
 DE 6.00 usec
 TE 296.3 K
 D1 2.00000000 sec
 d11 0.03000000 sec
 d12 0.00002000 sec

===== CHANNEL f1 =====
 NUC1 13C
 P1 9.40 usec
 PL1 -1.00 dB
 SFO1 75.4752953 MHz

===== CHANNEL f2 =====
 CPDPRG2 waltz16
 NUC2 1H
 PCPD2 80.00 usec
 PL2 -1.00 dB
 PL12 18.00 dB
 PL13 18.00 dB
 SFO2 300.1312005 MHz

F2 - Processing parameters
 SI 32768
 SF 75.4677490 MHz
 WDW EM
 SSB 0
 LB 1.00 Hz
 GB 0
 PC 1.40

1D NMR plot parameters
 CX 22.00 cm
 CY 5.00 cm
 F1P 200.000 ppm
 F1 15093.55 Hz
 F2P -5.000 ppm
 F2 -377.34 Hz
 PPMCM 9.31818 ppm/cm
 HZCM 703.22217 Hz/cm

S18

R-10

B9P6A2

Current Data Parameters
NAME gm-B9P6A2
EXPNO 60
PROCNO 1

F2 - Acquisition Parameters
Date_ 20060419
Time 16.25
INSTRUM av300
PROBHD 5 mm DUL 13C-1
PULPROG zg30
TD 65536
SOLVENT CDCl3
NS 282
DS 2
SWH 6172.839 Hz
FIDRES 0.094190 Hz
AQ 5.3084660 sec
RG 456.1
DW 81.000 usec
DE 6.00 usec
TE 298.5 K
D1 2.00000000 sec

===== CHANNEL f1 =====
NUC1 1H
P1 9.30 usec
PL1 -1.00 dB
SFO1 300.1318534 MHz

F2 - Processing parameters
SI 32768
SF 300.1300064 MHz
WDW EM
SSB 0
LB 0.30 Hz
GB 0
PC 1.00

1D NMR plot parameters
CX 22.00 cm
CY 50.00 cm
F1P 9.000 ppm
F1 2701.17 Hz
F2P -0.500 ppm
F2 -150.07 Hz
PPMCM 0.43182 ppm/cm
HZCM 129.60159 Hz/cm

6. HPLC analysis

Compound	Column	Mobile phase	MI / min	T °C	t ₁ min	t ₂ min
	chiralcel					
1a	OD	Hex:IPA 9:1	0.8	25	16.9	20.6
2a	AD	Hex:IPA 9:1	0.8	25	9.1	10.3
3a	ADH	Hex:IPA 9:1	0.3	17	17.6	20.0
2b	AD	Hex:IPA 9:1	0.8	25	11.6	14.5
3b	AD	Hex:IPA:AcOH 9:1:0.05	0.8	25	8.1	9.7
2c	AD	Hex:IPA 9:1	0.8	25	8.5	10.4
3c	AD	Hex:IPA:AcOH 9:1:0.05	0.5	25	10.1	11.8
2d	AD	Hex:IPA 9:1	0.8	25	9.1	10.2
3d	AD	Hex:IPA:AcOH 9:1:0.05	0.8	25	7.0	7.8
2e	AD	Hex:IPA 9:1	0.8	25	9.4	10.8
3e	ADH	Hex:IPA 9:1	0.5	25	11.9	13.7
2f	ADH	Hex:IPA 9:1	0.5	25	13.5	14.8
3f	ADH	Hex:IPA 95:5	0.3	17	25.1	27.8
2g	ADH	Hex:IPA 9:1	0.5	25	10.3	11.2
3g	OJH	Hex:IPA 9:1	0.5	25	11.9	14.4
2h	AD	Hex:IPA 9:1	0.8	25	9.7	11.3
3h	AD	Hex:IPA:AcOH 9:1:0.05	0.8	25	7.5	8.6
4	OJ	Hex:NPA 95:5	0.8	15	13.1	14.6
5	AD	Hex:IPA 9:1	0.8	25	8.4	9.6
6	CDX-B	N ₂	-	140	29.0	30.1
9	pennicillin	2mMCuSO ₄ + 5% acetonitrile	0.5	20	72.5	122.6
12	ADH	Hex:IPA 9:1	0.5	25	19.7	21.8
13	ADH	Hex:IPA 9:1	0.5	25	27.6	38.8

7. Reference

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