Supporting Information for

Catalytic Asymmetric Multiple Dearomatizations of Phenols

Enabled by a Cascade 1,8-Addition and Diels-Alder Reaction

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(A) General information

Unless stated otherwise, all reactions were carried out in flame dried glassware. All solvents were
dried according to established procedures. Reactions were monitored by thin layer
chromatography (TLC), column chromatography purifications were carried out using silica gel. 1H
and 13C NMR spectra were recorded on a Varian instrument (300 MHz and 75 MHz, respectively)
and internally referenced to tetramethylsilane signal or residual protio solvent signals. Data for 1H
NMR are recorded as follows: chemical shift, integration, multiplicity (br = broad, s = singlet, d =
doublet, t = triplet, q = quartet, m = multiplet, cm = complex multiplet) and coupling constant in
Hertz (Hz). Data for 13C NMR are reported in terms of chemical shift (δ, ppm). Optical rotations
were reported as follows: [α]D (c: g/100mL, in CHCl3). The ee values determination was carried
out using chiral high-performance liquid chromatography (HPLC) with Daicel Chiracel column on
Waters with a 996 UV-detector. β-Naphthols[1-3] and propargylic alcohols[4] were synthesized
according to the previous reported procedures.

(B) Optimization of the reaction conditions

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To a solution of catalyst A8 (0.01 mmol, 10 mol%) and β-naphthol 1 (0.12 mmol, 1.2 equiv) in dry toluene (1.0 mL) was added pyridine (2.5 mol%), and the mixture was stirred at room temperature for 10 min. Then, the solution was cooled to -60 °C (-45 °C for 3f, 3g, 3l and 3p; -50 °C for 3i-3k, 3ac and 3ae; -70 °C for 3w) and stirred for another 10 min. Finally, propargylic alcohol 2 (0.1 mmol, 1.0 equiv) was added and the reaction mixture was stirred at this temperature until the complete consumption of starting material (monitored by TLC). After which the reaction mixture was warmed to room temperature and stirred for further 72 h. Upon completion, the residue was directly purified by silica gel chromatography (eluting with petroleum ether/ethyl acetate = 20:1 to 10:1) to afford the desired products 3. (For the cases of 3c-3g, 2.0 mol% pyridine was added)
(D) Characterization data of compounds 3

Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 198 – 199 °C, 41.8 mg, 92% yield; 83% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, \(t_{\text{major}} = 5.3 \text{ min, } t_{\text{minor}} = 7.8 \text{ min}\); [\(\alpha\)]\(_D^{23.2}\) = 907 (c = 1.0 in CHCl\(_3\)); \(^1\)H NMR (300 MHz, CDCl\(_3\) \(\delta\) 7.38 – 6.94 (m, 9H), 6.93 – 6.70 (m, 4H), 6.34 (dd, \(J = 5.1, 3.3 \text{ Hz, 2H}\), 5.86 (d, \(J = 10.1 \text{ Hz, 1H}\), 3.58 – 3.35 (m, 1H), 3.30 (s, 1H), 3.07 – 2.89 (m, 2H), 1.61 (s, 3H), 1.34 (s, 3H) ppm; \(^{13}\)C NMR (75 MHz, CDCl\(_3\) \(\delta\) 213.67, 198.07, 150.42, 143.59, 141.68, 141.27, 141.12, 140.15, 137.52, 133.45, 132.92, 129.45, 129.19, 128.30, 128.06, 128.01, 127.62, 127.26, 127.09, 126.25, 124.31, 57.74, 53.97, 52.33, 46.86, 44.82, 15.26, 11.40 ppm; HRMS (ESI): C\(_{33}\)H\(_{26}\)NaO\(_2\) [M + Na]\(^+\) calcd: 477.1825, found: 477.1829.

Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 92 – 93 °C, 38.4 mg, 80% yield; 98% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, \(t_{\text{major}} = 5.1 \text{ min, } t_{\text{minor}} = 9.3 \text{ min}\); [\(\alpha\)]\(_D^{23.2}\) = 740 (c = 1.0 in CHCl\(_3\)); \(^1\)H NMR (300 MHz, CDCl\(_3\) \(\delta\) 7.39 – 7.30 (m, 1H), 7.30 – 7.06 (m, 7H), 6.99 (t, \(J = 7.4 \text{ Hz, 1H}\), 6.90 – 6.70 (m, 4H), 6.38 – 6.23 (m, 2H), 5.84 (d, \(J = 10.1 \text{ Hz, 1H}\), 5.73 (ddt, \(J = 17.0, 10.2, 6.8 \text{ Hz, 1H}\), 4.97 (d, \(J = 10.3 \text{ Hz, 1H}\), 4.84 (dd, \(J = 17.1, 1.5 \text{ Hz, 1H}\), 3.40 (t, \(J = 10.1 \text{ Hz, 1H}\), 3.28 (s, 1H), 2.99 – 2.86 (m, 2H), 2.76 (dd, \(J = 14.4, 6.3 \text{ Hz, 1H}\), 2.59 (dd, \(J = 14.4, 7.3 \text{ Hz, 1H}\), 1.61 (s, 3H) ppm; \(^{13}\)C NMR (75 MHz,
CDCl₃ δ 212.98, 198.09, 149.73, 143.65, 142.11, 141.76, 140.92, 140.33, 138.16, 133.72, 132.90, 132.81, 129.70, 129.17, 128.39, 128.14, 127.61, 127.03, 126.28, 124.60, 118.57, 60.88, 54.27, 52.59, 46.85, 44.68, 29.91, 15.21 ppm; HRMS (ESI): C₃₅H₂₈NaO₂ [M + Na]⁺ calcd: 503.1982, found: 503.2001.

Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 131 – 132 °C, 40.7 mg, 87% yield; 91% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, t_major = 5.0 min, t_minor = 8.4 min); [α]₀²³.² = 874 (c = 1.0 in CDCl₃); ¹H NMR (300 MHz, CDCl₃) δ 7.39 – 7.28 (m, 1H), 7.28 – 7.05 (m, 7H), 6.99 (t, J = 7.4 Hz, 1H), 6.91 – 6.73 (m, 4H), 6.45 – 6.24 (m, 2H), 5.83 (d, J = 10.1 Hz, 1H), 3.40 (t, J = 10.1 Hz, 1H), 3.27 (s, 1H), 3.05 – 2.87 (m, 2H), 2.01 (dq, J = 14.4, 7.2 Hz, 1H), 1.82 (tt, J = 16.4, 8.2 Hz, 1H), 1.62 (s, 3H), 0.84 (t, J = 7.3 Hz, 3H) ppm; ¹³C NMR (75 MHz, CDCl₃) δ 213.68, 198.21, 149.87, 143.75, 142.65, 141.93, 141.72, 140.39, 138.51, 134.04, 132.80, 129.63, 129.25, 128.25, 128.18, 127.68, 127.24, 126.32, 124.66, 62.43, 54.47, 52.86, 46.94, 44.71, 18.22, 15.33, 8.84 ppm; HRMS (ESI): C₃₅H₂₉NaO₂ [M + Na]⁺ calcd: 491.1982, found: 491.1983.

Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 113 – 114 °C, 43.4 mg, 90% yield; 88% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, t_major = 4.8 min, t_minor = 6.1 min); [α]₀²³.² = 696 (c = 1.0 in CDCl₃); ¹H NMR (300 MHz, CDCl₃) δ 7.37 – 7.28 (m, 1H), 7.29 – 7.10 (m, 7H), 6.99 (t, J = 7.4 Hz, 1H), 6.89 – 6.74 (m,
4H), 6.36 – 6.25 (m, 2H), 3.40 (t, \( J = 10.1 \) Hz, 1H), 3.26 (s, 1H), 2.93 (d, \( J = 10.7 \) Hz, 2H), 2.03 – 1.83 (m, 1H), 1.78 – 1.63 (m, 1H), 1.61 (s, 3H), 1.57 – 1.37 (m, 1H), 1.20 – 0.97 (m, 1H), 0.79 (t, \( J = 7.2 \) Hz, 3H) ppm; \(^{13}\)C NMR (75 MHz, CDCl\(_3\)) δ 213.85, 198.13, 150.08, 143.68, 142.28, 141.87, 141.66, 140.27, 138.34, 133.91, 132.69, 129.57, 129.17, 128.15, 128.07, 127.59, 127.16, 127.09, 126.22, 124.62, 62.04, 54.43, 52.79, 46.86, 44.64, 27.65, 17.60, 15.24, 14.70 ppm; HRMS (ESI): \( \text{C}_{35}\text{H}_{30}\text{NaO}_{2}\ [\text{M + Na}^+] \) calcd: 505.2138, found: 505.2141.

Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 80 – 81 °C, 39.8 mg, 78% yield; 88% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, \( t_{\text{major}} = 4.6 \) min, \( t_{\text{minor}} = 6.3 \) min); \([\alpha]_D^{23.2} = 972 \) (c = 1.0 in CHCl\(_3\)); \(^1\)H NMR (300 MHz, CDCl\(_3\)) δ 7.40 – 7.29 (m, 1H), 7.29 – 7.07 (m, 7H), 6.99 (t, \( J = 7.4 \) Hz, 1H), 6.93 – 6.73 (m, 4H), 6.30 (d, \( J = 7.5 \) Hz, 2H), 5.83 (d, \( J = 10.1 \) Hz, 1H), 3.40 (t, \( J = 10.1 \) Hz, 1H), 3.26 (s, 1H), 2.94 (d, \( J = 10.1 \) Hz, 2H), 1.94 (dd, \( J = 16.8, 8.5 \) Hz, 1H), 1.72 (t, \( J = 11.4 \) Hz, 1H), 1.61 (s, 3H), 1.55 – 1.38 (m, 1H), 1.22 – 0.92 (m, 5H), 0.75 (t, \( J = 6.8 \) Hz, 3H) ppm; \(^{13}\)C NMR (75 MHz, CDCl\(_3\)) δ 213.89, 198.19, 150.19, 143.75, 142.30, 141.97, 141.83, 140.37, 138.45, 134.00, 132.80, 129.63, 129.25, 128.22, 128.18, 127.65, 127.21, 127.16, 126.30, 124.72, 62.08, 54.52, 52.86, 46.95, 44.74, 32.37, 25.40, 23.73, 22.20, 15.32, 13.93 ppm; HRMS (ESI): \( \text{C}_{37}\text{H}_{34}\text{NaO}_{2}\ [\text{M + Na}^+] \) calcd: 533.2451, found: 533.2464.

Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 51 – 52 °C, 46.3
mg, 91% yield; 74% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, t$_{major}$ = 4.4 min, t$_{minor}$ = 5.5 min); [$\alpha$]$_D^{23.2}$ = 522 (c = 1.0 in CHCl$_3$); $^1$H NMR (300 MHz, CDCl$_3$) δ 7.39 – 7.29 (m, 1H), 7.29 – 7.08 (m, 7H), 6.98 (dd, J = 10.6, 4.3 Hz, 1H), 6.82 (dd, J = 11.0, 4.7 Hz, 4H), 6.42 – 6.25 (m, 2H), 5.83 (d, J = 10.1 Hz, 1H), 3.40 (t, J = 10.1 Hz, 1H), 3.27 (s, 1H), 2.94 (d, J = 10.6 Hz, 2H), 1.96 (ddd, J = 17.3, 11.2, 3.1 Hz, 1H), 1.84 – 1.66 (m, 1H), 1.61 (s, 3H), 1.52 – 1.25 (m, 2H), 0.94 – 0.81 (m, 1H), 0.79 (d, J = 6.4 Hz, 3H), 0.61 (d, J = 6.5 Hz, 3H) ppm; $^{13}$C NMR (75 MHz, CDCl$_3$) δ 213.80, 198.16, 150.10, 143.72, 142.17, 141.91, 141.83, 140.30, 138.44, 133.85, 132.72, 129.56, 129.19, 128.18, 127.59, 127.09, 126.21, 124.65, 61.90, 54.42, 52.77, 46.87, 44.65, 32.75, 28.49, 23.18, 22.41, 22.00, 15.25 ppm; HRMS (ESI): C$_{37}$H$_{34}$NaO$_2$ [M + H]$^+$ calcd: 511.2632, found: 511.2628.

Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 96 – 97 °C, 42.0 mg, 78% yield; 74% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, t$_{major}$ = 4.3 min, t$_{minor}$ = 6.8 min); [$\alpha$]$_D^{23.2}$ = 666 (c = 1.0 in CHCl$_3$); $^1$H NMR (300 MHz, CDCl$_3$) δ 7.41 – 7.28 (m, 1H), 7.28 – 7.10 (m, 7H), 6.99 (t, J = 7.4 Hz, 1H), 6.92 – 6.78 (m, 4H), 6.30 (d, J = 7.4 Hz, 2H), 5.83 (d, J = 10.1 Hz, 1H), 3.39 (t, J = 10.1 Hz, 1H), 3.26 (s, 1H), 2.93 (d, J = 10.1 Hz, 2H), 2.00 – 1.84 (m, 1H), 1.84 – 1.65 (m, 1H), 1.61 (s, 3H), 1.55 – 1.37 (m, 1H), 1.37 – 0.92 (m, 9H), 0.81 (t, J = 6.9 Hz, 3H) ppm; $^{13}$C NMR (75 MHz, CDCl$_3$) δ 213.84, 198.13, 150.19, 143.70, 142.29, 141.95, 141.85, 140.38, 138.47, 134.01, 132.82, 129.62, 129.25, 128.22, 128.19, 127.64, 127.21, 127.16, 126.30, 124.72, 62.08, 54.54, 52.86, 46.95, 44.76, 31.62, 30.10, 28.80, 25.42, 24.02, 22.56, 15.32, 14.05 ppm; HRMS (ESI): C$_{39}$H$_{38}$NaO$_2$ [M + Na]$^+$ calcd: 561.22764, found: 561.22763.
Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 194 – 195 °C, 33.6 mg, 72% yield; 98% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, t\textsubscript{major} = 5.7 min, t\textsubscript{minor} = 6.8 min); [α]\textsubscript{D}^{23.2} = 1041 (c = 1.0 in CHCl\textsubscript{3}); \textsuperscript{1}H NMR (300 MHz, CDCl\textsubscript{3}) δ 7.42 – 7.31 (m, 1H), 7.24 (dd, J = 16.1, 8.3 Hz, 3H), 7.17 – 7.03 (m, 4H), 6.97 (t, J = 7.3 Hz, 1H), 6.91 – 6.76 (m, 4H), 6.31 (d, J = 7.4 Hz, 2H), 5.84 (d, J = 10.1 Hz, 1H), 5.82 – 5.69 (m, 1H), 5.01 (d, J = 10.2 Hz, 1H), 4.87 (d, J = 17.1 Hz, 1H), 3.63 – 3.50 (m, 2H), 3.50 – 3.36 (m, 1H), 2.94 – 2.82 (m, 2H), 2.75 (dd, J = 14.4, 6.0 Hz, 1H), 2.59 (dd, J = 14.3, 7.0 Hz, 1H) ppm; \textsuperscript{13}C NMR (75 MHz, CDCl\textsubscript{3}) δ 211.91, 198.27, 151.67, 144.61, 143.06, 141.73, 138.47, 137.65, 137.12, 133.56, 133.29, 132.99, 130.21, 129.30, 128.54, 128.43, 128.13, 127.69, 127.34, 127.27, 127.06, 126.75, 124.86, 118.67, 62.16, 52.51, 48.21, 45.84, 44.75, 29.86 ppm; HRMS (ESI): C\textsubscript{34}H\textsubscript{26}NaO\textsubscript{2}[M + Na]\textsuperscript{+} calcd: 489.1825, found: 489.1819.

Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 63 – 64 °C, 14.4 mg, 28% yield; 95% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, t\textsubscript{major} = 4.6 min, t\textsubscript{minor} = 8.1 min); [α]\textsubscript{D}^{23.2} = 992 (c = 1.0 in CHCl\textsubscript{3}); \textsuperscript{1}H NMR (300 MHz, CDCl\textsubscript{3}) δ 7.33 (t, J = 7.3 Hz, 1H), 7.28 – 7.02 (m, 7H), 6.98 (t, J = 7.4 Hz, 1H), 6.81 (dd, J = 18.0, 7.5 Hz, 4H), 6.31 (d, J = 7.4 Hz, 2H), 5.83 (d, J = 10.1 Hz, 1H), 5.73 (td, J = 17.0, 6.9 Hz, 1H), 5.02 (d, J = 10.1 Hz, 1H), 4.90 (d, J = 17.1 Hz, 1H), 3.41 (dd, J = 12.1, 8.2 Hz, 1H), 3.29 (s, 1H), 3.03 – 2.87 (m,
2H), 2.77 (dd, J = 14.3, 6.0 Hz, 1H), 2.54 (dd, J = 14.4, 7.5 Hz, 1H), 2.15 – 1.90 (m, 2H), 1.57 (dd, J = 15.7, 7.7 Hz, 2H), 1.06 (t, J = 7.2 Hz, 3H) ppm; $^1$H NMR (75 MHz, CDCl$_3$) δ 213.61, 198.21, 151.31, 144.01, 141.73, 141.60, 140.90, 140.40, 137.82, 133.97, 133.23, 132.97, 129.86, 129.61, 128.62, 128.39, 128.08, 127.65, 127.15, 127.06, 126.27, 124.56, 118.64, 61.73, 57.27, 53.74, 47.02, 45.13, 31.06, 29.81, 18.37, 14.91 ppm; $^{13}$C NMR (75 MHz, CDCl$_3$) δ 213.55, 198.21, 151.30, 143.99, 141.73, 141.57, 140.92, 140.43, 137.81, 133.97, 133.26, 132.99, 129.84, 129.61, 128.63, 128.37, 128.07, 127.64, 127.13, 127.06, 126.26, 124.58, 118.61, 61.69, 57.22, 53.73, 47.04, 45.14, 32.57, 29.82, 28.77, 24.59, 22.60, 14.13 ppm; HRMS (ESI): C$_{39}$H$_{36}$NaO$_2$ [M + Na]$^+$ calcd: 559.2608, found: 559.2600.

Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 92 – 93 °C, 17.6 mg, 33% yield; 85% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, $t_{\text{major}}$ = 4.5 min, $t_{\text{minor}}$ = 8.7 min); [α]$^{\text{D}23.2} = 764$ (c = 1.0 in CHCl$_3$); $^1$H NMR (300 MHz, CDCl$_3$) δ 7.32 (t, J = 7.3 Hz, 1H), 7.28 – 7.02 (m, 7H), 6.98 (t, J = 7.3 Hz, 1H), 6.81 (dd, J = 17.1, 7.6 Hz, 4H), 6.32 (d, J = 7.5 Hz, 2H), 5.83 (d, J = 10.2 Hz, 1H), 5.72 (dt, J = 16.8, 8.2 Hz, 1H), 5.03 (d, J = 10.1 Hz, 1H), 4.91 (d, J = 17.2 Hz, 1H), 3.51 – 3.33 (m, 1H), 3.29 (s, 1H), 3.02 – 2.87 (m, 2H), 2.77 (dd, J = 14.7, 5.8 Hz, 1H), 2.54 (dd, J = 14.5, 7.2 Hz, 1H), 2.20 – 1.89 (m, 2H), 1.58 – 1.33 (m, 6H), 0.95 (t, J = 6.3 Hz, 3H) ppm; $^{13}$C NMR (75 MHz, CDCl$_3$) δ 213.55, 198.21, 151.30, 143.99, 141.73, 141.57, 140.92, 140.43, 137.81, 133.97, 133.26, 132.99, 129.84, 129.61, 128.63, 128.37, 128.07, 127.64, 127.13, 127.06, 126.26, 124.58, 118.61, 61.69, 57.22, 53.73, 47.04, 45.14, 32.57, 29.82, 28.77, 24.59, 22.60, 14.13 ppm; HRMS (ESI): C$_{39}$H$_{36}$NaO$_2$ [M + Na]$^+$ calcd: 559.2608, found: 559.2600.
Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 77 – 78 °C, 20.0 mg, 34% yield; 94% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, tmajor = 5.2 min, tminor = 10.0 min); [α] D23.2 = 859 (c = 1.0 in CHCl3); 1H NMR (300 MHz, CDCl3) δ 7.38 – 7.01 (m, 13H), 6.97 (t, J = 7.4 Hz, 1H), 6.82 (t, J = 7.6 Hz, 2H), 6.73 (d, J = 7.2 Hz, 2H), 6.29 (d, J = 7.4 Hz, 2H), 5.81 (d, J = 10.2 Hz, 1H), 5.70 (dt, J = 16.9, 8.6 Hz, 1H), 5.01 (d, J = 10.1 Hz, 1H), 4.89 (d, J = 17.1 Hz, 1H), 3.38 (dd, J = 13.2, 6.8 Hz, 1H), 3.27 (s, 1H), 2.92 – 2.63 (m, 5H), 2.53 (dd, J = 14.5, 7.3 Hz, 1H), 2.21 – 2.02 (m, 2H), 2.02 – 1.75 (m, 2H) ppm; 13C NMR (75 MHz, CDCl3) δ 213.40, 198.14, 151.47, 143.92, 141.93, 141.93, 141.56, 141.39, 140.70, 140.32, 137.67, 133.88, 133.31, 132.94, 129.82, 129.61, 128.61, 128.56, 128.41, 128.07, 127.66, 127.20, 127.08, 126.21, 125.94, 124.63, 118.73, 61.61, 57.03, 53.68, 46.94, 45.09, 36.53, 29.85, 28.46, 26.60 ppm; HRMS (ESI): C43H36NaO2 [M + Na]+ calcd: 607.2608, found: 607.2594.

Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 97 – 98 °C, 39.0 mg, 79% yield; 97% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, tmajor = 4.3 min, tminor = 9.1 min); [α] D23.2 = 978 (c = 1.0 in CHCl3); 1H NMR (300 MHz, CDCl3) δ 7.24 (d, J = 8.9 Hz, 1H), 7.20 – 7.07 (m, 3H), 7.09 – 6.94 (m, 4H), 6.90 – 6.75 (m, 4H), 6.32 (d, J = 7.3 Hz, 2H), 5.83 (d, J = 10.1 Hz, 1H), 5.72 (td, J = 17.0, 6.9 Hz, 1H), 4.96 (d, J = 10.1 Hz, 1H), 4.82 (d, J = 17.1 Hz, 1H), 3.49 – 3.30 (m, 1H), 3.23 (s, 1H), 3.08 – 2.85 (m, 2H), 2.74 (dd, J =
14.3, 6.2 Hz, 1H), 2.56 (dd, J = 14.4, 7.3 Hz, 1H), 2.35 (s, 3H), 1.60 (s, 3H) ppm; $^{13}$C NMR (75 MHz, CDCl$_3$) δ 213.06, 198.31, 149.94, 143.77, 142.05, 141.96, 140.21, 138.33, 138.22, 137.93, 133.91, 133.11, 132.86, 130.34, 129.25, 128.48, 128.19, 127.94, 127.64, 127.17, 127.06, 126.28, 124.54, 118.46, 60.69, 54.32, 52.58, 47.00, 44.71, 30.00, 21.13, 15.30 ppm; HRMS (ESI): C$_{36}$H$_{30}$NaO$_2$ [M + Na]$^+$ calcd: 517.2138, found: 517.2130.

Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 80 – 81 °C, 38.6 mg, 74% yield; 95% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, t$_{major}$ = 4.0 min, t$_{minor}$ = 8.6 min); [α]$_D$ = 23.2 = 894 (c = 1.0 in CHCl$_3$); $^1$H NMR (300 MHz, CDCl$_3$) δ 7.24 (dd, J = 12.0, 5.0 Hz, 1H), 7.21 – 7.08 (m, 3H), 7.07 – 6.91 (m, 4H), 6.82 (t, J = 8.2 Hz, 4H), 6.31 (d, J = 7.4 Hz, 2H), 5.84 (d, J = 10.1 Hz, 1H), 5.72 (dd, J = 10.1, 6.8 Hz, 1H), 4.96 (d, J = 10.1 Hz, 1H), 4.82 (d, J = 17.2 Hz, 1H), 3.39 (dd, J = 11.9, 8.2 Hz, 1H), 3.24 (s, 1H), 3.04 – 2.85 (m, 2H), 2.75 (dd, J = 14.4, 6.1 Hz, 1H), 2.67 – 2.45 (m, 3H), 1.66 (dd, J = 15.4, 7.9 Hz, 2H), 1.60 (s, 3H), 0.96 (t, J = 7.3 Hz, 3H) ppm; $^{13}$C NMR (75 MHz, CDCl$_3$) δ 213.08, 198.32, 149.90, 143.80, 143.11, 142.04, 141.98, 140.17, 138.37, 138.11, 133.94, 133.11, 132.87, 129.72, 129.26, 128.47, 128.19, 127.64, 127.30, 127.17, 127.06, 126.28, 124.49, 118.45, 60.73, 54.40, 52.61, 47.03, 44.74, 37.66, 30.01, 24.63, 15.31, 13.88 ppm; HRMS (ESI): C$_{38}$H$_{34}$NaO$_2$ [M + Na]$^+$ calcd: 545.2451, found: 545.2446.
chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 114 – 115 °C, 39.8 mg, 72% yield; 98% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, t_{major} = 5.0 min, t_{minor} = 20.1 min); [α]_{D}^{23.2} = 927 (c = 1.0 in CHCl₃); ²H NMR (300 MHz, CDCl₃) δ 7.58 (d, J = 7.3 Hz, 2H), 7.52 – 7.32 (m, 5H), 7.32 – 7.05 (m, 5H), 7.00 (t, J = 7.1 Hz, 1H), 6.83 (dd, J = 14.4, 7.0 Hz, 4H), 6.36 (d, J = 7.3 Hz, 2H), 5.84 (d, J = 10.1 Hz, 1H), 5.74 (dt, J = 16.3, 8.2 Hz, 1H), 4.99 (d, J = 10.1 Hz, 1H), 4.86 (d, J = 17.1 Hz, 1H), 3.49 (dd, J = 12.6, 7.2 Hz, 1H), 3.34 (s, 1H), 3.13 – 2.91 (m, 2H), 2.80 (dd, J = 14.1, 5.9 Hz, 1H), 2.63 (dd, J = 14.2, 7.3 Hz, 1H), 1.63 (s, 3H) ppm; ¹³C NMR (75 MHz, CDCl₃) δ 212.81, 198.06, 149.81, 143.74, 142.24, 141.90, 141.40, 140.83, 140.00, 139.90, 138.24, 133.82, 132.97, 132.90, 129.26, 128.98, 128.51, 128.36, 128.23, 127.81, 127.70, 127.30, 127.15, 127.02, 126.42, 125.91, 125.17, 118.66, 60.86, 54.51, 52.66, 46.99, 44.80, 30.06, 15.33 ppm; HRMS (ESI): C₄₁H₃₂NaO₂ [M + Na]⁺ calcd: 579.2295, found: 579.2282.

Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 117 – 118 °C, 44.4 mg, 78% yield; 98% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, t_{major} = 4.7 min, t_{minor} = 19.4 min); [α]_{D}^{23.2} = 931 (c = 1.0 in CHCl₃); ²H NMR (300 MHz, CDCl₃) δ 7.53 – 7.30 (m, 5H), 7.30 – 7.06 (m, 6H), 6.99 (d, J = 7.0 Hz, 1H), 6.93 – 6.75 (m, 4H), 6.36 (d, J = 7.1 Hz, 2H), 5.84 (d, J = 10.1 Hz, 1H), 5.81 – 5.61 (m, 1H), 4.99 (d, J = 9.9 Hz, 1H), 4.85 (d, J = 16.9 Hz, 1H), 3.49 (dd, J = 12.8, 6.8 Hz, 1H), 3.34 (s, 1H), 2.98 (d, J = 13.8 Hz, 2H), 2.79 (dd, J = 14.2, 6.0 Hz, 1H), 2.62 (dd, J = 14.0, 7.1 Hz, 1H), 2.45 (s, 3H), 1.63 (s, 3H) ppm; ¹³C NMR (75 MHz, CDCl₃) δ 212.86, 198.13, 149.86, 143.82, 142.22, 141.92, 141.62, 140.73, 139.89, 138.62, 138.25, 133.83, 133.00, 132.88, 129.26, 128.90, 128.52, 128.38, 128.23, 127.76, 127.69, 127.28, 127.14, 126.41, 126.02, 125.10, 124.20, 118.65, 60.88, 54.51, 52.65, 46.97, 44.76, 30.06, 21.61, 15.34 ppm; HRMS (ESI): C₄₂H₃₄NaO₂ [M + Na]⁺ calcd: 593.2451, found: 593.2443.
Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 121 – 122 °C, 33.4 mg, 57% yield; 88% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, t\text{major} = 3.9 min, t\text{minor} = 4.5 min); [\alpha]_D^{23.2} = 791 (c = 1.0 in CHCl₃); \(^1\text{H NMR}\) (300 MHz, CDCl₃) δ 7.27 (d, J = 11.2 Hz, 1H), 7.24 – 7.07 (m, 7H), 7.02 (s, 3H), 6.95 – 6.79 (m, 4H), 6.34 (d, J = 7.4 Hz, 2H), 5.82 (d, J = 10.1 Hz, 1H), 5.80 – 5.69 (m, 1H), 5.02 (d, J = 10.1 Hz, 1H), 4.90 (d, J = 17.1 Hz, 1H), 3.43 – 3.23 (m, 2H), 3.02 – 2.73 (m, 3H), 2.62 (dd, J = 14.4, 7.3 Hz, 1H), 2.07 (s, 3H), 2.02 (s, 3H), 1.63 (s, 3H) ppm; \(^1\text{C NMR}\) (75 MHz, CDCl₃) δ 213.15, 197.80, 149.67, 143.52, 142.45, 141.76, 141.46, 140.70, 139.26, 138.14, 135.90, 135.64, 133.97, 133.05, 132.89, 130.23, 129.28, 128.44, 128.19, 127.94, 127.71, 127.57, 127.43, 127.31, 127.22, 126.42, 124.79, 118.64, 60.92, 54.57, 52.87, 46.88, 45.11, 30.00, 21.06, 20.93, 15.22 ppm; \text{HRMS (ESI)}: C_{43}H_{36}NaO_{2}\ [M + Na]^+ \text{calcd: 607.2608, found: 607.2593.}

Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 94 – 95 °C, 36.0 mg, 73% yield; 89% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, t\text{major} = 4.9 min, t\text{minor} = 7.8 min); [\alpha]_D^{23.2} = 785 (c = 1.0 in CHCl₃); \(^1\text{H NMR}\) (300 MHz, CDCl₃) δ 7.39 – 7.18 (m, 4H), 7.14 (d, J = 7.5 Hz, 1H), 6.98 (dd, J = 16.8, 7.7 Hz, 3H), 6.83 (t, J = 7.5 Hz, 2H), 6.68 (d, J = 7.7 Hz, 2H), 6.32 (d, J = 7.4 Hz, 2H), 5.82 (d, J = 10.1 Hz, 1H), 5.71 (dt, J = 16.8, 8.3 Hz, 1H), 4.97 (d, J = 10.0 Hz, 1H), 4.84 (d, J = 17.1 Hz, 1H), 3.38 (t, J = 10.0 Hz, 1H), 3.26 (s, 1H), 2.93 (d, J = 9.9 Hz, 2H), 2.77 (dd, J = 14.5, 6.0 Hz, 1H), 2.59 (dd, J = 14.4, 7.2 Hz, 1H), 2.30 (s,
3H), 1.60 (s, 3H) ppm; $^{13}$C NMR (75 MHz, CDCl$_3$) δ 213.11, 198.23, 149.56, 143.92, 142.35, 142.03, 141.01, 140.48, 137.59, 135.29, 133.89, 133.03, 132.69, 129.73, 129.16, 128.86, 128.50, 128.39, 127.20, 127.05, 126.08, 124.65, 118.57, 60.93, 54.44, 52.72, 46.96, 44.78, 29.98, 29.72, 21.20, 15.27 ppm; HRMS (ESI): C$_{36}$H$_{30}$NaO$_2$ [M + Na]$^+$ calcd: 517.2138, found: 517.2143.

Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 193 – 194 °C, 40.5 mg, 82% yield; 98% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, $t_{\text{major}} = 4.6$ min, $t_{\text{minor}} = 7.3$ min); [$\alpha$]$_D^{23.2}$ = 1034 (c = 1.0 in CHCl$_3$); $^1$H NMR (300 MHz, CDCl$_3$) δ 7.33 (t, $J = 7.1$ Hz, 1H), 7.28 – 7.10 (m, 4H), 7.10 – 6.95 (m, 3H), 6.84 (t, $J = 7.6$ Hz, 2H), 6.62 (d, $J = 7.2$ Hz, 1H), 6.47 (s, 1H), 6.30 (d, $J = 7.3$ Hz, 2H), 5.82 (d, $J = 10.1$ Hz, 1H), 5.79 – 5.62 (m, 1H), 4.97 (d, $J = 10.0$ Hz, 1H), 4.84 (d, $J = 17.1$ Hz, 1H), 3.39 (t, $J = 10.1$ Hz, 1H), 3.27 (s, 1H), 2.94 (d, $J = 10.2$ Hz, 2H), 2.76 (dd, $J = 14.3, 6.2$ Hz, 1H), 2.60 (dd, $J = 14.4, 7.3$ Hz, 1H), 2.16 (s, 3H), 1.61 (s, 3H) ppm; $^{13}$C NMR (75 MHz, CDCl$_3$) δ 213.06, 198.22, 149.62, 143.97, 142.19, 142.07, 141.06, 140.44, 138.13, 137.80, 133.91, 133.03, 132.75, 129.76, 128.55, 128.39, 128.33, 128.12, 127.17, 127.02, 126.25, 126.17, 124.67, 118.59, 60.94, 54.28, 52.63, 46.92, 44.81, 30.02, 21.22, 15.32 ppm; HRMS (ESI): C$_{36}$H$_{30}$NaO$_2$ [M + Na]$^+$ calcd: 517.2138, found: 517.2144.

Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 102 – 103 °C, 37.6 mg, 74% yield; 97% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, $t_{\text{major}} = 4.4$ min, $t_{\text{minor}} = 6.4$ min); [$\alpha$]$_D^{23.2}$ = 848 (c = 1.0 in CHCl$_3$); $^1$H NMR
(300 MHz, CDCl$_3$) δ 7.40 – 7.29 (m, 1H), 7.29 – 7.12 (m, 4H), 7.02 (t, J = 7.5 Hz, 1H), 6.84 (dd, J = 15.3, 7.8 Hz, 3H), 6.35 – 6.27 (m, 4H), 5.81 (d, J = 10.1 Hz, 1H), 5.78 – 5.62 (m, 1H), 4.97 (dd, J = 10.3, 1.7 Hz, 1H), 4.85 (dd, J = 17.1, 1.7 Hz, 1H), 3.37 (t, J = 10.1 Hz, 1H), 3.26 (s, 1H), 2.93 (d, J = 10.6 Hz, 2H), 2.76 (dd, J = 14.4, 6.4 Hz, 1H), 2.61 (dd, J = 14.4, 7.2 Hz, 1H), 2.14 (s, 6H), 1.61 (s, 3H) ppm; $^{13}$C NMR (75 MHz, CDCl$_3$) δ 213.06, 198.27, 149.34, 144.17, 142.21, 142.08, 141.04, 140.38, 137.97, 137.62, 133.90, 132.99, 132.53, 129.73, 129.06, 128.54, 128.30, 127.12, 127.05, 126.87, 126.73, 125.92, 124.58, 118.50, 60.82, 54.13, 52.54, 46.84, 44.74, 29.98, 21.06, 15.30 ppm; HRMS (ESI): C$_{37}$H$_{32}$NaO$_2$ [M + Na]$^+$ calcd: 531.2295, found: 531.2298.

Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 93 – 94 ℃, 40.0 mg, 78% yield; 98% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, t$_{\text{major}}$ = 5.3 min, t$_{\text{minor}}$ = 10.9 min); [α]$_D^{23.2}$ = 908 (c = 1.0 in CHCl$_3$); $^1$H NMR (300 MHz, CDCl$_3$) δ 7.40 – 7.29 (m, 1H), 7.25 (d, J = 10.3 Hz, 3H), 7.19 – 6.98 (m, 3H), 6.87 (t, J = 7.6 Hz, 2H), 6.74 (d, J = 8.2 Hz, 1H), 6.44 (d, J = 7.5 Hz, 1H), 6.34 (d, J = 7.4 Hz, 2H), 6.21 (s, 1H), 5.83 (d, J = 10.1 Hz, 1H), 5.72 (td, J = 16.9, 6.8 Hz, 1H), 4.97 (d, J = 10.2 Hz, 1H), 4.84 (d, J = 17.2 Hz, 1H), 3.60 (s, 3H), 3.39 (t, J = 10.1 Hz, 1H), 3.27 (s, 1H), 2.94 (d, J = 10.2 Hz, 2H), 2.77 (dd, J = 14.4, 6.1 Hz, 1H), 2.60 (dd, J = 14.4, 7.2 Hz, 1H), 1.60 (s, 3H) ppm; $^{13}$C NMR (75 MHz, CDCl$_3$) δ 212.94, 198.14, 159.29, 149.68, 143.73, 141.95, 141.58, 141.04, 140.39, 139.54, 133.96, 132.95, 129.79, 129.34, 128.52, 128.41, 127.27, 127.23, 127.12, 126.37, 124.66, 121.68, 118.62, 114.39, 113.55, 60.95, 55.18, 54.28, 52.62, 46.90, 44.78, 29.98, 15.29 ppm; HRMS (ESI): C$_{36}$H$_{30}$NaO$_2$ [M + Na]$^+$ calcd: 533.2087, found: 533.2093.
Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 95 – 96 °C, 37.7 mg, 76% yield; 97% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, t_{major} = 5.2 min, t_{minor} = 8.2 min); [α]_{D}^{23.2} = 968 (c = 1.0 in CHCl₃); $^1$H NMR (300 MHz, CDCl₃) δ 7.42 – 7.29 (m, 1H), 7.29 – 7.08 (m, 4H), 7.02 (t, $J$ = 7.2 Hz, 1H), 6.95 – 6.63 (m, 6H), 6.30 (d, $J$ = 7.4 Hz, 2H), 5.85 (d, $J$ = 10.1 Hz, 1H), 5.73 (dt, $J$ = 16.8, 8.5 Hz, 1H), 5.00 (d, $J$ = 10.2 Hz, 1H), 4.86 (d, $J$ = 17.0 Hz, 1H), 3.40 (t, $J$ = 10.1 Hz, 1H), 3.28 (s, 1H), 2.94 (d, $J$ = 9.9 Hz, 2H), 2.76 (dd, $J$ = 14.3, 5.8 Hz, 1H), 2.58 (dd, $J$ = 14.3, 7.2 Hz, 1H), 1.60 (s, 3H) ppm; $^{13}$C NMR (75 MHz, CDCl₃) δ 212.91, 198.01, 162.23 ($J_{C-F}$ = 246.0 Hz), 150.23, 143.25, 142.12, 140.91, 140.60, 140.29, 134.05 ($J_{C-F}$ = 3.8 Hz), 133.74, 133.24, 132.95, 131.03, 130.92, 129.78, 128.44, 127.41, 127.27, 127.20, 126.60, 124.72, 118.71, 115.38, 115.09, 61.07, 54.27, 52.57, 46.85, 44.82, 29.98, 15.22 ppm; $^{19}$F NMR (282 MHz, CDCl₃) δ -113.68 ppm; HRMS (ESI): C₃₅H₂₇FNaO₂ [M + Na]$^+$ calcd: 521.1887, found: 521.1893.

Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 103 – 104 °C, 34.4 mg, 67% yield; 96% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, t_{major} = 5.4 min, t_{minor} = 8.3 min); [α]_{D}^{23.2} = 893 (c = 1.0 in CHCl₃); $^1$H NMR (300 MHz, CDCl₃) δ 7.34 (t, $J$ = 7.2 Hz, 1H), 7.29 – 6.98 (m, 7H), 6.88 (t, $J$ = 7.6 Hz, 2H), 6.71 (d, $J$ = 8.3 Hz, 2H), 6.30 (d, $J$ = 7.4 Hz, 2H), 5.85 (d, $J$ = 10.1 Hz, 1H), 5.74 (td, $J$ = 16.9, 7.0 Hz, 1H), 4.99 (d, $J$ = 10.2 Hz, 1H), 4.85 (d, $J$ = 17.1 Hz, 1H), 3.48 – 3.32 (m, 1H), 3.28 (s, 1H), 2.94 (d, $J$ = 9.6 Hz, 2H), 2.76 (dd, $J$ = 14.4, 6.1 Hz, 1H), 2.58 (dd, $J$ = 14.4, 7.3 Hz, 1H), 1.60 (s, 3H) ppm; $^{13}$C NMR (75 MHz, CDCl₃) δ 212.81, 197.92, 150.35, 143.05, 141.95, 140.87, 140.35, 140.24, 136.51, 133.72, 133.69.
Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 111 – 112 °C, 26.8 mg, 51% yield; 97% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, t_major = 5.7 min, t_minor = 9.0 min); \[\alpha\] D^23.2 = 828 (c = 1.0 in CHCl_3); ^1H NMR (300 MHz, CDCl_3) δ 7.77 (d, J = 7.6 Hz, 1H), 7.65 (d, J = 8.4 Hz, 1H), 7.57 (d, J = 7.4 Hz, 1H), 7.51 – 7.39 (m, 2H), 7.38 – 7.30 (m, 1H), 7.30 – 7.19 (m, 3H), 7.15 (s, 2H), 6.95 (d, J = 8.3 Hz, 1H), 6.85 (t, J = 7.4 Hz, 1H), 6.63 (t, J = 7.5 Hz, 2H), 6.26 (d, J = 7.4 Hz, 2H), 5.83 (d, J = 10.1 Hz, 1H), 5.71 (dt, J = 16.8, 8.4 Hz, 1H), 4.95 (d, J = 10.1 Hz, 1H), 4.82 (d, J = 17.2 Hz, 1H), 3.45 (t, J = 10.0 Hz, 1H), 3.31 (s, 1H), 2.97 (d, J = 10.1 Hz, 2H), 2.77 (dd, J = 14.3, 6.0 Hz, 1H), 2.59 (dd, J = 14.3, 7.4 Hz, 1H), 1.68 (s, 3H) ppm; ^13C NMR (75 MHz, CDCl_3) δ 198.14, 150.06, 143.80, 141.99, 141.81, 141.01, 140.43, 135.62, 133.71, 133.30, 132.97, 132.87, 132.47, 129.79, 128.42, 127.93, 127.55, 127.30, 127.00, 126.90, 126.46, 126.37, 126.30, 124.71, 118.63, 61.00, 54.38, 52.73, 46.95, 44.91, 30.00, 15.38 ppm; HRMS (ESI): C_{39}H_{30}NaO_2 [M + Na]^+ calcd: 553.2138, found: 553.2147.

Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 75 – 76 °C, 39.1 mg, 79% yield; 96% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow
rate = 1.0 mL/min, $t_{\text{major}} = 5.2$ min, $t_{\text{minor}} = 15.2$ min); $[\alpha]^{23.2} = 904$ (c = 1.0 in CHCl$_3$); $^1$H NMR (300 MHz, CDCl$_3$) δ 7.35 (t, $J = 7.1$ Hz, 1H), 7.30 – 7.04 (m, 7H), 6.81 (d, $J = 6.1$ Hz, 2H), 6.53 (t, $J = 8.7$ Hz, 2H), 6.27 (dd, $J = 8.5$, 5.6 Hz, 2H), 5.85 (d, $J = 10.1$ Hz, 1H), 5.79 – 5.61 (m, 1H), 4.97 (d, $J = 10.0$ Hz, 1H), 4.81 (d, $J = 17.1$ Hz, 1H), 3.40 (t, $J = 10.1$ Hz, 1H), 3.28 (s, 1H), 2.94 (d, $J = 10.4$ Hz, 2H), 2.77 (dd, $J = 14.4$, 5.9 Hz, 1H), 2.55 (dd, $J = 14.4$, 7.6 Hz, 1H), 1.61 (s, 3H) ppm; $^{13}$C NMR (75 MHz, CDCl$_3$) δ 212.76, 198.01, 161.83 ($J_{\text{C-F}} = 245.2$ Hz), 148.76, 143.53, 142.88, 141.44, 140.86, 140.35, 138.19, 132.99, 132.86, 130.28, 130.18, 129.88, 129.74 ($J_{\text{C-F}} = 3.38$ Hz), 129.21, 128.52, 128.33, 127.82, 127.30, 126.55, 124.52, 118.71, 114.28, 113.99, 60.88, 54.28, 52.66, 46.89, 44.78, 29.92, 15.23 ppm; $^{19}$F NMR (282 MHz, CDCl$_3$) δ -114.13 ppm; HRMS (ESI): C$_{35}$H$_{27}$FNaO$_2$ [M + Na]$^+$ calcd: 521.1887, found: 521.1888.

Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 97 – 98 °C, 39.2 mg, 76% yield; 97% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, $t_{\text{major}} = 5.6$ min, $t_{\text{minor}} = 17.5$ min); $[\alpha]^{23.2} = 935$ (c = 1.0 in CHCl$_3$); $^1$H NMR (300 MHz, CDCl$_3$) δ 7.35 (t, $J = 7.2$ Hz, 1H), 7.29 – 7.04 (m, 7H), 6.94 – 6.69 (m, 4H), 6.23 (d, $J = 8.3$ Hz, 2H), 5.85 (d, $J = 10.1$ Hz, 1H), 5.70 (td, $J = 16.9$, 7.3 Hz, 1H), 4.97 (d, $J = 10.1$ Hz, 1H), 4.81 (d, $J = 17.2$ Hz, 1H), 3.39 (t, $J = 10.1$ Hz, 1H), 3.28 (s, 1H), 2.94 (d, $J = 10.5$ Hz, 2H), 2.77 (dd, $J = 14.3$, 5.7 Hz, 1H), 2.55 (dd, $J = 14.3$, 7.6 Hz, 1H), 1.61 (s, 3H) ppm; $^{13}$C NMR (75 MHz, CDCl$_3$) δ 212.59, 197.98, 148.47, 143.48, 143.03, 141.29, 140.78, 140.31, 138.15, 133.20, 133.08, 132.77, 132.33, 129.89, 129.81, 129.23, 128.58, 128.38, 127.91, 127.34, 126.63, 124.51, 118.82, 60.86, 54.26, 52.69, 46.87, 44.77, 29.90, 15.24 ppm; HRMS (ESI): C$_{35}$H$_{27}$ClNaO$_2$ [M + Na]$^+$ calcd: 537.1592, found: 537.1599.
Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 104 – 105 °C, 40.3 mg, 82% yield; 94% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, $t_{\text{major}} = 4.9$ min, $t_{\text{minor}} = 10.7$ min); [$\alpha$] $^D_{23.2} = 1037$ (c = 1.0 in CHCl$_3$); $^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 7.39 – 7.05 (m, 8H), 6.81 (d, $J = 6.5$ Hz, 2H), 6.63 (d, $J = 7.9$ Hz, 2H), 6.20 (d, $J = 8.0$ Hz, 2H), 5.83 (d, $J = 10.1$ Hz, 1H), 5.71 (dq, $J = 10.2$, 6.8 Hz, 1H), 4.97 (d, $J = 10.0$ Hz, 1H), 4.86 (d, $J = 17.2$ Hz, 1H), 3.39 (t, $J = 10.1$ Hz, 1H), 3.27 (s, 1H), 2.93 (d, $J = 9.7$ Hz, 2H), 2.76 (dd, $J = 14.4$, 6.3 Hz, 1H), 2.60 (dd, $J = 14.4$, 7.1 Hz, 1H), 2.16 (s, 3H), 1.60 (s, 3H) ppm; $^{13}$C NMR (75 MHz, CDCl$_3$) $\delta$ 213.15, 198.19, 149.87, 143.77, 142.06, 141.95, 141.95, 140.46, 138.38, 136.94, 133.06, 132.83, 130.81, 129.71, 129.27, 128.31, 128.16, 127.81, 127.64, 127.17, 126.26, 124.65, 118.54, 60.92, 54.45, 52.69, 46.95, 44.75, 29.94, 21.15, 15.29 ppm; HRMS (ESI): C$_{36}$H$_{30}$NaO$_2$ [M + Na]$^+$ calcd: 517.2138, found: 517.2149.

Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 62 – 63 °C, 41.0 mg, 76% yield; 91% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, $t_{\text{major}} = 4.5$ min, $t_{\text{minor}} = 7.6$ min); [$\alpha$] $^D_{23.2} = 880$ (c = 1.0 in CHCl$_3$); $^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 7.33 (t, $J = 7.1$ Hz, 1H), 7.29 – 7.09 (m, 7H), 6.79 (d, $J = 6.9$ Hz, 2H), 6.63 (d, $J = 7.9$ Hz, 2H), 6.21 (d, $J = 7.9$ Hz, 2H), 5.83 (d, $J = 10.1$ Hz, 1H), 5.79 – 5.58 (m, 1H), 4.98 (d, $J = 10.0$ Hz, 1H), 4.86 (d, $J = 17.1$ Hz, 1H), 3.39 (t, $J = 10.1$ Hz, 1H), 3.27 (s, 1H), 2.93 (d, $J = 10.2$ Hz, 2H), 2.76
Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 79 – 80 °C, 38.0 mg, 75% yield; 87% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, t_major = 5.4 min, t_minor = 14.7 min); [α]D23.2 = 929 (c = 1.0 in CHCl3); 1H NMR (300 MHz, CDCl3) δ 7.39 – 7.10 (m, 8H), 6.83 (d, J = 5.6 Hz, 2H), 6.37 (d, J = 8.5 Hz, 2H), 6.25 (d, J = 8.5 Hz, 2H), 5.83 (d, J = 10.1 Hz, 1H), 5.70 (td, J = 17.0, 6.9 Hz, 1H), 4.96 (d, J = 10.2 Hz, 1H), 4.84 (d, J = 17.1 Hz, 1H), 3.66 (s, 3H), 3.39 (t, J = 10.0 Hz, 1H), 3.26 (s, 1H), 2.93 (d, J = 10.2 Hz, 2H), 2.76 (dd, J = 14.2, 6.1 Hz, 1H), 2.61 (dd, J = 14.3, 7.2 Hz, 1H), 1.60 (s, 3H) ppm; 13C NMR (75 MHz, CDCl3) δ 213.11, 198.18, 158.63, 149.57, 143.76, 142.07, 141.93, 141.07, 140.46, 138.55, 133.04, 132.81, 129.74, 129.68, 129.28, 128.34, 128.26, 127.69, 127.19, 126.26, 126.13, 124.57, 118.53, 112.59, 60.89, 55.08, 54.44, 52.68, 46.95, 44.73, 29.93, 15.29 ppm; HRMS (ESI): C36H30NaO3 [M + Na]+ calcd: 533.2087, found: 533.2104.
Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 91 – 92 °C, 45.4 mg, 89% yield; 95% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, t_major = 5.2 min, t_minor = 11.7 min); [α]_D^{23.2} = 961 (c = 1.0 in CHCl_3); ^1H NMR (300 MHz, CDCl_3) δ 7.39 – 7.29 (m, 1H), 7.29 – 7.03 (m, 7H), 6.94 – 6.68 (m, 3H), 6.55 (d, J = 7.6 Hz, 1H), 5.85 (t, J = 10.1 Hz, 3H), 5.72 (dt, J = 16.8, 8.4 Hz, 1H), 4.99 (d, J = 10.1 Hz, 1H), 4.87 (d, J = 17.1 Hz, 1H), 3.53 – 3.33 (m, 4H), 3.27 (s, 1H), 2.94 (d, J = 10.4 Hz, 2H), 2.77 (dd, J = 14.3, 6.1 Hz, 1H), 2.60 (dd, J = 14.3, 7.3 Hz, 1H), 1.61 (s, 3H) ppm; ^13C NMR (75 MHz, CDCl_3) δ 212.94, 198.09, 158.28, 149.63, 143.66, 142.13, 141.72, 141.01, 140.39, 138.23, 135.09, 133.08, 132.99, 129.78, 129.20, 128.46, 128.20, 127.70, 127.18, 126.41, 124.69, 120.83, 118.65, 113.58, 60.94, 54.81, 54.36, 52.68, 46.92, 44.77, 30.03, 15.28 ppm; HRMS (ESI): C_{36}H_{30}NaO_{3} [M + Na]^+ calcd: 533.2087, found: 533.2107.

Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 94 – 95 °C, 42.6 mg, 84% yield; 93% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, t_major = 4.7 min, t_minor = 12.8 min); [α]_D^{23.2} = 924 (c = 1.0 in CHCl_3); ^1H NMR (300 MHz, CDCl_3) δ 7.40 – 7.29 (m, 2H), 7.29 – 7.13 (m, 6H), 6.83 (d, J = 6.1 Hz, 2H), 6.64 (d, J = 7.7 Hz, 1H), 6.13 (d, J = 7.7 Hz, 1H), 6.02 (s, 1H), 5.82 (d, J = 10.1 Hz, 1H), 5.78 – 5.59 (m, 1H), 4.96 (d, J = 10.0 Hz, 1H), 4.86 (d, J = 17.1 Hz, 1H), 3.50 – 3.31 (m, 1H), 3.25 (s, 1H), 3.02 – 2.88 (m, 1H), 2.70 (ddd, J = 34.4, 14.3, 6.8 Hz, 2H), 2.07 (s, 3H), 1.80 (s, 3H), 1.59 (s, 3H) ppm; ^13C NMR (75 MHz, CDCl_3) δ 213.10, 198.25, 149.95, 143.82, 142.21, 141.52, 141.10, 140.49, 138.67, 135.67, 135.15, 133.08, 132.84, 131.25, 130.23, 129.69, 129.30, 128.34, 128.11, 127.67, 127.12, 126.19, 125.17, 124.67, 118.48, 60.80, 54.48, 52.69, 46.97, 44.66, 29.95, 19.44, 15.35 ppm; HRMS (ESI): C_{37}H_{32}NaO_{2} [M + Na]^+ calcd: 531.2295, found: 531.2311.
Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 100 – 101 °C, 42.1 mg, 80% yield; 99% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, t_major = 4.9 min, t_minor = 11.8 min); [α]_D$^{23.2}$ = 1013 (c = 1.0 in CHCl$_3$); $^1$H NMR (300 MHz, CDCl$_3$) δ 7.64 – 7.06 (m, 8H), 6.84 (d, J = 6.5 Hz, 2H), 6.70 (d, J = 7.7 Hz, 1H), 6.26 (s, 1H), 6.13 (d, J = 7.6 Hz, 1H), 5.85 (d, J = 10.1 Hz, 1H), 5.67 (dt, J = 16.7, 8.2 Hz, 1H), 4.98 (d, J = 10.0 Hz, 1H), 4.84 (d, J = 17.1 Hz, 1H), 3.54 – 3.31 (m, 1H), 3.27 (s, 1H), 2.94 (d, J = 9.5 Hz, 2H), 2.77 (dd, J = 14.1, 5.7 Hz, 1H), 2.59 (dd, J = 14.2, 7.2 Hz, 1H), 2.18 (s, 3H), 1.60 (s, 3H) ppm; $^{13}$C NMR (75 MHz, CDCl$_3$) δ 212.61, 198.01, 148.12, 143.54, 142.84, 141.45, 140.80, 140.30, 138.10, 135.06, 133.09, 132.90, 132.80, 129.85, 129.57, 129.18, 128.56, 128.32, 128.09, 127.32, 126.56, 126.43, 124.52, 118.80, 60.81, 54.30, 52.71, 46.89, 44.71, 29.90, 19.73, 15.26 ppm; HRMS (ESI): C$_{36}$H$_{28}$ClNaO$_2$ [M + Na]$^+$ calcd: 551.1748, found: 551.1767.

Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 101 – 102 °C, 44.6 mg, 92% yield; 97% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, t_major = 5.3 min, t_minor = 12.6 min); [α]_D$^{23.2}$ = 1050 (c = 1.0 in CHCl$_3$); $^1$H NMR (300 MHz, CDCl$_3$) δ 7.41 – 7.15 (m, 8H), 6.95 (dd, J = 6.4, 2.8 Hz, 1H), 6.86 (dd, J = 4.9, 3.0 Hz, 1H), 6.24 – 6.03 (m, 1H), 5.86 (d, J = 10.1 Hz, 1H), 5.65 (dq, J = 10.1, 6.9 Hz, 1H), 4.93 (d, J = 9.9 Hz, 1H), 4.79 (d, J = 17.1 Hz, 1H), 3.46 – 3.30 (m, 1H), 3.26 (s, 1H), 3.05 – 2.88 (m, 2H), 2.73 (ddd, J = 21.6,
14.2, 6.9 Hz, 2H), 1.59 (s, 3H) ppm; $^{13}$C NMR (75 MHz, CDCl$_3$) δ 212.78, 198.09, 145.02, 143.60, 141.70, 140.90, 140.45, 138.78, 133.49, 132.96, 132.88, 129.75, 129.35, 128.53, 128.45, 128.03, 127.35, 127.25, 126.48, 124.38, 123.98, 123.90, 118.51, 60.67, 54.54, 52.86, 46.94, 44.66, 29.83, 15.22 ppm; HRMS (ESI): C$_{33}$H$_{26}$NaO$_{2}$S [M + Na]$^+$ calcd: 509.1546, found: 509.1561.

Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 108 – 109 °C, 45.1 mg, 85% yield; 99% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, $t_{\text{major}}$ = 5.8 min, $t_{\text{minor}}$ = 17.8 min); [$\alpha$]$_D^{212.2}$ = 680 (c = 1.0 in CHCl$_3$); $^1$H NMR (300 MHz, CDCl$_3$) δ 7.63 (d, $J$ = 7.9 Hz, 1H), 7.45 – 7.19 (m, 9H), 7.19 – 6.99 (m, 3H), 6.78 (dd, $J$ = 8.6, 7.1 Hz, 3H), 6.53 (dd, $J$ = 8.5, 1.7 Hz, 1H), 5.82 (d, $J$ = 10.1 Hz, 1H), 5.71 (ddt, $J$ = 17.0, 10.2, 6.8 Hz, 1H), 4.93 (dd, $J$ = 10.2, 1.7 Hz, 1H), 4.75 (dd, $J$ = 17.1, 1.6 Hz, 1H), 3.43 (dd, $J$ = 12.1, 8.2 Hz, 1H), 3.30 (s, 1H), 3.03 – 2.89 (m, 2H), 2.84 – 2.73 (m, 1H), 2.65 (dd, $J$ = 14.4, 7.3 Hz, 1H), 1.64 (s, 3H) ppm; $^{13}$C NMR (75 MHz, CDCl$_3$) δ 212.76, 198.08, 149.47, 143.56, 142.31, 141.75, 140.96, 140.41, 138.78, 132.95, 132.81, 132.19, 131.30, 129.77, 129.17, 128.46, 128.21, 127.98, 127.76, 127.25, 126.51, 126.34, 125.95, 125.76, 125.61, 124.64, 118.66, 60.95, 54.38, 52.76, 46.89, 44.61, 29.97, 15.31 ppm; HRMS (ESI): C$_{39}$H$_{30}$NaO$_2$ [M + Na]$^+$ calcd: 553.2138, found: 553.2148.

Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 93 – 94 °C, 43.9
mg, 99% yield; 98% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, t_major = 6.8 min, t_minor = 13.3 min); [α]D^23.2 = 1009 (c = 1.0 in CHCl₃); ¹H NMR (300 MHz, CDCl₃) δ 7.52 (d, J = 10.2 Hz, 1H), 7.38 – 6.86 (m, 9H), 5.82 (d, J = 10.2 Hz, 1H), 5.71 (dt, J = 16.7, 8.4 Hz, 1H), 5.13 (d, J = 17.2 Hz, 1H), 5.00 (d, J = 10.2 Hz, 1H), 3.16 (dd, J = 13.3, 6.5 Hz, 1H), 3.01 (s, 1H), 2.97 – 2.64 (m, 4H), 1.33 (s, 3H), 0.92 – 0.64 (m, 1H), 0.23 – 0.81 (m, 1H), 0.08 – 0.09 (m, 2H), -0.09 – -0.31 (m, 1H) ppm; ¹³C NMR (75 MHz, CDCl₃) δ 213.50, 198.11, 148.54, 143.45, 142.15, 141.27, 141.16, 140.50, 137.78, 133.95, 132.59, 129.82, 129.40, 128.49, 128.21, 128.09, 126.92, 126.34, 124.08, 118.12, 60.83, 54.94, 52.97, 47.08, 44.61, 30.03, 14.82, 9.45, 6.82, 3.92 ppm; HRMS (ESI): C₃₂H₂₈NaO₂ [M + Na]^+ calcd: 467.1982, found: 467.1991.

Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 66 – 67 °C, 26.8 mg, 60% yield; >99% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, t_major = 4.7 min, t_minor = 7.5 min); [α]D^23.2 = 937 (c = 1.0 in CHCl₃); ¹H NMR (300 MHz, CDCl₃) δ 7.52 (d, J = 10.2 Hz, 1H), 7.38 (t, J = 7.9 Hz, 3H), 7.24 (d, J = 7.1 Hz, 3H), 7.14 (d, J = 4.4 Hz, 3H), 5.91 (d, J = 10.1 Hz, 1H), 5.76 (dd, J = 16.8, 10.0 Hz, 1H), 5.20 (d, J = 17.2 Hz, 1H), 5.09 (d, J = 10.1 Hz, 1H), 3.33 (t, J = 10.1 Hz, 1H), 3.17 (s, 1H), 3.01 – 2.70 (m, 4H), 1.90 – 1.63 (m, 1H), 1.48 (s, 4H), 1.02 – 0.63 (m, 2H), 0.29 (t, J = 7.1 Hz, 3H) ppm; ¹³C NMR (75 MHz, CDCl₃) δ 213.72, 198.11, 150.59, 143.50, 141.92, 141.24, 140.66, 140.23, 137.27, 133.59, 132.64, 129.49, 128.73, 128.35, 128.07, 126.94, 126.24, 124.18, 118.09, 59.99, 54.61, 52.15, 47.01, 44.74, 29.61, 28.95, 22.03, 14.90, 13.64 ppm; HRMS (ESI): C₃₂H₂₈NaO₂ [M + Na]^+ calcd: 469.2138, found: 469.2127.
Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 57 – 58 °C, 39.0 mg, 82% yield; >99% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, t\text{major} = 4.7 min, t\text{minor} = 7.3 min); [α]²³.² = 1066 (c = 1.0 in CHCl₃); ¹H NMR (300 MHz, CDCl₃) δ 7.53 (d, J = 10.1 Hz, 1H), 7.47 – 7.31 (m, 3H), 7.30 – 7.19 (m, 3H), 7.15 (d, J = 4.6 Hz, 3H), 5.91 (d, J = 10.1 Hz, 1H), 5.85 – 5.65 (m, 1H), 5.20 (d, J = 17.2 Hz, 1H), 5.10 (d, J = 10.3 Hz, 1H), 3.32 (t, J = 10.1 Hz, 1H), 3.17 (s, 1H), 3.01 – 2.70 (m, 4H), 1.85 – 1.70 (m, 1H), 1.60 – 1.40 (m, 4H), 1.02 – 0.41 (m, 9H) ppm; ¹³C NMR (75 MHz, CDCl₃) δ 213.79, 198.18, 150.75, 143.54, 141.96, 141.23, 140.64, 140.06, 137.34, 133.65, 132.61, 129.52, 129.48, 128.73, 128.36, 128.07, 126.93, 126.21, 124.22, 118.09, 59.98, 54.63, 52.17, 47.03, 44.73, 31.51, 29.69, 28.17, 27.01, 22.08, 14.91, 13.87 ppm; HRMS (ESI): C₃₄H₃₄NaO₂ [M + Na]+ calcd: 497.2451, found: 497.2464.

Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow oil, 35.6 mg, 65% yield; >99% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, t\text{major} = 4.0 min, t\text{minor} = 6.0 min); [α]²³.² = 952 (c = 1.0 in CHCl₃); ¹H NMR (300 MHz, CDCl₃) δ 7.53 (d, J = 10.1 Hz, 1H), 7.37 (t, J = 7.9 Hz, 3H), 7.24 (d, J = 6.7 Hz, 3H), 7.14 (d, J = 4.2 Hz, 3H), 5.91 (d, J = 10.1 Hz, 1H), 5.77 (td, J = 16.7, 6.5 Hz, 1H), 5.20 (d, J = 17.0 Hz, 1H), 5.10 (d, J = 10.0 Hz, 1H), 3.46 – 3.23 (m, 1H), 3.17 (s, 1H), 3.01 – 2.70 (m, 4H), 1.76 (dd, J = 12.5, 7.7 Hz, 1H), 1.61 – 1.50 (m, 1H), 1.47 (s, 3H), 1.37 – 1.02 (m, 9H), 1.02 – 0.54 (m, 10H) ppm; ¹³C NMR (75 MHz, CDCl₃) δ 213.72,
Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 10/1 to 4/1). Yellow solid, m.p. 186 – 187 °C, 36.7 mg, 78% yield; 98% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, $t_{\text{major}} = 9.3$ min, $t_{\text{minor}} = 11.8$ min); $[\alpha]_D^{23.2} = 792$ (c = 1.0 in CHCl$_3$); $^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 7.53 (d, $J = 10.1$ Hz, 1H), 7.49 – 7.33 (m, 3H), 7.26 (d, $J = 4.4$ Hz, 3H), 7.23 – 6.99 (m, 3H), 5.95 (d, $J = 10.2$ Hz, 1H), 5.87 – 5.61 (m, 1H), 5.22 (d, $J = 17.0$ Hz, 1H), 5.12 (d, $J = 10.1$ Hz, 1H), 3.43 – 3.26 (m, 1H), 3.20 (s, 1H), 2.87 (dq, $J = 34.9$, 7.4 Hz, 4H), 2.04 – 1.85 (m, 1H), 1.85 – 1.53 (m, 3H), 1.50 (s, 3H), 1.13 – 0.96 (m, 1H), 0.96 – 0.67 (m, 1H) ppm; $^{13}$C NMR (75 MHz, CDCl$_3$) $\delta$ 212.94, 197.75, 147.57, 143.00, 141.89, 140.88, 140.71, 140.42, 137.01, 133.25, 129.83, 129.37, 129.08, 128.71, 128.55, 127.40, 126.91, 123.97, 118.54, 59.98, 54.43, 52.40, 46.89, 44.85, 29.57, 25.88, 24.20, 16.42, 14.79 ppm; HRMS (ESI): $\text{C}_{39}\text{H}_{44}\text{NaO}_2$ [M + Na]$^+$ calcd: 567.3234, found: 567.3219.

Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 65 – 66 °C, 22.2 mg, 50% yield; 93% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, $t_{\text{major}} = 4.7$ min, $t_{\text{minor}} = 7.9$ min); $[\alpha]_D^{23.2} = 970$ (c = 1.0 in CHCl$_3$); $^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 7.53 (d, $J = 10.1$ Hz, 1H), 7.49 – 7.33 (m, 3H), 7.26 (d, $J = 4.4$ Hz, 3H), 7.23 – 6.99 (m, 3H), 5.95 (d, $J = 10.2$ Hz, 1H), 5.87 – 5.61 (m, 1H), 5.22 (d, $J = 17.0$ Hz, 1H), 5.12 (d, $J = 10.1$ Hz, 1H), 3.43 – 3.26 (m, 1H), 3.20 (s, 1H), 2.87 (dq, $J = 34.9$, 7.4 Hz, 4H), 2.04 – 1.85 (m, 1H), 1.85 – 1.53 (m, 3H), 1.50 (s, 3H), 1.13 – 0.96 (m, 1H), 0.96 – 0.67 (m, 1H) ppm; HRMS (ESI): $\text{C}_{39}\text{H}_{39}\text{NNaO}_2$ [M + Na]$^+$ calcd: 494.2091, found: 494.2080.
MHz, CDCl$_3$) δ 7.40 (d, $J = 10.1$ Hz, 1H), 7.36 – 7.21 (m, 4H), 7.21 – 7.01 (m, 5H), 5.89 (d, $J = 10.2$ Hz, 1H), 5.80 (ddd, $J = 16.8$, 8.5, 4.7 Hz, 1H), 5.17 (d, $J = 17.2$ Hz, 1H), 5.09 (d, $J = 10.2$ Hz, 1H), 4.54 (s, 1H), 3.96 (s, 1H), 3.35 (t, $J = 10.1$ Hz, 1H), 3.20 (s, 1H), 2.91 (d, $J = 10.8$ Hz, 2H), 2.88 – 2.67 (m, 2H), 1.53 (s, 3H), 1.15 (s, 3H) ppm; $^{13}$C NMR (75 MHz, CDCl$_3$) δ 213.18, 198.08, 151.70, 143.68, 141.86, 140.92, 140.30, 140.03, 137.97, 137.87, 133.69, 132.72, 129.64, 129.52, 128.31, 128.19, 128.05, 126.88, 126.37, 124.81, 118.28, 117.14, 60.36, 54.38, 52.40, 46.91, 44.74, 30.19, 22.94, 15.11 ppm; HRMS (ESI): $^{}_{\text{C}_{32}^{}H_{28}^{}NaO_2}$ [M + Na]$^+$ calcd: 467.1982, found: 467.1970.

Prepared according to the general procedure on a 0.1 mmol scale and purified by flash chromatography (petroleum ether/ethyl acetate = 20/1 to 10/1). Yellow solid, m.p. 54 – 55 °C, 30.0 mg, 62% yield; >99% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 8/2, flow rate = 1.0 mL/min, $t_{\text{major}} = 5.2$ min, $t_{\text{minor}} = 9.0$ min); [$\alpha]^D_{23.2} =$ 1013 (c = 1.0 in CHCl$_3$); $^1$H NMR (300 MHz, CDCl$_3$) δ 7.53 (d, $J = 10.1$ Hz, 1H), 7.47 – 7.30 (m, 3H), 7.26 (d, $J = 6.2$ Hz, 3H), 7.15 (d, $J = 4.0$ Hz, 3H), 5.92 (d, $J = 10.1$ Hz, 1H), 5.76 (td, $J = 16.8$, 6.6 Hz, 1H), 5.21 (d, $J = 17.0$ Hz, 1H), 5.10 (d, $J = 10.2$ Hz, 1H), 3.46 – 3.23 (m, 1H), 3.18 (s, 1H), 2.98 – 2.75 (m, 4H), 1.80 – 1.75 (m, 2H), 1.75 – 1.60 (m, 2H), 1.60 – 1.50 (m, 1H), 1.48 (s, 3H), 1.12 – 0.68 (m, 4H) ppm; $^{13}$C NMR (75 MHz, CDCl$_3$) δ 213.54, 198.06, 150.03, 143.38, 141.64, 141.15, 140.59, 137.28, 133.56, 132.80, 129.56, 129.49, 128.81, 128.44, 128.17, 127.00, 126.36, 124.19, 118.16, 84.02, 68.30, 59.97, 54.61, 52.22, 47.00, 44.73, 29.66, 27.93, 27.45, 26.39, 17.76, 14.88 ppm; HRMS (ESI): $^{}_{\text{C}_{35}^{}H_{32}^{}NaO_2}$ [M + Na]$^+$ calcd: 507.2295, found: 507.2278.
(E) Control experiments

To a solution of catalyst A8 (0.01 mmol, 10 mol%), β-naphthol 1b (0.12 mmol, 1.2 equiv), H2O (0.1 mmol, 1.0 equiv) and pyridine (0.0025 mmol, 2.5 mol%) in dry toluene (1.0 mL) was added para-quinone methide (0.1 mmol, 1.0 equiv) at -60 °C. The reaction mixture was stirred at this temperature until the complete consumption of p-QM. After which the reaction mixture was warmed to room temperature and stirred for further 48 h. Upon completion, the residue was directly purified by silica gel chromatography to afford the desired products 3b as a yellow solid (37.4 mg, 78% yield, 98% ee).

To a solution of catalyst A8 (0.01 mmol, 10 mol%), β-naphthol 1b (0.12 mmol, 1.2 equiv) and pyridine (0.0025 mmol, 2.5 mol%) in dry toluene (1.0 mL) was added propargylic alcohol 2i (0.1 mmol, 1.0 equiv) at -60 °C. The reaction mixture was stirred at this temperature until the complete consumption of the substrate 2i, the progress of which was monitored by TLC analysis. Then the reaction mixture was directly purified by silica gel chromatography (eluting with hexane/ethyl acetate = 10:1 to 7:1) to afford the desired chiral allene 4 as a yellow solid (42.3 mg, 85% yield, >20:1 dr). 96% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 9/1, flow rate = 0.7 mL/min, t_{minor} = 7.6 min, t_{major} = 21.2 min); 1H NMR (300 MHz, MeOD) δ 7.60 – 7.31 (m, 8H), 7.31 – 7.05 (m, 4H), 6.89 (t, J = 7.5 Hz, 4H), 6.76 (t, J = 8.6 Hz, 2H), 5.19 (dt, J = 17.2, 7.6 Hz, 1H), 4.76 – 4.60 (m, 2H), 3.33 (s, 1H), 2.95 (dd, J = 12.2, 8.5 Hz, 1H), 2.68 (dd, J = 12.6, 6.6 Hz, 1H), 1.96 (s, 3H) ppm; 13C NMR (75 MHz, MeOD) δ 208.43, 203.33, 163.13 (J_C-F = 244.5 Hz), 158.66, 144.58, 144.01, 138.38, 135.37, 132.89, 132.46, 130.59, 130.37, 130.05, 129.91, 129.78, 129.73,
129.67, 129.06, 128.65, 128.43, 127.46, 118.92, 116.61, 116.35, 116.17, 115.89, 113.86, 60.80, 51.06, 15.79 ppm; HRMS (ESI): C$_{35}$H$_{27}$FNaO$_2$ [M + Na]$^+$ calcd: 521.1887, found: 521.1875.

(F) Versatile transformations of the dearomatized products

To a solution of catalyst A8 (0.01 mmol, 10 mol%), β-naphthol 1b (0.12 mmol, 1.2 equiv) and pyridine (0.0025 mmol, 2.5 mol%) in dry toluene (1.0 mL) was added propargylic alcohol 2i (0.1 mmol, 1.0 equiv) at -60 °C. After stirring at -60 °C for indicated time, the reaction mixture was warmed to room temperature. Then, acetic anhydride (0.15 mmol, 1.5 equiv), triethylamine (0.15 mmol, 1.5 equiv) and 4-dimethylaminopyridine (0.02 mmol, 0.2 equiv) were successively added to the stirred solution. The resulting reaction mixture was stirred at room temperature for 30 min and directly purified by silica gel chromatography (eluting with hexane/ethyl acetate = 20:1 to 10:1) to afford compound 5 as a white solid (43.9 mg, 81% yield, 96% ee). 96% ee determined by HPLC on a Chiralpak IA-H column (hexane/iPrOH = 97/3, flow rate = 1.0 mL/min, $t_{\text{minor}} = 5.9$ min, $t_{\text{major}} = 7.6$ min); $^1$H NMR (300 MHz, CDCl$_3$) δ 7.52 (d, $J = 7.5$ Hz, 1H), 7.37 (s, 1H), 7.32 – 7.10 (m, 8H), 7.10 – 6.80 (m, 6H), 5.79 (td, $J = 16.9, 7.3$ Hz, 1H), 5.05 (d, $J = 10.1$ Hz, 1H), 4.91 (d, $J = 17.0$ Hz, 1H), 4.81 (s, 1H), 4.11 (s, 1H), 2.88 (dd, $J = 14.2, 5.6$ Hz, 1H), 2.65 (dd, $J = 14.2, 7.7$ Hz, 1H), 2.36 (s, 3H), 1.05 (s, 3H) ppm; $^{13}$C NMR (75 MHz, CDCl$_3$) δ 213.90, 169.47, 162.43 ($\delta_{C-F} = 246.0$ Hz), 149.15, 145.22, 141.99, 141.48, 140.05, 139.89, 137.45, 134.98, 133.31, 132.49, 130.37, 129.83, 128.50, 128.35, 127.76, 126.60, 124.02, 123.83, 120.22, 118.54, 115.40, 115.12, 59.49, 55.61, 51.18, 43.96, 30.11, 21.30, 16.00 ppm; $^{19}$F NMR (282 MHz, CDCl$_3$) δ -113.48 ppm; HRMS (ESI): C$_{37}$H$_{29}$FNaO$_3$ [M + Na]$^+$ calcd: 563.1993, found: 563.2016.
**Procedure A**: To a solution of 3x (0.061 mmol, 31.5 mg) in methanol (0.5 mL) was added NaBH$_4$ (0.3 mmol, 5 equiv) at room temperature. The mixture was stirred for 1 h until the complete consumption of the start material. Then the mixture was quenched by water and the aqueous layer was extracted with EtOAc for three times, and the combined organic layers were washed with brine, dried, and concentrated. The residue was then purified by flash chromatography (eluting with hexane/ethyl acetate = 4:1 to 2:1) to give 6 in 89% yield. White solid, m.p. 117-118 °C.; [α]$_D^{23.2}$ = 678 (c = 1.0 in CHCl$_3$); $^1$H NMR (300 MHz, MeOD) δ 7.40 – 7.21 (m, 2H), 7.20 – 7.02 (m, 5H), 6.78 (s, 2H), 6.49 (t, $J$ = 8.8 Hz, 2H), 6.38 – 6.21 (m, 2H), 6.17 (d, $J$ = 10.3 Hz, 1H), 5.74 (dt, $J$ = 15.9, 9.0 Hz, 1H), 5.62 (d, $J$ = 10.2 Hz, 1H), 5.04 (t, $J$ = 13.4 Hz, 2H), 4.91 (s, 1H), 4.54 (s, 1H), 4.26 (s, 1H), 2.89 (s, 1H), 2.74 – 2.38 (m, 4H), 1.86 (dd, $J$ = 25.0, 11.4 Hz, 1H), 1.39 (s, 3H) ppm; $^{13}$C NMR (75 MHz, MeOD) δ 162.82 ($J_{C-F}$ = 243.0 Hz), 146.78, 146.39, 145.24, 141.33, 140.37, 135.81, 135.45, 135.04, 134.49, 133.12 ($J_{C-F}$ = 3.0 Hz), 131.76, 131.65, 130.71, 130.39, 128.90, 128.24, 127.66, 126.93, 126.69, 126.07, 118.47, 114.84, 114.55, 80.14, 69.52, 57.84, 47.42, 44.30, 44.05, 33.86, 21.78 ppm; $^{19}$F NMR (282 MHz, MeOD) δ -117.87 ppm; HRMS (ESI): C$_{35}$H$_{31}$FNaO$_2$ [M + Na]$^+$ calcd: 525.2200, found: 525.2221.

**Procedure B**: To a solution of 3x (0.067 mmol, 33.4 mg) in methanol (1.0 mL) was added 10% palladium on carbon catalyst (0.0067 mmol, 0.1 equiv). The mixture was stirred with a hydrogen balloon at room temperature until the complete consumption of the start material (monitored by TLC). Then the mixture was filtrated with celite and evaporated to give a residue, which was purified by column chromatography on silica gel (eluting with hexane/ethyl acetate = 10:1) to afford the desired product 7 in 63% yield. White solid, m.p. 100-101 °C.; [α]$_D^{23.2}$ = 463 (c = 1.0 in CHCl$_3$); $^1$H NMR (300 MHz, CDCl$_3$) δ 7.40 – 7.14 (m, 3H), 7.14 – 7.00 (m, 4H), 6.70 (d, $J$ = 3.6 Hz, 2H), 6.48 (t, $J$ = 8.7 Hz, 2H), 6.29 – 6.11 (m, 2H), 3.26 (s, 6H), 3.13 (s, 1H), 2.80 (dd, $J$ = 13.5, 4.6 Hz, 1H), 2.44 (t, $J$ = 14.5 Hz, 1H), 2.14 – 1.76 (m, 4H), 1.70 – 1.38 (m, 5H), 1.35 – 1.13 (m, 1H), 1.13 – 0.92 (m, 1H), 0.78 (t, $J$ = 7.0 Hz, 3H) ppm; $^{13}$C NMR (75 MHz, CDCl$_3$) δ 214.55, 160.39 ($J_{C-F}$ = 244.5 Hz),
Procedure C: A solution of 1.6 M MeLi (0.06 mmol, 37.5 uL) in ether was added dropwise to a stirred solution of 3x (0.05 mmol, 25 mg) in ether (1.0 mL) at -78 °C under Ar. After being stirred for 1 h, the reaction mixture was quenched by saturated NH₄Cl aqueous solution. The aqueous layer was extracted with EtOAc for three times, and the combined organic layers were washed with brine, dried, and concentrated. The residue was then purified by flash chromatography (eluting with hexane/ethyl acetate = 7:1 to 4:1) to give 8 in 78% yield. White solid, m.p. 92-93 °C; [α]D 23.2 = 578 (c = 1.0 in CHCl₃); ¹H NMR (300 MHz, CDCl₃) δ 7.42 – 7.28 (m, 1H), 7.28 – 7.05 (m, 6H), 6.82 (d, J = 3.2 Hz, 2H), 6.52 (t, J = 8.6 Hz, 2H), 6.40 – 6.24 (m, 2H), 6.18 (d, J = 10.2 Hz, 1H), 5.79 – 5.62 (m, 1H), 5.60 (d, J = 10.2 Hz, 1H), 4.94 (d, J = 10.1 Hz, 1H), 4.79 (d, J = 17.0 Hz, 1H), 3.20 (s, 1H), 2.79 (dd, J = 25.2, 10.4 Hz, 2H), 2.58 (dd, J = 14.2, 7.4 Hz, 1H), 2.31 (d, J = 9.9 Hz, 1H), 2.10 (t, J = 13.4 Hz, 1H), 1.47 (s, 6H) ppm; ¹⁹F NMR (282 MHz, CDCl₃) δ -114.79 ppm; ¹³C NMR (75 MHz, CDCl₃) δ 213.64, 161.7 (J_{CF} = 244.5 Hz), 145.10, 143.68, 141.70, 141.19, 139.49, 136.82, 134.64, 133.14, 132.97, 130.42, 130.31, 129.45, 128.26, 128.06, 126.99, 126.94, 124.51, 124.33, 118.37, 114.37, 113.85, 71.12, 60.35, 55.08, 52.72, 48.81, 44.25, 29.97, 26.92, 15.20 ppm; HRMS (ESI): C_{36}H_{31}FNaO_{2} [M + Na]^+ calcd: 537.2200, found: 537.2185.

Procedure D: A solution of 1.6 M MeLi (0.06 mmol, 37.5 uL) in ether was added dropwise to a stirred solution of 3x (0.05 mmol, 25 mg) in ether (1.0 mL) at -78 °C under Ar. After being stirred for 1 h, 0.14 mmol of MeLi was added again and the reaction mixture was stirred for another 3 h. Then the reaction mixture was quenched by saturated NH₄Cl aqueous solution. The aqueous layer was extracted with EtOAc for three times, and the combined organic layers were washed with brine, dried, and concentrated. The residue was then purified by flash chromatography (eluting with...
hexane/ethyl acetate = 4:1 to 2:1) to give 9 in 71% yield. White solid, m.p. 108-109 °C.; \([\alpha]^{23.2}_D = 657 \) (c = 1.0 in CHCl₃); \( ^1H \) NMR (300 MHz, CDCl₃) δ 7.40 – 7.22 (m, 2H), 7.15 (d, \( J = 2.7 \) Hz, 2H), 7.05 (d, \( J = 2.5 \) Hz, 3H), 6.73 (d, \( J = 3.4 \) Hz, 2H), 6.53 (t, \( J = 8.7 \) Hz, 2H), 6.37 – 6.19 (m, 2H), 6.15 (d, \( J = 10.1 \) Hz, 1H), 6.02 (dt, \( J = 17.1, 7.7 \) Hz, 1H), 5.55 (d, \( J = 10.1 \) Hz, 1H), 5.12 (dd, \( J = 25.3, 13.6 \) Hz, 2H), 2.97 (s, 1H), 2.67 (dd, \( J = 19.0, 8.2 \) Hz, 2H), 2.53 – 2.29 (m, 2H), 2.13 (t, \( J = 13.4 \) Hz, 1H), 1.62 (d, \( J = 10.9 \) Hz, 6H), 1.47 (s, 3H), 1.28 (s, 3H) ppm; \( ^19F \) NMR (282 MHz, CDCl₃) δ -115.79 ppm; \( ^{13}C \) NMR (75 MHz, CDCl₃) δ 161.5 (\( J_{C-F} = 243.8 \) Hz), 146.51, 144.37, 143.72, 139.04, 138.00, 135.94, 134.70, 133.81, 133.42, 131.12, 130.29, 130.19, 129.43, 129.31, 127.69, 126.51, 125.81, 124.61, 117.77, 114.11, 113.83, 82.21, 71.25, 59.09, 51.10, 49.21, 47.19, 43.88, 33.10, 27.11, 18.73, 16.41 ppm; HRMS (ESI): C₃₇H₃₅FNaO₂ [M + Na]⁺ calcd: 553.2513, found: 553.2501.

(G) X-ray structure of 3a

Displacement ellipsoids are drawn at the 50% probability level.

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Temperature: 153 K
Calculated | Reported
--- | ---
Volume | 2430.58(14) | 2430.58(14)
Space group | P 21 21 21 | P 21 21 21
Hall group | P 2ac 2ab | P 2ac 2ab
Moiety formula | C33 H26 O2 | C33 H26 O2
Sum formula | C33 H26 O2 | C33 H26 O2
Mr | 454.54 | 454.54
Dx, g cm⁻³ | 1.242 | 1.242
Z | 4 | 4
Mu (mm⁻¹) | 0.591 | 0.591
F000 | 960.0 | 960.0
F000' | 962.67 | |
| h, k, lmax | 13,13,20 | 13,13,20
Nref | 3891[2222] | 3865
Tmin, Tmax | 0.899, 0.932 | 0.698, 0.752
Tmin' | 0.899 | |
Correction method = # Reported T Limits: Tmin=0.698  Tmax=0.752  AbsCorr = MULTI-SCAN
Data completeness= 1.74/0.99  Theta(max)= 62.730
R(reflections)= 0.0265(3784)  wR2(reflections)= 0.0663(3865)
S = 1.080  Npar= 318

(H) Reference

HPLC results

HPLC using an IA-H column (hexane/iPrOH = 8/2, flow rate 1.0 mL/min)

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HPLC using an IA-H column (hexane/iPrOH = 8/2, flow rate 1.0 mL/min)

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HPLC using an IA-H column (hexane/iPrOH = 8/2, flow rate 1.0 mL/min)

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**Chart 1: Retention Time vs. Area**

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HPLC using an IA-H column (hexane/iPrOH = 8/2, flow rate 1.0 mL/min)

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HPLC using an IA-H column (hexane/iPrOH = 8/2, flow rate 1.0 mL/min)

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HPLC using an IA-H column (hexane/iPrOH = 8/2, flow rate 1.0 mL/min)

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HPLC using an IA-H column (hexane/iPrOH = 8/2, flow rate 1.0 mL/min)

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Entry | Retention time | Area  | Area (%) | Height  | Int type |
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HPLC using an IA-H column (hexane/iPrOH = 8/2, flow rate 1.0 mL/min)

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HPLC using an IA-H column (hexane/iPrOH = 8/2, flow rate 1.0 mL/min)

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HPLC using an IA-H column (hexane/iPrOH = 8/2, flow rate 1.0 mL/min)

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HPLC using an IA-H column (hexane/iPrOH = 8/2, flow rate 1.0 mL/min)

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HPLC using an IA-H column (hexane/iPrOH = 8/2, flow rate 1.0 mL/min)

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HPLC using an IA-H column (hexane/iPrOH = 8/2, flow rate 1.0 mL/min)

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HPLC using an IA-H column (hexane/iPrOH = 8/2, flow rate 1.0 mL/min)

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HPLC using an IA-H column (hexane/iPrOH = 8/2, flow rate 1.0 mL/min)

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HPLC using an IA-H column (hexane/iPrOH = 8/2, flow rate 1.0 mL/min)

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HPLC using an IA-H column (hexane/iPrOH = 8/2, flow rate 1.0 mL/min)

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HPLC using an IA-H column (hexane/iPrOH = 8/2, flow rate 1.0 mL/min)

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HPLC using an IA-H column (hexane/iPrOH = 8/2, flow rate 1.0 mL/min)

<table>
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HPLC using an IA-H column (hexane/iPrOH = 8/2, flow rate 1.0 mL/min)

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HPLC using an IA-H column (hexane/iPrOH = 8/2, flow rate 1.0 mL/min)

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HPLC using an IA-H column (hexane/iPrOH = 8/2, flow rate 1.0 mL/min)

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HPLC using an IA-H column (hexane/iPrOH = 9/1, flow rate 0.7 mL/min)

<table>
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<th>Int type</th>
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Entry  Retention time  Area    Area (%)  Height   Int type
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2       21.245         15489334 98.20     409991  bb
HPLC using an IA-H column (hexane/iPrOH = 97/3, flow rate 1.0 mL/min)

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</table>
The image contains a chemical structure and an NMR spectrum for compound 3c. The spectrum shows various peaks at different ppm values, indicating the chemical shifts of the protons in the molecule. The structure includes aromatic rings (Ph), a methyl group (Me), and a ketone group (O=). The peaks at specific ppm values correspond to different protons within the molecule, providing information about the chemical environment and structure of the compound.
The image contains a chemical structure labeled as "3n" with a corresponding NMR spectrum. The spectrum shows peaks at various ppm values, indicating the chemical shifts of different protons in the molecule. The structure is decorated with aromatic (Ph) rings and a carbonyl (C=O) group, suggesting a complex organic compound. The NMR data and the structure provide insights into the molecular composition and chemical environment of the compound.
4 (unstable)
$S_{158}$
\begin{align*}
\text{ppm} & \\
-0.000 & \quad 1.390 \\
1.803 & \quad 1.841 \\
1.886 & \quad 1.924 \\
2.416 & \quad 2.446 \\
2.463 & \quad 2.493 \\
2.527 & \quad 2.549 \\
2.567 & \quad 2.586 \\
2.616 & \quad 2.639 \\
2.689 & \quad 2.893 \\
3.304 & \quad 4.256 \\
4.530 & \quad 4.537 \\
4.914 & \quad 4.993 \\
5.050 & \quad 5.083 \\
5.600 & \quad 5.634 \\
5.671 & \quad 5.689 \\
5.701 & \quad 5.724 \\
5.754 & \quad 5.778 \\
5.789 & \quad 5.808 \\
6.155 & \quad 6.189 \\
6.248 & \quad 6.268 \\
6.277 & \quad 6.296 \\
6.462 & \quad 6.491 \\
6.520 & \quad 6.773 \\
6.785 & \quad 6.793 \\
7.097 & \quad 7.107 \\
7.117 & \quad 7.129 \\
7.232 & \quad 7.246 \\
7.258 & \quad 7.271 \\
7.295 & \quad 7.320 \\
\end{align*}
214.55

MeO

OMe

F

7