A General Catalyst Controlled Route to

Prostaglandin F2α

Laura Cunningham, Sourabh Mishra, Leon Matthews, Stephen P. Fletcher*

stephen.fletcher@chem.ox.ac.uk

Department of Chemistry, Chemistry Research Laboratory, University of Oxford, Oxford,
OX1 3TA, UK
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Supplementary Figures

Figure S1. Structure of four possible diastereomers obtained from the reaction between \((\text{rac})-5\) and enantiopure Alkenyl boronic esters 4.

Figure S2. Comparison of \(^1\text{H}\) NMR spectra of crude reaction mixture when employing \((\text{rac})\)-, \((\text{S})\)- or \((\text{R})\)-BINAP. Signals shown correspond to the C-H signals of the alkene of the cyclopentene ring.
Experimental procedures

X.X General Methods

Procedures using oxygen and/or moisture-sensitive materials were performed with anhydrous solvents (vide infra) under an atmosphere of anhydrous argon in flame-dried flasks, using standard Schlenk techniques. Analytical thin-layer chromatography was performed on precoated glass-backed plates (Silica Gel 60 F254; Merck) and visualised using a combination of UV light (254 nm) and aqueous basic potassium permanganate stain. Flash column chromatography was carried out using Merck 60 Å silica gel.

Nuclear magnetic resonance (NMR) spectroscopy measurements were carried out at room temperature. \(^1\)H NMR, \(^{13}\)C NMR, COSY, and HSQC were carried out using Bruker AVB-400 (400/100 MHz), Bruker AVG-400 (400/100 MHz) and AVH-400 (400/100 MHz) spectrometers. Chemical shifts (\(\delta\)) are reported in ppm relative to the residual solvent peak with corresponding coupling constants (\(J\)) in Hertz (Hz) and multiplicities (s: singlet, d: doublet, t: triplet, q: quartet, br s: broad singlet, qt: quartet of triplet, qd: quartet of doublet, dtt: doublet of triplet of triplet )

Infrared (IR, neat or thin film) spectroscopy was carried out on a Bruker Tensor 27 FT–IR spectrometer within internal calibration range of 4000 – 600 cm\(^{-1}\). The samples are reported as absorption maxima in cm\(^{-1}\).

Chiral SFC (supercritical fluid chromatography) separations were conducted on a Waters Acquity UPC2 system using Waters Empower software. Chiralpak® columns (150×3 mm, particle size 3 µm) were used as specified in the text. Solvents used were of HPLC grade (Fisher Scientific, Sigma Aldrich or Rathburn).

High Resolution Mass spectra were carried out by internal service at the University of Oxford. Electron spray ionisation (ESI+) were recorded on a Thermo Exactive with an orbitrap ion analyser.

Commercially available reagents and ligands were purchased from Sigma Aldrich, Alfa Aesar, Acros Organics, Fluorochem and Strem Chemicals and unless otherwise stated were used without further purification. Dry and deuterated solvents were purchased from Sigma Aldrich.
**General procedure A**: Synthesis of Weinreb Amides

Carboxylic acid (1 equiv) was dissolved in DCM (0.3M) at 0 °C followed by the addition of N,O-dimethylhydroxylamine·HCl (1.2 equiv), EDC(1.2 equiv), DMAP(0.1 equiv) and triethyl amine (1.2 equiv). The reaction was warmed to room temperature and stirred for one hour. The mixture was washed with 0.5M HCl and saturated aq. NaHCO3. The aqueous phase was extracted with DCM before drying with NaSO4 and concentrating under vacuum. The crude Weinreb amide was obtained in sufficient purity for subsequent reaction. In some cases, contamination with dimethylhydroxylamine is observed in the 1H NMR of the crude product – this is accounted for in the calculated yields, and has no observed negative affect in subsequent reactions.

Weinreb amide **S1a** was prepared according to general procedure A from hexanoic acid (12.5 mL, 1 equiv, 100 mmol) in a 93% yield (14.8 g) as colourless oil and used without further purification.

1H NMR (400 MHz, CDCl3) δ 3.68 (s, 3H), 3.18 (s, 3H), 2.41 (t, J = 7.7 Hz, 2H), 1.69 – 1.55 (m, 4H), 1.33 (q, J = 3.6 Hz, 4H), 0.90 (td, J = 6.5, 2.5 Hz, 3H).

Prepared according to general procedure A from the corresponding carboxylic acid (7 mL, 1 equiv, 50 mmol), Weinreb amide **S1b** was isolated in 85% yield (7.36 g) as colourless oil.

1H NMR (400 MHz, CDCl3) δ 3.64 (s, 3H), 3.14 (s, 3H), 2.43 – 2.33 (m, 2H), 1.63 – 1.55 (m, 2H), 1.37 – 1.19 (m, 6H), 0.90 – 0.81 (m, 3H).

Prepared according to general procedure A from the corresponding carboxylic acid (5.4 mL, 1 equiv, 50 mmol), Weinreb amide **S1c** was isolated in 61% yield (4.79 g) as colourless oil.

1H NMR (400 MHz, CDCl3) δ 3.65 (s, 3H), 3.14 (s, 3H), 3.10 – 2.98 (m, 1H), 1.88 – 1.61 (m, 6H), 1.57 – 1.48 (m, 2H).

Weinreb amide **S1d** was prepared according to general procedure A from the corresponding carboxylic acid (5.3 g, 1 equiv, 35 mmol) in a 81% yield (5.4 g) as colourless oil.

1H NMR (400 MHz, CDCl3) δ 7.25 (qt, J = 15.8, 7.2 Hz, 5H), 3.61 (s, 3H), 3.18 (s, 3H), 2.96 (dd, J = 9.0, 6.9 Hz, 2H), 2.84 – 2.70 (m, 2H).
Prepared according to general procedure A from the corresponding carboxylic acid (5.45 g, 1 equiv, 25 mmol), Weinreb amide S1e was isolated in 88% yield (5.45 g) as colourless oil.

$^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.52 (d, $J = 8.0$ Hz, 2H), 7.33 (d, $J = 8.0$ Hz, 2H), 3.61 (s, 3H), 3.16 (s, 3H), 3.01 (t, $J = 7.7$ Hz, 2H), 2.75 (t, $J = 7.7$ Hz, 2H).

Prepared according to general procedure A from the corresponding carboxylic acid (4.1 g, 1 equiv, 25 mmol), Weinreb amide S1f was isolated in 73% yield (3.8 g) as colourless oil.

$^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.35 – 7.26 (m, 2H), 7.26 – 7.16 (m, 3H), 3.64 (s, 3H), 3.19 (s, 3H), 2.71 (t, $J = 7.6$ Hz, 2H), 2.47 (t, $J = 7.3$ Hz, 2H), 2.06 – 1.93 (m, 2H).

Weinreb amide S1g was prepared according to general procedure A from the corresponding carboxylic acid (5.5 g, 1 equiv, 25 mmol) in a 93% yield (6.2 g) as colourless oil.

$^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.48 – 7.34 (m, 1H), 7.26 (s, 1H), 7.20 – 7.15 (m, 1H), 7.15 – 7.08 (m, 1H), 4.86 (s, 2H), 3.78 (s, 3H), 3.25 (s, 3H).

Weinreb amide S1h was prepared according to general procedure A from the corresponding carboxylic acid (6.1 g, 1 equiv, 33 mmol) in a 98% yield (7.4 g) as colourless oil.

$^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.21 (dd, $J = 8.6$, 1.7 Hz, 1H), 7.03 – 6.92 (m, 2H), 6.91 – 6.82 (m, 1H), 4.82 (s, 2H), 3.93 – 3.54 (s, 3H), 3.26 (s, 3H).
**General procedure B:** Addition of TIPS acetylene to Weinreb amides

TIPS acetylene (1.2 equiv) was dissolved in anhydrous THF and cooled to 0 °C before the addition of \( n\)-BuLi (1.2 equiv, 2.5 M in hexanes) under inert atmosphere. This was stirred for 15 min, followed by the addition of neat Weinreb amide (1 equiv). The reaction was quenched after 30 min by the addition of sat. aq. NH\(_4\)Cl. The aqueous layer was extracted with Et\(_2\)O, and the combined organic layers were dried over Na\(_2\)SO\(_4\), filtered and concentrated under vacuum. The resulting oil was purified via column chromatography to yield the product ketone.

Ketone 2a was prepared according to general procedure B from crude Weinreb amide S1 (8 g, 50 mmol) in 86% yield (11.9 g) as colourless oil. Column conditions: pure hexane.

\(^1\)H NMR (400 MHz, CDCl\(_3\)) \( \delta \) 2.55 (t, \( J = 7.4 \) Hz, 2H), 1.70 (tt, \( J = 7.4, 6.1 \) Hz, 2H), 1.33 – 1.31 (m, 4H), 1.20 – 1.02 (m, 21H), 0.94 – 0.84 (m, 3H).

\(^1\)C NMR (101 MHz, CDCl\(_3\)) \( \delta \) 188.1, 104.2, 95.4, 45.6, 31.1, 24.0, 22.4, 18.5, 13.9, 11.0.

IR (neat) 2954, 2867, 2360, 1680, 1464, 882 cm\(^{-1}\).

HRMS (ESI) m/z: [M + Na]\(^+\) Calcd for C\(_{17}\)H\(_{32}\)OSiNa 302.2115; Found 302.2112.

Ketone 2b was prepared according to general procedure B from crude Weinreb amide S1b (42.6 mmol) in 78% yield (9.74 g) as colourless oil. Column conditions: pure hexane.

\(^1\)H NMR (400 MHz, CDCl\(_3\)) \( \delta \) 2.54 (t, \( J = 7.4 \) Hz, 2H), 1.74 – 1.62 (m, 2H), 1.40 – 1.21 (m, 6H), 1.09 (s, 21H), 0.90 – 0.82 (m, 3H).

\(^1\)C NMR (101 MHz, CDCl\(_3\)) \( \delta \) 188.0, 104.3, 95.2, 45.6, 31.5, 28.6, 24.3, 22.4, 18.4, 14.0, 11.0.

IR (neat) 2946, 2868, 1680, 1464, 1213, 1134, 1086, 997, 920, 883 cm\(^{-1}\).

HRMS (ESI) m/z: [M + H]\(^+\) Calcd for C\(_{18}\)H\(_{35}\)OSi 295.2452; Found 295.2453.

Ketone 2c was prepared according to general procedure B from crude Weinreb amide S1 (30.2 mmol) in 96% yield (8.07 g) as colourless oil. Column conditions: 0-2% diethylether in hexane.
$^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 2.91 (tt, $J = 8.7, 7.2$ Hz, 1H), 2.02 – 1.82 (m, 4H), 1.74 – 1.53 (m, 4H), 1.10 (s, 21H).

$^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 190.7, 103.6, 95.8, 53.8, 29.1, 26.1, 18.5, 11.0.

IR (neat) 2946, 2868, 1675, 1464, 1219, 1118, 1061, 997, 921, 883 cm$^{-1}$.

HRMS (ESI) $m/z$: [M + H]$^+$ Calcd for C$_{17}$H$_{31}$OSi 279.2139; Found 279.2140.

Ketone 2d was prepared according to general procedure B from crude Weinreb amide S1 (5 g, 24 mmol) in 100% yield (7.8 g) as colourless oil. Column conditions: pure hexane.

$^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.35 – 7.25 (m, 2H), 7.25 – 7.17 (m, 3H), 3.06 – 2.97 (m, 2H), 2.91 (ddd, $J = 8.3, 6.8, 1.1$ Hz, 2H), 1.21 – 1.03 (m, 21H).

$^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 186.6, 140.2, 128.6, 128.4, 126.3, 104.1, 96.1, 47.3, 30.1, 18.5, 11.0.

IR (neat) 2980, 2889, 2360, 1678, 1462, 679 cm$^{-1}$.

HRMS (ESI) $m/z$: [M + H]$^+$ Calcd for C$_{20}$H$_{31}$OSi 315.2130; Found 315.2136.

Ketone 2e was prepared according to general procedure B from crude Weinreb amide S1e (21.9 mmol) in 68% yield (5.7 g) as colourless oil. Column conditions: pure hexane.

$^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.47 (d, $J = 8.1$ Hz, 2H), 7.32 (d, $J = 8.1$ Hz, 2H), 2.99 (t, $J = 7.5$ Hz, 1H), 2.95 – 2.91 (m, 2H), 1.10 (s, 21H).

$^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 185.8, 144.4, 128.7, 125.6, 125.5 (q, $J = 3.7$ Hz), 122.9, 104.0, 96.6, 46.6, 29.8, 18.5, 11.0.

$^{19}$F NMR (376 MHz, CDCl$_3$) $\delta$ -62.4.

IR (neat) 2947, 2869, 2360, 1679, 1464, 1326, 1165, 1125, 1068, 1019, 998, 920, 883, 833 cm$^{-1}$.

HRMS (ESI) $m/z$: [M + H]$^+$ Calcd for C$_{21}$H$_{30}$F$_3$Si 383.2013; Found 383.2019.
Ketone 2f was prepared according to general procedure B from crude Weinreb amide S1f (18.4 mmol) in 80% yield (4.82 g) as colourless oil. Column conditions: pure hexane.

$^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.32 – 7.27 (m, 2H), 7.24 – 7.15 (m, 3H), 2.76 – 2.50 (m, 4H), 2.16 – 1.93 (m, 2H), 1.12 (s, 21H).

$^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 187.5, 141.3, 128.5, 128.4, 126.1, 104.2, 95.6, 44.9, 34.9, 25.8, 18.5, 11.0.

IR (neat) 2946, 2867, 1677, 1462, 1215, 1108, 1074, 1018, 997, 920, 883, 833 cm$^{-1}$.

HRMS (ESI) m/z: [M + H]$^+$ Calcd for C$_{21}$H$_{33}$OSi 329.2295; Found 329.2301.

Ketone 2g was prepared according to general procedure B from crude Weinreb amide S1g (7 g, 26 mmol) in 87% yield (8.1 g) as colourless oil. Column conditions: pure hexane.

$^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.41 (t, $J$ = 8.0 Hz, 1H), 7.26 (t, $J$ = 2.8 Hz, 1H), 7.14 (q, $J$ = 2.8 Hz, 1H), 7.03 (dd, $J$ = 8.0, 2.8 Hz, 1H), 4.73 (s, 2H), 1.19 – 1.02 (m, 21H).

$^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 182.6, 157.8, 132.1 (q, $J$ = 32.6 Hz), 130.2, 118.5, 118.5, 117.7, 112.1, 102.0, 101.4, 73.2, 18.4, 10.9.

$^{19}$F NMR (376 MHz, CDCl$_3$) $\delta$ -62.82.

IR (neat) 2948, 2869, 1680, 1326, 1129 cm$^{-1}$.

HRMS (ESI) m/z: [M + Na]$^+$ Calcd for C$_{20}$H$_{27}$F$_3$O$_2$SiNa 407.1625; Found 407.1621.

Ketone 2h was prepared according to general procedure B from crude Weinreb amide S1h (3.3 g 14 mmol) in 86% yield (2.8 g) as colourless oil. Column conditions: pure hexane.
$^1$H NMR (400 MHz, CDCl$_3$) δ 7.21 (t, $J = 8.1$ Hz, 1H), 7.01 – 6.94 (m, 1H), 6.92 – 6.85 (m, 1H), 6.76 (ddd, $J = 8.4$, 2.5, 0.9 Hz, 1H), 4.68 (s, 2H), 1.08 (s, 21H).

$^{13}$C NMR (101 MHz, CDCl$_3$) δ 182.7, 158.4, 135.1, 130.4, 122.0, 115.5, 112.9, 101.8, 101.45, 73.3, 18.5, 10.9.

IR (neat) 2980, 2887, 2360, 1681, 1594, 679 cm$^{-1}$.

HRMS (ESI) m/z: [M + H]$^+$ Calcd for C$_{19}$H$_{29}$ClO$_2$Si 351.1542; Found 351.1539.
General procedure C: Asymmetric reduction of ketone with Noyori’s catalyst

Activation of Noyori’s catalyst was carried out immediately prior to use following a procedure from Schiessl et al. [ref]

To a round bottom flask containing the activated RuCl[(S,S)-TsDPEN](mesitylene) (0.25 mol%), under an inert atmosphere, was added neat ketone (1 equiv) followed by the addition of IPA (0.2 M). The resulting orange solution was stirred for 10 min at RT before being concentrated under vacuum and purified by column chromatography to yield the product alcohol.

Alcohol 3a was prepared according to general procedure C from ketone 2a (17.0 g, 60 mmol) in 99% yield (17.0 g) and 99% ee as colourless oil. Column conditions: 10% diethylether in hexane.

1H NMR (400 MHz, CDCl3) δ 4.39 (t, J = 6.3 Hz, 1H), 1.80 – 1.61 (m, 2H), 1.55 – 1.42 (m, 2H), 1.40 – 1.20 (m, 4H), 1.15 – 1.00 (m, 21H), 0.96 – 0.84 (m, 3H).

13C NMR (101 MHz, CDCl3) δ 108.9, 85.4, 63.1, 37.9, 31.4, 24.8, 22.6, 18.6, 13.9, 11.1.

IR (neat) 2943, 2866, 2361, 1464, 1126, 677 cm⁻¹.

HRMS (ESI) m/z: [M + Na]⁺ Calcd for C17H34OSiNa 305.2271; Found 305.2272.

SFC Conditions: The enantioselectivity was determined using Chiralpak IA; 1500 PSI, 30 °C; flow: 1.5 mL/min; from 1% to 10% MeOH in 10 min; 99.65:0.35 er (major enantiomer tR = 2.55 min; minor enantiomer tR = 2.68 min), 99% ee.

[α]D²⁵ = –8.1 (c=0.36, CHCl₃)

Alcohol 3b was prepared according to general procedure C from crude ketone 2b (10 mmol) in 96% yield (2.85 g) and 99% ee as colourless oil. Column conditions: 0–5% diethylether in hexane.

1H NMR (400 MHz, CDCl3) δ 4.37 (q, J = 6.3 Hz, 1H), 1.97 (d, J = 4.4 Hz, 1H), 1.77 – 1.60 (m, 2H), 1.46 (dt, J = 15.6, 7.3 Hz, 2H), 1.38 – 1.19 (m, 6H), 1.06 (s, 21H), 0.93 – 0.81 (m, 1H).

13C NMR (101 MHz, CDCl3) δ 109.1, 85.4, 63.1, 38.1, 31.9, 29.0, 25.2, 22.7, 18.7, 14.2, 11.3.

IR (neat) 3337, 2943, 2866, 2170, 1465, 1383, 1040, 1016, 997, 920, 884 cm⁻¹.

HRMS (ESI) m/z: [M + Na]⁺ Calcd for C18H36OSiNa 319.2428; Found 319.2433.

SFC Conditions: The enantioselectivity was determined after Benzoyl protection and TIPS deprotection using Chiralpak IC; 1500 PSI, 30 °C; flow: 1.5 mL/min; from 1% to 30% MeOH in 5 min; 99.5:0.5 er (major enantiomer tR = 1.36 min; minor enantiomer tR = 1.45 min), 99% ee.
Alcohol 3c was prepared according to general procedure C from crude ketone 2c (10 mmol) in 95% yield (2.66 g) and 99% ee as colourless oil. Column conditions: 0-10% diethylether in hexane.

\[
\alpha_{25}^D = +2.9 \ (c=1.0, \text{CH}_2\text{OH})
\]

**\[\text{IR (neat)}\]** 3353, 2945, 2867, 2170, 1464, 1384, 1320, 1038, 997, 921, 884 cm\(^{-1}\).

**\[\text{HRMS (ESI)}\]** m/z: [M + Na]\(^+\) Calcd for C\(_{17}\)H\(_{32}\)OSiNa 303.2115; Found 303.2128.

**SFC Conditions:** The enantioselectivity was determined after Benzoyl protection and TIPS deprotection using Chiralpak IC; 1500 PSI, 30 °C; flow: 1.5 mL/min; from 1% to 30% MeOH in 5 min; 99.75:0.25 er (major enantiomer \(t_R = 1.55 \text{ min}; \) minor enantiomer \(t_R = 1.69 \text{ min}\), 99% ee.

\[
\alpha_{25}^D = +8.9 \ (c=1.0, \text{CHCl}_3)
\]

Alcohol 3d was prepared according to general procedure C from ketone 2d (4.5 g 14.3 mmol) in 96% yield (4.3 g) and 99% ee as colourless oil. Column conditions: 10% diethylether in hexane.

\[
\alpha_{25}^D =22.3 (c=0.70, \text{CHCl}_3)
\]

**\[\text{IR (neat)}\]** 2980, 2866, 2360, 1461, 1383, 741, 678 cm\(^{-1}\).

**\[\text{HRMS (ESI)}\]** m/z: [M + Na]\(^+\) Calcd for C\(_{20}\)H\(_{32}\)OSiNa 339.2115; Found 339.2112.

**SFC Conditions:** The enantioselectivity was determined using Chiralpak IB; 1500 PSI, 30 °C; flow: 1.5 mL/min; from 1% to 10% MeOH in 10 min; 99.84:0.16 er (major enantiomer \(t_R = 2.46 \text{ min}; \) minor enantiomer \(t_R = 2.78 \text{ min}\), 99% ee.

\[
\alpha_{25}^D = 22.3 \ (c=0.70, \text{CHCl}_3)
\]
Alcohol 3e was prepared according to general procedure C from crude ketone 2e (10 mmol) in 84% yield (3.23 g) and 99% ee as colourless oil. Column conditions: 0-10% diethylether in hexane.

1H NMR (500 MHz, CDCl3) δ 7.54 (d, J = 8.0 Hz, 2H), 7.32 (d, J = 8.0 Hz, 2H), 4.40 (q, J = 6.1 Hz, 1H), 2.89 (t, J = 7.9 Hz, 2H), 2.10 – 1.96 (m, 2H), 1.09 (s, 21H).

13C NMR (126 MHz, CDCl3) δ 145.7, 128.9, 128.5 (q, J = 32.6 Hz), 125.5 (q, J = 3.8 Hz), 123.4, 108.3, 86.5, 62.2, 39.3, 31.4, 18.7, 11.3.

19F NMR (376 MHz, CDCl3) δ -62.4.

IR (neat) 3354, 2945, 2867, 1327, 1166, 1128, 1069, 1019, 884, 844 cm⁻¹.

HRMS (ESI) m/z: [M + Na]+ Calcd for C21H31F3OSiNa 407.1989; Found 407.1972.

SFC Conditions: Chiralpak IG; 1500 PSI, 30 °C; flow: 1.5 mL/min; hold 1% MeOH for 3 min, then from 1% to 10% MeOH in 5 min; 99.65:0.35 er (major enantiomer tR = 6.55 min; minor enantiomer tR = 6.13 min), 99% ee.

[α]25D = +27.6 (c=1.0, CHCl3)

Alcohol 3f was prepared according to general procedure C from crude ketone 2f (10 mmol) in 88% yield (2.91 g) and 99% ee as colourless oil. Column conditions: 0-10% diethylether in hexane.

1H NMR (500 MHz, CDCl3) δ 7.31 (q, J = 7.9 Hz, 2H), 7.25 – 7.19 (m, 3H), 4.45 (q, J = 5.9 Hz, 1H), 2.71 (t, J = 7.5 Hz, 2H), 2.08 – 1.98 (m, 1H), 1.92 – 1.69 (m, 4H), 1.12 (s, 21H).

13C NMR (126 MHz, CDCl3) δ 142.2, 128.5, 128.4, 125.9, 108.8, 85.8, 63.0, 37.6, 35.6, 27.0, 18.7, 11.3.

IR (neat) 3345, 2944, 2866, 1463, 1073, 998, 919, 883 cm⁻¹.

HRMS (ESI) m/z: [M + Na]+ Calcd for C21H34OSiNa 353.2271; Found 353.2275.

SFC Conditions: Chiralpak IB; 1500 PSI, 30 °C; flow: 1.5 mL/min; from 1% to 30% MeOH in 5 min; 99.5:0.5 er (major enantiomer tR = 2.60 min; minor enantiomer tR = 2.53 min), 99% ee.

[α]25D = +20.8 (c=1.0, CHCl3)

Alcohol 3g was prepared according to general procedure C from crude ketone 2g (3.3 g, 8.5 mmol) in 85% yield (2.8 g) and 99% ee as colourless oil. Column conditions: 10% diethylether in hexane.
$^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.34 (t, $J = 8.0$ Hz, 1H), 7.17 (d, $J = 7.2$ Hz, 1H), 7.10 (t, $J = 2.1$ Hz, 1H), 7.04 (ddd, $J = 8.3, 2.6$ Hz, 1H), 4.77 – 4.69 (m, 1H), 4.11 (dd, $J = 9.5, 3.7$ Hz, 1H), 4.04 (dd, $J = 9.5, 6.8$ Hz, 1H), 1.01 (s, 21H).

$^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 158.5, 130.1, 118.2, 118.1, 111.8, 111.7, 104.1, 88.0, 71.9, 61.9, 18.5, 11.1.

$^{19}$F NMR (376 MHz, CDCl$_3$) $\delta$ -62.74.

IR (neat) 2980, 2888, 2360, 1461, 1131, 882 cm$^{-1}$.

HRMS (ESI) m/z: [M + Na]$^+$ Calcd for C$_{20}$H$_{29}$F$_3$O$_2$SiNa 409.1781; Found 409.1780.

SFC Conditions: The enantioselectivity was determined using Chiralpak IB; 1500 PSI, 30 °C; flow: 1.5 mL/min; from 1% to 10% MeOH in 10 min; 99.47:0.53 er (major enantiomer $t_R = 2.49$ min; minor enantiomer $t_R = 2.65$ min), 99% ee.

$[\alpha]^{25}_D = -8.1$ (c=0.31, CHCl$_3$)

Alcohol 3h was prepared according to general procedure C from crude ketone 2h (2.6 g, 7.5 mmol) in 93% yield (2.5 g) and 99% ee as colourless oil. Column conditions: 10% diethylether in hexane.

$^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.14 (t, $J = 8.1$ Hz, 1H), 6.90 (ddd, $J = 8.1, 2.2, 0.9$ Hz, 1H), 6.87 (t, $J = 2.2$ Hz, 1H), 6.76 (ddd, $J = 8.1, 2.2, 0.9$ Hz, 1H), 4.70 (dd, $J = 7.0, 3.6$ Hz, 1H), 4.05 (dd, $J = 9.6, 3.6$ Hz, 1H), 3.99 (dd, $J = 9.5, 7.0$ Hz, 1H), 1.00 (d, $J = 3.8$ Hz, 21H).

$^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 159.0, 134.9, 130.3, 121.6, 115.3, 113.3, 104.1, 87.9, 71.9, 61.9, 18.6, 11.1.

IR (neat) 2980, 2866, 2360, 2341, 1595, 678 cm$^{-1}$.

HRMS (ESI) m/z: [M + Na]$^+$ Calcd for C$_{19}$H$_{29}$ClO$_2$SiNa 375.1518; Found 375.1516.

SFC Conditions: The enantioselectivity was determined using Chiralpak IB; 1500 PSI, 30 °C; flow: 1.5 mL/min; from 1% to 10% MeOH in 10 min; 99.71:0.29 er (major enantiomer $t_R = 1.83$ min; minor enantiomer $t_R = 2.00$ min), 99% ee.

$[\alpha]^{25}_D = -20.0$ (c=0.11, CHCl$_3$)
General procedure D: Desilylation of alkyne

To a solution of alcohol (1 equiv) in THF (0.1 M) was added TBAF (1.2 equiv, 1.0 M in THF) at RT. After stirring for 1 h, the reaction was quenched with sat. aq. NH₄Cl and the aqueous layer was extracted with Et₂O. The combined organic layers were dried over Na₂SO₄, filtered and concentrated under vacuum. The resulting alcohol was used without further purification.

Alkyne S2a was prepared according to general procedure D from TIPS protected 3a (56 mmol) and was used without further purification.

\[^1\text{H NMR}\ (400\text{ MHz, CDCl}_3)\ \delta 4.37\ (\text{td}, J = 6.6, 2.1\text{ Hz}, 1\text{H}), 2.44\ (\text{d}, J = 2.0\text{ Hz}, 1\text{H}), 1.77 – 1.60\ (\text{m}, 2\text{H}), 1.56 -1.42 \ (\text{m}, 2\text{H}), 1.35 – 1.28 \ (\text{m}, 4\text{H}), 0.93 – 0.85 \ (\text{m}, 3\text{H}).\]

Alkyne S2b was prepared according to general procedure D from TIPS protected 3b (12 mmol) and used without further purification.

\[^1\text{H NMR}\ (400\text{ MHz, CDCl}_3)\ \delta 4.37\ (\text{td}, J = 6.6, 2.1\text{ Hz}, 1\text{H}), 2.46\ (\text{d}, J = 2.1\text{ Hz}, 1\text{H}), 1.76 – 1.64\ (\text{m}, 2\text{H}), 1.52 – 1.38 \ (\text{m}, 2\text{H}), 1.36 – 1.25 \ (\text{m}, 6\text{H}), 0.91 – 0.85 \ (\text{m}, 3\text{H}).\]

Alkyne S2c was prepared according to general procedure D from TIPS protected 3c (7 mmol) and used without further purification.

\[^1\text{H NMR}\ (400\text{ MHz, CDCl}_3)\ \delta 4.23\ (\text{dd}, J = 7.1, 2.1\text{ Hz}, 1\text{H}), 2.42\ (\text{d}, J = 2.1\text{ Hz}, 1\text{H}), 2.19\ (\text{h}, J = 8.0\text{ Hz}, 1\text{H}), 1.79\ (\text{dddd}, J = 16.1, 8.0, 6.2, 4.7\text{ Hz}, 2\text{H}), 1.72 – 1.46 \ (\text{m}, 4\text{H}), 1.51 – 1.35 \ (\text{m}, 2\text{H}).\]

Alkyne S2d was prepared according to general procedure D from TIPS protected 3d (10.6 mmol) and was used without further purification.

\[^1\text{H NMR}\ (400\text{ MHz, CDCl}_3)\ \delta 7.30 - 7.26 \ (\text{m}, 2\text{H}), 7.25 – 7.17 \ (\text{m}, 3\text{H}), 4.37\ (\text{td}, J = 6.6, 2.1\text{ Hz}, 1\text{H}), 2.81 \ (\text{t}, J = 7.8\text{ Hz}, 2\text{H}), 2.50 \ (\text{s}, 1\text{H}), 2.04 \ (\text{ddt}, J = 13.5, 10.8, 6.3\text{ Hz}, 2\text{H}).\]

Alkyne S2e was prepared according to general procedure D from TIPS protected 3e (6 mmol) and used without further purification.
$^1$H NMR (400 MHz, CDCl$_3$) δ 7.54 (d, $J = 8.0$ Hz, 2H), 7.33 (d, $J = 8.0$ Hz, 2H), 4.37 (t, $J = 5.7$ Hz, 1H), 2.87 (t, $J = 7.9$ Hz, 2H), 2.53 (d, $J = 2.1$ Hz, 1H), 2.12 – 1.92 (m, 2H).

Alkyne S2f was prepared according to general procedure D from TIPS protected 3f (9 mmol) and used without further purification.

$^1$H NMR (400 MHz, CDCl$_3$) δ 7.33 – 7.24 (m, 2H), 7.23 – 7.14 (m, 3H), 4.39 (td, $J = 6.1$, 1.9 Hz, 1H), 2.67 (t, $J = 7.2$ Hz, 2H), 2.46 (d, $J = 2.1$ Hz, 1H), 1.92 – 1.69 (m, 4H).

Alkyne S2g was prepared according to general procedure D from TIPS protected 3g (10 mmol) and was used without further purification.

$^1$H NMR (400 MHz, CDCl$_3$) δ 7.33 (t, $J = 8.0$ Hz, 1H), 7.18 – 7.14 (m, 1H), 7.11 (t, $J = 2.3z$ Hz, 1H), 7.06 (dd, $J = 8.0$, 2.3 Hz, 1H), 4.75 (ddd, $J = 6.0$, 4.8, 2.1 Hz, 1H), 4.26 – 3.97 (m, 2H), 2.44 (d, $J = 2.1$ Hz, 1H).

Alkyne S2h was prepared according to general procedure D from TIPS protected 3h (7.6 mmol) and was used without further purification.

$^1$H NMR (400 MHz, CDCl$_3$) δ 7.21 (t, $J = 8.1$ Hz, 1H), 6.97 (ddd, $J = 8.1$, 2.2, 0.9 Hz, 1H), 6.94 (t, $J = 2.2$ Hz, 1H), 6.83 (ddd, $J = 8.1$, 2.2, 0.9 Hz, 1H), 4.88 – 4.71 (m, 1H), 4.13 (dd, $J = 9.6$, 3.8 Hz, 1H), 4.07 (dd, $J = 9.6$, 6.8 Hz, 1H), 2.53 (d, $J = 2.2$ Hz, 1H).
General procedure E: TBS protection of alcohol

Alcohol (1 equiv) was dissolved in DCM (1 M) along with DMAP (5 mol%) and imidazole (1.5 equiv) at 0 °C. TBS chloride was added and the resulting suspension was warmed to RT and stirred for one hour. The mixture was diluted with DCM and washed with sat. aq. NH₄Cl. The organic layer was separated and the aqueous layer was extracted with DCM. The combined organic layers were dried over Na₂SO₄ and concentrated under vacuum. Purification by column chromatography yields the desired product.

TBS protected alcohol S₃ₐ was prepared according to general procedure E from free alcohol S₂ₐ (56 mmol) in 97% yield (13.1 g) over two steps as colourless oil. Column conditions: 1% Et₃N in hexane.

**¹H NMR** (400 MHz, CDCl₃) δ 4.33 (td, J = 6.5, 2.1 Hz, 1H), 2.37 (d, J = 2.1 Hz, 1H), 1.72 – 1.61 (m, 2H), 1.53 – 1.36 (m, 2H), 1.30 (dt, J = 6.7, 3.3 Hz, 4H), 0.90 (s, 9H), 0.86 (m, 3H), 0.13 (s, 3H), 0.11 (s, 3H).

**¹³C NMR** (101 MHz, CDCl₃) δ 85.8, 71.8, 62.8, 38.6, 31.4, 25.9, 24.8, 22.6, 18.2, 17.7, 17.2, 14.0, 12.3, −4.5, −5.1.

**IR (neat)** 2957, 2862, 2360, 1472, 1091, 837, 777 cm⁻¹.

**HRMS (ESI)** m/z: [M + H]⁺ Calcd for C₁₄H₂₉OSi 241.1982; Found 241.1983.

[α]₂₅D = −9.2 (c=0.81, CHCl₃)

TBS protected alcohol S₃ₐ was prepared according to general procedure E from free alcohol S₂₉ (12 mmol) in 98% yield over 2 steps (3.0 g) as colourless oil. Column conditions: Pure hexane.

**¹H NMR** (500 MHz, CDCl₃) δ 4.36 (td, J = 6.5, 1.7 Hz, 1H), 2.38 (d, J = 1.6 Hz, 1H), 1.75 – 1.62 (m, 2H), 1.52 – 1.38 (m, 2H), 1.30 (d, J = 12.1 Hz, 6H), 1.12 (t, J = 7.3 Hz, 3H), 0.93 (s, 9H), 0.15 (d, J = 12.4 Hz, 6H).

**¹³C NMR** (126 MHz, CDCl₃) δ 85.9, 72.0, 62.9, 38.8, 32.0, 29.1, 25.9, 25.3, 22.8, 18.3, 14.2, −4.4, −4.9.

**IR (neat)** 3314, 2931, 2860, 1465, 1256, 1095, 1050, 1007, 884, 838, 778 cm⁻¹.

**HRMS (ESI)** m/z: [M + H]⁺ Calcd for C₁₅H₃₁OSi 255.2139; Found 255.2155.

[α]₂₅D = −34.9 (c=1.0, CHCl₃)
TBS protected alcohol **S3c** was prepared according to general procedure E from free alcohol **S2c** (7 mmol) in 69% yield over 2 steps (1.15 g) as colourless oil. Column conditions: Pure hexane.

$^1$H NMR (500 MHz, CDCl$_3$) δ 4.18 (dd, $J = 6.8$, 2.0 Hz, 1H), 2.33 (d, $J = 2.0$ Hz, 1H), 2.16 (h, $J = 8.0$ Hz, 1H), 1.82 – 1.67 (m, 2H), 1.67 – 1.48 (m, 4H), 1.42 (dp, $J = 11.9$, 4.0 Hz, 2H), 0.90 (s, 9H), 0.27 – 0.01 (d, $J = 18.1$ Hz, 6H).

$^{13}$C NMR (126 MHz, CDCl$_3$) δ 85.6, 72.0, 66.5, 47.1, 28.9, 28.6, 25.9, 25.9, 25.8, 18.4, −4.3, −5.0.

IR (neat) 3313, 2959, 2861, 1473, 1257, 1097, 840, 779 cm$^{-1}$.

HRMS (ESI) m/z: [M + H]$^+$ Calcd for C$_{14}$H$_{27}$OSi 239.1826; Found 239.1830.

$[\alpha]$_{D}^{25} = −45.4 (c=1.0$, CHCl$_3$)

TBS protected alcohol **S3d** was prepared according to general procedure E from free alcohol **S2d** (10.6 mmol) in 95% yield (2.8 g) over two steps as colourless oil. Column conditions: 1% Et$_3$N in hexane.

$^1$H NMR (400 MHz, CDCl$_3$) δ 7.38 – 7.21 (m, 2H), 7.20-7.16 (m, 3H), 4.35 (td, $J = 6.3$, 2.1 Hz, 1H), 2.85 – 2.67 (m, 2H), 2.41 (dd, $J = 6.8$, 2.1 Hz, 1H), 2.06 – 1.92 (m, 2H), 0.90 (s, 9H), 0.12 (s, 3H), 0.09 (s, 3H).

$^{13}$C NMR (101 MHz, CDCl$_3$) δ 141.6, 128.5, 128.4, 125.9, 85.3, 72.4, 62.1, 40.2, 31.3, 25.8, 18.4, −4.6, −5.0.

IR (neat) 2980, 2888, 2360, 1472, 1384, 1091, 836 cm$^{-1}$.

HRMS (ESI) m/z: [M + H]$^+$ Calcd for C$_{17}$H$_{26}$OSi 275.1826; Found 275.1825.

$[\alpha]$_{D}^{25} = −11.4 (c=0.64$, CHCl$_3$)

TBS protected alcohol **S3e** was prepared according to general procedure E from free alcohol **S2e** (6 mmol) in 86% yield over 2 steps (1.77 g) as colourless oil. Column conditions: Pure hexane.
$^1$H NMR (500 MHz, CDCl$_3$) δ 7.54 (d, $J = 8.0$ Hz, 2H), 7.31 (d, $J = 8.0$ Hz, 2H), 4.39 (td, $J = 6.2$, 1.9 Hz, 1H), 2.84 (q, $J = 7.2$ Hz, 2H), 2.44 (d, $J = 2.0$ Hz, 1H), 2.06 – 1.95 (m, 2H), 0.92 (s, 9H), 0.13 (d, $J = 16.7$ Hz, 6H).

$^{13}$C NMR (126 MHz, CDCl$_3$) δ 146.0, 128.9, 128.5 (q, $J = 32.3$ Hz), 125.4 (q, $J = 3.8$ Hz), 85.1, 72.8, 62.1, 40.0, 31.3, 25.9, 18.3, –4.4, –4.9.

$^{19}$F NMR (376 MHz, CDCl$_3$) δ –62.3.

IR (neat) 3312, 2956, 2932, 2860, 1620, 1327, 1256, 1166, 1128, 1098, 1068, 839, 779 cm$^{-1}$.

HRMS (ESI) m/z: [M + H]$^+$ Calcd for C$_{18}$H$_{26}$F$_3$OSi 343.1700; Found 343.1709.

$[\alpha]_{D}^{25} = -14.5$ (c=1.0, CHCl$_3$)

TBS protected alcohol S3f was prepared according to general procedure E from free alcohol S2f (9 mmol) in 89% yield over 2 steps (2.3 g) as colourless oil. Column conditions: Pure hexane.

$^1$H NMR (500 MHz, CDCl$_3$) δ 7.34 (t, $J = 7.5$ Hz, 1H), 7.24 (d, $J = 7.3$ Hz, 2H), 4.43 (td, $J = 6.1$, 1.9 Hz, 2H), 2.71 (t, $J = 7.3$ Hz, 1H), 2.42 (d, $J = 2.0$ Hz, 1H), 1.93 – 1.72 (m, 4H), 0.97 (s, 9H), 0.18 (d, $J = 13.0$ Hz, 6H).

$^{13}$C NMR (126 MHz, CDCl$_3$) δ 142.4, 128.5, 128.4, 125.9, 85.7, 72.2, 62.7, 38.2, 35.6, 26.9, 25.9, 18.3, –4.4, –4.9.

IR (neat) 3310, 3028, 2951, 2930, 2858, 1497, 1463, 1254, 1098, 1006, 839, 779, 747, 699 cm$^{-1}$.

HRMS (ESI) m/z: [M + Na]$^+$ Calcd for C$_{18}$H$_{28}$OSiNa 311.1802; Found 311.1812.

$[\alpha]_{D}^{25} = -29.7$ (c=1.0, CHCl$_3$)

TBS protected alcohol S3g was prepared according to general procedure E from free alcohol S2g (7.2 mmol) in 83% yield (2.0 g) over two steps as colourless oil. Column conditions: 1% Et$_3$N in hexane.

$^1$H NMR (400 MHz, CDCl$_3$) δ 7.31 (t, $J = 8.0$ Hz, 1H), 7.14 (dq, $J = 7.7$, 0.9 Hz, 1H), 7.07 (d, $J = 2.2$ Hz, 1H), 7.01 (dd, $J = 8.3$, 2.6 Hz, 1H), 4.71 – 4.63 (m, 1H), 4.06-4.00 (m, 1H), 2.40 (dd, $J = 2.1$, 0.6 Hz, 1H), 0.84 (d, $J = 0.6$ Hz, 9H), 0.10 (s, 3H), 0.06 (s, 3H).
\textbf{13C NMR} (101 MHz, CDCl$_3$) $\delta$ 159.0, 132.2 (q, $J=32.3$ Hz), 130.3, 118.5, 118.0 (q, $J=4.0$ Hz), 111.8 (q, $J=3.9$ Hz), 82.3, 74.0, 72.5, 62.3, 25.9, 18.3, $-4.5$, $-4.7$.

\textbf{19F NMR} (376 MHz, CDCl$_3$) $\delta$ $-62.71$.

\textbf{IR (neat)} 2980, 2360, 1593, 1329, 1128, 837, 781 cm$^{-1}$.

\textbf{HRMS (ESI)} m/z: [M + Na]$^+$ Calcd for C$_{17}$H$_{23}$F$_3$O$_2$SiNa 367.1312; Found 367.1310.

$[\alpha]_{D}^{25}$ = $-33.1$ (c=0.8, CHCl$_3$)

TBS protected alcohol S3h was prepared according to general procedure E from free alcohol S2h (5.6 mmol) in 86% yield (1.2 g) over two steps as colourless oil. Column conditions: 1% Et$_3$N in hexane.

\textbf{1H NMR} (400 MHz, CDCl$_3$) $\delta$ 7.19 (dd, $J=8.4$, 7.8 Hz, 1H), 6.98 – 6.89 (m, 2H), 6.80 (ddd, $J=8.4$, 2.4, 0.9 Hz, 1H), 4.72 (ddd, $J=6.6$, 5.2, 2.1 Hz, 1H), 4.11 – 3.99 (m, 2H), 2.47 (d, $J=2.2$ Hz, 1H), 0.91 (s, 9H), 0.17 (s, 3H), 0.13 (s, 3H).

\textbf{13C NMR} (101 MHz, CDCl$_3$) $\delta$ 159.3, 134.9, 130.2, 121.3, 115.2, 113.2, 82.1, 73.6, 72.2, 62.1, 25.7, 18.3, $-4.8$, $-5.0$.

\textbf{IR (neat)} 2980, 2887, 2360, 2341, 1596, 1122, 837 cm$^{-1}$.

\textbf{HRMS (ESI)} m/z: [M + H]$^+$ Calcd for C$_{16}$H$_{25}$ClO$_2$Si 311.1229; Found 311.1230.

$[\alpha]_{D}^{25}$ = $-4.3$ (c=0.37, CHCl$_3$)
General procedure F: Borylation of alkyne

To a flame-tried high pressure flask was added 4-methylaminobenzoic acid (5 mol%) and pinacolborane (3 equiv) under an inert atmosphere. A solution of alkyne (1 equiv) in dry heptane (1 M) was added, and the flask was sealed then heated to 110 °C using an oil bath for 16 h. The flask was cooled, and the mixture was diluted with EtOAc and washed with NH₄Cl. The aqueous layer was separated and extracted with EtOAc, and the combined organic layers were dried over Na₂SO₄, filtered and concentrated under vacuum. The resulting oil was purified by column chromatography to yield the boronic ester.

Alkenyl boronic ester 4a was prepared according to general procedure E from alkyne S₃a (15.8 mmol) in 88% yield (5.2 g) as colourless oil. Column conditions: 1% Et₃N in Hexane.

**¹H NMR** (400 MHz, CDCl₃) δ 6.55 (dd, J = 18.0, 4.7 Hz, 1H), 5.56 (dd, J = 18.0, 1.6 Hz, 1H), 4.13 (tdd, J = 6.1, 4.7, 1.6 Hz, 1H), 1.53 – 1.39 (m, 4H), 1.25 (s, 18H), 0.88 (s, 9H), 0.01 (d, J = 6.5 Hz, 6H).

**¹³C NMR** (101 MHz, CDCl₃) δ 156.3, 83.1, 74.2, 37.5, 31.9, 25.9, 24.8, 24.8, 18.3, 14.1, −4.39, −4.86. (The C−B signal was not observed due to quadrupolar relaxation.)

**IR (neat)** 2958, 2931, 2360, 1643, 1356, 1146, 836 cm⁻¹

**HRMS (ESI) m/z:** [M + Na]⁺ Calcd for C₂₀H₄₁BO₃SiNa 391.2810; Found 391.2805.

[α]²⁵D = −5.0 (c=0.26 CHCl₃)

Alkenyl boronic ester 4b was prepared according to general procedure E from alkyne S₃b (5 mmol) in 43% yield (830 mg) as colourless oil. Column conditions: Pure hexane.

**¹H NMR** (400 MHz, CDCl₃) δ 6.55 (dd, J = 18.0, 4.9 Hz, 1H), 5.56 (dd, J = 18.0, 1.5 Hz, 1H), 4.14 (qd, J = 6.1, 1.4 Hz, 1H), 1.52 – 1.42 (m, 2H), 1.33 – 1.17 (m, 20H(12H+8H)), 0.87 (d, J = 8.7 Hz, 12H(9H+3H)), 0.01 (d, J = 6.6 Hz, 6H).

**¹³C NMR** (101 MHz, CDCl₃) δ 156.4, 83.2, 74.3, 37.7, 32.0, 29.5, 26.1, 25.1, 24.9, 24.9, 22.8, 18.4, 18.3, 14.2, 12.6, -4.2, -4.7.

**IR (neat)** 2980, 2959, 2934, 2860, 2360, 2342, 1370, 1343, 1148, 1091, 1002, 972, 838 cm⁻¹

**HRMS (ESI) m/z:** [M + Na]⁺ Calcd for C₂₁H₄₃BO₃SiNa 405.2967; Found 405.2977.

[α]²⁵D = −1.9 (c=1.0, CHCl₃)
Alkenyl boronic ester 4c was prepared according to general procedure E from alkyne S3c (5 mmol) in 57% yield (1.04 g) as colourless oil. Column conditions: Pure hexane.

^1H NMR (400 MHz, CDCl\textsubscript{3}) δ 6.62 – 6.50 (m, 1H), 5.58 – 5.48 (m, 1H), 4.00 – 3.92 (m, 1H), 1.90 (dt, \( J = 15.8, 7.9 \) Hz, 1H), 1.66 – 1.32 (m, 8H), 1.25 (d, \( J = 1.7 \) Hz, 12H), 0.88 (s, 9H), -0.00 (d, \( J = 14.3 \) Hz, 6H).

^13C NMR (101 MHz, CDCl\textsubscript{3}) δ 155.9, 83.2, 78.1, 46.3, 28.8, 28.5, 26.1, 25.8, 25.6, 25.0, 24.8, 18.4, -3.9, -4.7.

IR (neat) 2956, 2860, 1642, 1362, 1330, 1256, 1216, 1147, 1106, 1004, 972, 837, 757 cm\(^{-1}\).

HRMS (ESI) m/z: [M + Na]\(^{+}\) Calcd for C\textsubscript{20}H\textsubscript{39}BO\textsubscript{3}SiNa 389.2654; Found 389.2689.

[\( \alpha \)]\textsubscript{25}D = -17.8 (c=1.0, CHCl\textsubscript{3})

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Alkenyl boronic ester 4d was prepared according to general procedure E from alkyne S3d (3.5 mmol) in 81% yield (1.13 g) as colourless oil. Column conditions: 1% Et\textsubscript{3}N in Hexane.

^1H NMR (400 MHz, CDCl\textsubscript{3}) δ 7.32 – 7.24 (m, 2H), 7.17 (d, \( J = 7.4 \) Hz, 3H), 6.62 (dt, \( J = 18.0, 4.7 \) Hz, 1H), 5.64 (dd, \( J = 18.0, 1.6 \) Hz, 1H), 4.25 (qd, \( J = 5.8, 1.6 \) Hz, 1H), 2.71 – 2.56 (m, 2H), 1.94 – 1.76 (m, 2H), 1.28 (s, 12H), 0.92 (s, 9H), 0.05 (s, 3H), 0.03 (s, 3H).

^13C NMR (101 MHz, CDCl\textsubscript{3}) δ 155.6, 142.5, 128.4, 128.3, 125.7, 83.2, 73.6, 39.1, 31.1, 26.0, 24.81, 24.76, 18.2, -4.4, -4.9.

IR (neat) 2980, 2360, 1645, 1328, 1130 cm\(^{-1}\).

HRMS (ESI) m/z: [M + Na]\(^{+}\) Calcd for C\textsubscript{23}H\textsubscript{39}BO\textsubscript{3}SiNa 425.2654; Found 425.2652.

[\( \alpha \)]\textsubscript{25}D = +14.3 (c=0.6, CHCl\textsubscript{3})
Alkenyl boronic ester 4e was prepared according to general procedure E from alkyne S3e (5 mmol) in 54% yield (1.28 g) as colourless oil. Column conditions: Pure hexane.

$^1$H NMR (400 MHz, CDCl$_3$) δ 7.51 (d, $J = 8.1$ Hz, 2H), 7.27 (d, $J = 8.1$ Hz, 2H), 6.59 (dd, $J = 18.0$, 4.9 Hz, 1H), 5.65 (dd, $J = 18.0$, 1.4 Hz, 1H), 4.26 (qd, $J = 5.6$, 1.4 Hz, 1H), 2.77 – 2.64 (m, 2H), 1.90 – 1.77 (m, 2H), 1.28 (s, 12H), 0.92 (s, 9H), 0.04 (d, $J = 5.6$ Hz, 6H).

$^{13}$C NMR (101 MHz, CDCl$_3$) δ 155.3, 146.8, 128.8, 128.23 (ad, $J = 32.3$ Hz), 125.34 (q, $J = 3.6$ Hz), 83.3, 73.6, 38.9, 31.0, 26.1, 24.92, 24.87, 18.4, -4.2, -4.8.

$^{19}$F NMR (376 MHz, CDCl$_3$) δ -62.3.

IR (neat) 2980, 2957, 2932, 2859, 2360, 2343, 1642, 1370, 1327, 1255, 1217, 1165, 1146, 1127, 1069, 1020, 1001, 971 cm$^{-1}$

HRMS (ESI) m/z: [M + Na]$^+$ Calcd for C$_{24}$H$_{38}$BF$_3$O$_3$SiNa 493.2528; Found 493.2528.

$[\alpha]^{25}_D = +9.5$ (c=1.0, CHCl$_3$)

Alkenyl boronic ester 4f was prepared according to general procedure E from alkyne S3f (5 mmol) in 53% yield (1.1 g) as colourless oil. Column conditions: Pure hexane.

$^1$H NMR (400 MHz, CDCl$_3$) δ 7.31 – 7.22 (m, 2H), 7.21 – 7.13 (m, 3H), 6.55 (dd, $J = 18.0$, 4.9 Hz, 1H), 5.58 (dd, $J = 18.0$, 1.5 Hz, 1H), 4.18 (qd, $J = 6.0$, 1.5 Hz, 1H), 2.60 (t, $J = 7.6$ Hz, 2H), 1.76 – 1.59 (m, 2H), 1.58 – 1.48 (m, 2H), 1.27 (s, 12H), 0.89 (s, 9H), 0.02 (d, $J = 4.9$ Hz, 6H).

$^{13}$C NMR (101 MHz, CDCl$_3$) δ 156.1, 142.6, 128.6, 128.4, 125.8, 83.2, 74.1, 37.1, 36.0, 26.7, 26.1, 24.94, 24.89, 18.4, -4.2, -4.7.

IR (neat) 2979, 2932, 2858, 2360, 1642, 1463, 1370, 1341, 1256, 1217, 1147, 1105, 1003, 971 cm$^{-1}$

HRMS (ESI) m/z: [M + Na]$^+$ Calcd for C$_{24}$H$_{41}$BO$_3$SiNa 439.2810; Found 439.2833.

$[\alpha]^{25}_D = +3.7$ (c=1.0, CHCl$_3$)
Alkenyl boronic ester 4g was prepared according to general procedure E from alkyne S3g (3.5 mmol) in 88% yield (1.45 g) as colourless oil. Column conditions: 1% Et₃N in Hexane.

^1^H NMR (400 MHz, CDCl₃) δ 7.37 (t, J = 7.7 Hz, 1H), 7.19 (dd, J = 7.7, 2.3, 1H), 7.09 (t, J = 2.3 Hz, 1H), 7.04 (dd, J = 8.3, 2.3 Hz, 1H), 6.66 (dd, J = 18.0, 4.1 Hz, 1H), 5.86 (dd, J = 18.0, 1.8 Hz, 1H), 4.60 (dt, J = 7.5, 4.1, 1.8 Hz, 1H), 3.95 (dd, J = 9.4, 4.1 Hz, 1H), 3.85 (dd, J = 9.4, 7.5 Hz, 1H), 1.28 (s, 12H), 0.91 (s, 9H), 0.09 (s, 3H), 0.08 (s, 3H).

^13^C NMR (101 MHz, CDCl₃) δ 158.9, 151.0, 131.8 (app d, J = 32.3 Hz), 129.9, 118.1, 117.4 (app d, J = 3.9 Hz), 111.2, 111.1, 83.4, 72.5, 72.1, 25.9, 24.8, 18.3, −4.6, −4.7.

^19^F NMR (376 MHz, CDCl₃) δ −62.71.

IR (neat) 2980, 2360, 1645, 1448, 1328, 1130 cm⁻¹

HRMS (ESI) m/z: [M + H]^+ Calcd for C₂₃H₃₇BF₃O₄Si 473.2501; Found 473.2498.

[α]^{25}_D = −2.2 (c=0.25, CHCl₃)

Alkenyl boronic ester 4h was prepared according to general procedure E from alkyne S3h (2.9 mmol) in 78% yield (0.96 g) as colourless oil. Column conditions: 1% Et₃N in Hexane.

^1^H NMR (400 MHz, CDCl₃) δ 7.17 (t, J = 8.0 Hz, 1H), 6.91 (ddd, J = 8.0, 2.2, 0.9 Hz, 1H), 6.87 (d, J = 2.2 Hz, 1H), 6.76 (ddd, J = 8.0, 2.2, 0.9 Hz, 1H), 6.65 (dd, J = 18.0, 4.0 Hz, 1H), 5.85 (dd, J = 18.0, 1.8 Hz, 1H), 4.58 (dt, J = 7.6, 4.0, 1.8 Hz, 1H), 3.85 (s, 1H), 3.80 (dd, J = 9.5, 7.5 Hz, 1H), 1.28 (s, 12H), 0.91 (s, 9H), 0.09 (s, 3H), 0.08 (s, 3H).

^13^C NMR (101 MHz, CDCl₃) δ 159.5, 151.1, 134.8, 130.2, 120.9, 114.9, 113.0, 83.4, 72.5, 72.1, 25.9, 24.83, 24.76, 18.3, −4.66, −4.71.

IR (neat) 2985, 2931, 2360, 1643, 1365, 1146, 836 cm⁻¹

HRMS (ESI) m/z: [M + Na]^+ Calcd for C₂₂H₃₅BClO₃SiNa 461.2057; Found 461.2053.

[α]^{25}_D = −4.3 (c=0.37, CHCl₃)
**General procedure G**: Coupling of allyl chloride and Alkenyl boronic ester.

*Flask A.* $[\text{Rh(cod)OH}]{_2}$ (2.5 mol%) and (S)-DM-Segphos (6 mol%) were weighed and added to a 10 mL flame dried flask equipped with a magnetic stir bar. The flask was put under reduced pressure for 5 minutes, then back-filled with argon. This was repeated once more, before THF (1 mL) and CsOH (50 wt%, 1 equiv) was added and the flask was stirred at 65 °C using an oil bath for 30 min.

*Flask B.* Meanwhile, allyl chloride (rac)-5 (1 equiv.) and Alkenyl boronic ester (1.2 equiv) were added to a flame dried 5 mL RBF and dissolved in dry THF (0.7 mL).

After flask A stirred for 30 min, the contents of flask B were added via syringe, and flask B was washed with 0.3 mL THF which was also added to flask A. Reaction progress was monitored by $^1$H NMR spectroscopy. Upon completion (1-3 h), silica gel was added directly to the reaction mixture which was concentrated and dry loaded for purification by silica gel chromatography.

Note: For compound 6, no change was made to the experimental procedure when increasing scale to 5 mmol of allyl chloride other than the size of the flasks used — all other factors (time, temperature etc.) were consistent with the procedure used for reactions carried out on a 0.5 mmol scale. Flask A size used is 25 mL, and flask B size is 50 mL.

Coupled product 6 was prepared according to general procedure G from allyl chloride (rac)-5 (5 mmol) in 90% yield (1.54 g) in 99% de as colourless oil. Column conditions: 0-10% EtOAc in hexane.

Note: when carried out on a 0.5 mmol scale, the isolated yield of this reaction was 88% (151 mg), and when carried out on 3.2 mmol scale, the isolated yield was 90% (1.10 g). In all cases, the de observed was 99%.

$^1$H NMR (400 MHz, CDCl$_3$) δ 5.82 (dt, $J = 5.8, 1.8$ Hz, 1H), 5.79 – 5.74 (m, 1H), 5.55 – 5.39 (m, 2H), 5.19 – 5.12 (m, 1H), 4.40 (d, $J = 5.7$ Hz, 1H), 4.02 (dt, $J = 7.0, 5.4$ Hz, 1H), 3.45 – 3.38 (m, 1H), 1.42 (s, 3H), 1.34 (s, 3H), 1.31 (s, 8H), 0.90 – 0.85 (m, 12H), 0.03 (s, 3H), 0.00 (s, 3H).

$^{13}$C NMR (101 MHz, CDCl$_3$) δ 135.5, 135.1, 131.2, 129.0, 110.1, 85.1, 83.8, 73.1, 53.9, 38.3, 31.8, 27.5, 25.9, 25.0, 22.6, 18.3, 14.0, -4.2, -4.8.

IR 2957, 2931, 2360, 2341, 1472, 1377, 1251, 1212, 1066, 810, 774 cm$^{-1}$

[$\alpha$]$^\text{D}_{25}$ $-141.1$ (c=0.2, CHCl$_3$)

HRMS (ESI) m/z: [M + H]$^+$ Calcd for C$_{22}$H$_{41}$O$_3$Si 381.2820; Found 381.2812.
Coupled product 7 was prepared according to general procedure G from allyl chloride (*rac*)-5 (0.5 mmol) in 87% yield (172 mg) in 99% de as colourless oil. Column conditions: 2-10% diethylether in hexane.

\[ \text{H NMR (500 MHz, CDCl}_3) \delta 5.82 (dt, J = 5.7, 1.6 Hz, 1H), 5.75 (dd, J = 5.7, 2.3 Hz, 1H), 5.54 - 5.40 (m, 2H), 5.16 (d, J = 5.3 Hz, 1H), 4.41 (d, J = 5.7 Hz, 1H), 4.02 (q, J = 5.7 Hz, 1H), 3.42 (d, J = 6.1 Hz, 1H), 1.42 (s, 3H), 1.34 (s, 3H), 1.32 - 1.18 (m, 10H), 0.90 - 0.86 (m, 12H (9H + 3H)), 0.02 (s, J = 11.6 Hz, 6H).

\[ \text{C NMR (126 MHz, CDCl}_3) \delta 135.6, 135.3, 131.3, 129.1, 110.3, 85.2, 83.9, 73.3, 54.0, 38.5, 32.0, 29.4, 27.6, 26.1, 26.0, 25.4, 22.8, 18.4, 14.2, -4.1, -4.6.

\[ \text{IR (neat) 2957, 2931, 2858, 1463, 1369, 1253, 1216, 1160, 1069, 972, 868, 836, 775 cm}^{-1}.

\[ \text{HRMS (ESI) m/z: [M + Na]^+ Calcd for } C_{23}H_{42}O_3SiNa 417.2795; \text{ Found 417.2797.}

\[ \alpha_{25}^{D} = -120.3 (c=1.0, \text{CHCl}_3)

Coupled product 8 was prepared according to general procedure G from allyl chloride (*rac*)-5 (0.5 mmol) in 91% yield (173 mg) in 99% de as colourless oil. Column conditions: 2-10% diethylether in hexane.

\[ \text{H NMR (500 MHz, CDCl}_3) \delta 5.82 (dt, J = 5.6, 1.7 Hz, 1H), 5.74 (dd, J = 5.6, 2.5 Hz, 1H), 5.52 - 5.40 (m, 2H), 5.18 - 5.13 (m, 1H), 4.40 (d, J = 5.7 Hz, 1H), 3.87 - 3.80 (m, 1H), 3.45 - 3.39 (m, 1H), 1.86 (h, J = 8.0 Hz, 1H), 1.73 - 1.63 (m, 1H), 1.58 - 1.44 (m, 6H), 1.42 (s, 3H), 1.34 (s, 3H), 1.21 - 1.11 (m, 1H), 0.87 (s, 9H), 0.05 - 0.03 (m, 6H).

\[ \text{C NMR (126 MHz, CDCl}_3) \delta 135.6, 134.8, 131.3, 129.6, 110.3, 85.2, 83.9, 77.2, 54.0, 47.0, 29.0, 28.9, 27.6, 26.05, 26.00, 25.7, 25.6, 18.4, -3.7, -4.6.

\[ \text{IR (neat) 2956, 2859, 2360, 1463, 1369, 1253, 1215, 1159, 1054, 973, 868, 837, 775 cm}^{-1}.

\[ \text{HRMS (ESI) m/z: [M + Na]^+ Calcd for } C_{22}H_{38}O_3SiNa 401.2482; \text{ Found 401.2517.}

\[ \alpha_{25}^{D} = -126.9 (c=1.0, \text{CHCl}_3)
Coupled product 9 was prepared according to general procedure G from allyl chloride (rac)-5 (0.5 mmol) in 93% yield (192 mg) in 99% de as colourless oil. Column conditions: 0-10% EtOAc in hexane.

$^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.30-7.24 (m, 2H), 7.21-7.14 (m, 3H), 5.84 (dt, $J = 5.7, 1.8$ Hz, 1H), 5.79 – 5.74 (m, 1H), 5.58 – 5.43 (m, 2H), 5.16 (dq, $J = 5.7, 1.3$ Hz, 1H), 4.41 (d, $J = 5.7$ Hz, 1H), 4.08 (dt, $J = 6.5, 5.3$ Hz, 1H), 3.46 – 3.38 (m, 1H), 2.74 – 2.52 (m, 2H), 1.91 – 1.68 (m, 2H), 1.43 (s, 3H), 1.35 (s, 3H), 0.90 (s, 9H), 0.05 (s, 3H), 0.02 (s, 3H).

$^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 142.4, 135.4, 134.7, 131.3, 129.6, 128.4, 128.3, 125.7, 110.2, 85.0, 83.8, 72.6, 53.9, 40.0, 31.6, 27.5, 26.0, 18.1, -4.1, -4.7.

IR (neat) 2980, 2888, 2360, 2341, 1461, 1381, 1156, 1071 cm$^{-1}$.

HRMS (ESI) m/z: [M + Na]$^+$ Calcd for C$_{25}$H$_{38}$O$_3$SiNa 437.2482; Found 437.2482.

$[\alpha]_{D}^{25} = -104.2$ (c=0.2, CHCl$_3$)

Coupled product 10 was prepared according to general procedure G from allyl chloride (rac)-5 (0.5 mmol) in 79% yield (190 mg) in 99% de as colourless oil. Column conditions: 2-15% diethylether in hexane.

$^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.52 (d, $J = 8.0$ Hz, 2H), 7.27 (d, $J = 8.0$ Hz, 2H), 5.84 (dt, $J = 5.7, 1.7$ Hz, 1H), 5.79 – 5.70 (m, 1H), 5.61 – 5.43 (m, 2H), 5.20 – 5.13 (m, 1H), 4.41 (d, $J = 5.7$ Hz, 1H), 4.12 (q, $J = 5.7$ Hz, 1H), 3.45 (dd, $J = 4.8, 2.2$ Hz, 1H), 2.80 – 2.58 (m, 2H), 1.88 – 1.68 (m, 2H), 1.42 (s, 3H), 1.35 (s, 3H), 0.90 (s, 9H), 0.05 (s, 6H).

$^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 146.7, 135.4, 134.5, 131.5, 130.1, 128.8, 128.2 (ad, $J = 32.3$ Hz), 125.4 (q, $J = 3.7$ Hz), 124.50 (ad, $J = 271.7$ Hz), 110.4, 85.2, 83.9, 72.5, 54.0, 39.8, 31.5, 27.6, 26.0, 25.9, 18.4, -4.0, -4.6.

$^{19}$F NMR (376 MHz, CDCl$_3$) $\delta$ -62.3.

IR (neat) 2981, 2957, 2933, 2859, 2360, 2341, 1327, 1254, 1216, 1164, 1127, 1069, 1020, 972, 837, 776 cm$^{-1}$.

HRMS (ESI) m/z: [M + Na]$^+$ Calcd for C$_{26}$H$_{37}$F$_3$O$_3$SiNa 505.2356; Found 505.2377.

$[\alpha]_{D}^{25} = -97.7$ (c=0.25, CHCl$_3$)
Coupled product 11 was prepared according to general procedure G from allyl chloride (rac)-5 (0.5 mmol) in 82% yield (175 mg) in 99% de as colourless oil. Column conditions: 2-15% diethylether in hexane.

$^{1}$H NMR (400 MHz, CDCl$_3$) δ 7.31 – 7.20 (m, 2H), 7.20 – 7.10 (m, 3H), 5.81 (dt, $J$ = 5.7, 1.7 Hz, 1H), 5.77 – 5.69 (m, 1H), 5.53 – 5.37 (m, 2H), 5.18 – 5.09 (m, 1H), 4.38 (d, $J$ = 5.7 Hz, 1H), 4.05 (q, $J$ = 5.7 Hz, 1H), 3.44 – 3.33 (m, 1H), 2.58 (t, $J$ = 7.5 Hz, 2H), 1.69 – 1.43 (m, 4H), 1.33 (s, 3H), 1.40 (s, 3H), 0.86 (s, 9H), -0.00 (d, $J$ = 9.9 Hz, 6H).

$^{13}$C NMR (101 MHz, CDCl$_3$) δ 142.6, 135.5, 135.0, 131.4, 129.4, 128.5, 128.4, 125.8, 110.3, 85.2, 83.9, 73.0, 54.0, 37.9, 36.0, 27.6, 27.1, 26.1, 26.05, 25.95, 18.4, -4.0, -4.6.

IR (neat) 2932, 2858, 2360, 1497, 1462, 1370, 1253, 1214, 1159, 1053, 1005, 971 cm$^{-1}$.

HRMS (ESI) m/z: [M + Na]$^+$ Calcd for C$_{26}$H$_{40}$O$_3$SiNa 451.2639; Found 451.2654.

$[\alpha]_{D}^{25}$ = -96.8 (c=1.0, CHCl$_3$)

Coupled product 12 was prepared according to general procedure G from allyl chloride (rac)-5 (0.5 mmol) in 85% yield (200 mg) in 99% de as colourless oil. Column conditions: 0-10% EtOAc in hexane.

$^{1}$H NMR (400 MHz, CDCl$_3$) δ 7.37 (td, $J$ = 8.0, 1.0 Hz, 1H), 7.20 (ddt, $J$ = 8.0, 2.4, 1.0 Hz, 1H), 7.08 (t, $J$ = 2.4 Hz, 1H), 7.04 (dd, $J$ = 8.0, 2.4 Hz, 1H), 5.91 – 5.81 (m, 1H), 5.81 – 5.71 (m, 2H), 5.56 (dd, $J$ = 15.5, 5.4, 1.2 Hz, 1H), 4.53 – 4.45 (m, 1H), 4.45 – 4.39 (m, 1H), 3.92 – 3.81 (m, 2H), 3.50 – 3.42 (m, 1H), 1.45 – 1.40 (m, 3H), 1.35 (d, $J$ = 0.7 Hz, 3H), 0.95 – 0.86 (m, 9H), 0.14 – 0.05 (m, 6H).

$^{13}$C NMR (101 MHz, CDCl$_3$) δ 158.9, 135.1, 132.0, 131.6, 130.5, 123.0, 118.2, 117.4, 111.2, 110.3, 85.0, 83.7, 72.5, 71.4, 54.0, 27.5, 25.9, 18.3, -4.6, -4.7.

$^{19}$F NMR (376 MHz, CDCl$_3$) δ -62.69.

IR (neat) 2980, 2888, 2360, 2341, 1458, 1381, 1130, 955 cm$^{-1}$.

HRMS (ESI) m/z: [M + Na]$^+$ Calcd for C$_{25}$H$_{35}$F$_3$O$_4$SiNa 507.2149; Found 507.2148.

$[\alpha]_{D}^{25}$ = -109.1 (c=0.23, CHCl$_3$)

S28
Coupled product 13 was prepared according to general procedure G from allyl chloride \((rac)-5\) (0.5 mmol) in 94% yield (206 mg) in 99% de as colourless oil. Column conditions: 0-10% EtOAc in hexane.

\(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.17 (t, \(J = 8.1\) Hz, 1H), 6.91 (ddd, \(J = 8.1, 2.0, 0.9\) Hz, 1H), 6.86 (t, \(J = 2.5\) Hz, 1H), 6.75 (ddd, \(J = 8.1, 2.5, 0.9\) Hz, 1H), 5.86 (dt, \(J = 5.7, 1.8\) Hz, 1H), 5.81 – 5.69 (m, 2H), 5.59 – 5.49 (m, 1H), 5.16 (dq, \(J = 5.9, 1.4\) Hz, 1H), 4.46 (q, \(J = 5.8\) Hz, 1H), 4.41 (d, \(J = 5.7\) Hz, 1H), 3.81 (d, \(J = 5.9\) Hz, 2H), 3.51 – 3.43 (m, 1H), 1.42 (s, 3H), 1.35 (s, 3H), 0.89 (s, 9H), 0.07 (s, 6H).

\(^13\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 159.6, 135.1, 134.8, 131.8, 131.6, 130.5, 130.2, 120.9, 114.9, 113.0, 110.3, 85.0, 83.7, 72.5, 71.4, 54.0, 27.5, 25.8, -4.6, -4.7.

IR (neat) 2980, 2888, 2360, 1596, 1381, 1251, 955 cm\(^{-1}\).

HRMS (ESI) m/z: [M + Na]\(^+\) Calcd for C\(_{24}\)H\(_{35}\)ClO\(_4\)SiNa 473.1885; Found 473.1884.

\([\alpha]^{25}_D = -110.1\) (c=0.25, CHCl\(_3\))
To cross-coupling product 6 (1.1 g, 2.9 mmol) was added AcOH (7 mL) and water (3 mL) and the resulting mixture was stirred at 40 °C using an oil bath for 16 h. The solution was concentrated under vacuum before directly loading onto a silica column. Elution with DCM/MeOH 5% yielded triol S4 in 85% yield (560 mg) as an off-white amorphous solid.

\[ \text{1H NMR} (400 MHz, CDCl}_3) \delta 5.91 - 5.80 (m, 2H), 5.56 (dd, \text{J = 4.5}, 2.1 \text{ Hz}, 2H), 4.55 (ddd, \text{J = 5.8}, 2.1, 1.3 \text{ Hz}, 1H), 4.04 (dtt, \text{J = 8.5, 6.3, 3.9 Hz, 1H}), 3.86 (t, \text{J = 5.4 Hz, 1H}), 3.26 (s, 1H), 3.07 (s, 3H), 1.59 - 1.40 (m, 2H), 1.40 - 1.20 (m, 6H), 0.87 (t, \text{J = 6.6 Hz, 3H}). \]

\[ \text{13C NMR} (101 MHz, CDCl}_3) \delta 137.4, 134.7, 131.5, 130.9, 74.8, 72.9, 53.7, 37.1, 31.7, 25.2, 24.8, 22.6, 14.1. \]

\[ \text{IR} \text{ 3340, 2968, 2886, 1465, 1369, 1331, 1307, 1160, 951, 628 \text{ cm}^{-1} \]

\[ \text{HRMS (ESI) m/z: [M + Na]^{+}} \text{ Calcd for C}_{13}\text{H}_{22}\text{O}_3\text{Na 249.1461; Found 249.1460.} \]

\[ [\alpha]^{25D} = -165.8 \text{ (c = 0.5, CHCl}_3) \]
Triol S₄ (450 mg, 2.0 mmol) was dissolved in DCM, followed by the addition of Et₃N (3 mL, 16 mmol, 8 equiv) and CDI (1.80 g, 8 mmol, 4 equiv). The reaction was stirred at 50 °C using an oil bath for 2 hours and treated with sat. aq. NH₄Cl (20 mL). The aqueous layer was extracted with DCM (3 x 30 mL) and the combined organic layers were dried over Na₂SO₄, filtered and concentrated under vacuum. The crude product was purified by column chromatography (MeOH/DCM 2.5%), furnishing carbonate 1₄ as a colourless oil in 94% yield (469 mg).

¹H NMR (400 MHz, CDCl₃) δ 6.10 (dd, J = 5.8, 2.4 Hz, 1H), 5.95 (dt, J = 5.8, 1.9 Hz, 1H), 5.69 – 5.49 (m, 3H), 4.86 (d, J = 6.5 Hz, 1H), 4.15 – 4.05 (m, 1H), 3.74 – 3.67 (m, 1H), 1.50 (td, J = 7.2, 2.9 Hz, 2H), 1.33 – 1.23 (m, 6H), 0.93 – 0.85 (m, 3H).

¹³C NMR (101 MHz, CDCl₃) δ 154.4, 139.2, 136.5, 128.0, 127.5, 84.7, 82.9, 72.1, 53.5, 37.3, 31.7, 25.0, 22.6, 14.0.

IR (neat) 2980, 2360, 1793, 1461, 1380, 1156, 769 cm⁻¹.

HRMS (ESI) m/z: [M + Na]⁺ Calcd for C₁₄H₂₀O₄Na 275.1254; Found 275.1250.

[α]D²⁵ = −239.2 (c=0.11, CHCl₃)
Dimethyl malonate (0.72 mL, 4.7 mmol, 3.5 equiv) was added via syringe to a suspension of NaH (60% in mineral oil, washed with pentane, 219 mg, 4.0 mmol, 3 equiv) in THF (7 mL) under argon atmosphere at 0 °C. After stirring for 5 minutes, this solution was transferred to a flask containing carbonate 14 (160 mg, 1.35 mmol, 1 equiv) and Pd(dppf)Cl₂ (19 mg, 0.27 mmol, 2 mol %) in THF (22 mol). After stirring for 1 hour at room temperature, the reaction solution was poured into aq. Sat. NH₄Cl (15 mL) and extracted with EtOAc (3 x 20 mL). The combined organic layers were dried over Na₂SO₄, filtered, and concentrated under vacuum. Silica gel chromatography (40% EtOAc in Hexane) yielded the desired product 15 in 96% yield (477 mg) as colourless oil.

¹H NMR (400 MHz, CDCl₃) δ 5.86 (s, 2H), 5.71 – 5.46 (m, 2H), 4.50 (t, J = 5.7 Hz, 1H), 4.26 – 4.12 (m, 4H), 4.11 – 3.98 (m, 1H), 3.43 (dd, J = 6.4, 1.1 Hz, 1H), 3.17 – 2.99 (m, 1H), 2.57 – 2.37 (m, 1H), 1.61 – 1.36 (m, 3H), 1.33 – 1.21 (m, 11 H), 0.95 – 0.82 (m, 3H).

¹³C NMR (101 MHz, CDCl₃) δ 168.5, 168.2, 135.0, 134.4, 133.4, 131.5, 82.6, 72.6, 61.5, 61.5, 55.1, 54.7, 49.6, 37.3, 31.8, 25.2, 22.6, 14.2, 14.0.

IR (neat) 2980, 2888, 2360, 2341, 1732, 1461, 1381, 1252, 966 cm⁻¹.

HRMS (ESI) m/z: [M + Na]+ Calcd for C₂₀H₃₂O₆Na 391.2091; Found 391.2082.

[α]²⁵ D = +34 (c=0.4, CHCl₃)
An aq. Solution of NaOH (1M, 18 mL, 18 mmol, 18 equiv) was added to a solution of diester 15 (360 mg, 1 mmol, 1 equiv) in THF (10 mL) at RT and stirred for 24 h. The solution was acidified with an aq. Solution of HCL (1 M, 60 mL) and extracted with EtOAc (3 x 50 mL). The combined organic layers were dried over Na$_2$SO$_4$ and concentrated under vacuum. The resulting pale-yellow oil was used in the next step without further purification.

The crude diacid was dissolved in THF (22 mL) and CDI (450 mg, 2.5 mmol, 2.5 equiv) was added at RT. After 2 hours, an aq. Solution of NaOH (22 mL, 22 mmol, 25 equiv) was added and the reaction mixture was stirred for 14 hours. The solution was acidified with an aq. Solution of HCL (1 M, 60 mL) and extracted with EtOAc (3 x 50 mL). The combined organic layers were dried over Na$_2$SO$_4$ and concentrated under vacuum. The resulting carboxylic acid 16 was used in the next step without further purification.

The crude carboxylic acid 16 was dissolved in THF (5 mL) and a solution of NaHCO$_3$ (640 mg, 17.9 mmol, 2 equiv) in H$_2$O (6 mL) was added. A solution of KI (989 mg, 6.1 mmol, 6 equiv) and I$_2$ (510 mg, 2.0 mmol, 2 equiv) was also added and the mixture was stirred for 24 h in the dark. The reaction mixture was poured onto a sat. aq. solution of Na$_2$S$_2$O$_3$ (40 mL) and was extracted with EtOAc (3 x 50 mL). The combined organic layers were dried over Na$_2$SO$_4$ and concentrated under vacuum. Purification by silica gel chromatography (15% EtOAc in Hexane) to yield the iodolactonized S5 product as a pale yellow oil in a 69% yield (274 mg) over 3 steps.

$^1$H NMR (400 MHz, Acetone) δ 5.91 – 5.61 (m, 2H), 5.18 (dd, $J = 8.0$, 4.8 Hz, 1H), 4.89 (d, $J = 6.2$ Hz, 1H), 4.14 (dd, $J = 5.3$, 4.2 Hz, 2H), 4.08 (td, $J = 9.5$, 6.1 Hz, 1H), 3.75 (d, $J = 4.4$ Hz, 1H), 3.05 – 2.85 (m, 8H), 2.46 (dd, $J = 17.7$, 2.3 Hz, 1H), 2.34 (td, $J = 9.9$, 6.9 Hz, 1H), 1.69 – 1.47 (m, 1H), 1.46 – 1.34 (m, 6H), 1.10 – 0.92 (m, 4H).

$^{13}$C NMR (101 MHz, Acetone) δ 175.6, 137.9, 128.4, 89.9, 84.0, 72.1, 54.1, 41.4, 38.1, 33.9, 33.3, 32.3, 25.7, 23.0, 14.0.

IR (neat) 2980, 2360, 2341, 1773, 1381, 1252, 967, 668 cm$^{-1}$.

HRMS (ESI) m/z: [M + Na]$^+$ Calcd for C$_{15}$H$_{23}$IO$_4$Na 417.0533; Found 417.0526.

[$\alpha$]$^\text{D}$$^\text{b} = -14.8$ (c=0.16, CHCl$_3$)
Tributyltinhydride (0.3 mL, 1.17 mmol, 5.0 equiv.) and azobisisobutyronitrile (AIBN) (6 mg, 39 µmol, 0.15 equiv.) were added to solution of iodolactone S5 (90 mg, 0.23 mmol, 1.00 equiv.) in benzene (2.6 mL). The resulting mixture was stirred at 80 °C using an oil bath. After 1 h, the reaction mixture was cooled down to room temperature, solid KF (200 mg) was added and the resulting mixture was stirred for additional 1 h. The reaction mixture was then loaded directly on silica and the crude product purified by silica gel column chromatography (ethyl acetate/hexane = 30% to 70%, stationary phase K2CO3/silica = 1:9). The product 17 was obtained as a colorless oil (48 mg, 78%).

1H NMR (400 MHz, CDCl3) δ 5.55 (dd, J = 15.3, 7.4 Hz, 1H), 5.39 (dd, J = 15.2, 8.5 Hz, 1H), 4.87 (td, J = 7.0, 3.1 Hz, 1H), 4.00 (q, J = 6.8 Hz, 1H), 3.88 (q, J = 7.8 Hz, 1H), 2.72 (dd, J = 18.2, 9.5 Hz 1H), 2.51 (dq, J = 14.1, 7.7 Hz, 2H), 2.37 (dd, J = 17.9 Hz, 1H), 2.20 (q, J = 8.5 Hz, 1H), 1.88 (ddd, J = 14.7, 8.2, 3.2 Hz, 1H), 1.56-1.48 (m, 2H), 1.46-1.20 (m, 7H), 0.93 – 0.82 (m, 3H).

13C NMR (101 MHz, CDCl3) δ 177.2, 137.0, 130.5, 82.6, 76.3, 73.0, 56.2, 42.4, 39.7, 37.1, 34.1, 31.7, 25.2, 22.7, 14.1.

HRMS (ESI) m/z: [M + H]+ Calcd for C15H24O2 269.1747; Found 269.1746.

[α]25D = −4.8 (c=0.15, CHCl3) [−4.7, c = 0.72 CHCl3],1 [−7.2, c = 0.3, CHCl3],2 [−6.7, c = 1.0 CHCl3].3

All physical data is in accordance with literature.1-3
Lactone 17 (25 mg, 93 μmol, 1 equiv) was dissolved in DCM (2.5 mL) and DIBAL-H was added (0.38 mL, 380 μmol, 4 equiv) at -78 °C. After 1 h, the reaction was quenched with a sat. aq. solution of Rochelle’s salt (20 mL) and stirred for one hour at RT. The reaction mixture was extracted with DCM (5 x 10 mL) and the combined organic layers were dried over Na₂SO₄, filtered, and concentrated under vacuum. The crude hemiacetal was used without further purification in the next step.

To a flame dried round bottom flask was added (4-Carboxybutyl)triphenylphosphonium bromide (240 mg, 0.54 mmol, 6 equiv) and dry THF (1 mL). To this was added a solution of KHMDS (0.5 M in toluene, 2.16 mmol, 1.08 mmol, 12 equiv) at 0 °C. After 15 minutes, a solution of hemiacetal in THF (1 mL) was added to the bright orange ylide solution. The reaction was stirred for 2 h at RT and was quenched with 3 mL of H₂O. The reaction mixture was extracted with Et₂O (2 x 10 mL). The aqueous layer was acidified with HCL (1M, 2 mL) and was extracted with DCM (10 x 5 mL). The organic phases were dried over Na₂SO₄, filtered and concentrated under vacuum. The resulting crude oil was purified by silica gel chromatography (65/30/5 EtOAc/Hex/AcOH) to yield the PG F2α as a clear oil (27 mg, 82% over two steps).

$^1$H NMR (400 MHz, MeOD) δ 5.52 (t, $J = 7.4$ Hz, 3H), 5.44 – 5.32 (m, 1H), 4.13 (td, $J = 5.5$, 2.2 Hz, 1H), 4.05 (q, $J = 6.4$ Hz, 1H), 3.87 (q, $J = 7.8$ Hz, 1H), 2.39 (ddd, $J = 14.4$, 8.5, 5.9 Hz, 1H), 2.34 – 2.19 (m, 4H), 2.14 (tt, $J = 8.3$, 4.8 Hz, 3H), 1.73 – 1.56 (m, 4H), 1.55 – 1.45 (m, 2H), 1.45 – 1.30 (m, 9H) δ 0.94 – 0.89 (m, 3H).

$^{13}$C NMR (101 MHz, MeOD) δ 179.0, 136.5, 134.2, 130.7, 130.1, 77.9, 73.9, 72.2, 56.1, 50.9, 44.3, 38.4, 37.2, 33.0, 28.1, 27.1, 26.4, 26.2, 23.7, 14.4.

$[\alpha]^{25}_D = +23.3$ (c=0.42, THF). Lit. $[+23.5$, c = 1.0, THF]$^4$ $[+23.5$ (natural material), c = 1.0, THF]$^5$ $[24.9$, 0.57, THF]$^6$.

All physical data is in accordance with literature.$^4$$^6$
NMR Spectra:

$^1$H NMR (400 MHz, CDCl$_3$) of **S1a**

$^1$H NMR (400 MHz, CDCl$_3$) of **S1b**
$^1$H NMR (400 MHz, CDCl$_3$) of S1c

$^1$H NMR (400 MHz, CDCl$_3$) of S1d
$^1$H NMR (400 MHz, CDCl$_3$) of S1e

$^1$H NMR (400 MHz, CDCl$_3$) of S1f
$^1$H NMR (400 MHz, CDCl$_3$) of S1g

$^1$H NMR (400 MHz, CDCl$_3$) of S1h
$^1$H NMR (400 MHz, CDCl$_3$) of 2a

$^{13}$C NMR (101 MHz, CDCl$_3$) of 2a
**1H NMR (400 MHz, CDCl$_3$) of 2b**

**13C NMR (101MHz, CDCl$_3$) of 2b**
$^{1}$H NMR (400 MHz, CDCl$_3$) of 2c

$^{13}$C NMR (101 MHz, CDCl$_3$) of 2c
$^1$H NMR (400 MHz, CDCl$_3$) of 2d

$^{13}$C NMR (101 MHz, CDCl$_3$) of 2d
**1H NMR (400 MHz, CDCl₃) of 2e**

**13C NMR (101MHz, CDCl₃) of 2e**
$^1$H NMR (400 MHz, CDCl$_3$) of 2f

$^{13}$C NMR (101 MHz, CDCl$_3$) of 2f
$^1$H NMR (400 MHz, CDCl$_3$) of 2g

$^{13}$C NMR (101MHz, CDCl$_3$) of 2g
$^1$H NMR (400 MHz, CDCl$_3$) of 2h

$^{13}$C NMR (101MHz, CDCl$_3$) of 2h
$^1$H NMR (400 MHz, CDCl$_3$) of 3a

$^{13}$C NMR (101MHz, CDCl$_3$) of 3a
$\text{H NMR (400 MHz, CDCl}_3\text{) of 3b}$

$\text{C NMR (101MHz, CDCl}_3\text{) of 3b}$
**1H NMR (500MHz, CDCl₃) of 3c**

**13C NMR (126MHz, CDCl₃) of 3c**
$^1$H NMR (400 MHz, CDCl$_3$) of 3d

$^{13}$C NMR (101 MHz, CDCl$_3$) of 3d
$^1$H NMR (400 MHz, CDCl$_3$) of 3e

$^{13}$C NMR (101MHz, CDCl$_3$) of 3e
$^1$H NMR (400 MHz, CDCl$_3$) of 3f

$^{13}$C NMR (101MHz, CDCl$_3$) of 3f
$^{1}H$ NMR (400 MHz, CDCl$_3$) of 3g

$^{13}$C NMR (101 MHz, CDCl$_3$) of 3g
$^1$H NMR (400 MHz, CDCl$_3$) of 3h

$^{13}$C NMR (101 MHz, CDCl$_3$) of 3h
$^1$H NMR (400 MHz, CDCl$_3$) of S2a

$^1$H NMR (400 MHz, CDCl$_3$) of S2b
$^1$H NMR (400 MHz, CDCl$_3$) of S2c

$^1$H NMR (400 MHz, CDCl$_3$) of S2d
$^1$H NMR (400 MHz, CDCl$_3$) of S2e

$^1$H NMR (400 MHz, CDCl$_3$) of S2f
$^1$H NMR (400 MHz, CDCl$_3$) of S2g

$^1$H NMR (400 MHz, CDCl$_3$) of S2h
1H NMR (400 MHz, CDCl₃) of S3a

13C NMR (101MHz, CDCl₃) of S3a
$^1$H NMR (500MHz, CDCl$_3$) of S3b

$^{13}$C NMR (126MHz, CDCl$_3$) of S3b
$^1$H NMR (500MHz, CDCl$_3$) of S3c

$^{13}$C NMR (126MHz, CDCl$_3$) of S3c
\[ ^1H \text{NMR (400 MHz, CDCl}_3 \text{) of S3d} \]

\[ ^{13}C \text{NMR (101MHz, CDCl}_3 \text{) of S3d} \]
OTBS

$^1$H NMR (500 MHz, CDCl$_3$) of S3e

$^{13}$C NMR (126 MHz, CDCl$_3$) of S3e
^1^H NMR (500 MHz, CDCl\textsubscript{3}) of S3f

$^1^3$C NMR (126MHz, CDCl\textsubscript{3}) of S3f
$^1$H NMR (400 MHz, CDCl$_3$) of S$^3$g

$^{13}$C NMR (101MHz, CDCl$_3$) of S$^3$g
\( \text{\(^1\)H NMR (400 MHz, CDCl\textsubscript{3}) of S3h} \)

\( \text{\(^{13}\)C NMR (101MHz, CDCl\textsubscript{3}) of S3h} \)
$^1$H NMR (400 MHz, CDCl$_3$) of 4a

$^{13}$C NMR (101 MHz, CDCl$_3$) of 4a
$^1$H NMR (400 MHz, CDCl$_3$) of 4b

$^{13}$C NMR (101 MHz, CDCl$_3$) of 4b
$^1$H NMR (400 MHz, CDCl$_3$) of 4c

$^{13}$C NMR (101 MHz, CDCl$_3$) of 4c
$^1$H NMR (400 MHz, CDCl$_3$) of 4d

$^{13}$C NMR (101 MHz, CDCl$_3$) of 4d
$^1$H NMR (400 MHz, CDCl$_3$) of 4e

$^{13}$C NMR (101 MHz, CDCl$_3$) of 4e
$^1$H NMR (400 MHz, CDCl$_3$) of 4f

$^{13}$C NMR (101 MHz, CDCl$_3$) of 4f
$^1$H NMR (400 MHz, CDCl$_3$) of 4g

$^{13}$C NMR (101 MHz, CDCl$_3$) of 4g
$^{1} \text{H NMR (400 MHz, CDCl}_3 \text{)}$ of 4h

$^{13}\text{C NMR (101 MHz, CDCl}_3 \text{)}$ of 4h
$^1$H NMR (400 MHz, CDCl$_3$) of 6

$^{13}$C NMR (101 MHz, CDCl$_3$) of 6
$^1$H NMR (500 MHz, CDCl$_3$) of 7

$^{13}$C NMR (126 MHz, CDCl$_3$) of 7
$^1$H NMR (500 MHz, CDCl$_3$) of 8

$^{13}$C NMR (126 MHz, CDCl$_3$) of 8
$^1$H NMR (400 MHz, CDCl$_3$) of 9

$^{13}$C NMR (101 MHz, CDCl$_3$) of 9
$^1$H NMR (400 MHz, CDCl$_3$) of 10

$^{13}$C NMR (101 MHz, CDCl$_3$) of 10
$^1$H NMR (400 MHz, CDCl$_3$) of 11

$^{13}$C NMR (101 MHz, CDCl$_3$) of 11
$^1$H NMR (400 MHz, CDCl$_3$) of 12

$^{13}$C NMR (101 MHz, CDCl$_3$) of 12
$^1$H NMR (400 MHz, CDCl$_3$) of 13

$^{13}$C NMR (101 MHz, CDCl$_3$) of 13
$^1$H NMR (400 MHz, CDCl$_3$) of S4

$^{13}$C NMR (101 MHz, CDCl$_3$) of S4
\[ ^1H \text{NMR (400 MHz, CDCl}_3 \text{) of 14} \]

\[ ^{13}C \text{NMR (101 MHz, CDCl}_3 \text{) of 14} \]
$^{1}$H NMR (400 MHz, CDCl$_3$) of 15

$^{13}$C NMR (101 MHz, CDCl$_3$) of 15
$^1$H NMR (400 MHz, C$_2$D$_6$O) of S5

$^{13}$C NMR (101 MHz, C$_2$D$_6$O) of S5
$^1$H NMR (400 MHz, CDCl$_3$) of 17

$^{13}$C NMR (101 MHz, CDCl$_3$) of 17
$^1$H NMR (400 MHz, CD$_3$OD) of PG F2$\alpha$

$^{13}$C NMR (101 MHz, CD$_3$OD) of PG F2$\alpha$
SFC Traces:

Rac 3a

Ent 3a
Rac Bz-S3b

Ent Bz-S3b
Rac Bz-S3c

Ent Bz-S3c
Rac 3d

Ent 3d
Rac 3e

Ent 3e
Rac 3f

Ent 3f
Rac 3g

Ent 3g
Rac 3h

Ent 3h
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