Synthesis of C13–C23 Fragment of Iriomoteolide-1a

Shun-Yi Wang, Yen-Jin Chin, Teck-Peng Loh*

Division of Chemistry and Biological Chemistry, School of Physical and Mathematical Sciences, Nanyang Technological University, Singapore 637371, Singapore
Fax +65(6513)8203; E-mail: teckpeng@ntu.edu.sg

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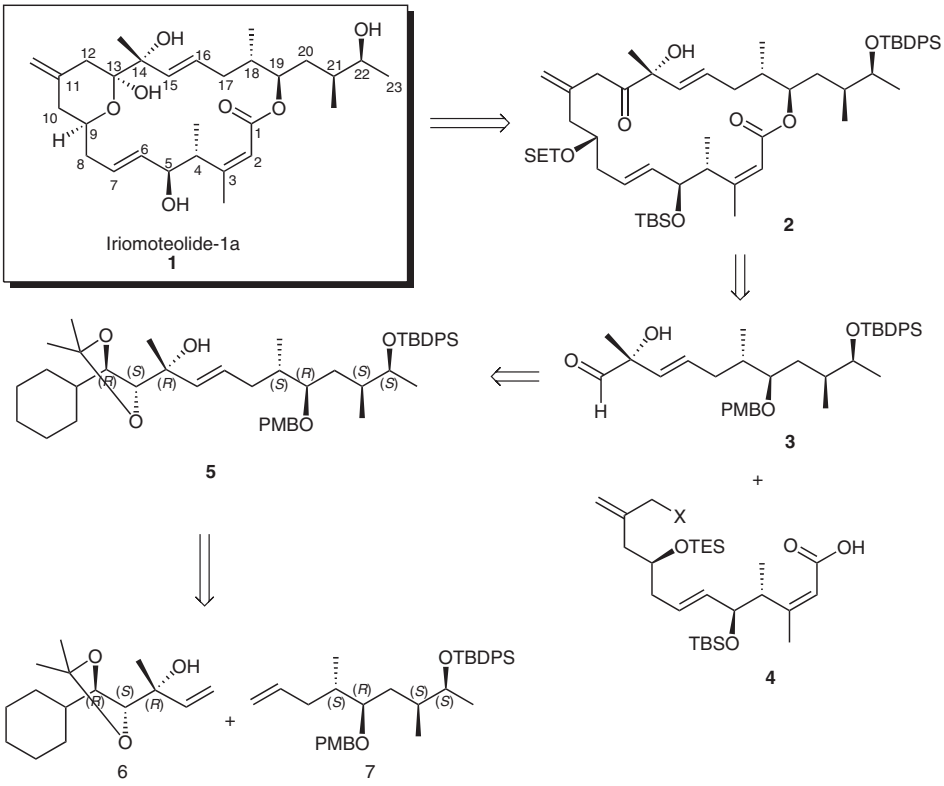
Abstract: Highly efficient asymmetric conjugate addition of MeMgBr to α,β-unsaturated esters catalyzed by CuI/Tol-BINAP, Paterson aldol, organocatalytic aldol, and cross-metathesis reactions were applied in the synthesis of C13–C23 fragment of Iriomoteolide-1a.

Key words: asymmetric conjugate addition, organocatalytic aldol, cross-metathesis, Iriomoteolide-1a

Iriomoteolide-1a (**1**),[1] -1b, and -1c[2] were isolated from the sea of Iriomote Island, Japan by Tsuda's group in 2007. These macrolides belong to the class of amphidinolides obtained from *Amphidinium* sp.[3,4] Iriomoteolide-1a has been shown to exhibit potent cytotoxic activity against human B lymphocyte DG-75 cells (IC_{50}: 0.002 μg/mL), of which the cytotoxicity has been shown to be equal to that of amphidinolide H.[3]This new type of potent cytotoxic macrolide **1** has interesting structure, containing a 20-membered ring, nine stereogenic centers, of which two of them are quartenary centers, a *cis*-conjugated ester, four hydroxy groups, and six methyls. Due to its interesting biological activities and challenging structures, it has been a popular target of total synthesis. Very recently, the Yang's group reported a short synthesis of C1–C12 fragment of **1**.[5]

Our retrosynthetic analysis of Iriomoteolide-1a is outlined in Scheme 1. We envisioned a metal-mediated allylation of aldehyde **3** using allylic metal generated species from **4** followed by oxidation allowing the formation of **2**. Subunit **3** could be obtained from **5**. Disconnection of the olefinic position of **5** by olefin cross metathesis (CM) will result in two key fragments **6** and **7**. Herein, we report a successful synthesis of **5** using a strategy based on our group's asymmetric conjugate addition,[6–10] Paterson al-



Scheme 1 Retrosynthetic analysis of Iriomoteolide-1a

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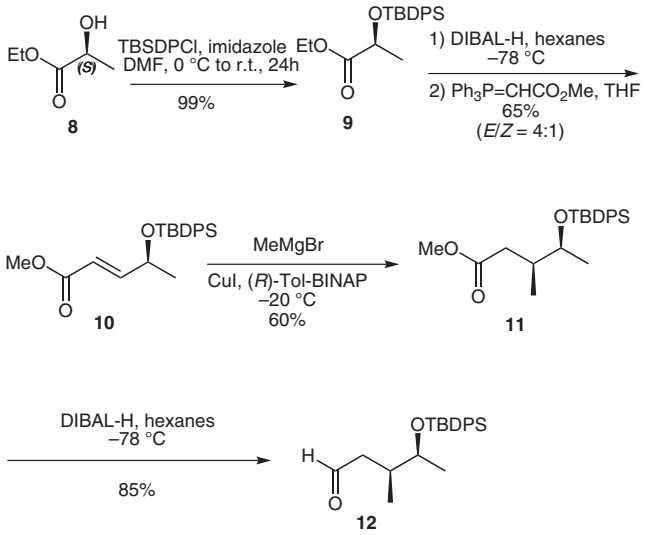


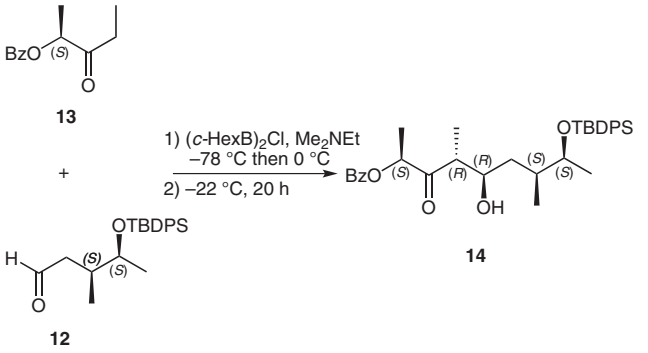
Scheme 2 Synthesis of **12** using asymmetric conjugate addition of MeMgBr as the key step

dol, organocatalytic aldol, and an intermolecular olefin cross-metathesis reaction.

First, we focused on the synthesis of the key fragment **7**. Our synthesis commenced from the commercially available (*S*)-ethyl lactate (**8**) (Scheme 2). Protection of the lactate **8** using TBDPSCl, followed by a one-pot DIBAL-H reduction and Wittig olefination afforded the desired conjugated ester **10** (*E*/*Z* = 4:1) in 65% yield over three steps (Scheme 2). With the *E*-enoate **10** in hand, we explored the CuI/Tol-BINAP catalyzed asymmetric conjugate addition (ACA) of **10** with MeMgBr. To our delight, the reaction of **10** with MeMgBr in the presence of 2 mol% CuI and 3 mol% (*R*)-Tol-BINAP at –20 °C afforded the desired β-methyl ester **11** in 60% isolated yield with more than 98:2 diastereoselectivity. The absolute configuration of the newly generated C21 stereogenic center was assigned as *S* by analogy to that reported for this catalytic system.[6,7] Subsequently, DIBAL-H reduction of the β-methyl ester **11** afforded the corresponding aldehyde **12** in 85% yield.

Next, we investigated the Paterson aldol reaction of **12** with (*S*)-ethyl lactate (**8**)-derived ethyl ketone **13** (Table 1).[11] With minor modification of the reported conditions, the desired aldol product **14** was obtained in 85% yield with high level of diastereoselectivity (>95% de) (Table 1, entry 4).

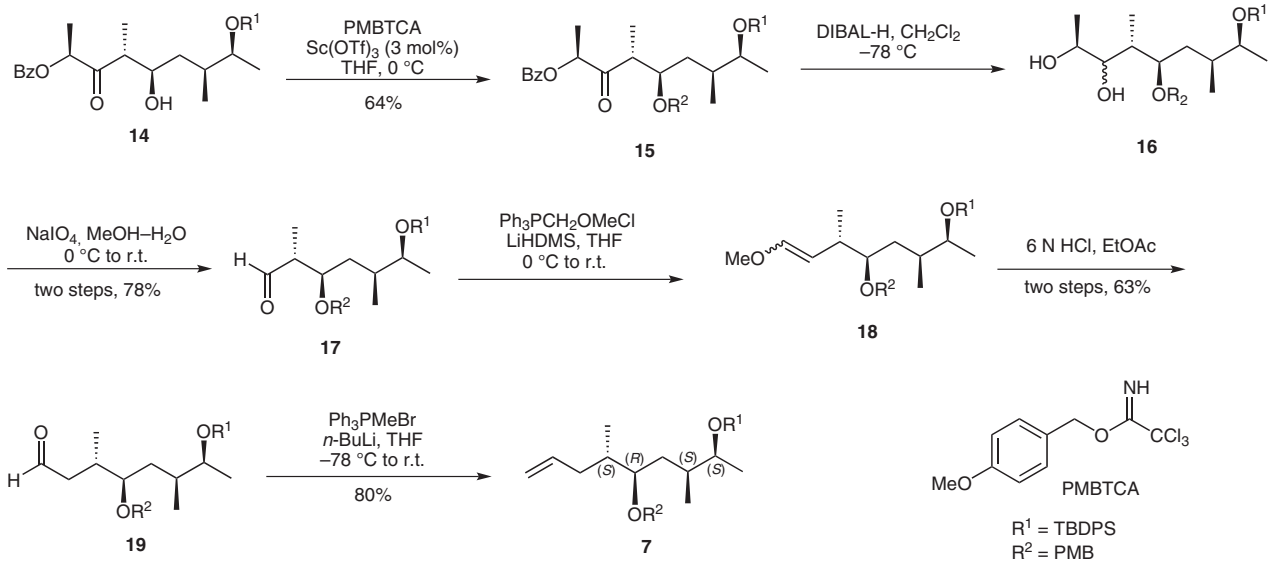
Table 1 Synthesis of **14**



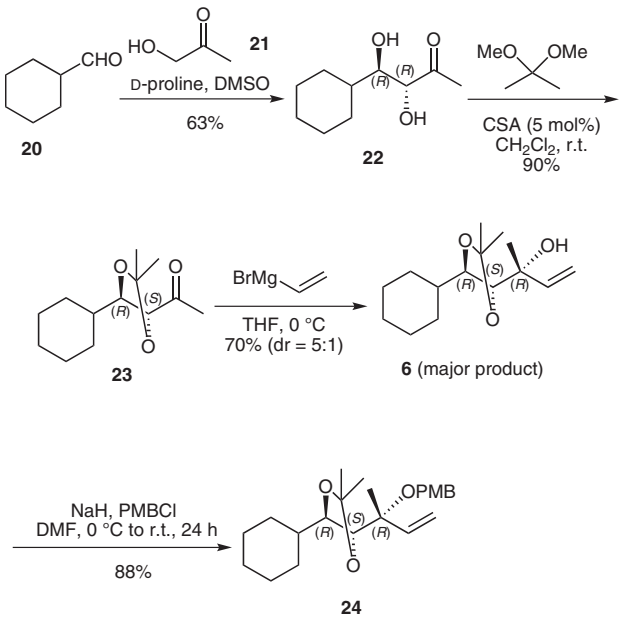
Entry	**12**/**13**/Me_2NEt/$(c\text{-HexB})_2Cl$	Yield (%)[a]
1	1.0:1.0:2.0:2.0	40
2	1.0:1.5:2.0:2.0	45
3	1.0:1.0:1.5:1.5	40
4	1.3:1.0:1.5:1.5	85 (>95%)[b]

[a] Isolated yields.
[b] The percentage de was determined on the crude product by NMR spectroscopy.

Subsequently, the hydroxy group was protected by PMBTCA catalyzed by 3 mol% $Sc(OTf)_3$ to afford the desired compound **15** in 64% yield.[12] After PMB protection, alde-



Scheme 3 Synthesis of **7**



Scheme 4 Synthesis of **24**

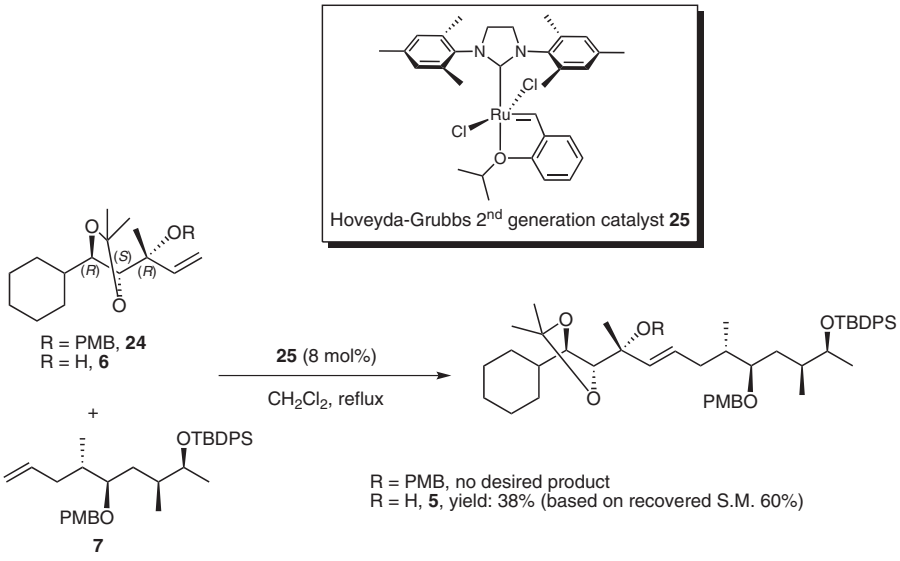
hyde **17** was then generated via DIBAL-H reduction followed by oxidative cleavage (78% from **15**). Subsequently, aldehyde **17** was subjected to Wittig homologation using methoxymethylenetriphenylphosphorane by employing LiHMDS as the base to generate the methyl ether **18**. Treatment of **18** with aqueous 6 N HCl in ethyl acetate furnished the desired aldehyde **19** in 63% yield over two steps. Another one-carbon homologation of **19** afforded **7** in 80% yield (Scheme 3).

For the synthesis of enantiomerically enriched fragment of **6**, we employed the List aldol reaction of cyclohexanecarboxaldehyde (**20**) with hydroxyacetone (**21**) catalyzed by D-proline (Scheme 4).[13] The desired aldol product (*R*,*R*)-**22** was obtained in high diastereoselectivity (dr >20:1) and high ee (>99%). Subsequently, the dihydroxy function of **22** was protected by 2,2-dimethoxypropane catalyzed by 5 mol% camphorsulfonic acid (CSA) to generate **23** in 90% yield. Next, the mixture of tertiary allylic alcohol diasteromer was obtained in 84% yield by treating **23** with excess of vinylmagnesium bromide (dr = 5:1). The favored desired diastereomer (*R*,*R*,*R*)-**6**, could be easily separated by column chromatography on silica gel (70% yield). After PMB protection of **6**, the olefin **24** was obtained in 88% yield.

With the tertiary allylic alcohol in hand, the cross-metathesis of **7** and **24** catalyzed by the Hoveyda–Grubbs 2nd generation catalyst **25** was attempted.[14] Unfortunately, we failed to get the cross-metathesis (CM) product for the bulky-protected tertiary alcohol. Fortunately, the desired CM product **5** was formed in 60% yield (based on recovered starting material) with excellent stereoselectivity (>95% *E*-isomer) when **7** was subjected to cross metathesis with 2.0 equivalents of the free allylic alcohol **6** under identical conditions (Scheme 5).[15]

In conclusion, we have successfully synthesized C13–C23 fragment of Iriomoteolide-1a (**1**) using the efficient and enantioselective CuI/Tol-BINAP catalyzed ACA of MeMgBr to α,β-unsaturated esters, Paterson's aldol, List aldol, and cross-metathesis reaction. Further investigations will be directed towards the syntheses of fragment **4** and completion of the total synthesis of **1** and analogues. Studies along these lines are in progress.

Experiments involving moisture- or air-sensitive components were performed in oven-dried glassware under a positive pressure of nitrogen using freshly distilled solvents. Commercial grade solvents and reagents were used without further purification unless otherwise indicated. Infrared spectra were recorded on a Bio-Rad FTS 165 FTIR spectrometer. The oil samples were examined under neat conditions. High-resolution mass spectra (HRMS) were obtained using Finnigan MAT95XP GC/HRMS (Thermo Electron Corporation). NMR spectra were recorded on a Bruker Avance DPX 300, a Bruker AMX 400 or a Bruker AMX 500 spectrophotometer ($CDCl_3$ as solvent). Chemical shifts for NMR spectra are reported as δ in units of parts per million (ppm) downfield from $SiMe_4$ (δ = 0.0



Scheme 5 Synthesis of **5**

ppm) and relative to the signal of chloroform-*d* (δ = 7.2600 ppm, singlet, for ^{1}H NMR; δ = 77.0 ppm, triplet, for ^{13}C NMR). Coupling constants are reported as a *J* value in Hz. The proportion of diastereomers and geometric isomers was determined from the integration of ^{1}H NMR and ^{13}C NMR spectra.

Ethyl (*S*)-2-(*tert*-Butyldiphenylsilyloxy)propanoate (9)

To a solution of ethyl (*S*)-(+)-lactate (**8**; 10.40 g, 100.0 mmol) in DMF (200 mL) was added imidazole (10.20 g, 150 mmol), followed by the addition of TBDPSCl (14.5 g, 96.1 mmol) in one portion at 0 °C. The reaction mixture was warmed to r.t. and stirred for 24 h. After cooling to 0 °C, the mixture was poured into aq 0.5 N HCl (50 mL) and extracted with EtOAc (3 × 100 mL). The combined organic extracts were successively washed with H_2O (150 mL) and brine (80 mL), and dried ($MgSO_4$). The solvent was removed under reduced pressure to give 35.60 g (quant) of crude silyl ether **9** as a colorless liquid. The material was used in the next step after purification through a pad of silica gel (EtOAc–hexanes, 1:10); R_f = 0.75 (EtOAc–hexanes, 1:4); $[\alpha]_D^{20}$ –47.6 (*c* = 1.3, $CHCl_3$).

FTIR (KBr, neat): 3070, 2980, 2958, 2893, 2858, 1753 (C=O), 1427, 1136, 1111, 702 cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$): δ = 7.66–7.67 (m, 4 H), 7.35–7.43 (m, 6 H), 4.25 (q, *J* = 6.5 Hz, 1 H), 4.02 (dq, *J* = 7.5, 1.5 Hz, 2 H), 1.37 (d, *J* = 6.5 Hz, 2 H), 1.15 (d, *J* = 7.5 Hz, 2 H), 1.10 (s, 9 H).

^{13}C NMR (125 MHz, $CDCl_3$): δ = 173.8 135.9, 135.7, 133.6, 133.2, 129.7, 127.6, 127.5, 69.0, 60.6, 26.8, 21.2, 19.2, 14.0.

HRMS: *m*/*z* calcd for $C_{21}H_{29}O_3Si$ [M + 1]: 379.1705; found: 379.1716.

Methyl (*S*,*E*)-4-(*tert*-Butyldiphenylsilyloxy)pent-2-enoate (10)

In a round-bottomed flask equipped with a stirring bar, ester **9** (19.11 g, 50.0 mmol) was dissolved in hexanes (50 mL) and cooled to –78 °C. DIBAL-H (Aldrich 1 M solution in heptane, 52.5 mL, 52.5 mmol), precooled to –78 °C, was added carefully over several portions. After stirring for another 1.0 h, MeOH (6.5 mL), precooled to –78 °C, was added carefully in one portion and stirred for a further 0.5 h till a white suspension was observed. Methyl (triphenylphosphoranylidene)acetate (25.0 g, 75.0 mmol) was added in one portion, followed by THF (50 mL) and the reaction mixture was allowed to warm to r.t. and then allowed to reflux for an additional 6 h. The mixture was then cooled to r.t., carefully diluted with EtOAc (100 mL) and sat. aq potassium sodium tartrate (200 mL), and stirred vigorously at r.t. till a clear biphasic separation was observed. The aqueous layer was extracted with EtOAc (2 × 200 mL) and the combined organics were dried (Na_2SO_4), filtered, and concentrated in vacuo. The Ph_3PO was removed by filtering through a short silica plug using hexanes. The filtrate was concentrated and purified by flash chromatography (hexanes to 200:1 hexanes–EtOAc) to afford the desired *E*-enoate **10** as a colorless oil (12.42 g, 65%; 81% for the mixture of *E*/*Z*-isomers, 80:20); R_f = 0.72 (EtOAc–hexanes, 1:4); $[\alpha]_D^{20}$ –41.8 (*c* = 0.9, $CHCl_3$).

FTIR (KBr, neat): 3070, 2954, 2927, 1703 (C=O), 1427, 1112, 700 cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$): δ = 7.64–7.71 (m, 4 H), 7.36–7.45 (m, 6 H), 6.93 (dd, *J* = 15.5, 4.4 Hz, 1 H), 6.93 (dd, *J* = 15.5, 1.5 Hz, 1 H), 4.45–4.51 (m, 6 H), 1.14 (d, *J* = 10.5 Hz, 3 H), 1.10 (s, 9 H).

^{13}C NMR (125 MHz, $CDCl_3$): δ = 167.2, 151.8, 135.8, 135.7, 134.0, 133.3, 129.8, 127.6, 127.6, 118.6, 68.6, 51.5, 27.0, 23.3, 19.2.

HRMS: *m*/*z* calcd for $C_{22}H_{28}O_3Si$ + Na [M + Na]: 391.1705; found: 391.1729.

Methyl (3*S*,4*S*)-4-(*tert*-Butyldiphenylsilyloxy)-3-methylpentanoate (11)

In a round-bottomed flask equipped with a septum and a stirring bar, (*R*)-Tol-BINAP (0.408 g, 0.6 mmol) and CuI (0.076 g, 0.4 mmol) were stirred in CH_2Cl_2 (10 mL) for 20 min, concentrated in vacuo, and then stirred in *t*-BuOMe (80 mL) till a bright yellow suspension was observed. The mixture was then cooled to –20 °C and MeMgBr (20.0 mL, Aldrich 3.0 M solution in Et_2O, 60.0 mmol) was added carefully. After stirring for 15 min, a solution of *E*-**10** (7.37 g, 20 mmol) in *t*-BuOMe (24 mL) was added dropwise over 10 h via a syringe pump. After stirring at –20 °C for an additional 1 h, the mixture was quenched with MeOH (30 mL) and sat. aq NH_4Cl (100 mL). The aqueous layer was extracted with Et_2O (3 × 100 mL) and the combined organic extracts were dried (Na_2SO_4), filtered, and concentrated in vacuo. The resulting residue was purified by flash chromatography (100:1 hexanes–EtOAc) to afford the desired product **11** as a colorless oil (4.61 g, 60%); R_f = 0.73 (EtOAc–hexanes, 1:4); $[\alpha]_D^{20}$ –8.4 (*c* = 1.2, $CHCl_3$).

FTIR (KBr, neat): 3070, 2960, 2929, 1737 (C=O), 1280, 1109, 702 cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$): δ = 7.66–7.82 (m, 4 H), 7.36–7.44 (m, 6 H), 7.79–3.82 (m, 1 H), 3.65 (s, 3 H), 2.61–2.65 (m, 1 H), 2.04–2.16 (m, 2 H), 1.07 (s, 9 H), 0.94 (d, *J* = 6.5 Hz, 3 H), 0.88 (d, *J* = 6.5 Hz, 3 H).

^{13}C NMR (125 MHz, $CDCl_3$): δ = 174.1, 135.9, 134.7, 133.9, 129.6, 129.4, 127.6, 127.4, 72.0, 51.4, 51.4, 37.1, 36.8, 27.0, 19.3, 19.1, 14.9.

HRMS: *m*/*z* calcd for $C_{23}H_{33}O_3Si$ [M + 1]: 385.2199; found: 385.2206.

(3*S*,4*S*)-4-(*tert*-Butyldiphenylsilyloxy)-3-methylpentanal (12)

In a round-bottomed flask equipped with a stirring bar, the ester **11** (3.84 g, 10.0 mmol) was dissolved in hexanes (10 mL) and cooled to –78 °C. DIBAL-H (Aldrich 1 M solution in heptane, 11.0 mL, 11.0 mmol), precooled to –78 °C, was added carefully. After stirring for another 1.0 h, the reaction was quenched with sat. aq potassium sodium tartrate (50 mL), warmed to r.t., and stirred vigorously till a clear biphasic separation was observed. The aqueous layer was extracted with EtOAc (2 × 200 mL), and the combined organics were dried (Na_2SO_4), filtered, and concentrated in vacuo. The residue was purified by flash chromatography (hexanes to 50:1 hexanes–EtOAc) to afford the desired **12** as a colorless oil (3.00 g, 85%); R_f = 0.70 (EtOAc–hexanes, 1:4); $[\alpha]_D^{20}$ –10.5 (*c* = 0.8, $CHCl_3$).

FTIR (KBr, neat): 3070, 2959, 2929, 2891, 2858, 1722 (C=O), 1110, 702 cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$): δ = 9.73 (s, 1 H), 7.68–7.70 (m, 4 H), 7.38–7.45 (m, 6 H), 3.84–3.86 (m, 1 H), 2.65–2.67 (m, 1 H), 2.18–2.25 (m, 2 H), 1.08 (s, 9 H), 0.97 (d, *J* = 6.5 Hz, 3 H), 0.87 (d, *J* = 6.5 Hz, 3 H).

^{13}C NMR (125 MHz, $CDCl_3$): δ = 202.8, 135.9, 135.8, 134.4, 133.8, 129.7, 129.6, 127.6, 127.4, 72.1, 46.2, 34.9, 27.0, 19.2, 18.4, 15.6.

HRMS: *m*/*z* calcd for $C_{22}H_{31}O_2Si$ [M + 1]: 355.2093; found: 355.2092.

(*S*)-3-Oxopentan-2-yl Benzoate (13)

To a cooled (–20 °C) mixture of ethyl (*S*)-lactate (**8**; 8.0 g, 67.6 mmol) and MeON(Me)H·HCl (16.4 g, 168 mmol) in THF (200 mL) was added a 2 M solution of *i*-PrMgCl in Et_2O (168 mL) dropwise over 30 min. The reaction mixture was stirred at –20 °C for 30 min and at 0 °C for a further 30 min before sat. aq NH_4Cl (500 mL) was added. The mixture was extracted with Et_2O (4 × 150 mL), followed by CH_2Cl_2 (4 × 150 mL). The combined organic extracts were dried ($MgSO_4$), concentrated in vacuo, and the residue was pu-

rified by column chromatography (EtOAc–hexanes, 50:50) to give the intermediate Weinreb amide (7.19 g, 80%) as a colorless oil. To a cooled (0 °C) solution of this amide (2.0 g, 15.0 mmol) in THF (30 mL) was added a 3 M solution of EtMgBr in Et_2O (16 mL) and the reaction mixture was allowed to warm to r.t. After 1 h, sat. aq NH_4Cl (80 mL) was added and the mixture was extracted with Et_2O (40 mL), followed by CH_2Cl_2 (2 × 40 mL). The combined organic extracts were dried ($MgSO_4$) and concentrated. Then, CH_2Cl_2 (100 mL) was added. To this solution was added Bz_2O (5.11 g, 22.6 mmol), DMAP (0.20 g, 1.64 mmol), and *i*-Pr_2NEt (5.0 mL, 28.6 mmol). After stirring for 14 h, excess Bz_2O was removed by the addition of ethylenediamine (1.0 g, 16.6 mmol). H_2O (80 mL) was added, the mixture extracted with Et_2O (4 × 40 mL); the combined organic extracts were dried ($MgSO_4$), and concentrated to an oil. Column chromatography (20% EtOAc in hexanes) afforded (*S*)-**13** (2.17 g, 70%) as a colorless oil; R_f = 0.52 (EtOAc–hexanes, 1:4); $[\alpha]_D^{20}$ +24.4 (*c* = 0.6, $CHCl_3$) {Lit.[11b] $[\alpha]_D^{20}$ +25.1 (*c* = 4.6, $CHCl_3$)}.

FTIR (KBr, neat): 3062, 2981, 2939, 1720 (C=O), 1716 (C=O), 1452, 1269, 1109, 1026, 711 cm^{-1}.

^1H NMR (300 MHz, $CDCl_3$): δ = 8.05–8.07 (m, 2 H), 7.41–7.59 (m, 3 H), 5.33 (q, *J* = 7.2 Hz, 2 H), 2.46–2.68 (m, 2 H), 1.51 (d, *J* = 7.0 Hz, 2 H), 1.07 (t, *J* = 7.2 Hz, 3 H).

^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 208.4, 165.8, 133.3, 129.7, 129.4, 128.4, 75.0, 31.4, 16.4, 7.1.

HRMS: *m*/*z* calcd for $C_{12}H_{15}O_3$ [M + 1]: 207.1013; found: 207.1021.

(2*S*,4*R*,5*R*,7*S*,8*S*)-8-(*tert*-Butyldiphenylsilyloxy)-5-hydroxy-4,7-dimethyl-3-oxononan-2-yl Benzoate (14)

To a stirred solution (–78 °C) of **13** (2.06 g, 10.0 mmol) in Et_2O (40 mL) was added chlorodicyclohexylborane (15.0 mL, 1 M in hexanes, 15.0 mmol) and Me_2NEt (1.5 mL, 15 mmol). The mixture was warmed to 0 °C, stirred for 2 h, and then recooled to –78 °C. A solution of aldehyde **12** (4.60 g, 13.0 mmol) in Et_2O (10 mL) was added dropwise over 2 min. After 2 h, the reaction mixture was kept in the freezer (–24 °C) for 20 h. The mixture was warmed to 0 °C and quenched by dropwise addition of MeOH (30 mL), pH 7 phosphate buffer (30 mL), and 35% H_2O_2 (30 mL), and stirred for 1 h at r.t. H_2O (100 mL) was added, the organic layer was separated and the aqueous layer extracted with Et_2O (3 × 80 mL). The combined organics were washed with brine (60 mL), dried ($MgSO_4$), filtered, and evaporated in vacuo. Silica gel chromatography (hexanes–EtOAc, gradient elution, 50:1 to 20:1) afforded alcohol **14** in 85% yield (4.76 g, 8.5 mmol) as a colorless solid; R_f = 0.48 (EtOAc–hexanes, 1:4); $[\alpha]_D^{20}$ +9.6 (*c* = 0.9, $CHCl_3$).

FTIR (KBr, neat): 3522, 3047, 2962, 2931, 2893, 2856, 1722 (C=O), 1714 (C=O), 1379, 1267, 1111, 702 cm^{-1}.

^1H NMR (400 MHz, $CDCl_3$): δ = 8.11 (d *J* = 7.6 Hz, 2 H), 7.37–7.69 (m, 13 H), 5.42 (q, *J* = 6.8 Hz, 1 H), 3.82–3.89 (m, 2 H), 2.80 (s, 1 H), 2.76–2.78 (m, 1 H), 1.73–1.95 (m, 2 H), 1.56 (d, *J* = 7.2 Hz, 3 H), 1.24–1.30 (m, 1 H), 1.23 (d, *J* = 7.2 Hz, 3 H), 1.07 (s, 9 H), 0.97 (d, *J* = 6.4 Hz, 3 H), 0.91 (d, *J* = 6.8 Hz, 3 H).

^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 211.7, 165.8, 135.9, 135.9, 135.7, 134.4, 133.8, 133.2, 129.7, 129.6, 129.5, 129.5, 128.4, 127.6, 127.4, 74.7, 72.2, 72.0, 48.8, 37.4, 36.4, 27.0, 19.2, 18.8, 16.8, 15.6, 14.4.

HRMS: *m*/*z* calcd for $C_{34}H_{45}O_5Si$ [M + 1]: 561.3036; found: 561.3011.

(2*S*,4*R*,5*R*,7*S*,8*S*)-8-(*tert*-Butyldiphenylsilyloxy)-5-(4-methoxybenzyloxy)-4,7-dimethyl-3-oxononan-2-yl Benzoate (15)

$Sc(OTf)_3$ (30.0 mg, 0.06 mmol, 0.06 equiv) was added to a stirred solution of freshly azeotroped alcohol **14** (0.560, 1.0 mmol, 1.0 equiv) and PMBTCA (0.423g, 1.5 mmol, 1.5 equiv) in THF (20 mL) at 0 °C. After stirring for 12 h, the reaction was quenched by the addition of aq $NaHCO_3$ (20 mL) and the phases were separated. The aqueous phase was extracted with EtOAc (3 × 20 mL) and the combined organic phases were dried ($MgSO_4$), and concentrated in vacuo. Flash column chromatography of the residue (hexanes–EtOAc, gradient elution, 50:1 to 20:1) afforded PMB ether **15** (0.435 g, 64%) as a pale yellow oil; R_f = 0.62 (EtOAc–hexanes, 1:4); $[\alpha]_D^{20}$ –15 (*c* = 0.7, $CHCl_3$).

FTIR (KBr, neat): 3068, 2962, 2931, 2893, 2858, 1722 (C=O), 1714 (C=O), 1265, 1111, 702 cm^{-1}.

^1H NMR (400 MHz, $CDCl_3$): δ = 8.09 (d, *J* = 7.6 Hz, 2 H), 7.67–7.69 (m, 4 H), 7.56–7.60 (m, 1 H), 7.35–7.48 (m, 8 H), 7.16 (d, *J* = 8.8 Hz, 2 H), 6.83 (d, *J* = 8.8 Hz, 2 H), 5.38 (q, *J* = 6.8 Hz, 3 H), 4.21 (d, *J* = 10.8 Hz, 1 H), 4.18 (d, *J* = 10.8 Hz, 1 H), 3.79–3.81 (m, 1 H), 3.77 (s, 3 H), 3.66–3.71 (m, 1 H), 2.99–3.07 (m, 1 H), 1.94 (dt, *J* = 14.4, 4.8 Hz, 1 H), 1.64–1.70 (m, 1 H), 1.44 (d, *J* = 7.2 Hz, 3 H), 1.24–1.33 (m, 2 H), 1.11 (d, *J* = 7.2 Hz, 3 H), 1.05 (s, 9 H), 0.94 (d, *J* = 6.6 Hz, 3 H), 0.90 (d, *J* = 6.4 Hz, 3 H).

^{13}C NMR (100.0 MHz, $CDCl_3$): δ = 209.6, 165.7, 159.0, 135.9, 135.8, 134.8, 134.1, 133.2, 130.5, 129.8, 129.4, 129.3, 128.4, 127.6, 127.4, 113.7, 113.5, 79.7, 74.9, 72.4, 72.3, 55.1, 48.3, 36.7, 35.1, 27.0, 19.7, 19.3, 15.8, 15.2, 13.7.

HRMS: *m*/*z* calcd for $C_{42}H_{52}O_6Si$ + Na [M + Na]: 703.3431; found: 703.3442.

(2*S*,4*S*,5*R*,7*S*,8*S*)-8-(*tert*-Butyldiphenylsilyloxy)-5-(4-methoxybenzyloxy)-4,7-dimethylnonane-2,3-diol (16)

In a round-bottomed flask equipped with a stirring bar, the ester **15** (1.36 g, 2.0 mmol) was dissolved in CH_2Cl_2 (5 mL) and cooled to –78 °C. DIBAL-H (Aldrich 1 M solution in heptane, 6.0 mL, 6.0 mmol), precooled to –78 °C, was added dropwise. After stirring for another 1.0 h, the reaction was quenched with sat. aq potassium sodium tartrate (50 mL), warmed to r.t., and stirred vigorously till a clear biphasic separation was observed. The aqueous layer was extracted with CH_2Cl_2 (3 × 15 mL), and the combined organic were dried (Na_2SO_4), filtered, and concentrated in vacuo. The residue was purified by flash chromatography (5:1 hexanes–EtOAc) to afford the desired diol **16** as a colorless oil (0.98 g); R_f = 0.13 and 0.14 (EtOAc–hexanes, 1:4); $[\alpha]_D^{20}$ –7.7 (*c* = 1.2, $CHCl_3$).

FTIR (KBr, neat): 3417, 3072, 2962, 2989, 1651, 1643, 1247, 1109, 665 cm^{-1}.

^1H NMR (400 MHz, $CDCl_3$): δ = 7.36–7.68 (m, 10 H), 7.29 (d, *J* = 8.4 Hz, 0.68 H), 7.16 (d, *J* = 8.4 Hz, 1.32 H), 6.85 (d, *J* = 8.4 Hz, 0.68 H), 6.81 (d, *J* = 8.4 Hz, 1.32 H), 4.68–4.70 (m, 2 H), 4.27–4.44 (m, 2 H), 3.55–3.58 (m, 1 H), 2.72 (s, 0.33 H), 2.48 (s, 0.67 H), 2.23 (s, 0.67 H), 2.20 (s, 0.33 H), 1.53–1.90 (m, 4 H), 1.11 (d, *J* = 7.0 Hz, 2 H), 1.06 (4) (s, 3 H), 1.05 (7) (s, 6 H), 1.04 (d, *J* = 7.0 Hz, 1 H), 0.97 (d, *J* = 7.0 Hz, 2 H), 0.90–0.93 (m, 5 H), 0.81 (d, *J* = 7.2 Hz, 2 H).

^{13}C NMR (100.0 MHz, $CDCl_3$): δ = 159.3, 159.1, 136.0, 135.9, 134.7, 134.6, 130.4, 130.1, 129.5, 129.4, 128.5, 127.6, 127.5, 127.4, 127.0, 113.8, 113.7, 83.4, 80.2, 76.2, 75.1, 72.6, 72.3, 72.2, 71.0, 68.9, 68.0, 65.3, 55.2 (5), 55.2 (2), 38.6, 37.0, 36.4, 34.6, 33.2, 27.0, 21.0, 20.0, 19.4, 19.3, 18.4, 15.8, 15.5, 14.5, 13.5, 12.0, 11.4.

HRMS: *m*/*z* calcd for $C_{35}H_{51}O_5Si$ [M]: 579.3506; found: 579.3521.

(2*R*,3*R*,5*S*,6*S*)-6-(*tert*-Butyldiphenylsilyloxy)-3-(4-methoxybenzyloxy)-2,5-dimethylheptanal (17)

To a stirred solution (0 °C) of the diol **16** (0.98 g, 1.7 mmol) in MeOH (16 mL) and H_2O (16 mL) was added $NaIO_4$ (2.16 g, 10.2 mmol) in small portions. After complete addition, the mixture was stirred for 2 h. H_2O (80 mL) was added and the mixture was extracted with Et_2O (4 × 80 mL). The combined organics were washed

with brine (80 mL), dried ($MgSO_4$), filtered, and evaporated in vacuo. Silica gel chromatography (hexanes–EtOAc, 20:1) afforded aldehyde **17** as a colorless oil (0.83 g, over two steps, 78%); R_f = 0.58 (EtOAc–hexanes, 1:4); $[\alpha]_D^{20}$ –26.6 (*c* = 1.3, $CHCl_3$).

FTIR (KBr, neat): 3062, 2960, 2931, 2856, 1722 (C=O), 1514, 1247, 1037, 740 cm^{-1}.

^1H NMR (500 MHz, $CDCl_3$): δ = 9.73 (d, *J* = 2.0 Hz, 2 H), 7.69–7.40 (m, 4 H), 7.37–7.43 (m, 6 H), 7.24 (d, *J* = 10.5 Hz, 2 H), 7.88 (d, *J* = 10.5 Hz, 2 H), 4.49 (d, *J* = 13.5 Hz, 1 H), 4.40 (d, *J* = 14.0 Hz, 1 H), 3.74–3.86 (m, 4 H), 3.64–3.66 (m, 1 H), 2.64–2.686 (m, 1 H), 1.45–1.76 (m, 3 H), 1.28 (m, 3 H), 1.07 (s, 9 H), 0.98 (d, *J* = 8.0 Hz, 3 H), 0.84 (d, *J* = 8.5 Hz, 3 H).

^{13}C NMR (125.0 MHz, $CDCl_3$): δ = 204.7, 159.2, 135.9, 135.8, 1334.9, 134.3, 130.3, 129.5, 129.4, 129.3, 127.5, 113.8, 79.5, 72.8, 71.2, 55.2, 49.3, 40.3, 29.1, 27.0, 26.6, 19.3, 19.2, 15.0, 10.2.

HRMS: *m*/*z* calcd for $C_{33}H_{45}O_4Si$ [M + 1]: 533.3087; found: 533.3092.

(3*S*,4*R*,6*S*,7*S*)-7-(*tert*-Butyldiphenylsilyloxy)-4-(4-methoxybenzyloxy)-3,6-dimethyloctanal (19)

Methoxymethyltriphenylphosphonium chloride (0.771 g, 2.25 mmol) was dissolved in anhyd THF (8 mL), and to this solution, cooled to 0 °C, was slowly added $LiN(SiMe_3)_2$ (2.1 mL of a 1 M solution in THF). After stirring 1 h at 0 °C, aldehyde **17** (0.532 g, 1.0 mmol) in anhyd THF (5 mL) was added. After stirring the mixture overnight at r.t., H_2O (10 mL) was added and the two phases were separated. The aqueous layer was extracted with Et_2O (3 × 20 mL), and the combined organic fractions were collected, dried, and evaporated. The crude product was purified by silica gel chromatography (hexanes–EtOAc, 100:1) to give the methyl ether **18**. This product was dissolved in EtOAc (4 mL) followed by a solution of aq 6 N HCl (2 mL). The mixture was stirred at r.t. until the disappearance of **18** as monitored by TLC and then sat. aq $NaHCO_3$ (10 mL) was added. The organic phase was separated, and the aqueous layer was extracted several times with EtOAc (3 × 20 mL). The combined organic fractions were collected and dried, and the solvent was evaporated to give crude aldehyde **19**. Silica gel chromatography (hexanes–EtOAc, 100:1) afforded aldehyde **19** as a colorless oil (over two steps, 63%); R_f = 0.59 (EtOAc–hexanes, 1:4); $[\alpha]_D^{20}$ –16.7 (*c* = 0.5, $CHCl_3$).

FTIR (KBr, neat): 2958, 2929, 2856, 1722 (C=O), 1247 cm^{-1}.

^1H NMR (500 MHz, $CDCl_3$): δ = 9.64 (s, 1 H), 7.64–7.67 (m, 4 H), 7.35–7.43 (m, 6 H), 7.16 (d, *J* = 8.5 Hz, 2 H), 6.83 (d, *J* = 8.5 Hz, 2 H), 4.32 (d, *J* = 11.0 Hz, 1 H), 4.28 (d, *J* = 11.0 Hz, 1 H), 3.76–3.80 (m, 4 H), 3.15–3.18 (m, 1 H), 2.17–2.36 (m, 3 H), 1.66–1.71 (m, 1 H), 1.32–1.40 (m, 2 H), 0.95 (s, 9 H), 0.941 (d, *J* = 6.5 Hz, 3 H), 0.940 (d, *J* = 6.5 Hz, 3 H), 0.89 (d, *J* = 7.0 Hz, 3 H).

^{13}C NMR (125.0 MHz, $CDCl_3$): δ = 202.4, 159.0, 135.9, 135.8, 134.7, 134.2, 130.6, 129.6, 129.4, 129.3, 127.5, 127.3, 113.6, 80.9, 72.11, 71.0, 55.2, 46.6, 36.7, 33.1, 31.1, 27.0, 19.7, 19.3, 16.5, 15.3.

HRMS: *m*/*z* calcd for $C_{34}H_{46}O_4Si$ + Na [M + Na]: 569.3063; found: 569.3083.

***tert*-Butyl[(2*S*,3*S*,5*R*,6*S*)-5-(4-methoxybenzyloxy)-3,6-dimethylnon-8-en-2-yloxy]diphenylsilane (7)**

Methyltriphenylphosphonium bromide (0.715 g, 2.0 mmol) was dissolved in anhyd THF (8 mL), and to this solution, cooled to –78 °C, was slowly added *n*-BuLi (1.2 mL of a 1.6 M solution in hexanes). After 1 h at –78 °C, aldehyde **19** (0.546 g, 1.0 mmol) in anhyd THF (5 mL) was added. The mixture was slowly warmed to r.t. H_2O (20 mL) was added and the two phases were separated. The aqueous layer was extracted several times with Et_2O (3 × 20 mL). The organic fractions were collected, and dried (Na_2SO_4), and the solvent was evaporated to give **7**. Silica gel chromatography (hexanes–EtOAc, 100:1) afforded pure **7** as pale yellow oil (80%); R_f = 0.75 (EtOAc–hexanes, 1:4); $[\alpha]_D^{20}$ –1.9 (*c* = 1.0, $CHCl_3$).

FTIR (KBr, neat): 3070, 2960, 2929, 2856, 1514, 1427, 1247, 1111 cm^{-1}.

^1H NMR (500 MHz, $CDCl_3$): δ = 7.66–7.69 (m, 4 H), 7.31–7.42 (m, 6 H), 7.18 (d, *J* = 8.4 Hz, 2 H), 6.82 (d, *J* = 8.4 Hz, 2 H), 5.72–5.80 (m, 1 H), 4.98–5.01 (m, 2 H), 4.40 (d, *J* = 13.9 Hz, 1 H), 4.26 (d, *J* = 13.9 Hz, 1 H), 3.75–3.81 (m, 4 H), 3.24–3.26 (m, 1 H), 2.05–2.22 (m, 3 H), 1.71–1.83 (m, 3 H), 1.25–1.32 (m, 2 H), 1.05 (s, 9 H), 0.84–1.02 (m, 9 H).

^{13}C NMR (125.0 MHz, $CDCl_3$): δ = 159.0, 137.9, 135.0, 134.3, 131.2, 129.5, 129.4, 115.5, 113.8, 81.5, 72.4, 72.3, 77.8, 55.2, 38.5, 37.4, 36.8, 35.4, 32.4, 30.3, 27.0, 19.8, 19.3, 17.2, 15.7, 14.7.

HRMS: *m*/*z* calcd for $C_{35}H_{48}O_3Si$ + Na [M + Na]: 567.3270; found: 567.3260.

(3*R*,4*R*)-4-Cyclohexyl-3,4-dihydroxybutan-2-one (22)

To a mixture of DMSO (80.0 mL) and hydroxyacetone (**21**; 20 mL) was added the cyclohexanecarbaldehyde (**20**; 10.0 mmol) followed by D-proline (0.35 g, 30 mol%), and the resulting homogeneous reaction mixture was stirred at r.t. for 60 h. Then, half sat. aq NH_4C1 (60 mL) and EtOAc (60 mL) were added with vigorous stirring, the layers were separated, and the aqueous phase was extracted thoroughly with EtOAc (3 × 60 mL). Then, the combined organic phases were washed with H_2O (100 mL), brine (100 mL), and dried ($MgSO_4$). The residue obtained by concentration was purified by flash column chromatography (hexanes–EtOAc, 5:1, 4:1, 2:1, 1:1) to afford the *anti*-diol **22** as a white powder (1.17 g, 63%). The ee of **22** was determined by HPLC analysis (chiral Daicel Chiralpak AS, hexanes–*i*-PrOH, 85:15, flow rate 1.0 mL/min, λ = 285 nm): t_R = 7.70 min); R_f = 0.50 (EtOAc–hexanes, 1:1); $[\alpha]_D^{20}$ –81.6 (*c* = 1.0, $CHCl_3$) {Lit.[13] $[\alpha]_D$ +83 (*c* = 1.0, $CHCl_3$), for (3*S*,4*S*)-4-cyclohexyl-3,4-dihydroxybutan-2-one}.

FTIR (KBr, neat): 3381, 2920, 2850, 1697 (C=O), 1421, 1359, 1076, 1039, 983 cm^{-1}.

^1H NMR (300 MHz, $CDCl_3$): δ = 4.23 (d, *J* = 5.4 Hz, 2 H), 3.51–3.54 (m, 2 H), 2.31 (s, 4 H), 1.53–1.93 (m, 6 H), 1.04–1.29 (m, 5 H).

^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 209.8, 78.3, 77.6, 39.8, 29.7, 27.7, 27.4, 26.2, 26.1, 25.8.

HRMS: *m*/*z* calcd for $C_{10}H_{19}O_3$ [M + 1]: 187.1329; found: 187.1334.

1-[(4*R*,5*R*)-5-Cyclohexyl-2,2-dimethyl-1,3-dioxolan-4-yl]ethanone (23)

To a mixture of **22** (1.860 g, 10.0 mmol), 2.2-dimethoxypropane (10.408 g, 100.0 mmol) and CH_2Cl_2 (20 mL) was added CSA (0.116 g, 0.05 mmol), and the reaction mixture was stirred at r.t. for overnight. Then, half sat. aq $NaHCO_3$ (30 mL) and CH_2Cl_2 (20 mL) added with vigorous stirring, the layers were separated, and the aqueous phase was extracted with CH_2Cl_2 (2 × 20 mL). Then, the combined organic phases were washed with H_2O (50 mL), brine (50 mL), and dried ($MgSO_4$). The residue obtained by concentration was purified by flash column chromatography (hexanes–EtOAc, 100:1) to afford **23** in 90% yield (2.042 g) as pale yellow oil; R_f = 0.692 (EtOAc–hexanes, 1:4); $[\alpha]_D^{20}$ +0.87 (*c* = 1.2, $CHCl_3$).

FTIR (KBr, neat): 2927, 2854, 1708 (C=O), 1450, 1355, 1060 cm^{-1}.

^1H NMR (400 MHz, $CDCl_3$): δ = 4.32 (d, *J* = 7.6 Hz, 1 H), 4.02 (dd, *J* = 8.8, 7.6, Hz, 1 H), 2.26 (s, 3 H), 1.63–1.87 (m, 5 H), 1.60 (s, 3 H), 1.34 (s, 3 H), 0.92–1.25 (m, 6 H).

^{13}C NMR (100.0 MHz, $CDCl_3$): δ = 209.7, 109.4, 82.8, 82.6, 37.6, 29.7, 29.3, 28.4, 26.6, 26.2, 25.4, 24.8.

HRMS: *m*/*z* calcd for $C_{13}H_{23}O_3$ [M + 1]: 227.1650; found: 227.1647.

(*R*)-2-[(4*R*,5*R*)-5-Cyclohexyl-2,2-dimethyl-1,3-dioxolan-4-yl]but-3-en-2-ol (6)

Freshly prepared vinylmagnesium bromide [prepared from Mg (0.72 g) and 1 M vinyl bromide in THF (30 mL)] was cooled to 0 °C. The ketone **23** (2.26 g, 10.0 mmol) in THF (50 mL) was added dropwise and the resulting reaction mixture was stirred at 0 °C for overnight. Then, sat. aq NH_4C1 (50 mL) was added carefully with vigorous stirring, the layers were separated, and the aqueous phase was extracted thoroughly with Et_2O (3 × 50 mL). Then, the combined organic phases were washed with brine (80 mL) and dried ($MgSO_4$), and concentrated to give a mixture of **6** and **6′**. The mixture was purified by flash column chromatography (hexanes–EtOAc, 250:1 to 20:1) to afford (*R*,*R*,*R*)-**6** (1.78 g, 70%) and (*R*,*R*,*S*)-**6′** (0.35 g, 14%); R_f = 0.60 (EtOAc–hexanes, 1:4); $[\alpha]_D^{20}$ –29.1 (*c* = 1.0, $CHCl_3$).

FTIR (KBr, neat): 3425, 2989, 2927, 2852, 1651, 1381, 1255, 1033, 758 cm^{-1}.

^1H NMR (400 MHz, $CDCl_3$): δ = 6.05 (dd, *J* = 23.2, 14.4 Hz, 1 H), 5.34 (dd, *J* = 23.2, 2.0 Hz, 1 H), 5.16 (dd, *J* = 14.4, 2.0 Hz, 1 H), 3.95 (d, *J* = 2.0 Hz, 1 H), 3.87 (dd, *J* = 12.0, 8.0 Hz, 1 H), 2.23 (s, 1 H), 1.66–2.04 (m, 5 H), 1.50 (s, 3 H), 1.34 (s, 3 H), 1.33 (s, 3 H), 1.23–1.28 (m, 6 H).

^{13}C NMR (100.0 MHz, $CDCl_3$): δ = 142.5, 113.3, 106.7, 82.7, 82.4, 74.7, 36.3, 31.7, 30.3, 28.7, 26.4, 25.7, 25.5, 25.4, 25.0.

HRMS: *m*/*z* calcd for $C_{15}H_{27}O_3$ [M + 1]: 255.1958; found: 255.1960.

(*S*)-2-[(4*R*,5*R*)-5-Cyclohexyl-2,2-dimethyl-1,3-dioxolan-4-yl]but-3-en-2-ol (6′)

R_f = 0.63 (EtOAc–hexanes, 1:4); $[\alpha]_D^{20}$ –42.2 (*c* = 1.5, $CHCl_3$).

FTIR (KBr, neat): 3552, 2893, 2926, 2852, 1614, 1450, 1045 cm^{-1}.

^1H NMR (300 MHz, $CDCl_3$): δ = 6.01 (dd, *J* = 17.1, 10.8 Hz, 1 H), 5.40 (dd, *J* = 17.4, 1.8 Hz, 1 H), 5.34 (dd, *J* = 10.5, 1.5 Hz, 1 H), 3.90 (d, *J* = 5.4 Hz, 1 H), 3.80–3.85 (m, 1 H), 2.56 (s, 1 H), 1.61–2.07 (m, 5 H), 1.37 (s, 3 H), 1.32 (s, 6 H), 1.20–1.31 (m, 6 H).

^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 142.7, 112.7, 106.8, 82.7, 81.9, 75.5, 36.0, 31.4, 30.2, 27.0, 26.8, 26.3, 25.6, 25.2, 24.8.

HRMS: *m*/*z* calcd for $C_{15}H_{27}O_3$ [M + 1]: 255.1953; found: 255.1960.

(4*R*,5*R*)-4-Cyclohexyl-5-[(*R*)-2-(4-methoxybenzyloxy)but-3-en-2-yl]-2,2-dimethyl-1,3-dioxolane (24)

To a mixture of DMF (10.0 mL) and **6** (1.27 g, 5.0 mmol) was added NaH (0.36 g, 60%; 9.0 mmol) carefully at 0 °C and the mixture was stirred at the same temperature for 1 h. PMBCl was added dropwise by a syringe and the mixture was slowly warmed to r.t. and stirred for 20 h. Then, sat. aq NH_4C1 (50 mL) was added carefully with vigorous stirring, the layers were separated and the aqueous phase was extracted thoroughly with EtOAc (3 × 50 mL). Then, the combined organic phases were washed with H_2O (80 mL), brine (80 mL), and dried ($MgSO_4$). concentrated and purified by flash column chromatography (hexanes–EtOAc, 50:1 to 20:1) to afford **24** (1.64 g, 88%) as a pale yellow powder; R_f = 0.70 (EtOAc–hexanes, 1:4); $[\alpha]_D^{20}$ +7.5 (*c* = 1.1, $CHCl_3$).

FTIR (KBr, neat): 3007, 2927, 2852, 1612, 1857, 1369, 1053, 767 cm^{-1}.

^1H NMR (400 MHz, $CDCl_3$): δ = 7.22 (d, *J* = 8.4 Hz, 1 H), 6.84 (d, *J* = 8.4 Hz, 1 H), 6.19 (dd, *J* = 17.6, 5.2 Hz, 1 H), 5.35 (ddd, *J* = 24.0, 10.8, 1.2 Hz, 1 H), 4.28 (s, 2 H), 3.99 (d, *J* = 5.6 Hz, 1 H), 3.80–3.82 (m, 4 H), 1.48–2.06 (m, 5 H), 1.43 (s, 3 H), 1.42 (s, 3 H), 0.77–1.37 (m, 9 H).

^{13}C NMR (100.0 MHz, $CDCl_3$): δ = 158.9, 139.5, 131.4, 129.4, 117.8, 113.6, 106.6, 83.2, 82.6, 80.1, 64.3, 55.3, 36.3, 31.4, 30.5, 26.9, 26.5, 25.8, 25.2, 25.1, 20.1.

HRMS: *m*/*z* calcd for $C_{23}H_{35}O_4$ [M + 1]: 375.2519; found: 375.2535.

(2*R*,6*S*,7*R*,9*S*,10*S*,*E*)-10-(*tert*-Butyldiphenylsilyloxy)-2-[(4*R*,5*R*)-5-cyclohexyl-2,2-dimethyl-1,3-dioxolan-4-yl]-7-(4-methoxybenzyloxy)-6,9-dimethylundec-3-en-2-ol (5)

To a solution of **7** (11.2 mg, 19.8 μmol) and allyllic alcohol **6** (10.0 mg, 39.6 mmol) in CH_2Cl_2 (1.0 mL) was added the 2nd generation Hoveyda–Grubbs catalyst **25** (1.0 mg, 1.6 μmol) and the mixture was heated at reflux for 12 h under N_2. The mixture was cooled to r.t. and concentrated under reduced pressure. The residue was purified by silica gel column chromatography (hexanes–EtOAc, 100:1 to 20:1) to afford **5** (5.8 mg, 38%) as a colorless oil and; R_f = 0.53 (EtOAc–hexanes, 1:4); $[\alpha]_D^{20}$ –16.0 (*c* = 0.5, $CHCl_3$). Recovered starting material **7**: 4.1 mg.

FTIR (KBr, neat): 3581, 3070, 2958, 2922, 2852, 1612, 1454, 1379, 1249, 1161, 1035 cm^{-1}.

^1H NMR (400 MHz, $CDCl_3$): δ = 7.73–7.86 (m, 4 H), 7.41–7.54 (m, 6 H), 7.10 (d, *J* = 8.4 Hz, 2 H), 7.01 (d, *J* = 8.4 Hz, 2 H), 5.53–5.71 (m, 2 H), 4.30 (d, *J* = 10.4 Hz, 1 H), 4.12 (d, *J* = 11.2 Hz, 1 H), 3.90–3.95 (m, 1 H), 3.84–3.87 (m, 1 H), 3.75–3.76 (m, 4 H), 3.26–3.33 (m, 1 H), 2.11–2.33 (m, 2 H), 1.64–1.98 (m, 4 H), 1.48 (s, 3 H), 1.11–1.41 (m, 15 H), 0.99 (s, 9 H), 0.79–0.97 (m, 9 H).

^{13}C NMR (100.0 MHz, $CDCl_3$): δ = 159.0, 136.0, 135.9, 135.3, 135.0, 134.3, 131.1, 129.6, 129.5, 129.4, 129.3, 128.8, 127.5, 127.3, 113.6, 106.6, 83.2, 82.2, 81.8, 74.0, 72.3, 70.9, 55.2, 37.4, 36.4, 35.9, 35.4, 32.7, 31.6, 30.2, 29.7, 27.1, 26.7, 26.4, 25.8, 25.6, 25.5, 25.0, 19.9, 19.4, 15.6, 14.8.

HRMS: *m*/*z* calcd for $C_{48}H_{71}O_6Si$ [M + 1]: 771.5020; found: 771.5011.

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