Supporting Information

An Efficient Total Synthesis of (+)-Entecavir

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I. General Experimental Protocols:

Nuclear magnetic resonance (NMR) spectra (^{1}H and ^{13}C) were recorded using a Bruker AX-400 spectrometer. Chemical shifts in ^{1}H NMR spectra recorded in $CDCl_3$ are referenced to $\delta = 7.26$ or $(CD_3)_2SO$ (δ 2.50) (Data are reported according to the following format: chemical shift (ppm) [multiplicity (e.g., s, d, t, q, etc.), coupling constant(s) (in Hz), integral value (to the nearest whole integer), and structural assignment of the proton]. Coupling constant values have been determined using reported methods.[1,2] Non-first order doubles are designated by 'nfod' and the apparent double coupling constant is indicated as J_{app}. Chemical shifts in ^{13}C NMR spectra are referenced to the carbon atom of $CDCl_3$ (δ 77.16) or $(CD_3)_2SO$ (δ 39.60).

Infrared (IR) spectra were measured on a FT-IR spectrophotometer. The samples were placed on a diamond window as thin films (solids by evaporation from a CH_2Cl_2 solution and liquids by direct deposition) and recorded in the attenuated total reflectance (ATR) mode. The absorption peak maxima are given in cm^{-1}.

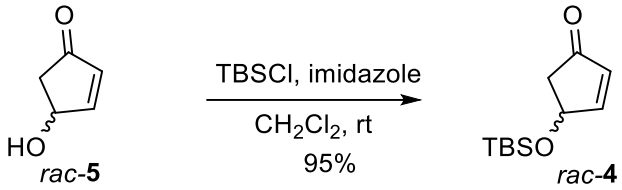
High-resolution mass spectrometry (HRMS) measurements were obtained on a Waters Q-TOF Premier Spectrometer (ESI or EI Source).

Optical rotation was obtained from Rudolph Autopol II automatic polarimeter.

Miscellaneous. Reactions performed above the ambient laboratory temperature were performed in silicone oil baths that had been pre-equilibrated to the temperature of choice before the reaction vessel was immersed. Column chromatography was generally performed on silica gel (300-400 mesh). Reactions were monitored by thin layer chromatography (TLC) using UV light to visualize the course of the reactions and an ethanolic solution of phosphomolybdic acid, and heat as developing agents.

II. Preparation Procedures and Characterization Data for All Compounds

4-((Tert-butyldimethylsilyl)oxy)cyclopent-2-en-1-one (*rac*-4)



To a stirred solution of 4-hydroxy-2-cyclopentenone *rac*-**5**[3] (2.50 g, 25.51 mmol) in CH_2Cl_2 (20 mL) were added tert-butyldimethylsilyl chloride (4.23 g, 28.06 mmol) and imidazole (2.08 g, 30.61 mmol) at room temperature. The resulting mixture was stirred at room temperature for 2 h before it was quenched by the addition of $NaHCO_3$ (20 mL, satd aq). The layers were separated and the aqueous layer was extracted with CH_2Cl_2 (3x20 mL). The combined organic layers were washed with brine (20 mL), dried (Na_2SO_4), filtered and concentrated *in vacuo*. Flash column chromatography (silica gel, hexanes:EtOAc = 20:1) afforded *rac*-**4** (5.14 g, 95%) as a colorless oil.

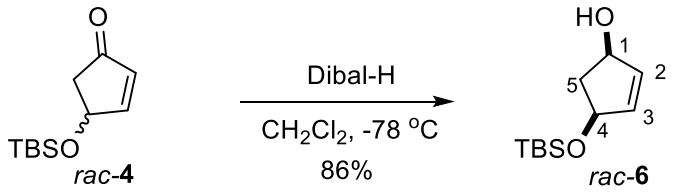
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.43 (dd, *J* = 2.4, 5.7 Hz, 1H, COCH=C*H*), 6.14 (dd, *J* = 1.3, 5.7 Hz, 1H, COC*H*=CH), 4.96 (tdd, *J* = 1.4, 2.4, 6.0 Hz, 1H, C*H*OTBS), 2.68 (dd, *J* = 6.0, 18.2 Hz, 1H, COCH_aH$_b$), 2.20 (dd, *J* = 2.4, 18.2 Hz, 1H, COCH$_a$$H_b$), 0.88 [s, 9H, SiC(C$H_3$)$_3$], 0.11 [s, 3H, Si(C$H_3$)$_2$], and 0.09 [s, 3H, Si(C$H_3$)$_2$].

^{13}C NMR (101 MHz, $CDCl_3$): δ 206.4, 163.9, 124.4, 70.9, 44.9, 25.8, 18.1, -4.71, and -4.74.

HRMS (ESI) *m/z*: $[M + H]^+$ Calcd for $C_{11}H_{21}O_2Si^+$ 213.1305; Found 213.1301.

IR (film): 2960, 2934, 2855, 1725, 1708, 1353, 1110, and 822 cm^{-1}.

***Trans*-4-((tert-butyldimethylsilyl)oxy)cyclopent-2-en-1-ol (*rac*-6)**



To a stirred solution of *rac*-**4** (2.17 g, 10.22 mmol) in CH_2Cl_2 (100 mL) was dropwise added diisobutylaluminium hydride (1.0 mol/L in hexane) (12.2 mL, 12.2 mmol) at -78°C. The resulting mixture was stirred at -78°C for 2 h before it was quenched by the addition of potassium sodium tartrate tetrahydrate (60 mL, satd aq). The resulting mixture was stirred at room temperature for 30 min. The layers were separated and the aqueous layer was extracted with CH_2Cl_2 (3x30 mL). The combined organic layers were dried (Na_2SO_4), filtered and concentrated *in vacuo*. Flash column chromatography (silica gel, hexanes:EtOAc = 5:1) afforded *rac*-**6** (1.89 g, 86%, dr>200:1, indicated in ^{1}HNMR) as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ 5.95 (dt, *J* = 5.7, 1.4 Hz, 1H, C_3H), 5.89 (dt, *J* = 5.7, 1.5 Hz, 1H, C_2H), 4.66-4.63 (m, 1H, C_4H), 4.59-4.56 (m, 1H, C_1H), 2.68 (dt, *J* = 14.0, 7.1 Hz, 1H, $C_5H_aH_b$), 2.16 (dt, *J* = 8.8 Hz, 1H, O*H*), 1.50 (dt, *J* = 13.8, 4.5 Hz, 1H, $C_5H_aH_b$), 0.89 (s, 9H, $SiC(CH_3)_3$), and 0.08 [s, 6H, $Si(CH_3)_2$].

^{13}C NMR (101 MHz, $CDCl_3$): δ 137.0, 135.8, 75.3, 75.2, 44.7, 26.0, 18.3, -4.53, and -4.55.

HRMS (ESI) *m/z*: $[M + H]^+$ Calcd for $C_{11}H_{23}O_2Si^+$ 215.1462; Found 214.1465.

IR (film): 3340, 2952, 1640, 1472, 1251, and 1130 cm^{-1}.

(1*S*,4*R*)-4-((Tert-butyldimethylsilyl)oxy)cyclopent-2-en-1-yl acetate (7)

In a dry flask were added *rac*-**6** (1.35 g, 6.33 mmol), vinyl acetate (1.20 mL, 12.66 mmol), lipase (1.89 g, 20u/mg, 300 mg/mmol) and *tert*-butyl methyl ether (12 mL, 2 mL/mmol). The mixture was shaken at 150r in shaking table oscillator at 35ºC for 36 h. The resulting mixture was filtered and concentrated *in vacuo*. Flash column chromatography (silica gel, hexanes:EtOAc = 20:1 to 5:1) afforded **6** (580 mg, 43%) and **7** (728 mg, 45%) as a colorless oil.

Data for **7**:

^{1}H NMR (400 MHz, $CDCl_3$): δ 5.97 (dt, *J* = 5.7, 1.4 Hz, 1H, C_3H), 5.87 (dt, *J* = 5.7, 1.5 Hz, 1H, C_2H), 5.45 (m, 1H, C_1H), 4.71 (m, 1H, C_4H), 2.80 (dt, *J* = 13.8, 7.3 Hz, 1H, $C_5H_aH_b$), 2.04 (s, 3H, $COCH_3$), 1.60 (dt, *J* = 13.8, 5.0 Hz, 1H, $C_5H_aH_b$), 0.89 (s, 9H, $SiC(CH_3)_3$), 0.084 [s, 3H, $Si(CH_3)_2$], and 0.08 [s, 3H, $Si(CH_3)_2$].

^{13}C NMR (101 MHz, $CDCl_3$): δ 171.0, 139.0, 131.3, 77.1, 75.0, 41.3, 26.0, 21.3, 18.3, -4.5, and -4.6.

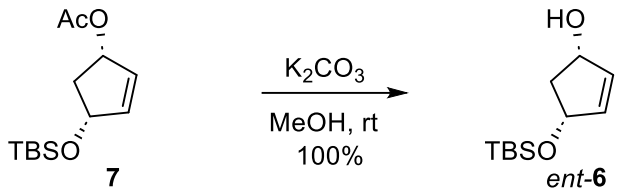
HRMS (ESI) *m/z*: $[M + H]^+$ Calcd for $C_{13}H_{25}O_3Si^+$ 257.1567; Found 257.1563.

IR (film): 3062, 2980, 2930, 2865, 1738, 1708, 1352, 1100, and 986 cm^{-1}.

Specific Rotation for 6: $[\alpha]_D^{25}$ = -23.0° (*c* = 1.0, $CHCl_3$).

Specific Rotation for 7: $[\alpha]_D^{25}$ = +0.7° (*c* = 1.0, $CHCl_3$).

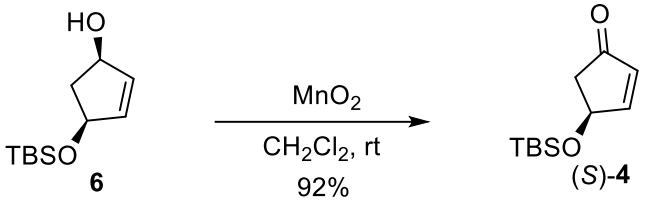
(1*S*,4*R*)-4-((Tert-butyldimethylsilyl)oxy)cyclopent-2-en-1-ol (*ent*-6)



To a stirred solution of **7** (750 mg, 2.93 mmol) in MeOH (4 mL) was added K_2CO_3 (606 mg, 4.40 mmol) at room temperature. The resulting mixture was stirred at room temperature for 1 h before it was quenched by the addition of $NaHCO_3$ (10 mL, satd aq). The layers were separated and the aqueous layer was extracted with EtOAc (3x10 mL). The combined organic layers were washed with brine (20 mL), dried (Na_2SO_4), filtered and concentrated *in vacuo*. Flash column chromatography (silica gel, hexanes:EtOAc = 5:1) afforded *ent*-**6** (625 mg, 100%) as a colorless oil.

Specific Rotation for *ent*-6: $[\alpha]_D^{25}$ = +23.2° (*c* = 1.0, $CHCl_3$).

(*S*)-4-((Tert-butyldimethylsilyl)oxy)cyclopent-2-en-1-one ((*S*)-4)



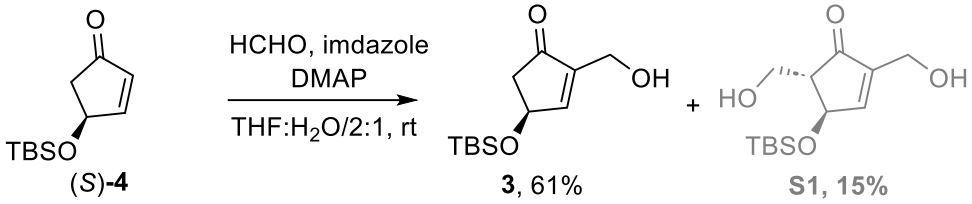
To a stirred solution of **6** (609 mg, 2.85 mmol) in CH_2Cl_2 (8 mL) was added MnO_2 (2.47 g, 28.5 mmol) at room temperature. The resulting mixture was stirred at room temperature for 24 h, then diluted with CH_2Cl_2 (5 mL). The reaction mixture was filtered through Celite and concentrated *in vacuo*. Flash column chromatography (silica gel, hexanes:EtOAc = 20:1) afforded (*S*)-**4** (557 mg, 92%) as a colorless solid.

(*R*)-**4** was synthesized from the *ent*-**6** as the same procedure as synthesis (*S*)-**4** and the yield is 89%.

Specific Rotation for (*S*)-4: $[\alpha]_D^{25}$ = -54.0° (*c* = 1.0, $CHCl_3$).

Specific Rotation for (*R*)-4: $[\alpha]_D^{25}$ = +52.6° (*c* = 0.5, $CHCl_3$).

(*S*)-4-((Tert-butyldimethylsilyl)oxy)-2-(hydroxymethyl)cyclopent-2-en-1-one (3)



To a stirred solution of (*S*)-**4** (2.00 g, 9.42 mmol) in mixture of THF (6 mL) and H_2O (3 mL) were added HCHO (37% w/w aqueous solution, 3.8 mL, 47.1 mmol), imidazole (320 mg, 4.72 mmol) and DMAP (1.15 g, 9.42 mmol). The resulting mixture was stirred at room temperature for 2 h before it was quenched by the addition of $NaHCO_3$ (10 mL, satd aq). The layers were separated and the aqueous layer was extracted with CH_2Cl_2 (3x15 mL). The combined organic layers were washed with brine (15 mL), dried (Na_2SO_4), filtered and concentrated *in vacuo*. Flash column chromatography (silica gel, hexanes:EtOAc = 4:1) afforded the **3** (1.40 g, 61%, 70% brsm) followed by the slower eluting **S1** (380 mg, 15%) as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.27-7.25 (m, 1H, COC=C*H*), 4.95-4.91 (m, 1H, C*H*OTBS), 4.37 (m, 2H, CH_2OH), 2.78 (dd, *J* = 5.9, 18.4 Hz, 1H, COCH_aH$_b$), 2.35 (brs, 1H, CH$_2$O*H*), 2.34 (dd, *J* = 2.2, 18.4 Hz, 1H, COCH$_a$*H$_b$*), 0.90 [s, 9H, SiC(CH_3)$_3$], 0.12 [s, 3H, Si(CH_3)$_2$], and 0.11 [s, 3H, Si(CH_3)$_2$].

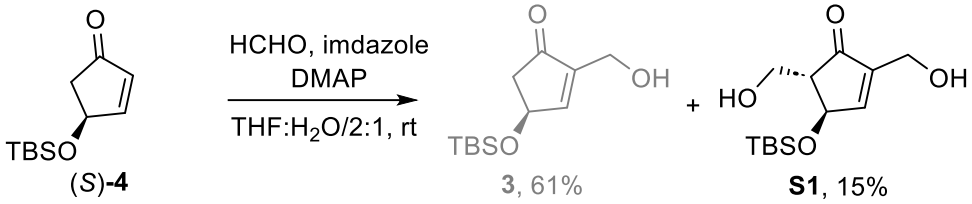
^{13}C NMR (101 MHz, $CDCl_3$): δ 206.2, 157.7, 145.7, 69.2, 57.4, 46.0, 25.9, 18.2, -4.64, and -4.65.

HRMS (ESI) *m/z*: $[M + H]^+$ Calcd for $C_{12}H_{23}O_3Si^+$ 243.1411; Found 243.1415.

IR (film): 3435 (broad), 2954, 2927, 2856m 1711m, 1251, and 1081 cm^{-1}.

Specific Rotation: $[\alpha]_D^{25}$ = -39.7° (*c* = 1.0, $CHCl_3$).

(4*R*,5*S*)-4-((Tert-butyldimethylsilyl)oxy)-2,5-bis(hydroxymethyl)cyclopent-2-en-1-one (S1)



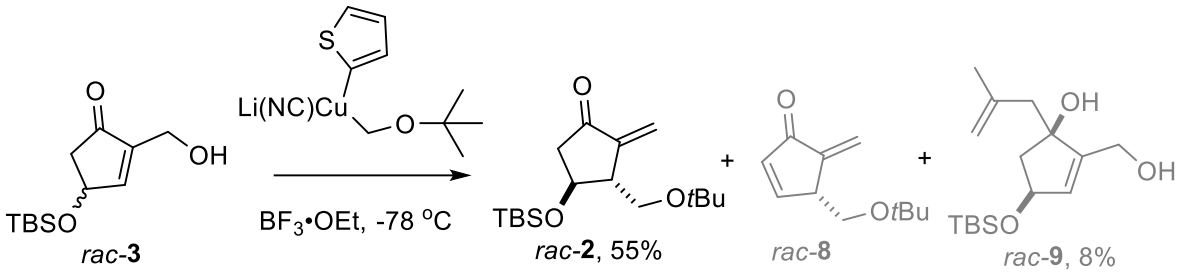
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.34-7.27 (m, 1H, COC=C*H*), 4.87 (m, 1H, C*H*OTBS), 4.27 (dt, *J* = 14.8, 24.2 Hz, 2H, CH=CC*H*$_2$OH), 4.05 (dd, *J* = 3.1, 11.0 Hz, 1H, CHC*H*$_a$H$_b$OH), 3.78 (dd, *J* = 4.5, 11.0 Hz, 1H, CHCH$_a$*H*$_b$OH), 3.19 (brs, 1H, O*H*$_a$), 3.17 (brs, 1H, O*H*$_b$), 2.40-2.36 (m, 1H, C*H*CH$_a$H$_b$OH), 0.88 [s, 9H, SiC(C*H*$_3$)$_3$], 0.14 [s, 3H, Si(C*H*$_3$)$_2$], and 0.11 [s, 3H, Si(C*H*$_3$)$_2$].

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.0, 158.6, 145.6, 71.6, 59.0, 58.9, 56.8, 25.8, 18.1, -4.5, and -4.6.

HRMS (ESI) *m/z*: $[M + H]^+$ Calcd for $C_{13}H_{25}O_4Si^+$ 273.1517; Found 273.1514.

IR (film): 3340 (broad), 2930, 2850, 2260, 1710, 1250, and 1070 cm^{-1}.

3-(Tert-butoxymethyl)-4-((tert-butyldimethylsilyl)oxy)-2-methylenecyclopentan-1-one (*rac*-2)



To a stirred solution of *t*-BuOK (550 mg, 4.9 mmol) in *tert*-butyl methyl ether (15 mL) was added *s*-BuLi (5.0 mL, 1.0 M in THF, 4.9 mmol) at -78 °C. The resulting mixture was stirred at the same temperature for 4 hours followed by adding lithium 2-thienylcyanocuprate (20 mL, 0.25 M in THF, 5.0 mmol). The resulting mixture was stirred at -40 °C for one hour, then *rac*-**3** (400 mg, 1.65 mmol) in THF was added at -78 °C followed by $BF_3{\cdot}Et_2O$ (0.9 ml, ⩾46.5% BF_3 basis, 3.3 mmol). The cooling bath was removed and the suspension was allowed to warm to room temperature. After completion of the reaction as monitored by TLC, the reaction was quenched with $NaHCO_3$ (10 mL, satd aq). The layers were separated and the aqueous layer was extracted with CH_2Cl_2 (3x20 mL). The combined organic layers were washed with brine (10 mL), dried (Na_2SO_4), filtered and concentrated *in vacuo*. Flash column chromatography (silica gel, hexanes:EtOAc = 5:1) afforded *rac*-**2** (280 mg, 55%) and *rac*-**9** (40 mg, 8%) as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ 6.10 (dd, *J* = 1.0, 2.6 Hz, 1H, COC=CC*H*$_a$H$_b$), 5.43 (dd, *J* = 1.0, 2.3 Hz, 1H, COC=CCH$_a$*H*$_b$), 4.32 (dt, *J* = 4.2, 6.2 Hz, 1H, C*H*OTBS), 3.45 (dq, *J* = 5.7, 10.0 Hz, 2H, C*H*$_2$O*t*Bu), 2.85 (m, 1H, C*H*CH$_2$O*t*Bu), 2.65 (dd, *J* = 6.3, 18.0 Hz, 1H, COC*H*$_a$H$_b$), 2.31 (ddd, *J* = 1.0, 4.5, 18.1 Hz, 1H, COCH$_a$*H*$_b$), 1.16 [s, 9H, O(C*H*$_3$)$_3$], 0.87 [s, 9H, SiC(C*H*$_3$)$_3$], 0.08 [s, 3H, Si(C*H*$_3$)$_2$], and 0.06 [s, 3H, Si(C*H*$_3$)$_2$].

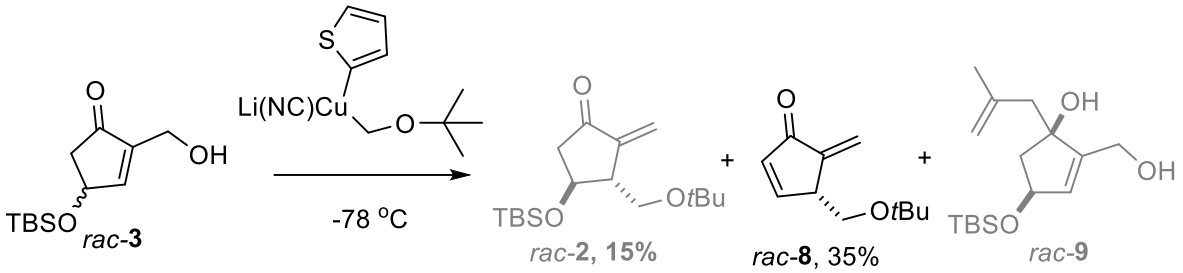
^{13}C NMR (101 MHz, $CDCl_3$): δ 205.1, 145.6, 119.1, 73.0, 69.7, 62.4, 52.1, 47.5, 27.5, 25.9, 18.2, -4.5, and -4.7.

HRMS (ESI) *m/z*: $[M + H]^+$ Calcd for $C_{17}H_{33}O_3Si^+$ 313.2193; Found 313.2196.

IR (film): 2950, 2930, 2849, 1728, 1369, and 1248 cm^{-1}.

By following the same procedure as above (+)-**2** (132 mg, 51%) was obtained from **3** (202 mg).
Specific Rotation for (+)-**2**: $[\alpha]_D^{25}$ = +22.6° (*c* = 1.0, $CHCl_3$).

4-(Tert-butoxymethyl)-5-methylenecyclopent-2-en-1-one (*rac*-8)



To a stirred solution of *t*-BuOK (135 mg, 1.2 mmol) in *tert*-butyl methyl ether (6 mL) was added *s*-BuLi (1.2 mL, 1.0 M in THF, 1.2 mmol) at -78 °C. The resulting mixture was stirred at the same temperature for 4 hours followed by adding lithium 2-thienylcyanocuprate (5 mL, 0.25 M in THF, 1.2 mmol). The resulting mixture was stirred at- 40 °C for one hour, then *rac*-**3** (100 mg, 0.42 mmol) in THF was added at -78 °C. The cooling bath was removed and the suspension was allowed to warm to room temperature. After completion of the reaction as monitored by TLC, the reaction was quenched with $NaHCO_3$ (10 mL, satd aq). The layers were separated and the aqueous layer was extracted with CH_2Cl_2 (3x10 mL). The combined organic layers were washed with brine (10 mL), dried (Na_2SO_4), filtered and concentrated *in vacuo*. Flash column chromatography (silica gel, hexanes:EtOAc = 5:1) afforded *rac*-**2** (20 mg, 15%) and *rac*-**8** (26 mg, 35%) as a colorless oil.

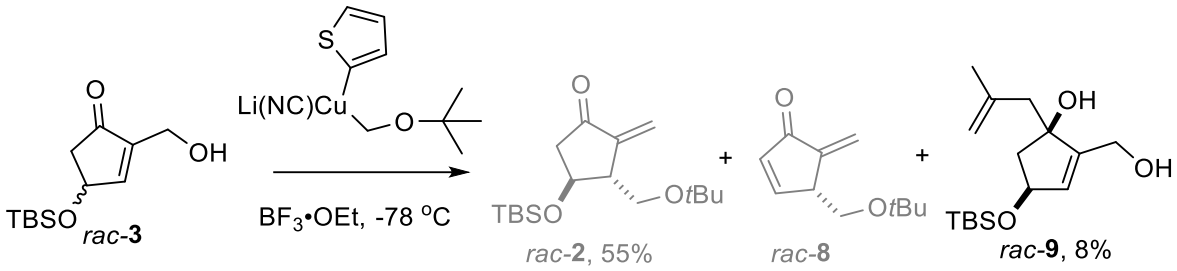
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.68 (nofd, J_{app} = 6.0 Hz, 1H, C*H*=CHCO), 6.41 (nofd, J_{app} = 6.1 Hz, 1H, CH=C*H*CO), 6.13 (nofd, J_{app} = 1.5 Hz, 1H, COC=CCH_aH_b), 5.57 (nofd, J_{app} = 1.5 Hz,, 1H, COC=CCH_aH_b), 3.56-3.51 (m, 1H, CH_2O*t*Bu), 3.39-3.36 (m, 1H, C*H*CH_2O*t*Bu), and 1.2 [s, 9H, O(CH_3)$_3$].

^{13}C NMR (101 MHz, $CDCl_3$): δ 196.7, 160.9, 143.4, 135.7, 117.7, 73.4, 64.0, 45.8, 27.5, and 27.5.

HRMS (ESI) *m/z*: $[M + H]^+$ Calcd for $C_{11}H_{17}O_2^+$ 181.1223; Found 181.1227.

IR (film): 3320, 3118, 2928, 2860, 1730, 1712, 1684, 1448, and 1012 cm^{-1}.

4-((Tert-butyldimethylsilyl)oxy)-2-(hydroxymethyl)-1-(2-methylallyl)cyclopent-2-en-1-ol (*rac*-9)



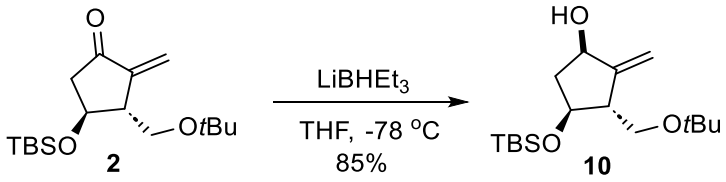
^{1}H NMR (400 MHz, $CDCl_3$): δ 5.72 (dt, *J* = 1.6, 1.8 Hz, 1H, C=C*H*CH), 4.89 (dt, *J* = 1.5, 3.7 Hz, 1H, C=CH_aH$_b$), 4.76 (dq, *J* = 1.0, 2.0 Hz, 1H, COC=CCH$_a$*H$_b$*), 4.61 (m, 1H, C*H*OTBS), 4.40 (dt, *J* = 1.6, 14.2 Hz, 2H, CH_aH$_b$OH), 4.29 (dt, *J* = 1.4, 14.2 Hz, 2H, CH$_a$*H$_b$*OH), 2.64 (dd, *J* = 6.7, 13.6 Hz, 1H, CHOTBSCH_aH$_b$), 2.49 (d, *J* = 14.0 Hz, 1H, CCH_aH$_b$), 2.18 (dd, *J* = 1.0, 13.6 Hz, 1H, CHOTBSCH$_a$*H$_b$*), 1.80 (noft, 3H, CCH_3), 1.76 (dd, *J* = 4.2, 13.5 Hz, 1H, CCH$_a$*H$_b$*), 0.89 [s, 9H, SiC(C*H*$_3$)$_3$], 0.08 [s, 3H, Si(C*H*$_3$)$_2$] and 0.078 [s, 3H, Si(C*H*$_3$)$_2$].

^{13}C NMR (101 MHz, $CDCl_3$): δ 9.8, 142.5, 130.9, 114.9, 83.7, 73.7, 59.4, 49.4, 46.3, 26.0, 24.4, 18.4, and -4.6.

HRMS (ESI) *m/z*: $[M + Na]^+$ Calcd for $C_{16}H_{30}NaO_3Si^+$ 321.1856; Found 321.1853.

IR (film): 3418, 2961, 2930, 2859, 1771, 1248, and 1068 cm^{-1}.

(1*R*,3*R*,4*S*)-3-(Tert-butoxymethyl)-4-((tert-butyldimethylsilyl)oxy)-2-methylenecyclopentan-1-ol (10)



To a stirred solution of **2** (130 mg, 0.42 mmol) in THF (3 mL) were added $LiBHEt_3$ (0.5 ml, 1.0 M in THF, 0.5 mmol). The resulting mixture was stirred at -78 °C for 30 min before it was quenched by the addition of NH_4Cl (10 mL, satd aq). The layers were separated and the aqueous layer was extracted with CH_2Cl_2 (3x10 mL). The combined organic layers were washed with brine (10 mL), dried (Na_2SO_4), filtered and concentrated *in vacuo*. Flash column chromatography (silica gel, hexanes:EtOAc = 5:1) afforded **10** (110 mg, 85%) as a colorless oil.

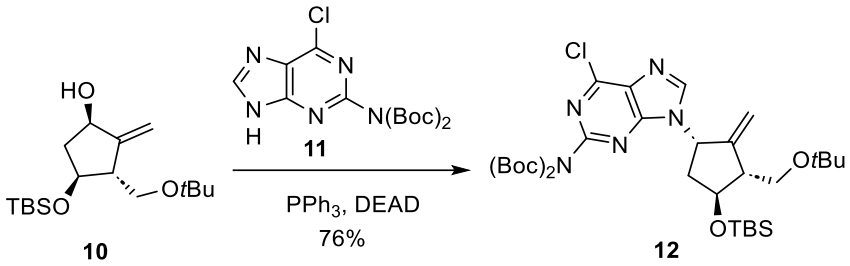
^{1}H NMR (400 MHz, $CDCl_3$): δ 5.38 (nofd, 1H, C=CCH_aH$_b$), 5.14 (nofd, 1H, C=CCH$_a$$H_b$), 4.36 (m, 1H, C*H*OH), 4.35-4.32 (m, 1H, C*H*OTBS), 3.30 (dd, *J* = 5.2, 9.2 Hz, 1H, CH_aH$_b$O*t*Bu), 3.10 (d, *J* =10.6 Hz, 1H, CHO*H*), 2.85 (t, *J* = 9.4 Hz, 1H, CH$_a$$H_b$O*t*Bu), 2.76 (m, 1H, C*H* CH$_a$H$_b$O*t*Bu), 1.94 (dd, *J* = 5.0, 13.5 Hz, 1H, CHOHCH_aH$_b$), 1.83 (dt, *J* = 2.1, 13.6 Hz, 1H, CHOHCH$_a$$H_b$), 1.15 [s, 9H, O(C$H_3$)$_3$], 0.88 [s, 9H, SiC(C$H_3$)$_3$], 0.093 [s, 3H, Si(C$H_3$)$_2$], and 0.091 [s, 3H, Si(CH_3)$_2$].

^{13}C NMR (101 MHz, $CDCl_3$): δ 154.8, 111.8, 76.4, 76.1, 72.8, 63.6, 53.3, 42.0, 27.6, 26.0, 18.1, -4.7, and -4.8.

HRMS (ESI) *m/z*: $[M + Na]^+$ Calcd for $C_{17}H_{34}NaO_3Si^+$ 337.2169; Found 337.2170.

IR (film): 3404 (broad), 2951, 2931, 2842, 1459, 1360, and 1081 cm^{-1}.
Specific Rotation: $[\alpha]_D^{25}$ = -30.0° (*c* = 1.0, $CHCl_3$).

Synthesis of compound 12



To a stirred solution of triphenylphosphine (138 mg, 0.52 mmol) in THF (4 mL) was added diethyl azodicarboxylate (DEAD) (82 uL, 0.52 mmol) at -10 ^{o}C dropwise. The resulting mixture was stirred at the same temperature for 30 min before it was added a mixture of compound **10** (110 mg, 0.35 mmol) and **11**[4] (192 mg, 0.52 mmol) in THF (2 mL) at 0 ^{o}C. The resulting mixture was stirred at 0 ^{o}C for 6 h before it quenched by the addition of $NaHCO_3$ (10 mL). The layers were separated and the aqueous layer was extracted with CH_2Cl_2 (3x10 mL). The combined organic layer was washed with brine (10 mL), dried (Na_2SO_4), filtered and concentrated *in vacuo*. The residue was purified by flash column chromatography (silica gel, hexanes:EtOAc = 4:1) to give **12** (176 mg, 76%) a white solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ 8.45 (s, 1H, N=C*H*), 5.65 (t, *J* = 7.7 Hz, 1H, NC*H*), 5.26 (t, *J* = 2.2 Hz, 1H, C=CH_aH$_b$), 4.91 (t, *J* = 7.7 Hz, 1H, C=CH$_a$$H_b$), 4.38 (dt, *J* = 3.6, 4.7 Hz, 1 H, C*H*OTBS), 3.61 (m, 2H, CH_2O*t*Bu), , CH$_a$$H_b$O*t*Bu), 2.67 (m, 1H, C*H*C=CH$_2$), 2.29 (ddd, *J* = 5.0, 7.9, 12.9 Hz, 1H, CHCH_aH$_b$), 2.20 (ddd, *J* = 5.0, 7.9, 12.9 Hz, CHCH$_a$$H_b$), 1.41 [s, 18 H, (*Boc*)$_2$], 1.21 [s, 9H, O(CH_3)$_3$], 0.86 [s, 9H, SiC(CH_3)$_3$], 0.04 [s, 3H, Si(CH_3)$_2$], and 0.02 [s, 3H, Si(CH_3)$_2$].

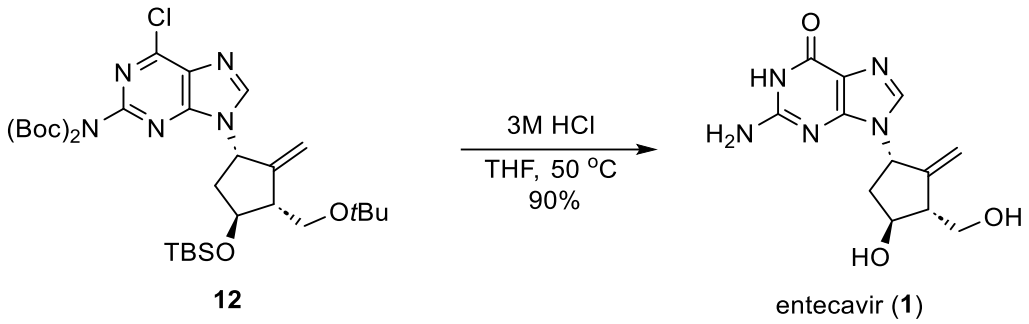
^{13}C NMR (101 MHz, $CDCl_3$): δ 152.8, 151.7, 150.9, 150.6, 149.3, 146.2, 130.1, 112.4, 83.6, 73.2, 73.1, 62.3, 57.0, 53.0, 41.5, 28.0, 27.6, 25.9, 18.1, -4.6, and -4.7.

HRMS (ESI) *m/z*: $[M + Na]^+$ Calcd for $C_{32}H_{52}ClN_5NaO_6Si^+$ 688.3268; Found 688.3284.

IR (film): 3410, 2970, 2860, 1796, 1680, 1560, and 1230 cm^{-1}.

Specific Rotation : $[\alpha]_D^{25}$ = +28.6° (*c* = 1.0, $CHCl_3$).

Synthesis of entecavir (1)



To a stirred solution of **12** (150 mg, 0.30 mmol) in THF (3 mL) was added 3 mL of 3M aqueous HCl. The resulting mixture was stirred at 50 °C for 10 h before it was quenched by the addition of Et_3N (1 mL). The mixture was concentrated, and the residue was purified by flash column chromatography (silica gel, CH_2Cl_2/MeOH 4:1) to give entecavir (**1**) (56 mg, 90%) as a white solid.

^{1}H NMR (400 MHz, DMSO-d_6): δ 10.84 (s, 1H, N*H*), 7.66 (s, 1H, N=C*H*), 6.66 (s, 2H, NH_2), 5.34 (t, *J* = 9.2 Hz, 1H, NC*H*CH_2), 5.09 (s, 1H, =CH_aH$_b$), 4.94 (brs, 1H, O*H*), 4.91 (brs, 1H, O*H*), 4.54 (s, 1H, =C$H_a$$H_b$), 4.23 (s, 1H, C*H*OH), 3.52 (t, *J* = 6.1 Hz, 2H, CH_2OH), 2.55-2.50 (m, 1H, C*H*CH_2OH), 2.24-2.17 (m, 1H, CH_aH$_b$CN), and 2.05-2.00 (m, 1H, C$H_a$$H_b$CN).

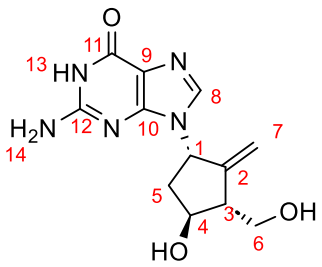
^{13}C NMR (101 MHz, DMSO-d_6): δ 156.9, 153.8, 151.5, 151.4, 136.0, 116.2, 109.3, 70.4, 63.0, 55.2, 54.1, and 39.2.

HRMS (ESI) *m/z*: $[M + Na]^+$ Calcd for $C_{12}H_{15}N_5NaO_3^+$ 300.1067; Found 300.1074.

IR (film): 3440, 3300, 3226, 2950, 2858, 2630, and 1609 cm^{-1}.

Specific Rotation : $[\alpha]_D^{25}$ = +26.4° (*c* = 0.25, DMF:H_2O/1:1).

^{1}H NMR Spectroscopic Comparison of Reported Work[5,6] and Our Synthetic (+)-Enticavir (1)

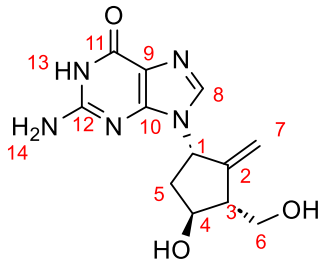


entecavir (**1**)

Position	^{1}H NMR (δ) (first reported by G. S. Bisacchi and co-workers)[a] (400 MHz, DMSO-d_6)	^{1}H NMR (δ) (reported by H. Xu and co-workers)[b] (500 MHz, DMSO-d_6)	^{1}H NMR (δ) This work (400 MHz, DMSO-d_6)
1	5.36 (m, 1H)	5.36 (dd, *J* = 10.3, 8.0 Hz, 1H)	5.34 (t, *J* = 9.2 Hz, 1H)
2	-	-	-
3	2.52 (m, 1H)	2.55-2.50 (m, 1H)	2.55-2.50 (m, 1H)
4	4.23 (m,1H)	4.23 (s, 1H)	4.23 (s, 1H)
5	2.2 (m, 1H)	2.26-2.17 (m, 1H)	2.24-2.17 (m, 1H)
	2.04 (m, 1H)	2.04 (dd, J= 12.5, 7.8 Hz,1H)	2.05-2.00 (m, 1H)
6	3.53 (m, 1H)	3.54 (t, *J* = 6.1 Hz, 2H)	3.52 (t, *J* = 6.1 Hz, 2H)
7	5.10 (m, 1H)	5.10 (s, 1H)	5.09 (s, 1H)
	4.56 (m, 1H)	4.56 (s, 1H)	4.54 (s, 1H)
8	7.66 (s, 1H)	7.65 (s, 1H)	7.66 (s, 1H)
9	-	-	-
10	-	-	-
11	-	-	-
12	-	-	-
13	10.54 (bs, 1H)	10.55 (s, 1H)	10.84 (s, 1H)
14	6.42 (s, 2H)	6.40 (s, 2H)	6.66 (s, 2H)

[a] ref. 5; [b] ref. 6

^{13}C NMR Spectroscopic Comparison of Reported Work[5,6] and Our Synthetic （+）-Enticavir (1)



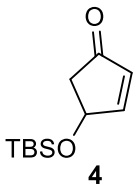
entecavir (**1**)

Position	^{13}C NMR (δ) (The original literature did not provide ^{13}C NMR data)[a]	^{13}C NMR (δ) (reported by H. Xu and co-workers)[b] (126 MHz, DMSO-d_6)	^{13}C NMR (δ) This work (101 MHz, DMSO-d_6)
1		55.1	55.2
2		156.8	156.9
3		54.1	54.1
4		70.4	70.4
5		39.2	39.2
6		63.0	63.0
7		109.2	109.3
8		135.9	136.0
9		116.2	116.2
10		151.3	151.4
11		153.4	153.8
12		151.4	151.5

[a] ref. 5; [b] ref. 6

III. HPLC Data

HPLC data of compound **4**



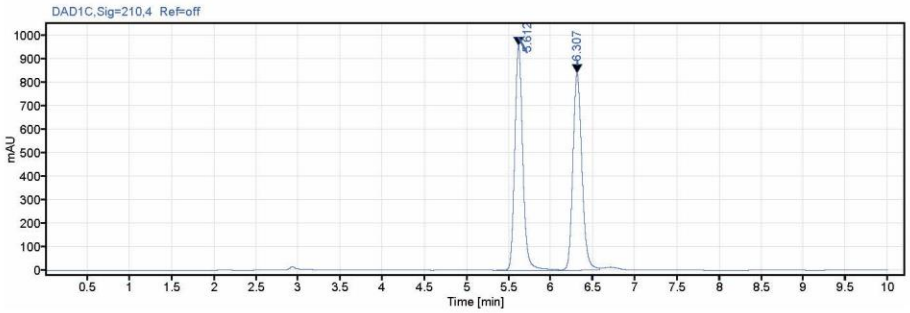
4

HPLC spectrum of *rac*-**4**

Single Injection Report

Agilent Technologies

Data file:	LC1260-2024-12-29 13-19-25+08-00.dx		
Sequence Name:	SingleSample	**Project Name:**	HPLC1
Sample name:	tbso+-2	**Operator:**	系统
Instrument:	LC1260	**Injection date:**	2024-12-29 13:20:22+08:00
Inj. volume:	3.000	**Location:**	P2-A6
Acq. method:	hplc1.amx	**Type:**	Sample
Processing method:	GC_LC Area Percent_DefaultMethod.pmx	**Sample amount:**	0.00
Manually modified:	Manual Integration		



Signal: DAD1C,Sig=210,4 Ref=off

RT [min]	Type	Width [min]	Area	Height	Area%	Name
5.612	BM m	0.10	6359.96	958.96	50.15	
6.307	MM m	0.12	6322.34	841.47	49.85	
		Sum	12682.31			

HPLC spectrum of (*S*)-**4**

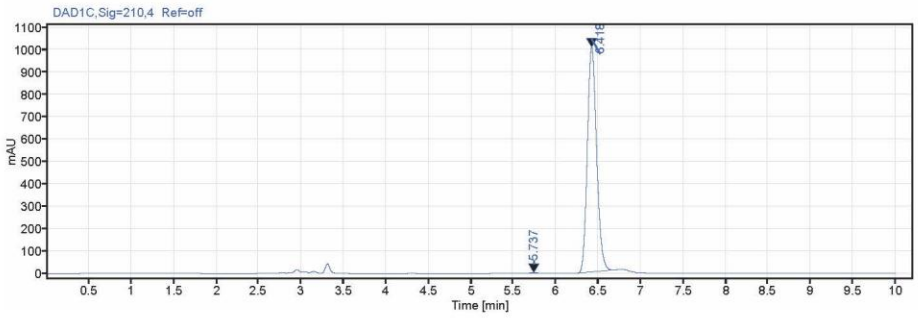
The enantiomeric excess (ee) was 99.26% ee,

determined by HPLC on Chiralpak AS-H column, *n*-hexane : isopropanol = 99:1; flow rate = 1.0 mL/min; UV detection at 210 nm; tR_1 = 5.737 min (minor), tR_2 = 6.418 min (major).

Single Injection Report

Agilent Technologies

Data file:	LC1260-2024-12-09 20-00-38+08-00.dx		
Sequence Name:	SingleSample	**Project Name:**	HPLC1
Sample name:	myp-12.9-2-108-2--2	**Operator:**	系统
Instrument:	LC1260	**Injection date:**	2024-12-09 20:01:40+08:00
Inj. volume:	4.000	**Location:**	P1-E2
Acq. method:	hplc1.amx	**Type:**	Sample
Processing method:	GC_LC Area Percent_DefaultMethod.pmx	**Sample amount:**	0.00
Manually modified:	Manual Integration		



Signal: DAD1C,Sig=210,4 Ref=off

RT [min]	Type	Width [min]	Area	Height	Area%	Name
5.737	MB m	0.10	28.25	4.42	0.37	
6.418	BM m	0.12	7584.97	1002.88	99.63	
		Sum	7613.22			

HPLC spectrum of (*R*)-**4**

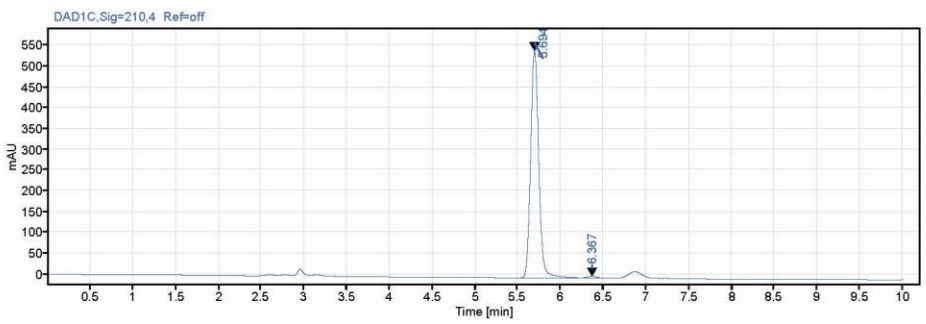
The enantiomeric excess (ee) was 98.06% ee,

determined by HPLC on Chiralpak AS-H column, *n*-hexane : isopropanol = 99:1; flow rate = 1.0 mL/min; UV detection at 210 nm; tR_1 = 5.694 min (major), tR_2 = 6.367 min (minor).

Single Injection Report

Agilent Technologies

Data file:	LC1260-2024-10-19 10-28-14+08-00.dx		
Sequence Name:	SingleSample	**Project Name:**	HPLC1
Sample name:	myp-10.19-tbs	**Operator:**	系统
Instrument:	LC1260	**Injection date:**	2024-10-19 10:29:15+08:00
Inj. volume:	5.000	**Location:**	P1-F1
Acq. method:	hplc1.amx	**Type:**	Sample
Processing method:	GC_LC Area Percent_DefaultMethod.pmx	**Sample amount:**	0.00
Manually modified:	Manual Integration		



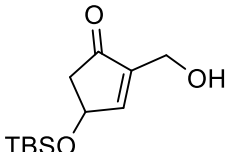
Signal: DAD1C,Sig=210,4 Ref=off

RT [min]	Type	Width [min]	Area	Height	Area%	Name
5.694	BV	0.73	3606.42	546.29	99.03	
6.367	VB	0.38	35.38	4.46	0.97	
		Sum	3641.80			

Short_Area_Letter.rdl [Rev. 1] Printed: 2024-12-29 13:36:02+08:00 Page 1 of 1

HPLC data of compound **3**

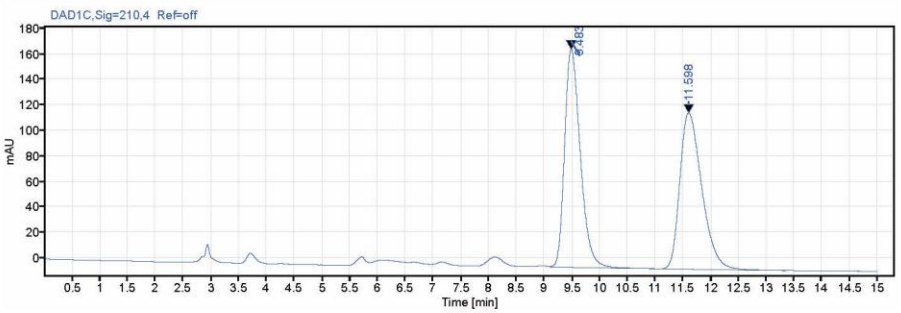
HPLC spectrum of *rac*-**3**



Single Injection Report

Agilent Technologies

Data file:	LC1260-2024-12-29 11-21-25+08-00.dx		
Sequence Name:	SingleSample	**Project Name:**	HPLC1
Sample name:	mbh+-1	**Operator:**	系统
Instrument:	LC1260	**Injection date:**	2024-12-29 11:22:20+08:00
Inj. volume:	2.000	**Location:**	P2-A5
Acq. method:	hplc1.amx	**Type:**	Sample
Processing method:	GC_LC Area Percent_DefaultMethod.pmx	**Sample amount:**	0.00
Manually modified:	Manual Integration		



Signal: DAD1C,Sig=210,4 Ref=off

RT [min]	Type	Width [min]	Area	Height	Area%	Name
9.483	VB	1.96	3357.43	170.97	49.94	
11.598	BB	2.25	3365.78	122.53	50.06	
		Sum	6723.21			

HPLC spectrum of (-)-**3**

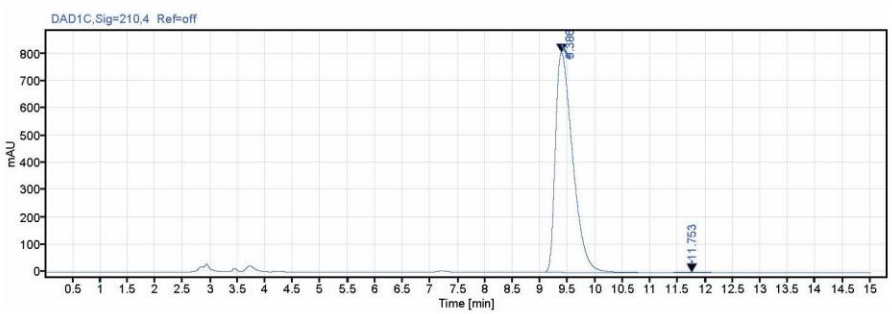
The enantiomeric excess (ee) was 99.24% ee,

determined by HPLC on Chiralpak AS-H column, *n*-hexane : isopropanol = 95:5; flow rate = 0.8 mL/min; UV detection at 210 nm; tR_1 = 9.386 min (major), tR_2 = 11.753 min (minor).

Single Injection Report

Agilent Technologies

Data file:	LC1260-2024-12-29 11-51-44+08-00.dx		
Sequence Name:	SingleSample	**Project Name:**	HPLC1
Sample name:	mbh-s	**Operator:**	系统
Instrument:	LC1260	**Injection date:**	2024-12-29 11:52:43+08:00
Inj. volume:	5.000	**Location:**	P2-A7
Acq. method:	hplc1.amx	**Type:**	Sample
Processing method:	GC_LC Area Percent_DefaultMethod.pmx	**Sample amount:**	0.00
Manually modified:	Manual Integration		



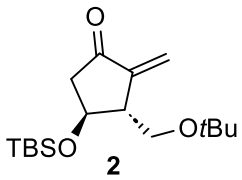
Signal: DAD1C,Sig=210,4 Ref=off

RT [min]	Type	Width [min]	Area	Height	Area%	Name
9.386	BV	1.93	17586.33	806.38	99.62	
11.753	BV	1.29	66.25	2.13	0.38	
		Sum	17652.57			

Short_Area.rdl [Rev. 1] Printed: 2024-12-29 12:17:25+08:00 Page 1 of 1

HPLC data of compound **2**

HPLC spectrum of *rac*-**2**

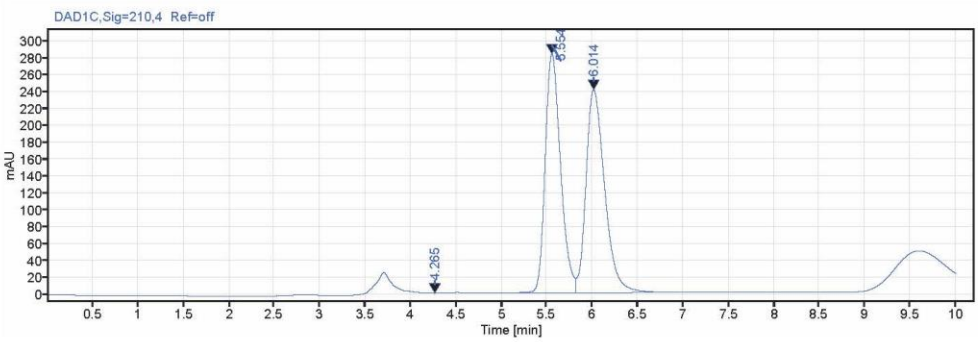


2

Single Injection Report

Agilent Technologies

Data file:	LC1260-2024-12-16 20-50-57+08-00.dx		
Sequence Name:	SingleSample	**Project Name:**	HPLC1
Sample name:	myp-12.16-racemic-3	**Operator:**	系统
Instrument:	LC1260	**Injection date:**	2024-12-16 20:51:55+08:00
Inj. volume:	3.000	**Location:**	P1-D1
Acq. method:	hplc1.amx	**Type:**	Sample
Processing method:	GC_LC Area Percent_DefaultMethod.pmx	**Sample amount:**	0.00
Manually modified:	Manual Integration		



Signal: DAD1C,Sig=210,4 Ref=off

RT [min]	Type	Width [min]	Area	Height	Area%	Name
4.265	MV m	0.00	0.03	0.31	0.00	
5.554	BV	0.80	3320.25	282.62	49.23	
6.014	VB	1.05	3423.70	240.08	50.77	
		Sum	6743.98			

Short_Area_Letter.rdl [Rev. 1] Printed: 2024-12-16 21:05:47+08:00 Page 1 of 1

HPLC spectrum of (+)-**2**

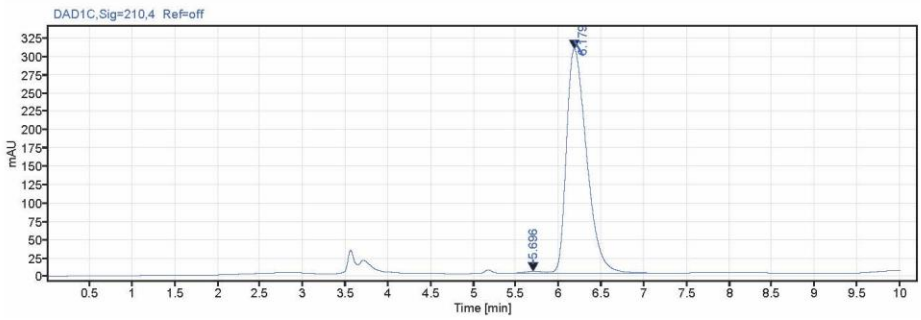
The enantiomeric excess (ee) was 98.32% ee,

determined by HPLC on Chiralpak AS-H column, *n*-hexane : isopropanol = 99:1; flow rate = 0.8 mL/min; UV detection at 210 nm; tR_1 = 5.696 min (minor), tR_2 = 6.179 min (major).

Single Injection Report

Agilent Technologies

Data file:	LC1260-2024-12-16 20-38-14+08-00.dx		
Sequence Name:	SingleSample	**Project Name:**	HPLC1
Sample name:	myp-12.16-single-1	**Operator:**	系统
Instrument:	LC1260	**Injection date:**	2024-12-16 20:39:14+08:00
Inj. volume:	3.000	**Location:**	P1-D2
Acq. method:	hplc1.amx	**Type:**	Sample
Processing method:	GC_LC Area Percent_DefaultMethod.pmx	**Sample amount:**	0.00
Manually modified:	Manual Integration		



Signal: DAD1C,Sig=210,4 Ref=off

RT [min]	Type	Width [min]	Area	Height	Area%	Name
5.696	MM m	0.23	42.94	2.66	0.84	
6.179	MB m	0.26	5049.00	306.20	99.16	
		Sum	5091.94			

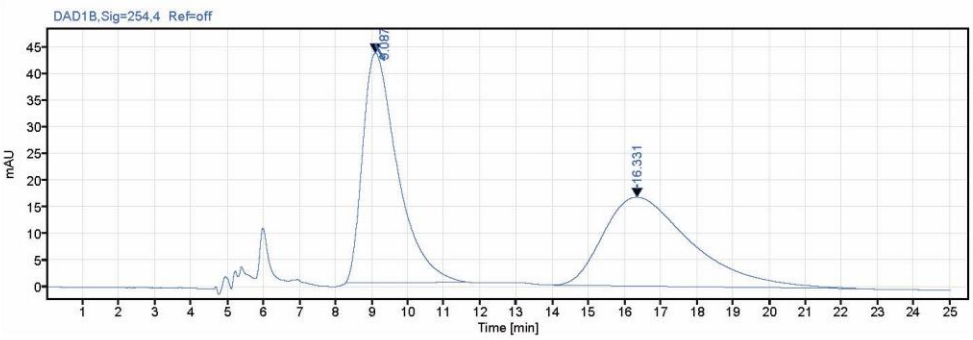
HPLC data of entecavir (**1**)

HPLC spectrum of *rac*-**1**

Single Injection Report

Agilent Technologies

Data file:	LC1260-2024-12-28 17-26-34+08-00.dx		
Sequence Name:	SingleSample	**Project Name:**	HPLC1
Sample name:	zcl-12.28-en-1-+--1(55/45)	**Operator:**	系统
Instrument:	LC1260	**Injection date:**	2024-12-28 17:27:33+08:00
Inj. volume:	8.000	**Location:**	P2-A3
Acq. method:	hplc1.amx	**Type:**	Sample
Processing method:	GC_LC Area Percent_DefaultMethod.pmx	**Sample amount:**	0.00
Manually modified:	Manual Integration		



Signal: DAD1B,Sig=254,4 Ref=off

RT [min]	Type	Width [min]	Area	Height	Area%	Name
9.087	MM m	1.00	2909.77	43.37	50.60	
16.331	MM m	1.99	2840.60	16.80	49.40	
		Sum	5750.37			

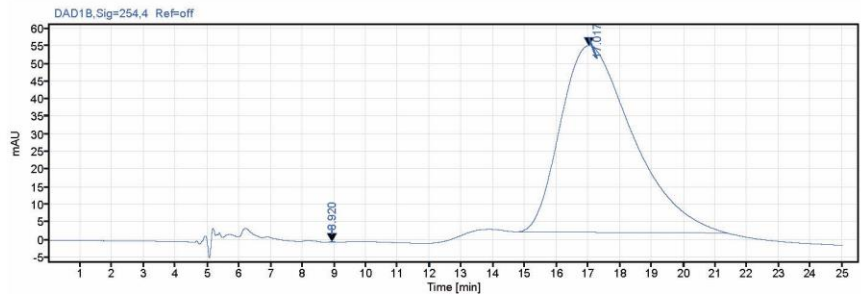
HPLC spectrum of entecavir (**1)**

The enantiomeric excess (ee) was 99.9% ee,

determined by HPLC on Chiralpak AD-H column, *n*-hexane : EtOH: Et_3N = 55:45:0.1; flow rate = 0.6 mL/min; UV detection at 210 nm; tR_1 = 8.920 min (minor), tR_2 = 17.017 min (major).

Single Injection Report — Agilent Technologies

Data file:	LC1260-2024-12-29 14-55-59+08-00.dx		
Sequence Name:	SingleSample	**Project Name:**	HPLC1
Sample name:	1229 ent-4	**Operator:**	系统
Instrument:	LC1260	**Injection date:**	2024-12-29 14:56:55+08:00
Inj. volume:	3.000	**Location:**	P2-A4
Acq. method:	hplc1.amx	**Type:**	Sample
Processing method:	*GC_LC Area Percent_DefaultMethod.pmx	**Sample amount:**	0.00
Manually modified:	Manual Integration		



Signal: DAD1B,Sig=254,4 Ref=off

RT [min]	Type	Width [min]	Area	Height	Area%	Name
8.920	MM m	0.13	1.95	0.19	0.02	
17.017	MM m	1.93	8369.46	53.02	99.98	
		Sum	8371.41			

Short_Area.rdl [Rev. 1] Printed: 2024-12-29 15:26:50+08:00 Page 1 of 1

IV. References for the Supporting Information

[1] T. R. Hoye, P. R. Hanson, J. R. Vyvyan, A practical guide to first-order multiplet analysis in 1H NMR spectroscopy, *J. Org. Chem.*, 1994, **59**, 4096−4013.

[2] T. R. Hoye, H. Zhao, A method for easily determining coupling constant values: An addendum to "a practical guide to first-order multiplet analysis in 1H NMR spectroscopy", *J. Org. Chem*., 2002, **67**, 4014−4016.

[3] P. R. Hamann, A. Wissner, The efficient synthesis of two prostaglandin intermediates, *Synthetic Commun*., 1989, **19**, 1509−1518.

[4] S. Dey, P. Garner, Synthesis of *tert*-butoxycarbonyl (Boc)-protected purines, *J. Org. Chem.*, 2000, **65**, 7697−7699.

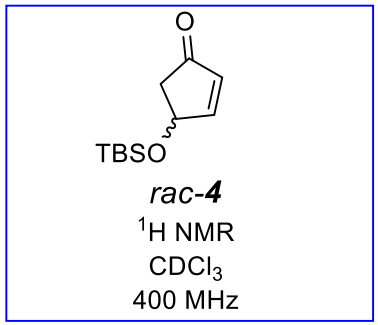
[5] G. S. Bisacchi, S. T. Chao, C. Bachard, J. P. Daris, S. Innaimo, G. A. Jacobs, O. Kocy, P. Lapointe, A. Martel, Z. Merchant, W. A. Slusarchyk, J. E. Sundeen, M. G. Young, R. Colonno, R. Zahler, BMS-200475, a novel carbocyclic 2'-deoxyguanosine analog with potent and selective antihepatitis B virus activity in vitro, *Bioorg. Med. Chem. Lett.*, 1997, **7**, 127−132.

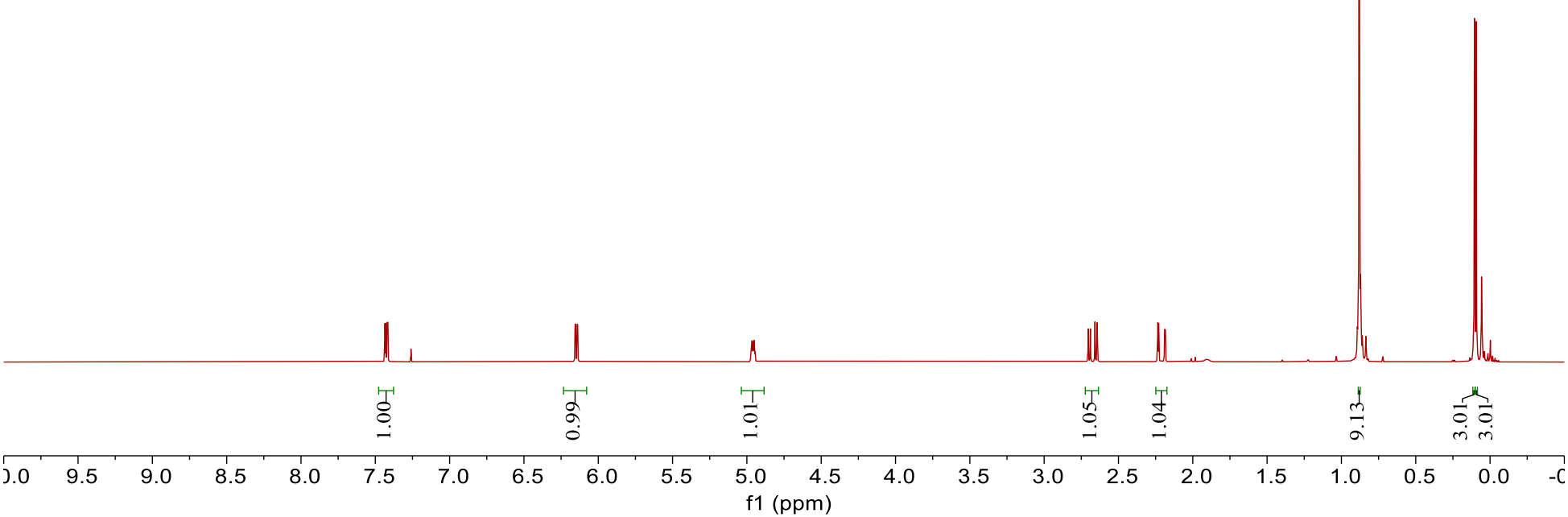
[6] H. Xu, F. Wang, W. Xue, Y. Zheng, Q. Wang, F. G. Qiu, Y. Jin, Total synthesis of entecavir: A robust route for pilot production. *Org. Process Res. Dev.*, 2018, **22**, 377−384.

V. Copies of ^{1}H and ^{13}C NMR Spectra

7.44 7.43 7.42 7.42 6.16 6.15 6.14 6.14 4.97 4.97 4.97 4.96 4.96 4.96 4.96 4.95 4.95 4.95 4.94 2.70 2.69 2.66 2.64 2.24 2.23 2.19 2.18 0.88 0.11 0.09

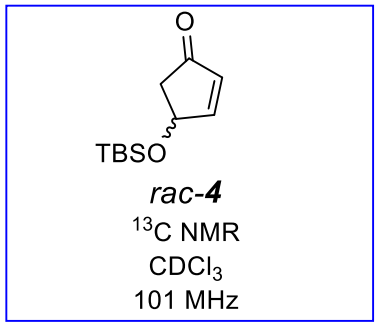
4/H

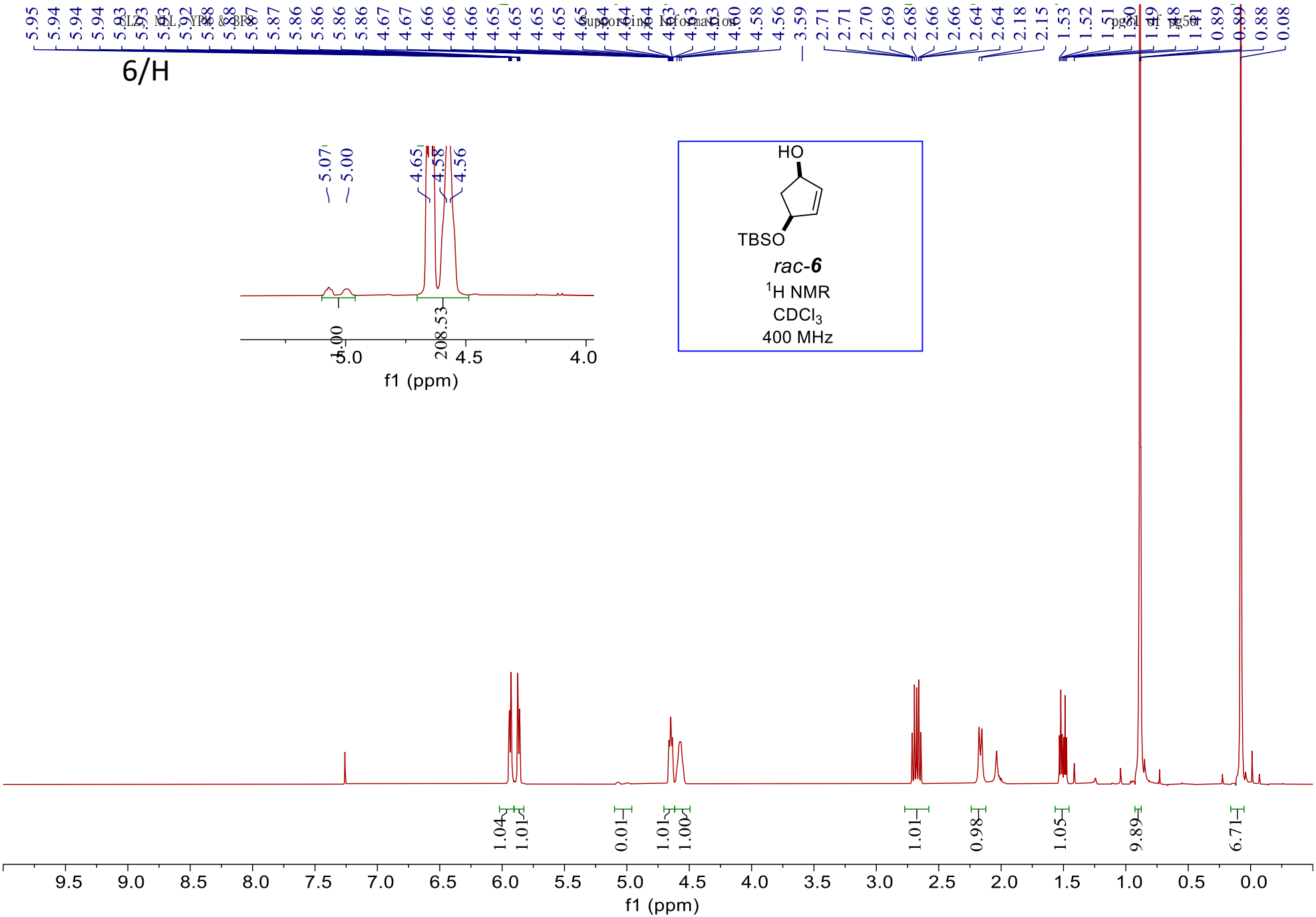




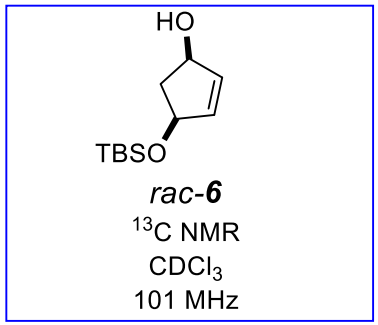
206.43 163.88 134.44 70.85 44.94 25.75 18.08 -4.71 -4.74

4/C



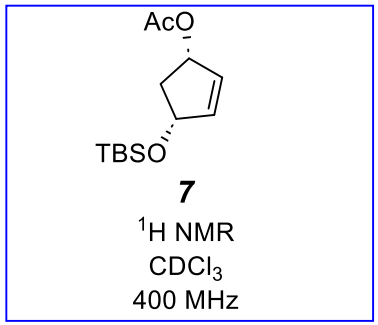

6/H
5.07
5.00
4.65
4.58
4.56
1.00
2.08
5.0
4.5
4.0
f1 (ppm)
HO
TBSO
rac-6
1H NMR
CDCl3
400 MHz
1.04
1.01
0.01
1.01
1.00
1.01
0.98
1.05
9.89
6.71
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

6/C



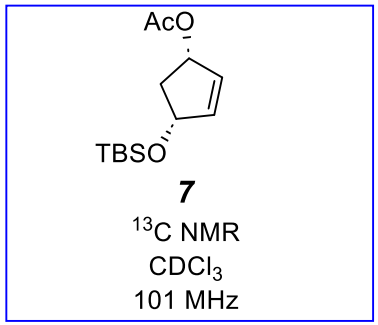
136.96
135.79
75.27
75.24
44.73
26.02
18.31
-4.53
-4.55

7/H


AcO
TBSO
7
1H NMR
CDCl3
400 MHz

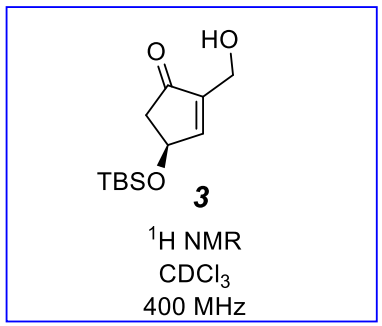
5.98 5.98 5.97 5.97 5.96 5.96 5.89 5.89 5.88 5.88 5.87 5.87 5.47 5.47 5.47 5.46 5.46 5.46 5.46 5.45 5.45 5.45 5.44 5.44 5.44 5.44
4.73 4.73 4.72 4.72 4.72 4.72 4.71 4.71 4.71 4.70 4.70 4.70 4.70 4.69 4.69
2.84 2.82 2.80 2.80 2.78 2.77 2.04 1.64 1.63 1.62 1.61 1.60 1.58 1.57 0.89 0.08 0.08
1.06 1.00 1.00 1.01 1.05 3.02 1.47 9.77 6.25
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

7/C


AcO
TBSO
7
^{13}C NMR
$CDCl_3$
101 MHz

171.03
139.02
131.27
77.06
74.97
41.27
25.98
21.31
18.29
-4.52
-4.57
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

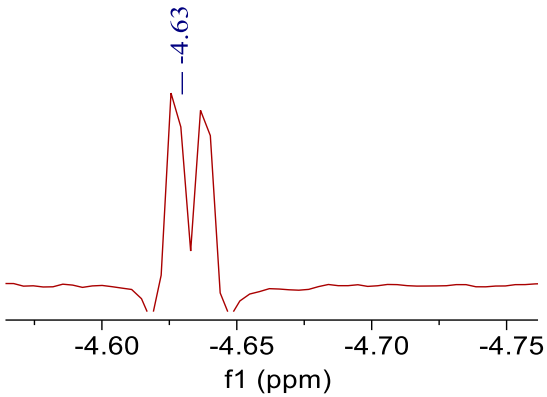
3/H

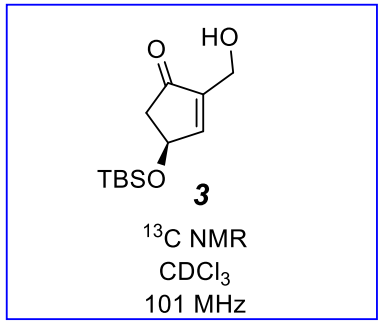

O
HO
TBSO
3
1H NMR
CDCl3
400 MHz

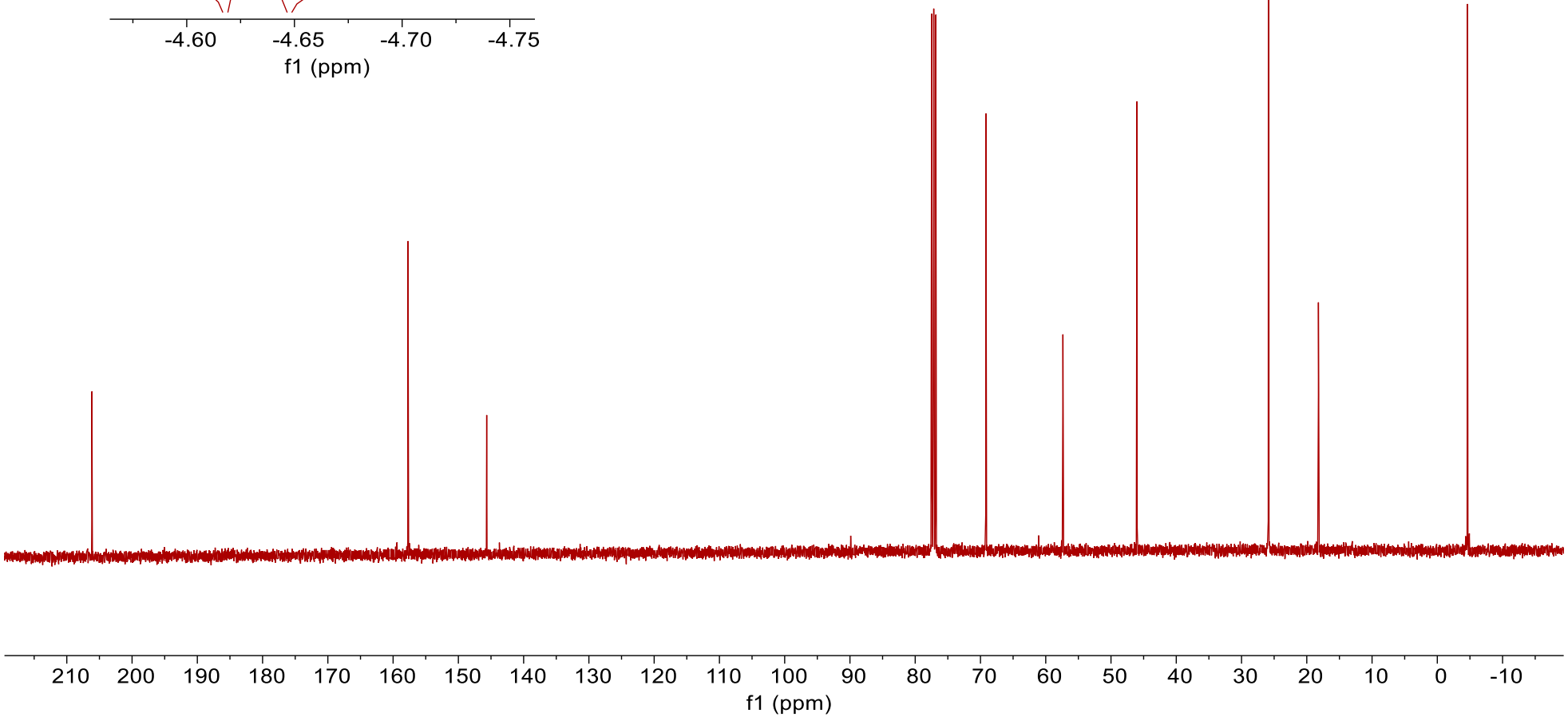
7.27
7.27
7.26
7.26
7.26
7.26
7.26
4.95
4.94
4.94
4.93
4.93
4.92
4.37
2.81
2.80
2.77
2.75
2.35
2.35
2.30
2.30
0.90
0.12
0.11
1.10
1.00
2.05
1.02
1.96
9.06
5.95
f1 (ppm)

206.15 157.72 145.66 69.17 57.37 46.01 25.86 18.22 -4.63

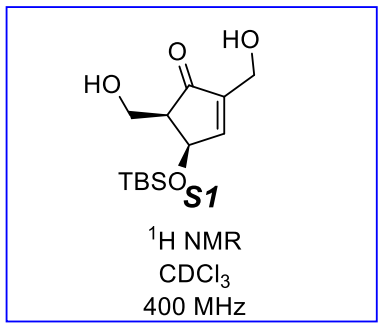
3/C







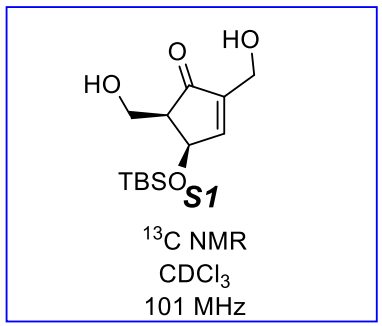
S1/H


HO
O
HO
TBSO
S1
1H NMR
CDCl3
400 MHz

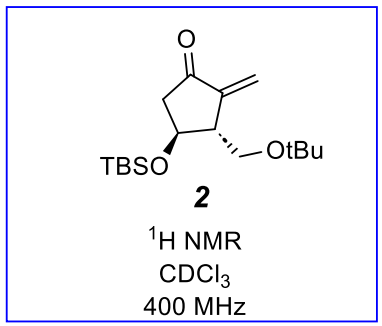
7.31
7.30
4.89
4.88
4.88
4.87
4.32
4.32
4.29
4.28
4.26
4.26
4.23
4.22
4.08
4.07
4.07
4.05
4.04
3.81
3.80
3.78
3.77
3.39
3.17
2.39
2.39
2.38
2.38
2.38
2.38
0.89
0.88
0.14
0.12
1.00
0.96
2.02
0.98
1.00
0.88
0.99
0.95
8.99
6.01
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

206.92 158.57 145.61 71.61 58.86 58.82 56.67 25.82 18.10 -4.54 -4.61

S1/C



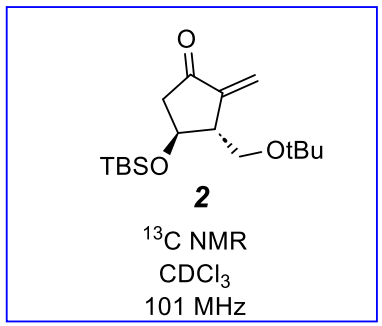
2/H

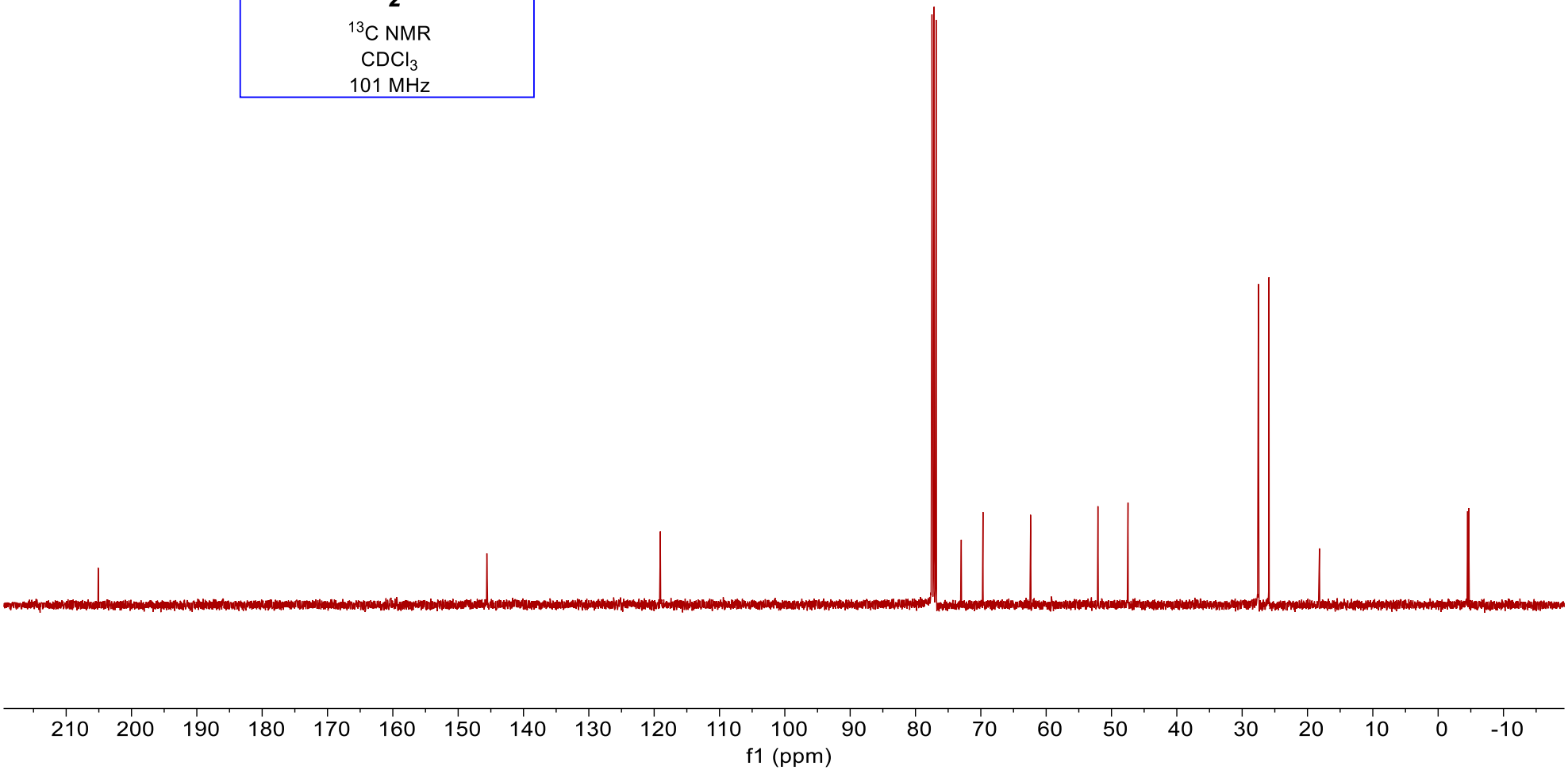

O
TBSO
OtBu
2
1H NMR
CDCl3
400 MHz

6.10
6.10
6.10
6.09
5.43
5.43
5.43
5.42
4.44
4.43
4.42
4.42
4.41
4.30
3.47
3.46
3.45
3.45
3.44
2.86
2.86
2.85
2.84
2.68
2.66
2.63
2.62
2.34
2.34
2.33
2.33
2.29
2.29
2.28
2.28
1.16
0.87
0.08
0.06
0.98
0.97
1.00
2.02
0.95
1.01
1.03
9.04
9.06
6.02
f1 (ppm)

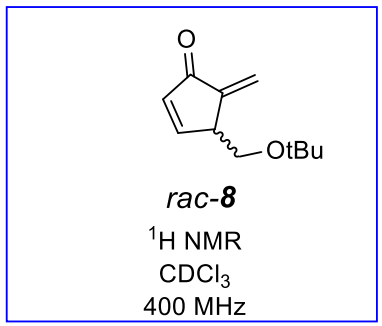
205.10
145.61
119.06
73.00
69.67
62.39
52.07
47.47
27.51
25.89
18.17
-4.51
-4.67

2/C





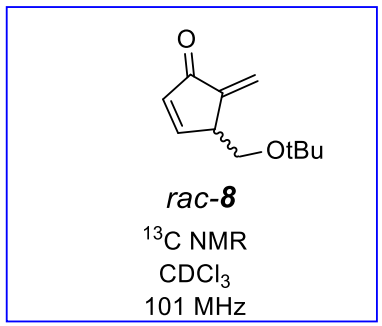
8/H


O
OtBu
rac-8
1H NMR
CDCl3
400 MHz

7.69
7.69
7.69
7.69
7.68
7.68
7.67
7.67
6.43
6.42
6.42
6.41
6.41
6.41
6.13
6.13
5.57
5.57
3.56
3.55
3.54
3.53
3.51
3.39
3.37
3.37
3.37
3.36
1.20
1.00
1.00
1.02
0.94
2.04
1.05
9.13
f1 (ppm)

8/C

196.68
160.90
143.44
135.71
117.70
73.37
63.99
45.80
27.53
27.52

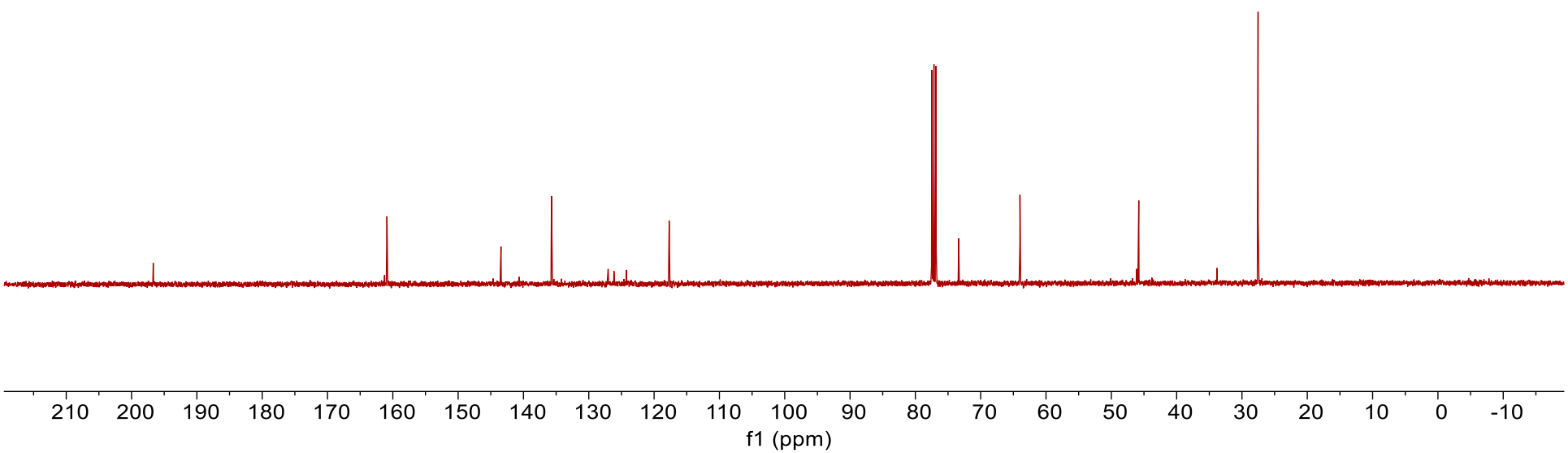


*rac-**8***

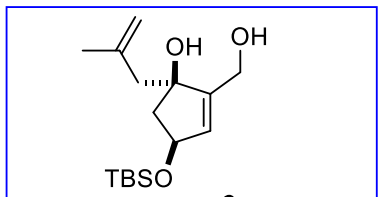
^{13}C NMR

$CDCl_3$

101 MHz

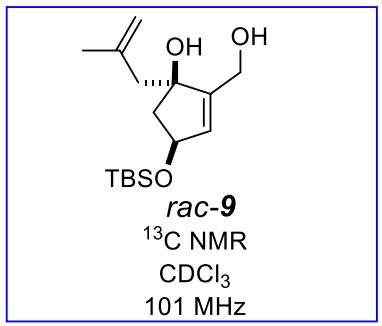


9/H



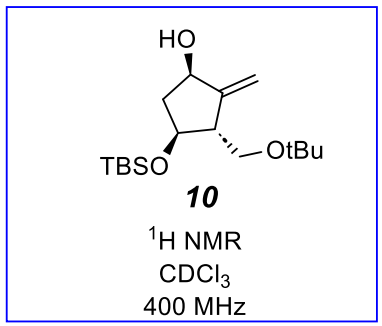
*rac-**9***
^{1}H NMR
$CDCl_3$
400 MHz

9/C


OH
OH
TBSO
rac-9
13C NMR
CDCl3
101 MHz

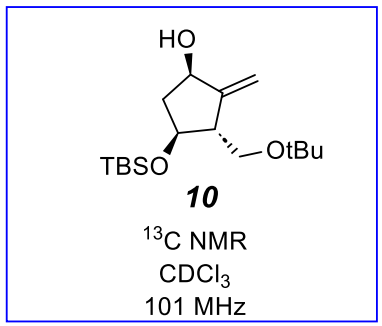
149.84
142.49
130.90
114.92
83.71
73.66
59.35
49.42
46.32
26.04
24.39
18.35
-4.56
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

10/H


HO
TBSO
OtBu
10
1H NMR
CDCl3
400 MHz

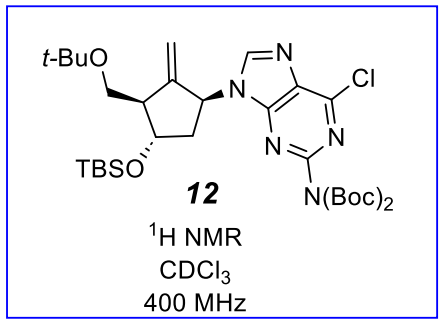
5.37
5.36
5.13
5.12
4.34
4.33
4.33
4.32
4.32
3.31
3.30
3.29
3.27
3.03
3.00
2.98
2.77
2.77
2.77
2.76
2.76
2.75
2.75
2.74
2.74
2.73
2.73
1.14
0.87
0.87
0.86
0.08
0.08
1.00
0.96
1.98
0.98
1.02
0.83
0.96
1.02
9.49
9.67
6.07
f1 (ppm)

10/C


HO
TBSO
OtBu
10
13C NMR
CDCl3
101 MHz

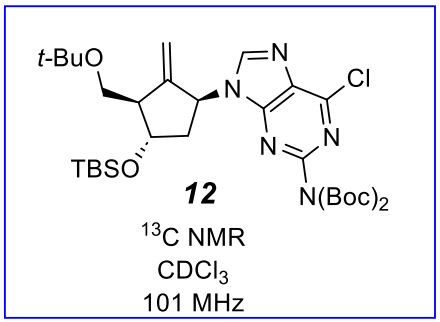
154.79
111.78
76.40
76.08
72.81
63.63
53.27
42.03
27.57
25.97
18.10
-4.66
-4.75
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

12/H


t-BuO
TBSO
Cl
N
N
N
N
N(Boc)2
12
1H NMR
CDCl3
400 MHz

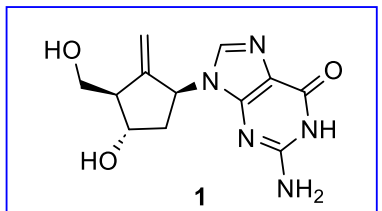
9.45
5.66
5.65
5.64
5.63
5.62
5.61
5.28
5.27
5.26
5.25
4.92
4.91
4.90
4.39
4.38
4.37
4.36
3.61
3.61
3.60
3.59
2.67
2.66
2.31
2.30
2.29
2.28
2.27
2.26
2.25
2.21
2.20
2.19
2.18
2.17
2.16
2.15
1.41
1.21
0.86
0.04
0.02
1.00
0.97
1.08
0.99
0.98
1.98
0.99
1.93
19.30
9.63
9.42
6.45
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

12/C


t-BuO
TBSO
Cl
N(Boc)2
12
13C NMR
CDCl3
101 MHz

152.79
151.73
150.91
150.60
149.31
146.21
130.13
112.44
83.56
73.21
73.10
62.30
57.04
53.04
41.54
27.97
27.58
25.87
18.09
-4.56
-4.68
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

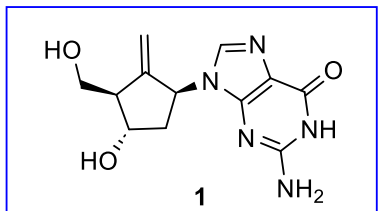
1/H



1

^{1}H NMR
DMSO-d^{6}
400 MHz

1/C



1

^{13}C NMR
DMSO-d^{6}
101 MHz