Supporting Information

Concise Asymmetric Total Synthesis of (+)-Arbornamine

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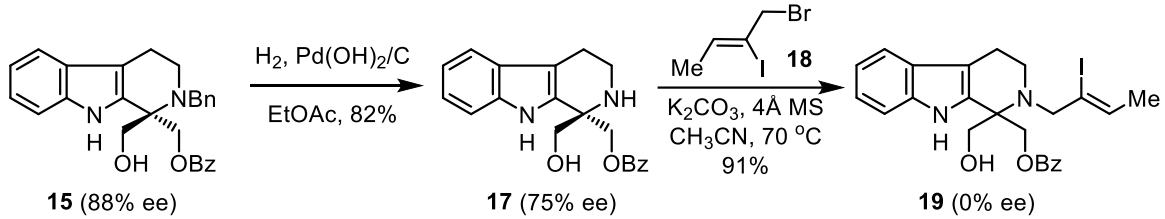
I. General information

All reactions were carried out under nitrogen atmosphere and under anhydrous conditions except noted. Anhydrous THF (tetrahydrofuran), DCM (dichloromethane) were obtained from Inert PS-MD-4. Anhydrous CH_3CN (acetonitrile), EtOAc (ethyl acetate) were purchased from Energy Chemical, Ltd. Anhydrous Et_3N (triethyl amine) was distilled from calcium hydride under a nitrogen atmosphere prior to use. All other commercial reagents were used as received. Analytical samples were obtained by chromatography on silica gel using an EtOAc/petroleum ether or DCM/MeOH mixture as the eluent. ^1H NMR and ^{13}C NMR spectra were recorded on a Bruker Avance 400 MHz NMR spectrometer (400 MHz for ^1H, 100 MHz for ^{13}C), Bruker Avance 500 MHz NMR spectrometer (500 MHz for ^1H, 125 MHz for ^{13}C). The chemical shifts were referenced using residual undeuterated solvent ($CDCl_3$: δ 7.26, 77.0 ppm; DMSO-d_6: δ 2.50, 39.52 ppm unless otherwise stated). High-resolution mass spectra were obtained with a LCMS-IT-TOF mass spectrometer. The IR spectra were recorded on Nicolet Nexus 670 FT-IR spectrometer. Optical rotations were measured on Anton Paar MCP 200 polarimeter at ambient temperature using the sodium D line. Melting points were measured on OptiMelt MPA100 micro melting point apparatus and were uncorrected. Chiral HPLC analyses were performed Agilent 1200 HPLC system. TLC was performed using commercially prepared 100-400 mesh silica gel plates (GF254), and visualization was effected at 254 nm, or by staining ceric ammonium molybdate, phosphomolybdic acid or potassium permanganate.

II. Synthetic Procedures and Characterization Data

Original route to prepare compound 19



15 (88% ee) **17** (75% ee) **19** (0% ee)

Compound **15** was prepared from *N*-benzyl-2-(1*H*-indol-3-yl)ethan-1-amine hydrochloride according to our previous report.[1] Spectroscopic data of synthetic compound **15** matched well with our previous report.

To a solution of **15** (298.3 mg, 0.70 mmol, 1.0 equiv) in EtOAc (7 mL) was added $Pd(OH)_2/C$ (20%wt based on carbon, wetted with 50%wt H_2O, 196.5 mg, 0.070 mmol, 0.1 equiv) at room temperature. The system was degassed and refilled with H_2 for three times. After stirred at room temperature overnight under H_2 atmosphere, the mixture was filtered through a pad of Celite (washed with MeOH) and concentrated. The residue was purified by flash column chromatography on silica gel (DCM/MeOH = 30:1) to give **17** as a white solid (194 mg, 82%).

^{1}H NMR (500 MHz, DMSO-d_6) δ 10.64 (s, 1H), 7.94 (d, J = 7.7 Hz, 2H), 7.63 (t, J = 7.4 Hz, 1H), 7.49 (t, J = 7.6 Hz, 2H), 7.40 (d, J = 7.8 Hz, 1H), 7.33 (d, J = 8.0 Hz, 1H), 7.02 (t, J = 7.5 Hz, 1H), 6.94 (t, J = 7.4 Hz, 1H), 5.04 (brs, 1H), 4.53 (d, J = 11.1 Hz, 1H), 4.48 (d, J = 11.1 Hz, 1H), 3.82 (d, J = 10.6 Hz, 1H), 3.67 (d, J = 10.6 Hz, 1H), 3.09 (t, J = 6.2 Hz, 2H), 2.75 – 2.52 (m, 2H).

^{13}C NMR (125 MHz, DMSO-d_6) δ 165.7, 135.8, 134.4, 133.3, 129.8, 129.3, 128.6, 126.6, 120.6, 118.1 117.6, 111.2 109.2, 66.6, 64.2, 57.2, 39.1, 22.3.

IR (KBr): 3298, 3104, 2920, 2849, 1702, 1452, 1279, 1120, 1070, 700 cm^{-1}.

HRMS (ESI): *m/z* calcd for $C_{20}H_{21}N_2O_3$, $[M+H]^+$: 337.1547, found: 337.1540.

M. p. = 182–184 ℃.

To a flask was added dry 4 Å molecular sieves (42 mg), then K_2CO_3 (365.3 mg, 1.4 mmol, 2.8 equiv), a solution of **17** (168 mg, 0.50 mmol, 1.0 equiv) in CH_3CN (1 mL) and (*Z*)-1-bromo-2-iodobut-2-ene (**18**) (125.2 mg, 0.48 mmol, 1.2 equiv) were added at room temperature. The resulting solution was stirred at 70 ℃ overnight in the dark. After cooled to room temperature, the reaction was quenched with water and extracted with EtOAc. The combined organic layers were washed with brine, dried over Na_2SO_4, filtered and concentrated *in vacuo*. The residue was purified by flash silica gel column chromatography (petroleum ether/EtOAc = 3:1 with 0.5% NEt_3) to afford **19** (235.9 mg, 91%) as a yellow solid.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.47 (s, 1H), 8.04 – 7.98 (m, 2H), 7.61 (t, J= 7.4 Hz, 1H), 7.53 –7.44 (m, 3H), 7.31 (d, J= 8.0 Hz, 1H), 7.16 (t, J= 7.5 Hz, 1H), 7.10 (t, J= 7.7 Hz, 1H), 6.01 (q, J= 6.4 Hz, 1H), 4.80 (d, J= 12.0 Hz, 1H), 4.69 (d, J= 12.1 Hz, 1H), 4.00 (s, 2H), 3.84 (d, J = 14.1 Hz, 1H), 3.36 (d, J= 14.1 Hz, 1H), 3.22 (brs, 1H), 3.12 (ddd, J= 12.0, 5.5, 3.0 Hz, 1H), 3.01 (ddd, J=12.0, 9.8, 4.2 Hz, 1H), 2.87 (ddd, J= 15.2, 9.8, 5.5 Hz, 1H), 2.77 (ddd, J= 15.2, 3.6, 3.6 Hz, 1H), 1.85 (d, J= 6.4 Hz, 3H).

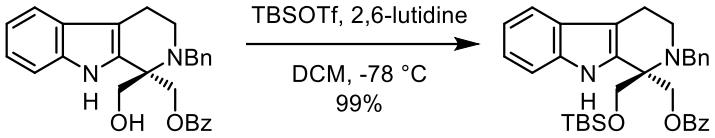
^{13}C NMR (125 MHz, $CDCl_3$) δ 166.6, 136.4, 133.4, 132.7, 132.3, 129.6, 129.4, 128.6, 126.5, 122.0, 119.2, 118.2, 111.8, 111.2, 111.1, 64.8, 62.5, 61.5, 60.4, 43.5, 21.7, 21.1.

IR (KBr): 3046, 2924, 2840, 1787, 1452, 1282, 1100, 1045, 756, 704 cm^{-1}.

HRMS (ESI): *m/z* calcd for $C_{24}H_{26}IN_2O_3$, $[M+H]^+$: 517.0988, found: 517.0983.

M. p. = 154–157 ℃.

Preparation of compound 20



15 (88% ee) **20** (87% ee)

To a solution of **15** (212 mg, 0.50 mmol, 1.0 equiv) in DCM (5 mL) was added 2,6-lutidine (290 μL, 2.49 mmol, 5.0 equiv) and TBSOTf (286 μL, 1.24 mmol, 2.5 equiv) at –78 ℃. After stirred at the same temperature for 45 min, the reaction was quenched with saturated aqueous $NaHCO_3$ and extracted with DCM. The combined organic layers were washed with brine, dried over Na_2SO_4, filtered and concentrated *in vacuo*. The residue was purified by flash silica gel column chromatography (petroleum ether/EtOAc = 15:1) to afford **20** (263.4 mg, 99%) as a yellow oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.76 (s, 1H), 7.96 (d, J = 7.7 Hz, 2H), 7.52 (t, J = 7.4 Hz, 1H), 7.48 (d, J = 7.8 Hz, 1H), 7.39 (t, J = 7.3 Hz, 2H), 7.36 (d, J = 7.6 Hz, 2H), 7.30 – 7.25 (m, 3H), 7.24 – 7.18 (m, 1H), 7.14 (t, J = 7.6 Hz, 1H), 7.06 (t, J = 7.5 Hz, 1H), 4.88 (d, J = 12.0 Hz, 1H), 4.82 (d, J = 12.0 Hz, 1H), 4.30 (d, J = 9.3 Hz, 1H), 4.25 (d, J = 14.5 Hz, 1H), 3.83 (d, J = 9.3 Hz, 1H), 3.79 (d, J = 14.5 Hz, 1H), 3.08 (ddd, J = 13.0, 9.6, 4.4 Hz, 1H), 2.92 (ddd, J = 12.1, 4.4 Hz, 4.2 Hz, 1H), 2.72 (ddd, J = 14.8, 9.6, 5.3 Hz, 1H), 2.64 (ddd, J = 15.2, 4.2, 4.2 Hz, 1H), 0.90 (s, 9H), 0.00 (s, 3H), -0.01 (s, 3H).

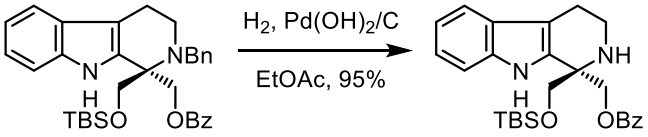
^{13}C NMR (125 MHz, $CDCl_3$) δ 166.2, 140.9, 136.0, 134.7, 133.0, 130.2, 129.5, 128.5, 128.3, 127.9, 126.9, 126.5, 121.8, 119.1, 118.3, 110.9, 110.2, 66.1, 64.3, 60.4, 54.1, 45.2, 25.8, 21.1, 18.1, -5.69, -5.70.

IR (KBr): 3063, 2930, 2853, 1719, 1641, 1459, 1268, 1109, 840, 749 cm^{-1}.

HRMS (ESI): *m/z* calcd for $C_{33}H_{41}N_2O_3Si$, $[M+H]^+$: 541.2881, found: 541.2878.

$[\boldsymbol{\alpha}]_{\boldsymbol{D}}^{\mathbf{24}}$ = +22 (*c* 0.1, $CHCl_3$).

Preparation of compound 21



20 **21**

To a solution of **20** (249.4 mg, 0.46 mmol, 1.0 equiv) in EtOAc (10 mL) was added $Pd(OH)_2/C$ (20%wt based on carbon, wetted with 50%wt H_2O, 145 mg, 0.046 mmol, 0.1 equiv) at room temperature. The system was degassed and refilled with H_2 for five times. After stirred at room temperature overnight under H_2 atmosphere, the mixture was filtered through a pad of Celite (washed with MeOH) and concentrated *in vacuo*. The residue was purified by flash silica gel column chromatography (petroleum ether/EtOAc = 4:1 with 0.5% NEt_3) to give **21** as a yellow oil (198.2 mg, 95%).

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.48 (s, 1H), 8.02 (d, J = 7.6 Hz, 2H), 7.58 (t, J = 7.2 Hz, 1H), 7.53 (d, J = 7.9 Hz, 1H), 7.45 (t, J = 7.2 Hz, 2H), 7.30 (d, J = 8.0 Hz, 1H), 7.17 (t, J = 7.6 Hz, 1H), 7.10 (t, J = 7.4 Hz, 1H), 4.68 (d, J = 11.2 Hz, 1H), 4.59 (d, J = 11.2 Hz, 1H), 3.93 (d, J = 9.3 Hz, 1H), 3.73 (d, J = 9.3 Hz, 1H), 3.28 (dt, J = 12.5, 4.7 Hz, 1H), 3.17 (dt, J = 12.5, 4.7 Hz, 1H), 2.87 – 2.71 (m, 2H), 0.94 (s, 9H), 0.06 (s, 3H), 0.05 (s, 3H).

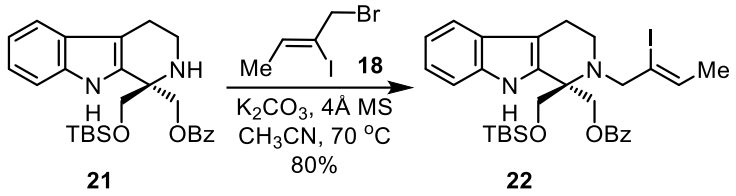
^{13}C NMR (125 MHz, $CDCl_3$) δ 166.1, 135.8, 134.0, 133.2, 129.9, 129.5, 128.5, 126.8, 121.9, 119.3, 118.4, 110.9, 110.0, 66.6, 64.7, 56.6, 39.5, 25.9, 22.3, 18.1, -5.6, -5.7.

IR (KBr): 3060, 2936, 2857, 1718, 1458, 1268, 1105, 839, 779, 711 cm^{-1}.

HRMS (ESI): *m/z* calcd for $C_{26}H_{35}N_2O_3Si$, $[M+H]^+$: 451.2411, found: 451.2408.

$[\boldsymbol{\alpha}]_{\boldsymbol{D}}^{\mathbf{24}}$ = +4 (*c* 0.1, $CHCl_3$).

Preparation of compound 22



To a flask was added dry 4 Å molecular sieves (20 mg), then K_2CO_3 (147.0 mg, 1.1 mmol, 5.0 equiv), a solution of **21** (95.7 mg, 0.21 mmol, 1.0 equiv) in CH_3CN (2.2 mL) and (*Z*)-1-bromo-2-iodobut-2-ene (**18**) (33.3 μL, 0.26 mmol, 1.2 equiv) were added at room temperature. The resulting solution was stirred at 70 ℃ overnight in the dark. After cooled to room temperature, the reaction was quenched with water and extracted with EtOAc. The combined organic layers were washed with brine, dried over Na_2SO_4, filtered and concentrated *in vacuo*. The residue was purified by flash silica gel column chromatography (petroleum ether/EtOAc = 12:1→6:1) to afford **22** (107.3 mg, 80%) as a yellow oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.73 (s, 1H), 7.98 (d, J = 7.7 Hz, 2H), 7.56 (t, J = 7.5 Hz, 1H), 7.52 (d, J = 7.7 Hz, 1H), 7.44 (t, J = 7.6 Hz, 2H), 7.29 (d, J = 8.1 Hz, 1H), 7.17 (t, J = 7.5 Hz, 1H), 7.09 (t, J = 7.4 Hz, 1H), 5.99 (q, J = 6.4 Hz, 1H), 4.81 (d, J = 12.1 Hz, 1H), 4.78 (d, J = 12.1 Hz, 1H), 4.28 (d, J = 9.5 Hz, 1H), 3.89 (d, J = 14.9 Hz, 1H), 3.85 (d, J = 9.5 Hz, 1H), 3.46 (d, J = 14.9 Hz, 1H), 3.08 (ddd, J = 13.2, 9.3, 4.3 Hz, 1H), 3.01 (ddd, J = 12.0, 4.3, 4.3 Hz, 1H), 2.82 (ddd, J = 14.7, 9.3, 5.3 Hz, 1H), 2.74 (ddd, J = 15.1, 3.5, 3.5 Hz, 1H), 1.81 (d, J = 6.4 Hz, 3H), 0.94 (s, 9H), 0.05 (s, 6H).

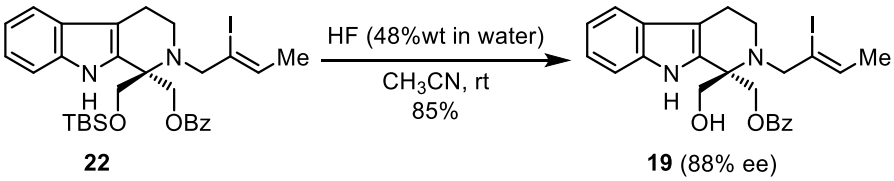
^{13}C NMR (125 MHz, $CDCl_3$) δ 166.1, 136.0, 134.6, 133.1, 130.8, 130.1, 129.6, 128.5, 126.4, 121.8, 119.2, 118.3, 111.7, 110.9, 110.3, 65.9, 64.4, 61.9, 60.0, 44.5, 25.9, 21.7, 21.3, 18.1, -5.67, -5.68.

IR (KBr): 3058, 2929, 2855, 1720, 1644, 1462, 1268, 1109, 839, 710 cm^{-1}.

HRMS (ESI): *m/z* calcd for $C_{30}H_{40}IN_2O_3Si$, $[M+H]^+$: 631.1847, found: 631.1842.

$[\alpha]_D^{24}$ = +10 (*c* 0.1, $CHCl_3$).

Preparation of compound 19



To a solution of **22** (205.6 mg, 0.33 mmol, 1.0 equiv) in CH_3CN (3.3 mL) was added 48% aqueous HF (60 μL, 0.49 mmol, 1.5 equiv) at room temperature. After stirred at room temperature for 50 min, the reaction was quenched slowly with saturated aqueous $NaHCO_3$ and extracted with EtOAc, the pH value of aqueous layer should be 7-8. The combined organic layers were washed with brine, dried over Na_2SO_4, filtered and concentrated *in vacuo*. The residue was purified by flash silica gel column chromatography (petroleum ether/EtOAc = 3:1→2:1 with 0.5% NEt_3) to afford **19** (141.2 mg, 85%) as a white soild.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.50 (s, 1H), 8.01 (d, J = 7.7 Hz, 2H), 7.61 (t, J = 7.5 Hz, 1H), 7.54 – 7.44 (m, 3H), 7.30 (d, J = 8.0 Hz, 1H), 7.16 (t, J = 7.5 Hz, 1H), 7.09 (t, J = 7.4 Hz, 1H), 6.01 (q, J = 6.4 Hz, 1H), 4.79 (d, J = 12.1 Hz, 1H), 4.69 (d, J = 12.1 Hz, 1H), 3.99 (d, J = 4.6 Hz, 2H), 3.83 (d, J = 14.1 Hz, 1H), 3.35 (d, J = 14.1 Hz, 1H), 3.22 (brs, 1H), 3.15 – 3.09 (m, 1H), 3.01 (ddd, J = 15.2, 12.1, 4.0 Hz, 1H), 2.87 (ddd, J = 15.2, 9.8, 5.5 Hz, 1H), 2.77 (ddd, J = 15.2, 3.6, 3.6 Hz, 1H), 1.85 (d, J = 6.4 Hz, 3H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 166.7, 136.4, 133.6, 132.8, 132.4, 129.7, 129.4, 128.7, 126.5, 122.1, 119.4, 118.3, 111.9, 111.2, 111.1, 64.8, 62.8, 61.5, 60.5, 43.4, 21.8, 21.1.

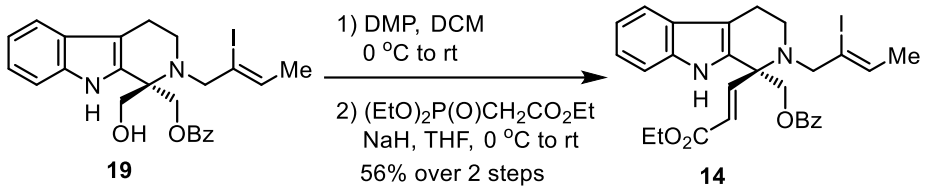
IR (KBr): 3046, 2924, 2840, 1787, 1452, 1282, 1100, 1045, 756, 704 cm^{-1}.

HRMS (ESI): *m/z* calcd for $C_{24}H_{26}IN_2O_3$, $[M+H]^+$: 517.0988, found: 517.0983.

M. p. = 154–157 ℃.

$[\alpha]_D^{24}$ = –28 (*c* 0.1, $CHCl_3$).

Preparation of compound 14



To a solution of **19** (130 mg, 0.25 mmol, 1.0 equiv) in DCM (2.6 mL) was added Dess-Martin periodinane (193 mg, 0.45 mmol, 1.8 equiv) at 0 ℃. The solution was warmed to room temperature and stirred for 40 min, the reaction was quenched with saturated aqueous $Na_2S_2O_3$ and saturated aqueous $NaHCO_3$. The solution was extracted with EtOAc. The combined organic layers were washed with brine, dried over Na_2SO_4, filtered and concentrated *in vacuo*. The obtained crude aldehyde product was used directly for the next step.

To a solution of NaH (60%wt in mineral oil, 50.4 mg, 1.26 mmol, 5.0 equiv) in THF (1.8 mL) was added $(EtO)_2P(O)CH_2CO_2Et$ (0.25 mL, 1.25 mmol, 5.0 equiv) at 0 ℃. The solution was warmed to room temperature and stirred for 30 min, then a solution of crude aldehyde product obtained above in THF (1.5 mL) was added dropwise. After stirred at room temperature for 15 min, the reaction was quenched with saturated aqueous NH_4Cl. The solution was diluted with water and extracted with EtOAc. The combined organic layers were washed with brine, dried over Na_2SO_4, filtered and concentrated *in vacuo*. The residue was purified by flash silica gel column chromatography (petroleum ether/EtOAc = 15:1→10:1→7:1) to afford **14** (82 mg, 56% over two steps) as a brown oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97 (s, 1H), 7.95 (d, J = 7.6 Hz, 2H), 7.57 (t, J = 7.5 Hz, 1H), 7.50 (d, J = 7.7 Hz, 1H), 7.44 (t, J = 7.6 Hz, 2H), 7.25 (d, J = 10.5 Hz, 1H), 7.17 – 7.06 (m, 3H), 6.00 (q, J = 6.4 Hz, 1H), 5.96 (d, J = 16.3 Hz, 1H), 4.90 (d, J = 11.7 Hz, 1H), 4.70 (d, J = 11.7 Hz, 1H), 4.16 (q, J = 7.1 Hz, 2H), 3.65 (d, J = 14.6 Hz, 1H), 3.40 (d, J = 14.6 Hz, 1H), 3.07 – 2.95 (m, 1H), 2.93 – 2.84 (m, 1H), 2.84 – 2.74 (m, 2H), 1.80 (d, J = 6.4 Hz, 3H), 1.24 (t, J = 7.1 Hz, 3H).

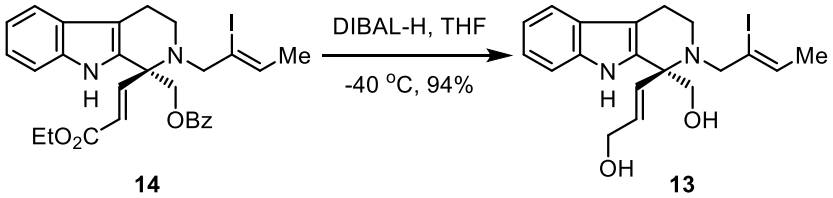
^{13}C NMR (125 MHz, $CDCl_3$) δ 166.1, 166.0, 147.0, 136.3, 133.2, 131.6, 131.3, 129.5, 129.4, 128.4, 126.5, 123.9, 122.1, 119.3, 118.4, 111.2, 111.0, 110.2, 66.1, 61.7, 61.3, 60.7, 43.4, 21.6, 21.3, 14.0.

IR (KBr): 3058, 2908, 2821, 1711, 1454, 1373, 1268, 1179, 1106, 711 cm^{-1}.

HRMS (ESI): *m/z* calcd for $C_{28}H_{30}IN_2O_4$, $[M+H]^+$: 585.1245, found: 585.1240.

$[\alpha]_D^{24}$ = –9 (*c* 0.1, $CHCl_3$).

Preparation of compound 13



To a solution of **14** (28.4 mg, 0.049 mmol, 1.0 equiv) in THF (0.5 mL) was added DIBAL-H (0.5 mL, 1.0 M in hexane, 0.5 mmol, 10 equiv) at –40 ℃. After stirred at the same temperature for 1 hour, the reaction was quenched with saturated aqueous Rochelle salt, and the resulting mixture was stirred at room temperature until clear. The solution was extracted with EtOAc. The combined organic layers were washed with brine, dried over Na_2SO_4, filtered and concentrated *in vacuo*. The residue was purified by PTLC (DCM/MeOH = 15:1) to afford **13** (20 mg, 94%) as a white solid.

^{1}H NMR (500 MHz, DMSO-d_6) δ 10.49 (s, 1H), 7.37 (d, J = 7.8 Hz, 1H), 7.30 (d, J = 8.0 Hz, 1H), 7.02 (t, J = 7.5 Hz, 1H), 6.94 (t, J = 7.4 Hz, 1H), 6.11 (q, J = 6.4 Hz, 1H), 5.78 (d, J = 15.9 Hz, 1H), 5.53 (dt, J = 15.9, 4.5 Hz, 1H), 4.71 (t, J = 5.1 Hz, 1H), 4.07 – 3.83 (m, 5H), 3.67 (d, J = 14.6 Hz, 1H), 3.16 (d, J = 14.6 Hz, 1H), 2.98 – 2.83 (m, 1H), 2.74 – 2.59 (m, 3H), 1.79 (d, J = 6.4 Hz, 3H).

^{13}C NMR (125 MHz, DMSO-d_6) δ 136.1, 135.7, 134.1, 131.3, 128.1, 126.2, 120.6, 118.0, 117.4, 112.4, 111.0, 108.8, 63.7, 62.6, 61.2, 60.1, 42.9, 21.7, 21.3.

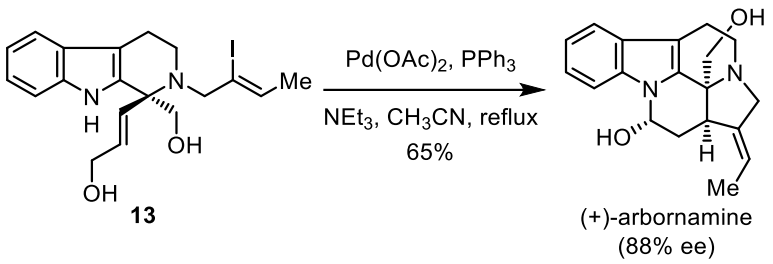
IR (KBr): 3742, 3235, 2868, 1641, 1382, 1301, 1093, 1029, 912, 742 cm^{-1}.

HRMS (ESI): *m/z* calcd for $C_{19}H_{24}IN_2O_2$, $[M+H]^+$: 439.0877, found: 439.0872.

M. p. = 192–195 °C.

$[\alpha]_D^{24}$ = +44 (*c* 0.1, $CHCl_3$).

Preparation of (+)-arbornamine



To a solution of **13** (20.0 mg, 0.046 mmol, 1.0 equiv) and PPh_3 (3.6 mg, 0.014 mmol, 0.3 equiv) in CH_3CN (1.5 mL) were added NEt_3 (19 μL, 0.098 mmol, 3.0 equiv) and $Pd(OAc)_2$ (1.0 mg, 0.0046 mmol, 0.1 equiv). The solution was heated to 90 °C and stirred at this temperature for 40 min. After cooled to room temperature, the reaction was quenched with saturated aqueous $NaHCO_3$ and extracted with EtOAc. The combined organic layers were washed with brine, dried over Na_2SO_4, filtered and concentrated *in vacuo*. The residue was purified by PTLC (DCM/MeOH = 15:1) to afford *ent*-arbornamine (9.2 mg, 65%) as a yellow solid.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.51 (d, *J* = 7.8 Hz, 1H), 7.44 (d, *J* = 8.1 Hz, 1H), 7.23 (t, *J* = 7.7 Hz, 1H), 7.15 (t, *J* = 7.5 Hz, 1H), 5.85 (t, *J* = 2.9 Hz, 1H), 5.37 (q, *J* = 7.0 Hz, 1H), 4.12 (d, *J* = 10.6 Hz, 1H), 3.80 (d, *J* = 10.6 Hz, 1H), 3.56 (dd, *J* = 9.2, 9.2 Hz, 1H), 3.49 – 3.39 (m, 1H), 3.34 (d, *J* = 11.3 Hz, 1H), 3.30 (d, *J* = 11.3 Hz, 1H), 3.21 (dd, *J* = 14.6, 6.3 Hz, 1H), 2.90 (ddd, *J* = 17.4, 11.3, 6.4 Hz, 1H), 2.70 – 2.65 (m, 1H), 2.65 – 2.61 (m, 1H), 1.65 (d, *J* = 7.0 Hz, 3H), 1.08 (ddd, *J* = 13.5, 10.3, 2.5 Hz, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 140.1, 138.1, 133.6, 128.2, 122.4, 120.5, 118.9, 117.3, 110.2, 107.9, 76.1, 66.8, 64.9, 54.3, 41.6, 37.0, 36.0, 16.7, 14.2.

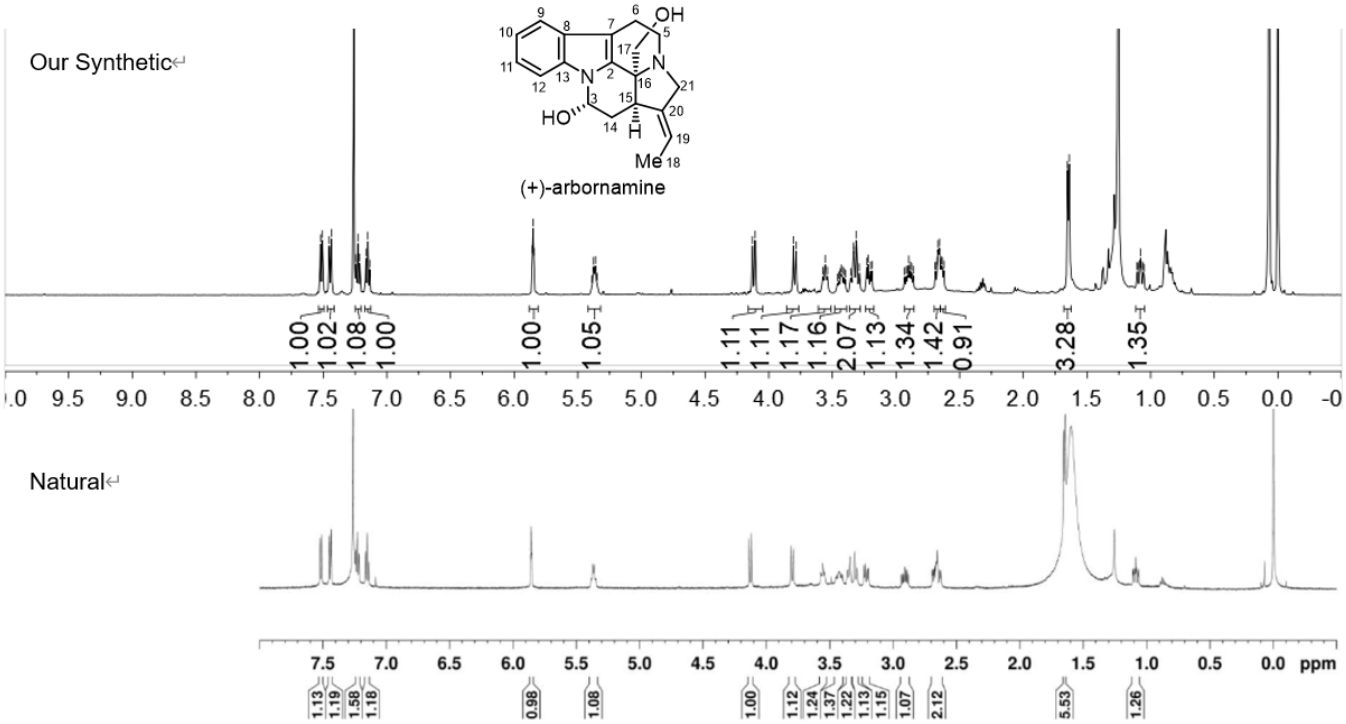
IR (KBr): 3741, 3255, 3062, 2930, 1690, 1450, 1331, 1207, 1077, 740 cm^{-1}.

HRMS (ESI): *m/z* calcd for $C_{19}H_{23}N_2O_2$, $[M+H]^+$: 311.1754, found: 311.1750.

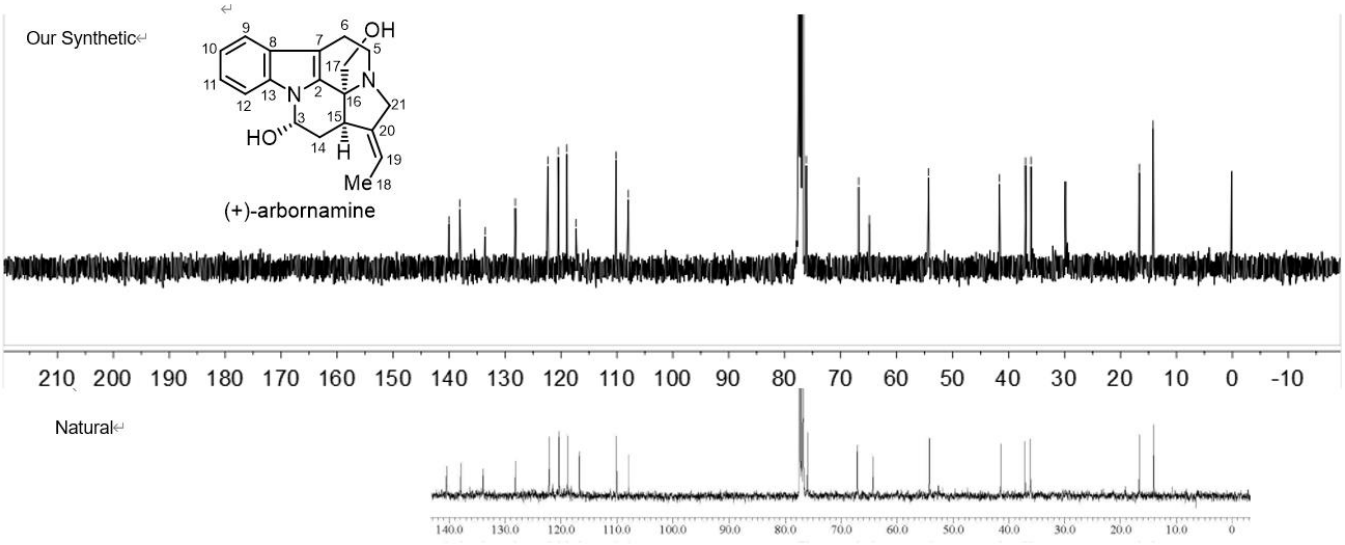
M. p. = 163–165 °C.

$[\alpha]_D^{24}$ = +32.5 (*c* 0.07, $CHCl_3$).

III. Comparison of the Spectra and Data of Natural and Synthetic Arbornamine



H	Natural[2] (600 MHz, $CDCl_3$)	This synthetic (500 MHz, $CDCl_3$)	Our previous synthetic[3] (400 MHz, $CDCl_3$)	Yang's synthetic[4] (400 MHz, $CDCl_3$)
2	-	-	-	
3α	5.86 (t, *J* = 3.0, 1H)	5.85 (t, *J* = 2.9, 1H)	5.86 (s, 1H)	5.82 (t, *J* = 2.8, 1H)
3β	-	-	-	
5α	3.21 (dd, *J* = 15.0, 6.0, 1H)	3.21 (dd, *J* = 14.6, 6.3, 1H)	3.18 (dd, *J* = 14.6, 6.0, 1H)	3.18 (dd, *J* = 14.7, 6.1, 1H)
5β	3.43 – 3.35 (m, 1H)	3.49 – 3.39 (m, 1H)	3.43 – 3.35 (m, 1H)	3.41 – 3.38 (m, 1H)
6α	2.91 (ddd, *J* = 16.0, 11.0, 6.0, 1H)	2.90 (ddd, *J* = 17.4, 11.3, 6.4, 1H)	2.89 (ddd, *J* = 16.4, 10.6, 6.7, 1H)	2.86 (ddd, *J* = 15.6, 11.1, 6.2, 1H)
6β	2.64 (dd, *J* = 16.0, 6.0, 1H)	2.65 – 2.61 (m, 1H)	2.63 (dd, *J* = 16.4, 6.0, 1H)	2.61 (dd, *J* = 15.7, 6.1, 1H)
7	-	-	-	-
8	-	-	-	-
9	7.52 (d, *J* = 8.0, 1H)	7.51 (d, *J* = 7.8, 1H)	7.51 (d, *J* = 7.9, 1H)	7.50 (d, *J* = 8.1, 1H)
10	7.15 (t, *J* = 8.0, 1H)	7.15 (t, *J* = 7.5, 1H)	7.14 (t, *J* = 7.5, 1H)	7.14 (t, *J* = 7.8, 1H)
11	7.23 (t, *J* = 8.0, 1H)	7.23 (t, *J* = 7.7, 1H)	7.22 (t, *J* = 7.5, 1H)	7.21 (t, *J* = 7.8, 1H)
12	7.44 (d, *J* = 8.0, 1H)	7.44 (d, *J* = 8.1, 1H)	7.43 (d, *J* = 7.9, 1H)	7.43 (d, *J* = 8.1, 1H)
13	-	-	-	
14α	1.09 (ddd, *J* = 14.0, 10.0, 3.0, 1H)	1.08 (ddd, *J* = 13.5, 10.3, 2.5, 1H)	1.06 (t, *J* = 11.9, 1H)	1.05 (ddd, *J* = 13.5, 10.5, 2.7, 1H)
14β	2.68 (ddd, *J* = 14.0, 8.0, 3.0, 1H)	2.70 – 2.65 (m, 1H)	2.69 – 2.56 (m, 1H)	2.66 (ddd, *J* = 13.5, 8.1, 3.2, 1H)
15	3.56 (dd, *J* = 10.0, 8.0, 1H)	3.56 (dd, *J* = 9.2, 9.2 Hz, 1H)	3.51 (t, *J* = 8.7, 1H)	3.50 (t, *J* = 8.9, 1H)
16	-	-	-	-
17a	3.80 (d, *J* = 11.0, 1H)	3.80 (d, *J* = 10.6, 1H)	3.75 (d, *J* = 10.3, 1H)	3.73 (d, *J* = 10.8, 1H)
17b	4.13 (d, *J* = 11.0, 1H)	4.12 (d, *J* = 10.6, 1H)	4.08 (d, *J* = 10.3, 1H)	4.07 (d, *J* = 10.8, 1H)
18	1.65 (d, *J* = 6.0, 3H)	1.65 (d, *J* = 7.0, 3H)	1.64 (d, *J* = 6.4, 3H)	1.63 (d, *J* = 6.3, 3H)
19	5.36 (q, *J* = 6.0, 1H)	5.37 (q, *J* = 7.0, 1H)	5.35 (q, *J* = 6.4, 1H)	5.34 (q, *J* = 6.2, 1H)
20	-	-	-	-
21α	3.35 (d, *J* = 11.0, 1H)	3.34 (d, *J* = 11.3, 1H)	3.32 (d, *J* = 11.3, 1H)	3.36 (d, *J* = 10.8, 1H)
21β	3.30 (d, *J* = 11.0, 1H)	3.30 (d, *J* = 11.3, 1H)	3.24 (d, *J* = 11.3, 1H)	3.31 (d, *J* = 10.8, 1H)



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2	134.0	133.6	134.5	134.3
3α	76.0	76.1	76.3	76.1
3β	-	-	-	-
5α	41.4	41.6	41.3	41.2
5β	-	-	-	-
6α	16.6	16.7	16.8	16.6
6β	-	-	-	-
7	107.8	107.8	108.2	108.0
8	128.2	128.2	128.4	128.2
9	118.8	118.9	118.9	118.8
10	120.3	120.5	120.5	120.3
11	122.2	122.4	122.2	122.0
12	110.1	110.2	110.0	109.9
13	138.0	138.1	138.0	137.8
14α	37.1	37.0	37.0	36.9
14β	-	-	-	-
15	36.1	36.0	36.1	36.0
16	64.3	64.9	63.9	63.8
17a	67.1	66.8	67.1	67.0
17b	-	-	-	-
18	14.1	14.2	14.1	14.0
19	116.8	117.3	116.4	116.3
20	140.5	140.1	141.0	140.8
21α	54.2	54.3	54.4	54.2
21β	-	-	-	-

IV. References

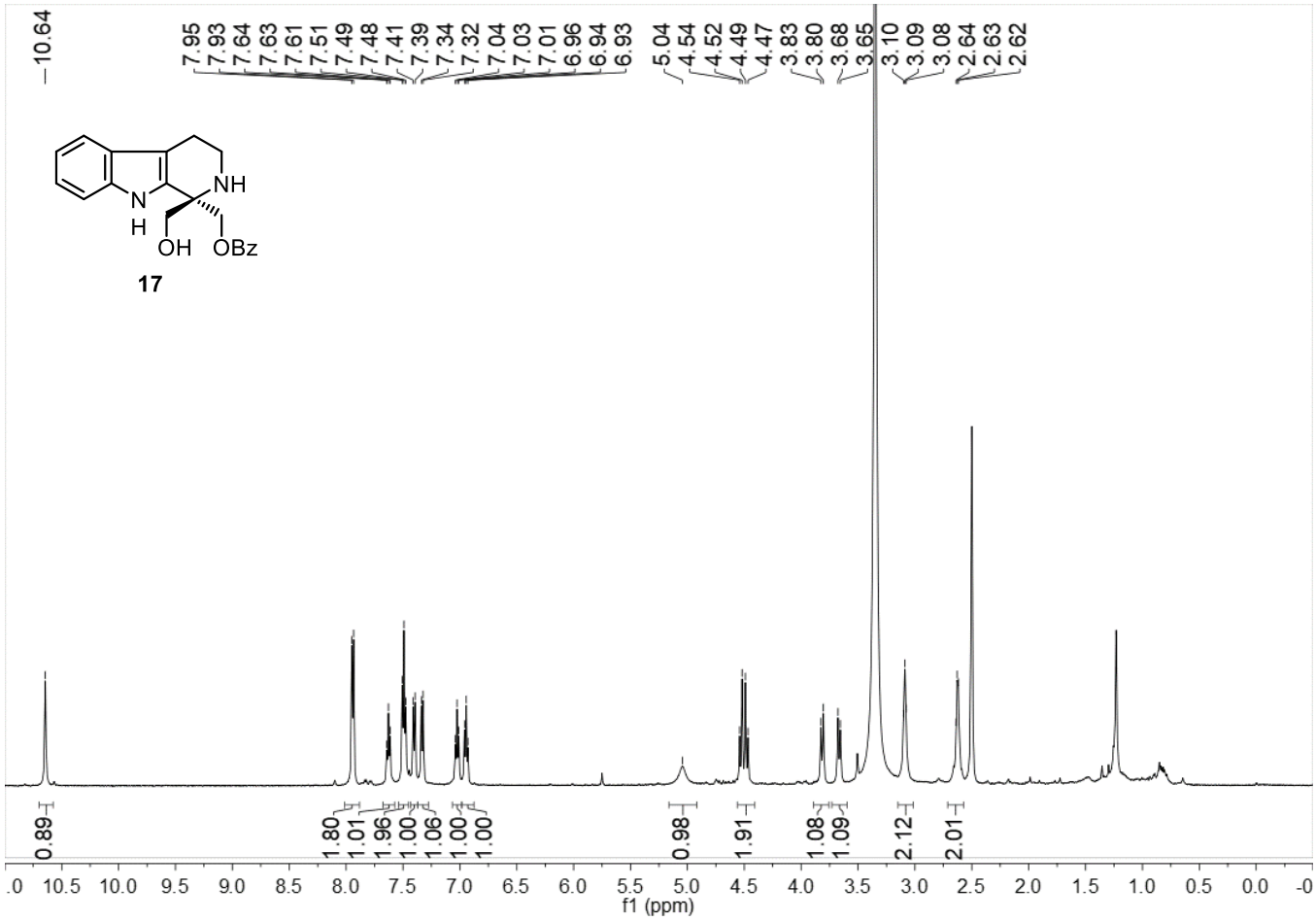
[1] N. Zhang, C. Wang, H. Xu, M. Zheng, H. Jiang, K. Chen and Z. Ma, Asymmetric Total Synthesis of Alstrostine G Utilizing a Catalytic Asymmetric Desymmetrization Strategy, *Angew. Chem. Int. Ed.* 2024, e202407127, DOI: 10.1002/anie.202407127.

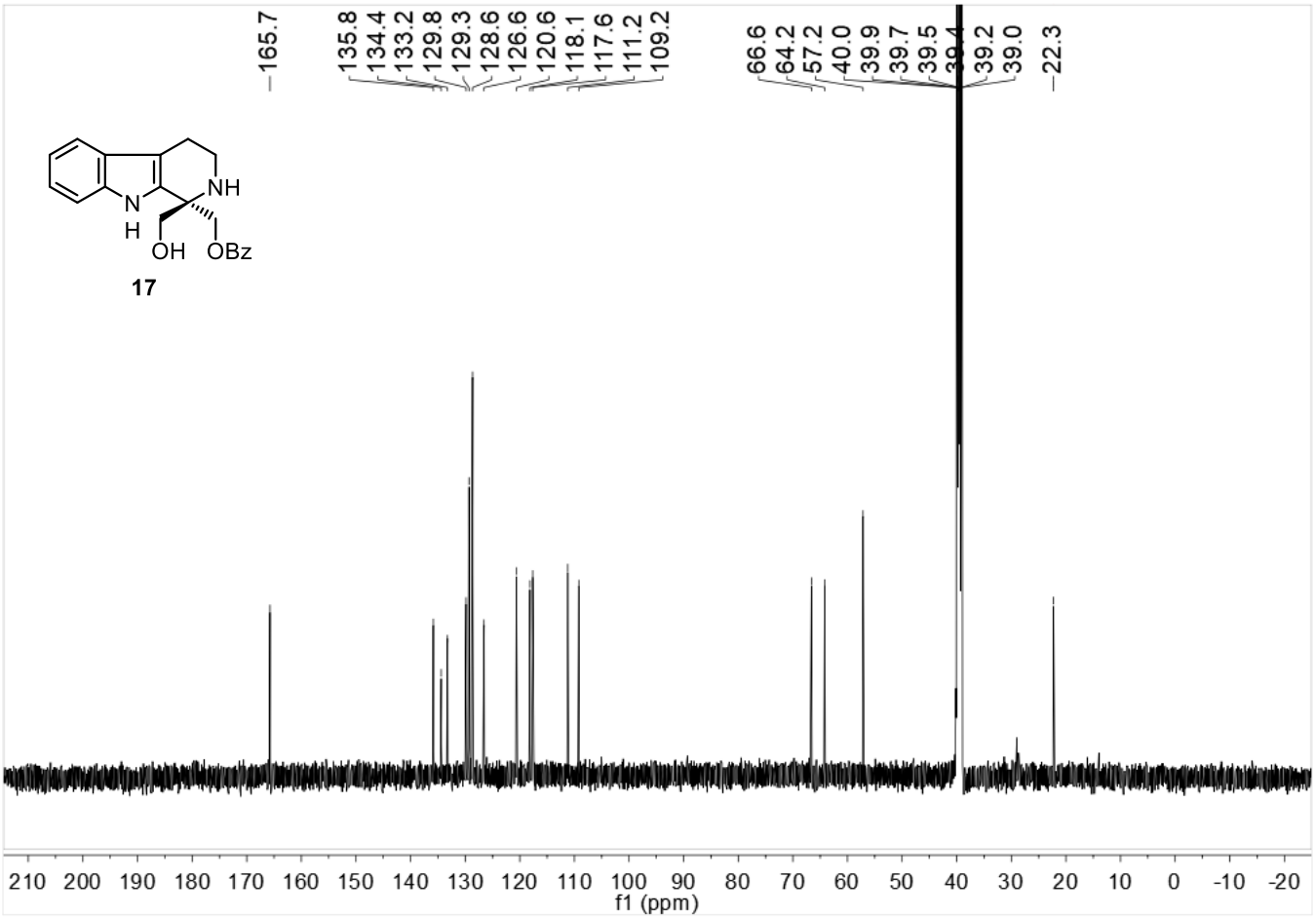
[2] S.-P. Wong, K.-W. Chong, K.-H. Lim, S.-H. Lim, Y.-Y. Low and T.-S. Kam, Arborisidine and Arbornamine, Two Monoterpenoid Indole Alkaloids with New Polycyclic Carbon–Nitrogen Skeletons Derived from a Common Pericine Precursor, *Org. Lett.* 2016, **18**, 1618−1621.

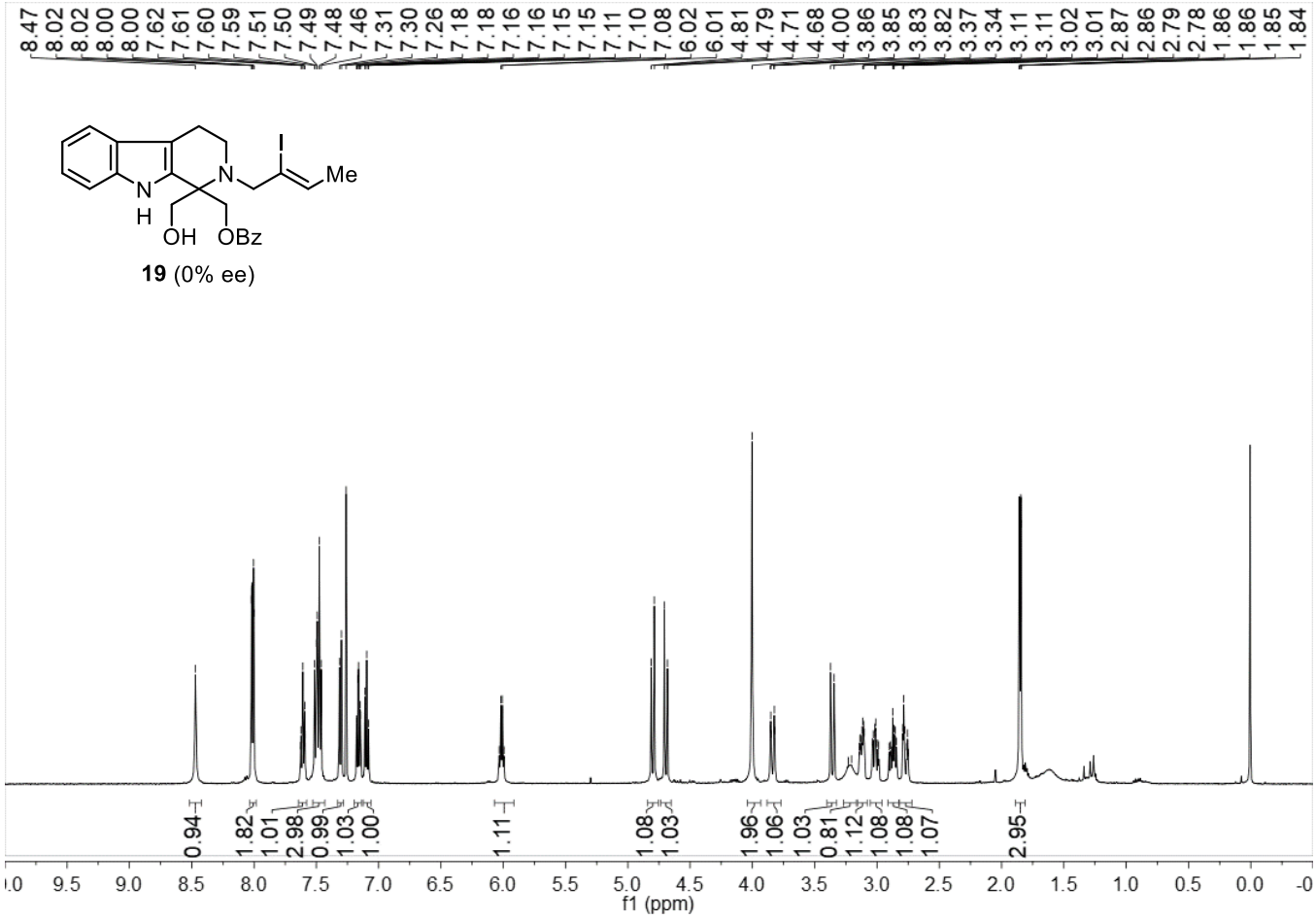
[3] Y. Li, C. Wang, Z. Ma, K. Zhang and X.-T. Xu, Asymmetric Total Synthesis and Assignment of Absolute Configuration of Arbornamine, *Org. Lett.* 2020, **22**, 8589−8592.

[4] Y. Zheng, B.-B. Yue, K. Wei and Y.-R. Yang, Short Synthesis of the Monoterpene Indole Alkaloid (±)-Arbornamine, *J. Org. Chem.* 2018, **83**, 4867−4870.

V. NMR spectra of the obtained compounds



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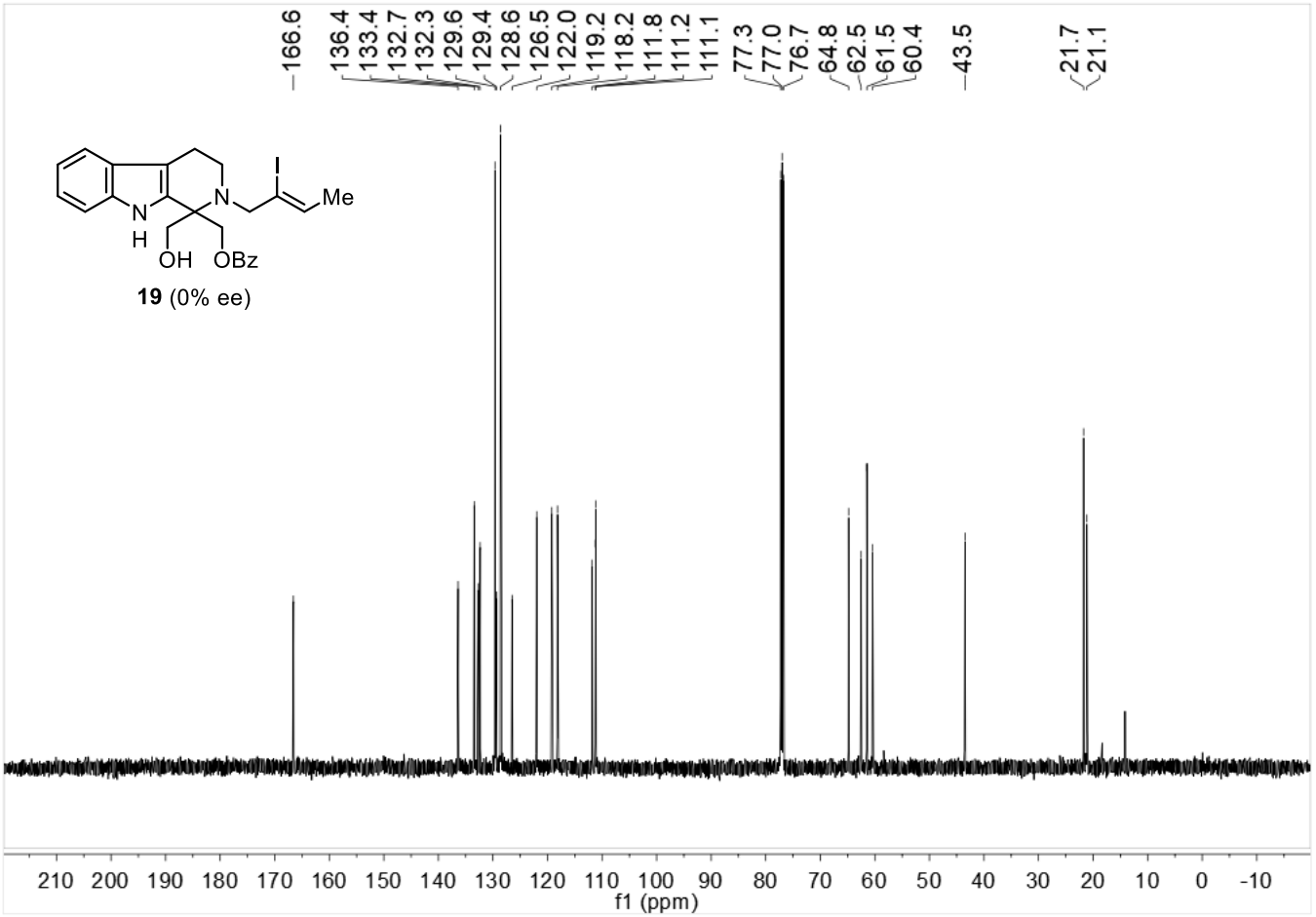
I
N
Me
N
H
OH OBz
19 (0% ee)
0.94 1.82 1.01 2.98 0.99 1.03 1.00 1.11 1.08 1.03 1.96 1.06 1.03 0.81 1.12 1.08 1.08 1.07 2.95
f1 (ppm)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I
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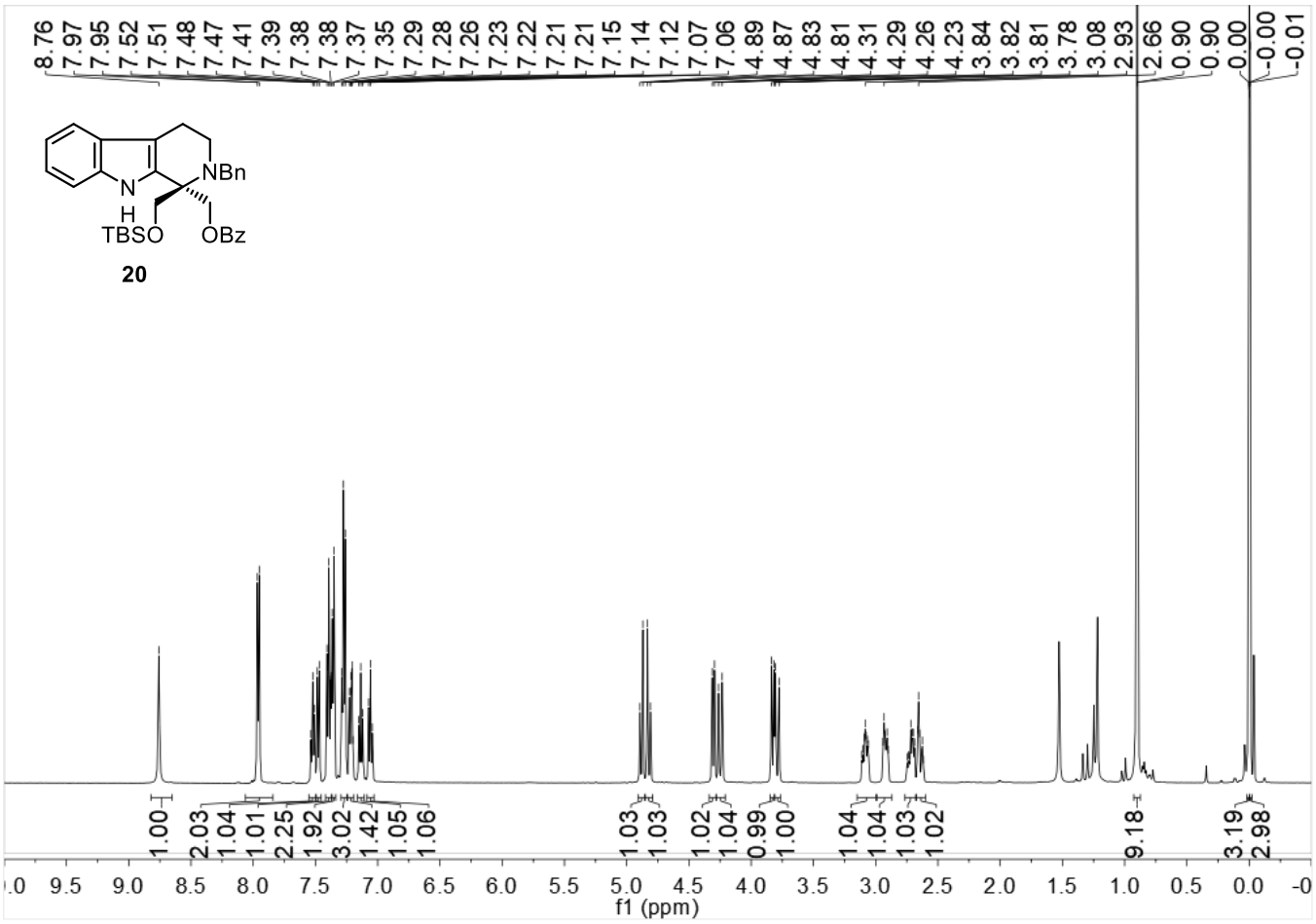
N
H
OH OBz
19 (0% ee)
f1 (ppm)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N
H
TBSO
OBz
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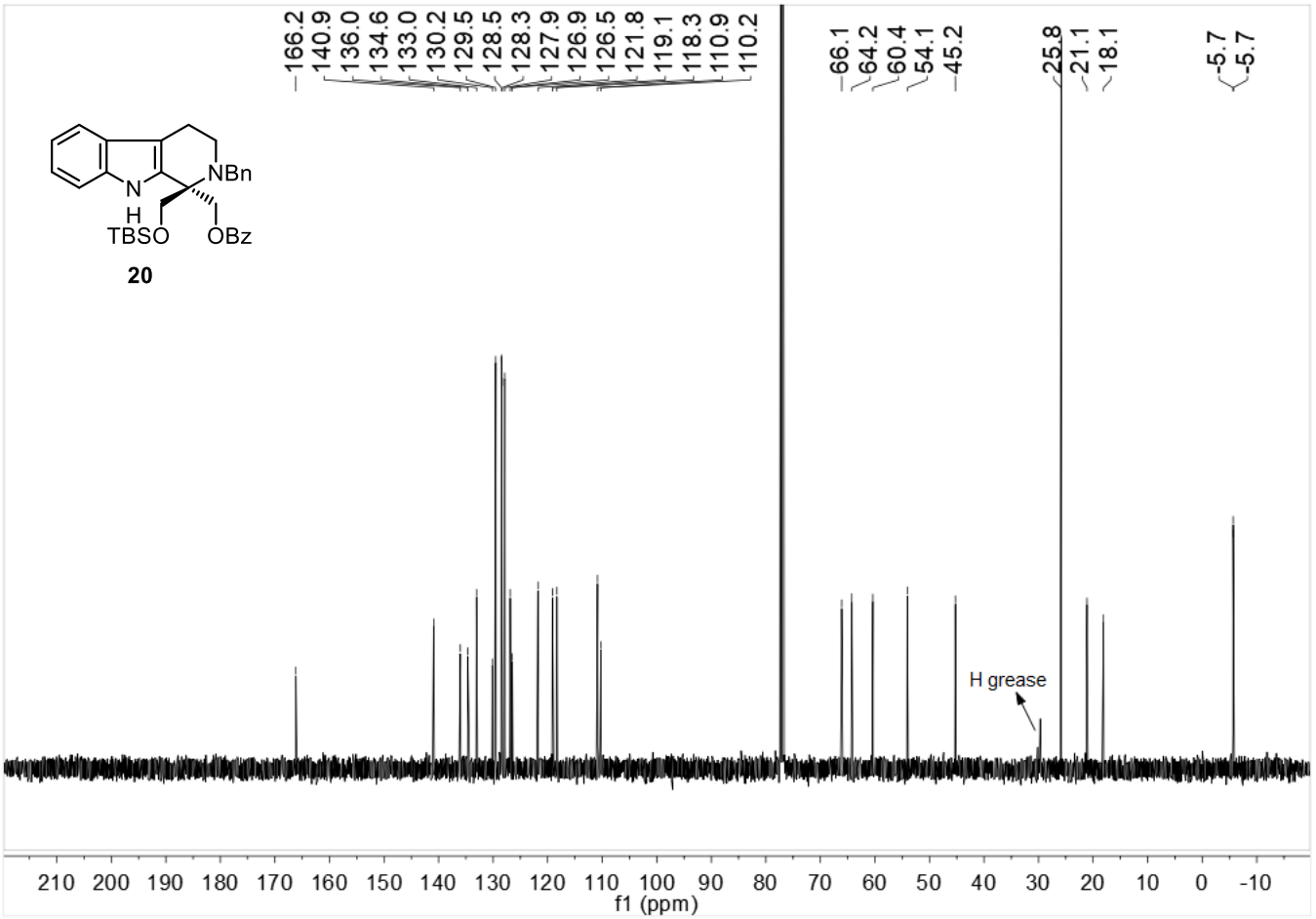
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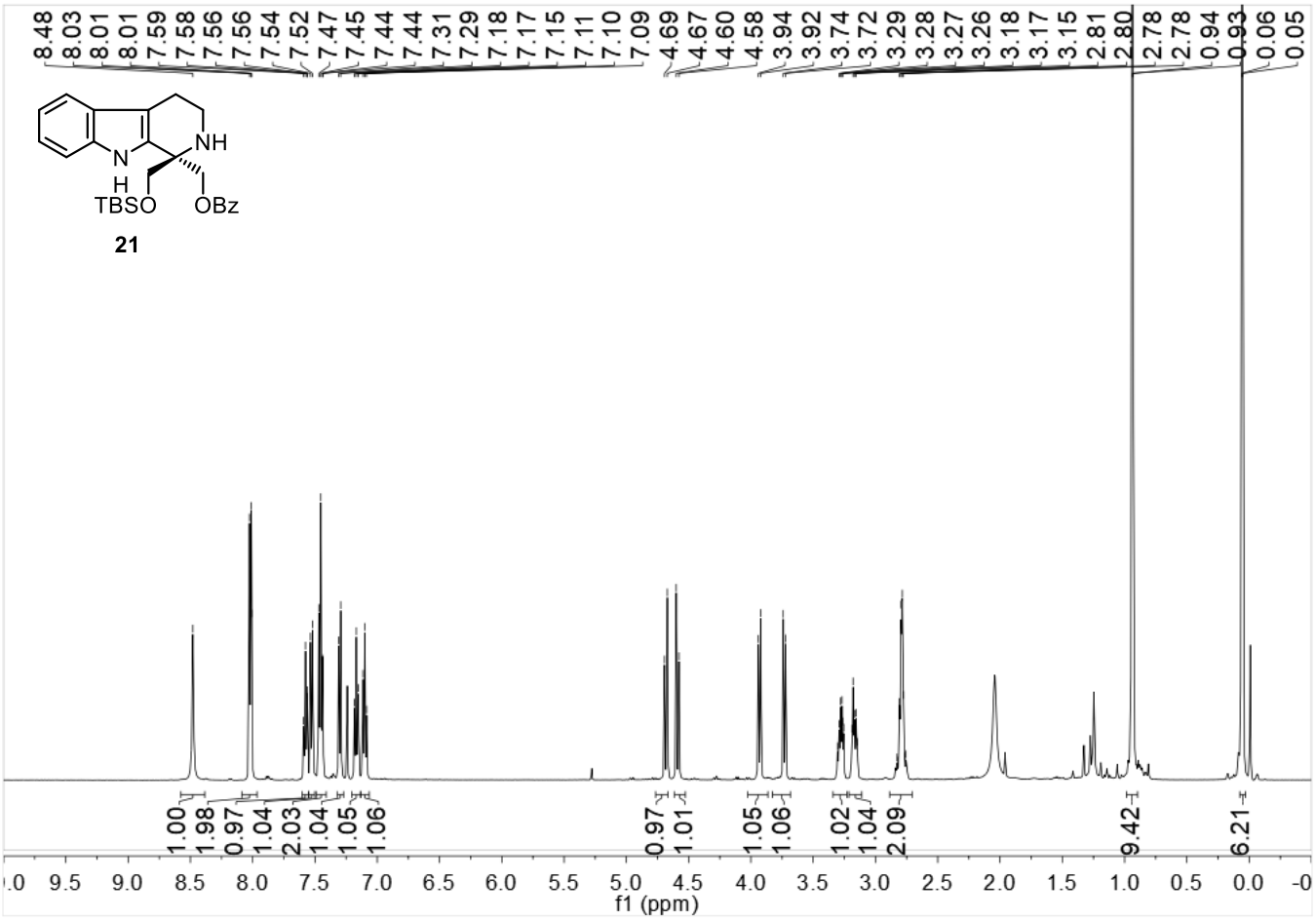
H
TBSO
OBz
20
H grease
f1 (ppm)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H
TBSO
OBz
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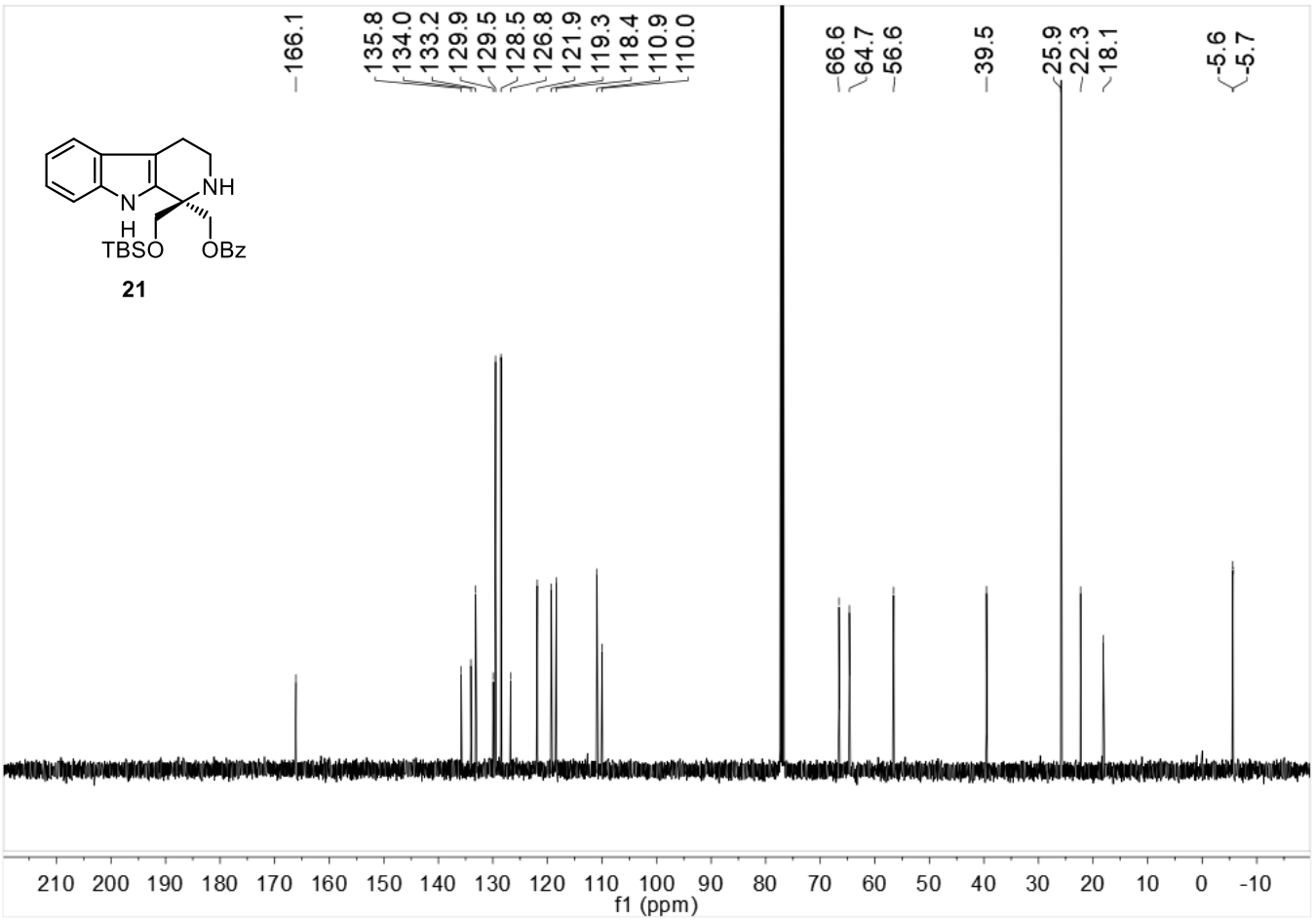
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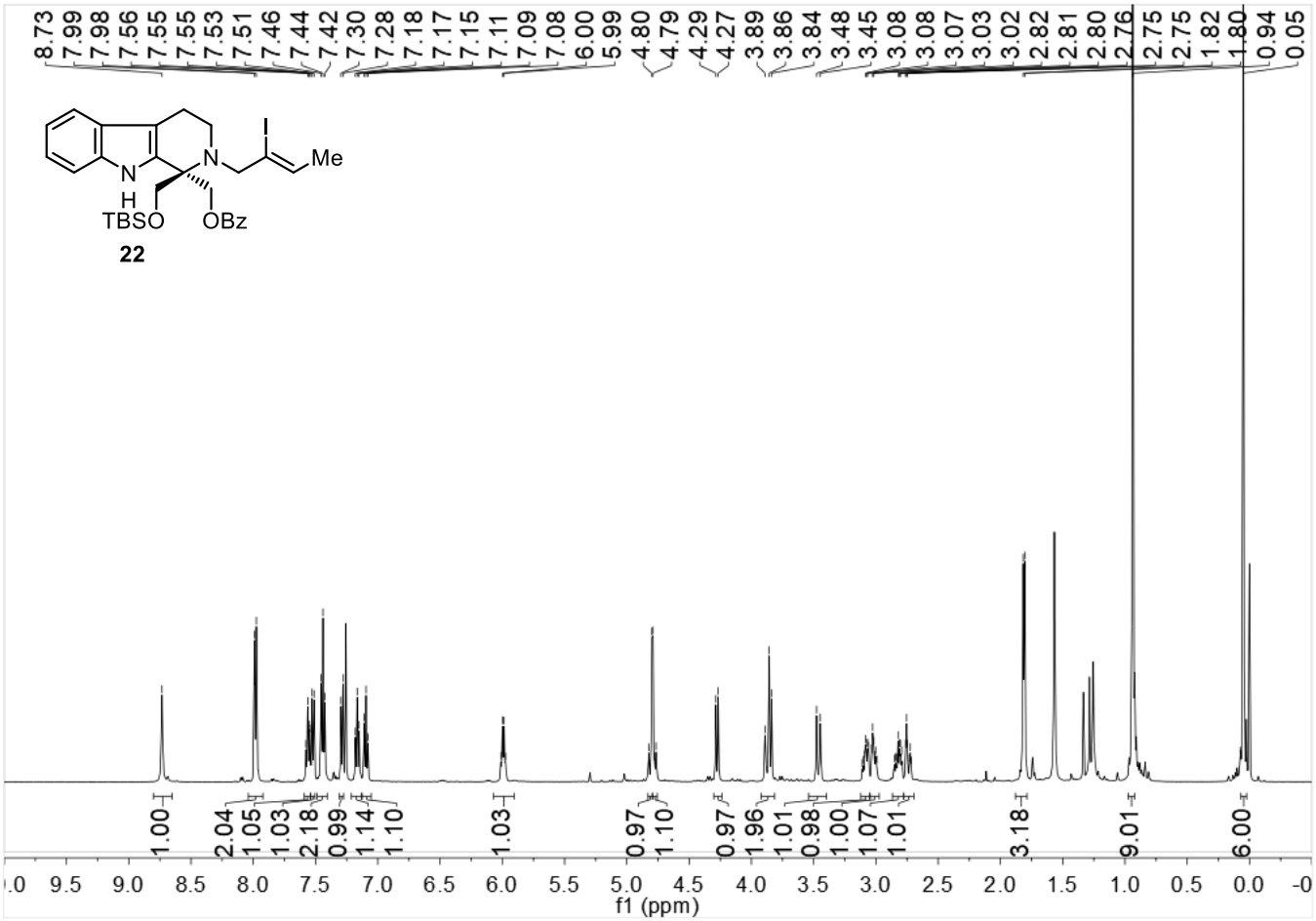
TBSO
OBz
21
f1 (ppm)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I
Me
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TBSO
OBz
22
1.00 2.04 1.05 1.03 2.18 0.99 1.14 1.10 1.03 0.97 1.10 0.97 1.96 1.01 0.98 1.00 1.07 1.01 3.18 9.01 6.00
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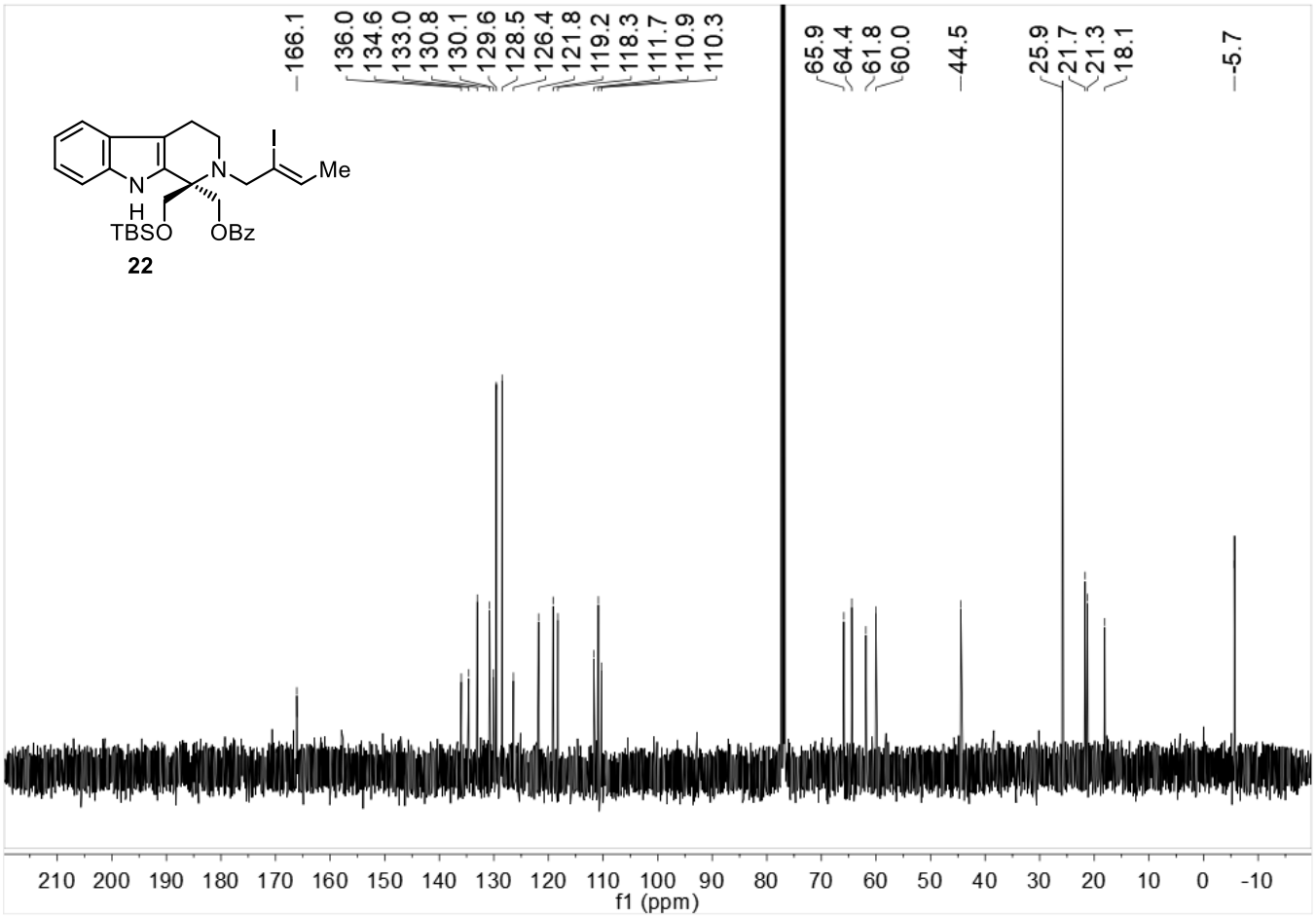
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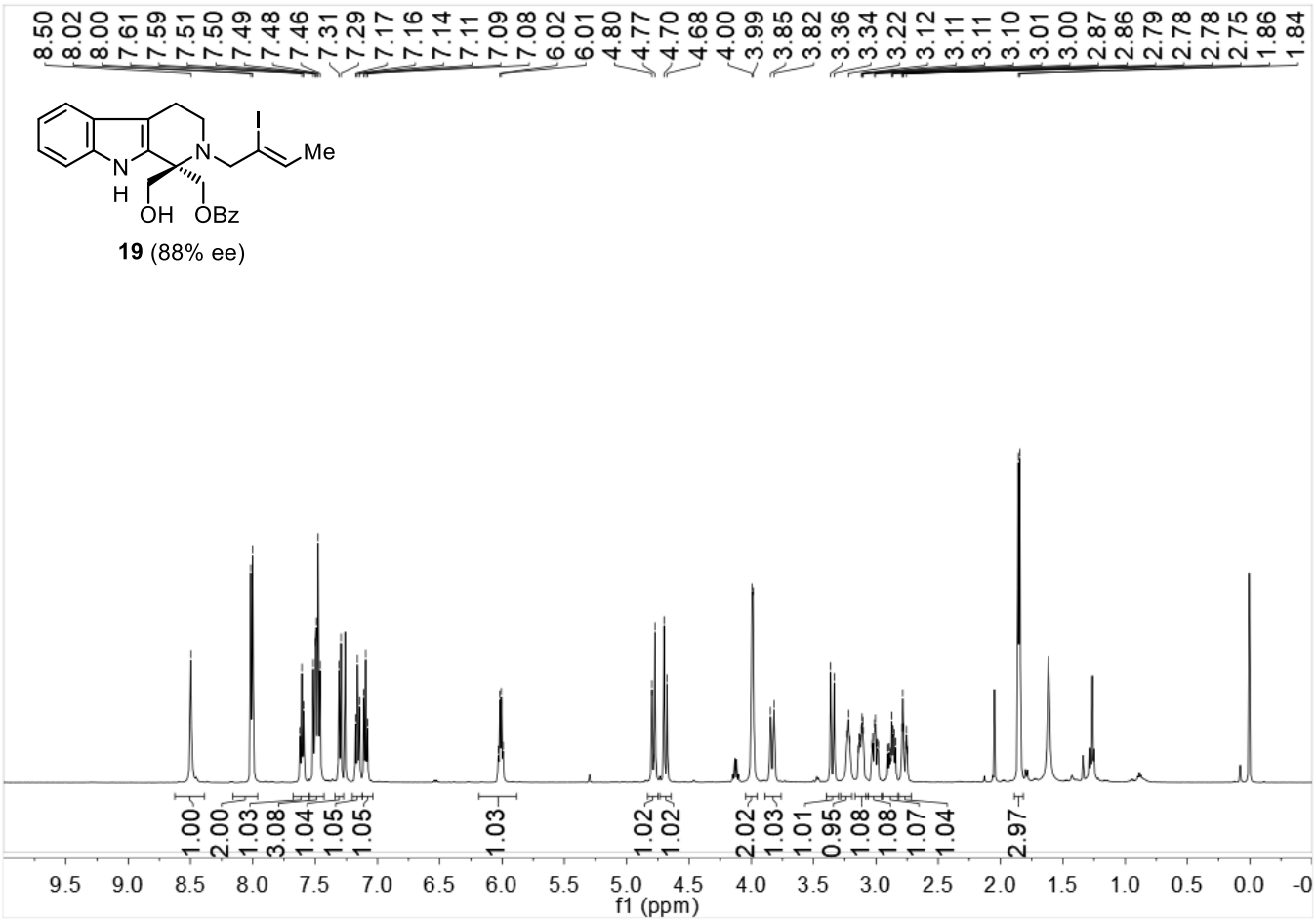
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I
Me
N
H
OH
OBz
19 (88% ee)
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9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0
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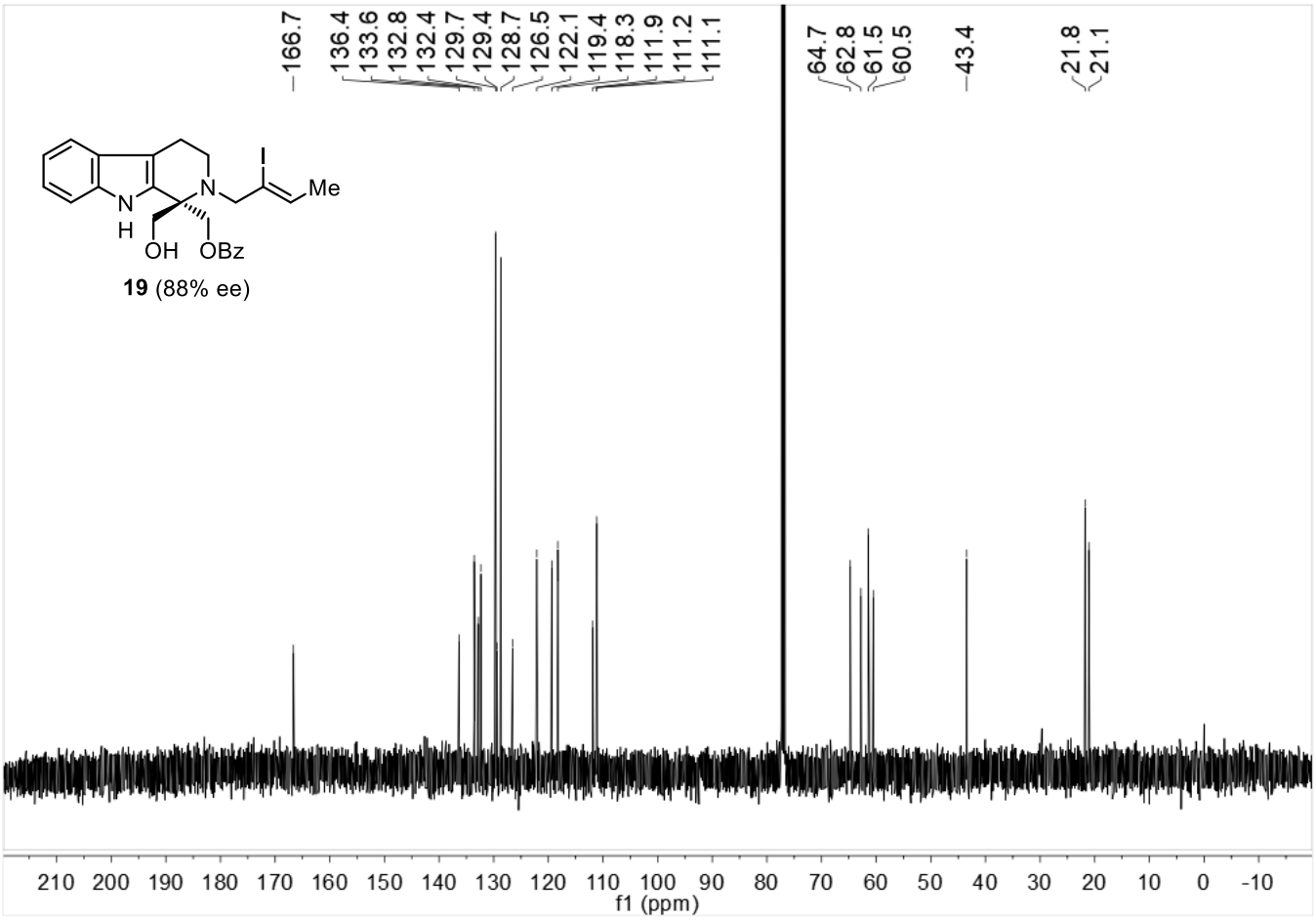
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43.4
21.8 21.1
I
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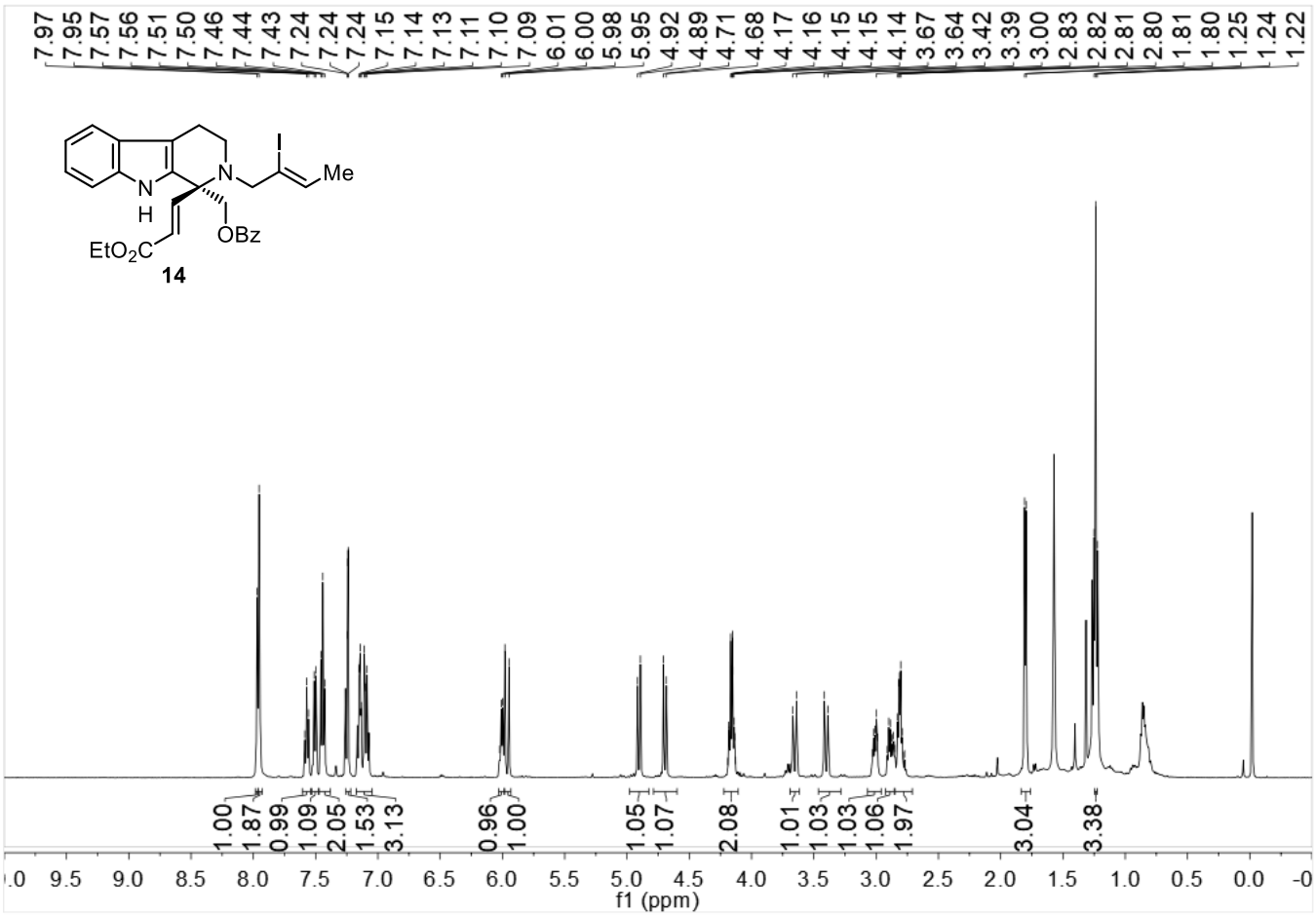
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EtO2C
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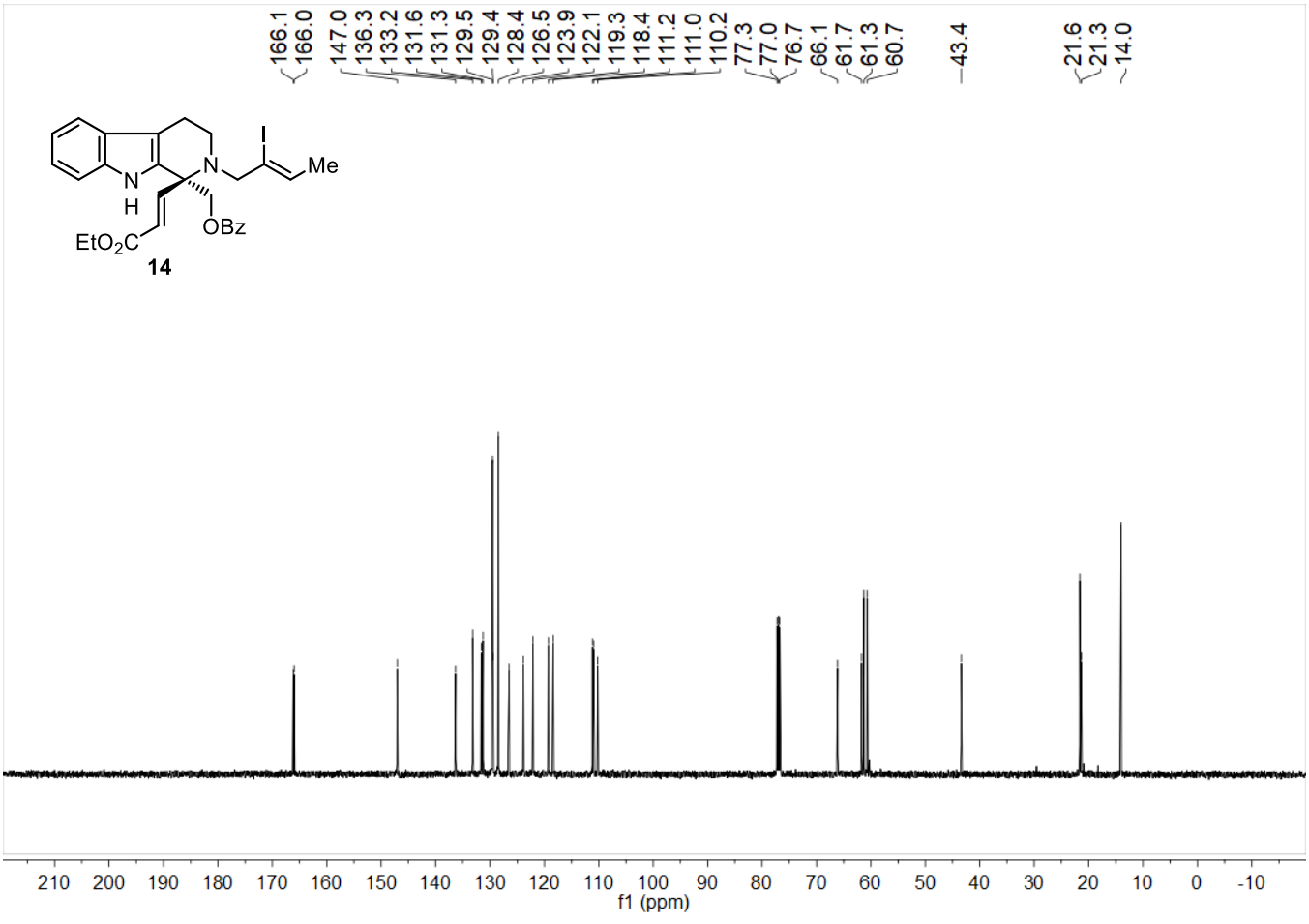
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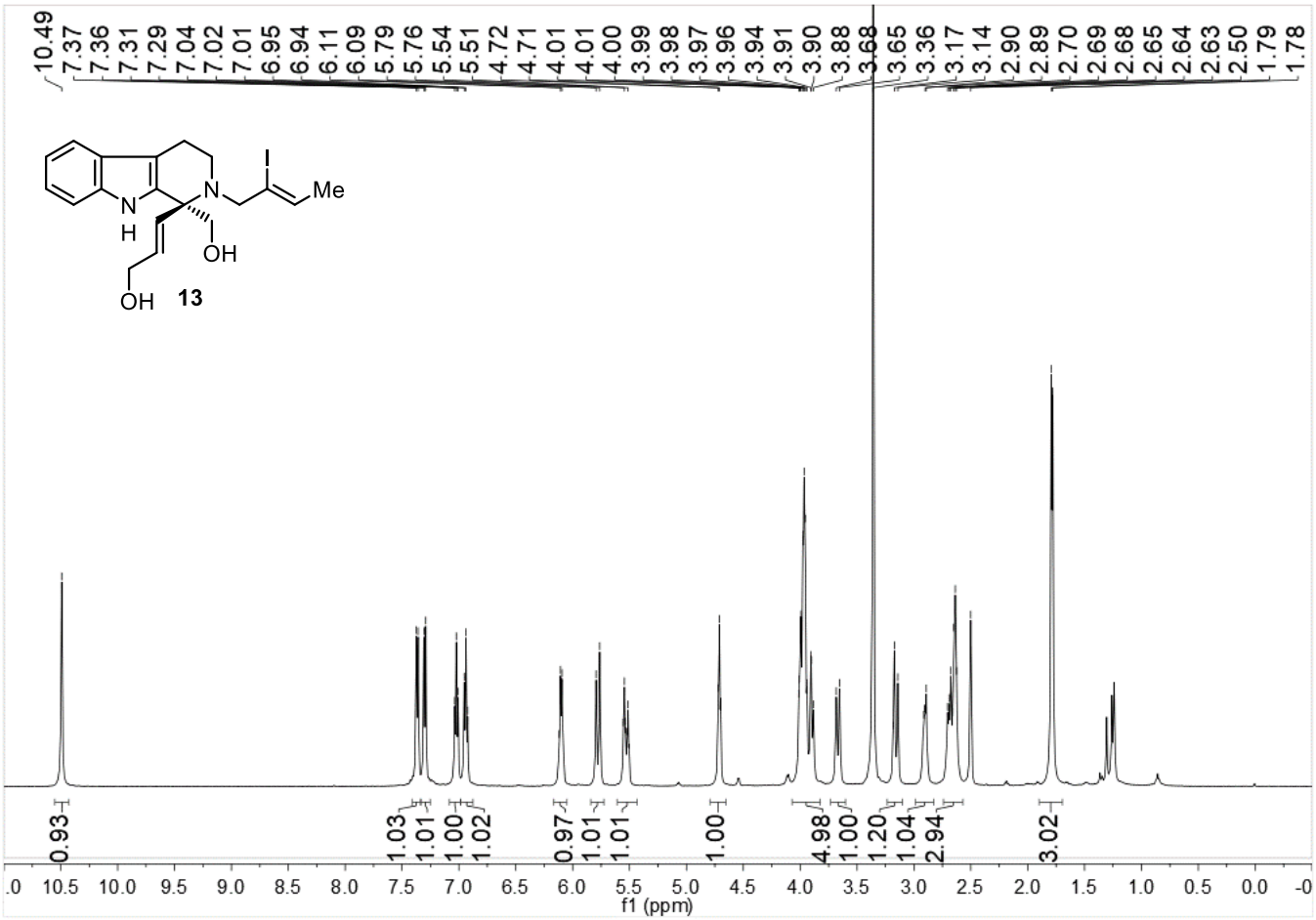
f1 (ppm)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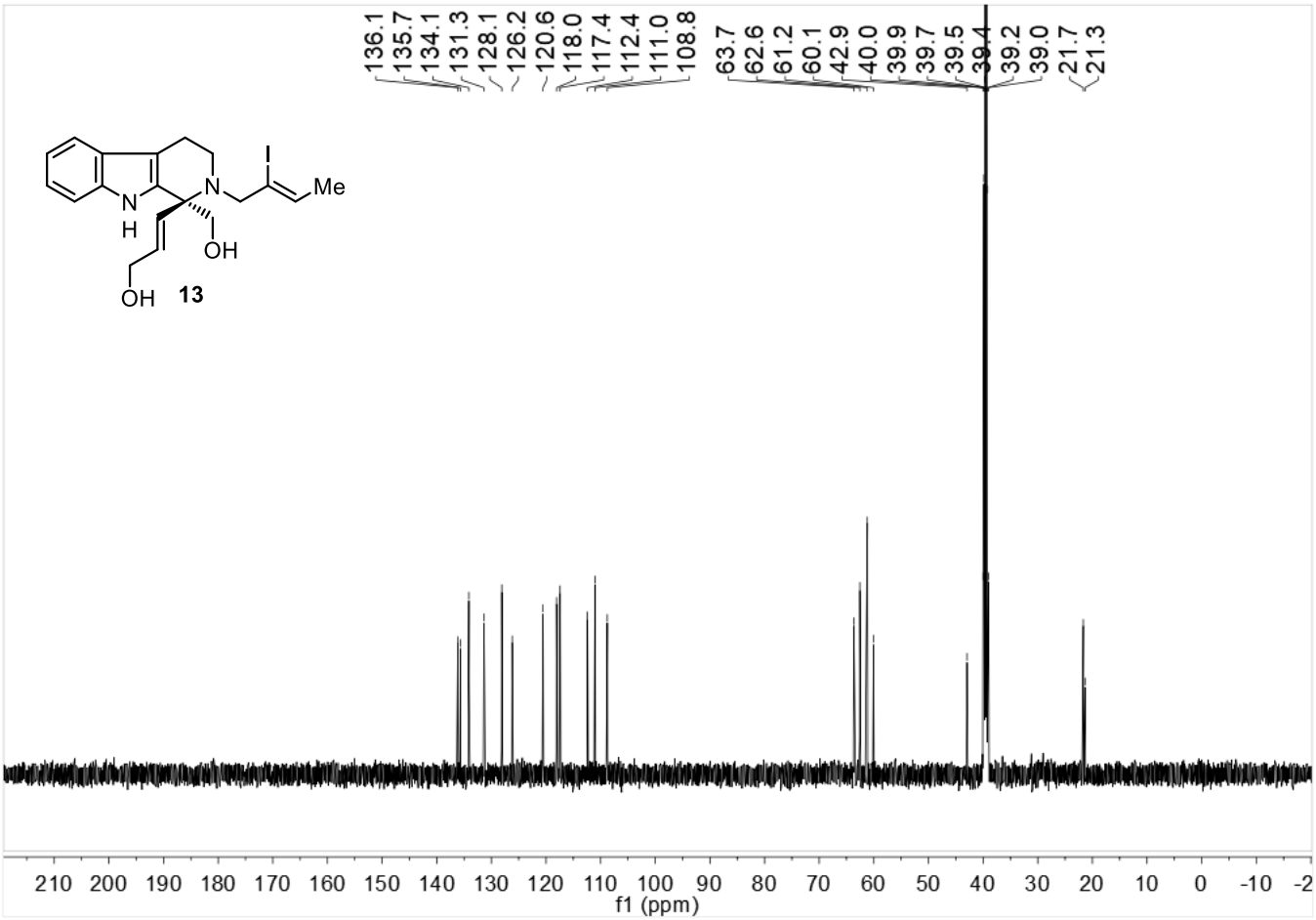
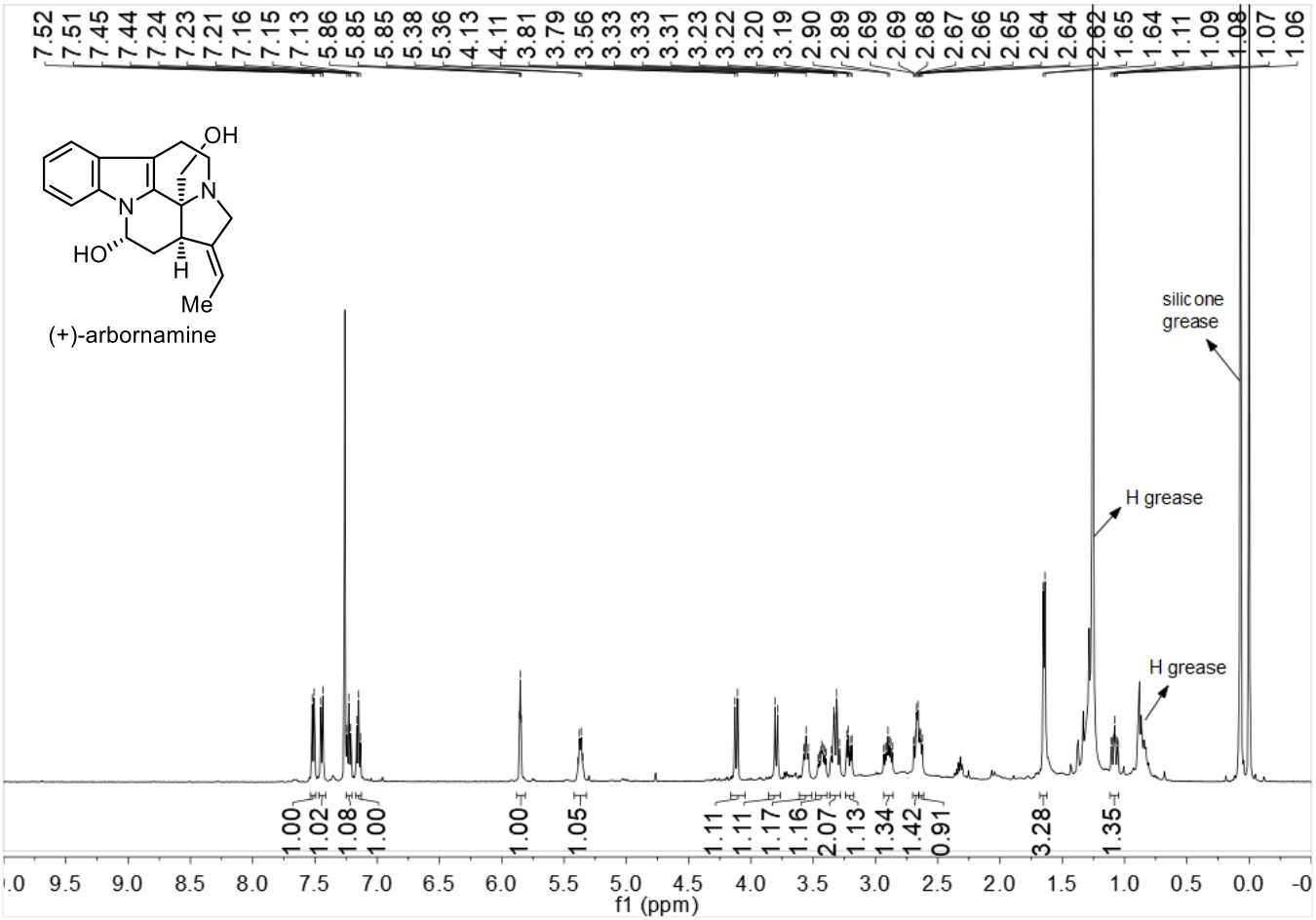
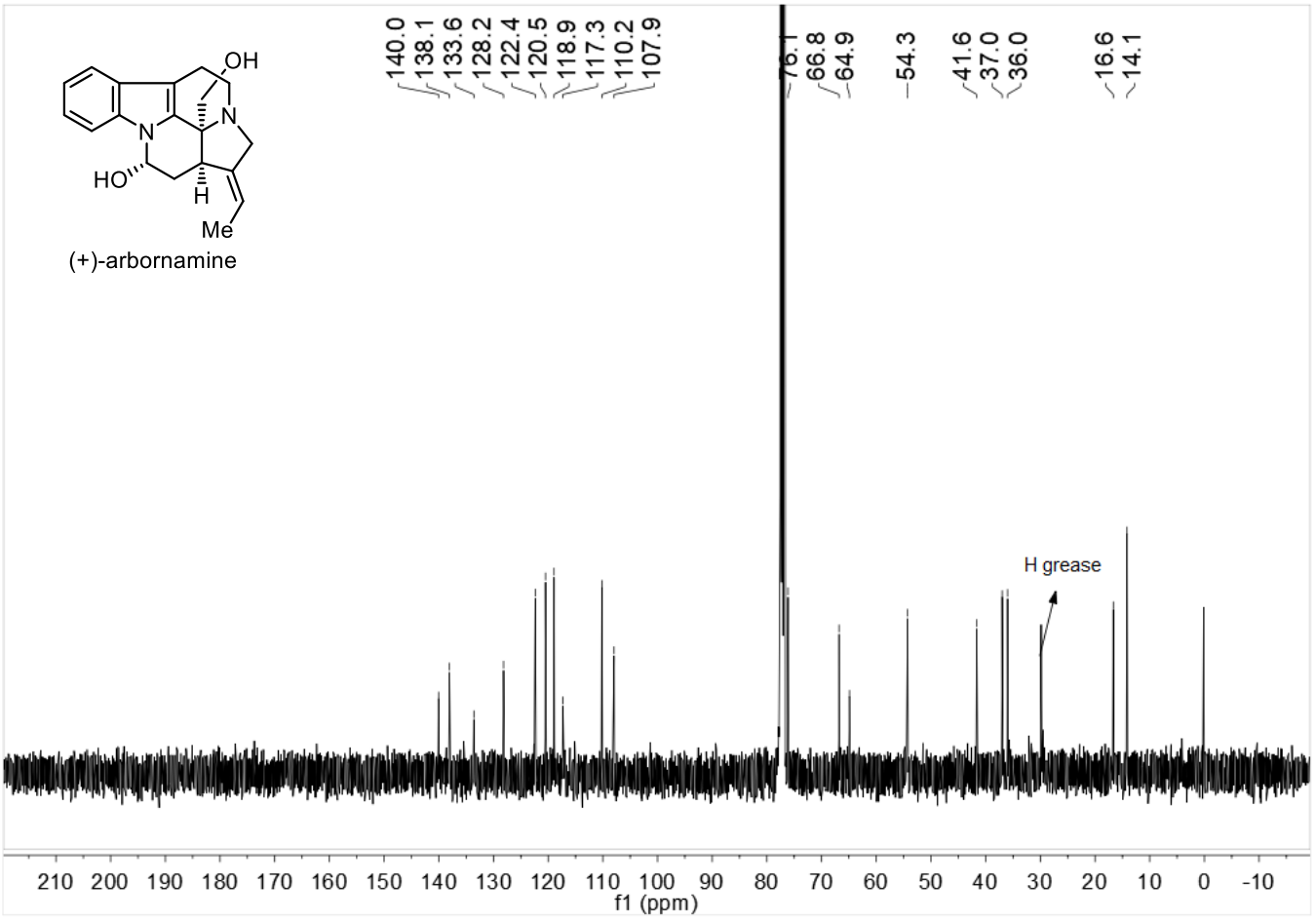
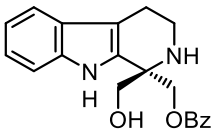
2.69
2.68
2.65
2.64
2.63
2.50
1.79
1.78
N
H
N
I
Me
OH
OH
13
0.93
1.03
1.01
1.00
1.02
0.97
1.01
1.01
1.00
4.98
1.00
1.20
1.04
2.94
3.02
f1 (ppm)


136.1
135.7
134.1
131.3
128.1
126.2
120.6
118.0
117.4
112.4
111.0
108.8
63.7
62.6
61.2
60.1
42.9
40.0
39.9
39.7
39.5
39.4
39.2
39.0
21.7
21.3
N
H
N
I
Me
OH
OH
13
f1 (ppm)


7.52 7.51 7.45 7.44 7.24 7.23 7.21 7.16 7.15 7.13 5.86 5.85 5.85 5.38 5.36 4.13 4.11 3.81 3.79 3.56 3.33 3.33 3.31 3.23 3.22 3.20 3.19 2.90 2.89 2.69 2.69 2.68 2.67 2.66 2.65 2.64 2.64 2.62 1.65 1.64 1.11 1.09 1.08 1.07 1.06
OH
N
N
HO
H
Me
(+)-arbornamine
silicone grease
H grease
H grease
1.00 1.02 1.08 1.00 1.00 1.05 1.11 1.11 1.17 1.16 2.07 1.13 1.34 1.42 0.91 3.28 1.35
f1 (ppm)

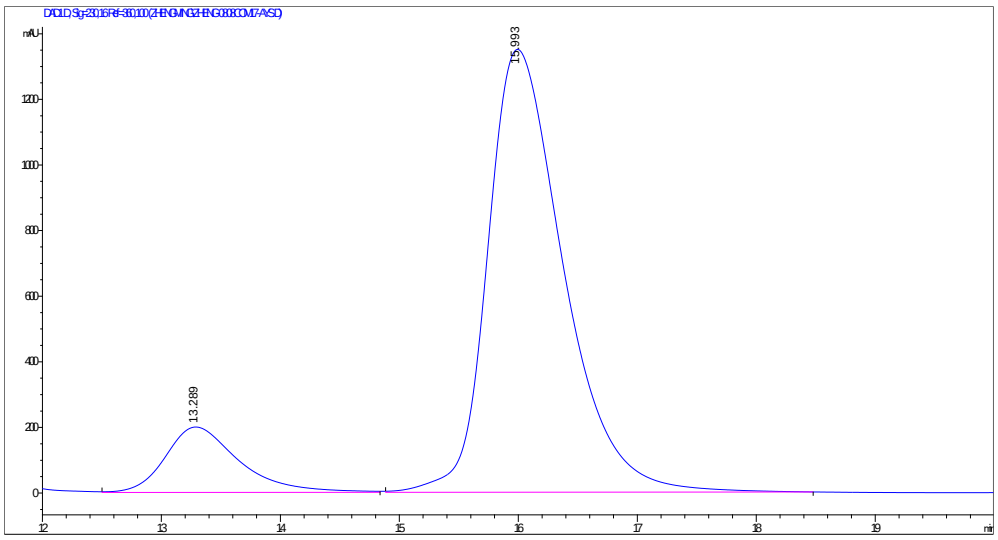

140.0 138.1 133.6 128.2 122.4 120.5 118.9 117.3 110.2 107.9
78.1 66.8 64.9 54.3 41.6 37.0 36.0 16.6 14.1
OH
N
N
HO
H
Me
(+)-arbornamine
H grease
f1 (ppm)

VI. Copies of the HPLC chromatograms

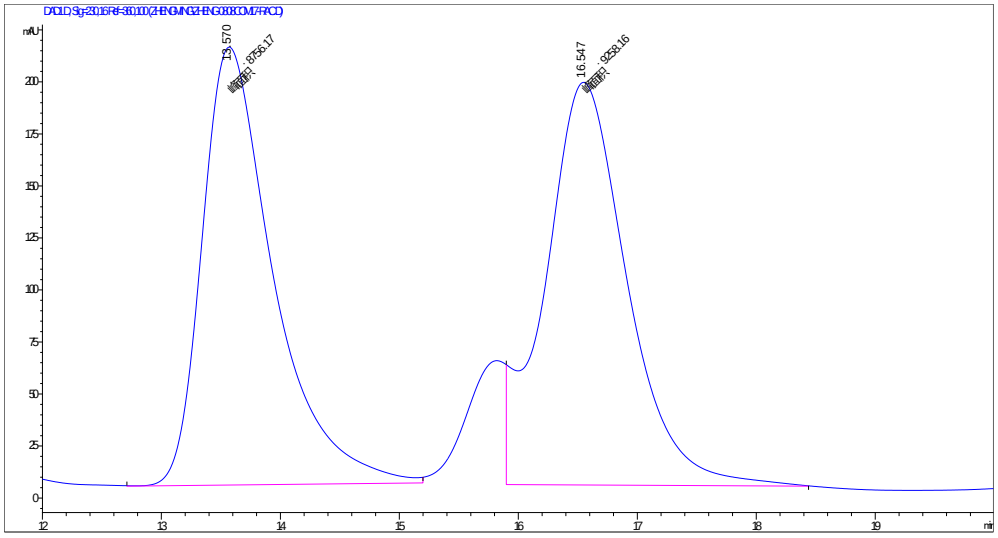


17

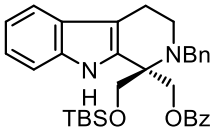
The enantiopurity was determined using chiral HPLC (OD-H column, 4.6 × 250 mm, 85:15 hexanes/*i*PrOH, 1 mL/min, UV detector at 210 nm) RT = 13.289 min (minor), RT = 15.993 min (major), ee = 75%.



Peak	RetTime [min]	Area [mAu*s]	Height [mAu]	Width [min]	Symmetry	Area [%]
1	13.289	8612	199.5	0.6436	0.668	12.608
2	15.993	59693.9	1350	0.6739	0.622	87.392

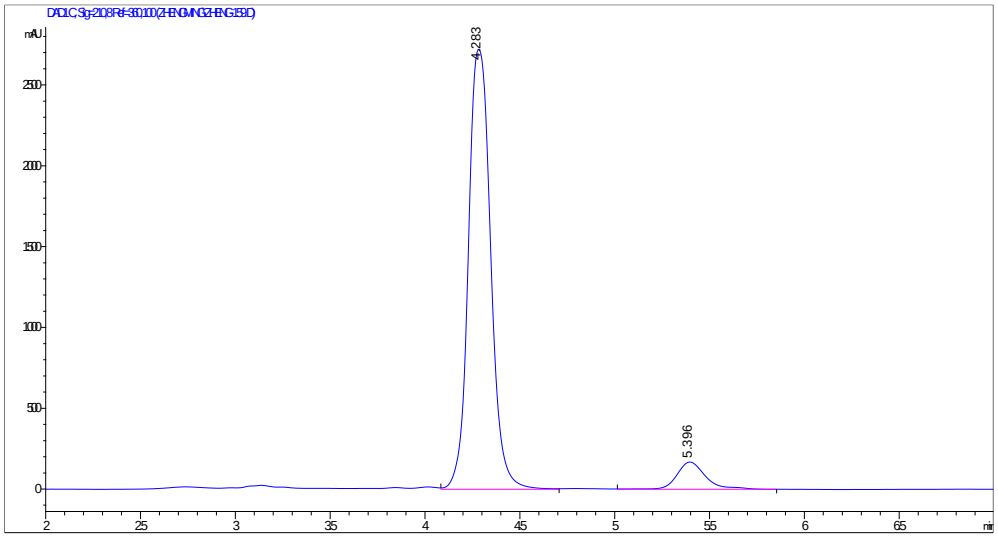


Peak	RetTime [min]	Area [mAu*s]	Height [mAu]	Width [min]	Symmetry	Area [%]
1	13.57	8756.2	210.6	0.6931	0.596	48.607
2	16.547	9258.2	193.6	0.7972	0.852	51.393

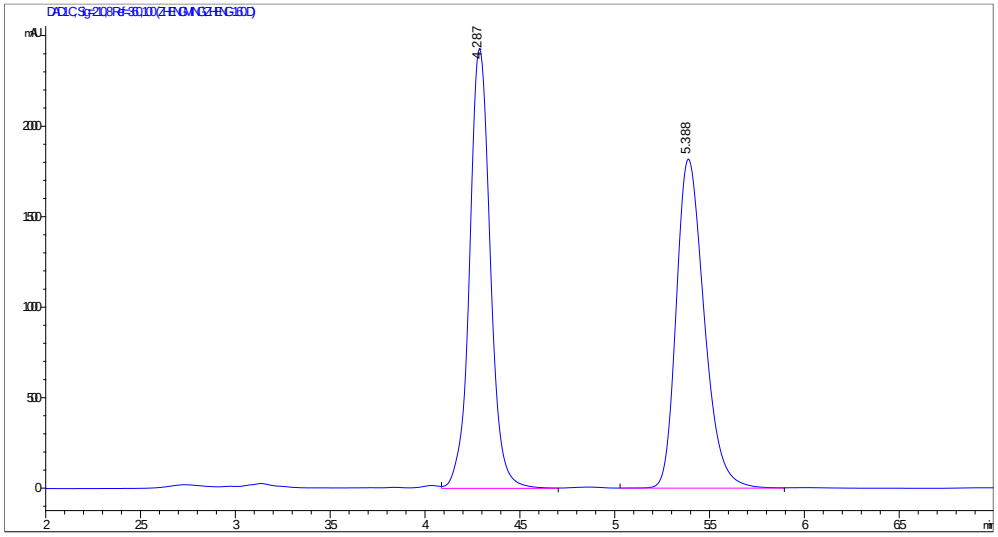


20

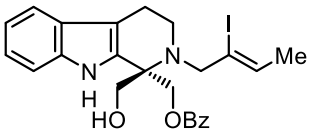
The enantiopurity was determined using chiral HPLC (OD-H column, 4.6 × 250 mm, 19:1 hexanes/*i*PrOH, 1 mL/min, UV detector at 210 nm) RT = 4.283 min (major), RT = 5.396 min (minor), ee = 87%.



Peak	RetTime [min]	Area [mAu*s]	Height [mAu]	Width [min]	Symmetry	Area [%]
1	4.283	22243.6	2723.6	0.1293	0.822	92.570
2	5.396	1785.3	168.6	0.1595	0.788	7.430

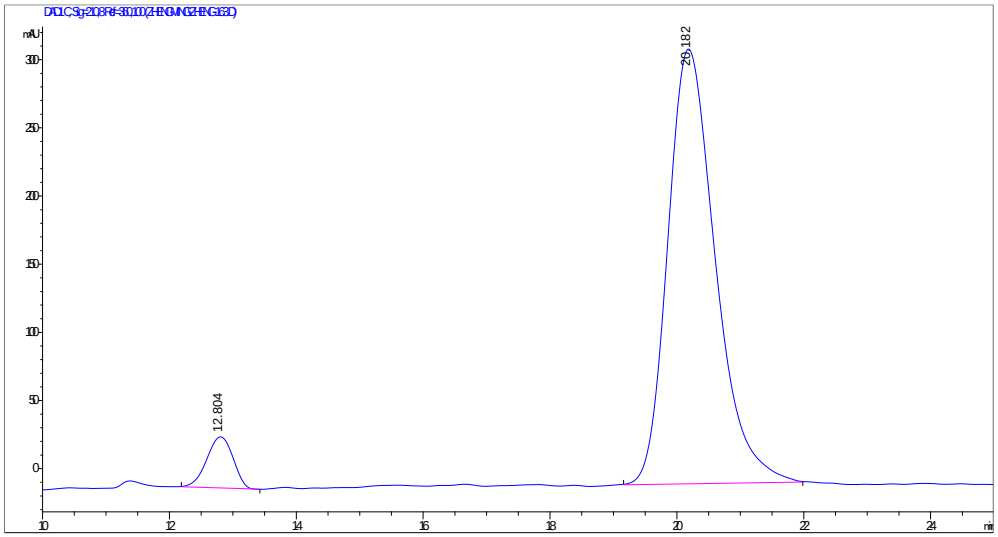


Peak	RetTime [min]	Area [mAu*s]	Height [mAu]	Width [min]	Symmetry	Area [%]
1	4.287	18462.8	2430.7	0.1186	0.879	49.748
2	5.388	18650.1	1820.1	0.1595	0.712	50.252

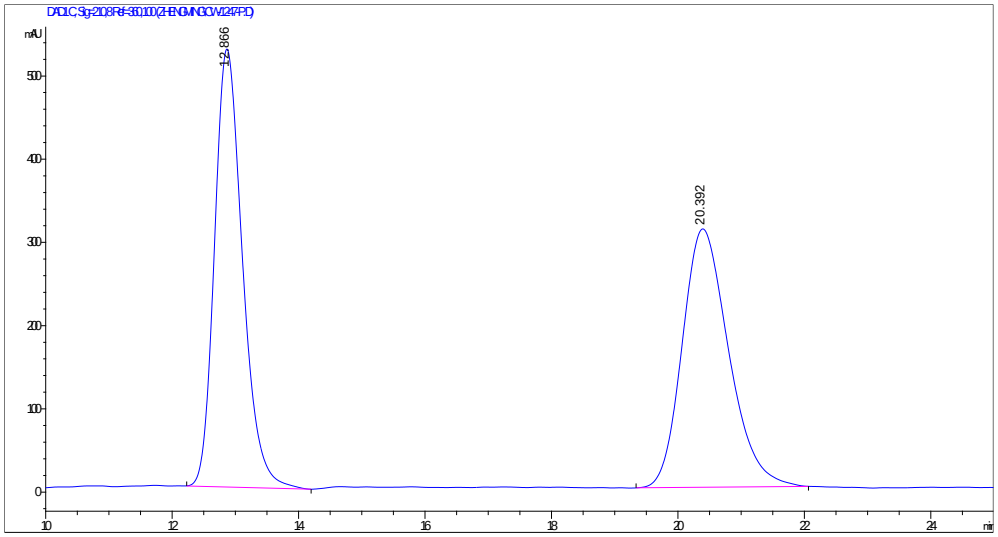


19

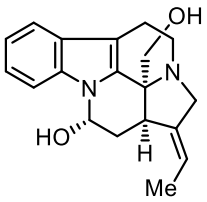
The enantiopurity was determined using chiral HPLC (OD-H column, 4.6 × 250 mm, 9:1 hexanes/*i*PrOH, 1 mL/min, UV detector at 210 nm) RT = 12.804 min (minor), RT = 20.182 min (major), ee = 88%.



Peak	RetTime [min]	Area [mAu*s]	Height [mAu]	Width [min]	Symmetry	Area [%]
1	12.804	1086.4	37.6	0.4633	1.088	6.146
2	20.182	16590.1	319	0.7987	0.729	93.854

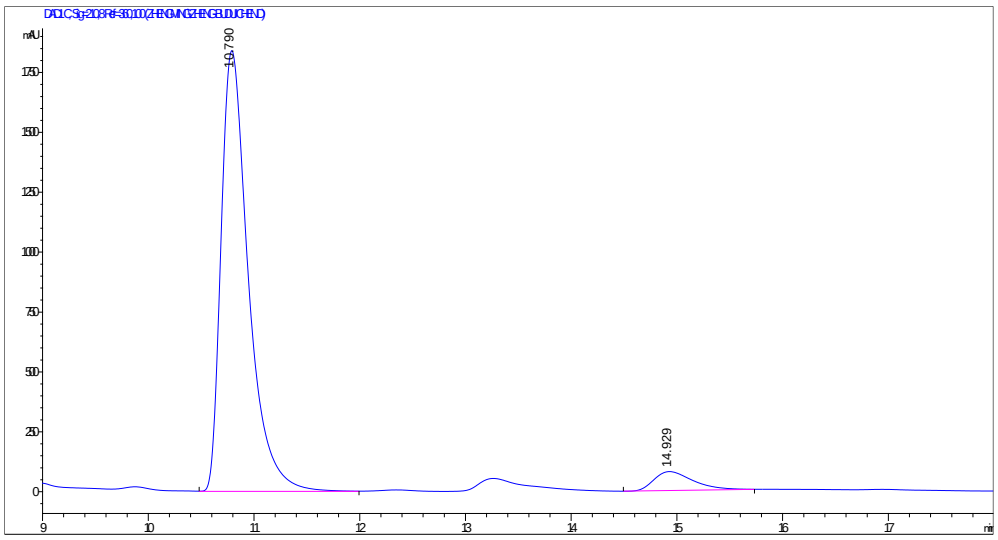


Peak	RetTime [min]	Area [mAu*s]	Height [mAu]	Width [min]	Symmetry	Area [%]
1	12.866	16168	526.4	0.4743	0.748	50.508
2	20.392	15843	310.6	0.7892	0.752	49.492

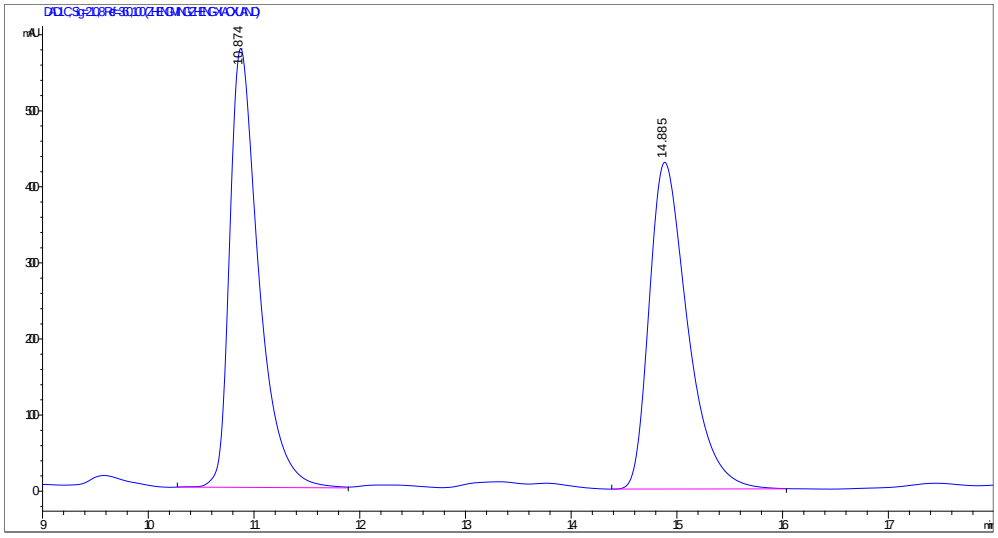


(+)-arbornamine

The enantiopurity was determined using chiral HPLC (AD-H column, 4.6 × 250 mm, 9:1 hexanes/*i*PrOH, 1 mL/min, UV detector at 210 nm) RT = 10.790 min (major), RT = 14.929 min (minor), ee = 88%.



Peak	RetTime [min]	Area [mAu*s]	Height [mAu]	Width [min]	Symmetry	Area [%]
1	10.79	32941.7	1840.2	0.2728	0.587	94.111
2	14.929	2061.3	79.5	0.3944	0.605	5.889



Peak	RetTime [min]	Area [mAu*s]	Height [mAu]	Width [min]	Symmetry	Area [%]
1	10.874	11098.4	577.2	0.2883	0.568	50.567
2	14.885	10849.4	429.4	0.3847	0.634	49.433