Electronic Supplementary Material (ESI) for ChemComm.

Supplementary Information

Concise syntheses of *eburnane* indole alkaloids

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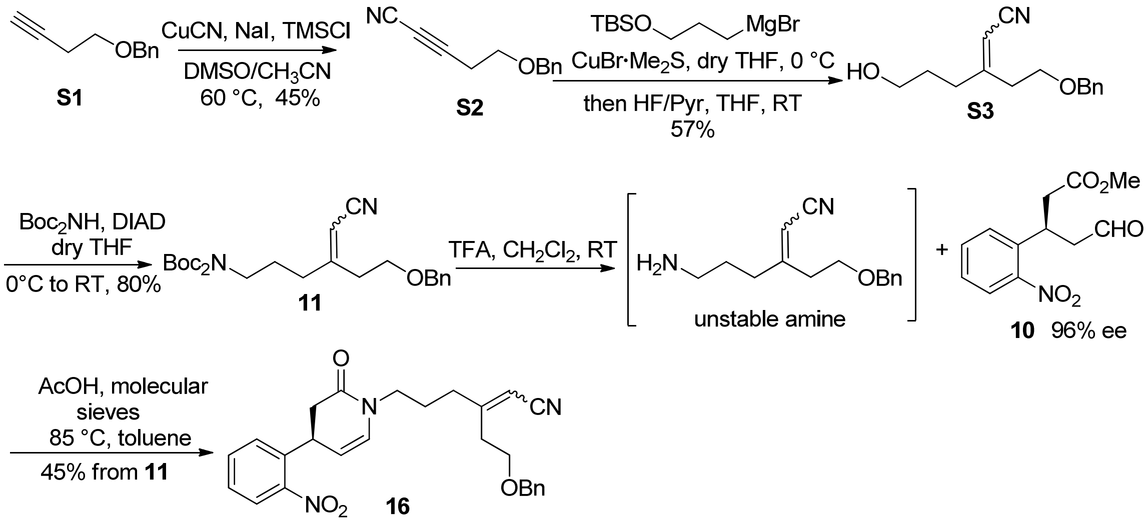
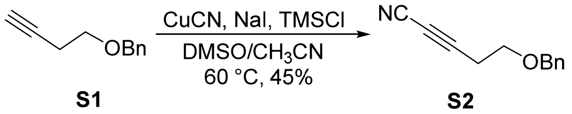
1. General information

Reagents and solvents were purchased from commercial sources and used without further purification unless otherwise noted. The solvent (tetrahydrofuran) for radical reaction was distilled from sodium. Solvent purification was conducted according to Purification of Laboratory Chemicals 2nd edn (Perrin, D. D., Armarego, W. L. F. and Perrin, D. R., Pergamon Press: Oxford, 1980). When solvents are indicated as dry they were either purchased as such, distilled prior to use or were dried by actived 4Å molecular sieves. Reactions that require anhydrous conditions were performed in oven-dried glassware under Ar atmosphere. The products were purified by flash column chromatography on silica gel (200 – 300 meshes) from the Anhui Liangchen Silicon Material Company (China). Reactions were monitored by thin layer chromatography (TLC, 0.2 mm, HSGF254) supplied by Yantai Chemicals (China). Visualization was accomplished with UV light, exposure to iodine or basic solution of $KMnO_4$. ^1H NMR and ^{13}C NMR spectra were recorded on Varian INOVA-400/54, Agilent DD2-600/54 and Bruker Ascend^{TM} 400 instruments and calibrated by using residual undeuterated chloroform (δ, ^1H NMR = 7.260, ^{13}C NMR = 77.00, unless otherwise noted). The following abbreviations were used to explain the multiplicities: s = singlet, d = doublet, t = triplet, q = quartet, br = broad, td = triple doublet, dt = double triplet, m = multiplet, and coupling constants (*J*) are reported in Hertz (Hz). Infrared (IR) spectra was recorded on a Perkin Elmer Spectrum Two FT-IR spectrometer. High-resolution mass spectra (HRMS) was recorded on Waters Q-TOF Premier mass spectrometers. The specific optical rotation was obtained from Rudolph Research Analytical Autopol VI automatic polarimeter. LC-MS analysis was performed on HP Agilent 6420 Triple Quad LC/MS. Melt point was recored on Shanghai Yice WRX-4.

2. Experimental Procedures and Characterization Data



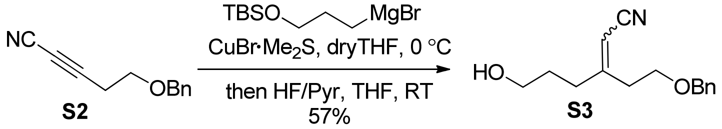
Preparation of alkyne S2



To a stirred solution of **S1**[1] (35.2 g, 0.220 mol, 1.0 equiv.) in DMSO (353 mL) and CH_3CN (118 mL) was slowly added CuCN (59.1 g, 0.660 mol, 3.0 equiv.) and NaI (6.60 g, 44.0 mmol, 0.2 equiv.). After 5 min, TMSCl (57.0 mL, 0.660 mol, 3.0 equiv.) was added dropwise to the mixture. The reaction was stirred at 60 °C for 40 h, cooled to room temperature and quenched by water (160 mL). The mixture was diluted with Et_2O (100 mL), and the cupurate salt was filtered by a pad of Celite and washed with Et_2O (5 × 100 mL). The filtrate was extracted with Et_2O (3 × 20 mL). The combined organic phase was dried over anhydrous Na_2SO_4 and concentrated in vacuo. The residue was purified by flash column chromatography on silica gel (petroleum ether : dichloromethane = 2 : 1, $R_f = 0.2$) to give alkyne **S2**[2] (17.0 g, 45%) as a yellow oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.41 – 7.30 (m, 5H), 4.56 (s, 2H), 3.64 (t, J = 6.4 Hz, 2H), 2.66 (t, J = 6.4 Hz, 2H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 137.3, 128.5, 128.5, 128.0, 127.7, 127.7, 105.1, 84.4, 73.2, 66.2, 56.1, 20.5; **IR** (neat): ν_{max} = 2314, 2262, 1097, 735, 697 cm^{-1}; **HRMS** (*m*/*z*): $[M + Na]^+$ calcd. For $C_{12}H_{11}NNaO$, 208.0738; found, 208.0735.

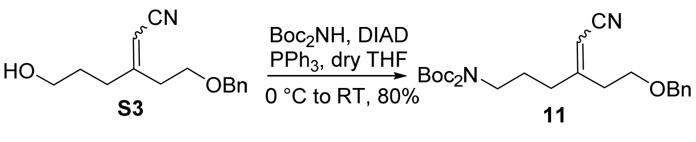
Preparation of alcohol S3



Under Ar and 0 °C, to a mixture of **S2** (5.40 g, 29.2 mmol, 1.0 equiv.) and CuBr • Me_2S (12.0 g, 58.4 mmol, 2.0 equiv.) in dry THF (90 mL) was dropwise added Grignard solution (1.0 M, 180 mL, 175 mmol, 6.0 equiv.) prepared according to the known procedure[3]. The reaction was stirred at 0 °C for 2 h and quenched by addition of sat. NH_4Cl aq. (50 mL). The mixture was extracted with ethyl acetate (3 × 50 mL). The organic phase was dried over Na_2SO_4 and concentrated. The residue was dissolved in THF (80 mL) and 70% HF/Pyr (8 mL) was added at 0 °C. The reaction was stirred at room temperature for 20 h before quenched by addition of sat. $NaHCO_3$ aq. at 0 °C. The mixture was extracted with ethyl acetate (5 × 50 mL). The organic phase was dried over Na_2SO_4 and concentrated. Purification of the residue by flash chromatography on silica gel (ethyl acetate : petroleum ether = 1 : 1.5, R_f = 0.3) afforded alcohol **S3** (4.10 g, 57% , *E/Z* = 10 : 1) as a yellow oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.36 – 7.27 (m, 5.5H), 5.20 (s, 1.1H), 4.51 (s, 2.2H), 3.65 (t, J = 6.4 Hz, 2.2H), 3.58 (t, J = 6.4 Hz, 2.2H), 2.72 (t, J = 6.4 Hz, 2H), 2.48 (t, J = 6.8 Hz, 0.2H), 2.32 (t, J = 7.6 Hz, 2.2H), 1.68 (dq, J = 14.0, 6.0 Hz, 2.2H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 166.3, 166.1, 137.7, 137.5, 128.4, 128.3, 127.8, 127.6, 127.5, 116.9, 116.9, 96.4, 96.3, 73.0, 72.8, 67.6, 67.0, 61.6, 61.3, 36.0, 35.0, 32.7, 31.4, 30.5, 29.7; **IR** (neat): ν_{max} = 3391, 2867, 2217, 1624, 1453, 1060, 737, 697 cm^{-1}; **HRMS** (*m/z*): $[M + Na]^+$ calcd. for $C_{15}H_{19}NNaO_2$, 268.1313; found, 268.1317.

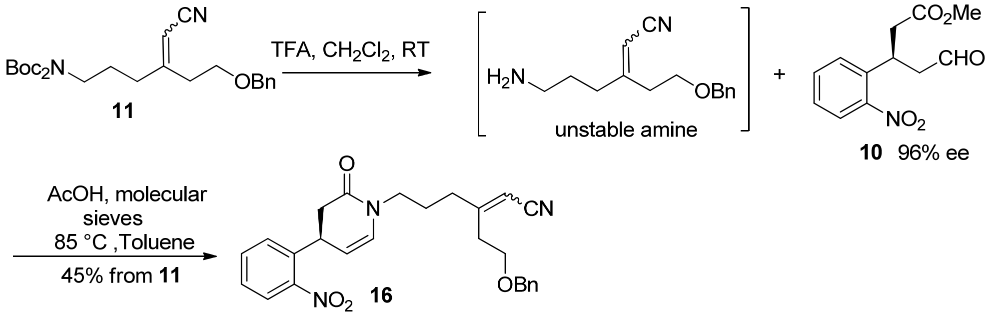
Preparation of 11



Under Ar, to a solution of **S3** (7.80 g, 31.8 mmol, 1.0 equiv.), Boc_2NH (7.60 g, 35.0 mmol, 1.1 equiv.) and PPh_3 (9.18 g, 35.0 mmol, 1.1 equiv.) in dry THF (320 mL) was dropwise added DIAD (7.00 mL, 35.0 mmol, 1.1 equiv.) at 0 °C. The reaction was stirred at 0 °C for 3 h and concentrated. Subjection of the residue to flash column chromatography on silica gel (cyclohexane : *i*-PrOH = 20 : 1, $R_f = 0.15$) provided **11** (11.0 g, 80%, *E/Z* = 10 : 1) as a colorless oil.

^{1}H NMR (600 MHz, $CDCl_3$): δ 7.36 – 7.26 (m, 5.5H), 5.23 (s, 1.1H), 4.51 (s, 2.0H), 4.50 (s, 0.2H), 3.64 (t, *J* = 6.0 Hz, 2H), 3.60 – 3.57 (m, 0.4H), 3.54 (t, *J* = 6.0 Hz, 2H), 2.72 (t, *J* = 6.0 Hz, 2H), 2.49 (t, *J* = 6.0 Hz, 0.2H), 2.42 (t, *J* = 6.0 Hz, 0.2H), 2.25 (t, *J* = 6.0 Hz, 2H), 1.74 (p, *J* = 6.0 Hz, 2.2H), 1.59 (s, 1.8H), 1.50 (s, 18H); **^{13}C NMR** (151 MHz, $CDCl_3$): δ 165.7, 165.0, 152.6, 152.4, 137.9, 137.7, 128.5, 128.4, 127.8, 127.7, 127.6, 116.9, 116.6, 96.8, 96.5, 82.5, 82.4, 73.1, 72.9, 67.7, 67.1, 45.8, 45.6, 35.8, 35.1, 33.8, 32.4, 28.1, 28.0, 26.9, 26.2; **IR** (neat): ν_{max} = 2978, 2217, 1691, 1365, 1135, 1108, 851, 697 cm^{-1}; **HRMS** (*m*/*z*): $[M + Na]^+$ calcd. for $C_{25}H_{36}N_2NaO_5$, 467.2522; found, 467.2517.

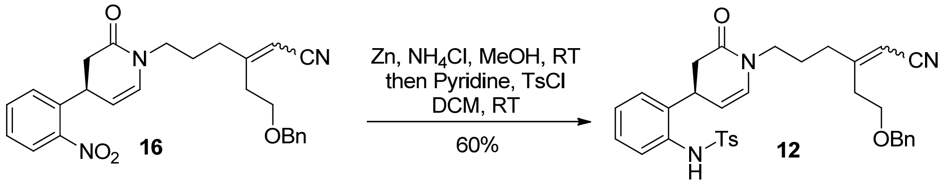
Preparation of 16



To a solution of **11** (2.00 g, 4.50 mmol, 1.0 equiv.) in dichloromethane (66 mL) was dropwise added TFA (3.35 mL, 45.0 mmol, 10 equiv.) at 0 °C. The reaction was stirred at room temperature for 20 h and concentrated. The residue was dissolved in dichloromethane (30 mL) and concentrated. This process was repeated for 5 times to remove TFA, then sat. $NaHCO_3$ aq. (30 mL) was added. The mixture was extracted with dichloromethane (8 × 30 mL). The organic phase was dried over Na_2SO_4 and concentrated. The residue was used without further purification. Before the next reaction, toluene (200 mL) was preheated to 85 °C. Molecular sieves (4Å, powder, 2.50 g) was firstly added to the hot toluene, then a mixture of crude amine and aldehyde **10** (1.35 g, 5.41 mmol, 1.2 equiv.) in toluene (10 mL) and AcOH (0.510 mL, 9.00 mmol, 2.0 equiv.) was added successively. The reaction was stirred at 85 °C for 20 h and filtered by a pad of Celite. The filtrate was concentrated and the residue was purified by flash column chromatography on silica gel (ethyl acetate : petroleum ether = 1 : 2, $R_f = 0.2$) to give enamide **16** (0.910 g, 45%, *E/Z* = 10 : 1) as a yellow oil.

^{1}H NMR (400 MHz, $CDCl_3$): *δ* 7.87 (d, *J* = 8.0 Hz, 1.1H), 7.56 (t, *J* = 7.6 Hz, 1.1H), 7.49 – 7.27 (m, 7.7H), 6.22 (dd, *J* = 8.0, 2.0 Hz, 0.1H), 6.14 (dd, *J* = 8.0, 2.0 Hz, 1H), 5.25 (s, 0.1H), 5.22 (s, 1H), 5.17 (dd, *J* = 8.0, 4.0 Hz, 1.1H), 4.50 (s, 2.2H), 4.36 – 4.31 (m, 1.1H), 3.65 (t, *J* = 6.0 Hz, 2H), 3.61 – 3.52 (m, 0.4H), 3.50 – 3.43 (m, 2H), 3.01 (dd, *J* = 16.4, 8.0 Hz, 1.1H), 2.75 – 2.62 (m, 3.3H), 2.49 (t, *J* = 6.0 Hz, 0.1H), 2.46 – 2.42 (m, 0.1H), 2.26 (t, *J* = 8.0 Hz, 2H), 1.78 – 1.71 (m, 2.2H); **^{13}C NMR** (101 MHz, $CDCl_3$): *δ* 167.4, 167.4, 165.4, 165.0, 148.9, 137.8, 137.6, 137.2, 137.1, 133.4, 133.4, 133.4, 130.8, 130.7, 129.0, 128.8, 128.4, 128.4, 128.0, 127.9, 127.8, 127.7, 127.6, 124.8, 124.7, 116.7, 108.2, 108.1, 97.0, 96.7, 73.1, 72.9, 67.8, 67.0, 46.0, 45.7, 38.6, 38.5, 35.9, 35.0, 33.7, 33.6, 33.6, 32.3, 26.5, 25.9; **IR** (neat): ν_{max} = 2946, 2216, 1662, 1522, 1351, 1098, 733, 699 cm^{-1}; **HRMS** (*m*/*z*): $[M + Na]^+$ calcd. for $C_{26}H_{27}N_3NaO_4$, 468.1899; found, 468.1895.

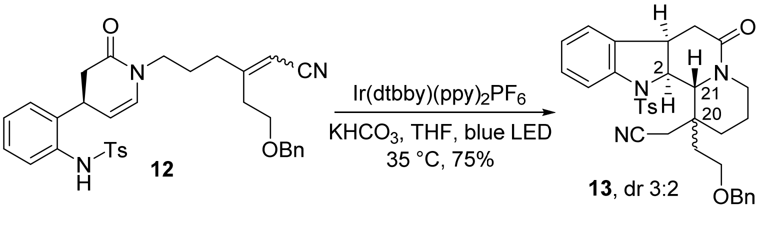
Preparation of 12



To a solution of **16** (4.18 g, 9.39 mmol, 1.0 equiv.) in methanol (420 mL) was added activated Zn powder (12.2 g, 0.190 mol, 20.0 equiv.) and NH_4Cl (10.1 g, 0.190 mol, 20.0 equiv.). The reaction was stirred at room temperature for 30 min and filtered by a pad of Celite. After the filtrate was concentrated, the residue was dissolved in sat. NH_4Cl aq. (30 mL) and extracted with dichloromethane (3 × 30 mL). The organic layer was dried over Na_2SO_4 and concentrated. The residue was used without further purification. To a solution of the crude product in dry dichloromethane (210 mL) was added TsCl (2.68 g, 14.1 mmol, 1.5 equiv.) and pyridine (15.1 mL, 0.190 mol, 20.0 equiv.). The reaction mixture was stirred at room temperature for 2 h and quenched by sat. NH_4Cl aq. (50 mL). The mixture was extracted with dichloromethane (3 × 50 mL). The organic layer was dried over Na_2SO_4 and concentrated. Purification of the crude product via flash chromatography on silica gel (petroleum ether : acetone = 4 : 1 to remove the pyridine then ethyl acetate : petroleum ether = 1 : 1.5, $R_f = 0.2$ for **12**) afforded the *E/Z* (10 : 1) mixture of product **12** (3.20 g, 60% from **16**) as a yellow foam.

^{1}H NMR (600 MHz, $CDCl_3$): δ 7.58 (d, *J* = 8.4 Hz, 2.2H), 7.40 – 7.27 (m, 4.6H), 7.23 (d, *J* = 7.8 Hz, 2H), 7.21 – 7.15 (m, 2.2H), 7.09 (td, *J* = 7.8, 2.4 Hz, 1.1H), 6.98 (s, 1.1H), 6.95 (d, *J* = 8.4 Hz, 1.1H), 6.05 (d, *J* = 7.8 Hz, 1.1H), 5.25 (s, 0.1H), 5.22 (s, 1H), 5.00 (dd, *J* = 7.8, 4.2 Hz, 1H), 4.94 (dd, *J* = 7.8, 3.6 Hz, 0.1H), 4.51 (s, 2.2H), 4.15 – 4.06 (m, 1H), 4.02 – 3.99 (m, 0.1H), 3.65 (t, *J* = 6.0 Hz, 2H), 3.60 (t, *J* = 6.0 Hz, 0.2H), 3.47 (t, *J* = 7.2 Hz, 2.2H), 2.72 (t, *J* = 6.0 Hz, 2H), 2.61 (dd, *J* = 16.2, 7.2 Hz, 1.1H), 2.50 (t, *J* = 6.0 Hz, 0.2H), 2.46 – 2.34 (m, 4.4H), 2.26 (t, *J* = 7.8 Hz, 2.2H), 1.74 (q, *J* = 7.8 Hz, 2.2H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 168.2, 168.0, 165.6, 165.5, 143.9, 143.8, 139.2, 138.0, 137.9, 137.6, 136.5, 136.3, 133.4, 133.1, 129.9, 129.8, 129.6, 128.4, 128.4, 127.8, 127.8, 127.7, 127.7, 127.7, 127.6, 127.3, 127.2, 127.0, 116.8, 116.6, 110.8, 109.8, 96.9, 96.7, 73.1, 72.9, 67.8, 67.1, 45.6, 45.2, 38.5, 38.4, 35.8, 35.0, 33.7, 32.7, 32.6, 32.1, 26.9, 25.9, 21.5; **IR** (neat): ν_{max} = 3212, 2217, 1650, 1332, 1159, 1091, 738, 699 cm^{-1}; **HRMS** (*m/z*): $[M + Na]^+$ calcd. for $C_{33}H_{35}N_3NaO_4S$, 592.2246; found, 592.2239.

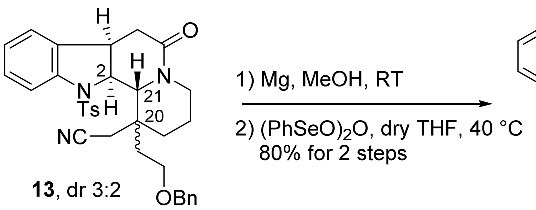
Preparation of 13



Under Ar, the mixture of **12** (3.00 g, 5.27 mmol, 1.0 equiv.), $Ir(dtbby)(ppy)_2PF_6$ (48.1 mg, 5.00 μmol, 0.01 equiv.) and potassium hydrogen carbonate (2.64 g, 26.4 mmol, 5.0 equiv.) in dry THF (300 mL) was stirred under 5W blue LED at 35 °C for 15 h. The reaction was concentrated in vacuo led to a crude product. Subsequent purification by flash column chromatography on silica gel (petroleum ether : ethyl acetate = 2 : 1, $R_f = 0.2$) yielded **13** (2.25 g, 75%, yellow foam) as a diastereomeric mixture (3 : 2).

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.65 (t, J = 7.6 Hz, 2.5H), 7.46 (dd, J = 16.0, 8.0 Hz, 5H), 7.42 – 7.26 (m, 15H), 7.21 – 7.09 (m, 7.5H), 6.98 (d, J = 7.6 Hz, 2.5H), 5.16 (d, J = 9.2 Hz, 1.5H), 4.74 (d, J = 8.4 Hz, 1H), 4.64 (d, J = 12.0 Hz, 1.5H), 4.55 – 4.50 (m, 6H), 3.88 – 3.77 (m, 5H), 3.68 – 3.57 (m, 2.5H), 3.11 – 2.98 (m, 3.5H), 2.91 (d, J = 17.6 Hz, 1H), 2.86 – 2.78 (m, 1.5H), 2.76 – 2.69 (m, 3.5H), 2.69 – 2.65 (m, 1.5H), 2.61 (dd, J = 17.2, 6.0 Hz, 1H), 2.45 (d, J = 16.8 Hz, 1.5H), 2.36 (s, 7.5H), 2.28 (td, J = 12.4, 3.6 Hz, 2.5H), 2.06 (d, J = 15.2 Hz, 1.5H), 1.99 (d, J = 9.6 Hz, 1H), 1.85 – 1.81 (m, 4H), 1.64 – 1.57 (m, 2.5H), 1.50 – 1.41 (m, 5H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 166.9, 166.7, 144.6, 144.6, 141.5, 141.2, 138.1, 137.5, 135.7, 135.4, 134.2, 133.7, 129.8, 129.7, 128.5, 128.4, 128.4, 127.9, 127.8, 127.7, 127.5, 127.2, 127.2, 126.7, 126.7, 123.0, 119.7, 119.6, 119.2, 118.5, 73.6, 73.3, 72.4, 72.4, 65.8, 65.5, 59.9, 58.9, 44.8, 44.3, 40.7, 40.5, 38.1, 37.9, 36.1, 35.8, 35.4, 31.4, 31.1, 29.6, 26.8, 21.6, 21.5, 21.0, 20.7; **IR** (neat): $\nu_{\max}$ = 2927, 1648, 1352, 1166, 1089, 750, 670 cm^{-1}; **HRMS** (*m*/*z*): $[M + Na]^+$ calcd. for $C_{33}H_{35}N_3NaO_4S$, 592.2246; found, 592.2247.

Preparation of indole 19

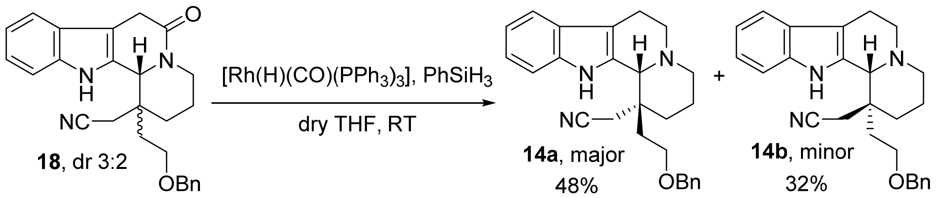


To a solution of **13** (1.60 g, 2.81 mmol, 1.0 equiv.) in methanol (160 mL) was added Mg (2.02 g, 84.3 mmol, 30.0 equiv.). The reaction was stirred at room temperature for 18 h and quenched by addition of sat. NH_4Cl aq. (200 mL). The mixture was extracted with ethyl acetate (5 × 100 mL). The organic phase was dried over Na_2SO_4 and concentrated in vacuo. The crude product was used without further purification.

Under Ar, the crude product was dissolved in dry THF (420 mL) and $(PhSeO)_2O$ (1.21 g, 3.37 mmol, 1.2 equiv.) was added. The reaction was stirred at 40 °C for 24 h and quenched by addition of sat. $NaHCO_3$ aq. (200 mL). The mixture was extracted with ethyl acetate (5 × 100 mL). The organic phase was dried over Na_2SO_4 and concentrated in vacuo. Purification of the crude product by flash chromatography on silica gel (ethyl acetate : petroleum ether = 1 : 1, $R_f = 0.2$) gave product **19** (930 mg, 80% for 2 steps, dr 3:2) as a yellow foam.

^{1}H NMR (400 MHz, $CDCl_3$): δ 9.66 (s, 1.5H), 8.16 (s, 1H), 7.49 – 7.36 (m, 10.5H), 7.33 – 7.24 (m, 4H), 7.20 – 7.08 (m, 8H), 5.02 – 4.91 (m, 4H), 4.84 (s, 1H), 4.74 (d, *J* = 11.2 Hz, 1.5H), 4.66 (d, *J* = 11.2 Hz, 1.5H), 4.34 (dd, *J* = 15.6, 12.0 Hz, 2H), 4.02 (t, *J* = 10.8 Hz, 1.5H), 3.89 – 3.85 (m, 1.5H), 3.80 – 3.73 (m, 2.5H), 3.67 – 3.58 (m, 2.5H), 3.44 – 3.36 (m, 2H), 2.87 (d, *J* = 17.6 Hz, 1H), 2.76 – 2.63 (m, 2H), 2.62 – 2.46 (m, 2.5H), 2.24 – 2.16 (m, 1.5H), 2.04 – 1.70 (m, 14.5H), 1.36 – 1.29 (m, 1H); **^{13}C NMR** (151 MHz, $CDCl_3$): δ 168.1, 167.9, 137.5, 137.2, 136.4, 136.2, 128.9, 128.8, 128.5, 128.5, 127.8, 127.6, 125.9, 125.8, 125.8, 125.3, 123.1, 122.6, 120.4, 119.6, 118.7, 118.4, 118.2, 117.3, 111.4, 111.2, 109.0, 106.9, 74.3, 73.4, 65.5, 65.4, 63.2, 61.3, 43.9, 43.9, 42.2, 41.7, 36.6, 32.2, 31.0, 29.6, 29.3, 28.6, 27.2, 21.9, 20.8; **IR** (neat): v_{max} = 3337, 2936, 1622, 1456, 1091, 732 cm^{-1}; **HRMS** (*m/z*): $[M + Na]^+$ calcd. for $C_{26}H_{27}N_3NaO_2$, 463.2001; found, 463.1999.

Preparation of compounds 14a and 14b

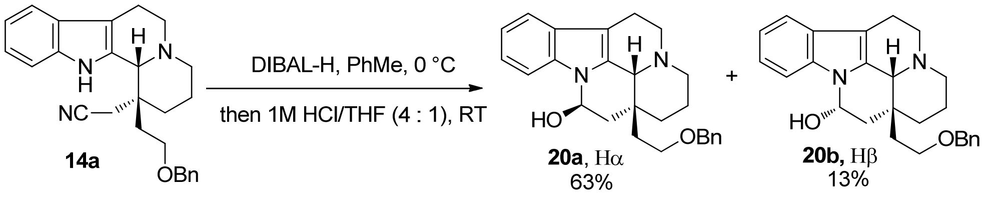


Under Ar, to a solution of **18** (0.99 g, 2.40 mmol, 1.0 equiv.) and $[Rh(H)CO](PPh_3)_3]$ (0.220 g, 0.240 mmol, 0.1 equiv.) in dry THF (100 mL) was added $PhSiH_3$ (0.886 μL, 7.20 mmol, 3.0 equiv.) at 0 °C. The reaction was stirred at 0 °C for 3 h and quenched by addition of sat. NH_4F aq. (50 mL). The mixture was extracted with ethyl acetate (5 × 80 mL). The organic phase was dried over Na_2SO_4 and concentrated. The resulting crude residue was subjected to flash chromatography on silica gel (ethyl acetate : petroleum ether = 1 : 10, $R_f = 0.15$ for **14a**, $R_f = 0.1$ for **14b**) to yield products **14a** (460 mg, 48%) and **14b** (310 mg, 32%) both as yellow foam.

14a. ^{1}H NMR (600 MHz, $CDCl_3$): δ 9.58 (s, 1H), 7.46 (d, J = 7.8 Hz, 1H), 7.39 – 7.27 (m, 5H), 7.14 (d, J = 7.8 Hz, 1H), 7.11 (t, J = 7.2 Hz, 1H), 7.07 (t, J = 7.2 Hz, 1H), 4.61 (J = 17.4, 11.4 Hz, 2H), 3.93 (t, J = 9.6 Hz, 1H), 3.85 – 3.78 (m, 1H), 3.62 (s, 1H), 3.49 (d, J = 18.0 Hz, 1H), 2.99 (d, J = 10.8 Hz, 1H), 2.93 (dd, J = 10.8, 4.8 Hz, 1H), 2.88 – 2.80 (m, 1H), 2.67 – 2.56 (m, 2H), 2.48 – 2.38 (m, 2H), 1.96 (dd, J = 16.2, 5.4 Hz, 1H), 1.91 – 1.84 (m, 2H), 1.79 – 1.66 (m, 2H), 1.63 (d, J = 13.2 Hz, 1H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 136.9, 136.4, 132.3, 128.6, 128.6, 128.2, 128.1, 128.1, 126.9, 121.4, 119.3, 119.0, 117.7, 112.5, 111.2, 73.7, 65.2, 64.5, 56.2, 53.2, 39.9, 37.8, 32.9, 23.3, 22.4, 22.3; **IR** (neat): $v_{\max}$ = 3343, 2923, 1454, 1263, 1092, 806 cm^{-1}; **$[\alpha]_D^{20}$** = −10 (c 0.19, $CHCl_3$); **HRMS** (m/z): $[M + H]^+$ calcd. for $C_{26}H_{30}N_3O$, 400.2389; found, 400.2389.

14b. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.71 (s, 1H), 7.47 (d, J = 7.8 Hz, 1H), 7.39 – 7.30 (m, 3H), 7.28 (d, J = 7.2 Hz, 1H), 7.22 (d, J = 7.2 Hz, 2H), 7.17 (t, J = 7.2 Hz, 1H), 7.11 (t, J = 7.2Hz, 1H), 4.35 (d, J = 12.0, 1H), 4.30 (d, J = 12.0, 1H), 3.64 (s, 1H), 3.47 (s, 1H), 3.41 (s, 1H), 3.05 – 2.98 (m, 3H), 2.95 – 2.82 (m, 2H), 2.64 (t, J = 14.4 Hz, 2H), 2.52 (t, J = 11.4 Hz, 1H), 2.34 (dt, J = 15.6, 4.8 Hz, 1H), 1.90 – 1.78 (m, 2H), 1.74 (t, J = 13.8 Hz, 1H), 1.69 – 1.58 (m, 2H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 138.0, 136.9, 132.1, 128.4, 128.4, 127.6, 127.5, 127.5, 127.2, 121.9, 119.7, 118.7, 117.9, 113.5, 111.2, 73.2, 66.6, 66.5, 55.7, 53.0, 39.5, 34.0, 31.6, 28.4, 22.2, 21.9; **IR** (neat): $v_{\max}$ = 3415, 2925, 1464, 1096, 809 cm^{-1}; **$[\alpha]_D^{20}$** = −12 (c 0.11, $CHCl_3$); **HRMS** (m/z): $[M + H]^+$ calcd. for $C_{26}H_{30}N_3O$, 400.2389; found, 400.2384.

Preparation of alcohols 20a and 20b

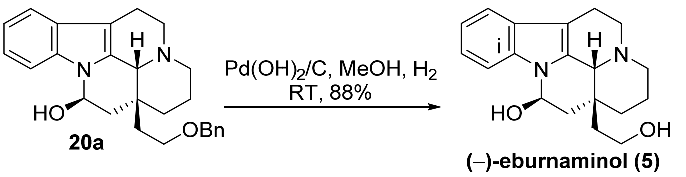


Under Ar, DIBAL-H (1.5 M in toluene, 434 μL, 0.650 mmol, 2.0 equiv.) was added to a solution of **14a** (130 mg, 0.330 mmol, 1.0 equiv.) in dry toluene (26 mL) at 0 °C. The reaction was stirred at 0 °C for 20 min and quenched by addition of sat. potassium sodium tartrate aq. (10 mL). The mixture was stirred at room temperature overnight and extracted with ethyl acetate (10 × 15 mL). The organic phase was dried over Na_2SO_4 and concentrated. The residue was dissolved in THF (2 mL), then 1M HCl (8 mL) was added at 0 °C. The reaction mixture was warmed to room temperature and stirred for 2 h. After it was quenched by addition of sat. $NaHCO_3$ aq. until the fully consumption of HCl, the mixture was extracted with ethyl acetate (15 × 10 mL). The organic phase was dried over Na_2SO_4 and concentrated. The residue was purified by preparative TLC (petroleum ether : acetone : methanol = 60 : 60 : 1, R_f = 0.35 for **20a**, R_f = 0.3 for **20b**) to obtain products **20a** (82.5 mg, 63%) and **20b** (17.0 mg, 13%) both as white foam.

20a. **^{1}H NMR** (400 MHz, $CDCl_3$): *δ* 7.81 (d, *J* = 8.0 Hz, 1H), 7.44 (d, *J* = 7.6 Hz, 1H), 7.40 – 7.30 (m, 3H), 7.30 – 7.11 (m, 4H), 5.60 (dd, *J* = 9.2, 5.2 Hz, 1H), 4.52 (s, 2H), 4.30 (s, 1H), 3.77 – 3.59 (m, 2H), 3.43 (dd, *J* = 13.6, 6.4 Hz, 1H), 3.26 (td, *J* = 13.2, 6.0 Hz, 1H), 3.00 – 2.79 (m, 2H), 2.73 – 2.61 (m, 2H), 2.57 – 2.52 (m, 2H), 2.07 – 1.96 (m, 2H), 1.91 (dd, *J* = 14.4, 9.2 Hz, 1H), 1.55 (d, *J* = 13.6 Hz, 1H), 1.43 (d, *J* = 14.0 Hz, 1H), 0.95 (td, *J* = 13.6, 3.2 Hz, 1H); **^{13}C NMR** (151 MHz, $CDCl_3$): *δ* 138.1, 137.3, 128.4, 128.4, 127.7, 127.7, 127.6, 127.6, 127.3, 122.7, 120.9, 118.3, 112.7, 104.7, 75.9, 73.1, 66.0, 59.4, 51.0, 44.0, 43.3, 37.1, 35.1, 24.6, 18.9, 16.1; **IR** (neat): ν_{max} = 3273, 2922, 1455, 1264, 1092, 734, 699 cm^{-1}; **$[\alpha]_D^{20}$** = −39 (*c* 0.14, $CHCl_3$); **HRMS** (*m/z*): $[M + H]^+$ calcd. for $C_{26}H_{31}N_2O_2$, 403.2386; found, 403.2385.

20b. **^{1}H NMR** (600 MHz, $CDCl_3$): *δ* 7.50 (t, *J* = 8.4 Hz, 2H), 7.34 – 7.30 (m, 4H), 7.28 – 7.25 (m, 2H), 7.19 (t, *J* = 7.2 Hz, 1H), 6.08 (d, *J* = 4.2 Hz, 1H), 4.50 (s, 2H), 4.32 (s, 1H), 3.79 – 3.65 (m, 2H), 3.61 (dd, *J* = 13.2, 5.4 Hz, 1H), 3.45 – 3.40 (m, 1H), 3.08 – 2.98 (m, 2H), 2.91 (d, *J* = 12.6 Hz, 1H), 2.80 (t, *J* = 11.4 Hz, 1H), 2.61 (dt, *J* = 15.0, 4.8 Hz, 1H), 2.49 (d, *J* = 15.0 Hz, 1H), 2.22 (dd, *J* = 15.0, 4.2 Hz, 1H), 2.18 – 2.06 (m, 1H), 2.06 – 1.96 (m, 1H), 1.91 (t, *J* = 13.8 Hz, 1H), 1.66 (d, *J* = 14.4 Hz, 1H), 1.50 (d, *J* = 13.8 Hz, 1H); **^{13}C NMR** (151 MHz, $CDCl_3$): *δ* 138.2, 135.6, 128.4, 128.4, 127.6, 127.6, 127.6, 127.6, 127.6, 122.7, 120.9, 118.7, 110.5, 104.6, 73.8, 73.1, 66.3, 59.9, 51.5, 44.6, 40.6, 35.5, 35.0, 25.9, 19.3, 16.3; **IR** (neat): $\nu_{\max}$ = 3269, 2923, 1455, 1199, 1050, 733, 698 cm^{-1}; **$[\alpha]_D^{20}$** = +48.4 (*c* 0.13, $CHCl_3$); **HRMS** (*m*/*z*): $[M + H]^+$ calcd. for $C_{26}H_{31}N_2O_2$, 403.2386; found, 403.2384.

Synthesis of (–)-eburnaminol (5)



The mixture of **20a** (45.0 mg, 0.110 mmol, 1.0 equiv.) and $Pd(OH)_2/C$ (20%, 27.0 mg, 10.0 μmol, 0.1 equiv.) in methanol (5 mL) was stirred under 1 atm H_2 at room temperature for 16 h and filtered through a pad of Celite. The filtrate was concentrated in vacuo and purified by flash column chromatography on silica gel (dichloromethane : methanol = 12 : 1, R_f = 0.2) to give product (–)-eburnaminol (30.7 mg, 88%) as a white foam.

^{1}H NMR (400 MHz, $CDCl_3$: CD_3OD = 25 : 1): δ 7.80 (d, *J* = 8.4 Hz, 1H), 7.43 (d, *J* = 7.2 Hz, 1H), 7.23 (t, *J* = 7.6 Hz, 1H), 7.17 (t, *J* = 7.4 Hz, 1H), 5.60 (dd, *J* = 9.2, 4.8 Hz, 1H), 4.46 (s, 1H), 3.95 – 3.85 (m, 1H), 3.84 – 3.75 (m, 1H), 3.32 (dd, *J* = 13.6, 6.8 Hz, 1H), 3.18 (td, *J* = 13.2, 6.0 Hz, 1H), 2.93 – 2.74 (m, 2H), 2.61 – 2.45 (m, 2H), 2.29 – 2.25 (m, 1H), 2.21 (dd, *J* = 14.0, 5.2 Hz, 1H), 2.08 – 1.98 (m, 2H), 1.77 – 1.67 (m, 1H), 1.45 (d, *J* = 14.0 Hz, 1H), 1.35 (d, *J* = 14.0 Hz, 1H), 1.07 (td, *J* = 13.6, 4.0 Hz, 1H); **^{13}C NMR** (151 MHz, $CDCl_3$: CD_3OD = 10 : 1): δ 137.0, 128.3, 127.5, 122.1, 120.4, 118.0, 112.4, 104.1, 75.4, 58.3, 58.0, 50.6, 43.5, 43.3, 39.3, 36.4, 26.2, 19.4, 16.2; **IR** (neat): $\nu_{\max}$ = 3307, 2920, 1456, 1264, 1059, 733, 702 cm^{-1}; **$[\alpha]_D^{25}$** = −63 (*c* 0.4, $CHCl_3$), lit.[4] **$[\alpha]_D^{25}$** = −54 (*c* 0.17, $CHCl_3$); **HRMS** (*m*/*z*): $[M + H]^+$ calcd. For $C_{19}H_{25}N_2O_2$, 313.1916; found, 313.1912.

Comparison of ^{1}H NMR ($CDCl_3$ + CD_3OD) spectroscopic date of the natural (−)-eburnaminol (5) in the literature[4] and in our study.

A: Natural (−) **5** *δ* H [ppm, mult, *J* (Hz)] 400 MHz	B: Our synthetic (−) **5** *δ* H [ppm, mult, *J* (Hz)] 400 MHz	Error (B - A)[a] Δ*δ*/ppm
2.32, br dd	2.29 – 2.25, 1H, m	–
2.48, br d	2.61 – 2.45, 2H, m	–
2.48, dd		
3.27, dd	3.32, 1H, dd, 13.6, 6.8	
3.36, ddd	3.84 – 3.75, 1H, m	–
2.61, br d	2.93 – 2.74, 2H, m	–
3.01, m	3.18, 1H, td, 13.2, 6.0	0.17
7.48, d	7.43, 1H, d, 7.2	0.05
7.12, t	7.17, 1H, t, 7.4	0.05
7.20, t	7.23, 1H, t, 7.6	0.03
7.78, d	7.80, 1H, d, 8.4	0.02
1.42, br d	1.35, 1H, d, 14.0	-0.07
1.85, br ddd	1.77 – 1.67, 1H, m	–
1.03, ddd	1.07, 1H, td, 13.6, 4.0	0.04
1.45, bd	1.45, 1H, d, 14.0	0
5.61, dd	5.60, 1H, dd, 9.2, 4.8	-0.01
3.80, m	3.95 – 3.85, 1H, m	–
2.05, m	2.08 – 1.98, 2H, m	–
1.88, dd		
2.15, m	2.21, 1H, dd, 14.0, 5.2	–
4.00, s	4.46, 1H, s	0.46

[a] *The percentage of CD$_3$OD in CDCl$_3$ was not given in the literature. The percentage of CD$_3$OD in CDCl$_3$ in our work was 3.8%. Compound* ***5*** *could be easily transferred to (+)-larutenine (****6****), which further proved compound* ***5*** *to be (–)-eburnaminol.*

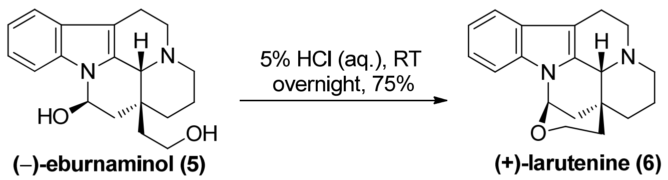
Comparison of ^{13}C NMR (CDCl$_3$ + CD$_3$OD) spectroscopic date of the natural (−)-eburnaminol (5) in the literature[4] and in our study.

A: Natural (−) **5** *δ* C (ppm), 50 MHz	B: Our synthetic (−) **5** *δ* C (ppm), 151 MHz	Error (B - A)[a] Δ*δ*/ppm
136.8	137.0	0.2
130.7	128.3	-2.4
128.1	127.5	-0.6
121.3	122.1	0.8
120.0	120.4	0.4
117.8	118.0	0.2
112.1	112.4	0.3
104.8	104.1	-0.7
75.5	75.4	-0.1
58.4	58.3	-0.1

58.2	58.0	-0.2
50.5	50.6	0.1
44.6	43.5	-1.1
43.5	43.3	-0.2
40.7	39.3	-1.4
36.4	36.4	0
26.4	26.2	-0.2
20.5	19.4	-1.1
16.6	16.2	-0.4

[a] *The percentage of CD_3OD in $CDCl_3$ was not given in the literature. The percentage of CD_3OD in $CDCl_3$ in our work was 9%. Compound* ***5*** *could be easily transferred to (+)-larutenine (**6**), which further proved compound* ***5*** *to be (–)-eburnaminol.*

Synthesis of (+)-larutenine (6)



Compound **5** (25.0 mg, 80.1 μmol, 1.0 equiv.) was dissolved in 5% aq. HCl (5 mL) and stirred overnight at room temperature. The solution was basified by dropwise addition of conc. aq. ammonia until the pH reached 11. The mixture was extracted with dichloromethane (5 × 10 mL). The organic phase was dried over Na_2SO_4 and concentrated. Flash column chromatography of the residue on silica gel (dichloromethane : methanol = 35 : 1, R_f = 0.2) was carried out to afford (+)-larutenine (**6**, 17.7 mg, 75%) as a yellow oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.46 (d, J = 8.0 Hz, 1H), 7.41 (d, J = 8.0 Hz, 1H), 7.19 (t, J = 7.2 Hz, 1H), 7.12 (t, J = 7.2 Hz, 1H), 5.84 (t, J = 2.4 Hz, 1H), 3.97 (td, J = 12.8, 2.4 Hz, 1H), 3.81 (dd, J = 12.4, 5.6 Hz, 1H), 3.24 (dd, J = 11.6, 8.0 Hz, 1H), 3.16 (s, 1H), 3.10 – 2.92 (m, 2H), 2.84 (dd, J = 16.0, 6.4 Hz, 1H), 2.69 (td, J = 11.2, 6.4 Hz, 1H), 2.31 – 2.21 (m, 1H), 1.84 (td, J = 13.6, 6.0 Hz, 1H), 1.79 – 1.64 (m, 5H), 1.56 (d, J = 13.2 Hz, 1H), 1.48 – 1.37 (m, 1H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 137.7, 136.5, 128.5, 121.5, 120.1, 118.3, 109.5, 107.7, 77.5, 63.3, 58.6, 54.2, 51.8, 40.7, 38.0, 35.5, 28.8, 21.1, 20.1; **IR** (neat): ν_{max} = 2925, 1457, 1265, 1078, 837, 731 cm^{-1}; **$[\alpha]_D^{25}$**

= +3.7 (*c* 0.16, $CHCl_3$), lit.[5] **[α]$_D^{25}$** = +5 (*c* 0.08, $CHCl_3$); **HRMS** (*m/z*): $[M + H]^+$ calcd. for $C_{19}H_{23}N_2O$, 295.1810; found, 295.1809.

Comparison of ^{1}H NMR ($CDCl_3$) spectroscopic date of the natural (+)-larutenine (6) in the literature[5] and in our study.

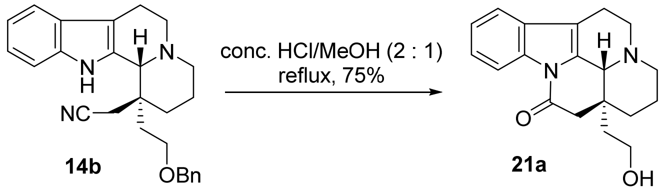
A: Natural (+) **6** *δ* H [ppm, mult, *J* (Hz)] 270 MHz	B: Our synthetic (+) **6** *δ* H [ppm, mult, *J* (Hz)] 400 MHz	Error (B - A) Δ*δ*/ppm
2.20 – 2.30, 1H, m	2.20 – 2.30, 1H, m	–
2.90 – 3.10, 2H, m	2.90 – 3.10, 2H, m	–
2.70, 1H, td, 11, 7	2.69, 1H, td, 11.2, 6.4	-0.01
3.24, 1H, dd, 11, 7	3.24, 1H, dd, 11.6, 8.0	0
2.84, 1H, br, ddd, 15, 7, 1.5	2.84, 1H, dd, 16.0, 6.4	0
7.46, 1H, d, 7	7.46, 1H, d, 8	0
7.11, 1H, t, 7	7.12, 1H, t, 7.2	0.01
7.18, 1H, t, 7	7.19, 1H, t, 7.2	0.01
7.41, 1H, d, 7	7.41, 1H, d, 8	0
1.60 – 1.80, 5H, m	1.64 – 1.80, 5H, m	–
1.35 – 1.48, 1H, m	1.37 – 1.48, 1H, m	–
5.83, 1H, t, 2	5.84, 1H, t, 2.4	0.01
3.80, 1H, dd, 13, 6	3.81, 1H, dd, 12.4, 5.6	0.01
3.95, 1H, td, 13, 3	3.97, 1H, td, 12.8, 2.4	0.02
1.54, 1H, d, 13	1.56, 1H, d, 13.2	0.02
1.82, 1H, td, 13, 6	1.84, 1H, td, 13.6, 6.0	0.02
3.17, 1H, s	3.16, 1H, s	-0.01

Comparison of ^{13}C NMR ($CDCl_3$) spectroscopic date of the natural (+)-larutenine (6) in the literature[5] and in our study.

A: Natural (+) **6** *δ* C (ppm), 67.8 MHz	B: Our synthetic (+) **6** *δ* C (ppm), 101 MHz	Error (B - A) Δ*δ*/ppm
136.5	136.5	0
51.8	51.8	0
54.2	54.2	0
21.1	21.1	0
107.7	107.7	0
128.5	128.5	0
118.3	118.3	0
120.1	120.1	0
121.5	121.5	0
109.5	109.5	0
137.7	137.7	0

20.0	20.1	0.1
35.5	35.5	0
77.5	77.5	0
38.0	38.0	0
58.5	58.6	0.1
40.6	40.7	0.1
28.8	28.8	0
63.3	63.3	0

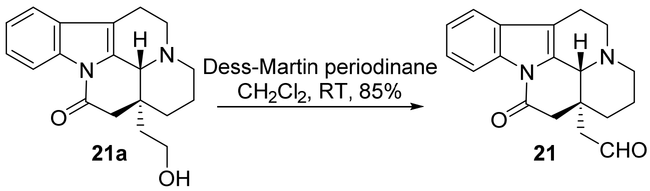
Preparation of 21a



Compound **14b** (120 mg, 0.300 mmol, 1.0 equiv.) was dissolved in a mixture of conc. HCl/MeOH (8 mL/4mL) and stirred under reflux for 10 h[6]. The reaction was quenched by addition of solid Na_2CO_3 and sat. $NaHCO_3$ aq. at 0 °C. Then the mixture was extracted with ethyl acetate (6 × 15 mL) and dichloromethane (6 × 15 mL). The organic phase was dried over Na_2SO_4 and concentrated. Purification of the residue by flash column chromatography on silica gel (dichloromethane : methanol = 40 : 1, R_f = 0.2) yielded product **21a** (69.9 mg, 75%) as a white foam.

^{1}H NMR (400 MHz, $CDCl_3$): δ 8.32 (dd, *J* = 6.8, 1.6 Hz, 1H), 7.41 (dd, *J* = 6.8, 1.6 Hz, 1H), 7.35 – 7.18 (m, 2H), 3.78 – 3.66 (m, 1H), 3.53 (dt, *J* = 11.6, 6.0 Hz, 1H), 3.13 (td, *J* = 11.6, 5.2 Hz, 2H), 3.06 (s, 1H), 2.96 – 2.87 (m, 1H), 2.79 (d, *J* = 16.4 Hz, 1H), 2.68 (d, *J* = 16.0 Hz, 1H), 2.58 (td, *J* = 11.2, 4.4 Hz, 1H), 2.52 (d, *J* = 16.8 Hz, 1H), 2.37 (td, *J* = 12.4, 3.6 Hz, 1H), 2.14 – 2.00 (m, 1H), 1.99 – 1.85 (m, 2H), 1.72 (d, *J* = 15.6 Hz, 1H), 1.39 (td, *J* = 13.2, 4.8 Hz, 1H), 1.25 (dt, *J* = 12.8, 5.2 Hz, 1H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 167.3, 135.0, 132.2, 129.7, 124.3, 123.9, 118.3, 116.1, 113.2, 65.3, 58.6, 55.1, 52.1, 47.7, 39.5, 34.0, 33.2, 22.1, 21.0; **IR** (neat): ν_{max} = 3387, 2924, 1701, 1652, 1364, 1149, 733 cm^{-1}; **$[\alpha]_D^{25}$** = +171 (*c* 0.14, $CHCl_3$); **HRMS** (*m/z*): $[M + Na]^+$ calcd. for $C_{19}H_{22}N_2NaO_2$, 333.1579; found, 333.1582.

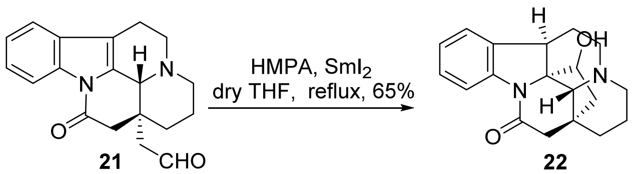
Preparation of 21



Dess-Martin periodinane (137 mg, 0.320 mmol, 2.0 equiv.) was added to a solution of compound **21a** (50.0 mg, 0.160 mmol, 1.0 equiv.) in dichloromethane (10 mL) at 0 °C. The reaction was stirred at 0 °C for 30 min before quenched by a mixture solution of sat. $Na_2S_2O_3$ aq. (5 mL) and sat. $NaHCO_3$ aq. (10 mL). The mixture was extracted with dichloromethane (6 × 10 mL). The organic phase was dried over Na_2SO_4 and concentrated in vacuo. Purification of the residue by flash column chromatography on silica gel (petroleum ether : acetone = 3 : 1, $R_f = 0.2$) gave product **21** (42.2 mg, 85%) as a white foam.

^{1}H NMR (400 MHz, $CHCl_3$): δ 9.73 (s, 1H), 8.34 (dd, *J* = 7.2, 1.6 Hz, 1H), 7.42 (dd, *J* = 6.4, 2.0 Hz, 1H), 7.36 – 7.27 (m, 2H), 3.18 – 3.05 (m, 3H), 3.00 (dt, *J* = 8.8, 2.0 Hz, 2H), 2.93 – 2.80 (m, 1H), 2.67 (d, *J* = 16.0 Hz, 1H), 2.62 – 2.50 (m, 2H), 2.36 (td, *J* = 12.4, 3.6 Hz, 1H), 2.19 (dt, *J* = 13.6, 2.8 Hz, 1H), 2.03 – 1.96 (m, 1H), 1.95 – 1.84 (m, 1H), 1.69 (d, *J* = 14.0 Hz, 1H), 1.39 (td, *J* = 13.6, 4.4 Hz, 1H); **^{13}C NMR** (151 MHz, $CHCl_3$): δ 201.0, 166.5, 135.0, 131.9, 129.7, 124.5, 124.1, 118.3, 116.3, 113.8, 65.2, 55.1, 52.0, 44.7, 43.2, 39.2, 33.0, 21.5, 21.2; **IR** (neat): ν_{max} = 2929, 1705, 1455, 1363, 1323, 1150, 811 cm^{-1}; **$[\alpha]_D^{25}$** = +98 (*c* 0.12, $CHCl_3$); **HRMS** (*m*/*z*): $[M + Na]^+$ calcd. for $C_{19}H_{20}N_2NaO_2$, 331.1422; found, 331.1425.

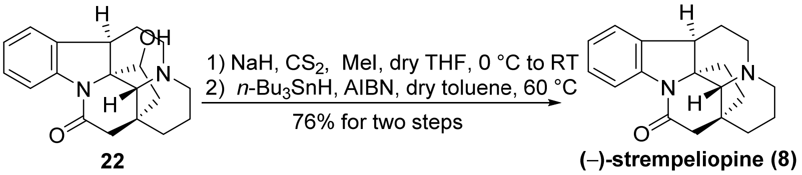
Preparation of 22



Under Ar, to a solution of **21** (45.0 mg, 0.150 mmol, 1.0 equiv.) in dry THF (4 mL) was added HMPA (127 μL, 0.730 mmol, 5.0 equiv.) at 0 °C, followed by addition of SmI_2 (0.1 M in THF, 15.0 mL, 1.50 mmol, 10.0 equiv.) at room temperature. The reaction was stirred under reflux for 40 min and cooled to room temperature. After being quenched by addition of sat. potassium sodium tartrate aq. (5 mL), the mixture was extracted with ethyl acetate (10 × 10 mL). The organic phase was dried over Na_2SO_4 and concentrated. Subjection of the crude product to flash column chromatography on silica gel (dichloromethane : ethyl acetate : methanol = 50 : 10 : 1, $R_f = 0.2$) afforded **22** (29.0 mg, 65%) as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ 8.06 (d, J = 8.0 Hz, 1H), 7.25 – 7.20 (m, 2H), 7.08 (t, J = 7.6 Hz, 1H), 4.10 – 3.76 (m, 2H), 3.14 (td, J = 11.2, 6.4 Hz, 1H), 2.92 (d, J = 11.2 Hz, 1H), 2.64 – 2.48 (m, 2H), 2.48 – 2.35 (m, 2H), 2.26 (dd, J = 15.2, 7.2 Hz, 1H), 2.17 (s, 1H), 2.15 – 2.01 (m, 2H), 1.93 – 1.83 (m, 2H), 1.75 (d, J = 13.6 Hz, 1H), 1.67 (d, J = 14.0 Hz, 1H), 1.34 (td, J = 13.2, 4.0 Hz, 1H); **^{13}C NMR** (151 MHz, $CDCl_3$): δ 166.9, 141.5, 134.0, 127.9, 124.5, 124.4, 116.9, 78.8, 75.0, 66.2, 53.9, 50.4, 50.0, 44.3, 40.6, 36.1, 30.3, 26.8, 21.5; **IR** (neat): ν_{max} = 3413, 2929, 1658, 1477, 1388, 1142, 756 cm^{-1}; **$[\alpha]_D^{25}$** = +17 (c 0.12, $CHCl_3$); **HRMS** (m/z): $[M + H]^+$ calcd. for $C_{19}H_{23}N_2O_2$, 311.1760; found, 311.1757.

Synthesis of (–)-strempeliopine (8)



Under Ar, to a solution of **22** (25.0 mg, 80.6 μmol, 1.0 equiv.) in dry THF (5 mL) was added NaH (32.0 mg, 0.806 mmol, 10.0 equiv.) at 0 °C. After 30 min, CS_2 (96.0 μL, 1.60 mmol, 20.0 equiv.) was added at the same temperature. The reaction was stirred at room temperature for another 30 min and MeI (100 μL, 1.60 mmol, 20.0 equiv.) was added. The reaction was stirred at room temperature for 1 h and quenched by addition of sat. NH_4Cl aq. (5 mL) at 0 °C. The mixture was extracted with ethyl acetate (3 × 10 mL). The organic phase was dried over Na_2SO_4 and concentrated. The residue was used without further purification.

Under Ar, to a mixture of the above crude product and AIBN (13.0 mg, 80.6 μmol, 1.0 equiv.) in dry toluene (5 mL) was added n-Bu$_3$SnH (108 μL, 0.403 mmol, 5.0 equiv.). The reaction was stirred at 80 °C for 30 min and concentrated in vacuo. Purification of the crude product by flash chromatography on silica gel (ethyl acetate : petroleum ether = 1 : 2, $R_f = 0.2$) yielded (–)-strempeliopine (**8**, 18.0 mg, 76%) as a white foam.

^{1}H NMR (400 MHz, CDCl$_3$): δ 8.05 (d, J = 8.0 Hz, 1H), 7.22 (t, J = 7.6 Hz, 1H), 7.16 (d, J = 7.2 Hz, 1H), 7.06 (t, J = 7.6 Hz, 1H), 3.25 (t, J = 7.2 Hz, 1H), 2.97 (dt, J = 11.6, 6.8 Hz, 1H), 2.86 (d, J = 10.8 Hz, 1H), 2.63 (d, J = 18.4 Hz, 1H), 2.46 (d, J = 18.4 Hz, 1H), 2.35 – 2.25 (m, 3H), 2.24 – 2.17 (m, 1H), 2.15 – 2.07 (m, 1H), 2.07 – 2.04 (1H, m), 2.03 (1H, s), 2.00 – 1.93 (1H, m), 1.92 – 1.77 (m, 1H), 1.74 (d, J = 13.6 Hz, 1H), 1.59 (d, J = 12.8 Hz, 1H), 1.53 – 1.45 (m, 1H), 1.28 (td, J = 13.2, 4.4 Hz, 1H); **^{13}C NMR** (151 MHz, CDCl$_3$): δ 169.3, 142.3, 133.3, 128.2, 124.1, 123.8, 116.0, 72.4, 69.8, 54.4, 50.8, 50.5, 43.2, 42.2, 39.0, 32.0, 31.5, 26.4, 22.0; **IR** (neat): ν_{max} = 2930, 1654, 1597, 1475, 1389, 1369, 1271, 1143, 752 cm^{-1}; **$[\alpha]_D^{20}$** = −24 (c 0.23, MeOH); lit.[7b] **$[\alpha]_{578}^{20}$** = −25.4 (c 1.8, MeOH); **HRMS** (m/z): $[M + Na]^+$ calcd. for $C_{19}H_{22}N_2NaO$, 317.1630; found, 317.1624; **m.p.**: 149.6 – 152.0 °C; lit.[7b] **m.p.**: 150.5 – 153 °C.

Comparison of ^{1}H NMR (CDCl$_3$) spectroscopic date of the natural (−)-strempeliopine (8) in the literature[7a] and in our study.

A: Natural (−) **8** δ H [ppm, mult, J (Hz)] 200 MHz	B: Our synthetic (−) **8** δ H [ppm, mult, J (Hz)] 400 MHz	Error (B - A) $\Delta\delta$/ppm
1.28, 1H, dt, 13.5, 13.0, 4.8	1.28, 1H, td, 13.2, 4.4	0
1.51, 1H, m	1.53 – 1.45, 1H, m	−
1.59, 1H, m, 13.3, 4.8, 4.0, 2.5	1.59, 1H, d, 12.8	0
1.74, 1H, dm, 13.5, 4.0, 2.5	1.74, 1H, d, 13.6	0
1.85, 1H, tq, 13.0, 13.3, 12.5, 4.0, 4.0	1.92 – 1.77, 1H, m	−
1.96, 1H, m, 14.1, 8.0, 8.0, 6.0	2.00 – 1.93, 1H, m	−
2.03, 1H, s	2.03, 1H, s	0
2.04, 1H, m, 12.5, 11.2, 3.0	2.07 – 2.04, 1H, m	−
2.09, 1H, dq, 14.1, 6.5, 6.0, 5.8	2.14 – 2.07, 1H, m	−

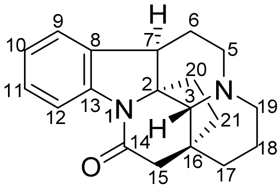
2.23, 1H, dt, 11.2, 6.0, 6.0	2.24 – 2.17, 1H, m	–
2.28, 3H, m	2.35 – 2.25, 3H, m	–
2.46, 1H, dd, 18.2, 2.4	2.46, 1H, d, 18.4	0
2.63, 1H, d, 18.2	2.63, 1H, d, 18.4	0
2.86, 1H, dt, 11.2, 4.0, 4.0	2.86, 1H, d, 10.8	0
2.97, 1H, ddd, 11.2, 8.0, 5.8	2.97, 1H, dt, 11.6, 6.8	0
3.25, 1H, bt, 6.5, 8.0	3.25, 1H, t, 7.2	0
7.06, 1H, bt, 7.4, 7.4	7.06, 1H, t, 7.6	0
7.17, 1H, bd, 7.4	7.16, 1H, d, 7.2	-0.01
7.23, 1H, bt, 7.4, 8.0	7.22, 1H, t, 7.6	-0.01
8.05, 1H, bd, 8.0	8.05, 1H, d, 8.0	0

Comparison of ^{13}C NMR (CDCl$_3$) spectroscopic date of the synthetic (±)-strempeliopine (8) in the literature[7c] and in our study.

A: Synthetic (±) **8** δ C (ppm), 150 MHz	B: Our synthetic (−) **8** δ C (ppm), 151 MHz	Error (B - A)[a] $\Delta\delta$/ppm
169.3	169.3	0
145.0	142.3	-2.7
128.2	128.2	0
124.2	133.3	9.1
124.1	124.1	0
123.8	123.8	0
116.0	116.0	0
72.4	72.4	0
69.8	69.8	0
54.3	54.4	0.1
50.8	50.8	0
50.5	50.5	0
43.2	43.2	0
42.1	42.2	0.1
39.0	39.0	0
32.0	32.0	0
31.5	31.5	0
26.4	26.4	0
22.0	22.0	0

[a] *There were two ^{13}C shifts that didn't match with those of the literature report. The two ^{13}C signals were ambiguous in the ^{13}C spectrum of literature. The structure of our synthetic **8** was confirmed by 2D NMR experiments.*

Assignment of the ^{1}H and ^{13}C NMR spectroscopic data of (−)-strempeliopine.

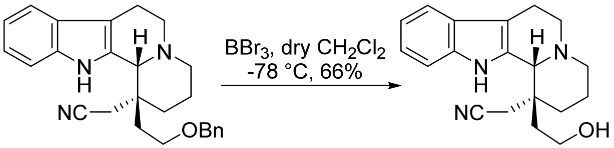


(−)-strempeliopine (**8**)

No.	δ_H mult. (J in Hz)	δ_C	COSY	HMBC
1	−	−	−	−
2	−	72.4	−	−
3	2.03 (s)	69.8	H-3	C15, C-19, C-20, C-21
4	−	−	−	−
5	H-5: 2.24 – 2.17 (m)	50.5	H-5, H-5’, H-6, H-6’	C-3, C-6, C-7, C-19
	H-5’: 2.97(dt,11.6, 6.8)		H-5, H-5’, H-6	C-3, C-6, C-7, C-19
6	H-6: 2.00 – 1.93 (m)	26.4	H-6, H-6’, H-5, H-5’, H-7	C-2, C-5, C-7, C-8
	H-6’: 2.14 – 2.07 (m)		H-6, H-6’, H-5	C-2, C-5, C-7, C-8
7	3.25 (t, 7.2)	42.2	H-6, H-7	C-2, C-3, C-6, C-8, C-20
8	−	133.3	−	−
9	7.16 (d, 7.2)	123.8	H-9, H-10	C-7, C-11, C-13
10	7.06 (t, 7.6)	124.1	H-9, H-10, H-11	C-12, C-8
11	7.22 (t, 7.6)	128.2	H-10, H-11, H-12	C-9, C-13
12	8.05 (d, 8.0)	116.0	H-11, H-12	C-8, C-10, C-13
13	−	142.3	−	−
14	−	169.3	−	−
15	H-15: 2.46 (d, 18.4)	50.8	H-15, H-15’	C-14, C-16, C-17
	H-15’: 2.63 (d, 18.4)		H-15, H-15’	C-3, C-14, C-16, C-21
16	−	43.2	−	−
17	H-17: 1.28 (td, 13.2, 4.4)	31.5	H-17, H-17’, H-18, H-18’	C-15, C-16, C-18, C-19, C-21
	H-17’: 1.74 (d, 13.6)		H-17, H-17’	C-3, C-16, C-19
18	H-18: 1.59 (d, 12.8)	22.0	H-18, H-18’, H-17	−

	H-18': 1.92 – 1.77 (m)		H-18, H-18', H-17, H-19	–
19	H-19: 2.07 – 2.04 (m)	54.4	H-19, H-19', H-18'	C-3, C-18
	H-19': 2.86 (d, 10.8)		H-19, H-19', H-18'	C-3, C-5, C-17, C-18
20	H-20: 2.35 – 2.25 (m)	39.0	H-20, H-20', H-21, H-21'	C-2, C-7, C-16, C-21
	H-20': 2.35 – 2.25 (m)		H-20, H-20', H-21, H-21'	C-2, C-7, C-16, C-21
21	H-21: 2.35 – 2.25 (m)	32.0	H-20, H-20', H-21, H-21'	C-3, C-20
	H-21': 1.53 – 1.45 (m)		H-20, H-20', H-21, H-21'	C-2, C-3, C-15, C-16, C-20

Preparation of 23



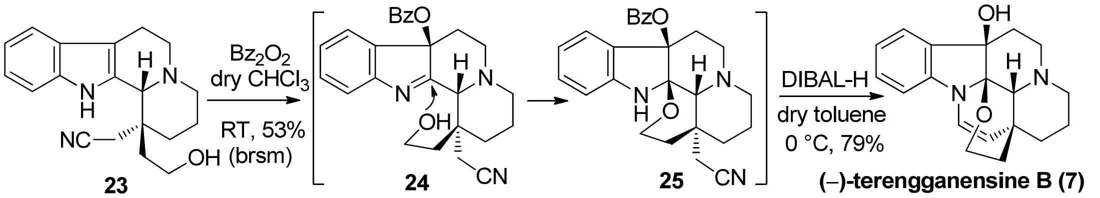
14a **23**

Under Ar, to a solution of **14a** (50.0 mg, 0.125 mmol, 1.0 equiv.) in dry dichloromethane (10 mL) was slowly added BBr_3 (250 µL, 0.250 mmol, 2.0 equiv.) at –78 °C. The reaction was stirred at –78 °C for 15 to 20 min. Then the reaction was poured into precooled (0°C) sat. $NaHCO_3$ aq. (20 mL). The mixture was extracted with ethyl acetate (10 × 10 mL). The organic phase was dried over Na_2SO_4 and concentrated. The obtained crude residue was subjected to column chromatography on silica gel (dichloromethane : methanol = 40 : 1, R_f = 0.2), giving product **23** (25.0 mg, 66%) as a white foam.

^{1}H NMR (400 MHz, $CDCl_3$): δ 9.51 (s, 1H), 7.47 (d, J = 8.0 Hz, 1H), 7.33 (d, J = 8.0 Hz, 1H), 7.14 (t, J = 7.2 Hz, 1H), 7.08 (t, J = 7.2 Hz, 1H), 4.19 (t, J = 10.4 Hz, 1H), 4.11 – 4.02 (m, 1H), 3.73 (s, 1H), 3.50 (d, J = 17.6 Hz, 1H), 3.02 (d, J = 10.8 Hz, 1H), 2.95 – 2.90 (m, 1H), 2.84 (d, J = 12.4 Hz, 1H), 2.69 – 2.56 (m, 2H), 2.51 (td, J = 11.6, 2.4 Hz, 1H), 2.46 – 2.36 (m, 1H), 1.98 – 1.84 (m, 3H), 1.83 – 1.78 (m, 2H), 1.66 (d, J = 12.4 Hz, 1H); **^{13}C NMR** (151 MHz, $CDCl_3$): δ 136.5, 132.4, 127.0, 121.5, 119.4, 119.2, 117.8, 112.7, 111.2, 64.9, 58.0, 56.3, 53.2, 39.9, 39.2, 32.8, 23.3, 22.4, 22.2;

IR (neat): ν_{max} = 3325, 2923, 1463, 1342, 1262, 1019, 804, 735 cm^{-1}; **[α]$_D^{25}$** = +38 (*c* 0.19, $CHCl_3$); **HRMS** (*m*/*z*): [M + Na]$^+$ calcd. for $C_{19}H_{23}N_3NaO$, 332.1739; found, 332.1743.

Synthesis of (–)-terengganensine B (7)



Under Ar, to a solution of **23** (32.0 mg, 0.104 mmol, 1.0 equiv.) in dry $CHCl_3$ (7 mL) was added freshly recrystallized dibenzoyl peroxide (25.0 mg, 0.104 mmol, 1.0 equiv.)[9] at room temperature. The reaction was stirred for 6 h before a mixture of triethylamine and diethylamine (113 µL and 169 µL) was added. After 30 min, the mixture was quenched with water (5 mL) and extracted with dichloromethane (8 × 5 mL). The organic phase was dried over Na_2SO_4 and concentrated. The residue was purified by preparative TLC (petroleum ether : acetone = 3 : 1, R_f = 0.4) to give unstable crude product **25** (10.2 mg, 53%, brsm, yellow foam) and recovered compound **23** (18.5 mg).

Under Ar, to a solution of crude **25** (20.0 mg, 46.6 µmol, 1.0 equiv.) in dry toluene (2 mL) was added DIBAL-H (1.5 M in toluene, 94.0 µL, 0.140 mmol, 3.0 equiv.) at 0 °C. The reaction was stirred at 0 °C for 20 min and quenched by addition of sat. potassium sodium tartrate aq. (5 mL). The mixture was stirred at room temperature for 1 h and extracted with ethyl acetate (6 × 5 mL). The organic phase was dried over Na_2SO_4 and concentrated. Purification of the residue by flash column chromatography on silica gel (petroleum ether : acetone = 3 : 1, R_f = 0.3) afforded (–)-terengganensine B (**7**, 11.0 mg, 79%) as a yellow amorphous solid.

^{1}H NMR (600 MHz, CD_3OD): δ 7.18 (d, *J* = 7.2 Hz, 1H), 7.15 (t, *J* = 7.8 Hz, 1H), 7.09 (d, *J* = 7.2 Hz, 1H), 6.84 (d, *J* = 7.8 Hz, 1H), 6.80 (t, *J* = 7.2 Hz, 1H), 4.49 (d, *J* = 7.8 Hz, 1H), 3.76 – 3.62 (m, 2H), 2.87 (d, *J* = 9.0 Hz, 1H), 2.56 (d, *J* = 7.8 Hz, 1H), 2.45 (s, 1H), 2.38 (s, 1H), 2.21 (s, 1H), 1.99 (d, *J* = 14.4 Hz, 1H), 1.83 – 1.79 (m, 3H), 1.67 – 1.54 (m, 2H), 1.49 – 1.40 (m, 1H), 1.37 (d, *J* = 12.6 Hz, 1H); **^{13}C NMR** (151 MHz, CD_3OD): *δ* 142.4, 137.8, 129.7, 127.4, 122.9, 121.1, 108.0, 103.6, 89.7, 78.5, 64.9, 61.6, 56.1, 52.1, 40.8, 39.3, 37.3, 35.7, 23.3; **IR** (neat): ν_{max} = 2917, 2849, 1637, 1486, 1302, 1123, 991, 738 cm^{-1}; **$[\alpha]_D^{25}$** = −33 (*c* 0.1, $CHCl_3$); lit.[8] **$[\alpha]_D^{25}$** = −19 ($CHCl_3$); **HRMS** (*m/z*): $[M + H]^+$ calcd. for $C_{19}H_{23}N_2O_2$, 311.1760; found, 311.1751.

Comparison of ^{1}H NMR (CD_3OD) spectroscopic date of the natural (−)-terengganensine B (7) in the literature[8] and in our study.

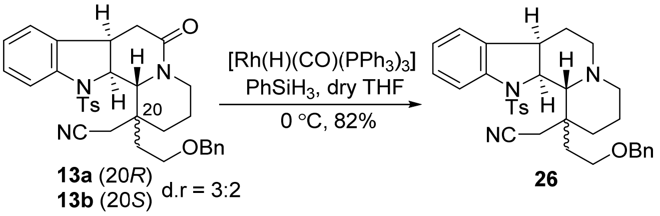
A: Natural (−) **7** *δ* H [ppm, mult, *J* (Hz)] 400 MHz	B: Our synthetic (−) **7** *δ* H [ppm, mult, *J* (Hz)] 600 MHz	Error (B - A) Δ*δ*/ppm
1.38, 1H, m	1.37, 1H, d, 12.6	−
1.45, 1H, m	1.49 – 1.40, 1H, m	−
1.60, 2H, m	1.67 – 1.54, 2H, m	−
1.80, 3H, m	1.83 – 1.79, 3H, m	−
2.00, 1H, m	1.99, 1H, d, 14.4	−
2,18, 1H, m	2.21, 1H, brs	−
2.35, 1H, brs	2.38, 1H, brs	0.03
2.40, 1H, m	2.45, 1H, brs	−
2.55, 1H, m	2.56, 1H, d, 7.8	−
2.85, 1H, m	2.87, 1H, d, 9.0	−
3.70, 2H, m	3.76 – 3.62, 2H, m	−
4.48, 1H, dd, 7.5, 1.5	4.49, 1H, d, 7.8	0.01
6.78, 1H, dd, 7.5, 7.5	6.80, 1H, t, 7.2	0.02
6.82, 1H, d, 7.5	6.84, 1H, d, 7.8	0.02
7.05, 1H, d, 7.5	7.09, 1H, d, 7.2	0.04
7.15, 1H, d, 7.5	7.15, 1H, t, 7.8	0
7.18, 1H, dd, 7.5, 7.5	7.18, 1H, d, 7.2	0

Comparison of ^{13}C NMR (CD_3OD) spectroscopic date of the natural (−)-terengganensine B (7) in the literature[8] and in our study.

A: Natural (+) **7** *δ* C (ppm), 62.5 MHz	B: Our synthetic (+) **7** *δ* C (ppm), 151 MHz	Error (B - A) Δ*δ*/ppm
89.7	89.7	0
56.1	56.1	0
52.1	52.1	0
39.3	39.3	0
78.5	78.5	0

137.8	137.8	0
122.9	122.9	0
121.1	121.1	0
129.7	129.7	0
108.0	108.0	0
142.5	142.4	-0.1
23.3	23.3	0
37.4	37.3	-0.1
127.4	127.4	0
103.7	103.6	-0.1
61.6	61.6	0
40.8	40.8	0
35.7	35.7	0
65.0	64.9	-0.1

Preparation of compound 26

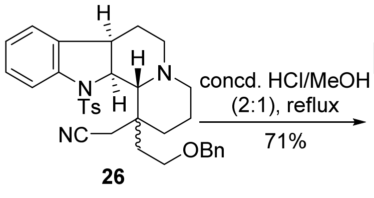


Under Ar, to a solution of **13** (290 mg, 0.510 mmol, 1.0 equiv.) and [Rh(H)(CO)(PPh$_3$)$_3$] (70.2 mg, 76.4 μmol, 0.150 equiv.) in dry THF (58 mL) was dropwise added PhSiH$_3$ (283 μL, 2.30 mmol, 4.5 equiv.) at 0 °C. After being stirred for 17 h, the reaction was quenched with sat. NH$_4$F aq. (5 mL) and extracted with ethyl acetate (3 × 10 mL). The combined organic layers were dried over anhydrous Na$_2$SO$_4$ and concentrated in vacuo. Purification of the crude product via column chromatography on silica gel (petroleum ether : acetone = 5 : 1, R$_f$ = 0.15) gave **26** as a pair of inseparable diastereomers (232 mg, 82%, white foam).

^{1}H NMR (400 MHz, CDCl$_3$): δ 7.75 (d, J = 7.6 Hz, 1H), 7.48 (d, J = 7.6 Hz, 3H), 7.43 – 7.23 (m, 18.5H), 7.21 – 7.26 (m, 2.5H), 7.08 (t, J = 7.6 Hz, 5H), 6.89 (t, J = 7.2 Hz, 2.5H), 4.68 – 4.44 (m, 6H), 4.38 (brs, 1.5H), 3.83 (d, J = 17.2 Hz, 1H), 3.70 – 3.55 (m, 5H), 3.13 (q, J = 16.4 Hz, 3H), 2.88 – 2.68 (m, 5H), 2.62 (brs, 1.5H), 2.58 – 2.45 (m, 3.5H), 2.35 – 2.33 (m, 9.5H), 2.21 – 2.01 (m, 5.5H), 2.01 – 1.91 (m, 3.5H), 1.90 – 1.59 (m, 11.5H), 1.57 – 1.46 (m, 2.5H), 1.45 – 1.36 (m, 1H); **^{13}C NMR** (151

MHz, $CDCl_3$): δ 144.3, 142.3, 142.1, 138.6, 138.2, 137.6, 137.4, 135.4, 135.2, 134.0, 129.6, 129.4, 128.5, 128.4, 128.3, 128.0, 127.9, 127.7, 127.6, 127.6, 127.4, 127.4, 127.3, 127.0, 126.9, 122.7, 122.3, 121.5, 119.0, 118.9, 73.0, 72.8, 67.0, 66.3, 63.2, 57.6, 51.3, 51.2, 40.4, 39.9, 38.4, 37.6, 37.2, 34.2, 30.1, 29.0, 23.8, 22.7, 21.6, 21.1, 21.0; **IR** (neat): ν_{max} = 2937, 1596, 1348, 1163, 1087, 909, 729, 666 cm^{-1}; **HRMS** (*m*/*z*): $[M + H]^+$ calcd. for $C_{33}H_{38}N_3O_3S$, 556.2634; found, 556.2639.

Preparation of compound 27

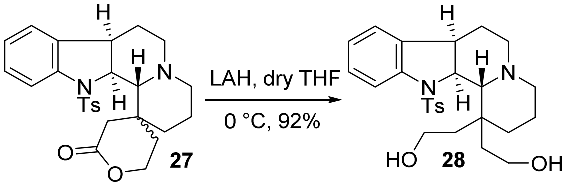


Concentrated HCl (16 mL) was added dropwise to the solution of compound **26** (232 mg, 0.420 mmol, 1.0 equiv.) in methanol (8 mL) at 0 °C. The reaction was then heated under reflux for 9 h and quenched by adding sat. $NaHCO_3$ aq. and solid Na_2CO_3 in ice bath until pH > 8. Then methanol was evaporated under reduced pressure and the aqueous phase was extracted with dichloromethane (6 × 10 mL). The combined organic layers were dried over Na_2SO_4 and concentrated in vacuo. The obtained crude product was purified by column chromatography on silica gel (petroleum ether : acetone = 3.5 : 1, R_f = 0.2) to give **27** (138 mg, 71%, white foam). *Note: The two diastereomers of **27** could be partly separated by chromatography. However, separation of both diastereomers at this stage was unnecessary because the next reduction step would produce the same diol. The dr value in NMR was determined by the sample collected during purification, so it was different from that of **26**.*

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.61 (d, *J* = 7.6 Hz, 1H), 7.57 (d, *J* = 8.0 Hz, 0.2H), 7.40 – 7.27 (m, 3.6H), 7.19 (t, *J* = 7.6 Hz, 1.2H), 7.08 (d, *J* = 8.0 Hz, 2.4H), 6.92 (d, *J* = 7.2 Hz, 1.2H), 4.71 – 4.49 (m, 2.4H), 4.42 – 4.36 (m, 0.2H), 4.34 – 4.28 (m, 1H), 3.91 (d, *J* = 16.0 Hz, 0.2H), 3.12 (d, *J* = 16.0 Hz, 1H), 2.94 (d, *J* = 16.0 Hz, 1.4H), 2.83 – 2.77 (m, 1.2H), 2.67 – 2.60 (m, 1.2H), 2.52 (dt, *J* = 13.2, 2.8 Hz, 1.2H), 2.44 – 2.39 (m, 0.2H), 2.34 (s, 3.6H), 2.20 – 1.98 (m, 4.2H), 1.97 – 1.80 (m, 2.4H), 1.76 –

1.65 (m, 2.6H), 1.61 – 1.54 (m, 1.2H), 1.52 – 1.41 (m, 1.2H), 1.33 – 1.24 (m, 1.2H); **^{13}C NMR** (151 MHz, $CDCl_3$): *δ* 173.2, 173.1, 144.4, 144.3, 141.9, 141.8, 137.9, 137.8, 135.4, 135.2, 129.5, 129.5, 128.0, 127.9, 127.4, 127.3, 127.1, 126.9, 122.9, 122.8, 121.6, 121.5, 66.4, 66.1, 65.5, 63.1, 62.8, 53.5, 51.0, 50.4, 41.2, 40.4, 40.3, 37.0, 36.8, 36.6, 32.8, 21.6, 21.1, 20.9, 20.6; **IR** (neat): ν_{max} = 2918, 1739, 1348, 1163, 753, 666, 578 cm^{-1}; **HRMS** (*m*/*z*): $[M + H]^+$ calcd. for $C_{26}H_{31}N_2O_4S$, 467.2005; found, 467.1998.

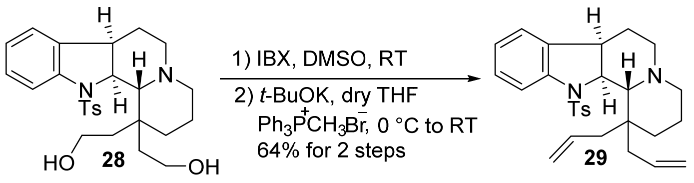
Preparation of diol 28



Under Ar, to a solution of **27** (124 mg, 0.266 mmol, 1.0 equiv.) in dry THF (25 mL) was added dropwise $LiAlH_4$ (1 M in THF, 0.530 mL, 0.530 mmol, 2.0 equiv.) at 0 °C. The reaction was stirred for 20 min and quenched by water (0.1 mL). The solvent was evaporated under reduced pressure and the aqueous phase was extracted with dichloromethane (8 × 8 mL). The combined organic layers were dried over Na_2SO_4 and concentrated in vacuo. The residue was subjected to column chromatography on silica gel (petroleum ether : acetone = 4 : 5, R_f = 0.2) to yield diol **28** (115 mg, 92%) as a white foam.

^{1}H NMR (400 MHz, $CDCl_3$): *δ* 7.64 (d, *J* = 8.0 Hz, 1H), 7.41 (d, *J* = 8.0 Hz, 2H), 7.29 (t, *J* = 7.6 Hz, 1H), 7.17 (t, *J* = 7.6 Hz, 1H), 7.06 (d, *J* = 8.0 Hz, 2H), 6.89 (d, *J* = 7.6 Hz, 1H), 5.05 (dd, *J* = 8.8, 7.2 Hz, 1H), 3.96 (t, *J* = 11.2 Hz, 1H), 3.88 – 3.72 (m, 2H), 3.66 – 3.51 (m, 1H), 2.86 – 2.68 (m, 3H), 2.68 – 2.46 (m, 2H), 2.31 (s, 3H), 2.10 – 1.81 (m, 7H), 1.81 – 1.66 (m, 2H), 1.64 – 1.45 (m, 4H); **^{13}C NMR** (151 MHz, $CDCl_3$): *δ* 144.2, 142.3, 137.7, 135.1, 129.3, 129.3, 128.0, 127.6, 127.6, 126.9, 122.9, 121.1, 64.7, 63.9, 59.7, 59.3, 57.5, 51.0, 45.1, 40.5, 40.3, 39.7, 35.7, 22.7, 22.1, 21.5; **IR** (neat): ν_{max} = 3369, 2926, 1259, 1087, 1018, 797, 665, 580 cm^{-1}; **$[\alpha]_D^{25}$** = +52.2 (*c* 0.27, $CHCl_3$); **HRMS** (*m*/*z*): $[M + H]^+$ calcd. for $C_{26}H_{35}N_2O_4S$, 471.2318; found, 471.2318.

Preparation of diene 29



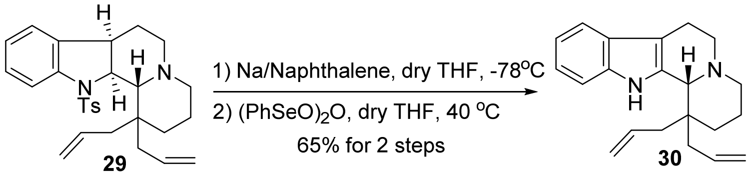
Under Ar, IBX (184 mg, 0.654 mmol, 2.5 equiv.) was added to a solution of **28** (123 mg, 0.261 mmol, 1.0 equiv.) in dry DMSO (17 mL). The mixture was stirred for 5 h at room temperature and quenched by sat. $NaHCO_3$ aq. (10 mL) at 0 °C. The mixture was extracted with ethyl acetate (3 × 10 mL) and the organic phase was washed by brine (2 × 5 mL), dried over Na_2SO_4 and concentrated in vacuo. The crude product was used without further purification.

Under Ar, to a solution of methyltriphenylphosphonium bromide (467 mg, 1.31 mmol, 5.0 equiv.) in dry THF (5 mL) was dropwise added *t*-BuOK (1 M in THF, 890 μL, 0.890 mmol, 3.4 equiv.) at 0 °C. The mixture turned into a yellow solution, which was stirred at room temperature for 30 min. Then the solution of above crude dialdehyde in dry THF (5 mL) was added dropwise to the reaction. After 3 h, the mixture was quenched by sat. NH_4Cl aq. (5 mL) and extracted with ethyl acetate (3 × 10 mL). The organic phase was dried over anhydrous Na_2SO_4 and concentrated in vacuo. Purification of the crude product by column chromatography on silica gel (petroleum ether : ethyl acetate = 5 : 2, $R_f = 0.15$) gave diene **29** (77.0 mg, 64% for 2 steps) as a yellow foam.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.64 (d, J = 8.0 Hz, 1H), 7.37 (d, J = 8.0 Hz, 2H), 7.31 (t, J = 7.6 Hz, 1H), 7.19 (t, J = 7.6 Hz, 1H), 7.08 (d, J = 8.0 Hz, 2H), 6.90 (d, J = 7.2 Hz, 1H), 5.94 – 5.77 (m, 2H), 5.25 (d, J = 16.8 Hz, 1H), 5.12 (t, J = 8.8 Hz, 2H), 5.03 (d, J = 10.0 Hz, 1H), 4.71 (s, 1H), 3.38 (dd, J = 14.0, 5.2 Hz, 1H), 2.95 – 2.71 (m, 3H), 2.60 – 2.49 (m, 2H), 2.34 (s, 3H), 2.07 (dd, J = 14.4 Hz, 8.8 Hz, 3H), 1.84 (d, J = 11.2 Hz, 3H), 1.44 – 1.28 (m, 4H); **^{13}C NMR** (151 MHz, $CDCl_3$): δ 144.1, 142.7, 135.7, 135.1, 129.4, 127.8, 127.4, 126.7, 122.6, 121.6, 117.9, 65.5, 63.8, 57.7, 52.0, 42.4, 40.2, 39.2, 36.4, 32.8, 22.5, 21.6, 20.5; **IR** (neat): ν_{max} = 2926, 1456, 1352, 1165, 1016, 913, 798, 665, 578 cm^{-1}; **$[\alpha]_D^{25}$** = +40.8 (*c* 0.17, $CHCl_3$); **HRMS** (*m*/*z*): [M +

H]$^+$ calcd. for $C_{28}H_{35}N_2O_2S$, 463.2419; found, 463.2422.

Preparation of indole 30



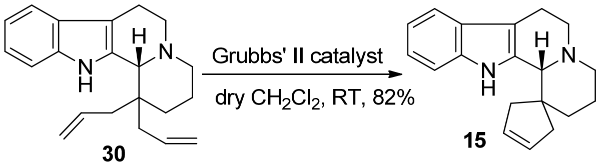
The Na/Naphthalene solution (0.43 M in THF) was prepared as following procedure: Under Ar, to a solution of Na (20 mg, 0.87 mmol) in dry THF (2 mL) was added naphthalene (143 mg, 1.12 mmol) at room temperature and stirred for 1.5 h.

Under Ar, to the solution of **29** (22.0 mg, 47.6 μmol, 1.0 equiv.) in dry THF (3 mL) at –78 °C was added dropwise the Na/Naphthalene solution (0.554 mL, 0.238 mmol, 5.0 equiv.). After being stirred for 20 min at –78 °C, the mixture was quenched with sat. NH_4Cl aq. (3 mL) and extracted with ethyl acetate (3 × 5 mL). The organic phase was dried over anhydrous Na_2SO_4, filtrated and concentrated in vacuo. The residue was used without further purification.

Under Ar, the mixture of the crude product and $(PhSeO)_2O$ (20.7 mg, 57.7 μmol, 1.2 equiv.) in dry THF (10 mL) was stirred at 40 °C for 5 h. The reaction was quenched with sat. $NaHCO_3$ aq. (5 mL) and extracted with ethyl acetate (3 × 8 mL), the combined organic layers were dried over anhydrous Na_2SO_4, filtrated and concentrated in vacuo. Purification by column chromatography on silica gel (petroleum ether : ethyl acetate = 10 : 1, $R_f = 0.2$) yielded indole **30** (9.5 mg, 65%) as a yellow foam.

^{1}H NMR (600 MHz, $CDCl_3$): δ 8.03 (s, 1H), 7.47 (d, J = 7.8 Hz, 1H), 7.31 (d, J = 8.4 Hz, 1H), 7.14 (t, J = 7.8 Hz, 1H), 7.09 (t, J = 7.8 Hz, 1H), 6.22 – 6.15 (m, 1H), 5.70 – 5.62 (m, 1H), 5.34 (d, J = 16.8 Hz, 1H), 5.27 (d, J = 9.6 Hz, 1H), 4.98 – 4.94 (m, 2H), 3.36 (s, 1H), 3.04 – 2.97 (m, 2H), 2.96 – 2.89 (m, 1H), 2.78 (dd, J = 14.4, 7.8 Hz, 1H), 2.64 – 2.55 (m, 3H), 2.42 – 2.37 (m, 2H), 1.97 – 1.90 (m, 1H), 1.85 (dd, J = 14.4, 7.8 Hz, 1H), 1.63 – 1.60 (m, 2H), 1.55 – 1.51 (m, 1H); **^{13}C NMR** (151 MHz, $CDCl_3$): δ 136.0, 135.0, 134.8, 133.6, 126.8, 121.4, 119.3, 118.3, 117.8, 117.3, 111.9, 110.7, 66.5, 56.8, 53.9, 43.7, 40.8, 37.5, 33.1, 22.2, 22.1; **IR** (neat): ν_{max} = 2918, 2849, 1460, 1258, 1017, 795 cm^{-1}; **[α]$_D$^{25}** = +10.5 (*c* 0.67, $CHCl_3$); **HRMS** (*m*/*z*): $[M + H]^+$ calcd. for $C_{21}H_{27}N_2$, 307.2174; found, 307.2180.

Preparation of compound 15



Under Ar, Grubbs' II catalyst (0.6 mg, 0.735 µmol, 0.05 equiv.) was dissolved in dry dichloromethane (0.1 mL) and dropwise added to a solution of **30** (4.5 mg, 14.7 µmol, 1.0 equiv.) in dry dichloromethane (3 mL) at 0 °C. After 5 min, the reaction was warmed to room temperature and stirred for 5 h. The mixture was concentrated in vacuo and purified by flash column chromatography on silica gel (petroleum ether : acetone = 5 : 1, R_f = 0.15) to deliver the desired intermediate **15** (3.4 mg, 82%) as a yellow foam.

^{1}H NMR (400 MHz, $CDCl_3$): *δ* 7.89 (s, 1H), 7.45 (d, *J* = 7.6 Hz, 1H), 7.23 (d, *J* = 8.0 Hz, 1H), 7.12 (t, *J* = 7.6 Hz, 1H), 7.06 (t, *J* = 7.6 Hz, 1H), 5.84 – 5.82 (m, 1H), 5.74 – 5.72 (m, 1H), 3.35 (s, 1H), 3.12 – 2.98 (m, 4H), 2.73 – 2.63 (m, 2H), 2.45 – 2.18 (m, 4H), 1.91 – 1.80 (m, 2H), 1.68 – 1.54 (m, 2H); **^{13}C NMR** (151 MHz, $CDCl_3$): *δ* 136.3, 134.9, 134.4, 127.2, 126.9, 121.6, 119.4, 118.0, 111.0, 111.0, 69.5, 56.5, 54.9, 48.3, 43.5, 41.2, 40.3, 23.0, 21.7; **IR** (neat): ν_{max} = 2919, 2849, 1461, 1262, 1018, 799, 737 cm^{-1}; **[α]$_D$^{25}** = –20 (*c* 0.09, $CHCl_3$); lit.[9] **[α]$_D$^{25}** = –22.4 (*c* 0.77, $CHCl_3$); **HRMS** (*m*/*z*): $[M + H]^+$ calcd. for $C_{19}H_{23}N_2$, 279.1861; found,279.1863.

3. Supplemental References

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4. NMR Spectra

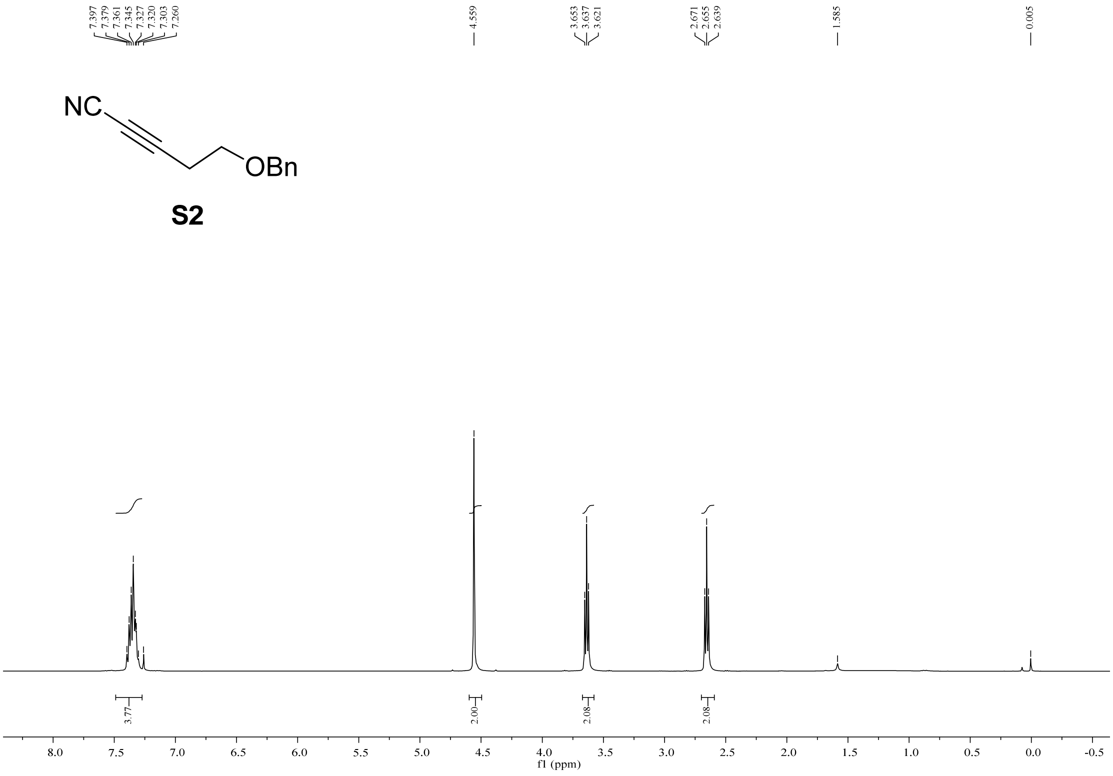


Figure S1: ^{1}H NMR spectrum of **S2**

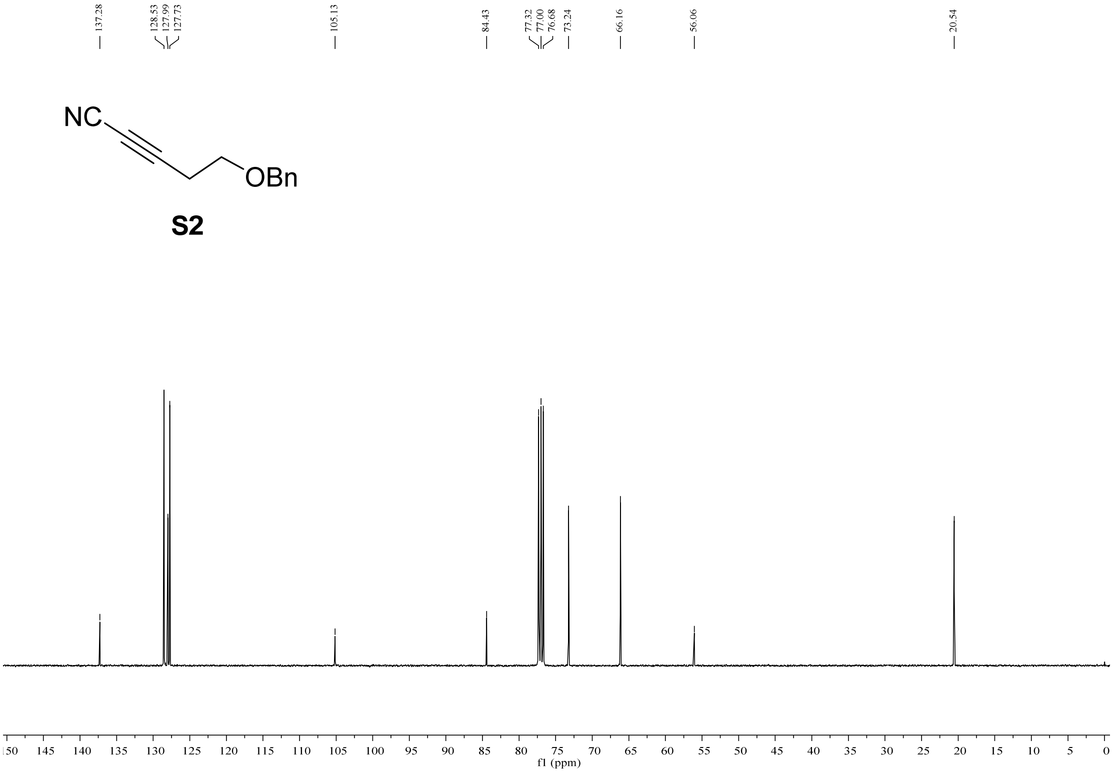


Figure S2: ^{13}C NMR spectrum of **S2**

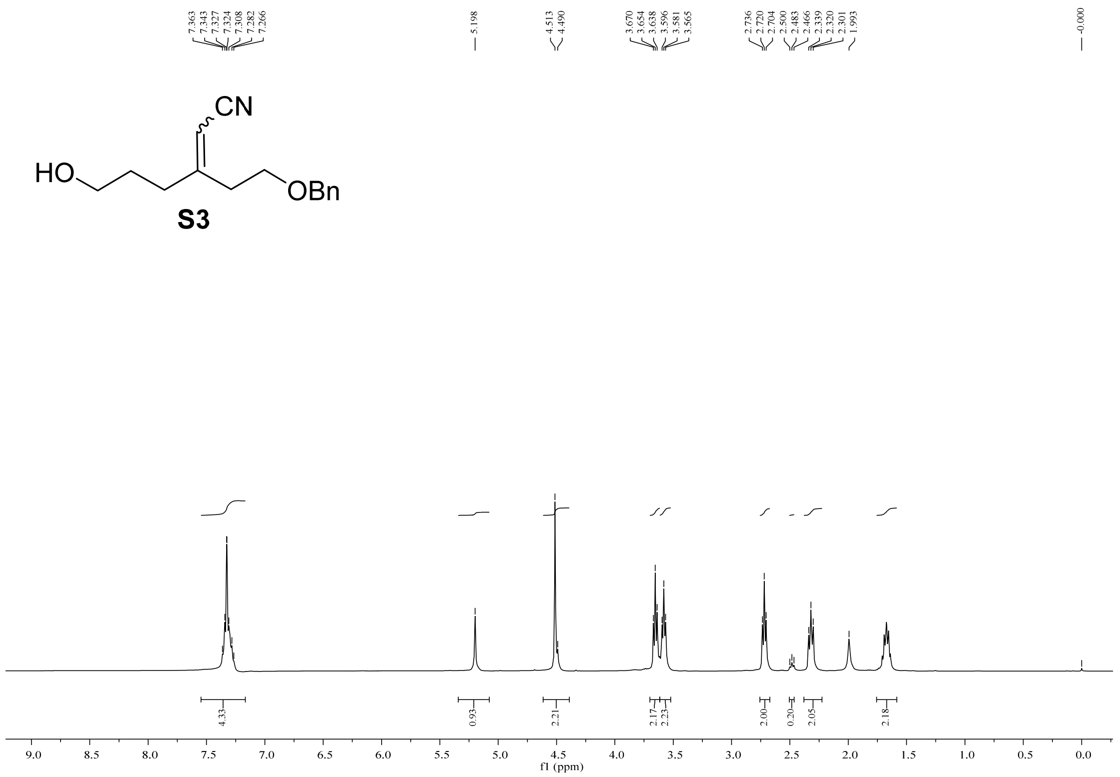


Figure S3: ^{1}H NMR spectrum of **S3**

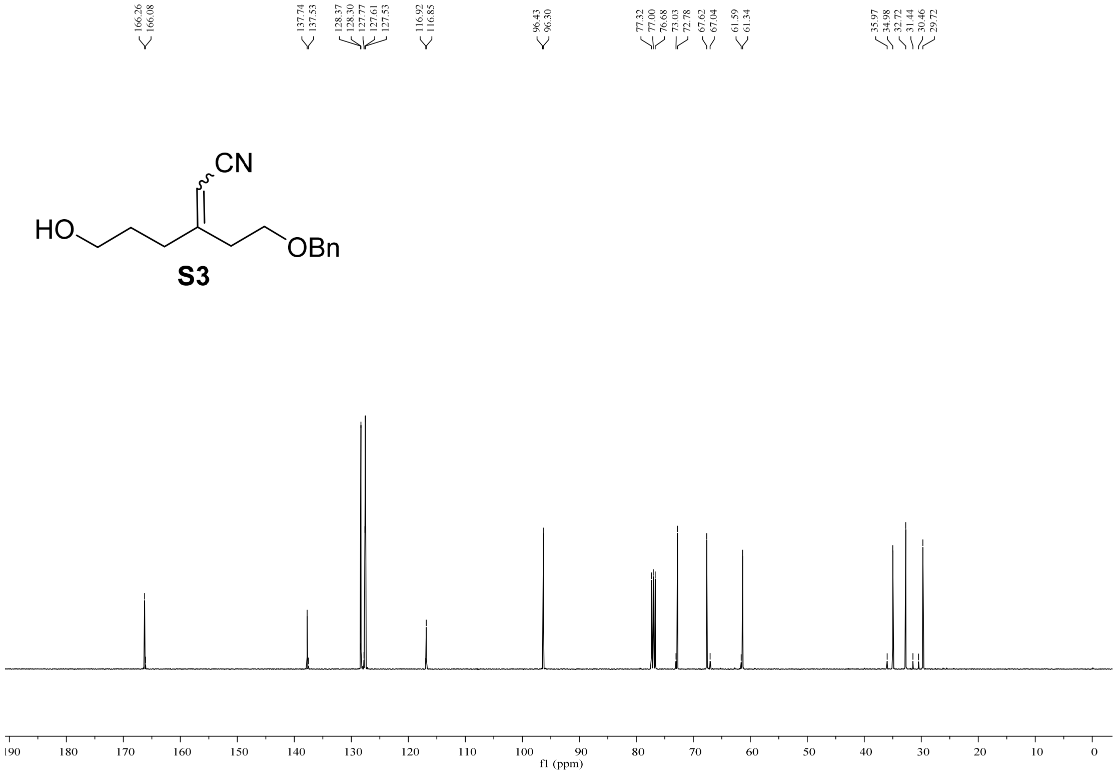


Figure S4: ^{13}C NMR spectrum of **S3**

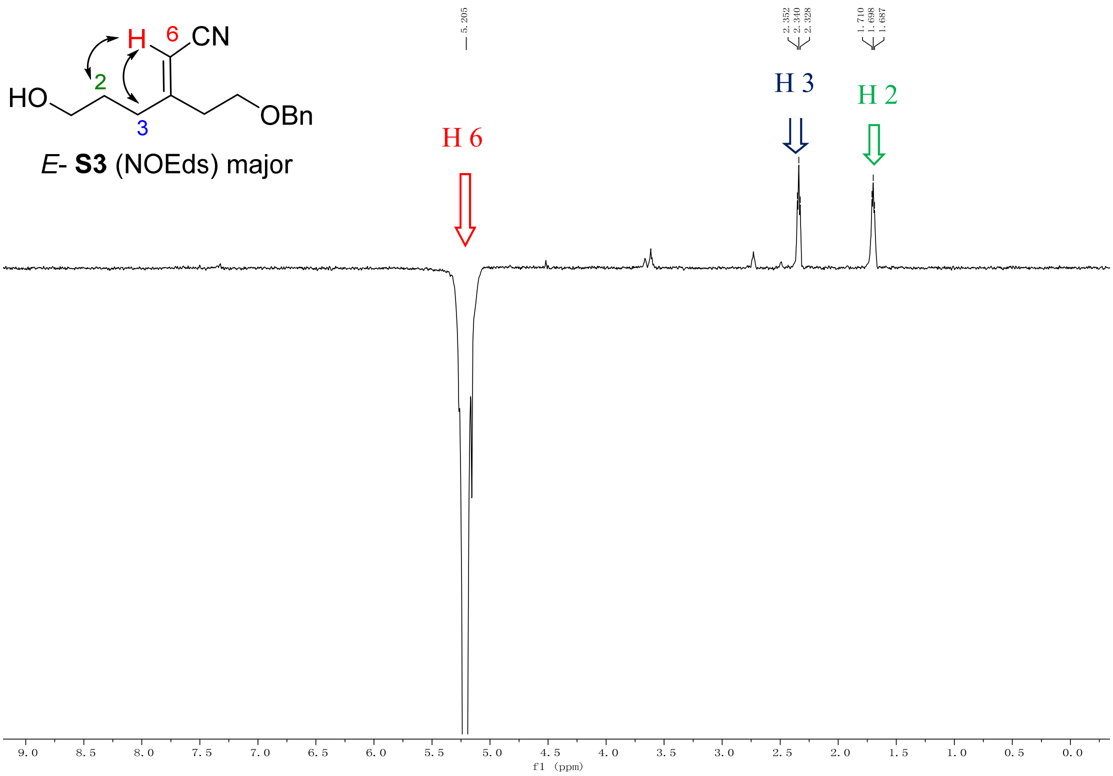


Figure S5: NOE spectra of **S3** (*E*/*Z*=10:1)

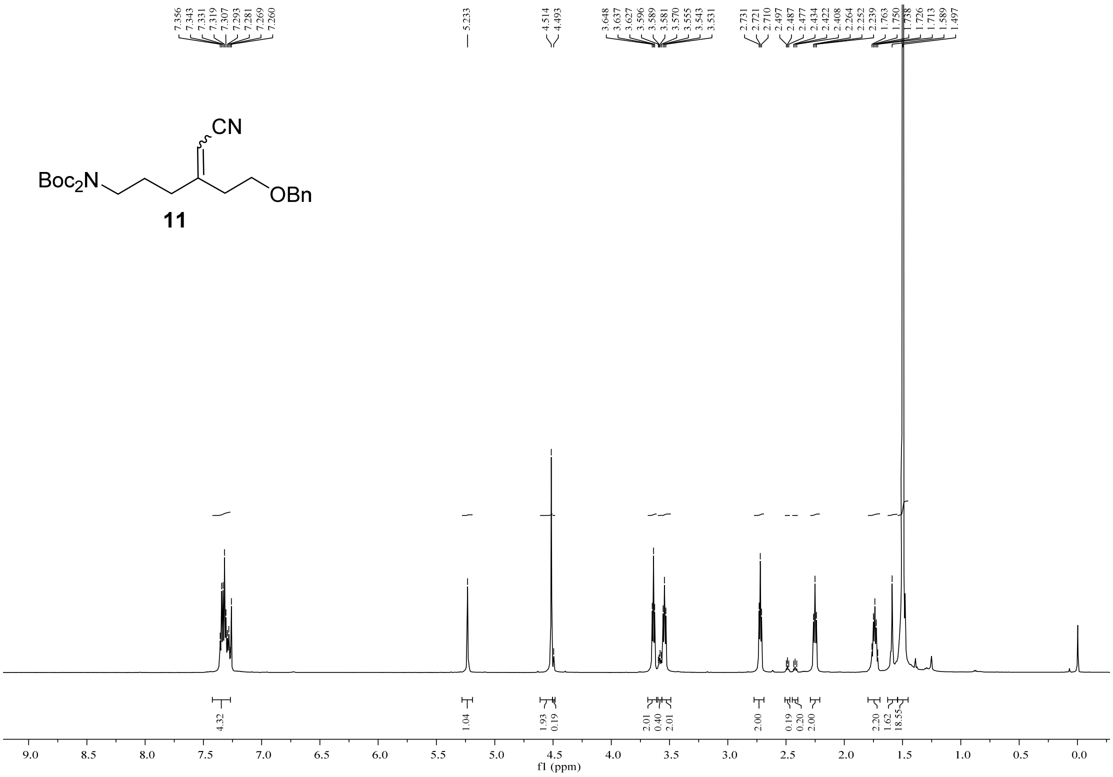


Figure S6: ^{1}H NMR spectrum of **11**

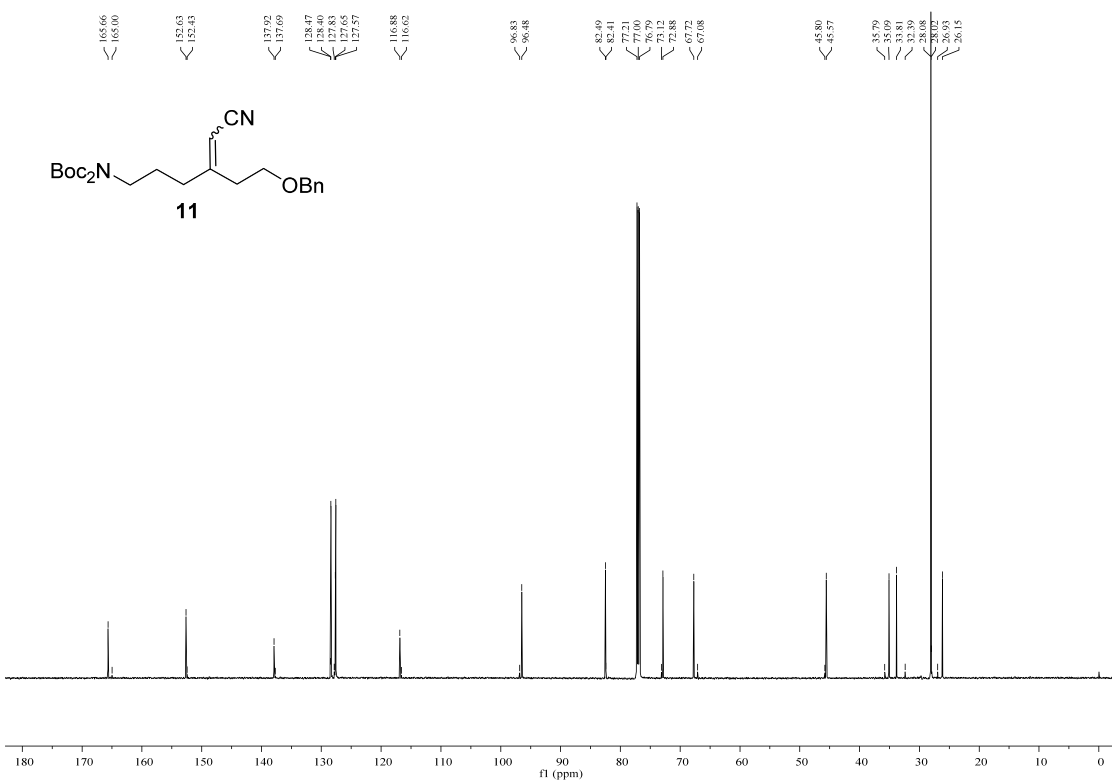


Figure S7: ^{13}C NMR spectrum of **11**

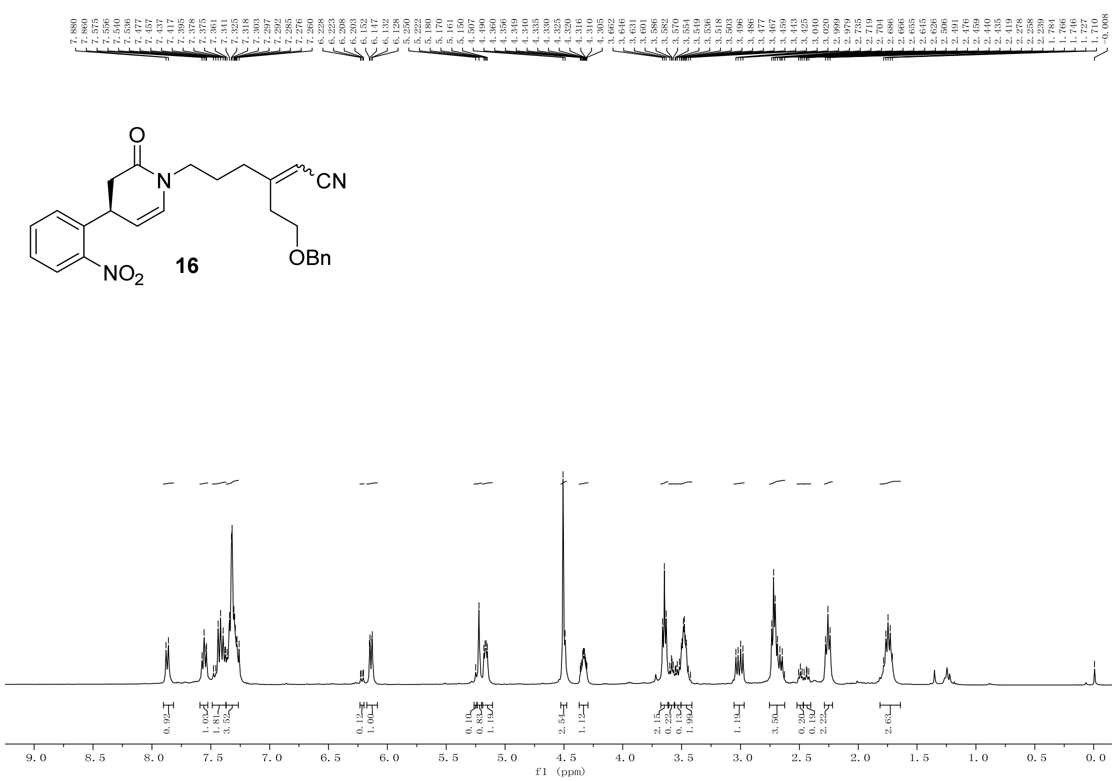


Figure S8: ^{1}H NMR spectrum of **16**

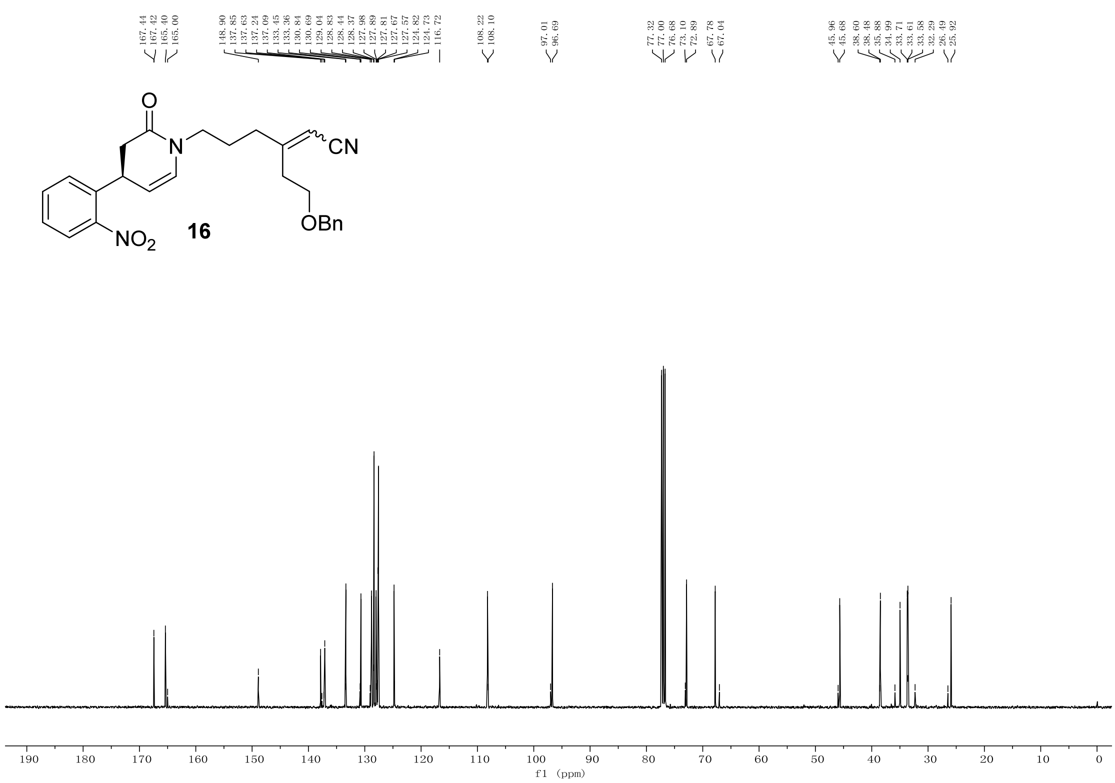


Figure S9: ^{13}C NMR spectrum of **16**

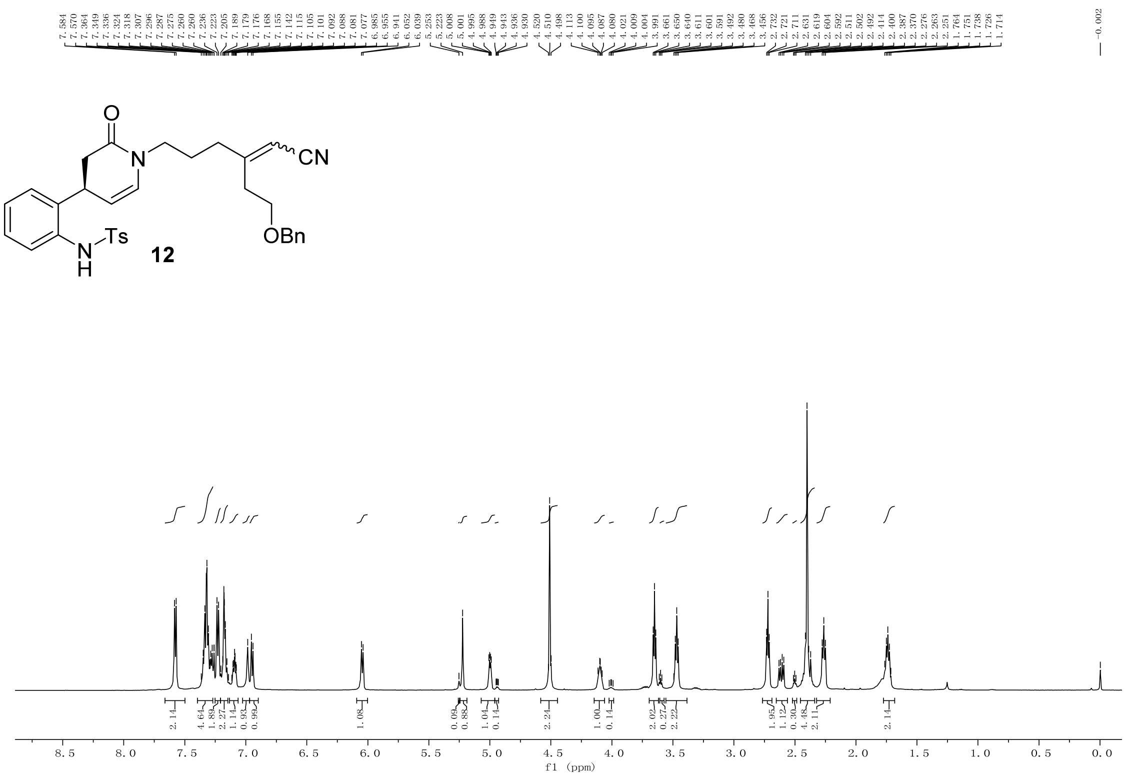


Figure S10: ^{1}H NMR spectrum of **12**

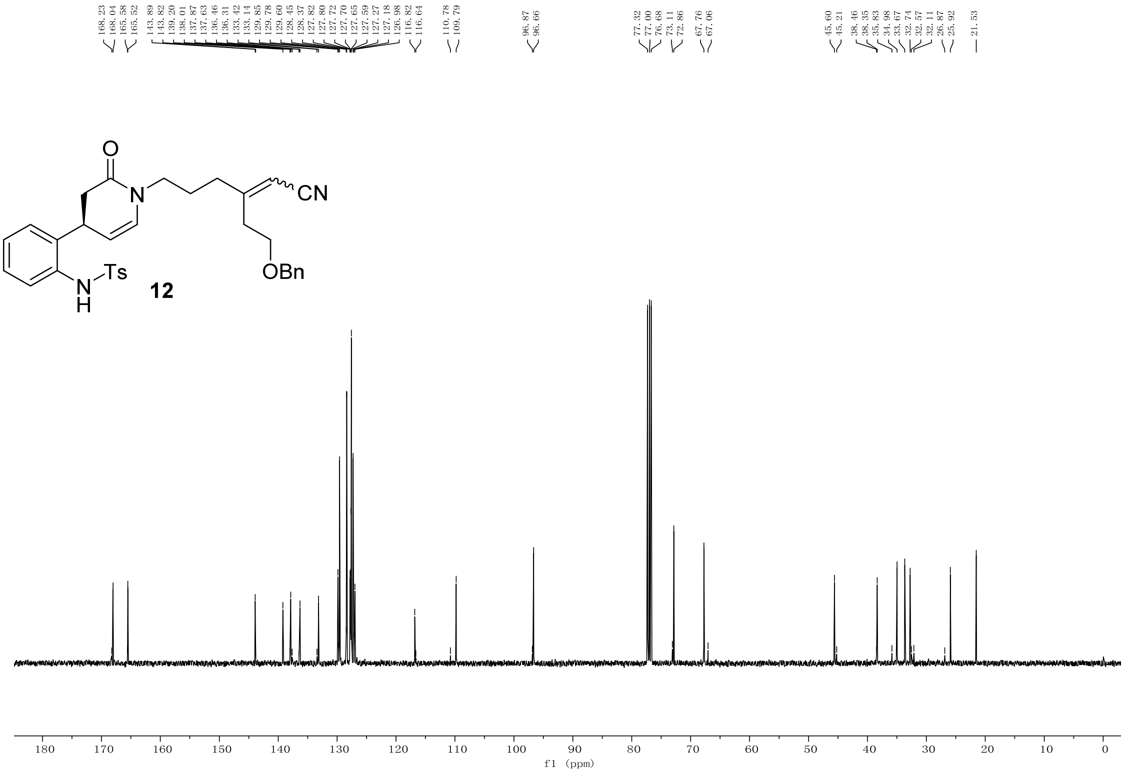


Figure S11: ^{13}C NMR spectrum of **12**

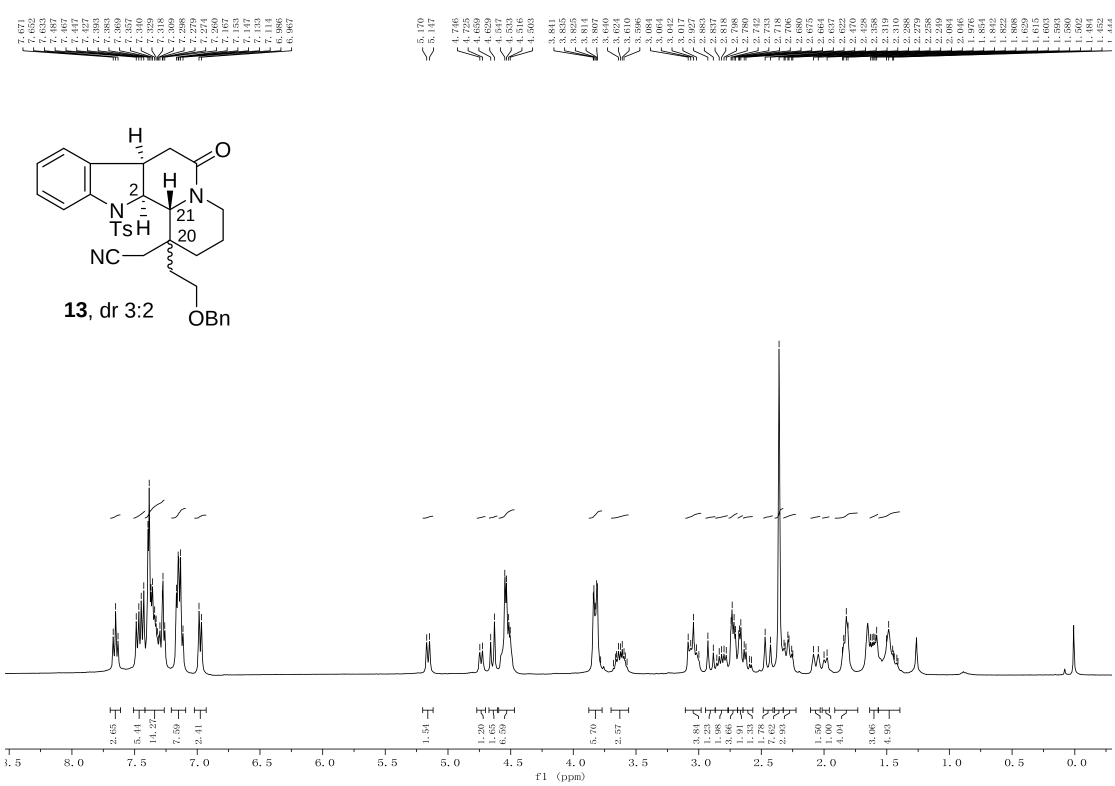


Figure S12: ^{1}H NMR spectrum of **13**

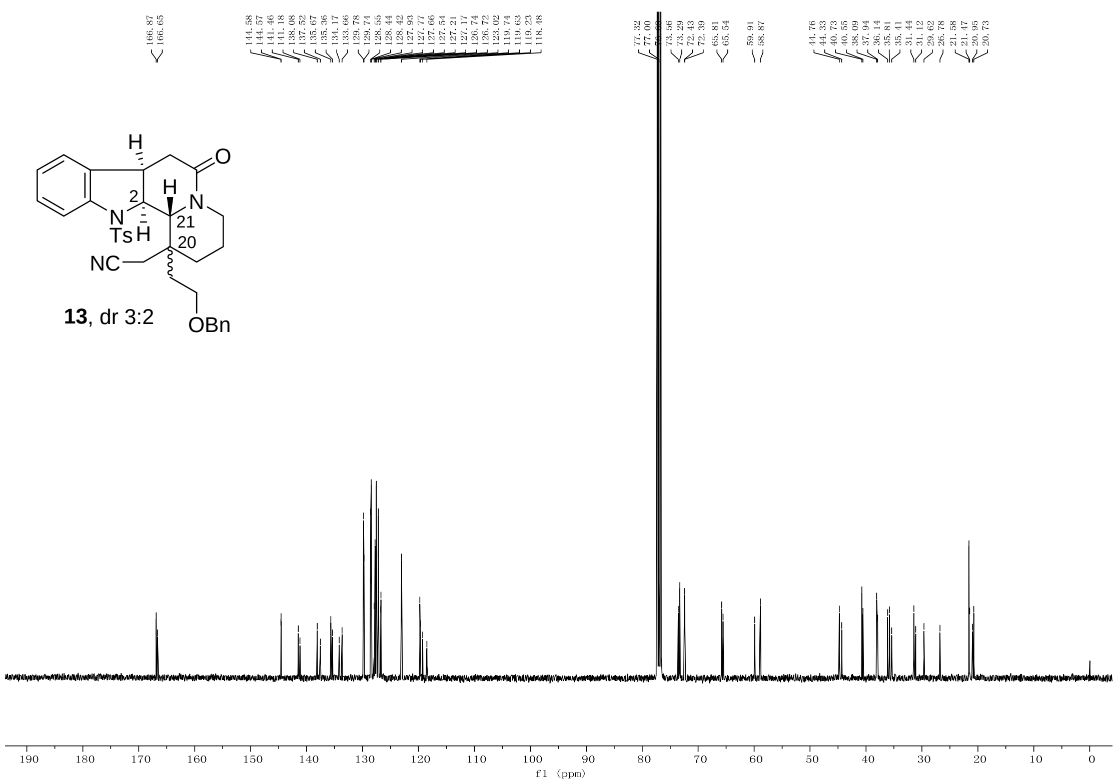


Figure S13: ^{13}C NMR spectrum of **13**

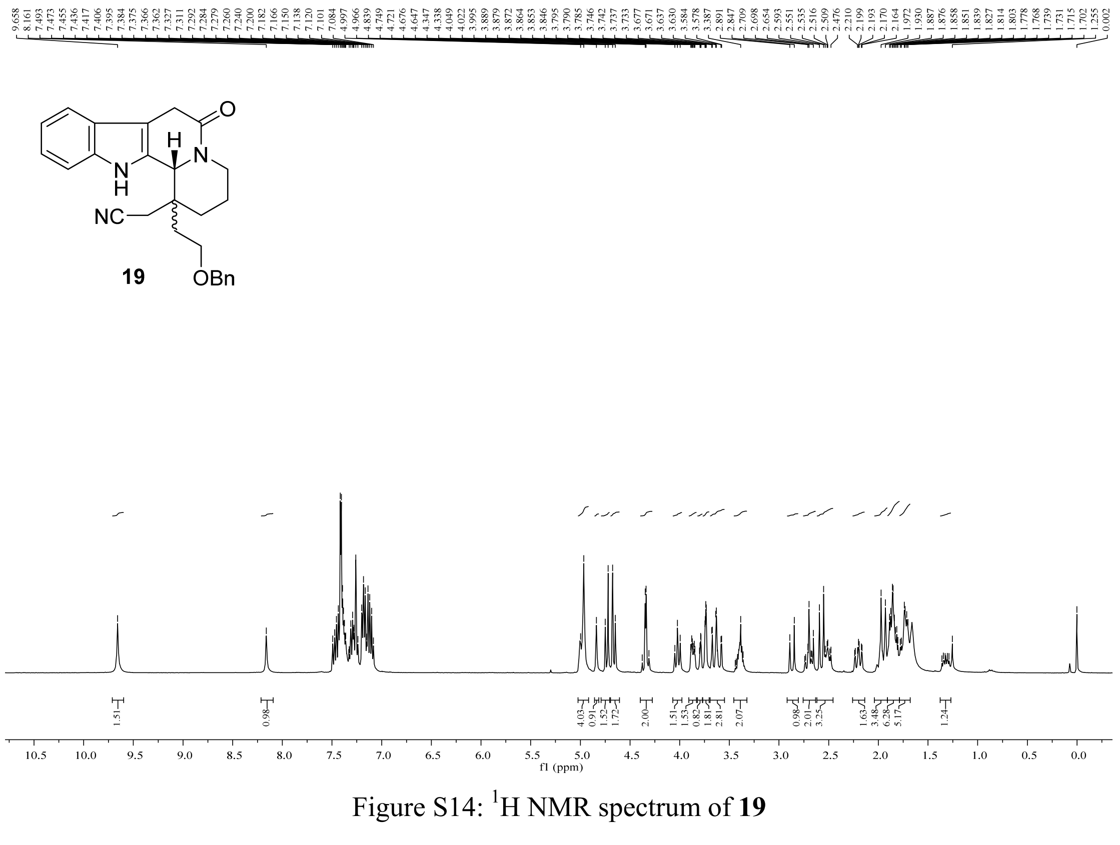


Figure S14: ^{1}H NMR spectrum of **19**

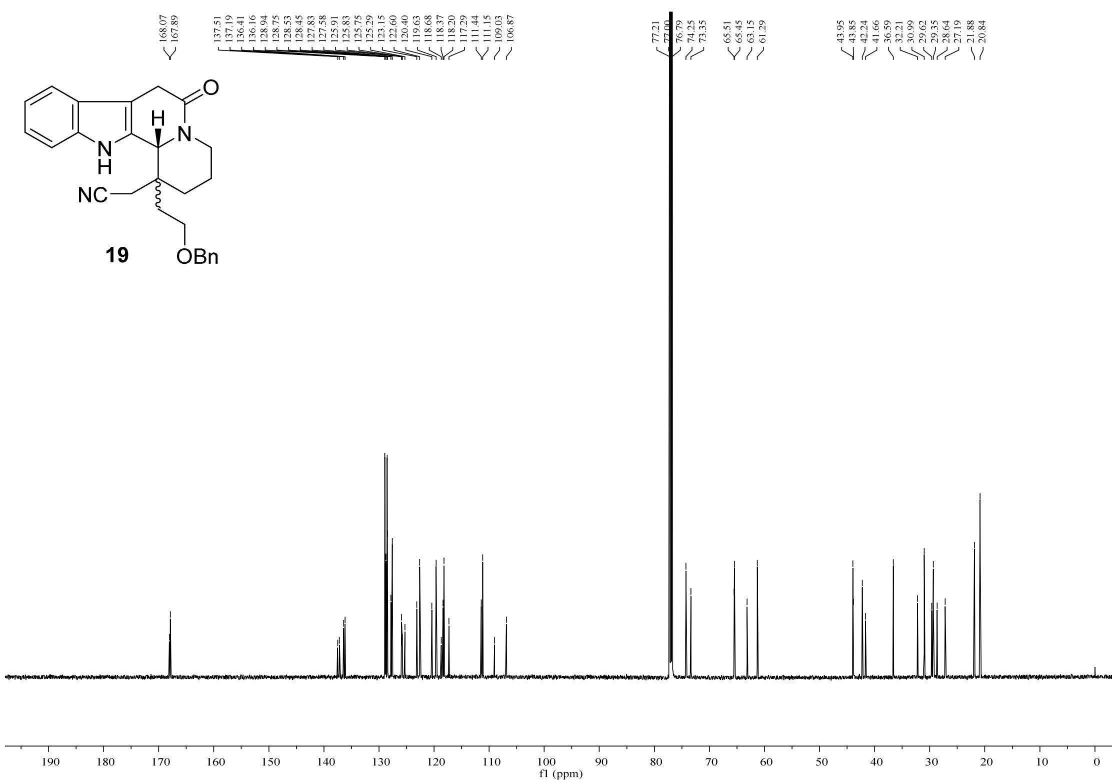


Figure S15: ^{13}C NMR spectrum of **19**

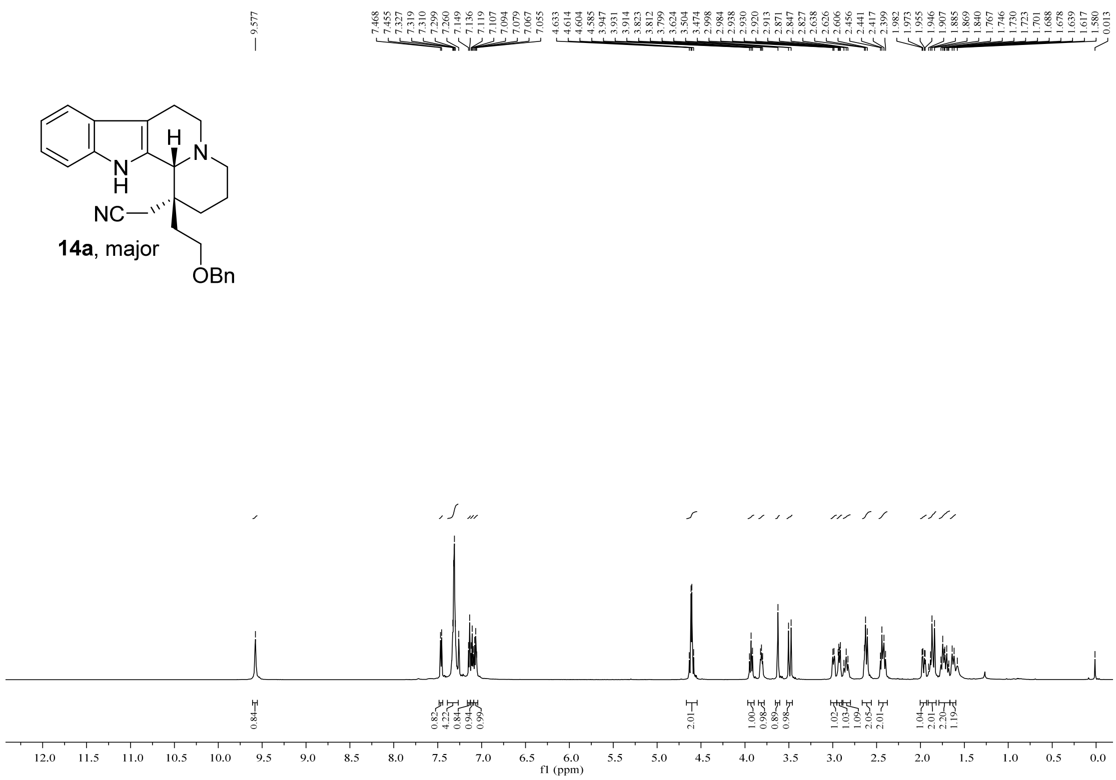


Figure S16: ^{1}H NMR spectrum of **14a**

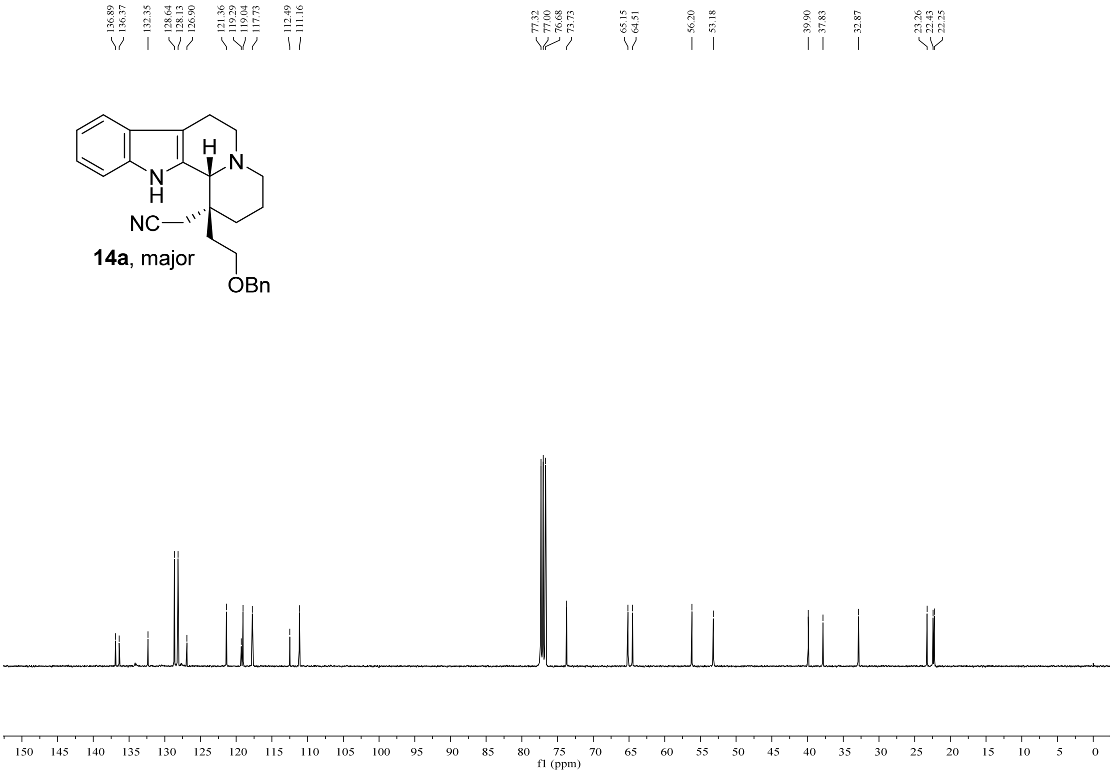


Figure S17: ^{13}C NMR spectrum of **14a**

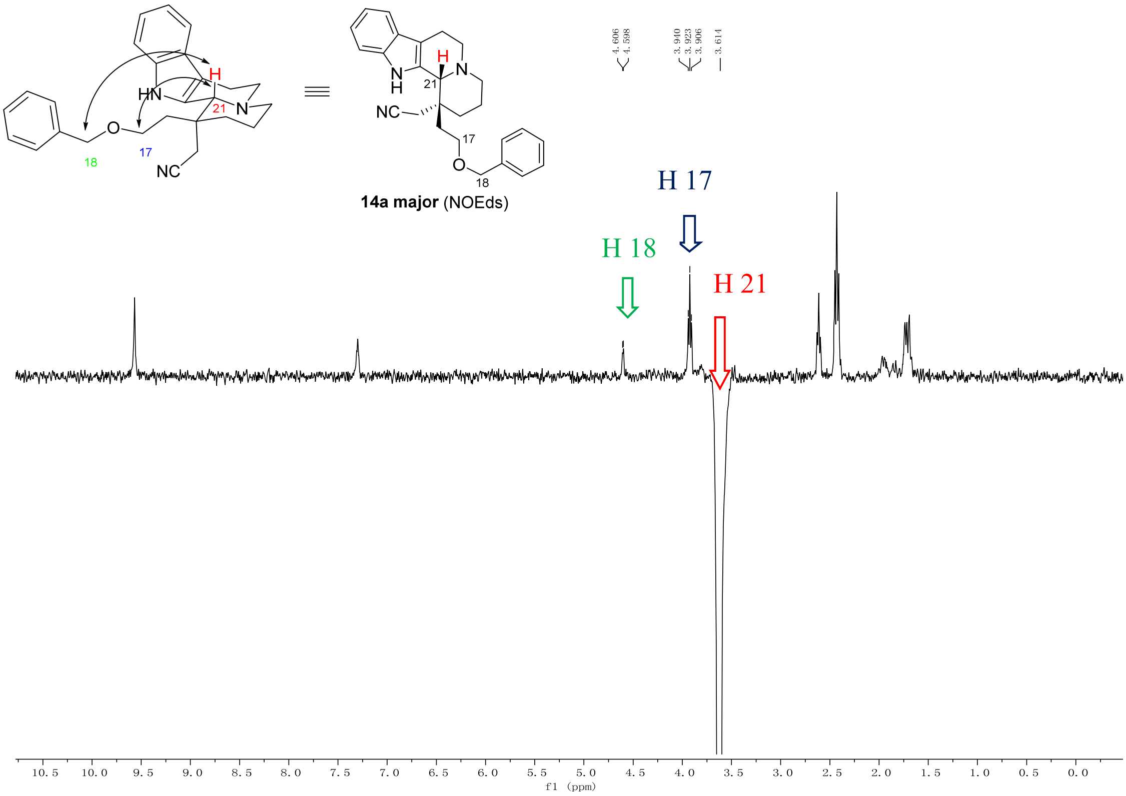


Figure S18: NOE spectra of **14a**

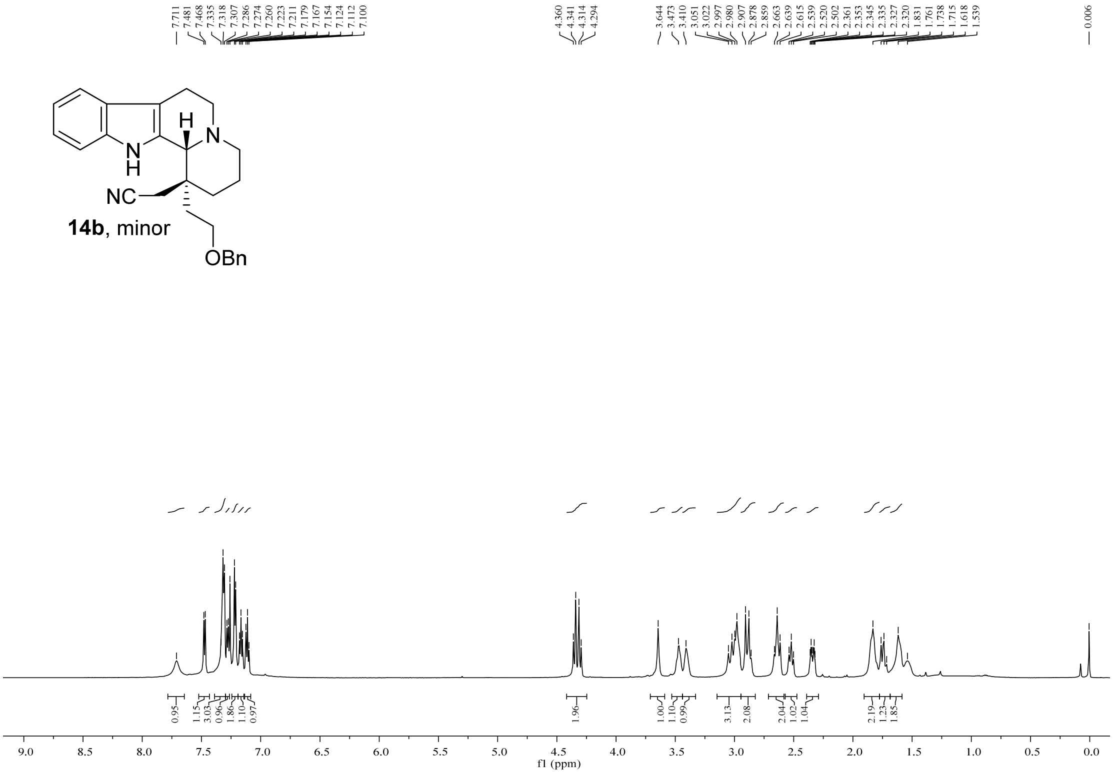


Figure S19: ^{1}H NMR spectrum of **14b**

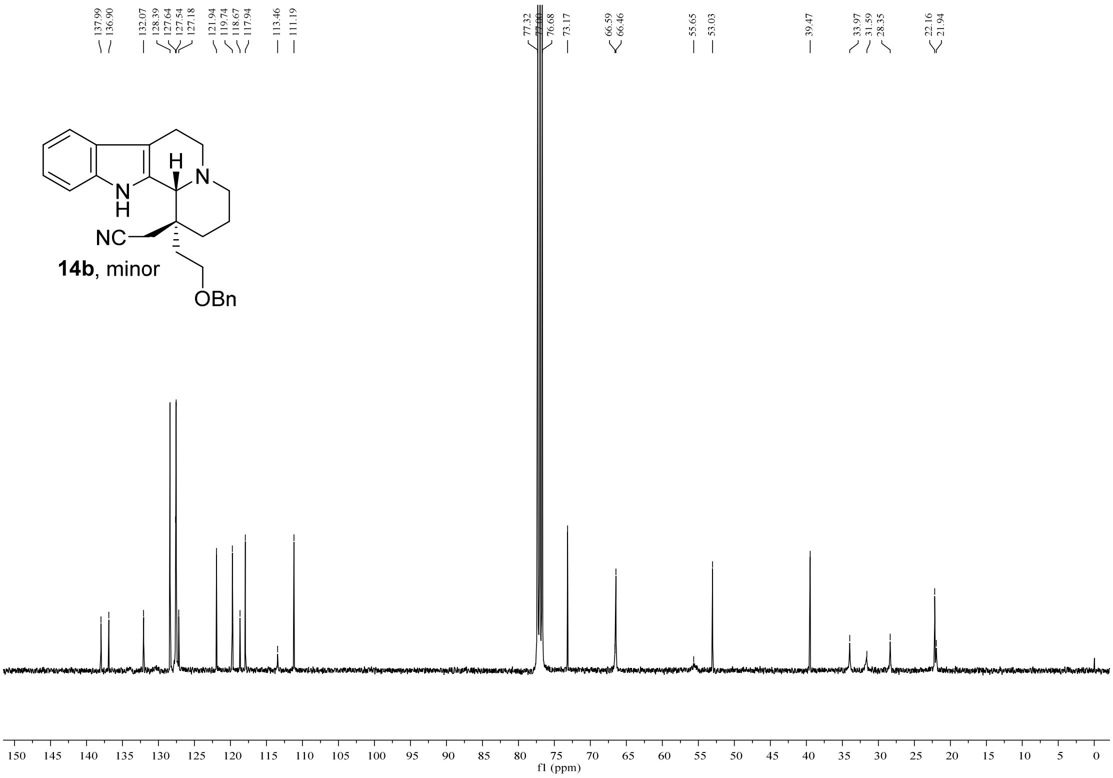
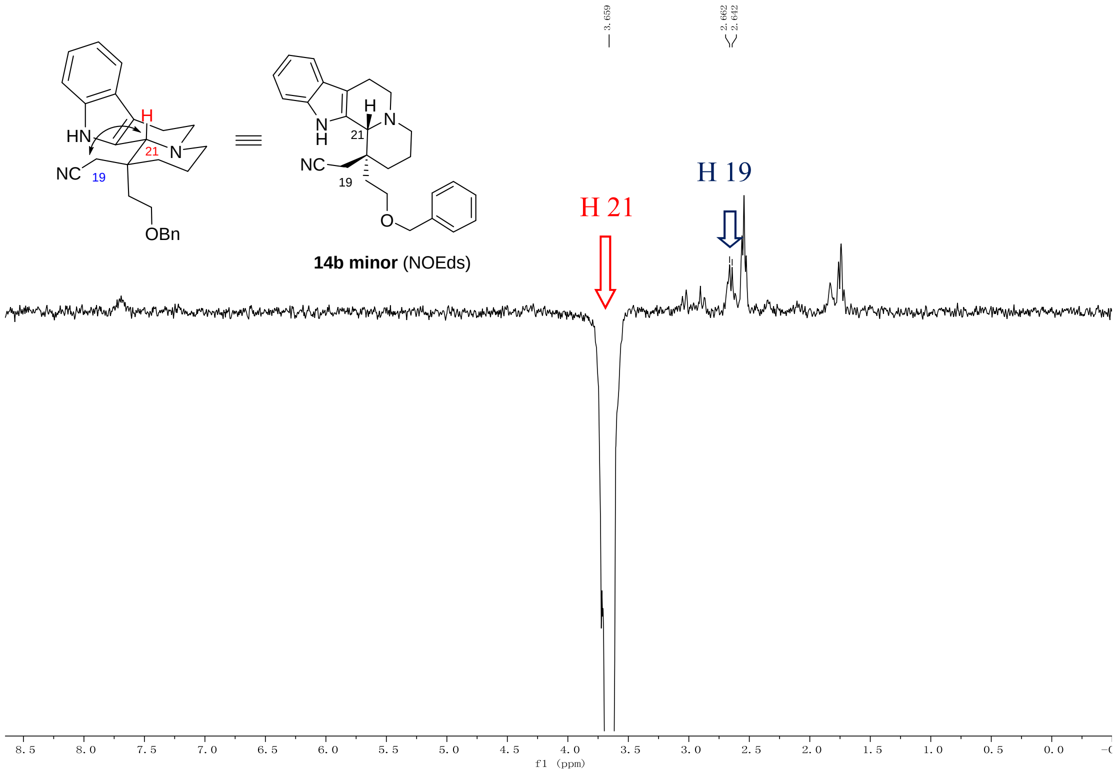
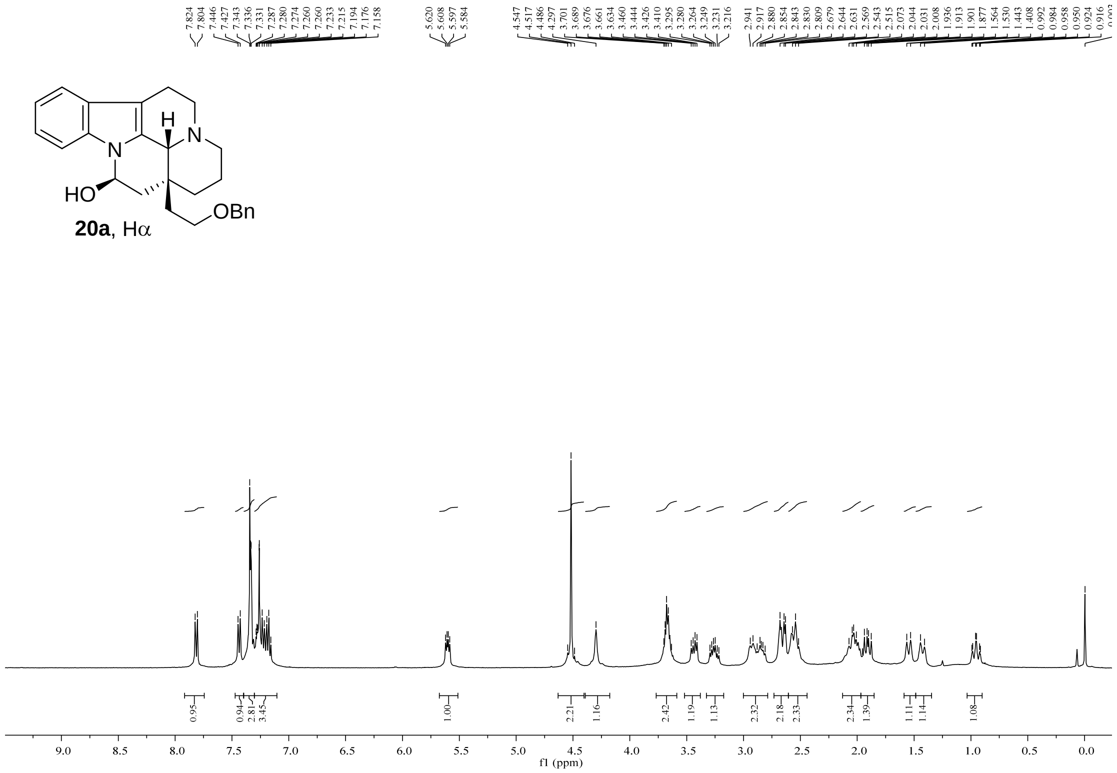


Figure S20: ^{13}C NMR spectrum of **14b**



14b minor (NOEds)

Figure S21: NOE spectra of **14b**



20a, Hα

Figure S22: ^{1}H NMR spectrum of **20a**

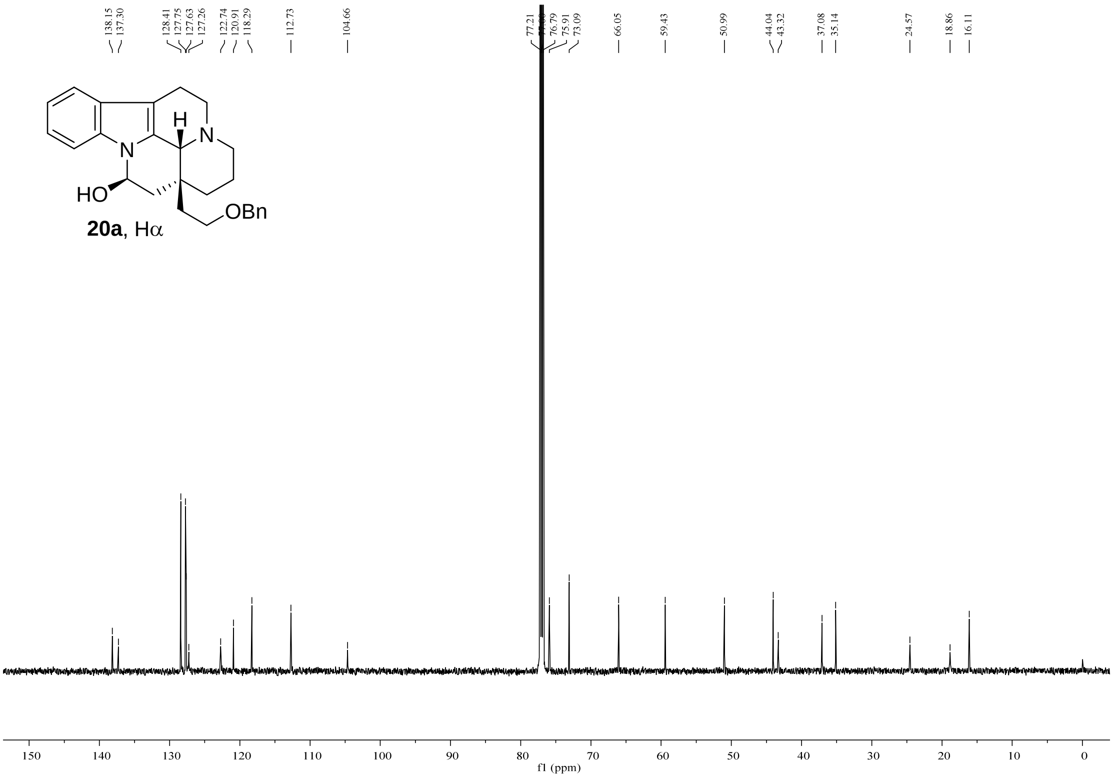


Figure S23: ^{13}C NMR spectrum of **20a**

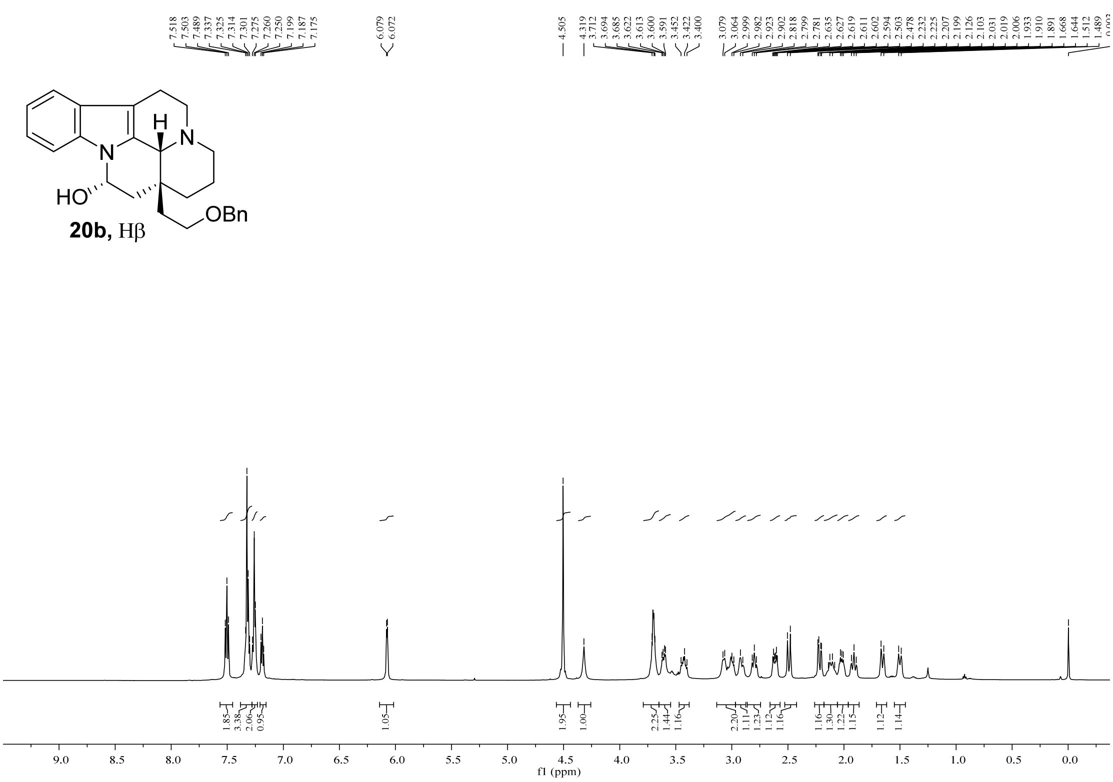


Figure S24: ^{1}H NMR spectrum of **20b**

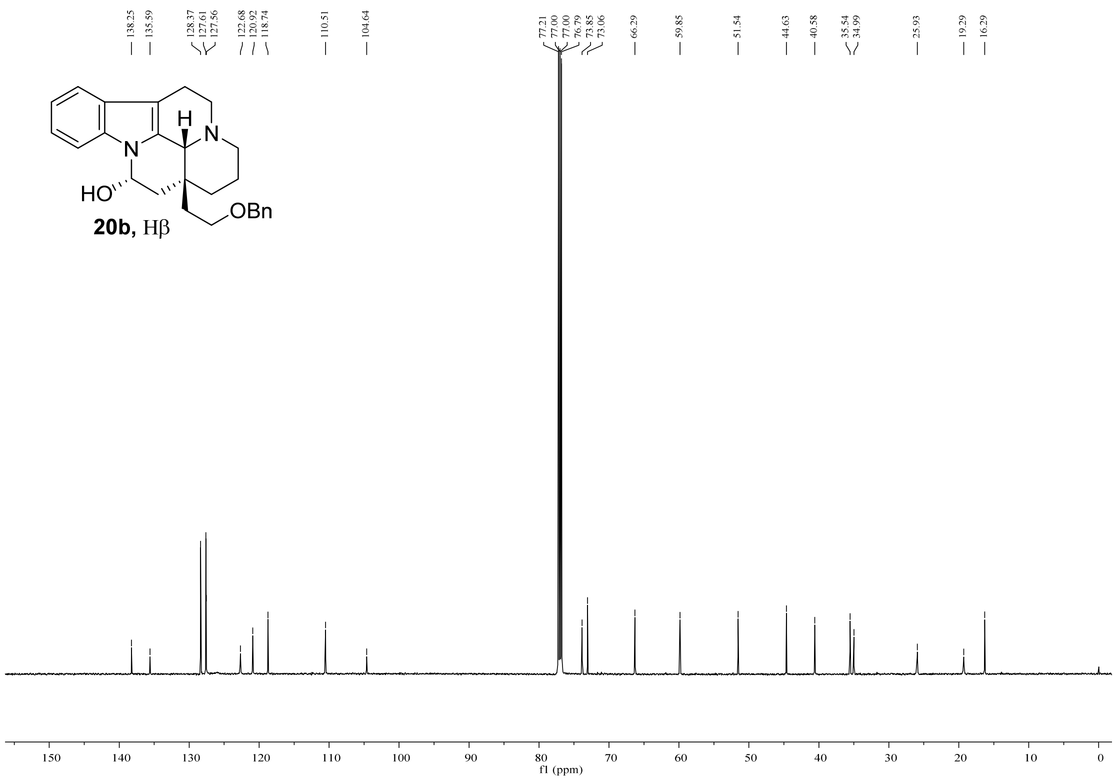


Figure S25: ^{13}C NMR spectrum of **20b**

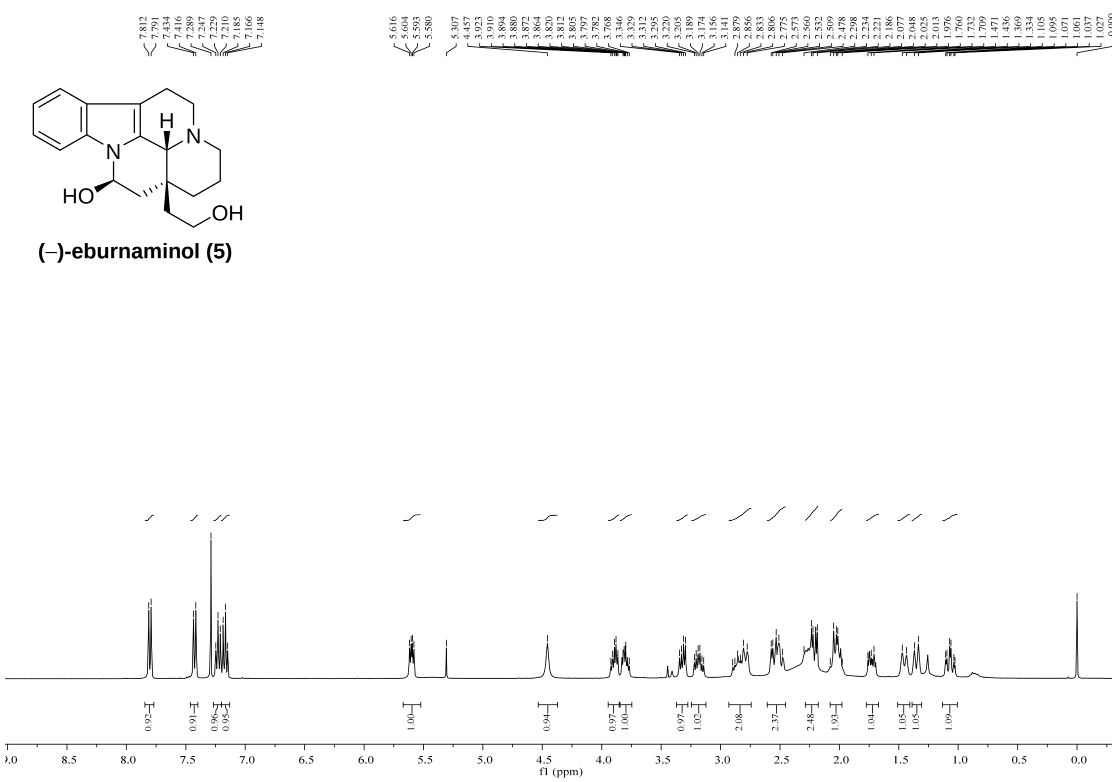


Figure S26: ^{1}H NMR spectrum of **5**

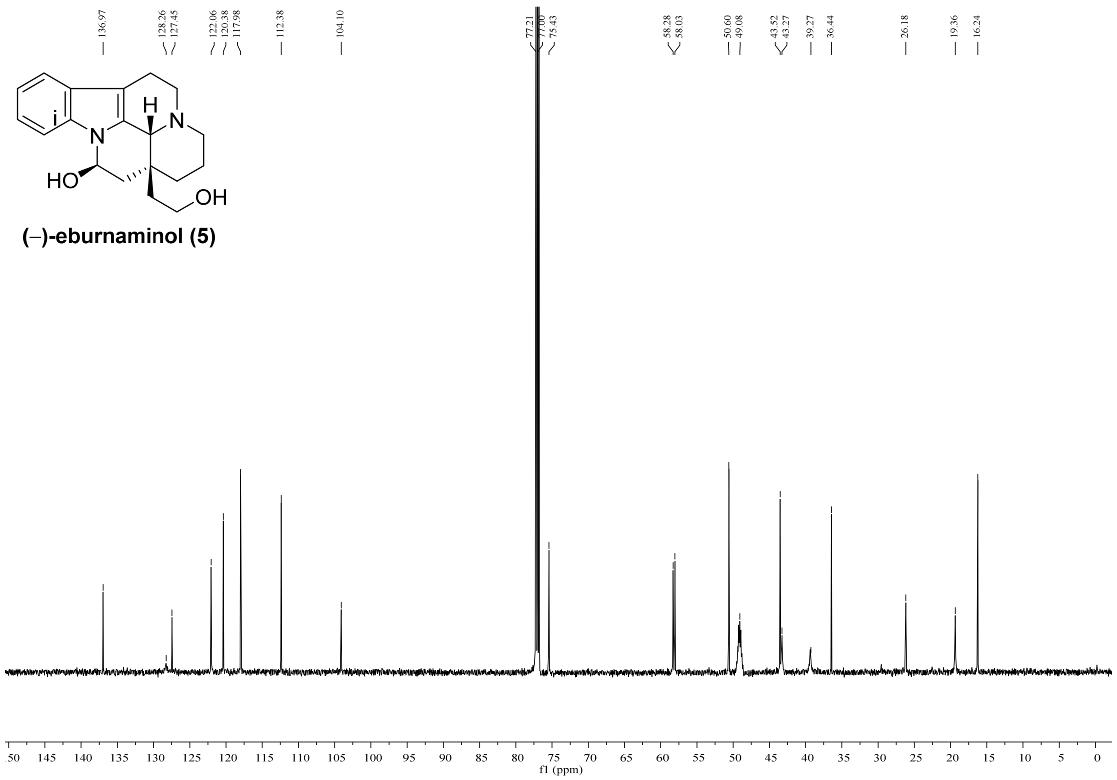


Figure S27: ^{13}C NMR spectrum of **5**

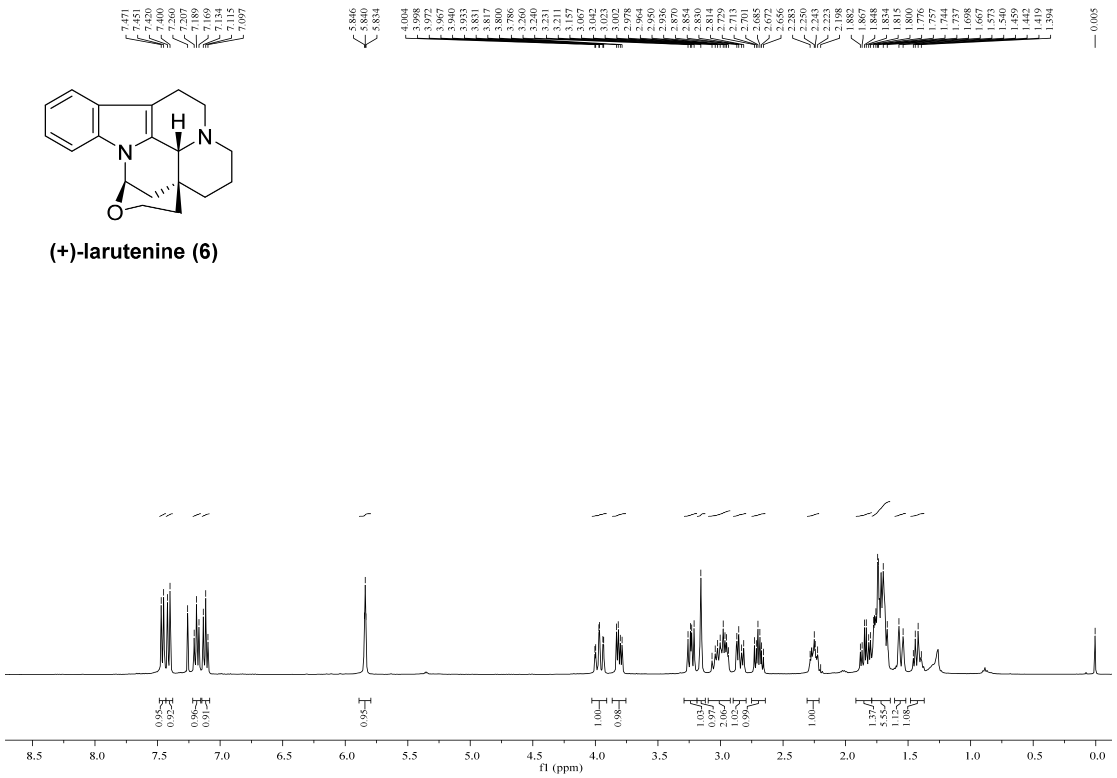
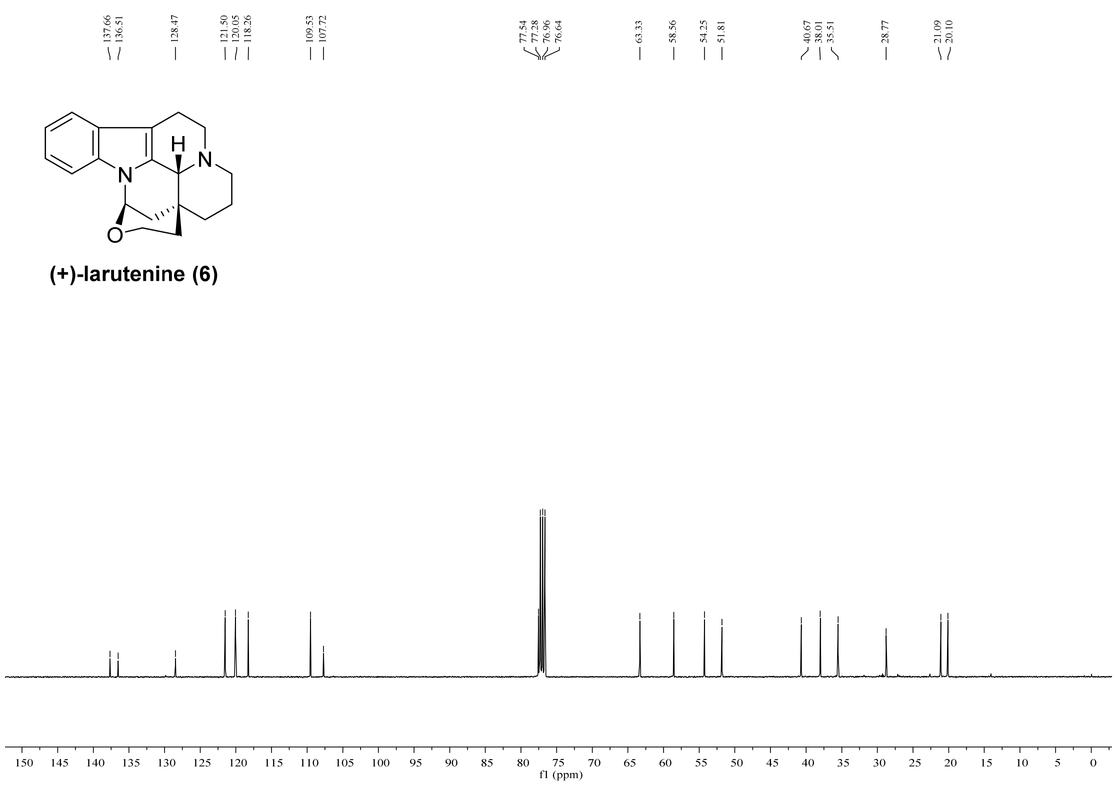
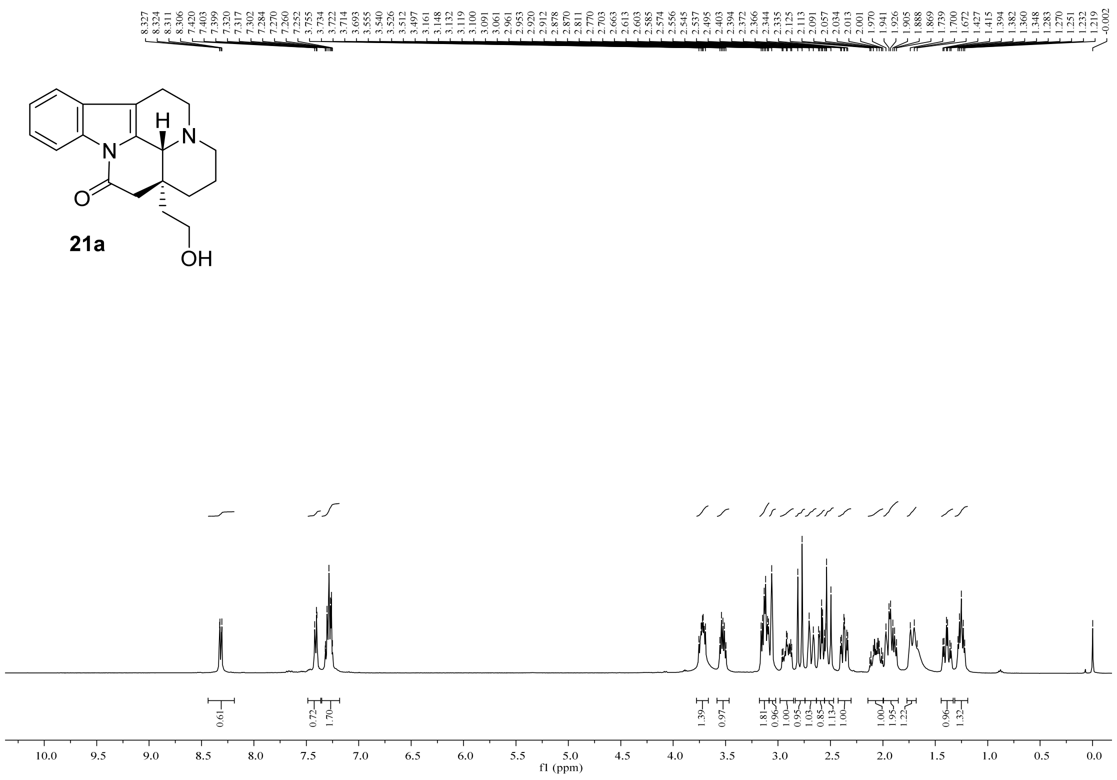


Figure S28: ^{1}H NMR spectrum of **6**



(+)-larutenine (6)

Figure S29: ^{13}C NMR spectrum of **6**



21a

Figure S30: ^{1}H NMR spectrum of **21a**

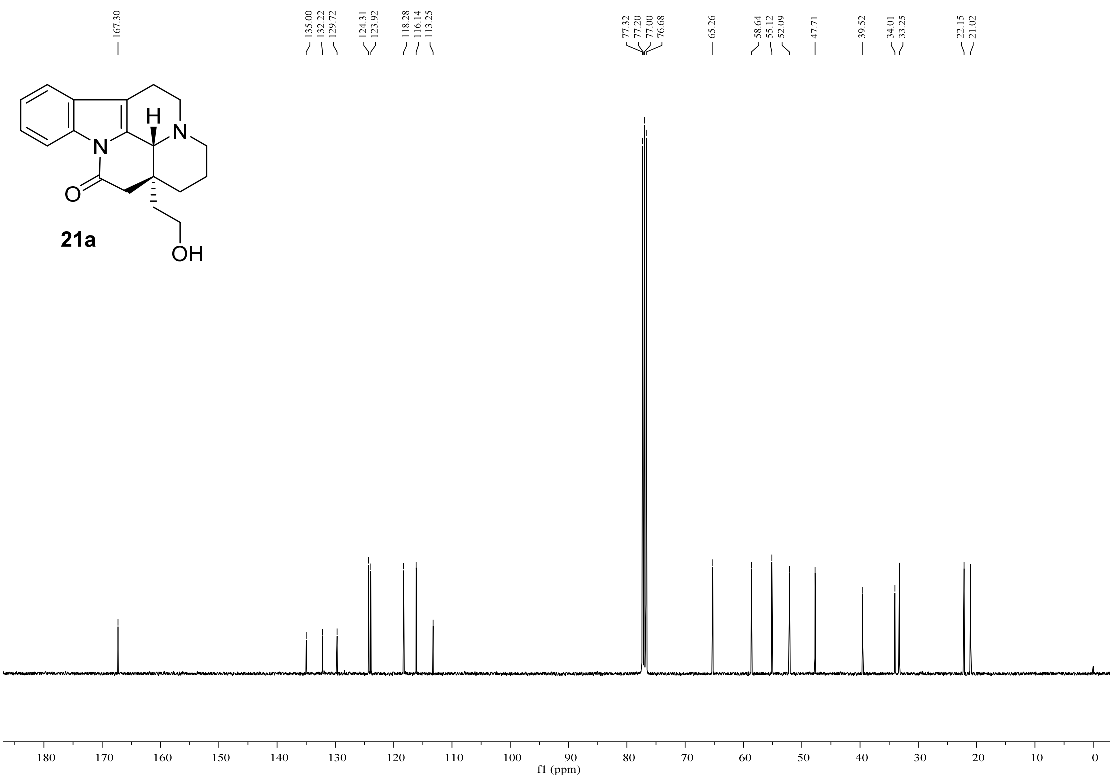


Figure S31: ^{13}C NMR spectrum of **21a**

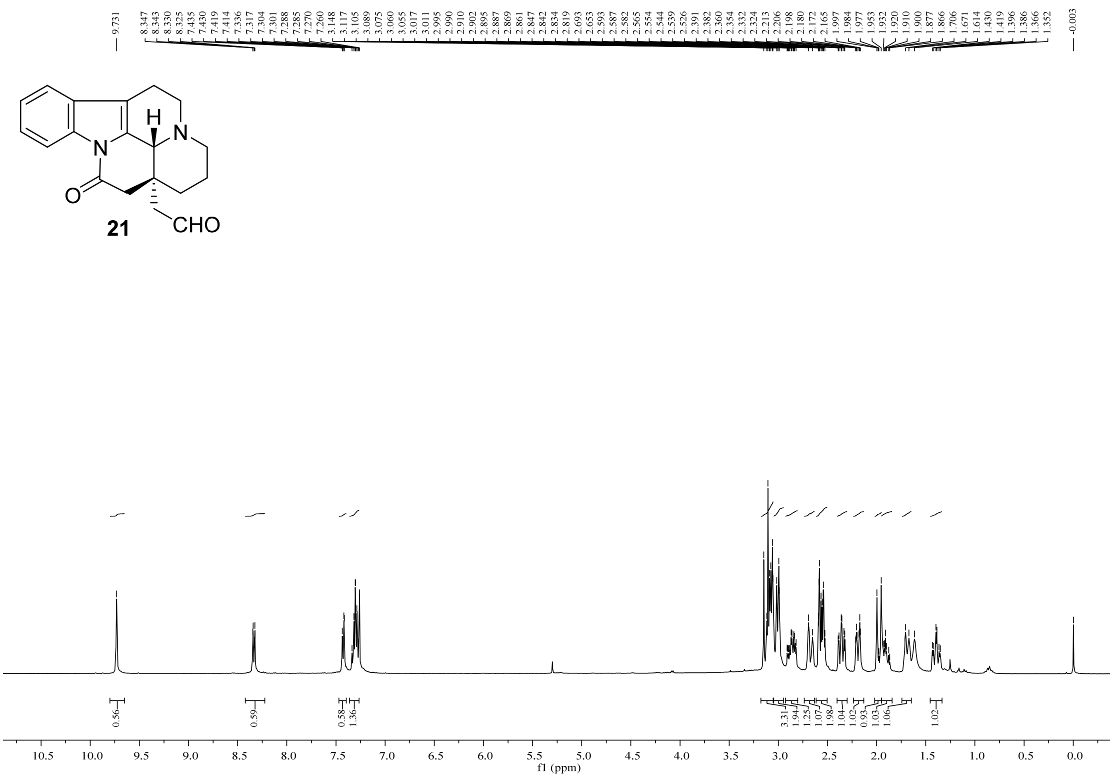


Figure S32: ^{1}H NMR spectrum of **21**

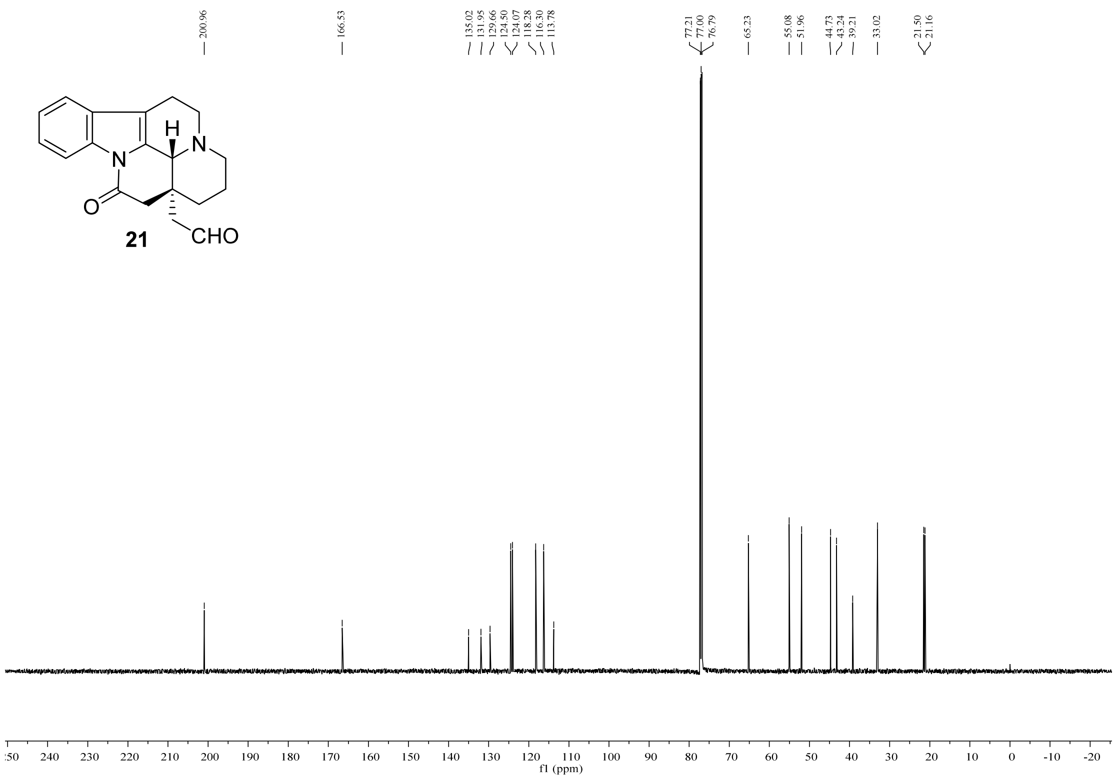


Figure S33: ^{13}C NMR spectrum of **21**

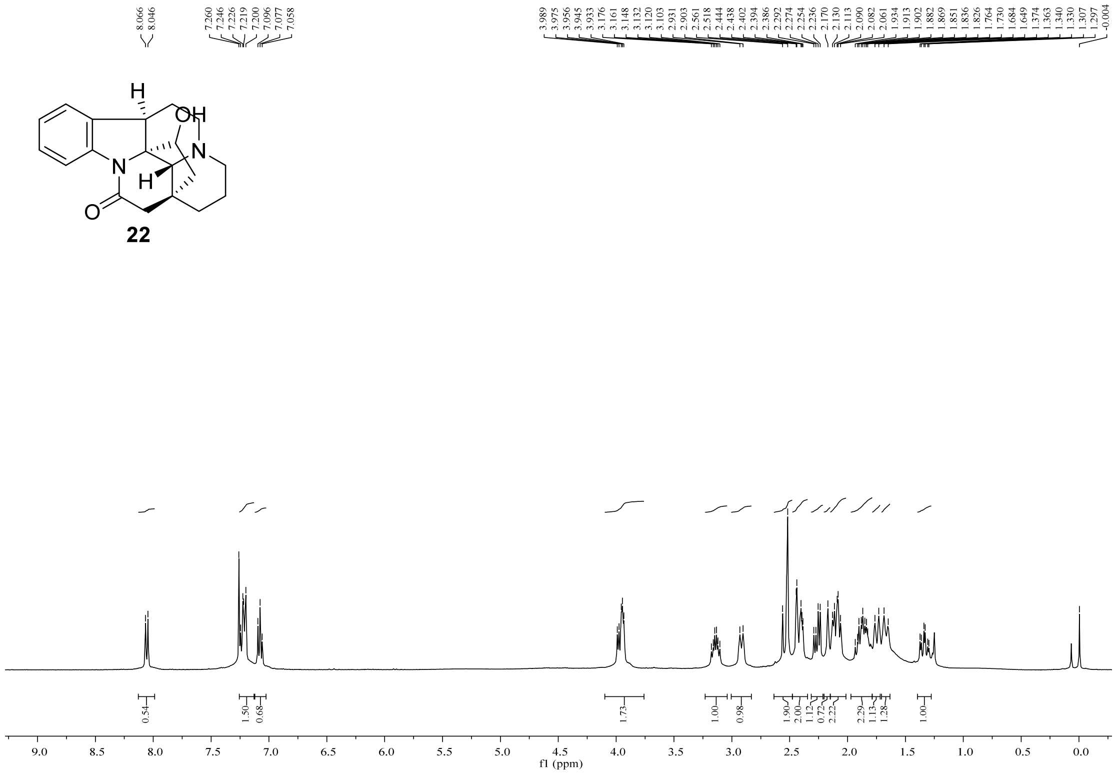


Figure S34: ^{1}H NMR spectrum of **22**

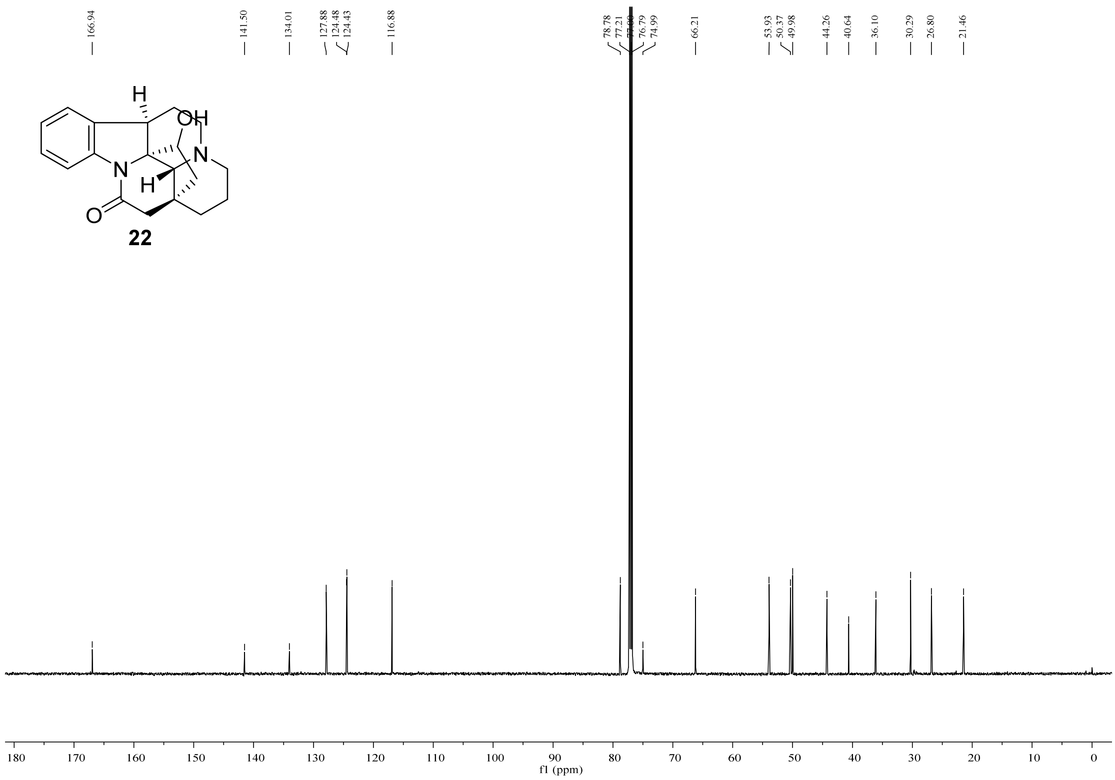


Figure S35: ^{13}C NMR spectrum of **22**

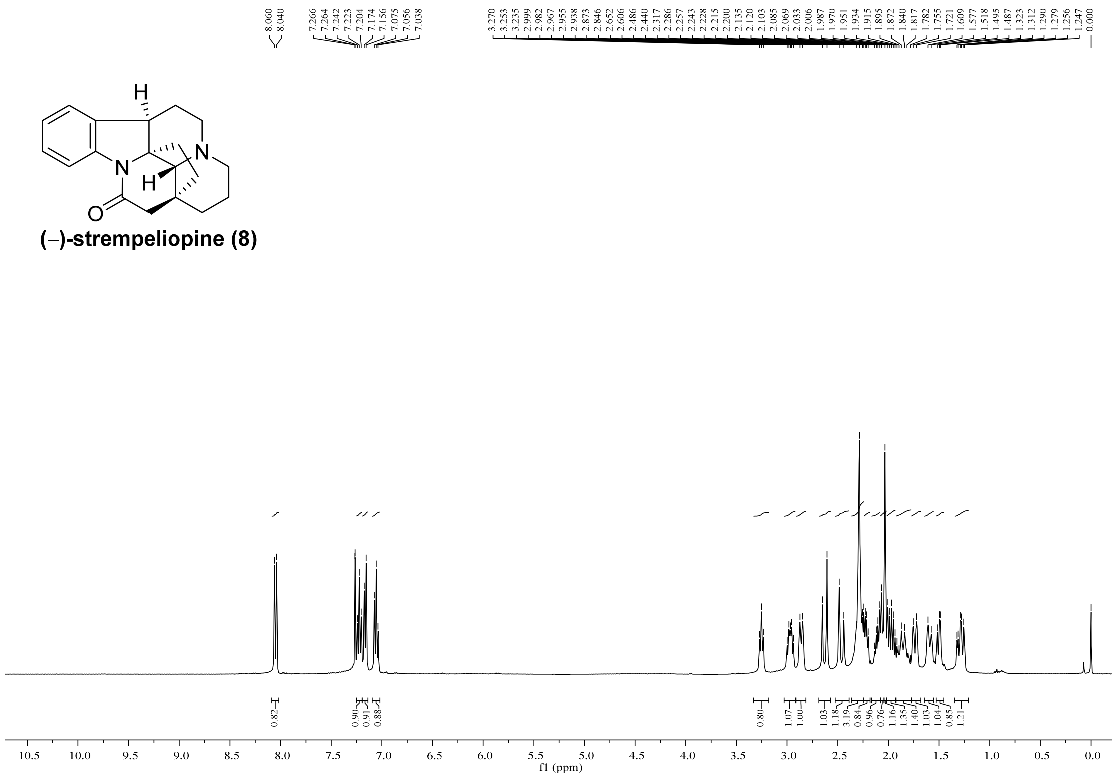


Figure S36: ^{1}H NMR spectrum of **8**

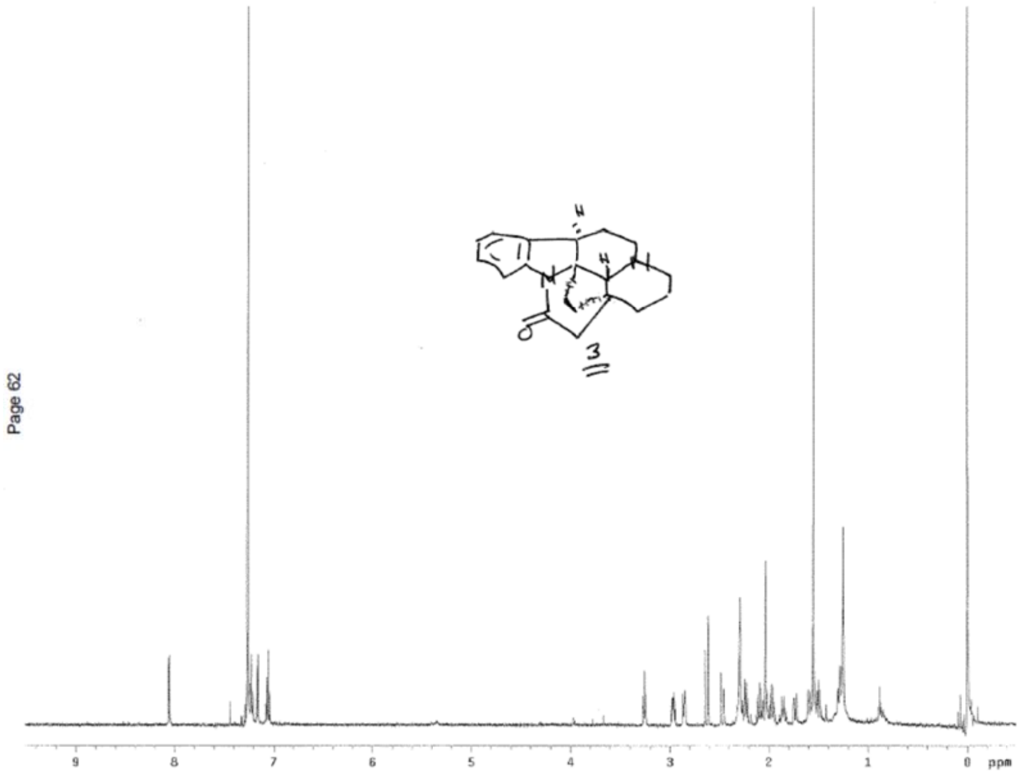


Figure S37: ^{1}H NMR spectrum of **8** from lit.[7c]

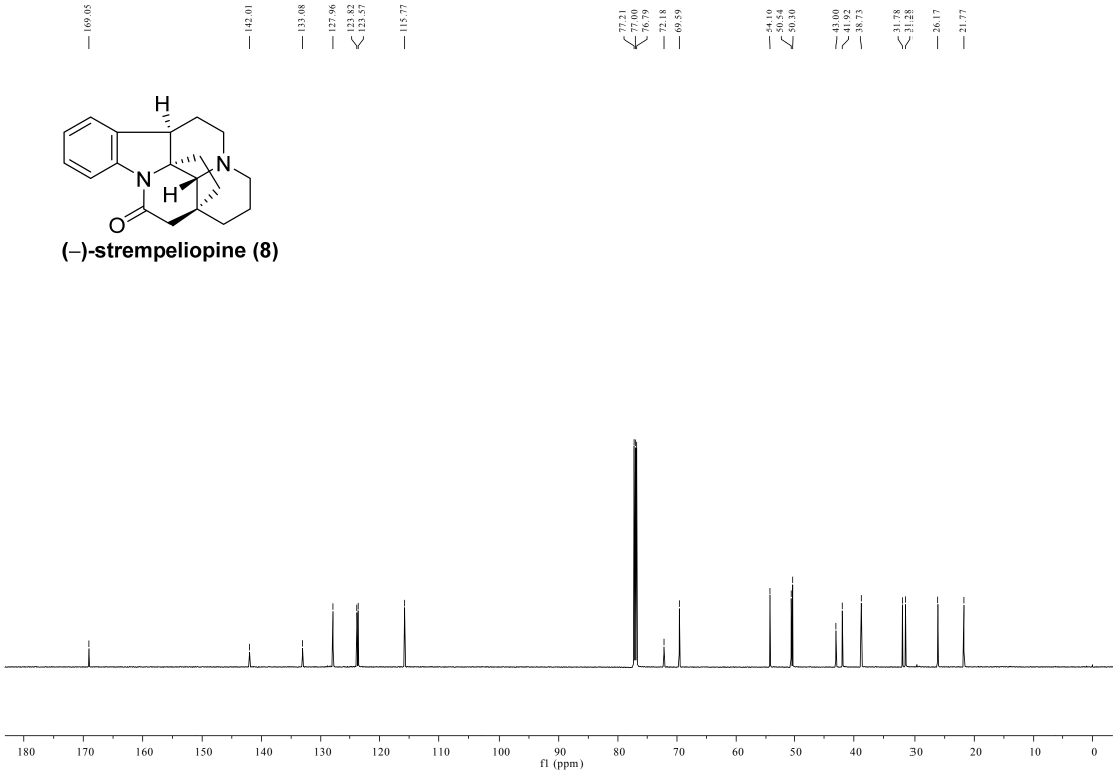


Figure S38: ^{13}C NMR spectrum of **8**

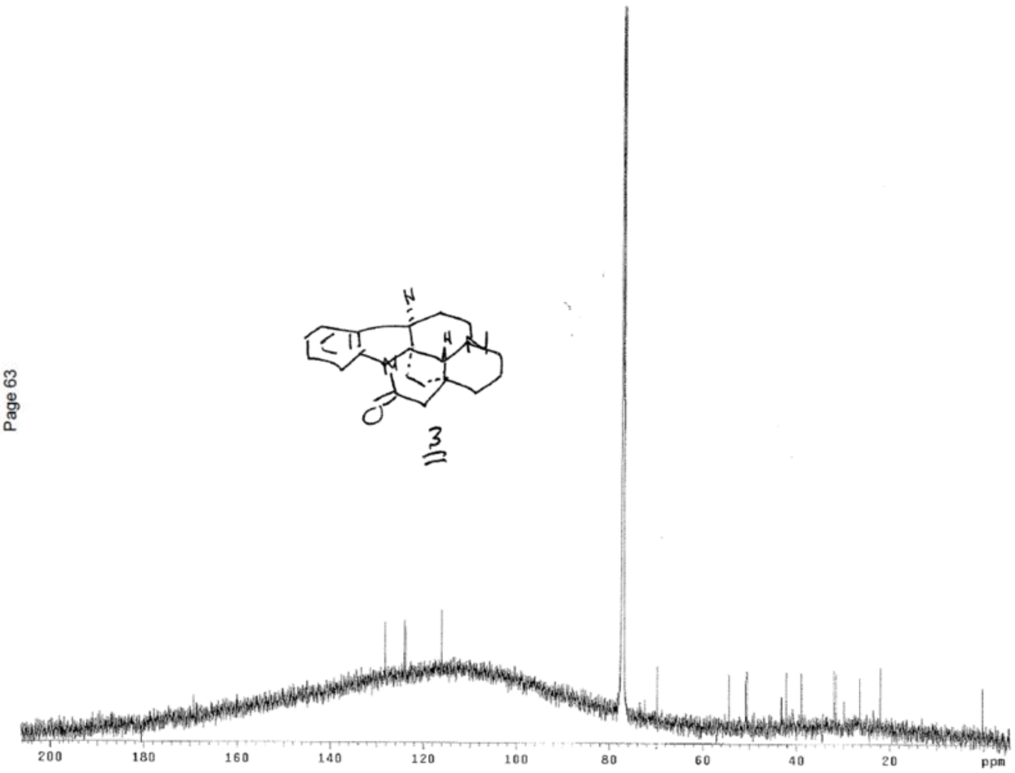


Figure S39: ^{13}C NMR spectrum of **8** from lit.[7c]

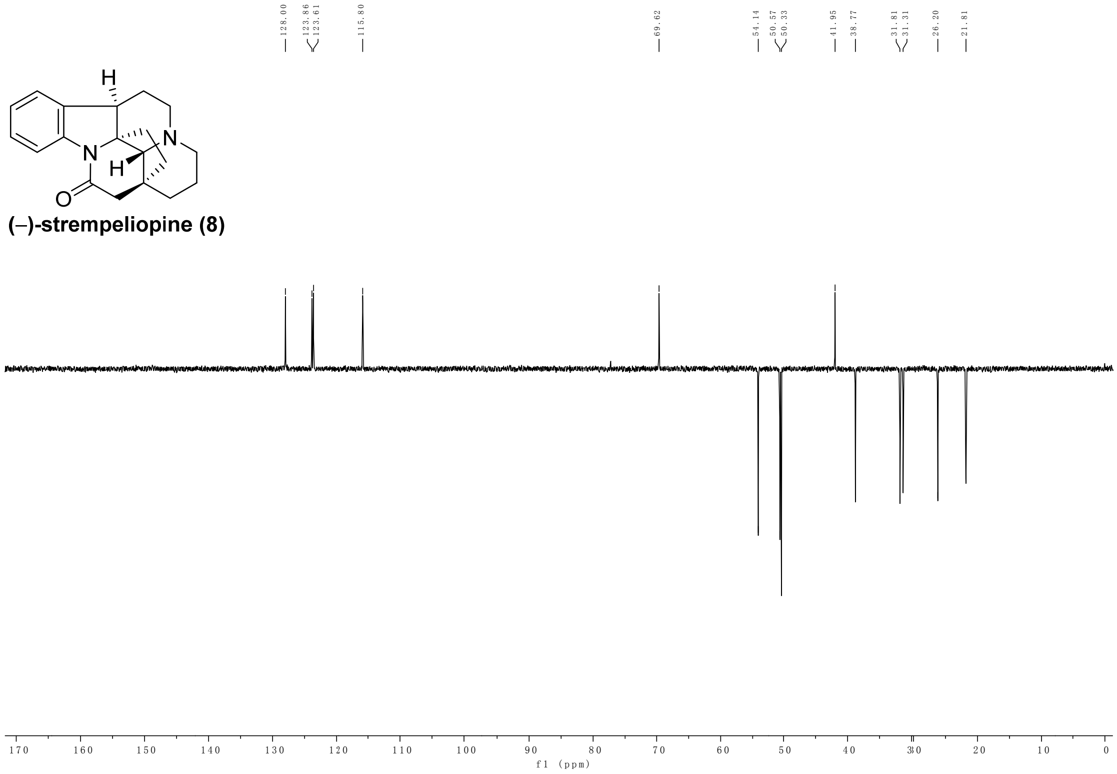


Figure S40: DEPT spectrum of **8**

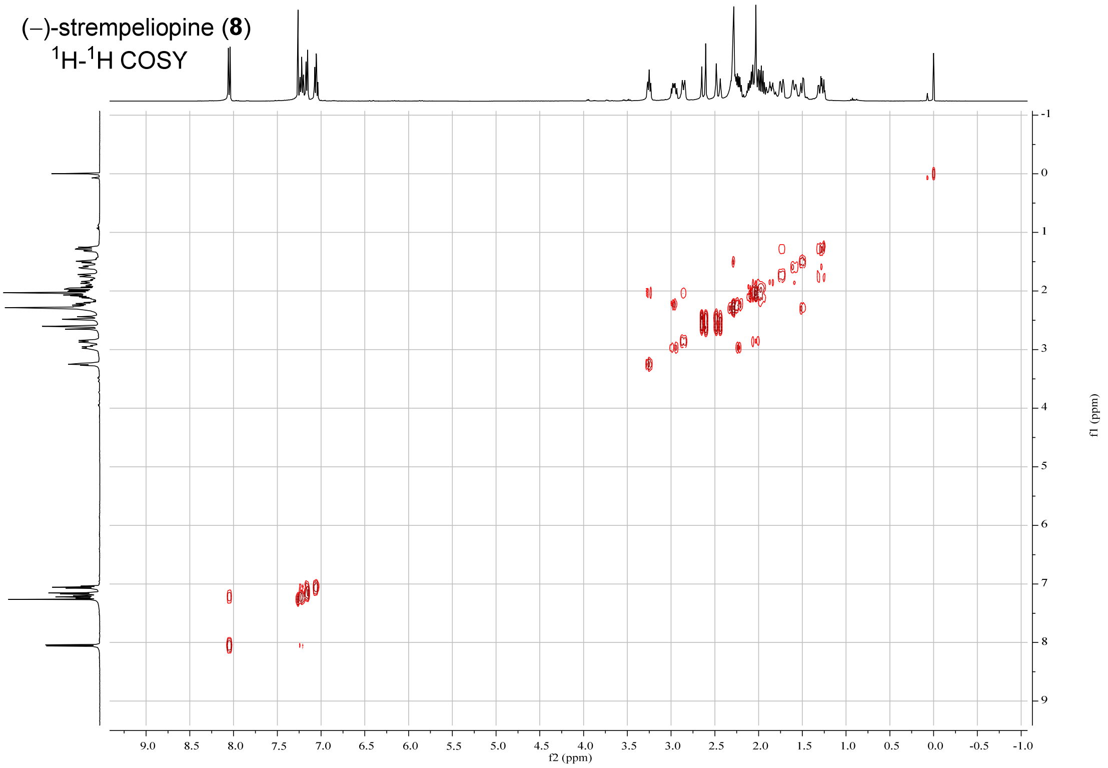


Figure S41: ^{1}H-^{1}H COSY spectrum of **8**

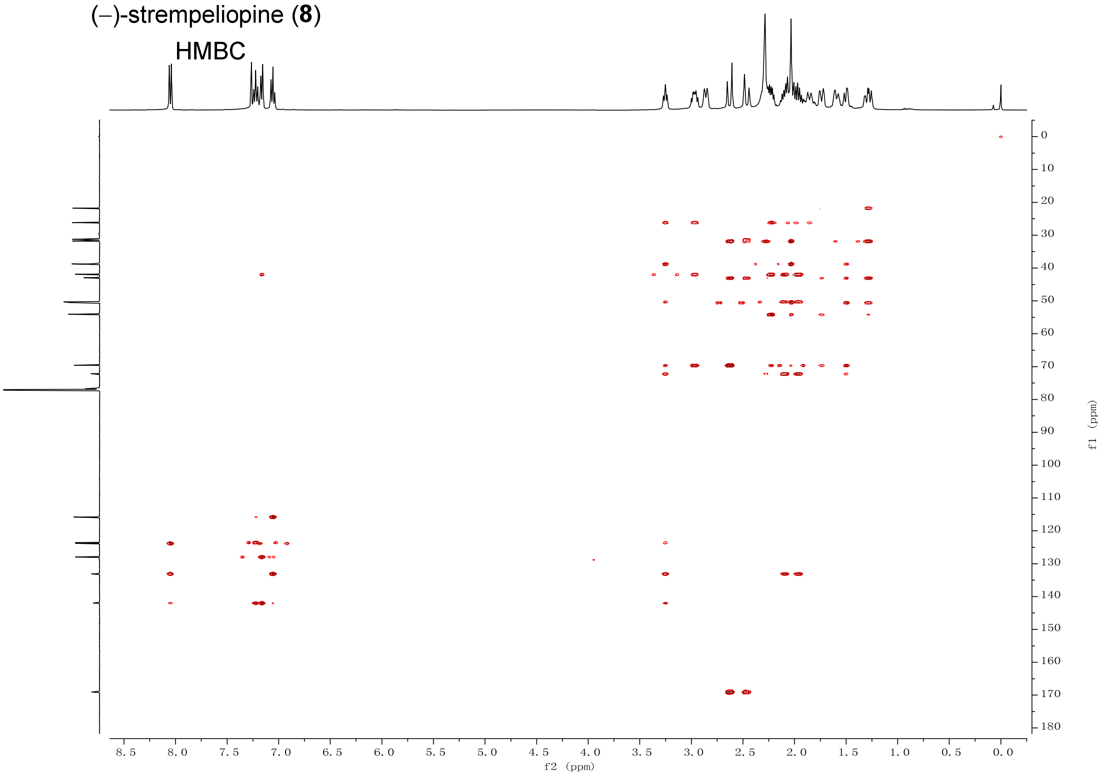


Figure S42: HMBC spectrum of **8**

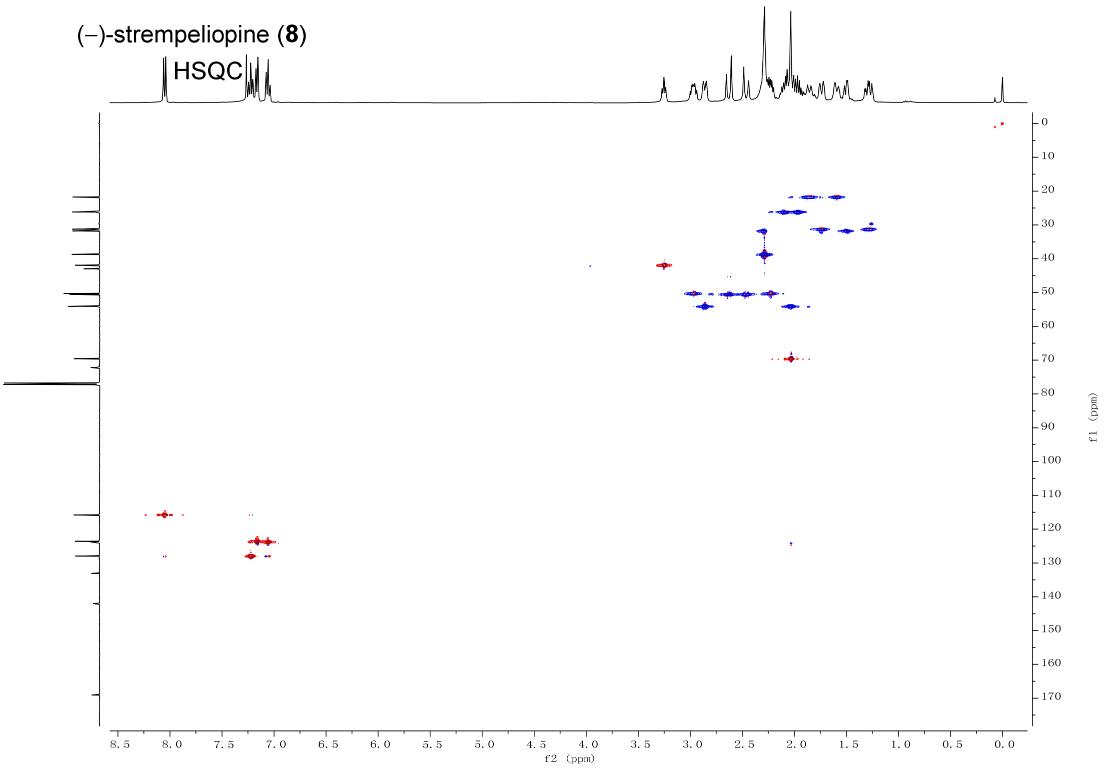


Figure S43: HSQC spectrum of **8**

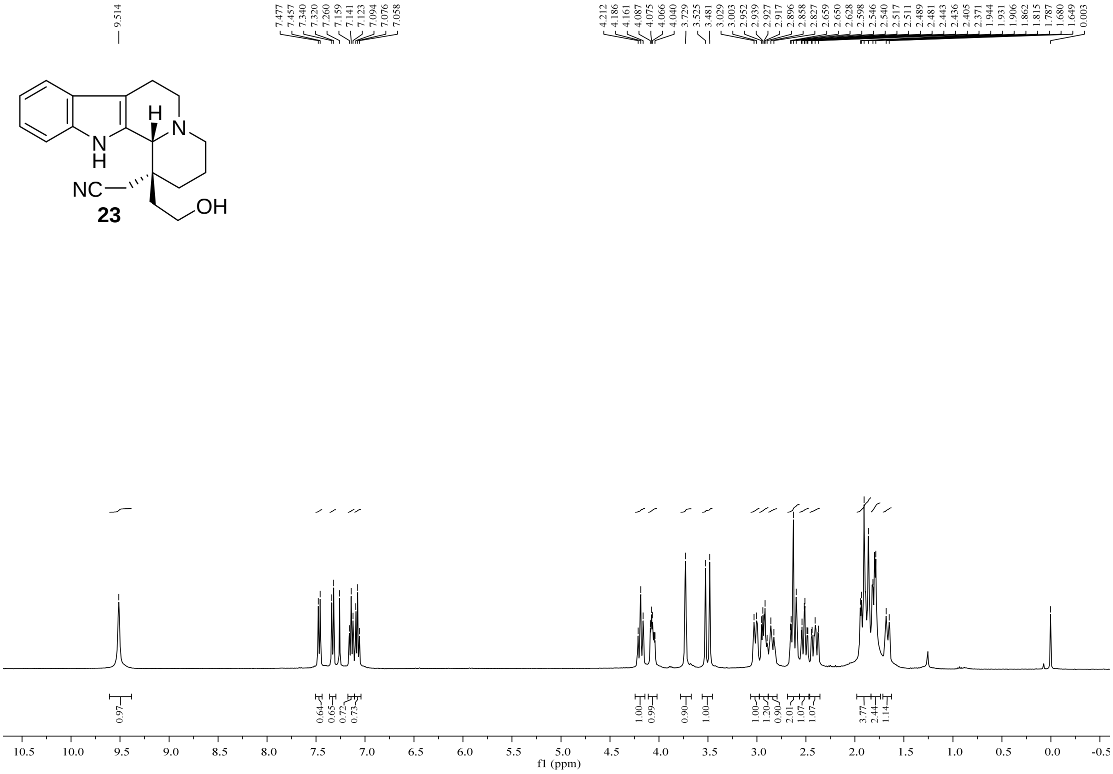


Figure S44: ^{1}H NMR spectrum of **23**

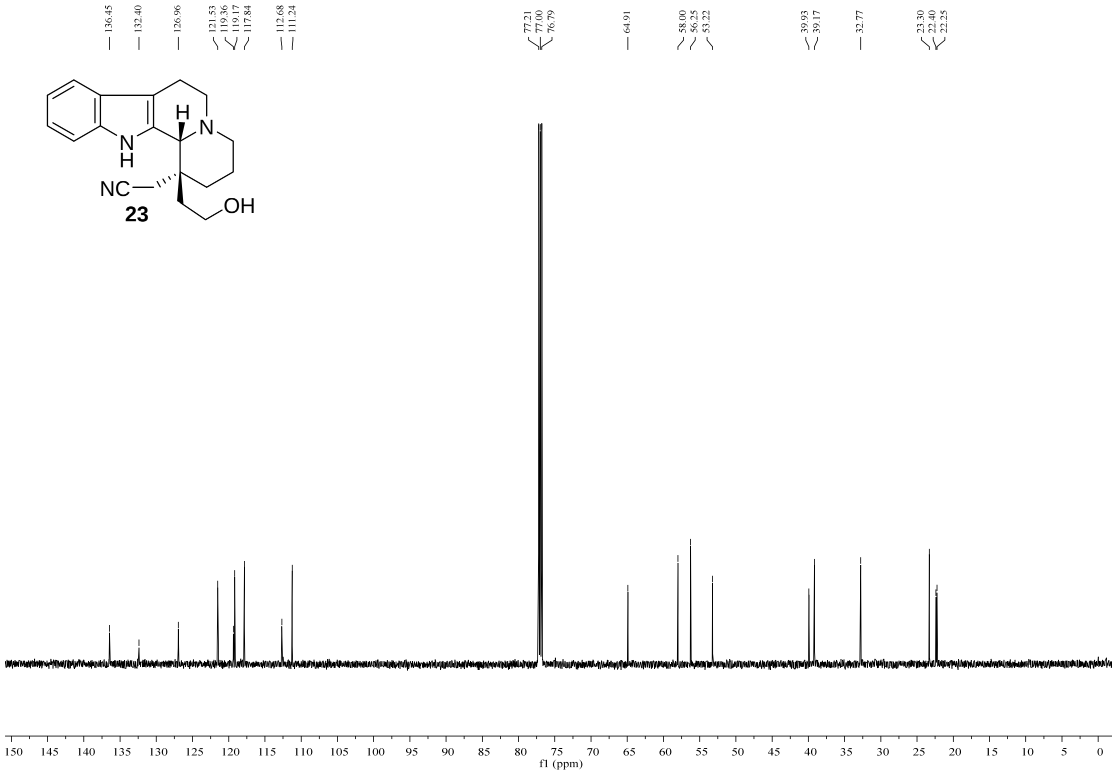


Figure S45: ^{13}C NMR spectrum of **23**

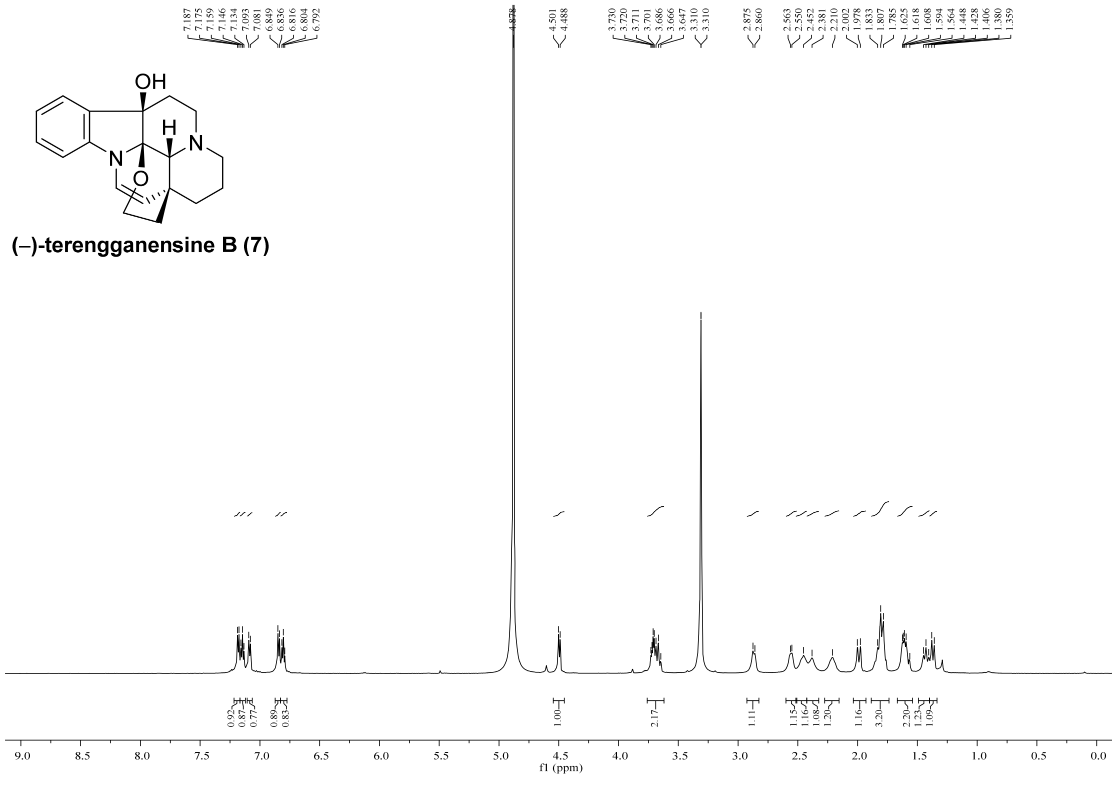


Figure S46: ^{1}H NMR spectrum of **7**

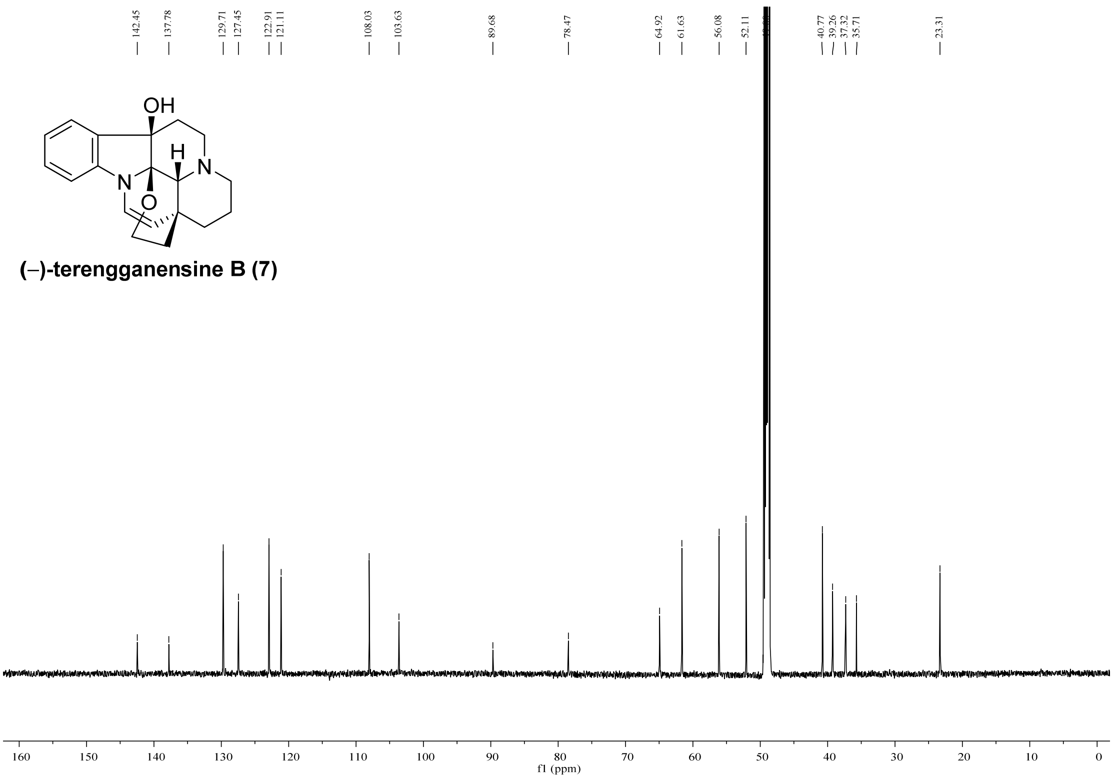


Figure S47: ^{13}C NMR spectrum of **7**

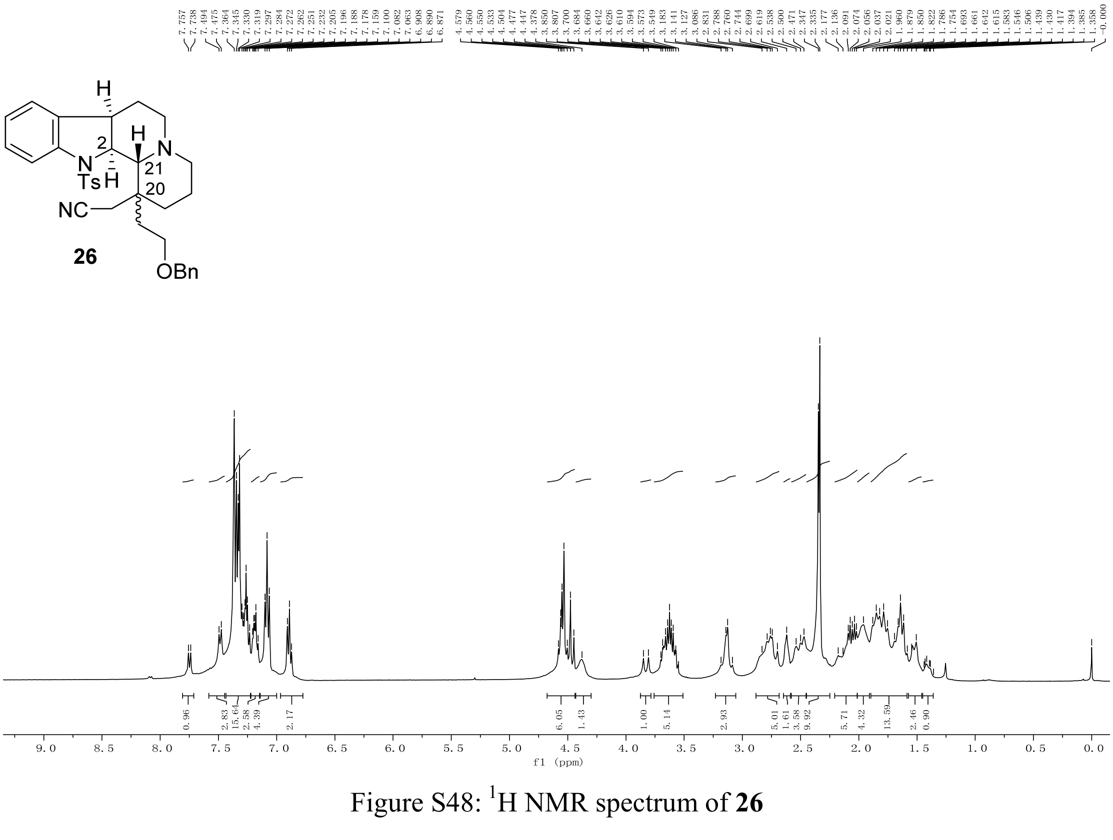


Figure S48: ^{1}H NMR spectrum of **26**

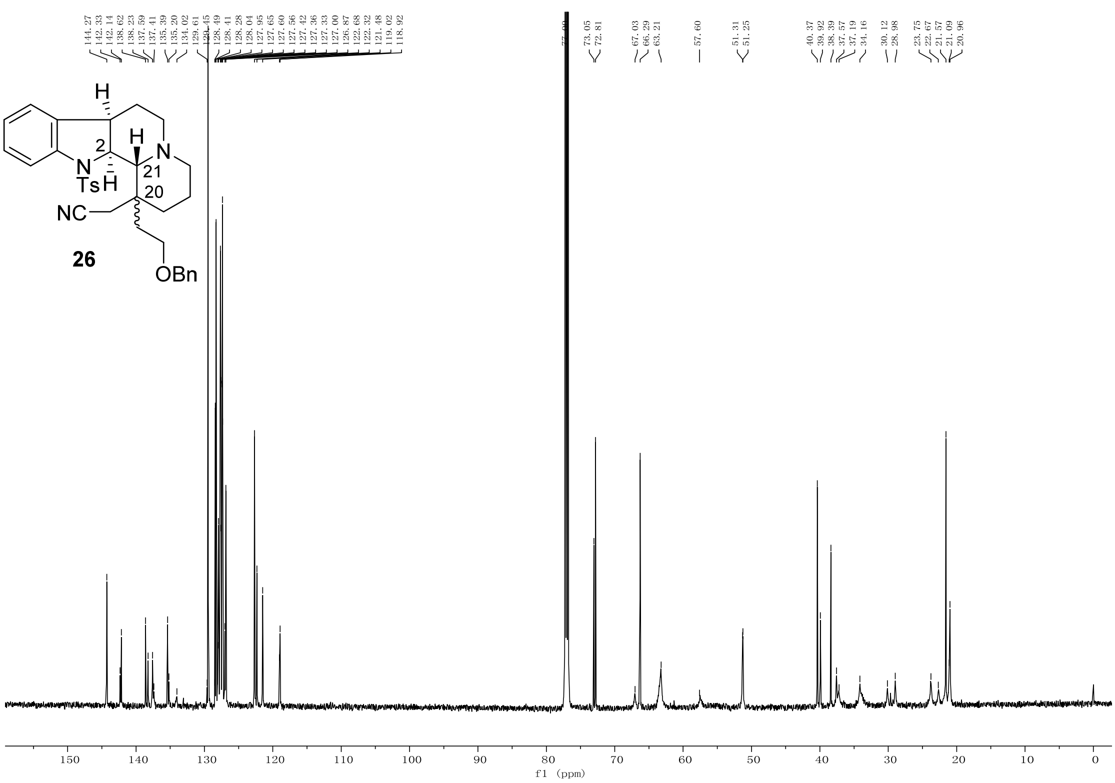


Figure S49: ^{13}C NMR spectrum of **26**

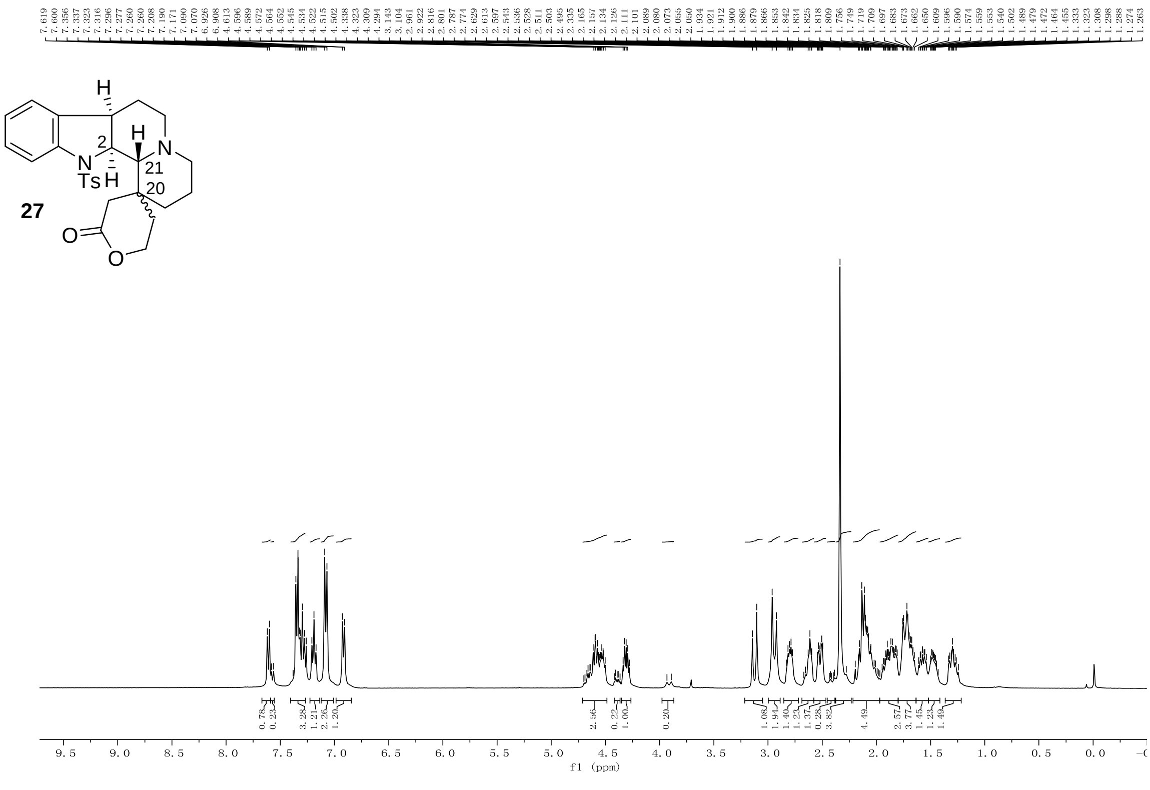


Figure S50: ^{1}H NMR spectrum of **27**

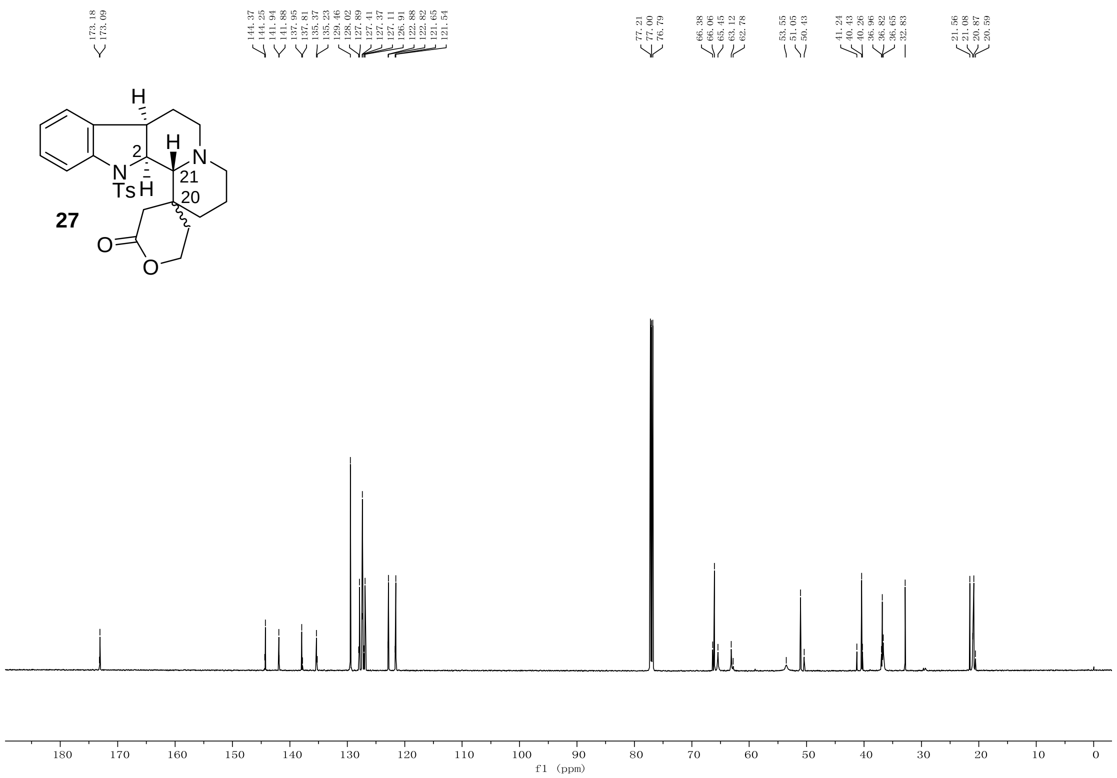


Figure S51: ^{13}C NMR spectrum of **27**

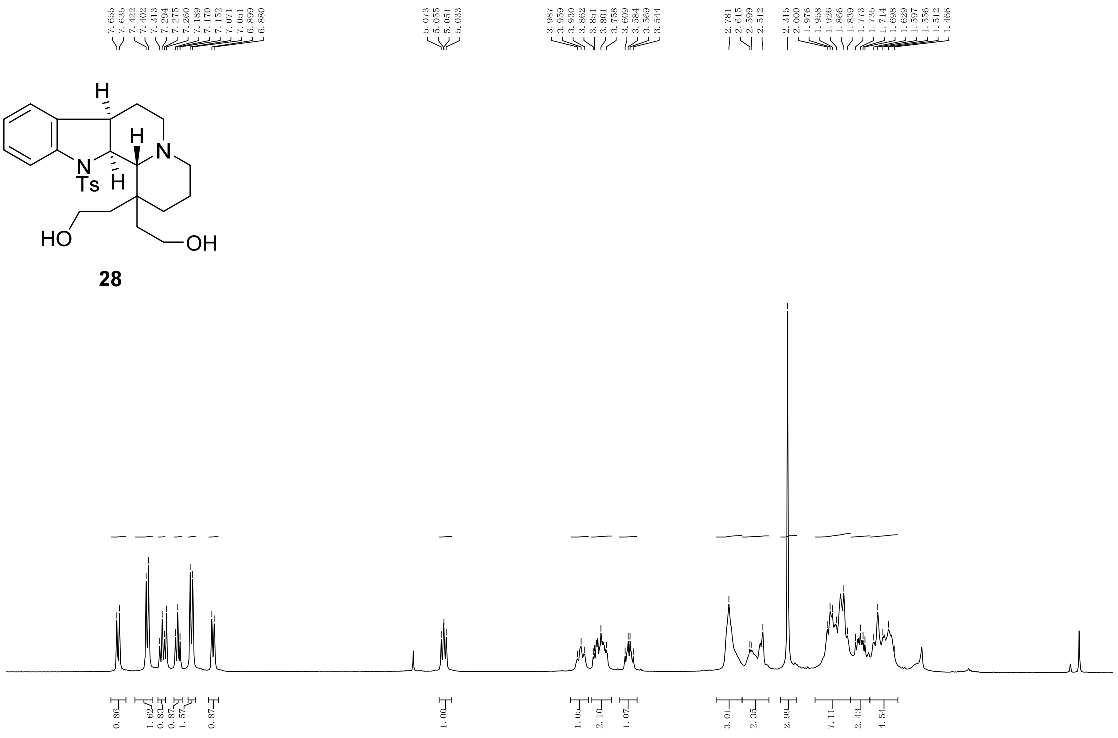


Figure S52: ^{1}H NMR spectrum of **28**

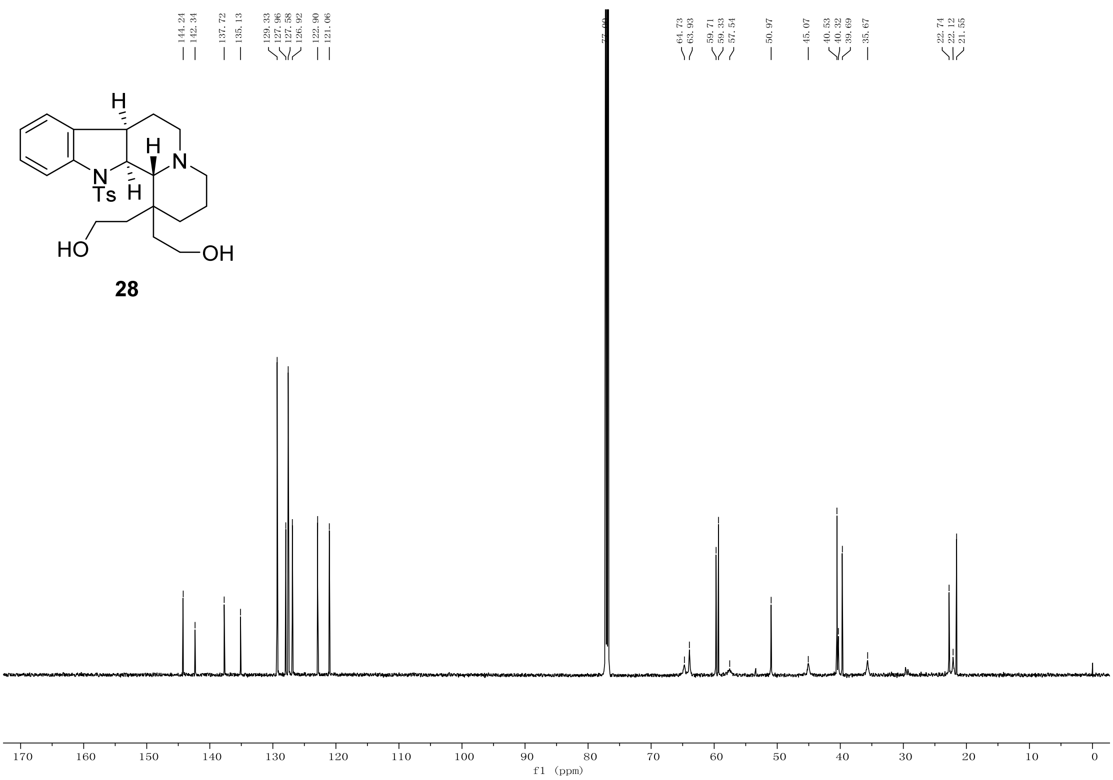


Figure S53: ^{13}C NMR spectrum of **28**

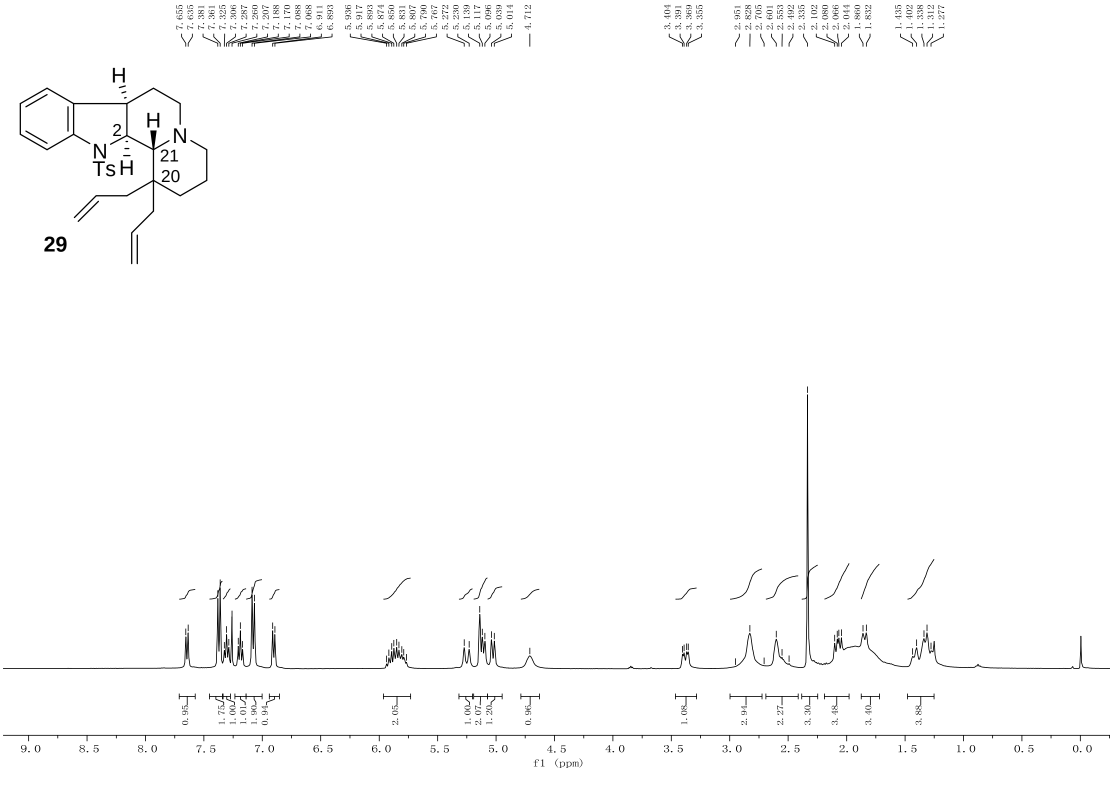


Figure S54: ^{1}H NMR spectrum of **29**

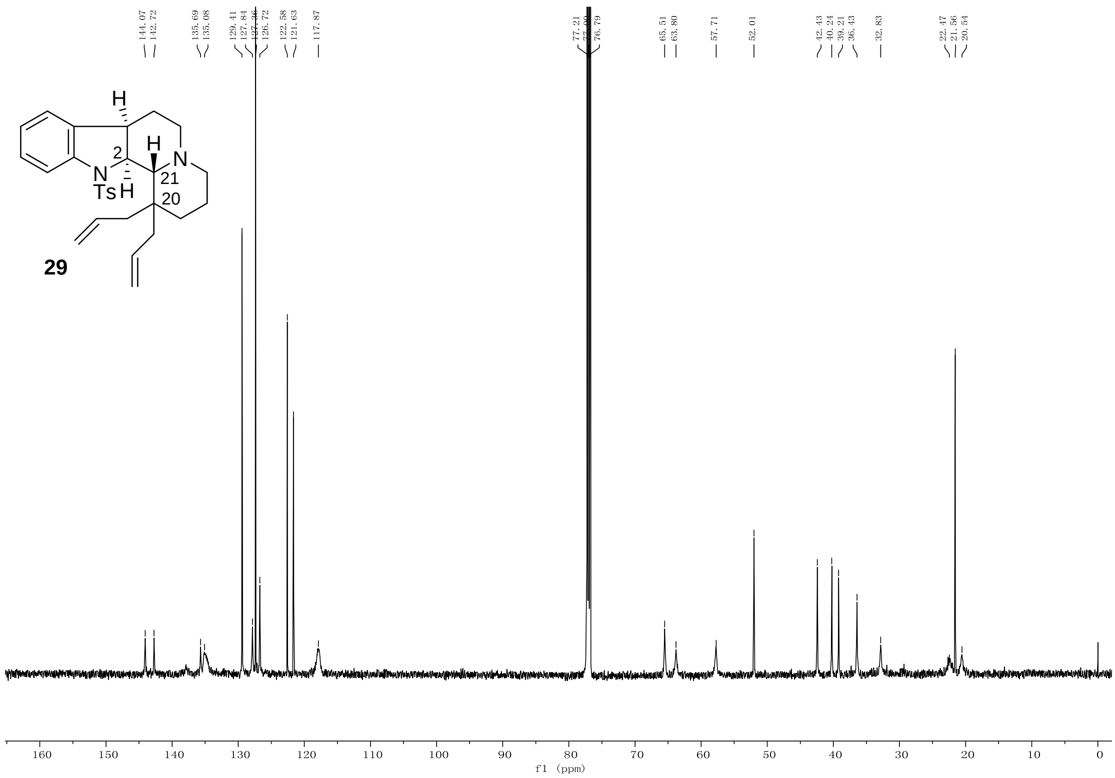


Figure S55: ^{13}C NMR spectrum of **29**

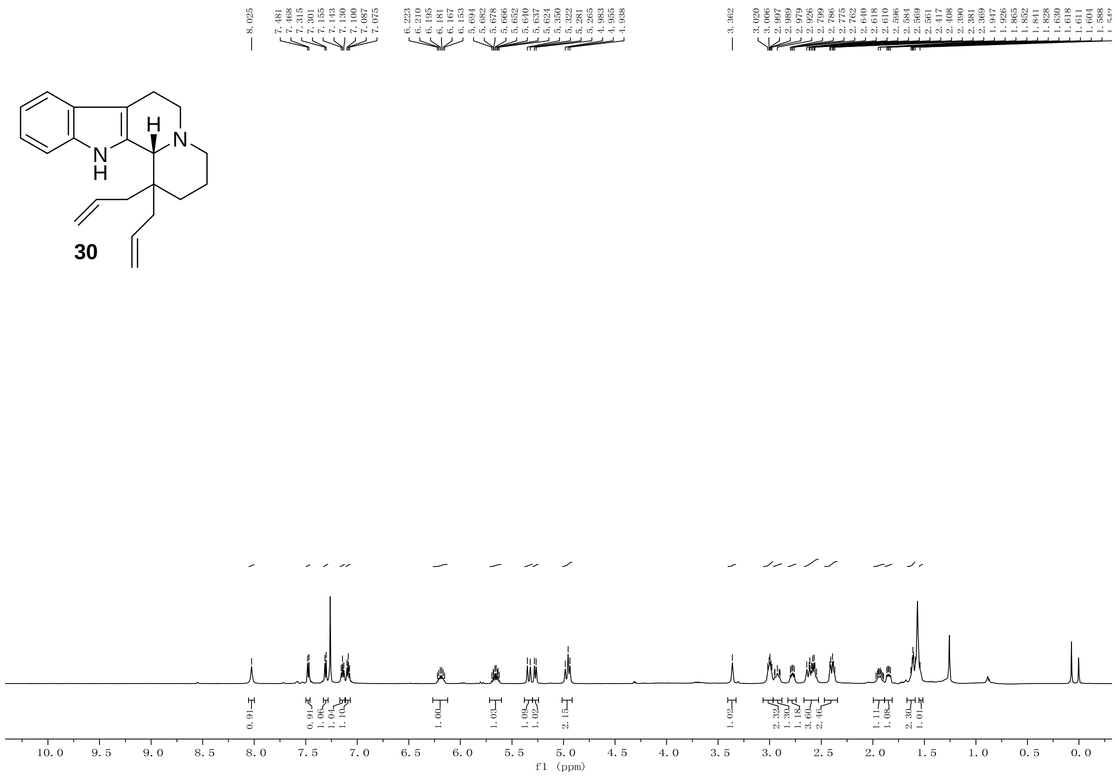


Figure S56: ^{1}H NMR spectrum of **30**

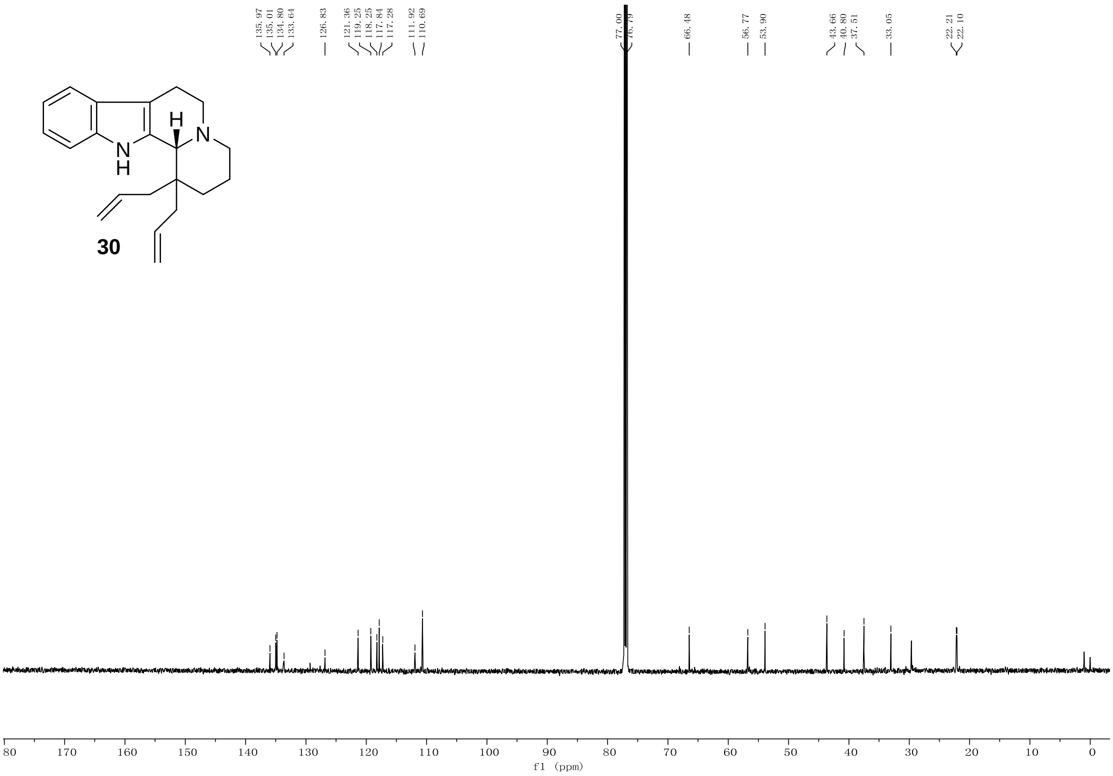


Figure S57: ^{13}C NMR spectrum of **30**

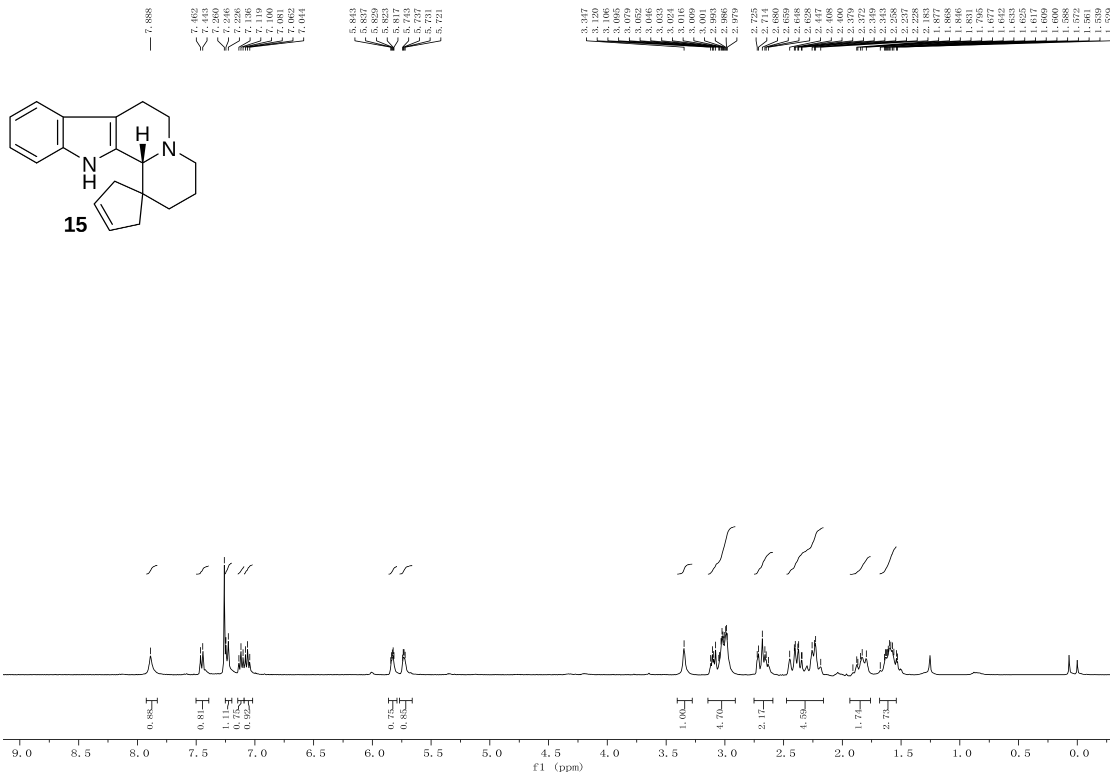


Figure S58: ^{1}H NMR spectrum of **15**

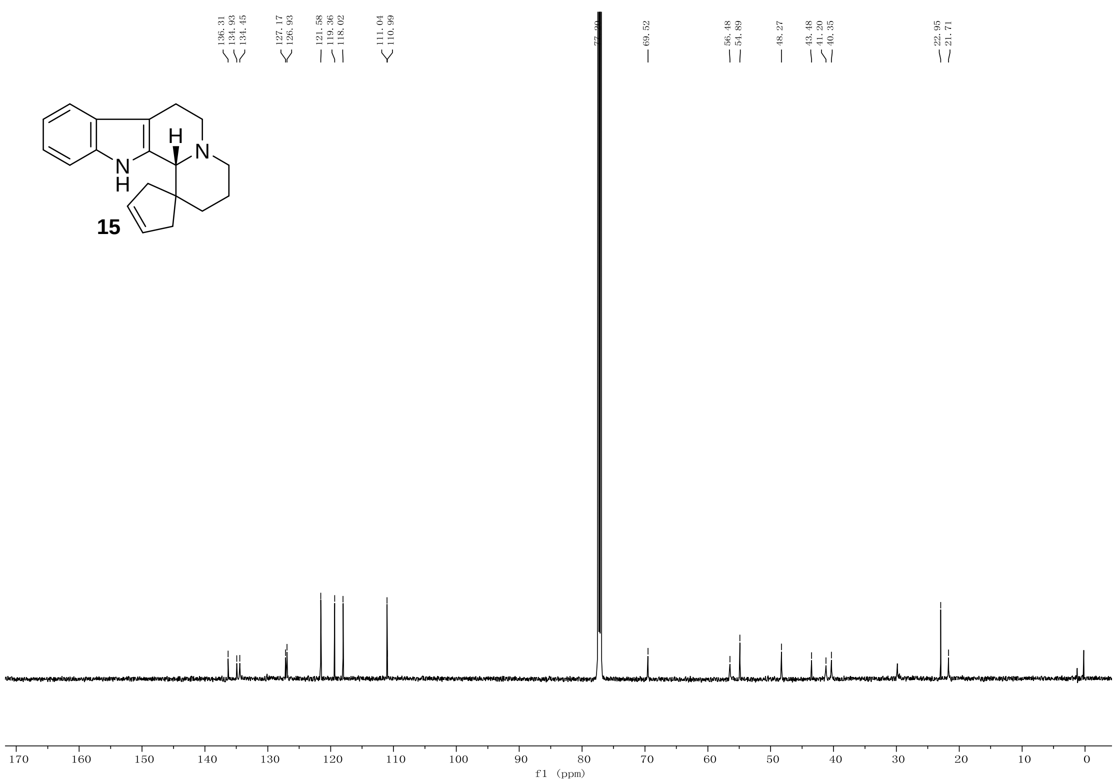
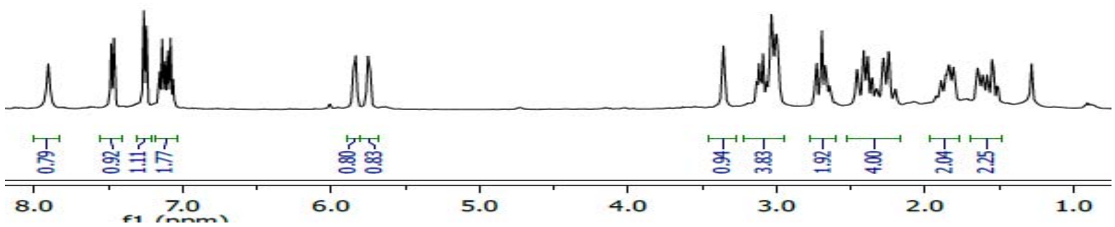
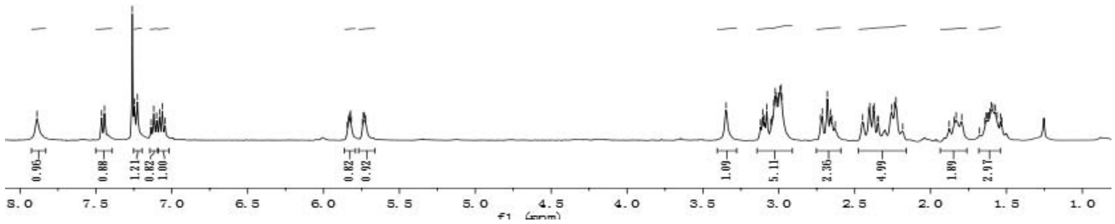


Figure S59: ^{13}C NMR spectrum of **15**

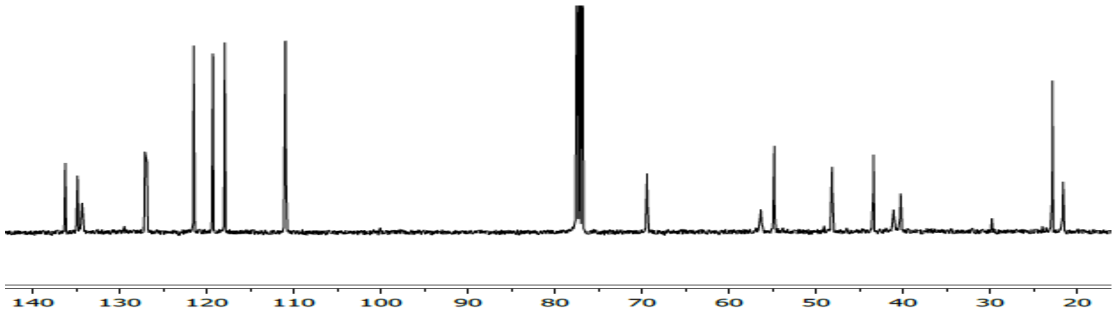


^{1}H NMR (CDCl$_3$) spectrum of **15** from lit.[9]

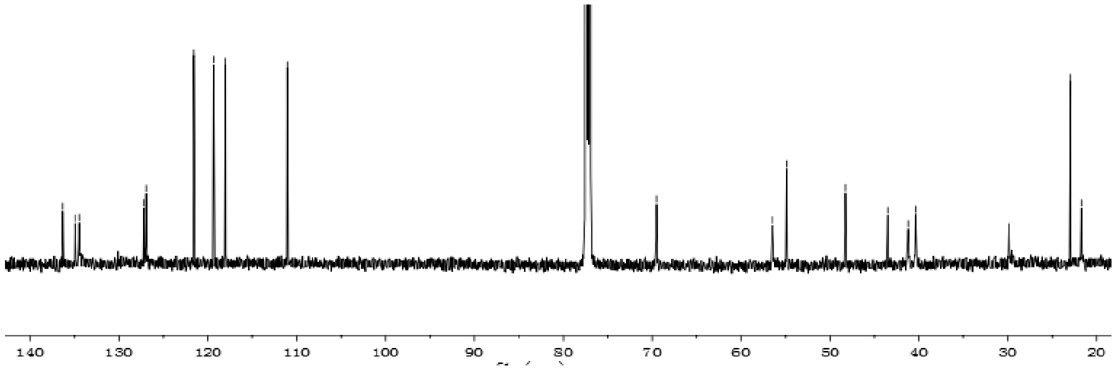


^{1}H NMR (CDCl$_3$) spectrum of our **15**

Figure S60: Comparison of ^{1}H NMR (CDCl$_3$) spectrum of **15** between lit.[9] and our work



^{13}C NMR ($CDCl_3$) spectrum of **15** from lit.[9]



^{13}C NMR ($CDCl_3$) spectrum of our **15**

Figure S61: Comparison of ^{13}C NMR ($CDCl_3$) spectrum of **15** between lit.[9] and our work