Supplementary material for:

Methoxypyridines in the Synthesis of Lycopodium Alkaloids: Total Synthesis of (±)- Lycoposerramine R

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Table of contents

Materials and Methods: 3

Dibromo Compound (**8**) 3

Vinylogous ester (**7**) 4

α-Substituted vinylogous ester(**S2**).....4

Enone (**6**).....5

Tricyclic enone (**9**).....6

α-Methylated tricyclic enone (**S3**).....6

Allylic alcohol (**10**) 7

Amide (**11**).....8

Iodolactone (**12**) 9

Diol (**13**) 9

Ketoaldehyde (**14**) 10

Ketoaldehyde (**4**) 11

Ketoalkyne (**15**).....11

Alternative route to ketoaldehyde (**4**)……12

Tetracyclic amine (**S4**).....13

Tetracyclic amine (**S5**).....13

(±)-Lycoposerramine R (**2**) ……....14

Crystal structure of Iodolactone (**12**)……...15

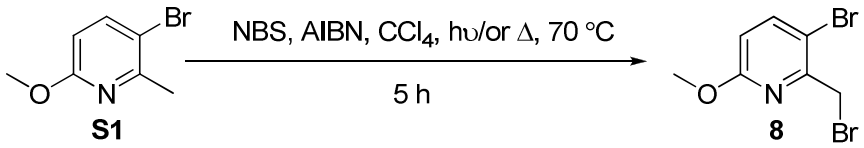
Comparision of Literature data with our data……..17

^{1}H and **^{13}C** Spectra of all the compounds……18

Materials and Methods:

Unless otherwise stated, reactions were performed in oven-dried glassware fitted with rubber septa under a nitrogen atmosphere and were stirred with Teflon-coated magnetic stirring bars. Liquid reagents and solvents were transferred via syringe using standard Schlenk techniques. Tetrahydrofuran (THF) and diethyl ether (Et_2O) were distilled over sodium/benzophenone ketyl. Dichloromethane (CH_2Cl_2), toluene, and benzene were distilled over calcium hydride. Acetonitrile was distilled over potassium carbonate. N,N-Diisopropylethylamine (DIPEA) was distilled over calcium hydride prior to use. All other solvents and reagents were used as received unless otherwise noted. Reaction tempera-tures above 23 °C refer to oil bath temperature, which was controlled by an OptiCHEM temperature modulator. Thin layer chromatography was performed using SiliCycle silica gel 60 F-254 precoated plates (0.25 mm) and visualized by UV irradiation and anisaldehyde stain. SiliCycle Silia-P silica gel (particle size 40-63 μm) was used for flash chromatography. Melting points were recorded on a Laboratory Devices Mel-Temp 3.0 and are uncorrected. ^1H and ^{13}C NMR spectra were recorded on Bruker AVB-400, DRX-500 and AV-500 MHz spectrometers with ^{13}C operating frequencies of 100, 125 and 125 MHz, respectively. Chemical shifts (δ) are reported in ppm relative to the residual solvent signal (δ = 7.26 for ^1H NMR and δ = 77.0 for ^{13}C NMR). Data for ^1H NMR spectra are reported as follows: chemical shift (multiplicity, coupling constants,number of hydrogens). Abbreviations are as follows: s (singlet), d (doublet), t (triplet), q (quartet), m (multiplet), br (broad). IR spectra were recorded on a Nicolet MAGNA-IR 850 spectrometer and are reported in frequency of absorption (cm^{-1}). Only selected IR absorbencies are reported. High resolution mass spectral data were obtained from the Mass Spectral Facility at the University of California, Berkeley.

Dibromo compound (8)[1]



The dibromo compound (**8**) was prepared according to a modified literature procedure:[1] In a flame-dried schlenk tube was added bromomethoxypicoline (**S1**, 10.0 g, 49.5 mmol, 1.0 equiv) in CCl_4 (80 mL)

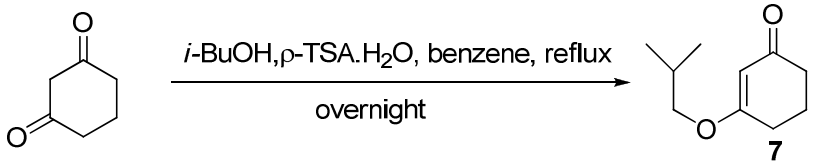
[1]Known compound: Kelly, S. A.; Foricher, Y.; Mann, J.; Bentley, J. M. *Org. Biomol. Chem.* **2003**, *1*, 2865.

and to this solution was added NBS (8.81 g, 49.5 mmol, 1.0 equiv), catalytic AIBN (300 mg) and acetic acid (5 mL). The reaction mixture was evacuated and backfilled with nitrogen and heated to 70 ºC for 4.5h. The reaction mixture was cooled to room temperature and washed sequentially with saturated aq. sodium bisulphite solution and saturated $NaHCO_3$ solution and extracted with DCM (2 x 5 mL). The combined organic phases were dried over $MgSO_4$ and the solvents were removed under reduced pressure. Purification by flash chromatography (8:1 hexanes/EtOAc) gave 11.96 g (86% yield) of **8** as a yellow viscous oil. $\mathbf{R_f}$ = 0.68 (8:1 hexanes/EtOAc).

$C_7H_7BrNO_2$, MW: 280.94 g/mol. **^{1}H NMR** (600 MHz, $CDCl_3$, 21 °C): δ = 7.69-7.64 (m, 1H), 6.59-6.57 (m, 1H), 4.60 (s, 1H), 3.92 (s, 1H).

All other analytical data were in accordance with the literature data[1].

Vinylogous ester (7)[2]

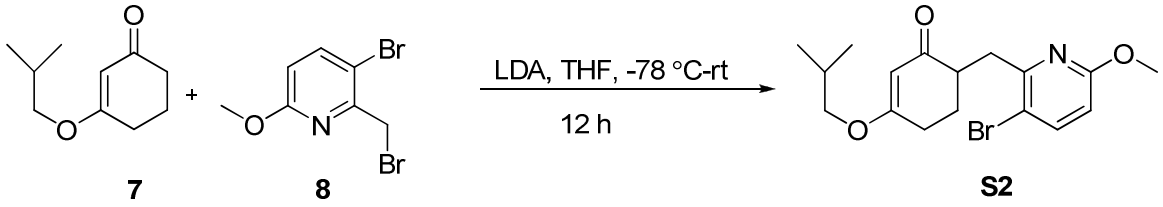


A mixture of 1,3-cyclohexanedione (10.0 g, 89.18 mmol, 1.0 equiv.), p-toluenesulfonic acid monohydrate (848 mg, 4.46 mmol) and isobutyl alcohol (24 mL) in benzene (100 mL) was held at reflux for 12 h and then cooled to rt. Most of the solvent was removed under vacuum and the resulting residue was poured into brine and extracted with ether. The organic phase was dried($MgSO_4$), filtered , and concentrated to give a crude residue which on purification by flash chromatography (8:1 hexanes/EtOAc) afforded 13.8 g (93% yield) of compound **7** as a yellow oil in 93% yield. $\mathbf{R_f}$ = 0.49 (2:1 hexanes/EtOAc).

$C_{10}H_{16}O_2$, MW: 168.23 g/mol. **^{1}H NMR** (500 MHz, $CDCl_3$, 21 °C): δ = 5.33 (s, 1H), 3.58 (d, *J* = 6.51 Hz, 2H), 2.41 (t, *J* = 6.29 Hz, 2H), 2.36-2.31 (m, 2H), 2.07-1.93 (m, 3H), 0.97 (d, *J* = 6.73 Hz, 6H).

All other analytical data were in accordance with the literature data[2].

α-Substituted vinylogous ester (S2)

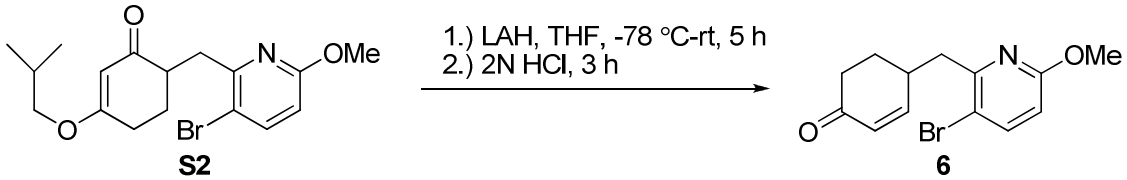


[2]Known compound: Gulias, M.; Rodriguez, J. R.; Castedo, L.; Mascarenas, J. L. *Org. Lett.* **2003**, *5*, 1975.

To a stirred solution of diispropylamine (5.0 mL, 35.5 mmol, 1 equiv.) in THF (100mL) at 0 ºC was added *n*-butyllithium (2.5 M in hexanes, 7.11 mL, 35.5 mmol, 1 equiv) dropwise over 5 min. After 30 min, the solution was cooled to -78 ºC and a solution of vinylogous ester **7** (5.98 g, 35.5 mmol, 1 equiv) in THF (20 mL) was added by cannula over 5 minutes. After stirring for another 30 min, a solution of bromo compound **8** (10.0 g, 35.5 mmol, 1 equiv) in THF (20 mL) was added slowly via syringe. The reaction mixture was stirred for 4 h at -78 ºC then allowed to warm to room temperature and stirred for 10h. The reaction mixture was quenched by the addition of saturated NH_4Cl solution. The resulting mixture was extracted with Et_2O (3 x 20 mL). The combined organic layers were dried over $MgSO_4$ and concentrated under reduced pressure. The crude product was purified by flash chromatography (3:1 hexanes/EtOAc) to give 10.71 g (82% yield) of **S2** as a yellow viscous oil. $\mathbf{R_f}$ = 0.79 (2:1 hexanes/EtOAc).

$C_{17}H_{22}BrNO_3$, MW: 368.26 g/mol. **^{1}H NMR** (500 MHz, $CDCl_3$, 21 °C): δ = 7.61 (d, *J* = 8.62 Hz, 1H), 6.46 (d, *J* = 8.61 Hz, 1H), 5.37 (s, 1H), 3.84 (s, 3H), 3.64-3.53 (m, 2H), 3.50 (dd, *J* = 14.7, 3.31 Hz, 1H), 2.97-2.88 (m, 1H), 2.85 (dd, *J* = 14.7, 9.97 Hz, 1H), 2.44 (dd, *J* = 7.46, 4.79 Hz, 2H), 2.06-1.91 (m, 2H), 1.76 (m, 1H), 0.96 (d, *J* = 5.5 Hz, 6H) **^{13}C NMR** (150 MHz, $CDCl_3$, 21 °C): δ = 200.1, 176.9, 162.2, 155.4, 142.2, 112.2, 109.7, 102.2, 74.6, 53.4, 44.2, 36.2, 28.4, 27.6, 26.0, 19.0, 14.1. **IR** (film) υmax = 2959, 2873, 1655, 1608, 1575, 1459, 1417, 1383, 1343, 1324, 1298, 1260, 1194, 1178, 1117, 1040, 10005, 821cm-1; **HRMS (ESI) *m/e*:** Calcd for $(MH)^+$ **$C_{17}H_{22}BrNO_3$** : 369.0763. Found: 369.0751.

Enone (6)

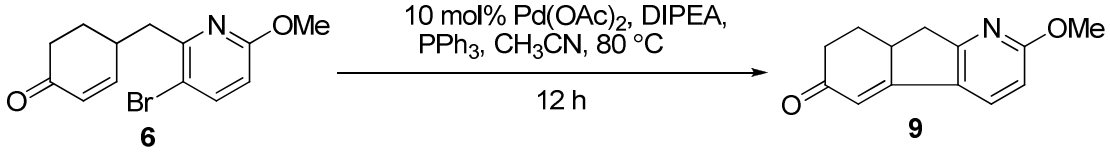


S2 **6**

To a suspension of LAH (3.09 g, 81.5 mmol, 3 equiv) in THF (150 mL) at -78 °C was added a solution of compound **S2** (10.0 g, 27.2 mmol, 1 equiv) in THF (20 mL). The mixture was stirred at -78 °C for 3 h and than at 0 °C- rt for 2 h. The reaction mixture was cooled to 0 ºC and added 2N HCl solution (60mL) and was stirred for 3 h with warming to room temperature and then neutralized by the addition of 4N NaOH (50 mL). The resulting mixture was extracted with Et_2O (3 x 30 mL) and the combined organic layers were dried over $MgSO_4$ and concentrated under reduced pressure. The crude product was purified by flash chromatography (4:1 hexanes/EtOAc) to give 6.18 g (77% yield) of enone (**6**) as a yellow viscous oil. . $\mathbf{R_f}$ = 0.75 (2:1 hexanes/EtOAc).

$C_{13}H_{14}BrNO_2$, MW: 296.16 g/mol. **^{1}H NMR** (300 MHz, $CDCl_3$, 21 °C): δ = 7.60 (d, *J* = 8.66 Hz, 1H), 6.91 (ddd, *J* = 10.18, 2.49, 1.10 Hz, 1H), 6.46 (d, *J* = 8.66 Hz, 1H), 5.94 (dd, *J* = 10.18, 2.30 Hz, 1H), 3.83 (s, 3H), 3.17-3.01 (m, 1H), 2.99-2.90 (m, 2H), 2.50 (m, 1H), 2.34 (ddd, *J* = 16.83, 12.04, 4.87 Hz, 1H), 2.15-1.93 (m, 1H), 1.77 (ddt, *J* = 13.50, 9.16, 4.61 Hz, 1H). **^{13}C NMR** (75 MHz, $CDCl_3$, 21 °C): δ = 199.4, 162.2, 154.1, 142.3, 130.2, 128.9, 112.0, 110.2, 53.5, 40.5, 36.7, 35.2, 28.4. **IR** (film) υmax 3468, 2946, 2077, 1676, 1577, 1460, 1417, 1302, 1260, 1139, 1037, 1011, 821 cm-1;**HRMS (ESI) *m/e*:** Calcd for $(MH)^+$ **$C_{13}H_{14}BrNO_2$**: 297.0187. Found: 297.0322.

Tricyclic Enone (9)

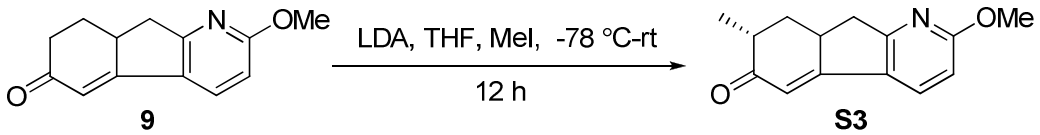


6 **9**

An oven-dried Schlenk flask was charged with enone **6** (6 g, 20.3 mmol, 1 equiv) in acetonitrile (90 mL). To this reaction mixture was added N,N-diisopropylethylamine (DIPEA) (10.5 mL, 60.9 mmol, 3 equiv) followed by triphenylphosphine (1.06 g, 4.06 mmol, 0.2 equiv) and $Pd(OAc)_2$ (788 mg, 2.03 mmol, 0.1 equiv). The flask was then sealed and heated at 80 ºC for 12 h. The reaction mixture was allowed to cool to rt and filtered through Celite. The solids were washed with EtOAc (3 x 10 mL), and the combined organic layers were concentrated under reduced pressure. The crude product was purified by flash chromatography (2:1 hexanes/EtOAc) to give 3.45 g (79% yield) of **9** as a yellow viscous oil. **R_f =** 0.41 (2:1 hexanes/EtOAc).

$C_{13}H_{13}NO_2$, MW: 215.25 g/mol. **^{1}H NMR** (600 MHz, $CDCl_3$, 21 °C): δ = 7.71 (d, *J* = 8.53 Hz, 1H), 6.67 (d, *J* = 8.52 Hz, 1H), 6.19 (d, *J* = 1.64 Hz, 1H), 3.99 (s, 3H), 3.32-3.14 (m, 2H), 2.75 (dd, *J* = 16.3, 5.77 Hz, 1H), 2.63 (d, *J* = 16.4 Hz, 1H), 2.43 (m, 2H), 1.90 (ddd, *J* = 26.20, 12.49, 4.16 Hz, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$, 21 °C): δ = 198.9, 167.6, 167.2, 166.8, 132.9, 125.2, 116.4, 110.5, 54.0, 40.4, 38.9, 38.2, 29.2. **IR** (film) υmax = 3384, 2942, 1648, 1586, 1481, 1408, 1342, 1310, 1240, 1195, 1102, 1021, 960, 849, 617 cm^{-1}; **HRMS (ESI) *m/e*:** Calcd for $(MH)^+$ **$C_{13}H_{13}NO_2$**: 216.0980. Found: 216.1027.

α-Methylated tricyclic enone (S3)

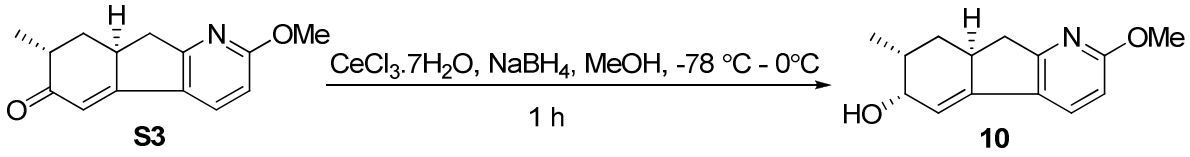


9 **S3**

To a stirred solution of diispropylamine (6.31 mL, 44.6 mmol, 3.2 equiv) in THF (60 mL) at 0 ºC was added *n*-butyllithium (2.5 M in hexanes, 16.7 mL, 41.7 mmol, 3 equiv) dropwise over 5 min. After 30 min, the solution was cooled to -78 ºC and a solution of enone **9** (3 g, 13.9 mmol, 1 equiv) in THF (40 mL) was added by cannula over 5 minutes. After stirring for another 30 min, MeI (13 mL, 208.5 mmol, 15 equiv) was added slowly via syringe. The reaction mixture was stirred for 6 h at -78 ºC then warmed to room temperature and stirred for an additional 3h at same temperature. The reaction mixture was quenched by the addition of saturated NH_4Cl solution. The resulting mixture was extracted with Et_2O (3 x 10 mL). The combined organic layers were dried over $MgSO_4$ and concentrated under reduced pressure. The crude product was purified by flash chromatography (2:1 hexanes/EtOAc) to give 2.97 g (93% yield) of **10** as a pale yellow solid. $\mathbf{R_f}$ **=** 0.48 (2:1 hexanes/EtOAc).

$C_{14}H_{15}NO_2$, MW: 229.27 g/mol **^{1}H NMR** (500 MHz, $CDCl_3$, 21 °C): δ = 7.70 (d, *J* = 8.53 Hz, 1H), 6.66 (d, *J* = 8.52 Hz, 1H), 6.12 (s, 1H), 3.98 (s, 3H), 3.44-3.28 (m, 1H), 3.22 (dd, *J* = 16.9, 8.08 Hz, 1H), 2.74 (dd, *J* = 16.9, 6.49 Hz, 1H), 2.68-2.57 (m, 1H), 2.18 (ddd, *J* = 12.8, 4.75, 1.64 Hz, 1H), 2.12-2.03 (m, 1H), 1.29 (d, *J* = 7.62 Hz, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$, 21 °C): δ = 202.1, 167.6, 167.1, 165.7, 132.8, 125.2, 115.6, 110.5, 54.0, 40.4, 39.0, 35.5, 35.5, 16.1. **IR** (film) υmax = 3384, 2942, 1648, 1586, 1481, 1408, 1342, 1310, 1240, 1195, 1102, 1021, 960, 849, 617 cm^{-1}; **HRMS (ESI) *m/e*:** Calcd for $(MH)^+$ **$C_{14}H_{15}NO_2$**: 230.1136. Found: 230.1183.

Allylic alcohol (10)

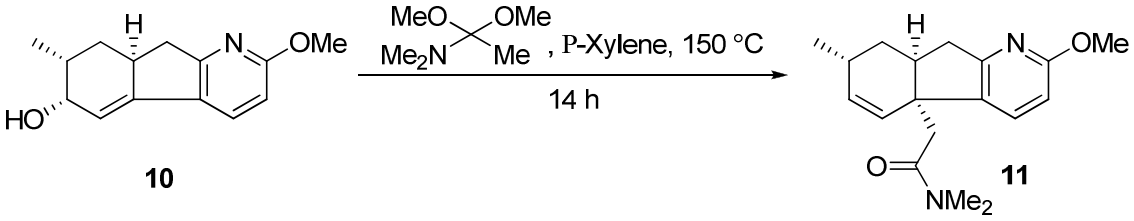


In a round-bottom flask, tricyclic enone **S3** (2.90 g, 12.64 mmol, 1 equiv) was dissolved in MeOH (75 mL). To this solution was added $CeCl_3$•$7H_2O$ (6.13 g, 16.44 mmol, 1.3 equiv). The reaction mixture was stirred at rt for 15 min and then was cooled to -78 C ºC. $NaBH_4$ (622 mg, 16.44 mmol, 1.3 equiv) was added to the reaction mixture in four portions (4 X 156 mg) over 15 mins. The reaction mixture was slowly allowed to warm to 0 ºC with continued stirring. At the completion of the reaction (TLC, 2 h), it was quenched with saturated aq. NH_4Cl (10 mL) and aq. $NaHCO_3$ (10 mL). After stirring vigorously for 30 mins, the solvent was removed under reduced pressure. Water (10 mL) was added to the crude reaction mixture and it was extracted with EtOAc (3 X 10 mL). The combined organic extracts were washed with saturated aq. NaCl (20 mL), dried over $MgSO_4$, and concentrated under reduced pressure. The crude product was

purified by flash chromatography (4:1 hexanes/EtOAc) to provide 2.89 g (99% yield) of Allylic alcohol **10** as a white gel. $\mathbf{R_f}$ = 0.62 (2:1 hexanes/EtOAc).

$C_{14}H_{17}NO_2$, MW: 231.3 g/mol. **^{1}H NMR** (300 MHz, $CDCl_3$, 21 °C): δ = 7.54 (d, J = 8.39 Hz, 1H), 6.55 (d, J = 8.38 Hz, 1H), 5.67 (s, 1H), 4.65-4.54 (m, 1H), 3.93 (s, 3H), 3.00 (m, 1H), 2.65-2.50 (m, 1H), 2.43-2.27 (m, 1H), 2.05 (td, J = 13.0, 4.21 Hz, 1H), 1.74 (ddd, J = 13.2, 11.1, 3.33 Hz, 1H), 1.66-1.50 (m, 1H), 1.08 (d, J = 6.02, 3H). **^{13}C NMR** (100 MHz, $CDCl_3$, 21 °C): δ = 164.8, 163.8, 143.7, 130.9, 127.1, 117.9, 108.8, 70.5, 53.6, 39.3, 35.1, 34.4, 32.8, 12.5. **IR (film)** υmax = 3373, 2913, 1624, 1587, 1474, 1406, 1343, 1302, 1247, 1231, 1093, 1066, 1031, 910, 825, 576 cm-1; **HRMS (ESI) m/z:** Calcd for (MH)+ **$C_{14}H_{17}NO_2$**: 232.1293. Found: 232.1336.

Amide (11)

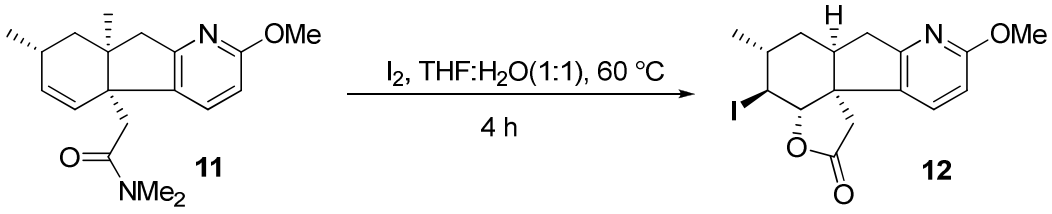


10 **11**

An oven-dried Schlenk flask was charged with a solution of alcohol **10** (2.5 g, 10.8 mmol, 1 equiv) in p-xylene followed by addition of *N*, *N*-dimethylacetamide dimethyl acetal (15.8 mL, 108 mmol, 10 equiv). The solution was sparged with N_2 and then sealed and heated at 150 ºC for 14 h. The reaction mixture was allowed to cool to rt and concentrated. The crude product was purified by flash chromatography (1:1 hexanes/EtOAc) to give 3.24 g (94% yield) of amide **11** as a pale yellow viscous oil. **Rf** = 0.40 (1:1 hexanes/EtOAc).

$C_{18}H_{24}N_2O_2$, MW: 300.39 g/mol. **^{1}H NMR** (600 MHz, $CDCl_3$, 21 °C): δ = 7.59 (d, *J* = 8.37 Hz, 1H), 6.50 (d, *J* = 8.36 Hz, 1H), 5.82 (dd, *J* = 10.10, 1.92 Hz, 1H), 5.60 (dd, *J* = 10.11, 3.10 Hz, 1H), 3.89 (s, 3H), 3.02 (m, 1H), 2.90 (s, 6H), 2.78-2.70 (m, 3H), 2.64 (d, *J* = 10.95, Hz, 1H), 2.34-2.25 (m, 1H), 1.80 (m, 1H), 1.47 (ddd, *J* = 13.73, 8.14, 3.94 Hz, 1H), 1.03 (d, *J* = 7.05 Hz, 1H). **^{13}C NMR** (125 MHz, $CDCl_3$, 21 °C): δ = 170.6, 164.0, 160.4, 134.8, 134.1, 132.3 130.7, 108.0, 53.4, 47.4, 42.0, 40.4, 38.2, 37.1, 35.5, 31.7, 26.2, 21.2. **IR** (film) υmax = 2868, 2360, 1718, 1637, 1593, 1472, 1418, 1300, 1260, 1143, 1029, 826, 775, 744, 624 cm^{-1}; **HRMS (ESI) *m/z*:** Calcd for $(MH)^+$ **$C_{18}H_{24}N_2O_2$**: 301.1871. Found: 301.1922.

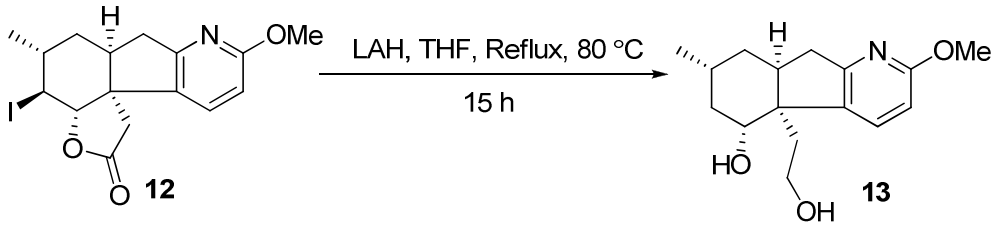
Iodolactone (12)



A solution of amide **11** (3 g, 9.99 mmol, 1 equiv), in 50:50 mixture of THF:Water (50mL:50 mL) was added iodine (7.6 g, 29.96 mmol, 3 equiv) and the reaction mixture was heated at 60 ºC for 4h and cooled to room temperature. This was followed by reductive work up with saturated aqueous sodium bisulphate solution. The reaction mixture was extracted with Et_2O (3 X 20 mL). The combined organic extracts were washed with saturated aq. NaCl (30 mL), dried over $MgSO_4$, and concentrated under reduced pressure. The crude product was purified by flash chromatography (1:1 hexanes/EtOAc) to provide 3.11 g (78% yield) of **12** as a white solid. $\mathbf{R_f}$ **=** 0.66 (1:1 hexanes/EtOAc).

$C_{16}H_{18}INO_3$, MW: 399.22 g/mol. M.P. 222-225 ºC; **^{1}H NMR** (400 MHz, $CDCl_3$, 21 °C): δ = 7.34 (d, *J* = 8.46 Hz, 1H), 6.58 (d, *J* = 8.46 Hz, 1H), 4.55 (d, *J* = 10.06 Hz, 1H), 3.92 (s, 3H), 3.67 (dd, *J* = 11.13, 10.24 Hz, 1H), 2.95 (m, 3H), 2.81-2.69 (m, 1H), 2.49 (d, *J* = 17.55 Hz, 1H), 2.18-1.95 (m, 2H), 1.58 (ddd, *J* = 14.95, 11.34, 5.76 Hz, 1H), 1.27 (d, *J* = 6.61 Hz, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$, 21 °C): δ = 174.1, 165.1, 159.4, 132.9, 132.5, 109.3, 91.3, 53.7, 51.6, 40.1, 39.4, 37.3, 37.0, 33.5, 32.3, 24.1. **IR** (film) υmax = 2922, 1785, 1592, 1475, 1453, 1421, 1303, 1278, 1239, 1135, 1083, 1026, 982, 876, 822, 735, 632, 588, 552 cm^{-1}; **HRMS (ESI)** ***m/z*****:** Calcd for $(MH)^+$ **$C_{16}H_{18}INO_3$**: 400.0365. Found: 400.0413.

Diol 13



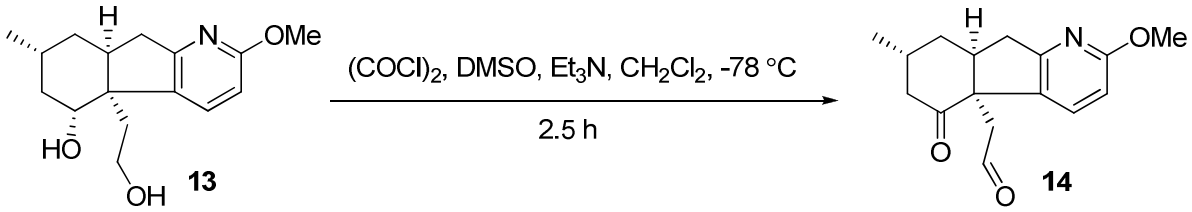
To a suspension of LAH (1.14 g, 30.1 mmol, 4 equiv) in THF (100 mL) at 0 °C was added a solution of compound **12** (3 g, 7.51 mmol, 1 equiv) in THF (30 mL). The reaction mixture was allowed to warm to room temperature, fitted with a water condenser, heated to 80 ºC and held at reflux for 15h.

The reaction mixture was cooled to rt and then to 0 ºC and quenched with EtOAc , basified with 4N NaOH solution and extracted with EtOAc (3 X 25 mL). The combined organic extracts were washed with saturated aq. NaCl (30 mL), dried over $MgSO_4$, and concentrated under reduced pressure. The crude product was

purified by flash chromatography (1:1 hexanes/EtOAc) to provide 1.50 g (72% yield) of **13** as a white solid. **R_f =** 0.29 (1:1 hexanes/EtOAc).

$C_{16}H_{23}NO_3$, MW: 277.36 g/mol. M.P. 143-145 ºC; **^{1}H NMR** (300 MHz, $CDCl_3$, 21 °C): δ = 7.50 (*d*, J = 8.1, 1 H), 6.53 (*d*, J = 8.4, 1 H), 3.91 (*s*, 3 H), 3.68 (*m*, 2 H), 3.43 (*dd*, J = 12.0, J = 3.9, 1 H), 2.79 (*m*, 2 H), 2.58 (*m*, 1 H), 2.32 (*m*, 1 H), 1.94 (*m*, 2 H), 1.85 – 1.63 (*m*, 3 H), 1.39 – 1.23 (*m*, 3 H), 1.08 (*d*, J = 6.3, 3 H). **^{13}C NMR** (100 MHz, $CDCl_3$, 21 °C): δ = 163.9, 160.8, 135.2, 134.5, 107.5, 74.7, 59.8, 53.5, 50.1, 43.3, 38.3, 36.7, 32.6, 30.2, 27.6, 22.0. **IR** (film) υmax = 3583, 3315, 2948, 2922, 1590, 1469, 1415, 1300, 1234, 1194, 1083, 1029, 823, 735, 625, 580 cm^{-1};**HRMS (ESI) *m/z*:** Calcd for $(MH)^+$ **$C_{16}H_{23}NO_3$**: 278.1711. Found: 278.1759.

Ketoaldehyde (14)

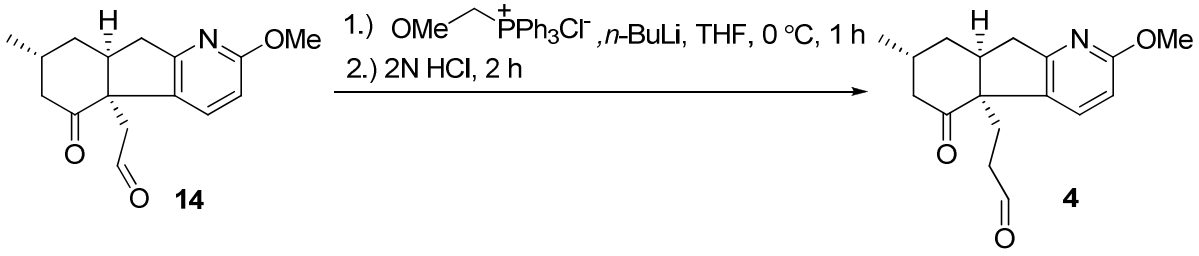


A flame-dried round-bottom flask was charged with DMSO (2.56 mL, 36.0 mmol, 10 equiv), CH_2Cl_2 (25 mL) and cooled to -78 ºC. In a separate flask, oxalyl chloride (1.03 mL, 10.8 mmol, 3 equiv) was dissolved in CH_2Cl_2 (10 mL). The oxalyl chloride solution was added dropwise to the DMSO/ CH_2Cl_2 solution at -78 ºC *via* syringe over 15 mins. After stirring for 30 mins at -78 ºC, diol **13** (1.0 g, 3.6 mmol, 1 equiv) in CH_2Cl_2 (30 mL) was added dropwise over 30 mins and the reaction mixture was stirred at -78 ºC for an additional 2.5 h. Triethylamine (5.02 mL, 36.0 mmol, 10 equiv) was added dropwise and then the reaction mixture was stirred at that temperature for an hour and then allowed to slowly warm to rt. After stirring at rt for 1 h, the reaction mixture was poured into a separatory funnel and washed with water (30 mL). The aqueous layer was extracted with CH_2Cl_2 (2 X 25 mL). The combined organic extracts were dried over $MgSO_4$ and concentrated under vacuum. The crude product was purified by flash chromatography (2:1 hexanes/EtOAc) to afford 983 mg (quant.) of **14** as a light yellow gel. **R_f =** 0.45 (1:1 hexanes/EtOAc).

$C_{16}H_{19}NO_3$, MW: 273.33 g/mol. **^{1}H NMR** (600 MHz, $CDCl_3$, 21 °C): δ = 9.6 (*s*, 1 H), 7.22 (d, J = 8.4 Hz, 1 H), 6.5 (*d*, J = 8.4 Hz, 1 H), 3.9 (*s*, 3 H), 3.31 (*dd*, J = 17.4, J = 8.4 Hz, 1 H), 3.10 (*d*, J = 1.2 Hz, 1 H), 2.82 (*m*, 1 H), 2.71 (*dd,* J = 17.4, J = 3.09 Hz, 1 H), 2.58 (*d,* J = 16.2 Hz, 1 H), 2.40 (*dd*, J = 17.2, J = 4.4 Hz, 1 H), 2.10 (*m*, 1 H), 2.02 (*m*, 1 H), 1.81 (*m*, 1H), 1.69 (*m*, 1H), 0.93 (*d*, J = 6.6 Hz, 3 H). **^{13}C NMR** (100 MHz, $CDCl_3$, 21 °C): δ = 211.1, 200.1, 165.1, 161.9, 134.5, 128.4, 109.1, 58.5, 53.6, 51.2, 45.5, 41.5, 40.2, 36.9,

26.7, 20.8. **IR** (film) υmax = 3399, 2949, 1700, 1594, 1473, 1420, 1306, 1264, 1188, 1102, 1029, 938, 825, 736, 703 cm^{-1}; **HRMS (ESI) *m/z*:** Calcd for $(MH)^+$ $\mathbf{C_{16}H_{19}NO_3}$: 274.1398. Found: 274.1444.

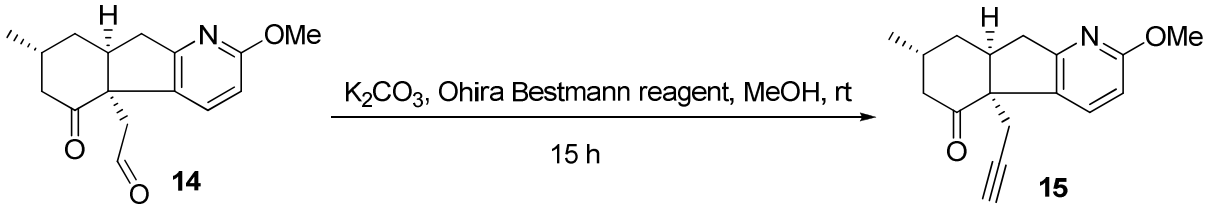
Ketoaldehyde (4)



A flame-dried round-bottom flask was charged with the wittig reagent (163 mg, 0.47 mmol, 1.3 equiv) and THF (20 mL) and cooled to 0 ºC followed by addition of *n*-butyllithium (188 µl, 0.47 mmol, 1.3 equiv) dropwise. The resulting reddish brown solution was stirred at 0 ºC for 30 min and then a solution of ketoaldehyde **14** (100 mg, 0.36 mmol, 1.0 equiv) in THF (10 mL) was added dropwise via syringe to the reaction vessel. The reaction mixture was stirred for another 1h at 0 ºC and quenched with 2N HCl (20 mL) at 0 ºC. Stirring was continued for 2h and then the reaction mixture was warmed to room temperature and neutralized by the addition of saturated $NaHCO_3$ (40 mL). The resulting mixture was extracted with Et_2O (3 x 10 mL). The combined organic layers were dried over $MgSO_4$ and concentrated under reduced pressure. The crude product was purified by flash chromatography (2:1 hexanes/EtOAc) to give ketoaldehyde (**4**) 62 mg (60% yield) as a light yellow viscous oil. $\mathbf{R_f}$ = 0.47 (2:1 hexanes/EtOAc).

$C_{17}H_{21}NO_3$, MW: 287.35 g/mol. **^{1}H NMR** (600 MHz, $CDCl_3$, 21 °C): δ = 9.71 (*s*, 1 H), 7.32 (*d*, J = 8.4, 1 H), 6.55 (*d*, J = 8.4, 1 H), 3.92 (*s*, 3 H), 3.13 (*q*, J = 10.8, 1H), 2.74 – 2.69 (*m*, 2 H), 2.43-2.36 (*m*, 2H), 2.18 (*m*, 1 H), 2.11-2.06 (*m*, 2 H), 2.03-1.99 (*m*, 1H), 1.79 (*m*, 1 H), 1.68 (*m*, 1 H), 1.01 (*d*, J = 6.6, 3 H). **^{13}C NMR** (150 MHz, $CDCl_3$, 21 °C): δ = 212.9, 200.9, 164.8, 161.1, 135.3, 128.8, 108.6, 59.8, 53.4, 46.4, 41.5, 39.7, 38.9, 35.4, 28.0, 27.3, 21.2. **HRMS (ESI) *m/e*:** Calcd for $(MH)^+$ $\mathbf{C_{17}H_{21}NO_3}$: 288. 1555 Found: 288.1479.

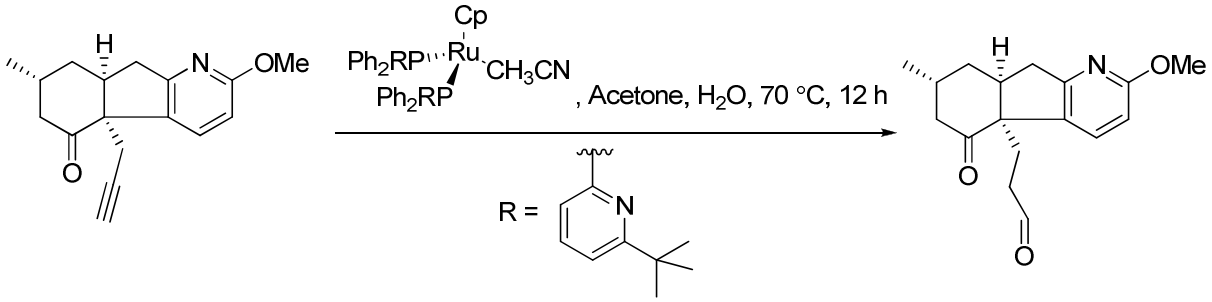
Ketoalkyne 15



A flame-dried round-bottom flask was charged with a solution of ketoaldehyde **14** (100 mg, 0.36 mmol, 1.0 equiv) in MeOH (5 mL) followed by addition of K_2CO_3 (101 mg, 0.73 mmol, 2 equiv) and Ohira-Bestmann reagent (90 mg, 0.47 mmol, 1.3 equiv) at room temperature respectively. The reaction mixture was stirred for 15 h at rt and then quenched with the addition of saturated $NaHCO_3$ (10 mL). The resulting mixture was extracted with Et_2O (2 x 10 mL). The combined organic layers were dried over $MgSO_4$ and concentrated under reduced pressure. The crude product was purified by flash chromatography (4:1 hexanes/EtOAc) to give ketoalkyne (**15**) 97 mg (86% yield) as a light yellow viscous oil. $\mathbf{R_f}$ **=** 0.81 (2:1 hexanes/EtOAc).

$C_{17}H_{19}NO_2$, MW: 269.34 g/mol **^{1}H NMR** (500 MHz, $CDCl_3$, 21 °C): δ = 7.36 (*d*, J = 8.5 Hz, 1 H), 6.52 (d, J = 8.5 Hz, 1 H), 3.89 (*s*, 3H), 3.22 (*dd*, J = 16.5, J = 8.0 Hz, 1 H), 3.04 (*m*, 1 H), 2.79 (*dd*, J = 16.5, J = 2.5 Hz, 1H), 2.71 (*dd,* J = 17.0, J = 5.5 Hz, 1 H), 2.45 (*dd,* J = 17.0, J = 5.5 Hz, 1 H), 2.38 (d*d,* J = 15.0, J = 3.5 Hz, 1H), 2.11 (*m*, 2H), 1.95 (*t*, J = 2.5 Hz, 1H), 1.76 (*m*, 2 H), 1.22 (*d*, J = 7.0 Hz, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$, 21 °C): δ = 211.7, 165.4, 161.7, 135.5, 129.4, 109.2, 81.3, 71.2, 60.2, 54.0, 46.9, 42.3, 39.7, 36.2, 27.8, 27.7, 21.5. **IR (film): IR** (film) υmax = 3390, 2089, 1643, 1473 cm^{-1}; **HRMS (ESI) *m/e*:** Calcd for $(MH)^+$ **$C_{17}H_{19}NO_2$**: 270.1149. Found: 270. 1241.

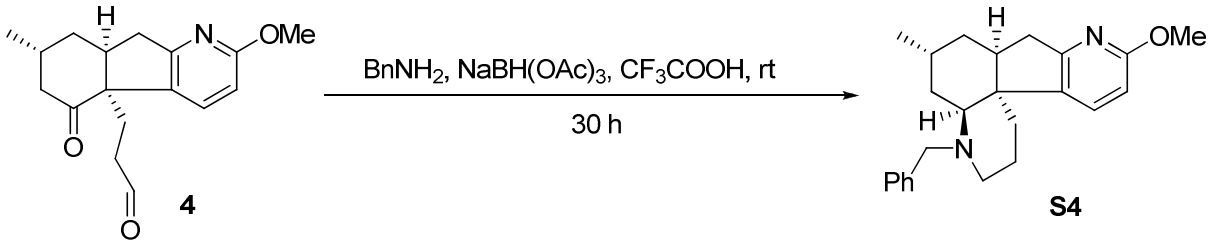
Alternative route to Ketoaldehyde (4)[3]



The Ru-catalyst, which was weighed in glove box was added to a mixture of ketoalkyne (50 mg, 0.19 mmol, 1.0 equiv) in degassed acetone (400 µL) and water (18 µL, 0.95 mmol, 5.0 equiv). The reaction mixture was heated to 70 ºC and stirred for 12h or until complete conversion of the substrate was observed by TLC. A solution of ammonium chloride is added to the reaction mixture and extracted with Et_2O (2 x 5 mL). The combined organic layers were washed with $NaHCO_3$ and dried over $MgSO_4$ and concentrated under reduced pressure. The crude product was purified by flash chromatography (2:1 hexanes/EtOAc) to give ketoaldehyde (**4**) 53.5 mg (98% yield) as a light yellow viscous oil. $\mathbf{R_f}$ **=** 0.47 (2:1 hexanes/EtOAc).

[3] Grotjahn, D. B.; Daniel A. L. *J. Am. Chem. Soc*. **2004**, *126*, 12232.

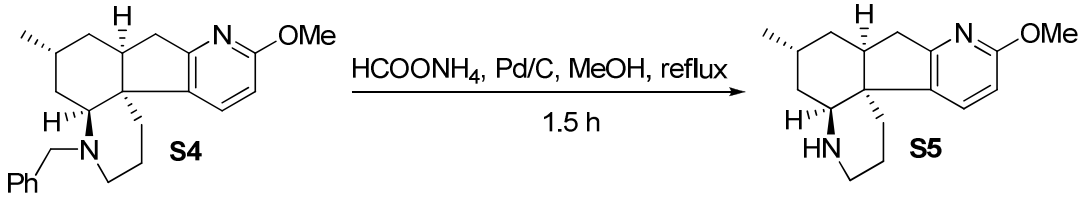
Tetracyclic amine S4



A flame-dried round-bottom flask was charged with ketoaldehyde **4** (50 mg, 0.17 mmol, 1.0 equiv) in THF (3 mL), followed by addition of benzylamine (23 µL, 0.21 mmol, 1.2 equiv) , TFA (7 µL, 0.087 mmol, 0.5 equiv), and $NaBH(OAc)_3$ (111 mg, 0.52 mmol, 3.0 equiv) respectively. The reaction mixture was stirred at room temperature for 30 h . The reaction mixture was then basified with 2N NaOH and extracted with Et_2O. The combined organic layers were dried over anhydrous K_2CO_3 and concentrated under vacuum. The crude product was purified by flash chromatography (2:1 hexanes/EtOAc) to give tetracyclic amine (**S4**) 61.5 mg (79% yield) as a light yellow viscous oil. $\mathbf{R_f}$ **=** 0.82 (2:1 hexanes/EtOAc).

$C_{24}H_{30}N_2O$, MW: 362.51 g/mol **^{1}H NMR** (600 MHz, $CDCl_3$, 21 °C): δ = 8.39 (d, *J* = 8.30 Hz, 1H), 7.40-7.21 (m, 5H), 6.53 (d, *J* = 8.29 Hz, 1H), 4.21 (d, *J* = 12.99 Hz, 1H), 3.93 (s, 3H), 3.35 (dd, *J* = 16.69, 7.38 Hz, 1H), 2.93 (d, *J* = 11.3 Hz, 1H), 2.83 (d, *J* = 12.9 Hz, 1H), 2.56 (dd, *J* = 11.6, 5.54 Hz, 1H), 2.41 (d, *J* = 16.7 Hz, 1H), 2.27 (m, 1H), 1.89 (m, 1H), 1.67-1.52 (m, 4H), 1.46-1.35 (m, 3H), 1.26 (m, 3H), 0.92 (d, *J* = 6.54 Hz, 3H). **^{13}C NMR** (150 MHz, $CDCl_3$, 21 °C): δ = 163.7, 162.6, 140.6, 138.6, 133.7, 128.8, 128.2, 126.6, 106.1, 62.8, 58.0, 54.3, 53.3, 49.2, 42.6, 40.3, 38.3, 36.2, 32.9, 25.3, 21.7, 21.5. **IR** (film) υmax = 2926, 2849, 2780, 1590, 1573, 1469, 1437, 1412, 1398, 1333, 1303, 1274, 1254, 1222, 1061, 1033, 931, 858, 827, 767, 717, 648 cm^{-1};. **HRMS (ESI) *m/z*:** Calcd for $(MH)^+$ **$C_{24}H_{30}N_2O$**: 363.2392. Found: 363.2448.

Tetracyclic amine S5

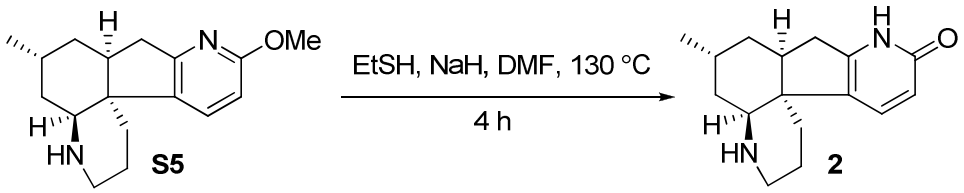


A flame-dried round-bottom flask was charged with tetracyclic amine **S4** (30 mg, 0.083 mmol, 1.0 equiv) in MeOH (5 mL) followed by addition of ammonium formate (52 mg, 0.83 mmol, 10.0 equiv) and 20 mol% of 10% Pd/C. The reaction mixture was sparged with N_2 and then heated to 65 ºC and held at reflux for 1.5h. The reaction mixture was cooled to room temperature and filtered through a celite pad. The filterate was concentrated , washed with 2N NaOH and then again extracted with DCM (3 x 1 mL). The combined organic layers were dried over anhydrous K_2CO_3 and concentrated under reduced pressure. The

crude product was purified by flash chromatography (1:4) MeOH/DCM to give tetracyclic amine (**S5**) 22.5 mg (quant.) as a pale white gel. $\mathbf{R_f}$ **=** 0.21 (1:4 MeOH/DCM).

$C_{17}H_{24}N_2O$, MW: 272.38 g/mol. **^{1}H NMR** (500 MHz, $CDCl_3$, 21 °C): δ = 8.25 (*d*, J = 8.0, 1 H), 6.47 (*d*, J = 8.0, 1 H), 3.91 (*s*, 3 H), 3.23 (*dd*, J = 16, J = 6.5, 1H), 3.15-3.18 (*m*, 1H), 2.93 (*dd*, J = 12.5, J = 4.5, 1H), 2.80 (*m*, 1H), 2.29 (*d*, J=16.5, 1H), 2.17 (*m*, 1H), 1.67-1.76 (*m*, 2H), 1.39-1.59 (*m*, 6H), 1.20 (*m*, 2H), 0.99 (*d*, J = 7.5, 3H). **^{13}C NMR** (150 MHz, $CDCl_3$, 21 °C): δ = 163.7, 162.9, 138.4, 132.5, 106.2, 57.1, 53.4, 49.3, 47.6, 41.3, 39.2, 37.1, 35.8, 34.5, 26.3, 22.3, 19.9 **IR** (film) υmax = 2926, 2849, 2780, 1590, 1573, 1469, 1437, 1412, 1398, 1333, 1303, 1274, 1254, 1222, 1061, 1033, 931, 858, 827, 767, 717, 648 cm^{-1}; **HRMS (ESI) *m/z*:** Calcd for $(MH)^+$ **$C_{17}H_{24}N_2O$**: 273.1922. Found: 273.1931.

Lycoposerramine R (2)[4]

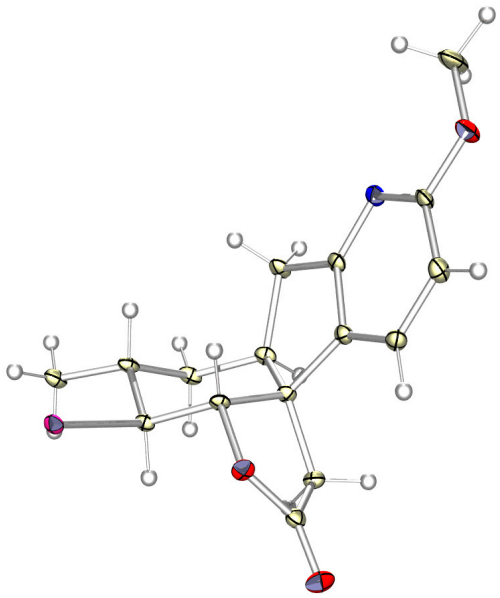


An oven-dried Schlenk tube was charged with tetracyclic amine **S5** (10.0 mg, 0.037 mmol, 1 equiv) in DMF (400 µL) and cooled to 0 ºC. To this reaction mixture was added EtSH (55 µL, 0.74 mmol, 20 equiv) followed by addition of NaH (60 % dispersion on mineral oil) (15 mg, 0.37 mmol, 10 equiv). The Schlenk tube was then sealed and heated at 120 ºC for 5 h. The reaction mixture was allowed to cool to rt, then water (400 µL) was added and the mixture was extracted with CH_2Cl_2 (3 X 2 mL). The combined organic extracts were dried over K_2CO_3 and concentrated under reduced pressure to afford 7.3 mg of **2** (76% yield) as a yellow gel. $\mathbf{R_f}$ **=** 0.11 (1:4 MeOH/DCM).

$C_{16}H_{22}N_2O$, MW: 258.36 g/mol. **^{1}H NMR** (600 MHz, $CDCl_3$, 21 °C): δ = 8.34 (d, *J* = 9.1 Hz, 1H), 6.34 (d, *J* = 9.1 Hz, 1H), 3.21 (dd, *J* = 16.8, 6.8 Hz, 2H), 2.95 (br, 1H), 2.80 (t, *J* = 10.8 Hz, 1H), 2.34 (d, *J* = 17.0 Hz, 1H), 2.21 (dd, *J* = 12.6, 6.1 Hz, 1H), 1.78 (m, 1H), 1.68-1.70 (*m*, 1 H), 1.62 (*m*, 1H), 1.54 (*m*, 1H), 1.45-1.52 (*m*, 2H), 1.42 (*m*, 1H), 1.23 (*m*, 2 H), 0.96 (*d*, J = 7.2, 3H). **^{13}C NMR** (150 MHz, $CDCl_3$, 21 °C): δ = 165.7, 150.3, 143.0, 124.2, 115.1, 57.0, 49.3, 47.6, 42.0, 37.9, 36.1, 36.0, 34.4, 25.5, 22.7, 20.5. **IR** (film) υmax = 3583, 3566, 2924, 2853, 2092, 1658, 1643, 1531, 1135 cm^{-1}; **HRMS (ESI) *m/z*:** Calcd for $(MH)^+$ **$C_{16}H_{22}N_2O$**: 259.1766. Found: 259.1806.

[4] Isolation: Katakawa, K.; Kogure, N.; Kitajima, M.; Takayama, H. *Helv. Chim. Acta* **2009**, *92*, 445.

Crystal structure of iodolactone 12



A colorless prism 0.12 x 0.10 x 0.10 mm in size was mounted on a Cryoloop with Paratone oil. Data were collected in a nitrogen gas stream at 100(2) K using phi and omega scans. Crystal-to-detector distance was 60 mm and exposure time was 5 seconds per frame using a scan width of 1.0°. Data collection was 100.0% complete to 67.00° in □. A total of 19318 reflections were collected covering the indices, -8<=*h*<=11, -8<=*k*<=9, -24<=*l*<=24. 2781 reflections were found to be symmetry independent, with an R_{int} of 0.0247. Indexing and unit cell refinement indicated a primitive, monoclinic lattice. The space group was found to be P2(1)/c (No. 14). The data were integrated using the Bruker SAINT software program and scaled using the SADABS software program. Solution by direct methods (SIR-2004) produced a complete heavy-atom phasing model consistent with the proposed structure. All non-hydrogen atoms were refined anisotropically by full-matrix least-squares (SHELXL-97). All hydrogen atoms were placed using a riding model. Their positions were constrained relative to their parent atom using the appropriate HFIX command in SHELXL-97.

Table 1. Crystal data and structure refinement for sarpong Iodolactone (12).

X-ray ID	sarpong12
Sample/notebook ID	VM-iodolactone
Empirical formula	$C_{16}H_{18}INO_3$
Formula weight	399.21
Temperature	100(2) K

Wavelength	1.54178 Å	
Crystal system	Monoclinic	
Space group	P2(1)/c	
Unit cell dimensions	a = 9.6608(9) Å	α= 90°.
	b = 7.7675(7) Å	β= 91.435(3)°.
	c = 20.3906(19) Å	Y = 90°.
Volume	1529.6(2) $Å^3$	
Z	4	
Density (calculated)	1.734 Mg/m^3	
Absorption coefficient	16.536 mm^{-1}	
F(000)	792	
Crystal size	0.12 x 0.10 x 0.10 mm^3	
Crystal color/habit	colorless prism	
Theta range for data collection	4.34 to 68.18°.	
Index ranges	-8<=h<=11, -8<=k<=9, -24<=l<=24	
Reflections collected	19318	
Independent reflections	2781 [R(int) = 0.0247]	
Completeness to theta = 67.00°	100.0 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	0.2886 and 0.2416	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	2781 / 0 / 192	
Goodness-of-fit on F^2	1.116	
Final R indices [I>2sigma(I)]	R1 = 0.0196, wR2 = 0.0509	
R indices (all data)	R1 = 0.0199, wR2 = 0.0510	
Largest diff. peak and hole	0.865 and -0.547 $e.Å^{-3}$	

Comparison of ^{1}H NMR Data for Isolated Lycoposerramine R by Takayama *et al.* and Synthetic Lycoposerramine R by Our Group.[4]

Takayama (Isolation)
(400 MHz, $CDCl_3$)

δ (ppm)	int.	mult.	*J* (Hz)
8.33	1H	d	9.2
6.34	1H	d	9.2
3.17-3.23	2H	m	-
2.92	1H	dd	12.1, 4.8
2.80	1H	ddd	11.6, 3.0
2.33	1H	d	17.0
2.19	1H	ddd	6.9,6.9
1.72-1.79	1H	m	-
1.66-1.69	1H	m	-
1.47-1.55	1H	m	-
1.42-1.50	1H	m	-
1.41-1.59	2H	m	-
1.39-1.50	1H	m	-
1.20-1.25	2H	m	-
0.96	3H	d	6.9

Sarpong (Synthetic)
(600 MHz, $CDCl_3$)

δ (ppm)	int.	mult.	*J* (Hz)
8.34	1H	d	9.1
6.34	1H	d	9.1
3.21	2H	dd	16.8, 6.8
2.95	1H	br	-
2.80	1H	t	10.8
2.34	1H	d	17.0
2.21	1H	dd	12.6, 6.1
1.78	1H	m	-
1.68-1.70	1H	m	-
1.62	1H	m	-
1.54	1H	m	-
1.45-1.52	2H	m	-
1.42	1H	m	-
1.23	2H	m	-
0.96	3H	d	7.2

Comparison of ^{13}C NMR Data for Isolated Lycoposerramine R by Takayama *et al.* and Synthetic Lycoposerramine R by Our Group.[4]

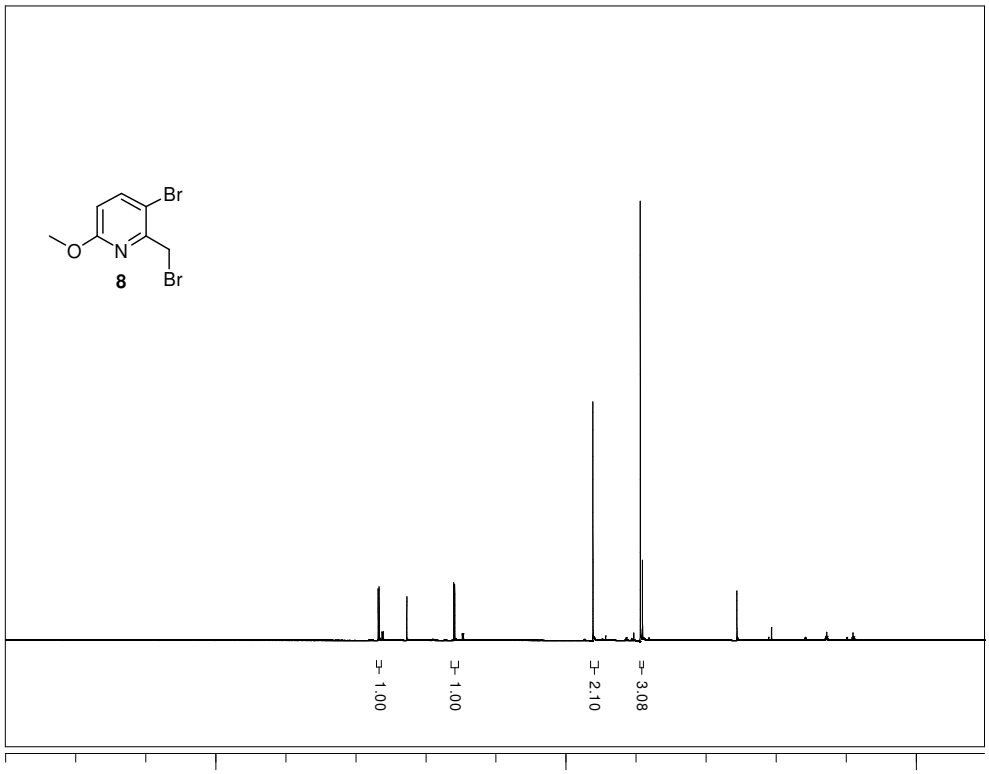
Takayama (Isolation)
(100 MHz, $CDCl_3$)

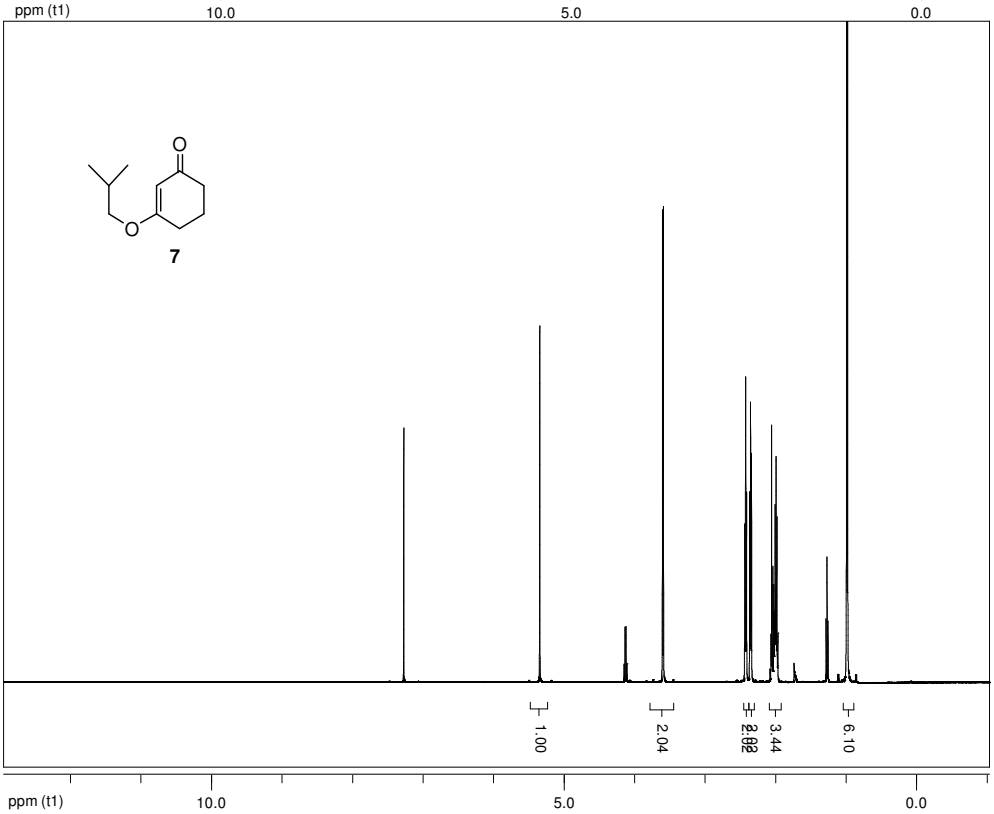
δ (ppm)
165.8
150.4
143.3
124.5
115.0
57.1
49.4
47.8
42.0
38.1
36.2
36.0
34.6
25.6
22.7
20.6

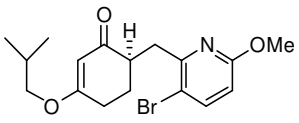
Sarpong (Synthetic)
(150 MHz, $CDCl_3$)

δ (ppm)
165.7
150.3
143.0
124.2
115.1
57.0
49.3
47.6
42.0
37.9
36.1
36.0
34.4
25.5
22.7
20.5

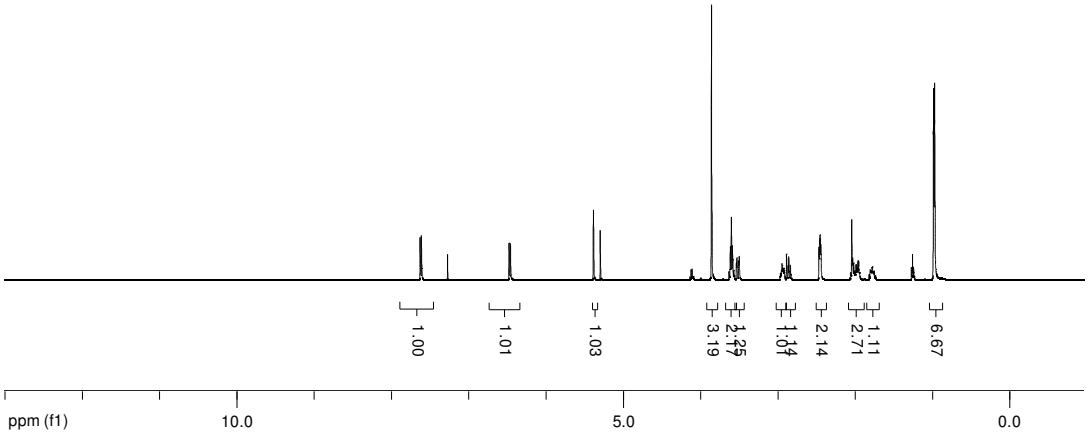
^{1}H and ^{13}C NMR spectra of all the compounds:

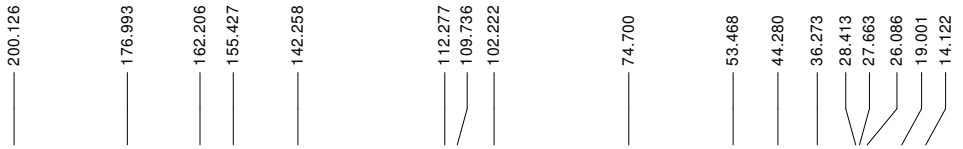


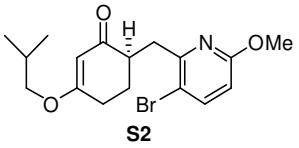



O
H
N
OMe
Br
O

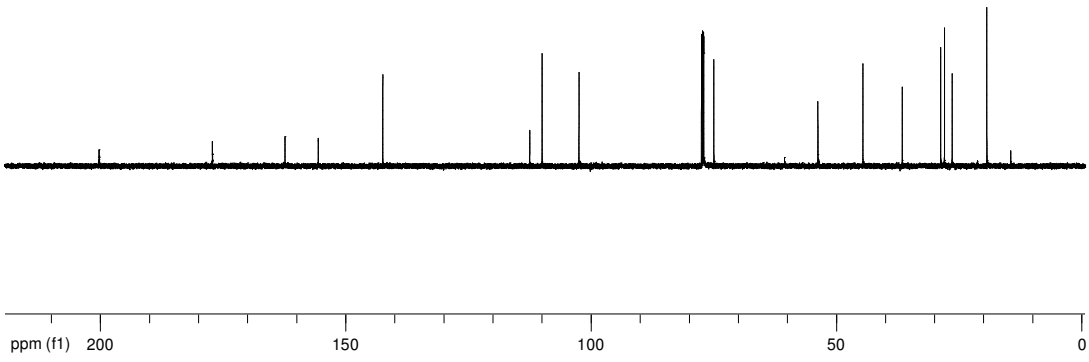
S2

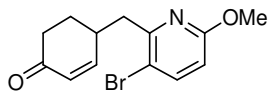

1.00
1.01
1.03
3.19
2.14
2.71
1.11
9.67
ppm (f1)
10.0
5.0
0.0


200.126
176.993
162.206
155.427
142.258
112.277
109.736
102.222
74.700
53.468
44.280
36.273
28.413
27.663
26.086
19.001
14.122


O
H
N
OMe
Br
O

S2

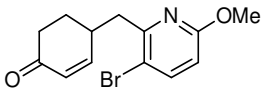

ppm (f1)
200
150
100
50
0


N
OMe
O
Br

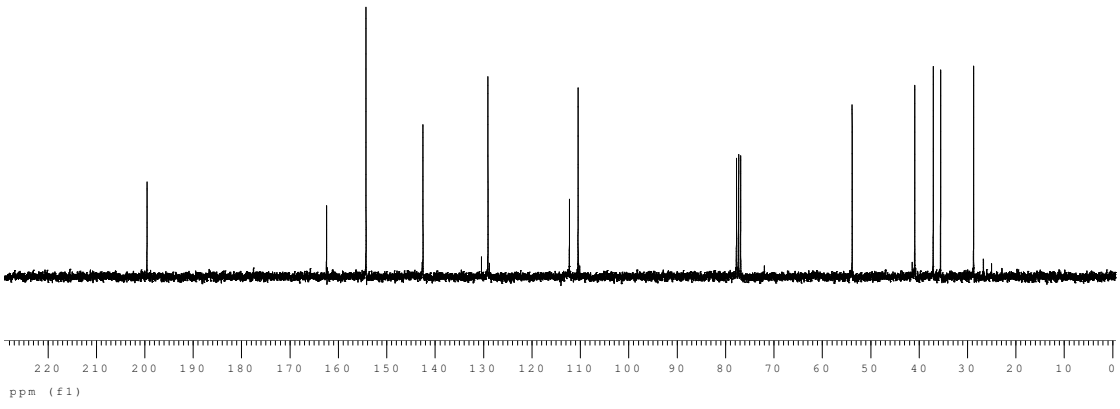
6

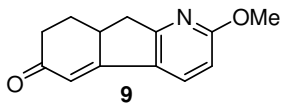
1.00
0.99
1.01
0.96
3.25
1.75
1.06
0.98
1.01
1.33
1.11
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (f1)


199.406
162.249
154.089
142.310
130.204
128.861
112.015
110.203
53.503
40.547
36.726
35.205
28.374


N
OMe
O
Br

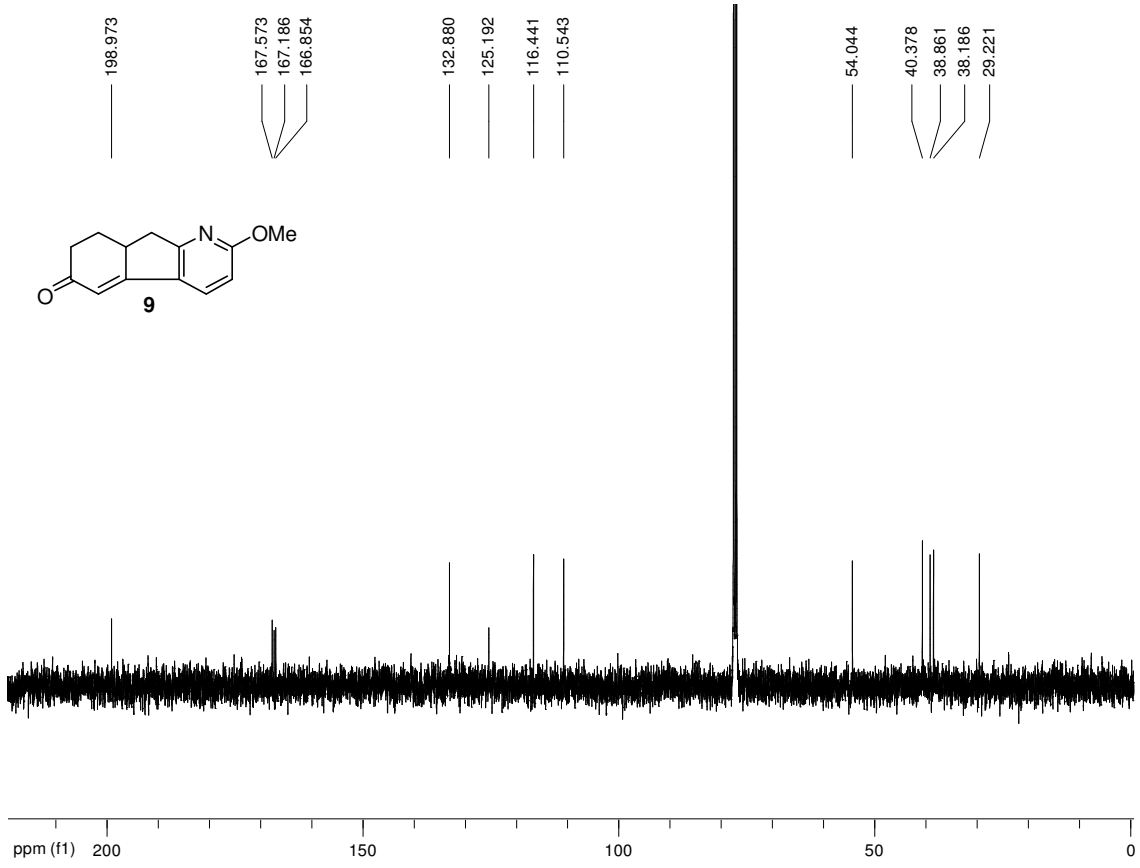
6


220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm (f1)

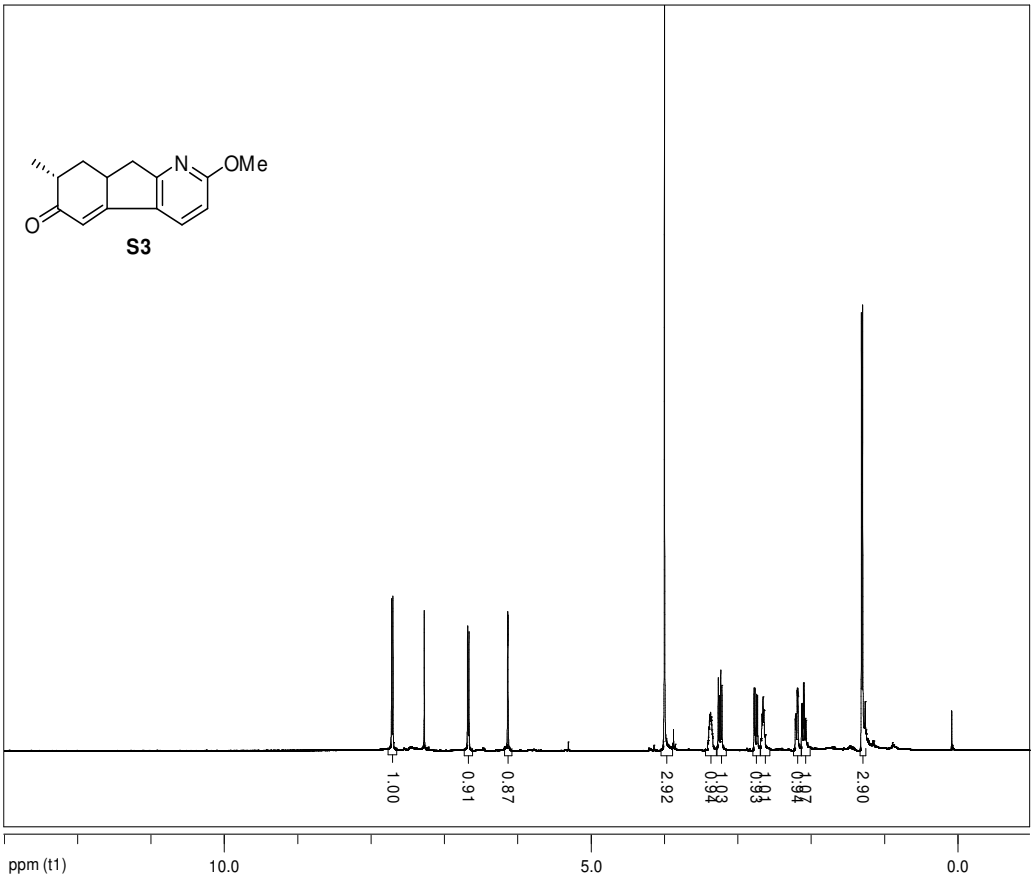

N
OMe
O

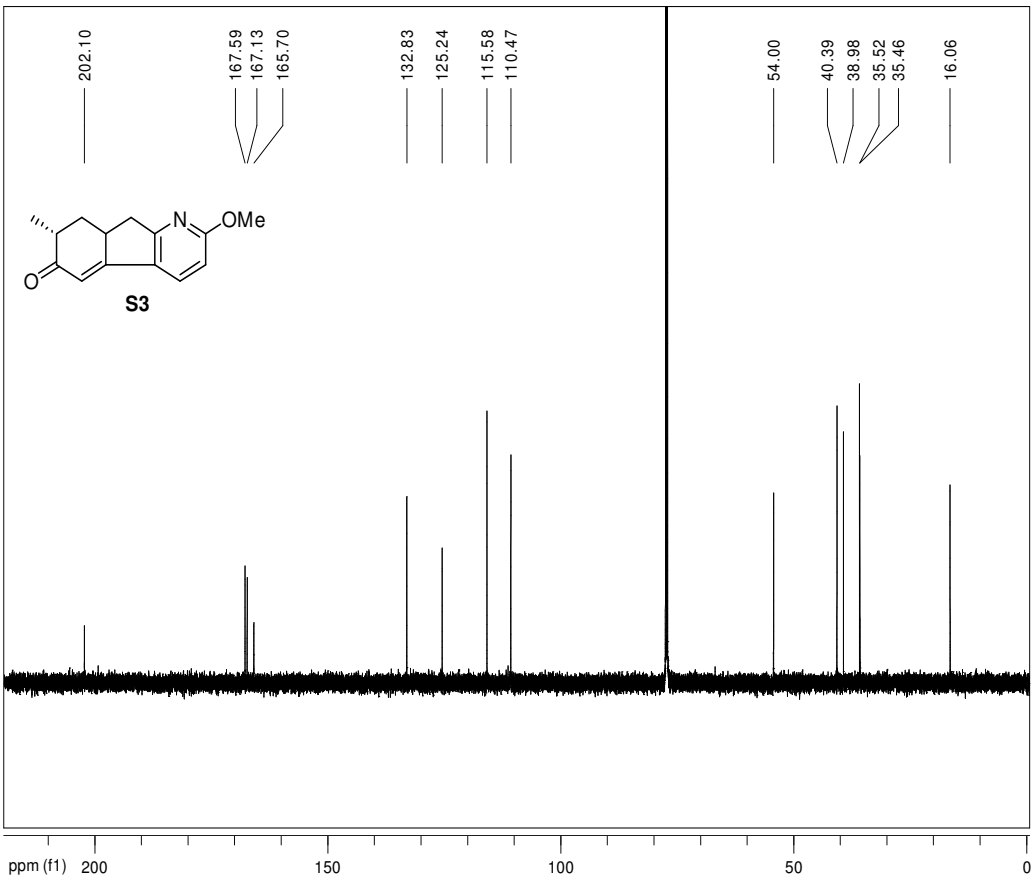
9

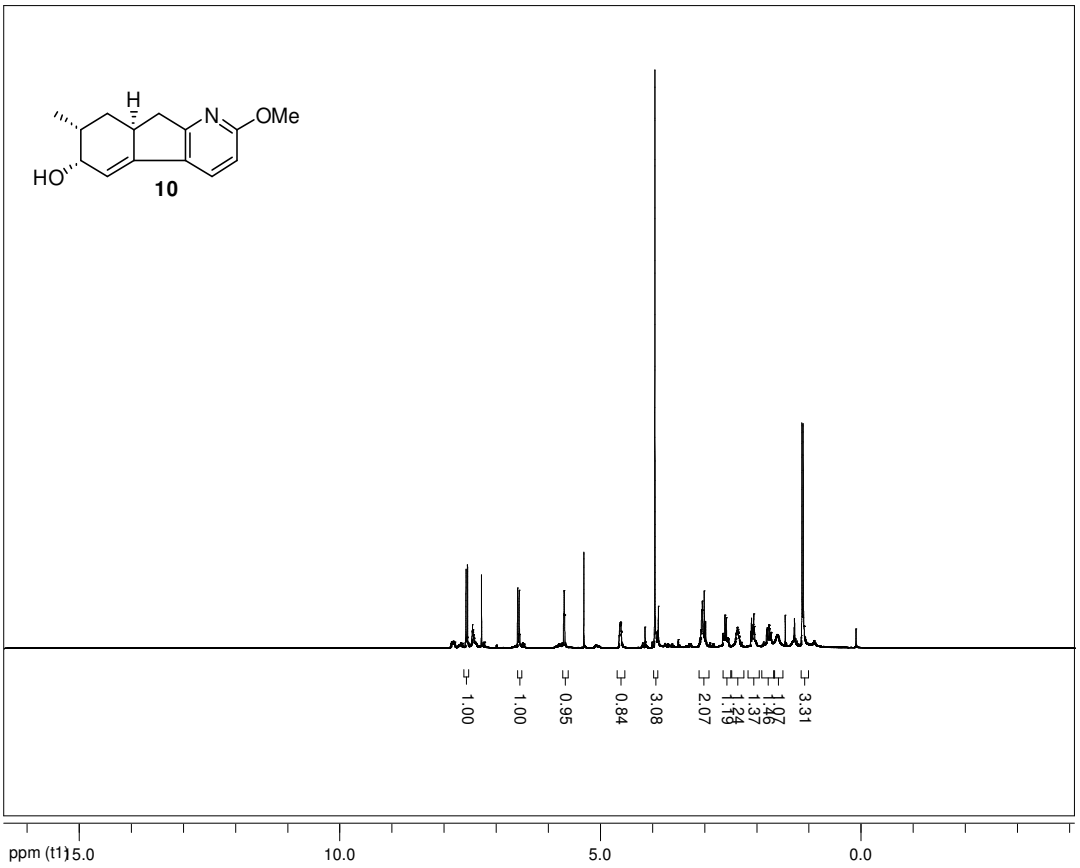
1.00
0.94
0.90
3.15
2.12
1.08
1.10
2.14
0.18
1.13
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (f1)

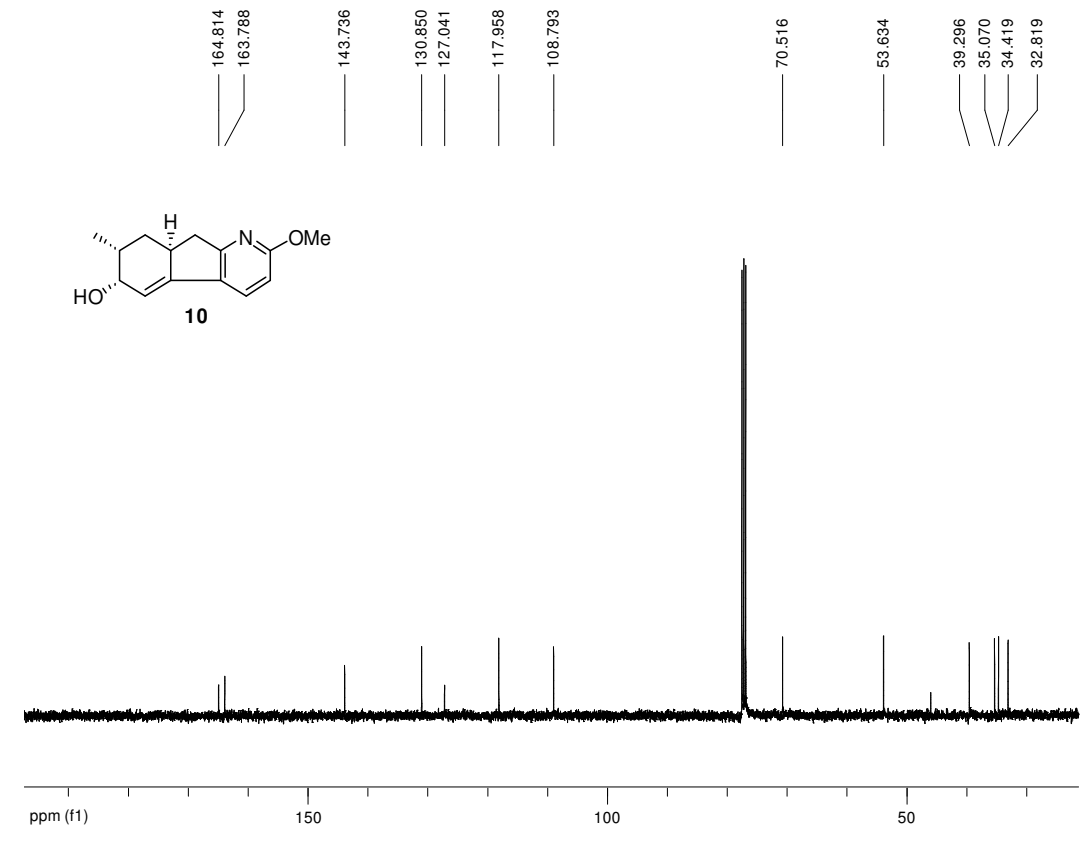

198.973
167.573
167.186
166.854
132.880
125.192
116.441
110.543
54.044
40.378
38.861
38.186
29.221
N
OMe
O
ppm (f1)
200
150
100
50
0

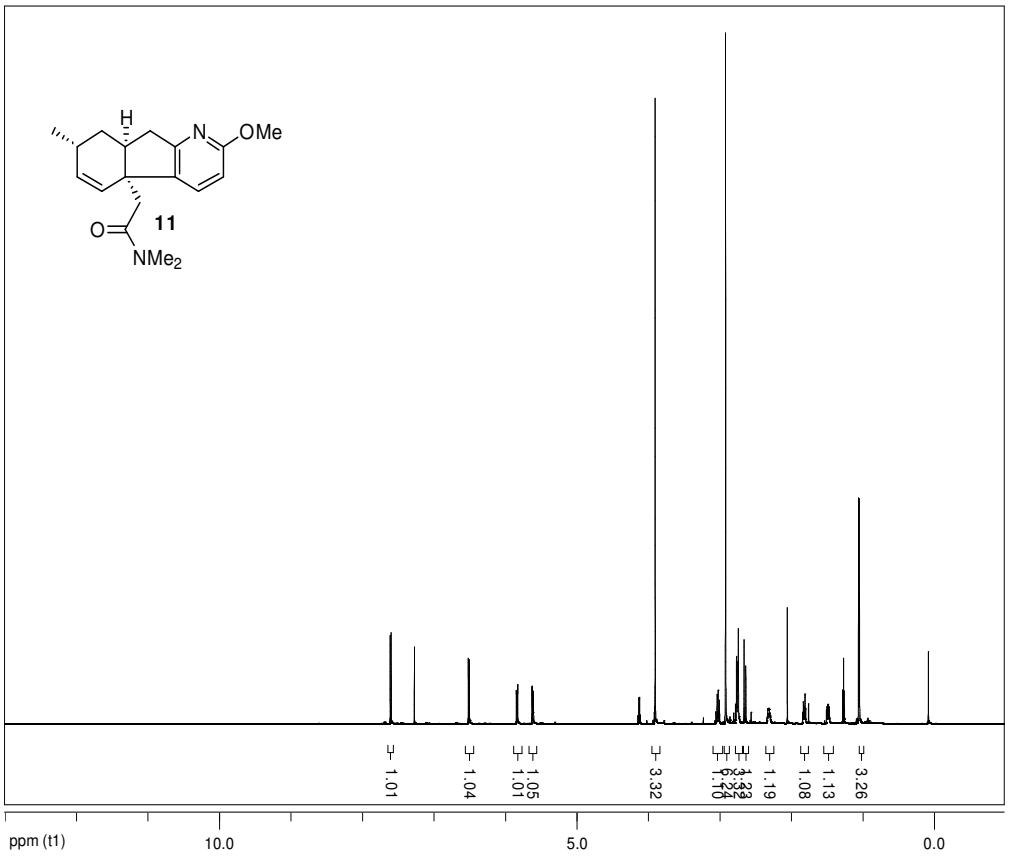
9

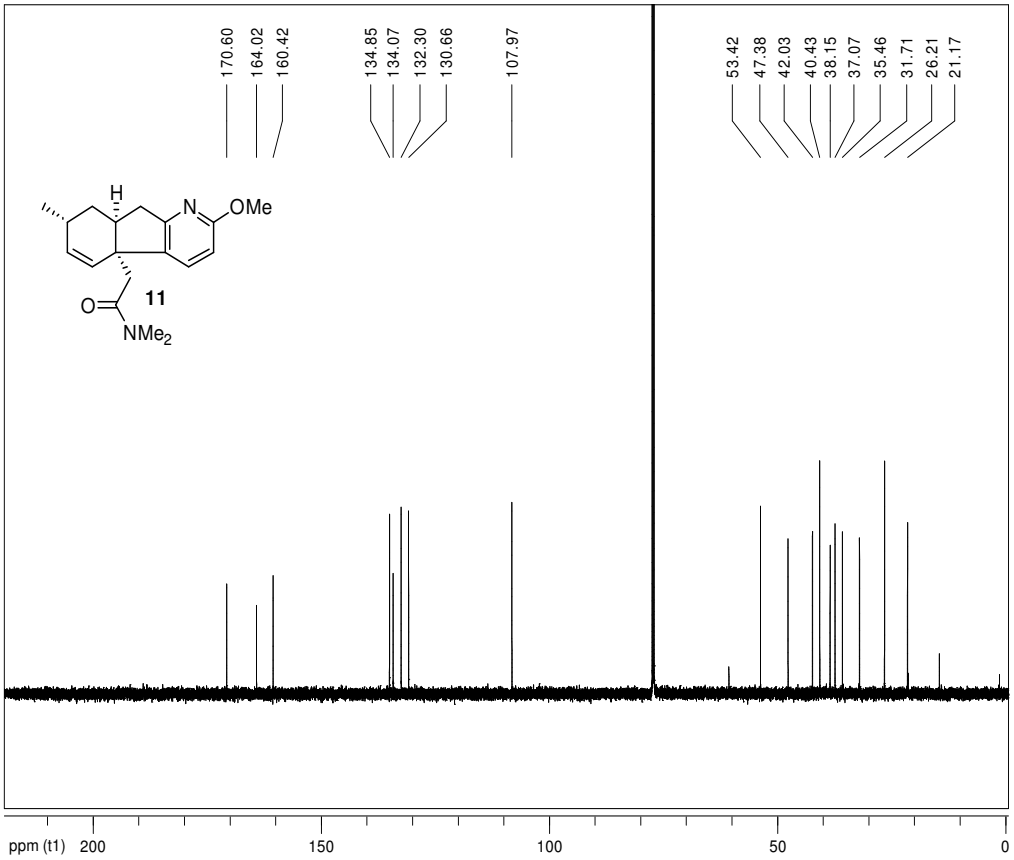

N
OMe
O
S3
1.00
0.91
0.87
2.92
0.94
1.03
1.03
0.93
1.04
0.94
2.90
ppm (t1)
10.0
5.0
0.0

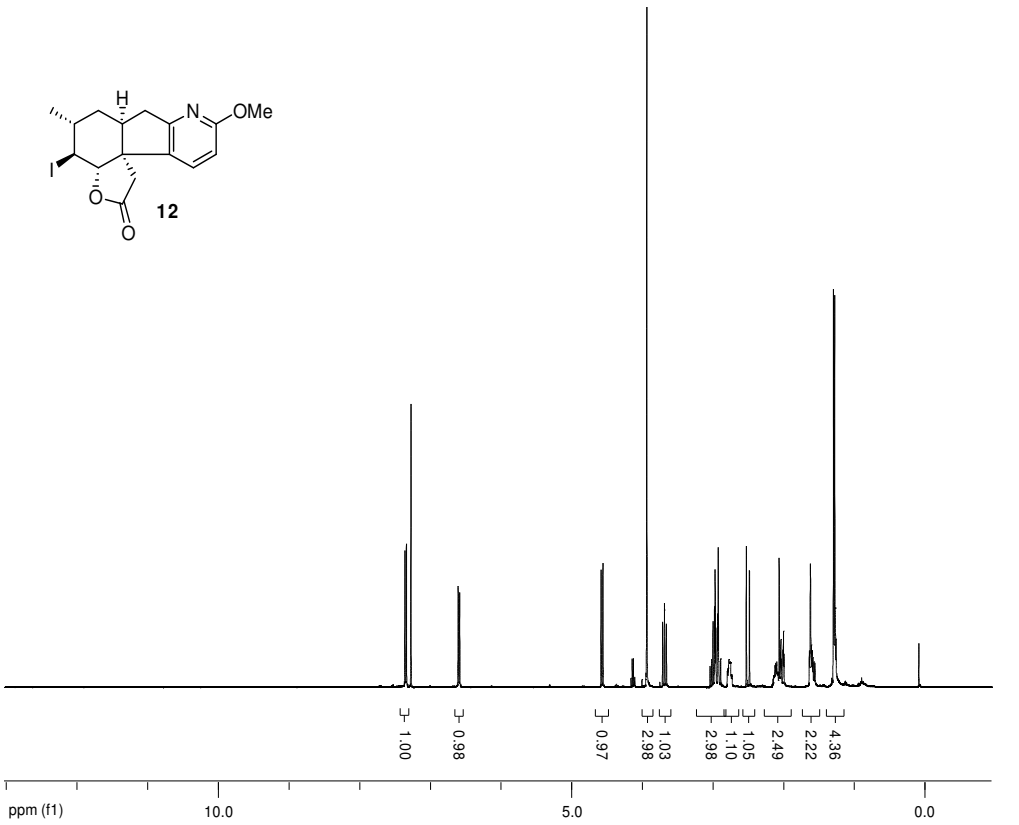

202.10
167.59
167.13
165.70
132.83
125.24
115.58
110.47
54.00
40.39
38.98
35.52
35.46
16.06
N
OMe
O
S3
ppm (f1)
200
150
100
50
0

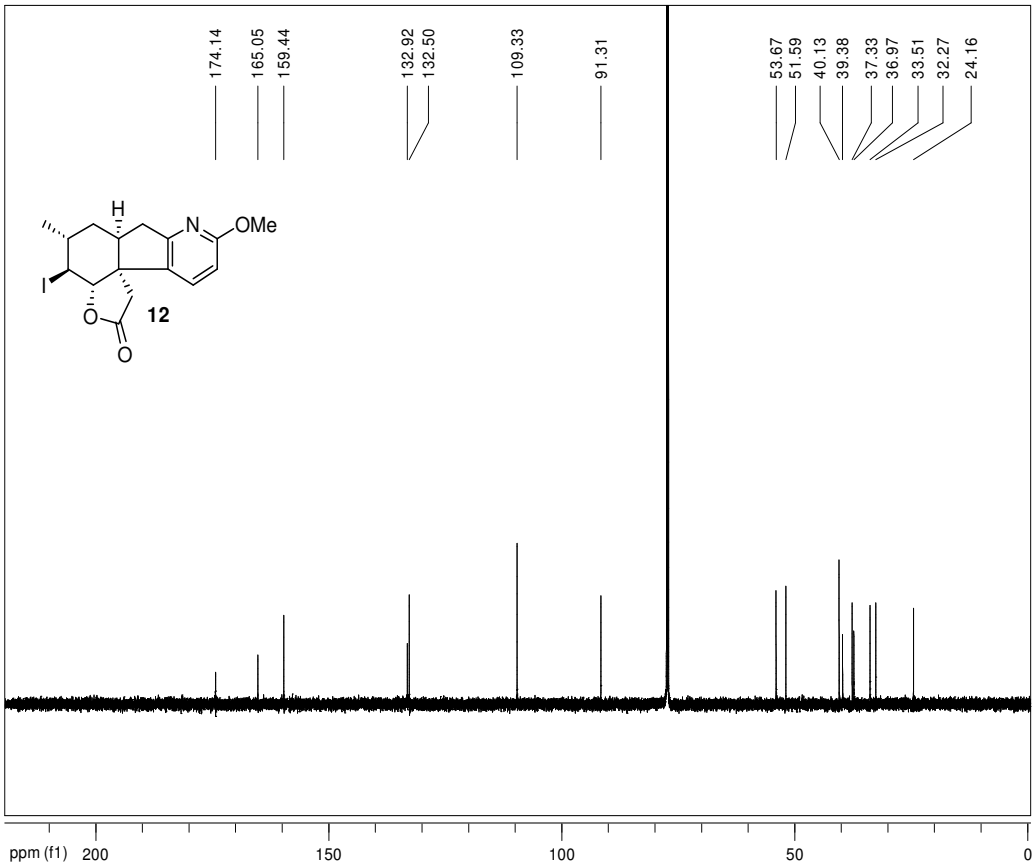

H
N
OMe
HO
10
1.00
1.00
0.95
0.84
3.08
2.07
1.19
1.24
1.37
1.46
1.07
3.31
ppm (t1)
15.0
10.0
5.0
0.0

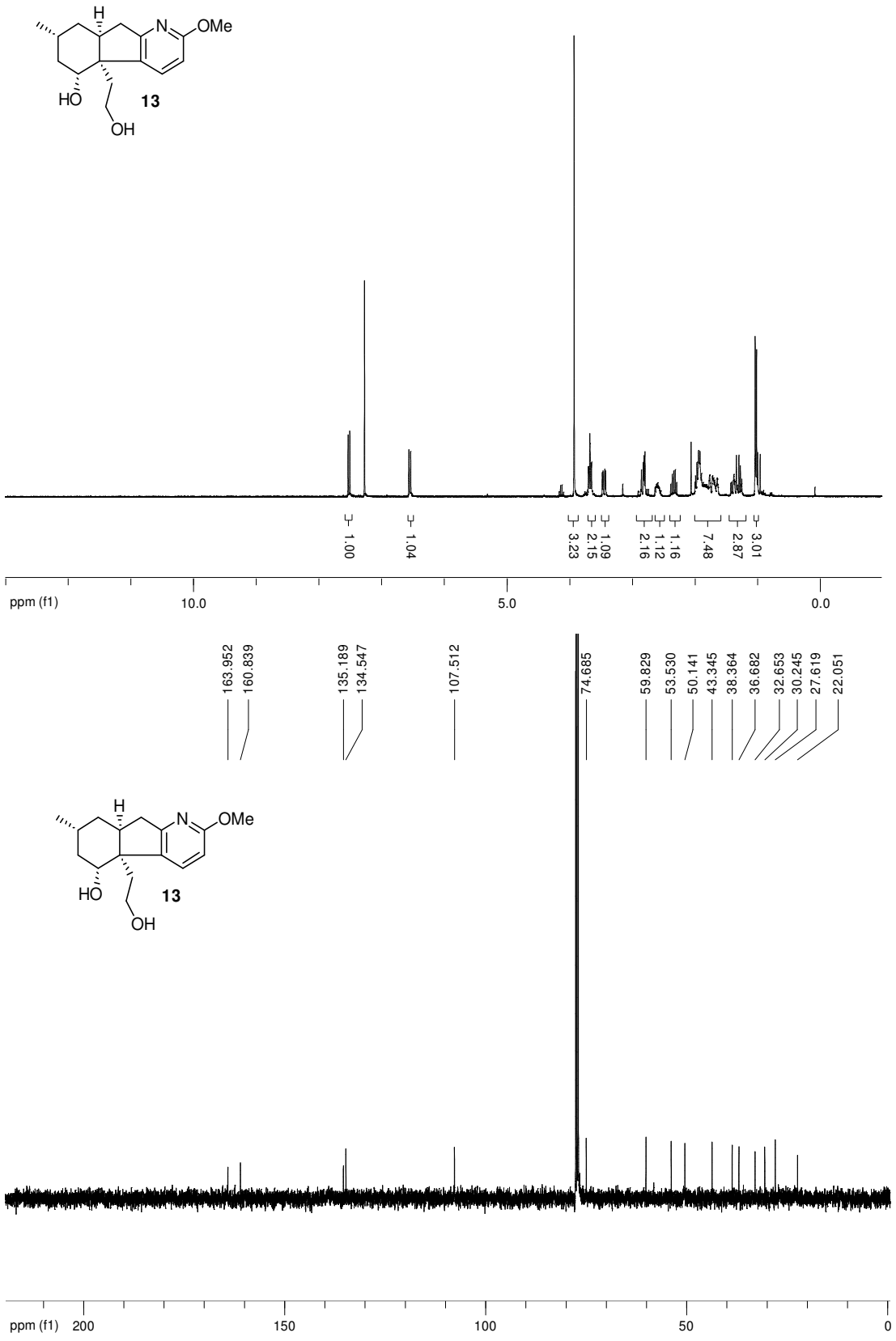

164.814
163.788
143.736
130.850
127.041
117.958
108.793
70.516
53.634
39.296
35.070
34.419
32.819
H
N
OMe
HO
10
ppm (f1)
150
100
50

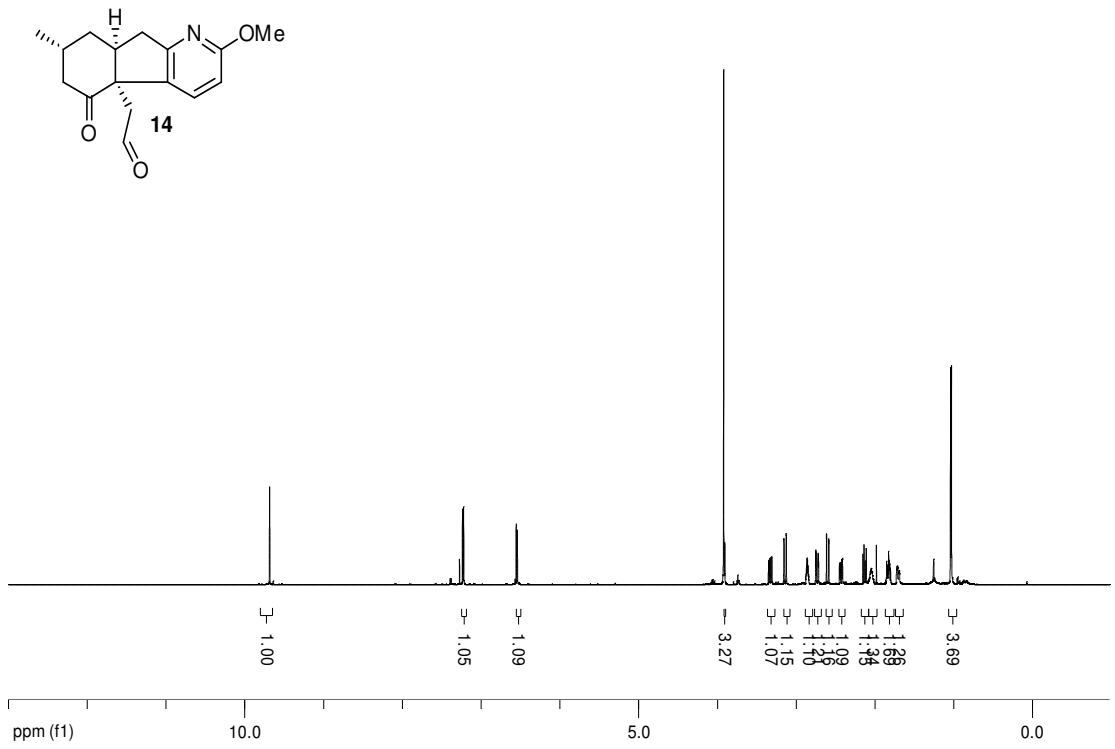

H
N
OMe
11
O
NMe2
1.01
1.04
1.01
1.05
3.32
1.19
1.08
1.13
3.26
ppm (t1)
10.0
5.0
0.0

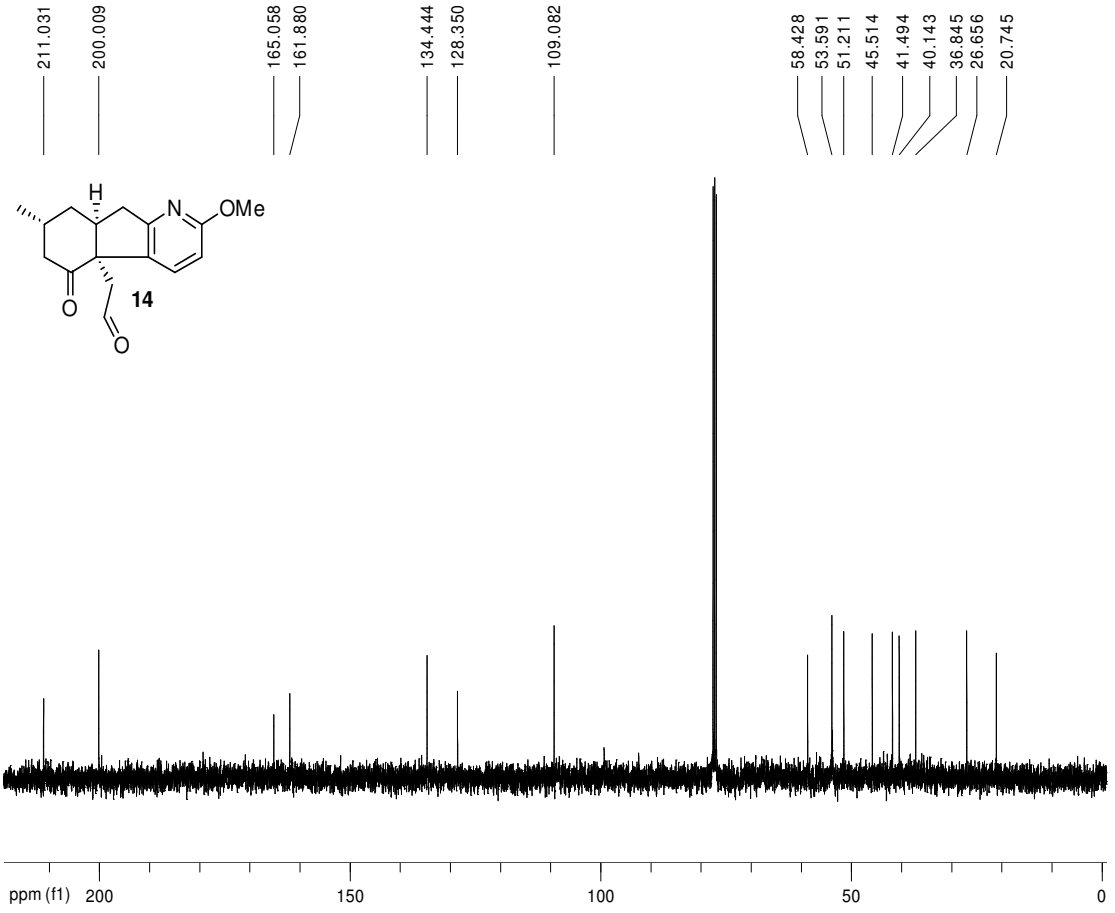

170.60
164.02
160.42
134.85
134.07
132.30
130.66
107.97
53.42
47.38
42.03
40.43
38.15
37.07
35.46
31.71
26.21
21.17
H
N
OMe
11
O
NMe2
ppm (t1)
200
150
100
50
0

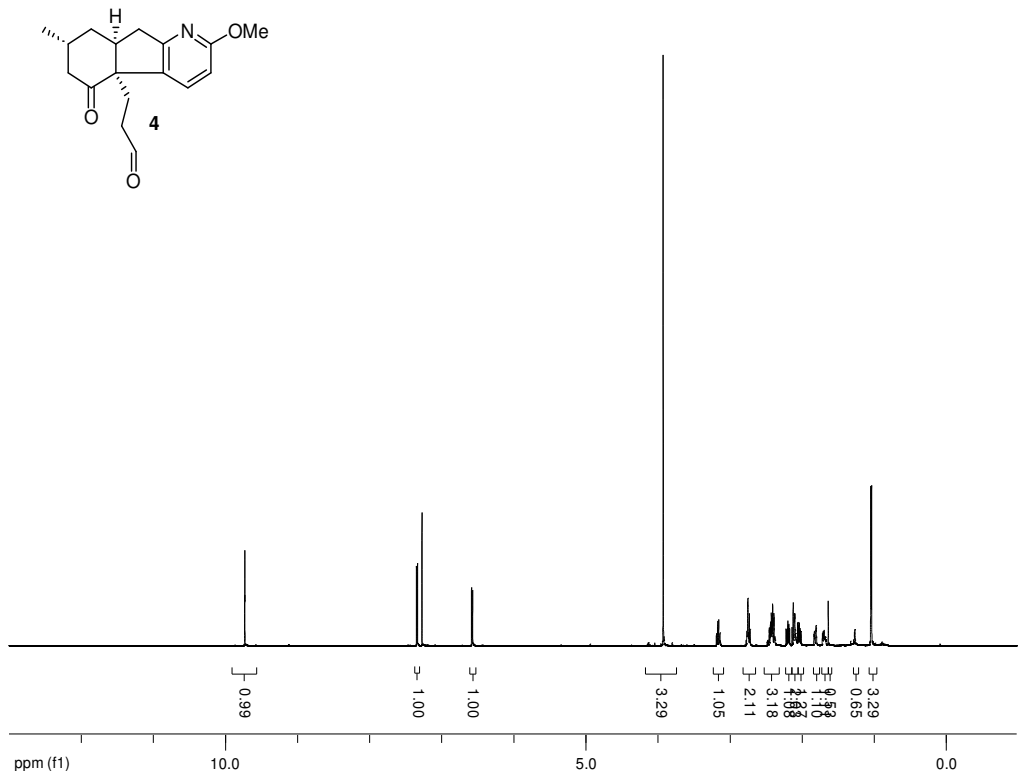

H
N
OMe
I
O
O
12
1.00
0.98
0.97
2.98
1.03
2.98
1.10
1.05
2.49
2.22
4.36
ppm (f1)
10.0
5.0
0.0

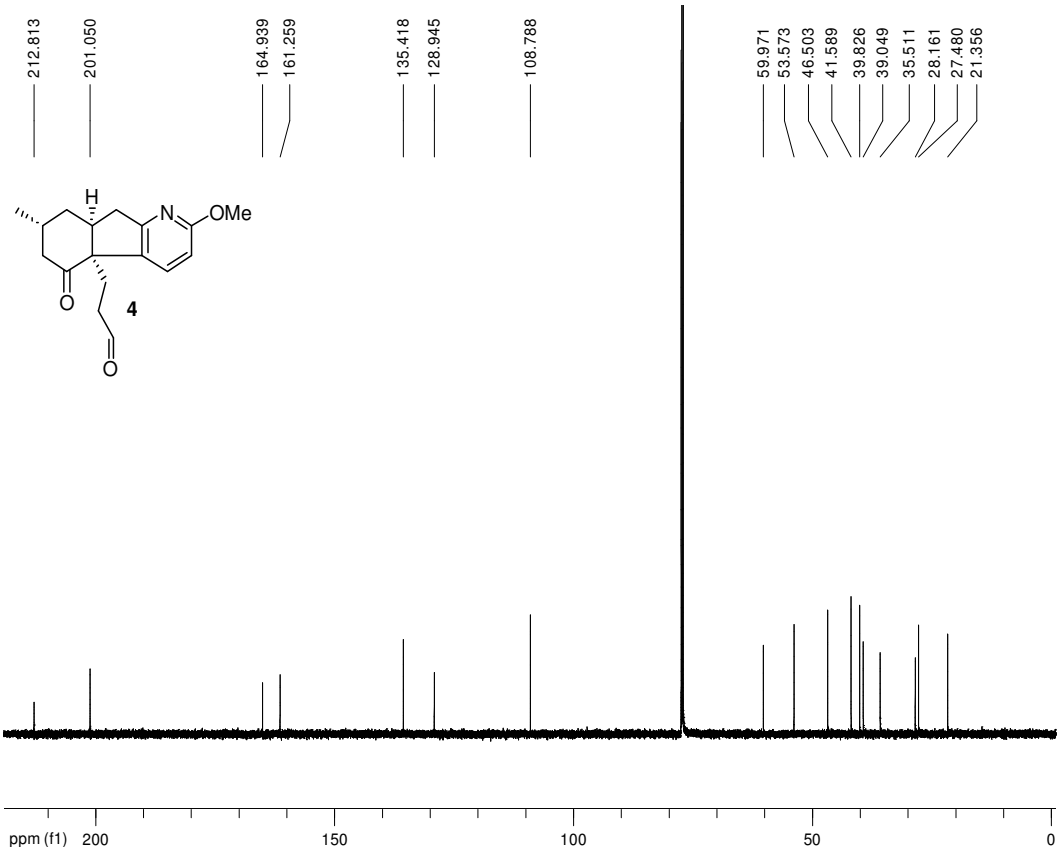

174.14
165.05
159.44
132.92
132.50
109.33
91.31
53.67
51.59
40.13
39.38
37.33
36.97
33.51
32.27
24.16
H
N
OMe
I
O
O
12
ppm (f1)
200
150
100
50
0

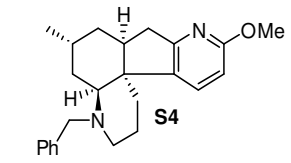

H
N
OMe
HO
13
OH
1.00
1.04
3.23
1.09
2.15
2.16
1.12
1.16
7.48
2.87
3.01
ppm (f1)
10.0
5.0
0.0
163.952
160.839
135.189
134.547
107.512
74.685
59.829
53.530
50.141
43.345
38.364
36.682
32.653
30.245
27.619
22.051
H
N
OMe
HO
13
OH
ppm (f1)
200
150
100
50
0


H
N
OMe
O
O
14
1.00
1.05
1.09
3.27
1.07
1.15
3.69
ppm (f1)
10.0
5.0
0.0

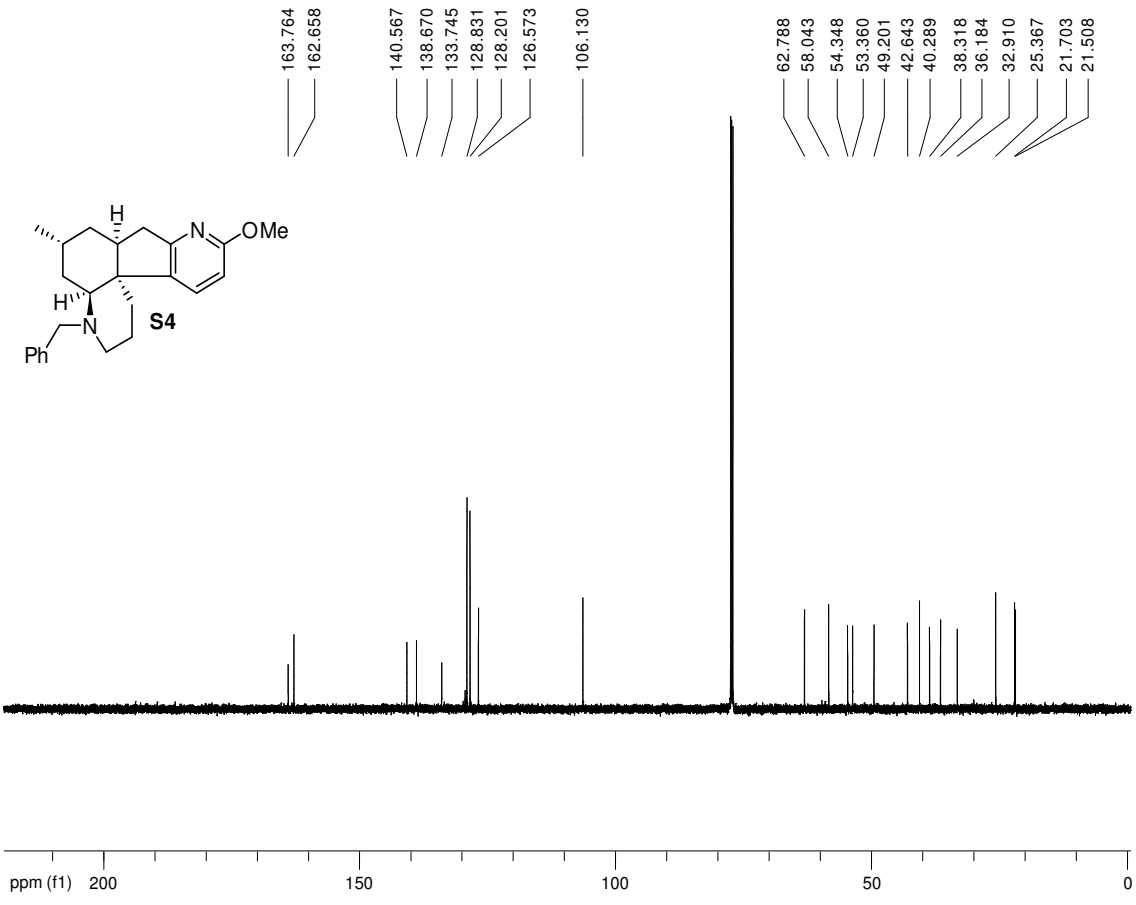

211.031
200.009
165.058
161.880
134.444
128.350
109.082
58.428
53.591
51.211
45.514
41.494
40.143
36.845
26.656
20.745
H
N
OMe
O
O
14
ppm (f1)
200
150
100
50
0

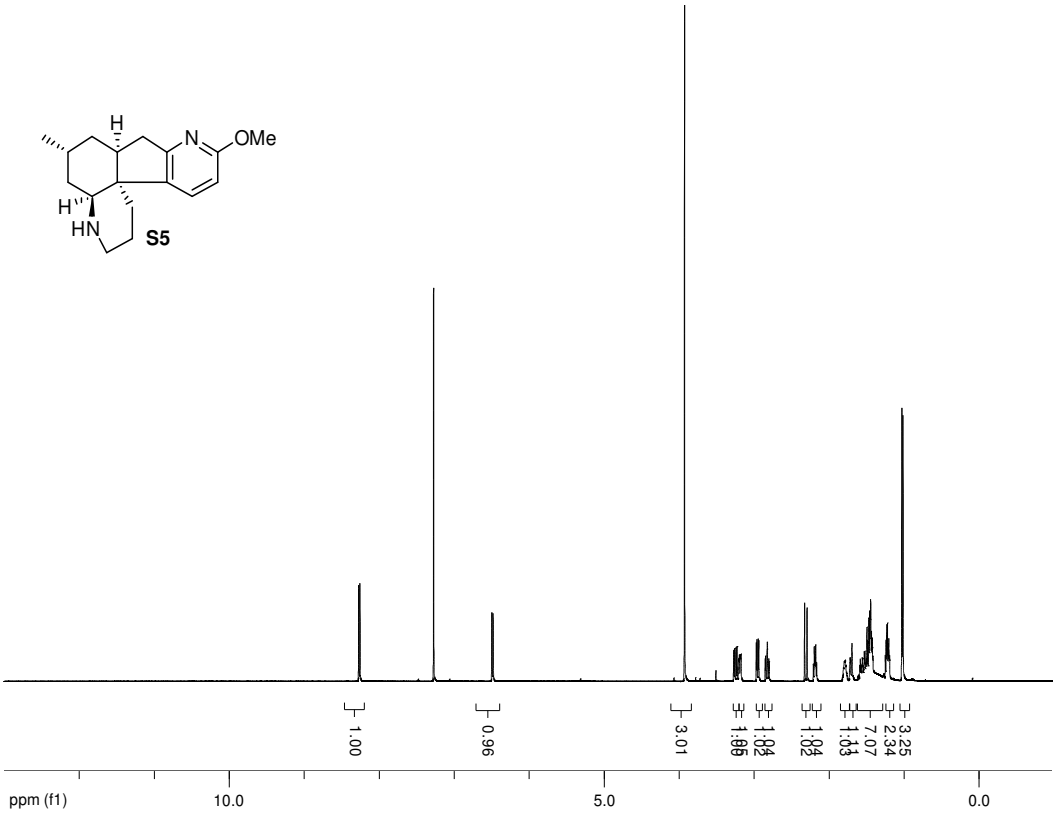

H
N
OMe
O
4
O
0.99
1.00
1.00
3.29
1.05
2.11
3.18
0.95
3.29
ppm (f1)
10.0
5.0
0.0

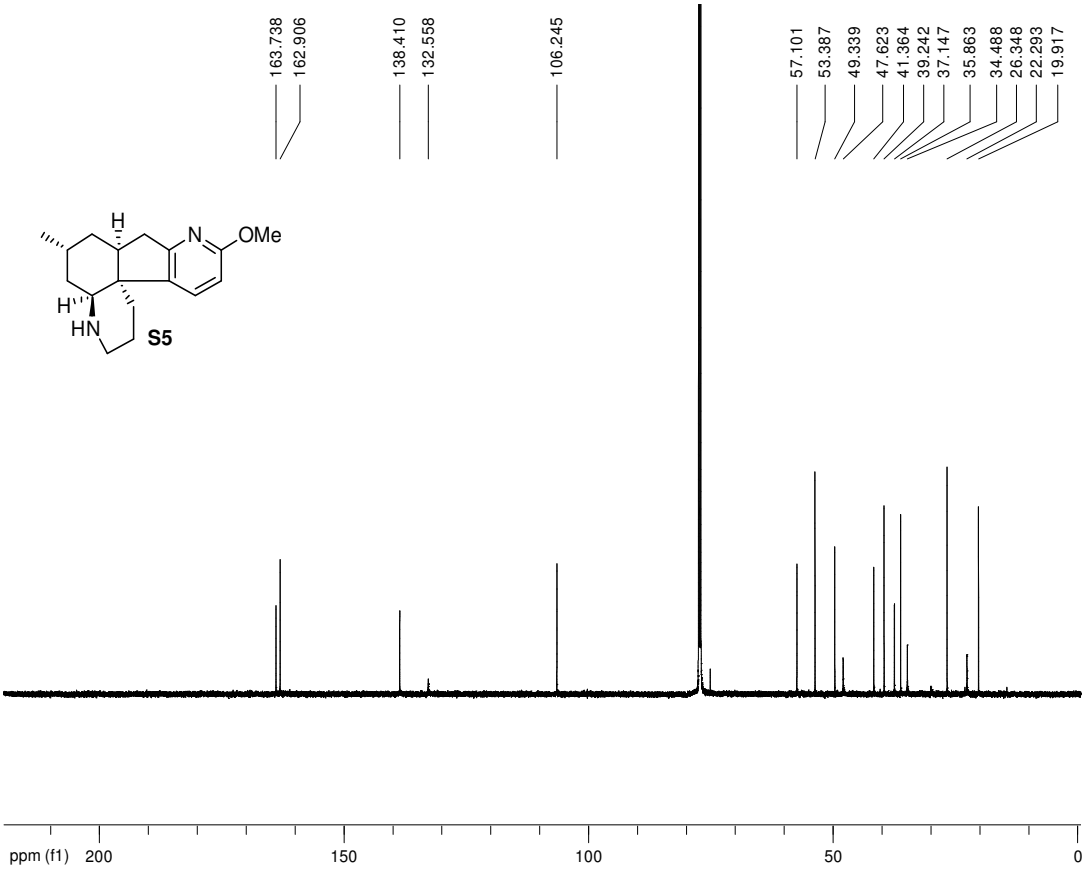

212.813
201.050
164.939
161.259
135.418
128.945
108.788
59.971
53.573
46.503
41.589
39.826
39.049
35.511
28.161
27.480
21.356
H
N
OMe
O
4
O
ppm (f1)
200
150
100
50
0

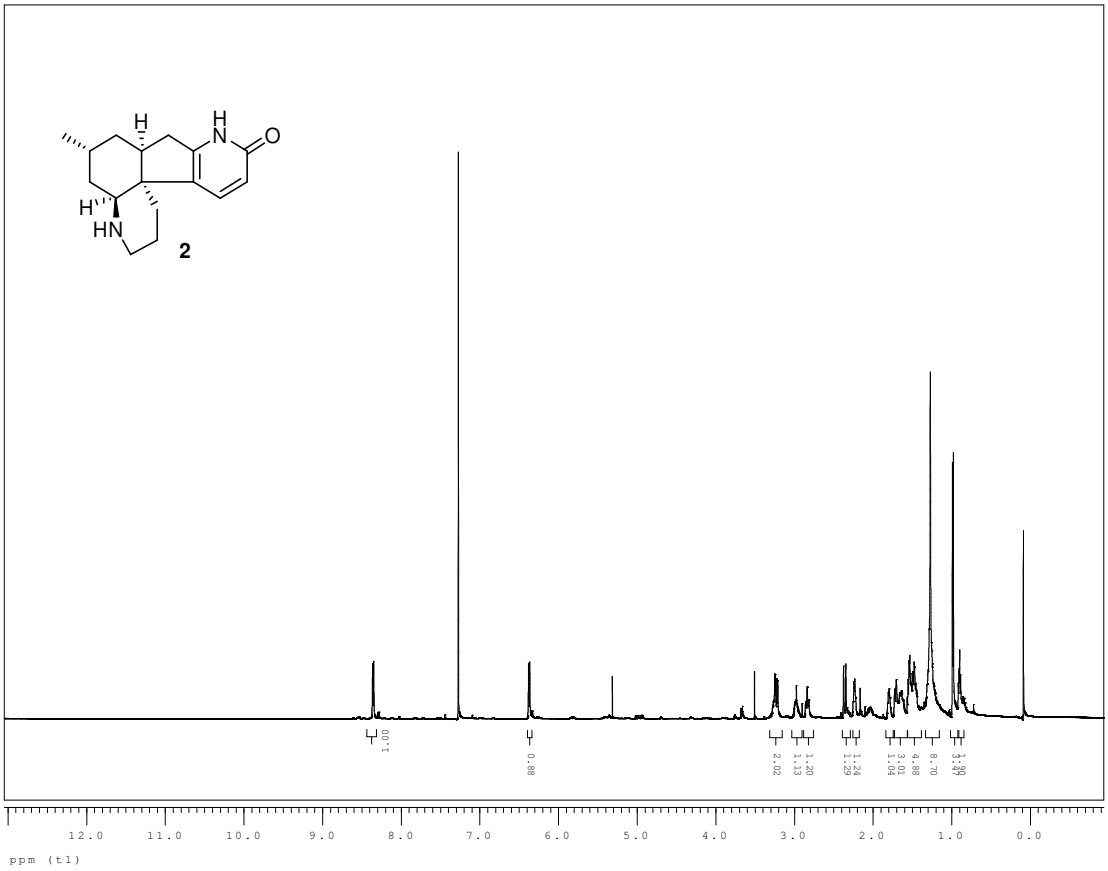

H
N
OMe
H
N
Ph
S4

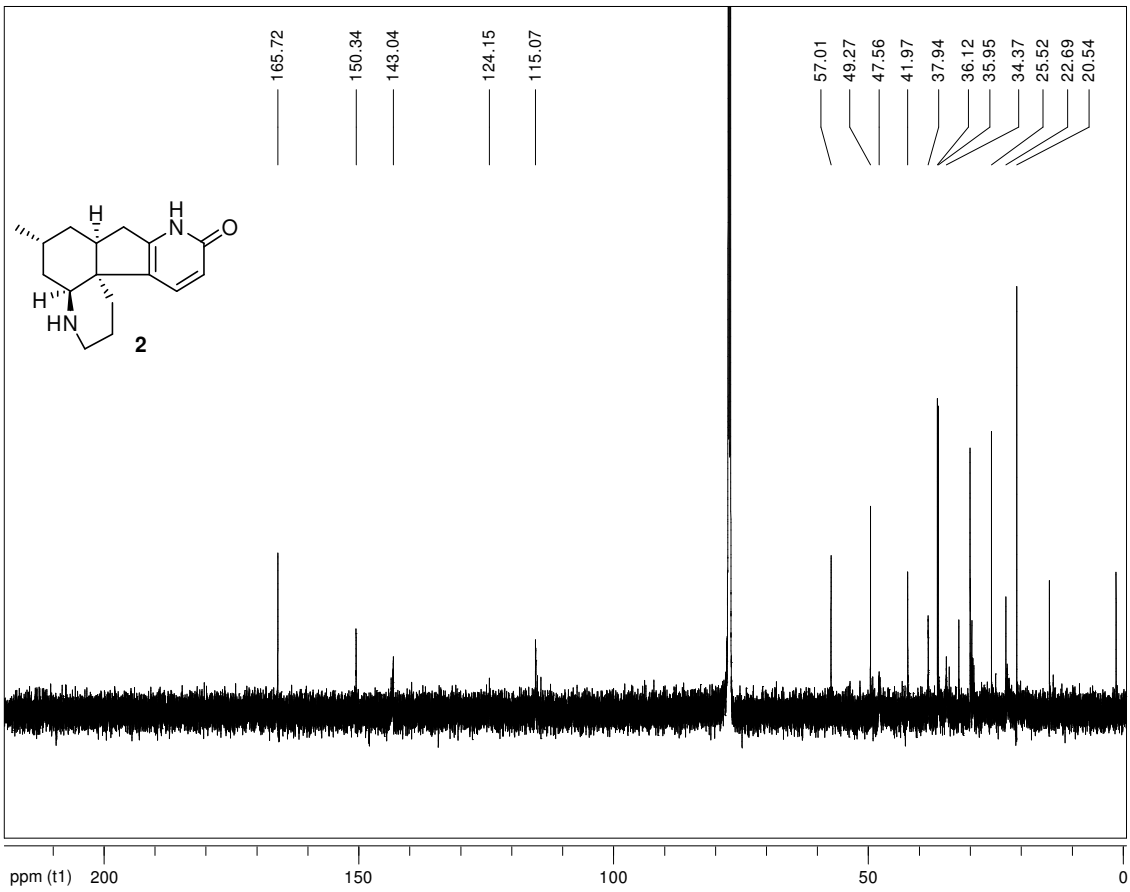
1.00
6.24
0.99
1.06
3.14
1.04
0.97
1.00
1.07
1.04
2.28
6.04
4.28
3.88
ppm (f1)
10.0
5.0
0.0


163.764
162.658
140.567
138.670
133.745
128.831
128.201
126.573
106.130
62.788
58.043
54.348
53.360
49.201
42.643
40.289
38.318
36.184
32.910
25.367
21.703
21.508
H
N
OMe
H
N
Ph
S4
ppm (f1)
200
150
100
50
0


H
N
OMe
H
HN
S5
1.00
0.96
3.01
1.04
1.02
1.03
7.07
2.34
3.25
ppm (f1)
10.0
5.0
0.0


163.738
162.906
138.410
132.558
106.245
57.101
53.387
49.339
47.623
41.364
39.242
37.147
35.863
34.488
26.348
22.293
19.917
H
N
OMe
H
HN
S5
ppm (f1)
200
150
100
50
0


H
H
N
O
H
HN
2
1.00
0.88
2.02
1.13
1.20
1.29
1.24
1.04
3.01
4.88
8.70
1.90
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)


165.72
150.34
143.04
124.15
115.07
57.01
49.27
47.56
41.97
37.94
36.12
35.95
34.37
25.52
22.69
20.54
H
H
N
O
H
HN
2
ppm (t1)
200
150
100
50
0