Supporting Information

Diverse Display of Non-covalent Interacting Elements using Pyrimidine-Embedded Polyheterocycles

Yoona Choi[1], Heejun Kim[1], Young-Hee Shin[1], and Seung Bum Park*[,1,2]

[1]Department of Chemistry and [2]Department of Biophysics and Chemical Biology/ Center for Chemical Proteomics, Seoul National University, Seoul 151-747, Korea
sbpark@snu.ac.kr

S. No. Content **Page No.**

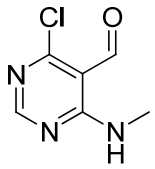
I. General Experimental Information

All commercially available reagents and solvents were used without further purification unless noted otherwise. All the solvents were purchased from commercial venders. ^{1}H and ^{13}C NMR spectra were obtained using Agilent 400–MR DD2 (Agilent, USA) or Varian Inova–500 (Varian Assoc., Palo Alto, USA) instruments. Chemical shifts were reported in ppm from tetramethylsilane (TMS) as internal standard or the residual solvent peak ($CDCl_3$; ^{1}H: δ = 7.26 ppm; ^{13}C: δ = 77.23 ppm). Multiplicity was indicated as follows: s (singlet), d (doublet), t (triplet), q (quartet), m (multiplet), dd (doublet of doublet), dt (doublet of triplet), td (triplet of doublet), brs (broad singlet), and so on. Coupling constants are reported in hertz. Mass spectrometric analysis was performed using a Finnigan Surveyor MSQ Plus LC/MS (Thermo) with electrospray ionization (ESI). The conversion of starting materials was monitored by thin–layer chromatography (TLC) using pre–coated glass–backed plates (silica gel 60; F_{254} = 0.25 mm), and the reaction components were visualized by observation under UV light (254 and 365 nm) or by treatment of TLC plates with visualizing agents such as $KMnO_4$, phosphomolybdic acid, and ninhydrin followed by heating. Products were purified by flash column chromatography on silica gel (230–400 mesh) using a mixture of EtOAc/hexane or MeOH/CH_2Cl_2 as eluents. The energy–minimized structures of molecules were obtained by V_{conf} Interface v2.0 using default parameters and visualized by Discovery Studio 3.5. The polar surface area is illustrated by an isosurface diagram (isovalule is set as 0.017 C) after calculations were performed using the Materials Studio 4.2 program. A generalized gradient of approximation (GAA) for the exchange correlation function of Perdew, Burke, and Ernzerhof (PBE) was used with the double-numerical basis set with polarization (DNP) as implemented in DMol3.

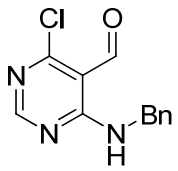
II. Synthetic Procedures and Characterization of All New Compounds

1. General synthetic procedure for compounds 1–3

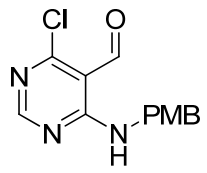
To a solution of 4,6-dichloropyrimidine-5-carbaldehyde (5.0 g) in chloroform (280 mL), amine (1.2 equiv.) and trimethylamine (5.9 mL, 1.5 equiv.) were added at room temperature. After 1 h (the reaction completion was checked by TLC), the reaction mixture was diluted with dichloromethane (DCM) and washed with deionized water and brine. The combined organic layer was dried with anhydrous Na_2SO_4(s). After the removal of solvent under the reduced pressure, the residue was purified by silica-gel flash column chromatography to obtain the desired compounds (**1**–**3**).



Compound 1: Yield: 92%; white solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.37 (s, 1H), 9.17 (brs, 1H), 8.45 (s, 1H), 3.12 (d, *J* = 4.8 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 191.3, 165.2, 161.7, 160.8, 108.1, 27.8; IR (neat)*ν*max: 3438, 2942, 2833, 2509, 2042, 1661, 1450, 1414, 1028, 729; LRMS (ESI) *m/z* calcd for $C_6H_6ClN_3O$ $[M+H]^+$: 172.02; Found: 172.0; Registration No.:14160-94-2.



Compound 2: Yield: 97%; pale brown solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.37 (s, 1H), 9.52 (brs, 1H), 8.45 (s, 1H), 7.37-7.27 (m, 5H), 4.81 (d, *J* = 5.6 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 191.4, 165.4, 161.1, 160.9, 137.0, 128.8, 128.60, 128.55, 127.7, 127.6, 127.5, 108.0, 44.8; IR (neat)*ν*max: 3476, 2829, 2404, 2038, 1663, 1582, 1418, 1386, 1120, 1068, 1026; LRMS (ESI) *m/z* calcd for $C_{12}H_{10}ClN_3O$ $[M+H]^+$: 248.05; Found: 248.00; Registration No.: 59311-82-9.

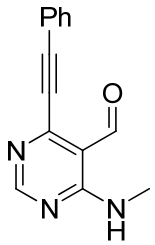


Compound 3: Yield: 63%; yellow solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.36 (s, 1H), 9.46 (brs, 1H), 8.46 (s, 1H), 7.25 (d, *J* = 8.4 Hz, 2H), 6.88 (d, *J* = 8.4 Hz, 2H), 4.74 (d, *J* = 4.8 Hz, 2H), 3.80 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 191.3, 165.3, 160.9, 160.8, 159.2, 129.06, 129.03, 114.2, 108.0, 55.3, 44.4; IR (neat)*ν*max: 3531, 2947, 2830, 2471, 2040, 1652, 1119, 1022; LRMS (ESI) *m/z*

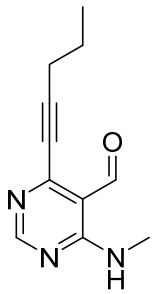
calcd for $C_{13}H_{12}ClN_3O_2$ $[M+H]^+$: 278.06; Found: 278.10; Registration No.: 1532748-79-0.

2. General synthetic procedure for compounds 4–10

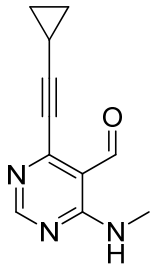
To a solution of **1**–**3** (1.0 g), $Pd(PPh_3)_2Cl_2$ (5 mol%), and CuI (20 mol%) in anhydrous DMF (60 mL), terminal alkynes (2.0 equiv.) and triethylamine (2.0 equiv.) were added under the argon atmosphere. After being stirred at room temperature for 4 h, the reaction mixture was quenched with deionized water (200 mL). The resultant was extracted with EtOAc (100 mL × 3) and the combined organic layer was washed with brine (100 mL). After drying with anhydrous Na_2SO_4(s), the filtered solution was concentrated under the reduced pressure. The residue was purified by silica-gel flash column chromatography to obtain the desired compound (**4–10**).



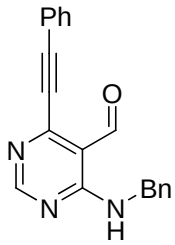
Compound 4: Yield: 98%; Pale yellow solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.55 (s, 1H), 8.91 (brs, 1H), 8.67 (s, 1H), 7.65–7.62 (m, 2H), 7.47–7.38 (m, 3H), 3.14 (d, *J* = 5.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 192.5, 161.5, 160.4, 155.0, 132.4, 130.3, 128.6, 120.6, 98.3, 83.8, 27.4; IR (neat)*ν*max: 3969, 3856, 2832, 2534, 2223, 2041, 1517, 1110, 1022; LRMS (ESI) *m/z* calcd for $C_{14}H_{11}N_3O$ $[M+H]^+$: 238.09; Found: 237.99; Registration No.: 1477472-98-2.



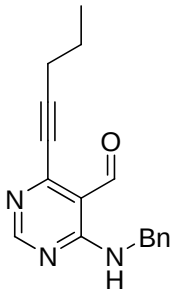
Compound 5: Yield: 96%; Brown solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.42 (s, 1H), 8.86 (s 1H), 8.60 (s, 1H), 3.11 (d, *J* = 5.2 Hz, 3H), 2.50 (t, *J* = 6.8 Hz, 2H), 1.72–1.66 (m, 2H), 1.07 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 192.9, 161.4, 160.4, 155.5, 111.9, 101.3, 76.0, 27.3, 21.5, 21.4, 13.6; IR (neat)*ν*max: 3859, 3715, 3387, 2830, 2505, 2228, 2038, 1446, 1115, 1020; LRMS (ESI) *m/z* calcd for $C_{11}H_{13}N_3O$ $[M+H]^+$: 204.11; Found: 204.02; Registration No.: 1477472-99-3.



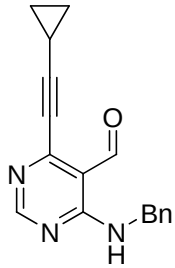
Compound 6: Yield: 97%; Brown solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.36 (s, 1H), 8.84 (brs, 1H), 8.57 (s, 1H), 3.10 (d, *J* = 4.8 Hz, 3H), 1.58–1.52 (m, 1H), 1.04-0.95 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 192.8, 161.3, 160.4, 155.5, 111.8, 104.9, 71.3, 27.3, 9.4; IR (neat)*ν*max: 3973, 3856, 3394, 3252, 2828, 2521, 2216, 2034, 1696, 1631, 1471, 1016; LRMS (ESI) *m/z* calcd for $C_{11}H_{11}N_3O$ $[M+H]^+$: 202.09; Found: 201.90.



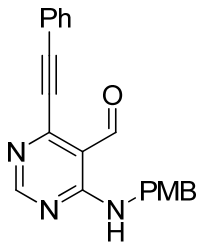
Compound 7: Yield: 55%; Brown solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.57 (s, 1H), 9.26 (brs, 1H), 8.67 (s, 1H), 7.62 (d, *J* = 4.0 Hz, 2H), 7.45–7.25 (m, 8H), 4.81 (d, *J* = 5.6 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 192.6, 161.6, 159.9, 155.3, 137.4, 132.5, 130.4, 128.8, 128.7, 127.66, 127.61, 120.7, 111.7, 98.5, 83.8, 44.4; IR (neat)*ν*max: 3365, 2830, 2515, 2201, 2038, 1693, 1626, 1471, 1120, 1017; LRMS (ESI) *m/z* calcd for $C_{20}H_{15}N_3O$ $[M+H]^+$: 314.12; Found: 314.01; Registration No.: 1103638-86-9.



Compound 8: Yield: 78%; Brown solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.43 (s, 1H), 9.23 (brs, 1H), 8.61 (s, 1H), 7.36–7.27 (m, 5H), 4.79 (d, *J* = 5.6 Hz, 2H), 2.50 (t, *J* = 7.2 Hz, 2H), 1.74–1.65 (m, 2H), 1.06 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 193.0, 161.5, 159.9, 155.8, 137.5, 128.7, 127.59, 127.56, 111.8, 101.5, 76.1, 44.3, 21.55, 21.47, 13.6; IR (neat)*ν*max: 3858, 3703, 3451, 2946, 2832, 2437, 2230, 2041, 1539, 1481, 1112, 1022; LRMS (ESI) *m/z* calcd for $C_{17}H_{17}N_3O$ $[M+H]^+$: 280.14; Found: 280.06.



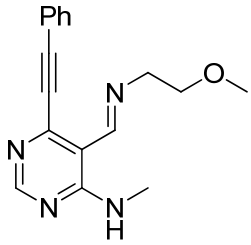
Compound 9: Yield: 97%; Orange solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.37 (s, 1H), 9.21 (brs, 1H), 8.58 (s, 1H), 7.36–7.27 (m, 5H), 4.78 (d, *J* = 5.5 Hz, 2H), 1.58–1.51 (m, 1H), 1.04–0.94 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 192.9, 161.5, 159.8, 155.7, 137.5, 128.7, 127.58, 127.56, 111.7, 105.1, 71.3, 44.3, 9.5; IR (neat)*ν*max: 3856, 3421, 2943, 2832, 2445, 2221, 2041, 1517, 1122, 1023; LRMS (ESI) *m/z* calcd for $C_{17}H_{15}N_3O$ $[M+H]^+$: 278.12; Found: 278.06.



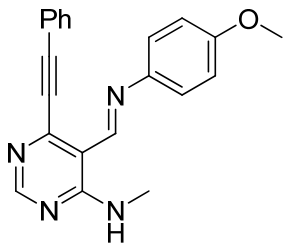
Compound 10: Yield: 82%; Pale brown solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.55 (s, 1H), 9.20 (brs, 1H), 8.68 (s, 1H), 7.63 (d, *J* = 8.4 Hz, 2H), 7.45–7.38 (m, 3H), 7.28 (d, *J* = 9.2 Hz, 2H), 6.89 (d, *J* = 8.4 Hz, 2H), 4.74 (d, *J* = 5.6 Hz, 2H), 3.80 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 192.6, 161.6, 159.7, 159.1, 155.2, 132.4, 130.4, 129.4, 129.1, 128.6, 120.7, 114.2, 111.6, 98.4, 83.9, 55.3, 43.9; IR (neat)*ν*max: 3496, 2946, 2833, 2437, 2040, 1453, 1117, 1017; LRMS (ESI) *m/z* calcd for $C_{21}H_{17}N_3O_2$ $[M+H]^+$: 344.13; Found: 344.02.

3. General synthetic procedure for compounds 4a´–10b´

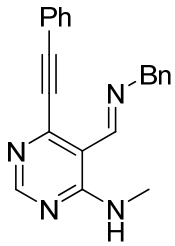
To a solution of **4–10** (3.0 mmol) in dichloroethane (DCE), amine (5.0 equiv.), Na_2SO_4, and AcOH were added. After stirring at 80 ºC until starting materials were consumed, the reaction mixture was quenched with deionized water. The resultant was extracted with dichloromethane (DCM) twice and dried with anhydrous Na_2SO_4(s). After the solvent was removed under the reduced pressure, the residue was purified by silica-gel flash column chromatography to obtain **4a´–10b´**.



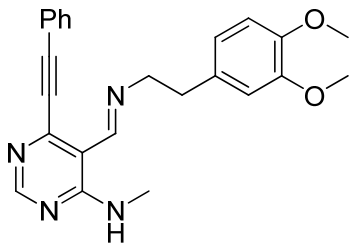
Compound 4a´: Yield: 86%; Pale yellow solid; ^{1}H NMR (500 MHz, $CDCl_3$) δ 9.98 (brs, 1H), 8.97 (s, 1H), 8.55 (s, 1H), 7.62–7.60 (m, 2H), 7.42–7.36 (m, 3H), 3.84 (t, *J* = 5.2 Hz, 2H), 3.71 (t, *J* = 5.2 Hz, 2H), 3.4 (s, 3H), 3.11 (d, *J* = 4.8 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 161.8, 160.5, 158.4, 150.4, 111.3, 99.0, 77.1, 72.2, 61.0, 58.9, 27.2, 21.6, 21.5, 13.6; IR (neat)*ν*max: 3422, 2811, 2521, 2216, 2041, 1694, 1453, 1122, 1021 cm^{-1}; LRMS (ESI) *m/z* calcd for $C_{17}H_{18}N_3O$ $[M+H]^+$: 295.15; Found: 295.00; Registration No.: 1477473-09-8.



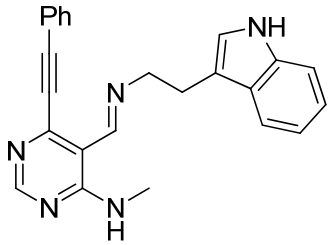
Compound 4b´: Yield: 84%; Yellow solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.12 (s, 1H), 9.18 (s, 1H), 8.58 (s, 1H), 7.60 (d, *J* = 6.8 Hz, 2H), 7.40 (t, *J* = 7.6 Hz, 3H), 7.26 (d, *J* = 8.0 Hz, 2H), 6.97 (d, *J* = 8.4 Hz, 2H), 3.85 (s, 3H), 3.18 (d, *J* = 4.8 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.2, 158.78, 158.61, 156.3, 150.5, 143.5, 132.1, 129.8, 128.5, 122.3, 121.3, 114.6, 112.1, 97.0, 85.1, 55.5, 27.5; IR (neat)*ν*max: 3983, 3857, 3672, 3361, 2935, 2828, 2525, 2214, 2036, 1668, 1450, 1117, 1018 cm^{-1}; LRMS (ESI) *m/z* calcd for $C_{21}H_{18}N_4O$ $[M+H]^+$: 343.15; Found: 343.00; Registration No.: 1477473-04-3.



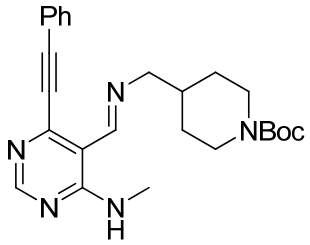
Compound 4c´: Yield: 89%; Brown solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.02 (d, *J* = 5.4 Hz, 1H), 9.03 (s, 1H), 8.56 (s, 1H), 7.56 (dd, *J* = 8.0 Hz, *J* = 1.8 Hz, 2H), 7.43-7.36 (m, 5H), 7.31 (t, *J* = 7.0 Hz, 3H), 4.88 (s, 2H), 3.09 (d, *J* = 4.7 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.8, 160.5, 158.6, 150.0, 138.5, 132.1, 129.7, 128.7, 128.5, 127.9, 127.3, 121.3, 111.5, 96.5, 85.0, 65.0, 27.4; IR (neat)*ν*max: 3981, 3859, 33672, 3613, 3586, 3411, 3358, 2939, 2824, 2510, 2215, 2043, 1633, 1454, 1120, 1021, 808 cm^{-1}; LRMS (ESI) *m/z* calcd for $C_{21}H_{18}N_4$ $[M+H]^+$: 327.15; Found: 327.03.



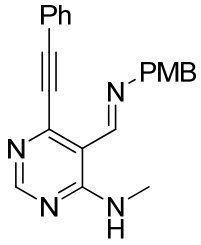
Compound 4d´: Yield: 91%; Brown oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.97 (brs, 1H), 8.85 (s, 1H), 8.54 (s, 1H), 7.57 (d, *J* = 7.6 Hz, 2H), 7.42–7.36 (m, 3H), 6.83–6.76 (m, 2H), 6.75 (s, 1H), 3.90 (t, *J* = 7.2 Hz, 2H), 3.85 (s, 3H), 3.84 (s, 3H), 3.05 (d, *J* = 4.8 Hz, 3H), 2.95 (t, *J* = 7.2 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.6, 160.1, 158.6, 149.8, 149.0, 147.7, 132.3, 132.2, 129.8, 128.6, 121.6, 121.0, 112.4, 111.6, 111.4, 96.5, 85.2, 63.2, 56.0, 55.9, 37.4, 27.4; IR (neat)*ν*max: 3984, 3857, 3686, 3359, 2944, 2818, 2508, 2216, 2040, 1632, 1444, 1022 cm^{-1}; LRMS (ESI) *m/z* calcd for $C_{24}H_{24}N_4O_2$ $[M+H]^+$: 401.19; Found: 401.13.



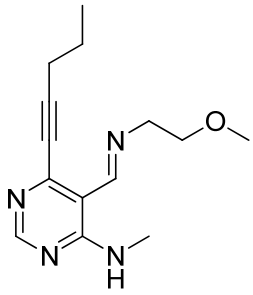
Compound 4e´: Yield: 91%; Brown solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.02 (d, *J* = 5.1 Hz, 1H), 8.79 (s, 1H), 8.53 (s, 1H), 8.29 (brs, 1H), 7.64 (d, *J* = 7.8 Hz, 7.43–7.31 (m, 6H), 7.18 (t, *J* = 7.2 Hz, 1H), 7.12 (t, *J* = 7.2 Hz, 1H), 7.00 (s, 1H), 3.99 (t, *J* = 7.2 Hz, 2H), 3.17 (t, *J* = 7.2 Hz, 2H), 3.00 (d, *J* = 4.8 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.4, 159.9, 158.3, 149.5, 136.3, 132.1, 129.6, 128.4, 127.4, 122.03, 121.99, 121.3, 119.3, 118.7, 113.7, 111.5, 111.2, 96.4, 84.9, 62.0, 27.2, 27.0; IR (neat)*ν*max: 3856, 3308, 2823, 2509, 2213, 2038, 1673, 1556, 1483, 1199, 1115, 1017 cm^{-1}; LRMS (ESI) *m/z* calcd for $C_{24}H_{21}N_5$ $[M+H]^+$: 380.18; Found: 380.12.



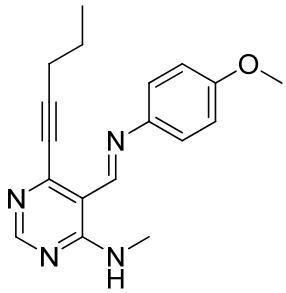
Compound 4f´: Yield: 86%; Yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.96 (brs, 1H), 8.90 (s, 1H), 8.55 (s, 1H), 7.61 (dd, *J* = 7.6 Hz, *J* = 1.8 Hz, 2H), 7.43–7.26 (m, 3H), 4.16 (brs, 2H), 3.55 (d, *J* = 6.4 Hz, 2H), 3.11 (d, *J* = 4.8 Hz, 3H), 2.73 (t, *J* = 12.2 Hz, 2H), 1.85–1.81 (m, 1H), 1.74 (d, *J* = 12.0 Hz, 2H), 1.46 (s, 9H), 1.30–1.23 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.7, 160.4, 158.7, 155.0, 149.9, 132.3, 129.9, 128.7, 121.6, 111.6, 96.6, 85.2, 79.5, 77.4, 67.9, 37.8, 30.5, 28.6, 27.5, 21.2, 14.3; IR (neat)*ν*max: 3974, 3857, 3686, 3442, 3345, 3312, 3279, 2943, 2833, 2537, 2214, 2044, 1667, 1573, 1521, 1022 cm^{-1}; LRMS (ESI) *m/z* calcd for $C_{25}H_{31}N_5O_2$ $[M+H]^+$: 434.25; Found: 434.12.



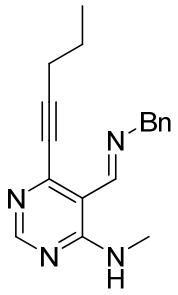
Compound 4g´: Yield: 86%; Brown oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.03 (brs, 1H), 8.97 (s, 1H), 8.55 (s, 1H), 7.54 (d, *J* = 7.6 Hz, 2H), 7.42–7.36 (m, 3H), 7.23 (d, *J* = 8.8 Hz, 2H), 6.92 (d, *J* = 8.4 Hz, 2H), 4.82 (s, 2H), 3.80 (s, 3H), 3.08 (d, *J* = 4.8 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.5, 160.3, 158.9, 158.5, 149.9, 132.1, 130.3, 129.7, 129.4, 128.5, 121.4, 114.1, 111.5, 96.5, 85.0, 64.2, 55.2, 27.3; IR (neat)*ν*max: 3861, 3687, 3369, 2943, 2827, 2501, 2214, 2041, 1672, 1112, 1023 cm^{-1}; LRMS (ESI) *m/z* calcd for $C_{22}H_{20}N_4O$ $[M+H]^+$: 357.16; Found: 357.05.



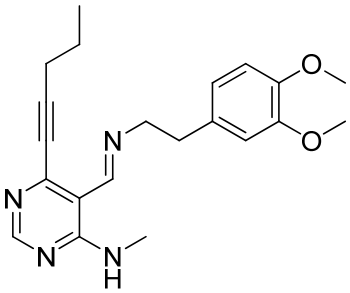
Compound 5a´: Yield: 66%; Pale yellow solid; ^{1}H NMR (500 MHz, $CDCl_3$) δ 9.91 (brs, 1H), 8.86 (s, 1H), 8.48 (s, 1H), 3.80 (t, *J* = 5.0 Hz, 2H), 3.69 (t, *J* = 5.0 Hz, 2H), 3.39 (s, 3H), 3.08 (d, *J* = 4.5 Hz, 3H), 2.47 (t, *J* = 7.0 Hz, 2H), 1.71–1.66 (m, 2H), 1.07 (t, *J* = 7.5 Hz, 3H); ^{13}C NMR (125 MHZ, $CDCl_3$) δ 161.8, 160.5, 158.4, 150.4, 111.3, 99.0, 77.1, 72.2, 61.0, 58.9, 27.2, 21.6, 21.5, 13.6; IR (neat)*ν*max: 3822, 3670, 3318, 2946, 2791, 2520, 2229, 2037, 1679, 1553, 1415, 1233, 1125, 1016 cm^{-1}; LRMS (ESI) *m/z* calcd for $C_{14}H_{20}N_4O$ $[M+H]^+$: 261.16; Found: 261.05; Registration No.: 1477473-13-4.



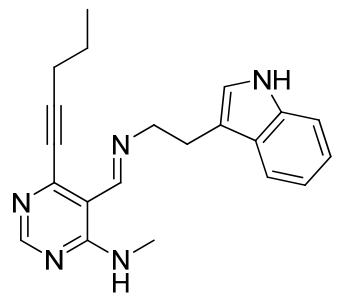
Compound 5b´: Yield: 68%; Yellow solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.06 (d, *J* = 4.4 Hz, 1H), 9.08 (s, 1H), 8.52 (s, 1H), 7.21 (d, *J* = 7.2 Hz, 2H), 6.95 (d, *J* = 6.8 Hz, 2H), 3.85 (s, 3H), 3.15 (d, *J* = 4.8 Hz, 3H), 2.49 (t, *J* = 6.8 Hz, 3H), 1.73–1.64 (m, 2H), 1.07 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.2, 158.6, 158.5, 156.8, 151.2, 143.6, 122.3, 114.5, 111.9, 99.6, 76.8, 55.5, 27.4, 21.6, 21.5, 13.6; IR (neat)*ν*max: 3970, 3858, 3321, 2945, 2831, 2526, 2228, 2041, 1668, 1249, 1115, 1019 cm^{-1}; LRMS (ESI) *m/z* calcd for $C_{18}H_{20}N_4O$ $[M+H]^+$: 309.16; Found: 309.06; Registration No.: 1477473-07-6.



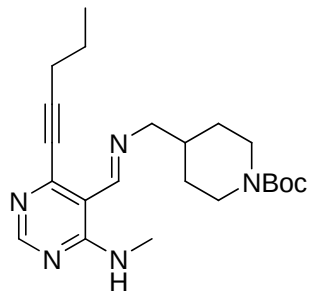
Compound 5c´: Yield: 74%; Brown oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.95 (brs, 1H), 8.94 (s, 1H), 8.49 (s, 1H), 7.40–7.29 (m, 5H), 4.83 (s, 2H), 3.28 (d, *J* = 4.4 Hz, 3H), 2.46 (t, *J* = 7.0 Hz, 2H), 1.72–1.63 (m, 2H), 1.06 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.4, 160.3, 158.3, 150.2, 148.8, 147.5, 132.3, 120.8, 112.1, 111.3, 111.1, 98.9, 63.0, 55.9, 55.8, 37.3, 27.1, 21.6, 21.5, 13.6; IR (neat)*ν*max: 3858, 3672, 3398, 2826, 2522, 2227, 2042, 1633, 1118, 1021 cm^{-1}; LRMS (ESI) *m/z* calcd for $C_{18}H_{20}N_4$ $[M+H]^+$: 293.17; Found: 293.07.



Compound 5d´: Yield: 80%; Brown oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.91 (brs, 1H), 8.75 (s, 1H), 8.47 (s, 1H), 6.82 (d, *J* = 7.6 Hz, 1H), 6.76 (d, *J* = 9.2 Hz, 2H), 3.87 (s, 3H), 3.86 (s, 3H), 3.84 (t, *J* = 6.8 Hz, 2H), 3.02 (d, *J* = 4.8 Hz, 3H), 2.93 (t, *J* = 6.8 Hz, 2H), 2.45 (t, *J* = 7.0 Hz, 2H), 1.69–1.64 (m, 2H), 1.05 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHZ, $CDCl_3$) δ 160.4, 160.3, 158.3, 150.2, 148.8, 147.5, 132.3, 120.8, 112.2, 111.3, 111.2, 98.9, 63.0, 55.9, 55.8, 37.3, 27.1, 21.6, 21.5, 13.6; IR (neat)*ν*max: 3981, 3857, 3689, 3350, 2819, 2515, 2228, 2037, 1694, 1613, 1566, 1535, 1402, 1109, 1021 cm^{-1}; LRMS (ESI) *m/z* calcd for $C_{21}H_{26}N_4O_2$ $[M+H]^+$: 367.21; Found: 367.11.

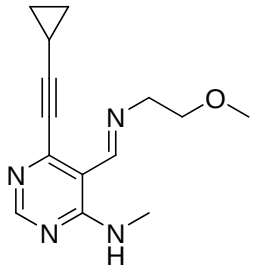


Compound 5e´: Redish brown solid; Yield: 84%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.97 (brs, 1H), 8.72 (s, 1H), 8.47 (s, 1H), 8.31 (brs, 1H), 7.63 (d, *J* = 8.0 Hz, 1H), 7.38 (d, *J* = 8.4 Hz, 1H), 7.20 (t, *J* = 7.6 Hz, 1H), 7.12 (t, *J* = 7.6 Hz, 1H), 7.00 (s, 1H), 3.94 (t, *J* = 6.8 Hz, 2H), 3.14 (t, *J* = 6.8 Hz, 2H), 2.96 (d, *J* = 4.8 Hz, 3H), 2.37 (t, *J* = 6.8 Hz, 2H), 1.63–1.54 (m, 2H), 1.00 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHZ, $CDCl_3$) δ 160.4, 160.2, 158.2, 150.1, 136.3, 127.4, 122.0, 121.9, 119.2, 118.7, 113.8, 111.4, 111.2, 99.0, 76.9, 61.9, 27.13, 27.11, 21.6, 21.4, 13.6; IR (neat)*ν*max: 3574, 2829, 2472, 2200, 2039, 1681, 1615, 1565, 1478, 1401, 1262, 1021, 843, 771, 726; LRMS (ESI) *m/z* calcd for $C_{21}H_{23}N_5$ $[M+H]^+$: 346.20; Found: 346.15.

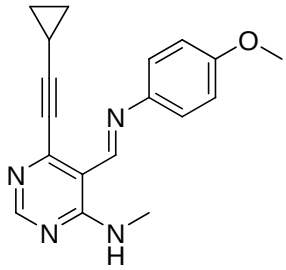


Compound 5f´: Pale yellow solid; Yield: 95%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.90 (brs, 1H), 8.79 (s, 1H), 8.49 (s, 1H), 4.15 (brs, 2H), 3.51 (d, *J* = 6.0 Hz, 2H), 3.08 (d, *J* = 5.2 Hz, 3H), 2.73 (t, *J* = 11.2 Hz, 2H), 2.48 (t, *J* = 7.2 Hz, 2H), 1.86–1.79 (m, 1H), 1.74–1.65 (m, 4H), 1.46 (s, 9H), 1.30–1.17 (m, 2H), 1.07 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.6, 160.5, 158.4, 154.8, 150.3, 111.2, 99.0, 79.3, 77.1, 67.6, 37.6, 30.3, 28.4, 27.3, 21.6, 21.5, 13.6; IR (neat)*ν*max: 3857, 3745, 3457,

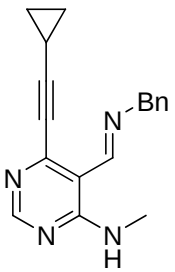
2790, 2228, 2040, 1715, 1669, 1471, 1403, 1114, 1018; LRMS (ESI) *m/z* calcd for $C_{22}H_{33}N_5O_2$ $[M+H]^+$: 400.26; Found: 400.20.



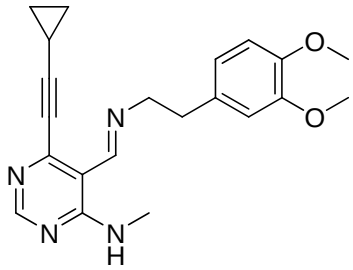
Compound 6a´: Redish brown solid; Yield: 83%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.91 (brs, 1H), 8.81 (s, 1H), 8.45 (s, 1H), 3.80 (t, *J* = 5.2 Hz, 2H), 3.69 (t, *J* = 5.2 Hz, 2H), 3.40 (s, 3H), 3.07 (d, *J* = 5.2 Hz, 3H), 1.52–1.50 (m, 1H), 0.98–0.94 (m, 4H); ^{13}C NMR (100 MHZ, $CDCl_3$) δ 161.7, 160.4, 158.3, 150.3, 111.3, 102.4, 72.25, 72.22, 61.0, 58.9, 27.2, 9.1, 0.3; IR (neat)*ν*max: 3562, 2951, 2833, 2473, 2222, 1666, 1451, 1423, 1112, 1023; LRMS (ESI) *m/z* calcd for $C_{14}H_{18}N_4O$ $[M+H]^+$: 259.15; Found: 259.03.



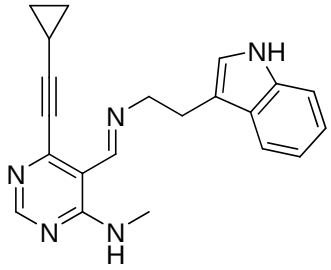
Compound 6b´: Yellow solid; Yield: 66%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.04 (brs, 1H), 9.02 (s, 1H), 8.50 (s, 1H), 7.22 (d, *J* = 7.6 Hz, 2H), 6.97 (d, *J* = 7.6 Hz, 2H), 3.86 (s, 3H), 3.15 (d, *J* = 4.8 Hz, 3H), 1.56–1.52 (m, 1H), 1.00–0.92 (m, 4H); ^{13}C NMR (100 MHZ, $CDCl_3$) δ 160.2, 158.6, 158.5, 156.8, 151.1, 143.7, 122.3, 114.5, 103.0, 55.5, 27.4, 9.3, 0.4; IR (neat)*ν*max: 3439, 3415, 3337, 3317, 2834, 2222, 1620, 1575, 1543, 1504, 1444, 1418, 1372, 1296, 1248, 1168, 1109, 1031, 932, 865, 832, 798, 636, 623; LRMS (ESI) *m/z* calcd for $C_{18}H_{18}N_4O$ $[M+H]^+$: 307.15; Found: 306.97.



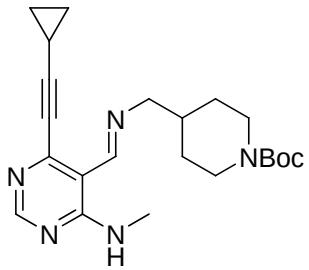
Compound 6c´: Brown solid; Yield: 99%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.95 (brs, 1H), 8.88 (s, 1H), 8.46 (s, 1H), 7.37 (d, *J* = 7.2 Hz, 2H), 7.32 (t, *J* = 7.2 Hz, 3H), 4.84 (s, 2H), 3.05 (d, *J* = 4.8 Hz, 3H), 1.53–1.49 (m, 1H), 0.99-0.89 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 161.2, 160.4, 158.4, 150.5, 138.7, 128.6, 127.8, 127.2, 111.2, 102.5, 72.2, 64.9, 27.3, 9.2, 0.3; IR (neat)*ν*max: 3974, 3857, 3356, 2941, 2828, 2520, 2223, 2040, 1667, 1119, 1022; LRMS (ESI) *m/z* calcd for $C_{18}H_{18}N_4$ $[M+H]^+$: 291.15; Found: 291.00.



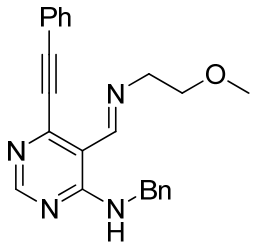
Compound 6d´: Brown solid; Yield: 93%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.91 (brs, 1H), 8.70 (s, 1H), 8.44 (s, 1H), 6.83 (d, *J* = 7.8 Hz, 1H), 6.77 (d, *J* = 7.8 Hz, 2H), 3.87 (s, 3H), 3.863 (s, 3H), 3.862 (t, *J* = 6.9 Hz, 2H), 3.01 (d, *J* = 4.7 Hz, 3H), 2.93 (t, *J* = 6.9 Hz, 2H), 1.53–1.47 (m, 1H), 0.98–0.89 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.4, 160.2, 158.2, 150.1, 148.8, 147.5, 132.2, 120.8, 112.1, 111.2, 111.1, 102.3, 72.1, 62.9, 55.9, 55.8, 37.2, 27.1, 9.1, 0.2; IR (neat)*ν*max: 3859, 3685, 3298, 2771, 2515, 2222, 2037, 1681, 1486, 1400, 1121, 1020; LRMS (ESI) *m/z* calcd for $C_{21}H_{24}N_4O_2$ $[M+H]^+$: 365.19; Found: 365.09.



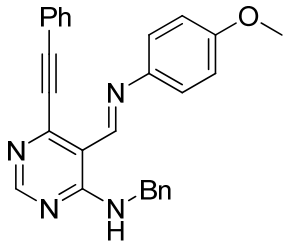
Compound 6e´: Brown solid; Yield: 93%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.98 (brs, 1H), 8.67 (s, 1H), 8.45 (s, 1H), 7.63 (d, *J* = 8.4 Hz, 1H), 7.37 (d, *J* = 8.4 Hz, 1H), 7.19 (t, *J* = 8.0 Hz, 1H), 7.12 (t, *J* = 8.0 Hz, 1H), 7.00 (s, 1H), 3.94 (t, *J* = 7.2 Hz, 2H), 3.14 (t, *J* = 7.2 Hz, 2H), 2.95 (d, *J* = 4.8 Hz, 3H), 1.45–1.38 (m, 1H), 0.90–0.87 (m, 2H), 0.84–0.81 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.4, 160.1, 158.1, 149.9, 136.3, 127.4, 122.0, 121.9, 119.2, 118.7, 113.7, 111.3, 111.2, 102.4, 72.1, 61.9, 27.1, 9.1, 0.2; IR (neat)*ν*max: 3972, 3604, 2948, 2833, 2508, 2223, 2042, 1634, 1512, 1115, 1026, 801; LRMS (ESI) *m/z* calcd for $C_{21}H_{21}N_5$ $[M+H]^+$: 344.18; Found: 344.05.



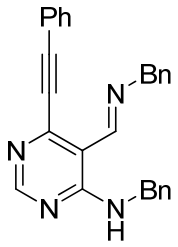
Compound 6f´: Brown solid; Yield: 95% ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.90 (brs, 1H), 8.74 (s, 1H), 8.46 (s, 1H), 4.13 (brs, 2H), 3.52 (d, *J* = 6.0 Hz, 2H), 3.07 (d, *J* = 4.8 Hz, 3H), 2.73 (t, *J* = 11.4 Hz, 2H), 1.82 (brs, 1H), 1.72 (d, *J* = 12.8 Hz, 2H), 1.56–1.50 (m, 1H), 1.47 (s, 9H), 1.26–1.21 (m, 2H), 0.99–0.94 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.44, 160.37, 158.2, 154.7, 150.1, 111.1, 102.3, 79.2, 72.1, 67.5, 30.2, 28.3, 27.2, 9.1, 0.2; IR (neat)*ν*max: 3858, 3326, 2942, 2821, 2522, 2222, 2039, 1926, 1633, 1447, 1167, 1021; LRMS (ESI) *m/z* calcd for $C_{22}H_{31}N_5O_2$ $[M+H]^+$: 398.25; Found: 398.19.



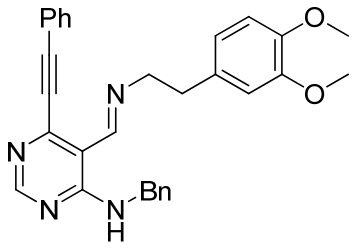
Compound 7a´: Pale yellow solid; Yield: 67%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.54 (brs, 1H), 8.99 (s, 1H), 8.55 (s, 1H), 7.62 (d, *J* = 7.6 Hz, 2H), 7.42–7.35 (m, 7H), 7.30–7.27 (m, 1H), 4.81 (d, *J* = 5.6 Hz, 2H), 3.81 (t, *J* = 5.6 Hz, 2H), 3.64 (t, *J* = 5.6 Hz, 2H), 3.33 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 161.2, 159.9, 158.5, 150.1, 138.3, 132.1, 129.7, 128.6, 128.5, 127.3, 127.2, 121.4, 111.3, 96.6, 85.0, 72.1, 60.9, 58.9, 44.4; IR (neat)*ν*max: 3858, 3823, 3687, 3360, 3259, 2830, 2510, 2215, 2039, 1714, 1661, 1450, 1400, 1110, 1022; LRMS (ESI) *m/z* calcd for $C_{23}H_{22}N_4O$ $[M+H]^+$: 371.18; Found: 370.99.



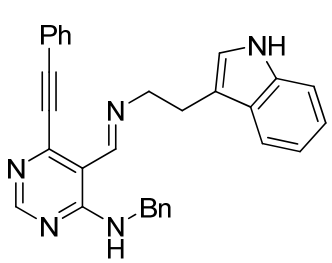
Compound 7b´: Yellow solid; Yield: 62%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.70 (brs, 1H), 9.23 (s, 1H), 8.59 (s, 1H), 7.62 (d, *J* = 6.4 Hz, 2H), 7.41–7.30 (m, 8H), 7.20 (d, *J* = 8.4 Hz, 2H), 6.94 (d, *J* = 9.2 Hz, 2H), 4.88 (d, *J* = 5.6 Hz, 2H), 3.83 (s, 3H); ^{13}C NMR (100 MHZ, $CDCl_3$) δ 159.6, 158.9, 158.7, 155.9, 150.8, 143.2, 138.2, 132.2, 129.8, 128.7, 128.6, 127.3, 122.3, 121.3, 114.6, 111.9, 97.1, 85.2, 55.5, 44.6; IR (neat)*ν*max: 3356, 2797, 2523, 2144, 2042, 1680, 1614, 1557, 1472, 1412, 1107, 1017; LRMS (ESI) *m/z* calcd for $C_{27}H_{22}N_4O$ $[M+H]^+$: 419.18; Found: 419.24.



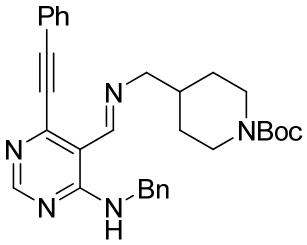
Compound 7c´: Pale yellow solid; Yield: 84%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.57 (brs, 1H), 9.05 (s, 1H), 8.56 (s, 1H), 7.58 (d, *J* = 7.6 Hz, 2H), 7.42–7.36 (m, 3H), 7.30-7.24 (m, 7H), 7.22 (d, *J* = 7.6 Hz, 2H), 4.84 (s, 2H), 4.78 (d, *J* = 5.6 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.4, 159.8, 158.6, 150.2, 138.5, 138.1, 132.1, 129.7, 128.60, 128.58, 128.5, 127.8, 127.5, 127.2, 127.2, 121.3, 111.3, 96.6, 85.0, 65.0, 44.5; IR (neat)*ν*max: 3672, 3441, 2828, 2506, 2215, 2037, 1630, 1104, 1027, 796; LRMS (ESI) *m/z* calcd for $C_{27}H_{22}N_4$ $[M+H]^+$: 403.18; Found: 403.06.



Compound 7d´: Yellow oil; Yield: 88%; ^{1}H NMR (500 MHz, $CDCl_3$) δ 10.53 (brs, 1H), 8.86 (s, 1H), 8.53 (s, 1H), 7.58 (d, *J* = 8.0 Hz, 2H), 7.42–7.28 (m, 8H), 6.69 (s, 3H), 4.78 (d, *J* = 5.5 Hz, 2H), 3.89 (t, *J* = 7.5 Hz, 2H), 3.792 (s, 3H), 3.787 (s, 3H), 2.91 (t, *J* = 7.0 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.02, 159.97, 158.5, 150.0, 148.8, 147.5, 138.5, 132.1, 132.0, 129.7, 128.6, 128.5, 127.2, 121.4, 120.8, 112.0, 111.3, 111.2, 96.5, 85.0, 63.0, 55.8, 55.7, 44.2, 37.1, 14.2; IR (neat)*ν*max: 3976, 3856, 3401, 2806, 2512, 2216, 2042, 1671, 1611, 1555, 1464, 1413, 1021; LRMS (ESI) *m/z* calcd for $C_{30}H_{28}N_4O_2$ $[M+H]^+$: 477.22; Found: 477.17.

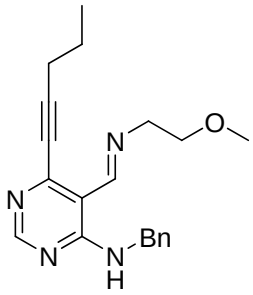


Compound 7e´: Pale yellow solid; Yield: 85%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.58 (brs, 1H), 8.82 (s, 1H), 8.53 (s, 1H), 7.89 (brs, 1H), 7.60 (d, *J* = 8.0 Hz, 1H), 7.48–7.45 (m, 2H), 7.41–7.29 (m, 8H), 7.17 (t, *J* = 7.2 Hz, 1H), 7.10 (t, *J* = 7.2 Hz, 1H), 6.8s1 (d, *J* = 2.4 Hz, 1H), 4.75 (d, *J* = 6.0 Hz, 2H), 3.96 (t, *J* = 6.8 Hz, 2H), 3.10 (t, *J* = 6.8 Hz, 2H); ^{13}C NMR (100 MHZ, $CDCl_3$) δ 159.94, 159.90, 158.4, 149.8, 138.6, 136.2, 132.1, 131.8, 129.7, 128.9, 128.8, 128.6, 128.5, 128.3, 127.4, 127.3, 127.2, 126.3, 122.1, 122.0, 121.3, 119.2, 118.6, 113.5, 111.3, 111.2, 96.6, 84.9, 61.6, 44.2, 27.0; IR (neat)*ν*max: 3980, 3856, 3383, 2945, 2830, 2501, 2233, 2037, 1681, 1612, 1557, 1530, 1473, 1407, 1209, 1116, 1021; LRMS (ESI) *m/z* calcd for $C_{30}H_{25}N_5$ $[M+H]^+$: 456.21; Found: 456.15.

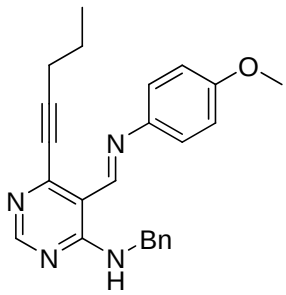


Compound 7f´: Yellow oil; Yield: 86%; ^{1}H NMR (400 MHz, $CDCl_3$) δ ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.43 (brs, 1H), 8.91 (s, 1H), 8.57 (s, 1H), 7.61 (dd, *J* = 7.8 Hz, *J* = 1.6 Hz, 2H), 7.43–7.31 (m, 8H), 4.77 (d, *J* = 5.5 Hz, 2H), 4.06 (brs, 2H), 3.49 (d, *J* = 6.6 Hz, 2H), 2.62 (t, *J* = 11.4 Hz, 2H), 1.69–1.63 (m, 1H), 1.57 (d, *J* = 15.2 Hz, 2H), 1.46 (s, 9H), 1.16-1.05 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 162.5, 160.0, 159.7, 158.5, 154.8, 149.9, 138.0, 132.1, 129.8, 128.6, 128.5, 127.8, 127.5, 121.3, 111.2, 96.6, 84.9, 79.3, 67.3, 44.8, 37.7, 36.4, 31.4, 30.2, 28.4, 28.3; IR (neat)*ν*max: 3855, 3673, 3321, 2829, 2506,

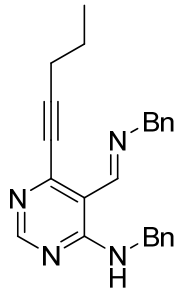
2215, 2043, 1423, 1026; LRMS (ESI) *m/z* calcd for $C_{31}H_{35}N_5O_2$ $[M+H]^+$: 510.28; Found: 510.24.



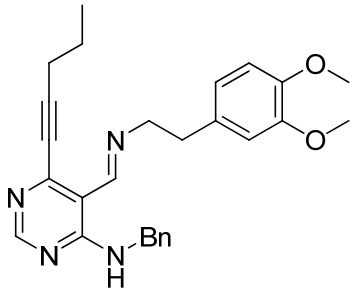
Compound 8a´: Brown oil; Yield: 66%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.49 (brs, 1H), 8.88 (s, 1H), 8.48 (s, 1H), 7.34 (d, *J* = 4.4 Hz, 4H), 7.30–7.25 (m, 1H), 4.79 (d, *J* = 5.6 Hz, 2H), 3.77 (t, *J* = 6.0 Hz, 2H), 3.62 (t, *J* = 6.0 Hz, 2H), 3.32 (s, 3H), 2.48 (t, *J* = 7.2 Hz, 2H), 1.73–1.64 (m, 2H), 1.07 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 161.6, 159.9, 158.4, 150.7, 138.4, 128.5, 127.3, 127.1, 111.1, 99.1, 72.2, 60.8, 58.9, 44.3, 21.6, 21.5, 13.6; IR (neat)*ν*max: 3453, 2936, 2833, 2229, 1643, 1604, 1554, 1522, 1450, 1113, 1030, 798, 742, 670, 645; LRMS (ESI) *m/z* calcd for $C_{20}H_{24}N_4O$ $[M+H]^+$: 337.20; Found: 337.06.



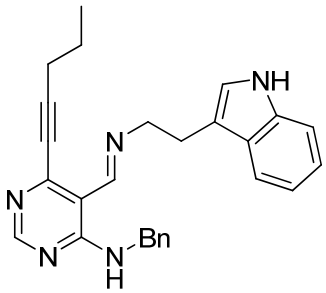
Compound 8b´: Yellow solid; Yield: 69%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.65 (t, *J* = 4.9 Hz, 1H), 9.13 (s, 1H), 8.52 (s, 1H), 7.40-7.29 (m, 5H), 7.17 (d, *J* = 8.4 Hz, 2H), 6.93 (d, *J* = 8.4 Hz, 2H), 4.85 (d, *J* = 5.5 Hz, 2H), 3.83 (s, 3H), 2.50 (t, *J* = 7.0 Hz, 2H), 1.75–1.65 (m, 2H), 1.08 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.6, 158.8, 158.6, 156.4, 151.4, 143.3, 138.3, 128.6, 127.3, 127.3, 122.3, 114.5, 111.7, 99.7, 77.2, 55.5, 44.5, 21.7, 21.6, 13.7; IR (neat)*ν*max: 3857, 3686, 3332, 2941, 2830, 2941, 2228, 2040, 1412, 1022; LRMS (ESI) *m/z* calcd for $C_{24}H_{24}N_4O$ $[M+H]^+$: 385.20; Found: 385.14.



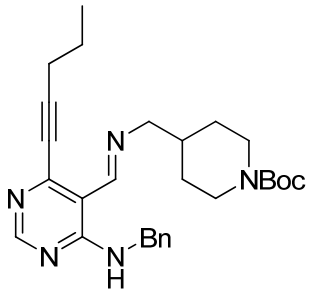
Compound 8c´: Brown solid; Yield: 94%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.51 (brs, 1H), 8.95 (s, 1H), 8.49 (s, 1H), 7.33–7.26 (m, 8H), 7.21 (d, *J* = 7.2 Hz, 2H), 4.80 (s, 2H), 4.76 (d, *J* = 5.2 Hz, 2H), 2.47 (t, *J* = 7.2 Hz, 2H), 1.73–1.64 (m, 2H), 1.07 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHZ, $CDCl_3$) δ 160.9, 159.8, 158.6, 150.8, 138.7, 138.2, 128.6, 128.5, 127.7, 127.4, 127.2, 127.1, 111.2, 99.2, 65.0, 44.4, 21.6, 21.5, 13.7; IR (neat)*ν*max: 3981, 3857, 3351, 2830, 2498, 2217, 2043, 1695, 1406, 1022; LRMS (ESI) *m/z* calcd for $C_{24}H_{24}N_4$ $[M+H]^+$: 369.20; Found: 369.12.



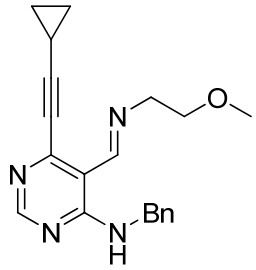
Compound 8d´: Brown oil; Yield: 83%; ^{1}H NMR (500 MHz, $CDCl_3$) δ 10.48 (brs, 1H), 8.76 (s, 1H), 8.46 (s, 1H), 7.34–7.26 (m, 5H), 6.71-6.66 (m, 3H), 4.76 (d, *J* = 5.5 Hz, 2H), 3.85 (t, *J* = 7.0 Hz, 2H), 3.82 (s, 3H), 3.81 (s, 3H), 2.89 (t, *J* = 7.0 Hz, 2H), 2.45 (t, *J* = 7.5 Hz, 2H), 1.70–1.63 (m, 2H), 1.05 (t, *J* = 7.5 Hz, 3H); ^{13}C NMR (100 MHZ, $CDCl_3$) δ 160.3, 159.9, 158.4, 150.5, 148.8, 147.4, 138.5, 132.0, 128.6, 128.5, 127.7, 127.3, 127.1, 120.8, 111.9, 111.1, 99.1, 62.9, 55.8, 55.7, 44.1, 37.1, 21.6, 21.5, 13.6; IR (neat)*ν*max: 3974, 3857, 3746, 3405, 2943, 2828, 2506, 2230, 2043, 1695, 1404, 1112, 1024; LRMS (ESI) *m/z* calcd for $C_{27}H_{30}N_4O_2$ $[M+H]^+$: 443.24; Found: 443.15.



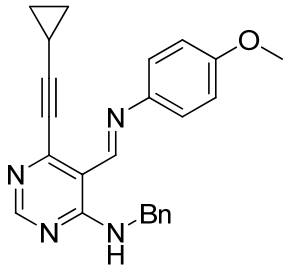
Compound 8e´: Pale orange solid; Yield: 84%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.54 (brs, 1H), 8.75 (s, 1H), 8.46 (s, 1H), 7.92 (brs, 1H), 7.59 (d, *J* = 7.8 Hz, 1H), 7.33–7.25 (m, 6H), 7.18 (t, *J* = 7.4 Hz, 1H), 7.10 (t, *J* = 7.4 Hz, 1H), 6.79 (s, 1H), 4.72 (d, *J* = 5.5 Hz, 2H), 3.93 (t, *J* = 6.8 Hz, 2H), 3.08 (t, *J* = 6.8 Hz, 2H), 2.39 (t, *J* = 7.0 Hz, 2H), 1.65-1.56 (m, 2H), 1.01 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.2, 159.9, 158.3, 150.4, 138.7, 136.2, 128.5, 127.4, 127.3, 127.1, 122.0, 121.9, 119.2, 118.6, 113.5, 111.19, 111.16, 99.1, 76.7, 61.5, 44.1, 27.1, 21.6, 21.4, 13.6; IR (neat)*ν*max: 3858, 3597, 2948, 2831, 2530, 2229, 2039, 1568, 1118, 1023, 744; LRMS (ESI) *m/z* calcd for $C_{27}H_{27}N_5$ $[M+H]^+$: 422.23; Found: 422.17.



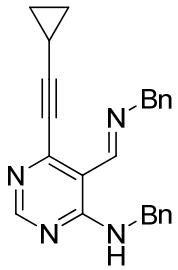
Compound 8f´: Yellow oil; Yield: 92%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.38 (brs, 1H), 8.81 (s, 1H), 8.49 (s, 1H), 7.37–7.30 (m, 5H), 4.74 (d, *J* = 5.2 Hz, 2H), 4.05 (brs, 2H), 3.45 (d, *J* = 6.4 Hz, 2H), 2.61 (t, *J* = 12.0 Hz, 2H), 2.48 (t, *J* = 7.2 Hz, 2H), 1.72–1.63 (m, 3H), 1.55 (d, *J* = 12.4 Hz, 2H), 1.47 (s, 9H), 1.11 (td, *J* = 12.4 Hz, *J* = 4.0 Hz, 2H), 1.07 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.4, 159.7, 158.4, 154.8, 150.5, 138.1, 128.6, 127.7, 127.4, 111.0, 99.2, 79.3, 77.0, 67.2, 44.7, 37.7, 30.2, 28.4, 21.6, 21.5, 13.6; IR (neat)*ν*max: 3862, 3432, 2827, 2522, 2229, 2039, 1695, 1450, 1024; LRMS (ESI) *m/z* calcd for $C_{28}H_{37}N_5O_2$ $[M+H]^+$: 476.29; Found: 476.31.



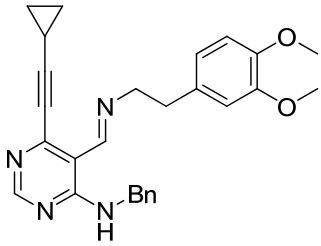
Compound 9a´: Brown oil; Yield: 87%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.49 (brs, 1H), 8.83 (s, 1H), 8.45 (s, 1H), 7.34 (d, *J* = 4.3 Hz, 4H), 7.30-7.24 (m, 1H), 4.78 (d, *J* = 5.8 Hz, 2H), 3.77 (t, *J* = 5.3 Hz, 2H), 3.62 (t, *J* = 5.3 Hz, 2H), 3.33 (s, 3H), 1.56–1.49 (m, 1H), 0.97-0.94 (m, 4H); ^{13}C NMR (100 MHZ, $CDCl_3$) δ 161.5, 159.9, 158.4, 150.6, 138.4, 128.5, 127.3, 127.1, 111.1, 102.5, 72.2, 60.8, 58.9, 44.3, 9.2, 0.3; IR (neat)*ν*max: 3972, 3858, 3347, 2516, 2223, 2040, 1494, 1192, 1115, 1023; LRMS (ESI) *m/z* calcd for $C_{20}H_{22}N_4O$ $[M+H]^+$: 335.18; Found: 335.04.



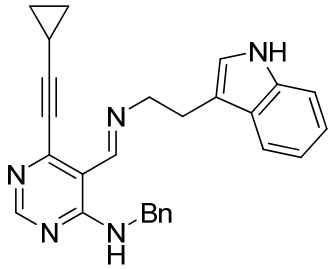
Compound 9b´: Brown solid; Yield: 61%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.63 (brs, 1H), 9.06 (s, 1H), 8.50 (s, 1H), 7.40–7.34 (m, 4H), 7.29 (d, *J* = 6.7 Hz, 1H), 7.17 (d, *J* = 8.8 Hz, 2H), 6.94 (d, *J* = 8.8 Hz, 2H), 4.84 (d, *J* = 5.9 Hz, 2H), 3.83 (s, 3H), 1.58–1.52 (m, 1H), 1.00-0.94 (m, 4H); ^{13}C NMR (100 MHZ, $CDCl_3$) δ 159.6, 158.7, 158.6, 156.4, 151.3, 143.3, 138.3, 128.6, 127.3, 127.3, 122.3, 116.4, 114.8, 114.6, 111.7, 103.2, 72.3, 55.5, 44.5, 9.3, 0.4; IR (neat)*ν*max: 3859, 3690, 3357, 2826, 2506, 2221, 2040, 1696, 1615, 1567, 1414, 1020; LRMS (ESI) *m/z* calcd for $C_{24}H_{22}N_4O$ $[M+H]^+$: 383.18; Found: 383.10.



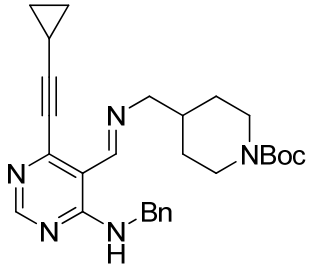
Compound 9c´: Orange solid; Yield: 95%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.55 (brs, 1H), 8.88 (s, 1H), 8.46 (s, 1H), 7.32–7.24 (m, 8H), 7.19 (d, *J* = 8.0 Hz, 2H), 4.79 (s, 2H), 4.74 (d, *J* = 5.6 Hz, 2H), 1.53-1.50 (m, 1H), 0.97–0.93 (m, 4H); ^{13}C NMR (100 MHZ, $CDCl_3$) δ 160.7, 159.8, 158.2, 150.3, 138.6, 138.1, 128.6, 128.5, 127.7, 127.4, 127.2, 127.1, 111.0, 98.9, 71.9, 64.9, 44.5, 9.3, 0.3; IR (neat)*ν*max: 3857, 3698, 3389, 2825, 2500, 2223, 2042, 1447, 1023; LRMS (ESI) *m/z* calcd for $C_{24}H_{22}N_4$ $[M+H]^+$: 367.18; Found: 367.09.



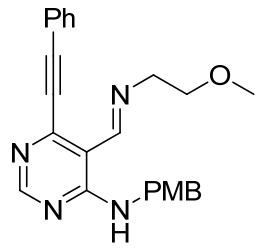
Compound 9d´: Brown oil; Yield: 92%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.49 (brs, 1H), 8.71 (s, 1H), 8.44 (s, 1H), 7.35–7.26 (m, 5H), 6.69 (t, *J* = 6.5 Hz, 3H), 4.75 (d, 5.9 Hz, 2H), 3.85 (t, *J* = 7.0 Hz, 2H), 3.82 (s, 3H), 3.81 (s, 3H), 2.89 (t, *J* = 7.0 Hz, 2H), 1.54–1.47 (m, 1H), 0.98-0.89 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.3, 160.1, 158.0, 148.9, 147.6, 138.5, 132.2, 128.7, 127.32, 127.31, 120.9, 112.1, 111.2, 111.1, 63.0, 56.0, 55.9, 44.3, 37.3, 9.4, 0.3; IR (neat)*ν*max: 3857, 3360, 2823, 2514, 2222, 2040, 1680, 1612, 1558, 1478, 1024; LRMS (ESI) *m/z* calcd for $C_{27}H_{28}N_4O_2$ $[M+H]^+$: 441.22; Found: 441.16.



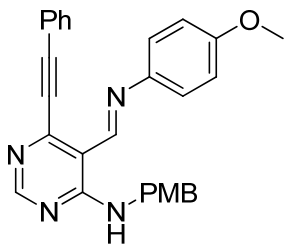
Compound 9e´: Yellow solid; Yield: 71%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.53 (brs, 1H), 8.70 (s, 1H), 8.44 (s, 1H), 7.79 (brs, 1H), 7.60 (d, *J* = 8.0 Hz, 1H), 7.35–7.21 (m, 5H), 7.19 (t, *J* = 7.4 Hz, 1H), 7.11 (t, *J* = 7.4 Hz, 1H), 6.79 (s, 1H), 4.72 (d, *J* = 5.6 Hz, 2H), 3.93 (t, *J* = 6.8 Hz, 2H), 3.08 (t, *J* = 6.8 Hz, 2H), 1.47–1.43 (m, 1H), 0.95-0.84 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.1, 159.9, 158.2, 150.3, 138.6, 136.2, 128.5, 127.35, 127.27, 127.1, 122.0, 121.9, 119.2, 118.6, 113.5, 111.2, 111.1, 102.6, 72.1, 61.5, 44.1, 27.1, 9.1, 0.3; IR (neat)*ν*max: 3977, 3857, 3682, 3374, 2806, 2502, 2224, 2038, 1402, 1113, 1025; LRMS (ESI) *m/z* calcd for $C_{27}H_{25}N_5$ $[M+H]^+$: 420.21; Found: 420.13.



Compound 9f´: Yellow oil; Yield: 92%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.38 (brs, 1H), 8.76 (s, 1H), 8.47 (s, 1H), 7.35–7.30 (m, 5H), 4.73 (d, *J* = 5.2 Hz, 2H), 4.05 (brs, 1H), 3.45 (d, *J* = 6.8 Hz, 2H), 2.61 (t, *J* = 10.8 Hz, 2H), 1.65–1.62 (m, 1H), 1.57-1.51 (m, 3H), 1.47 (s, 9H), 1.11-1.07 (m, 2H), 0.98-0.95 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.3, 159.6, 158.3, 154.7, 150.4, 138.1, 128.6, 127.7, 127.4, 111.0, 102.5, 79.3, 72.1, 67.2, 44.7, 37.7, 30.2, 28.4, 9.2, 0.3; IR (neat)*ν*max: 3973, 3857, 3571, 2941, 2831, 2517, 2224, 2042, 1571, 1023; LRMS (ESI) *m/z* calcd for $C_{28}H_{35}N_5O_2$ $[M+H]^+$: 474.28; Found: 474.14.



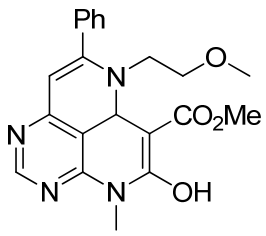
Compound 10a´: Yellow solid; Yield: 95%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.46 (t, *J* = 5.5 Hz, 1H), 8.98 (s, 1H), 8.55 (s, 1H), 7.61 (dd, *J* = 7.6 Hz, *J* = 1.8 Hz, 2H), 7.44–7.36 (m, 3H), 7.29 (d, *J* = 8.6 Hz, 2H), 6.89 (d, *J* = 8.6 Hz, 2H), 4.73 (d, *J* = 5.5 Hz, 2H), 3.80 (s, 3H), 3.77 (t, *J* = 5.5 Hz, 2H), 3.63 (t, *J* = 5.5 Hz, 2H), 3.33 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 161.2, 159.8, 158.8, 158.5, 150.1, 132.1, 130.4, 129.7, 128.7, 128.5, 121.4, 114.0, 111.3, 96.5, 85.0, 72.2, 60.9, 58.9, 55.2, 43.9; IR (neat)*ν*max: 3591, 2947, 2836, 2504, 2039, 1649, 1116, 1020; LRMS (ESI) *m/z* calcd for $C_{24}H_{24}N_4O_2$ $[M+H]^+$: 401.19; Found: 401.15.



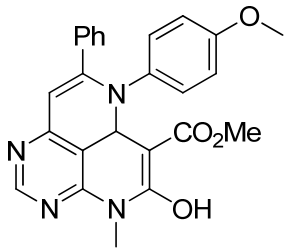
Compound 10b´: Yellow solid; Yield: 92%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.63 (brs, 1H), 9.22 (s, 1H), 8.59 (s,1H), 7.62 (d, *J* = 7.2 Hz, 2H), 7.44–7.38 (m, 3H), 7.34 (d, *J* = 8.4 Hz, 2H), 7.20 (d, *J* = 8.8 Hz, 2H), 6.94 (d, *J* = 8.8 Hz, 2H), 6.91 (d, *J* = 8.4 Hz, 2H), 4.80 (d, *J* = 5.6 Hz, 2H), 3.84 (s, 3H), 3.82 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.5, 158.89, 159.87, 158.7, 155.9, 150.7, 143.2, 132.2, 130.2, 129.8, 128.7, 128.6, 122.3, 121.4, 114.6, 114.1, 111.9, 97.1, 85.1, 55.5, 55.3, 44.1; IR (neat)*ν*max: 3974, 3856, 3660, 3372, 2831, 2516, 2225, 2040, 1473, 1118, 1021; LRMS (ESI) *m/z* calcd for $C_{28}H_{24}N_4O_2$ $[M+H]^+$: 449.19; Found: 449.15.

4. General synthetic procedure for compounds 4a–10a

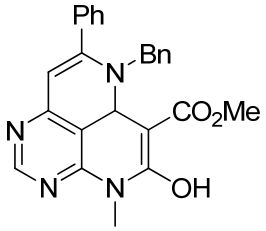
To a DCE solution of **4a´–10a´** (0.3 mmol), AgOTf (10 mol%) and AcOH (2.0 equiv.) were added. After stirring at 80 °C for 2 h (the reaction completion was monitored by TLC), the reaction mixture was filtered under Na_2SO_4 pad and washed thrice with DCM. After the removal of solvent under the reduced pressure, the reaction mixture was dissolved with dimethylformamide (DMF) and added with 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU) (3.0 equiv.) and dimethylmalonates (3.0 equiv.). The resulting mixture was stirred at 80 °C for 2 h. The resultant was quenched by addition of deionized water and extracted twice with ethyl acetate (EtOAc). The combined organic layer was washed with brine and dried with anhydrous Na_2SO_4(s). After the solvent was removed under the reduced pressure, the residue was purified by silica-gel flash column chromatography to obtain **4a**–**10a**.



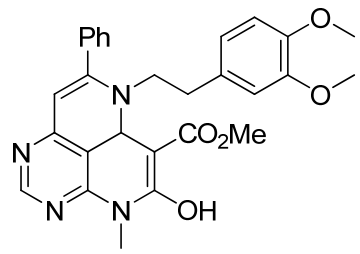
Compound 4a: Yield: 97%; Yellow solid; mp: 124–128 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 11.10 (s, 1H), 8.71 (s, 1H), 8.62 (s, 1H), 7.49–7.47 (m, 3H), 7.44–7.42 (m, 2H), 5.55 (s, 1H), 3.91 (s, 3H), 3.77 (s, 3H), 3.49 (t, *J* = 5.5 Hz, 2H), 3.42 (t, *J* = 6.0 Hz, 2H), 3.40 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.5, 163.6, 162.8, 159.9, 157.8, 155.1, 138.6, 136.4, 129.5, 128.6, 127.8, 119.6, 104.5, 89.3, 71.9, 59.0, 52.5, 44.9, 28.6; IR (neat)*ν*max: 3859, 3526, 2948, 2834, 2413, 2041, 1661, 1568, 1119, 1021 cm^{-1}; HRMS (FAB+) *m/z* calcd for $C_{21}H_{22}N_4O_4$ $[M+H]^+$: 395.1719; Found: 395.1728; Registration No.: 1477473-56-5.



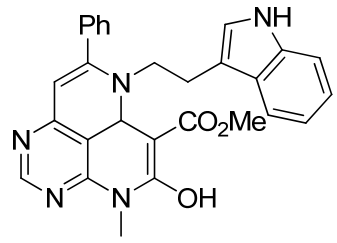
Compound 4b: Yield: 70%; Scarlet solid; mp: 141–145 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 12.58 (s, 1H), 8.79 (s, 1H), 8.73 (s, 1H), 7.42–7.36 (m, 5H), 6.77 (d, *J* = 8.5 Hz, 2H), 6.70 (d, *J* = 8.0 Hz, 2H), 5.86 (s, 1H), 3.96 (s, 3H), 3.80 (s, 3H), 3.74 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 165.4, 162.6, 159.7, 158.9, 157.7, 156.4, 155.2, 138.4, 136.6, 132.8, 129.5, 128.52, 128.49, 124.7, 120.4, 114.0, 105.3, 92.1, 55.3, 52.6, 28.7; IR (neat)*ν*max: 3858, 3607, 2944, 2832, 2437, 2041, 1661, 1110, 1022 cm^{-1}; HRMS (FAB+) *m/z* calcd for $C_{25}H_{22}N_4O_4$ $[M+H]^+$:443.1719; Found: 443.1728; Registration No.: 1477473-54-3.



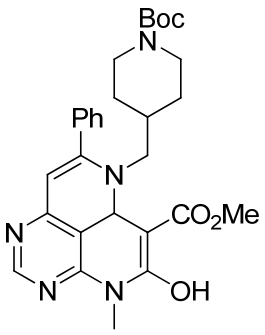
Compound 4c: Yield: 76%; Yellow solid; mp: 126–130 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 11.31 (brs, 1H), 8.66 (s, 1H), 8.64 (s, 1H), 7.47–7.40 (m, 5H), 7.34 (t, *J* = 7.2 Hz, 2H), 7.28 (d, *J* = 7.2 Hz, 1H), 7.23 (d, *J* = 7.2 Hz, 2H), 5.62 (s, 1H), 4.48(d, *J* = 6.2 Hz, 2H), 3.92 (s, 3H), 3.77 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.5, 163.8, 163.0, 159.9, 157.9, 155.2, 138.8, 138.6, 136.2, 129.6, 128.7, 128.6, 127.8, 127.4, 126.7, 120.0, 112.5, 104.7, 89.8, 63.9, 52.6, 48.9, 28.6; IR (neat)*ν*max: 3985, 3857, 3623, 2506, 2229, 2041, 1661, 1450, 1106, 1023 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{25}H_{22}N_4O_3$ $[M+Na]^+$: 449.1590; Found: 449.1584.



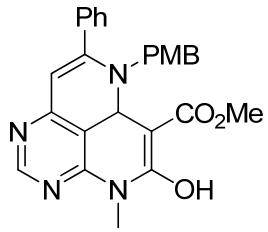
Compound 4d: Yield: 69%; Yellow solid; mp: 145–149 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.96 (brs, 1H), 8.59 (s, 1H), 8.55 (s, 1H), 7.46–7.44 (m, 3H), 7.31-7.29 (m, 2H), 6.80 (d, *J* = 8.0 Hz, 1H), 6.70 (d, *J* = 8.0 Hz, 1H), 6.60 (s, 1H), 5.48 (s, 1H), 3.95 (s, 3H), 3.91 (s, 3H), 3.77 (s, 3H), 3.76 (s, 3H), 3.49 (q, *J* = 6.4 Hz, 2H), 2.79 (t, *J* = 6.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.5 163.7, 162.7, 159.9, 157.7, 155.1, 149.0, 147.9, 138.6, 136.5, 130.8, 129.4, 128.5, 127.7, 121.0, 119.6, 112.0, 111.2, 104.4, 89.2, 77.2, 56.0, 55.7, 52.5, 46.9, 37.0, 28.6; IR (neat)*ν*max: 3858, 3466, 2831, 2226, 2039, 1681, 1414, 1112, 1024 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{28}H_{28}N_4O_5$ $[M+Na]^+$: 523.1957; Found: 523.1954.



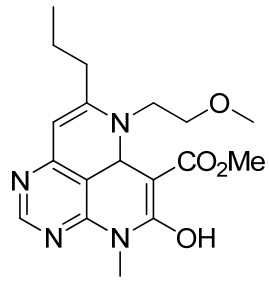
Compound 4e: Yield: 62%; Scarlet solid; mp: 155–159 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 11.00 (brs, 1H), 8.58 (s, 1H), 8.37 (s, 1H), 8.07 (brs, 1H), 7.46-7.38 (m, 5H), 7.33 (dd, *J* = 7.8 Hz, *J* = 1.0 Hz, 2H), 7.20 (t, *J* = 7.4 Hz, 1H), 7.07-7.04 (m, 2H), 5.48 (s, 1H), 3.90 (s, 3H), 3.75 (s, 3H), 3.59 (q, *J* = 6.9 Hz, 2H), 3.01 (t, *J* = 6.9 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.5, 163.8, 162.6, 159.9, 157.7, 155.1, 138.7, 136.5, 136.3, 129.4, 128.6, 127.7, 127.2, 122.6, 122.2, 119.4, 118.5, 112.3, 111.3, 104.4, 89.1, 52.5, 45.8, 28.6, 26.9; IR (neat)*ν*max: 3760, 3452, 2920, 2834, 2524, 2231, 2043, 1734, 1649, 1553, 1454, 1284, 1230 ,1120, 1027, 800, 733 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{28}H_{25}N_5O_3$ $[M+Na]^+$: 502.1855; Found: 502.1847.



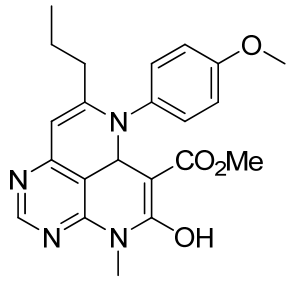
Compound 4f: Yield: 78%; Yellow solid; mp: 136–140 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 11.03 (brs, 1H), 8.68 (s, 1H), 8.61 (s, 1H), 7.49 (t, *J* = 3.0 Hz, 3H), 7.42–7.40 (m, 2H), 5.54 (s, 1H), 4.11 (brs, 2H), 3.92 (s, 3H), 3.77 (s, 3H), 3.16 (t, *J* = 6.4 Hz, 2H), 2.67 (brs, 2H), 1.69–1.61 (m, 3H), 1.44 (s, 9H), 1.15–1.07 (m, 2H)s; ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.5, 164.0, 162.7, 159.8, 157.8, 155.2, 154.7, 138.6, 136.4, 129.6, 128.7, 127.8, 119.8, 104.6, 89.3, 79.5, 52.5, 50.8, 37.8, 29.7, 28.6, 28.4; IR (neat)*ν*max: 3979, 3856, 3647, 2947, 2833, 2451, 2226, 2040, 1668, 1023 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{29}H_{35}N_5O_5$ $[M+Na]^+$: 556.2536; Found: 556.2533.



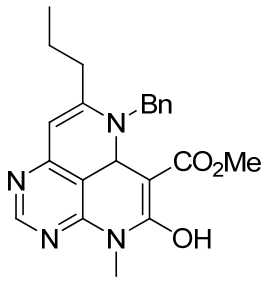
Compound 4g: Yield: 78%; Yellow solid; mp: 142–146 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 11.25 (brs, 1H), 8.65 (s, 1H), 8.63 (s, 1H), 7.48–7.40 (m, 5H), 7.14 (d, *J* = 8.8 Hz, 2H), 6.87 (d, *J* = 8.8 Hz, 2H), 5.60 (s, 1H), 4.40 (d, *J* = 6.0 Hz, 2H), 3.92 (s, 3H), 3.80 (s, 3H), 3.77 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.6, 163.7, 162.9, 159.9, 158.9, 157.9, 155.2, 138.6, 136.3, 130.7, 129.6, 128.6, 128.0, 127.8, 119.9, 114.1, 104.7, 89.6, 55.3, 53.7, 52.6, 48.5, 29.7, 28.6; IR (neat)*ν*max: 3857, 3526, 2942, 2830, 2410, 2222, 2043, 1648, 1118, 1026 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{26}H_{24}N_4O_4$ $[M+Na]^+$: 479.1695; Found: 479.1690.



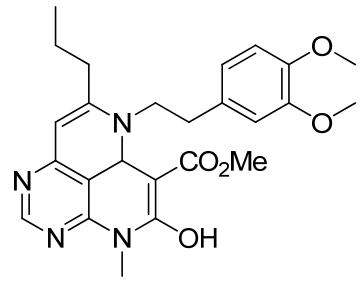
Compound 5a: Yield: 77%; Yellow solid; mp: 131–135 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 11.17 (s, 1H), 8.67 (s, 1H), 8.57 (s, 1H), 5.48 (s, 1H), 3.96 (s, 3H), 3.75 (s, 3H), 3.62 (t, *J* = 5.0 Hz, 2H), 3.57 (t, *J* = 5.0 Hz, 2H), 3.45 (s, 3H), 2.40 (t, *J* = 8.0 Hz, 2H), 1.71–1.61 (m, 2H), 1.06 (t, *J* = 7.0 Hz, 3H); ^{13}C NMR (100 MHZ, $CDCl_3$) δ 165.9, 165.4, 162.7, 160.0, 157.8, 155.1, 138.9, 118.9, 103.8, 86.8, 71.6, 59.1, 52.5, 43.2, 35.8, 29.6, 28.5, 22.0, 14.0; IR (neat)*ν*max: 3858, 3600, 2947, 2830, 2446, 2042, 1536, 1117, 1021 cm^{-1}; HRMS (FAB+) *m/z* calcd for $C_{18}H_{24}N_4O_4$ $[M+H]^+$: 361.1876; Found: 361.1873; Registration No.:1477473-62-3.



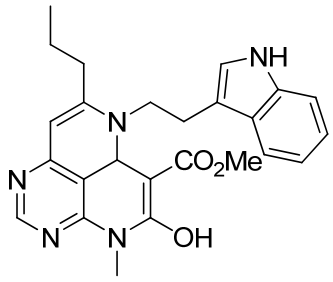
Compound 5b: Yield: 83%; Scarlet solid; mp: 124–128 ^{o}C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 12.51 (s, 1H), 8.73 (s, 1H), 8.63 (s, 1H), 7.13 (d, *J* = 8.5 Hz, 2H), 6.93 (d, *J* = 9.0 Hz, 2H), 5.66 (s, 1H), 3.98 (s, 3H), 3.85 (s, 3H), 3.77 (s, 3H), 2.40 (t, *J* = 7.5 Hz, 2H), 1.59–1.54 (m, 2H), 0.90 (t, *J* = 7.5 Hz, 3H); ^{13}C NMR (125 MHZ, $CDCl_3$) δ 165.8, 164.2, 162.7, 159.8, 157.7, 157.5, 155.1, 138.8, 138.6, 131.3, 127.3, 119.5, 114.4, 104.2, 87.6, 55.5, 52.6, 35.4, 28.6, 22.1, 13.8; IR (neat)*ν*max: 3987, 3856, 3611, 3516, 2514, 2227, 2041, 1680, 1446, 1117, 1026 cm^{-1}; HRMS (FAB+) *m/z* calcd for $C_{22}H_{24}N_4O_4$ $[M+H]^+$: 409.1876; Found: 409.1882; Registration No.: 1477473-60-1.



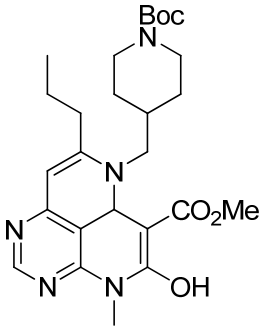
Compound 5c: Yield: 79%; Brown oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 11.40 (brs, 1H), 8.70 (s, 1H), 8.54 (s, 1H), 7.41–7.30 (m, 5H), 5.55 (s, 1H), 4.64 (d, *J* = 6.4 Hz, 2H), 3.97 (s, 3H), 3.75 (s, 3H), 2.40 (t, *J* = 7.6 Hz, 2H), 1.71–1.63 (m, 3H), 1.04 (t, *J* = 7.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.8, 165.6, 162.9, 157.8, 155.1, 138.9, 138.2, 128.9, 128.3, 127.8, 127.6, 126.6, 119.1, 104.0, 87.2, 52.6, 47.1, 35.7, 28.6, 14.1; IR (neat)*ν*max: 3981, 3857, 3444, 2231, 2041, 1683, 1453, 1024 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{22}H_{24}N_4O_3$ $[M+Na]^+$: 415.1746; Found: 415.1742.



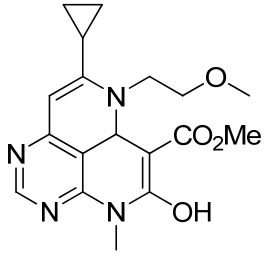
Compound 5d: Yield: 58%; Brown oil; ^{1}H NMR (500 MHz, $CDCl_3$) δ 11.03 (brs, 1H), 8.65 (s, 1H), 8.41 (s, 1H), 6.86–6.83 (m, 2H), 6.76 (s, 1H), 5.43 (s, 1H), 3.96 (s, 3H), 3.88 (s, 3H), 3.83 (s, 3H), 3.74 (s, 3H), 3.64 (q, *J* = 6.9 Hz, 2H), 2.92 (t, *J* = 6.9 Hz, 2H), 2.32 (t, *J* = 7.9 Hz, 2H), 1.66–1.61 (m, 2H), 1.04 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.9, 165.3, 162.6, 159.9, 157.6, 155.1, 149.0, 148.0, 138.8, 130.7, 120.9, 118.9, 112.1, 111.3, 103.7, 86.6, 55.9, 55.8, 52.5, 45.2, 36.3, 35.7, 28.5, 22.0, 14.0; IR (neat)*ν*max: 3973, 3856, 3648, 3420, 2946, 2832, 2233, 2043, 1697, 1409, 1026 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{25}H_{30}N_4O_5$ $[M+Na]^+$: 489.2114; Found :489.2109.



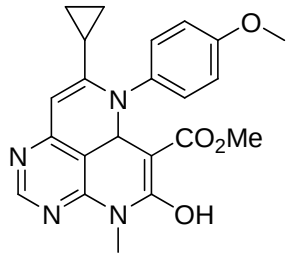
Compound 5e: Yield: 69%; Scarlet solid; mp: 169–173 ºC; ^{1}H NMR (500 MHz, $CDCl_3$) δ 11.07 (brs, 1H), 8.64 (s, 1H), 8.23 (s, 1H), 8.12 (brs, 1H), 7.63 (d, *J* = 8.0 Hz, 1H), 7.42 (d, *J* = 8.0 Hz, 1H), 7.24 (t, *J* = 7.5 Hz, 1H), 7.16–7.12 (m, 2H), 5.41 (s, 1H), 3.95 (s, 3H), 3.74 (q, *J* = 6.8 Hz, 2H), 3.72 (s, 3H), 3.15 (t, *J* = 6.8 Hz, 2H), 2.33 (t, *J* = 8.0 Hz, 2H), 1.66–1.60 (m, 2H), 1.02 (t, *J* = 7.3 Hz, 3H); ^{13}C NMR (100 MHz, DMSO-*d*$_6$) δ; 165.6, 164.8, 161.6, 158.7, 157.3, 154.3, 137.0, 136.4, 127.0, 124.0, 121.0, 119.3, 118.33, 118.28, 111.5, 110.7, 102.5, 86.1, 52.0, 43.6, 34.9, 28.1, 25.4, 21.5, 13.8; IR (neat)*ν*max: 3867, 3366, 2942, 2832, 2516, 2226, 2042, 1719, 1642, 1527, 1452, 1194, 1112, 1023, 738 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{25}H_{27}N_5O_3$ [M+Na]$^+$: 468.2012; Found: 468.2007.



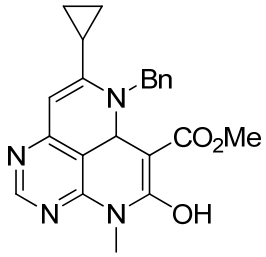
Compound 5f: Yield: 49%; Brown oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 11.14 (brs, 1H), 8.67 (s, 1H), 8.54 (s, 1H), 5.46 (s, 1H), 4.18 (brs ,2H), 3.96 (s, 3H), 3.74 (s, 3H), 3.29 (t, *J* = 5.6 Hz, 2H), 2.74 (s, 2H), 2.37 (t, *J* = 7.6 Hz, 2H), 1.82–1.76 (m, 3H), 1.73-1.64 (m, 2H), 1.47 (s, 9H), 1.30–1.24 (m, 2H), 1.06 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.9, 165.5, 162.7, 159.9, 157.7, 155.1, 154.7, 138.9, 119.0, 103.8, 86.7, 79.6, 52.6, 49.1, 37.4, 35.7, 29.9, 28.6, 28.4, 22.1, 14.0; IR (neat)*ν*max: 3981, 3859, 3427, 2833, 2231, 2043, 1667, 1452, 1021 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{26}H_{37}N_5O_5$ [M+Na]$^+$: 522.2692; Found: 522.2685.



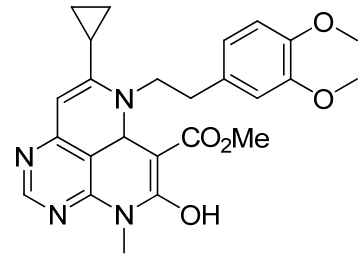
Compound 6a: Yield: 74%; Orange solid; mp: 144–148 ºC; ^{1}H NMR (400 MHz, $CDCl_3$) δ 11.23 (brs, 1H), 8.63 (s, 1H), 8.58 (s, 1H), 5.34 (s, 1H), 3.96 (s, 3H), 3.78 (t, *J* = 5.6 Hz, 2H), 3.74 (s, 3H), 3.65 (t, *J* = 5.6 Hz, 22H), 3.46 (s, 3H), 1.77–1.72 (m, 1H), 1.05–1.01 (m, 2H), 0.89–0.85 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.9, 165.4, 162.9, 159.9, 157.7, 155.1, 138.7, 119.0, 104.0, 83.4, 71.6, 59.1, 52.5, 43.2, 28.5, 13.9, 7.1; IR (neat)*ν*max: 3855, 3566, 2947, 2830, 2392, 2043, 1765, 1650, 1471, 1112, 1023 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{18}H_{22}N_4O_4$ [M+Na]$^+$: 381.1539; Found: 381.1534.



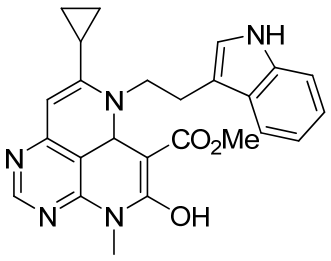
Compound 6b: Yield: 87%; Red solid; mp: 191–195 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 12.79 (brs, 1H), 8.63 (s, 1H), 8.61 (s, 1H), 7.24 (d, *J* = 8.6 Hz, 2H), 6.94 (d, *J* = 8.6 Hz, 2H), 5.31 (s, 1H), 3.97 (s, 3H), 3.84 (s, 3H), 3.75 (s, 3H), 1.77–1.70 (m, 1H), 0.98 (d, *J* = 6.9 Hz, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.9, 164.8, 162.7, 159.8, 157.7, 157.5, 155.1, 138.5, 131.6, 126.8, 119.5, 114.3, 104.2, 82.2, 55.5, 52.6, 28.6, 14.2, 9.9; IR (neat)*ν*max: 3856, 3614, 3388, 2828, 2230, 2038, 1682, 1449, 1024 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{22}H_{22}N_4O_4$ $[M+Na]^+$: 429.1539; Found: 429.1535.



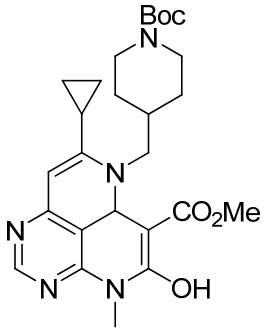
Compound 6c: Yield: 76%; Orange solid; mp: 137–141 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 11.49 (brs, 1H), 8.64 (s, 1H), 8.55 (s, 1H), 7.40–7.31 (m, 5H), 5.39 (s, 1H), 4.84 (d, *J* = 5.9 Hz, 2H), 3.96 (s, 3H), 3.74 (s, 3H), 1.72–1.65 (m, 1H), 1.01–0.96 (m, 2H), 0.89-0.84 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.8, 165.7, 163.0, 159.9, 157.7, 155.1, 138.7, 138.4, 128.8, 127.5, 126.6, 119.2, 104.2, 83.7, 52.6, 47.1, 28.6, 13.9, 7.3; IR (neat)*ν*max: 3857, 3533, 2833, 2409, 2041, 1651, 1022 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{22}H_{22}N_4O_3$ $[M+Na]^+$: 413.1590; Found: 413.1583.



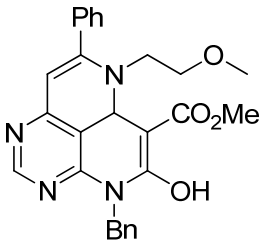
Compound 6d: Yield: 53%; Brown oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 11.13 (brs, 1H), 8.60 (s, 1H), 8.44 (s, 1H), 6.84 (s, 2H), 6.77 (s, 1H), 5.30 (s, 1H), 3.95 (s, 3H), 3.88 (s, 3H), 3.86 (t, *J* = 6.0 Hz, 2H), 3.83 (s, 3H), 3.73 (s, 3H), 2.95 (t, *J* = 6.8 Hz, 2H), 1.66–1.62 (m, 1H), 1.02–0.97 (m, 2H), 0.84–0.80 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.9, 165.3, 162.8, 159.9, 157.6, 155.1, 149.0, 147.9, 138.7, 131.0, 120.9, 119.0, 112.1, 111.2, 103.9, 83.2, 55.9, 55.8, 52.6, 45.1, 36.3, 28.6, 13.9, 7.2; IR (neat)*ν*max: 3856, 3543, 2833, 2438, 2042, 1518, 1114, 1022, 759 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{25}H_{28}N_4O_5$ $[M+Na]^+$: 487.1957; Found: 487.1953.



Compound 6e: Yield: 87%; Orange solid; mp: 170–174 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 11.07 (brs, 1H), 10.96 (brs, 1H), 8.50 (s, 1H), 8.24 (s, 1H), 7.61 (d, J = 8.0 Hz, 1H), 7.37 (d, J = 7.2 Hz, 1H), 7.32 (s, 1H), 7.08 (t, J = 7.4 Hz, 1H), 6.98 (t, J = 7.4 Hz, 1H), 5.20 (s, 1H), 3.88 (d, J = 6.4 Hz, 2H), 3.78 (s, 3H), 3.33 (s, 3H), 3.09 (t, J = 6.4 Hz, 2H), 1.86 (brs, 1H), 0.95 (d, J = 8.4 Hz, 2H), 0.86 (d, J = 3.6 Hz, 2H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 165.9, 165.0, 161.8, 158.8, 157.1, 154.2, 136.6, 136.4, 127.0, 123.9, 121.0, 119.8, 118.3, 111.5, 110.9, 102.7, 81.8, 52.1, 38.9, 28.1, 25.2, 13.5, 7.2; IR (neat)*ν*max: 3855, 3552, 2826, 2438, 2042, 1661, 1520, 1020 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{25}H_{25}N_5O_3$ $[M+Na]^+$: 466.1855; Found: 466.1849.

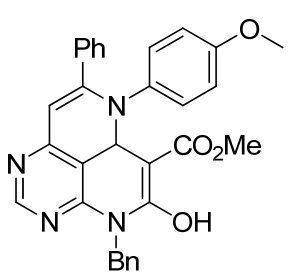


Compound 6f: Yield: 47%; Brown oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 11.23 (brs, 1H), 8.62 (s, 1H), 8.55 (s, 1H), 5.31 (s, 1H), 3.96 (brs, 2H), 3.82 (s, 3H), 3.74 (s, 3H), 3.50 (t, J = 6.0 Hz, 2H), 2.74 (brs, 2H), 1.81 (d, J = 10.8 Hz, 2H), 1.71–1.67 (m, 1H), 1.58 (brs, 1H), 1.47 (s, 9H), 1.31–1.24 (m, 2H), 1.04 (q, J = 5.6 Hz, 2H), 0.87 (q, J = 5.6 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.9, 165.3, 162.8, 159.9, 157.6, 155.1, 149.1, 148.0, 138.7, 131.0, 120.9, 119.0, 112.1, 111.3, 103.9, 83.2, 77.3, 56.0, 55.8, 52.6, 45.1, 36.3, 29.7, 28.6, 13.9, 7.2; IR (neat)*ν*max: 3976, 3856, 3611, 2980, 2824, 2476, 2231, 2043, 1680, 1625, 1539, 1024 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{26}H_{35}N_5O_5$ $[M+Na]^+$: 520.2536; Found: 520.2531.

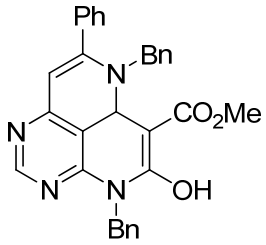


Compound 7a: Yield: 61%; Yellow solid; mp: 95–99 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 11.12 (brs, 1H), 8.72 (s, 1H), 8.64 (s, 1H), 7.50–7.46 (m, 5H), 7.45–7.41 (m, 2H), 7.28–7.19 (m, 3H), 5.68 (s, 2H), 5.55 (s, 1H), 3.90 (s, 3H), 3.48 (t, J = 5.8 Hz, 2H), 3.41 (t, J = 5.8 Hz, 2H), 3.40 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.5, 163.6, 163.0, 159.6, 158.0, 157.5, 155.1, 139.2, 137.1, 136.5, 129.5, 128.9, 128.6, 128.2, 127.8, 127.2, 119.9, 104.7, 89.4, 71.9, 59.1, 52.6, 45.0, 44.4; IR (neat)*ν*max: 3407, 2841, 2524, 2163, 1660, 1453, 1117, 1019 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{27}H_{26}N_4O_4$ $[M+Na]^+$: 493.1852; Found: 493.1845.

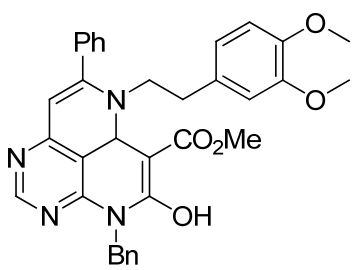
Compound 7b: Yield: 70%; Yellow solid; mp: 187–191 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ



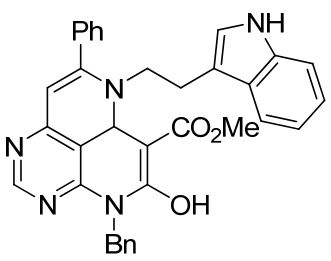
12.57 (brs, 1H), 8.78 (s, 1H), 8.74 (s, 1H), 7.51 (d, *J* = 7.0 Hz, 2H), 7.40–7.31 (m, 5H), 7.28–7.19 (m, 3H), 6.75 (d, *J* = 9.0 Hz, 2H), 6.68 (d, *J* = 9.0 Hz, 2H), 5.84 (s, 1H), 5.69 (s, 2H), 3.93 (s, 3H), 3.72 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.4, 162.7, 159.3, 158.8, 157.8, 156.4, 155.1, 138.8, 136.9, 136.6, 132.8, 129.5, 128.9, 128.5, 128.2, 127.3, 124.7, 120.7, 114.0, 105.4, 92.2, 55.3, 52.7, 44.5; IR (neat)*ν*max: 3418, 2951, 2838, 2522, 2147, 1664, 1453, 1114, 1020 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{31}H_{26}N_4O_4$ $[M+Na]^+$: 541.1852; Found: 541.1844.



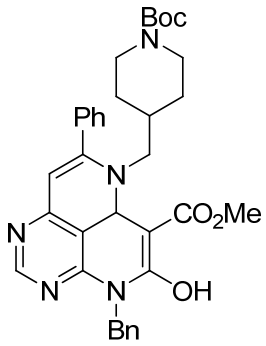
Compound 7c: Yield: 91%; Yellow solid; mp: 105–109 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 11.33 (brs, 1H), 8.67 (s, 1H), 8.66 (s, 1H), 7.50 (d, *J* = 6.8 Hz, 2H), 7.48–7.39 (m, 5H), 7.34 (t, *J* = 7.6 Hz, 2H), 7.29–7.19 (m, 6H), 5.68 (s, 2H), 5.62 (s, 1H), 4.47 (d, *J* = 6.8 Hz, 2H), 3.91 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.5, 163.8, 163.0, 159.5, 158.0, 155.1, 139.2, 138.8, 137.1, 136.2, 129.6, 128.9, 128.7, 128.6, 128.2, 127.8, 127.4, 127.3, 126.6, 120.1, 104.8, 89.8, 52.6, 48.9, 44.4; IR (neat)*ν*max: 3861, 3609, 2498, 2038, 1681, 1024 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{31}H_{26}N_4O_3$ $[M+Na]^+$: 525.1903; Found: 525.1898.



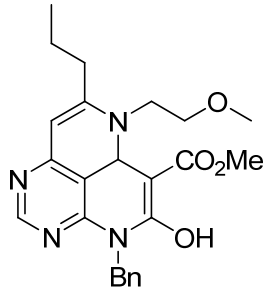
Compound 7d: Yield: 70%; Yellow solid; mp: 116–120 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 10.95 (brs, 1H), 8.61 (s, 1H), 8.55 (s, 1H), 7.50 (d, *J* = 7.5 Hz, 2H), 7.47-7.42 (m, 3H), 7.30–7.21 (m, 5H), 6.79 (d, *J* = 8.5 Hz, 1H), 6.68 (dd, *J* = 8.5 Hz, *J* = 2.0 Hz, 1H), 6.59 (d, *J* = 2.0 Hz, 1H), 5.67 (s, 2H), 5.48 (s, 1H), 3.89 (s, 3H), 3.87 (s, 3H), 3.76 (s, 3H), 3.49 (q, *J* = 6.8 Hz, 2H), 2.77 (t, *J* = 6.8 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.5, 163.7, 162.8, 159.6, 157.8, 155.0, 149.0, 147.9, 139.1, 137.1, 136.4, 130.8, 129.4, 128.8, 128.5, 128.2, 127.7, 127.3, 121.0, 119.8, 112.0, 111.2, 104.5, 89.2, 56.0, 55.7, 52.6, 46.9, 44.4, 37.0; IR (neat)*ν*max: 3547, 2947, 2836, 2407, 2040, 1644, 1113, 1019 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{34}H_{32}N_4O_5$ $[M+Na]^+$: 599.2270; Found: 599.2265.



Compound 7e: Yield: 67%; Orange solid; mp: 199–203 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 11.00 (brs, 1H), 8.60 (s, 1H), 8.39 (s, 1H), 8.30 (brs, 1H), 7.46–7.36 (m, 7H), 7.32 (dd, *J* = 7.8 Hz, *J* = 1.2 Hz, 2H), 7.25–7.15 (m, 4H), 7.05–7.01 (m, 2H), 5.64 (s, 2H), 5.46 (s, 1H), 3.87 (s, 3H), 3.57 (q, *J* = 6.6 Hz, 2H), 2.99 (t, *J* = 6.6 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.5, 163.7, 162.7, 159.6, 157.8, 155.0, 139.2, 137.1, 136.5, 136.3, 129.4, 128.7, 128.6, 128.2, 127.7, 127.2, 127.1, 122.6, 122.2, 119.6, 119.4, 118.5, 112.3, 111.3, 104.4, 89.1, 52.6, 45.8, 44.4, 27.0; IR (neat)*ν*max: 3860, 3525, 2947, 2834, 2390, 2042, 1650, 1453, 1120, 1025 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{34}H_{29}N_5O_3$ $[M+Na]^+$: 578.2168; Found: 578.2165.

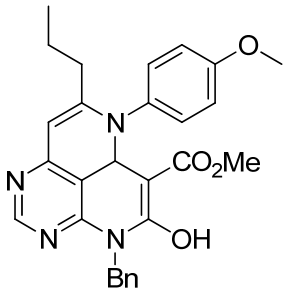


Compound 7f: Yield: 56%; Orange solid; mp: 161–165 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 11.05 (brs, 1H), 8.69 (s, 1H), 8.64 (s, 1H), 7.51–7.48 (m, 5H), 7.40–7.38 (m, 2H), 7.28-7.19 (m, 3H), 5.68 (s, 2H), 5.53 (s, 1H), 4.10 (brs, 2H), 3.90 (s, 3H), 3.16 (t, *J* = 6.4 Hz, 2H), 2.66 (brs, 2H), 1.67 (d, *J* = 12.7 Hz, 2H), 1.64–1.60 (m, 1H), 1.43 (s, 9H), 1.12–1.09 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.5, 164.0, 162.8, 159.5, 157.9, 155.1, 154.7, 139.1, 137.1, 136.3, 129.6, 128.9, 128.7, 128.2, 127.8, 127.3, 120.0, 104.6, 89.3, 79.5, 52.6, 50.8, 44.4, 37.8, 29.7, 28.4; IR (neat)*ν*max: 3745, 3409, 2976, 2139, 1738, 1683, 1559, 1452, 1427, 1345, 1251, 1141, 1019 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{35}H_{39}N_5O_5$ $[M+Na]^+$: 632.2849; Found: 632.2843.

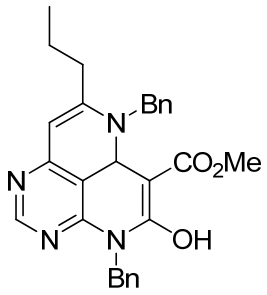


Compound 8a: Yield: 62%; Orange solid; mp: 112–116 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 11.19 (brs, 1H), 8.70 (s, 1H), 8.58 (s, 1H), 7.47 (d, *J* = 7.4 Hz, 2H), 7.24–7.19 (m, 3H), 5.66 (s, 2H), 5.48 (s, 1H), 3.95 (s, 3H), 3.60 (t, *J* = 4.9 Hz, 2H), 3.57 (t, *J* = 4.9 Hz, 2H), 3.44 (s, 3H), 2.39 (t, *J* = 7.9 Hz, 2H), 1.71–1.63 (m, 2H), 1.06 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.9, 165.4, 162.9, 159.6, 157.9, 155.0, 139.5, 137.2, 128.8, 128.2, 127.2, 119.2, 103.9, 86.8, 71.6, 59.1, 52.6, 44.3, 43.2, 35.8, 22.1, 14.0; IR

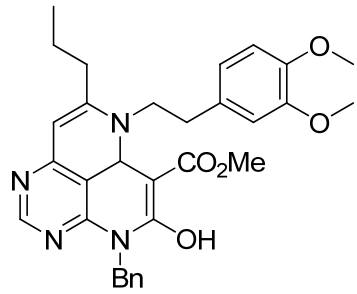
(neat)*ν*max: 3979, 3858, 3638, 2831, 2488, 2227, 2041, 1667, 1107, 1020 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{24}H_{28}N_4O_4$ $[M+Na]^+$: 459.2008; Found: 459.2003.



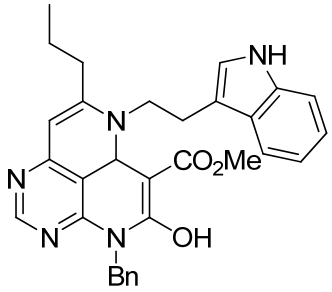
Compound 8b: Yield: 85%; Yellow solid; mp: 159–163 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 12.51 (brs, 1H), 8.75 (s, 1H), 8.64 (s, 1H), 7.49 (d, *J* = 7.2 Hz, 2H), 7.27–7.20 (m, 3H), 7.12 (d, *J* = 8.8 Hz, 2H), 6.93 (d, *J* = 8.8 Hz, 2H), 5.68 (s, 2H), 5.66 (s, 1H), 3.96 (s, 3H), 3.84 (s, 3H), 2.39 (t, *J* = 8.0 Hz, 2H), 1.58–1.52 (m, 2H), 0.90 (t, *J* = 7.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.8, 164.2, 162.8, 159.5, 158.1, 157.8, 155.1, 139.2, 137.1, 131.4, 128.8, 128.2, 127.25, 127.21, 119.9, 116.4, 114.8, 114.4, 104.3, 87.9, 55.7, 55.5, 52.7, 44.4, 35.4, 29.7, 22.2, 13.9; IR (neat)*ν*max: 3861, 3654, 2950, 2829, 2494, 2233, 2042, 1650, 1024 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{28}H_{28}N_4O_4$ $[M+Na]^+$: 507.2008; Found: 507.2003.



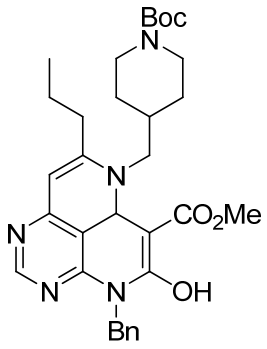
Compound 8c: Yield: 74%; Brown oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 11.41 (brs, 1H), 8.72 (s, 1H), 8.54 (s, 1H), 7.47 (d, *J* = 7.6 Hz, 2H), 7.40–7.36 (m, 2H), 7.33–7.29 (m, 3H), 7.25–7.18 (m, 3H), 5.66 (s, 2H), 5.55 (s, 1H), 4.63 (d, *J* = 6.0 Hz, 2H), 3.92 (s, 3H), 2.39 (t, *J* = 7.6 Hz, 2H), 1.70–1.64 (m, 2H), 1.03 (t, *J* = 7.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.9, 165.5, 163.0, 159.6, 157.9, 155.0, 139.4, 138.2, 137.2, 128.9, 128.8, 128.2, 127.6, 127.2, 126.5, 119.4, 104.0, 87.1, 52.6, 47.1, 44.4, 35.6, 29.6, 22.2, 14.0; IR (neat)*ν*max: 3975, 3856, 3652, 2942, 2826, 2493, 2230, 2041, 1682, 1452, 1110, 1023 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{28}H_{28}N_4O_3$ $[M+Na]^+$: 491.2059; Found: 491.2054.



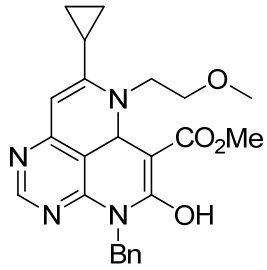
Compound 8d: Yield: 48%; Orange solid; mp: 129–133 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 11.03 (brs, 1H), 8.67 (s, 1H), 8.41 (s, 1H), 7.47 (d, *J* = 6.8 Hz, 2H), 7.25–7.20 (m, 3H), 6.86–6.82 (m, 2H), 6.76 (s, 1H), 5.65 (s, 2H), 5.42 (s, 1H), 3.94 (s, 3H), 3.88 (s, 3H), 3.82 (s, 3H), 3.64 (q, *J* = 6.0 Hz, 2H), 2.90 (t, *J* = 6.8 Hz, 2H), 2.31 (t, *J* = 7.2 Hz, 2H), 1.66-1.60 (m, 2H), 1.03 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.9, 165.3, 162.7, 159.6, 157.7, 155.0, 149.0, 148.0, 139.4, 137.2, 130.7, 128.8, 128.2, 127.2, 121.0, 119.2, 112.1, 111.3, 103.7, 86.7, 56.0, 55.8, 52.6, 45.2, 44.3, 36.4, 35.7, 26.7, 22.0. 14.0; IR (neat)*ν*max: 3856, 3561, 2942, 2832, 2424, 2222, 2043, 1667, 1118, 1023 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{31}H_{34}N_4O_5$ $[M+Na]^+$: 565.2427; Found: 565.2421.



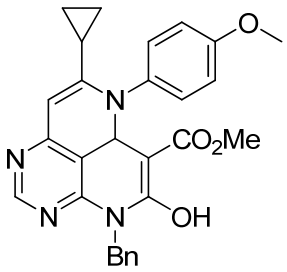
Compound 8e: Yield: 64%; Orange solid; mp: 214–218 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 11.07 (t, *J* = 5.7 Hz, 1H), 8.67 (s, 1H), 8.26 (s, 1H), 8.14 (brs, 1H), 7.62 (d, *J* = 7.6 Hz, 1H), 7.45 (d, *J* = 7.6 Hz, 2H), 7.41 (d, *J* = 8.4 Hz, 1H), 7.25–7.20 (m, 4H), 7.15–7.12 (m, 2H), 5.63 (s, 2H), 5.41 (s, 1H), 3.94 (s, 3H), 3.73 (q, *J* = 6.4 Hz, 2H), 3.14 (t, *J* = 6.4 Hz, 2H), 2.33 (t, *J* = 7.6 Hz, 2H), 1.65-1.58 (m, 2H), 1.01 (t, *J* = 7.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.0, 165.4, 162.6, 159.7, 157.7, 155.0, 139.5, 137.2, 136.4, 128.7, 128.2, 127.2, 127.1, 122.6, 122.3, 119.6, 118.9, 118.5, 112.3, 111.4, 103.7, 86.6, 52.6, 44.3, 44.0, 35.8, 26.3, 22.1, 14.0; IR (neat)*ν*max: 3973, 3859, 3618, 2941, 2830, 2511, 2228, 2041, 1661, 1120, 1021 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{31}H_{31}N_5O_3$ $[M+Na]^+$: 544.2325; Found: 544.2319.



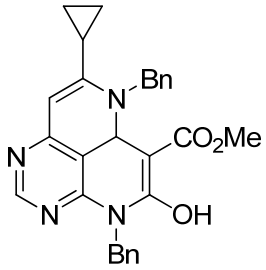
Compound 8f: Yield: 48%; Brown oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 11.16 (brs, 1H), 8.69 (s, 1H), 8.56 (s, 1H), 7.48 (d, *J* = 6.9 Hz, 2H), 7.25–7.18 (m, 3H), 5.66 (s, 2H), 5.46 (s, 1H), 4.18 (brs, 2H), 3.95 (s, 3H), 3.28 (t, *J* = 6.4 Hz, 2H), 2.73 (brs, 2H), 2.36 (t, *J* = 7.9 Hz, 2H), 1.79 (d, *J* = 12.7 Hz, 2H), 1.75–1.72 (m, 1H), 1.66 (q, *J* = 7.9 Hz, 2H), 1.46 (s, 9H), 1.43 (d, *J* = 8.8 Hz, 2H), 1.06 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.8, 165.5, 162.7, 159.6, 157.8, 155.0, 154.7, 139.4, 137.1, 128.8, 128.2, 127.2, 119.1, 103.8, 86.7, 79.5, 52.6, 49.1, 44.4, 37.4, 35.6, 29.8, 28.4, 22.1, 14.0; IR (neat)*ν*max: 3856, 3647, 2825, 2495, 2232, 2040, 1669, 1109, 1022 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{32}H_{41}N_5O_5$ $[M+Na]^+$: 598.3005; Found: 598.3000.



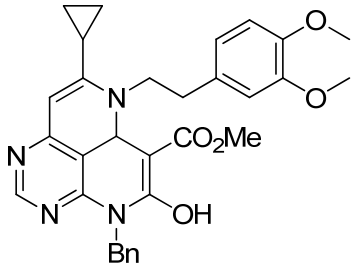
Compound 9a: Yield: 67%; Orange solid; mp: 121–125 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 11.24 (brs, 1H), 8.65 (s, 1H), 8.59 (s, 1H), 7.47 (d, *J* = 6.9 Hz, 2H), 7.24–7.19 (m, 3H), 5.65 (s, 2H), 5.34 (s, 1H), 3.95 (s, 3H), 3.78 (q, *J* = 5.4 Hz, 2H), 3.64 (t, *J* = 5.4 Hz, 2H), 3.45 (s, 3H), 1.77–1.72 (m, 1H), 1.04–1.00 (m, 2H), 0.87–0.84 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.9, 165.4, 163.0, 159.6, 157.8, 155.0, 139.2, 137.2, 128.8, 128.2, 127.1, 119.2, 104.0, 83.4, 71.6, 59.1, 52.6, 44.3, 43.1, 13.9, 7.1; IR (neat)*ν*max: 3983, 3856, 3652, 2942, 2829, 2501, 2233, 2041, 1681, 1453, 1102, 1021 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{24}H_{26}N_4O_4$ $[M+Na]^+$: 457.1852; Found: 457.1846.



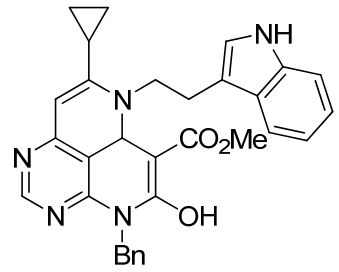
Compound 9b: Yield: 92%; Scarlet solid; mp: 176–180 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 12.79 (brs, 1H), 8.67 (s, 1H), 8.62 (s, 1H), 7.48 (d, *J* = 7.4 Hz, 2H), 7.27–7.20 (m, 5H), 6.93 (d, *J* = 8.8 Hz, 2H), 5.67 (s, 2H), 5.31 (s, 1H), 3.96 (s, 3H), 3.84 (s, 3H), 1.75–1.69 (m, 1H), 0.99–0.97 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.8, 164.8, 162.8, 159.5, 157.73, 157.65, 155.1, 139.0, 137.1, 131.6, 128.8, 128.2, 127.2, 126.8, 119.7, 114.3, 104.3, 82.2, 55.5, 52.7, 44.4, 14.2, 9.9; IR (neat)*ν*max: 3975, 3857, 3664, 2933, 2826, 2500, 2224, 2041, 1693, 1453, 1113, 1026, 669 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{28}H_{26}N_4O_4$ $[M+Na]^+$: 505.1852; Found: 505.1846.



Compound 9c: Yield: 72%; Brown oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 11.50 (brs, 1H), 8.67 (s, 1H), 8.55 (s, 1H), 7.47 (d, *J* = 6.7 Hz, 2H), 7.39–7.19 (m, 8H), 5.64 (s, 2H), 5.39 (s, 1H), 4.83 (d, *J* = 5.1 Hz, 2H), 3.93 (s, 3H), 1.71-1.64 (m, 1H), 1.00–0.95 (m, 2H), 0.87–0.83 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.7, 165.6, 163.1, 159.6, 157.8, 155.0, 139.2, 138.4, 137.1, 128.8, 128.7, 128.2, 127.4, 127.2, 126.6, 119.4, 104.2, 83.7, 52.6, 47.0, 44.4, 13.9, 7.3; IR (neat)*ν*max: 3981, 3857, 3645, 2829, 2513, 2226, 2042, 1680, 1417, 1113, 1026 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{28}H_{26}N_4O_3$ $[M+Na]^+$: 489.1903; Found: 489.1897.

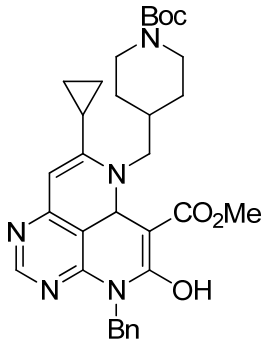


Compound 9d: Yield: 65%; Orange solid; mp: 134–138 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 11.11 (brs, 1H), 8.63 (s, 1H), 8.44 (s, 1H), 7.47 (d, *J* = 7.4 Hz, 2H), 7.29–7.18 (m, 3H), 6.85–6.81 (m, 2H), 6.77 (d, *J* = 1.5 Hz, 1H), 5.64 (s, 2H), 5.28 (s, 1H), 3.94 (s, 3H), 3.88 (s, 3H), 3.85 (t, *J* = 6.9 Hz, 2H), 3.82 (s, 3H), 2.94 (t, *J* = 6.9 Hz, 2H), 1.66–1.60 (m, 1H), 1.01–0.97 (m, 2H), 0.82–0.79 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.9, 165.3, 162.8, 159.6, 157.7, 155.0, 149.0, 147.9, 139.2, 137.2, 131.0, 128.8, 128.2, 127.2, 120.9, 119.2, 112.0, 111.3, 104.0, 83.2, 55.9, 55.8, 52.6, 45.1, 44.4, 36.3, 13.9, 7.2; IR (neat)*ν*max: 3976, 3858, 3649, 2825, 2515, 2229, 2042, 1680, 1419, 1024 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{31}H_{32}N_4O_5$ $[M+Na]^+$: 563.2270; Found: 563.2265.

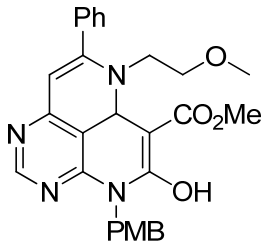


Compound 9e: Yield: 64%; Orange solid; mp: 191–195 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 11.16 (brs, 1H), 8.62 (s, 1H), 8.29 (s, 1H), 8.09 (brs, 1H), 7.63 (d, *J* = 8.0 Hz, 1H), 7.45 (d, *J* = 7.6 Hz, 2H), 7.41 (d, *J* = 7.6 Hz, 1H), 7.26–7.11 (m, 6H), 5.63 (s, 2H), 5.26 (s, 1H), 3.95 (t, *J* = 6.8 Hz, 2H), 3.94 (s, 3H), 3.17 (t, *J* = 6.8 Hz, 2H), 1.68–1.64 (m, 1H), 0.96–0.92 (m, 2H), 0.82–0.78 (m, 2H); ^{13}C NMR (100 MHz, DMSO-*d*$_6$) δ 166.1, 164.9, 161.9, 158.4, 157.3, 154.1, 137.2, 136.4, 128.3, 127.2, 127.0, 126.9, 124.0, 121.0, 120.1, 118.3, 111.5, 110.8, 102.8, 81.9, 52.1, 43.63, 43.57,

25.2, 13.6, 7.3; IR (neat)*ν*max: 3860, 3565, 2948, 2835, 2443, 2036, 1679, 1456, 1115, 1021 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{31}H_{29}N_5O_3$ $[M+Na]^+$: 542.2168; Found: 542.2163.



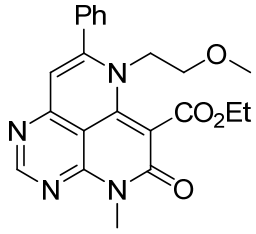
Compound 9f: Yield: 55%; Orange solid; mp: 139–143 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 11.26 (brs, 1H), 8.64 (s, 1H), 8.56 (s, 1H), 7.48 (d, *J* = 7.0 Hz, 2H), 7.25–7.17 (m, 3H), 5.65 (s, 2H), 5.30 (s, 1H), 4.18 (brs, 2H), 3.95 (s, 3H), 3.49 (t, *J* = 5.5 Hz, 2H), 2.73 (t, *J* = 11.8 Hz, 2H), 1.80 (d, *J* = 11.4 Hz, 3H), 1.72–1.65 (m, 1H), 1.46 (s, 9H), 1.45 (d, *J* = 2.7 Hz, 2H), 1.06–1.01 (m, 2H), 0.90–0.84 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.9, 165.6, 162.9, 159.6, 157.8, 155.0, 154.7, 139.2, 137.2, 128.8, 128.2, 127.2, 119.3, 104.0, 83.1, 79.5, 52.6, 49.0, 44.4, 37.3, 30.0, 28.4, 13.8, 7.4; IR (neat)*ν*max: 3975, 3858, 3651, 2941, 2828, 2499, 2226, 2041, 1668, 1021 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{32}H_{39}N_5O_5$ $[M+Na]^+$: 596.2849; Found: 596.2843.



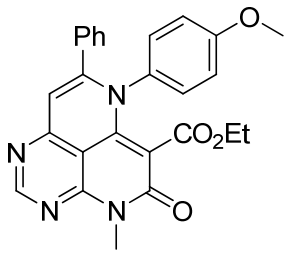
Compound 10a: Yield: 60%; Orange solid; mp: 133–137 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 11.11 (brs, 1H), 8.74 (s, 1H), 8.62 (s, 1H), 7.52 (d, *J* = 8.4 Hz, 2H), 7.48–7.41 (m, 5H), 6.79 (d, *J* = 8.4 Hz, 2H), 5.61 (s, 2H), 5.54 (s, 1H), 3.90 (s, 3H), 3.75 (s, 3H), 3.48 (t, *J* = 5.2 Hz, 2H), 3.43 (t, *J* = 5.2 Hz, 2H), 3.40 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.6, 163.6, 163.0, 159.6, 158.8, 158.0, 155.0, 139.1, 136.5, 130.7, 129.5, 129.4, 128.6, 127.9, 119.9, 113.6, 104.7, 89.4, 71.9, 59.0, 55.2, 52.6, 45.0, 43.8; IR (neat)*ν*max: 3855, 3648, 2831, 2517, 2220, 2040, 1669, 1414, 1114, 1019 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{28}H_{28}N_4O_5$ $[M+Na]^+$: 523.1957; Found: 523.1954.

5. General synthetic procedure for compounds 11a–13b

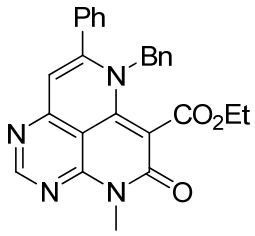
To a DCE solution of imine (**4a´–4d´, 4f´, 4g´, 7a´–7d´, 10a´, 10b´**) (0.3 mmol), AgOTf (10 mol%) and AcOH (2.0 equiv.) were added. After stirring at 80 °C for 1 h, the reaction mixture was filtered under Na_2SO_4 pad and washed thrice with DCM. After the removal of solvent under the reduced pressure, the reaction mixture was dissolved with DMF and added with 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU) (3.0 equiv.) and diethyl chloromalonate (3.0 equiv.). The resulting solution was stirred at 80 °C for 4 h. After the completion of reaction monitored by TLC, the reaction mixture was quenched with deionized water and extracted thrice with DCM. The combined organic layer was washed with brine and dried with anhydrous Na_2SO_4(s). After the solvent was removed under the reduced pressure, the residue was purified by silica-gel flash column chromatography to obtain **11a**–**13b**.



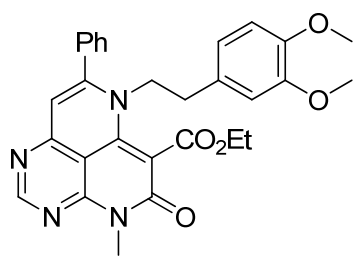
Compound 11a: Yield: 53%; Pale yellow solid; mp: 149–153 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.84 (s, 1H), 7.52–7.44 (m, 5H), 6.49 (s, 1H), 4.42 (q, *J* = 7.0 Hz, 2H), 4.03 (t, *J* = 5.1 Hz, 2H), 3.72 (s, 3H), 3.42 (t, *J* = 5.1 Hz, 2H), 3.06 (s, 3H), 1.42 (t, *J* = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.3, 161.2, 160.2, 156.0, 155.8, 153.9, 145.1, 135.5, 130.0, 129.0, 128.7, 110.8, 106.5, 102.4, 68.3, 62.1, 58.8, 51.2, 28.1, 14.1; IR (neat)*ν*max: 3856, 3647, 2784, 2508, 2221, 2040, 1717, 1553, 1448, 1113, 1021 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{22}H_{22}N_4O_4$ [M+Na]$^+$: 429.1539; Found: 429.1533.



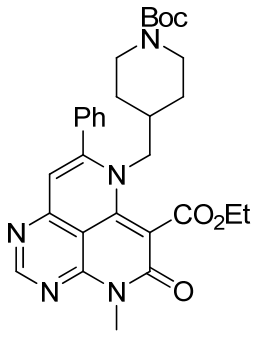
Compound 11b: Yield: 76%; Yellow solid; mp: 235–239 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.85 (s, 1H), 7.22–7.16 (m, 3H), 7.04–7.01 (m, 4H), 6.69 (d, *J* = 8.6 Hz, 2H), 6.46 (s, 1H), 3.74 (s, 3H), 3.69 (s, 3H), 3.60 (d, *J* = 9.0 Hz, 2H), 1.28 (t, *J* = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.3, 161.5, 160.2, 159.9, 156.5, 154.8, 153.7, 144.0, 134.7, 132.2, 130.5, 128.91, 128.86, 127.9, 113.7, 109.3, 106.1, 102.6, 61.3, 55.4, 28.1, 13.6; IR (neat)*ν*max: 3857, 3552, 2945, 2831, 2416, 2041, 1668, 1407, 1120, 1021, 766 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{26}H_{22}N_4O_4$ [M+Na]$^+$: 477.1539; Found: 477.1533.



Compound 11c: Yield: 69%; Pale yellow solid; mp: 150–154 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.89 (s, 1H), 7.41 (t, *J* = 7.4 Hz, 1H), 7.33 (t, *J* = 7.4 Hz, 2H), 7.18 (d, *J* = 8.2 Hz, 2H), 7.14 (d, *J* = 7.1 Hz, 1H), 7.09 (t, *J* = 7.4 Hz, 2H), 6.58 (d, *J* = 7.4 Hz, 2H), 6.55 (s, 1H), 4.95 (s, 2H), 4.33 (q, *J* = 7.0 Hz, 2H), 3.72 (s, 3H), 1.33 (t, *J* = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.1, 161.2, 160.4, 156.0, 155.3, 154.0, 148.5, 135.5, 135.2, 130.0, 128.8, 128.5, 128.0, 127.8, 126.6, 112.0, 106.4, 101.9, 61.8, 58.1, 28.2, 14.0; IR (neat)*ν*max: 3861, 3611, 2944, 2829, 2515, 2223, 2039, 1682, 1408, 1118, 1019 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{26}H_{22}N_4O_3$ $[M+Na]^+$: 461.1590; Found: 461.1584.

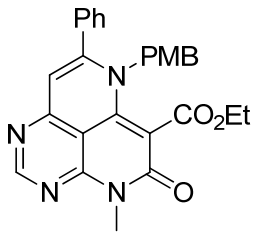


Compound 11d: Yield: 57%; Pale yellow solid; mp: 139–143 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.82 (s, 1H), 7.53–7.47 (m, 3H), 7.30–7.28 (m, 2H), 6.54 (d, *J* = 8.6 Hz, 1H), 6.40 (s, 1H), 6.21 (d, *J* = 8.2 Hz, 1H), 6.20 (s, 1H), 4.42 (q, *J* = 7.0 Hz, 2H), 4.06 (t, *J* = 7.0 Hz, 2H), 3.79 (s, 3H), 3.73 (s, 3H), 3.64 (s, 3H), 2.72 (t, *J* = 7.0 Hz, 2H), 1.40 (t, *J* = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.1, 161.2, 160.2, 155.8, 155.0, 153.8, 148.8, 148.0, 145.4, 135.2, 130.1, 129.0, 128.7, 128.5, 120.7, 111.6, 111.1, 110.9, 106.6, 102.5, 62.0, 55.8, 55.5, 53.5, 33.6, 28.2, 14.1; IR (neat)*ν*max: 3862, 3524, 2944, 2832, 2518, 2223, 2044, 1668, 1572, 1418, 1115, 1021 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{29}H_{28}N_4O_5$ $[M+Na]^+$: 535.1957; Found: 535.1952.

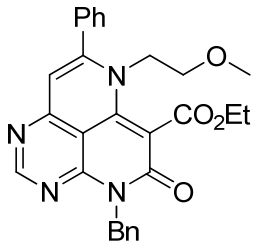


Compound 11f: Yield: 53%; Pale yellow solid; mp: 119–123 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.86 (s, 1H), 7.53 (t, *J* = 3.5 Hz, 3H), 7.46 (brs, 2H), 6.54 (s, 1H), 4.44 (brs, 2H), 3.95 (brs, 2H), 3.73 (s, 3H), 3.70 (d, *J* = 7.0 Hz, 2H), 2.48 (brs, 2H), 2.10–1.99 (m, 1H), 1.45 (t, *J* = 7.0 Hz, 3H), 1.39 (s, 9H), 1.21 (brs, 2H), 0.76 (d, *J* = 11.0 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.0, 161.1, 160.4, 156.0, 155.7, 154.4, 154.0, 145.7, 135.3, 130.4, 129.4, 128.5, 111.0, 106.5, 79.6, 62.2, 57.5, 31.0, 28.8, 28.3, 28.2, 14.2; IR (neat)*ν*max: 3971, 3857, 3650, 2942, 2827, 2503, 2229, 2040, 1681,

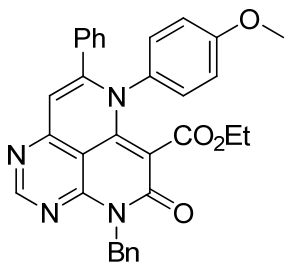
1414, 1025, 691 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{30}H_{35}N_5O_5$ $[M+Na]^+$: 568.2536; Found: 568.2530.



Compound 11g: Yield: 60%; Off-white solid; mp: 160–164 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.88 (s, 1H), 7.43 (t, *J* = 7.4 Hz, 1H), 7.36 (t, *J* = 7.4 Hz, 2H), 7.21 (d, *J* = 6.7 Hz, 2H), 6.60 (d, *J* = 9.0 Hz, 2H), 6.55 (s, 1H), 6.47 (d, *J* = 8.6 Hz, 2H), 4.87 (s, 2H), 4.38 (q, *J* = 7.0 Hz, 2H), 3.72 (s, 3H), 3.71 (s, 3H), 1.37 (t, *J* = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.1, 161.1, 160.4, 159.1, 156.0, 155.3, 154.0, 148.8, 135.4, 130.0, 128.8, 128.1, 127.9, 127.5, 113.9, 112.2, 106.5, 101.9, 61.8, 58.1, 55.2, 28.2, 14.1; IR (neat)*ν*max: 3858, 3652, 2940, 2830, 2498, 2223, 2041, 1668, 1022 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{27}H_{24}N_4O_4$ $[M+Na]^+$: 491.1965; Found: 491.1969.

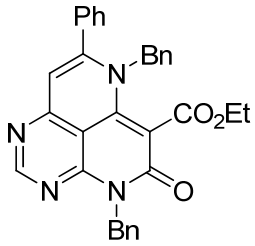


Compound 12a: Yield: 52%; Pale yellow solid; mp: 129–133 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.84 (s, 1H), 7.56 (d, *J* = 7.0 Hz, 2H), 7.51–7.49 (m, 3H), 7.46–7.43 (m, 2H), 7.30–7.22 (m, 3H), 6.47 (s, 1H), 5.60 (s, 2H), 4.41 (q, *J* = 7.2 Hz, 2H), 4.01 (t, *J* = 5.2 Hz, 2H), 3.41 (t, *J* = 5.2 Hz, 2H), 3.06 (s, 3H), 1.40 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.3, 160.9, 160.3, 156.1, 155.8, 153.9, 145.4, 136.6, 130.0, 129.07, 129.05, 128.6, 128.3, 127.4, 111.0, 106.6, 102.5, 68.3, 58.8, 51.2, 44.3, 14.1; IR (neat)*ν*max: 3979, 3857, 3648, 2938, 2828, 2502, 2224, 2041, 1695, 1416, 1109, 1023 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{28}H_{26}N_4O_4$ $[M+Na]^+$: 505.1852; Found: 505.1846.

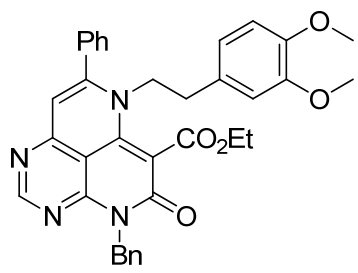


Compound 12b: Yield: 53%; Yellow solid; mp: 205–209 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.85 (s, 1H), 7.54 (d, *J* = 7.2 Hz, 2H), 7.30–7.15 (m, 6H), 7.04–6.99 (m, 4H), 6.69 (d, *J* = 8.8 Hz, 2H), 6.43 (s, 1H), 5.57 (s, 2H), 3.73 (s, 3H), 3.59 (s, 2H), 1.12 (t, *J* = 7.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.3, 161.2, 160.2, 159.9, 156.6, 154.7,

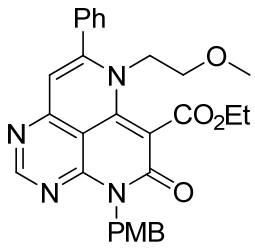
153.6, 144.2, 136.6, 134.7, 132.3, 130.5, 129.0, 128.92, 128.86, 128.3, 127.9, 127.4, 113.7, 109.3, 106.2, 102.7, 61.3, 55.4, 44.2, 13.5; IR (neat)*ν*max: 3980, 3858, 3648, 2498, 2229, 2042, 1695, 1447, 1114, 1021 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{32}H_{26}N_4O_4$ $[M+Na]^+$: 553.1852; Found: 553.1846.



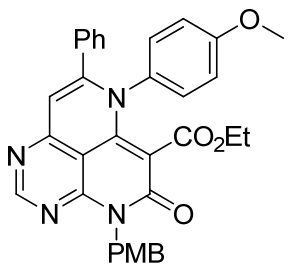
Compound 12c: Yield: 53%; Pale yellow solid; mp: 182–186 °C; ^1H NMR (500 MHz, $CDCl_3$) δ 8.89 (s, 1H), 7.57 (d, *J* = 7.4 Hz, 2H), 7.39 (t, *J* = 7.4 Hz, 1H), 7.33–7.22 (m, 5H), 7.14 (t, *J* = 6.6 Hz, 3H), 7.07 (t, *J* = 7.6 Hz, 2H), 6.56 (d, *J* = 7.4 Hz, 2H), 6.53 (s, 1H), 5.61 (s, 2H), 4.92 (s, 2H), 4.34 (q, *J* = 7.1 Hz, 2H), 1.32 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.1, 160.9, 160.4, 156.1, 155.2, 153.9, 149.0, 136.6, 135.5, 135.2, 129.9, 129.0, 128.8, 128.5, 128.3, 127.9, 127.8, 127.4, 126.7, 112.2, 106.5, 101.9, 61.9, 58.5, 44.3, 14.1; IR (neat)*ν*max: 3857, 3552, 2945, 2833, 2417, 2041, 1673, 1415, 1116, 1023 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{32}H_{26}N_4O_3$ $[M+Na]^+$: 537.1903; Found: 537.1897.



Compound 12d: Yield: 52%; Pale yellow solid; mp: 196–200 °C; ^1H NMR (500 MHz, $CDCl_3$) δ 8.82 (s, 1H), 7.57 (d, *J* = 7.4 Hz, 2H), 7.53–7.48 (m, 3H), 7.32–7.24 (m, 5H), 6.55 (d, *J* = 7.9 Hz, 1H), 6.50 (brs, 1H), 6.22–6.20 (m, 2H), 5.62 (s, 2H), 4.42 (q, *J* = 7.4 Hz, 2H), 4.07 (t, *J* = 7.1 Hz, 2H), 3.79 (s, 3H), 3.62 (s, 3H), 2.73 (t, *J* = 7.1 Hz, 2H), 1.39 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.9, 160.7, 158.9, 153.7, 148.8, 148.0, 145.3, 136.3, 135.0, 130.3, 129.1, 128.5, 128.4, 128.3, 127.5, 120.6, 111.5, 110.9, 110.1, 106.4, 102.9, 62.1, 55.8, 55.5, 53.6, 44.5, 33.6, 14.1; IR (neat)*ν*max: 3859, 3545, 2944, 2833, 2432, 2225, 2042, 1669, 1408, 1116, 1022 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{35}H_{32}N_4O_5$ $[M+Na]^+$: 611.2270; Found: 611.2265.



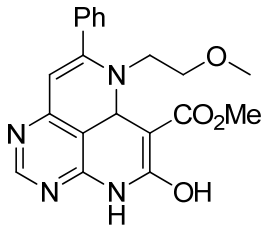
Compound 13a: Yield: 48%; Pale yellow solid; mp: 141–145 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.85 (s, 1H), 7.57 (d, *J* = 9.0 Hz, 2H), 7.50–7.44 (m, 5H), 6.82 (d, *J* = 8.6 Hz, 2H), 6.46 (s, 1H), 5.53 (s, 2H), 4.41 (q, *J* = 7.0 Hz, 2H), 4.00 (t, *J* = 5.1 Hz, 2H), 3.77 (s, 3H), 3.40 (t, *J* = 5.5 Hz, 2H), 3.05 (s, 3H), 1.40 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.3, 160.9, 160.2, 159.0, 156.1, 155.7, 153.8, 145.3, 135.5, 130.8, 130.0, 129.0, 128.9, 128.6, 113.6, 110.9, 106.6, 102.6, 68.3, 62.1, 58.8, 55.2, 51.2, 43.7, 14.1; IR (neat)*v*max: 3859, 3616, 2941, 2830, 2443, 2224, 2039, 15334, 1114, 1018 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{29}H_{28}N_4O_5$ $[M+Na]^+$: 535.1957; Found: 535.1952.



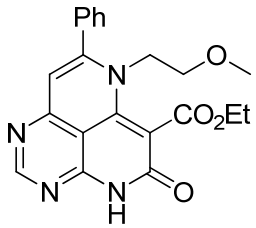
Compound 13b: Yield: 57%; Yellow solid; mp: 204–208 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.86 (s, 1H), 7.54 (d, *J* = 8.8 Hz, 2H), 7.21–7.15 (m, 4H), 7.02 (d, *J* = 6.8 Hz, 2H), 7.00 (d, *J* = 6.8 Hz, 2H), 6.80 (d, J = 8.8 Hz, 2H), 6.68 (d, *J* = 9.2 Hz, 2H), 6.42 (s, 1H), 5.50 (s, 2H), 3.77 (s, 3H), 3.73 (s, 3H), 3.58 (s, 2H), 1.12 (t, J = 7.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.4, 161.2, 160.2, 159.9, 158.9, 156.6, 154.7, 153.5, 144.1, 134.7, 132.3, 130.7, 130.5, 129.3, 128.89, 128.84, 128.1, 127.9, 113.65, 113.58, 109.3, 106.2, 102.8, 61.3, 55.4, 55.2, 43.6, 13.5; IR (neat)*v*max: 3857, 3628, 2947, 2828, 2463 2226, 2042, 1666, 1112, 1024 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{33}H_{28}N_4O_5$ $[M+Na]^+$: 583.1957; Found: 583.1952.

6. General synthetic procedure for compounds 14 and 18

10a or **13a** (0.2 mmol) was dissolved with trifluoroacetic acid (1.0 mL) and stirred at room temperature for 4 h. The reaction mixture was neutralized with aqueous sodium bicarbonate and extracted thrice with DCM. After drying with anhydrous Na_2SO_4(s), the solvent was removed under reduced pressure. The residue was purified by silica-gel flash column chromatography to obtain **14** and **18**.



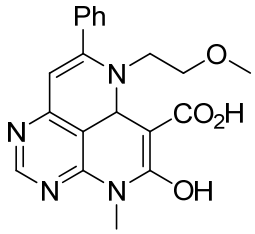
Compound 14: Yield: 77%; Orange solid; mp: 195–199 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 11.25 (brs, 1H), 8.77 (s, 1H), 8.68 (s, 1H), 7.56–7.49 (m, 3H), 7.45–7.43 (m ,2H), 5.54 (s, 1H), 3.93 (s, 3H), 3.50 (t, *J* = 5.6 Hz, 2H), 3.43 (t, *J* = 5.2 Hz, 2H), 3.42 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.1, 164.4, 162.5, 159.9, 158.5, 154.7, 141.3, 136.3, 129.7, 128.7, 127.8, 120.4, 104.0, 89.5, 71.7, 59.1, 52.6, 45.2; IR (neat)*ν*max: 3859, 3653, 2941, 2827, 2480, 2224, 2042, 1680, 1111, 1022 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{20}H_{20}N_4O_4$ $[M+Na]^+$: 403.1382; Found: 403.1377.



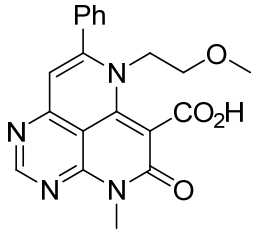
Compound 18: Yield: 76%; Pale yellow solid; mp: 211–215 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.74 (brs, 1H), 8.87 (s, 1H), 7.52–7.51 (m, 3H), 7.48 (s, 2H), 6.54 (s, 1H), 4.43 (q, *J* = 7.2 Hz, 2H), 4.04 (t, *J* = 5.2 Hz, 2H), 3.41 (t, *J* = 5.2 Hz, 2H), 3.07 (s, 3H), 1.41 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.7, 161.2, 160.6, 156.6, 156.2, 153.6, 147.5, 135.5, 130.2, 129.2, 128.6, 111.2, 106.3, 102.6, 68.2, 62.1, 58.9, 51.9, 14.2; IR (neat)*ν*max: 3856, 3671, 3352, 2831, 2508, 2231, 2040, 1682, 1414, 1113, 1022 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{21}H_{20}N_4O_4$ $[M+Na]^+$: 415.1382; Found: 415.1377.

7. General synthetic procedure for compounds 15 and 19

To a solution of **4a** or **11a** (0.2 mmol) in MeOH (2.0 mL), NaOH (3.0 equiv.) was added. After stirring at 60 °C for 3 h (the reaction completion was monitored by TLC), the solvent was removed under the reduced pressure. The reaction mixture was dissolved with deionized water and extracted thrice with DCM. After drying with anhydrous Na_2SO_4(s), the solvent was removed under the reduced pressure. The residue was purified by silica-gel flash column chromatography to obtain **15** and **19**.



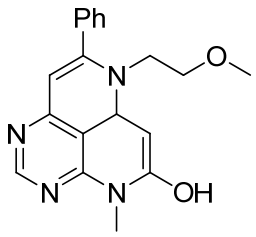
Compound 15: Yield: 80%; Yellow solid; mp: 223–227 °C; ^{1}H NMR (500 MHz, DMSO-*d*$_6$) δ 12.4 (brs, 1H), 11.06 (brs, 1H), 8.60 (s, 1H), 8.57 (s, 1H), 7.51 (s, 5H), 5.57 (s, 1H), 3.74 (s, 3H), 3.42 (s, 2H), 3.34 (s, 2H), 3.27 (s, 3H); ^{13}C NMR (100 MHz, DMSO-*d*$_6$) δ 164.5, 163.1, 161.7, 159.5, 158.1, 154.7, 138.9, 136.1, 129.5, 128.6, 127.9, 121.5, 103.2, 88.6, 71.2, 58.2, 52.0, 44.4, 40.1; IR (neat)*ν*max: 3986, 3857, 3649, 2941, 2830, 2503, 2227, 2040, 1666, 1114, 1021 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{20}H_{20}N_4O_4$ $[M+Na]^+$: 403.1382; Found: 403.1377.



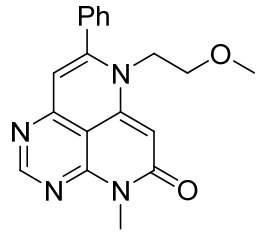
Compound 19: Yield: 70%; Off-white solid; mp: 172–176 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.04 (s, 1H), 7.75–7.73 (m, 2H), 7.58–7.56 (m, 3H), 7.03 (s, 1H), 4.38 (s, 2H), 3.84 (s, 3H), 3.15 (t, *J* = 5.2 Hz, 2H), 2.94 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.9, 165.0, 161.0, 156.0, 155.9, 154.0, 153.7, 134.9, 130.9, 129.5, 129.0, 128.6, 128.2, 125.3, 113.9, 97.1, 69.5, 59.3, 58.7, 28.8; IR (neat)*ν*max: 3972, 3857, 3358, 2943, 2827, 2507, 2225, 2040, 1680, 153, 1023 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{20}H_{18}N_4O_4$ $[M+Na]^+$: 401.1226; Found: 401.1220.

8. General synthetic procedure for compounds 16 and 20

To a solution of **4a** or **11a** (0.2 mmol) in DMF (2.0 mL), NaOH (3.0 equiv.) was added. After stirring at 120 ^{o}C for 12 h (the reaction completion was monitored by TLC), the reaction mixture was quenched with deionized water. The resultant was extracted with DCM (10 mL × 3) and the combined organic layer was washed with brine (10 mL). After drying with anhydrous Na_2SO_4(s), the solvent was removed under the reduced pressure. The residue was purified by silica-gel flash column chromatography to obtain **16** and **20**.



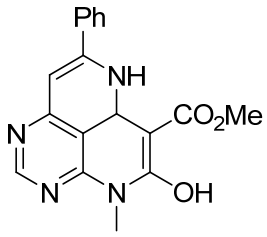
Compound 16: Yield: 64%; Pale yellow solid; mp: 155–159 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.85 (brs, 1H), 8,.73 (s, 1H), 7.84 (d, *J* = 9.6 Hz, 1H), 7.45 (s, 5H), 6.59 (d, *J* = 9.6 Hz, 1H), 5.46 (s, 1H), 3.77 (s, 3H), 3.48 (t, *J* = 5.6 Hz, 2H), 3.39 (s, 3H), 3.38 (t, *J* = 5.2 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 163.4, 162.2, 162.0, 156.1, 153.8, 136.9, 133.1, 132.8, 129.8, 129.2, 128.5, 128.2, 127.9, 120.0, 106.1, 89.3, 72.1, 59.0, 44.8, 28.2; IR (neat)*ν*max: 3857, 3646, 2941, 2831, 2495, 2230, 2041, 1680, 1453, 1114, 1023 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{19}H_{20}N_4O_2$ $[M+Na]^+$: 359.1484; Found: 359.1478.



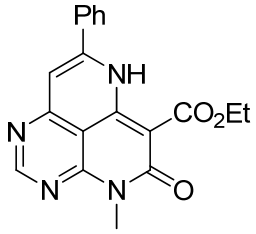
Compound 20: Yield: 74%; Brown solid; mp: 120–124 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.80 (s, 1H), 7.52–7.50 (m, 3H), 7.40–7.37 (m, 2H), 6.24 (s, 1H), 5.86 (s, 1H), 3.91 (t, *J* = 5.6 Hz, 2H), 3.71 (s, 3H), 3.53 (t, *J* = 5.6 Hz, 2H), 3.17 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 163.5, 160.1, 155.8, 154.4, 154.3, 146.3, 134.7, 130.8, 129.8, 128.8, 128.5, 108.3, 106.5, 91.7, 66.8, 58.9, 47.3, 27.8; IR (neat)*ν*max: 3978, 3858, 3674, 3300, 2827, 2495, 2232, 2041, 1454, 1024 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{19}H_{18}N_4O_2$ $[M+Na]^+$: 357.1327; Found: 357.1322.

9. General synthetic procedure for compounds 17 and 21

4g or **11g** (0.2 mmol) was dissolved with trifluoroacetic acid (1.0 mL) and stirred at 50 °C for 4 h. The reaction mixture was neutralized with aqueous sodium bicarbonate and extracted thrice with DCM. After drying with anhydrous Na_2SO_4(s), the solvent was removed under the reduced pressure. The residue was purified by silica-gel flash column chromatography to obtain **17** and **21**.



Compound 17: Yield: 86%; Orange solid; mp: 181–185; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.29 (brs, 1H), 8.79 (s, 1H), 8.76 (s, 1H), 7.68–7.66 (m, 2H), 7.53–7.48 (m, 3H), 5.93 (s, 1H), 3.96 (s, 3H), 3.79 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.6, 164.0, 160.0, 159.8, 157.9, 155.3, 138.6, 138.5, 130.6, 129.1, 128.7, 126.5, 120.5, 105.5, 87.9, 52.7, 28.7; IR (neat)*ν*max: 3859, 3646, 2945, 2830, 2508, 2229, 2039, 1695, 1452, 1115, 1022 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{18}H_{16}N_4O_3$ $[M+Na]^+$: 359.1120; Found: 359.1115.



Compound 21: Yield: 67%; Off-white solid; mp: 209–213 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 13.79 (brs, 1H), 8.93 (s, 1H), 7.83–7.81 (m, 2H), 7.63–7.60 (m, 3H), 4.47 (q, *J* = 7.2 Hz, 2H), 3.78 (s, 3H), 1.49 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 170.3, 161.8, 160.4, 157.3, 155.8, 150.0, 148.4, 132.6, 131.6, 129.9, 126.1, 106.6, 104.5, 90.6, 61.3, 27.9, 14.4; IR (neat)*ν*max: 3858, 3687, 3432, 2942, 2830, 2508, 2225, 2043, 1450, 1113, 1024 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{19}H_{16}N_4O_3$ $[M+Na]^+$: 371.1120; Found: 371.1115.

IV. Experimental Procedures for Cell Viability Test and LD screening

1. Reagents and materials

SF44, a fluorescent bioprobe for lipid droplets, was prepared by following the reported procedure.[1,2] Hoechst 33342 was purchased from Invitrogen. Micro BCA™ Protein Assay Kit was purchased from PIERCE. Ez-cytox kit was purchased from Daeil Co. (Korea). Cell culture reagents including fatal bovine serum, culture media, and antibiotic-antimycotic solution were purchased from GIBCO, Invitrogen. The culturing dish or screening plates were purchased from CORNING. Antibodies for western blot analyses were purchased from Abcam and Cell Signaling. Amersham ECL Prime Western Blotting Detection System was purchased from GE Healthcare Life Science.

2. Instruments for biological assays

High-contents screening was performed by InCell Analyzer 2000 (GE Healthcare). Data were analyzed by InCell Analyzer 1000 workstation 3.6 program according to the manufacturer's protocol. Fluorescence microscopic images were taken by Olympus Inverted Microscope Model IX71, equipped for epi-illumination using a halogen bulb (Philips No. 7724). Emission signal of each experiment was observed at the indicated spectral setting: green channel, using a 450–480 band pass exciter filter, a 500 nm center wavelength chromatic beam splitter, a 515 nm-long pass barrier filter (Olympus filter set U-MWB2). Emission signals of each experiment were detected with 12.5 M pixel recording digital color camera (Olympus, DP71). For western blots, chemiluminescent signal was monitored by ChemiDocTM MP imaging system (Bio-Rad) and quantified by ImageLab 4.0.1 program. For the EZ-cytox-based cell cytotoxicity test, the absorbance of 96-well plate was measured by BioTek Synergy HT Microplate reader.

3. Cell culture

HeLa and HEK293T were obtained from American Type Culture Collection [ATCC, Manassas, VA, USA]. HeLa cell lines were cultured in RPMI 1640 [GIBCO, Invitrogen] supplemented with heat-inactivated 10% (v/v) fetal bovine serum [GIBCO, Invitrogen] and 1% (v/v) antibiotic-antimycotic solution [GIBCO, Invitrogen]. HEK293T cells were maintained in DMEM [GIBCO, Invitrogen] supplemented with heat-inactivated 10% (v/v) calf serum [GIBCO, Invitrogen] and 1% (v/v) antibiotic-antimycotic solution [GIBCO, Invitrogen]. Cells were maintained in a humidified atmosphere of 5% CO_2 incubator at 37 °C, and cultured in 100 mm cell culture dish [CORNING].

4. Cell viability assay

In vitro cytotoxicity was measured by using EZ-cytox assay kit, and the experimental procedure was based on the manufacturer's manual. Briefly, HeLa or HEK293T cells were cultured on 96-well plates at a density of 3×10^3 cells/well for 24 h, and then cells were treated with compounds in various concentrations. After incubating for 24 h in presence of compounds, 10 μL of WST-1 solution containing (2-(4-nitrophenyl)-5-(2-sulfophenyl)-3-[4-(4-sulfophenylazo)-2-sulfophenyl]-2H-tetrazolium disodium salt was added to each well, and the plates were incubated for additional 1 h at 37 °C. Absorbance in 455 nm was measured by a microplate reader. The percentage of cell viability was calculated by following formula: % cell viability = (mean absorbance in test wells)/(mean absorbance in control well)×100. Each experiment was performed in triplicate experiments.

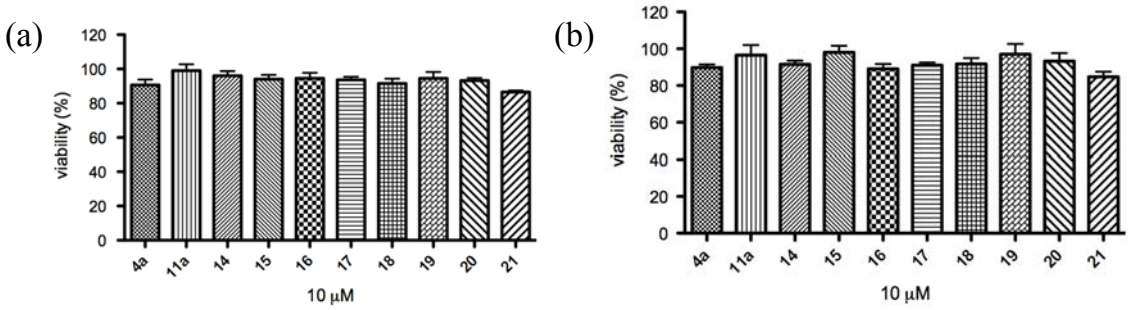


Figure S1. Cell cytotoxicity of pyrimidine-embedded compounds. (a) HeLa and (b) HEK293T cells were incubated with each compound (10 μM) for 24 h, and the cell viability was measured using WST-1 solution. Data were normalized to the viability data from the cells treated with DMSO.

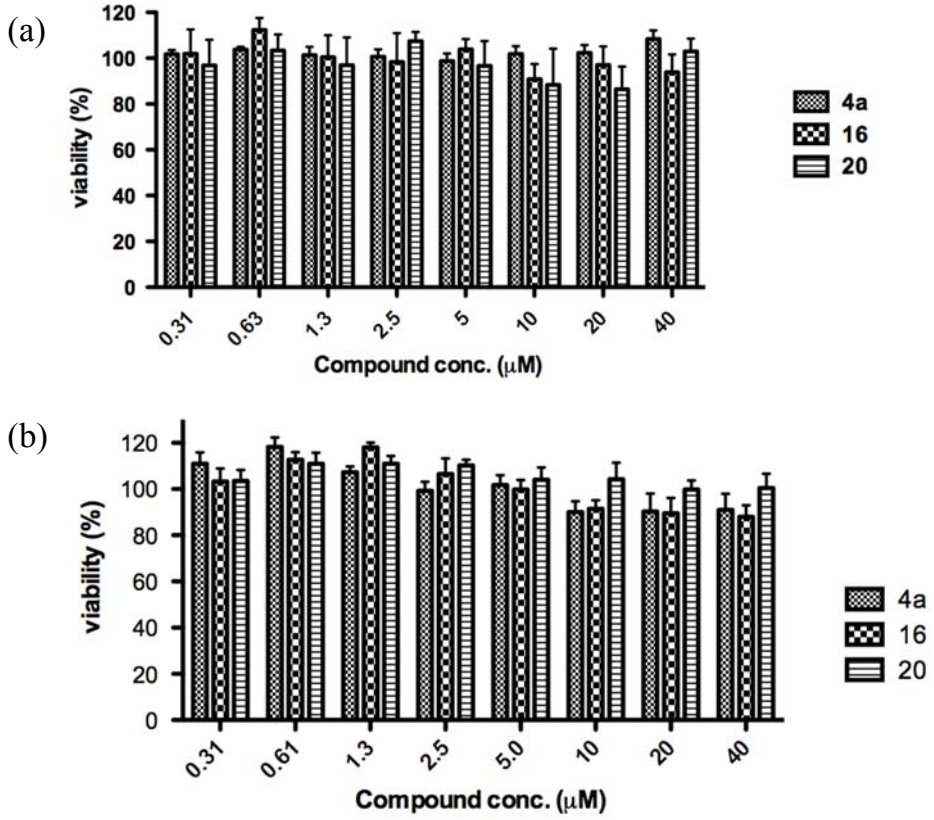


Figure S2. Cell viability test of pyrimidine-embedded compounds with various concentrations ranging from 0.3 to 40 μM. (a) HeLa and (b) HEK293T cells were incubated with **4a**, **16**, and **20** for 24 h, and the cell viability was measured using WST-1 solution. Data were normalized to the viability data from the cells treated with DMSO.

5. High-content screening for cellular lipid droplets

The image-based high-throughput screening for cellular LDs was carried out by following the reported protocol.[1,2] Briefly, HeLa cells were seeded on 96-well plates at a density of 3×10^3 cells/well and incubated for 24 h at 5% CO_2, 37 °C. After the incubation, compounds were treated to the cells on each well of the plates with their final concentration as 10 μM (for the initial screening) or with various concentrations (for dose-dependency test), for 24 h in 5% CO_2 incubator at 37 °C. Individual screening plates contained the reference wells as a control such as DMSO for the normalization, oleic acid (5 μM) as a positive control, and serum-free condition as a negative control. SF44 (5 μM) and Hoechst 33342 (2 μg/mL) was added to cells for probing lipid droplets and nuclei, respectively, and incubated for 30 min at 37 °C. LD-staining patterns in live cells were measured using automated fluorescence microscopy (InCell Analyzer 2000) directly without additional washing steps. Four different fields in each well of a 96-well plate were randomly selected for the automatic image capturing in auto-focusing mode (20 nm scale) with indicated filter setting; Excitation filter: 430/24 nm and Emission filter 605/64 nm for LD; Excitation filter: 350/50 nm and Emission filter: 455/50 nm for nuclei.

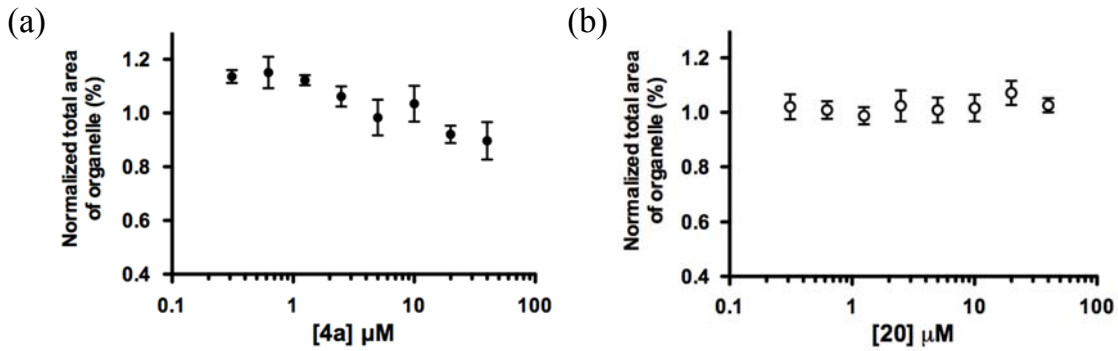


Figure S3. Dose-dependent analysis of the cellular LDs in HeLa cells upon treatment with (a) **4a** and (b) **20**. Experiments were triplicated.

6. Fluorescence imaging

HeLa cells were seeded on cover glass bottom dish and incubated for 24 h at 5% CO_2, 37 °C. Compounds (**4a**, **16**, **20** and oleic acid) were added to the cells in media, and incubated for 24 h. SF44 (5 μM, 30 min) and Hoechst 33342 (2 μg/mL, 20 min) were added to cells in normal growth media. Fluorescence, and bright-field images were taken under a fluorescence microscopy (Olympus Inverted Microscope Model IX71) in PBS buffer.

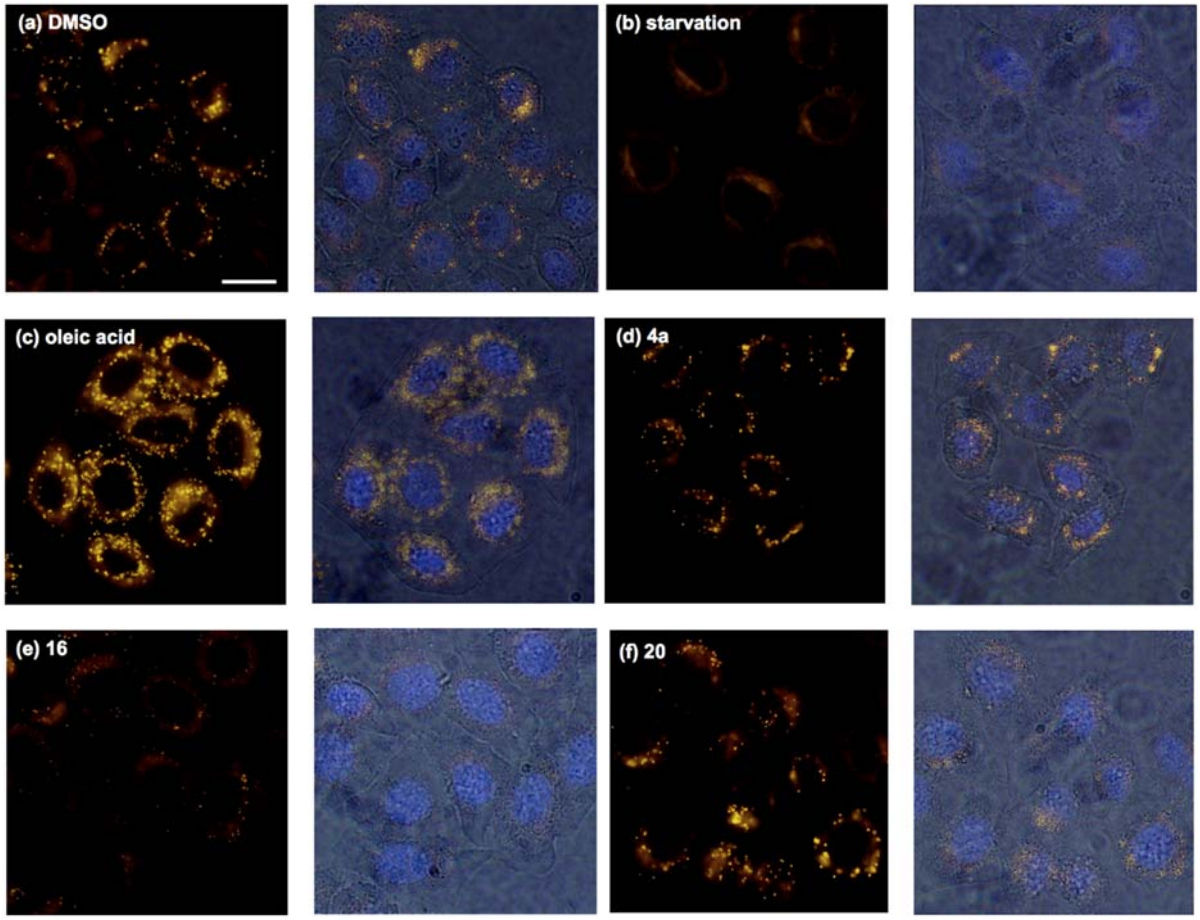


Figure S4. Fluorescence (LDs) and merged (fluorescence and bright field) images of live HeLa cells presenting different cellular LD levels. Cells were incubated with (a) DMSO; (b) serum-free media; (c) oleic acid, 5 μM; (d) **4a**, 10 μM; (e) **16**, 10 μM; (f) **20**, 10 μM for 24 h. Scale bar: 20 μm.

6. Western blot analysis

HeLa cells were seeded on 6-well plate and incubated for 24 h at 5% CO_2, 37 °C. Cells were treated with compounds (10 μM for **4a**, **16** and **20**, 10 nM for bafilomycin A1 and 200 nM for rapamycin). After 12 h of incubation, cells were harvested and frozen at −80 °C. Cells were lysed in RIPA buffer containing protease inhibitors and phosphatase inhibitors on ice for 30 min. After centrifuging down the cell lysates (14,000 rpm and 4 °C for 10 min), the supernatant was transferred and the total protein concentrations were measured by BCA assay. The resulting proteome were analyzed by SDS-PAGE and transferred into PVDF membrane, followed by 2% BSA blocking in TBST over 1 h. The samples were subjected to immunoblotting to detect the conversion of LC3-I to LC3-II and the degradation of p62 with specific primary antibodies, e.g. anti-LC3 (abcam), anti-p62 (cell signaling), and β-actin (cell signaling) antibodies for overnight at 4 °C, followed by washing with TBST for 1 h. The resulting membrane was exposed into HRP-conjugated secondary antibody for 1 h at room temperature. After washing membranes with TBST for 1 h, the membrane was developed by ECL prime solution and the chemiluminescent signal was measured by ChemiDocTM MP imaging system.

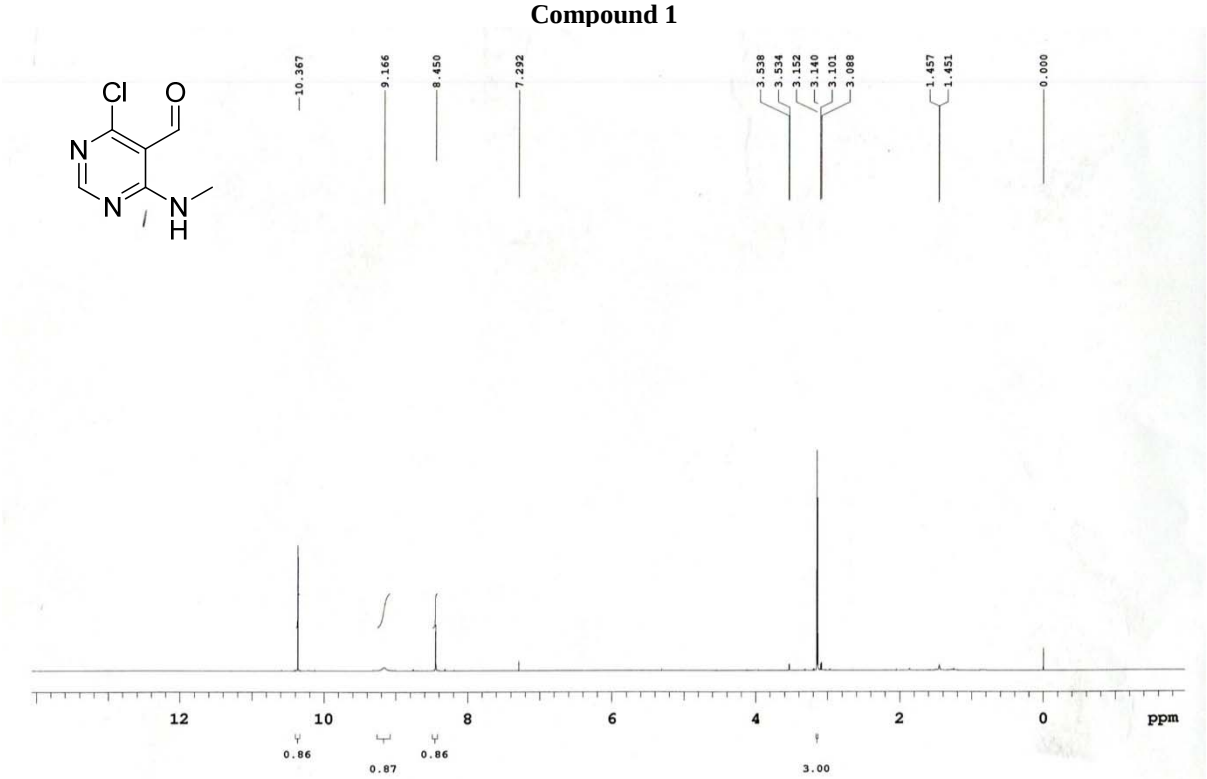
References

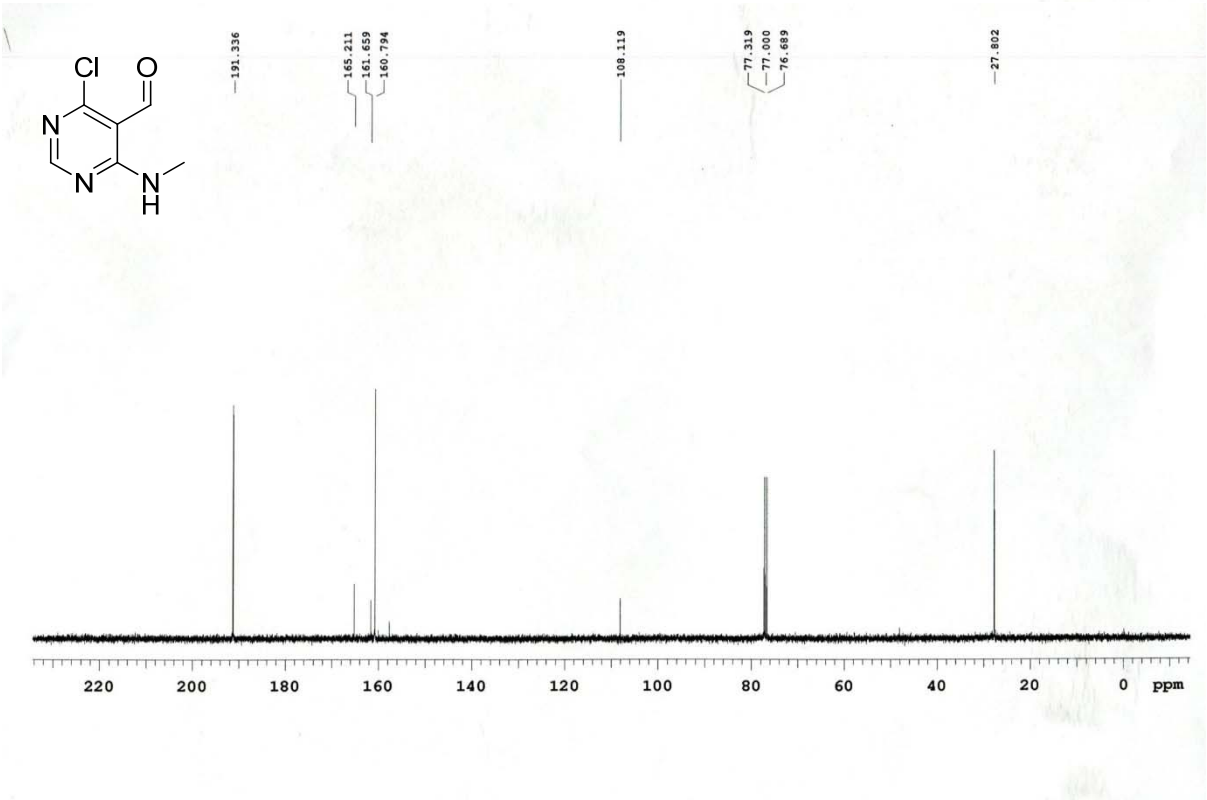
1. 'Discovery of autophagy modulators through the construction of high-content screening platform via monitoring of lipid droplets.' Lee, S; Kim, E.; Park, S.B. *Chemical Science,* **2013**, *4*, 3282.

2. 'Seoul-Fluor-based Bioprobe for Lipid Droplet and its Application in Image-based High-Throughput Screening.' Kim, E.; Lee, S.; Park, S. B. *Chem. Commun.* **2012**, *48*, 2331.

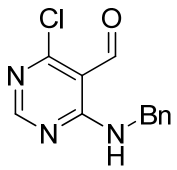
IV. ^{1}H and ^{13}C NMR spectra of All New Compounds

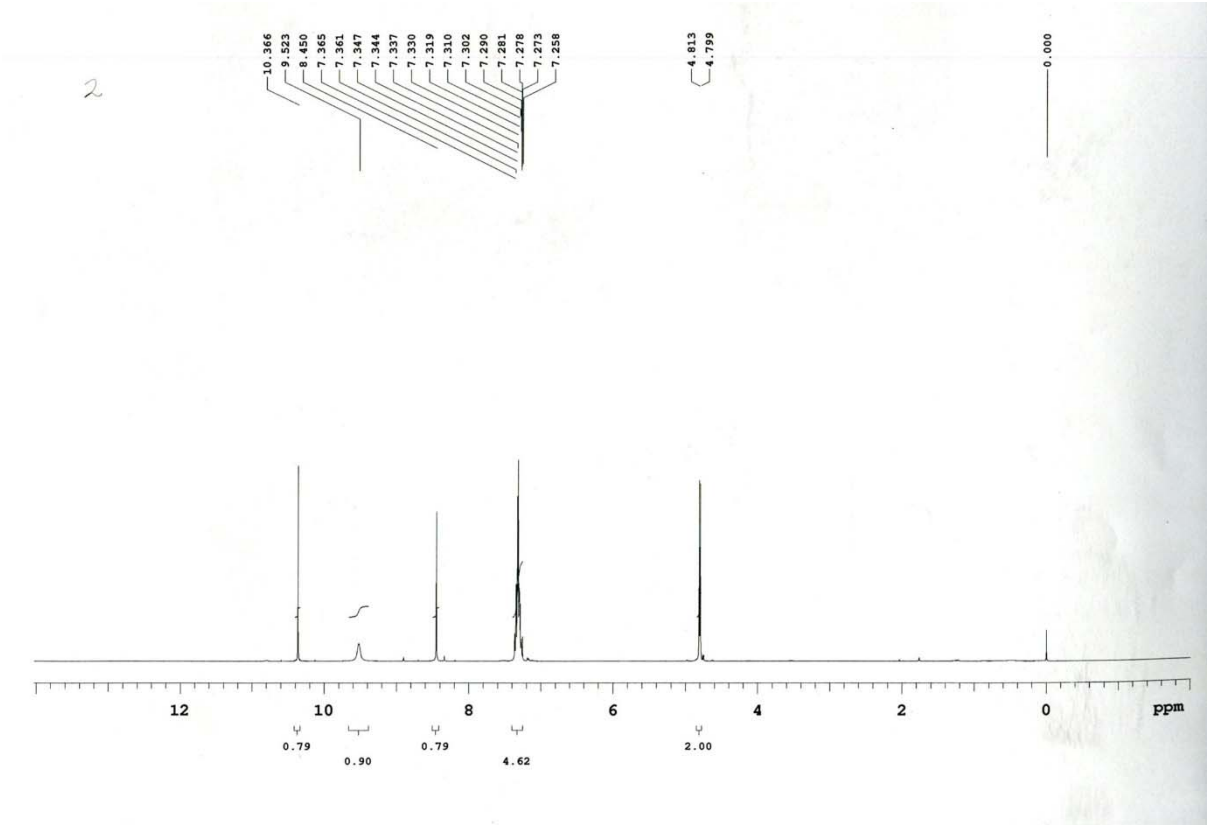
Compound 1

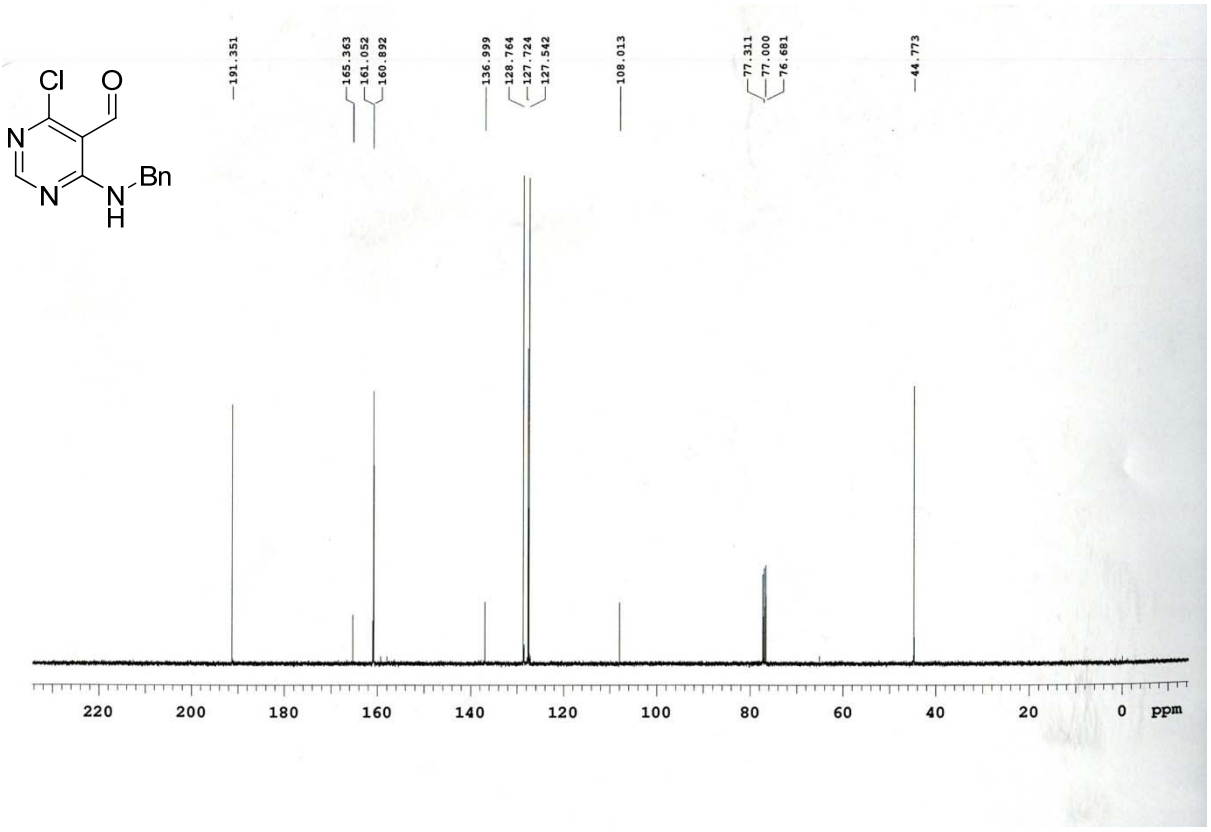




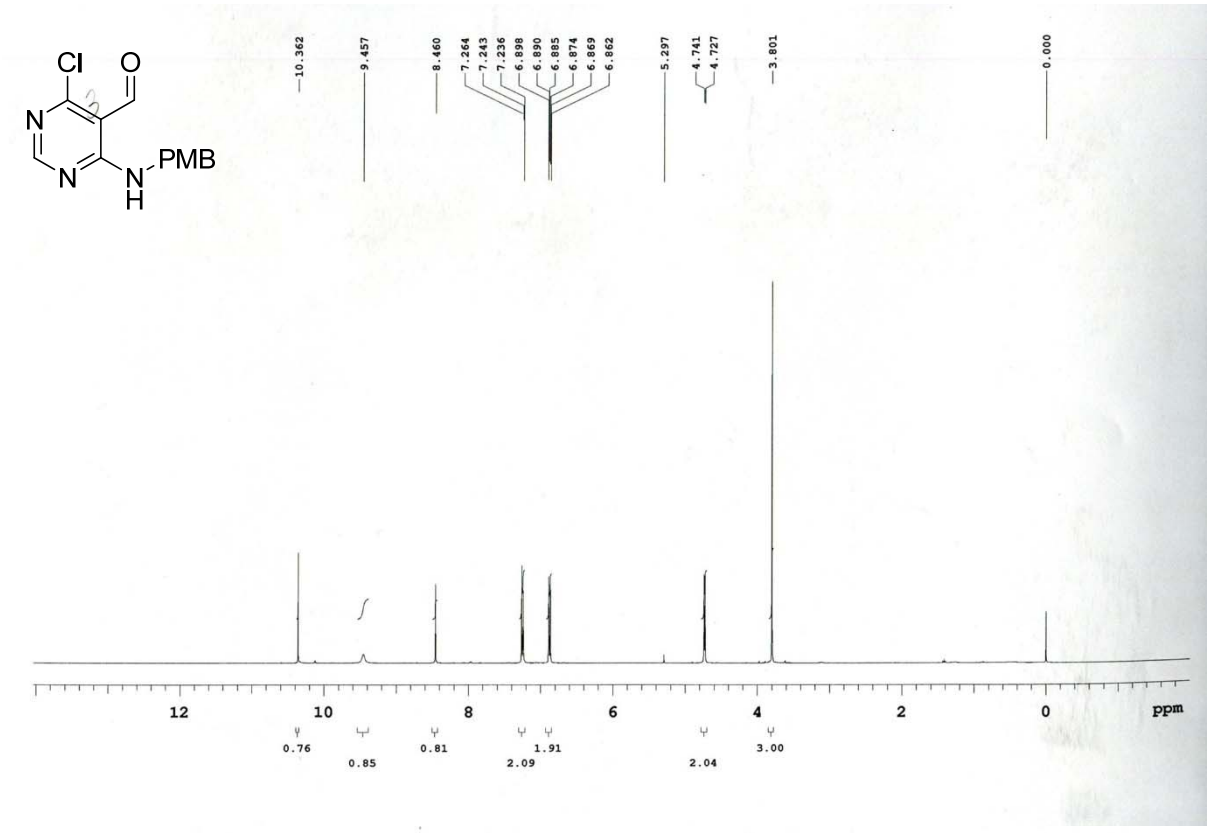
Compound 2

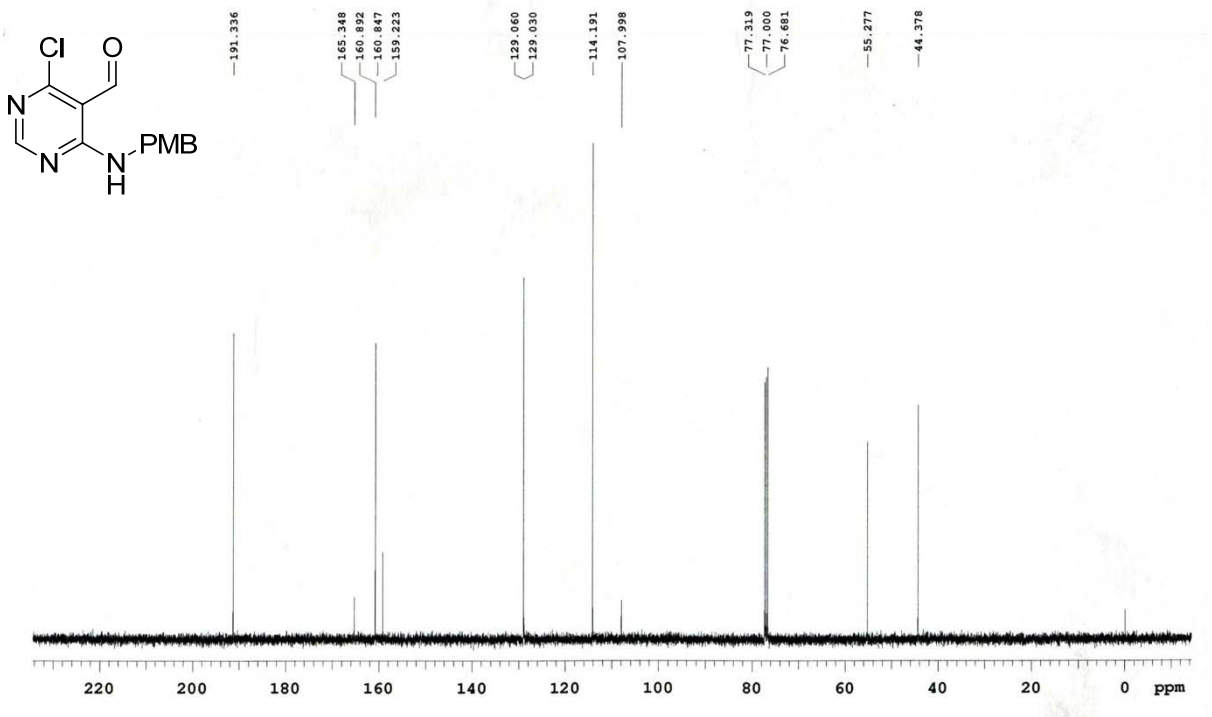



10.366
9.523
8.450
7.365
7.361
7.347
7.344
7.337
7.330
7.319
7.310
7.302
7.290
7.281
7.278
7.273
7.258
4.813
4.799
0.000
12
10
8
6
4
2
0
ppm
0.79
0.90
0.79
4.62
2.00

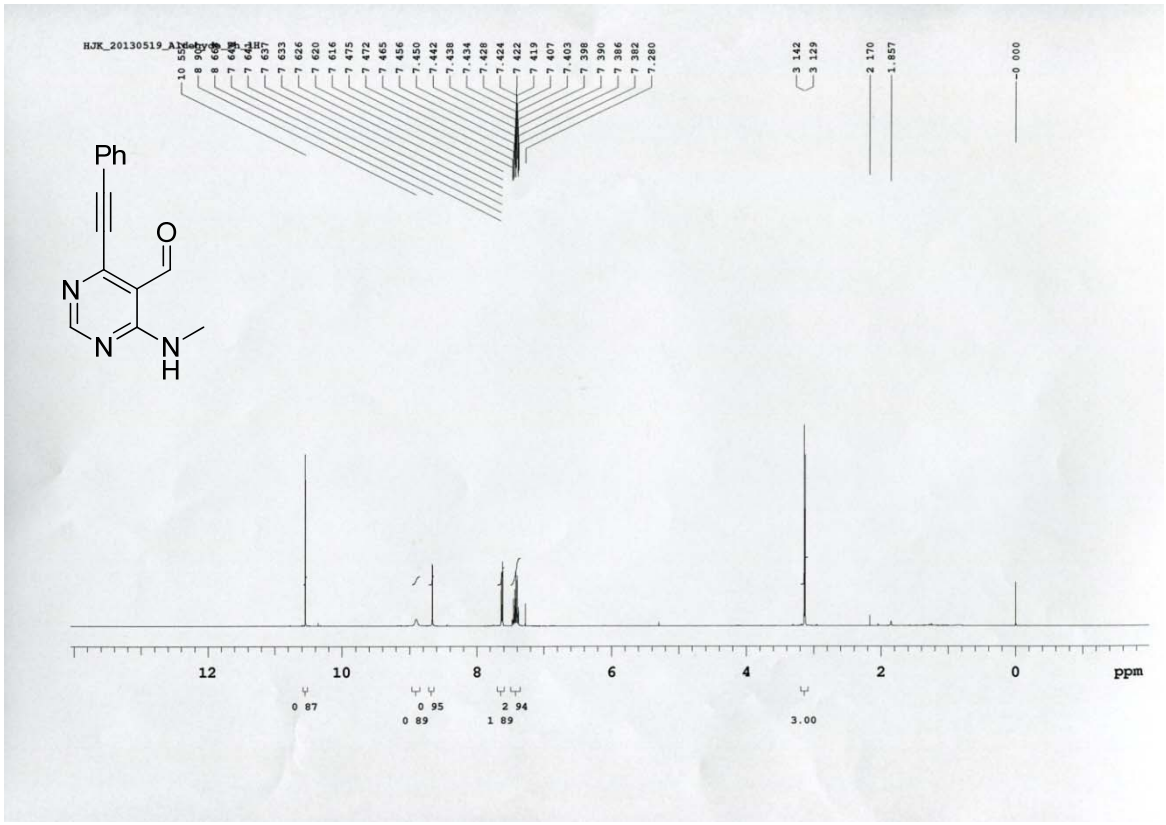

Cl
O
N
N
N
H
Bn
191.351
165.363
161.052
160.892
136.999
128.764
127.724
127.542
108.013
77.311
77.000
76.681
44.773
220
200
180
160
140
120
100
80
60
40
20
0
ppm

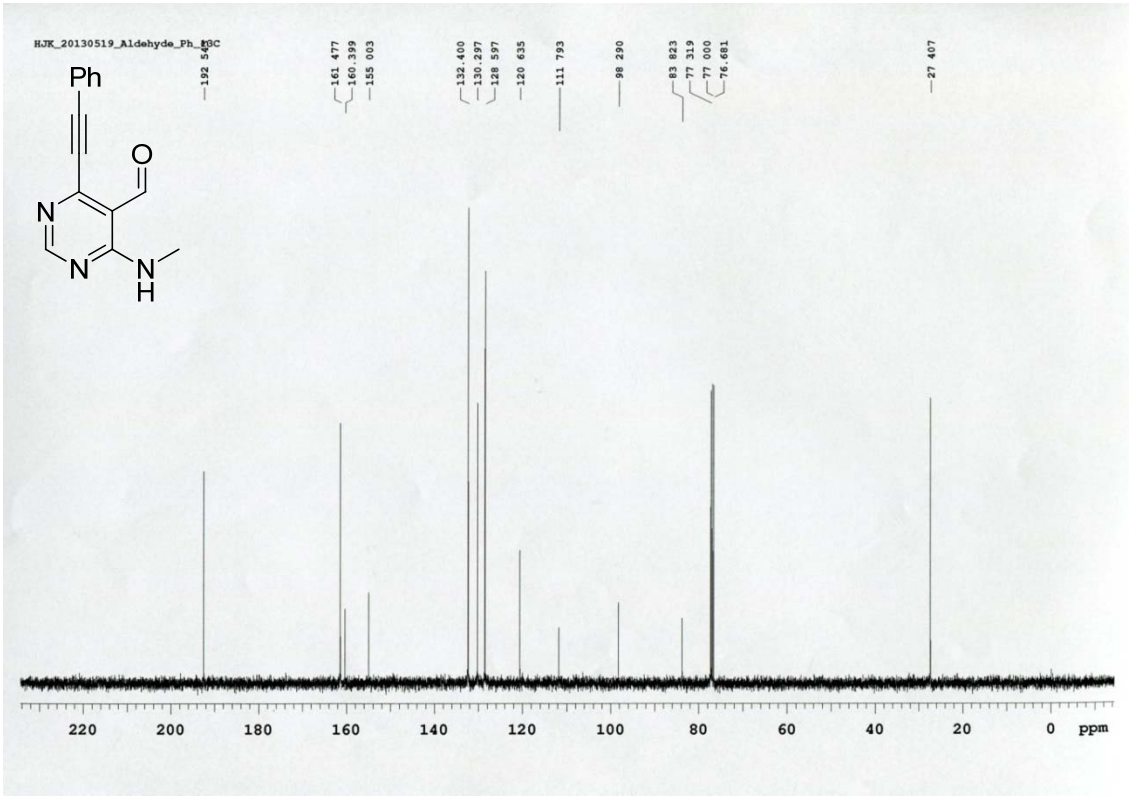
Compound 3


Cl
O
N
N
N
H
PMB
10.362
9.457
8.460
7.264
7.243
7.236
6.898
6.890
6.885
6.874
6.869
6.862
5.297
4.741
4.727
3.801
0.000
12
10
8
6
4
2
0
ppm
0.76
0.85
0.81
2.09
1.91
2.04
3.00

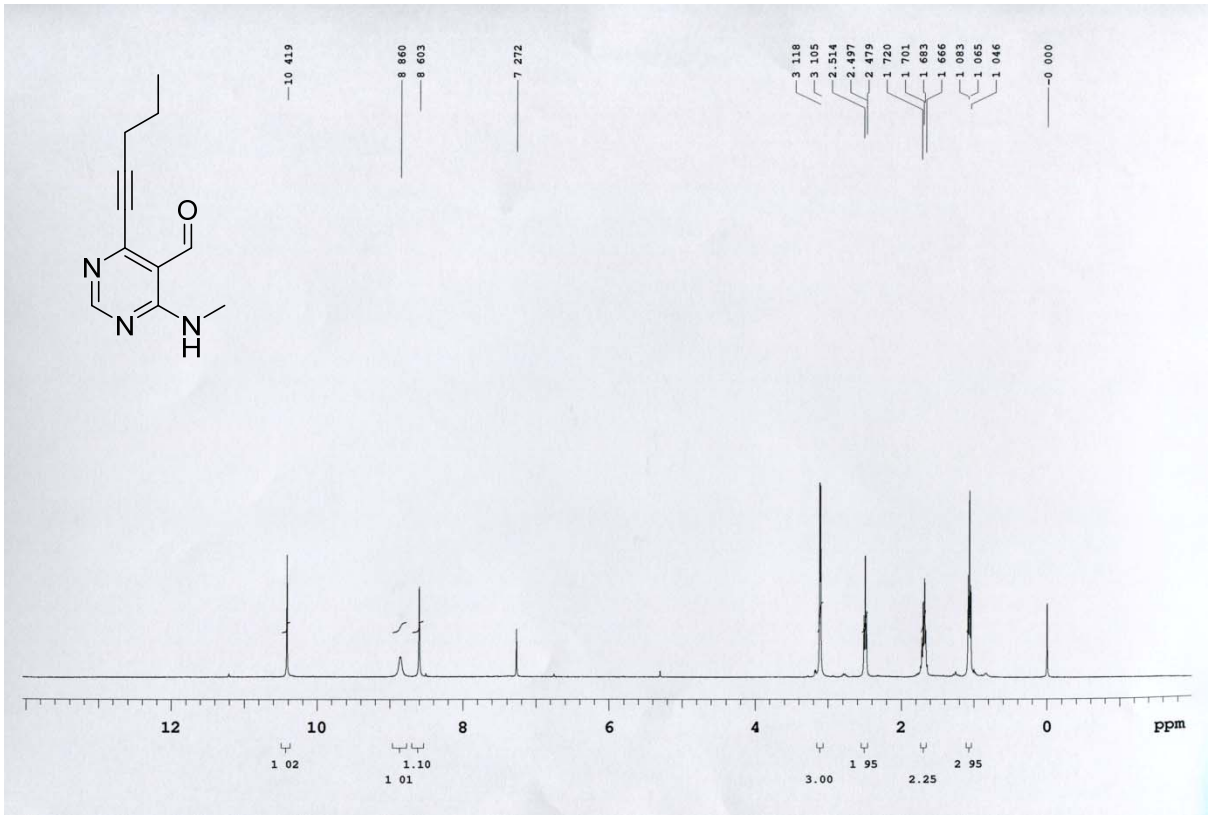

Cl
O
N
N
N
H
PMB
191.336
165.348
160.892
160.847
159.223
129.060
129.030
114.191
107.998
77.319
77.000
76.681
55.277
44.378
220
200
180
160
140
120
100
80
60
40
20
0
ppm

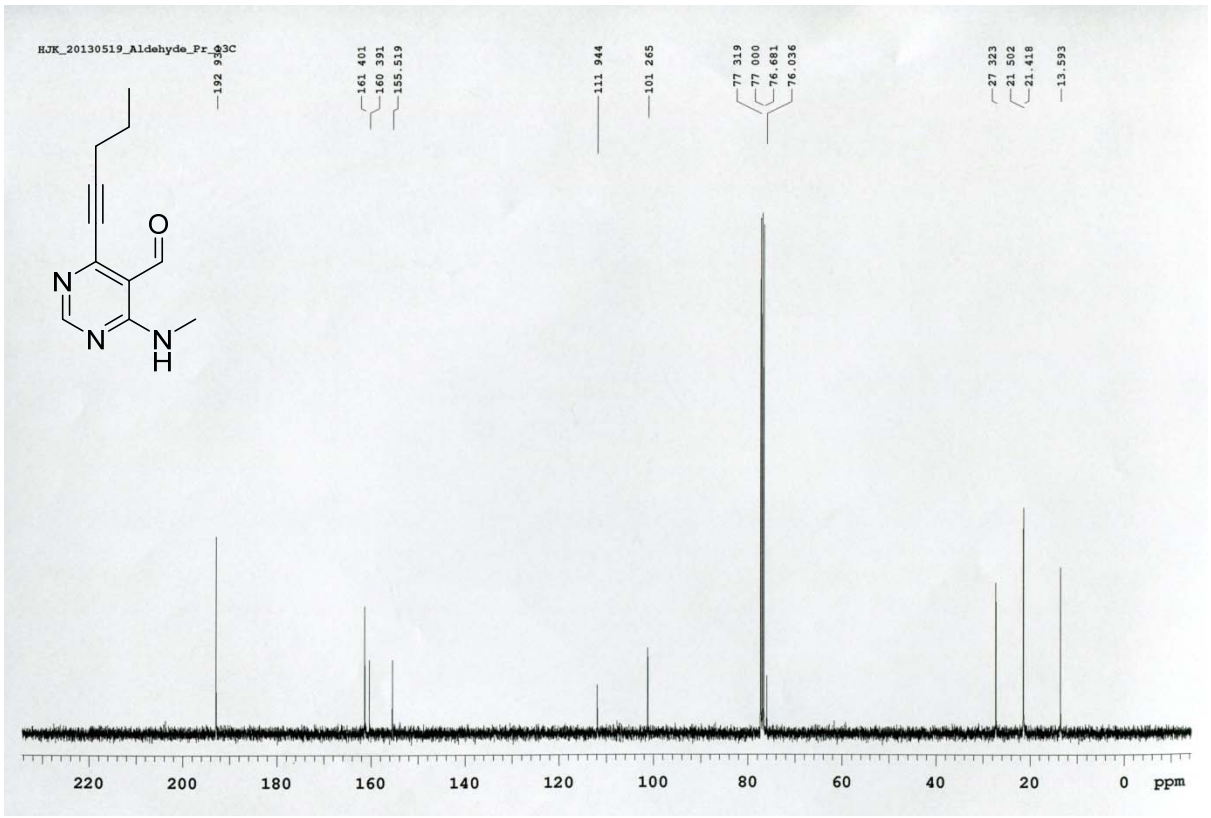
Compound 4


Ph
O
N
N
N
H
12
10
8
6
4
2
0
ppm
0 87
0 89
0 95
1 89
2 94
3.00

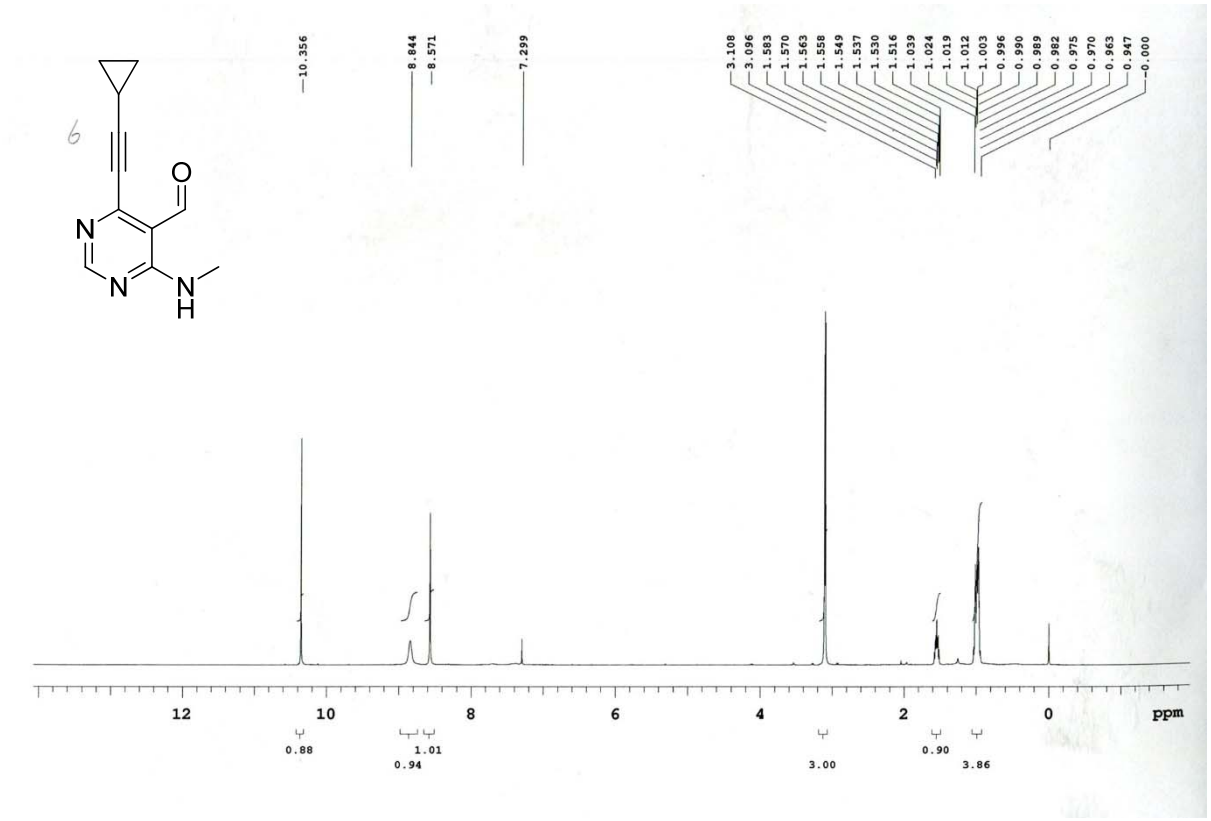

Ph
O
N
N
N
H
220
200
180
160
140
120
100
80
60
40
20
0
ppm

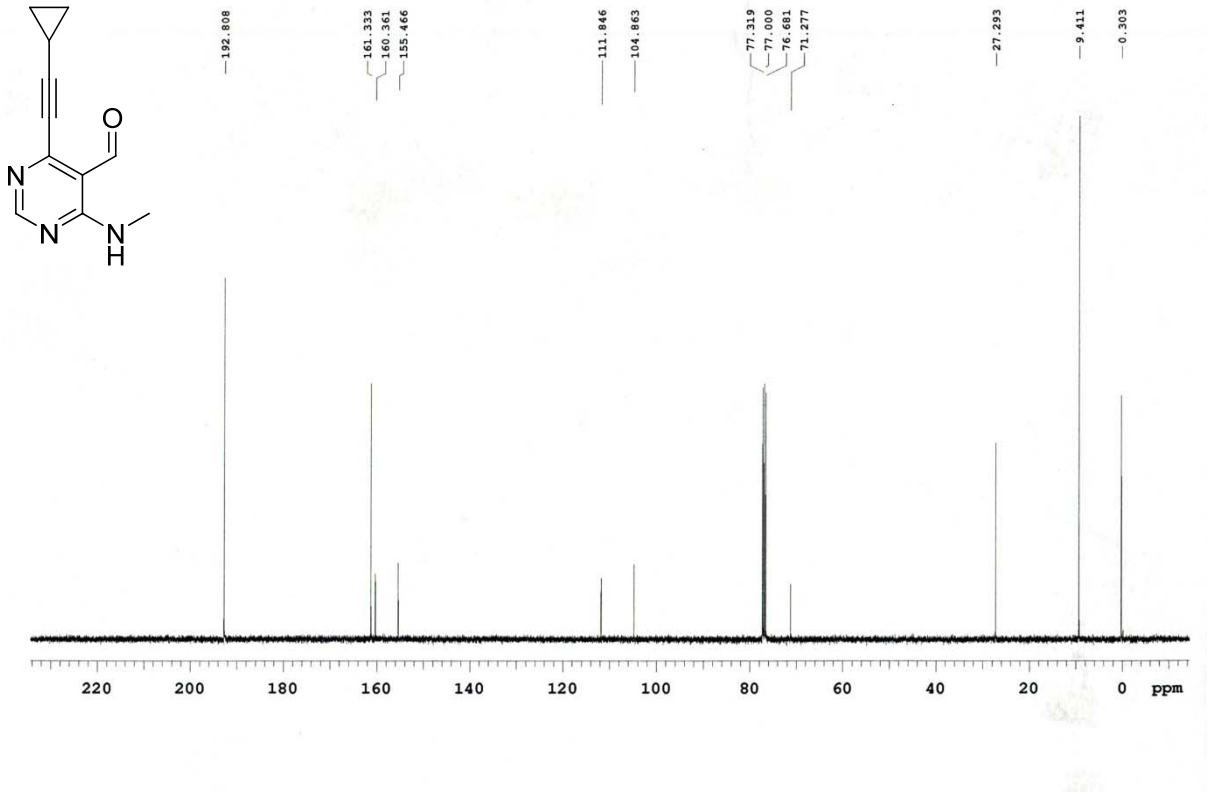
Compound 5


10.419
8.860
8.603
7.272
3.118
3.105
2.514
2.497
2.479
1.720
1.701
1.683
1.666
1.083
1.065
1.046
0.000
12
10
8
6
4
2
0
ppm
1.02
1.10
1.01
3.00
1.95
2.25
2.95

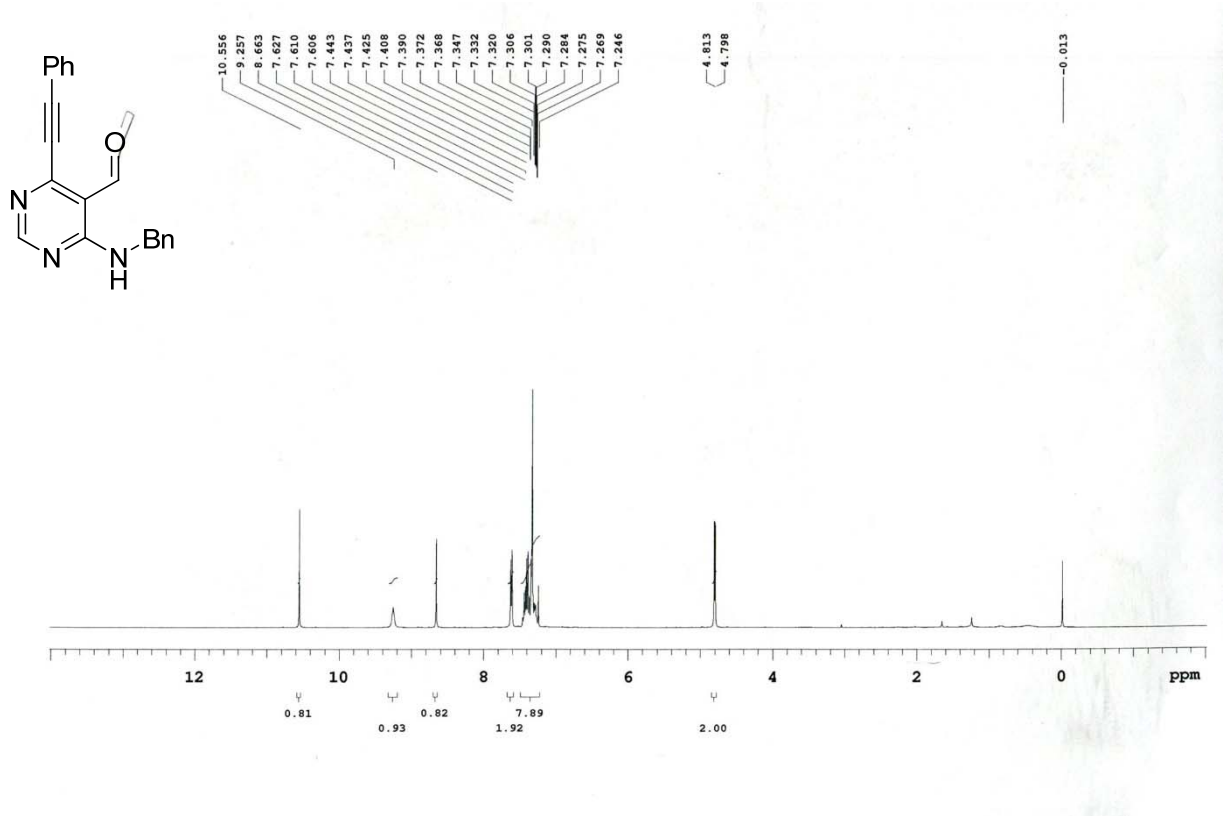

HJK_20130519_Aldehyde_Pr_13C
192.930
161.401
160.391
155.519
111.944
101.265
77.319
77.000
76.681
76.036
27.323
21.502
21.418
13.593
220
200
180
160
140
120
100
80
60
40
20
0
ppm

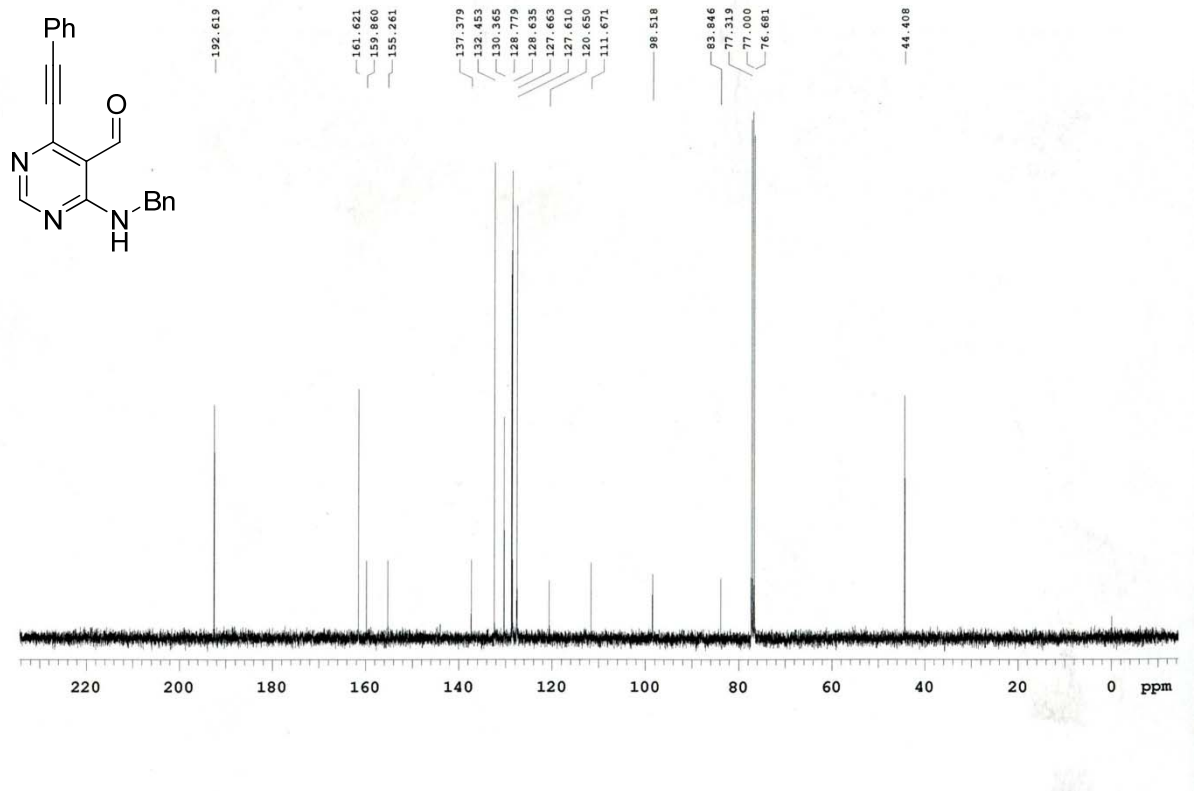
Compound 6


6
O
N
N
N
H
10.356
8.844
8.571
7.299
3.108
3.096
1.583
1.570
1.563
1.558
1.549
1.537
1.530
1.516
1.039
1.024
1.019
1.012
1.003
0.996
0.990
0.989
0.982
0.975
0.970
0.963
0.947
0.000
12
10
8
6
4
2
0
ppm
0.88
1.01
0.94
3.00
0.90
3.86

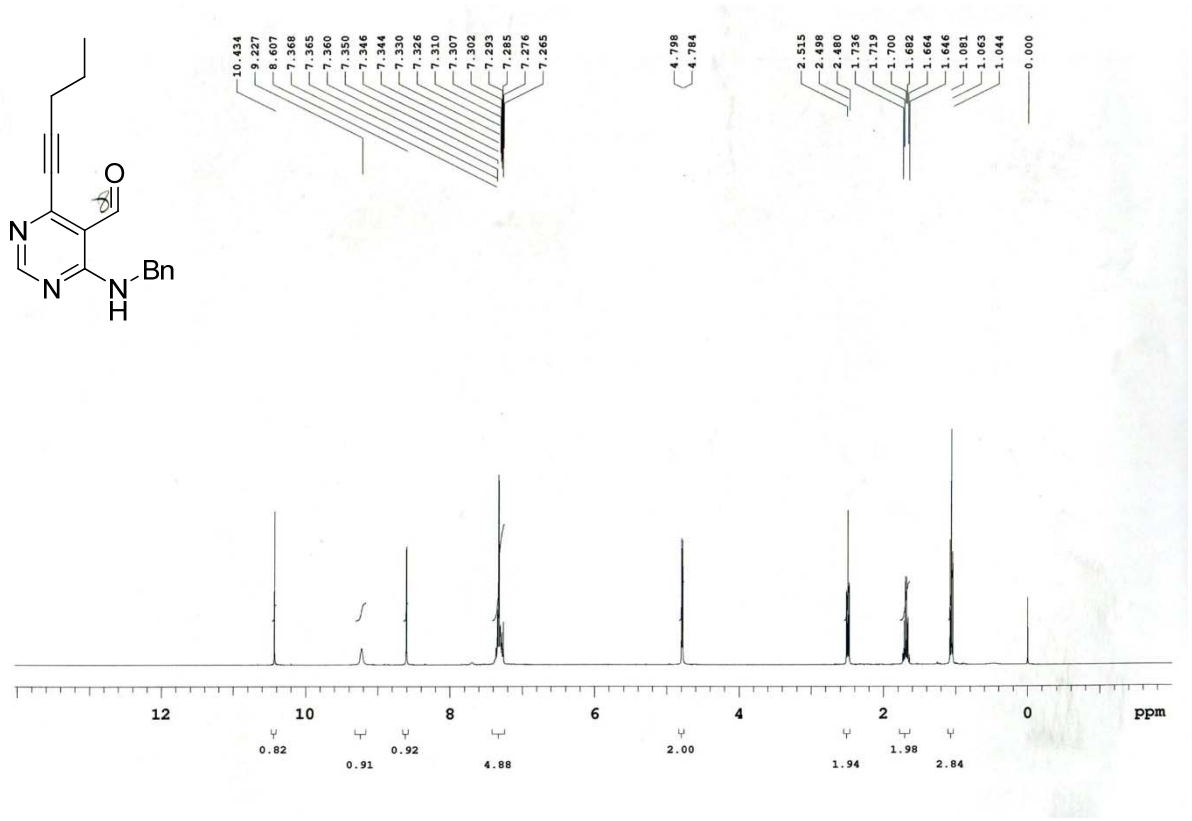

O
N
N
N
H
192.808
161.333
160.361
155.466
111.846
104.863
77.319
77.000
76.681
71.277
27.293
9.411
0.303
220
200
180
160
140
120
100
80
60
40
20
0
ppm

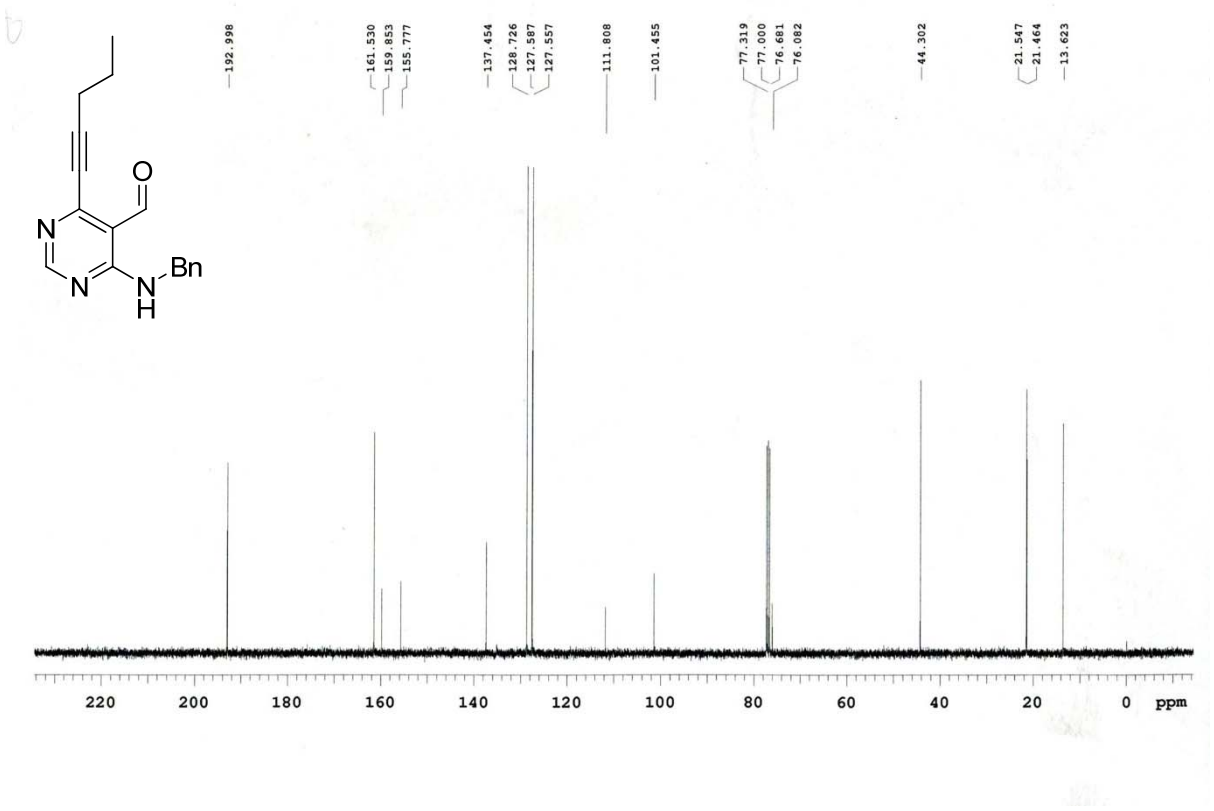
Compound 7


Ph
O
N
N
Bn
N
H
10.556
9.257
8.663
7.627
7.610
7.606
7.443
7.437
7.425
7.408
7.390
7.372
7.368
7.347
7.332
7.320
7.306
7.301
7.290
7.284
7.275
7.269
7.246
4.813
4.798
-0.013
12
10
8
6
4
2
0
ppm
0.81
0.93
0.82
1.92
7.89
2.00

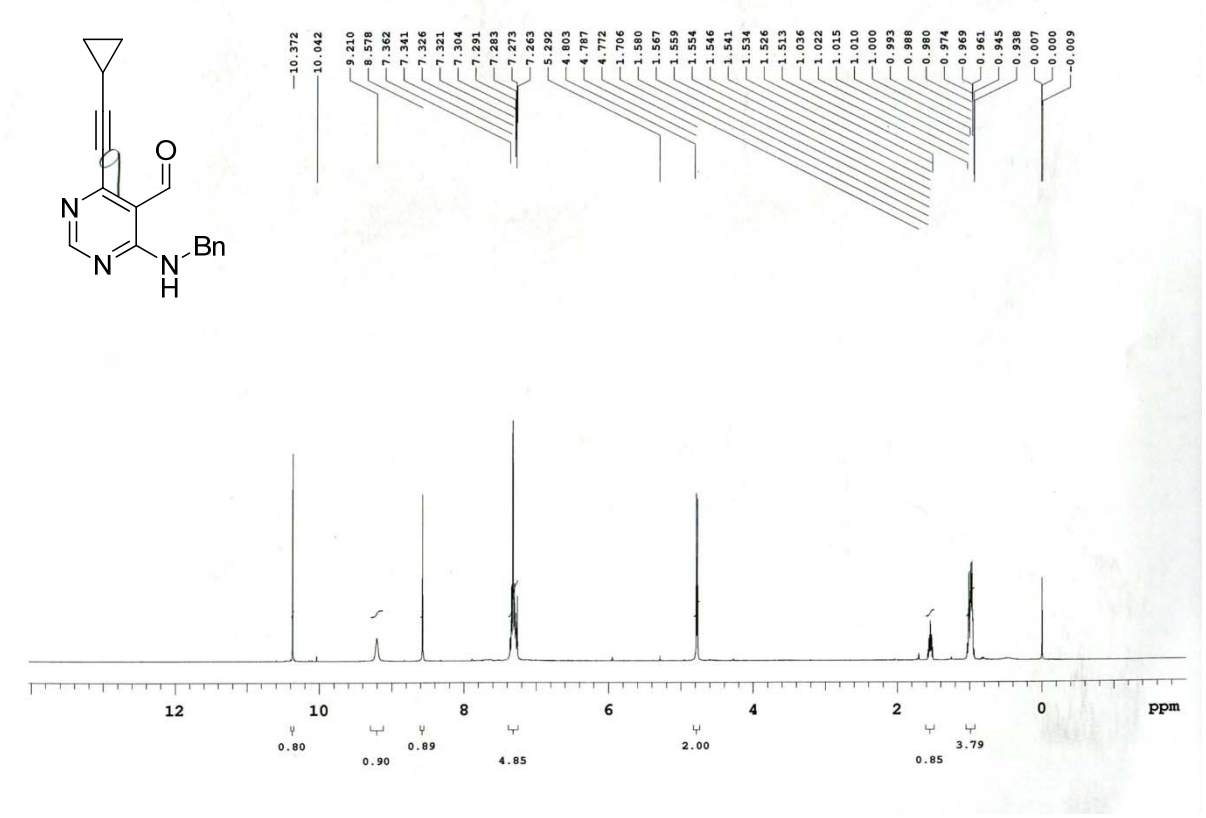

Ph
O
N
N
Bn
N
H
192.619
161.621
159.860
155.261
137.379
132.453
130.365
128.779
128.635
127.663
127.610
120.650
111.671
98.518
83.846
77.319
77.000
76.681
44.408
220
200
180
160
140
120
100
80
60
40
20
0
ppm

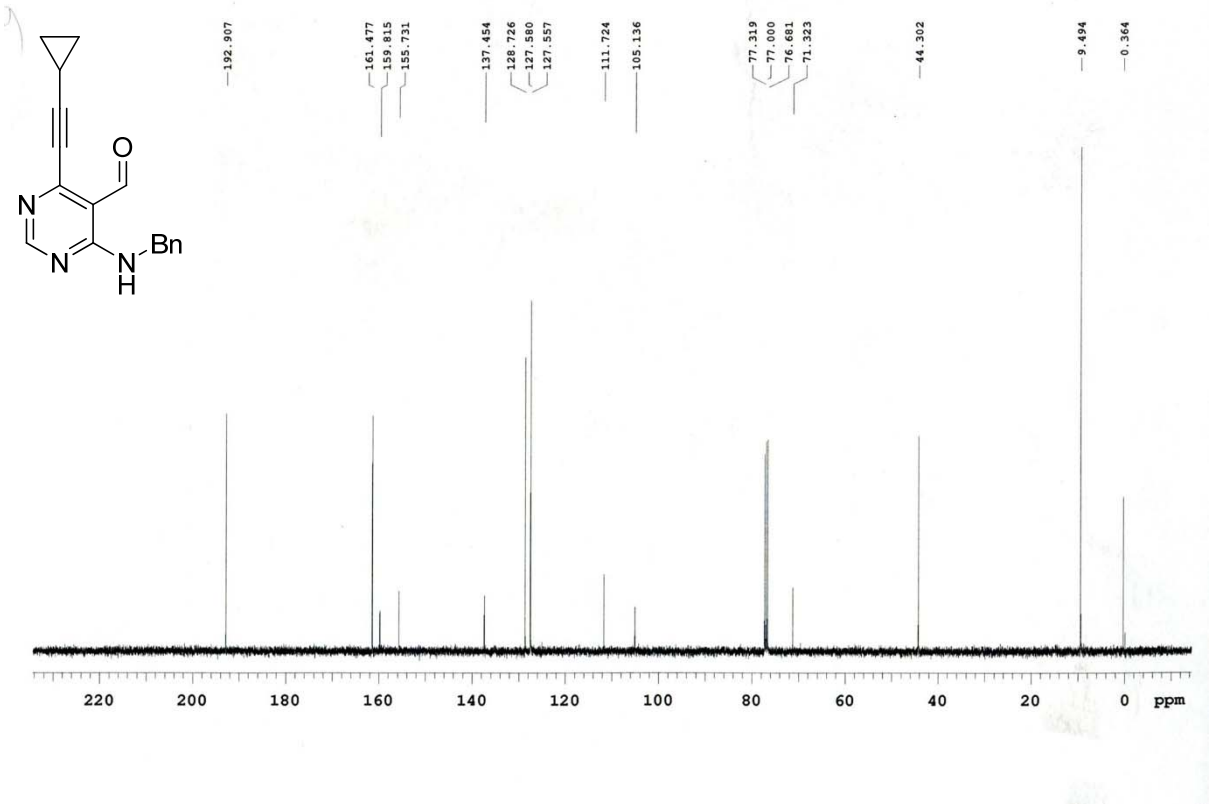
Compound 8


10.434
9.227
8.607
7.368
7.365
7.360
7.350
7.346
7.344
7.330
7.326
7.310
7.307
7.302
7.293
7.285
7.276
7.265
4.798
4.784
2.515
2.498
2.480
1.736
1.719
1.700
1.682
1.664
1.646
1.081
1.063
1.044
0.000
O
N
N
N
H
Bn
12
10
8
6
4
2
0
ppm
0.82
0.91
0.92
4.88
2.00
1.94
1.98
2.84

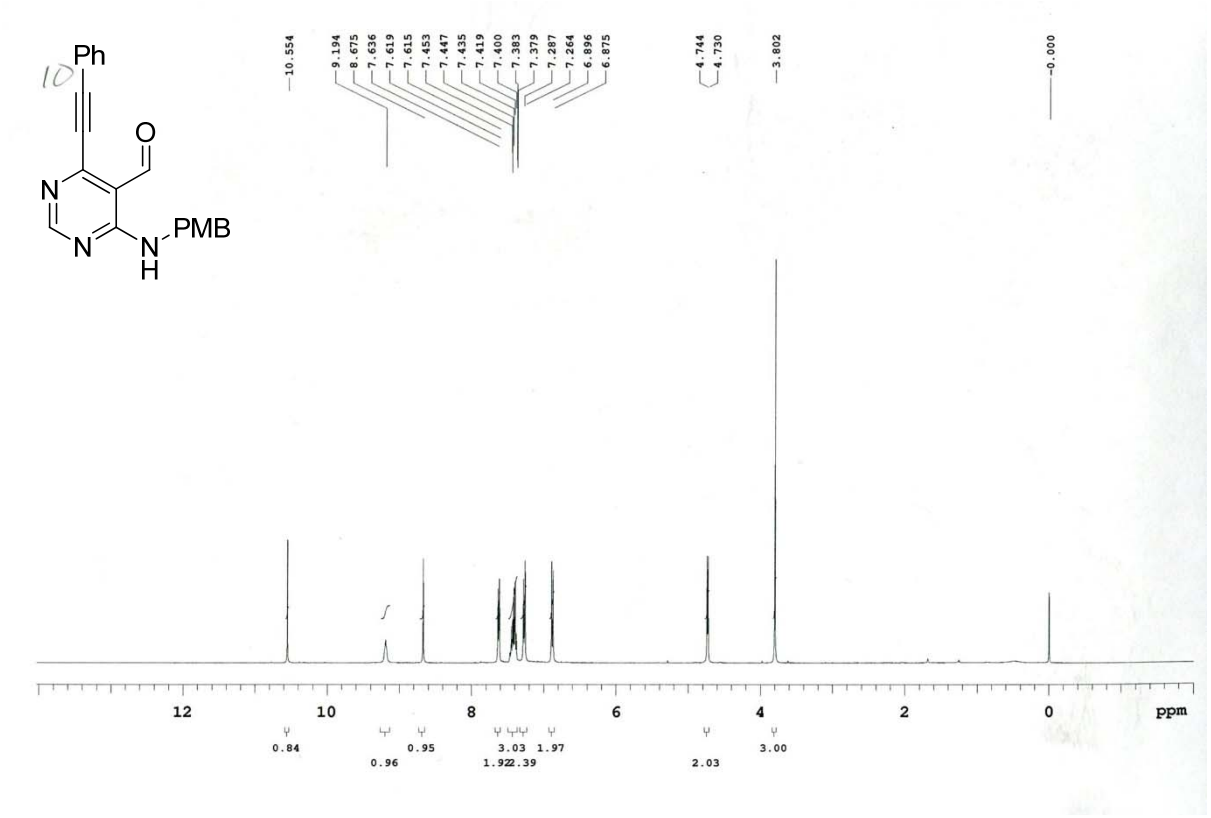

192.998
161.530
159.853
155.777
137.454
128.726
127.587
127.557
111.808
101.455
77.319
77.000
76.681
76.082
44.302
21.547
21.464
13.623
O
N
N
N
H
Bn
220
200
180
160
140
120
100
80
60
40
20
0
ppm

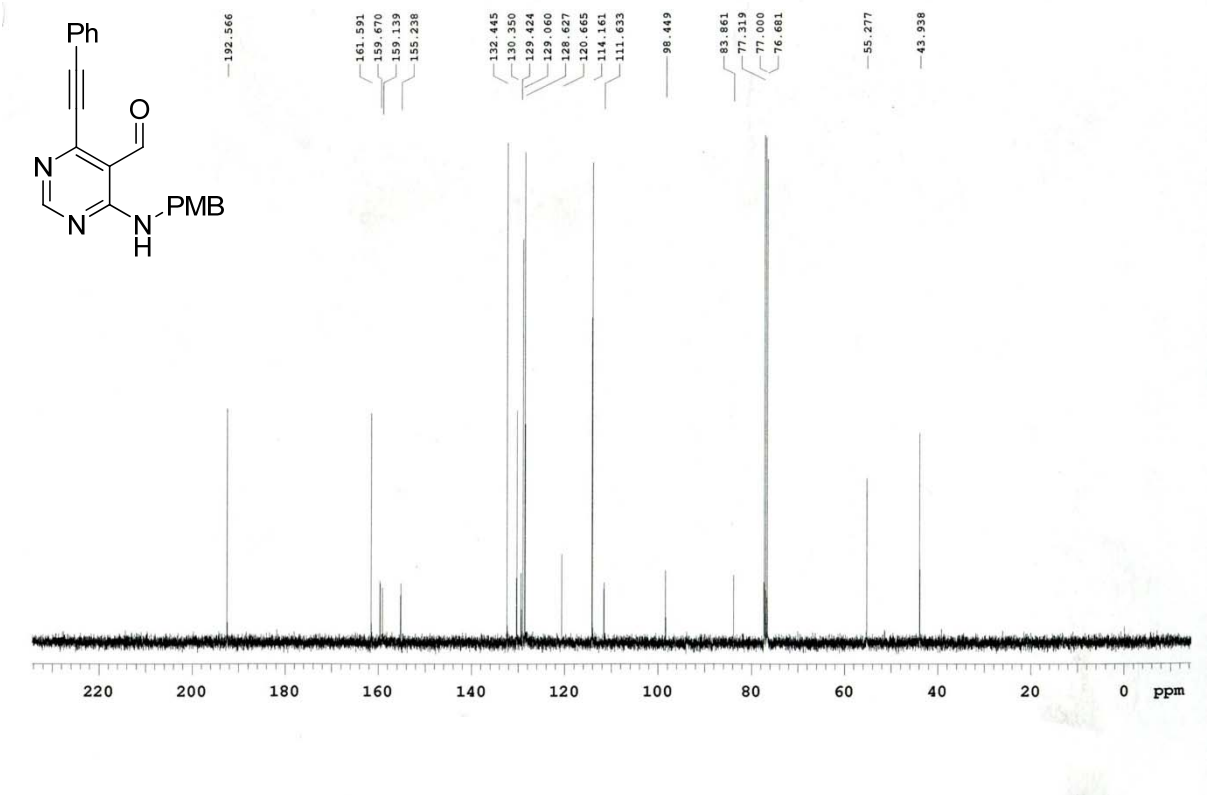
Compound 9


10.372
10.042
9.210
8.578
7.362
7.341
7.326
7.321
7.304
7.291
7.283
7.273
7.263
5.292
4.803
4.787
4.772
1.706
1.580
1.567
1.559
1.554
1.546
1.541
1.534
1.526
1.513
1.036
1.022
1.015
1.010
1.000
0.993
0.988
0.980
0.974
0.969
0.961
0.945
0.938
0.007
0.000
-0.009
O
N
N
N
H
Bn
12
10
8
6
4
2
0
ppm
0.80
0.90
0.89
4.85
2.00
0.85
3.79

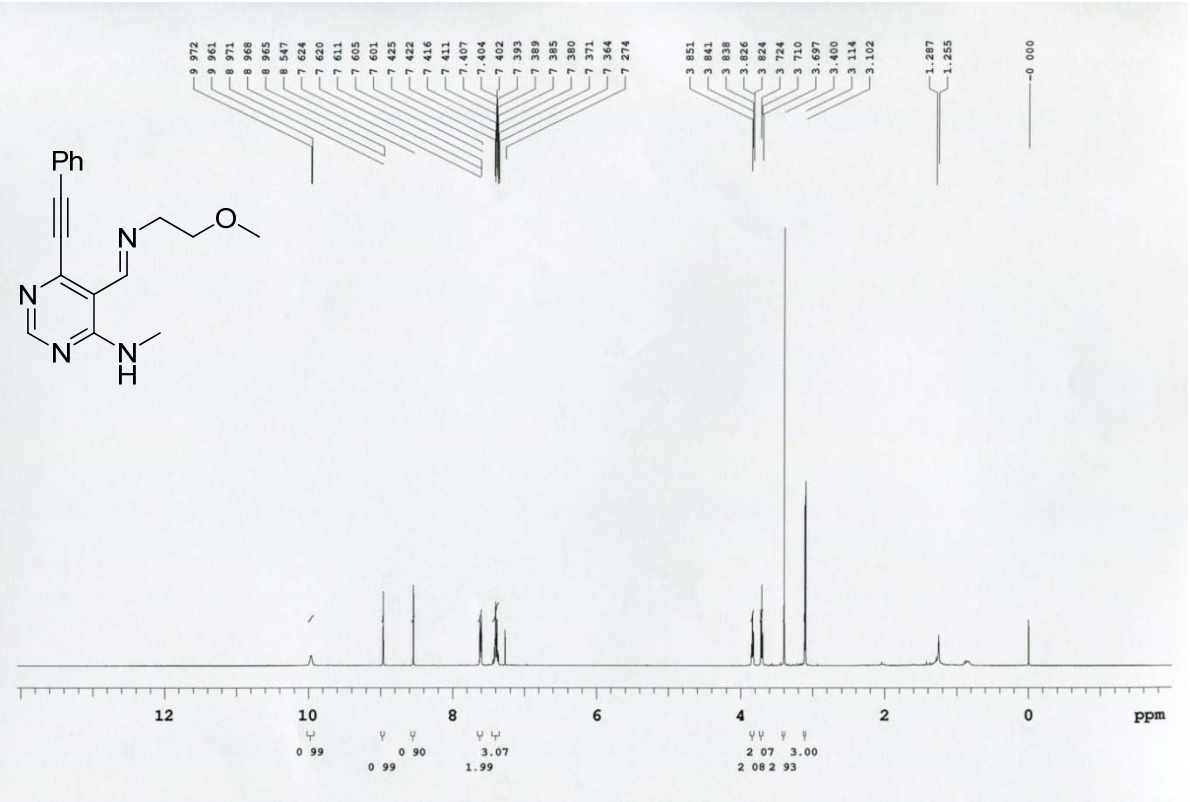

192.907
161.477
159.815
155.731
137.454
128.726
127.580
127.557
111.724
105.136
77.319
77.000
76.681
71.323
44.302
9.494
0.364
O
N
N
N
H
Bn
220
200
180
160
140
120
100
80
60
40
20
0
ppm

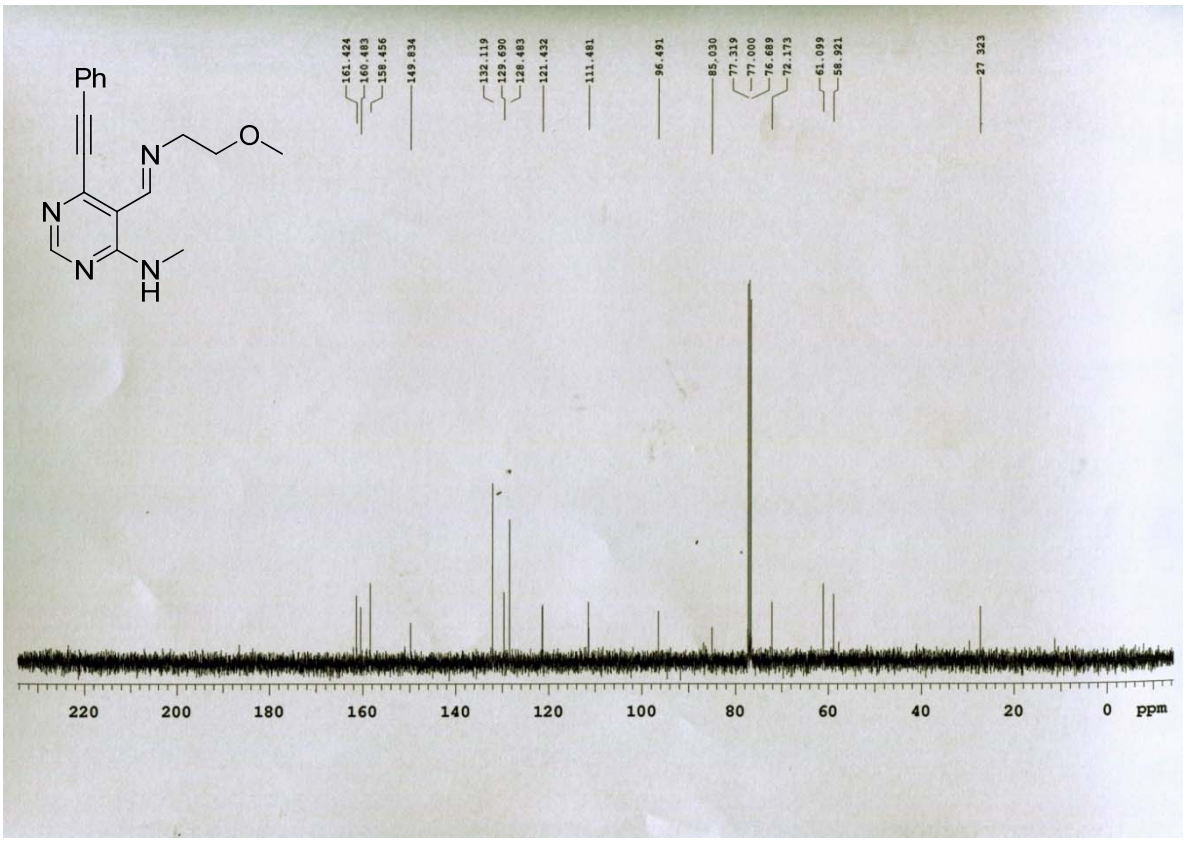
Compound 10


Ph
O
N
N
PMB
N
H
10.554
9.194
8.675
7.636
7.619
7.615
7.453
7.447
7.435
7.419
7.400
7.383
7.379
7.287
7.264
6.896
6.875
4.744
4.730
3.802
0.000
12
10
8
6
4
2
0
ppm
0.84
0.96
0.95
3.03
1.92
1.97
2.39
2.03
3.00

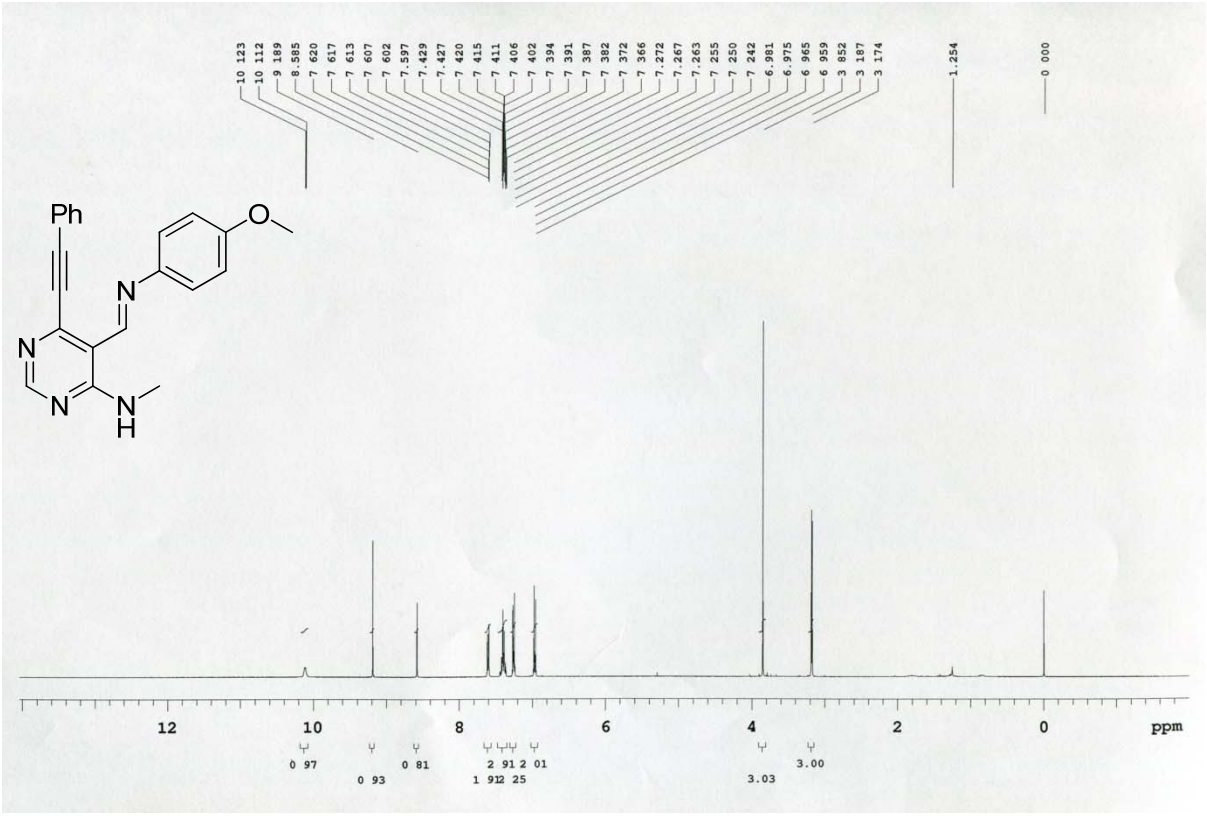

Ph
O
N
N
PMB
N
H
192.566
161.591
159.670
159.139
155.238
132.445
130.350
129.424
129.060
128.627
120.665
114.161
111.633
98.449
83.861
77.319
77.000
76.681
55.277
43.938
220
200
180
160
140
120
100
80
60
40
20
0
ppm

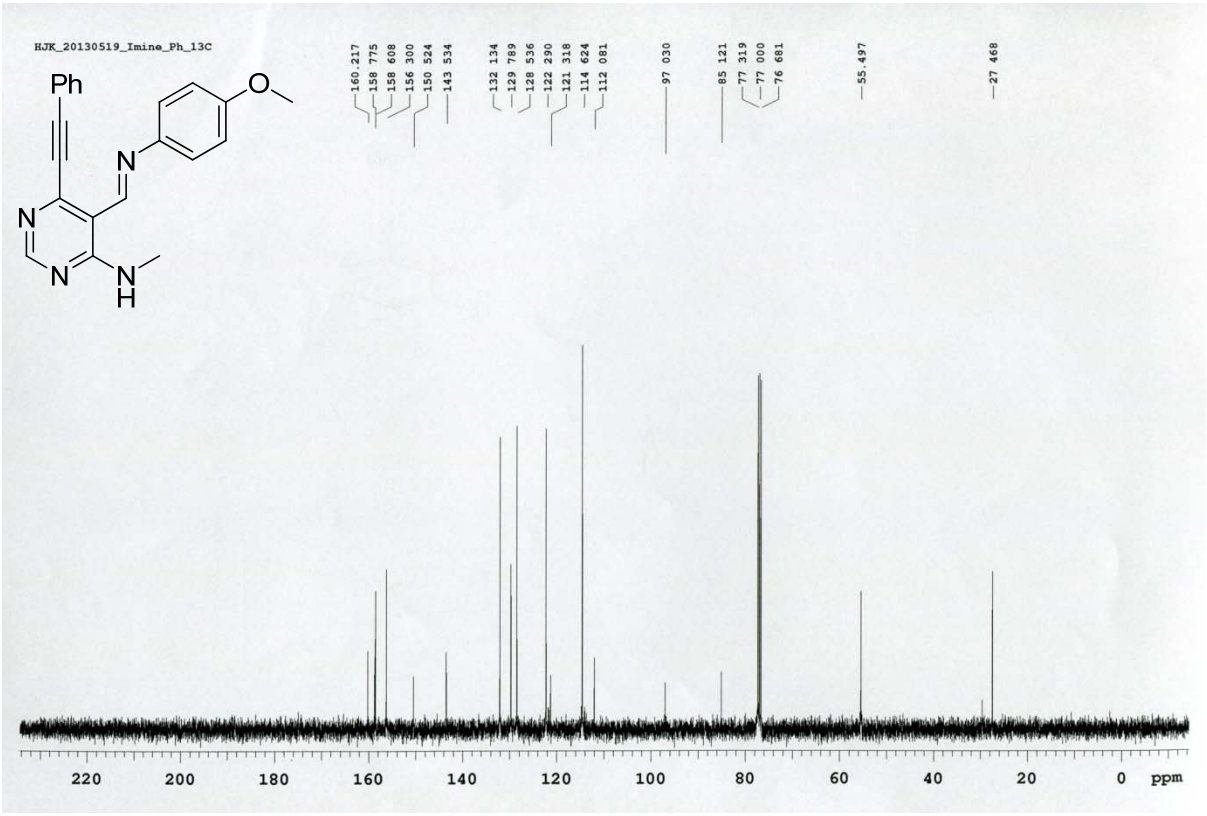
Compound 4a`


9.972
9.961
8.971
8.968
8.965
8.547
7.624
7.620
7.611
7.605
7.601
7.425
7.422
7.416
7.411
7.407
7.404
7.402
7.393
7.389
7.385
7.380
7.371
7.364
7.274
3.851
3.841
3.838
3.826
3.824
3.724
3.710
3.697
3.400
3.114
3.102
1.287
1.255
0.000
Ph
N
O
N
N
N
H
12
10
8
6
4
2
0
ppm
0.99
0.90
3.07
0.99
1.99
2.07
3.00
2.08
2.93

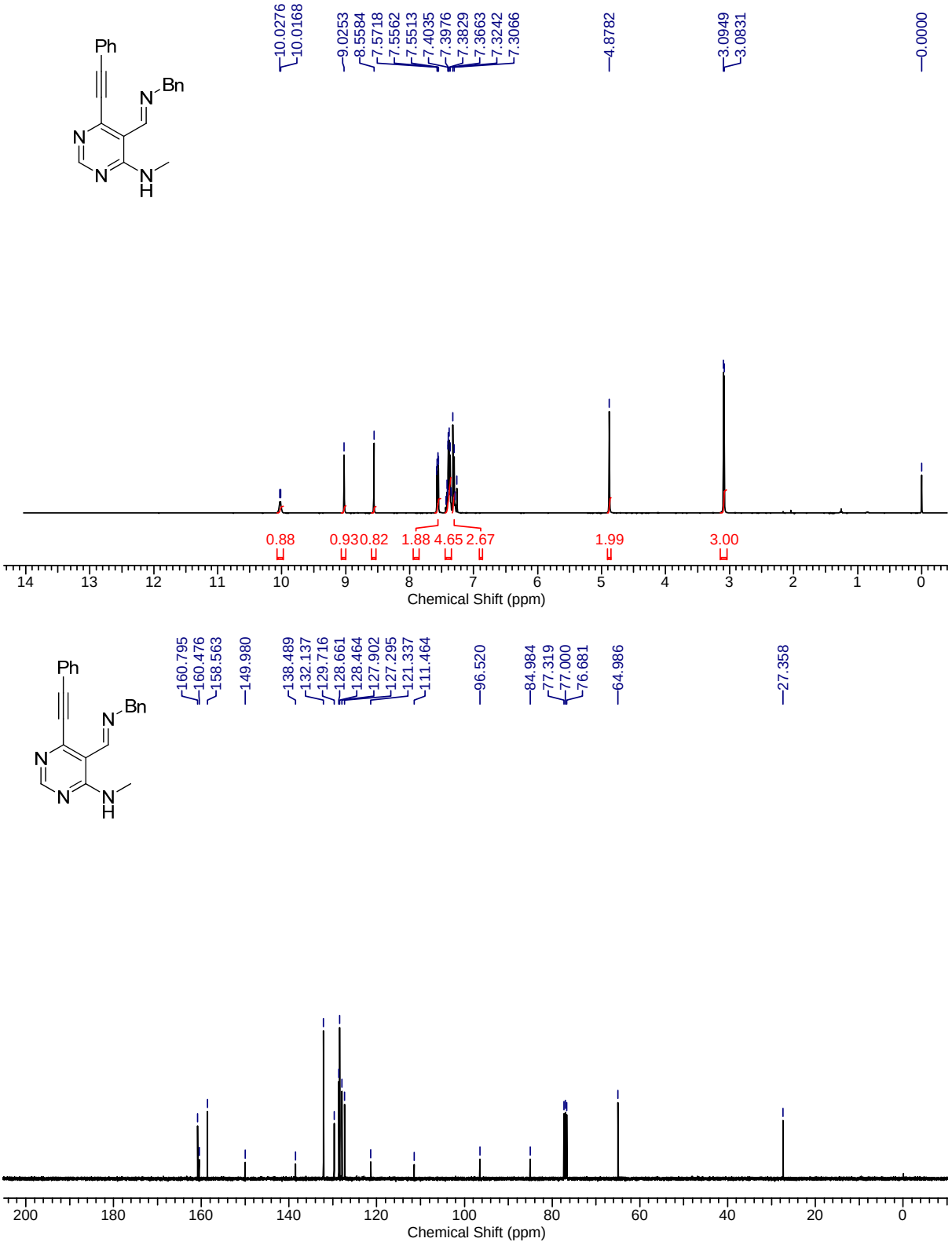

161.424
160.483
158.456
149.834
132.119
129.690
128.483
121.432
111.481
96.491
85.030
77.319
77.000
76.689
72.173
61.099
58.921
27.323
Ph
N
O
N
N
N
H
220
200
180
160
140
120
100
80
60
40
20
0
ppm

Compound 4b`

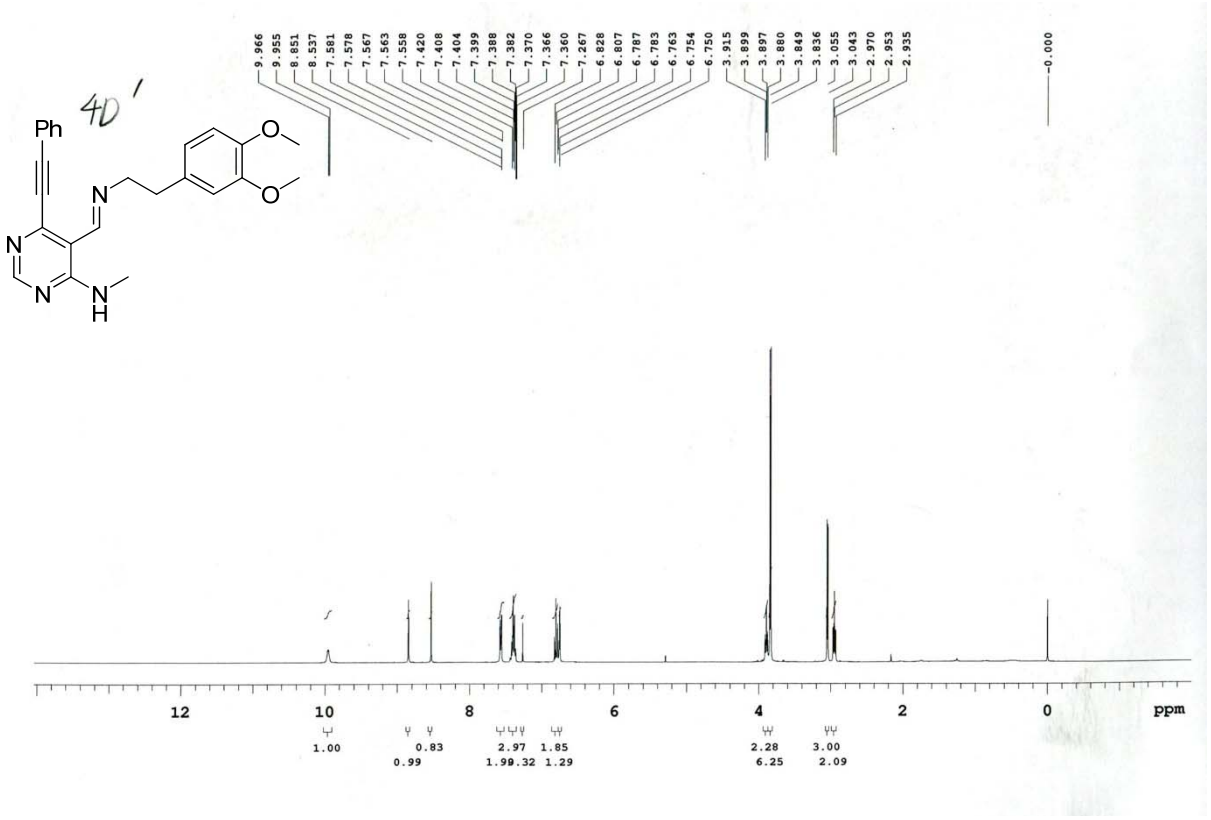

10.123
10.112
9.189
8.585
7.620
7.617
7.613
7.607
7.602
7.597
7.429
7.427
7.420
7.415
7.411
7.406
7.402
7.394
7.391
7.387
7.382
7.372
7.366
7.272
7.267
7.263
7.255
7.250
7.242
6.981
6.975
6.965
6.959
3.852
3.187
3.174
1.254
0.000
Ph
O
N
N
N
N
H
12
10
8
6
4
2
0
ppm
0.97
0.93
0.81
2.91
2.01
1.91
2.25
3.03
3.00

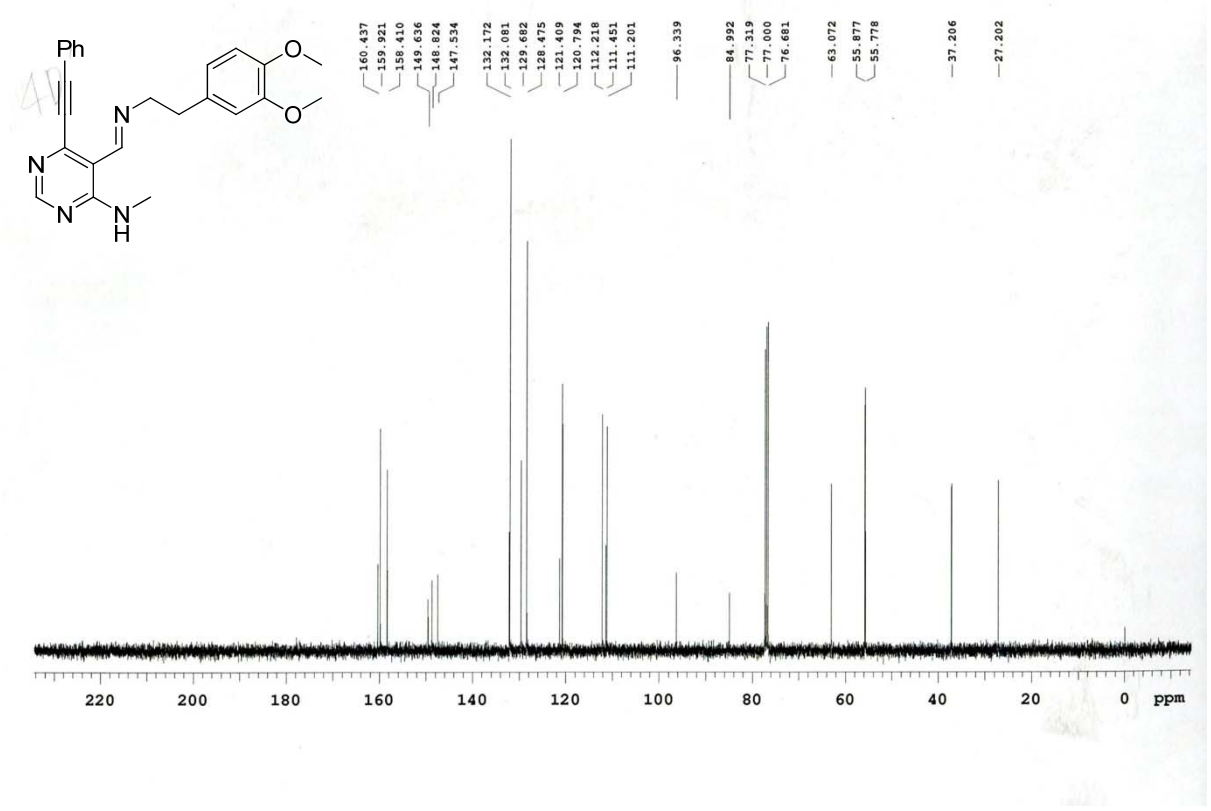

HJK_20130519_Imine_Ph_13C
160.217
158.775
158.608
156.300
150.524
143.534
132.134
129.789
128.536
122.290
121.318
114.624
112.081
97.030
85.121
77.319
77.000
76.681
55.497
27.468
Ph
O
N
N
N
N
H
220
200
180
160
140
120
100
80
60
40
20
0
ppm

Compound 4c`

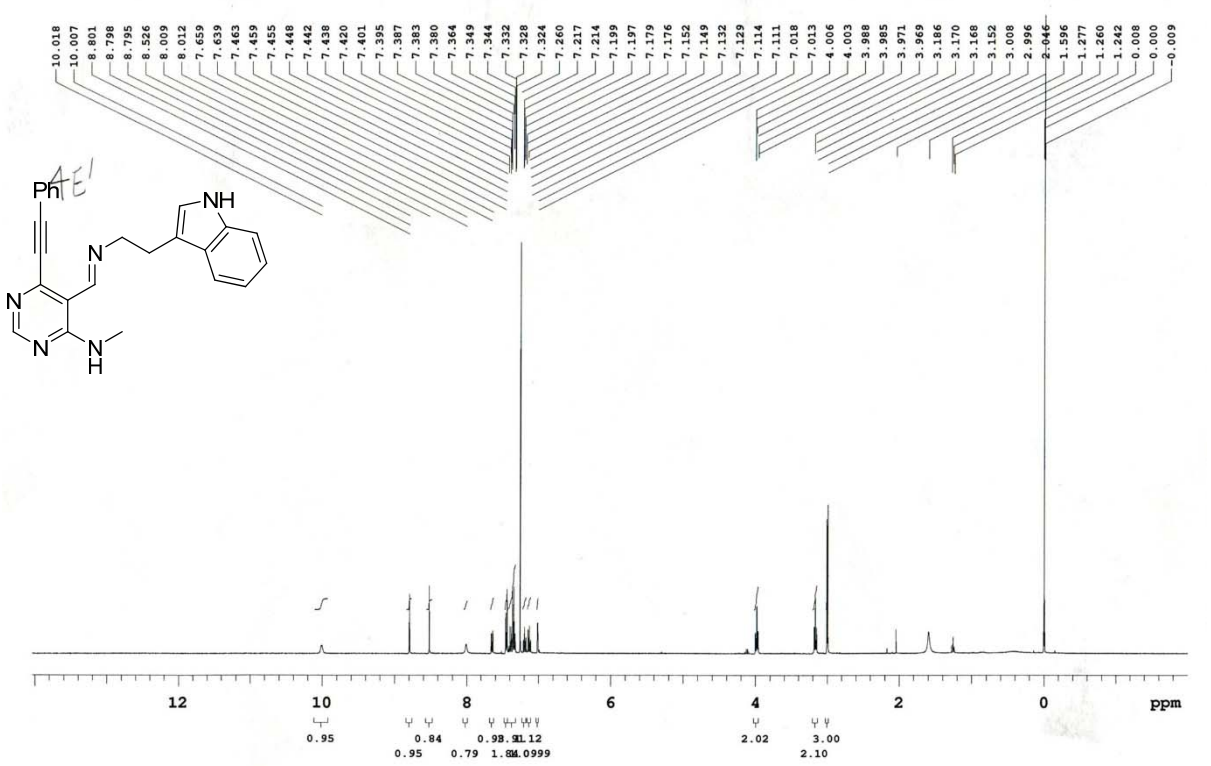

Ph
N
Bn
N
N
H
10.0276
10.0168
9.0253
8.5584
7.5718
7.5562
7.5513
7.4035
7.3976
7.3829
7.3663
7.3242
7.3066
4.8782
3.0949
3.0831
0.0000
0.88
0.93
0.82
1.88
4.65
2.67
1.99
3.00
Chemical Shift (ppm)
160.795
160.476
158.563
149.980
138.489
132.137
129.716
128.661
128.464
127.902
127.295
121.337
111.464
96.520
84.984
77.319
77.000
76.681
64.986
27.358
Chemical Shift (ppm)

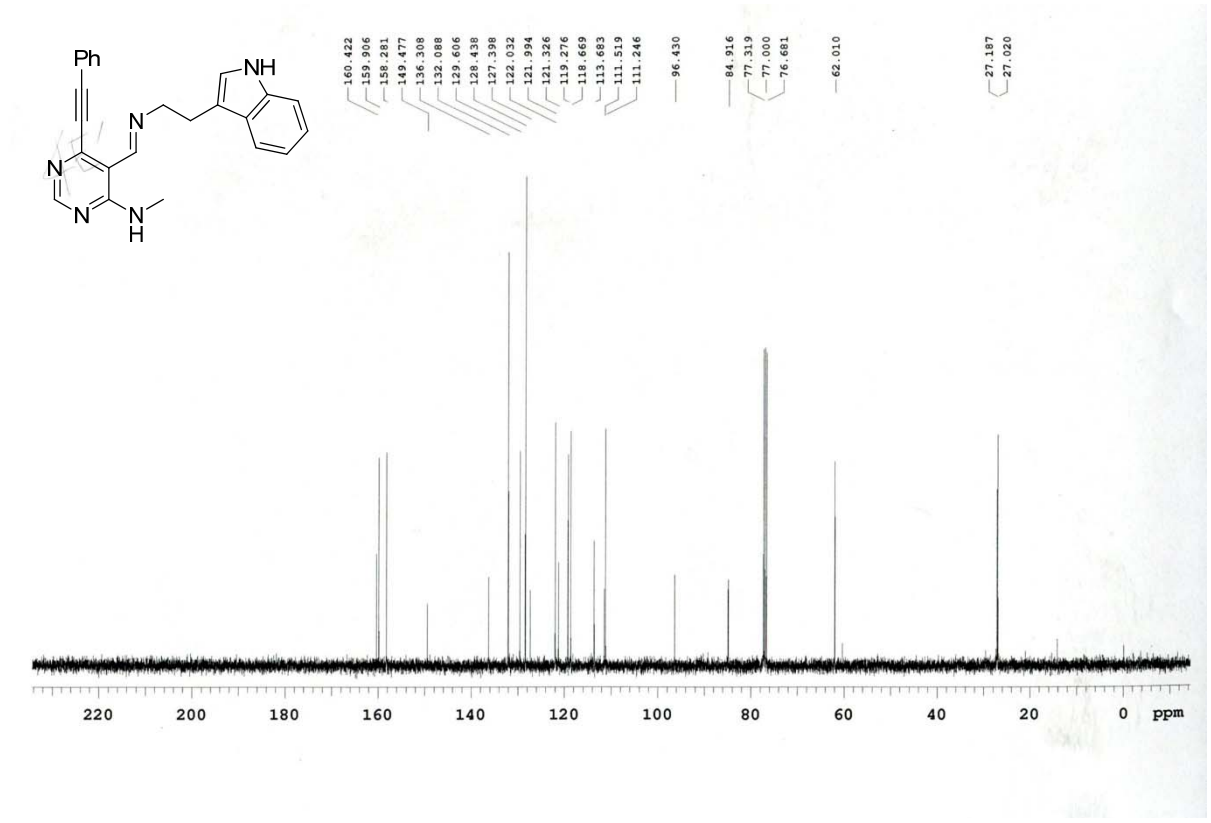
Compound 4d`


Ph
4D'
O
O
N
N
N
N
H
9.966
9.955
8.851
8.537
7.581
7.578
7.567
7.563
7.558
7.420
7.408
7.404
7.399
7.388
7.382
7.370
7.366
7.360
7.267
6.828
6.807
6.787
6.783
6.763
6.754
6.750
3.915
3.899
3.897
3.880
3.849
3.836
3.055
3.043
2.970
2.953
2.935
0.000
12
10
8
6
4
2
0
ppm
1.00
0.83
0.99
2.97
1.85
1.99
1.32
1.29
2.28
3.00
6.25
2.09

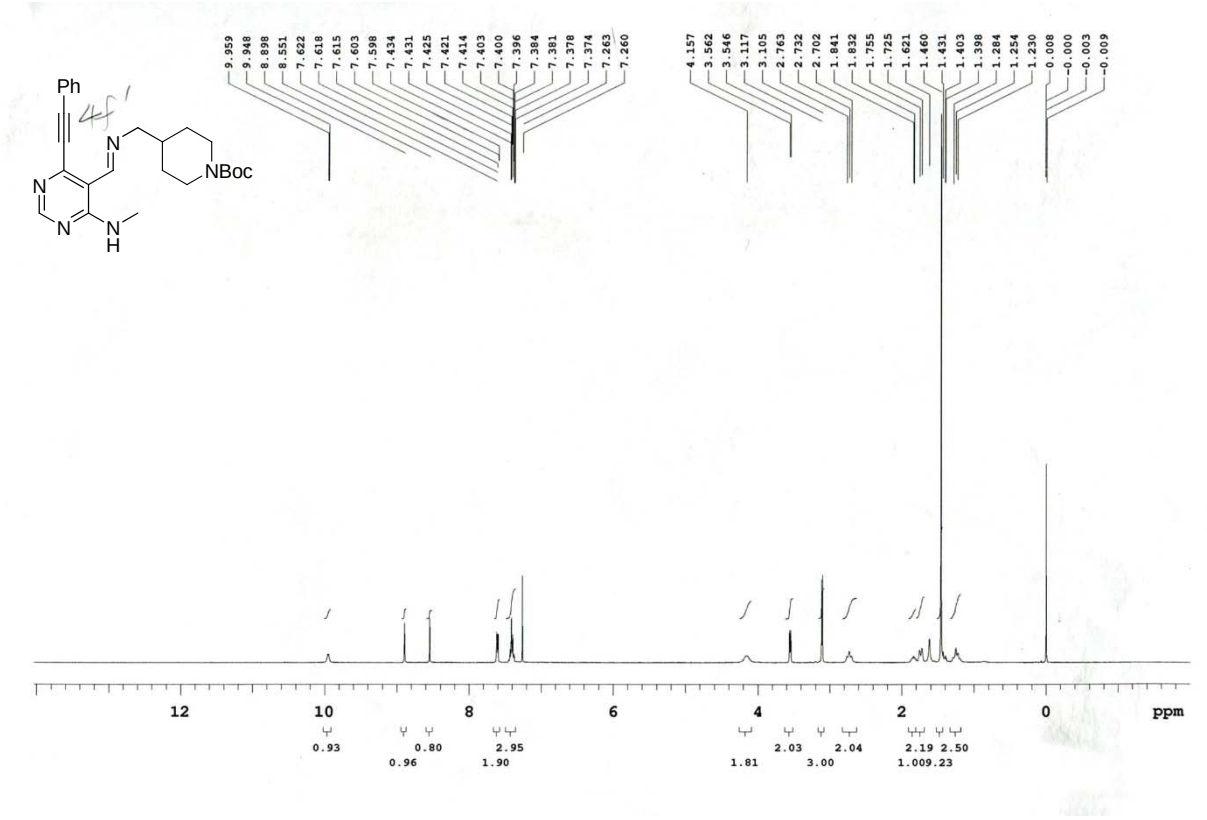

Ph
O
O
N
N
N
N
H
160.437
159.921
158.410
149.636
148.824
147.534
132.172
132.081
129.682
128.475
121.409
120.794
112.218
111.451
111.201
96.339
84.992
77.319
77.000
76.681
63.072
55.877
55.778
37.206
27.202
220
200
180
160
140
120
100
80
60
40
20
0
ppm

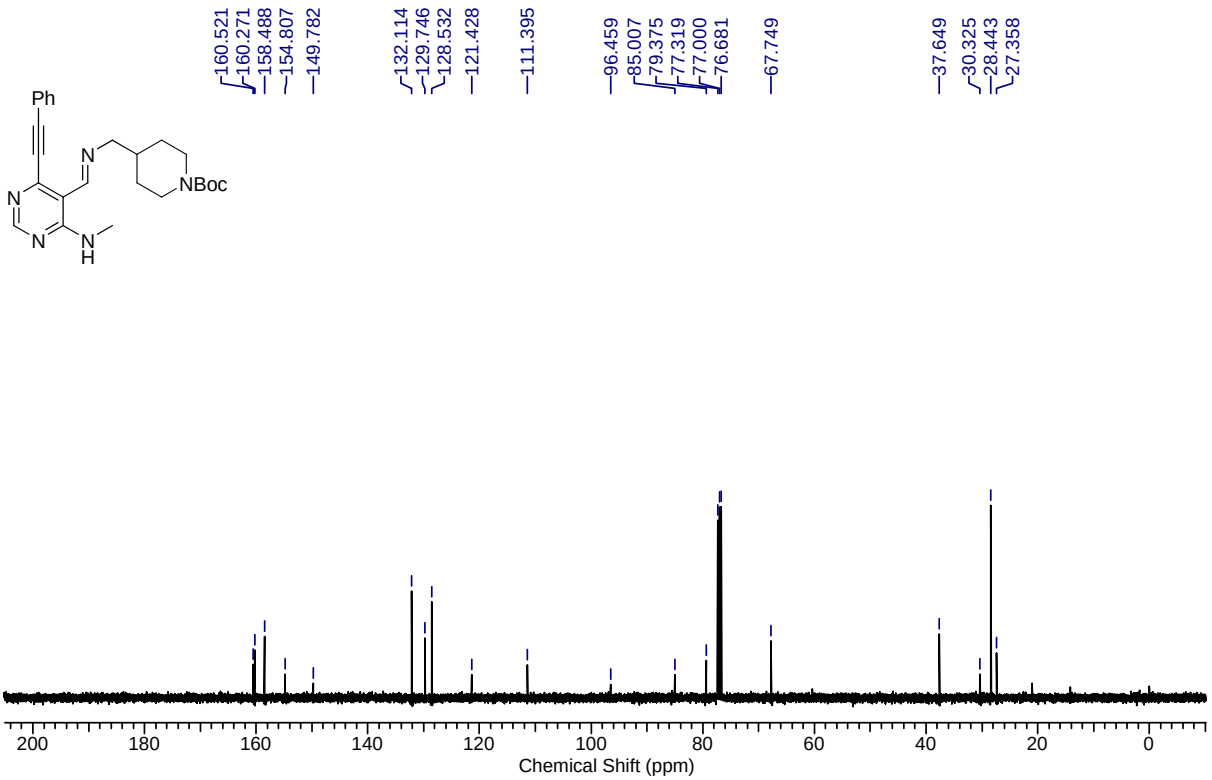
Compound 4e`



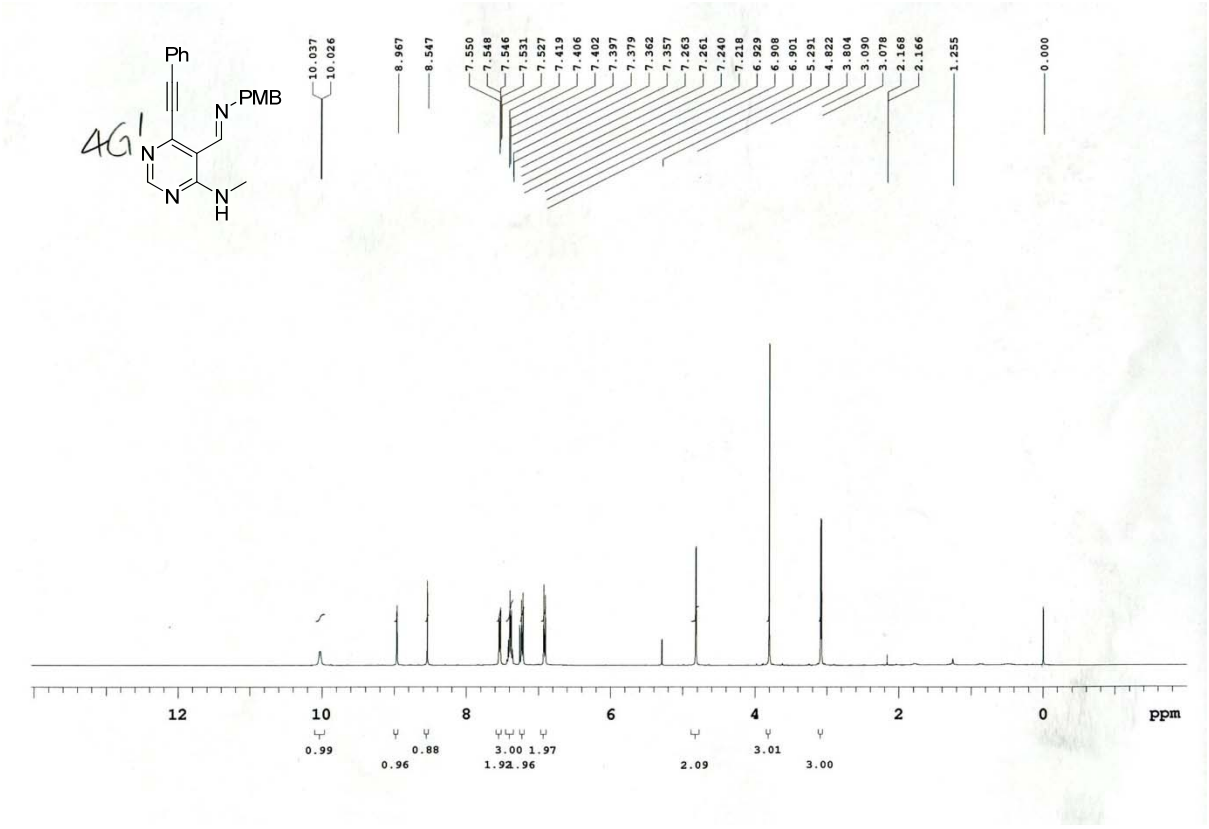


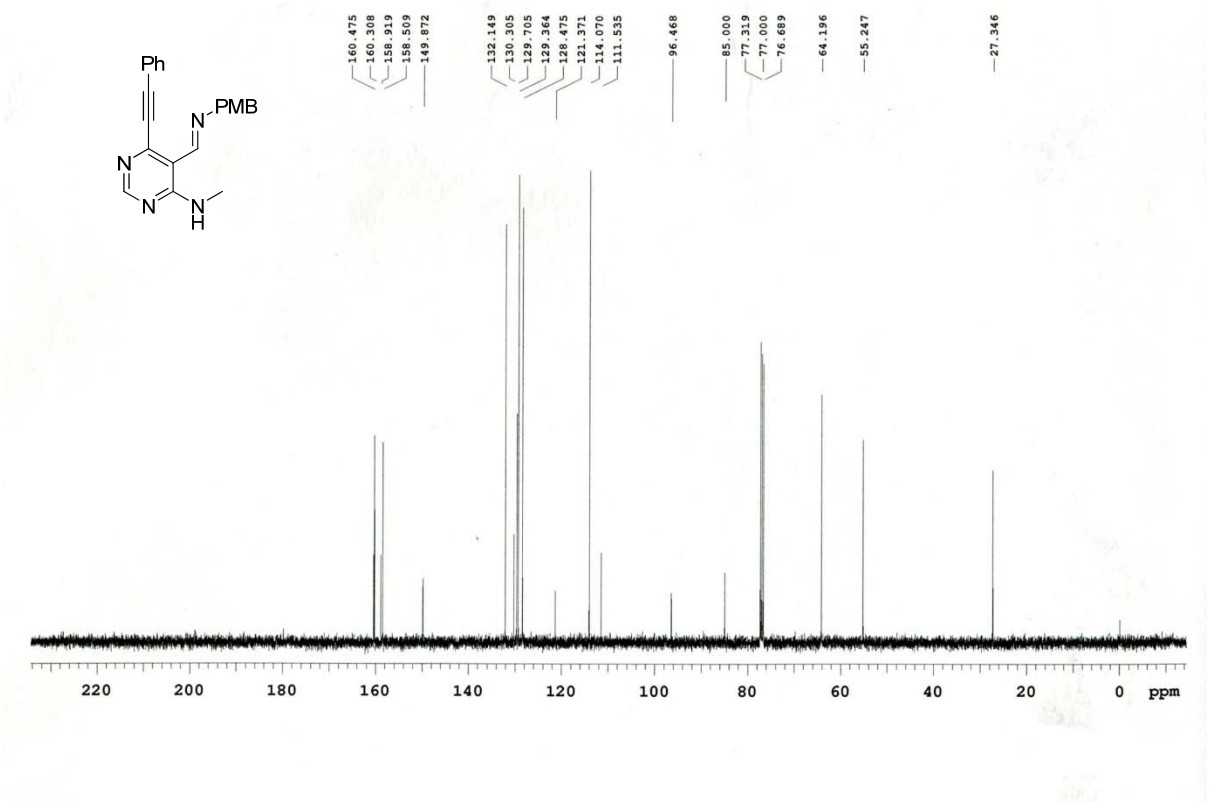
Conmpound 4f`


Ph
4f'
N
NBoc
N
N
N
H
9.959
9.948
8.898
8.551
7.622
7.618
7.615
7.603
7.598
7.434
7.431
7.425
7.421
7.414
7.403
7.400
7.396
7.384
7.381
7.378
7.374
7.263
7.260
4.157
3.562
3.546
3.117
3.105
2.763
2.732
2.702
1.841
1.832
1.755
1.725
1.621
1.460
1.431
1.403
1.398
1.284
1.254
1.230
0.008
0.000
-0.003
-0.009
12
10
8
6
4
2
0
ppm
0.93
0.80
2.95
0.96
1.90
2.03
2.04
1.81
3.00
2.19
2.50
1.009.23

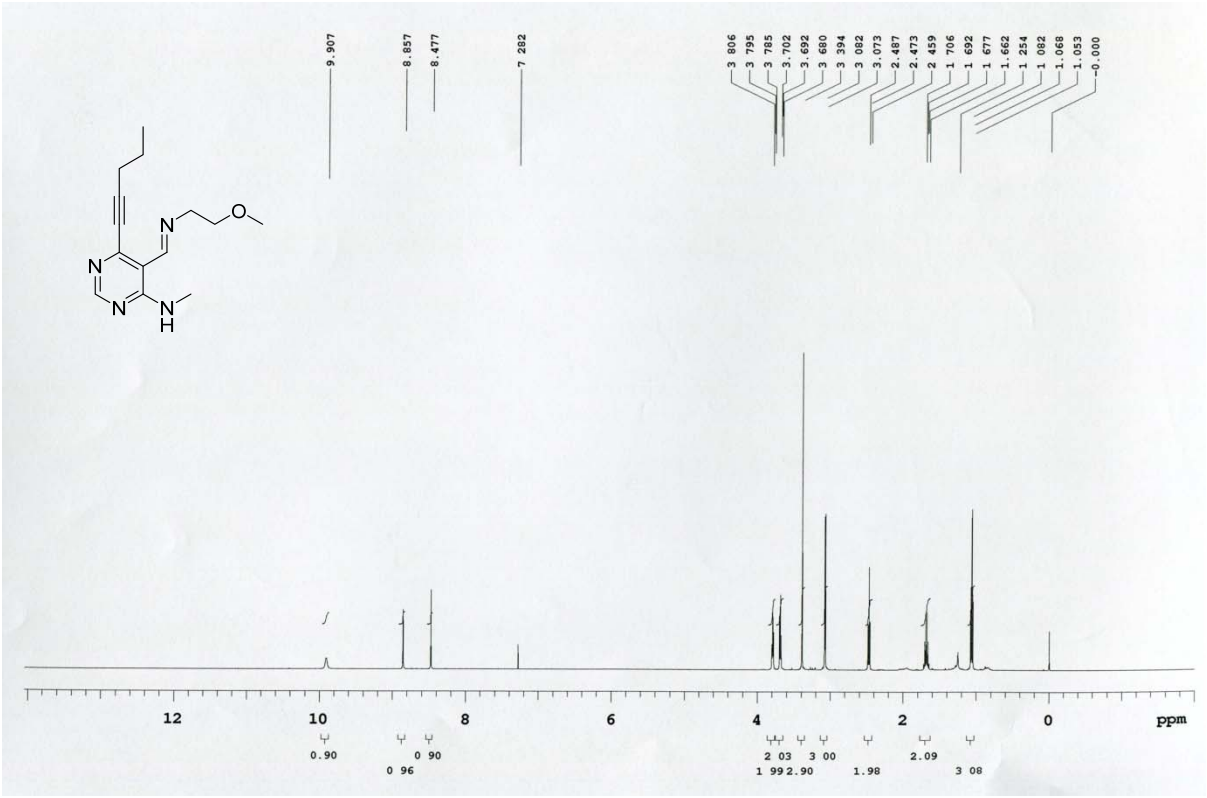

160.521
160.271
158.488
154.807
149.782
132.114
129.746
128.532
121.428
111.395
96.459
85.007
79.375
77.319
77.000
76.681
67.749
37.649
30.325
28.443
27.358
Ph
N
NBoc
N
N
N
H
200
180
160
140
120
100
80
60
40
20
0
Chemical Shift (ppm)

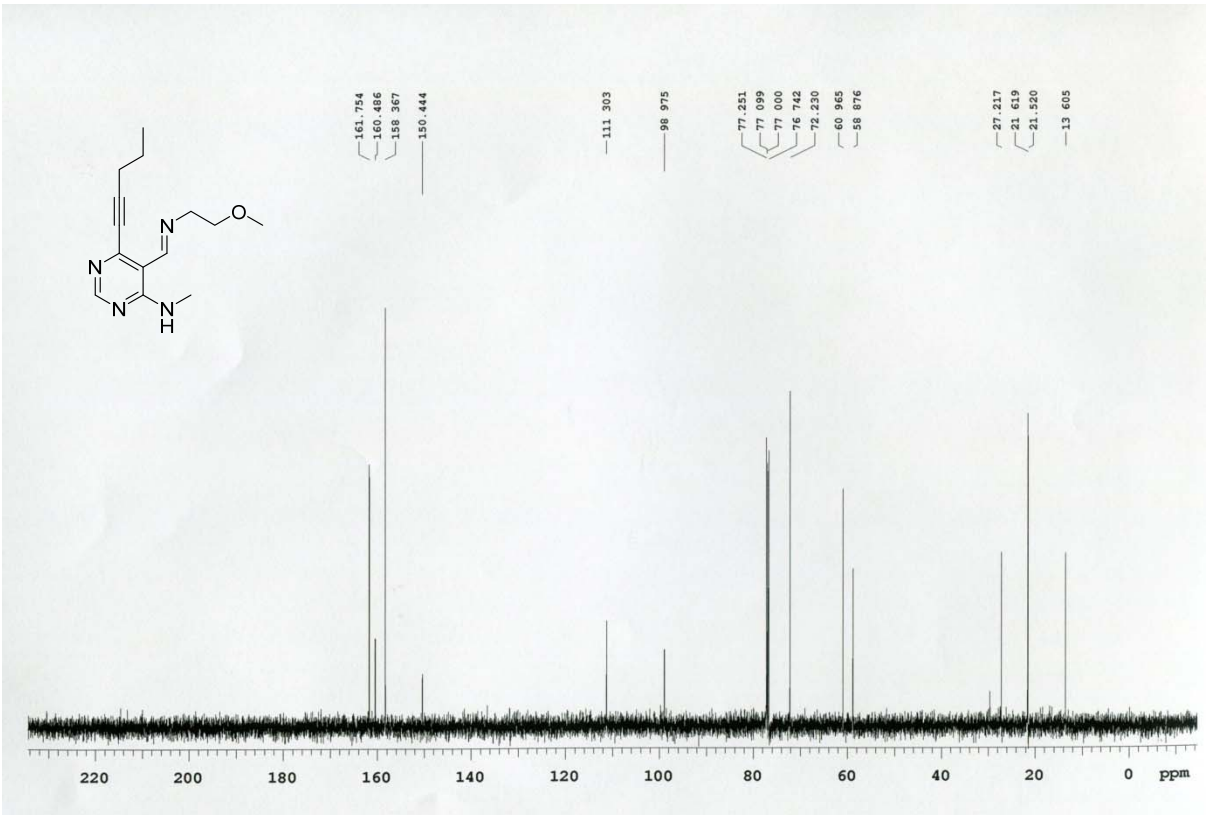
Compound 4g`


Ph
PMB
N
N
N
H
4G1
10.037
10.026
8.967
8.547
7.550
7.548
7.546
7.531
7.527
7.419
7.406
7.402
7.397
7.379
7.362
7.357
7.263
7.261
7.240
7.218
6.929
6.908
6.901
5.291
4.822
3.804
3.090
3.078
2.168
2.166
1.255
0.000
12
10
8
6
4
2
0
ppm
0.99
0.96
0.88
3.00
1.92
1.97
1.96
2.09
3.01
3.00

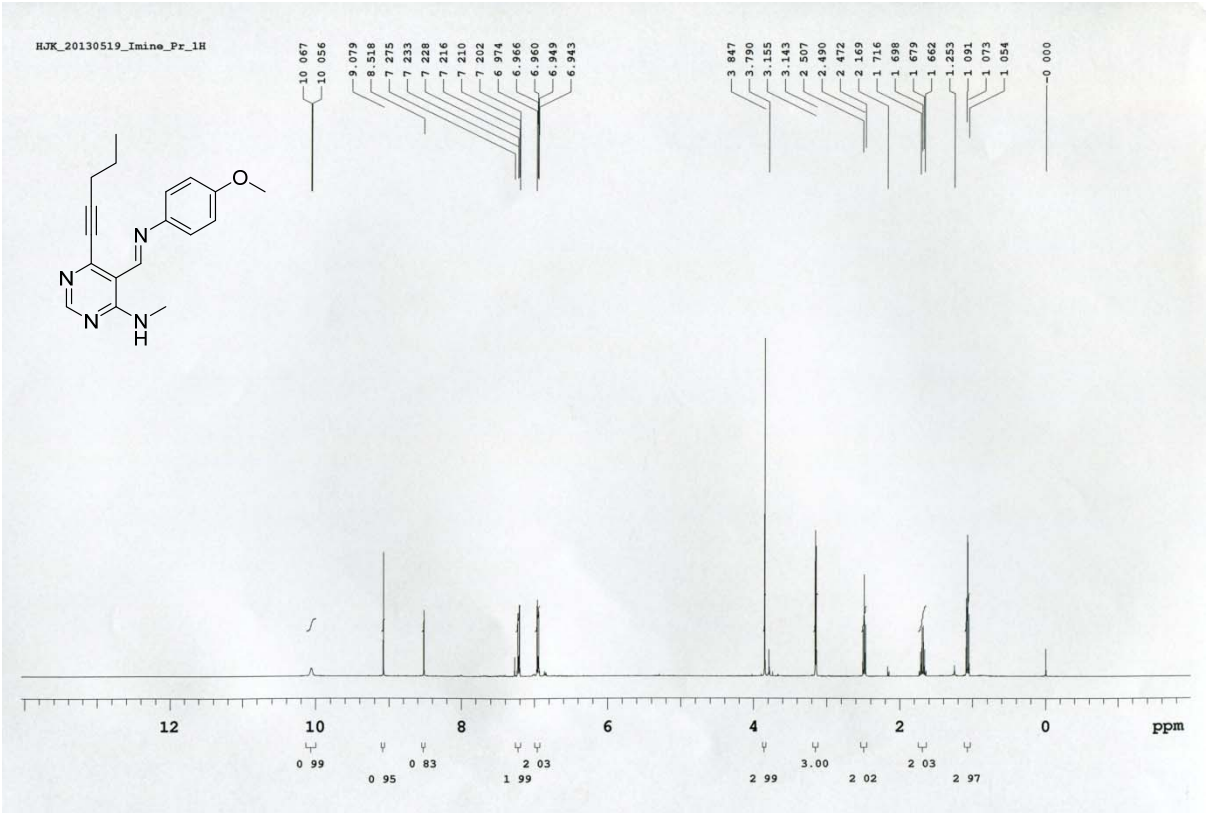

Ph
PMB
N
N
N
H
160.475
160.308
158.919
158.509
149.872
132.149
130.305
129.705
129.364
128.475
121.371
114.070
111.535
96.468
85.000
77.319
77.000
76.689
64.196
55.247
27.346
220
200
180
160
140
120
100
80
60
40
20
0
ppm

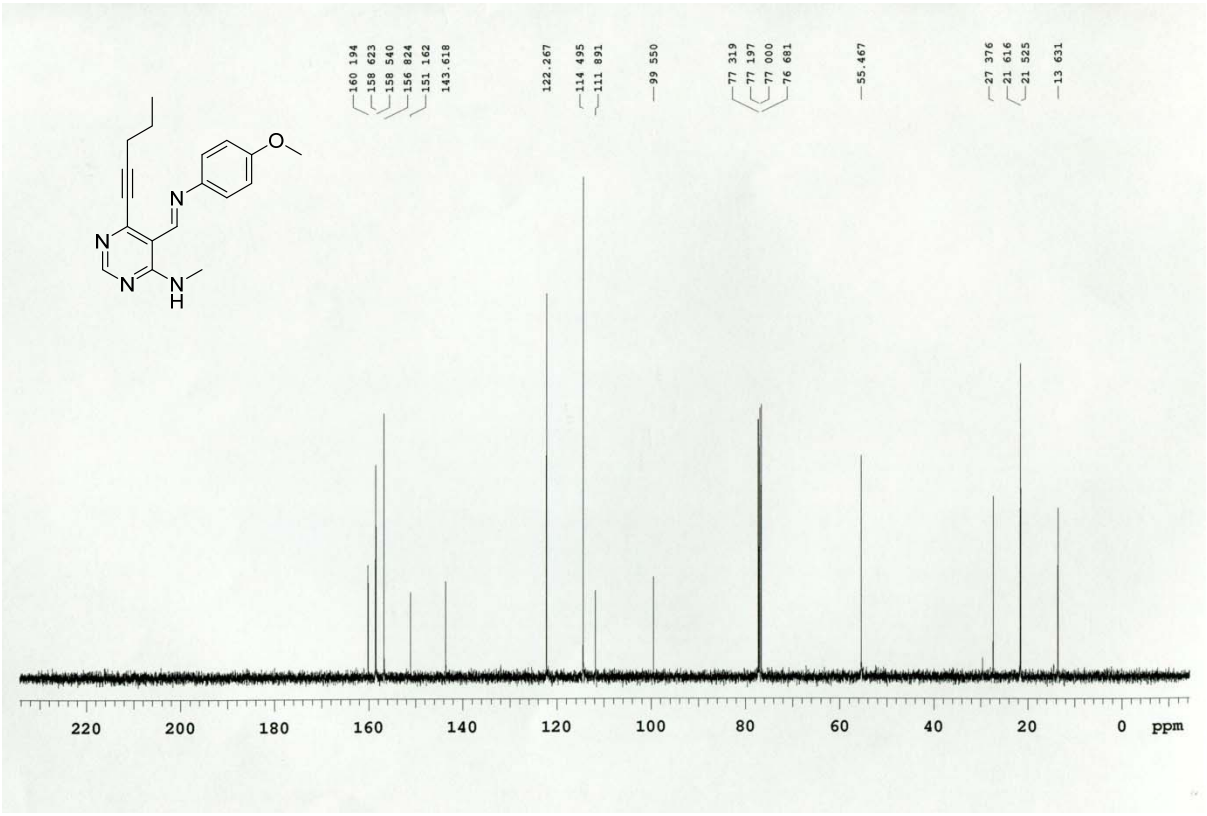
Compound 5a`


9.907
8.857
8.477
7.282
3.806
3.795
3.785
3.702
3.692
3.680
3.394
3.082
3.073
2.487
2.473
2.459
1.706
1.692
1.677
1.662
1.254
1.082
1.068
1.053
0.000
12
10
8
6
4
2
0
ppm
0.90
0.96
0.90
2.03
3.00
1.99
2.90
1.98
2.09
3.08

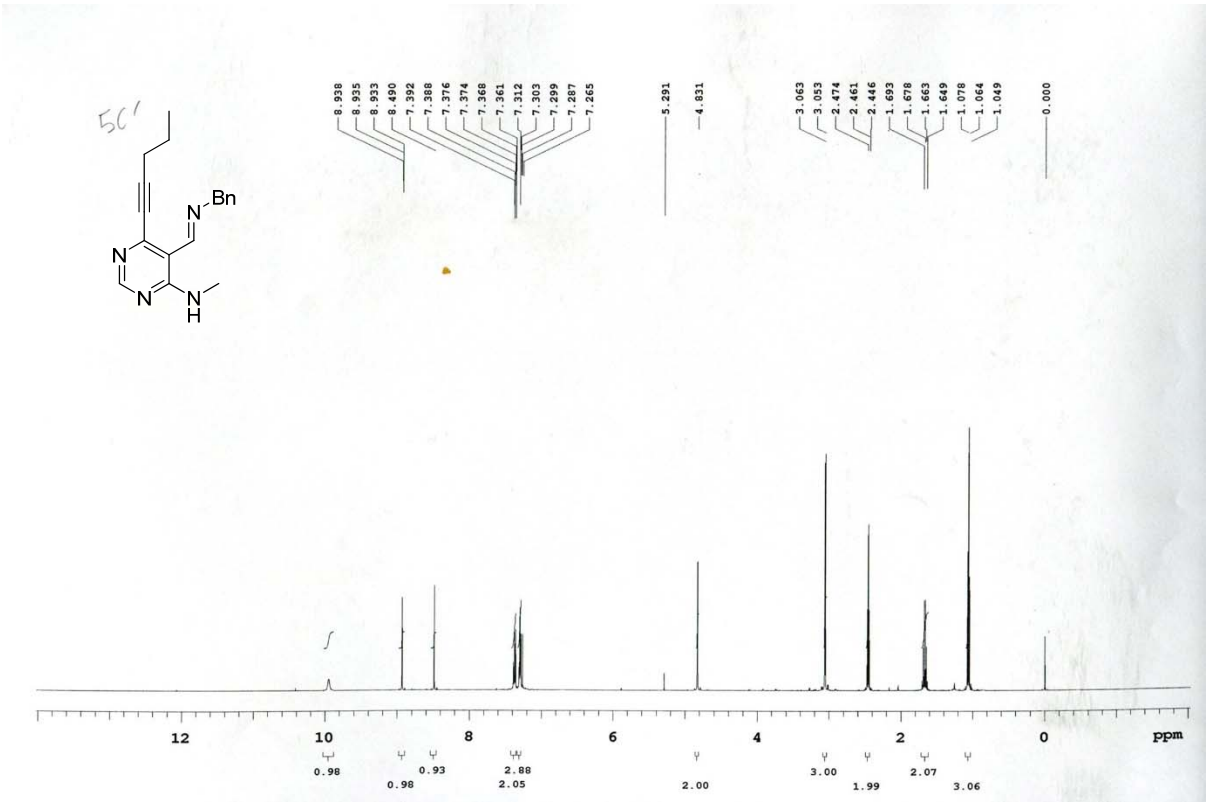

161.754
160.486
158.367
150.444
111.303
98.975
77.251
77.099
77.000
76.742
72.230
60.965
58.876
27.217
21.619
21.520
13.605
220
200
180
160
140
120
100
80
60
40
20
0
ppm

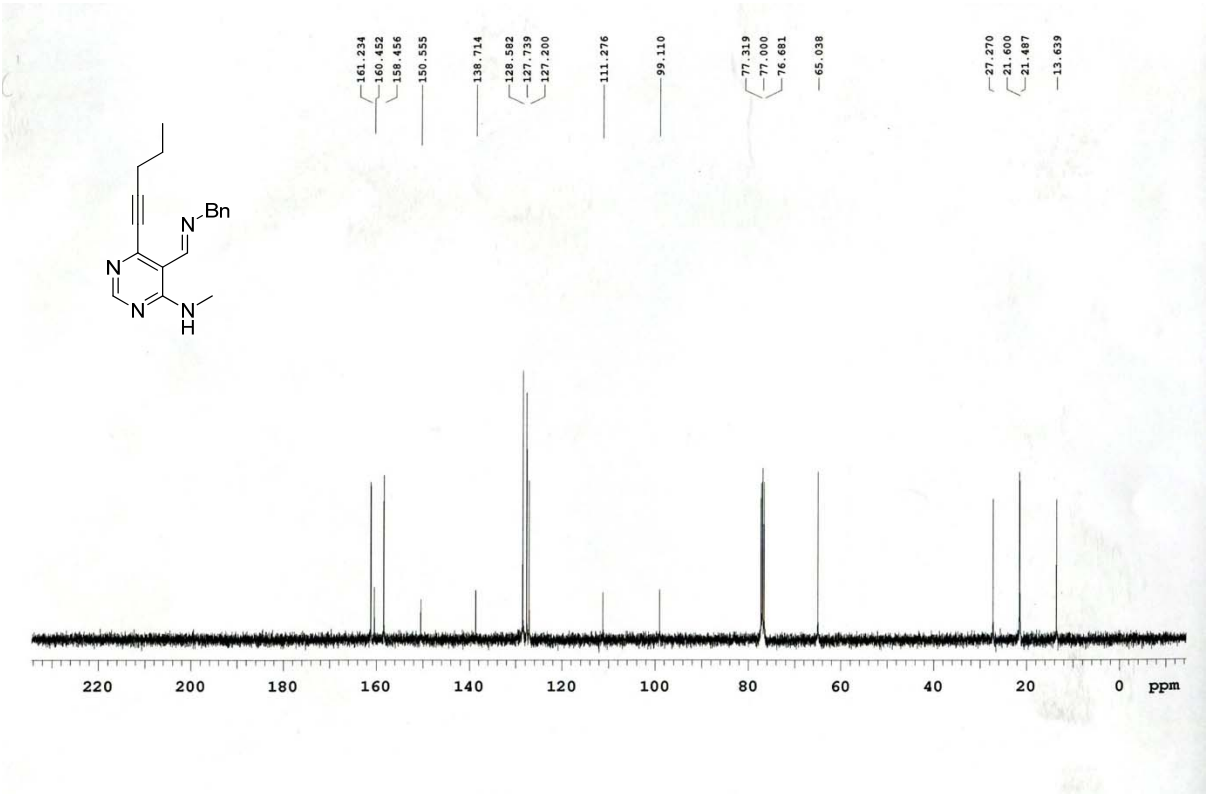
Compound 5b`


HJK_20130519_Imine_Pr_1H
10.067
10.056
9.079
8.518
7.275
7.233
7.228
7.216
7.210
7.202
6.974
6.966
6.960
6.949
6.943
3.847
3.790
3.155
3.143
2.507
2.490
2.472
2.169
1.716
1.698
1.679
1.662
1.253
1.091
1.073
1.054
0.000
12
10
8
6
4
2
0
ppm
0.99
0.95
0.83
2.03
1.99
2.99
3.00
2.02
2.03
2.97

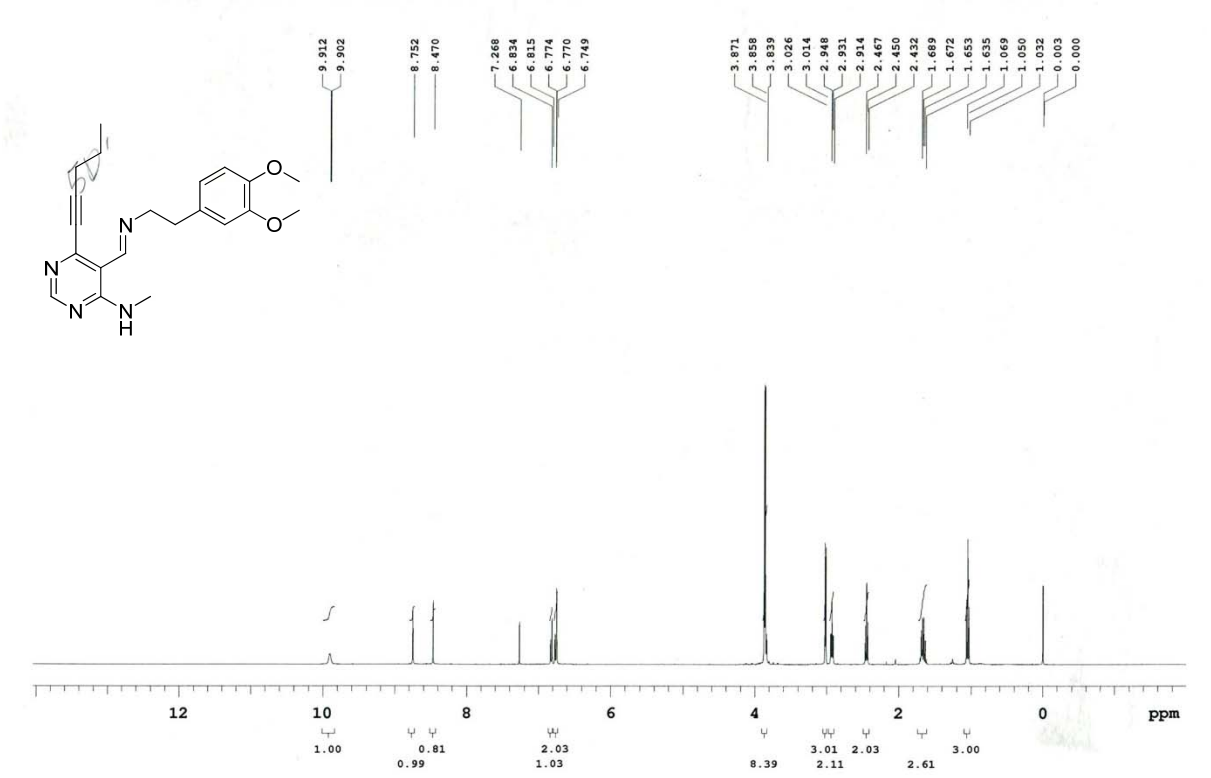

160.194
158.623
158.540
156.824
151.162
143.618
122.267
114.495
111.891
99.550
77.319
77.197
77.000
76.681
55.467
27.376
21.616
21.525
13.631
220
200
180
160
140
120
100
80
60
40
20
0
ppm

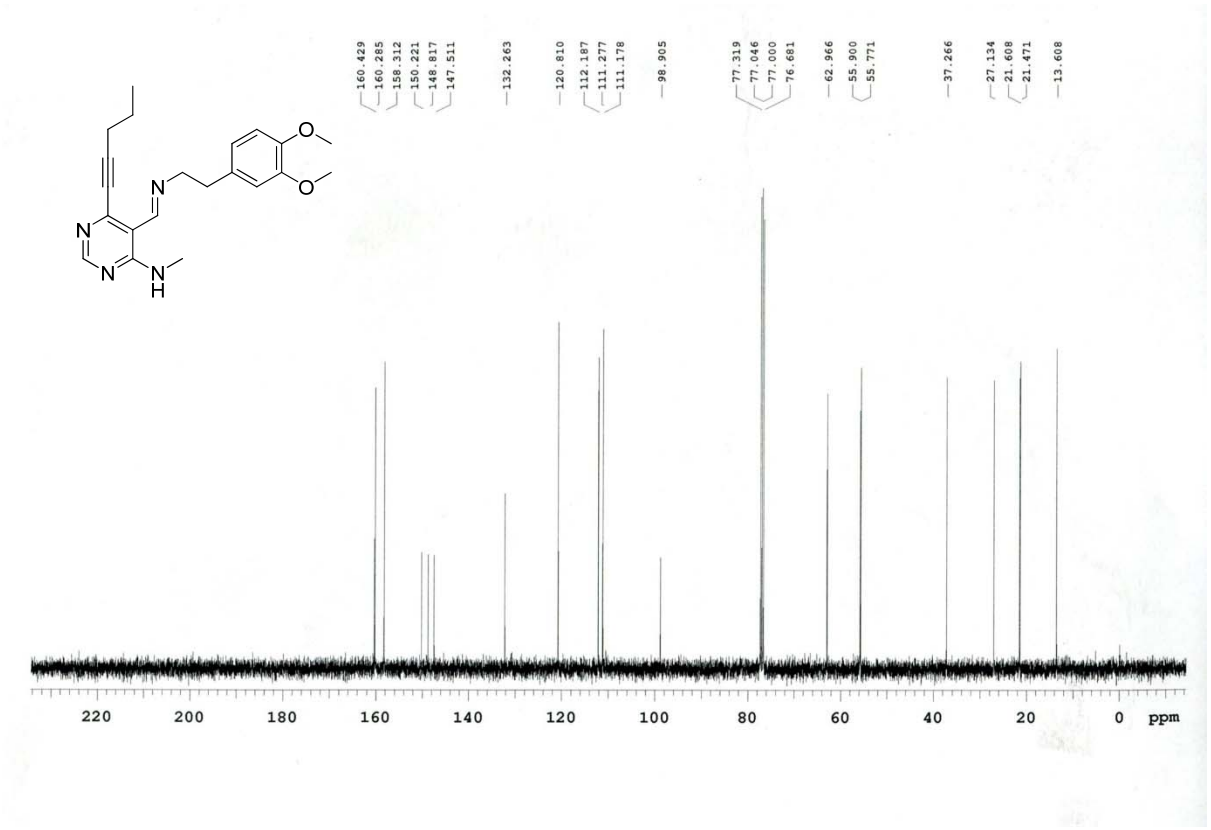
Compound 5c`


8.938
8.935
8.933
8.490
7.392
7.388
7.376
7.374
7.368
7.361
7.312
7.303
7.299
7.287
7.265
5.291
4.831
3.063
3.053
2.474
2.461
2.446
1.693
1.678
1.663
1.649
1.078
1.064
1.049
0.000
Bn
N
N
N
H
12
10
8
6
4
2
0
ppm
0.98
0.98
0.93
2.88
2.05
2.00
3.00
1.99
2.07
3.06

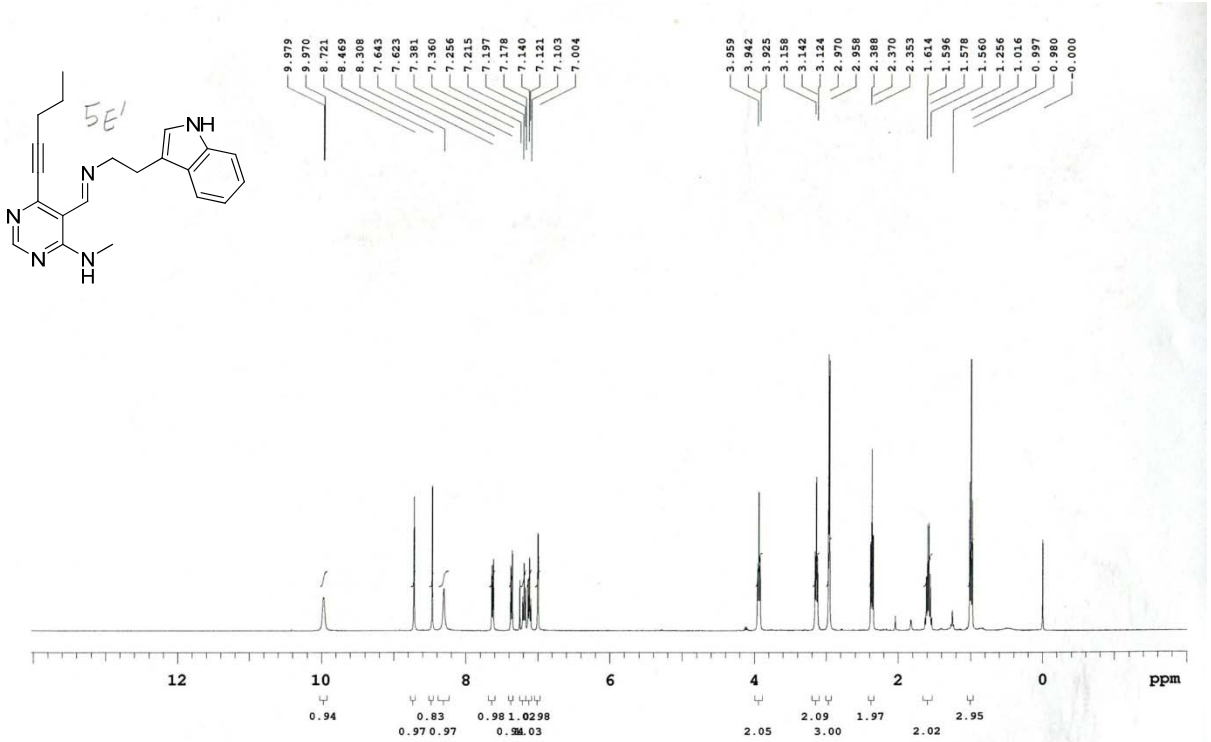

161.234
160.452
158.456
150.555
138.714
128.582
127.739
127.200
111.276
99.110
77.319
77.000
76.681
65.038
27.270
21.600
21.487
13.639
Bn
N
N
N
H
220
200
180
160
140
120
100
80
60
40
20
0
ppm

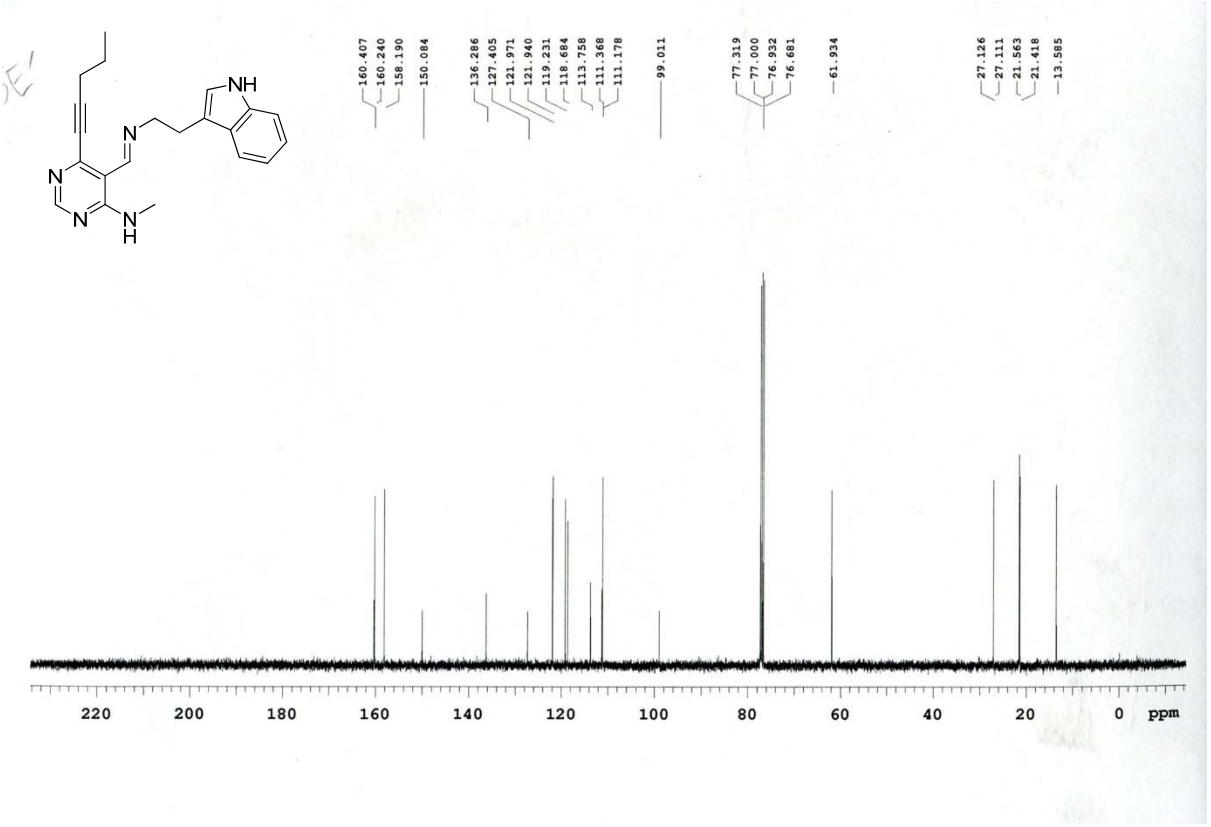
Compound 5d`


9.912
9.902
8.752
8.470
7.268
6.834
6.815
6.774
6.770
6.749
3.871
3.858
3.839
3.026
3.014
2.948
2.931
2.914
2.467
2.450
2.432
1.689
1.672
1.653
1.635
1.069
1.050
1.032
0.003
0.000
12
10
8
6
4
2
0
ppm
1.00
0.99
0.81
2.03
1.03
8.39
3.01
2.11
2.03
2.61
3.00

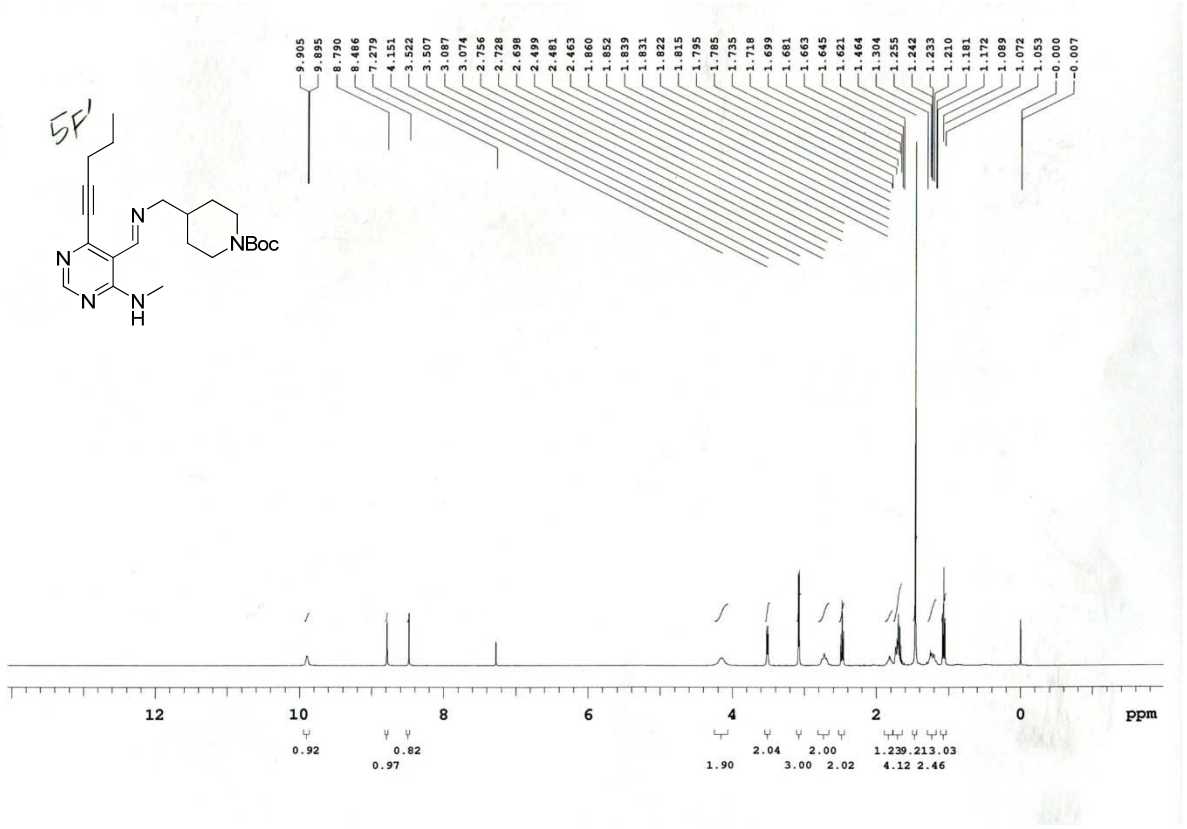

160.429
160.285
158.312
150.221
148.817
147.511
132.263
120.810
112.187
111.277
111.178
98.905
77.319
77.046
77.000
76.681
62.966
55.900
55.771
37.266
27.134
21.608
21.471
13.608
220
200
180
160
140
120
100
80
60
40
20
0
ppm

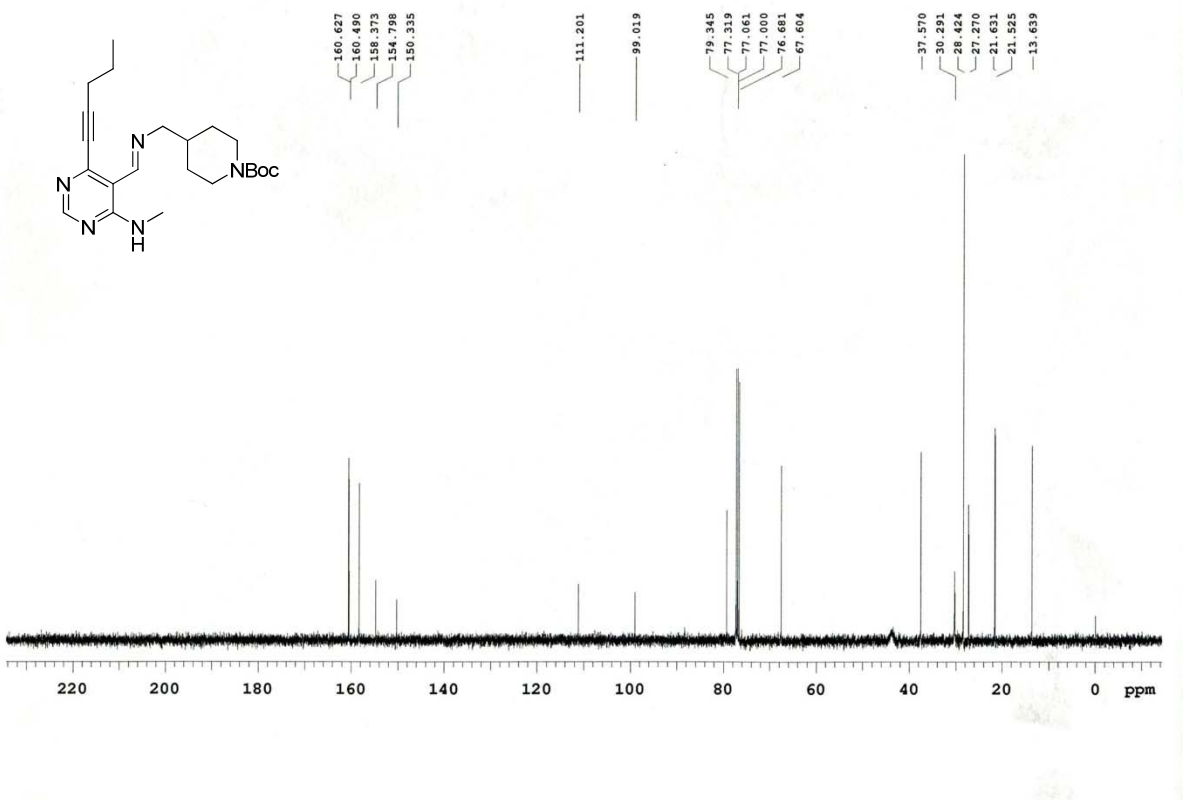
Compound 5e`


5E'
NH
N
N
N
H
9.979
9.970
8.721
8.469
8.308
7.643
7.623
7.381
7.360
7.256
7.215
7.197
7.178
7.140
7.121
7.103
7.004
3.959
3.942
3.925
3.158
3.142
3.124
2.970
2.958
2.388
2.370
2.353
1.614
1.596
1.578
1.560
1.256
1.016
0.997
0.980
-0.000
12
10
8
6
4
2
0
ppm
0.94
0.83
0.97 0.97
0.98 1.02 98
2.05
2.09
3.00
1.97
2.02
2.95

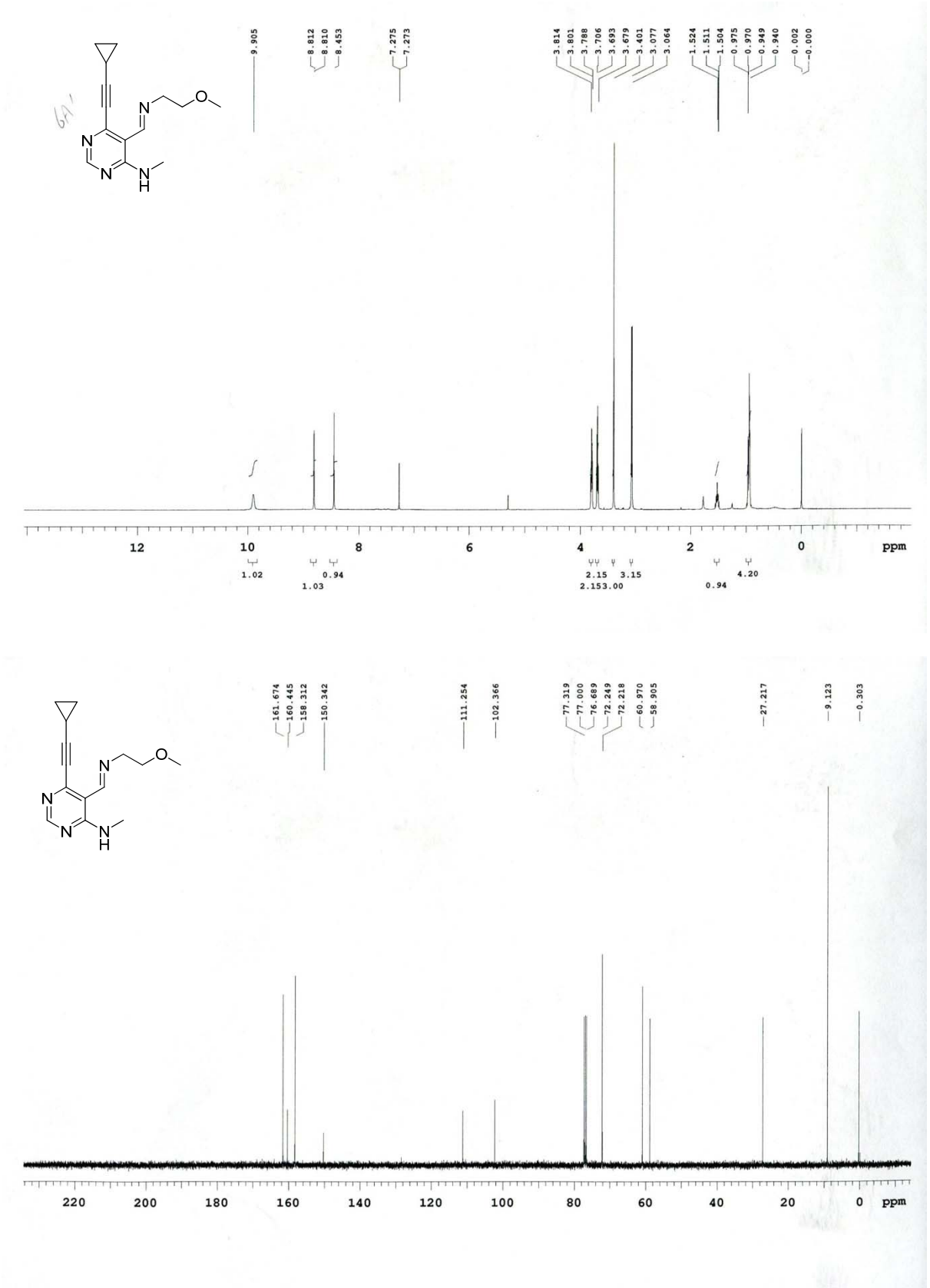

NH
N
N
N
H
160.407
160.240
158.190
150.084
136.286
127.405
121.971
121.940
119.231
118.684
113.758
111.368
111.178
99.011
77.319
77.000
76.932
76.681
61.934
27.126
27.111
21.563
21.418
13.585
220
200
180
160
140
120
100
80
60
40
20
0
ppm

Compound 5f`

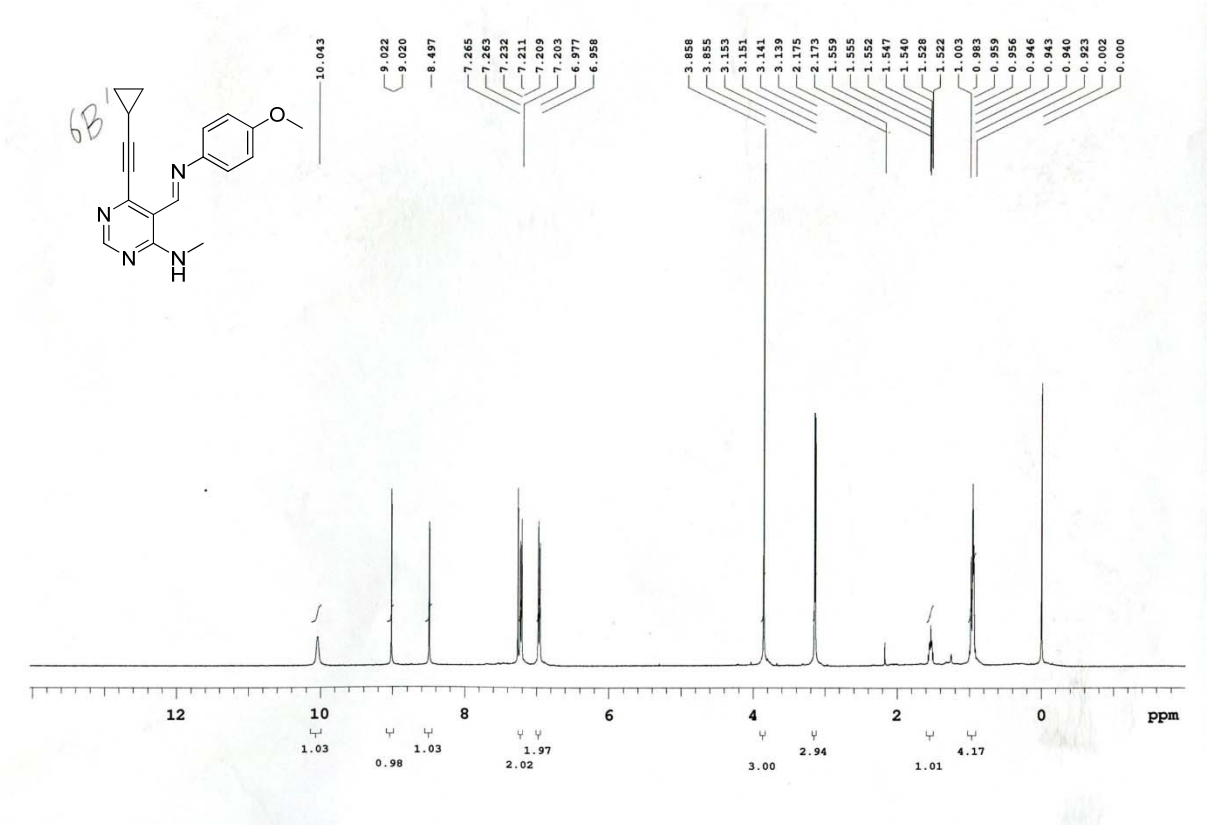

5F'
NBoc
9.905
9.895
8.790
8.486
7.279
4.151
3.522
3.507
3.087
3.074
2.756
2.728
2.698
2.499
2.481
2.463
1.860
1.852
1.839
1.831
1.822
1.815
1.795
1.785
1.735
1.718
1.699
1.681
1.663
1.645
1.621
1.464
1.304
1.255
1.242
1.233
1.210
1.181
1.172
1.089
1.072
1.053
-0.000
-0.007
12
10
8
6
4
2
0
ppm
0.92
0.82
0.97
1.90
2.04
2.00
3.00
2.02
1.23
9.21
3.03
4.12
2.46

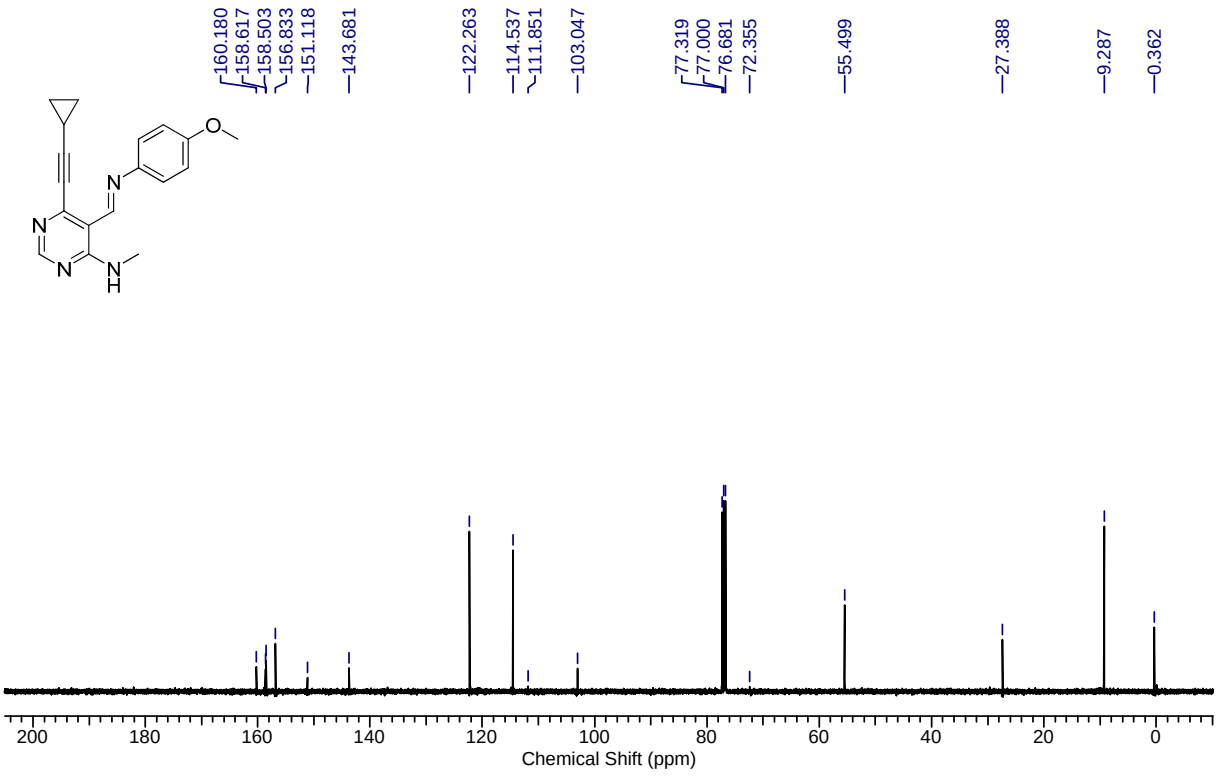

NBoc
160.627
160.490
158.373
154.798
150.335
111.201
99.019
79.345
77.319
77.061
77.000
76.681
67.604
37.570
30.291
28.424
27.270
21.631
21.525
13.639
220
200
180
160
140
120
100
80
60
40
20
0
ppm

Compound 6a`

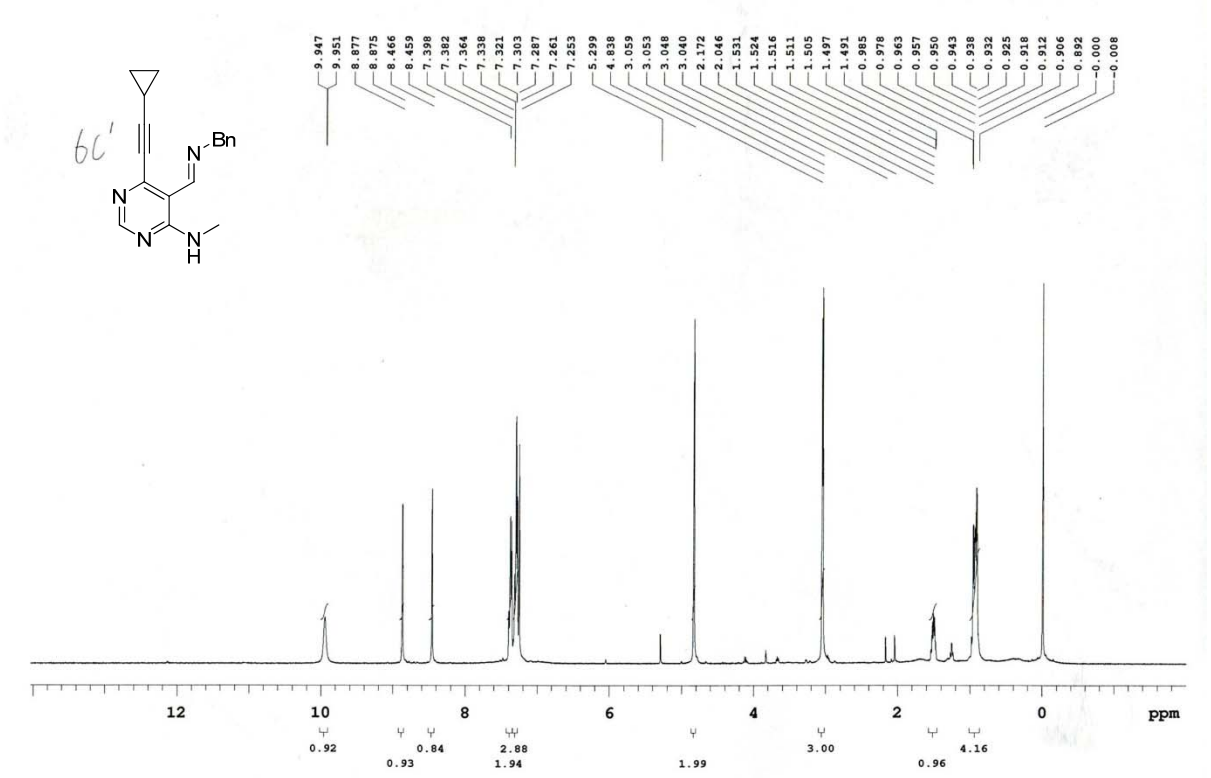

9.905
8.812
8.810
8.453
7.275
7.273
3.814
3.801
3.788
3.706
3.693
3.679
3.401
3.077
3.064
1.524
1.511
1.504
0.975
0.970
0.949
0.940
0.002
-0.000
12
10
8
6
4
2
0
ppm
1.02
0.94
1.03
2.15
3.15
2.153.00
0.94
4.20
161.674
160.445
158.312
150.342
111.254
102.366
77.319
77.000
76.689
72.249
72.218
60.970
58.905
27.217
9.123
0.303
220
200
180
160
140
120
100
80
60
40
20
0
ppm

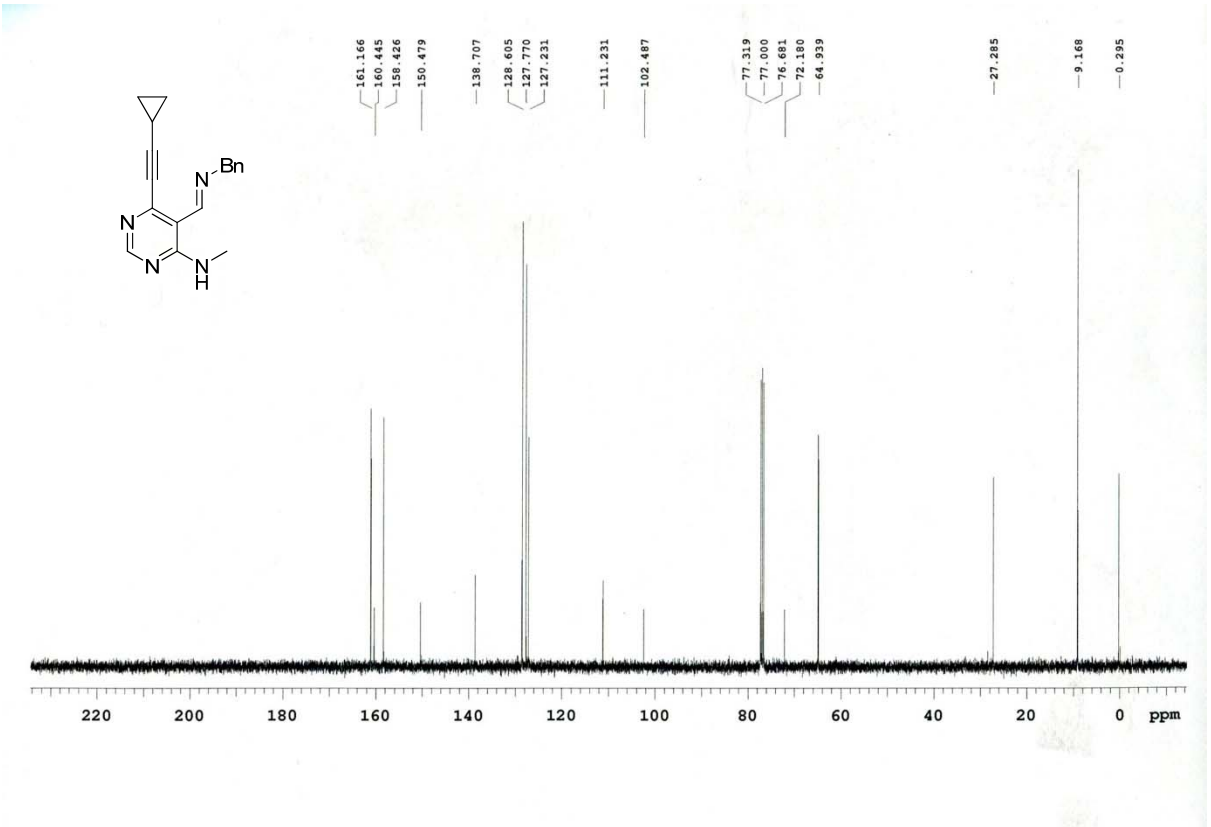
Compound 6b`


6B'
10.043
9.022
9.020
8.497
7.265
7.263
7.232
7.211
7.209
7.203
6.977
6.958
3.858
3.855
3.153
3.151
3.141
3.139
2.175
2.173
1.559
1.555
1.552
1.547
1.540
1.528
1.522
1.003
0.983
0.959
0.956
0.946
0.943
0.940
0.923
0.002
0.000
12
10
8
6
4
2
0
ppm
1.03
0.98
1.03
1.97
2.02
3.00
2.94
1.01
4.17

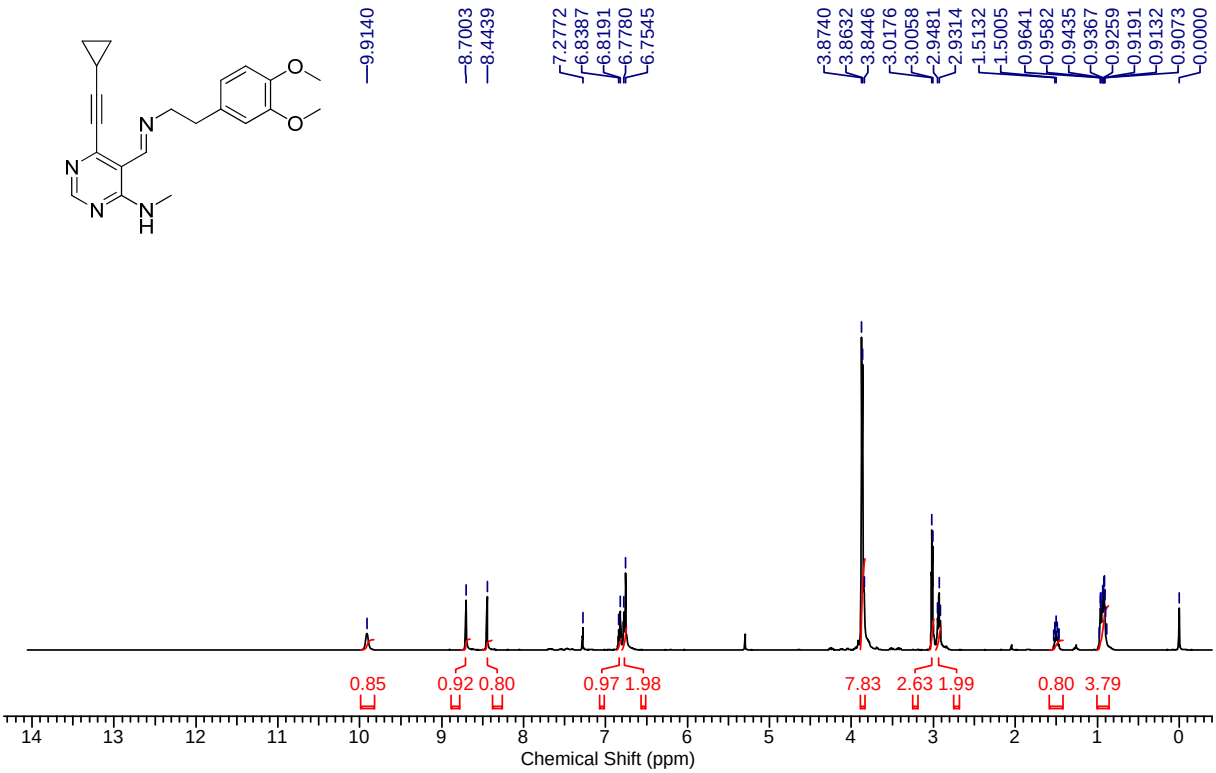

160.180
158.617
158.503
156.833
151.118
143.681
122.263
114.537
111.851
103.047
77.319
77.000
76.681
72.355
55.499
27.388
9.287
0.362
200
180
160
140
120
100
80
60
40
20
0
Chemical Shift (ppm)

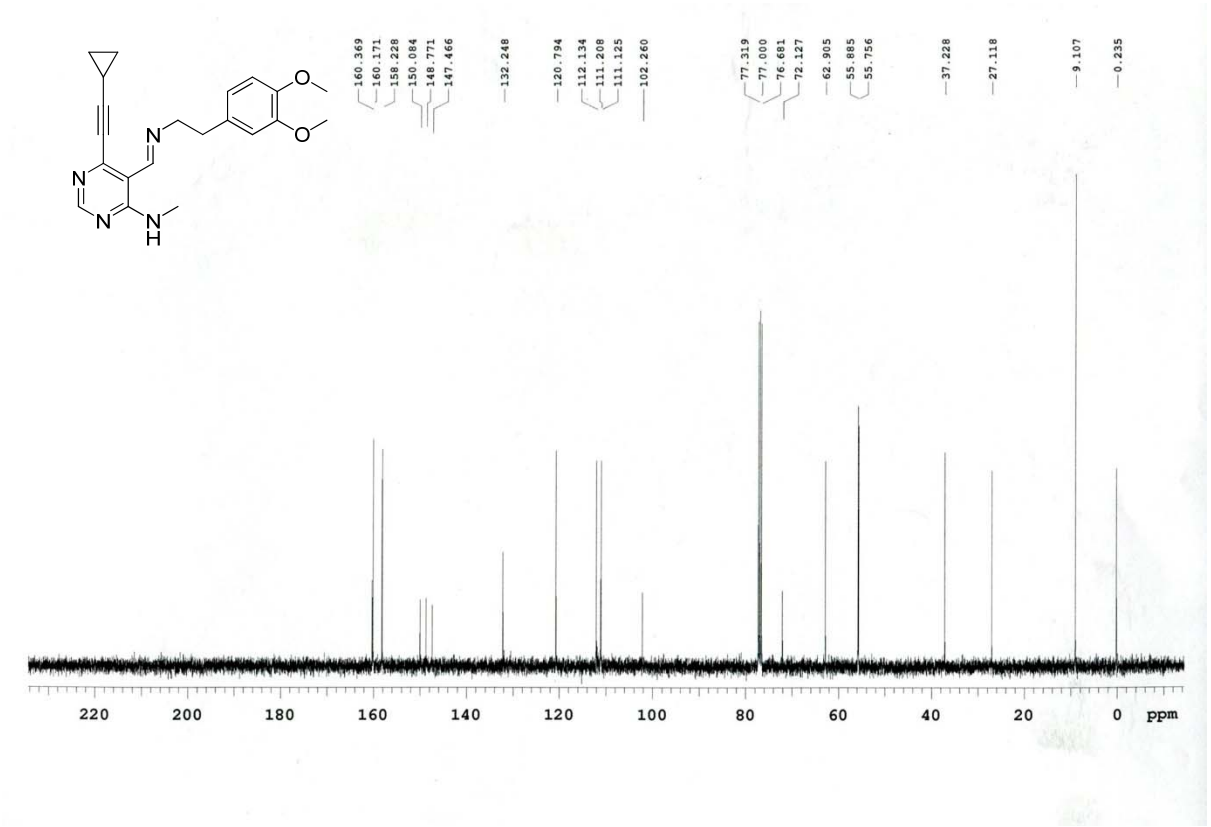
Compound 6c`


6d'
N
Bn
N
N
H
9.947
9.951
8.877
8.875
8.466
8.459
7.398
7.382
7.364
7.338
7.321
7.303
7.287
7.261
7.253
5.299
4.838
3.059
3.053
3.048
3.040
2.172
2.046
1.531
1.524
1.516
1.511
1.505
1.497
1.491
0.985
0.978
0.963
0.957
0.950
0.943
0.938
0.932
0.925
0.918
0.912
0.906
0.892
0.000
-0.008
12
10
8
6
4
2
0
ppm
0.92
0.93
0.84
2.88
1.94
1.99
3.00
0.96
4.16

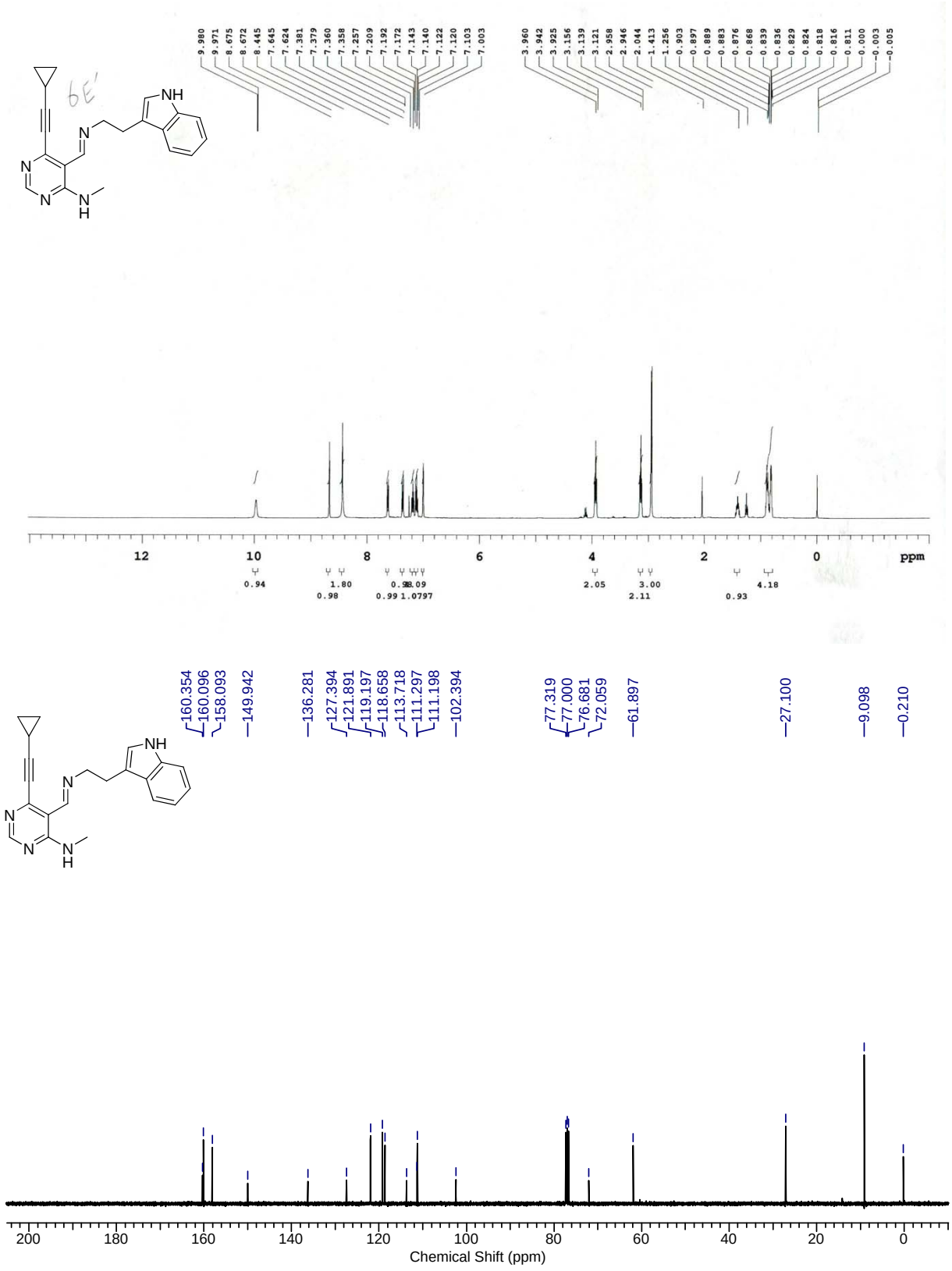

N
Bn
N
N
H
161.166
160.445
158.426
150.479
138.707
128.605
127.770
127.231
111.231
102.487
77.319
77.000
76.681
72.180
64.939
27.285
9.168
0.295
220
200
180
160
140
120
100
80
60
40
20
0
ppm

Compound 6d`


9.9140
8.7003
8.4439
7.2772
6.8387
6.8191
6.7780
6.7545
3.8740
3.8632
3.8446
3.0176
3.0058
2.9481
2.9314
1.5132
1.5005
0.9641
0.9582
0.9435
0.9367
0.9259
0.9191
0.9132
0.9073
0.0000
0.85
0.92
0.80
0.97
1.98
7.83
2.63
1.99
0.80
3.79
Chemical Shift (ppm)


160.369
160.171
158.228
150.084
148.771
147.466
132.248
120.794
112.134
111.208
111.125
102.260
77.319
77.000
76.681
72.127
62.905
55.885
55.756
37.228
27.118
9.107
0.235
ppm

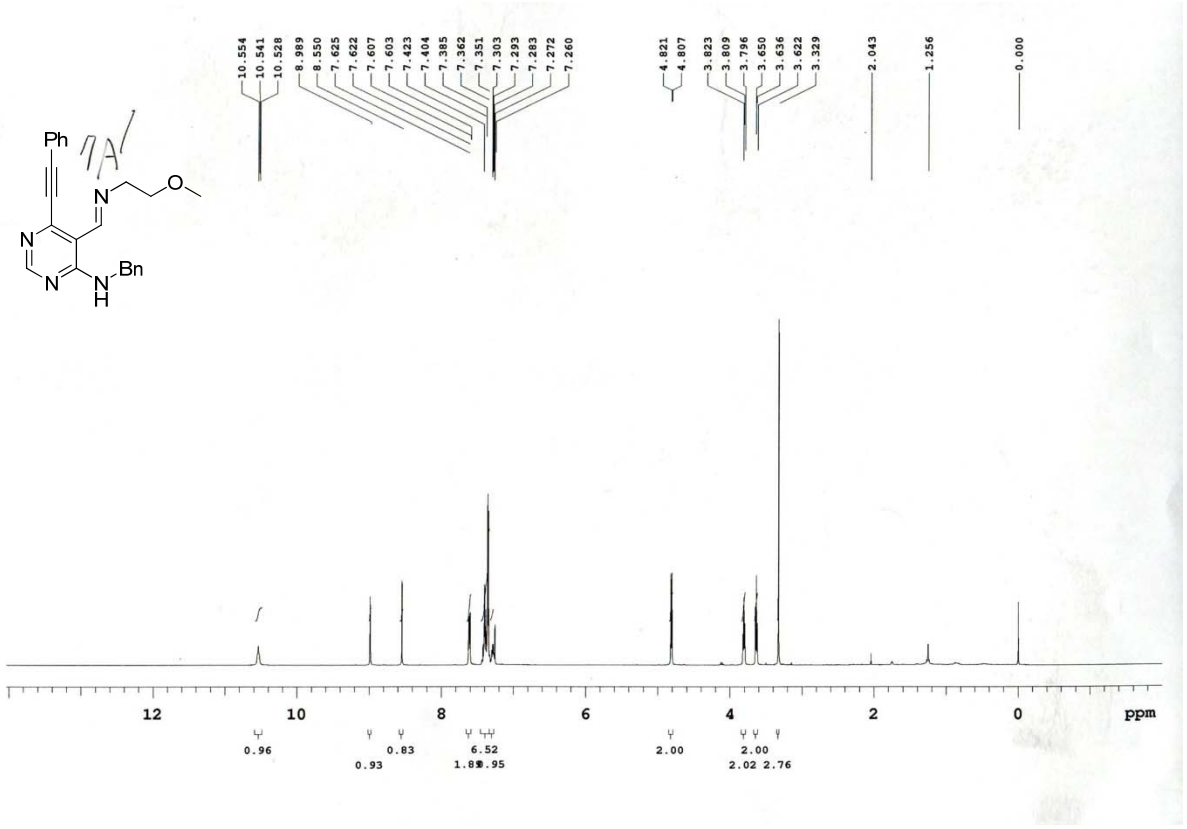
Compound 6e`

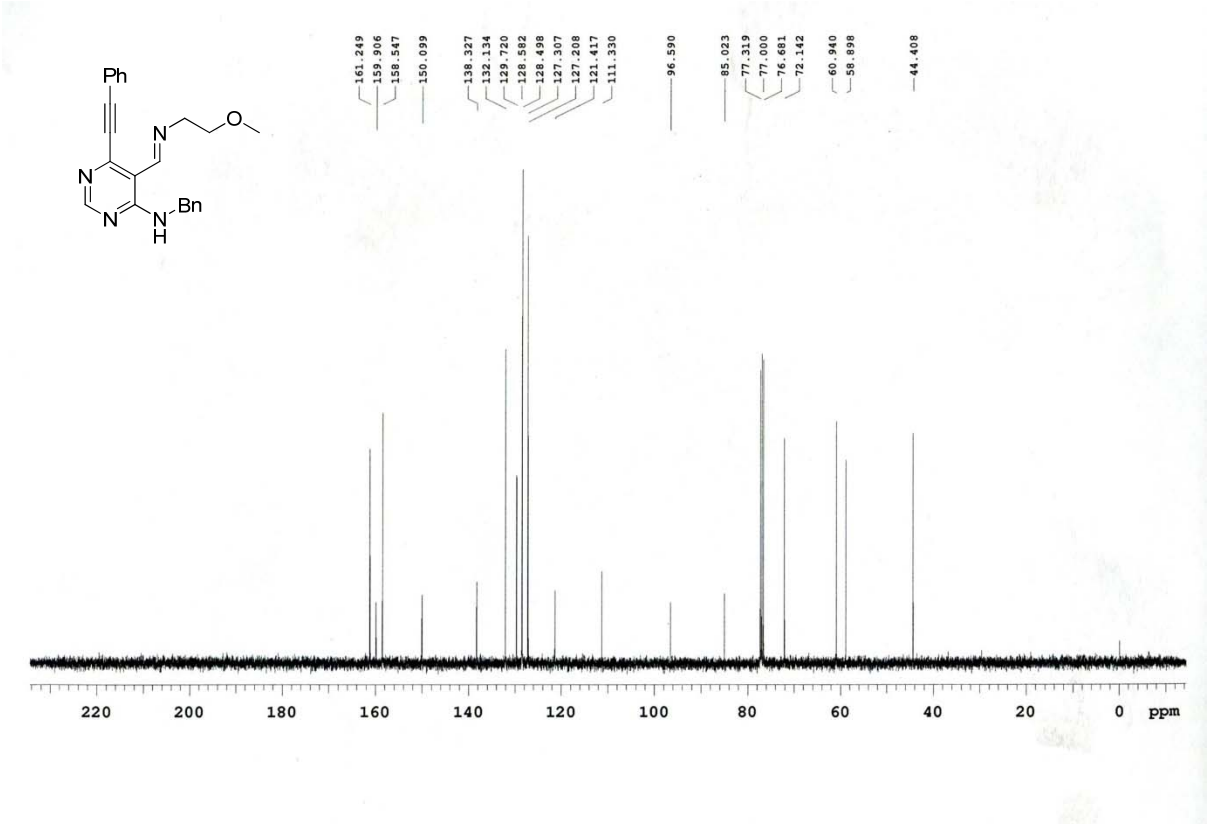

6E'
NH
N
N
N
H
9.980
9.971
8.675
8.672
8.445
7.645
7.624
7.381
7.379
7.360
7.358
7.257
7.209
7.192
7.172
7.143
7.140
7.122
7.120
7.103
7.003
3.960
3.942
3.925
3.156
3.139
3.121
2.958
2.946
2.044
1.413
1.256
0.903
0.897
0.889
0.883
0.876
0.868
0.839
0.836
0.829
0.824
0.818
0.816
0.811
0.000
-0.003
-0.005
12
10
8
6
4
2
0
ppm
0.94
1.80
0.98
0.99
1.0797
2.05
3.00
2.11
0.93
4.18
160.354
160.096
158.093
149.942
136.281
127.394
121.891
119.197
118.658
113.718
111.297
111.198
102.394
77.319
77.000
76.681
72.059
61.897
27.100
9.098
0.210
200
180
160
140
120
100
80
60
40
20
0
Chemical Shift (ppm)

Compound 6f`

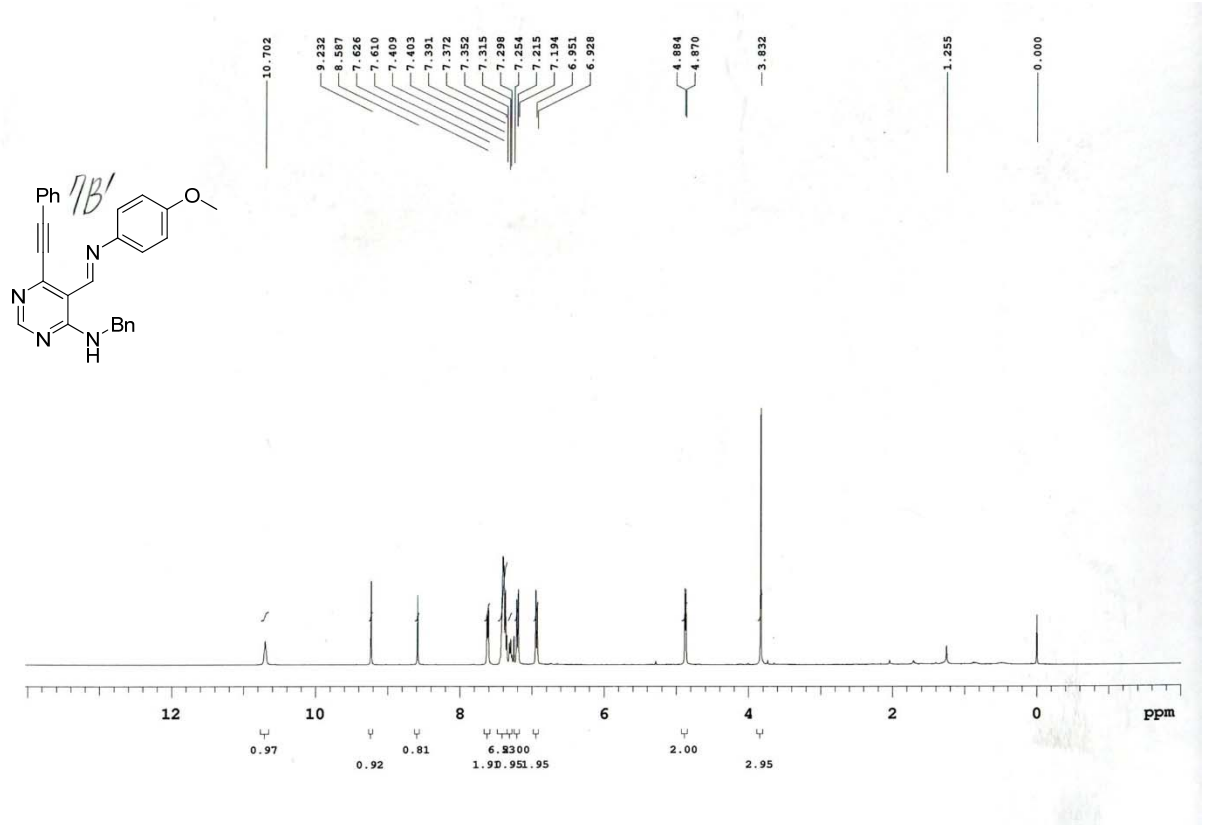

9.895
8.741
8.459
7.268
4.131
3.523
3.508
3.078
3.066
2.728
2.047
1.739
1.707
1.531
1.510
1.465
1.261
1.242
1.214
0.985
0.979
0.973
0.964
0.958
0.953
0.945
0.941
0.935
0.000
NBoc
N
N
N
H
12
10
8
6
4
2
0
ppm
0.92
0.83
0.99
1.97
2.01
3.00
1.91
2.08
0.97
4.09
0.96
2.51
160.437
160.369
158.198
154.707
150.145
111.079
102.305
79.239
77.319
77.000
76.681
72.104
67.467
37.502
30.223
28.340
27.172
9.100
0.235
220
200
180
160
140
120
100
80
60
40
20
0
ppm

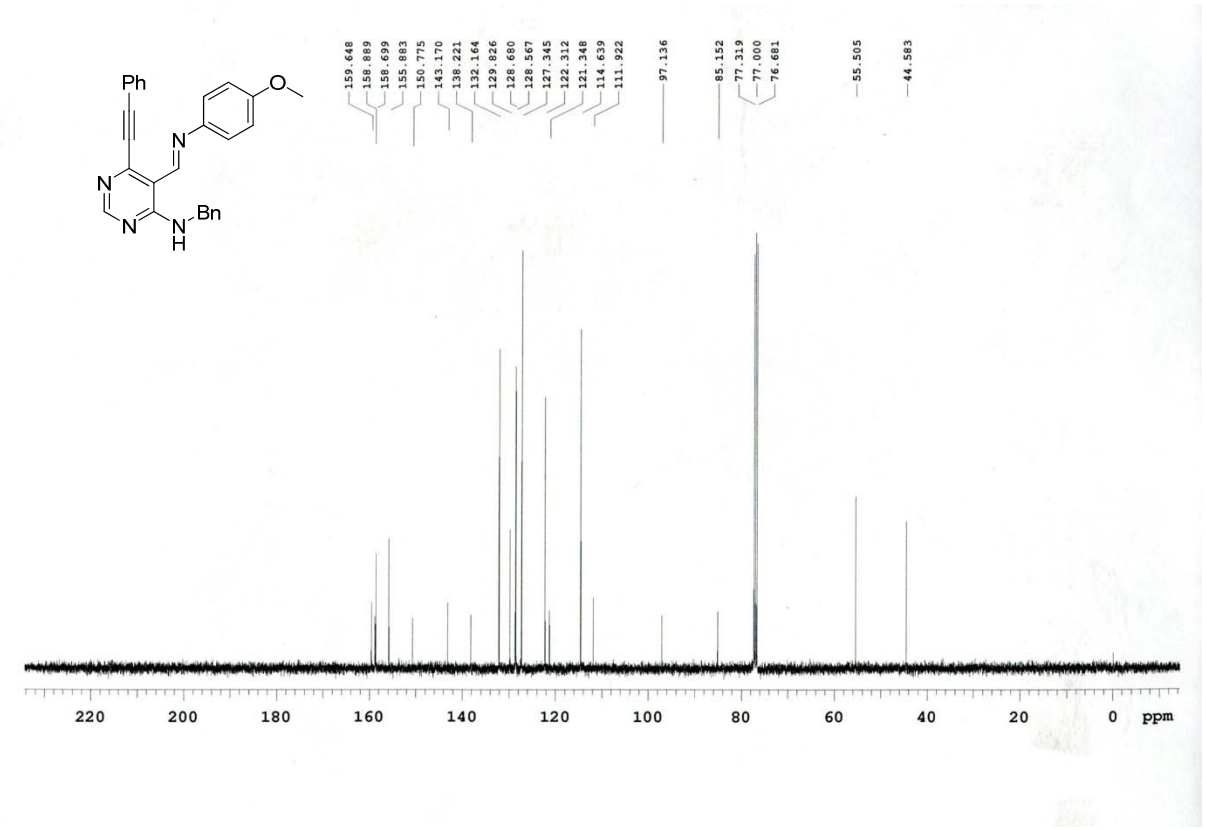
Compound 7a`


Ph
N
O
N
N
Bn
N
H
10.554
10.541
10.528
8.989
8.550
7.625
7.622
7.607
7.603
7.423
7.404
7.385
7.362
7.351
7.303
7.293
7.283
7.272
7.260
4.821
4.807
3.823
3.809
3.796
3.650
3.636
3.622
3.329
2.043
1.256
0.000
12
10
8
6
4
2
0
ppm
0.96
0.93
0.83
6.52
2.00
2.00
2.02
2.76

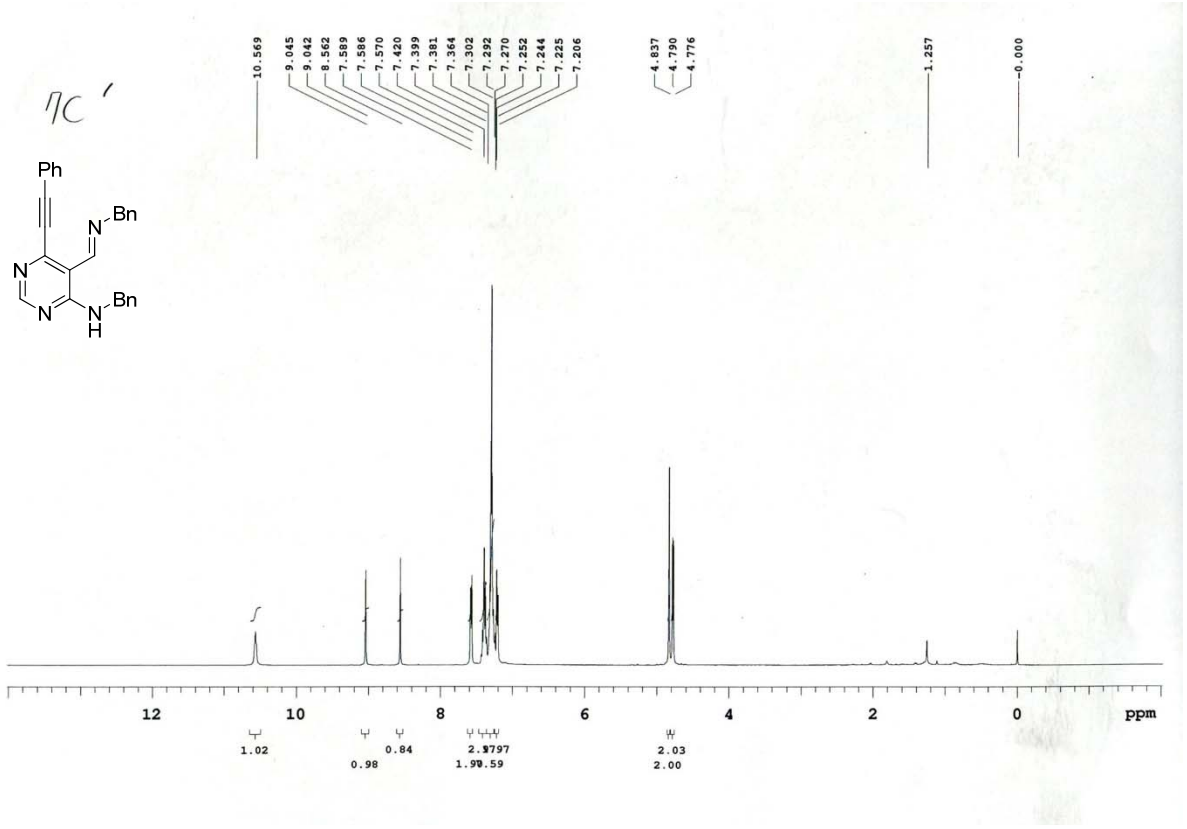

Ph
N
O
N
N
Bn
N
H
161.249
159.906
158.547
150.099
138.327
132.134
129.720
128.582
128.498
127.307
127.208
121.417
111.330
96.590
85.023
77.319
77.000
76.681
72.142
60.940
58.898
44.408
220
200
180
160
140
120
100
80
60
40
20
0
ppm

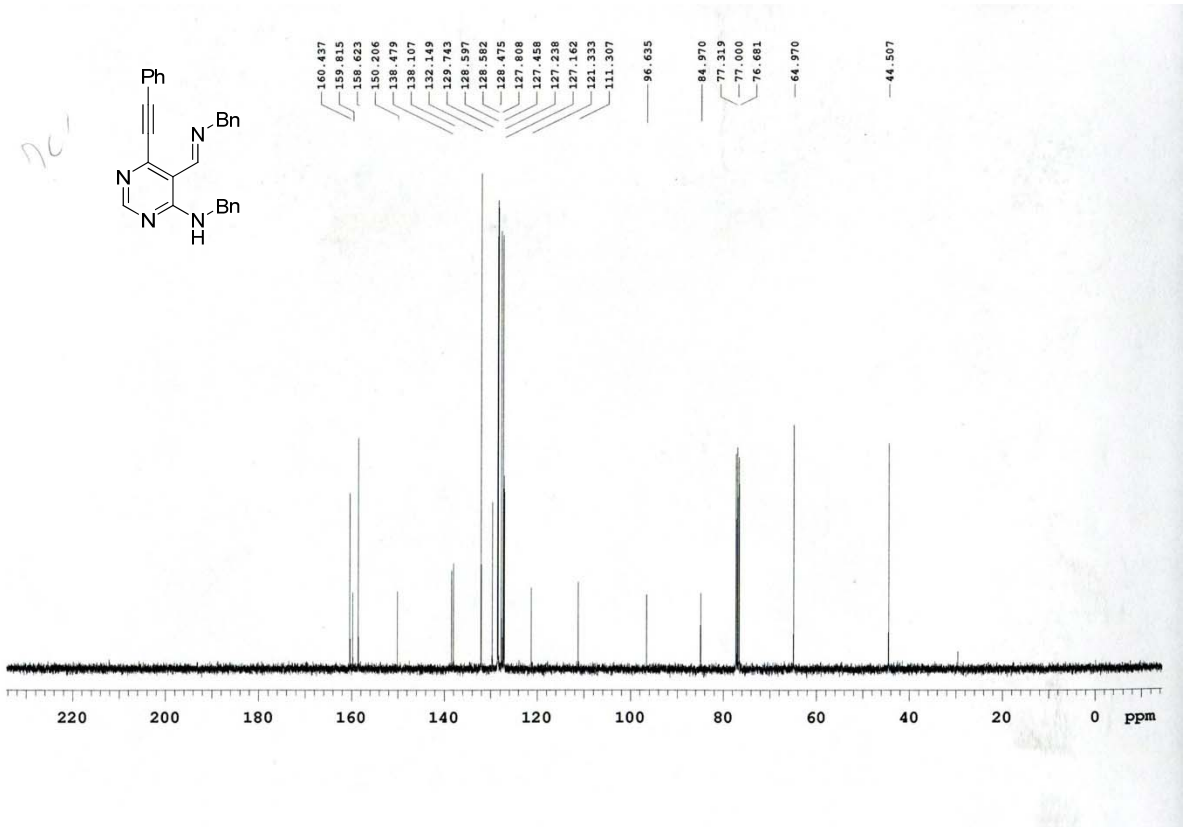
Compound 7b`


10.702
9.232
8.587
7.626
7.610
7.409
7.403
7.391
7.372
7.352
7.315
7.298
7.254
7.215
7.194
6.951
6.928
4.884
4.870
3.832
1.255
0.000
Ph
O
N
N
N
Bn
H
12
10
8
6
4
2
0
ppm
0.97
0.92
0.81
2.00
2.95

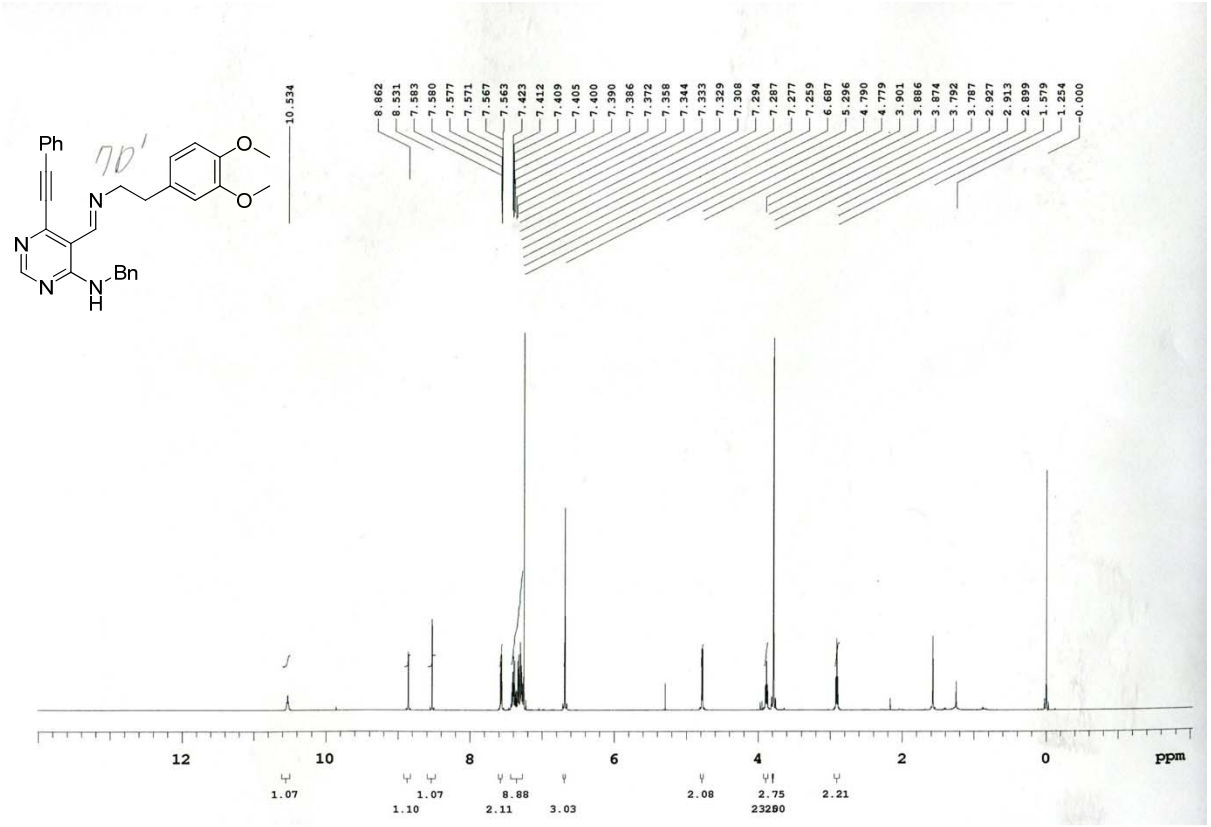

159.648
158.889
158.699
155.883
150.775
143.170
138.221
132.164
129.826
128.680
128.567
127.345
122.312
121.348
114.639
111.922
97.136
85.152
77.319
77.000
76.681
55.505
44.583
Ph
O
N
N
N
Bn
H
220
200
180
160
140
120
100
80
60
40
20
0
ppm

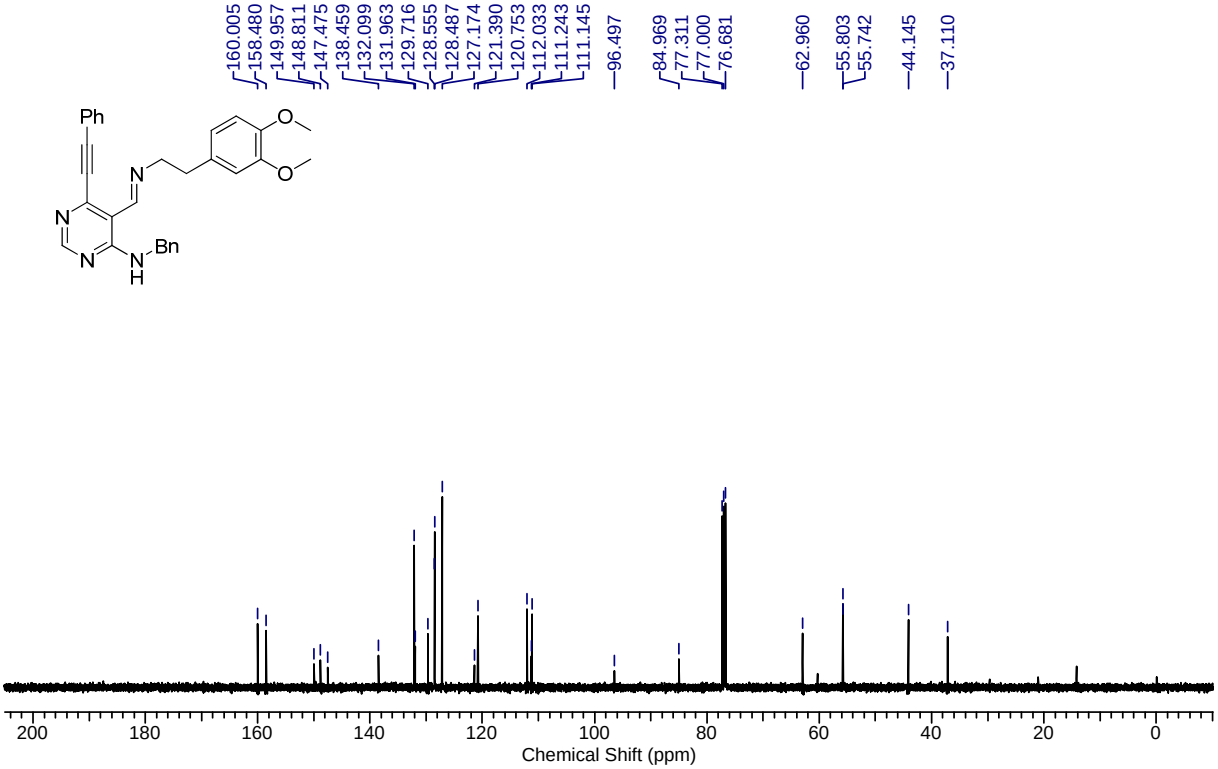
Compound 7c`


10.569
9.045
9.042
8.562
7.589
7.586
7.570
7.420
7.399
7.381
7.364
7.302
7.292
7.270
7.252
7.244
7.225
7.206
4.837
4.790
4.776
1.257
0.000
Ph
N
Bn
N
N
Bn
N
H
12
10
8
6
4
2
0
ppm
1.02
0.98
0.84
2.03
2.00

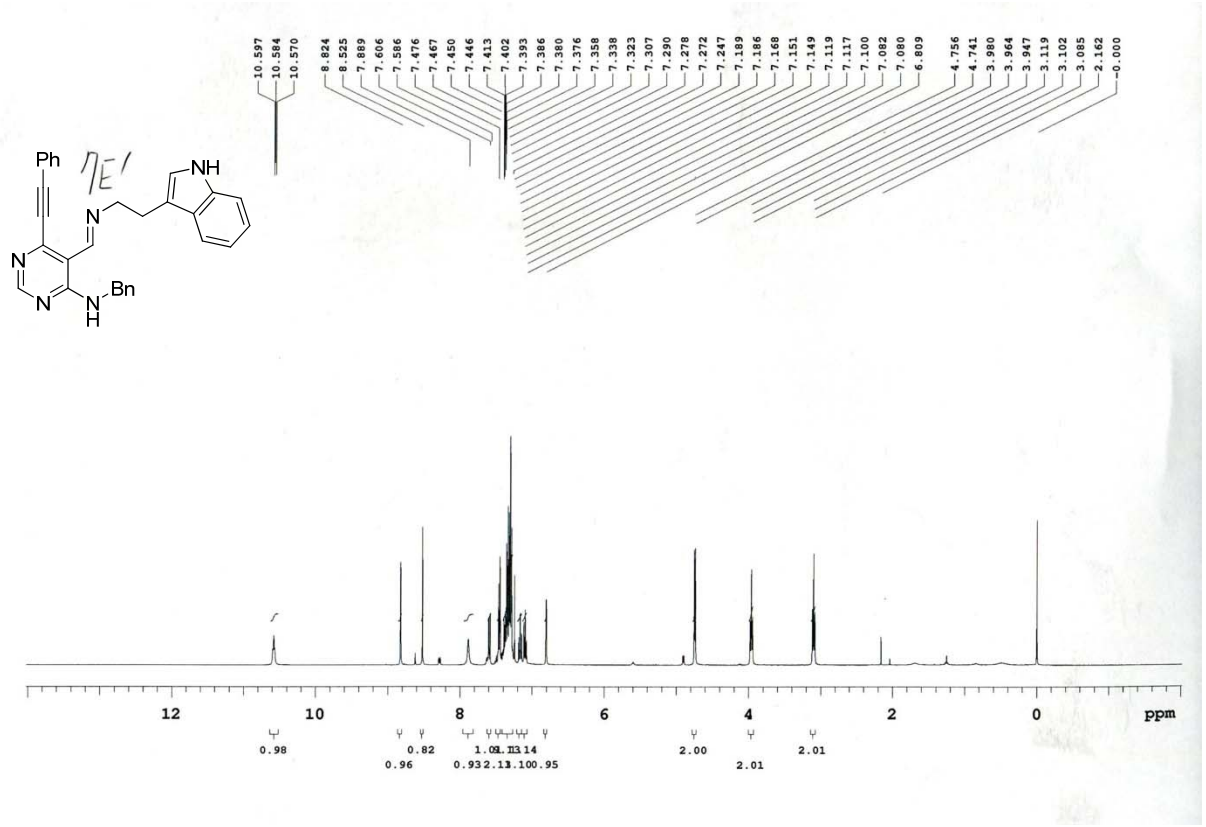

160.437
159.815
158.623
150.206
138.479
138.107
132.149
129.743
128.597
128.582
128.475
127.808
127.458
127.238
127.162
121.333
111.307
96.635
84.970
77.319
77.000
76.681
64.970
44.507
Ph
N
Bn
N
N
Bn
N
H
220
200
180
160
140
120
100
80
60
40
20
0
ppm

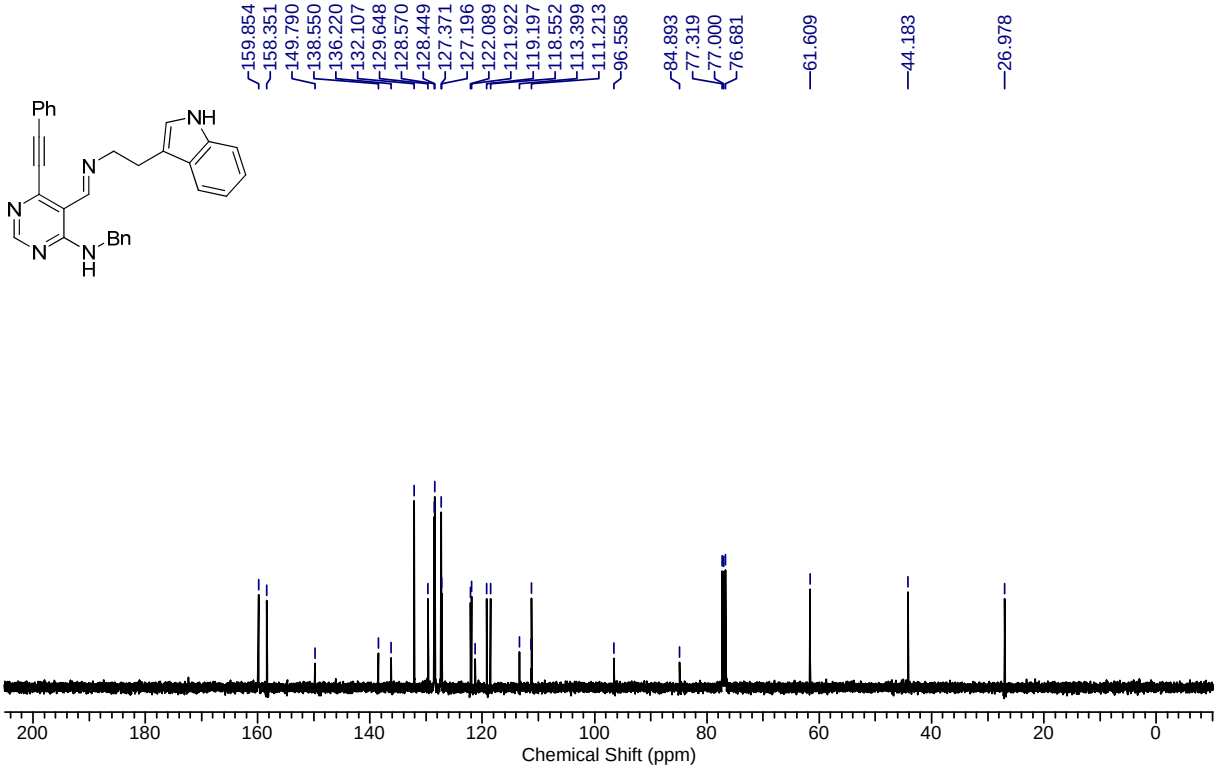
Compound 7d`


Ph
O
O
N
N
N
Bn
H
10.534
8.862
8.531
7.583
7.580
7.577
7.571
7.567
7.563
7.423
7.412
7.409
7.405
7.400
7.390
7.386
7.372
7.358
7.344
7.333
7.329
7.308
7.294
7.287
7.277
7.259
6.687
5.296
4.790
4.779
3.901
3.886
3.874
3.792
3.787
2.927
2.913
2.899
1.579
1.254
0.000
12
10
8
6
4
2
0
ppm
1.07
1.07
1.10
8.88
2.11
3.03
2.08
2.75
23280
2.21

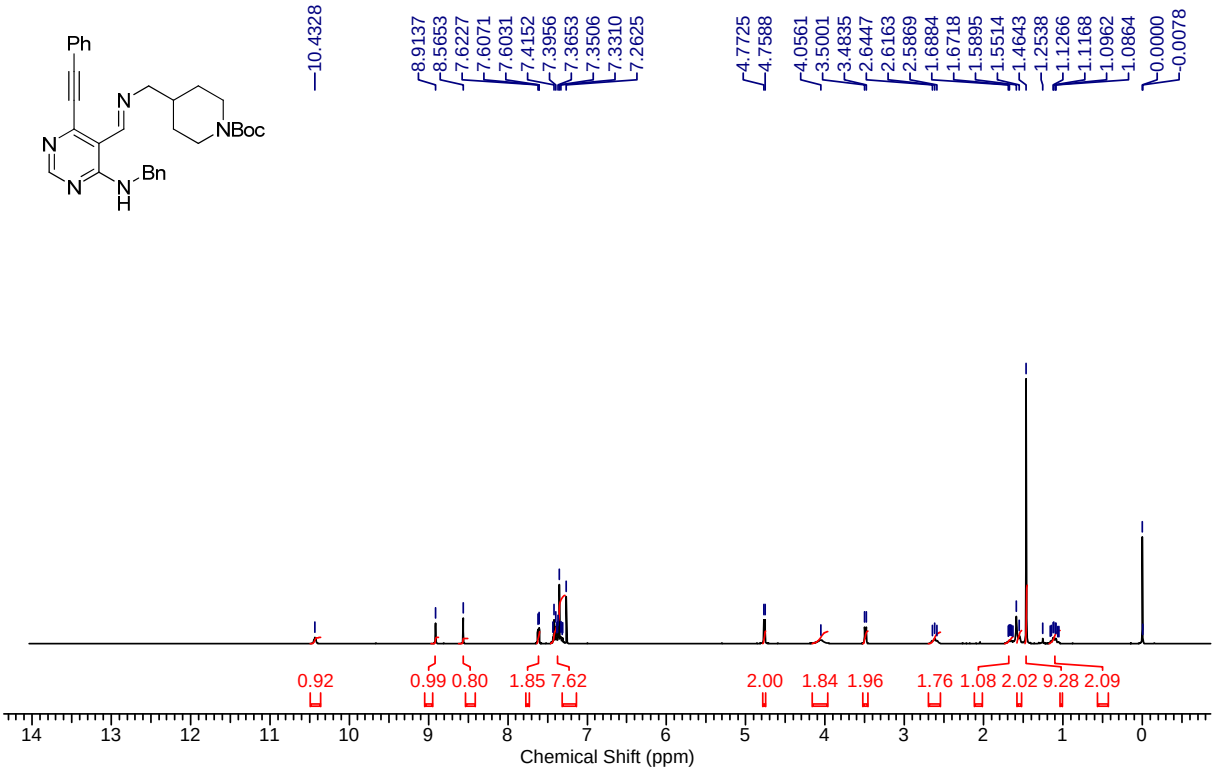

160.005
158.480
149.957
148.811
147.475
138.459
132.099
131.963
129.716
128.555
128.487
127.174
121.390
120.753
112.033
111.243
111.145
96.497
84.969
77.311
77.000
76.681
62.960
55.803
55.742
44.145
37.110
Ph
O
O
N
N
N
Bn
H
200
180
160
140
120
100
80
60
40
20
0
Chemical Shift (ppm)

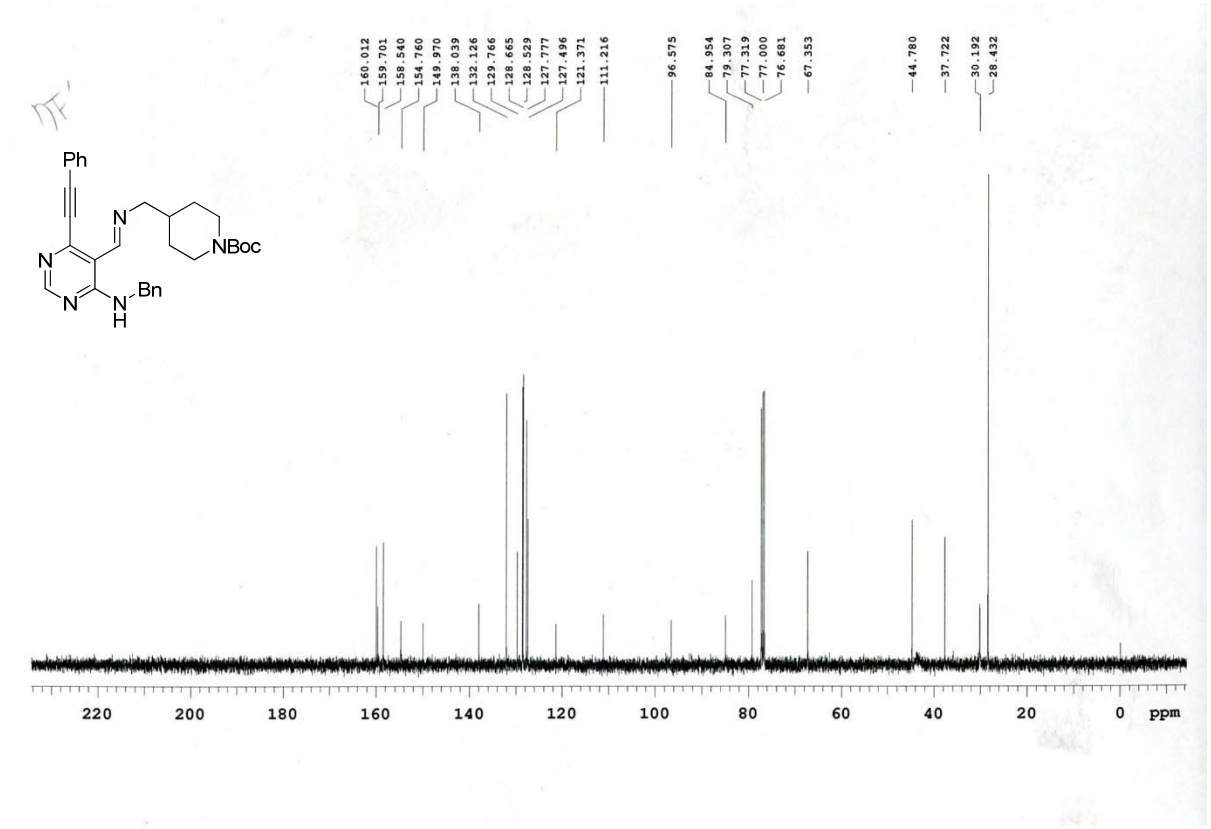
Compound 7e`


Ph
NH
N
N
N
Bn
H
10.597
10.584
10.570
8.824
8.525
7.889
7.606
7.586
7.476
7.467
7.450
7.446
7.413
7.402
7.393
7.386
7.380
7.376
7.358
7.338
7.323
7.307
7.290
7.278
7.272
7.247
7.189
7.186
7.168
7.151
7.149
7.119
7.117
7.100
7.082
7.080
6.809
4.756
4.741
3.980
3.964
3.947
3.119
3.102
3.085
2.162
0.000
12
10
8
6
4
2
0
ppm
0.98
0.82
0.96
2.00
2.01
2.01

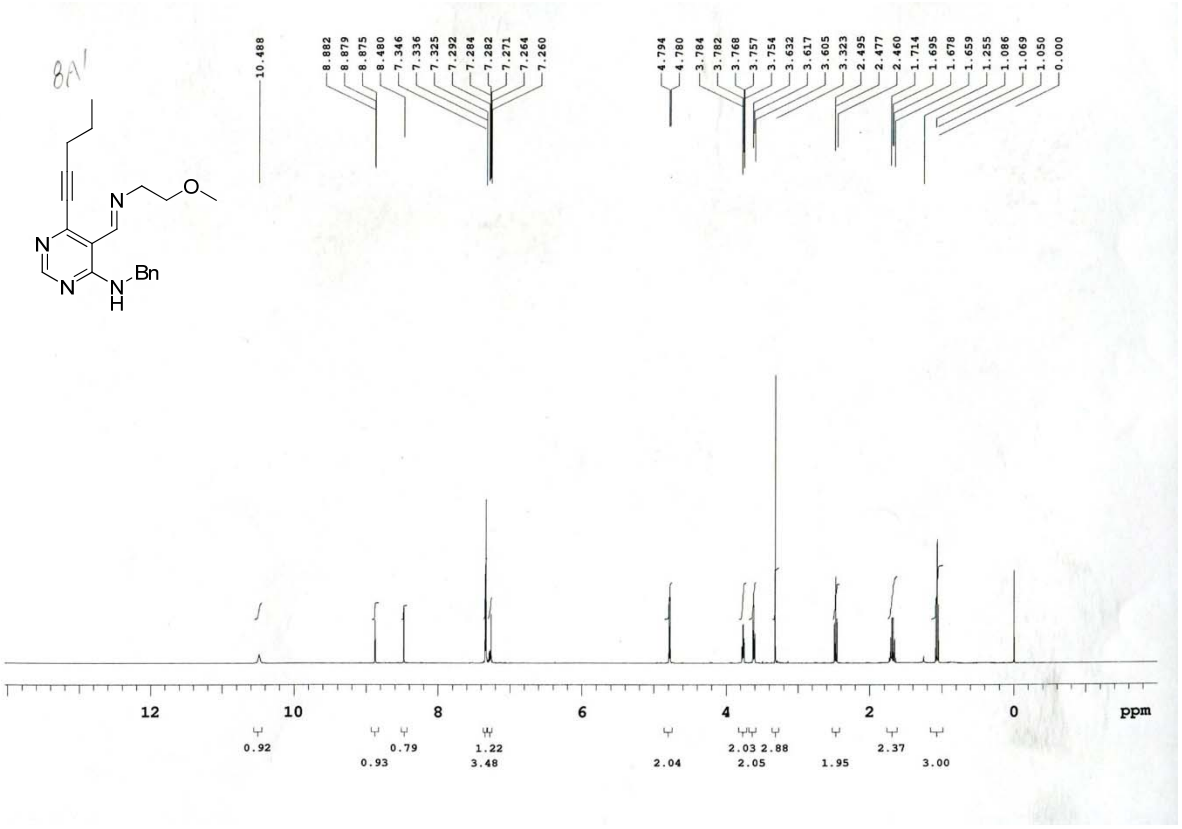

159.854
158.351
149.790
138.550
136.220
132.107
129.648
128.570
128.449
127.371
127.196
122.089
121.922
119.197
118.552
113.399
111.213
96.558
84.893
77.319
77.000
76.681
61.609
44.183
26.978
Ph
NH
N
N
N
Bn
H
200
180
160
140
120
100
80
60
40
20
0
Chemical Shift (ppm)

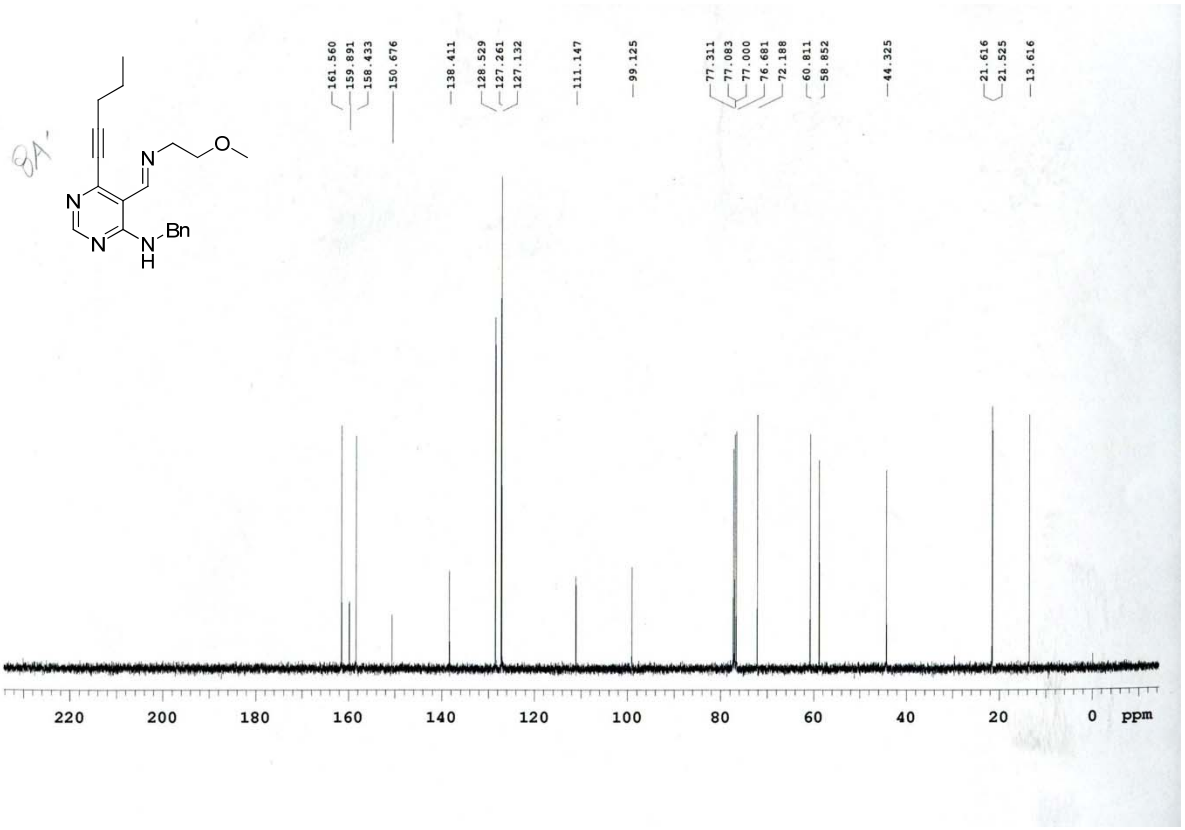
Compound 7f`


Ph
N
NBoc
N
N
N
Bn
H
10.4328
8.9137
8.5653
7.6227
7.6071
7.6031
7.4152
7.3956
7.3653
7.3506
7.3310
7.2625
4.7725
4.7588
4.0561
3.5001
3.4835
2.6447
2.6163
2.5869
1.6884
1.6718
1.5895
1.5514
1.4643
1.2538
1.1266
1.1168
1.0962
1.0864
0.0000
-0.0078
0.92
0.99
0.80
1.85
7.62
2.00
1.84
1.96
1.76
1.08
2.02
9.28
2.09
Chemical Shift (ppm)

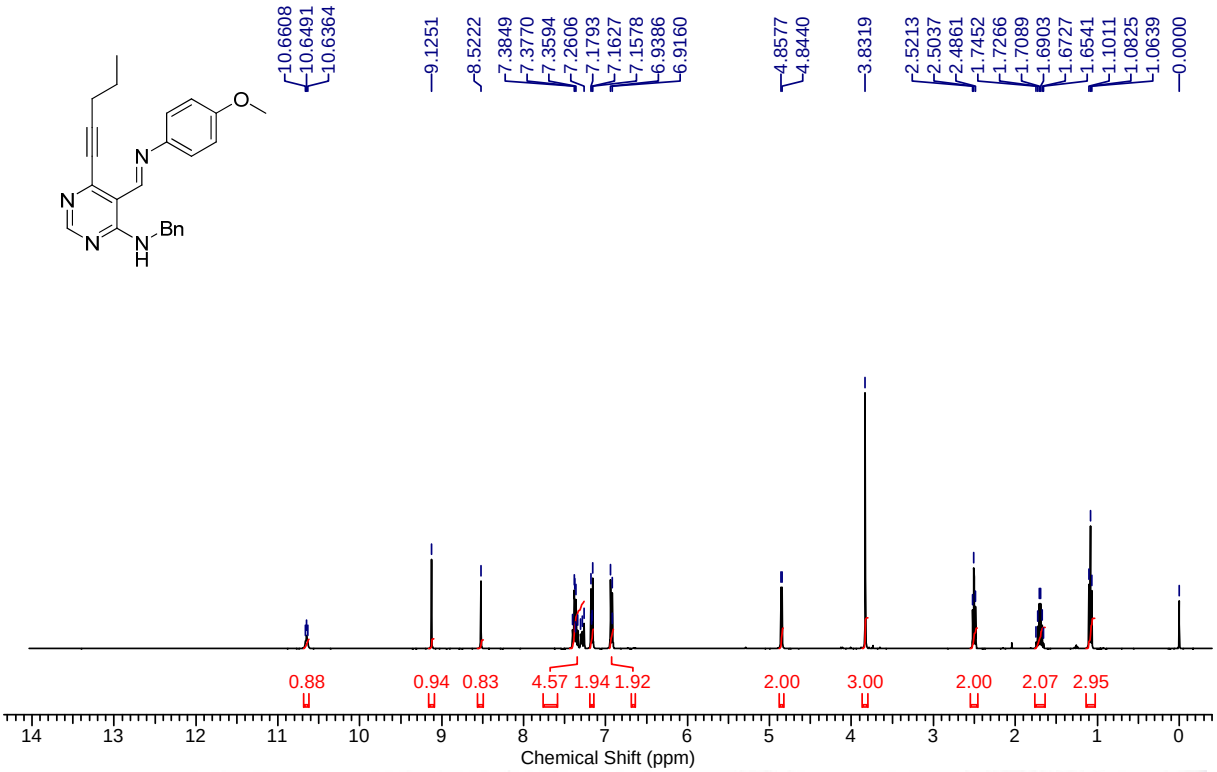

Ph
N
NBoc
N
N
N
Bn
H
160.012
159.701
158.540
154.760
149.970
138.039
132.126
129.766
128.665
128.529
127.777
127.496
121.371
111.216
96.575
84.954
79.307
77.319
77.000
76.681
67.353
44.780
37.722
30.192
28.432
ppm

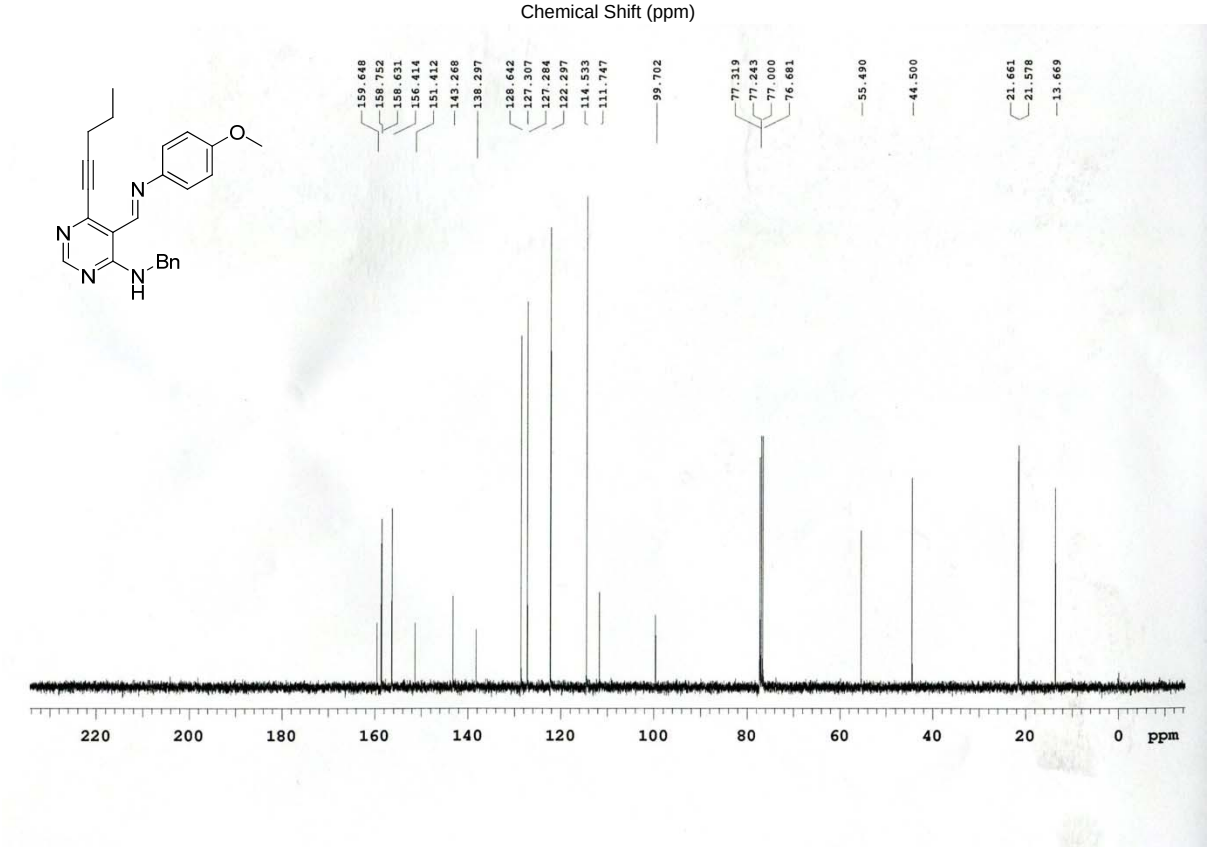
Compound 8a`


8A'
10.488
8.882
8.879
8.875
8.480
7.346
7.336
7.325
7.292
7.284
7.282
7.271
7.264
7.260
4.794
4.780
3.784
3.782
3.768
3.757
3.754
3.632
3.617
3.605
3.323
2.495
2.477
2.460
1.714
1.695
1.678
1.659
1.255
1.086
1.069
1.050
0.000
N
O
N
N
N
H
Bn
12
10
8
6
4
2
0
ppm
0.92
0.93
0.79
1.22
3.48
2.04
2.03
2.05
2.88
1.95
2.37
3.00

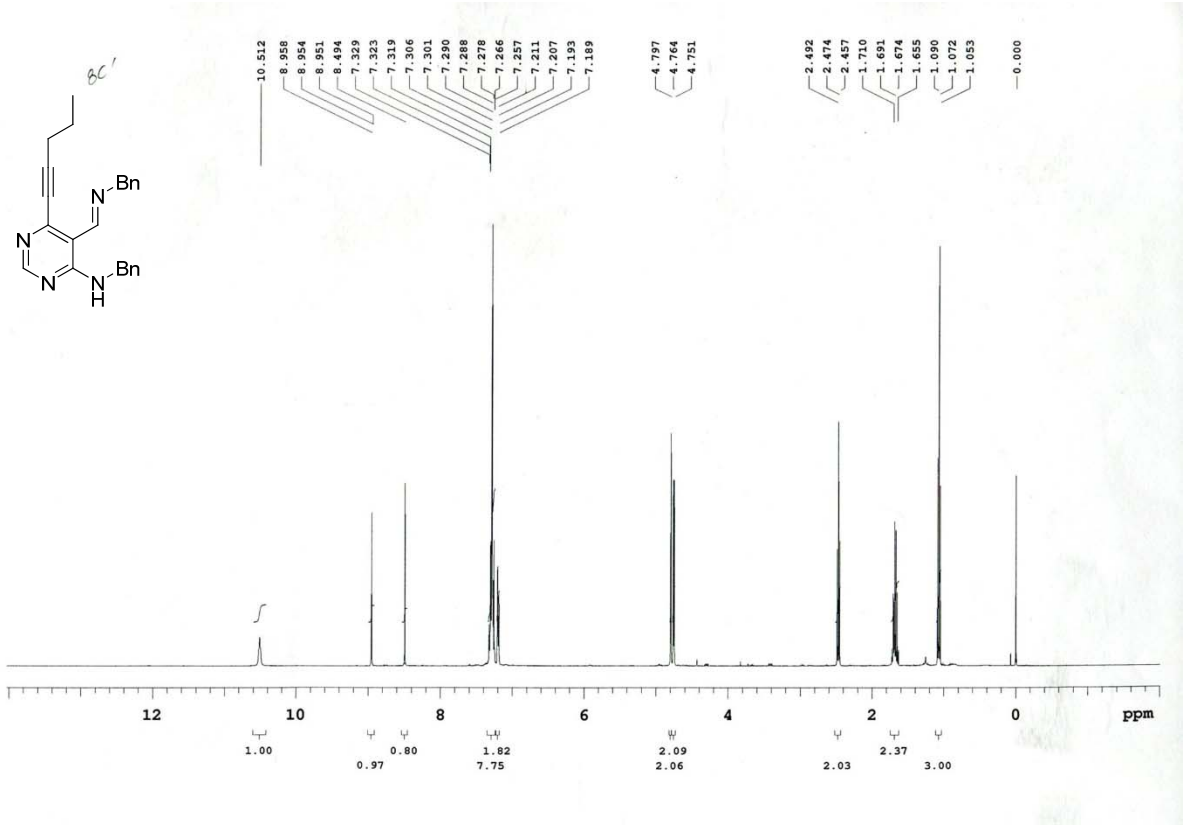

8A'
161.560
159.891
158.433
150.676
138.411
128.529
127.261
127.132
111.147
99.125
77.311
77.083
77.000
76.681
72.188
60.811
58.852
44.325
21.616
21.525
13.616
N
O
N
N
N
H
Bn
220
200
180
160
140
120
100
80
60
40
20
0
ppm

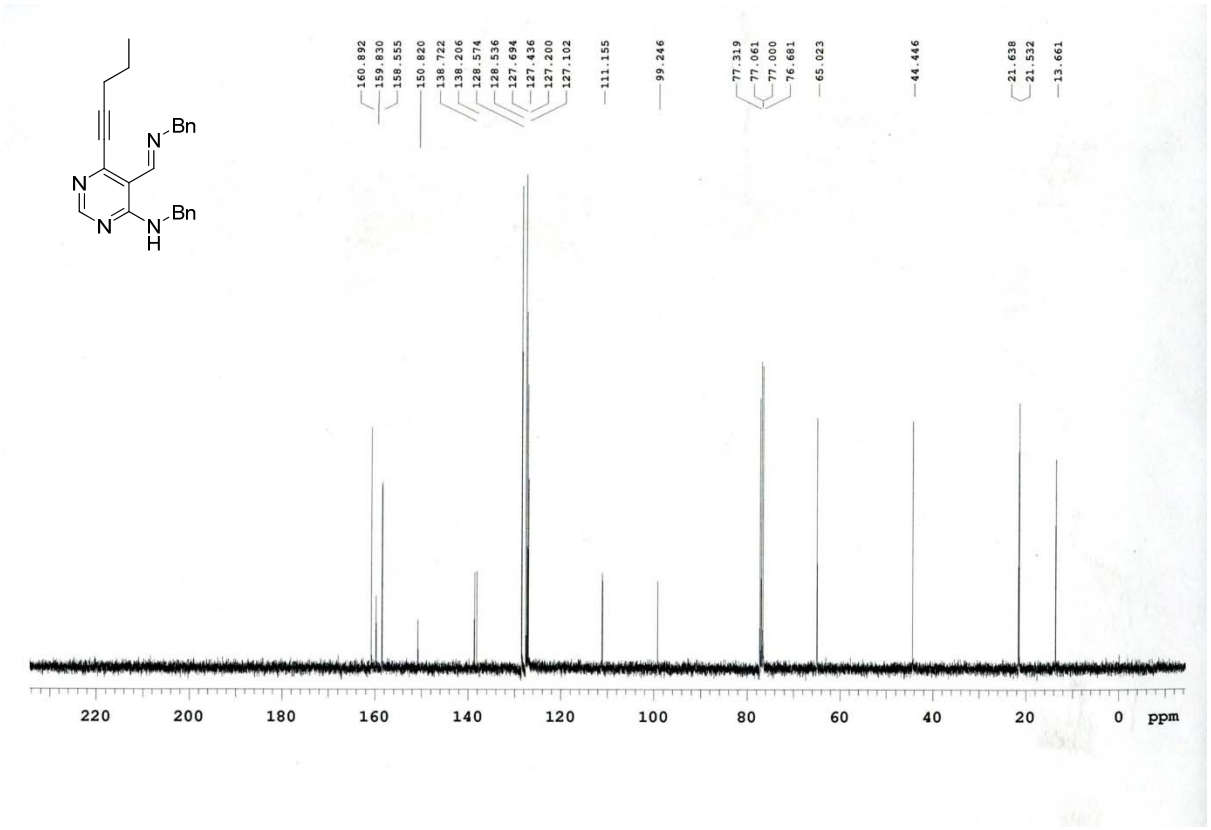
Compound 8b`


10.6608
10.6491
10.6364
9.1251
8.5222
7.3849
7.3770
7.3594
7.2606
7.1793
7.1627
7.1578
6.9386
6.9160
4.8577
4.8440
3.8319
2.5213
2.5037
2.4861
1.7452
1.7266
1.7089
1.6903
1.6727
1.6541
1.1011
1.0825
1.0639
0.0000
0.88
0.94
0.83
4.57
1.94
1.92
2.00
3.00
2.00
2.07
2.95
Chemical Shift (ppm)

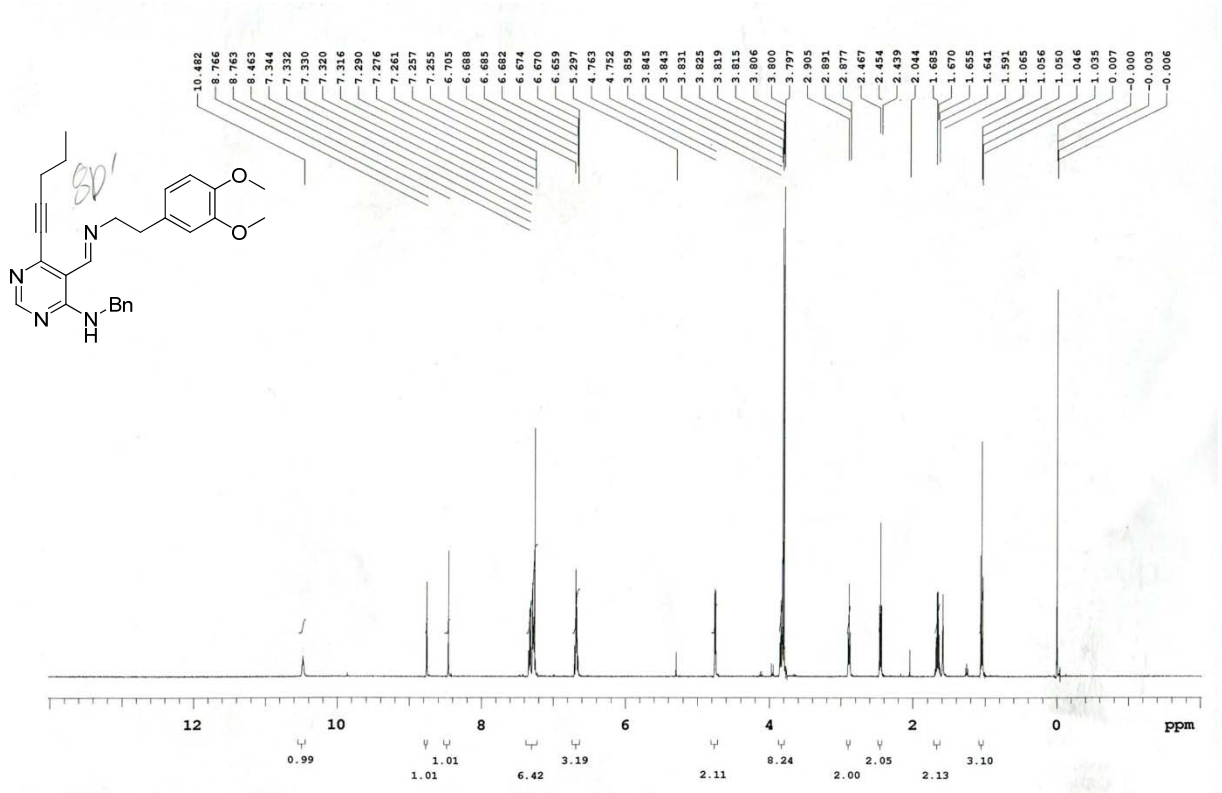

159.648
158.752
158.631
156.414
151.412
143.268
138.297
128.642
127.307
127.284
122.297
114.533
111.747
99.702
77.319
77.243
77.000
76.681
55.490
44.500
21.661
21.578
13.669
ppm

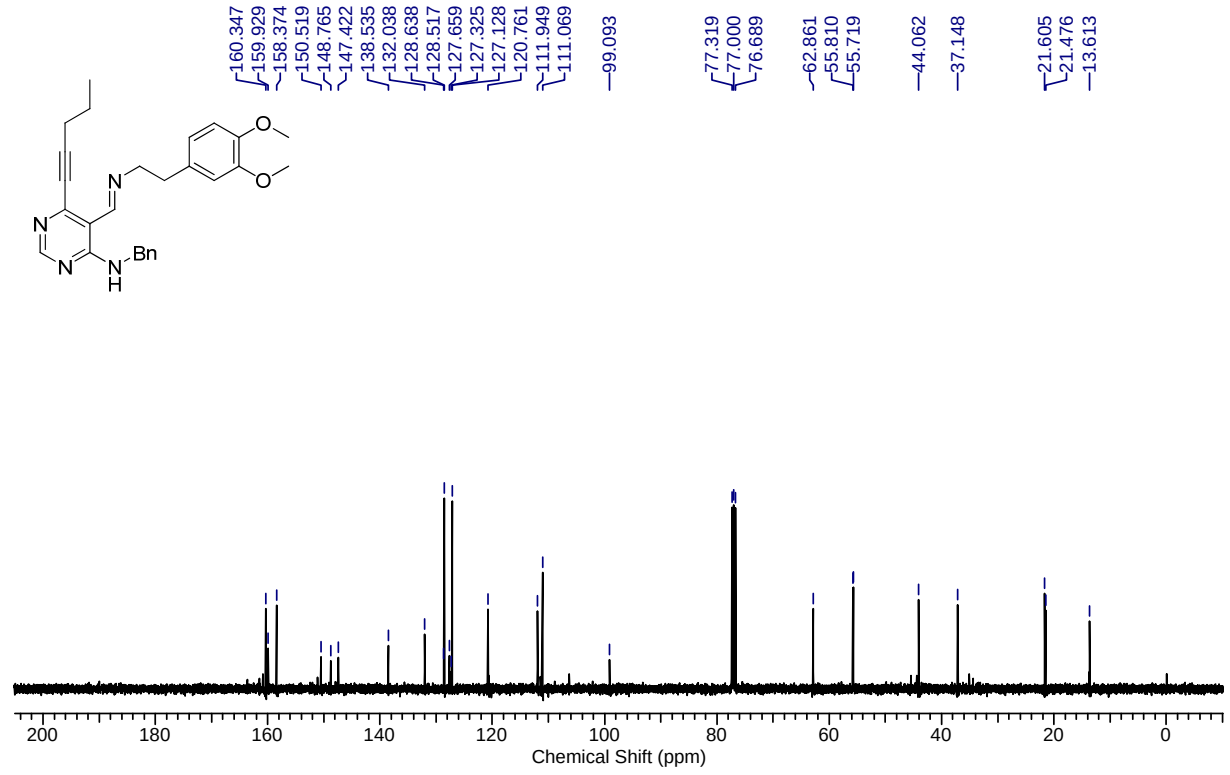
Compound 8c`


10.512
8.958
8.954
8.951
8.494
7.329
7.323
7.319
7.306
7.301
7.290
7.288
7.278
7.266
7.257
7.211
7.207
7.193
7.189
4.797
4.764
4.751
2.492
2.474
2.457
1.710
1.691
1.674
1.655
1.090
1.072
1.053
0.000
Bn
N
N
N
Bn
H
12
10
8
6
4
2
0
ppm
1.00
0.97
0.80
1.82
7.75
2.09
2.06
2.03
2.37
3.00

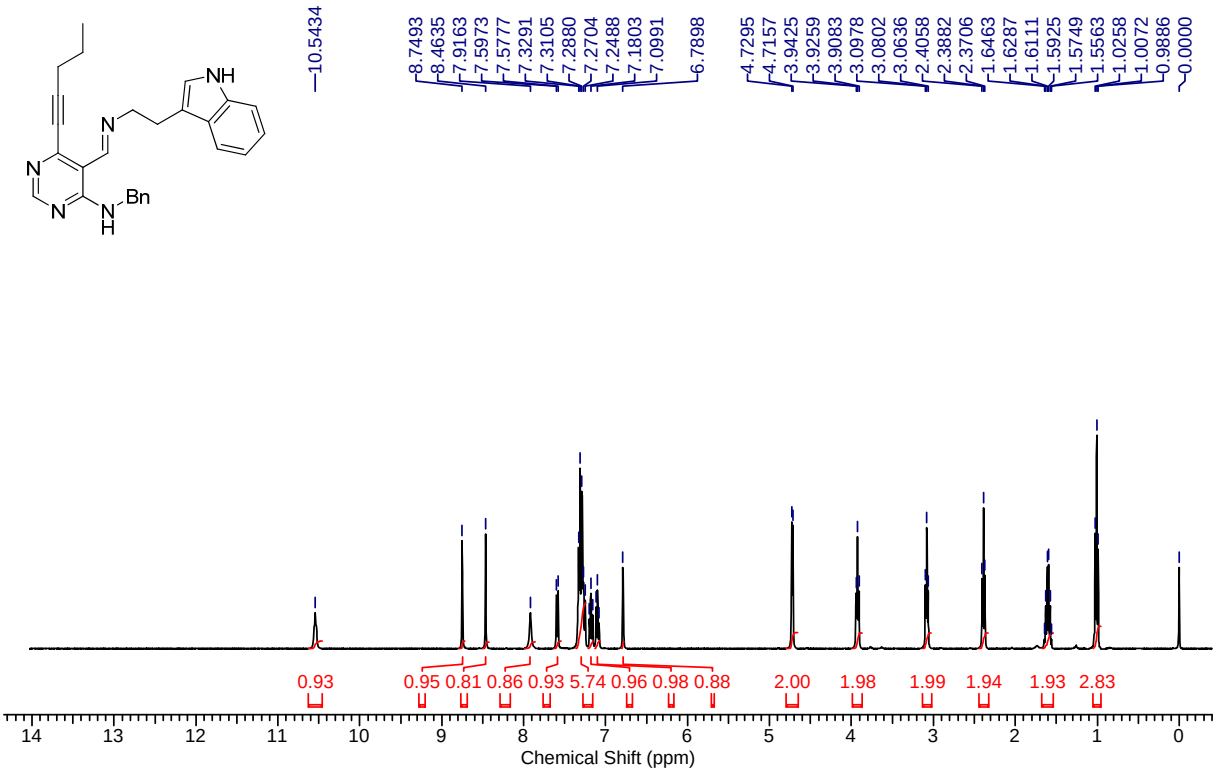

160.892
159.830
158.555
150.820
138.722
138.206
128.574
128.536
127.694
127.436
127.200
127.102
111.155
99.246
77.319
77.061
77.000
76.681
65.023
44.446
21.638
21.532
13.661
Bn
N
N
N
Bn
H
220
200
180
160
140
120
100
80
60
40
20
0
ppm

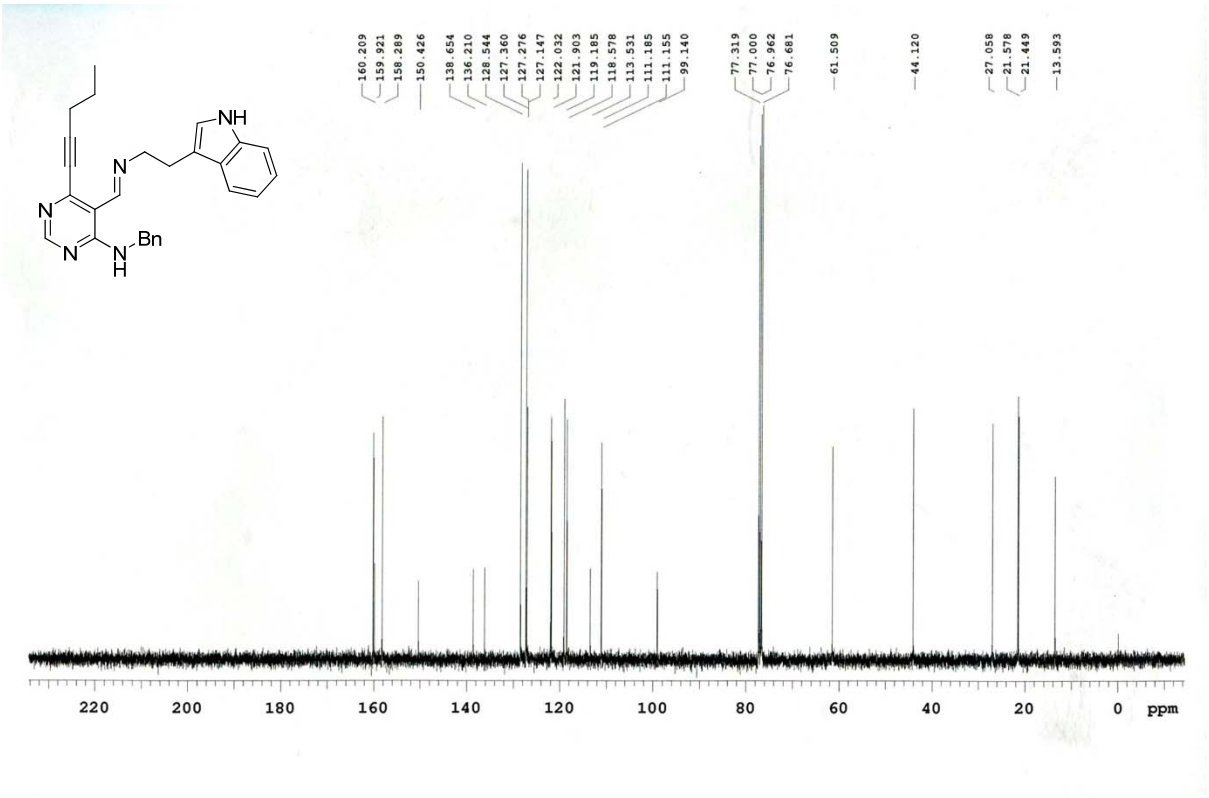
Compound 8d`


10.482
8.766
8.763
8.463
7.344
7.332
7.330
7.320
7.316
7.290
7.276
7.261
7.257
7.255
6.705
6.688
6.685
6.682
6.674
6.670
6.659
5.297
4.763
4.752
3.859
3.845
3.843
3.831
3.825
3.819
3.815
3.806
3.800
3.797
2.905
2.891
2.877
2.467
2.454
2.439
2.044
1.685
1.670
1.655
1.641
1.591
1.065
1.056
1.050
1.046
1.035
0.007
-0.000
-0.003
-0.006
O
O
N
N
N
Bn
H
12
10
8
6
4
2
0
ppm
0.99
1.01
1.01
6.42
3.19
2.11
8.24
2.00
2.05
2.13
3.10

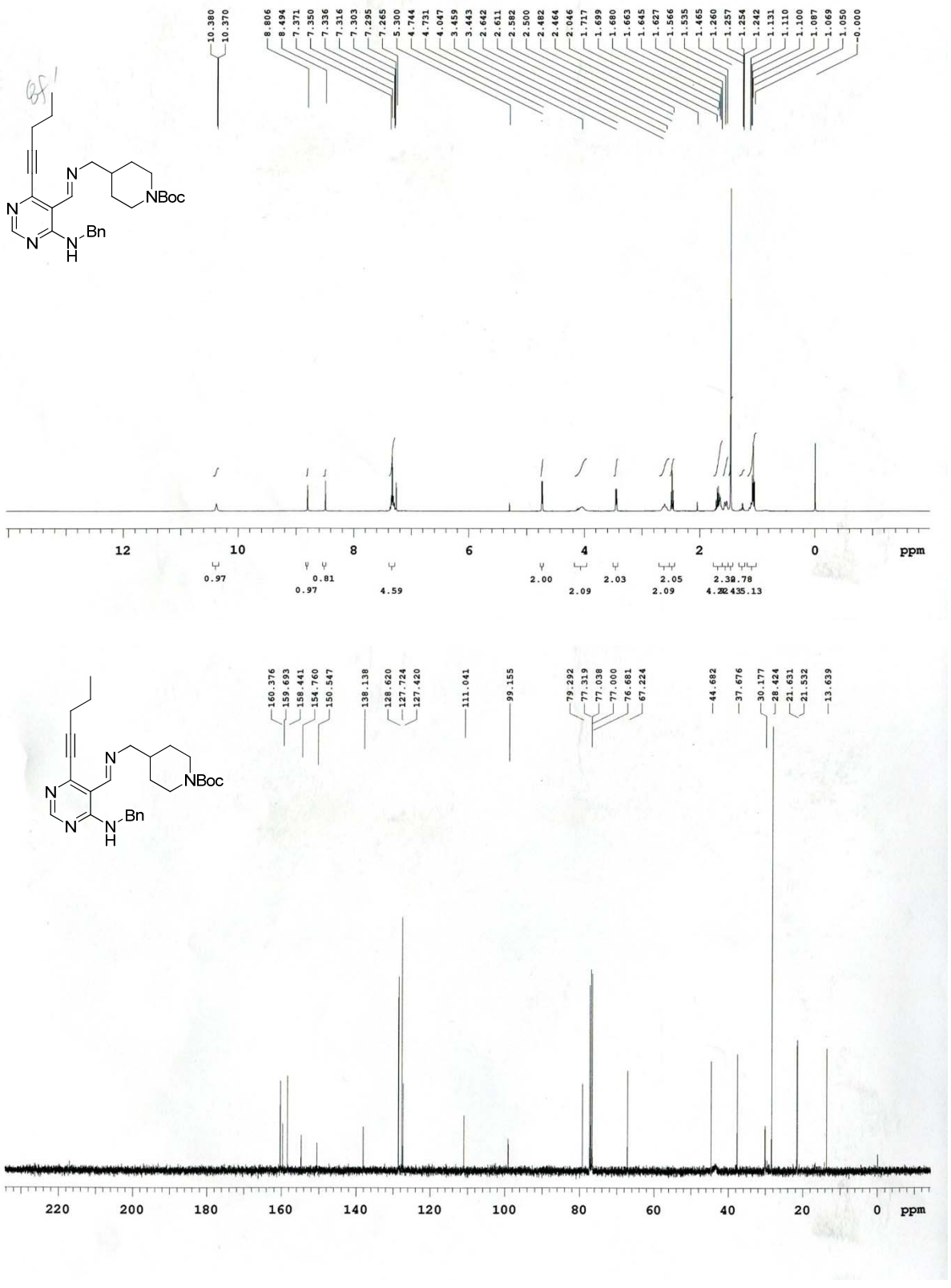

160.347
159.929
158.374
150.519
148.765
147.422
138.535
132.038
128.638
128.517
127.659
127.325
127.128
120.761
111.949
111.069
99.093
77.319
77.000
76.689
62.861
55.810
55.719
44.062
37.148
21.605
21.476
13.613
O
O
N
N
N
Bn
H
200
180
160
140
120
100
80
60
40
20
0
Chemical Shift (ppm)

Compound 8e`

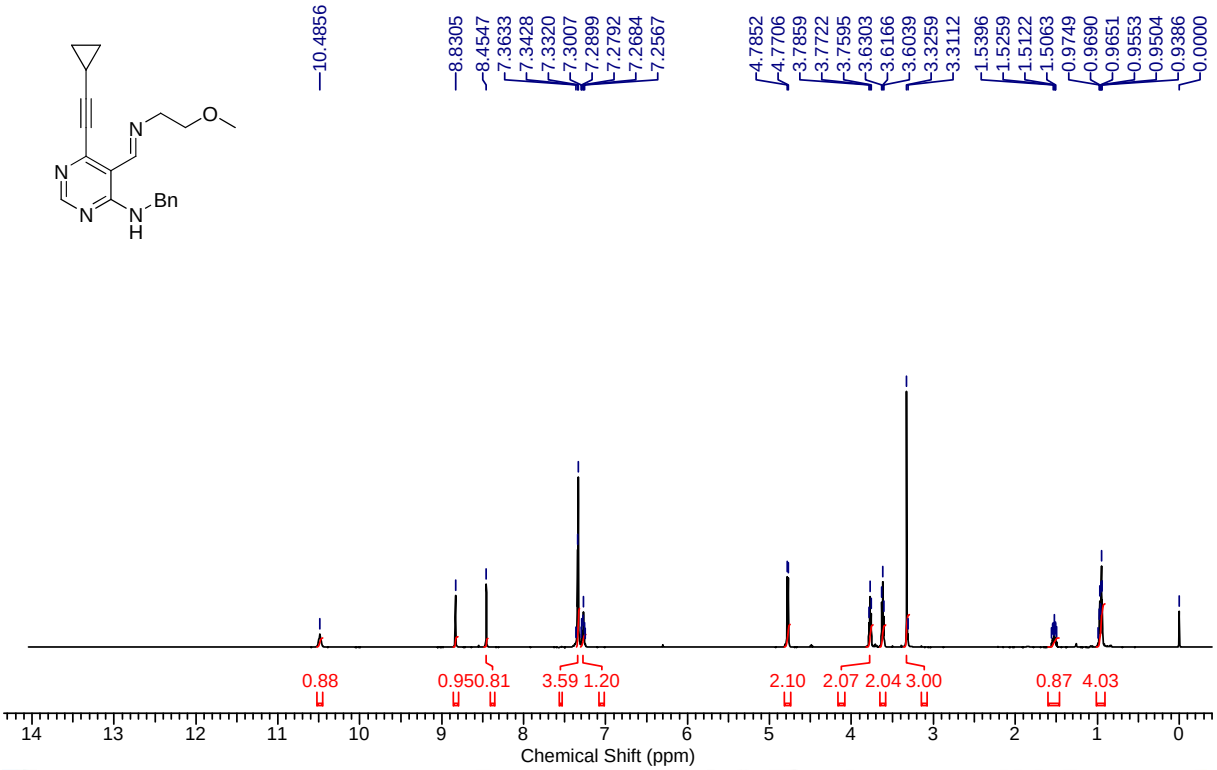

10.5434
8.7493
8.4635
7.9163
7.5973
7.5777
7.3291
7.3105
7.2880
7.2704
7.2488
7.1803
7.0991
6.7898
4.7295
4.7157
3.9425
3.9259
3.9083
3.0978
3.0802
3.0636
2.4058
2.3882
2.3706
1.6463
1.6287
1.6111
1.5925
1.5749
1.5563
1.0258
1.0072
0.9886
0.0000
NH
N
N
N
Bn
H
0.93
0.95
0.81
0.86
0.93
5.74
0.96
0.98
0.88
2.00
1.98
1.99
1.94
1.93
2.83
Chemical Shift (ppm)

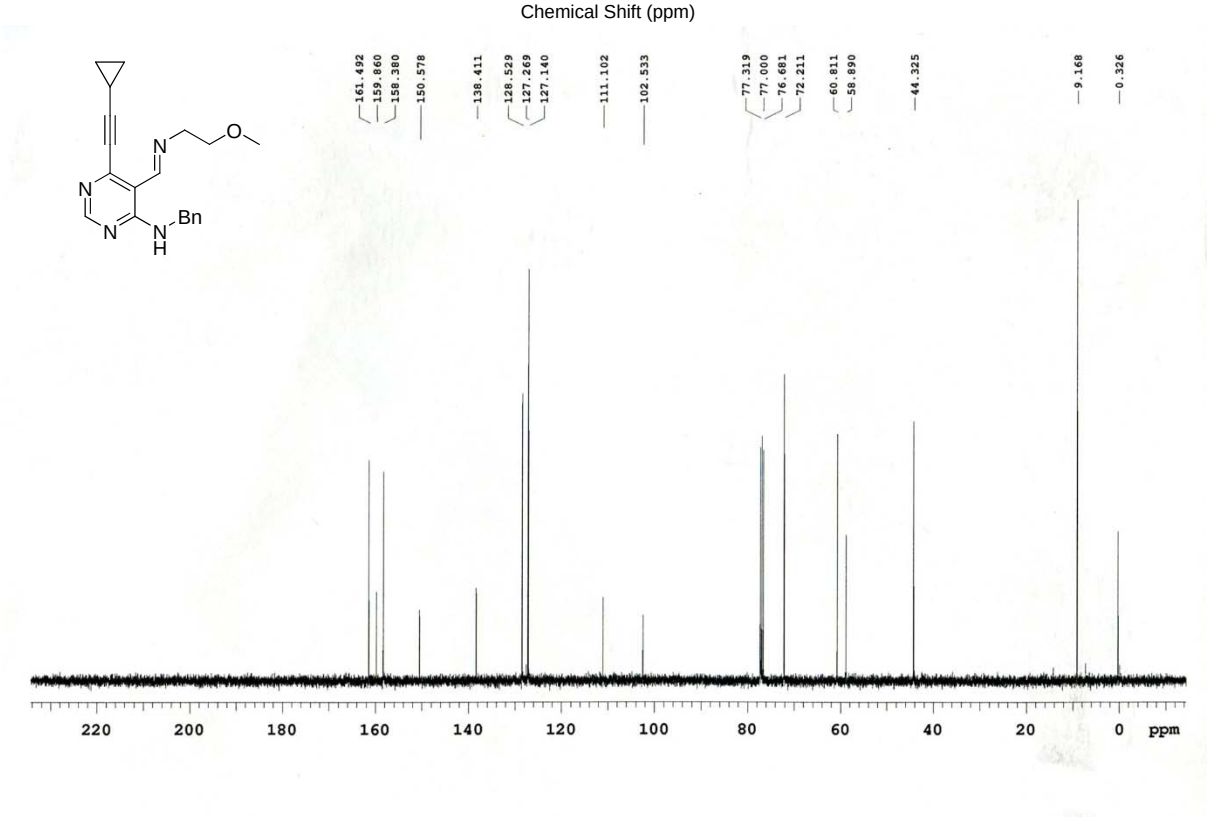

160.209
159.921
158.289
150.426
138.654
136.210
128.544
127.360
127.276
127.147
122.032
121.903
119.185
118.578
113.531
111.185
111.155
99.140
77.319
77.000
76.962
76.681
61.509
44.120
27.058
21.578
21.449
13.593
NH
N
N
N
Bn
H
ppm

Compound 8f`

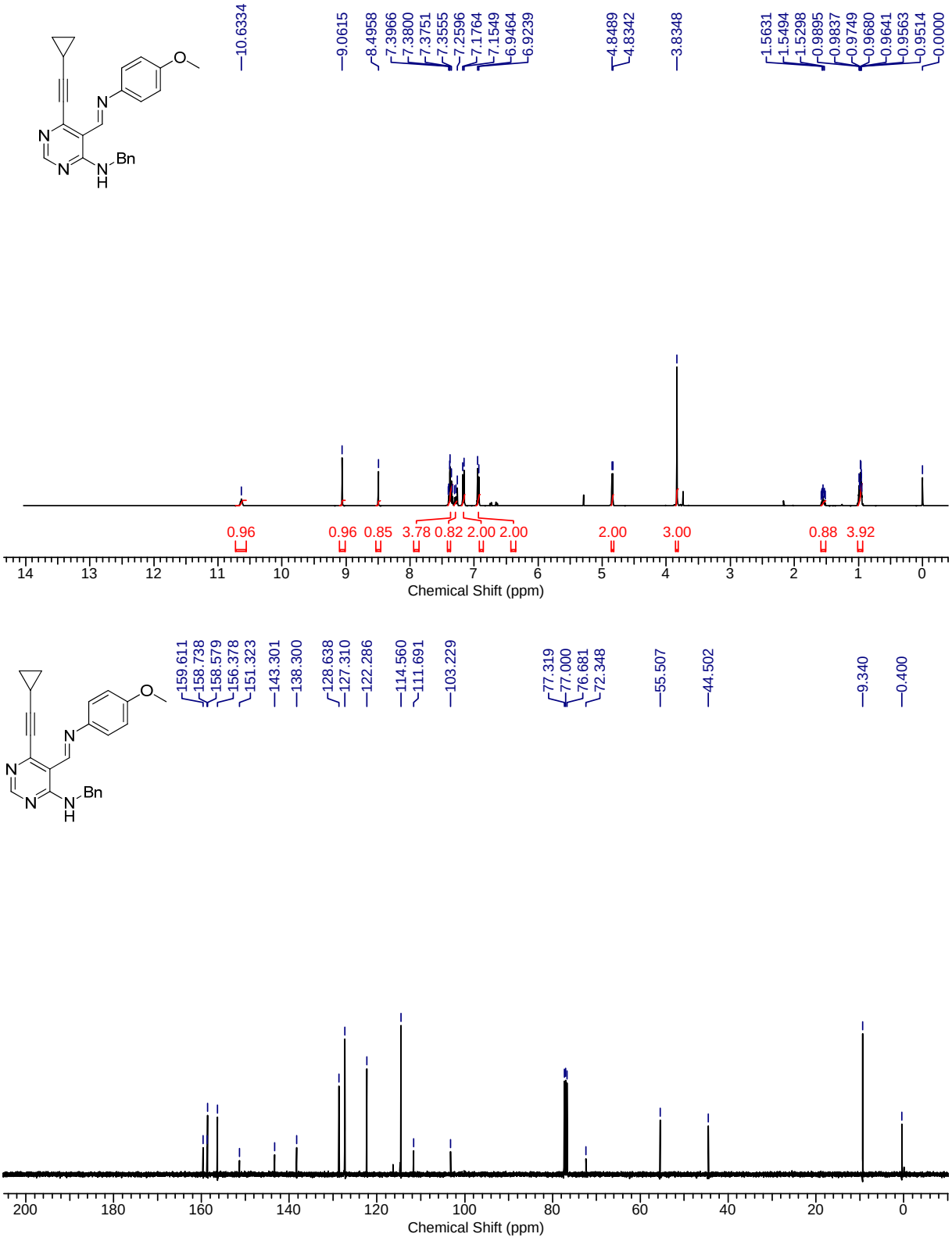

N
NBoc
N
N
Bn
H
10.380
10.370
8.806
8.494
7.371
7.350
7.336
7.316
7.303
7.295
7.265
5.300
4.744
4.731
4.047
3.459
3.443
2.642
2.611
2.582
2.500
2.482
2.464
2.046
1.717
1.699
1.680
1.663
1.645
1.627
1.566
1.535
1.465
1.260
1.257
1.254
1.242
1.131
1.110
1.100
1.087
1.069
1.050
0.000
12
10
8
6
4
2
0
ppm
0.97
0.81
0.97
4.59
2.00
2.09
2.03
2.05
2.09
2.30
0.78
4.28
2.43
5.13
N
NBoc
N
N
Bn
H
160.376
159.693
158.441
154.760
150.547
138.138
128.620
127.724
127.420
111.041
99.155
79.292
77.319
77.038
77.000
76.681
67.224
44.682
37.676
30.177
28.424
21.631
21.532
13.639
220
200
180
160
140
120
100
80
60
40
20
0
ppm

Compound 9a`

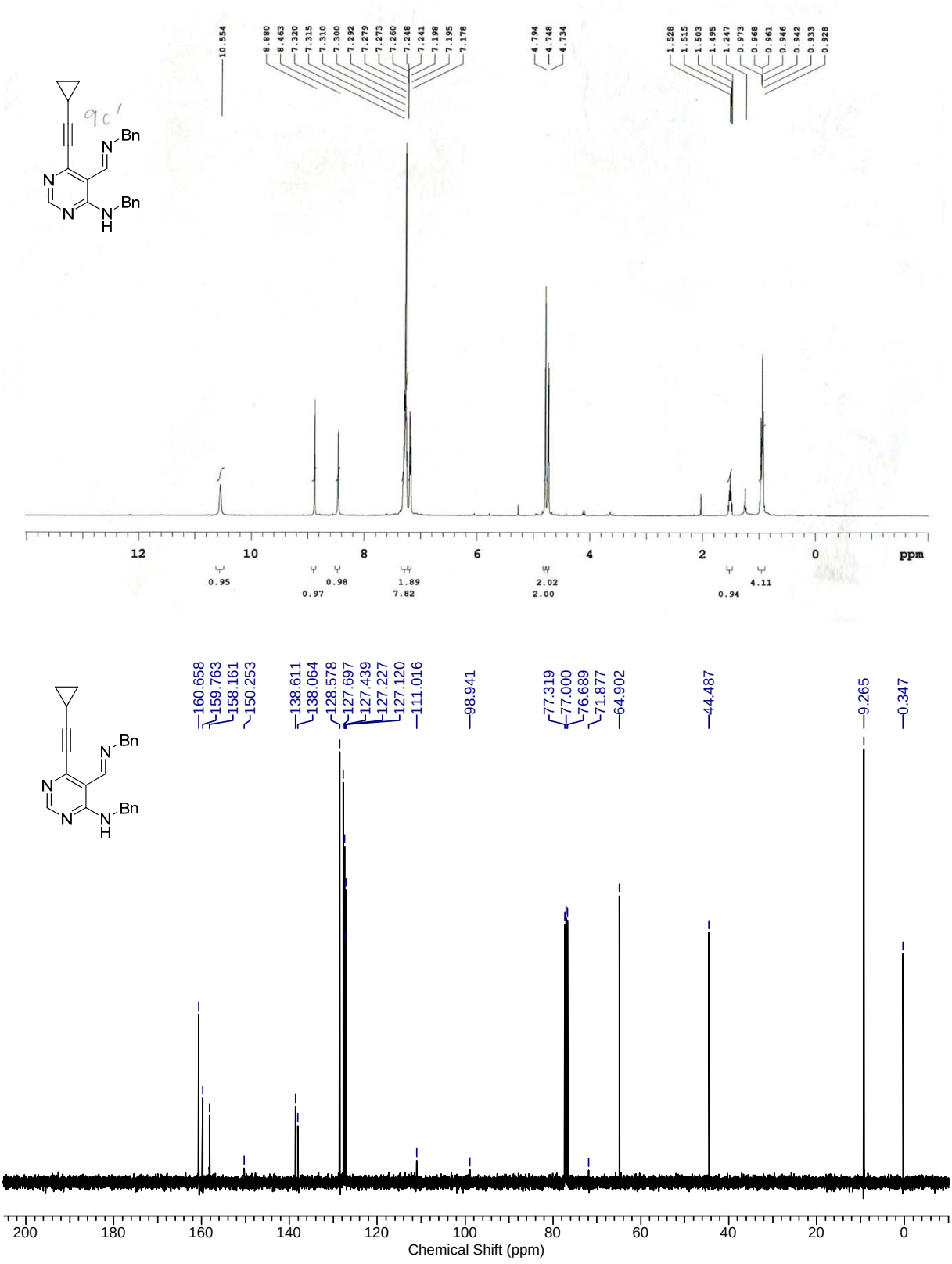

10.4856
8.8305
8.4547
7.3633
7.3428
7.3320
7.3007
7.2899
7.2792
7.2684
7.2567
4.7852
4.7706
3.7859
3.7722
3.7595
3.6303
3.6166
3.6039
3.3259
3.3112
1.5396
1.5259
1.5122
1.5063
0.9749
0.9690
0.9651
0.9553
0.9504
0.9386
0.0000
0.88
0.95
0.81
3.59
1.20
2.10
2.07
2.04
3.00
0.87
4.03
Chemical Shift (ppm)


161.492
159.860
158.380
150.578
138.411
128.529
127.269
127.140
111.102
102.533
77.319
77.000
76.681
72.211
60.811
58.890
44.325
9.168
0.326
ppm

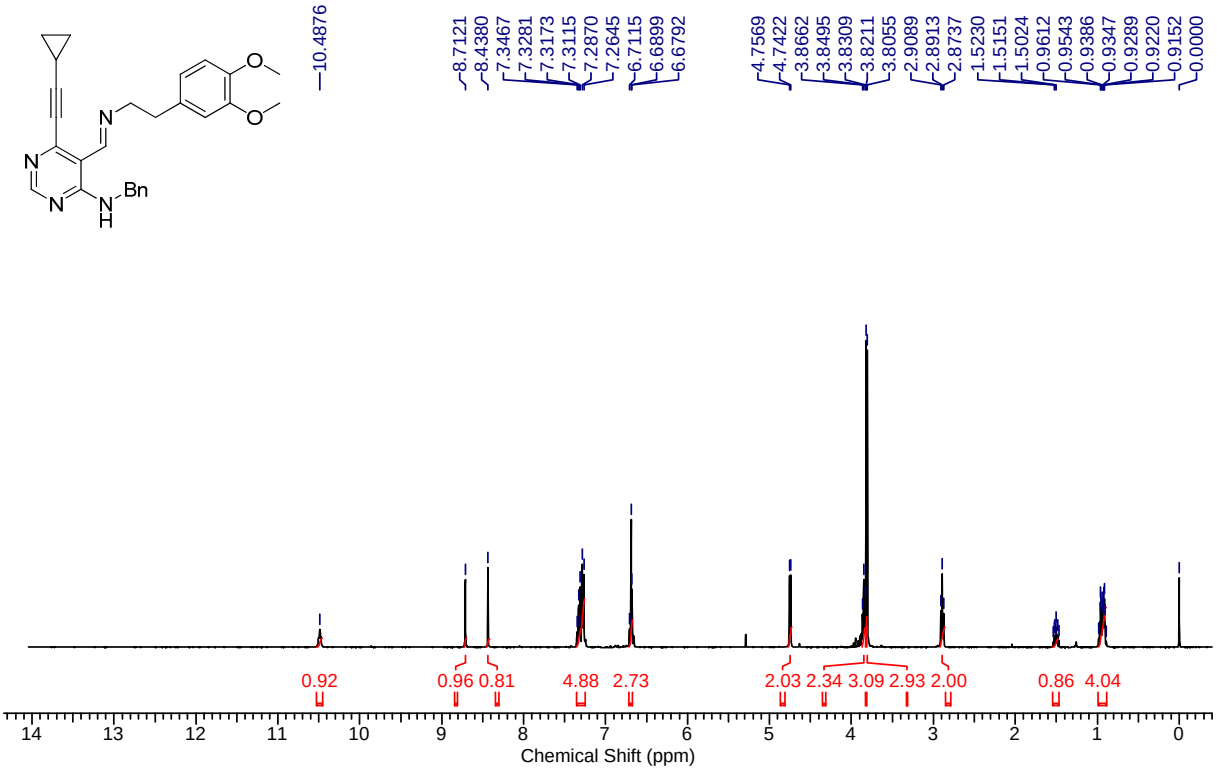
Compound 9b`

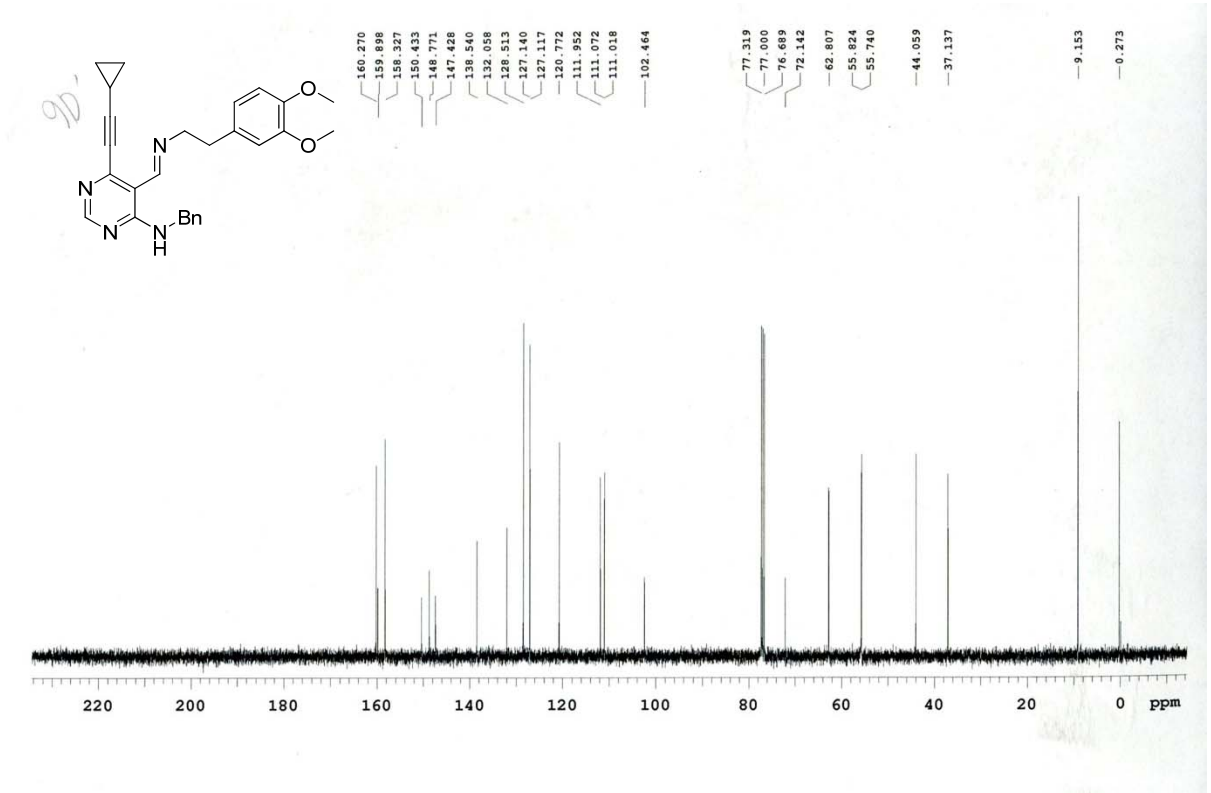

10.6334
9.0615
8.4958
7.3966
7.3800
7.3751
7.3555
7.2596
7.1764
7.1549
6.9464
6.9239
4.8489
4.8342
3.8348
1.5631
1.5494
1.5298
0.9895
0.9837
0.9749
0.9680
0.9641
0.9563
0.9514
0.0000
0.96
0.96
0.85
3.78
0.82
2.00
2.00
2.00
3.00
0.88
3.92
Chemical Shift (ppm)
159.611
158.738
158.579
156.378
151.323
143.301
138.300
128.638
127.310
122.286
114.560
111.691
103.229
77.319
77.000
76.681
72.348
55.507
44.502
9.340
0.400
Chemical Shift (ppm)

Compound 9c`

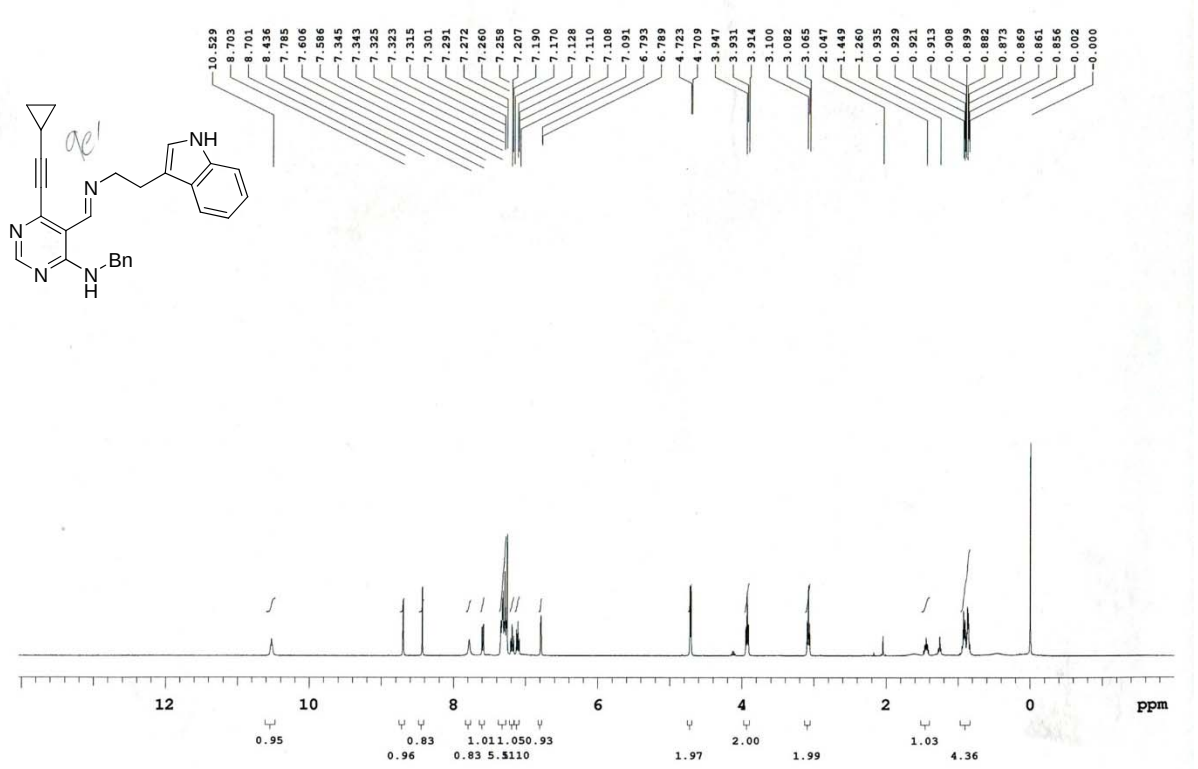

10.554
8.880
8.463
7.320
7.315
7.310
7.300
7.292
7.279
7.273
7.260
7.248
7.241
7.198
7.195
7.178
4.794
4.748
4.734
1.528
1.515
1.503
1.495
1.247
0.973
0.968
0.961
0.946
0.942
0.933
0.928
9c'
Bn
Bn
12
10
8
6
4
2
0
ppm
0.95
0.97
0.98
1.89
7.82
2.02
2.00
0.94
4.11
160.658
159.763
158.161
150.253
138.611
138.064
128.578
127.697
127.439
127.227
127.120
111.016
98.941
77.319
77.000
76.689
71.877
64.902
44.487
9.265
0.347
200
180
160
140
120
100
80
60
40
20
0
Chemical Shift (ppm)

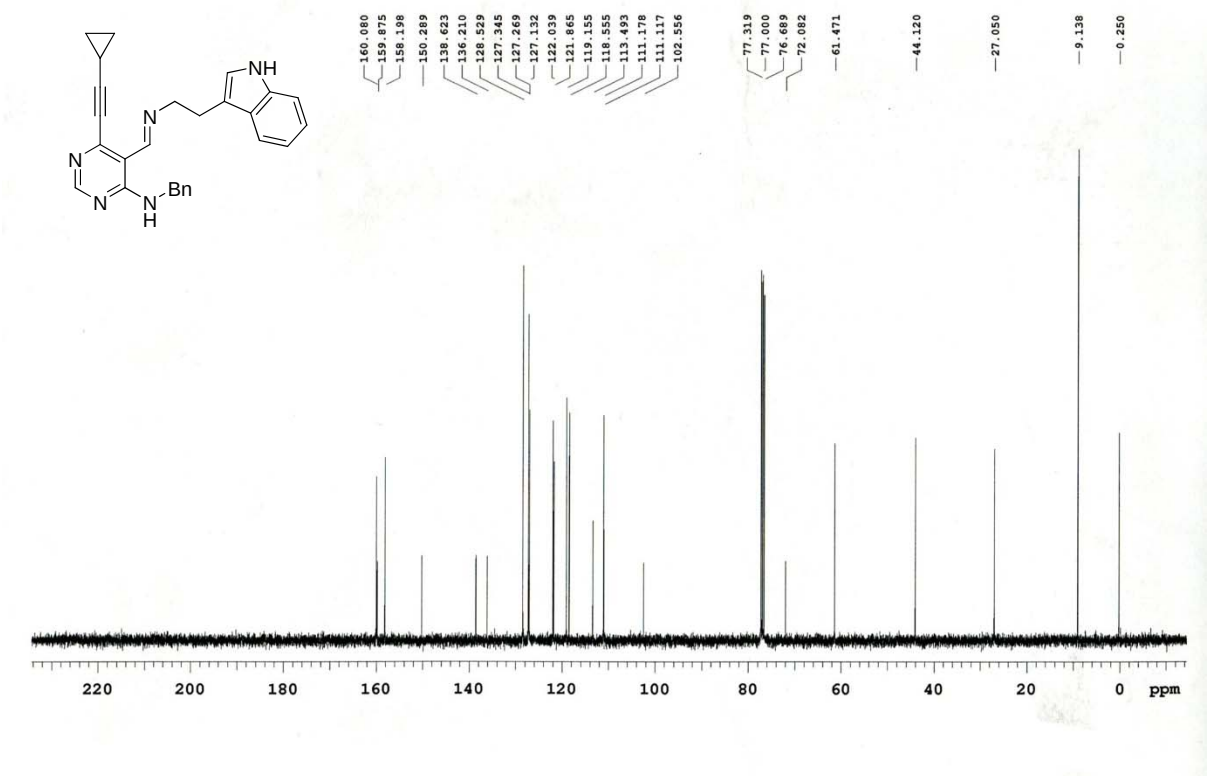
Compound 9d`


10.4876
8.7121
8.4380
7.3467
7.3281
7.3173
7.3115
7.2870
7.2645
6.7115
6.6899
6.6792
4.7569
4.7422
3.8662
3.8495
3.8309
3.8211
3.8055
2.9089
2.8913
2.8737
1.5230
1.5151
1.5024
0.9612
0.9543
0.9386
0.9347
0.9289
0.9220
0.9152
0.0000
0.92
0.96
0.81
4.88
2.73
2.03
2.34
3.09
2.93
2.00
0.86
4.04
Chemical Shift (ppm)

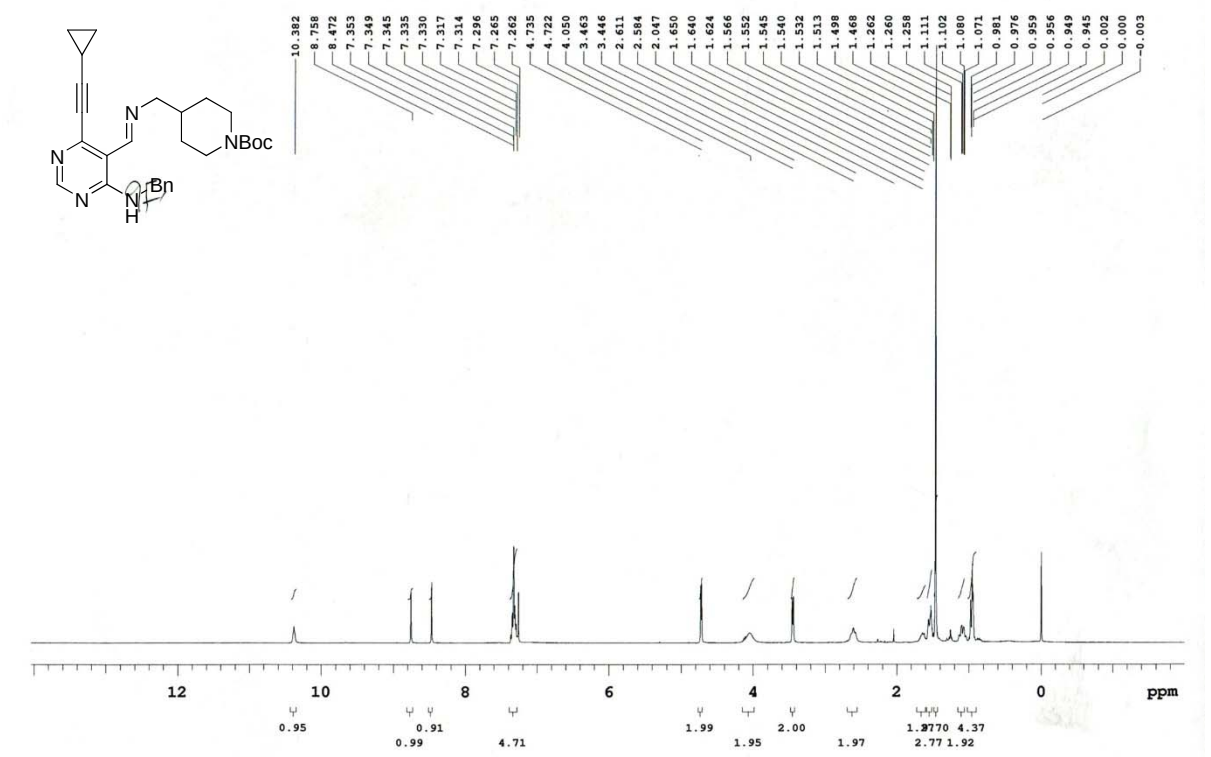

160.270
159.898
158.327
150.433
148.771
147.428
138.540
132.058
128.513
127.140
127.117
120.772
111.952
111.072
111.018
102.464
77.319
77.000
76.689
72.142
62.807
55.824
55.740
44.059
37.137
9.153
0.273
ppm

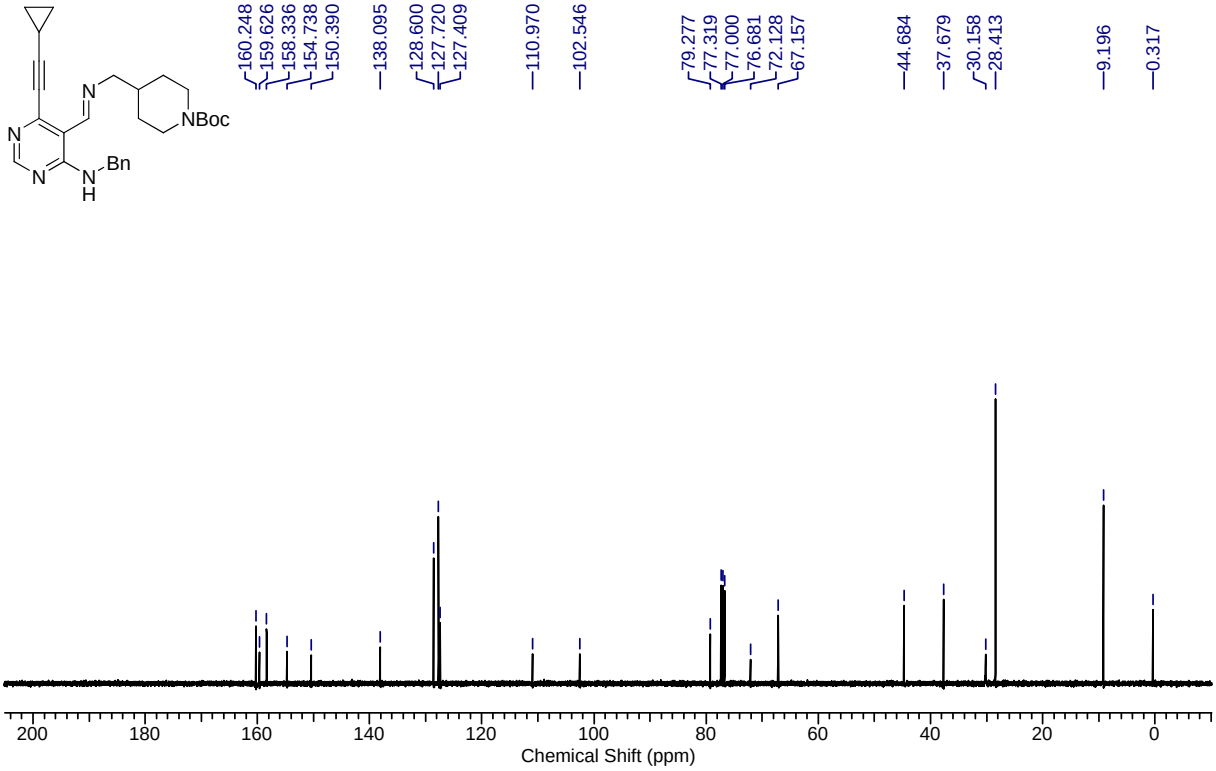
Compound 9e`


NH
N
N
N
Bn
H
10.529
8.703
8.701
8.436
7.785
7.606
7.586
7.345
7.343
7.325
7.323
7.315
7.301
7.291
7.272
7.260
7.258
7.207
7.190
7.170
7.128
7.110
7.108
7.091
6.793
6.789
4.723
4.709
3.947
3.931
3.914
3.100
3.082
3.065
2.047
1.449
1.260
0.935
0.929
0.921
0.913
0.908
0.899
0.882
0.873
0.869
0.861
0.856
0.002
0.000
12
10
8
6
4
2
0
ppm
0.95
0.83
0.96
1.01
0.83
1.05
5.51
0.93
1.10
1.97
2.00
1.99
1.03
4.36

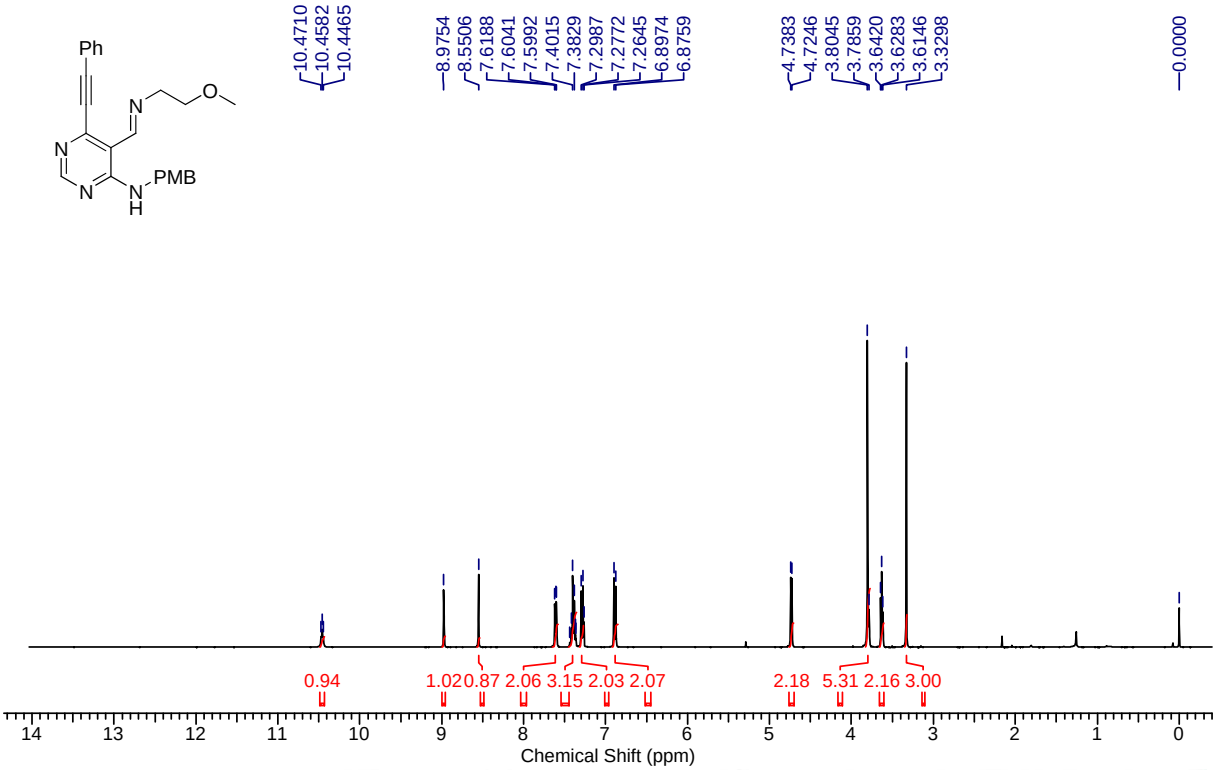

NH
N
N
N
Bn
H
160.080
159.875
158.198
150.289
138.623
136.210
128.529
127.345
127.269
127.132
122.039
121.865
119.155
118.555
113.493
111.178
111.117
102.556
77.319
77.000
76.689
72.082
61.471
44.120
27.050
9.138
0.250
220
200
180
160
140
120
100
80
60
40
20
0
ppm

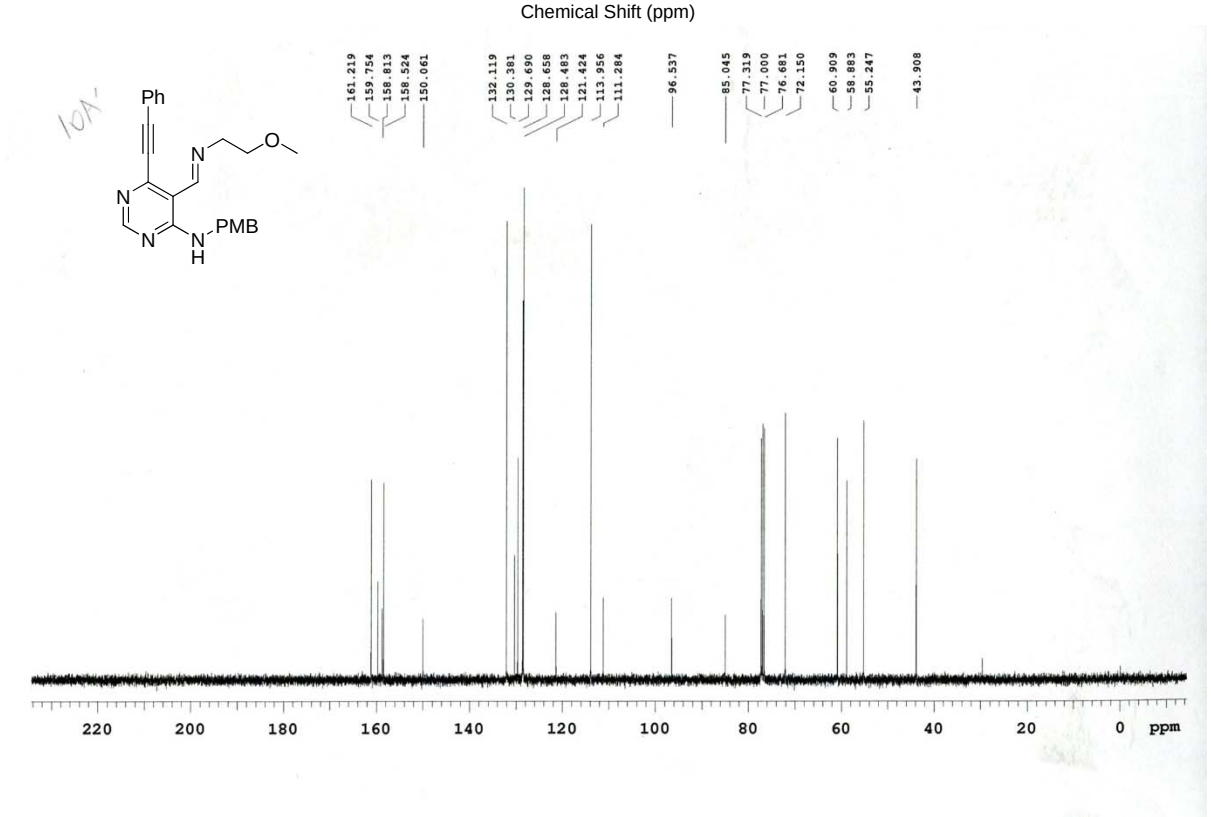
Compound 9f`



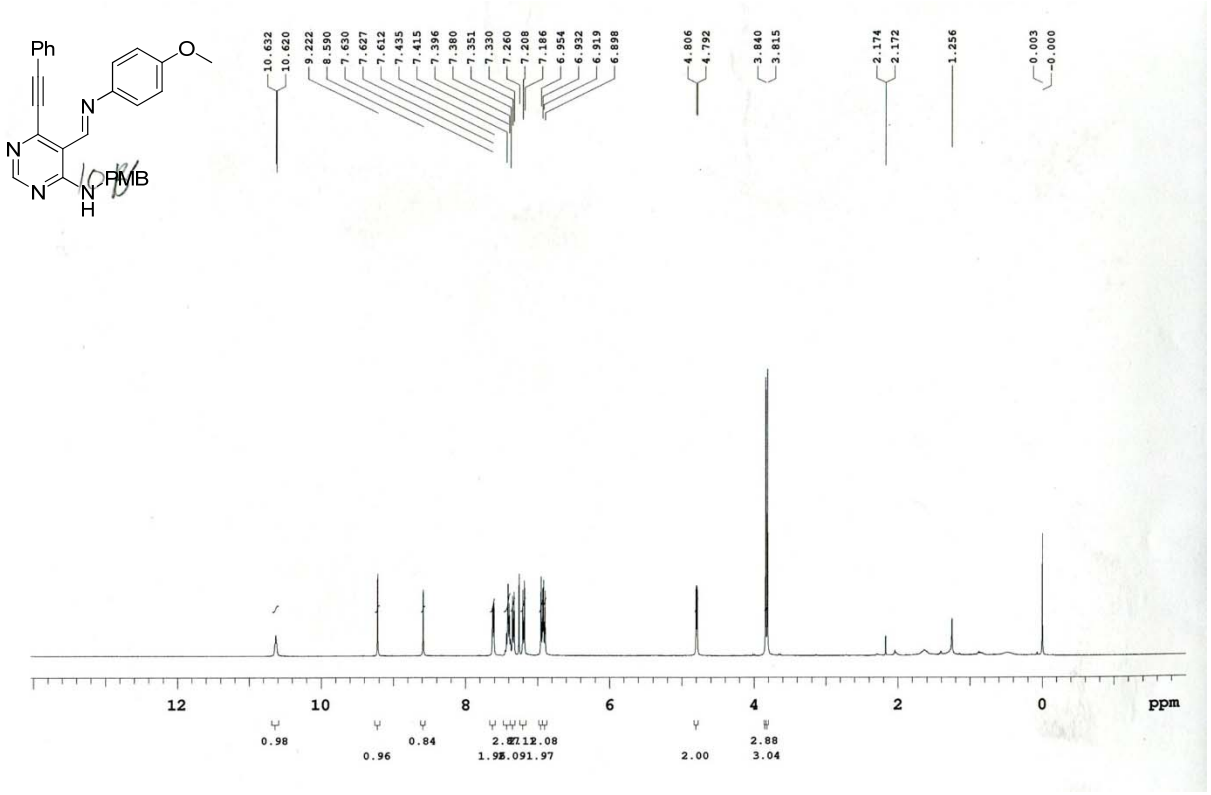


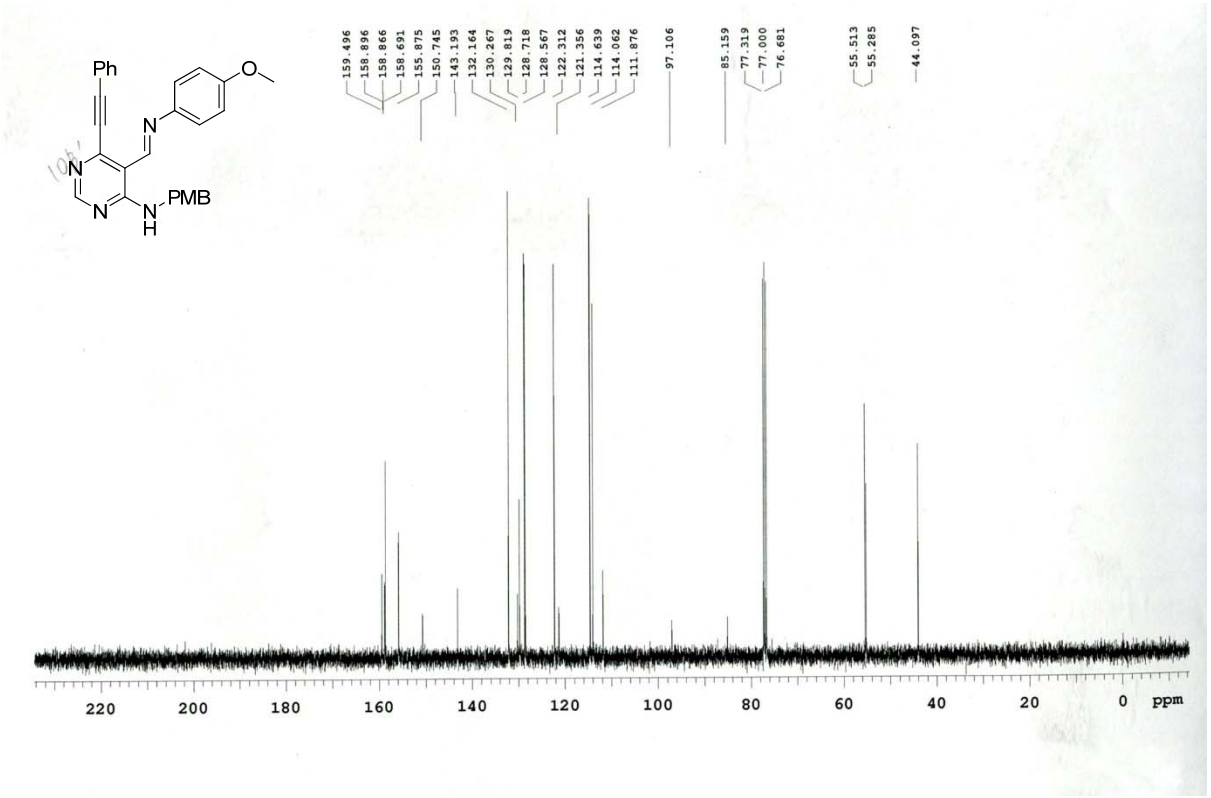
Compound 10a`



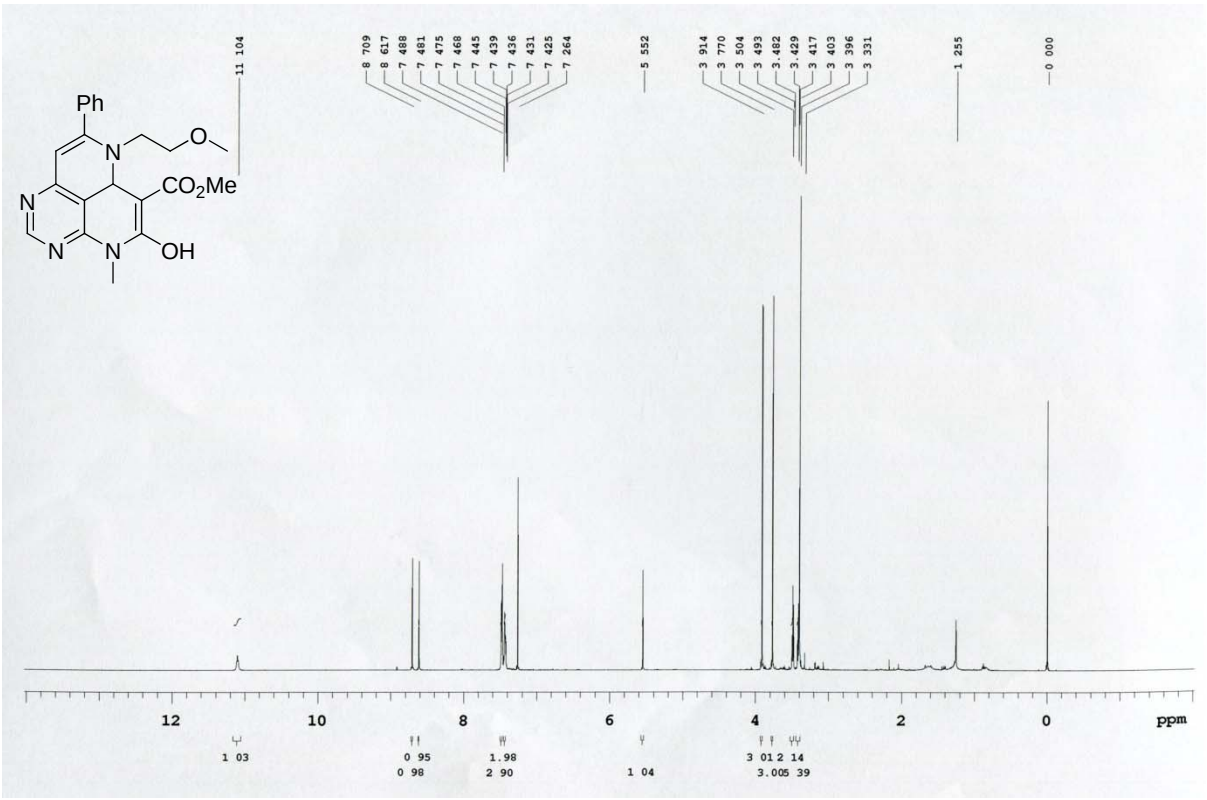


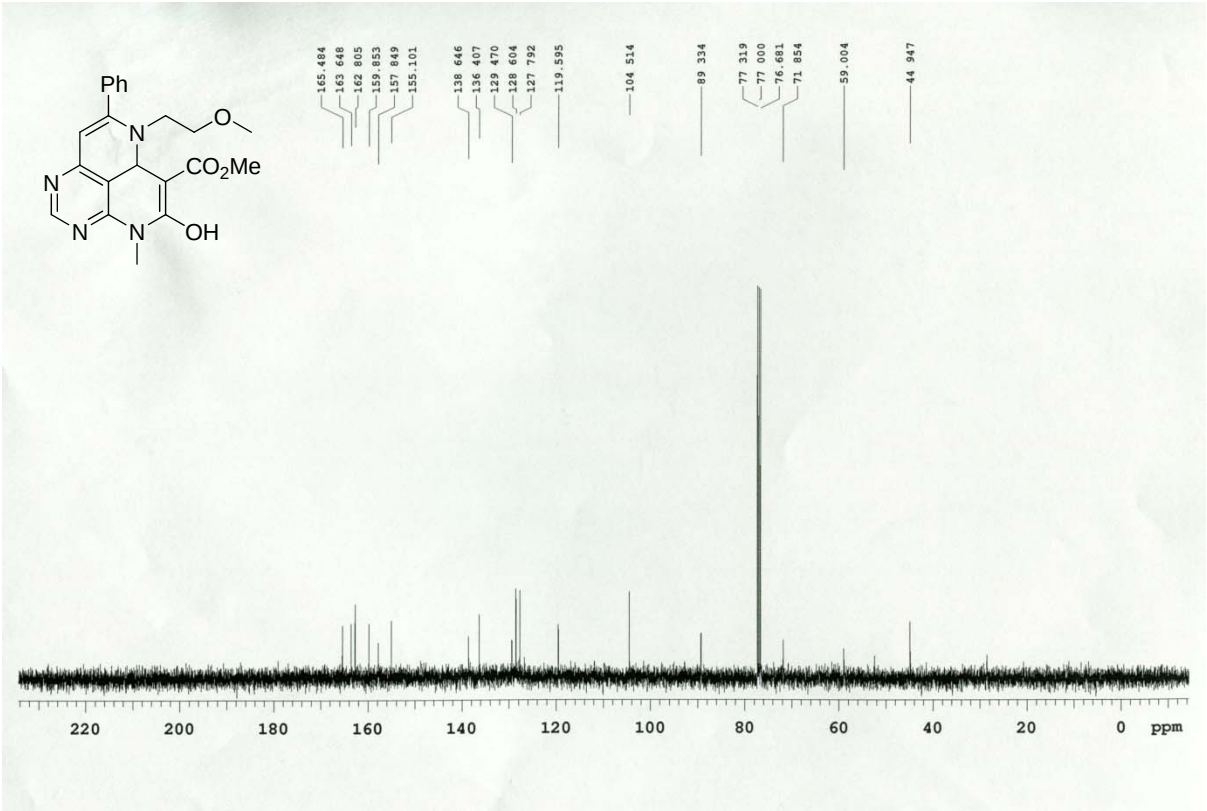
Compound 10b`


Ph
O
N
N
N
PMB
H
10.632
10.620
9.222
8.590
7.630
7.627
7.612
7.435
7.415
7.396
7.380
7.351
7.330
7.260
7.208
7.186
6.954
6.932
6.919
6.898
4.806
4.792
3.840
3.815
2.174
2.172
1.256
0.003
-0.000
12
10
8
6
4
2
0
ppm
0.98
0.96
0.84
2.00
2.88
3.04

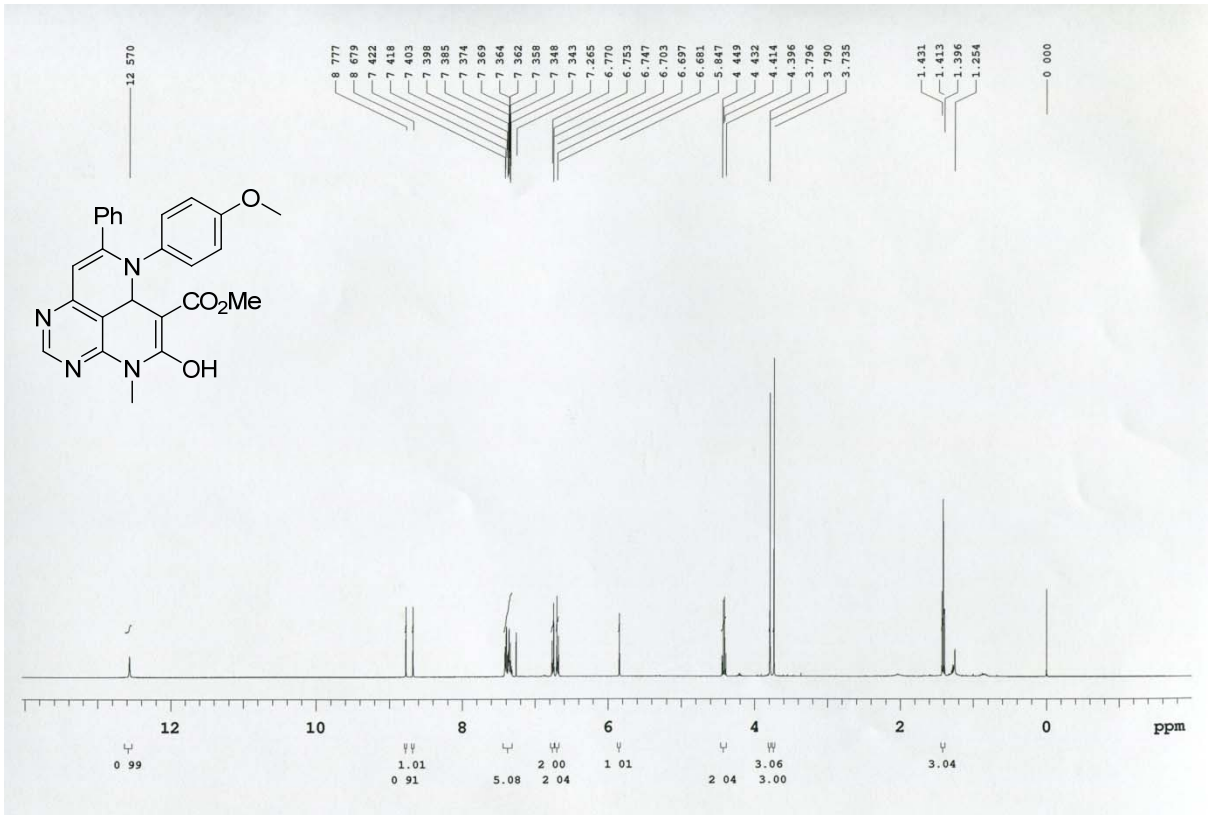

Ph
O
N
N
N
PMB
H
159.496
158.896
158.866
158.691
155.875
150.745
143.193
132.164
130.267
129.819
128.718
128.567
122.312
121.356
114.639
114.062
111.876
97.106
85.159
77.319
77.000
76.681
55.513
55.285
44.097
220
200
180
160
140
120
100
80
60
40
20
0
ppm

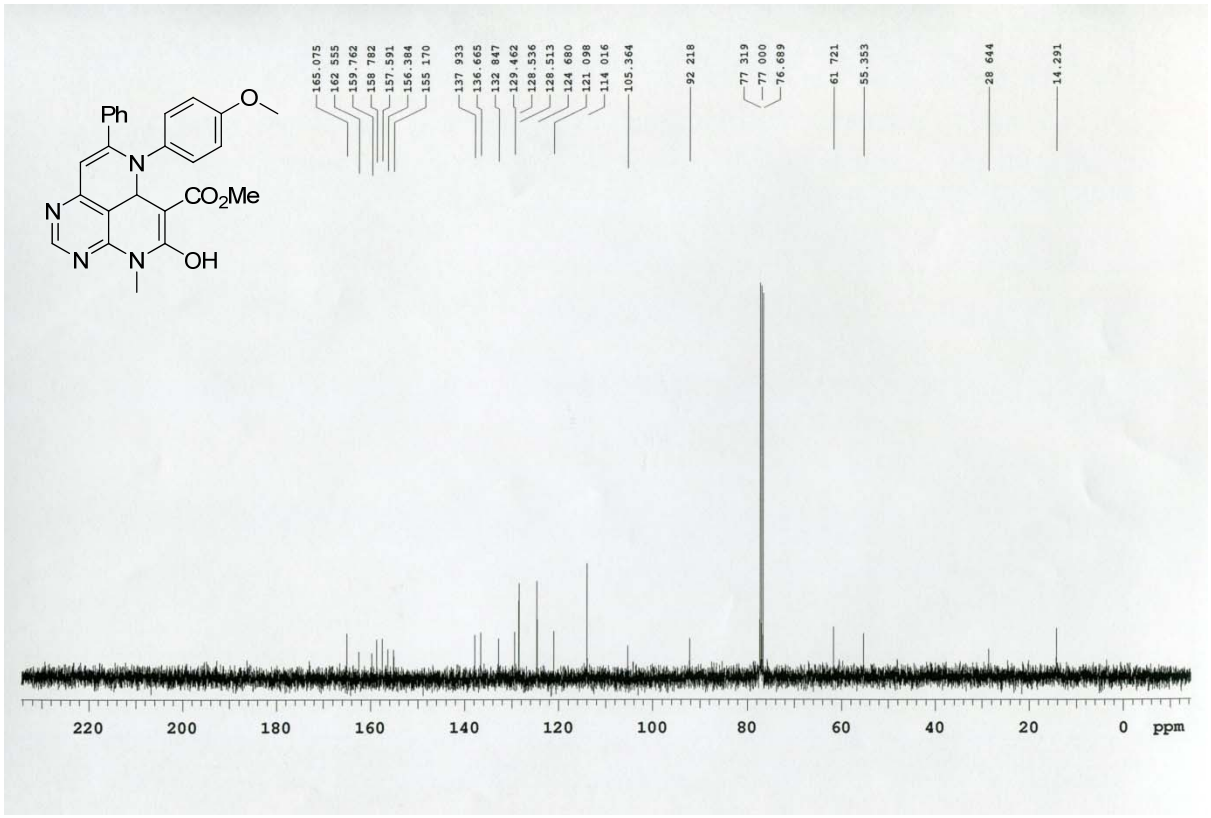
Compound 4a


11.104
8.709
8.617
7.488
7.481
7.475
7.468
7.445
7.439
7.436
7.431
7.425
7.264
5.552
3.914
3.770
3.504
3.493
3.482
3.429
3.417
3.403
3.396
3.331
1.255
0.000
Ph
N
O
CO2Me
N
N
N
OH
12
10
8
6
4
2
0
ppm
1.03
0.95
0.98
1.98
2.90
1.04
3.01
2.14
3.005
39

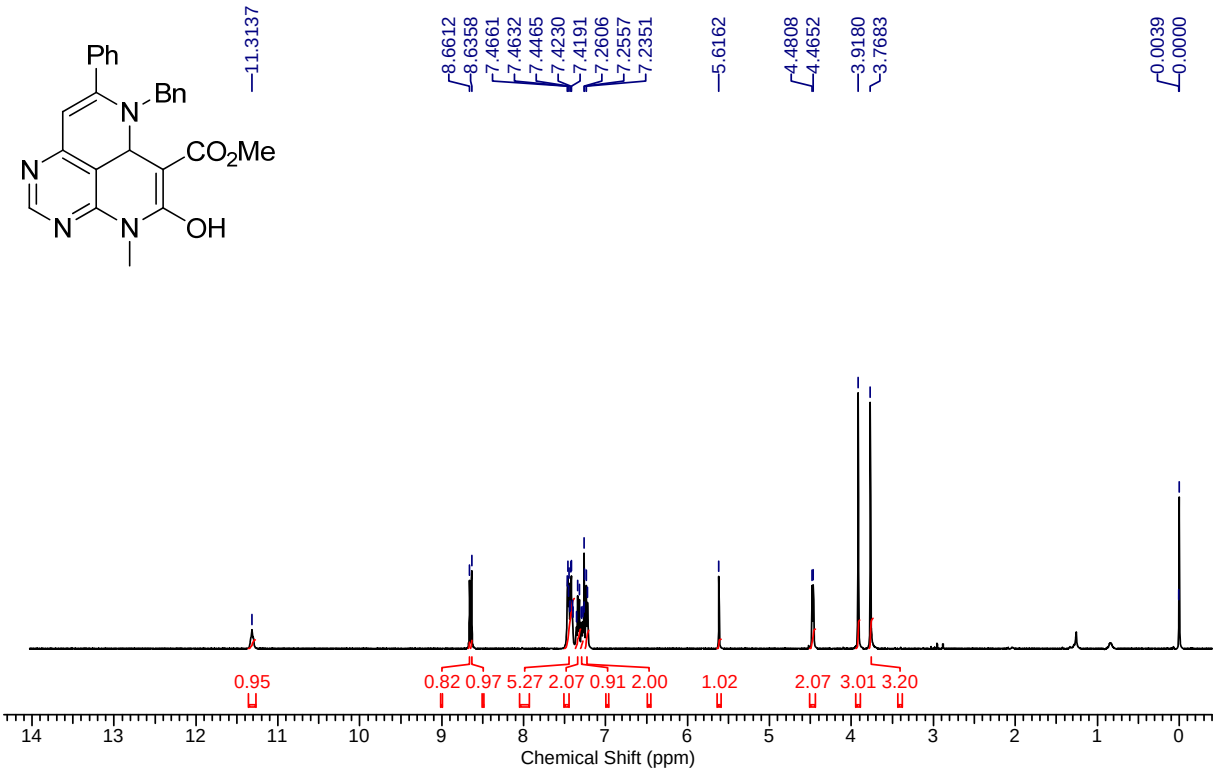

165.484
163.648
162.805
159.853
157.849
155.101
138.646
136.407
129.470
128.604
127.792
119.595
104.514
89.334
77.319
77.000
76.681
71.854
59.004
44.947
Ph
N
O
CO2Me
N
N
N
OH
220
200
180
160
140
120
100
80
60
40
20
0
ppm

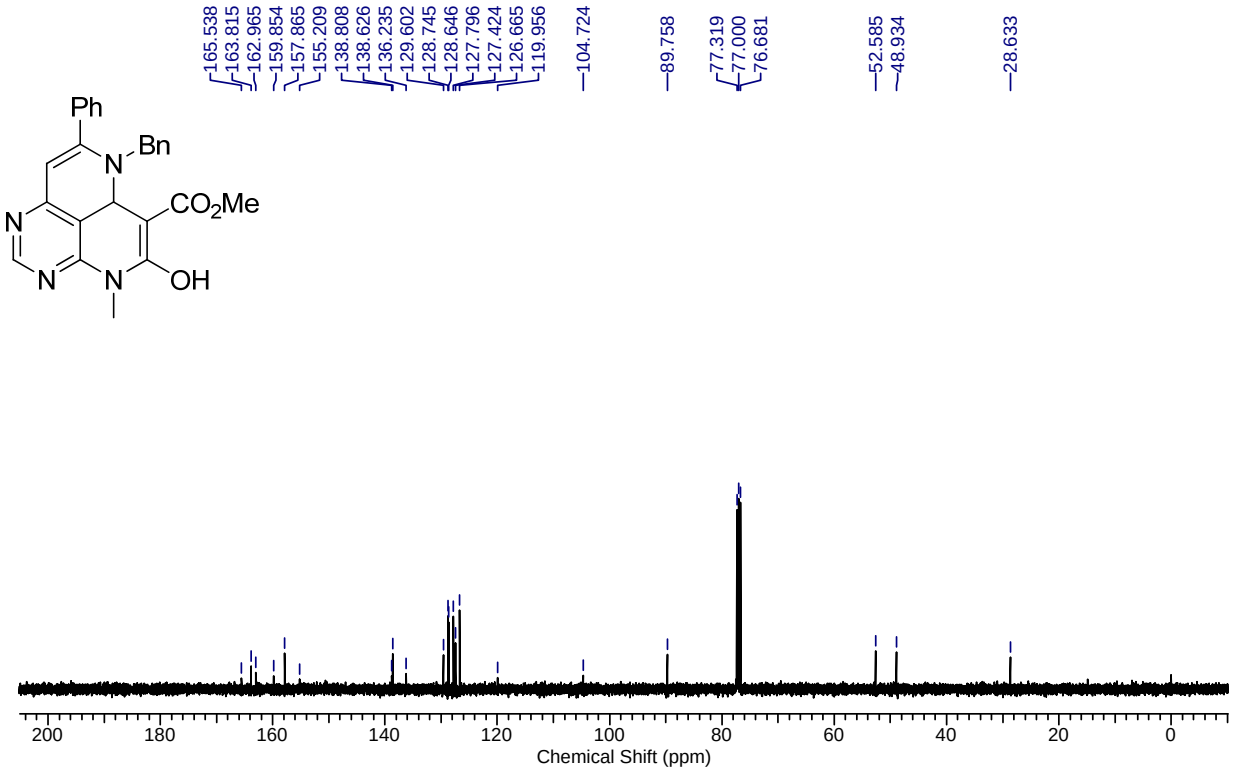
Compound 4b


12.570
8.777
8.679
7.422
7.418
7.403
7.398
7.385
7.374
7.369
7.364
7.362
7.358
7.348
7.343
7.265
6.770
6.753
6.747
6.703
6.697
6.681
5.847
4.449
4.432
4.414
4.396
3.796
3.790
3.735
1.431
1.413
1.396
1.254
0.000
Ph
O
N
CO2Me
N
N
N
OH
12
10
8
6
4
2
0
ppm
0.99
1.01
0.91
5.08
2.00
2.04
1.01
2.04
3.06
3.00
3.04

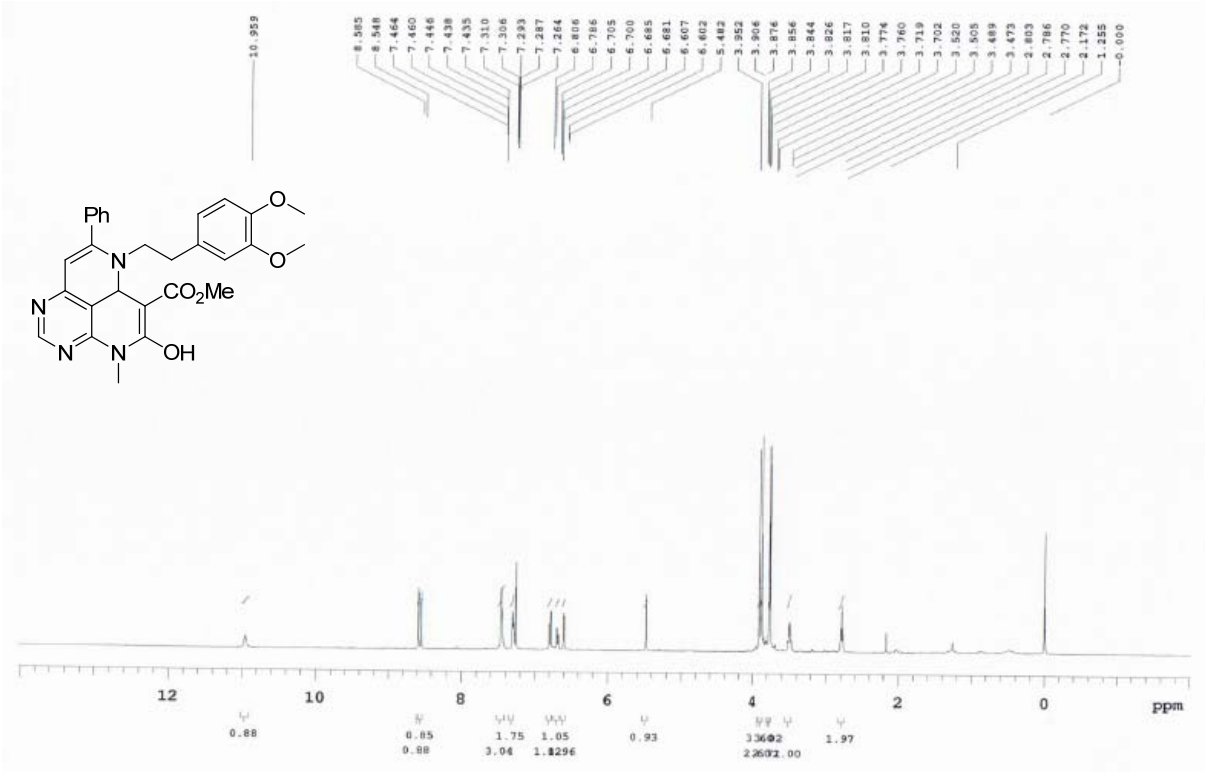

165.075
162.555
159.762
158.782
157.591
156.384
155.170
137.933
136.665
132.847
129.462
128.536
128.513
124.680
121.098
114.016
105.364
92.218
77.319
77.000
76.689
61.721
55.353
28.644
14.291
Ph
O
N
CO2Me
N
N
N
OH
220
200
180
160
140
120
100
80
60
40
20
0
ppm

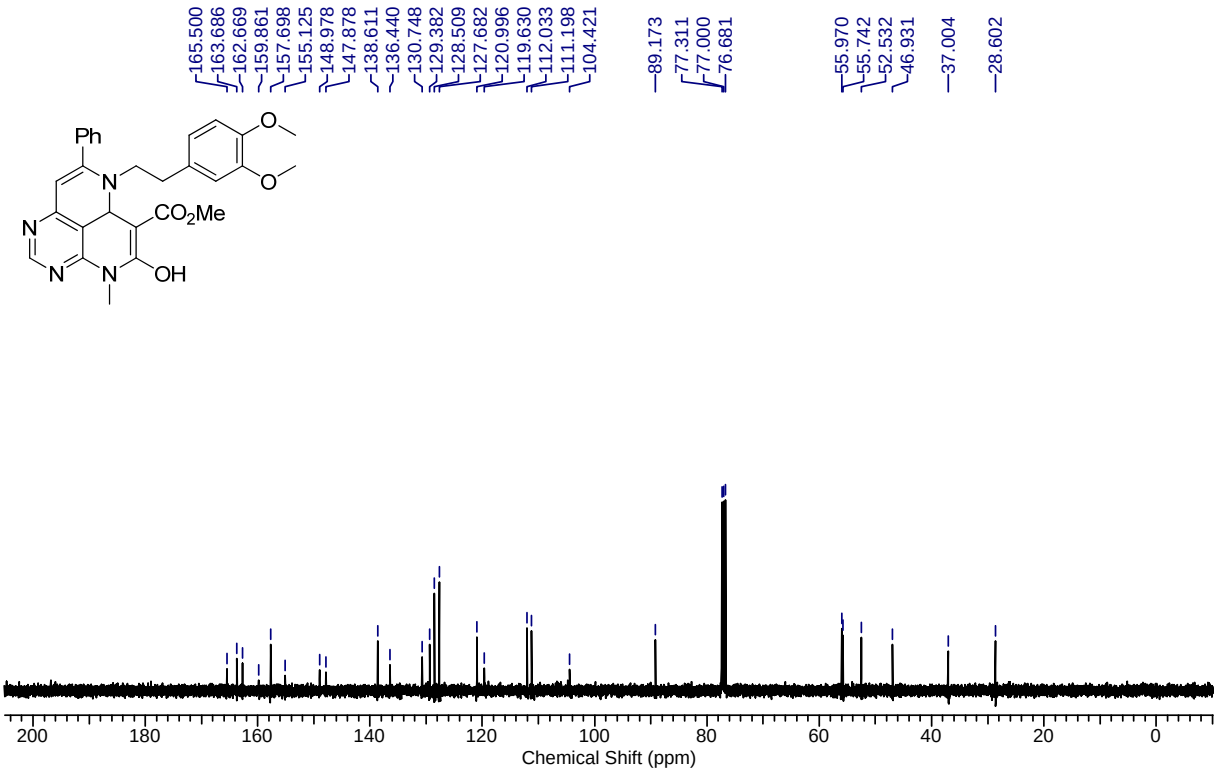
Compound 4c


Ph
Bn
N
CO2Me
N
N
N
OH
11.3137
8.6612
8.6358
7.4661
7.4632
7.4465
7.4230
7.4191
7.2606
7.2557
7.2351
5.6162
4.4808
4.4652
3.9180
3.7683
0.0039
0.0000
0.95
0.82
0.97
5.27
2.07
0.91
2.00
1.02
2.07
3.01
3.20
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Chemical Shift (ppm)

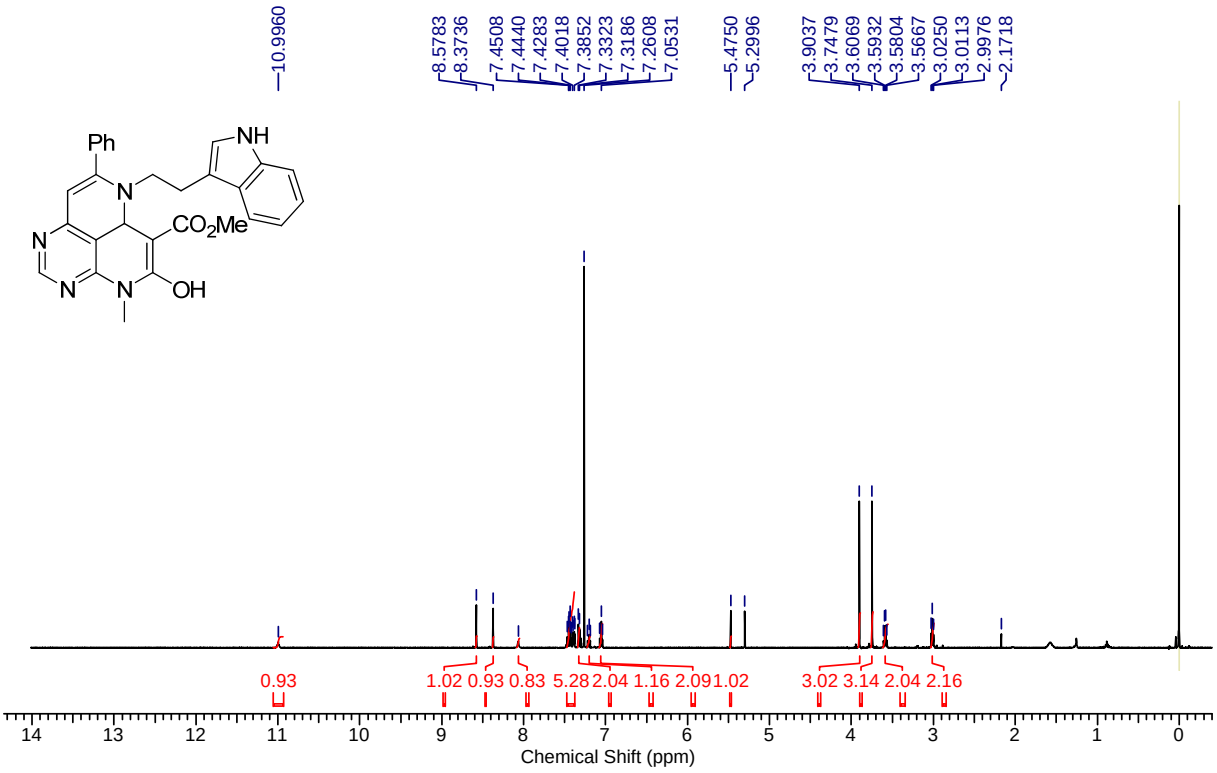

165.538
163.815
162.965
159.854
157.865
155.209
138.808
138.626
136.235
129.602
128.745
128.646
127.796
127.424
126.665
119.956
104.724
89.758
77.319
77.000
76.681
52.585
48.934
28.633
Ph
Bn
N
CO2Me
N
N
N
OH
200
180
160
140
120
100
80
60
40
20
0
Chemical Shift (ppm)

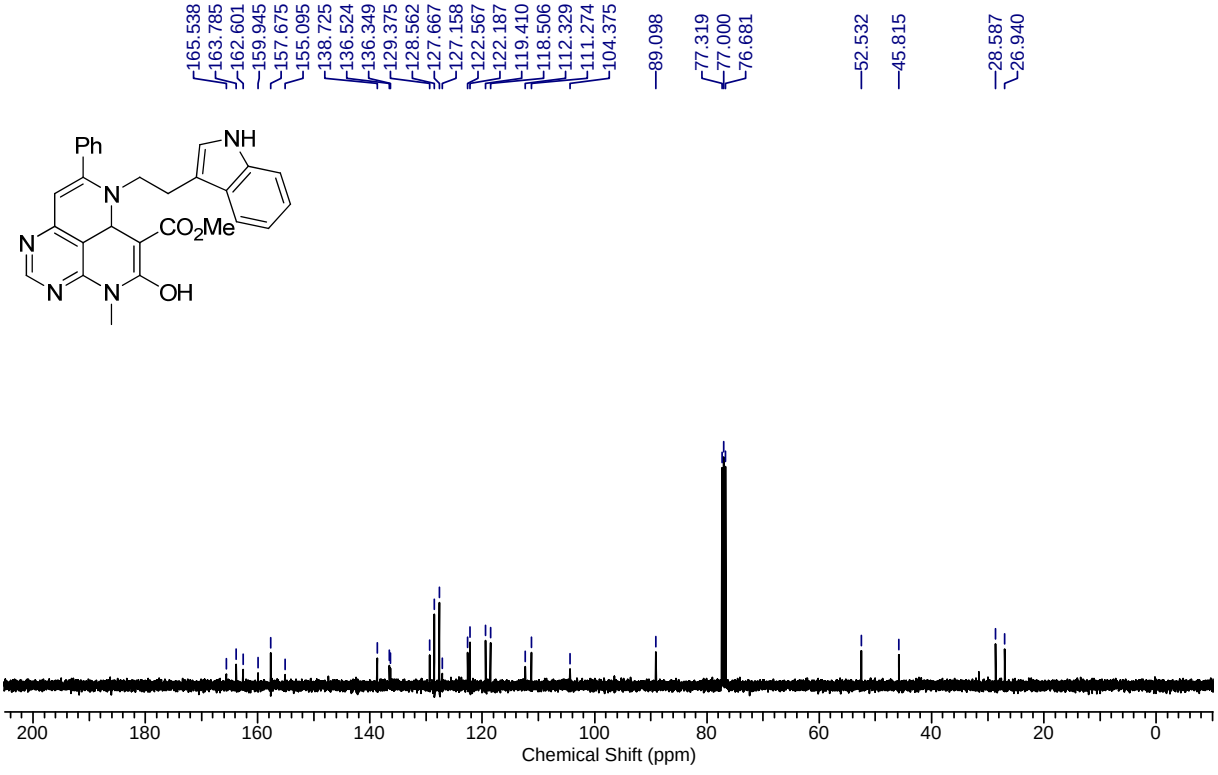
Compound 4d


10.959
8.585
8.548
7.464
7.460
7.446
7.438
7.435
7.310
7.306
7.293
7.287
7.264
6.806
6.786
6.705
6.700
6.685
6.681
6.607
6.602
5.482
3.952
3.906
3.876
3.856
3.844
3.826
3.817
3.810
3.774
3.760
3.719
3.702
3.520
3.508
3.489
3.473
2.803
2.786
2.770
2.172
1.255
0.000
Ph
O
O
N
CO2Me
N
N
N
OH
12
10
8
6
4
2
0
ppm
0.88
0.85
0.88
1.75
3.04
1.05
1.93
0.93
1.97

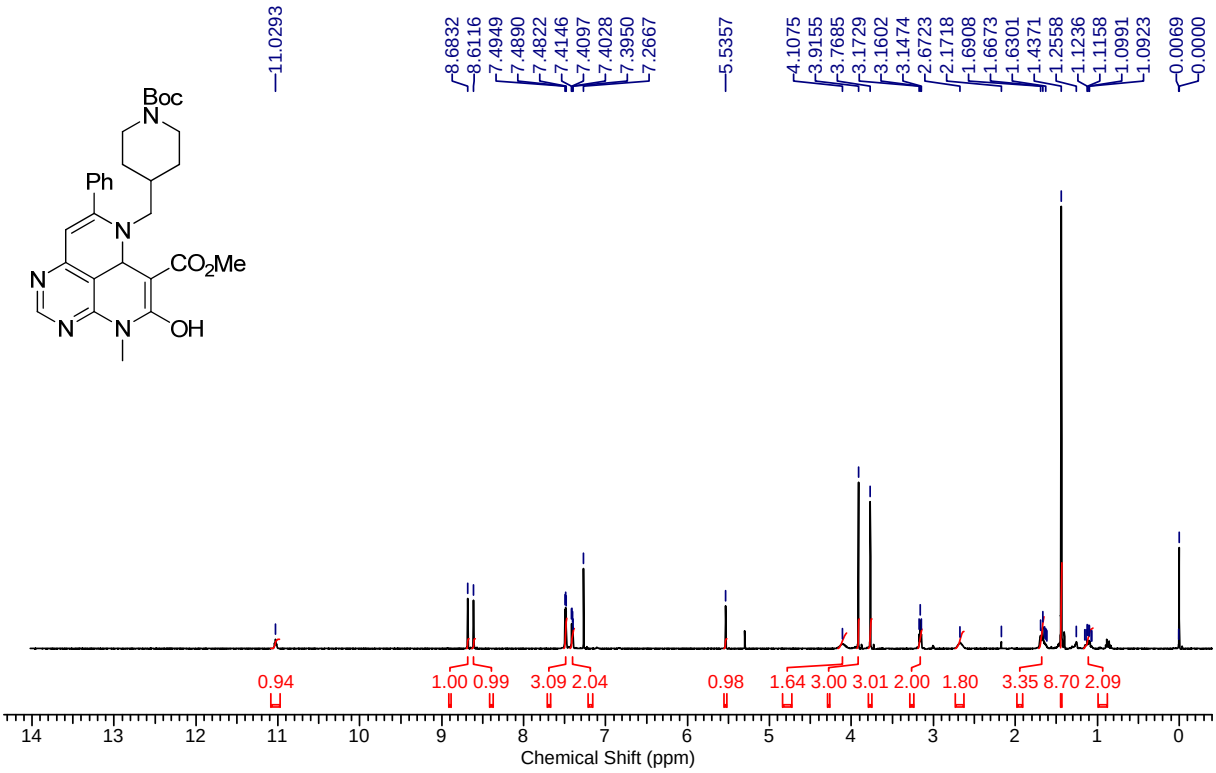

165.500
163.686
162.669
159.861
157.698
155.125
148.978
147.878
138.611
136.440
130.748
129.382
128.509
127.682
120.996
119.630
112.033
111.198
104.421
89.173
77.311
77.000
76.681
55.970
55.742
52.532
46.931
37.004
28.602
Ph
O
O
N
CO2Me
N
N
N
OH
200
180
160
140
120
100
80
60
40
20
0
Chemical Shift (ppm)

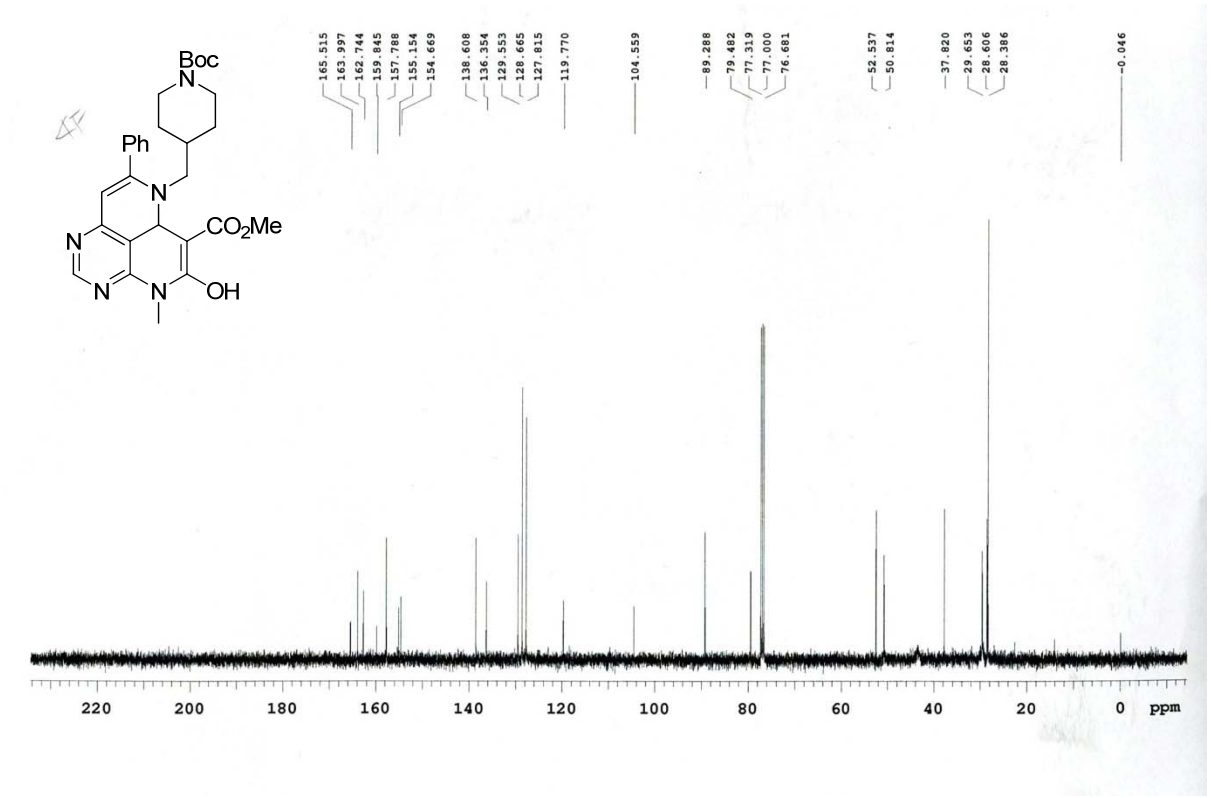
Compound 4e


10.9960
8.5783
8.3736
7.4508
7.4440
7.4283
7.4018
7.3852
7.3323
7.3186
7.2608
7.0531
5.4750
5.2996
3.9037
3.7479
3.6069
3.5932
3.5804
3.5667
3.0250
3.0113
2.9976
2.1718
Ph
NH
N
CO2Me
N
N
N
OH
0.93
1.02
0.93
0.83
5.28
2.04
1.16
2.09
1.02
3.02
3.14
2.04
2.16
Chemical Shift (ppm)

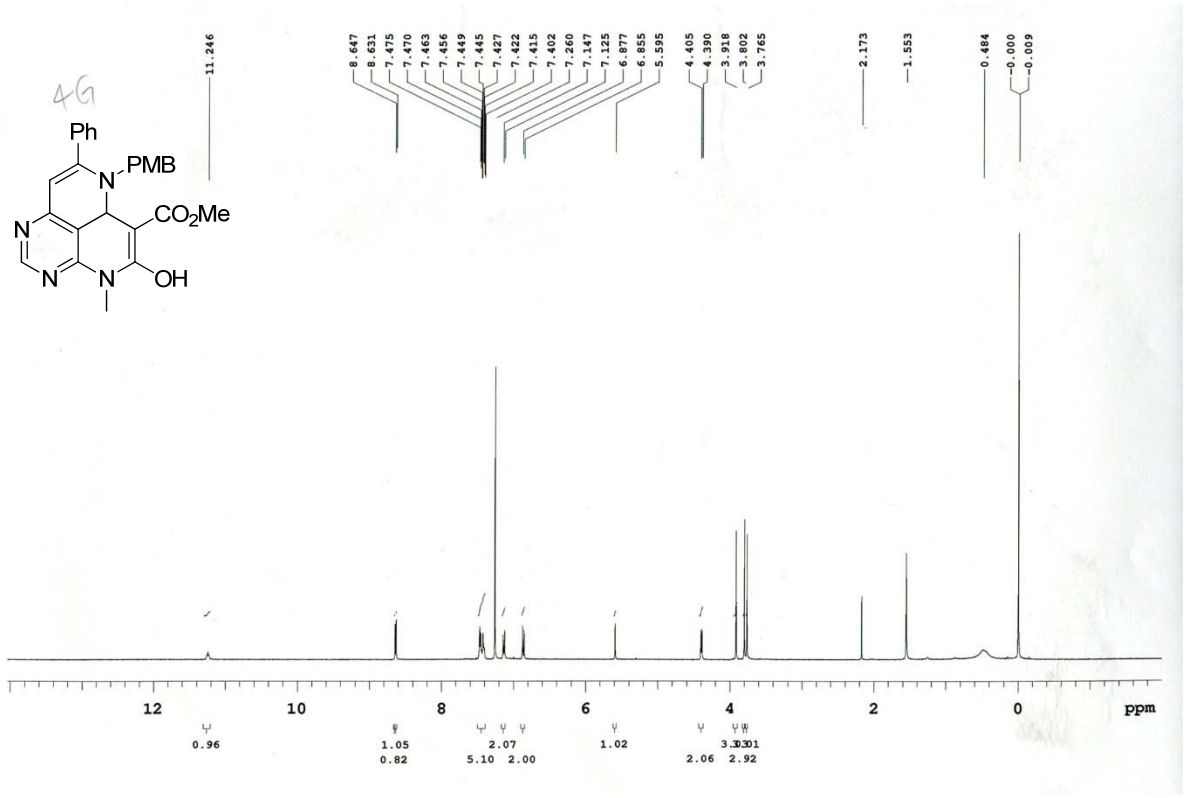

165.538
163.785
162.601
159.945
157.675
155.095
138.725
136.524
136.349
129.375
128.562
127.667
127.158
122.567
122.187
119.410
118.506
112.329
111.274
104.375
89.098
77.319
77.000
76.681
52.532
45.815
28.587
26.940
Ph
NH
N
CO2Me
N
N
N
OH
Chemical Shift (ppm)

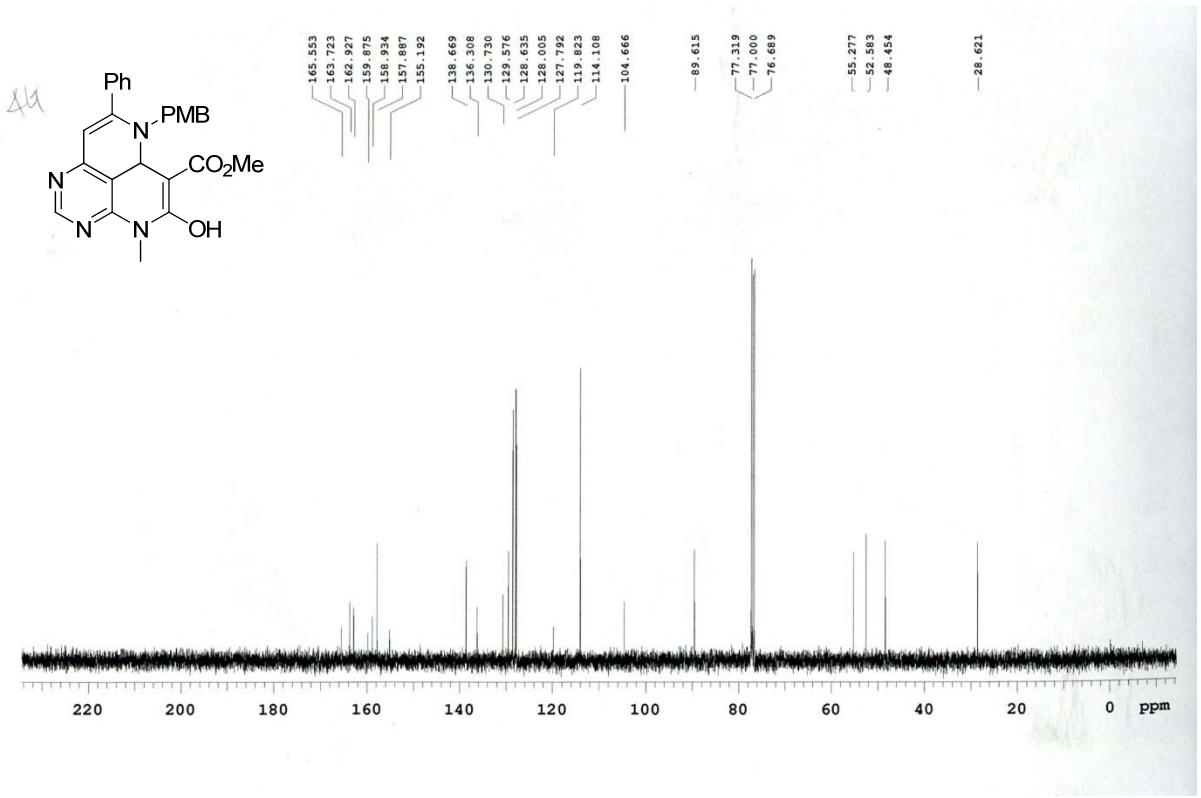
Compound 4f


11.0293
8.6832
8.6116
7.4949
7.4890
7.4822
7.4146
7.4097
7.4028
7.3950
7.2667
5.5357
4.1075
3.9155
3.7685
3.1729
3.1602
3.1474
2.6723
2.1718
1.6908
1.6673
1.6301
1.4371
1.2558
1.1236
1.1158
1.0991
1.0923
0.0069
0.0000
Boc
N
Ph
N
CO2Me
N
N
N
OH
0.94
1.00
0.99
3.09
2.04
0.98
1.64
3.00
3.01
2.00
1.80
3.35
8.70
2.09
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Chemical Shift (ppm)

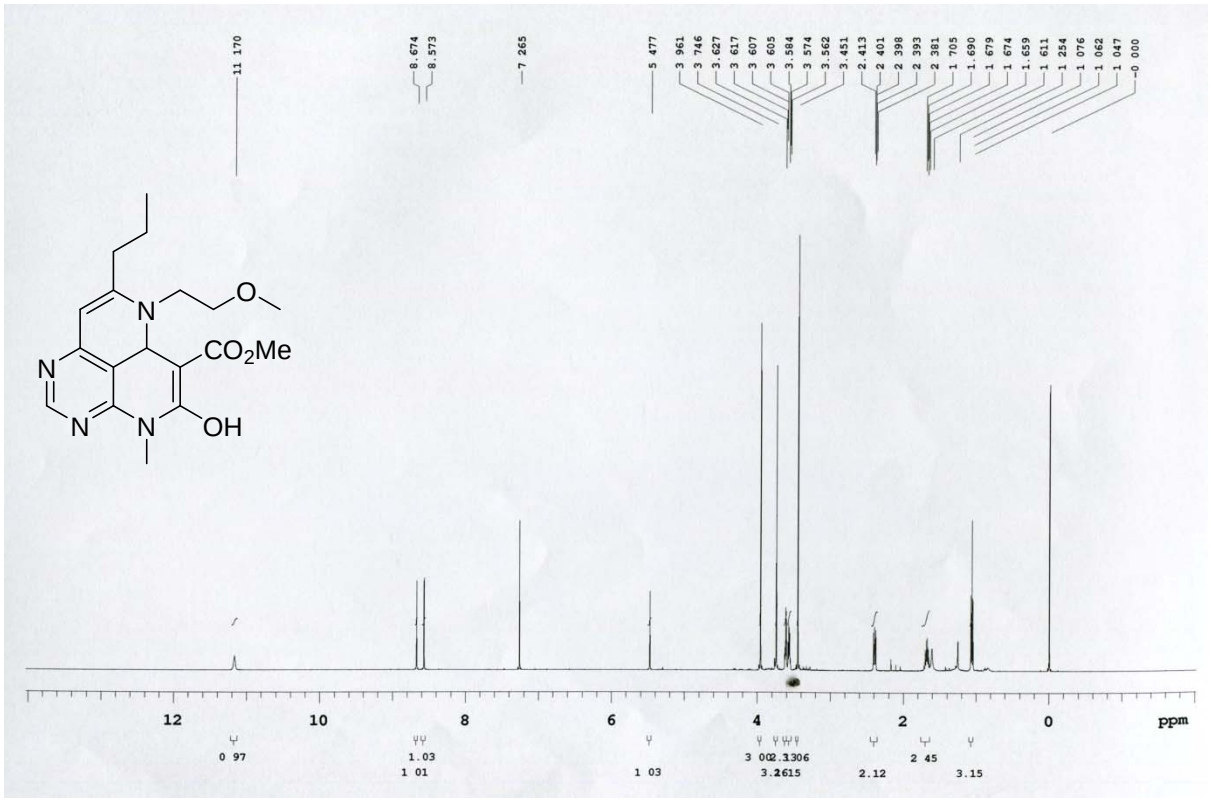

165.515
163.997
162.744
159.845
157.788
155.154
154.669
138.608
136.354
129.553
128.665
127.815
119.770
104.559
89.288
79.482
77.319
77.000
76.681
52.537
50.814
37.820
29.653
28.606
28.386
0.046
Boc
N
Ph
N
CO2Me
N
N
N
OH
220
200
180
160
140
120
100
80
60
40
20
0
ppm

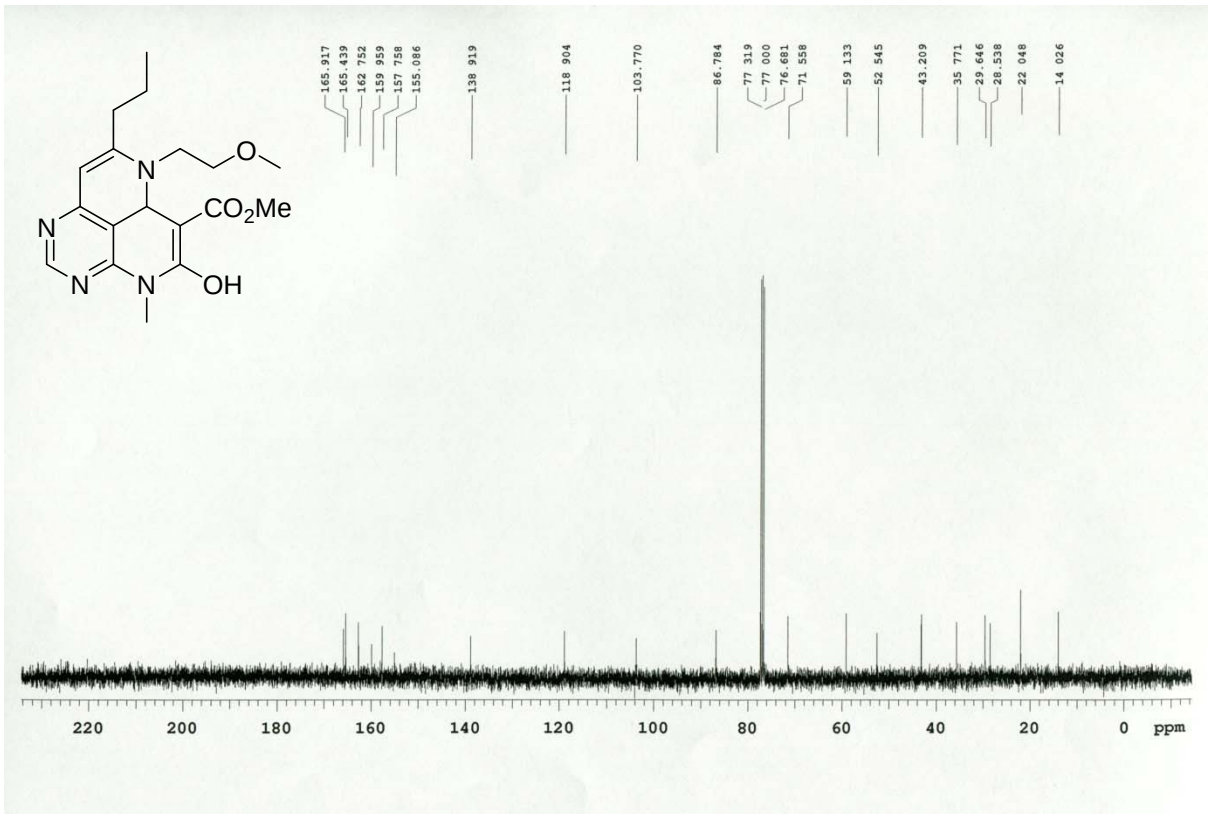
Compound 4g


Ph
PMB
N
CO2Me
OH
11.246
8.647
8.631
7.475
7.470
7.463
7.456
7.449
7.445
7.427
7.422
7.415
7.402
7.260
7.147
7.125
6.877
6.855
5.595
4.405
4.390
3.918
3.802
3.765
2.173
1.553
0.484
0.000
0.009
12
10
8
6
4
2
0
ppm
0.96
1.05
0.82
2.07
5.10
2.00
1.02
2.06
2.92

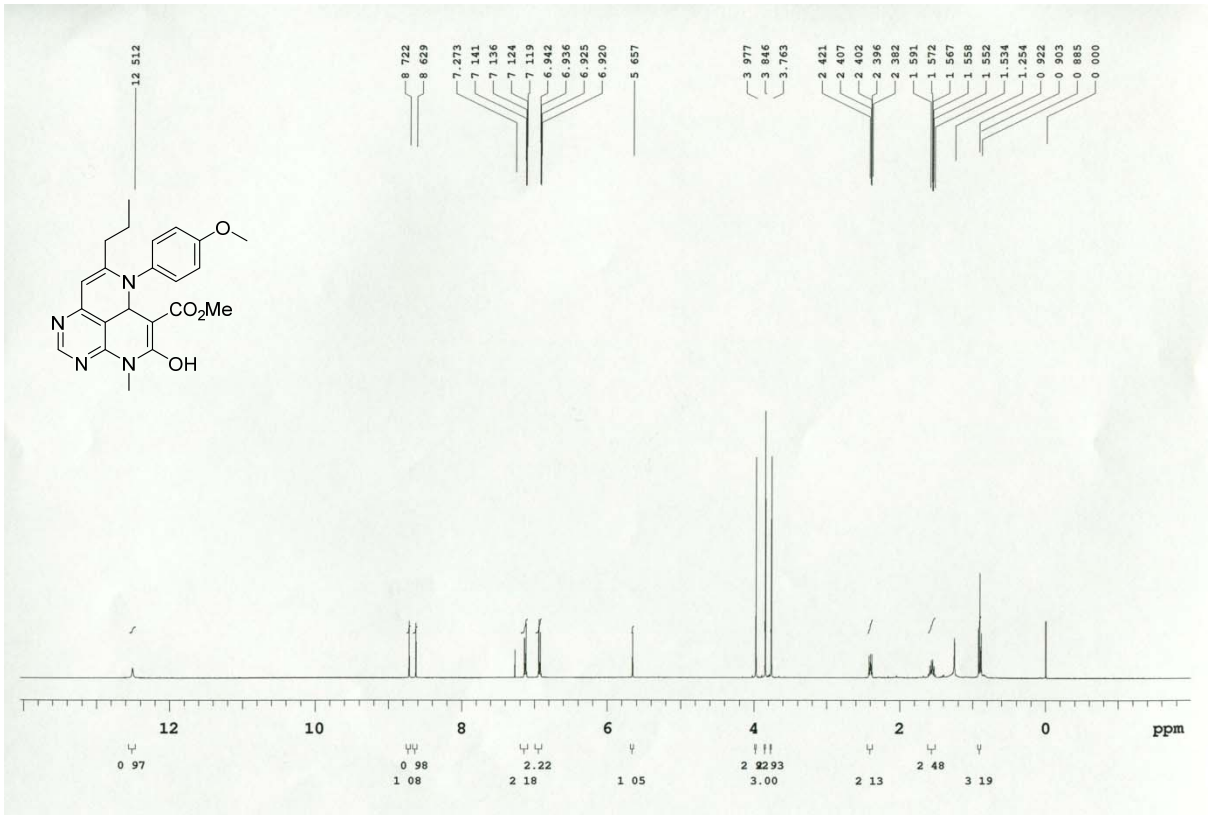

Ph
PMB
N
CO2Me
OH
165.553
163.723
162.927
159.875
158.934
157.887
155.192
138.669
136.308
130.730
129.576
128.635
128.005
127.792
119.823
114.108
104.666
89.615
77.319
77.000
76.689
55.277
52.583
48.454
28.621
220
200
180
160
140
120
100
80
60
40
20
0
ppm

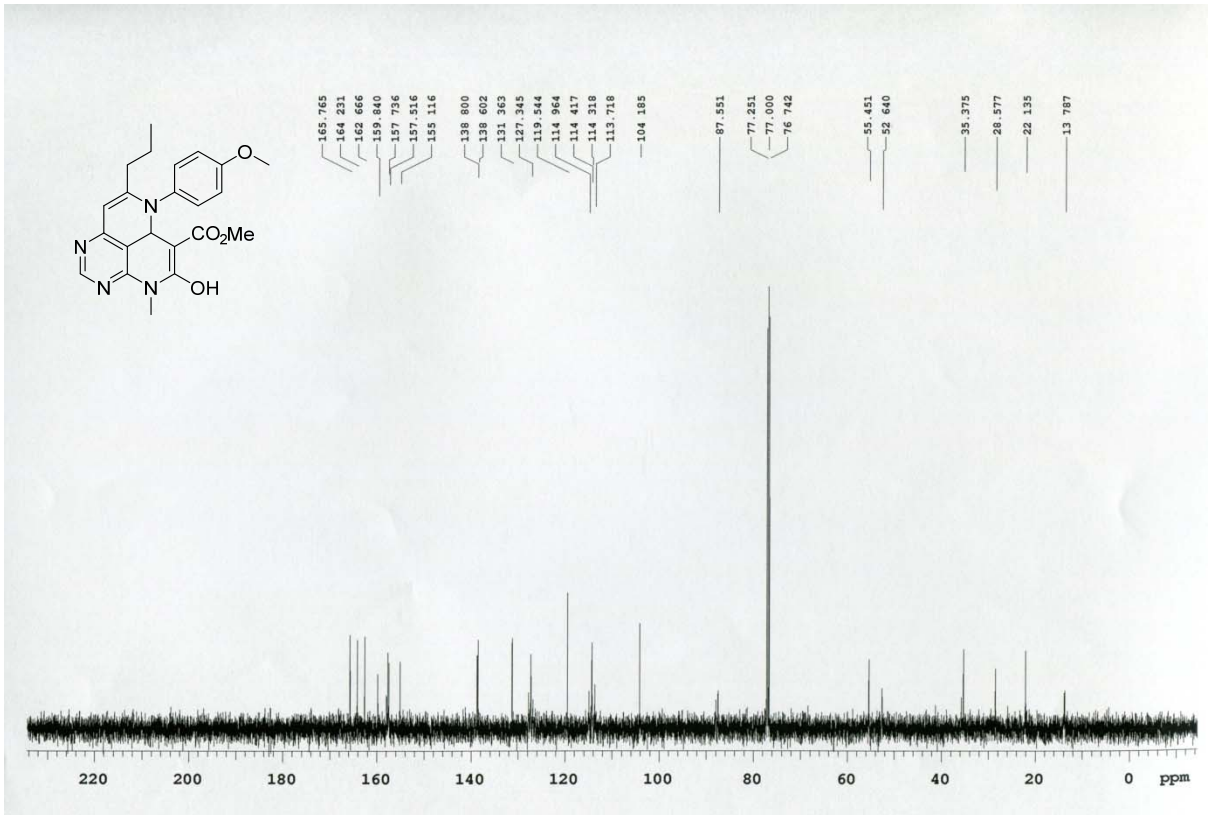
Compound 5a


11.170
8.674
8.573
7.265
5.477
3.961
3.746
3.627
3.617
3.607
3.605
3.584
3.574
3.562
3.451
2.413
2.401
2.398
2.393
2.381
1.705
1.690
1.679
1.674
1.659
1.611
1.254
1.076
1.062
1.047
0.000
N
O
CO2Me
N
N
N
OH
12
10
8
6
4
2
0
ppm
0.97
1.03
1.01
1.03
3.00
2.13
06
3.26
15
2.12
2.45
3.15

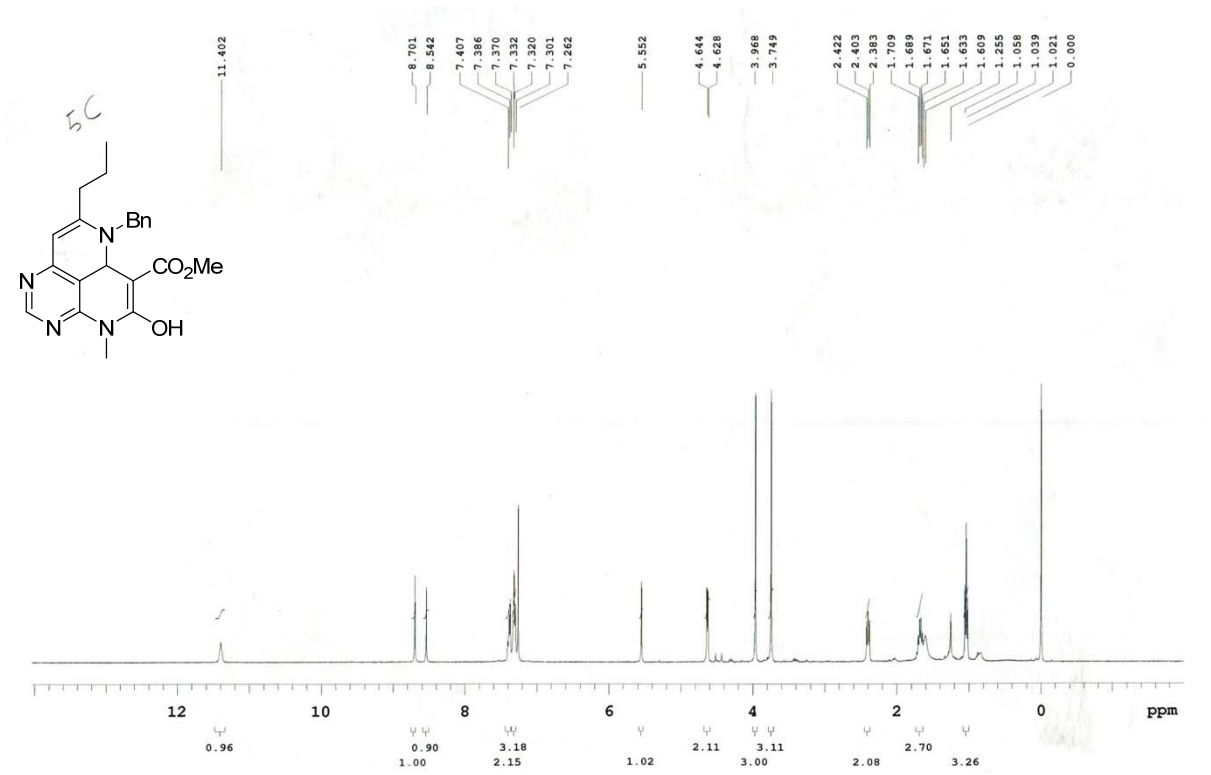

165.917
165.439
162.752
159.959
157.758
155.086
138.919
118.904
103.770
86.784
77.319
77.000
76.681
71.558
59.133
52.545
43.209
35.771
29.646
28.538
22.048
14.026
N
O
CO2Me
N
N
N
OH
220
200
180
160
140
120
100
80
60
40
20
0
ppm

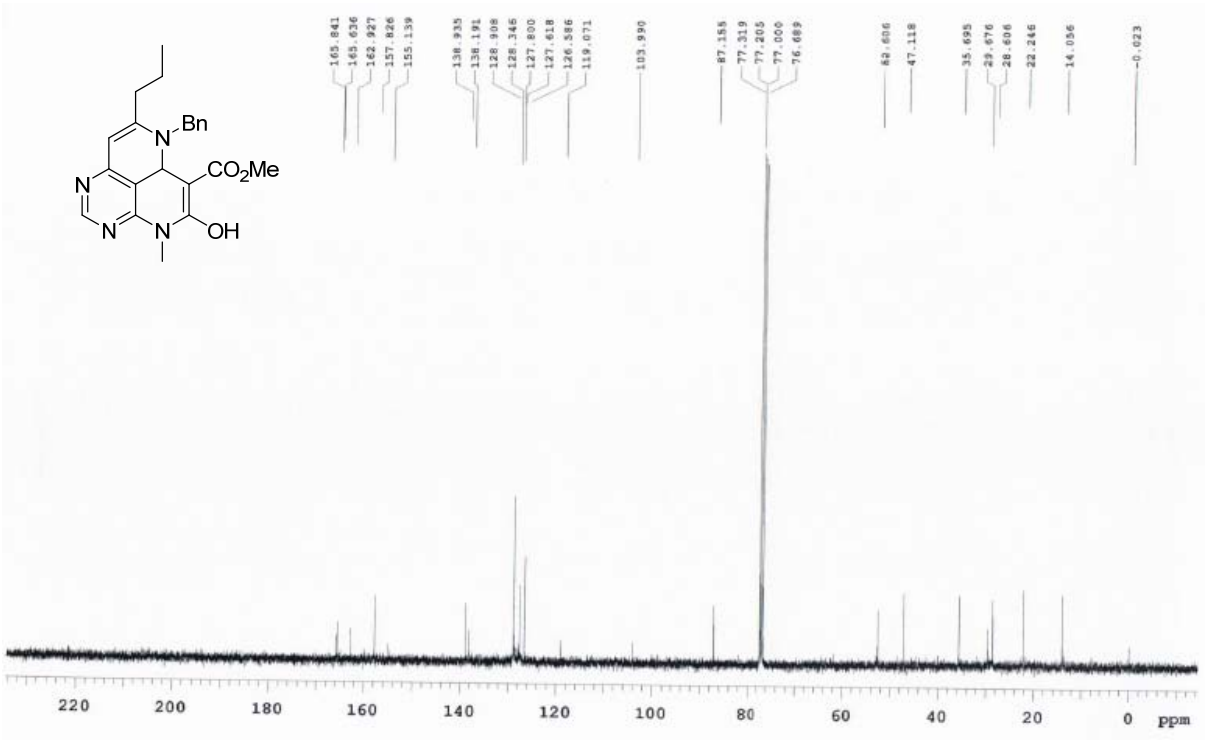
Compound 5b


12.512
8.722
8.629
7.273
7.141
7.136
7.124
7.119
6.942
6.936
6.925
6.920
5.657
3.977
3.846
3.763
2.421
2.407
2.402
2.396
2.382
1.591
1.572
1.567
1.558
1.552
1.534
1.254
0.922
0.903
0.885
0.000
O
N
CO2Me
N
N
N
OH
12
10
8
6
4
2
0
ppm
0.97
0.98
1.08
2.22
2.18
1.05
2.93
3.00
2.13
2.48
3.19

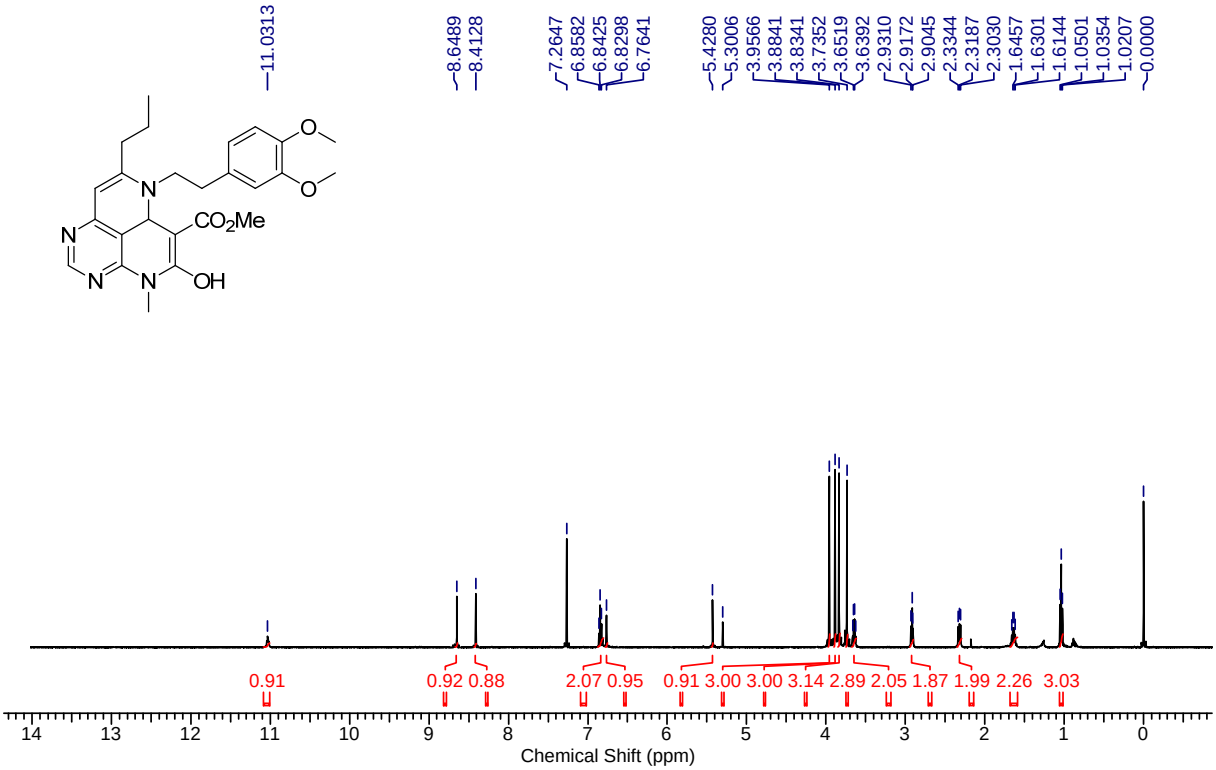

165.765
164.231
162.666
159.840
157.736
157.516
155.116
138.800
138.602
131.363
127.345
119.544
114.964
114.417
114.318
113.718
104.185
87.551
77.251
77.000
76.742
55.451
52.640
35.375
28.577
22.135
13.787
O
N
CO2Me
N
N
N
OH
220
200
180
160
140
120
100
80
60
40
20
0
ppm

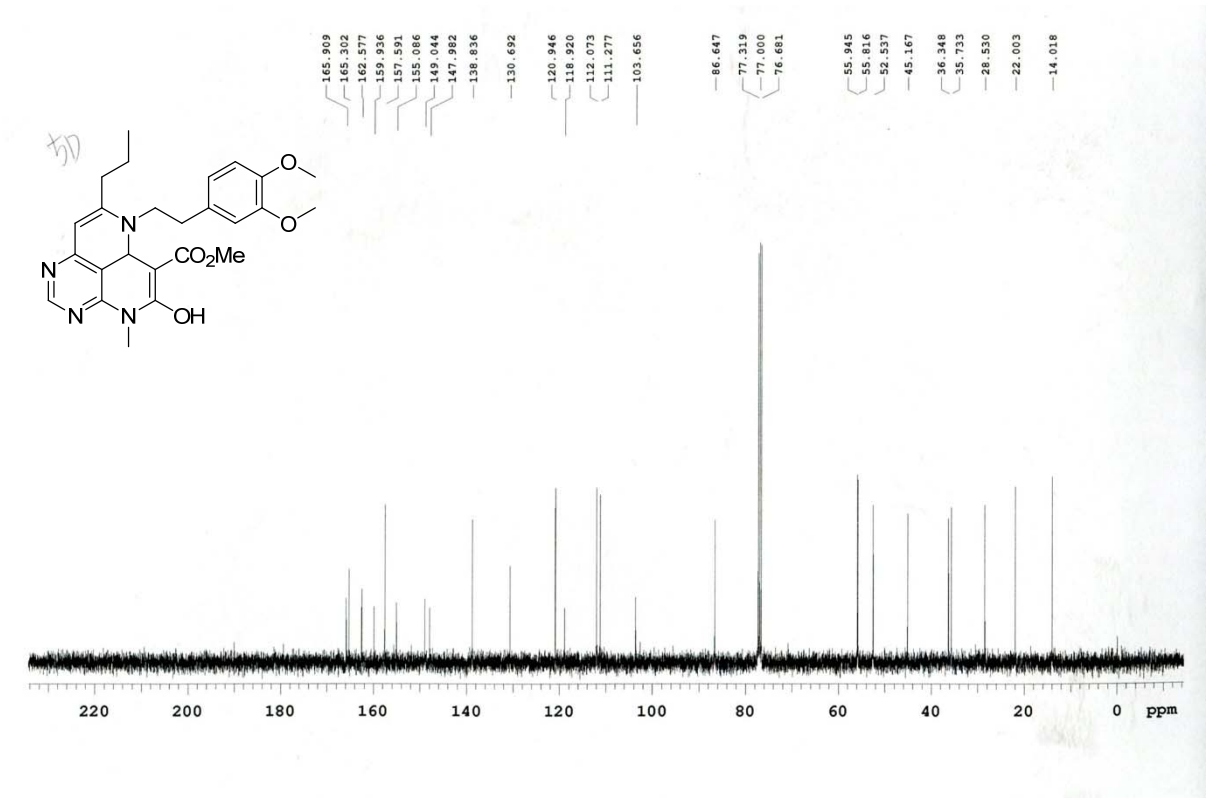
Compound 5c


5C
Bn
CO2Me
OH
11.402
8.701
8.542
7.407
7.386
7.370
7.332
7.320
7.301
7.262
5.552
4.644
4.628
3.968
3.749
2.422
2.403
2.383
1.709
1.689
1.671
1.651
1.633
1.609
1.255
1.058
1.039
1.021
0.000
12
10
8
6
4
2
0
ppm
0.96
0.90
1.00
3.18
2.15
1.02
2.11
3.11
3.00
2.08
2.70
3.26

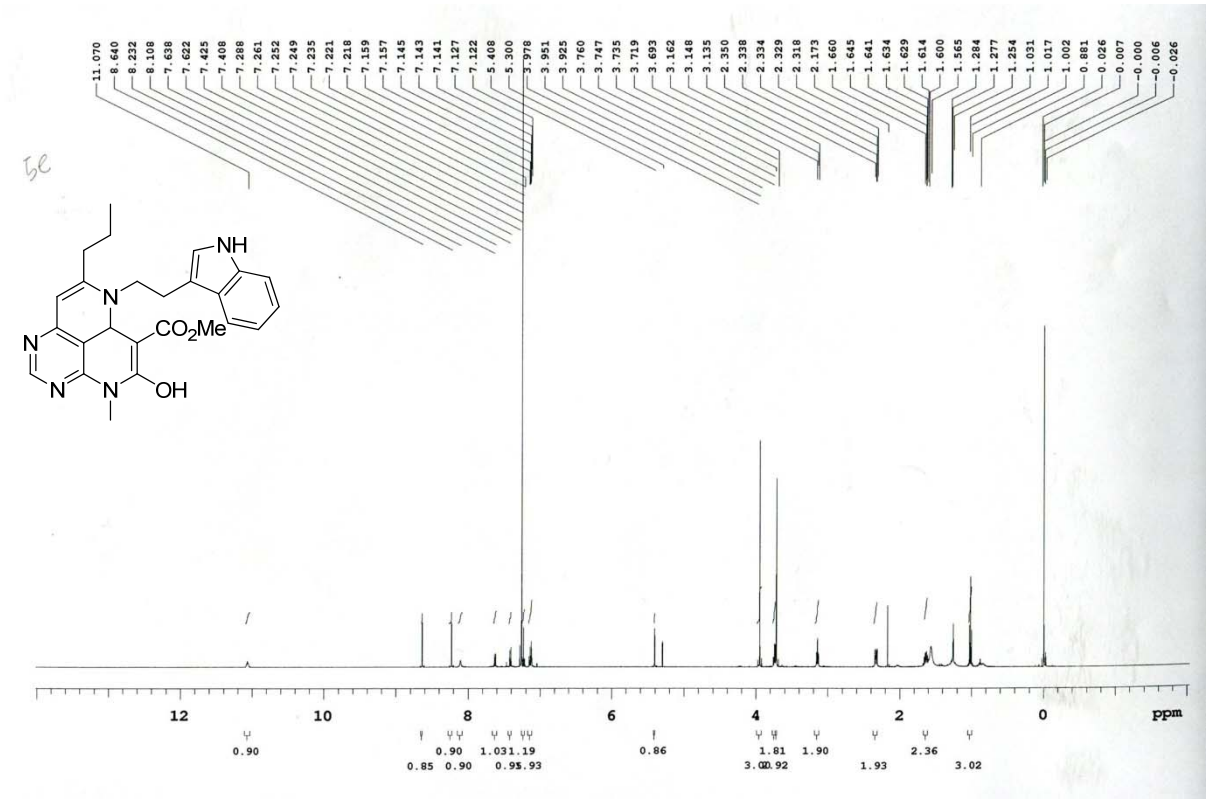

Bn
CO2Me
OH
165.841
163.636
162.927
157.826
155.139
138.935
138.191
128.908
128.346
127.800
127.618
126.586
119.071
103.990
87.155
77.319
77.205
77.000
76.689
62.606
47.118
35.695
29.676
28.606
22.246
14.056
-0.623
220
200
180
160
140
120
100
80
60
40
20
0
ppm

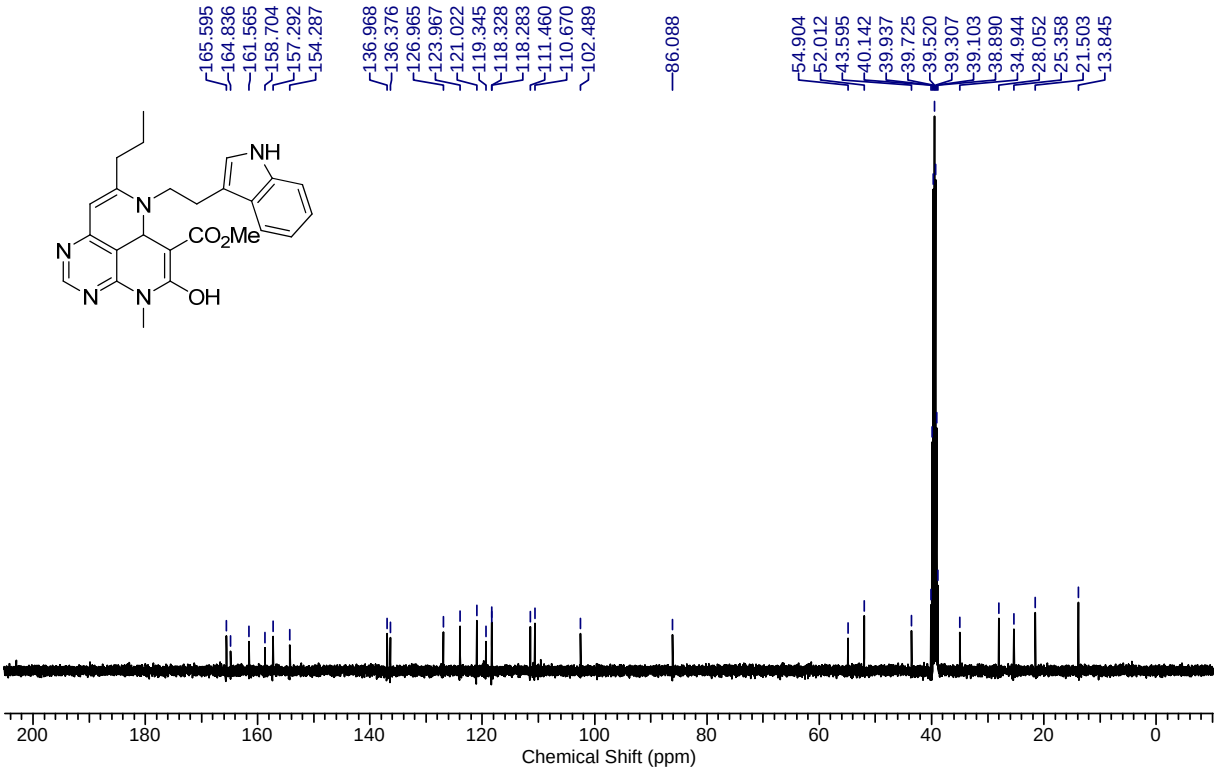
Compound 5d


11.0313
8.6489
8.4128
7.2647
6.8582
6.8425
6.8298
6.7641
5.4280
5.3006
3.9566
3.8841
3.8341
3.7352
3.6519
3.6392
2.9310
2.9172
2.9045
2.3344
2.3187
2.3030
1.6457
1.6301
1.6144
1.0501
1.0354
1.0207
0.0000
CO2Me
OH
0.91
0.92 0.88
2.07 0.95
0.91 3.00 3.00 3.14 2.89 2.05 1.87 1.99 2.26 3.03
Chemical Shift (ppm)

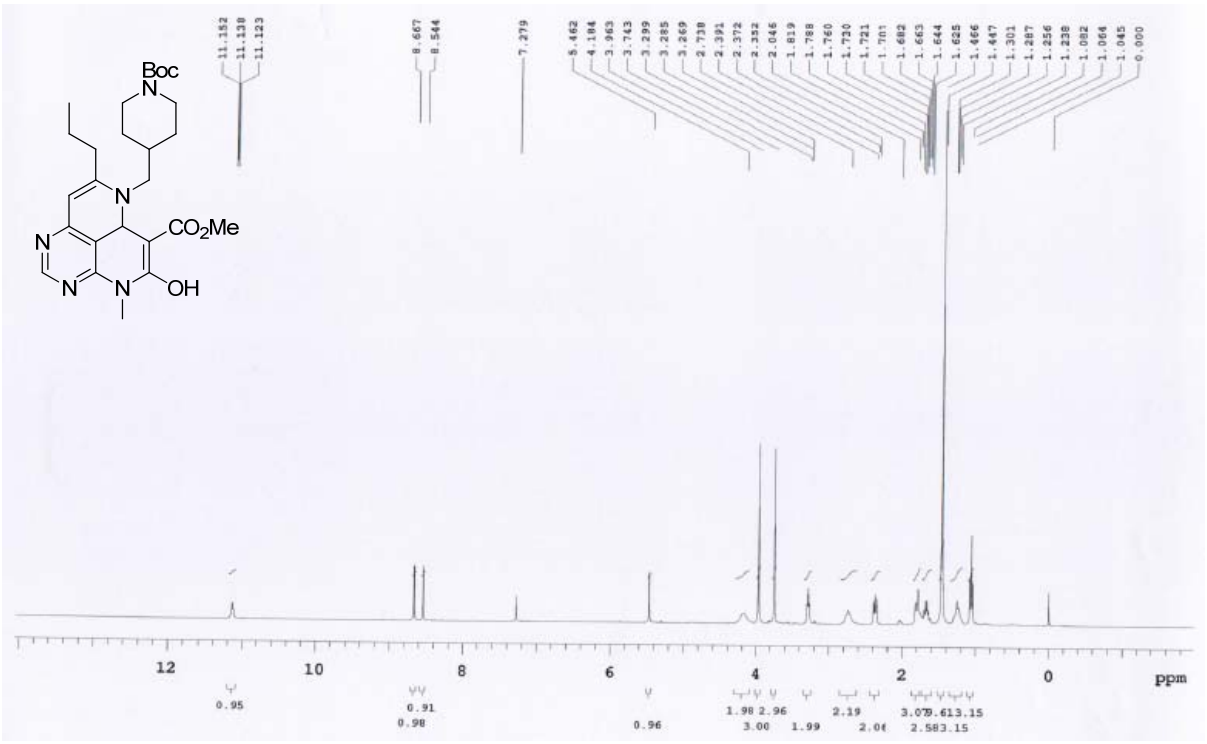

165.909
165.302
162.577
159.936
157.591
155.086
149.044
147.982
138.836
130.692
120.946
118.920
112.073
111.277
103.656
86.647
77.319
77.000
76.681
55.945
55.616
52.537
45.167
36.348
35.733
28.530
22.003
14.018
CO2Me
OH
ppm

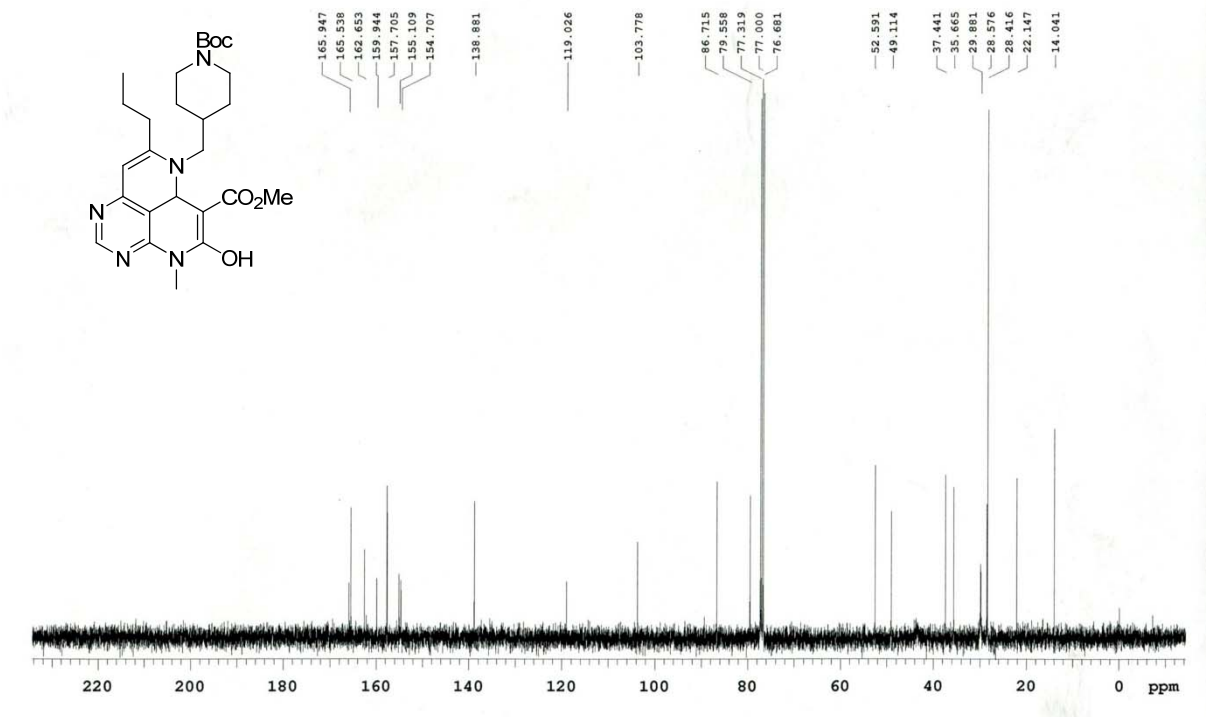
Compound 5e


11.070
8.640
8.232
8.108
7.638
7.622
7.425
7.408
7.288
7.261
7.252
7.249
7.235
7.221
7.218
7.159
7.157
7.145
7.143
7.141
7.127
7.122
5.408
5.300
3.978
3.951
3.925
3.760
3.747
3.735
3.719
3.693
3.162
3.148
3.135
2.350
2.338
2.334
2.329
2.318
2.173
1.660
1.645
1.641
1.634
1.629
1.614
1.600
1.565
1.284
1.277
1.254
1.031
1.017
1.002
0.881
0.026
0.007
0.000
-0.000
-0.006
-0.026
NH
N
CO2Me
N
N
N
OH
12
10
8
6
4
2
0
ppm
0.90
0.85
0.90
0.90
1.03
0.95
1.19
1.93
0.86
1.81
1.90
1.92
1.93
2.36
3.02

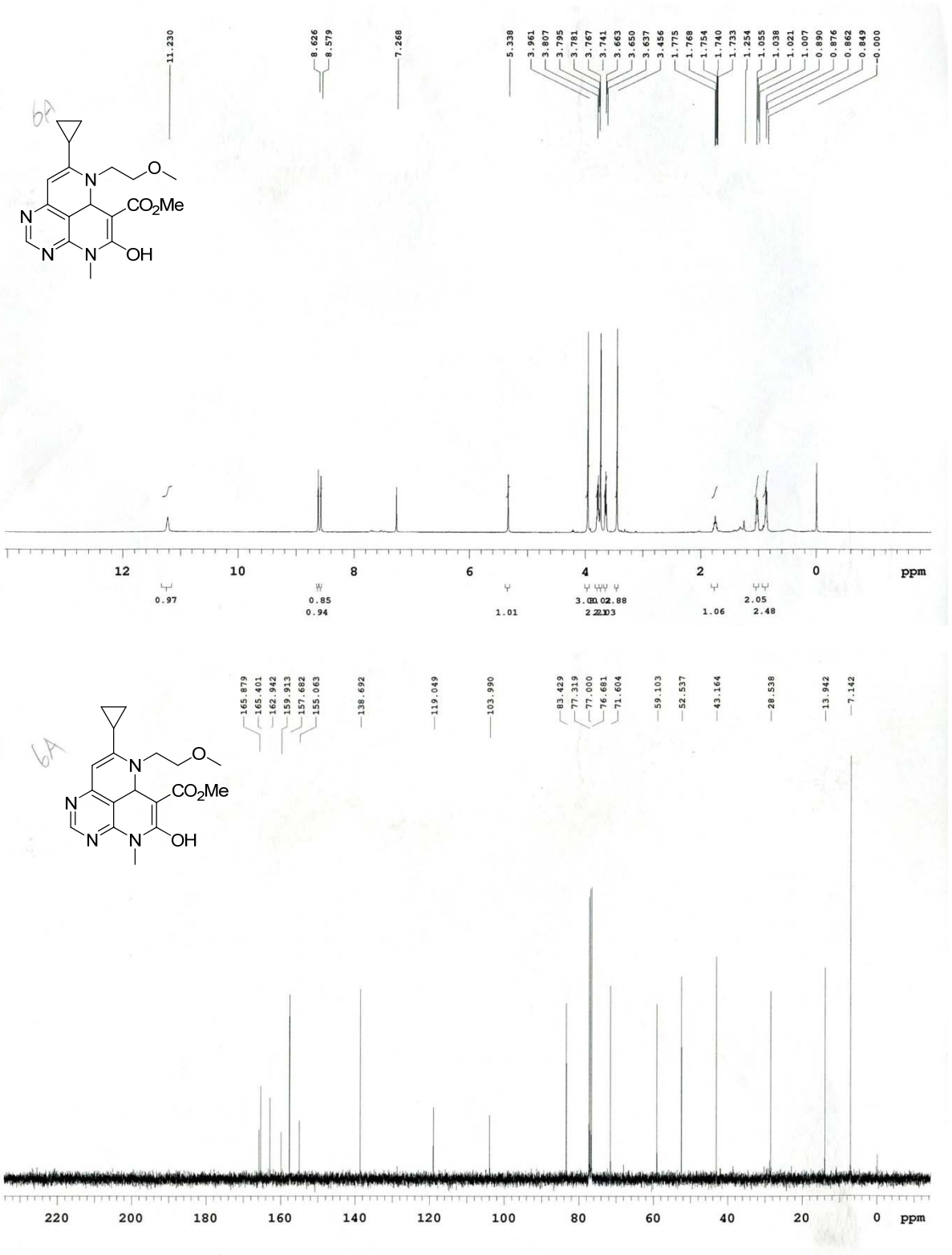

165.595
164.836
161.565
158.704
157.292
154.287
136.968
136.376
126.965
123.967
121.022
119.345
118.328
118.283
111.460
110.670
102.489
86.088
54.904
52.012
43.595
40.142
39.937
39.725
39.520
39.307
39.103
38.890
34.944
28.052
25.358
21.503
13.845
NH
N
CO2Me
N
N
N
OH
200
180
160
140
120
100
80
60
40
20
0
Chemical Shift (ppm)

Compound 5f

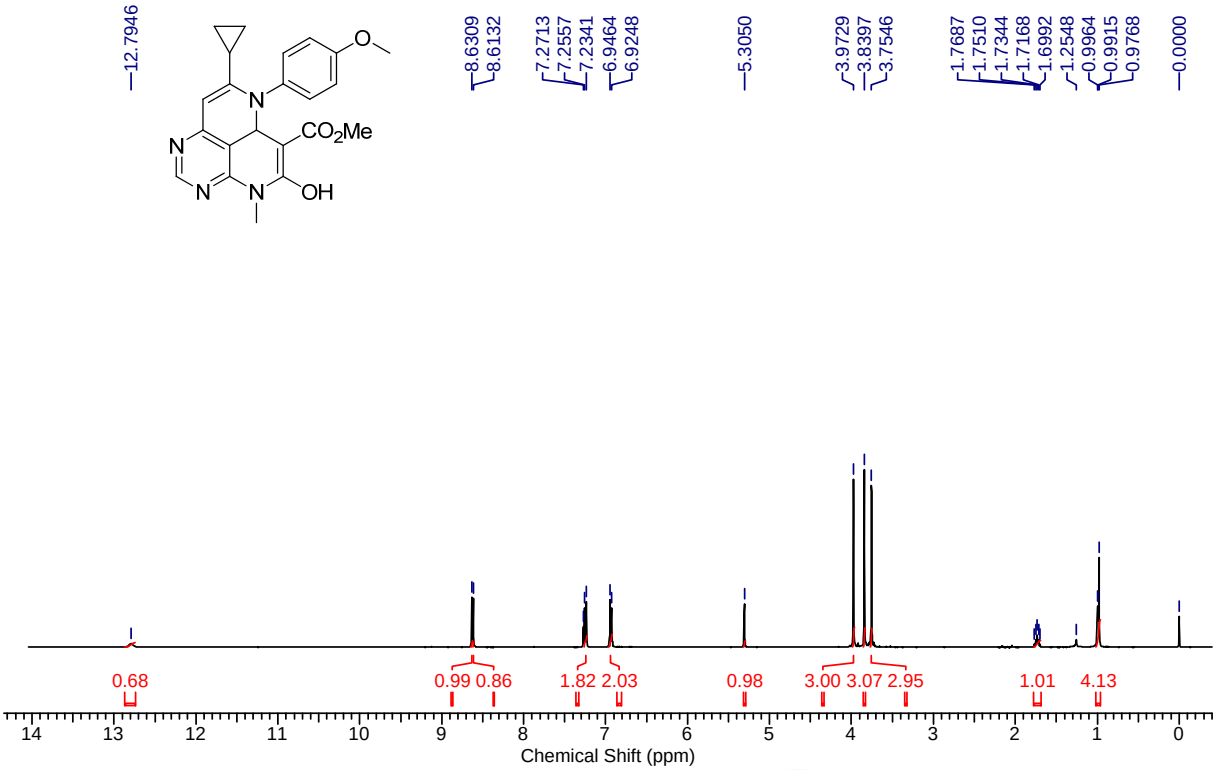

Boc
N
N
CO2Me
N
N
N
OH
11.152
11.138
11.123
8.667
8.544
7.279
5.462
4.184
3.963
3.743
3.299
3.285
3.269
2.738
2.391
2.372
2.352
2.046
1.819
1.788
1.760
1.730
1.721
1.682
1.663
1.644
1.625
1.466
1.447
1.301
1.287
1.256
1.238
1.082
1.064
1.045
0.000
12
10
8
6
4
2
0
ppm
0.95
0.91
0.98
0.96
1.98
2.96
3.00
1.99
2.19
2.04
3.07
9.613.15
2.583.15

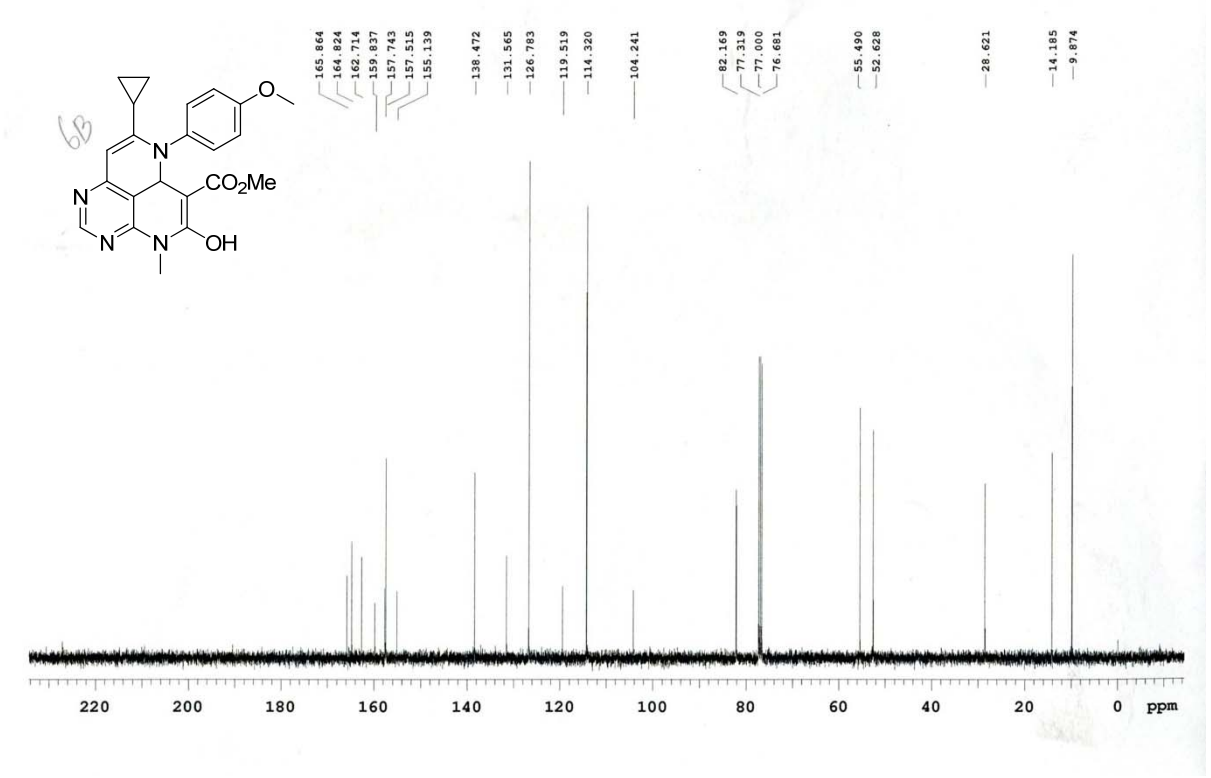

Boc
N
N
CO2Me
N
N
N
OH
165.947
165.538
162.653
159.944
157.705
155.109
154.707
138.881
119.026
103.778
86.715
79.558
77.319
77.000
76.681
52.591
49.114
37.441
35.665
29.881
28.576
28.416
22.147
14.041
220
200
180
160
140
120
100
80
60
40
20
0
ppm

Compound 6a

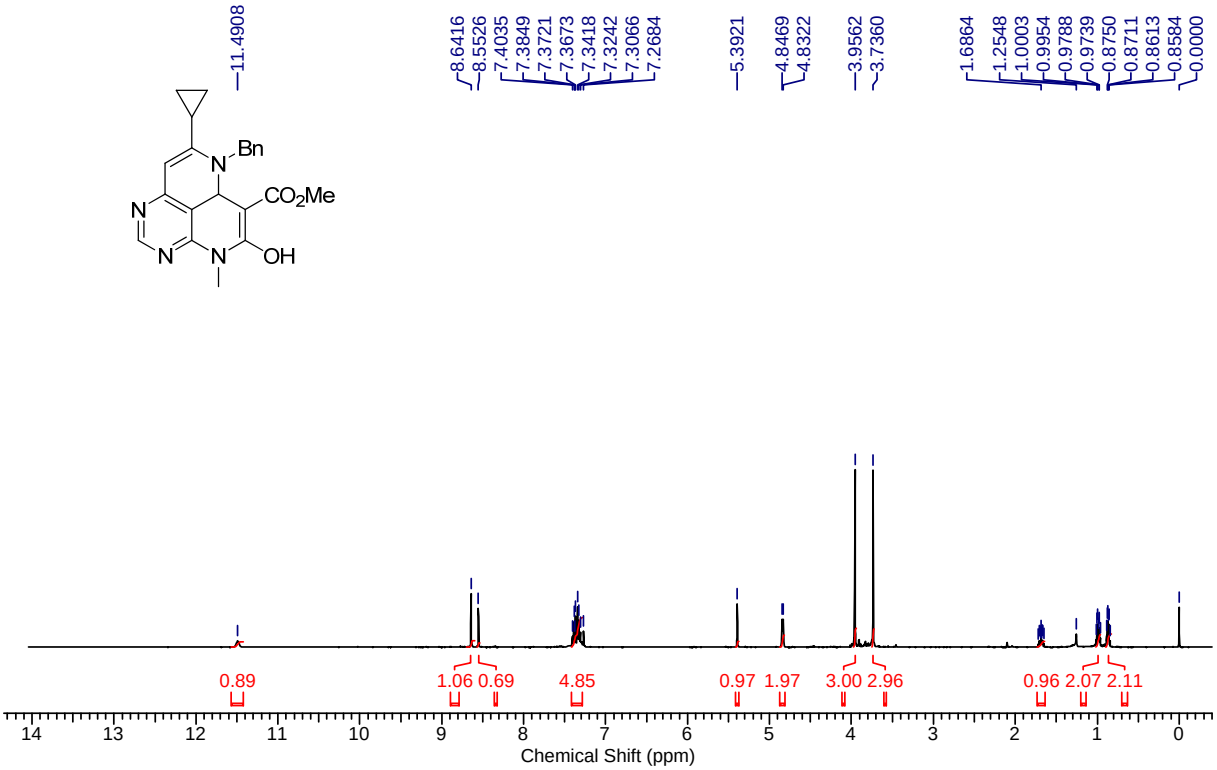

6A
11.230
8.626
8.579
7.268
5.338
3.961
3.807
3.795
3.781
3.767
3.741
3.663
3.650
3.637
3.456
1.775
1.768
1.754
1.740
1.733
1.254
1.055
1.038
1.021
1.007
0.890
0.876
0.862
0.849
0.000
N
O
CO2Me
OH
12
10
8
6
4
2
0
ppm
0.97
0.85
0.94
1.01
3.00
2.88
1.06
2.05
2.48
6A
165.879
165.401
162.942
159.913
157.682
155.063
138.692
119.049
103.990
83.429
77.319
77.000
76.681
71.604
59.103
52.537
43.164
28.538
13.942
7.142
220
200
180
160
140
120
100
80
60
40
20
0
ppm

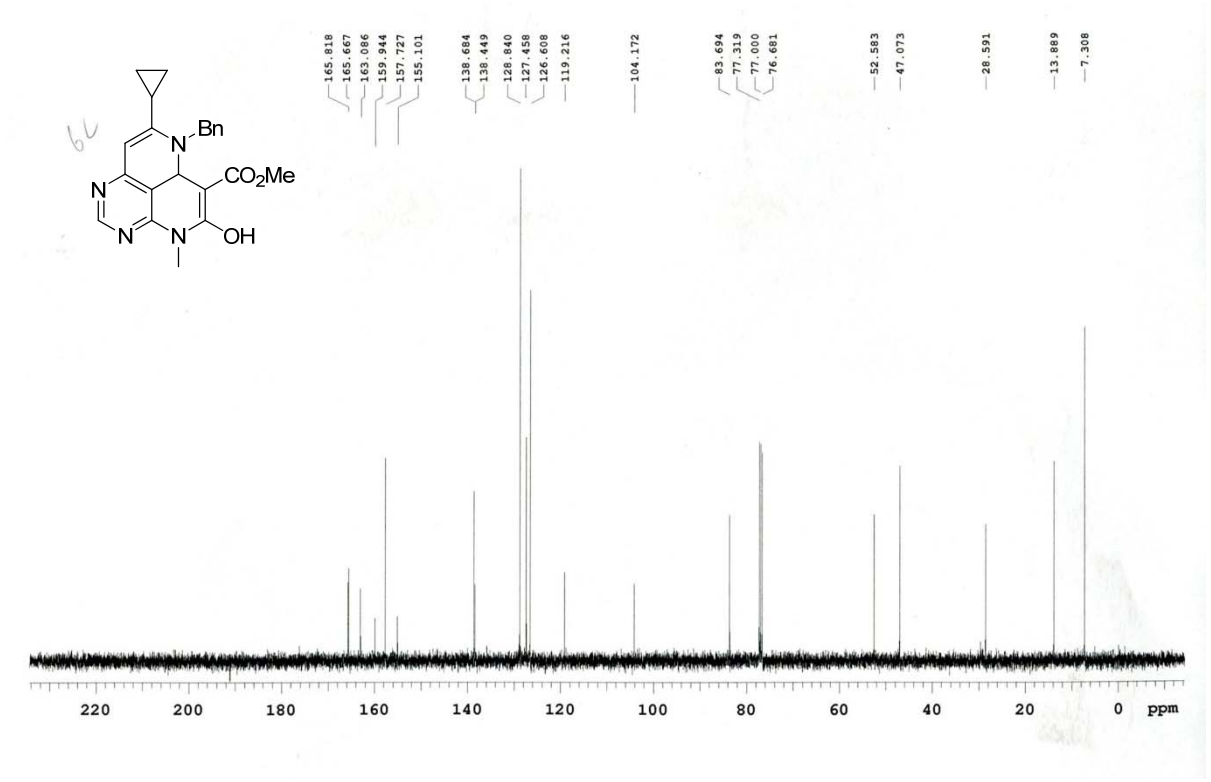
Compound 6b


12.7946
8.6309
8.6132
7.2713
7.2557
7.2341
6.9464
6.9248
5.3050
3.9729
3.8397
3.7546
1.7687
1.7510
1.7344
1.7168
1.6992
1.2548
0.9964
0.9915
0.9768
0.0000
CO2Me
OH
0.68
0.99 0.86
1.82 2.03
0.98
3.00 3.07 2.95
1.01
4.13
Chemical Shift (ppm)

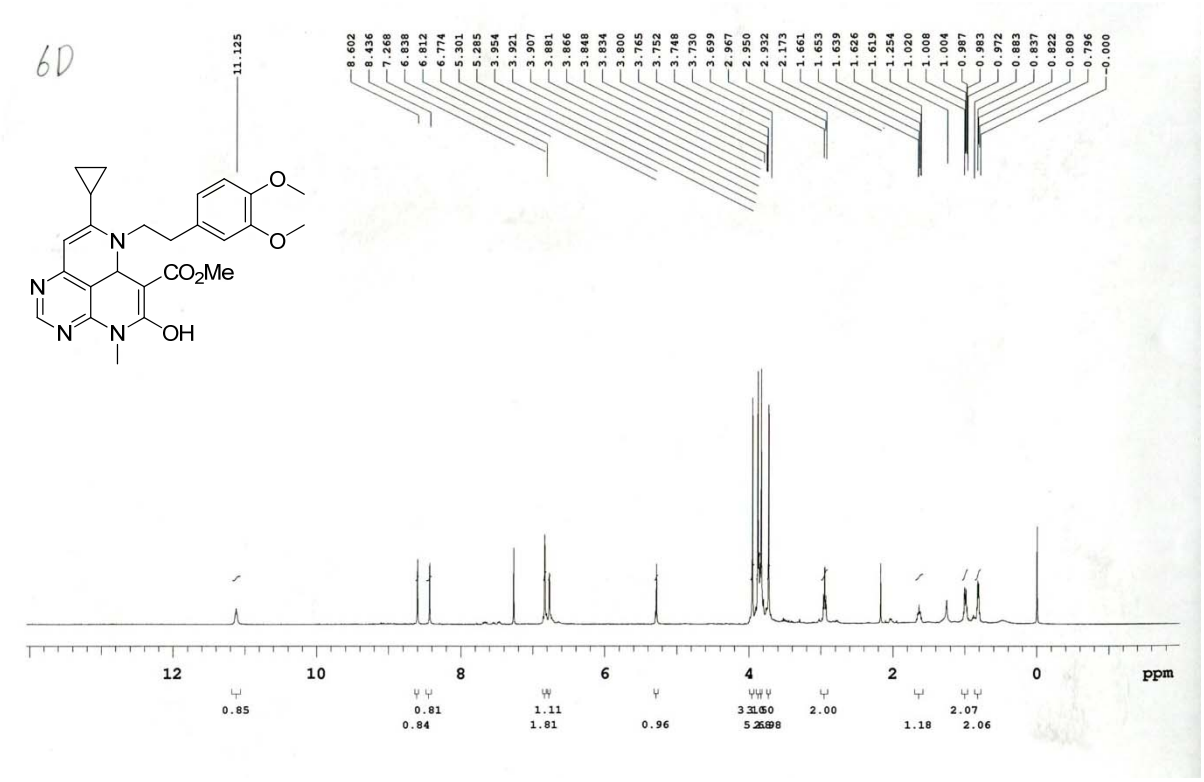

165.864
164.824
162.714
159.837
157.743
157.515
155.139
138.472
131.565
126.783
119.519
114.320
104.241
82.169
77.319
77.000
76.681
55.490
52.628
28.621
14.185
9.874
CO2Me
OH
ppm

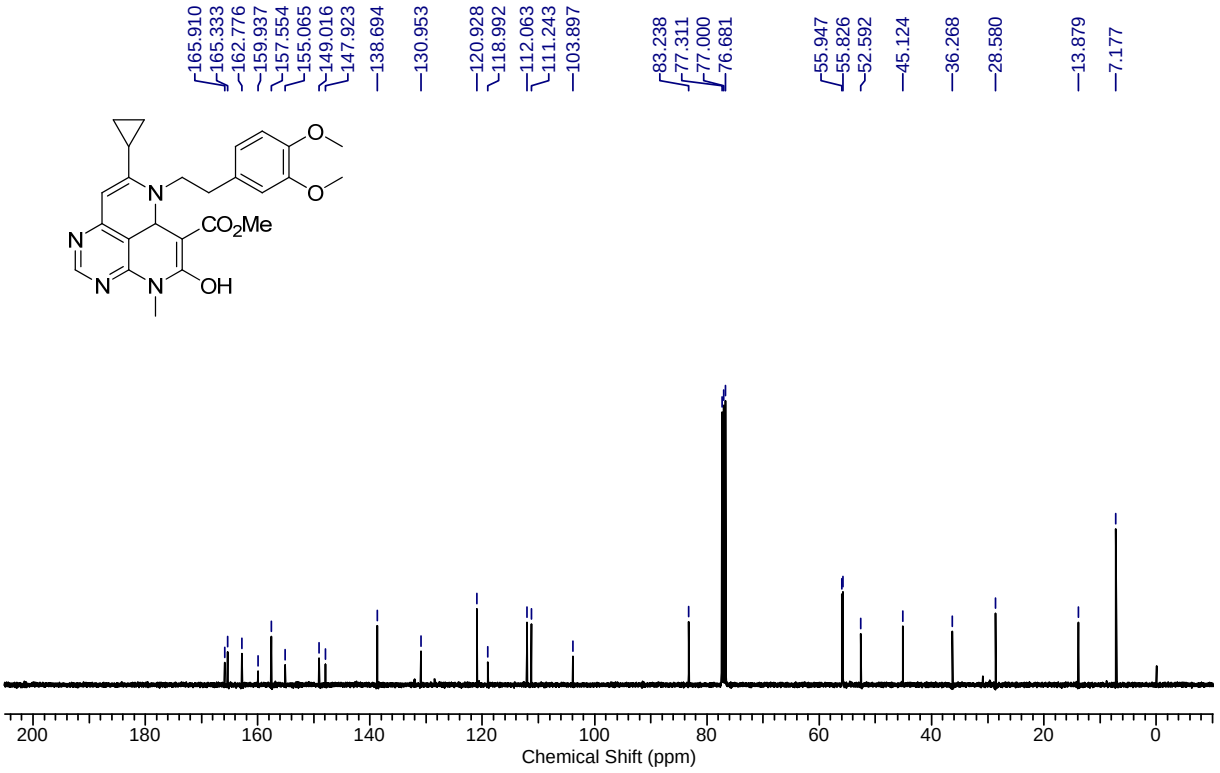
Compound 6c


11.4908
8.6416
8.5526
7.4035
7.3849
7.3721
7.3673
7.3418
7.3242
7.3066
7.2684
5.3921
4.8469
4.8322
3.9562
3.7360
1.6864
1.2548
1.0003
0.9954
0.9788
0.9739
0.8750
0.8711
0.8613
0.8584
0.0000
Bn
CO2Me
OH
0.89
1.06
0.69
4.85
0.97
1.97
3.00
2.96
0.96
2.07
2.11
Chemical Shift (ppm)

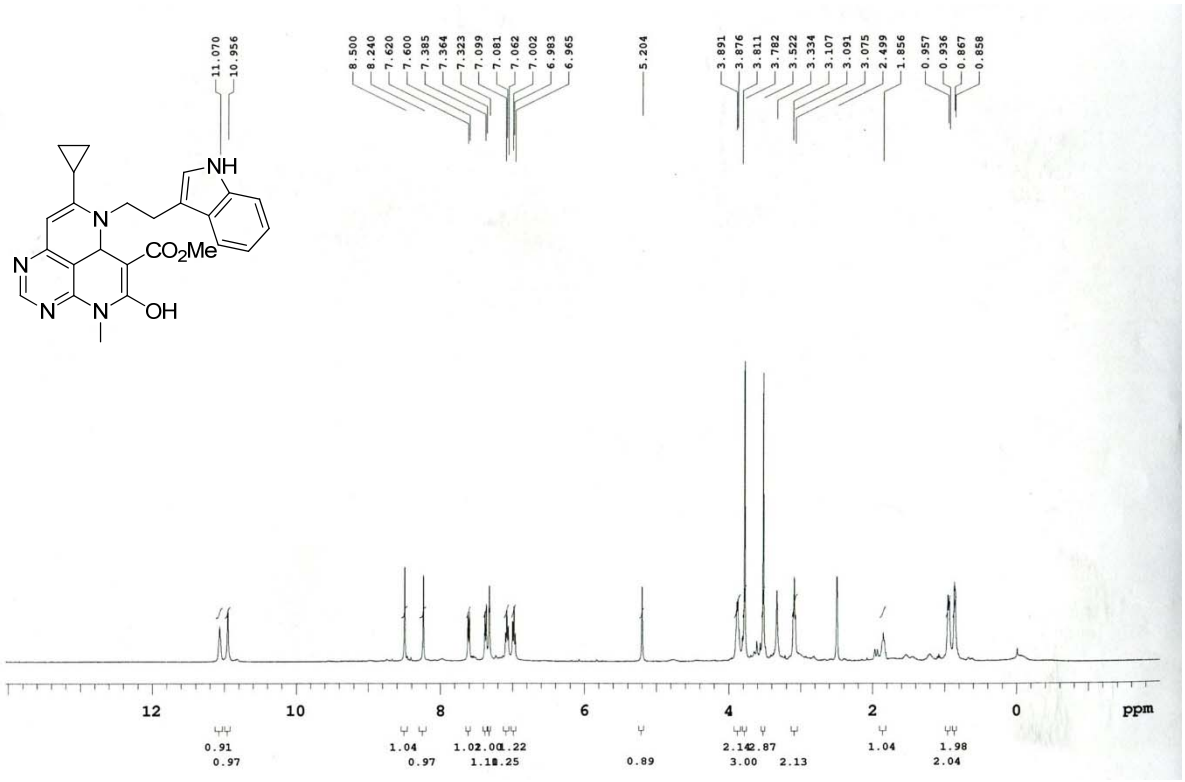

165.818
165.667
163.086
159.944
157.727
155.101
138.684
138.449
128.840
127.458
126.608
119.216
104.172
83.694
77.319
77.000
76.681
52.583
47.073
28.591
13.889
7.308
Bn
CO2Me
OH
ppm

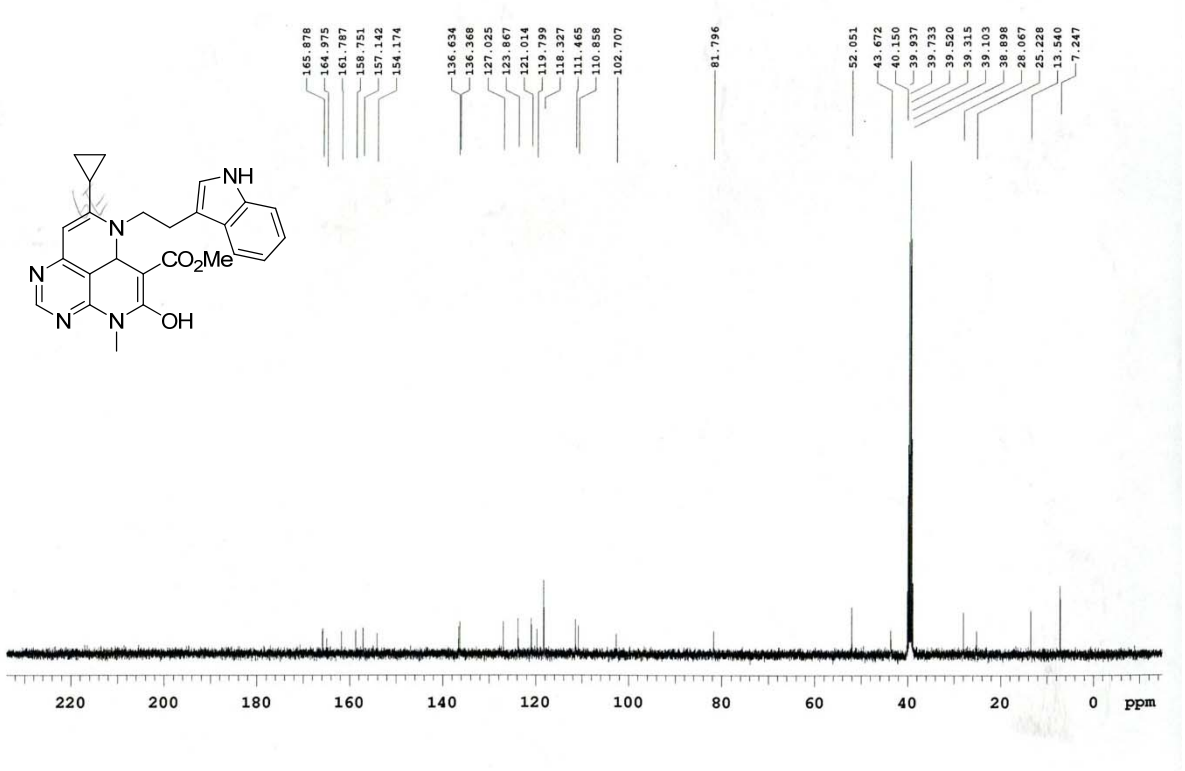
Compound 6d


6D
11.125
8.602
8.436
7.268
6.838
6.812
6.774
5.301
5.285
3.954
3.921
3.907
3.881
3.866
3.848
3.834
3.800
3.765
3.752
3.748
3.730
3.699
2.967
2.950
2.932
2.173
1.661
1.653
1.639
1.626
1.619
1.254
1.020
1.008
1.004
0.987
0.983
0.972
0.883
0.837
0.822
0.809
0.796
0.000
CO2Me
OH
12
10
8
6
4
2
0
ppm
0.85
0.81
0.84
1.11
1.81
0.96
2.00
1.18
2.07
2.06

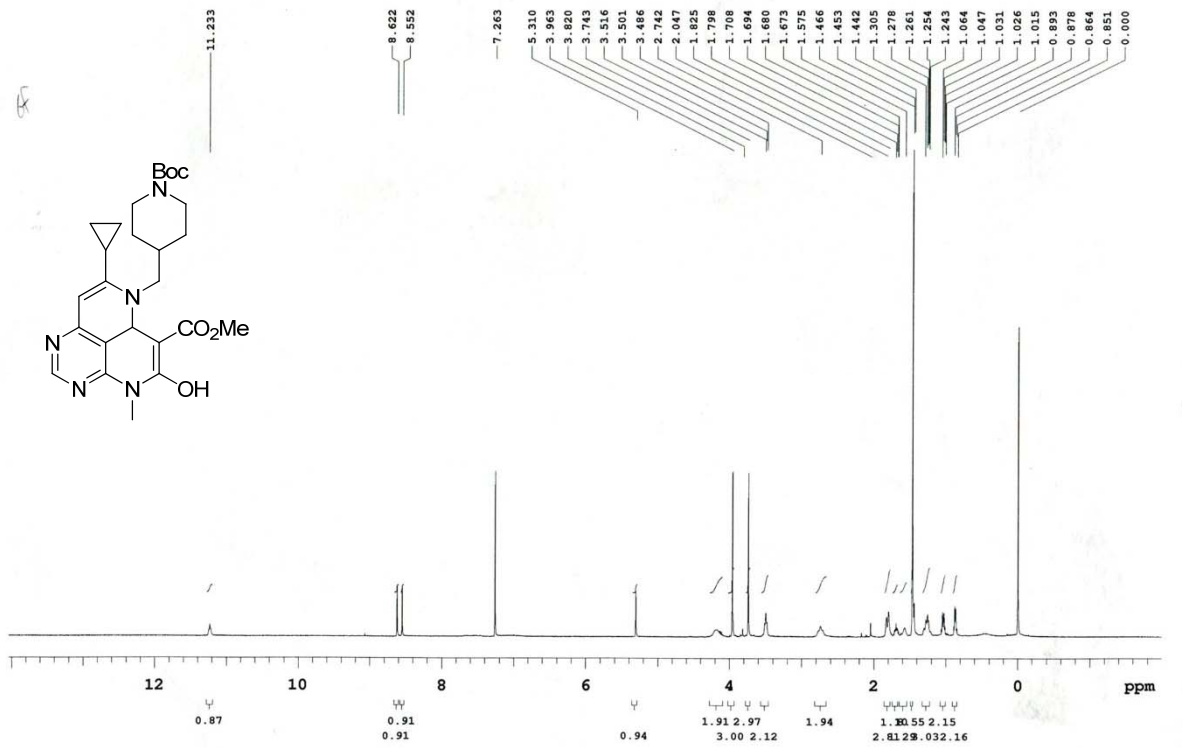

165.910
165.333
162.776
159.937
157.554
155.065
149.016
147.923
138.694
130.953
120.928
118.992
112.063
111.243
103.897
83.238
77.311
77.000
76.681
55.947
55.826
52.592
45.124
36.268
28.580
13.879
7.177
CO2Me
OH
200
180
160
140
120
100
80
60
40
20
0
Chemical Shift (ppm)

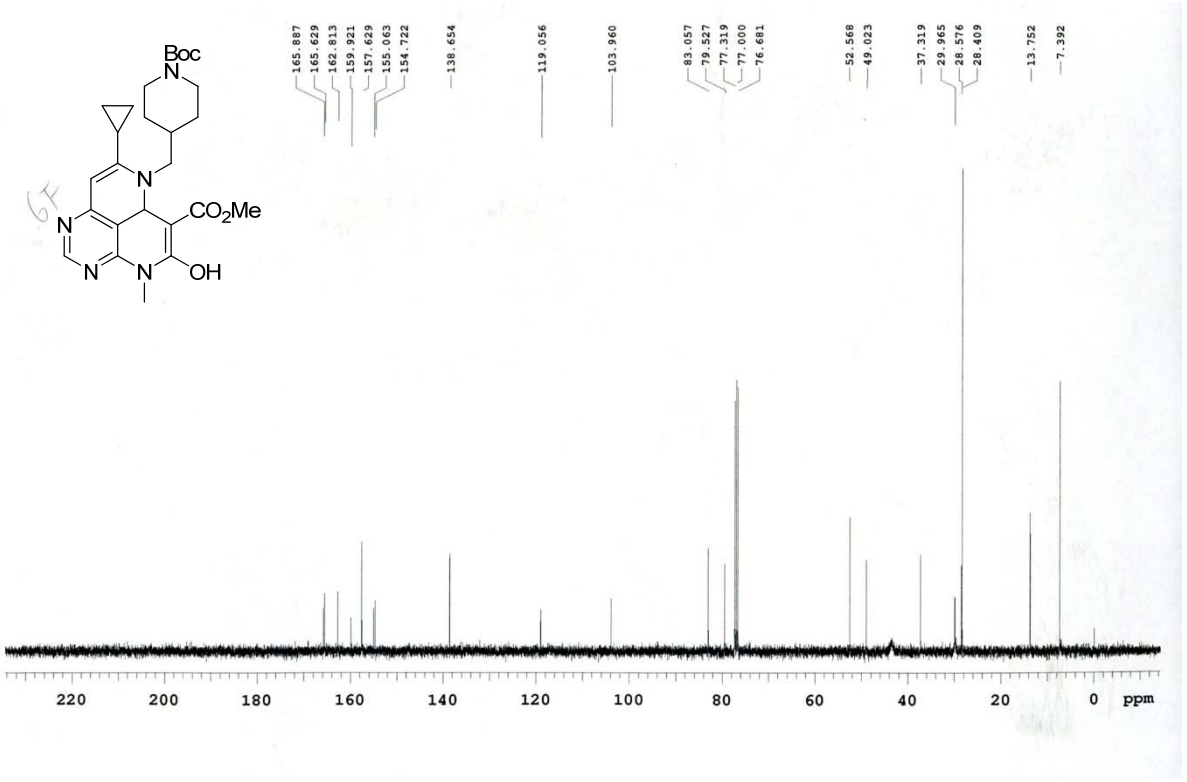
Compound 6e


11.070
10.956
8.500
8.240
7.620
7.600
7.385
7.364
7.323
7.099
7.081
7.062
7.002
6.983
6.965
5.204
3.891
3.876
3.811
3.782
3.522
3.334
3.107
3.091
3.075
2.499
1.856
0.957
0.936
0.867
0.858
NH
CO2Me
OH
12
10
8
6
4
2
0
ppm
0.91
0.97
1.04
0.97
1.02
2.00
1.22
1.18
1.25
0.89
2.14
2.87
3.00
2.13
1.04
1.98
2.04

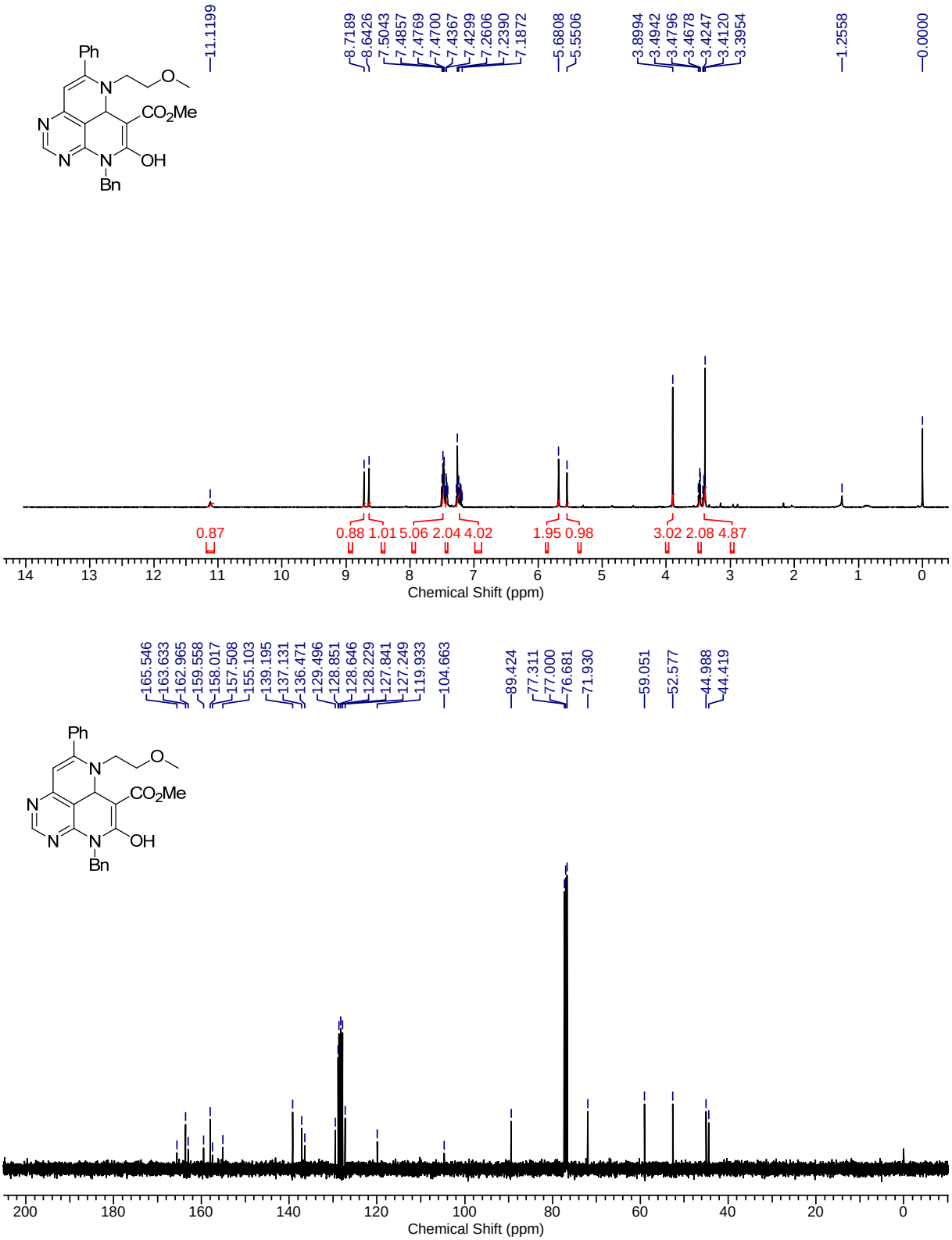

165.878
164.975
161.787
158.751
157.142
154.174
136.634
136.368
127.025
123.867
121.014
119.799
118.327
111.465
110.858
102.707
81.796
52.051
43.672
40.150
39.937
39.733
39.520
39.315
39.103
38.898
28.067
25.228
13.540
7.247
NH
CO2Me
OH
220
200
180
160
140
120
100
80
60
40
20
0
ppm

Compound 6f

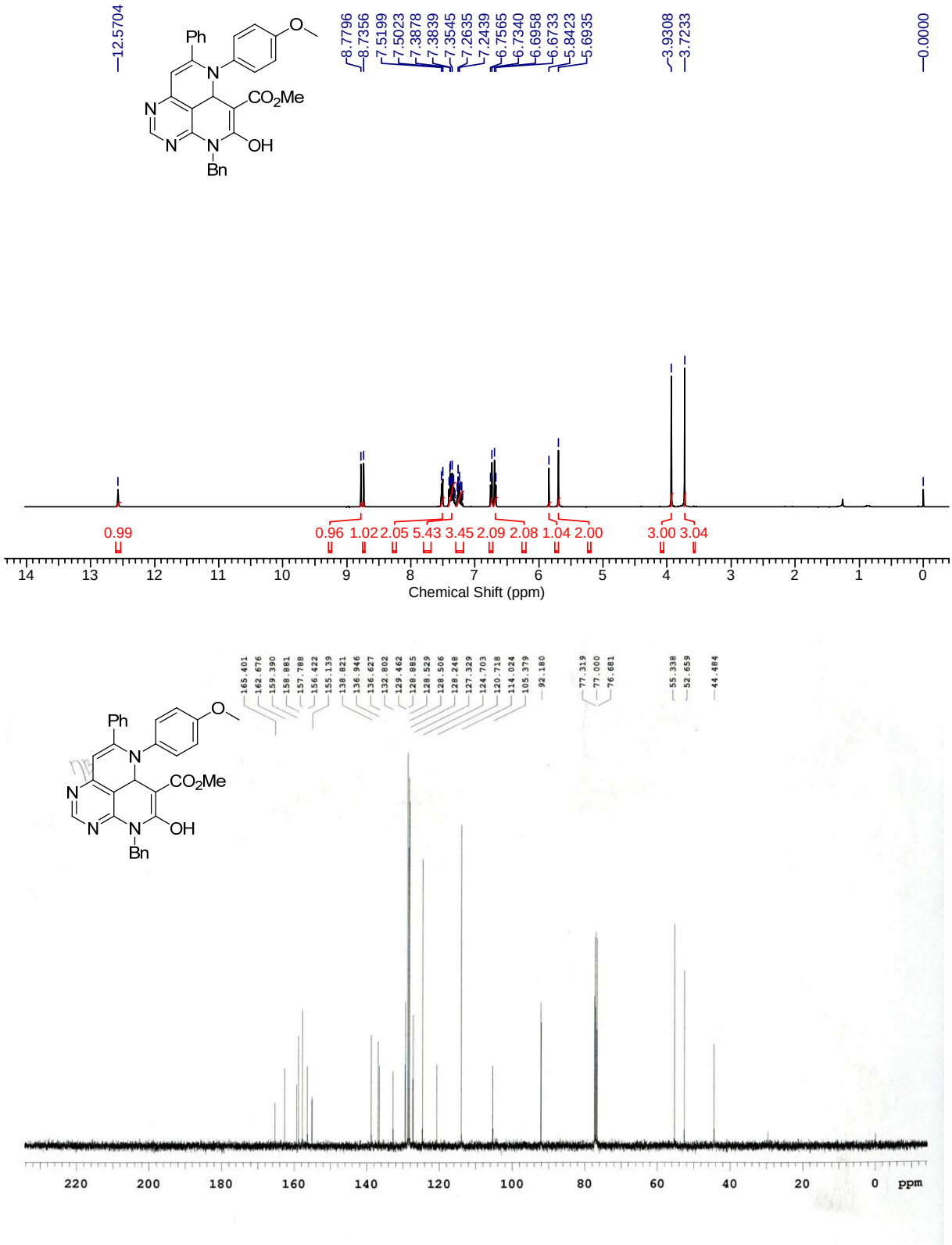

Boc
N
N
CO2Me
N
N
N
OH
11.233
8.622
8.552
7.263
5.310
3.963
3.820
3.743
3.516
3.501
3.486
2.742
2.047
1.825
1.798
1.708
1.694
1.680
1.673
1.575
1.466
1.453
1.442
1.305
1.278
1.261
1.254
1.243
1.064
1.047
1.031
1.026
1.015
0.893
0.878
0.864
0.851
0.000
12
10
8
6
4
2
0
ppm
0.87
0.91
0.91
0.94
1.91
2.97
3.00
2.12
1.94
2.15
2.81
1.03
2.16


Boc
N
N
CO2Me
N
N
N
OH
165.887
165.629
162.813
159.921
157.629
155.063
154.722
138.654
119.056
103.960
83.057
79.527
77.319
77.000
76.681
52.568
49.023
37.319
29.965
28.576
28.409
13.752
7.392
220
200
180
160
140
120
100
80
60
40
20
0
ppm

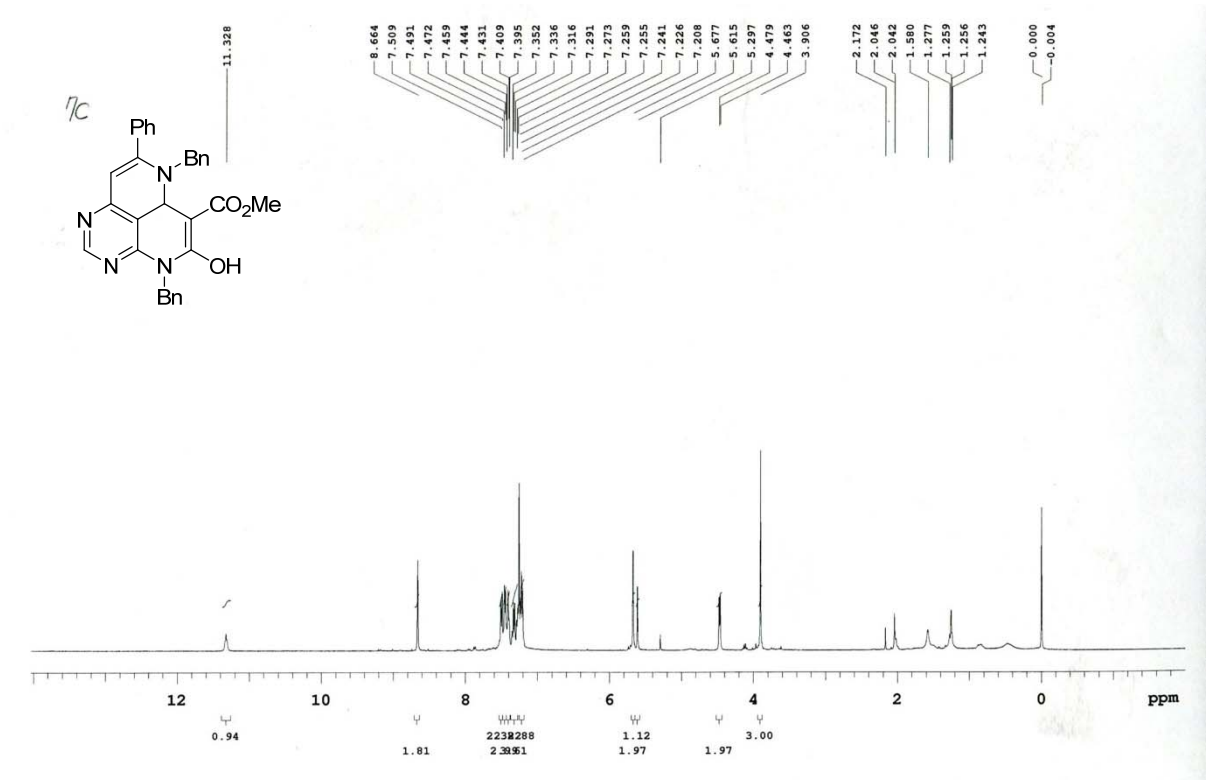
Compound 7a

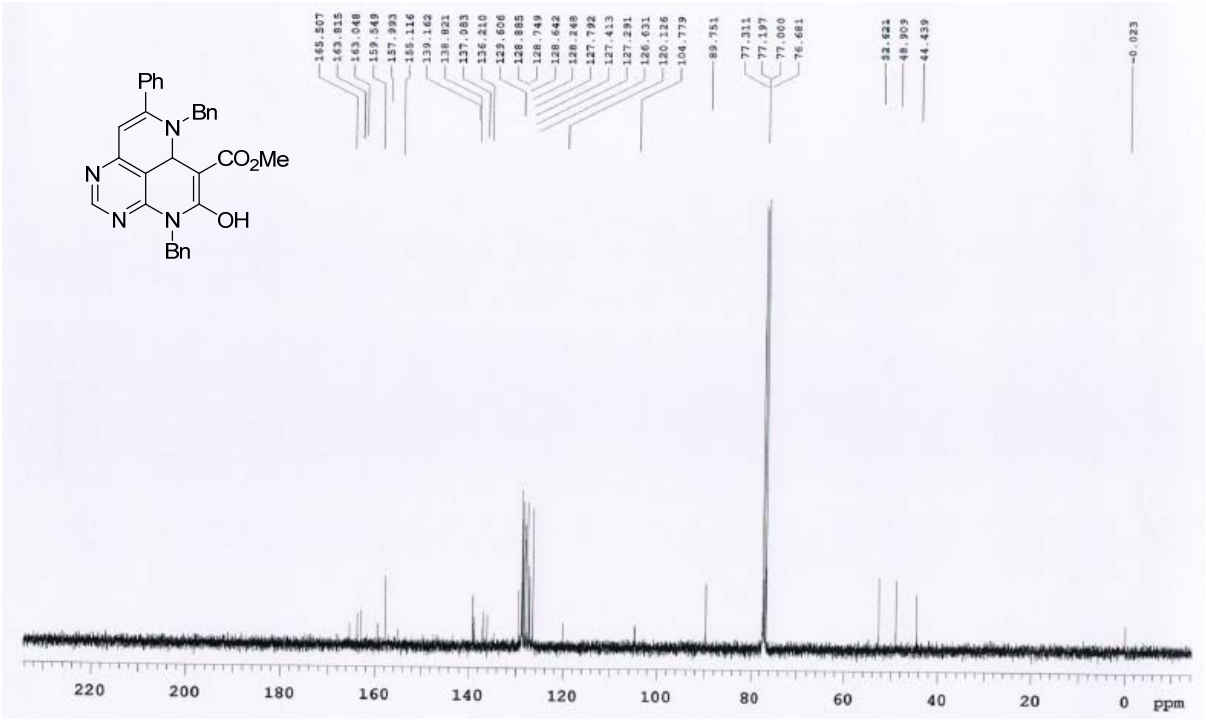

11.1199
8.7189
8.6426
7.5043
7.4857
7.4769
7.4700
7.4367
7.4299
7.2606
7.2390
7.1872
5.6808
5.5506
3.8994
3.4942
3.4796
3.4678
3.4247
3.4120
3.3954
1.2558
0.0000
Ph
N
O
CO2Me
N
N
N
OH
Bn
0.87
0.88
1.01
5.06
2.04
4.02
1.95
0.98
3.02
2.08
4.87
Chemical Shift (ppm)
165.546
163.633
162.965
159.558
158.017
157.508
155.103
139.195
137.131
136.471
129.496
128.851
128.646
128.229
127.841
127.249
119.933
104.663
89.424
77.311
77.000
76.681
71.930
59.051
52.577
44.988
44.419
Chemical Shift (ppm)

Compound 7b

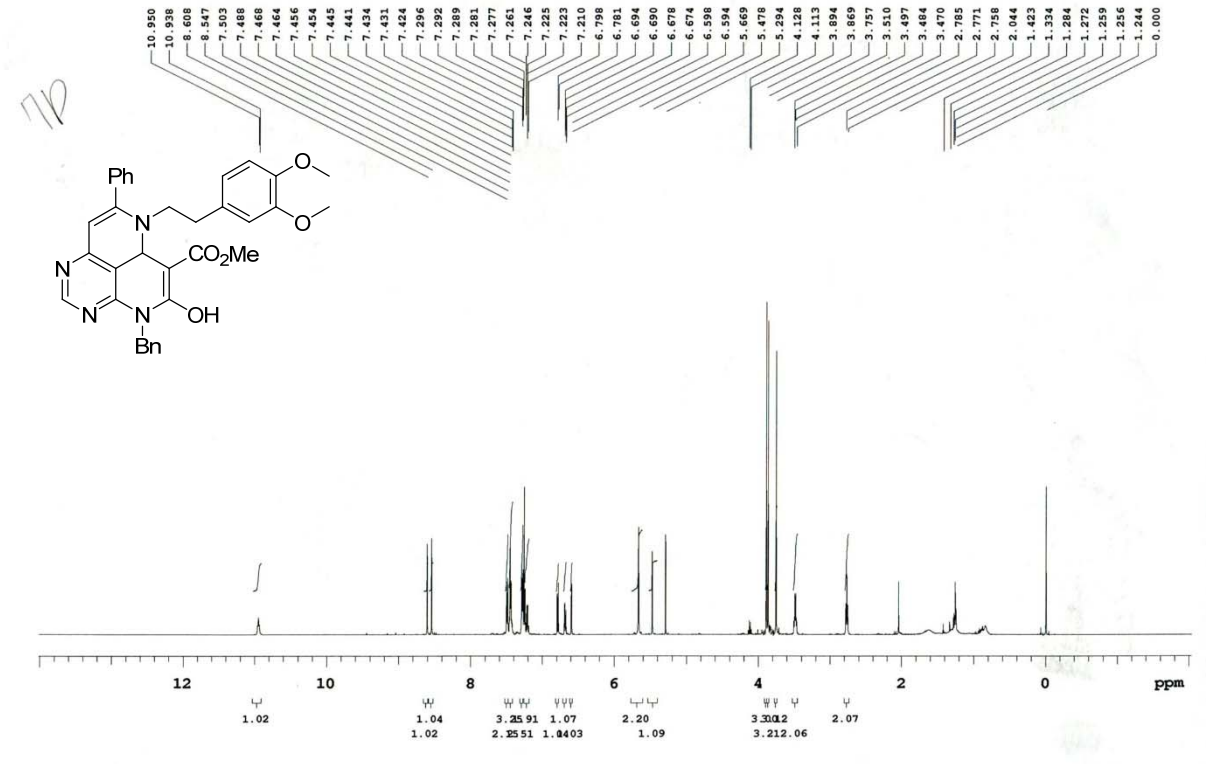

12.5704
8.7796
8.7356
7.5199
7.5023
7.3878
7.3839
7.3545
7.2635
7.2439
6.7565
6.7340
6.6958
6.6733
5.8423
5.6935
3.9308
3.7233
0.0000
Ph
O
N
CO2Me
N
N
N
OH
Bn
0.99
0.96
1.02
2.05
5.43
3.45
2.09
2.08
1.04
2.00
3.00
3.04
Chemical Shift (ppm)
165.401
162.676
159.390
158.881
157.788
156.422
155.139
138.821
136.946
136.627
132.802
129.462
128.885
128.529
128.506
128.248
127.329
124.703
120.718
114.024
105.379
92.180
77.319
77.000
76.681
55.338
52.659
44.484
ppm

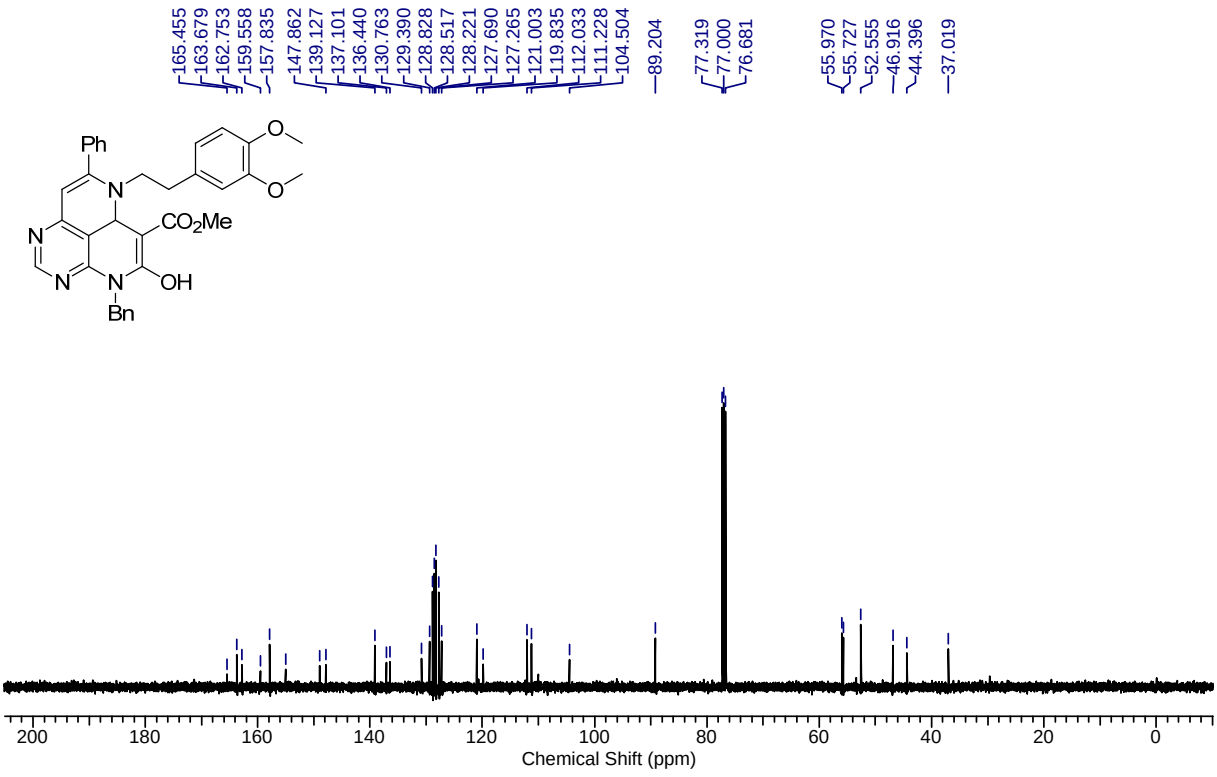
Compound 7c


7c
Ph
Bn
N
CO2Me
OH
Bn
11.328
8.664
7.509
7.491
7.472
7.459
7.444
7.431
7.409
7.395
7.352
7.336
7.316
7.291
7.273
7.259
7.255
7.241
7.226
7.208
5.677
5.615
5.297
4.479
4.463
3.906
2.172
2.046
2.042
1.580
1.277
1.259
1.256
1.243
0.000
-0.004
12
10
8
6
4
2
0
ppm
0.94
1.81
1.12
1.97
1.97
3.00

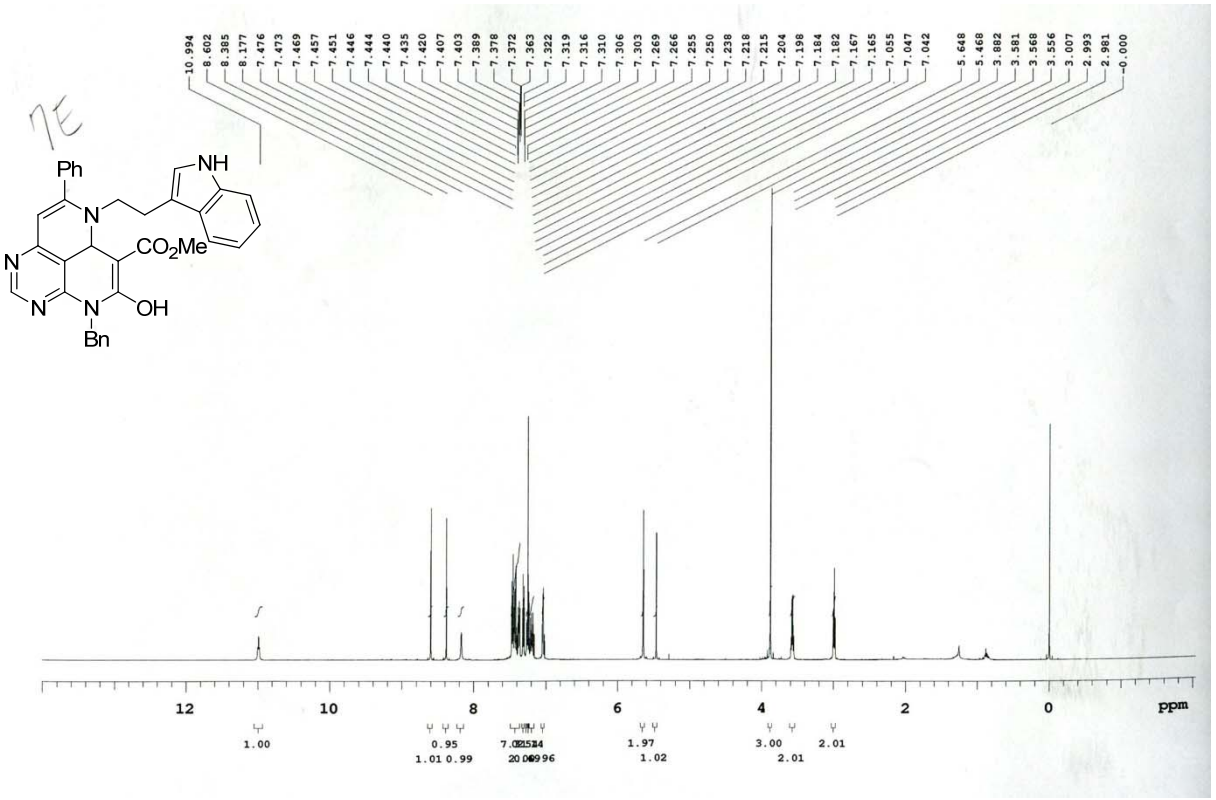

Ph
Bn
N
CO2Me
OH
Bn
165.507
163.815
163.048
159.549
157.993
155.116
139.162
138.821
137.083
136.210
129.606
128.885
128.749
128.642
128.248
127.792
127.413
127.291
126.631
120.126
104.779
89.751
77.311
77.197
77.000
76.681
52.621
48.909
44.439
-0.023
220
200
180
160
140
120
100
80
60
40
20
0
ppm

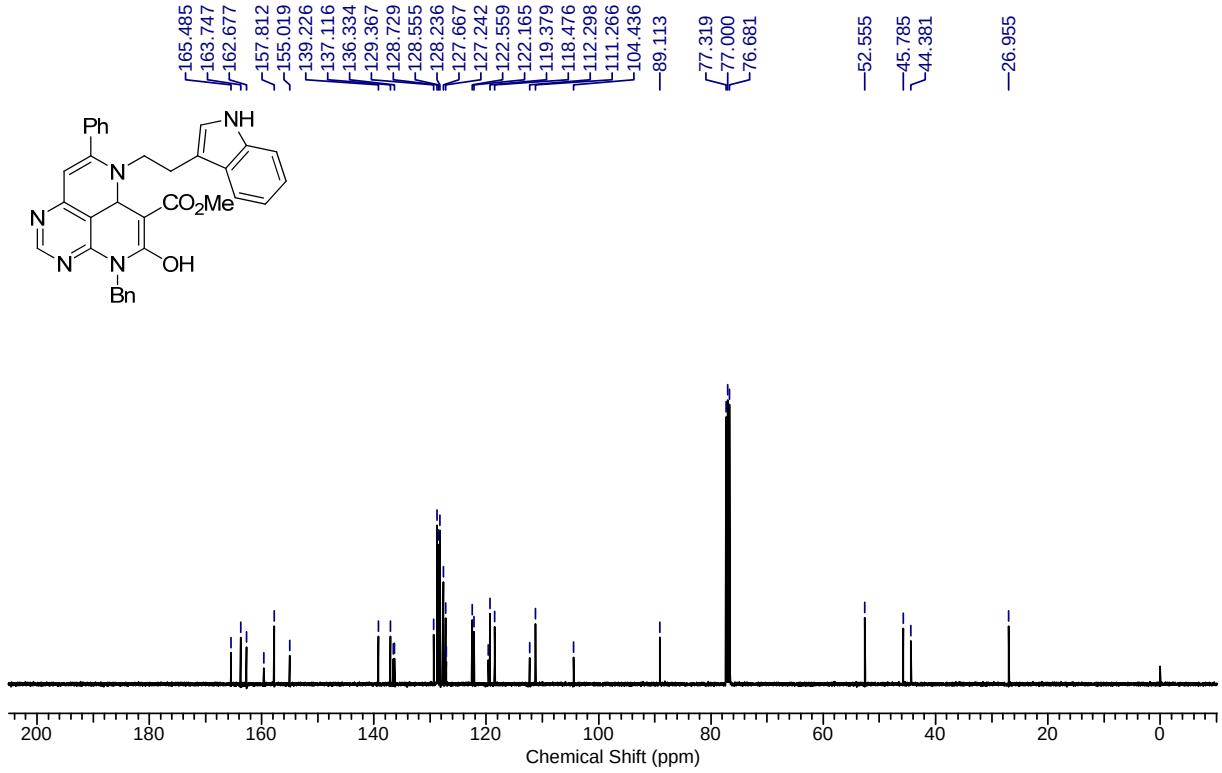
Compound 7d


10.950
10.938
8.608
8.547
7.503
7.488
7.468
7.464
7.456
7.454
7.445
7.441
7.434
7.431
7.424
7.296
7.292
7.289
7.281
7.277
7.261
7.246
7.225
7.223
7.210
6.798
6.781
6.694
6.690
6.678
6.674
6.598
6.594
5.669
5.478
5.294
4.128
4.113
3.894
3.869
3.757
3.510
3.497
3.484
3.470
2.785
2.771
2.758
2.044
1.423
1.334
1.284
1.272
1.259
1.256
1.244
0.000
Ph
N
O
O
CO2Me
N
N
N
OH
Bn
12
10
8
6
4
2
0
ppm
1.02
1.04
1.02
3.25
2.25
1.07
1.04
2.20
1.09
3.30
3.21
2.06
2.07

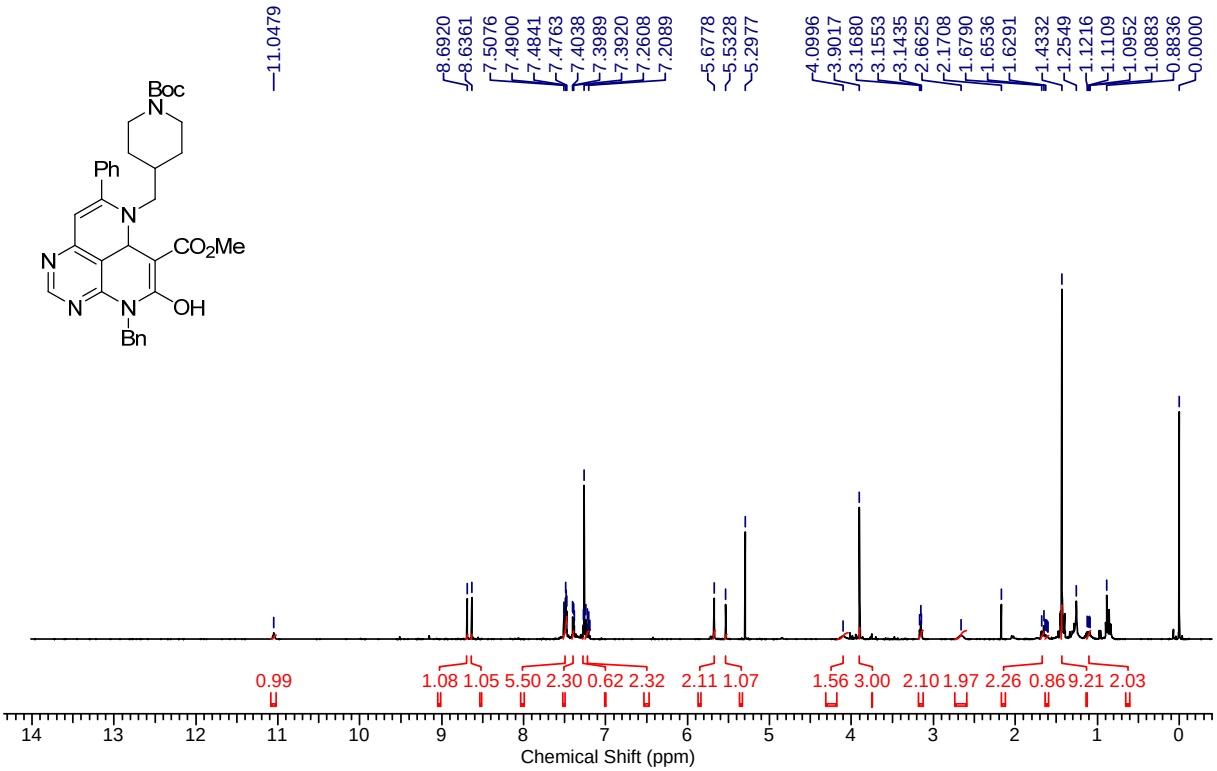

165.455
163.679
162.753
159.558
157.835
147.862
139.127
137.101
136.440
130.763
129.390
128.828
128.517
128.221
127.690
127.265
121.003
119.835
112.033
111.228
104.504
89.204
77.319
77.000
76.681
55.970
55.727
52.555
46.916
44.396
37.019
Ph
N
O
O
CO2Me
N
N
N
OH
Bn
200
180
160
140
120
100
80
60
40
20
0
Chemical Shift (ppm)

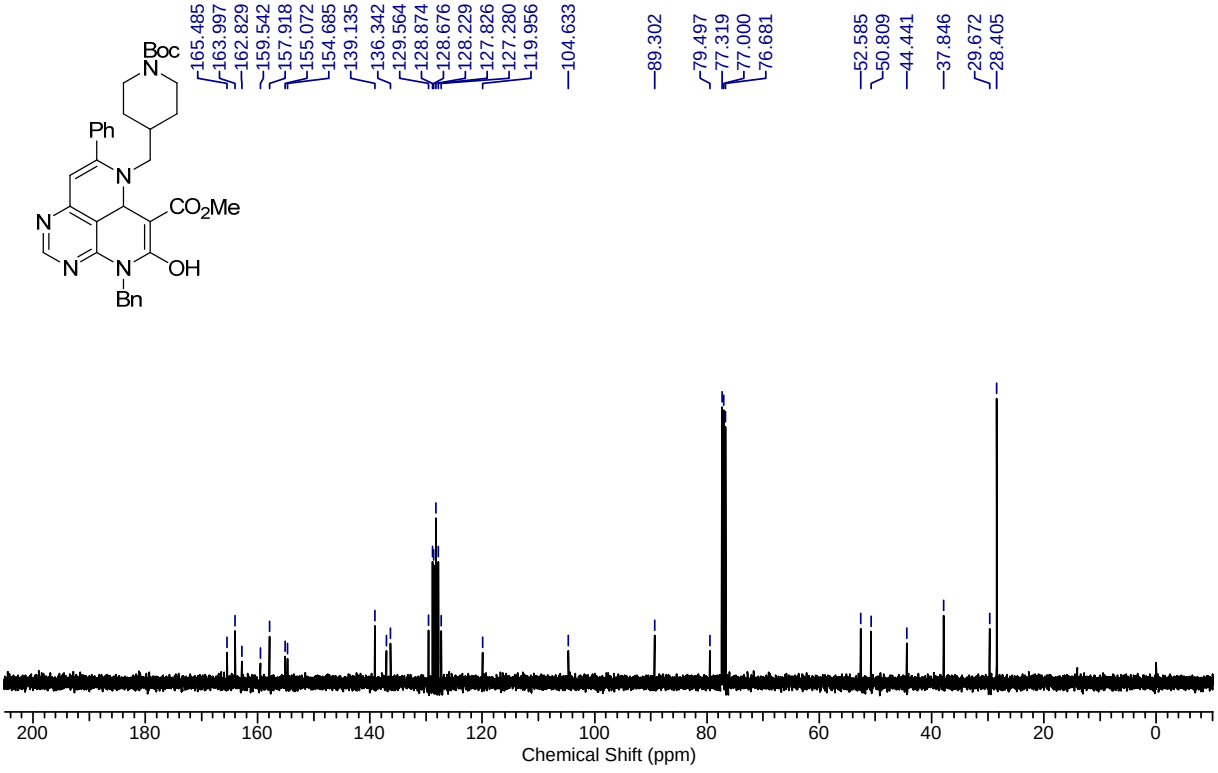
Compound 7e


Ph
NH
N
CO2Me
N
N
N
OH
Bn
ppm

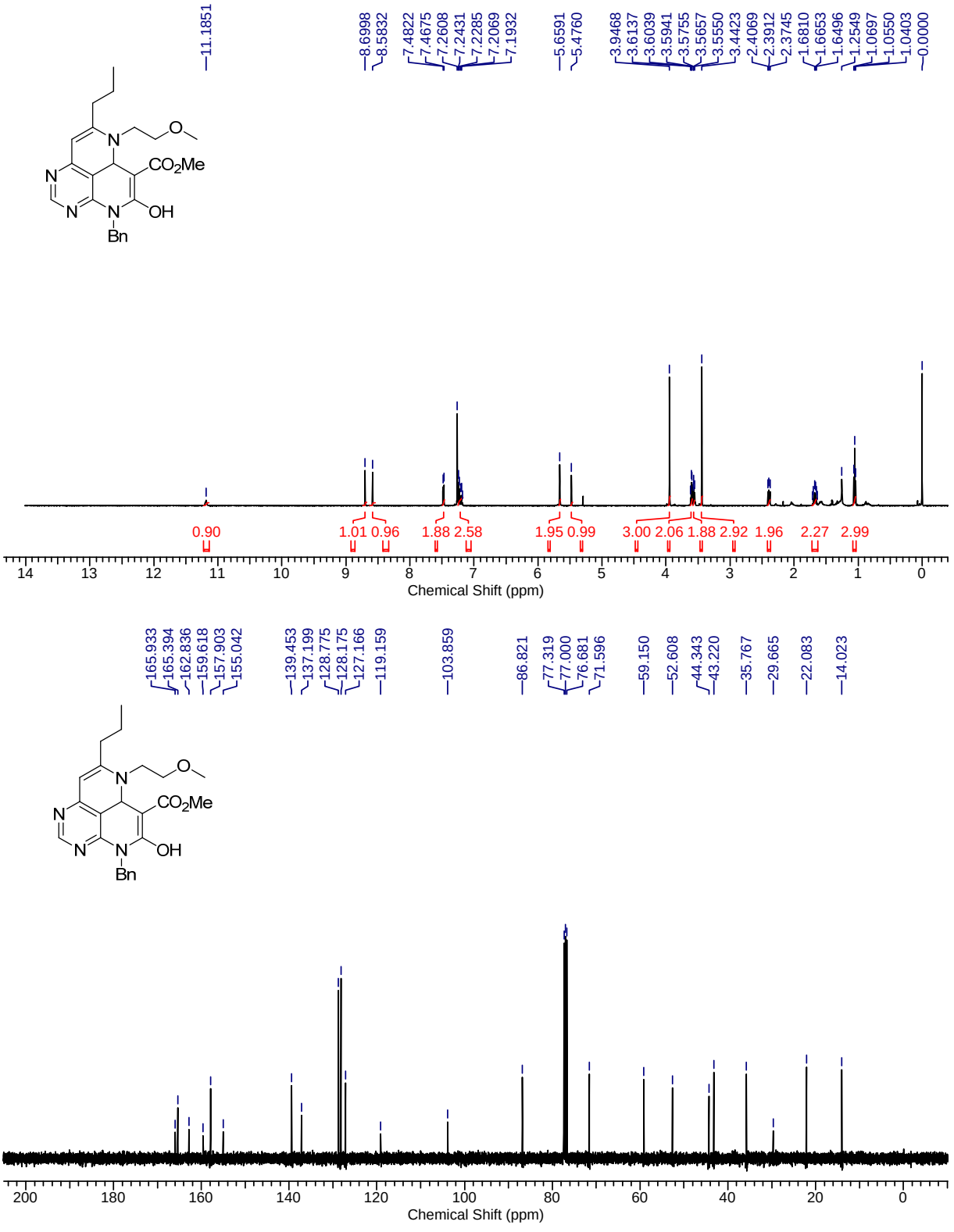

Ph
NH
N
CO2Me
N
N
N
OH
Bn
Chemical Shift (ppm)

Compound 7f

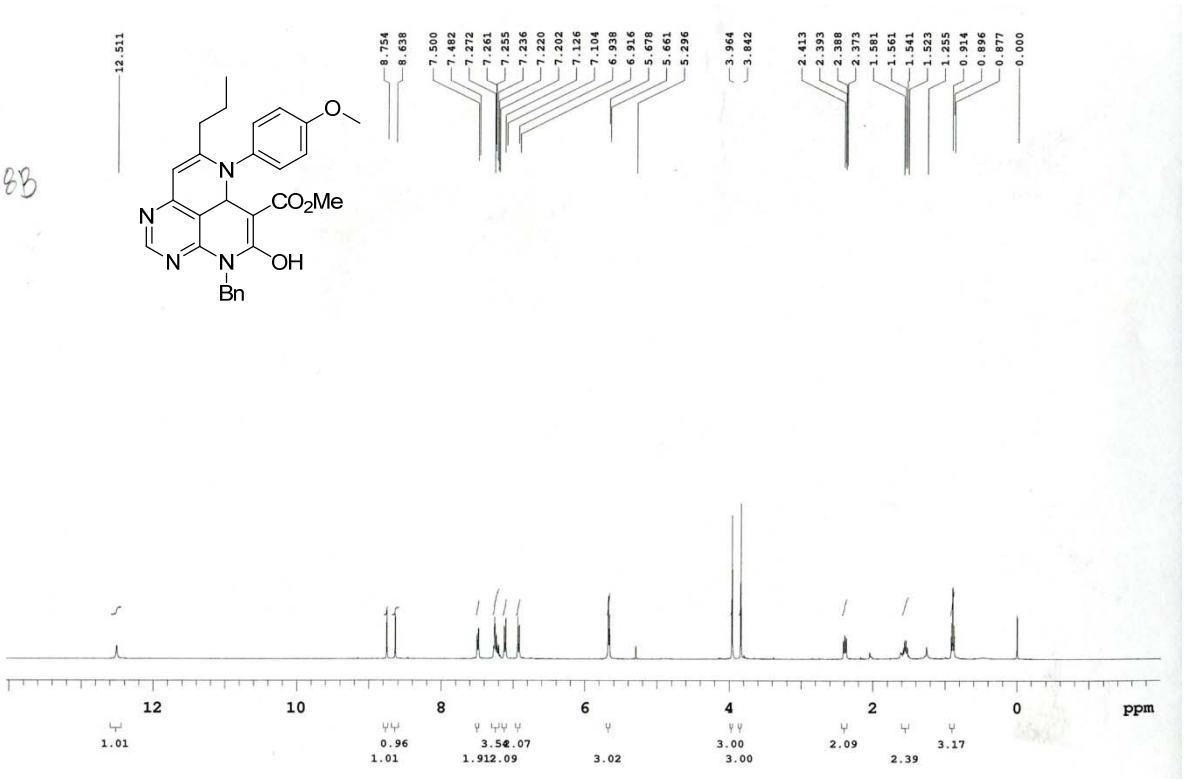

11.0479
8.6920
8.6361
7.5076
7.4900
7.4841
7.4763
7.4038
7.3989
7.3920
7.2608
7.2089
5.6778
5.5328
5.2977
4.0996
3.9017
3.1680
3.1553
3.1435
2.6625
2.1708
1.6790
1.6536
1.6291
1.4332
1.2549
1.1216
1.1109
1.0952
1.0883
0.8836
0.0000
Boc
Ph
CO2Me
OH
Bn
0.99
1.08 1.05 5.50 2.30 0.62 2.32
2.11 1.07
1.56 3.00
2.10 1.97 2.26 0.86 9.21 2.03
Chemical Shift (ppm)

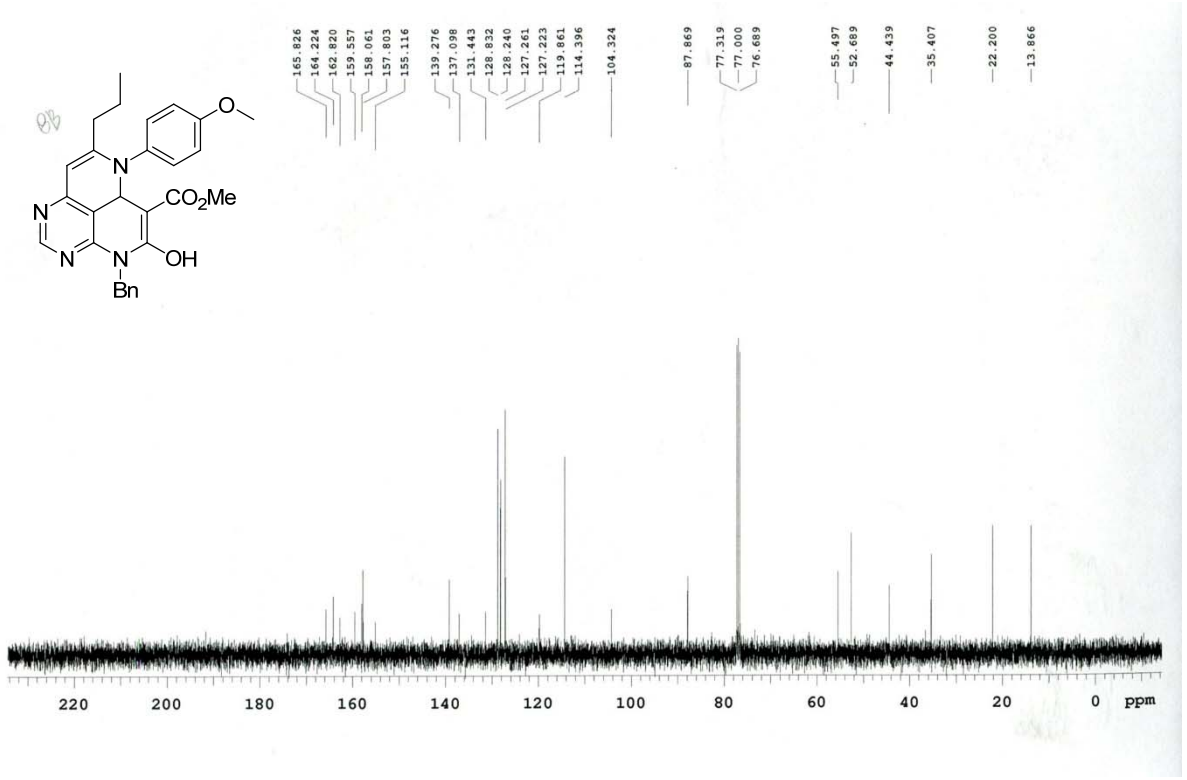

165.485
163.997
162.829
159.542
157.918
155.072
154.685
139.135
136.342
129.564
128.874
128.676
128.229
127.826
127.280
119.956
104.633
89.302
79.497
77.319
77.000
76.681
52.585
50.809
44.441
37.846
29.672
28.405
Boc
Ph
CO2Me
OH
Bn
Chemical Shift (ppm)

Compound 8a

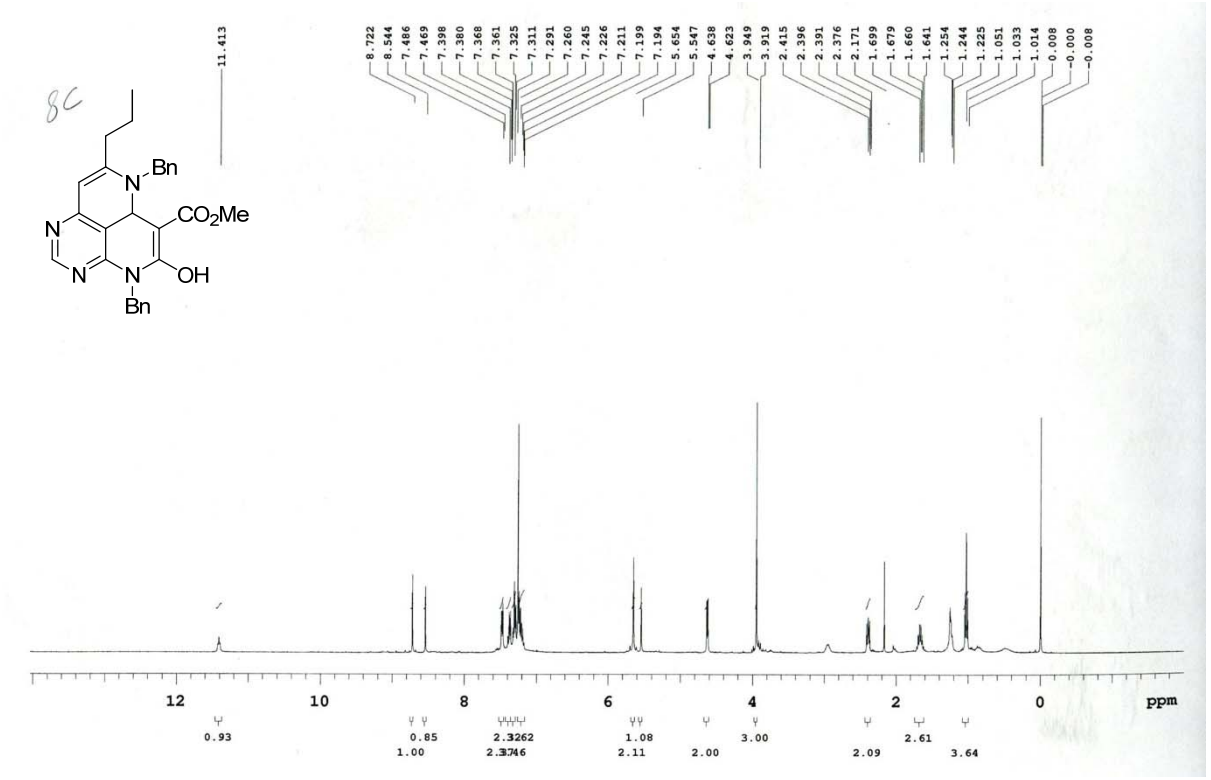

11.1851
8.6998
8.5832
7.4822
7.4675
7.2608
7.2431
7.2285
7.2069
7.1932
5.6591
5.4760
3.9468
3.6137
3.6039
3.5941
3.5755
3.5657
3.5550
3.4423
2.4069
2.3912
2.3745
1.6810
1.6653
1.6496
1.2549
1.0697
1.0550
1.0403
0.0000
N
O
CO2Me
N
N
N
OH
Bn
0.90
1.01
0.96
1.88
2.58
1.95
0.99
3.00
2.06
1.88
2.92
1.96
2.27
2.99
Chemical Shift (ppm)
165.933
165.394
162.836
159.618
157.903
155.042
139.453
137.199
128.775
128.175
127.166
119.159
103.859
86.821
77.319
77.000
76.681
71.596
59.150
52.608
44.343
43.220
35.767
29.665
22.083
14.023
Chemical Shift (ppm)

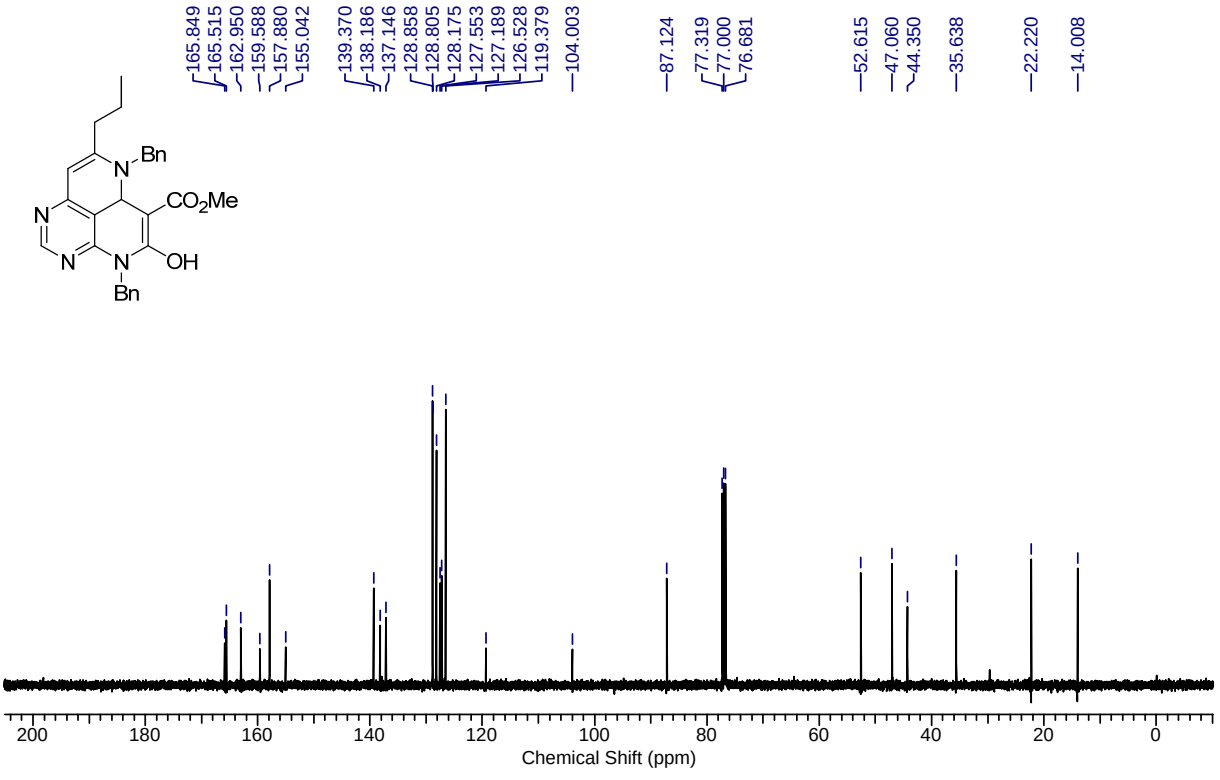
Compound 8b


12.511
8.754
8.638
7.500
7.482
7.272
7.261
7.255
7.236
7.220
7.202
7.126
7.104
6.938
6.916
5.678
5.661
5.296
3.964
3.842
2.413
2.393
2.388
2.373
1.581
1.561
1.541
1.523
1.255
0.914
0.896
0.877
0.000
88
O
N
CO2Me
N
N
N
OH
Bn
12
10
8
6
4
2
0
ppm
1.01
0.96
1.01
3.54
1.91
2.07
2.09
3.02
3.00
3.00
2.09
2.39
3.17

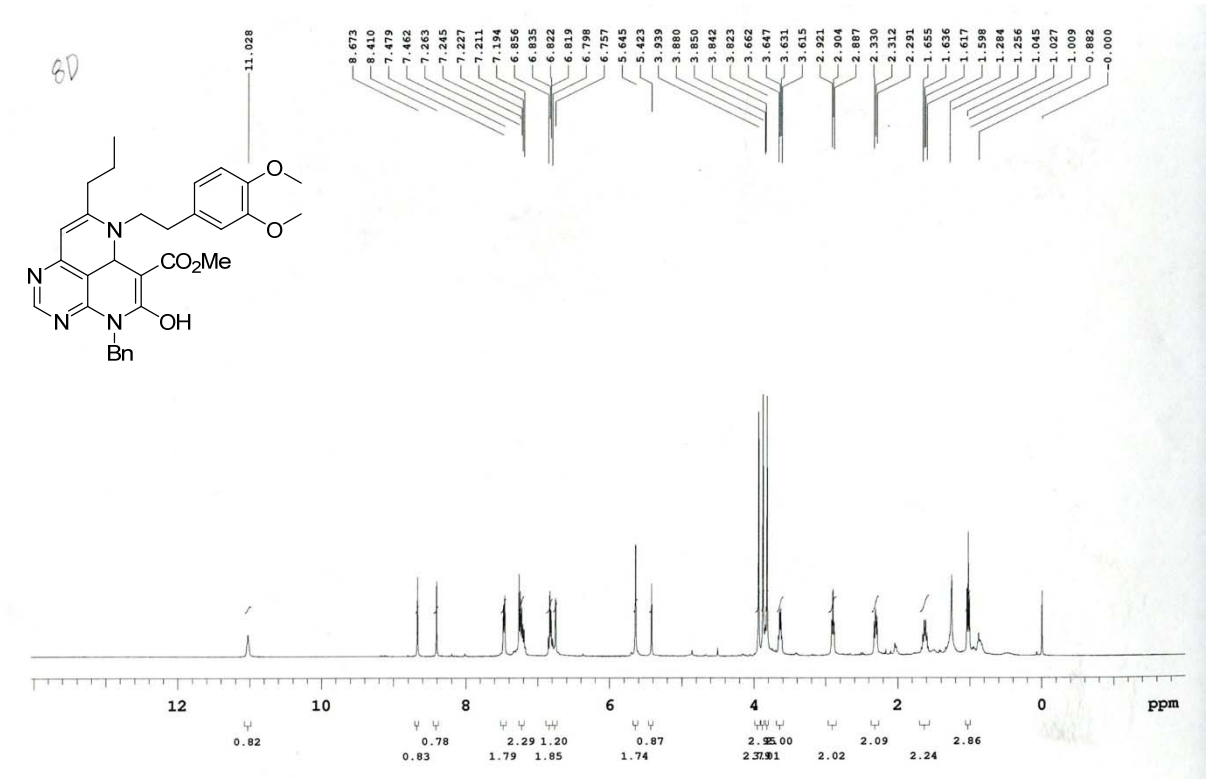

165.826
164.224
162.820
159.557
158.061
157.803
155.116
139.276
137.098
131.443
128.832
128.240
127.261
127.223
119.861
114.396
104.324
87.869
77.319
77.000
76.689
55.497
52.689
44.439
35.407
22.200
13.866
88
O
N
CO2Me
N
N
N
OH
Bn
220
200
180
160
140
120
100
80
60
40
20
0
ppm

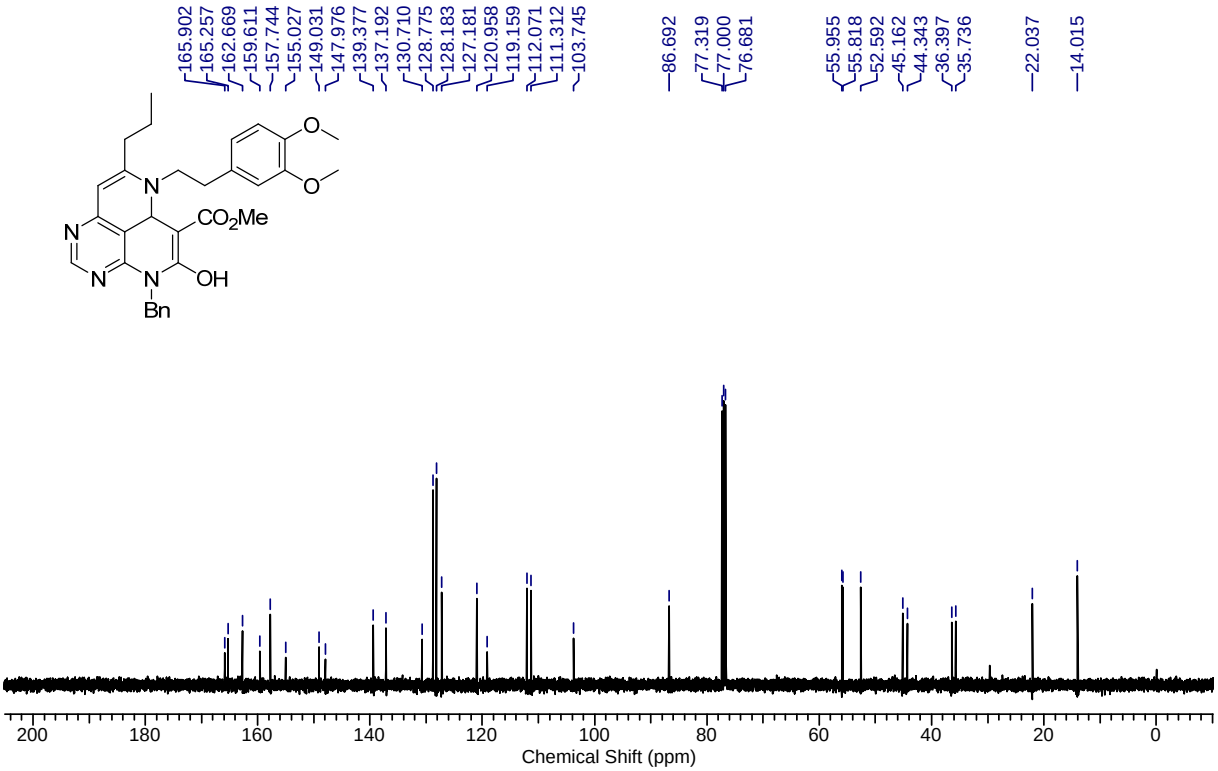
Compound 8c


8c
Bn
N
CO2Me
N
N
N
OH
Bn
11.413
8.722
8.544
7.486
7.469
7.398
7.380
7.368
7.361
7.325
7.311
7.291
7.260
7.245
7.226
7.211
7.199
7.194
5.654
5.547
4.638
4.623
3.949
3.919
2.415
2.396
2.391
2.376
2.171
1.699
1.679
1.660
1.641
1.254
1.244
1.225
1.051
1.033
1.014
0.008
0.000
-0.008
12
10
8
6
4
2
0
ppm
0.93
0.85
1.00
2.3262
2.3746
1.08
2.11
2.00
3.00
2.09
2.61
3.64

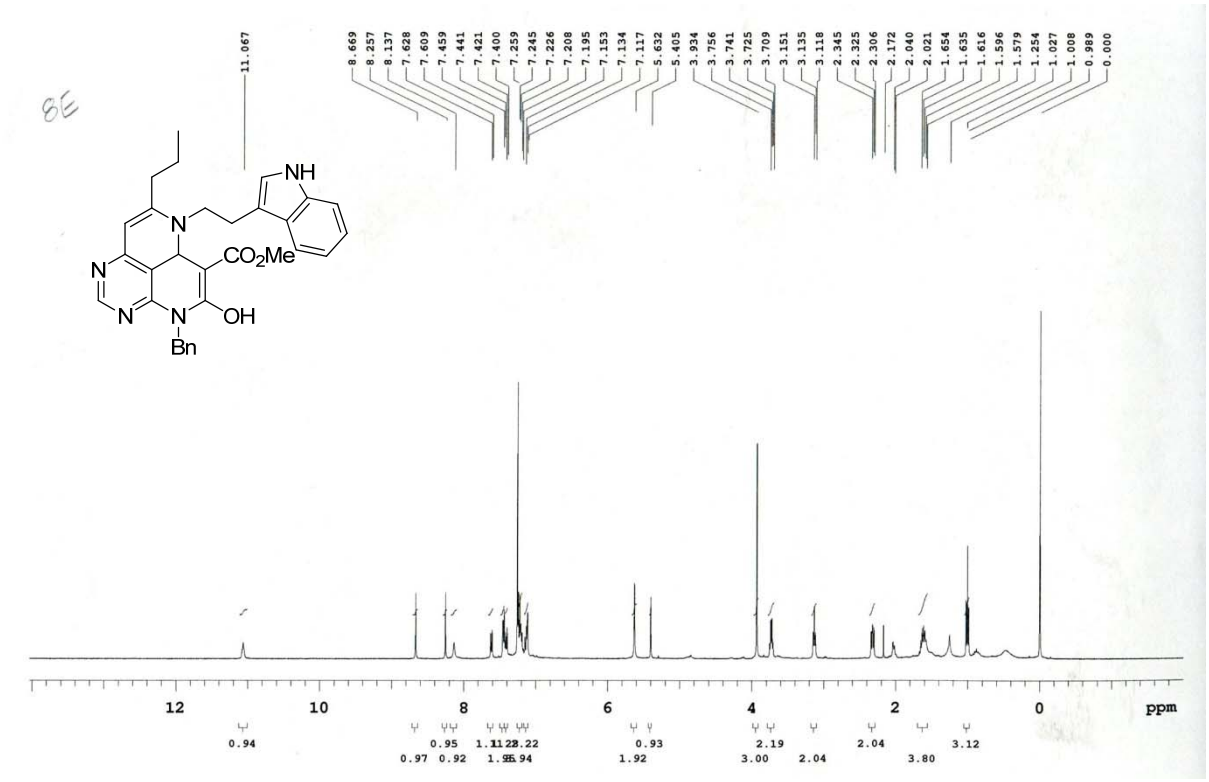

165.849
165.515
162.950
159.588
157.880
155.042
139.370
138.186
137.146
128.858
128.805
128.175
127.553
127.189
126.528
119.379
104.003
87.124
77.319
77.000
76.681
52.615
47.060
44.350
35.638
22.220
14.008
Bn
N
CO2Me
N
N
N
OH
Bn
200
180
160
140
120
100
80
60
40
20
0
Chemical Shift (ppm)

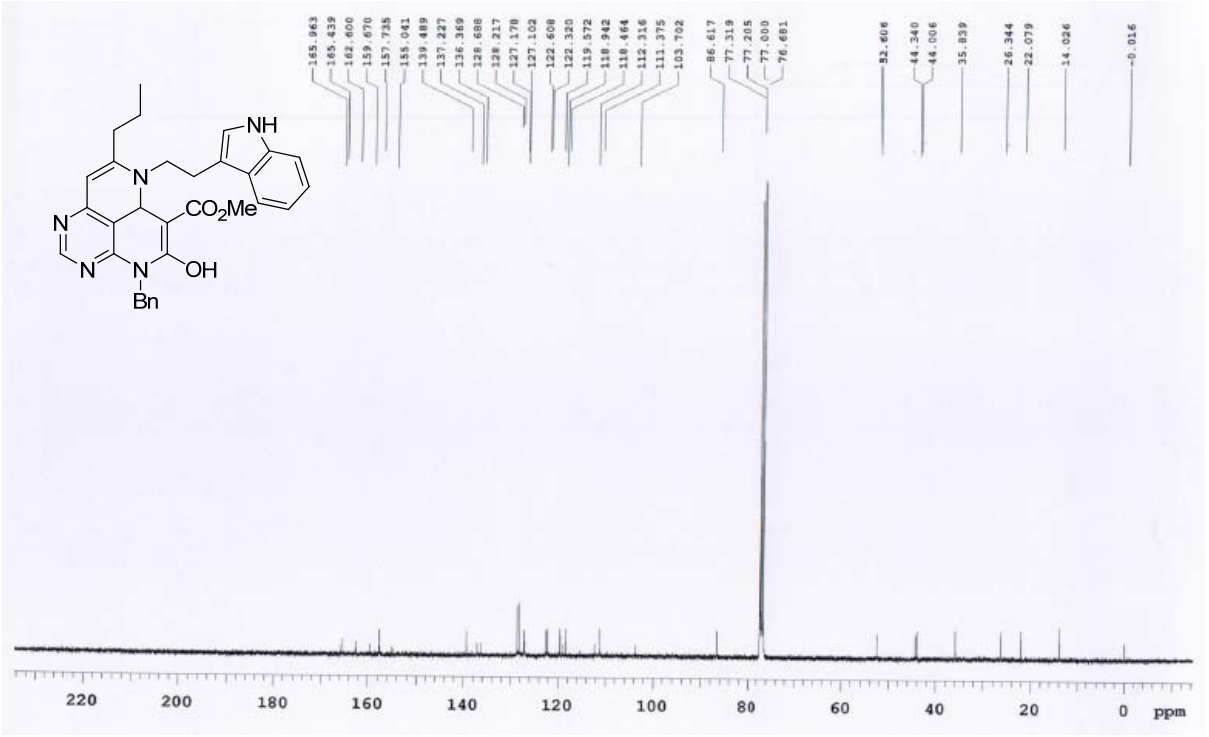
Compound 8d


6D
11.028
8.673
8.410
7.479
7.462
7.263
7.245
7.227
7.211
7.194
6.856
6.835
6.822
6.819
6.798
6.757
5.645
5.423
3.939
3.880
3.850
3.842
3.823
3.662
3.647
3.631
3.615
2.921
2.904
2.887
2.330
2.312
2.291
1.655
1.636
1.617
1.598
1.284
1.256
1.045
1.027
1.009
0.882
0.000
O
O
N
CO2Me
N
N
N
OH
Bn
12
10
8
6
4
2
0
ppm
0.82
0.78
0.83
2.29
1.79
1.20
1.85
0.87
1.74
2.00
2.02
2.09
2.24
2.86

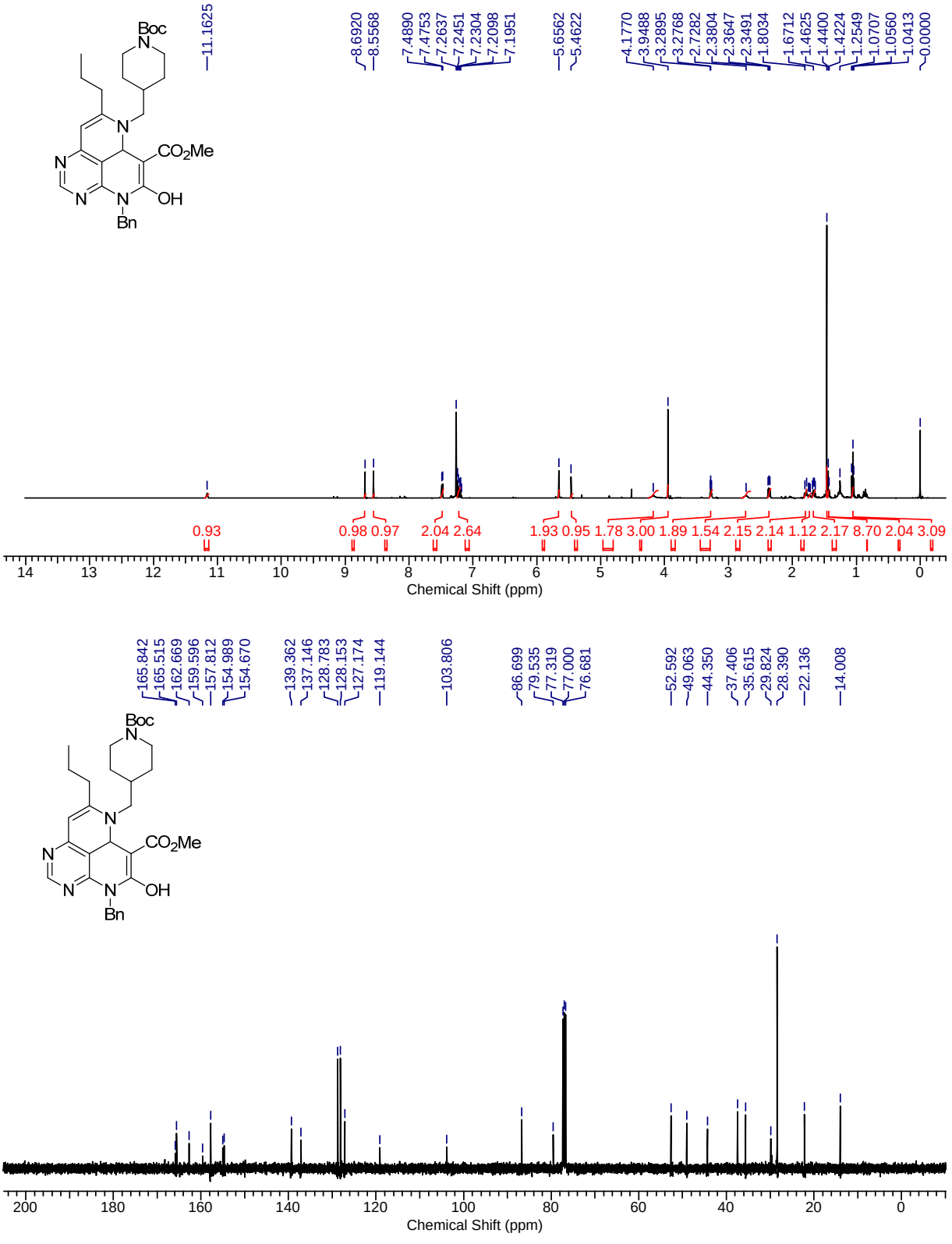

165.902
165.257
162.669
159.611
157.744
155.027
149.031
147.976
139.377
137.192
130.710
128.775
128.183
127.181
120.958
119.159
112.071
111.312
103.745
86.692
77.319
77.000
76.681
55.955
55.818
52.592
45.162
44.343
36.397
35.736
22.037
14.015
O
O
N
CO2Me
N
N
N
OH
Bn
200
180
160
140
120
100
80
60
40
20
0
Chemical Shift (ppm)

Compound 8e

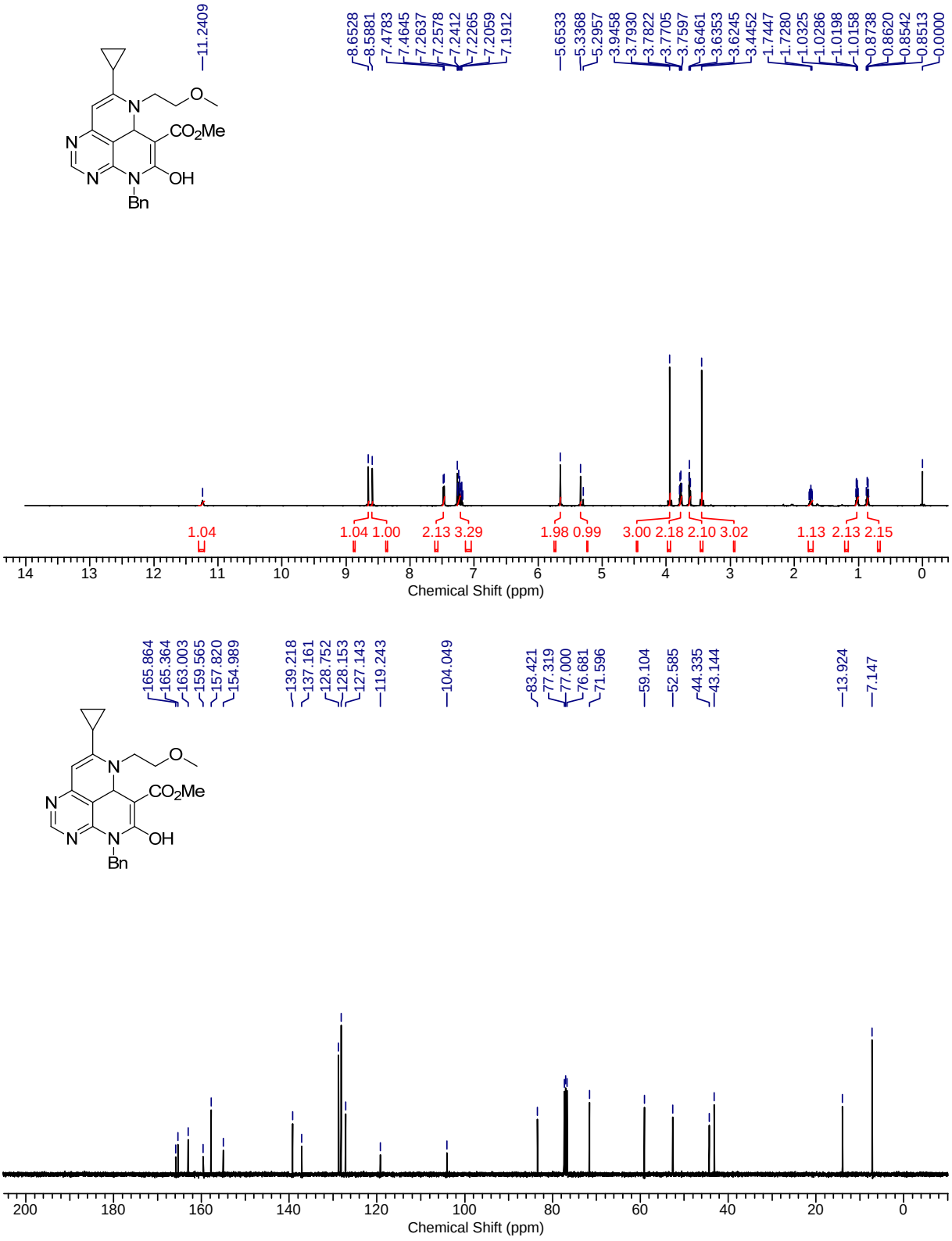

8E
11.067
8.669
8.257
8.137
7.628
7.609
7.459
7.441
7.421
7.400
7.259
7.245
7.226
7.208
7.195
7.153
7.134
7.117
5.632
5.405
3.934
3.756
3.741
3.725
3.709
3.151
3.135
3.118
2.345
2.325
2.306
2.172
2.040
2.021
1.654
1.635
1.616
1.596
1.579
1.254
1.027
1.008
0.989
0.000
NH
N
CO2Me
N
N
N
OH
Bn
12
10
8
6
4
2
0
ppm
0.94
0.97
0.95
0.92
1.92
0.93
1.92
2.19
3.00
2.04
2.04
3.80
3.12


165.963
163.439
162.600
159.670
157.735
155.041
139.489
137.227
136.369
128.688
128.217
127.170
127.102
122.608
122.320
119.572
118.942
118.464
112.316
111.375
103.702
86.617
77.319
77.205
77.000
76.681
52.606
44.340
44.006
35.839
26.344
22.079
14.026
-0.016
NH
N
CO2Me
N
N
N
OH
Bn
220
200
180
160
140
120
100
80
60
40
20
0
ppm

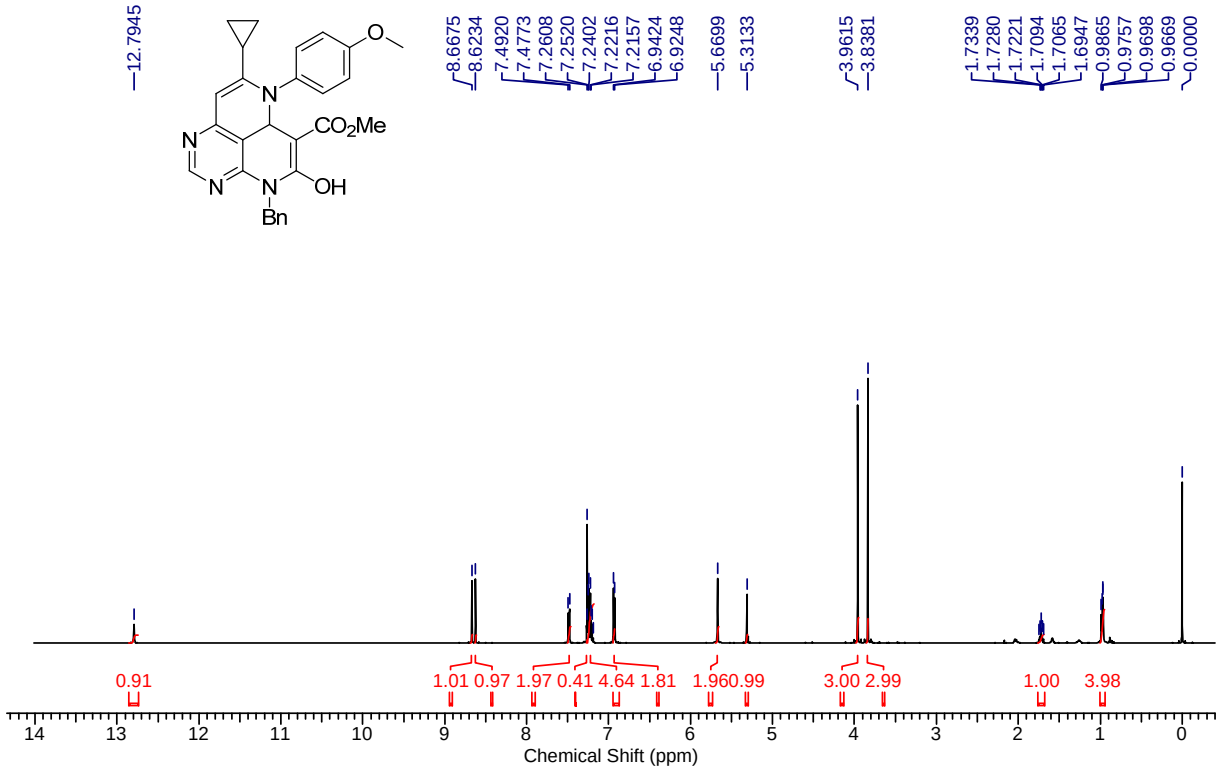
Compound 8f

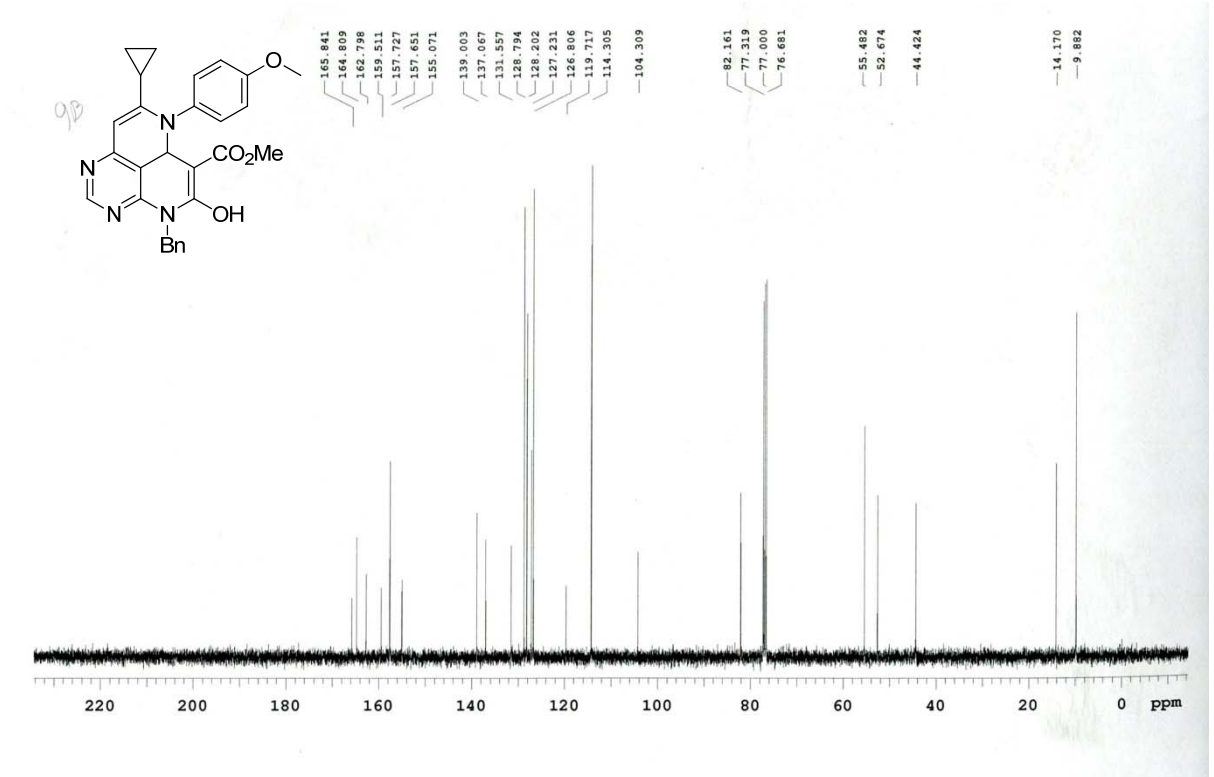

Boc
N
N
CO2Me
N
N
N
OH
Bn
11.1625
8.6920
8.5568
7.4890
7.4753
7.2637
7.2451
7.2304
7.2098
7.1951
5.6562
5.4622
4.1770
3.9488
3.2895
3.2768
2.7282
2.3804
2.3647
2.3491
1.8034
1.6712
1.4625
1.4400
1.4224
1.2549
1.0707
1.0560
1.0413
0.0000
0.93
0.98 0.97
2.04 2.64
1.93 0.95 1.78 3.00 1.89 1.54 2.15 2.14 1.12 2.17 8.70 2.04 3.09
Chemical Shift (ppm)
165.842
165.515
162.669
159.596
157.812
154.989
154.670
139.362
137.146
128.783
128.153
127.174
119.144
103.806
86.699
79.535
77.319
77.000
76.681
52.592
49.063
44.350
37.406
35.615
29.824
28.390
22.136
14.008
Chemical Shift (ppm)

Compound 9a

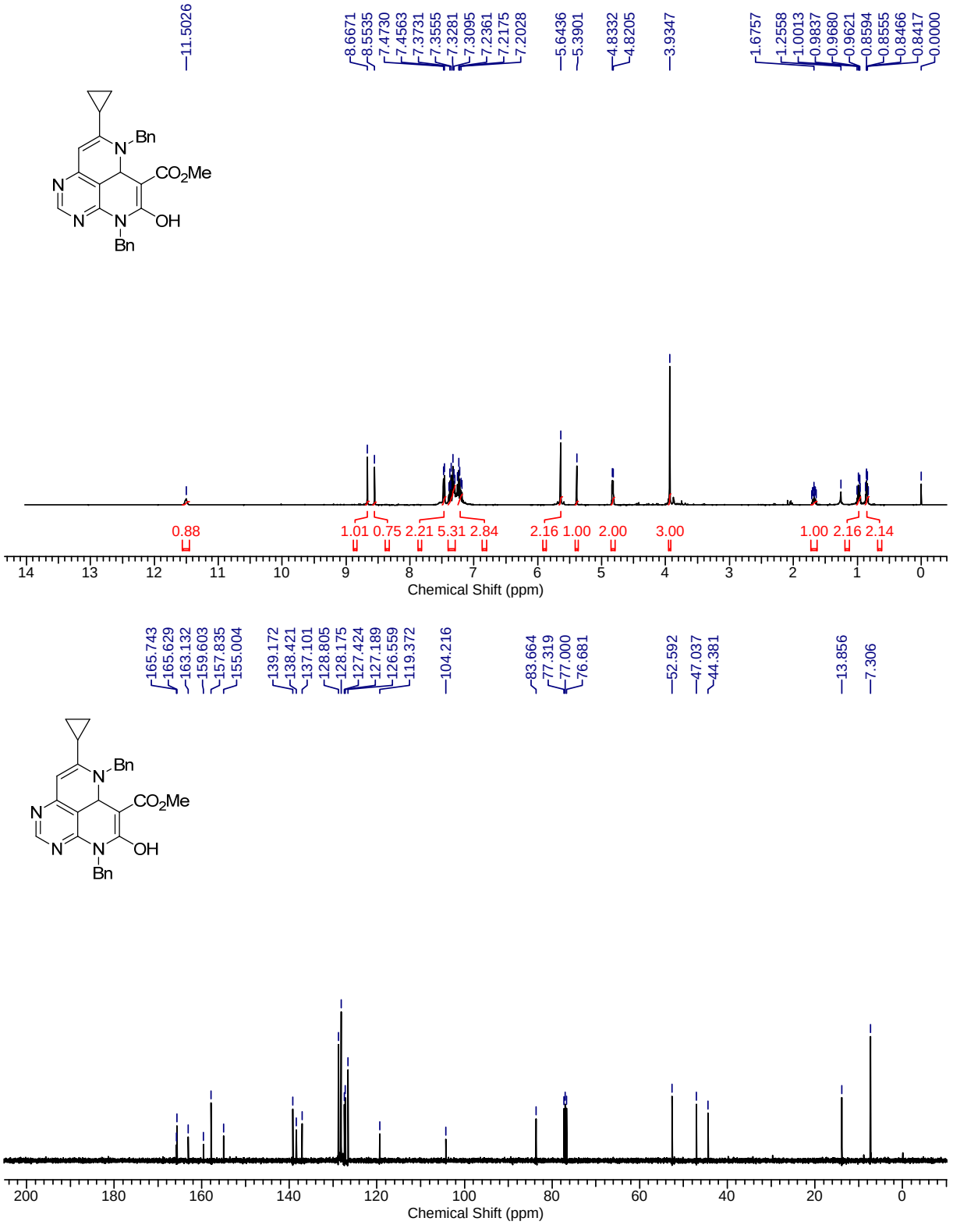

11.2409
8.6528
8.5881
7.4783
7.4645
7.2637
7.2578
7.2412
7.2265
7.2059
7.1912
5.6533
5.3368
5.2957
3.9458
3.7930
3.7822
3.7705
3.7597
3.6461
3.6353
3.6245
3.4452
1.7447
1.7280
1.0325
1.0286
1.0198
1.0158
0.8738
0.8620
0.8542
0.8513
0.0000
CO2Me
OH
Bn
1.04
1.04 1.00
2.13 3.29
1.98 0.99
3.00 2.18 2.10 3.02
1.13 2.13 2.15
Chemical Shift (ppm)
165.864
165.364
163.003
159.565
157.820
154.989
139.218
137.161
128.752
128.153
127.143
119.243
104.049
83.421
77.319
77.000
76.681
71.596
59.104
52.585
44.335
43.144
13.924
7.147
Chemical Shift (ppm)

Compound 9b

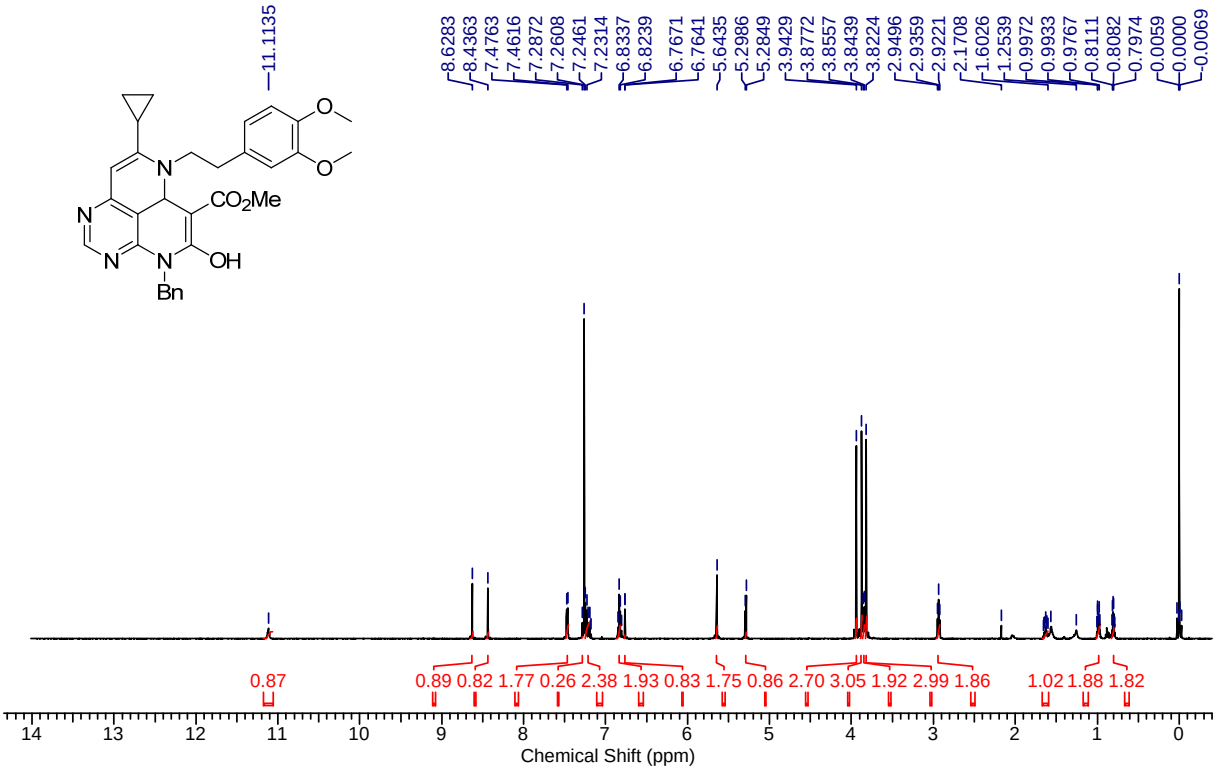

12.7945
8.6675
8.6234
7.4920
7.4773
7.2608
7.2520
7.2402
7.2216
7.2157
6.9424
6.9248
5.6699
5.3133
3.9615
3.8381
1.7339
1.7280
1.7221
1.7094
1.7065
1.6947
0.9865
0.9757
0.9698
0.9669
0.0000
CO2Me
OH
Bn
0.91
1.01
0.97
1.97
0.41
4.64
1.81
1.96
0.99
3.00
2.99
1.00
3.98
Chemical Shift (ppm)

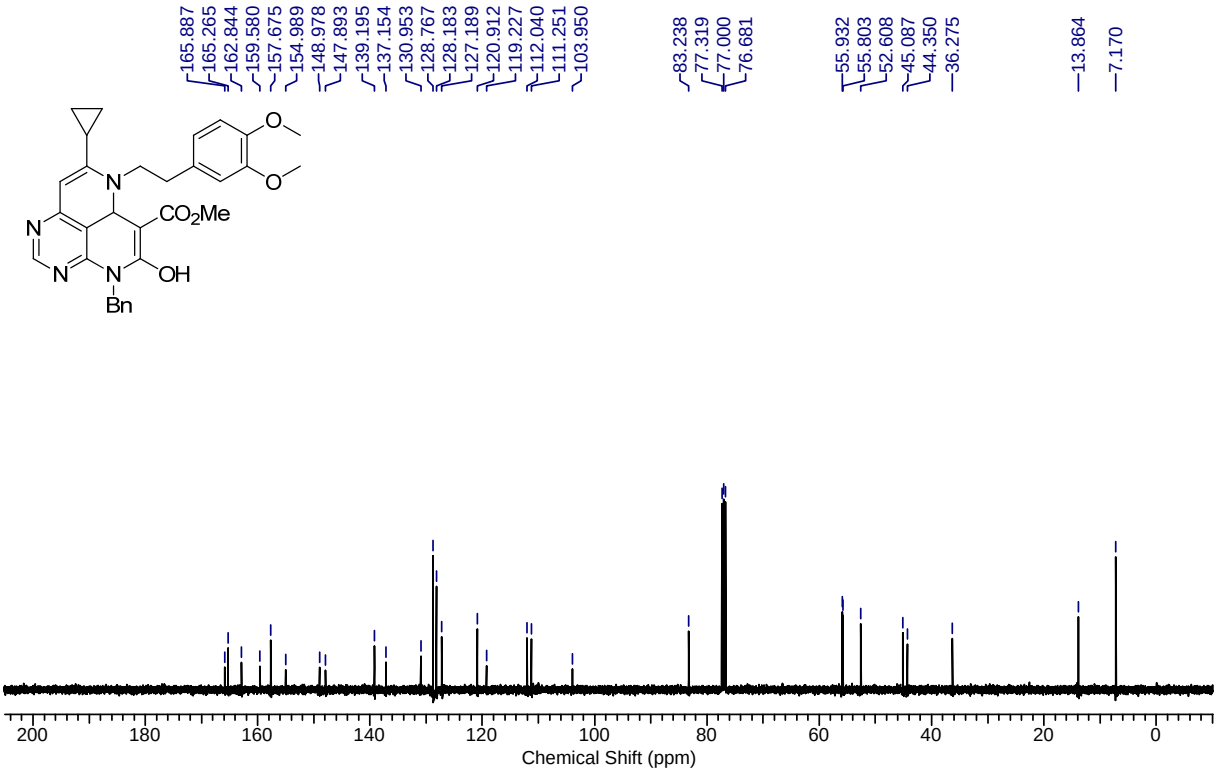

165.841
164.809
162.798
159.511
157.727
157.651
155.071
139.003
137.067
131.557
128.794
128.202
127.231
126.806
119.717
114.305
104.309
82.161
77.319
77.000
76.681
55.482
52.674
44.424
14.170
9.882
CO2Me
OH
Bn
ppm

Compound 9c

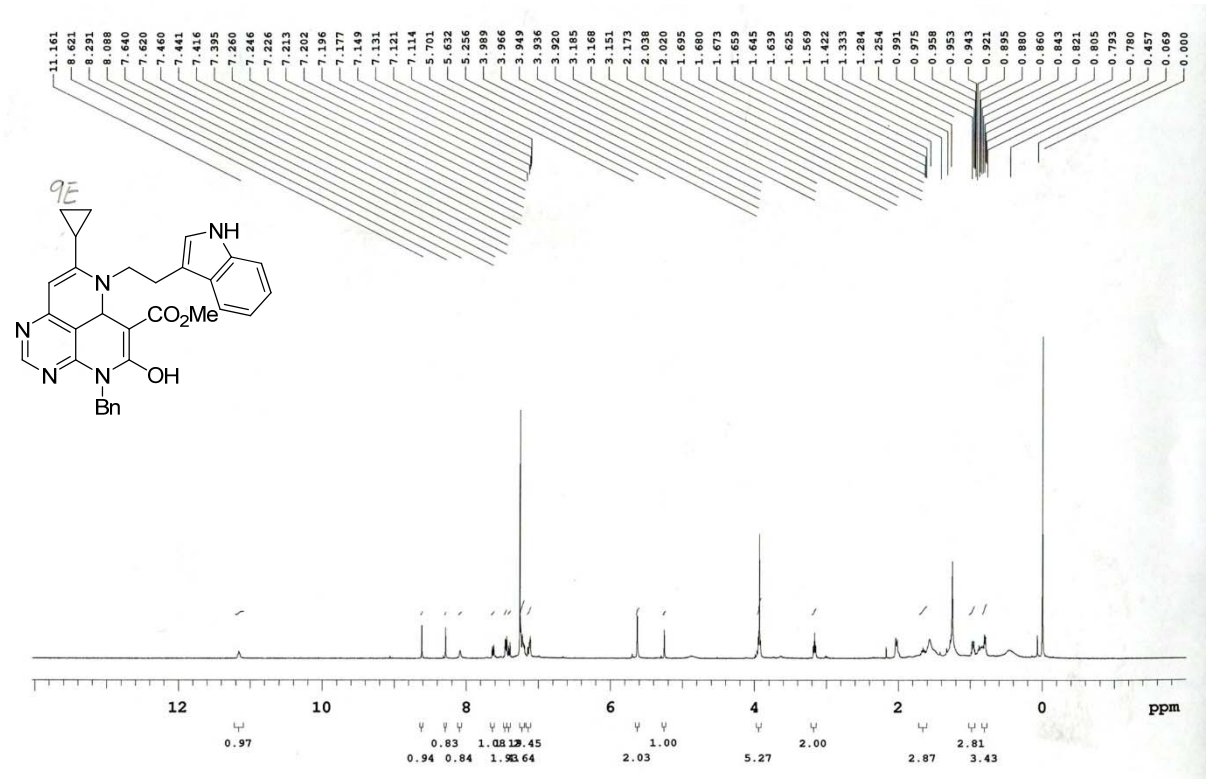

11.5026
8.6671
8.5535
7.4730
7.4563
7.3731
7.3555
7.3281
7.3095
7.2361
7.2175
7.2028
5.6436
5.3901
4.8332
4.8205
3.9347
1.6757
1.2558
1.0013
0.9837
0.9680
0.9621
0.8594
0.8555
0.8466
0.8417
0.0000
Bn
N
CO2Me
N
N
OH
Bn
0.88
1.01
0.75
2.21
5.31
2.84
2.16
1.00
2.00
3.00
1.00
2.16
2.14
Chemical Shift (ppm)
165.743
165.629
163.132
159.603
157.835
155.004
139.172
138.421
137.101
128.805
128.175
127.424
127.189
126.559
119.372
104.216
83.664
77.319
77.000
76.681
52.592
47.037
44.381
13.856
7.306
Chemical Shift (ppm)

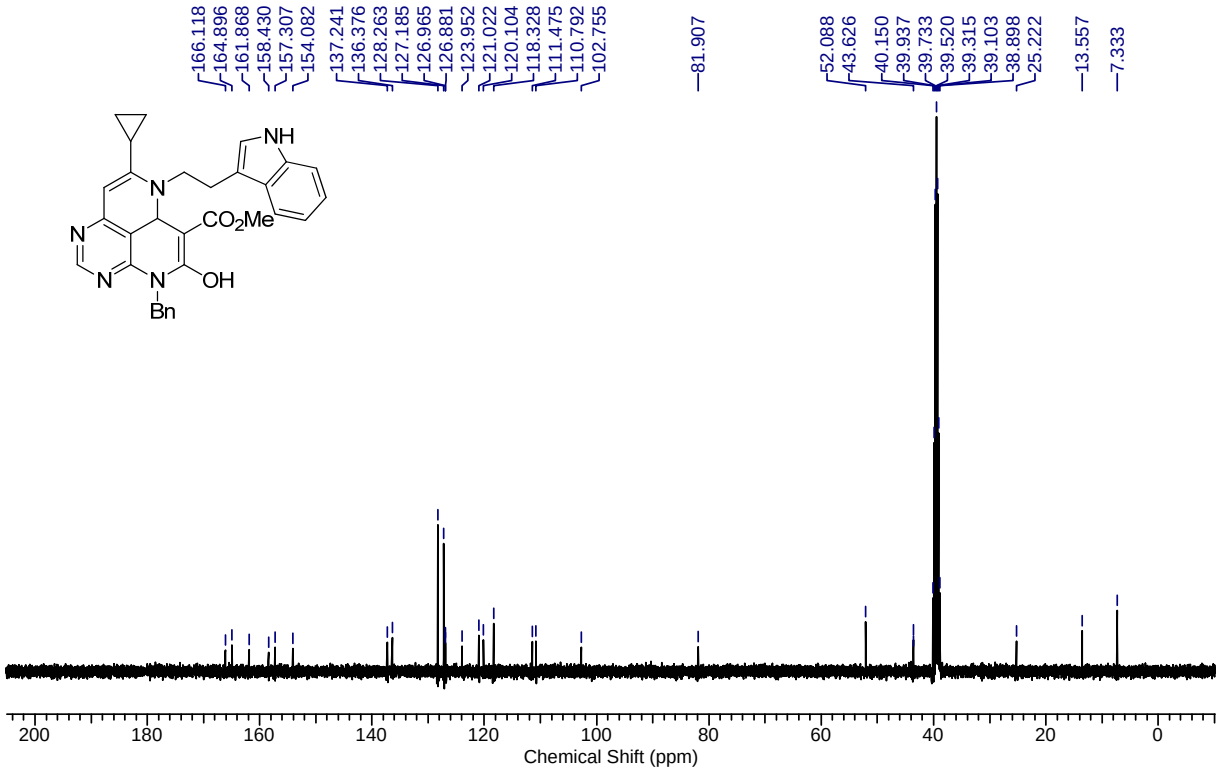
Compound 9d


11.1135
8.6283
8.4363
7.4763
7.4616
7.2872
7.2608
7.2461
7.2314
6.8337
6.8239
6.7671
6.7641
5.6435
5.2986
5.2849
3.9429
3.8772
3.8557
3.8439
3.8224
2.9496
2.9359
2.9221
2.1708
1.6026
1.2539
0.9972
0.9933
0.9767
0.8111
0.8082
0.7974
0.0059
0.0000
0.0069
CO2Me
OH
Bn
0.87
0.89 0.82 1.77 0.26 2.38 1.93 0.83 1.75 0.86 2.70 3.05 1.92 2.99 1.86
1.02 1.88 1.82
Chemical Shift (ppm)

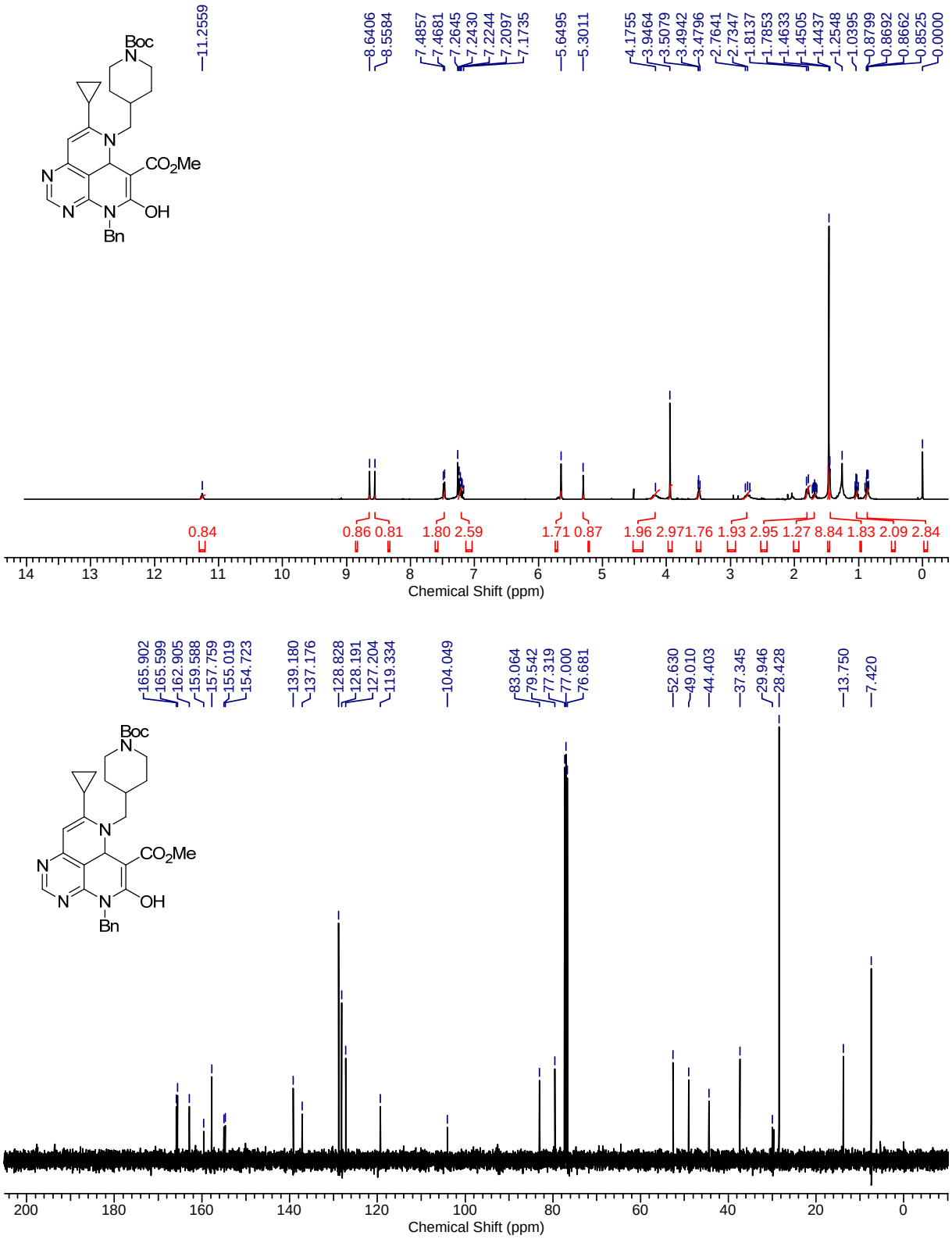

165.887
165.265
162.844
159.580
157.675
154.989
148.978
147.893
139.195
137.154
130.953
128.767
128.183
127.189
120.912
119.227
112.040
111.251
103.950
83.238
77.319
77.000
76.681
55.932
55.803
52.608
45.087
44.350
36.275
13.864
7.170
CO2Me
OH
Bn
Chemical Shift (ppm)

Compound 9e

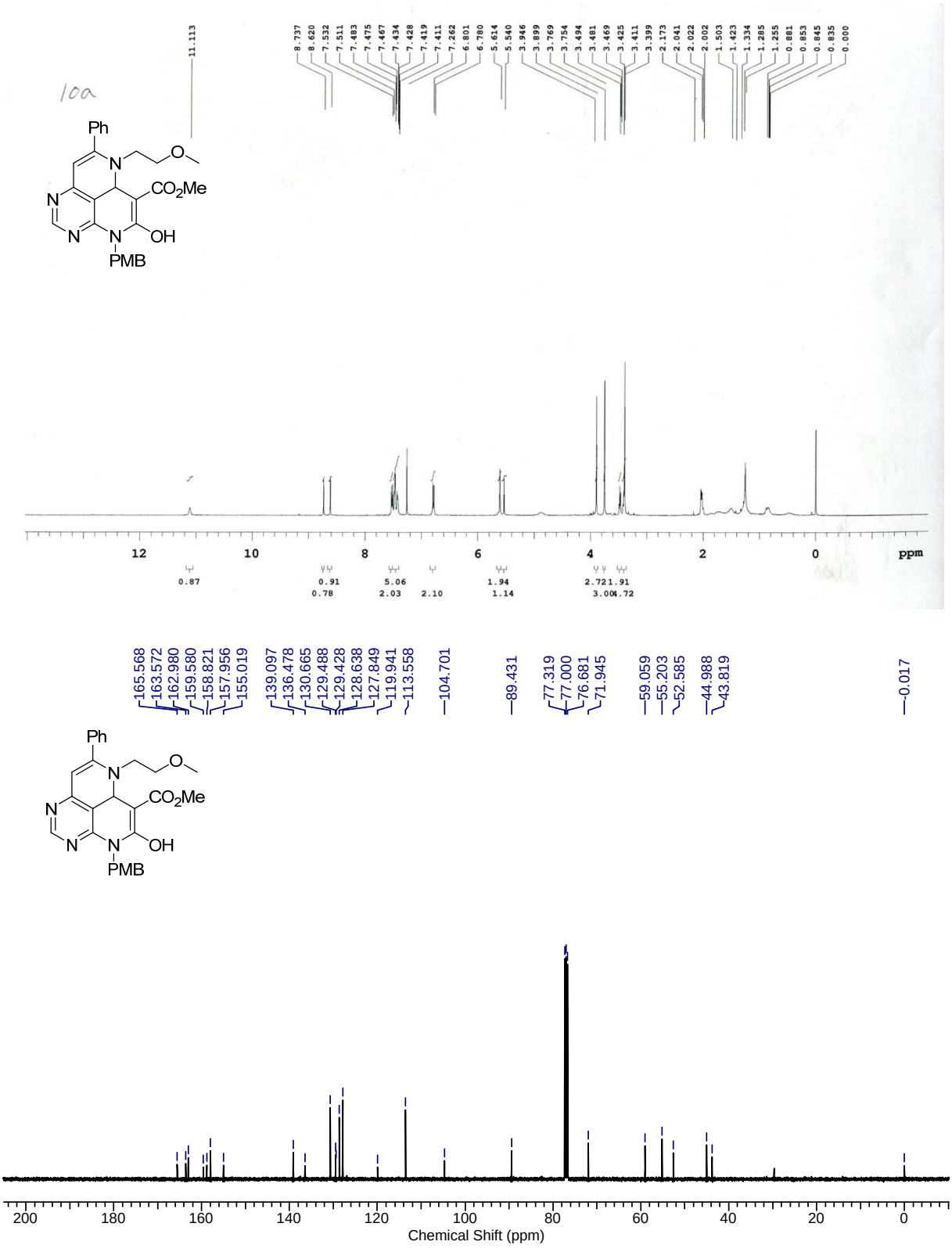

9E
NH
N
CO2Me
N
N
N
OH
Bn
ppm


NH
N
CO2Me
N
N
N
OH
Bn
Chemical Shift (ppm)

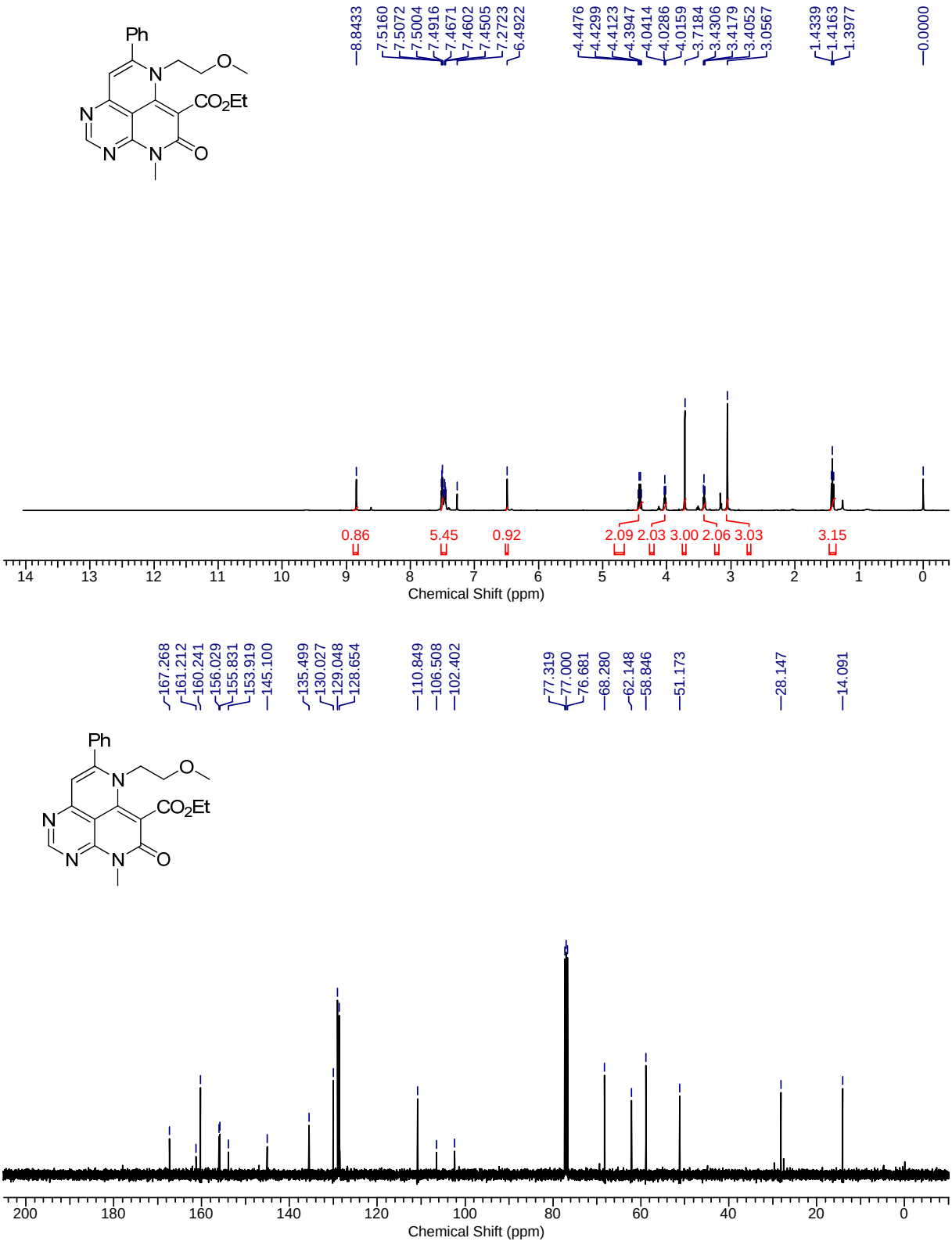
Compound 9f



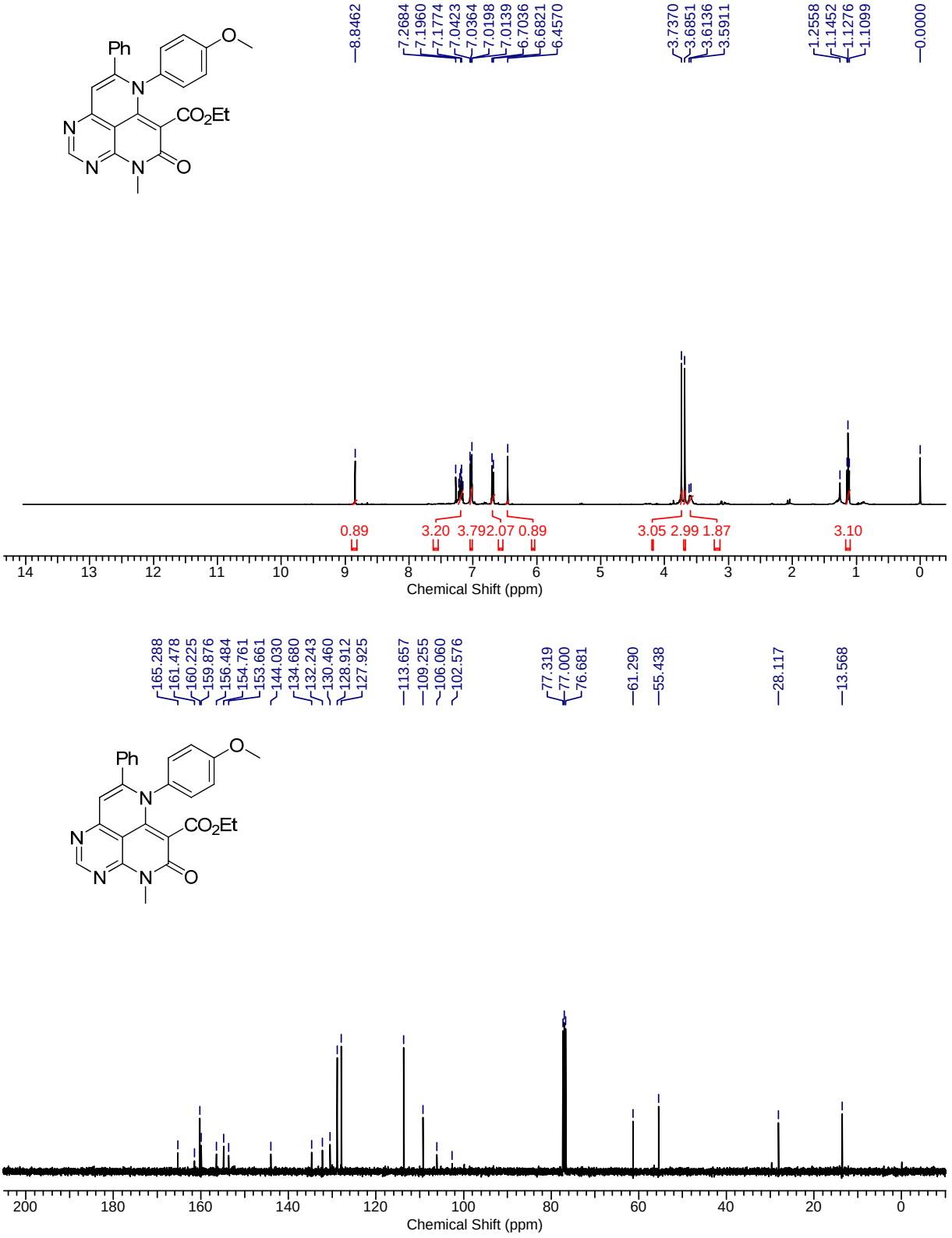
Compound 10a



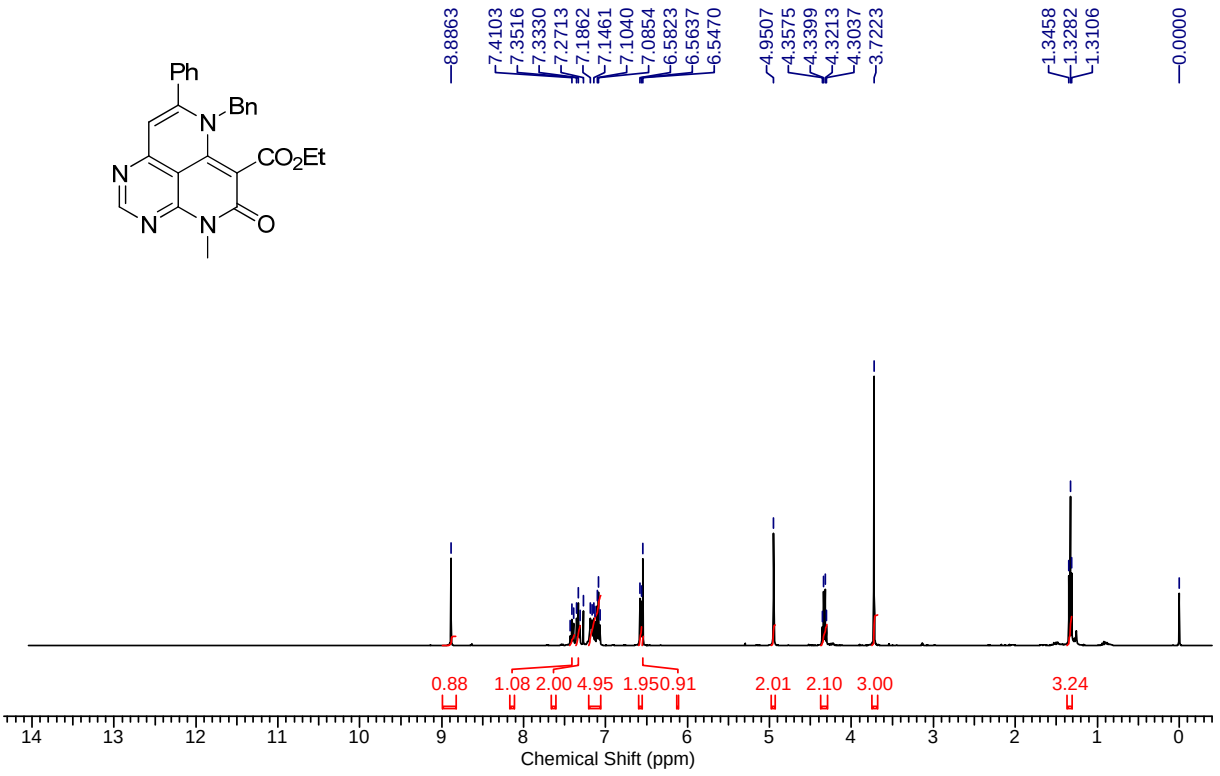
Compound 11a

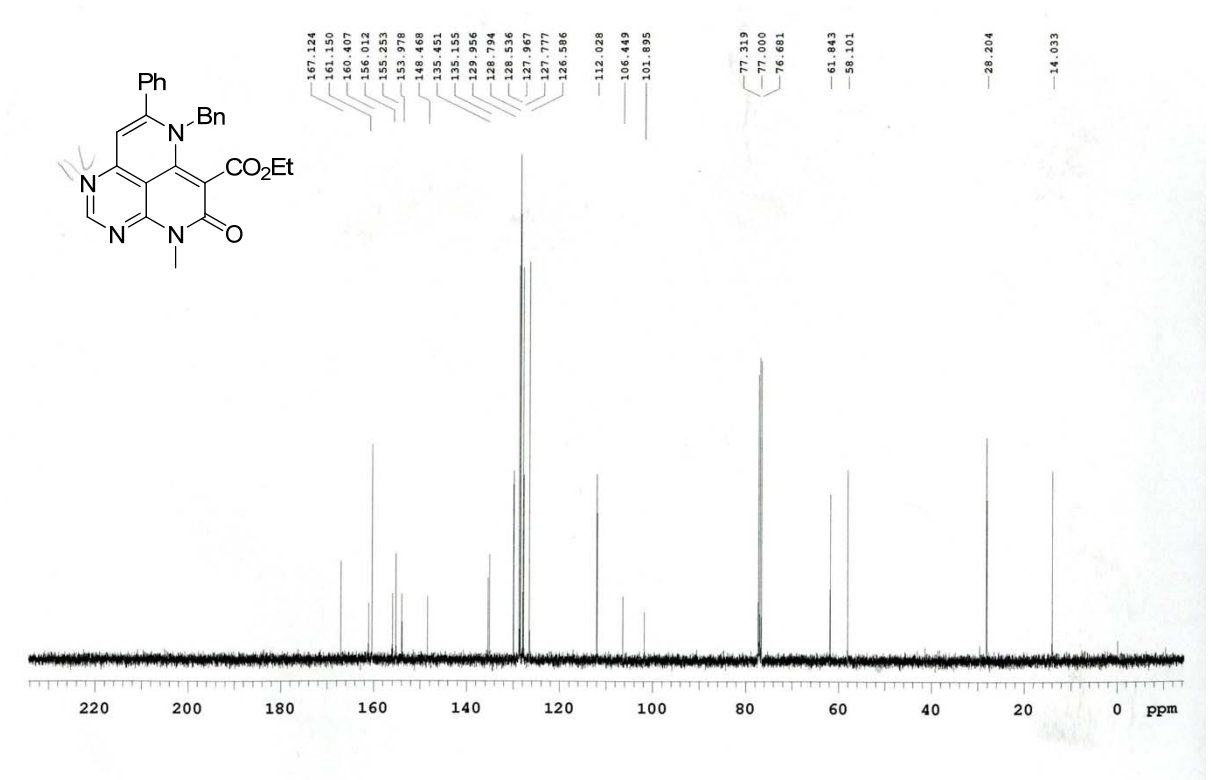


Compound 11b

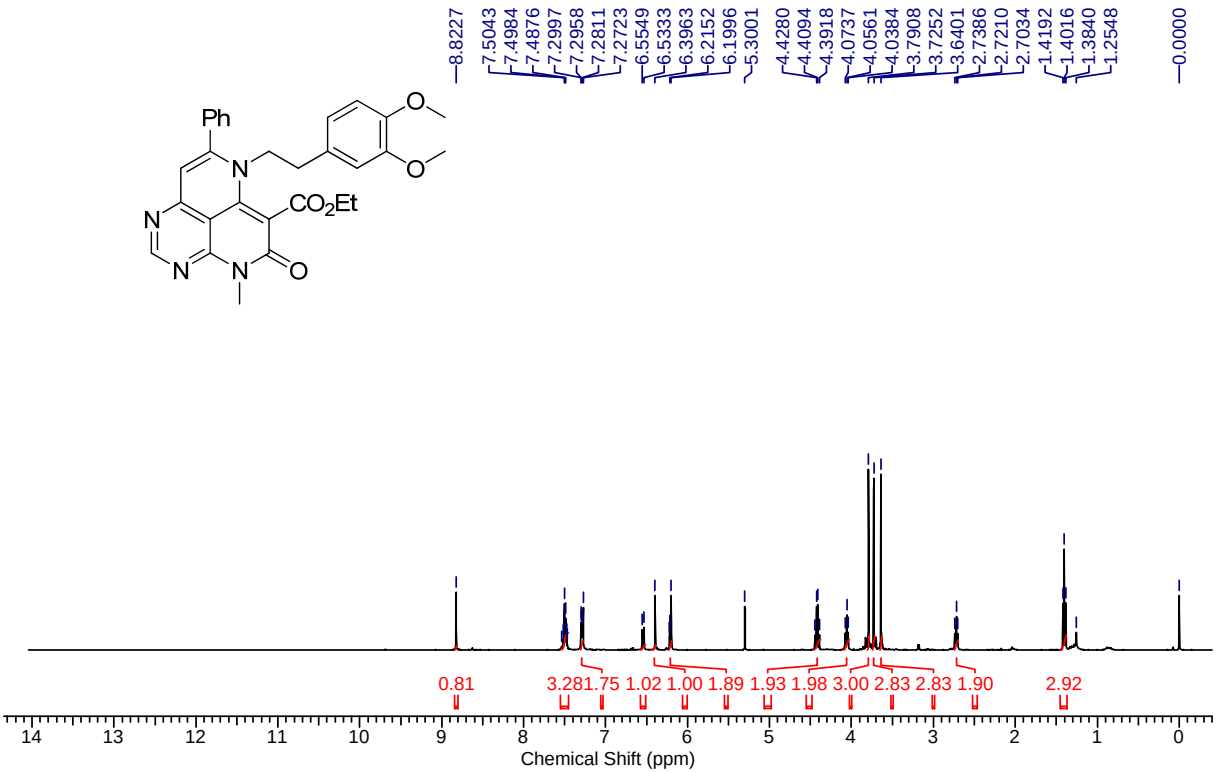


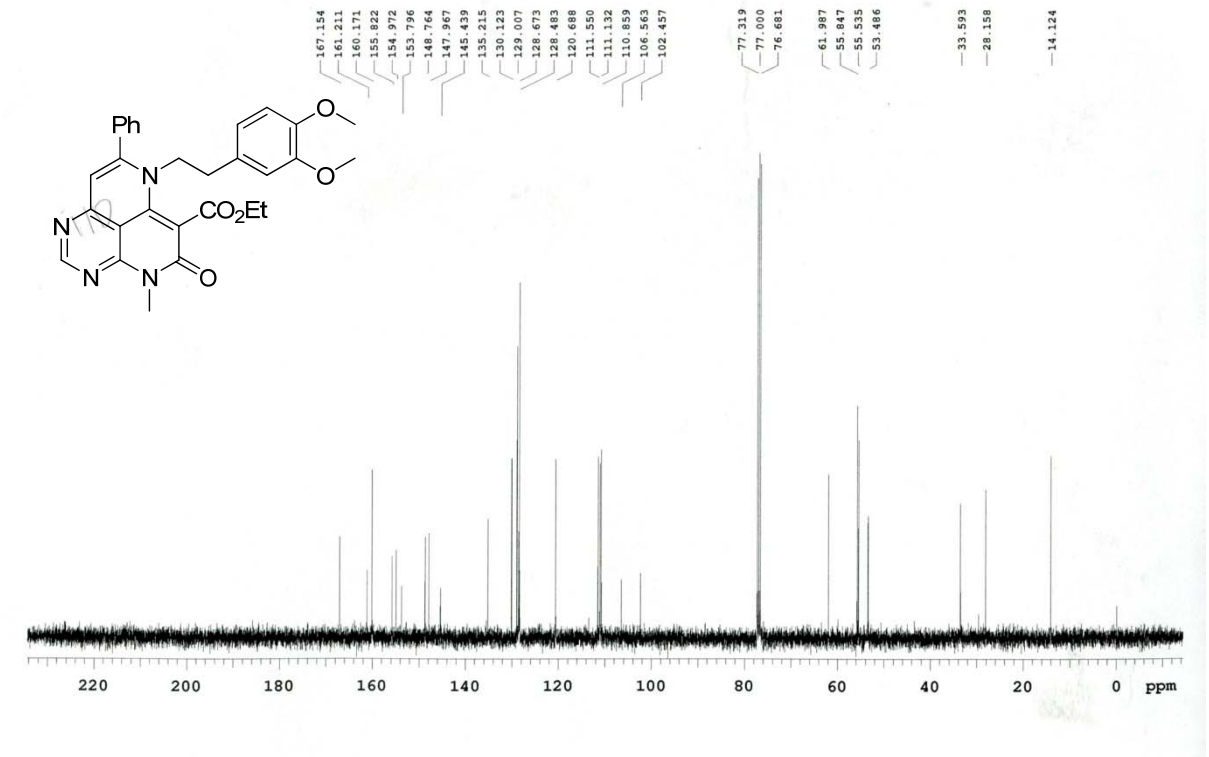
Compound 11c



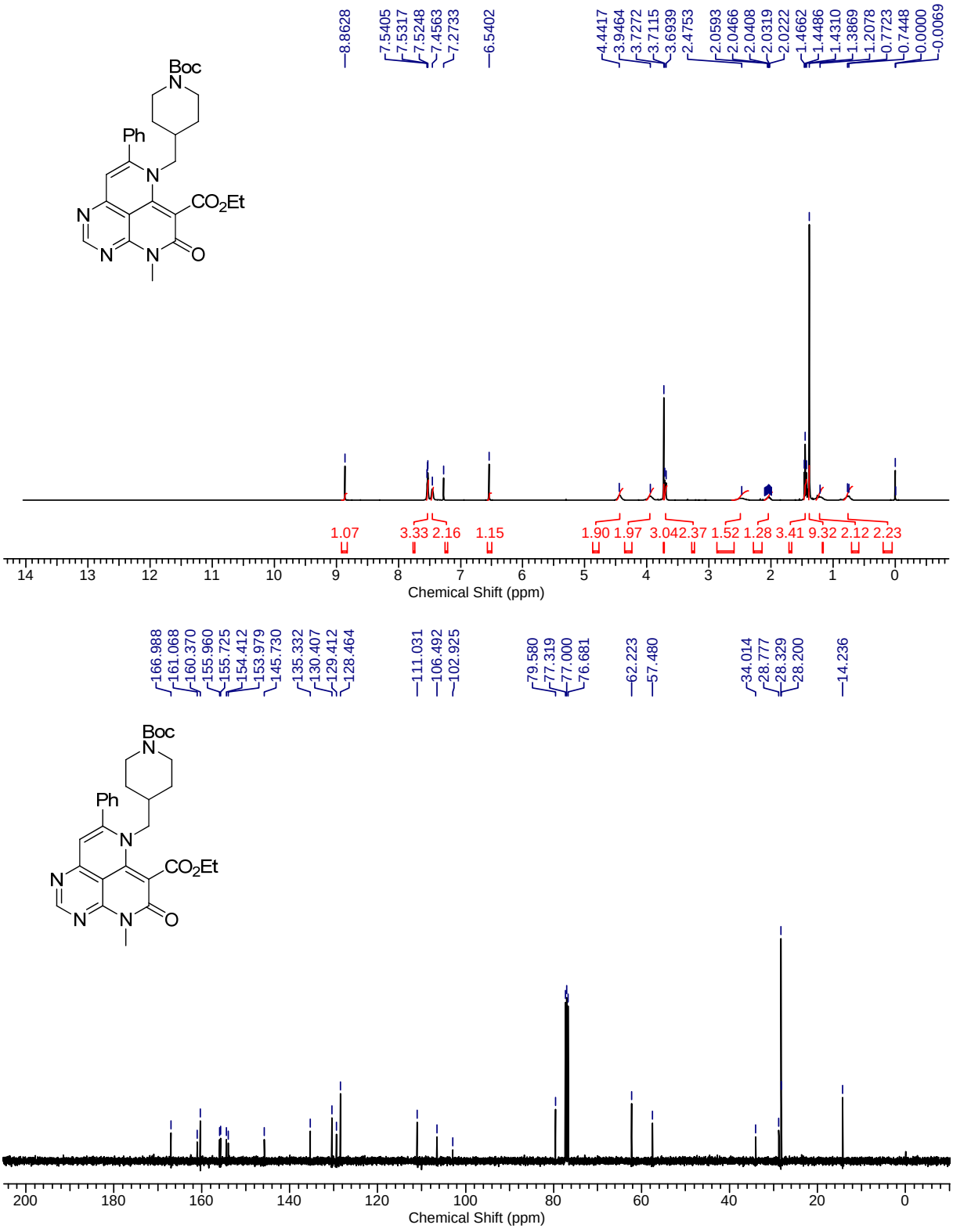


Compound 11d

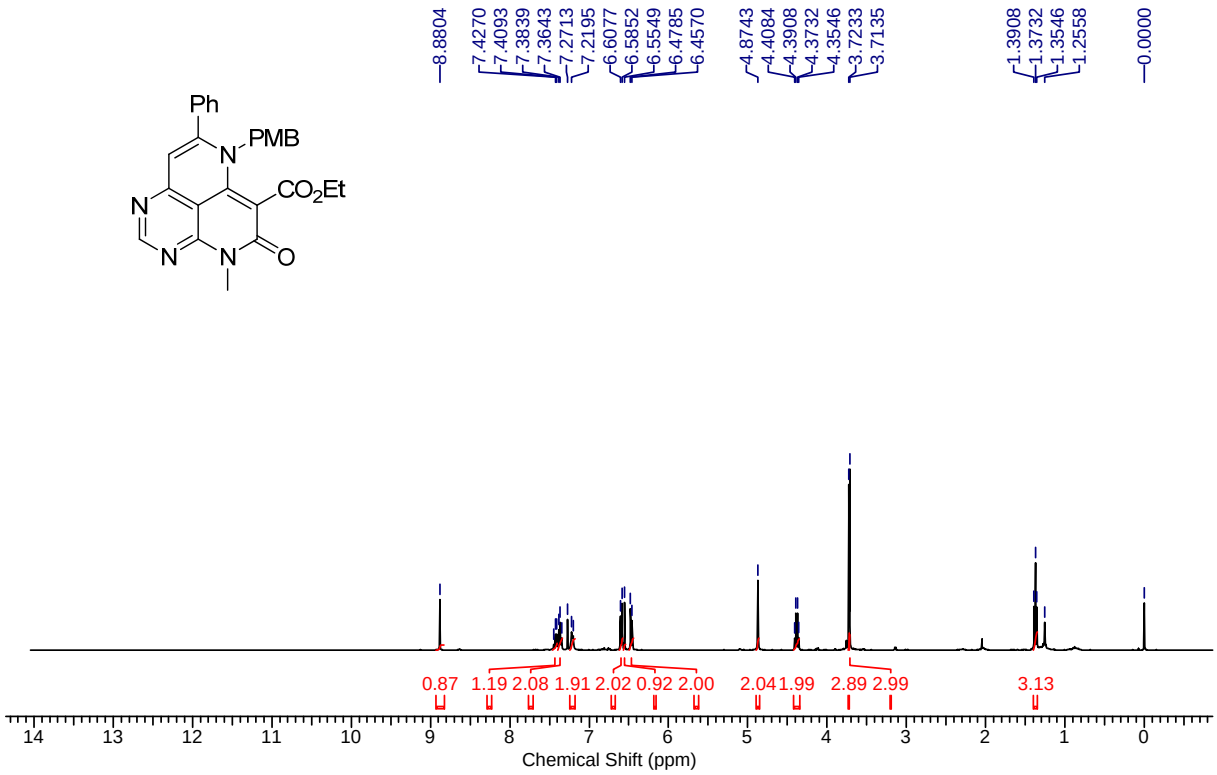


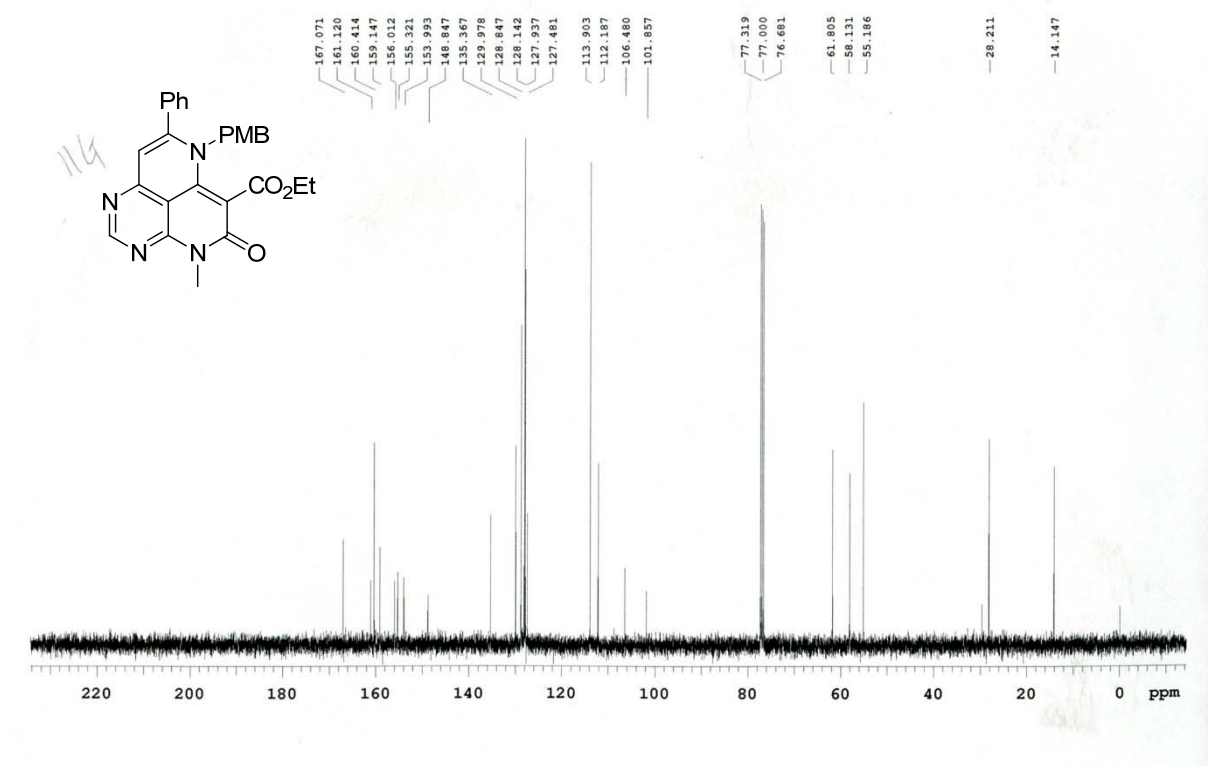


Compound 11f

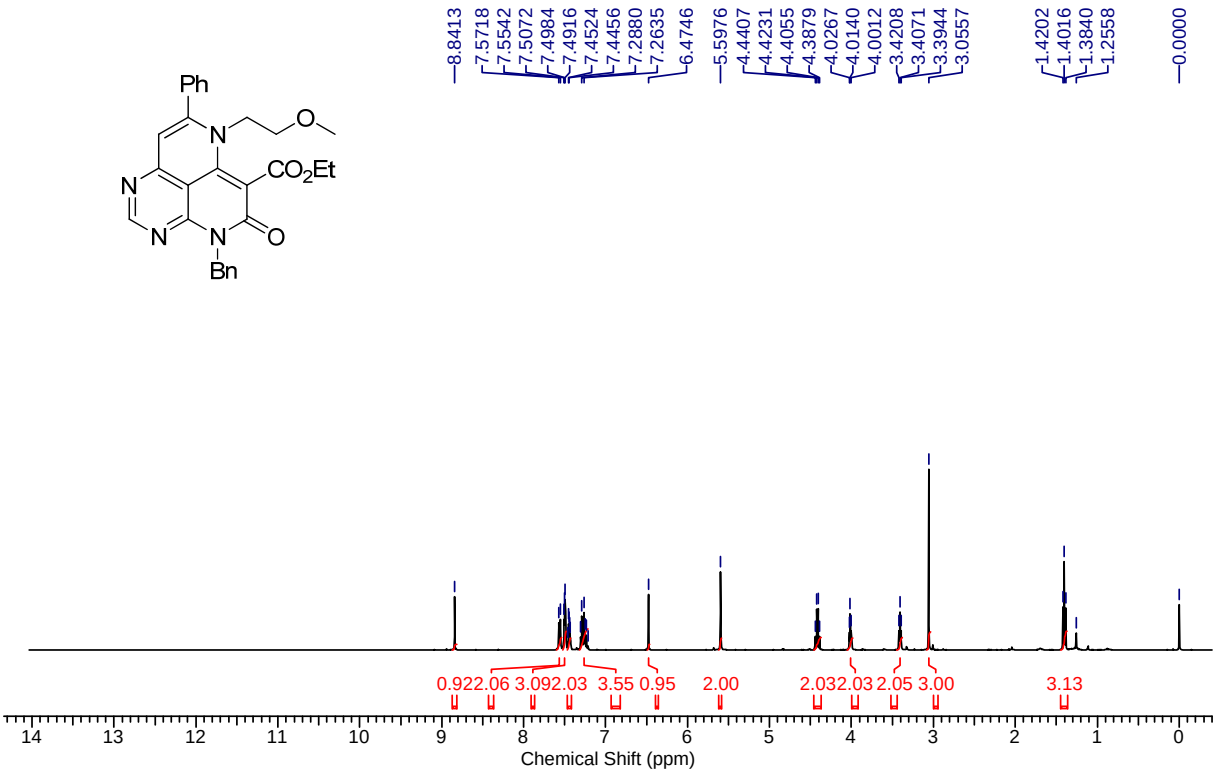


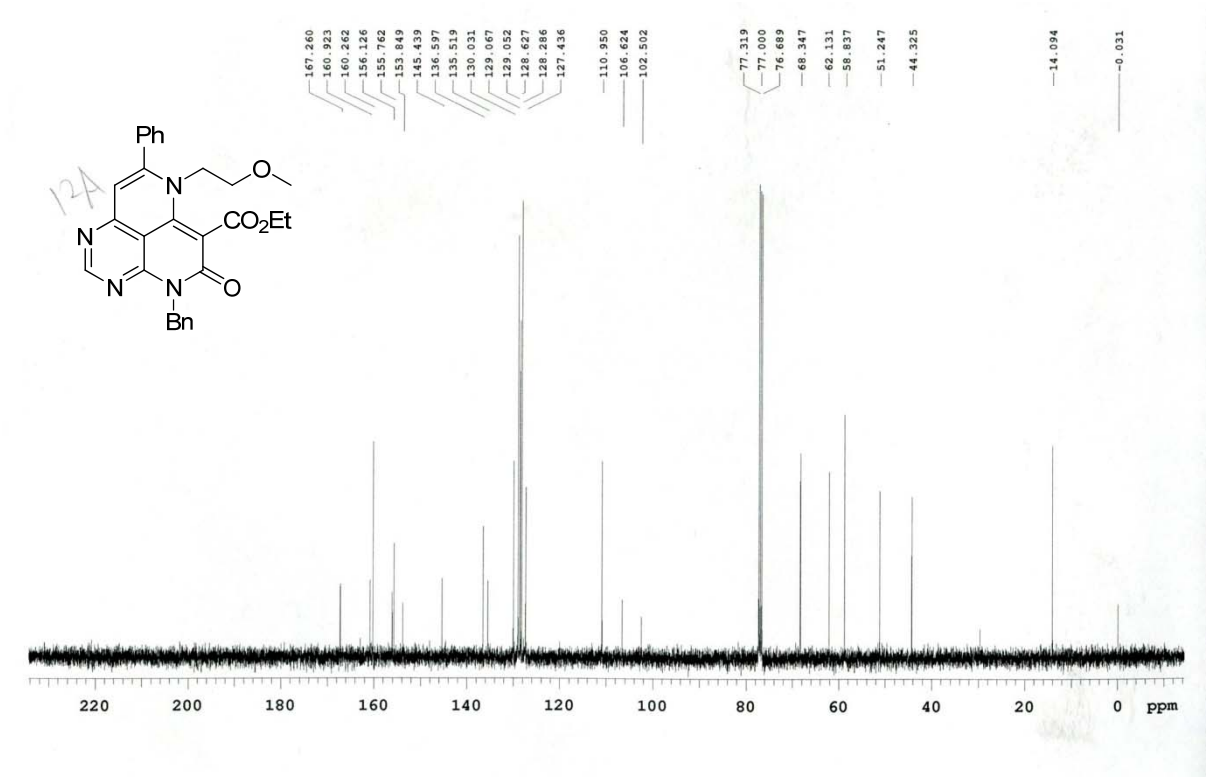
Compound 11g



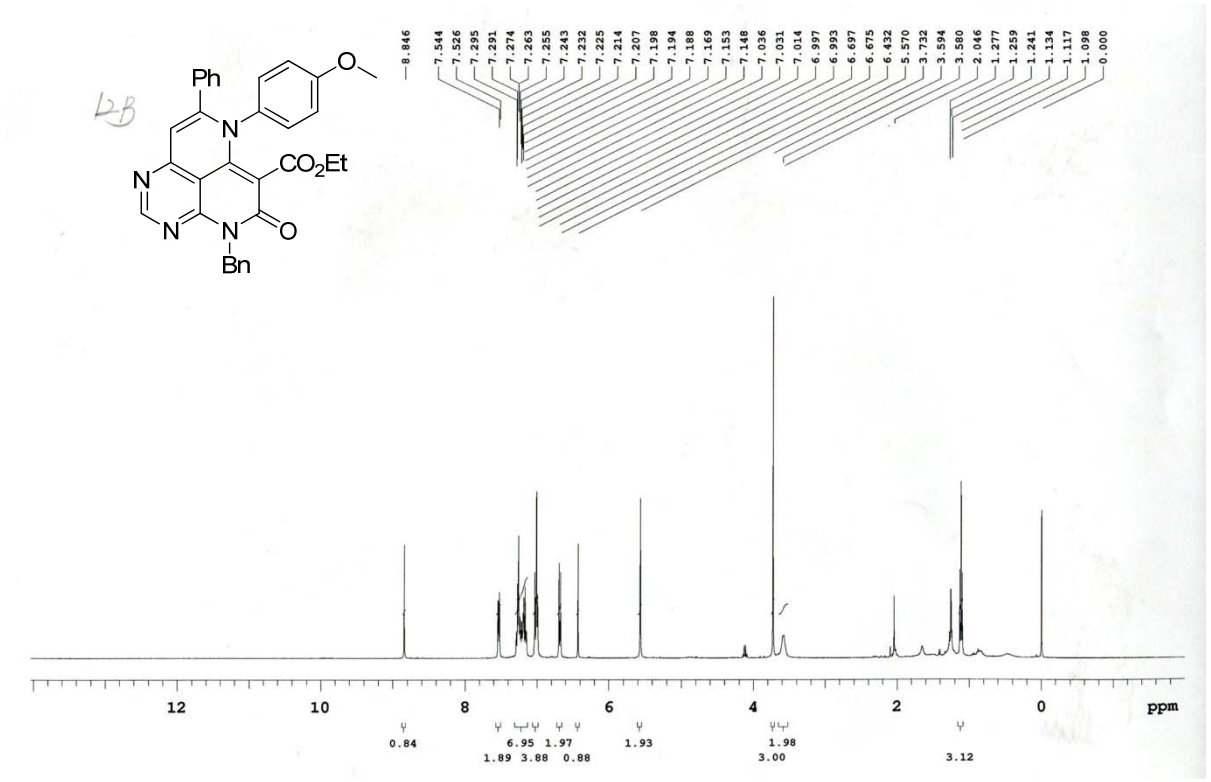


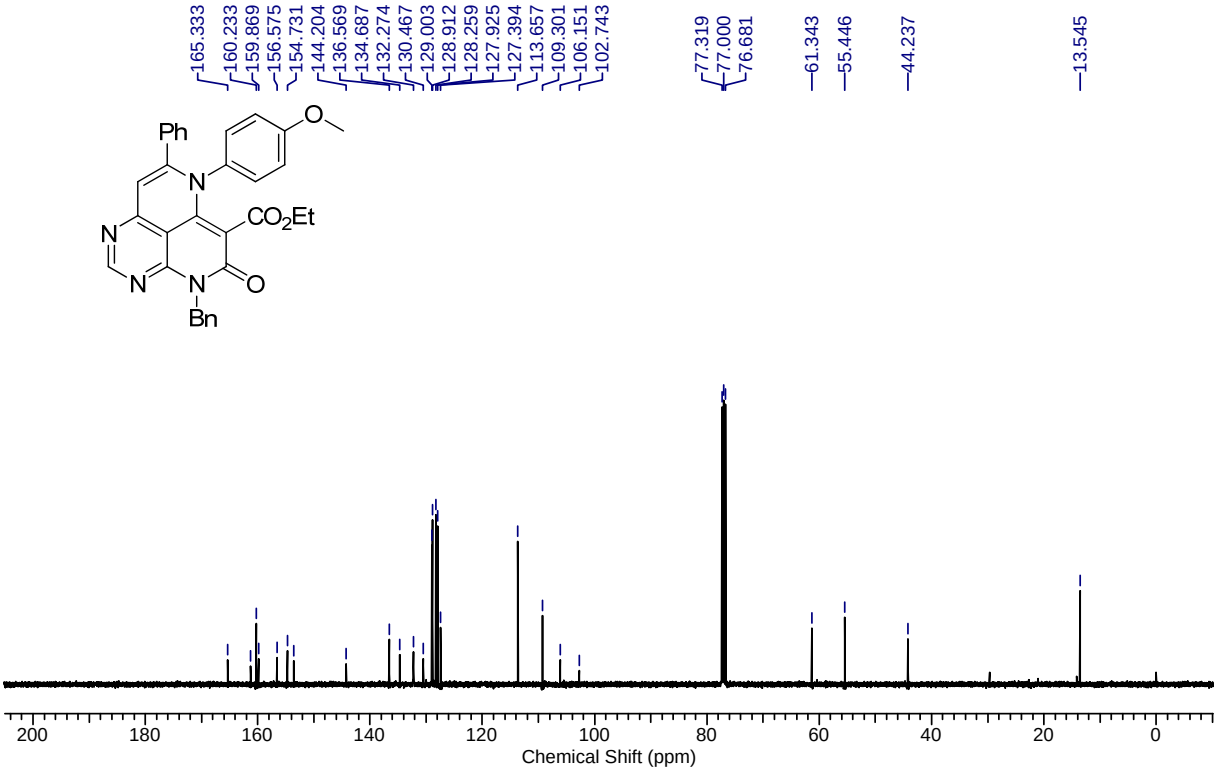
Compound 12a



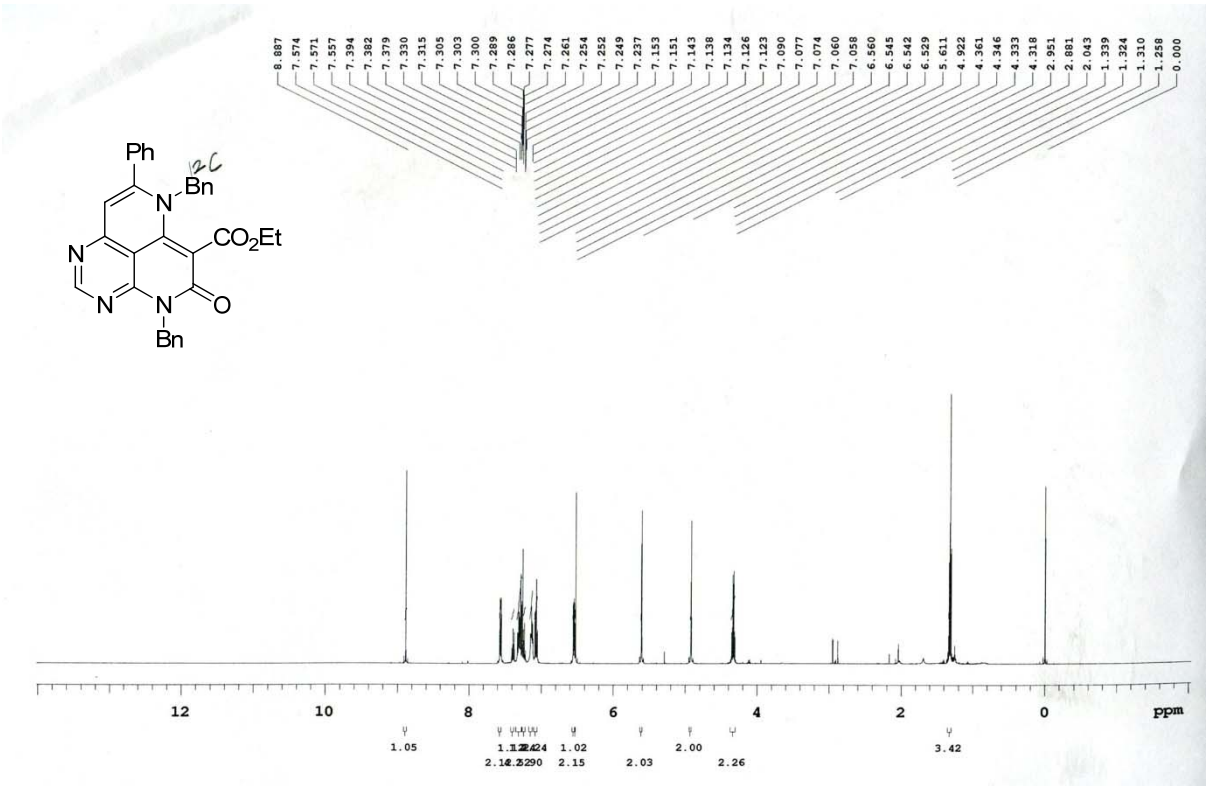


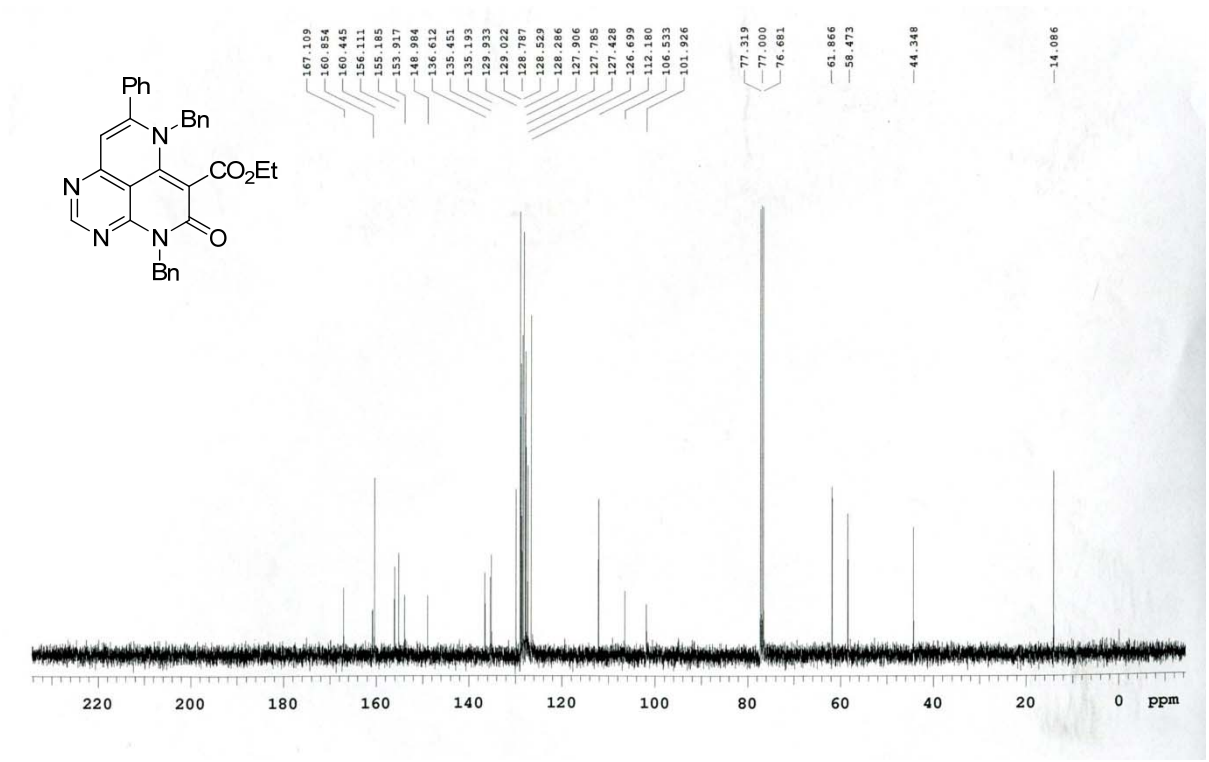
Compound 12b



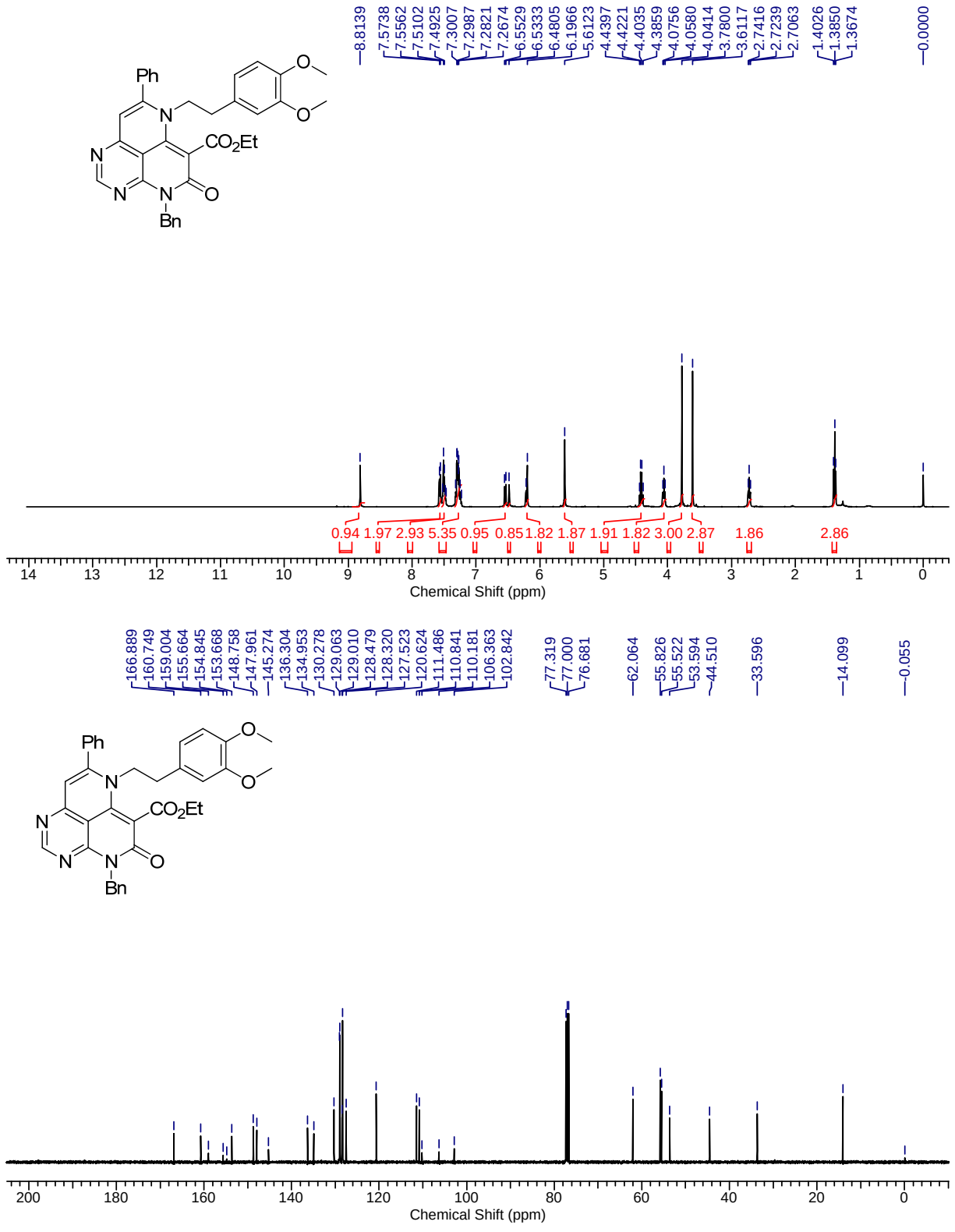


Compound 12c

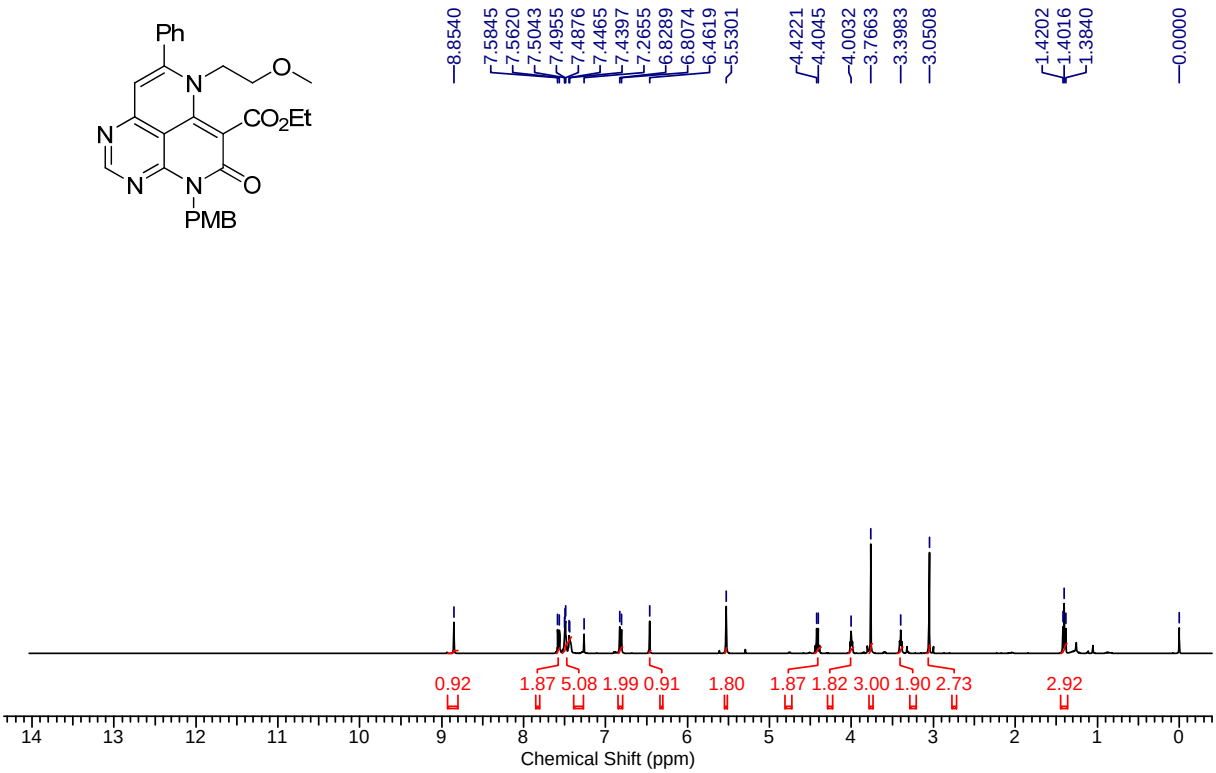


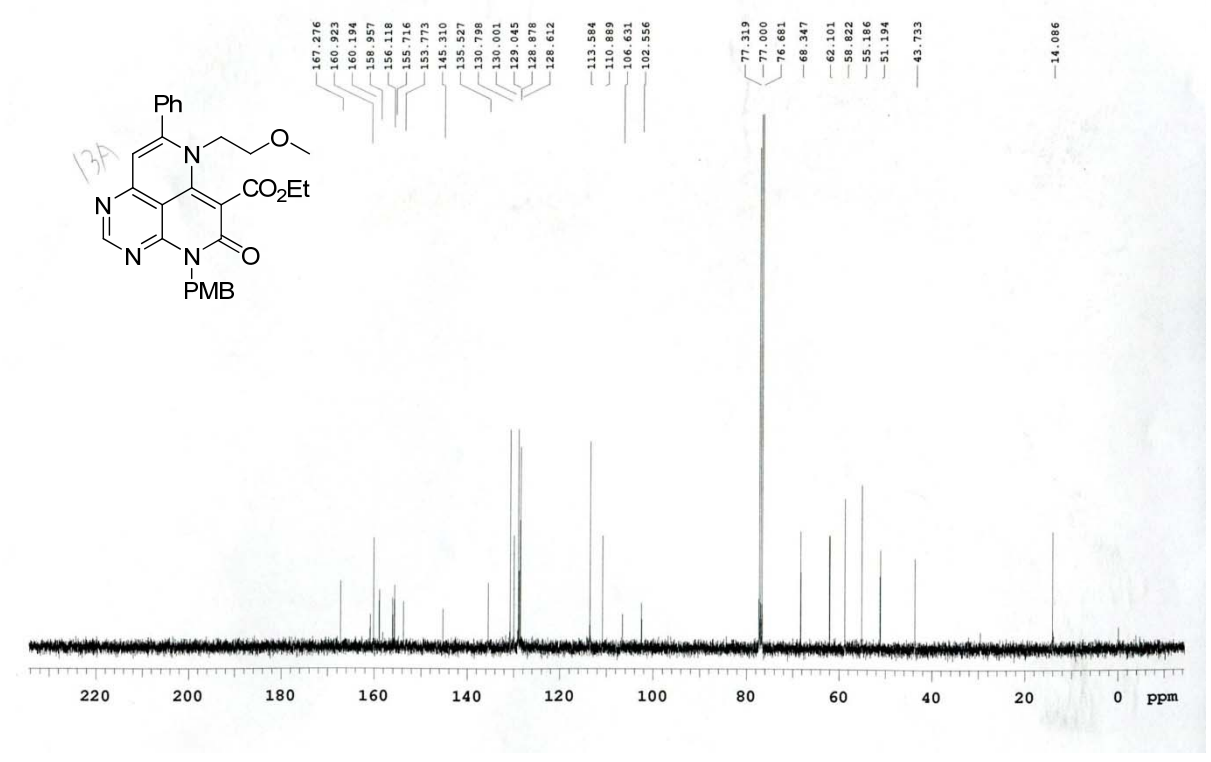


Compound 12d

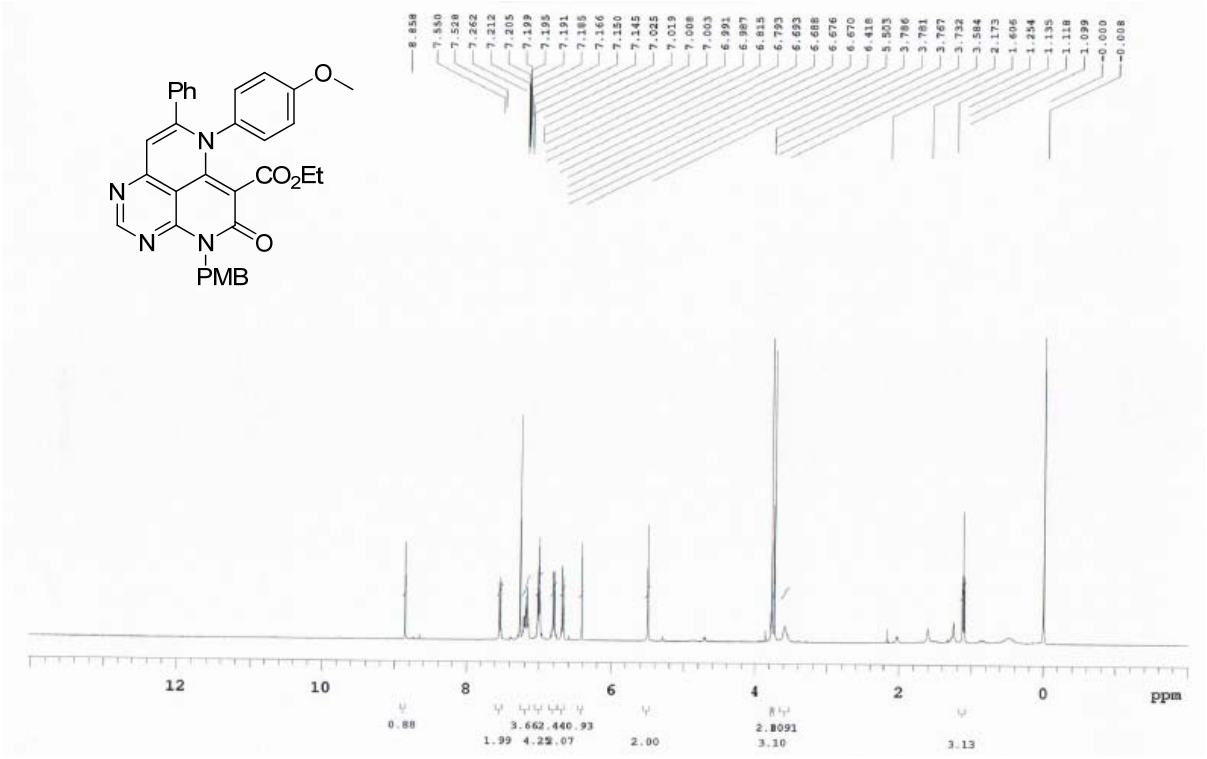


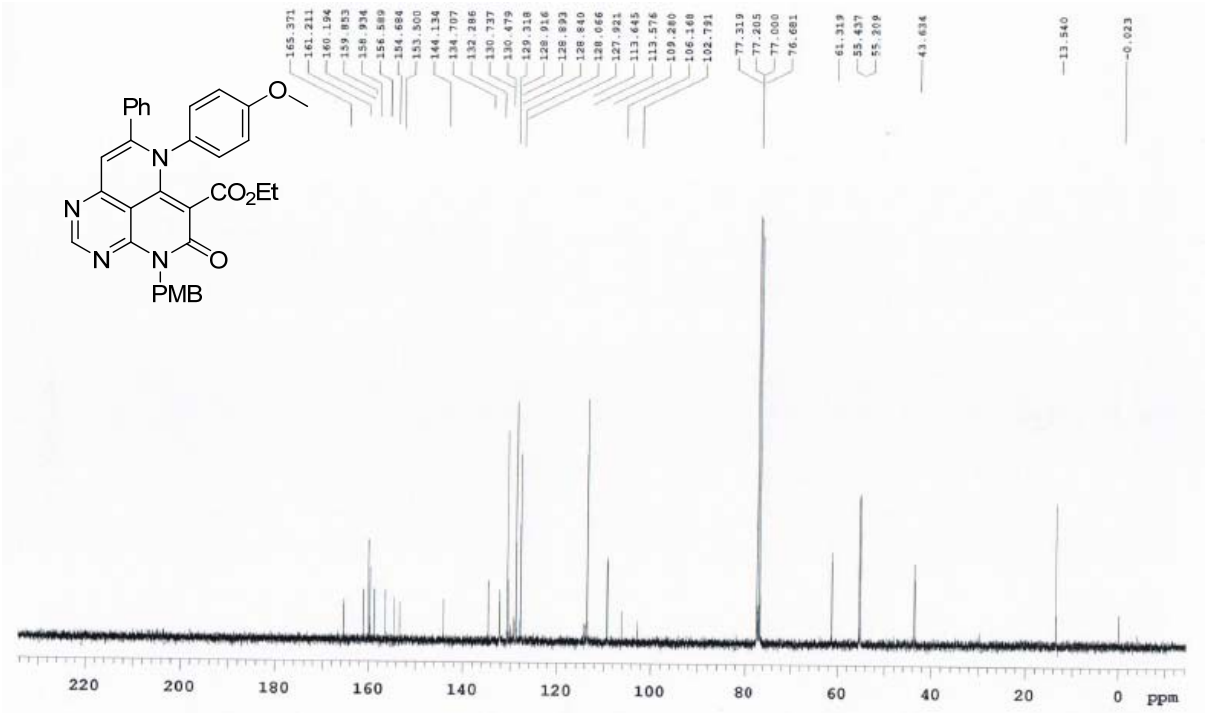
Compound 13a



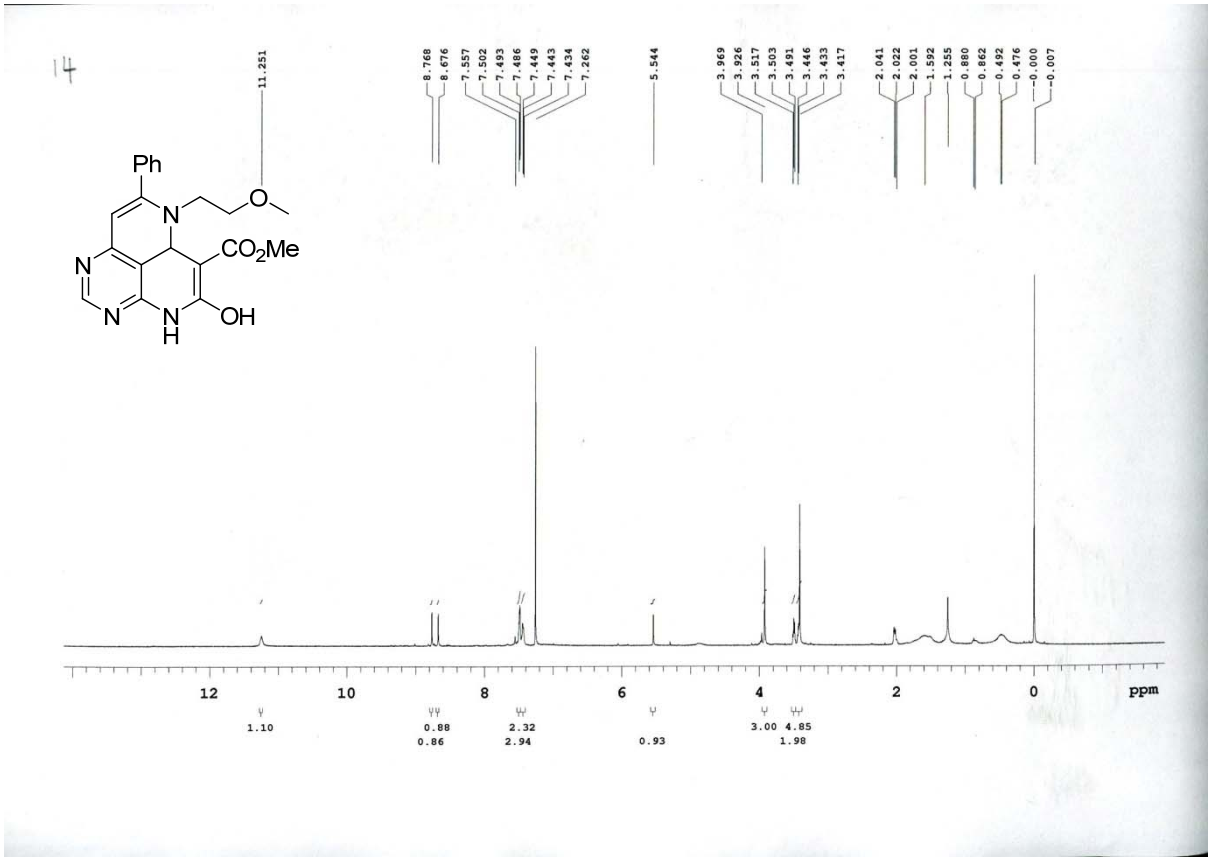


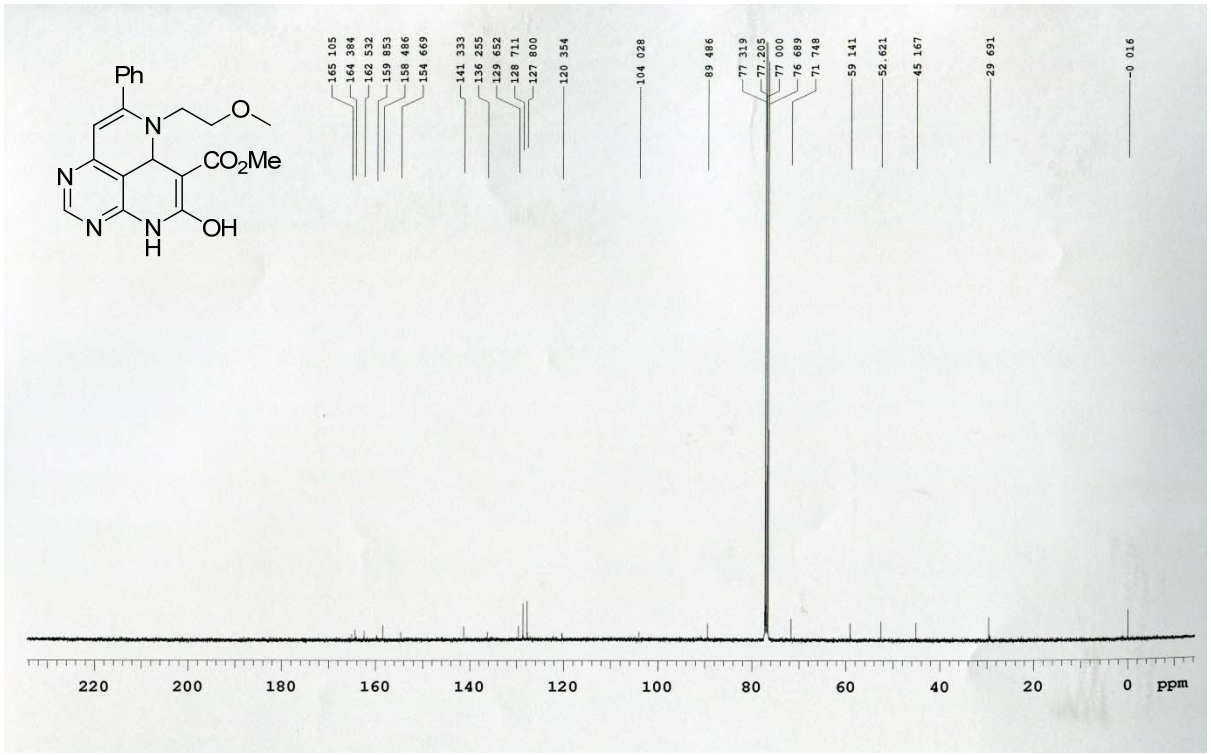
Compound 13b


Ph
O
N
CO2Et
N
N
N
O
PMB
12
10
8
6
4
2
0
ppm

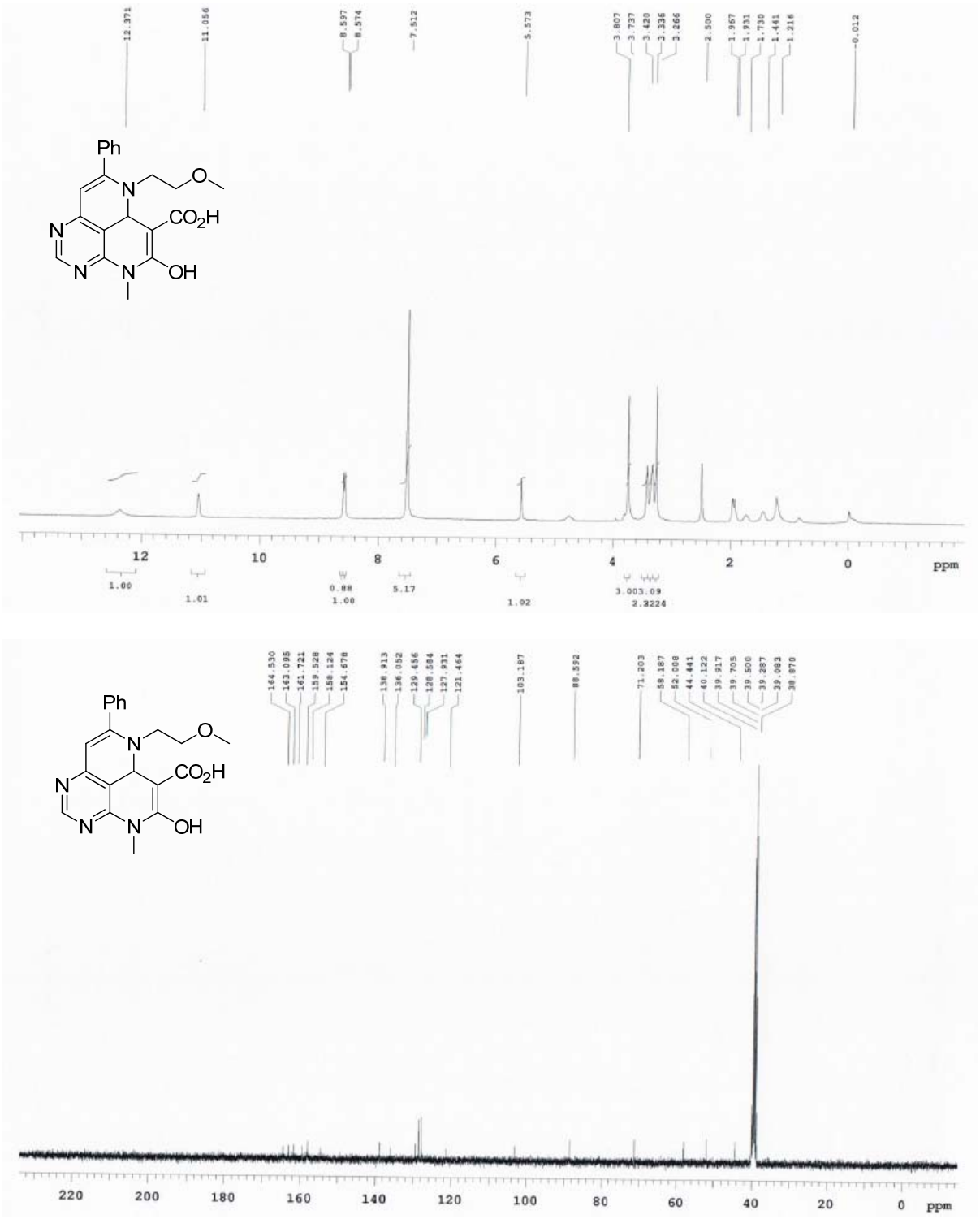

Ph
O
N
CO2Et
N
N
N
O
PMB
220
200
180
160
140
120
100
80
60
40
20
0
ppm

Compound 14

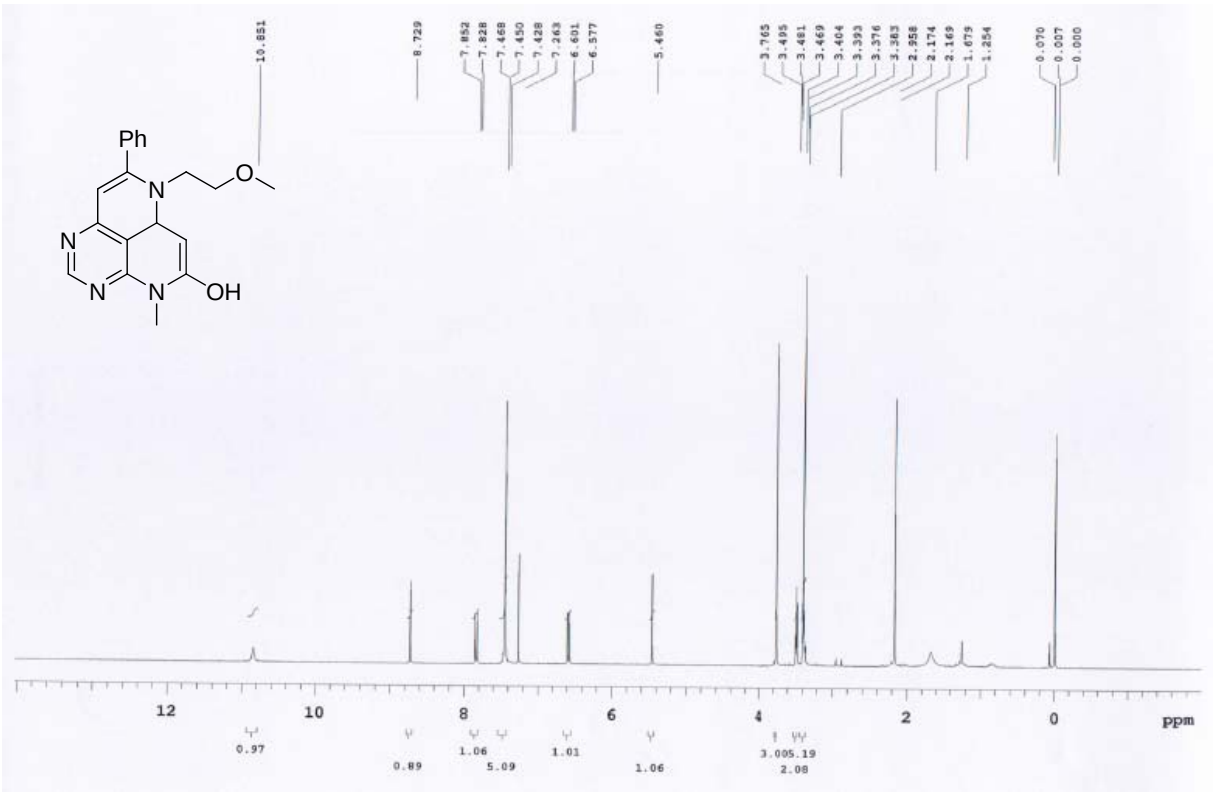

11.251
8.768
8.676
7.557
7.502
7.493
7.486
7.449
7.443
7.434
7.262
5.544
3.969
3.926
3.517
3.503
3.491
3.446
3.433
3.417
2.041
2.022
2.001
1.592
1.255
0.880
0.862
0.492
0.476
0.000
-0.007
Ph
N
O
CO2Me
N
N
N
H
OH
12
10
8
6
4
2
0
ppm
1.10
0.88
0.86
2.32
2.94
0.93
3.00
4.85
1.98

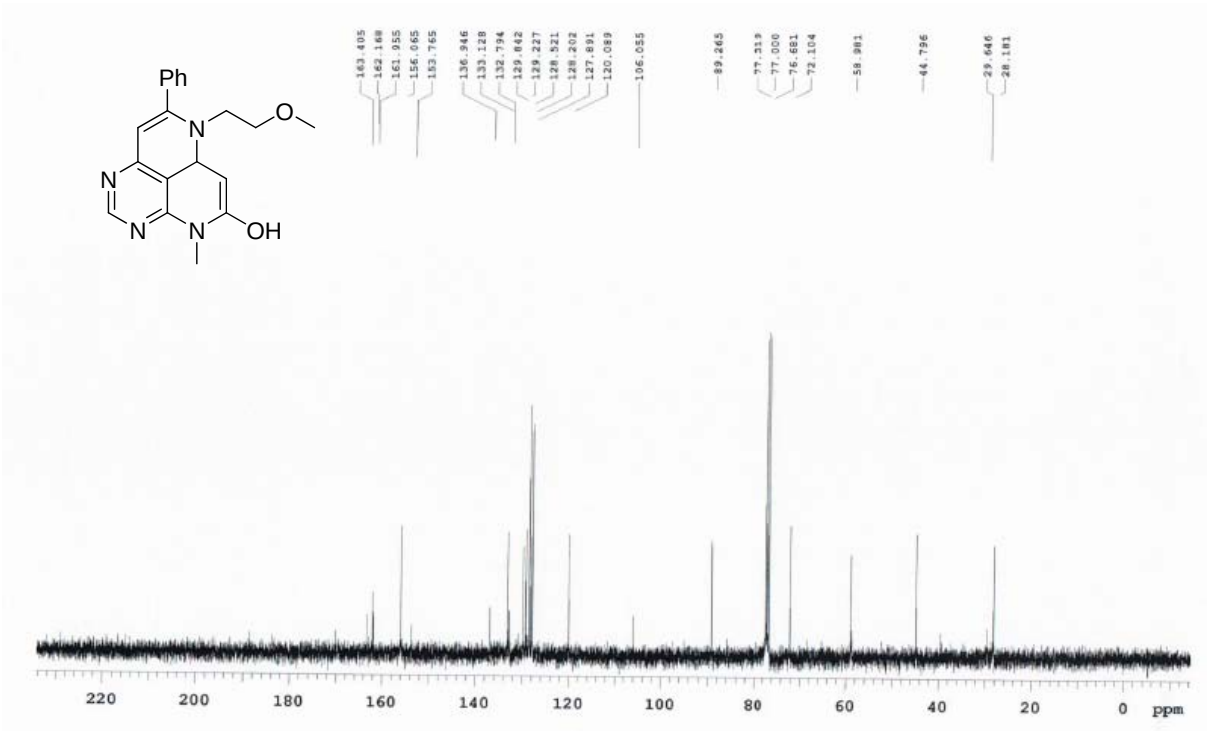

165.105
164.384
162.532
159.853
158.486
154.669
141.333
136.255
129.652
128.711
127.800
120.354
104.028
89.486
77.319
77.205
77.000
76.689
71.748
59.141
52.621
45.167
29.691
0.016
Ph
N
O
CO2Me
N
N
N
H
OH
220
200
180
160
140
120
100
80
60
40
20
0
ppm

Compound 15

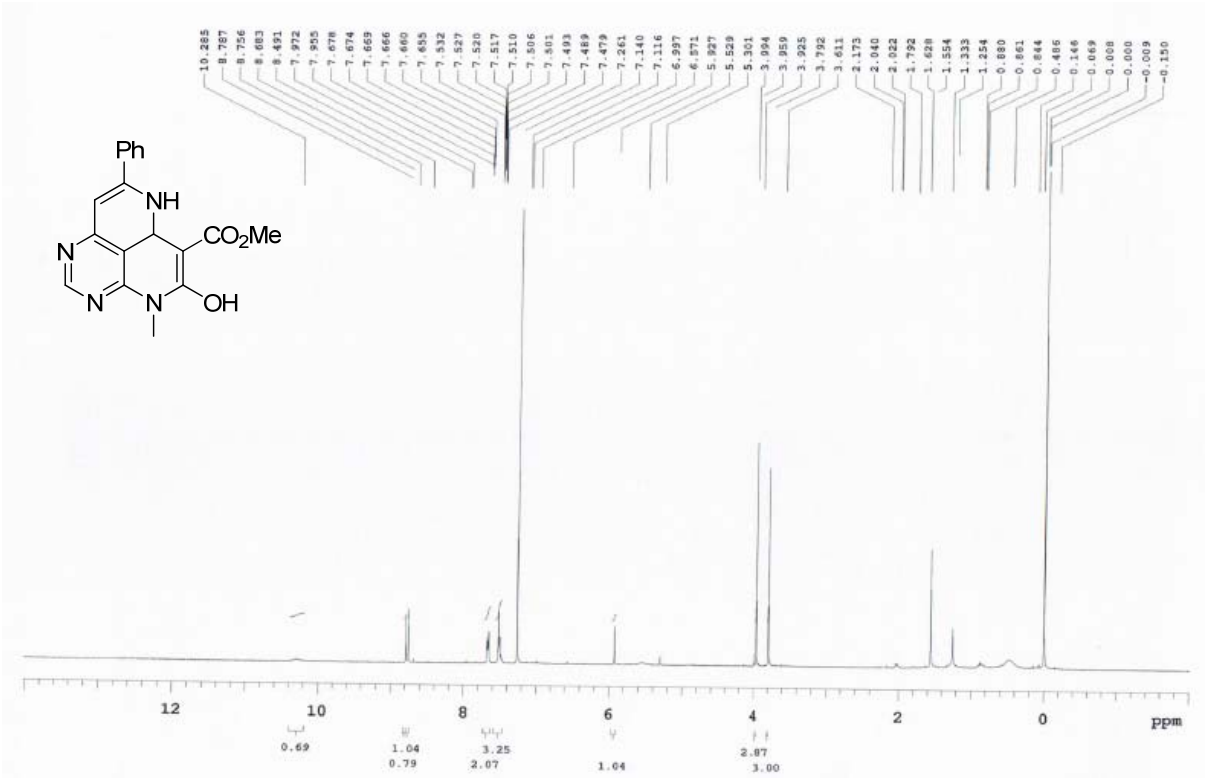

12.371
11.056
8.597
8.574
7.512
5.573
3.807
3.737
3.420
3.336
3.266
2.500
1.967
1.931
1.730
1.441
1.216
-0.012
Ph
N
O
CO2H
N
N
N
OH
12
10
8
6
4
2
0
ppm
1.00
1.01
0.88
1.00
5.17
1.02
3.003.09
2.2224
164.530
163.095
161.721
159.528
158.124
154.670
138.913
136.052
129.456
128.584
127.931
121.464
103.187
88.592
71.803
59.187
52.008
44.441
40.122
39.917
39.705
39.500
39.287
39.083
38.870
220
200
180
160
140
120
100
80
60
40
20
0
ppm

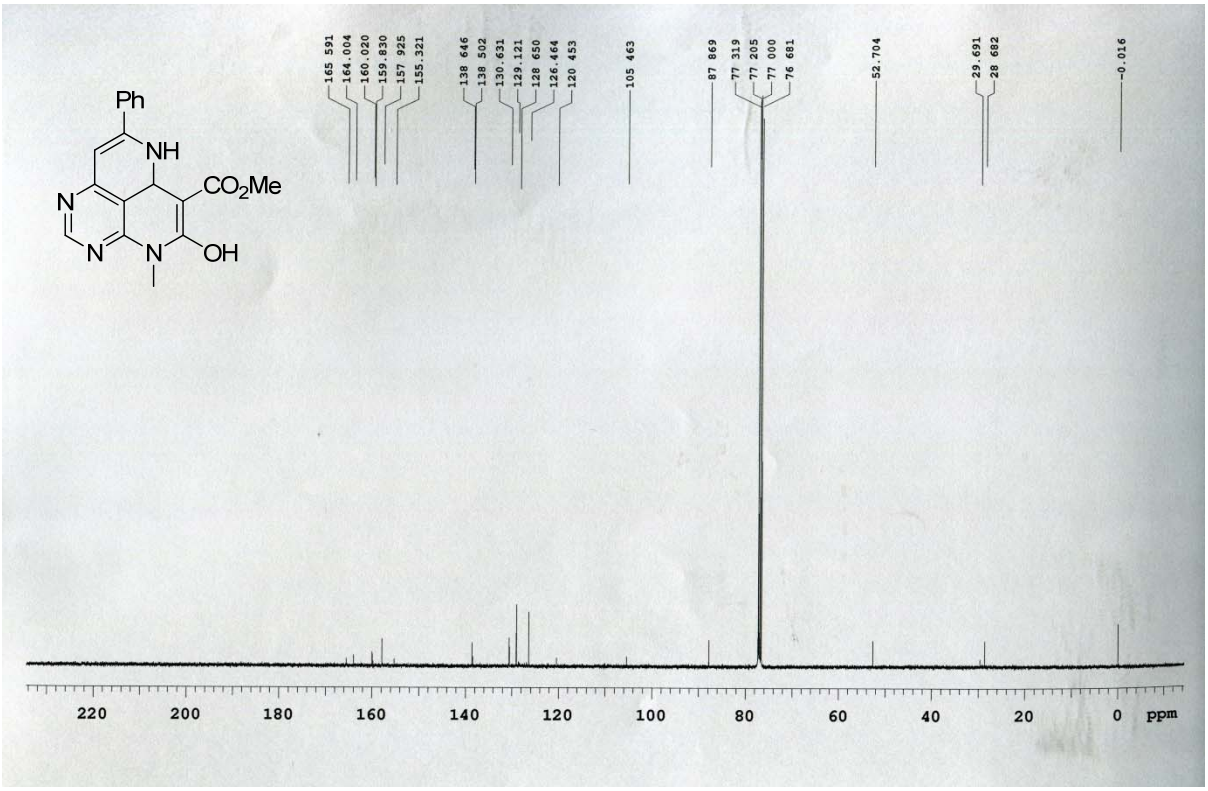
Compound 16


Ph
N
O
N
N
N
OH
10.851
8.729
7.852
7.828
7.468
7.450
7.428
7.263
6.601
6.577
5.460
3.765
3.495
3.481
3.469
3.404
3.393
3.376
3.363
2.958
2.174
2.169
1.679
1.254
0.070
0.007
0.000
12
10
8
6
4
2
0
ppm
0.97
0.89
1.06
5.09
1.01
1.06
3.005.19
2.08

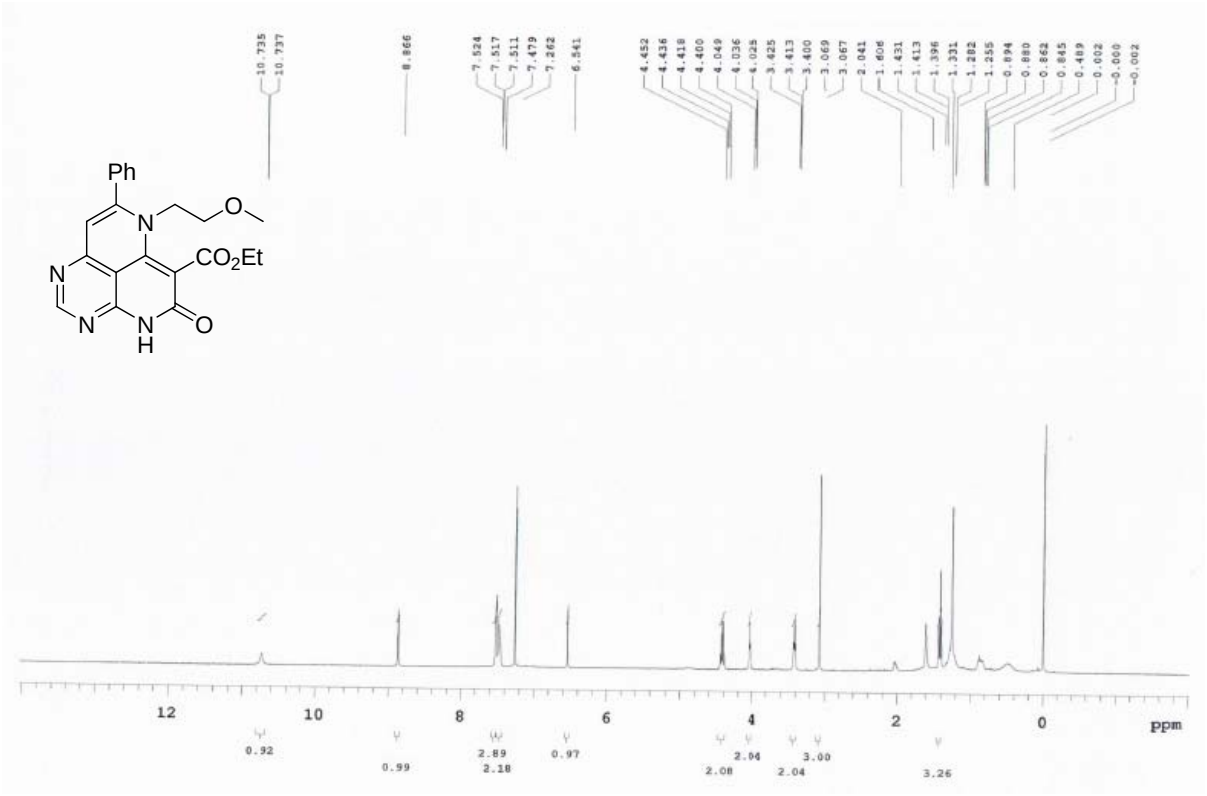

Ph
N
O
N
N
N
OH
163.405
162.168
161.055
156.065
153.765
136.946
133.128
132.794
129.842
129.227
128.521
128.202
127.891
120.089
106.055
89.265
77.319
77.000
76.681
72.104
58.981
44.796
29.646
28.181
220
200
180
160
140
120
100
80
60
40
20
0
ppm

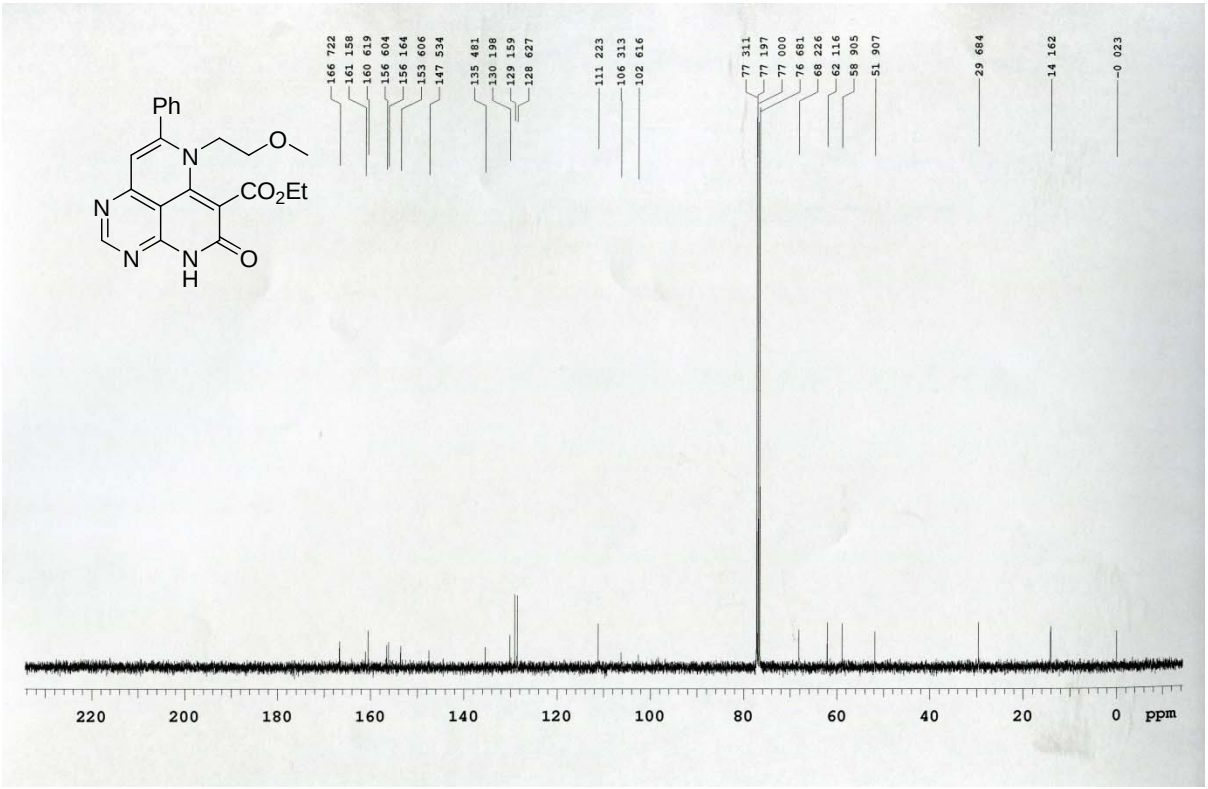
Compound 17


Ph
NH
CO2Me
N
N
N
OH
10.285
8.787
8.756
8.683
8.491
7.972
7.955
7.678
7.674
7.669
7.666
7.660
7.655
7.532
7.527
7.520
7.517
7.510
7.506
7.501
7.493
7.489
7.479
7.261
7.140
7.116
6.997
6.571
5.927
5.529
5.301
3.994
3.959
3.925
3.792
3.611
2.173
2.040
2.022
1.792
1.628
1.554
1.333
1.254
0.880
0.861
0.844
0.486
0.146
0.069
0.008
0.000
-0.009
-0.150
12
10
8
6
4
2
0
ppm
0.69
1.04
0.79
3.25
2.07
1.04
2.87
3.00

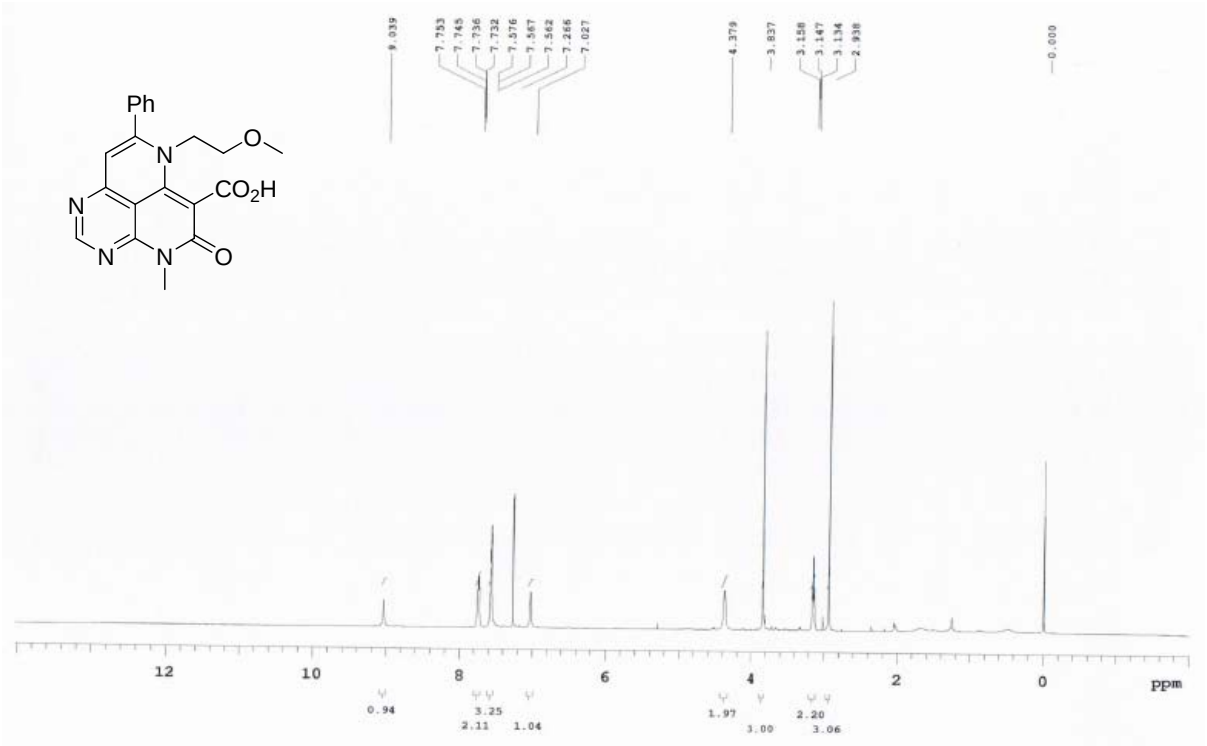

Ph
NH
CO2Me
N
N
N
OH
165.591
164.004
160.020
159.830
157.925
155.321
138.646
138.502
130.631
129.121
128.650
126.464
120.453
105.463
87.869
77.319
77.205
77.000
76.681
52.704
29.691
28.682
-0.016
220
200
180
160
140
120
100
80
60
40
20
0
ppm

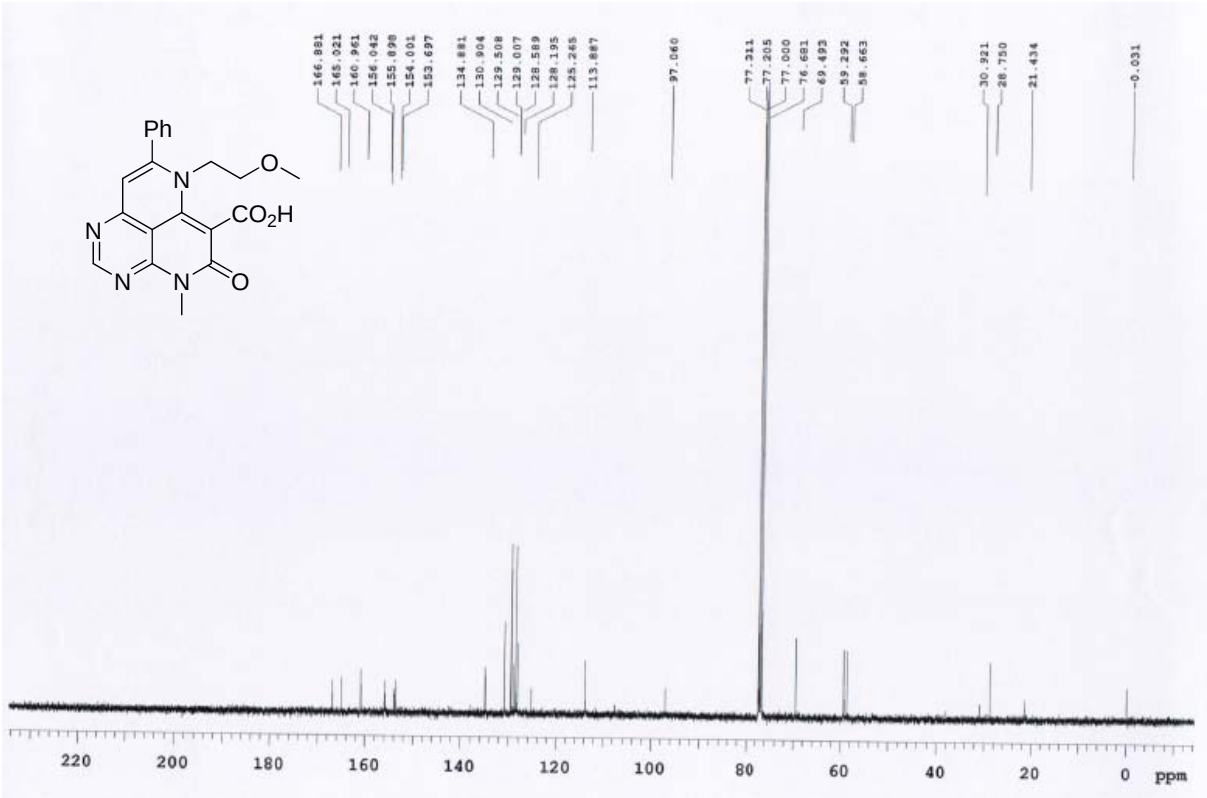
Compound 18


Ph
N
O
CO2Et
N
N
N
H
O
10.735
10.737
8.866
7.524
7.517
7.511
7.479
7.262
6.541
4.452
4.436
4.418
4.400
4.049
4.036
4.025
3.425
3.413
3.400
3.069
3.067
2.041
1.606
1.431
1.413
1.396
1.331
1.282
1.255
0.894
0.880
0.862
0.845
0.489
0.002
-0.000
-0.002
12
10
8
6
4
2
0
ppm
0.92
0.99
2.89
2.18
0.97
2.08
2.04
3.00
2.04
3.26

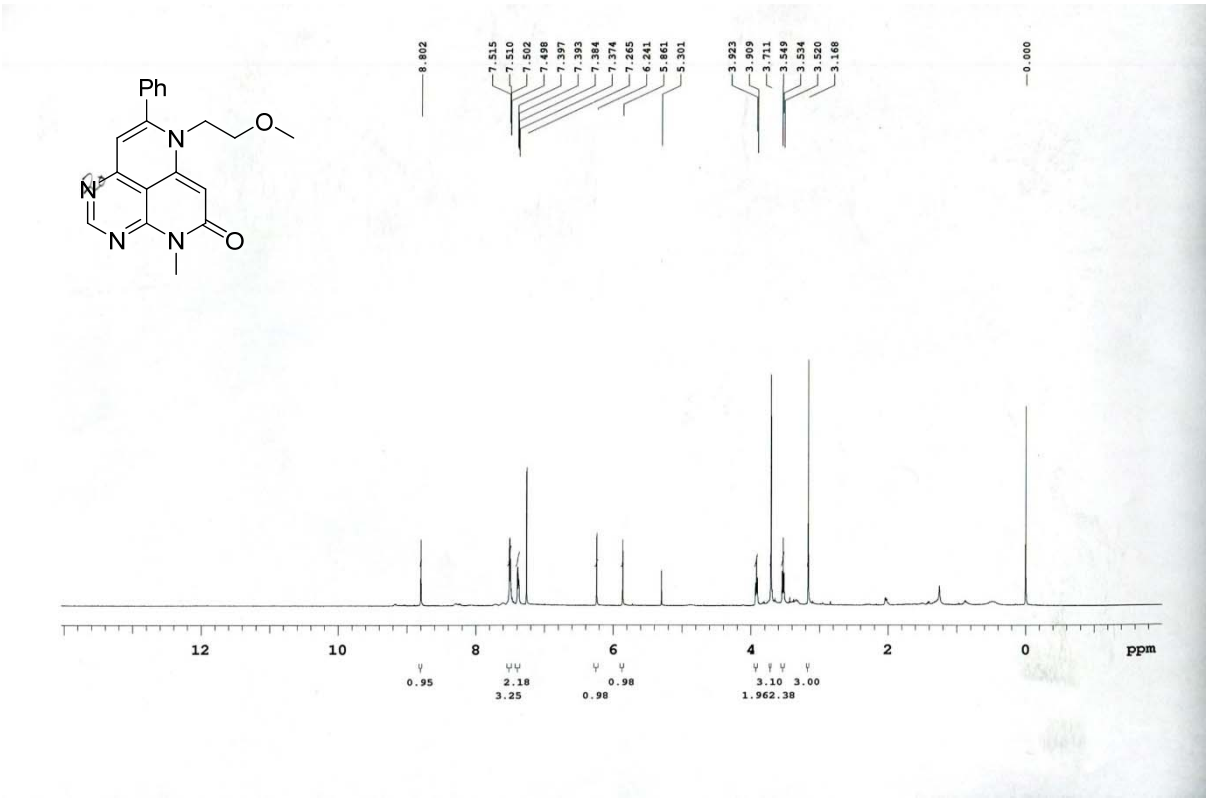

Ph
N
O
CO2Et
N
N
N
H
O
166 722
161 158
160 619
156 604
156 164
153 606
147 534
135 481
130 198
129 159
128 627
111 223
106 313
102 616
77 311
77 197
77 000
76 681
68 226
62 116
58 905
51 907
29 684
14 162
-0 023
220
200
180
160
140
120
100
80
60
40
20
0
ppm

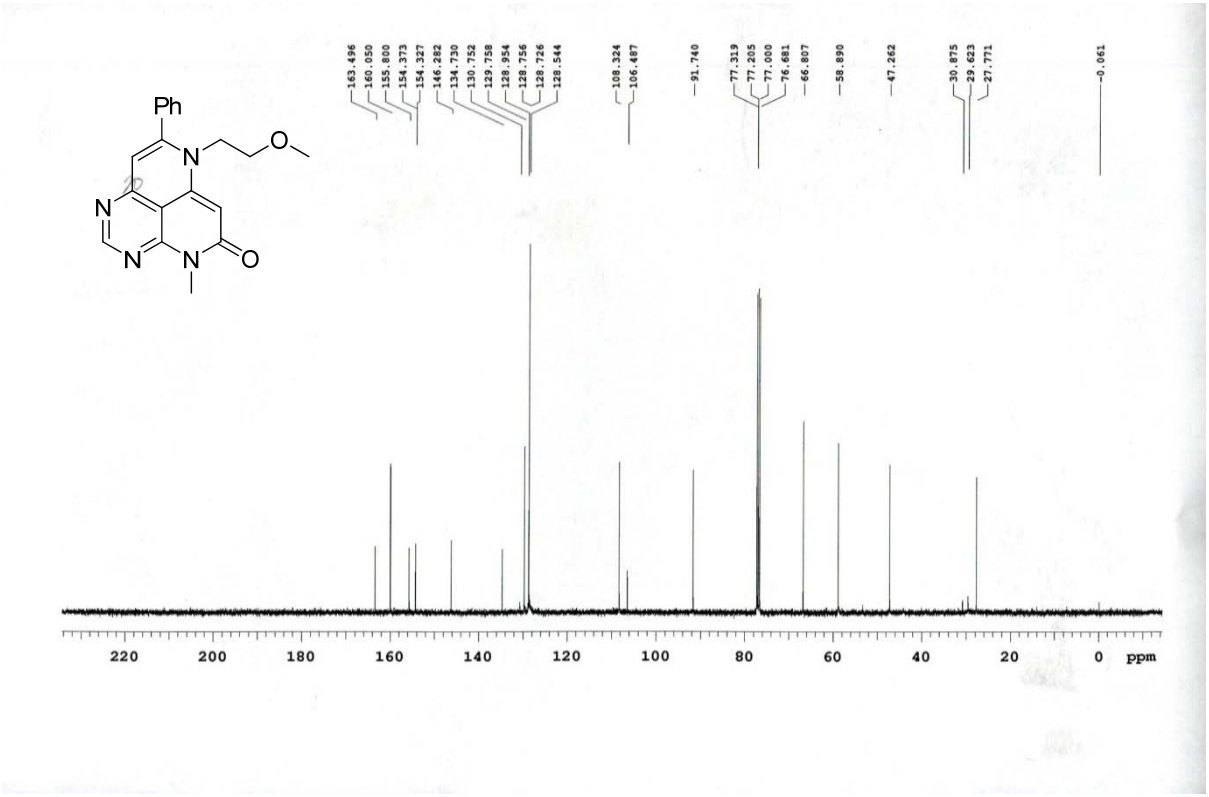
Compound 19


Ph
N
O
CO2H
N
N
N
O
9.039
7.783
7.745
7.736
7.732
7.576
7.567
7.562
7.266
7.027
4.379
3.837
3.158
3.147
3.134
2.938
0.000
12
10
8
6
4
2
0
ppm
0.94
3.25
2.11
1.04
1.97
3.00
2.20
3.06

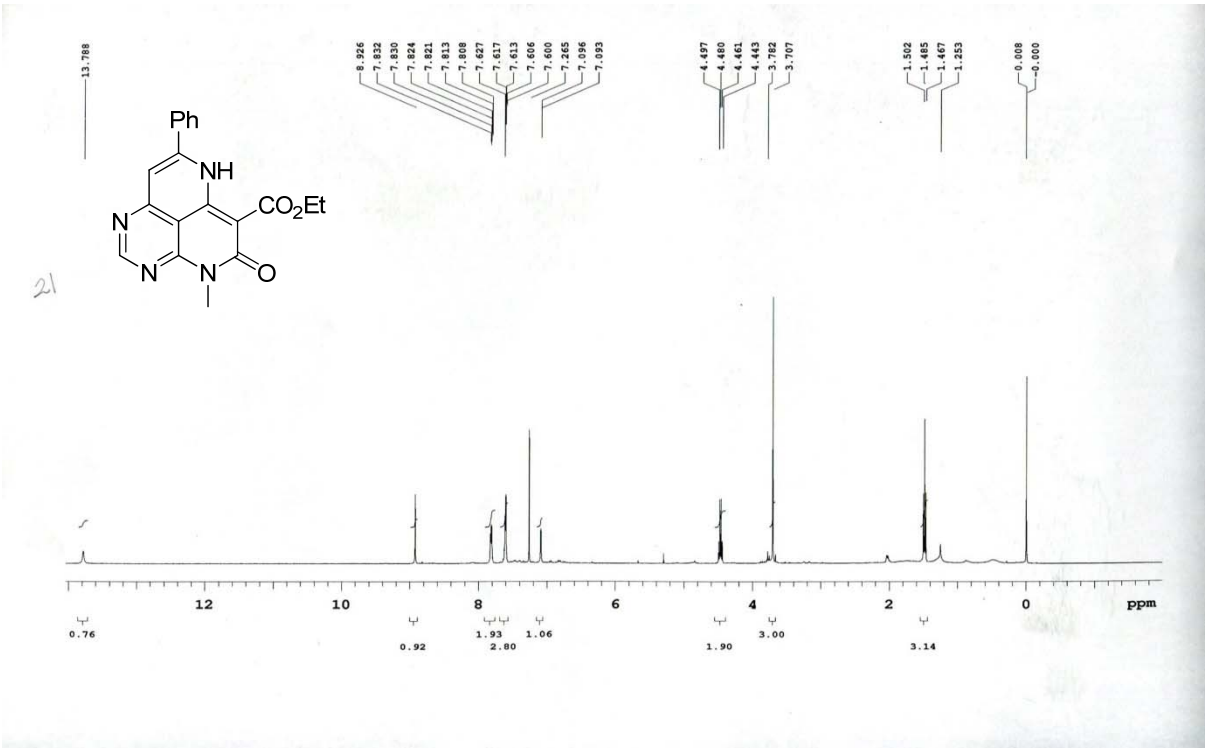

Ph
N
O
CO2H
N
N
N
O
166.881
165.021
160.961
156.042
155.098
154.001
153.697
134.881
130.904
129.508
129.007
128.589
128.195
125.265
113.887
97.060
77.311
77.205
77.000
76.681
69.493
59.292
58.663
30.921
28.750
21.434
-0.031
220
200
180
160
140
120
100
80
60
40
20
0
ppm

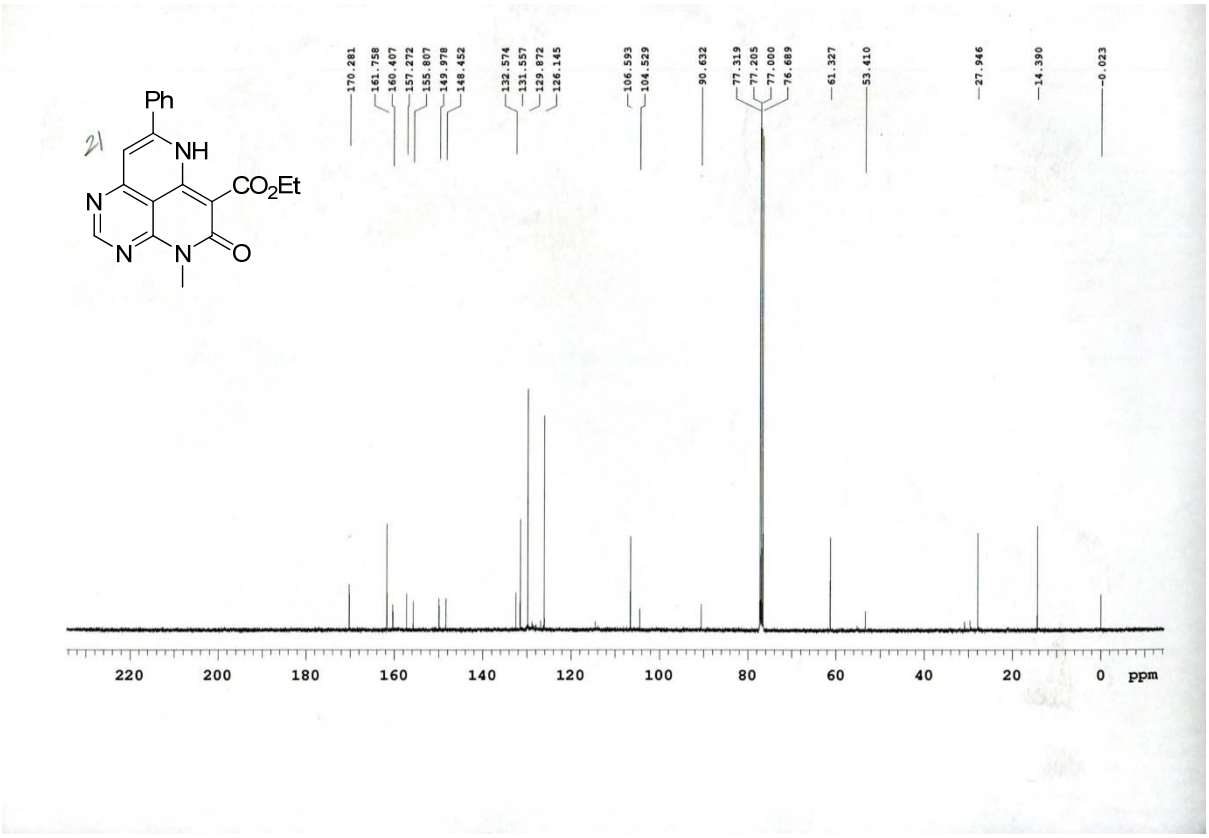
Compound 20


Ph
N
O
N
N
N
O
8.802
7.515
7.510
7.502
7.498
7.397
7.393
7.384
7.374
7.265
6.241
5.861
5.301
3.923
3.909
3.711
3.549
3.534
3.520
3.168
0.000
12
10
8
6
4
2
0
ppm
0.95
2.18
3.25
0.98
0.98
3.10
3.00
1.962.38


Ph
N
O
N
N
N
O
163.496
160.050
155.800
154.373
154.327
146.282
134.730
130.752
129.758
128.954
128.756
128.726
128.544
108.324
106.487
91.740
77.319
77.205
77.000
76.681
66.807
58.890
47.262
30.875
29.623
27.771
0.061
220
200
180
160
140
120
100
80
60
40
20
0
ppm

Compound 21


13.788
8.926
7.832
7.830
7.824
7.821
7.813
7.808
7.627
7.617
7.613
7.606
7.600
7.265
7.096
7.093
4.497
4.480
4.461
4.443
3.782
3.707
1.502
1.485
1.467
1.253
0.008
0.000
Ph
NH
CO2Et
N
N
N
O
21
12
10
8
6
4
2
0
ppm
0.76
0.92
1.93
2.80
1.06
1.90
3.00
3.14


170.281
161.758
160.407
157.272
155.807
149.978
148.452
132.574
131.557
129.872
126.145
106.593
104.529
90.632
77.319
77.205
77.000
76.689
61.327
53.410
27.946
14.390
-0.023
Ph
NH
CO2Et
N
N
N
O
21
220
200
180
160
140
120
100
80
60
40
20
0
ppm