

Supporting Information

Palladium/Silver Synergistic Catalysis in Direct Aerobic Carbonylation of C(sp²)-H Bonds Using DMF as Carbon Source: Synthesis of Pyrido-Fused Quinazolinones and Phenanthridinones

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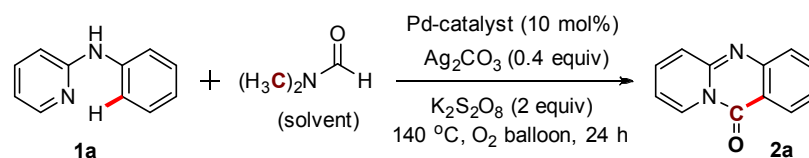
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1. General information:

All the starting materials **1** and **3** were prepared according to literature methods.^{1, 2} All purchased chemicals were used without further purification. All reactions were performed under oxygen balloon atmosphere. Anhydrous DMF was purchased from sigma Aldrich and used without further purification. Analytical thin layer chromatography was performed using TLC pre-coated silica gel 60 F254 MERCK (20x20 cm). TLC plates were visualized by exposing UV light or by iodine vapors. Organic solutions were concentrated by rotatory evaporation on BUCHI–Switzerland; R–120 rotatory evaporator and vacuum pump V–710. Flash column chromatography was performed on Merck flash silica gel 100–200 mesh size. Melting points of solid compounds were determined on BUCHI–B–545–Switzerland melting point apparatus. ¹H and ¹³C NMR spectra were recorded with BRUKER 500 and 400 MHz NMR instruments. Proton and carbon magnetic resonance spectra (¹H NMR and ¹³C NMR) were recorded using tetramethylsilane (TMS) in the solvent of CDCl₃ as the internal standard (¹H NMR: TMS at 0.00 ppm, CHCl₃ at 7.24 ppm; ¹³C NMR: CDCl₃ at 77.0 ppm) or were recorded using tetramethylsilane (TMS) in the solvent of DMSO–*d*₆ as the internal standard (¹H NMR: TMS at 0.00 ppm, DMSO at 2.50 ppm, ¹³C NMR: DMSO at 40.0 ppm) or were recorded using tetramethylsilane (TMS) in the solvent of Acetone–*d*₆ as the internal standard (¹H NMR: TMS at 0.00 ppm, Acetone at 2.09 ppm, ¹³C NMR: Acetone at 29.9 ppm, 206.7 ppm). All the NMR spectra were processed in MestReNova. HRMS spectra were recorded with LCMS-QTOF Module No. G6540 A (UHD) instrument.

2. Optimization details for the Pd-catalyzed pyrido carbonylation of C(sp²-H) bond:

Table S1: Optimization by varying different Pd catalysts ^a:

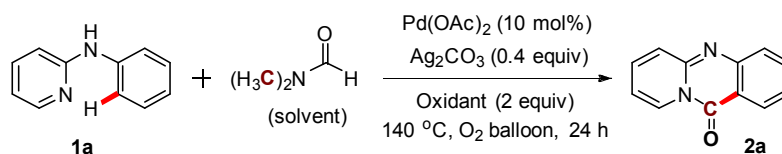


Sr. No	Catalyst	Yield (%) ^b 2a
1	Pd(OAc)₂	10
2	Pd(TFA) ₂	5
3	Pd(PPh ₃) ₂ Cl ₂	N.R.
4	PdCl ₂	N.R.
5	Pd(MeCN) ₂ Cl ₂	N.R.
6	Pd ₂ (dba) ₃	N.R.

^aReaction conditions: *N*-phenyl-2-aminopyridine (1.0 equiv), Pd-catalyst (10 mol%), Ag_2CO_3 (0.4 equiv), $\text{K}_2\text{S}_2\text{O}_8$ (2 equiv), DMF (2 mL), 140 °C, O₂ balloon, 24 h;

^b Isolated yield, N.R. = no reaction.

Table S2: Optimization by varying different external oxidants ^a:

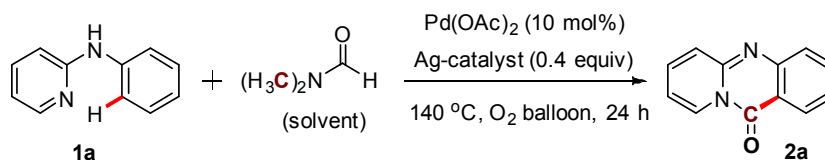


Sr. No	Oxidant	Yield (%) ^b 2a
1	K ₂ S ₂ O ₈	10
2	Na ₂ S ₂ O ₈	15
3	PhI(OAc) ₂	10
4	BQ	20
5	oxone	5
6	KHSO ₅	trace
7	H ₂ O ₂	N.R.
8	<i>m</i> -CPBA	N.R.
9	TBHP	N.R.
10	Cu(OAc) ₂	10
11	Cu(OTf) ₂	15
12	--	10

^aReaction conditions: *N*-phenyl-2-aminopyridine (1.0 equiv), Pd(OAc)₂ (10 mol%), Ag₂CO₃ (0.4 equiv), oxidant (2 equiv), DMF (2 mL), 140 °C, O₂ balloon, 24 h;

^b Isolated yield, N.R. = no reaction.

Table S3: Optimization by varying different Ag catalysts ^a:

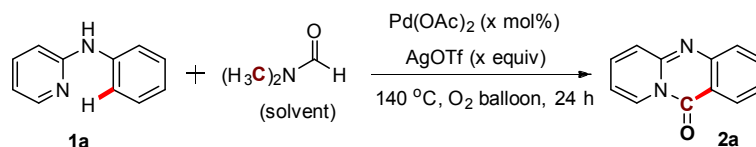


Sr. No	Ag-catalyst	Yield (%) ^b 2a
1	Ag ₂ CO ₃	10
2	Ag ₂ O	30
3	AgOAc	45
4	Ag ₂ SO ₄	25
5	AgSbF ₆	60
6	AgNO ₃	N.R.
7	AgF	15
8	AgTFA	62
9	AgOTf	91
10	AgNO ₂	N.R.

^aReaction conditions: *N*-phenyl-2-aminopyridine (1.0 equiv), Pd(OAc)₂ (10 mol%), Ag-catalyst (0.4 equiv), DMF (2 mL), 140 °C, O₂ balloon, 24 h;

^bIsolated yield, N.R. = no reaction.

Table S4: Optimization by varying catalyst loading ^a:



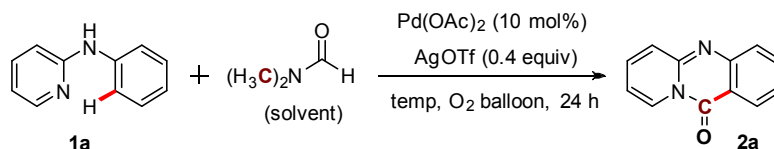
Sr. No	Pd-catalyst	Ag-catalyst	Yield (%) ^b 2a
1	Pd((OAc) ₂ (5 mol%)	AgOTf (0.1 equiv)	25
2	Pd((OAc) ₂ (10 mol%)	AgOTf (0.1 equiv)	40
3	Pd((OAc) ₂ (10 mol%)	AgOTf (0.2 equiv)	55
4	Pd((OAc) ₂ (10 mol%)	AgOTf (0.3 equiv)	80
5	Pd((OAc)₂ (10 mol%)	AgOTf (0.4 equiv)	91

6	Pd(OAc) ₂ (10 mol%)	AgOTf (0.5 equiv)	91
7	Pd(OAc) ₂ (10 mol%)	AgOTf (1 equiv)	92

^aReaction conditions: *N*-phenyl-2-aminopyridine (1.0 equiv), Pd(OAc)₂ (10 mol%), AgOTf (0.4 equiv), DMF (2 mL), 140 °C, O₂ balloon, 24 h;

^bIsolated yield.

Table S5: Optimization by varying different temperatures ^a:

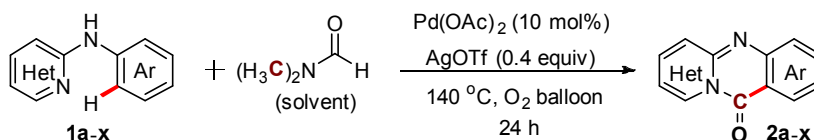


Sr. No	Temp °C	Yield (%) ^b 2a
1	rt	N.R.
2	60	N.R.
3	80	N.R.
4	100	40
5	120	55
6	140	91
7	160	88

^aReaction conditions: *N*-phenyl-2-aminopyridine (1.0 equiv), Pd(OAc)₂ (10 mol%), AgOTf (0.4 equiv), DMF (2 mL), temp °C, O₂ balloon, 24 h;

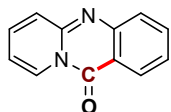
^bIsolated yield, N.R. = no reaction.

3. General procedure for the Pd-catalyzed pyridocarbonylation of C(sp²-H) bond:



N-aryl-2-amino heterocycles (**1a-x**) (50 mg, 1 equiv), Pd(OAc)₂ (10 mol%), and AgOTf (0.4 equiv), were added to an oven dried sealed tube with cap. DMF (2 mL) was added to the tube and the tube was placed under vacuum and purged with O₂ trice and capped well. The reaction mixture was stirred for 24 h at 140 °C temperature. The progress of the reaction was monitored by TLC and after completion of the reaction, the reaction mixture was diluted with EtOAc (20 mL) filtered through a plug of celite. Total organic portion was concentrated and purified via column chromatography through silica gel using hexane–EtOAc as eluent to provide the desired pyridocarbonylation products (**2a-x**).

11*H*-Pyrido[2,1-*b*]quinazolin-11-one (**2a**): ^{3a}



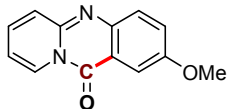
Following general procedure for the palladium catalyzed pyridocarbonylation of C(sp²-H) bond, a mixture of *N*-phenylpyridin-2-amine (50 mg, 0.294 mmol), Pd(OAc)₂ (6.6 mg, 0.0294 mmol), AgOTf (30 mg, 0.117 mmol), and DMF (2 mL) was stirred at 140 °C for 24 h under oxygen atmosphere. The crude product was purified via flash chromatography (Hexanes/EtOAc, 5:5) to provide the title compound as a pale yellow solid (52 mg, 91%), mp 208–210 °C. ¹H NMR (400 MHz, DMSO-*d*₆) δ 8.79 (d, *J* = 7.3 Hz, 1H), 8.31 (d, *J* = 8.1 Hz, 1H), 7.97 – 7.86 (m, 1H), 7.80 – 7.67 (m, 2H), 7.52 (dd, *J* = 8.4, 5.5 Hz, 2H), 7.07 (dd, *J* = 10.1, 3.7 Hz, 1H); ¹³C NMR (125 MHz, CDCl₃) δ 159.0, 148.4, 147.7, 135.2, 134.3, 128.8, 127.3, 126.7, 126.2, 125.3, 116.2, 112.6; HRMS (ESI): calcd. for C₁₂H₉N₂O [M+H]⁺, 197.0710; found: 197.0715.

2-Methyl-11*H*-pyrido[2,1-*b*]quinazolin-11-one(2b):^{3a}



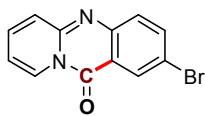
Following general procedure for the palladium catalyzed pyrido carbonylation of C(sp²-H) bond, a mixture of *N*-(*p*-tolyl)pyridin-2-amine (50 mg, 0.271 mmol), Pd(OAc)₂ (6.1 mg, 0.0271 mmol), AgOTf (28 mg, 0.108 mmol), and DMF (2 mL) was stirred at 140 °C for 24 h under oxygen atmosphere. The crude product was purified via flash chromatography (Hexanes/EtOAc, 5:5) to provide the title compound as a pale yellow solid (51 mg, 89%), mp 138–140 °C. ¹H NMR (500 MHz, CDCl₃) δ 8.69 (d, *J* = 7.4 Hz, 1H), 8.04 (s, 1H), 7.51 (d, *J* = 9.7 Hz, 2H), 7.42 – 7.30 (m, 2H), 6.72 (t, *J* = 6.5 Hz, 1H), 2.37 (s, 3H); ¹³C NMR (125 MHz, CDCl₃) δ 157.6, 145.98, 145.4, 141.7, 135.8, 134.2, 132.7, 125.4, 125.2, 125.0, 114.8, 111.4, 20.2; HRMS (ESI): calcd. for C₁₃H₁₁N₂O [M+H]⁺, 211.0866; found: 211.0867.

2-Methoxy-11*H*-pyrido[2,1-*b*]quinazolin-11-one (2c):^{3a}



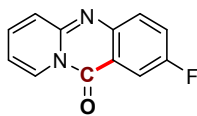
Following general procedure for the palladium catalyzed pyrido carbonylation of C(sp²-H) bond, a mixture of *N*-(4-methoxyphenyl)pyridin-2-amine (50 mg, 0.25 mmol), Pd(OAc)₂ (5.6 mg, 0.025 mmol), AgOTf (26 mg, 0.1 mmol), and DMF (2 mL) was stirred at 140 °C for 24 h under oxygen atmosphere. The crude product was purified via flash chromatography (Hexanes/EtOAc, 4:6) to provide the title compound as a pale yellow solid (49 mg, 87%), mp 158–160 °C. ¹H NMR (400 MHz, CDCl₃) δ 8.88 (d, *J* = 7.4 Hz, 1H), 7.76 (d, *J* = 2.8 Hz, 1H), 7.73 (s, 1H), 7.54 – 7.45 (m, 3H), 6.86 (ddd, *J* = 7.6, 6.2, 1.6 Hz, 1H), 3.96 (s, 3H); ¹³C NMR (100 MHz, CDCl₃) δ 158.7, 157.3, 146.0, 143.7, 132.8, 128.6, 126.8, 126.4, 126.3, 116.8, 112.6, 105.1, 55.8; HRMS (ESI): calcd. for C₁₃H₁₁N₂O₂ [M+H]⁺, 227.0815; found: 227.0817.

2-Bromo-11*H*-pyrido[2,1-*b*]quinazolin-11-one (2d):^{3c}



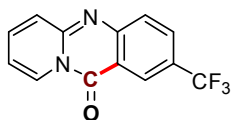
Following general procedure for the palladium catalyzed pyrido carbonylation of C(sp²-H) bond, a mixture of *N*-(4-bromophenyl)pyridin-2-amine (50 mg, 0.20 mmol), Pd(OAc)₂ (4.5 mg, 0.020 mmol), AgOTf (21 mg, 0.08 mmol), and DMF (2 mL) was stirred at 140 °C for 24 h under oxygen atmosphere. The crude product was purified via flash chromatography (Hexanes/EtOAc, 5:5) to provide the title compound as a pale yellow solid (43 mg, 78%), mp 136–138 °C. ¹H NMR (400 MHz, CDCl₃) δ 8.88 (d, *J* = 7.2 Hz, 1H), 8.58 (d, *J* = 2.3 Hz, 1H), 7.90 (dd, *J* = 8.9, 2.3 Hz, 1H), 7.67 (d, *J* = 8.9 Hz, 1H), 7.58 – 7.51 (m, 2H), 6.91 (ddd, *J* = 7.6, 6.2, 1.7 Hz, 1H); ¹³C NMR (100 MHz, CDCl₃) δ 157.9, 147.9, 147.3, 138.2, 134.5, 129.5, 128.8, 127.3, 126.7, 126.4, 118.3, 113.0; HRMS (ESI): calcd. for C₁₂H₈BrN₂O [M+H]⁺, 274.9815; found: 274.9818.

2-Fluoro-11*H*-pyrido[2,1-*b*]quinazolin-11-one (2e):^{3a}



Following general procedure for the palladium catalyzed pyrido carbonylation of C(sp²-H) bond, a mixture of *N*-(4-fluorophenyl)pyridin-2-amine (50 mg, 0.265 mmol), Pd(OAc)₂ (6 mg, 0.0265 mmol), AgOTf (27 mg, 0.106 mmol), and DMF (2 mL) was stirred at 140 °C for 24 h under oxygen atmosphere. The crude product was purified via flash chromatography (Hexanes/EtOAc, 5:5) to provide the title compound as a light yellow solid (46 mg, 80%), mp 162–164 °C. ¹H NMR (500 MHz, CDCl₃) δ 8.91 – 8.77 (m, 1H), 8.06 (dd, *J* = 8.5, 2.9 Hz, 1H), 7.81 (dd, *J* = 9.1, 4.8 Hz, 1H), 7.60 (ddd, *J* = 9.1, 8.0, 3.0 Hz, 1H), 7.55 – 7.47 (m, 2H), 6.90 (ddd, *J* = 7.5, 5.4, 2.3 Hz, 1H); ¹³C NMR (125 MHz, CDCl₃) δ 160.7, 158.7, 158.4 (d, *J* = 4.0 Hz), 147.1, 145.4, 134.0, 129.4 (d, *J* = 8.1 Hz), 126.4 (d, *J* = 14.1 Hz), 124.5 (d, *J* = 24.9 Hz), 117.0 (d, *J* = 8.6 Hz), 112.9, 111.2 (d, *J* = 23.5 Hz); HRMS (ESI): calcd. for C₁₂H₈FN₂O [M+H]⁺, 215.0615; found: 215.0614.

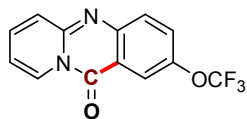
2-(Trifluoromethyl)-11*H*-pyrido[2,1-*b*]quinazolin-11-one (2f):



Following general procedure for the palladium catalyzed pyrido carbonylation of C(sp²-H) bond, a mixture of *N*-(4-(trifluoromethyl)phenyl)pyridin-2-amine (50 mg, 0.210 mmol), Pd(OAc)₂ (4.7 mg, 0.0210 mmol), AgOTf (22 mg, 0.084 mmol),

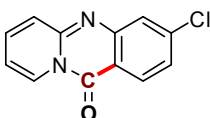
and DMF (2 mL) was stirred at 140 °C for 24 h under oxygen atmosphere. The crude product was purified via flash chromatography (Hexanes/EtOAc, 4:6) to provide the title compound as a light yellow solid (42 mg, 75%), mp 150–152 °C. $^1\text{H NMR}$ (500 MHz, CDCl_3) δ 8.93 (dd, $J = 7.3, 0.8$ Hz, 1H), 8.76 (s, 1H), 8.01 (dd, $J = 8.8, 2.1$ Hz, 1H), 7.88 (d, $J = 8.8$ Hz, 1H), 7.67 – 7.62 (m, 1H), 7.58 (d, $J = 9.1$ Hz, 1H), 7.02 – 6.96 (m, 1H); $^{13}\text{C NMR}$ (125 MHz, CDCl_3) δ 157.5, 149.4, 148.0 (d, $J = 6.3$ Hz), 134.6, 129.9 (d, $J = 3.1$ Hz), 126.9, 125.9, 125.3, 124.4 (q, $J = 17.5$ Hz), 123.8, 117.2, 114.5, 112.4; **HRMS** (ESI): calcd. for $\text{C}_{13}\text{H}_8\text{F}_3\text{N}_2\text{O}$ $[\text{M}+\text{H}]^+$, 265.0583; found: 265.0585.

2-(Trifluoromethoxy)-11H-pyrido[2,1-b]quinazolin-11-one (2g):



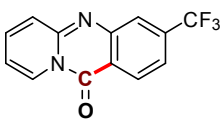
Following general procedure for the palladium catalyzed pyrido carbonylation of $\text{C}(\text{sp}^2\text{-H})$ bond, a mixture of *N*-(4-(trifluoromethoxy)phenyl)pyridin-2-amine (50 mg, 0.196 mmol), $\text{Pd}(\text{OAc})_2$ (4.5 mg, 0.0196 mmol), AgOTf (20 mg, 0.078 mmol), and DMF (2 mL) was stirred at 140 °C for 24 h under oxygen atmosphere. The crude product was purified via flash chromatography (Hexanes/EtOAc, 4:6) to provide the title compound as a light yellow solid (43 mg, 78%), mp 112–114 °C. $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 8.89 (d, $J = 7.3$ Hz, 1H), 8.28 (s, 1H), 7.84 (d, $J = 9.0$ Hz, 1H), 7.69 (d, $J = 8.9$ Hz, 1H), 7.64 – 7.49 (m, 2H), 6.94 (t, $J = 6.6$ Hz, 1H); $^{13}\text{C NMR}$ (125 MHz, CDCl_3) δ 158.4, 147.8, 147.1, 145.8, 134.6, 129.0 (d, $J = 32.5$ Hz), 126.5 (d, $J = 30.7$ Hz), 122.1, 121.5, 119.4, 118.1, 116.6, 113.2; **HRMS** (ESI): calcd. for $\text{C}_{13}\text{H}_8\text{F}_3\text{N}_2\text{O}_2$ $[\text{M}+\text{H}]^+$, 281.0533; found: 281.0540.

3-Chloro-11H-pyrido[2,1-b]quinazolin-11-one (2h):^{3d}



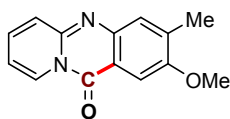
Following general procedure for the palladium catalyzed pyrido carbonylation of $\text{C}(\text{sp}^2\text{-H})$ bond, a mixture of *N*-(3-chlorophenyl)pyridin-2-amine (50 mg, 0.245 mmol), $\text{Pd}(\text{OAc})_2$ (5.5 mg, 0.0245 mmol), AgOTf (25 mg, 0.098 mmol), and DMF (2 mL) was stirred at 140 °C for 24 h under oxygen atmosphere. The crude product was purified via flash chromatography (Hexanes/EtOAc, 4:6) to provide the title compound as a light yellow solid (41 mg, 73%), mp 158–160 °C. $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 8.87 (d, $J = 7.3$ Hz, 1H), 8.37 (d, $J = 8.7$ Hz, 1H), 7.77 (s, 1H), 7.57 – 7.53 (m, 1H), 7.50 (d, $J = 8.9$ Hz, 1H), 7.41 (dd, $J = 8.7, 1.8$ Hz, 1H), 6.91 (t, $J = 6.8$ Hz, 1H); $^{13}\text{C NMR}$ (100 MHz, CDCl_3) δ 158.5, 149.4, 148.5, 141.4, 134.8, 128.8, 126.8, 126.3, 126.2, 125.9, 114.6, 112.8; **HRMS** (ESI): calcd. for $\text{C}_{12}\text{H}_8\text{ClN}_2\text{O}$ $[\text{M}+\text{H}]^+$, 231.0320; found: 231.0321.

3-(Trifluoromethyl)-11H-pyrido[2,1-b]quinazolin-11-one (2i):



Following general procedure for the palladium catalyzed pyrido carbonylation of $\text{C}(\text{sp}^2\text{-H})$ bond, a mixture of *N*-(3-(trifluoromethyl)phenyl)pyridin-2-amine (50 mg, 0.210 mmol), $\text{Pd}(\text{OAc})_2$ (4.7 mg, 0.0210 mmol), AgOTf (22 mg, 0.084 mmol), and DMF (2 mL) was stirred at 140 °C for 24 h under oxygen atmosphere. The crude product was purified via flash chromatography (Hexanes/EtOAc, 4:6) to provide the title compound as a light yellow solid (42 mg, 75%), mp 120–122 °C. $^1\text{H NMR}$ (500 MHz, CDCl_3) δ 8.91 (d, $J = 7.3$ Hz, 1H), 8.57 (d, $J = 8.5$ Hz, 1H), 8.09 (s, 1H), 7.75 – 7.70 (m, 1H), 7.65 (dd, $J = 8.6, 1.4$ Hz, 1H), 7.61 (dd, $J = 6.3, 1.5$ Hz, 1H), 7.00 – 6.92 (m, 1H); $^{13}\text{C NMR}$ (125 MHz, CDCl_3) δ 158.4, 148.5, 148.3, 135.1, 130.9, 128.8, 128.6, 126.8, 126.4, 124.7 (dd, $J = 8.4, 4.2$ Hz), 120.7 (d, $J = 3.3$ Hz), 114.1 (d, $J = 9.1$ Hz), 113.3; **HRMS** (ESI): calcd. for $\text{C}_{13}\text{H}_8\text{F}_3\text{N}_2\text{O}$ $[\text{M}+\text{H}]^+$, 265.0583; found: 265.0584.

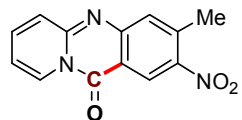
2-Methoxy-3-methyl-11H-pyrido[2,1-b]quinazolin-11-one (2j):



Following general procedure for the palladium catalyzed pyrido carbonylation of $\text{C}(\text{sp}^2\text{-H})$ bond, a mixture of *N*-(4-methoxy-3-methylphenyl)pyridin-2-amine (50 mg, 0.233 mmol), $\text{Pd}(\text{OAc})_2$ (5.2 mg, 0.0233 mmol), AgOTf (24 mg, 0.0932 mmol), and DMF (2 mL) was stirred at 140 °C for 24 h under oxygen atmosphere. The crude product was purified via flash chromatography (Hexanes/EtOAc, 4:6) to provide the title compound

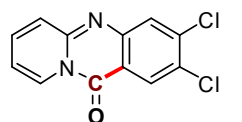
as a light yellow solid (46 mg, 82%), mp 156–158 °C. $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 8.88 (d, $J = 7.4$ Hz, 1H), 7.69 (s, 1H), 7.60 (s, 1H), 7.53 – 7.38 (m, 2H), 6.84 (ddd, $J = 9.0, 5.3, 2.2$ Hz, 1H), 3.99 (s, 3H), 2.42 (s, 3H); $^{13}\text{C NMR}$ (100 MHz, CDCl_3) δ 156.4, 146.1, 143.5, 138.0, 132.6, 128.3, 126.4, 126.3, 121.3, 112.3, 110.7, 103.6, 55.8, 17.2; **LC-MS** (ESI) m/z : 241.30 $[\text{M}+\text{H}]$.

3-Methyl-2-nitro-11H-pyrido[2,1-b]quinazolin-11-one (2k):



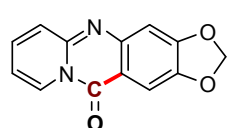
Following general procedure for the palladium catalyzed pyrido carbonylation of $\text{C}(\text{sp}^2\text{-H})$ bond, a mixture of *N*-(3-methyl-4-nitrophenyl)pyridin-2-amine (50 mg, 0.218 mmol), $\text{Pd}(\text{OAc})_2$ (5 mg, 0.0218 mmol), AgOTf (23 mg, 0.087 mmol), and DMF (2 mL) was stirred at 140 °C for 24 h under oxygen atmosphere. The crude product was purified via flash chromatography (Hexanes/EtOAc, 3:7) to provide the title compound as a light yellow solid (39 mg, 70%), mp 178–180 °C. $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 8.88 (d, $J = 7.4$ Hz, 1H), 8.40 (s, 1H), 8.28 (s, 1H), 7.76 – 7.68 (m, 2H), 6.96 (ddd, $J = 7.6, 6.2, 1.6$ Hz, 1H), 2.69 (s, 3H); $^{13}\text{C NMR}$ (100 MHz, CDCl_3) δ 158.5, 147.7, 144.9, 137.8, 127.7, 125.8, 121.3, 115.1, 114.0, 110.7, 107.2, 101.6, 22.5; **HRMS** (ESI): calcd. for $\text{C}_{13}\text{H}_{10}\text{N}_3\text{O}_3$ $[\text{M}+\text{H}]^+$, 256.0717; found: 256.0720.

2,3-Dichloro-11H-pyrido[2,1-b]quinazolin-11-one (2l):



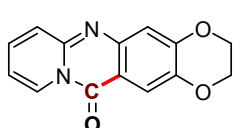
Following general procedure for the palladium catalyzed pyrido carbonylation of $\text{C}(\text{sp}^2\text{-H})$ bond, a mixture of *N*-(3,4-dichlorophenyl)pyridin-2-amine (50 mg, 0.210 mmol), $\text{Pd}(\text{OAc})_2$ (4.7 mg, 0.0210 mmol), AgOTf (22 mg, 0.084 mmol), and DMF (2 mL) was stirred at 140 °C for 24 h under oxygen atmosphere. The crude product was purified via flash chromatography (Hexanes/EtOAc, 4:6) to provide the title compound as a light yellow solid (43 mg, 77%), mp 170–172 °C. $^1\text{H NMR}$ (500 MHz, CDCl_3) δ 8.87 (d, $J = 7.4$ Hz, 1H), 8.52 (s, 1H), 8.19 (d, $J = 4.4$ Hz, 1H), 7.92 (s, 1H), 7.36 (d, $J = 8.7$ Hz, 1H), 6.94 (t, $J = 6.8$ Hz, 1H); $^{13}\text{C NMR}$ (125 MHz, CDCl_3) δ 158.5, 144.4, 143.1, 134.0, 129.8, 129.6, 127.8, 125.7, 125.3, 119.9, 112.2, 108.3; **HRMS** (ESI): calcd. for $\text{C}_{12}\text{H}_7\text{Cl}_2\text{N}_2\text{O}$ $[\text{M}+\text{H}]^+$, 264.9930; found: 264.9932.

11H-[1,3]Dioxolo[4,5-g]pyrido[2,1-b]quinazolin-11-one (2m):



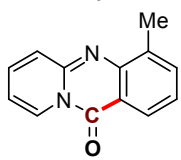
Following general procedure for the palladium catalyzed pyrido carbonylation of $\text{C}(\text{sp}^2\text{-H})$ bond, a mixture of *N*-(benzo[*d*][1,3]dioxol-5-yl)pyridin-2-amine (50 mg, 0.233 mmol), $\text{Pd}(\text{OAc})_2$ (5.5 mg, 0.0233 mmol), AgOTf (24 mg, 0.0932 mmol), and DMF (2 mL) was stirred at 140 °C for 24 h under oxygen atmosphere. The crude product was purified via flash chromatography (Hexanes/EtOAc, 4:6) to provide the title compound as a light yellow solid (45 mg, 81%), mp 216–218 °C. $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 8.88 (dt, $J = 7.4, 1.1$ Hz, 1H), 7.71 (s, 1H), 7.54 – 7.44 (m, 2H), 7.12 (s, 1H), 6.88 (ddd, $J = 7.6, 4.4, 3.4$ Hz, 1H), 6.14 (s, 2H); $^{13}\text{C NMR}$ (100 MHz, CDCl_3) δ 157.8, 154.6, 147.1, 146.8, 146.7, 133.4, 126.5, 125.8, 112.6, 111.2, 104.3, 103.1, 102.2; **LC-MS** (ESI) m/z : 241.20 $[\text{M}+\text{H}]$.

2,3-Dihydro-12H-[1,4]dioxino[2,3-g]pyrido[2,1-b]quinazolin-12-one (2n):



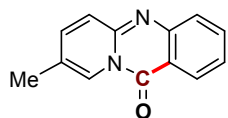
Following general procedure for the palladium catalyzed pyrido carbonylation of $\text{C}(\text{sp}^2\text{-H})$ bond, a mixture of *N*-(2,3-dihydrobenzo[*b*][1,4]dioxin-6-yl)pyridin-2-amine (50 mg, 0.219 mmol), $\text{Pd}(\text{OAc})_2$ (5 mg, 0.0219 mmol), AgOTf (23 mg, 0.088 mmol), and DMF (2 mL) was stirred at 140 °C for 24 h under oxygen atmosphere. The crude product was purified via flash chromatography (Hexanes/EtOAc, 4:6) to provide the title compound as a light yellow solid (43 mg, 78%), mp 180–182 °C. $^1\text{H NMR}$ (500 MHz, CDCl_3) δ 8.86 – 8.79 (m, 1H), 7.89 (s, 1H), 7.73 (td, $J = 5.6, 3.3$ Hz, 1H), 7.46 (d, $J = 1.3$ Hz, 1H), 7.26 (s, 1H), 6.81 (ddd, $J = 7.5, 5.4, 2.4$ Hz, 1H), 4.10 (s, 2H), 4.08 (s, 2H); $^{13}\text{C NMR}$ (125 MHz, CDCl_3) δ 156.9, 150.0, 142.1, 138.2, 132.3, 129.8, 127.8, 125.4, 124.7, 113.0, 112.1, 111.0, 63.7, 63.0; **HRMS** (ESI): calcd. for $\text{C}_{14}\text{H}_{11}\text{N}_2\text{O}_3$ $[\text{M}+\text{H}]^+$, 255.0764; found: 255.0768.

4-Methyl-11*H*-pyrido[2,1-*b*]quinazolin-11-one (2o):^{3a}



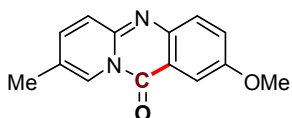
Following general procedure for the palladium catalyzed pyrido carbonylation of C(sp²-H) bond, a mixture of *N*-(*o*-tolyl)pyridin-2-amine (50 mg, 0.271 mmol), Pd(OAc)₂ (6.1 mg, 0.0271 mmol), AgOTf (28 mg, 0.108 mmol), and DMF (2 mL) was stirred at 140 °C for 24 h under oxygen atmosphere. The crude product was purified via flash chromatography (Hexanes/EtOAc, 4:6) to provide the title compound as a light yellow solid (47 mg, 82%), mp 142–144 °C. ¹H NMR (500 MHz, CDCl₃) δ 8.85 (d, *J* = 7.4 Hz, 1H), 8.31 (d, *J* = 8.1 Hz, 1H), 7.69 (d, *J* = 7.0 Hz, 1H), 7.54 (d, *J* = 9.2 Hz, 1H), 7.47 (ddd, *J* = 9.1, 6.3, 1.3 Hz, 1H), 7.37 (t, *J* = 7.6 Hz, 1H), 6.90 – 6.78 (m, 1H), 2.70 (s, 3H); ¹³C NMR (125 MHz, CDCl₃) δ 159.4, 147.4, 146.7, 135.3, 135.1, 133.4, 126.9, 126.5, 124.9, 124.8, 116.2, 112.4, 17.7; HRMS (ESI): calcd. for C₁₃H₁₁N₂O [M+H]⁺, 211.0866; found: 211.0866.

8-Methyl-11*H*-pyrido[2,1-*b*]quinazolin-11-one (2p):^{3b}



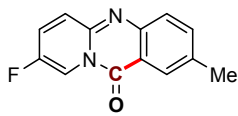
Following general procedure for the palladium catalyzed pyrido carbonylation of C(sp²-H) bond, a mixture of 5-methyl-*N*-phenylpyridin-2-amine (50 mg, 0.271 mmol), Pd(OAc)₂ (6.1 mg, 0.0271 mmol), AgOTf (28 mg, 0.108 mmol), and DMF (2 mL) was stirred at 140 °C for 24 h under oxygen atmosphere. The crude product was purified via flash chromatography (Hexanes/EtOAc, 4:6) to provide the title compound as a light yellow solid (50 mg, 88%), mp 148–150 °C. ¹H NMR (500 MHz, CDCl₃) δ 8.68 (s, 1H), 8.45 (d, *J* = 8.1 Hz, 1H), 7.83 (ddd, *J* = 8.3, 6.9, 1.4 Hz, 1H), 7.77 (d, *J* = 8.3 Hz, 1H), 7.52 – 7.43 (m, 2H), 7.39 (dd, *J* = 9.3, 1.8 Hz, 1H), 2.36 (s, 3H); ¹³C NMR (125 MHz, CDCl₃) δ 157.8, 147.4, 145.9, 136.4, 133.7, 126.2, 125.7, 124.7, 123.9, 122.5, 121.3, 115.1, 17.2; LC-MS (ESI) *m/z*: 211.10 [M+H].

2-Methoxy-8-methyl-11*H*-pyrido[2,1-*b*]quinazolin-11-one(2q):^{3c}



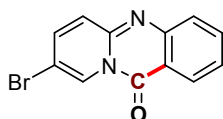
Following general procedure for the palladium catalyzed pyrido carbonylation of C(sp²-H) bond, a mixture of *N*-(4-methoxyphenyl)-5-methylpyridin-2-amine (50 mg, 0.233 mmol), Pd(OAc)₂ (5.5 mg, 0.0233 mmol), AgOTf (24 mg, 0.0932 mmol), and DMF (2 mL) was stirred at 140 °C for 24 h under oxygen atmosphere. The crude product was purified via flash chromatography (Hexanes/EtOAc, 3:7) to provide the title compound as a light yellow solid (51 mg, 90%), mp 149–151 °C. ¹H NMR (500 MHz, CDCl₃) δ 8.67 (s, 1H), 7.74 (dd, *J* = 11.0, 6.0 Hz, 2H), 7.54 – 7.41 (m, 2H), 7.33 (dd, *J* = 9.3, 1.8 Hz, 1H), 3.96 (s, 3H), 2.37 (s, 3H); ¹³C NMR (125 MHz, CDCl₃) δ 157.4, 156.1, 144.3, 142.6, 135.2, 127.5, 125.6, 124.7, 122.1, 121.4, 115.7, 103.9, 54.8, 17.3; HRMS (ESI): calcd. for C₁₄H₁₃N₂O₂ [M+H]⁺, 241.0972; found: 241.0992.

8-Fluoro-2-methyl-11*H*-pyrido[2,1-*b*]quinazolin-11-one (2r):



Following general procedure for the palladium catalyzed pyrido carbonylation of C(sp²-H) bond, a mixture of 5-fluoro-*N*-(*p*-tolyl)pyridin-2-amine (50 mg, 0.247 mmol), Pd(OAc)₂ (5.6 mg, 0.0247 mmol), AgOTf (26 mg, 0.099 mmol), and DMF (2 mL) was stirred at 140 °C for 24 h under oxygen atmosphere. The crude product was purified via flash chromatography (Hexanes/EtOAc, 3:7) to provide the title compound as a light yellow solid (44 mg, 78%), mp 166–168 °C. ¹H NMR (500 MHz, CDCl₃) δ 8.77 (dd, *J* = 4.8, 2.5 Hz, 1H), 8.22 (s, 1H), 7.76 – 7.64 (m, 2H), 7.52 (dd, *J* = 9.9, 5.4 Hz, 1H), 7.47 – 7.41 (m, 1H), 2.54 (s, 3H); ¹³C NMR (125 MHz, CDCl₃) δ 157.3, 152.2, 150.3, 144.1, 135.9, 135.2, 127.3 (d, *J* = 7.4 Hz), 126.2 (d, *J* = 27.4 Hz), 125.8, 125.0, 114.4, 110.9 (d, *J* = 41.9 Hz), 20.4; LC-MS (ESI) *m/z*: 229.30 [M+H].

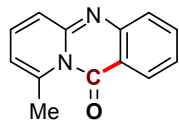
8-Bromo-11*H*-pyrido[2,1-*b*]quinazolin-11-one (2s):



Following general procedure for the palladium catalyzed pyrido carbonylation of C(sp²-H) bond, a mixture of 5-bromo-*N*-phenylpyridin-2-amine (50 mg, 0.20 mmol), Pd(OAc)₂ (4.5 mg, 0.020 mmol), AgOTf (21 mg, 0.08 mmol), and DMF (2

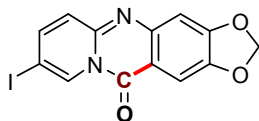
mL) was stirred at 140 °C for 24 h under oxygen atmosphere. The crude product was purified via flash chromatography (Hexanes/EtOAc, 3:7) to provide the title compound as a light yellow solid (45 mg, 80%), mp 186–188 °C. ¹H NMR (400 MHz, CDCl₃) δ 9.01 (s, 1H), 8.45 (d, *J* = 8.1 Hz, 1H), 7.87 (t, *J* = 7.3 Hz, 1H), 7.80 (d, *J* = 8.3 Hz, 1H), 7.52 (t, *J* = 7.2 Hz, 2H), 7.43 (d, *J* = 9.6 Hz, 1H); ¹³C NMR (125 MHz, CDCl₃) δ 157.9, 148.0, 145.9, 137.6, 135.3, 127.4, 127.3, 127.0, 126.5, 125.9, 116.2, 107.7; LC-MS (ESI) *m/z*: 275.20 [M+H].

9-Methyl-11*H*-pyrido[2,1-*b*]quinazolin-11-one (2t):



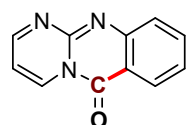
Following general procedure for the palladium catalyzed pyrido carbonylation of C(sp²-H) bond, a mixture of 6-methyl-*N*-phenylpyridin-2-amine (50 mg, 0.271 mmol), Pd(OAc)₂ (6.1 mg, 0.0271 mmol), AgOTf (28 mg, 0.108 mmol), and DMF (2 mL) was stirred at 140 °C for 24 h under oxygen atmosphere. The crude product was purified via flash chromatography (Hexanes/EtOAc, 3:7) to provide the title compound as a light yellow solid (43 mg, 75%), mp 140–142 °C. ¹H NMR (500 MHz, CDCl₃) δ 8.28 (dd, *J* = 8.1, 1.5 Hz, 1H), 7.76 (ddd, *J* = 8.4, 6.9, 1.5 Hz, 1H), 7.70 (dd, *J* = 8.3, 0.5 Hz, 1H), 7.40 (dddd, *J* = 8.1, 6.9, 5.3, 1.5 Hz, 1H), 7.31 (dd, *J* = 9.2, 0.6 Hz, 1H), 7.29 – 7.21 (m, 1H), 6.42 (dd, *J* = 6.6, 1.0 Hz, 1H), 2.98 (s, 3H); ¹³C NMR (125 MHz, CDCl₃) δ 161.3, 149.0, 146.3, 141.6, 133.7, 132.6, 126.1, 124.7, 120.0, 117.4, 114.4, 113.5, 23.6; HRMS (ESI): calcd. for C₁₃H₁₁N₂O [M+H]⁺, 211.0866; found: 211.0872.

8-Iodo-11*H*-[1,3]dioxolo[4,5-*g*]pyrido[2,1-*b*]quinazolin-11-one (2u):



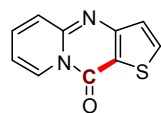
Following general procedure for the palladium catalyzed pyrido carbonylation of C(sp²-H) bond, a mixture of *N*-(benzo[*d*][1,3]dioxol-5-yl)-5-iodopyridin-2-amine (50 mg, 0.147 mmol), Pd(OAc)₂ (3.5 mg, 0.0147 mmol), AgOTf (15 mg, 0.058 mmol), and DMF (2 mL) was stirred at 140 °C for 24 h under oxygen atmosphere. The crude product was purified via flash chromatography (Hexanes/EtOAc, 3:7) to provide the title compound as a light yellow solid (42 mg, 78%), mp 132–134 °C. ¹H NMR (400 MHz, CDCl₃) δ 8.88 (s, 1H), 8.13 (d, *J* = 10.9 Hz, 1H), 7.73 (s, 1H), 7.49 (d, *J* = 3.2 Hz, 1H), 7.14 (s, 1H), 6.14 (s, 2H). ¹³C NMR (125 MHz, CDCl₃) δ 159.2, 148.6, 146.5, 139.2, 137.6, 135.3, 134.9, 130.9, 128.8, 122.8, 114.0, 107.7, 89.3; LC-MS (ESI) *m/z*: 367.20 [M+H].

6*H*-Pyrimido[2,1-*b*]quinazolin-6-one (2v):^{3a}



Following general procedure for the palladium catalyzed pyrido carbonylation of C(sp²-H) bond, a mixture of *N*-phenylpyrimidin-2-amine (50 mg, 0.292 mmol), Pd(OAc)₂ (6.5 mg, 0.0292 mmol), AgOTf (30 mg, 0.116 mmol), and DMF (2 mL) was stirred at 140 °C for 24 h under oxygen atmosphere. The crude product was purified via flash chromatography (Hexanes/EtOAc, 2:8) to provide the title compound as a light yellow solid (47 mg, 82%), mp 210–212 °C. ¹H NMR (500 MHz, CDCl₃) δ 9.13 (dd, *J* = 6.5, 1.6 Hz, 1H), 8.91 (dd, *J* = 7.4, 2.5 Hz, 1H), 8.50 (d, *J* = 1.7 Hz, 1H), 7.76 (ddd, *J* = 8.4, 6.9, 1.5 Hz, 2H), 7.52 – 7.45 (m, 1H), 6.81 (dd, *J* = 7.2, 1.3 Hz, 1H); ¹³C NMR (125 MHz, CDCl₃) δ 161.3, 159.4, 149.0, 147.1, 135.8, 135.4, 127.8, 127.4, 126.1, 117.4, 107.3; HRMS (ESI): calcd. for C₁₁H₈N₃O [M+H]⁺, 198.0662; found: 198.0661.

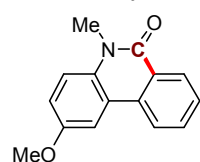
10*H*-Pyrido[1,2-*a*]thieno[3,2-*d*]pyrimidin-10-one (2w):



Following general procedure for the palladium catalyzed pyrido carbonylation of C(sp²-H) bond, a mixture of *N*-(thiophen-3-yl)pyridin-2-amine (50 mg, 0.284 mmol), Pd(OAc)₂ (6.4 mg, 0.0284 mmol), AgOTf (29 mg, 0.114 mmol), and DMF (2 mL) was stirred at 140 °C for 24 h under oxygen atmosphere. The crude product was purified via flash chromatography (Hexanes/EtOAc, 4:6) to provide the title compound as a light yellow solid (39 mg, 68%), mp 158–160 °C. ¹H NMR (500 MHz, CDCl₃) δ 9.05 (dd, *J* = 7.3, 1.0 Hz, 1H), 7.97 (d, *J* = 5.3 Hz, 1H), 7.69 – 7.63 (m, 2H), 7.43 (d, *J* = 5.3 Hz, 1H), 7.11 – 7.01 (m, 1H); ¹³C NMR (125 MHz, CDCl₃) δ

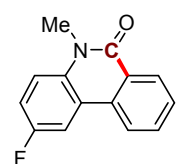
135.7, 133.1, 132.5, 128.4, 127.5, 125.8, 124.4, 123.1, 121.7, 116.1, 112.7, 30.1, 21.9; **HRMS** (ESI): calcd. for $C_{15}H_{14}NO$ $[M+H]^+$, 224.1070; found: 224.1072.

2-Methoxy-5-methylphenanthridin-6(5H)-one(4c):^{4b}



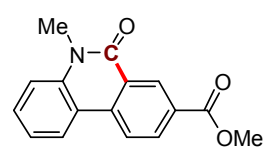
Following general procedure for the palladium catalyzed amino carbonylation of $C(sp^2-H)$ bond, a mixture of 5-methoxy-*N*-methyl-[1,1'-biphenyl]-2-amine (50 mg, 0.234 mmol), $Pd(OAc)_2$ (5.3 mg, 0.0234 mmol), $AgOTf$ (24 mg, 0.094 mmol), and DMF (2 mL) was stirred at 140 °C for 24 h under oxygen atmosphere. The crude product was purified via flash chromatography (Hexanes/EtOAc, 7:3) to provide the title compound as a slight orange solid (48 mg, 85%), mp 121–123 °C. **¹H NMR** (500 MHz, $CDCl_3$) δ 8.50 (dd, $J = 8.0, 1.3$ Hz, 1H), 8.15 – 8.11 (m, 2H), 7.72 (ddd, $J = 8.3, 7.2, 1.4$ Hz, 1H), 7.55 – 7.47 (m, 1H), 7.14 (d, $J = 2.5$ Hz, 1H), 6.91 (dd, $J = 8.9, 2.6$ Hz, 1H), 3.94 (s, 4H), 3.86 (s, 3H); **¹³C NMR** (125 MHz, $CDCl_3$) δ 161.4, 132.6, 131.4, 131.0, 128.4, 126.9, 125.1, 124.7, 121.3, 120.7, 113.0, 110.6, 96.7, 55.6, 30.03; **HRMS** (ESI): calcd. For $C_{15}H_{14}NO_2$ $[M+H]^+$, 240.1019; found: 240.1020.

2-Fluoro-5-methylphenanthridin-6(5H)-one(4d):



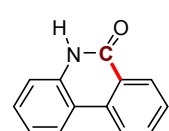
Following general procedure for the palladium catalyzed amino carbonylation of $C(sp^2-H)$ bond, a mixture of 5-fluoro-*N*-methyl-[1,1'-biphenyl]-2-amine (50 mg, 0.248 mmol), $Pd(OAc)_2$ (6 mg, 0.0248 mmol), $AgOTf$ (26 mg, 0.099 mmol), and DMF (2 mL) was stirred at 140 °C for 24 h under oxygen atmosphere. The crude product was purified via flash chromatography (Hexanes/EtOAc, 7:3) to provide the title compound as a white solid (43 mg, 76%), mp 126–128 °C. **¹H NMR** (500 MHz, $CDCl_3$) δ 8.53 (dd, $J = 8.0, 1.1$ Hz, 1H), 8.23 (dd, $J = 8.9, 5.6$ Hz, 1H), 8.18 (d, $J = 8.1$ Hz, 1H), 7.86 – 7.68 (m, 1H), 7.66 – 7.51 (m, 1H), 7.37 (dd, $J = 10.1, 2.6$ Hz, 1H), 7.13 – 6.99 (m, 1H), 3.85 (s, 3H); **¹³C NMR** (125 MHz, $CDCl_3$) δ 164.8, 162.8, 157.5, 137.3 (d, $J = 11.0$ Hz), 132.9, 132.5, 128.6, 127.9, 125.6, 125.3 (d, $J = 9.8$ Hz), 121.7, 110.9 (d, $J = 22.8$ Hz), 99.8 (d, $J = 27.8$ Hz), 29.7; **HRMS** (ESI): calcd. for $C_{14}H_{11}FNO$ $[M+H]^+$, 228.0819; found: 228.0818

Methyl 5-methyl-6-oxo-5,6-dihydrophenanthridine-8-carboxylate (4e):



Following general procedure for the palladium catalyzed amino carbonylation of $C(sp^2-H)$ bond, a mixture of methyl 2'-(methylamino)-[1,1'-biphenyl]-4-carboxylate (50 mg, 0.207 mmol), $Pd(OAc)_2$ (5 mg, 0.0207 mmol), $AgOTf$ (21 mg, 0.0828 mmol), and DMF (2 mL) was stirred at 140 °C for 24 h under oxygen atmosphere. The crude product was purified via flash chromatography (Hexanes/EtOAc, 6:4) to provide the title compound as a white solid (39 mg, 70%), mp 161–163 °C. **¹H NMR** (400 MHz, $CDCl_3$) δ 8.57 (d, $J = 8.0$ Hz, 1H), 8.31 (dd, $J = 8.1, 3.8$ Hz, 3H), 7.99 (dd, $J = 8.4, 1.3$ Hz, 1H), 7.81 (dd, $J = 11.1, 4.1$ Hz, 1H), 7.66 (t, $J = 7.5$ Hz, 1H), 4.00 (s, 3H), 3.81 (s, 3H); **¹³C NMR** (100 MHz, $CDCl_3$) δ 166.3, 162.0, 135.7, 132.8, 132.0, 131.2, 129.1, 128.7, 128.3, 123.9, 123.4, 122.6, 114.0, 52.5, 29.7; **HRMS** (ESI): calcd. for $C_{16}H_{14}NO_3$ $[M+H]^+$, 268.0968; found: 268.0972.

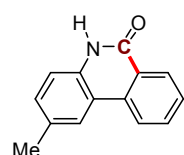
phenanthridin-6(5H)-one (4f):^{4c}



Following general procedure for the palladium catalyzed amino carbonylation of $C(sp^2-H)$ bond, a mixture of [1,1'-biphenyl]-2-amine (50 mg, 0.295 mmol), $Pd(OAc)_2$ (6.6 mg, 0.0295 mmol), $AgOTf$ (31 mg, 0.118 mmol), and DMF (2 mL) was stirred at 140 °C for 24 h under oxygen atmosphere. The crude product was purified via flash chromatography (Hexanes/EtOAc, 8:2) to provide the title compound as a pale yellow solid (40 mg, 70%), mp 308–310 °C. **¹H NMR** (500 MHz, MeOD) δ 8.43 (d, $J = 8.0$ Hz, 1H), 8.30 (d, $J = 8.2$ Hz, 1H), 8.21 (d, $J = 8.1$ Hz, 1H), 8.04 – 7.99 (m, 1H), 7.82 – 7.75 (m, 1H), 7.60 – 7.57 (m, 1H), 7.39 (d, $J = 8.4$ Hz,

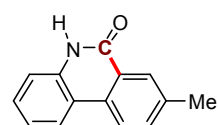
1H), 7.30 (d, $J = 8.6$ Hz, 1H); ^{13}C NMR (125 MHz, MeOD) δ 161.7, 134.6, 133.8, 131.9, 128.6, 128.4, 127.1, 126.7, 121.9, 121.7, 121.0, 117.5, 115.3; LC-MS (ESI) m/z : 196.20 [M+H].

2-Methylphenanthridin-6(5H)-one (4g):^{4d}



Following general procedure for the palladium catalyzed amino carbonylation of C(sp²-H) bond, a mixture of 5-methyl-[1,1'-biphenyl]-2-amine (50 mg, 0.273 mmol), Pd(OAc)₂ (6.1 mg, 0.0273 mmol), AgOTf (28 mg, 0.109 mmol), and DMF (2 mL) was stirred at 140 °C for 24 h under oxygen atmosphere. The crude product was purified via flash chromatography (Hexanes/EtOAc, 7:3) to provide the title compound as a white solid (41 mg, 72%), mp 198–200 °C. ^1H NMR (400 MHz, CDCl₃) δ 11.11 (s, 1H), 8.54 (d, $J = 8.0$ Hz, 1H), 8.31 (d, $J = 8.2$ Hz, 1H), 8.03 (s, 1H), 7.80 (dd, $J = 5.6, 2.4$ Hz, 1H), 7.60 (dd, $J = 7.7, 3.8$ Hz, 1H), 7.51 – 7.43 (m, 2H), 2.50 (s, 3H); ^{13}C NMR (125 MHz, CDCl₃) δ 161.2, 134.8, 134.0, 131.8, 129.2, 128.4, 127.7, 126.8, 121.9, 121.7, 121.0, 117.5, 115.3, 21.5; HRMS (ESI): calcd. for C₁₄H₁₂NO [M+H]⁺, 210.0914; found: 210.0916.

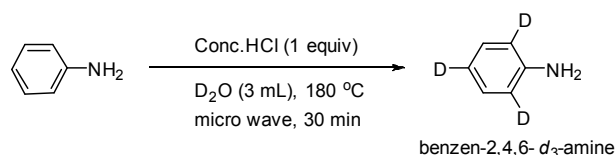
8-Methylphenanthridin-6(5H)-one (4h):^{4e}



Following general procedure for the palladium catalyzed amino carbonylation of C(sp²-H) bond, a mixture of 4'-methyl-[1,1'-biphenyl]-2-amine (50 mg, 0.273 mmol), Pd(OAc)₂ (6.1 mg, 0.0273 mmol), AgOTf (28 mg, 0.109 mmol), and DMF (2 mL) was stirred at 140 °C for 24 h under oxygen atmosphere. The crude product was purified via flash chromatography (Hexanes/EtOAc, 7:3) to provide the title compound as a gray white solid (43 mg, 75%), mp 220–222 °C. ^1H NMR (500 MHz, CDCl₃) δ 11.25 (s, 1H), 8.32 (d, $J = 8.1$ Hz, 1H), 8.11 (d, $J = 7.8$ Hz, 1H), 8.01 – 7.97 (m, 2H), 7.40 – 7.30 (m, 3H), 2.49 (s, 3H); ^{13}C NMR (125 MHz, CDCl₃) δ 161.7, 142.2, 133.7, 131.6, 128.7, 128.2, 127.1, 127.0, 121.6, 121.5, 120.9, 117.3, 115.6, 21.0; HRMS (ESI): calcd. for C₁₄H₁₂NO [M+H]⁺, 210.0914; found: 210.0913.

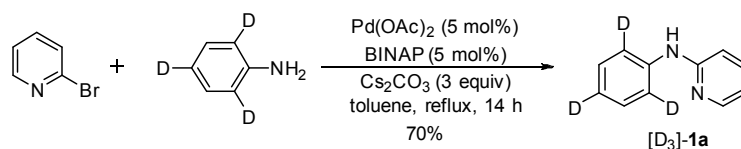
5. Determination of intermolecular kinetic isotopic effect:

a) Synthesis of benzen-2,4,6-d₃-amine:⁵



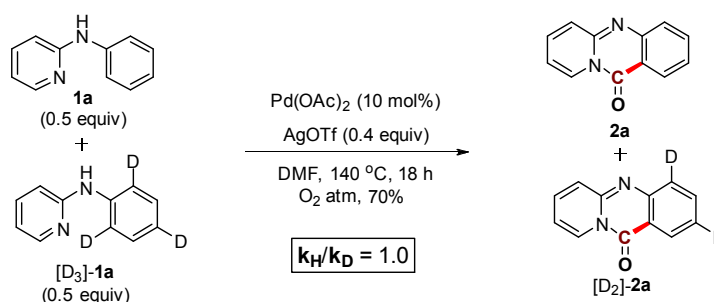
In a microwave reaction vial with a magnetic stir bar, aniline (2.15 mmol, 1 equiv) was added, followed by Conc. HCl (260 μL , 1 equiv) in 5 mL of D₂O. The vial was capped and sealed and heated in the microwave synthesis apparatus for 30 minutes at a temperature of 180 °C. The reaction mixture can be directly concentrated to afford the DCl salt of the aniline. Alternatively, basic aqueous workup (*via* addition of 10 mL 3M NaOH, 6 mL brine and 20 mL Et₂O, separation of phases, and washing the organic phase with brine) can be used to afford the benzene-2,4,6-*d*₃-aniline as light brown colour liquid (186 mg, 90%). ^1H NMR (400 MHz, CDCl₃) δ = 7.13 (s, 1H), 3.57 (s, 1H); ^{13}C NMR (125 MHz, CDCl₃) δ = 145.5, 128.2, 128.1; LC-MS (ESI) m/z : 97.10 [M+H].

b) Synthesis of *N*-(phenyl-2,4,6-d₃)pyridin-2-amine:^{1b}



To a round-bottomed flask were added palladium diacetate (0.0318 mmol, 5 mol %), (\pm)-2,2'-bis(diphenylphosphino)-1,1'-binaphthyl [(\pm)-BINAP] (0.0318 mmol, 5 mol%) and toluene (anhydrous, 5 mL), and the resulting mixture then stirred under a stream of argon for 10 minutes. After this time 2-bromo pyridine (0.636 mmol, 1 equiv) and 2, 4, 6-deuterated aniline (0.763 mmol, 1.2 equiv) were added with caesium carbonate (1.908 mmol, 3 equiv), the reaction was fitted with a condenser, and heated to reflux with vigorous stirring under argon for 14 h. After this time the solids were removed by filtration through celite, the pad washed with DCM (2 x 20 mL) and the volatiles removed under reduced pressure. The resulting residue was purified by columnar chromatography on silica gel, to give pure *N*-(phenyl-2,4,6- d_3)pyridin-2-amine as white solid (77 mg, 70%). $^1\text{H NMR}$ (400 MHz, CDCl_3) δ = 8.24 – 8.19 (m, 1H), 7.54 – 7.46 (m, 1H), 7.34 (s, 2H), 6.88 (d, J =8.4, 1H), 6.77 – 6.71 (m, 1H), 6.61 (s, 1H). $^{13}\text{C NMR}$ (125 MHz, CDCl_3) δ = 155.1, 147.3, 139.3, 136.6, 128.1, 128.0, 113.93, 107.1; LC-MS (ESI) m/z : 174.10 [M+H].

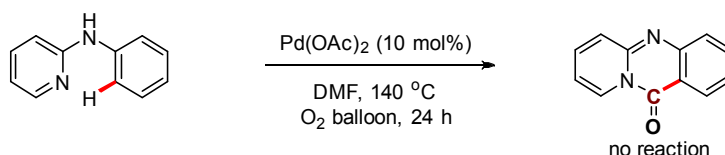
c) Determination of kinetic isotopic effect:



N-phenyl-2-amino pyridine (**1a**, 0.5 equiv) and *N*-(phenyl-2, 4, 6- d_3) pyridin-2-amine ([D_3]-**1a**, 0.5 equiv) Pd(OAc) $_2$ (10 mol%), and AgOTf (0.4 equiv), were added to an oven dried sealed tube with cap. DMF (2 mL) was added to the tube and the tube was placed under vacuum and purged with O_2 trice and capped well. The reaction mixture was stirred for 18 h at 140 °C temperature. The progress of the reaction was monitored by TLC, the reaction mixture was diluted with EtOAc (20 mL) filtered through a plug of celite. Total organic portion was concentrated and purified via column chromatography the kinetic isotopic effect (KIE) value was calculated as $k_H/k_D = 1.0$. $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 8.89 (dt, $J = 7.4$, 1.2 Hz, 2H), 8.54 – 8.39 (m, 2H), 7.92 – 7.83 (m, 2H), 7.81 (s, 1H), 7.79 (s, 1H), 7.52 (dd, $J = 3.7$, 1.0 Hz, 4H), 6.87 (dt, $J = 7.6$, 3.9 Hz, 2H).

6. Controlled experiments:

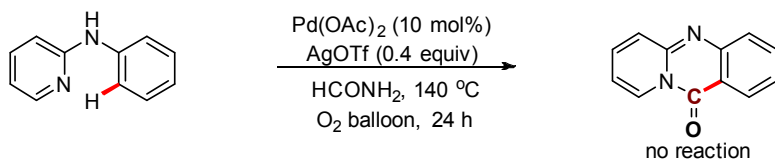
a) In absence of AgOTf:



N-phenyl-2-amino pyridine (**1a**) (50 mg, 0.294 mmol, 1 equiv), and Pd(OAc) $_2$ (6.6 mg, 0.0294 mmol, 10 mol%), were added to an oven dried sealed tube with cap. DMF (2 mL) was added to the tube and the tube was placed under vacuum and purged with O_2 trice and capped well. The reaction mixture was stirred for 24 h at 140 °C temperature and cooled to room temperature. The reaction mixture was diluted

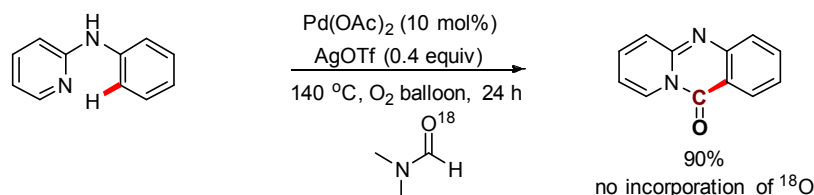
with 10 mL of CH₂Cl₂, and filtered through a celite pad, then detected by TLC. The result showed that **2a** was not obtained.

b) Reaction in formamide as solvent instead of DMF:



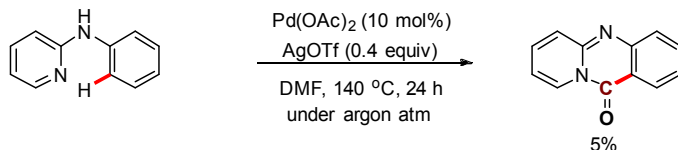
N-phenyl-2-amino pyridine (**1a**) (50 mg, 0.294 mmol, 1 equiv), Pd(OAc)₂ (6.6 mg, 0.0294 mmol, 10 mol%), and AgOTf (30 mg, 0.117 mmol, 0.4 equiv) were added to an oven dried sealed tube with cap. HCONH₂ (formamide) (2 mL) was added to the tube and the tube was placed under vacuum and purged with O₂ trice and capped well. The reaction mixture was stirred for 24 h at 140 °C temperature and cooled to room temperature. The reaction mixture was diluted with 10 mL of CH₂Cl₂, and filtered through a celite pad, then detected by TLC. The result showed that **2a** was not obtained.

c) In the presence of ¹⁸O labelled DMF as solvent:



N-phenyl-2-amino pyridine (**1a**) (50 mg, 0.294 mmol, 1 equiv), Pd(OAc)₂ (6.6 mg, 0.0294 mmol, 10 mol%), and AgOTf (30 mg, 0.117 mmol, 0.4 equiv) were added to an oven dried sealed tube with cap. ¹⁸O labeled DMF (C=O¹⁸) (1 mL) was added to the tube and the tube was placed under vacuum and purged with O₂ trice and capped well. The reaction mixture was stirred for 24 h at 140 °C temperature. The progress of the reaction was monitored by TLC and after completion of the reaction, the reaction mixture was diluted with EtOAc (20 mL) filtered through a plug of celite. Total organic portion was concentrated and purified via column chromatography through silica gel using hexane-EtOAc as eluent. Found that there is no incorporation of ¹⁸O labelled carbonyl was observed in final product.

d) Reaction under argon atmosphere:



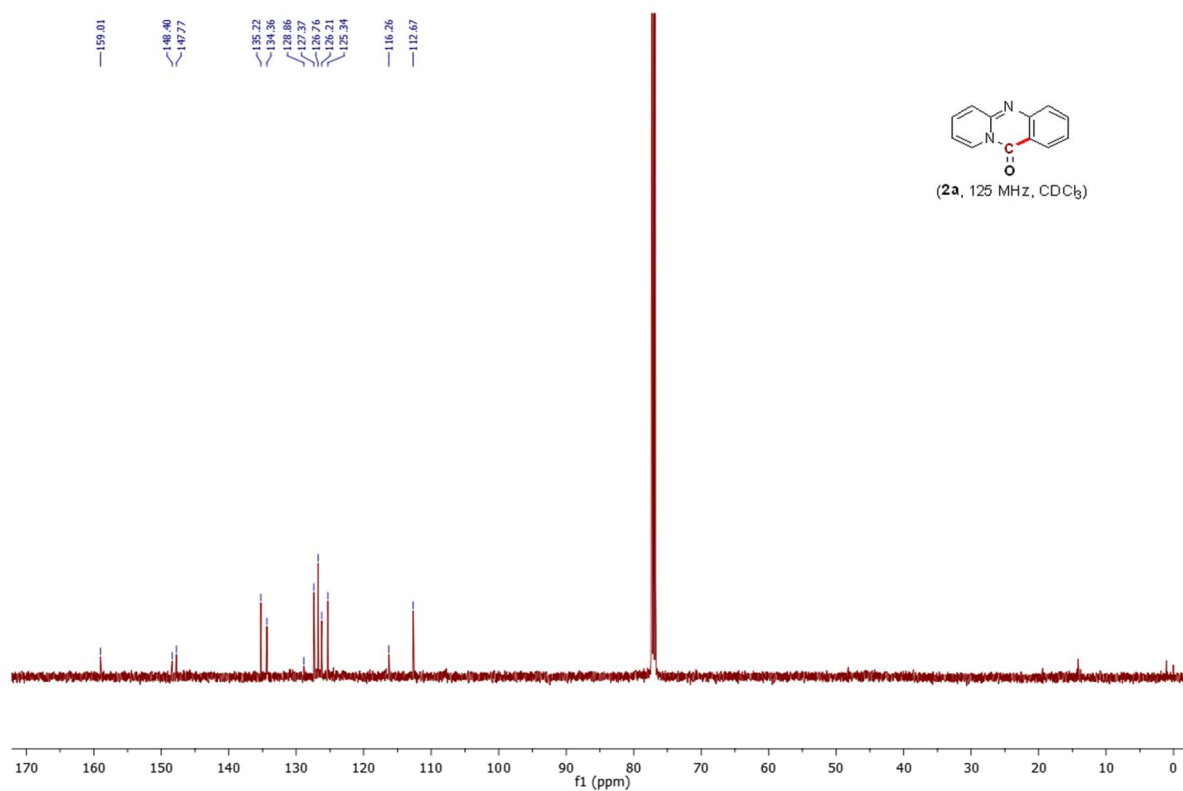
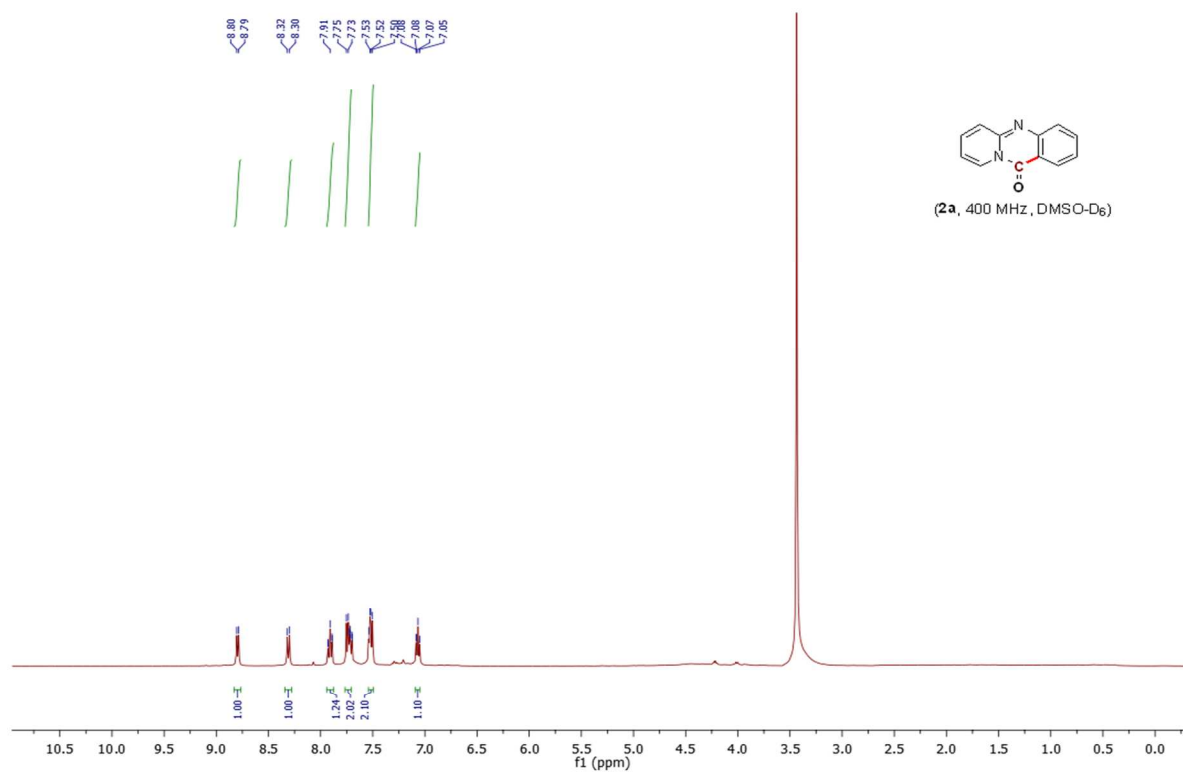
N-phenyl-2-amino pyridine (**1a**) (50 mg, 0.294 mmol, 1 equiv), Pd(OAc)₂ (6.6 mg, 0.0294 mmol, 10 mol%), and AgOTf (30 mg, 0.117 mmol, 0.4 equiv) were added to an oven dried sealed tube with cap. DMF (2 mL) was added to the tube and the tube was placed under vacuum and purged with argon trice and capped well. The reaction mixture was stirred for 24 h at 140 °C temperature. The progress of the reaction was monitored by TLC, the reaction mixture was diluted with EtOAc (20 mL) filtered through a plug of celite. Total organic portion was concentrated and purified via column chromatography through silica gel using hexane-EtOAc as eluent to provide the desired pyrido carbonylation products (**2a**) was isolated in 5% yield.

7. References:

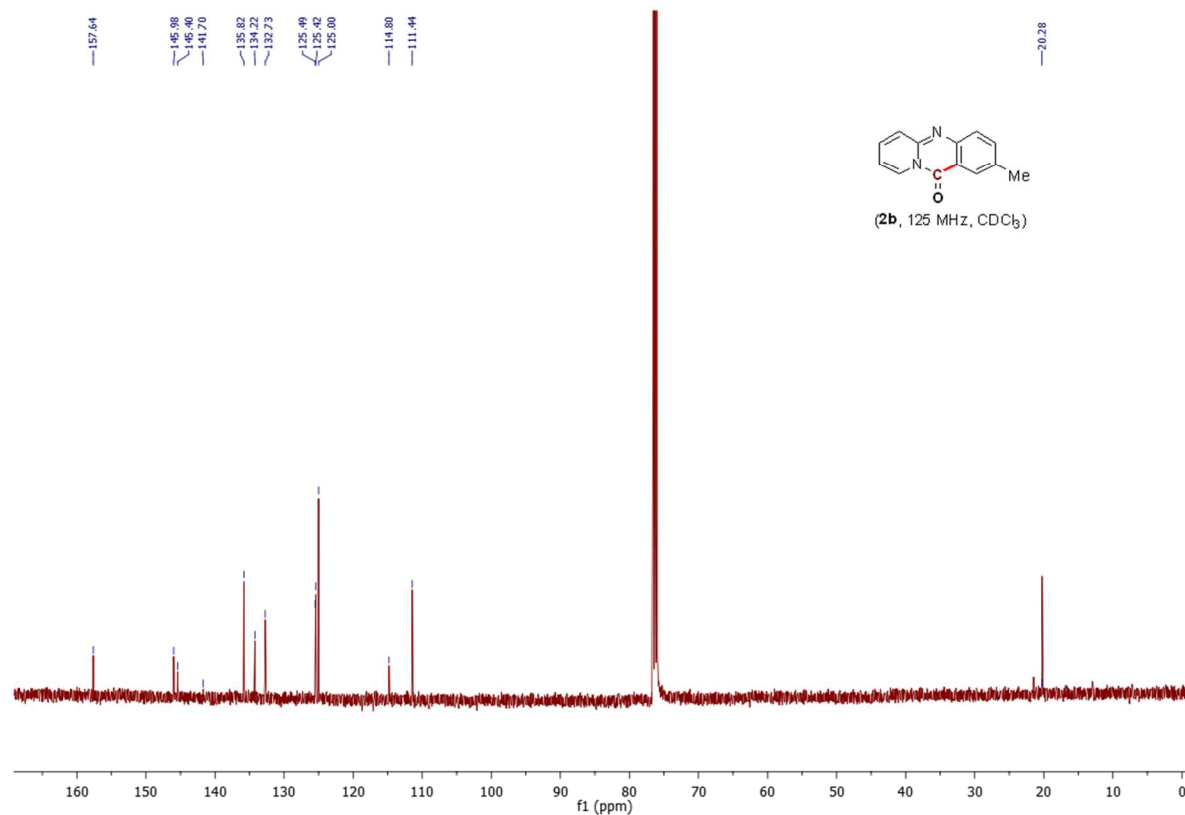
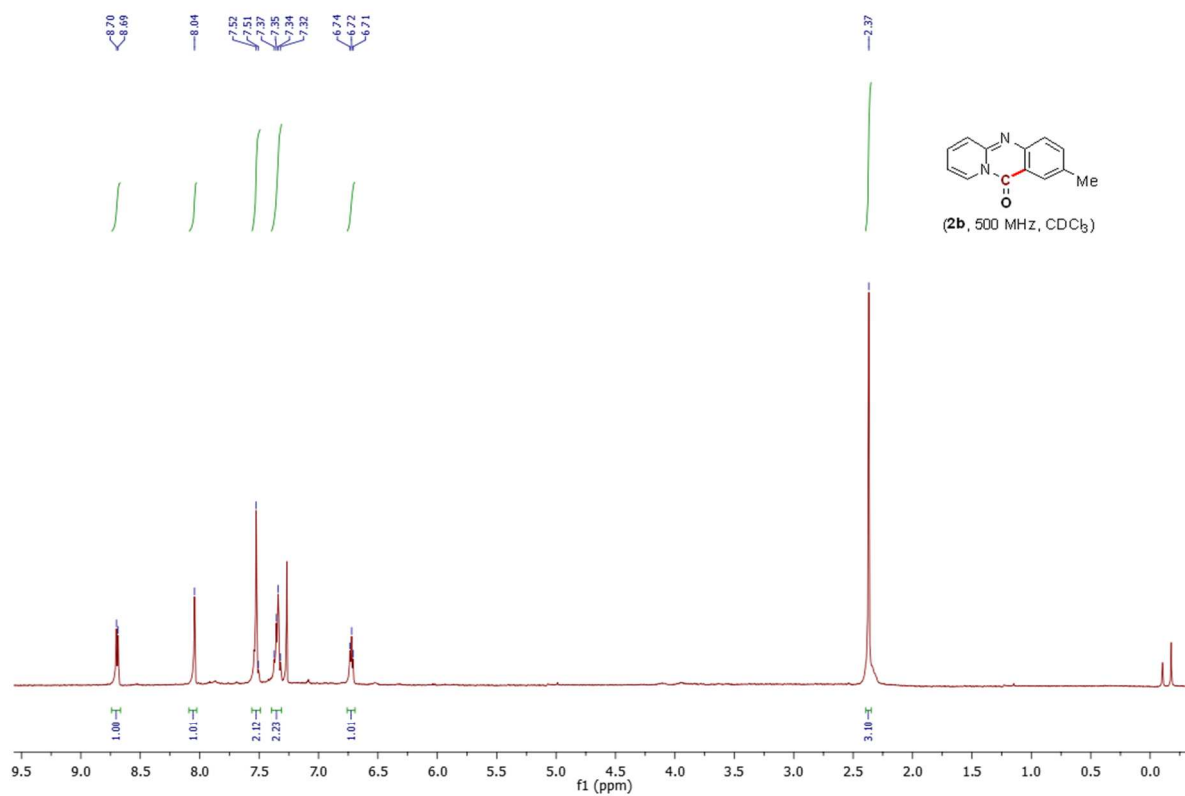
- (1) (a) Rao, D. N.; Rasheed, S.; Aravinda, S.; Vishwakarma, R. A.; Das, P. *Rsc. Adv.*, **2013**, *3*, 11472. (b) Masters, K. –S.; Rauws, T. R. M.; Yadav, A. K.; Herrebout, W. A.; Veken, B. V.; Maes, B. U. M. *Chem. Eur. J.*, **2011**, *17*, 6315. (c) Wang, D.; Kuang, D.; Zhang, F.; Liu, Y.; Ning, S. *Tetrahydron Letters* **2014**, *55*, 7121.
- (2) (a) Xi, J.; Dong, Q.-L.; Liu, G.-S.; Wang, S.; Chen, L.; Yao, Z.-J. *Synlett.*, **2010**, *11*, 1674. (b) Suzuki, C.; Hirano, K.; Satoh, T.; Miura, M. *Org. Lett.* **2015**, *17*, 1597. (c) Rajeshkumar, V.; Lee, T. –H.; Chuang, S. –C. *Org. Lett.* **2013**, *15*, 1468.
- (3) (a) Liang, D.; He, Y.; Zhu, Q. *Org. Lett.* **2014**, *16*, 2748. (b) Sun, J.; Tan, Q.; Yang, W.; Liu, B.; Xu, B. *Adv. Synth. Catal.*, **2014**, *356*, 388. (c) Liu, M.; Shu, M.; Yao, C.; Yin, G.; Wang, D.; Huang, J. *Org. Lett.* **2016**, *18*, 824. (d) Chen, J.; Natte, K.; Spannenberg, A.; Neumann, H.; Langer, P.; Beller, M.; Wu, X. –F. *Angew. Chem. Int. Ed.*, **2014**, *53*, 7579.
- (4) (a) Liang, D.; Hu, Z.; Peng, J.; Huang, J.; Zhu, Q. *Chem. Commun.*, **2013**, *49*, 173. (b) Zhang, G.; Zhao, X.; Yan, Y.; Ding, C. *Eur. J. Org. Chem.*, **2012**, 669. (c) Wang, G.-W.; Yuan, T.-T.; Li, D.-D. *Angew. Chem., Int. Ed.*, **2011**, *50*, 1380. (d) Bhakuni, B. S.; Kumar, A.; Balkrishna, S. J.; Sheikh, J. A.; Konar, S.; Kumar, S. *Org. Lett.*, **2012**, *14*, 2838. (e) Taylojrr, B. E. C.; Strojny, E. J. *J. Am. Chem. Soc.*, **1956**, *78*, 5104.
- (5) Martins, A.; Lautens, M. *Org. Lett.* **2008**, *10*, 4351.

8. Copies of ^1H -NMR and ^{13}C -NMR spectra:

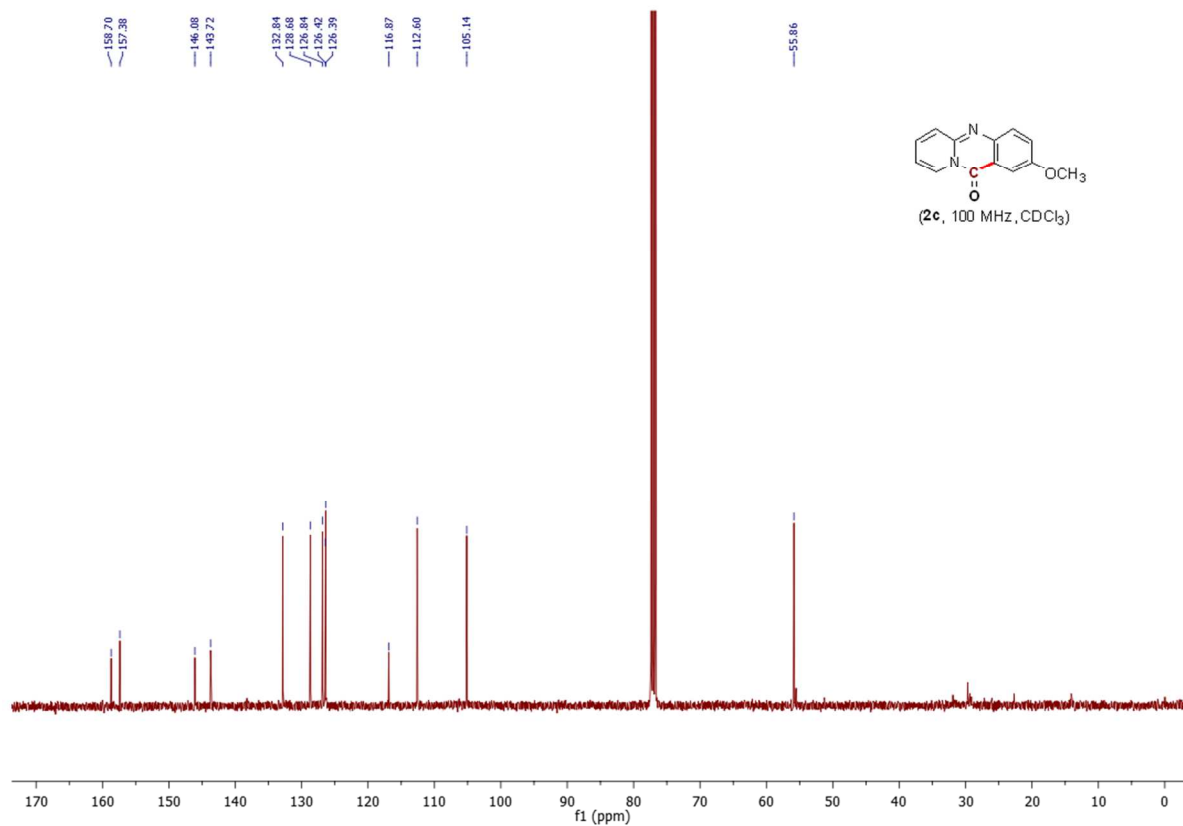
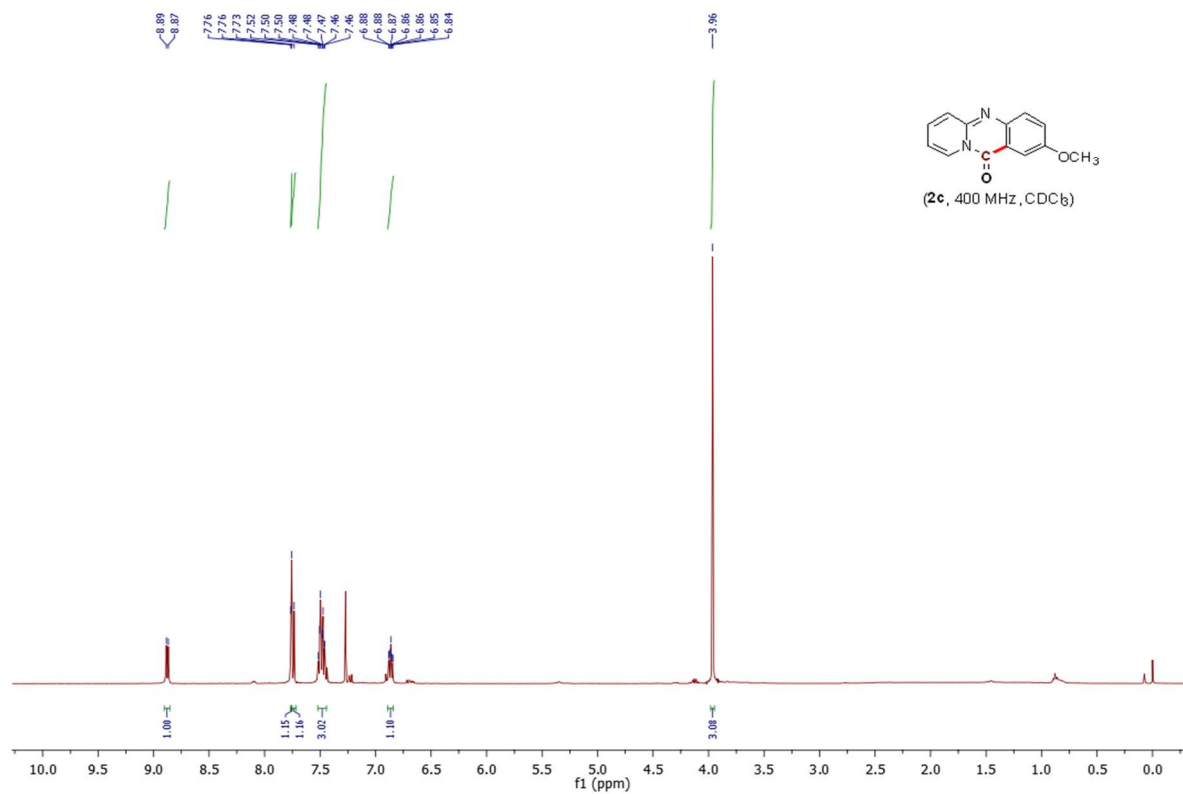
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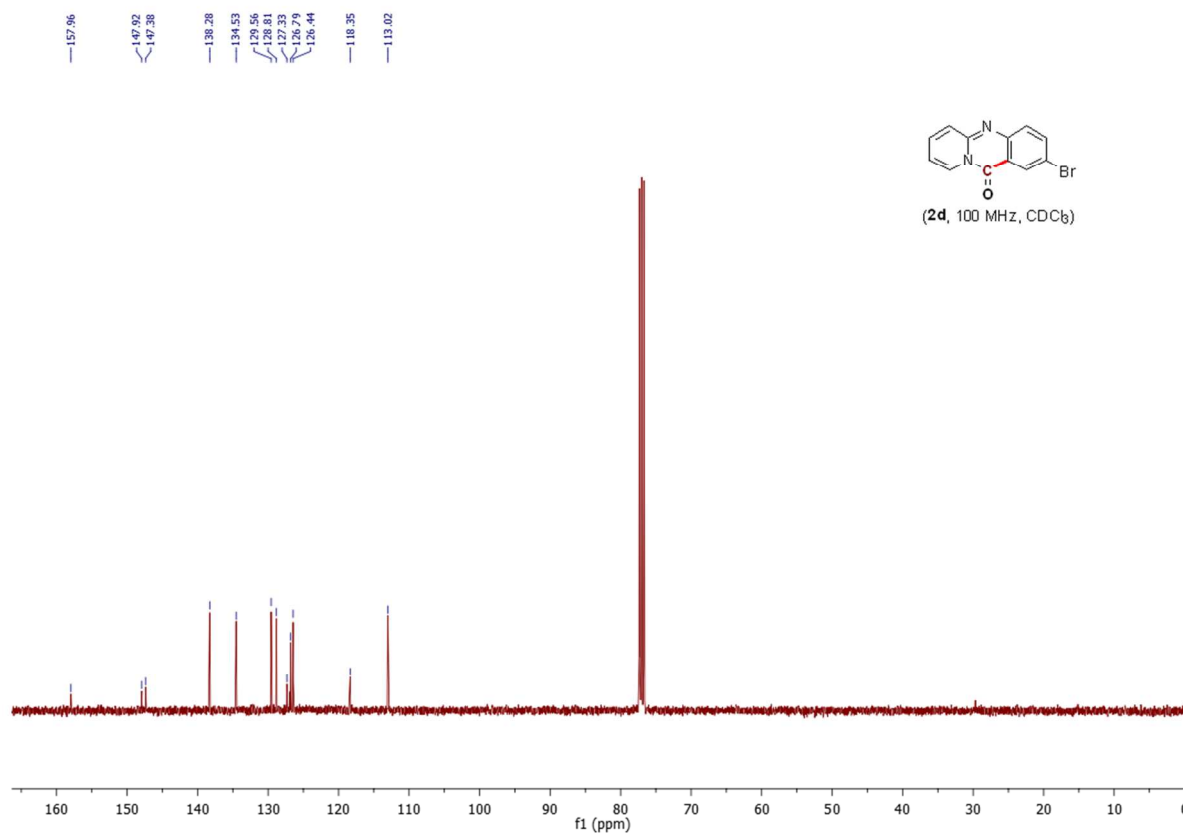
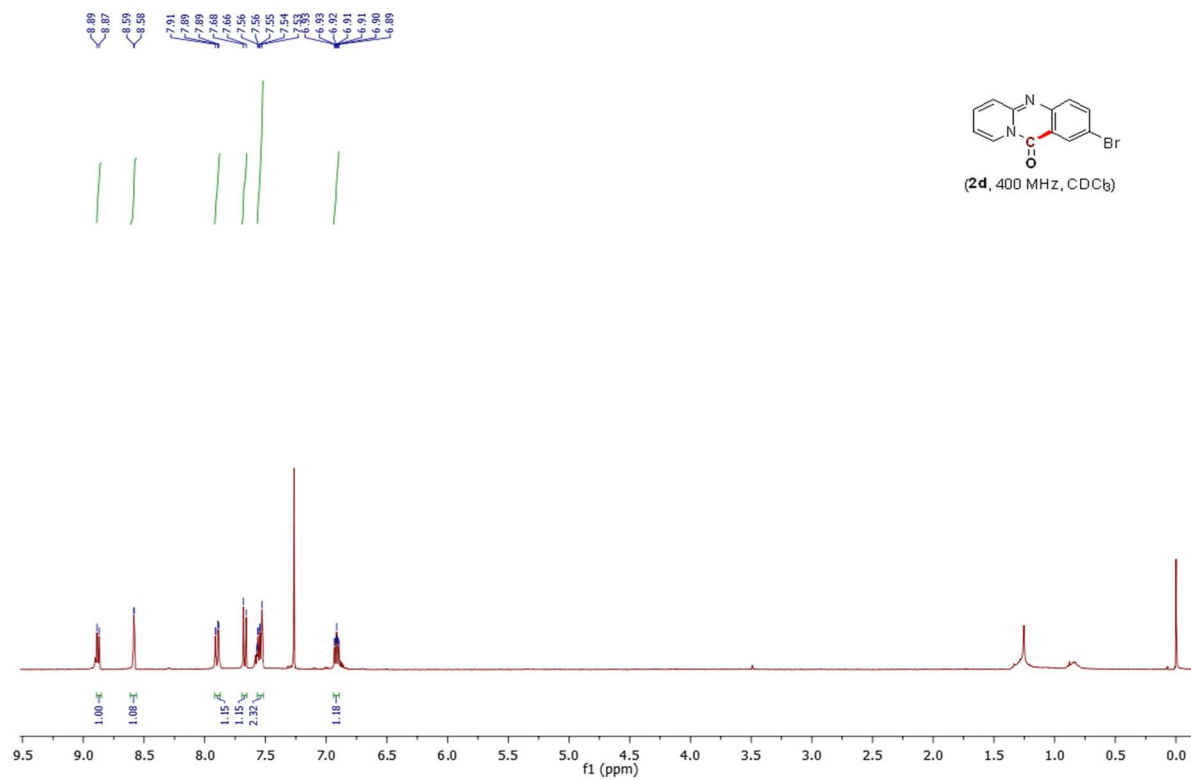
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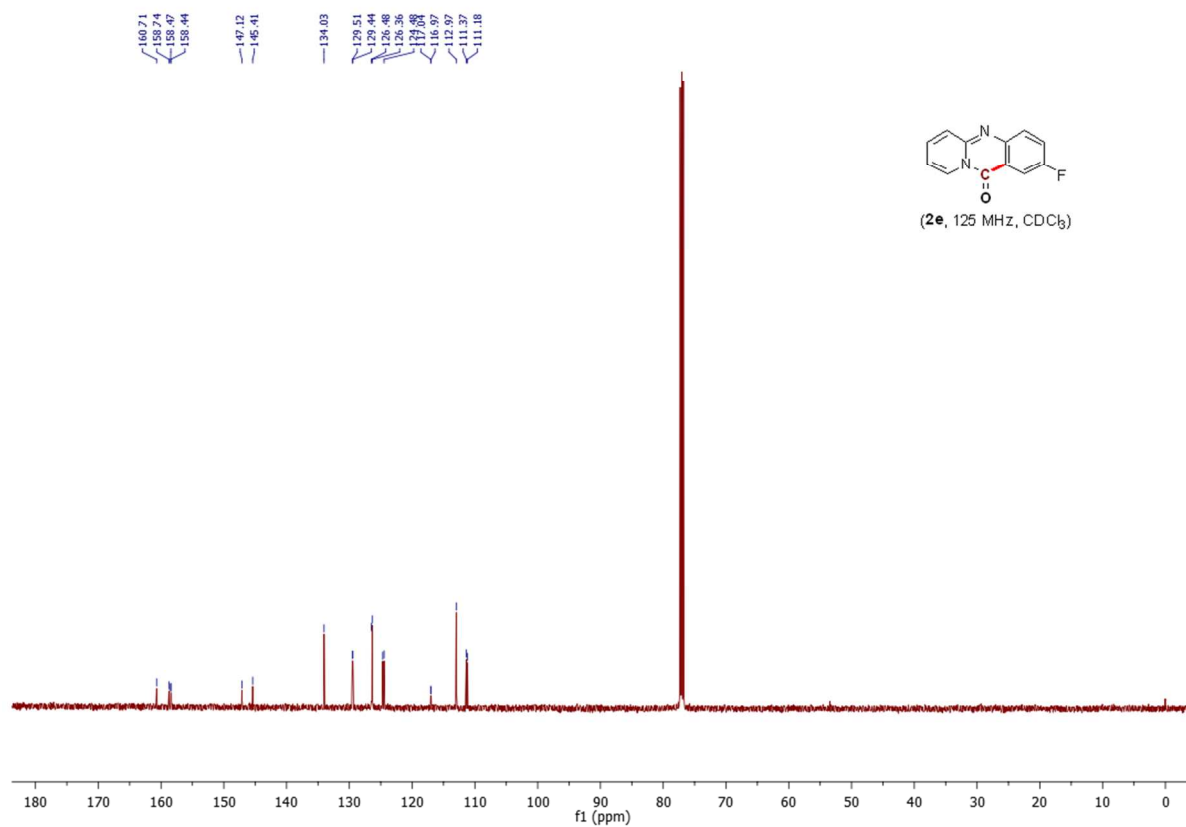
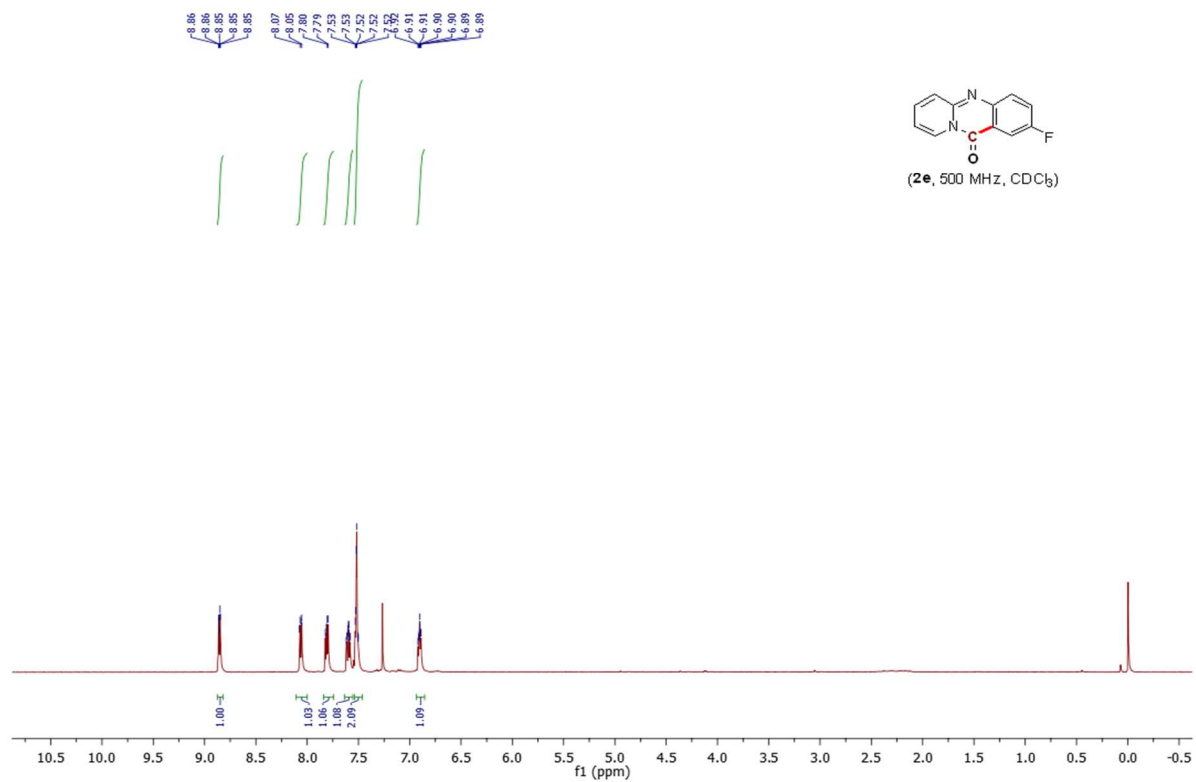
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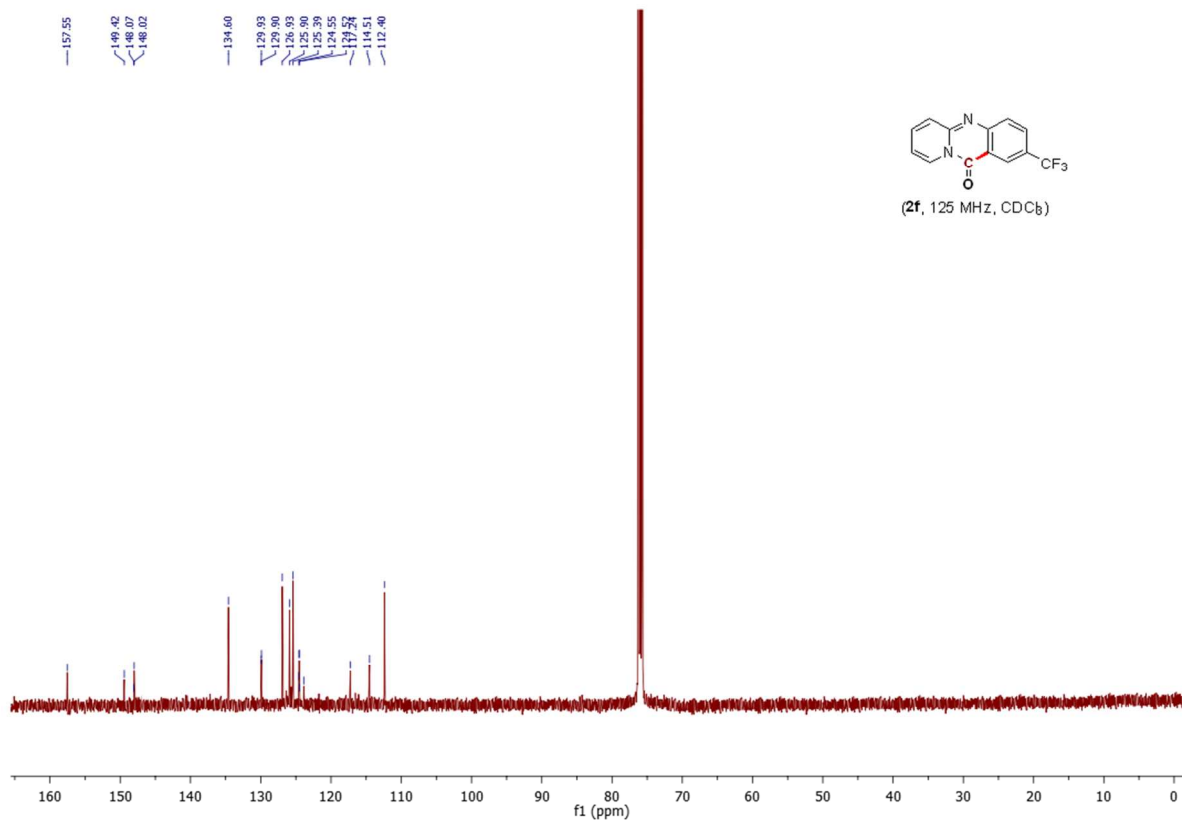
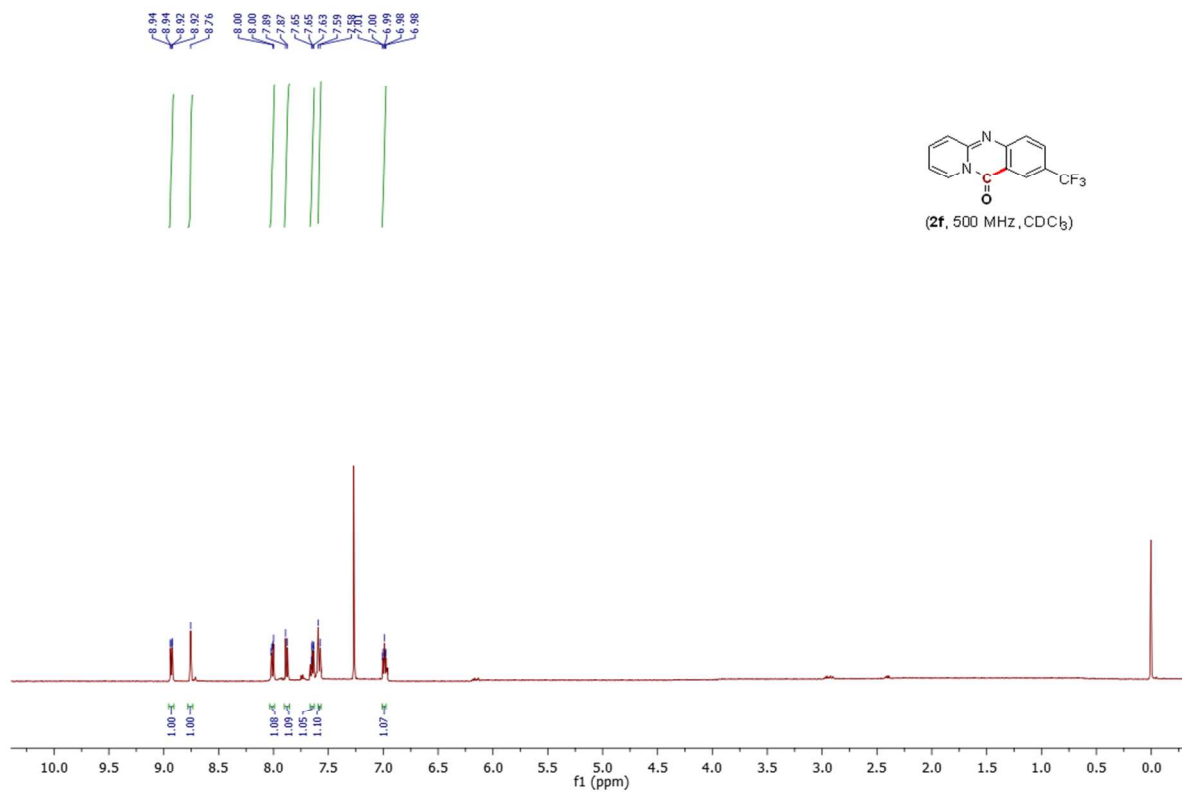
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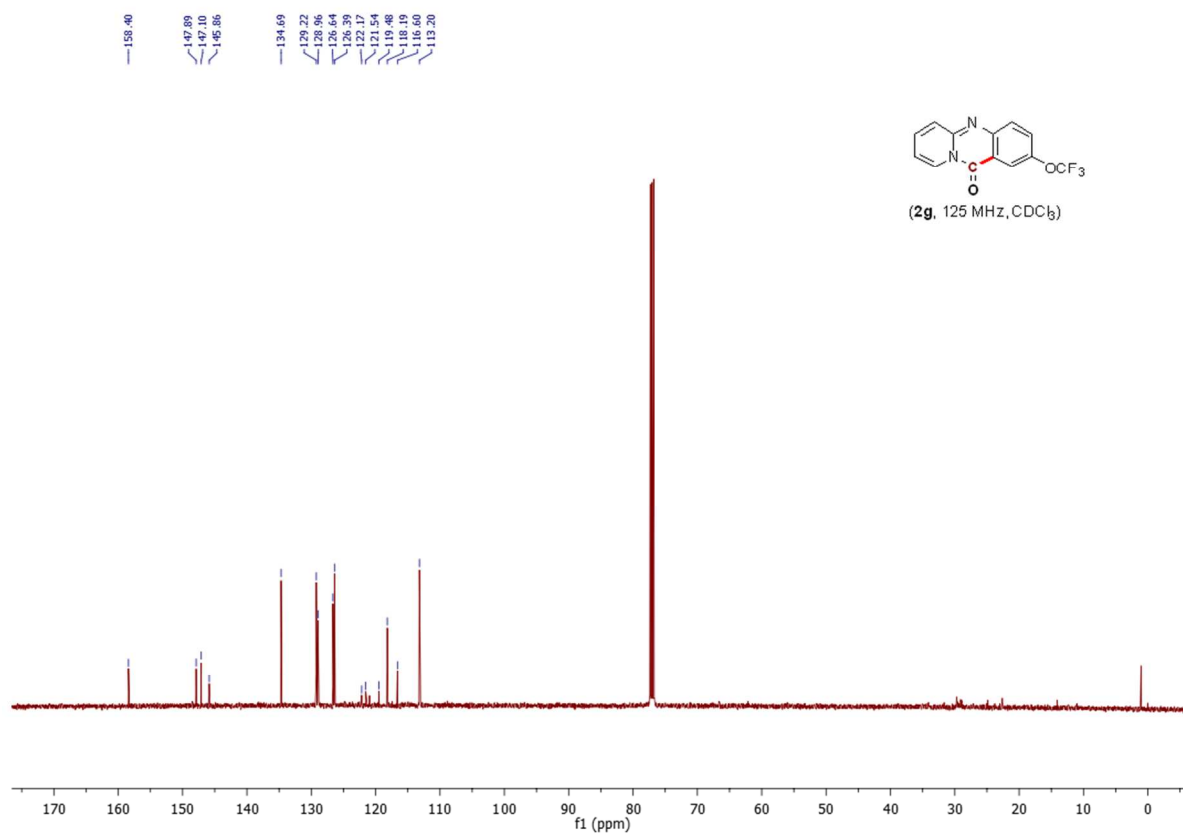
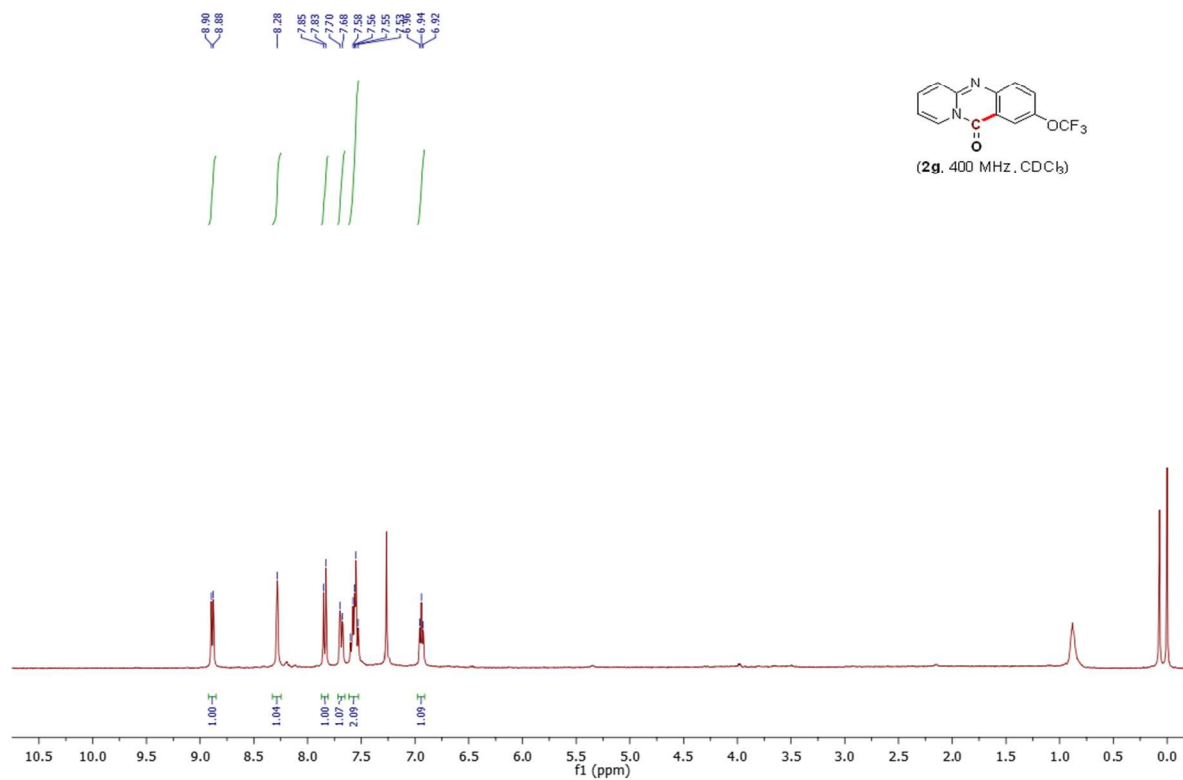
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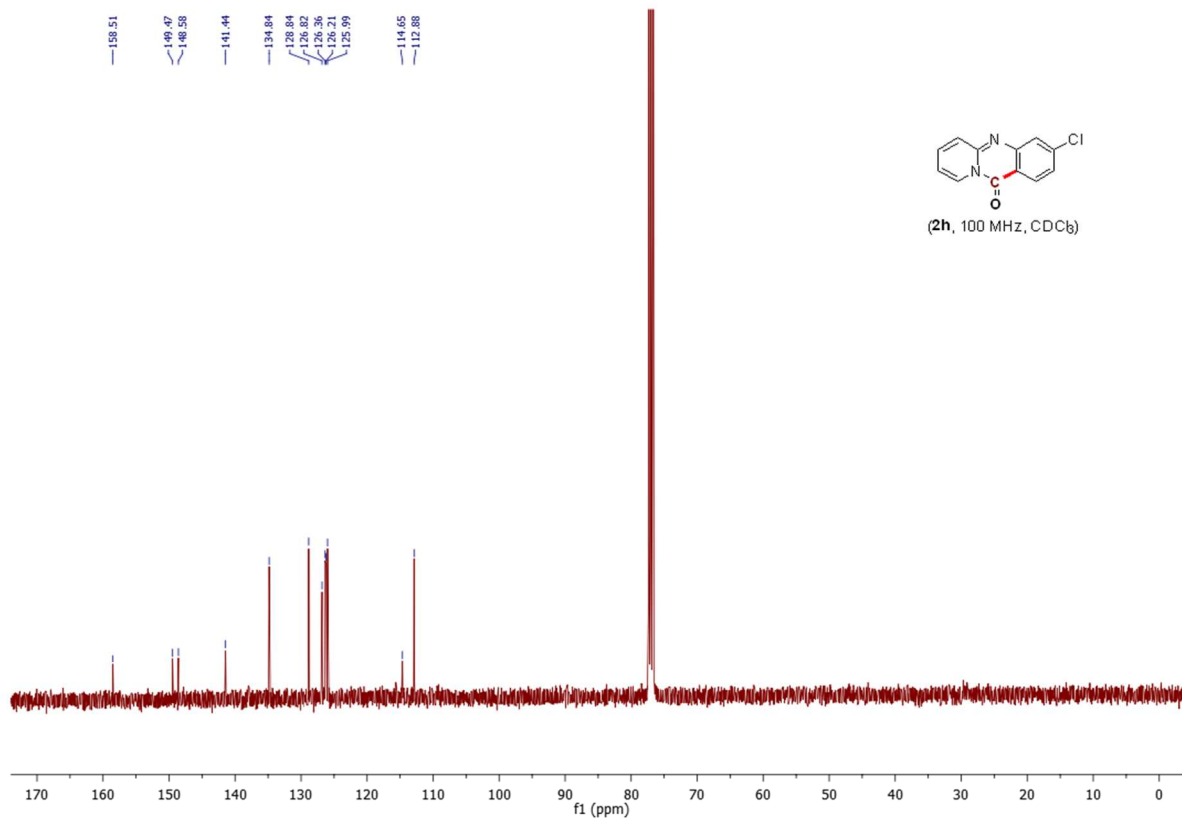
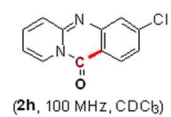
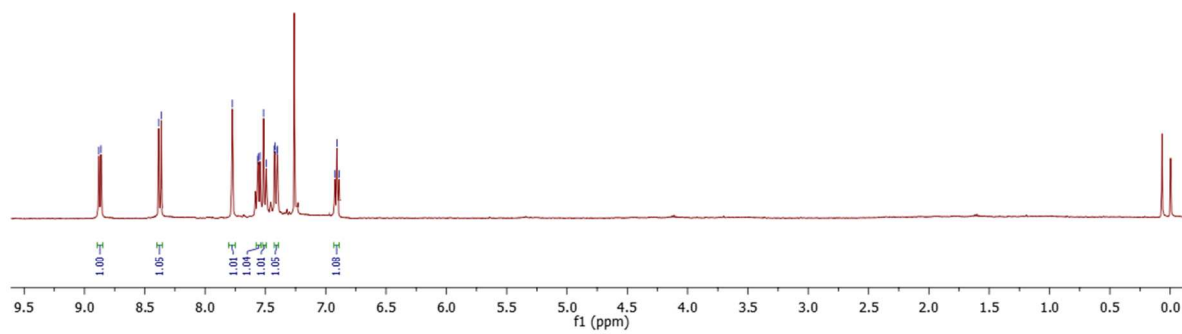
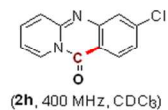
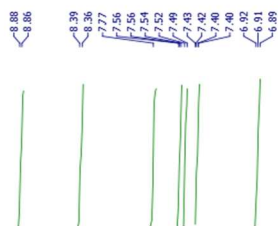
2-(Trifluoromethyl)-11H-pyrido[2,1-b]quinazolin-11-one



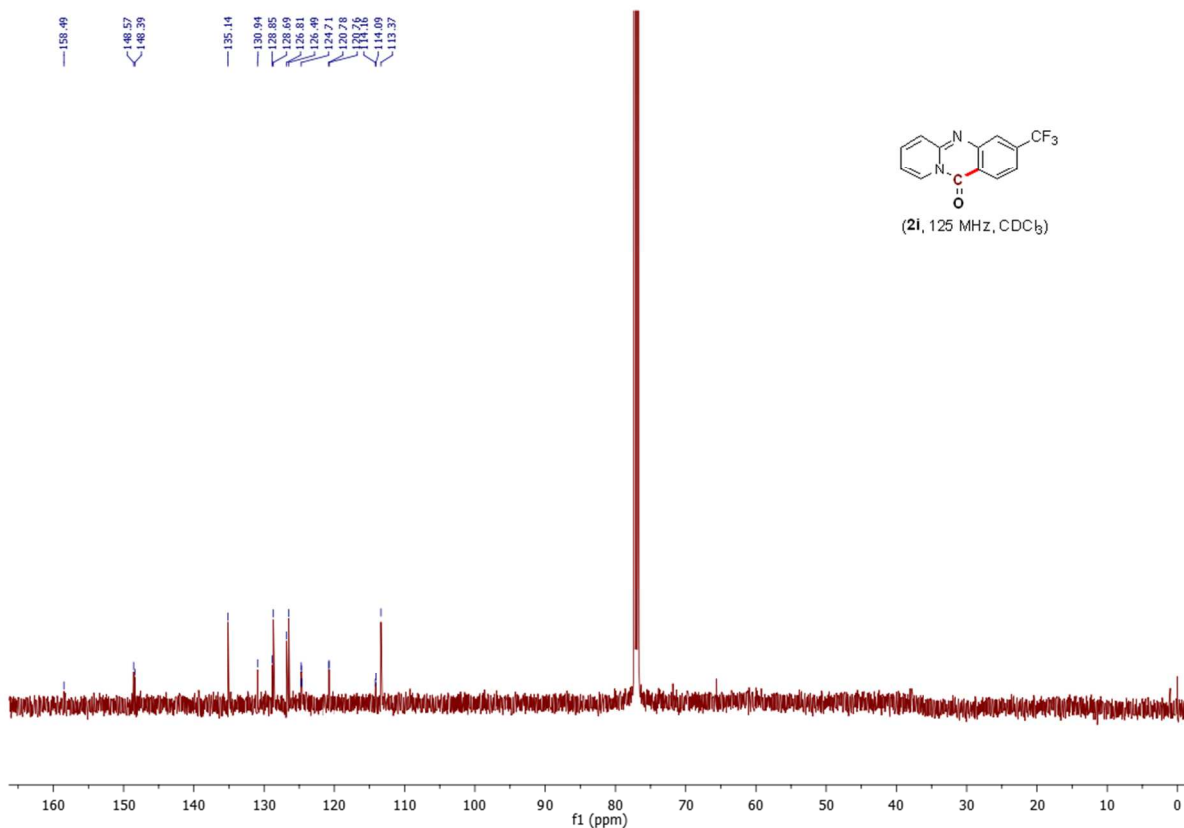
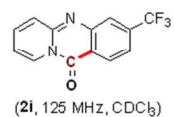
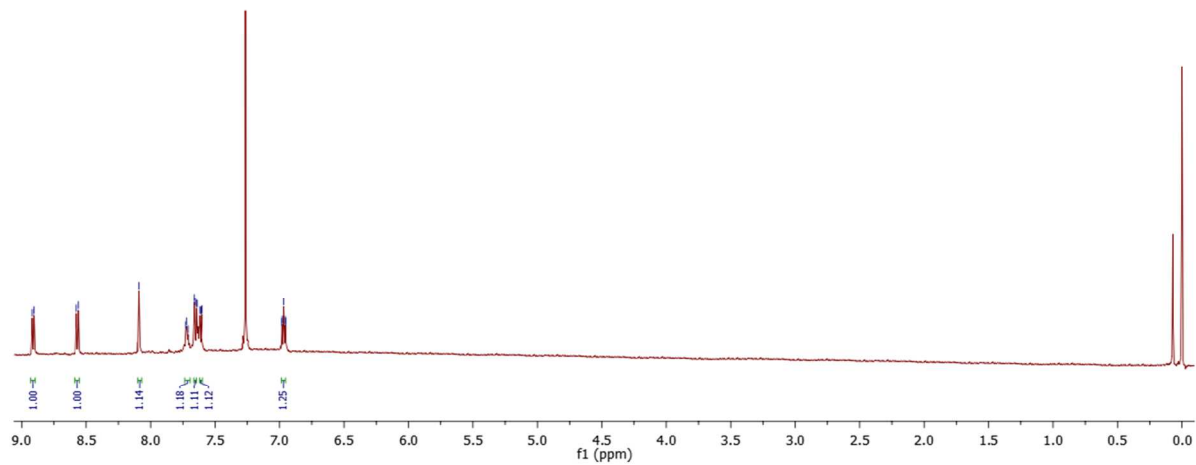
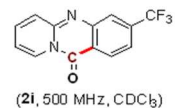
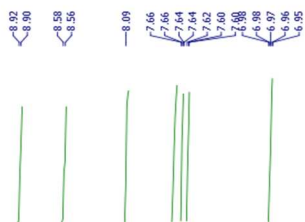
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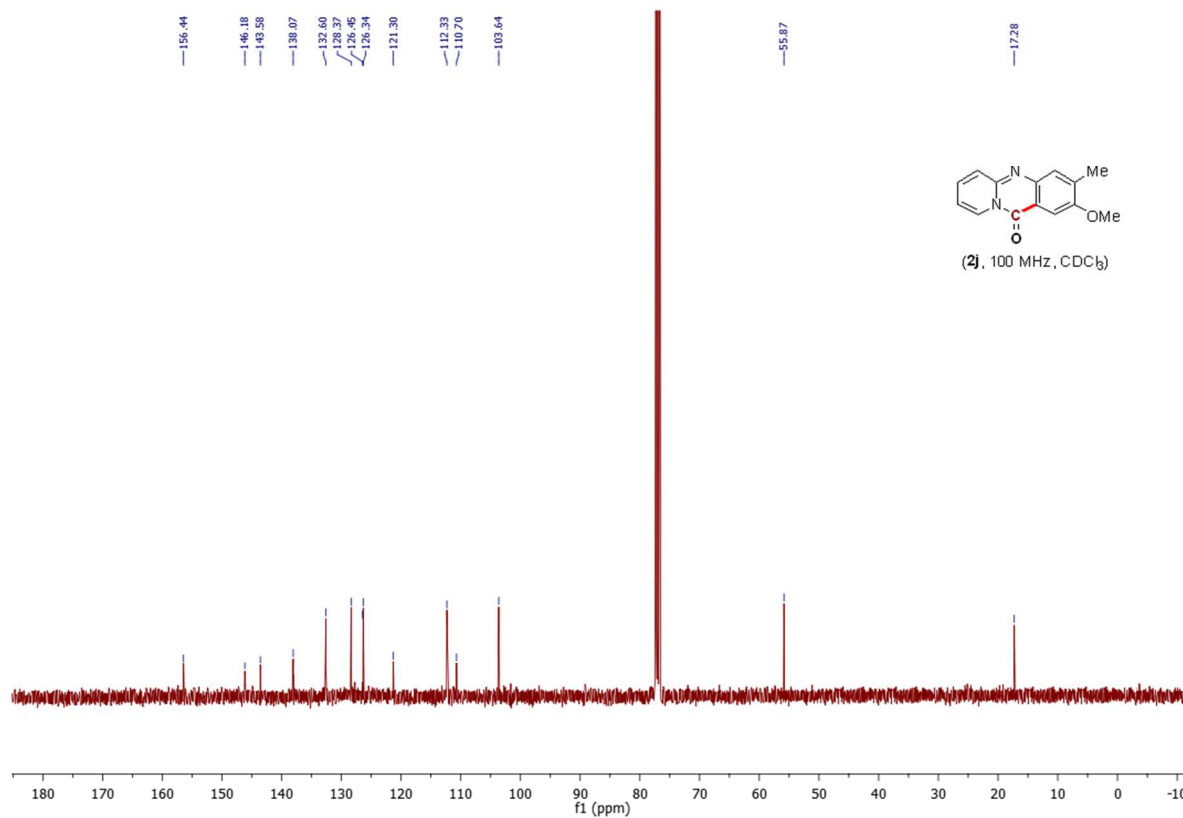
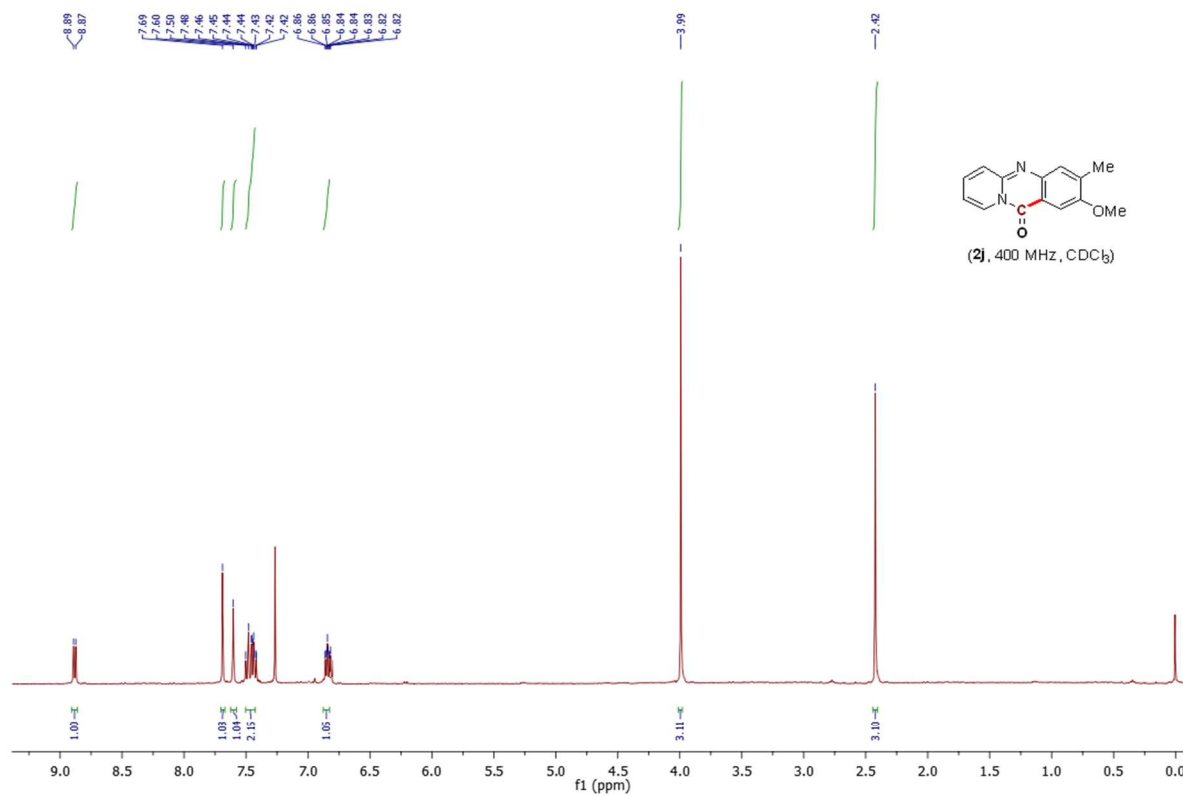
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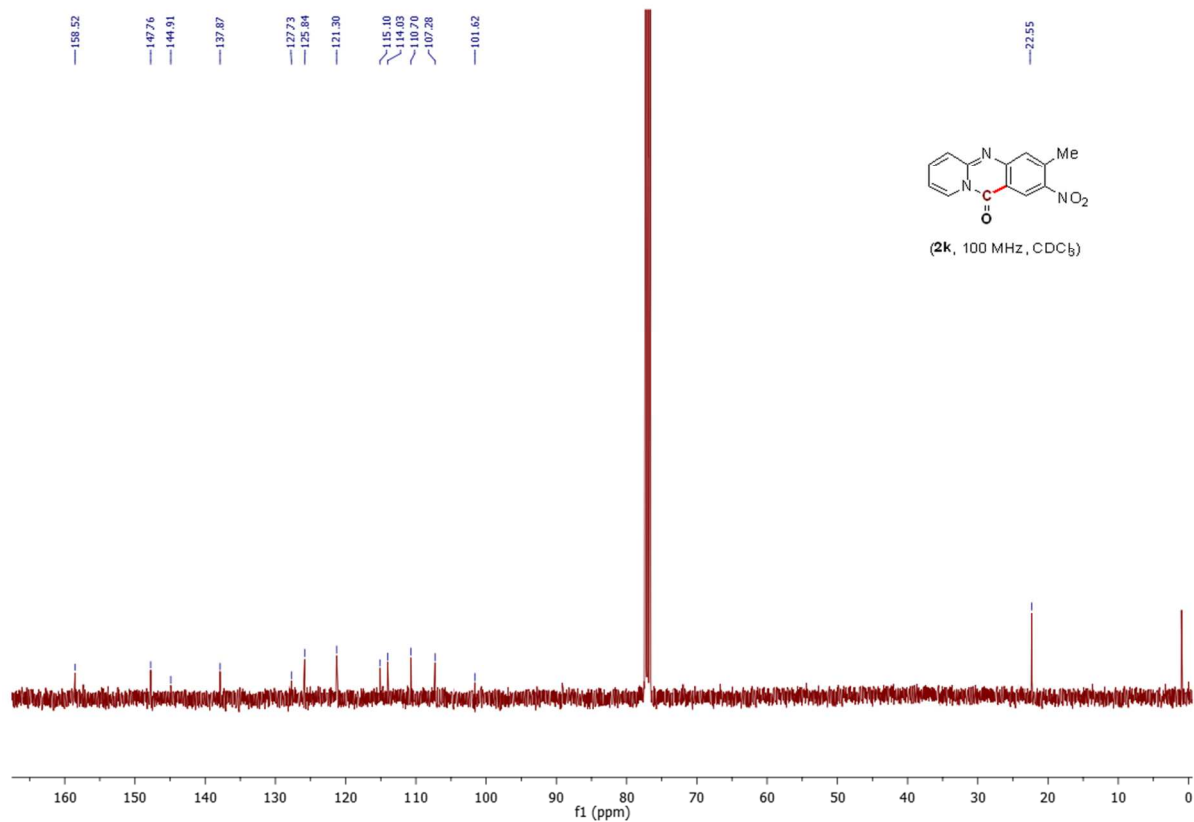
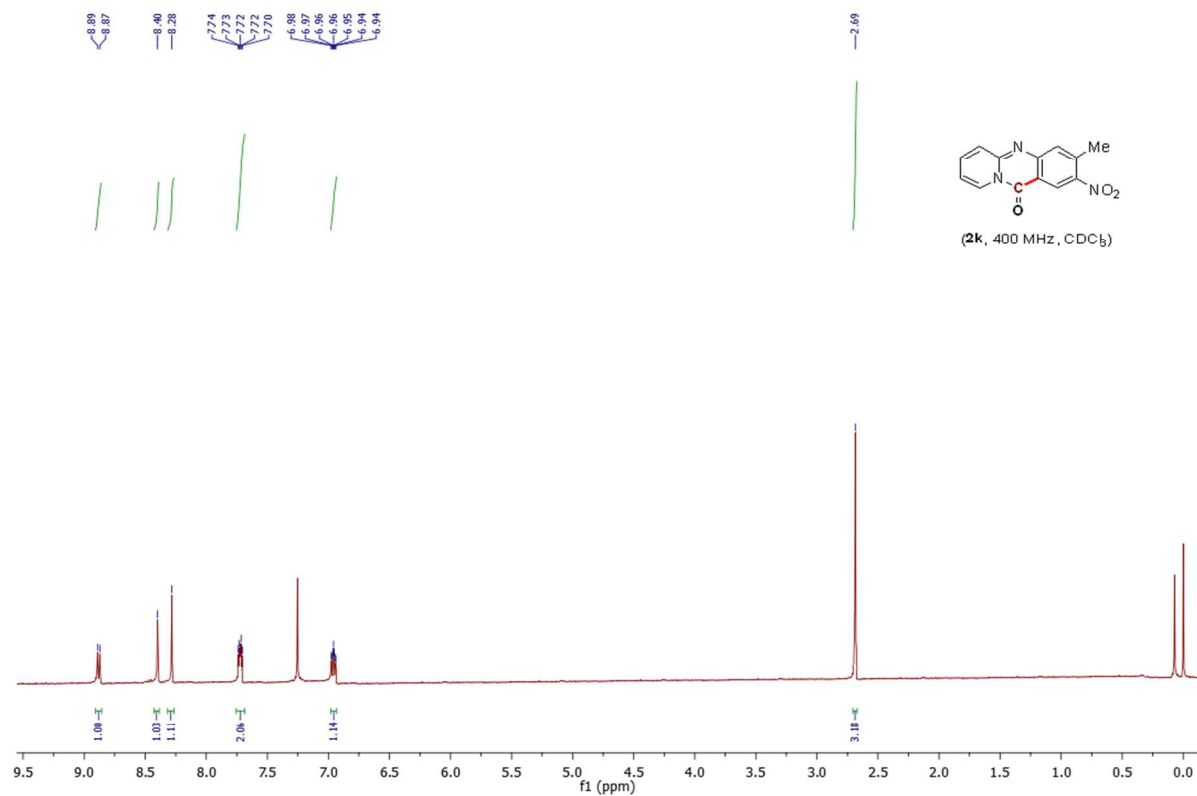
3-(Trifluoromethyl)-11H-pyrido[2,1-b]quinazolin-11-one



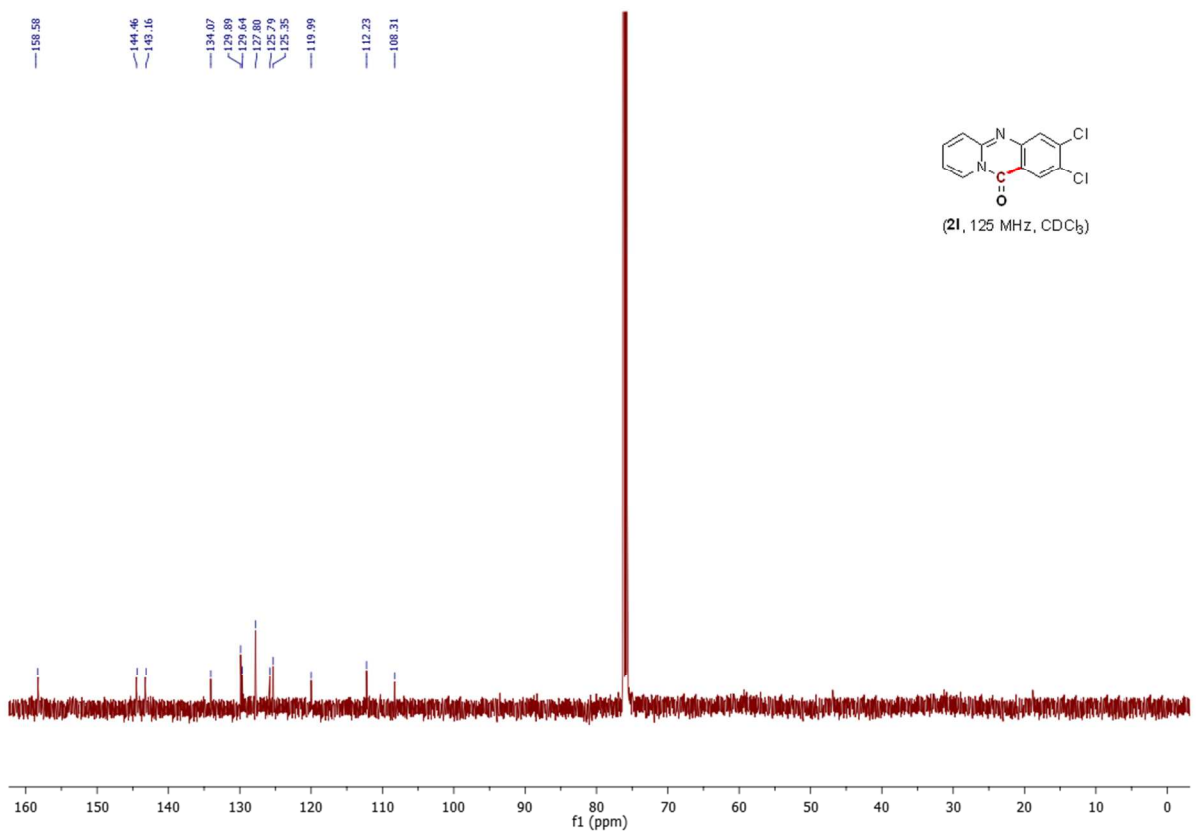
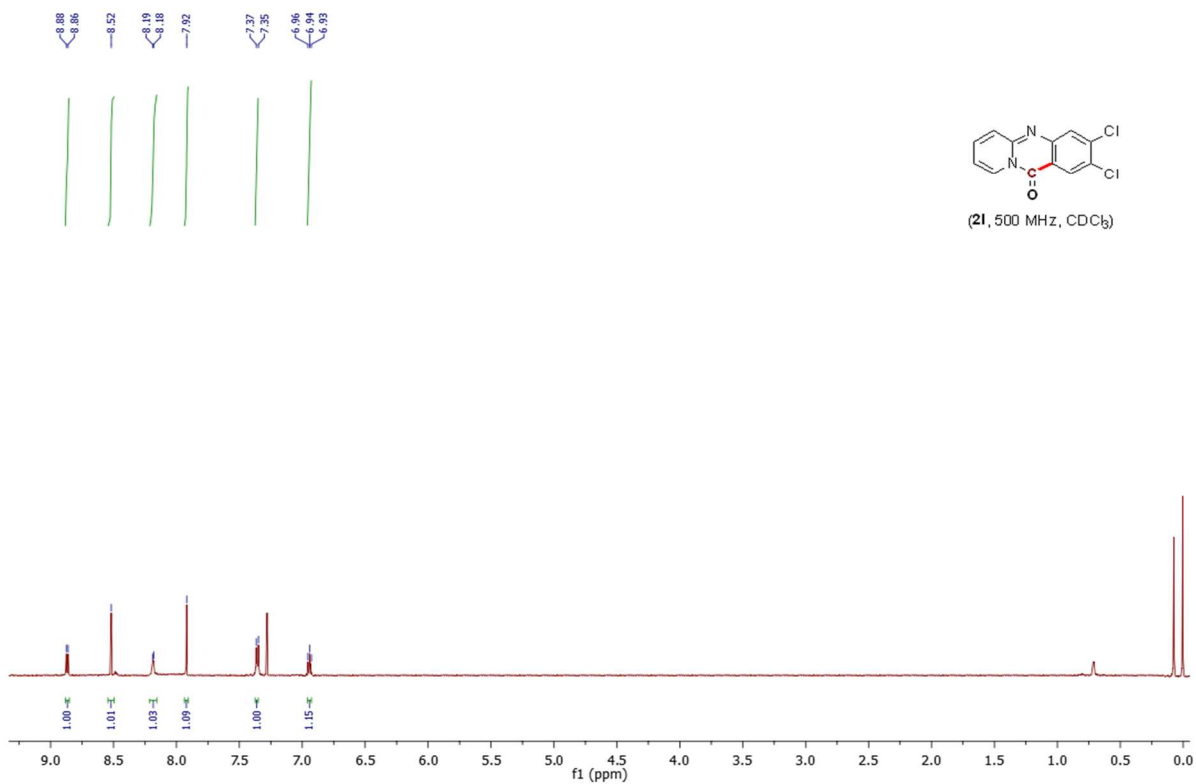
2-Methoxy-3-methyl-11H-pyrido[2,1-b]quinazolin-11-one



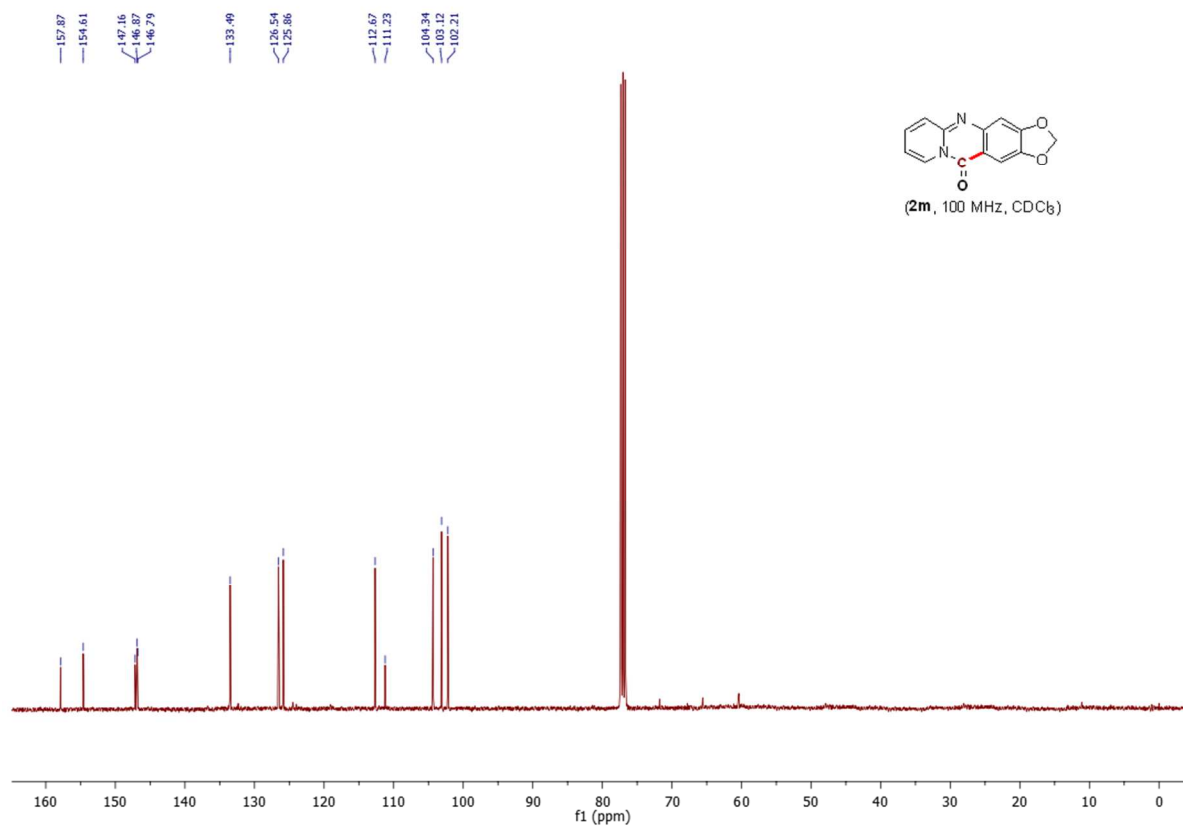
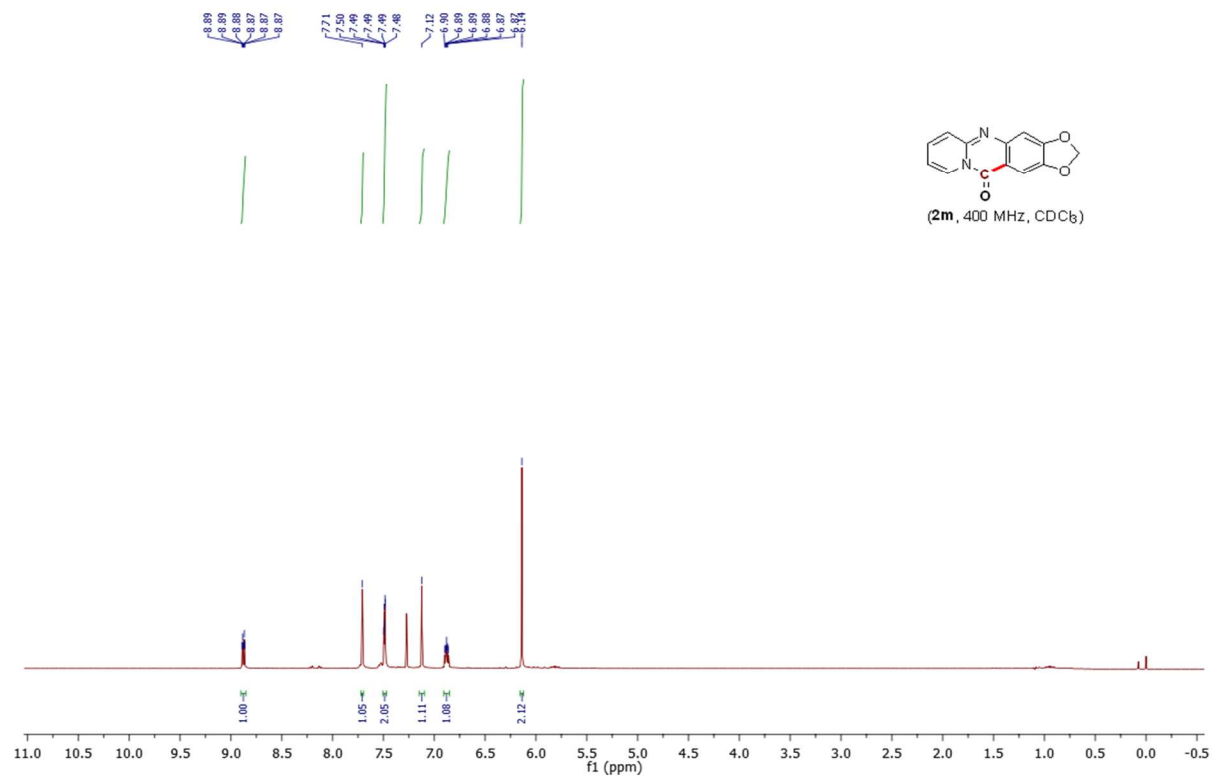
3-Methyl-2-nitro-11H-pyrido[2,1-b]quinazolin-11-one



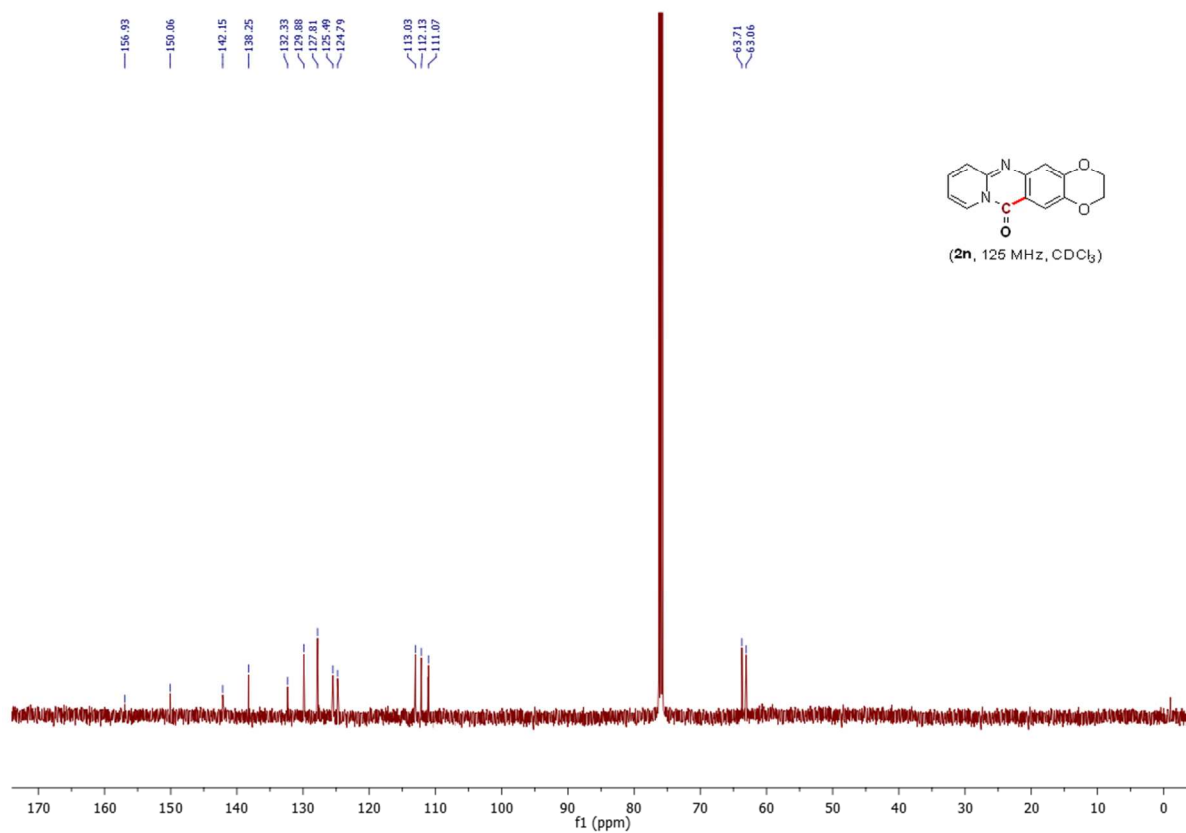
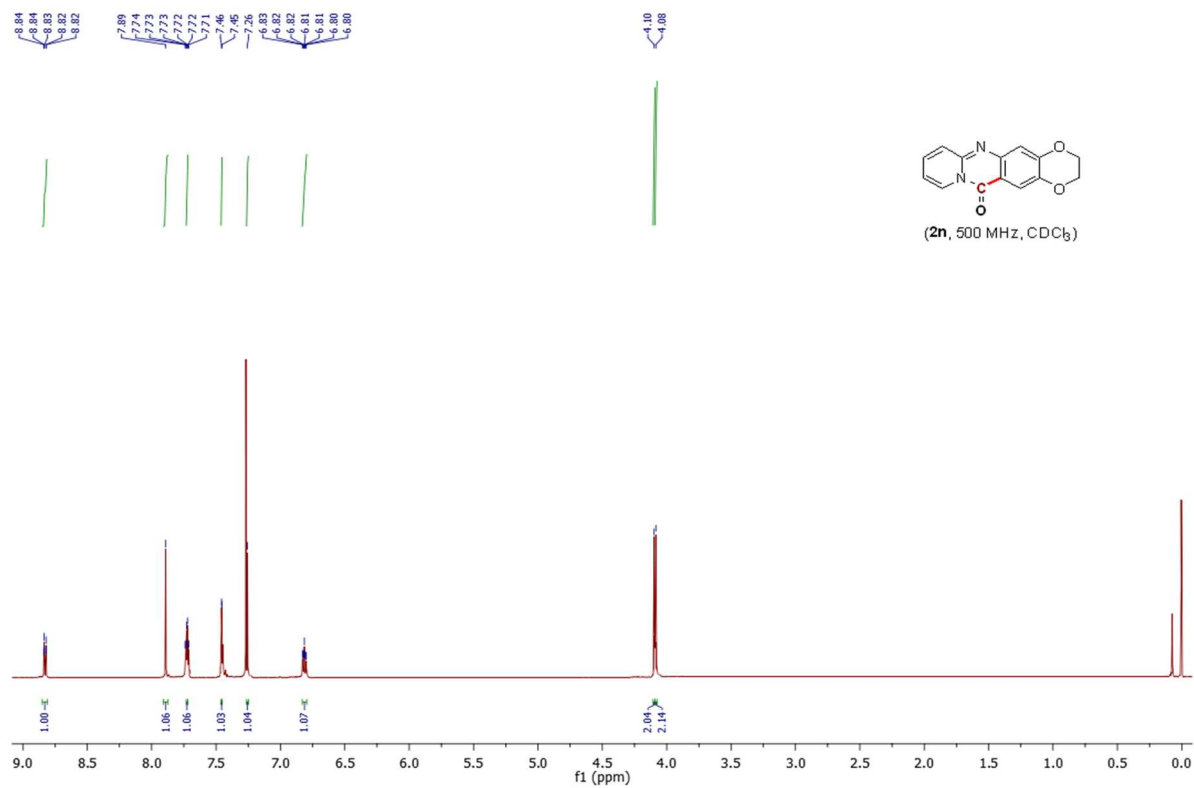
2, 3-Dichloro-11*H*-pyrido[2,1-*b*]quinazolin-11-one



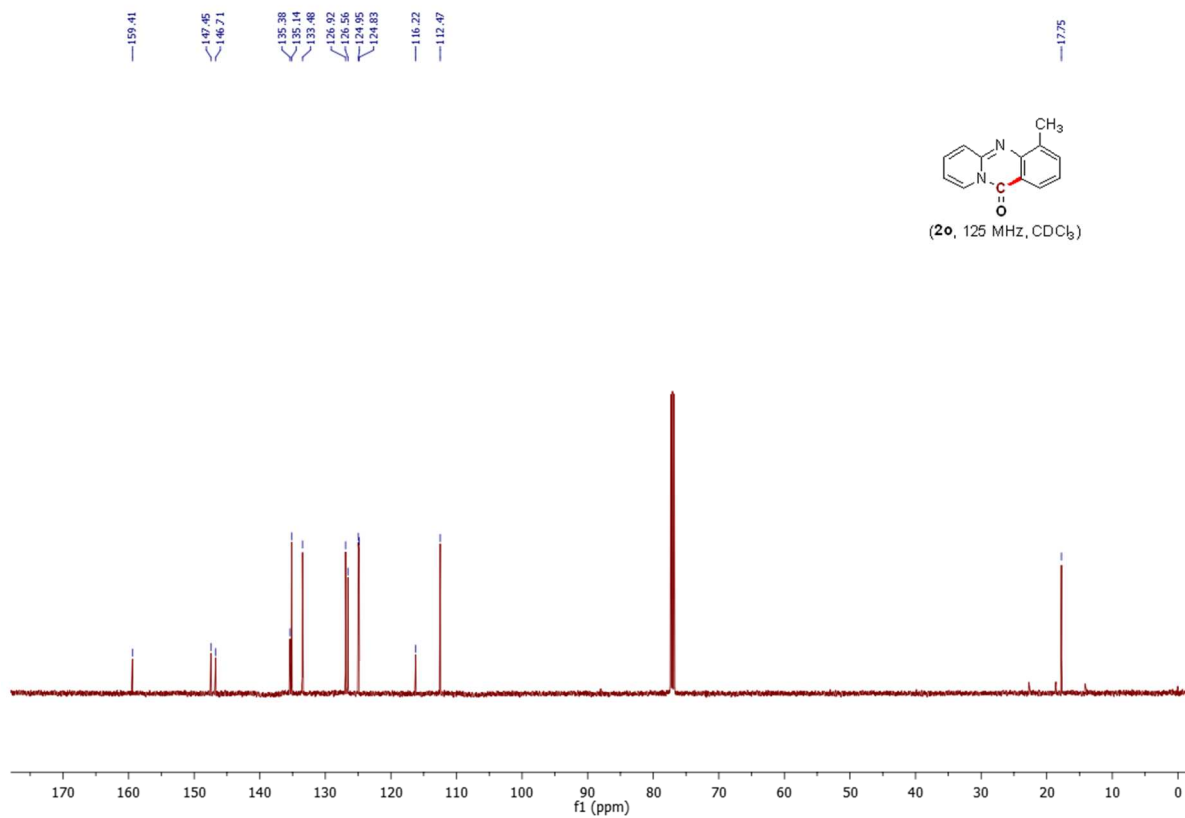
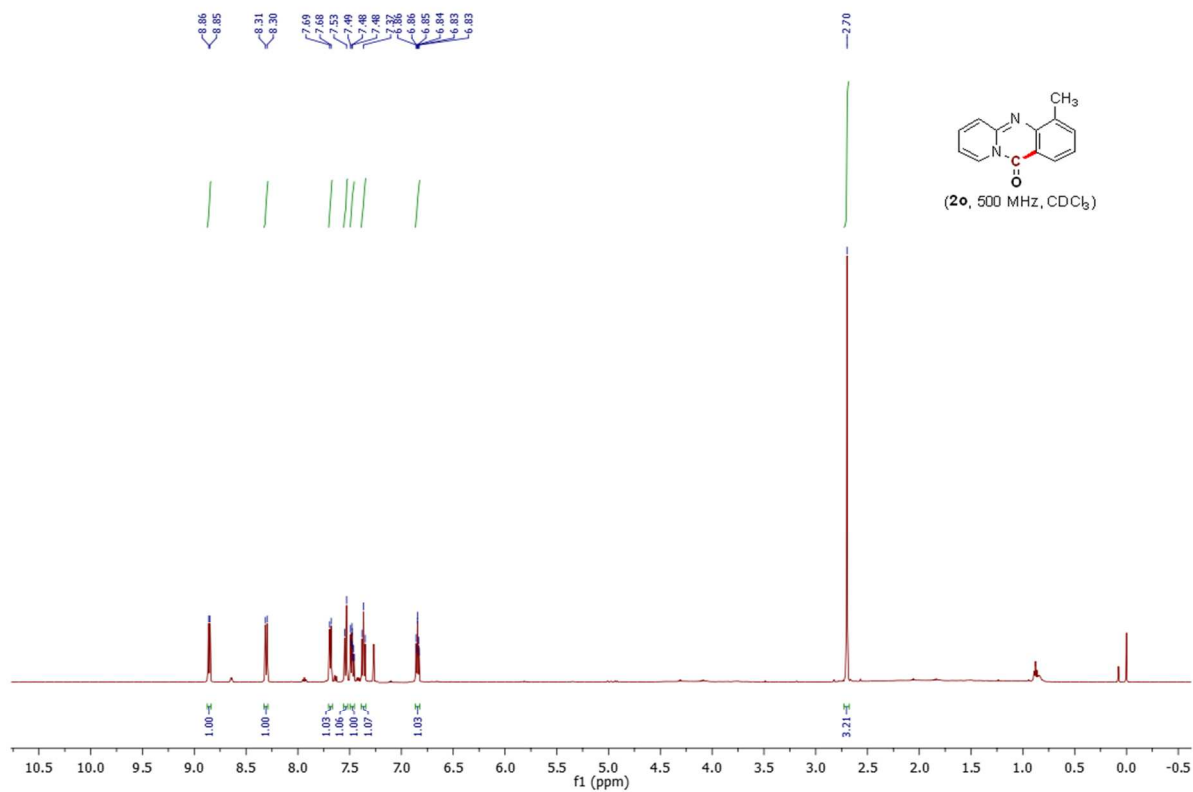
11H-[1,3]Dioxolo[4,5-g]pyrido[2,1-b]quinazolin-11-one



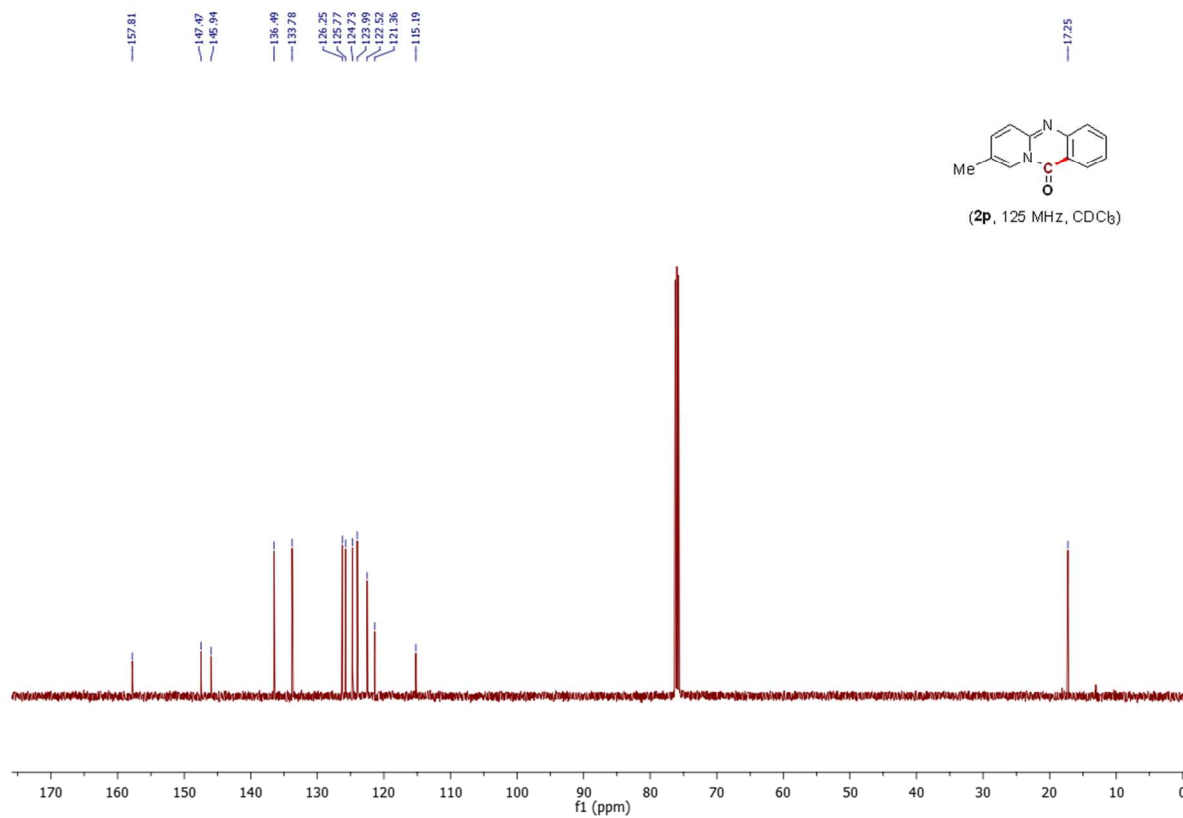
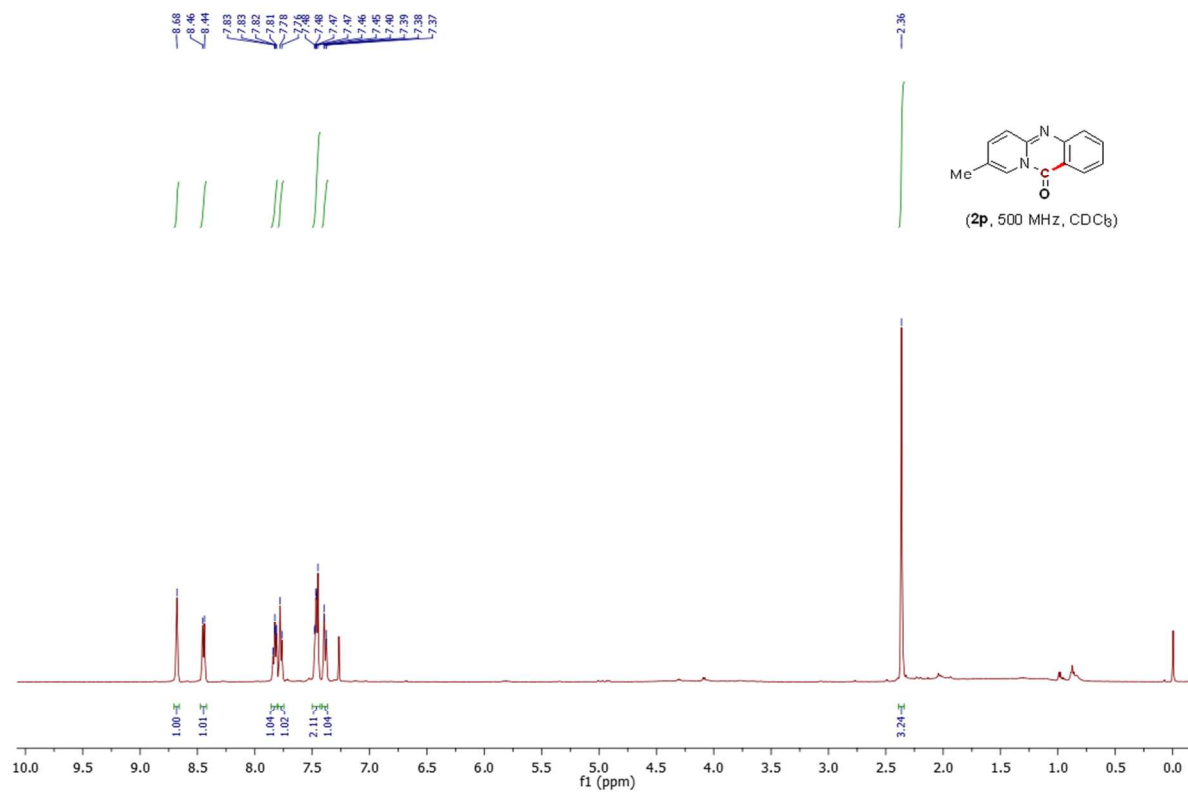
2,3-Dihydro-12*H*-[1,4]dioxino[2,3-*g*]pyrido[2,1-*b*]quinazolin-12-one



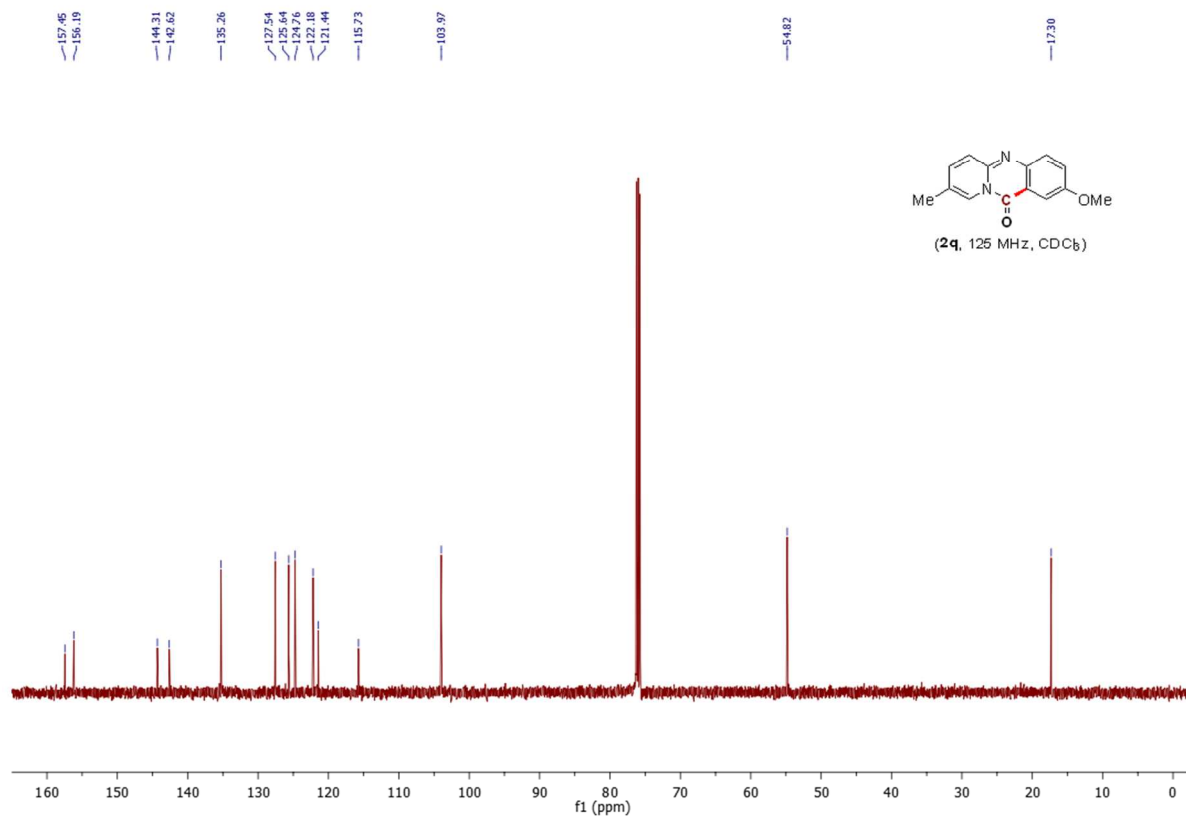
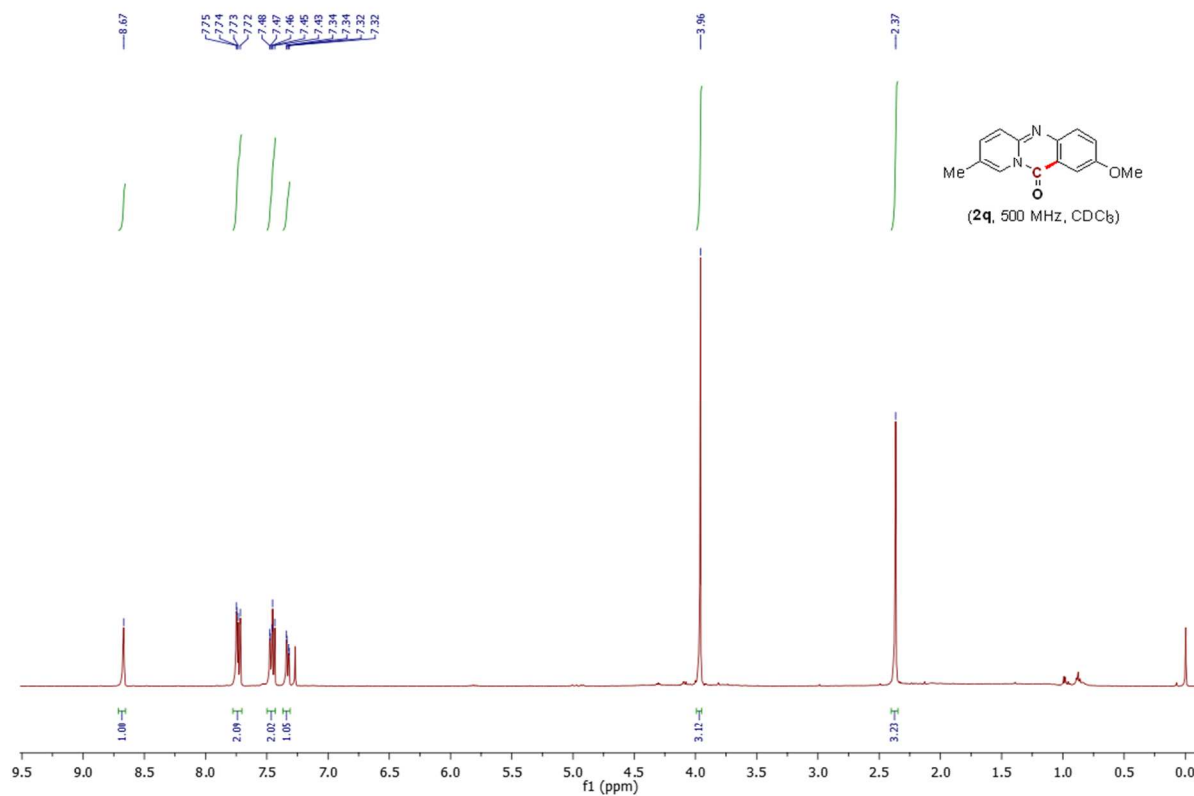
4-Methyl-11H-pyrido[2,1-b]quinazolin-11-one



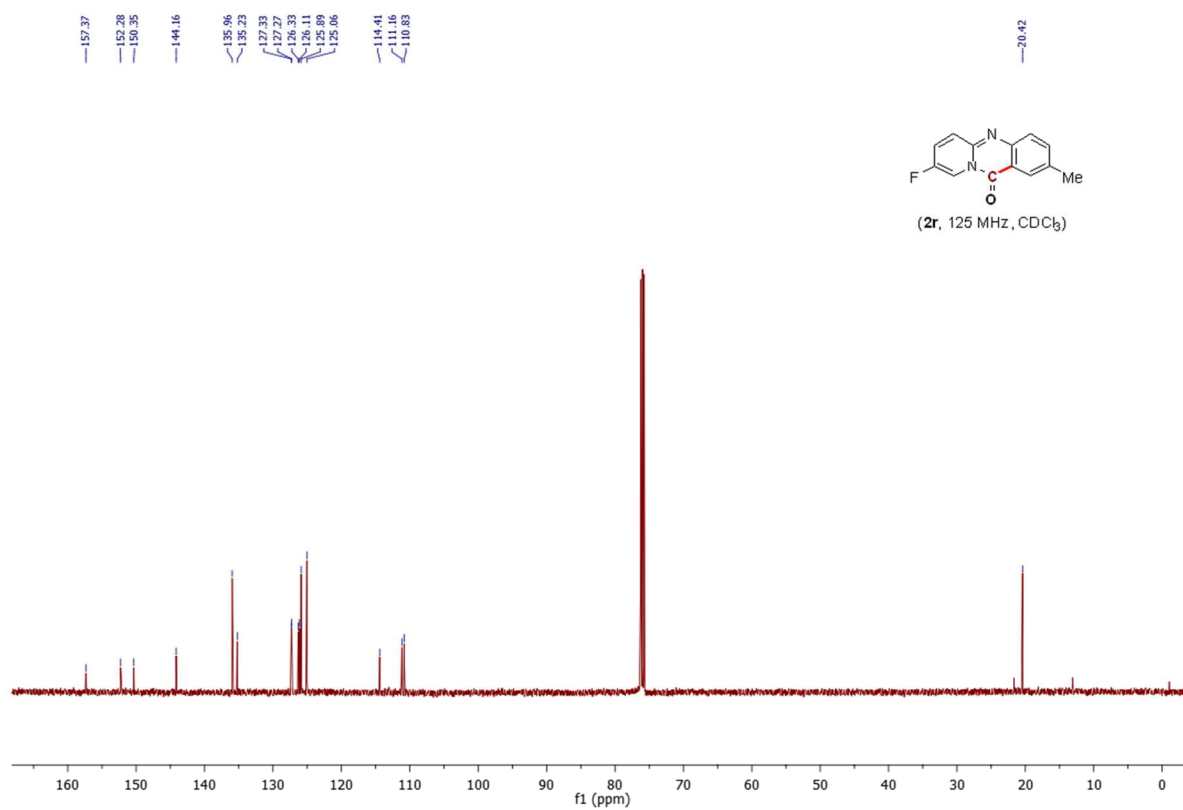
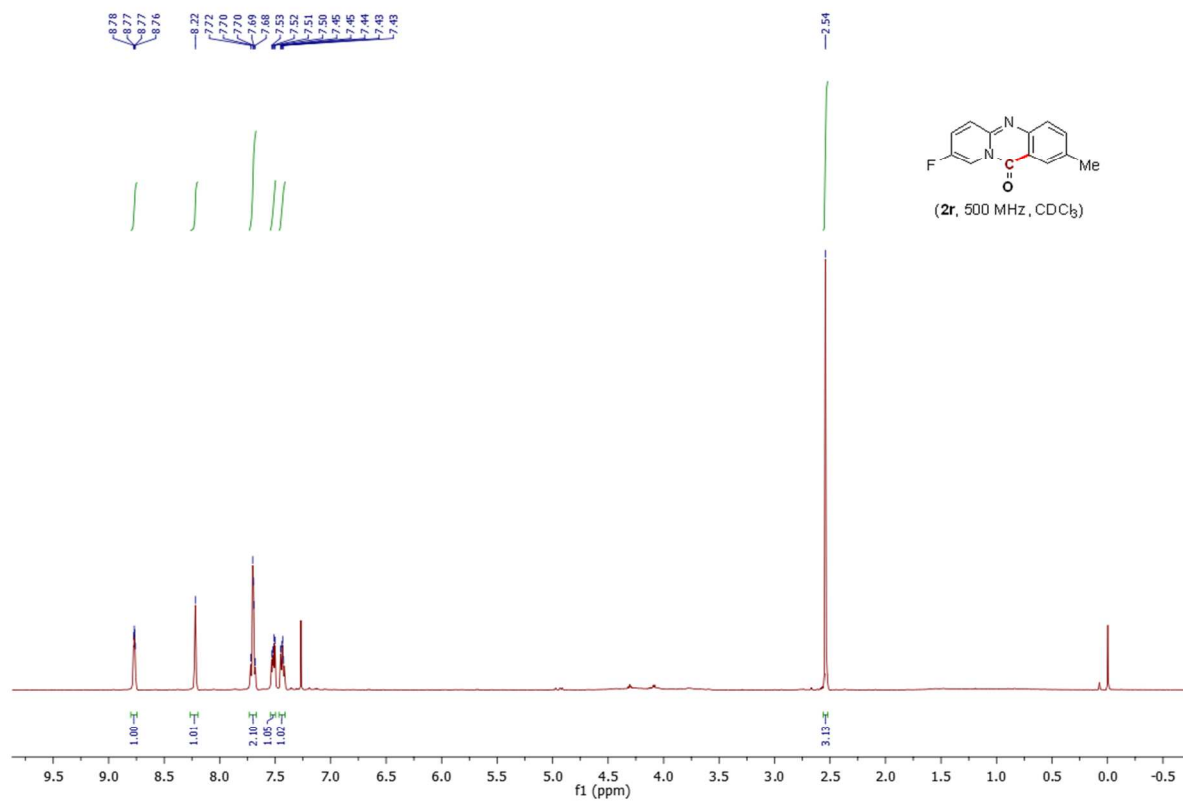
8-Methyl-11H-pyrido[2,1-b]quinazolin-11-one



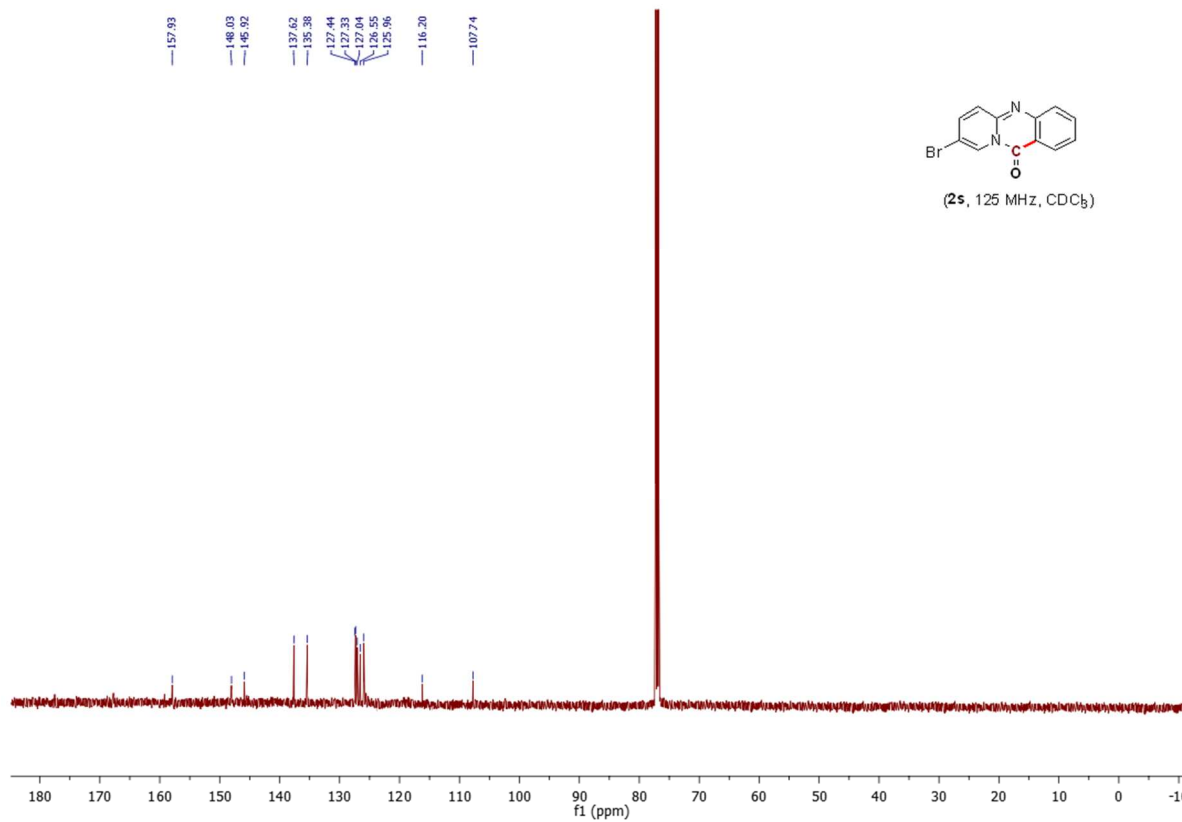
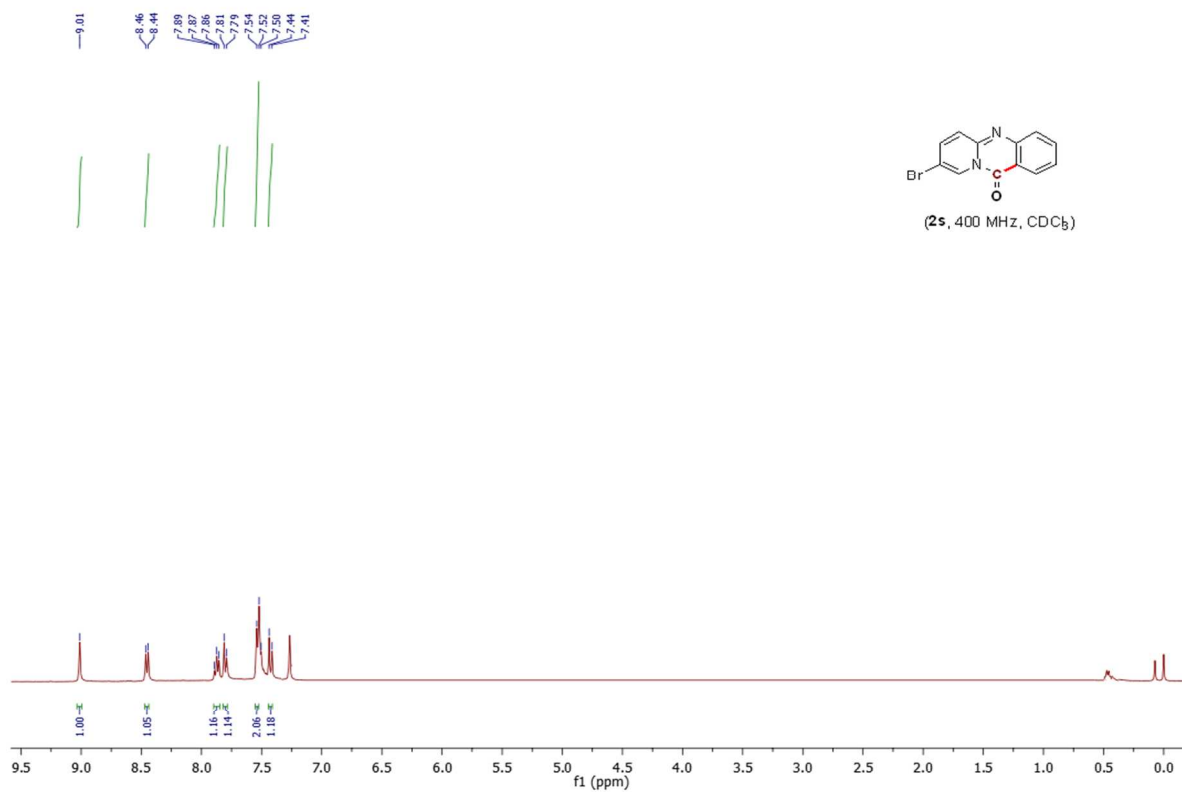
2-Methoxy-8-methyl-11H-pyrido[2,1-b]quinazolin-11-one



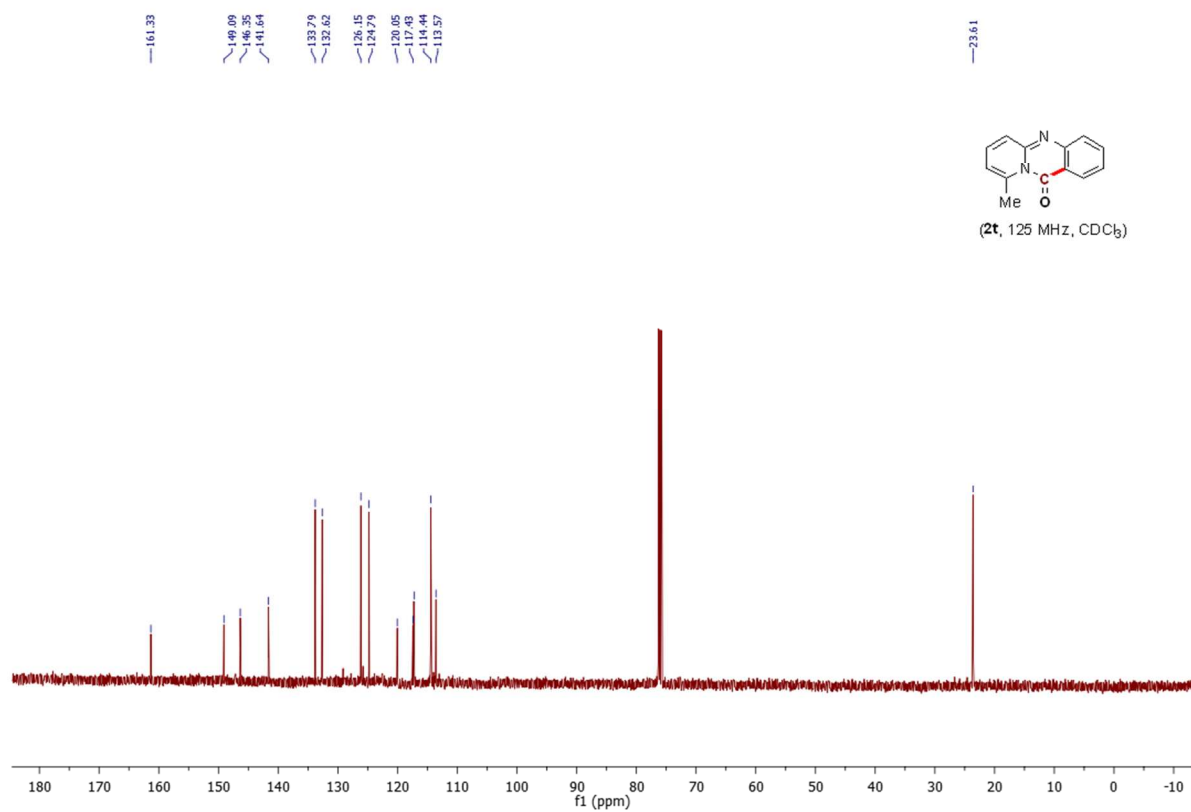
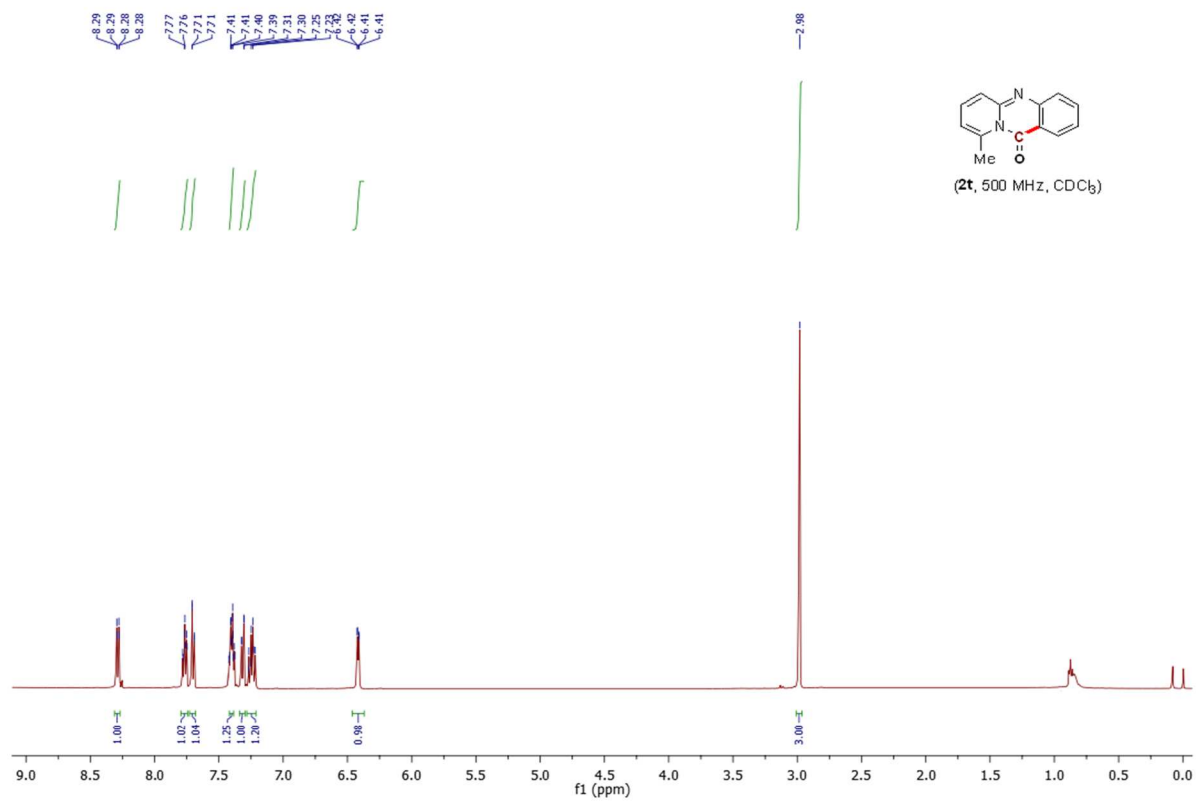
8-Fluoro-2-methyl-11H-pyrido[2,1-b]quinazolin-11-one



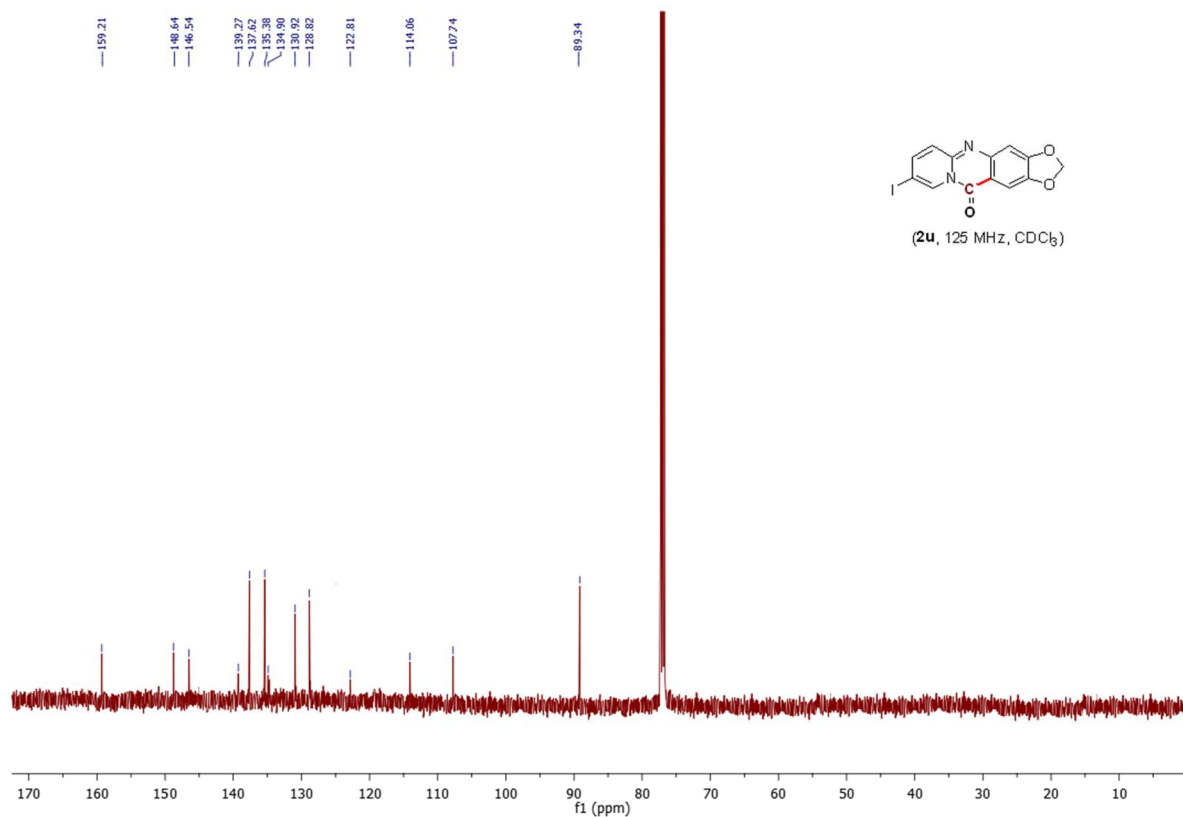
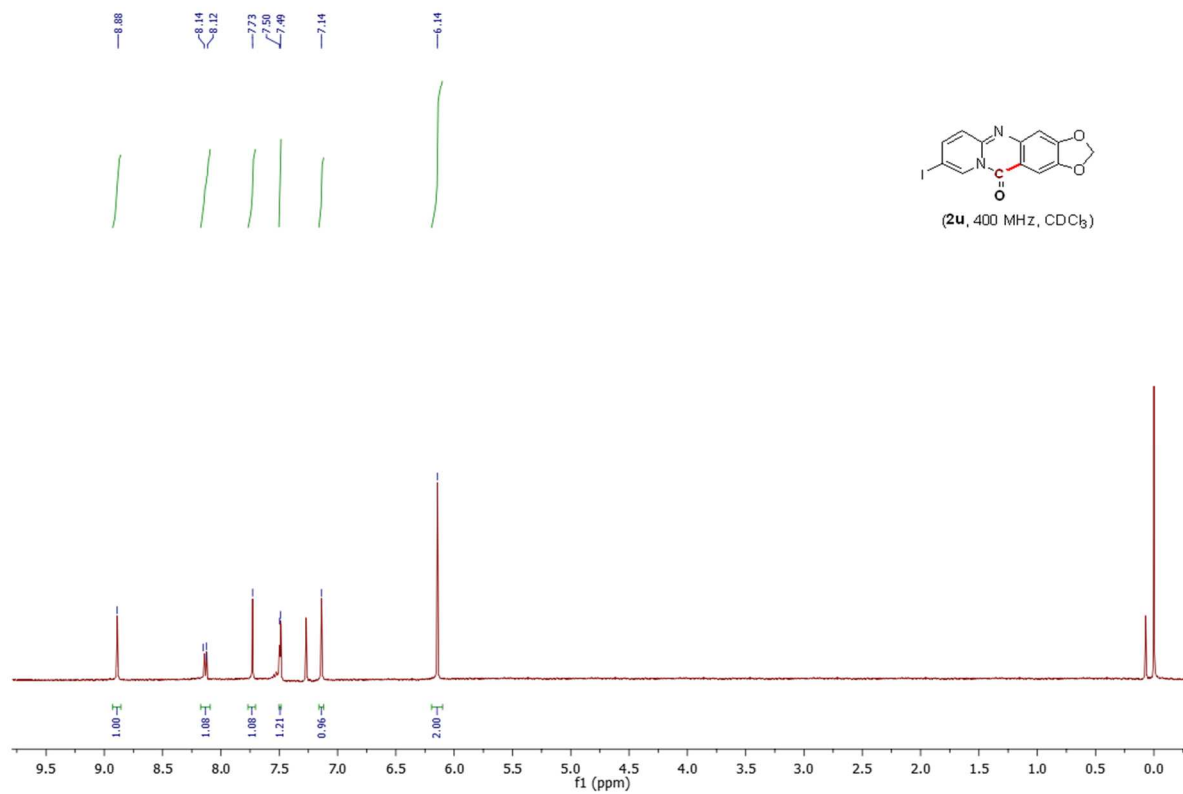
8-Bromo-11H-pyrido[2,1-b]quinazolin-11-one



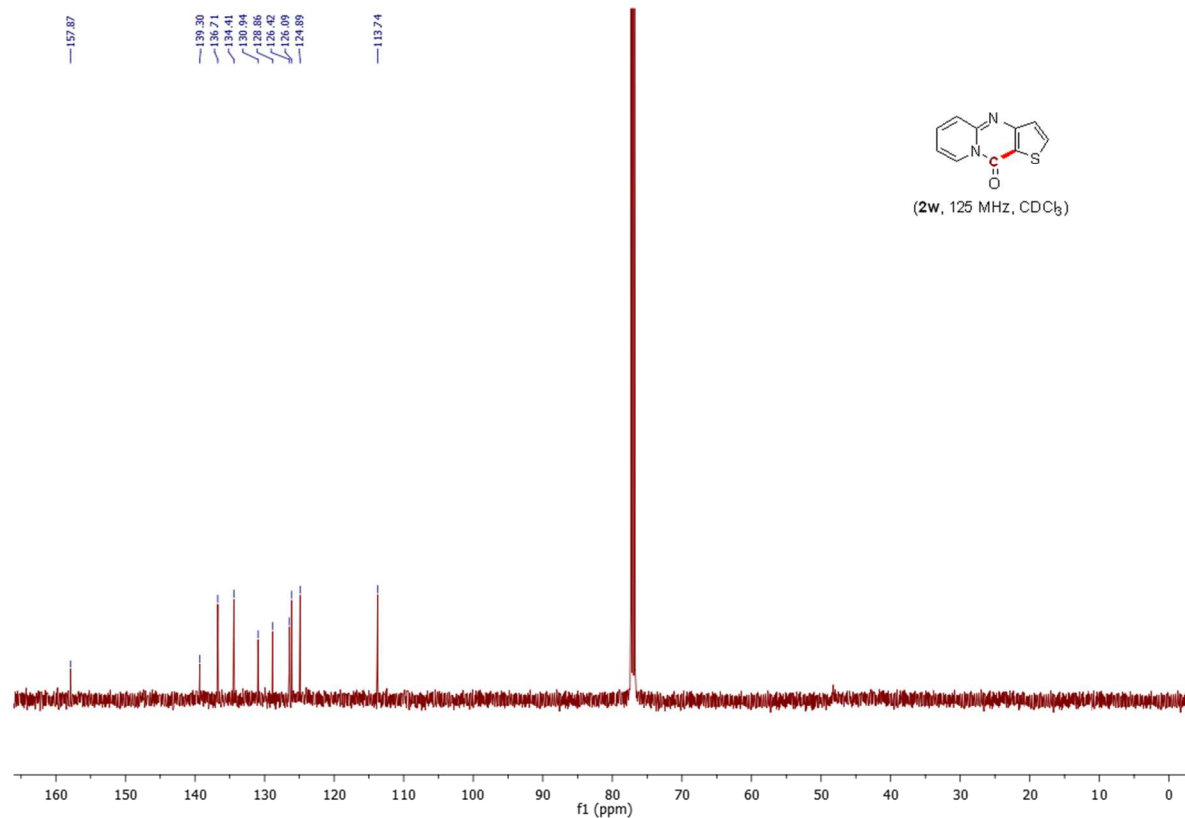
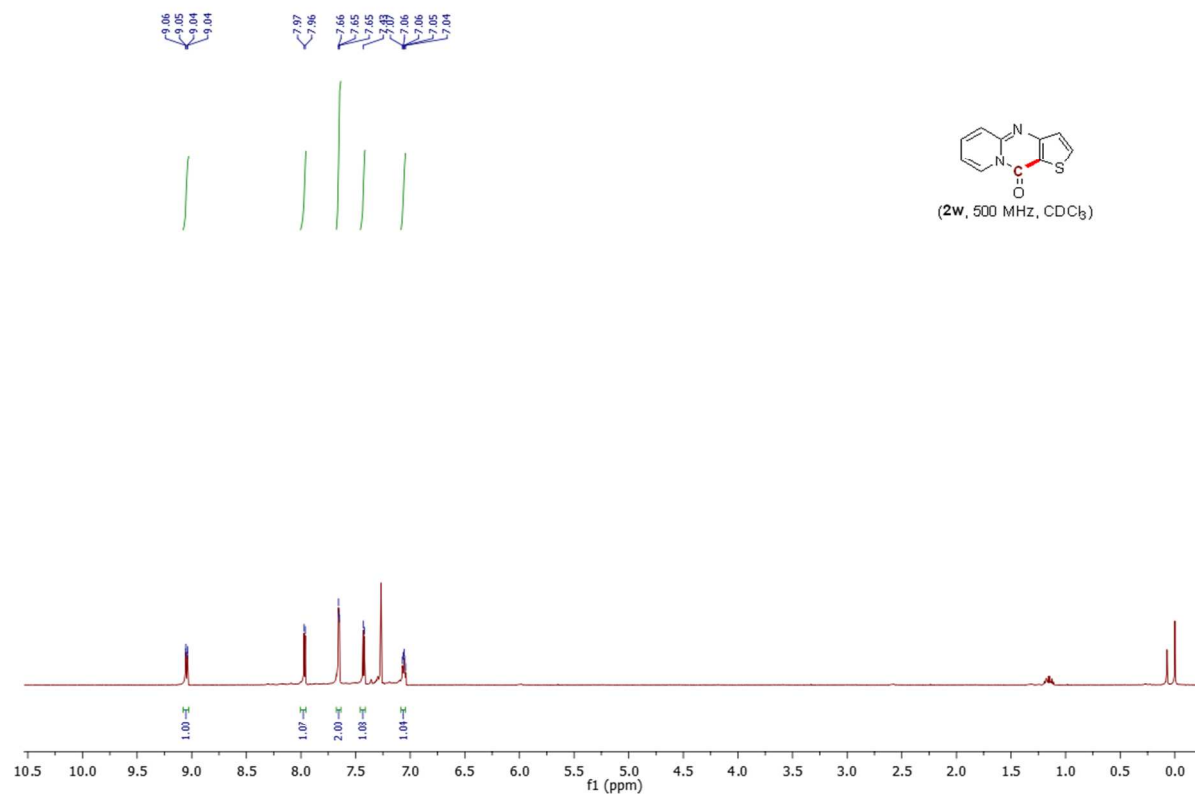
9-Methyl-11H-pyrido[2,1-b]quinazolin-11-one



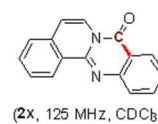
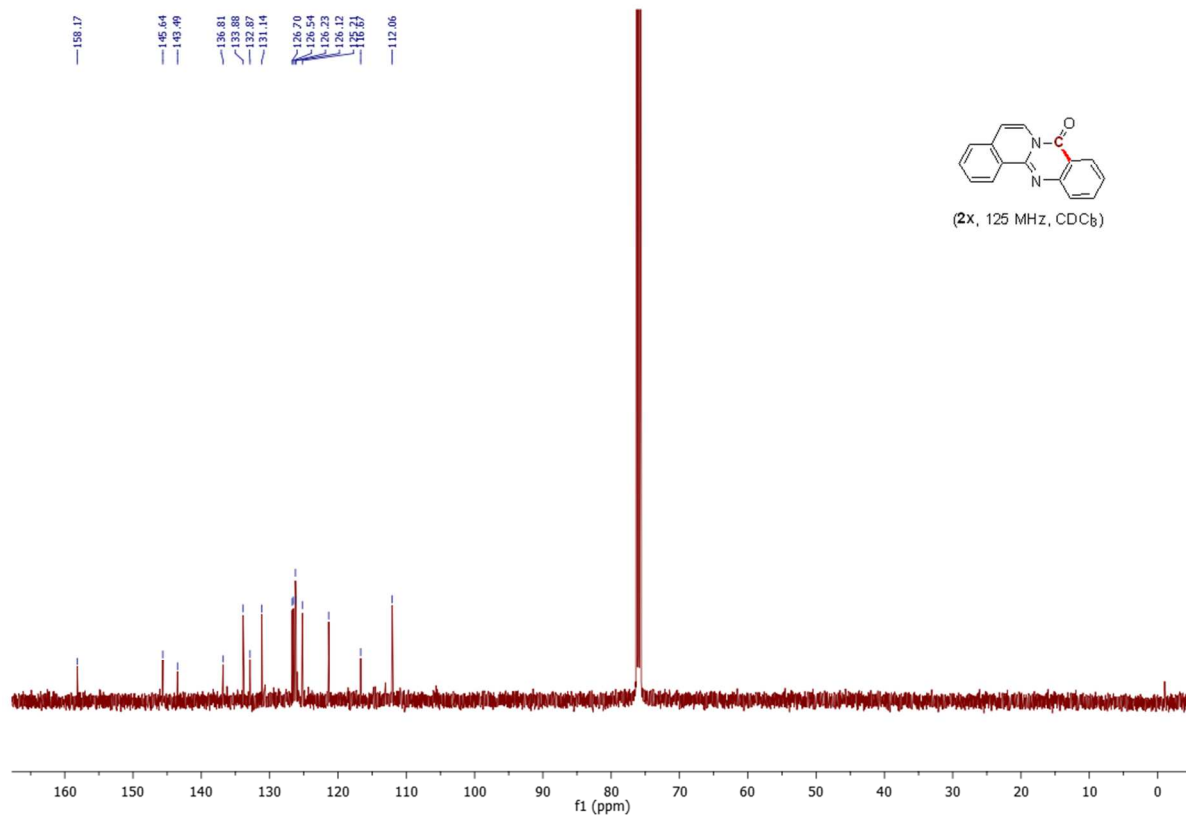
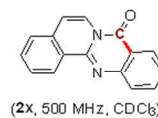
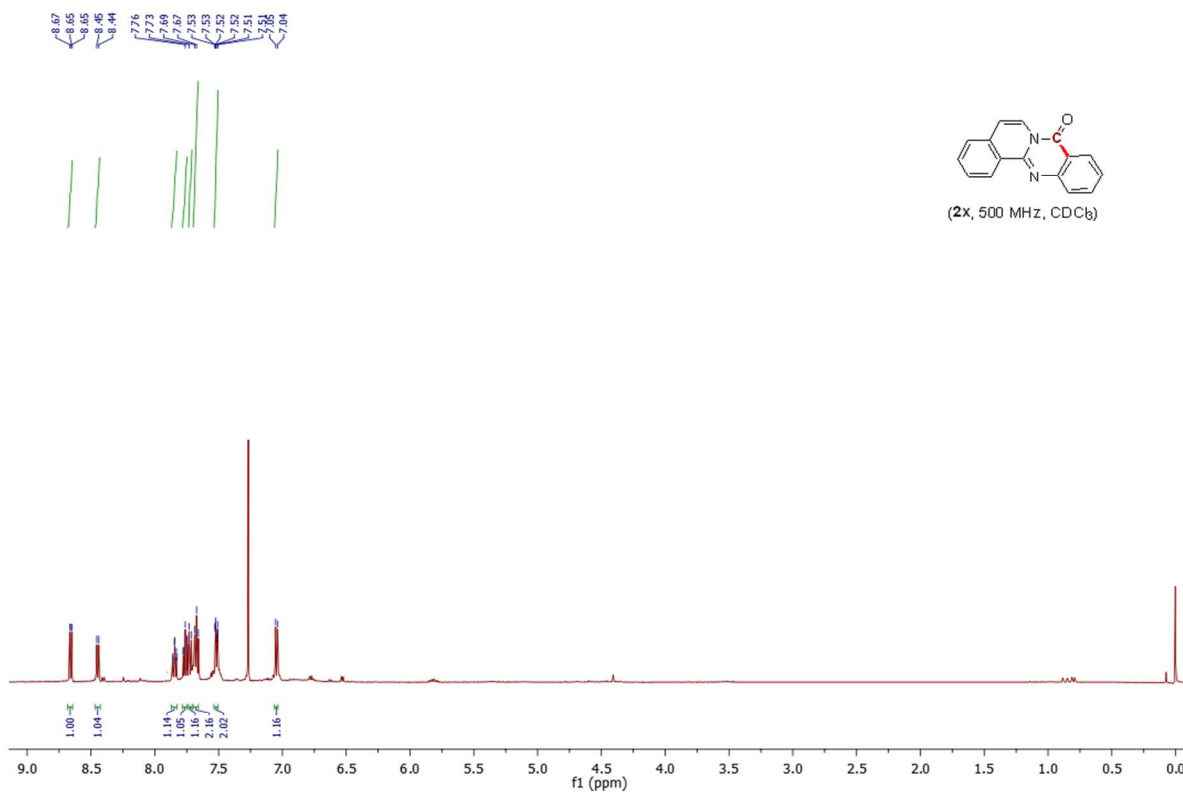
8-Iodo-11*H*-[1,3]dioxolo[4,5-*g*]pyrido[2,1-*b*]quinazolin-11-one



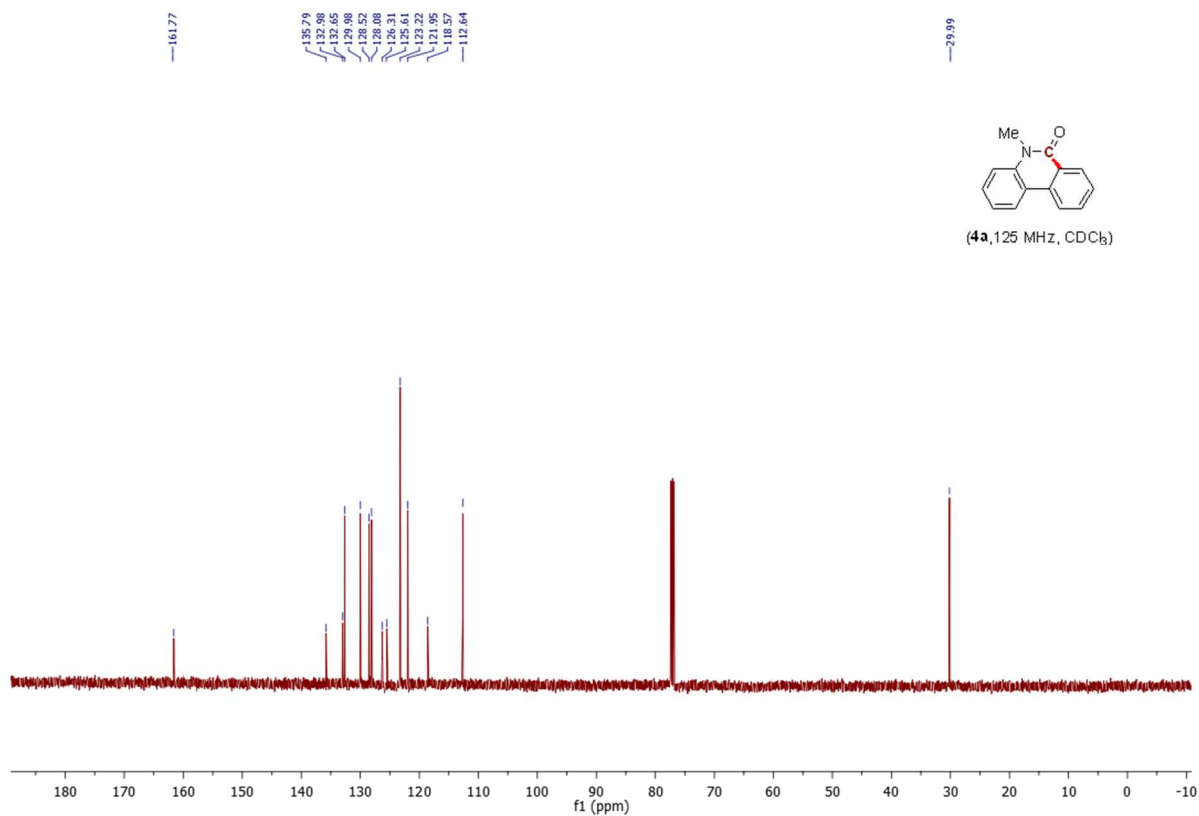
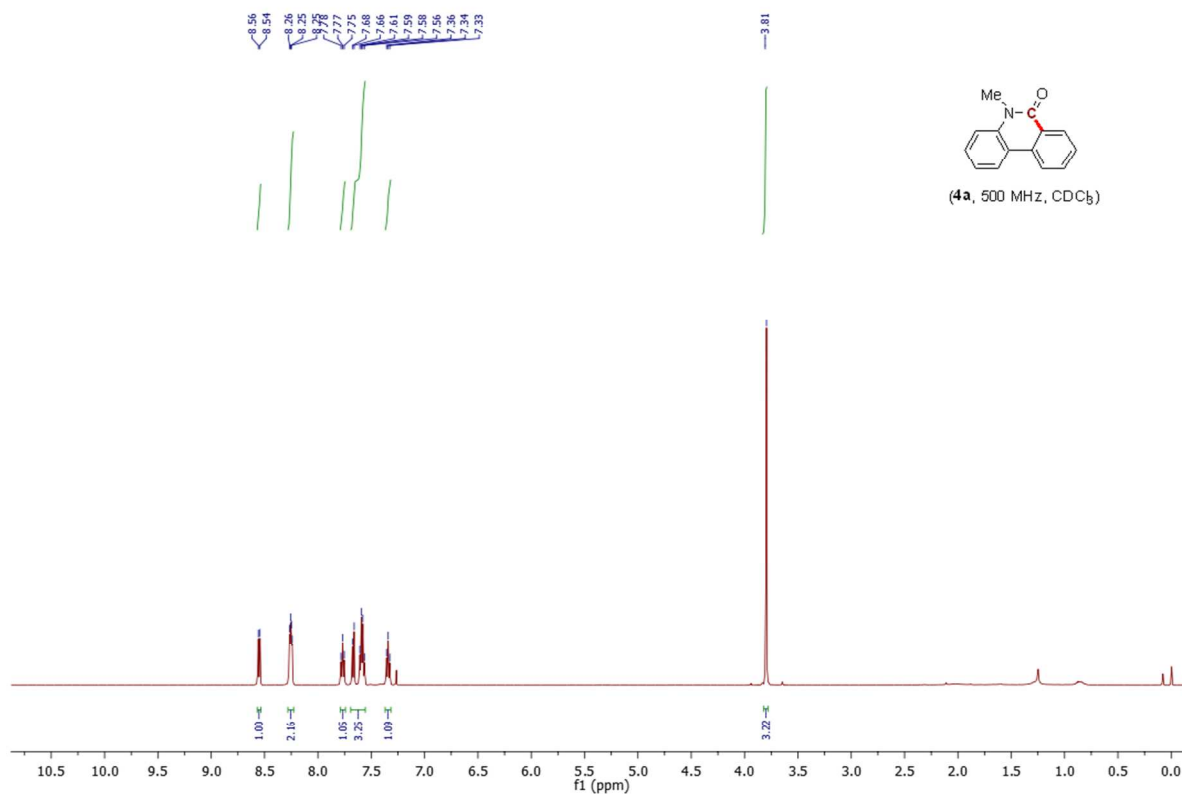
10H-Pyrido[1,2-a]thieno[3,2-d]pyrimidin-10-one



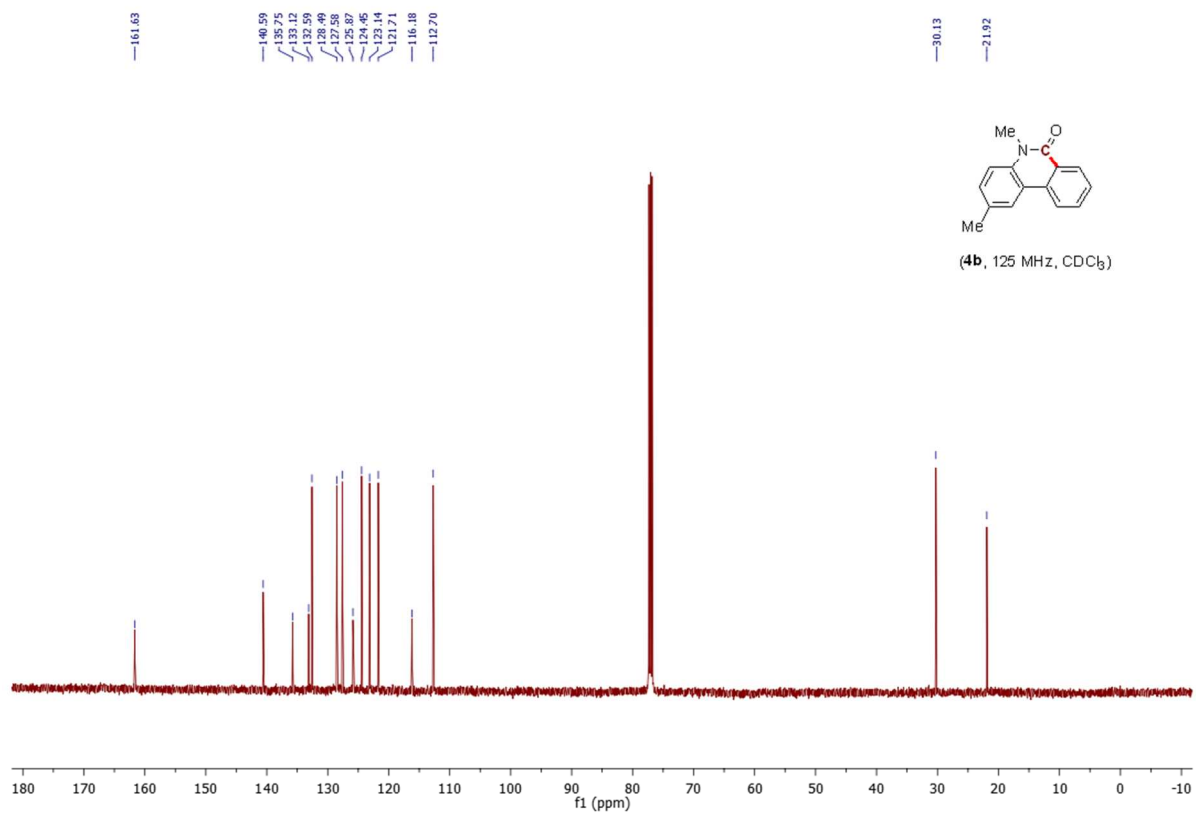
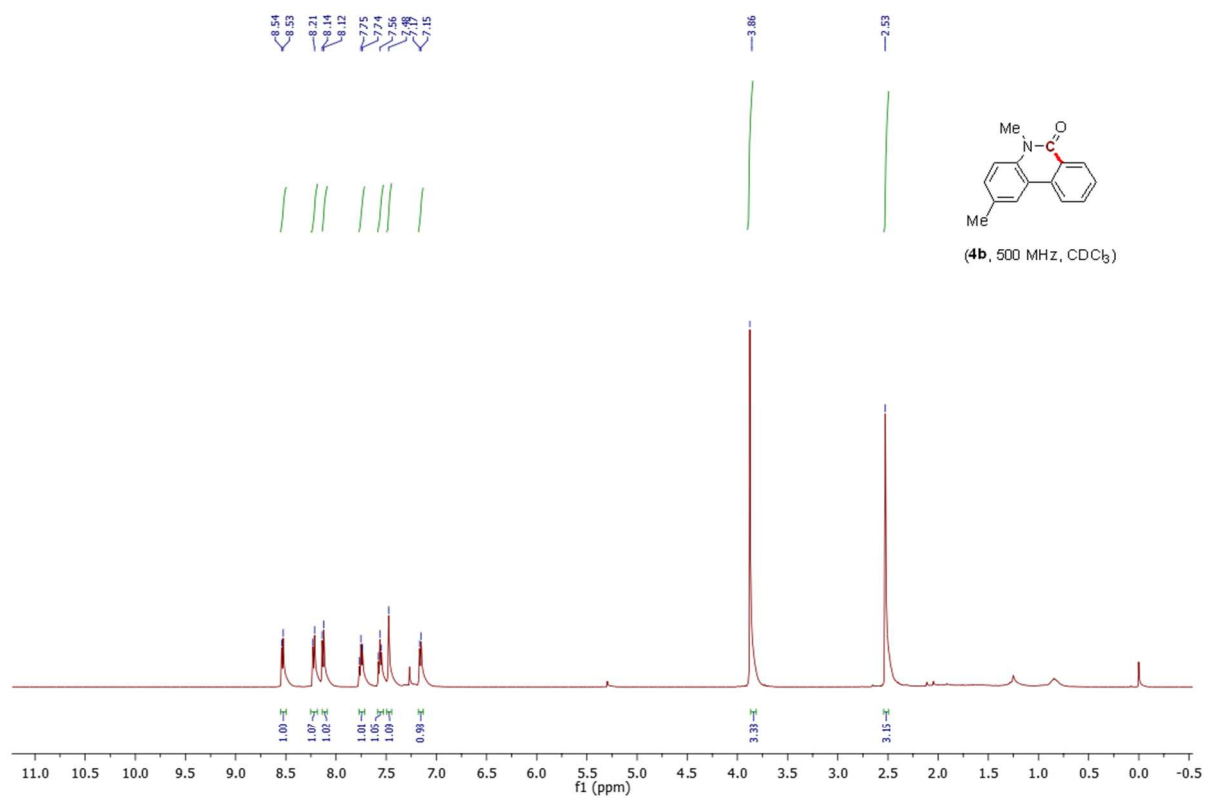
8H-isoquinolino[1,2-b]quinazolin-8-one



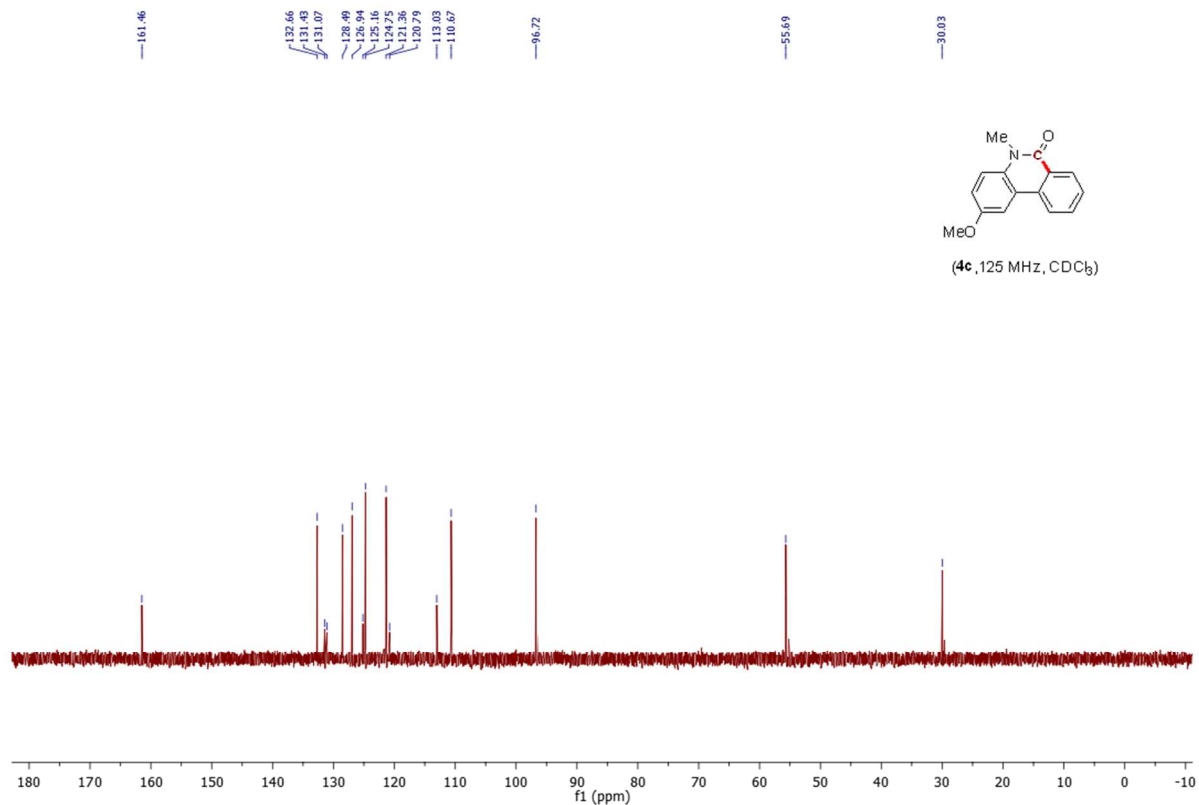
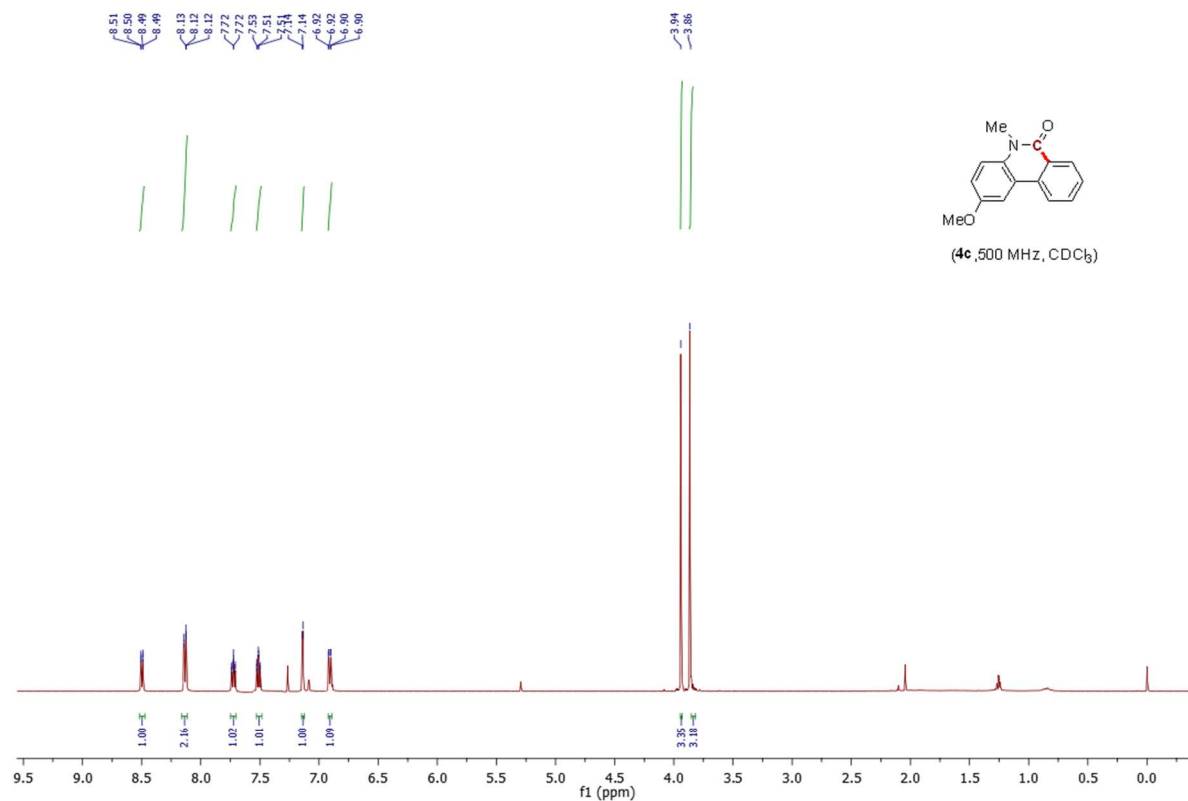
5-Methylphenanthridin-6(5H)-one



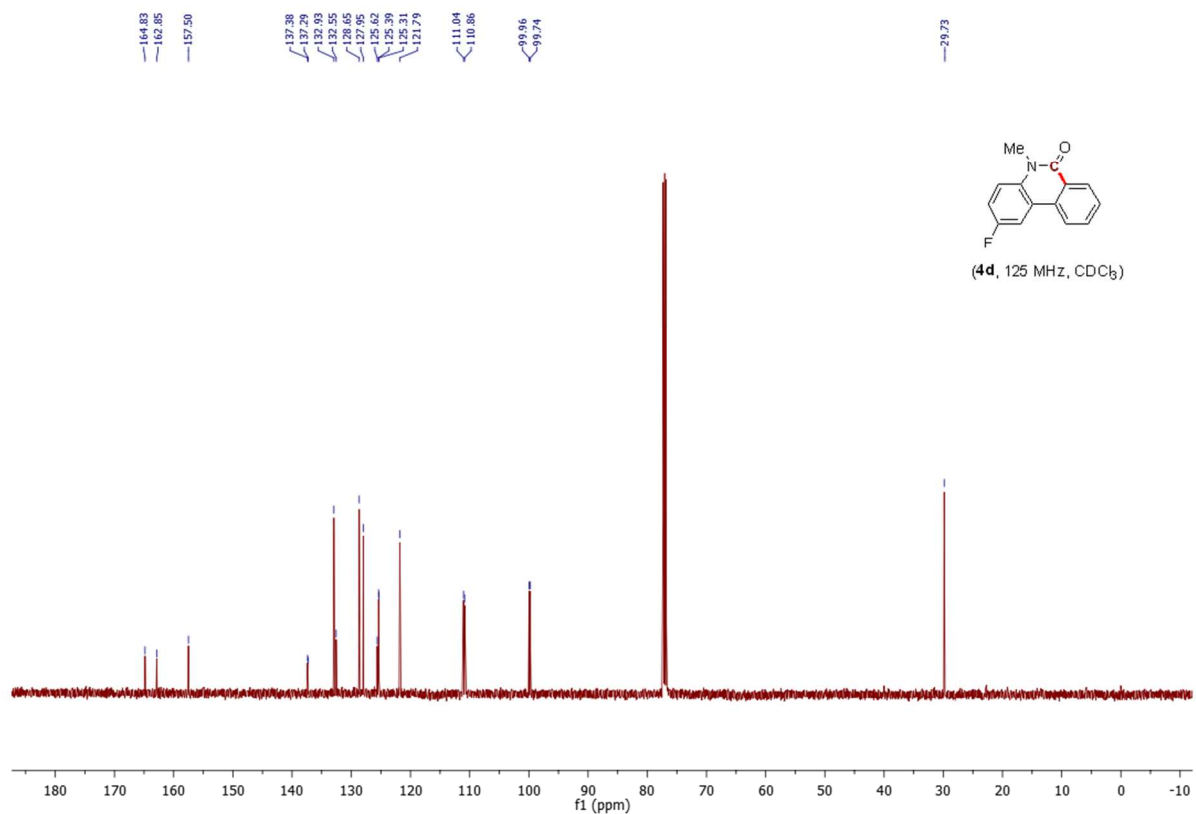
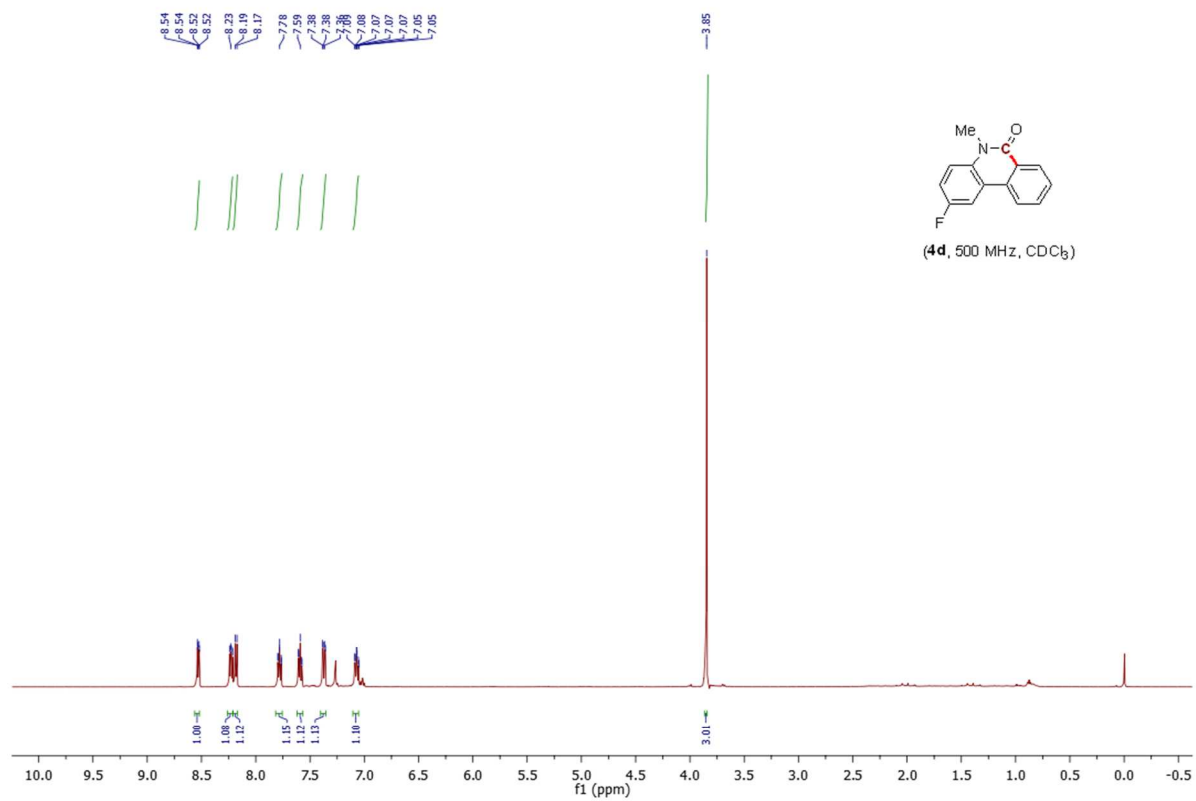
2, 5-Dimethylphenanthridin-6(5H)-one



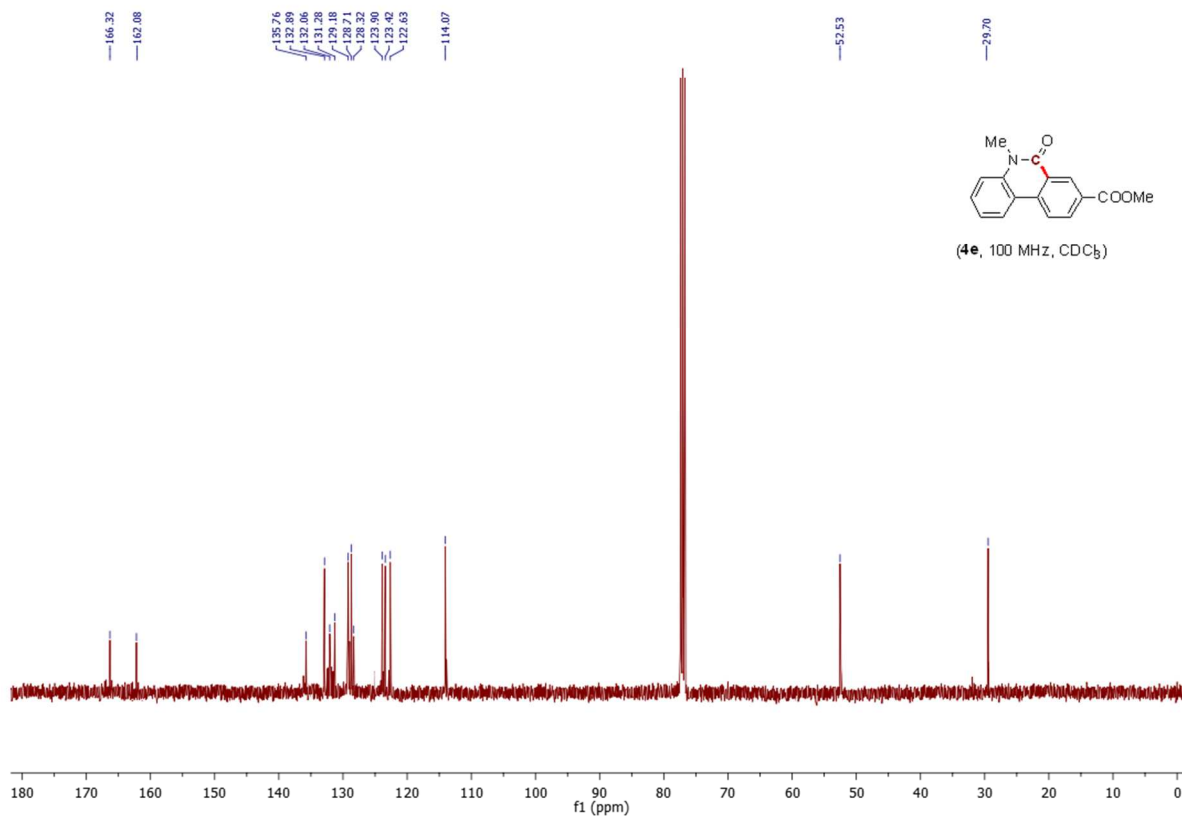
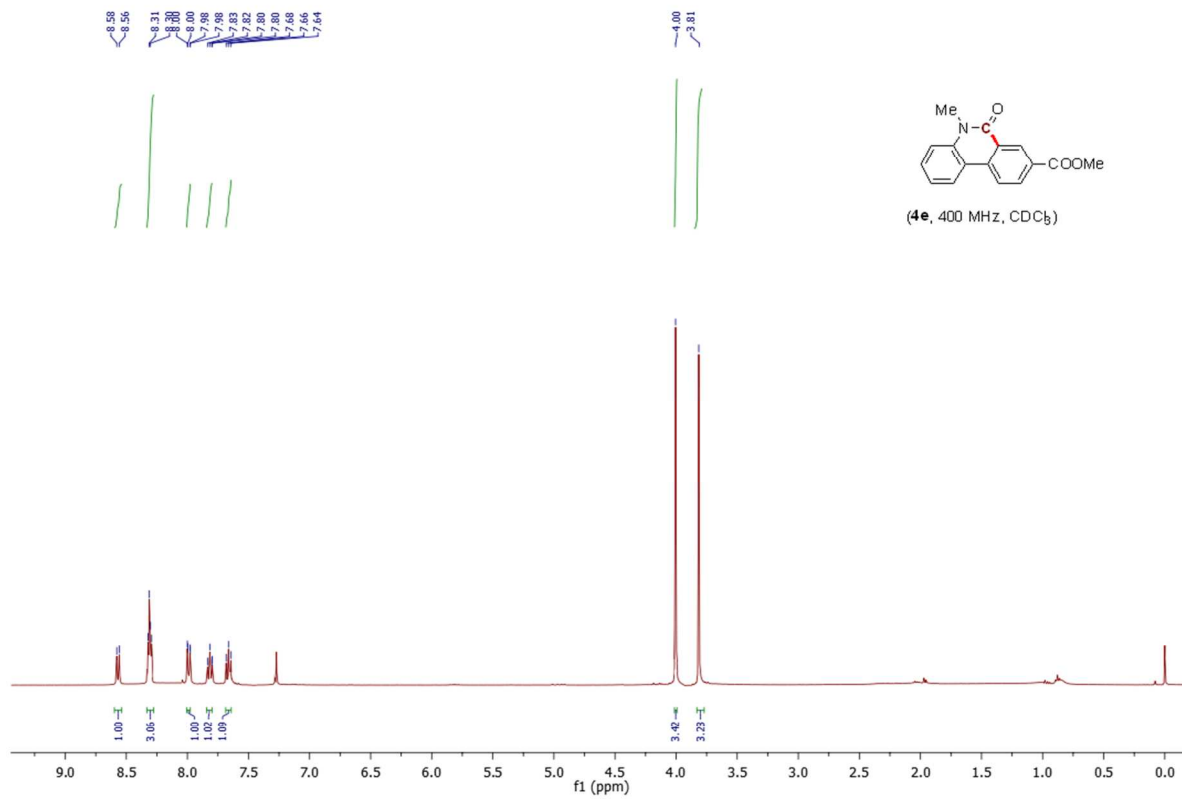
2-Methoxy-5-methylphenanthridin-6(5H)-one



2-Fluoro-5-methylphenanthridin-6(5H)-one

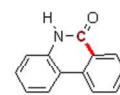


Methyl 5-methyl-6-oxo-5,6-dihydrophenanthridine-8-carboxylate

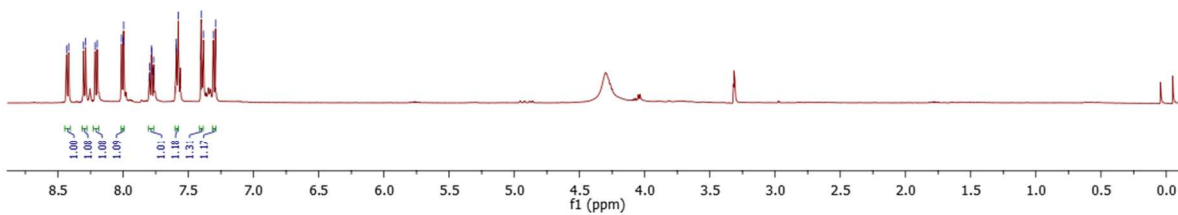


phenanthridin-6(5H)-one

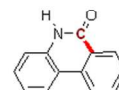
8.48
8.42
8.36
8.29
8.22
8.20
8.01
8.00
7.80
7.79
7.78
7.77
7.77
7.59
7.58
7.40
7.38
7.31
7.29



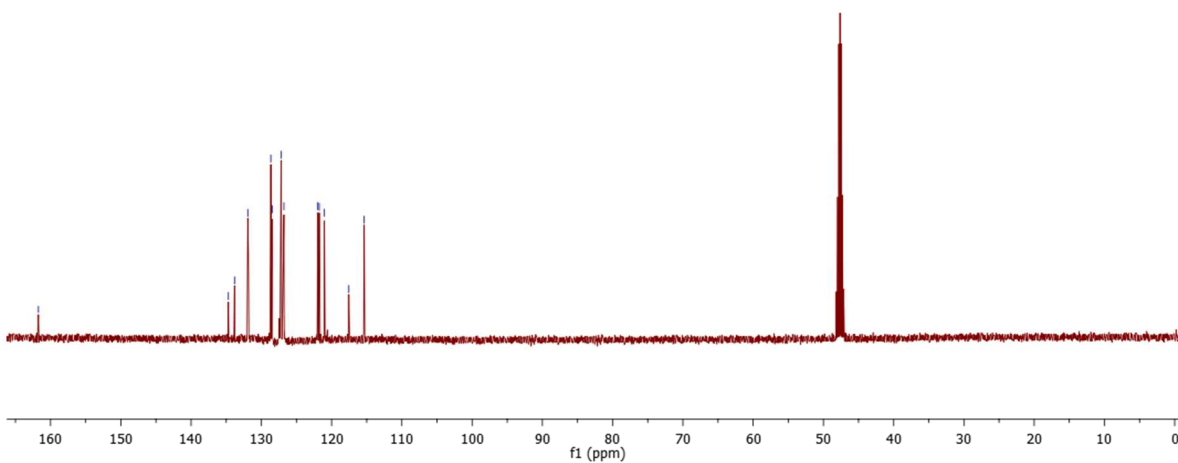
(4f, 500 MHz, MeOD)



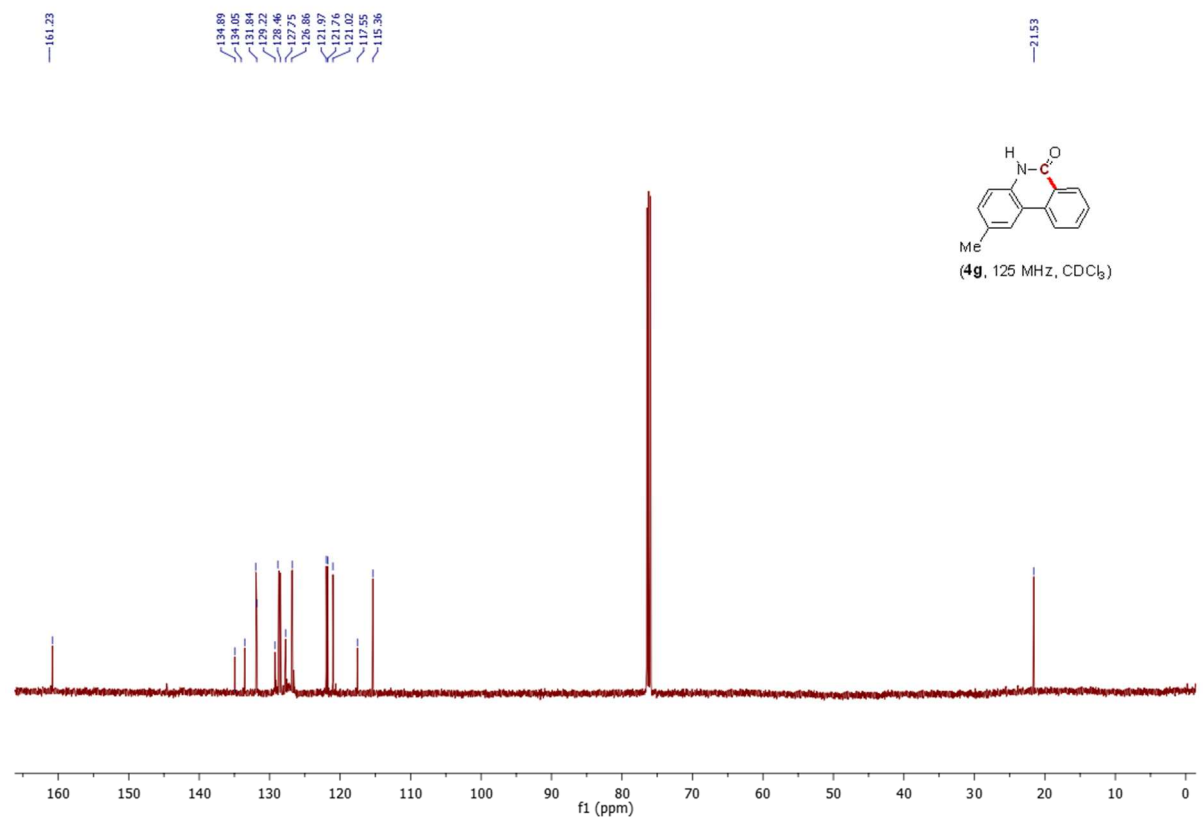
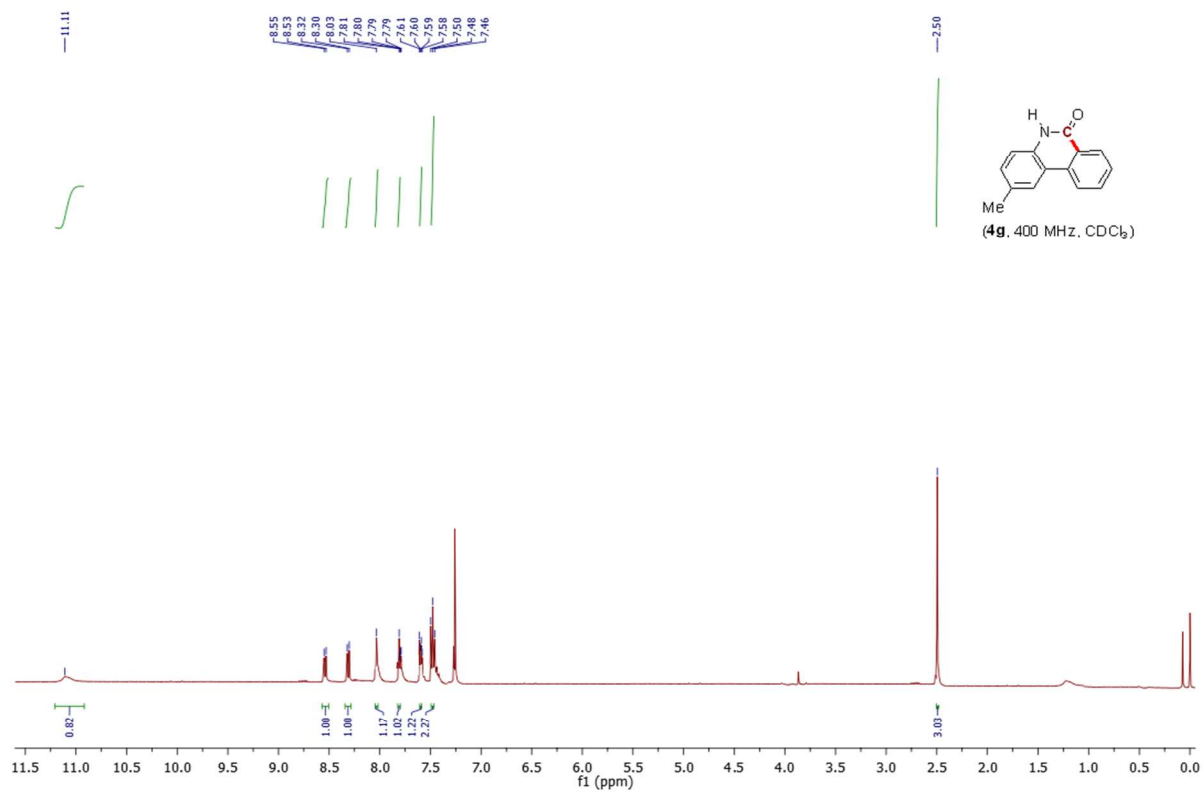
161.73
134.69
133.81
131.03
128.65
128.46
127.19
126.78
121.97
121.76
121.02
117.55
115.36



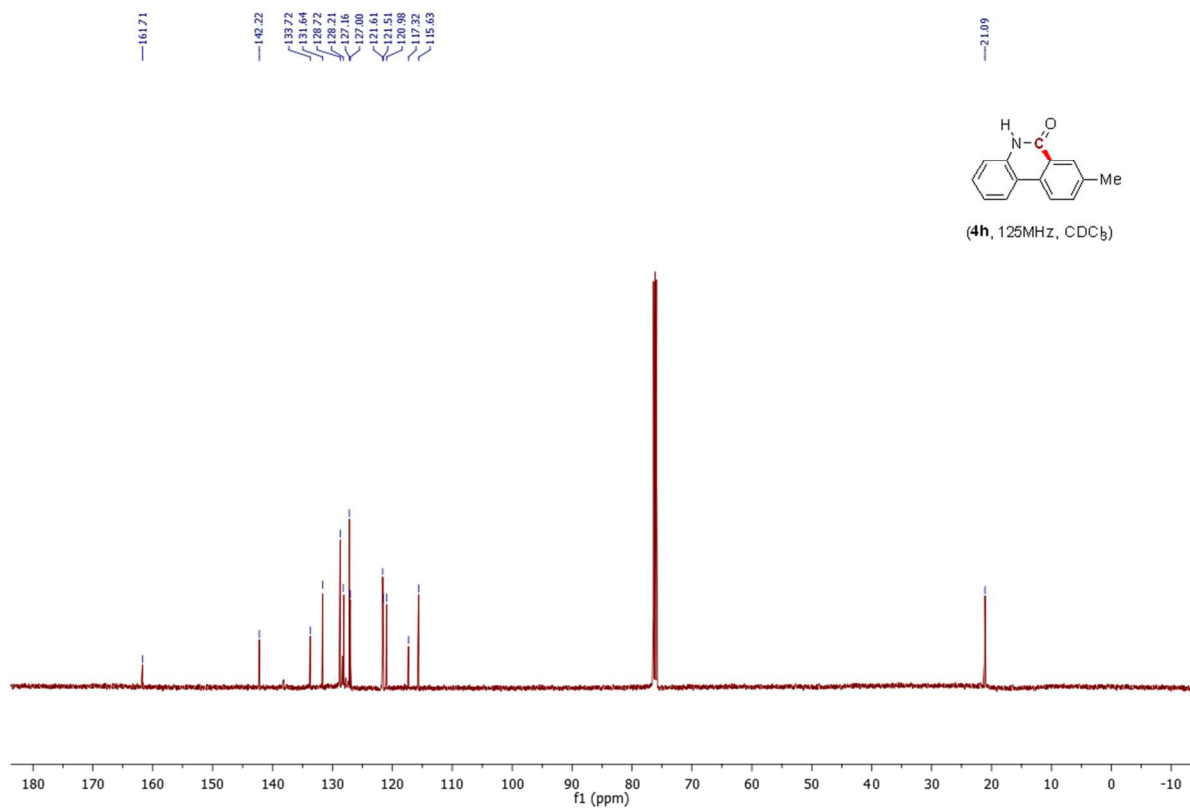
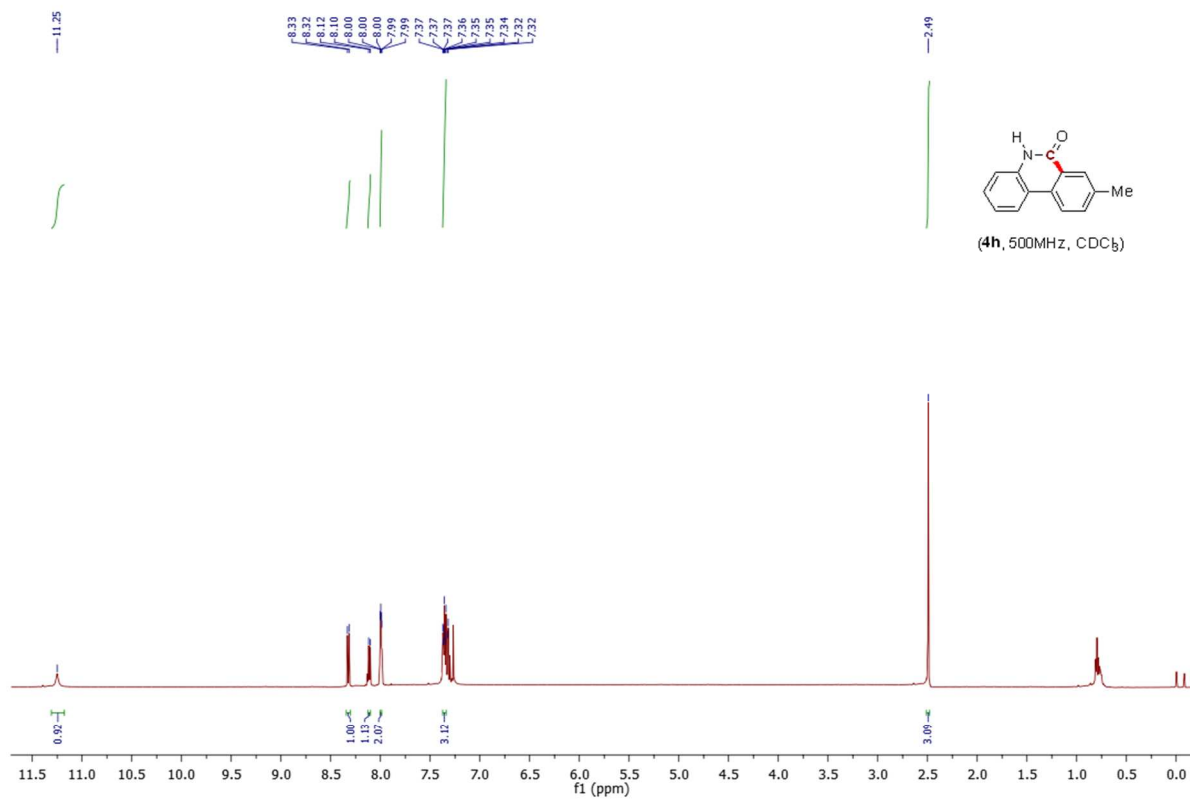
(4f, 125 MHz, MeOD)



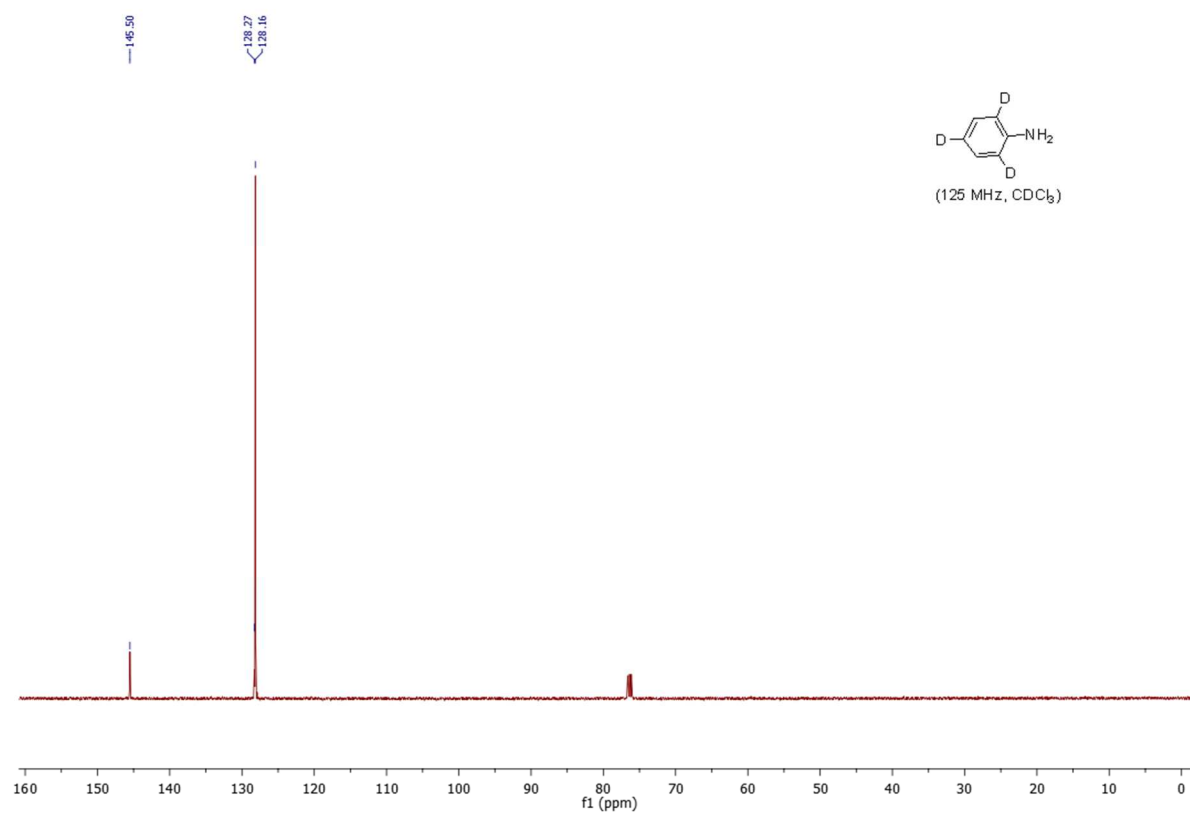
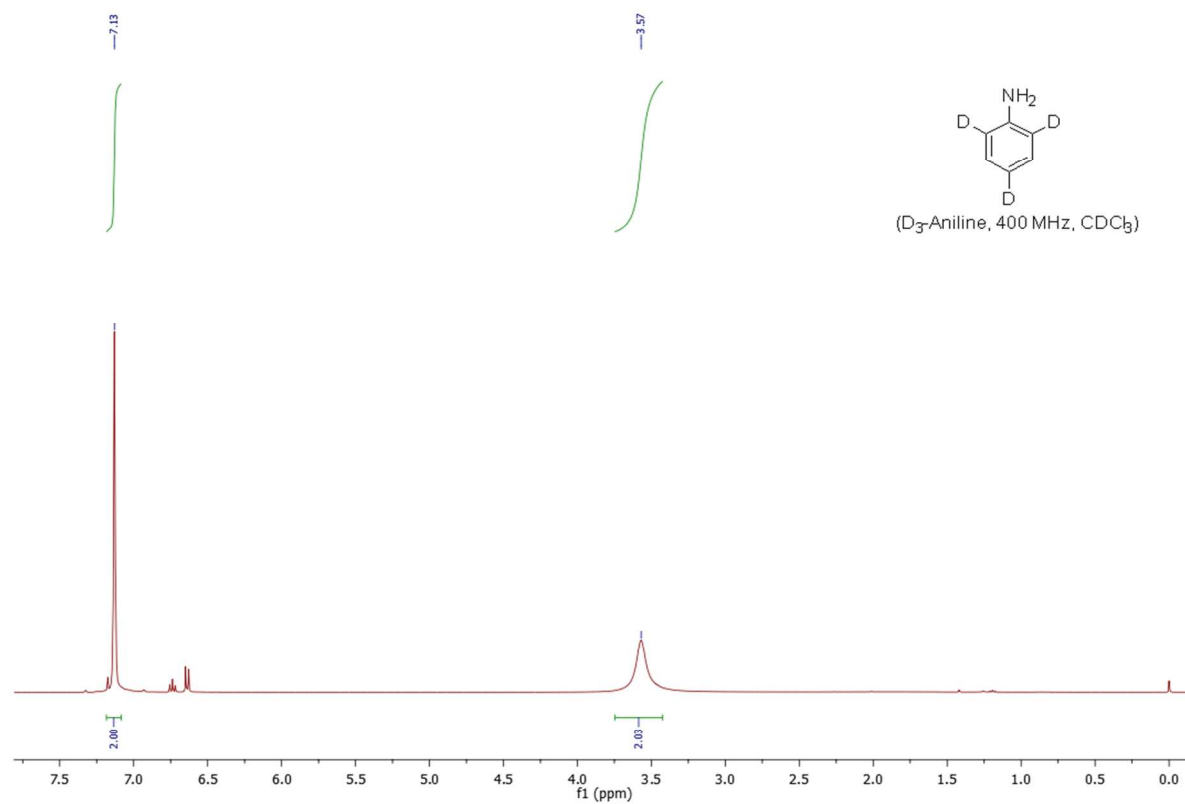
2-Methylphenanthridin-6(5H)-one



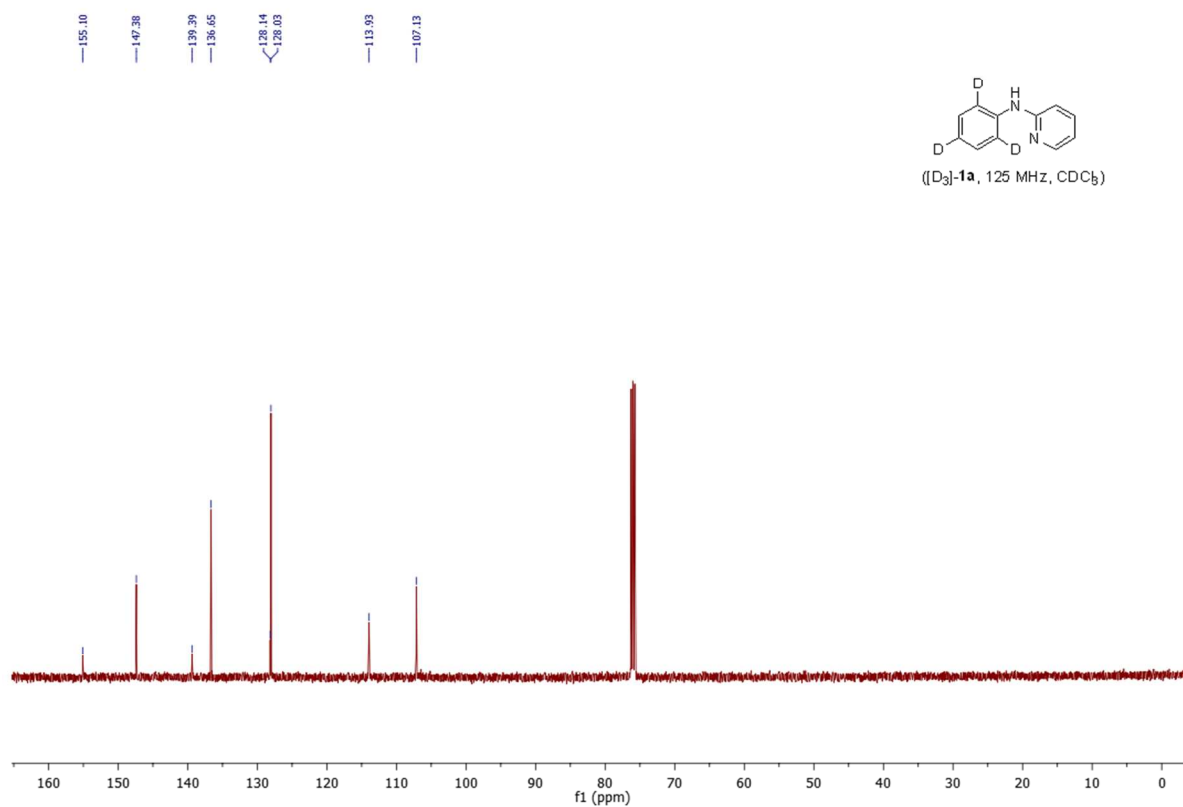
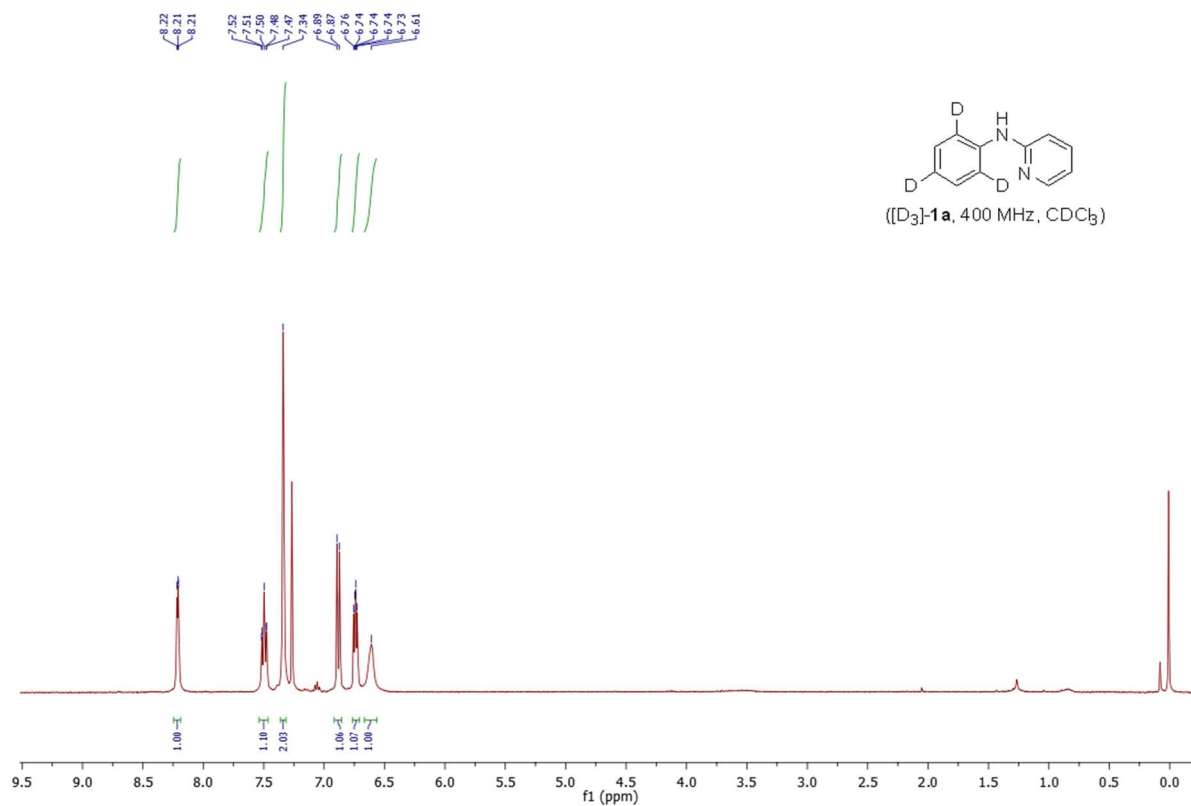
8-Methylphenanthridin-6(5H)-one



Benzen-2,4,6-d₃-amine:



***N*-(phenyl-2,4,6-d₃)pyridin-2-amine:**



11H-Pyrido[2,1-b]quinazolin-11-one and 11H-pyrido[2,1-b]quinazolin-11-one-2,4-d₂:

