Supporting Information for

Stereoselective Construction of Deoxy-Cruciferane Alkaloids by NHC-Catalyzed Intramolecular Annulation of Homoenolate with Quinazolinone

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Sr. No.	Table of Contents	Pages

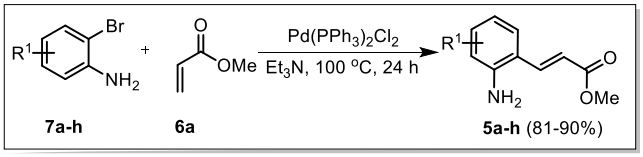
1. General Information:

All reagents and solvents were used as received from commercial sources unless and otherwise noted. THF was freshly distilled over benzophenone-ketyl under an atmosphere of argon. Toluene was dried by distillation over sodium wire under argon atmosphere and stored over 4 Å molecular sieves. All experiments were performed under an argon atmosphere. Precoated plates (silica gel 60 PF254, 0.25 or 0.50 mm) were utilized for thin-layer chromatography (TLC). Column chromatographic purifications were carried out on flash silica-gel (240-400 mesh) or neutral alumina (70-230 mesh) using petroleum ether and ethyl acetate or DCM:MeOH as eluents. The ^{1}H, ^{13}C, and distortionless enhancement by polarization transfer (DEPT)-NMR spectra were recorded on 200/400/500 and 100/125 MHz NMR spectrometers, respectively in $CDCl_3$. Chemical shifts are reported as δ values from standard peaks. The multiplicities of signals are designated by the following abbreviations: s (singlet), d (doublet), t (triplet), q (quartet), quint. (quintet), m (multiplet). Coupling constants (*J*) are reported in hertz. Optical rotations were measured with a P-2000 polarimeter at 589 nm. The enantiomeric ratio of deoxy-cruciferanes was determined by chiral HPLC analysis using Agilent technologies 1260 Infinity series. Single-crystal X-ray intensity data measurements of compound **2a** was carried out on Bruker D8 VENTURE Kappa Duo PHOTON II CPAD diffractometer equipped with Incoatech multilayer mirrors optics. The intensity measurements were carried out with Mo micro-focus sealed tube diffraction source (CuK_α= 1.54178 Å) at 100(2) K temperature. High-resolution mass spectrometry (HRMS) was performed on a time-of-flight (TOF)/quadrupole-TOF mass spectrometer.

2. Experimental section:

[A] General Experimental Procedure for Aniline-esters 5a-h.

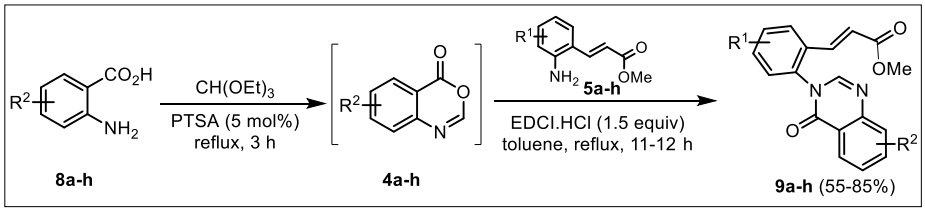
All the reactions were performed on 1 g of *o*-bromoaniline. The esters **5a-h** were prepared by using the literature procedure.[1]



A sealed tube was charged with *o*-bromoaniline **7a-h** (11.6 mmol) and $PdCl_2(PPh_3)_2$ (5 mol %). Methyl acrylate (**6a**, 13.9 mmol) and Et_3N (10 mL) were added, and the sealed tube was flushed twice with argon gas. It was sealed with a screw cap and placed in a preheated oil bath at 100 ^oC for 24 h. The reaction mixture was then cooled to room temperature and diluted with water (60 mL) followed by extraction with EtOAc (3 x 100 mL). The organic layer was separated and dried over anhydrous Na_2SO_4. Evaporation of the solvent under *vacuo* to dryness followed by the purification of the crude product using column chromatography (petrolium ether:ethyl acetate, 4:1) provided the expected aniline-ester **5a-h** in very good yields.

[B] General Experimental Procedure for Quinazolinone-ester 9a-h.

All the reactions were performed on 1 g of **5a-h**.

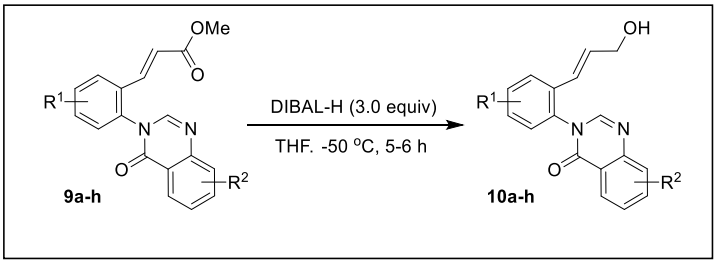


Triethyl orthoformate (15 equiv) was added to a mixture of anthranilic acid **8a-h** (1 equiv) and *p*-toluenesulfonic acid (5 mol %) at room temperature. The reaction mixture was refluxed for 3 hours. After completion of the reaction, triethyl orthoformate was evaporated under *vacuo*. The obtained pale yellow solid **4a-h** was used further without any purification.[2]

The solution of benzoxazinone **4a-h** (1 equiv), EDCI (1.5 equiv) and amine-ester **5a-h** (0.75 equiv) in toluene was refluxed for 11-12 hours. After completion, the reaction mixture was cooled to room temperature and the solution was poured into 15 mL of distilled water and extracted with EtOAc (3 x 15 mL). The organic phase was washed successively with water and brine solution followed by drying over Na_2SO_4. The combined organic layer was concentrated and the crude product was purified by flash column chromatography using petroleum ether and ethyl acetate to afford quinazolinone-ester **9a-h** in moderate to very good yields.

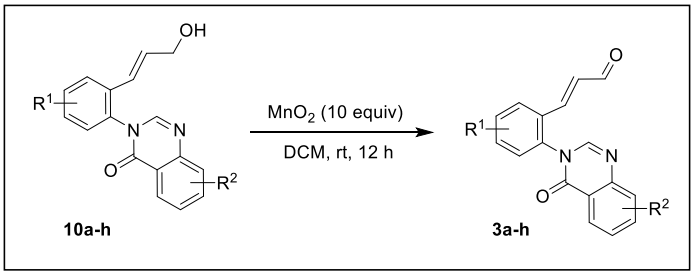
[C] General Experimental Procedure for Quinazolinone-alcohol 10a-h.

All the reactions were performed on 1 g of **9a-h**.



To a solution of quinazolinone-ester **9a-h** (1.0 equiv) in anhydrous THF (10 mL) in a flame-dried two-neck round-bottom flask was added DIBAL-H (1.0 M in THF, 3.0 equiv) at -50 ºC under argon atmosphere. The resultant reaction mixture was stirred at -50 ºC for 5-6 h under argon atmosphere before quenching with saturated aqueous solution of Rochelle salt (2 mL). The aqueous phase was extracted with DCM (5 x 10 mL). The combined organic extracts were dried over anhydrous Na_2SO_4, filtered through a thin plug of celite®, and concentrated under reduced pressure. The crude products **10a-h** were used for the next step without further purification.

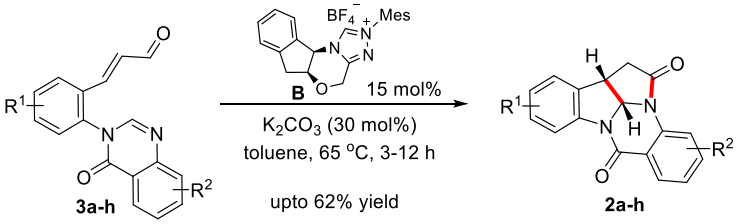
[D] General Experimental Procedure for Quinazolinone-aldehyde 3a-h.



The solution of crude alcohol **10a-h** (1 equiv) in DCM (10 mL) was added MnO_2 (10.0 equiv.). The reaction mixture was stirred overnight at room temperature. Excess MnO_2 was removed by filtration. The combined organic layer was concentrated. The crude product was purified by flash column chromatography using first petroleum ether:ethyl acetate (4:1, 150mL) followed by DCM:MeOH (19:1) to afford quinazolinone-aldehyde **3a-h** in good yields.

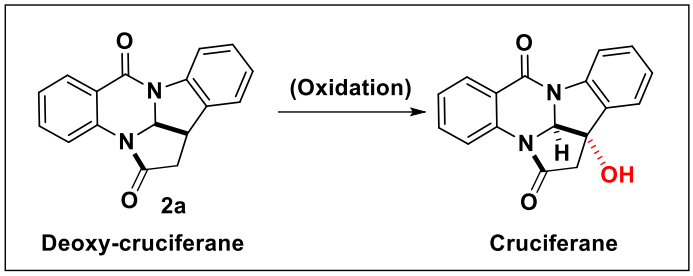
[E] General Experimental Procedure for the synthesis of Pyrroloindoloquinazolinone 2a-h.

All the reactions were performed on 50 mg of **3a-h**.



A reaction mixture containing K_2CO_3 (30 mol%), NHC-precatalyst **B** (15 mol %), and aldehyde **3a-h** (50 mg, 1.0 equiv) in dry toluene (2 mL) under argon atmosphere was stirred by a magnetic stirring bar at 65 °C for 3-12 h. The progress of the reaction was monitored by TLC. After completion of the reaction, the crude reaction mixture was cooled to room temperature and filtered through a bed of celite®. The residue was washed with ethyl acetate (3 x 5 mL) and the combined filtrate was evaporated under reduced pressure. The crude product was purified by column chromatography on neutral alumina (70-230 mesh) using a solvent gradient of petroleum ether and ethyl acetate to furnish the desired products **2a-h** in moderate to good yields.

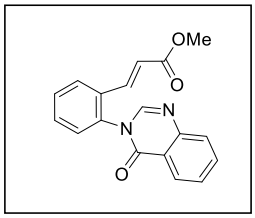
[F] Selected oxidation reactions of deoxy-cruciferane attempted:



Sr. No	Condition	Solvent	Observation
1	DDQ, rt/heating	DCM	No reaction
2	SeO_2, rt/heating	1,4-dioxane	No reaction
3	$RuCl_3.nH_2O$; Pyridine; KBrO, 60 ^oC	CAN-H_2O	Decomposition
4	NBS; H_2O, rt/heating	1,4-dioxane	No reaction
5	$K_2S_2O_8$; $CuSO_4.5H_2O$, rt/heating	Pyridine	Complex reaction mix.
6	CrO_3; H_5IO_6, rt/heating	ACN	Decomposition
7	$KMnO_4$; $BnEt_3N.Cl$, rt/heating	DCE	No reaction
8	$KMnO_4$, rt/heating	Acetone	No reaction
9	MnO_2, rt/heating	DCM	No reaction

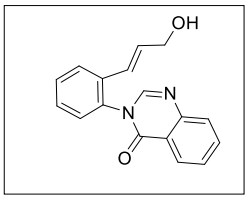
3. Characterization Data of Compounds:

Methyl (E)-3-(2-(4-oxoquinazolin-3(4H)-yl)phenyl)acrylate (9a) : Procedure [B]



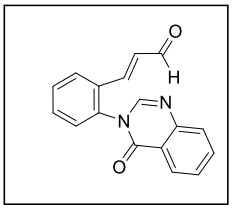
Reaction Time: 11 h; R*f*: 0.4 (3:2, Pet. Ether:EtOAc); white solid; Mp = 122-123 ^{o}C; 1.46 g, 85% yield; **^{1}H NMR (400 MHz, CDCl$_3$)** δ 8.30 (dd, *J* = 8.4, 1.5 Hz, 1H), 7.91 (s, 1H), 7.80-7.71 (m, 3H), 7.54-7.46 (m, 3H), 7.38 (d, *J* = 16.0 Hz, 1H), 7.31-7.24 (m, 1H), 6.40 (d, *J* = 16.0 Hz, 1H), 3.63 (s, 3H); **^{13}C NMR (100 MHz, CDCl$_3$)** δ 166.4, 160.7, 148.0, 145.8, 138.2, 136.6, 134.9, 132.6, 131.3, 130.1, 128.9, 127.9, 127.8, 127.7, 127.3, 122.2, 121.7, 51.8; **ESI HRMS**: calcd for $C_{18}H_{14}N_2O_3$ $[M + H]^+$: 307.1077, found: 307.1079.

(E)-3-(2-(3-Hydroxyprop-1-en-1-yl)phenyl)quinazolin-4(3H)-one (10a) : Procedure [C]



Reaction Time: 6 h; R*f*: 0.4 (1:1, Pet. Ether:EtOAc); **ESI HRMS**: calcd for $C_{17}H_{14}O_2N_2$ $[M + H]^+$: 279.1128, found: 279.1127.

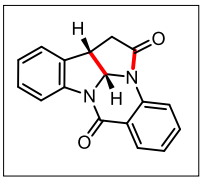
(E)-3-(2-(4-Oxoquinazolin-3(4H)-yl)phenyl)acrylaldehyde (3a) : Procedure [D]



Reaction Time: 12 h; R*f*: 0.5 (3:2, Pet. Ether:EtOAc); white solid; Mp = 236-238 ^{o}C; 0.63 mg, 70% yield; **^{1}H NMR (400 MHz, CDCl$_3$)** δ 9.48 (d, *J* = 7.3 Hz, 1H), 8.32 (d, 7.9 Hz, 1H), 7.95 (s, 1H), 7.87-7.72 (m, 3H), 7.63-7.49 (m, 3H), 7.33 (d, *J* = 7.9 Hz, 1H), 7.19 (d, *J* = 15.9 Hz, 1H), 6.67 (dd, *J* = 15.9, 7.3 Hz, 1H); **^{13}C NMR (100 MHz, CDCl$_3$)** δ 193.1, 160.7,

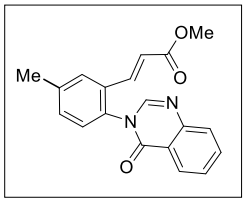
148.0, 145.7, 145.4, 136.8, 135.1, 132.3, 132.1, 131.4, 130.3, 129.0, 128.1, 127.92, 127.91, 127.3, 122.0 ; **ESI HRMS**: calcd for $C_{17}H_{12}O_2N_2$ $[M + H]^+$: 277.0972, found: 277.0971.

2a[1],11b-Dihydro-7H-2a,7a-diazabenzo[b]cyclopenta[lm]fluorene-2,7(1H)-dione (2a) : Procedure [E]



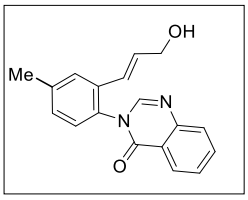
Reaction Time: 4 h; R*f*: 0.5 (3:2, Pet. Ether:EtOAc); white solid; Mp = 178-180 ^oC; 21 mg, 42% yield; $[\alpha]^{24}_D$ –272.0 (*c* 0.2, $CHCl_3$); **^{1}H NMR (400 MHz, CDCl$_3$)** δ 8.10 (d, *J* = 8.3 Hz, 1H), 7.99 (d, *J* = 7.5 Hz, 1H), 7.74 (d, *J* = 7.5 Hz, 1H), 7.56 (t, *J* = 7.5 Hz, 1H), 7.35-7.23 (m, 3H), 7.06 (t, *J* = 7.5 Hz, 1H), 5.94 (d, *J* = 8.3 Hz, 1H), 4.18-4.05 (m, 1H), 3.23 (dd, *J* = 18.8, 11.2 Hz, 1H), 2.62 (dd, *J* = 18.8, 4.9 Hz, 1H); **^{13}C NMR (100 MHz, CDCl$_3$)** δ 170.8, 159.7, 141.3, 136.2, 133.6, 132.23, 129.3, 129.0, 126.3, 124.91, 124.88, 123.6, 121.7, 115.8, 76.7, 37.9, 36.1; **ESI HRMS**: calcd for $C_{17}H_{12}O_2N_2$ $[M + H]^+$: 277.0972, found: 277.0970. **HPLC**: Chiralpak IC, n-hexane/IPA = 70:30, 1.0 mL/min, λ = 220 nm, t_R (major) = 25.257 min, t_R (minor) = 28.610 min (78:22 er).

Methyl (E)-3-(4-methyl-2-(4-oxoquinazolin-3(4H)-yl)phenyl)acrylate (9b) : Procedure [B]



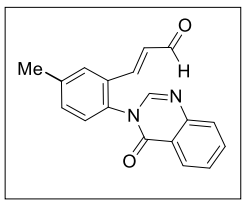
Reaction Time: 11 h; R*f*: 0.5 (3:2, Pet. Ether:EtOAc); white solid; Mp = 161-163 ^oC; 1.3 g, 77% yield; **^{1}H NMR (500 MHz, CDCl$_3$)** δ 8.36 (dd, *J* = 8.0, 1.1 Hz, 1H), 7.97 (s, 1H), 7.83 (t, *J* = 8.0 Hz, 1H), 7.80 (d, *J* = 7.3 Hz, 1H), 7.61 (s, 1H), 7.57 (t, *J* = 8.0 Hz, 1H), 7.43 (d, *J* = 16.0 Hz, 1H), 7.37 (dd, *J* = 8.0, 1.1 Hz, 1H), 7.23 (d, *J* = 8.0 Hz, 1H), 6.46 (d, *J* = 16.0 Hz, 1H), 3.70 (s, 3H), 2.47 (s, 3H); **^{13}C NMR (125 MHz, CDCl$_3$)** δ 166.4, 160.8, 148.0, 146.0, 140.2, 138.3, 134.7, 134.2, 132.1, 132.3, 128.6, 128.1, 127.8, 127.7, 127.3, 122.2, 121.4, 51.7, 21.2; **ESI HRMS**: calcd for $C_{19}H_{16}O_3N_2$ $[M + H]^+$: 321.1234, found: 321.1232.

(E)-3-(2-(3-Hydroxyprop-1-en-1-yl)-5-methylphenyl)quinazolin-4(3H)-one (10b) : Procedure [C]



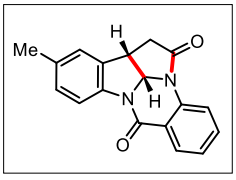
Reaction Time: 6 h; R*f*: 0.4 (1:1, Pet. Ether:EtOAc); **ESI HRMS**: calcd for $C_{18}H_{16}O_2N_2$ $[M + H]^+$: 293.1285, found: 293.1284.

(E)-3-(4-Methyl-2-(4-oxoquinazolin-3(4H)-yl)phenyl)acrylaldehyde (3b) : Procedure [D]



Reaction Time: 12 h; R*f*: 0.5 (3:2, Pet. Ether:EtOAc); white solid; Mp = 208-210 ^oC; 642 mg, 71% yield; **^{1}H NMR (500 MHz, $CDCl_3$)** δ 9.45 (d, J = 7.6 Hz, 1H), 8.29 (d, J = 8.0 Hz, 1H), 7.92 (s, 1H), 7.77 (t, J = 8.0 Hz, 1H), 7.74 (d, J = 8.0 Hz, 1H), 7.58 (s, 1H), 7.51 (t, J = 7.6 Hz, 1H), 7.36 (d, J = 8.0 Hz, 1H), 7.20 (d, J = 7.6 Hz, 1H), 7.15 (d, J = 16.0 Hz, 1H), 6.63 (dd, J = 15.6, 7.6 Hz, 1H), 2.41 (s, 3H); **^{13}C NMR (125 MHz, $CDCl_3$)** δ 193.1, 160.8, 148.0, 145.9, 145.6, 140.5, 134.9, 134.3, 133.0, 131.6, 131.2, 128.7, 128.3, 128.0, 127.8, 127.3, 122.0, 21.2; **ESI HRMS**: calcd for $C_{18}H_{14}O_2N_2$ $[M + H]^+$: 291.1128, found: 291.1127.

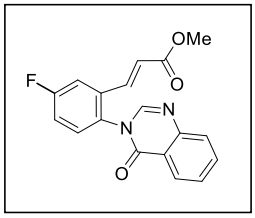
9-Methyl-2a^1,11b-dihydro-7H-2a,7a-diazabenzo[b]cyclopenta[lm]fluorene-2,7(1H)-dione (2b) : Procedure [E]



Reaction Time: 3 h; R*f*: 0.6 (3:2, Pet. Ether:EtOAc); white solid; Mp = 196-198 ^oC; 18 mg, 35% yield; $[\alpha]^{24}_D$ –198.2 (*c* 0.2, $CHCl_3$); **^{1}H NMR (500 MHz, $CDCl_3$)** δ 8.17 (d, J = 7.6 Hz, 1H), 7.95 (d, J = 8.0 Hz, 1H), 7.81 (d, J = 8.0 Hz, 1H), 7.63 (t, J = 7.6 Hz, 1H), 7.40 (t, J =

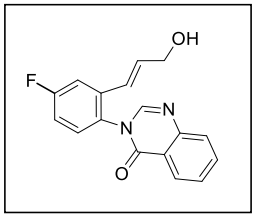
7.6 Hz, 1H), 7.18-7.09 (m, 2H), 6.00 (d, *J* = 8.4 Hz, 1H), 3.29 (dd, *J* = 17.9, 11.1 Hz, 1H), 2.69 (dd, *J* = 18.3, 4.2 Hz, 1H), 2.36 (s, 3H); **^{13}C NMR (125 MHz, CDCl$_3$)** δ 170.9, 159.4, 139.0, 136.2, 134.8, 133.5, 132.3, 129.7, 129.0, 126.2, 125.5, 123.8, 121.8, 115.5, 76.8, 37.9, 36.1, 21.1; **ESI HRMS**: calcd for $C_{18}H_{14}O_2N_2$ $[M + H]^+$: 291.1128, found: 291.1136. **HPLC**: Chiralpak IA, n-hexane/IPA = 80:20, 1.0 mL/min, λ = 220 nm, t_R (major) = 28.610 min, t_R (minor) = 25.257 min (73:27 er).

Methyl (E)-3-(4-fluoro-2-(4-oxoquinazolin-3(4H)-yl)phenyl)acrylate (9c) : Procedure [B]



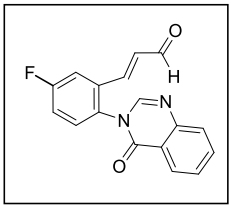
Reaction Time: 11 h; R*f*: 0.5 (3:2, Pet. Ether:EtOAc); white solid; Mp = 165-167 ^{o}C; 1.41 g, 85% yield; **^{1}H NMR (400 MHz, CDCl$_3$)** δ 8.36 (dd, *J* = 7.6, 1.5 Hz, 1H), 7.96 (s, 1H), 7.85 (dd, *J* = 6.9, 1.5 Hz, 1H), 7.81 (d, *J* = 8.4 Hz, 1H), 7.62-7.56 (m, 1H), 7.50 (dd, *J* = 9.2, 3.1 Hz, 1H), 7.40-7.32 (m, 2H), 7.30-7.24 (m, 1H), 6.46 (d, *J* = 16.0 Hz, 1H), 3.72 (s, 3H); **^{13}C NMR (100 MHz, CDCl$_3$)** δ 166.0, 162.9 (d, *J* = 250.2 Hz, C-F), 160.8, 147.9, 145.6, 137.1 (d, *J* = 1.9 Hz), 135.0, 134.76 (d, *J* = 8.6 Hz), 132.5 (d, *J* = 2.9 Hz), 130.84 (d, *J* = 8.6 Hz), 128.0, 127.8, 127.3, 122.9, 122.0, 118.3 (d, *J* = 23.0 Hz), 114.2 (d, *J* = 24 Hz), 52.0; **ESI HRMS**: calcd for $C_{18}H_{13}O_3N_2F$ $[M + H]^+$: 325.0983, found: 325.0986.

(E)-3-(5-Fluoro-2-(3-hydroxyprop-1-en-1-yl)phenyl)quinazolin-4(3H)-one (10c) : Procedure [C]



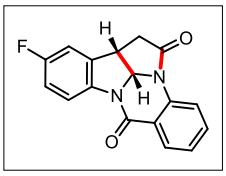
Reaction Time: 6 h; R*f*: 0.4 (1:1, Pet. Ether:EtOAc); **ESI HRMS**: calcd for $C_{17}H_{13}O_2N_2F$ $[M + H]^+$: 297.1034, found: 297.1032.

(E)-3-(4-Fluoro-2-(4-oxoquinazolin-3(4H)-yl)phenyl)acrylaldehyde (3c) : Procedure [D]



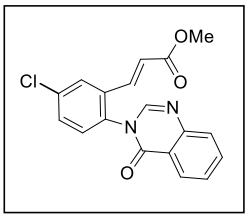
Reaction Time: 12 h; R*f*: 0.5 (3:2, Pet. Ether:EtOAc); white solid; Mp = 195-197 ^{o}C; 551 mg, 61% yield; **^{1}H NMR (500 MHz, CDCl$_3$)** δ 9.56 (d, *J* = 7.6 Hz, 1H), 8.37 (d, *J* = 8.0 Hz, 1H), 7.99 (s, 1H), 7.87 (t, *J* = 7.3 Hz, 1H), 7.83 (d, *J* = 8.0 Hz, 1H), 7.61 (t, *J* = 7.3 Hz, 1H), 7.54 (dd, *J* = 8.7, 2.3 Hz, 1H), 7.40 (dd, *J* = 8.4, 4.5 Hz, 1H), 7.36-7.31 (m, 1H), 7.19 (d, *J* = 16.0 Hz, 1H), 6.70 (dd, *J* = 15.6, 7.3 Hz, 1H); **^{13}C NMR (125 MHz, CDCl$_3$)** δ 192.6, 163.0 (d, *J* = 251.7 Hz, C-F), 160.7, 147.9, 145.6, 143.9, 135.2, 134.3 (d, *J* = 7.6 Hz), 132.7 (d, *J* = 2.9 Hz), 132.3, 131.0 (d, *J* = 9.5 Hz), 128.2, 128.0, 127.3, 122.0, 119.2 (d, *J* = 23.8 Hz), 114.5 (d, *J* = 23.8 Hz); **ESI HRMS**: calcd for $C_{17}H_{11}O_2N_2F[M + H]^+$: 295.0877, found: 295.0877.

9-Fluoro-2a^{1},11b-dihydro-7H-2a,7a-diazabenzo[b]cyclopenta[lm]fluorene-2,7(1H)-dione. (2c) : Procedure [E]



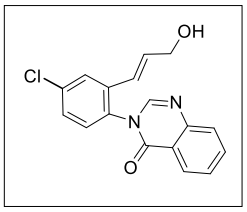
Reaction Time: 4 h; R*f*: 0.6 (3:2, Pet. Ether:EtOAc); white solid; Mp = 210-212 ^{o}C; 19 mg, 37% yield; $[\alpha]^{24}_{D}$ –197.4 (*c* 0.24, $CHCl_3$); **^{1}H NMR (400 MHz, CDCl$_3$)** δ 8.17 (d, *J* = 7.9 Hz, 1H), 8.04 (dd, *J* = 9.7, 4.9 Hz, 1H), 7.82 (d, *J* = 8.5 Hz, 1H), 7.65 (t, *J* = 7.4 Hz, 1H), 7.41 (t, *J* = 7.4 Hz, 1H), 7.05 (d, *J* = 8.5 Hz, 2H), 6.05 (d, *J* = 8.5 Hz, 1H), 4.26-4.09 (m, 1H), 3.31 (dd, *J* = 17.7, 11.0 Hz, 1H), 2.70 (dd, *J* = 18.3, 4.9 Hz, 1H); **^{13}C NMR (100 MHz, CDCl$_3$)** δ 170.4. 159.9 (d, *J* = 244.3 Hz, C-H), 159.5, 137.5 (d, *J* = 1.5 Hz), 136.1, 133.9 (d, *J* = 7.7 Hz), 133.7, 129.0, 126.4, 123.5, 121.8, 116.7 (d, *J* = 8.5 Hz), 115.8 (d, *J* = 23.1 Hz), 112.3 (d, *J* = 24.7 Hz), 76.9, 37.6, 36.1; **ESI HRMS**: calcd for $C_{17}H_{11}O_2N_2F$ $[M + H]^+$: 295.0877, found: 295.0879. **HPLC**: Chiralpak IC, n-hexane/IPA = 70:30, 1.0 mL/min, λ = 220 nm, t_R (major) = 38.227 min, t_R (minor) = 31.203 min (71:29 er).

Methyl (E)-3-(4-chloro-2-(4-oxoquinazolin-3(4H)-yl)phenyl)acrylate (9d) : Procedure [B]



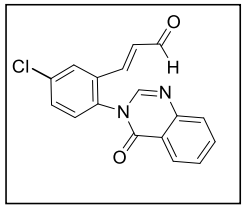
Reaction Time: 11 h; R*f*: 0.5 (3:2, Pet. Ether:EtOAc); white solid; Mp = 190-192 ^{o}C; 1.15 g, 72% yield; **^{1}H NMR (400 MHz, CDCl$_3$)** δ 8.28 (dd, *J* = 7.6, 1.5 Hz, 1H), 7.86 (s, 1H), 7.77 (dd, *J* = 6.9, 1.5 Hz, 1H), 7.74 (s, 1H), 7.72-7.70 (m, 1H), 7.54-7.44 (m, 1H), 7.46 (dd, *J* = 8.4, 2.3 Hz, 1H), 7.29 (d, *J* = 16.0 Hz, 1H), 7.23 (d, *J* = 8.4 Hz, 1H), 6.40 (d, *J* = 16.0 Hz, 1H), 3.64 (s, 3H); **^{13}C NMR (100 MHz, CDCl$_3$)** δ 166.0, 160.6, 147.9, 145.4, 136.9, 136.2, 135.0, 134.9, 134.2, 131.2, 130.2, 128.1, 127.9, 127.7, 127.3, 123.0, 122.0, 52.0; **ESI HRMS**: calcd for $C_{18}H_{13}O_3N_2Cl$ $[M + H]^+$: 341.0687, found: 341.0687.

(E)-3-(5-Chloro-2-(3-hydroxyprop-1-en-1-yl)phenyl)quinazolin-4(3H)-one (10d) : Procedure [C]



Reaction Time: 6 h; R*f*: 0.4 (1:1, Pet. Ether:EtOAc); **ESI HRMS**: calcd for $C_{17}H_{13}O_2N_2Cl$ $[M + H]^+$: 313.0738, found: 313.0736.

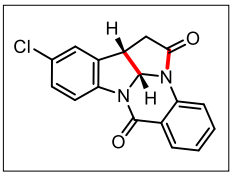
(E)-3-(4-chloro-2-(4-oxoquinazolin-3(4H)-yl)phenyl)acrylaldehyde (3d) : Procedure [D]



Reaction Time: 12 h; R*f*: 0.5 (3:2, Pet. Ether:EtOAc); white solid; Mp = 218-220 ^{o}C; 581 mg, 64% yield; **^{1}H NMR (400 MHz, CDCl$_3$)** δ 9.47 (d, *J* = 7.3 Hz, 1H), 8.29 (d, *J* = 7.9 Hz, 1H), 7.90 (s, 1H), 7.85-7.70 (m, 3H), 7.53 (t, *J* = 7.9 Hz, 2H), 7.28 (d, *J* = 8.5 Hz, 1H), 7.10

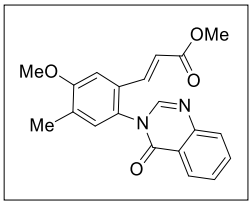
(d, *J* = 15.9 Hz, 1H), 6.63 (dd, *J* = 16.2, 7.9 Hz, 1H); **^{13}C NMR (100 MHz, CDCl$_3$)** δ 192.6, 160.5, 147.9, 145.3, 143.7, 136.5, 135.2, 135.0, 133.7, 132.2, 132.0, 130.3, 128.2, 127.9, 127.8, 127.3, 121.9; **ESI HRMS**: calcd for $C_{17}H_{11}O_2N_2Cl$ $[M + H]^+$: 311.0582, found: 311.0580.

9-Chloro-2a^1,11b-dihydro-7H-2a,7a-diazabenzo[b]cyclopenta[lm]fluorene-2,7(1H)-dione. (2d) : Procedure [E]



Reaction Time: 4 h; R*f*: 0.6 (3:2, Pet. Ether:EtOAc); white solid; Mp = 190-192 ^{o}C; 20 mg, 40% yield; $[\alpha]^{24}_D$ –215.3 (*c* 0.1, $CHCl_3$); **^{1}H NMR (500 MHz, CDCl$_3$)** δ 8.18 (dd, *J* = 7.6, 1.1 Hz, 1H), 8.01 (d, *J* = 9.2 Hz, 1H), 7.83 (d, *J* = 8.0 Hz, 1H), 7.66 (t, *J* = 7.6 Hz, 1H), 7.42 (t, *J* = 7.6 Hz, 1H), 7.34-7.29 (m, 2H), 6.04 (d, *J* = 8.8 Hz, 1H), 4.22-4.14 (m, 1H), 3.31 (dd, *J* = 18.0, 11.1 Hz, 1H), 2.71 (dd, *J* = 18.3, 5.0 Hz, 1H); **^{13}C NMR (125 MHz, CDCl$_3$)** δ 170.4, 159.6, 140.0, 136.2, 134.0, 133.8, 129.8, 129.4, 129.1, 126.4, 125.2, 123.4, 121.9, 116.7, 76.8, 37.6, 36.0; **ESI HRMS**: calcd for $C_{17}H_{11}O_2N_2Cl$ $[M + H]^+$: 311.0582, found: 311.0583. **HPLC**: Chiralpak IC, n-hexane/IPA = 70:30, 1.0 mL/min, λ = 220 nm, t_R (major) = 42.273 min, t_R (minor) = 35.413 min (76:24 er).

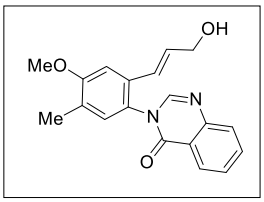
Methyl (E)-3-(5-methoxy-4-methyl-2-(4-oxoquinazolin-3(4H)-yl)phenyl)acrylate (9e) : Procedure [B]



Reaction Time: 11 h; R*f*: 0.5 (1:1, Pet. Ether:EtOAc); white solid; Mp = 212-214 ^{o}C; 871 mg, 55% yield; **^{1}H NMR (400 MHz, CDCl$_3$)** δ 8.37 (d, *J* = 6.9 Hz, 1H), 7.97 (s, 1H), 7.87-7.77 (m, 2H), 7.57 (t, *J* = 8.0 Hz, 1H), 7.39 (d, *J* = 15.3 Hz, 1H), 7.16 (s,1H), 7.10 (s, 1H), 6.43 (d, *J* = 16.0 Hz, 1H), 3.94 (s, 3H), 3.71 (s, 3H), 2.28 (s, 3H); **^{13}C NMR (100 MHz, CDCl$_3$)** δ 166.6, 161.1, 158.6, 148.0, 146.4, 138.4, 134.7, 131.4, 130.7, 130.6, 129.1, 127.8,

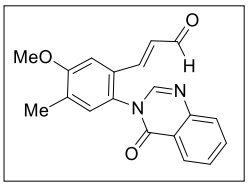
127.7, 127.3, 122.2, 120.5, 107.6, 55.7, 51.8, 16.3; **ESI HRMS**: calcd for $C_{20}H_{18}O_4N_2$ [M + H]$^+$: 351.1339, found: 351.1343.

(E)-3-(2-(3-Hydroxyprop-1-en-1-yl)-4-methoxy-5-methylphenyl)quinazolin-4(3H)-one (10e) : Procedure [C]



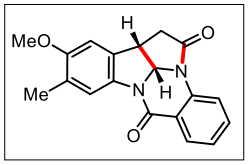
Reaction Time: 5 h; R*f*: 0.3 (1:1, Pet. Ether:EtOAc); **ESI HRMS**: calcd for $C_{19}H_{18}O_3N_2$ [M + H]$^+$: 323.1390, found: 323.1388.

(E)-3-(5-Methoxy-4-methyl-2-(4-oxoquinazolin-3(4H)-yl)phenyl)acrylaldehyde (3e) : Procedure [D]



Reaction Time: 12 h; R*f*: 0.5 (1:1, Pet. Ether:EtOAc); white solid; Mp = 234-236 ^{o}C; 475 mg, 52% yield; **^{1}H NMR (400 MHz, CDCl$_3$)** δ 9.45 (d, *J* = 7.6 Hz, 1H), 8.30 (d, *J* = 7.6 Hz, 1H), 7.93 (s, 1H), 7.82-7.71 (m, 2H), 7.52 (t, *J* = 8.4 Hz, 1H), 7.12 (d, *J* = 16.0 Hz, 1H), 7.13 (s, 1H), 7.08 (s, 1H), 6.63 (dd, *J* = 16.0, 7.6 Hz, 1H), 3.88 (s, 3H), 2.23 (s, 3H); **^{13}C NMR (100 MHz, CDCl$_3$)** δ 193.3, 161.0, 158.6, 147.9, 146.2, 145.7, 134.9, 132.6, 130.7, 130.3, 130.2, 129.3, 127.9, 127.8, 127.2, 122.0, 107.5, 55.7, 16.4; **ESI HRMS**: calcd for $C_{19}H_{16}O_3N_2$ [M + H]$^+$: 321.1234, found: 321.1239.

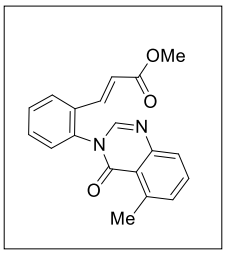
10-Methoxy-9-methyl-2a^1,11b-dihydro-7H-2a,7a-diazabenzo[b]cyclopenta[lm]fluorene-2,7(1H)-dione. (2e) : Procedure [E]



Reaction Time: 3 h; R*f*: 0.4(1:1, Pet. Ether:EtOAc); white solid; Mp = 194-196 ^{o}C; 20 mg, 39% yield; $[\alpha]^{24}_D$ –247.3 (*c* 0.1, $CHCl_3$); **^{1}H NMR (400 MHz, CDCl$_3$)** δ 8.17 (d, *J* = 7.3 Hz,

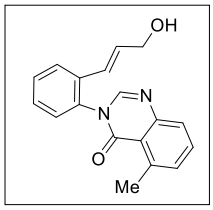
1H), 7.91 (s, 1H), 7.80 (d, *J* = 8.5 Hz, 1H), 7.62 (t, *J* = 7.6 Hz, 1H), 7.40 (t, *J* = 7.6 Hz, 1H), 6.80 (s, 1H), 5.99 (d, *J* = 8.5 Hz, 1H), 4.21-4.09 (m, 1H), 3.85 (s, 3H), 3.27 (dd, *J* = 18.3, 11 Hz, 1H), 2.68 (dd, *J* = 17.7, 4.9 Hz, 1H), 2.25 (s, 3H); **^{13}C NMR (100 MHz, CDCl$_3$)** δ 170.9, 159.0, 155.4, 136.1, 134.4, 133.3, 130.3, 128.9, 127.9, 126.3, 123.9, 121.8, 118.1, 106.7, 76.9, 55.8, 37.7, 36.4, 16.6; **ESI HRMS**: calcd for $C_{19}H_{16}O_3N_2$ $[M + H]^+$: 321.1234, found: 321.1223. **HPLC**: Chiralpak IC, n-hexane/IPA = 70:30, 1.0 mL/min, λ = 220 nm, t_R (major) = 30.787 min, t_R (minor) = 28.243 min (77:23 er).

Methyl (E)-3-(2-(5-methyl-4-oxoquinazolin-3(4H)-yl)phenyl)acrylate (9f) : Procedure [B]



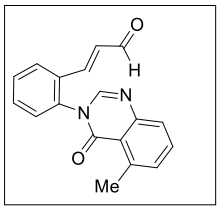
Reaction Time: 11 h; R*f*: 0.5 (3:2, Pet. Ether:EtOAc); white solid; Mp = 130-132 ^{o}C; 1.31 g, 73% yield; **^{1}H NMR (500 MHz, CDCl$_3$)** δ 7.93 (s, 1H), 7.82 (dd, *J* = 7.3, 1.9 Hz, 1H), 7.67 (t, *J* = 8.0 Hz, 1H), 7.64 (d, *J* = 6.8 Hz, 1H), 7.59-7.52 (m, 2H), 7.49 (d, *J* = 16.0 Hz, 1H), 7.36-7.31 (m, 2H), 6.49 (d, *J* = 16.0 Hz, 1H), 3.73 (s, 3H), 2.87 (s, 3H); **^{13}C NMR (125 MHz, CDCl$_3$)** δ 166.5, 161.3, 149.6, 145.5, 142.0, 138.3, 136.9, 133.9, 132.6, 131.3, 130.6, 129.9, 129.1, 127.6, 126.0, 121.6, 120.7, 51.8, 23.2; **ESI HRMS**: calcd for $C_{19}H_{16}O_3N_2$ $[M + H]^+$: 321.1234, found: 321.1233.

(E)-3-(2-(3-Hydroxyprop-1-en-1-yl)phenyl)-5-methylquinazolin-4(3H)-one (10f) : Procedure [C]



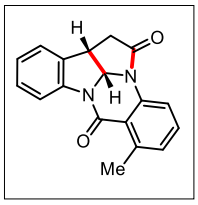
Reaction Time: 5 h; R*f*: 0.3 (1:1, Pet. Ether:EtOAc); **ESI HRMS**: calcd for $C_{18}H_{16}O_2N_2$ $[M + H]^+$: 293.1285, found: 293.1283.

(E)-3-(2-(5-Methyl-4-oxoquinazolin-3(4H)-yl)phenyl)acrylaldehyde (3f) : Procedure [D]



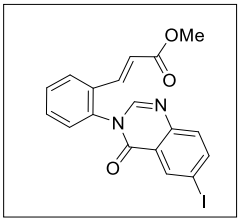
Reaction Time: 12 h; R*f*: 0.5 (3:2, Pet. Ether:EtOAc); white solid; 589 mg, 65% yield; **^{1}H NMR (400 MHz, $CDCl_3$)** δ 9.55 (d, *J* = 7.6 Hz, 1H), 7.94 (s, 1H), 7.85 (dd, *J* = 7.6, 1.5 Hz, 1H), 7.68-7.57 (m, 4H), 7.38 (dd, *J* = 7.6, 1.5 Hz, 1H), 7.33 (d, *J* = 6.9 Hz, 1H), 7.27 (d, *J* = 16.0 Hz, 1H), 6.72 (dd, *J* = 16.0, 7.6 Hz, 1H), 2.9 (s, 3H); **^{13}C NMR (100 MHz, $CDCl_3$)** δ 193.2, 161.3, 149.6, 145.5, 145.4, 142.0, 136.9, 134.2, 132.2, 132.1, 131.3, 130.8, 130.2, 129.2, 127.7, 126.0, 120.5, 23.2; **ESI HRMS**: calcd for $C_{18}H_{14}O_2N_2$ $[M + H]^+$: 291.1128, found: 291.1129.

6-Methyl-2a^{1},11b-dihydro-7H-2a,7a-diazabenzo[b]cyclopenta[lm]fluorene-2,7(1H)-dione (2f) : Procedure [E]



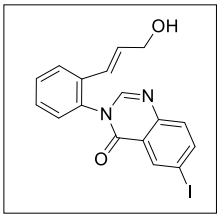
Reaction Time: 6 h; R*f*: 0.6 (3:2, Pet. Ether:EtOAc); white solid; 16 mg, 32% yield; $[\alpha]^{24}_{D}$ – 184.3 (*c* 0.1, $CHCl_3$); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.19 (d, *J* = 7.6 Hz, 1H), 7.96 (d, *J* = 8.0 Hz, 1H), 7.83 (d, *J* = 8.0 Hz, 1H), 7.64 (t, *J* = 7.6 Hz, 1H), 7.41 (t, *J* = 7.4 Hz, 1H), 7.20-7.10 (m, 2H), 6.02 (d, *J* = 8.4 Hz, 1H), 4.22-4.10 (m, 1H), 3.30 (dd, *J* = 18.1, 11.0 Hz, 1H), 2.69 (dd, *J* = 18.3, 4.3 Hz, 1H), 2.38 (s, 3H); **^{13}C NMR (100 MHz, $CDCl_3$)** δ 170.9, 159.4, 139.0, 136.2, 134.8, 133.5, 132.3, 129.7, 129.0, 126.2, 125.5, 123.8, 121.8, 115.5, 76.8, 37.9, 36.1, 21.1; **ESI HRMS**: calcd for $C_{18}H_{14}O_2N_2$ $[M + H]^+$: 291.1128, found: 291.1149. **HPLC**: Chiralpak IC, n-hexane/IPA = 70:30, 1.0 mL/min, λ = 220 nm, t_R (major) = 23.107 min, t_R (minor) = 27.243 min (77:23 er).

Methyl (E)-3-(2-(6-iodo-4-oxoquinazolin-3(4H)-yl)phenyl)acrylate (9g) : Procedure [B]



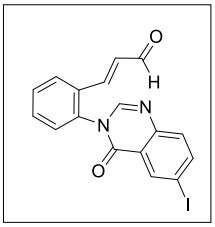
Reaction Time: 12 h; R*f*: 0.5 (3:2, Pet. Ether:EtOAc); white solid; 2.04 g, 84% yield; **^{1}H NMR (500 MHz, CDCl$_3$)** δ 8.69 (s, 1H), 8.11 (dt, *J* = 8.8, 1.9 Hz, 1H), 7.98 (s, 1H), 7.85-7.79 (m, 1H), 7.59 (d, *J* = 2.6 Hz, 1H), 7.58 (d, *J* = 3.0 Hz, 1H), 7.54 (dd, *J* = 8.4, 1.5 Hz, 1H), 7.42 (d, *J* = 16.0 Hz, 1H), 7.36-7.31 (m, 1H), 6.48 (d, *J* = 15.6 Hz, 1H), 3.72 (s, 3H); **^{13}C NMR (125 MHz, CDCl$_3$)** δ 166.4, 159.3, 147.3, 146.3, 143.7, 138.0, 136.3, 136.1, 132.5, 131.3, 130.3, 129.6, 128.8, 127.8, 123.7, 121.9, 92.6, 51.9; **ESI HRMS**: calcd for $C_{18}H_{13}O_3N_2I$ $[M + H]^+$: 433.0044, found: 433.0042.

(E)-3-(2-(3-Hydroxyprop-1-en-1-yl)phenyl)-6-iodoquinazolin-4(3H)-one (10g) : Procedure [C]



Reaction Time: 6 h; R*f*: 0.4 (1:1, Pet. Ether:EtOAc); **ESI HRMS**: calcd for $C_{17}H_{13}O_2N_2I$ $[M + H]^+$: 405.0094, found: 405.0093.

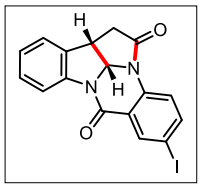
(E)-3-(2-(6-Iodo-4-oxoquinazolin-3(4H)-yl)phenyl)acrylaldehyde (3g) : Procedure [D]



Reaction Time: 12 h; R*f*: 0.5 (3:2, Pet. Ether:EtOAc); white solid; 623 mg, 67% yield; **^{1}H NMR (400 MHz, CDCl$_3$)** δ 9.48 (d, *J* = 7.32 Hz, 1H), 8.63 (s, 1H), 8.06 (d, *J* = 7.9 Hz, 1H), 7.95 (s, 1H), 7.79 (d, *J* = 7.9 Hz, 1H), 7.62-7.52 (m, 2H), 7.49 (d, *J* = 8.5 Hz, 1H), 7.31 (d, *J*

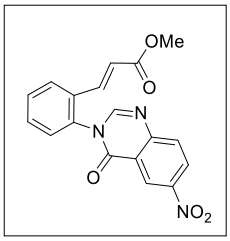
= 6.7 Hz, 1H), 7.14 (d, *J* = 15.9 Hz, 1H), 6.66 (dd, *J* = 15.9, 7.3 Hz, 1H); **^{13}C NMR (100 MHz, CDCl$_3$)** δ 193.0, 159.2, 147.2, 146.2, 145.1, 143.9, 136.4, 136.1, 132.3, 132.0, 131.6, 130.5, 129.6, 128.9, 128.0, 123.5, 92.9; **ESI HRMS**: calcd for $C_{17}H_{11}O_2N_2I$ $[M + H]^+$: 402.9938, found: 402.9935.

5-Iodo-2a1,11b-dihydro-7H-2a,7a-diazabenzo[b]cyclopenta[lm]fluorene-2,7(1H)-dione. (2g) : Procedure [E]



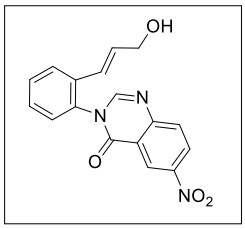
Reaction Time: 4 h; R*f*: 0.6 (3:2, Pet. Ether:EtOAc); white solid; 31 mg, 62% yield; $[\alpha]^{24}_D$ – 288.6 (*c* 0.1, $CHCl_3$); **^{1}H NMR (400 MHz, CDCl$_3$)** δ 8.48 (s, 1H), 8.04 (d, *J* = 7.9 Hz, 1H), 7.93 (d, *J* = 8.5 Hz, 1H), 7.59 (d, *J* = 8.5 Hz, 1H), 7.39-7.30 (m, 2H), 7.16 (t, *J* = 7.3 Hz, 1H), 6.00 (d, *J* = 8.5 Hz, 1H), 4.25-4.15 (m, 1H), 3.30 (dd, *J* = 18.3, 11.0 Hz, 1H), 2.70 (dd, *J* = 18.3, 4.9 Hz, 1H); **^{13}C NMR (100 MHz, CDCl$_3$)** δ 170.6, 158.2, 142.3, 141.1, 137.8, 135.8, 132.1, 129.4, 125.2, 124.9, 123.5, 115.9, 90.2, 76.5, 37.8, 36.2; **ESI HRMS**: calcd for $C_{17}H_{11}O_2N_2I$ $[M + H]^+$: 402.9938, found: 402.9933. **HPLC**: Chiralpak IA, n-hexane/IPA = 85:15, 1.0 mL/min, λ = 220 nm, t_R (major) = 25.583 min, t_R (minor) = 13.403 min (81:19 er).

Methyl (E)-3-(2-(6-nitro-4-oxoquinazolin-3(4H)-yl)phenyl)acrylate (9h) : Procedure [B]



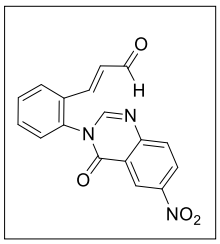
Reaction Time: 12 h; R*f*: 0.4 (3:2, Pet. Ether:EtOAc); yellow solid; 1.10 g, 56% yield; **^{1}H NMR (400 MHz, CDCl$_3$)** δ 9.21 (d, *J* = 2.4 Hz, 1H), 8.63 (dd, *J* = 9.2, 2.4 Hz, 1H), 8.12 (s, 1H), 7.95 (d, *J* = 9.2 Hz, 1H), 7.85 (dd, *J* = 5.5, 3.7 Hz, 1H), 7.61 (dd, *J* = 5.5, 3.7 Hz, 2H), 7.42 (d, *J* = 15.9 Hz, 1H), 7.37 (dd, *J* = 5.5, 3.7 Hz, 1H), 6.50 (d, *J* = 15.3 Hz, 1H), 3.73 (s, 3H); **^{13}C NMR (100 MHz, CDCl$_3$)** δ 166.3, 159.5, 152.0, 148.7, 146.5, 137.6, 135.7, 132.4, 131.5, 130.6, 129.5, 128.9, 128.6, 127.9, 123.8, 122.5, 122.2, 51.9; **ESI HRMS**: calcd for $C_{18}H_{13}O_5N_3$ $[M + H]^+$: 352.0928, found: 352.0923.

(E)-3-(2-(3-Hydroxyprop-1-en-1-yl)phenyl)-6-nitroquinazolin-4(3H)-one (10h) : Procedure [C]



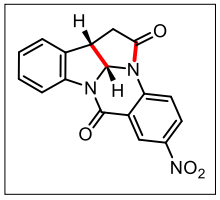
Reaction Time: 5 h; R*f*: 0.3 (1:1, Pet. Ether:EtOAc); **ESI HRMS**: calcd for $C_{17}H_{13}O_4N_3$ $[M + H]^+$: 324.0979, found: 324.0978.

(E)-3-(2-(6-Nitro-4-oxoquinazolin-3(4H)-yl)phenyl)acrylaldehyde (3h) : Procedure [D]



Reaction Time: 12 h; R*f*: 0.5 (3:2, Pet. Ether:EtOAc); yellow solid; 393 mg, 43% yield; **^{1}H NMR (500 MHz, $CDCl_3$)** δ 9.58 (d, J = 7.6 Hz, 1H), 9.23 (d, J = 2.7 Hz, 1H), 8.66 (dd, J = 8.8, 2.7 Hz, 1H), 8.17 (s, 1H), 7.98 (d, J = 9.2 Hz, 1H), 7.91-7.87 (m, 1H), 7.69-7.66 (m, 2H), 7.44-7.39 (m, 1H), 7.23 (d, J = 16.0 Hz, 1H), 6.75 (dd, J = 16.0, 7.6 Hz, 1H); **^{13}C NMR (125 MHz, $CDCl_3$)** δ 192.7, 159.5, 151.9, 148.6, 146.6, 144.5, 135.8, 132.4, 132.0, 131.9, 130.9, 129.6, 129.1, 128.9, 128.2, 123.8, 122.4; **ESI HRMS**: calcd for $C_{17}H_{11}O_4N_3$ $[M + H]^+$: 322.0822, found: 322.0822.

5-Nitro-2a^1,11b-dihydro-7H-2a,7a-diazabenzo[b]cyclopenta[lm]fluorene-2,7(1H)-dione. (2h) : Procedure [E]



Reaction Time: 12 h; R*f*: 0.6 (3:2, Pet. Ether:EtOAc); yellow solid; 11 mg, 22% yield; $[\alpha]^{24}_D$ –377.3 (*c* 0.1, $CHCl_3$); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 9.06 (d, J = 2.4 Hz, 1H), 8.50 (dd, J =

9.2, 2.5 Hz, 1H), 8.09 (d, *J* = 7.9 Hz, 1H), 8.08 (d, *J* = 8.5 Hz, 1H), 7.44-7.34 (m, 2H), 7.20 (t, *J* = 7.3 Hz, 1H), 6.08 (d, *J* = 9.2 Hz, 1H), 4.34-4.21 (m, 1H), 3.37 (dd, *J* = 18.3, 11.0 Hz, 1H), 2.79 (dd, *J* = 18.3, 4.9 Hz, 1H); **^{13}C NMR (125 MHz, CDCl$_3$)** δ 170.8, 157.6, 145.5, 140.9, 131.7, 129.7, 128.2, 125.6, 125.3, 125.0, 124.9, 124.4, 122.5, 115.9, 76.4, 37.8, 36.3; **ESI HRMS**: calcd for $C_{17}H_{11}O_4N_3$ $[M + H]^+$: 322.0822, found: 322.0820. **HPLC**: Chiralpak IA, n-hexane/IPA = 70:30, 1.0 mL/min, λ = 220 nm, t_R (major) = 14.343 min, t_R (minor) = 11.903 min (85:15 er).

4. X-ray crystallographic data of deoxy-cruciferane (2a):

X-ray intensity data measurements of compound **MA_1_R (2a)** was carried out on a Bruker D8 VENTURE Kappa Duo PHOTON II CPAD diffractometer equipped with Incoatech multilayer mirrors optics. The intensity measurements were carried out with Mo micro-focus sealed tube diffraction source (CuK_α= 1.54178 Å) at 100(2) K temperature. The X-ray generator was operated at 50 kV and 1.1 mA. A preliminary set of cell constants and an orientation matrix were calculated from three sets of 36 frames. Data were collected with ω scan width of 0.5° at different settings of φ and 2θ with a frame time of 30 secs keeping the sample-to-detector distance fixed at 6.00 cm. The X-ray data collection was monitored by APEX3 program (Bruker, 2016).[3] All the data were corrected for Lorentzian, polarization and absorption effects using SAINT and SADABS programs (Bruker, 2016). ShelX-97 was used for structure solution and full matrix least-squares refinement on F^2.[4] All the hydrogen atoms were placed in a geomerically idalized position (C-H = 0.95 Å for the phenyl H atoms, C-H = 1.00 Å for the methine H atoms and C-H = 0.99 Å of the methylene H atoms) and constrained to ride on its parent atoms [Uiso(H) = 1.2 Ueq(C) for phenyl, methine and methylene H atoms]. An *ORTEP* III[5] view of compound was drawn with 50% probability displacement ellipsoids and H atoms are shown as small spheres of arbitrary radii. The absolute configuration was established by anomalous dispersion effect (Flack parameter, -0.08(7)) in X-ray diffraction measurements carried out with Cu radiation (λ = 1.54178 Å). The single crystal X-ray diffraction data analysis clearly established that our synthesized compound has *R* and *S* configurations at C8 and C11 positions respectively.

Crystal data of **MA_1_R (2a)**, $C_{17}H_{12}N_2O_2$, M = 276.29, colorless prismatic, 0.34 x 0.13 x 0.11 mm^3, Orthorhombic, space group $P2_12_12_1$, a = 8.2455(12) Å, b = 11.3533(16) Å, c = 13.652(2) Å, α = β = γ = 90°, V = 1278.0(3) $Å^3$, Z = 4, T = 100(2) K, $2\theta_{max}$= 144.854°, D_{calc} (g cm^{-3}) = 1.436, $F(000)$ = 576, μ (mm^{-1}) = 0.779, 16043 reflections collected, 2369 unique reflections (R_{int}= 0.0448, R_{sig} = 0.0291), 2301 observed ($I > 2\sigma(I)$) reflections, multi-scan absorption correction, T_{min} = 0.778, T_{max} = 0.919, 190 refined parameters, Good of Fit = S = 1.056, $R1$ = 0.0334, $wR2$ = 0.0877 (all data R = 0.0348, $wR2$ = 0.0914), maximum and minimum residual electron densities; $\Delta\rho_{max}$ = 0.228, $\Delta\rho_{min}$ = -0. 218 ($eÅ^{-3}$).

The crystallographic data for **2a** was deposited in the Cambridge Crystallographic Data Centre (CCDC deposition numbers: 1904732). The data can be obtained freely from the Cambridge Crystallographic Data Centre by visiting sites of www.ccdc.cam.ac.uk/conts/retrieving.html.

5. References:

(1) Cai, S.; Lin, S.; Yi, X.; Xi, C. *J. Org. Chem.* **2017**, *82*, 512.

(2) Coogan, M. P.; Ooi, L.; Pertusati, F. *Org. Biomol. Chem.* **2005**, *3*, 1134.

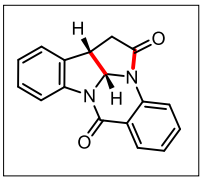
(3) Bruker (2016). *APEX2*, *SAINT* and *SADABS*. Bruker AXS Inc., Madison, Wisconsin, USA.

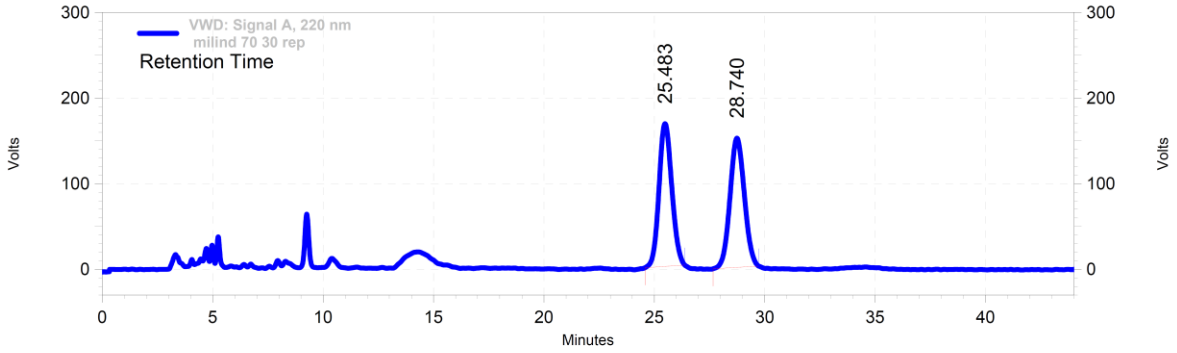
(4) G. M. Sheldrick, *Acta Crystallogr*., 2008, A**64**, 112.

(5) L. J. Farrugia, *J. Appl. Cryst.* 1997, **30**, 565.

6. Copies of HPLC Chromatograms:

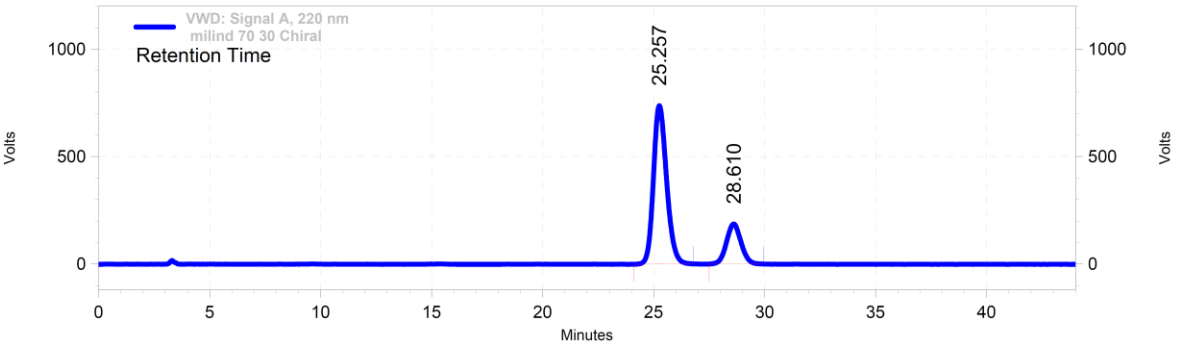
HPLC of **2a**





VWD: Signal A,
220 nm Results

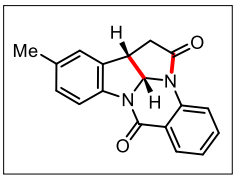
Retention Time	Area	Area %	Height	Height %
25.483	113108711	49.68	2797384	52.49
28.740	114575458	50.32	2532288	47.51
Totals	227684169	100.00	5329672	100.00

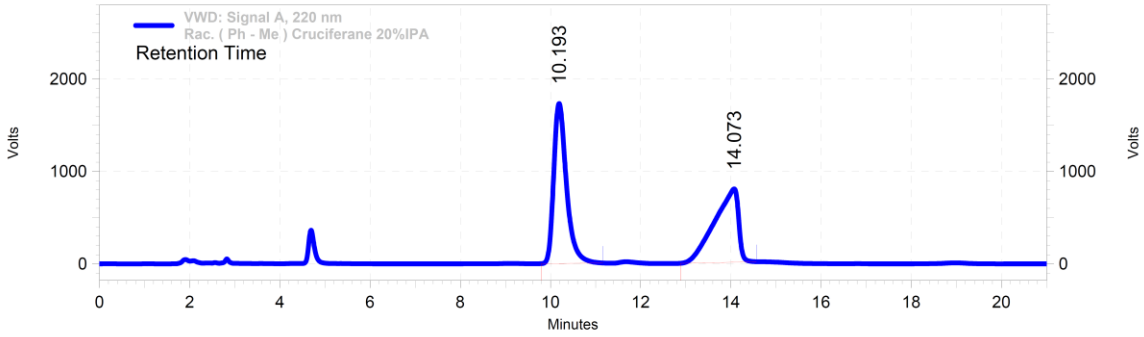


VWD: Signal A,
220 nm Results

Retention Time	Area	Area %	Height	Height %
25.257	509522563	78.18	12362990	79.83
28.610	142209070	21.82	3124585	20.17
Totals	651731633	100.00	15487575	100.00

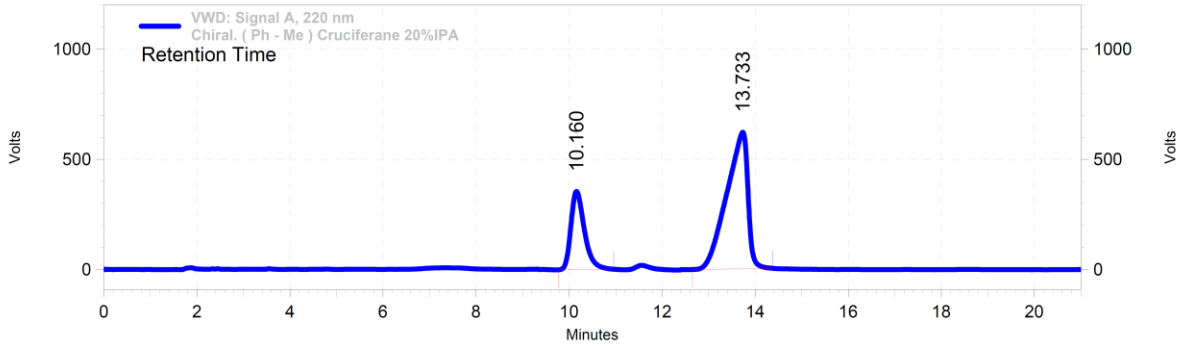
HPLC of **2b**





VWD: Signal A,
220 nm Results

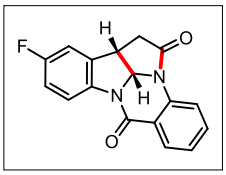
Retention Time	Area	Area %	Height	Height %
10.193	572172984	53.75	29055194	68.59
14.073	492306617	46.25	13307758	31.41
Totals	1064479601	100.00	42362952	100.00

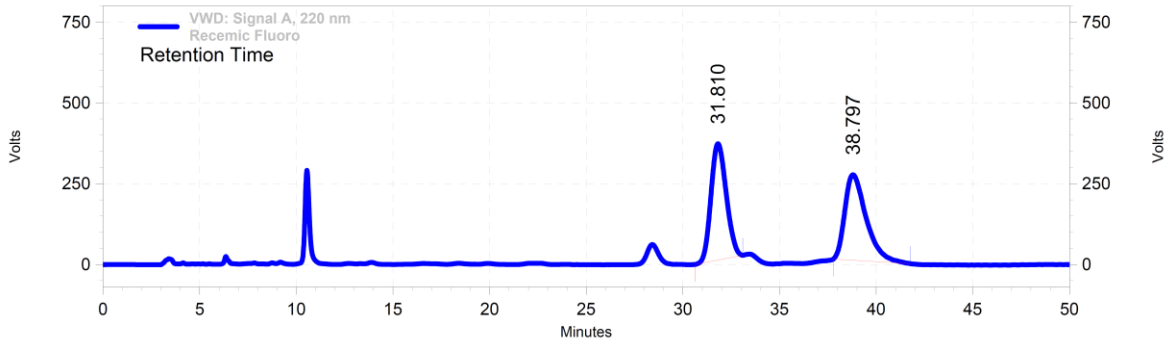


VWD: Signal A,
220 nm Results

Retention Time	Area	Area %	Height	Height %
10.160	120676830	26.74	5955494	36.42
13.733	330606335	73.26	10398877	63.58
Totals	451283165	100.00	16354371	100.00

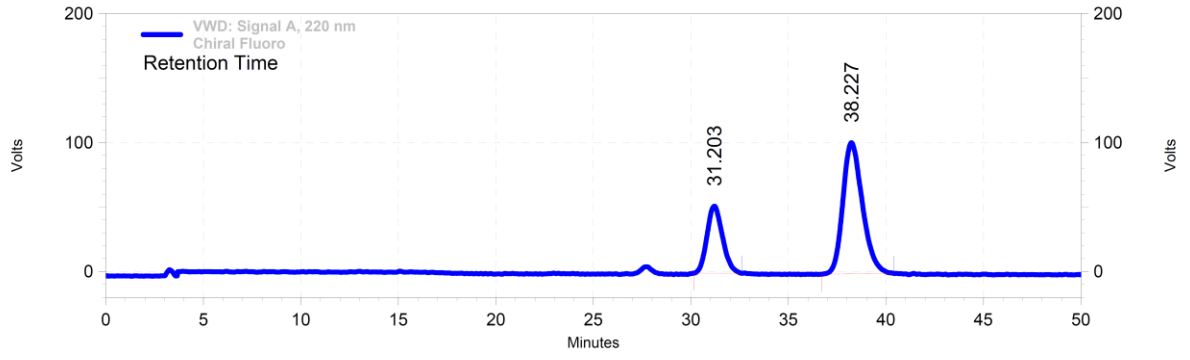
HPLC of **2c**





VWD: Signal A,
220 nm Results

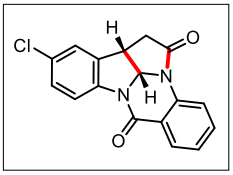
Retention Time	Area	Area %	Height	Height %
31.810	332582978	49.35	6039809	57.65
38.797	341411305	50.65	4436192	42.35
Totals	673994283	100.00	10476001	100.00

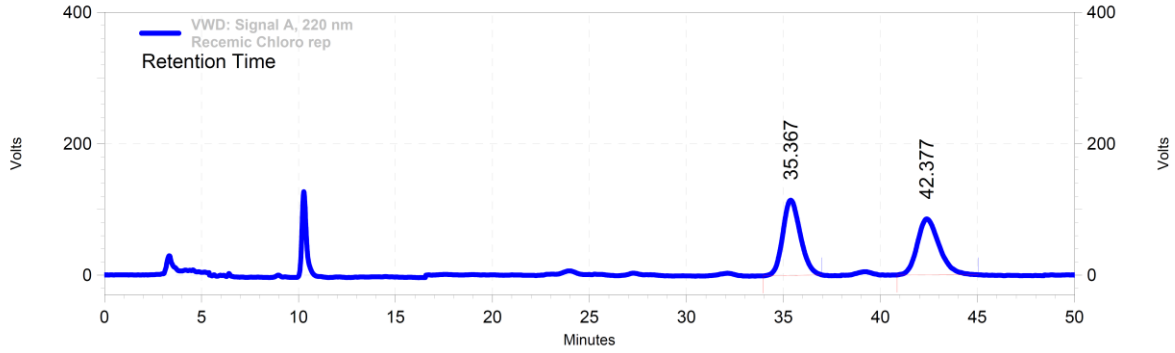


VWD: Signal A,
220 nm Results

Retention Time	Area	Area %	Height	Height %
31.203	48303901	28.80	871099	33.80
38.227	119428546	71.20	1705864	66.20
Totals	167732447	100.00	2576963	100.00

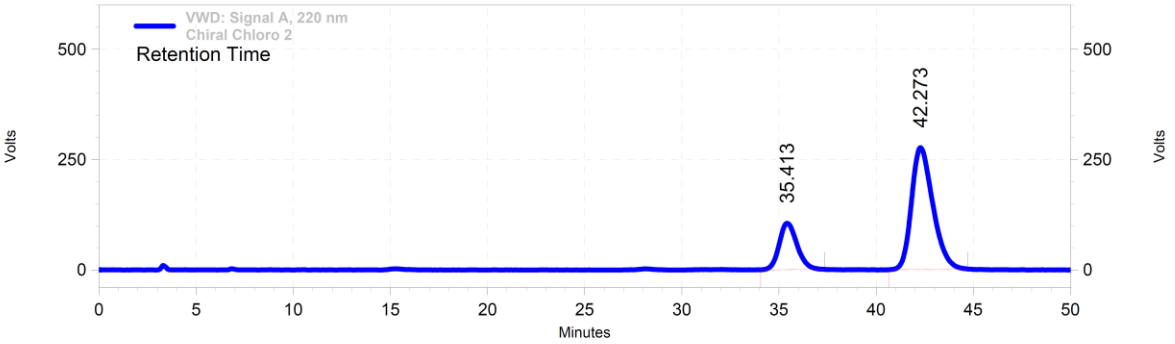
HPLC of **2d**





VWD: Signal A,
220 nm Results

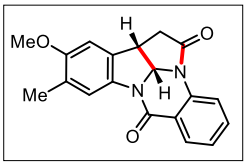
Retention Time	Area	Area %	Height	Height %
35.367	121134431	51.86	1919871	57.32
42.377	112429955	48.14	1429277	42.68
Totals	233564386	100.00	3349148	100.00

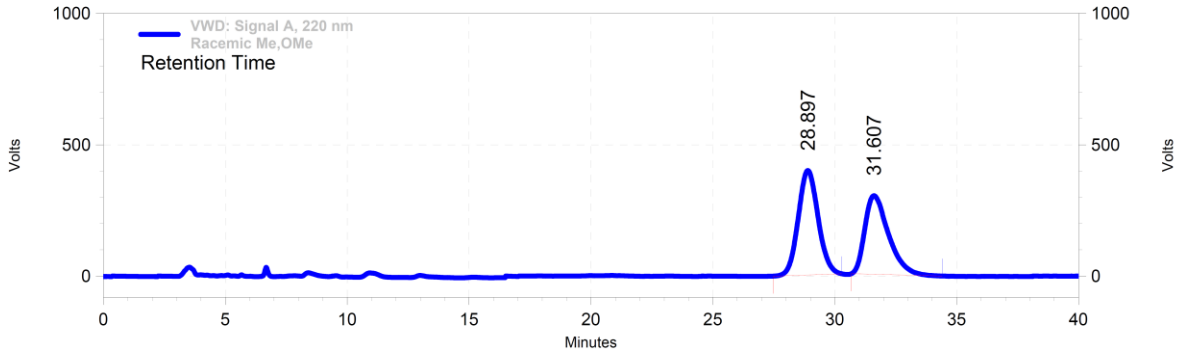


VWD: Signal A,
220 nm Results

Retention Time	Area	Area %	Height	Height %
35.413	112714445	24.13	1761060	27.54
42.273	354379463	75.87	4632485	72.46
Totals	467093908	100.00	6393545	100.00

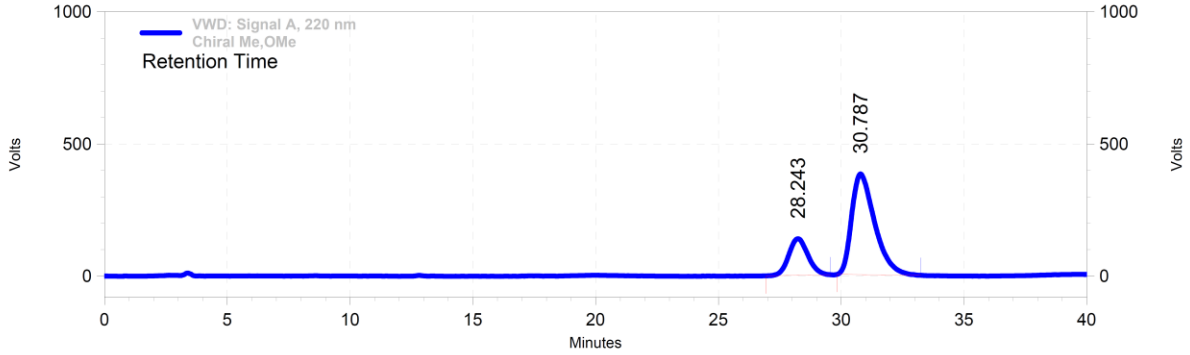
HPLC of **2e**





VWD: Signal A,
220 nm Results

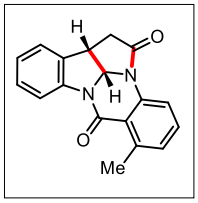
Retention Time	Area	Area %	Height	Height %
28.897	378254300	52.65	6667399	57.06
31.607	340152122	47.35	5017819	42.94
Totals	718406422	100.00	11685218	100.00

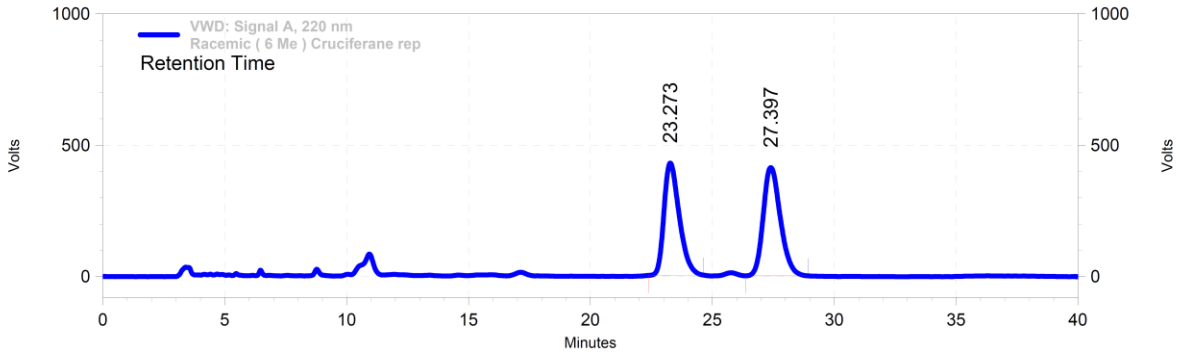


VWD: Signal A,
220 nm Results

Retention Time	Area	Area %	Height	Height %
28.243	126498039	23.25	2316045	26.60
30.787	417509164	76.75	6391685	73.40
Totals	544007203	100.00	8707730	100.00

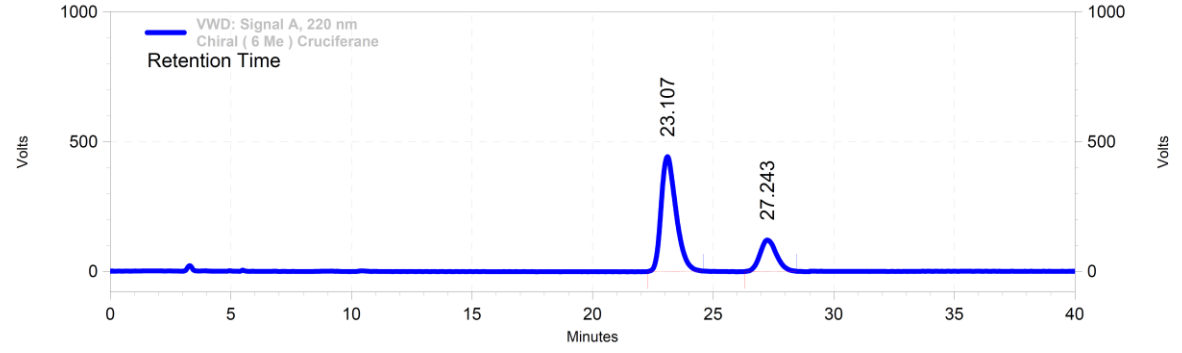
HPLC of **2f**





VWD: Signal A,
220 nm Results

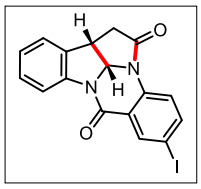
Retention Time	Area	Area %	Height	Height %
23.273	313139877	48.04	7168274	50.89
27.397	338652716	51.96	6916655	49.11
Totals	651792593	100.00	14084929	100.00

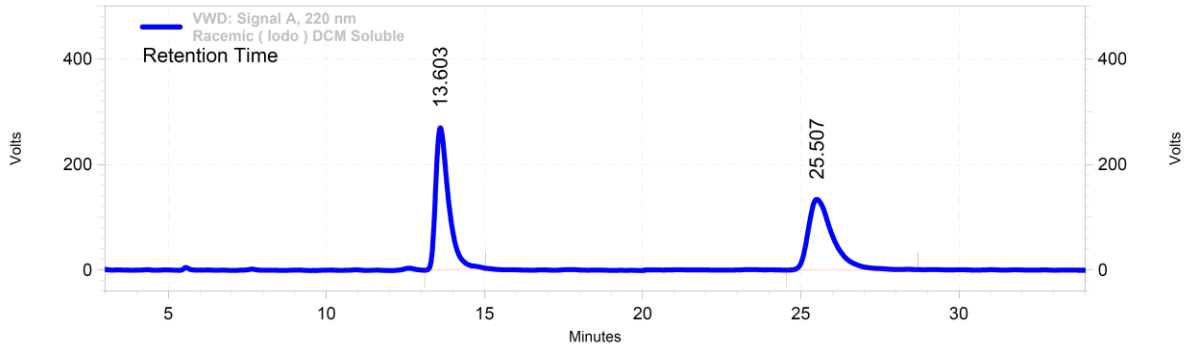


VWD: Signal A,
220 nm Results

Retention Time	Area	Area %	Height	Height %
23.107	318033275	76.73	7416975	78.54
27.243	96425787	23.27	2026098	21.46
Totals	414459062	100.00	9443073	100.00

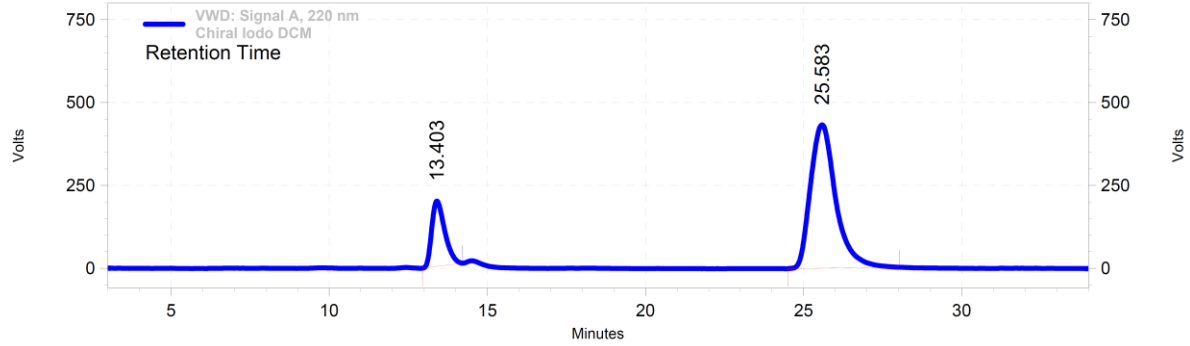
HPLC of **2g**





VWD: Signal A,
220 nm Results

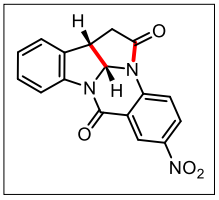
Retention Time	Area	Area %	Height	Height %
13.603	128867180	51.60	4504318	66.77
25.507	120855439	48.40	2241883	33.23
Totals	249722619	100.00	6746201	100.00

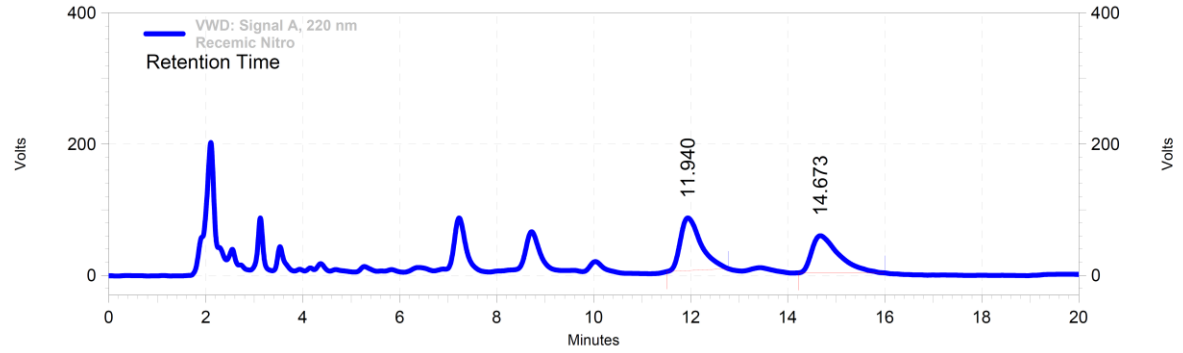


VWD: Signal A,
220 nm Results

Retention Time	Area	Area %	Height	Height %
13.403	94720591	19.01	3304888	31.29
25.583	403518644	80.99	7255736	68.71
Totals	498239235	100.00	10560624	100.00

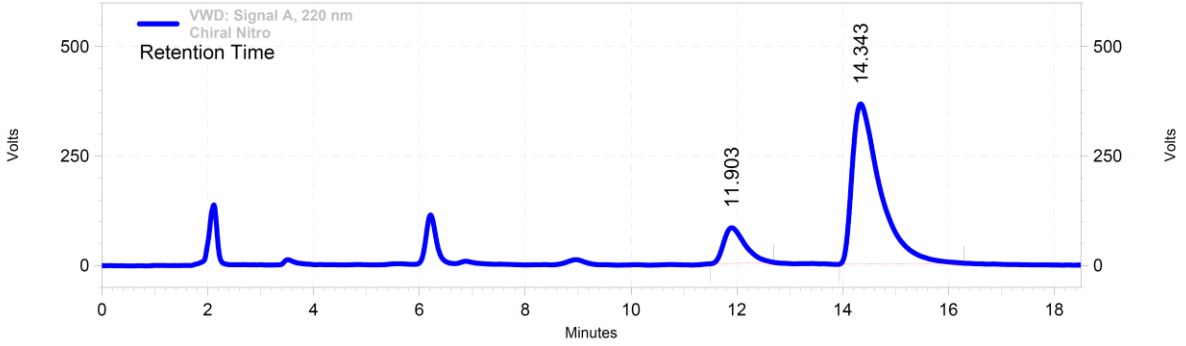
HPLC of **2h**





VWD: Signal A,
220 nm Results

Retention Time	Area	Area %	Height	Height %
11.940	39942306	51.97	1346429	58.68
14.673	36913462	48.03	947969	41.32
Totals	76855768	100.00	2294398	100.00

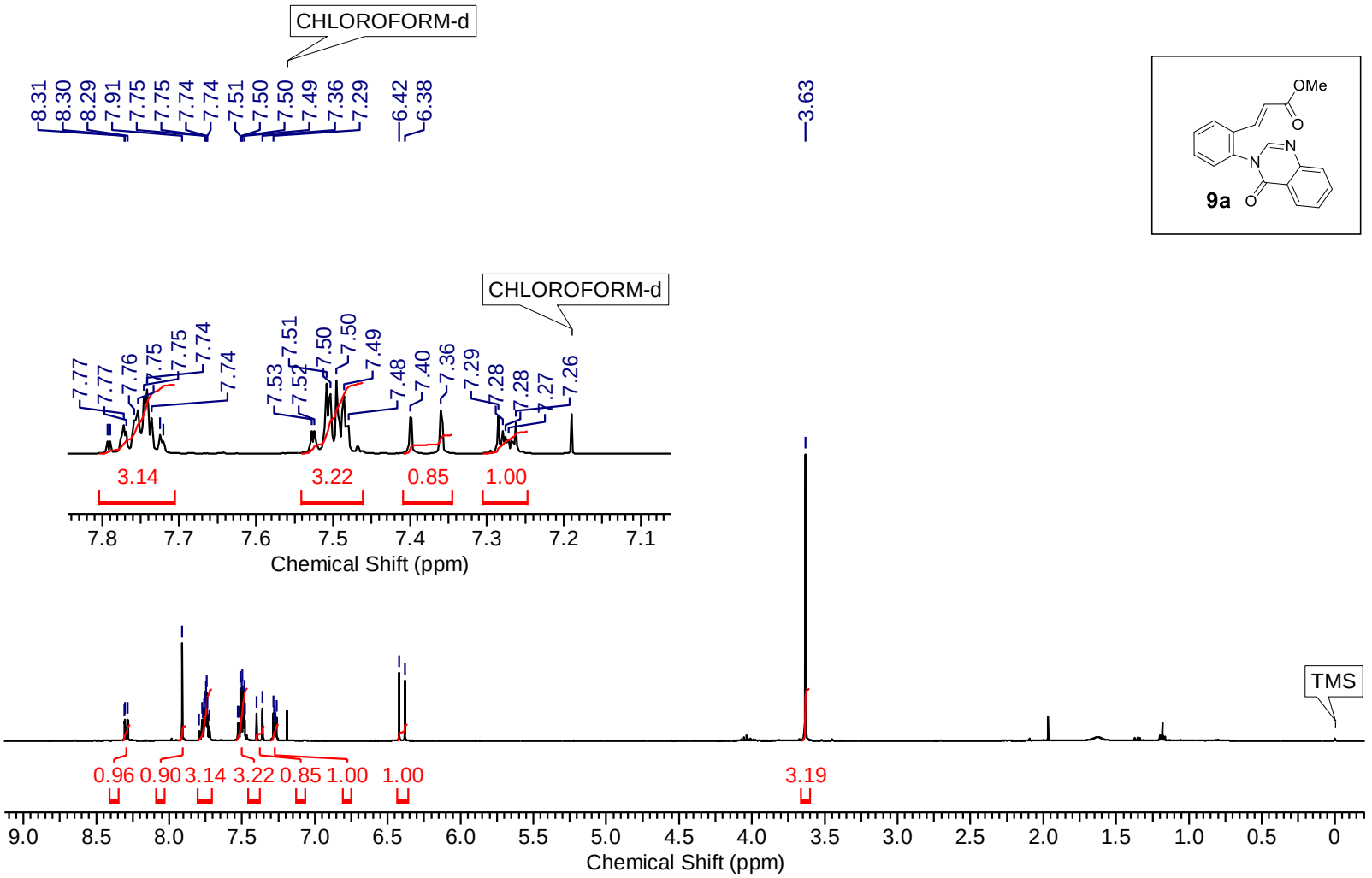


VWD: Signal A,
220 nm Results

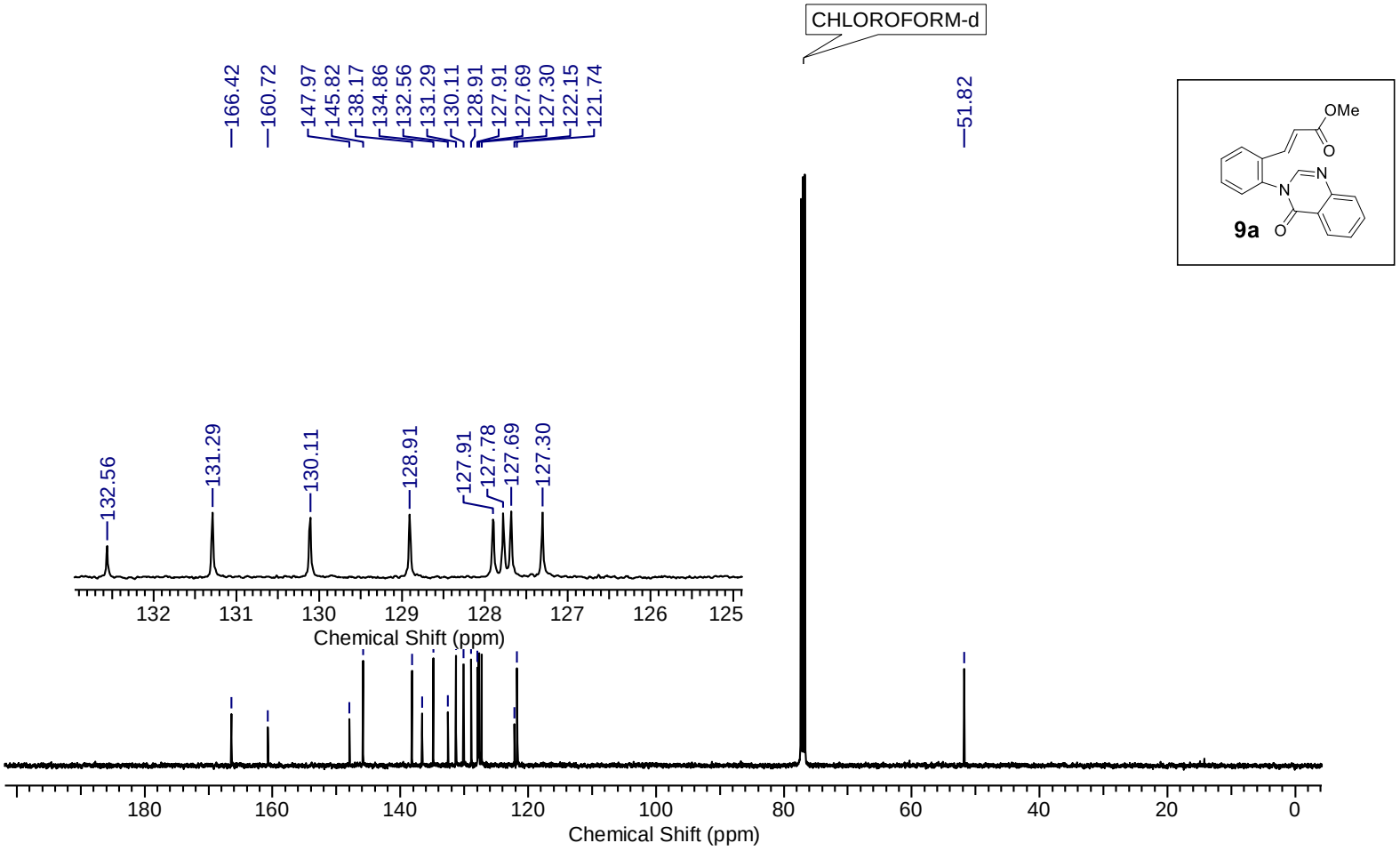
Retention Time	Area	Area %	Height	Height %
11.903	38536242	14.54	1364054	18.20
14.343	226578595	85.46	6131395	81.80
Totals	265114837	100.00	7495449	100.00

7. Copies of ^{1}H NMR, ^{13}C, DEPT NMR Spectra

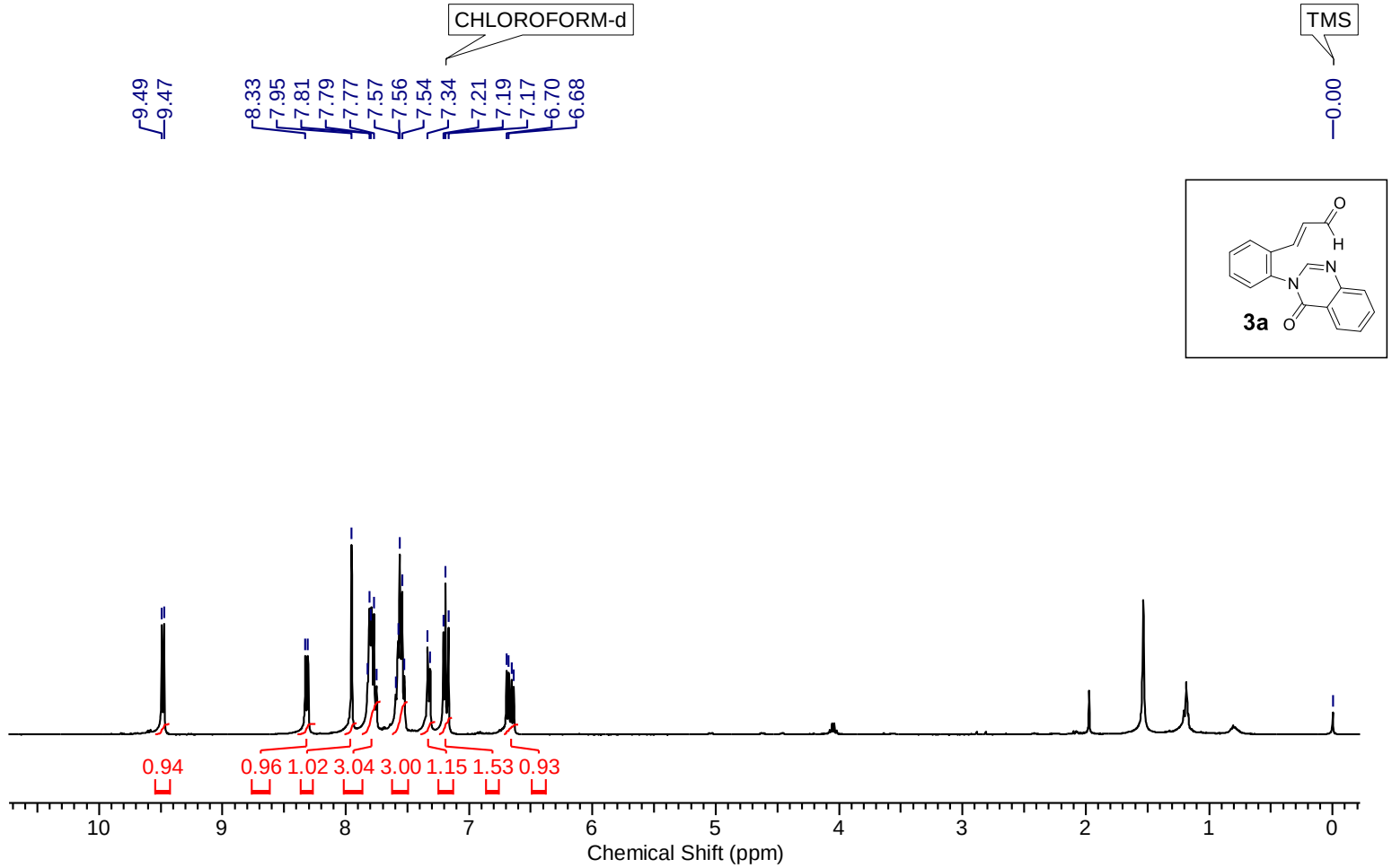
^{1}H NMR (400 MHz, $CDCl_3$)



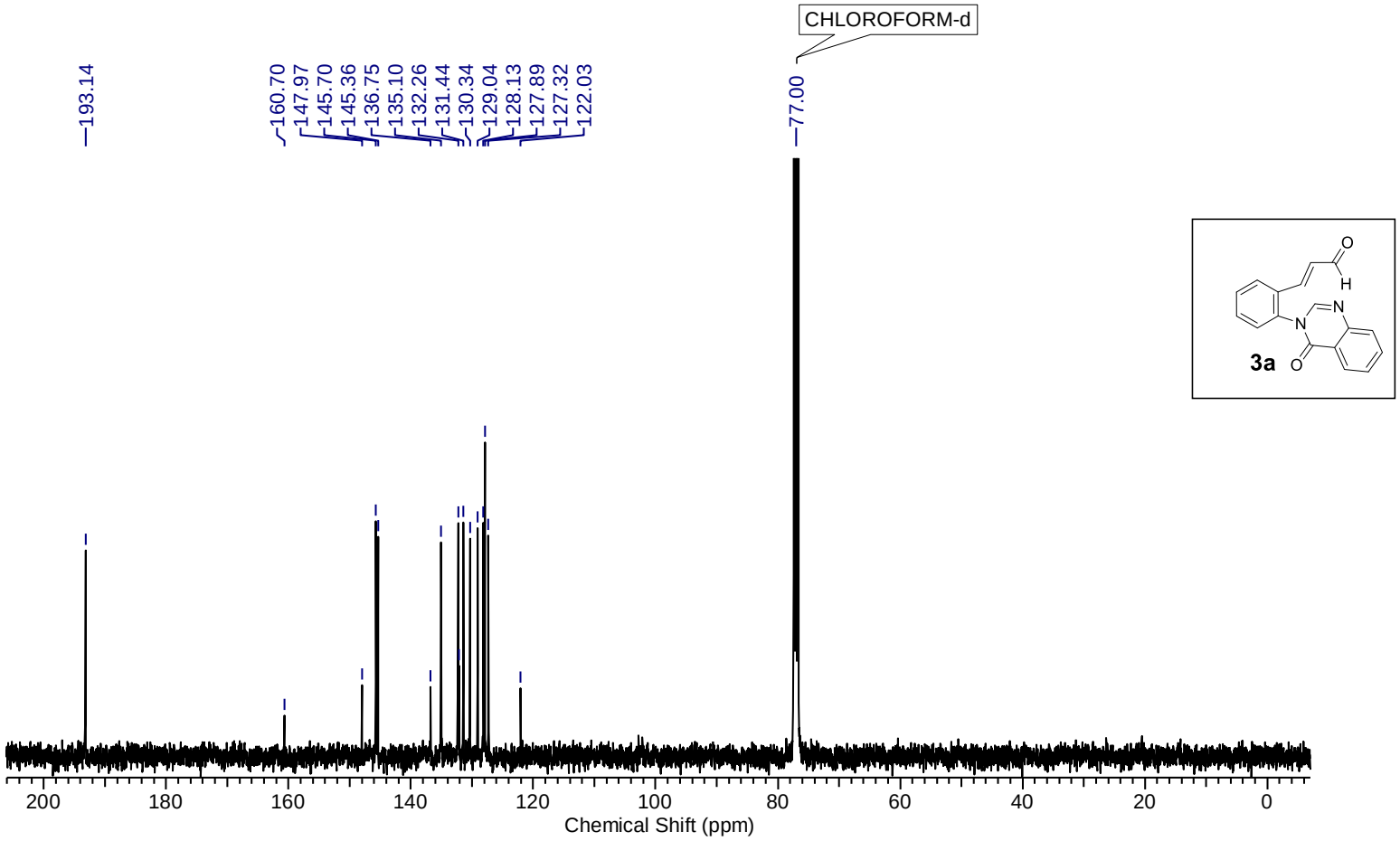
^{13}C NMR (100 MHz, $CDCl_3$)



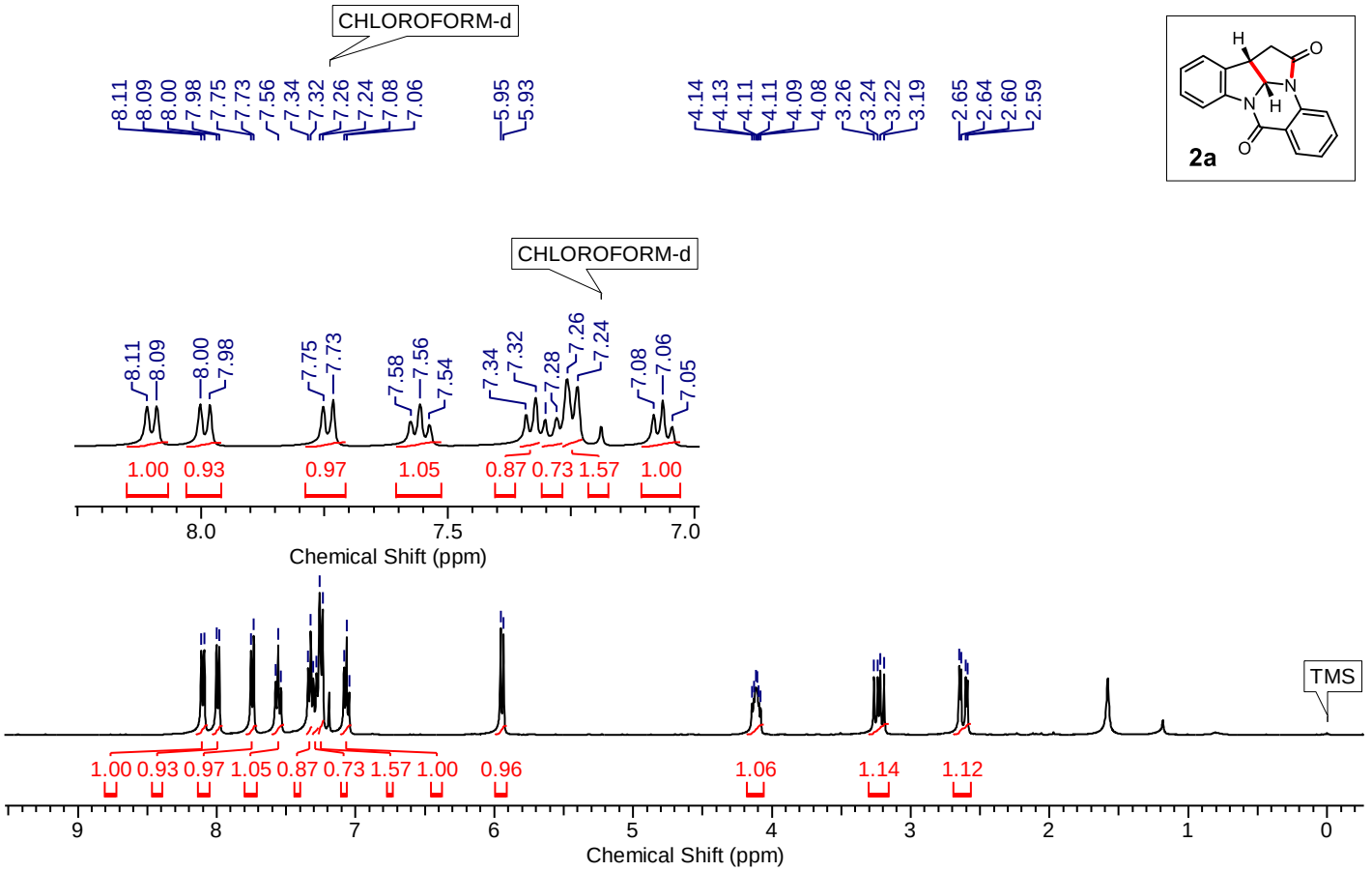
^{1}H NMR (400 MHz, $CDCl_3$)



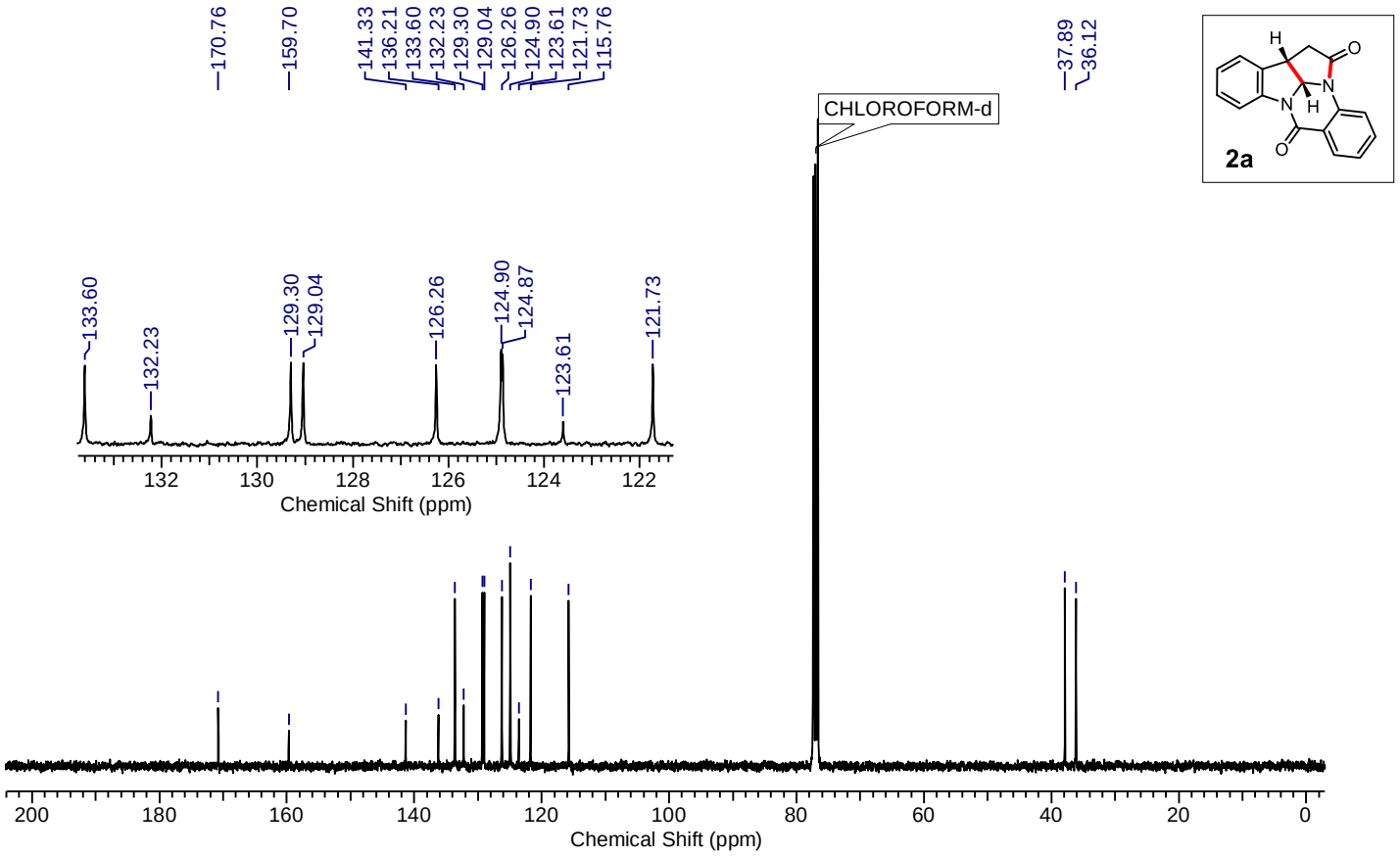
^{13}C NMR (100 MHz, $CDCl_3$)



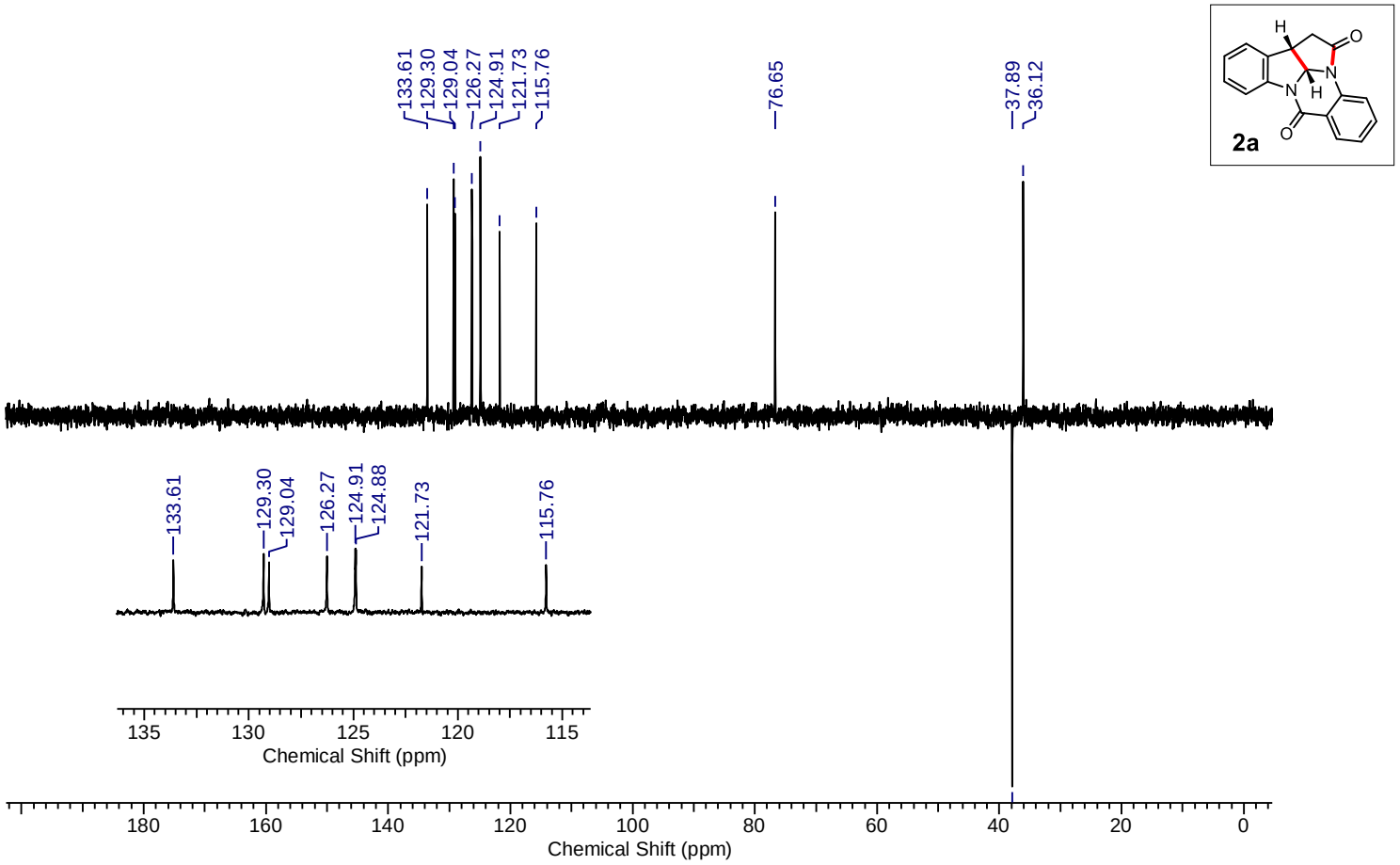
^{1}H NMR (400 MHz, $CDCl_3$)



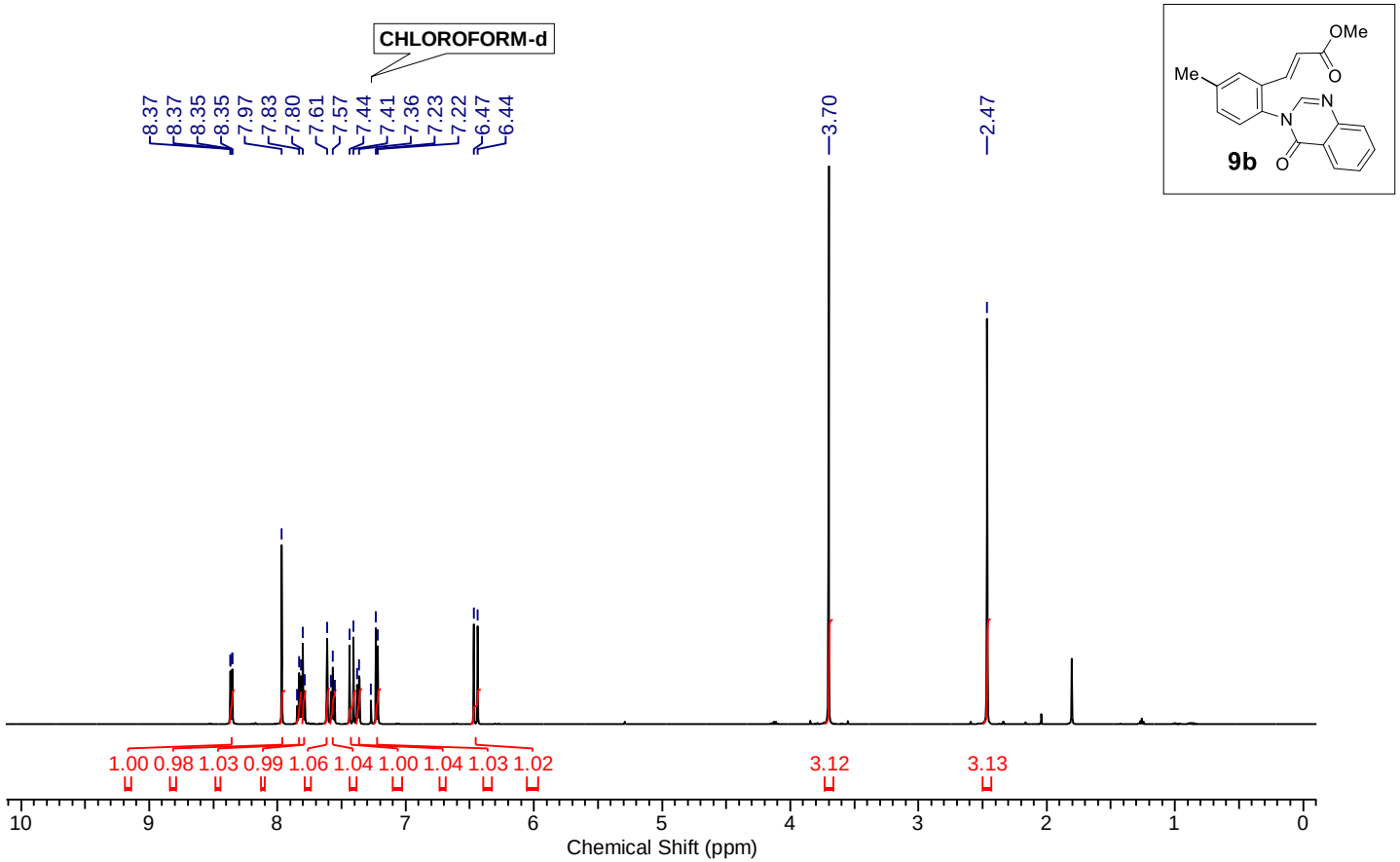
^{13}C NMR (100 MHz, $CDCl_3$)



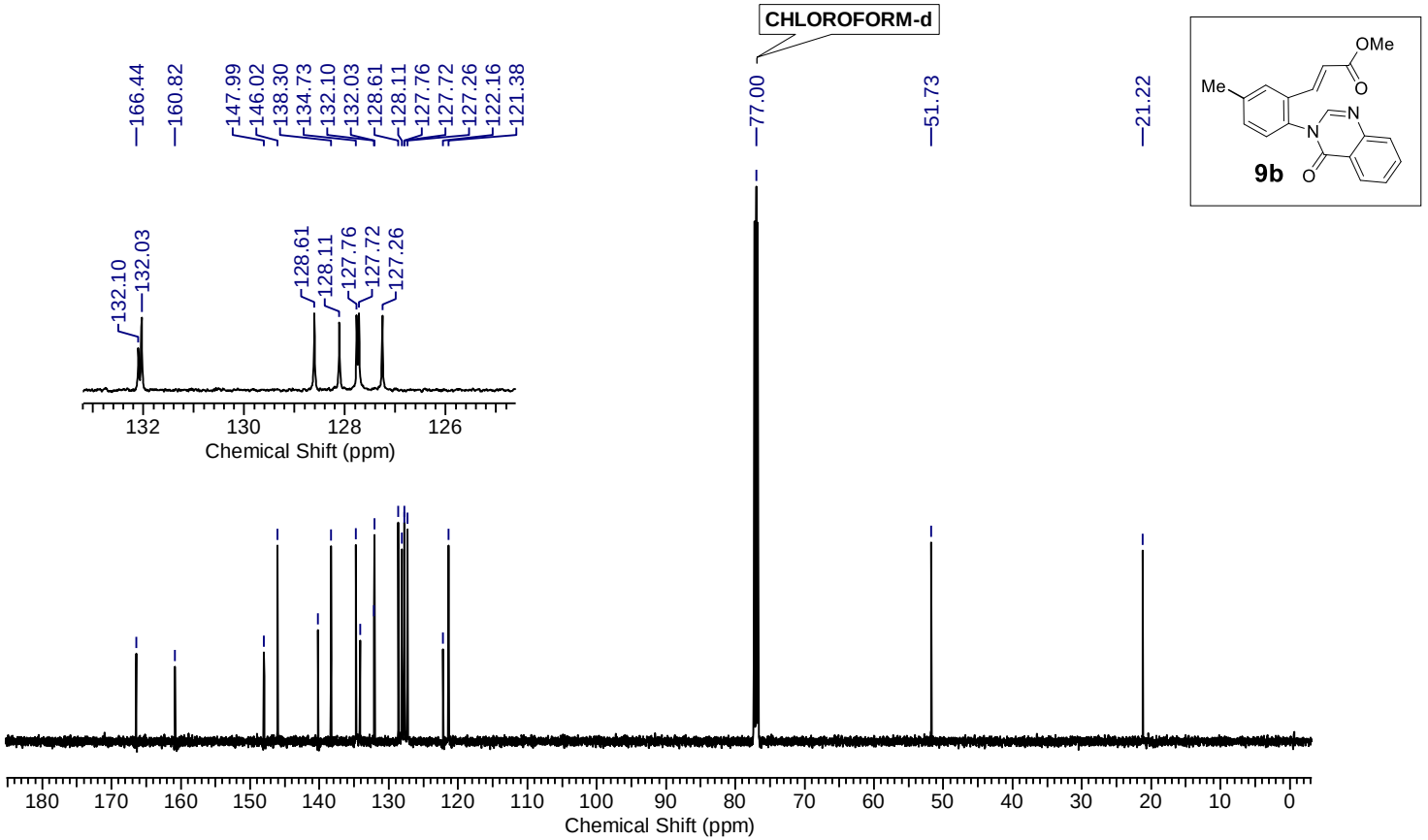
DEPT NMR


133.61
129.30
129.04
126.27
124.91
121.73
115.76
76.65
37.89
36.12
2a
133.61
129.30
129.04
126.27
124.91
124.88
121.73
115.76
135
130
125
120
115
Chemical Shift (ppm)
180
160
140
120
100
80
60
40
20
0
Chemical Shift (ppm)

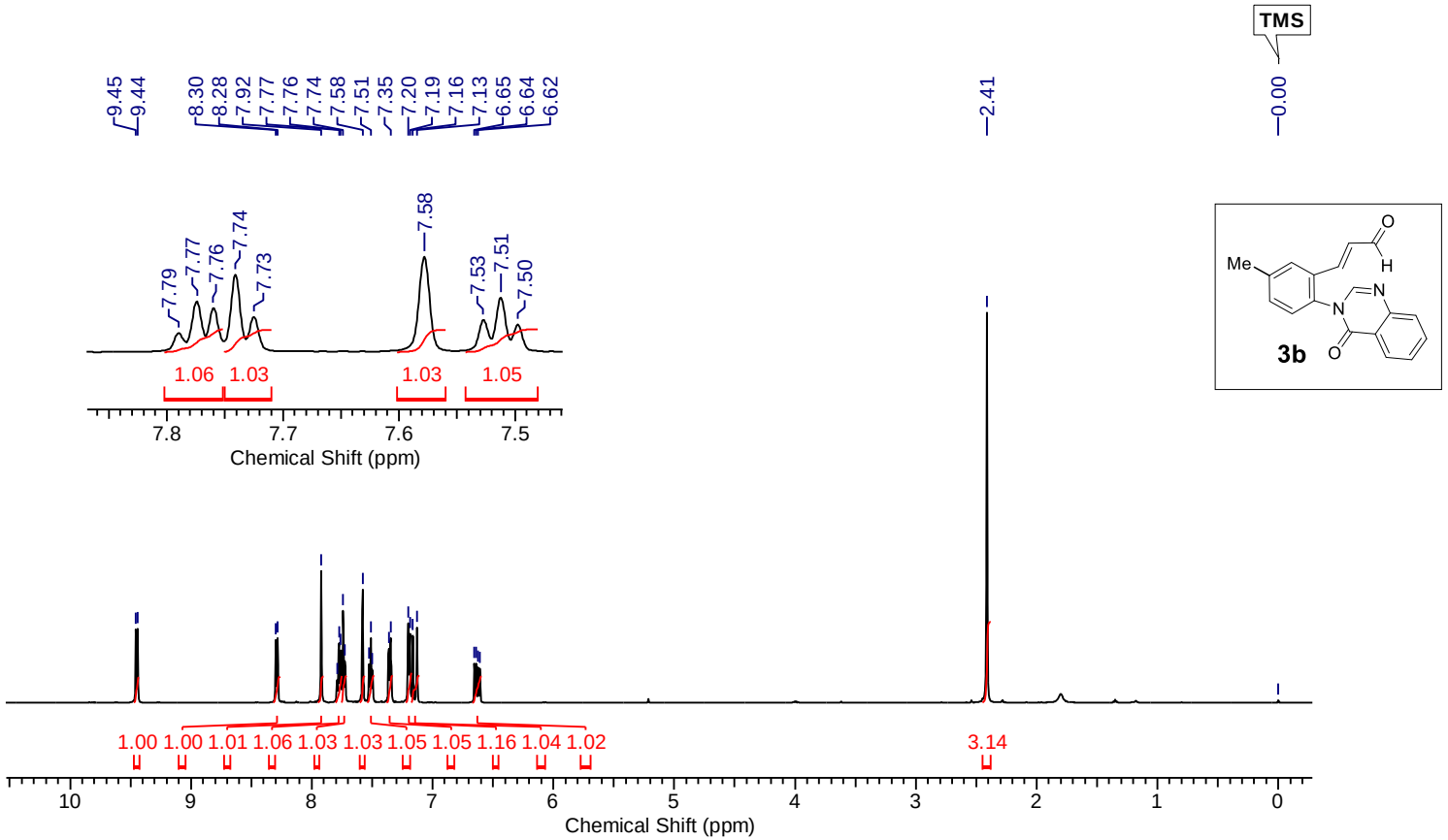
^{1}H NMR (500 MHz, $CDCl_3$)



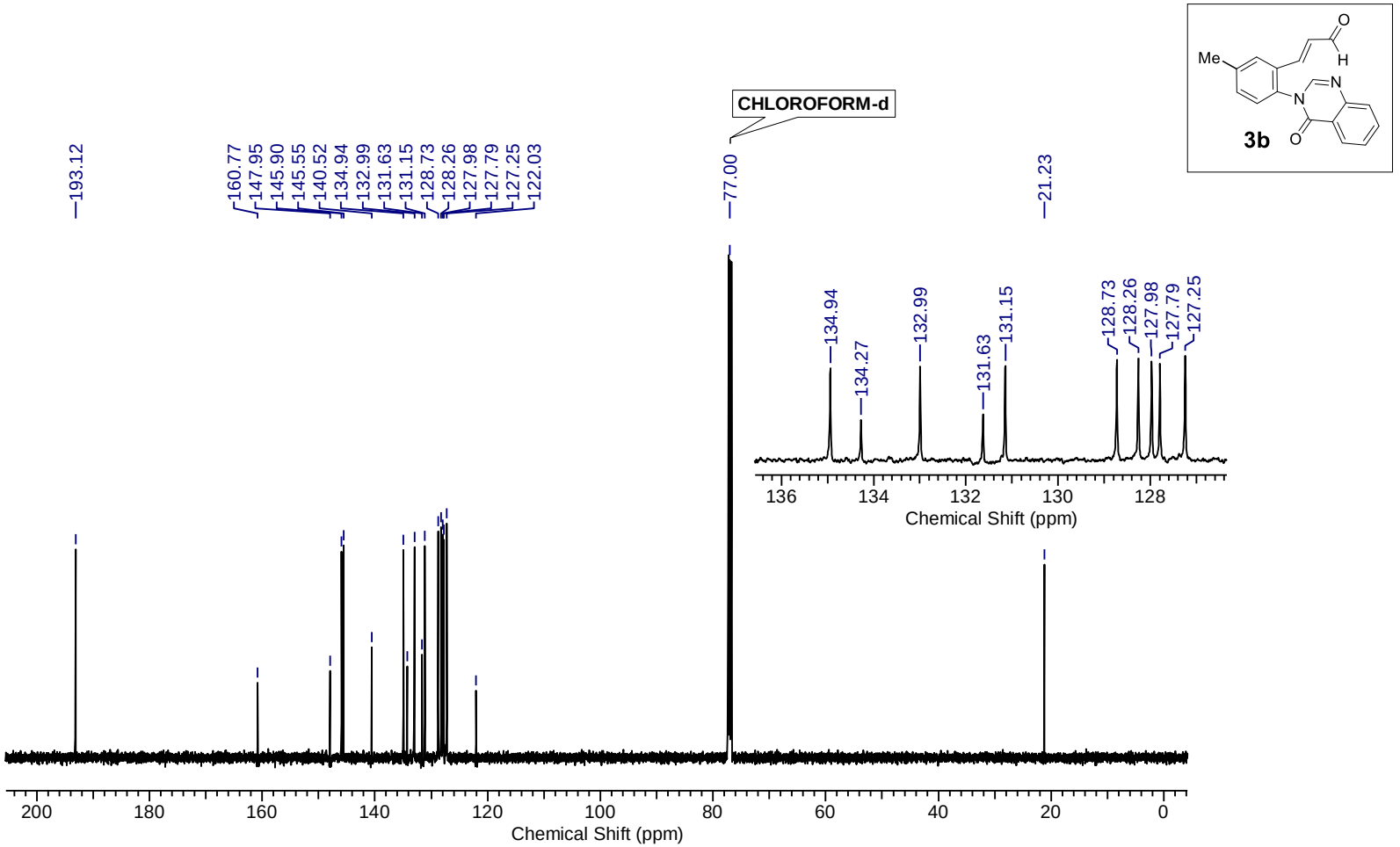
^{13}C NMR (125 MHz, $CDCl_3$)



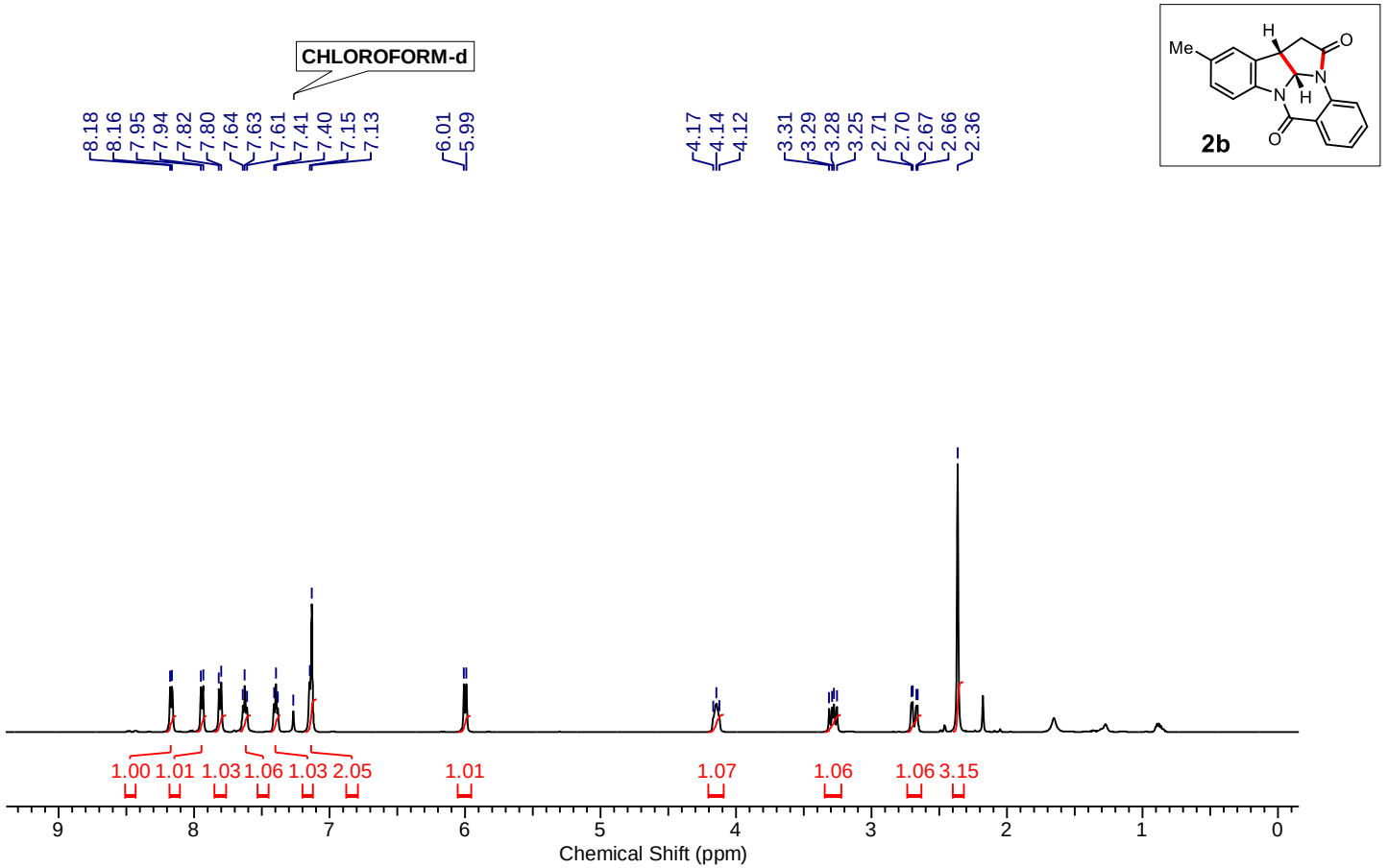
^{1}H NMR (500 MHz, $CDCl_3$)



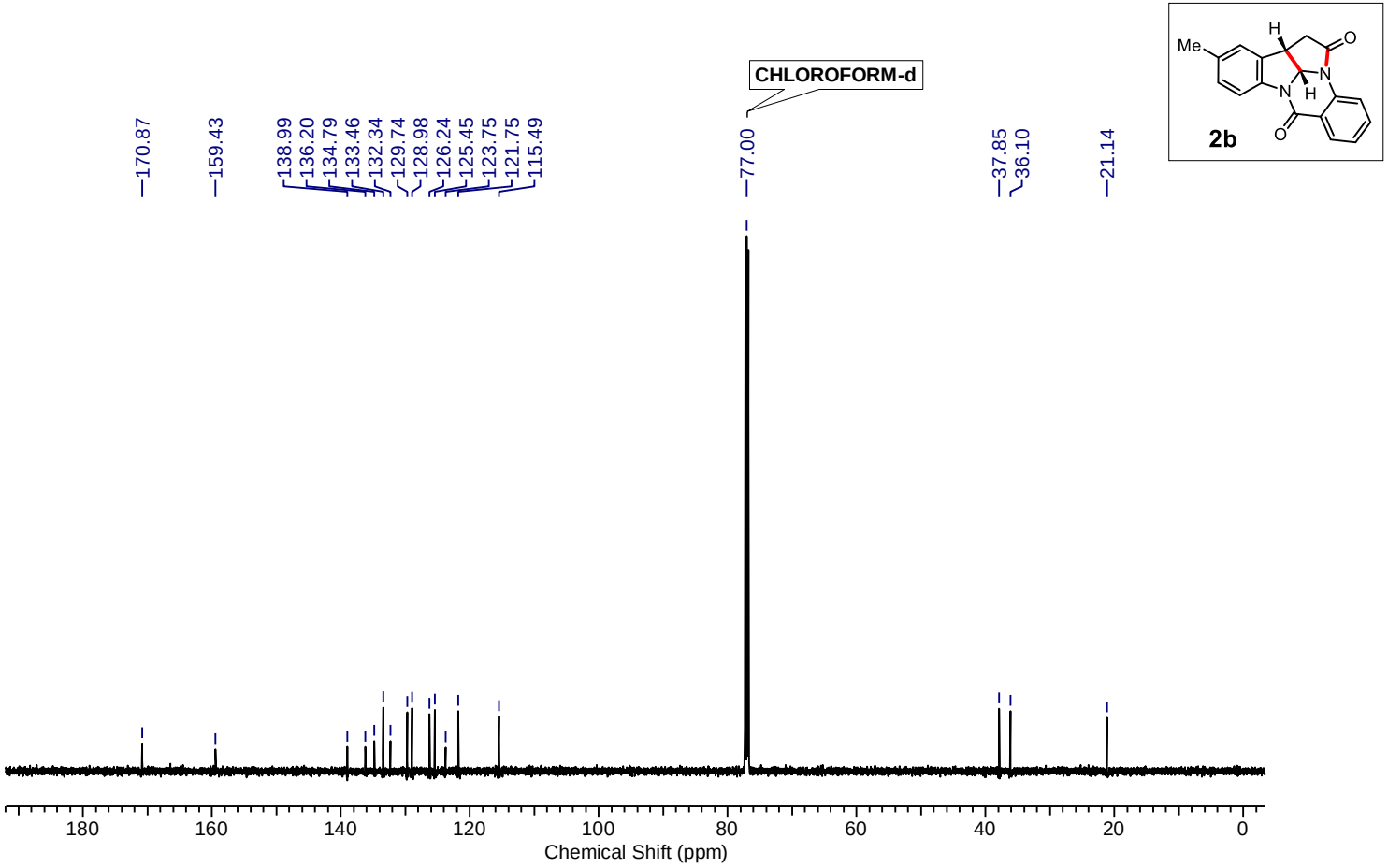
^{13}C NMR (125 MHz, $CDCl_3$)



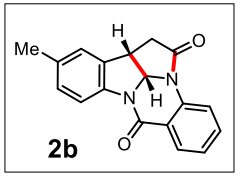
^{1}H NMR (500 MHz, $CDCl_3$)

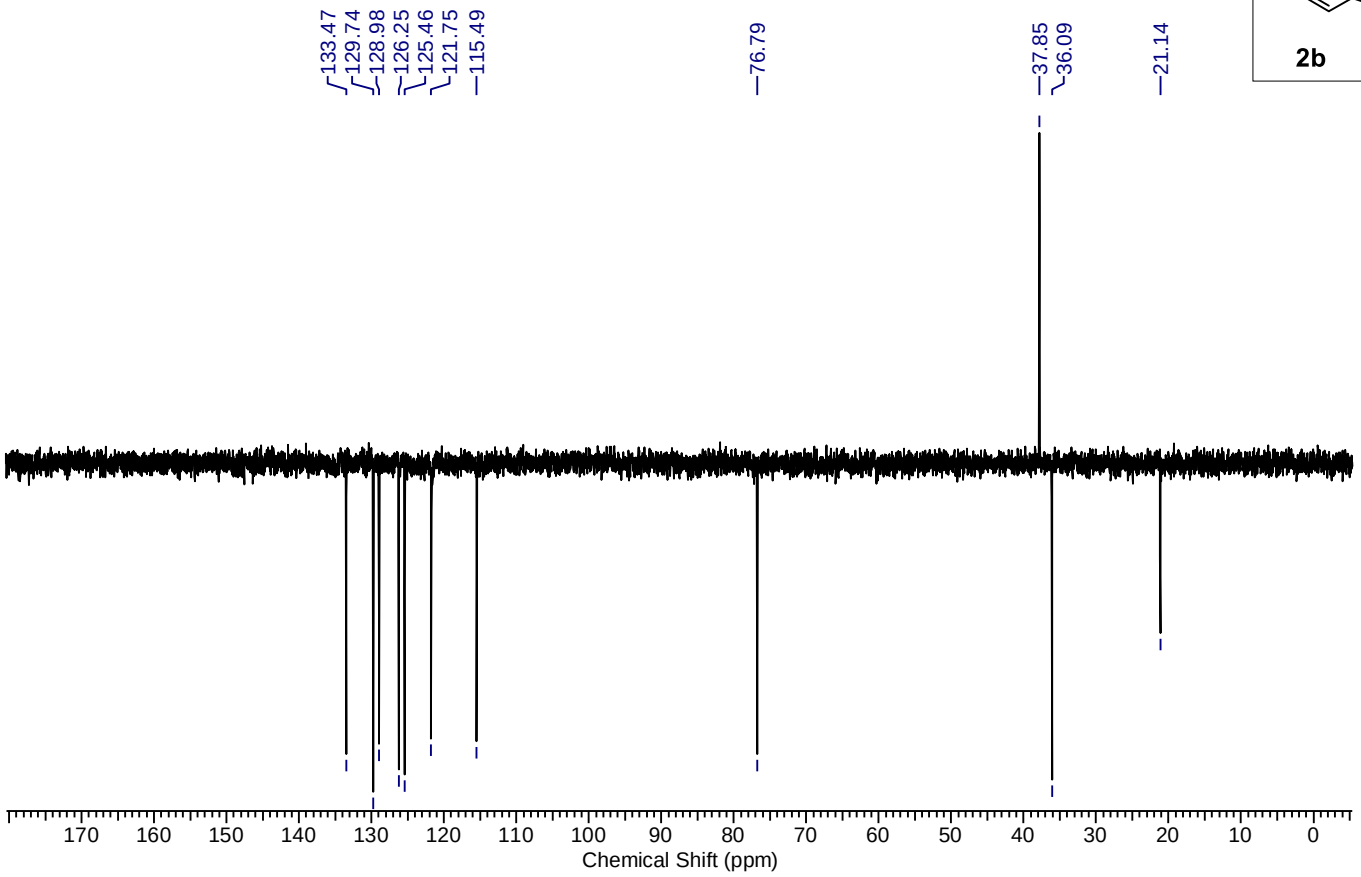


^{13}C NMR (125 MHz, $CDCl_3$)

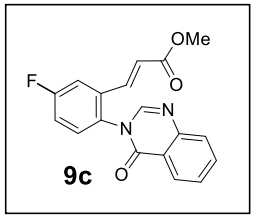


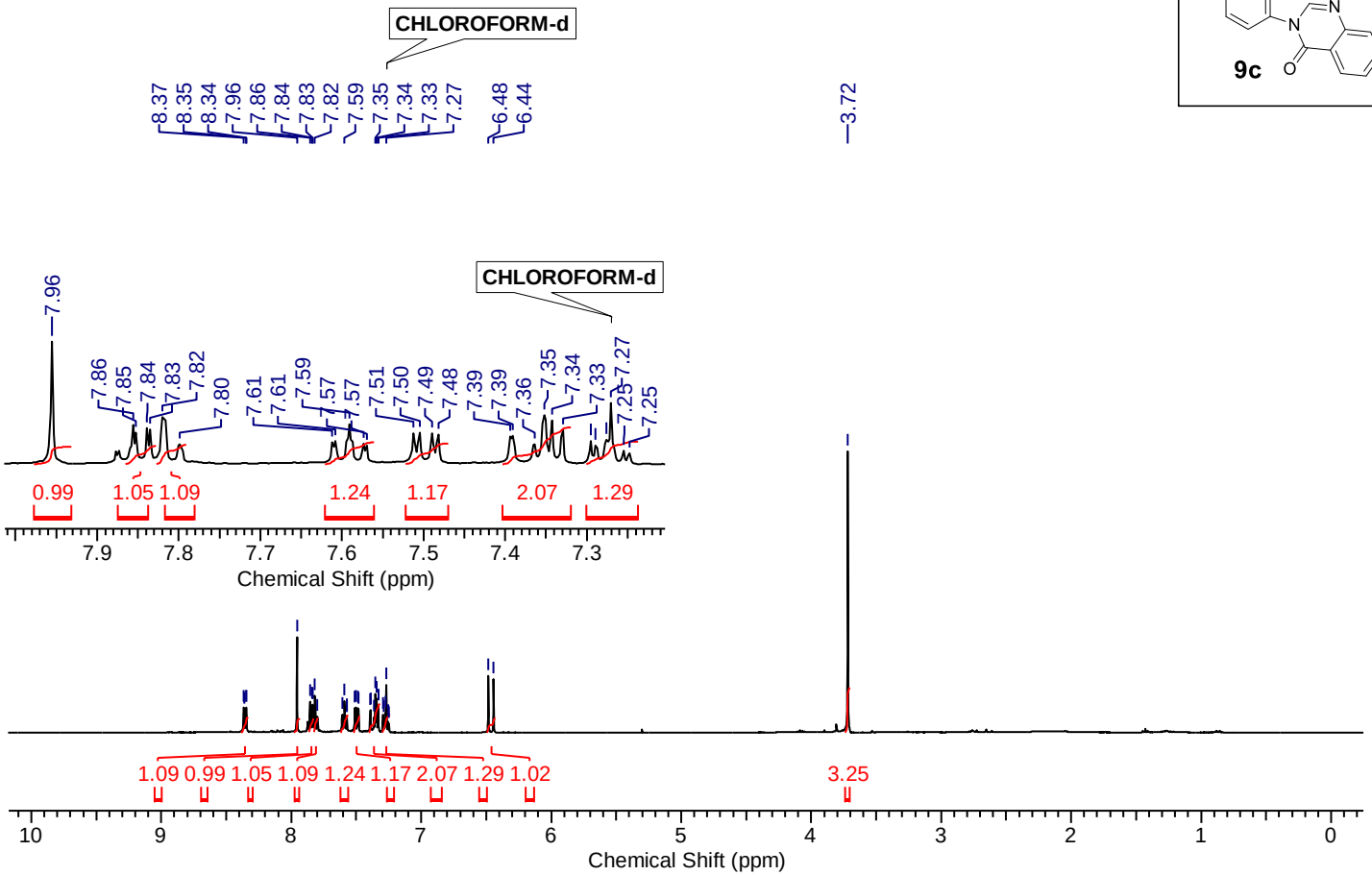
DEPT NMR


Me
H
O
N
N
H
O
2b

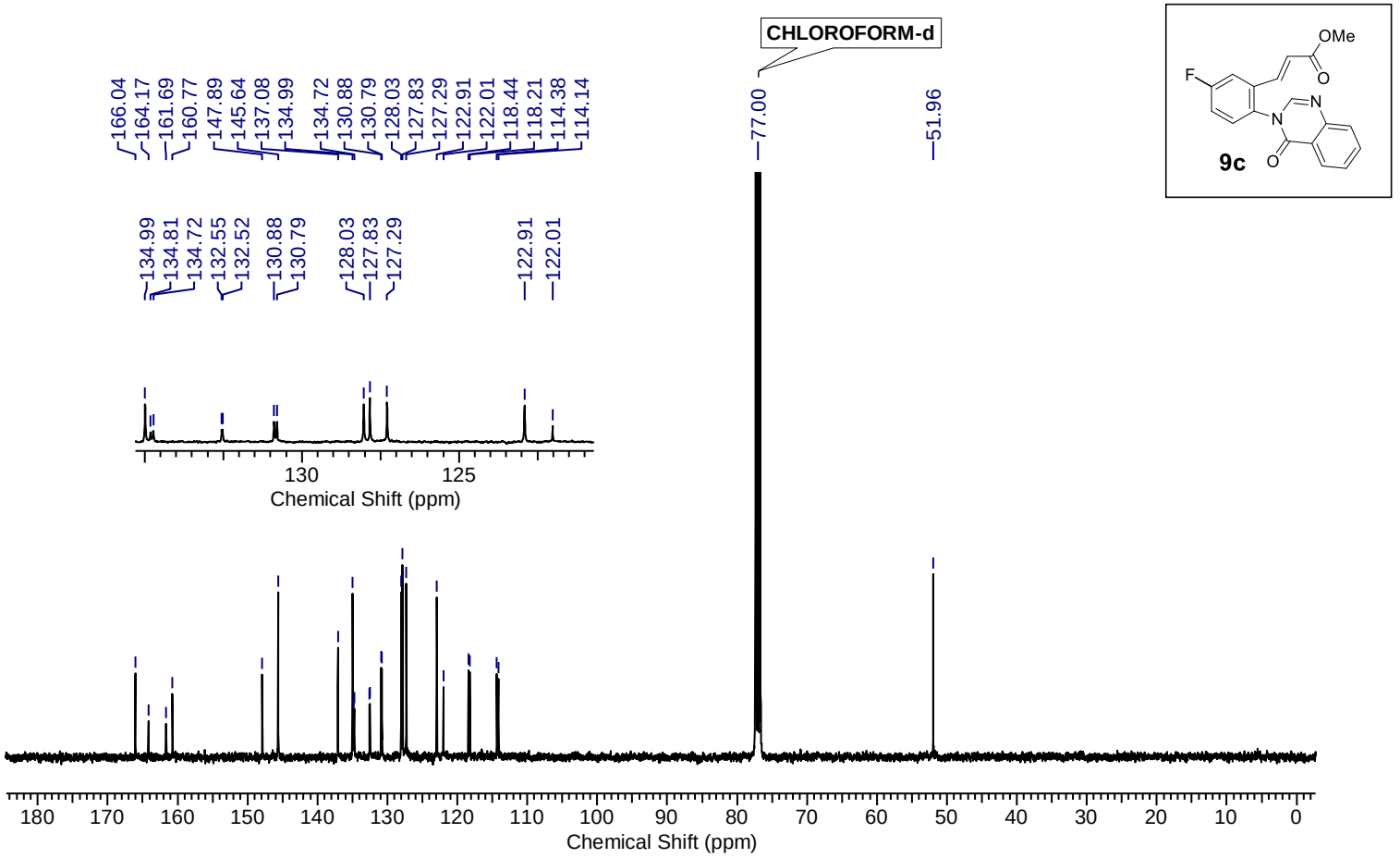

133.47
129.74
128.98
126.25
125.46
121.75
115.49
76.79
37.85
36.09
21.14
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Chemical Shift (ppm)

^{1}H NMR (400 MHz, $CDCl_3$)

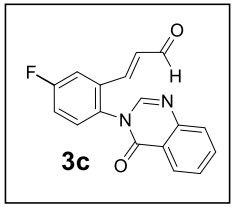


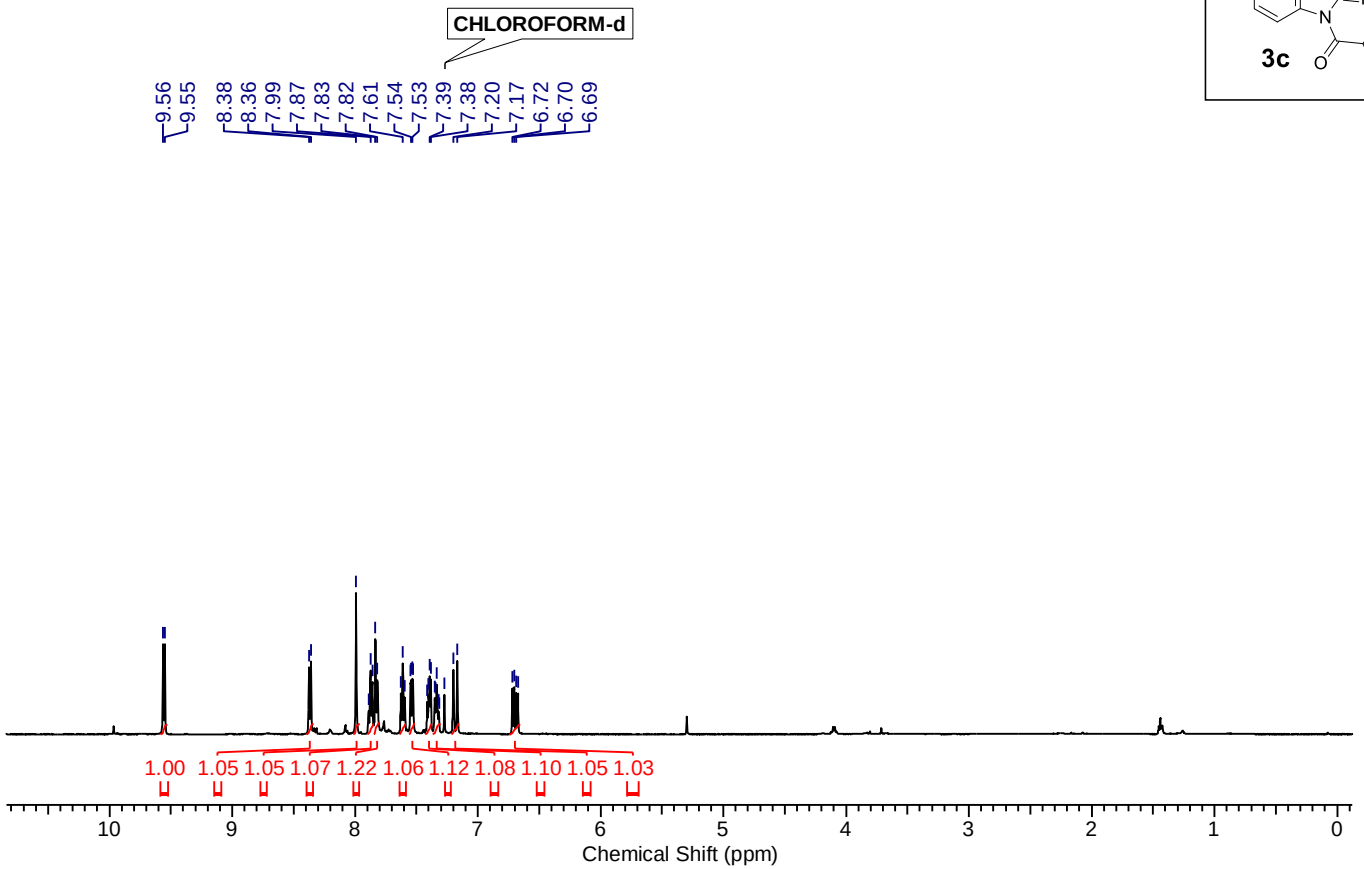


^{13}C NMR (100 MHz, $CDCl_3$)

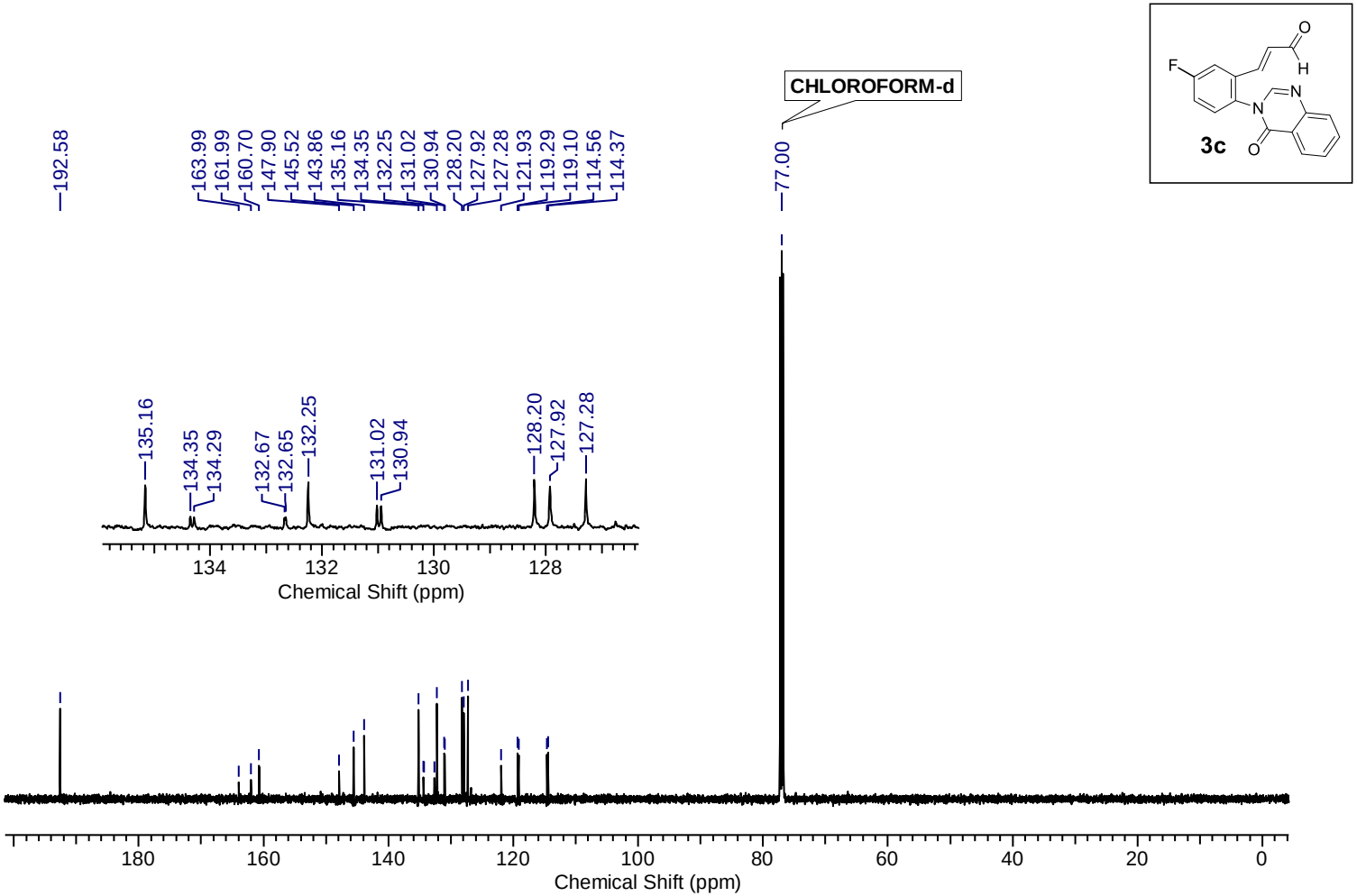


^{1}H NMR (500 MHz, $CDCl_3$)

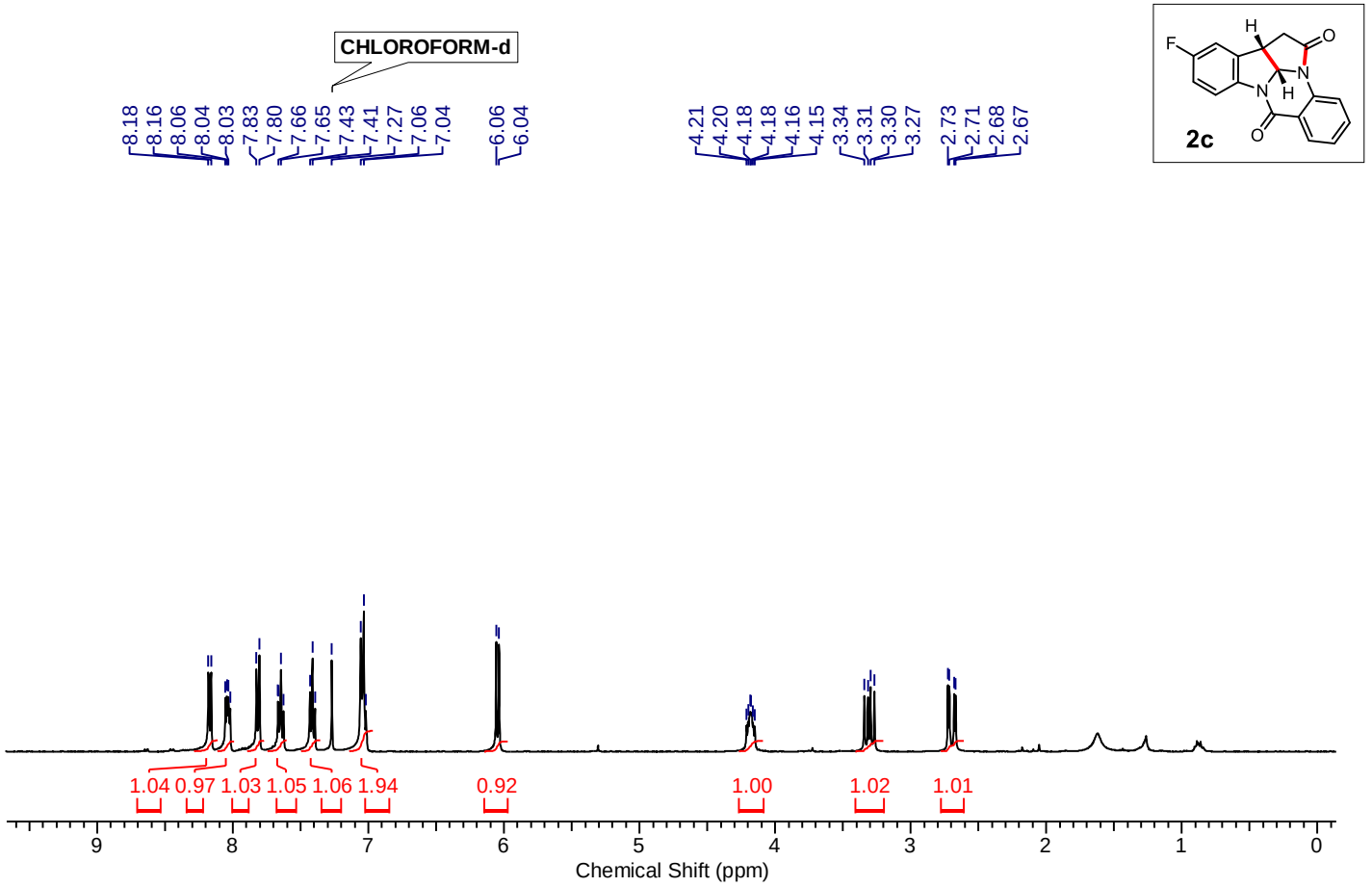




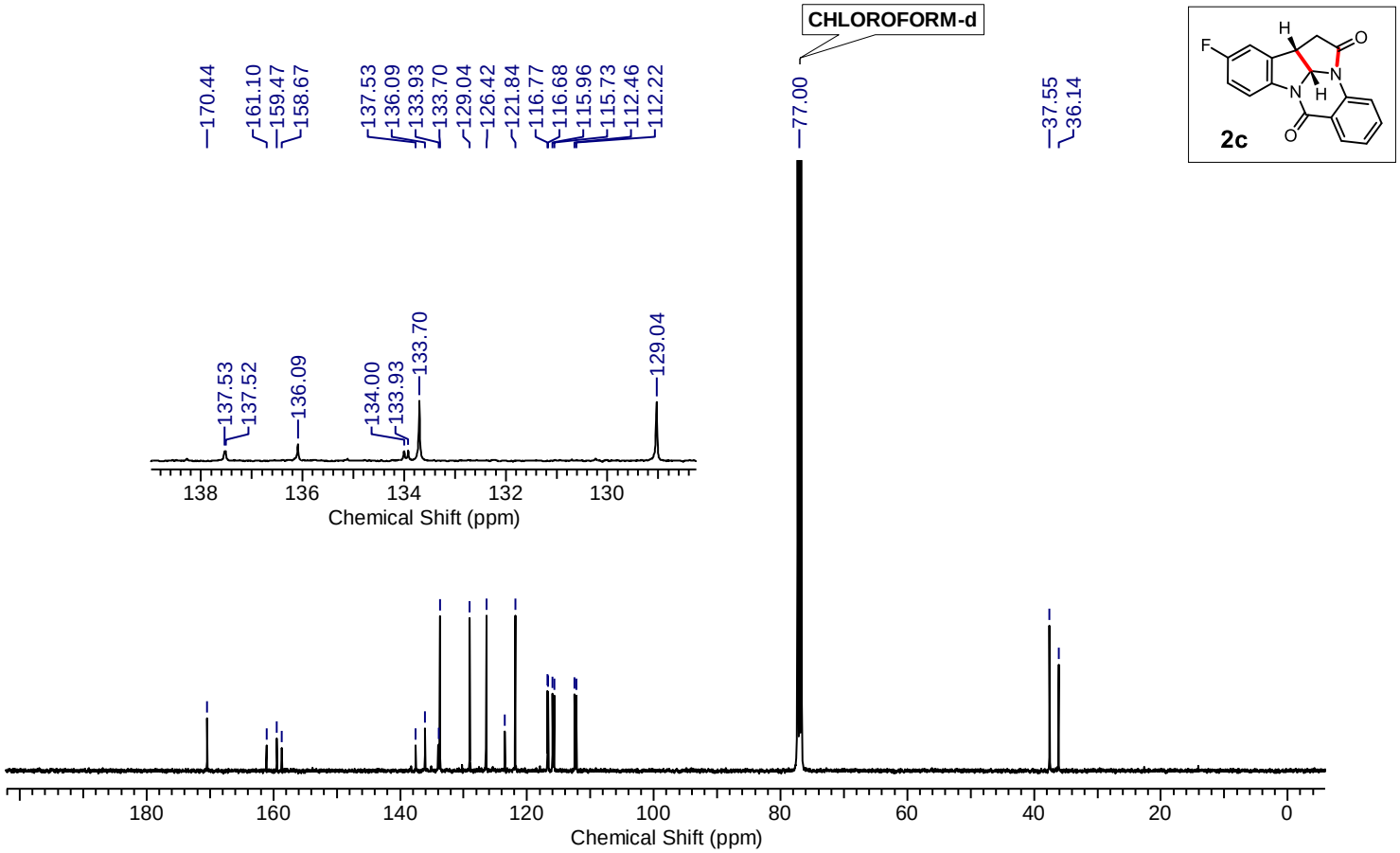
^{13}C NMR (125 MHz, $CDCl_3$)



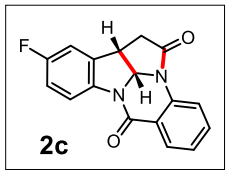
^{1}H NMR (400 MHz, $CDCl_3$)

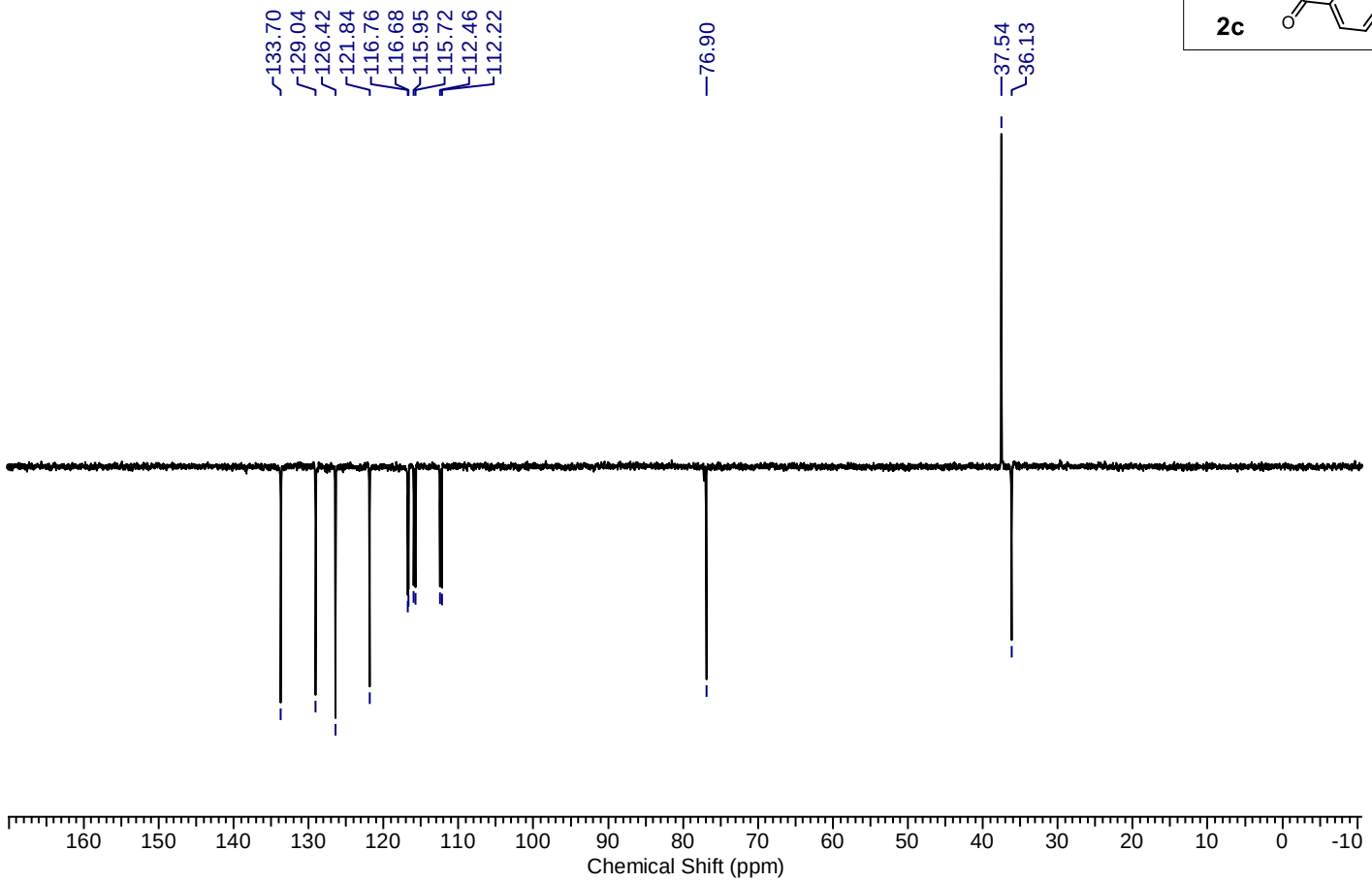


^{13}C NMR (100 MHz, $CDCl_3$)

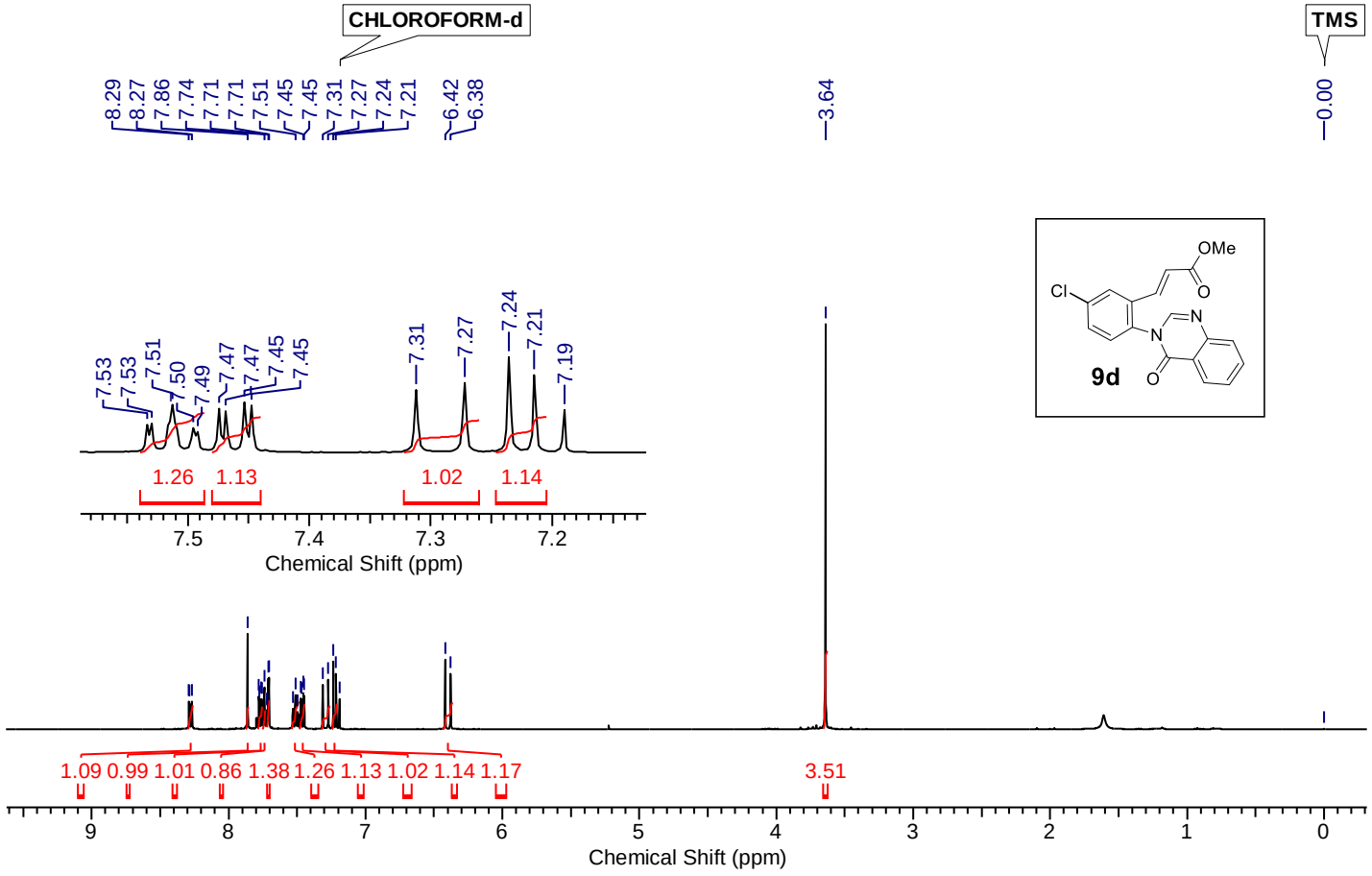


DEPT NMR

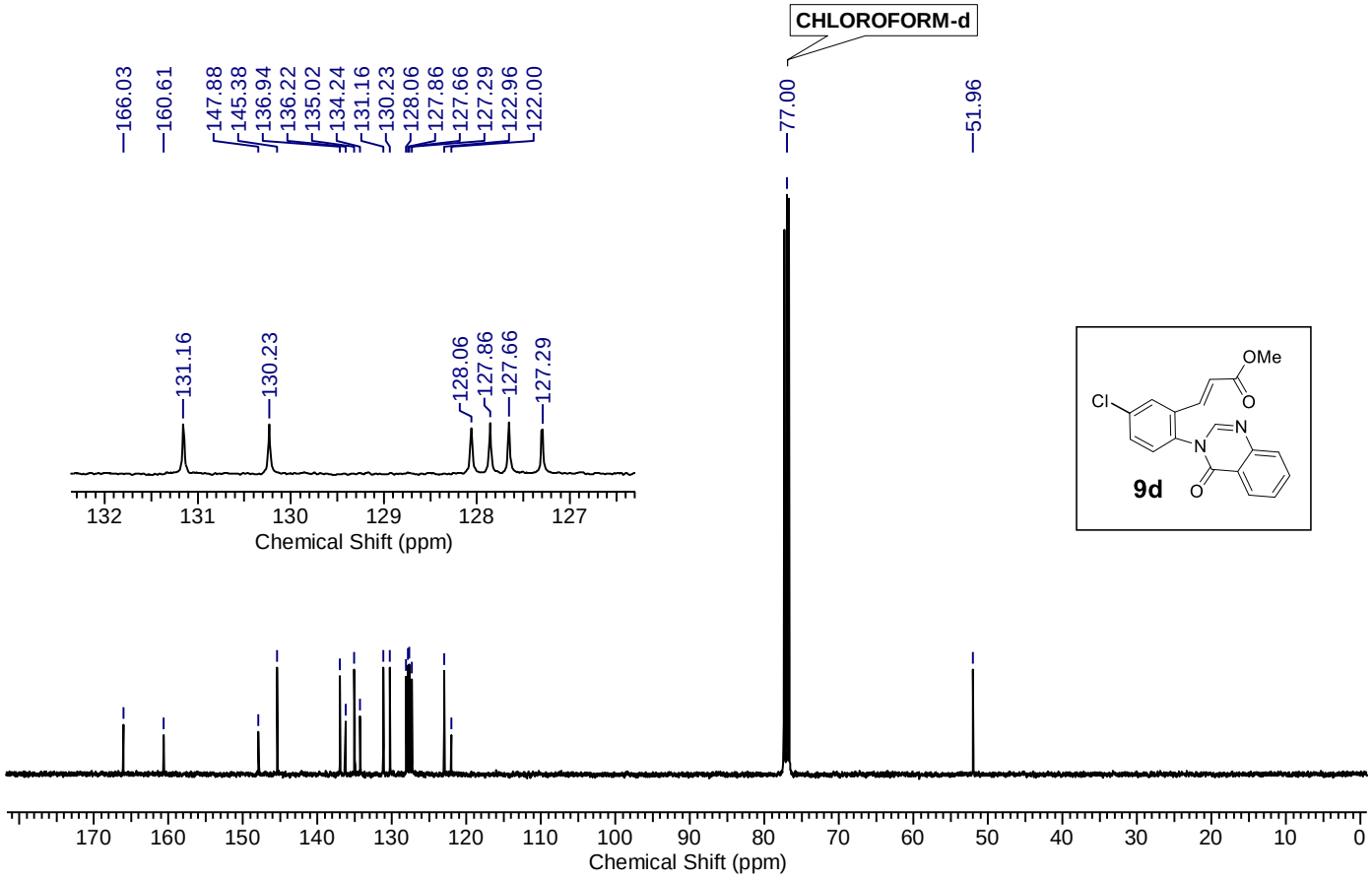

F
H
O
N
N
H
O
2c


133.70
129.04
126.42
121.84
116.76
116.68
115.95
115.72
112.46
112.22
76.90
37.54
36.13
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
Chemical Shift (ppm)

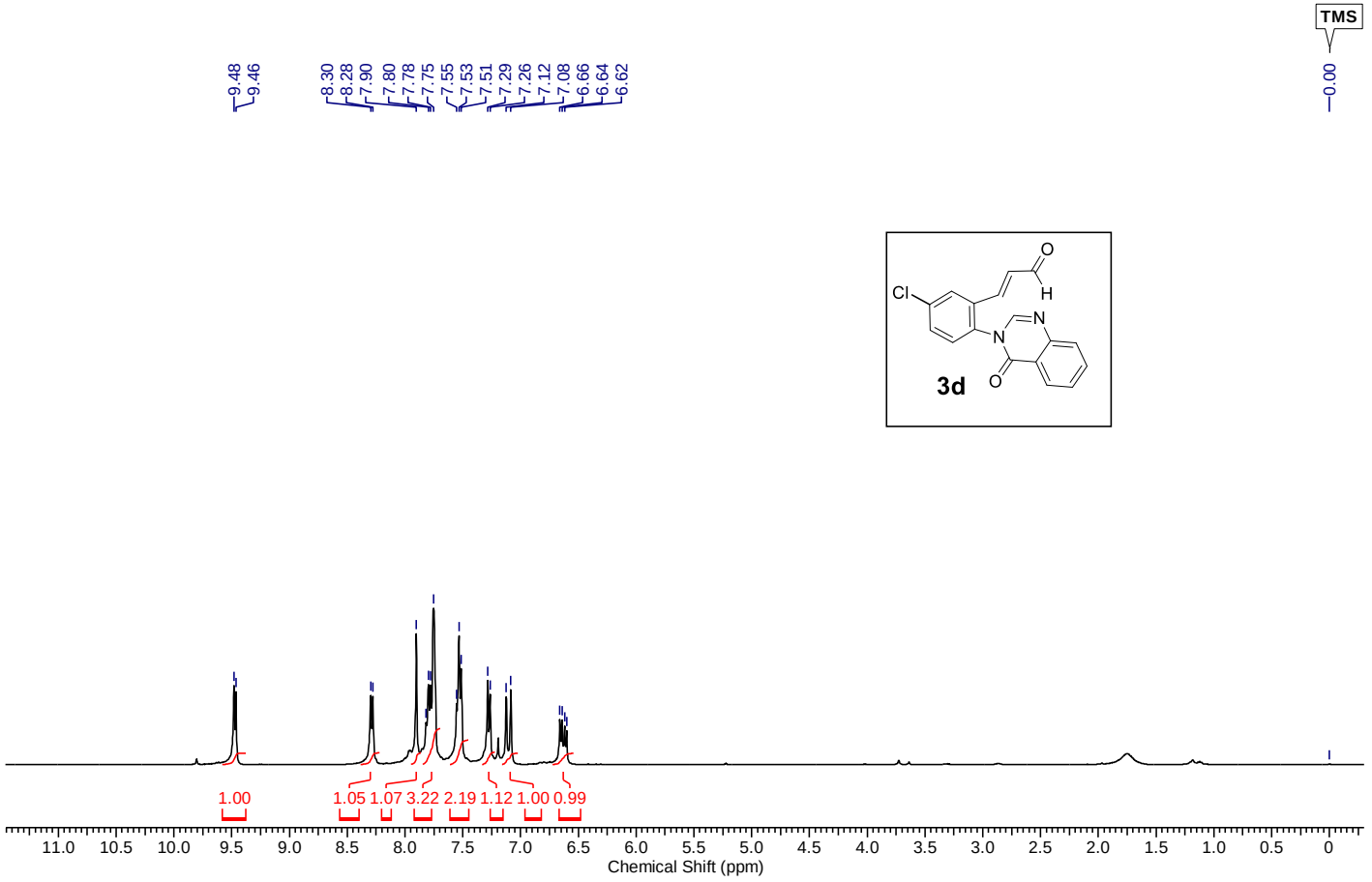
^{1}H NMR (400 MHz, $CDCl_3$)



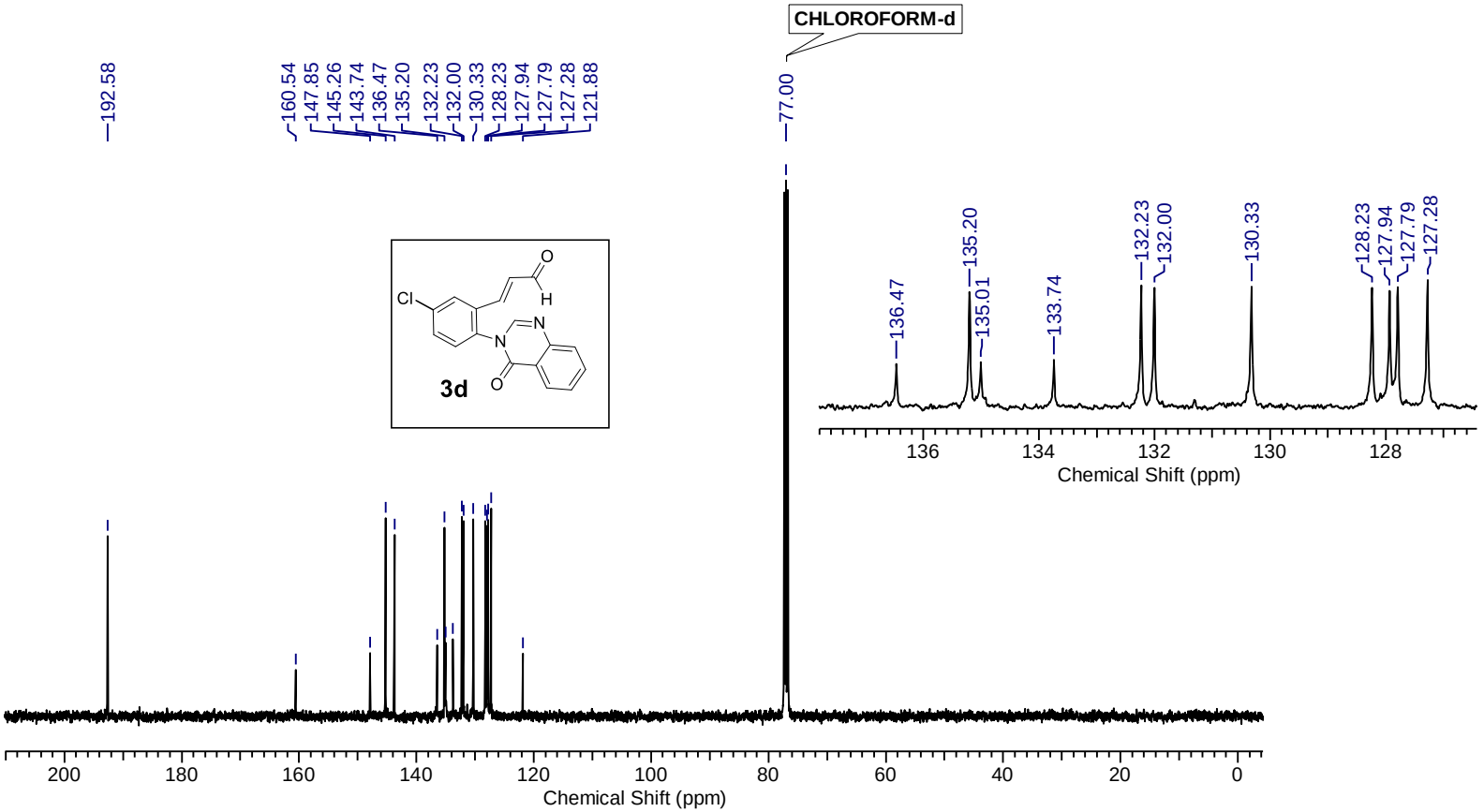
^{13}C NMR (100 MHz, $CDCl_3$)



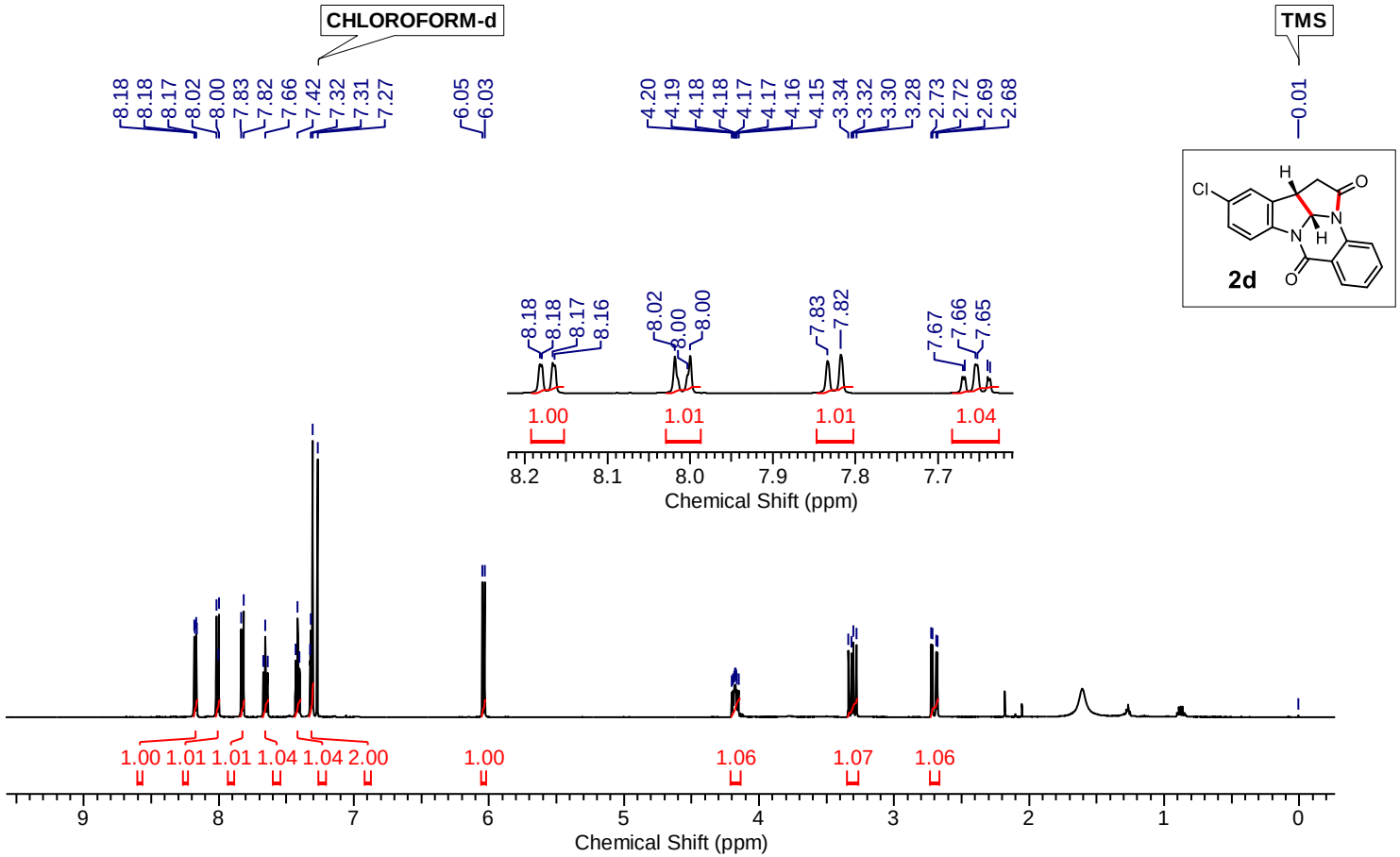
^{1}H NMR (400 MHz, $CDCl_3$)



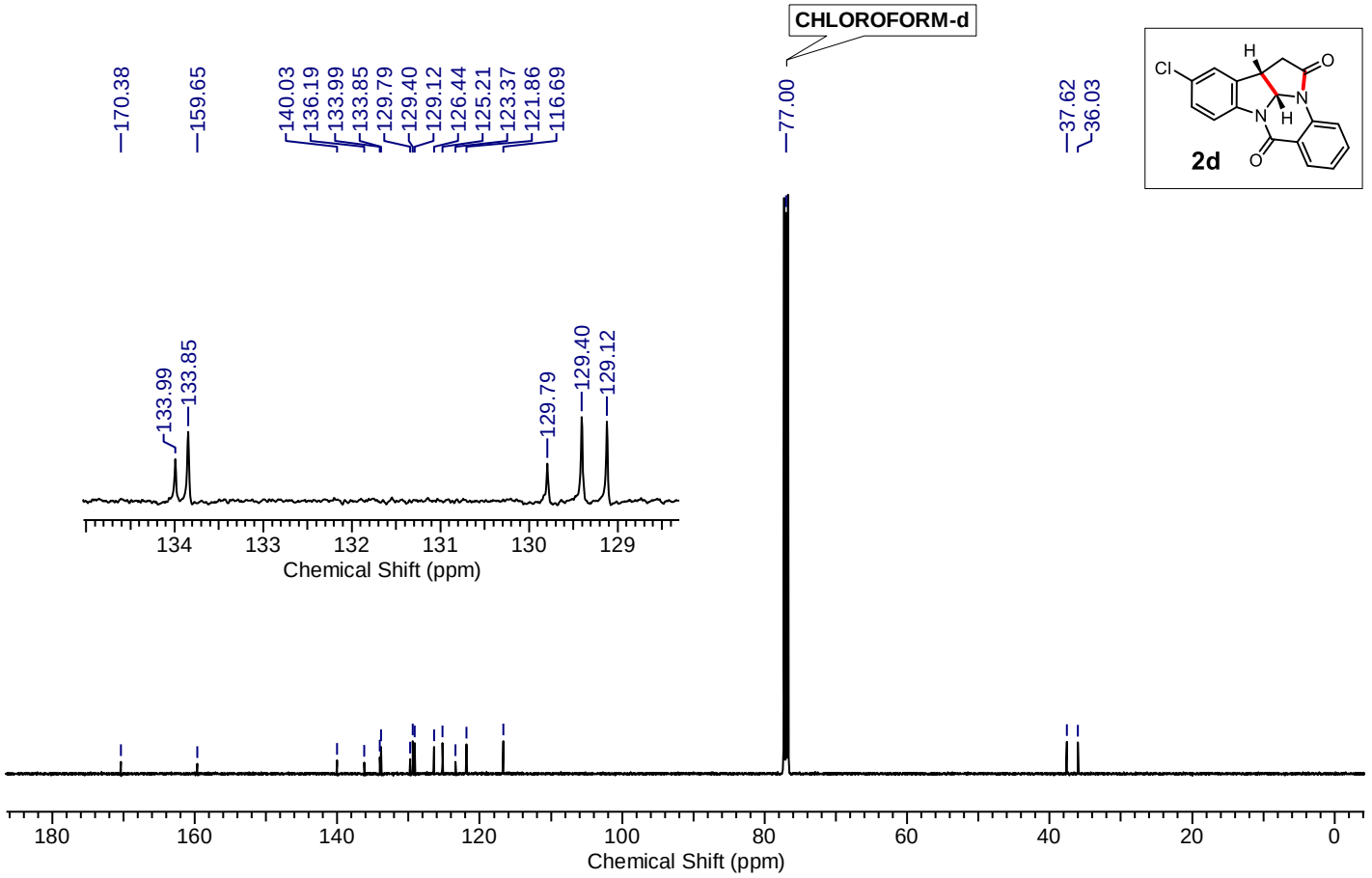
^{13}C NMR (100 MHz, $CDCl_3$)



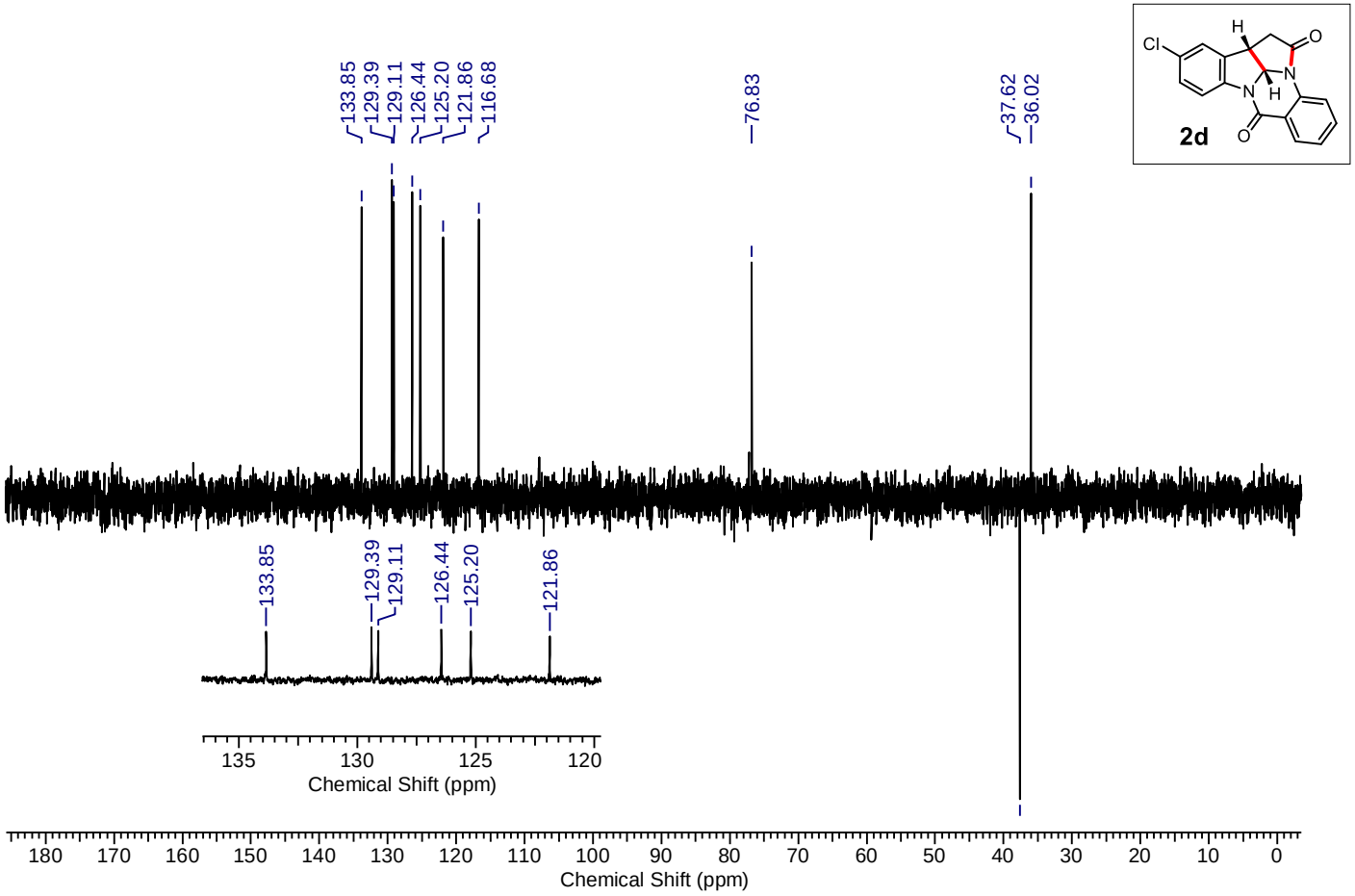
^{1}H NMR (500 MHz, $CDCl_3$)



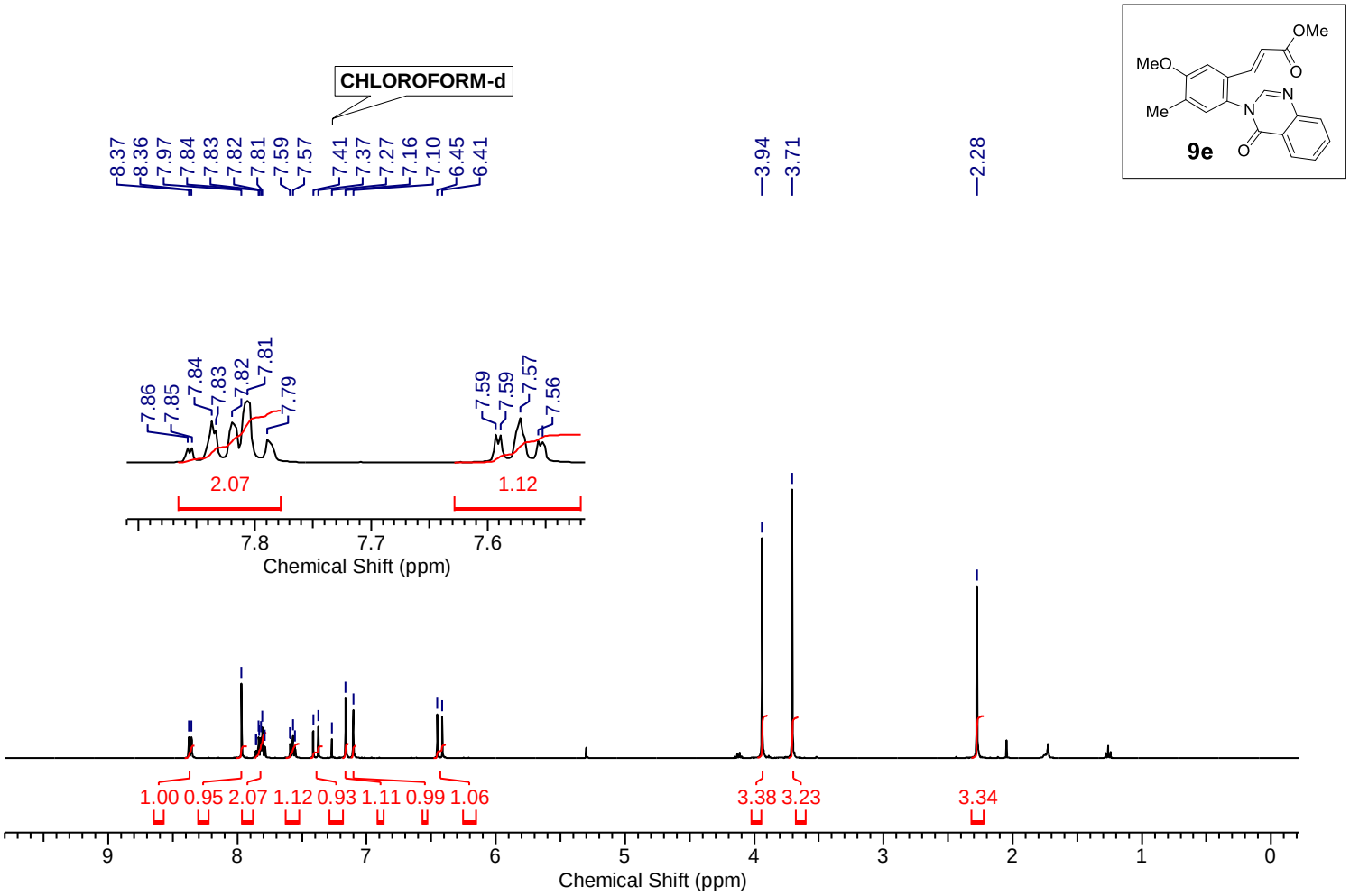
^{13}C NMR (125 MHz, $CDCl_3$)



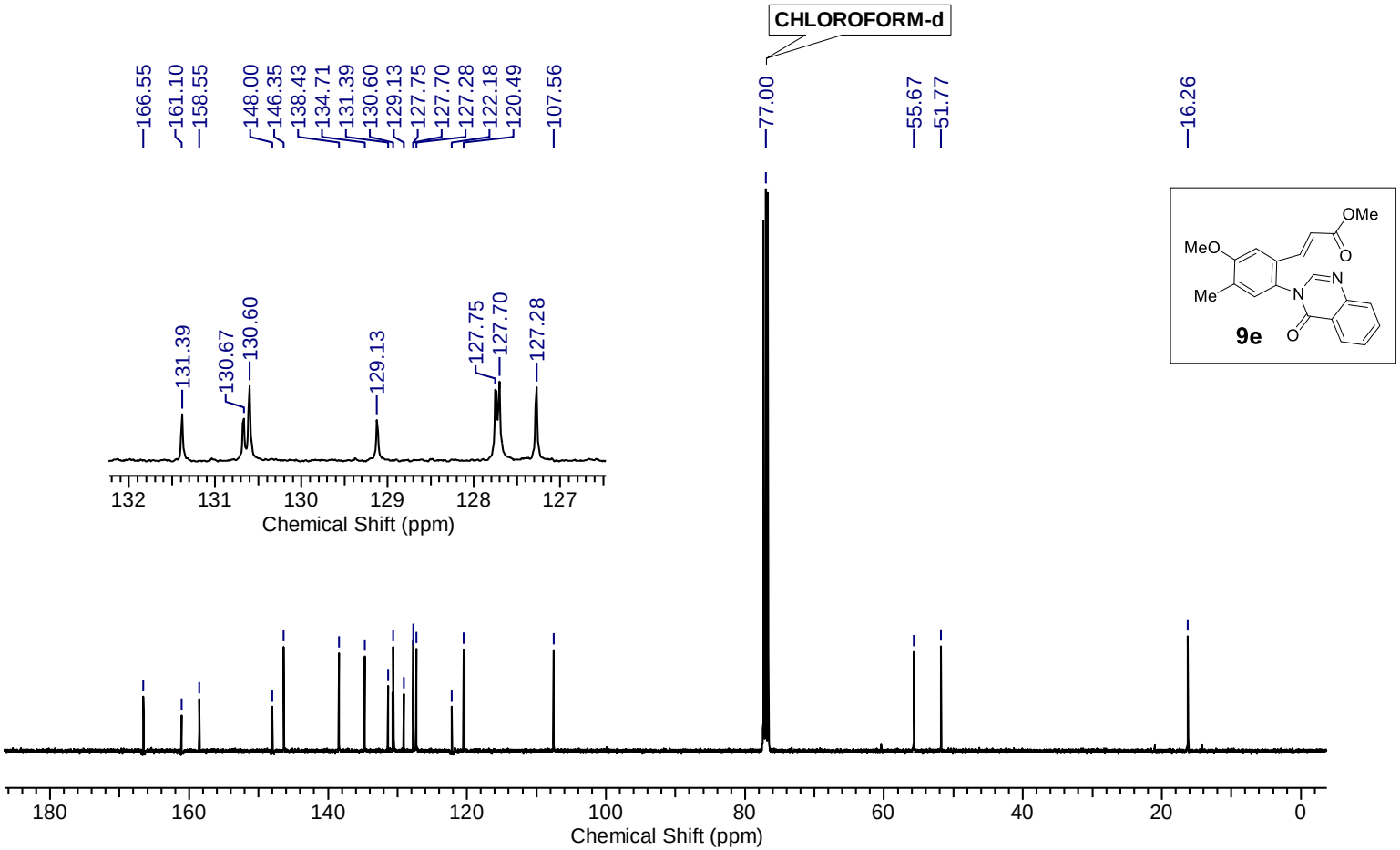
DEPT NMR


133.85
129.39
129.11
126.44
125.20
121.86
116.68
76.83
37.62
36.02
Cl
H
O
N
N
H
O
2d
133.85
129.39
129.11
126.44
125.20
121.86
135
130
125
120
Chemical Shift (ppm)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Chemical Shift (ppm)

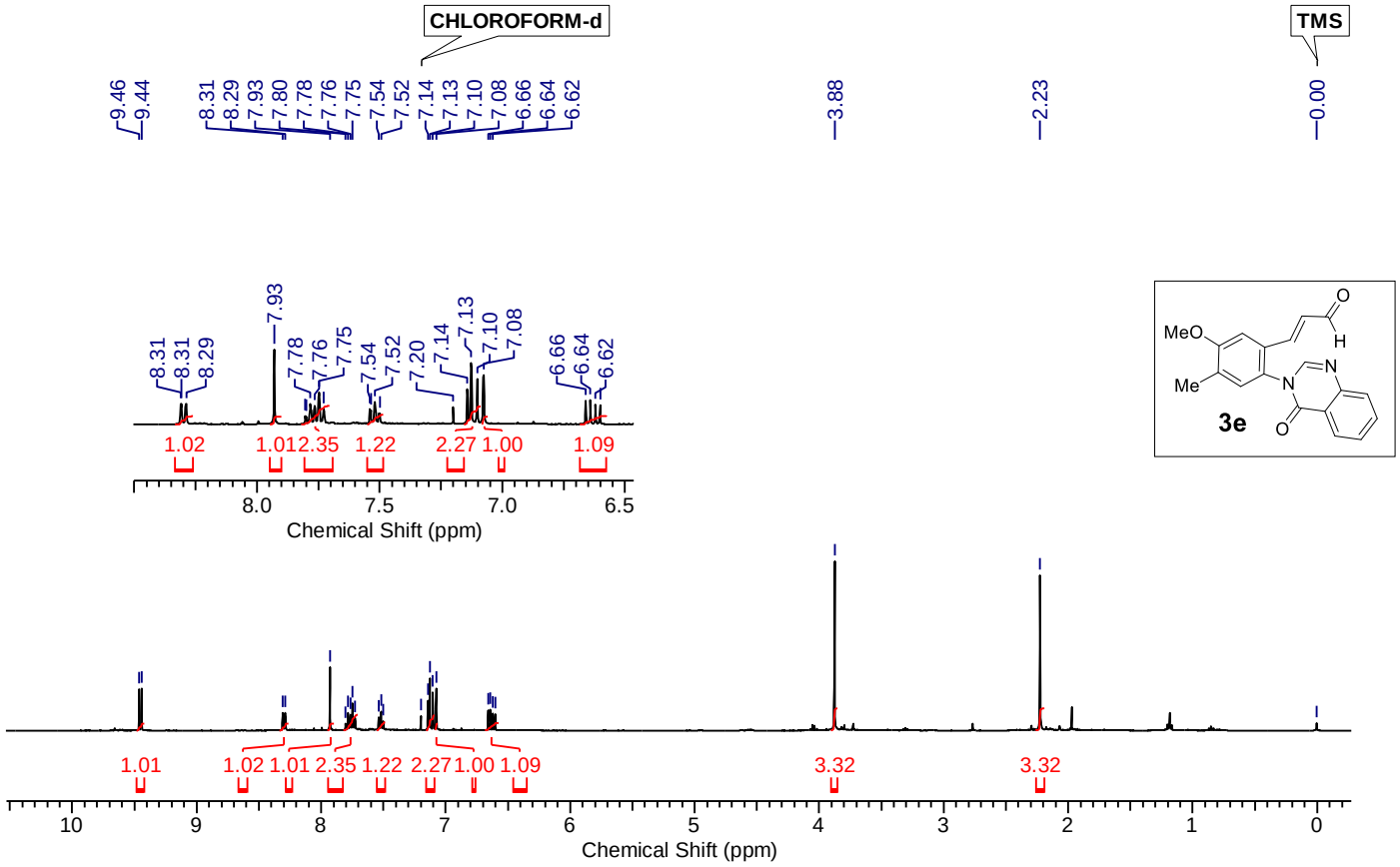
^{1}H NMR (400 MHz, $CDCl_3$)



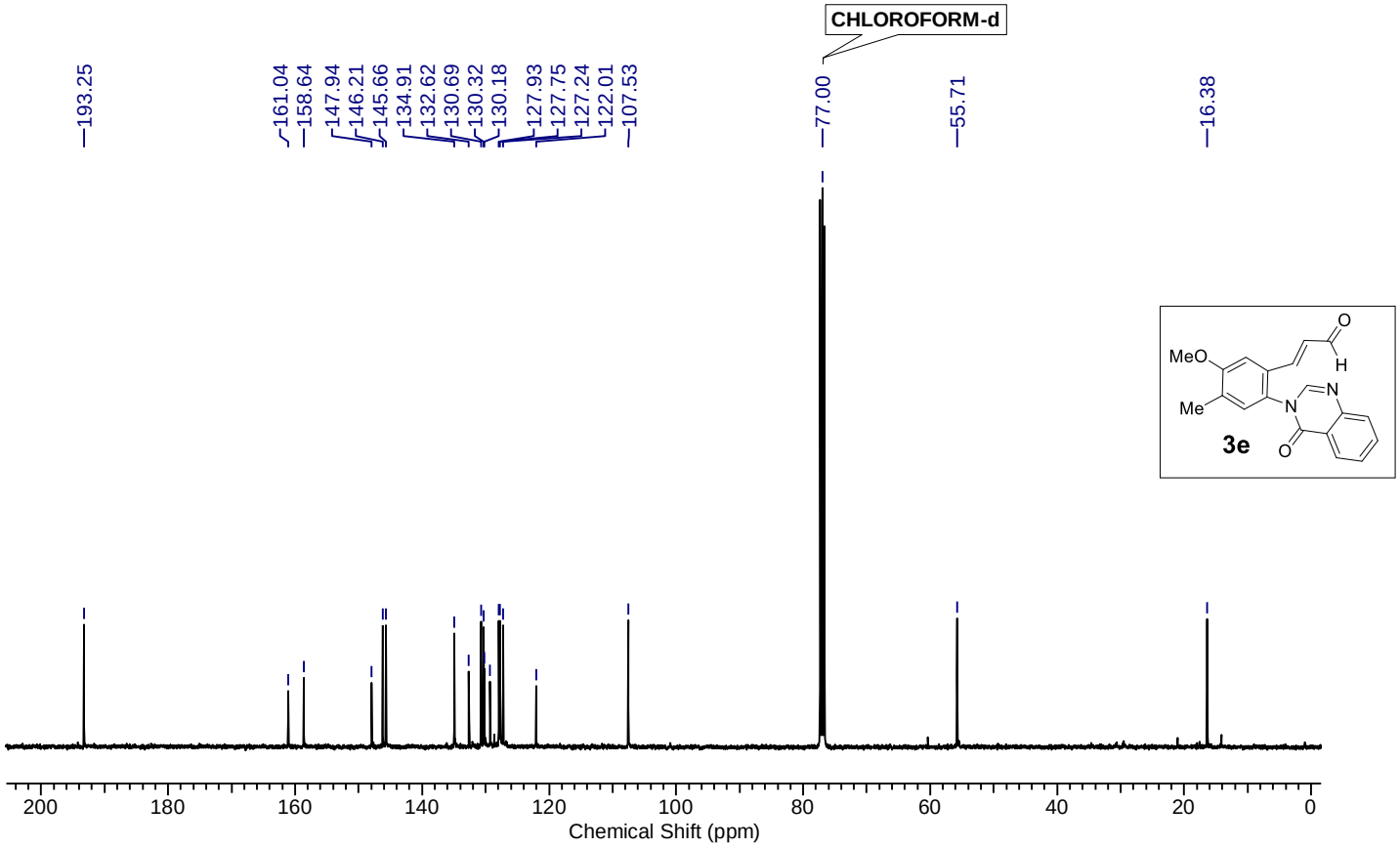
^{13}C NMR (100 MHz, $CDCl_3$)



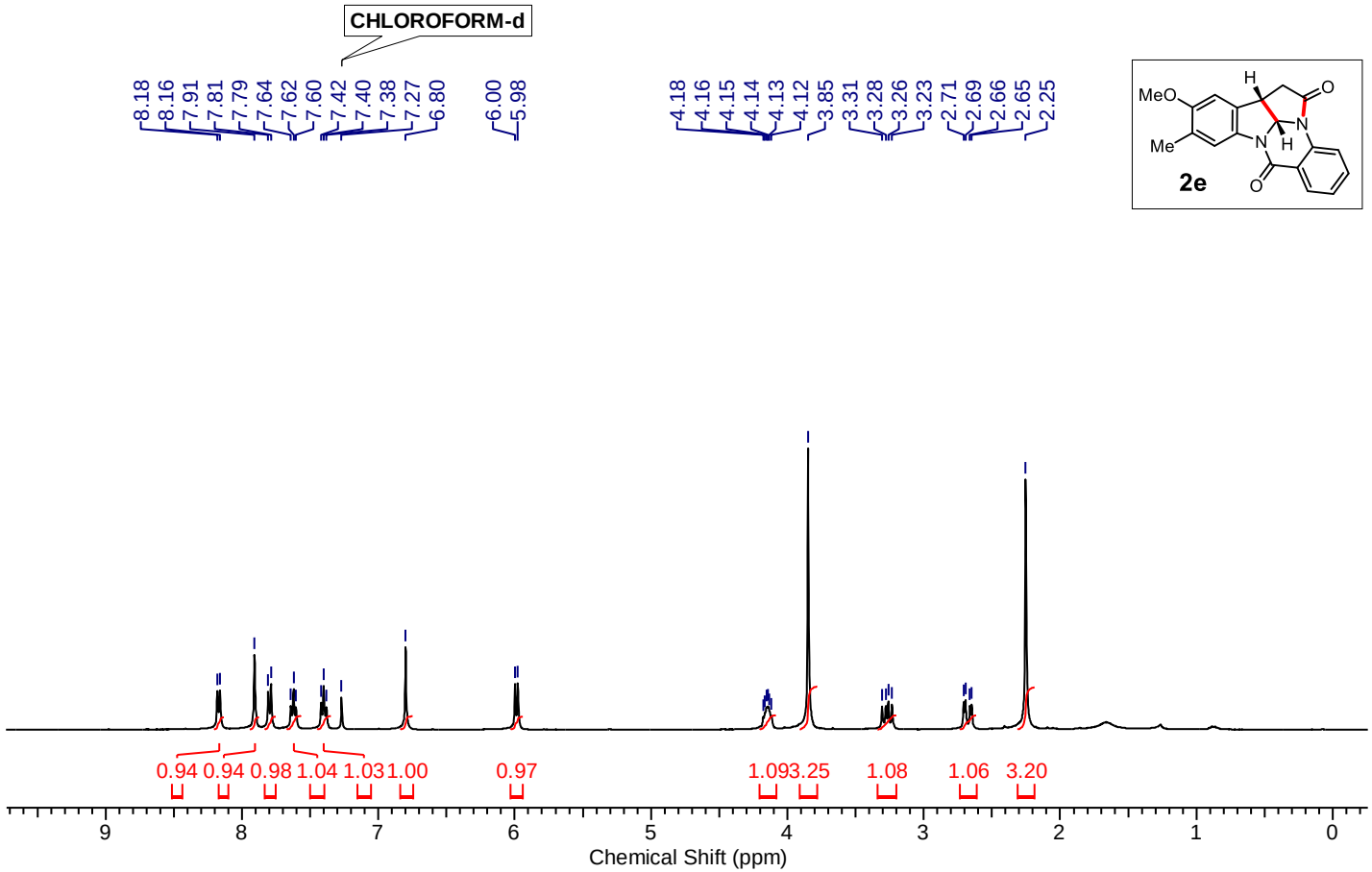
^{1}H NMR (400 MHz, $CDCl_3$)



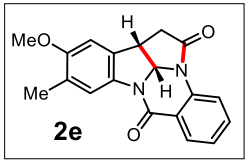
^{13}C NMR (100 MHz, $CDCl_3$)

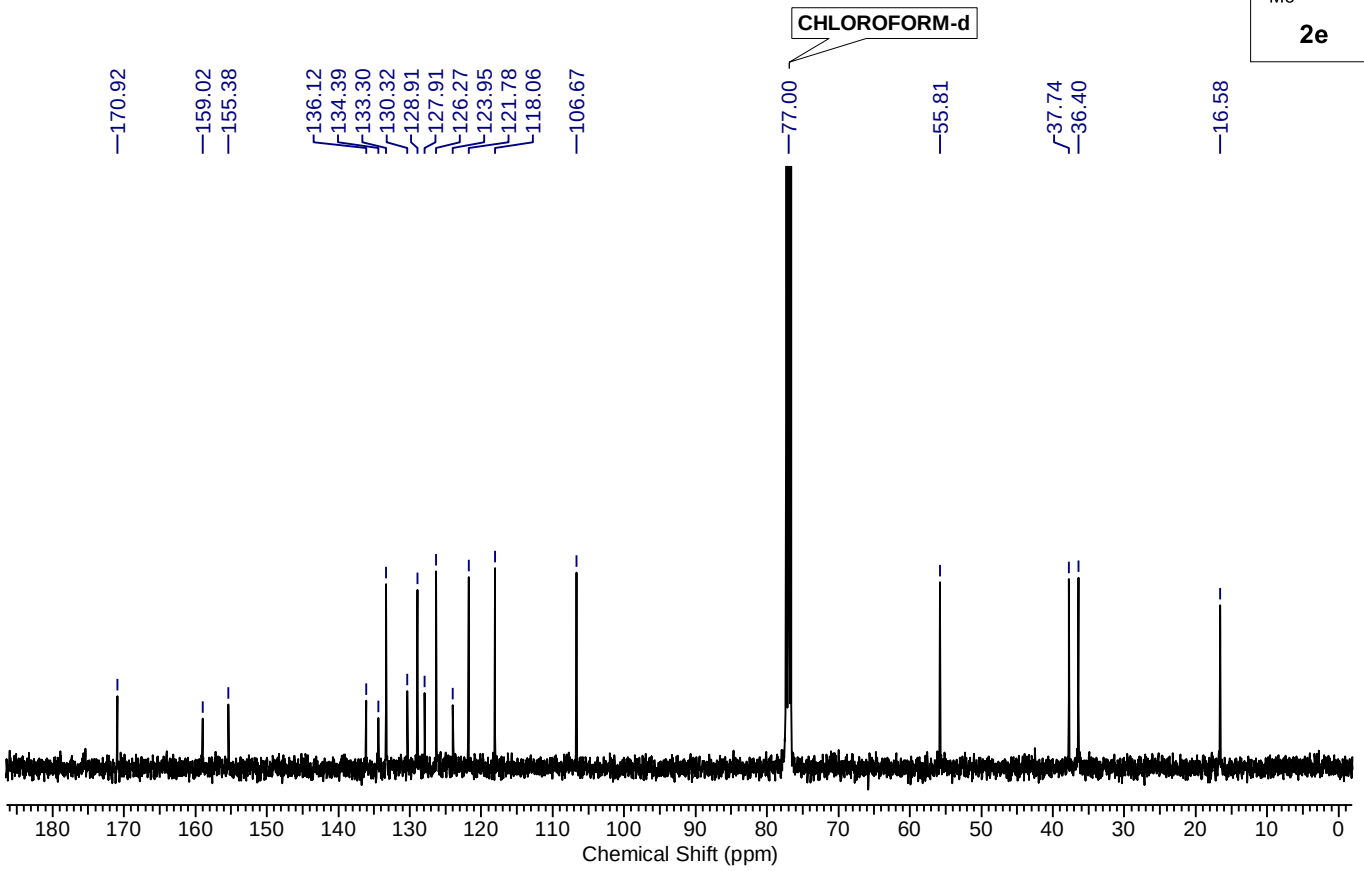


^{1}H NMR (400 MHz, $CDCl_3$)

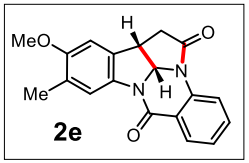


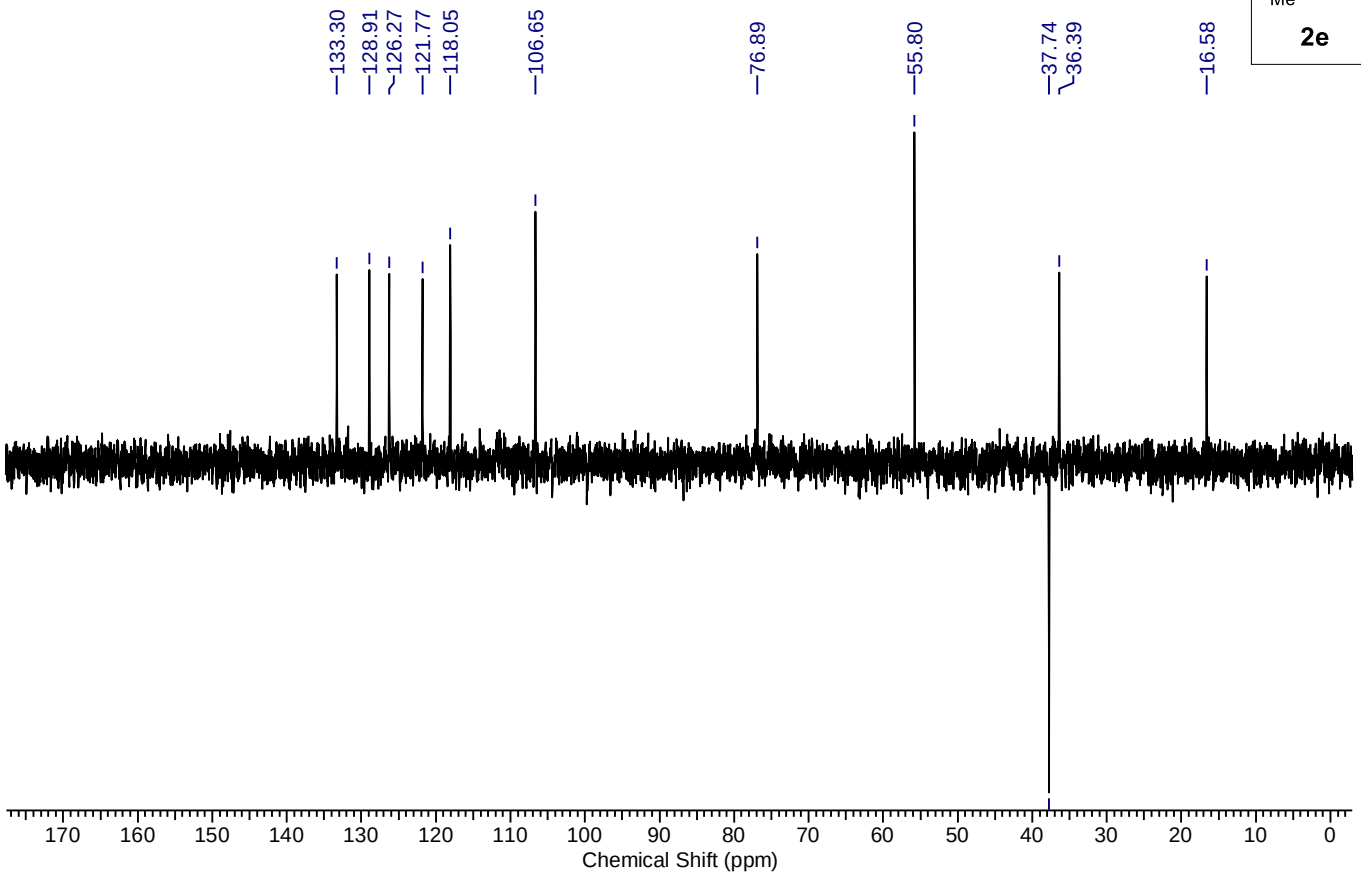
^{13}C NMR (100 MHz, $CDCl_3$)



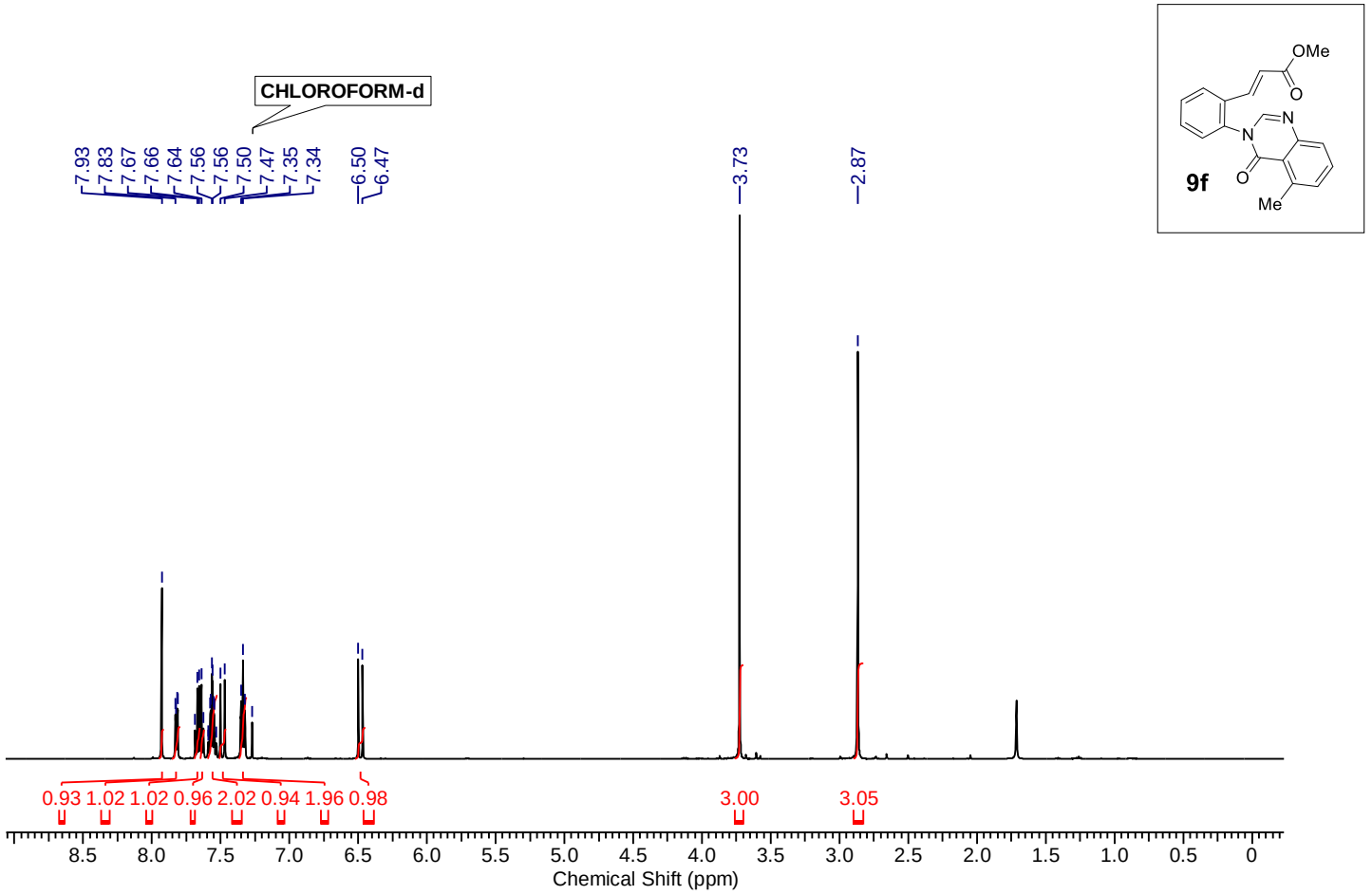


DEPT NMR

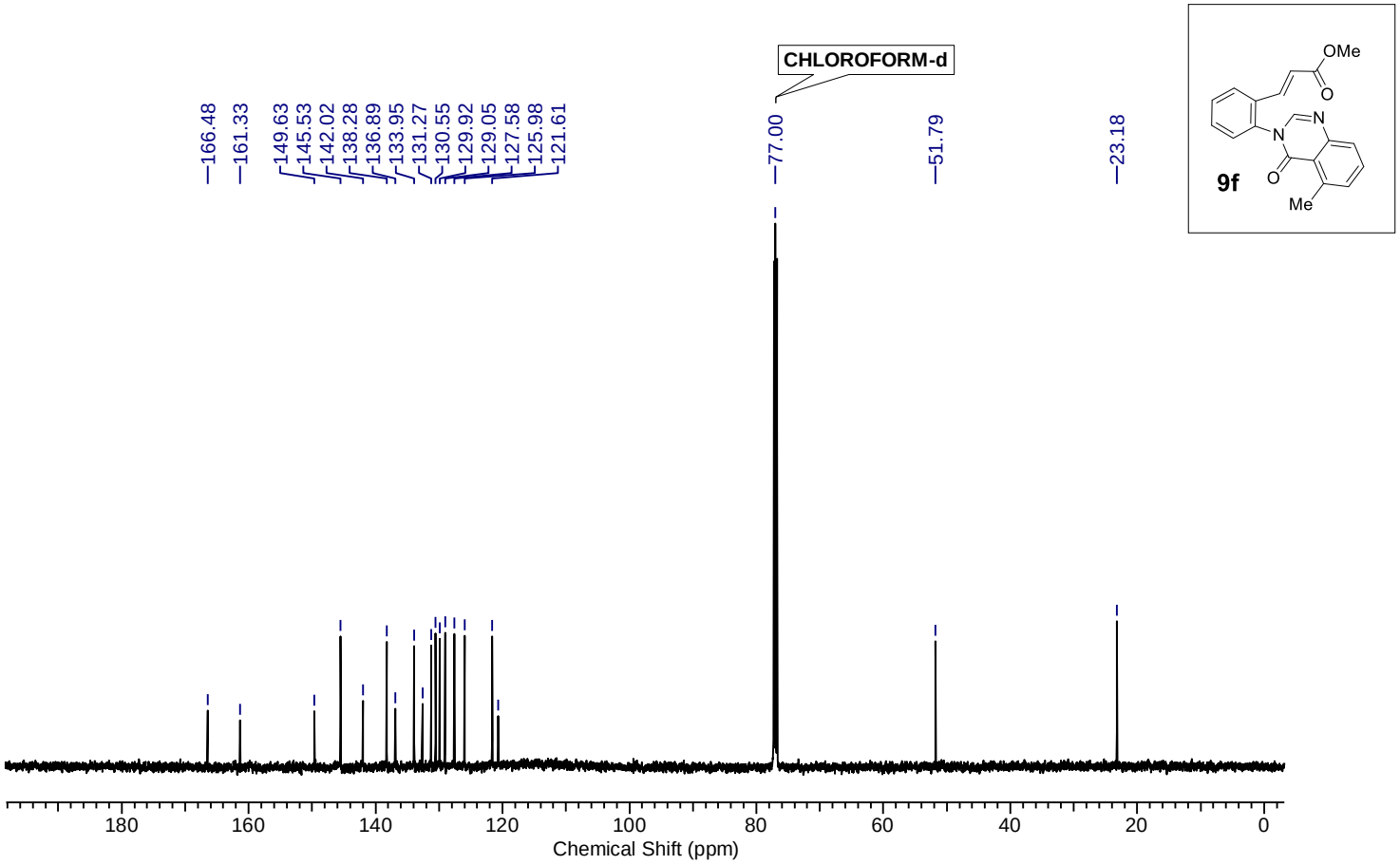

MeO
Me
H
O
N
N
H
O
2e


133.30
128.91
126.27
121.77
118.05
106.65
76.89
55.80
37.74
36.39
16.58
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Chemical Shift (ppm)

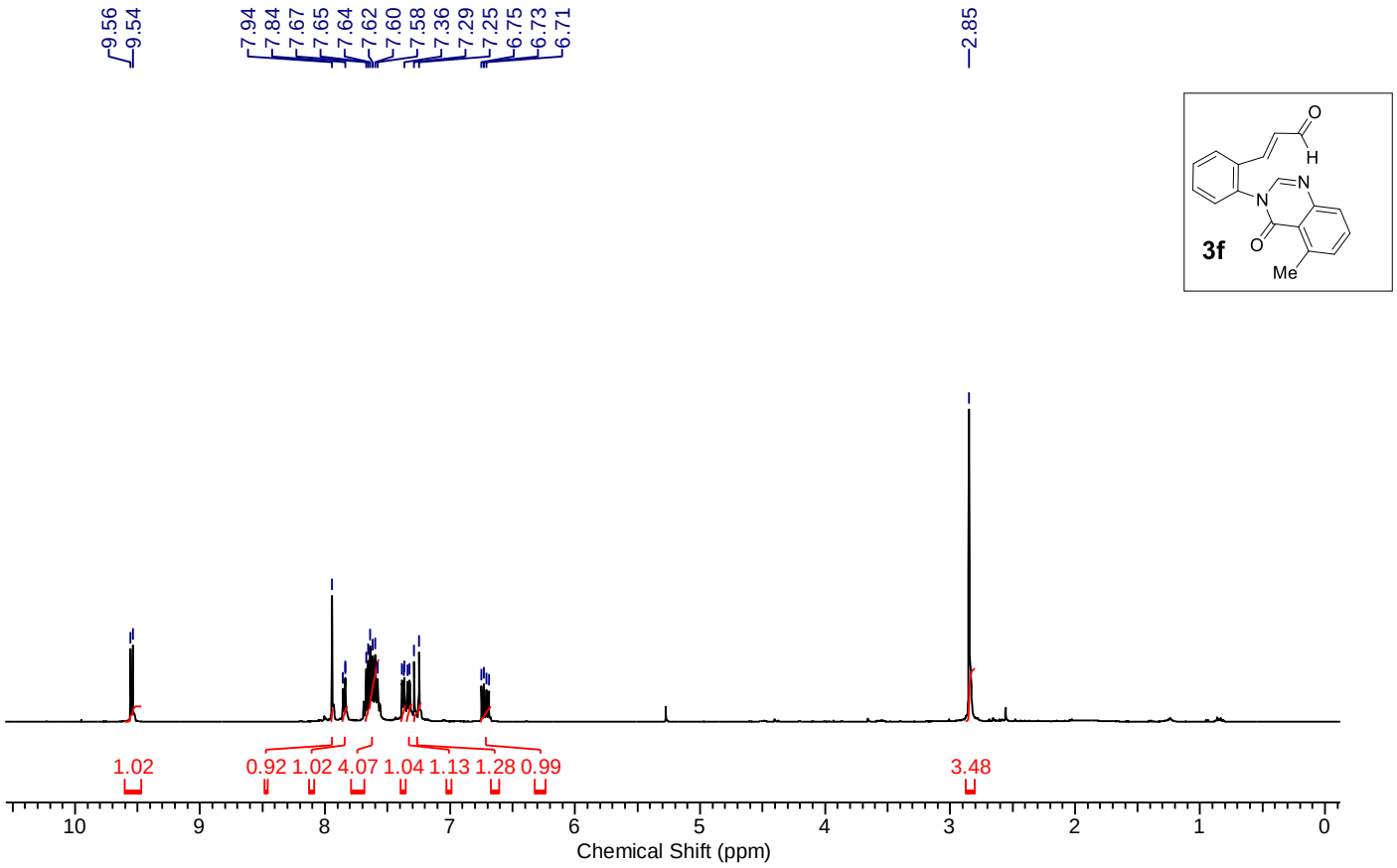
^{1}H NMR (500 MHz, $CDCl_3$)



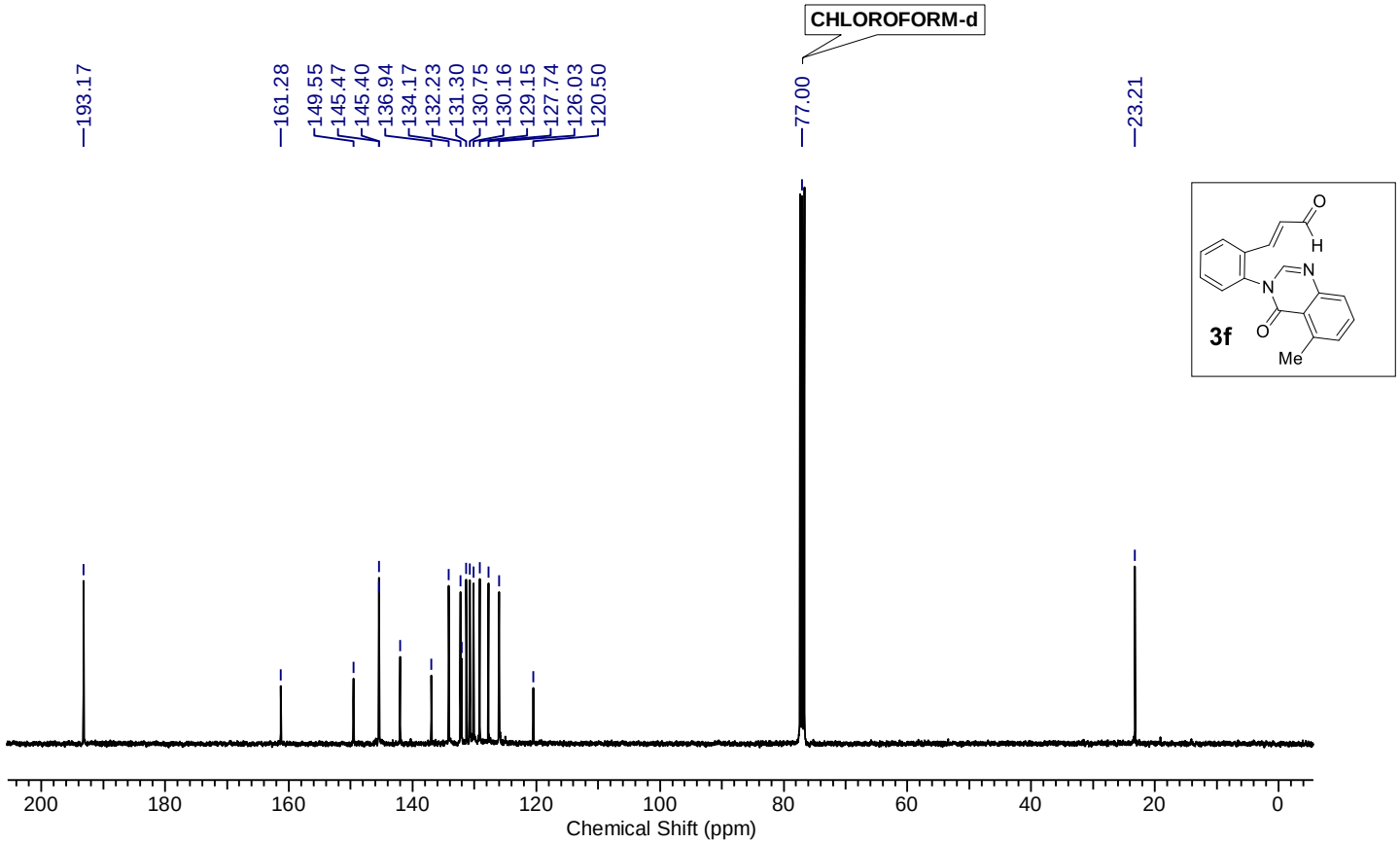
^{13}C NMR (125 MHz, $CDCl_3$)



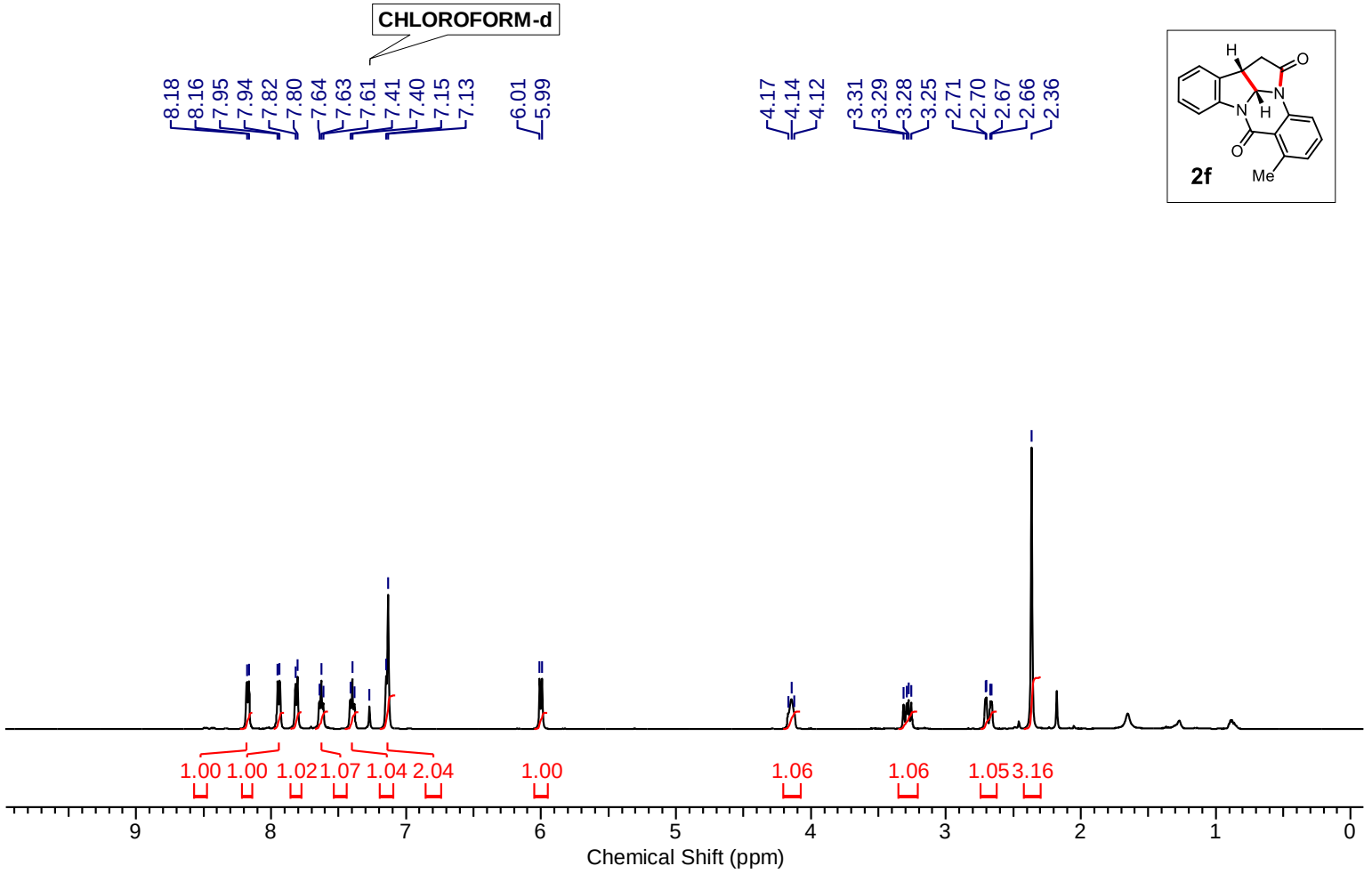
^{1}H NMR (400 MHz, $CDCl_3$)



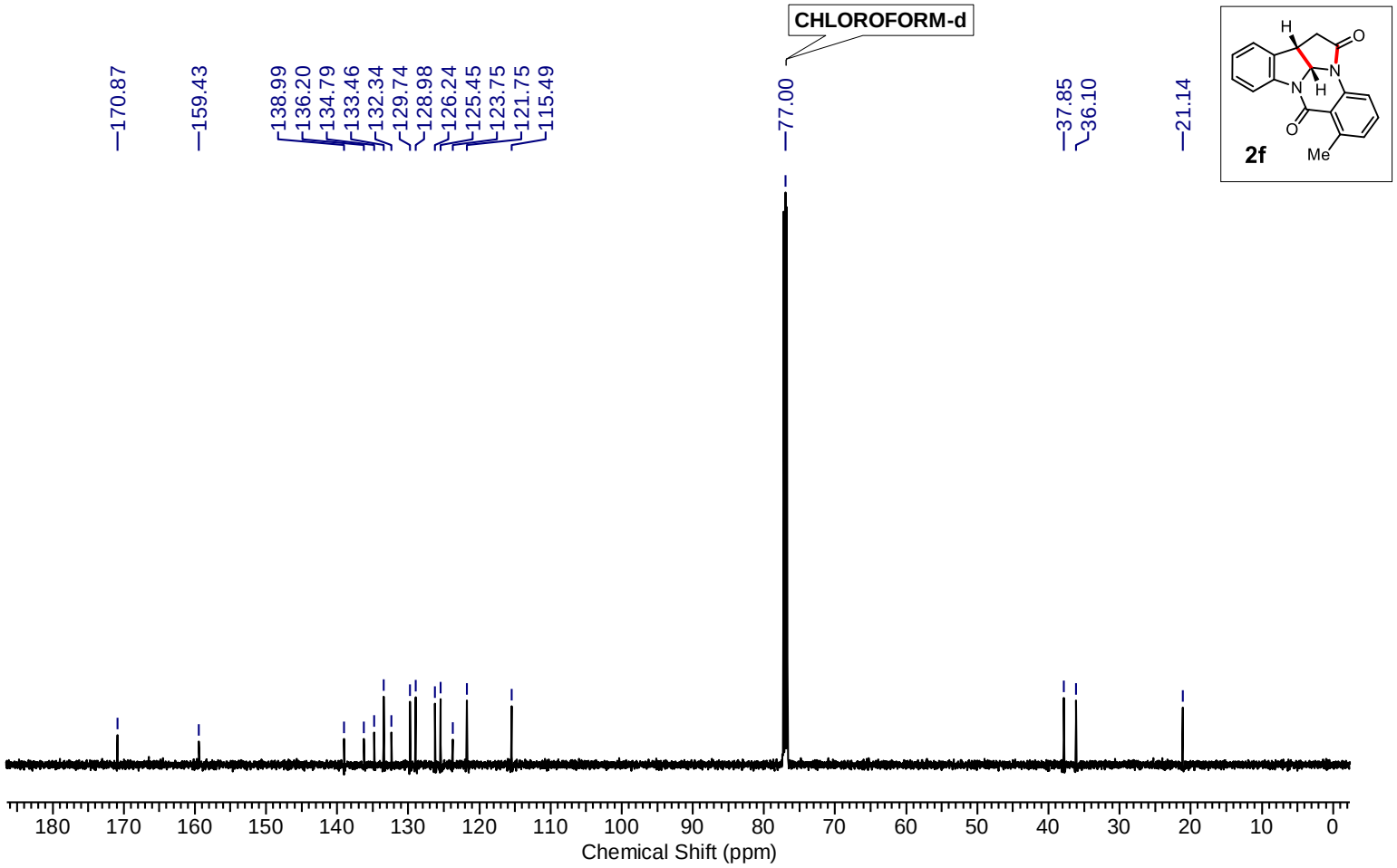
^{13}C NMR (100 MHz, $CDCl_3$)



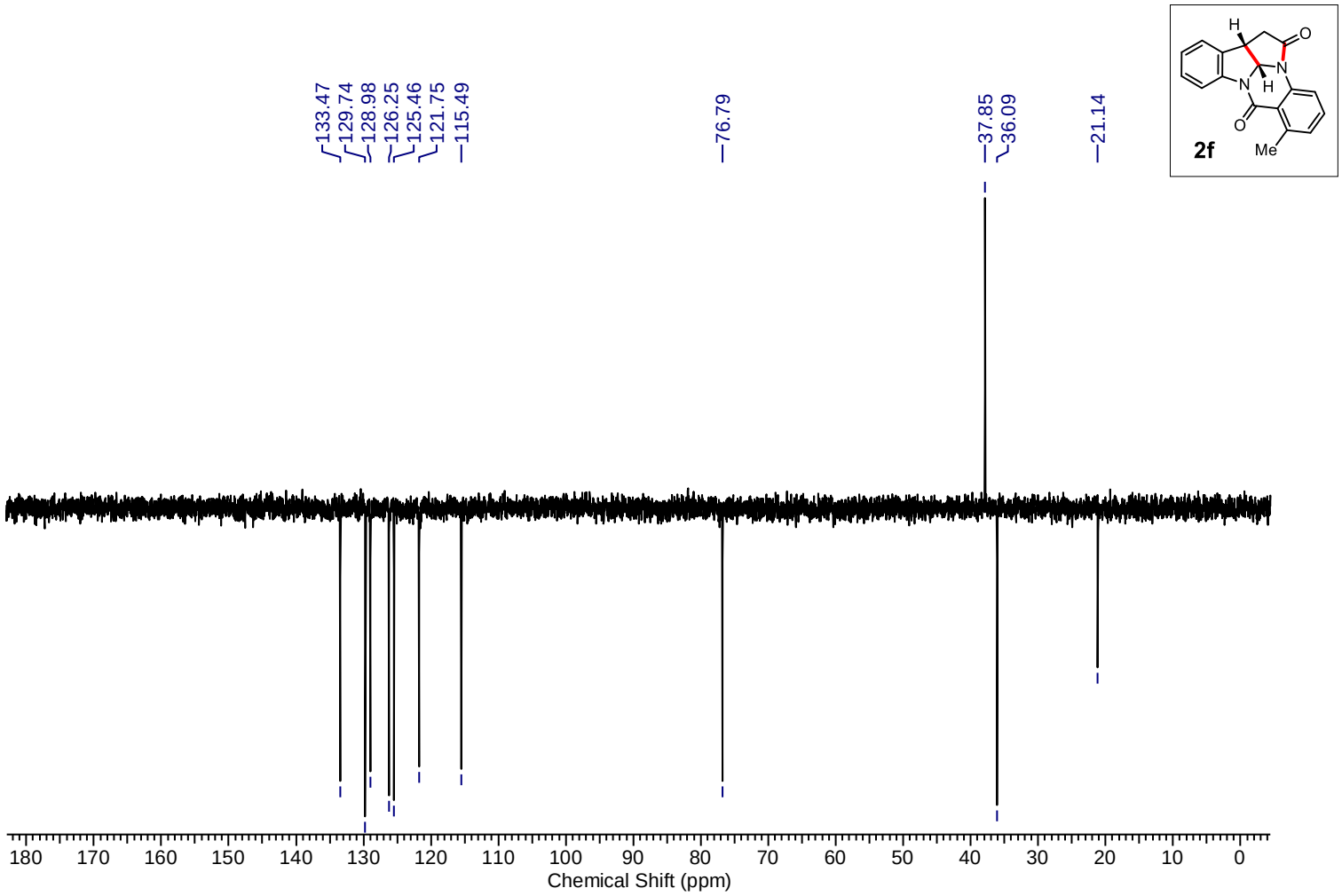
^{1}H NMR (400 MHz, $CDCl_3$)



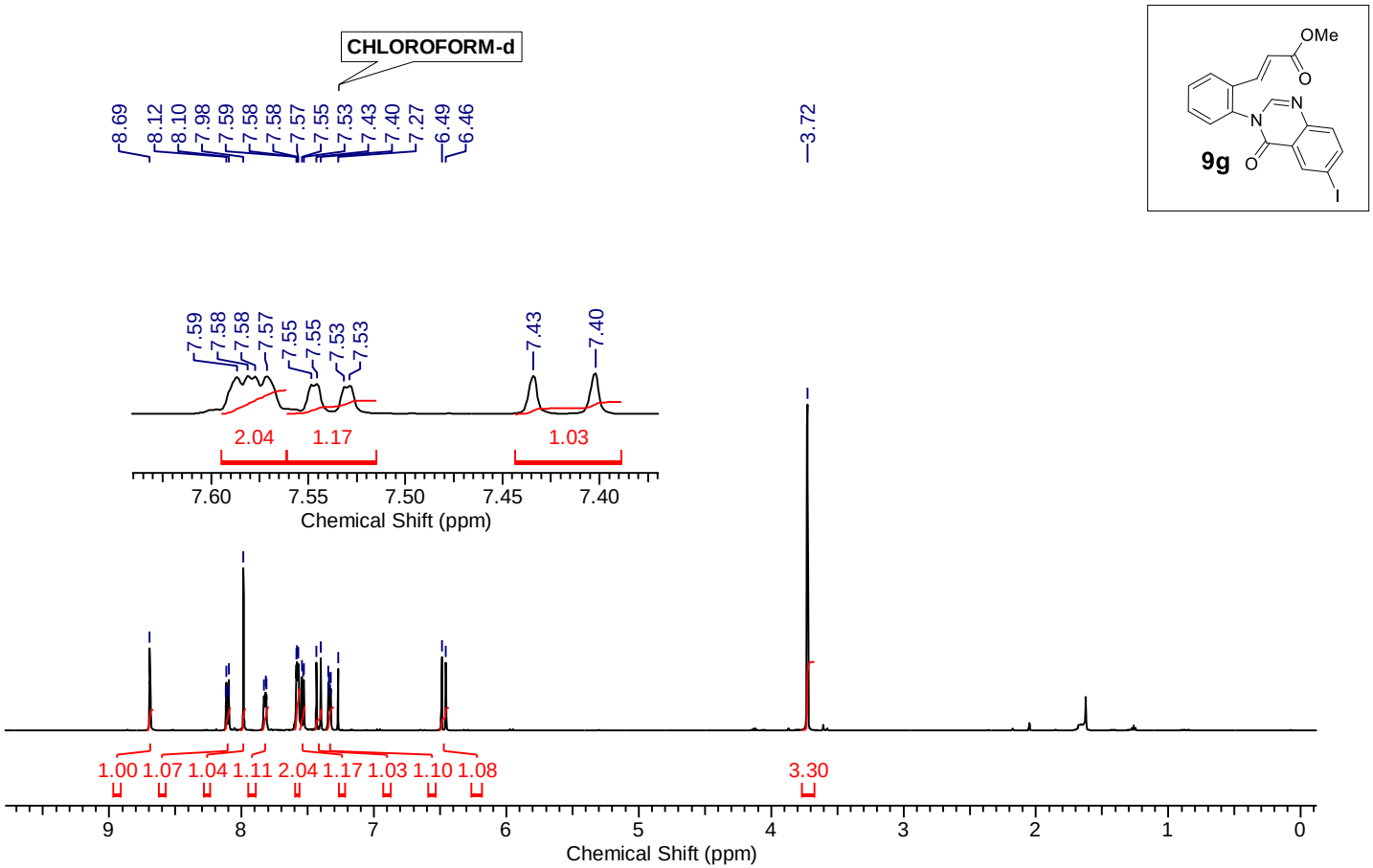
^{13}C NMR (100 MHz, $CDCl_3$)



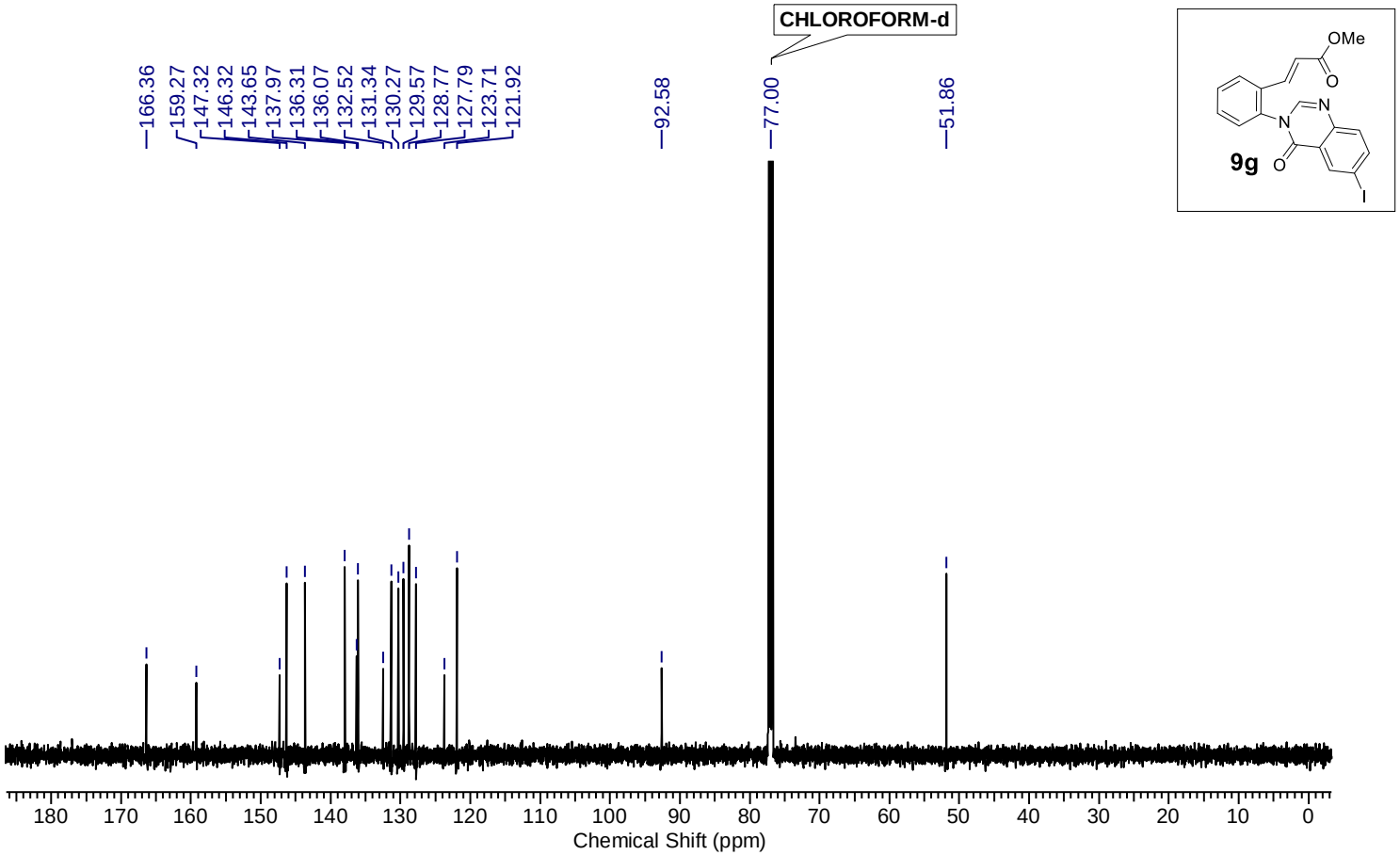
DEPT NMR


133.47
129.74
128.98
126.25
125.46
121.75
115.49
76.79
37.85
36.09
21.14
H
O
N
N
H
O
Me
2f
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Chemical Shift (ppm)

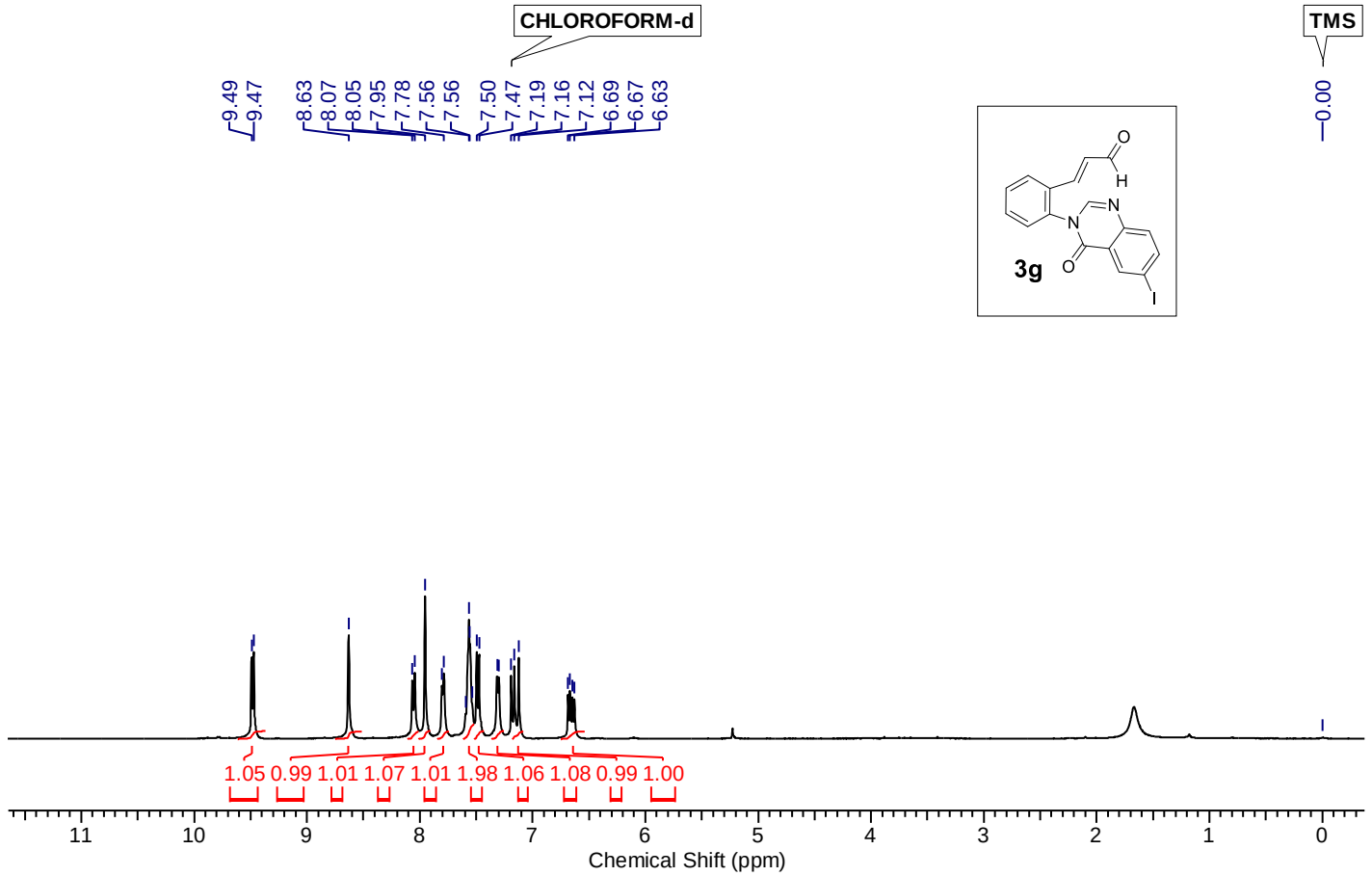
^{1}H NMR (500 MHz, $CDCl_3$)



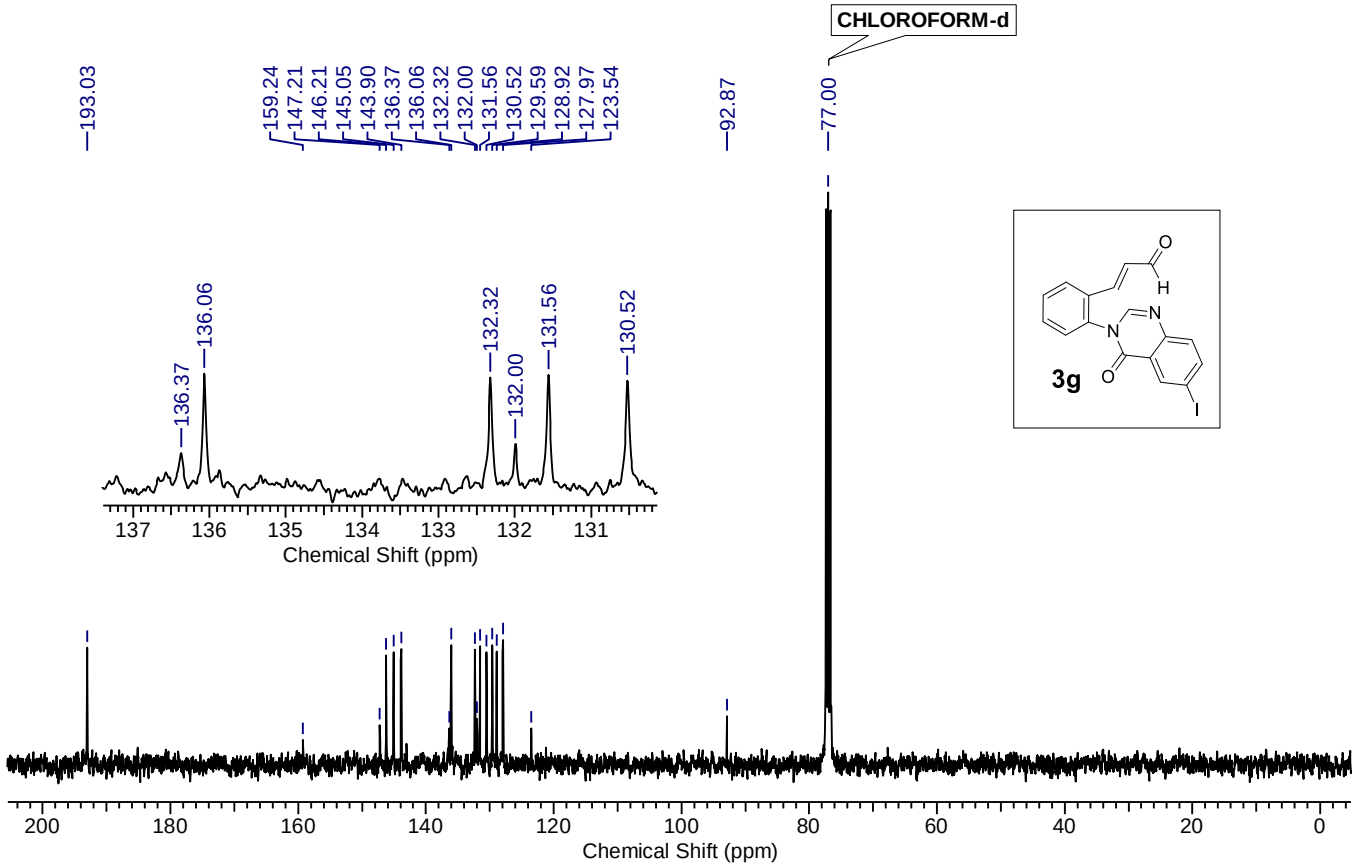
^{13}C NMR (125 MHz, $CDCl_3$)



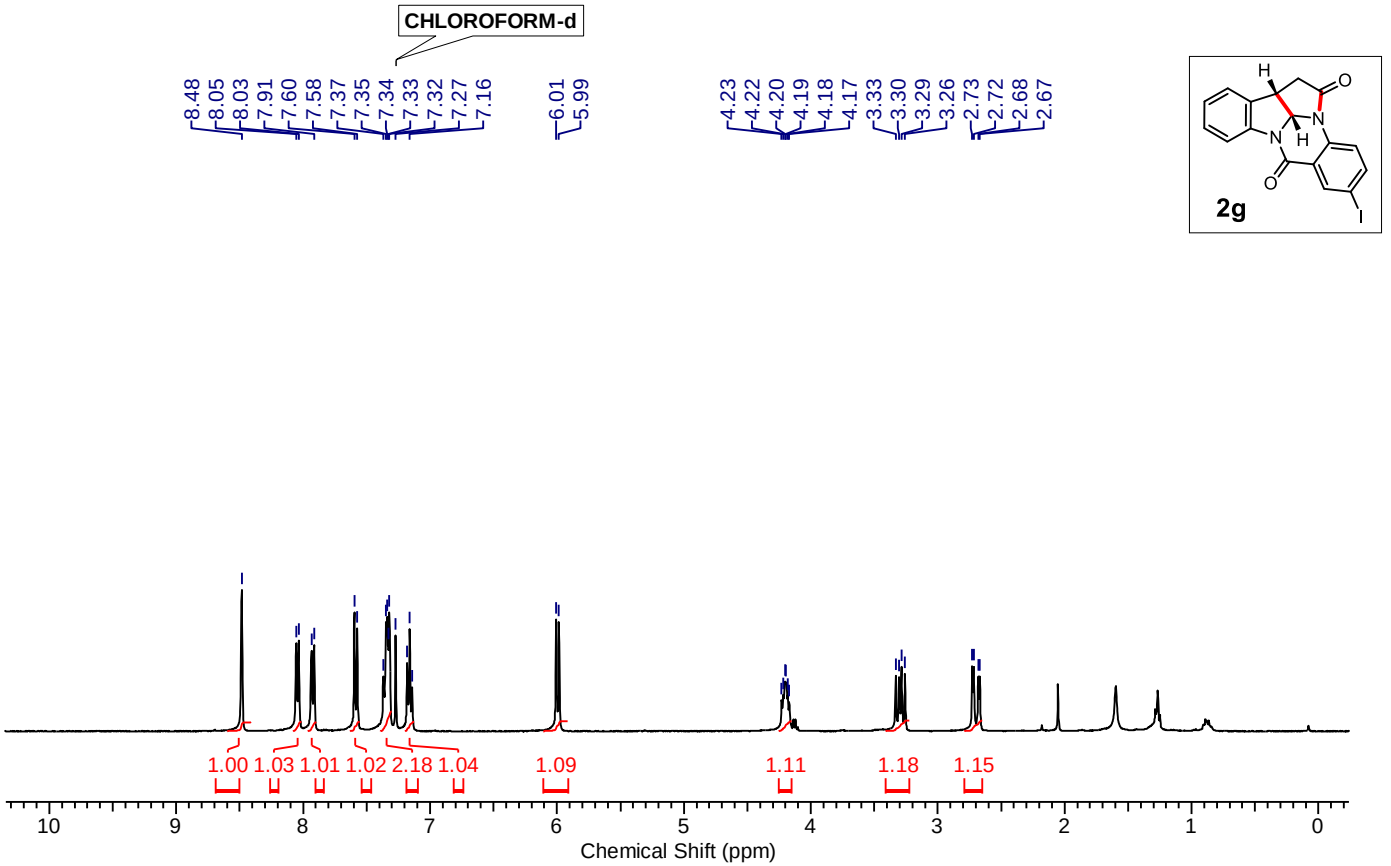
^{1}H NMR (400 MHz, $CDCl_3$)



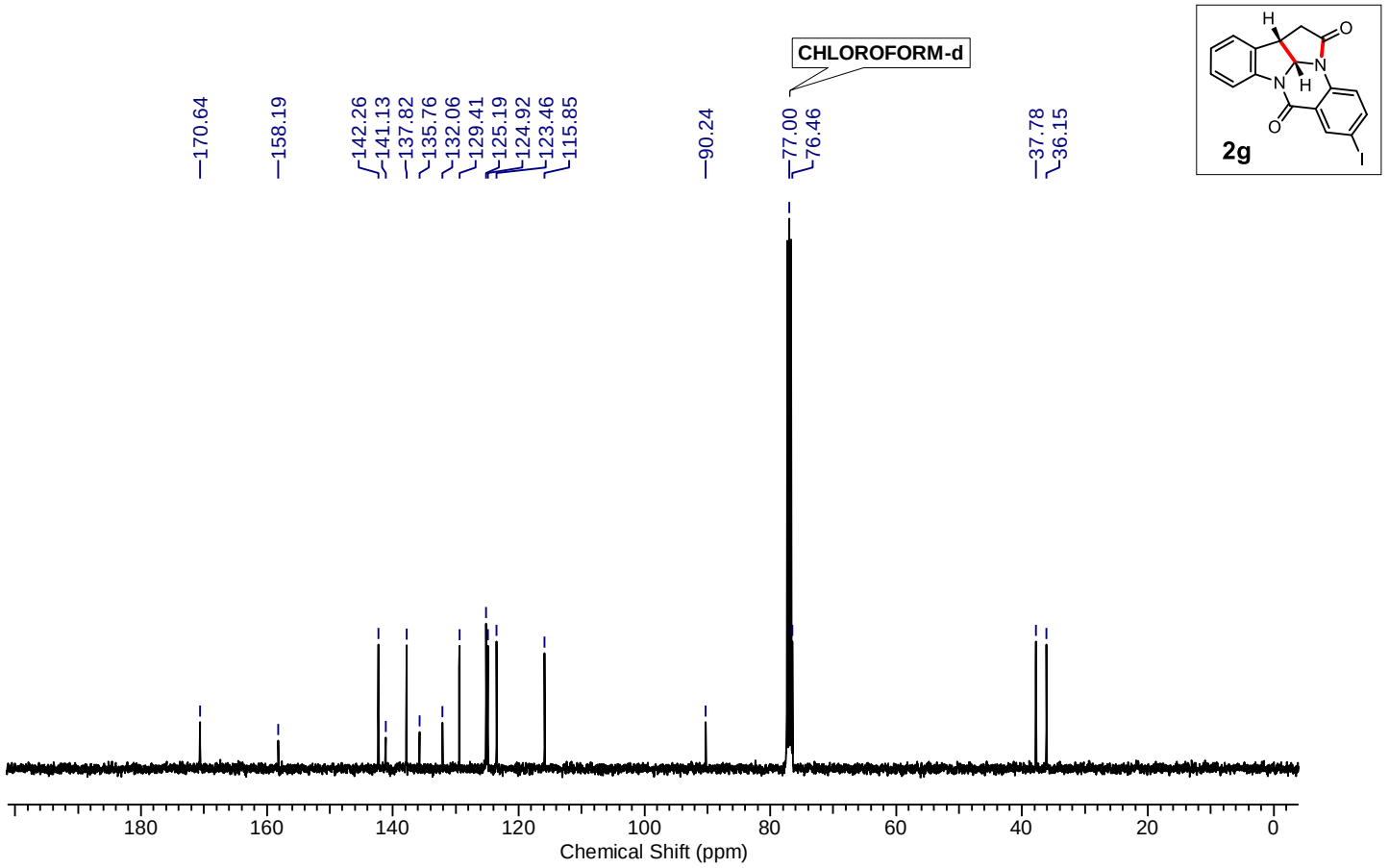
^{13}C NMR (100 MHz, $CDCl_3$)



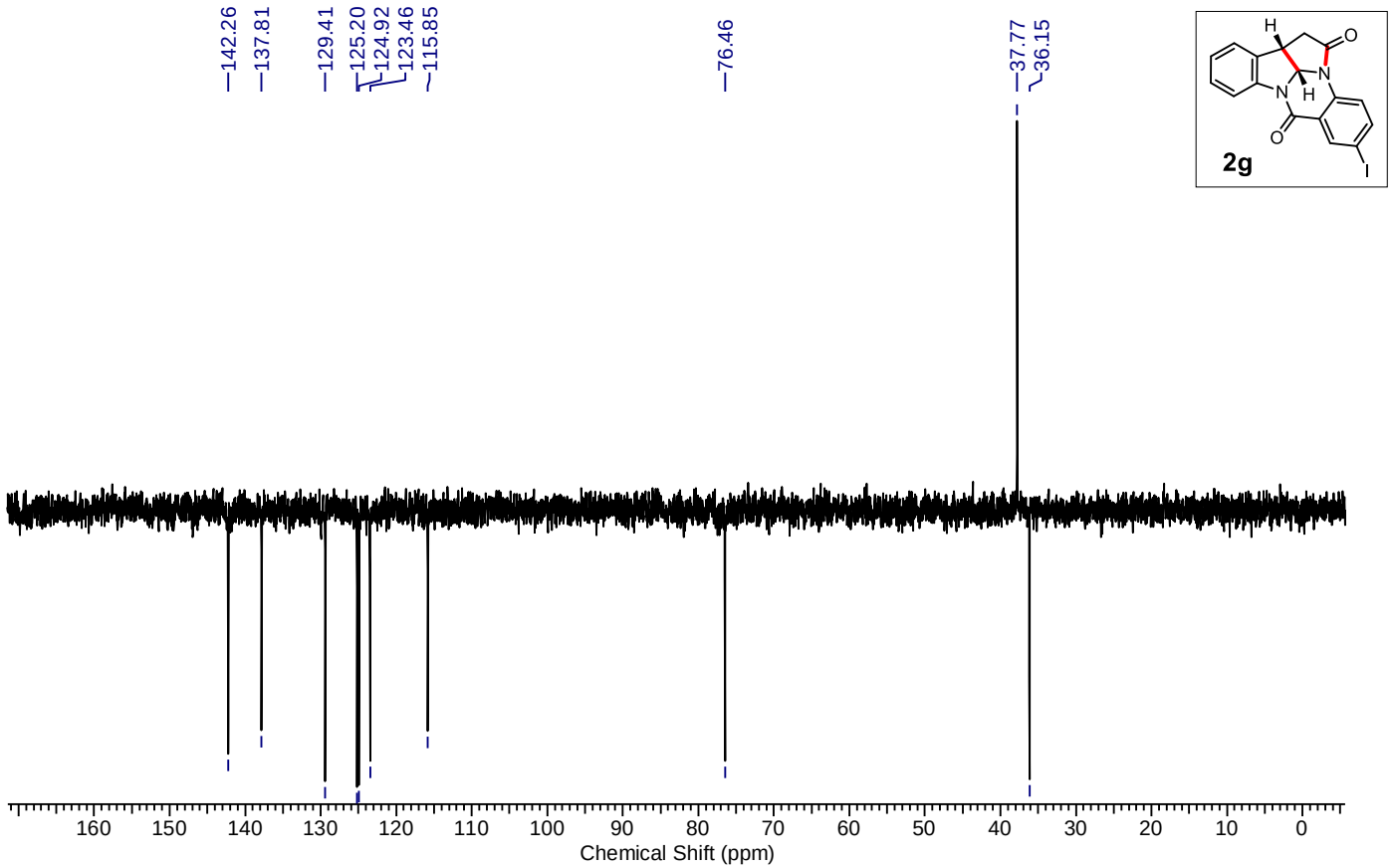
^{1}H NMR (400 MHz, $CDCl_3$)



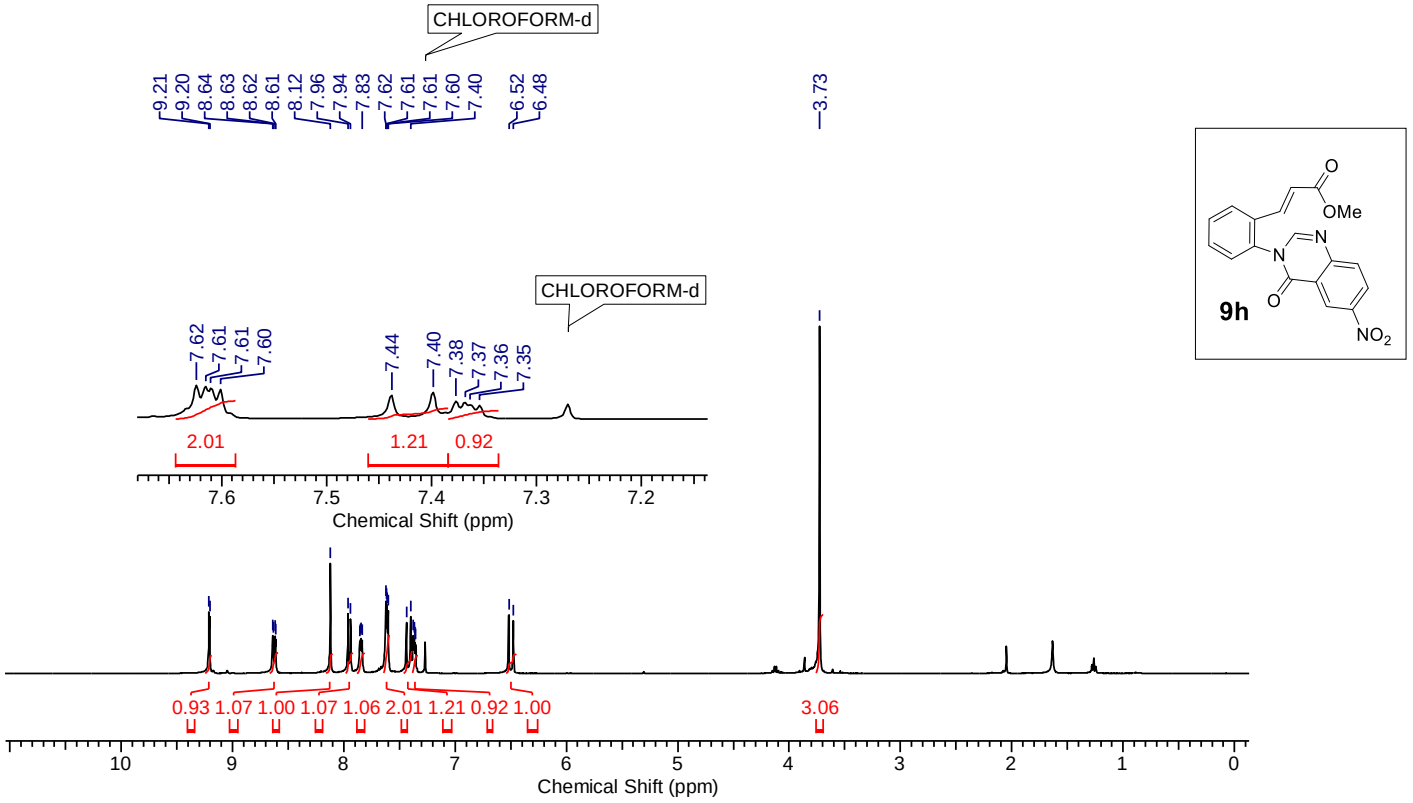
^{13}C NMR (100 MHz, $CDCl_3$)



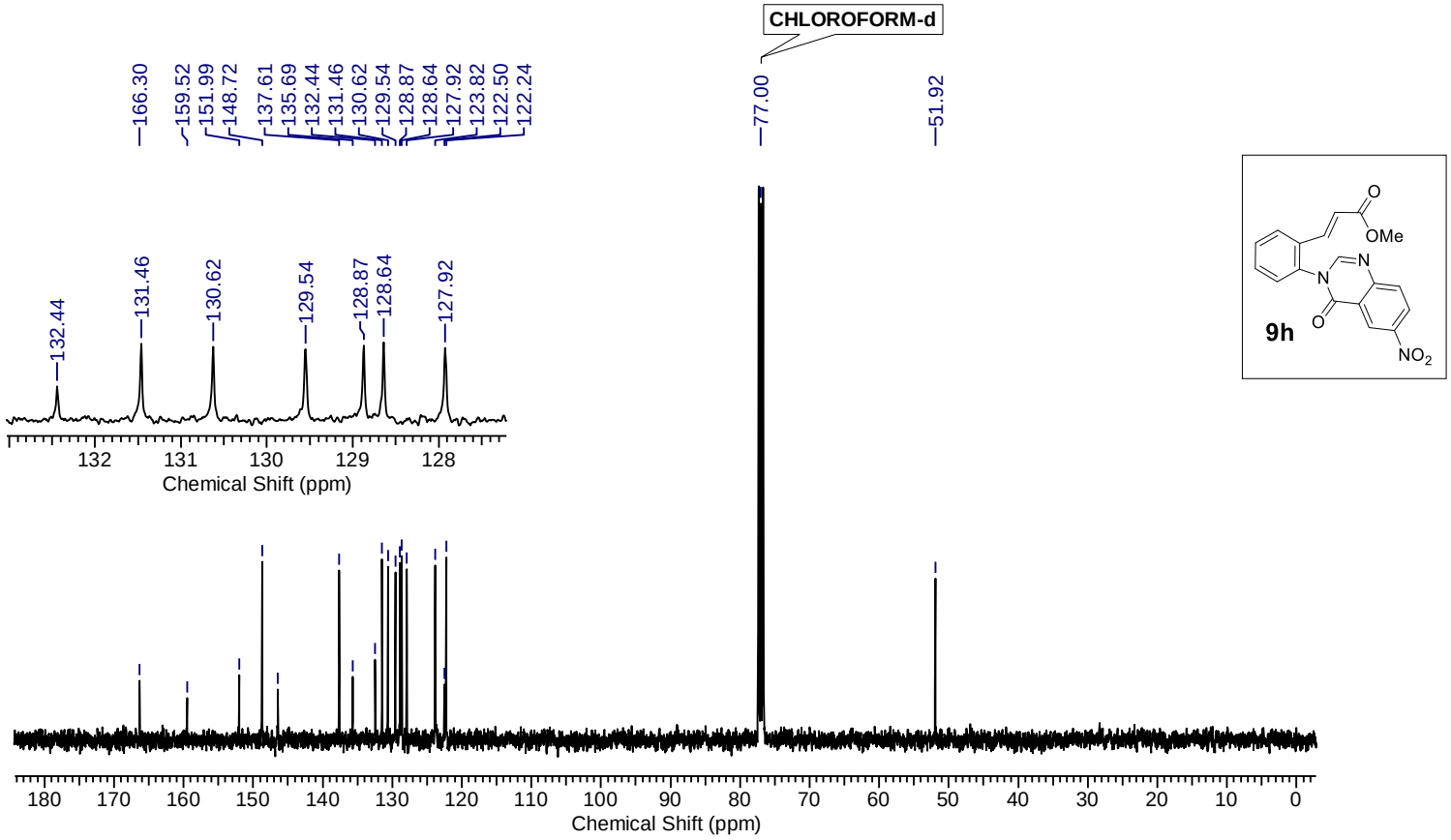
DEPT NMR


142.26
137.81
129.41
125.20
124.92
123.46
115.85
76.46
37.77
36.15
2g
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Chemical Shift (ppm)

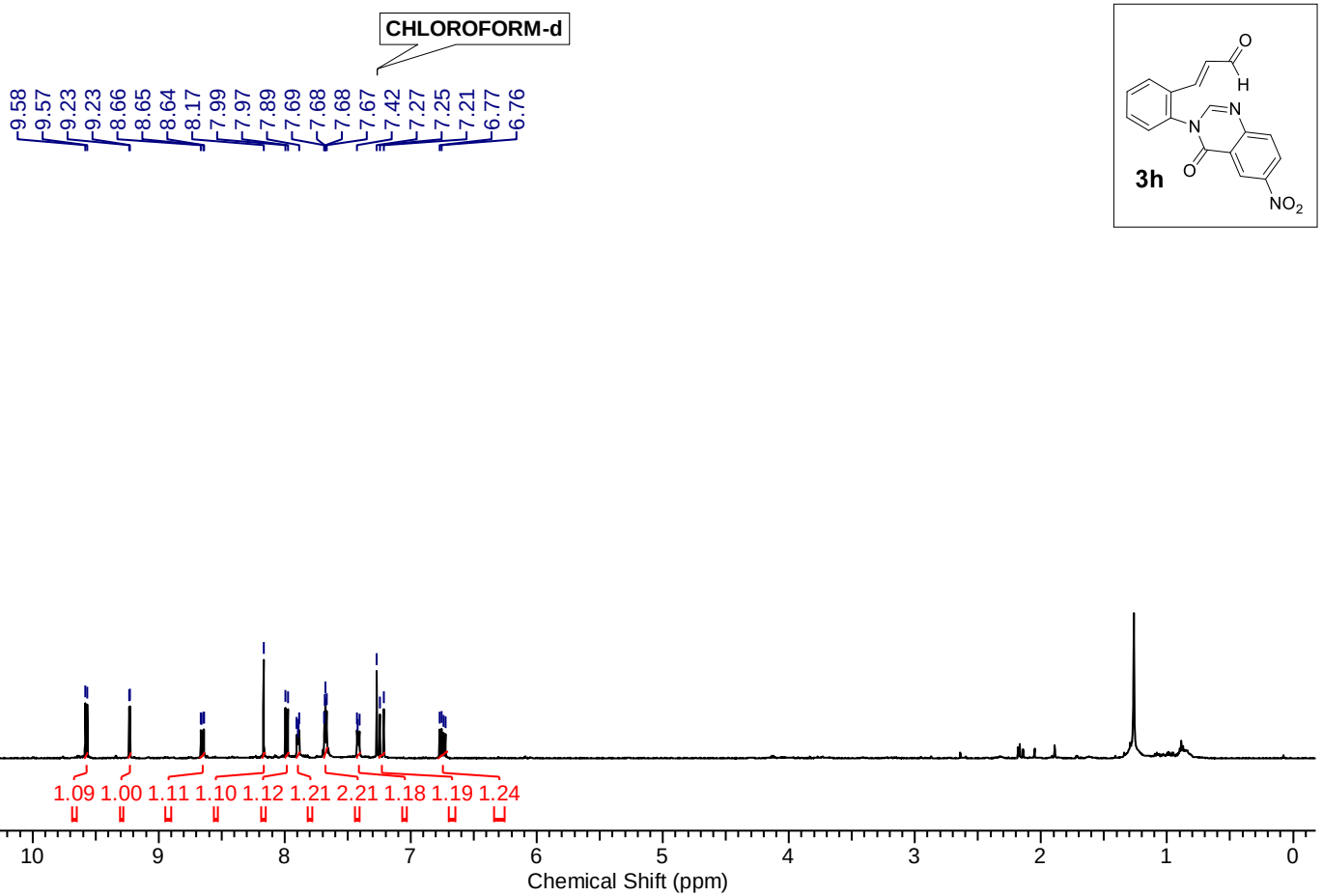
^{1}H NMR (400 MHz, $CDCl_3$)



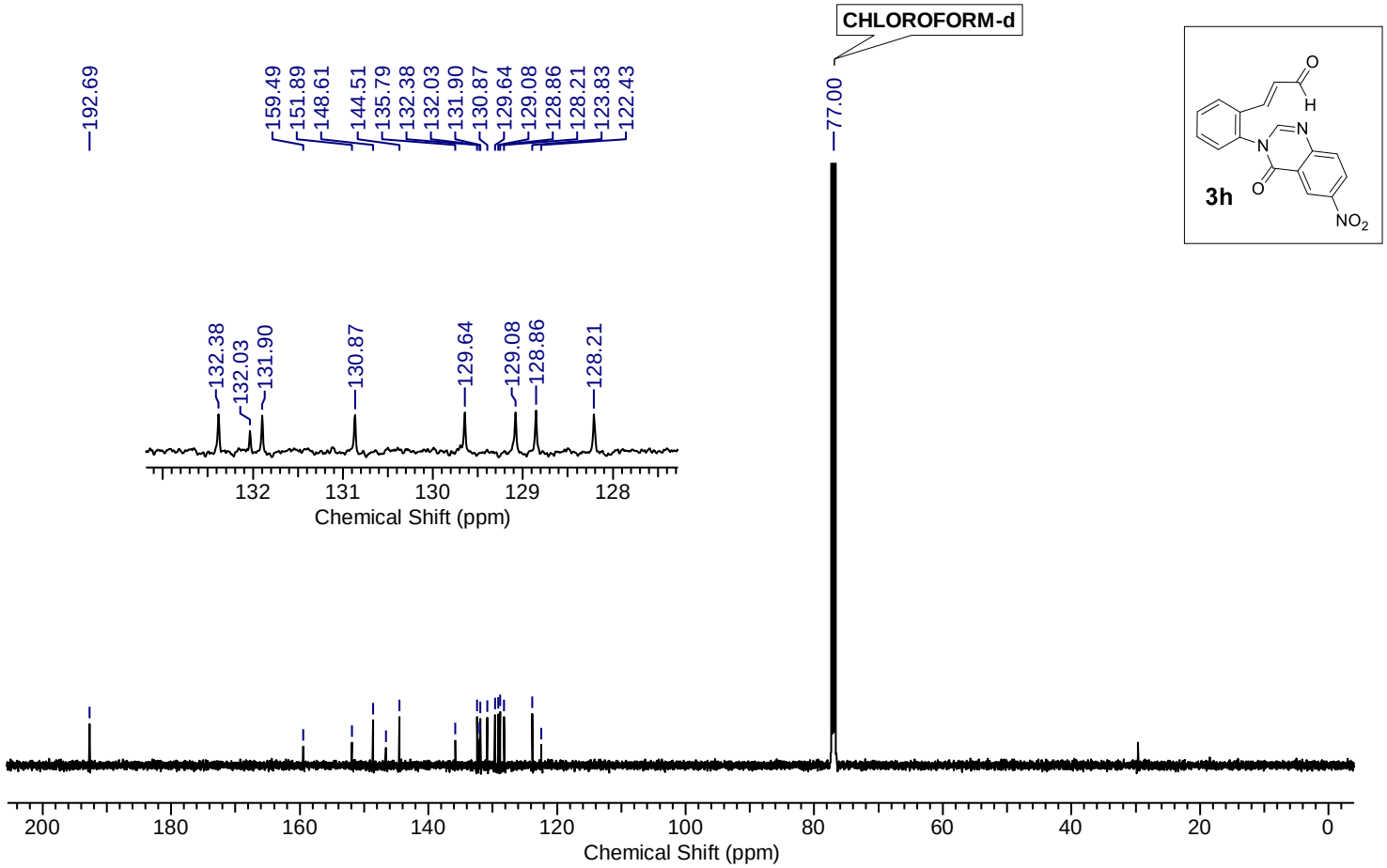
^{13}C NMR (100 MHz, $CDCl_3$)



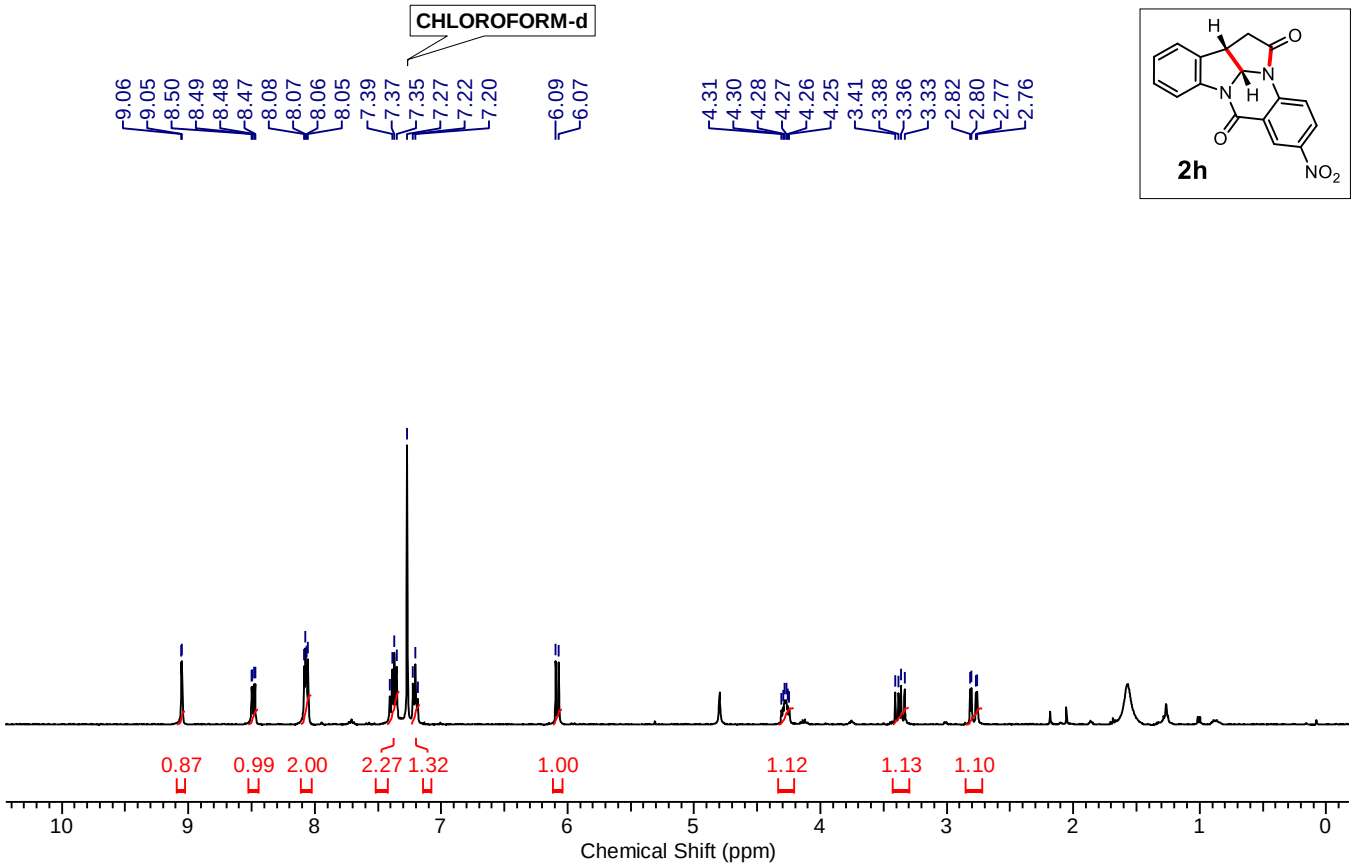
^{1}H NMR (500 MHz, $CDCl_3$)



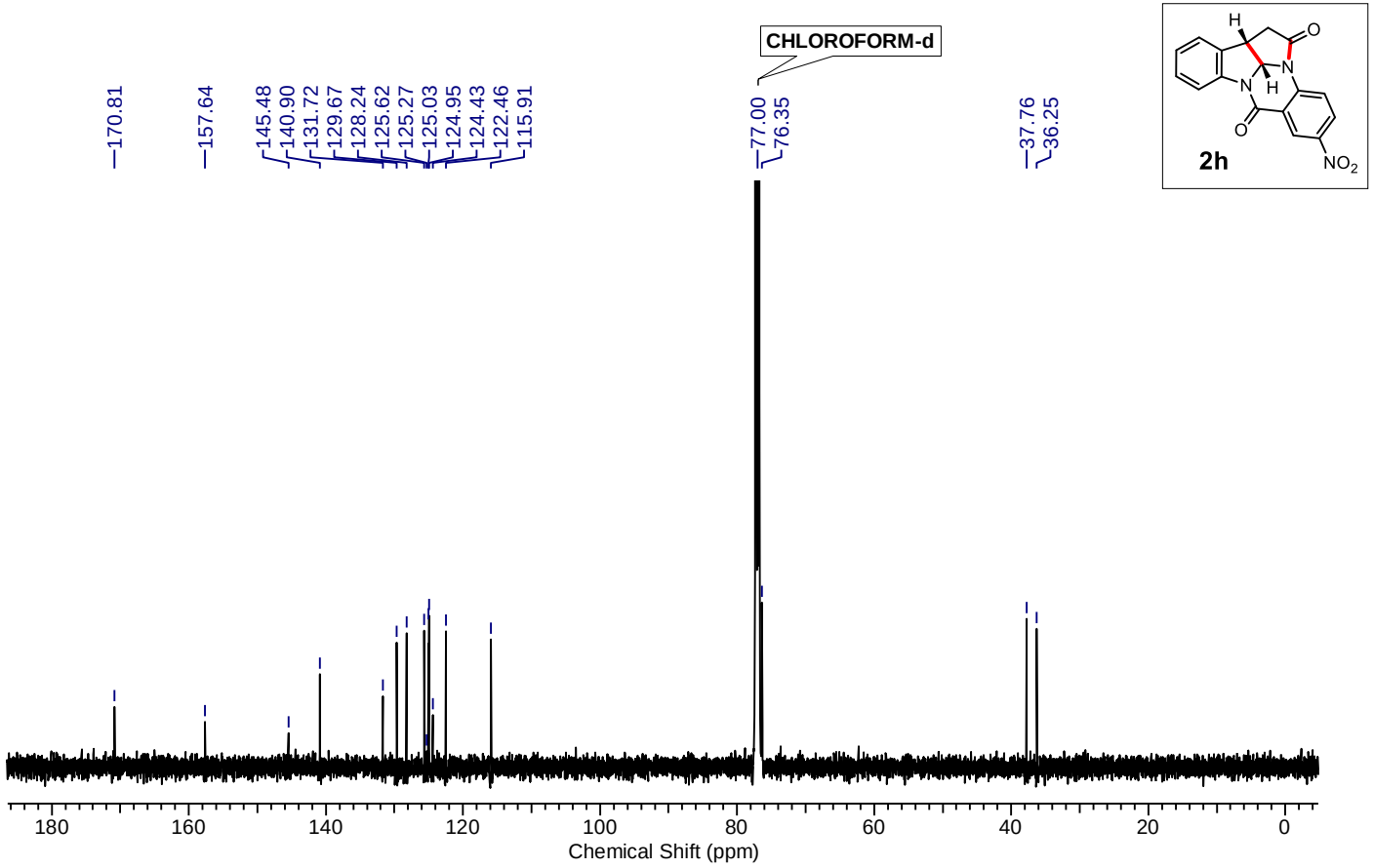
^{13}C NMR (125 MHz, $CDCl_3$)



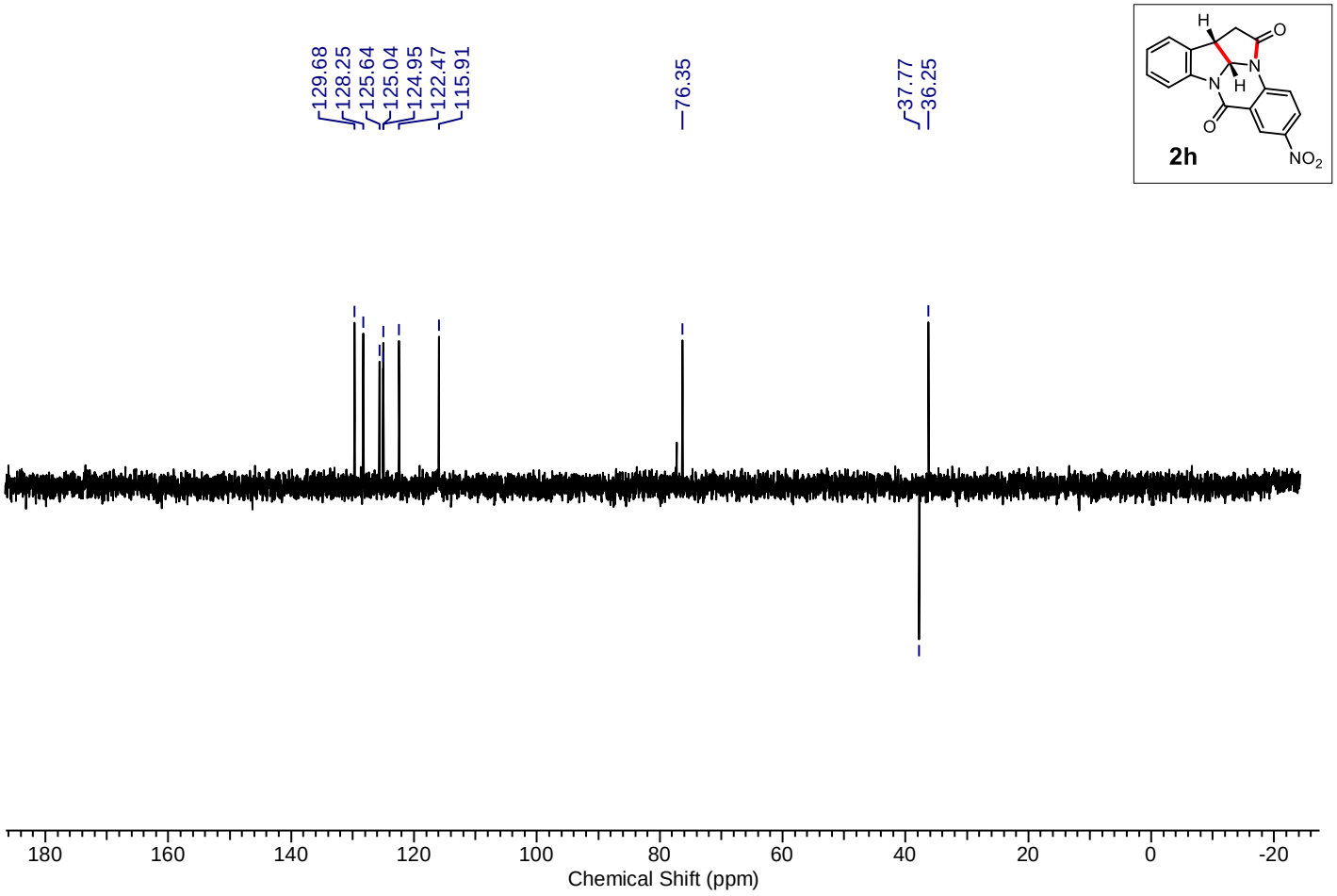
^{1}H NMR (400 MHz, $CDCl_3$)



^{13}C NMR (125 MHz, $CDCl_3$)



DEPT NMR


129.68
128.25
125.64
125.04
124.95
122.47
115.91
76.35
37.77
36.25
2h
H
O
N
N
H
O
NO2
180
160
140
120
100
80
60
40
20
0
-20
Chemical Shift (ppm)