Cobalt(III)-catalyzed redox-neutral [4+2]-annulation of *N*-chlorobenzamides/acrylamides with alkylidenecyclopropanes at room temperature

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Electronic Supplementary Information (ESI)

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Experimental Section

General information: All reactions were carried out under the N_2 atmosphere in flame-dried glassware. Syringes which were used to transfer anhydrous solvents or reagents were purged with nitrogen prior to use (three times). Dry solvents are used for the reaction. Column chromatographically purifications were performed using SiO_2 (120- 200 mesh ASTM) from Merck if not indicated otherwise. Abbreviations for signal coupling are as follows: s, singlet; d, doublet; t, triplet; q, quartet; m, multiplet. Starting Materials: Amides[1], Alkylidenecyclopropanes[2] and $CoCp^*COI_2$[3] were prepared according to the literature procedures. Commercially available metal salts and other chemicals were purchased from Sigma-Aldrich and Spectrochem. Pvt. Ltd., India and used without further purification.

General Procedure for the synthesis of Alkylidenecyclopropanes 2:

The procedure was adapted from literature.[2]

3-Bromopropylphosphonium bromide (2.79 g, 6 mmol, 1.2 equiv) was dissolved in dry THF (10 mL) and *t*-BuOK (1.35 g, 12 mmol, 2.4 equiv) was added as a solution in dry THF (10 mL). The resulting suspension was heated at reflux for 10 minutes and substituted benzaldehyde (5 mmol, 1 equiv) was added as a solution in dry THF (5 mL). The mixture was heated at reflux for 2 h. After cooling down to room temperature, the mixture was layered with cyclohexane (20 mL) and the cloudy suspension filtered over Celite washing thoroughly with cyclohexane. The filtrate was concentrated and the residue purified by chromatography on silica gel eluting with cyclohexane to afford substituted alkylidenecyclopropane.

General Procedure for the Synthesis of 3,4-Dihydroisoquinolinones 3:

A 15-mL pressure tube with septum containing $CoCp^*COI_2$ (10 mol %) and amides **1** (50 mg, 1.0 equiv), alkylidenecyclopropanes **2** (1.5 equiv), AgOAc (20 mol %) and NaOAc (1.0 equiv) was evacuated and purged with nitrogen gas three times. Followed by solvent 2,2,2- trifluoroethanol (1.5 mL) is added to pressure tube *via* syringe and again the reaction mixture was evacuated and purged with nitrogen gas three times. Then rubber septum was taken out and screw cap was used to cover the tube. The reaction mixture was allowed to stir at rt for 24 h. Then the reaction mixture was diluted with CH_2Cl_2, filtered through celite and the filtrate concentrated. The crude residue was purified through a silica gel column using hexane and ethyl acetate as eluent to give pure dihydroisoquinolinones **3**.

General procedure for the synthesis of Dihydroisoquinoline 6:

A solution of **3aa** (70 mg, 1.0 equiv) in THF (5 mL) protected under Argon was treated with $LiAlH_4$ (32 mg, 3.0 equiv), and the mixture heated at reflux for 8h. After cooling to ambient temperature water (1.0 mL) was poured into the reaction mixture, then stirred for 10 min at rt and treated with NaOH (0.5 mL of 2 M aqueous solution), stirred for 5 min and diluted with additional water (5 mL). The solution was extracted with ethyl acetate (10 mL×2), the combined organic layer were dried (Na_2SO_4), filtered, concentrated under vacuum. The purification was performed by flash column chromatography on basic alumina using ethyl acetate/petroleum ether (v/v, 1:1) as eluent to give the product **6** as pale yellow gel (53 mg, 79%).

General procedure for the synthesis of 1-Chloro Dihydroisoquinolines 7:

Dihydroisoquinolinone **3** (0.070, 1.0 equiv) was dissolved in dry toluene (3 mL) before freshly distilled phosphoryl trichloride (0.13 mL, 6.8 equiv) was added dropwise *via* syringe to the stirred mixture. The reaction mixture was allowed to stir at 90 °C for 2 h. After cooling to ambient temperature the solvent was removed under vacuum. The resulting residue was cooled to -30 °C and a mixture of Et_2O/Et_3N 5% was added dropwise to the flask. The mixture was then stirred at room temperature for 10 minutes. Finally, it was filtered over basic alumina, eluting with Et_2O/Et_3N 5%. The filtrate was concentrated under reduced pressure to give the desired 1-chloro dihydroisoquinoline **7**.

Table S1. Optimization of the Cyclization Reaction.

entry	catalyst	solvent	additive	Base	yield (%)[b]
1	Cp*Co(CO)I_2	TFE	-	NaOAc (1 equiv)	75
2	**Cp*Co(CO)I_2**	**TFE**	**AgOAc (20 mol %)**	**NaOAc (1 equiv)**	**90**
5	Cp*Co(CO)I_2	TFE	Ag_2O (20 mol %)	NaOAc (1 equiv)	87
6	Cp*Co(CO)I_2	TFE	$Cu(OAc)_2$ (20 mol %)	NaOAc (1 equiv)	80
7	Cp*Co(CO)I_2	TFE	AgOAc (20 mol %)	LiOAc (1 equiv)	62
8	Cp*Co(CO)I_2	TFE	AgOAc (20 mol %)	KOAc (1 equiv)	69
9	Cp*Co(CO)I_2	TFE	AgOAc (20 mol %)	CsOAc (1 equiv)	45
10	Cp*Co(CO)I_2	TFE	AgOAc (20 mol %)	K_2CO_3	15
11	Cp*Co(CO)I_2	TFE	AgOAc (20 mol %)	K_3PO_4	10
12	Cp*Co(CO)I_2	$ClCH_2CH_2Cl$	AgOAc (20 mol %)	NaOAc (1 equiv)	25
13	Cp*Co(CO)I_2	MeOH	AgOAc (20 mol %)	NaOAc (1 equiv)	45
14	Cp*Co(CO)I_2	THF	AgOAc (20 mol %)	NaOAc (1 equiv)	15
15	Cp*Co(CO)I_2	toluene	AgOAc (20 mol %)	NaOAc (1 equiv)	10
16	-	TFE	AgOAc (20 mol %)	NaOAc (1 equiv)	NR

[a]All reactions were carried out using **1** (50 mg, 1 equiv), **2** (1.5 equiv), $CoCp^*COI_2$ (10 mol %), AgOAc (20 mol %), NaOAc (1 equiv) in TFE (1.5 mL) under N_2 at rt for 24 h. [b]Isolated yield of **3**.

In the reaction, a catalytic amount of AgOAc plays a crucial role to increase the yield of the product **3aa**. Notably, in the absence of AgOAc, the reaction offered the product **3aa** in only 75% yield. It is expected that the AgOAc acts as a halogen scavenger to form a cobalt acetate species. The reaction was examined with *N*-alkoxy benzamides (**4a**-**b**). However, in the reaction, no expected cyclization product **3aa** was formed due to energy constraints. Among the silver salts used, AgOAc offered a better conversion as compared with other salts like Ag_2O and $Cu(OAc)_2$. The reaction was examined with various bases such as LiOAc, NaOAc, KOAc, CsOAc, K_2CO_3 and K_3PO_4.

Among them, NaOAc was very effective, affording the product **3aa** in 90% yield. LiOAc, KOAc and CsOAc were partially effective, giving the product **3aa** in 45-69% yields. K_2CO_3 and K_3PO_4 were less effective for the reaction. The cyclization reaction was further investigated with various solvents such as TFE, THF, toluene, $ClCH_2CH_2Cl$ and MeOH. Among them, TFE was very effective, providing the product **3aa** in 90% yield. The other solvents such as THF, $ClCH_2CH_2Cl$, toluene and MeOH were less effective for the reaction.

Mechanistic Studies

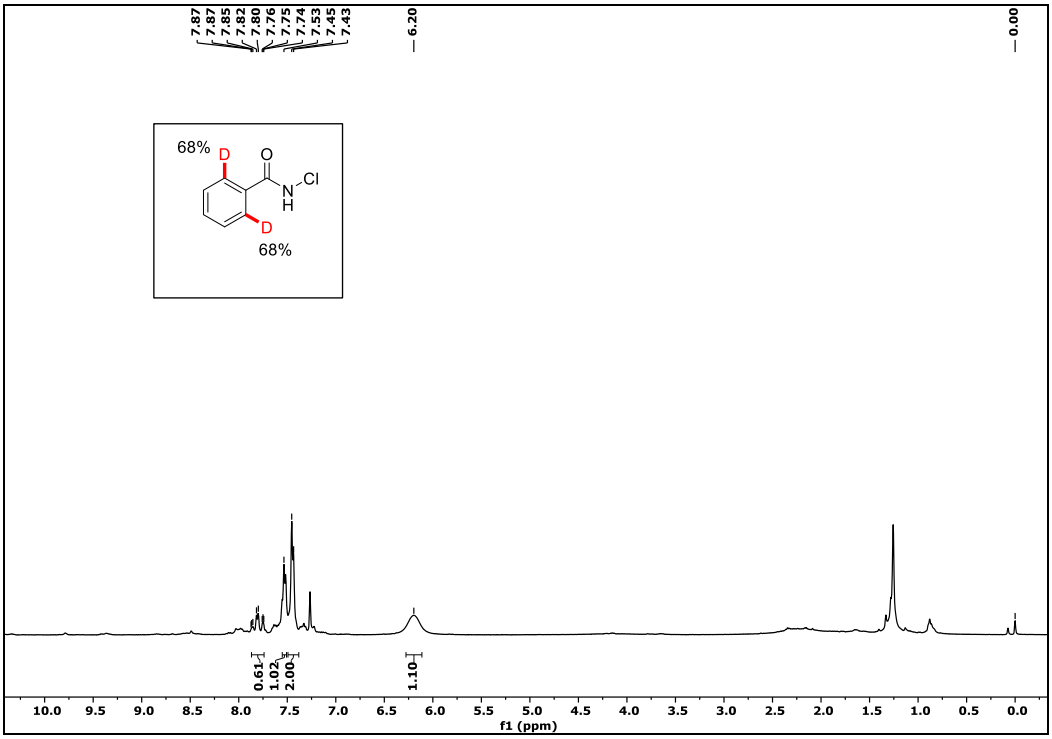
Deuterium Studies

To a 15-mL pressure tube containing $CoCp^*COI_2$ (10 mol %), amide **1a** (50 mg, 1.0 equiv), AgOAc (20 mol %) and NaOAc (1.0 equiv) was evacuated and purged with N_2 gas three times. To the tube were then added 1,2-dichloroethane (1.5 mL) solvent *via* syringe. D_2O (10.0 equiv) were added via syringes and again the reaction mixture was evacuated and purged with nitrogen gas three times. Then the septum was taken out and immediately screw cap was used to cover the tube. Then, the reaction mixture was allowed to stir at rt for 24 h. Then the reaction mixture was diluted with CH_2Cl_2, filtered through celite and the filtrate concentrated. The crude residue was purified through a silica gel column using hexane and ethyl acetate as eluent to give product **D-1a**. In the reaction, product **D-1a** was observed in 48% yield with 68% of deuterium incorporation at the both *ortho* carbons of *N*-chlorobenzamide, respectively. These results also clearly reveal that the C-H bond activation as a key intermediate in the reaction as well as it is the reversible process.

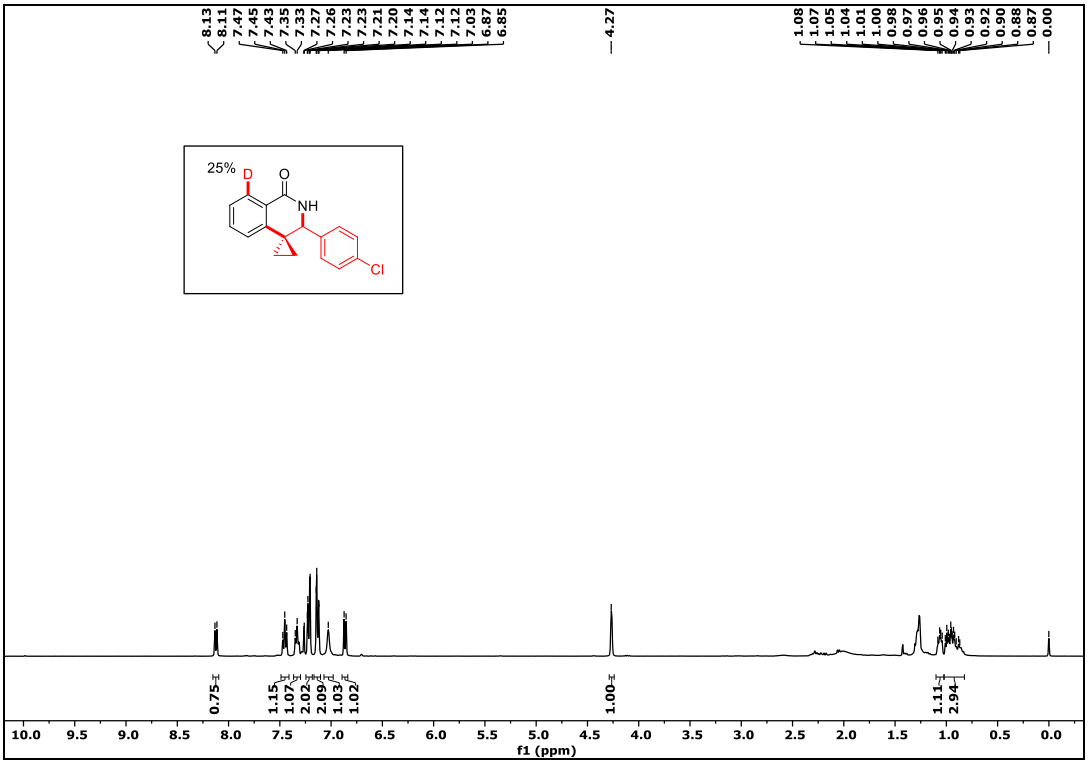
Preparation of Compounds D-3ad.

To a 15-mL pressure tube containing $CoCp^*COI_2$ (10 mol %), amide **1a** (50 mg, 1.0 equiv), alkylidenecyclopropane **2a** (1.5 equiv), AgOAc (20 mol %) and NaOAc (1.0 equiv) was evacuated and purged with N_2 gas three times. To the tube were then added 1,2-dichloroethane (1.5 mL) solvent *via* syringe. D_2O (10.0 equiv) were added via syringes and again the reaction mixture was evacuated and purged with nitrogen gas three times. Then the septum was taken out and immediately screw cap was used to cover the tube. Then, the reaction mixture was allowed to stir at rt for 24 h. Then the reaction mixture was diluted with CH_2Cl_2, filtered through celite and the filtrate concentrated. The crude residue was purified through a silica gel column using hexane and ethyl acetate as eluent to give cyclized product **D-3ad**. In the reaction, cyclized product **D-3ad** was observed in 21% yield with 25% of deuterium incorporation at the *ortho* carbon along with the unreacted starting material **D-1a** were isolated in 38% yield.

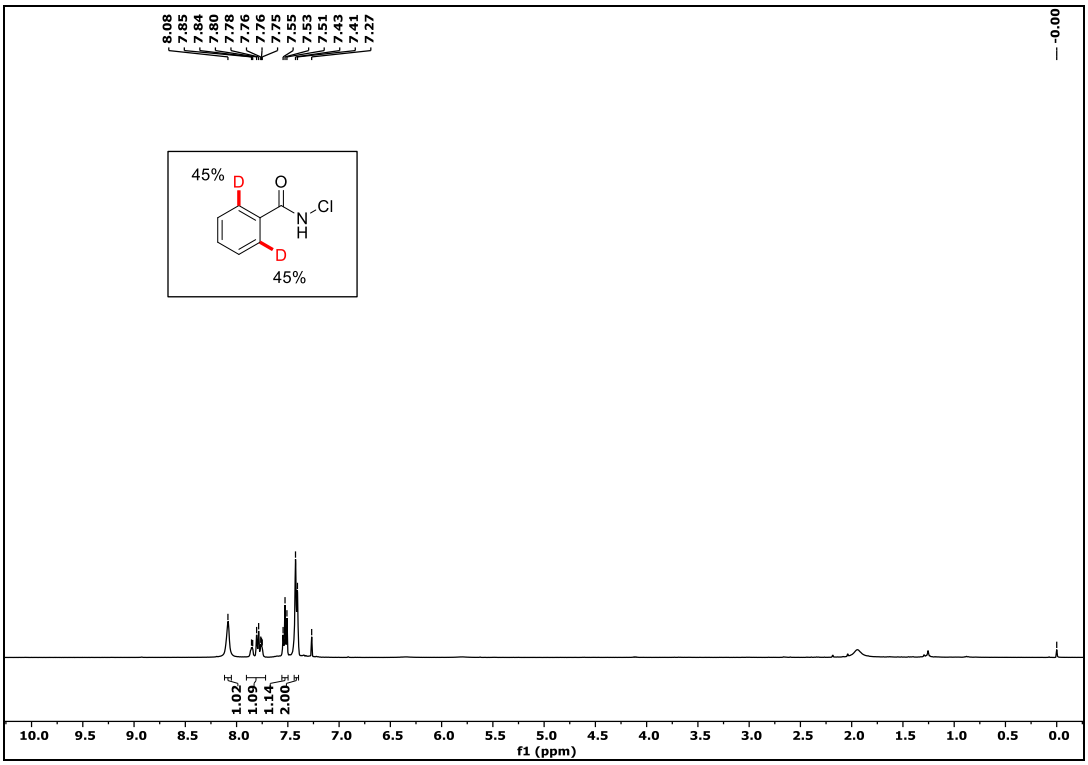
^{1}H NMR spectrum of compound **D-1a** ($CDCl_3$ was used).



^{1}H NMR spectrum of compound **D-3ad** ($CDCl_3$ was used).

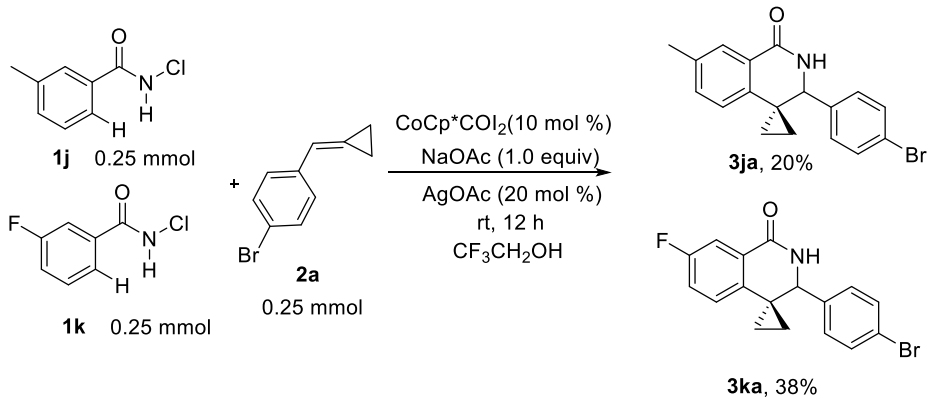


^{1}H NMR spectrum of compound **D-1a** ($CDCl_3$ was used).



Procedure for Competition Reaction between Amides.

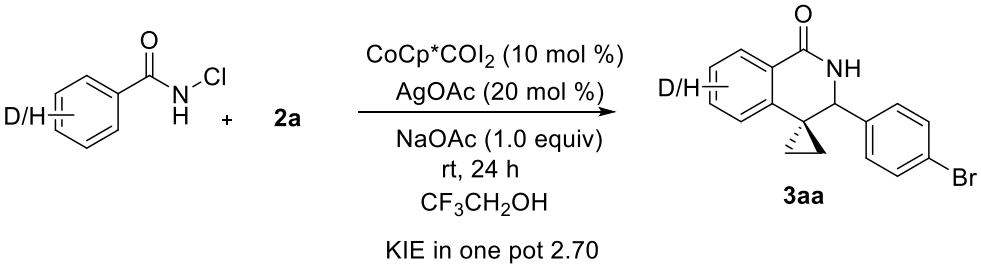
To a 15-mL pressure tube containing $CoCp^*COI_2$ (10 mol %), amide **1j** (0.25 mmol, 1.0 equiv), amide **1k** (0.25 mmol, 1.0 equiv), alkylidenecyclopropane **2a** (0.25 mmol, 1.0 equiv), and NaOAc (1.0 equiv) was evacuated and purged with N_2 gas three times. To the tube were then added 2,2,2-trifluoroethanol solvent *via* syringe. After that, the tube was purged and evacuated with N_2 gas three times and screw cap was used to cover the tube. Then, the reaction mixture was allowed to stir at rt for 12 h. Then the reaction mixture was diluted with CH_2Cl_2, filtered through celite and the filtrate concentrated. The crude residue was purified through a silica gel column using hexane and ethyl acetate as eluent to give products **3ja** and **3ka** in 20% and 38% yields, respectively.

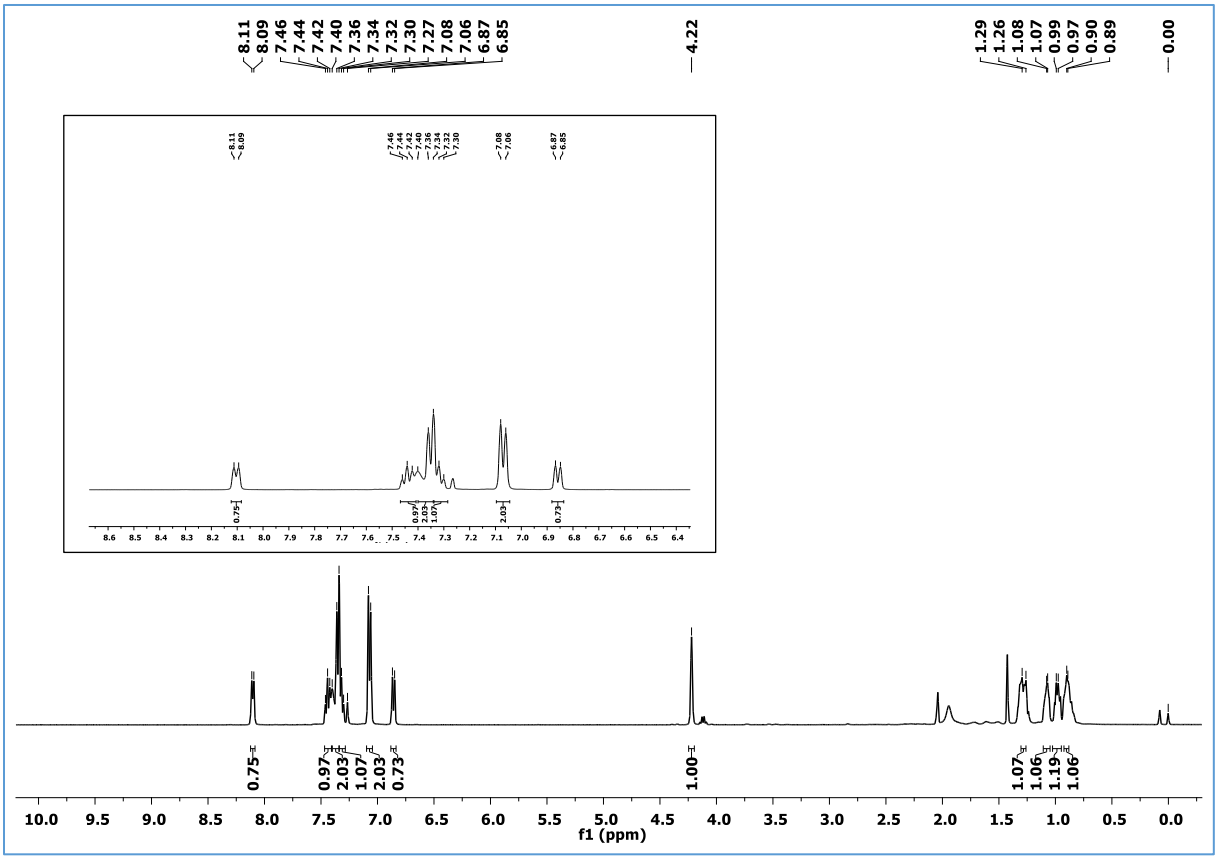


Studies on the Kinetic Isotope Effect

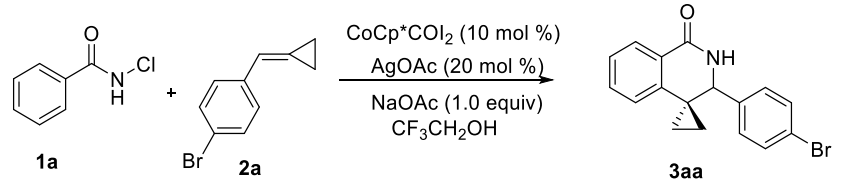
(a) Competition Experiment using amide 1a and [D]-1a.

To a 15mL pressure tube containing $CoCp^*COI_2$ (10 mol %), amides **1a** (50 mg, 1.0 equiv), and amide [**D**]-**1a** (50 mg, 1.0 equiv), alkylidenecyclopropane **2a** (0.25mmol, 1.0 equiv), AgOAc (20 mol%) and NaOAc (1.0 equiv) was evacuated and purged with N_2 gas three times. To the tube were then added 2,2,2-trifluoroethanol solvent *via* syringe. After that, the tube was purged and evacuated with N_2 gas three times and screw cap was used to cover the tube. Then, the reaction mixture was allowed to stir at rt for 24 h. Then the reaction mixture was allowing to reach rt and it was diluted with CH_2Cl_2, filtered through celite and the filtrate concentrated. The crude residue was purified through a silica gel column using hexane and ethyl acetate as eluent to give combined products **3aa** and [D]-**3aa** in 85% yields, respectively.

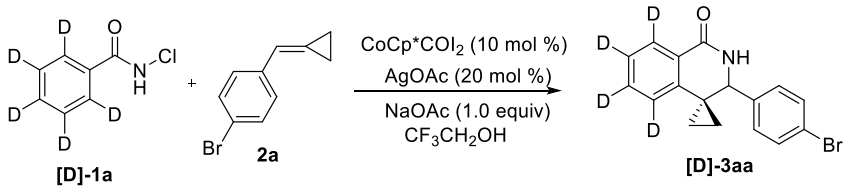




b) By Two parallel reactions



To a 15mL pressure tube containing $CoCp^*COI_2$ (10 mol %), amides **1a** (100 mg, 1.0 equiv), and alkylidenecyclopropane **2a** (1.5 equiv), AgOAc (20 mol%) and NaOAc (1.0 equiv) was evacuated and purged with N_2 gas three times. To the tube were then added 2,2,2-trifluoroethanol solvent *via* syringe. After that, the tube was purged and evacuated with N_2 gas three times and screw cap was used to cover the tube. For 120 min, an aliquot (0.1 mL) was removed by a syringe every 20 min and directly analyzed by ^{1}H-NMR. The yield of product was determined by ^{1}H NMR spectroscopy using CH_2Br_2 as an internal standard.



The procedure above was followed using **[D]-1a** (100 mg). Data from independent kinetic isotope studies are collected in the figure below and KIE was found to be $k_H/k_D \approx 2.63$.

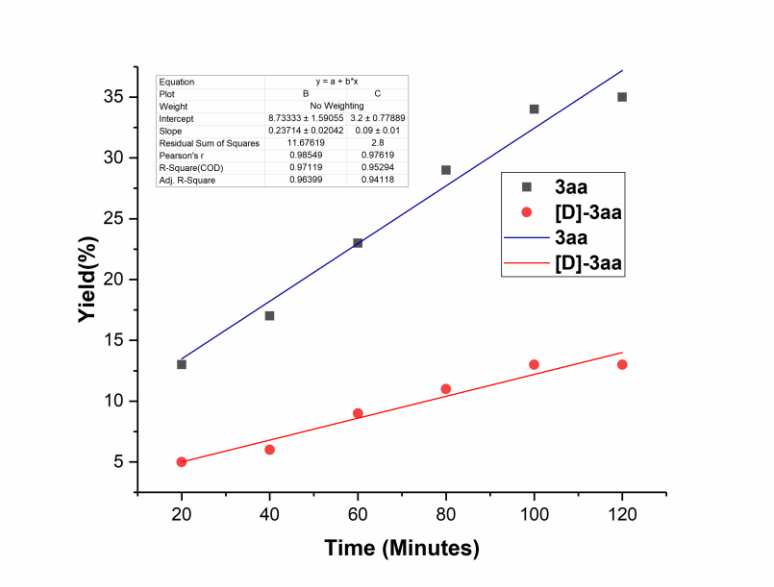
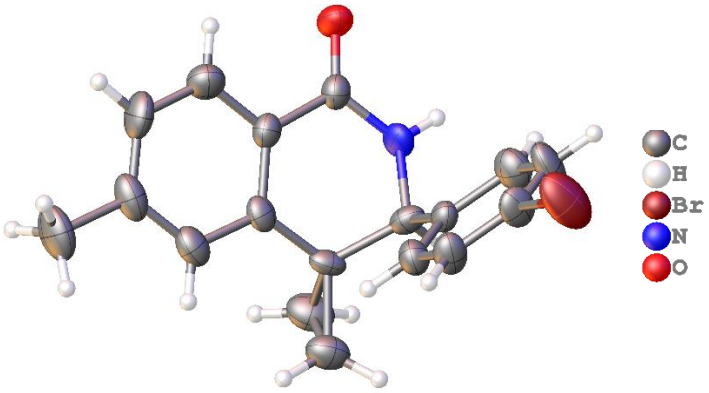


Table S2. X-Ray Analysis of Compound 3aa.

	3aa
empirical formula	$C_{18}H_{16}BrNO$
formula wt	342.23
temp (K)	296
Cryst. syst.	monoclinic
space group	P 2_1/c
a (Å)	14.4966(16)
b (Å)	10.4123(11)
c (Å)	11.2334(10)
α (deg)	90
β (deg)	111.258(5)
γ (deg)	90
V (Å^3)	1580.2(3)
Z	4
ρ_{calcd} (Mg m^{-3})	1.439
μ (mm^{-1})	2.599
F(000)	696.0
Cryst size (mm)	0.25 × 0.22 × 0.1
Θ range (deg)	3.014 to 49.98
no. of collected/unique rflns	9144/2783 [Rint = 0.0636]
no.of. data /restraints/ params	2783/0/195
*R*1, *wR*2 (I> 2σ(I))	0.0576, 0.0885
*R*1, *wR*2 (all data)	0.1245, 0.0947
GOF	1.674
$\Delta\rho_{max}/\Delta\rho_{min}$ (e Å^{-3})	0.66/-0.58

ORTEP Diagram of Compounds 3aa (CCDC No. 2041146).



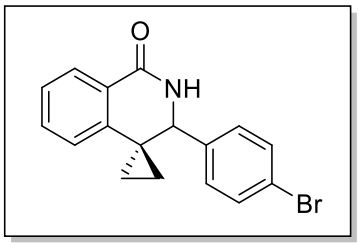
3aa

References

1. X. Yu, K. Chen, S. Guo, P. Shi, C. Song and J. Zhu, *Org. Lett*., 2017, **19**, 5348.
2. (a) Z.-Z. Zhu, K. Chen, L.-Z. Yu, X.-Y. Tang and M. Shi, *Org. Lett*., 2015, **17**, 5994; (b) Y. Wang, M. E. Muratore, Z. Rong and A. M. Echavarren, *Angew. Chem. Int. Ed*., 2014, **53**, 14022. (c) T. Kippo, K. Hamaoka and I. Ryu, *J. Am. Chem. Soc.*, 2013, **135**, 632.
3. B. Sun, T. Yoshino, S. Matsunaga and M. Kanai, *Adv. Synth. Catal*., 2014, **356**, 1491.

Spectral Data of all Compounds:

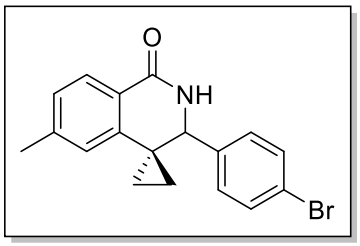
3'-(4-Bromophenyl)-2',3'-dihydro-1'*H*-spiro[cyclopropane-1,4'-isoquinolin]-1'-one (3aa).



White Solid; eluent (12% ethyl acetate in hexane). The reaction scale is 50 mg (**1a**), 95 mg was isolated and yield is 90%. **^{1}H NMR (400 MHz, $CDCl_3$):** δ 8.11 (d, *J* = 7.7 Hz, 1H), 7.45 (t, *J* = 7.5 Hz, 1H), 7.34 (dd, *J* = 16.5, 8.0 Hz, 4H), 7.07 (d, *J* = 8.3 Hz, 2H), 6.86 (d, *J* = 7.8 Hz, 1H), 4.23 (d, *J* = 3.5 Hz, 1H), 1.36 – 1.28 (m, 1H), 1.13 – 1.04 (m, 1H), 0.99 (dd, *J* = 10.6, 4.8 Hz, 1H), 0.94 – 0.88 (m, 1H). **^{13}C NMR (101 MHz, $CDCl_3$):** δ 166.2, 141.3, 139.0, 133.1, 131.6, 129.1, 129.0, 128.2, 126.5, 122.0, 121.7, 61.5, 23.3, 18.0, 10.9.

HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{17}H_{14}BrNOH$ 328.0337; Found 328.0340.

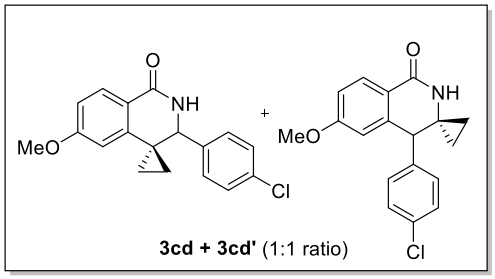
3'-(4-Bromophenyl)-6'-methyl-2',3'-dihydro-1'*H*-spiro[cyclopropane-1,4'-isoquinolin]-1'-one (3ba).



White Solid; eluent (12% ethyl acetate in hexane). The reaction scale is 50 mg (**1b**), 77 mg was isolated and yield is 77%. **^{1}H NMR (500 MHz, $CDCl_3$)**: δ 7.97 (d, *J* = 7.9 Hz, 1H), 7.55 (d, *J* = 27.1 Hz, 1H), 7.33 (d, *J* = 8.4 Hz, 2H), 7.11 (d, *J* = 7.9 Hz, 1H), 7.06 (d, *J* = 8.5 Hz, 2H), 6.64 (s, 1H), 4.15 (d, *J* = 3.6 Hz, 1H), 2.34 (s, 3H), 1.32 (dt, *J* = 9.5, 5.9 Hz, 1H), 1.07 (ddd, *J* = 10.6, 6.1, 4.7 Hz, 1H), 0.96 (dt, *J* = 9.7, 6.1 Hz, 1H), 0.86 (ddd, *J* = 9.6, 6.5, 4.6 Hz, 1H). **^{13}C NMR (126 MHz, $CDCl_3$):** δ 166.4, 143.6, 141.2, 139.3, 131.5, 129.0, 129.0, 128.2, 127.3, 126.6, 122.3, 121.8, 61.6, 23.2, 21.9, 18.3, 10.6.

HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{18}H_{16}BrNOH$ 342.0494; Found 342.0493.

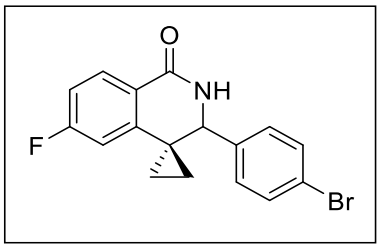
3'-(4-Bromophenyl)-6'-methoxy-2',3'-dihydro-1'*H*-spiro[cyclopropane-1,4'-isoquinolin]-1'-one (3cd + 3cd').



Pale yellow Solid; eluent (18% ethyl acetate in hexane). The reaction scale is 50 mg (**1c**), 51 mg was isolated and yield is 60%. **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 8.13 (d, *J* = 1.6 Hz, 1H), 8.07 (d, *J* = 8.6 Hz, 1H), 7.25 – 7.19 (m, 4H), 7.12 (dd, *J* = 8.3, 4.6 Hz, 4H), 6.95 (s, 1H), 6.85 – 6.78 (m, 2H), 6.34 (d, *J* = 2.4 Hz, 1H), 6.31 (s, 1H), 4.21 (d, *J* = 3.5 Hz, 2H), 3.89 (s, 3H), 3.82 (s, 3H), 1.13 (dd, *J* = 9.9, 5.0 Hz, 1H), 1.04 (t, *J* = 8.2 Hz, 2H), 0.93 (tdd, *J* = 19.4, 10.5, 4.2 Hz, 5H). **^{13}C NMR (101 MHz, $CDCl_3$):** δ 166.0, 164.9, 163.6, 158.7, 143.6, 142.0, 138.6, 138.2, 134.0, 133.8, 130.5, 130.3, 128.8, 128.7, 128.6, 128.5, 122.6, 122.0, 121.1, 111.2, 107.7, 104.8, 61.6, 56.2, 55.4, 23.8, 23.6, 18.2, 18.0, 11.3, 11.1.

HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{18}H_{16}ClNO_2H$ 314.0948; Found 314.0944.

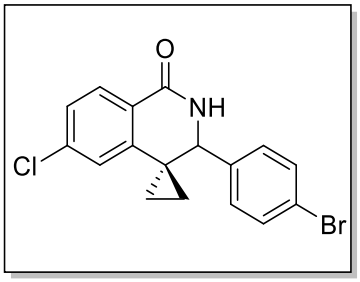
3'-(4-Bromophenyl)-6'-fluoro-2',3'-dihydro-1'*H*-spiro[cyclopropane-1,4'-isoquinolin]-1'-one (3da).



Pale yellow Solid; eluent (12% ethyl acetate in hexane). The reaction scale is 50 mg (**1d**), 76 mg was isolated and yield is 76%. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.12 (dd, J = 8.5, 6.1 Hz, 1H), 7.39 (d, J = 8.3 Hz, 2H), 7.12 (s, 1H), 7.07 (d, J = 8.2 Hz, 2H), 6.99 (d, J = 2.0 Hz, 1H), 6.58 – 6.51 (m, 1H), 4.25 (d, J = 3.3 Hz, 1H), 1.28 – 1.20 (m, 1H), 1.15 – 1.08 (m, 1H), 1.07 – 0.99 (m, 1H), 0.94 (dd, J = 9.8, 4.6 Hz, 1H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 167.2, 165.0, 144.7, 138.6, 131.7, 131.1 128.9, 125.4, 122.2, 113.8, 109.1, 61.4, 23.5, 18.1, 11.5.

HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{17}H_{13}BrFNOH$ 346.0243; Found 346.0234.

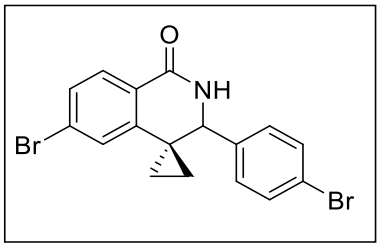
3'-(4-Bromophenyl)-6'-chloro-2',3'-dihydro-1'*H*-spiro[cyclopropane-1,4'-isoquinolin]-1'-one (3ea).



White Solid; eluent (12% ethyl acetate in hexane). The reaction scale is 50 mg (**1e**), 70 mg was isolated and yield is 74%. **^{1}H NMR (400 MHz, CDCl$_3$)** δ 8.03 (d, *J* = 8.3 Hz, 1H), 7.42 (s, 1H), 7.37 (d, *J* = 8.3 Hz, 2H), 7.29 (d, *J* = 8.3 Hz, 1H), 7.06 (d, *J* = 8.3 Hz, 2H), 6.83 (s, 1H), 4.22 (d, *J* = 3.5 Hz, 1H), 1.33 – 1.25 (m, 1H), 1.16 – 1.08 (m, 1H), 1.07 – 1.00 (m, 1H), 0.97 – 0.88 (m, 1H). **^{13}C NMR (101 MHz, CDCl$_3$)** δ 165.3, 143.3, 139.4, 138.6, 131.7, 129.8, 128.9, 127.7, 126.9, 122.1, 61.4, 23.4, 18.3, 11.2.

HRMS (**ESI-TOF**) m/z: $[M + H]^+$ Calcd for $C_{17}H_{13}BrClNOH$ 361.9947; Found 361.9948.

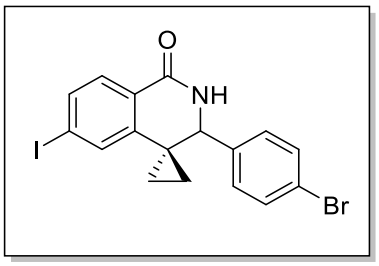
6'-Bromo-3'-(4-bromophenyl)-2',3'-dihydro-1'*H*-spiro[cyclopropane-1,4'-isoquinolin]-1'-one (3fa).



White Solid; eluent (12% ethyl acetate in hexane). The reaction scale is 50 mg (**1f**), 71 mg was isolated and yield is 81%. **^{1}H NMR (400 MHz, CDCl$_3$)** δ 7.95 (d, J = 8.3 Hz, 1H), 7.46 (d, J = 8.3 Hz, 1H), 7.38 (d, J = 8.4 Hz, 2H), 7.35 (s, 1H), 7.06 (d, J = 8.3 Hz, 2H), 6.99 (s, 1H), 4.21 (d, J = 3.5 Hz, 1H), 1.34 – 1.24 (m, 1H), 1.15 – 1.08 (m, 1H), 1.07 – 0.99 (m, 1H), 0.97 – 0.89 (m, 1H). **^{13}C NMR (101 MHz, CDCl$_3$)** δ 165.4, 143.4, 138.6, 131.7, 129.9, 129.9, 128.9, 128.1, 125.1, 122.2, 61.5, 23.4, 18.3, 11.3.

HRMS (**ESI-TOF**) m/z: $[M + H]^+$ Calcd for $C_{17}H_{13}Br_2NOH$ 405.9442; Found 405.9443.

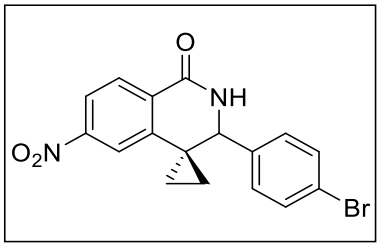
3'-(4-Bromophenyl)-6'-iodo-2',3'-dihydro-1'*H*-spiro[cyclopropane-1,4'-isoquinolin]-1'-one (3ga).



White Solid; eluent (12% ethyl acetate in hexane). The reaction scale is 50 mg (**1g**), 58 mg was isolated and yield is 73%. **^{1}H NMR (400 MHz, CDCl$_3$)** δ 7.79 (d, *J* = 8.2 Hz, 1H), 7.68 (d, *J* = 8.2 Hz, 1H), 7.37 (d, *J* = 8.1 Hz, 3H), 7.19 (s, 1H), 7.05 (d, *J* = 8.2 Hz, 2H), 4.19 (d, *J* = 3.4 Hz, 1H), 1.30 (dd, *J* = 10.2, 5.1 Hz, 1H), 1.15 – 1.07 (m, 1H), 1.02 (dd, *J* = 10.7, 4.8 Hz, 1H), 0.96 – 0.88 (m, 1H). **^{13}C NMR (101 MHz, CDCl$_3$)** δ 165.6, 143.2, 138.6, 135.9, 131.7, 131.0, 129.7, 128.9, 128.7, 122.2, 100.8, 61.5, 23.2, 18.3, 11.2.

HRMS (**ESI-TOF**) m/z: $[M + H]^+$ Calcd for $C_{17}H_{13}BrINOH$ 453.9303; Found 453.9290.

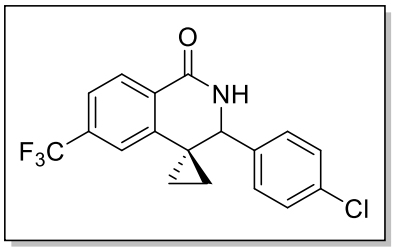
3'-(4-Bromophenyl)-6'-nitro-2',3'-dihydro-1'*H*-spiro[cyclopropane-1,4'-isoquinolin]-1'-one (3ha).



Yellow Solid; eluent (15% ethyl acetate in hexane). The reaction scale is 50 mg (**1h**), 75 mg was isolated and yield is 80%. **^{1}H NMR (400 MHz, CDCl$_3$)** δ 8.27 (d, *J* = 8.5 Hz, 1H), 8.14 (d, *J* = 8.5 Hz, 1H), 7.76 (s, 1H), 7.73 (s, 1H), 7.39 (d, *J* = 8.3 Hz, 2H), 7.07 (d, *J* = 8.3 Hz, 2H), 4.33 (d, *J* = 3.3 Hz, 1H), 1.44 (dt, *J* = 11.2, 5.4 Hz, 1H), 1.25 – 1.12 (m, 2H), 1.07 – 1.00 (m, 1H). **^{13}C NMR (101 MHz, CDCl$_3$)** δ 164.2, 150.8, 143.6, 138.0, 134.3, 131.9, 129.7, 128.8, 122.5, 121.4, 117.4, 61.2, 23.7, 18.6, 11.8.

HRMS (**ESI-TOF**) m/z: $[M + Na]^+$ Calcd for $C_{17}H_{13}BrN_2O_3Na$ 395.0007; Found 395.0008.

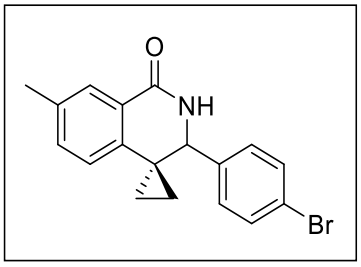
3'-(4-Bromophenyl)-6'-(trifluoromethyl)-2',3'-dihydro-1'*H*-spiro[cyclopropane-1,4'-isoquinolin]-1'-one (3id).



White Solid; eluent (15% ethyl acetate in hexane). The reaction scale is 50 mg (**1i**), 61 mg was isolated and yield is 78%. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.25 (d, *J* = 8.1 Hz, 1H), 7.59 (d, *J* = 8.1 Hz, 1H), 7.26 (dd, *J* = 8.4, 1.7 Hz, 2H), 7.13 (s, 1H), 7.12 – 7.08 (m, 2H), 7.05 (d, *J* = 3.5 Hz, 1H), 4.33 (d, *J* = 3.4 Hz, 1H), 1.31 (dd, *J* = 10.6, 5.0 Hz, 1H), 1.13 – 1.09 (m, 1H), 1.03 – 0.96 (m, 1H), 0.90 – 0.84 (m, 1H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 165.0, 142.4, 137.9, 134.6 (q, J_{C-F} = 32.8 Hz), 134.1, 132.2, 128.8, 128.5, 123.3 (q, J_{C-F} = 3.8 Hz), 118.9 (q, J_{C-F} = 3.8 Hz), 61.21, 23.45, 18.34, 11.32.

HRMS (**ESI-TOF**) m/z: $[M + H]^+$ Calcd for $C_{18}H_{13}ClF_3NO$ 352.0716; Found 352.0714.

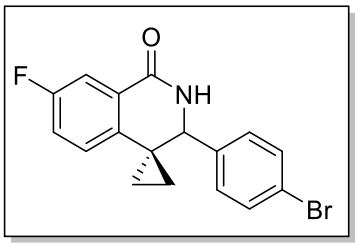
3'-(4-Bromophenyl)-7'-methyl-2',3'-dihydro-1'*H*-spiro[cyclopropane-1,4'-isoquinolin]-1'-one (3ja).



White Solid; eluent (12% ethyl acetate in hexane). The reaction scale is 50 mg (**1j**), 69 mg was isolated and yield is 69%. **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 7.91 (s, 1H), 7.57 (d, *J* = 2.7 Hz, 1H), 7.33 (d, *J* = 7.8 Hz, 2H), 7.24 (d, *J* = 7.8 Hz, 1H), 7.06 (d, *J* = 7.9 Hz, 2H), 6.74 (d, *J* = 7.9 Hz, 1H), 4.17 (d, *J* = 3.2 Hz, 1H), 2.36 (s, 3H), 1.33 – 1.24 (m, 1H), 1.06 (dt, *J* = 10.2, 5.2 Hz, 1H), 0.99 – 0.90 (m, 1H), 0.85 (dd, *J* = 9.6, 4.8 Hz, 1H). **^{13}C NMR (101 MHz, $CDCl_3$)**: δ 166.4, 139.3, 138.3, 136.2, 133.8, 131.5, 129.0, 128.6, 121.8, 121.7, 61.6, 23.0, 21.0, 18.1, 10.6.

HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{18}H_{16}BrNOH$ 342.0494; Found 342.0501.

3'-(4-Bromophenyl)-7'-fluoro-2',3'-dihydro-1'*H*-spiro[cyclopropane-1,4'-isoquinolin]-1'-one (3ka).

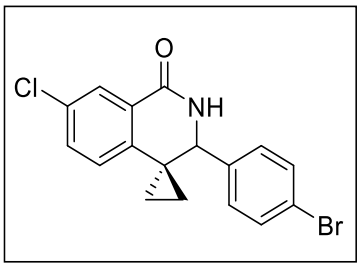


White Solid; eluent (12% ethyl acetate in hexane). The reaction scale is 50 mg (**1k**), 76 mg was isolated and yield is 76%. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.78 (d, J = 8.7 Hz, 1H), 7.71 (s, 1H), 7.36 (d, J = 7.9 Hz, 2H), 7.13 (t, J = 8.2 Hz, 1H), 7.05 (d, J = 8.0 Hz, 2H), 6.88 – 6.79 (m, 1H), 4.20 (s, 1H), 1.29 (d, J = 8.1 Hz, 1H), 1.08 (d, J = 4.2 Hz, 1H), 1.04 – 0.95 (m, 1H), 0.87 (d, J =

4.8 Hz, 1H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 165.2, 161.4, 138.7, 137.0, 131.6, 131.1, 128.9, 123.8, 122.0, 120.1, 114.9, 61.5, 22.9, 18.0, 10.8.

HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{17}H_{13}BrFNOH$ 346.0243; Found 346.0242.

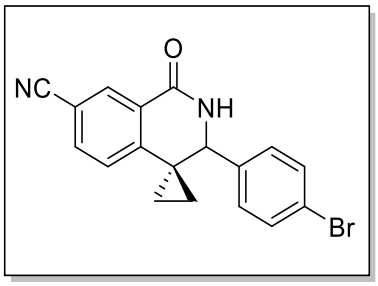
3'-(4-Bromophenyl)-7'-chloro-2',3'-dihydro-1'*H*-spiro[cyclopropane-1,4'-isoquinolin]-1'-one (3la).



White Solid; eluent (12% ethyl acetate in hexane). The reaction scale is 50 mg (**1l**), 71 mg was isolated and yield is 74%. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.06 (d, *J* = 1.9 Hz, 1H), 7.85 (d, *J* = 2.4 Hz, 1H), 7.39 (dd, *J* = 8.4, 2.2 Hz, 1H), 7.36 (d, *J* = 8.4 Hz, 2H), 7.05 (d, *J* = 8.2 Hz, 2H), 6.80 (d, *J* = 8.3 Hz, 1H), 4.19 (d, *J* = 3.6 Hz, 1H), 1.36 – 1.28 (m, 1H), 1.12 (dt, *J* = 10.5, 5.3 Hz, 1H), 1.02 (dd, *J* = 10.9, 4.8 Hz, 1H), 0.92 – 0.82 (m, 1H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 165.1, 139.8, 138.7, 133.0, 132.6, 131.7, 130.7, 128.9, 128.1, 123.4, 122.1, 61.4, 23.0, 18.5, 11.0.

HRMS (**ESI-TOF**) m/z: $[M + H]^+$ Calcd for $C_{17}H_{13}BrClNOH$ 361.9947; Found 361.9950.

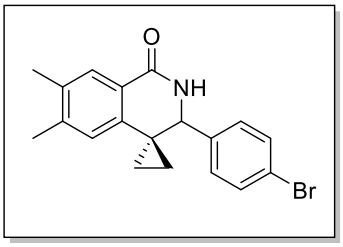
3'-(4-Bromophenyl)-1'-oxo-2',3'-dihydro-1'*H*-spiro[cyclopropane-1,4'-isoquinoline]-7'-carbonitrile (3ma).



White Solid; eluent (15% ethyl acetate in hexane). The reaction scale is 50 mg (**1m**), 76 mg was isolated and yield is 78%. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.40 (s, 1H), 7.71 (d, *J* = 8.0 Hz, 1H), 7.40 (d, *J* = 8.0 Hz, 3H), 7.05 (d, *J* = 8.0 Hz, 2H), 6.98 (d, *J* = 8.1 Hz, 1H), 4.30 (s, 1H), 1.43 – 1.32 (m, 1H), 1.26 – 1.17 (m, 1H), 1.17 – 1.08 (m, 1H), 1.05 – 0.95 (m, 1H). **^{13}C NMR (101 MHz, CDCl3)** δ 164.0, 146.8, 138.1, 136.1, 132.0, 131.9, 130.2, 128.8, 122.9, 122.5, 118.0, 110.7, 61.1, 23.8, 19.0, 12.1.

HRMS (**ESI-TOF**) m/z: $[M + H]^+$ Calcd for $C_{18}H_{13}BrN_2OH$ 353.0290; Found 353.0285.

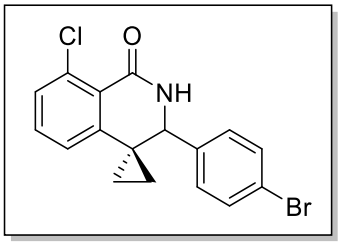
3'-(4-Bromophenyl)-6',7'-dimethyl-2',3'-dihydro-1'*H*-spiro[cyclopropane-1,4'-isoquinolin]-1'-one (3na).



Pale yellow Solid; eluent (12% ethyl acetate in hexane). The reaction scale is 50 mg (**1n**), 72 mg was isolated and yield is 75%. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.87 (s, 1H), 7.36 (d, *J* = 8.3 Hz, 2H), 7.06 (d, *J* = 8.2 Hz, 2H), 6.85 (s, 1H), 6.59 (s, 1H), 4.17 (d, *J* = 3.3 Hz, 1H), 2.28 (s, 3H), 2.25 (s, 3H), 1.27 (dd, *J* = 14.4, 6.2 Hz, 1H), 1.08 – 1.00 (m, 1H), 0.98 – 0.91 (m, 1H), 0.89 – 0.83 (m, 1H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 166.3, 142.4, 139.2, 138.6, 135.0, 131.6, 129.1, 129.0, 126.6, 122.9, 121.9, 61.8, 23.0, 20.2, 19.3, 17.8, 10.7.

HRMS (**ESI-TOF**) m/z: $[M + H]^+$ Calcd for $C_{19}H_{18}BrNOH$ 356.0650; Found 356.0642.

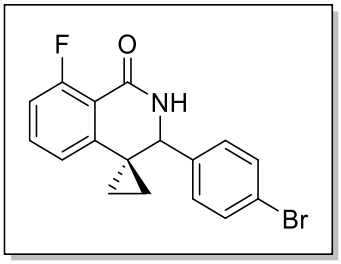
3'-(4-Bromophenyl)-8'-chloro-2',3'-dihydro-1'*H*-spiro[cyclopropane-1,4'-isoquinolin]-1'-one (3oa).



White Solid; eluent (12% ethyl acetate in hexane). The reaction scale is 50 mg (**1o**), 43 mg was isolated and yield is 45%. **^{1}H NMR (400 MHz, $CDCl_3$)** ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.45 – 7.34 (m, 3H), 7.33 (s, 1H), 7.29 (d, *J* = 7.6 Hz, 1H), 7.08 (d, *J* = 7.8 Hz, 2H), 6.79 (d, *J* = 7.4 Hz, 1H), 4.15 (d, *J* = 3.5 Hz, 1H), 1.35 (d, *J* = 9.7 Hz, 1H), 1.08 (s, 2H), 0.96 – 0.87 (m, 1H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 163.9, 143.9, 138.1, 135.1, 132.6, 131.6, 130.5, 128.8, 122.0, 121.0, 60.7, 25.2, 16.9, 10.9.

HRMS (**ESI-TOF**) m/z: $[M + H]^+$ Calcd for $C_{17}H_{13}BrClNOH$ 361.9947; Found 361.9946.

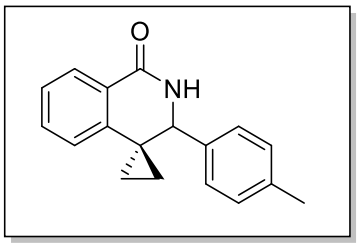
3'-(4-Bromophenyl)-8'-fluoro-2',3'-dihydro-1'*H*-spiro[cyclopropane-1,4'-isoquinolin]-1'-one (3pa).



White Solid; eluent (12% ethyl acetate in hexane). The reaction scale is 50 mg (**1p**), 62 mg was isolated and yield is 62%. **^{1}H NMR (400 MHz, CDCl$_3$)** δ 7.75 (s, 1H), 7.36 (dd, J = 10.0, 6.9 Hz, 3H), 7.10 (d, J = 8.3 Hz, 2H), 6.99 (dd, J = 10.7, 8.6 Hz, 1H), 6.67 (d, J = 7.8 Hz, 1H), 4.16 (d, J = 4.3 Hz, 1H), 1.39 (dt, J = 10.9, 5.3 Hz, 1H), 1.17 – 1.02 (m, 2H), 0.95 – 0.86 (m, 1H). **^{13}C NMR (101 MHz, CDCl$_3$)** δ 163.6, 161.0, 144.1, 138.6, 134.1, 131.6, 128.9, 121.9, 117.8, 117.7, 115.5, 60.9, 24.1, 17.9, 11.0.

HRMS (**ESI-TOF**) m/z: $[M + H]^+$ Calcd for $C_{17}H_{13}BrFNOH$ 346.0243; Found 346.0242.

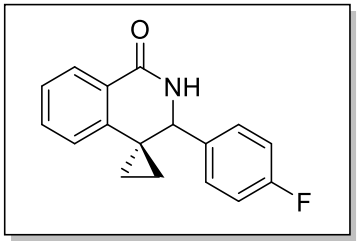
3'-(*p*-Tolyl)-2',3'-dihydro-1'*H*-spiro[cyclopropane-1,4'-isoquinolin]-1'-one (3ab).



White Solid; eluent (12% ethyl acetate in hexane). The reaction scale is 50 mg (**1a**), 68 mg was isolated and yield is 80%. **^{1}H NMR (500 MHz, CDCl$_3$)**: δ 8.13 (d, J = 7.5 Hz, 1H), 7.43 (t, J = 7.6 Hz, 1H), 7.31 (t, J = 7.4 Hz, 1H), 7.07 (q, J = 8.1 Hz, 4H), 6.86 (d, J = 7.8 Hz, 1H), 4.37 (d, J = 9.2 Hz, 1H), 2.28 (s, 3H), 1.12 (t, J = 5.7 Hz, 1H), 1.02 – 0.93 (m, 3H). **^{13}C NMR (126 MHz, CDCl$_3$)**: δ 166.1, 142.0, 137.9, 136.3, 132.9, 129.3, 129.2, 128.2, 127.4, 126.3, 121.6, 61.6, 23.4, 21.1, 16.2, 11.6.

HRMS (ESI-TOF) m/z: $[M+H]^+$ Calcd for $C_{18}H_{17}NOH$ 264.1388; Found 264.1371.

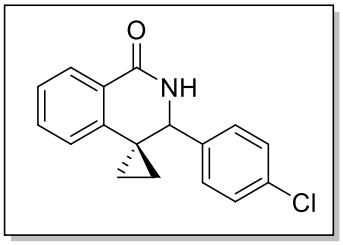
3'-(4-Fluorophenyl)-2',3'-dihydro-1'*H*-spiro[cyclopropane-1,4'-isoquinolin]-1'-one (3ac).



White Solid; eluent (12% ethyl acetate in hexane). The reaction scale is 50 mg (**1a**), 60 mg was isolated and yield is 70%. **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 8.13 (d, J = 7.7 Hz, 1H), 7.45 (t, J = 7.5 Hz, 1H), 7.33 (t, J = 7.5 Hz, 1H), 7.17 (dd, J = 8.2, 5.5 Hz, 2H), 7.03 (s, 1H), 6.93 (t, J = 8.5 Hz, 2H), 6.87 (d, J = 7.8 Hz, 1H), 4.31 (d, J = 3.2 Hz, 1H), 1.25 (dd, J = 9.5, 4.5 Hz, 1H), 1.07 – 1.01 (m, 1H), 0.98 (d, J = 5.1 Hz, 1H), 0.94 (dd, J = 9.3, 6.1 Hz, 1H). **^{13}C NMR (101 MHz, $CDCl_3$)**: δ 166.1, 162.4, 141.5, 135.6, 133.1, 129.2, 129.0, 128.2, 126.4, 121.7, 115.4, 61.4, 23.4, 17.3, 11.2.

HRMS (ESI-TOF) m/z: $[M+H]^+$ Calcd for $C_{17}H_{14}FNOH$ 268.1138; Found 268.1144.

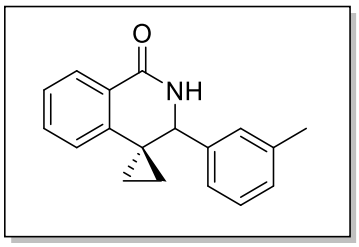
3'-(4-Chlorophenyl)-2',3'-dihydro-1'*H*-spiro[cyclopropane-1,4'-isoquinolin]-1'-one (3ad).



White Solid; eluent (12% ethyl acetate in hexane). The reaction scale is 50 mg (**1a**), 80 mg was isolated and yield is 87%. **^{1}H NMR (500 MHz, $CDCl_3$):** δ 8.13 (d, J = 7.7 Hz, 1H), 7.45 (t, J = 7.6 Hz, 1H), 7.33 (t, J = 7.6 Hz, 1H), 7.22 (d, J = 8.3 Hz, 2H), 7.13 (d, J = 8.3 Hz, 2H), 6.86 (d, J = 7.9 Hz, 2H), 4.27 (d, J = 3.3 Hz, 1H), 1.27 (dd, J = 10.0, 5.3 Hz, 1H), 1.08 – 1.03 (m, 1H), 0.99 (dd, J = 10.6, 5.0 Hz, 1H), 0.94 (dd, J = 9.7, 3.9 Hz, 1H). **^{13}C NMR (126 MHz, $CDCl_3$):** δ 166.0, 141.3, 138.3, 133.9, 133.1, 129.1, 128.7, 128.6, 128.2, 126.5, 121.7, 61.5, 23.4, 17.6, 11.1.

HRMS (ESI-TOF) m/z: $[M+H]^+$ Calcd for $C_{17}H_{14}ClNOH$ 284.0842; Found 284.0845.

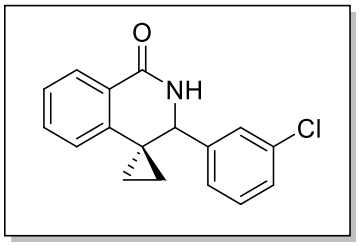
3'-(*m*-Tolyl)-2',3'-dihydro-1'*H*-spiro[cyclopropane-1,4'-isoquinolin]-1'-one (3ae).



White Solid; eluent (12% ethyl acetate in hexane). The reaction scale is 50 mg (**1a**), 61 mg was isolated and yield is 72%. **^{1}H NMR** (400 MHz, CDCl3) δ 8.15 (d, J = 7.7 Hz, 1H), 7.43 (d, J = 7.6 Hz, 1H), 7.33 (d, J = 7.5 Hz, 1H), 7.15 (t, J = 7.5 Hz, 1H), 7.07 (d, J = 7.5 Hz, 1H), 7.00 (d, J = 9.5 Hz, 2H), 6.87 (d, J = 7.7 Hz, 1H), 6.59 (s, 1H), 4.40 (s, 1H), 2.29 (s, 3H), 1.14 – 1.08 (m, 1H), 0.97 (dd, J = 11.7, 6.5 Hz, 3H). **^{13}C NMR** (101 MHz, CDCl3) δ 166.1, 142.0, 139.2, 138.2, 132.9, 128.9, 128.4, 128.3, 128.2, 127.5, 126.3, 124.6, 121.6, 61.8, 23.3, 21.5, 16.0, 11.8.

HRMS (ESI-TOF) m/z: $[M+H]^+$ Calcd for $C_{18}H_{17}NOH$ 264.1388; Found 264.1377.

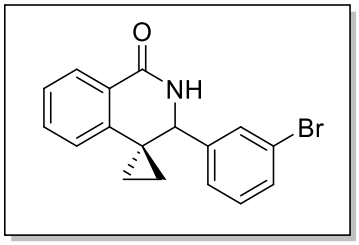
3'-(3-Chlorophenyl)-2',3'-dihydro-1'*H*-spiro[cyclopropane-1,4'-isoquinolin]-1'-one (3af).



White Solid; eluent (12% ethyl acetate in hexane). The reaction scale is 50 mg (**1a**), 79 mg was isolated and yield is 86%. **^{1}H NMR (400 MHz, CDCl$_3$):** δ 8.13 (d, J = 7.7 Hz, 1H), 7.45 (t, J = 7.6 Hz, 1H), 7.33 (t, J = 7.6 Hz, 1H), 7.24 – 7.15 (m, 3H), 7.08 (d, J = 7.5 Hz, 1H), 7.01 (s, 1H), 6.87 (d, J = 7.8 Hz, 1H), 4.24 (d, J = 3.3 Hz, 1H), 1.32 (dt, J = 10.8, 5.5 Hz, 1H), 1.14 – 1.06 (m, 1H), 1.06 – 0.98 (m, 1H), 0.98 – 0.90 (m, 1H). **^{13}C NMR (101 MHz, CDCl$_3$):** δ 166.0, 142.0, 141.3, 134.4, 133.1, 129.8, 129.1, 128.2, 127.5, 126.5, 125.4, 121.6, 61.7, 23.3, 17.9, 11.0.

HRMS (ESI-TOF) m/z: $[M+H]^+$ Calcd for $C_{17}H_{14}ClNOH$ 284.0842; Found 284.0841.

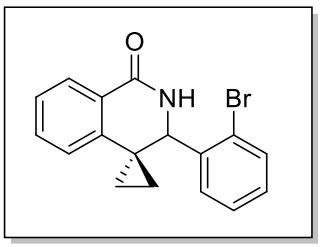
3'-(3-Bromophenyl)-2',3'-dihydro-1'*H*-spiro[cyclopropane-1,4'-isoquinolin]-1'-one (3ag).



White Solid; eluent (12% ethyl acetate in hexane). The reaction scale is 50 mg (**1a**), 75 mg was isolated and yield is 72%. **^{1}H NMR (400 MHz, CDCl$_3$)**: δ 8.12 (dd, *J* = 7.7, 0.9 Hz, 1H), 7.45 (td, *J* = 7.7, 1.3 Hz, 1H), 7.38 – 7.30 (m, 4H), 7.10 (dt, *J* = 11.8, 7.8 Hz, 2H), 6.87 (d, *J* = 7.7 Hz, 1H), 4.22 (d, *J* = 3.7 Hz, 1H), 1.36 – 1.28 (m, 1H), 1.12 – 1.06 (m, 1H), 1.00 (dd, *J* = 9.7, 5.8 Hz, 1H), 0.91 (ddd, *J* = 10.2, 6.2, 4.4 Hz, 1H). **^{13}C NMR (101 MHz, CDCl$_3$):** δ 166.1, 142.3, 141.2, 133.1, 131.1, 130.5, 130.1, 129.2, 128.2, 126.5, 125.9, 122.5, 121.6, 61.6, 23.3, 18.1, 10.9.

HRMS (ESI-TOF) m/z: $[M+H]^+$ Calcd for $C_{17}H_{14}BrNOH$ 328.0337; Found 328.0323.

3'-(2-Bromophenyl)-2',3'-dihydro-1'*H*-spiro[cyclopropane-1,4'-isoquinolin]-1'-one (3ah).

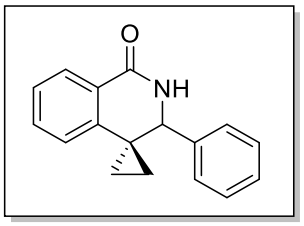


White Solid; eluent (12% ethyl acetate in hexane). The reaction scale is 50 mg (**1a**), 80 mg was isolated and yield is 76%. **^{1}H NMR (400 MHz, CDCl$_3$)**: δ 8.12 (d, *J* = 7.7 Hz, 1H), 7.52 (dd, *J* =

13.2, 7.1 Hz, 2H), 7.34 (t, *J* = 7.5 Hz, 1H), 7.23 (d, *J* = 7.4 Hz, 1H), 7.11 (p, *J* = 7.5 Hz, 2H), 6.97 (d, *J* = 7.8 Hz, 1H), 6.59 (s, 1H), 4.61 (d, *J* = 3.7 Hz, 1H), 1.49 – 1.39 (m, 1H), 1.27 – 1.17 (m, 1H), 0.99 (t, *J* = 7.2 Hz, 2H). **^{13}C NMR (101 MHz, $CDCl_3$):** δ 165.2, 142.0, 139.4, 133.2, 133.1, 129.5, 129.0, 128.9, 128.5, 127.8, 126.4, 124.0, 121.1, 60.7, 21.8, 20.5, 11.0.

HRMS (ESI-TOF) m/z: $[M+H]^+$ Calcd for $C_{17}H_{14}BrNOH$ 328.0337; Found 328.0336.

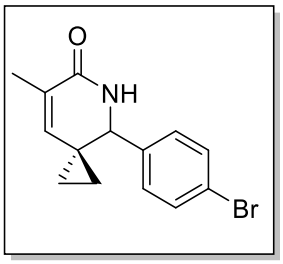
3'-Phenyl-2',3'-dihydro-1'*H*-spiro[cyclopropane-1,4'-isoquinolin]-1'-one (3ai).



White Solid; eluent (12% ethyl acetate in hexane). The reaction scale is 50 mg (**1a**), 60 mg was isolated and yield is 75%. **^{1}H NMR (400 MHz, $CDCl_3$)**: δ 8.14 (d, *J* = 7.7 Hz, 1H), 7.44 (t, *J* = 7.6 Hz, 1H), 7.32 (t, *J* = 7.5 Hz, 1H), 7.25 (d, *J* = 5.3 Hz, 3H), 7.22 – 7.18 (m, 2H), 6.89 (s, 1H), 6.87 (d, *J* = 7.8 Hz, 1H), 4.37 (d, *J* = 2.8 Hz, 1H), 1.17 (dd, *J* = 8.1, 4.0 Hz, 1H), 1.00 (d, *J* = 4.4 Hz, 2H), 0.96 (dd, *J* = 10.2, 5.6 Hz, 1H). **^{13}C NMR (101 MHz, $CDCl_3$)**: δ 166.1, 141.8, 139.5, 132.9, 129.3, 128.5, 128.2, 128.1, 127.4, 126.3, 121.6, 62.0, 23.4, 16.8, 11.4.

HRMS (ESI-TOF) m/z: $[M+H]^+$ Calcd for $C_{17}H_{15}NOH$ 250.1232; Found 250.1230.

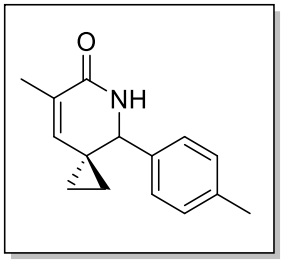
4-(4-Bromophenyl)-7-methyl-5-azaspiro[2.5]oct-7-en-6-one (5aa).



Yellow Solid; eluent (10% ethyl acetate in hexane). The reaction scale is 50 mg (**5a**), 54 mg was isolated and yield is 45%. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.47 (d, *J* = 8.2 Hz, 2H), 7.15 (d, *J* = 8.1 Hz, 2H), 5.84 (s, 1H), 5.75 (s, 1H), 4.51 (s, 1H), 1.91 (s, 3H), 0.80 – 0.74 (m, 1H), 0.65 (dt, *J* = 14.0, 8.8 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 167.8, 143.3, 137.9, 131.7, 129.4, 129.1, 122.3, 60.4, 22.1, 16.4, 13.5, 11.7.

HRMS (**ESI-TOF**) m/z: $[M+H]^+$ Calcd for $C_{14}H_{14}BrNOH$ 292.0337; Found 292.0325.

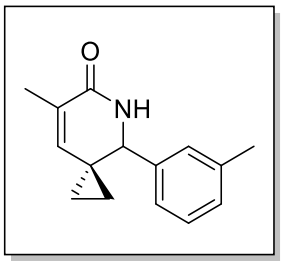
7-Methyl-4-(*p*-tolyl)-5-azaspiro[2.5]oct-7-en-6-one (5ab).



Yellow Solid; eluent (10% ethyl acetate in hexane). The reaction scale is 50 mg (**5a**), 35 mg was isolated and yield is 36%. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.14 (s, 4H), 5.77 (s, 1H), 5.68 (s, 1H), 4.63 (s, 1H), 2.34 (s, 3H), 1.92 (s, 3H), 0.71 (d, J = 11.5 Hz, 1H), 0.64 (d, J = 12.3 Hz, 2H), 0.56 (d, J = 9.6 Hz, 1H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 168.2, 143.9, 138.2, 135.2, 129.2, 128.9, 60.4, 22.33, 21.1, 16.4, 12.8, 11.5.

HRMS (**ESI-TOF**) m/z: $[M+H]^+$ Calcd for $C_{15}H_{17}NOH$ 228.1388; Found 228.1380.

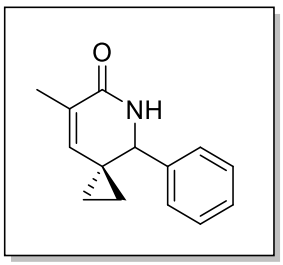
7-Methyl-4-(*m*-tolyl)-5-azaspiro[2.5]oct-7-en-6-one (5ae).



Yellow Solid; eluent (10% ethyl acetate in hexane). The reaction scale is 50 mg (**5a**), 32 mg was isolated and yield is 33%. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.21 (d, J = 7.5 Hz, 1H), 7.12 (d, J = 7.6 Hz, 1H), 7.05 (d, J = 8.8 Hz, 2H), 5.78 (s, 1H), 5.70 (s, 1H), 4.62 (s, 1H), 2.34 (s, 3H), 1.93 (s, 3H), 0.73 (d, J = 11.5 Hz, 1H), 0.70 – 0.63 (m, 2H), 0.57 (d, J = 9.2 Hz, 1H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 168.1, 143.9, 138.2, 129.1, 128.8, 128.6, 128.4, 125.0, 60.7, 22.2, 21.4, 16.4, 12.9, 11.6.

HRMS (**ESI-TOF**) m/z: $[M+H]^+$ Calcd for $C_{15}H_{17}NOH$ 228.1388; Found 228.1385.

7-Methyl-4-phenyl-5-azaspiro[2.5]oct-7-en-6-one (5ai).

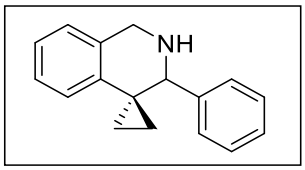


Yellow Solid; eluent (10% ethyl acetate in hexane). The reaction scale is 50 mg (**5a**), 32 mg was isolated and yield is 37%. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.34 (q, J = 6.2 Hz, 3H), 7.29 – 7.26 (m,

2H), 5.78 (s, 1H), 5.70 (s, 1H), 4.64 (s, 1H), 1.93 (s, 3H), 0.77 – 0.72 (m, 1H), 0.70 – 0.65 (m, 2H), 0.61 – 0.55 (m, 1H). **^{13}C NMR (101 MHz, CDCl3)** δ 168.1, 143.7, 138.4, 128.9, 128.5, 128.4, 127.9, 60.8, 22.3, 16.4, 13.0, 11.5.

HRMS (**ESI-TOF**) m/z: $[M+H]^+$ Calcd for $C_{14}H_{15}NOH$ 214.1232; Found 214.1228.

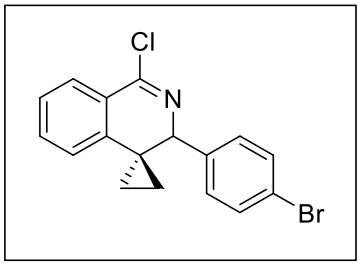
3'-Phenyl-2',3'-dihydro-1'*H*-spiro[cyclopropane-1,4'-isoquinoline] (6).



Pale Yellow Liquid; eluent (50% ethyl acetate in hexane). The reaction scale is 50 mg (**3aa**), 37 mg was isolated and yield is 79%. **^{1}H NMR (400 MHz, CDCl$_3$)** δ ^{1}H NMR (400 MHz, CDCl3) δ 7.32 (d, J = 6.8 Hz, 2H), 7.30 – 7.24 (m, 3H), 7.16 (d, J = 7.6 Hz, 1H), 7.09 (t, J = 7.2 Hz, 1H), 6.98 (d, J = 7.4 Hz, 1H), 6.83 (d, J = 7.8 Hz, 1H), 4.09 (d, J = 16.1 Hz, 1H), 3.94 (d, J = 16.8 Hz, 1H), 1.14 (d, J = 7.2 Hz, 1H), 0.90 (dd, J = 16.0, 6.4 Hz, 2H), 0.85 – 0.77 (m, 1H). **^{13}C NMR (101 MHz, CDCl$_3$)** δ 140.5, 139.9, 135.7, 128.6, 128.0, 127.1, 126.8, 125.7, 124.8, 121.8, 64.0, 46.5, 21.7, 17.9, 14.2.

HRMS (**ESI-TOF**) m/z: $[M+H]^+$ Calcd for $C_{17}H_{17}NH$ 236.1439; Found 236.1441.

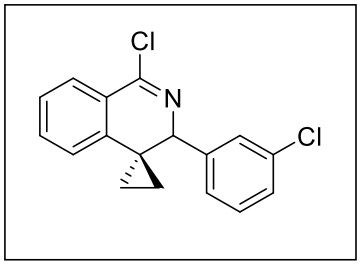
3'-(4-Bromophenyl)-1'-chloro-3'*H*-spiro[cyclopropane-1,4'-isoquinoline] (7aa).



Pale Yellow Liquid; eluent (5% triethylamine in diethyl ether). The reaction scale is 50 mg (**3aa**), 39 mg was isolated and yield is 75%. **^{1}H NMR (400 MHz, CDCl$_3$)** δ 7.84 (d, J = 7.7 Hz, 1H), 7.45 (t, J = 7.5 Hz, 1H), 7.37 (d, J = 8.2 Hz, 2H), 7.32 (t, J = 7.6 Hz, 1H), 7.11 (d, J = 8.1 Hz, 2H), 6.94 (d, J = 7.7 Hz, 1H), 4.63 (s, 1H), 1.18 (d, J = 6.8 Hz, 1H), 1.04 (t, J = 7.1 Hz, 1H), 0.92 (d, J = 7.7 Hz, 2H). **^{13}C NMR (101 MHz, CDCl$_3$)** δ 155.6, 141.9, 137.8, 133.1, 131.3, 129.7, 128.9, 127.7, 126.5, 121.7, 121.5, 68.9, 20.2, 17.1, 9.7.

HRMS (**ESI-TOF**) m/z: $[M+H]^+$ Calcd for $C_{17}H_{13}BrClNH$ 345.9998; Found 345.9997.

1'-Chloro-3'-(3-chlorophenyl)-3'*H*-spiro[cyclopropane-1,4'-isoquinoline] (7af).

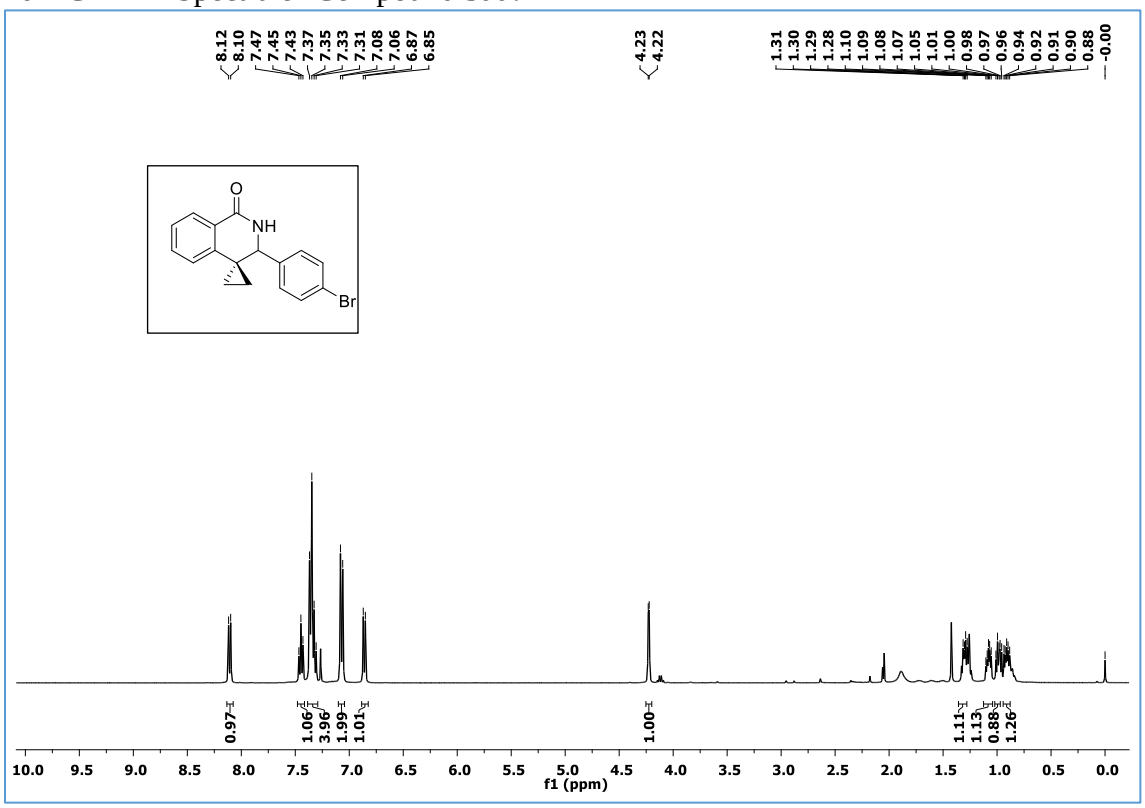


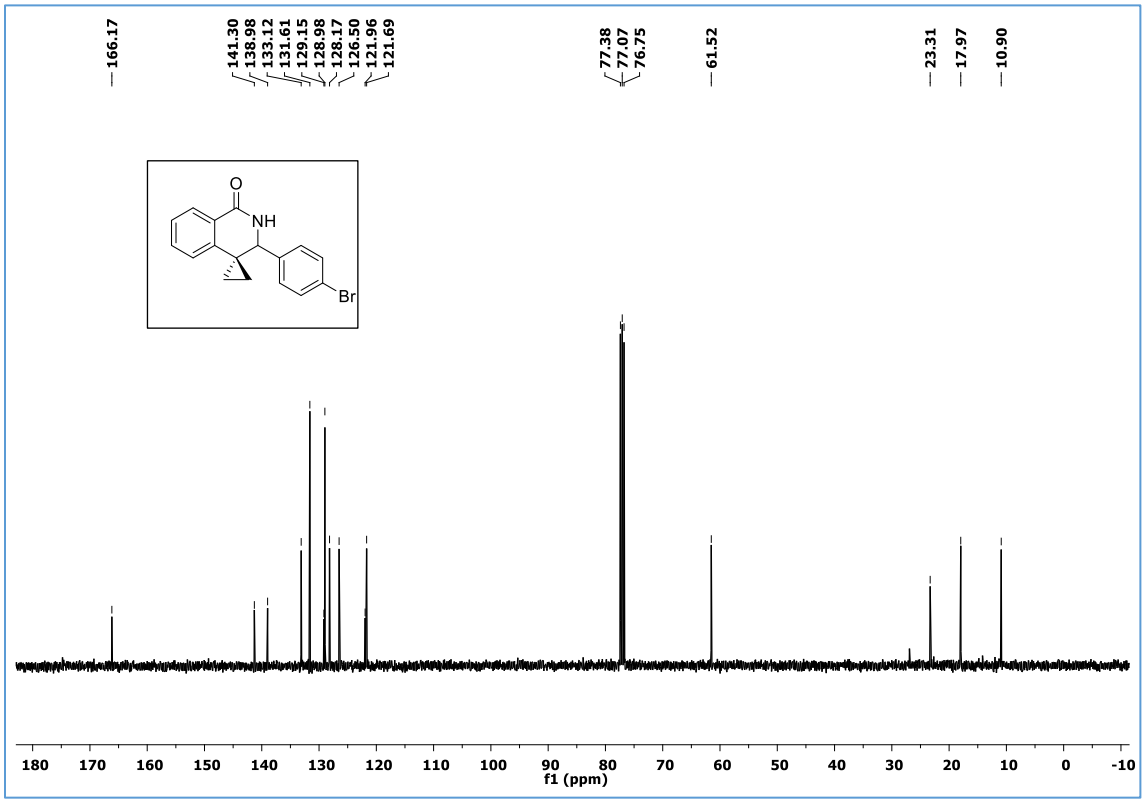
Pale Yellow Liquid; eluent (5% triethylamine in diethyl ether). The reaction scale is 50 mg (**3af**), 37 mg was isolated and yield is 70%. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.85 (d, J = 7.7 Hz, 1H), 7.46 (t, J = 7.4 Hz, 1H), 7.32 (t, J = 7.5 Hz, 1H), 7.25 (s, 1H), 7.23 – 7.14 (m, 2H), 7.12 (d, J = 7.0 Hz, 1H), 6.96 (d, J = 7.7 Hz, 1H), 4.66 (s, 1H), 1.21 – 1.13 (m, 1H), 1.03 (t, J = 7.1 Hz, 1H), 0.95 – 0.86 (m, 2H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 155.7, 141.9, 140.8, 134.0, 133.2, 129.4, 128.9, 128.3, 127.8, 126.5, 126.2, 121.6, 68.9, 20.1, 16.8, 9.9.

HRMS (**ESI-TOF**) m/z: [M+H]+ Calcd for $C_{17}H_{13}Cl_2NH$ 302.0503; Found 302.0504.

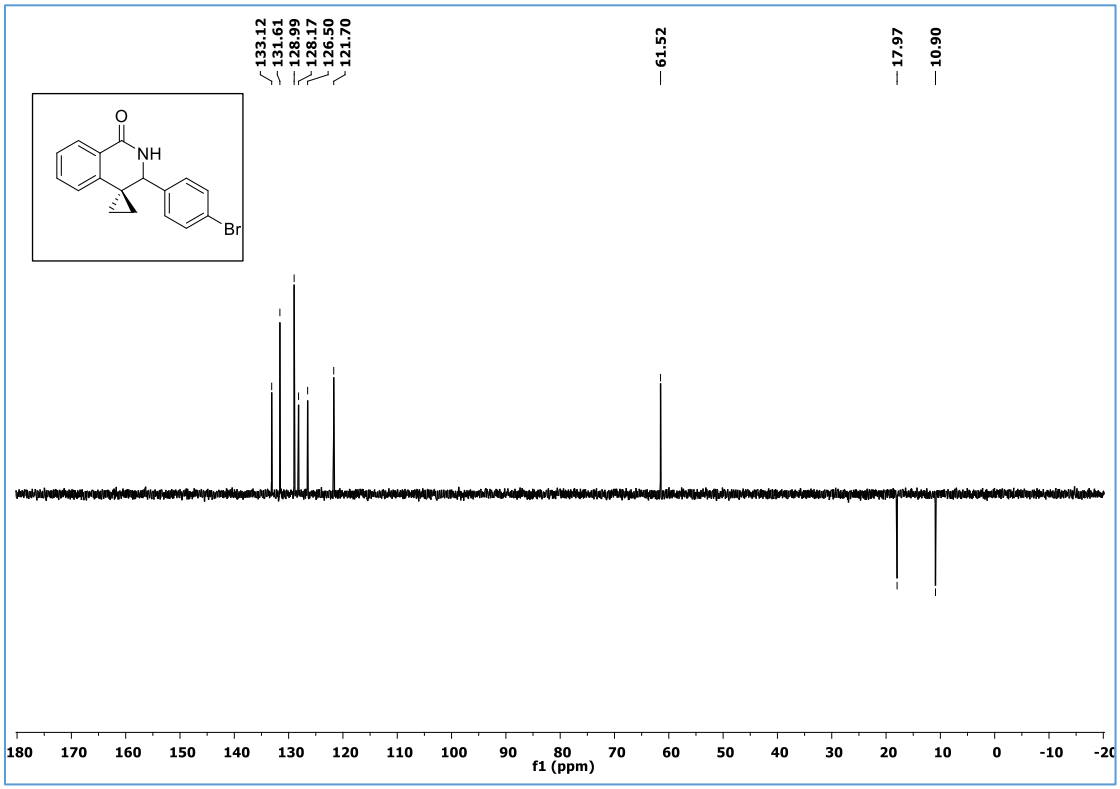
Characteristic spectra of all compounds

^{1}H and ^{13}C NMR Spectra of Compound **3aa.**

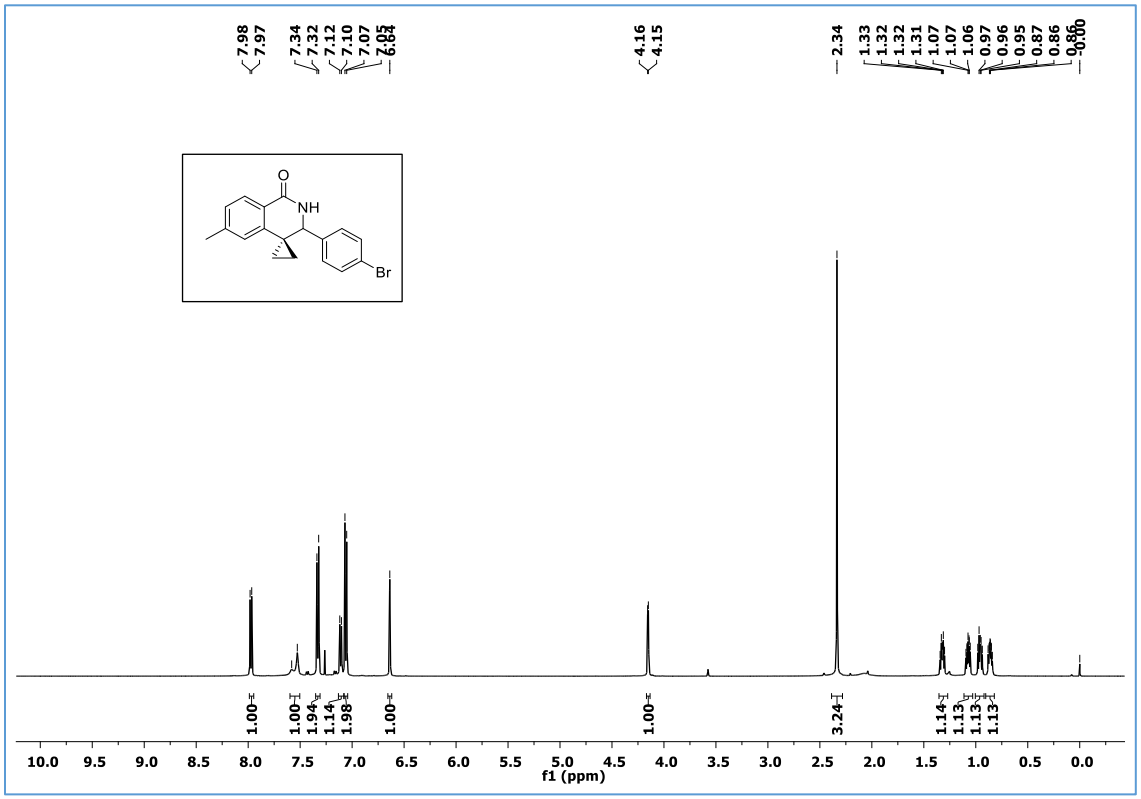


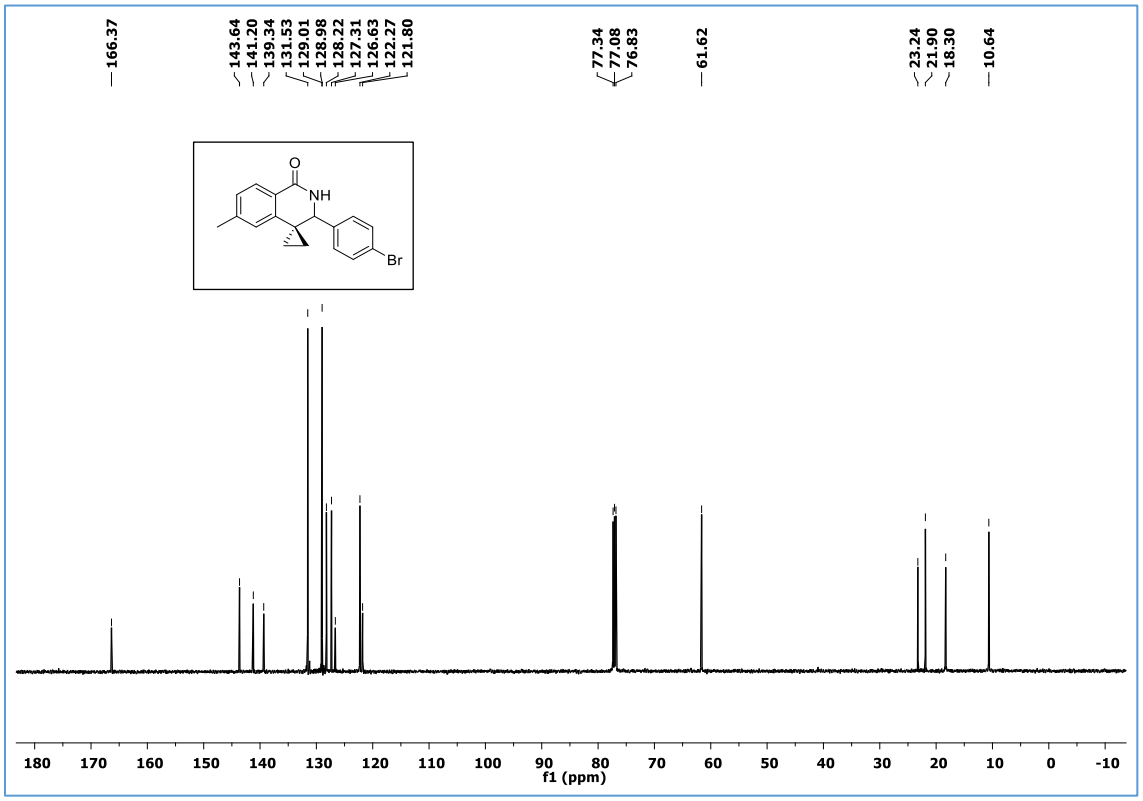


DEPT (135) NMR Spectrum of Compound **3aa.**

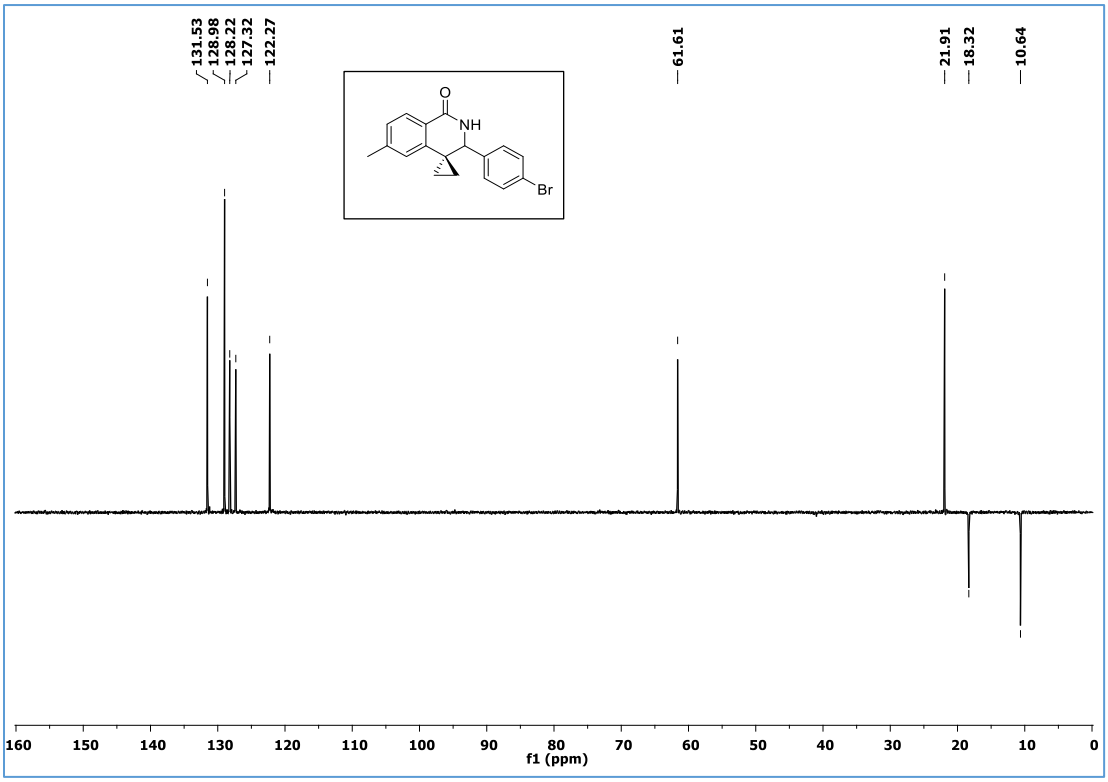


^{1}H and ^{13}C NMR Spectra of Compound **3ba.**

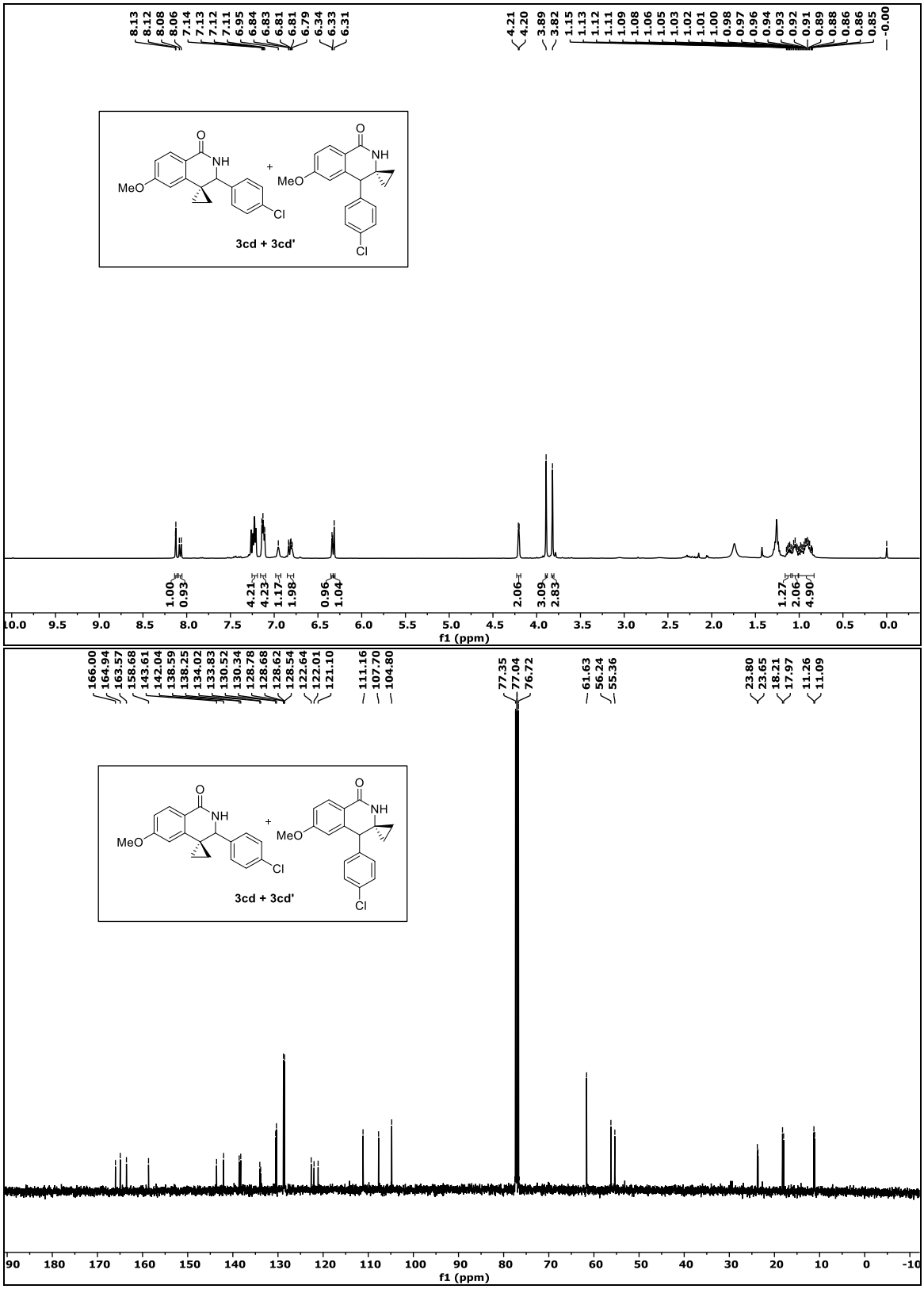




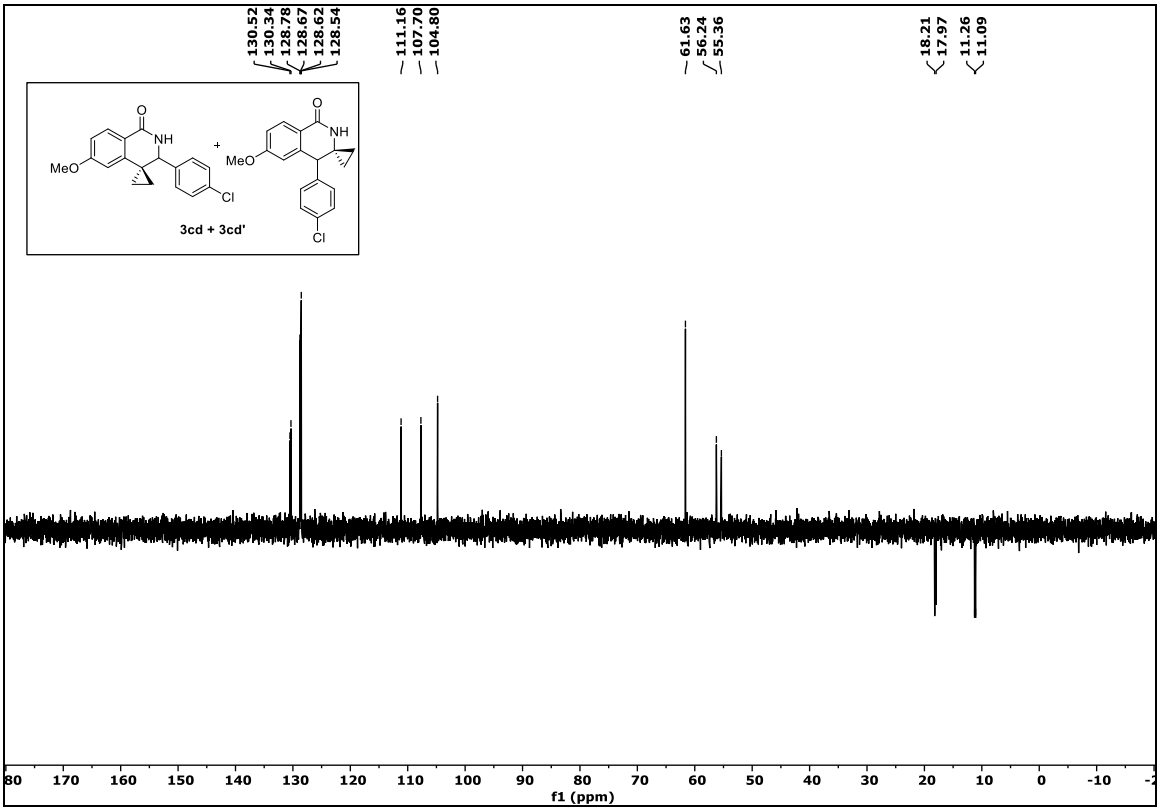
DEPT (135) NMR Spectrum of Compound **3ba.**



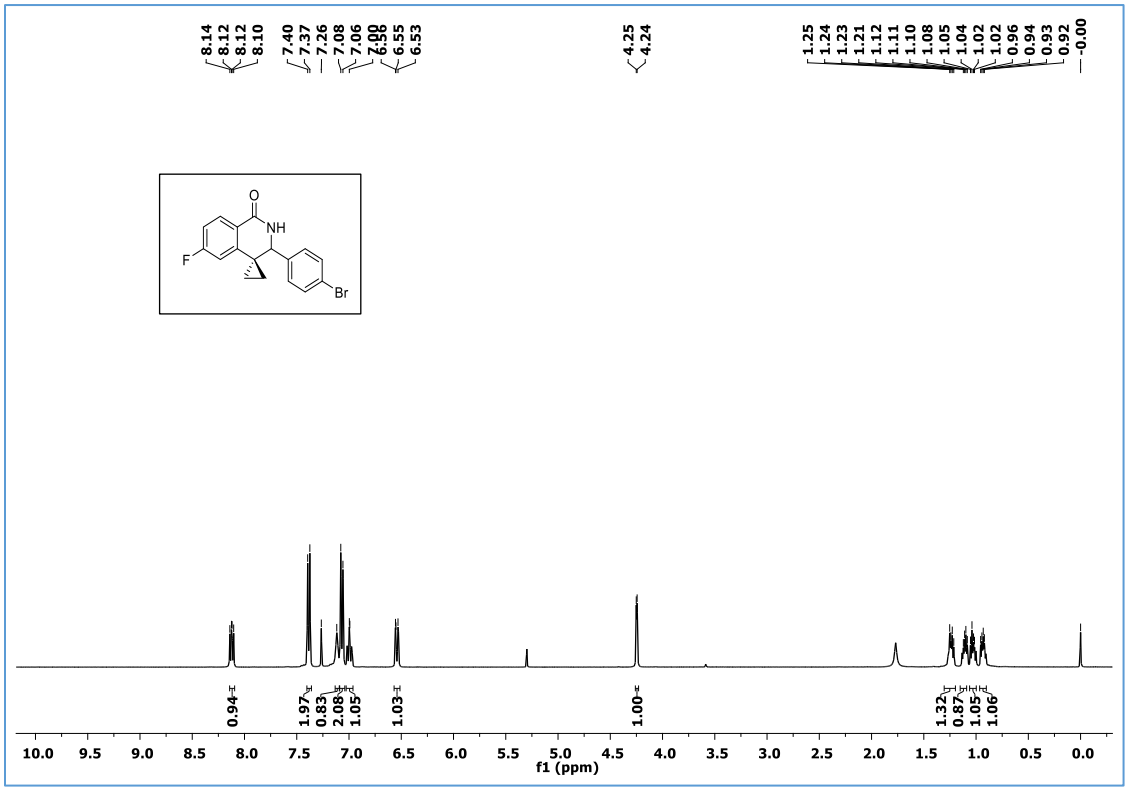
^{1}H and ^{13}C NMR Spectra of Compound **3cd.**

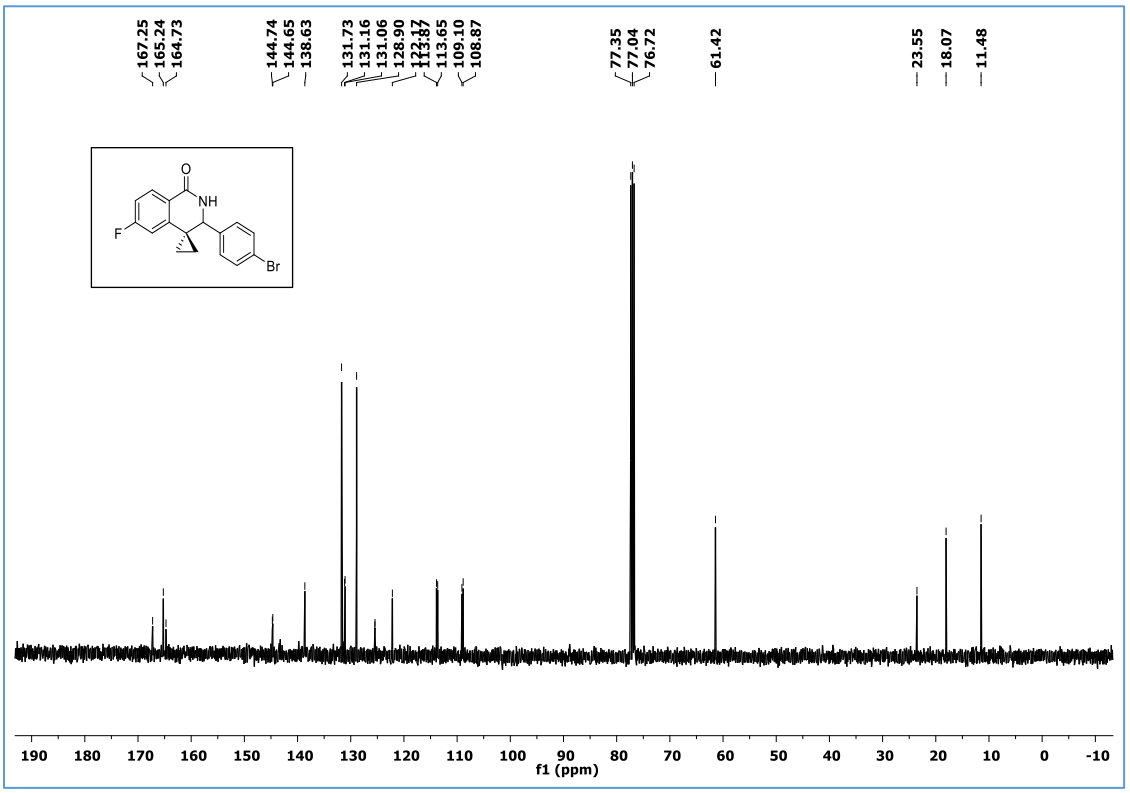


DEPT (135) NMR Spectrum of Compound **3cd.**

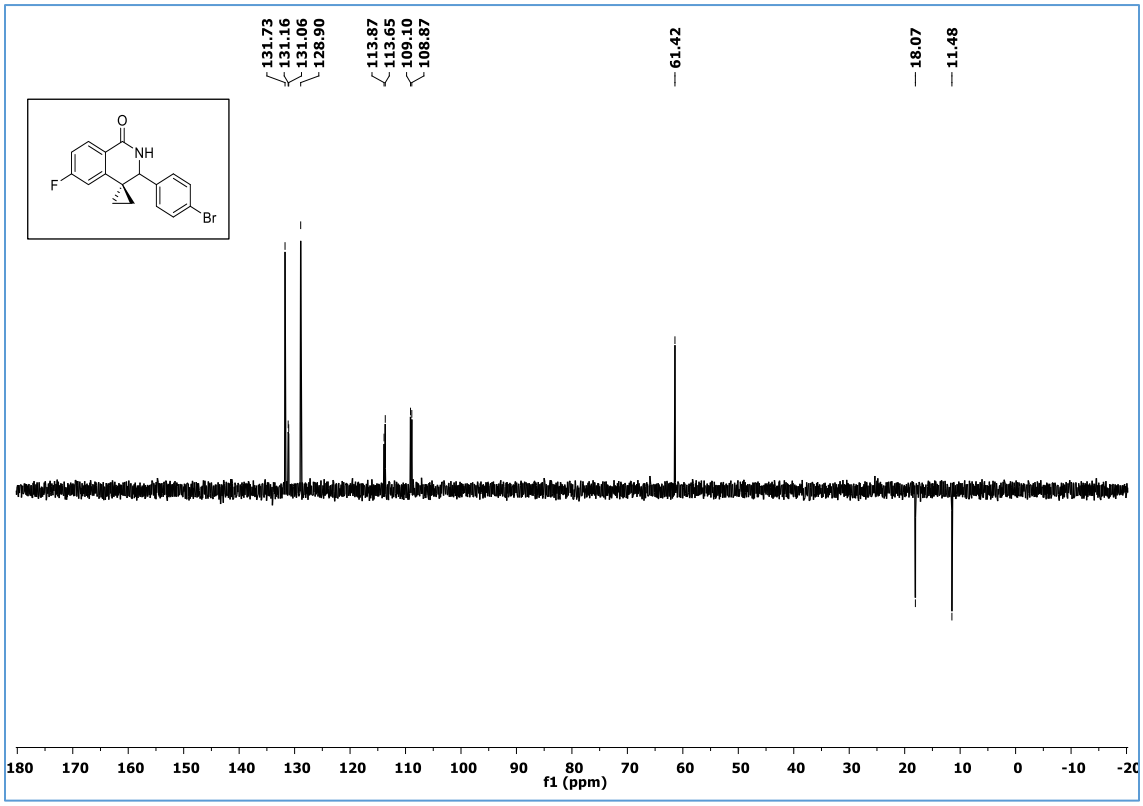


^{1}H and ^{13}C NMR Spectra of Compound **3da.**

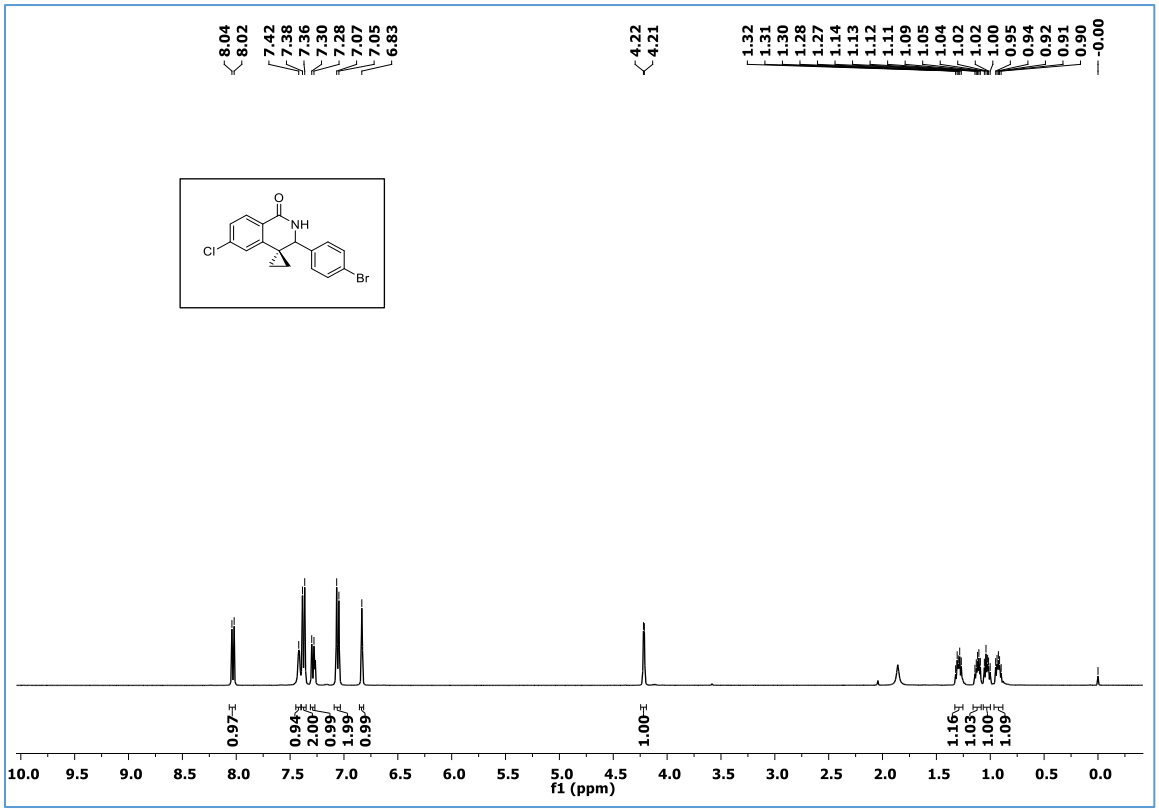


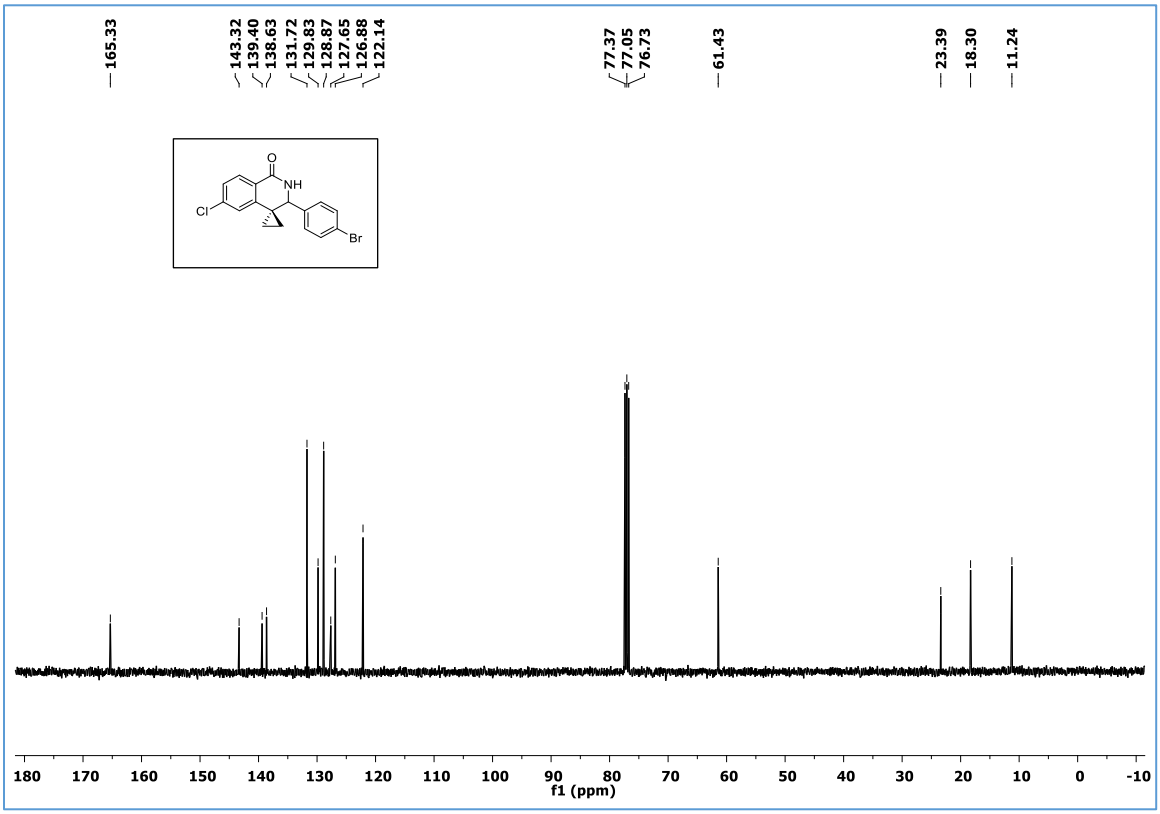


DEPT (135) NMR Spectrum of Compound **3da.**

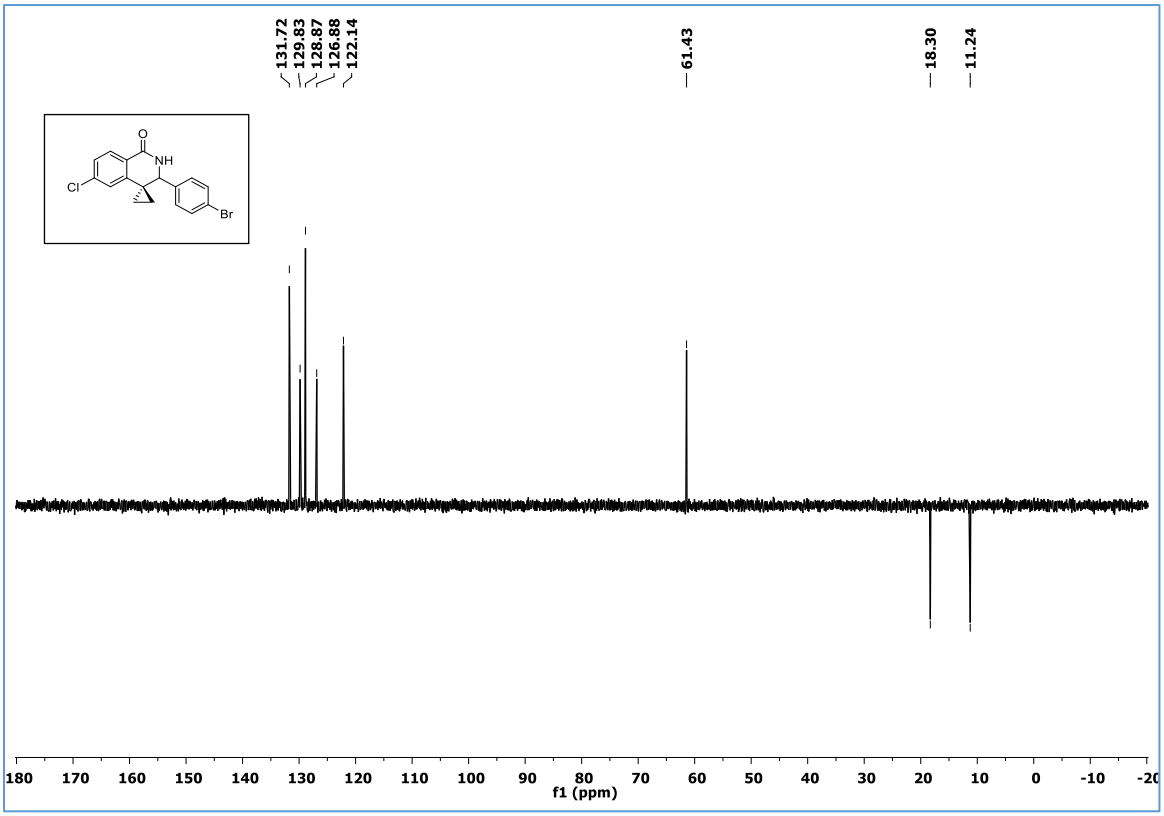


^{1}H and ^{13}C NMR Spectra of Compound **3ea.**

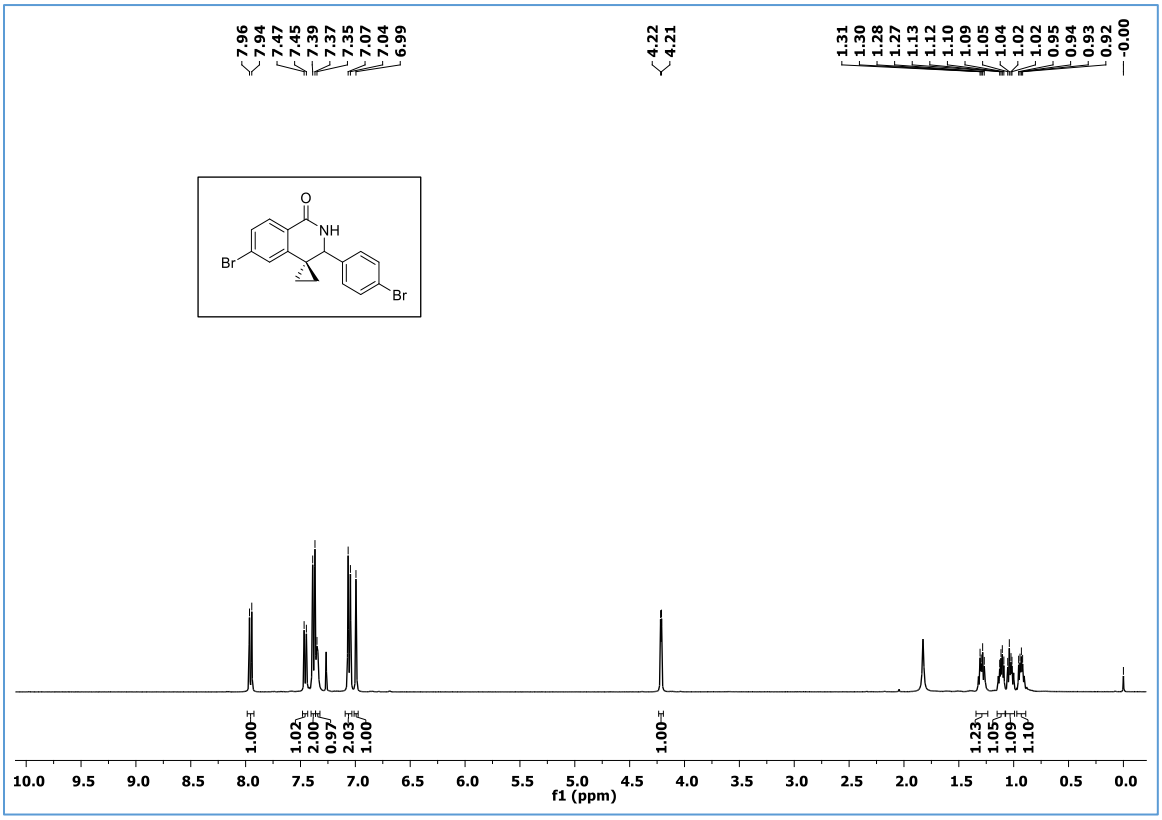


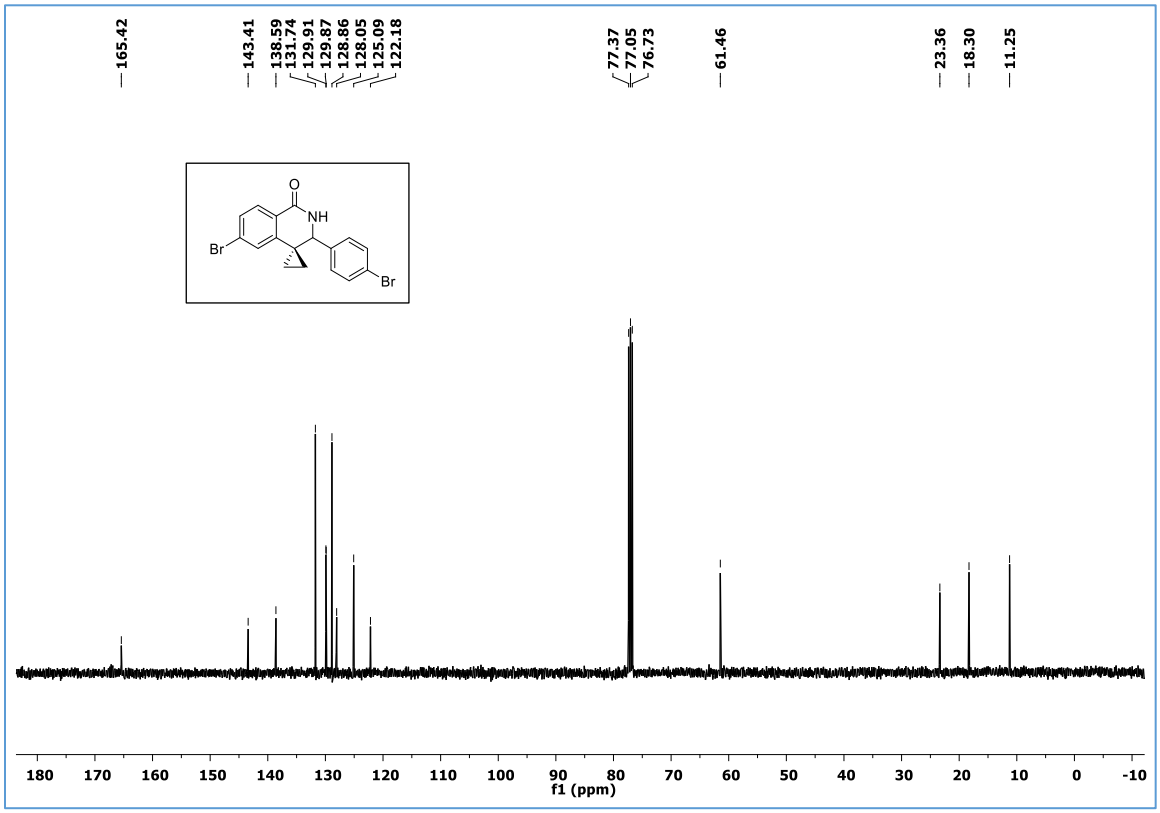


DEPT (135) NMR Spectrum of Compound **3ea.**

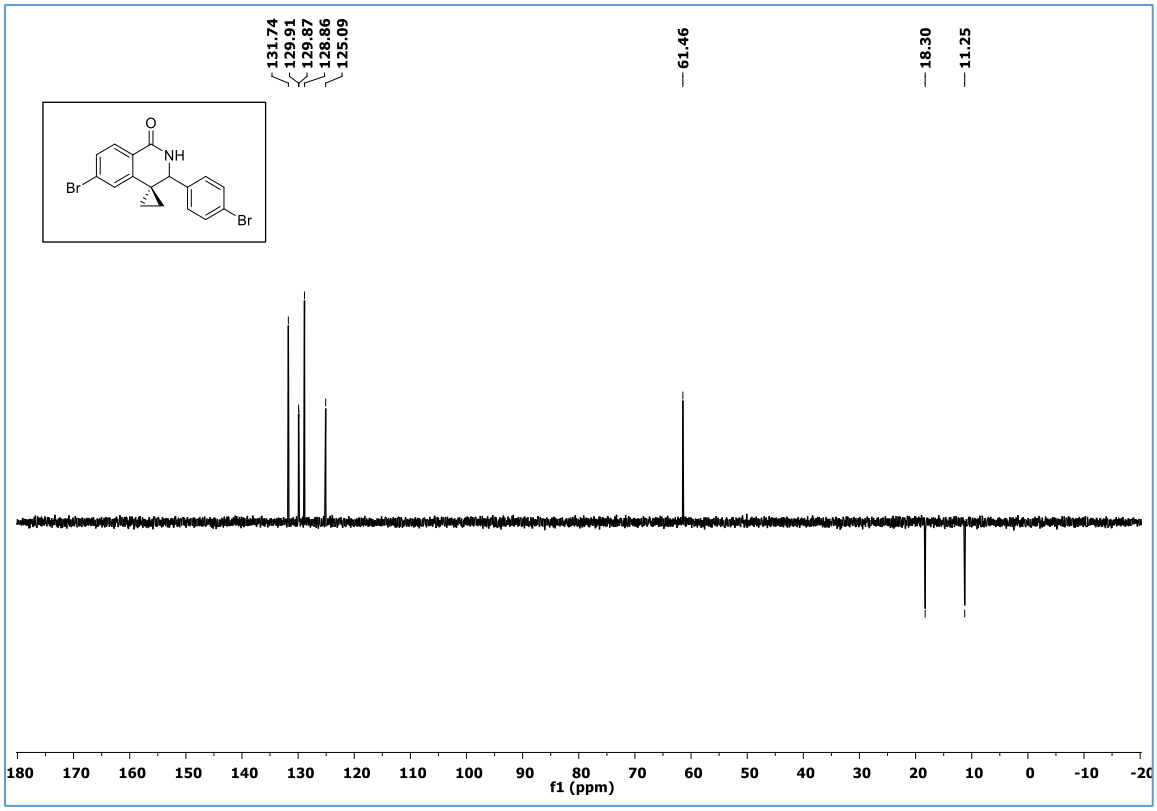


^{1}H and ^{13}C NMR Spectra of Compound **3fa.**

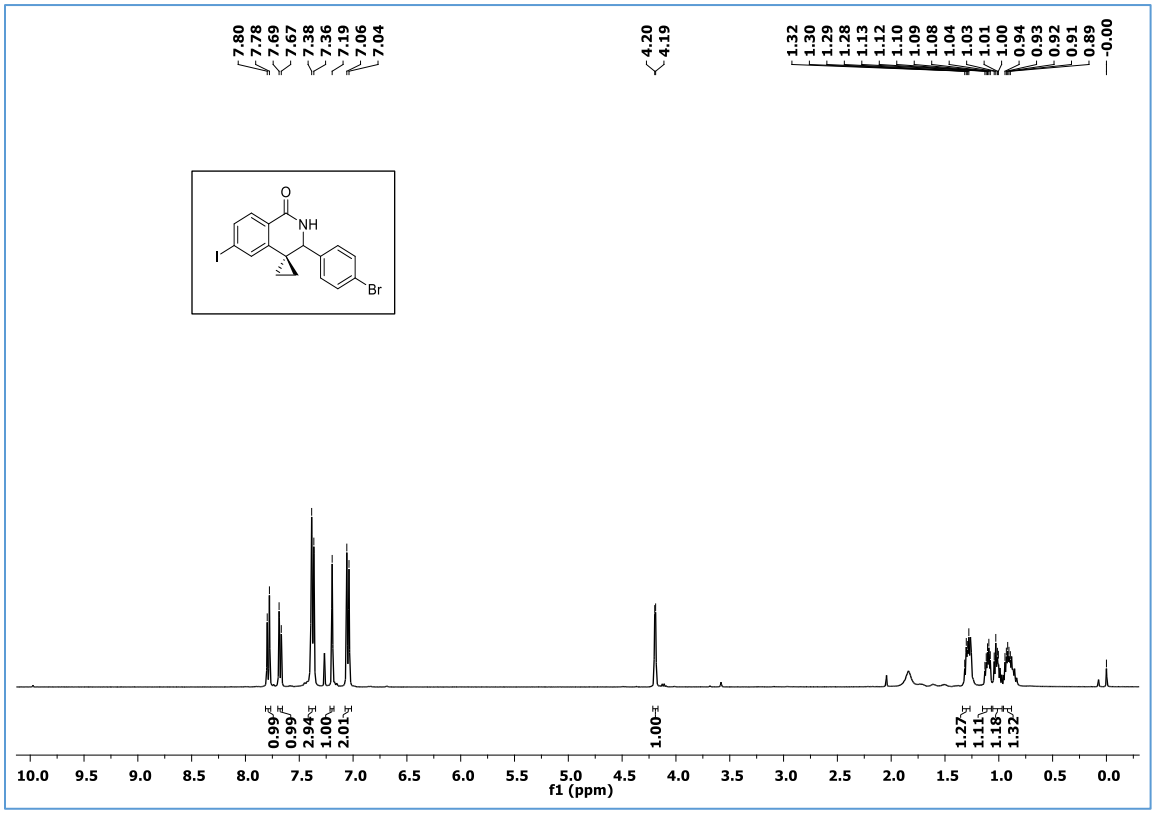


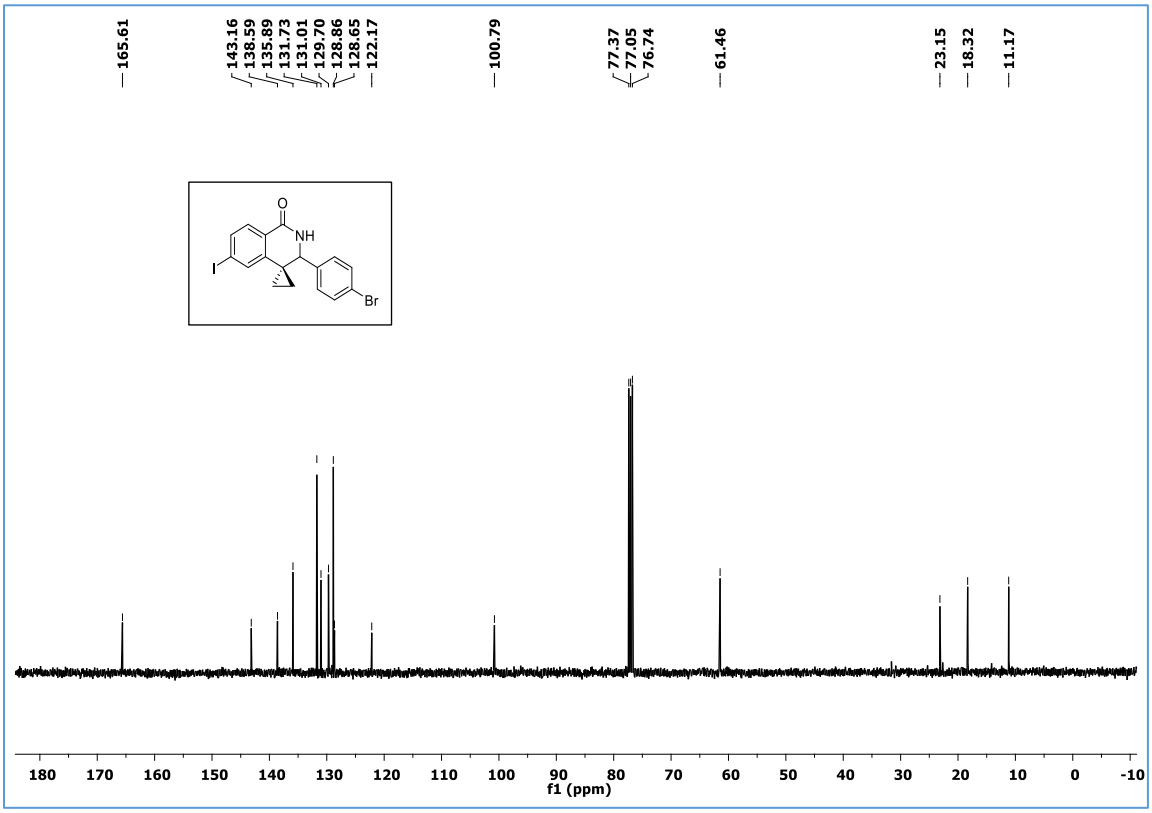


DEPT (135) NMR Spectrum of Compound **3fa.**

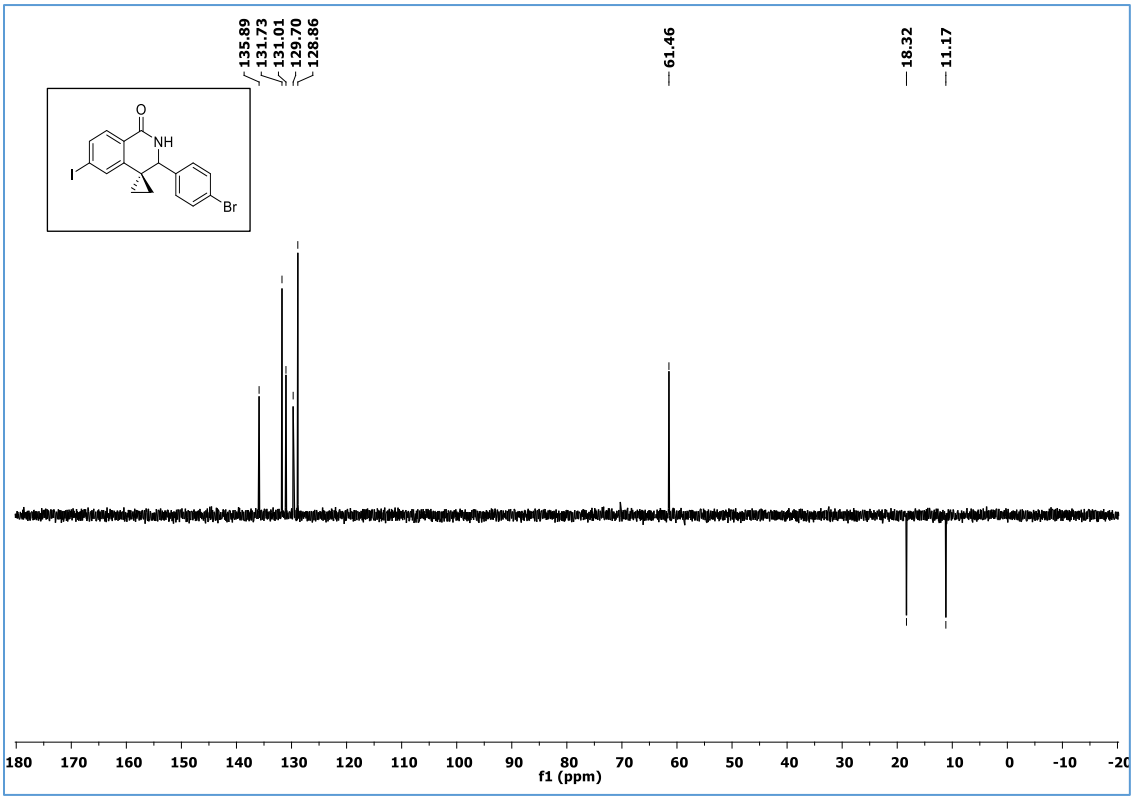


^{1}H and ^{13}C NMR Spectra of Compound **3ga.**

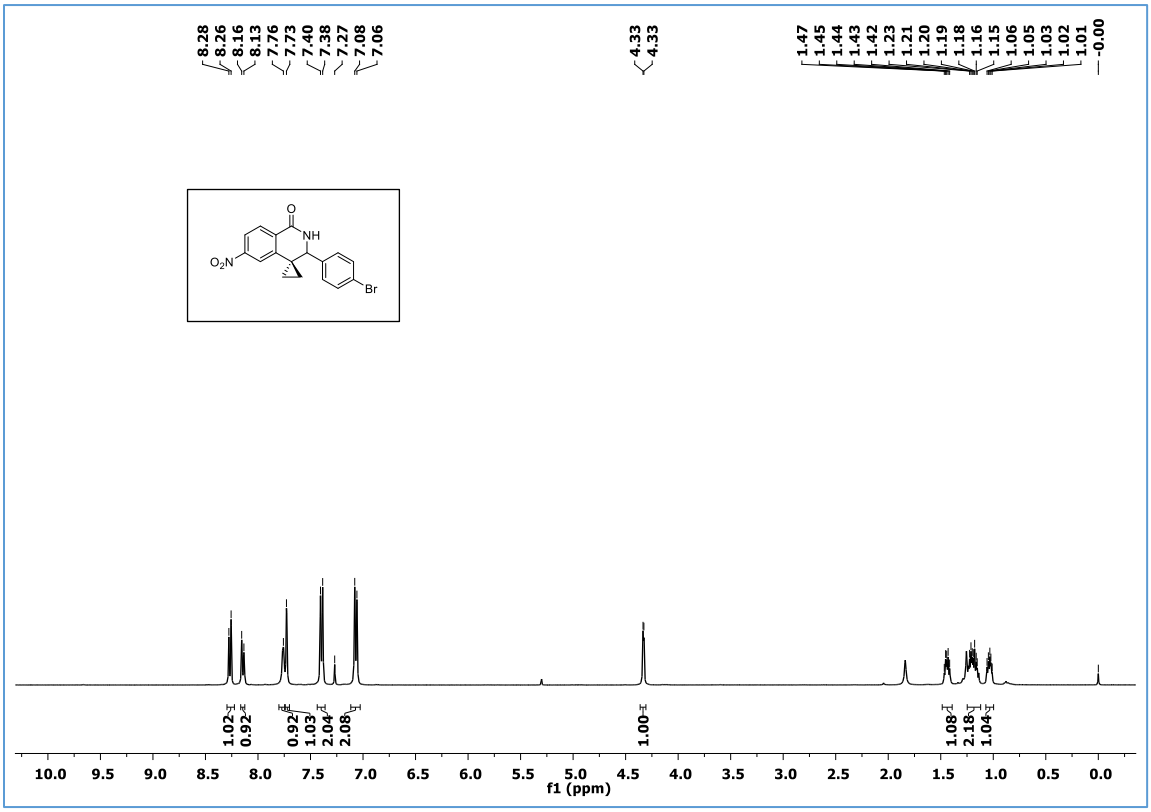


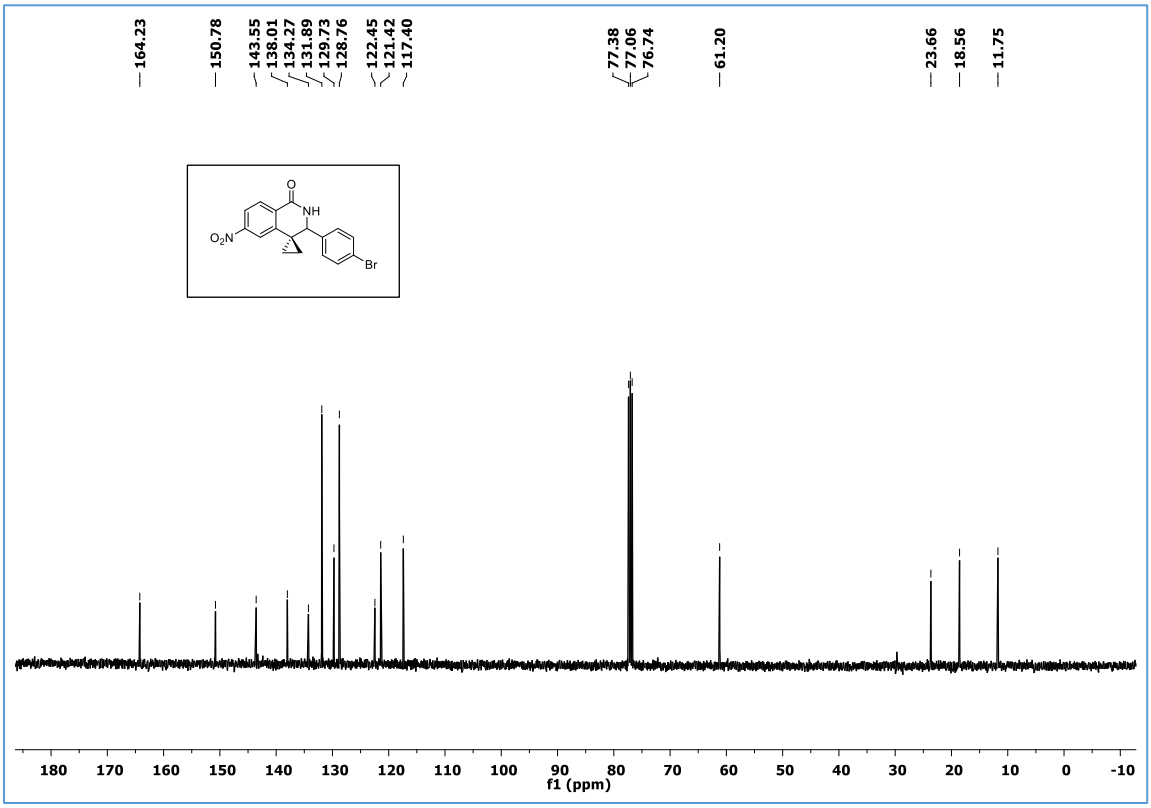


DEPT (135) NMR Spectrum of Compound **3ga.**

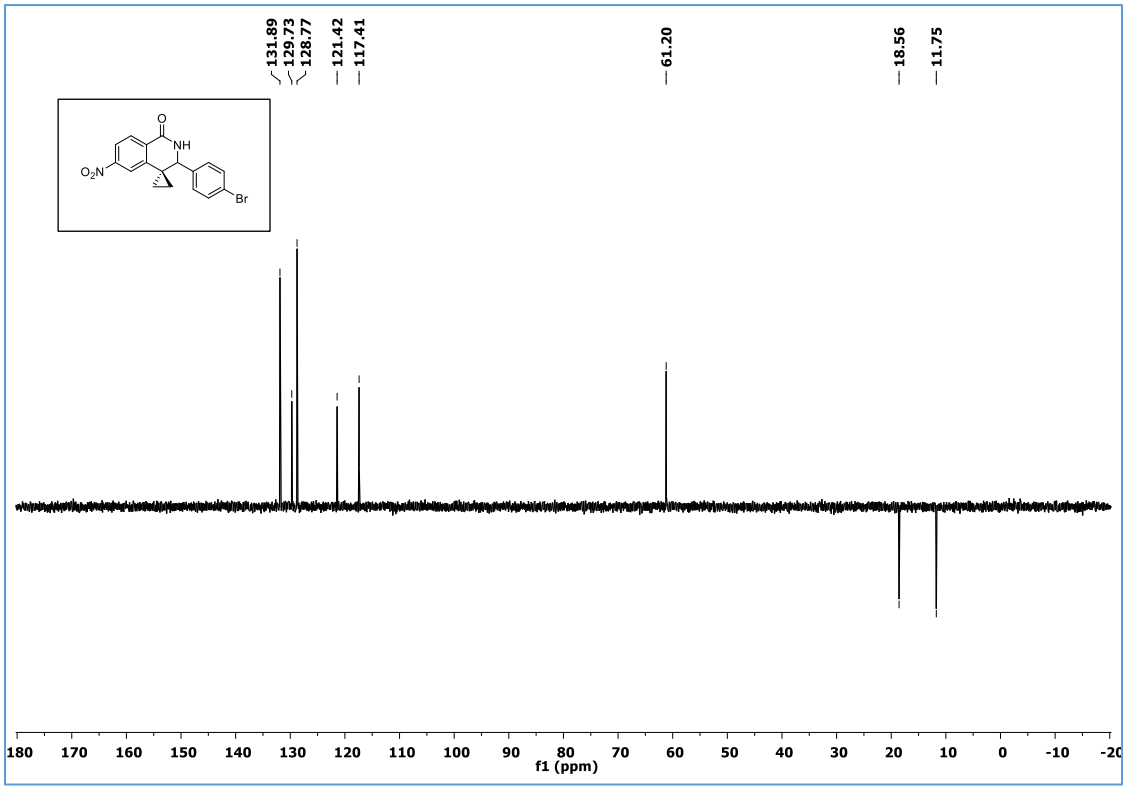


^{1}H and ^{13}C NMR Spectra of Compound **3ha.**

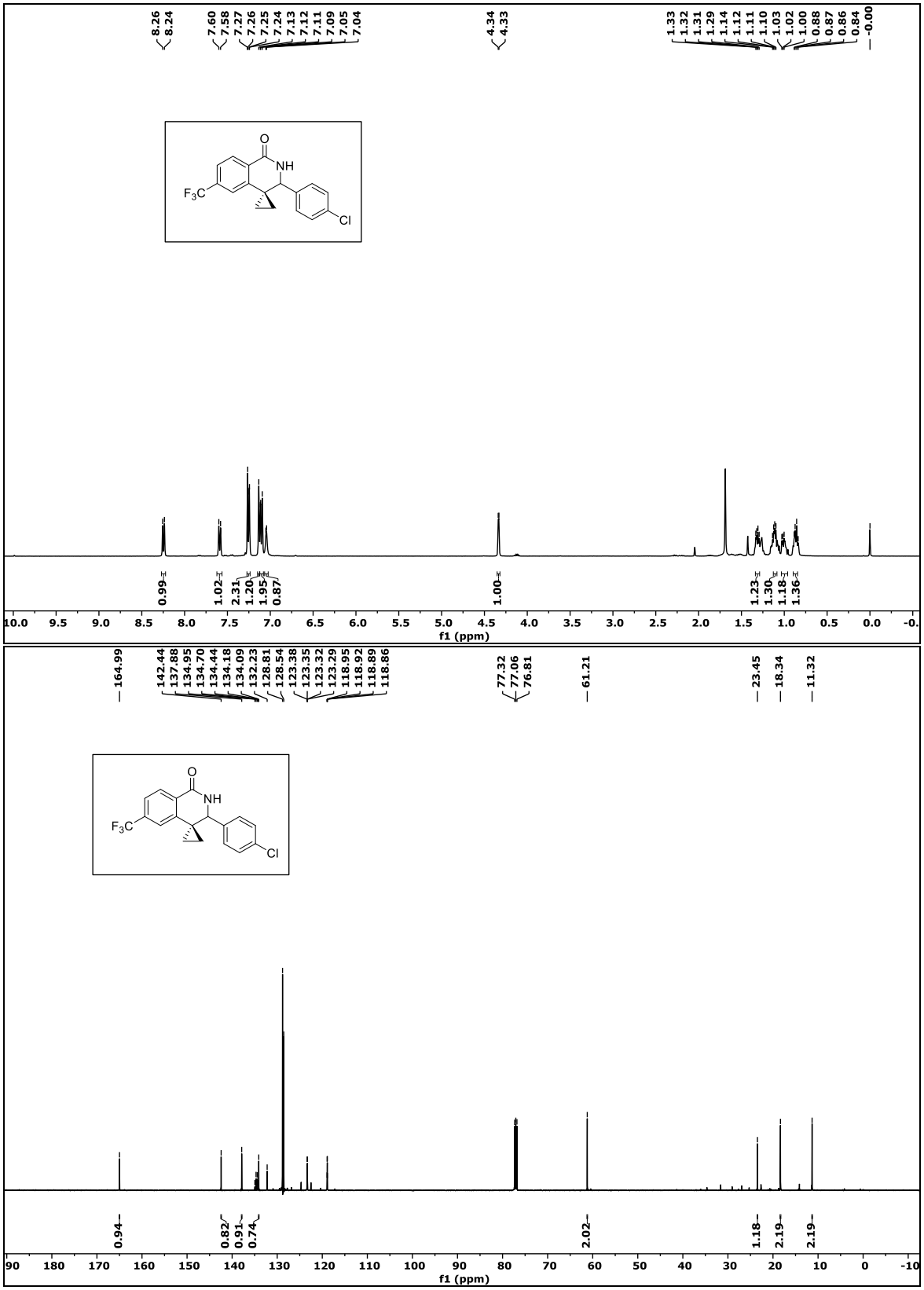




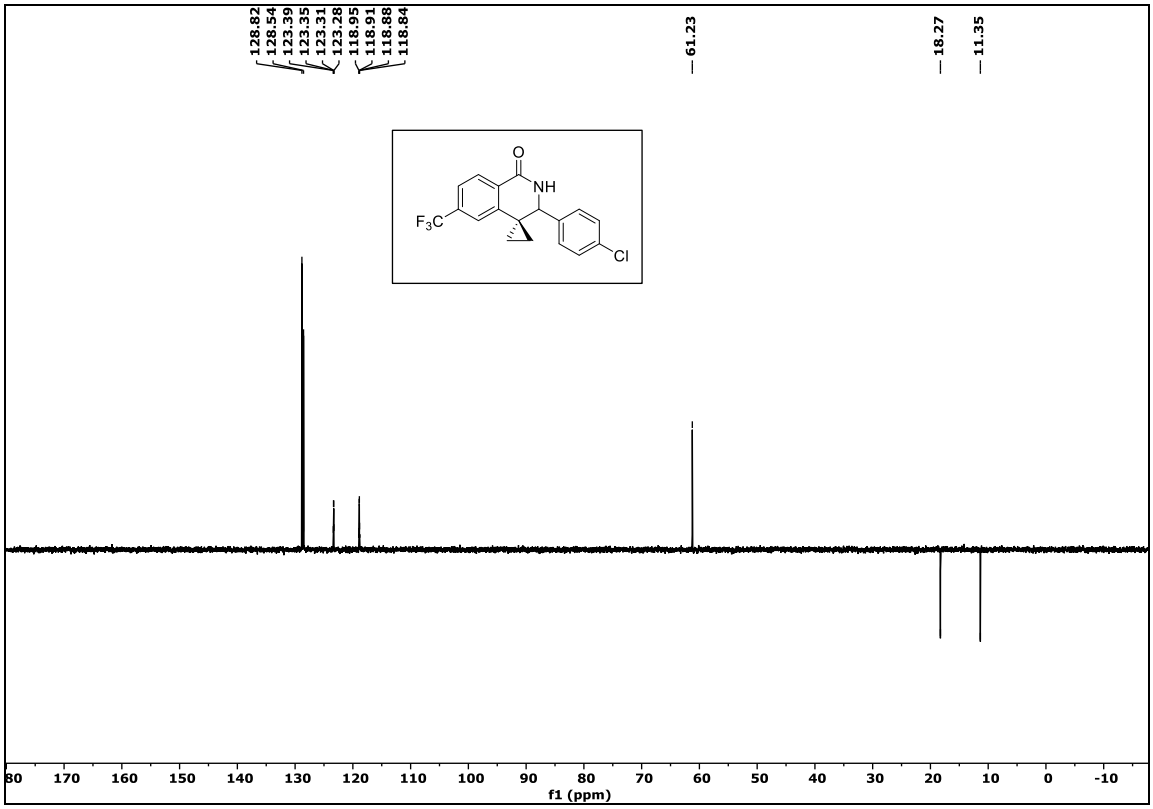
DEPT (135) NMR Spectrum of Compound **3ha.**



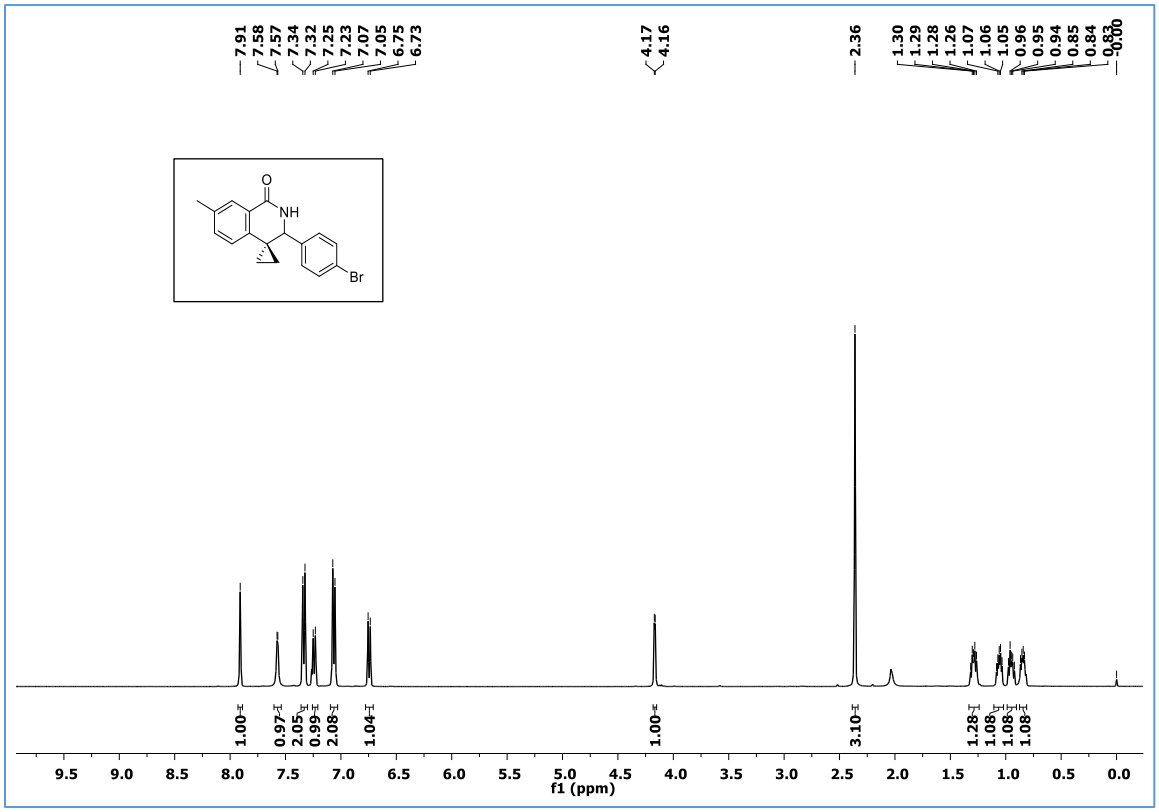
^{1}H and ^{13}C NMR Spectra of Compound **3id.**

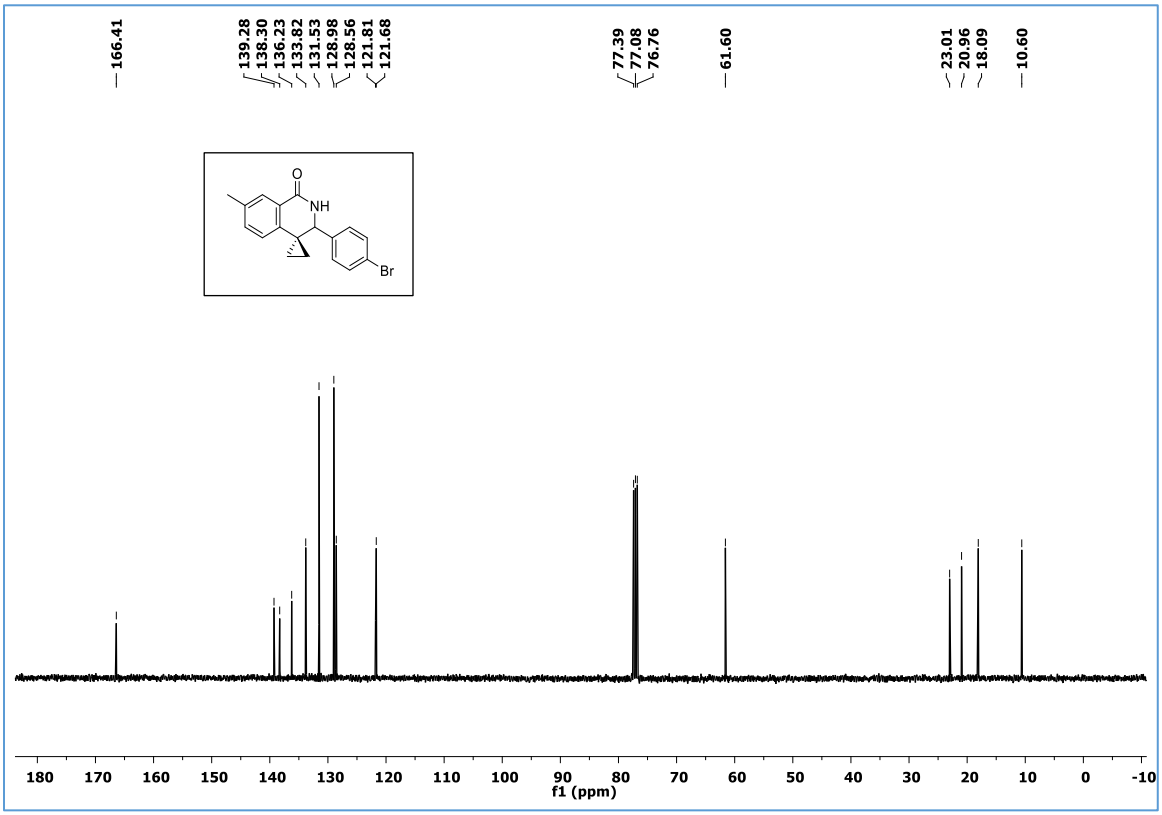


DEPT (135) NMR Spectrum of Compound **3id.**

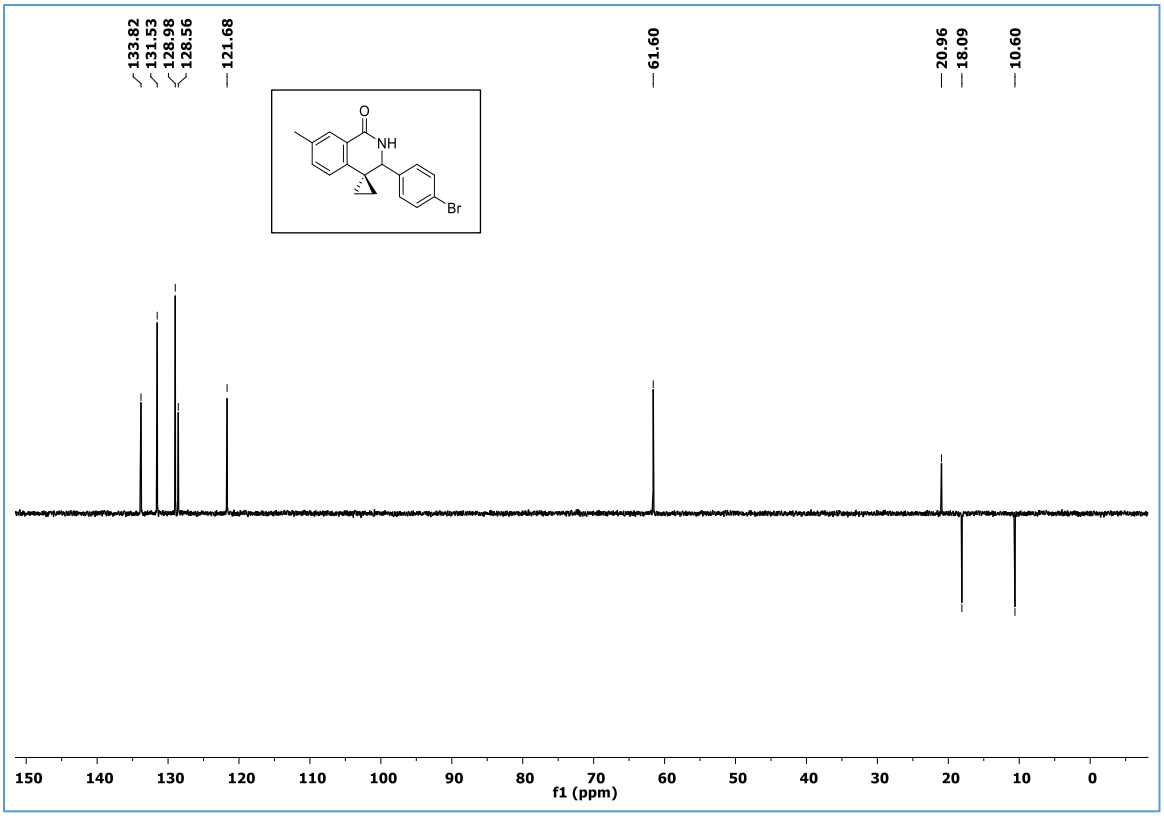


^{1}H and ^{13}C NMR Spectra of Compound **3ja.**

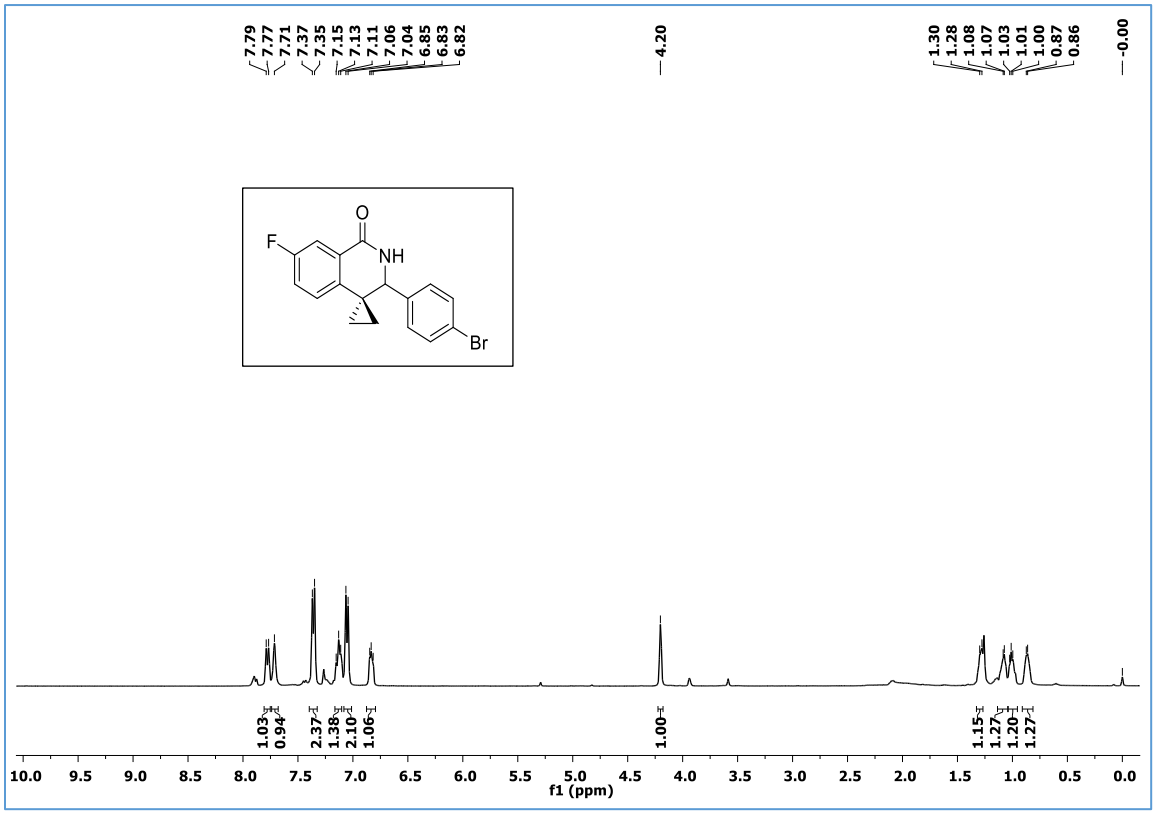


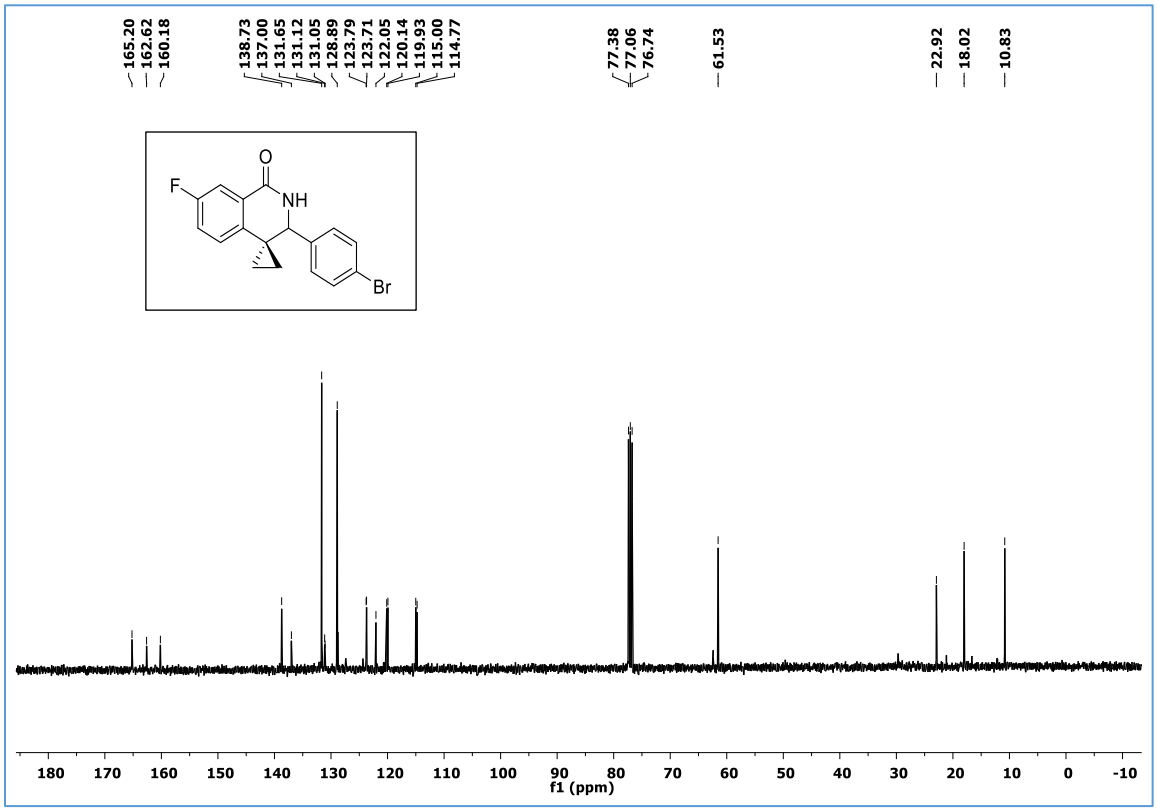


DEPT (135) NMR Spectrum of Compound **3ja.**

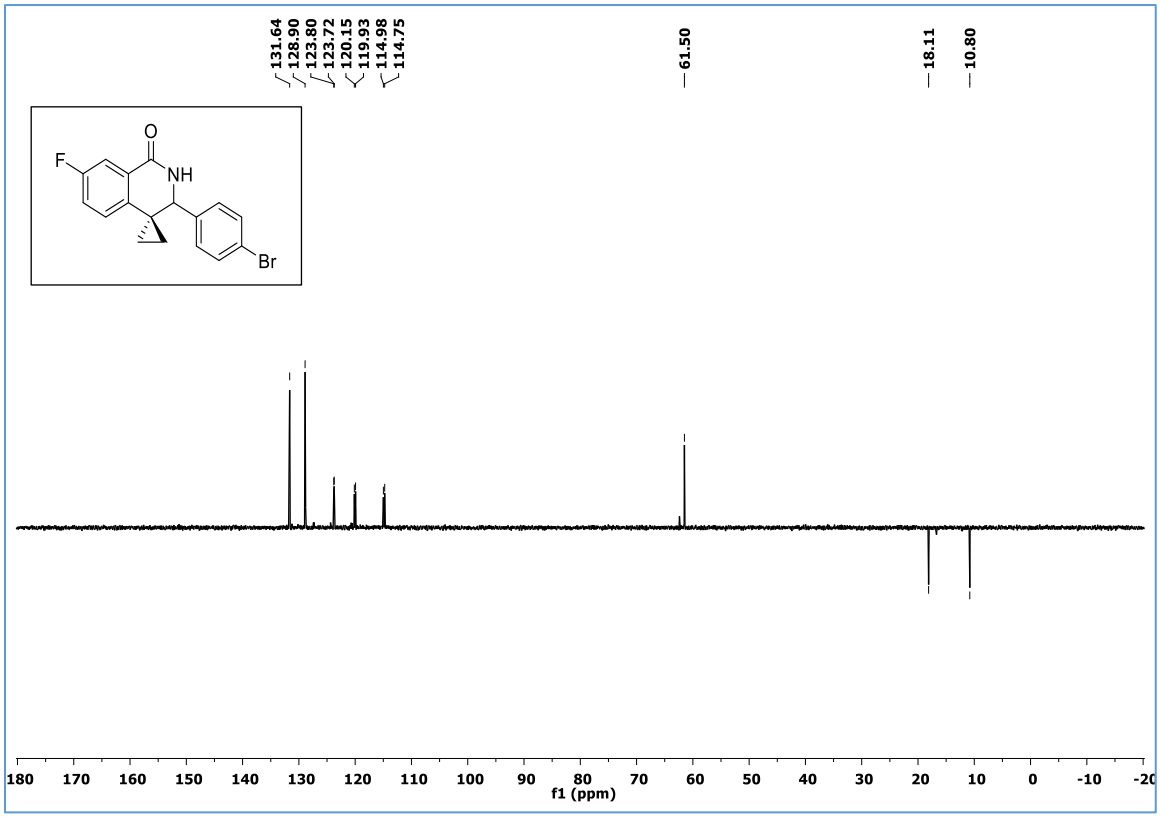


^{1}H and ^{13}C NMR Spectra of Compound **3ka.**

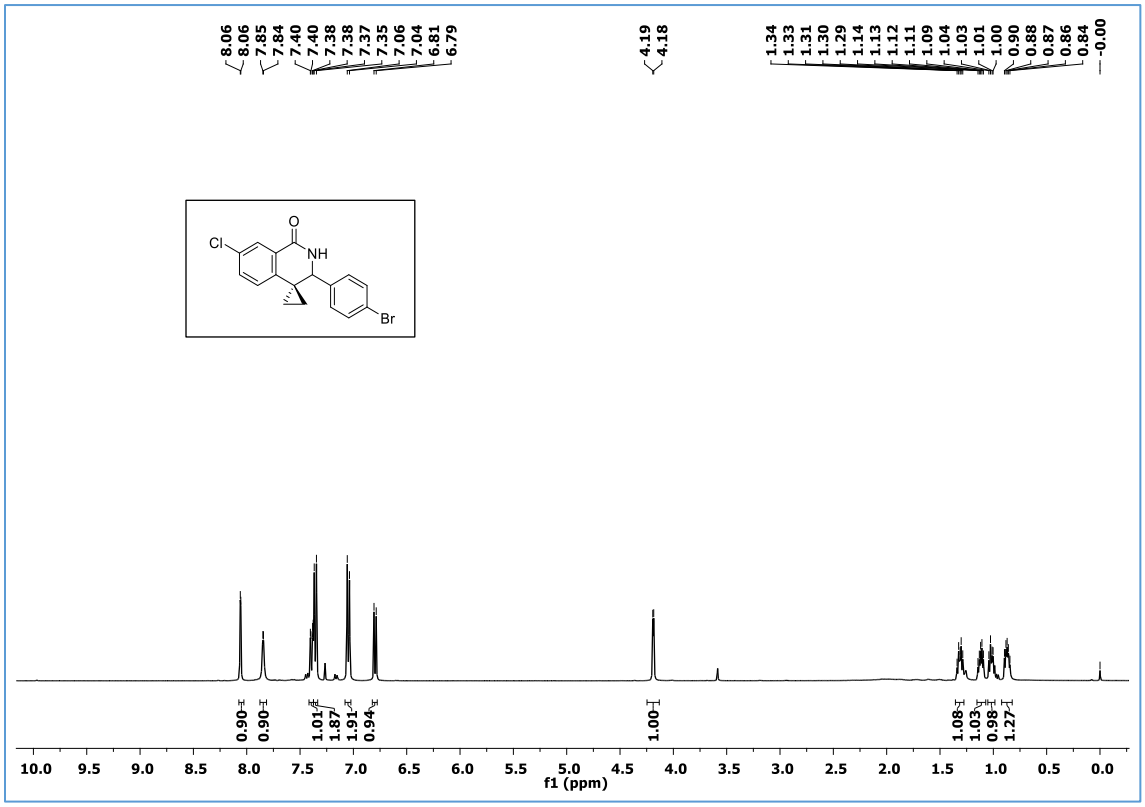


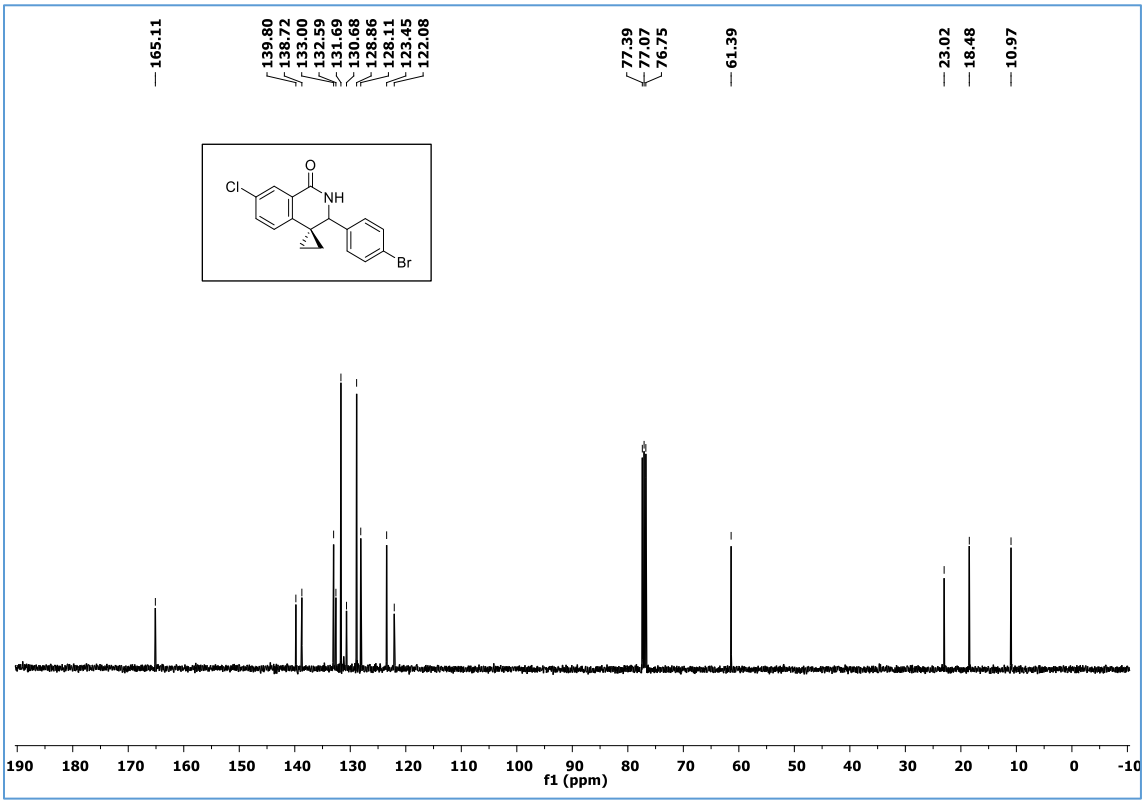


DEPT (135) NMR Spectrum of Compound **3ka.**

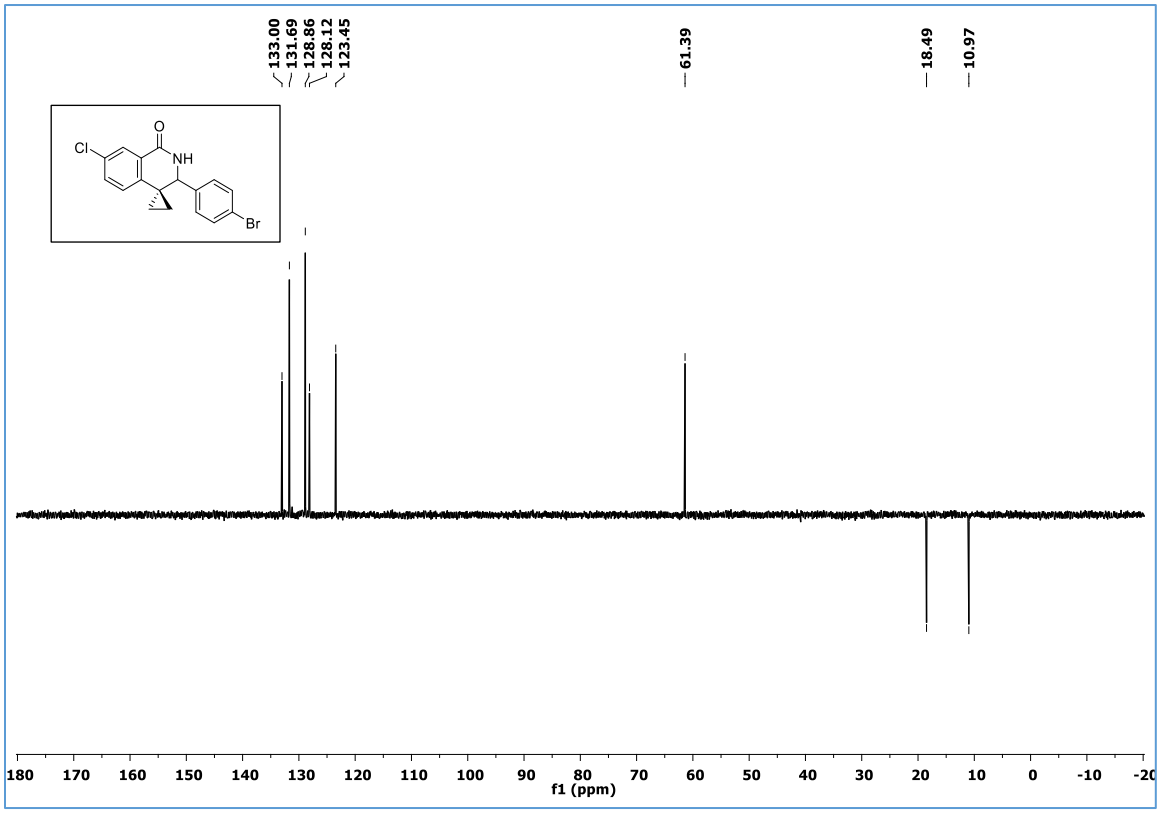


^{1}H and ^{13}C NMR Spectra of Compound **3la.**

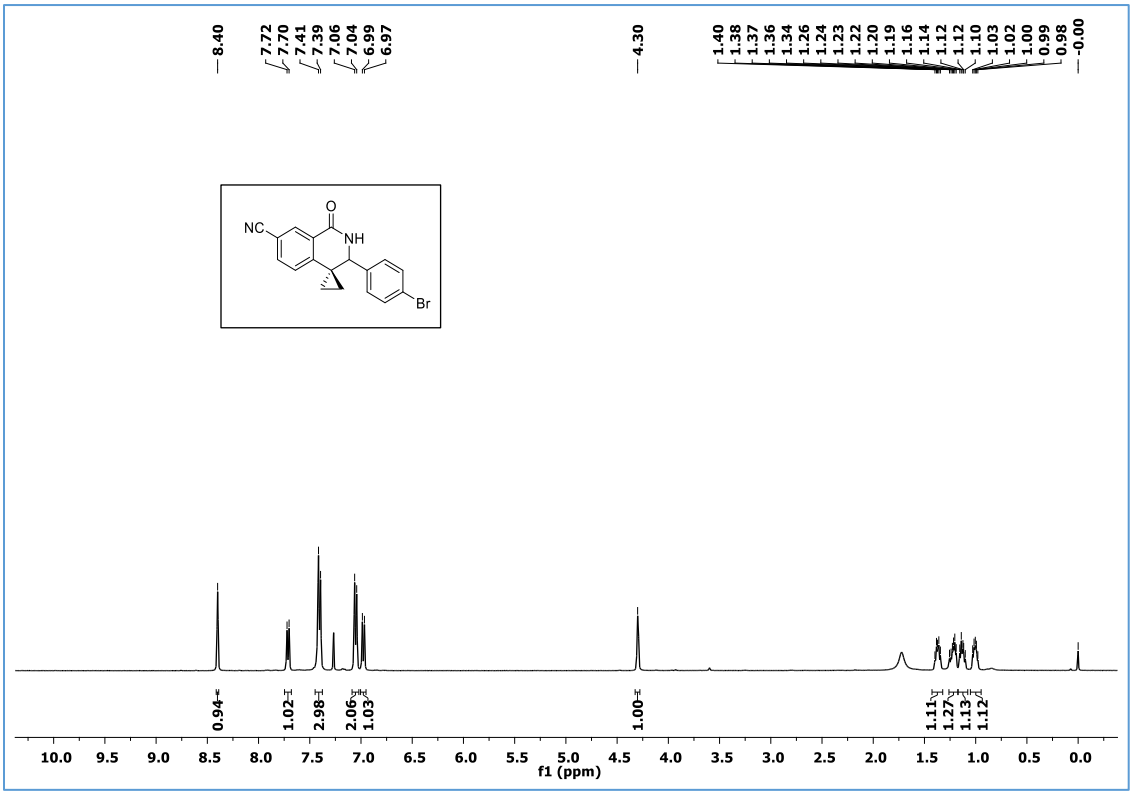


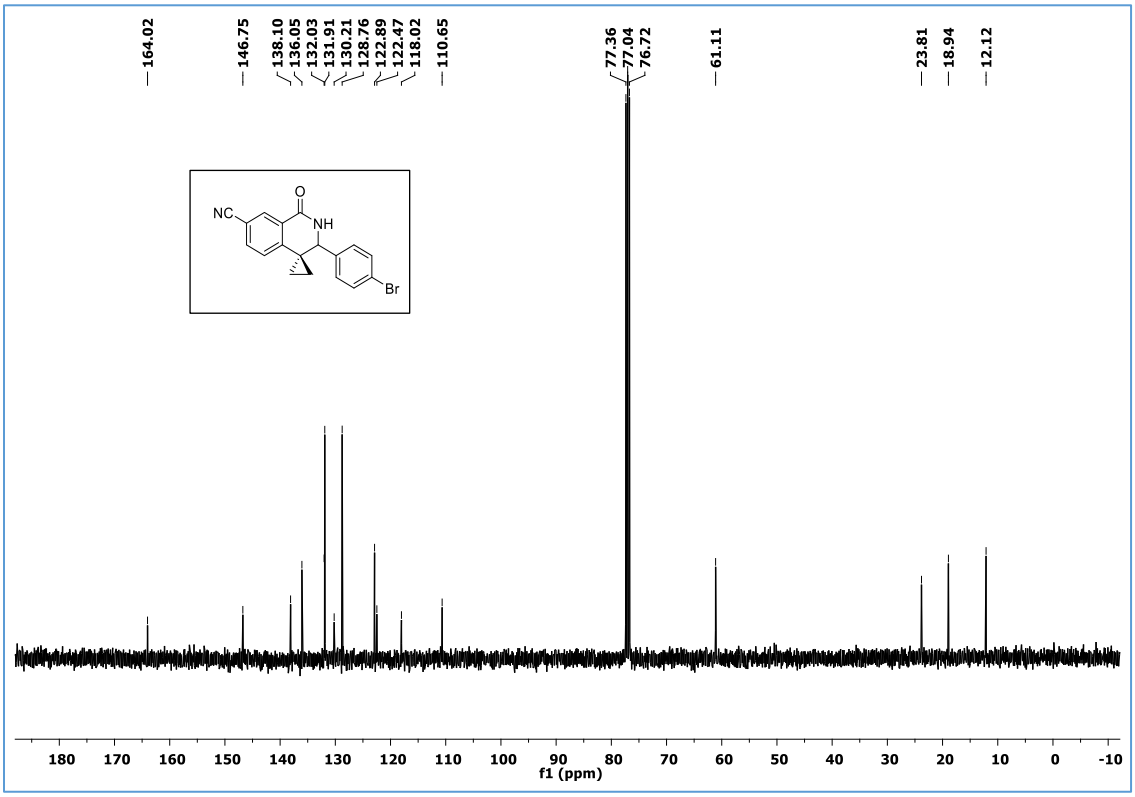


DEPT (135) NMR Spectrum of Compound **3la.**

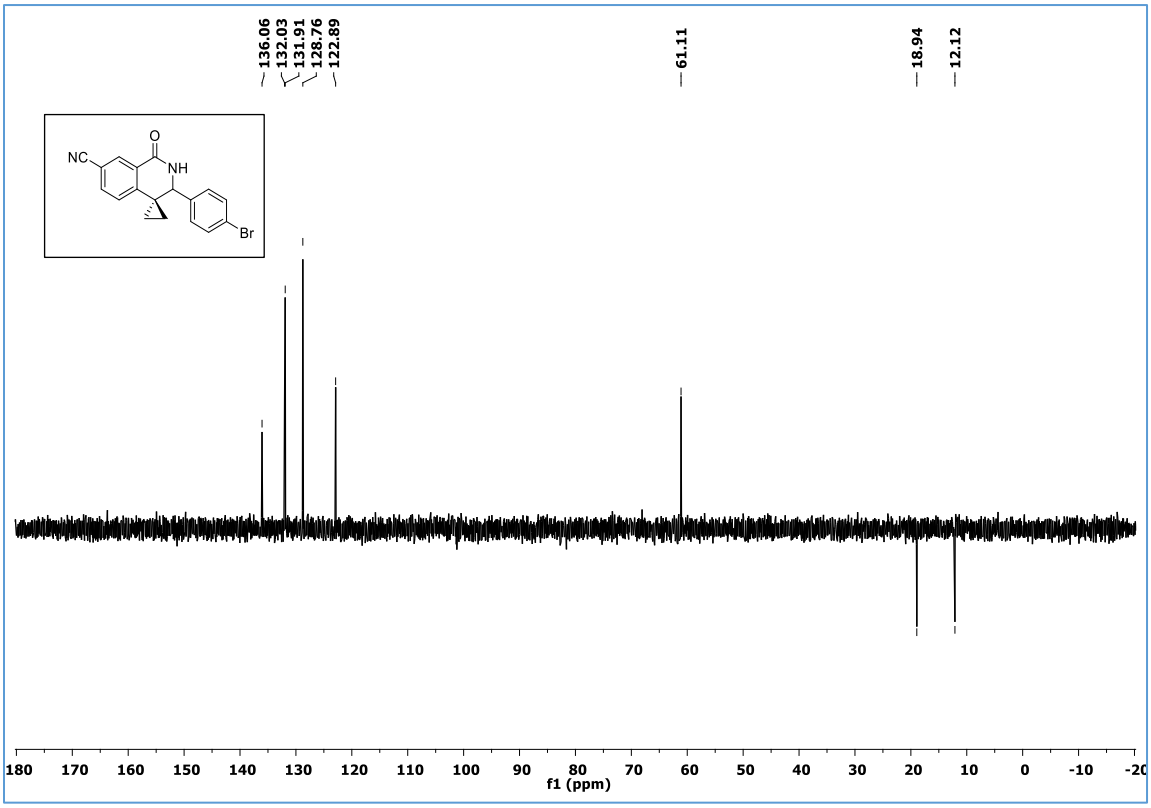


^{1}H and ^{13}C NMR Spectra of Compound **3ma.**

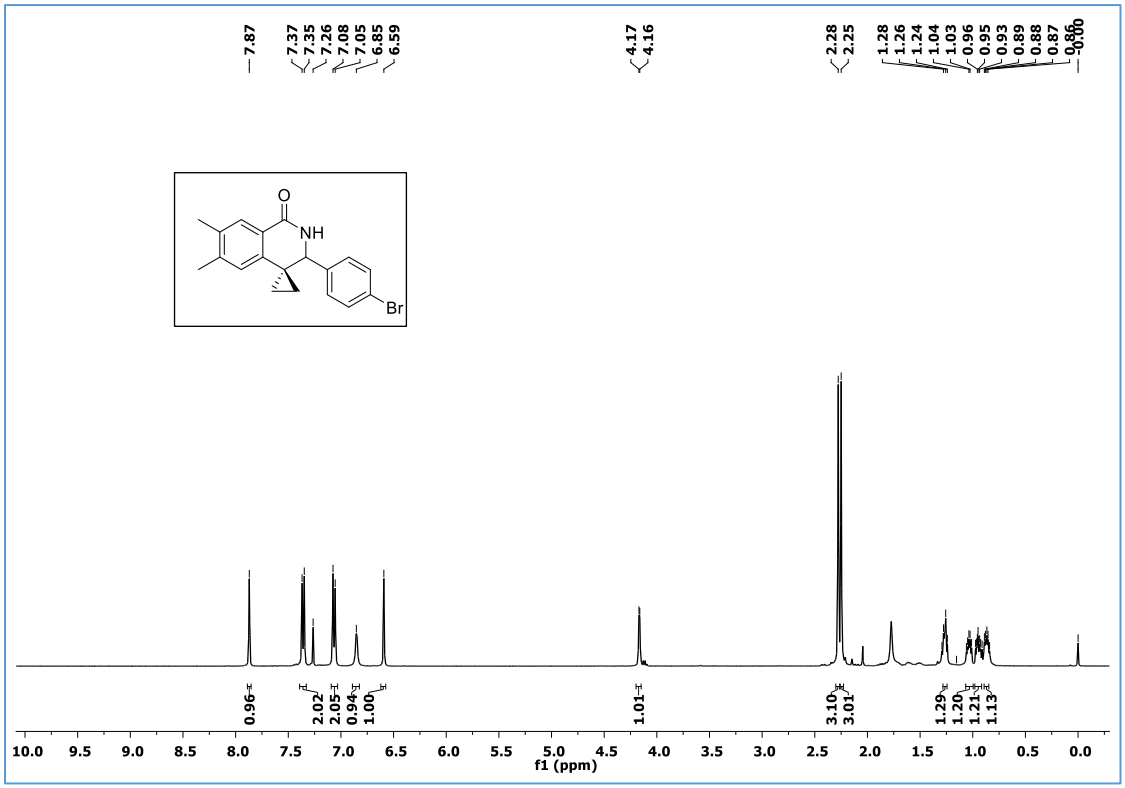


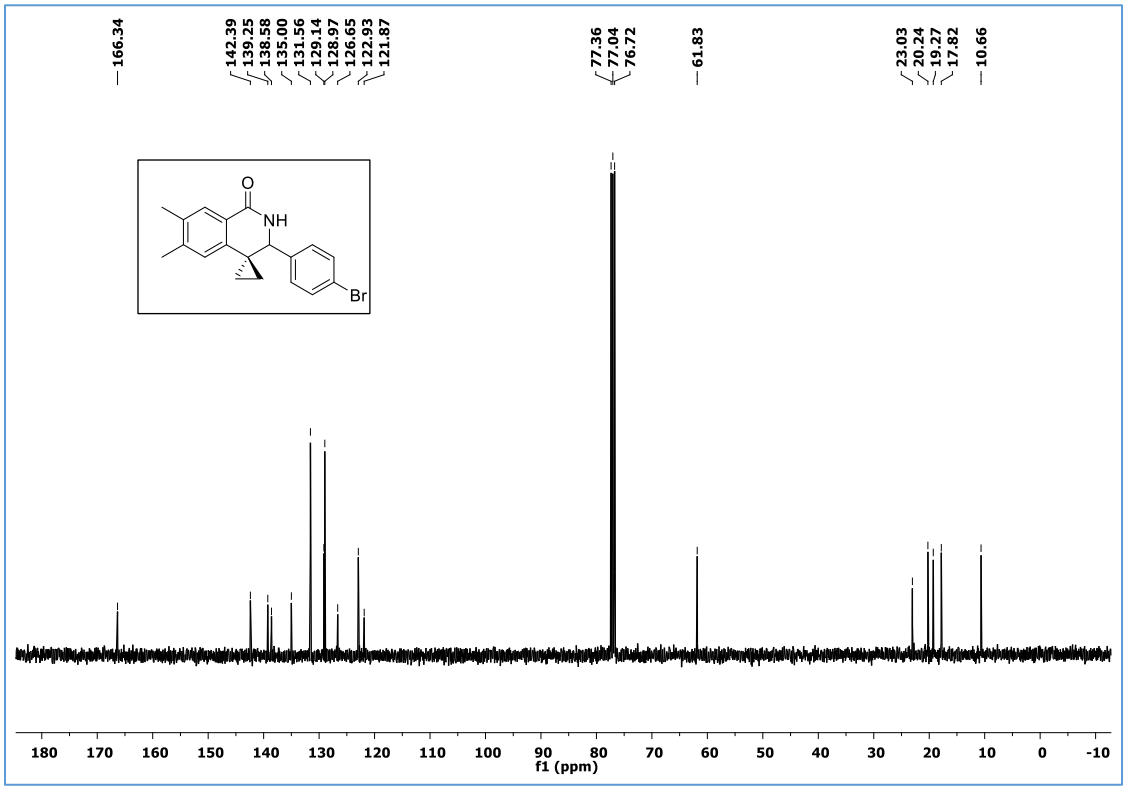


DEPT (135) NMR Spectrum of Compound **3ma.**

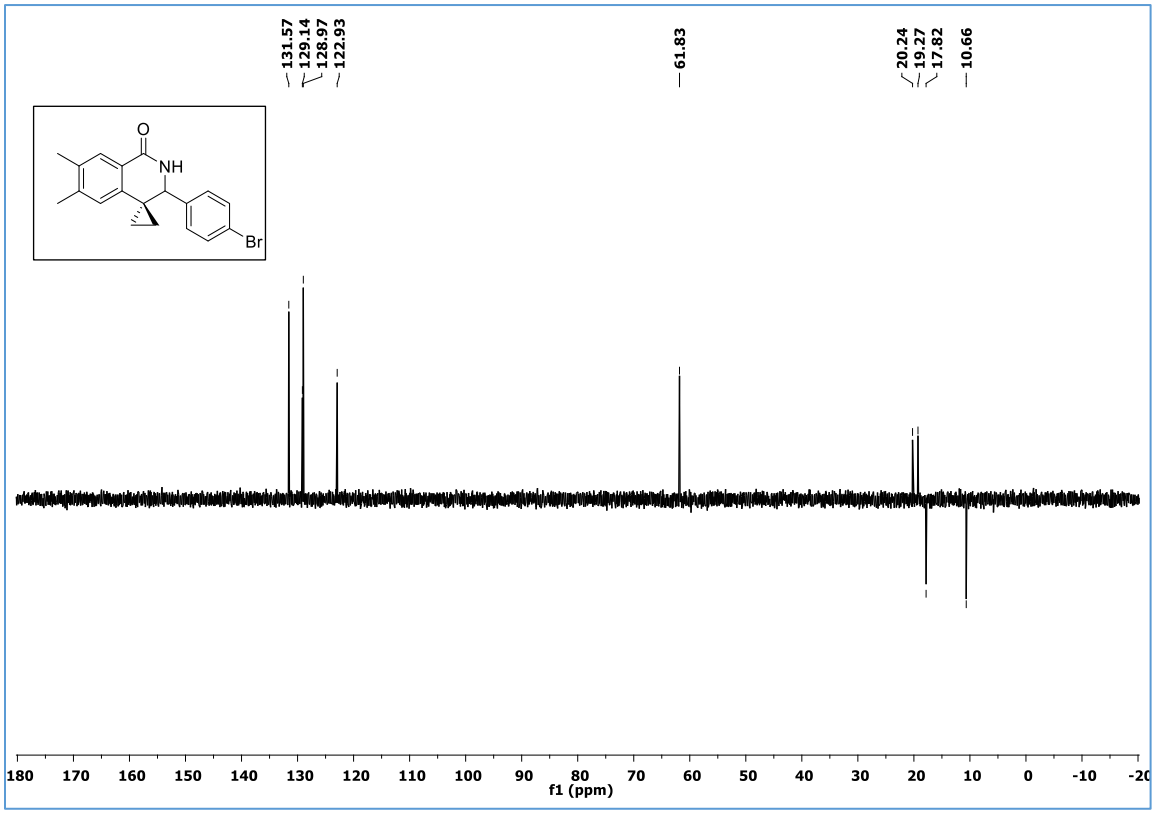


^{1}H and ^{13}C NMR Spectra of Compound **3na.**

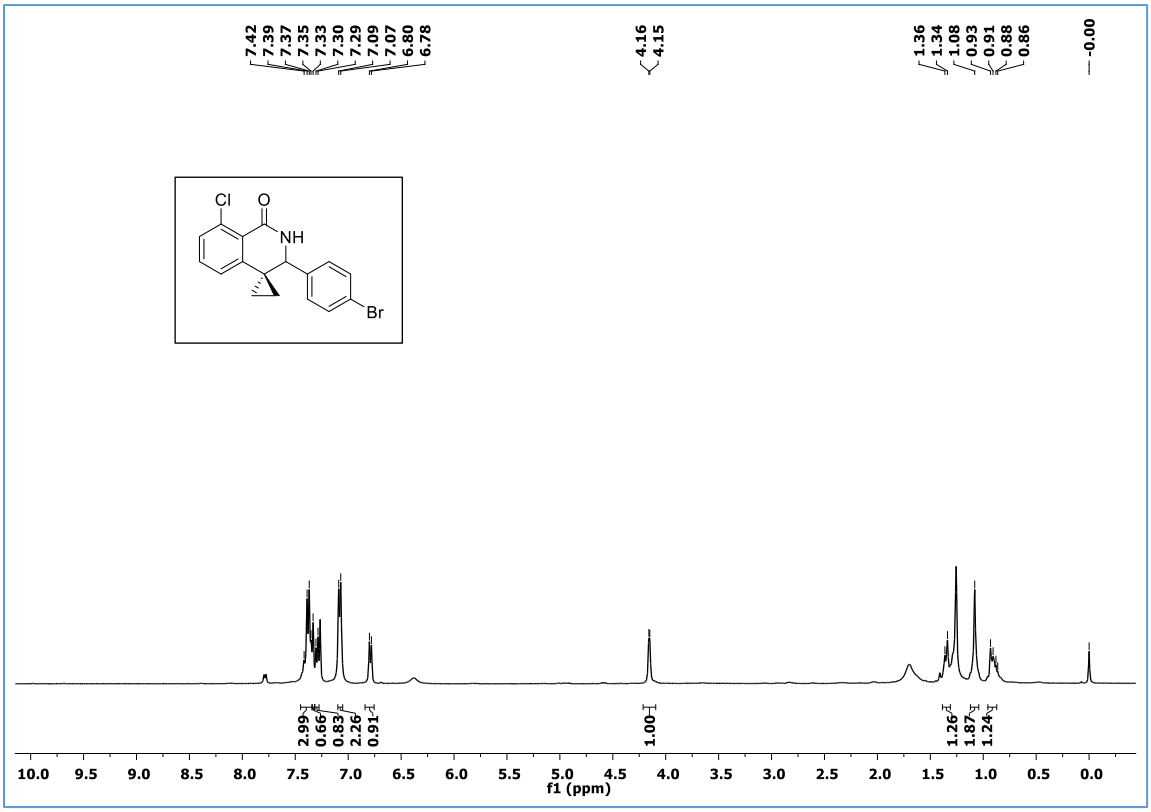


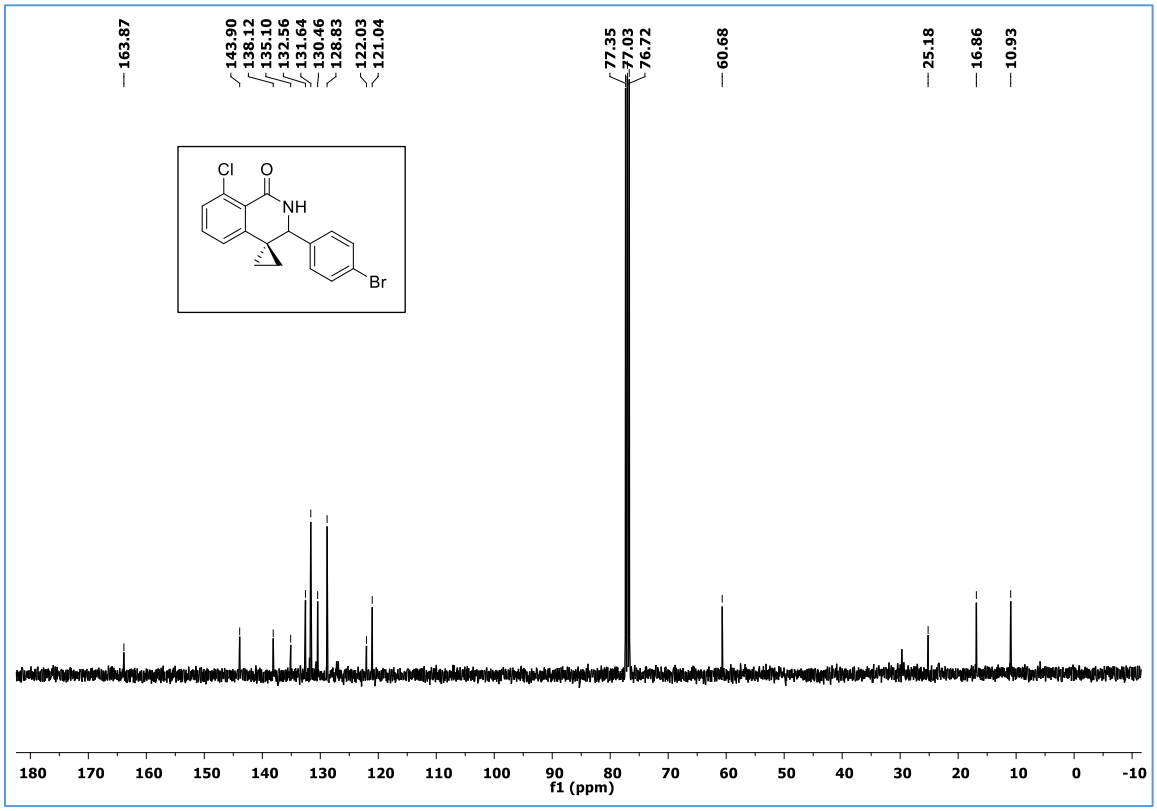


DEPT (135) NMR Spectrum of Compound **3na.**

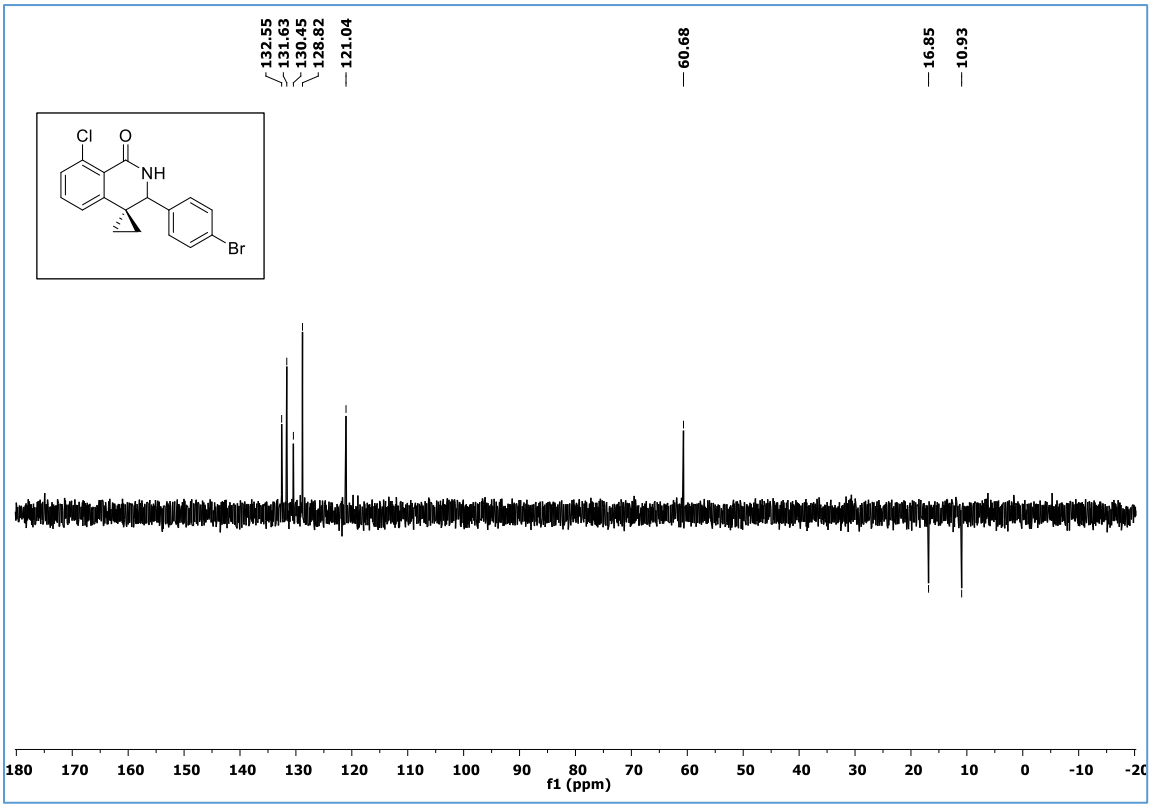


^{1}H and ^{13}C NMR Spectra of Compound **3oa.**

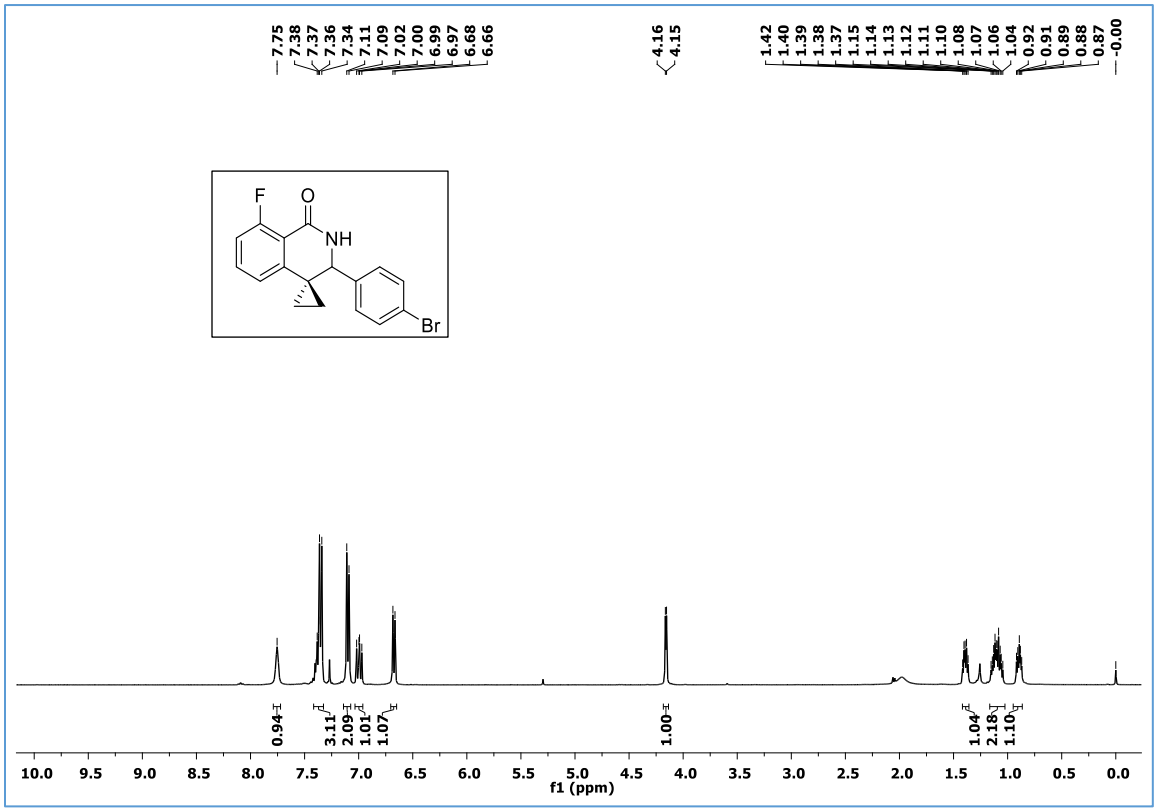


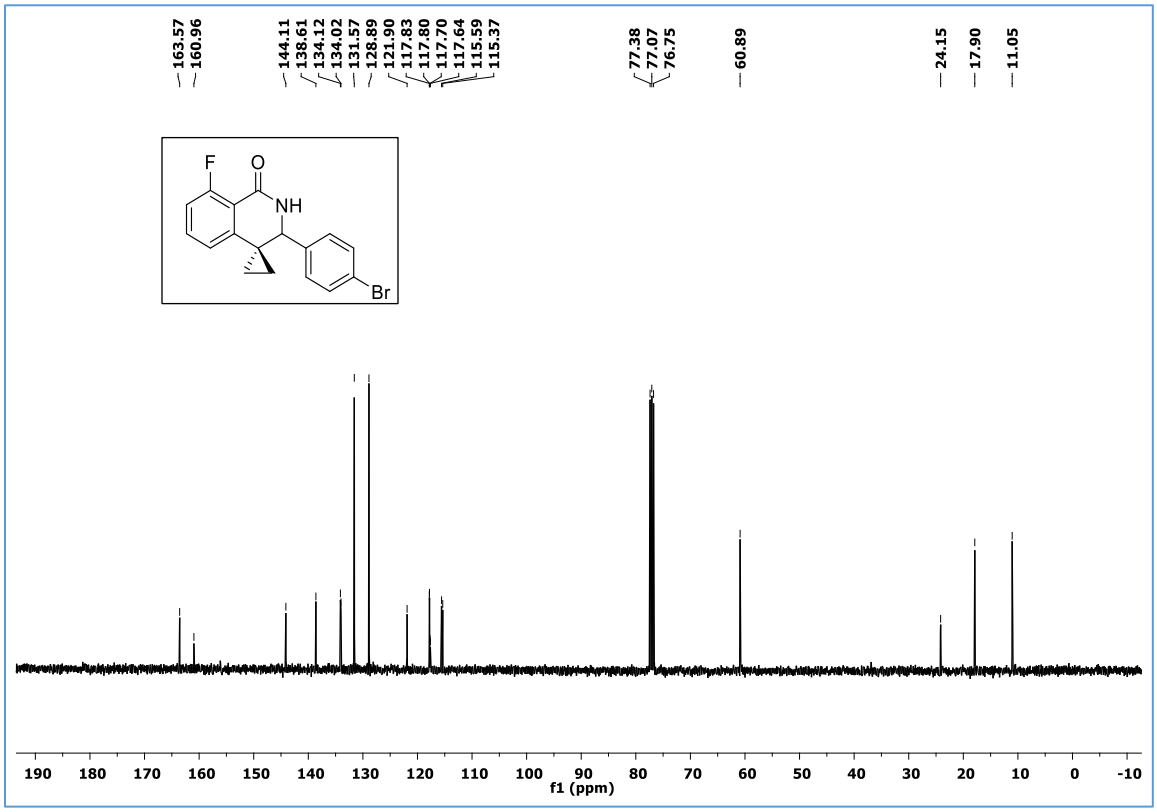


DEPT (135) NMR Spectrum of Compound **3oa.**

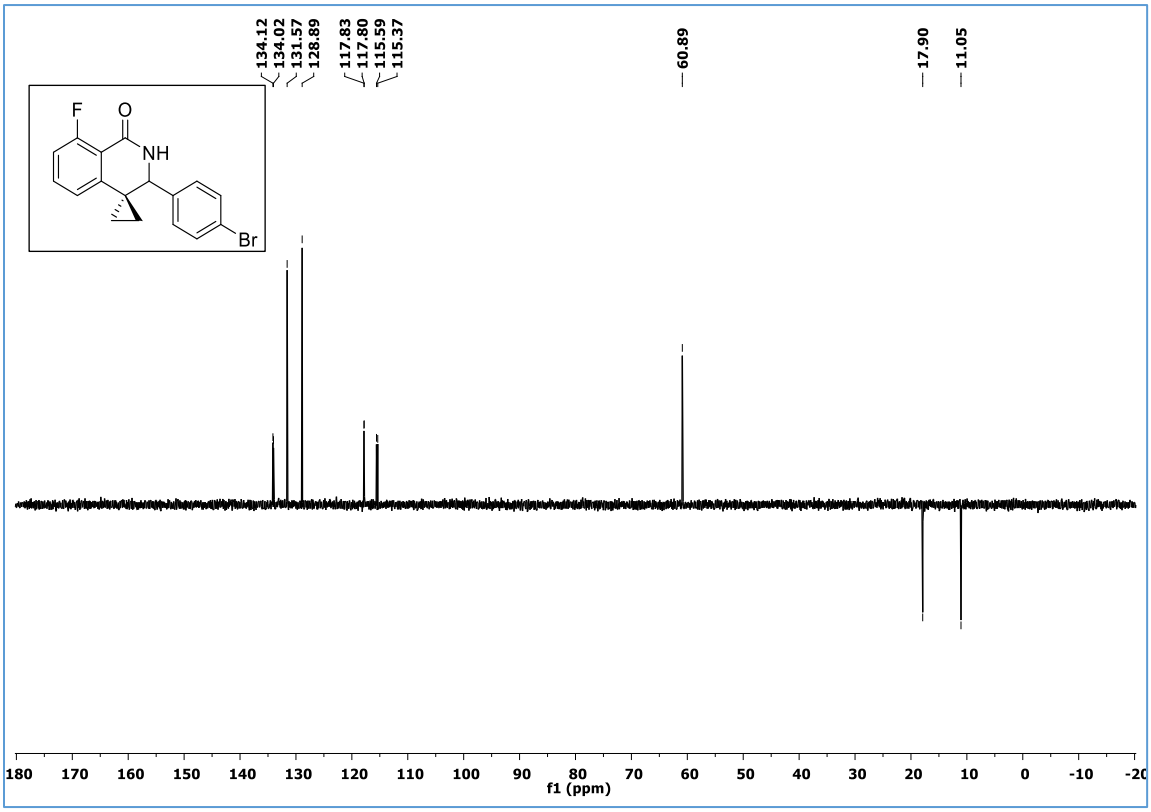


^{1}H and ^{13}C NMR Spectra of Compound **3pa.**

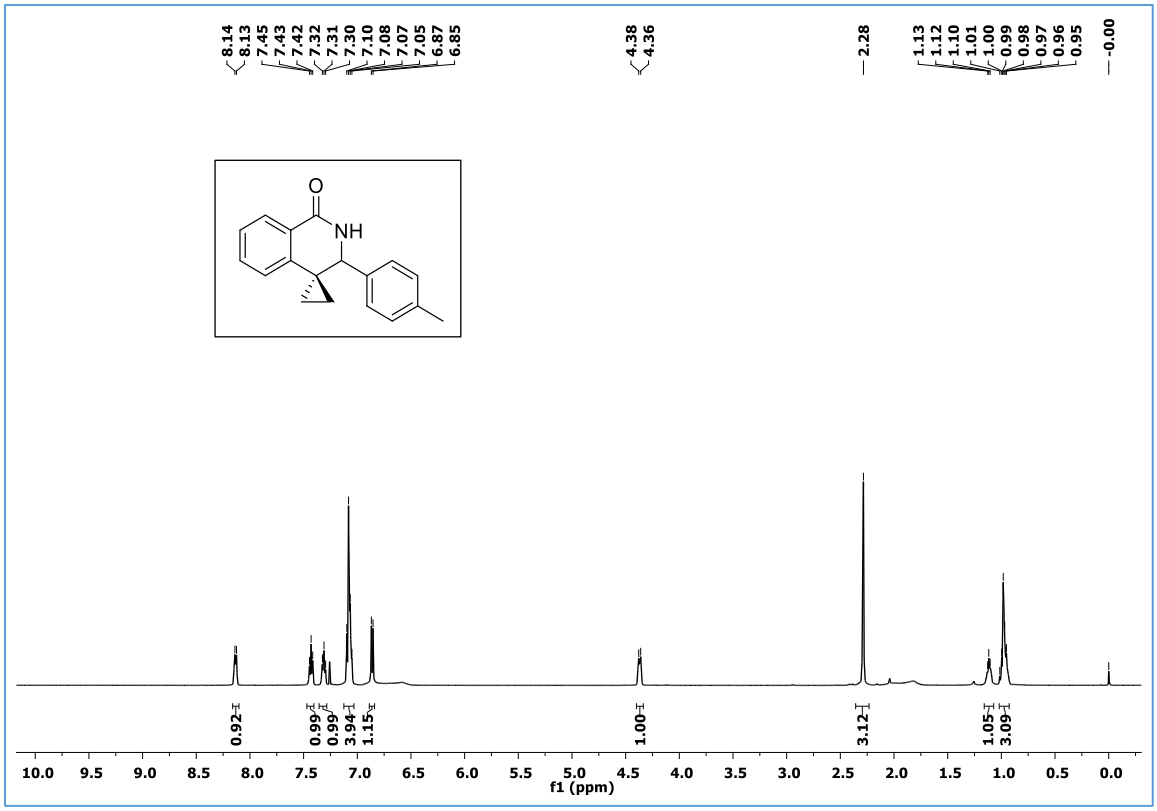


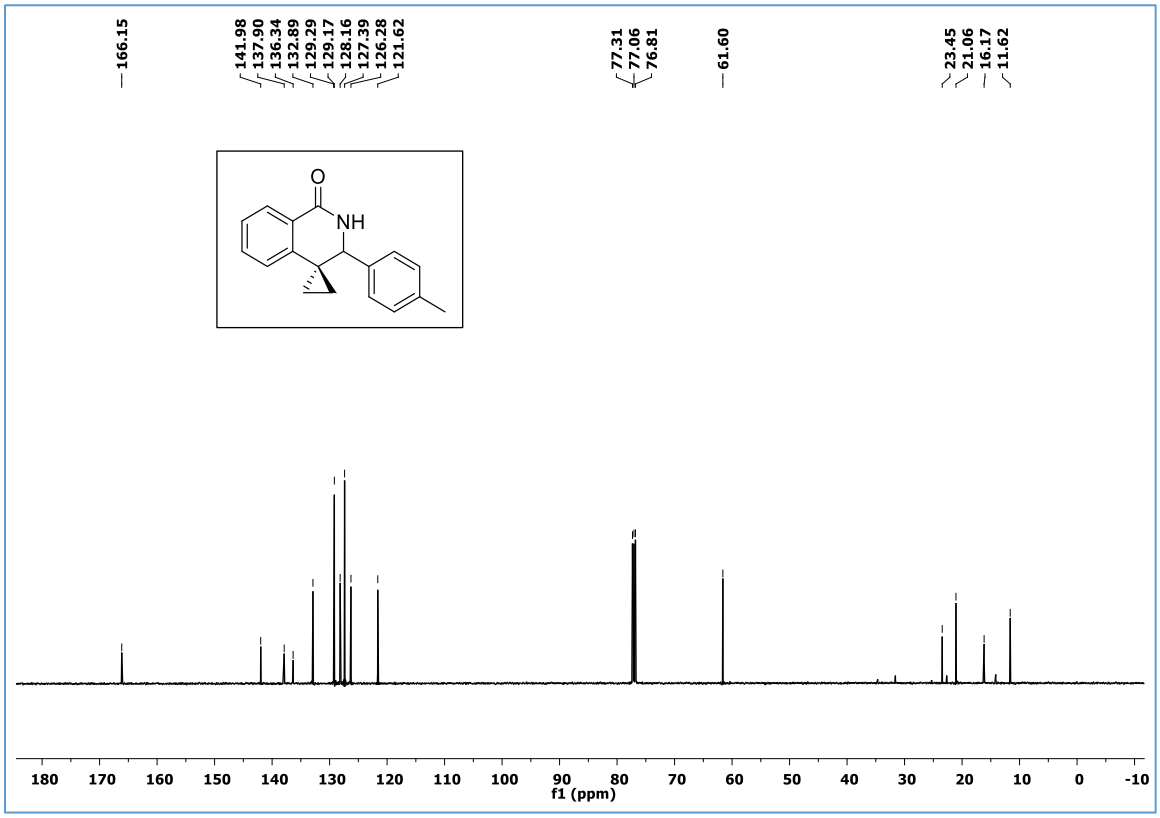


DEPT (135) NMR Spectrum of Compound **3pa.**

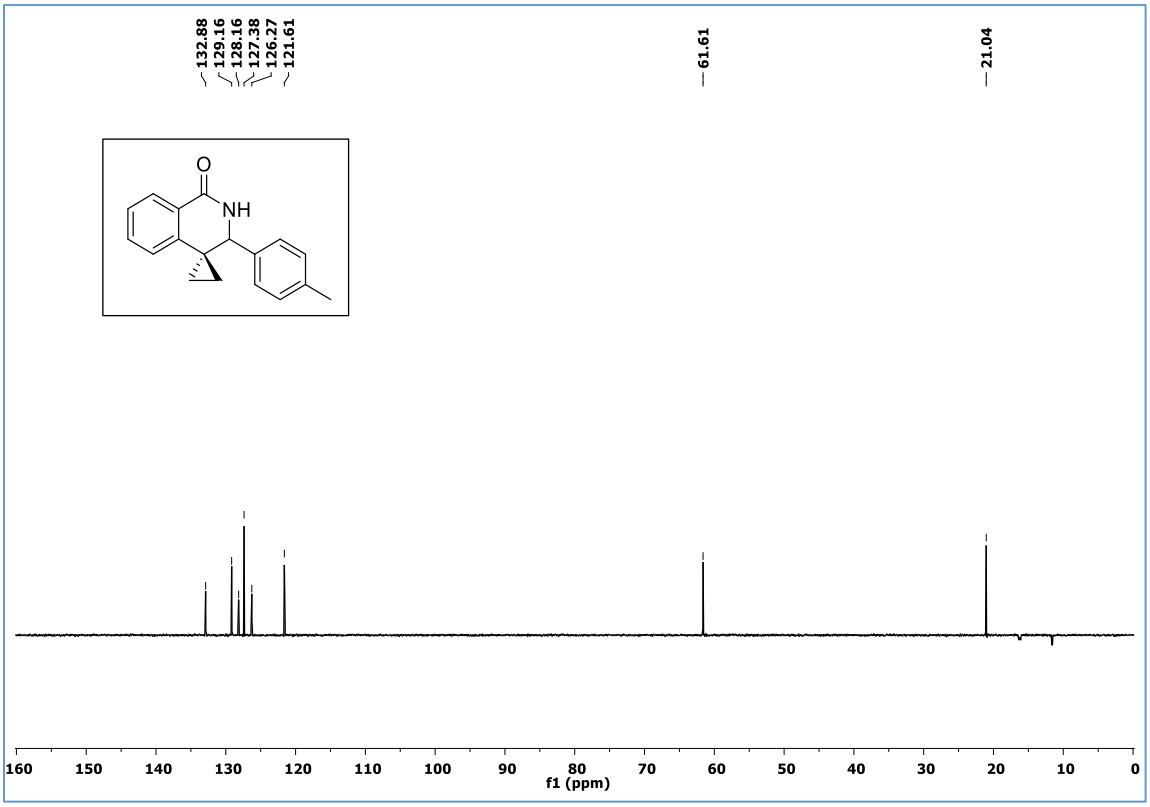


^{1}H and ^{13}C NMR Spectra of Compound **3ab.**

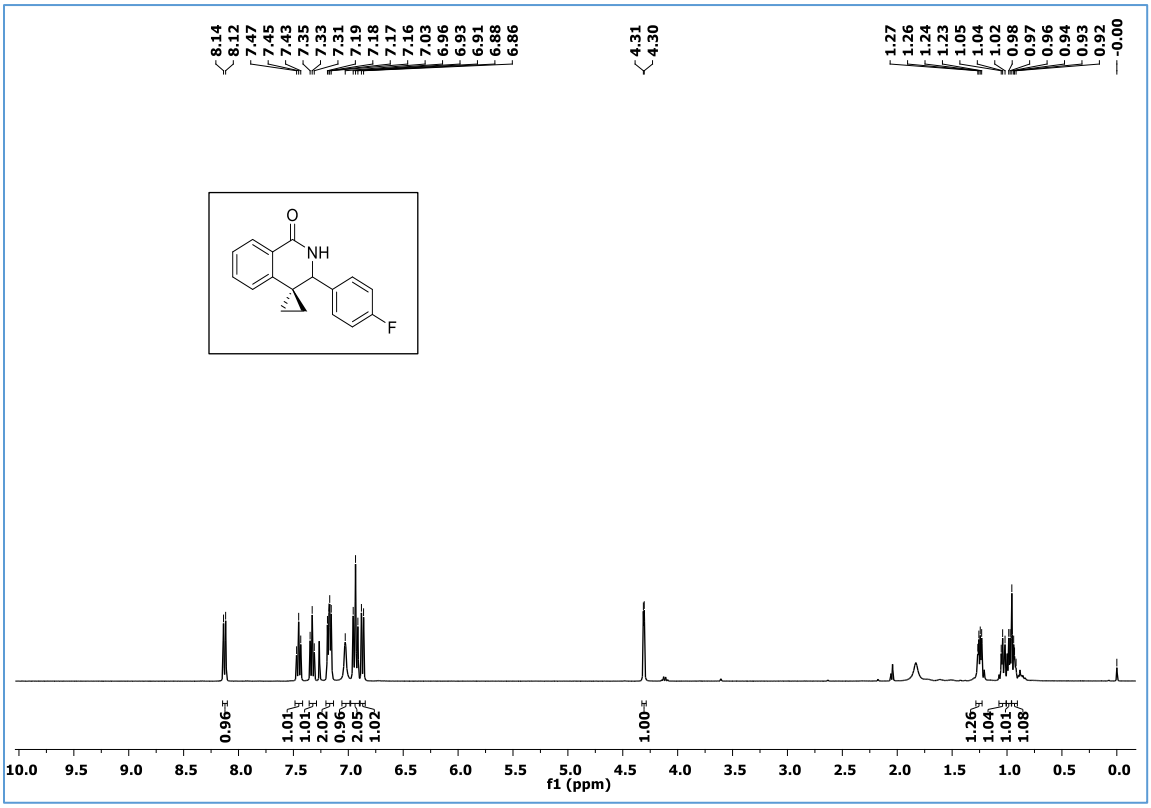


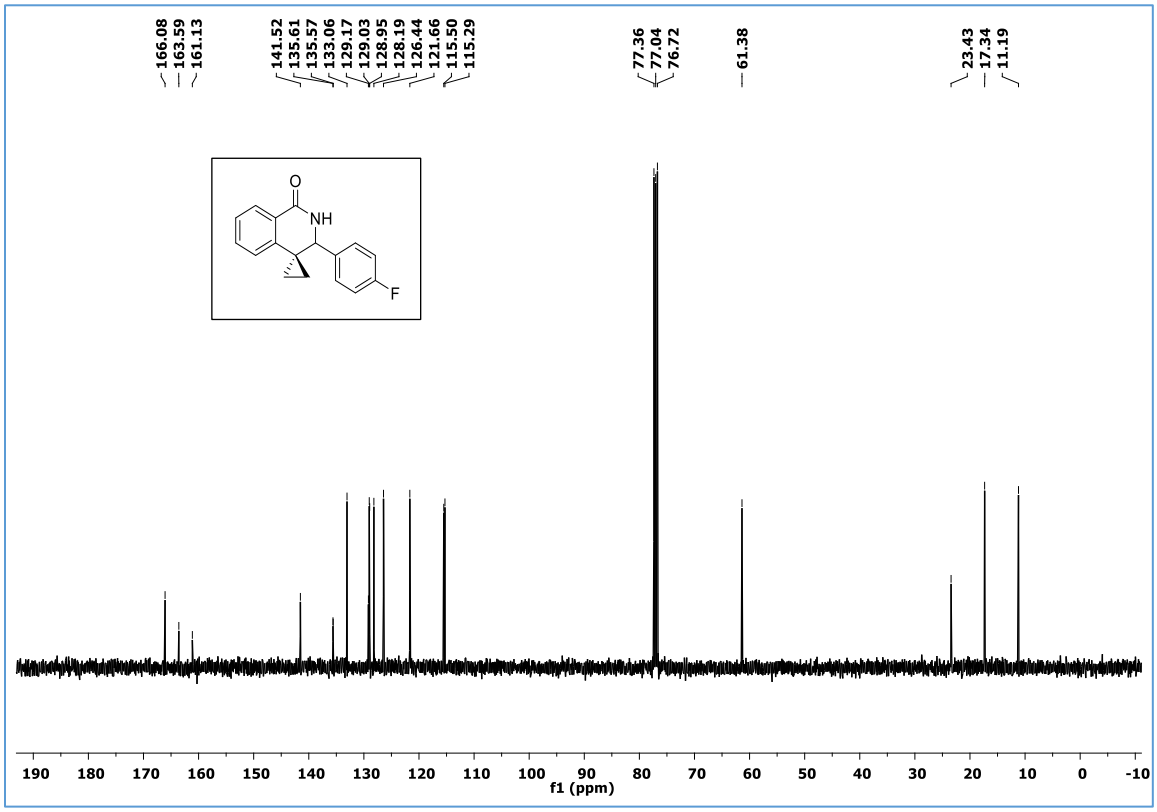


DEPT (135) NMR Spectrum of Compound **3ab.**

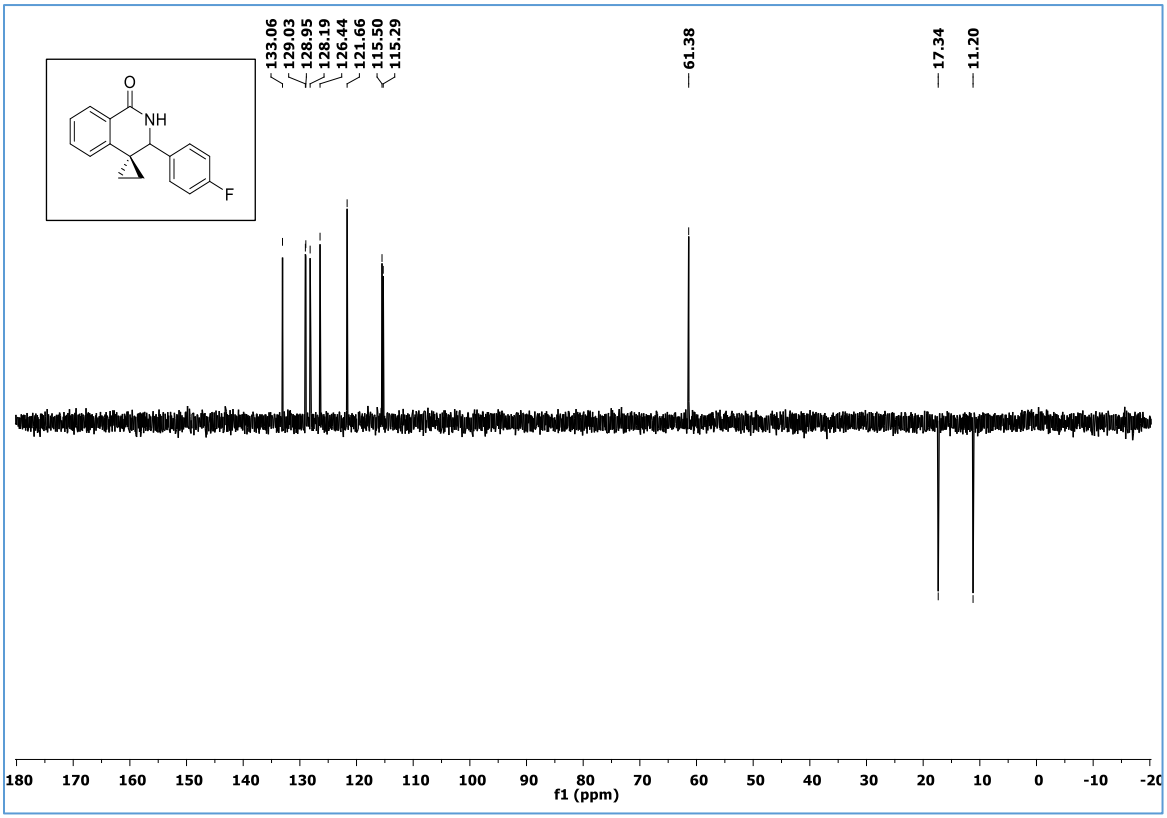


^{1}H and ^{13}C NMR Spectra of Compound **3ac.**

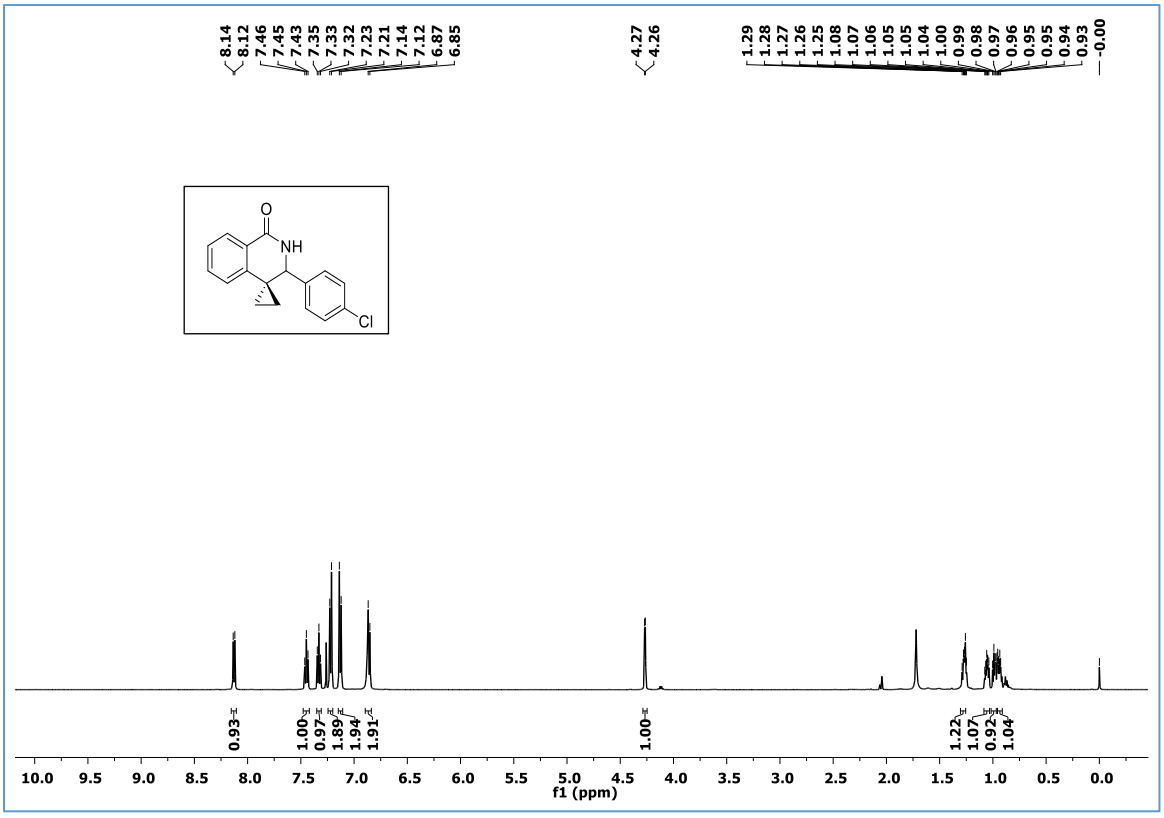


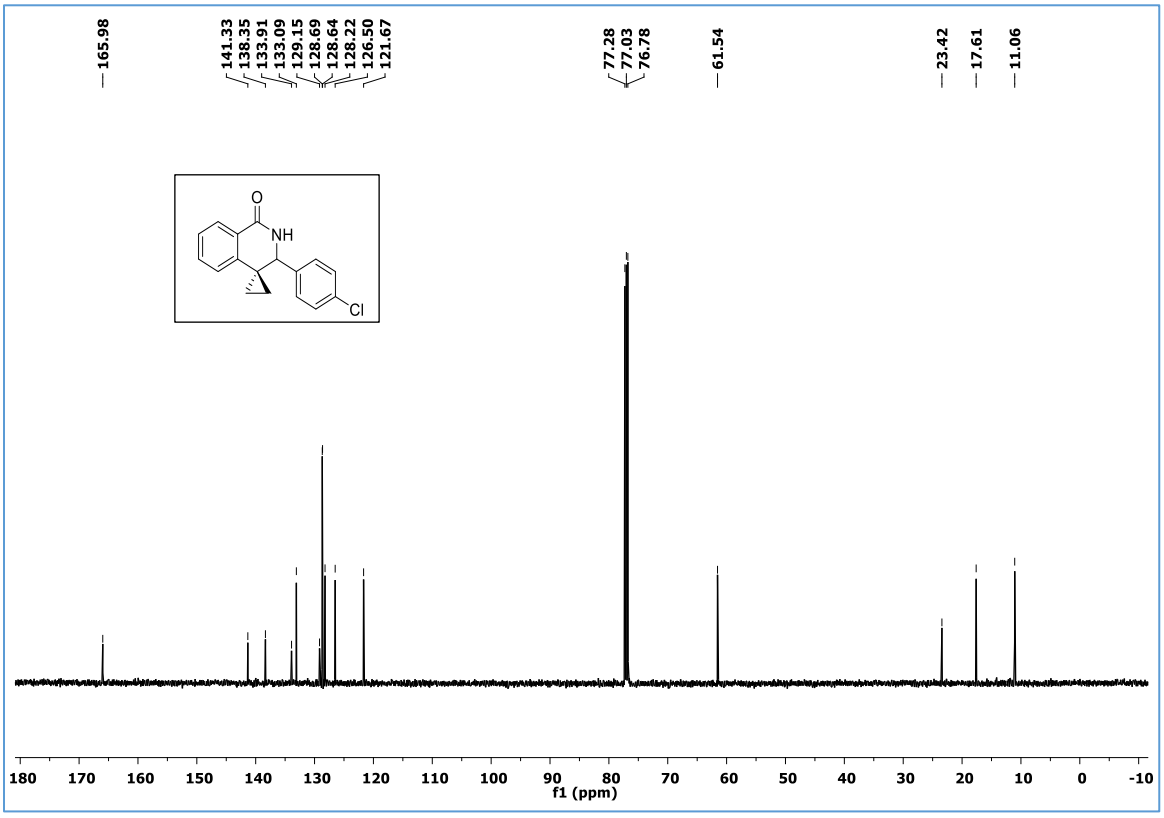


DEPT (135) NMR Spectrum of Compound **3ac.**

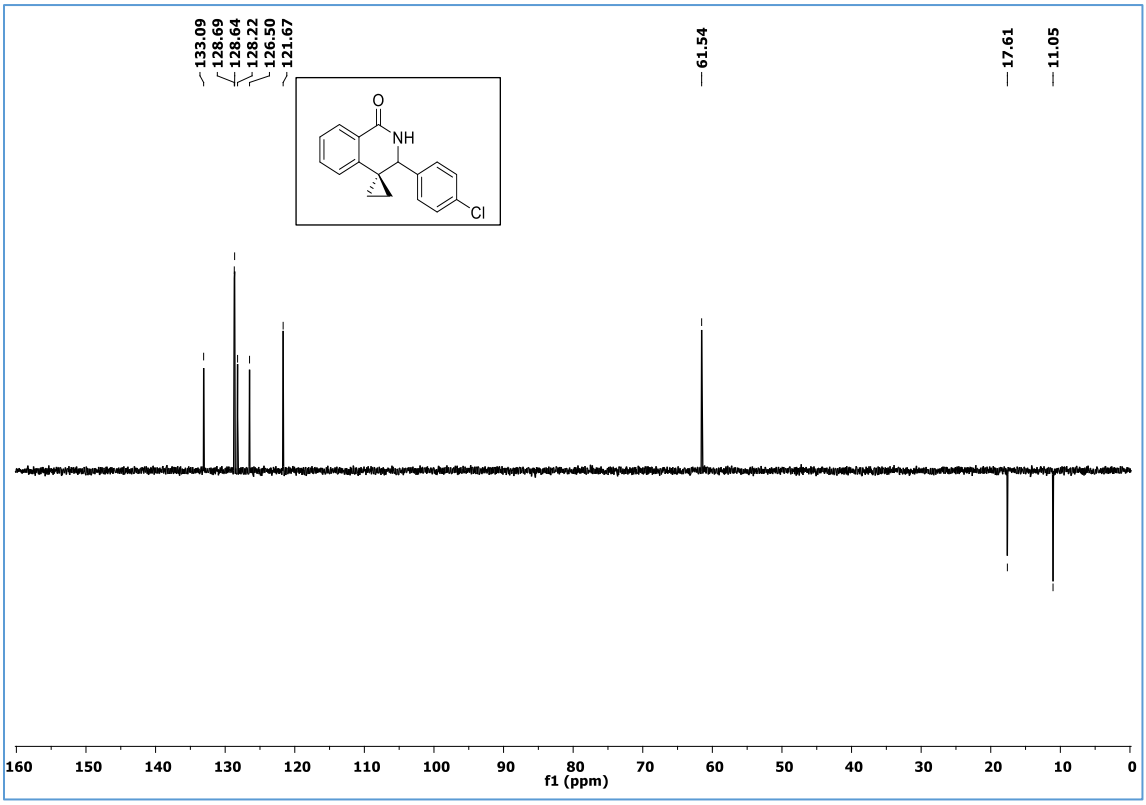


^{1}H and ^{13}C NMR Spectra of Compound **3ad.**

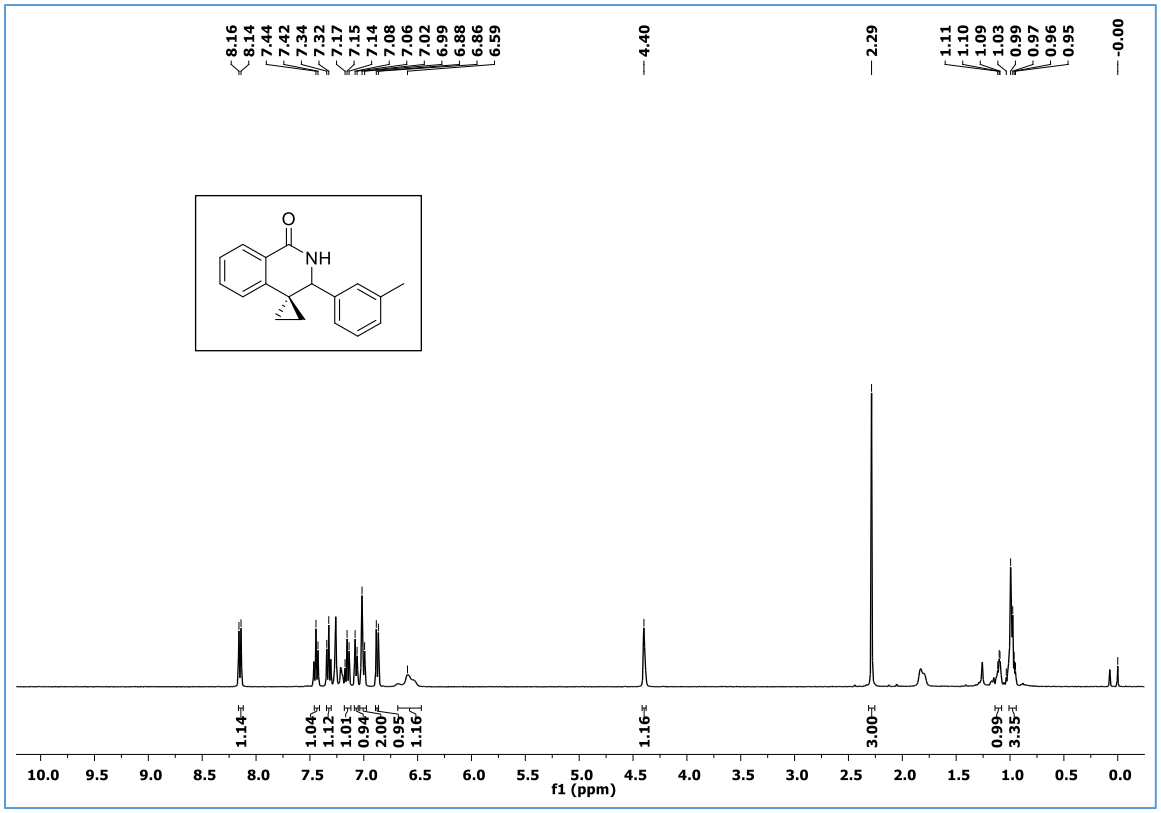


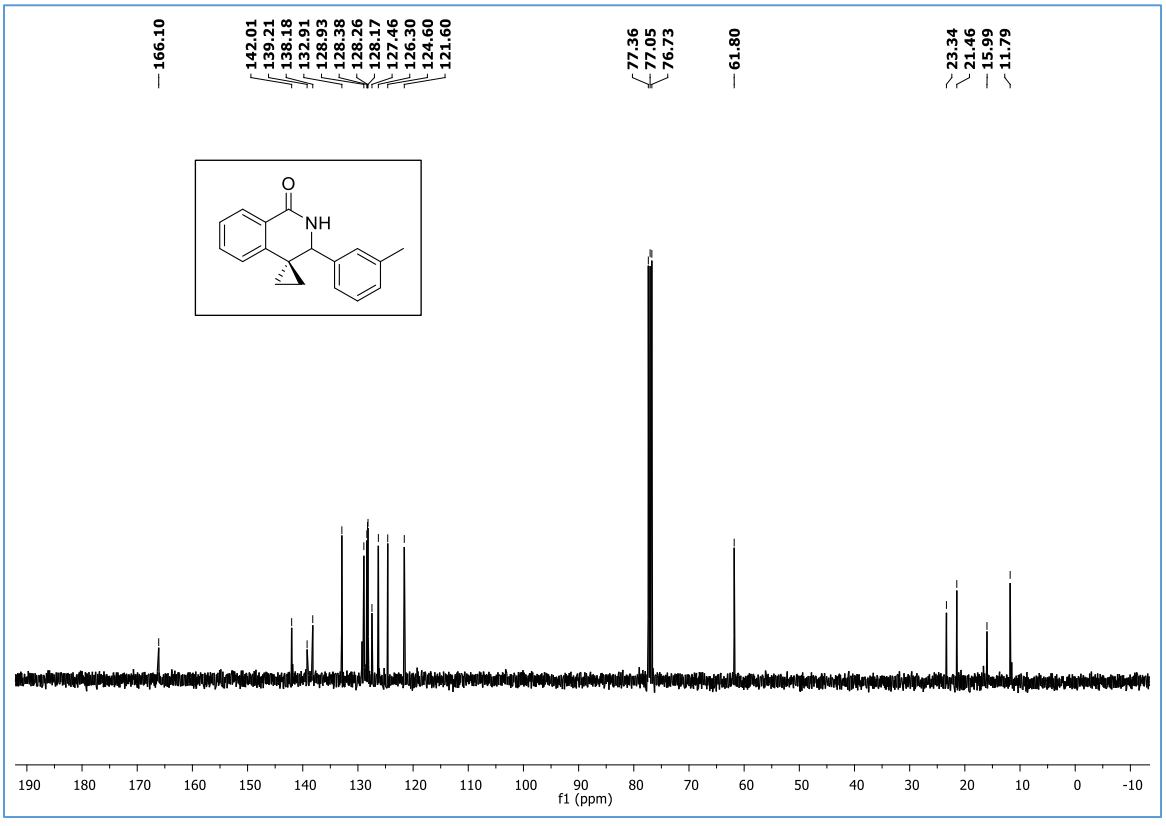


DEPT (135) NMR Spectrum of Compound **3ad.**

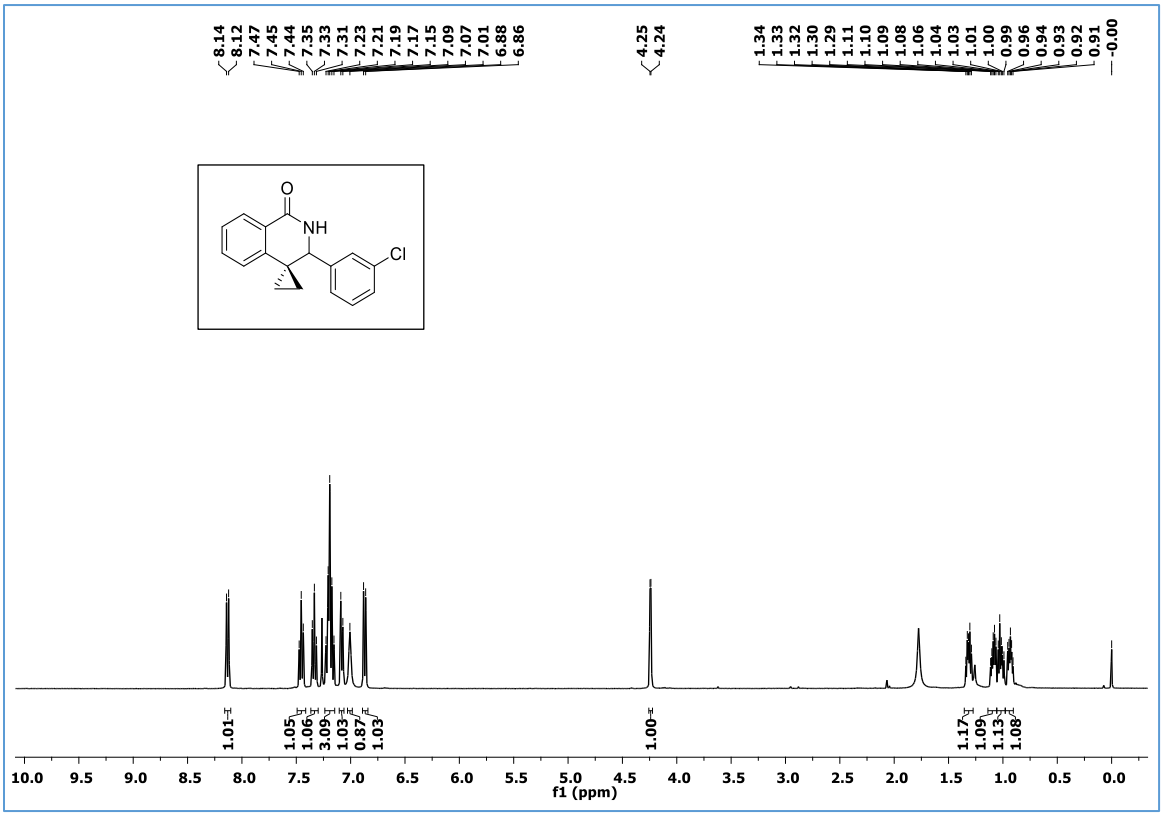


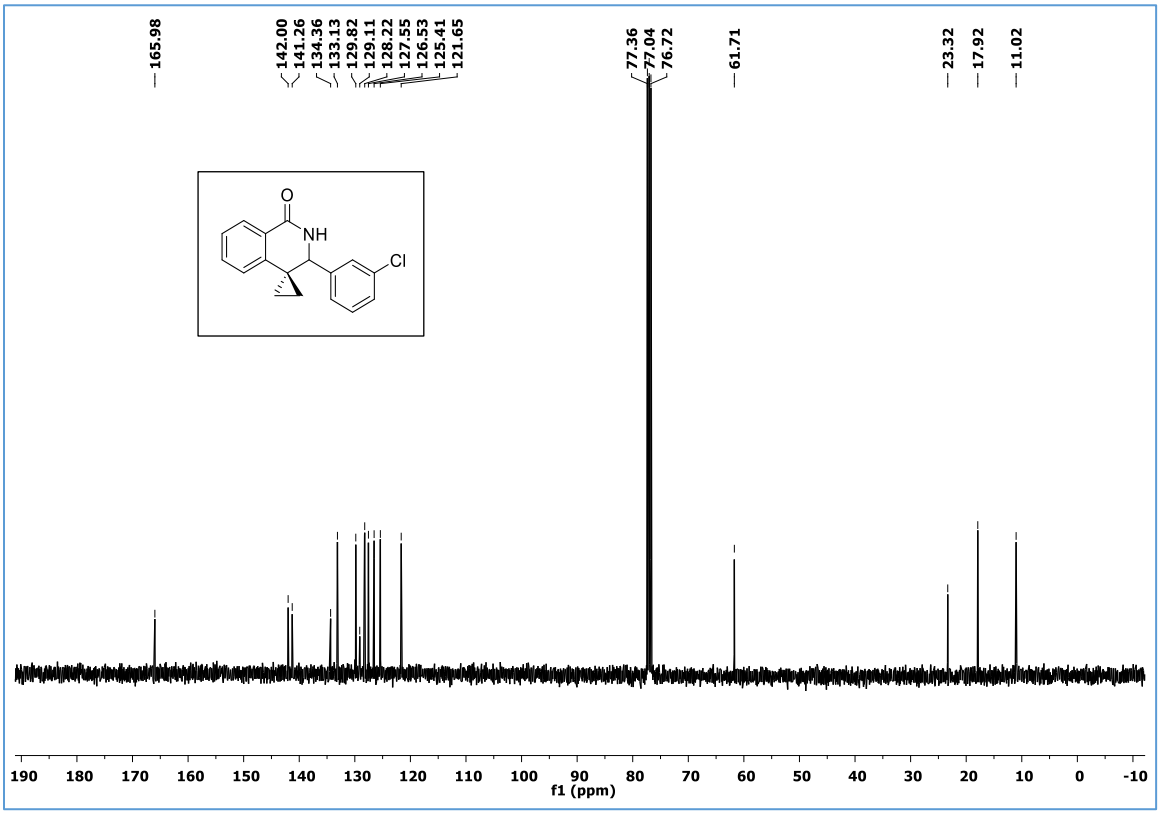
^{1}H and ^{13}C NMR Spectra of Compound **3ae.**



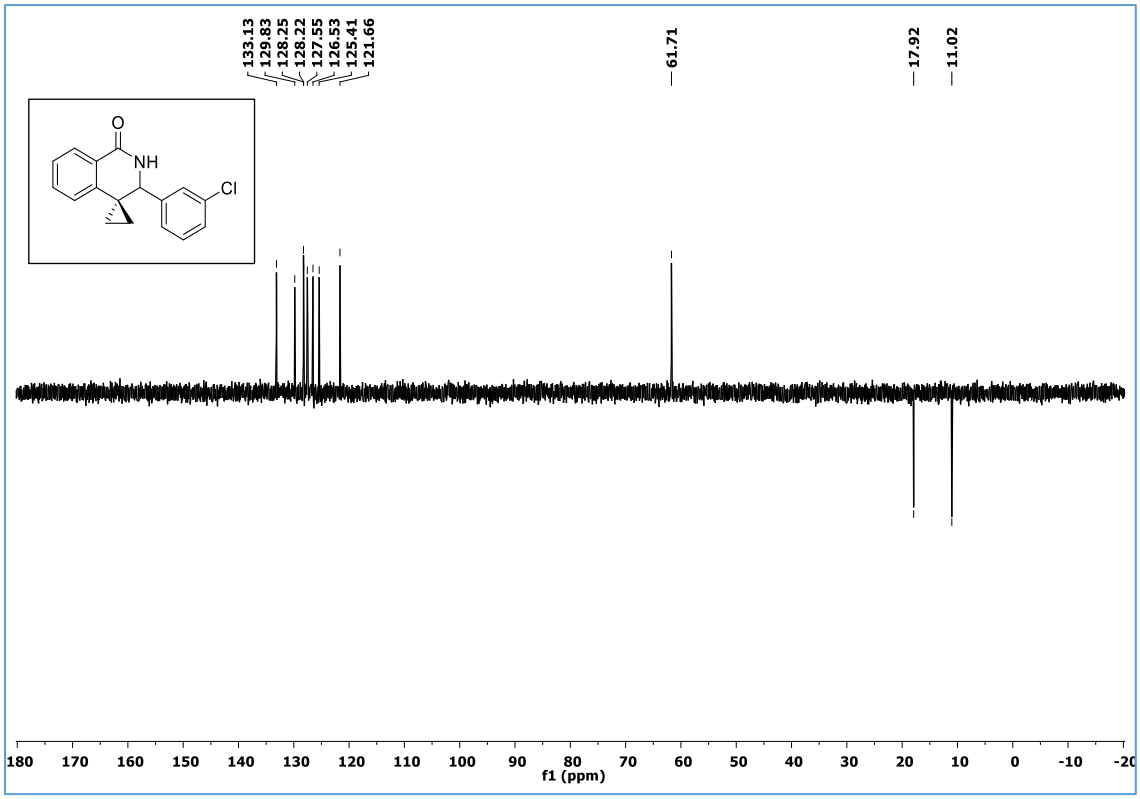


^{1}H and ^{13}C NMR Spectra of Compound **3af.**

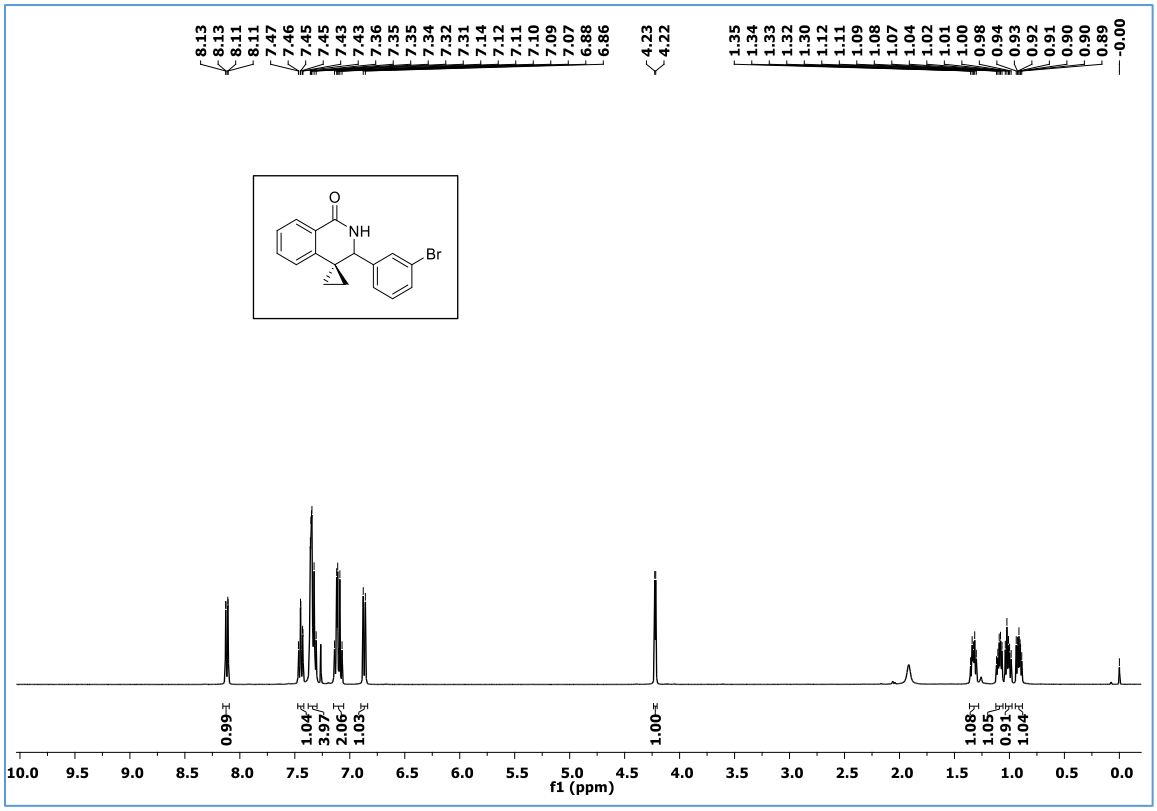


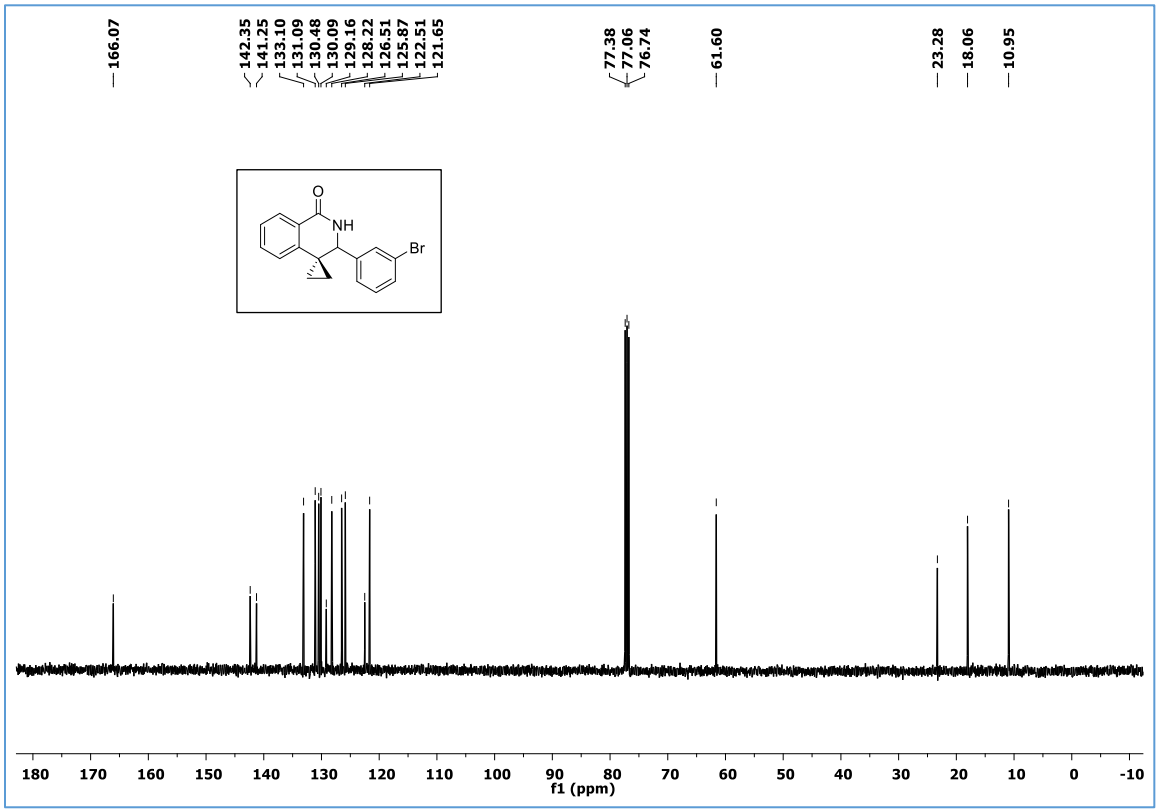


DEPT (135) NMR Spectrum of Compound **3af.**

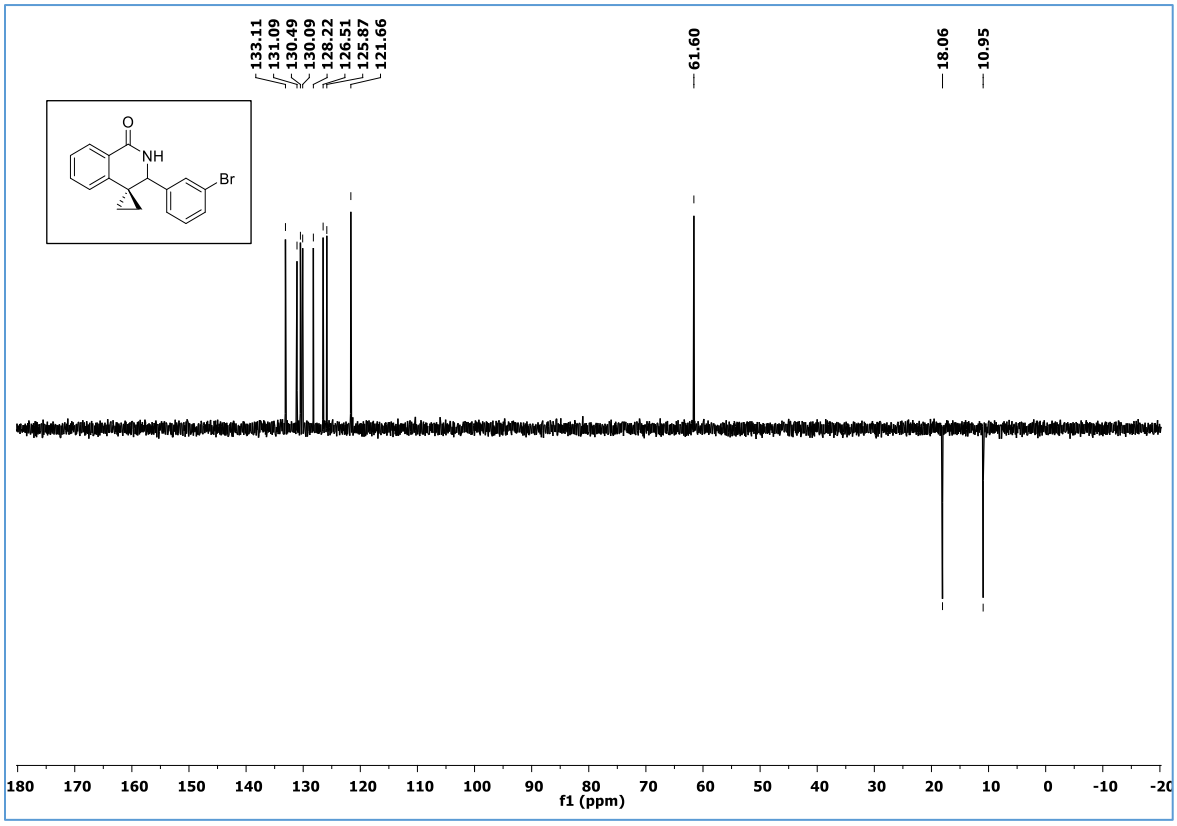


^{1}H and ^{13}C NMR Spectra of Compound **3ag.**

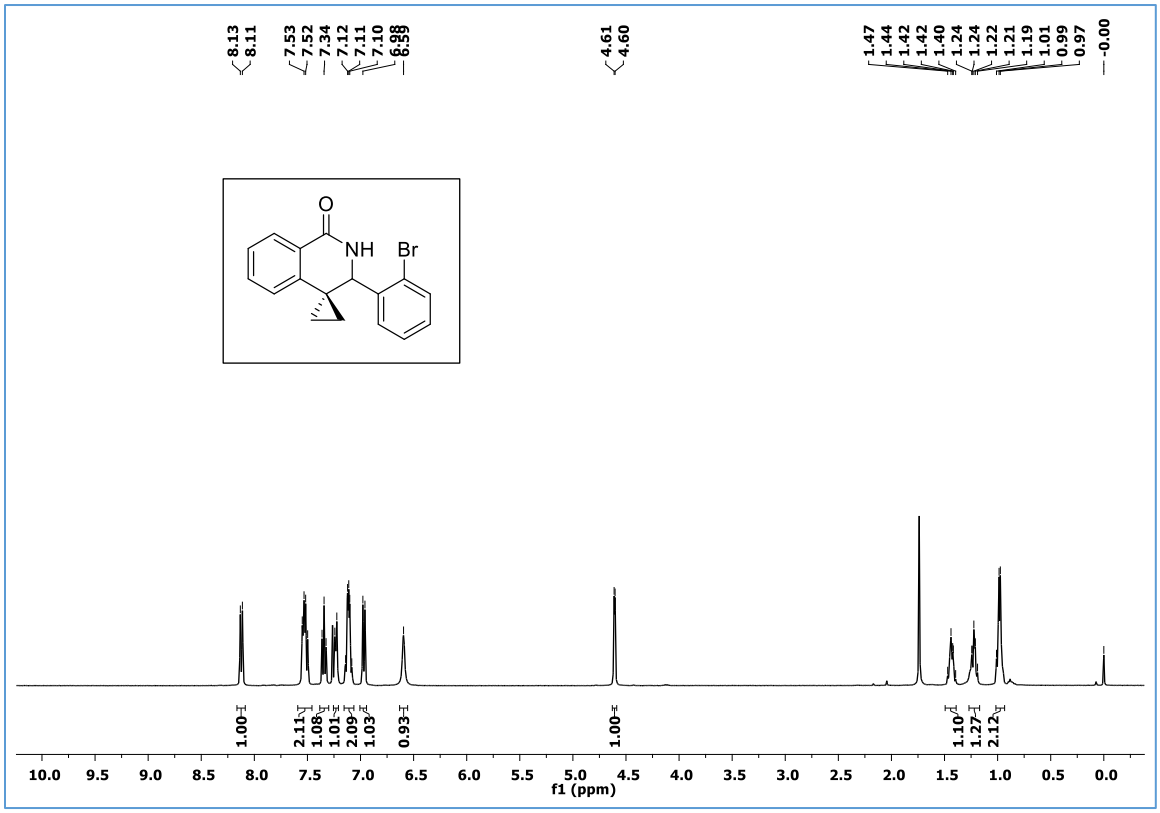


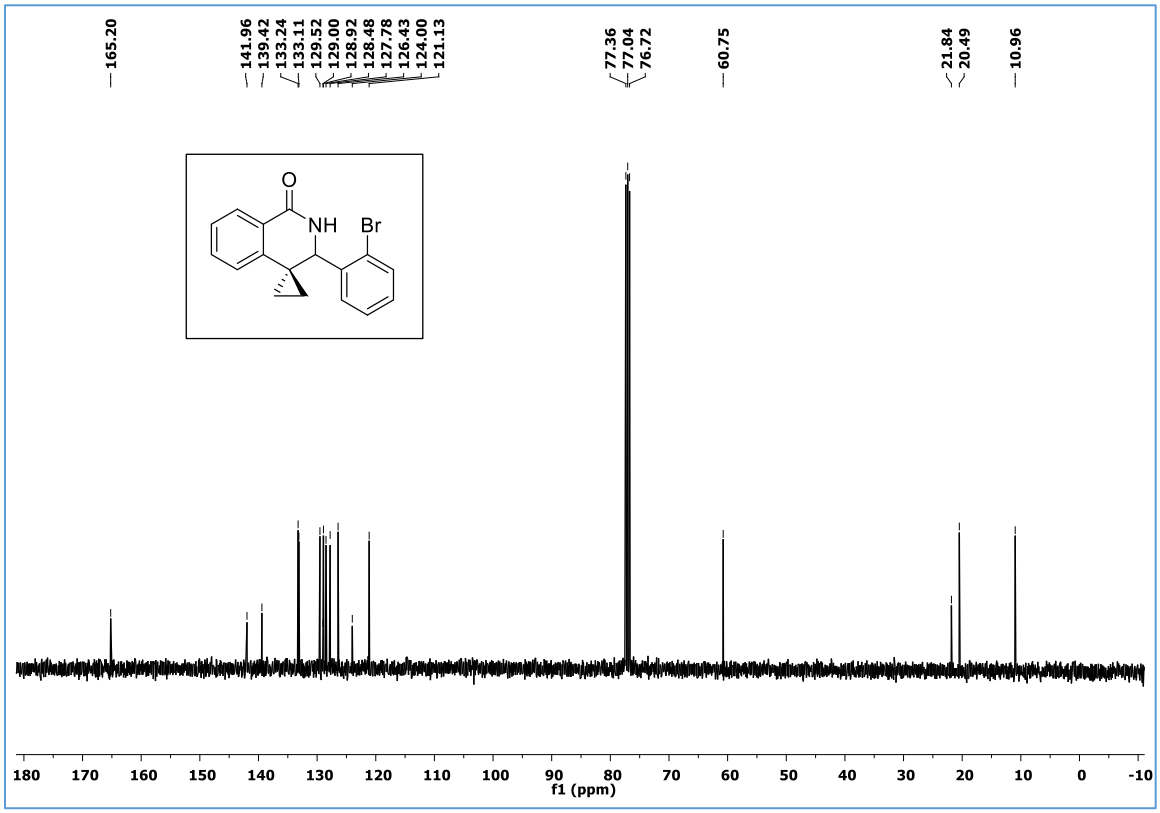


DEPT (135) NMR Spectrum of Compound **3ag.**

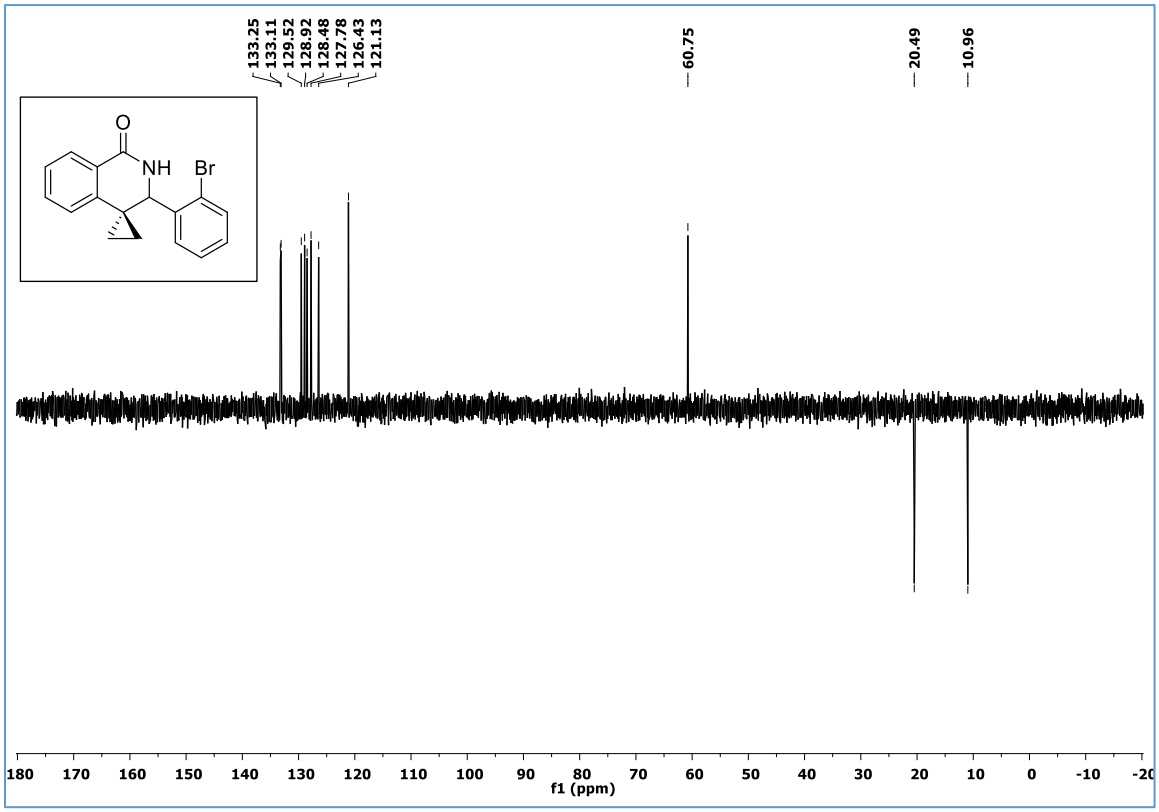


^{1}H and ^{13}C NMR Spectra of Compound **3ah.**

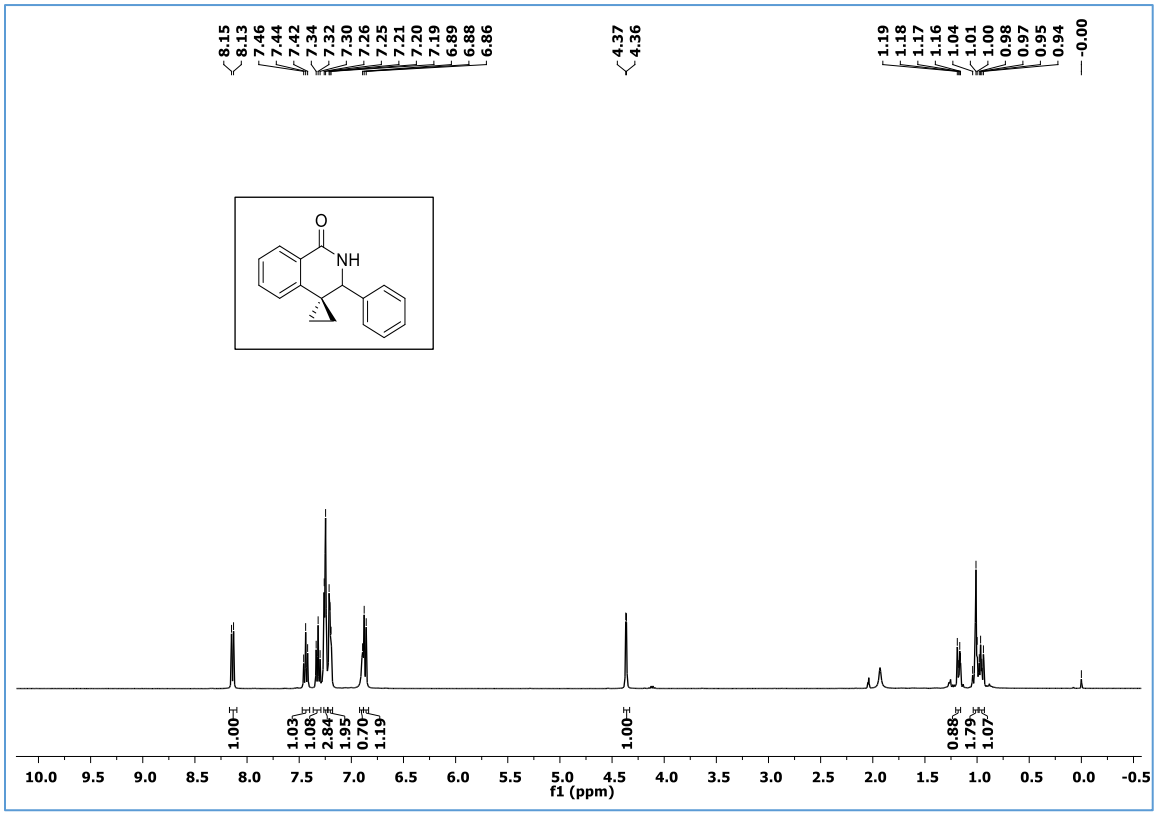


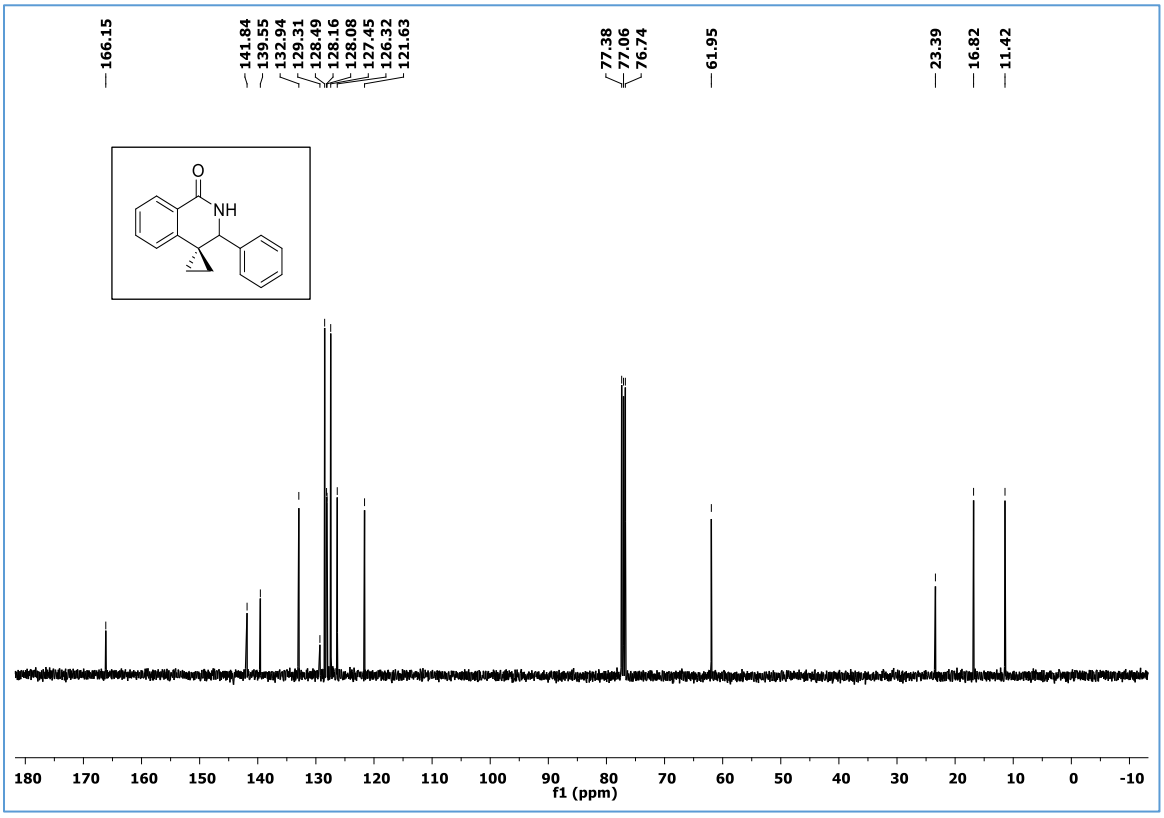


DEPT (135) NMR Spectrum of Compound **3ah.**

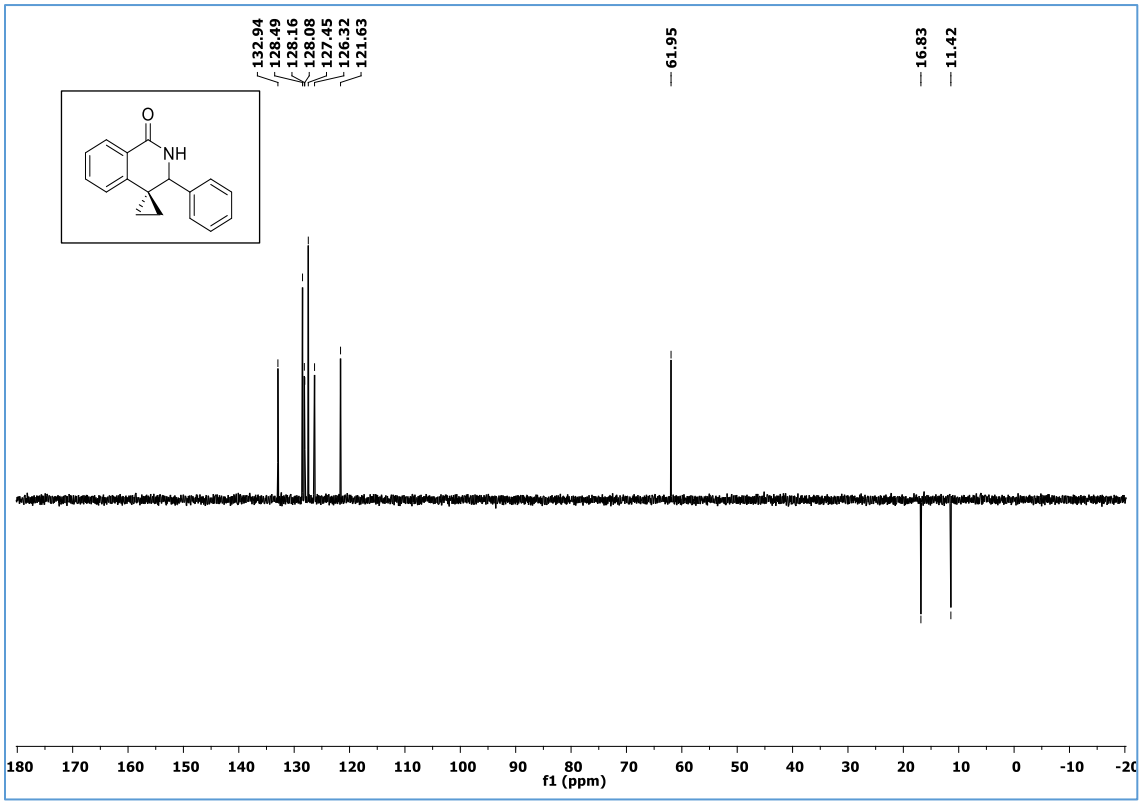


^{1}H and ^{13}C NMR Spectra of Compound **3ai.**

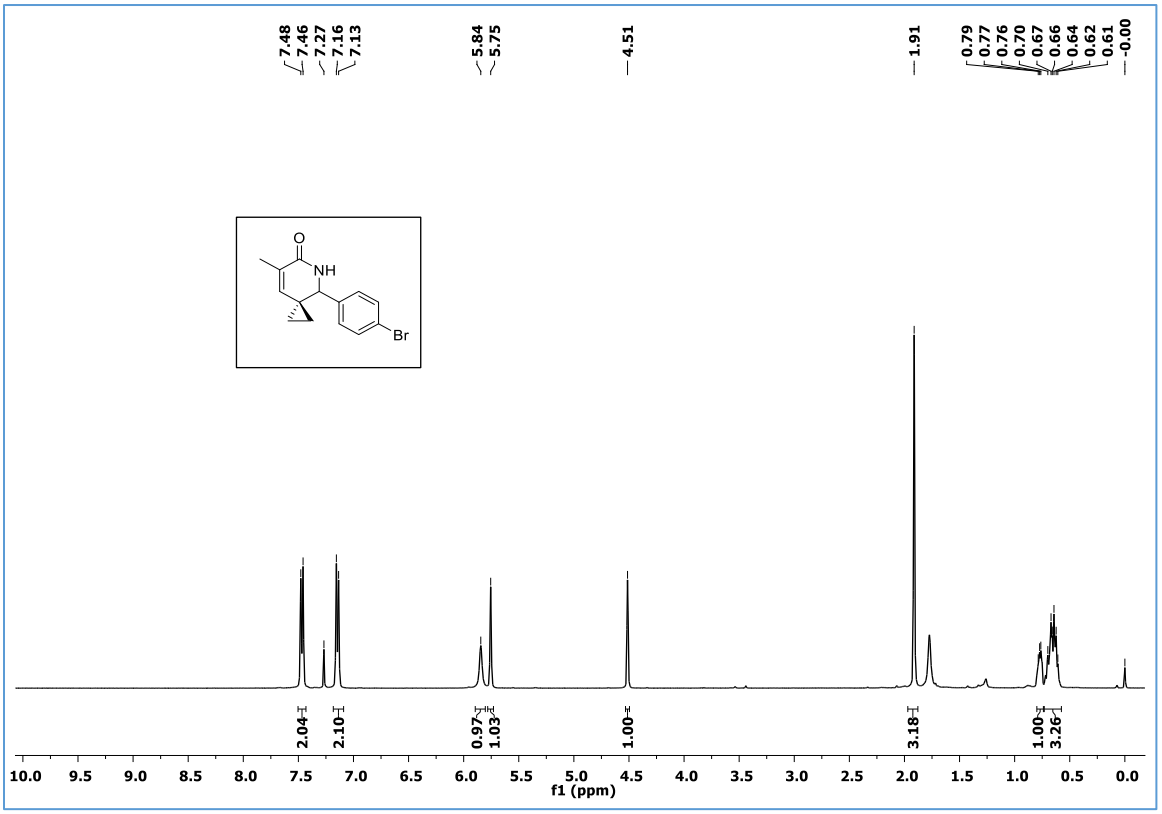


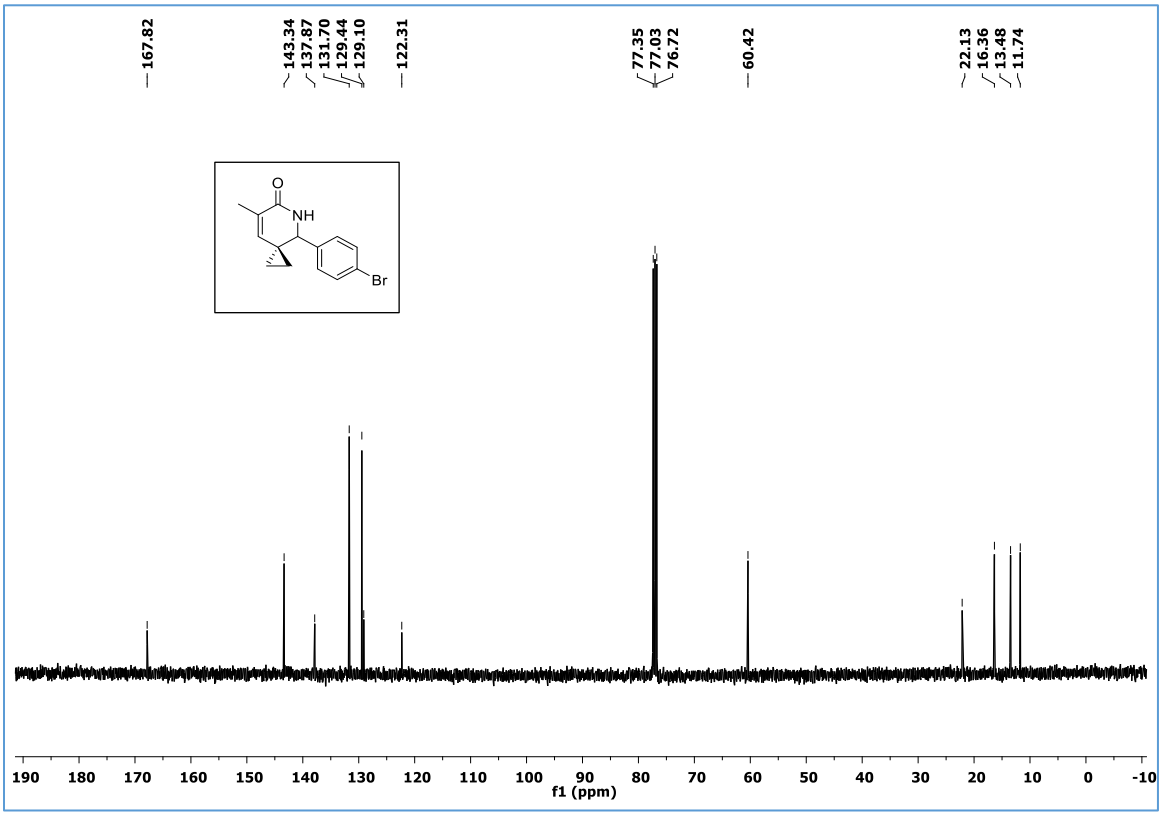


DEPT (135) NMR Spectrum of Compound **3ai.**

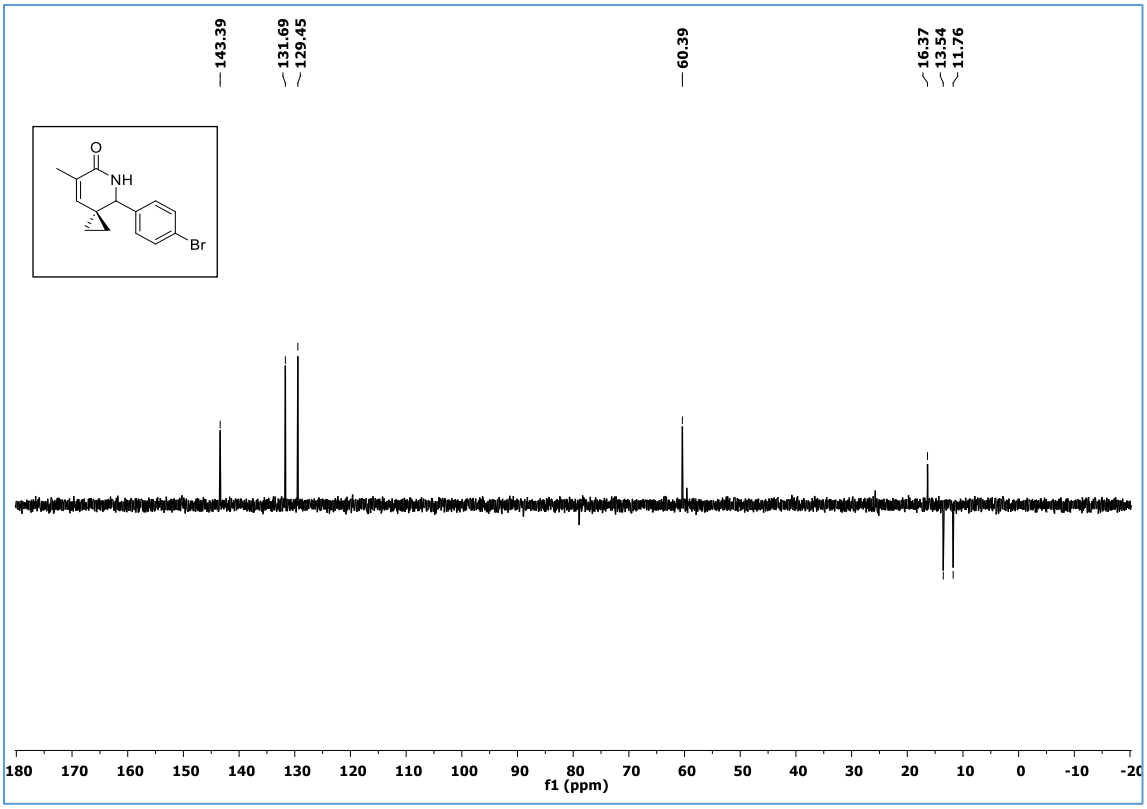


^{1}H and ^{13}C NMR Spectra of Compound **5aa.**

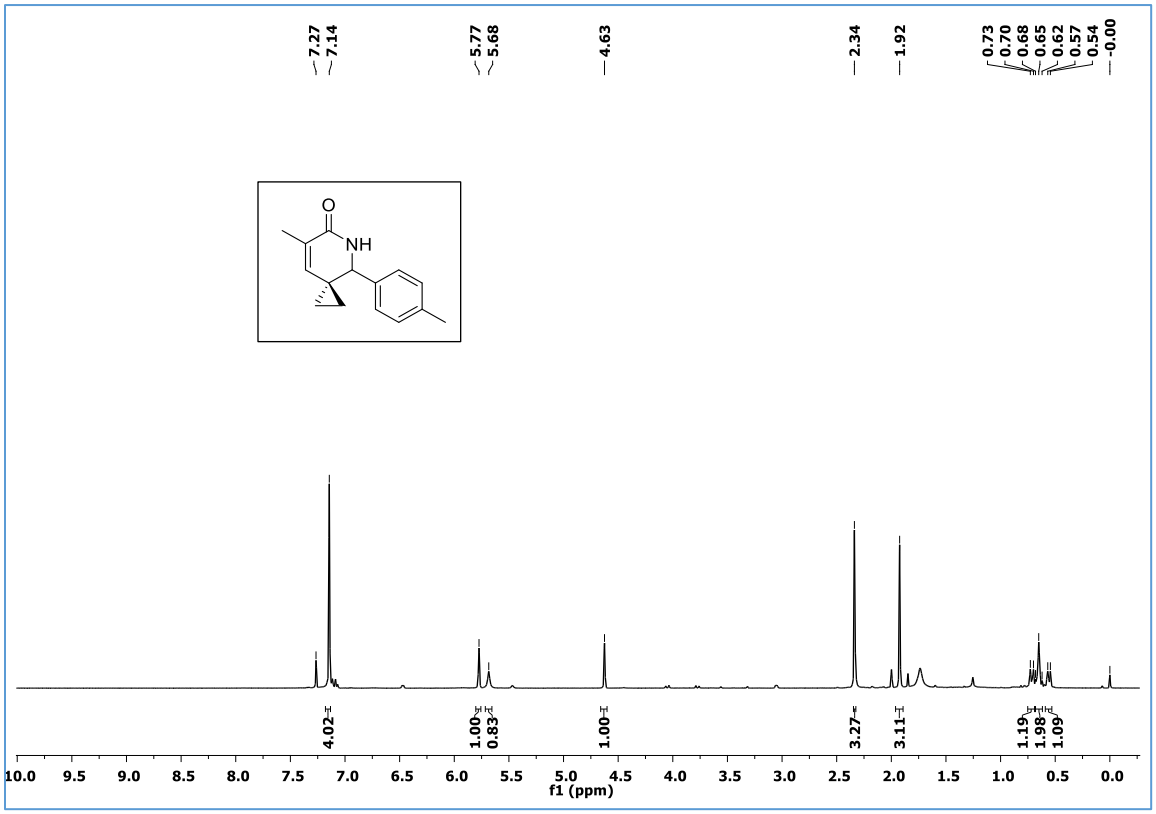


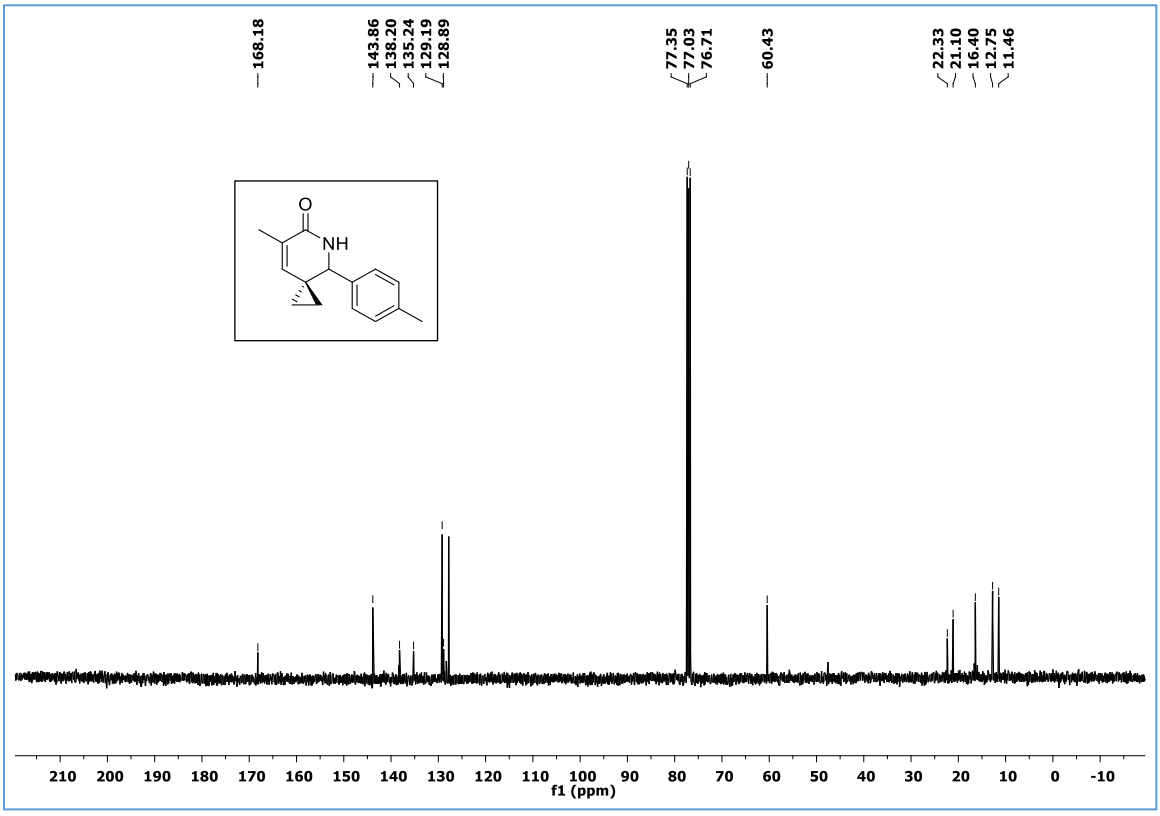


DEPT (135) NMR Spectrum of Compound **5aa.**

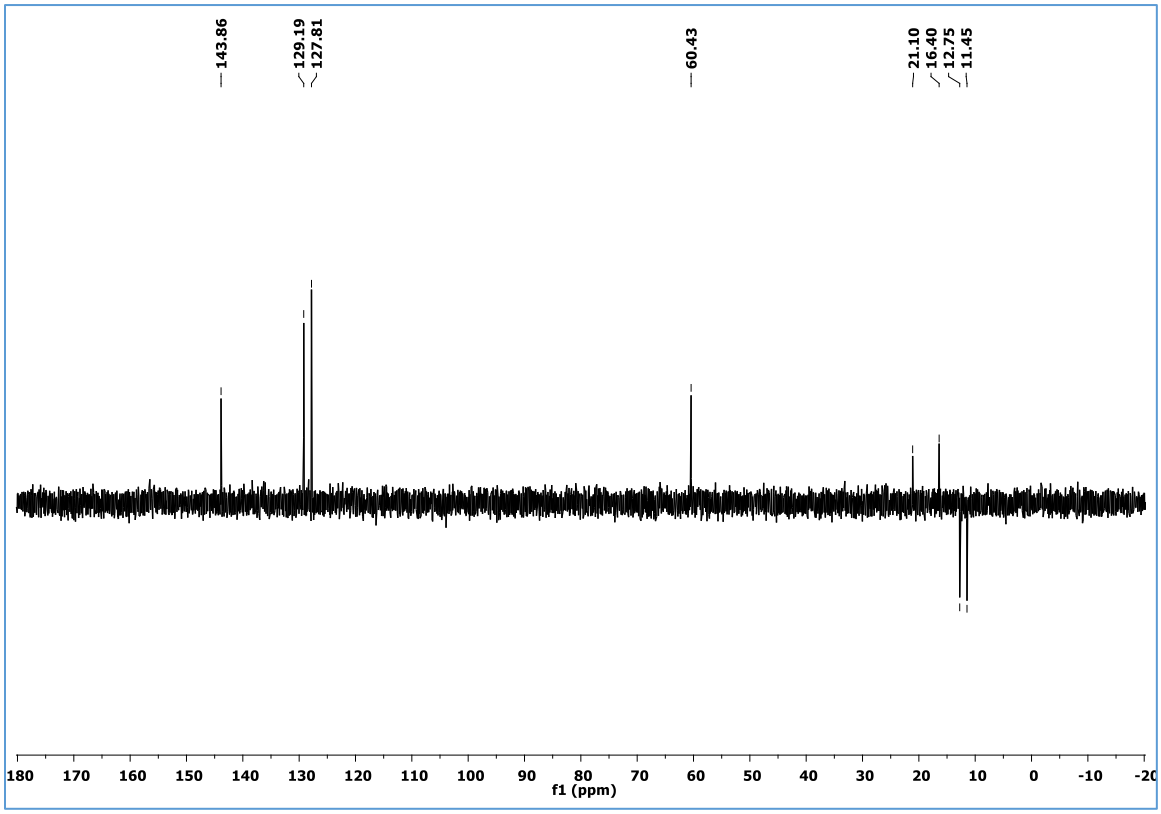


^{1}H and ^{13}C NMR Spectra of Compound **5ab.**

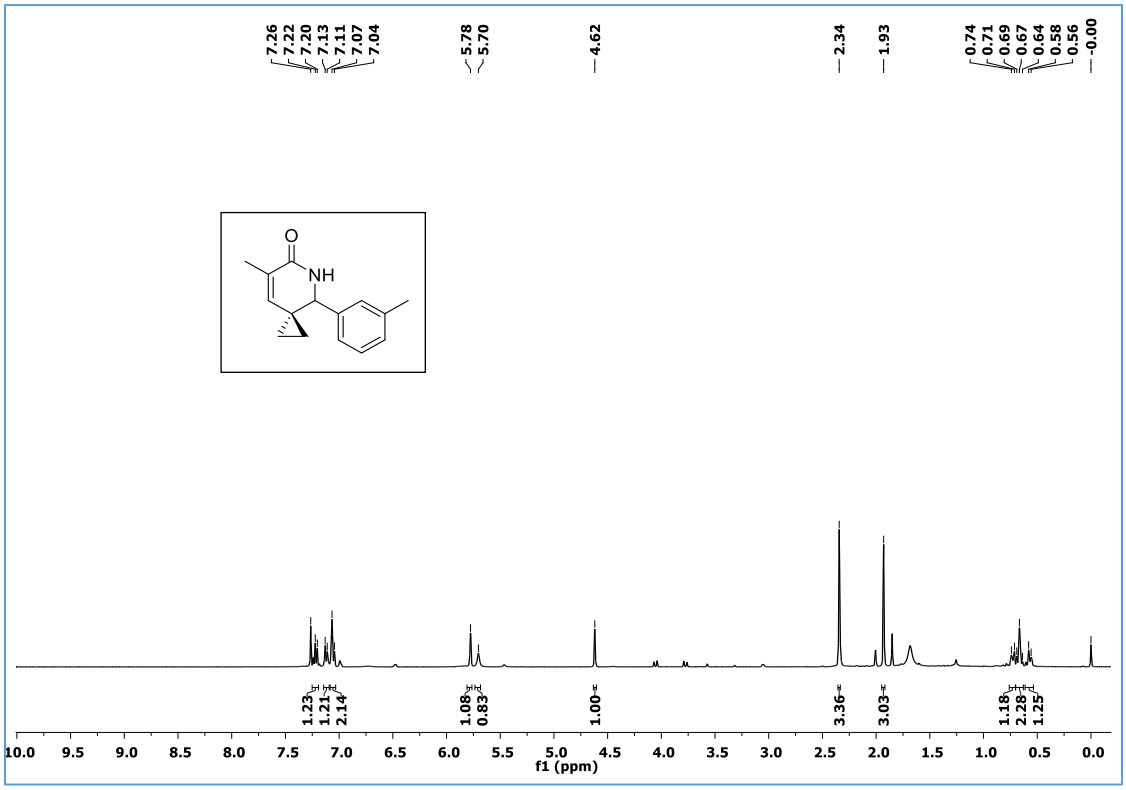


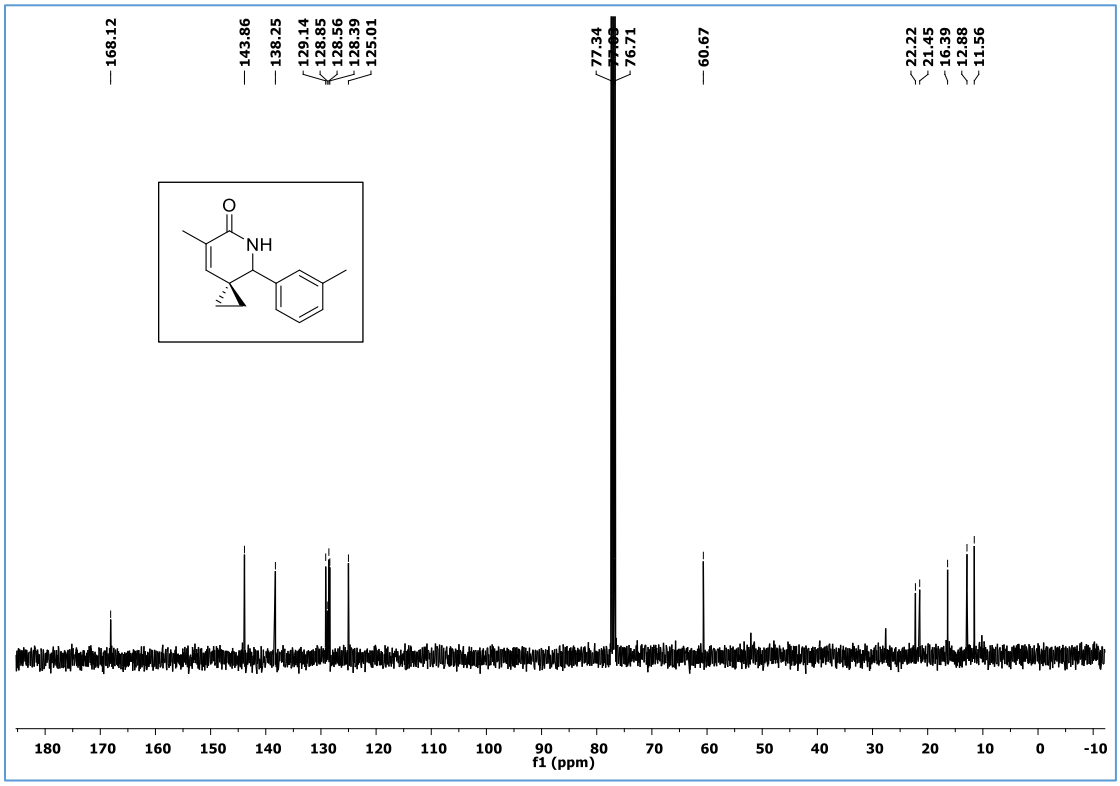


DEPT (135) NMR Spectrum of Compound **5ab.**

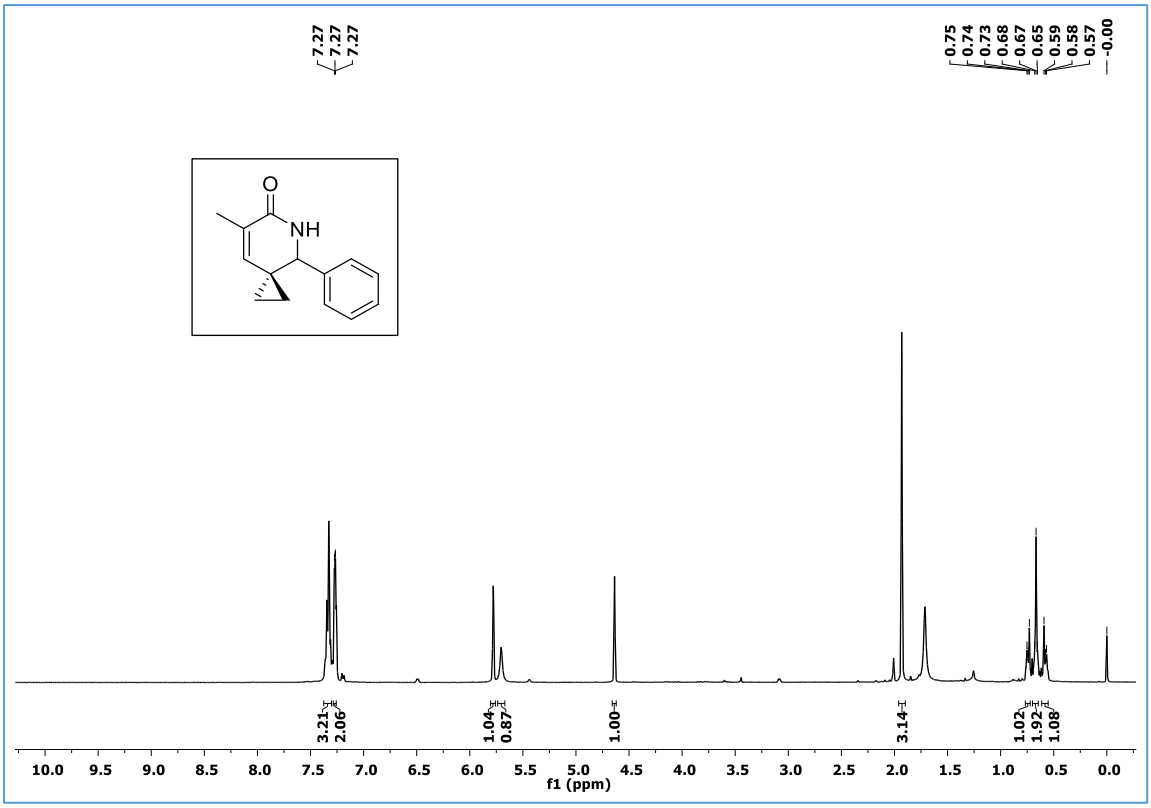


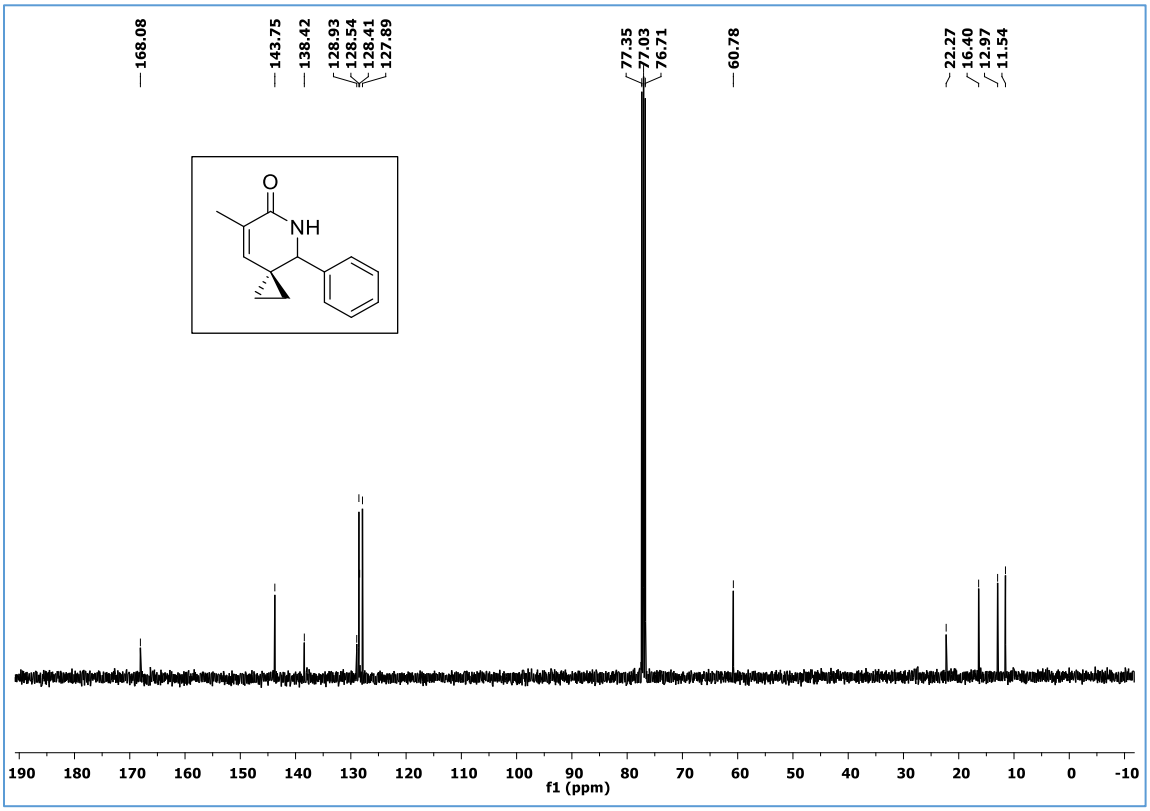
^{1}H and ^{13}C NMR Spectra of Compound **5ae.**



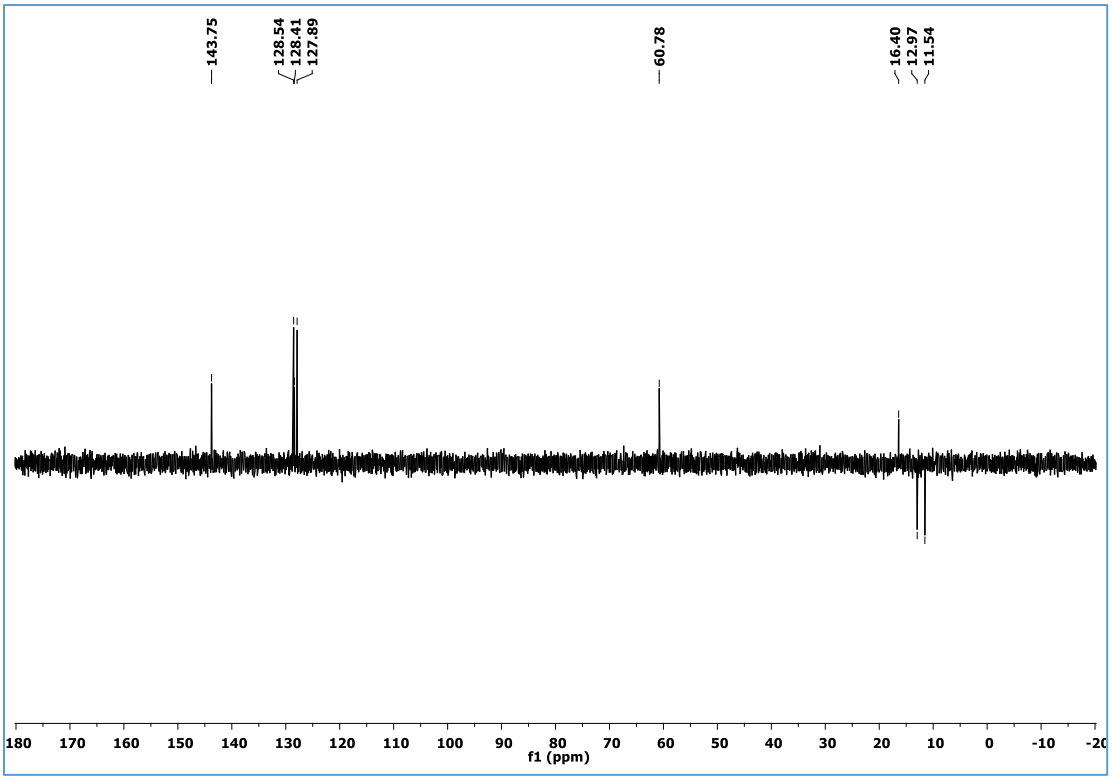


^{1}H and ^{13}C NMR Spectra of Compound **5ai.**

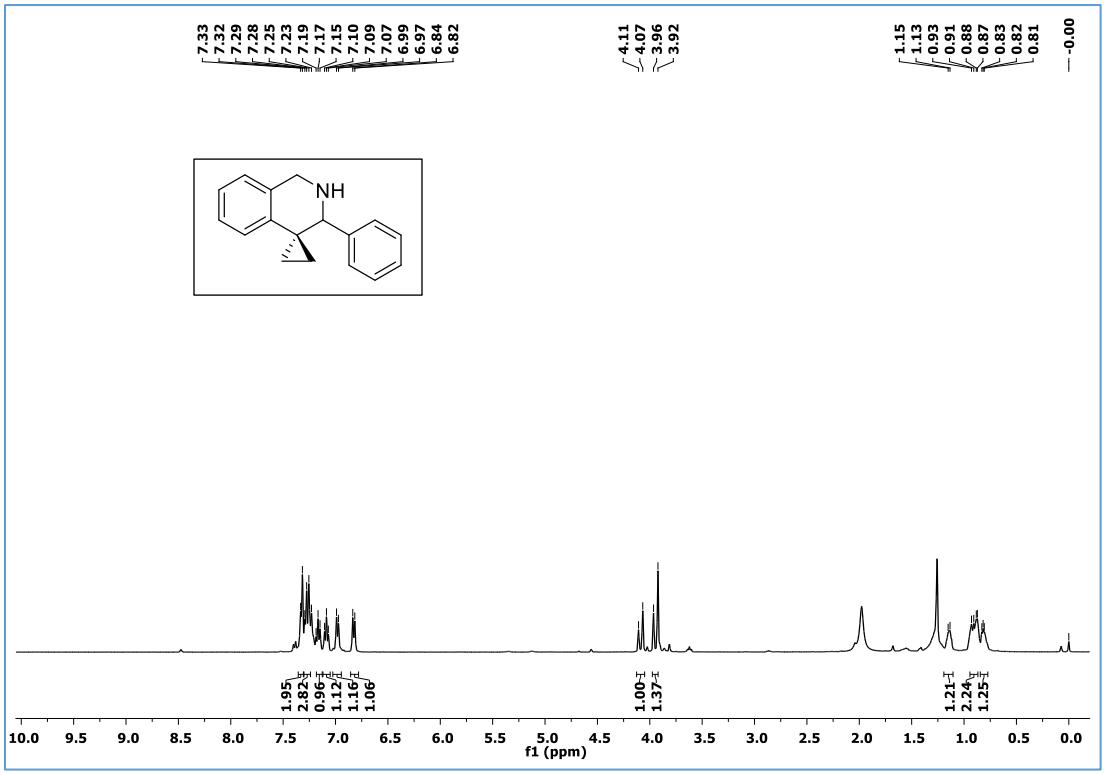


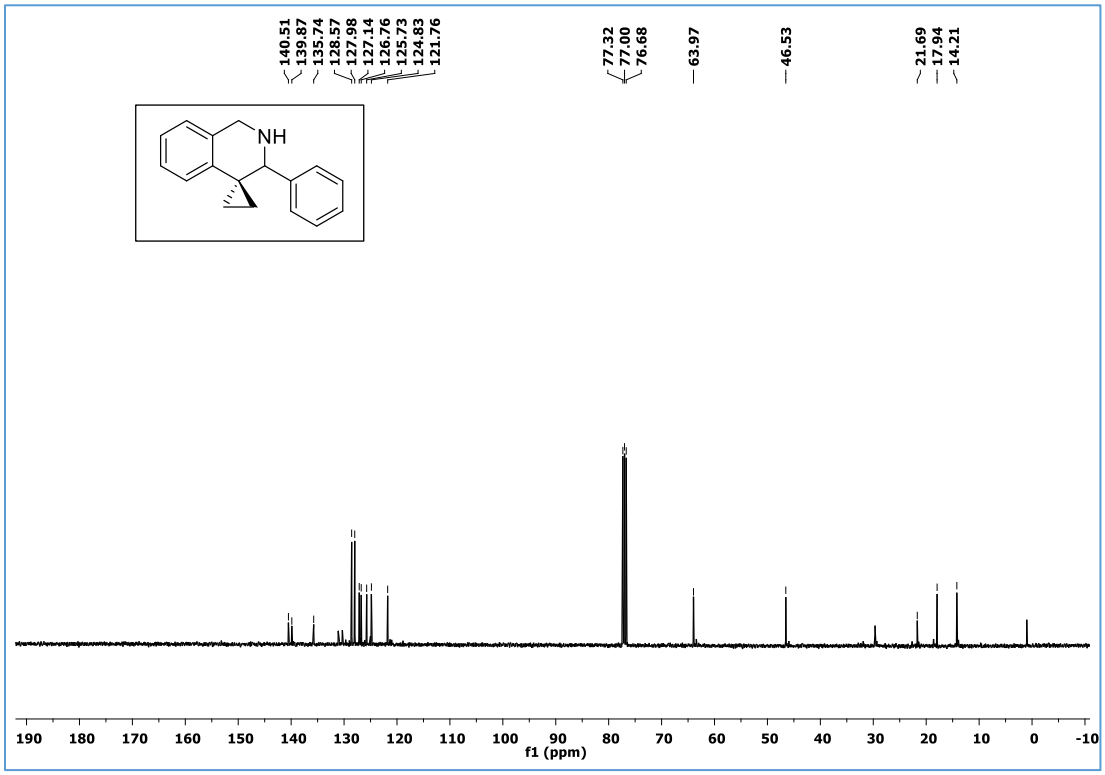


DEPT (135) NMR Spectrum of Compound **5ai.**

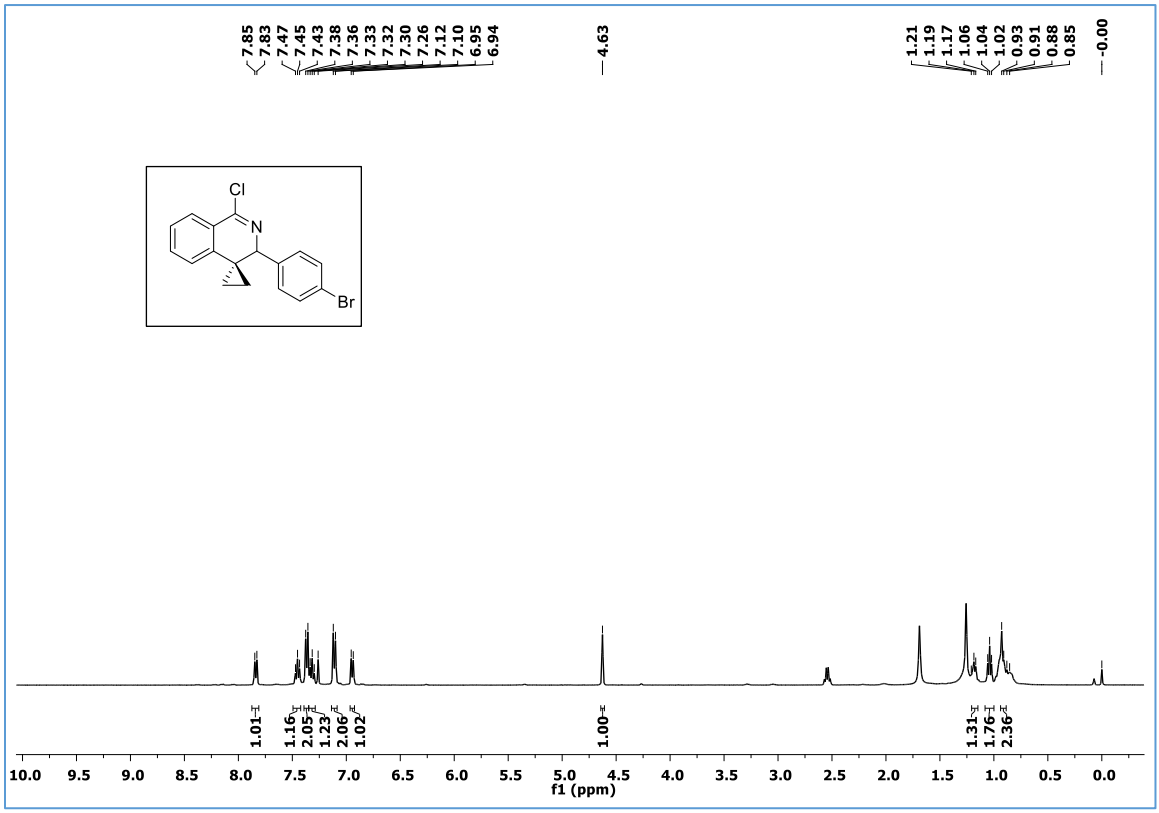


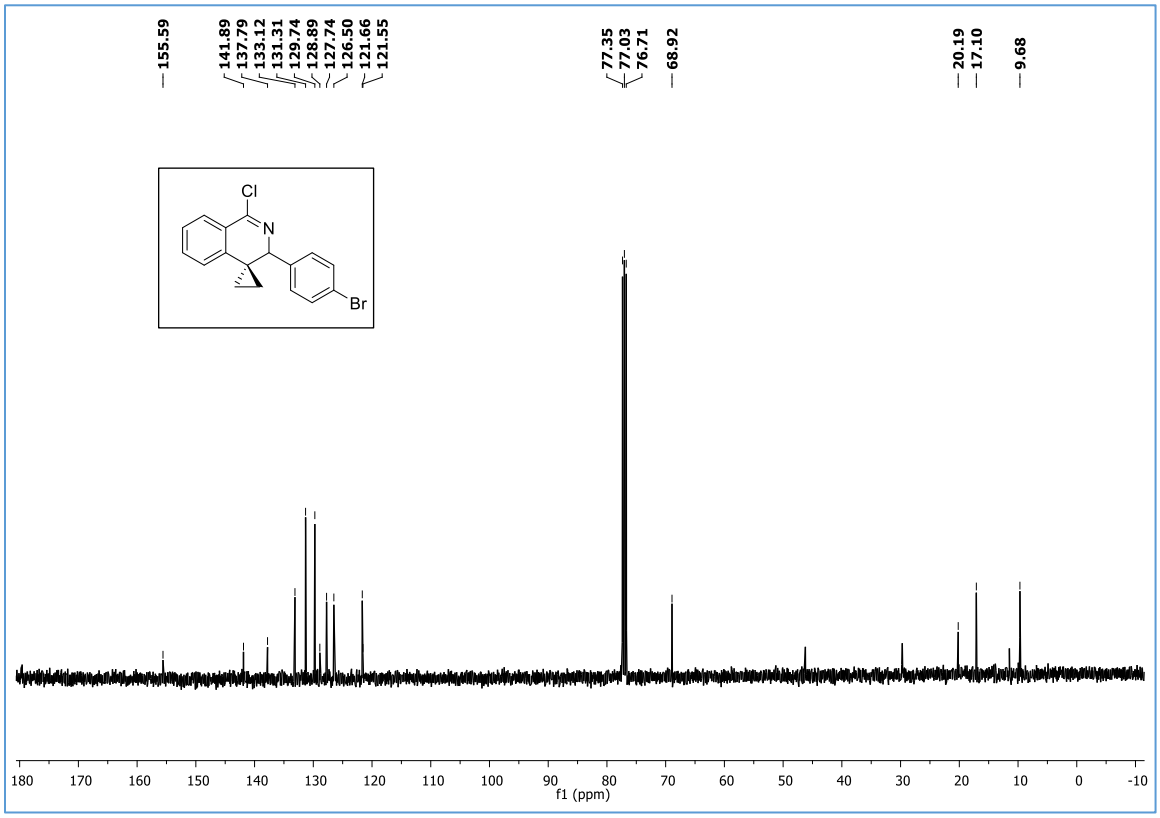
^{1}H and ^{13}C NMR Spectra of Compound **6.**





^{1}H and ^{13}C NMR Spectra of Compound **7aa.**





^{1}H and ^{13}C NMR Spectra of Compound **7af.**