Electronic Supplementary Information (ESI)

Palladium-catalysed stereoselective synthesis of 4-(diarylmethylidene)-3,4-dihydroisoquinolin-1(2*H*)-ones: Expedient access to 4-substituted isoquinolin-1(2*H*)-ones and isoquinolines

Amrita Mondal, Priyanka Kundu, Moumita Jash and Chinmay Chowdhury*

Organic and Medicinal Chemistry Division, CSIR-Indian Institute of Chemical Biology, 4, Raja S.C. Mullick Road, Kolkata-700032, India.

chinmay@iicb.res.in

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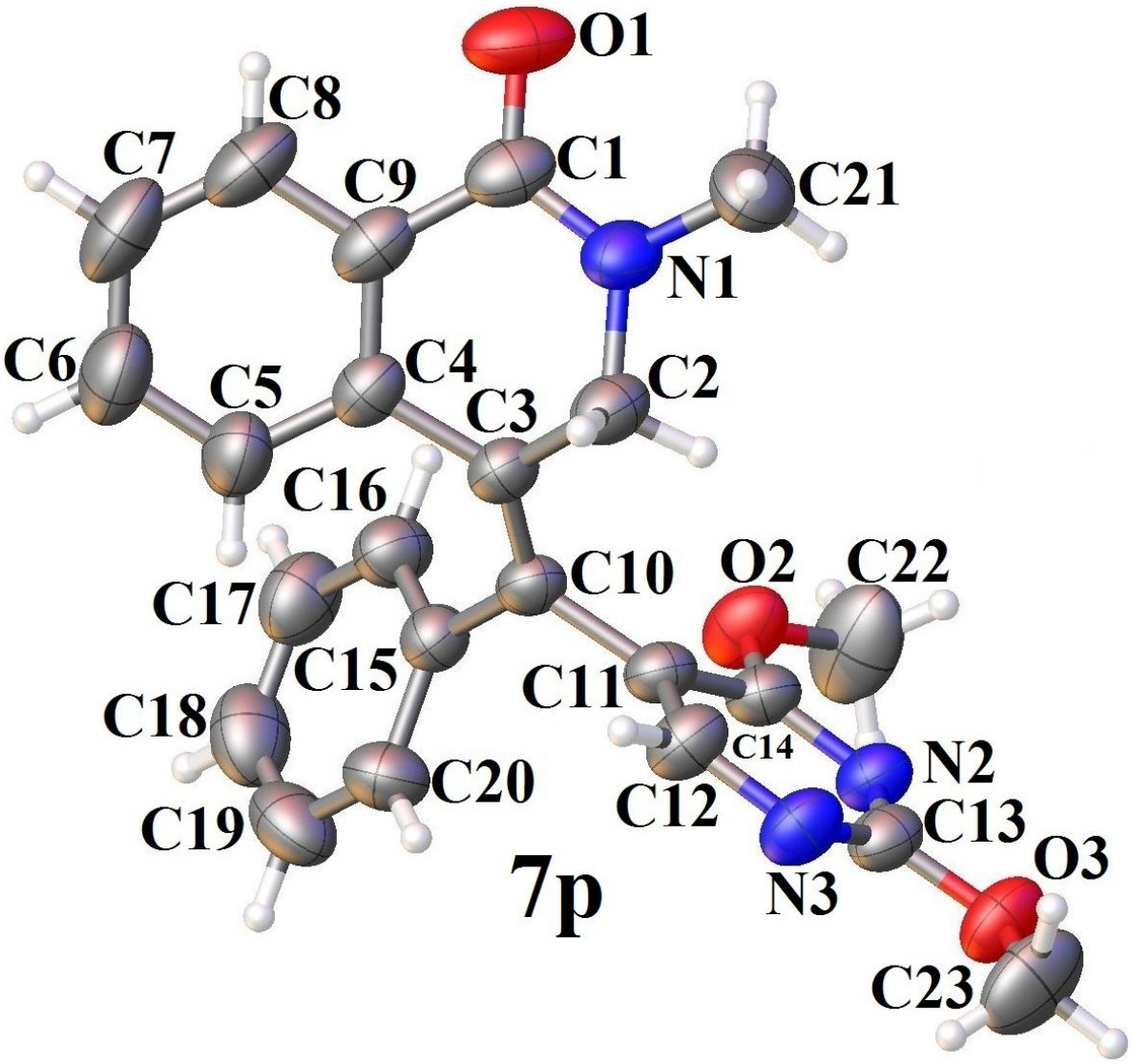


Figure S1: ORTEP[1] diagram of compound **7p** (drawn at 50% probability).

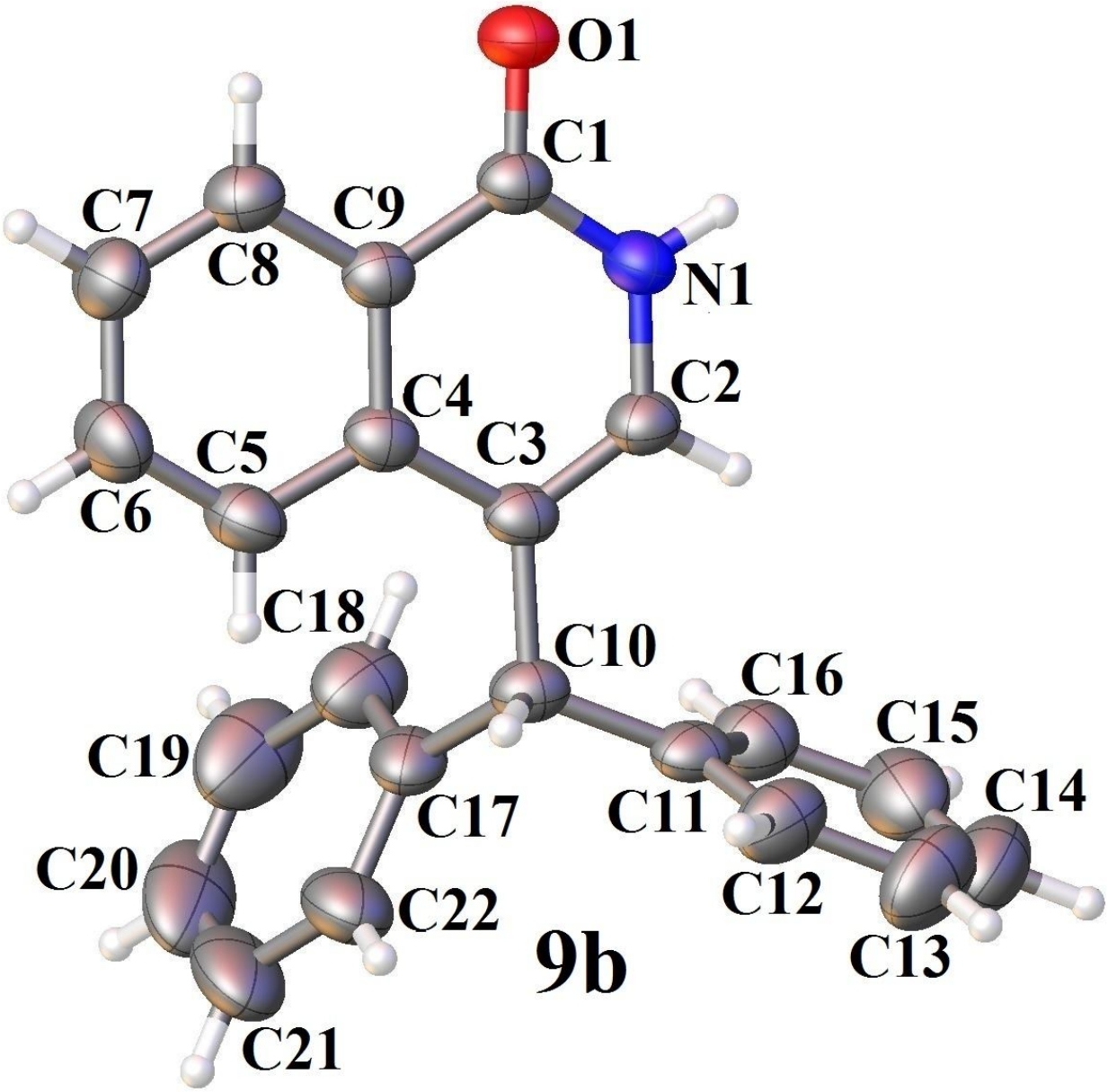


Figure S2: ORTEP[1] diagram of compound **9b** (drawn at 50% probability).

Note: ORTEP diagrams of **10ba** and **14** have already been provided in the manuscript.

1 O.V. Dolomanov, L.J. Bourhis, R.J. Gildea, J.A.K. Howard, H. Puschman; *OLEX2:A complete structure solution, refinement and analysis program*. *J. Appl. Cryst.* **2009**, *42*, 339.

Table S1 Important crystal data of products **7p**, **9b**

	7p	**9b**
Empirical Formula	$C_{23}H_{21}N_3O_3$	$C_{22}H_{17}NO$
Formula weight	387.43	311.36
Temperature (K)	273.15	296.15
Wavelength	0.71073	0.71073
Crystal System	Monoclinic	Triclinic
Space Group	I 1 2/a 1	P -1
Unit Cell Dimension	a=12.091(4) Å b=12.635(5) Å c=25.986(10) Å α=90° β=92.324(14)° γ=90°	a=6.6454(2) Å b=8.8659(4) Å c=15.1694(5) Å α=94.198(3)° β=102.080(2)° γ=102.439(2)°
Volume $Å^3$	3967(3)	846.86(5)
Z	8	2
Density Calculated g/cm^3	1.298	1.221
Absorption coefficient(Mu) mm^{-1}	0.088	0.075
F(000)	1632	328
Theta range for data collection	2.77 -23.59°	2.370-26.146°
Index ranges	-15<=h<=15 -14<=k<=15 -32<=l<=32	-8<=h<=8 -11<=k<=10 -18<=l<=18
Reflection Collected	24976	12644
Independent Reflections	4158 [R(int) = 0.0670]	3416 [R(int) = 0.0361]
Completeness to the theta=25.44°	99.2%	98.4%
Absorption Correction	Multi-scan	Multi-scan
Max. and min. Transmission	0.7455 and 0.6600	0.7454 and 0.6826
Refinement method	Full-matrix least-squares on F^2	Full-matrix least-squares on F^2
Data/Restraints/parameter	4158/0/265	3416/0/217
Goodness of fit on F^2	1.038	0.996
Final R indices [I>=2sigma(I)]	R_1=0.0563 wR_2=0.1404	R_1= 0.0458 wR_2= 0.1258
R indices (all data)	R_1= 0.1165 wR_2=0.1729	R_1= 0.0743 wR_2= 0.1416
Largest difference peak and hole [e. $^{б-3}$]	0.191 and - 0.241	0.158 and -0.156

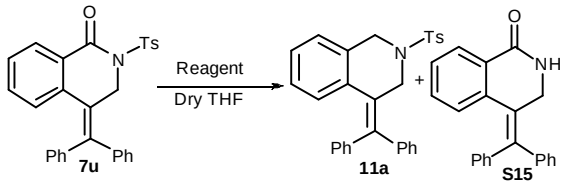
The crystal data of products **7p** and **9b** have been deposited at Cambridge Crystallographic Data Centre; the CCDC reference number s are 1571341 and 1571342, respectively.

Table S2 Important crystal data of compounds **10ba** and **14**

	10ba	**14**
Empirical Formula	$C_{22}H_{17}NO$	$C_{24}H_{17}NO_3$
Formula weight	311.36	367.38
Temperature (K)	296.15	273.15
Wavelength	0.71073	0.71073
Crystal System	monoclinic	monoclinic
Space Group	P 1 21/n 1	C 1 2/c 1
Unit Cell Dimension	a= 10.117(3) Å b=13.923(4)Å c=12.307(4) Å α= 90° β=99.313(2)° γ=90°	a= 20.6490(17) Å b= 10.8202(8) Å c= 20.1324(17) Å α=90° β= 126.199(2)° γ=90°
Volume $Å^3$	1710.8(9)	3629.8(5)
Z	4	8
Density Calculated g/cm^3	1.209	1.345
Absorption coefficient(Mu) mm^{-1}	0.074	0.089
F(000)	656	1536
Theta range for data collection	8.496 - 25.702 °	2.776 – 25.137 °
Index ranges	-12<=h<=12 -17<=k<=17 -15<=l<=12	-25<=h<=25 -13<=k<=13 -25<=l<=25
Reflection Collected	15040	40405
Independent Reflections	3644 [R(int) = 0.0473]	3787 [R(int)= 0.1134]
Completeness to the theta=25.44°	95.8%	98.6%
Absorption Correction	Multi-scan	Multi-scan
Max. and min. Transmission	0.7456 and 0.6789	0.7454 and 0.6395
Refinement method	Full-matrix least-squares on F^2	Full-matrix least-squares on F^2
Data/Restraints/parameter	3644/0/218	3787/0/254
Goodness of fit on F^2	1.032	1.035
Final R indices [I>=2sigma(I)]	R_1= 0.0458 wR_2= 0.1019	R_1= 0.0405 wR_2= 0.1194
R indices (all data)	R_1= 0.0670 wR_2= 0.1131	R_1= 0.0773 wR_2=0 .1620
Largest difference peak and hole [e. $Å^{-3}$]	0.189 and -0.154	0.271 and -0.258

The crystal data of products **10ba** and **14** have been deposited at Cambridge Crystallographic Data Centre; the CCDC reference numbers are 1571343 and 1571344 respectively.

Table S3 Optimisation of the reaction conditions for the synthesis of compound **11a**[a]



Sl. No	Reagents	equivalent	temperature	time (h)	product	yield[d] %
1[b]	$LiAlH_4$	20	reflux	2h	**S15**	50
2[b]	$LiAlH_4$	10	reflux	3h	**S15**	41
3	BH_3, Me_2S	2	rt	24h	**11a**	0
4	BH_3, Me_2S	100	rt	8h	**11a**	62
5[c]	BH_3, Me_2S	6	rt	17h	**11a**	40
6	**BH_3, Me_2S**	**10**	**rt**	**24h**	**11a**	**89**
7	BH_3, Me_2S	20	rt	8h	**11a**	83

[a]Reaction conditions: **7u** (1 equiv), $LiAlH_4$ or $BH_3.Me_2S$ in dry THF under argon gas. [b]Only detosylated product **S15** was produced. [c]Starting compound **7u** was recovered (45%).

Synthesis of 2-Iodo-*N*-methyl-*N*-(prop-2-ynyl)benzamide (5ah) and 4-Chloro-2-Iodo-*N*-methyl-*N*-(prop-2-ynyl)benzamide (S1)

2-Iodo-*N*-methyl-*N*-(prop-2-yn-1-yl)benzamide (**5ah)** was prepared according to the known procedure.[2] 4-Chloro-2-iodo-*N*-methyl-*N*-(prop-2-yn-1-yl)benzamide (**S1**) was prepared adopting the same procedure but using 4-Chloro-2-iodobenzoyl chloride in place of 2-iodobenzoyl chloride. The NMR spectra of these and other related amides showed multiplicity of peaks which merged at higher temperature, suggesting the influence of rotational isomerism as commonly observed with amides.

2-Iodo-N-methyl-N-(prop-2-yn-1-yl)benzamide[2] ***(5ah)***. Light yellow solid (96% yield); m.p.51-52 ˚C (reported[2] m.p. 48-49 °C); ^{1}H NMR ($CDCl_3$, 300 MHz) δ (amide isomers) 7.85-7.82 (m, 1H), 7.44-7.38 (m, 1H), 7.30-7.21 (m, 1H), 7.13-7.06 (m, 1H), 4.43 (s, 1H), 3.89-3.87 (m, 1H), 3.21 and 2.91 (2×s, 3H, NCH_3), 2.30-2.29 (m, 1H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 170.3, 141.9, 141.7, 139.3, 139.2, 130.5, 130.3, 128.4, 127.1, 127.0, 92.4, 92.2, 73.4, 72.6, 40.7, 35.9, 35.5, 32.1 ppm. HRMS (ESI^+) *m/z* calculated for $C_{11}H_{11}INO$ $[M+H]^+$ 299.9885, found 299.9882.

4-Chloro-2-iodo-N-methyl-N-(prop-2-yn-1-yl)benzamide ***(S1)***. White solid (98% yield); mp 58-60 °C; ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.85-7.83 (m, 1H), 7.41-7.37 (m, 1H), 7.22-7.14 (m, 1H), 4.40 (d, *J* = 2.4 Hz, 1H), 3.86 (s, 1H), 3.19 and 2.90 (2xs, 3H, NCH_3), 2.31-2.28 (m, 1H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 169.4, 140.2, 140.0, 138.6, 138.5, 135.3, 135.1, 128.7, 128.7, 127.8, 127.7, 92.6, 92.3, 73.6, 72.7, 40.6, 35.9, 35.4, 32.2 ppm. HRMS (EI^+) *m/z* calculated for $C_{11}H_9ClINO$ $[M]^+$ 332.9417, found 332.9412.

General Procedure for the Synthesis of 2-Iodo-*N*-methyl-*N*-(3-arylprop-2-ynyl)benzamides (5aa-5ag) through *Sonogashira Reaction* between 2-Iodo-*N*-methyl-*N*-(3-prop-2-ynyl)benzamides (5ah) and Aryl Iodides

To a well-stirred and ice-cooled solution of $PdCl_2(PPh_3)_2$ (14.7 mg, 0.02 mmol) in dry DMF (3 mL) under argon atmosphere copper iodide (8.0 mg, 0.04 mmol), Et_3N (0.4 mL, 2.5 mmol) and

2 P. Fretwell, R. Grigg, J. M. Sansano, V. Sridharan, S. Sukirthalingam, D. Wilson and J. Redpath *Tetrahedron,* 2000, **56**, 7525.

aryl iodide (1.05 mmol) were added and the reaction mixture was allowed to stir under argon atmosphere for 3-5 min. Thereafter, a solution of 2-iodo-*N*-methyl-*N*-(3-prop-2-ynyl)benzamide (299.0 mg, 1 mmol) dissolved in dry DMF (1.0 mL) was added to the reaction under ice-cold condition. The reaction mixture was then allowed to stir at rt for 1 h. After completion of the reaction (TLC), the solvent was evaporated *in vacuo*; the resulting residue was extracted with ethyl acetate (3 x 20 mL). The combined organic extracts were washed with water (10 mL), dried over anhydrous Na_2SO_4 and concentrated under reduced pressure. The crude product was purified through silica gel column chromatography using ethyl acetate-petroleum ether (v/v) as eluent to afford pure products (**5aa**-**5ag**).

2-Iodo-*N*-methyl-*N*-(3-phenylprop-2-ynyl)benzamide[3] **(5aa).** Pale yellow gum (281.2 mg, 75%); ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.88-7.83 (m, 1H), 7.47-7.39 (m, 3H), 7.35-7.32 (m, 3H), 7.26-7.24 (m, 1H), 7.14-7.07 (m, 1H), 4.66 and 4.11 (2×s, 2H, NCH_2), 3.27and 2.97 (2×s, 3H, NCH_3); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 170.3, 170.2, 141.9, 141.7, 139.2, 139.0, 131.7, 131.5, 130.3, 130.2, 129.2, 128.5, 128.3, 128.2, 128.2, 127.1, 126.9, 122.6, 122.1, 92.4, 92.1, 85.0, 84.2, 83.1, 82.8, 41.4, 36.6, 35.5, 32.2 ppm. HRMS (EI^+) *m/z* calculated for $C_{17}H_{14}INO$ $[M]^+$ 375.0120, found 375.0123.

Methyl 4-[3-(2-iodo-*N*-methylbenzamido)prop-1-ynyl]benzoate (5ab). Brown gum (337.7 mg, 78%); ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.98 (d, *J* = 8.4 Hz, 2H), 7.85 (t, *J* = 7.2 Hz, 1H), 7.52-7.39 (m, 3H), 7.33-7.24 (m, 1H), 7.14-7.07 (m, 1H), 4.66 and 4.12 (2×s, 2H, NCH_2) (s, 1H), 3.92 (s, 3H), 3.26 and 2.97 (2×s, 3H, NCH_3); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 170.3, 166.3, 141.7, 141.6, 139.2, 139.1, 131.6, 131.5, 130.4, 130.3, 129.8, 129.6, 129.4, 129.3, 128.4, 128.3, 127.2, 127.1, 126.9, 126.7, 92.4, 92.0, 86.3, 85.8, 84.2, 83.4, 52.1, 41.4, 36.6, 35.6, 32.3 ppm. HRMS (EI^+) *m/z* calculated for $C_{19}H_{16}INO_3$ $[M]^+$ 433.0175, found 433.0166.

***N*-[3-(4-Fluorophenyl)prop-2-ynyl]-2-iodo-*N*-methylbenzamide (5ac).** Yellow gum (220.1 mg, 56%); ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.84 (t, *J* = 7.0 Hz, 1H), 7.46-7.36 (m, 3H), 7.33-7.24 (m, 1H), 7.14-7.07 (m, 1H), 7.01 (t, *J*= 8.7 Hz, 2H), 4.63 and 4.09 (2×s, 2H, NCH_2), 3.25 and 2.96 (2×s, 3H, NCH_3); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 170.4, 170.3, 162.5 (d, *J* = 248.2 Hz), 141.9, 141.8, 139.3, 139.2, 133.7 (d, *J* =8.3 Hz), 133.6 (d, *J*= 8.2 Hz), 130.5, 130.3, 128.5, 128.4,

3 D. Brown, R. Grigg, V. Sridharan, V. Tamhyrajah and M. Thornton- Pett, *Tetrahedron*, 1998, **54,** 2595.

127.2, 127.1, 118.7 (d, J =3.4 Hz), 118.3 (d, J = 3.4 Hz), 115.7 (d, J = 22.0 Hz), 115.6 (d, J = 22 Hz), 41.5, 36.7, 35.7, 32.3 ppm. MS (ESI^+) *m/z* calculated for $C_{17}H_{13}FINONa$ $[M+Na]^+$ 415.9923, found 415.9925.

2-Iodo-*N*-methyl-*N*-(3-*p*-tolylprop-2-ynyl)benzamide (5ad). Brown gum (210.1 mg, 54%); ^1H NMR ($CDCl_3$, 300 MHz) δ 7.84 (t, J = 7.0 Hz, 1H), 7.44-7.38 (m, 1H), 7.36-7.31 (m, 2H), 7.28-7.24 (m, 1H), 7.13-7.06 (m, 3H), 4.64 and 4.09 (2×s, 2H, NCH_2), 3.26 and 2.96 (2×s, 3H, NCH_3), 2.35 (s, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 170.5, 170.3, 142.0, 141.9, 139.3, 139.2, 138.8, 138.6, 131.7, 131.5, 130.4, 130.3, 129.1, 129.1, 128.4, 128.4, 127.2, 127.1, 119.6, 119.1, 92.5, 92.2, 85.2, 84.4, 82.5, 82.1, 41.6, 36.8, 35.6, 32.3, 21.5 ppm. MS (EI^+) *m/z* calculated for $C_{18}H_{16}INO$ $[M]^+$ 389.0277, found 389.0280.

2-Iodo-*N*-[3-(4-methoxyphenyl)prop-2-ynyl]-*N*-methylbenzamide (5ae). Brown gum (210.6 mg, 52%); ^1H NMR ($CDCl_3$, 300 MHz) δ 7.85 (t, J = 7.0 Hz, 1H), 7.45-7.25 (m, 4H), 7.14-7.07 (m, 1H), 6.85 (d, J = 9 Hz, 2H), 4.64 and 4.09 (2×s, 2H, NCH_2), 3.82 (s, 3H), 3.26 and 2.97 (2×s, 3H, NCH_3); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 170.4, 170.3, 159.8, 159.6, 142.0, 141.9, 139.2, 139.1, 133.2, 133.1, 130.4, 130.2, 128.4, 128.3, 127.2, 127.0, 114.7, 114.3, 114.0, 113.9, 92.5, 92.2, 84.9, 84.2, 81.7, 81.4, 55.3, 41.6, 36.7, 35.5, 32.2 ppm. MS (ESI^+) *m/z* calculated for $C_{18}H_{16}INO_2Na$ $[M+Na]^+$ 428.0123, found 428.0121.

***N*-[3-(2,4-Dimethoxypyrimidin-5-yl)prop-2-ynyl]-2-iodo-*N*-methylbenzamide (5af).** Yellow gum (297.2 mg, 68%); ^1H NMR ($CDCl_3$, 300 MHz) δ 8.33-8.29 (m, 1H), 7.87-7.82 (m, 1H), 7.44-7.39 (m, 1H), 7.35-7.24 (m, 1H), 7.11-7.07 (m, 1H), 4.68 and 4.13 (2×s, 2H, NCH_2), 4.04,4.01 (2×s, 2×3H, 2×OCH_3), 3.26 and 2.96 (2×s, 3H, NCH_3); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 170.6, 170.4, 170.3, 161.5, 161.5, 141.8, 141.7, 139.2, 139.1, 130.4, 130.3, 128.4, 128.3, 127.2, 127.0, 92.4, 92.1, 89.6, 89.2, 75.8, 55.1, 55.1, 54.5, 54.5, 41.6, 36.8, 35.6, 32.3 ppm. HRMS (EI^+) *m/z* calculated for $C_{17}H_{16}IN_3O_3$ $[M]^+$ 437.0236, found 437.0228.

2-Iodo-*N*-methyl-*N*-[3-(thiophen-2-yl)prop-2-ynyl]benzamide (5ag). Brown gum (259.1 mg, 68%); ^1H NMR ($CDCl_3$, 300 MHz) δ 7.85 (t, J = 7.3 Hz, 1H), 7.46-7.39 (m, 1H), 7.34-7.31 (m, 1H), 7.28-7.20 (m, 2H), 7.14-7.06 (m, 1H), 6.99-6.96 (m, 1H), 4.66 and 4.12 (2×s, 2H, NCH_2),

3.25 and 2.95 (2×s, 3H, NCH_3); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 170.4, 170.3, 141.9, 141.8, 139.3, 139.2, 132.4, 132.3, 130.5, 130.3, 128.4, 127.5, 127.2, 127.0, 127.0, 126.9, 122.6, 92.5, 92.2, 87.4, 86.9, 41.7, 36.9, 35.7, 32.4 ppm. HRMS (ESI^+) *m/z* calculated for $C_{15}H_{12}INOSNa$ $[M+Na]^+$ 403.9582, found 403.9586.

Substrate **5ba** was prepared using 4-chloro-2-iodo-*N*-methyl-*N*-(prop-2-yn-1-yl)benzamide (**S1**) (333.0 mg, 1 mmol) and phenyl iodide (214.2 mg, 1.05 mmol) as reactants and adopting the above procedure.

4-Chloro-2-iodo-*N*-methyl-*N*-(3-phenylprop-2-yn-1-yl)benzamide (5ba). Brown gum (184.0 mg, 45%); ^1H NMR ($CDCl_3$, 300 MHz) δ 7.89-7.86 (m, 1H), 7.48-7.40 (m, 3H), 7.35-7.33 (m, 2H), 7.29-7.26 (m, 1H), 7.22-7.19 (m, 1H), 4.65 and 4.10 (2xs, 2H, NCH_2), 3.27 and 2.98 (2xs, 3H, NCH_3); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 169.6, 169.5, 140.4, 140.3, 138.7, 138.6, 135.4, 135.2, 131.8, 131.6, 128.8, 128.7, 128.7, 128.5, 128.4, 128.3, 127.9, 127.8, 122.5, 122.1, 92.7, 92.4, 85.3, 84.4, 83.0, 82.6, 41.6, 36.8, 35.6, 32.4 ppm. HRMS (EI^+) *m/z* calculated for $C_{17}H_{13}ClINO$ $[M]^+$ 408.9730, found 408.9730.

General Procedure for the Synthesis of 2-Iodo-*N*-(3-arylprop-2-ynyl)-*N*-tosylbenzamides (5ca, 5cc, 5ce, 5ci, 5cj): Syntheses of substrates **5ca, 5cc, 5ce, 5ci, 5cj** were achieved through condensation between benzoyl chloride and 4-methyl-*N*-(3-arylprop-2-ynyl)benzenesulfonamide (**S3-7**) which in turn could easily be accessed via *Sonogashira reaction* between commercially available aryl iodide and known 4-methyl-*N*-(prop-2-ynyl)benzenesulfonamide.[4]

General Procedure for the Synthesis of 4-Methyl-N-(3-arylprop-2-ynyl)benzenesulfonamides (S3-7)

A mixture of aryl iodide (1.05 mmol), $Pd(PPh_3)_2Cl_2$ (14.7 mg, 0.021 mmol), CuI (8.0 mg, 0.042 mmol) and Et_3N (0.4 mL, 2.5 mmol) in dry DMF (3.0 mL) was stirred under argon atmosphere for few minutes. Next, a solution of 4-methyl-*N*-(prop-2-ynyl)benzenesulfonamide (209 mg, 1 mmol) in dry DMF (1.0 mL) was added slowly and the reaction mixture was allowed

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to stir at rt. After completion of reaction (TLC), the solvent was evaporated under reduced pressure and the residue was extracted with ethyl acetate (3x 20 mL). The combined organic extracts were washed with water (10 mL), dried over Na_2SO_4 and concentrated *in vacuo*. The crude residue was then purified through silica gel column chromatography using ethyl acetate-petroleum ether (v/v) as eluent to afford 4-methyl-*N*-(3-arylprop-2-ynyl)benzenesulfonamides (**S3-7**).

4-Methyl-*N*-(3-phenylprop-2-ynyl)benzenesulfonamide (S3). Brown solid (219.4 mg, 77% yield); mp 112-113 ˚C; ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.82 (d, *J* = 8.4 Hz, 2H), 7.27-7.20 (m, 5H), 7.13-7.10 (m, 2H), 5.02-5.01 (m, 1H), 4.06 (d, *J* = 6.0 Hz, 2H), 2.33 (s, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 143.7, 136.8, 131.5, 129.7, 128.5, 128.1, 127.5, 122.0, 84.6, 83.2, 33.7, 21.4 ppm; HRMS (EI^+) *m*/*z* calculated for $C_{16}H_{15}NO_2S$ $[M]^+$ 285.0823, found 285.0829.

***N*-[3-(4-Fluorophenyl)prop-2-ynyl]-4-methylbenzenesulfonamide (S4).** Yellow solid (245.4 mg, 81% yield); mp 150-152 °C; ^{1}H NMR ($CDCl_3$, 600 MHz) δ 7.82 (d, *J* = 8.4 Hz, 2H), 7.27-7.26 (m, 2H), 7.12-7.09 (m, 2H), 6.94-6.91 (m, 2H), 4.99 (brs, 1H), 4.05 (d, *J* = 6.0 Hz, 2H), 2.35 (s, 3H); ^{13}C NMR ($CDCl_3$, 150 MHz) δ 162.5 (d, *J* = 249.0 Hz), 143.7, 136.9, 133.5 (d, *J* = 7.5Hz), 129.7, 127.5, 118.2 (d, *J* = 4.5 Hz), 115.5 (d, *J* = 22.5 Hz), 83.7, 83.0, 33.7, 21.5 ppm; HRMS (EI^+) *m*/*z* calculated for $C_{16}H_{14}FNO_2S$ $[M]^+$ 303.0729, found 303.0717.

***N*-[3-(4-Methoxyphenyl)prop-2-ynyl]-4-methylbenzenesulfonamide (S5).** Pale yellow crystalline solid (214.2 mg, 68% yield); mp 116-117 ˚C; ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.81 (d, *J* = 8.1 Hz, 2H), 7.30-7.27 (m, 2H), 7.09 (d, *J* = 9 Hz, 2H), 6.77 (d, *J* = 9 Hz, 2H), 4.64 (t, *J* = 5.8 Hz, 1H), 4.06 (d, *J* = 6 Hz, 2H), 3.80 (s, 3H), 2.38 (s, 3H) ; ^{13}C NMR ($CDCl_3$, 75 MHz) δ 159.7, 143.7, 136.8, 133.0, 129.7, 127.5, 114.1, 113.8, 84.6, 81.8, 55.3, 33.8, 21.5 ppm; HRMS (EI^+) *m*/*z* calculated for $C_{17}H_{17}NO_3S$ $[M]^+$ 315.0929, found 315.0922.

4-Methyl-*N*-{3-[4-(trifluoromethyl)phenyl]prop-2-ynyl}benzenesulfonamide (S6). Brown solid (293.0 mg, 83% yield); mp 122-123 ˚C; ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.82 (d, *J* = 8.1 Hz, 2H), 7.52 (d, *J* = 8.4 Hz, 2H), 7.30-7.23 (m, 4H), 4.64 (t, *J* = 5.7 Hz, 1H), 4.11 (d, *J* = 6.3 Hz, 2H), 2.36 (s, 3H) ; ^{13}C NMR ($CDCl_3$, 75 MHz) δ 143.8, 136.8, 131.8, 130.2 (q, J = 32.5 Hz), 129.7, 127.5, 125.9, 125.1 (q, *J* = 3.9 Hz), 85.8, 83.3, 33.6, 21.4 ppm; HRMS (EI^+) *m*/*z*

calculated for $C_{17}H_{14}F_3NO_2S$ $[M]^+$ 353.0697, found 353.0693.

4-Methyl-*N*-[3-(pyridin-3-yl)prop-2-ynyl]benzenesulfonamide (S7). Light-yellow solid (263.1 mg, 92% yield); mp 82-83 ˚C; ^{1}H NMR ($CDCl_3$, 300 MHz) δ 8.52-8.36 (m, 2H), 7.78 (d, *J* = 8.4 Hz, 2H), 7.46 (d, *J* = 8.1 Hz, 1H), 7.29-7.19 (m, 3H), 6.03 (t, *J* = 5.8 Hz, 1 H), 4.08 (d, *J* = 6 Hz, 2 H), 2.33 (s, 3H); ^{13}C NMR ($CDCl_3$, 150 MHz) δ 152.0, 148.7, 143.9, 138.7, 136.9, 129.8, 129.7, 127.5, 127.3, 87.1, 81.2, 33.6, 21.5 ppm; HRMS (EI^+) *m*/*z* calculated for $C_{15}H_{14}N_2O_2S$ $[M]^+$ 286.0776, found 286.0775.

General procedure for the synthesis of 2-Iodo-N-(3-arylprop-2-ynyl)-N-tosylbenzamides (5ca, 5cc, 5ce, 5ci, 5cj)

To a well-stirred solution of 2-iodobenzoyl chloride (266.0 mg, 1 mmol) in THF (3.0 mL), a solution of 4-methyl-*N*-(3-arylprop-2-ynyl)benzenesulfonamide (0.4 mmol) in THF (1.0 mL) was added dropwise over a period of 3 min. The resulting solution was cooled to 0 °C and NaH (60% oil suspension; 80 mg, 2 mmol) was added to it slowly. The reaction mixture was then allowed to reach room temperature gradually and stirred at rt until completion (TLC). After quenching with water (2.0 mL), the mixture was extracted with ethyl acetate (3x20 mL). The combined organic extracts were washed consecutively with saturated $NaHCO_3$ solution (20 mL) and water (10 mL) and dried over anhydrous sodium sulfate. After evaporation of solvent, the residue was purified by silica gel column chromatography using 5-10% ethyl acetate-petroleum ether (v/v) as eluent to afford the product **5ca/ 5cc/ 5ce/ 5ci/5cj**.

2-Iodo-*N*-(3-phenylprop-2-ynyl)-*N*-tosylbenzamide (5ca). White solid (156.6 mg, 76% yield); mp 127-129 ˚C; ^{1}H NMR ($CDCl_3$, 600 MHz) δ 7.96 (d, *J* = 9 Hz, 2H), 7.79 (d, *J* = 7.8 Hz, 1H), 7.39-7.35 (m, 4H), 7.35-7.32 (m, 2H), 7.28-7.26 (m, 3H), 7.14 (td, J_1= 7.6 Hz, J_2= 1.6 Hz, 1H), 4.78 (brs, 2H), 2.42 (s, 3H); ^{13}C NMR ($CDCl_3$, 150 MHz) δ 169.0, 145.3, 140.1, 139.3, 135.4, 131.7, 131.3, 129.3, 129.3, 128.8, 128.4, 128.0, 127.8, 122.1, 92.1, 84.8, 83.5, 38.0, 21.8 ppm; HRMS (EI^+) *m*/*z* calculated for $C_{23}H_{18}INO_3S$ $[M]^+$ 515.0052, found 515.0036.

***N*-(3-(4-Fluorophenyl)prop-2-ynyl)-2-iodo-*N*-tosylbenzamide (5cc).** White solid (145.0 mg, 68% yield); mp 138-140 °C; ^{1}H NMR ($CDCl_3$, 600 MHz) δ 7.93 (d, *J* = 8.4 Hz, 2H), 7.79 (d, *J* = 8.4 Hz, 1H), 7.38 (t, *J* = 7.5 Hz, 1H), 7.35-7.32 (m, 2H), 7.27-7.26 (m, 3H), 7.15-7.12 (m, 1H), 7.02 (t, *J* = 8.7 Hz, 2H), 4.76 (brs, 2H), 2.42 (s, 3H); ^{13}C NMR ($CDCl_3$, 150 MHz) δ 169.0, 162.7 (d, *J* = 248.7 Hz), 145.3, 140.1, 139.3, 135.4, 133.7 (d, *J* = 8.7 Hz), 131.4, 129.3, 129.2, 128.0, 127.8, 118.2 (d, *J* =3.3 Hz), 115.7 (d, *J* = 21.7 Hz), 92.2, 83.7, 83.3, 37.9, 21.8 ppm; HRMS (EI^+) *m*/*z* calculated for $C_{23}H_{17}FINO_3S$ $[M]^+$ 532.9958, found 532.9961.

2-Iodo-*N*-[3-(4-methoxyphenyl)prop-2-ynyl]-*N*-tosylbenzamide (5ce). Light-yellow solid (130.8 mg, 60% yield); mp 152-154 °C; ^{1}H NMR ($CDCl_3$, 600 MHz) δ 8.05 (d, *J* = 7.8 Hz, 1H), 8.00-7.96 (m, 3H), 7.79 (d, *J* = 7.8 Hz, 1H), 7.44 (t, *J* = 7.8 Hz, 1H), 7.38 (t, *J* = 7.5 Hz, 1H), 7.30-7.26 (m, 1H), 7.20 (t, *J* = 7.2 Hz, 1H), 7.13 (t, *J* = 7.8 Hz, 1H), 6.85 (d, *J* = 8.4 Hz, 2H), 4.74 (brs, 2H), 3.83 (s, 3H), 2.42 (s, 3H); ^{13}C NMR ($CDCl_3$, 150 MHz) δ 169.1, 159.9, 145.2, 141.9, 140.1, 139.3, 135.4, 133.2, 131.9, 131.3, 129.3, 128.0, 127.7, 114.0, 92.1, 84.8, 82.2, 55.3, 38.1, 21.7 ppm; HRMS (ESI^+) *m*/*z* calculated for $C_{24}H_{21}INO_4S$ $[M+H]^+$ 546.0236, found 546.0238.

2-Iodo-*N*-tosyl-*N*-{3-[4-(trifluoromethyl)phenyl]prop-2-ynyl}-*N*-tosylbenzamide (5ci). White solid (116.6 mg, 50% yield); mp 160-162 °C; ^{1}H NMR ($CDCl_3$, 600 MHz) δ 7.91 (d, *J* = 8.4 Hz, 2H), 7.80-7.78 (m, 1H), 7.58 (d, *J* = 7.8 Hz, 2H), 7.46 (d, *J* = 7.8 Hz, 2H), 7.39 (td, J_1 = 7.5 Hz, J_2 = 0.6 Hz, 1H), 7.28-7.26 (m, 3H), 7.14 (td, J_1 = 7.6 Hz, J_2 = 1.6 Hz, 1H), 4.81 (brs, 2H), 2.43(s, 3H); ^{13}C NMR ($CDCl_3$, 150 MHz) δ 168.9, 145.5, 140.0, 139.4, 135.3, 132.0, 131.4, 130.5 (q, *J* = 32.5 Hz), 129.4, 129.2, 128.0, 127.8, 125.9, 125.3 (q, *J* = 3.5 Hz), 123.8 (q, *J* = 271 Hz), 92.2, 86.0, 83.3, 37.7, 21.8 ppm; HRMS (ESI^+) *m*/*z* calculated for $C_{24}H_{17}F_3INO_3SNa$ $[M+Na]^+$ 605.9824, found 605.9822.

2-Iodo-*N*-[3-(pyridin-3-yl)prop-2-ynyl]-*N*-tosylbenzamide (5cj). White solid (156.9 mg, 76% yield); mp 100-102 °C; ^{1}H NMR ($CDCl_3$, 600 MHz) δ 8.57-8.56 (m, 2H), 7.88 (d, *J* = 7.8 Hz, 2H), 7.76 (d, *J* = 8.4 Hz, 1H), 7.66 (d, *J* = 7.8 Hz, 1H), 7.37 (t, *J* = 7.5 Hz, 1H), 7.28-7.24 (m, 4H), 7.12 (td, J_1= 7.5 Hz, J_2 = 1.2 Hz, 1H), 4.80 (brs, 2H), 2.40 (s, 3H); ^{13}C NMR ($CDCl_3$, 150 MHz) δ 168.9, 152.0, 148.8, 145.6, 139.9, 139.4, 139.0, 135.2, 131.5, 129.4, 129.2, 128.0, 127.8,

123.3, 92.3, 87.2, 81.2, 37.7, 21.7 ppm; HRMS (EI^+) *m/z* calculated for $C_{22}H_{17}IN_2O_3S$ $[M]^+$ 516.0005, found 516.0017.

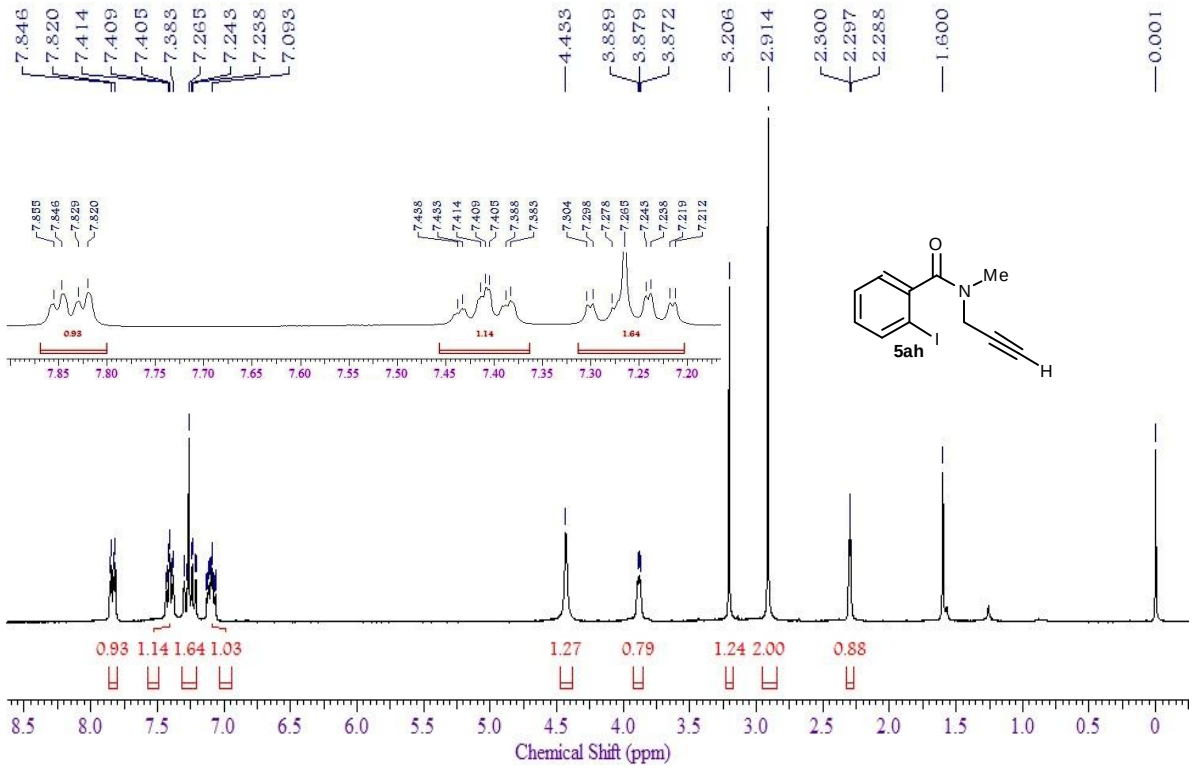
Reduction of 4-[bis(phenyl)methylidene]-N-tosyl-3,4-dihydroisoquinolin-1(2H)-one (7r)using $LiAlH_4$ (see Table S3).

To a well-stirred and ice-cooled solution of **7r** (46.5 mg, 0.1 mmol) in dry THF (4 mL) under argon atmosphere lithium aluminium hydride (76 mg, 2 mmol) was added and the reaction mixture was allowed to stir at rt followed by heating under reflux. After completion of the reaction (TLC) (2 h), the solvent was evaporated *in vacuo* and $LiAlH_4$ was quenched using standard procedure. After usual workup, combined organic extracts (diethyl ether) were dried over anhydrous Na_2SO_4 and concentrated under reduced pressure. The crude product was purified through silica gel column chromatography using ethyl acetate-petroleum ether (v/v) as eluent to afford pure product **S15** which was unanticipated.

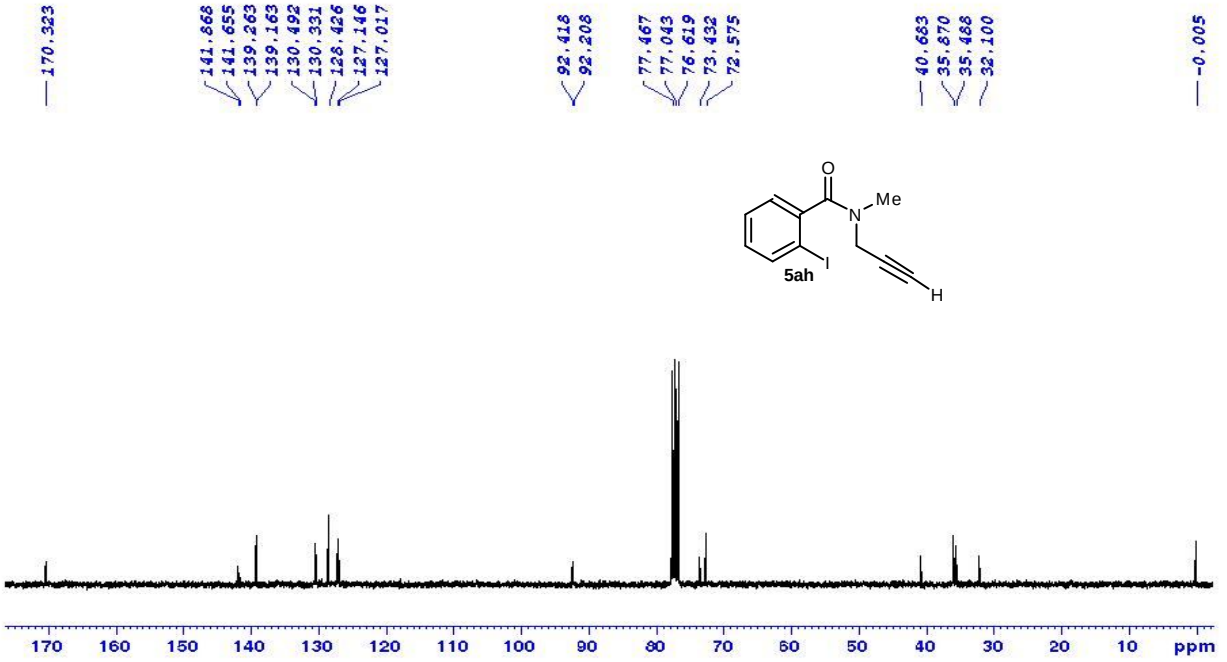
However, the synthesis of desired product **11a** was achieved by the reduction of **7r** using $BH_3.Me_2S$ that has been described in the manuscript under experimental section.

4-(Diphenylmethylene)-3,4-dihydroisoquinolin-1(2*H*)-one (S15). White gum (15.6 mg, 50% yield); ^1H NMR ($CDCl_3$, 300 MHz) δ 8.06 (d, *J* = 7.5 Hz, 1H), 7.39-7.37 (m, 4H), 7.24-7.07 (m, 8H), 6.86-6.84 (m, 1H), 6.19 (brs, 1H), 4.25 (d, *J* = 2.4 Hz, 2H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 165.7, 142.5, 141.5, 141.4, 137.8, 131.0, 130.9, 130.0, 129.2, 129.1, 128.3, 128.0, 127.7, 127.6, 126.5, 45.5 ppm; HRMS (EI^+) *m/z* calculated for $C_{22}H_{17}NO$ $[M]^+$ 311.1310, found 311.1281.

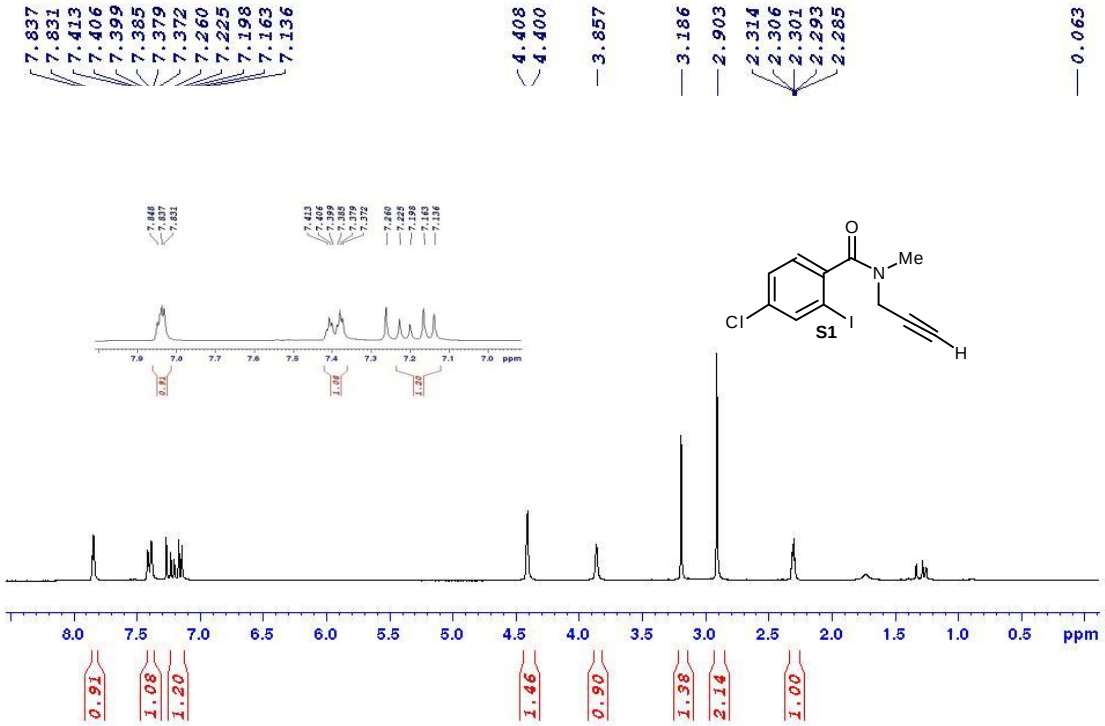
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **5ah**:



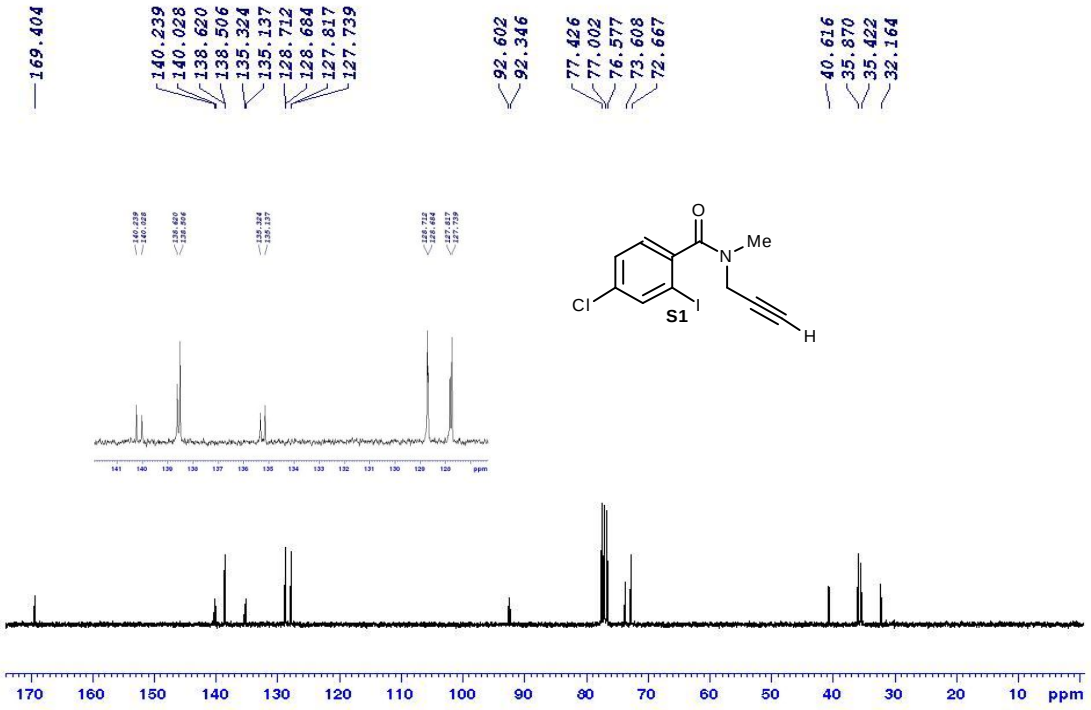
^{13}C NMR ($CDCl_3$, 75 MHz) spectrum of compound **5ah**:



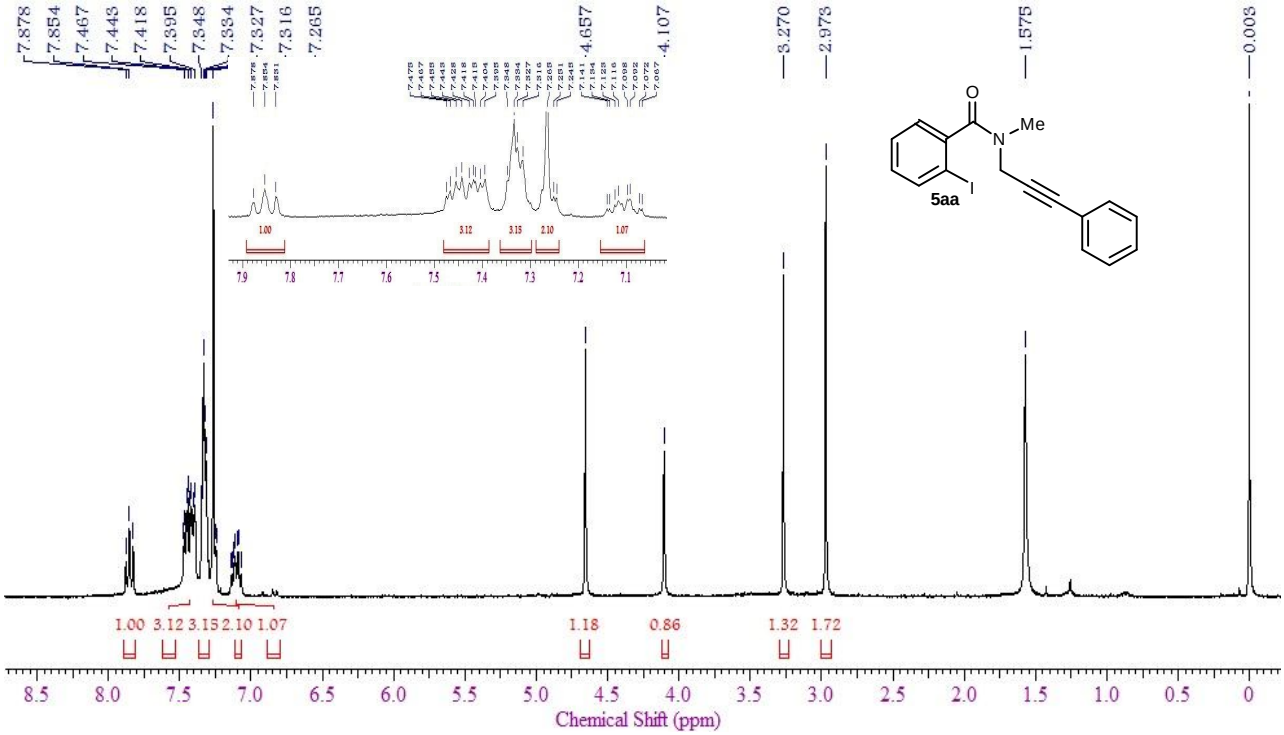
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **S1**:



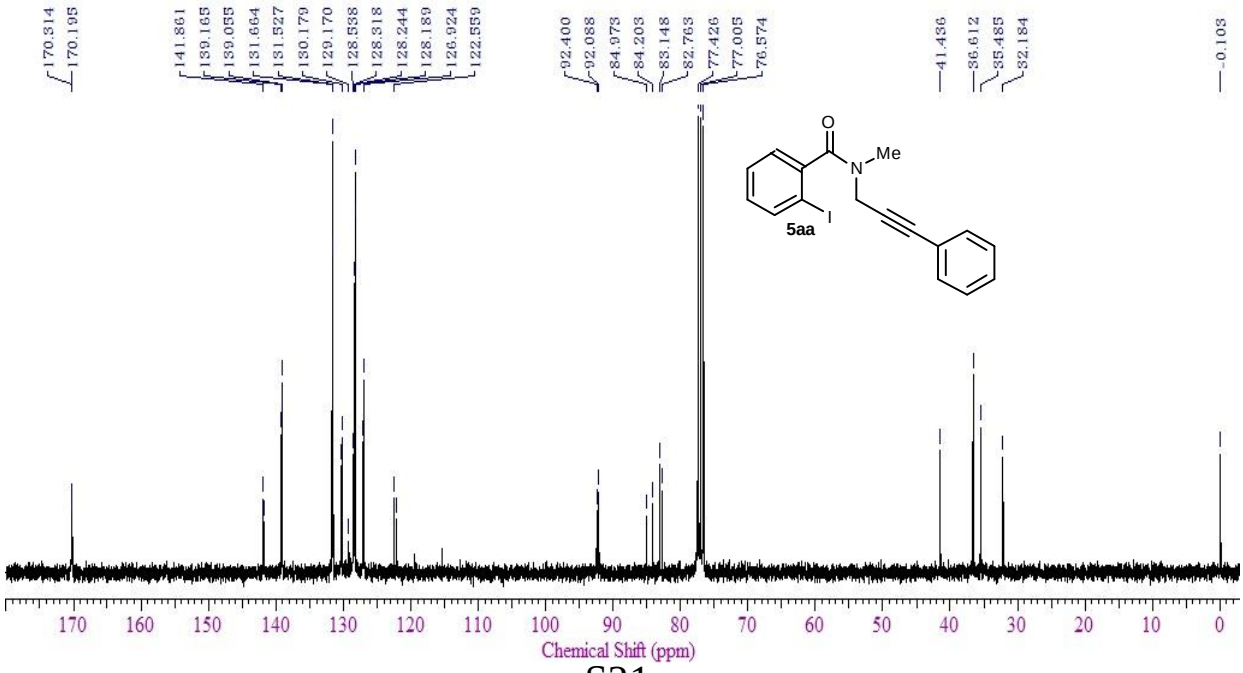
^{13}C NMR ($CDCl_3$, 75 MHz) spectrum of compound **S1**:



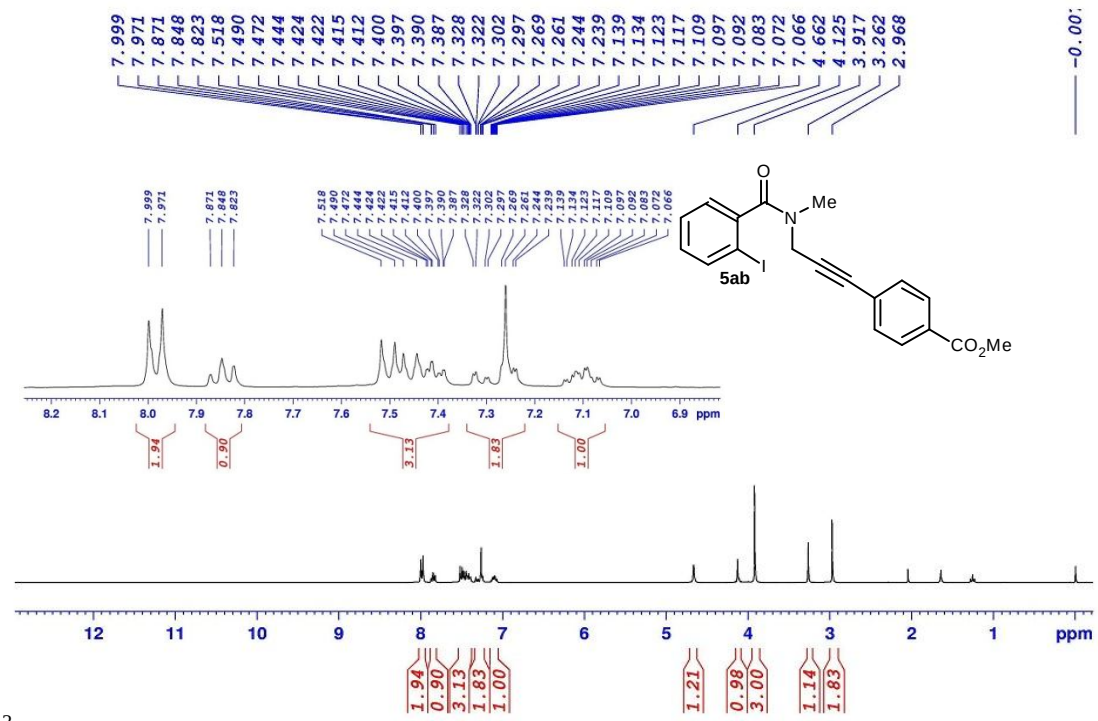
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **5aa**:



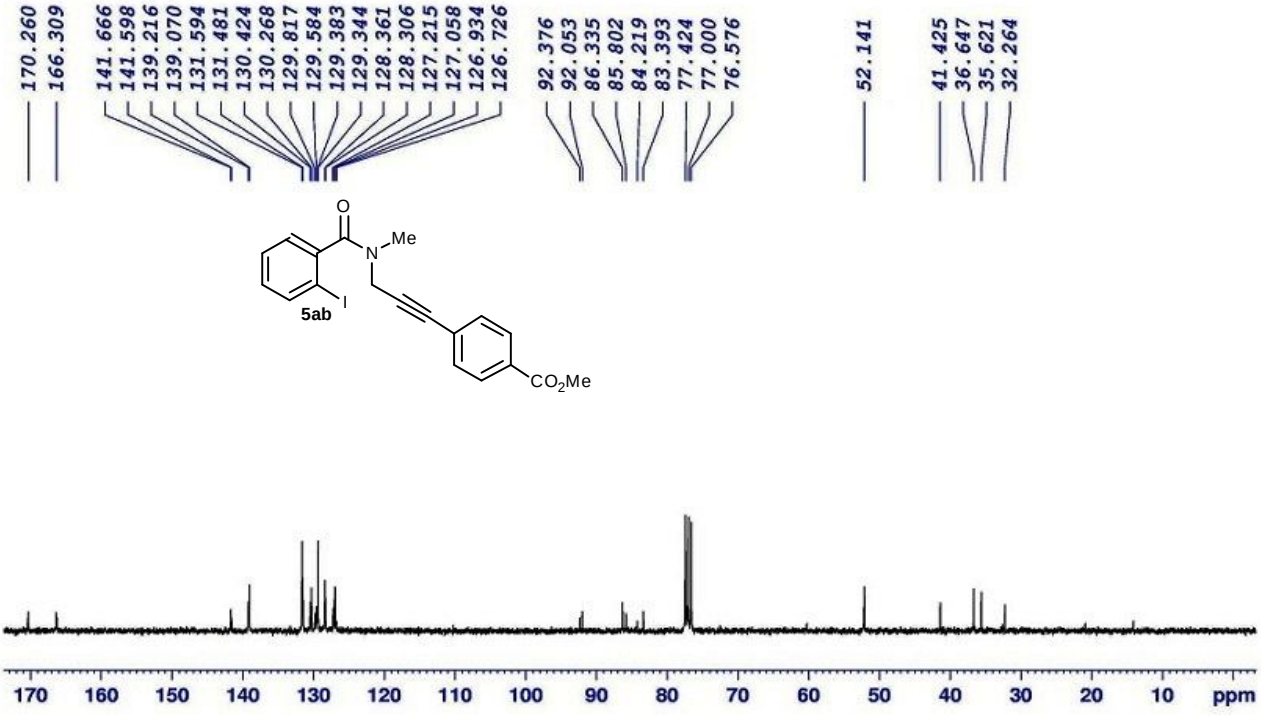
^{13}C NMR ($CDCl_3$, 75 MHz) spectrum of **5aa**:



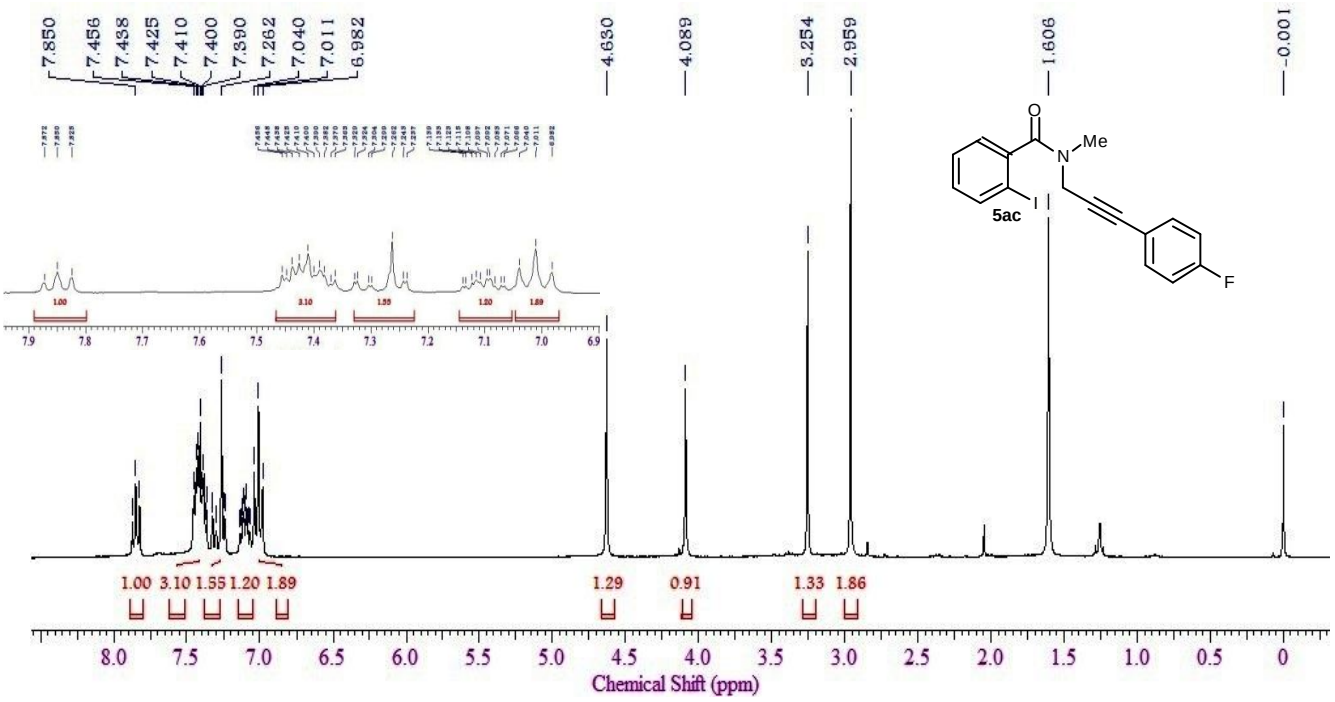
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **5ab**:



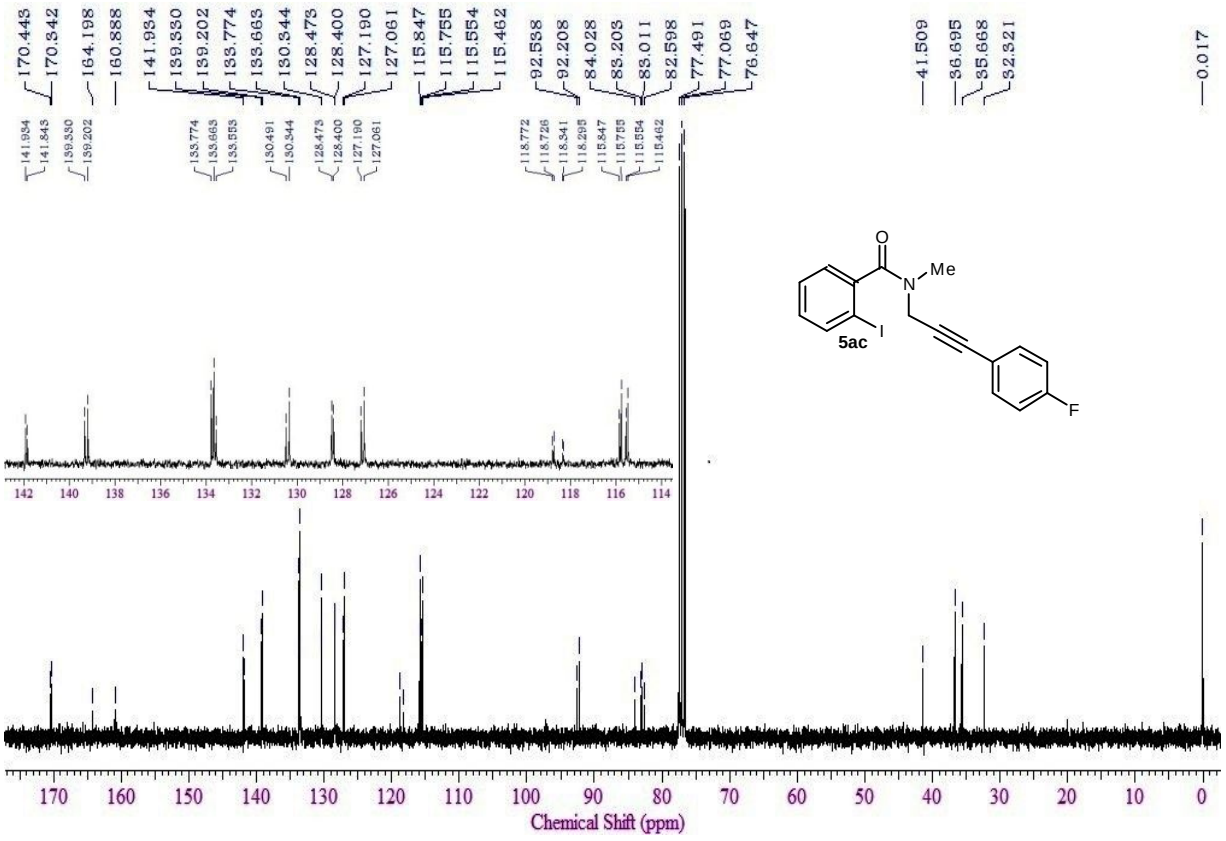
^{13}C NMR ($CDCl_3$, 75 MHz) spectrum of compound **5ab**:



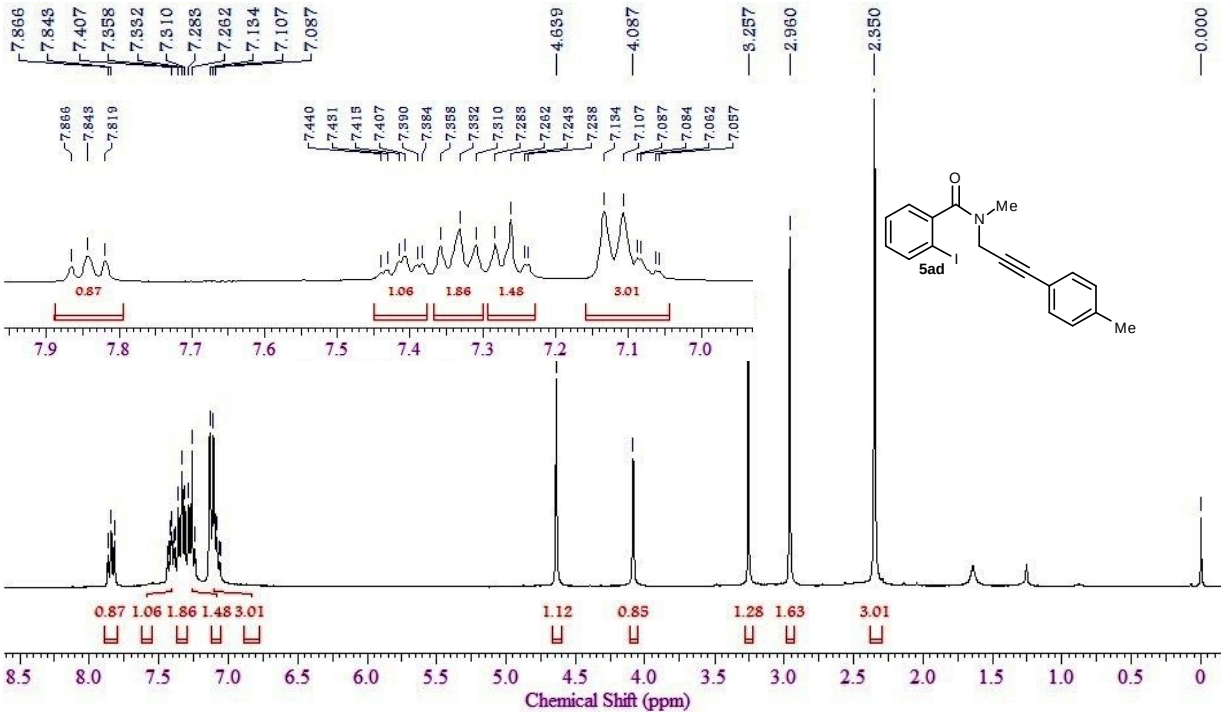
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **5ac**:



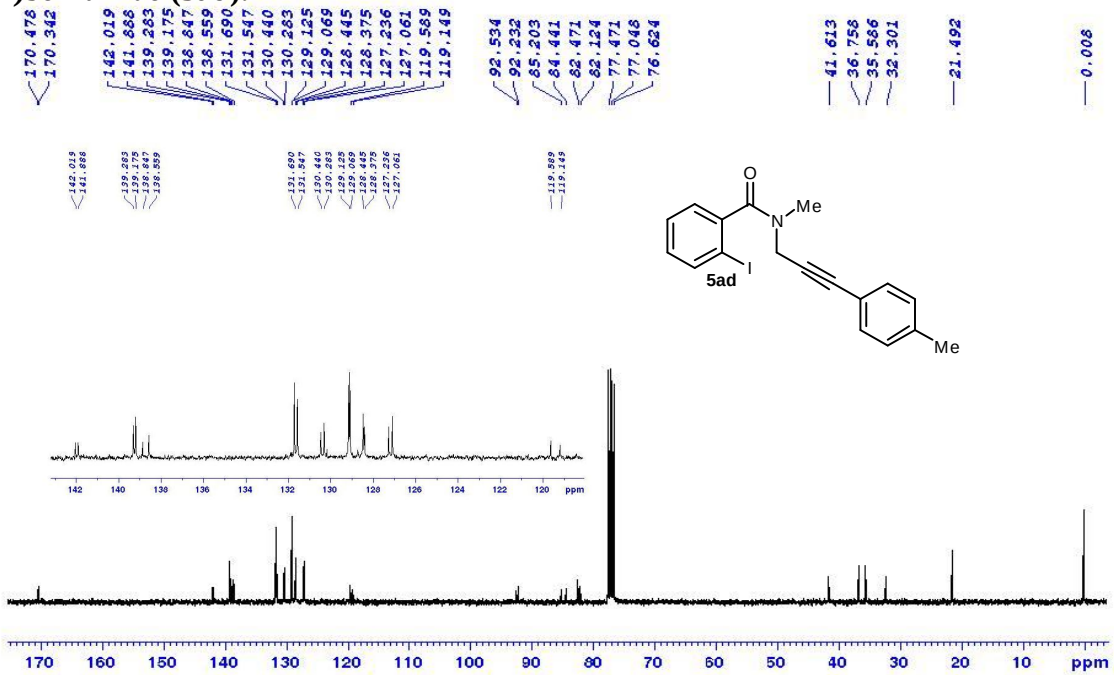
^{13}C NMR ($CDCl_3$, 75 MHz) spectrum of **5ac**:



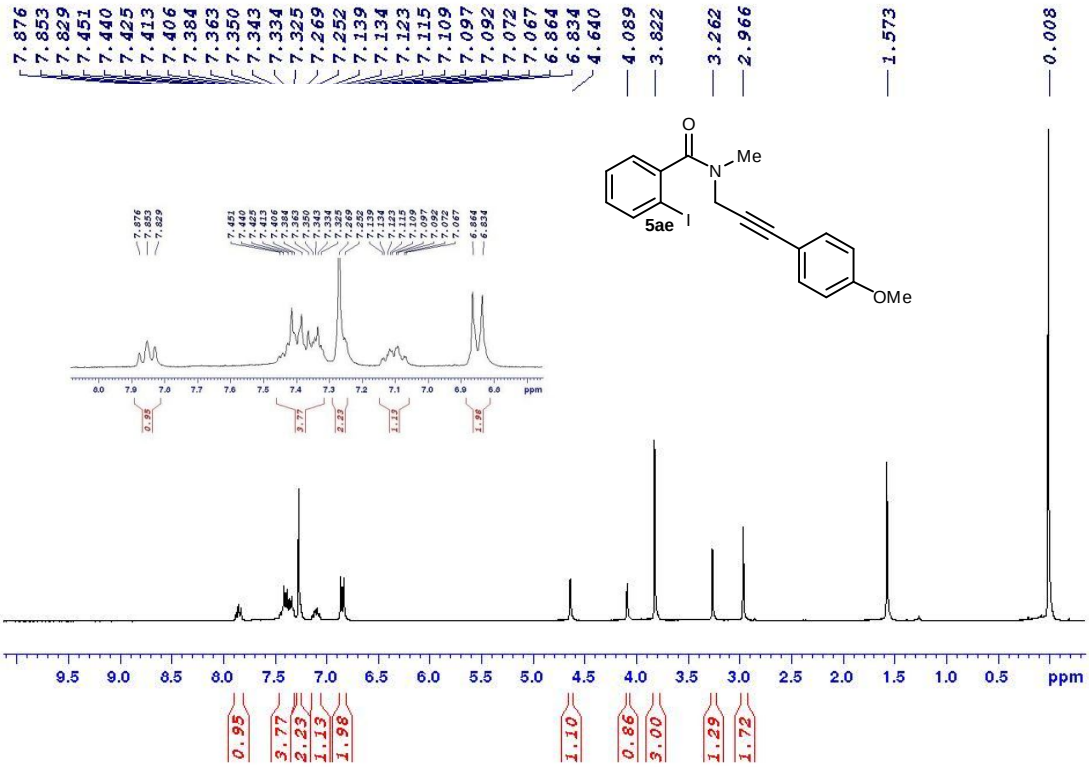
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **5ad**:



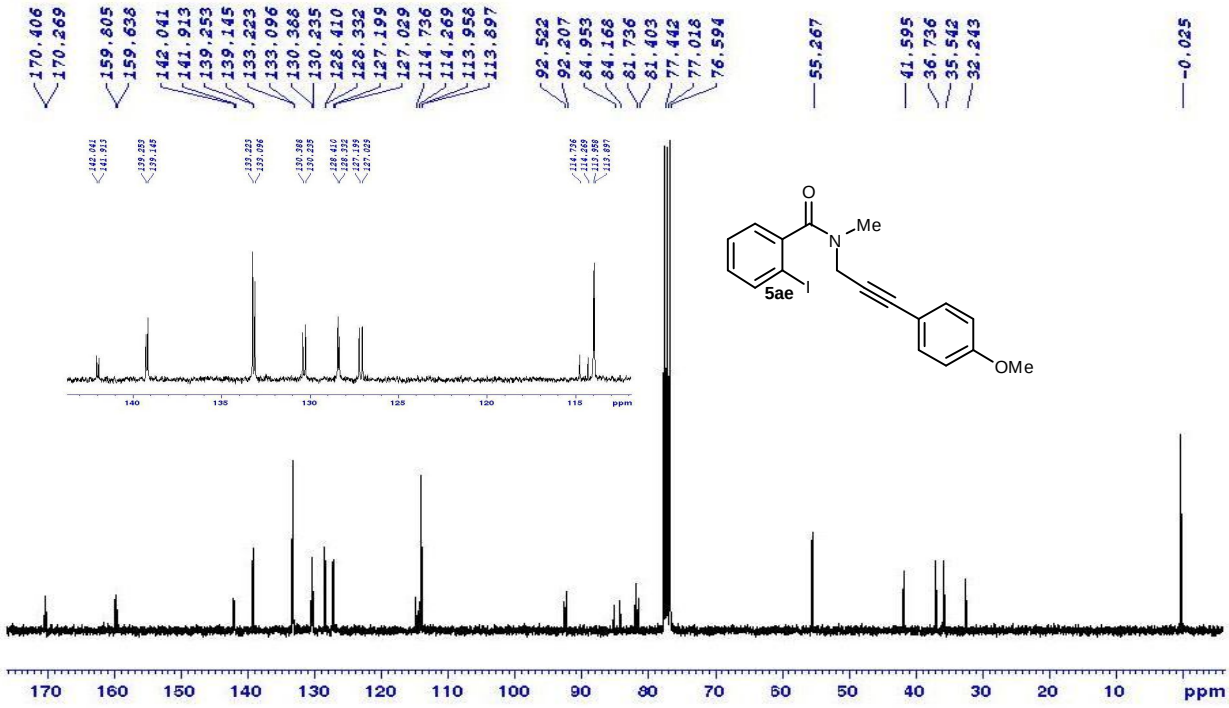
^{13}C NMR ($CDCl_3$, 75 MHz) spectrum of compound ***2-iodo-N-methyl-N-(3-p-tolylprop-2-ynyl)benzamide*** **(5ad):**



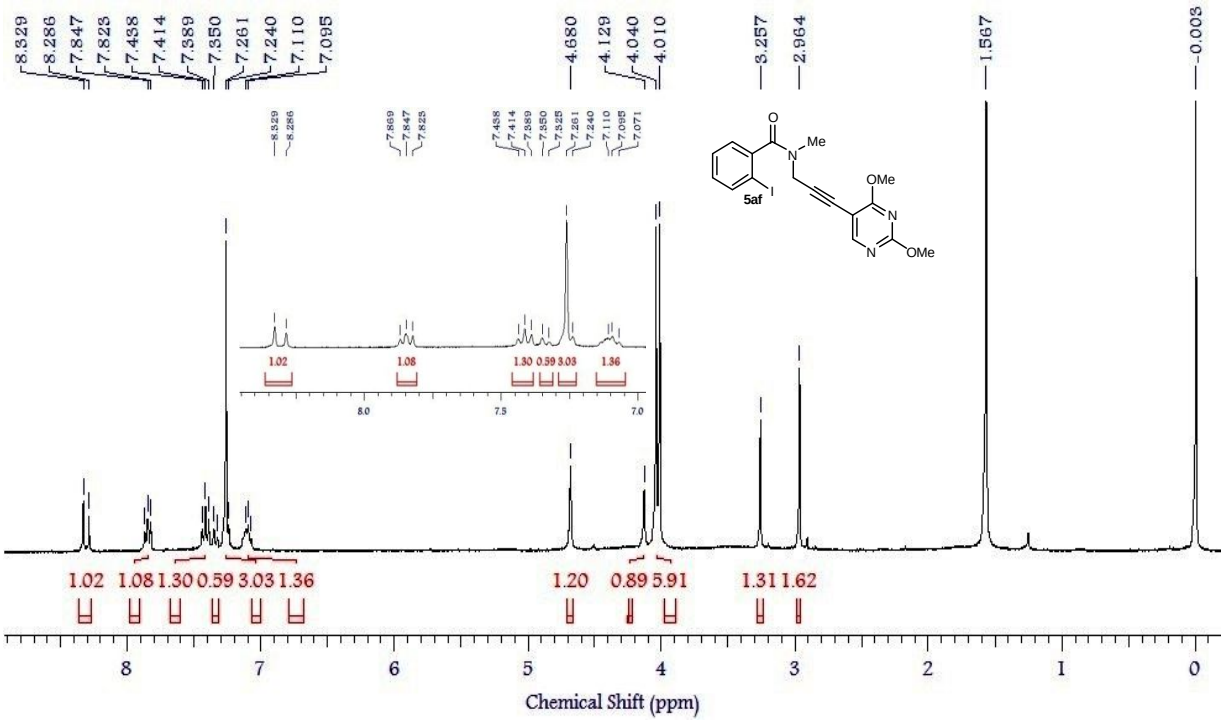
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **5ae**:



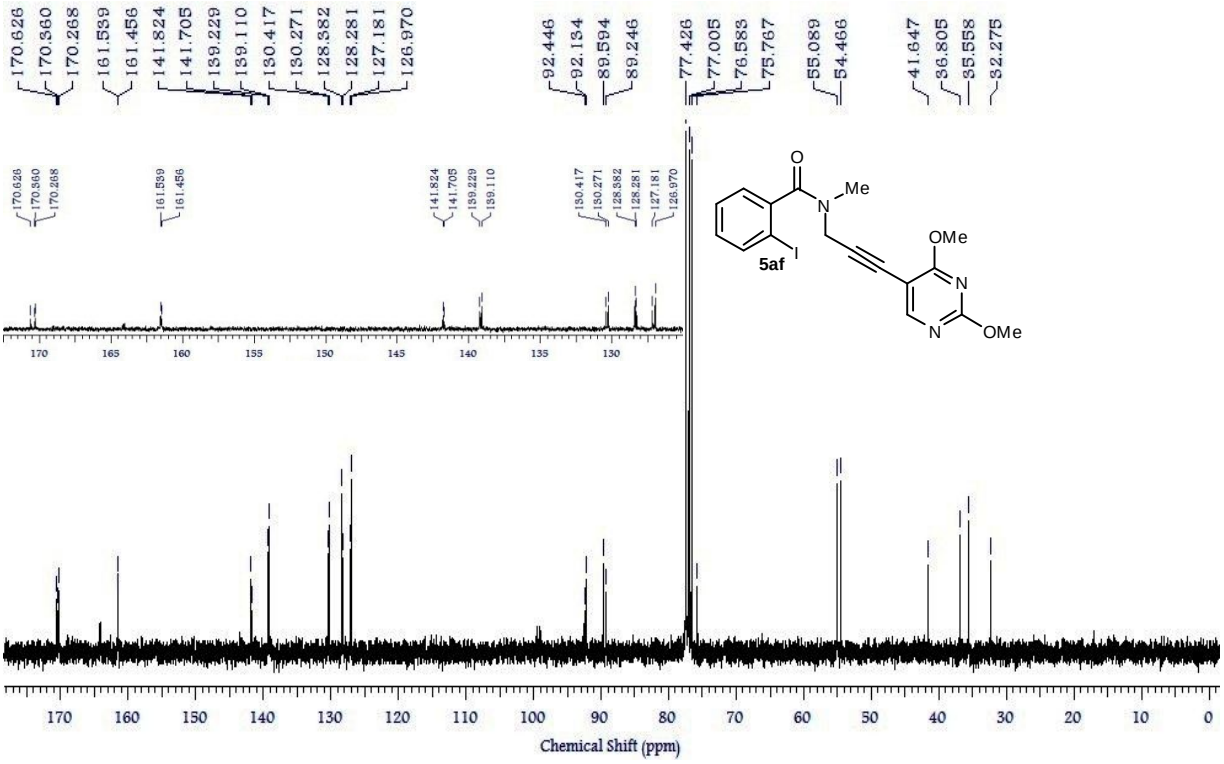
^{13}C NMR ($CDCl_3$, 75 MHz) spectrum of compound **5ae**:



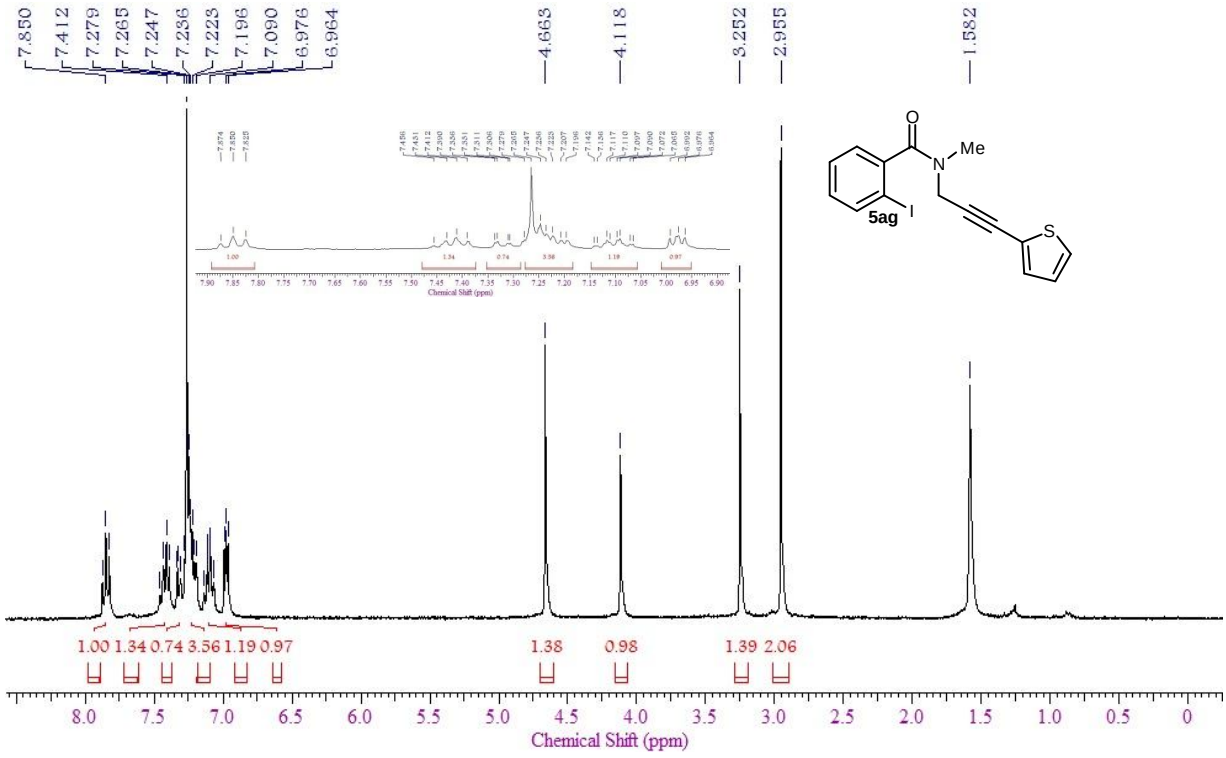
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **5af**:



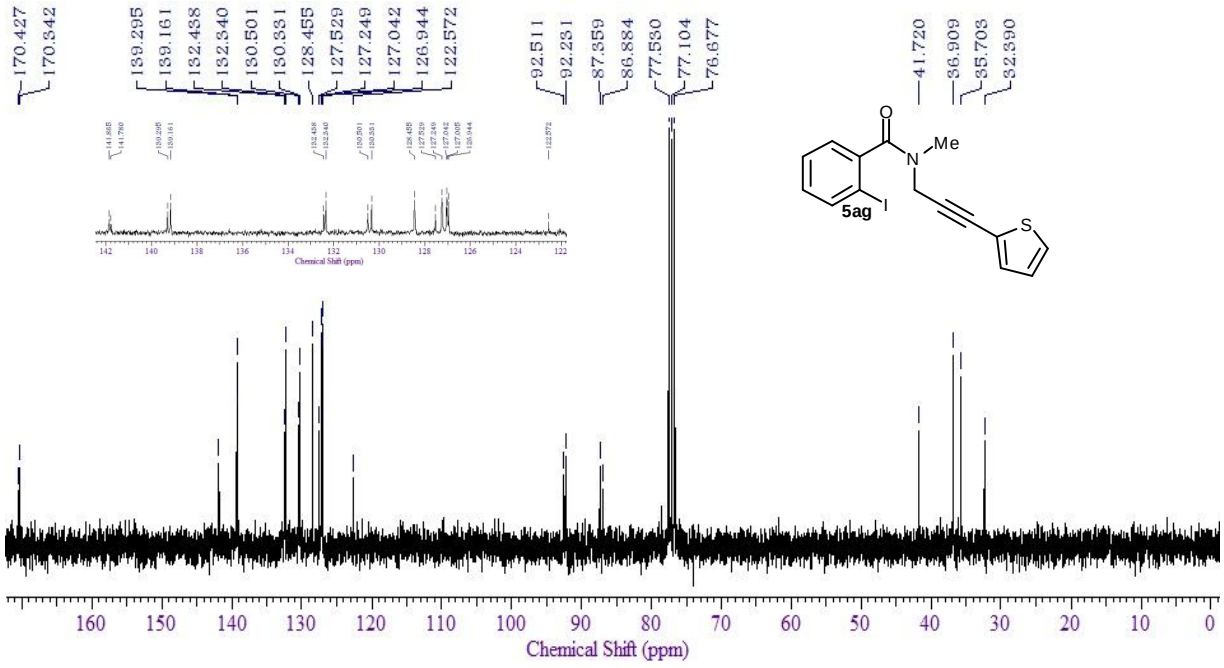
^{13}C NMR ($CDCl_3$, 75 MHz) spectrum of compound **5af**:



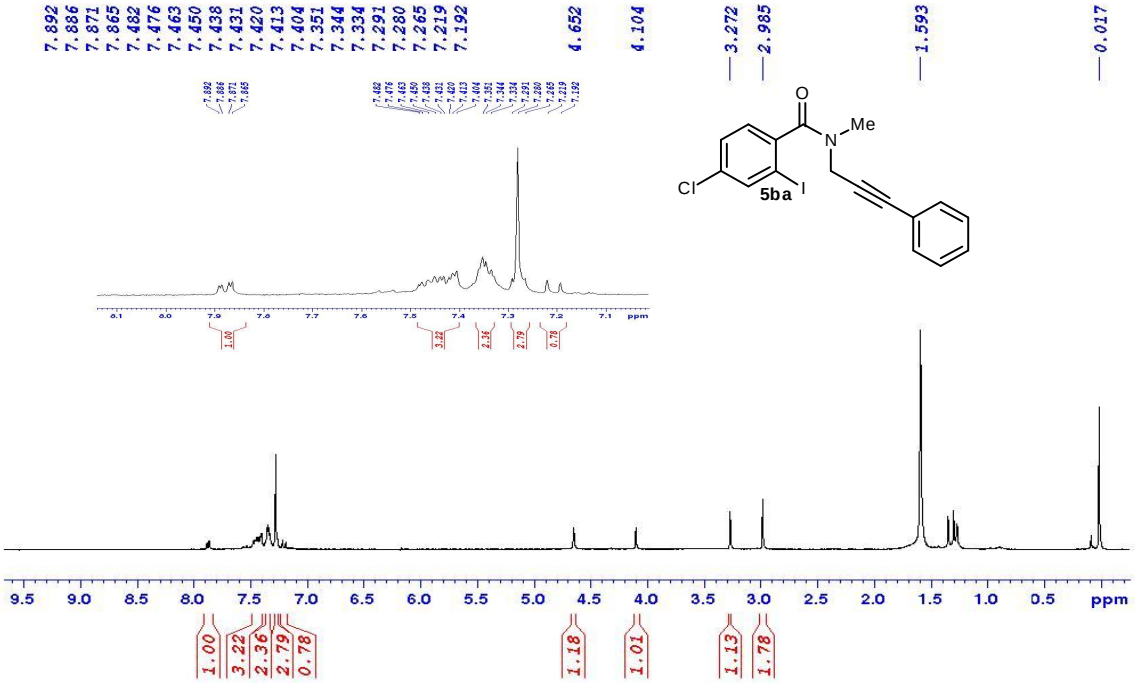
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **5ag**:



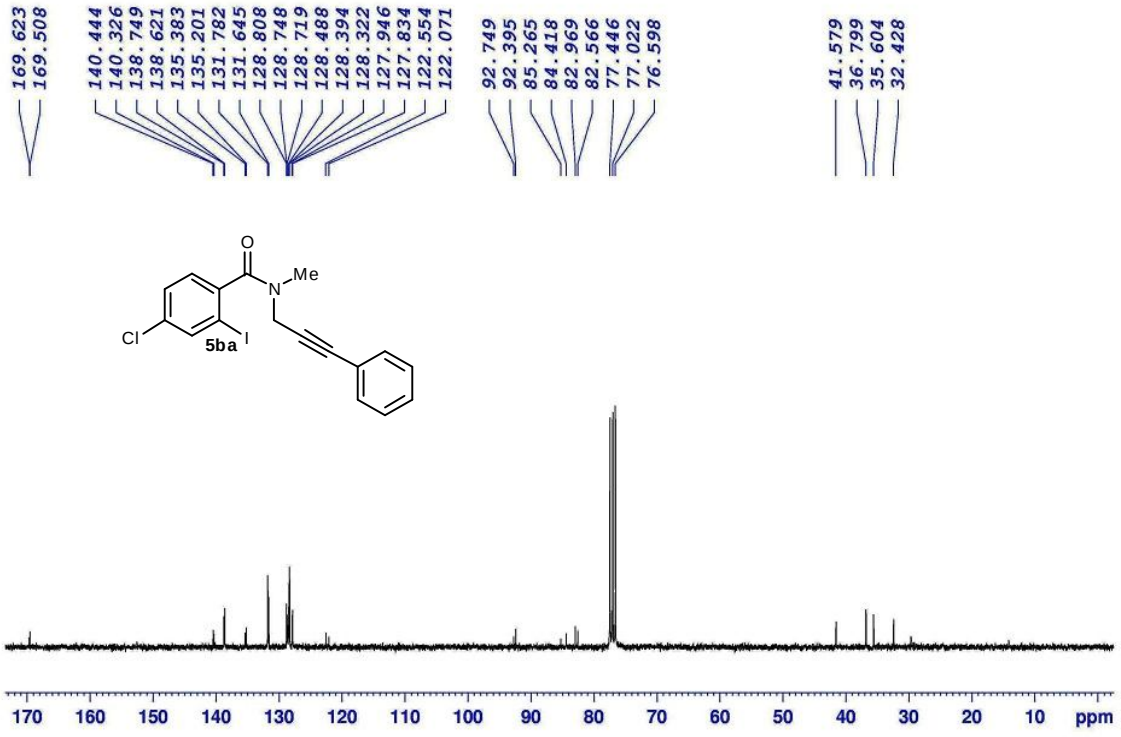
^{13}C NMR ($CDCl_3$, 75 MHz) spectrum of compound **5ag**:



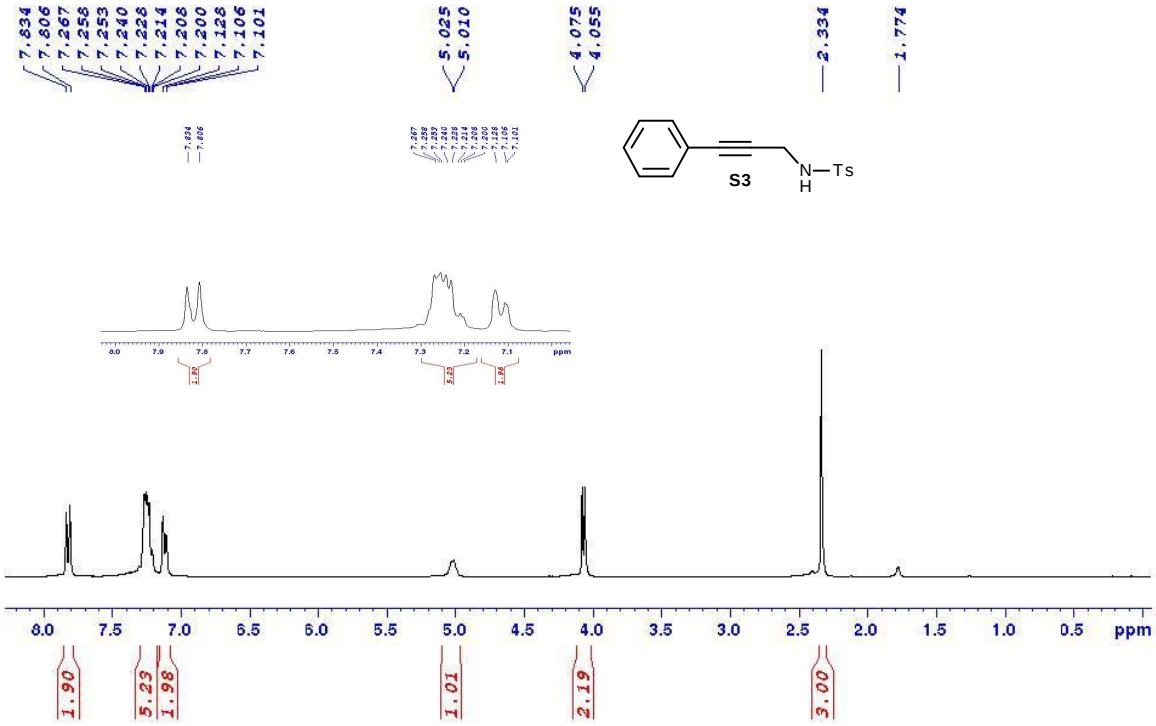
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **5ba**:



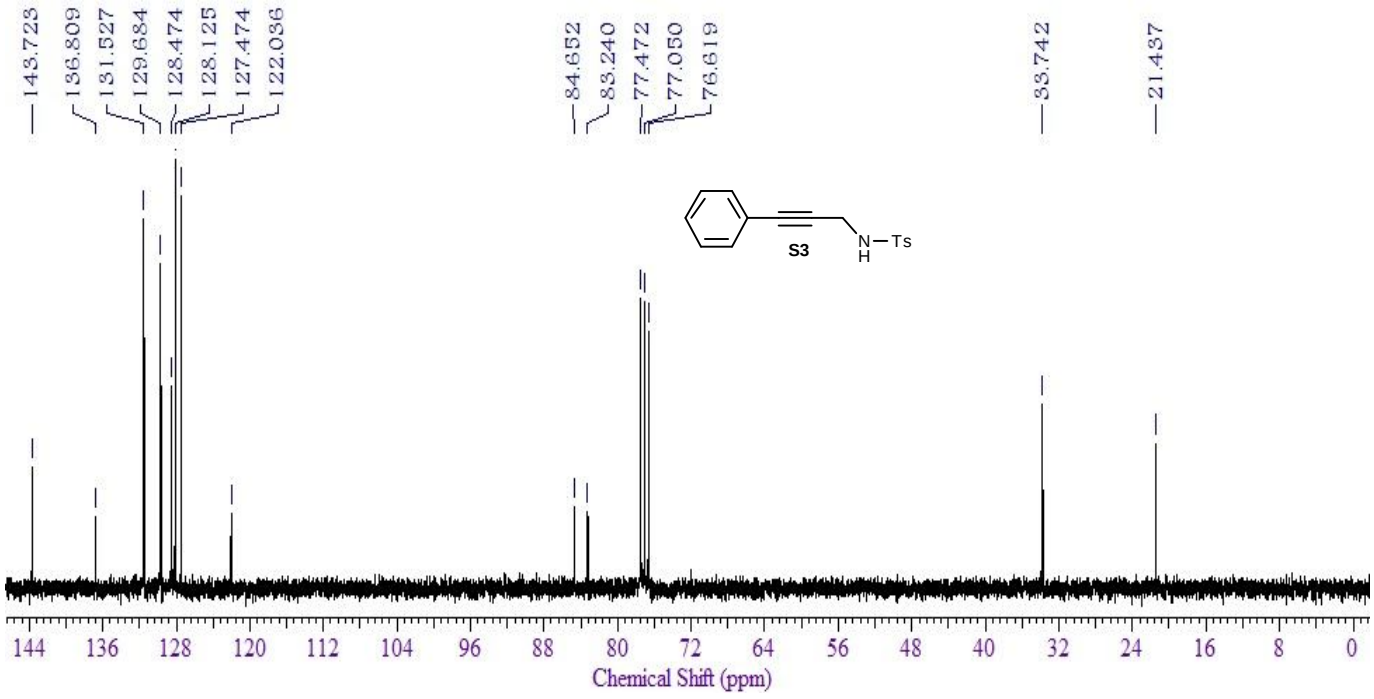
^{13}C NMR ($CDCl_3$, 75 MHz) spectrum of compound **5ba**:



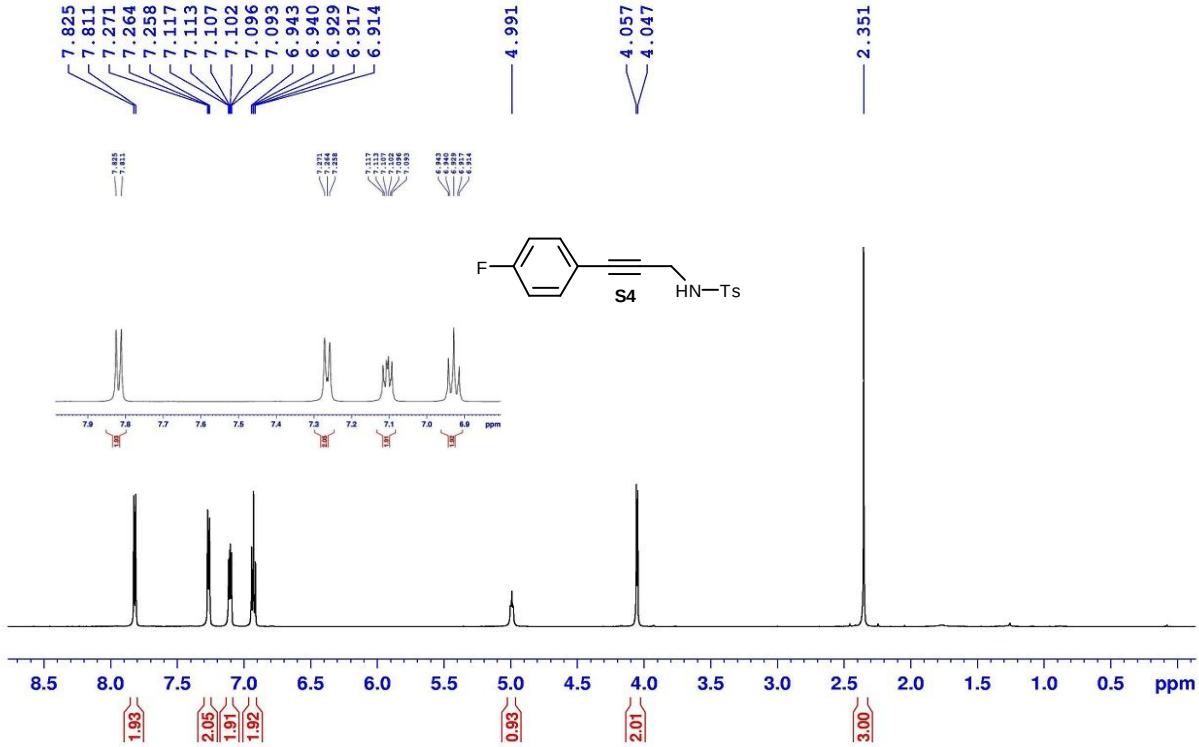
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **S3**:



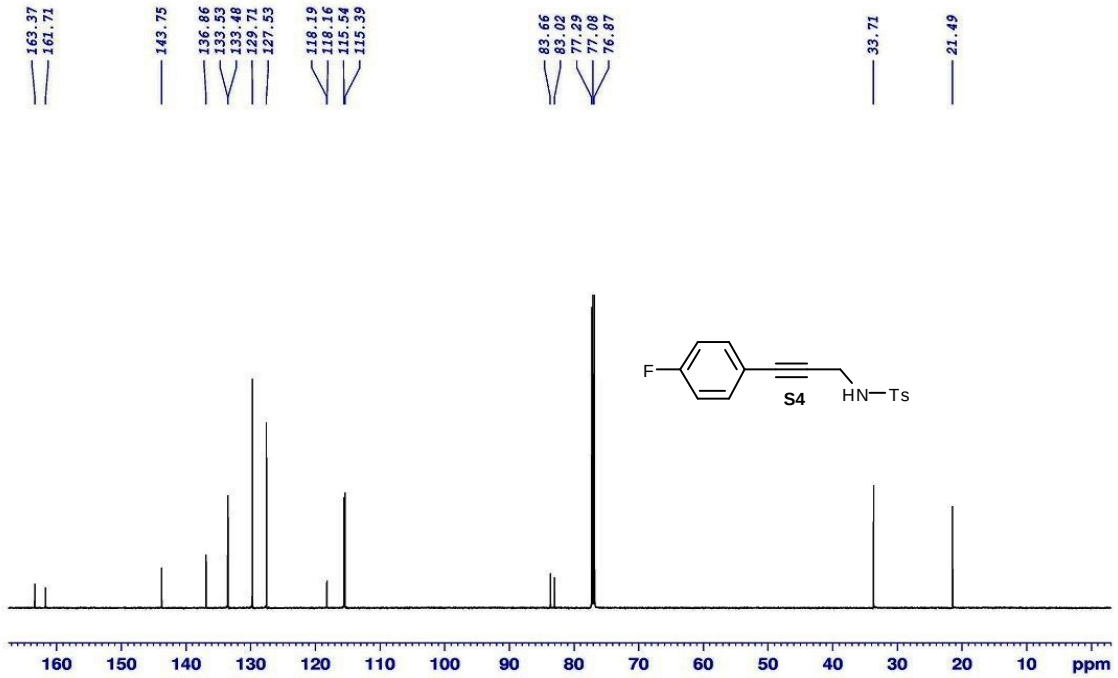
^{13}C NMR ($CDCl_3$, 75 MHz) spectrum of compound **S3**:



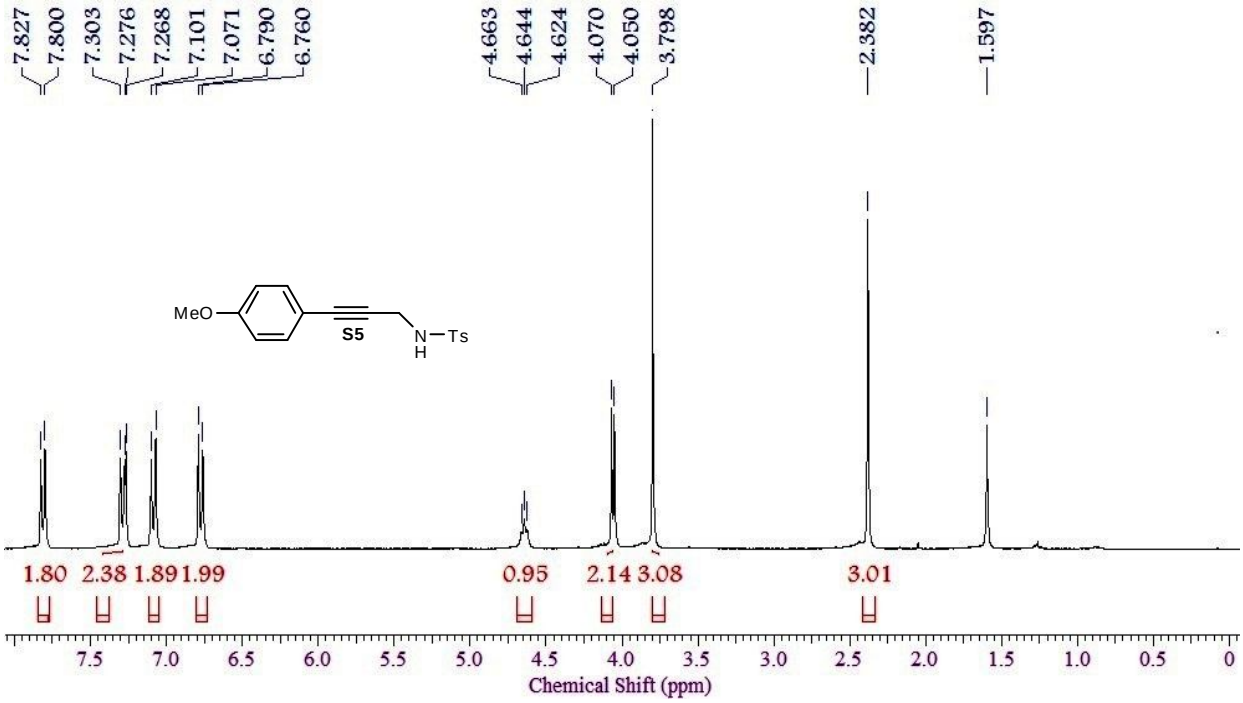
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **S4**:



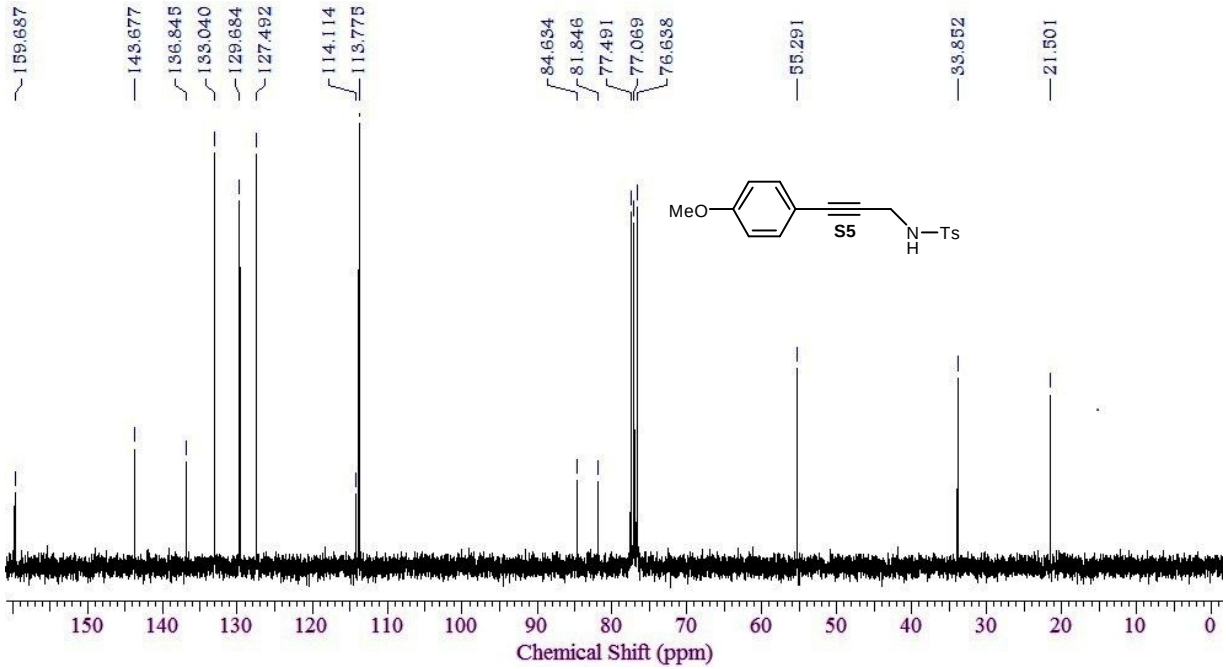
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of compound **S4**:



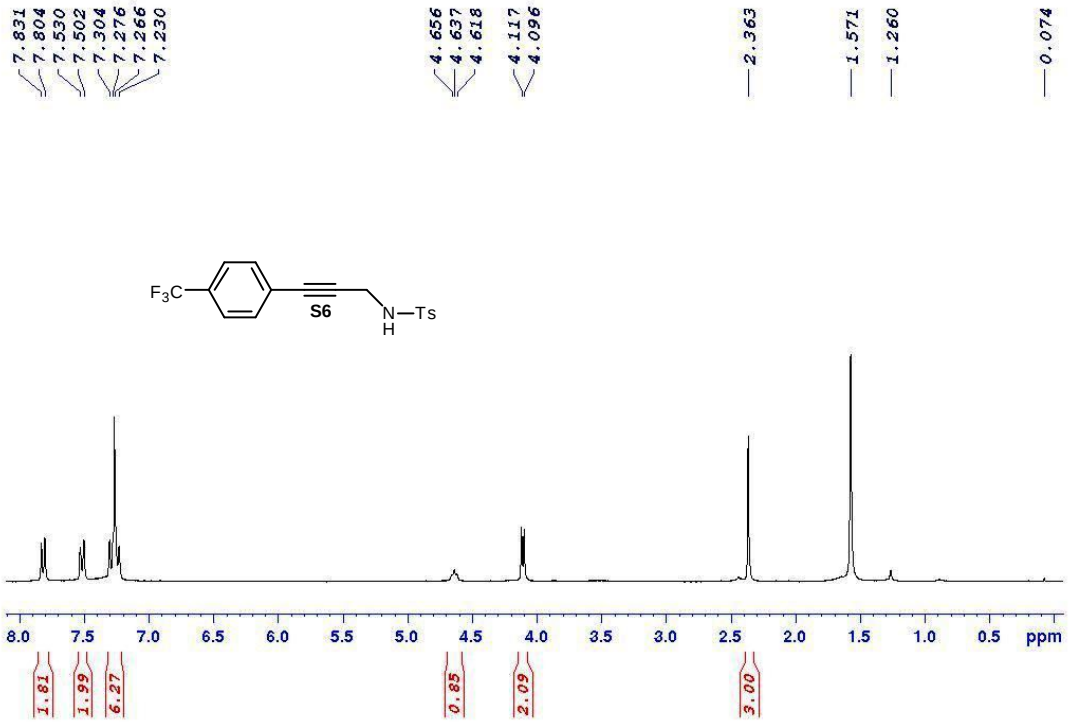
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **S5**:



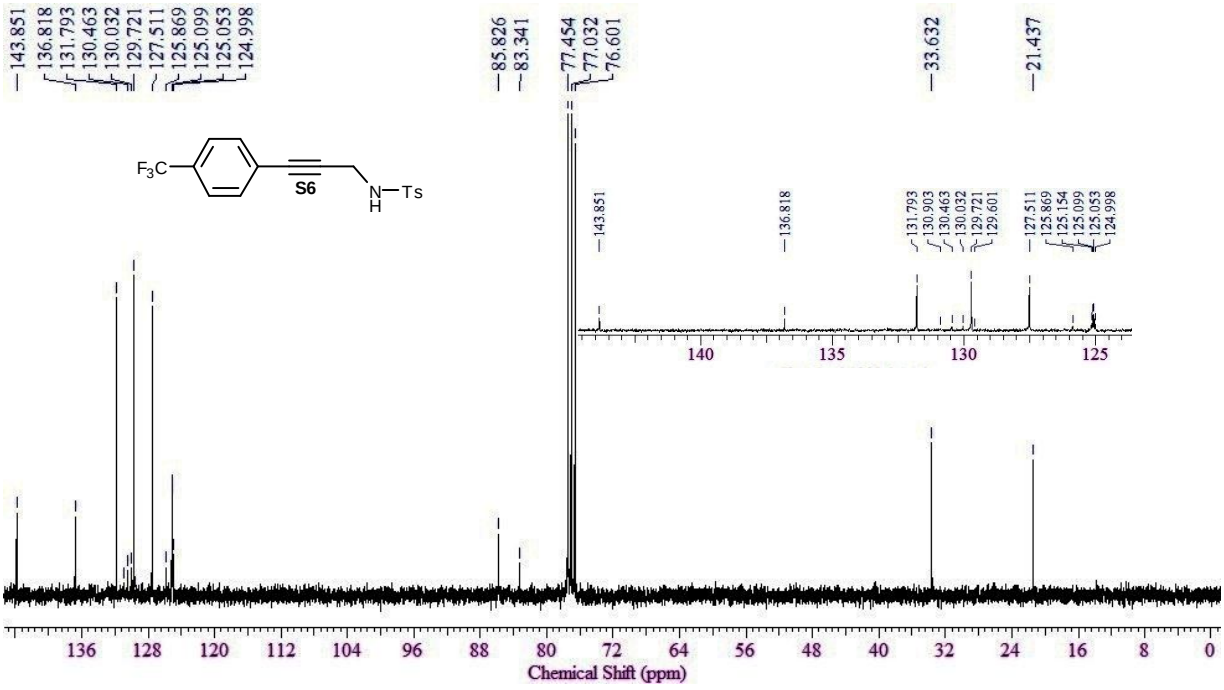
^{13}C NMR ($CDCl_3$, 75 MHz) spectrum of compound **S5**:



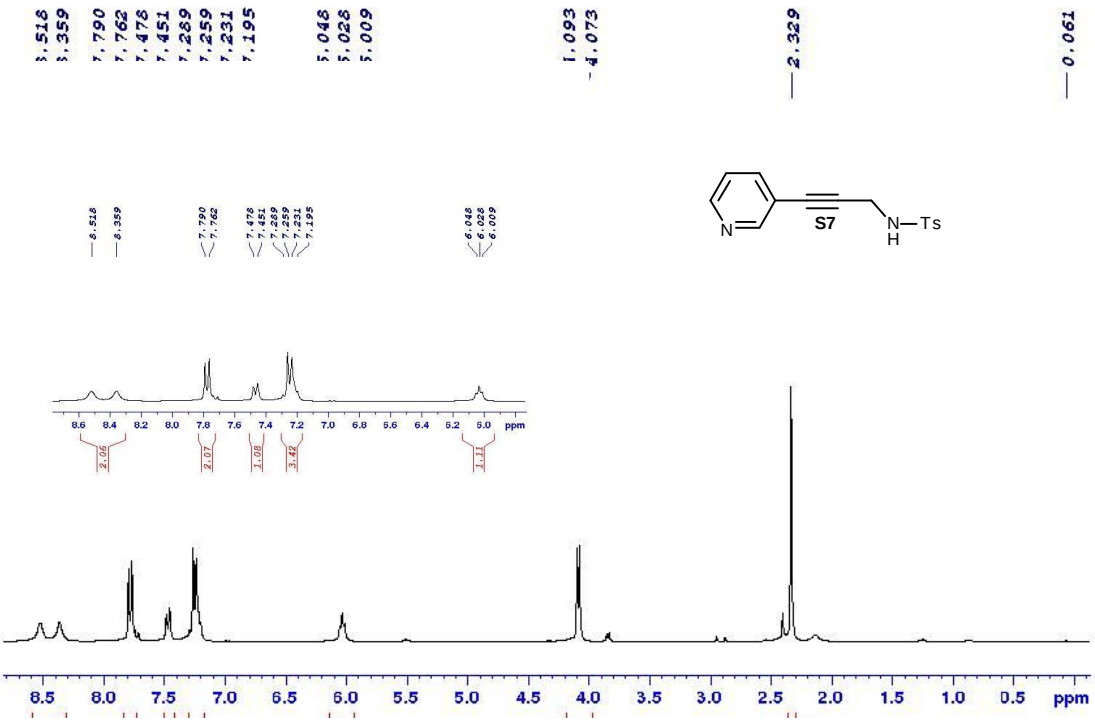
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **S6**:



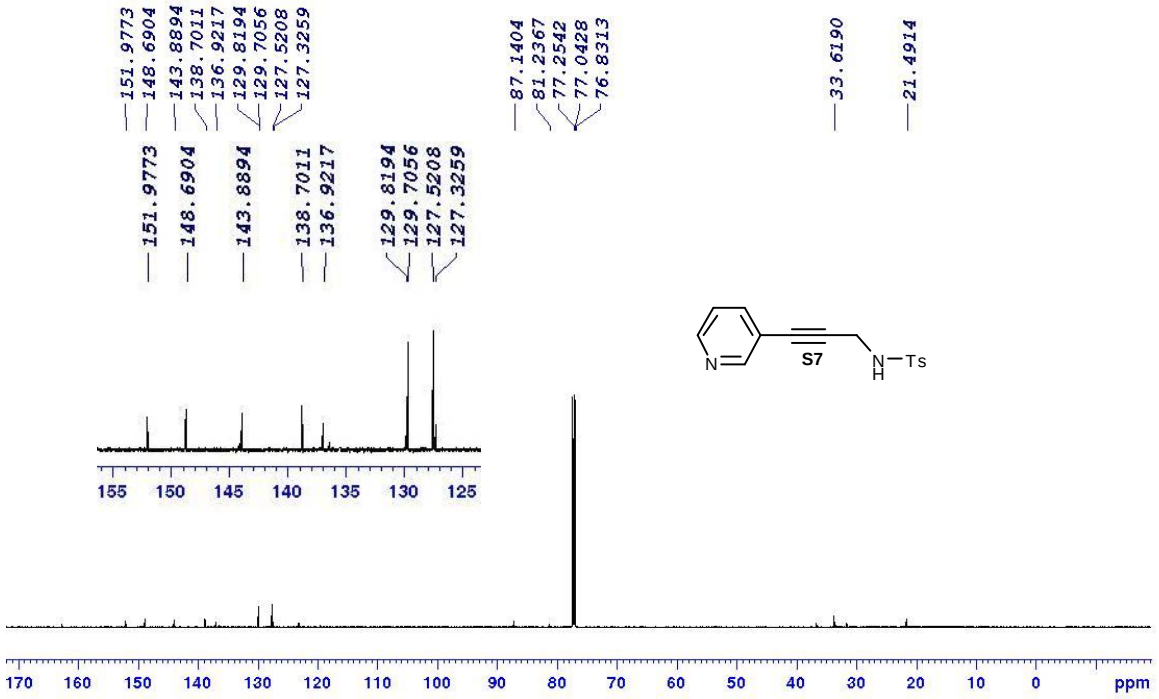
^{13}C NMR ($CDCl_3$, 75 MHz) spectrum of com **S6**:



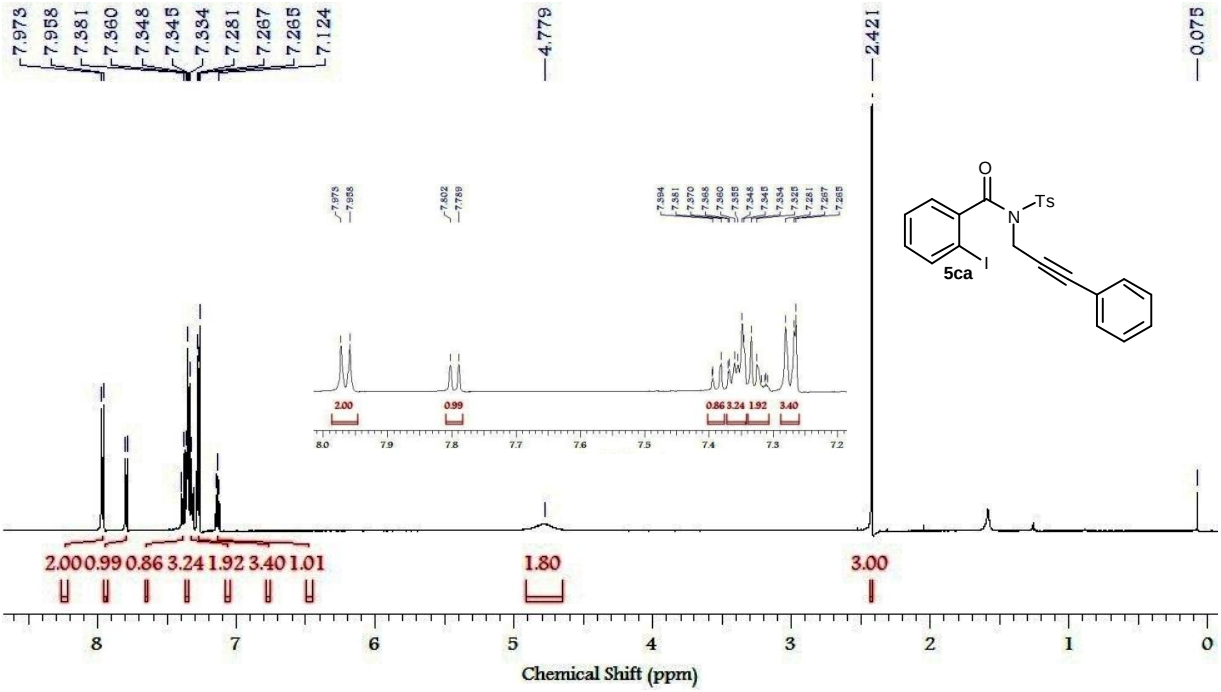
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **S7**:



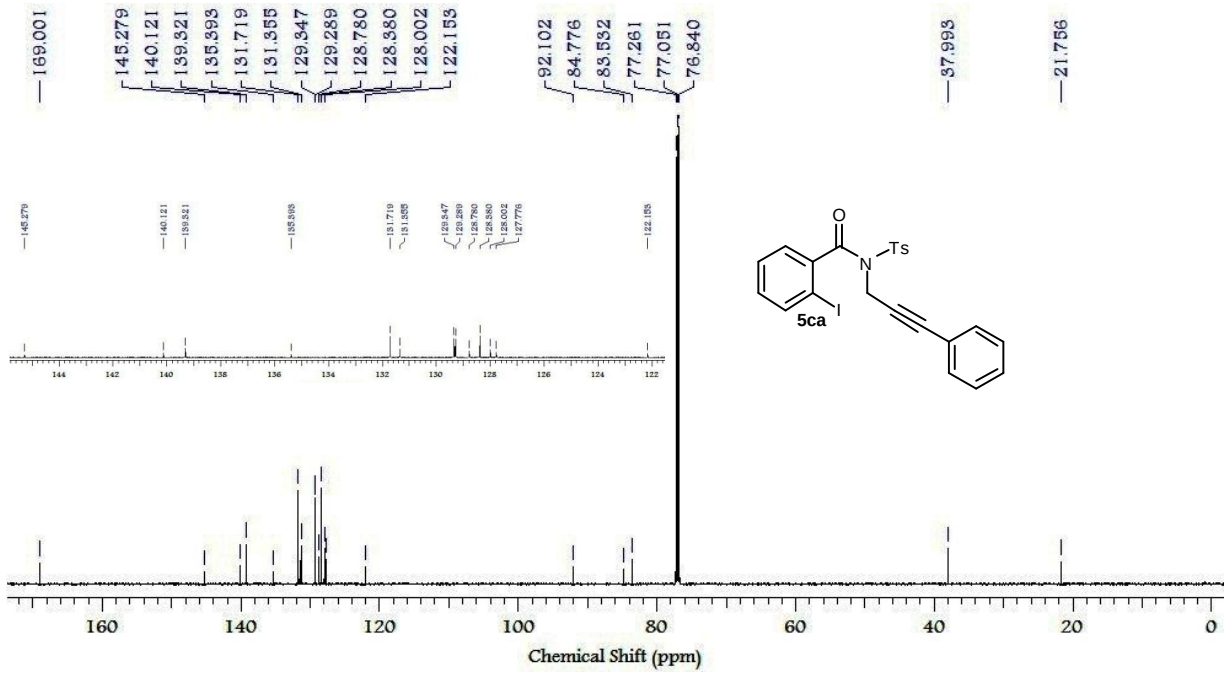
^{13}C NMR ($CDCl_3$, 150MHz) spectrum of compound **S7:**



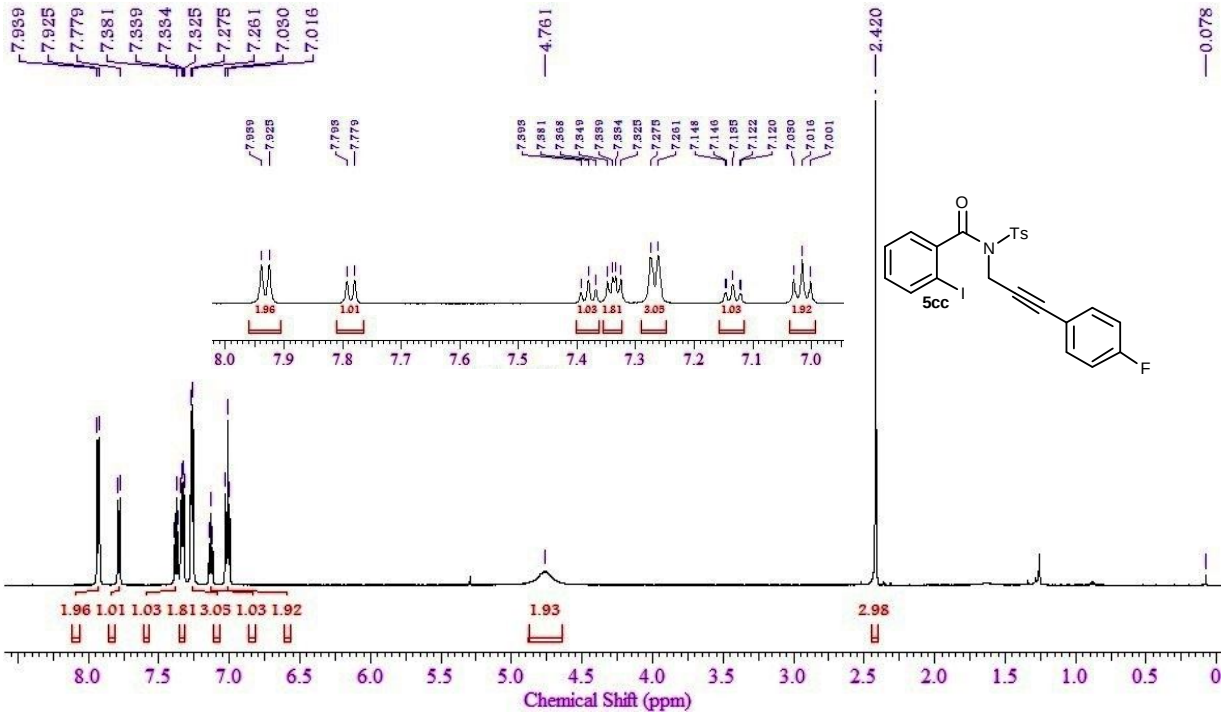
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **5ca**:



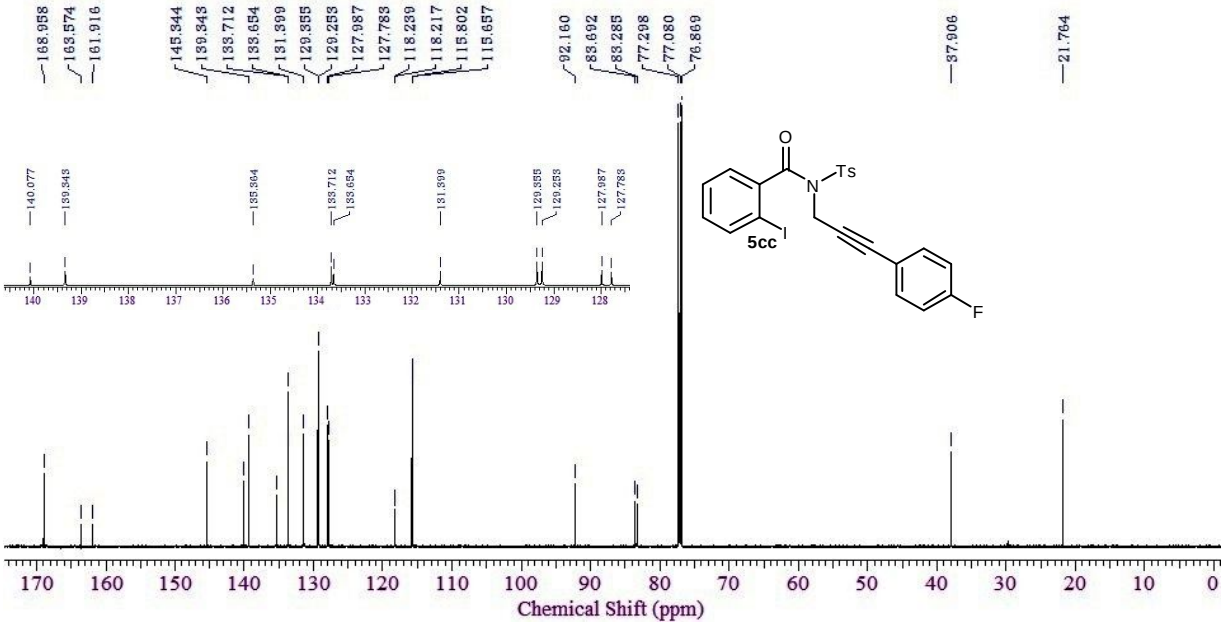
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of compound **5ca**:



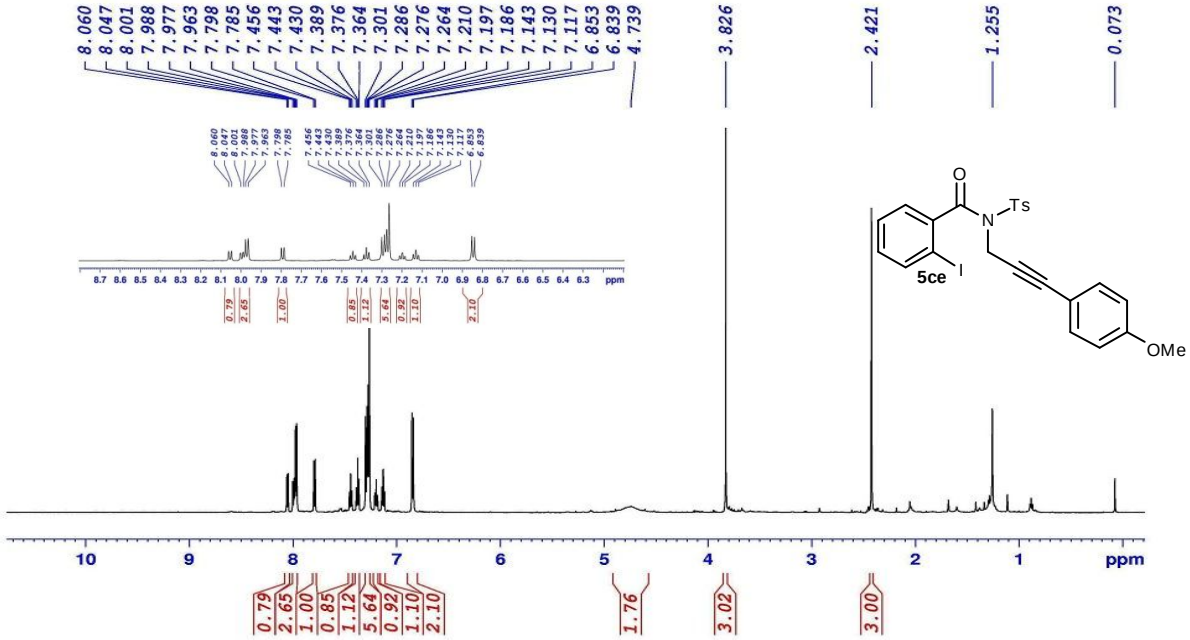
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **5cc**:



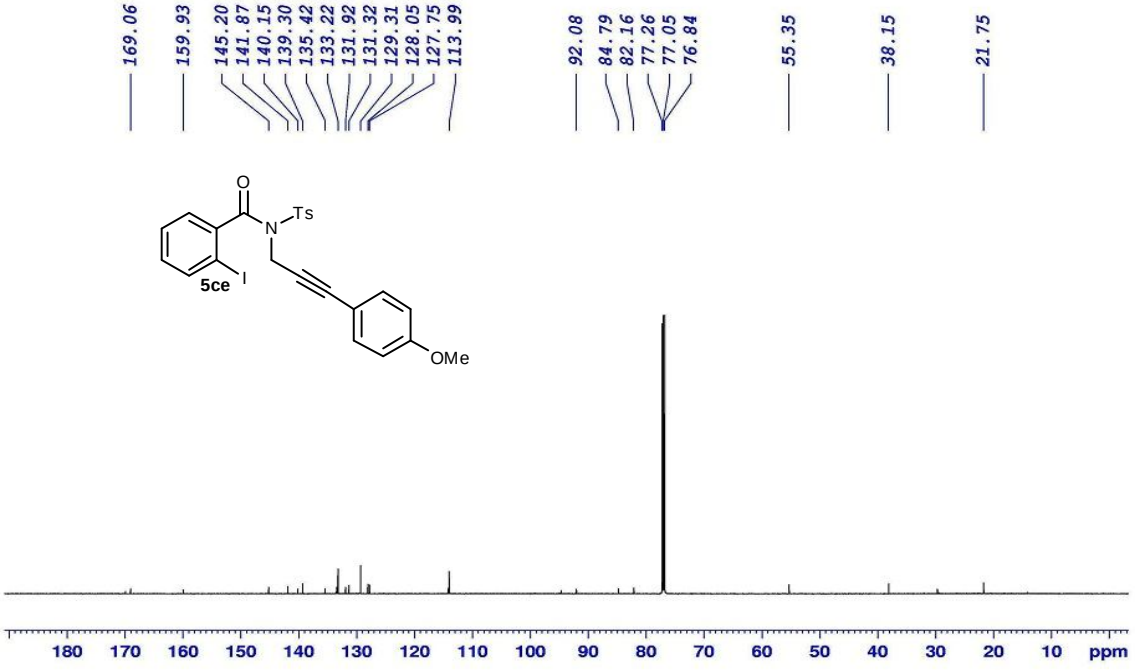
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of compound **5cc**:



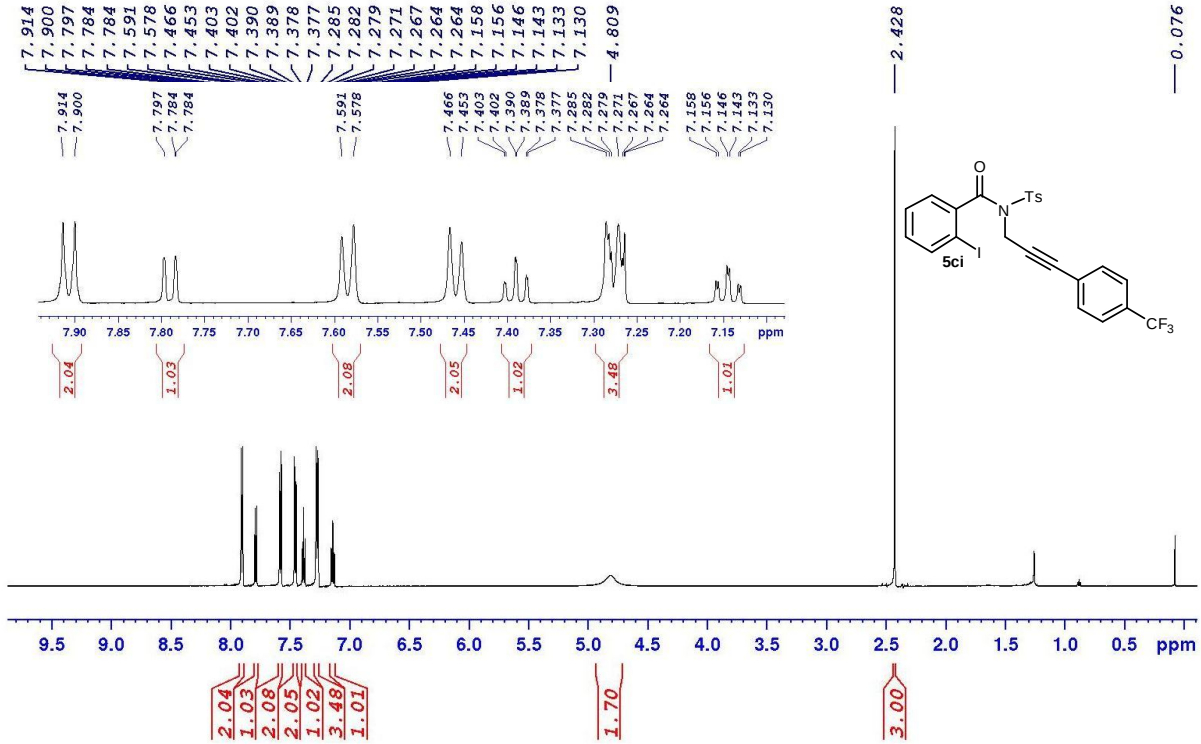
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **5ce**:



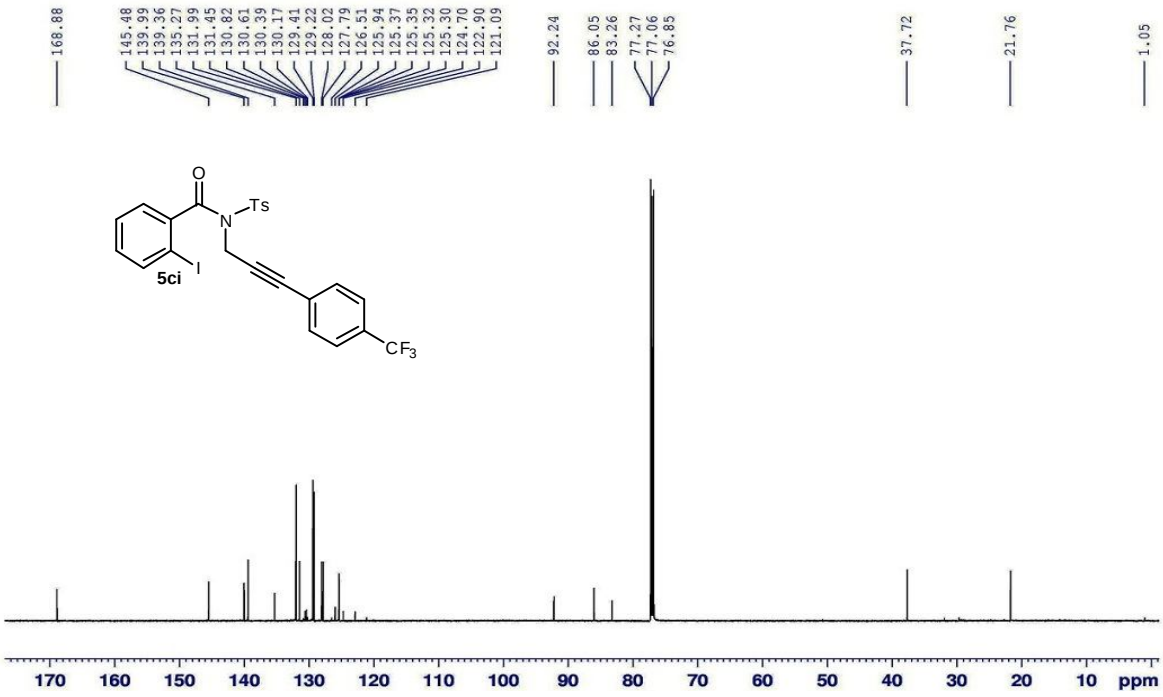
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of compound **5ce:**



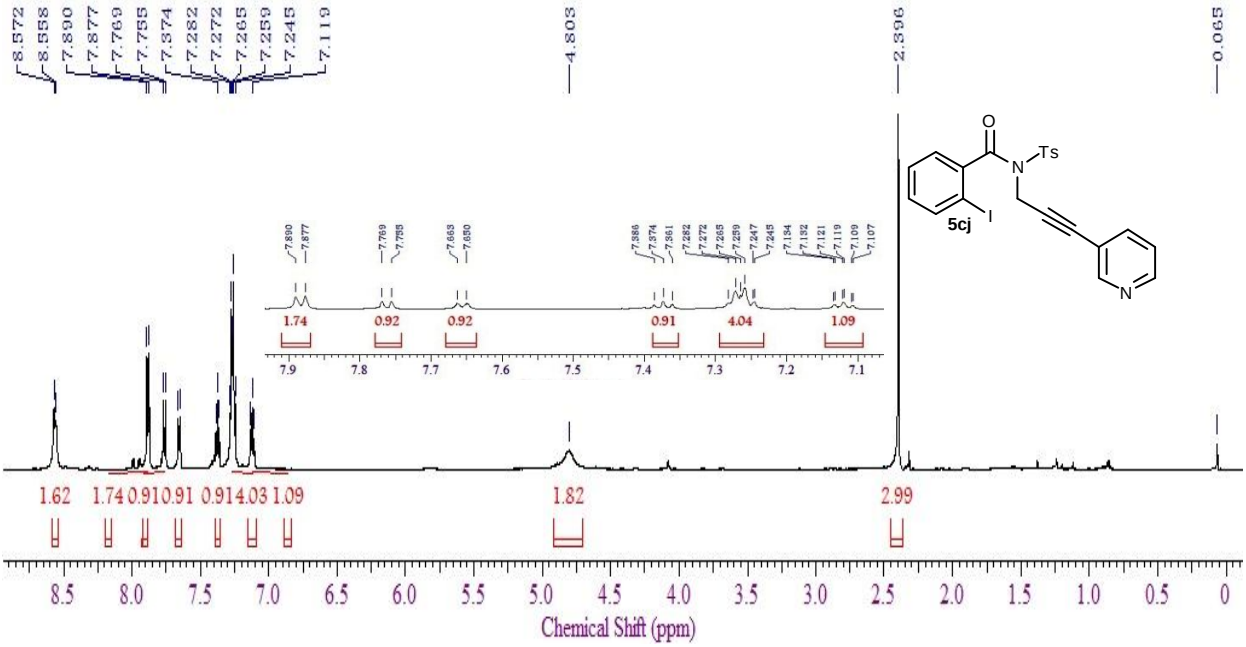
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **5ci**:



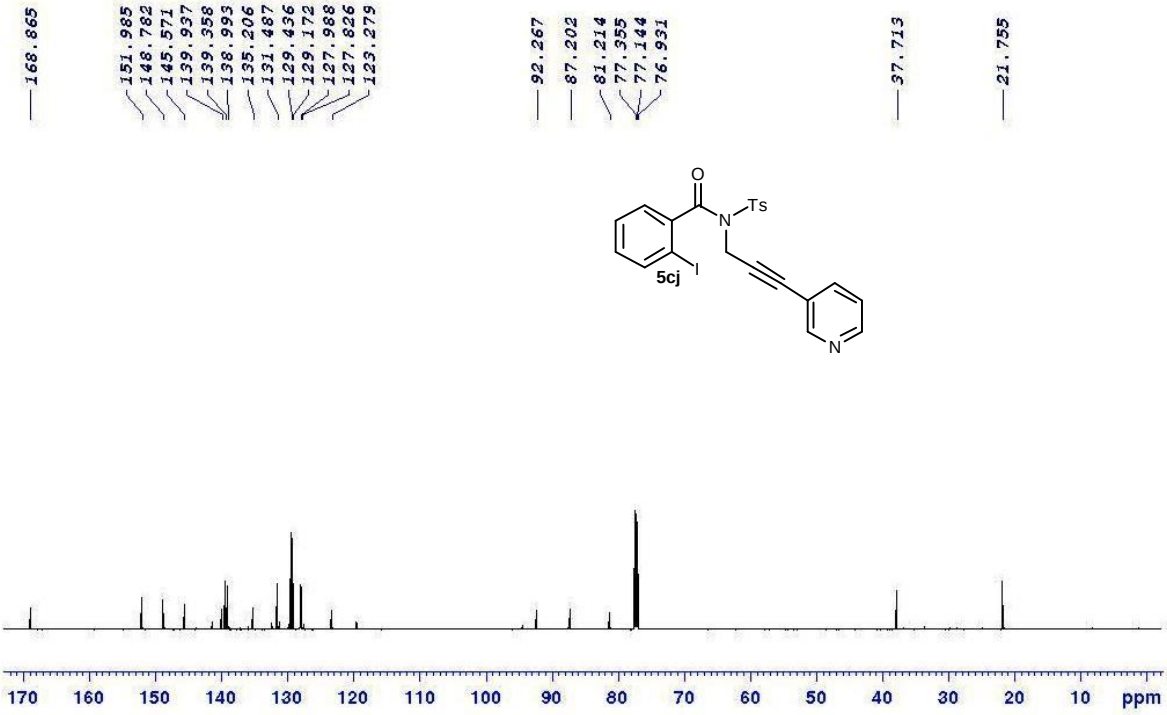
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of compound **5ci**:



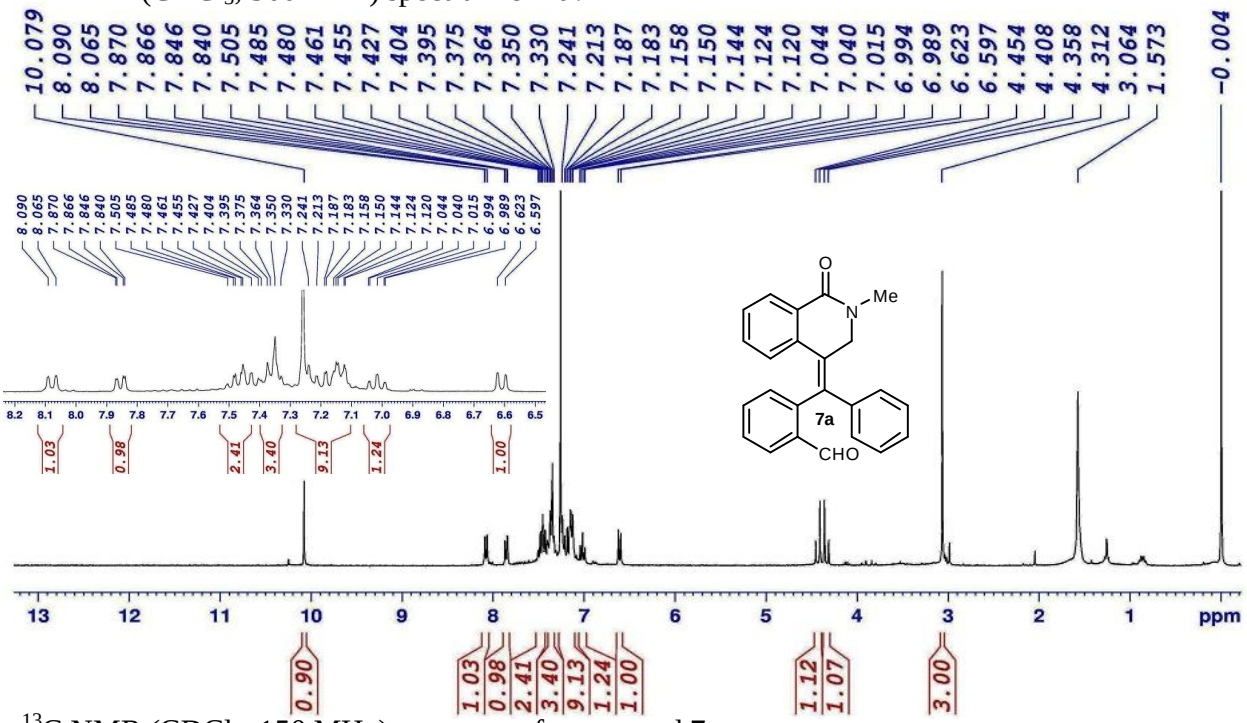
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **5cj**:



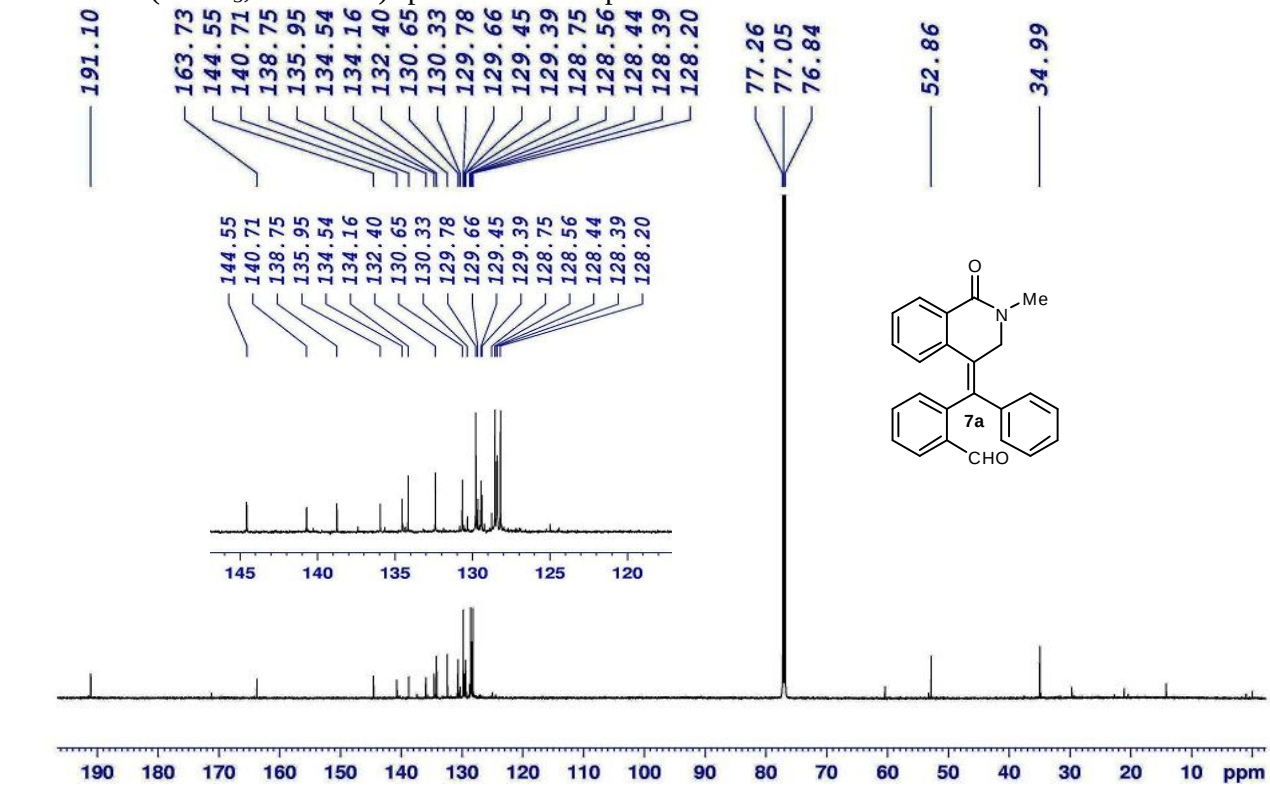
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of compound **5cj**:



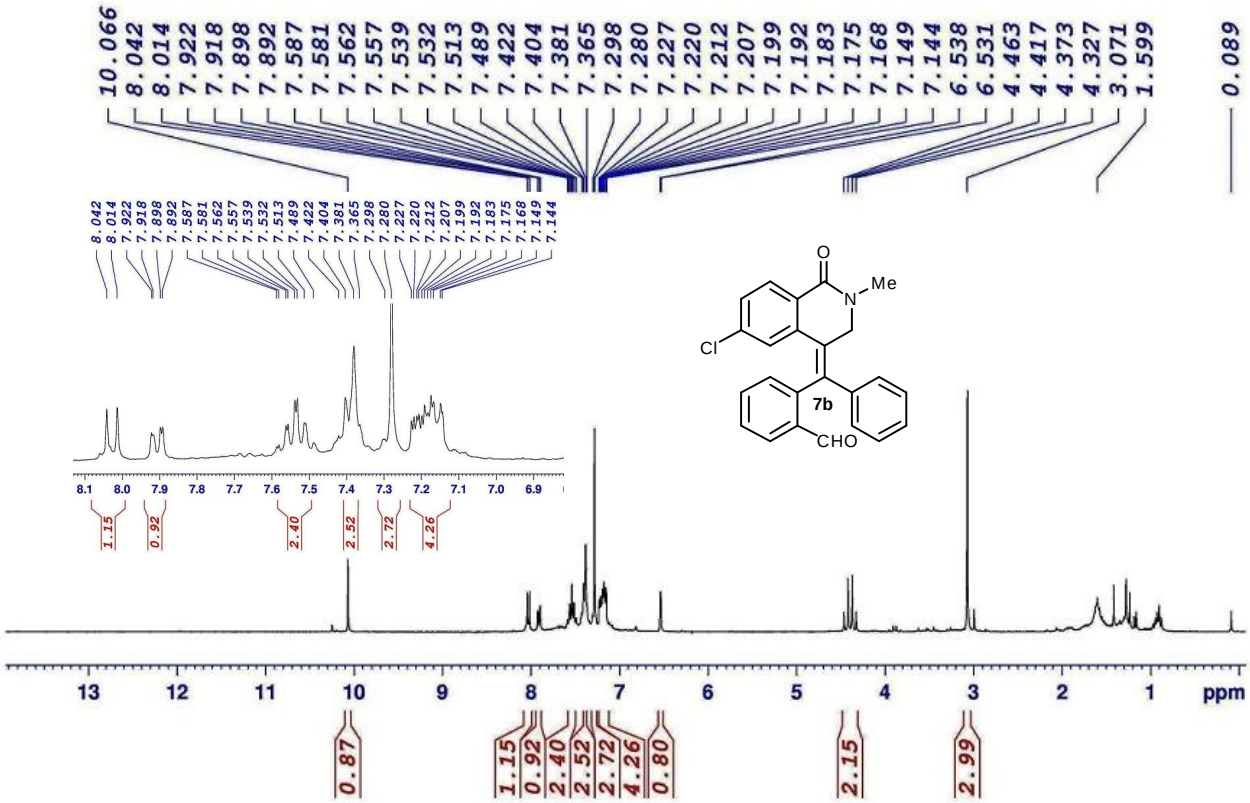
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **7a**:



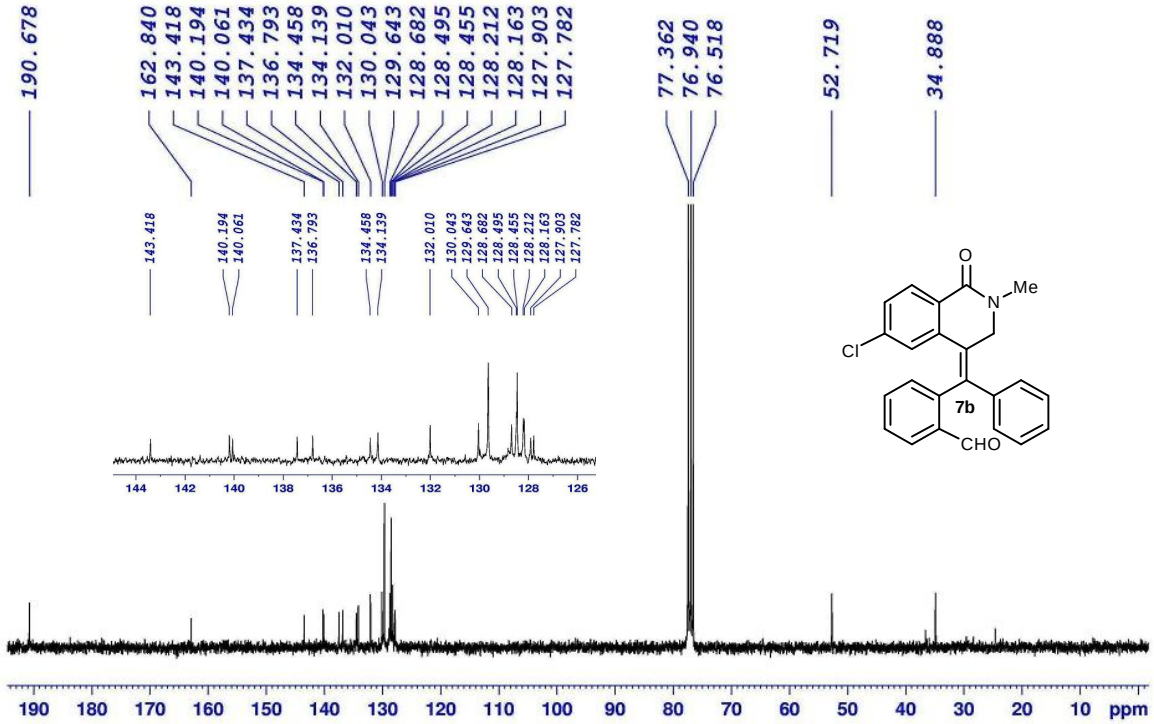
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of compound **7a**:



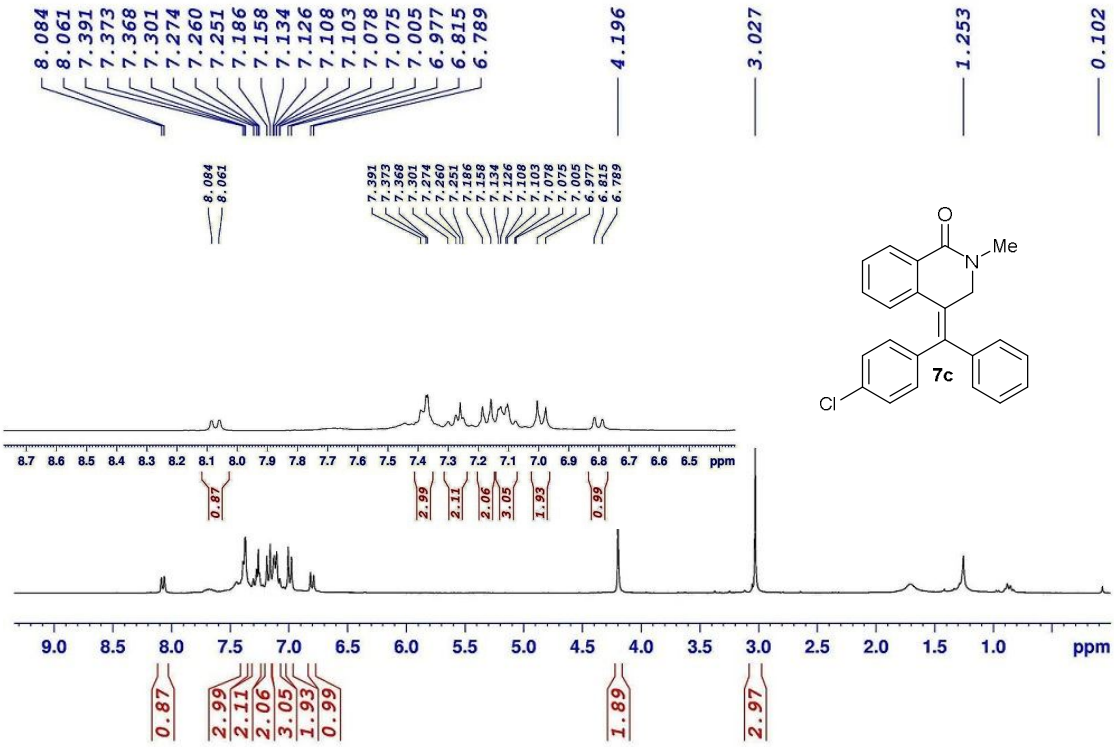
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **7b**:



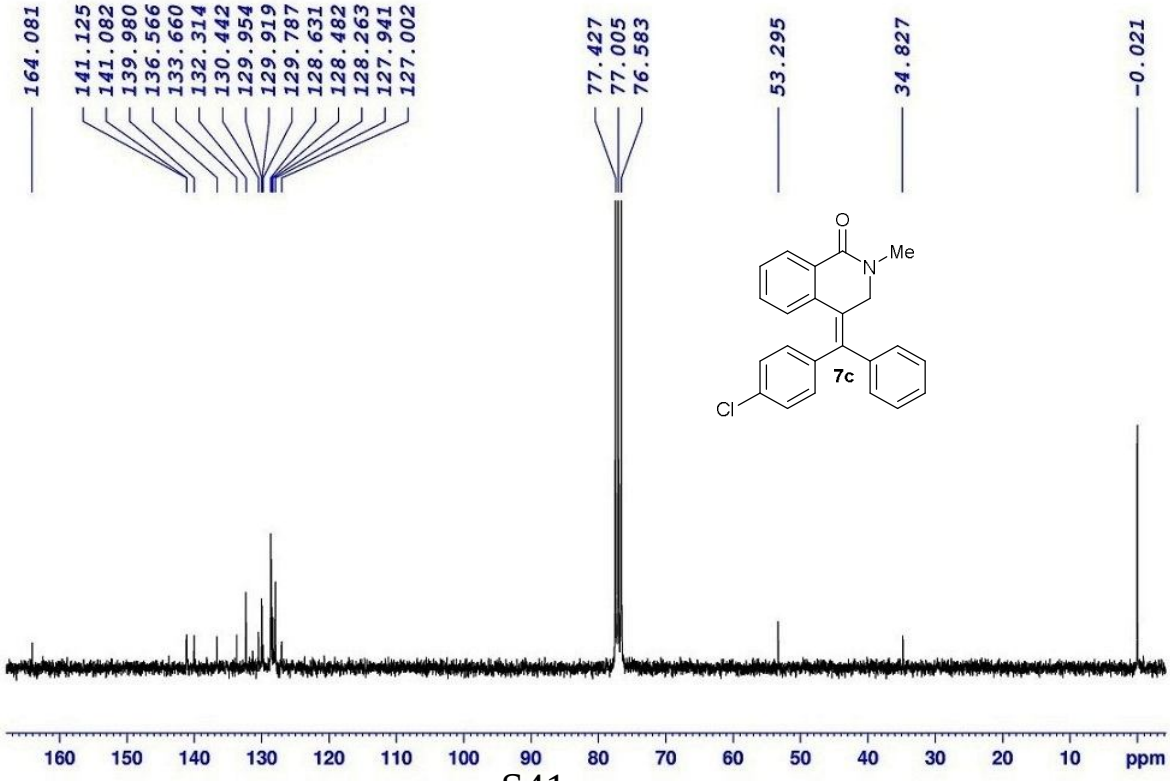
^{13}C NMR ($CDCl_3$, 75 MHz) spectrum of compound **7b**:



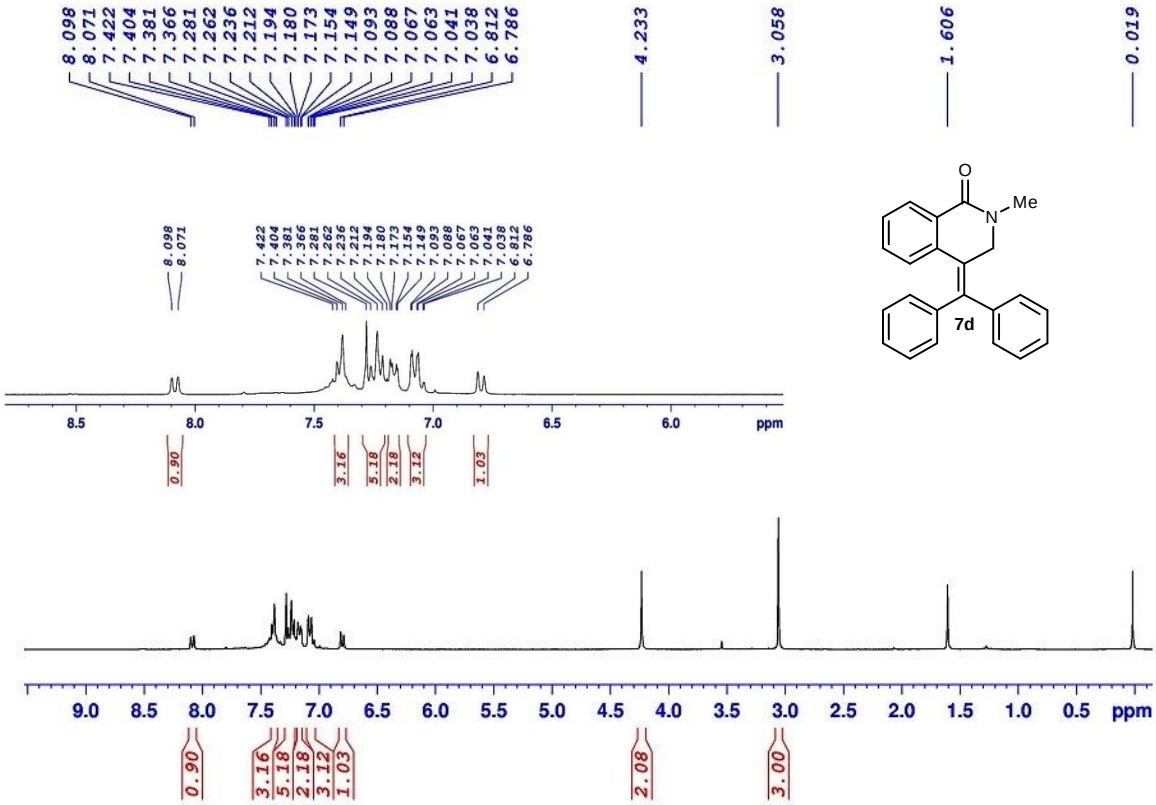
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **7c**:



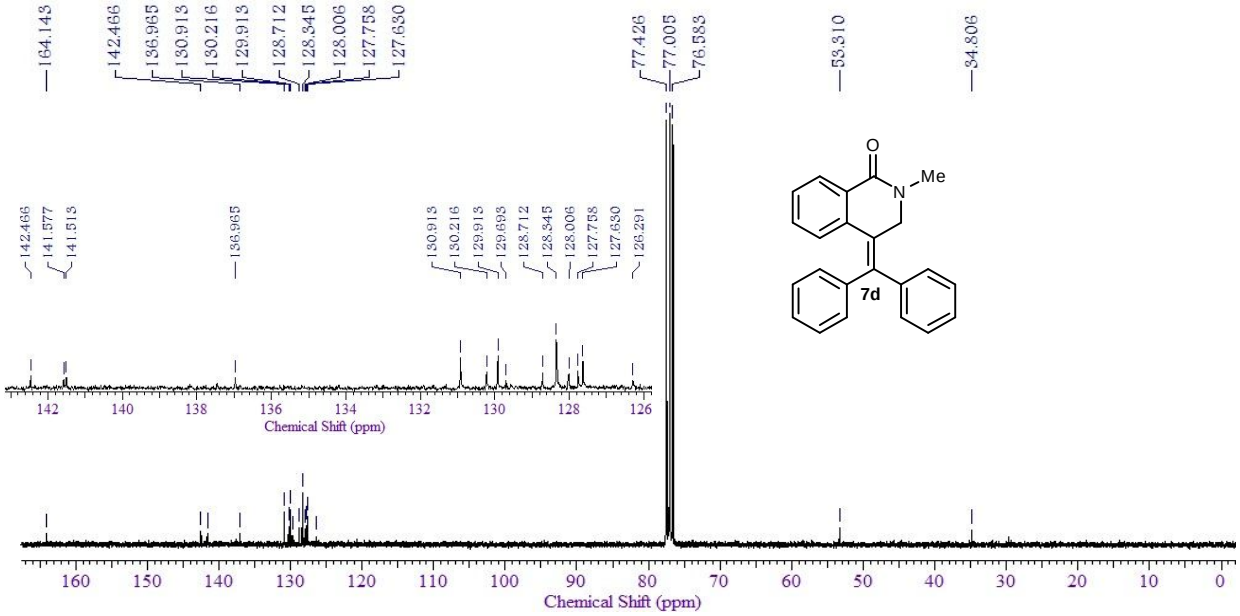
^{13}C NMR ($CDCl_3$, 75 MHz) spectrum of compound **7c**:



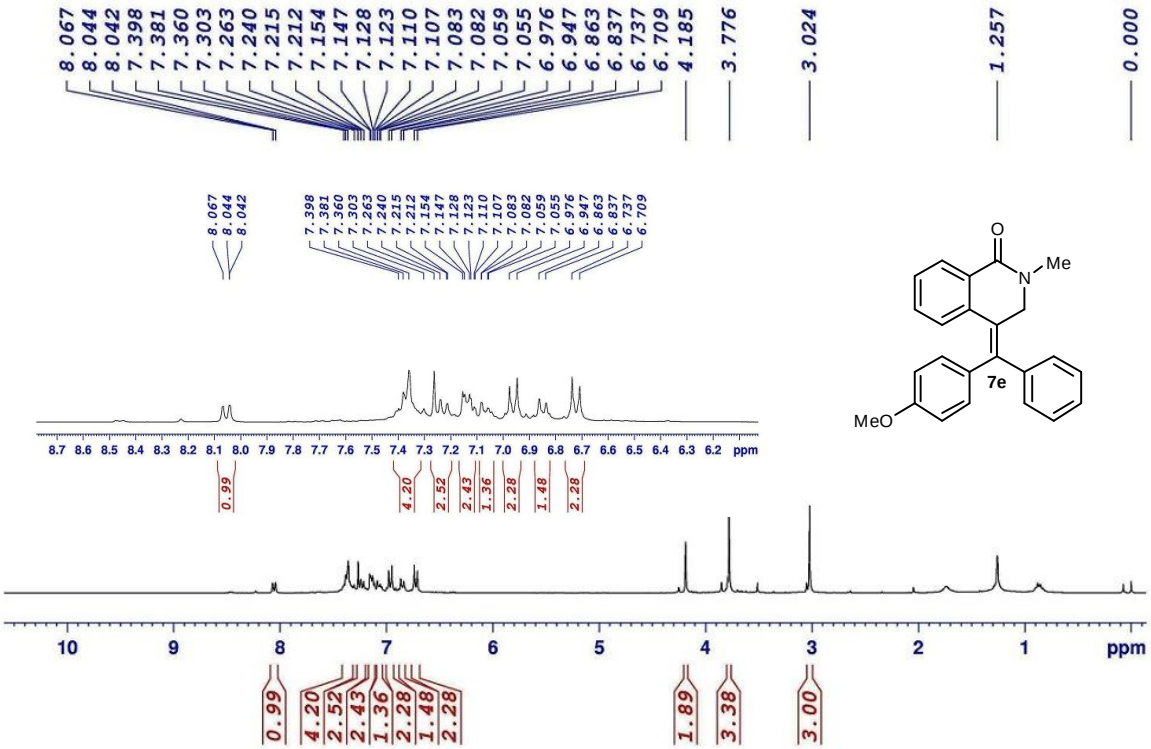
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **7d**:



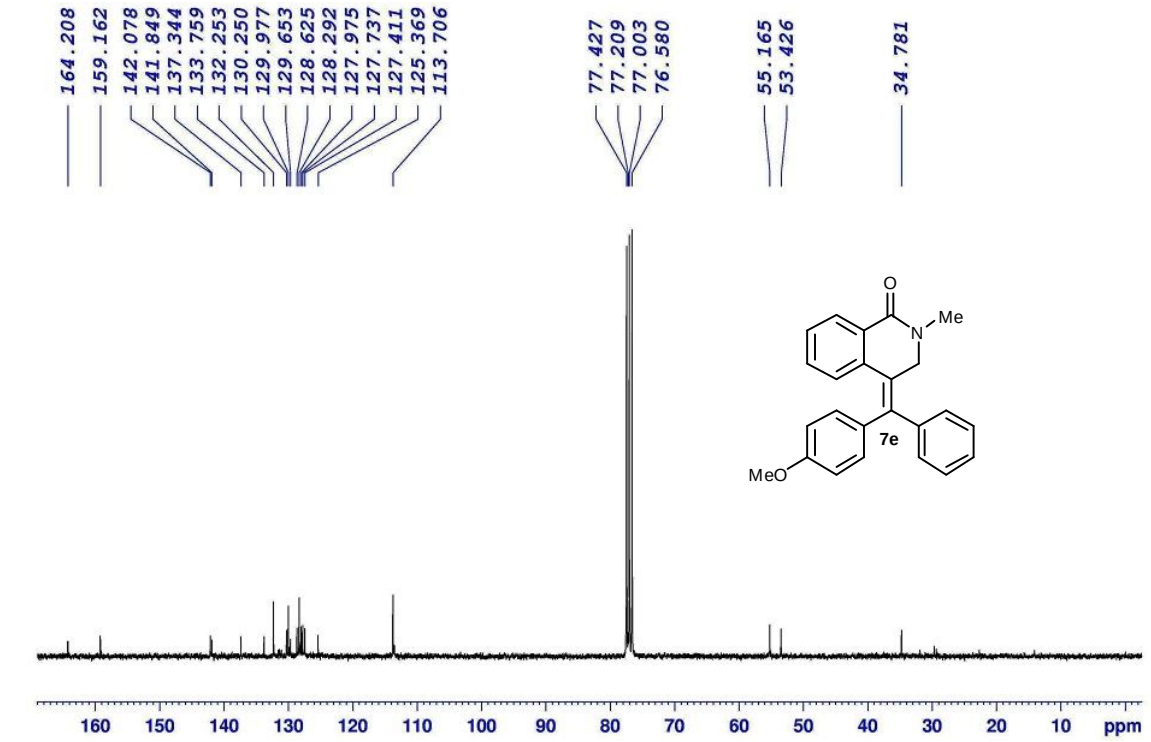
^{13}C NMR ($CDCl_3$, 75 MHz) spectrum of compound **7d**:



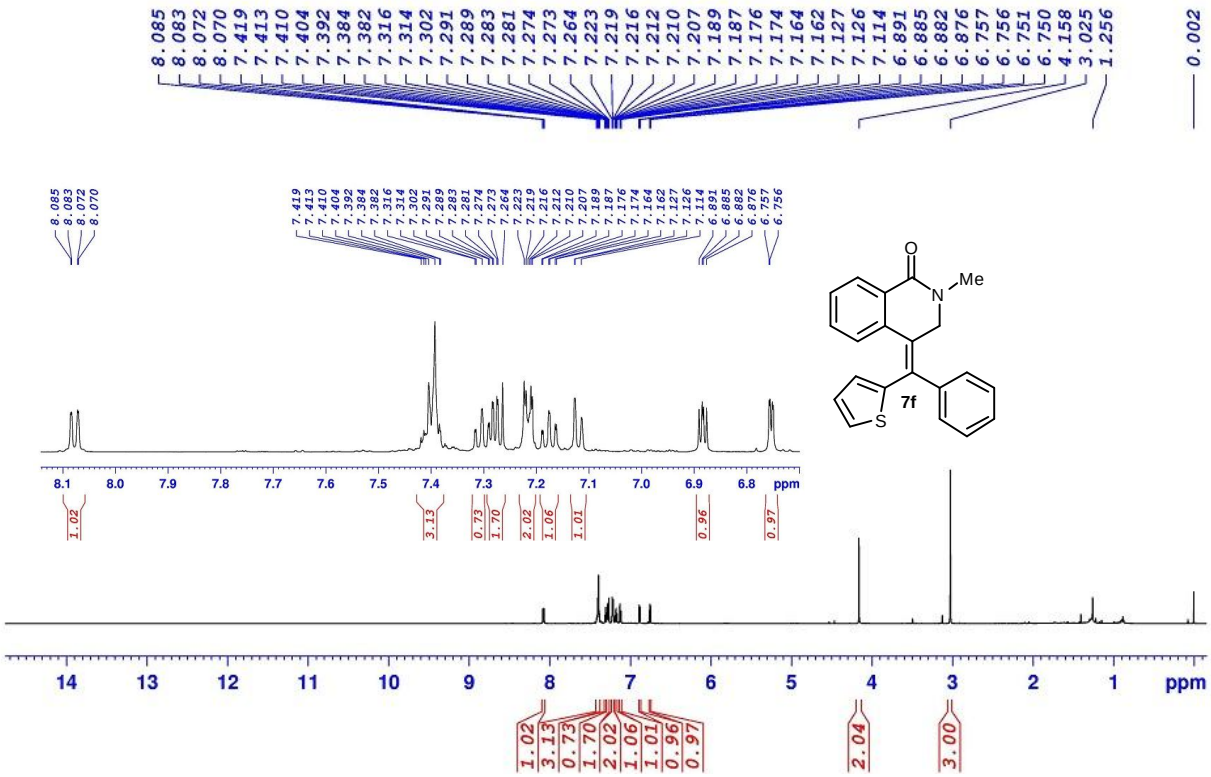
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **7e**:



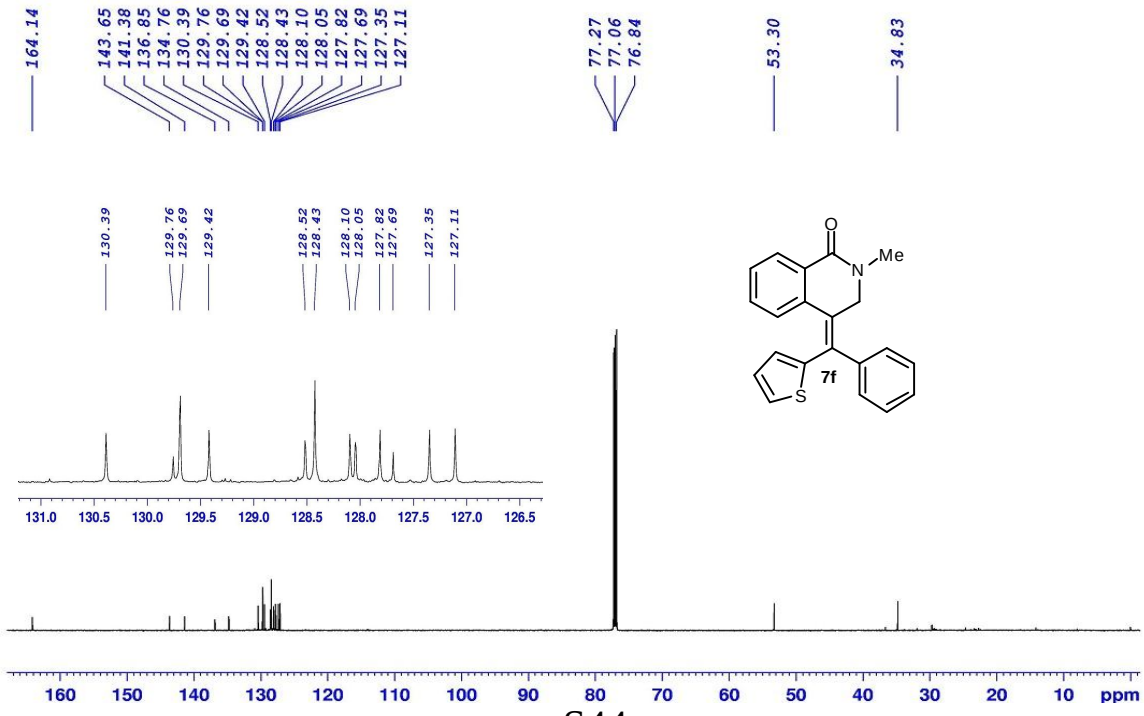
^{13}C NMR ($CDCl_3$, 75 MHz) spectrum of compound **7e**:



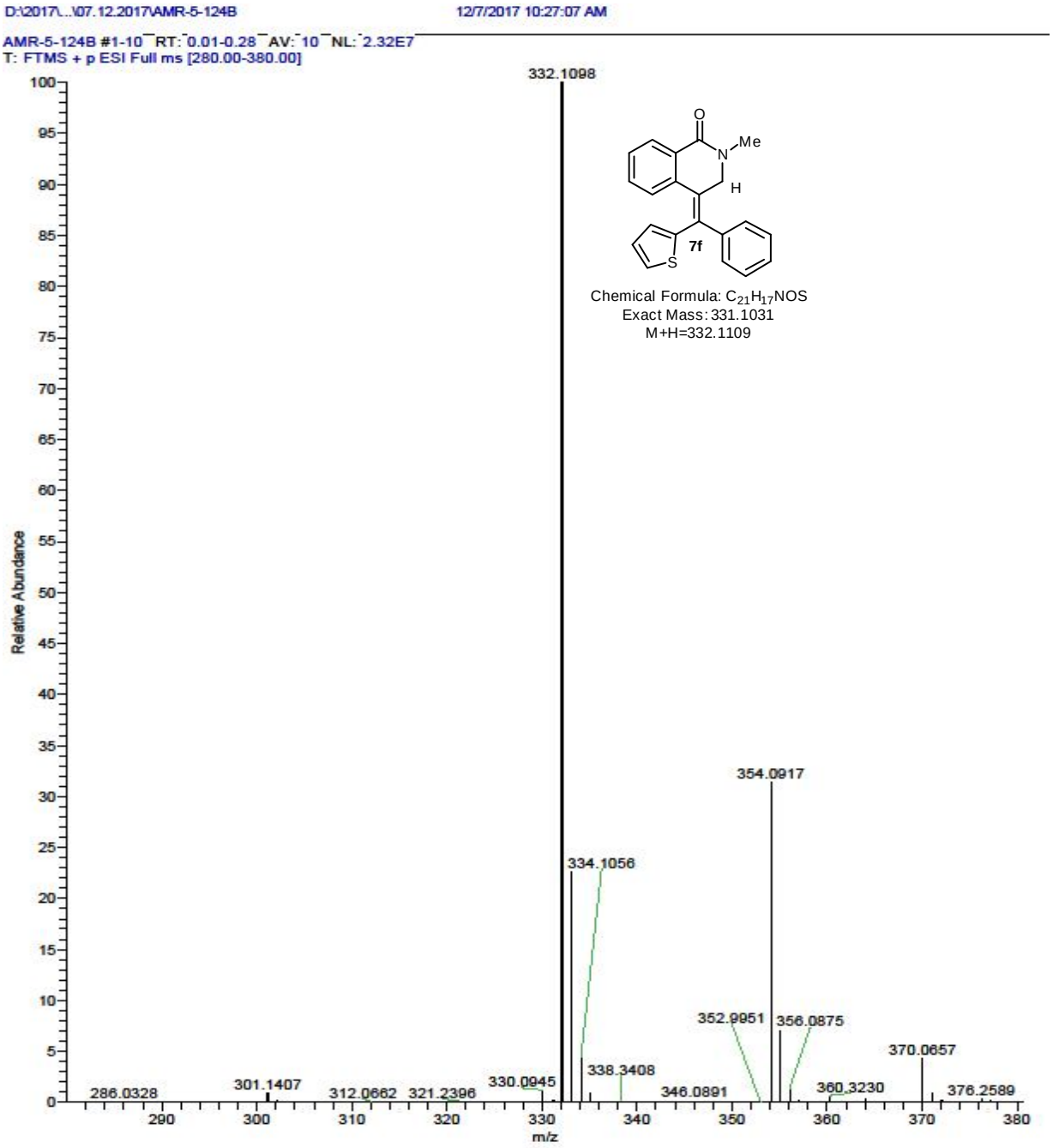
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **7f**:



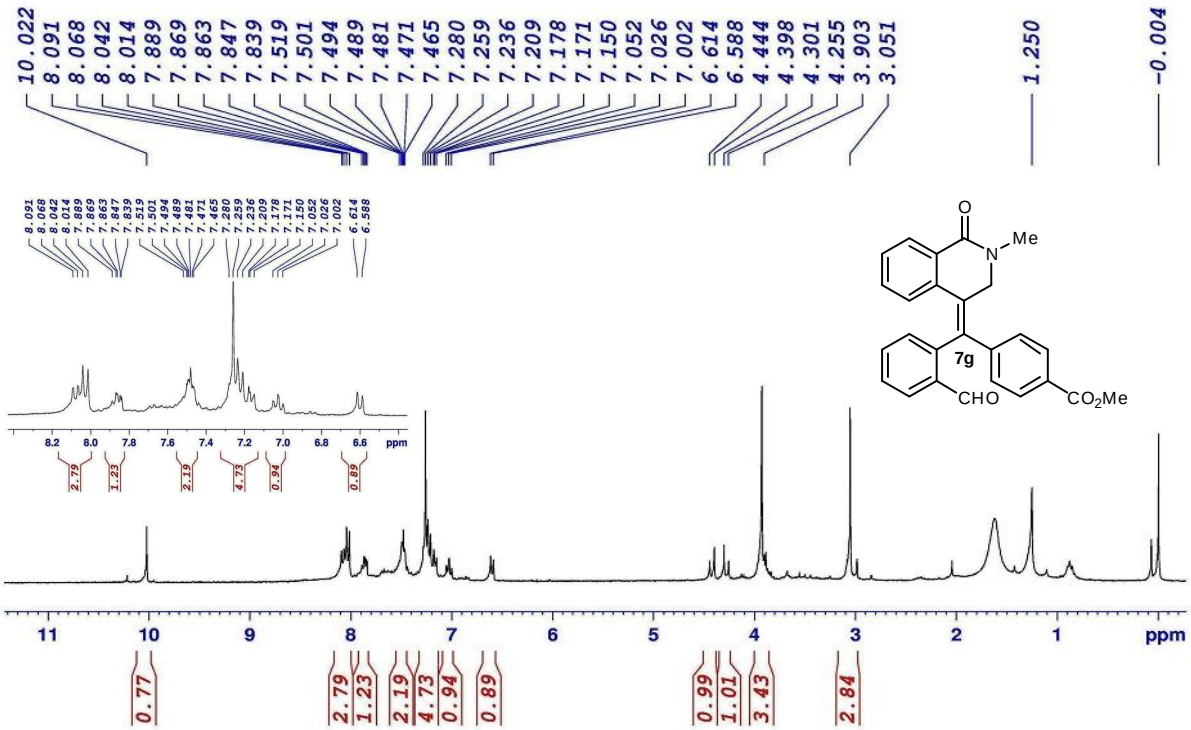
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of compound **7f**:



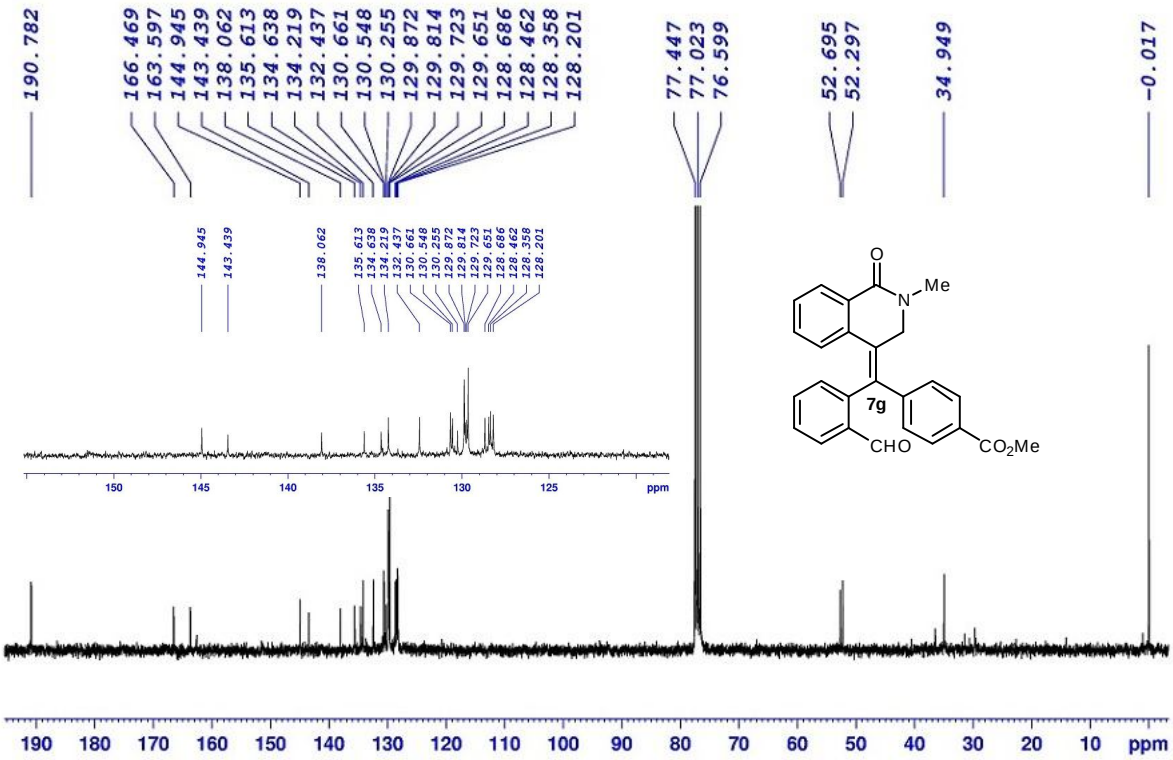
HRMS (ESI^{+}) spectrum of compound **7f**:



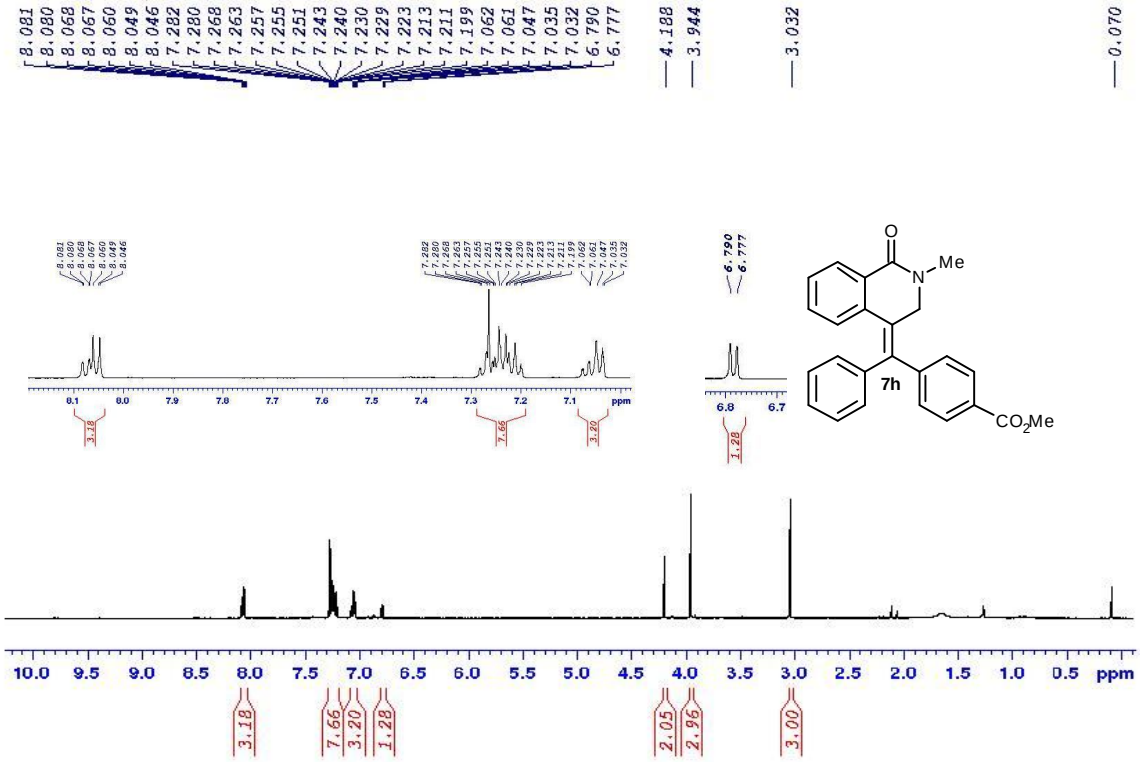
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **7g**:



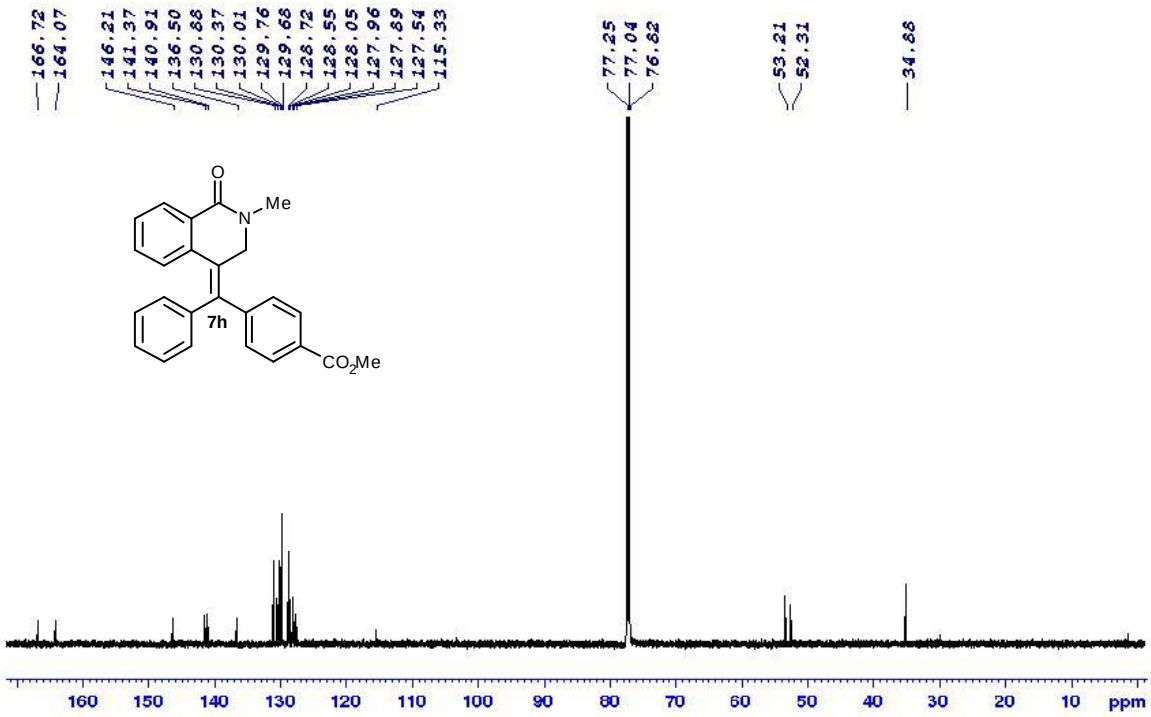
^{13}C NMR ($CDCl_3$, 75 MHz) spectrum of compound **7g**:



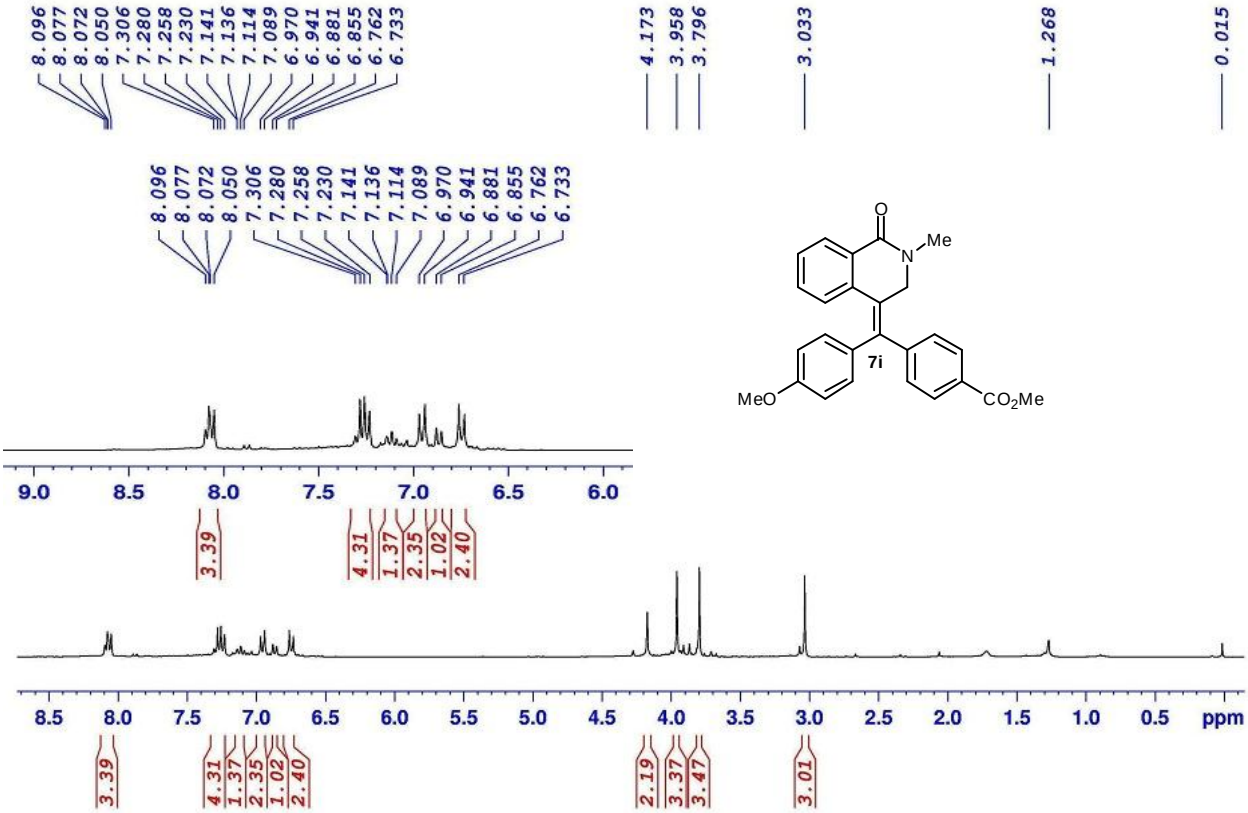
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **7h**:



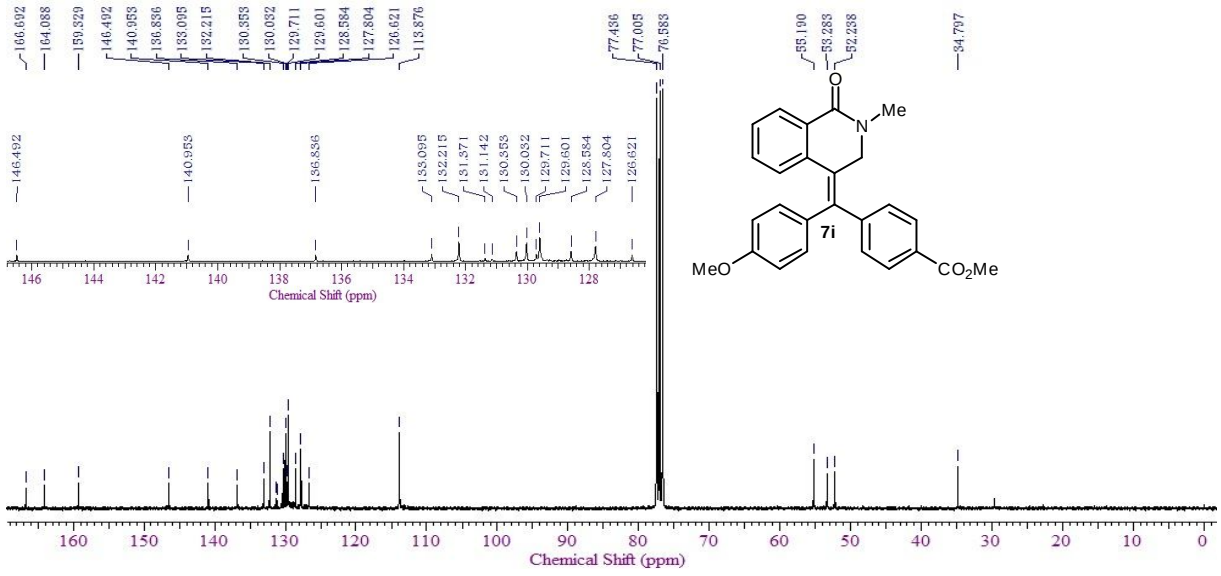
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of compound **7h**:



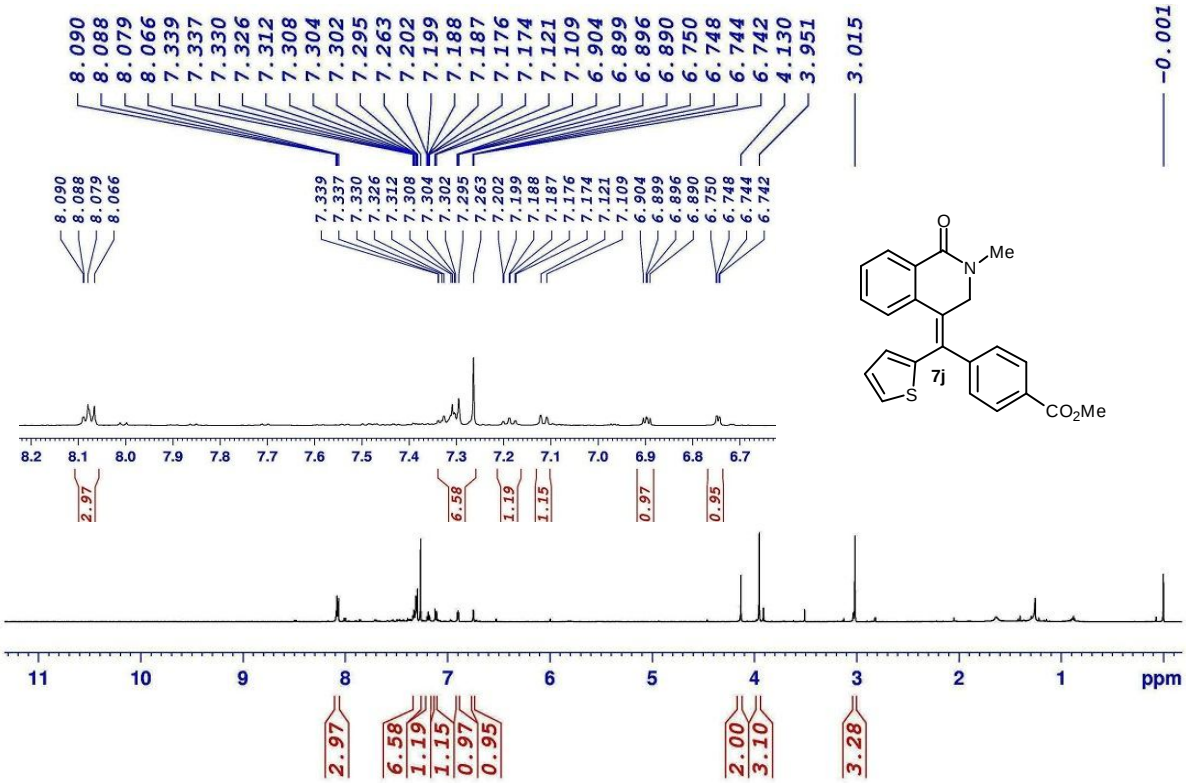
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **7i**:



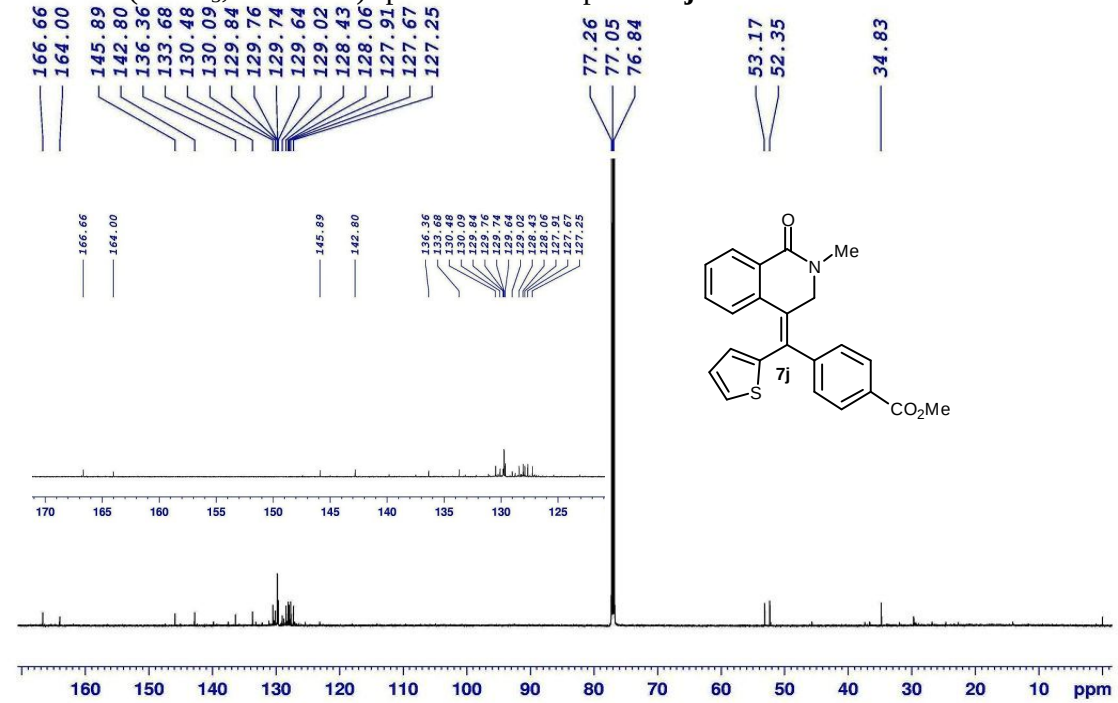
^{13}C NMR ($CDCl_3$, 75 MHz) spectrum of compound **7i**:



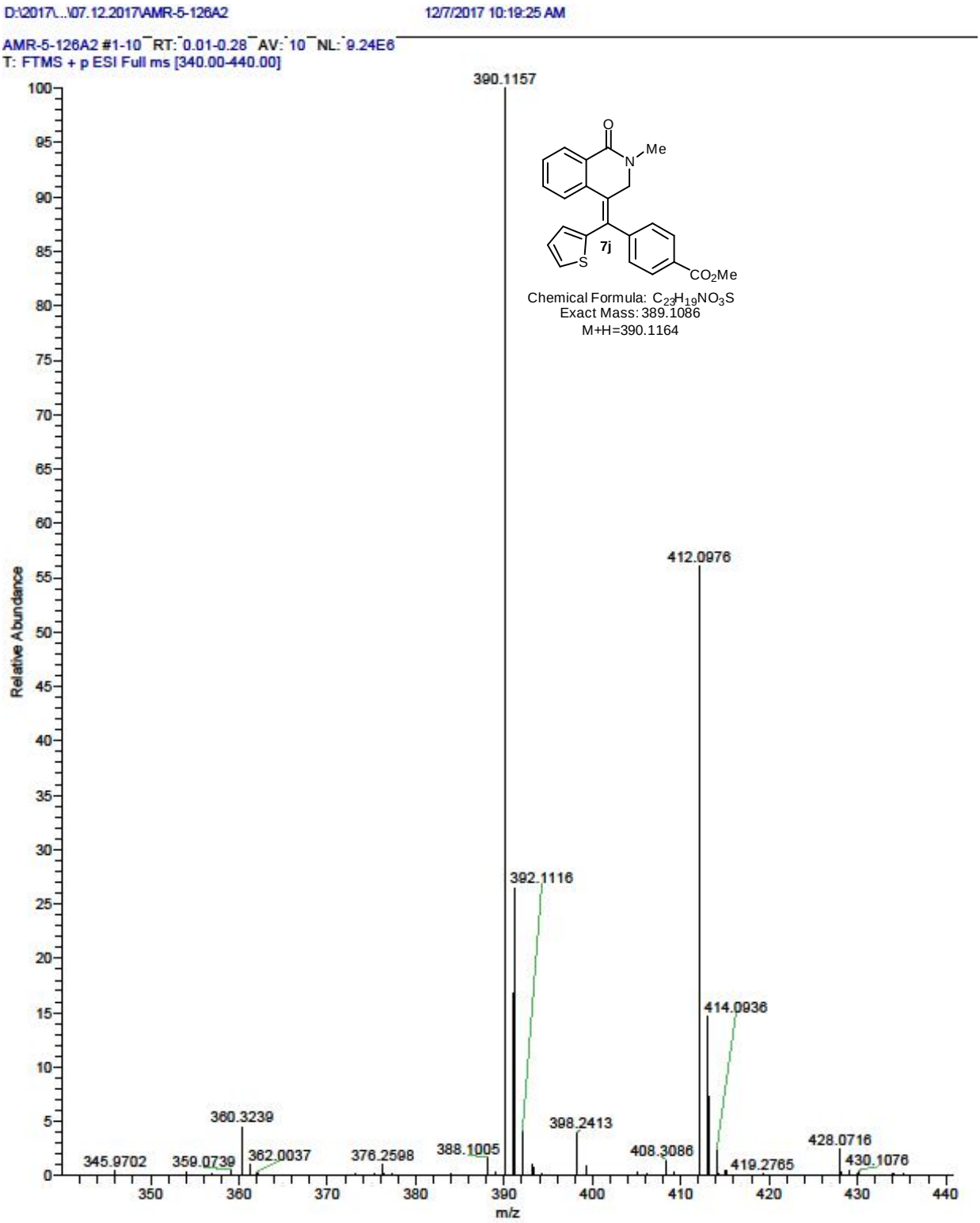
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **7j**:



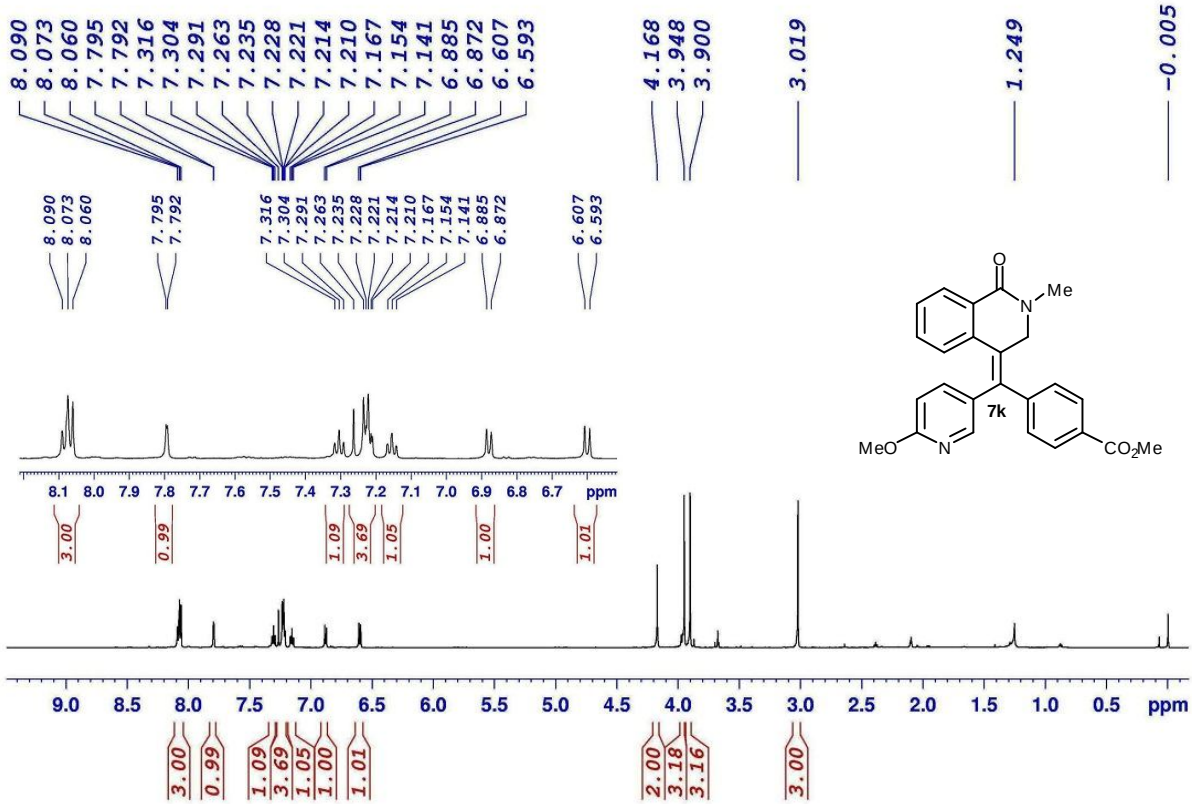
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of compound **7j**:



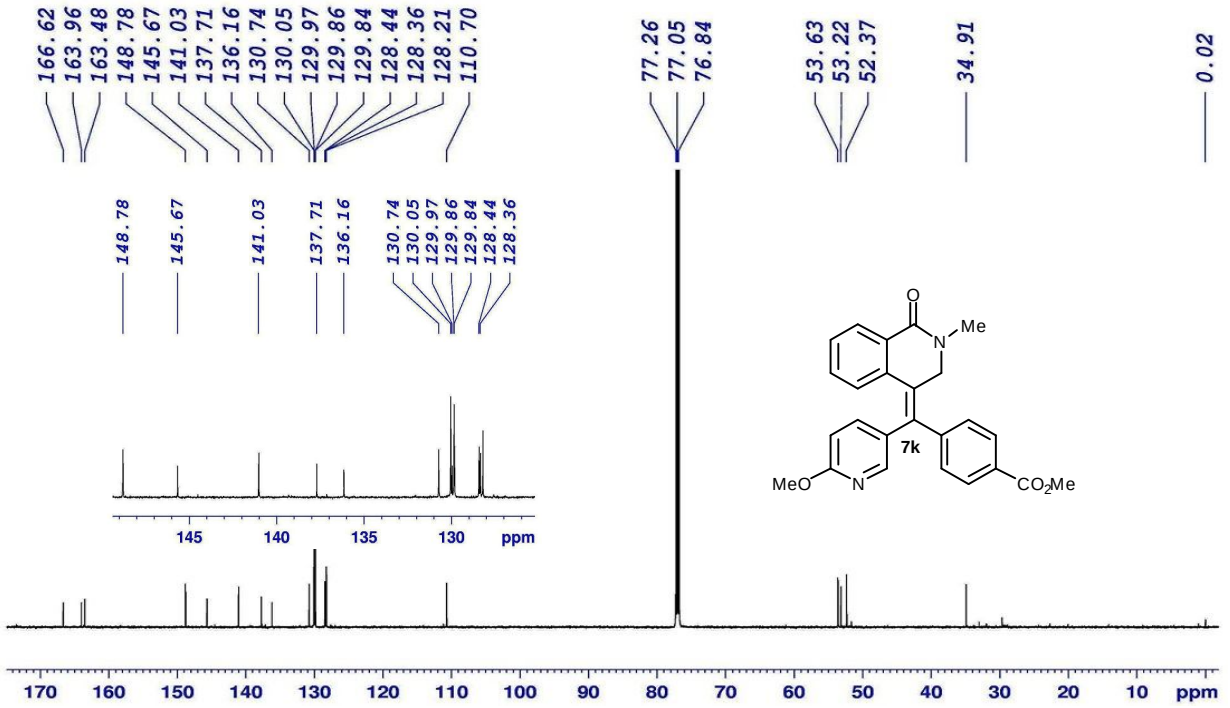
HRMS (ESI^{+}) spectrum of compound **7j** :



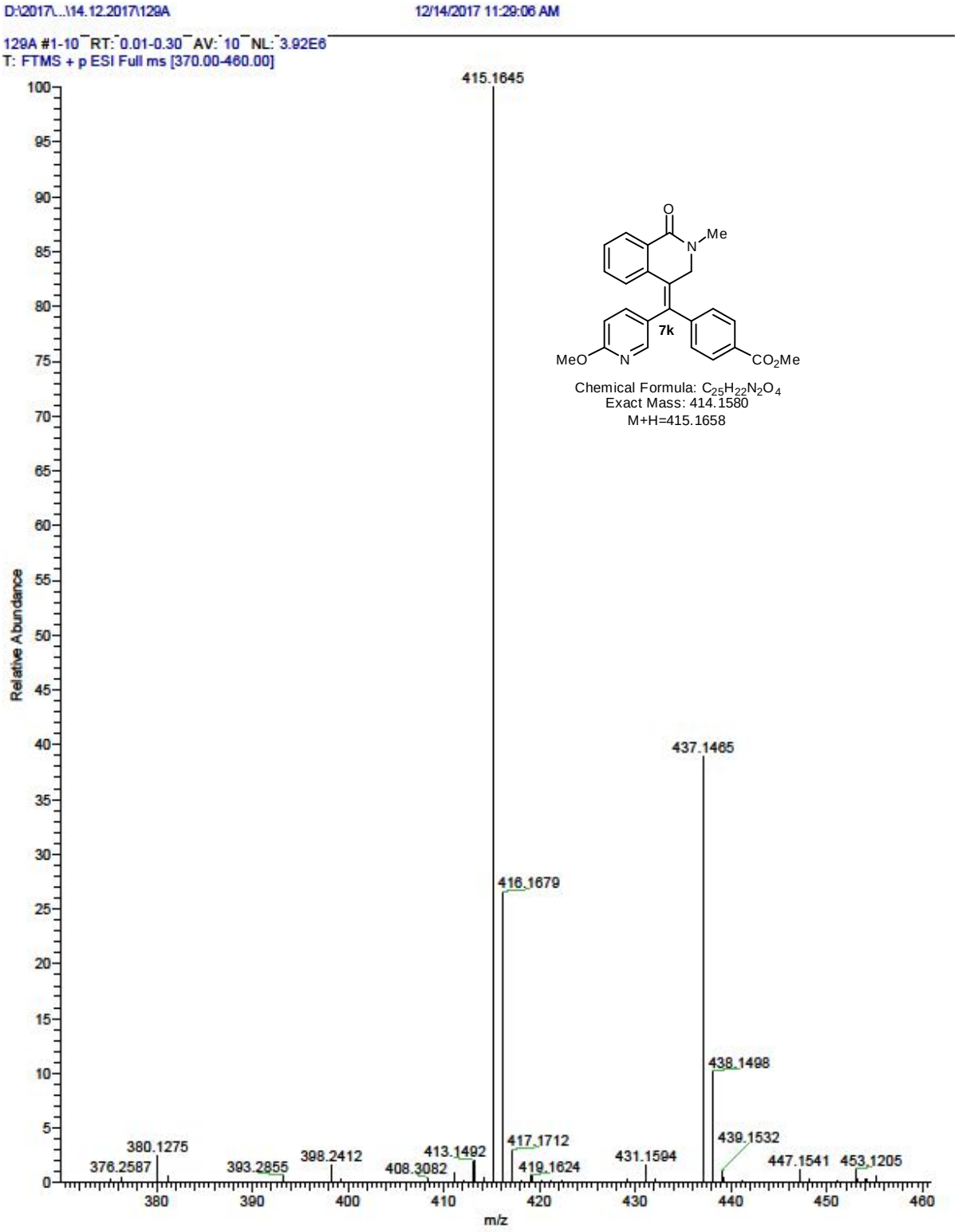
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **7k**:



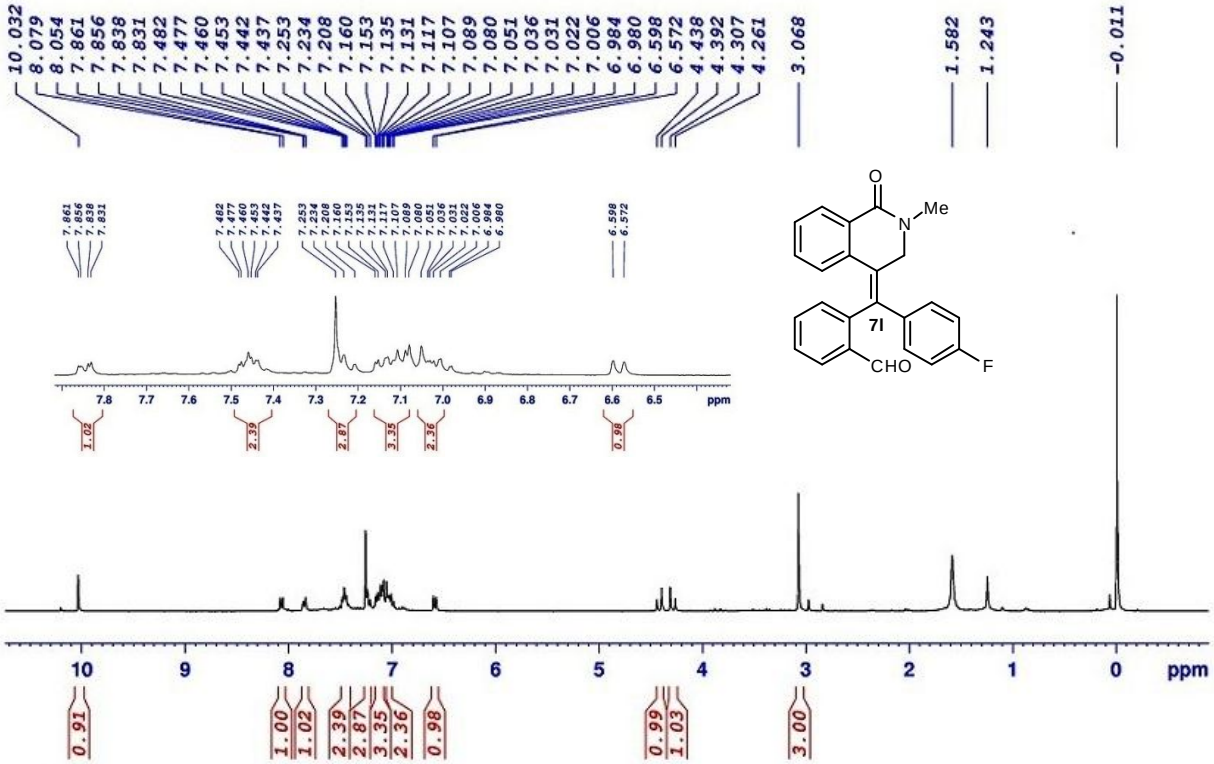
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of compound **7k**:



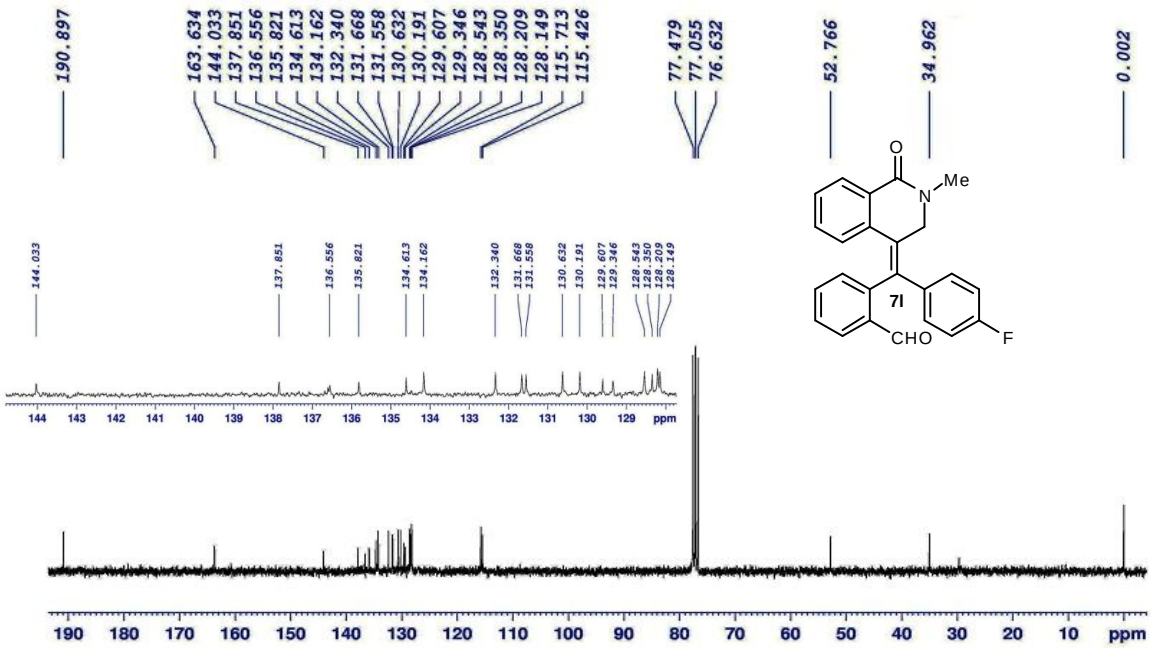
HRMS (ESI$^+$) spectrum of compound **7k**:



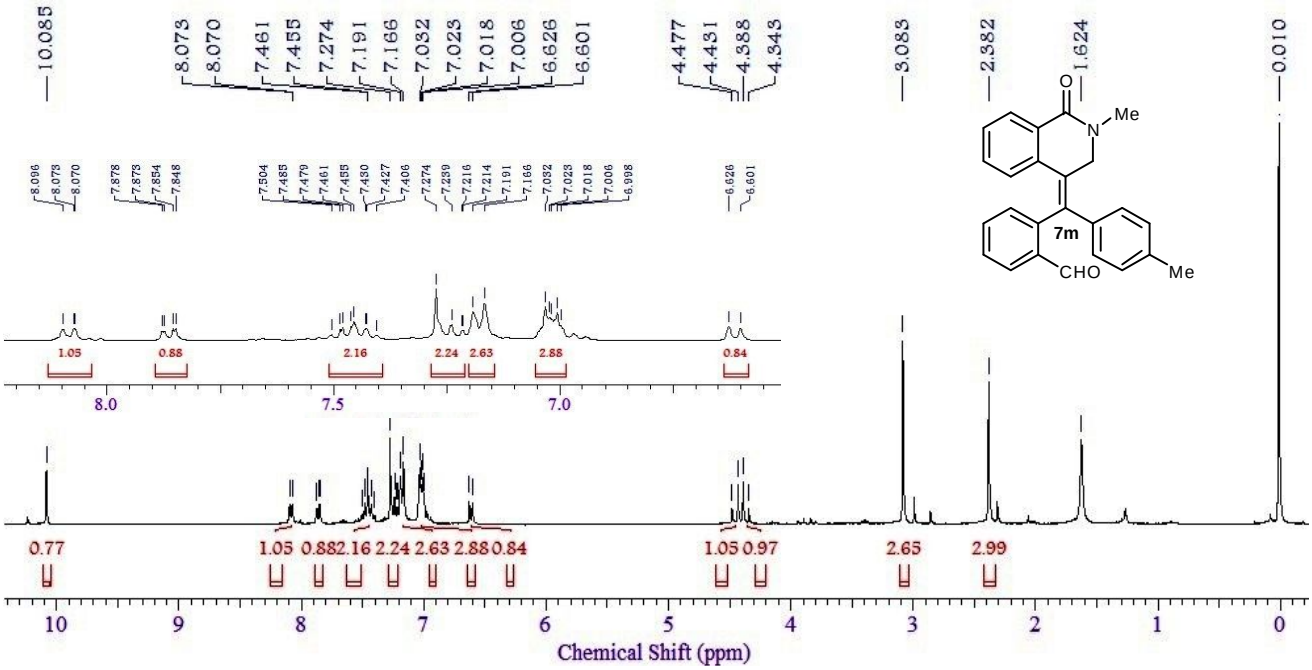
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **7l**:



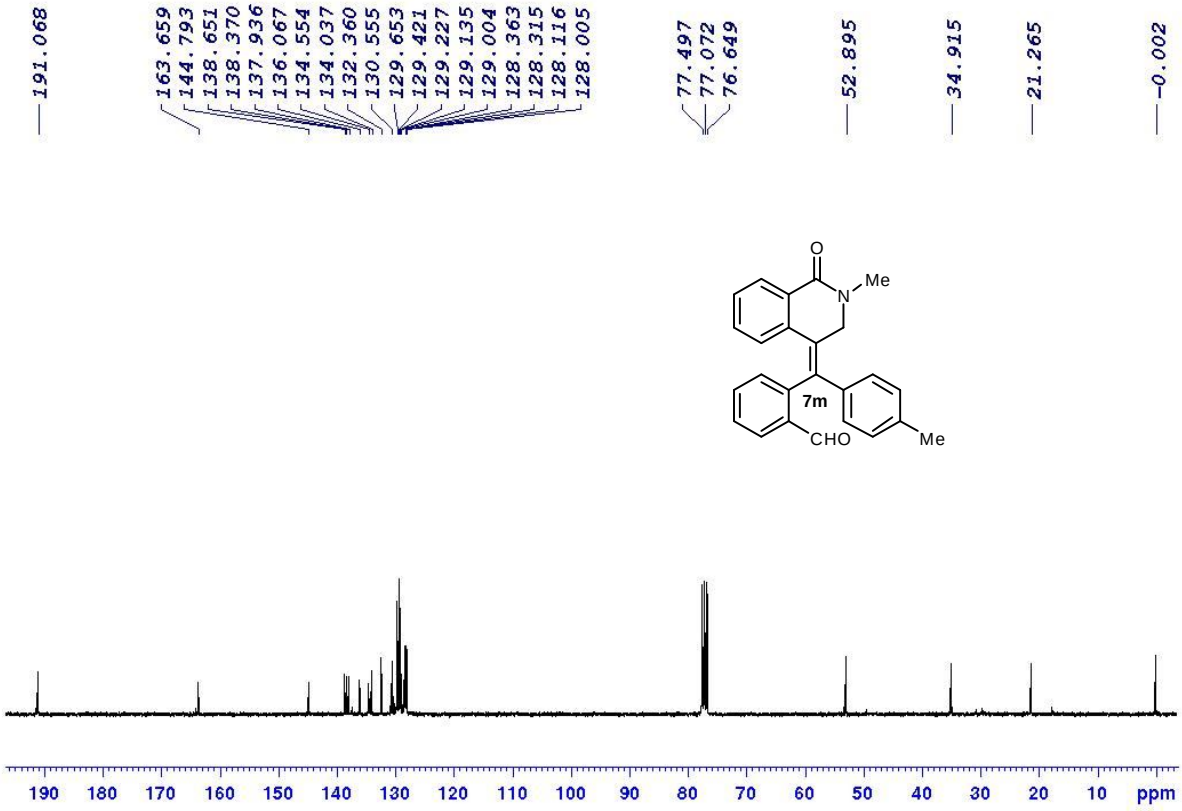
^{13}C NMR ($CDCl_3$, 75 MHz) spectrum of compound **7l**:



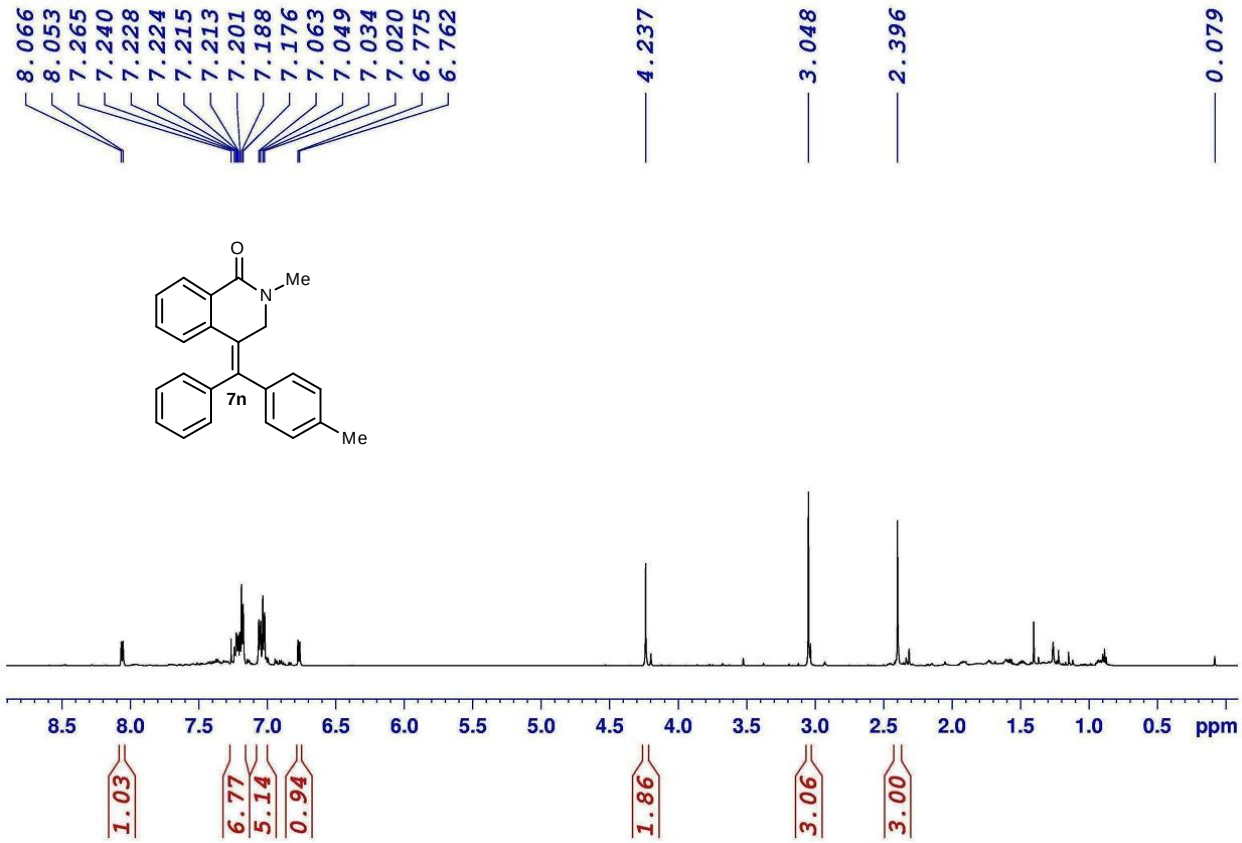
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **7m**:



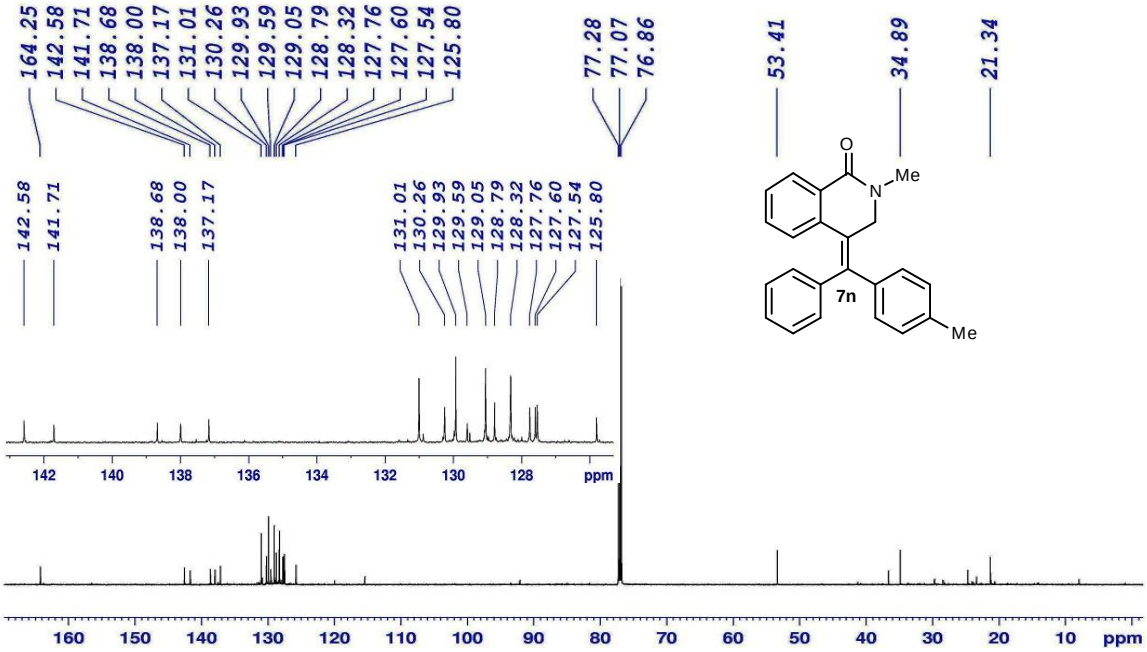
^{13}C NMR ($CDCl_3$, 75 MHz) spectrum of compound **7m**:



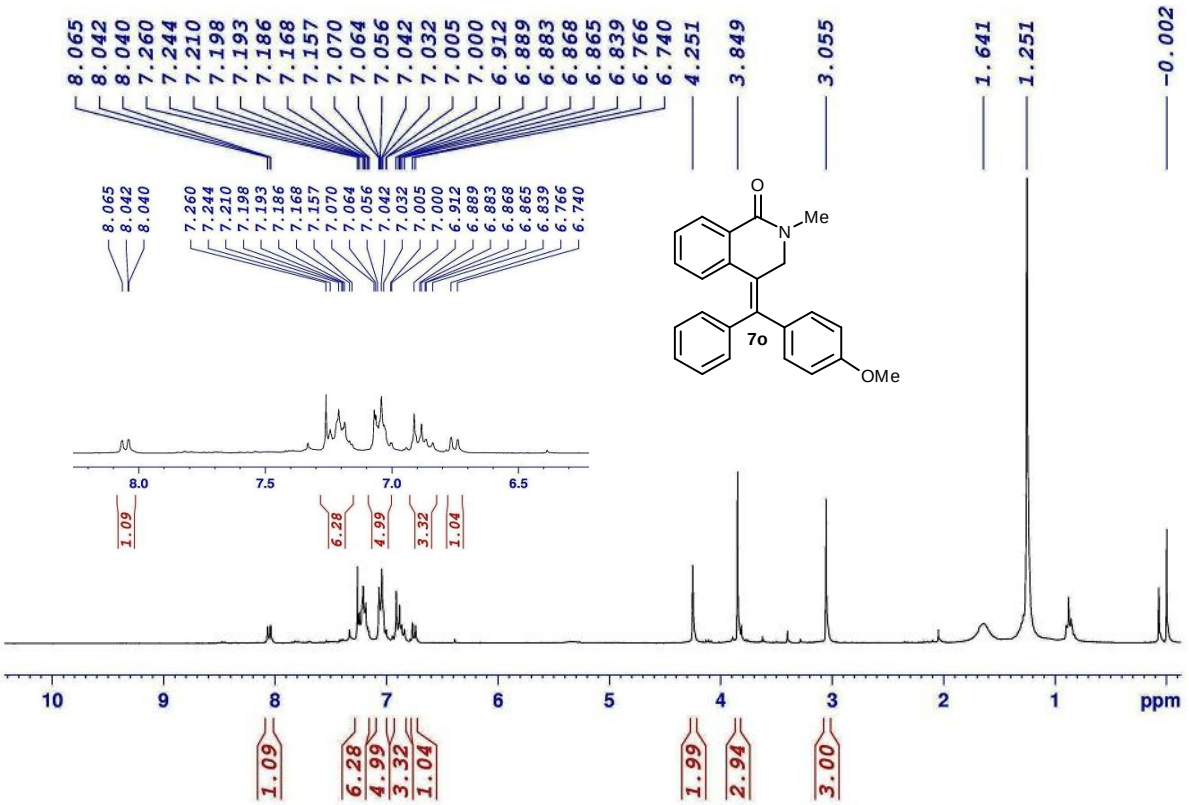
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **7n**:



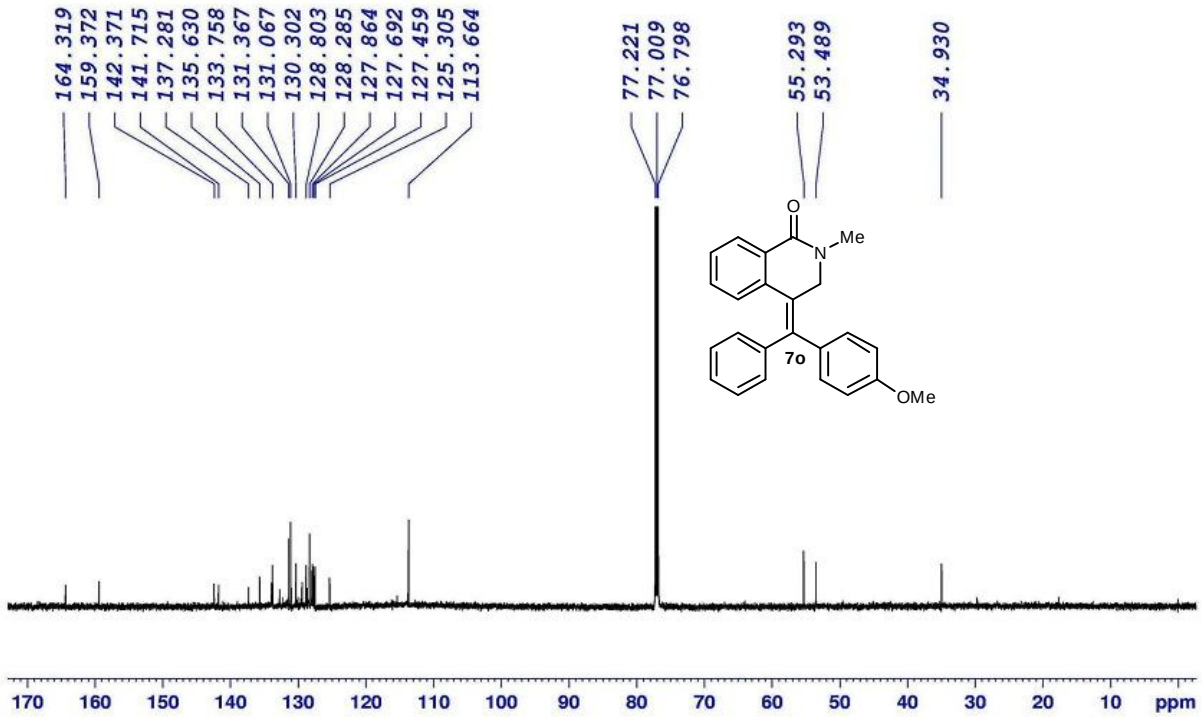
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of compound **7n**:



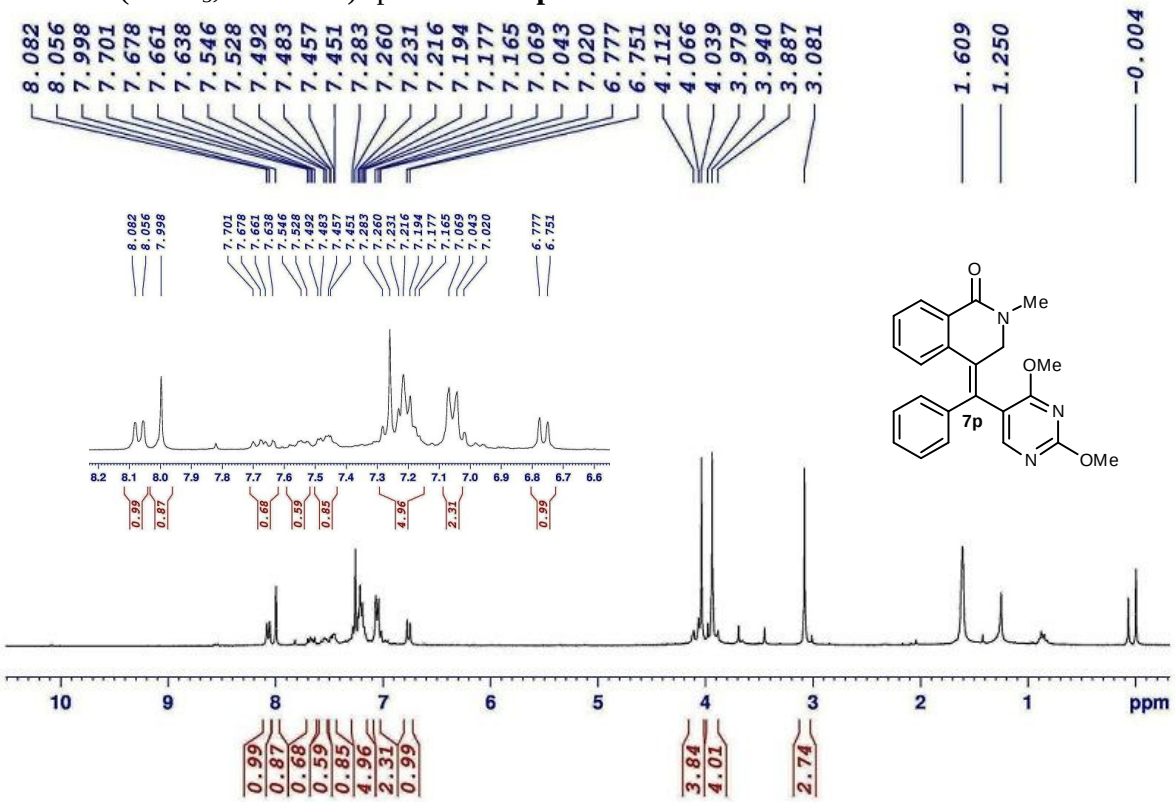
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **7o**:



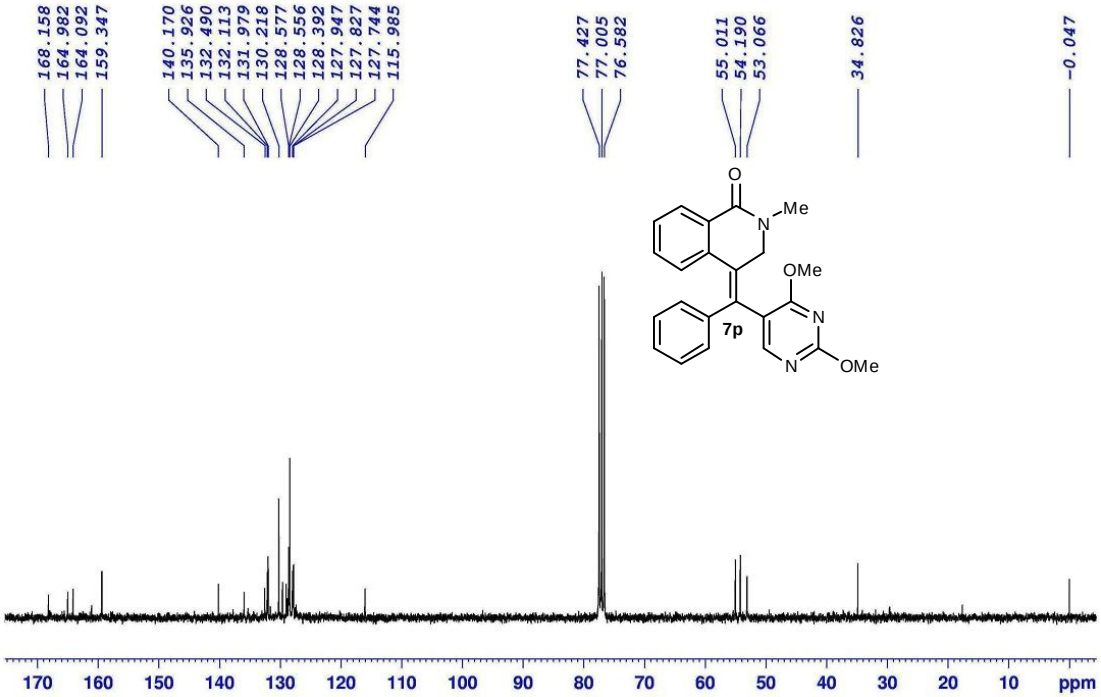
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of compound **7o**:



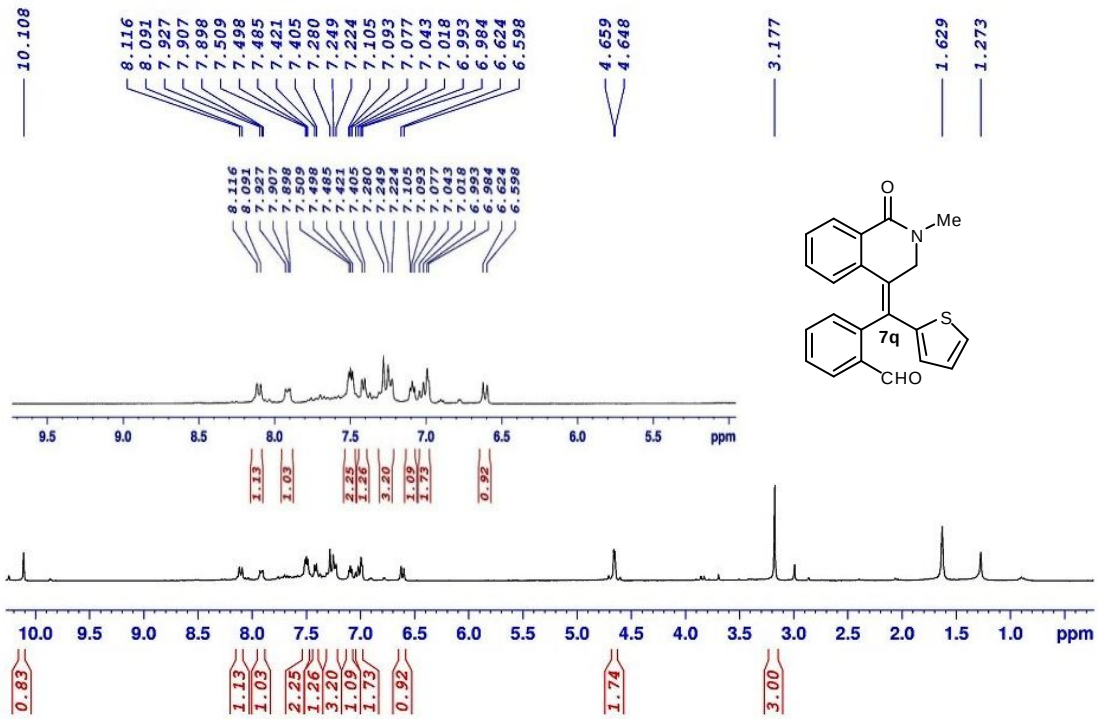
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **7p**:



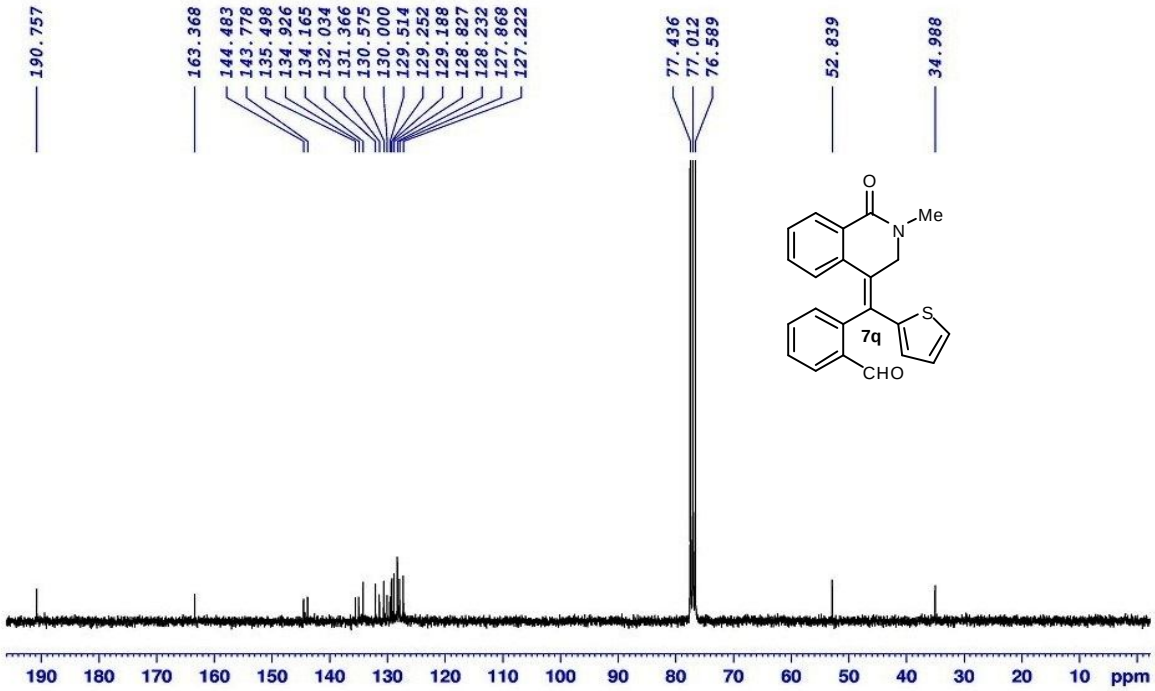
^{13}C NMR ($CDCl_3$, 75 MHz) spectrum of compound **7p**:



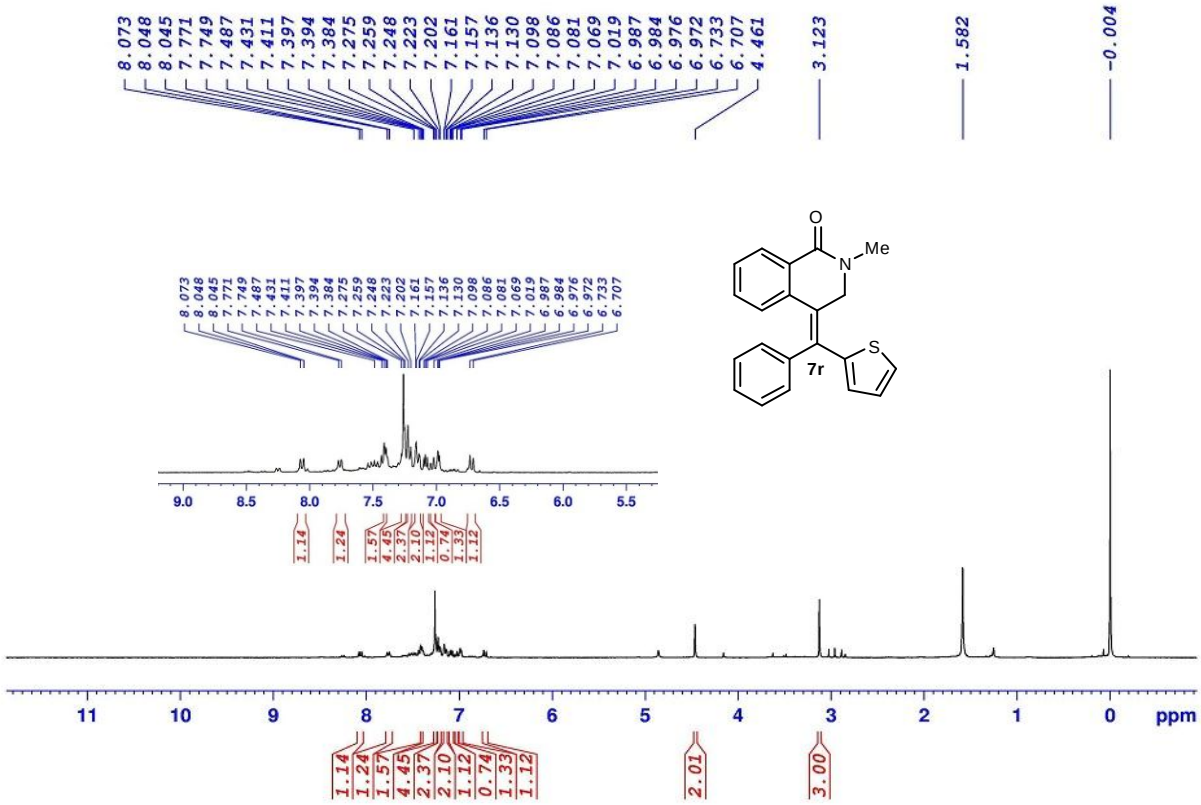
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **7q**:



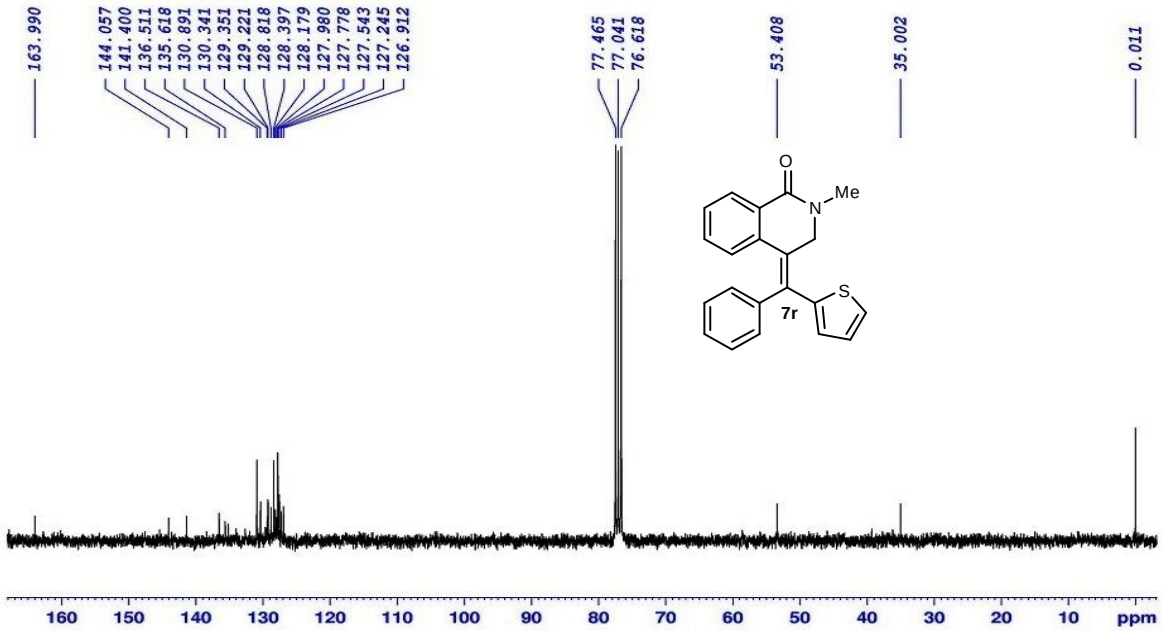
^{13}C NMR ($CDCl_3$, 75 MHz) spectrum of compound **7q**:



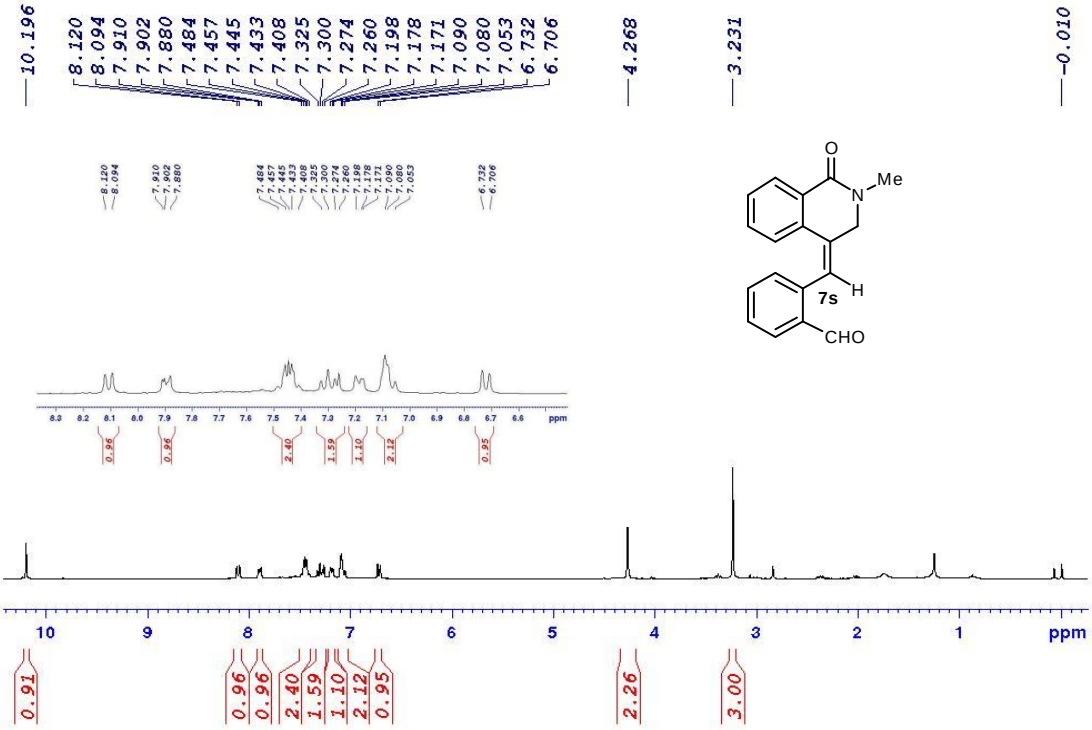
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **7r**:



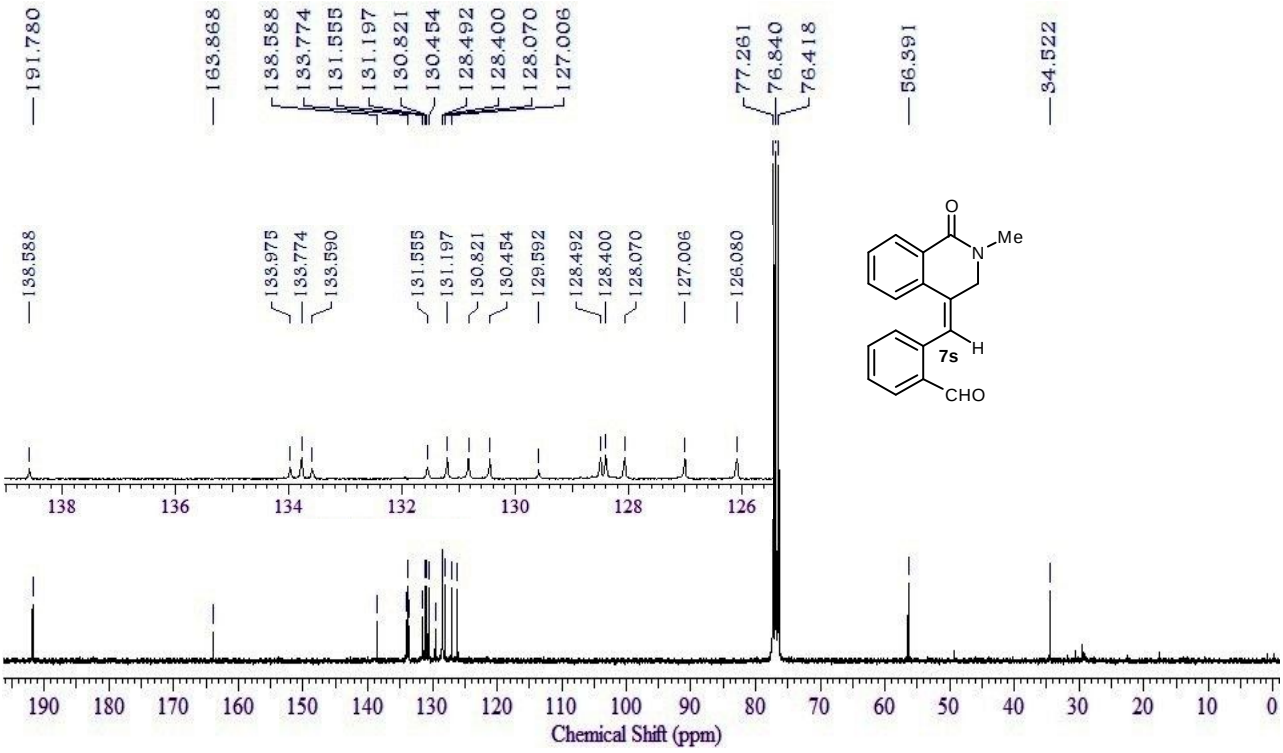
^{13}C NMR ($CDCl_3$, 75 MHz) spectrum of compound **7r**:



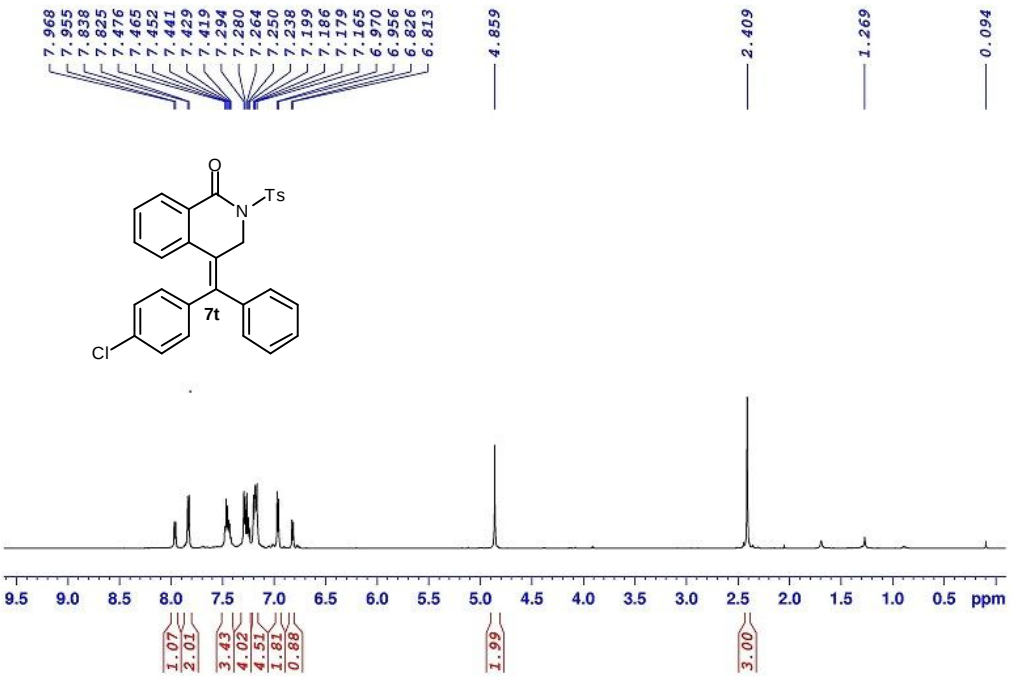
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **7s**:



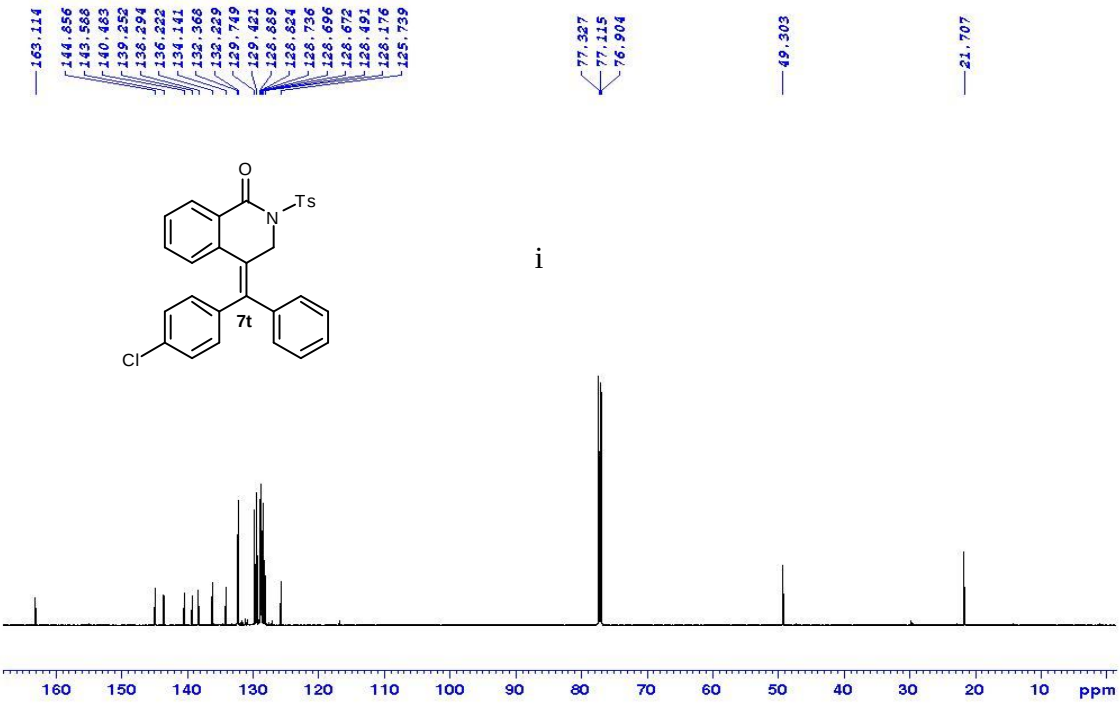
^{13}C NMR ($CDCl_3$, 75 MHz) spectrum of compound **7s**:



^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **7t**:

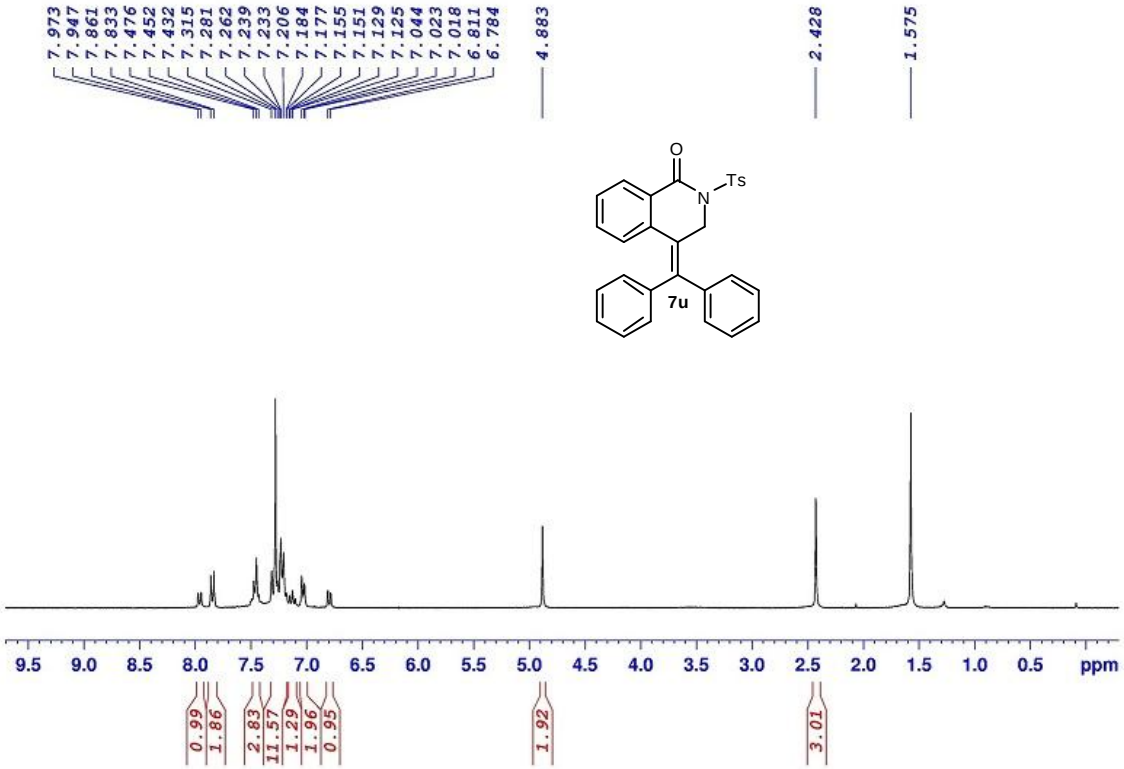


^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of **7t**:

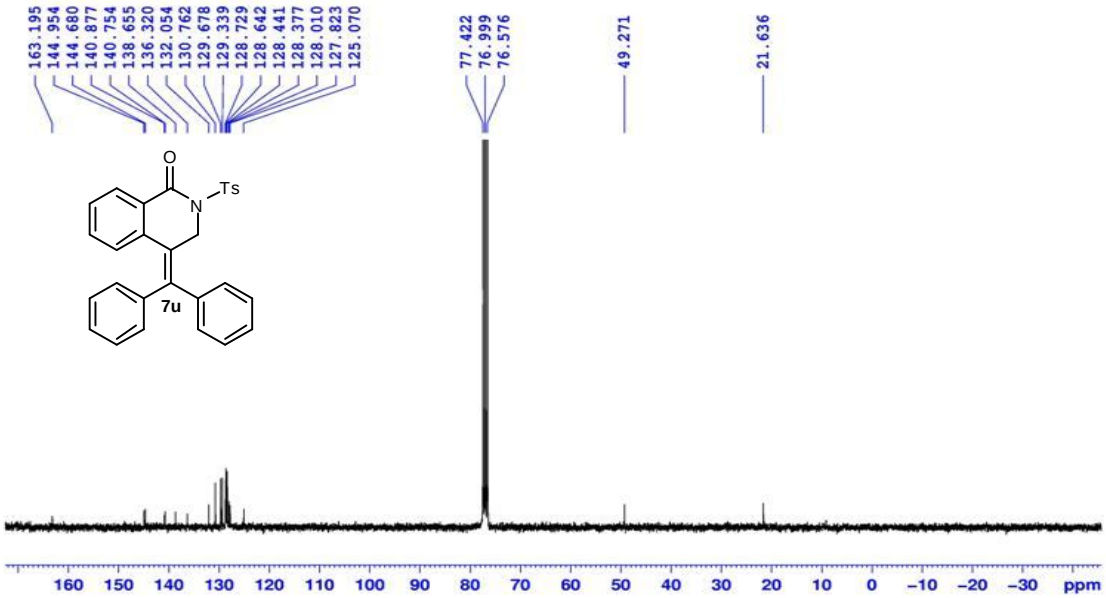


i

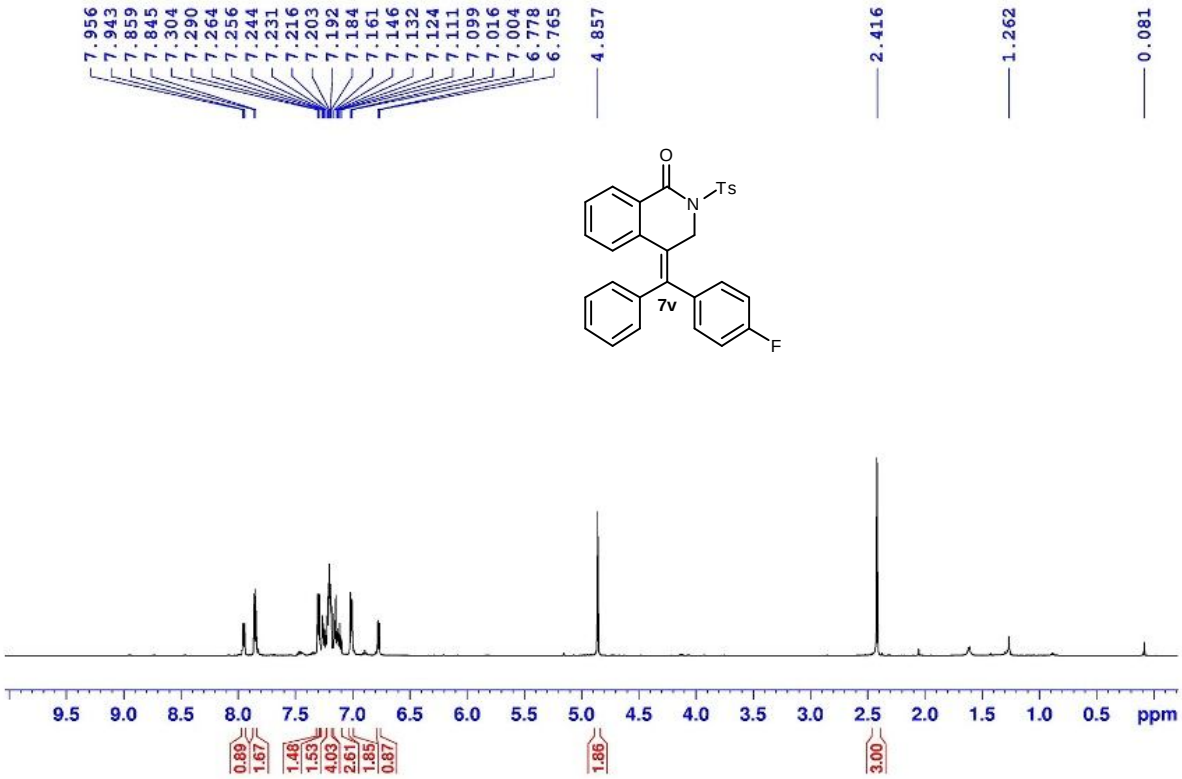
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **7u**:



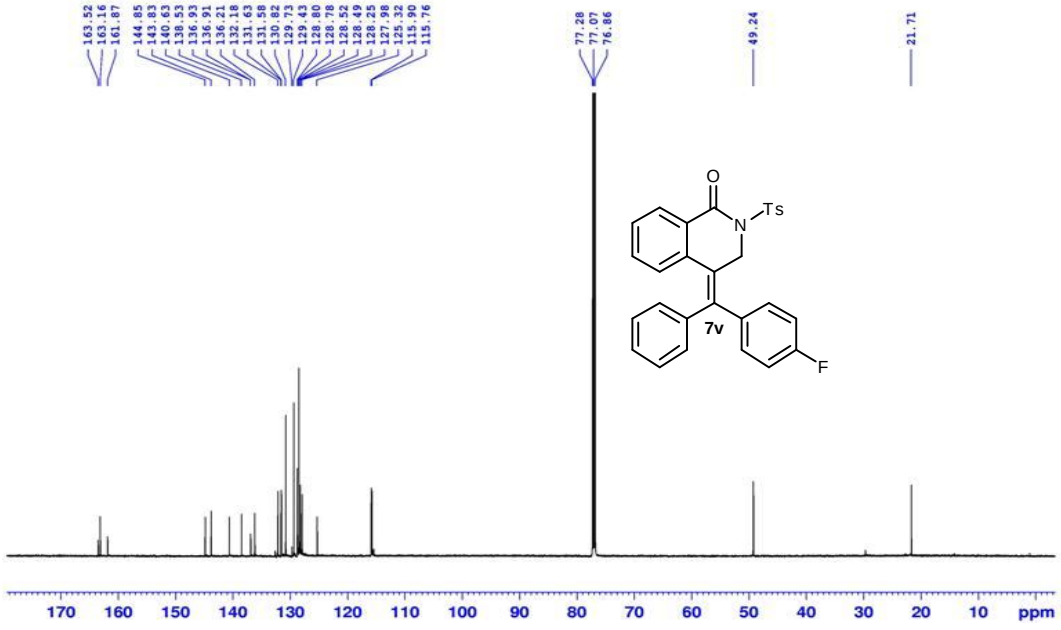
^{13}C NMR ($CDCl_3$, 75 MHz) spectrum of compound **7u**:



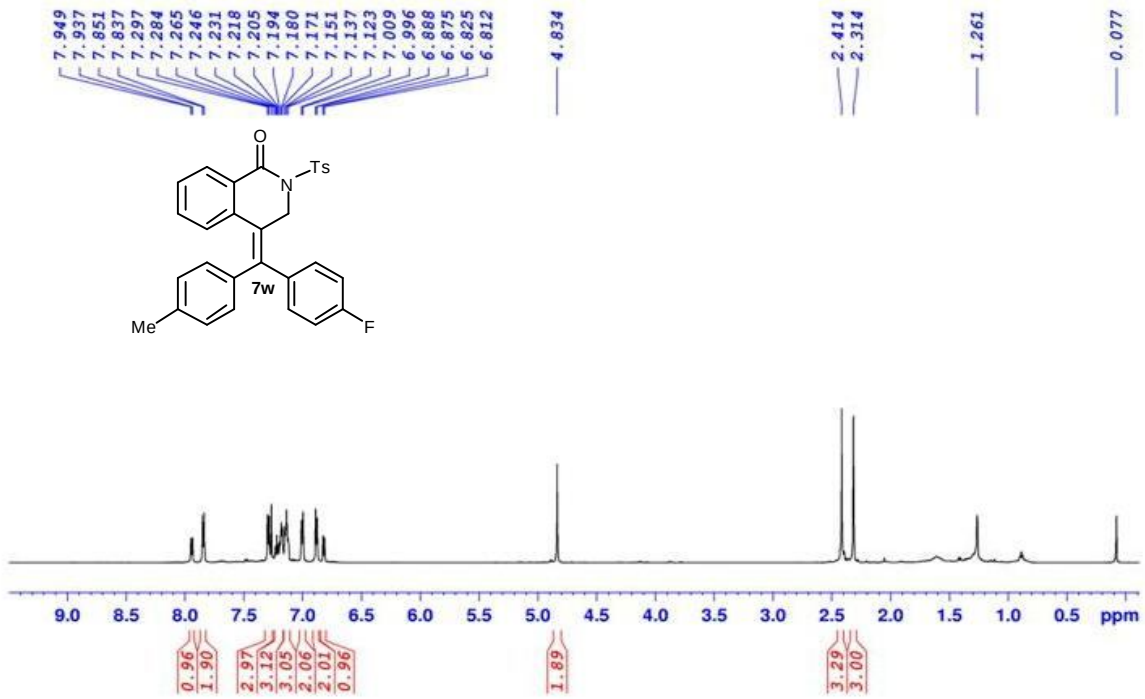
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **7v**:



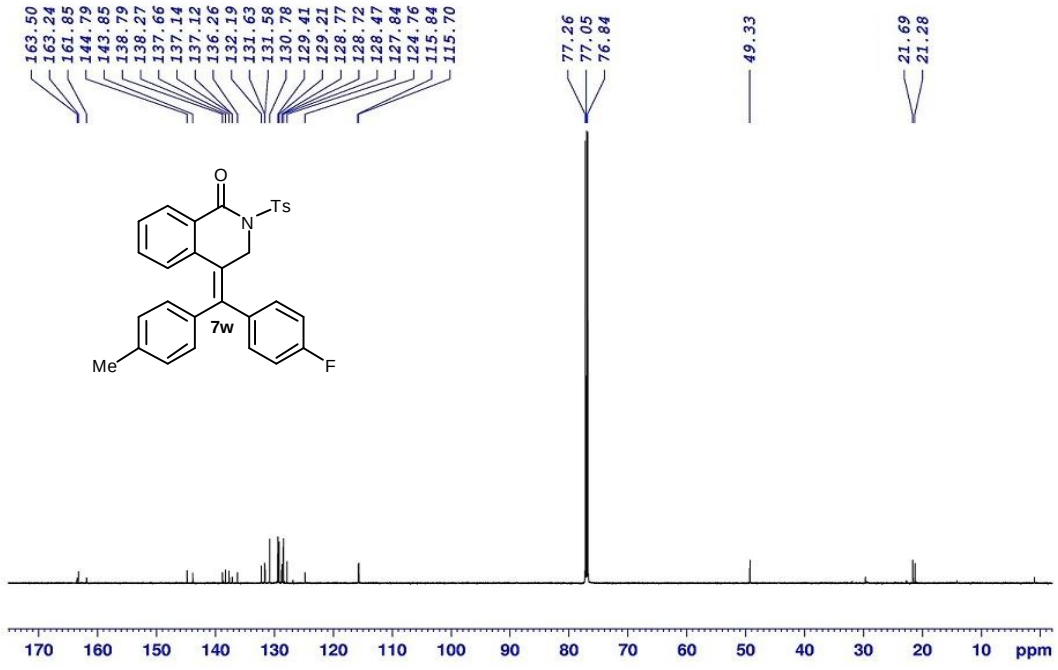
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of **7v**:



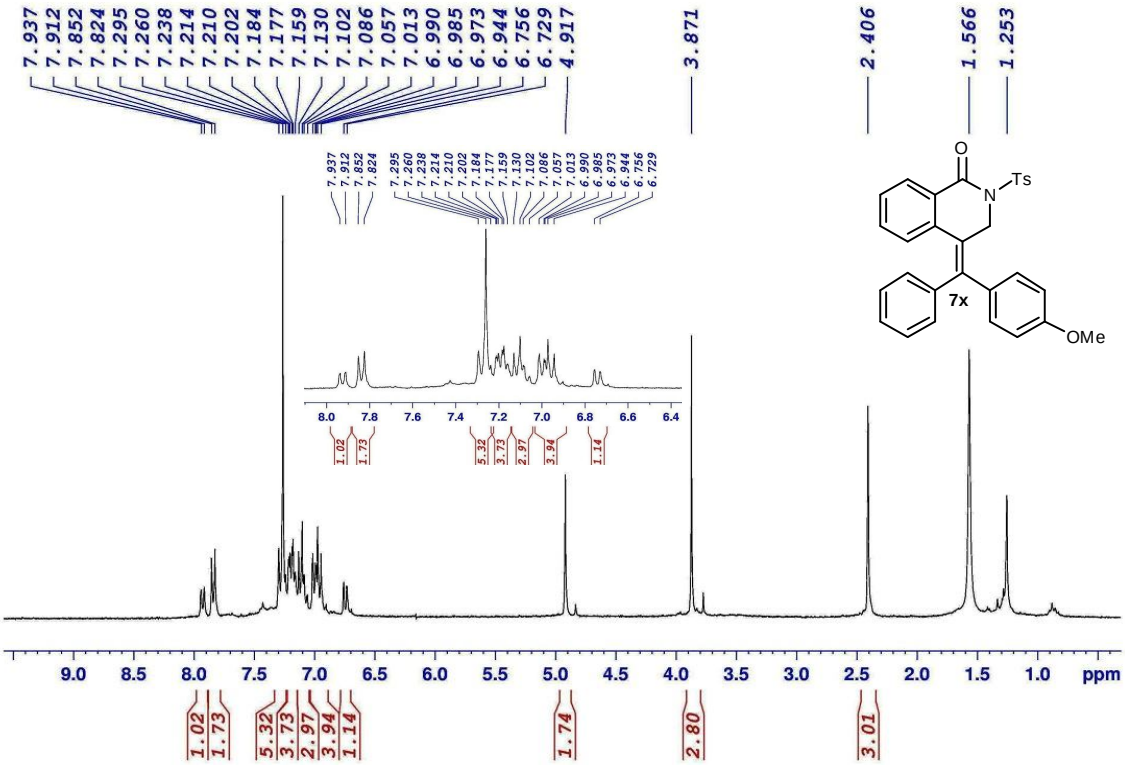
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **7w**:



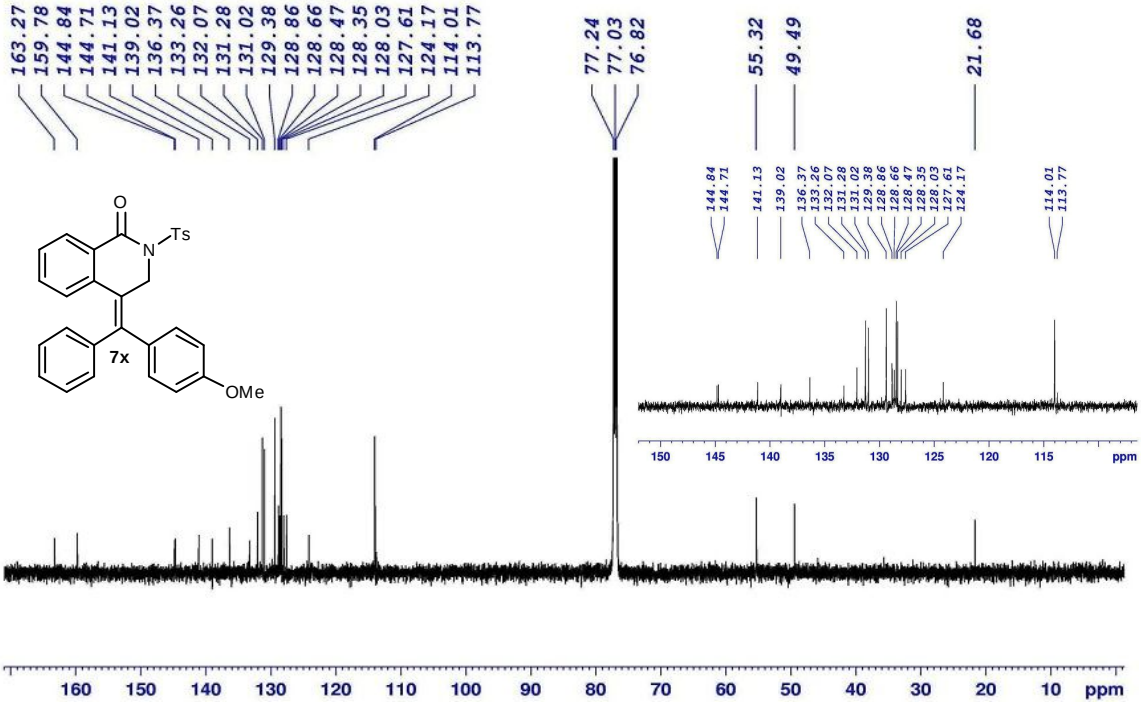
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum **7w**:



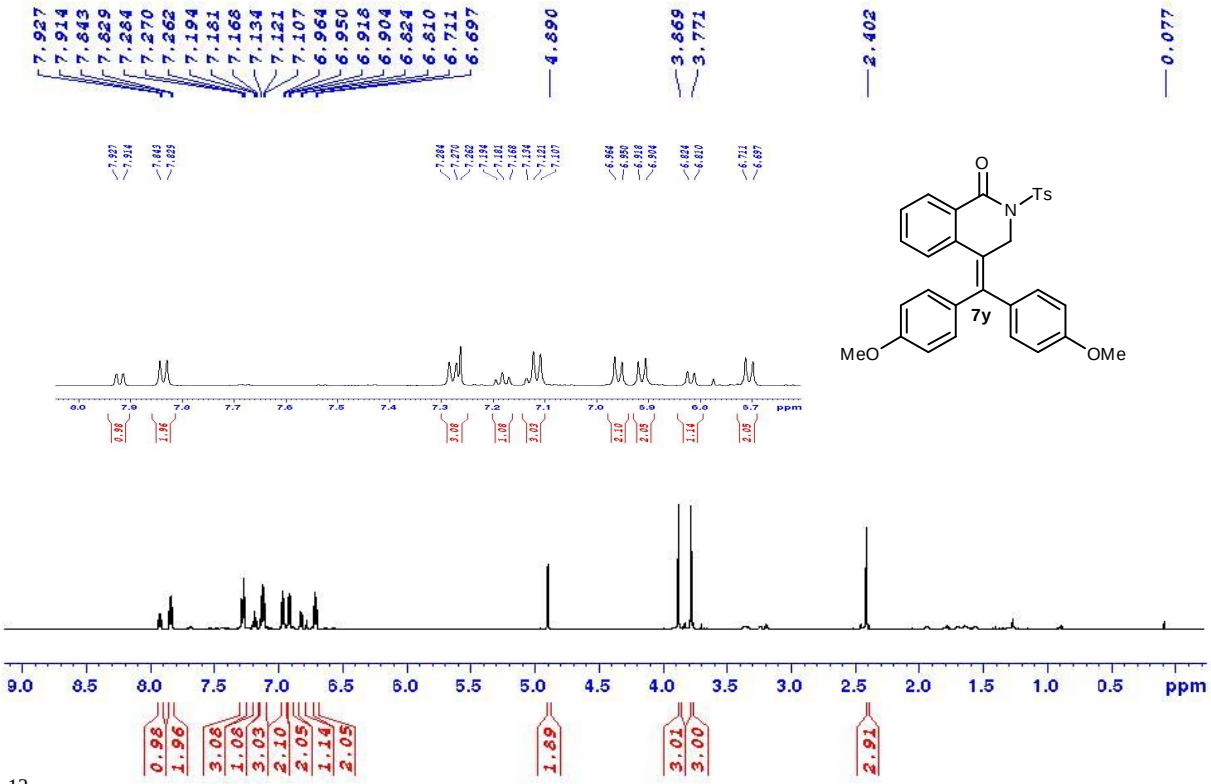
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **7x**:



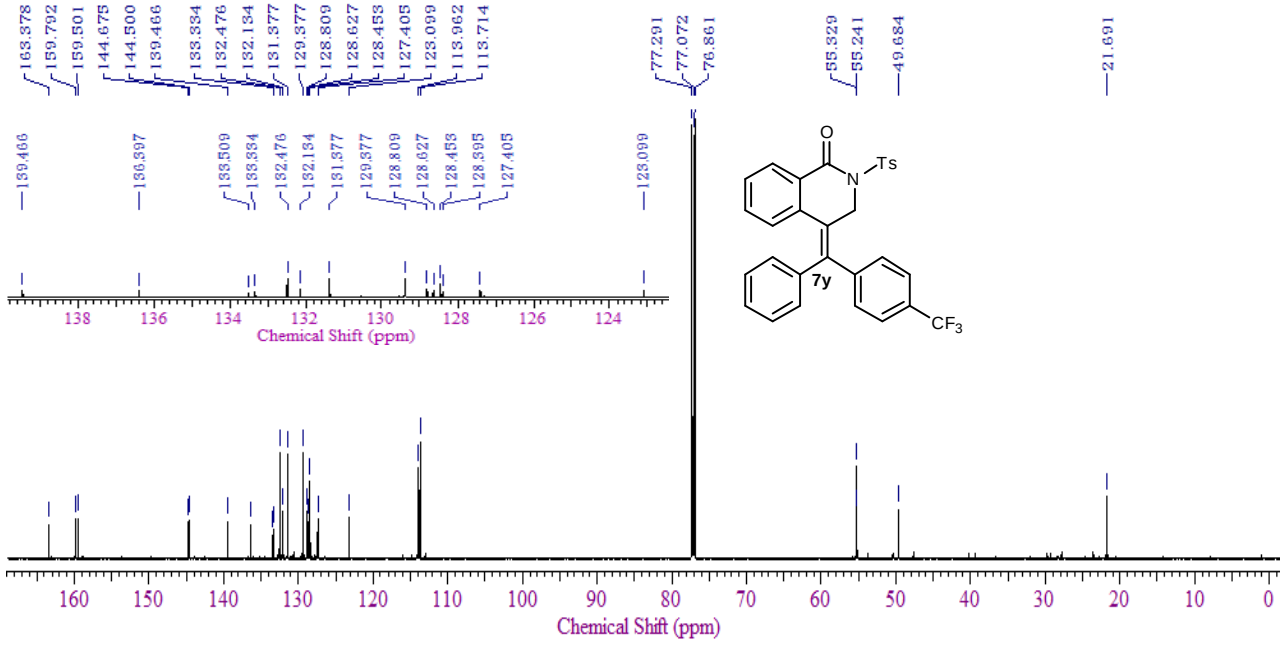
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of **7x**:



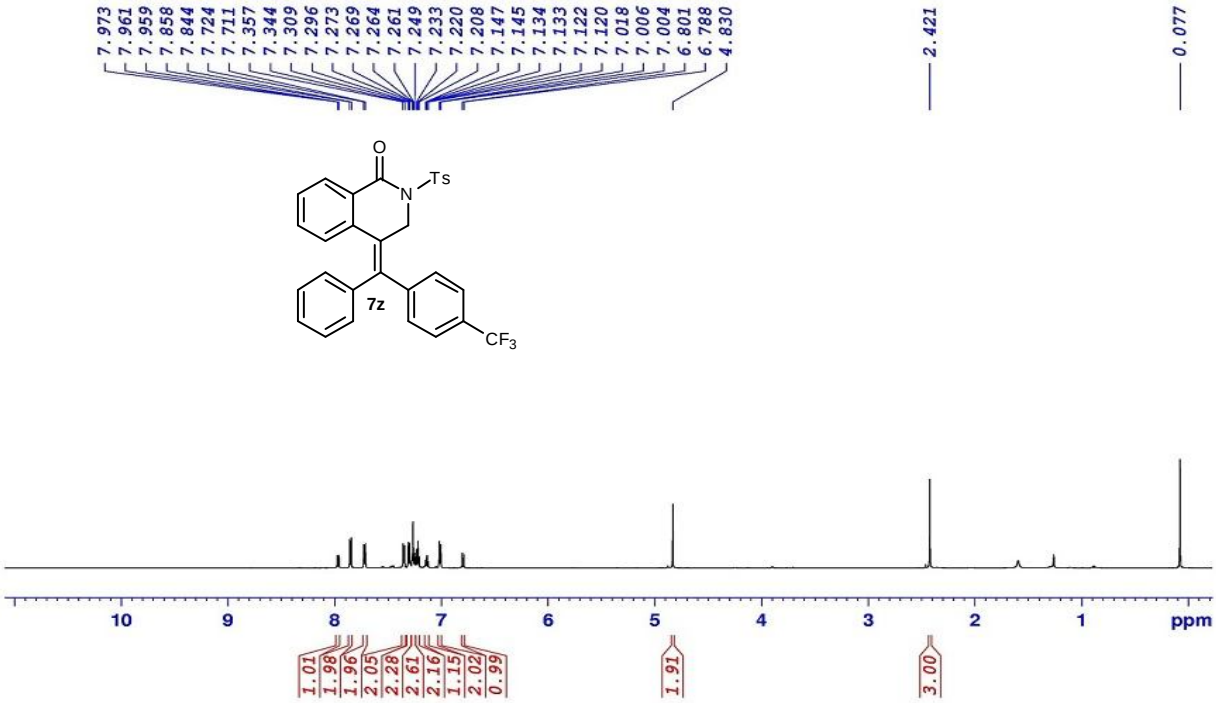
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **7y**:



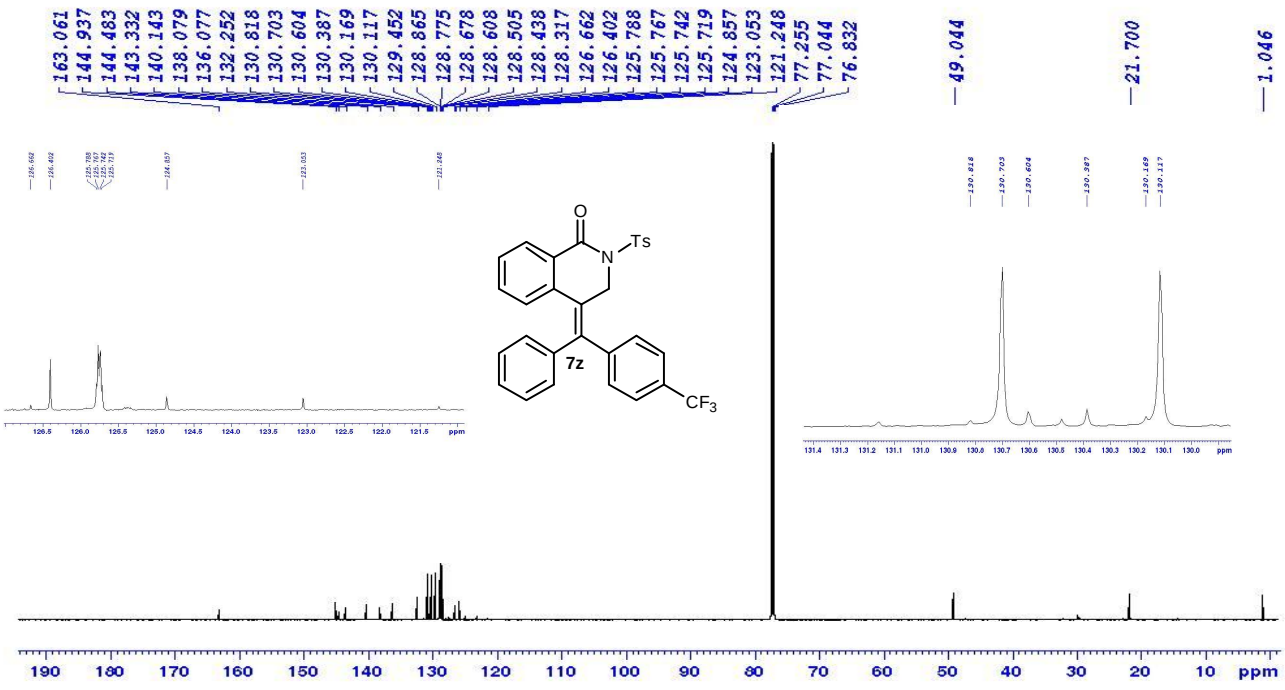
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of **7y**:



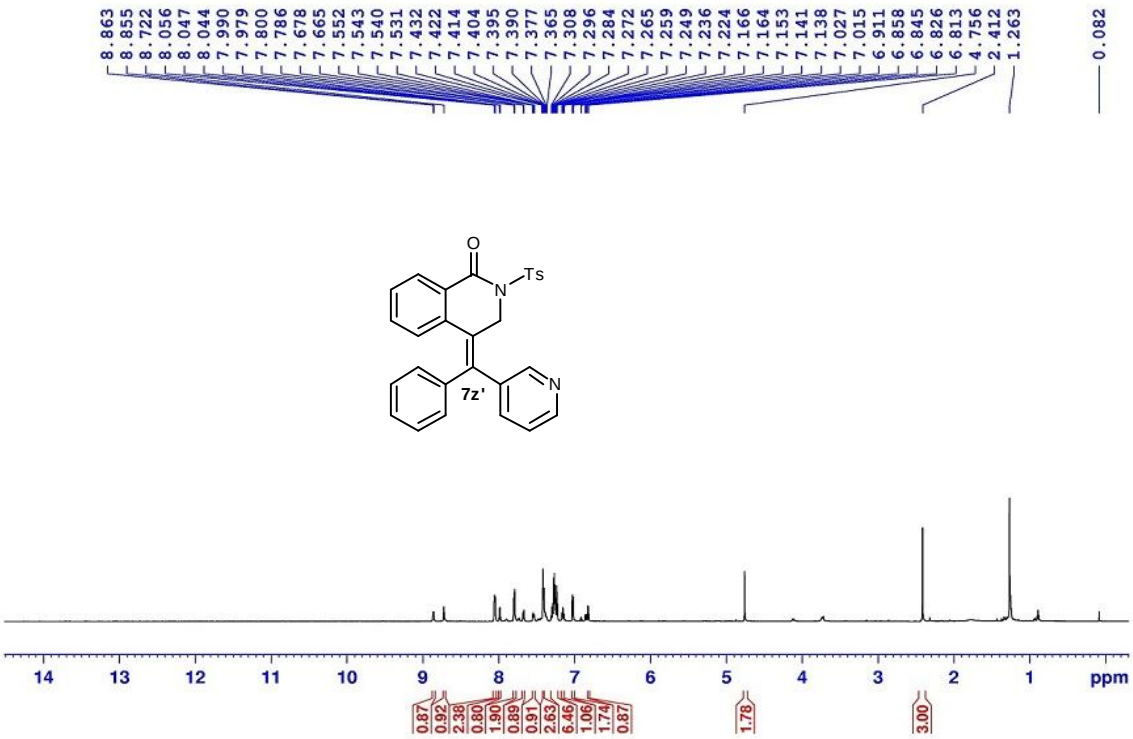
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **7z**:



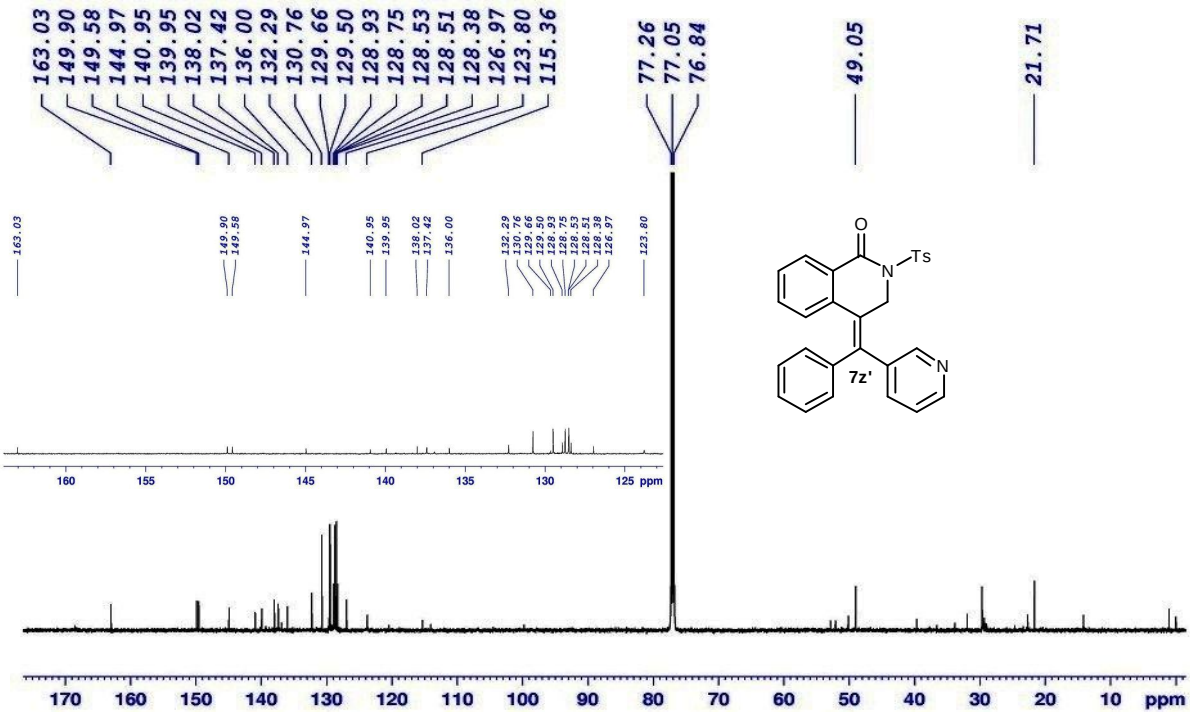
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of **7z**:



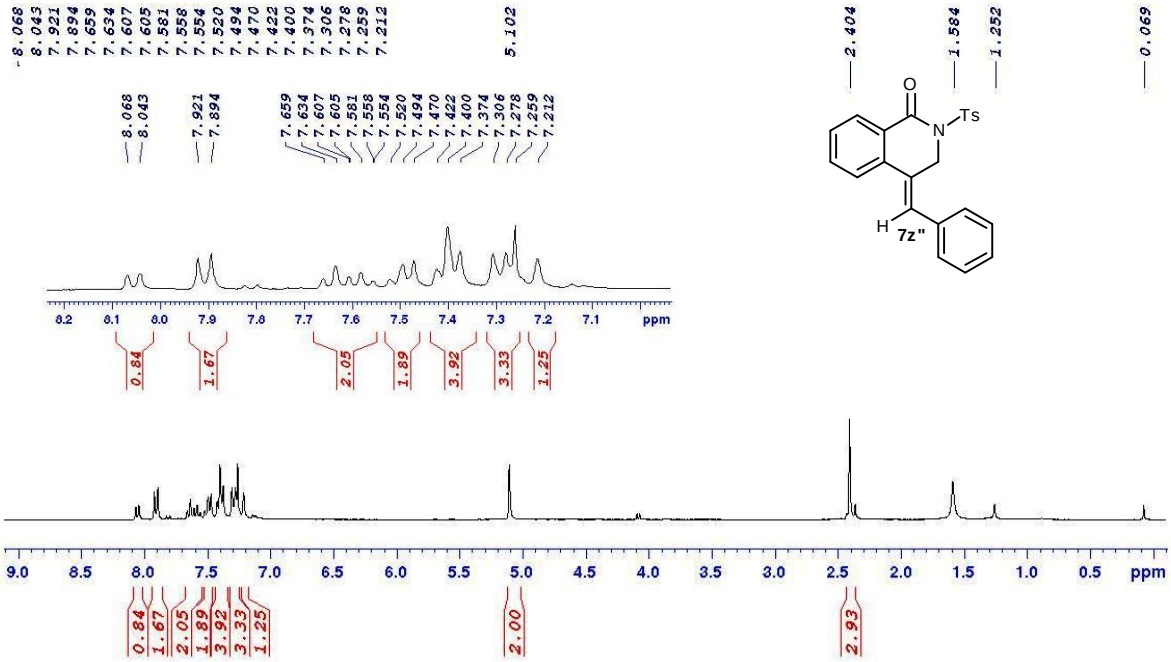
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **7z'**:



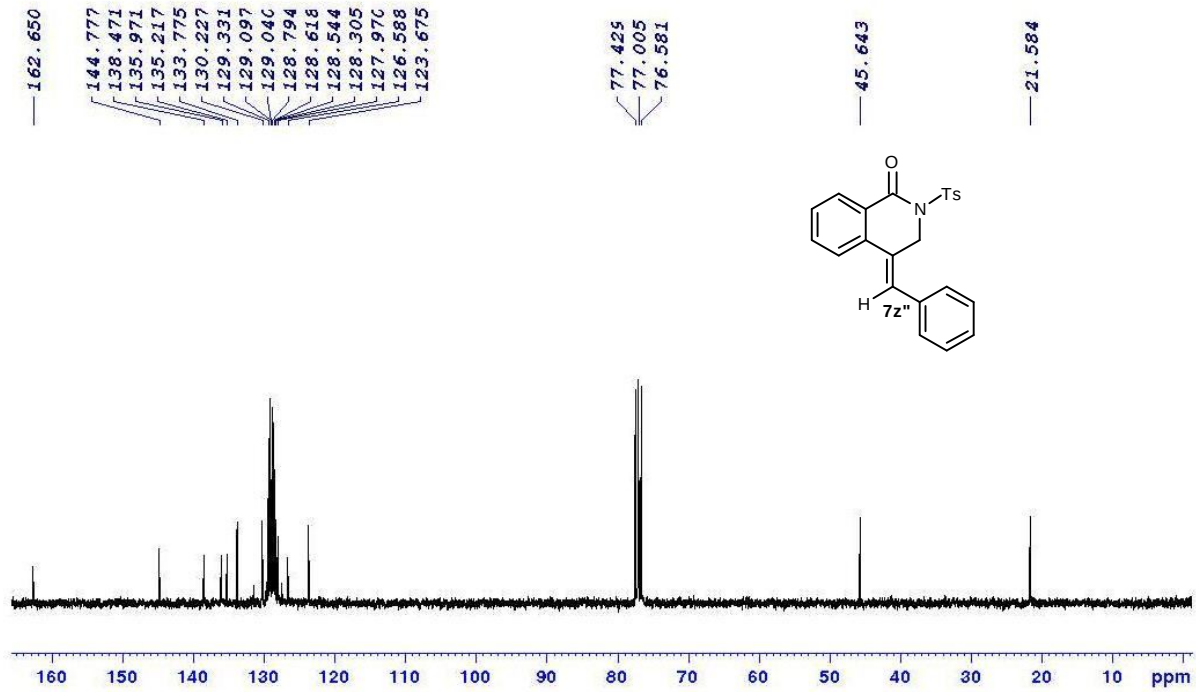
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of **7z'**:



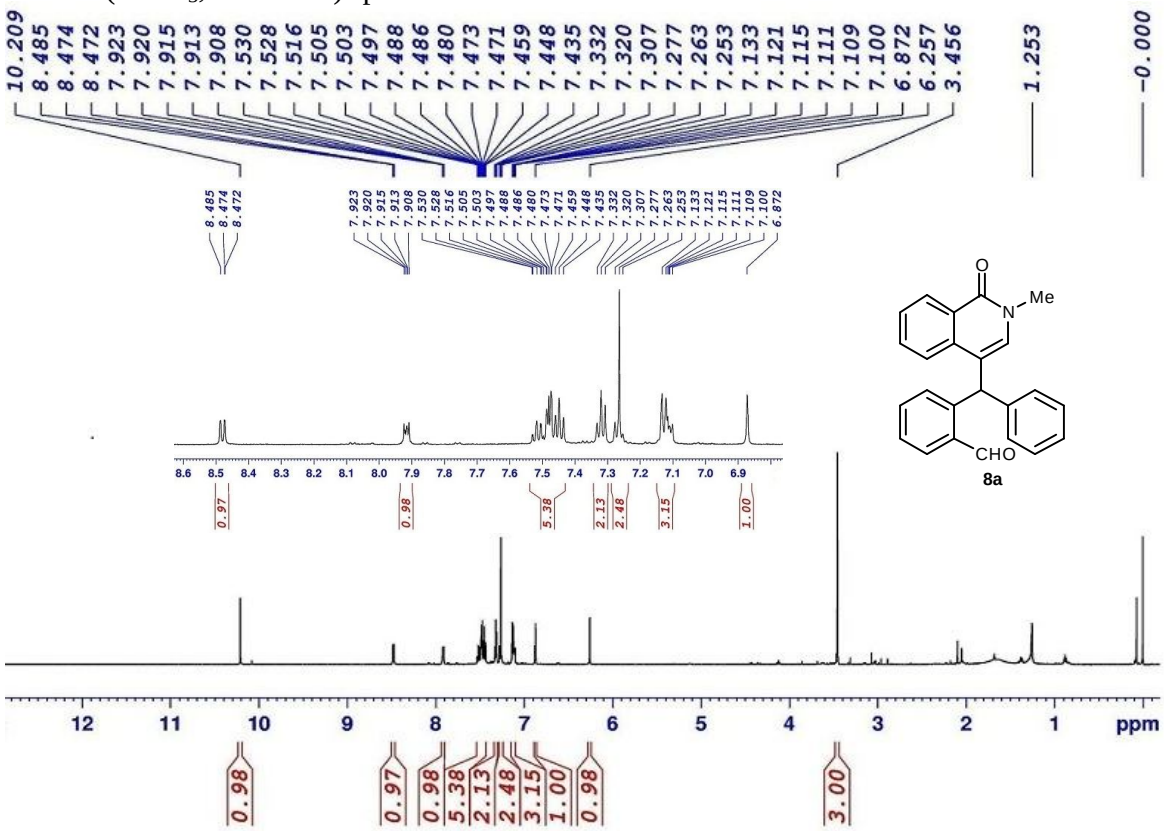
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **7z''**:



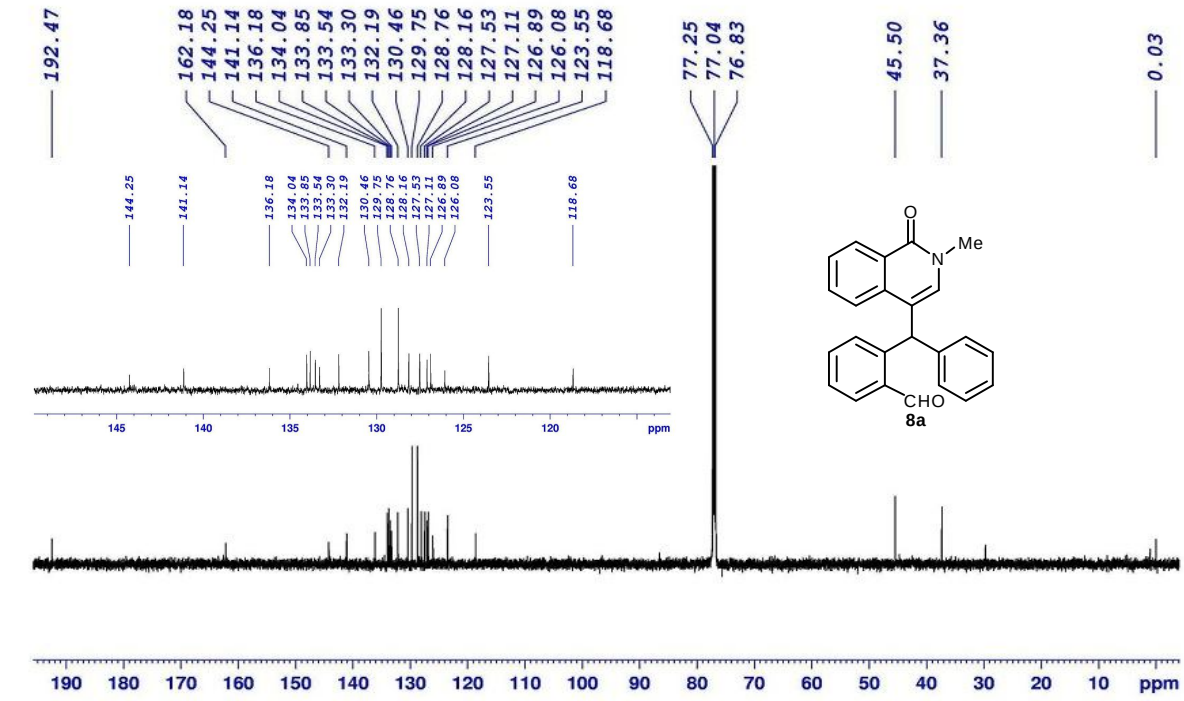
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of **7z''**:



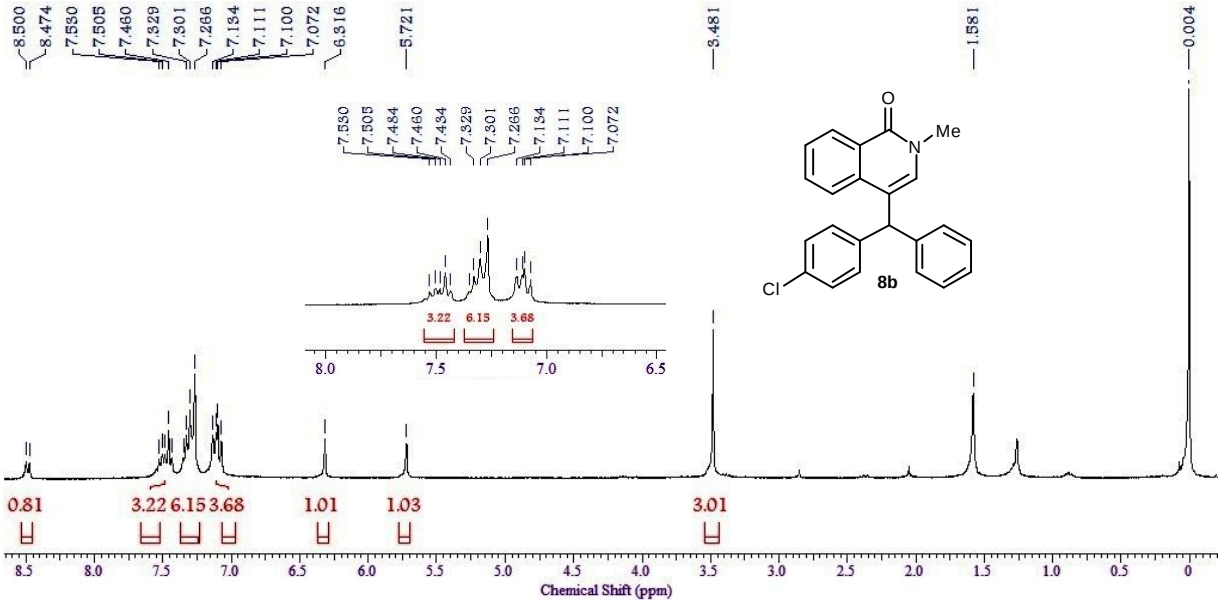
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **8a**:



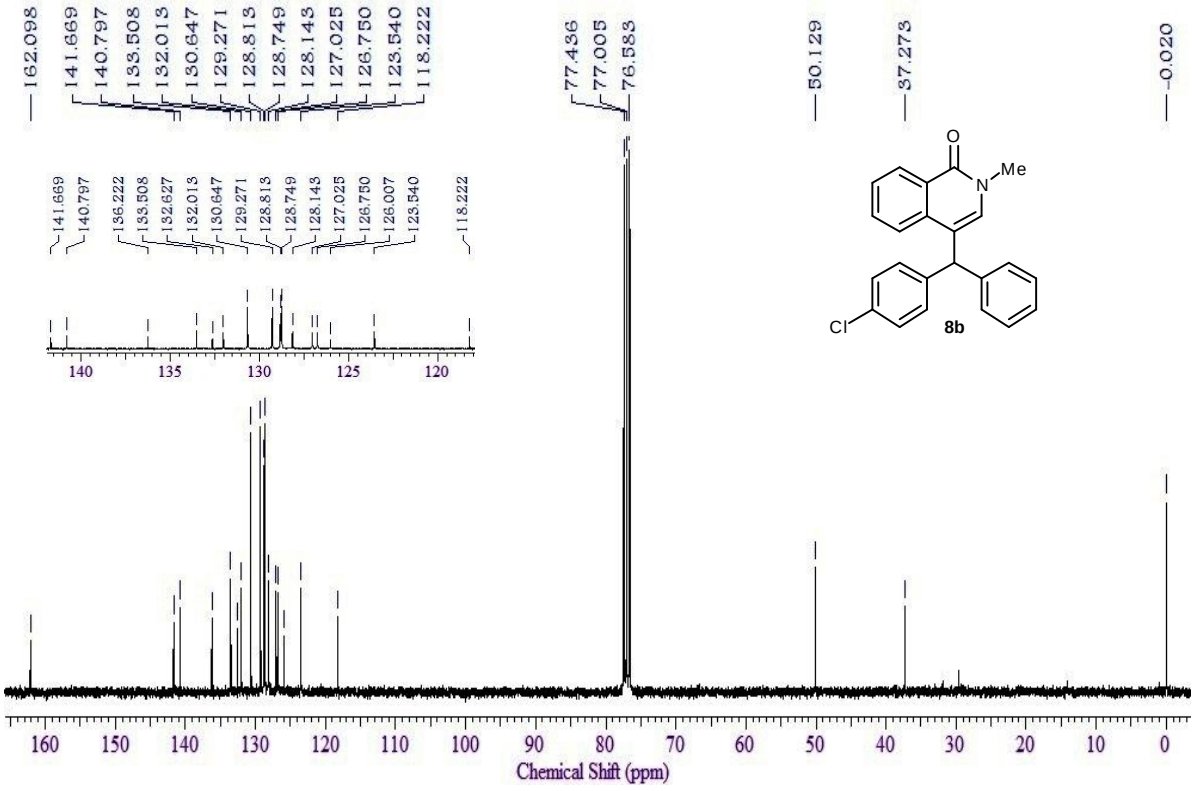
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum **8a**:



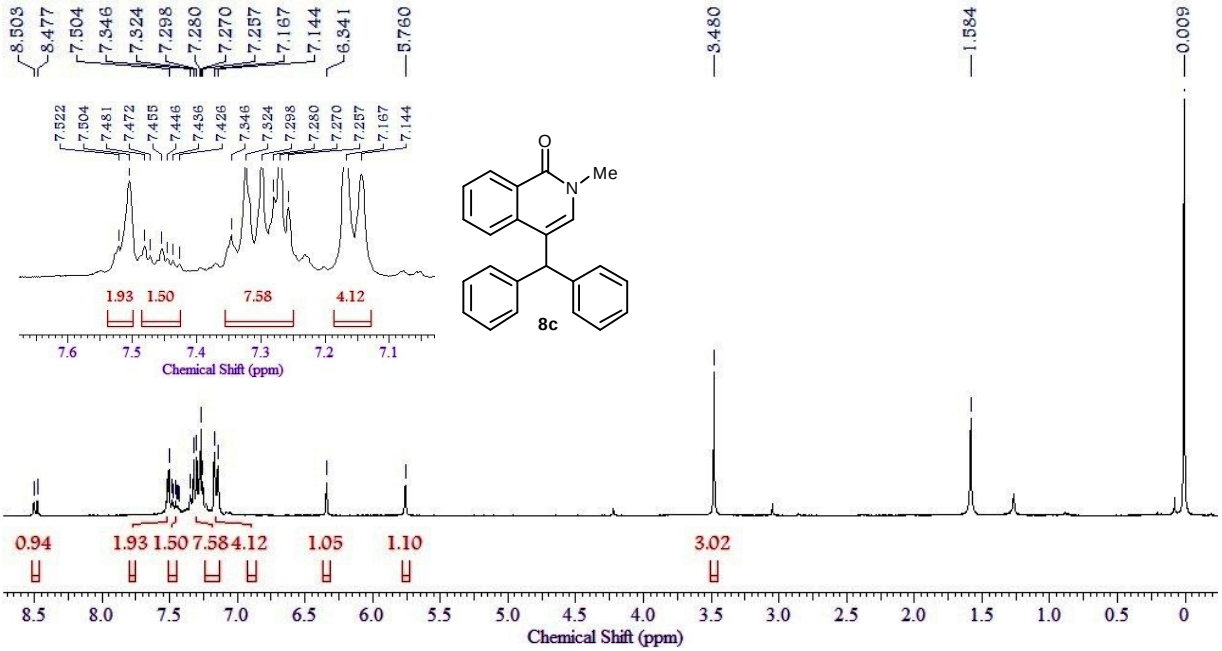
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **8b**:



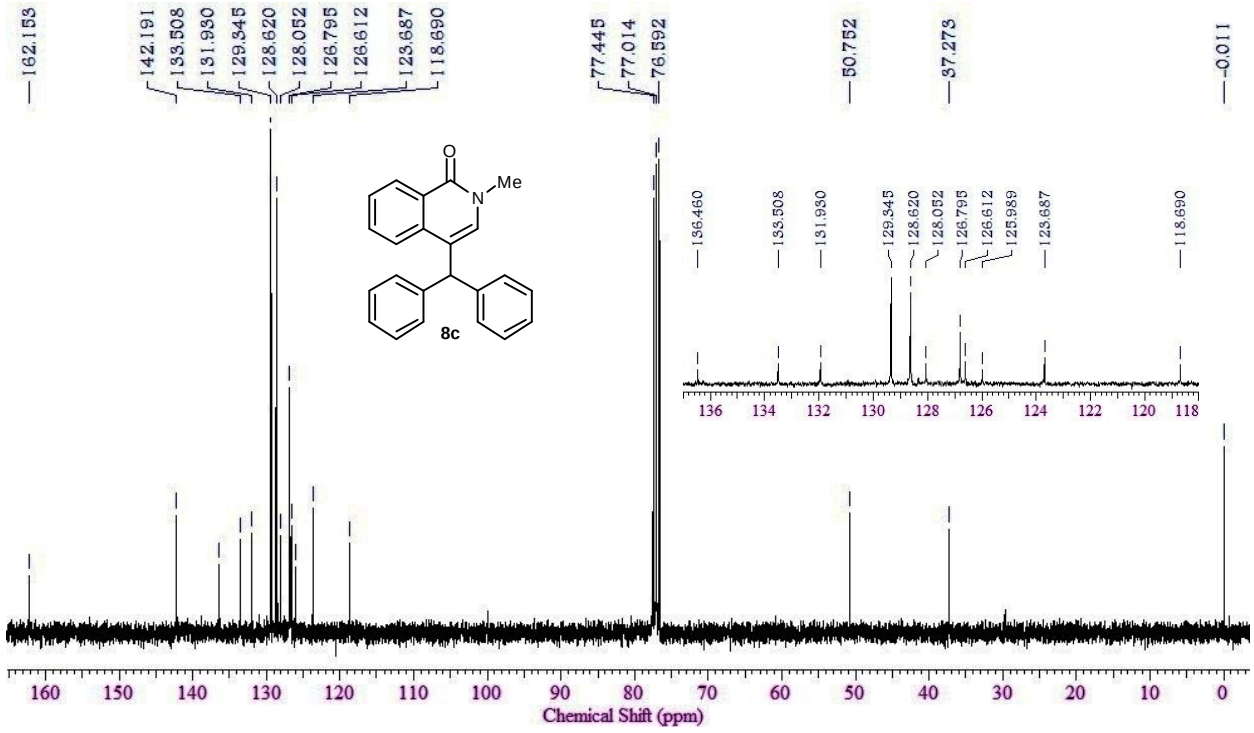
^{13}C NMR ($CDCl_3$, 75 MHz) spectrum **8b**:



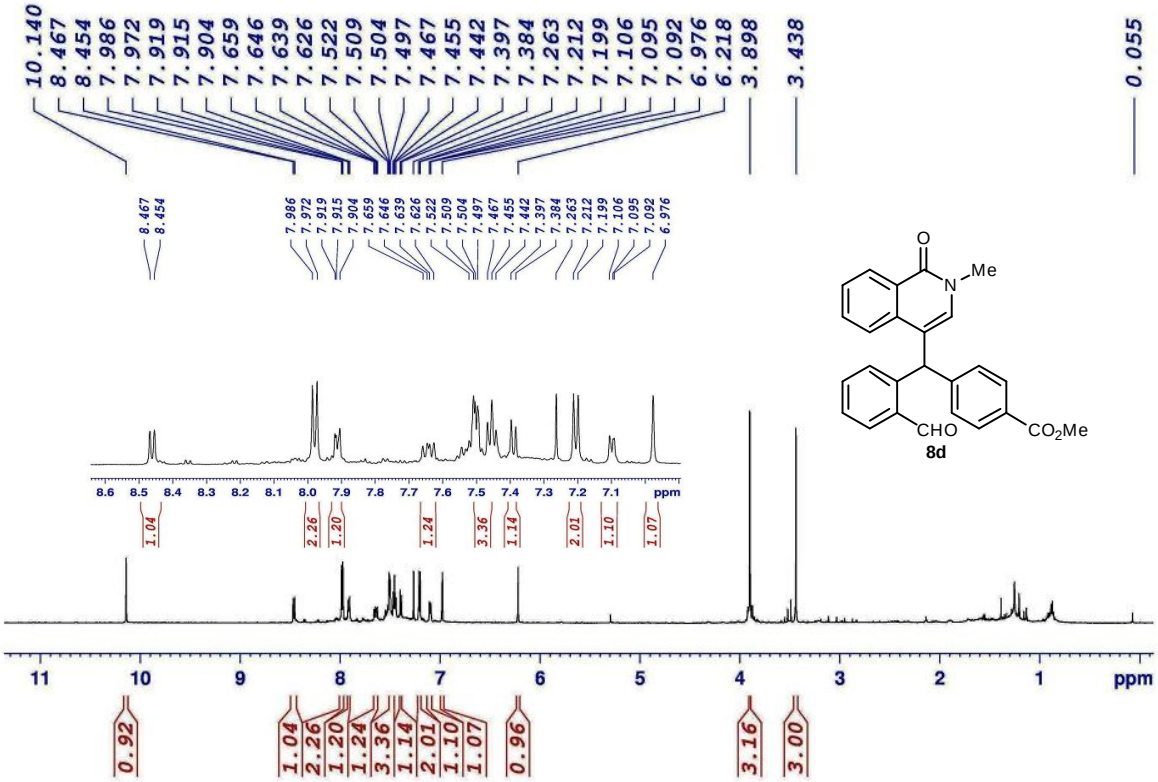
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **8c**:



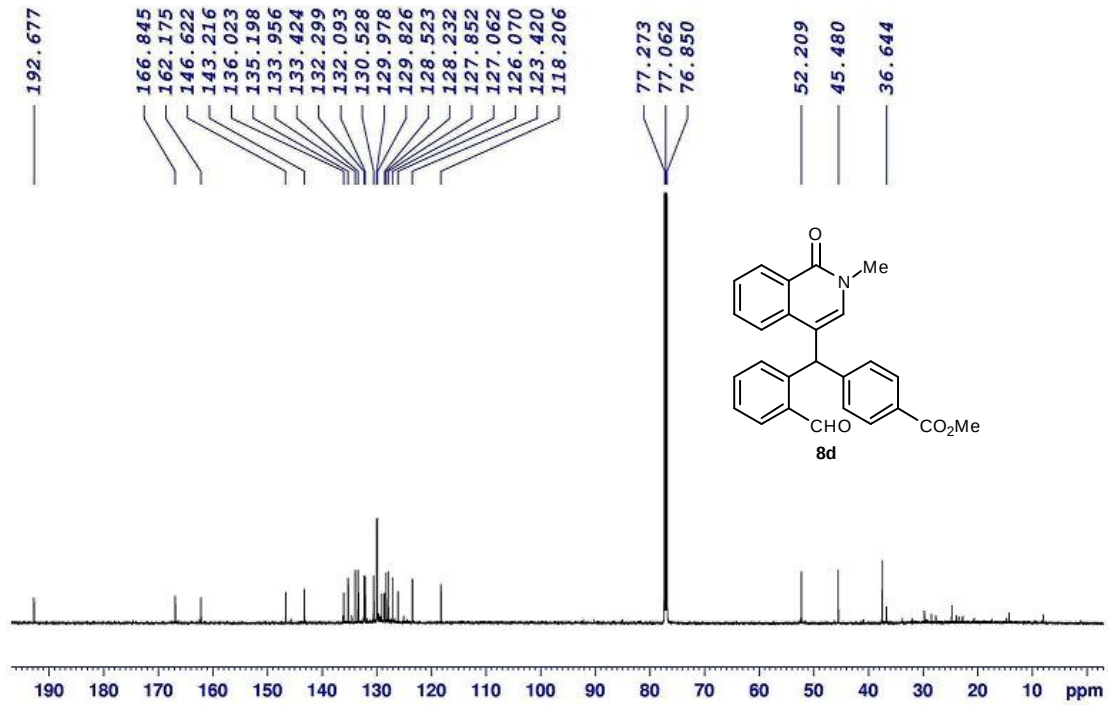
^{13}C NMR ($CDCl_3$, 75 MHz) spectrum of **8c**:



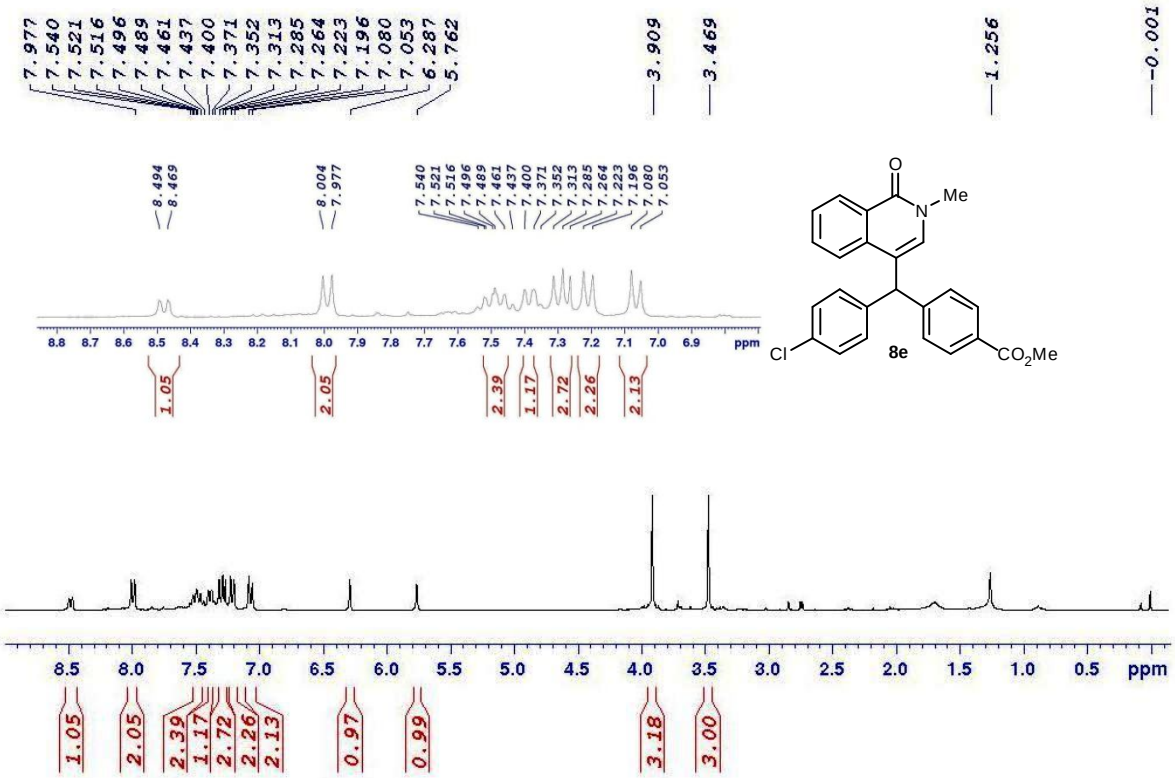
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **8d**:



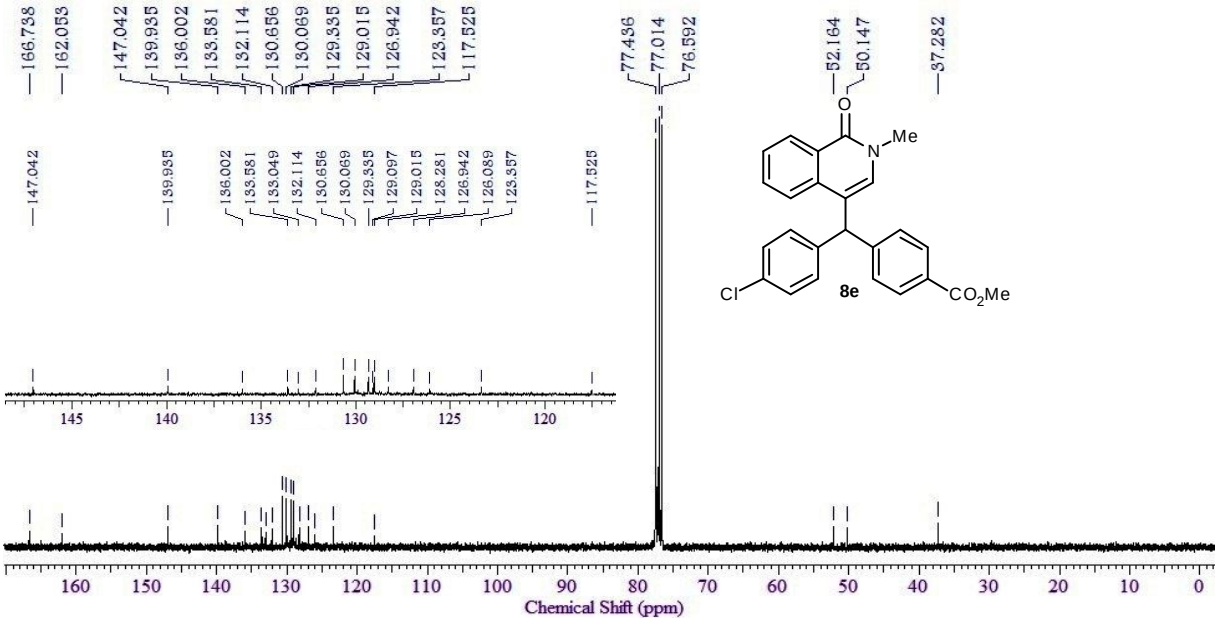
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum **8d**:



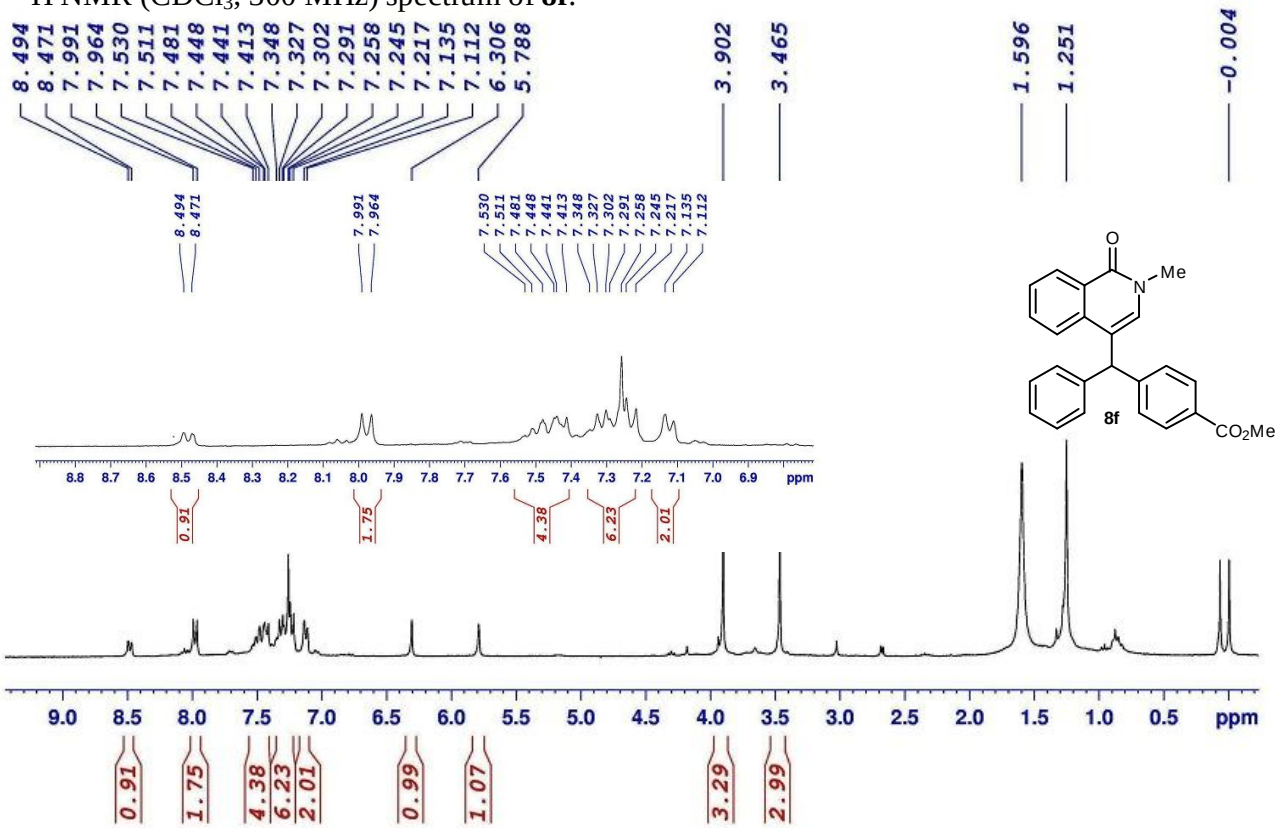
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **8e**:



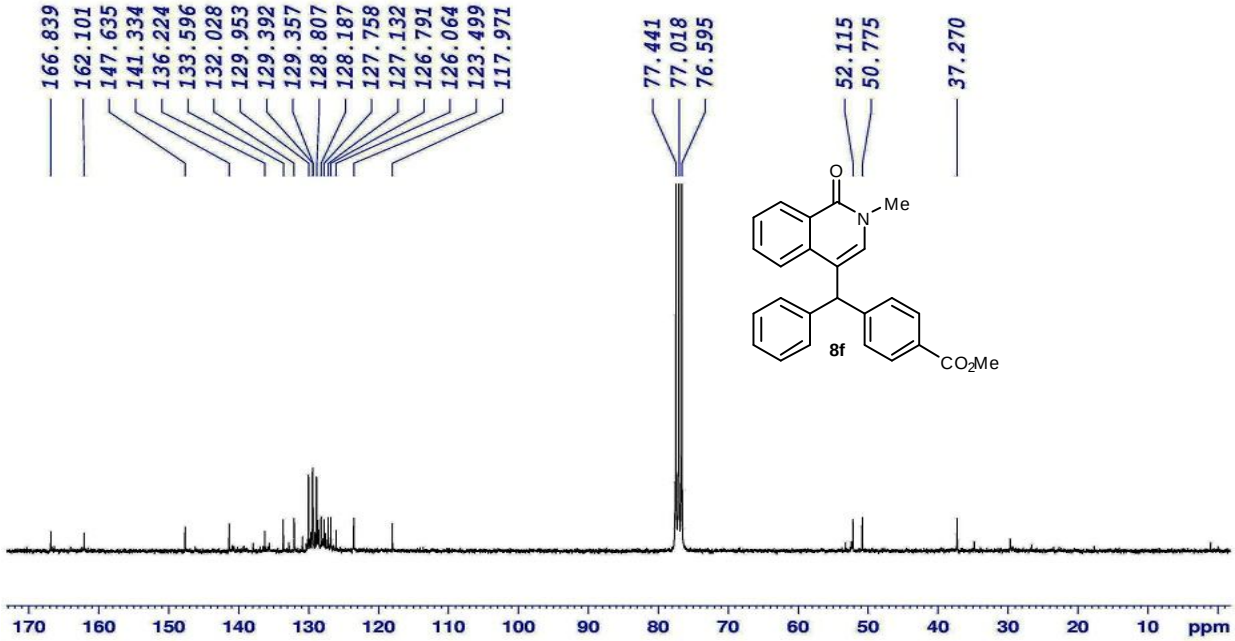
^{13}C NMR ($CDCl_3$, 75 MHz) spectrum **8e**:



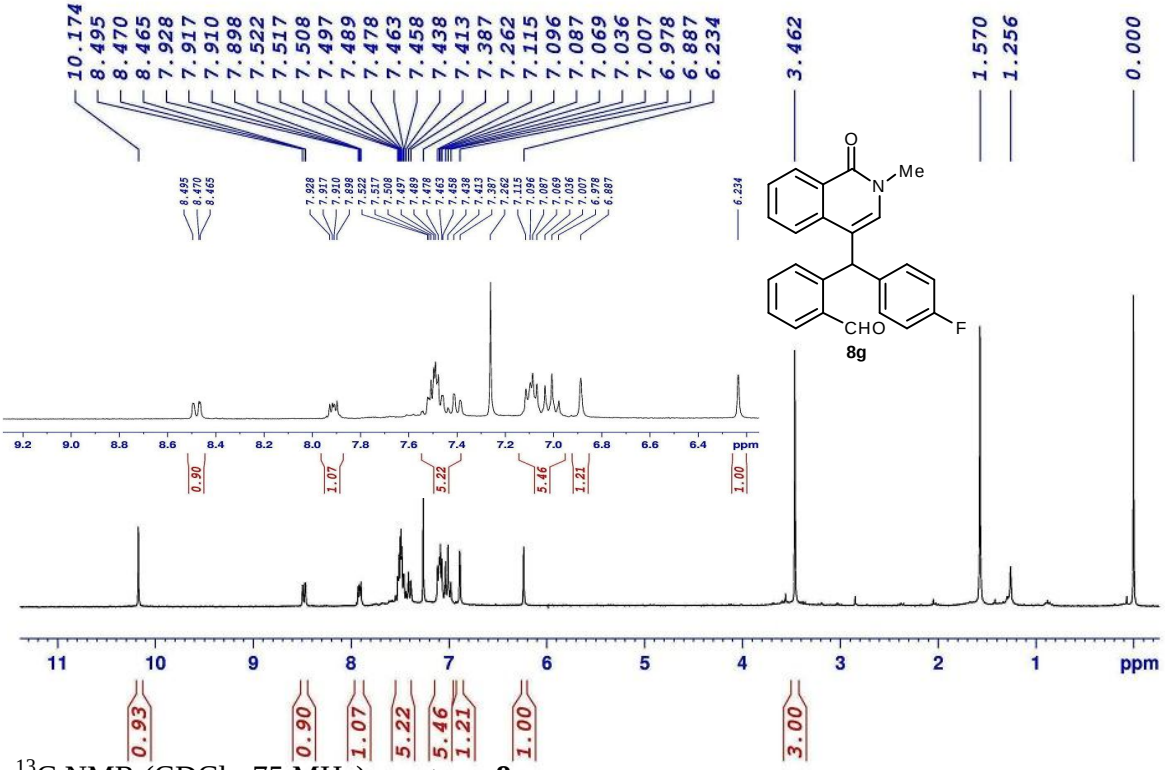
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **8f**:



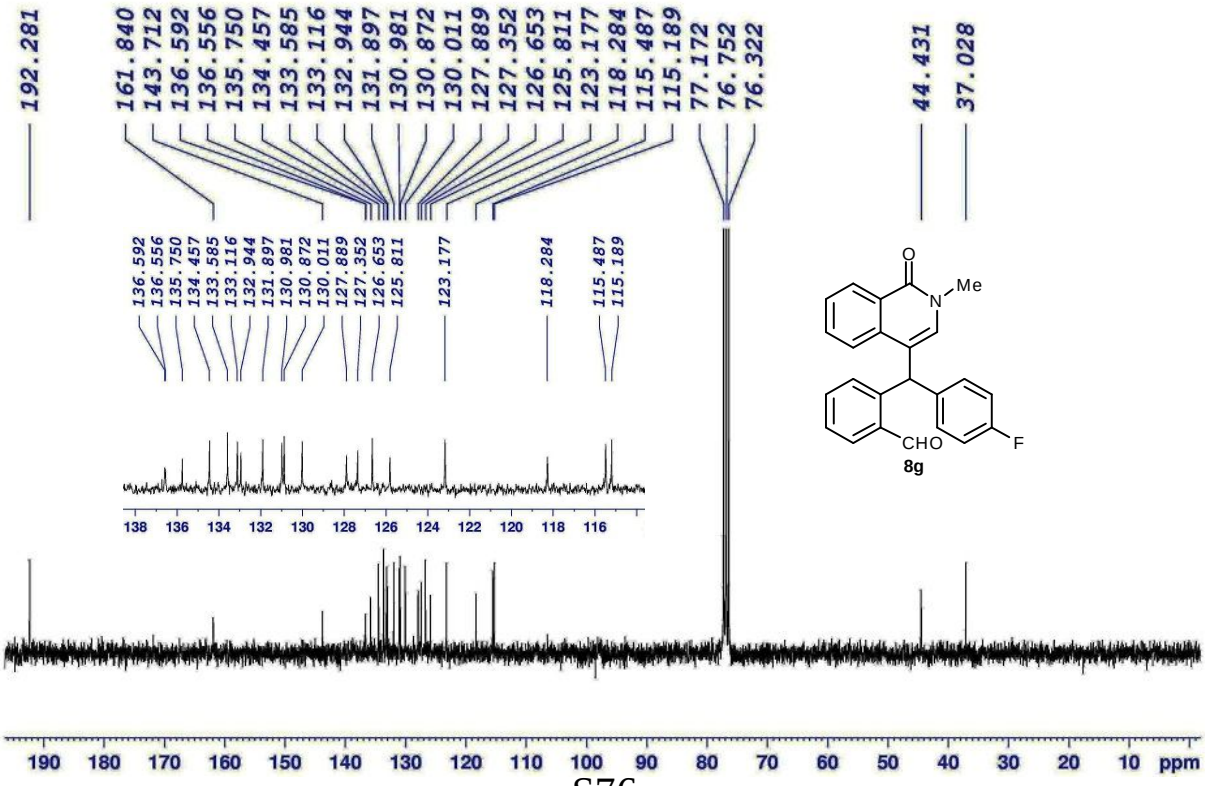
^{13}C NMR ($CDCl_3$, 75 MHz) spectrum **8f**:



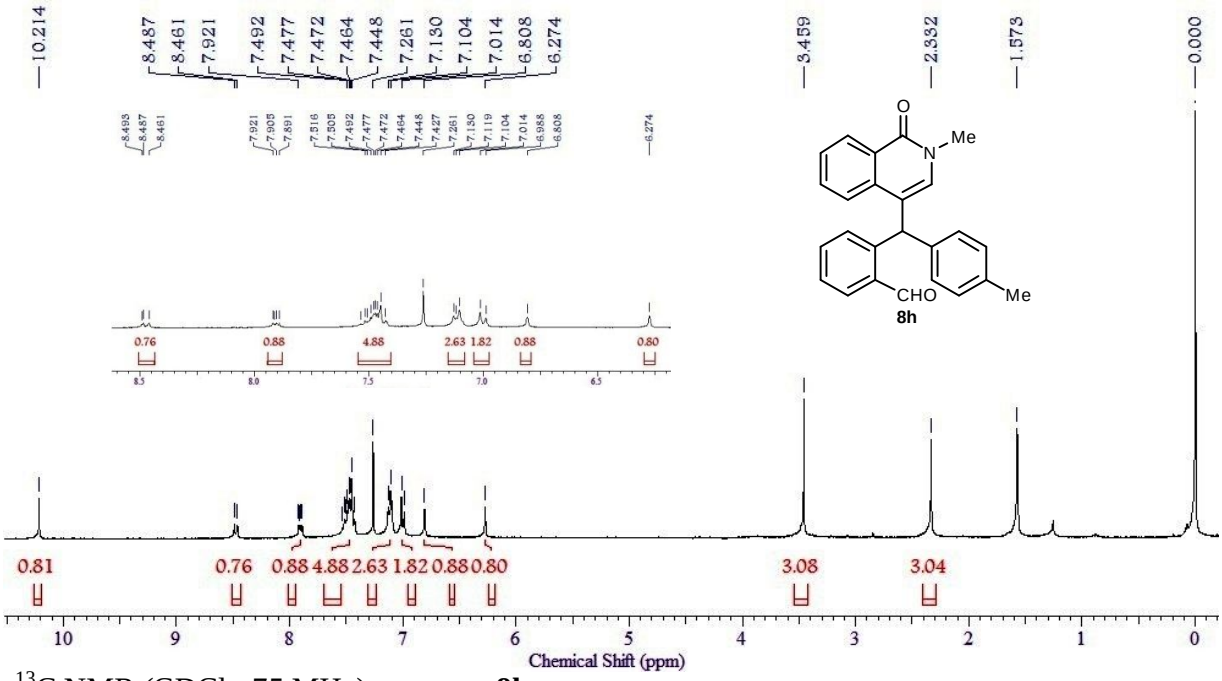
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **8g**:



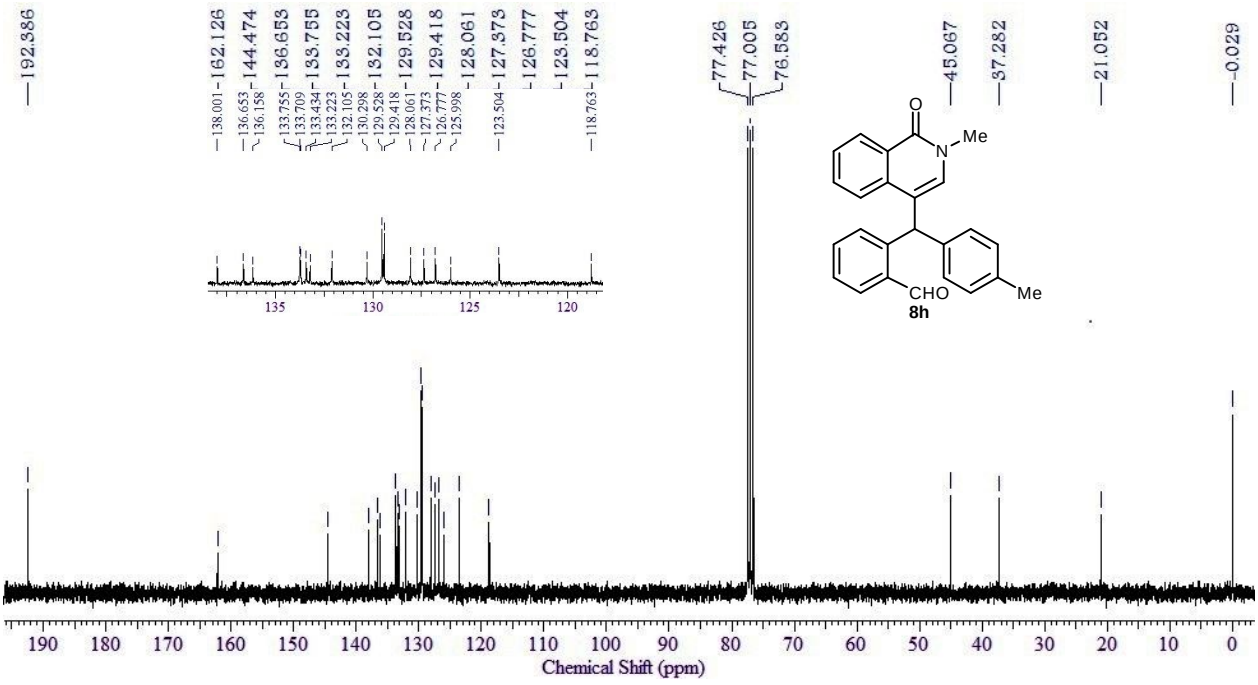
^{13}C NMR ($CDCl_3$, 75 MHz) spectrum **8g**:



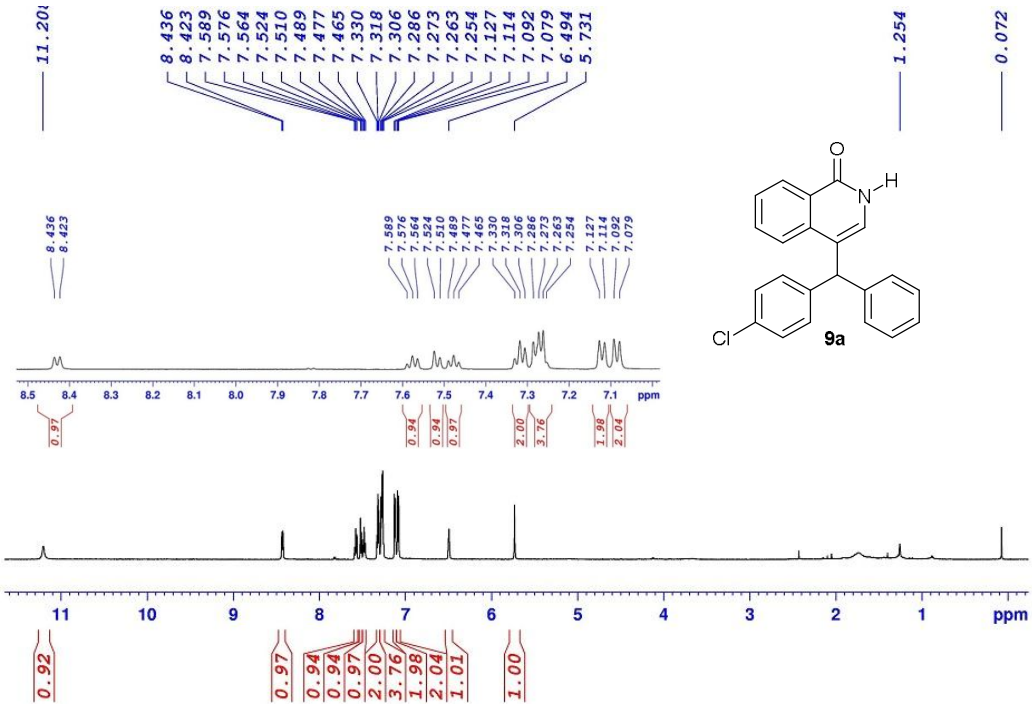
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum **8h**:



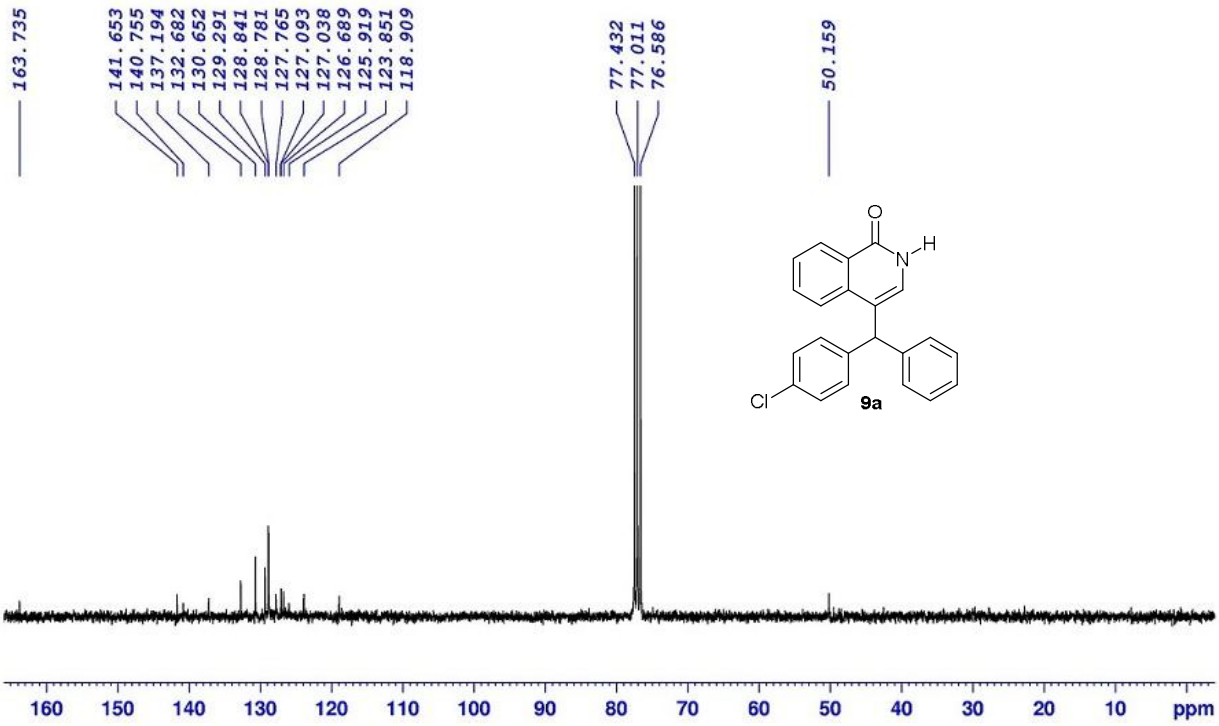
^{13}C NMR ($CDCl_3$, 75 MHz) spectrum **8h**:



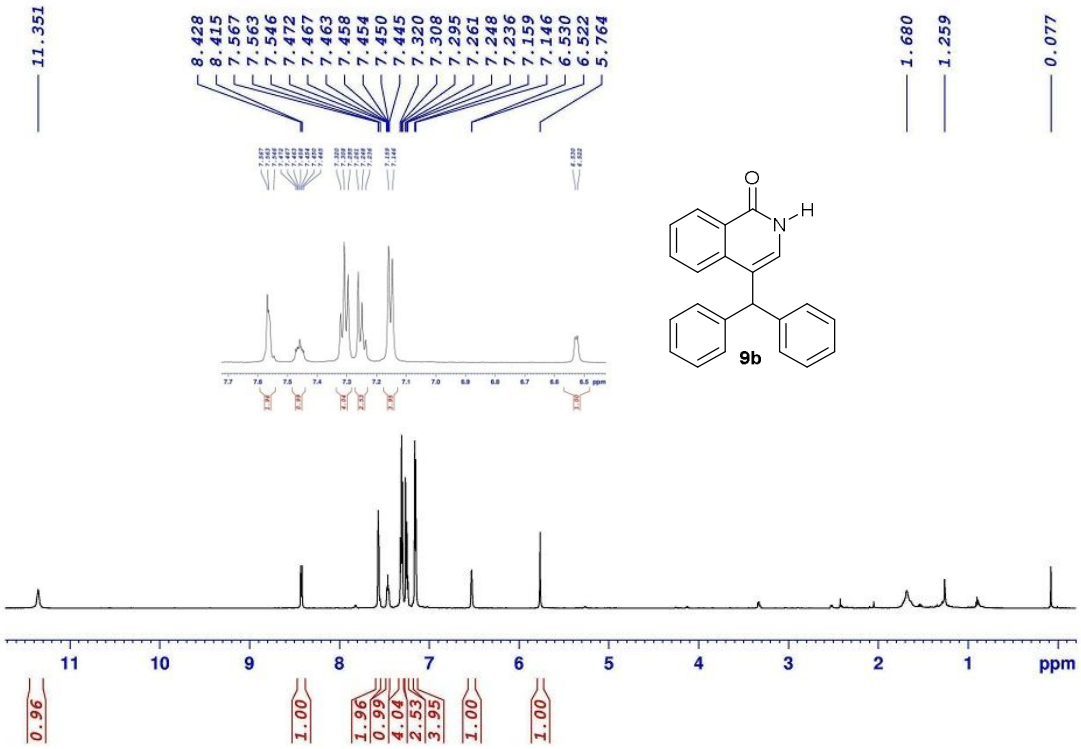
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **9a:**



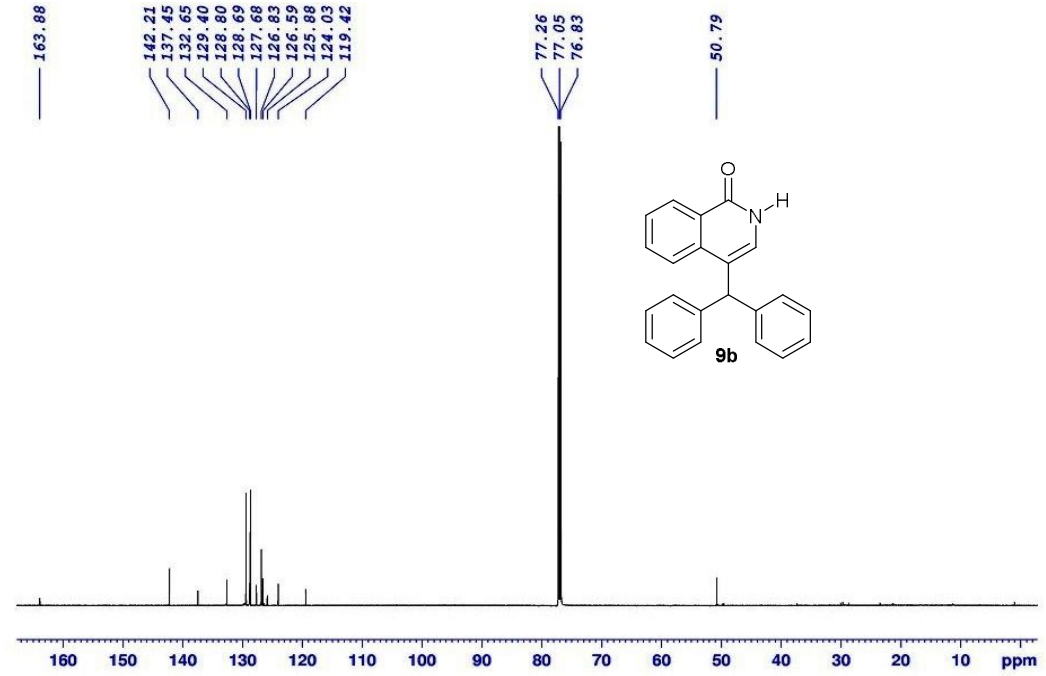
^{13}C NMR ($CDCl_3$, 75 MHz) spectrum **9a**:



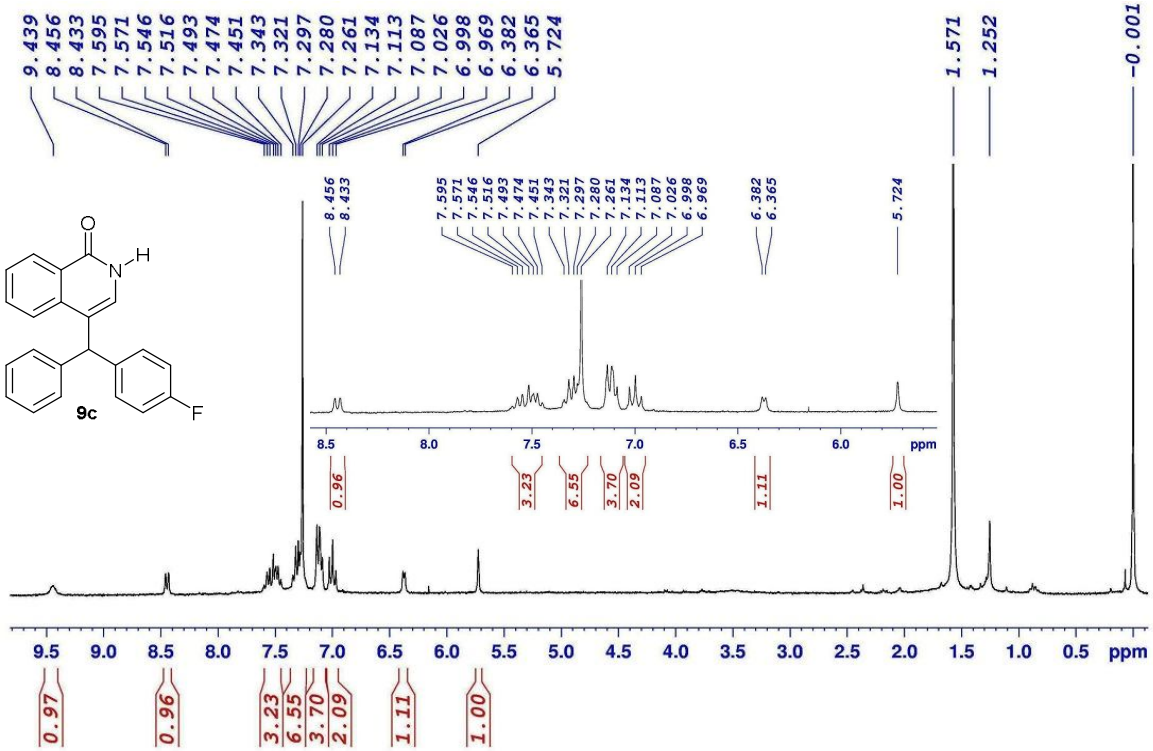
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **9b**:



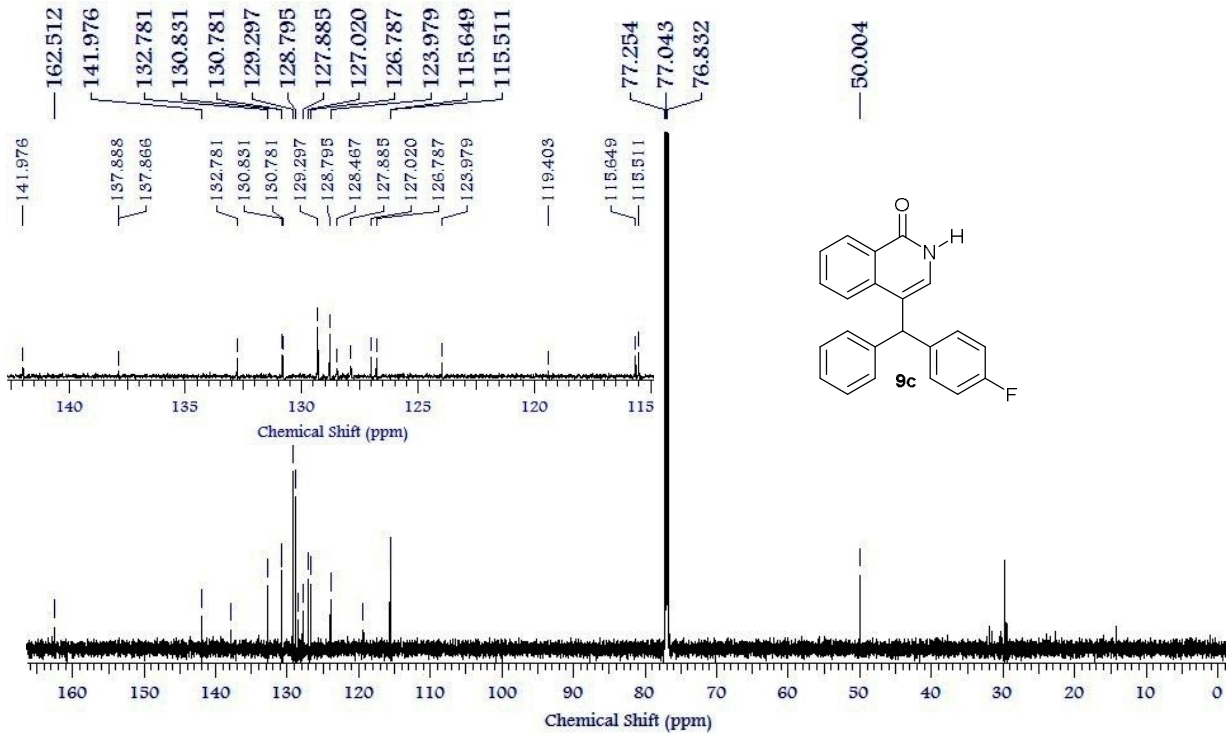
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of **9b**:



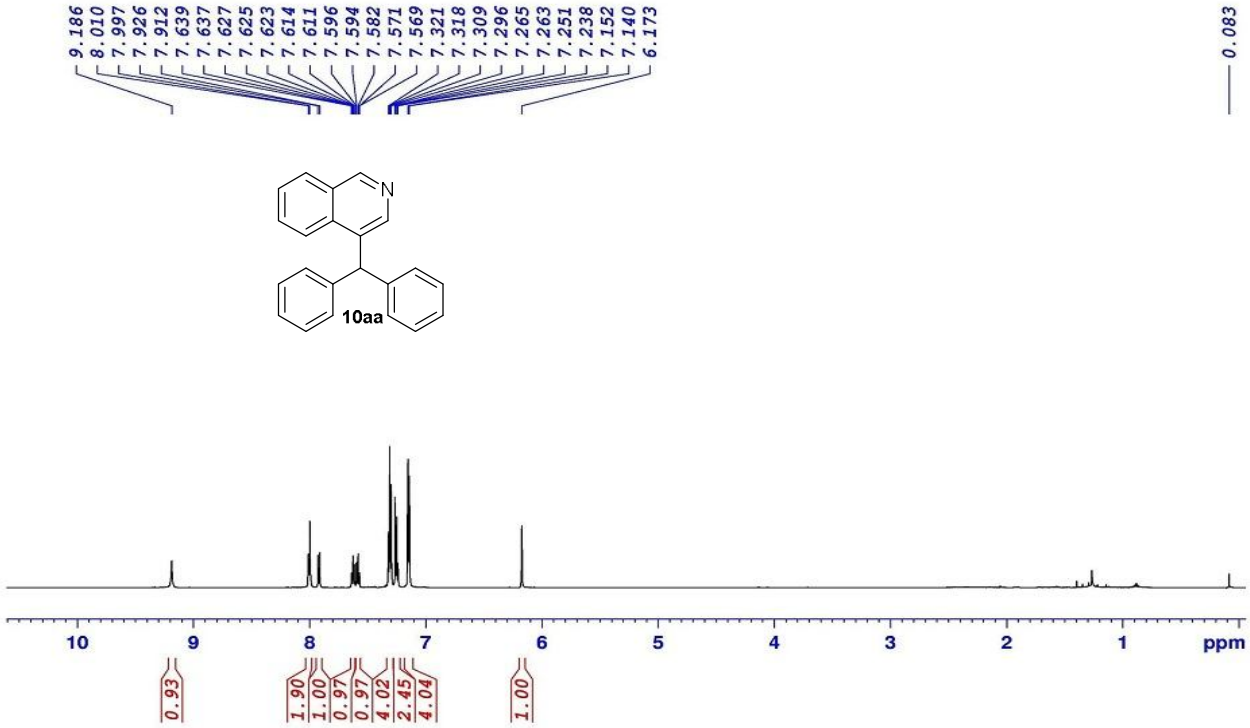
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **9c**:



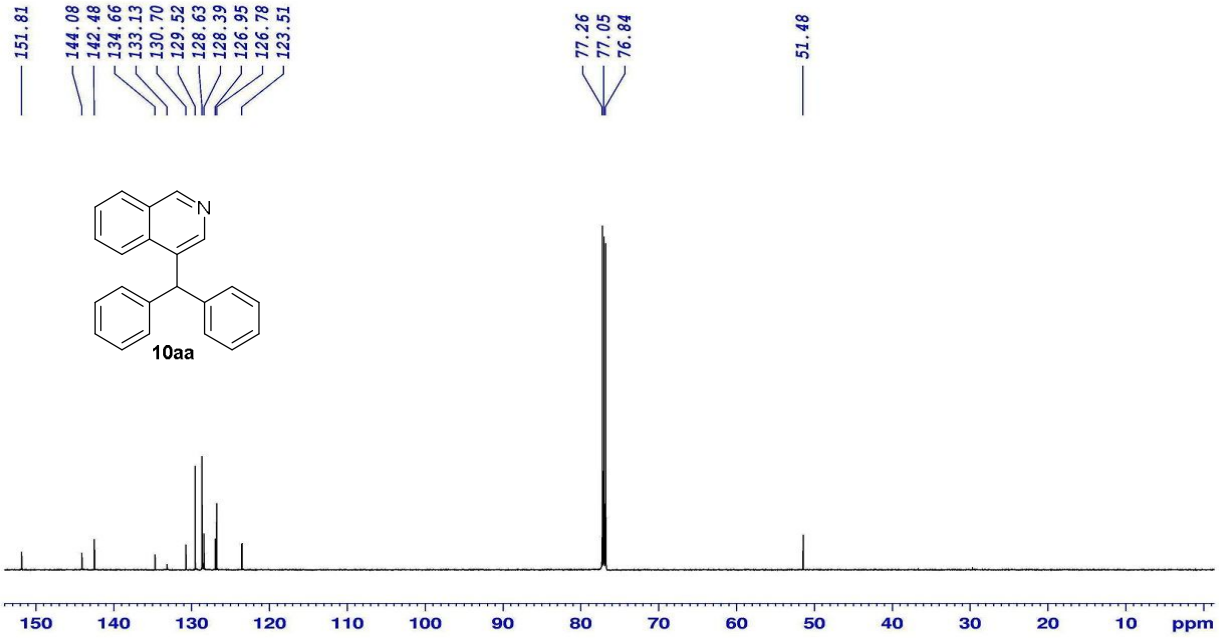
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of **9c**:



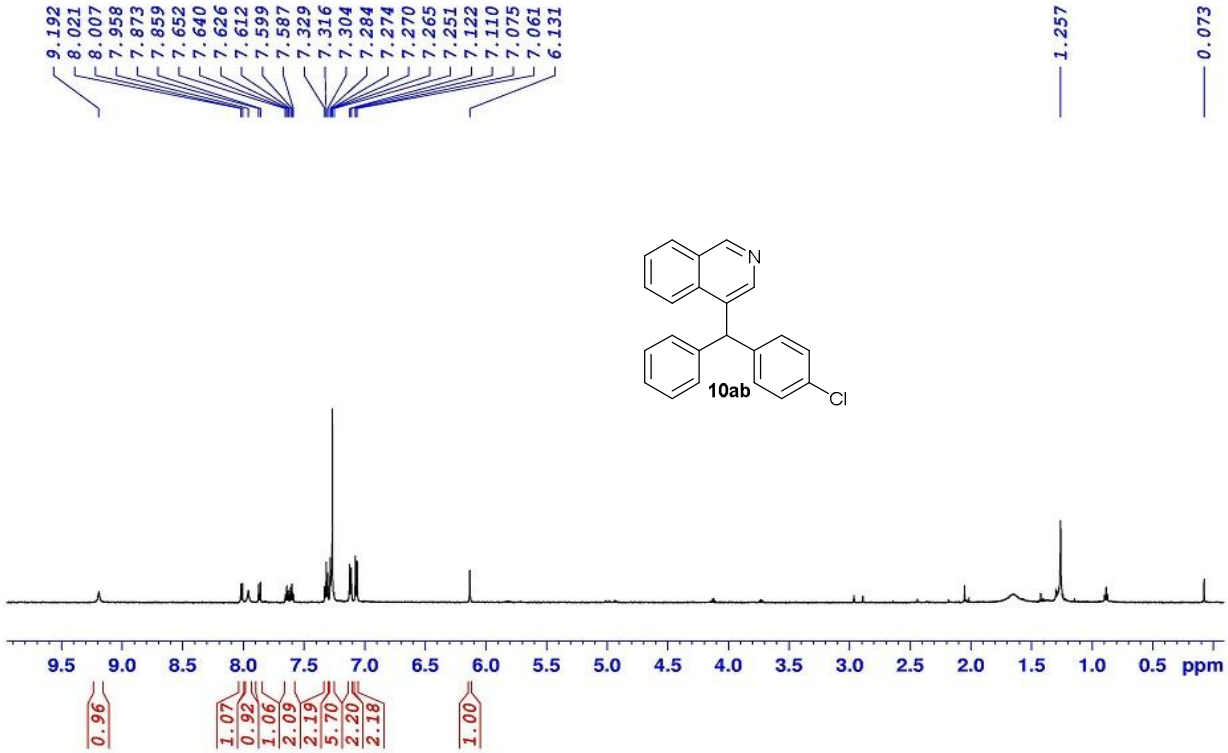
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **10aa**:



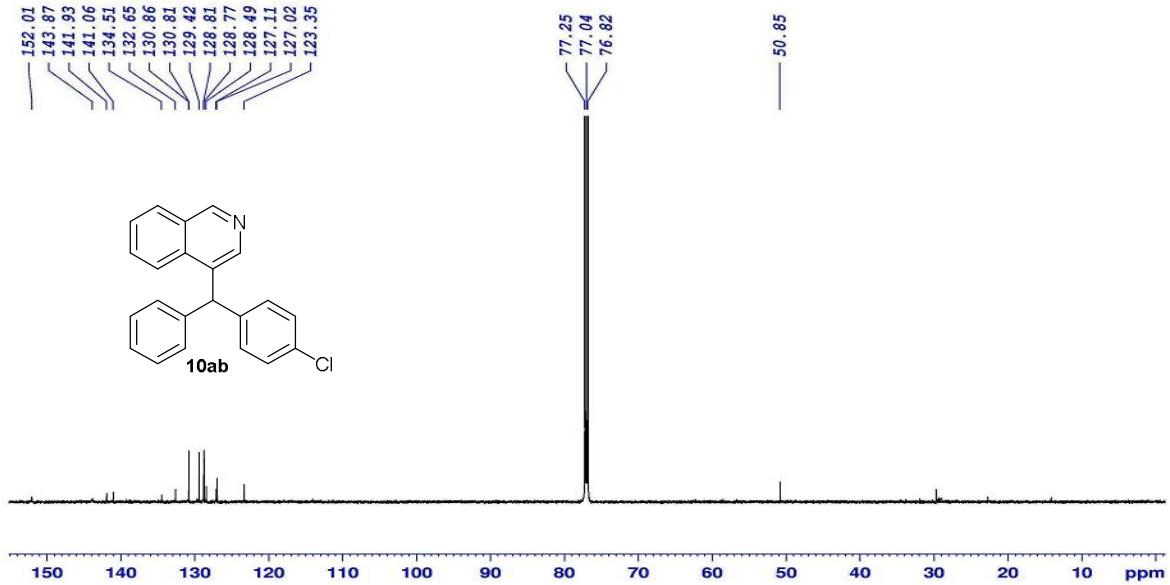
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of **10aa**:



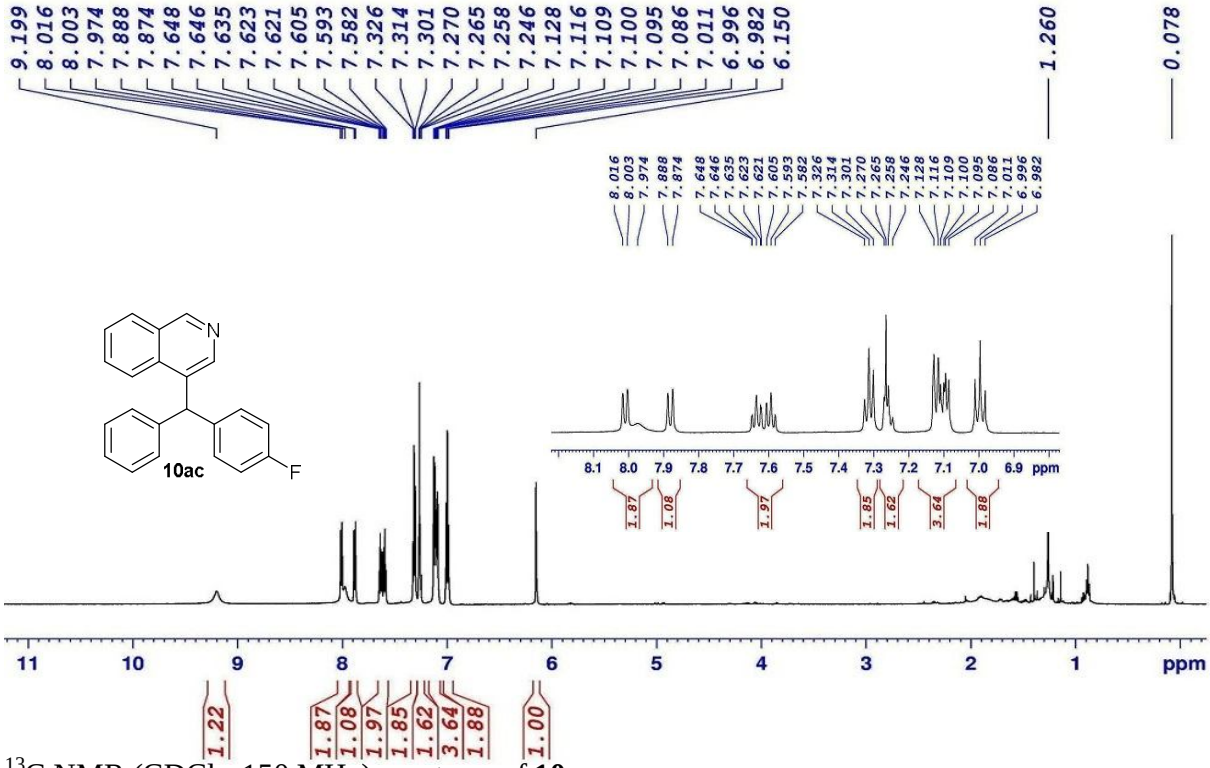
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **10ab**:



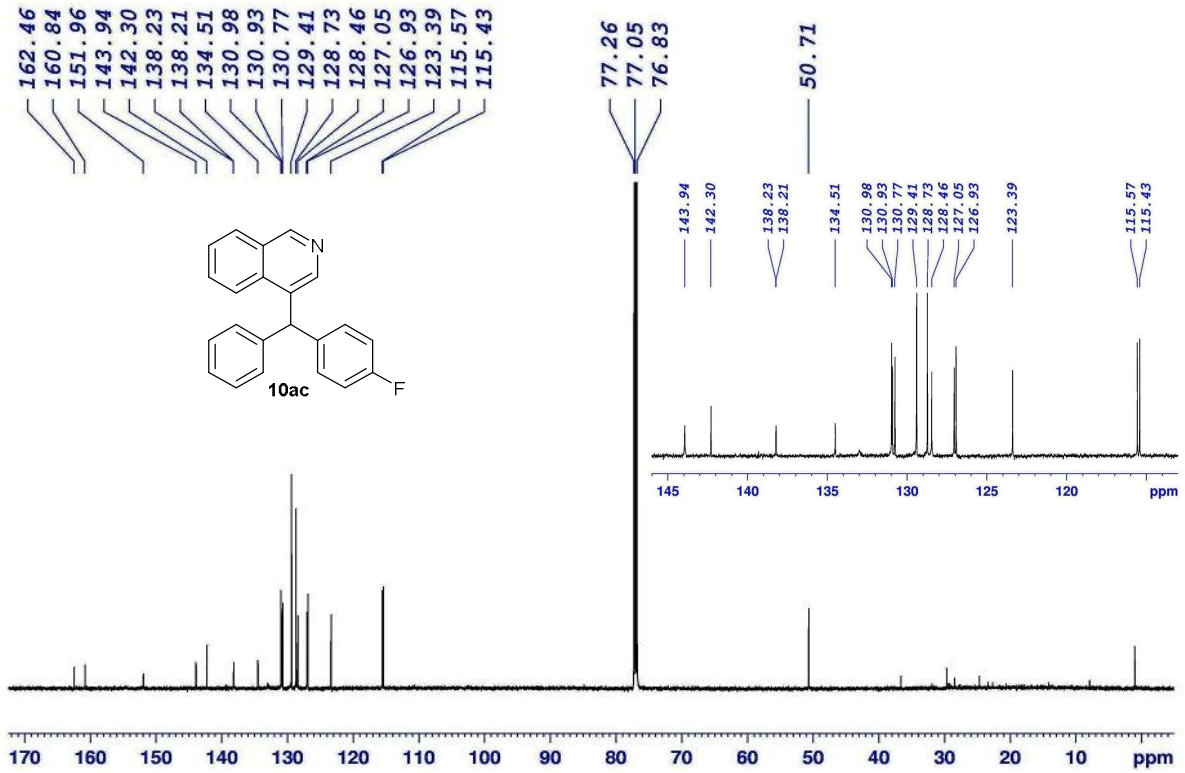
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of **10ab**:



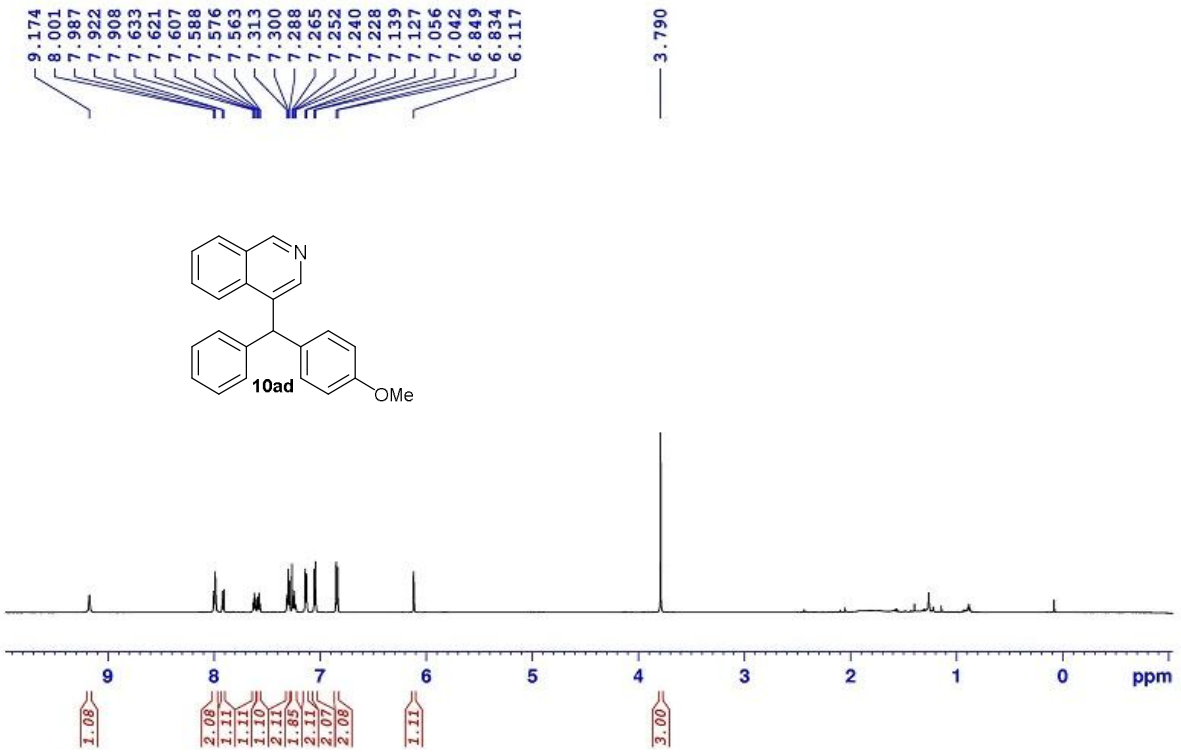
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **10ac**:



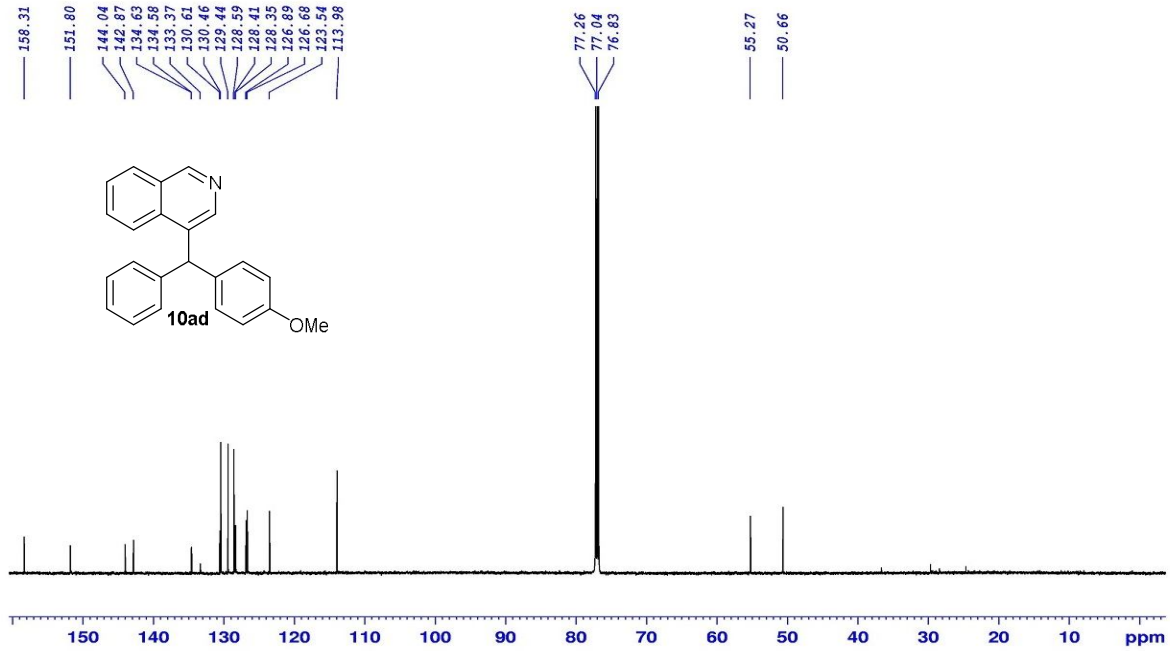
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of **10ac**:



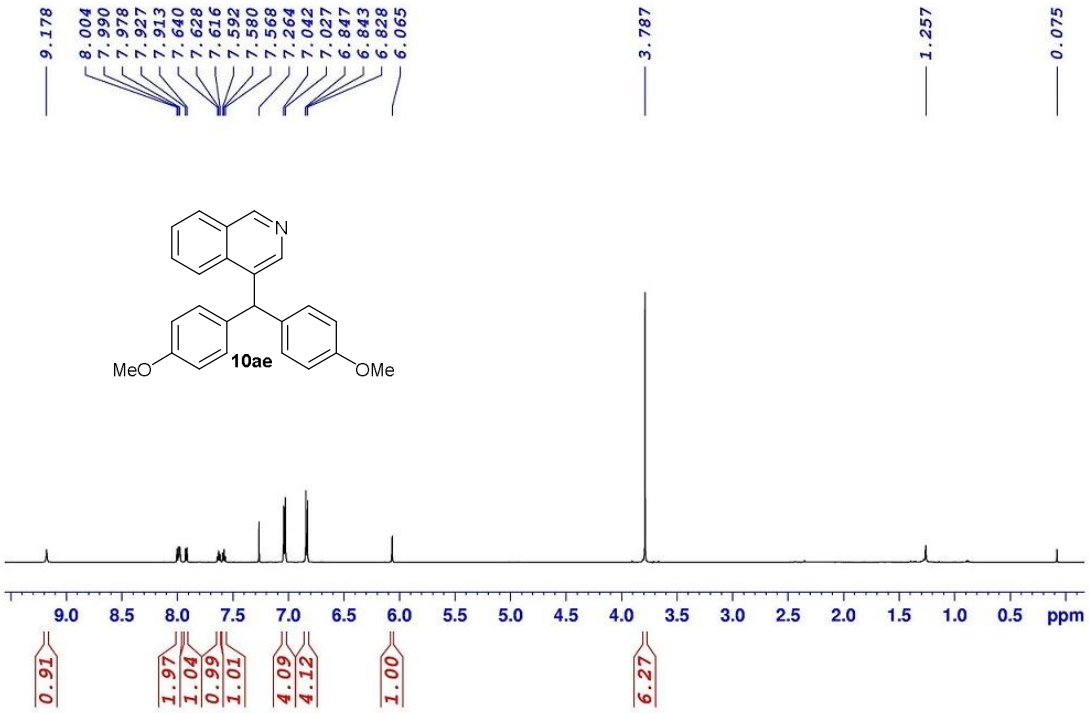
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **10ad**:



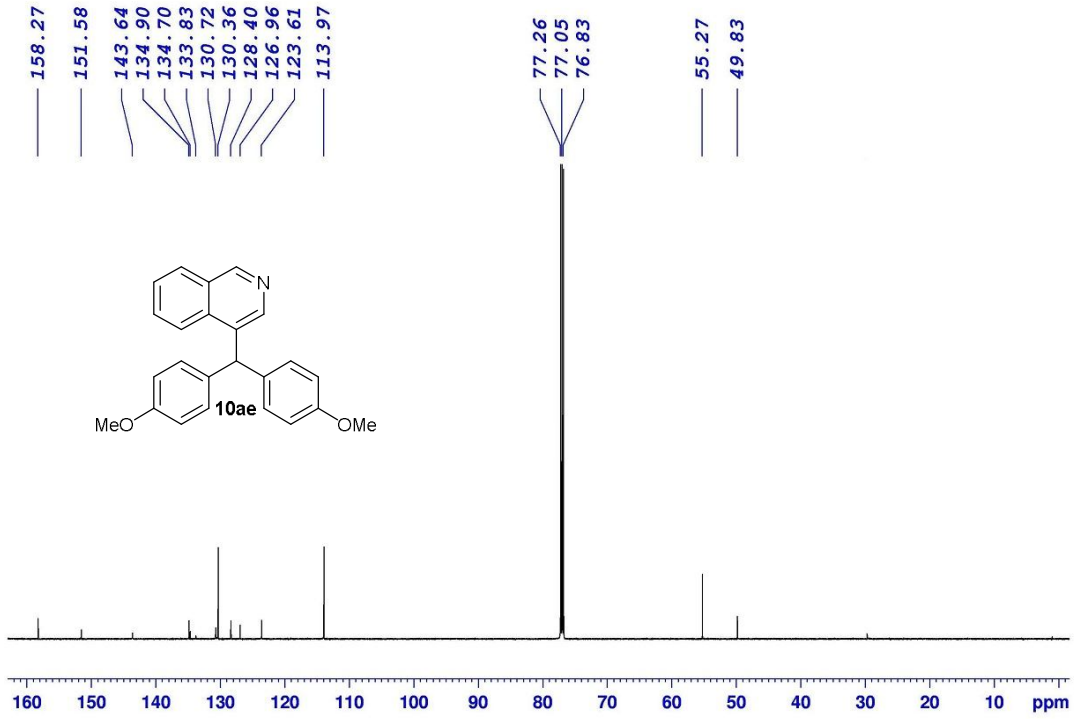
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of **10ad**:



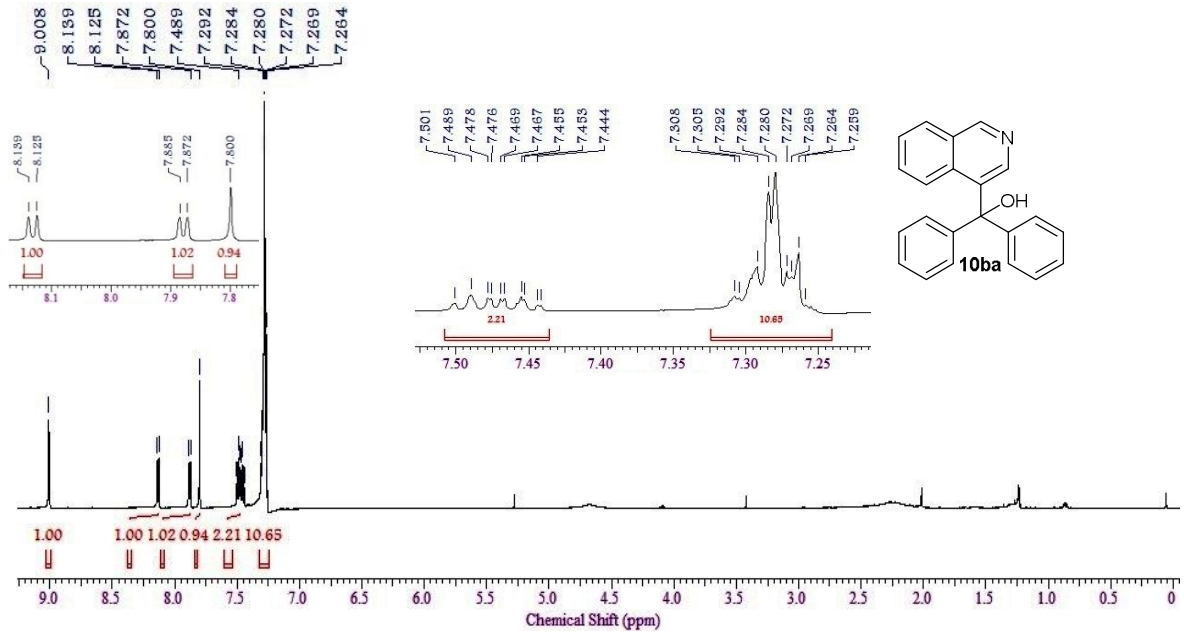
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **10ae**:



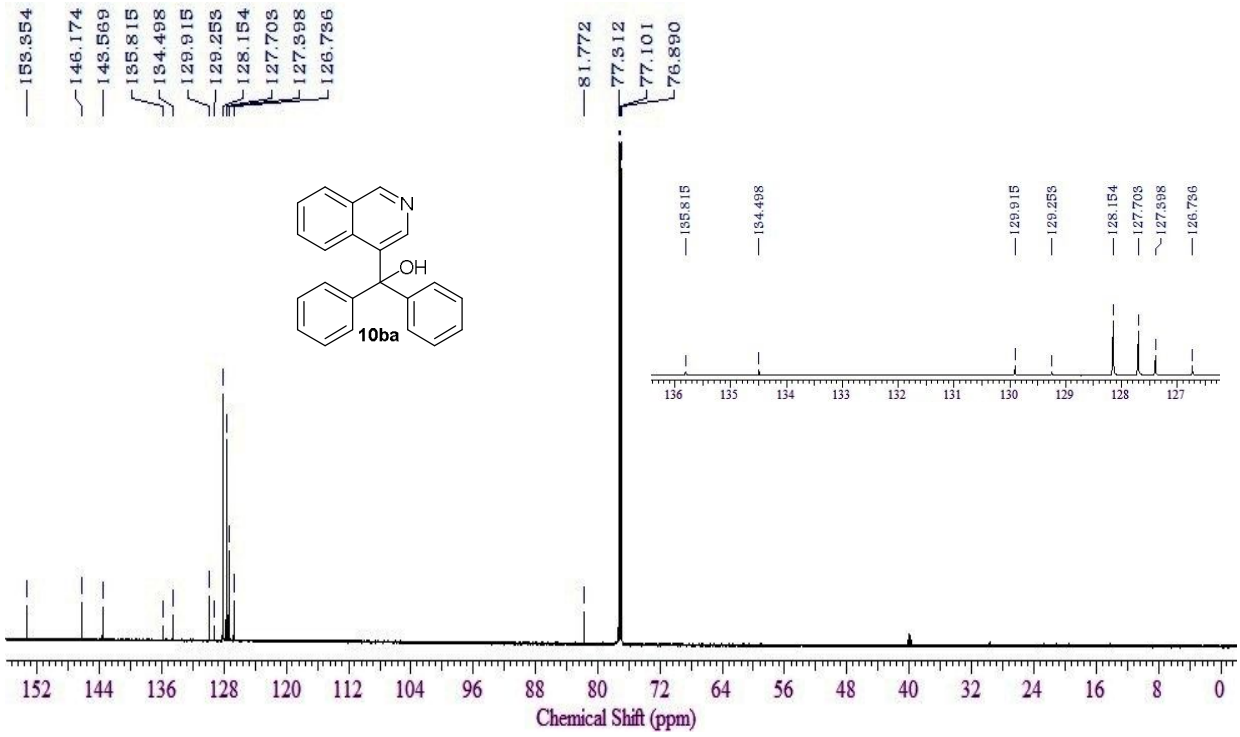
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of **10ae**:



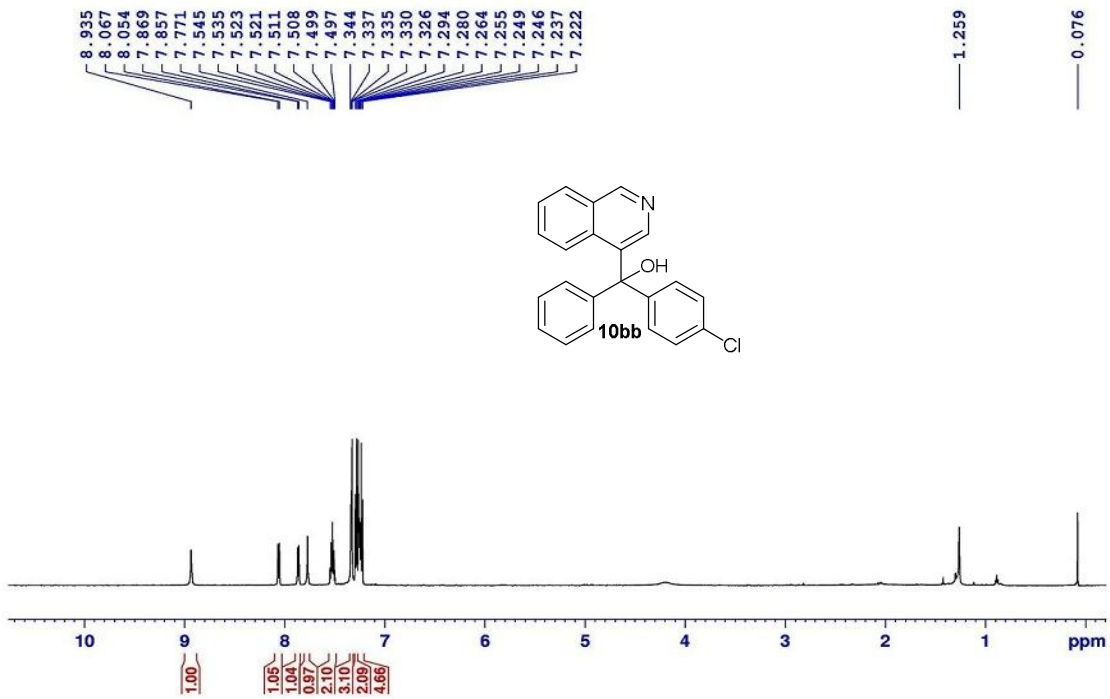
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **10ba**:



^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of **10ba**:

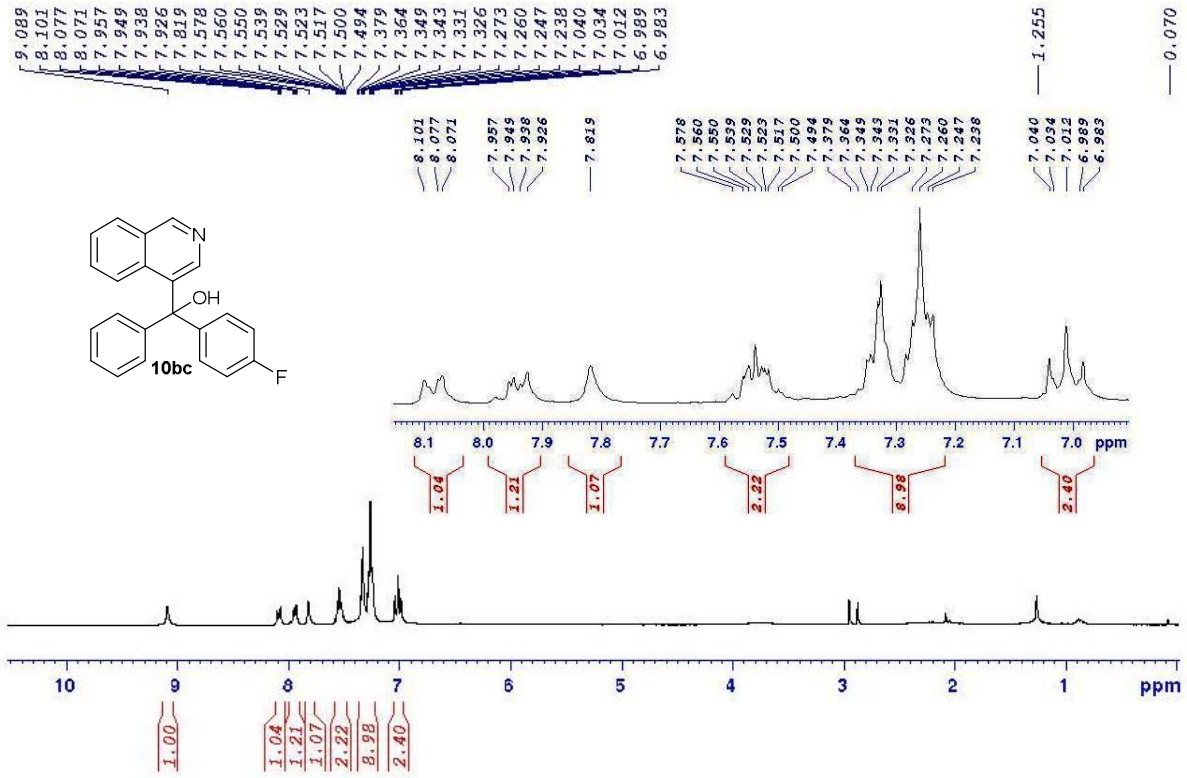


^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **10bb**:

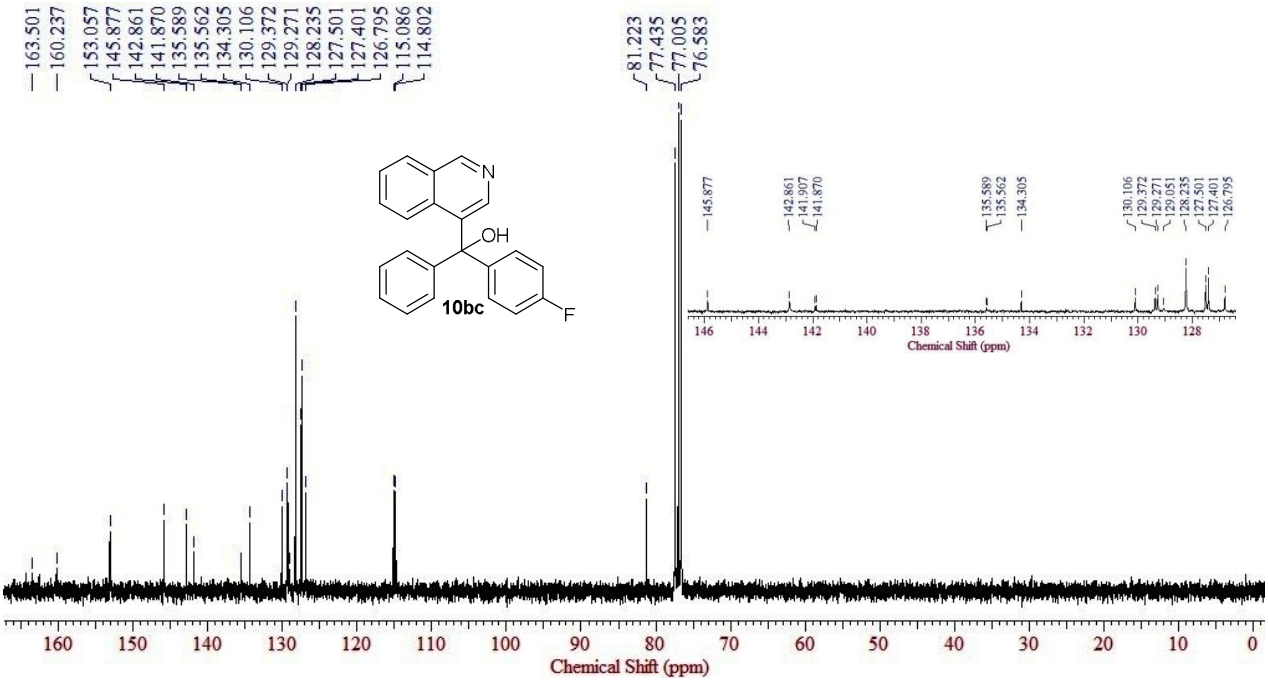


^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of **10bb**:

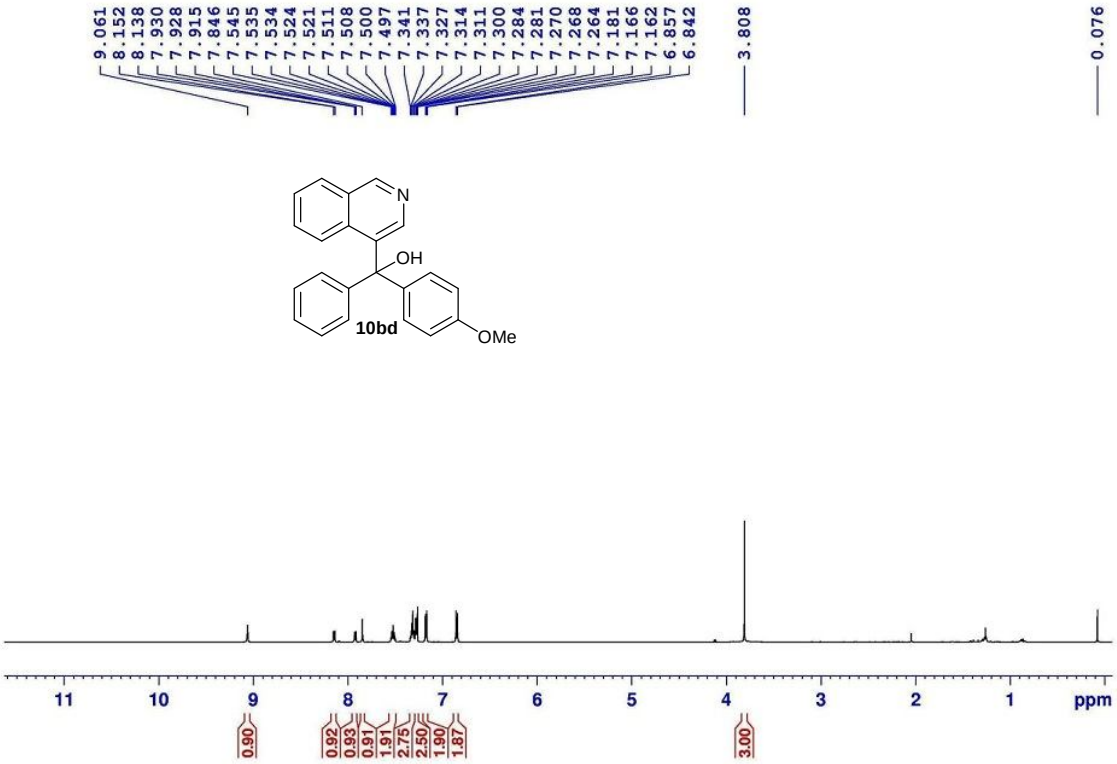
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **10bc**:



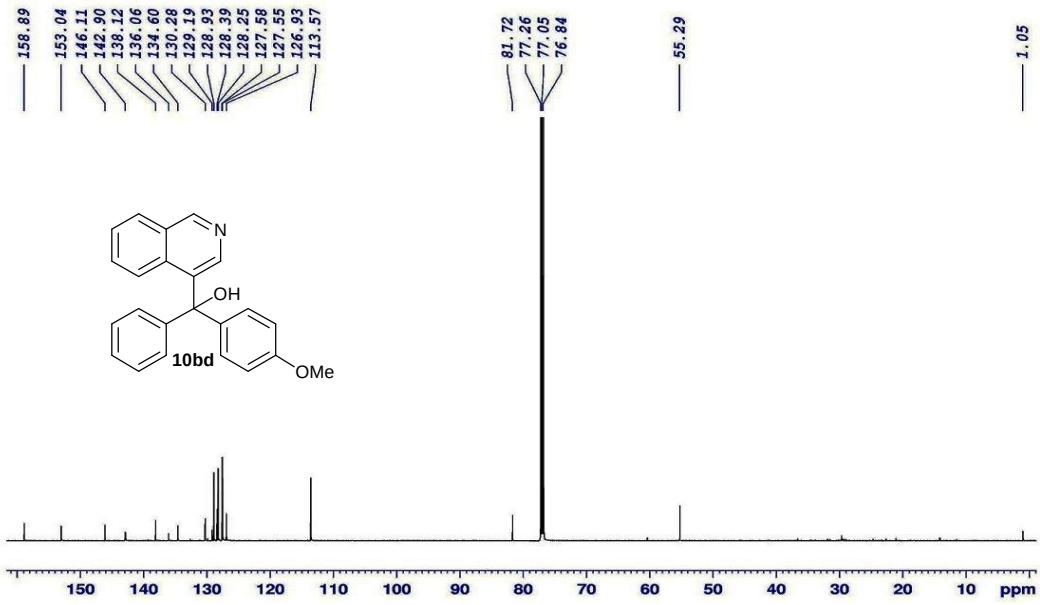
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of **10bc**:



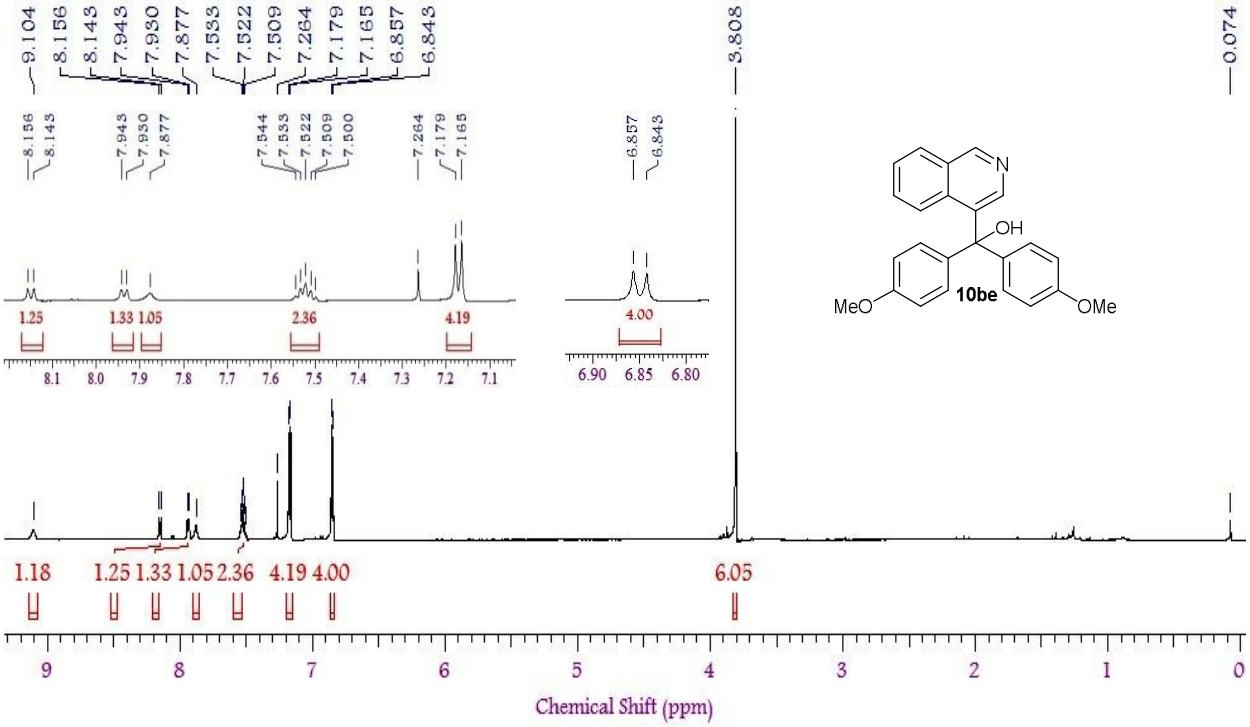
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **10bd**:



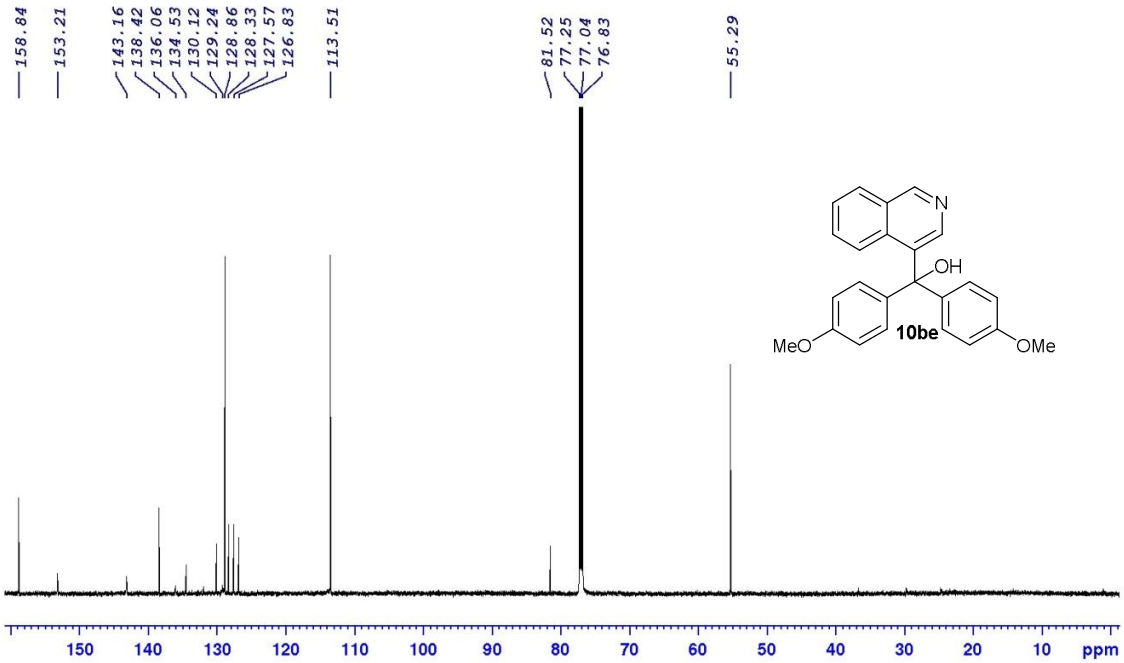
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of **10bd**:



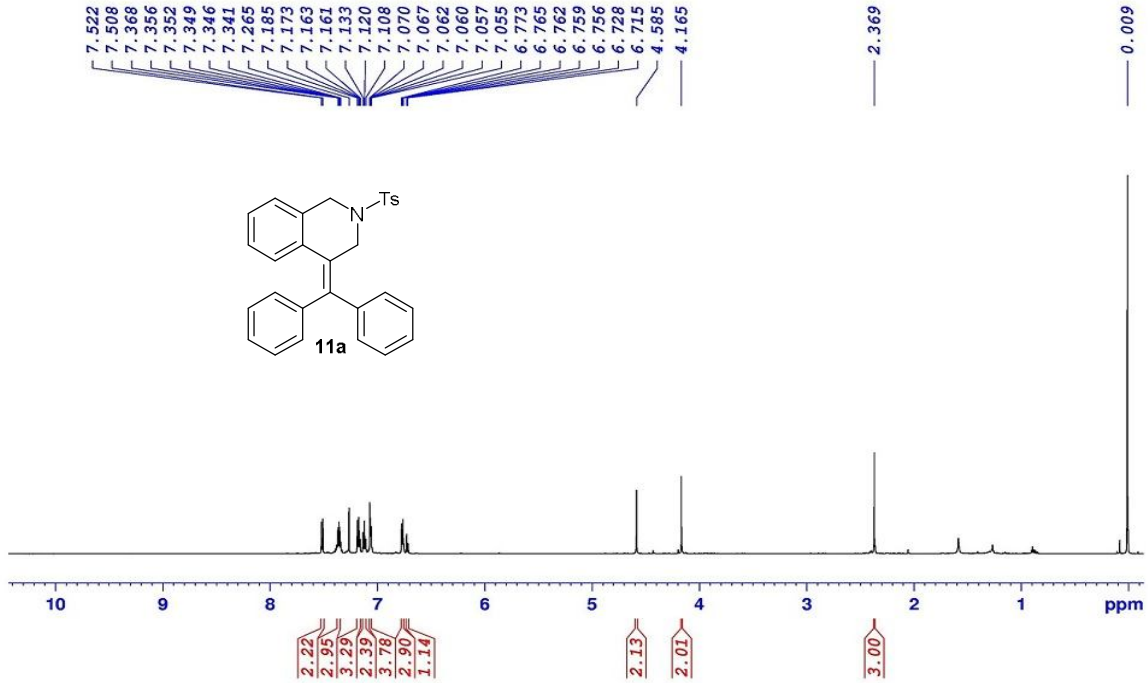
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **10be**:



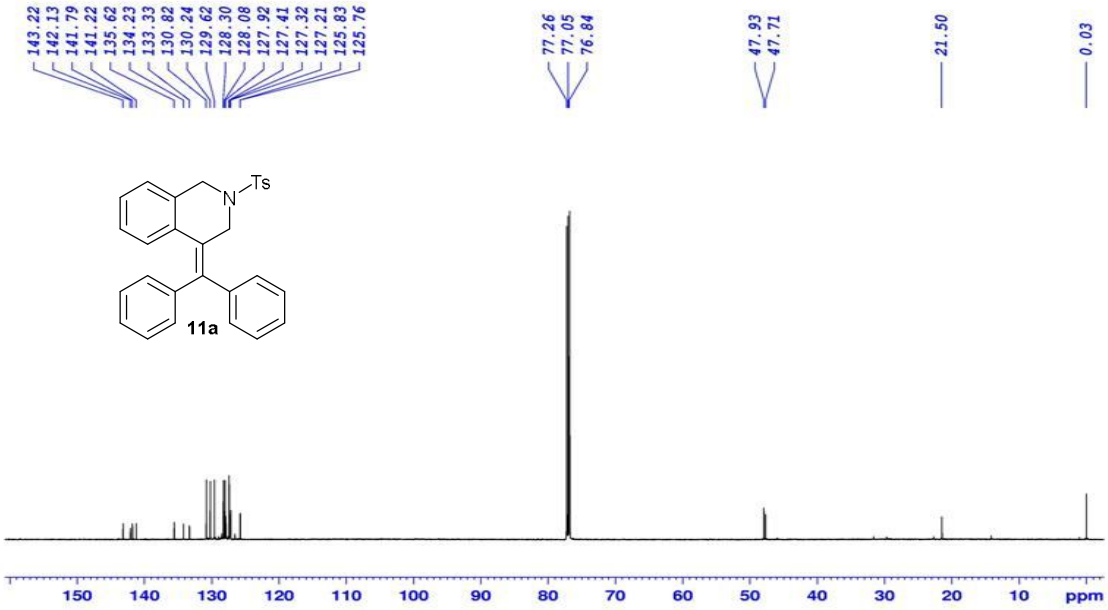
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of **10be**:



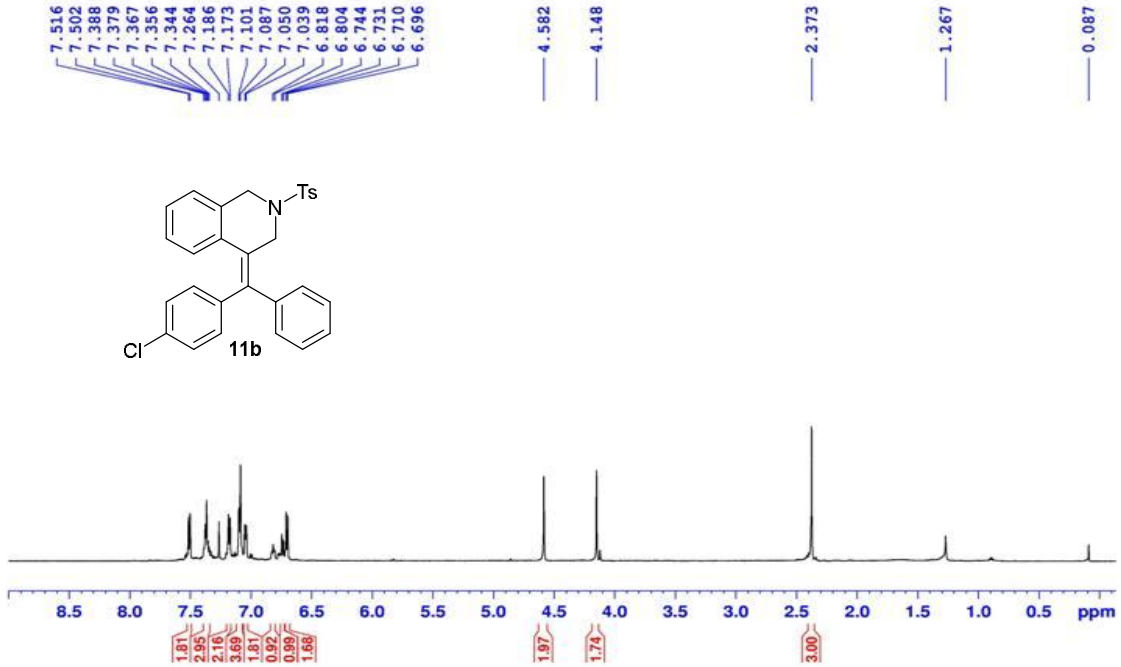
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **11a**:



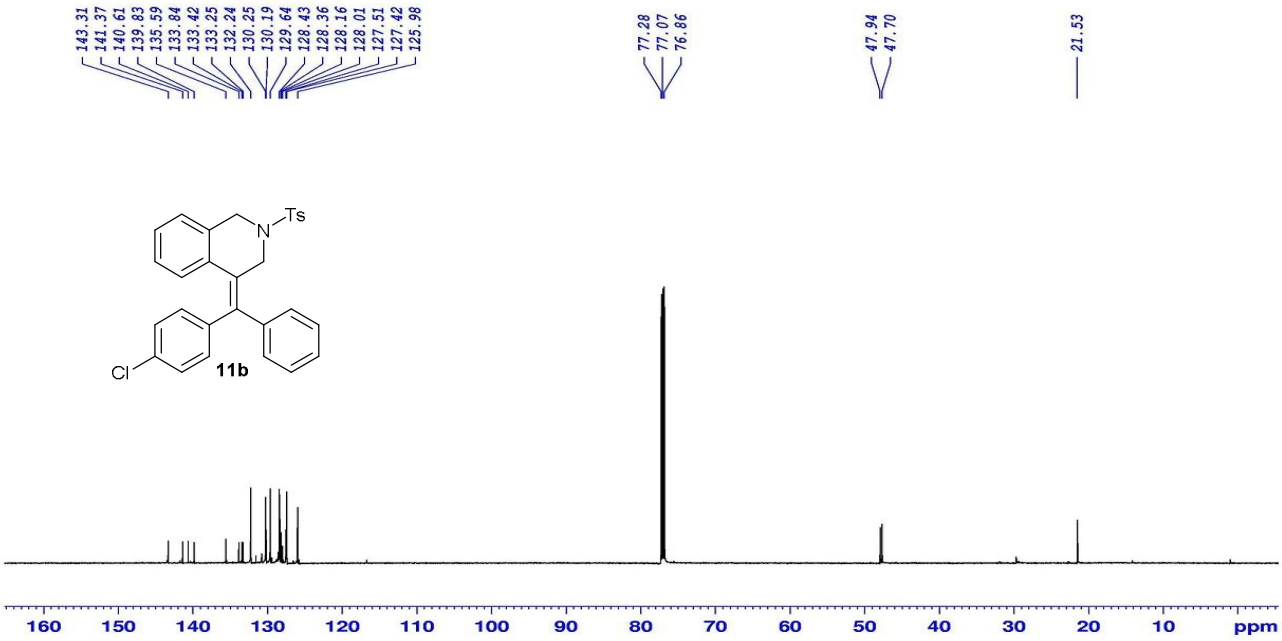
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of **11a**:



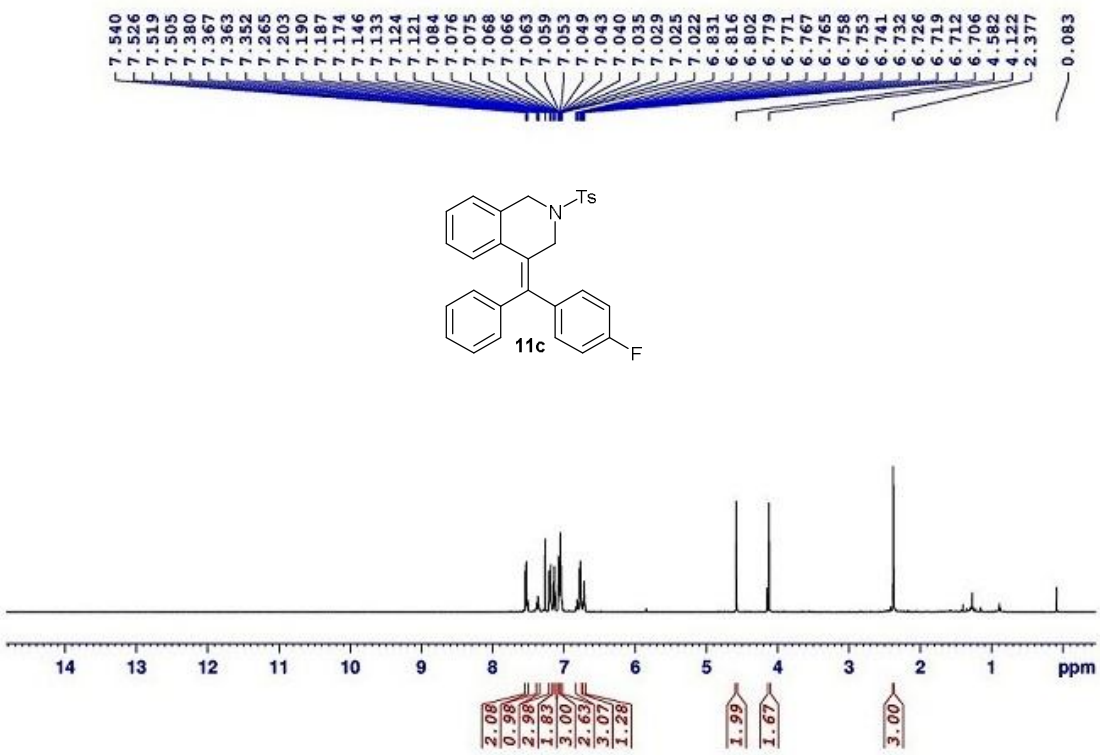
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **11b**:



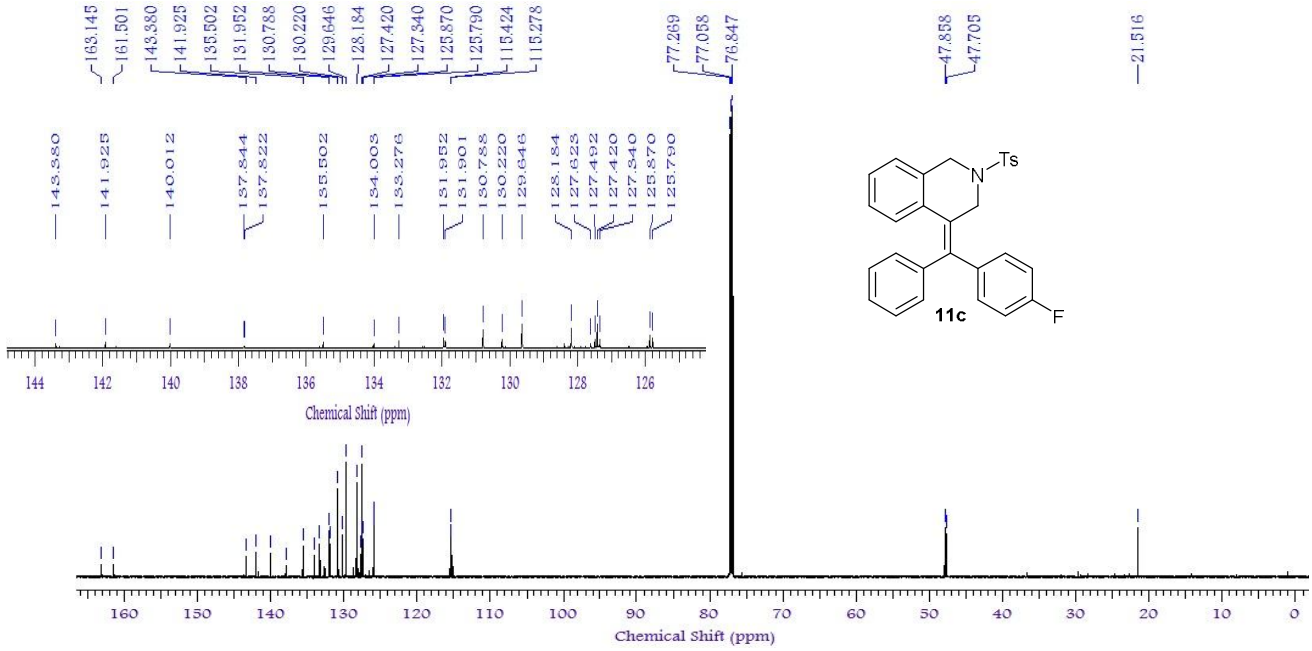
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of **11b**:



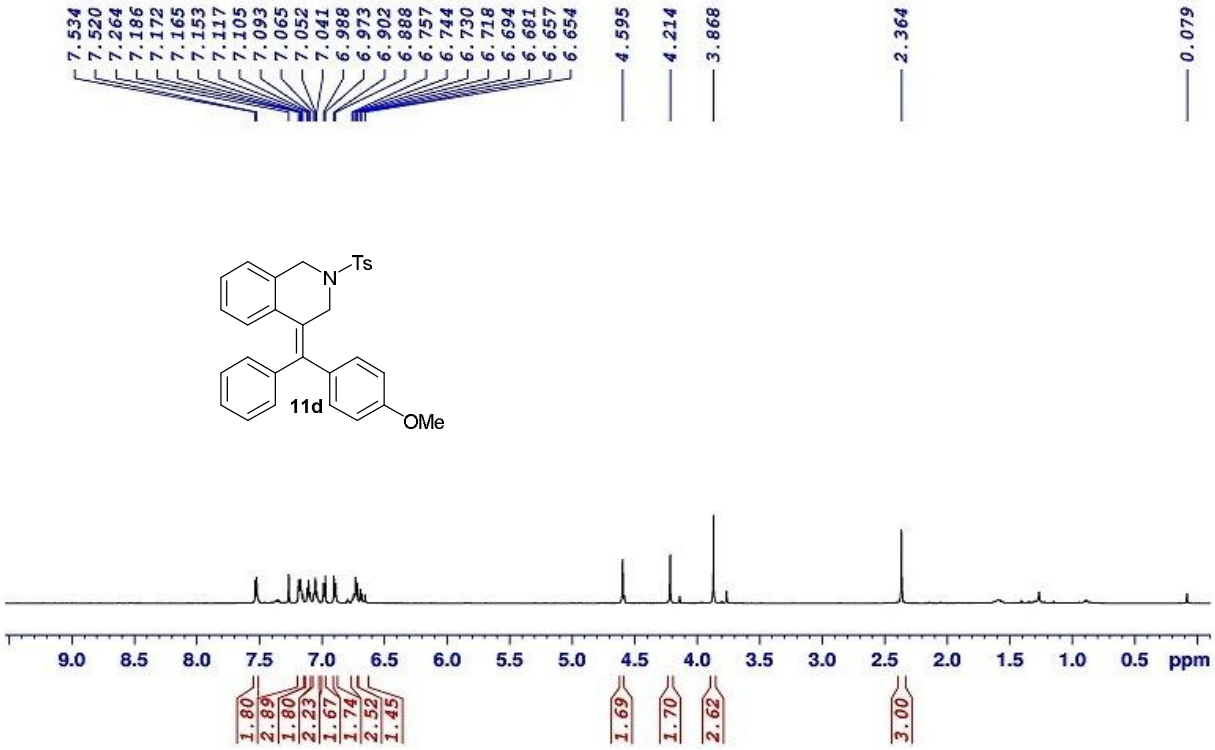
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **11c**:



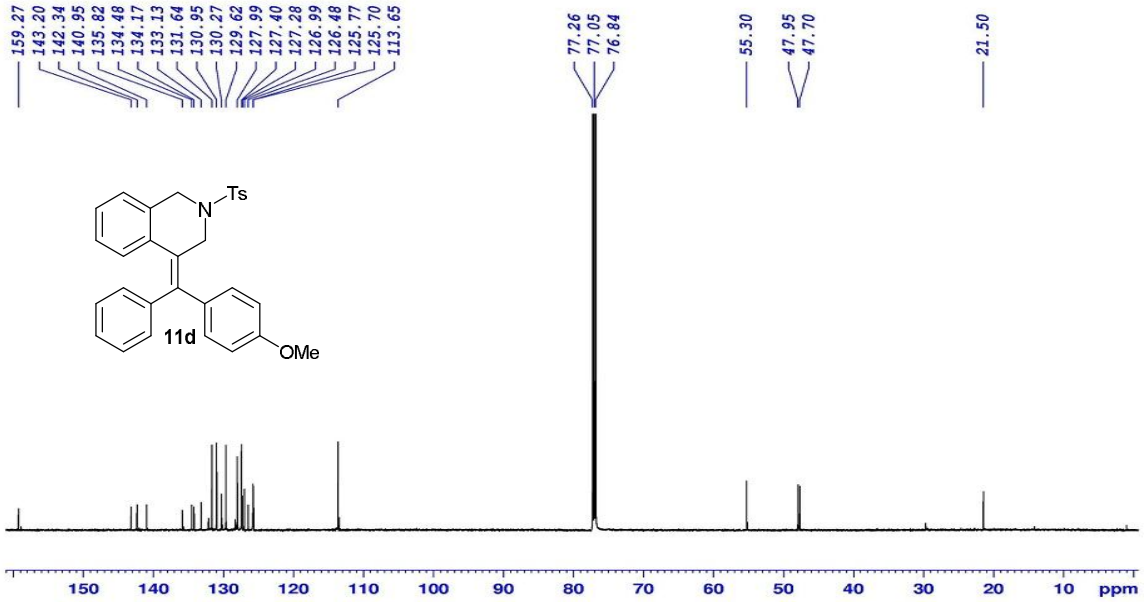
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of **11c**:



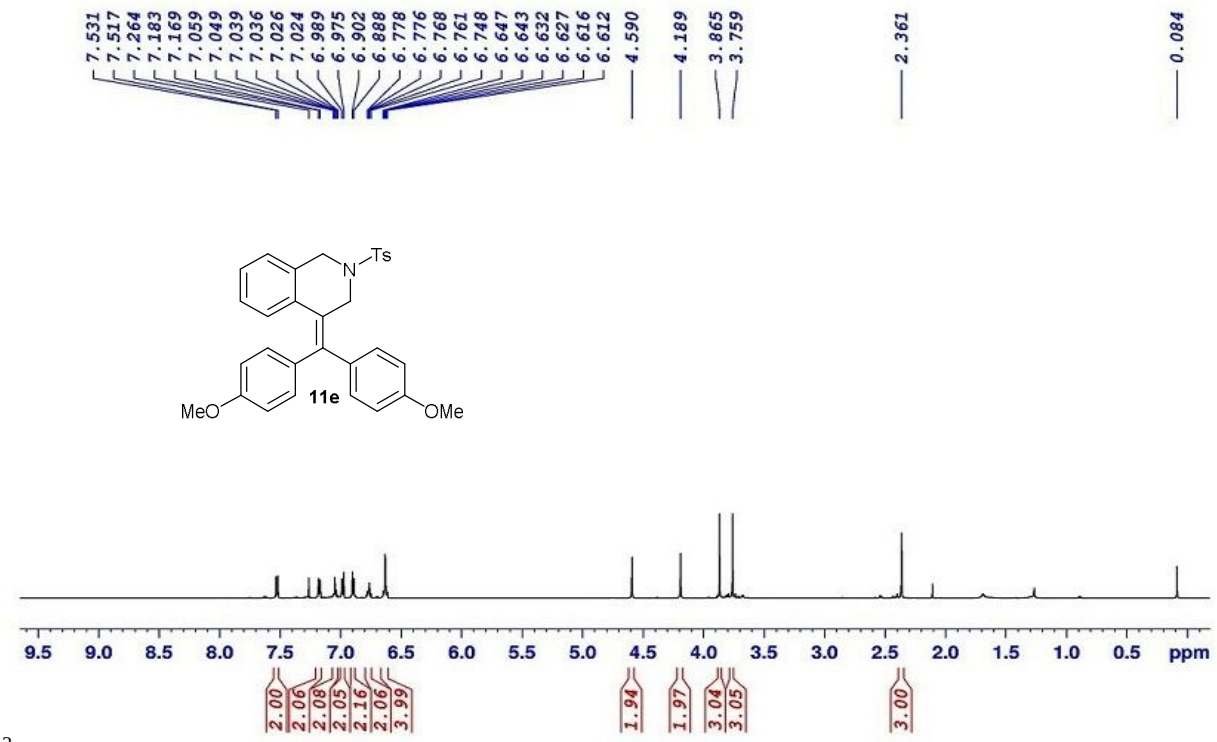
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **11d**:



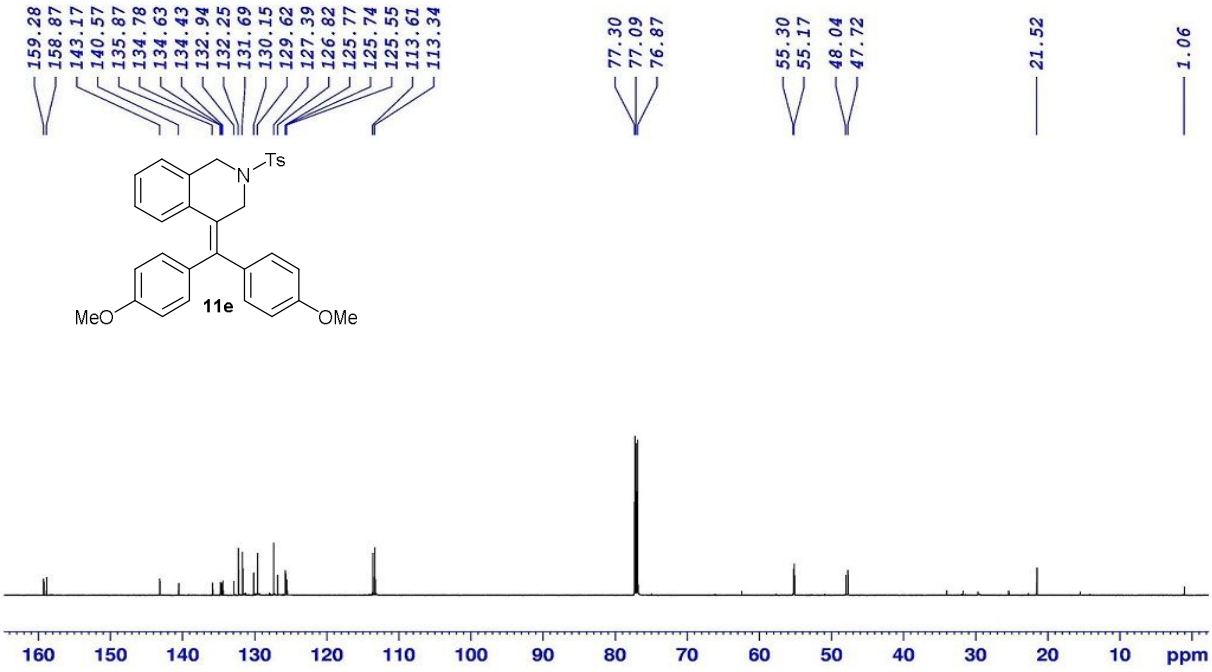
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of **11d**:



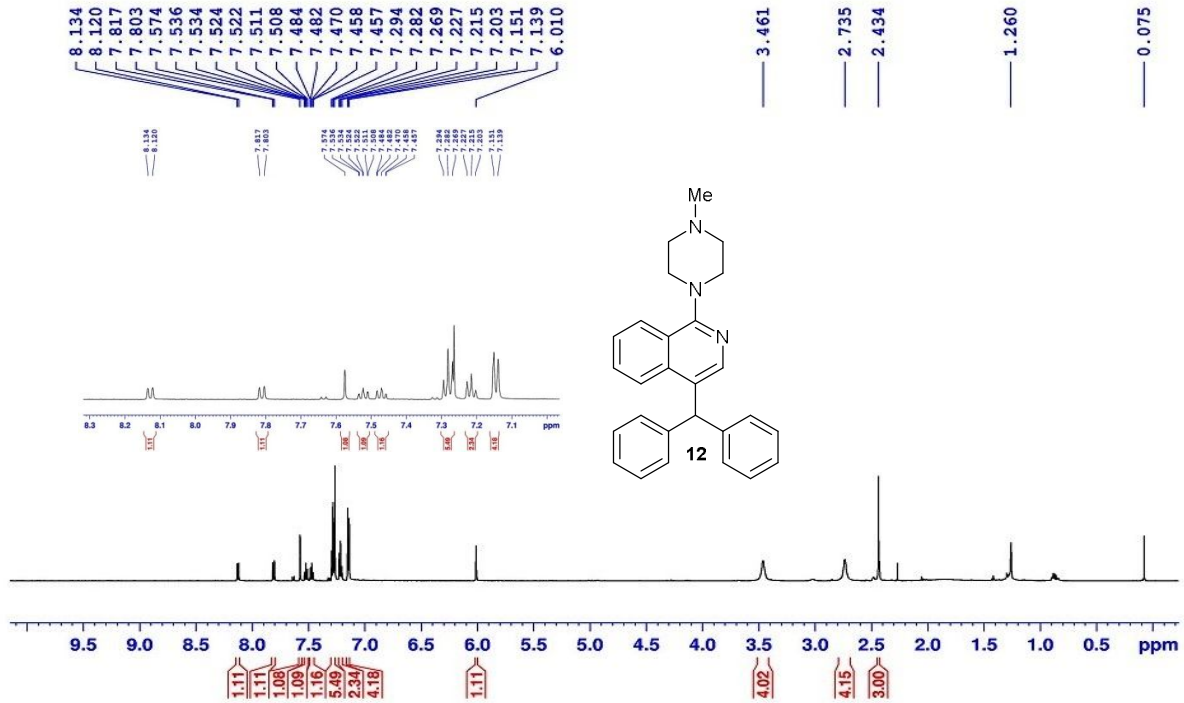
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **11e**:



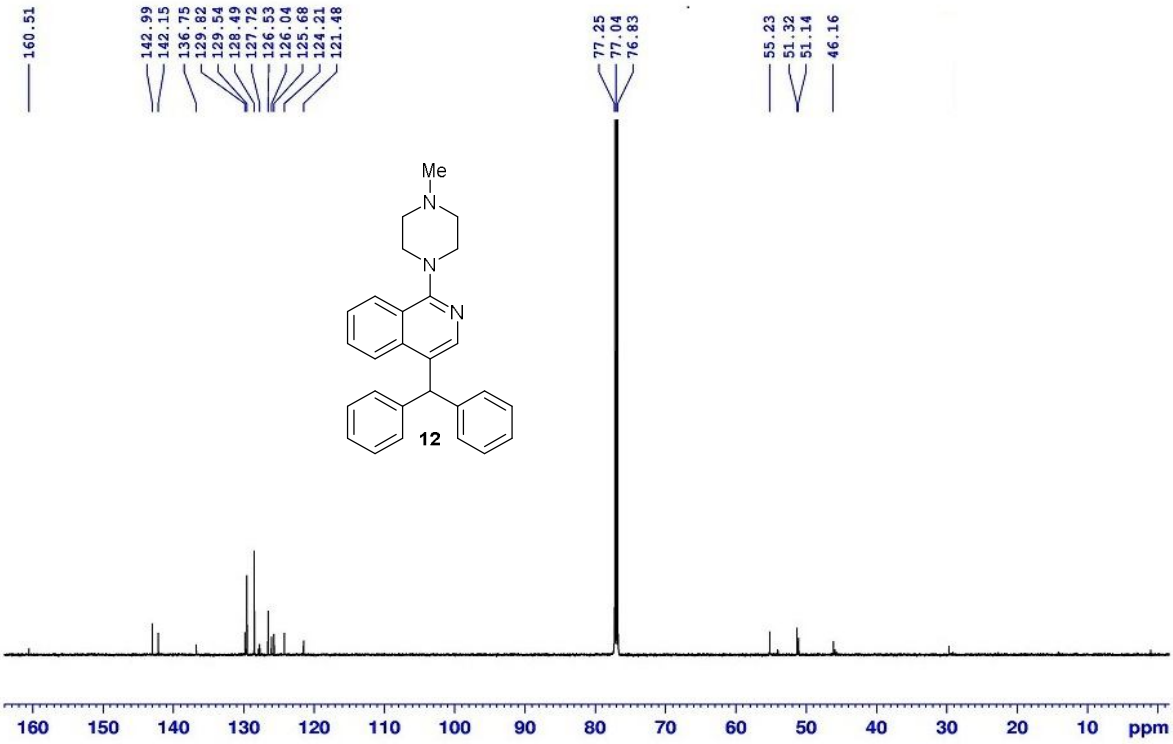
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of **11e**:



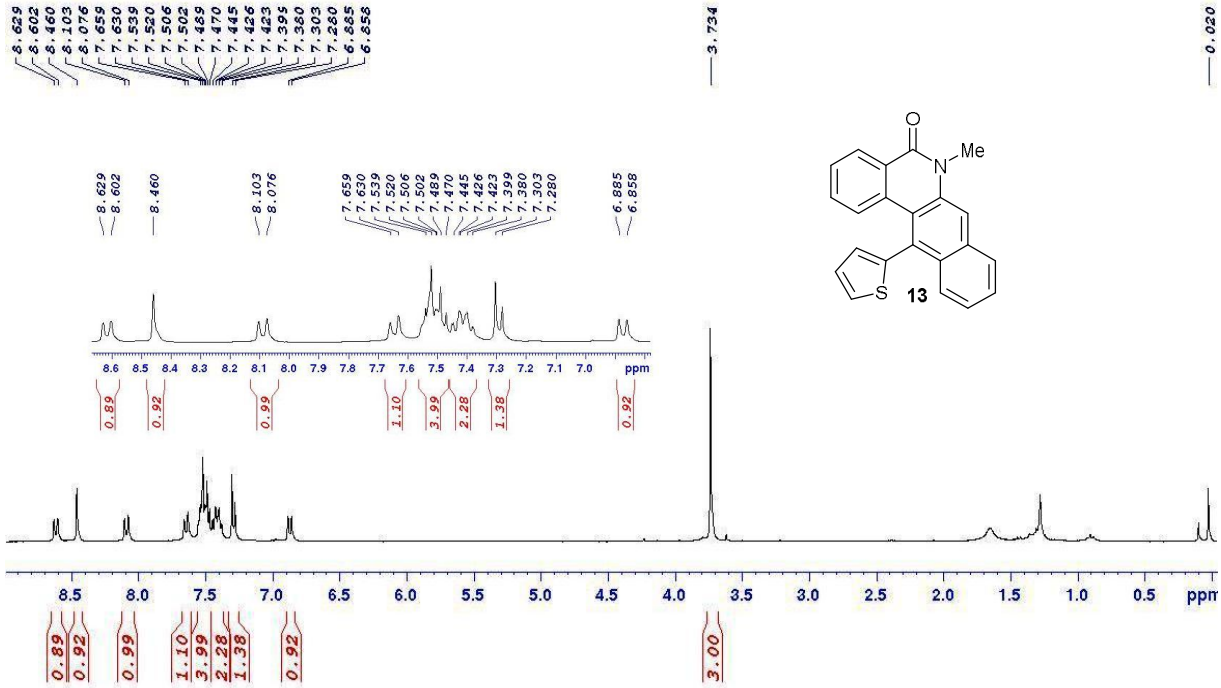
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **12**:



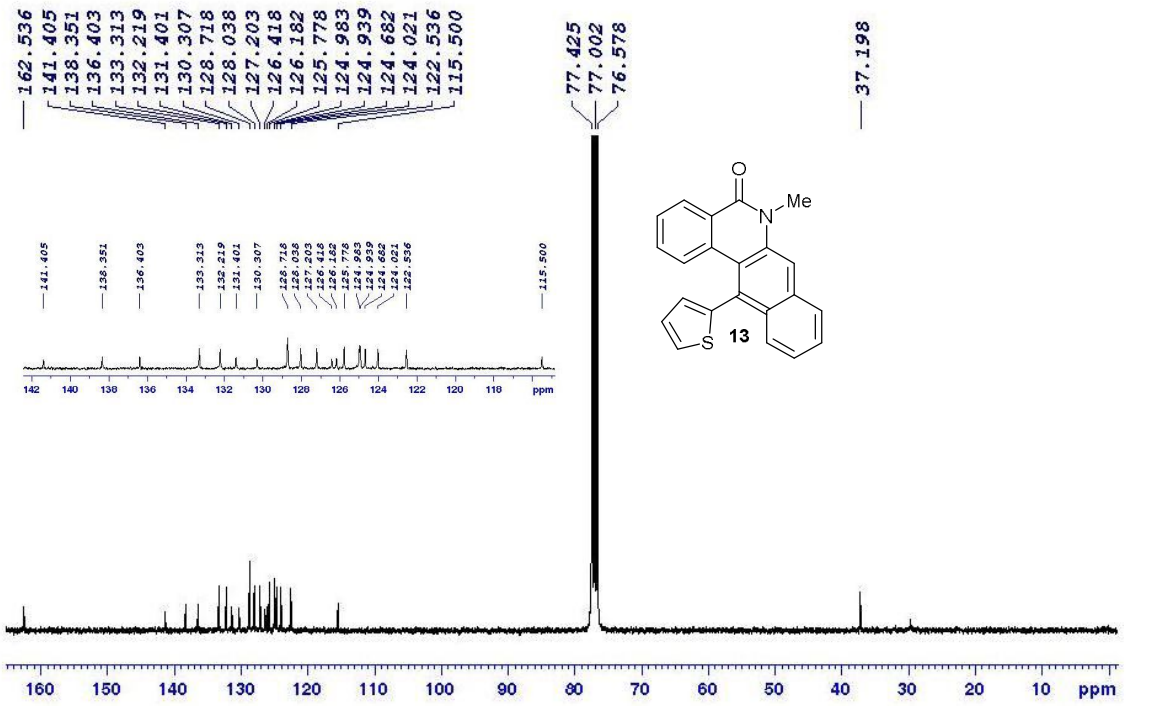
^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of **12**:



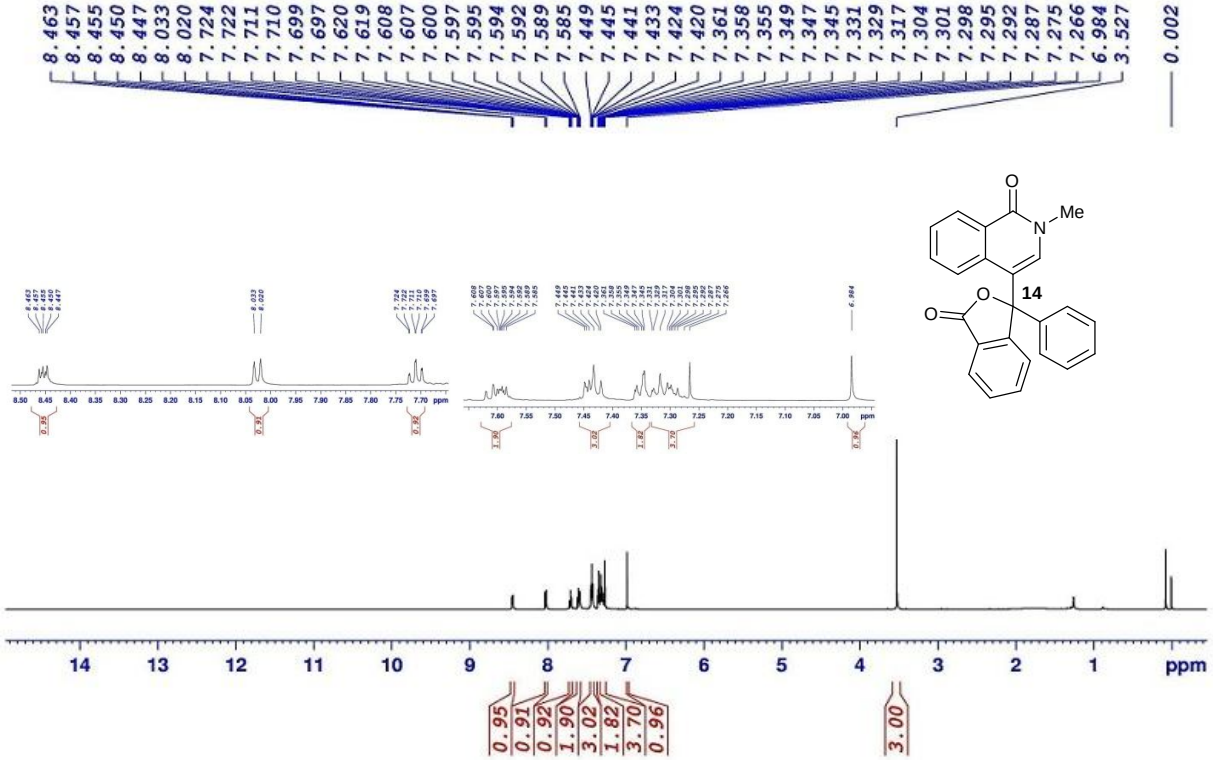
^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **13**:



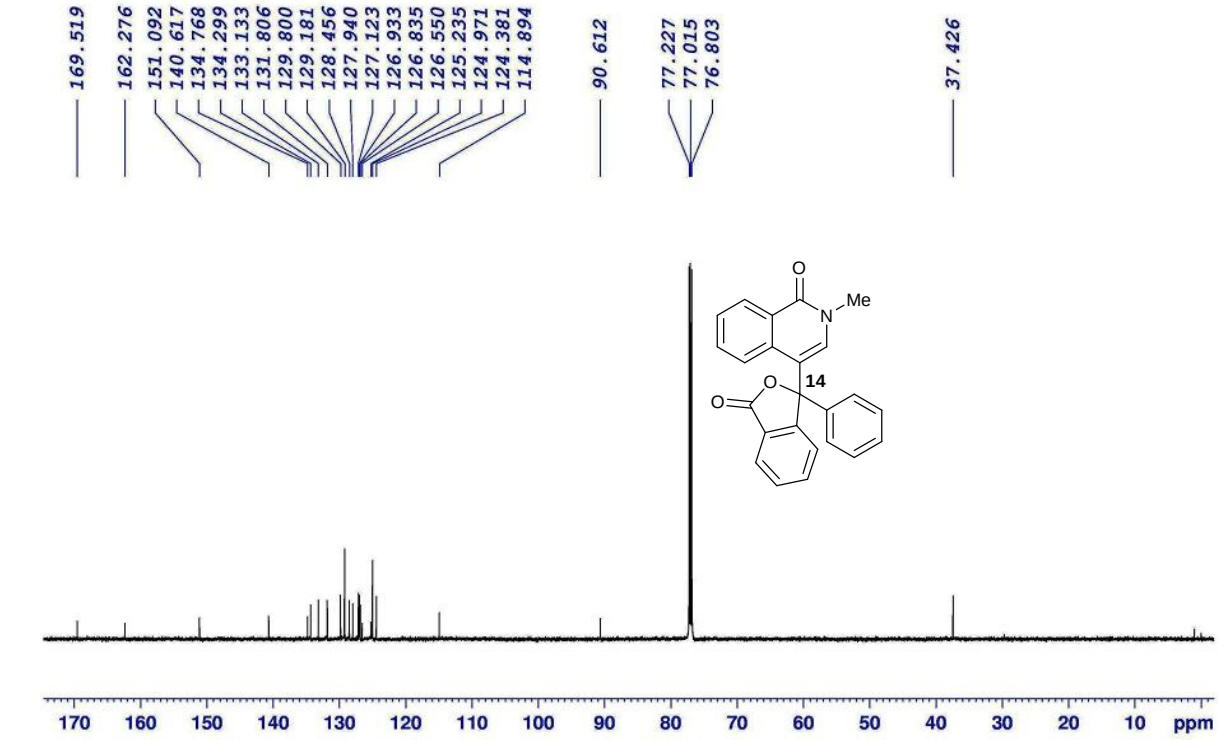
^{13}C NMR ($CDCl_3$, 75 MHz) spectrum of **13**:



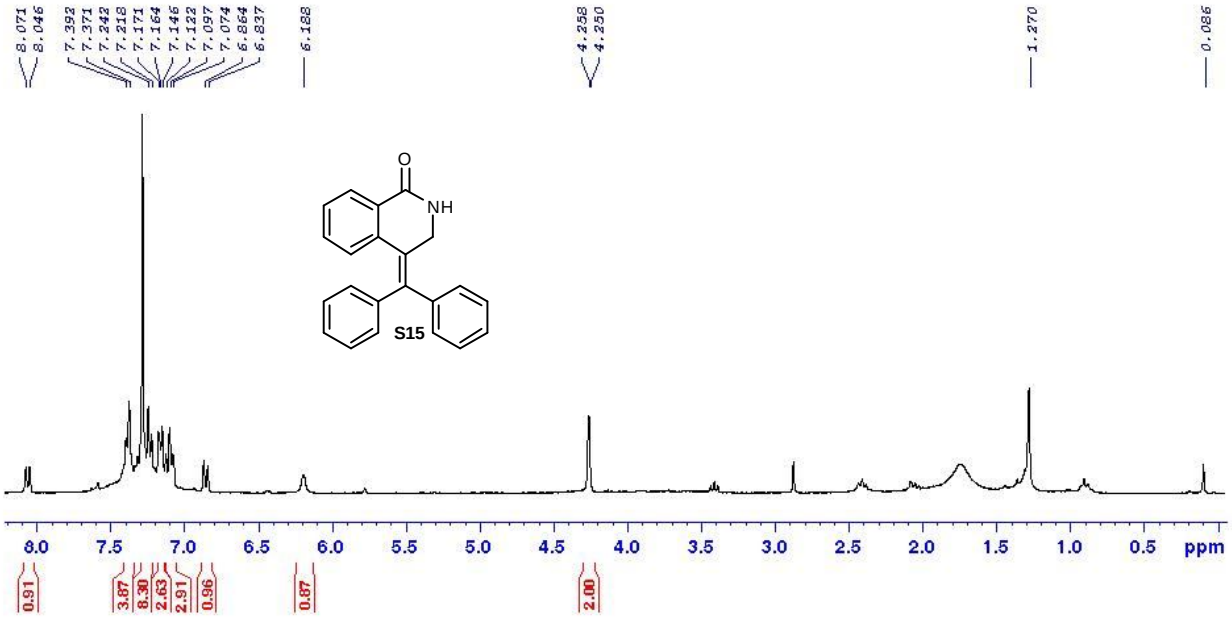
^{1}H NMR ($CDCl_3$, 600 MHz) spectrum of **14**:



^{13}C NMR ($CDCl_3$, 150 MHz) spectrum of **14**:



^{1}H NMR ($CDCl_3$, 300 MHz) spectrum of **S15**:



^{13}C NMR ($CDCl_3$, 75 MHz) spectrum of **S15**: