Supporting Information

Metallaphotoredox-Catalyzed C−H Activation: Regio-Selective Annulation of Allenes with Benzamide

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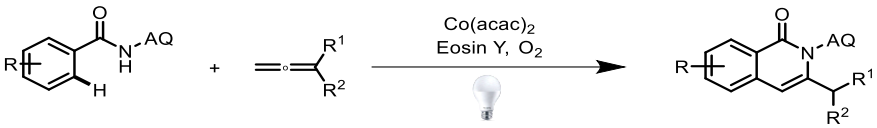

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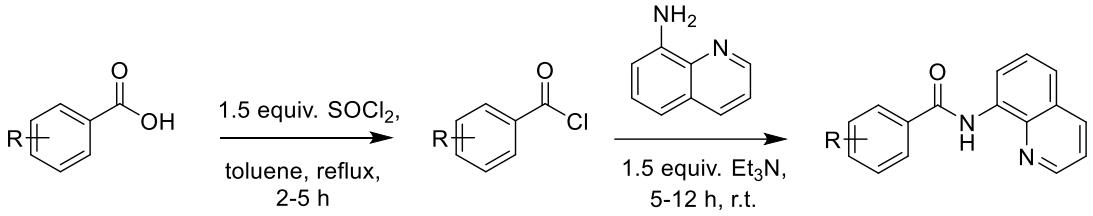
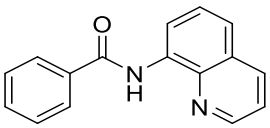
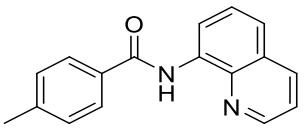
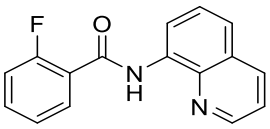
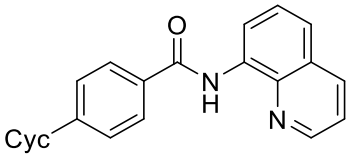
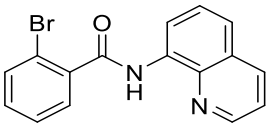
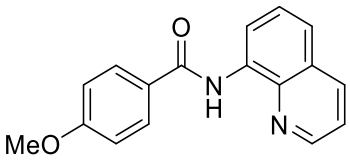
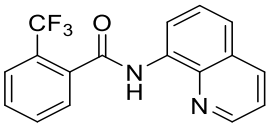
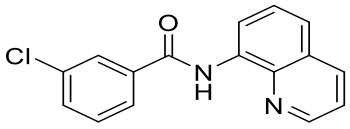
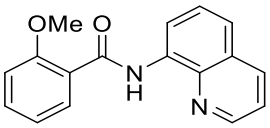
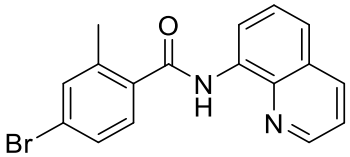
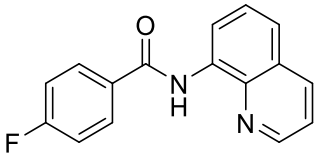
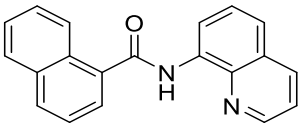
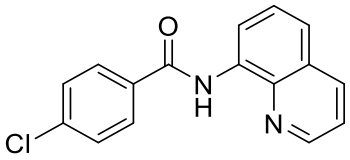
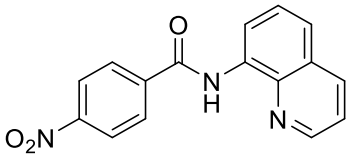
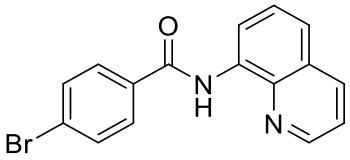
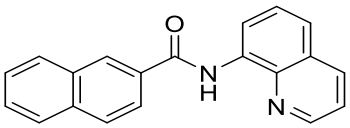
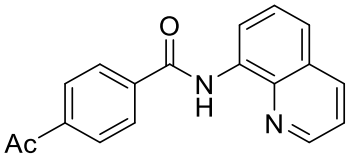
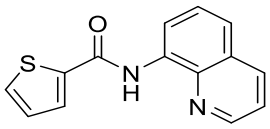
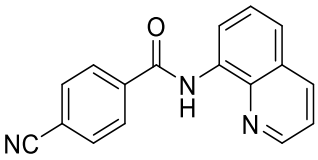
Materials and Methods：

Unless otherwise indicated, all solvents and organic reagents were obtained from commercially available sources and were used without further purification. Silica gel was used for column chromatography and was performed with 60 A mesh standard grade silica gel. The reaction process was monitored using thin layer chromatography (TLC) with silica gel plates (thickness = 0.20 mm, GF254) under UV light and LC-MS (Waters Acquity UPLC/ SQD). Mass spectra was obtained using a Waters Acquity UPLC-SQD mass spectrometer. High resolution mass spectra (HRMS) were recorded on an Agilent Technologies LC/MSD TOF spectrometer. ^{1}H NMR spectra was recorded on a Varian Mercury-400 or 500 MHz instrument, and ^{13}C NMR spectra was recorded at 400 or 500 MHz on a Varian Mercury using $CDCl_3$ as a solvent and tetramethylsilane (TMS) as an internal standard. Chemical shifts are reported in parts per million relative to $CDCl_3$ (d, 7.26), CD_3OD (d, 3.31) and DMSO-d_6 (d, 2.50) for ^{1}H NMR and relative to $CDCl_3$, CD_3OD and DMSO-d_6 for ^{13}C NMR with TMS as an internal standard. Abbreviations used for 1H NMR splitting are as follows: s = singlet, brs = broad singlet, d = doublet, dd = doublet of doublets, t = triplet, q = quartet, m = multiplet, br m = broad multiplet.

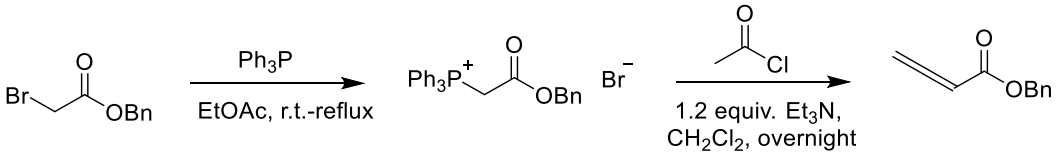
Benzamides substrates:



A 100 mL round bottom flask was charged with carboxylic acid (15 mmol) to which thionyl chloride (30 mmol) was added dropwise under flow of argon at ice cold water in dry toluene as solvent. he reaction mixture was reflux at 110 ^{o}C for 2-5 h, then the excess $SOCl_2$ was removed in vacuum to afford the crude acid chloride on one hand, whereas in another flask solution of 8-aminoquinoline (10 mmol) and Et_3N (22.5 mmol) in dichloromethane (30 mL) was stirred for 30 minutes. Deprotonated amine was added to a solution of acid chloride at 0°C. The reaction was allowed to warm to room temperature and stirred overnight (5-12 h) for complete conversion. Upon completion, it was quenched with saturated $NaHCO_3$ solution and extracted with CH_2Cl_2 three times. These extracts were combined and dried over anhydrous Na_2SO_4. Solvent was evaporated and the corresponding crude amide product was purified by flash column chromatography (Hexane: ethyl acetate 10:1) through silica gel.

Compound ID	Structure	Compound ID	Structure
1a		**1k**	
1b		**1l**	
1c		**1m**	
1d		**1n**	
1e		**1o**	
1f		**1p**	
1g		**1q**	
1h		**1u**	
1i		**1s**	
1j			

Allenes substrates:



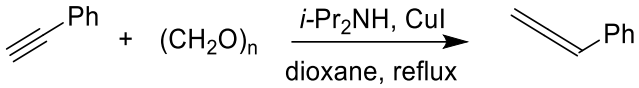
A number of these compounds are known and we follow the general procedure illustrated for the synthesis of buta-2,3-dienoate, the detail procedure was as following[1,4-8]:

Triphenyl phosphine (26.2 g, 100 mmol) and methyl bromoacetate (10.4 mL, 1.1 equiv. 110 mmol) dissolved in 400 mL ethyl acetate, was refluxed overnight to produce a white solid which was removed by suction filtration and wash with cold ethyl acetate. The filter cake was dried over 60 °C at the reduce pressure, gave methoxycarbonyl methyl triphenylphosphonium bromide (44.6 g, 91%).

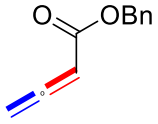
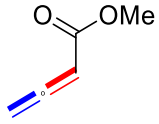
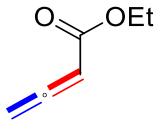
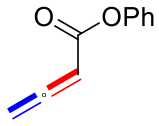
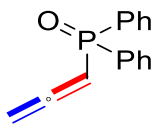
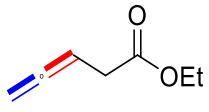
Benzyl(triphenylphosphoranylidene)acetate (19.6 g, 40 mmol) was dissolved in CH_2Cl_2 (210 mL) in a three-necked, round-bottomed flask under nitrogen. The solution was stirred at 0 °C as solution of Et_3N (6.65 mL, 48.0 mmol, 1.2 equiv.) in CH_2Cl_2 (50 mL) was added dropwise (10 min). After 30 min, acetyl choloride (2.84 mL, 40 mmol, 1.0 equiv.) in CH_2Cl_2 (20 mL) was added dropwise over a period of 30 min. After addition, the reaction was allowed to warm to room temperature. The reaction was stirring overnight, and the clear, slight yellow solution was evaporated on a rotary evaporator at reduced pressure. A portion of ether (200 mL) was added to the residue and the slurry was allow to stand for 1 hour while it was shaken periodically to facilitate solidification. The precipitate was removed by filtration and the solid was washed with ether (50 × 2 mL). The filtrates were combined and solvent was evaporated. The mixture was purified by chromatography (PE: EtOAc = 100:0-90:10) afforded the desired product (5.6, 80%) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.42-7.28 (m, 5H), 5.69 (t, J = 6.4 Hz, 1H), 5.25 (d, J = 6.4 Hz, 2H), 5.21 (s, 2H).

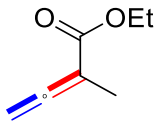
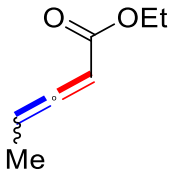
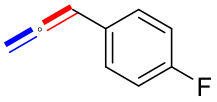
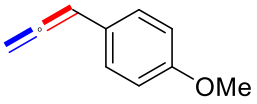
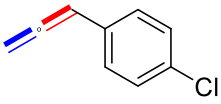
To a solution of propargylic alcohol (2.8 g, 50.0 mmol, 0.5 equiv.) and triethyl orthoacetate (19.3 mL, 17.1 g, 105.0 mmol, 1.05 equiv.) was dropwise added propionic acid (298.1 µL, 4.0 mmol, 4.0 mol%) at 100°C. The reaction mixture was then heated to 160°C and resulting EtOH was continuously distilled off under atmospheric pressure. After 2 h, another aliquot of propargylic alcohol (2.8 g, 50 mmol, 0.5

equiv.) was added and further heated for 3 h. After cooling to room temperature, the reaction was quenched by addition of HCl (2 M, 100 ml). The phases were separated, the aqueous phase was extracted with Et_2O (3×100 ml) and the combined organic layers were washed with Brine, dried over Na_2SO_4, filtrated and concentrated under reduced pressure. The crude product was purified by chromatography (PE: Ether= 100:0-90:10) afforded the desired product (4.5, 35%) [2] as a as a colorless liquid. ^{1}H-NMR(400 MHz, $CDCl_3$): δ= 5.28 (m, 1 H), 4.77 (dd, *J* = 3.0, 3.0 Hz, 1 H), 4.75 (dd, *J* = 3.0, 3.0 Hz, 1 H), 4.16 (q, *J* = 7.2 Hz, 2H), 3.04 (m, 2H), 1.27 (t, *J* = 7.2 Hz, 3H).

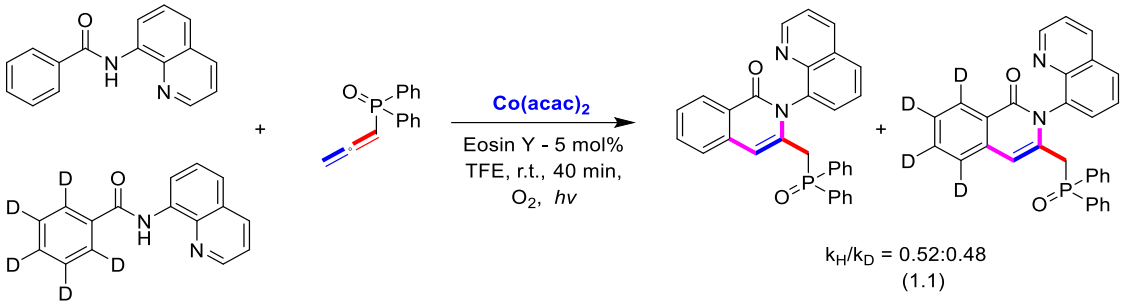


Paraformaldehyde (4.6 g, 2.5 equiv., 50.0 mmol), CuI (1.9 g, 0. 5 equiv., 10 mmol), dioxane (75 mL), phenylacetylene (2.25 g, 1.0 equiv., 20 mmol), and diisopropylamine (5.6 mL, 2.0 equiv., 40.0 mmol) were added sequentially into an oven-dried reaction tube equipped with a reflux condenser under an argon atmosphere. The resulting mixture was stirred under reflux. When the reaction was complete as monitored by TLC, it was cooled to rt. Water (100 mL) and ether (100 mL) were added and then the aqueous solution was separated and extracted with ether (3 × 50 mL). The organic layer was then washed with brine and dried over anhydrous Na_2SO_4. Evaporation and column chromatography on silica gel (petroleum ether/Et_2O) afforded propa-1,2-dien-1-ylbenzene (531.7 mg, 45%)[3]. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35-7.28 (m, 4H), 7.22-7.15 (m, 1H), 6.17 (t, *J* = 6.4 Hz, 1H), 5.14 (*d*, *J* = 7.0 Hz, 2H).

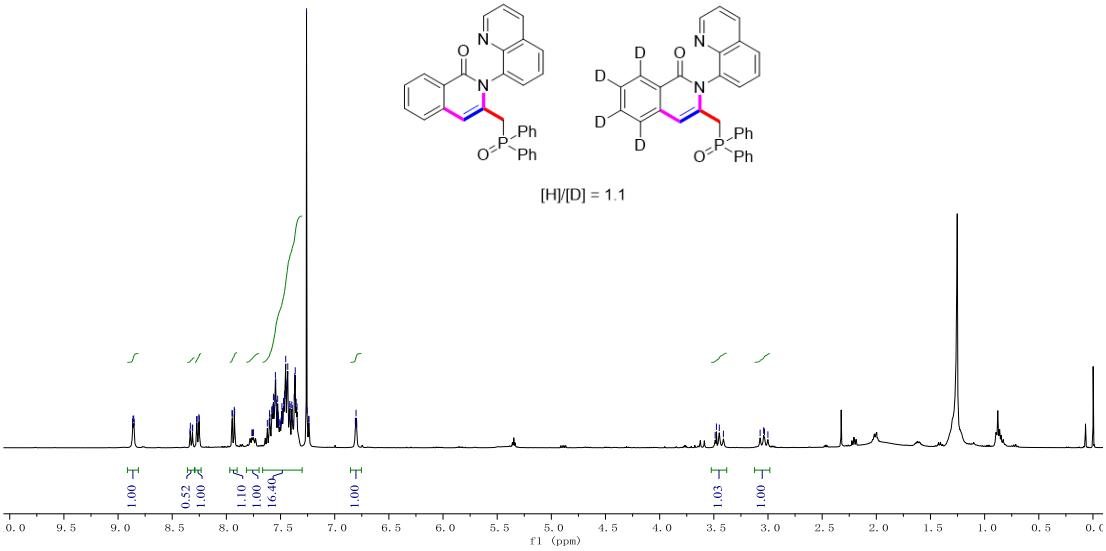
Compound ID	Structure	Compound ID	Structure
2a		**2b**	
2c		**2d**	
2e		**2f**	

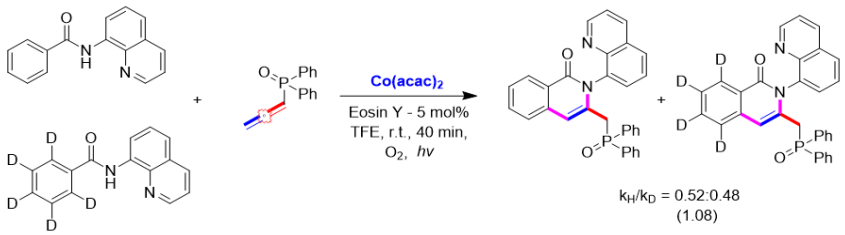
2g		**2h**	
2i		**2j**	
2k		**2l**	

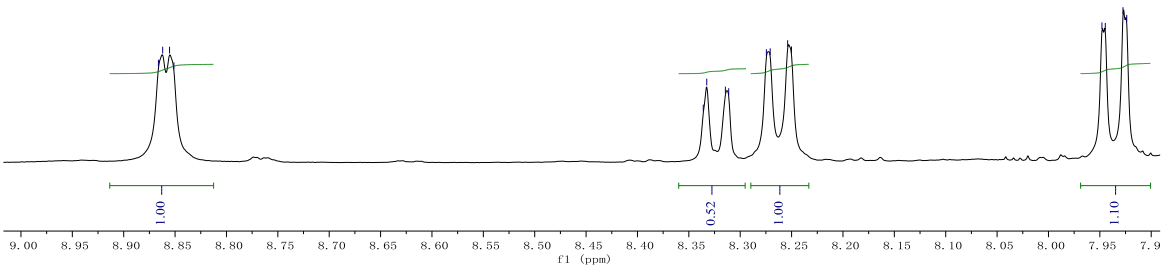
Deuteration experiments and KIE study[9-10]:



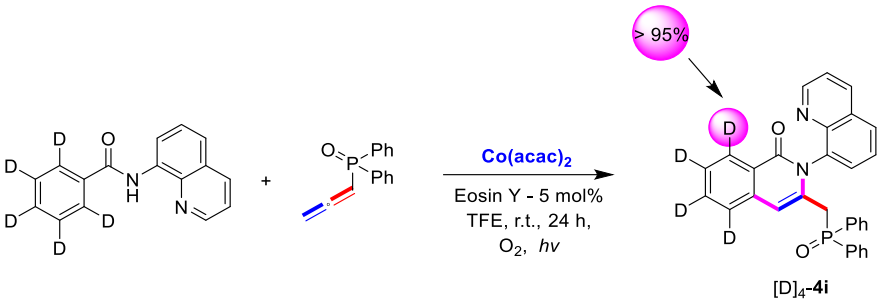
A sealed tube with a screw cape (PTFE) was charged with N-(quinoline-8-yl)benzamide (12.4 mg, 0.05 mmol) and N-(quinoline-8-yl)benzamide-2,3-4,5,6-d5 (12.7 mg, 0.05 mmol), KOTf (3.76 mg, 20 mol%, 0.02 mmol), $Co(acac)_2$ (5.14 mmol, 20 mmol%, 0.02 mmol), Eosin Y (3.45 mg, 5 mol%, 0.005 mmol), and diphenyl(propa-1,2-dien-1-yl)phosphine oxide (48.0 mg, 2.0 equiv., 0.2 mmol) in 1.5 mL 2,2,2-trifluroethanol under oxygen atmosphere. Then, the resulted solution was placed in 15 W white LED at room temperature for 40 min, and analyzed by TLC (petroleum ether: ethyl acetate =10:1, dichloromethane: acetone =80:20). Intermolecular deuterium labeled competition experiment gave [H:D] =1.08 value. The [H:D] was determined by ^{1}H-NMR spectroscopy analysis of the pure product.


[H]/[D] = 1.1
f1 (ppm)

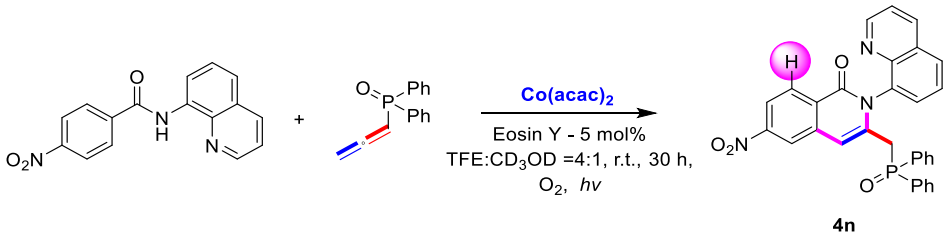

Co(acac)2
Eosin Y - 5 mol%
TFE, r.t., 40 min,
O2, hv
kH/kD = 0.52:0.48
(1.08)


f1 (ppm)

3-((Diphenylphosphoryl)methyl)-2-(quinolin-8-yl)isoquinolin-1(2H)-one-5,6,7,8-d$_4$



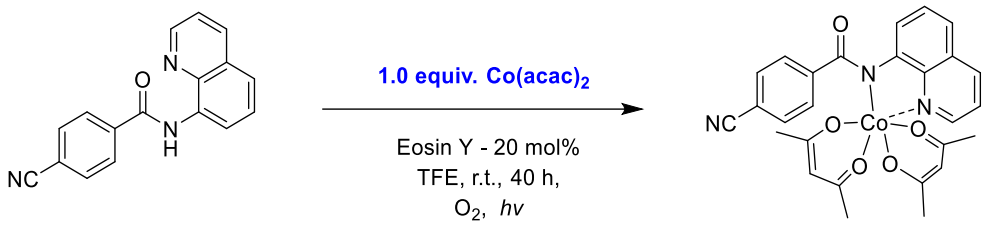
A sealed tube with a screw cape (PTFE) was charged with *N*-(quinoline-8-yl)benzamide-2,3-4,5,6-d5 (25.4 mg, 0.1 mmol), KOTf (3.76 mg, 20 mol%, 0.02 mmol), $Co(acac)_2$ (5.14 mmol, 20 mmol%, 0.02 mmol), Eosin Y (3.45 mg, 5 mol%, 0.005 mmol), and diphenyl(propa-1,2-dien-1-yl)phosphine oxide (48.0 mg, 2.0 equiv., 0.2 mmol) in 1.5 mL 2,2,2-trifluroethanol under oxygen atmosphere. Then, the resulted solution was placed in 15 W white LED at room temperature for 24 h, the reaction process was detected by thin-layer chromatography (TLC). Upon completion, the reaction mixture was evaporated under reduced pressure and passed through the column for purification. Dichloromethane and acetone mixture were used as an eluent. [D]$_4$-**4i** is obtained as a yellow solid; 39.2 mg, 80% yield. **^{1}H-NMR (400 MHz, Chloroform-*d*)** δ 8.85 (d, *J* = 4.0 Hz, 1H), 8.28 (d, *J* = 4.0, 1H), 7.94 (d, *J* = 8.0 Hz, 1H), 7.77 - 7.74 (m, 1H), 7.60 - 7.28 (m, 12H), 6.78 (d, *J* = 4.0 Hz, 1H), 3.46 (dd, *J* = 15.9, 8.0 Hz, 1H), 3.03 (dd, *J* = 16.0, 8.0 Hz, 1H)**.^{13}C-NMR (100 MHz, Chloroform-*d*)** δ 163.7, 151.6, 144.5, 136.9, 136.5, 135.7, 134.3, 134.2, 133.1, 132.5, 132.3, 132.2, 132.1, 131.74, 131.70, 131.5, 131.4, 131.0, 130.9, 130.7, 129.5, 129.3, 129.0, 128.9, 128.86, 128.78, 128.7, 126.6, 125.3, 122.0, 108.1, 35.3, 34.6. HRMS (ESI): calculated for $C_{31}H_{19}D_4N_2O_2P$ for $[M+H]^+$ 491.1825, found: 491.1824.



In an oven dried Schlenk tube charged with magnetic stirrer, 4-nitro-*N*-(quinolin-8-yl)benzamide (0.1 mmol, 1.0 equiv.), $Co(acac)_2$ (0.02 mmol, 20 mol%), potassium trifluoride mesylate (0.02 mmol, 20 mol%) and Eosin Y disodium salt (0.005 mmol, 5 mol%) were added. Freshly prepared allene was subsequently added to the reaction mixture followed by freshly distilled 2,2,2-trifluroethanol (1.2 mL)

and methanol-d_4 (0.5 mL) as a mixture solvent. The Schlenk tube was evacuated and purged with oxygen. Then, the resulted solution was placed in 15 W white LED at room temperature for 30 h. After the reaction, the crude purified by flash chromatography (silica gel, petroleum ether/ ethyl actate = 1:1 to 1:2), affording the desired product as a yellow solid (32.1 mg, 65% isolated yield). **^{1}H-NMR (400 MHz, Chloroform-*d*)** δ 8.85 (d, *J* = 4.0 Hz, 1H), 8.45 (d, *J* = 4.0, 1H), 8.28-8.27 (m, 2H), 8.15 (dd, *J* = 8.0, 4.0 Hz, 1H), 7.98 (d, *J* = 4.0 Hz, 1H), 7.77-7.73 (m, 3H), 7.63 - 7.45 (m, 13H), 7.37-7.35 (m, 3H), 6.78 (d, *J* = 4.0 Hz, 1H), 3.45 (dd, *J* = 15.9, 8.0 Hz, 1H), 3.07 (dd, *J* = 16.0, 8.0 Hz, 1H).

Isolation of Co(III) intermediate:



In an oven dried Schlenk tube charged with magnetic stirrer, 4-cyano-*N*-(quinolin-8-yl)benzamide (0.1 mmol, 1.0 equiv., 27.3 mg), $Co(acac)_2$ (0.1 mmol, 1.0 equiv., 51.4 mg), potassium trifluoride mesylate (0.02 mmol, 20 mol%, 3.76 mg) and Eosin Y disodium salt (0.02 mmol, 20 mol%) were added. Freshly prepared allene was subsequently added to the reaction mixture followed by freshly distilled 2,2,2-trifluroethanol (1.5 mL) as a mixture solvent. The Schlenk tube was evacuated and purged with oxygen. Then, the resulted solution was placed in 15 W white LED at room temperature for 40 h. After the reaction, the crude purified by flash chromatography (silica gel, petroleum ether/ ethyl actate = 1:1 to 1:2), affording the desired product as a green black solid (13.3 mg, 25% isolated yield). **^{1}H-NMR (400 MHz, Chloroform-*d*)** δ 8.91 (d, *J* = 8.0 Hz, 1H), 8.45 (d, *J* = 8.0 Hz, 1H), 8.20 (dd, *J* = 8.0, 4.0 Hz, 1H), 7.86-7.84 (m, 2H), 7.59 - 7.51 (m, 4H), 7.38 (d, *J* = 8.0 Hz, 1H), 5.50 (s 1H), 5.25 (s, 1H), 2.14 (s, 3H), 2.03 (s, 3H), 1.80 (s, 3H), 1.45 (s, 3H); **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 189.9, 189.0, 188.9, 188.5, 151.7, 149.3, 147.9, 138.7, 131.0, 130.0, 130.0, 129.5, 123.5, 121.3, 118.3, 112.1, 98.1, 97.4, 29.9, 29.5, 26.7, 26.4, 26.0, 25.7. HRMS (ESI): calculated for $C_{26}H_{25}CoN_3O_5$ for $[M+H]^+$ 530.1122, found: 530.1119.

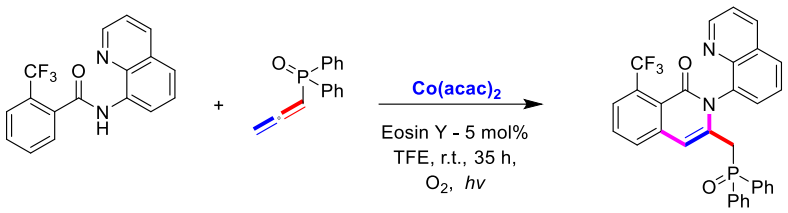
Experimental Section:

Typical procedure for annulation of benzamides with allenes:

In an oven dried Schlenk tube charged with magnetic stirrer, benzamide (0.1 mmol, 1.0 equiv.), $Co(acac)_2$ (0.02 mmol, 20 mol%), potassium trifluoride mesylate (0.02 mmol, 20 mol%) and Eosin Y disodium salt (0.005 mmol, 5 mol%) were added. Freshly prepared allene was subsequently added to the reaction mixture followed by freshly distilled 2,2,2-trifluroethanol (1.5 mL) as solvent. The Schlenk tube was evacuated and purged with oxygen. Then, the resulted solution was placed in 15 W white LED at room temperature for 24 h. The reaction process was detected by thin-layer chromatography (TLC). Upon completion, the reaction mixture was evaporated under reduced pressure and passed through the column for purification. Petroleum ether and ethyl acetate mixture was used as an eluent.

Gram scale synthesis of dihydrisoquinolin-1(2*H*)-ones

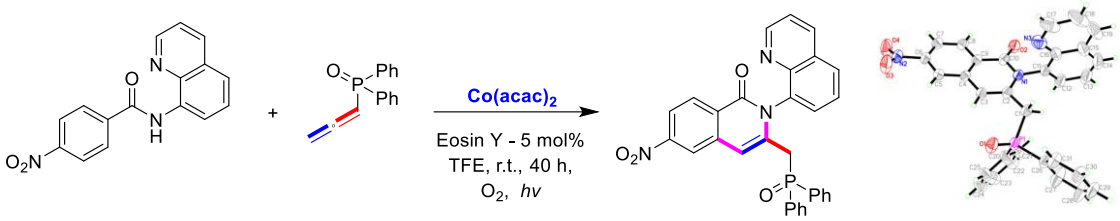
3-((diphenylphosphoryl)methyl)-2-(quinolin-8-yl)-8-(trifluoromethyl)isoquinolin-1(2H)-one (4m)



In an oven dried Schlenk tube charged with magnetic stirrer, *N*-(quinolin-8-yl)-2-(trifluoromethyl)benzamide (1.90 mmol, 1.0 equiv., 0.60 g), $Co(acac)_2$ (0.38 mmol, 20 mol%, 97.7 mg), potassium trifluoride mesylate (0.38 mmol, 20 mol%, 71.4 mg) and Eosin Y disodium salt (0.095 mmol, 5 mol%, 66.2 mg) were added. Freshly prepared diphenyl(propa-1,2-dien-1-yl)phosphine (2.85 mmol, 1.5 equiv., 684.0 mg) was subsequently added to the reaction mixture followed by freshly distilled 2,2,2-trifluroethanol (12 mL) as solvent. The Schlenk tube was evacuated and purged with oxygen. Then, the resulted solution was placed in 15 W white LED at room temperature for 35 h. The reaction process was detected by thin-layer chromatography (TLC). After the reaction, the crude purified by flash chromatography (silica gel, petroleum ether/ ethyl actate = 1:1 to 1:2), affording the desired product **4m** as a yellow solid (864.6 mg, 79% isolated yield). **^{1}H-NMR (400 MHz, Chloroform-*d*)** δ ^{1}H NMR (400

MHz, $CDCl_3$) δ 8.85 (d, *J* = 4.0 Hz, 1H), 8.25 (dd, *J* = 8.0, 4.0 Hz, 1H), 7.92 (d, *J* = 8.0 Hz, 1H), 7.85 (dd, *J* = 8.0, 4.0 Hz, 1H), 7.67-7.34 (m, 15H), 7.30 (d, *J* = 8.0 Hz, 1H), 6.85 (s, 1H), 3.37 (dd, *J* = 15.9, 8.0 Hz, 1H), 3.00 (dd, *J* = 16.0, 8.0 Hz, 1H). **^{13}C NMR (100 MHz, $CDCl_3$)** δ 160.7, 151.5, 144.4, 136.5, 136.3, 135.5, 132.9, 132.4, 131.9, 131.8, 131.5, 131.4, 131.3, 131.2, 130.99, 130.89, 130.8, 129.5, 129.5, 129.0, 128.9, 128.86, 128.8, 126.8, 126.4, 122.5, 122.1, 107.4, 107.38, 35.18, 34.52. HRMS (ESI): calculated for $C_{32}H_{23}F_3N_2O_2P$ for $[M+H]^+$ 555.1451, found: 555.1450.

3-((diphenylphosphoryl)methyl)-6-nitro-2-(quinolin-8-yl)isoquinolin-1(2H)-one (4n)



In an oven dried Schlenk tube charged with magnetic stirrer, 4-nitro-*N*-(quinolin-8-yl)benzamide (4 mmol, 1.0 equiv., 1.17 g), $Co(acac)_2$ (0.8 mmol, 20 mol%, 205.6 mg), potassium trifluoride mesylate (0.8 mmol, 20 mol%, 150 mg) and Eosin Y disodium salt (0.2 mmol, 5 mol%, 139.4 mg) were added. Freshly prepared diphenyl(propa-1,2-dien-1-yl)phosphine (6 mmol, 1.5 equiv., 1.44 g) was subsequently added to the reaction mixture followed by freshly distilled 2,2,2-trifluroethanol (20 mL) as solvent. The Schlenk tube was evacuated and purged with oxygen. Then, the resulted solution was placed in 15 W white LED at room temperature for 40 h. The reaction process was detected by thin-layer chromatography (TLC). After the reaction, the crude purified by flash chromatography (silica gel, dicholormethanene / acetone = 90:10 to 70:30), affording the desired product **4n** as a yellow solid (1.91 g, 87% isolated yield). The corresponding crystal was obtained in ether : methanol (50:50). **^{1}H-NMR (400 MHz, Chloroform-*d*)** δ 8.85 (d, *J* = 4.0 Hz, 1H), 8.45 (*J* = 4.0, 1H), 8.28-8.27 (m, 2H), 8.15 (dd, *J* = 8.0, 4.0 Hz, 1H), 7.98 (d, *J* = 4.0 Hz, 1H), 7.77-7.73 (m, 3H), 7.63 - 7.45 (m, 13H), 7.37-7.35 (m, 3H), 6.78 (d, *J* = 4.0 Hz, 1H), 3.45 (dd, *J* = 15.9, 8.0 Hz, 1H), 3.07 (dd, *J* = 16.0, 8.0 Hz, 1H). **^{13}C NMR (100 MHz, $CDCl_3$)** δ 169.4, 151.6, 144.6, 143.3, 137.3, 136.5, 136.5, 135.8, 135.3, 131.5, 129.6, 129.4, 128.68, 128.65, 128.6, 128.5, 128.4, 126.4, 125.8, 123.5, 122.0, 108.0, 67.0, 40.2, 22.0. HRMS (ESI): calculated for $C_{31}H_{22}N_3O_4P$ for $[M+H]^+$ 532.1431, found: 532.1429.

Cyclic Voltammetry

The cyclic voltammetry was carried out with an Advances Measurement Technology Inc, 12608W and the analysis was performed with the Nova 2.0 software. A glassy-carbon electrode (3 mm-diameter, disc-electrode) was used as the working electrode, 2DPBTA+PDA on Au electrode in 0.1M tetrabutylammonium hexafluorophosphate (TBAP)/CH_3CN solution with Ag/AgCl as the reference electrode.

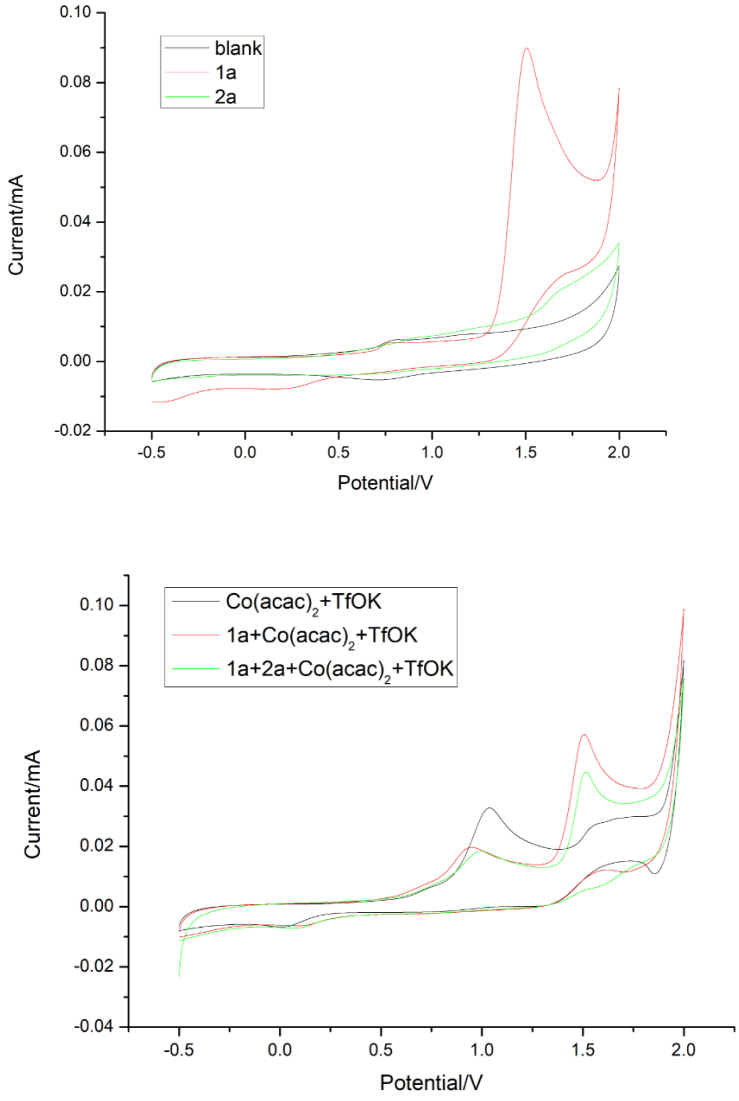
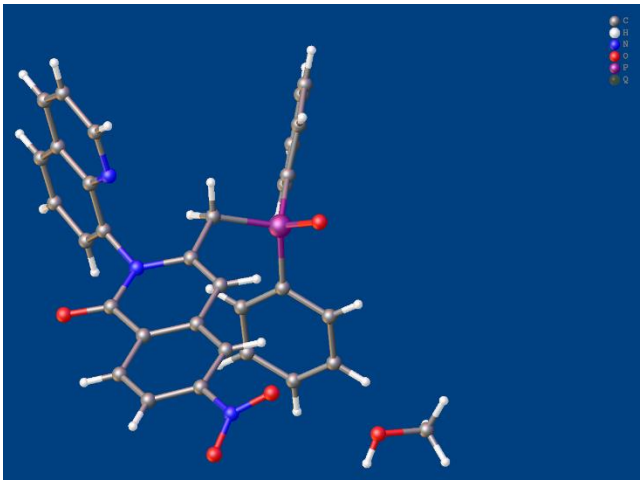


Figure S1 Cyclic voltammograms at 100 mVs^{-1}. General conditions: acetonitrile, 0.1 M n-Bu4NPF6, 5 mM TfOK, 5 mM Co(acac)2, 5 mM substrates 1a and 2a, and 100 mV/s.

Crystal Data and Experimental



Experimental. Single slight yellow bulk crystals of **B-2-41 (4n)** were used as supplied. A suitable crystal with dimensions 0.31 × 0.26 × 0.21 mm^3 was selected and mounted on a Xcalibur, Atlas, Gemini ultra diffractometer. The crystal was kept at a steady T = 293(2) K during data collection. The structure was solved with the **Superflip** (Palatinus & Chapuis, 2007; Palatinus & van der Lee, 2008; Palatinus et al., 2012) solution program using iterative methods and by using **Olex2** (Dolomanov et al., 2009) as the graphical interface. The model was refined with **ShelXL** 2018/3 (Sheldrick, 2015) using full matrix least squares minimisation on F^2.

Crystal Data. $C_{32}H_{26}N_3O_5P$, M_r = 563.53, monoclinic, $P2_1/c$ (No. 14), a = 10.3471(8) Å, b = 19.4565(10) Å, c = 14.7658(9) Å, β = 107.958(7)°, $\alpha = \gamma = 90°$, V = 2827.8(3) $Å^3$, T = 293(2) K, Z = 4, Z' = 1, μ(Cu Kα) = 1.247, 19240 reflections measured, 5006 unique (R_{int} = 0.0484) which were used in all calculations. The final wR_2 was 0.2427 (all data) and R_1 was 0.0722 (I > 2(I)).

Compound	**B-2-41 (4n)**
Formula	$C_{32}H_{26}N_3O_5P$
$D_{calc.}$/ g cm^{-3}	1.324
μ/mm^{-1}	1.247
Formula Weight	563.53
Colour	Slight yellow
Shape	Bulk crystals
Size/mm^3	0.31 ×0.26 ×0.21
T/K	293(2)
Crystal System	monoclinic
Space Group	$P2_1/c$
a/Å	10.3471(8)
b/Å	19.4565(10)
c/Å	14.7658(9)
α/°	90
β/°	107.958(7)
γ/°	90
V/$Å^3$	2827.8(3)
Z	4
Z'	1
Wavelength/Å	1.54184
Radiation type	Cu Kα
Θ_{min}/°	3.881
Θ_{max}/°	67.938
Measured Refl's.	19240
Ind't Refl's	5006
Refl's with I > 2(I)	3517
R_{int}	0.0484
Parameters	372
Restraints	6
Largest Peak	0.810
Deepest Hole	-0.441
GooF	1.039
wR_2 (all data)	0.2427
wR_2	0.2135
R_1 (all data)	0.0968
R_1	0.0722

Table 1 Crystal data and structure refinement for B-2-41 (4n).

Identification code	B-2-41
Empirical formula	$C_{32}H_{26}N_3O_5P$
Formula weight	563.53
Temperature/K	293(2)
Crystal system	monoclinic
Space group	$P2_1/c$
a/Å	10.3471(8)
b/Å	19.4565(10)
c/Å	14.7658(9)
α/°	90
β/°	107.958(7)
γ/°	90
Volume/Å^3	2827.8(3)
Z	4
ρ_{calc}g/cm^3	1.324
μ/mm^{-1}	1.247
F(000)	1176.0
Crystal size/mm^3	0.31 ×0.26 ×0.21
Radiation	Cu Kα (λ = 1.54184)
2Θ range for data collection/°	7.762 to 135.876
Index ranges	-11 ≤ h ≤ 12, -23 ≤ k ≤ 20, -17 ≤ l ≤ 17
Reflections collected	19240
Independent reflections	5006 [R_{int} = 0.0484, R_{sigma} = 0.0316]
Data/restraints/parameters	5006/6/372
Goodness-of-fit on F^2	1.039
Final R indexes [I>=2σ (I)]	R_1 = 0.0722, wR_2 = 0.2135
Final R indexes [all data]	R_1 = 0.0968, wR_2 = 0.2427
Largest diff. peak/hole / e Å^{-3}	0.81/-0.44

Table 2 Fractional Atomic Coordinates (×10^4) and Equivalent Isotropic Displacement Parameters (Å^2×10^3) for B-2-41 (4n). U_{eq} is defined as 1/3 of of the trace of the orthogonalised U_{IJ} tensor.

Atom	*x*	*y*	*z*	U(eq)
P12	6959.6(2)	2485.8(2)	2826.3(2)	63.23(5)
O13	6654.0(6)	2237.5(3)	3685.9(3)	84.38(18)
O27	12335.0(5)	4176.6(3)	3778.0(4)	82.64(18)

O26	10768.2(8)	5137.3(4)	7823.2(4)	115.8(2)
N10	10637.6(5)	3389.6(3)	3469.6(4)	58.70(17)
C28	6202.0(7)	3307.5(4)	2424.4(5)	66.6(2)
N24	10326.4(7)	4599.8(3)	7432.3(4)	78.7(2)
C8	11066.6(7)	4105.9(3)	4866.9(4)	56.4(2)
C19	13360.7(10)	1593.3(6)	2679.4(10)	158.0(4)
O25	9727.4(8)	4185.3(4)	7771.4(4)	117.8(3)
C3	10012.7(6)	3774.0(3)	5096.8(4)	54.13(19)
C34	6362.8(7)	1906.4(3)	1830.9(5)	60.7(2)
C5	10566.8(7)	4437.3(4)	6528.8(5)	61.5(2)
C1	9538.8(7)	3082.1(3)	3678.5(5)	58.6(2)
C4	9778.1(7)	3941.5(4)	5956.0(5)	60.6(2)
C9	11409.0(7)	3913.0(4)	4012.0(5)	60.8(2)
C7	11840.1(7)	4614.4(4)	5466.7(5)	64.1(2)
C11	8746.6(7)	2551.7(4)	2968.7(5)	66.2(2)
C2	9223.2(7)	3269.4(4)	4457.8(4)	60.2(2)
C14	11162.4(7)	3074.8(4)	2767.3(5)	71.5(2)
N16	12263.7(7)	2247.7(4)	3962.9(6)	93.5(3)
C15	12000.5(7)	2485.4(4)	3052.8(6)	79.9(3)
C6	11588.4(8)	4783.1(4)	6297.4(5)	67.7(2)
C20	12511.6(8)	2178.3(5)	2370.3(7)	106.4(3)
C33	6633.5(8)	3733.3(4)	1821.3(6)	78.1(3)
C17	13047.4(10)	1705.0(5)	4205.8(11)	124.9(5)
C41	7065.1(14)	4024.4(7)	9591.8(9)	171.6(5)
C18	13616.5(11)	1366.7(6)	3572.7(13)	165.0(7)
C39	6529.3(9)	1212.3(4)	1986.3(6)	79.9(3)
C38	6100.7(10)	748.4(4)	1253.9(6)	87.0(3)
C23	10871.5(9)	3339.8(6)	1876.5(5)	93.9(3)
C37	5459.7(10)	971.7(4)	355.3(6)	90.2(3)
C29	5061.0(8)	3509.5(5)	2661.7(6)	87.4(3)
C32	5965.0(10)	4329.5(4)	1486.0(8)	94.4(3)
C21	12175.4(9)	2460.8(6)	1447.6(7)	134.4(3)
C30	4399.1(9)	4122.7(5)	2308.3(8)	105.6(3)
C31	4842.7(10)	4523.7(5)	1729.6(8)	105.1(4)
C36	5254.0(16)	1651.9(5)	195.8(7)	139.9(6)
C22	11380.0(10)	3014.1(7)	1201.5(7)	127.0(4)
C35	5715.4(14)	2122.0(5)	926.9(6)	117.3(5)
O40	8334.4(19)	4203.7(10)	9757.9(13)	273.3(3)

Table 3 Anisotropic Displacement Parameters ($Å^2×10^3$) for B-2-41 (4n). The Anisotropic displacement factor exponent takes the form: $-2\pi^2[h^2a^{*2}U_{11}+2hka^*b^*U_{12}+\ldots]$.

Atom	U_{11}	U_{22}	U_{33}	U_{23}	U_{13}	U_{12}
P12	73.95(9)	64.28(9)	56.54(8)	-15.58(7)	27.55(6)	-19.19(7)
O13	107.3(3)	91.8(3)	61.8(2)	-14.6(2)	37.5(2)	-31.7(3)
O27	90.4(3)	92.2(3)	72.4(3)	-15.8(3)	35.4(2)	-32.9(3)
O26	144.4(5)	116.2(4)	98.5(3)	-57.1(3)	54.8(3)	-33.2(4)
N10	59.9(3)	63.1(3)	53.6(2)	-8.7(2)	18.4(2)	-6.3(2)
C28	72.0(3)	63.5(4)	73.0(3)	-25.5(3)	35.3(2)	-19.6(3)
N24	87.4(4)	86.9(4)	61.4(3)	-20.1(3)	22.5(3)	-5.6(3)
C8	61.7(3)	51.5(3)	51.2(3)	1.2(3)	10.3(2)	1.2(3)
C19	83.9(4)	122.6(6)	292.6(10)	-118.4(6)	94.8(5)	-42.4(4)
O25	163.0(5)	125.3(5)	83.6(3)	-27.0(3)	65.2(3)	-42.3(4)
C3	57.4(3)	50.3(3)	51.4(3)	-0.2(3)	12.0(2)	0.7(3)
C34	70.7(3)	58.7(3)	55.2(3)	-9.9(3)	23.3(2)	-13.8(3)
C5	74.9(4)	57.8(3)	49.9(3)	-6.1(3)	16.4(3)	2.7(3)
C1	59.9(3)	55.6(3)	58.6(3)	-7.5(3)	15.7(3)	-4.5(3)
C4	65.0(3)	60.9(4)	55.7(3)	-2.8(3)	18.2(2)	-0.2(3)
C9	65.3(3)	59.0(4)	57.3(3)	-2.2(3)	17.5(3)	-7.4(3)
C7	70.8(4)	57.8(4)	61.8(3)	-5.0(3)	17.6(3)	-7.8(3)
C11	68.8(4)	66.4(4)	63.7(3)	-17.4(3)	21.1(3)	-8.4(3)
C2	62.8(3)	63.0(4)	56.0(3)	-6.4(3)	19.9(2)	-8.0(3)
C14	67.7(4)	83.0(4)	67.2(3)	-26.8(3)	26.0(3)	-15.6(3)
N16	78.7(4)	73.8(4)	125.0(5)	-16.2(4)	26.9(4)	3.0(3)
C15	62.4(3)	79.3(4)	106.3(4)	-41.8(3)	38.3(3)	-22.7(3)
C6	78.9(4)	54.9(3)	63.0(4)	-11.8(3)	12.8(3)	-3.6(3)
C20	72.5(4)	110.2(5)	154.4(5)	-77.8(4)	61.2(3)	-38.8(4)
C33	84.6(4)	62.3(4)	100.0(4)	-8.9(4)	46.8(3)	-9.7(3)
C17	85.5(6)	74.5(5)	206.0(11)	-15.3(7)	32.1(6)	8.1(5)
C41	235.0(9)	150.3(10)	187.0(7)	-70.7(7)	149.5(5)	-48.5(8)
C18	81.2(6)	96.3(7)	316.2(16)	-62.6(8)	59.2(7)	0.4(5)
C39	109.7(6)	60.8(4)	61.5(4)	-2.3(3)	14.9(4)	-1.0(4)
C38	115.4(6)	54.2(4)	82.1(5)	-13.2(4)	16.6(4)	-7.1(4)
C23	93.2(5)	134.7(7)	60.0(4)	-21.8(4)	32.6(3)	-31.4(5)
C37	117.7(6)	70.2(4)	71.0(4)	-25.7(3)	11.6(4)	-5.6(5)
C29	82.2(4)	89.1(5)	105.7(4)	-33.3(4)	50.6(3)	-23.9(4)
C32	101.8(5)	64.4(4)	125.5(6)	-0.1(5)	47.6(4)	-6.0(4)
C21	107.0(4)	178.6(7)	148.4(5)	-111.1(4)	84.7(3)	-73.5(5)

C30	85.1(4)	94.2(6)	149.2(6)	-42.9(5)	53.3(4)	-2.0(4)
C31	97.4(6)	69.0(5)	149.7(8)	-21.9(5)	39.3(5)	-5.5(4)
C36	240.1(14)	81.0(6)	58.0(5)	-12.1(4)	-13.5(7)	21.1(8)
C22	113.2(5)	194.3(10)	89.4(4)	-62.7(5)	54.8(4)	-59.9(6)
C35	206.2(11)	59.3(5)	63.8(5)	-7.3(4)	8.4(6)	4.8(6)
O40	272.8(5)	279.0(5)	268.5(5)	-5.6(4)	84.2(4)	1.4(4)

Table 4 Bond Lengths for B-2-41 (4n).

Atom	Atom	Length/Å	Atom	Atom	Length/Å
P12	O13	1.4805(6)	C5	C6	1.3818(12)
P12	C28	1.7988(7)	C1	C11	1.5185(9)
P12	C34	1.8036(7)	C1	C2	1.3399(11)
P12	C11	1.7999(8)	C7	C6	1.3701(11)
O27	C9	1.2266(10)	C14	C15	1.4210(11)
O26	N24	1.2138(9)	C14	C23	1.3574(11)
N10	C1	1.4007(10)	N16	C15	1.3668(12)
N10	C9	1.3861(8)	N16	C17	1.3122(12)
N10	C14	1.4466(10)	C15	C20	1.4075(14)
C28	C33	1.3870(12)	C20	C21	1.4097(14)
C28	C29	1.3880(12)	C33	C32	1.3630(11)
N24	O25	1.2151(11)	C17	C18	1.412(2)
N24	C5	1.4650(10)	C41	O40	1.307(2)
C8	C3	1.3963(10)	C39	C38	1.3730(11)
C8	C9	1.4614(11)	C38	C37	1.3589(12)
C8	C7	1.4025(9)	C23	C22	1.4124(15)
C19	C20	1.4242(13)	C37	C36	1.3496(13)
C19	C18	1.338(2)	C29	C30	1.3944(13)
C3	C4	1.4016(10)	C32	C31	1.3705(16)
C3	C2	1.4304(9)	C21	C22	1.3356(16)
C34	C39	1.3717(10)	C30	C31	1.3384(17)
C34	C35	1.3621(11)	C36	C35	1.3828(13)
C5	C4	1.3734(9)			

Table 5 Bond Angles for B-2-41 (4n).

Atom	Atom	Atom	Angle/°	Atom	Atom	Atom	Angle/°
O13	P12	C28	112.73(4)	O27	C9	N10	120.34(7)
O13	P12	C34	112.62(3)	O27	C9	C8	123.67(6)
O13	P12	C11	113.98(3)	N10	C9	C8	115.97(6)
C28	P12	C34	106.37(3)	C6	C7	C8	120.36(7)
C28	P12	C11	107.62(3)	C1	C11	P12	116.46(6)
C11	P12	C34	102.77(4)	C1	C2	C3	120.82(7)
C1	N10	C14	119.11(6)	C15	C14	N10	117.30(7)
C9	N10	C1	123.26(6)	C23	C14	N10	120.91(7)
C9	N10	C14	116.66(6)	C23	C14	C15	121.78(8)
C33	C28	P12	123.29(6)	C17	N16	C15	117.39(10)
C33	C28	C29	117.40(7)	N16	C15	C14	118.89(8)
C29	C28	P12	119.11(6)	N16	C15	C20	123.73(7)
O26	N24	O25	122.76(8)	C20	C15	C14	117.38(8)
O26	N24	C5	118.31(7)	C7	C6	C5	118.41(6)
O25	N24	C5	118.90(6)	C15	C20	C19	116.14(10)
C3	C8	C9	120.45(6)	C15	C20	C21	119.42(8)
C3	C8	C7	120.61(7)	C21	C20	C19	124.44(10)
C7	C8	C9	118.92(7)	C32	C33	C28	120.92(9)
C18	C19	C20	119.64(12)	N16	C17	C18	122.89(13)
C8	C3	C4	118.60(6)	C19	C18	C17	120.21(11)
C8	C3	C2	119.14(6)	C34	C39	C38	121.47(7)
C4	C3	C2	122.25(7)	C37	C38	C39	120.05(8)
C39	C34	P12	119.03(5)	C14	C23	C22	119.59(9)
C35	C34	P12	123.19(6)	C36	C37	C38	119.16(8)
C35	C34	C39	117.75(7)	C28	C29	C30	120.37(9)
C4	C5	N24	118.48(7)	C33	C32	C31	121.03(10)
C4	C5	C6	122.98(7)	C22	C21	C20	121.67(10)
C6	C5	N24	118.54(6)	C31	C30	C29	120.81(10)
N10	C1	C11	116.13(6)	C30	C31	C32	119.46(9)
C2	C1	N10	120.15(6)	C37	C36	C35	120.96(9)
C2	C1	C11	123.71(7)	C21	C22	C23	120.14(9)
C5	C4	C3	119.01(7)	C34	C35	C36	120.56(8)

Table 6 Torsion Angles for B-2-41 (4n).

A	B	C	D	Angle/°	A	B	C	D	Angle/°
P12	C28	C33	C32	175.47(6)	C9	C8	C3	C4	175.69(6)
P12	C28	C29	C30	-175.75(6)	C9	C8	C3	C2	-3.44(9)
P12	C34	C39	C38	-179.65(8)	C9	C8	C7	C6	-176.79(6)
P12	C34	C35	C36	-178.56(11)	C7	C8	C3	C4	-2.35(9)
O13	P12	C28	C33	161.09(6)	C7	C8	C3	C2	178.52(6)
O13	P12	C28	C29	-24.18(7)	C7	C8	C9	O27	-0.77(10)
O13	P12	C34	C39	-41.73(8)	C7	C8	C9	N10	177.68(6)
O13	P12	C34	C35	136.43(9)	C11	P12	C28	C33	34.55(7)
O13	P12	C11	C1	-65.56(6)	C11	P12	C28	C29	-150.71(6)
O26	N24	C5	C4	-162.27(7)	C11	P12	C34	C39	81.35(8)
O26	N24	C5	C6	18.58(10)	C11	P12	C34	C35	-100.49(10)
N10	C1	C11	P12	-148.16(5)	C11	C1	C2	C3	-179.90(6)
N10	C1	C2	C3	-1.21(10)	C2	C3	C4	C5	-179.23(6)
N10	C14	C15	N16	0.11(10)	C2	C1	C11	P12	30.57(9)
N10	C14	C15	C20	179.98(6)	C14	N10	C1	C11	-15.79(8)
N10	C14	C23	C22	-178.93(8)	C14	N10	C1	C2	165.43(6)
C28	P12	C34	C39	-165.69(7)	C14	N10	C9	O27	13.51(9)
C28	P12	C34	C35	12.46(10)	C14	N10	C9	C8	-164.99(6)
C28	P12	C11	C1	60.24(6)	C14	C15	C20	C19	179.32(7)
C28	C33	C32	C31	-0.41(13)	C14	C15	C20	C21	-0.18(11)
C28	C29	C30	C31	0.55(13)	C14	C23	C22	C21	-1.99(15)
N24	C5	C4	C3	-179.01(6)	N16	C15	C20	C19	-0.82(12)
N24	C5	C6	C7	177.92(6)	N16	C15	C20	C21	179.68(8)
C8	C3	C4	C5	1.66(9)	N16	C17	C18	C19	-0.39(16)
C8	C3	C2	C1	4.33(9)	C15	C14	C23	C22	1.75(13)
C8	C7	C6	C5	0.49(10)	C15	N16	C17	C18	0.10(14)
C19	C20	C21	C22	-179.53(10)	C15	C20	C21	C22	-0.08(14)
O25	N24	C5	C4	19.66(10)	C6	C5	C4	C3	0.10(10)
O25	N24	C5	C6	-159.50(7)	C20	C19	C18	C17	0.06(16)
C3	C8	C9	O27	-178.84(6)	C20	C21	C22	C23	1.16(16)
C3	C8	C9	N10	-0.39(9)	C33	C28	C29	C30	-0.71(11)
C3	C8	C7	C6	1.28(10)	C33	C32	C31	C30	0.22(15)
C34	P12	C28	C33	-75.02(6)	C17	N16	C15	C14	-179.61(8)
C34	P12	C28	C29	99.72(6)	C17	N16	C15	C20	0.53(12)
C34	P12	C11	C1	172.27(5)	C18	C19	C20	C15	0.50(13)
C34	C39	C38	C37	-1.97(16)	C18	C19	C20	C21	179.97(10)
C1	N10	C9	O27	-177.84(6)	C39	C34	C35	C36	-0.39(19)

C1	N10	C9	C8	3.67(9)	C39	C38	C37	C36	0.06(18)
C1	N10	C14	C15	-77.29(8)	C38	C37	C36	C35	1.6(2)
C1	N10	C14	C23	103.36(9)	C23	C14	C15	N16	179.45(8)
C4	C3	C2	C1	-174.77(6)	C23	C14	C15	C20	-0.68(11)
C4	C5	C6	C7	-1.19(10)	C37	C36	C35	C34	-1.5(2)
C9	N10	C1	C11	175.83(6)	C29	C28	C33	C32	0.65(11)
C9	N10	C1	C2	-2.95(9)	C29	C30	C31	C32	-0.29(15)
C9	N10	C14	C15	91.85(8)	C35	C34	C39	C38	2.09(15)
C9	N10	C14	C23	-87.50(8)					

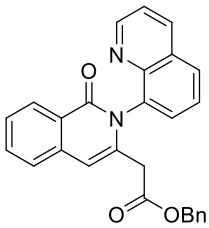
Table 7 Hydrogen Atom Coordinates (Å×10^4) and Isotropic Displacement Parameters (Å^2×10^3) for B-2-41 (4n).

Atom	*x*	*y*	*z*	U(eq)
H19	13735.09	1370.03	2262.46	190
H4	9098.57	3720.25	6135.5	73
H7	12527.65	4838.34	5299.69	77
H11A	9157.23	2105.36	3160.89	79
H11B	8850.05	2656.75	2352.57	79
H2	8481.59	3068.94	4584.79	72
H6	12092.97	5122.23	6696	81
H33	7389.44	3610.37	1643.33	94
H17	13236.18	1535.72	4821.97	150
H41A	6620.85	4348.73	9886.07	257
H41B	7024.21	3574.92	9849.69	257
H41C	6618	4017.86	8917.41	257
H18	14171.09	985.09	3777.49	198
H39	6941.78	1052.37	2601.39	96
H38	6249.21	280.95	1372.92	104
H23	10340.65	3733.38	1711.54	113
H37	5166.46	659.74	-143.39	108
H29	4736.04	3234.4	3058.81	105
H32	6275.32	4608.81	1085.7	113
H21	12516.02	2256.8	998.8	161
H30	3640.11	4254.62	2476.64	127
H31	4392.94	4930.88	1494.69	126
H36	4795.29	1806.72	-414.74	168
H22	11160.51	3185.27	584.52	152

H35	5582.6	2589.37	800.26	141
H40	8381.07	4621.04	9697.54	410

Benzyl 2-(1-oxo-2-(quinolin-8-yl)-1,2-dihydroisoquinolin-3-yl)acetate (4a)

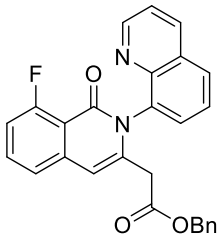
Compound **4a** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (EtOAc: hexane =30:70). It is obtained as a yellow solid; 36.4 mg, 87% yield.



^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.84 (d, *J* = 4.0 Hz, 1H), 8.40 (d, *J* = 8.0 Hz, 1H), 8.22 (d, *J* = 8.2 Hz, 1H), 7.90 (d, *J* = 8.2 Hz, 1H), 7.67 (d, *J* = 7.6 Hz, 1H), 7.60 (d, *J* = 7.0 Hz, 1H), 7.55 (d, *J* = 7.9 Hz, 1H), 7.48 (td, *J* = 7.7, 3.6 Hz, 2H), 7.42 (dd, *J* = 8.4, 4.2 Hz, 1H), 7.33 (t, *J* = 5.4 Hz, 3H), 7.20-7.13 (m, 2H), 6.63 (s, 1H), 4.90 (d, *J* = 5.2 Hz, 2H), 3.41 (d, *J* = 17.0 Hz, 1H), 3.12 (d, *J* = 17.0 Hz, 1H). **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 169.4, 163.6, 151.6, 137.1, 136.5, 136.4, 135.7, 135.2, 132.7, 131.0, 129.7, 129.4, 128.0, 128.7, 128.6, 128.6, 128.4, 126.8, 126.3, 126.0, 125.7, 122.0,108.1, 67.0, 40.1. HRMS (ESI): calculated for $C_{27}H_{20}N_2O_3$ for $[M+H]^+$ 421.1547, found 421.1549.

Benzyl 2-(8-fluoro-1-oxo-2-(quinolin-8-yl)-1,2-dihydroisoquinolin-3-yl)acetate (4b)

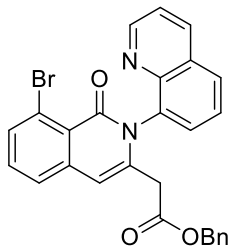
Compound **4b** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (EtOAc: hexane =30:70). It is obtained as a yellow solid; 37.2 mg, 85% yield.



^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.84 (d, *J* = 4.0 Hz, 1H), 8.21 (d, *J* = 8.2 Hz, 1H), 7.89 (d, *J* = 8.1 Hz, 1H), 7.59 (d, *J* = 7.4 Hz, 2H), 7.47 (d, *J* = 7.8 Hz, 1H), 7.43 (dt, *J* = 8.2, 5.1 Hz, 1H), 7.33 (d, *J* = 4.8 Hz, 3H), 7.30 (d, *J* = 8.2 Hz, 1H), 7.20 - 7.14 (m, 2H), 7.08 (d, *J* = 3.3 Hz, 1H), 6.58 (s, 1H), 4.90 (d, *J* = 4.7 Hz, 2H), 3.38 (d, *J* = 16.9 Hz, 1H), 3.10 (d, *J* = 16.9 Hz, 1H).**^{13}C NMR (101 MHz, Chloroform-*d*)** δ 169.1, 164.2, 161.5, 151.4, 144.3, 139.8, 137.7, 136.6, 135.2, 135.1, 133.6, 133.5, 131.6, 129.7, 129.4, 128.6, 126.3, 122.0, 121.9, 121.8, 113.8, 113.5, 107.3, 107.3, 67.0, 40.0. HRMS (ESI): calculated for $C_{27}H_{19}FN_2O_3$ for $[M+H]^+$ 439.1453, found: 439.1455.

Benzyl 2-(8-bromo-1-oxo-2-(quinolin-8-yl)-1,2-dihydroisoquinolin-3-yl)acetate (3c)

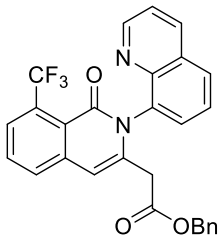
Compound **3c** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (EtOAc: hexane =30:70). It is obtained as a yellow solid; 40.6 mg, 83% yield.



^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.85 (d, *J* = 4.0 Hz, 1H), 8.21 (d, *J* = 8.2 Hz, 1H), 7.89 (d, *J* = 8.2 Hz, 1H), 7.73 (d, *J* = 7.6 Hz, 1H), 7.60 (d, *J* = 7.3 Hz, 1H), 7.46 (dt, *J* = 7.4, 3.6 Hz, 2H), 7.40 (q, *J* = 7.7, 7.0 Hz, 2H), 7.33 (d, *J* = 4.7 Hz, 3H), 7.21 - 7.14 (m, 2H), 6.56 (s, 1H), 4.90 (d, *J* = 4.4 Hz, 2H), 3.37 (d, *J* = 17.0 Hz, 1H), 3.09 (d, *J* = 16.9 Hz, 1H).**^{13}C NMR (101 MHz, Chloroform-*d*)** δ 169.0, 161.8, 151.4, 144.2, 140.1, 137.4, 136.6, 135.4, 135.1, 133.9, 132.6, 131.5, 129.6, 129.4, 128.6, 128.6, 126.4, 126.1, 123.6, 122.9, 122.1, 107.7, 67.0, 40.0. HRMS (ESI): calculated for $C_{27}H_{19}BrN_2O_3$ for $[M+Na]^+$ 521.0482, found: 521.0479.

Benzyl 2-(1-oxo-2-(quinolin-8-yl)-8-(trifluoromethyl)-1,2-dihydroisoquinolin-3-yl)acetate (3d)

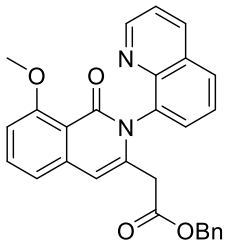
Compound **3d** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (EtOAc: hexane =30:70). It is obtained as a yellow solid; 43.3 mg, 89% yield.



^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.88 (d, *J* = 3.9 Hz, 1H), 8.25 (d, *J* = 8.2 Hz, 1H), 7.94 (d, *J* = 7.4 Hz, 2H), 7.81-7.72 (m, 2H), 7.67 (d, *J* = 7.2 Hz, 1H), 7.51 (t, *J* = 7.8 Hz, 1H), 7.47 (dd, *J* = 8.5, 4.1 Hz, 1H), 7.38 (m, 3H), 7.25 - 7.16 (m, 2H), 6.68 (s, 1H), 4.95 (s, 2H), 3.45 (d, *J* = 17.1 Hz, 1H), 3.15 (d, *J* = 17.1 Hz, 1H).**^{13}C NMR (101 MHz, Chloroform-*d*)** δ 169.0, 160.6, 151.5, 144.2, 139.8, 138.3, 136.5, 135.4, 135.1, 131.5, 131.5, 131.0, 129.7, 129.5, 128.7, 128.6, 126.5, 126.5, 126.4, 122.8, 122.1, 107.4, 67.1, 39.9. HRMS (ESI): calculated for $C_{27}H_{19}F_3N_2O_3$ for $[M+H]^+$ 489.1424, found: 489.1427.

Benzyl 2-(8-methoxy-1-oxo-2-(quinolin-8-yl)-1,2-dihydroisoquinolin-3-yl)acetate (3e)

Compound **3e** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (EtOAc: hexane =30:70). It is obtained as a yellow solid; 32.8 mg, 73% yield.

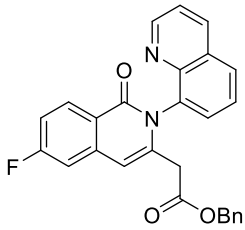


^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.88-8.83 (m, 1H), 8.26 (d, *J* = 8.4 Hz, 1H), 7.90 (d, *J* = 7.2 Hz, 2H), 7.81-7.50 (m, 2H), 7.33-7.30 (m, 5H), 7.20-7.15 (m, 2H), 7.09 (d, *J* = 3.4 Hz, 1H), 6.58 (s, 1H), 4.96-4.80 (m, 2H), 3.94 (s, 3H),

3.37 (d, *J* = 16.8 Hz, 1H), 3.09 (d, *J* = 16.8 Hz, 1H)**. ^{13}C-NMR (101 MHz, Chloroform-*d*)** δ 169.3, 162.1, 161.5, 151.5, 144.7, 140.3, 137.1, 136.4', 136.0, 135.3, 133.4, 131.7, 129.4, 129.4, 128.7, 128.6, 128.6, 126.26, 121.9, 118.4, 115.1, 108.6, 107.7, 77.5, 77.2, 76.8, 67.0, 56.1, 40.1. HRMS (ESI): calculated for $C_{28}H_{22}N_2O_4$ for $[M+H]^+$ 451.1661, found: 451.1659.

Benzyl 2-(6-fluoro-1-oxo-2-(quinolin-8-yl)-1,2-dihydroisoquinolin-3-yl)acetate (3f)

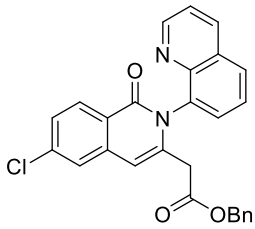
Compound **3f** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (EtOAc: hexane =30:70). It is obtained as a yellow solid; 38.5 mg, 88% yield.



^{1}H-NMR (400 MHz, Chloroform-*d*) δ 8.85 (d, *J* = 3.9 Hz, 1H), 8.40 (t, *J* = 7.2 Hz, 1H), 8.23 (d, *J* = 8.1 Hz, 1H), 7.92 (d, *J* = 8.1 Hz, 1H), 7.59 (d, *J* = 7.2 Hz, 1H), 7.48 (d, *J* = 7.9 Hz, 1H), 7.45 (d, *J* = 6.9 Hz, 1H), 7.33 (d, *J* = 5.2 Hz, 3H), 7.18 (t, *J* = 7.6 Hz, 4H), 6.57 (s, 1H), 4.90 (d, *J* = 3.9 Hz, 2H), 3.40 (d, *J* = 17.0 Hz, 1H), 3.10 (d, *J* = 17.0 Hz, 1H).**^{13}C-NMR (101 MHz, Chloroform-*d*)** δ 164.7, 164.4, 149.8, 146.9, 138.3, 137.9, 135.3, 132.1, 132.0, 131.4, 130.1, 128.8, 128.7, 128.7, 128.5, 128.4, 128.2, 127.2, 121.8, 119.6, 118.1, 117.8, 117.5, 111.8, 111.6, 88.1, 78.9, 67.0, 66.8 . HRMS (ESI): calculated for $C_{27}H_{19}FN_2O_3$ for $[M+H]^+$ 439.1453, found: 439.1457.

Benzyl 2-(6-chloro-1-oxo-2-(quinolin-8-yl)-1,2-dihydroisoquinolin-3-yl)acetate (3g)

Compound **3g** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (EtOAc: hexane =30:70). It is obtained as a yellow solid; 41.0 mg, 91% yield.

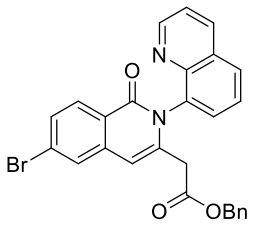


^{1}H-NMR (400 MHz, Chloroform-*d*) δ 8.85 (d, *J* = 3.9 Hz, 1H), 8.31 (d, *J* = 8.5 Hz, 1H), 8.23 (d, *J* = 8.2 Hz, 1H), 7.91 (d, *J* = 8.2 Hz, 1H), 7.59 (d, *J* = 7.2 Hz, 1H), 7.53 (s, 1H), 7.48 (d, *J* = 7.7 Hz, 1H), 7.46 - 7.40 (m, 2H), 7.33 (d, *J* = 5.0 Hz, 3H), 7.21 - 7.13 (m, 2H), 6.53 (s, 1H), 4.90 (d, *J* = 2.9 Hz, 2H), 3.40 (d, *J* = 17.0 Hz, 1H), 3.11 (d, *J* = 17.0 Hz, 1H).**^{13}C NMR (101 MHz, Chloroform-*d*)** δ 169.0, 151.5, 144.1, 139.1, 138.3, 138.0, 136.6, 135.2, 135.1, 131.3, 130.2, 129.8, 129.4, 128.6, 128.6, 127.3, 126.3,

125.2, 124.0, 122.1, 107.0, 67.0, 40.1. HRMS (ESI): calculated for $C_{27}H_{19}ClN_2O_3$ for $[M+H]^+$ 455.1159, found: 455.1161.

Benzyl 2-(6-bromo-1-oxo-2-(quinolin-8-yl)-1,2-dihydroisoquinolin-3-yl)acetate (3h)

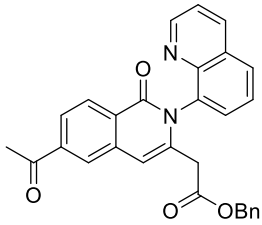
Compound **3h** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (EtOAc: hexane =30:70). It is obtained as a yellow solid; 42.8 mg, 86% yield.



^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.84 (d, *J* = 3.9 Hz, 1H), 8.23 (d, *J* = 8.2 Hz, 2H), 7.92 (d, *J* = 8.1 Hz, 1H), 7.71 (s, 1H), 7.57 (t, *J* = 5.4 Hz, 2H), 7.48 (s, 1H), 7.44 (dd, *J* = 10.9, 5.4 Hz, 2H), 7.33 (d, *J* = 5.2 Hz, 3H), 7.17 (d, *J* = 5.7 Hz, 2H), 6.53 (s, 1H), 4.90 (d, *J* = 4.6 Hz, 2H), 3.40 (d, *J* = 17.1 Hz, 1H), 3.10 (d, *J* = 17.0 Hz, 1H)**. ^{13}C NMR (101 MHz, Chloroform-*d*)** δ 169.0, 163.9, 151.6, 144.7, 144.4, 140.2, 137.7, 136.5, 135.7, 135.1, 132.6, 131.4, 129.6, 129.5, 128.6, 128.6, 126.7, 126.7, 126.4, 122.8, 122.1, 107.3, 67.0, 40.0. HRMS (ESI): calculated for $C_{27}H_{19}BrN_2O_3$ for $[M+Na]^+$ 521.0482, found: 521.0480.

Benzyl 2-(6-acetyl-1-oxo-2-(quinolin-8-yl)-1,2-dihydroisoquinolin-3-yl)acetate (3i)

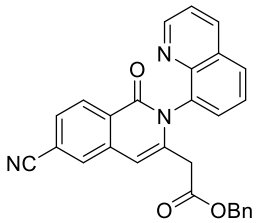
Compound **3i** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (EtOAc: hexane =30:70). It is obtained as a yellow solid; 41.6 mg, 90% yield.



^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.84 (d, *J* = 3.9 Hz, 1H), 8.46 (d, *J* = 8.1 Hz, 1H), 8.23 (d, *J* = 8.2 Hz, 1H), 8.13 (s, 1H), 7.99 (d, *J* = 8.4 Hz, 1H), 7.92 (d, *J* = 8.2 Hz, 1H), 7.60 (d, *J* = 7.3 Hz, 1H), 7.48 (t, *J* = 7.8 Hz, 1H), 7.44 (dd, *J* = 8.2, 4.1 Hz, 1H), 7.33 (d, *J* = 5.0 Hz, 3H), 7.20 - 7.14 (m, 2H), 6.70 (s, 1H), 4.91 (s, 2H), 3.43 (d, *J* = 17.0 Hz, 1H), 3.12 (d, *J* = 17.0 Hz, 1H), 2.72 (s, 3H). **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 198.0, 169.1, 163.0, 151.6, 144.2, 140.1, 137.7, 137.1, 136.6, 135.3, 135.1, 131.2, 129.9, 129.4, 129.0, 128.7, 128.6, 128.4, 126.6, 126.3, 125.5, 122.1, 108.1, 67.1, 40.1, 27.2. HRMS (ESI): calculated for $C_{29}H_{22}N_2O_3$ for $[M+H]^+$ 463.1656, found: 463.1659.

Benzyl 2-(6-cyano-1-oxo-2-(quinolin-8-yl)-1,2-dihydroisoquinolin-3-yl)acetate (3j)

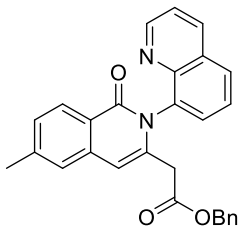
Compound **3j** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (EtOAc: hexane =30:70-50:50). It is obtained as a yellow solid; 41.4 mg, 93% yield.



^{1}H-NMR (400 MHz, Chloroform-*d*) δ 8.83 (d, *J* = 4.0 Hz, 1H), 8.46 (d, *J* = 8.3 Hz, 1H), 8.23 (d, *J* = 8.3 Hz, 1H), 7.93 (d, *J* = 8.3 Hz, 1H), 7.87 (s, 1H), 7.65 (d, *J* = 8.3 Hz, 1H), 7.59 (d, *J* = 7.2 Hz, 1H), 7.49 (d, *J* = 7.8 Hz, 1H), 7.45 (dd, *J* = 8.9, 4.6 Hz, 1H), 7.34 (d, *J* = 5.7 Hz, 3H), 7.21 - 7.13 (m, 2H), 6.62 (s, 1H), 4.91 (s, 2H), 3.42 (d, *J* = 17.1 Hz, 1H), 3.12 (d, *J* = 17.1 Hz, 1H).**^{13}C-NMR (101 MHz, Chloroform-*d*)** δ 168.8, 162.5, 151.7, 144.0, 139.1, 137.1, 136.6, 135.0, 134.9, 131.1, 130.6, 130.0, 129.5, 129.4, 128.7, 128.7, 128.5, 128.0, 126.3, 122.2, 118.3, 116.1, 106.7, 67.2, 40.0. HRMS (ESI): calculated for $C_{28}H_{19}N_3O_3$ for $[M+H]^+$ 446.1548, found: 446.1551.

Benzyl 2-(6-methyl-1-oxo-2-(quinolin-8-yl)-1,2-dihydroisoquinolin-3-yl)acetate (3k)

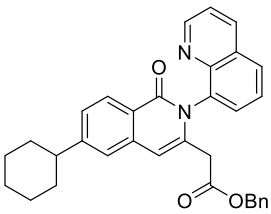
Compound **3k** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (EtOAc: hexane =30:70). It is obtained as a yellow solid; 36.0 mg, 83% yield.



^{1}H-NMR (400 MHz, $CDCl_3$) δ (ppm) 8.85 (dd, *J* = 4.4, 1.6 Hz, 1H), 8.27 (d, *J* = 8.0 Hz, 1H), 8.20 (dd, J = 8.4, 1.6 Hz, 1H), 7.90 (dd, *J* = 8.4, 1.2 Hz, 1H), 7.58 (dd, *J* = 7.2, 1.2 Hz, 1H), 7.49-7.41 (m, 2H), 7.35-7.27 (m, 5H), 7.18-7.16 (m, 2H), 6.57 (s, 1H), 4.90-4.89 (m, 2H), 3.42 (d, *J* = 16.8 Hz, 1H), 3.13 (d, *J* = 16.8 Hz, 1H), 2.51 (s, 3H); **^{13}C-NMR (101 MHz, Chloroform-d)** δ 169.2, 162.1, 161.3, 151.4, 144.7, 140.2, 137.1, 136.4, 135.9, 135.2, 133.4, 131.7, 129.4, 129.3, 128.6, 128.6, 128.5, 126.2, 121.8, 118.4, 115.1, 108.2, 107.6, 67.0, 56.0, 40.0. HRMS (ESI): calculated for $C_{28}H_{22}N_2O_3$ for $[M+H]^+$ 435.1705, found: 435.1703.

Benzyl 2-(6-cyclohexyl-1-oxo-2-(quinolin-8-yl)-1,2-dihydroisoquinolin-3-yl)acetate (3l)

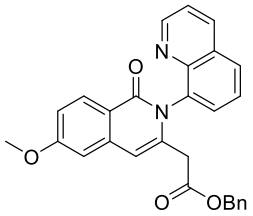
Compound **3l** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (EtOAc: hexane =30:70). It is obtained as a yellow solid; 40.5 mg, 81% yield.



^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.84 (d, *J* = 4.3 Hz, 1H), 8.35 (d, *J* = 8.4 Hz, 1H), 8.16 (d, *J* = 8.1 Hz, 1H), 7.88 (d, *J* = 8.2 Hz, 1H), 7.74 (d, *J* = 7.4 Hz, 1H), 7.64 (t, *J* = 7.8 Hz, 1H), 7.56 (s, 1H), 7.53 (dd, *J* = 8.3, 4.3 Hz, 1H), 7.43 (d, *J* = 7.9 Hz, 1H), 7.31 (s, 5H), 7.14 (s, 1H), 6.52 (s, 1H), 5.18 (d, *J* = 12.3 Hz, 1H), 5.09 (d, *J* = 12.4 Hz, 1H), 2.63 (s, 1H), 1.91 (dd, *J* = 25.1, 11.6 Hz, 5H), 1.78 (d, *J* = 12.8 Hz, 1H), 1.55-1.37 (m, 5H), 1.36-1.22 (m, 2H).**^{13}C NMR (101 MHz, Chloroform-d)** δ 169.4, 163.6, 153.2, 151.4, 144.4, 137.3, 136.6, 136.2, 135.7, 135.2, 131.6, 129.5, 129.4, 128.6, 128.5, 128.4, 126.5, 126.4, 123.8, 123.7, 122.0, 108.3, 67.0, 58.6, 45.0, 40.1, 34.3, 26.9, 26.2, 18.5. HRMS (ESI): calculated for $C_{33}H_{30}N_2O_3$ for $[M+H]^+$ 503.2341, found: 503.2339.

Benzyl 2-(6-methoxy-1-oxo-2-(quinolin-8-yl)-1,2-dihydroisoquinolin-3-yl)acetate (3m)

Compound **3m** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (EtOAc: hexane =30:70-50:50). It is obtained as a yellow solid; 35.6 mg, 79% yield.

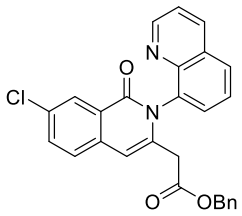


^{1}H-NMR (400 MHz, Chloroform-*d*) δ 8.85 (d, *J* = 3.9 Hz, 1H), 8.30 (d, *J* = 8.9 Hz, 1H), 8.21 (d, *J* = 8.1 Hz, 1H), 7.89 (d, *J* = 8.1 Hz, 1H), 7.59 (d, *J* = 7.2 Hz, 1H), 7.47 (d, *J* = 7.8 Hz, 1H), 7.45 - 7.39 (m, 1H), 7.32 (d, *J* = 4.5 Hz, 3H), 7.17 (d, *J* = 5.5 Hz, 2H), 7.05 (d, *J* = 8.8 Hz, 1H), 6.91 (s, 1H), 6.55 (s, 1H), 4.90 (d, *J* = 5.0 Hz, 2H), 3.93 (s, 3H), 3.38 (d, *J* = 16.9 Hz, 1H), 3.10 (d, *J* = 16.9 Hz, 1H)**.^{13}C NMR (101 MHz, Chloroform-d)** δ 169.3, 163.2, 151.5, 144.5, 139.2, 137.1, 136.5, 135.7, 135.2, 131.5, 130.5, 129.6, 129.4, 128.6, 128.5, 126.3, 121.9, 119.5, 116.2, 107.8, 107.0, 67.0, 55.6, 40.1. HRMS (ESI): calculated for $C_{28}H_{21}BrN_2O_3$ for $[M+H]^+$ 451.1661, found: 451.1663.

Benzyl 2-(7-chloro-1-oxo-2-(quinolin-8-yl)-1,2-dihydroisoquinolin-3-yl)acetate (3n)
Benzyl 2-(5-chloro-1-oxo-2-(quinolin-8-yl)-1,2-dihydroisoquinolin-3-yl)acetate (3n')

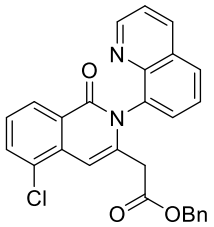
Compound **3n** and **3n'** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (EtOAc: hexane =30:70). It is obtained as a yellow solid which contained two isomers, and further purified by flash column chromatography (Ether: hecane = 30:70-100:0) to give the desired products **3n** (21 mg) in 46% yield and **3n'** (14 mg) in 31% yield.

Benzyl 2-(7-chloro-1-oxo-2-(quinolin-8-yl)-1,2-dihydroisoquinolin-3-yl)acetate (3n)



^{1}H-NMR (400-MHz, Chloroform-*d*) δ 8.93 (s, 1H), 8.39 (s, 1H), 8.30 (d, *J* = 8.2 Hz, 1H), 7.97 (d, *J* = 8.2 Hz, 1H), 7.65 (t, *J* = 8.1 Hz, 2H), 7.52 (t, *J* = 6.9 Hz, 4H), 7.37 (d, *J* = 5.1 Hz, 3H), 7.21 (d, *J* = 5.7 Hz, 2H), 6.62 (s, 1H), 4.95 (m, 2H), 3.44 (d, *J* = 16.9 Hz, 1H), 3.16 (d, *J* = 17.0 Hz, 1H). **^{13}C-NMR (101-MHz, $CDCl_3$)** δ 169.2, 164.1, 151.7, 144.4, 139.2, 138.0, 136.6, 136.3, 135.2, 134.4, 132.6, 132.3, 131.3, 129.7, 129.6, 128.7, 128.71, 128.5, 128.4, 127.5, 126.5, 126.3, 124.9, 122.1, 119.0, 108.8, 67.1, 40.2. HRMS (ESI): calculated for $C_{28}H_{21}ClN_2O_3$ for $[M+H]^+$ 445.1159, found: 445.1163.

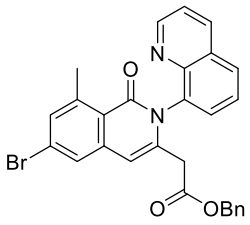
Benzyl 2-(5-chloro-1-oxo-2-(quinolin-8-yl)-1,2-dihydroisoquinolin-3-yl)acetate (3n')



H-NMR (400-MHz, Chloroform-*d*) δ 8.94 (s, 1H), 8. 31 (s, 1H), 8.22 (d, *J* = 8.4 Hz, 1H), 7.95-7.89 (m, 2H), 7.60 (d, *J* = 7.2 Hz, 1H), 7.49-7.41 (m, 2H), 7.34-7.29 (m, 4H), 7.20-7.17 (m, 2H), 6.60 (s, 1H), 4.96 (m, 2H), 3.45 (d, *J* = 16.9 Hz, 1H), 3.17 (d, *J* = 16.9 Hz, 1H). **^{13}C-NMR (101-MHz, $CDCl_3$)** δ 169.3, 163.2, 151.7, 144.6, 138.1, 136.5, 135.4, 135.2, 132.4, 131.5, 129.6, 128.7, 128.3, 128.1, 127.3, 126.3, 124.9, 122.1, 120.9, 106.8, 77.5, 76.8, 67.4, 40.5. HRMS (ESI): calculated for $C_{28}H_{21}ClN_2O_3$ for $[M+H]^+$ 445.1159, found: 445.1162.

Benzyl 2-(6-bromo-8-methyl-1-oxo-2-(quinolin-8-yl)-1,2-dihydroisoquinolin-3-yl)acetate (3o)

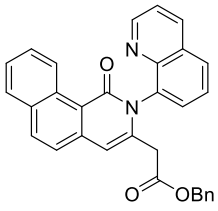
Compound **3o** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (EtOAc: hexane =30:70). It is obtained as a yellow solid; 33.2 mg, 65% yield.



^{1}H-NMR (400 MHz, Chloroform-*d*) δ 8.86 (d, *J* = 4.0 Hz, 1H), 8.22 (d, *J* = 8.2 Hz, 1H), 7.90 (d, *J* = 8.1 Hz, 1H), 7.58 (d, *J* = 7.1 Hz, 1H), 7.52 (s, 1H), 7.47 (d, *J* = 7.9 Hz, 1H), 7.43 (dd, *J* = 8.8, 4.6 Hz, 1H), 7.34 (t, *J* = 5.9 Hz, 4H), 7.17 (d, *J* = 5.7 Hz, 2H), 6.45 (s, 1H), 4.90 (d, *J* = 4.1 Hz, 2H), 3.35 (d, *J* = 17.1 Hz, 1H), 3.04 (d, *J* = 17.0 Hz, 1H), 2.80 (s, 3H).**^{13}C-NMR (101 MHz, Chloroform-d)** δ 169.0, 163.9, 151.6, 144.7, 144.3, 140.2, 137.6, 136.6, 135.7, 135.1, 132.6, 131.4, 129.6, 129.5, 128.6, 128.6, 126.7, 126.7, 126.4, 122.8, 122.1, 107.3, 67.0, 39.9, 23.6. HRMS (ESI): calculated for $C_{28}H_{21}BrN_2O_3$ for $[M+H]^+$ 513.0811, found: 513.0798.

Benzyl 2-(1-oxo-2-(quinolin-8-yl)-1,2-dihydrobenzo[h]isoquinolin-3-yl)acetate (3p)

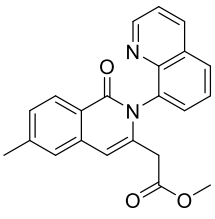
Compound **3p** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (EtOAc: hexane =30:70). It is obtained as a yellow solid; 33.4 mg, 71% yield.



^{1}H-NMR (400 MHz, Chloroform-*d*) δ 10.04 (d, *J* = 8.6 Hz, 1H), 8.84 (d, *J* = 3.8 Hz, 1H), 8.25 (d, *J* = 8.3 Hz, 1H), 8.07 (d, *J* = 8.6 Hz, 1H), 7.95 (d, *J* = 8.2 Hz, 1H), 7.90 (d, *J* = 7.9 Hz, 1H), 7.68 - 7.60 (m, 2H), 7.58 (d, *J* = 8.1 Hz, 2H), 7.52 (t, *J* = 8.0 Hz, 1H), 7.44 (dd, *J* = 8.2, 4.1 Hz, 1H), 7.33 (d, *J* = 4.8 Hz, 3H), 7.19 (d, *J* = 5.6 Hz, 2H), 6.80 (s, 1H), 4.94 (t, *J* = 10.1 Hz, 2H), 3.51 (d, *J* = 17.0 Hz, 1H), 3.20 (d, *J* = 17.0 Hz, 1H).**^{13}C-NMR (101 MHz, Chloroform-*d*)** δ 169.1, 164.1, 151.7, 144.3, 139.1, 137.9, 136.6, 136.2, 135.2, 134.3, 132.6, 132.2, 131.3, 129.6, 129.5, 128.7, 128.6, 128.4, 128.3, 127.4, 126.4, 126.3, 124.8, 122.1, 118.9, 108.8, 67.1, 40.1. HRMS (ESI): calculated for $C_{31}H_{22}N_2O_3$ for $[M+H]^+$ 471.1712, found: 471.1710.

Methyl 2-(6-methyl-1-oxo-2-(quinolin-8-yl)-1,2-dihydroisoquinolin-3-yl)acetate (4a)

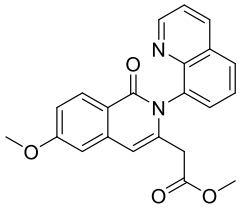
Compound **4a** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (EtOAc: hexane =30:70). It is obtained as a yellow solid; 26.9 mg, 75% yield.



^{1}H-NMR (400 MHz, Chloroform-*d*) δ 8.86 (d, *J* = 4.0 Hz, 1H), 8.28 (d, *J* = 8.1 Hz, 1H), 8.26 - 8.21 (m, 1H), 7.97 (dd, *J* = 8.1, 1.5 Hz, 1H), 7.72 - 7.67 (m, 1H), 7.65 (d, *J* = 7.8 Hz, 1H), 7.44 (dd, *J* = 8.3, 4.2 Hz, 1H), 7.35 (s, 1H), 7.30 (d, *J* = 8.1 Hz, 1H), 6.56 (s, 1H), 3.43 (s, 3H), 3.36 (d, *J* = 16.8 Hz, 1H), 3.09 (d, *J* = 16.8 Hz, 1H), 2.50 (s, 3H).**^{13}C NMR (101-MHz, Chloroform-d)** δ 169.8, 151.5, 144.6, 143.3, 137.3, 136.5, 135.9, 131.4, 129.7, 129.4, 128.4, 128.3, 126.2, 125.8, 123.4, 122.0, 107.9, 52.1, 40.0, 22.0. HRMS (ESI): calculated for $C_{23}H_{17}N_3O_3$ for $[M+H]^+$ 359.1421, found: 359.1420.

Methyl 2-(6-methoxy-1-oxo-2-(quinolin-8-yl)-1,2-dihydroisoquinolin-3-yl)acetate (4b)

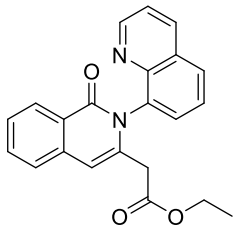
Compound **4b** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (EtOAc: hexane =30:70). It is obtained as a yellow solid; 27.0 mg, 72% yield.



^{1}H-NMR (400 MHz, Chloroform-*d*) δ 8.87 (dd, *J* = 4.4, 1.6 Hz, 1H), 8.31 (d, *J* = 8.8 Hz, 1H), 8.24 (dd, *J* = 8.4, 1.8 Hz, 1H), 7.97 (dd, *J* = 8.1, 1.5 Hz, 1H), 7.73 - 7.67 (m, 1H), 7.65 (t, *J* = 7.7 Hz, 1H), 7.44 (dd, *J* = 8.3, 4.2 Hz, 1H), 7.05 (dd, *J* = 8.8, 2.6 Hz, 1H), 6.93 (d, *J* = 2.5 Hz, 1H), 6.56 (s, 1H), 3.92 (s, 3H), 3.43 (s, 3H), 3.35 (d, *J* = 16.8 Hz, 1H), 3.09 (d, *J* = 16.8 Hz, 1H)**. ^{13}C-NMR (100 MHz, Chloroform-d)** δ 169.8, 163.3, 163.2, 151.5, 144.5, 139.2, 137.2, 136.6, 135.8, 131.4, 130.5, 129.7, 129.4, 126.2, 122.0, 119.5, 116.2, 107.8, 107.0, 55.6, 52.2, 40.0. HRMS (ESI): calculated for $C_{22}H_{18}N_2O_4$ for $[M+Na]^+$ 375.1345, found: 375.1347.

Ethyl 2-(1-oxo-2-(quinolin-8-yl)-1,2-dihydroisoquinolin-3-yl)acetate (4c)

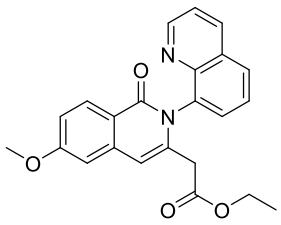
Compound **4c** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (EtOAc: hexane =40:60-60:40). It is obtained as a yellow solid; 22.4 mg, 65% yield.



^{1}H-NMR (400 MHz, Chloroform-*d*) δ 8.91 (d, *J* = 4.2 Hz, 1H), 8.44 (d, *J* = 8.0 Hz, 1H), 8.30 (d, *J* = 8.3 Hz, 1H), 8.02 (d, *J* = 8.2 Hz, 1H), 7.77 (d, *J* = 7.2 Hz, 1H), 7.74 - 7.67 (m, 2H), 7.62 (d, *J* = 8.1 Hz, 1H), 7.55 - 7.50 (m, 1H), 7.50 - 7.46 (m, 1H), 6.69 (s, 1H), 3.95 (q, *J* = 7.2 Hz, 2H), 3.41 (d, *J* = 16.9 Hz, 1H), 3.13 (d, *J* = 16.9 Hz, 1H), 1.11 (t, *J* = 7.1 Hz, 3H). **^{13}C-NMR (101 MHz, Chloroform-*d*)** δ 169.4, 163.6, 151.5, 144.4, 137.1, 136.6, 136.4, 135.7, 132.6, 131.3, 129.6, 129.3, 128.3, 126.7, 126.2, 125.9, 125.5, 121.9, 107.9, 61.1, 40.1, 13.9. HRMS (ESI): calculated for $C_{22}H_{19}N_2O_3P$ for $[M+H]^+$ 359.1341, found: 359.1339.

Ethyl 2-(6-methoxy-1-oxo-2-(quinolin-8-yl)-1,2-dihydroisoquinolin-3-yl)acetate (4d)

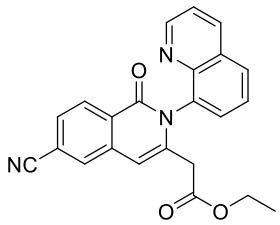
Compound **4d** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (EtOAc: hexane =30:70). It is obtained as a yellow solid; 29.4 mg, 76% yield.



^{1}H-NMR (400 MHz, Chloroform-*d*) δ 8.91 (dd, *J* = 4.3, 1.8 Hz, 1H), 8.35 (d, *J* = 8.8 Hz, 1H), 8.29 (dd, *J* = 8.4, 1.6 Hz, 1H), 8.01 (d, *J* = 8.1 Hz, 1H), 7.76 (d, *J* = 6.8 Hz, 1H), 7.69 (d, *J* = 7.8 Hz, 1H), 7.49 (dd, *J* = 8.3, 4.2 Hz, 1H), 7.10 (dd, *J* = 8.8, 2.5 Hz, 1H), 6.98 (d, *J* = 2.5 Hz, 1H), 6.61 (s, 1H), 3.96 - 3.92 (m, 2H), 3.38 (d, *J*

= 16.8 Hz, 1H), 3.11 (d, *J* = 16.8 Hz, 1H), 1.11 (t, *J* = 7.1 Hz, 3H). **^{13}C-NMR (101 MHz, Chloroform-*d*)** 169.5, 163.7, 151.7, 144.6, 137.2, 136.7, 136.5, 135.9, 132.7, 131.5, 129.7, 129.5, 128.4, 126.8, 126.3, 126.1, 125.7, 122.1, 108.0, 61.3, 40.2, 29.8, 14.1. HRMS (ESI): calculated for $C_{23}H_{20}N_2O_4$ for $[M+H]^+$ 389.1486, found: 389.1489.

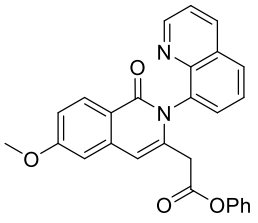
Ethyl 2-(6-cyano-1-oxo-2-(quinolin-8-yl)-1,2-dihydroisoquinolin-3-yl)acetate (4e)



Compound **4e** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (EtOAc: hexane =30:70). It is obtained as a yellow solid; 27.6 mg, 72% yield. **^{1}H-NMR (400 MHz, Chloroform-*d*)** δ 8.90 (d, *J* = 4.6 Hz, 1H), 8.52 (d, *J* = 8.3 Hz, 1H), 8.32 (d, *J* = 8.1 Hz, 1H), 8.05 (d, *J* = 8.1 Hz, 1H), 7.95 (s, 1H), 7.76 (d, *J* = 7.2 Hz, 1H), 7.71 (dt, *J* = 7.7, 3.4 Hz, 2H), 7.52 (dd, *J* = 8.3, 4.2 Hz, 1H), 6.69 (s, 1H), 3.96 (q, *J* = 7.1 Hz, 2H), 3.42 (d, *J* = 17.0 Hz, 1H), 3.13 (d, *J* = 17.0 Hz, 1H), 1.12 (t, *J* = 7.1 Hz, 3H).**^{13}C-NMR (101 MHz, Chloroform-*d*)** δ 168.9, 162.4, 151.6, 144.0, 139.2, 137.1, 136.5, 135.0, 131.0, 130.5, 130.0, 129.5, 129.4, 128.4, 127.9, 126.2, 122.1, 118.3, 116.1, 106.6, 61.3, 40.0, 13.9. HRMS (ESI): calculated for $C_{23}H_{17}N_3O_3$ for $[M+H]^+$ 406.1173, found: 406.1169.

Phenyl 2-(6-methoxy-1-oxo-2-(quinolin-8-yl)-1,2-dihydroisoquinolin-3-yl)acetate (4f)

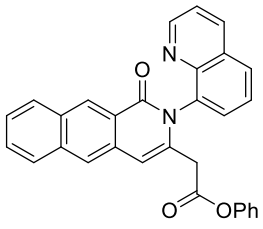
Compound **4f** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (EtOAc: hexane =30:70). It is obtained as a yellow solid; 37.1 mg, 85% yield.



^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.89 (dd, *J* = 4.4, 1.7 Hz, 1H), 8.33 (d, *J* = 8.8 Hz, 1H), 8.26 (dd, *J* = 8.4, 1.8 Hz, 1H), 8.01 (d, *J* = 8.2 Hz, 1H), 7.79 (d, *J* = 7.1 Hz, 1H), 7.69 (t, *J* = 7.8 Hz, 1H), 7.45 (dd, *J* = 8.4, 4.2 Hz, 1H), 7.32 (t, *J* = 7.9 Hz, 2H), 7.20 (t, *J* = 7.3 Hz, 1H), 7.07 (dd, *J* = 8.8, 2.5 Hz, 1H), 6.95 (d, *J* = 2.5 Hz, 1H), 6.84 (d, *J* = 8.0 Hz, 2H), 6.66 (s, 1H), 3.93 (s, 3H), 3.61 (d, *J* = 17.2 Hz, 1H), 3.33 (d, *J* = 17.2 Hz, 1H). **^{13}C NMR (101 MHz, Chloroform-d)** δ 168.0, 163.4, 163.3, 151.8, 150.4, 144.7, 139.2, 136.7, 136.6, 135.9, 131.8, 130.6, 129.9, 129.6, 129.6, 129.5, 126.5, 126.16, 122.1, 121.2, 119.6, 116.4, 108.1, 107.1, 55.7, 40.2. HRMS (ESI): calculated for $C_{27}H_{20}N_2O_4$ for $[M+H]^+$ 437.1493, found: 437.1502.

Phenyl 2-(1-oxo-2-(quinolin-8-yl)-1,2-dihydrobenzo[g]isoquinolin-3-yl)acetate (4g)

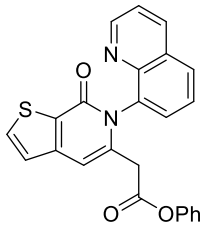
Compound **4g** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (EtOAc: hexane =30:70). It is obtained as a yellow solid;45.6 mg, 82% yield.



^{1}H-NMR (400 MHz, Chloroform-*d*) δ 9.07 (s, 1H), 8.94 (d, *J* = 4.2 Hz, 1H), 8.33 (d, *J* = 8.2 Hz, 1H), 8.13 - 8.06 (m, 4H), 8.01 (d, *J* = 8.4 Hz, 1H), 7.90 (d, *J* = 7.1 Hz, 1H), 7.76 (t, *J* = 7.8 Hz, 1H), 7.64 (t, *J* = 7.6 Hz, 1H), 7.56 (d, *J* = 7.7 Hz, 1H), 7.53 - 7.49 (m, 1H), 7.37 (t, *J* = 7.9 Hz, 2H), 7.25 (t, *J* = 7.5 Hz, 1H), 6.92-6.87 (m, 3H), 3.71 (d, *J* = 17.3 Hz, 1H), 3.41 (d, *J* = 17.3 Hz, 1H). **^{13}C-NMR (101 MHz, $CDCl_3$)** δ 168.2, 164.2, 151.8, 150.4, 144.8, 136.7, 135.8, 134.9, 133.0 132.1, 131.9, 129.9, 129.9, 129.8, 129.6, 129.5, 128.3, 127.7, 126.5, 126.1, 126.0, 124.3, 124.2, 122.2, 121.3, 108.5, 77.5, 77.2, 76.8, 40.3. HRMS (ESI): calculated for $C_{30}H_{20}N_2O_3$ for $[M+H]^+$ 457.1549, found: 457.1551.

Phenyl 2-(4-oxo-5-(quinolin-8-yl)-4,5-dihydrothieno[3,2-c]pyridin-6-yl)acetate (4h)

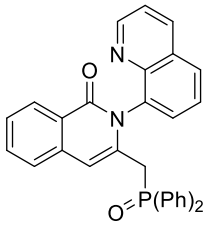
Compound **4h** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (EtOAc: hexane =30:70). It is obtained as a yellow solid; 25.7 mg, 62% yield.



^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.98 (d, *J* = 4.0 Hz, 1H), 8.33 (d, *J* = 8.4 Hz, 1H), 8.22 (d, *J* = 8.0 Hz, 1H), 7.75 (d, *J* = 8.4 Hz, 1H), 7.89 (d, *J* = 7.2 Hz, 1H), 7.75 (t, *J* = 7.8 Hz, 1H), 7.65 (t, *J* = 7.6 Hz, 1H), 7.59-7.32 (m, 3H), 7.21-7.08 (m, 4H), 6.98 (s, 1H), 3.62 (d, *J* = 17.2 Hz, 1H), 3.35 (d, *J* = 17.2 Hz, 1H). **^{13}C NMR (101 MHz, Chloroform-d)** δ 167.8, 159.5, 151.7, 150.2, 145.2, 144.3, 137.4, 136.5, 135.2, 133.9, 131.6, 130.0, 129.7, 129.4, 129.4, 126.3, 126.0, 124.4, 122.1, 121.1, 105.3, 40.1. HRMS (ESI): calculated for $C_{24}H_{18}N_2O_3S$ for $[M+H]^+$ 415.1110, found:415.1109.

3-((Diphenylphosphoryl)methyl)-2-(quinolin-8-yl)isoquinolin-1(2*H*)-one (4i)

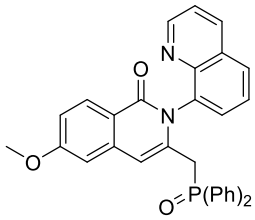
Compound **4i** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (EtOAc: hexane =40:60-60:40). It is obtained as a yellow solid; 40.0 mg, 83% yield.



^{1}H-NMR (400 MHz, Chloroform-*d*) δ 8.84 (dd, *J* = 4.2, 1.7 Hz, 1H), 8.33 (dd, *J* = 8.0, 1.2 Hz, 1H), 8.23 (dd, *J* = 8.3, 1.7 Hz, 1H), 7.92 (dd, *J* = 8.3, 1.4 Hz, 1H), 7.67 - 7.50 (m, 6H), 7.49 - 7.32 (m, 11H), 7.19 (dd, *J* = 7.3, 1.4 Hz, 1H), 6.83 (d, *J* = 3.0 Hz, 1H), 3.42 (ddd, *J* = 15.9, 14.8, 1.1 Hz, 1H), 3.03 (dd, *J* = 16.0, 12.6 Hz, 1H)**.^{13}C-NMR (101 MHz, Chloroform-*d*)** δ 163.7, 151.6, 144.5, 136.7, 135.7, 134.2, 134.1, 132.7, 132.3, 132.3, 132.2, 132.2, 132.0, 131.7, 131.5, 131.4, 131.0, 130.9, 129.4, 129.3, 128.9, 128.8, 128.8, 128.7, 128.2, 126.7, 126.6, 126.2, 125.4, 122.0, 108.1(d), 35.2, 34.6 . HRMS (ESI): calculated for $C_{31}H_{23}N_2O_3P$ for $[M+H]^+$ 509.1416, found: 509.1412.

3-((Diphenylphosphoryl)methyl)-6-methoxy-2-(quinolin-8-yl)isoquinolin-1(2*H*)-one (4j)

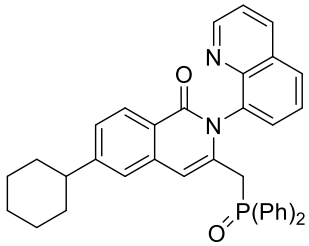
Compound **4j** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (EtOAc: hexane =40:60-60:40). It is obtained as a yellow solid; 47.5 mg, 92% yield.



^{1}H-NMR (400 MHz, Chloroform-*d*) δ 8.85 (dd, *J* = 4.2, 1.7 Hz, 1H), 8.27 - 8.20 (m, 2H), 7.92 (dd, *J* = 8.3, 1.4 Hz, 1H), 7.59 - 7.47 (m, 6H), 7.46 - 7.40 (m, 4H), 7.40 - 7.34 (m, 4H), 7.10 (dd, *J* = 7.3, 1.4 Hz, 1H), 7.01 (dd, *J* = 8.9, 2.5 Hz, 1H), 6.87 (dd, *J* = 7.6, 2.7 Hz, 2H), 3.91 (s, 3H), 3.45 - 3.34 (m, 1H), 3.01 (dd, *J* = 16.1, 12.2 Hz, 1H).**^{13}C-NMR (101 MHz, Chloroform-*d*)** δ 163.2, 163.0, 151.4, 144.4, 136.3, 135.6, 134.6, 132.2, 132.2, 132.1, 132.1, 131.5, 131.5, 131.3, 131.2, 130.9, 130.8, 130.1, 129.2, 129.1, 128.7, 128.7, 128.6, 128.6, 126.4, 121.9, 119.1, 116.2, 107.9, 107.8, 106.8, 55.5, 35.0, 34.4. HRMS (ESI): calculated for $C_{32}H_{25}N_2O_3P$ for $[M+H]^+$ 539.1495, found: 539.1498.

6-Cyclohexyl-3-((diphenylphosphoryl)methyl)-2-(quinolin-8-yl)isoquinolin-1(2*H*)-one (4k)

Compound **4k** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (EtOAc: hexane = 40:60-60:40). It is obtained as a yellow solid; 48.3 mg, 85% yield.

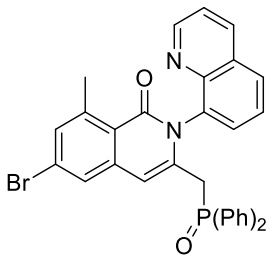


^{1}H-NMR (400 MHz, Chloroform-*d*) δ 8.87 (dd, *J* = 4.3, 1.6 Hz, 1H), 8.29 (dd, *J* = 8.3, 1.6 Hz, 1H), 8.23 (d, *J* = 8.2 Hz, 1H), 7.93 (dd, *J* = 8.3, 1.3 Hz, 1H), 7.79 - 7.71 (m, 1H), 7.64 - 7.52 (m, 5H), 7.50 - 7.41 (m, 5H), 7.37 (ddd, *J* = 10.6, 5.8, 2.4 Hz, 4H), 7.30 (dd, *J* = 8.3, 1.6 Hz, 1H),

7.25 (d, *J* = 4.6 Hz, 1H), 6.79 (d, *J* = 3.0 Hz, 1H), 3.47 (t, *J* = 15.3 Hz, 1H), 3.01 (dd, *J* = 16.0, 12.6 Hz, 1H), 2.61 (ddd, *J* = 11.7, 8.0, 3.2 Hz, 1H), 1.95 - 1.84 (m, 4H), 1.83 - 1.73 (m, 1H), 1.54 - 1.36 (m, 5H), 1.32 - 1.23 (m, 3H). **^{13}C-NMR (101 MHz, Chloroform-*d*)** δ 163.6, 153.1, 150.86, 137.3, 137.0, 135.2, 133.7, 132.3, 132.2, 132.21, 132.1, 132.1, 132.0, 131.4, 131.4, 131.3, 131.3, 130.9, 130.8, 129.2, 129.2, 128.8, 128.77, 128.7, 128.6, 128.5, 128.4, 128.1, 126.8, 126.3, 123.7, 123.3, 121.9, 108.5, 108.4, 44.8, 35.1, 34.4, 34.1, 26.8, 26.1. HRMS (ESI): calculated for $C_{37}H_{33}N_2O_2P$ for $[M+H]^+$ 591.2203, found: 591.2205.

6-Bromo-3-((diphenylphosphoryl)methyl)-8-methyl-2-(quinolin-8-yl)isoquinolin-1(2*H*)-one (4l)

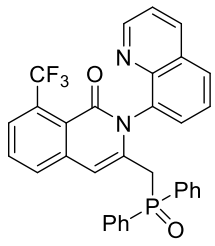
Compound **4l** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (EtOAc: hexane =40:60-60:40). It is obtained as a yellow solid; 45.7 mg, 79% yield.



^{1}H-NMR (400 MHz, Chloroform-*d*) δ 8.86 (dd, *J* = 4.2, 1.7 Hz, 1H), 8.25 (dd, *J* = 8.3, 1.7 Hz, 1H), 7.93 (dd, *J* = 8.3, 1.3 Hz, 1H), 7.81 - 7.70 (m, 4H), 7.62 - 7.50 (m, 6H), 7.46 (dd, *J* = 8.6, 4.5, 2.9 Hz, 7H), 7.40 - 7.32 (m, 5H), 7.30 - 7.26 (m, 1H), 6.57 (d, *J* = 3.0 Hz, 1H), 5.85 (td, *J* = 6.8, 4.0 Hz, 1H), 4.89 (dd, *J* = 11.2, 6.8 Hz, 2H), 3.48 - 3.31 (m, 1H), 2.97 (dd, *J* = 15.9, 12.9 Hz, 1H), 2.74 (s, 3H).**^{13}C-NMR (101 MHz, Chloroform-*d*)** δ 151.3, 144.4, 144.0, 136.8, 135.5, 132.9, 132.3, 132.3, 132.2, 132.1, 132.0, 132.0, 131.9, 131.4, 131.3, 131.3, 131.2, 130.8, 130.7, 129.3, 129.2, 128.8, 128.8, 128.7, 128.6, 128.5, 128.4, 126.7, 126.6, 126.5, 122.4, 122.0, 107.2, 107.1, 85.1, 84.0, 35.1, 34.4, 23.5. HRMS (ESI): calculated for $C_{32}H_{24}BrN_2O_2P$ for $[M+Na]^+$ 601.0662, found: 601.0659.

3-((diphenylphosphoryl)methyl)-2-(quinolin-8-yl)-8-(trifluoromethyl)isoquinolin-1(2H)-one (4m)

Compound **4m** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (silica gel, petroleum ether/ ethyl actate = 1:1 to 1:2). It is obtained as a yellow solid; 46.1 mg, 83% yield.

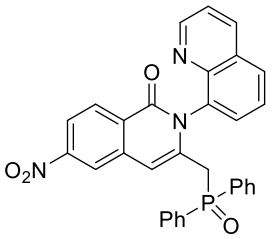


^{1}H-NMR (400 MHz, Chloroform-*d*) δ ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.85 (d, *J* = 4.0 Hz, 1H), 8.25 (dd, *J* = 8.0, 4.0 Hz, 1H), 7.92 (d, *J* = 8.0 Hz, 1H), 7.85 (dd, *J* = 8.0, 4.0 Hz, 1H), 7.67-7.34 (m, 15H), 7.30 (d, *J* = 8.0 Hz, 1H), 6.85 (s, 1H), 3.37 (dd, *J* = 15.9, 8.0 Hz, 1H), 3.00 (dd, *J* = 16.0, 8.0 Hz, 1H). **^{13}C NMR**

(101 MHz, $CDCl_3$) δ 160.7, 151.5, 144.4, 136.5, 136.3, 135.5, 132.9, 132.4, 131.9, 131.8, 131.5, 131.4, 131.3, 131.2, 130.99, 130.89, 130.8, 129.5, 129.5, 129.0, 128.9, 128.86, 128.8, 126.8, 126.4, 122.5, 122.1, 107.4, 107.38, 35.18, 34.52. HRMS (ESI): calculated for $C_{32}H_{23}F_3N_2O_2P$ for $[M+H]^+$ 555.1451, found: 555.1450.

3-((Diphenylphosphoryl)methyl)-6-nitro-2-(quinolin-8-yl)isoquinolin-1(2*H*)-one (4n)

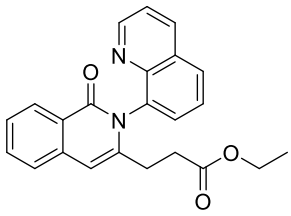
Compound **4n** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (silica gel, petroleum ether/ ethyl actate = 1:1 to 1:2). It is obtained as a yellow solid; 48.3 mg, 91% yield.



^{1}H-NMR (400 MHz, Chloroform-*d*) δ 8.85 (d, *J* = 4.0 Hz, 1H), 8.45 (*J* = 4.0, 1H), 8.28-8.27 (m, 2H), 8.15 (dd, *J* = 8.0, 4.0 Hz, 1H), 7.98 (d, *J* = 4.0 Hz, 1H), 7.77-7.73 (m, 3H), 7.63 - 7.45 (m, 13H), 7.37-7.35 (m, 3H), 6.78 (d, *J* = 4.0 Hz, 1H), 3.45 (dd, *J* = 15.9, 8.0 Hz, 1H), 3.07 (dd, *J* = 16.0, 8.0 Hz, 1H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 169.4, 151.6, 144.6, 143.3, 137.3, 136.5, 136.5, 135.8, 135.3, 131.5, 129.6, 129.4, 128.68, 128.65, 128.6, 128.5, 128.4, 126.4, 125.8, 123.5, 122.0, 108.0, 67.0, 40.2, 22.0. HRMS (ESI): calculated for $C_{31}H_{22}N_3O_4P$ for $[M+H]^+$ 532.1431, found: 532.1429.

Ethyl 3-(1-oxo-2-(quinolin-8-yl)-1,2-dihydroisoquinolin-3-yl)propanoate (4o)

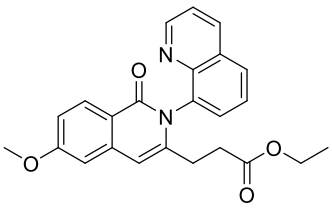
Compound **4o** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (EtOAc: hexane =40:60). It is obtained as a yellow solid; 22.7 mg, 61% yield.



^{1}H-NMR (400 MHz, Chloroform-*d*) δ 8.89 (d, *J* = 5.0 Hz, 1H), 8.29 (d, *J* = 8.1 Hz, 1H), 8.25 (d, *J* = 8.1 Hz, 1H), 7.99 (dd, *J* = 8.0, 1.8 Hz, 1H), 7.77 - 7.68 (m, 2H), 7.47 (dd, *J* = 8.3, 4.1 Hz, 1H), 7.32 (s, 1H), 7.27 (s, 1H), 6.45 (s, 1H), 4.02 (qd, *J* = 7.1, 2.4 Hz, 2H), 2.60 - 2.36 (m, 7H), 1.16 (t, *J* = 7.2 Hz, 3H). **^{13}C-NMR (101 MHz, Chloroform-*d*)** δ 172.2, 163.9, 150.9, 143.3, 142.2, 137.5, 131.3, 129.7, 129.5, 128.3, 128.2, 127.1, 125.7, 123.0, 122.1, 104.7, 77.5, 77.2, 76.8, 60.8, 32.6, 28.4, 22.0, 14.3. HRMS (ESI): calculated for $C_{23}H_{20}N_2O_3$ for $[M+H]^+$ 373.1557, found: 373.1555.

Ethyl 3-(6-methoxy-1-oxo-2-(quinolin-8-yl)-1,2-dihydroisoquinolin-3-yl)propanoate (4p)

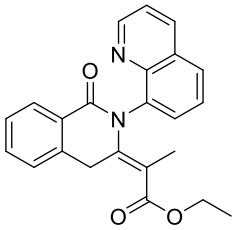
Compound **4p** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (EtOAc: hexane =40:60). It is obtained as a yellow solid; 26.1 mg, 65% yield.



^{1}H-NMR (400 MHz, Chloroform-*d*) δ 8.90 - 8.84 (m, 1H), 8.28 (d, *J* = 8.8 Hz, 1H), 8.26 - 8.22 (m, 1H), 7.97 (dd, *J* = 8.0, 1.6 Hz, 1H), 7.77 - 7.66 (m, 2H), 7.44 (dd, *J* = 8.3, 4.2 Hz, 1H), 7.02 (dd, *J* = 9.0, 2.5 Hz, 1H), 6.90 (d, *J* = 2.6 Hz, 1H), 6.44 (s, 1H), 4.08 - 3.98 (m, 2H), 3.93 (s, 3H), 2.58 - 2.34 (m, 4H), 1.15 (t, *J* = 7.1 Hz, 3H). **^{13}C-NMR (101 MHz, Chloroform-*d*)** δ 172.2, 163.5, 163.2, 151.2, 143.0, 139.5, 137.4, 136.1, 131.1, 130.5, 129.6, 129.5, 126.9, 122.1, 119.1, 115.9, 106.8, 104.5, 77.5, 77.4, 77.2, 76.8, 60.8, 55.6, 32.7, 28.5, 14.2. HRMS (ESI): calculated for $C_{22}H_{18}N_2O_4$ for $[M+H]^+$ 403.1665, found: 403.1668.

Ethyl (*E*)-2-(1-oxo-2-(quinolin-8-yl)-1,4-dihydroisoquinolin-3(2*H*)-ylidene)propanoate (4q)

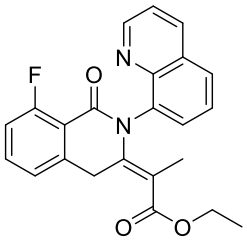
Compound **5g** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (EtOAc: hexane =50:50). It is obtained as a yellow solid; 27.0 mg, 73% yield.



^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.99 (s, 1H), 8.32 (d, *J* = 7.8 Hz, 1H), 8.12 (d, *J* = 7.6 Hz, 1H), 7.94 (d, *J* = 7.4 Hz, 1H), 7.87 (d, *J* = 8.1 Hz, 1H), 7.69 (q, *J* = 7.7, 7.0 Hz, 1H), 7.51 (t, *J* = 7.5 Hz, 2H), 7.39 (t, *J* = 7.7 Hz, 1H), 7.32 (d, *J* = 7.6 Hz, 1H), 4.89 (d, *J* = 16.0 Hz, 1H), 4.57 (s, 1H), 4.16 (q, *J* = 7.2 Hz, 2H), 1.29 (s, 3H), 1.27 - 1.24 (m, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 169.3, 164.5, 150.2, 148.7, 143.6, 138.5, 137.7, 136.3, 132.7, 131.2, 129.2, 128.8, 128.7, 127.6, 127.1, 126.8, 125.9, 121.5, 116.2, 77.5, 77.2, 76.8, 60.7, 34.9, 15.9, 14.3. HRMS (ESI): calculated for $C_{23}H_{20}N_2O_3$ for $[M+H]^+$ 373.1547, found: 373.1550.

Ethyl (*E*)-2-(8-fluoro-1-oxo-2-(quinolin-8-yl)-1,4-dihydroisoquinolin-3(2*H*)-ylidene)propanoate (4r)

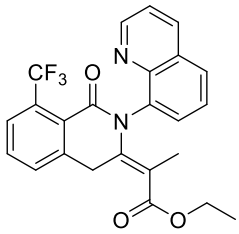
Compound **5h** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (EtOAc: hexane =30:70). It is obtained as a yellow solid; 25.4 mg, 65% yield.



^{1}H-NMR (400 MHz, Chloroform-*d*) δ 8.87 (d, *J* = 3.8 Hz, 1H), 8.17 (d, *J* = 8.2 Hz, 1H), 7.85 (d, *J* = 7.6 Hz, 1H), 7.82 (d, *J* = 8.0 Hz, 1H), 7.74 (d, *J* = 7.4 Hz, 1H), 7.62 (t, *J* = 7.9 Hz, 1H), 7.57 (d, *J* = 8.4 Hz, 2H), 7.40 (dd, *J* = 8.2, 4.0 Hz, 1H), 4.99 (d, *J* = 16.1 Hz, 1H), 4.68 (d, *J* = 16.2 Hz, 1H), 4.16 (q, *J* = 6.8 Hz, 2H), 1.32 (s, 3H), 1.24 (t, *J* = 7.3 Hz, 3H).**^{13}C-NMR (101 MHz, Chloroform-d)** δ 169.0, 163.9, 151.6, 144.7, 144.4, 140.2, 137.7, 136.5, 135.7, 135.1, 132.2, 131.4, 129.6, 129.5, 128.6, 128.6, 126.7, 126.7, 126.4, 122.8, 122.1, 107.3, 77.4, 77.1, 76.8, 67.0, 40.0, 23.6. HRMS (ESI): calculated for $C_{23}H_{19}FN_2O_3$ for $[M+H]^+$ 391.1465, found: 391.1461.

Ethyl (*E*)-2-(1-oxo-2-(quinolin-8-yl)-8-(trifluoromethyl)-1,4-dihydroisoquinolin-3(2*H*)-ylidene) propanoate (4s)

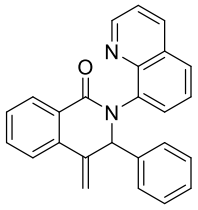
Compound **5i** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (EtOAc: hexane =50:50). It is obtained as a yellow solid; 34.3 mg, 78% yield.



^{1}H-NMR (400 MHz, Chloroform-*d*) δ 8.87 (d, *J* = 3.8 Hz, 1H), 8.17 (d, *J* = 8.2 Hz, 1H), 7.85 (d, *J* = 7.5 Hz, 1H), 7.82 (d, *J* = 8.1 Hz, 1H), 7.74 (d, *J* = 7.4 Hz, 1H), 7.62 (t, *J* = 7.9 Hz, 1H), 7.57 (d, *J* = 8.3 Hz, 2H), 7.40 (dd, *J* = 8.2, 4.0 Hz, 1H), 4.99 (d, *J* = 16.1 Hz, 1H), 4.68 (d, *J* = 16.1 Hz, 1H), 4.16 (q, *J* = 6.7 Hz, 2H), 1.32 (s, 3H), 1.24 (t, *J* = 7.3 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 168.3, 149.9, 149.6, 147.0, 143.1, 139.2, 137.8, 135.9, 131.3, 130.42, 130.35, 128.9, 127.5, 125.8, 125.6, 121.3, 116.1, 60.2, 35.3, 30.0, 15.2, 13.7. HRMS (ESI): calculated for $C_{24}H_{19}F_3N_2O_3$ for $[M+H]^+$ 441.1432, found: 441.1429.

6-Methyl-4-methylene-3-phenyl-2-(quinolin-8-yl)-3,4-dihydroisoquinolin-1(2*H*)-one (5a)

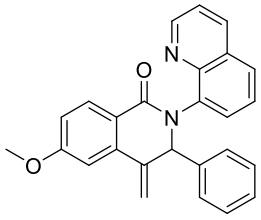
Compound **5a** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (EtOAc: hexane =30:70). It is obtained as a yellow solid; 22.8 mg, 63% yield.



^{1}H-NMR (400 MHz, Chloroform-*d*) δ 8.96 (d, *J* = 4.0 Hz, 1H), 8.32 (d, *J* = 8.0 Hz, 1H), 8.19 (d, *J* = 8.0 Hz, 1H), 7.78 (d, *J* = 8.0 Hz, 1H), 7.57-7.41 (m, 6H), 7.24-7.18 (m, 5H), 5.86 (s, 1H), 5.72(s, 1H), 5.44(s, 1H). **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 163.9, 150.8, 144.3, 141.5, 141.2, 136.5, 135.4, 132.6, 130.5, 129.8, 129.0, 128.9, 128.7, 128.2, 128.1, 127.9, 126.7, 126.2, 124.3, 121.6, 113.8, 77.5, 77.4, 77.2, 76.8, 69.8. HRMS (ESI): calculated for $C_{25}H_{18}N_2O$ for $[M+H]^+$ 363.1618, found: 363.1617.

6-Methoxy-4-methylene-3-phenyl-2-(quinolin-8-yl)-3,4-dihydroisoquinolin-1(2*H*)-one (5b)

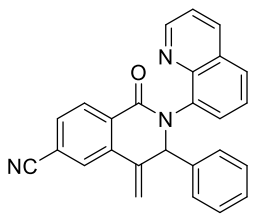
Compound **5b** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (hexane : EtOAc=70:30). It is obtained as a yellow solid; 23.9 mg, 61% yield.



^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.98 (d, *J* = 4.0 Hz, 1H), 8.26 (dd, *J* = 4.0, 8.0 Hz, 1H) , 8.20 (d, *J* = 8.0 Hz, 1H), 7.77 (d, *J* = 8.0 Hz, 1H), 7.44-7.41 (m, 3H), 7.26-7.19 (m, 5H), 7.01-6.99 (m, 2H), 5.82 (s, 1H), 5.70 (s, 1H), 5.43 (s, 1H), 3.87 (s, 3H). **^{13}C-NMR (101-MHz, Chloroform-*d*)** δ 163.7, 162.9, 150.5, 144.0, 141.5, 141.1, 138.4, 137.0, 136.5, 130.9, 130.4, 129.6, 128.5, 127.9, 127.8, 127.7, 126.5, 126.0, 121.3, 121.2, 114.9, 113.7, 108.5, 69.7, 55.4. HRMS (ESI): calculated for $C_{26}H_{20}N_2O_2$ for $[M+Na]^+$ 415.1415, found: 415.1417.

4-methylene-1-oxo-3-phenyl-2-(quinolin-8-yl)-1,2,3,4-tetrahydroisoquinoline-6-carbonitrile (5c)

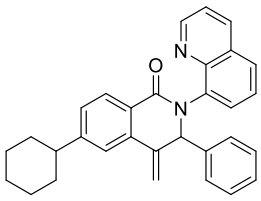
Compound **5c** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (hexane : EtOAc=70:30). It is obtained as a yellow solid; 20.8 mg, 55% yield.



^{1}H NMR (400 MHz, Chloroform-*d*) δ 9.01 (d, *J* = 4.0 Hz, 1H), 8.40 (dd, *J* = 4.0, 8.0 Hz, 1H), 8.27 (d, *J* = 8.0 Hz, 1H), 7.84-7.81 (m, 2H), 7.74 (dd, *J* = 4.0, 8.0 Hz, 1H), 7.52-7.46 (m, 3H), 7.22-7.20 (m, 5H), 5.90 (s, 1H), 5.80 (s, 1H), 5.56 (s, 1H). **^{13}C-NMR (101-MHz, Chloroform-*d*)** δ 162.5, 150.4, 139.6, 136.4, 132.0, 131.5, 130.5, 129.8, 129.8, 129.0, 128.5, 128.48, 128.3, 126.6, 121.8, 118.2, 116.3, 69.6. HRMS (ESI): calculated for $C_{26}H_{17}N_3O$ for $[M+H]^+$ 388.1443, found: 388.1446.

6-cyclohexyl-4-methylene-3-phenyl-2-(quinolin-8-yl)-3,4-dihydroisoquinolin-1(2H)-one (5d)

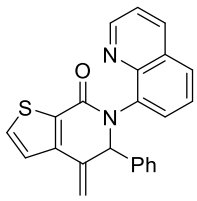
Compound **5d** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (hexane : EtOAc=70:30). It is obtained as a yellow solid; 25.3 mg, 57% yield.



^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.95 (d, *J* = 4.0 Hz, 1H), 8.23 (d, *J* = 8.0 Hz, 1H), 8.17 (dd, *J* = 4.0, 8.0 Hz, 1H), 7.76 (d, *J* = 4.0 Hz, 1H), 7.44-7.38 (m, 4H), 7.33 (dd, *J* = 4.0, 8.0 Hz, 1H), 7.25-7.18 (m, 5H), 5.83 (s, 1H), 5.72 (s, 1H), 5.40 (s, 1H), 2.60 (m, 1H), 1.91-1.75 (m, 5H), 1.47-1.39 (m, 3H), 1.26, 0.87(m, 2H). **^{13}C-NMR (101-MHz, $CDCl_3$)** δ 153.0, 150.9, 141.9, 136.5, 135.3, 129.8, 129.1, 128.8, 128.1, 127.9, 127.9, 126.9, 126.3, 126.0, 122.6, 121.6, 113.4, 77.6, 77.5, 77.3, 76.9, 70.0, 45.1, 34.4, 34.4, 30.0, 27.0, 26.3. HRMS (ESI): calculated for $C_{31}H_{28}N_2O$ for $[M+H]^+$ 445.2275, found: 445.2276.

4-methylene-5-phenyl-6-(quinolin-8-yl)-5,6-dihydrothieno[2,3-c]pyridin-7(4H)-one (5e)

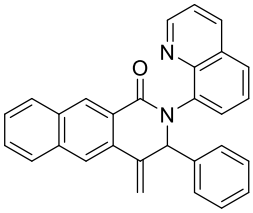
Compound **5e** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (hexane : EtOAc=70:30). It is obtained as a yellow solid; 16.5 mg, 45% yield.



^{1}H NMR (400 MHz, Chloroform-*d*) δ 9.01(d, *J* = 4.0 Hz, 1H), 8.23 (d, *J* = 8.0 Hz, 1H), 7.76(dd, *J* = 4.0, 8.0 Hz, 1H), 7.56 (d, *J* = 8.0 Hz, 1H), 7.48-7.45 (m, 1H), 7.40-7.38 (m, 1H), 7.25, 7.24-7.19 (m, 6H), 6.02 (s, 1H), 5.61 (s, 1H), 5.24 (s, 1H). **^{13}C-NMR (101-MHz, Chloroform-*d*)** δ 160.4, 150.7, 144.4, 141.9, 138.8, 136.5, 132.9, 132.4, 132.3, 131.4, 129.7, 129.5, 129.2, 129.0, 128.9, 128.7, 128.4, 128.3, 128.1, 123.0, 127.2, 127.0, 126.6, 126.6, 126.1, 124.1, 121.5, 113.1, 77.5, 77.2, 76.8, 70.8, 29.8. HRMS (ESI): calculated for $C_{23}H_{16}N_2O_2S$ for $[M+H]^+$ 369.1093, found: 369.1089.

4-methylene-3-phenyl-2-(quinolin-8-yl)-3,4-dihydrobenzo[g]isoquinolin-1(2*H*)-one (5f)

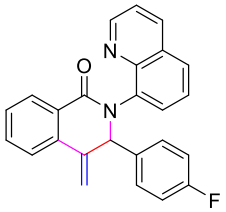
Compound **5f** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (hexane : EtOAc=70:30). It is obtained as a yellow solid; 19.3 mg, 45% yield.



^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.98 (d, *J* = 4.0 Hz, 1H), 8.87 (s, 1H), 8.21 (dd, *J* = 4.0, 8.0 Hz, 1H), 8.01-8.00 (m, 2H), 7.84 (d, *J* = 8.0 Hz, 1H), 7.80 (d, *J* = 8.0 Hz, 1H), 7.58-7.50 (m, 3H), 7.46-7.42 (m, 2H), 7.24-7.22 (m, 2H), 7.17, 7.16-7.15 (m, 3H), 5.89 (s, 1H), 5.83 (s, 1H), 5.51 (s, 1H). **^{13}C-NMR (101-MHz, Chloroform-*d*)** δ 164.2, 150.8, 144.3, 141.8, 141.1, 136.5, 135.4, 133.3, 132.3, 130.3, 130.1, 129.8, 129.7, 128.7, 128.21, 128.16, 128.02, 127.8, 126.8, 126.6, 126.58, 126.3, 126.2, 123.7, 121.6, 113.5, 70.3. HRMS (ESI): calculated for $C_{29}H_{20}N_2O$ for $[M+H]^+$ 413.1652, found:413.1654.

3-(4-fluorophenyl)-4-methylene-2-(quinolin-8-yl)-3,4-dihydroisoquinolin-1(2H)-one (5g)

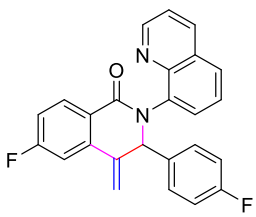
Compound **5g** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (petroleum ether : EtOAc =70:30). It is obtained as a yellow solid; 21.4 mg, 56% yield.



^{1}H NMR (400 MHz, $CDCl_3$) δ 8.95 (s, 1H), 8.30 (d, *J*=4.0 Hz, 1H), 8.19 (d, *J*=8.0 Hz, 1H), 7.77 (t, *J*=4.0 Hz, 1H), 7.56 (m, 2H), 7.49 (t, *J*=8.0 Hz, 1H), 7.43 (m, 3H), 7.19 (t, *J*=8.0 Hz, 2H), 6.86 (t, *J*=8.0 Hz, 2H), 5.87 (s, 1H), 5.73 (s, 1H), 5.39 (s, 1H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 163.5, 150.4, 141.0, 136.7, 136.3, 134.9, 132.4, 130.2, 129.4, 128.8, 128.6, 128.1, 128.0, 127.9, 127.7, 125.9, 124.0, 121.3, 115.3, 115.1, 113.7, 68.8. HRMS (ESI) calcd. for $C_{25}H_{18}FN_2O$ 381.1398; found 381.1391.

6-fluoro-3-(4-fluorophenyl)-4-methylene-2-(quinolin-8-yl)-3,4-dihydroisoquinolin-1(2H)-one (5h)

Compound **5h** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (petroleum ether : EtOAc =70:30). It is obtained as a yellow solid; 21.0 mg, 52% yield.

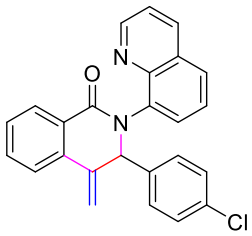


^{1}H NMR (400 MHz, $CDCl_3$) δ 8.95 (s, 1H), 8.19 (d, J= 4.0 Hz, 1H), 7.79 (d, J=4.0 Hz, 1H), 7.55 (d, J=4.0 Hz, 1H), 7.47-7.42 (m, 3H), 7.32 (d, J=8.0 Hz, 1H), 7.17 (t, J=8.0 Hz, 2H), 6.89(t, J=8.0 Hz, 2H), 5.82 (s, 1H), 5.74 (s, 1H), 5.50 (s, 1H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 163.8, 163.6, 161.2, 161.1, 150.7, 144.1, 141.2, 138.2, 136.6, 136.1, 133.9, 133.8, 130.4, 129.8, 128.3, 128.3, 128.2, 126.2, 121.6, 120.6,

120.5, 117.8, 117.5, 116.5, 116.4, 115.7, 115.4, 115.1, 68.9. HRMS (ESI) calcd. for $C_{25}H_{17}F_2N_2O$ 399.1416; found 399.1413.

3-(4-chlorophenyl)-4-methylene-2-(quinolin-8-yl)-3,4-dihydroisoquinolin-1(2H)-one (5i)

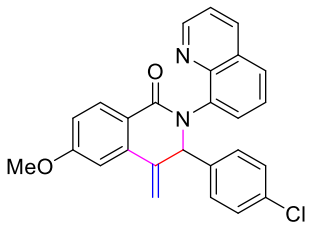
Compound **5i** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (petroleum ether : EtOAc =70:30). It is obtained as a yellow solid; 22.7 mg, 57% yield.



^{1}H NMR (400 MHz, $CDCl_3$) δ 8.96 (s, 1H), 8.30 (d, J=8.0 Hz, 1H), 8.18 (d, J=8.0 Hz, 1H), 7.77 (m, 1H), 7.76, 7.55-7.43 (m, 9H), 7.16 (m, 4H), 5.84 (s, 1H), 5.71 (s, 1H), 5.41 (s, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 163.8, 150.8, 144.1, 141.1, 139.7, 136.6, 135.1, 133.7, 132.7, 130.4, 129.8, 129.3, 129.1, 128.9, 128.8, 128.7, 128.7, 128.5, 128.4, 128.3, 128.1, 128.0, 127.9, 126.2, 124.3, 121.7, 121.6, 114.0, 69.2. HRMS (ESI) calcd. for $C_{25}H_{18}ClN_2O$ 397.1242; found 397.1243.

3-(4-chlorophenyl)-6-methoxy-4-methylene-2-(quinolin-8-yl)-3,4-dihydroisoquinolin-1(2H)-one (5j)

Compound **5j** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (petroleum ether : EtOAc =50:50). It is obtained as a yellow solid; 21.7 mg, 51% yield.

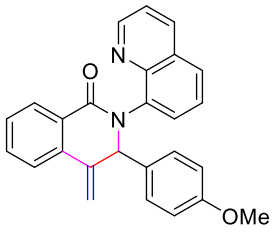


^{1}H NMR (400 MHz, $CDCl_3$) δ 8.95 (s, 1H), 8.25 (d, J=8.0 Hz, 1H), 8.17 (d, J=8.0 Hz, 1H), 7.77, 7.75, 7.45, 7.45, 7.43, 7.41, 7.40, 7.26, 7.19, 7.18, 7.17, 7.15, 7.01, 7.00, 5.85, 5.70, 5.42, 3.87. ^{13}C NMR (101 MHz, $CDCl_3$) δ 163.8, 150.8, 144.1, 141.1, 139.7, 136.6, 135.1, 133.6, 132.8, 130.4, 129.8, 129.3, 129.1, 128.9, 128.8, 128.7, 128.7, 128.5, 128.4, 128.3, 128.1, 128.0, 127.9, 126.2, 124.3, 121.7, 121.6, 114.0, 69.2, 55.6. HRMS (ESI) calcd. for $C_{26}H_{20}ClN_2O_2$ 427.1259; found 427.1261.

3-(4-methoxyphenyl)-4-methylene-2-(quinolin-8-yl)-3,4-dihydroisoquinolin-1(2H)-one (5k)

Compound **5k** was prepared by the typical procedure in 0.1 mmol scale and the reaction mixture was purified by flash column chromatography (petroleum ether : EtOAc =50:50). It is obtained as a

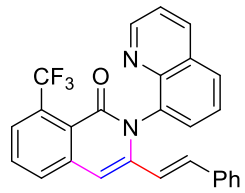
yellow solid; 23.5 mg, 60% yield.



^{1}H NMR (400 MHz, $CDCl_3$) δ 8.97(d, J =4.0 Hz, 1H), 8.30 (d, J=8.0 Hz, 1H), 8.19 (d, J = 8.0 Hz, 1H), 7.77 (t, J=4.0 Hz, 1H), 7.56 (m, 1 H), 7.53 (t, J=4.0 Hz, 1H), 7.48 (m, 1H), 7.43 (m, 3H), 7.12 (d, J=8.0 Hz, 2H), 6.72 (d, J=8.0 Hz, 2H), 5.79 (s, 1H), 5.70 (s, 1H), 5.38 (s, 1H), 3.72 (s, 3H). 13C NMR (100 MHz, CDCl3) δ 163.6, 159.0, 150.5, 144.0, 141.5, 136.3, 135.2, 133.1, 132.4, 130.3, 129.5, 128.7, 128.6, 127.8, 127.6, 125.9, 124.1, 121.3, 113.7, 113.3, 69.0, 55.0. HRMS (ESI) calcd. for $C_{26}H_{21}N_2O_2$ 393.1718; found 393.1721.

(*E*)-2-(quinolin-8-yl)-3-styryl-8-(trifluoromethyl)isoquinolin-1(2*H*)-one (6)

The reaction was carried out in a 10 mL round-bottom flask and the compound 4m (0.1 mmol) was dissolved in 3 mL anhydrous DMF under argon atmosphere. 60% NaH (1.2 equiv.) was added slowly at 0 °C, then followed by the addition of aldehyde (0.12 mmol). The resulting mixture was allowed to warm to room temperature and stirred for overnight. The mixture was quenched with ice and extracted with CH2Cl2 three times. The organic phase was combined and dried over Na_2SO_4. After removing the solvent in vacuo, the crude product was purified by flash column chromatography (petroleum ether : EtOAc =50:50) through silica gel.



^{1}H NMR (400 MHz, $CDCl_3$) δ 8.93 (s, 1H), 8.33 (d, *J* = 4.0 Hz, 1H), 8.01 (d, *J* = 4.0 Hz, 1H), 7.88 (d, *J* = 4.0 Hz, 1H), 7.84 (d, *J* = 8.0 Hz, 1H), 7.78 (d, *J* = 4.0 Hz, 1H) , 7.72 (m, 2H), 7.50 (m, 1H), 7.19 (m, 3H), 7.12 (d, *J* = 12.1 Hz, 1H), 7.06-7.04 (m, 2H), 7.01 (s, 1H), 6.17 (d, *J* = 12.1 Hz, 1H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 160.4, 150.5, 140.3, 134.0 135.6, 133.9, 131.9, 131.7, 131.4, 130.2, 129.9, 129.7, 129.6, 128.83, 128.80, 127.5, 127.1, 126.5, 126.4, 122.6, 122.3, 121.7, 104.1, 29.8. LRMS (ESI) calcd. for $C_{27}H_{18}F_3N_2O$ 443.15; found 443.26.

Reference:

1. *Org. Lett.*, **2017**, 19, 13, 3524–3527

2. *Angew. Chem. Int. Ed*., **2016**, 55, 5765-5769.

3. *J. Org. Chem*., **2009**, 74, 763-1765.

4. *Org. Lett.*, **2017**, 19, 3524-3527.

5. *Chem. Comm.*, **2018**, 54, 12389-12392.

6. *J. Am. Chem. Soc.*, **2009**, 131, 6105-6107.

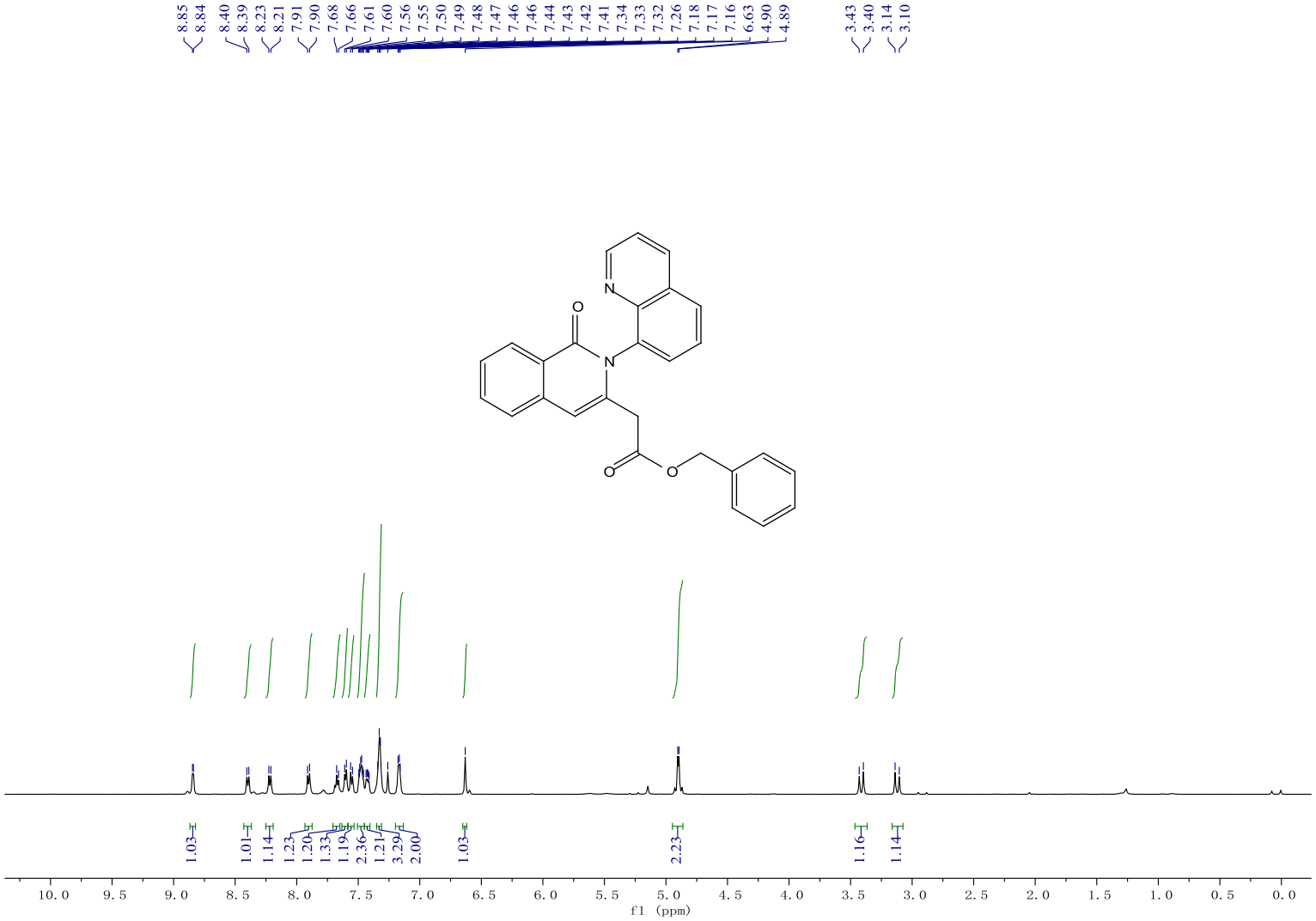
7. *J. Am. Chem. Soc.*, **2019**, 141, 1135-1140.

8. *J. Org. Chem*., **1962**, 27, 1828-33.

9. *Angew. Chem. Int. Ed*., **2016**, 55, 12361-12365.

10. *ACS Catal.*, **2018**, 8, 8115-8120.

^{1}H-NMR Spectra and ^{13}C-NMR Spectra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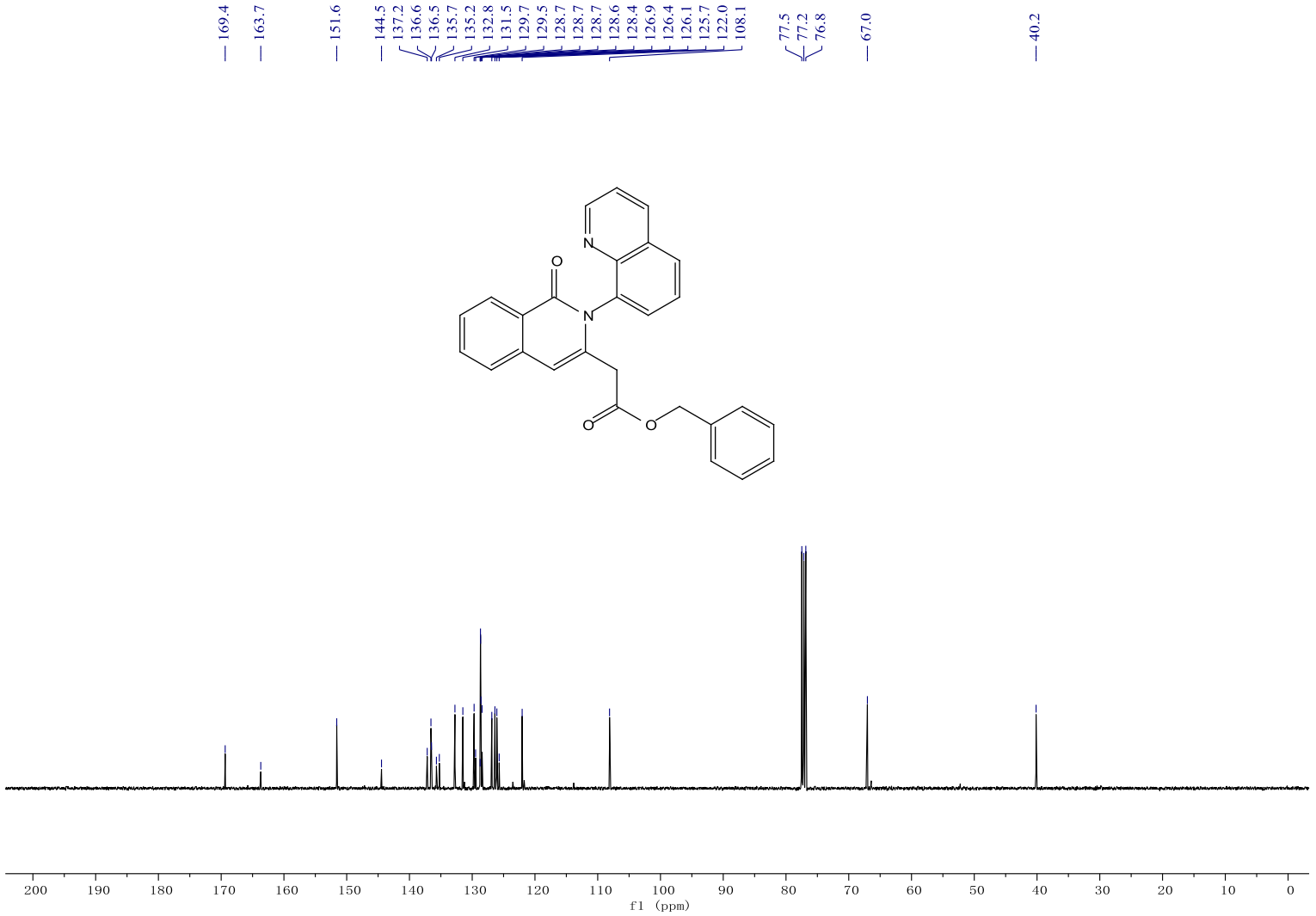
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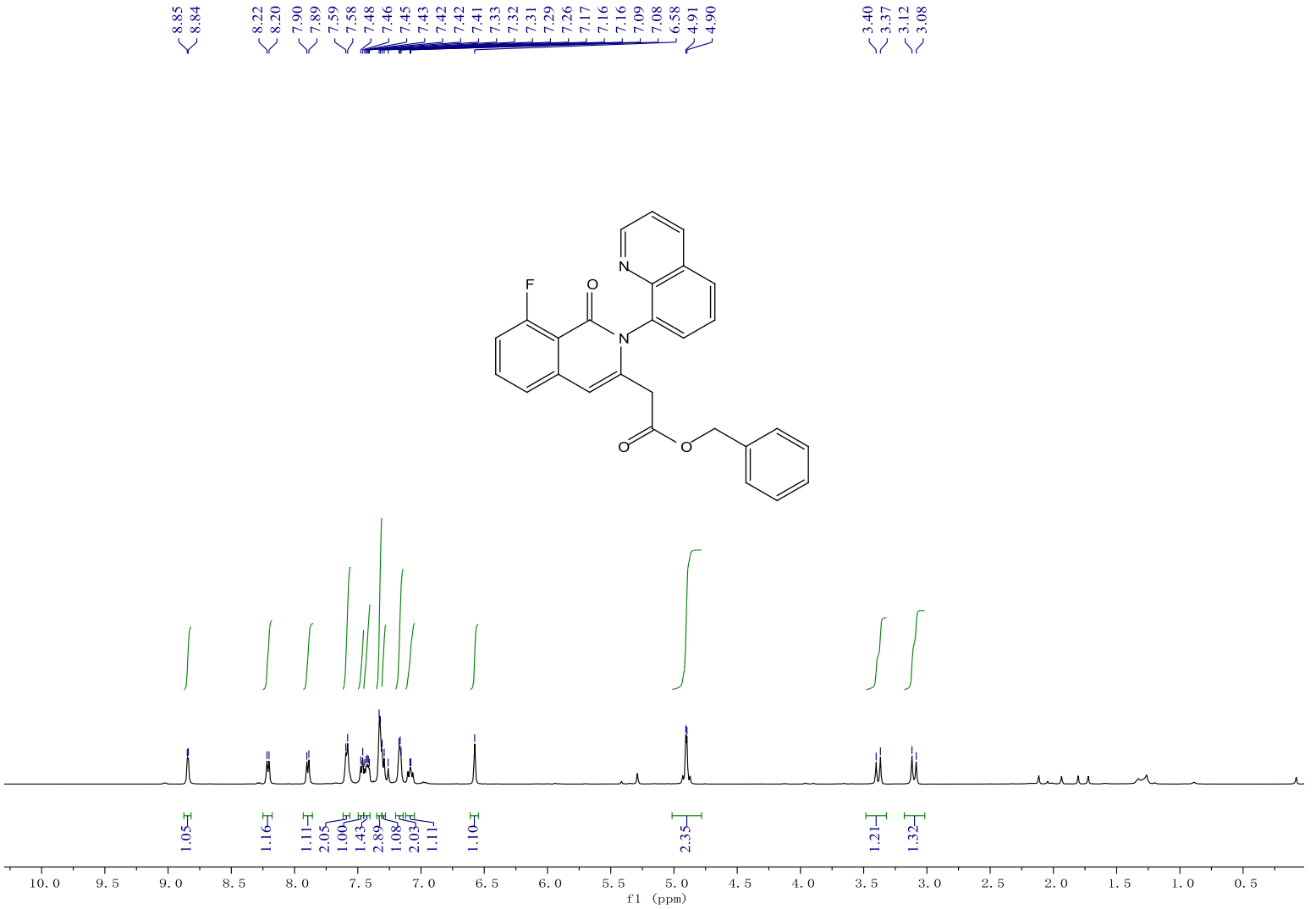
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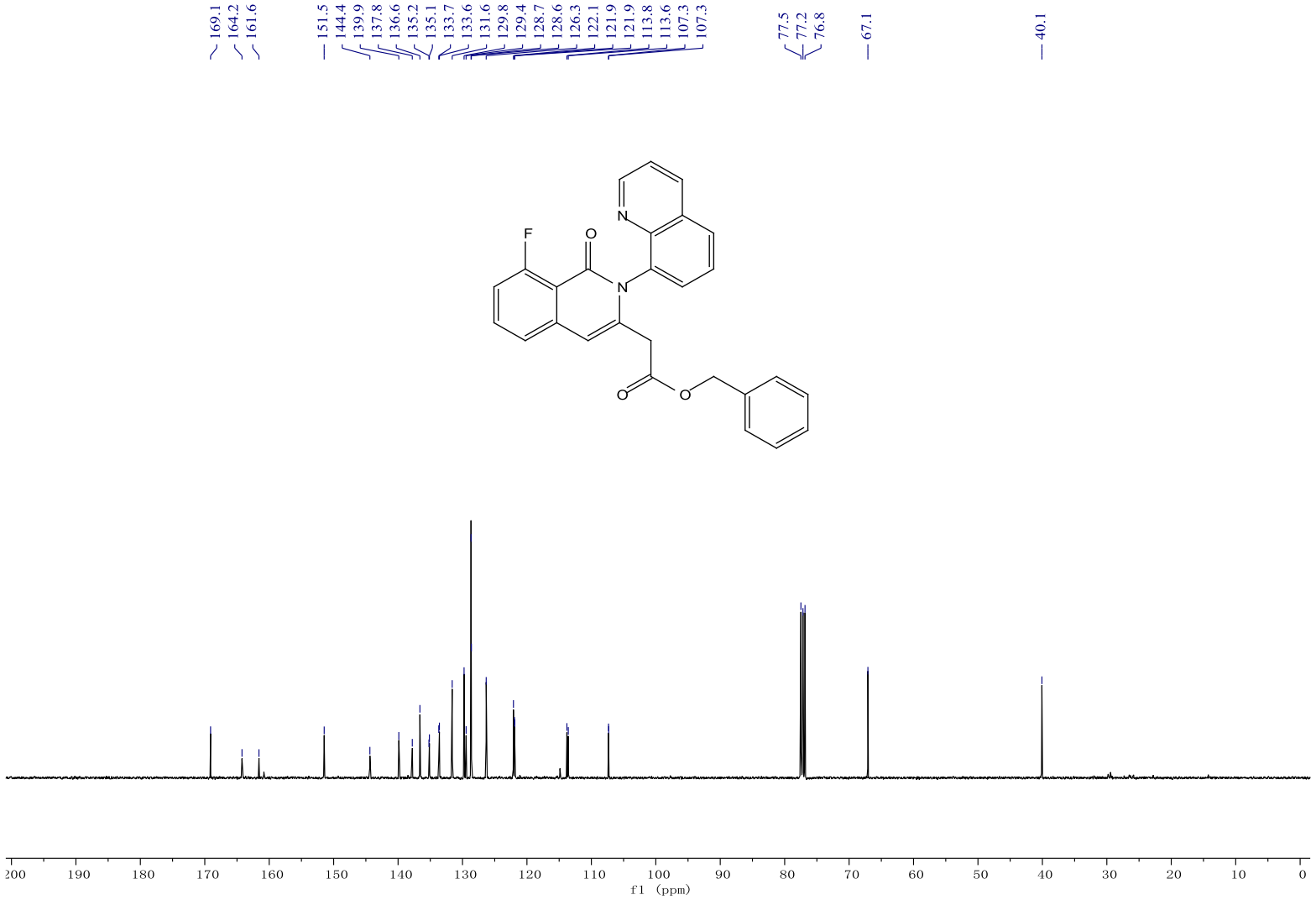
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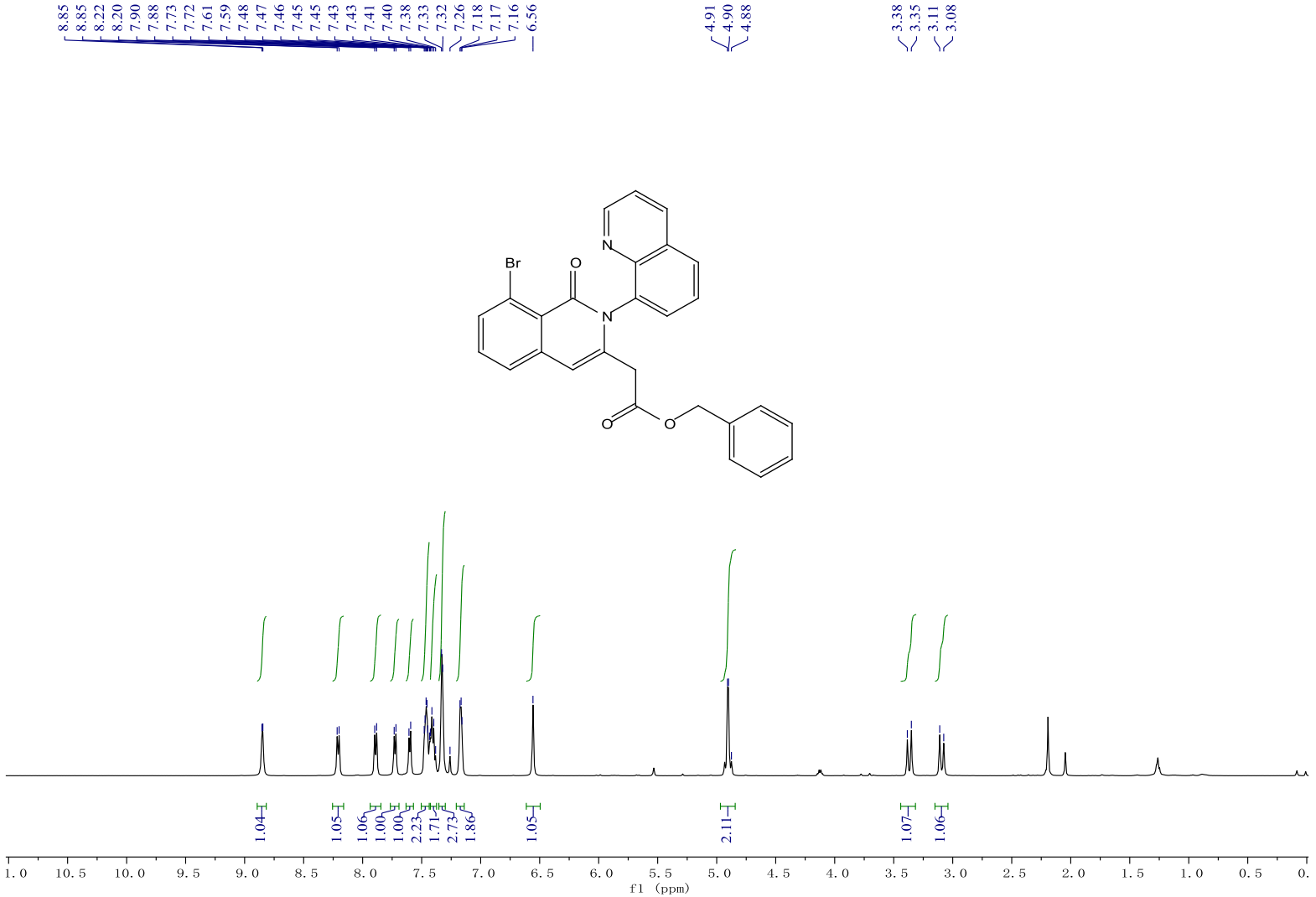
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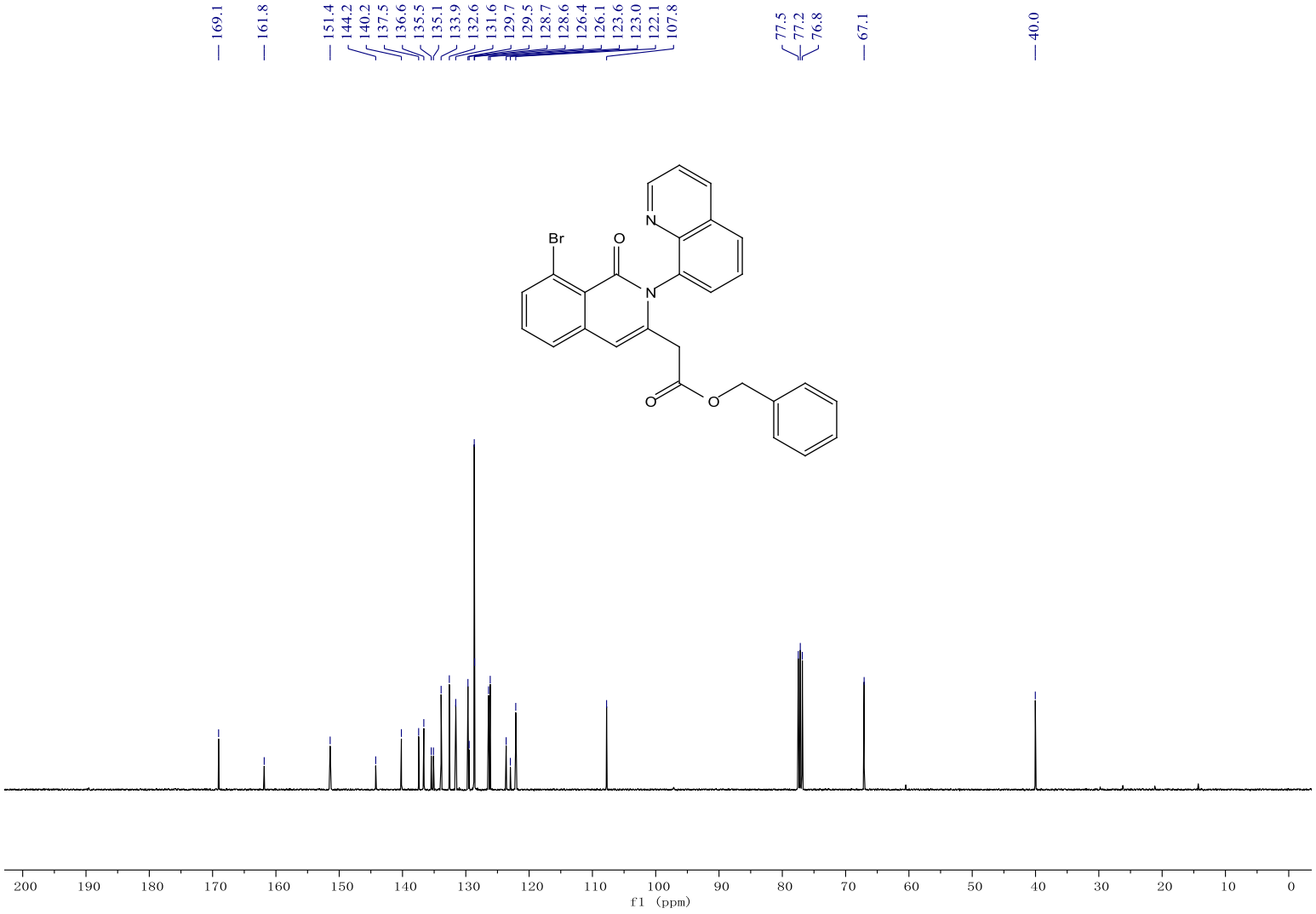
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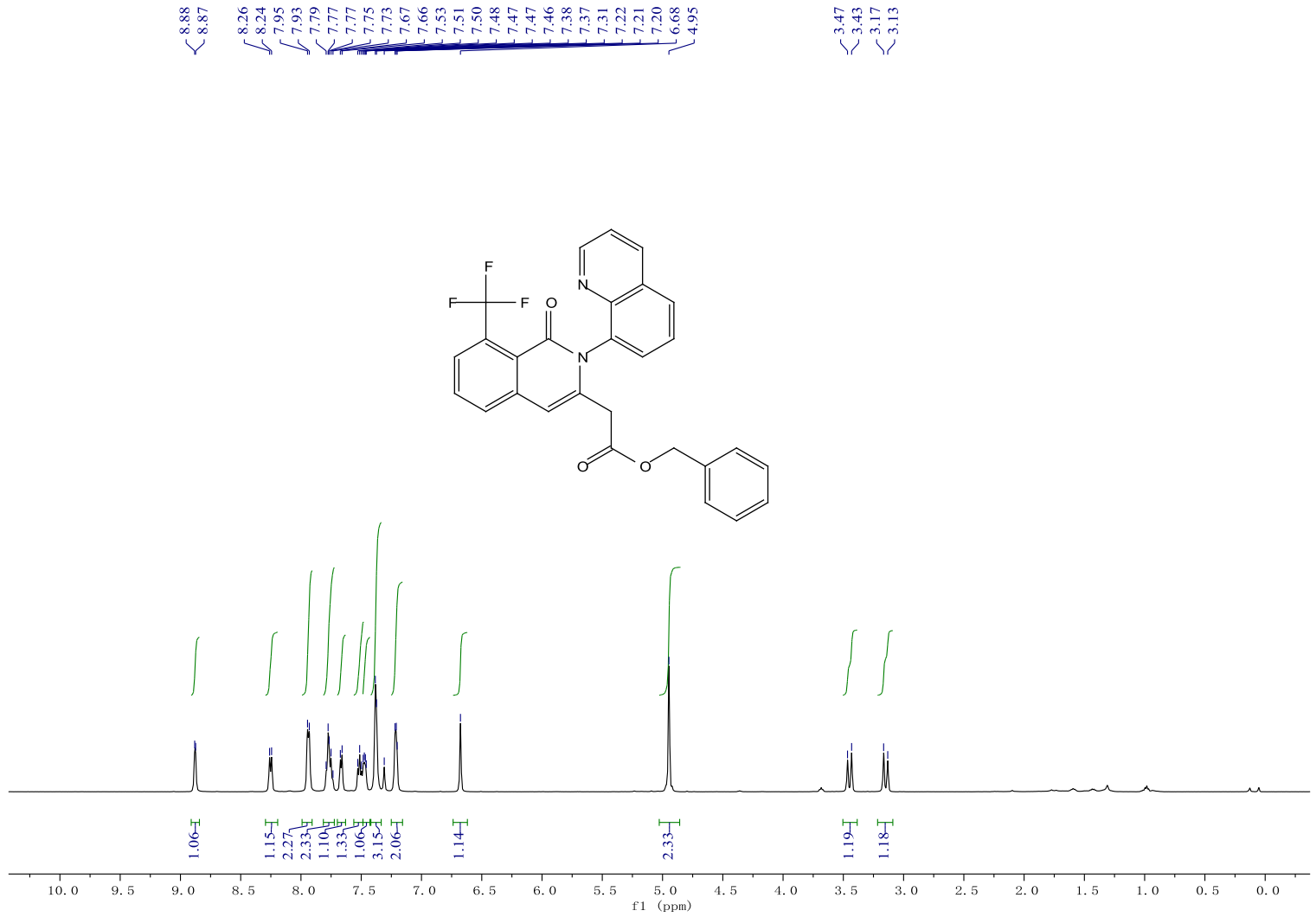
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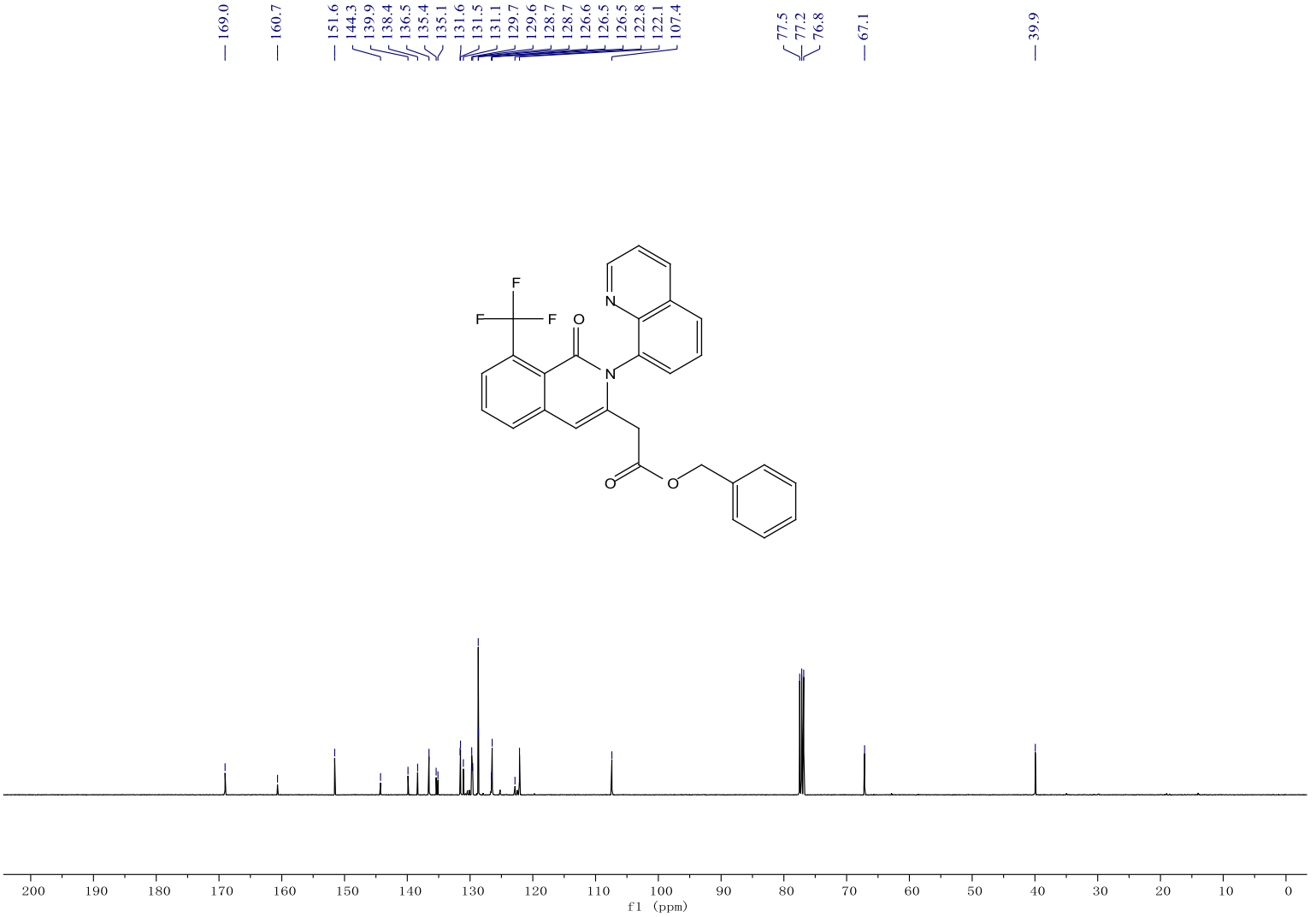
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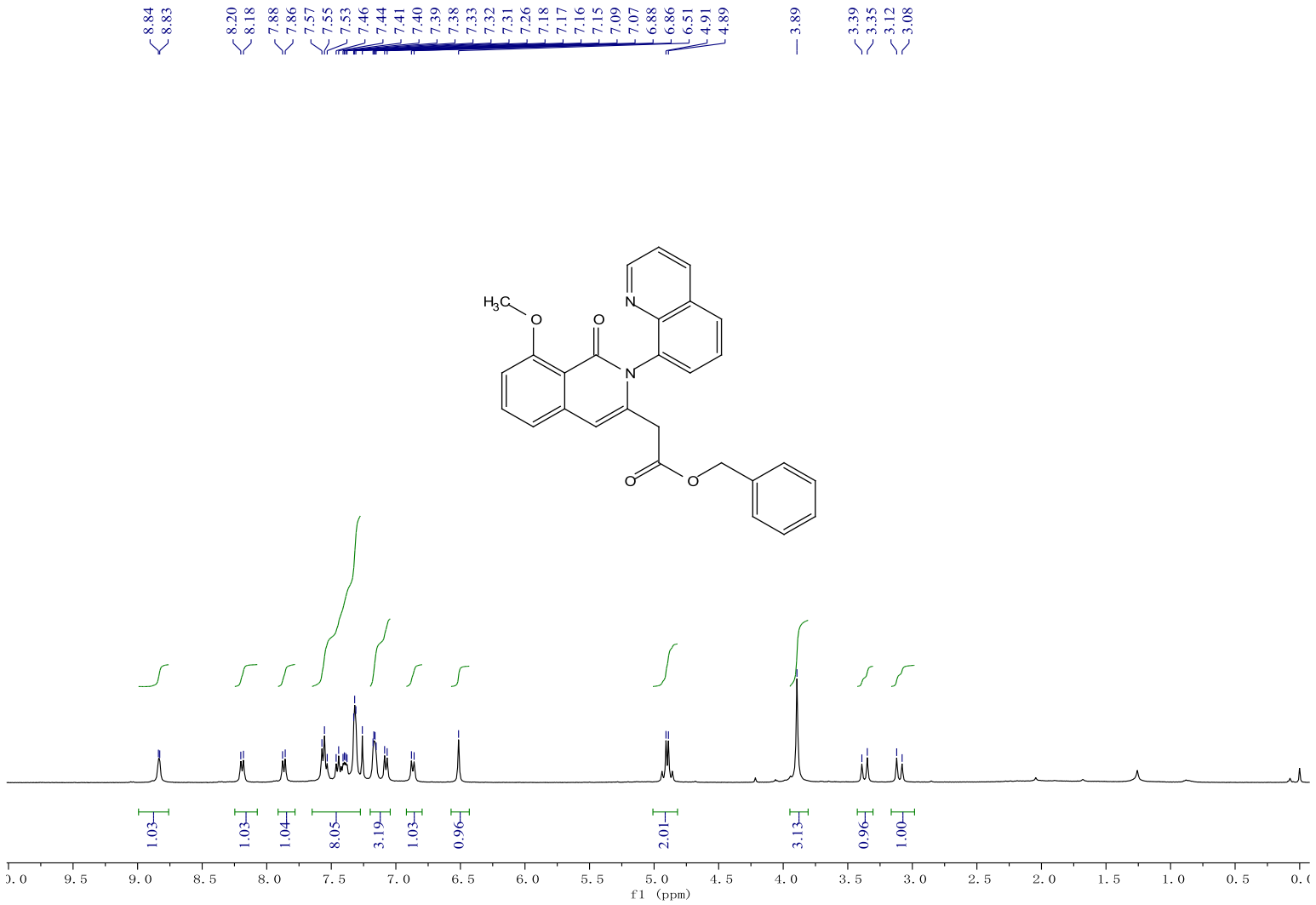
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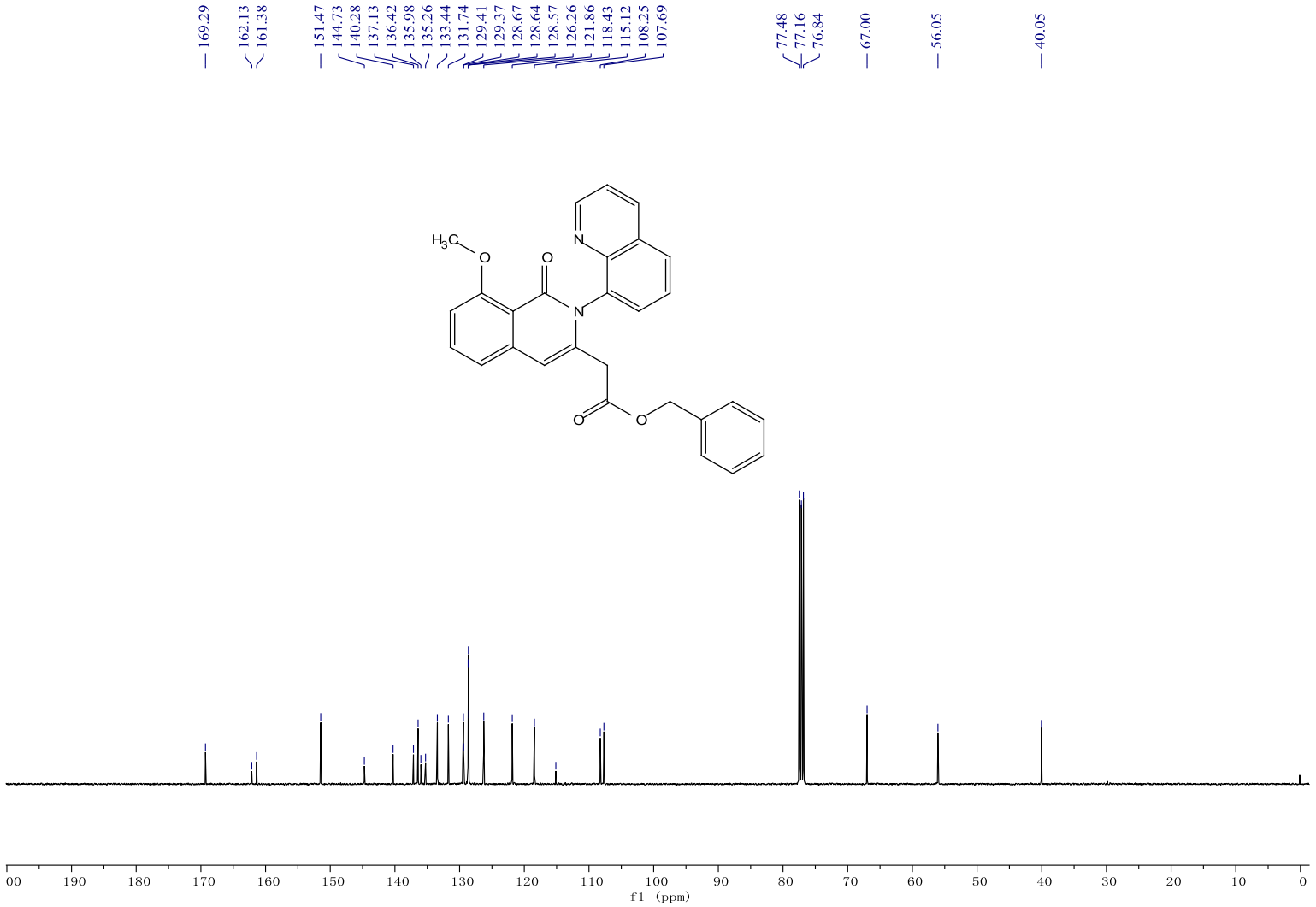
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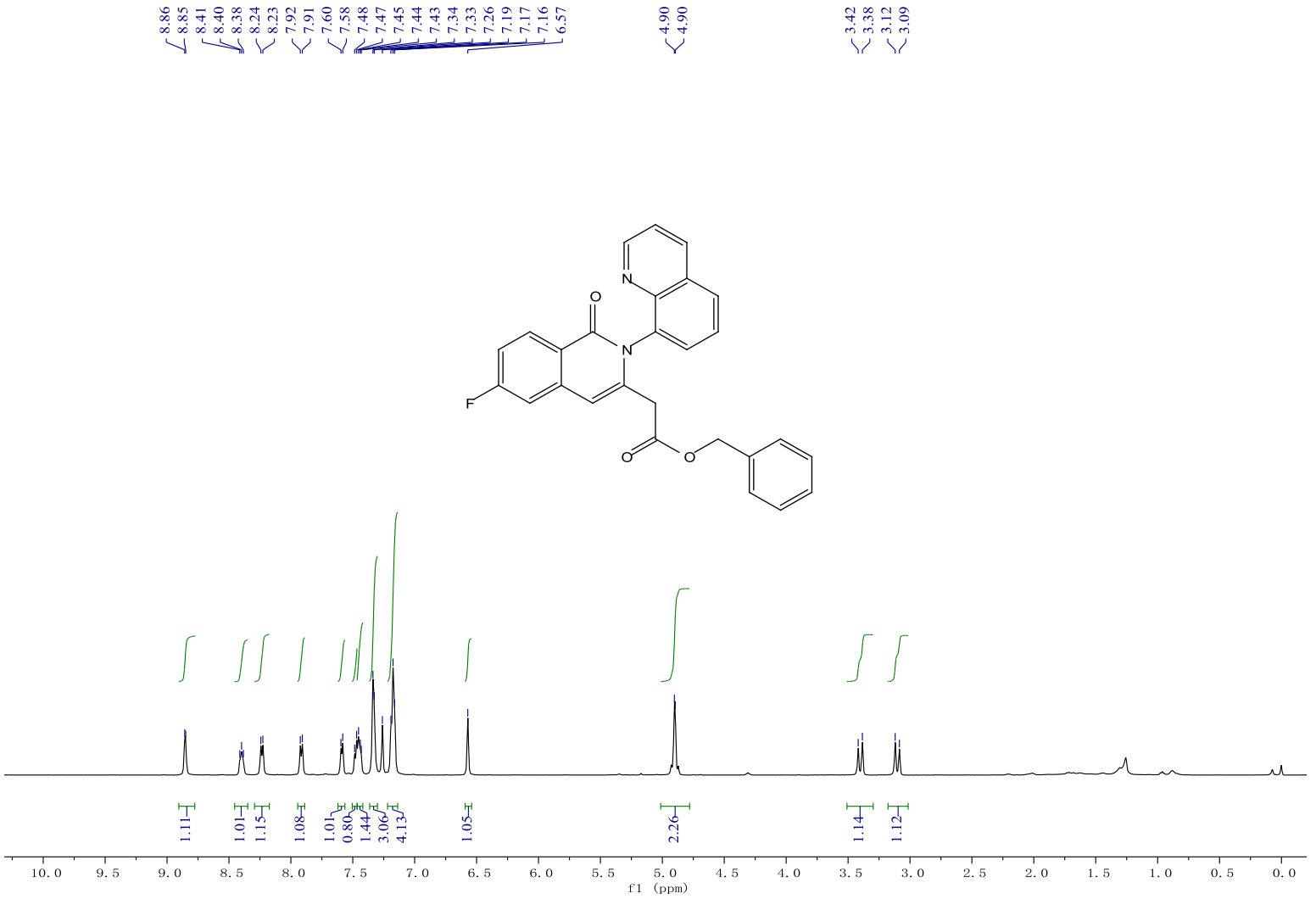
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3.38
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O
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1.15
1.08
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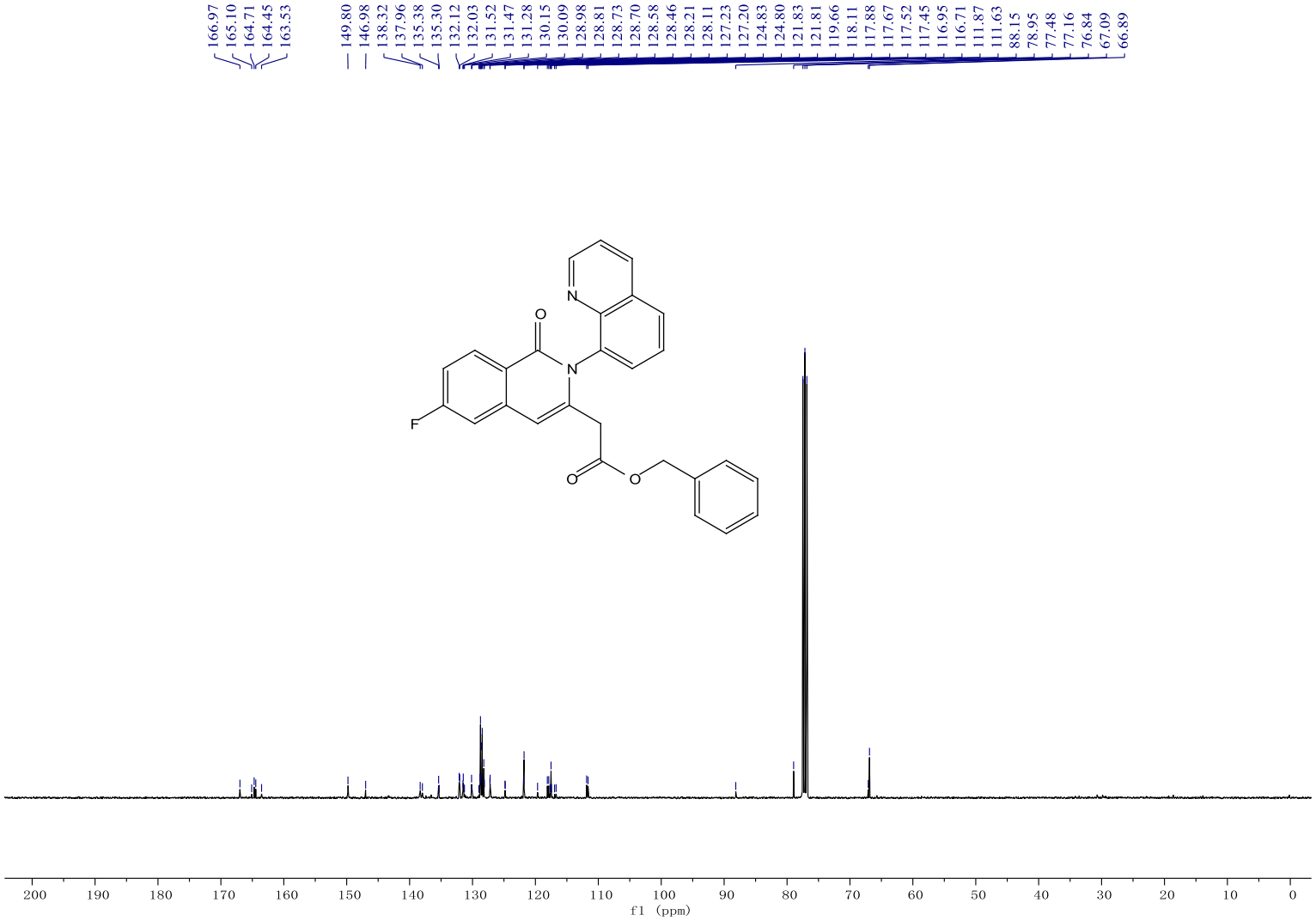
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111.63
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76.84
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N
F
O
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180
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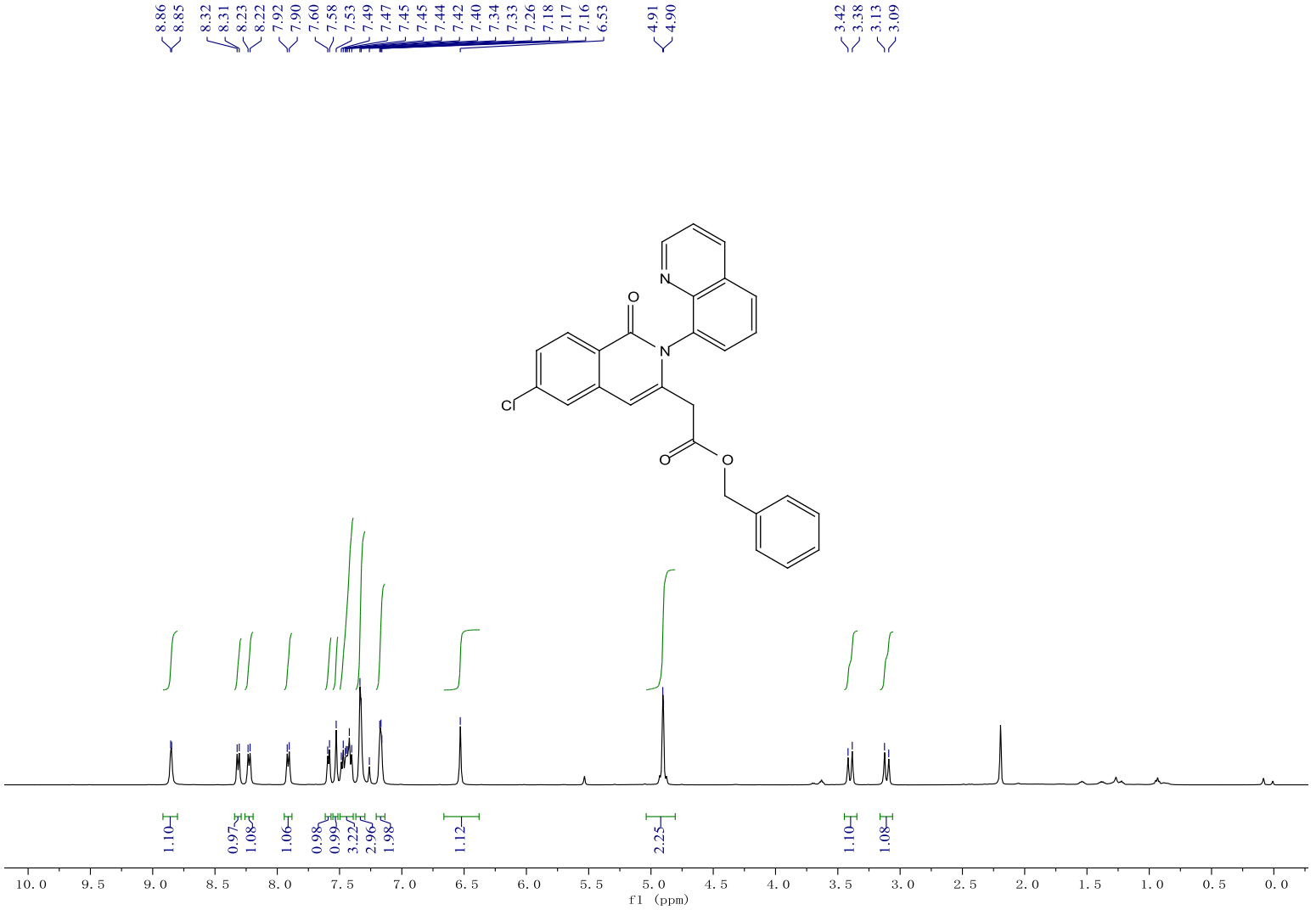
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3.38
3.13
3.09
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O
N
Cl
O
O
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1.08
1.06
0.98
0.99
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1.12
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1.08
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6.5
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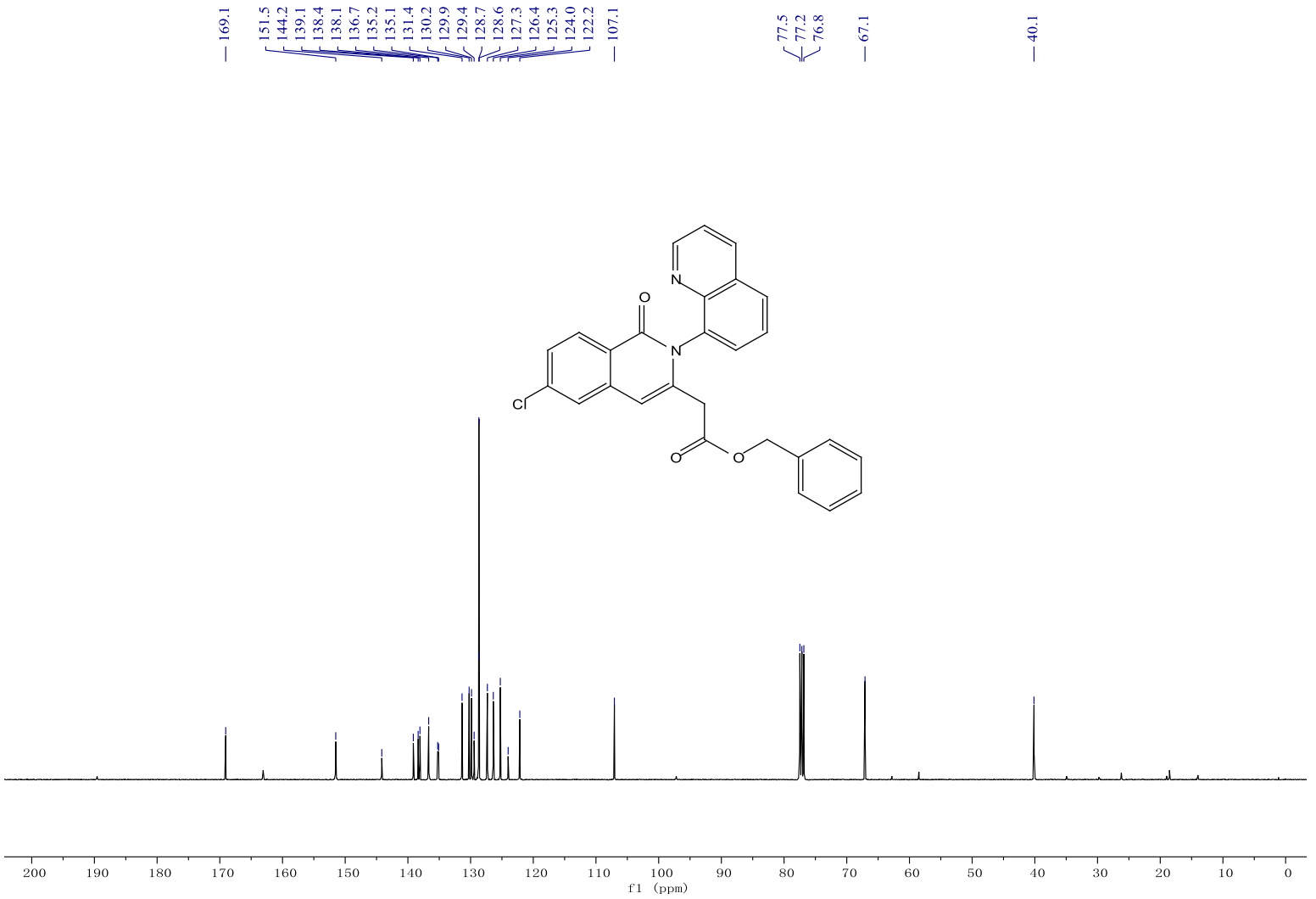
0.0
f1 (ppm)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128.6
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122.2
107.1
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77.2
76.8
67.1
40.1
N
O
N
Cl
O
O
200
190
180
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50
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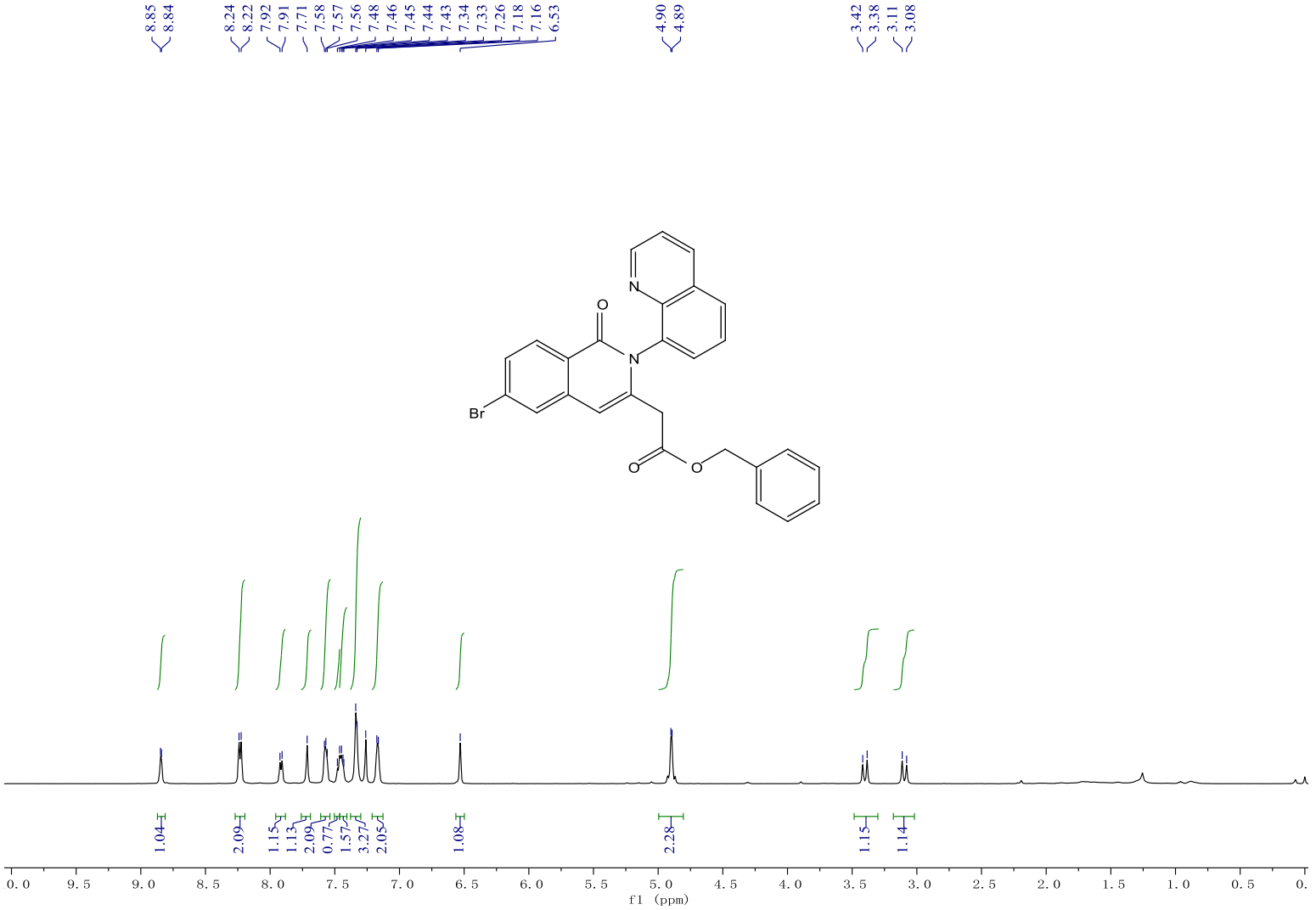
f1 (ppm)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7.44
7.43
7.34
7.33
7.26
7.18
7.16
6.53
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3.42
3.38
3.11
3.08
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N
Br
O
O
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2.09
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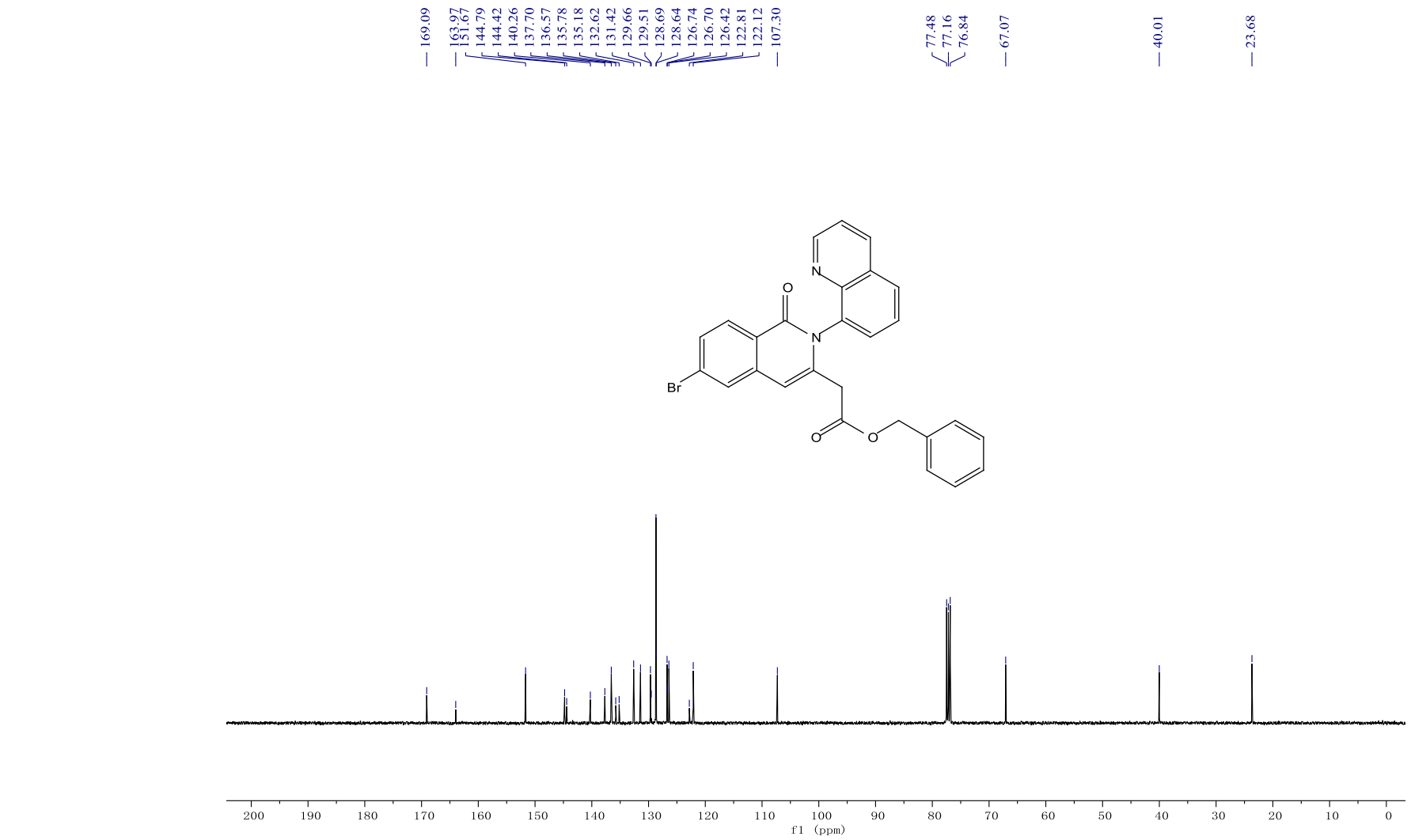
1.08
2.28
1.15
1.14
f1 (ppm)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132.62
131.42
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126.70
126.42
122.81
122.12
107.30
77.48
77.16
76.84
67.07
40.01
23.68
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N
Br
O
O
200
190
180
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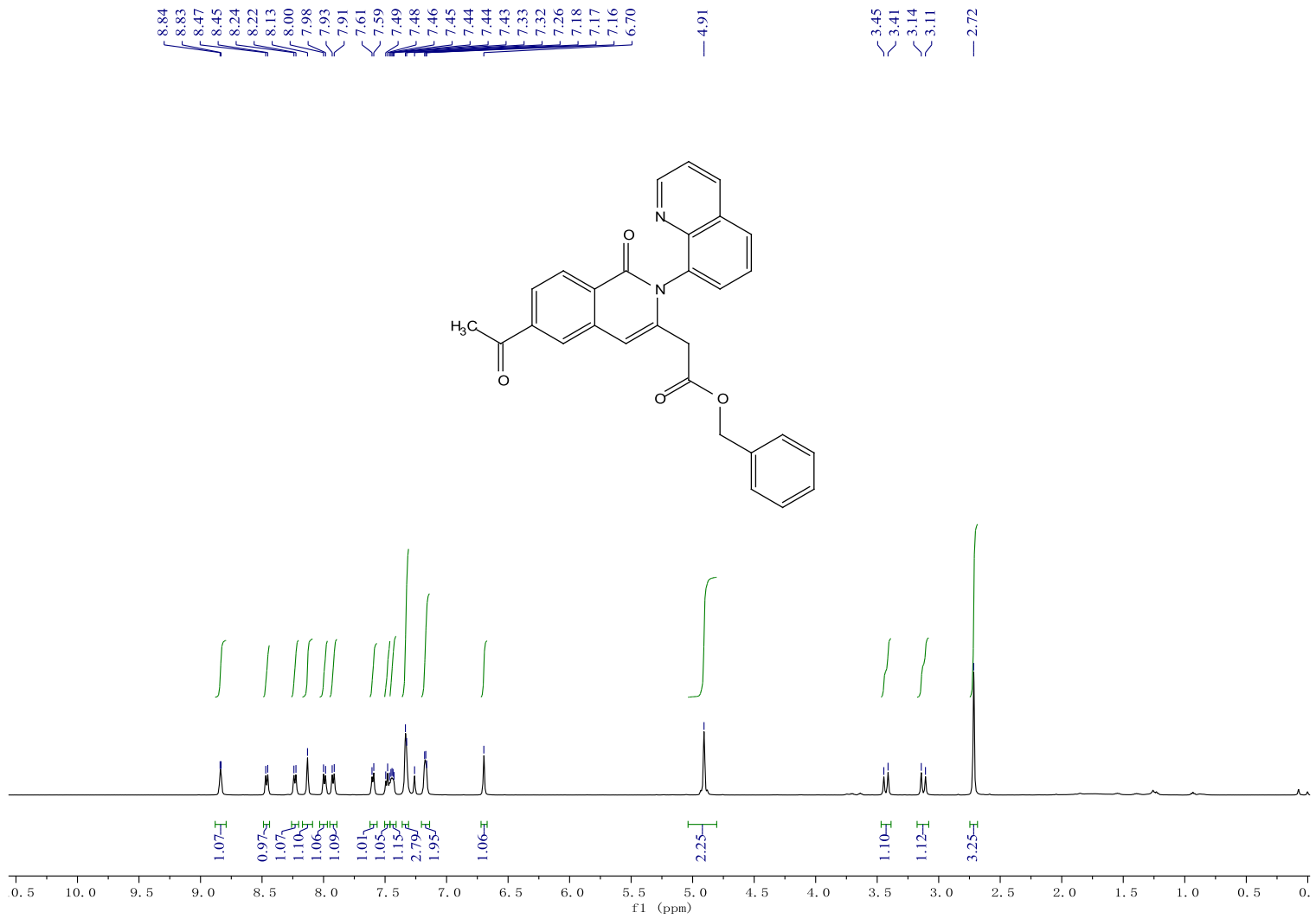
f1 (ppm)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7.48
7.46
7.45
7.44
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7.43
7.33
7.32
7.26
7.18
7.17
7.16
6.70
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3.45
3.41
3.14
3.11
2.72
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N
H3C
O
O
O
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1.07
1.10
1.06
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1.06
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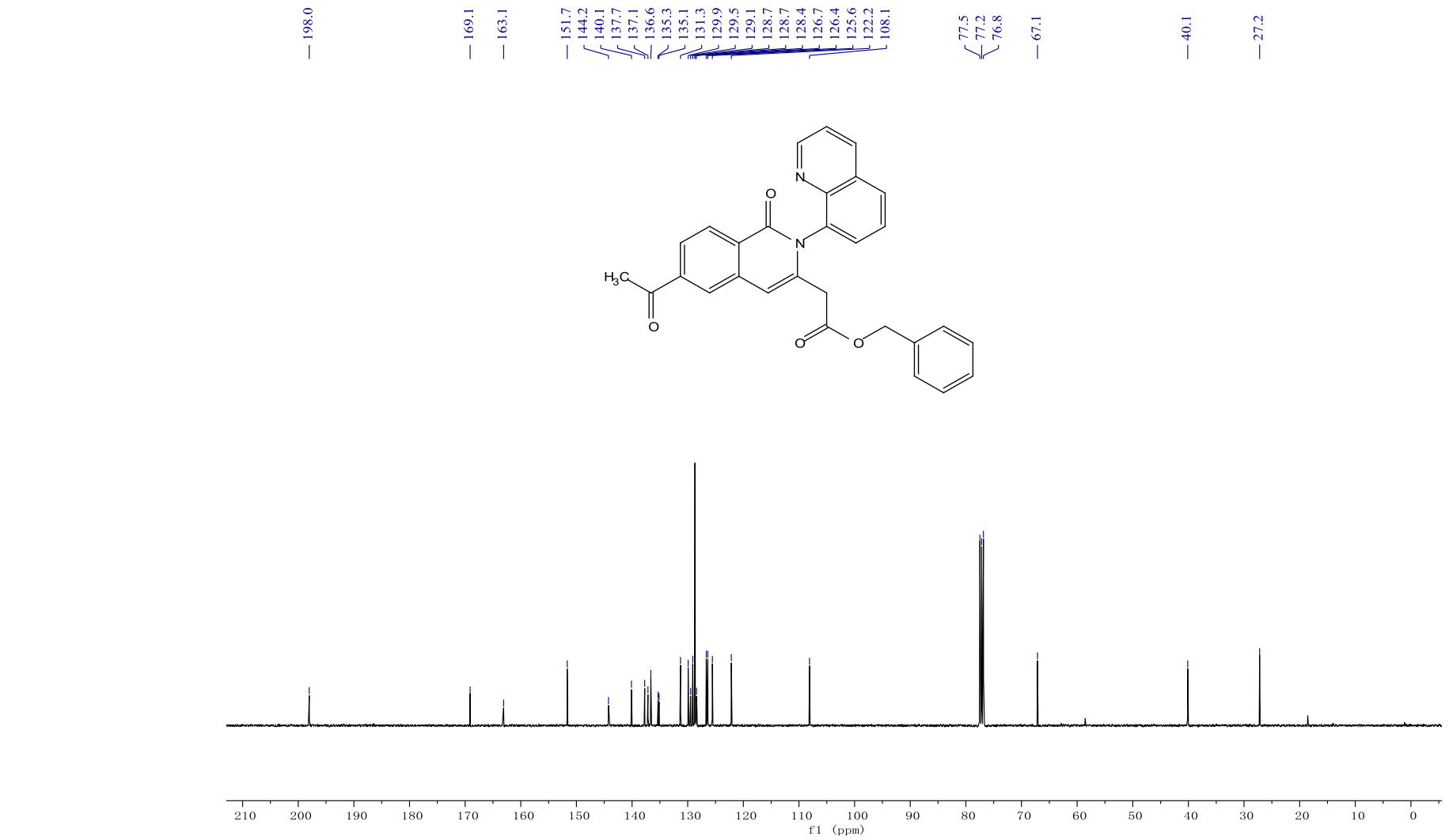
1.10
1.12
3.25
f1 (ppm)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128.4
126.7
126.4
125.6
122.2
108.1
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77.2
76.8
67.1
40.1
27.2
N
O
N
H3C
O
O
O
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200
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180
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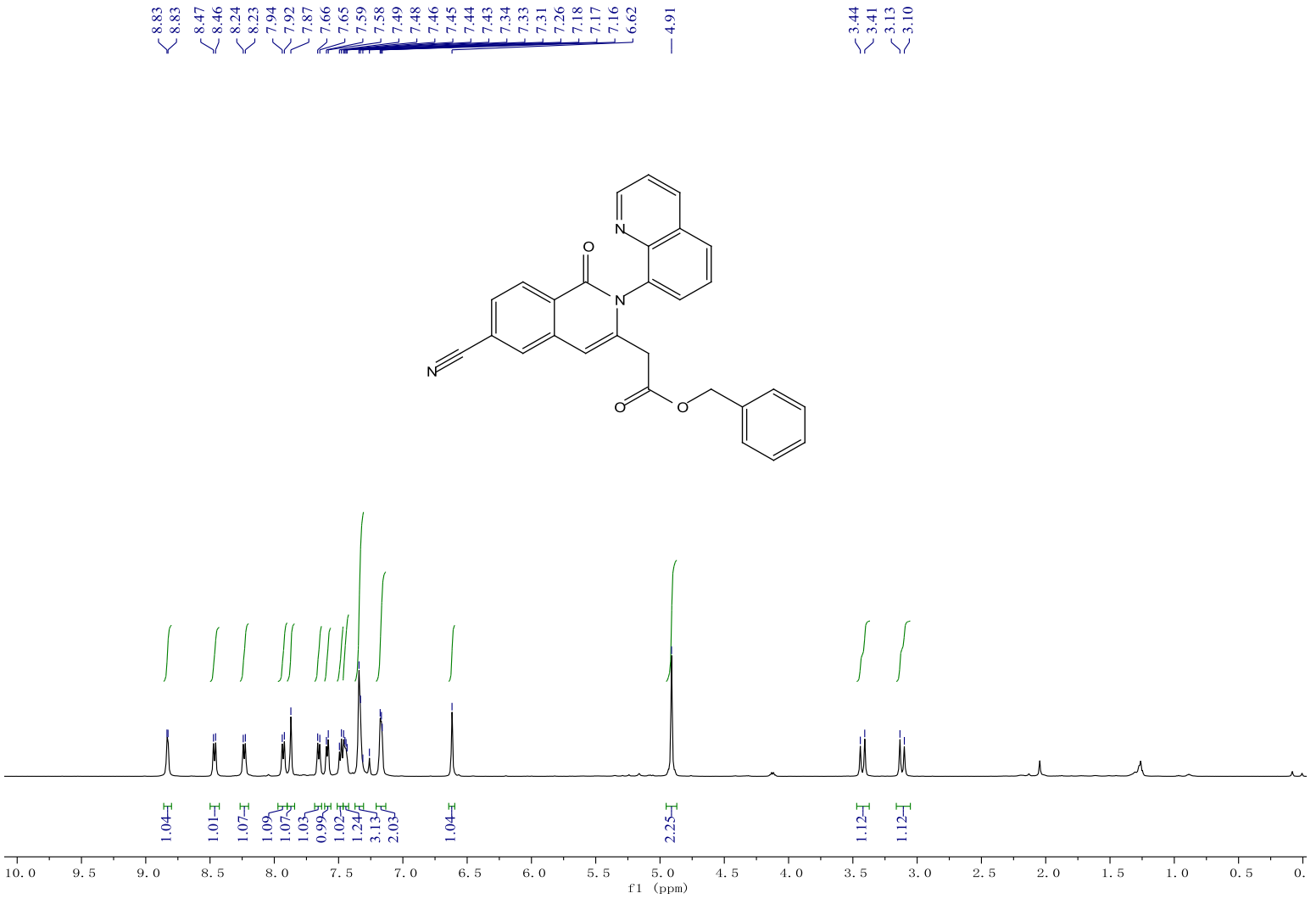
f1 (ppm)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7.33
7.31
7.26
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3.41
3.13
3.10
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N
N
O
O
N
1.04
1.01
1.07
1.09
1.07
1.03
0.99
1.02
1.24
3.13
2.03
1.04
2.25
1.12
1.12
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8.0
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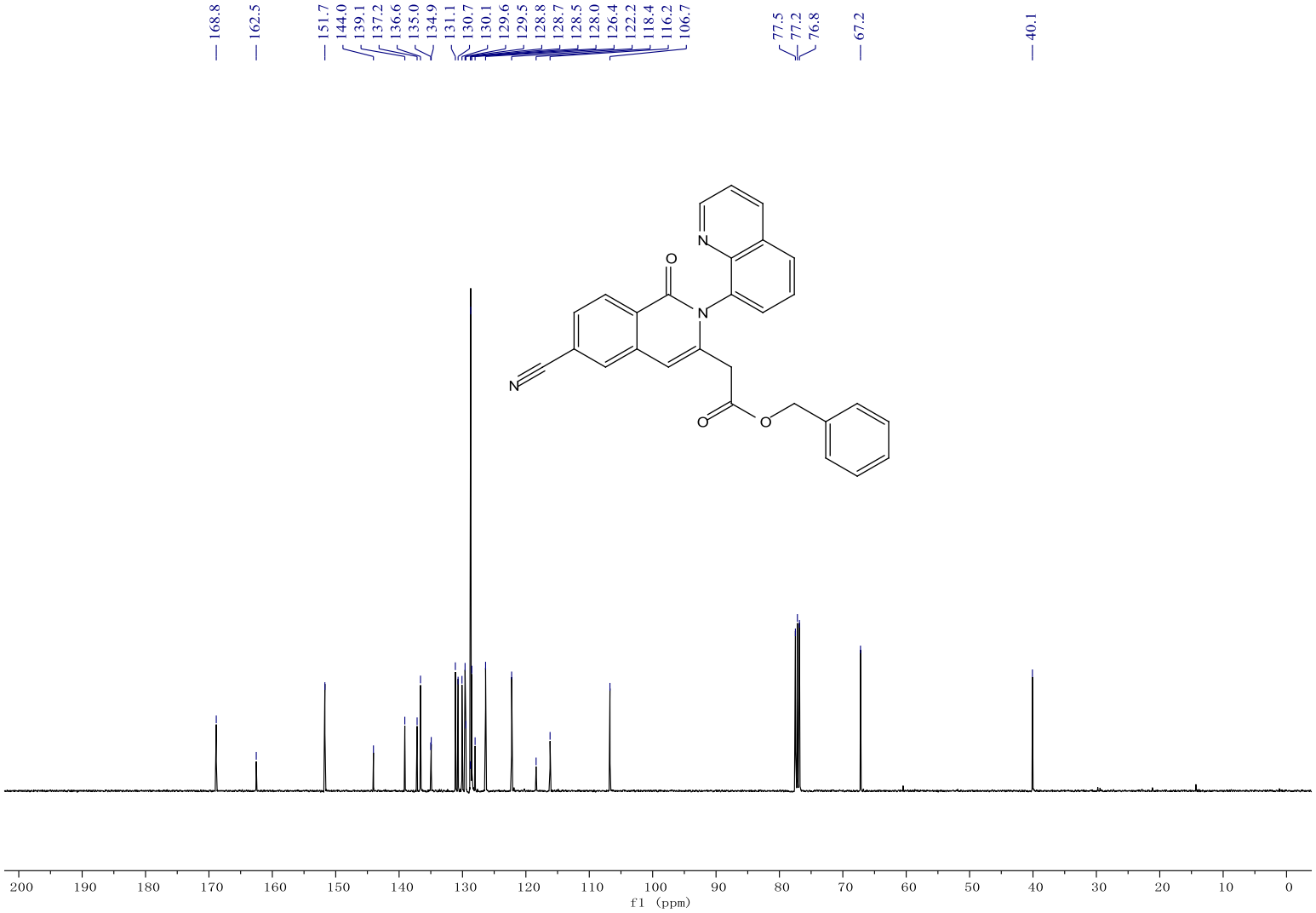
0.
f1 (ppm)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106.7
77.5
77.2
76.8
67.2
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O
N
N
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200
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180
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110
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50
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10
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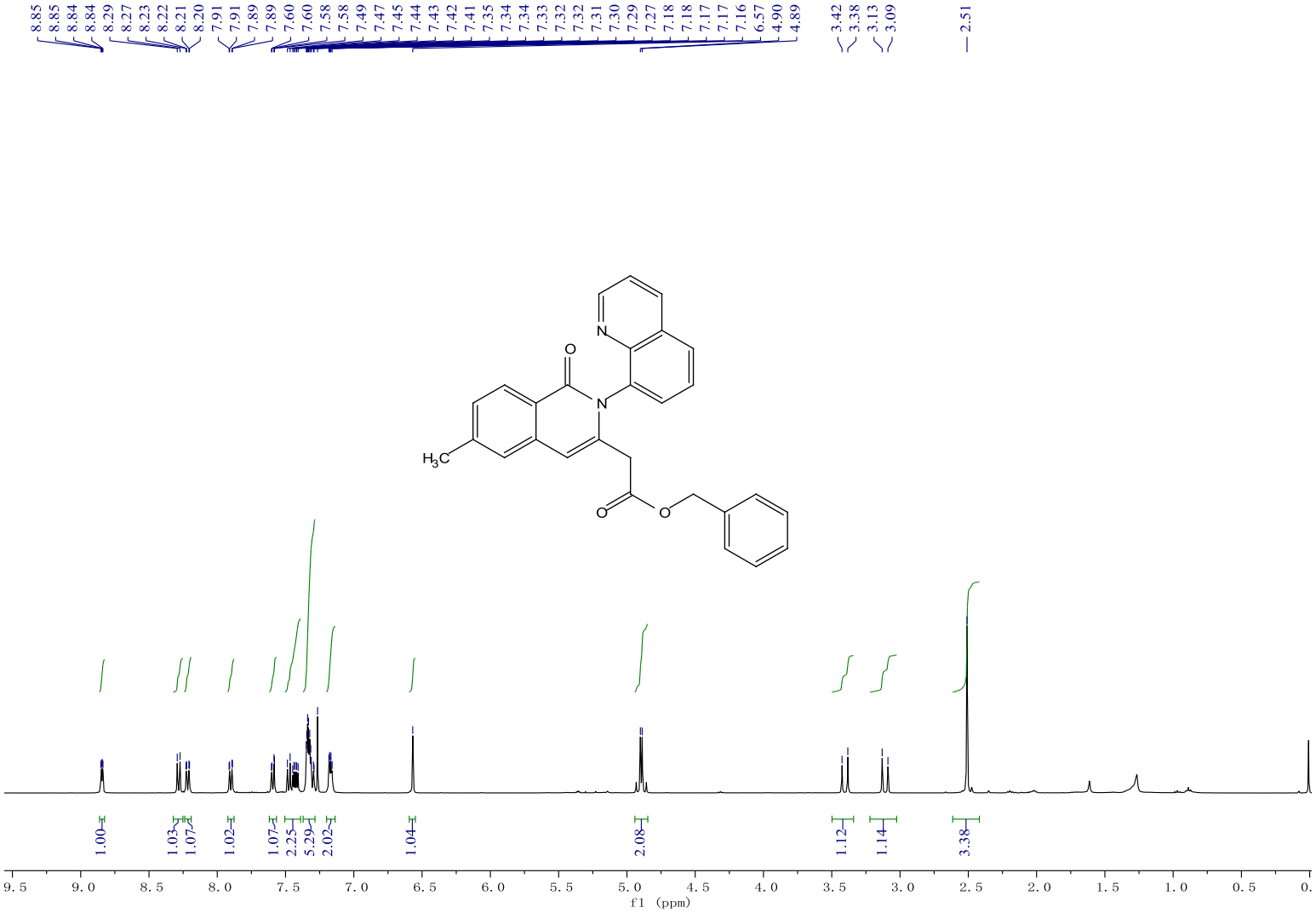
f1 (ppm)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7.27
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7.18
7.17
7.17
7.16
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4.89
3.42
3.38
3.13
3.09
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N
O
N
H3C
O
O
1.00
1.03
1.07
1.02
1.07
2.25
5.29
2.02
1.04
2.08
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1.14
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8.0
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7.0
6.5
6.0
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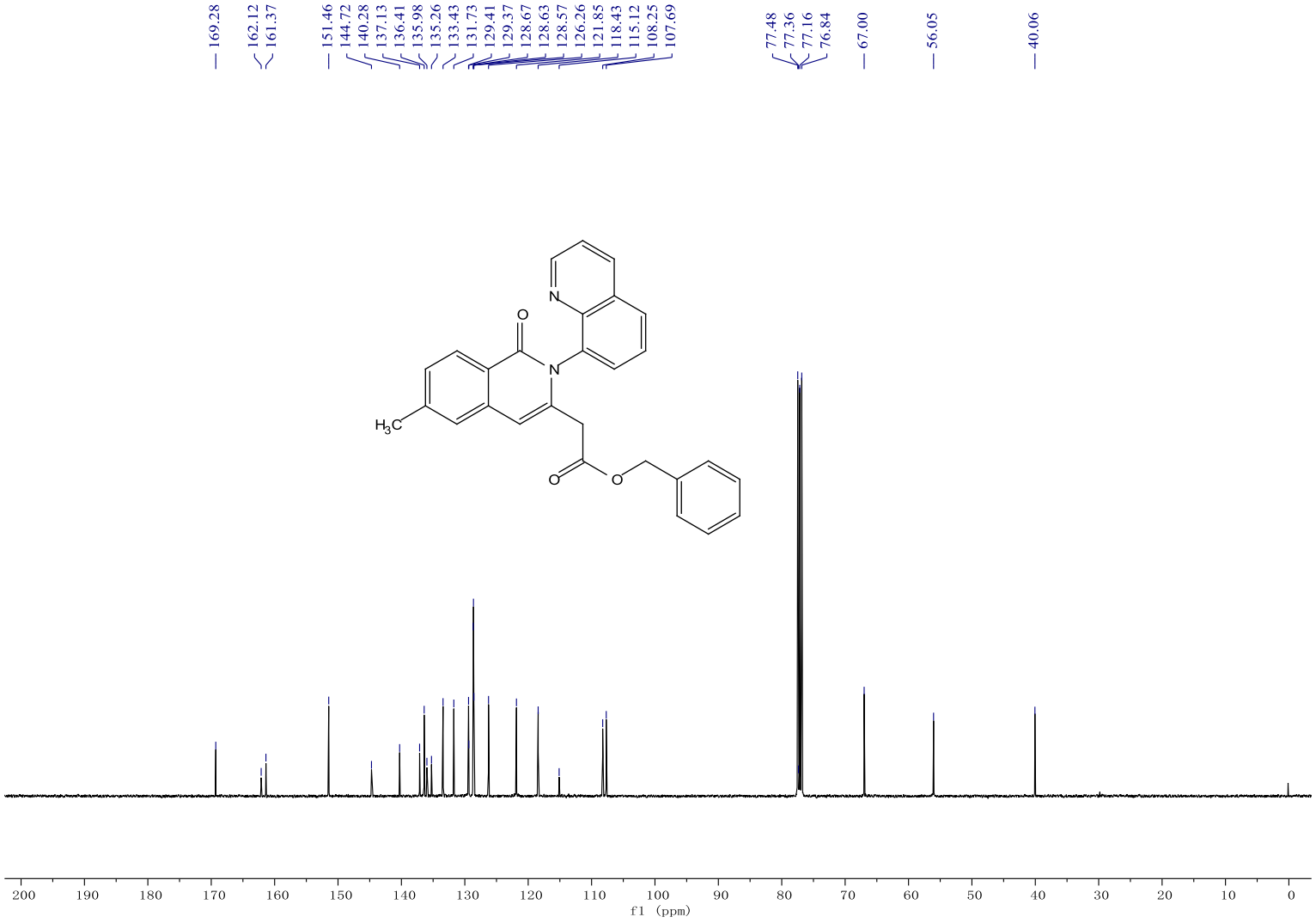
f1 (ppm)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128.57
126.26
121.85
118.43
115.12
108.25
107.69
77.48
77.36
77.16
76.84
67.00
56.05
40.06
N
O
N
H3C
O
O
200
190
180
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110
100
90
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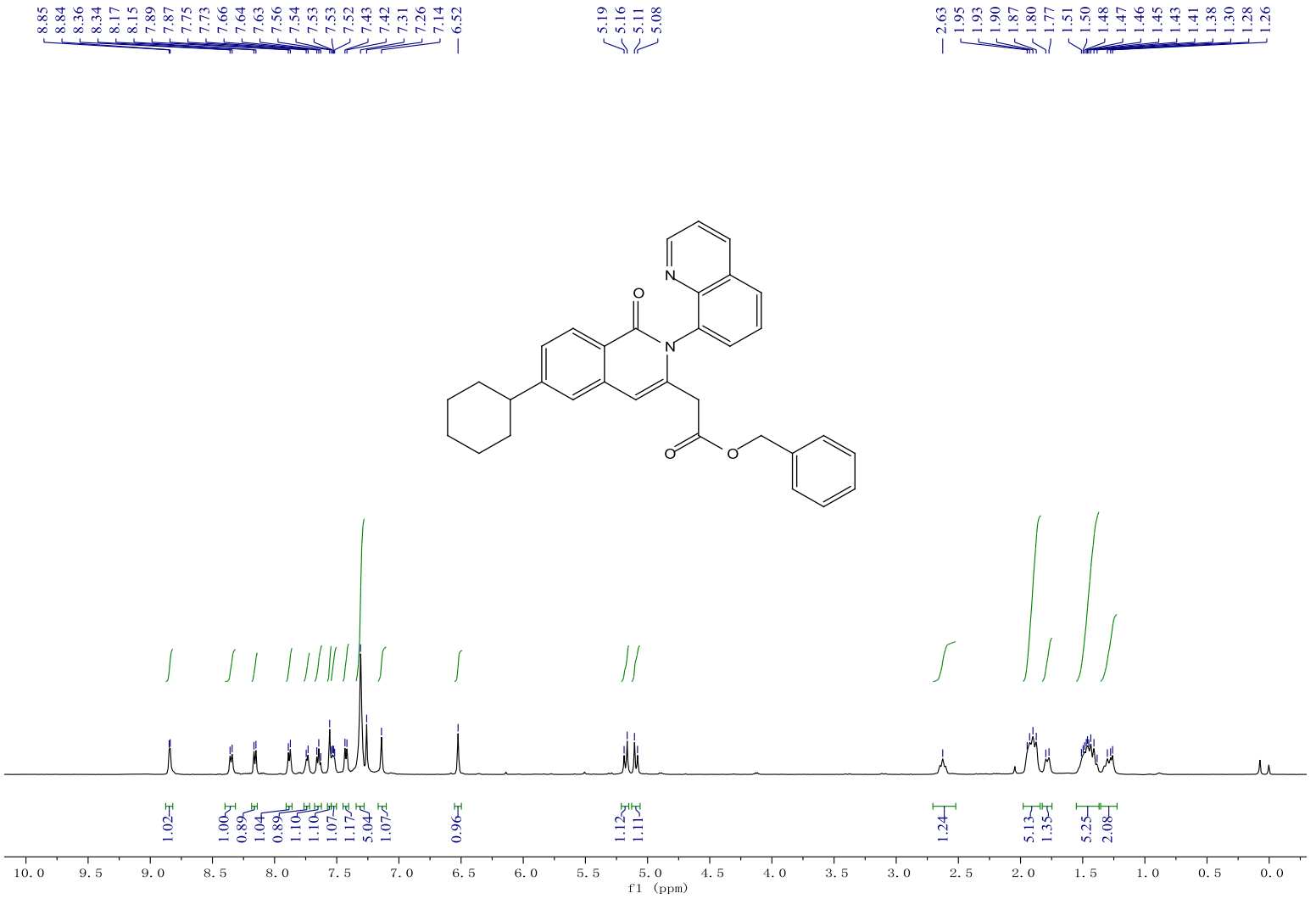
f1 (ppm)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1.48
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O
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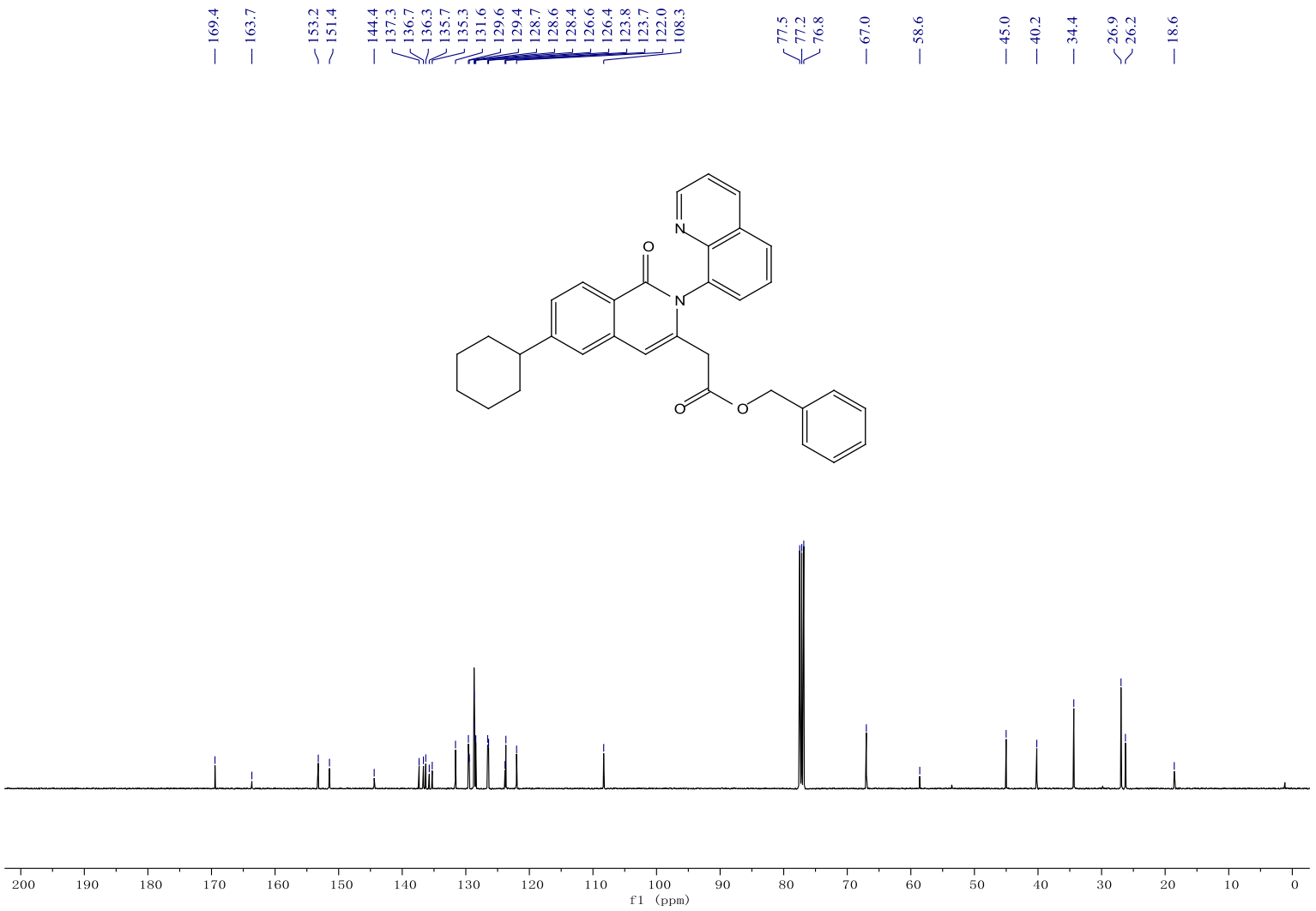
f1 (ppm)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76.8
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26.2
18.6
N
O
N
O
O
200
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180
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70
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50
40
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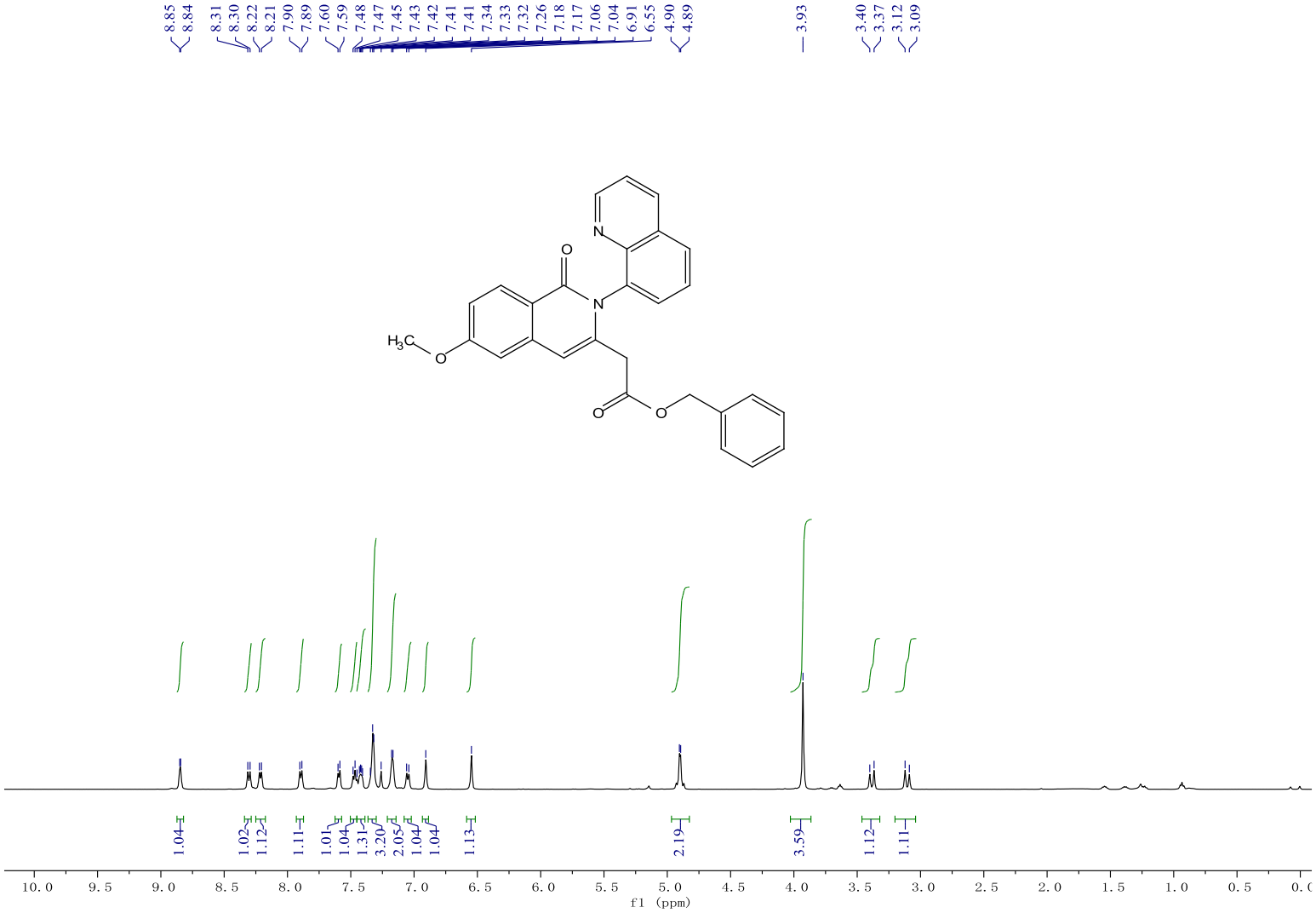
f1 (ppm)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7.41
7.41
7.34
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7.26
7.18
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6.91
6.55
4.90
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3.37
3.12
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H3C
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O
1.04
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1.5
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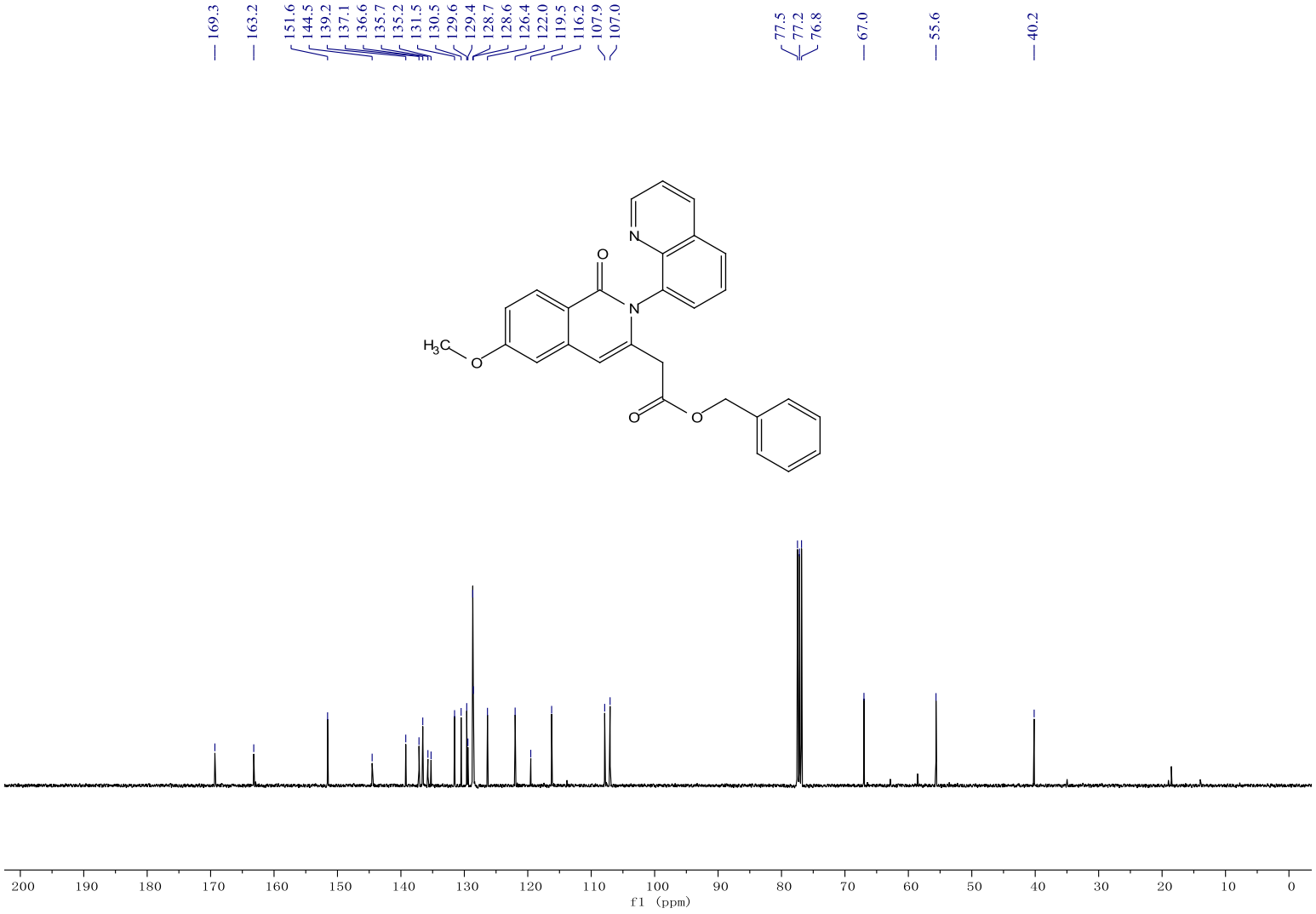
0.5
f1 (ppm)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107.0
77.5
77.2
76.8
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40.2
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N
H3C
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200
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180
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110
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90
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50
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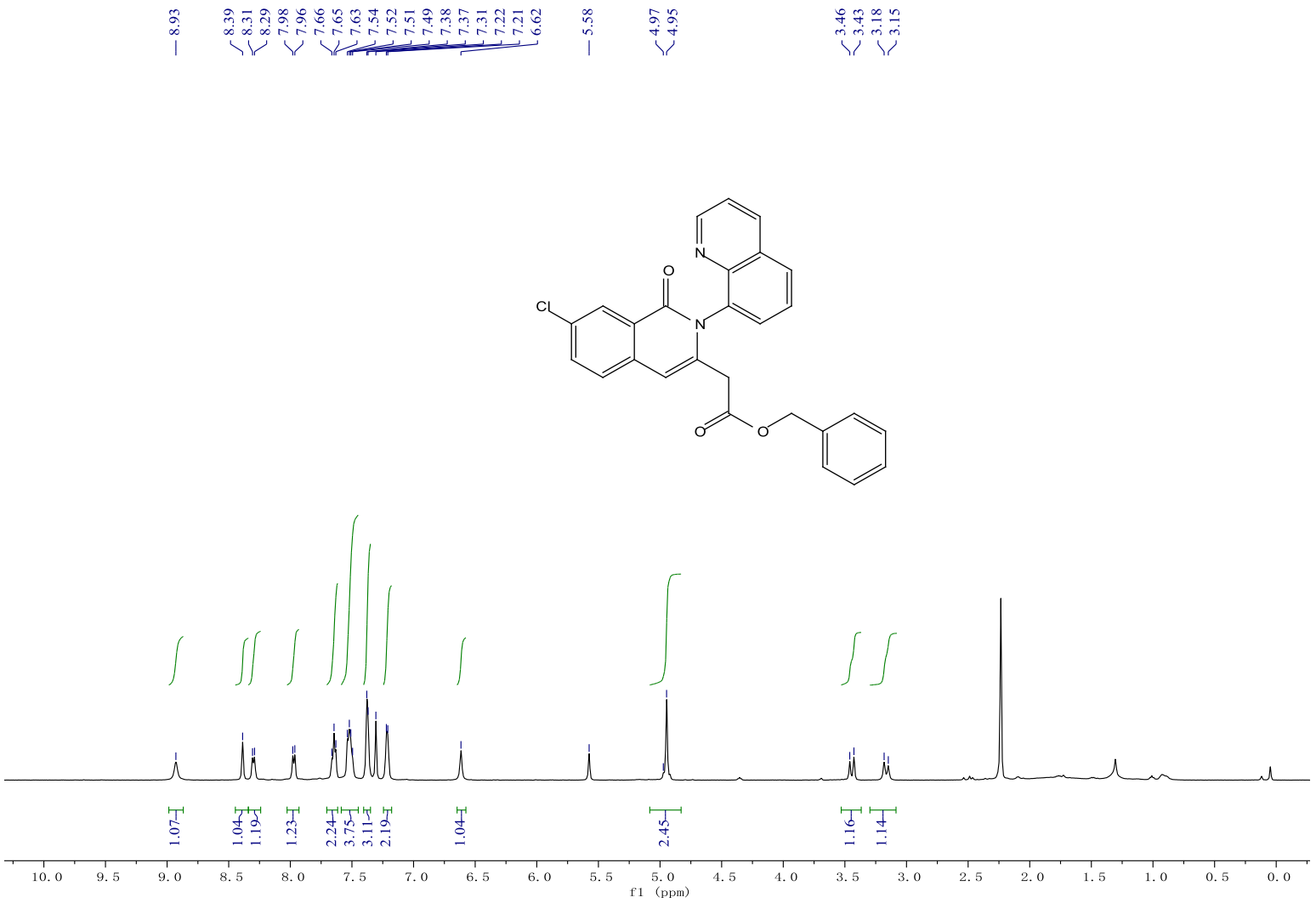
0
f1 (ppm)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3.18
3.15
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1.04
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7.5
7.0
6.5
6.0
5.5
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2.0
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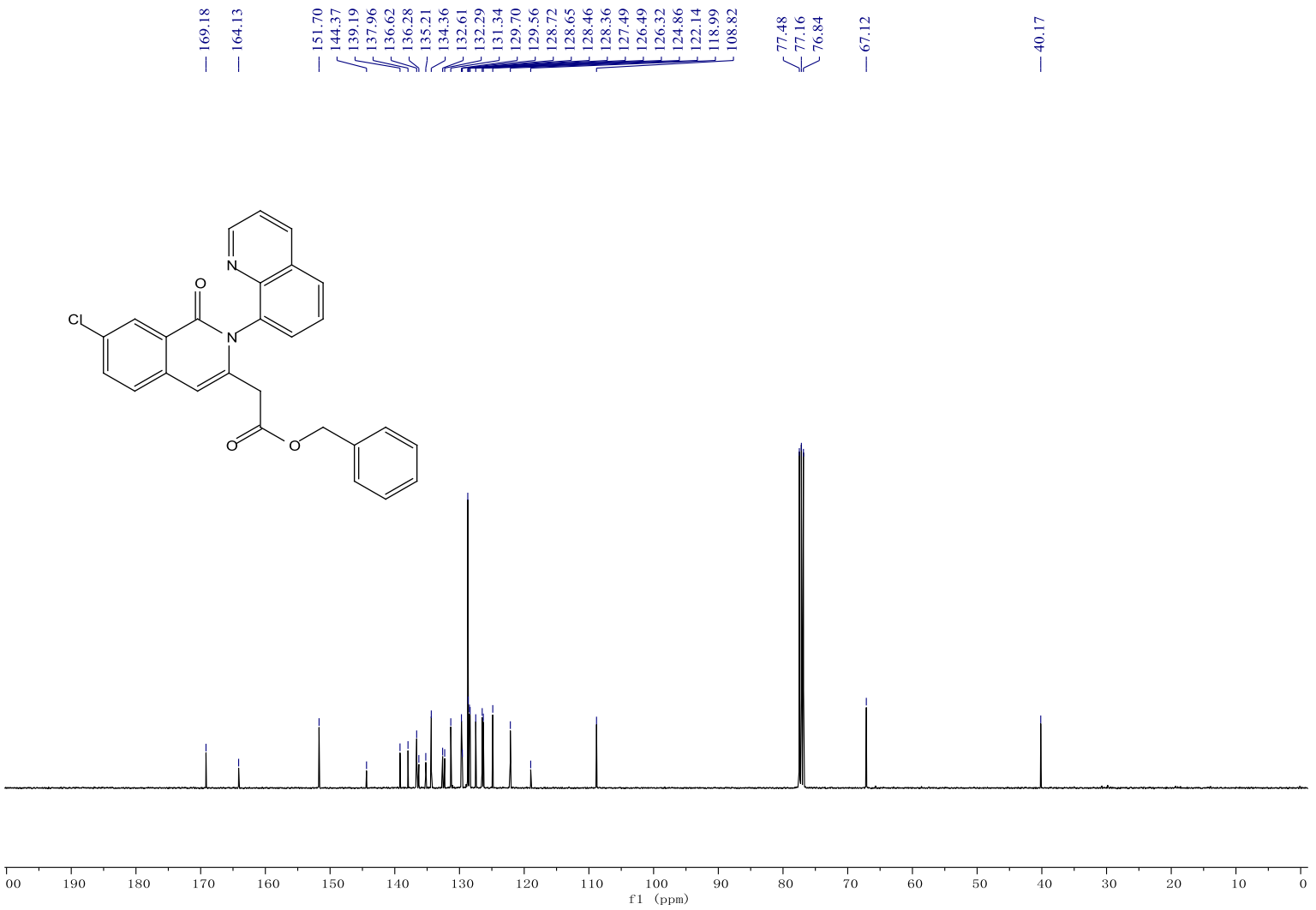
f1 (ppm)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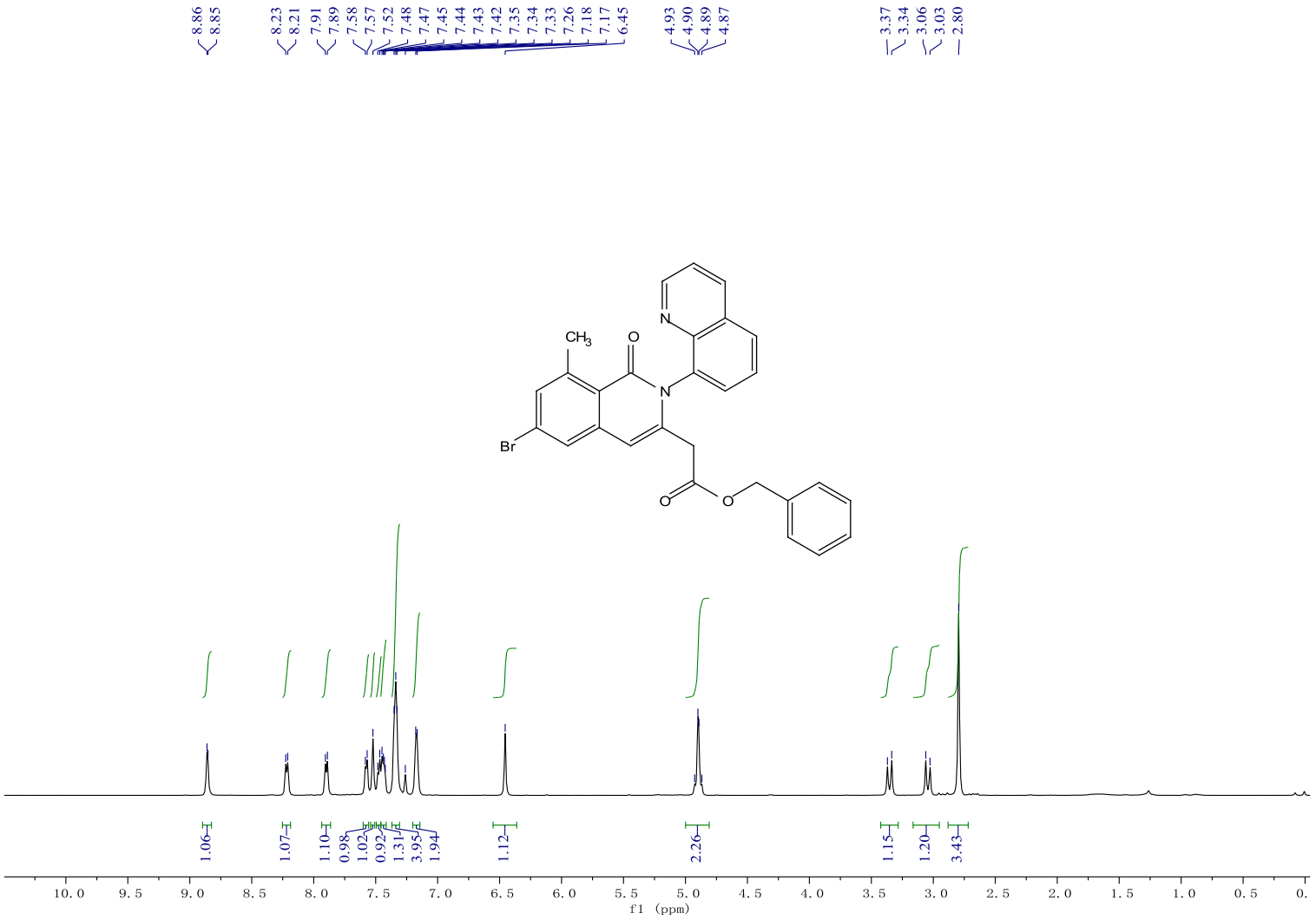
O
f1 (ppm)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7.18
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CH3
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3.95
1.94
1.12
2.26
1.15
1.20
3.43
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9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
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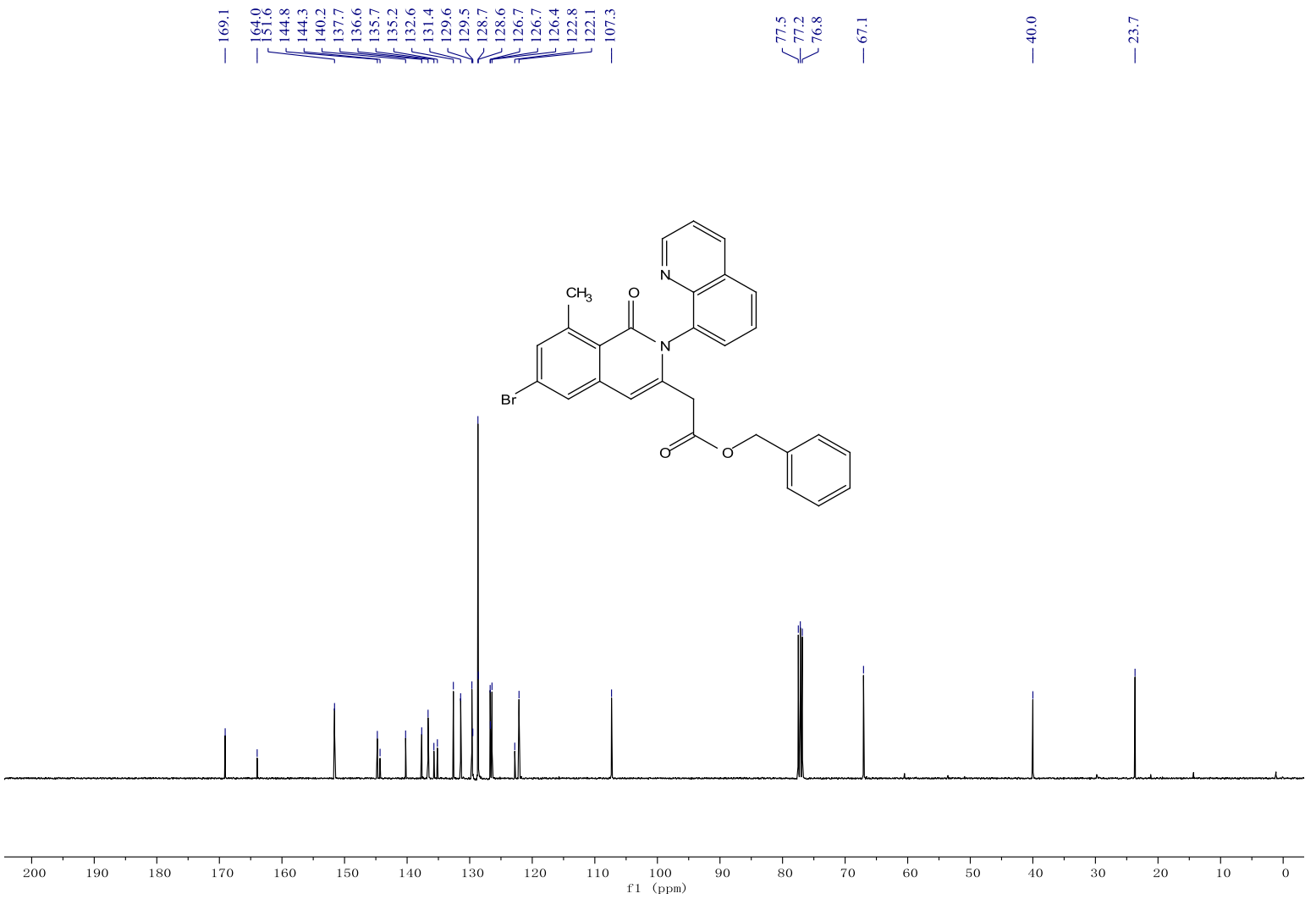
f1 (ppm)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135.2
132.6
131.4
129.6
129.5
128.7
128.6
126.7
126.4
122.8
122.1
107.3
77.5
77.2
76.8
67.1
40.0
23.7
CH3
O
N
N
Br
O
O
200
190
180
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130
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110
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90
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50
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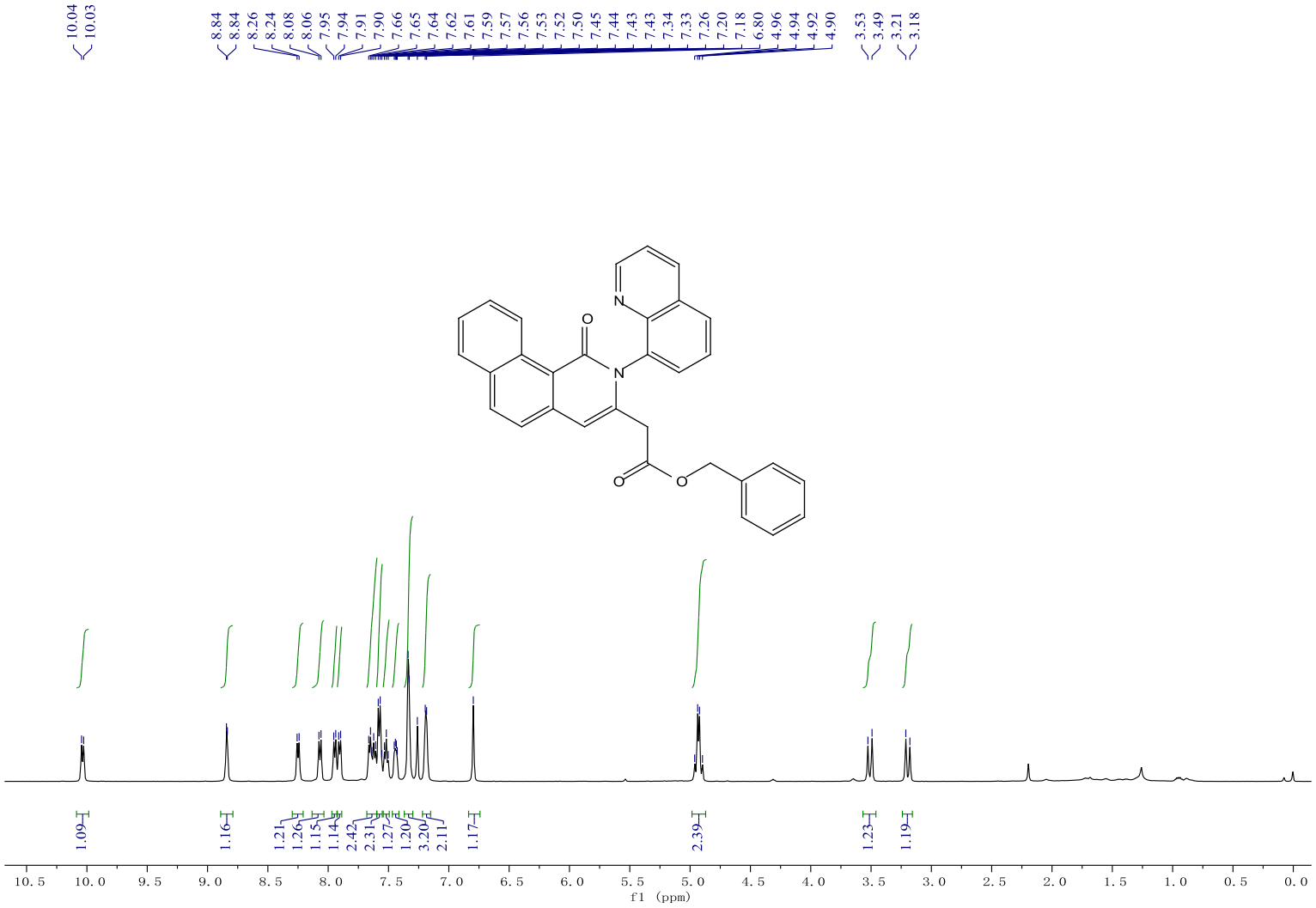
0
f1 (ppm)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7.94
7.91
7.90
7.66
7.65
7.64
7.62
7.61
7.59
7.57
7.56
7.53
7.52
7.50
7.45
7.44
7.43
7.43
7.34
7.33
7.26
7.20
7.18
6.80
4.96
4.94
4.92
4.90
3.53
3.49
3.21
3.18
N
O
N
O
O
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1.16
1.21
1.26
1.15
1.14
2.42
2.31
1.27
1.20
3.20
2.11
1.17
2.39
1.23
1.19
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8.5
8.0
7.5
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6.5
6.0
5.5
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2.5
2.0
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1.0
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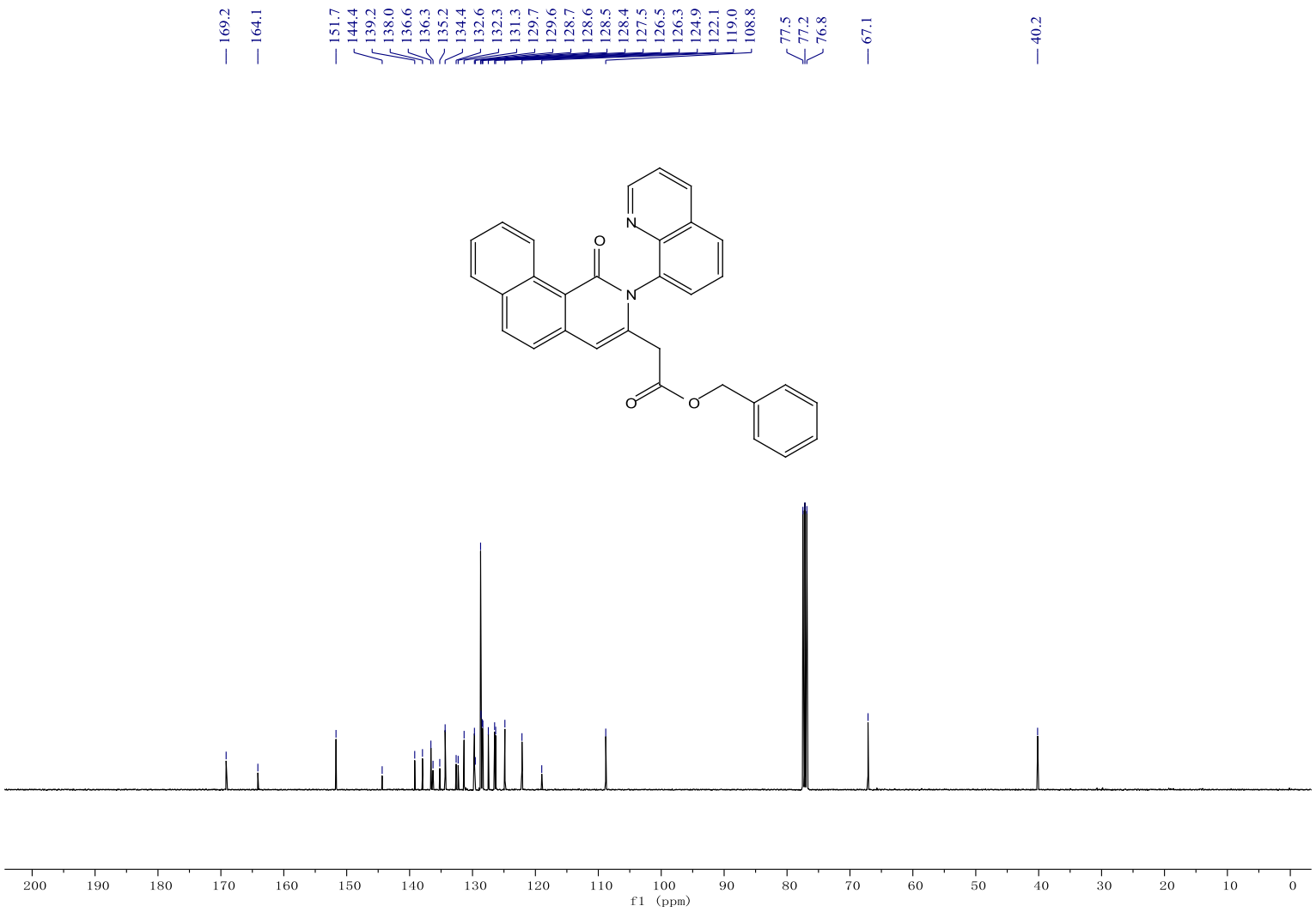
0.0
f1 (ppm)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134.4
132.6
132.3
131.3
129.7
129.6
128.7
128.6
128.5
128.4
127.5
126.5
126.3
124.9
122.1
119.0
108.8
77.5
77.2
76.8
67.1
40.2
O
N
N
O
O
200
190
180
170
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150
140
130
120
110
100
90
80
70
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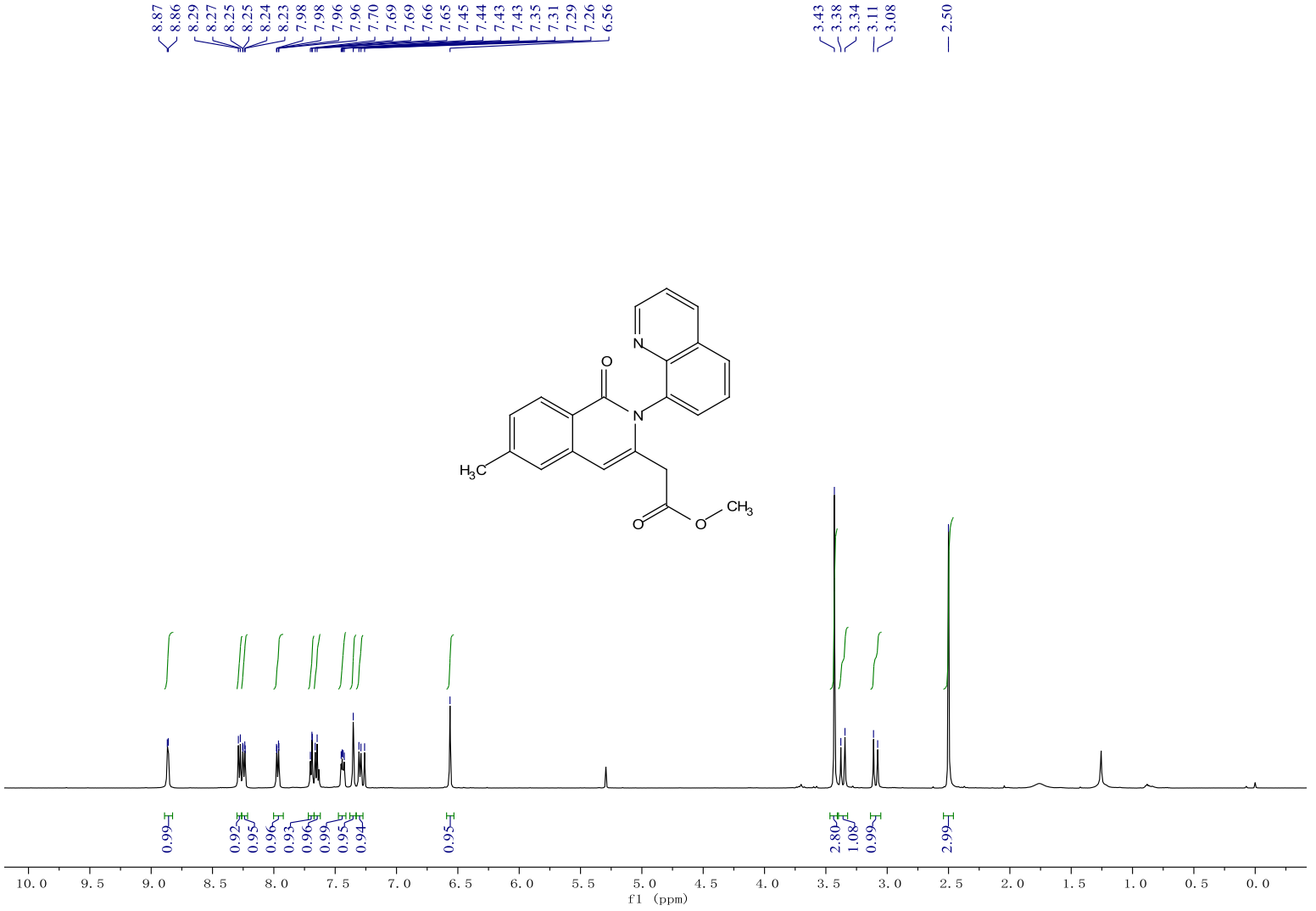
50
40
30
20
10
0
f1 (ppm)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8.86
8.29
8.27
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8.25
8.24
8.23
7.98
7.98
7.96
7.96
7.70
7.69
7.69
7.66
7.65
7.45
7.44
7.43
7.43
7.35
7.31
7.29
7.26
6.56
3.43
3.38
3.34
3.11
3.08
2.50
O
N
N
H3C
O
O
CH3
0.99
0.92
0.95
0.96
0.93
0.96
0.99
0.95
0.94
0.95
2.80
1.08
0.99
2.99
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
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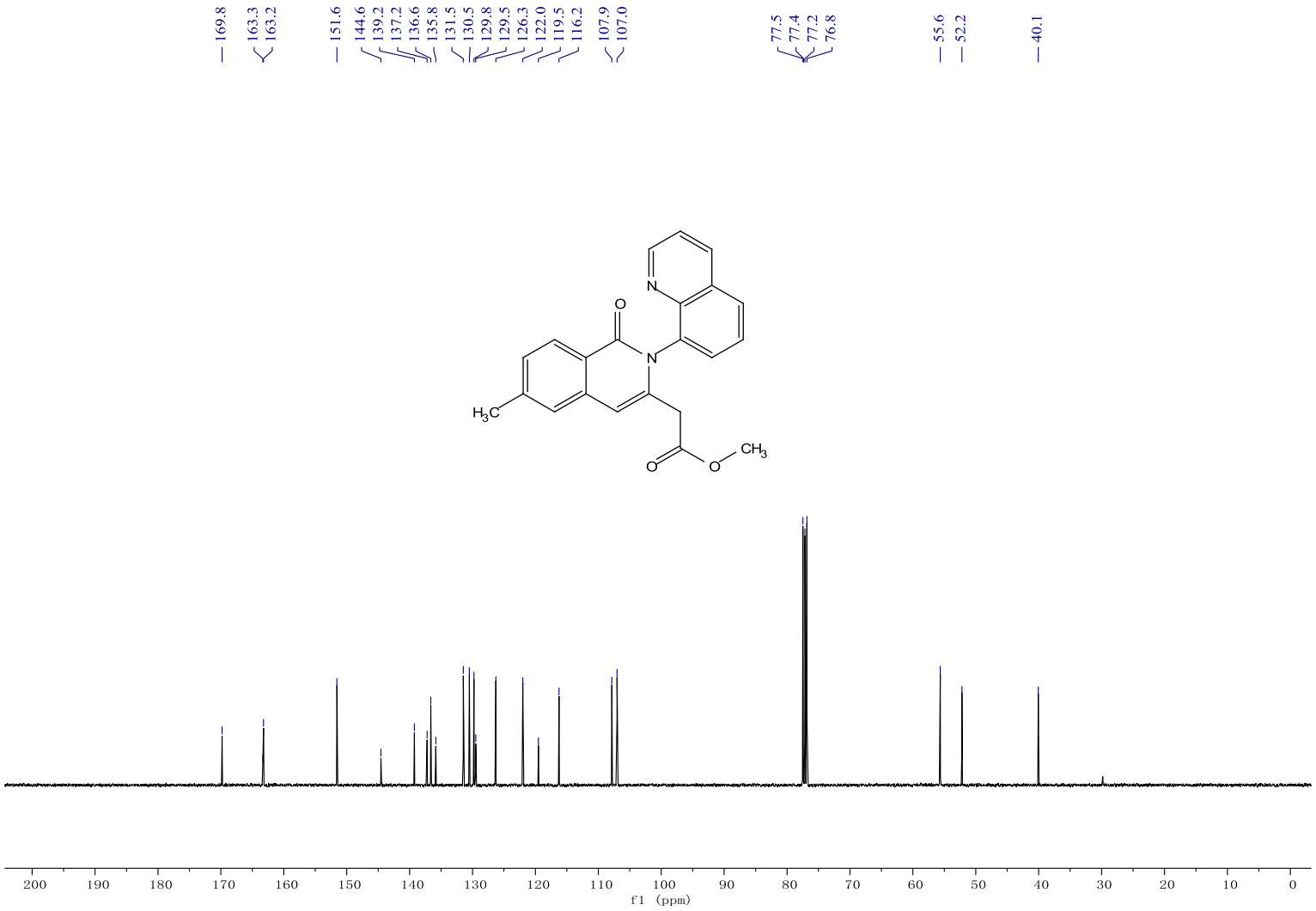
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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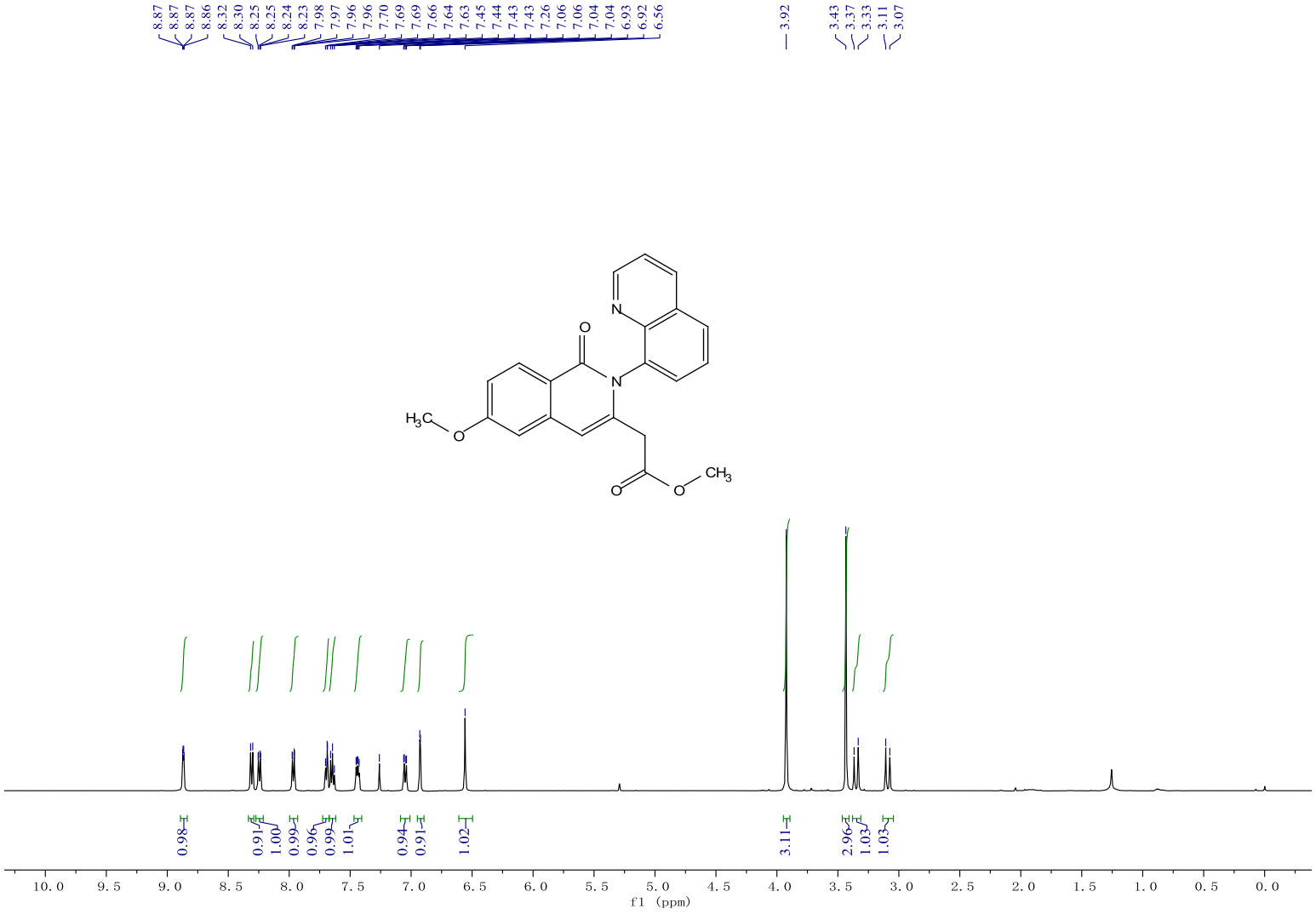
139.2
137.2
136.6
135.8
131.5
130.5
129.8
129.5
126.3
122.0
119.5
116.2
107.9
107.0
77.5
77.4
77.2
76.8
55.6
52.2
40.1
N
O
N
H3C
O
O
CH3
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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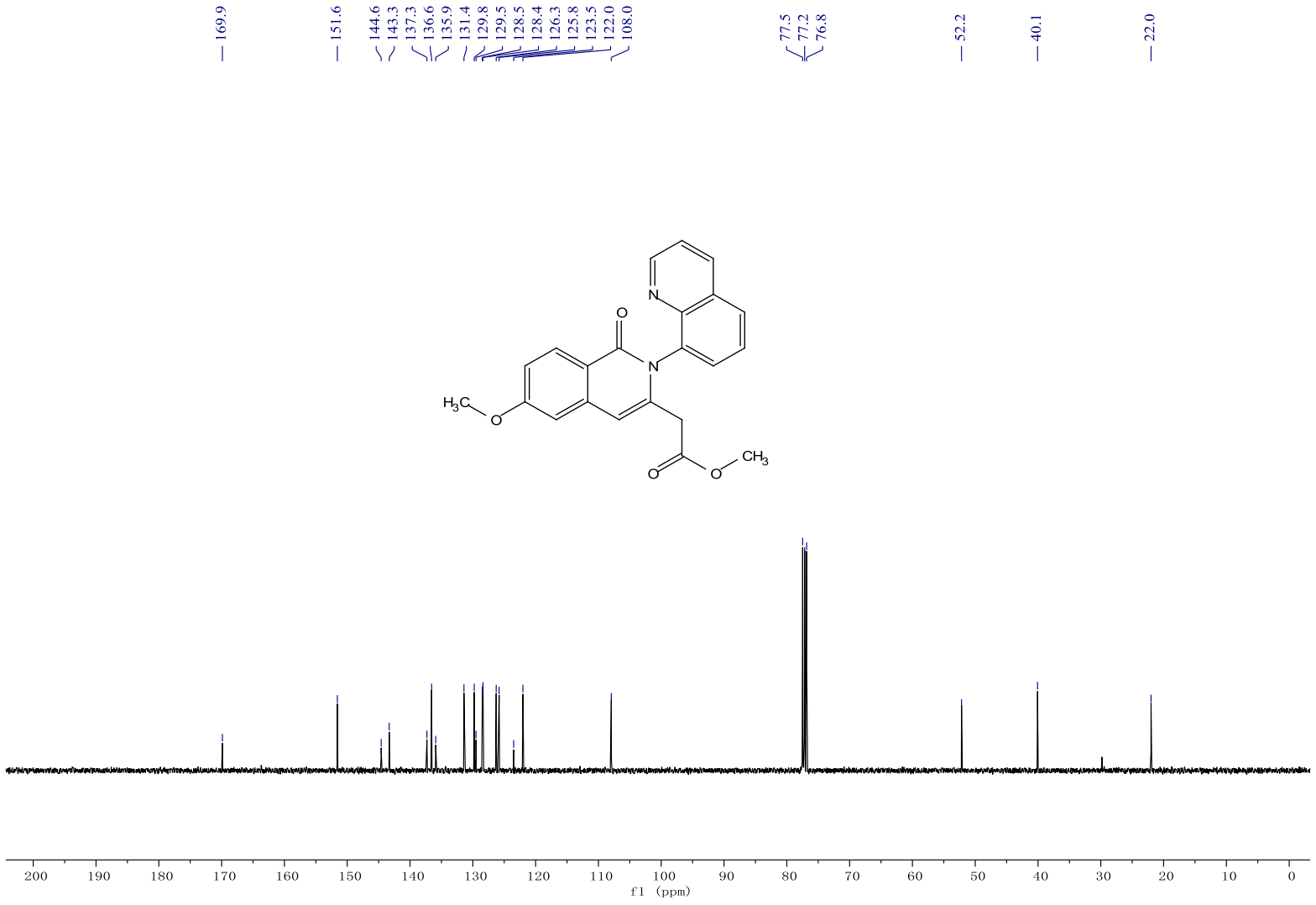
8.87
8.87
8.86
8.32
8.30
8.25
8.25
8.24
8.23
7.98
7.97
7.96
7.96
7.70
7.69
7.69
7.66
7.64
7.63
7.45
7.44
7.43
7.43
7.26
7.06
7.06
7.04
7.04
6.93
6.92
6.56
3.92
3.43
3.37
3.33
3.11
3.07
N
O
N
H3C
O
O
O
CH3
0.98
0.91
1.00
0.99
0.96
0.99
1.01
0.94
0.91
1.02
3.11
2.96
1.03
1.03
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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136.6
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131.4
129.8
129.5
128.5
128.4
126.3
125.8
123.5
122.0
108.0
77.5
77.2
76.8
52.2
40.1
22.0
N
O
N
H3C
O
O
O
CH3
200
190
180
170
160
150
140
130
120
110
100
90
80
70
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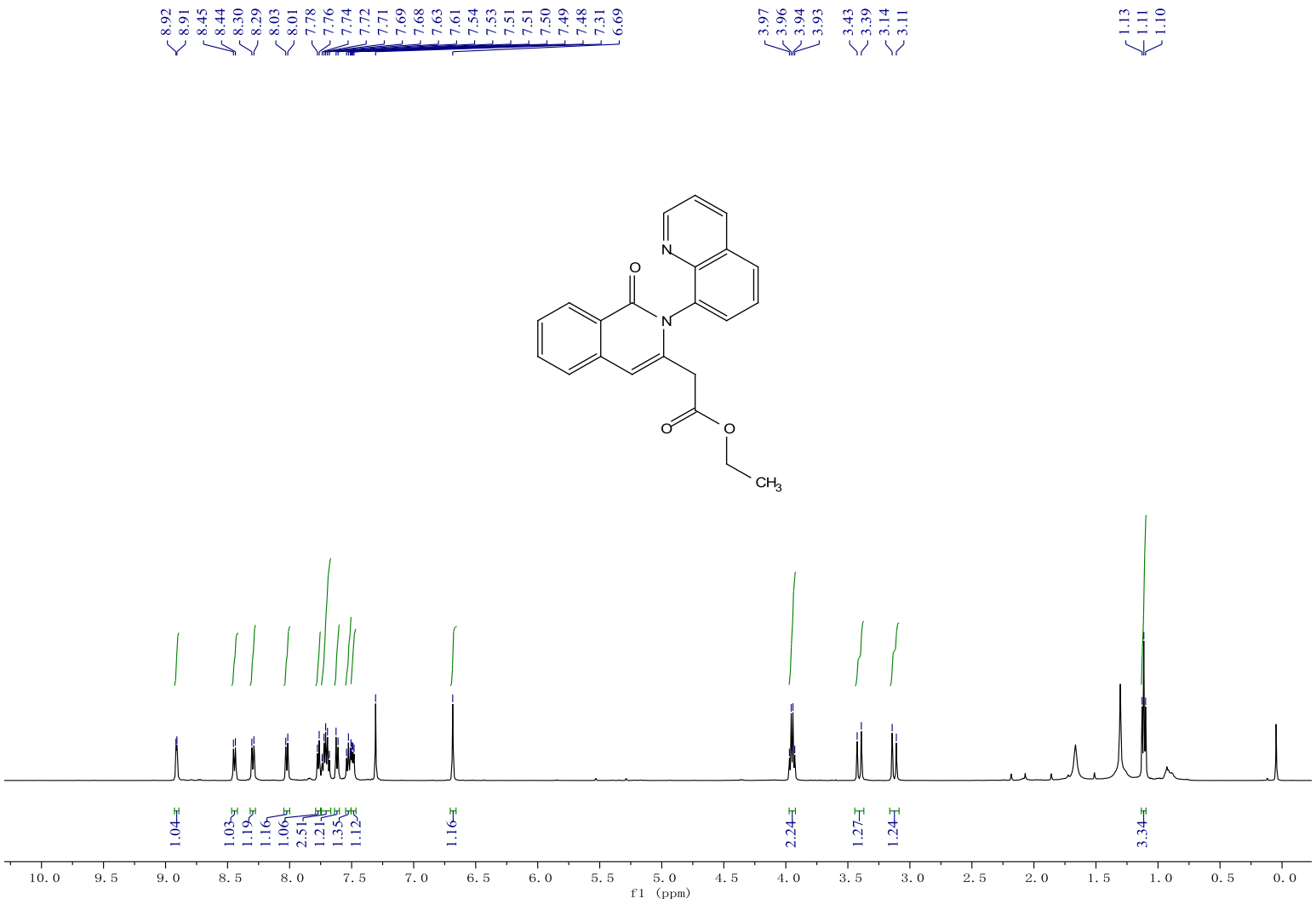
50
40
30
20
10
0
f1 (ppm)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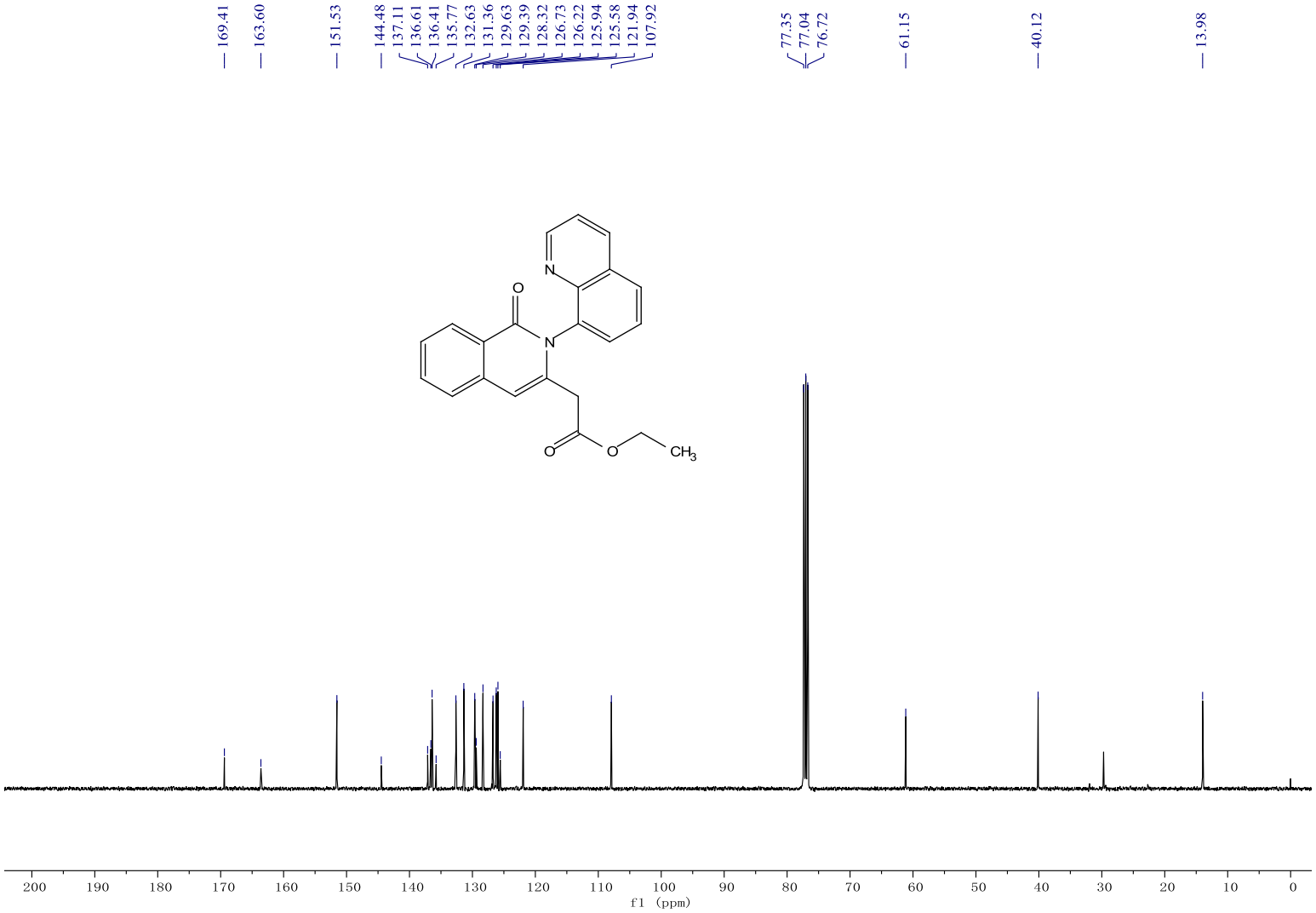
8.44
8.30
8.29
8.03
8.01
7.78
7.76
7.74
7.72
7.71
7.69
7.68
7.63
7.61
7.54
7.53
7.51
7.51
7.50
7.49
7.48
7.31
6.69
3.97
3.96
3.94
3.93
3.43
3.39
3.14
3.11
1.13
1.11
1.10
N
O
N
O
O
CH3
1.04
1.03
1.19
1.16
1.06
2.51
1.21
1.35
1.12
1.16
2.24
1.27
1.24
3.34
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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132.63
131.36
129.63
129.39
128.32
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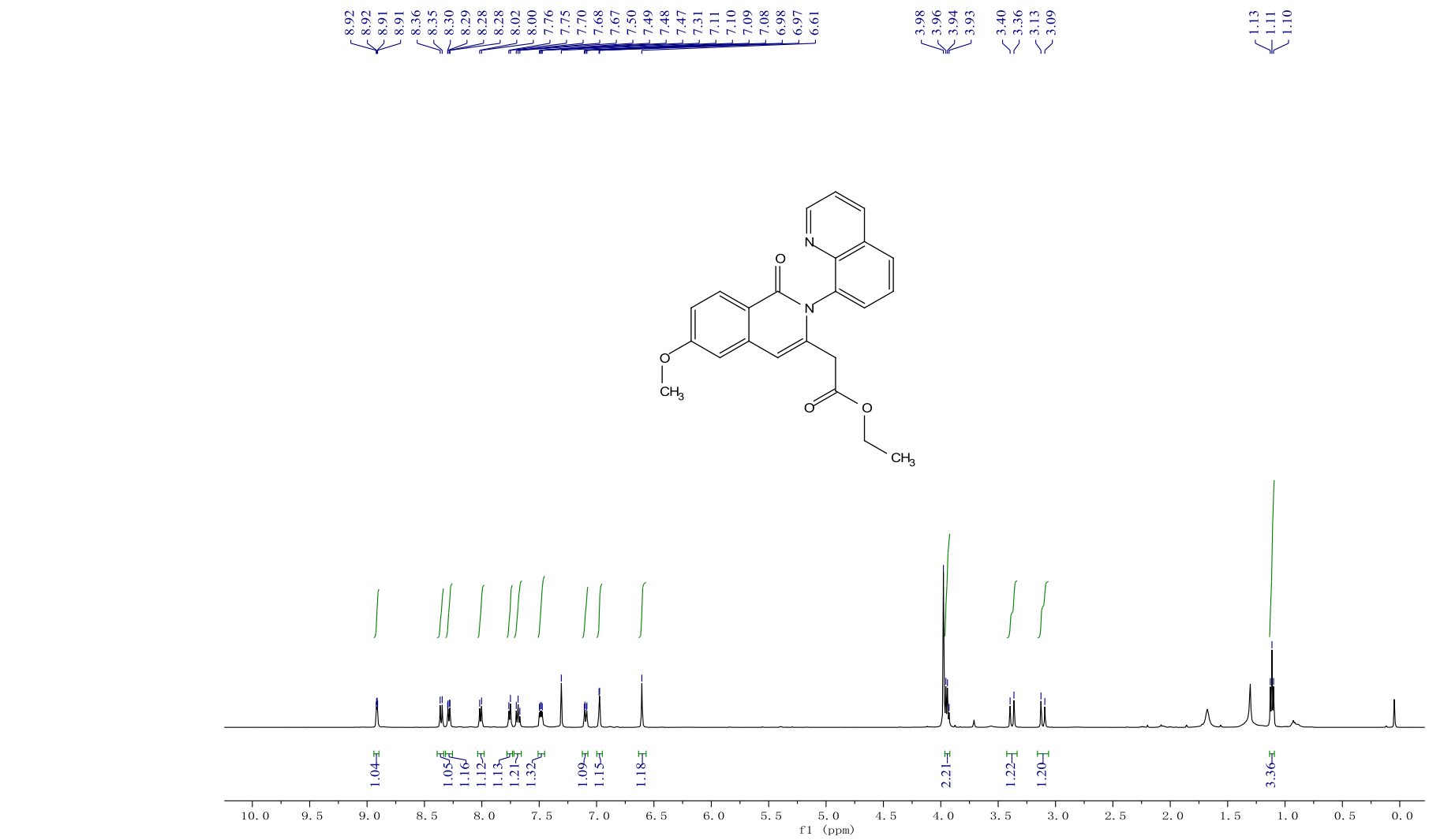
126.22
125.94
125.58
121.94
107.92
77.35
77.04
76.72
61.15
40.12
13.98
O
N
N
O
O
CH3
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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8.91
8.91
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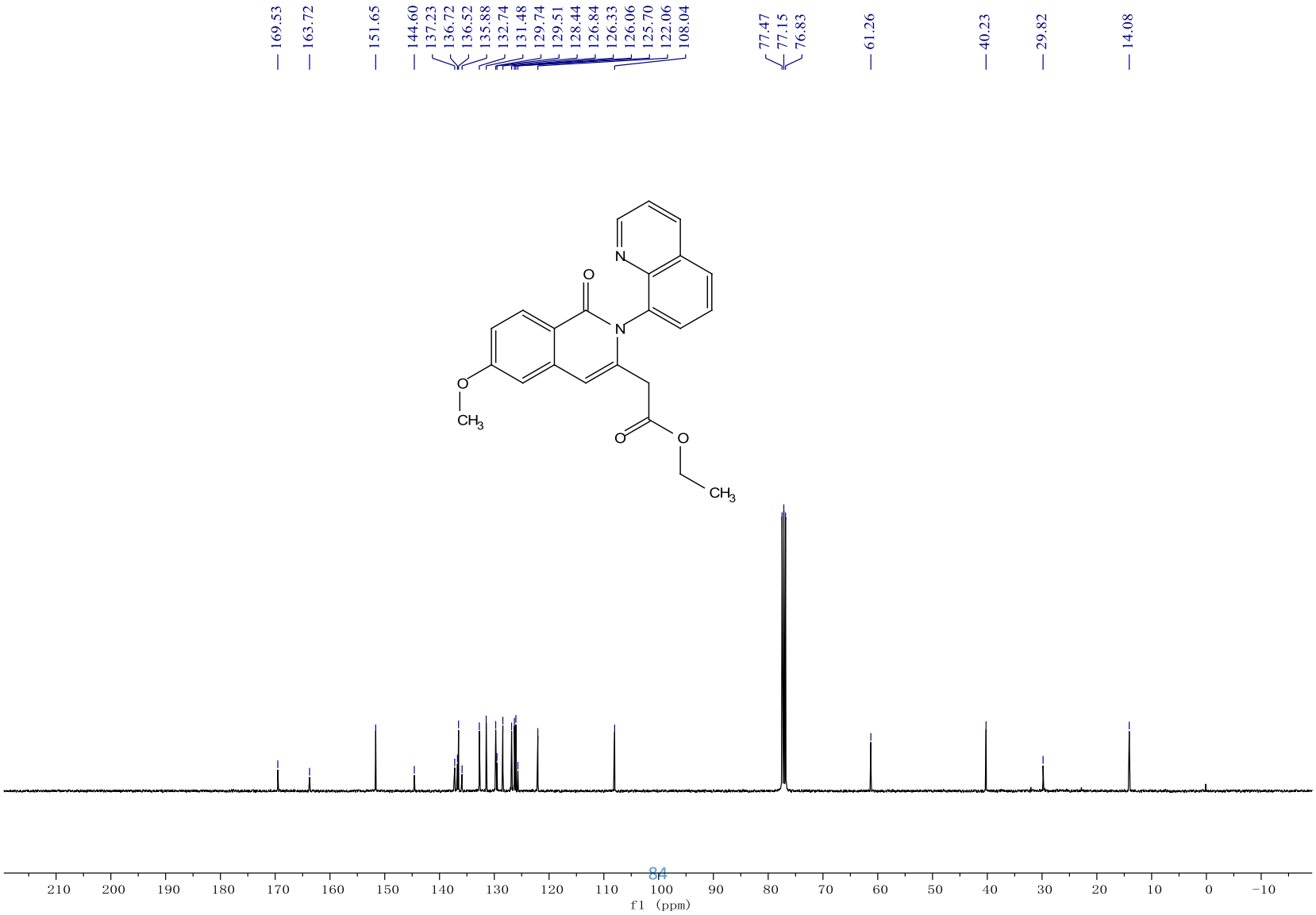
8.35
8.30
8.29
8.28
8.28
8.02
8.00
7.76
7.75
7.70
7.68
7.67
7.50
7.49
7.48
7.47
7.31
7.11
7.10
7.09
7.08
6.98
6.97
6.61
3.98
3.96
3.94
3.93
3.40
3.36
3.13
3.09
1.13
1.11
1.10
N
O
N
O
CH3
O
O
CH3
1.04
1.05
1.16
1.12
1.13
1.21
1.32
1.09
1.15
1.18
2.21
1.22
1.20
3.36
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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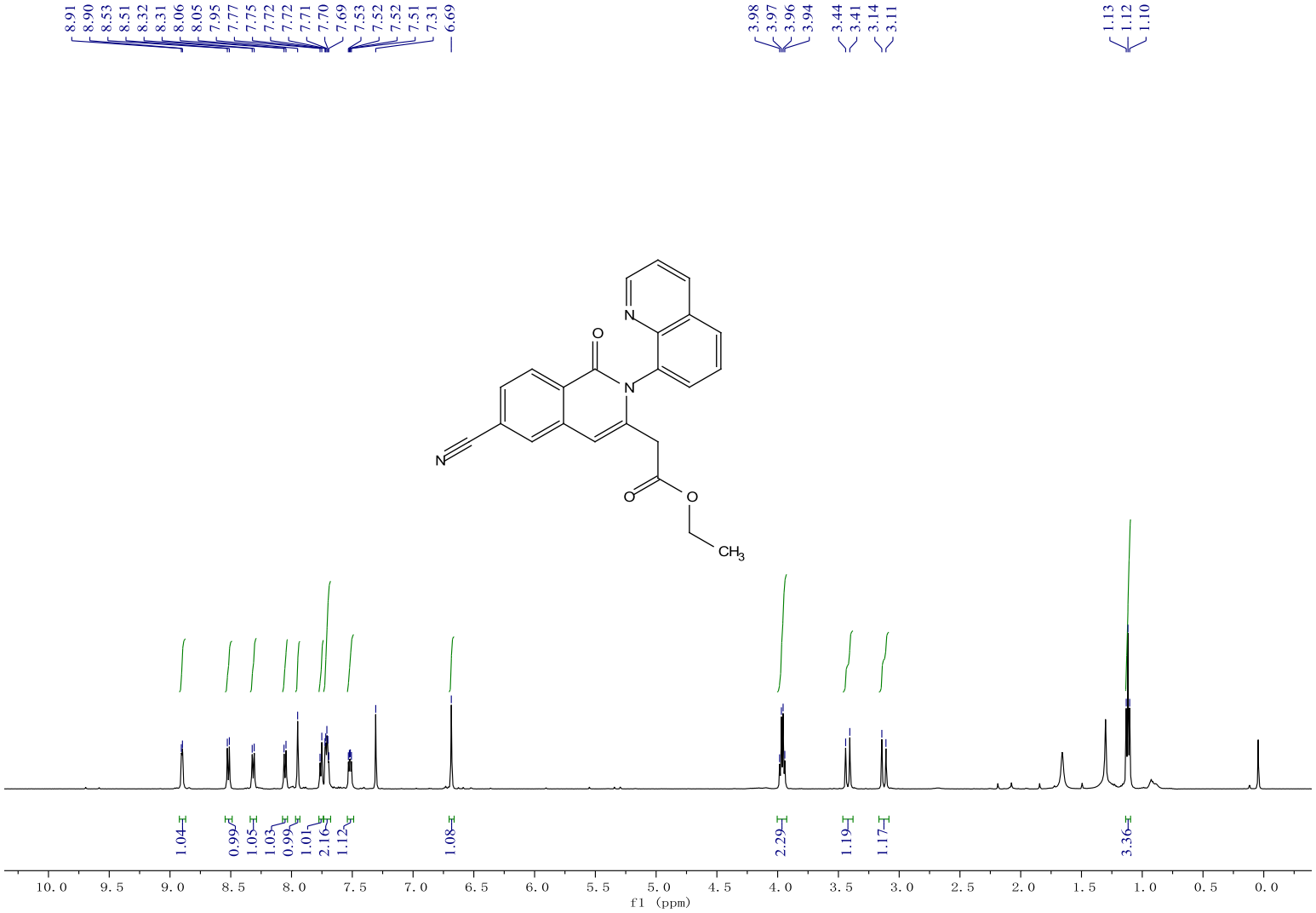
135.88
132.74
131.48
129.74
129.51
128.44
126.84
126.33
126.06
125.70
122.06
108.04
77.47
77.15
76.83
61.26
40.23
29.82
14.08
N
O
N
O
CH3
O
O
CH3
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)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8.32
8.31
8.06
8.05
7.95
7.77
7.75
7.72
7.72
7.71
7.70
7.69
7.53
7.52
7.51
7.31
6.69
3.98
3.97
3.96
3.94
3.44
3.41
3.14
3.11
1.13
1.12
1.10
N
O
N
N
O
O
CH3
1.04
0.99
1.05
1.03
0.99
1.01
2.16
1.12
1.08
2.29
1.19
1.17
3.36
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
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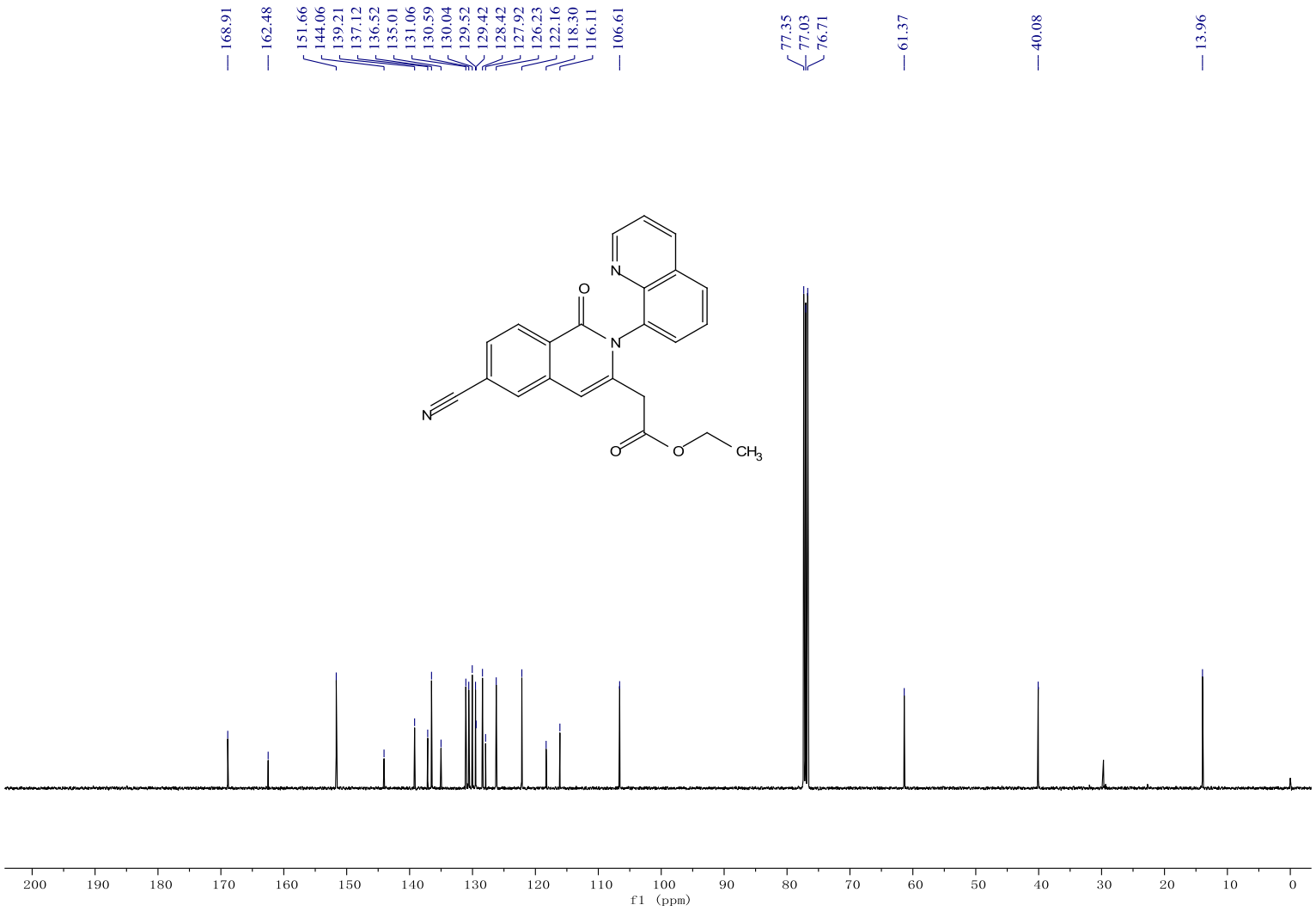
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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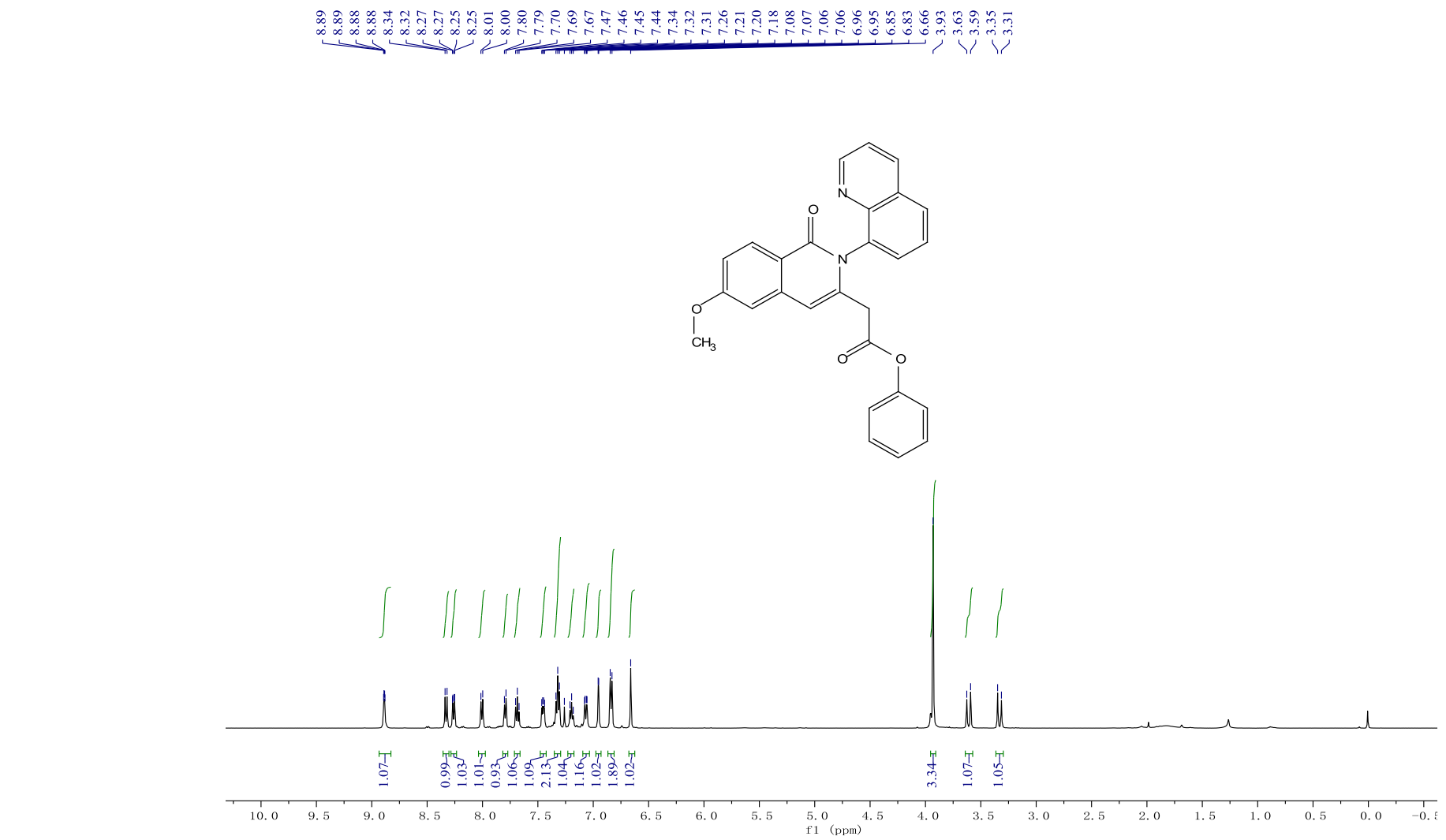
135.01
131.06
130.59
130.04
129.52
129.42
128.42
127.92
126.23
122.16
118.30
116.11
106.61
77.35
77.03
76.71
61.37
40.08
13.96
O
N
N
O
O
CH3
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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8.25
8.25
8.01
8.00
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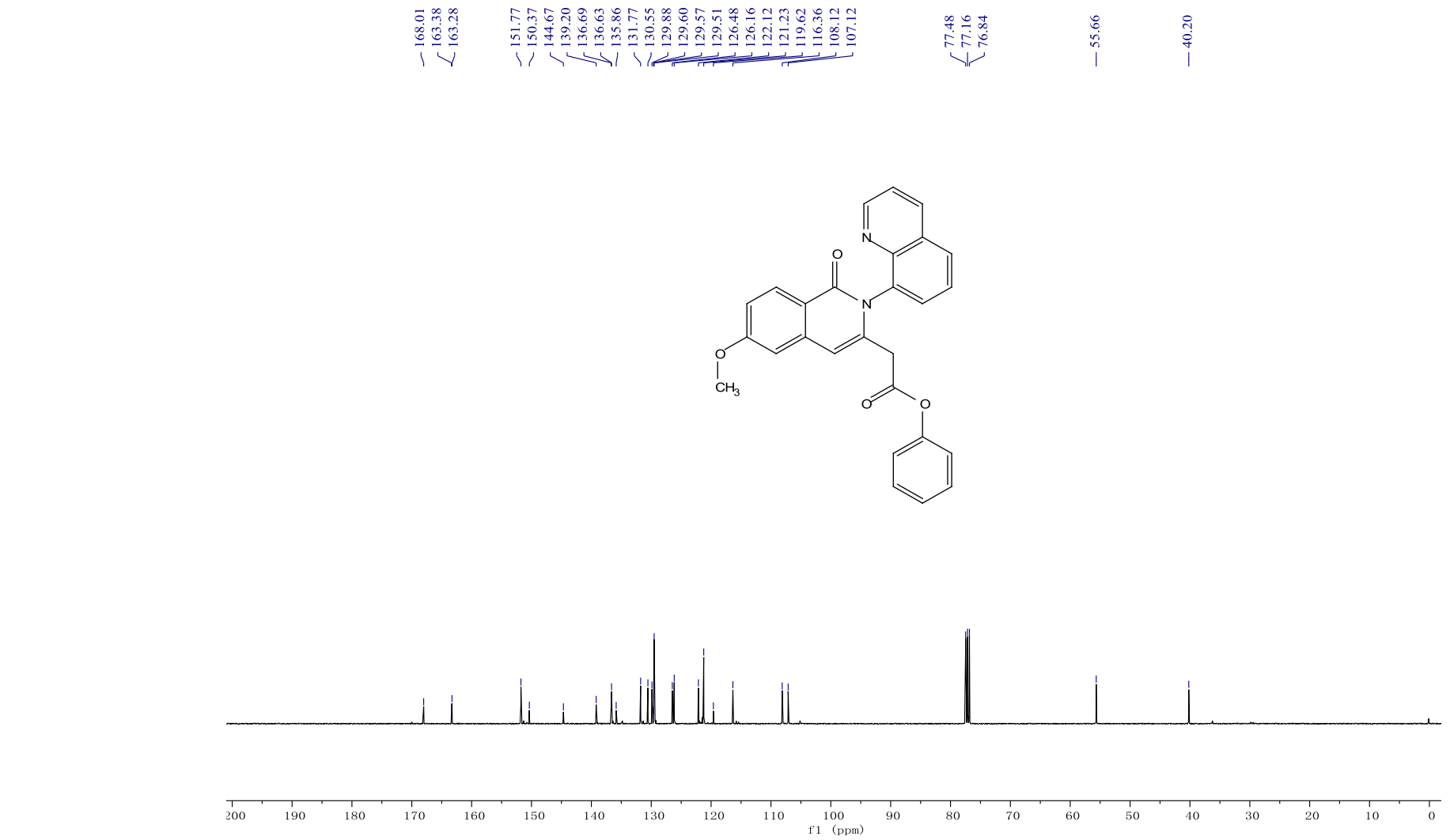
7.70
7.69
7.67
7.47
7.46
7.45
7.44
7.34
7.32
7.31
7.26
7.21
7.20
7.18
7.08
7.07
7.06
7.06
6.96
6.95
6.85
6.83
6.66
3.93
3.63
3.59
3.35
3.31
O
N
N
O
O
CH3
O
O
1.07
0.99
1.03
1.01
0.93
1.06
1.09
2.13
1.04
1.16
1.02
1.89
1.02
3.34
1.07
1.05
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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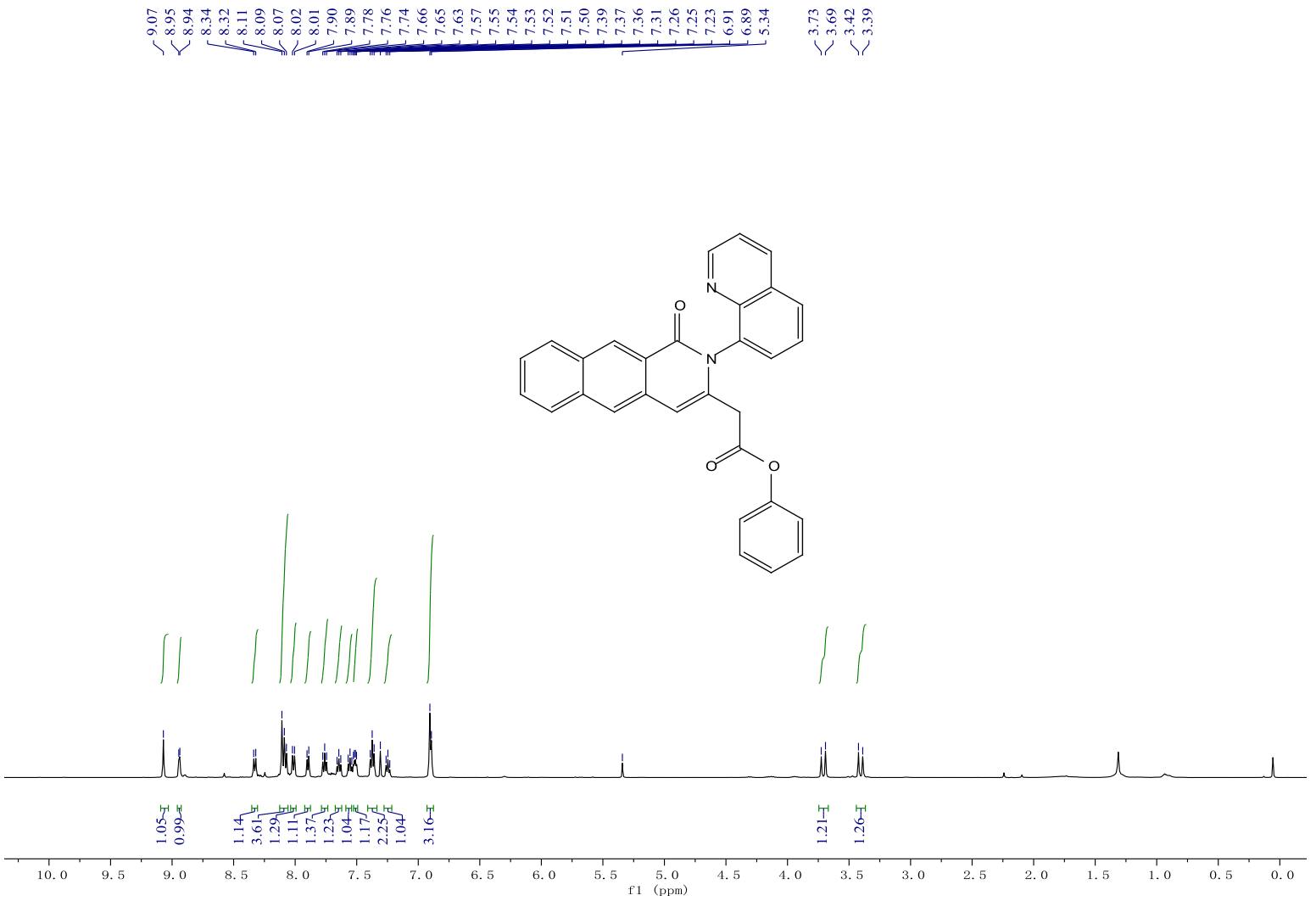
136.69
136.63
135.86
131.77
130.55
129.88
129.60
129.57
129.51
126.48
126.16
122.12
121.23
119.62
116.36
108.12
107.12
77.48
77.16
76.84
55.66
40.20
N
O
N
O
CH3
O
O
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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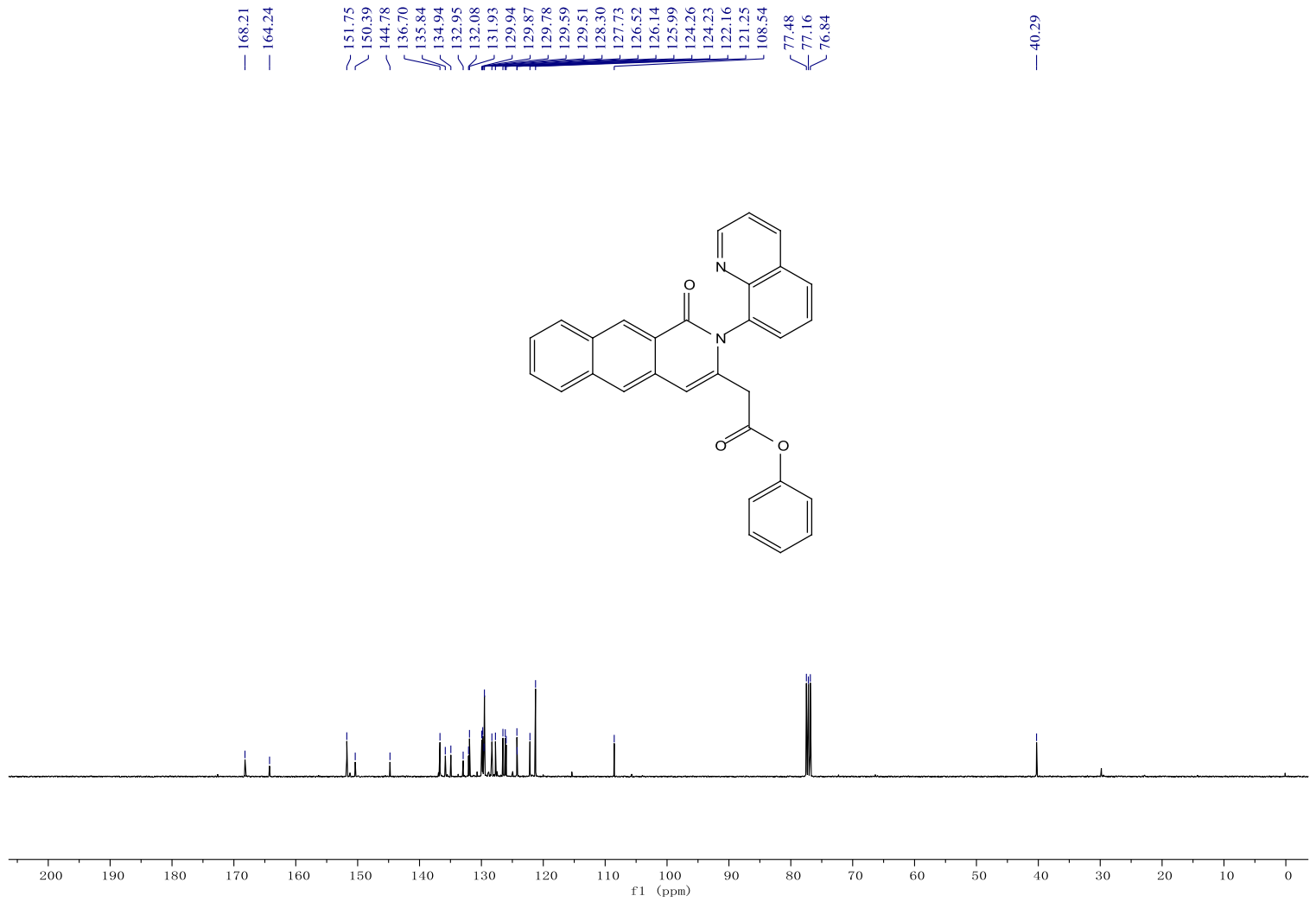
8.95
8.94
8.34
8.32
8.11
8.09
8.07
8.02
8.01
7.90
7.89
7.78
7.76
7.74
7.66
7.65
7.63
7.57
7.55
7.54
7.53
7.52
7.51
7.50
7.39
7.37
7.36
7.31
7.26
7.25
7.23
6.91
6.89
5.34
3.73
3.69
3.42
3.39
O
N
N
O
O
1.05
0.99
1.14
3.61
1.29
1.11
1.37
1.23
1.04
1.17
2.25
1.04
3.16
1.21
1.26
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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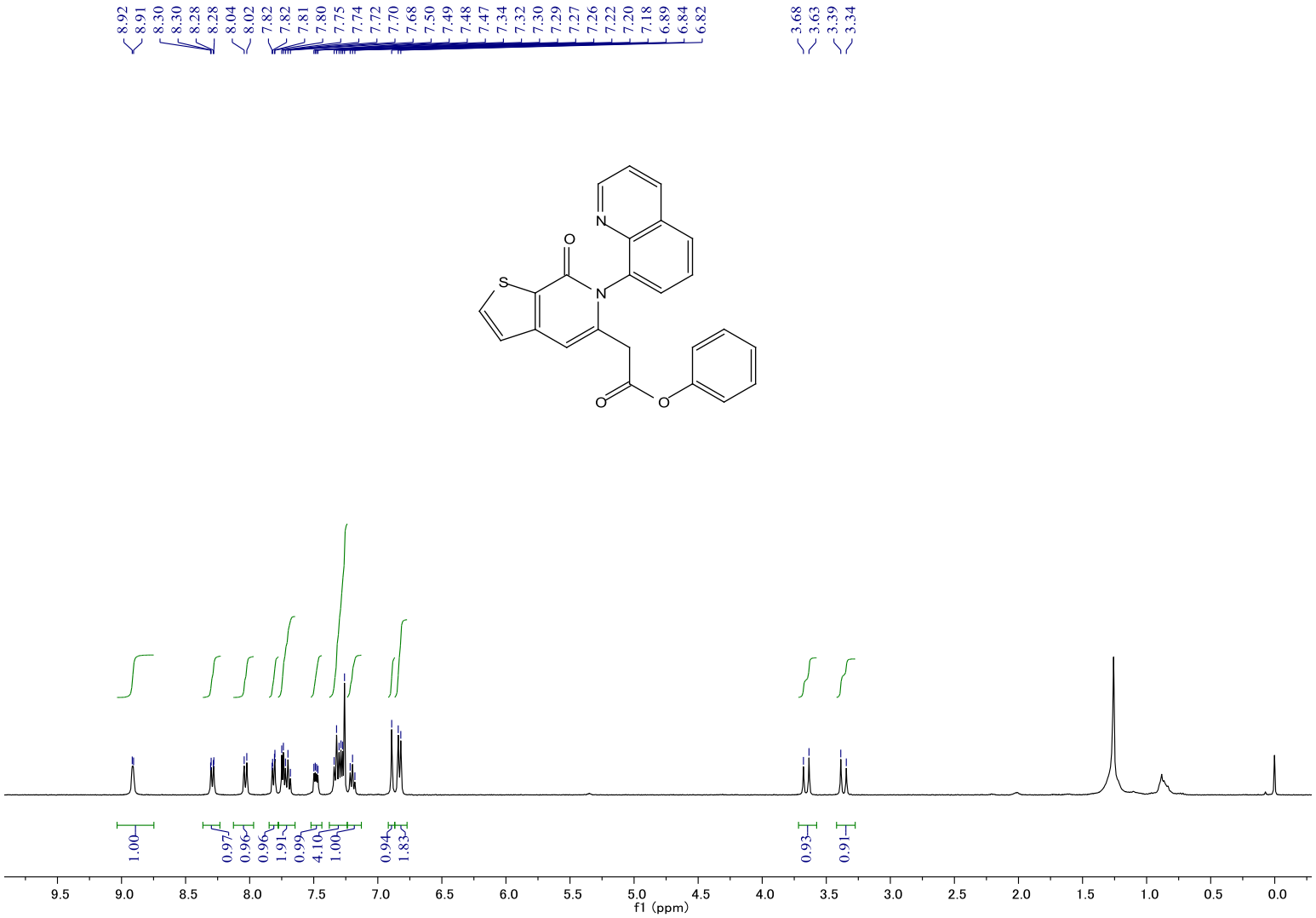
136.70
135.84
134.94
132.95
132.08
131.93
129.94
129.87
129.78
129.59
129.51
128.30
127.73
126.52
126.14
125.99
124.26
124.23
122.16
121.25
108.54
77.48
77.16
76.84
40.29
N
O
N
O
O
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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8.30
8.28
8.28
8.04
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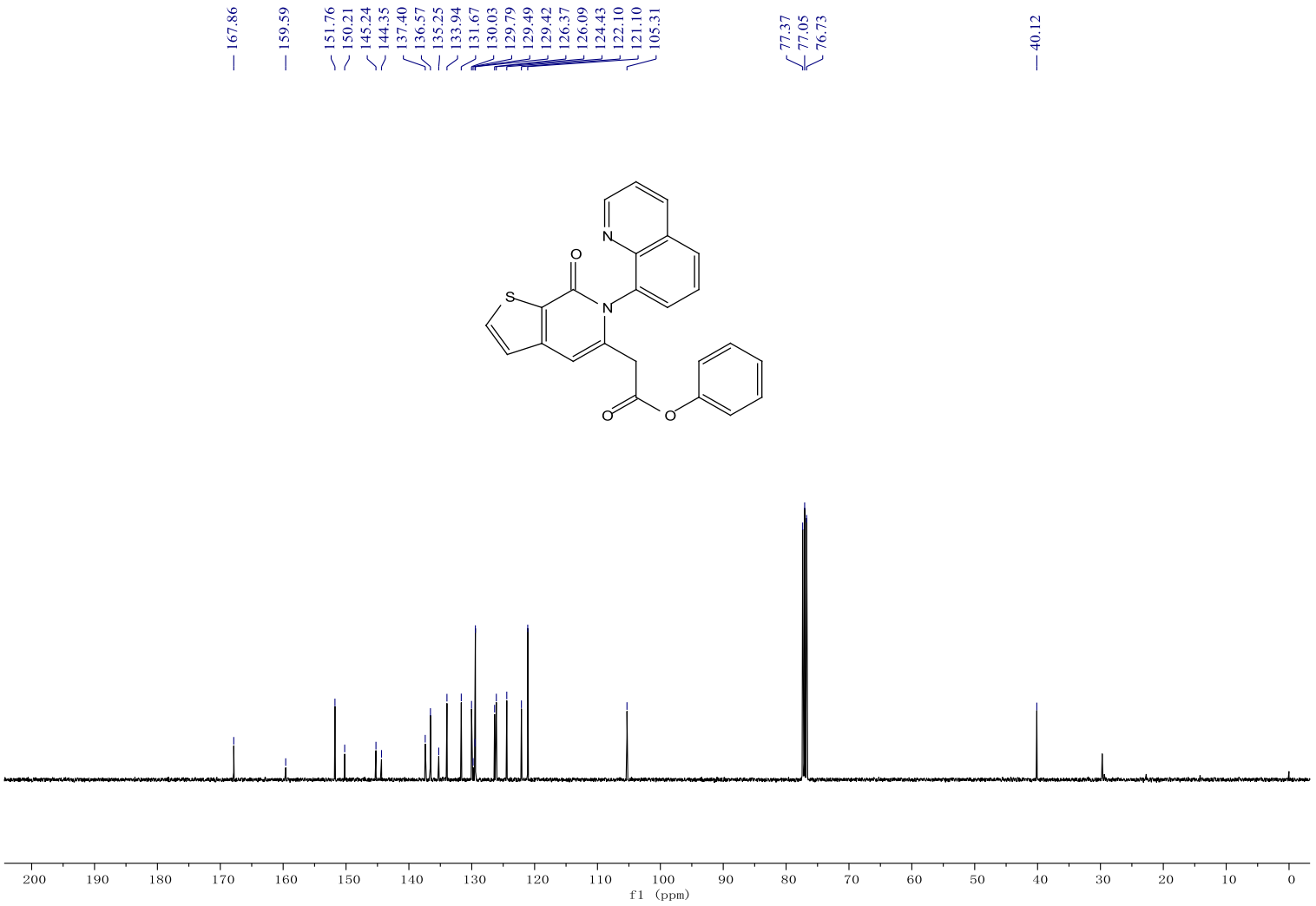
7.82
7.81
7.80
7.75
7.74
7.72
7.70
7.68
7.50
7.49
7.48
7.47
7.34
7.32
7.30
7.29
7.27
7.26
7.22
7.20
7.18
6.89
6.84
6.82
3.68
3.63
3.39
3.34
O
N
S
N
O
O
1.00
0.97
0.96
0.96
1.91
0.99
4.10
1.00
0.94
1.83
0.93
0.91
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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131.67
130.03
129.79
129.49
129.42
126.37
126.09
124.43
122.10
121.10
105.31
77.37
77.05
76.73
40.12
N
O
S
N
O
O
200
190
180
170
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130
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110
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90
80
70
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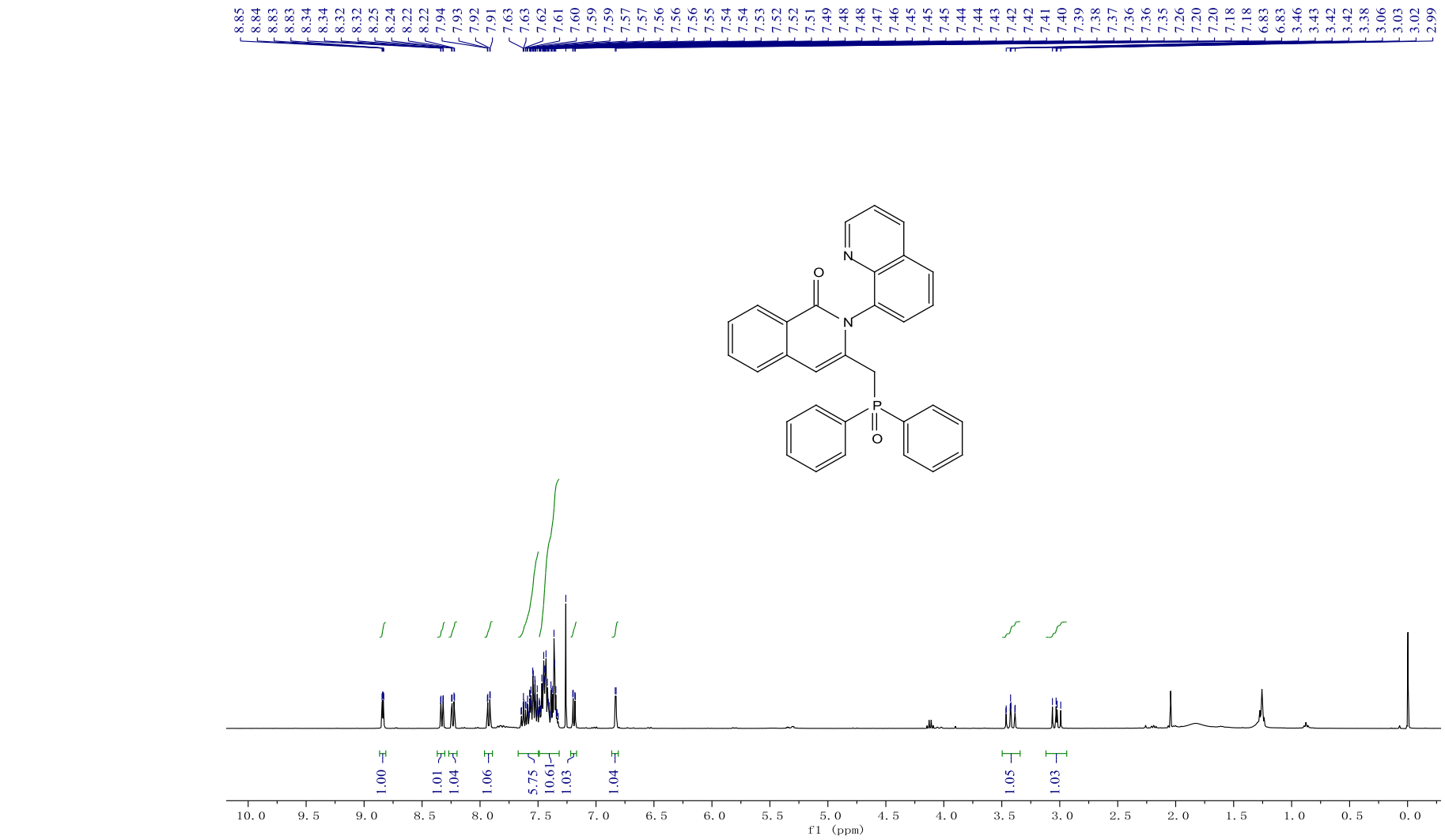
50
40
30
20
10
0
f1 (ppm)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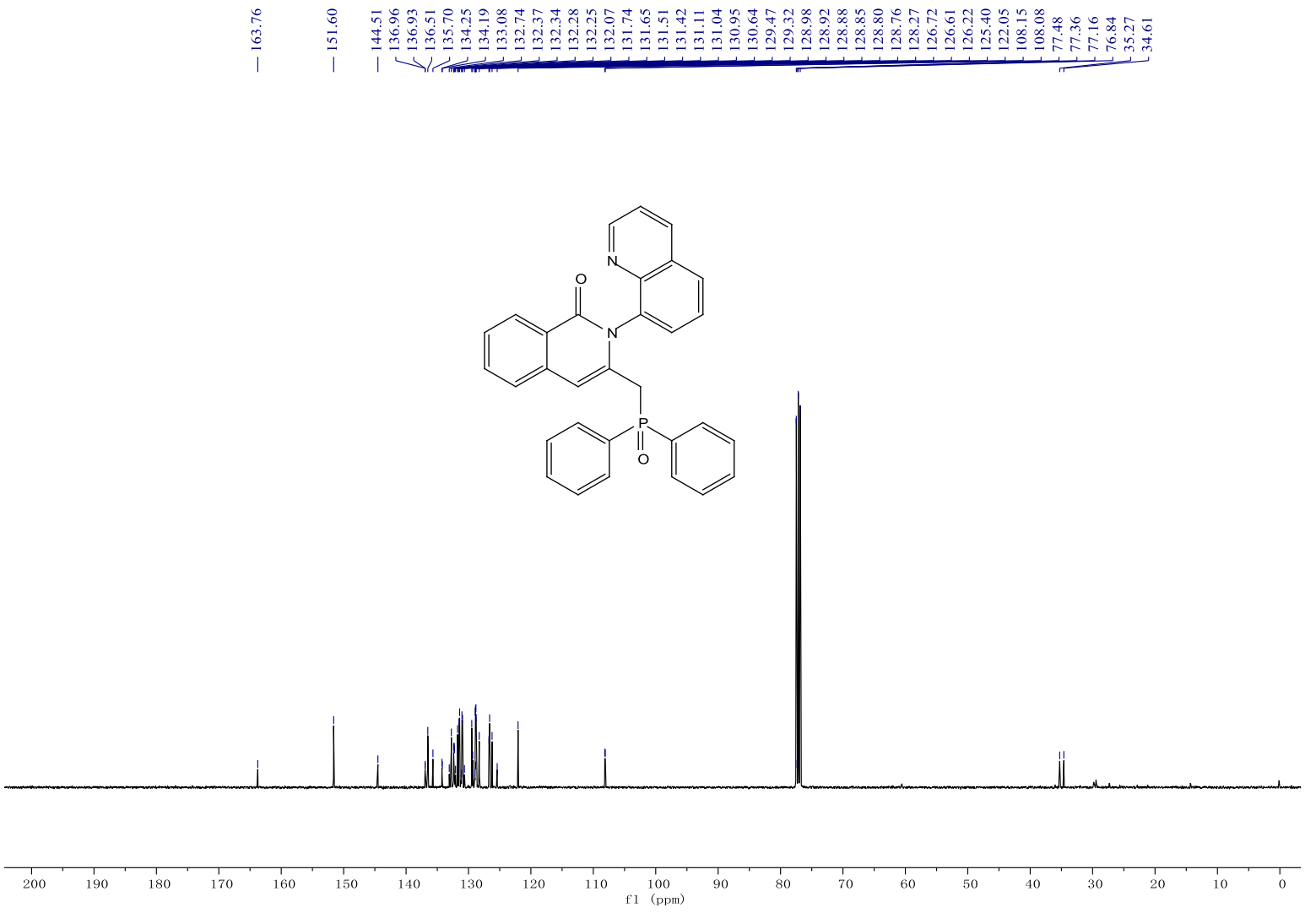
O
N
N
P
O
1.00
1.01
1.04
1.06
5.75
10.61
1.03
1.04
1.05
1.03
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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126.61
126.22
125.40
122.05
108.15
108.08
77.48
77.36
77.16
76.84
35.27
34.61
N
O
N
P
O
200
190
180
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120
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100
90
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70
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50
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30
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10
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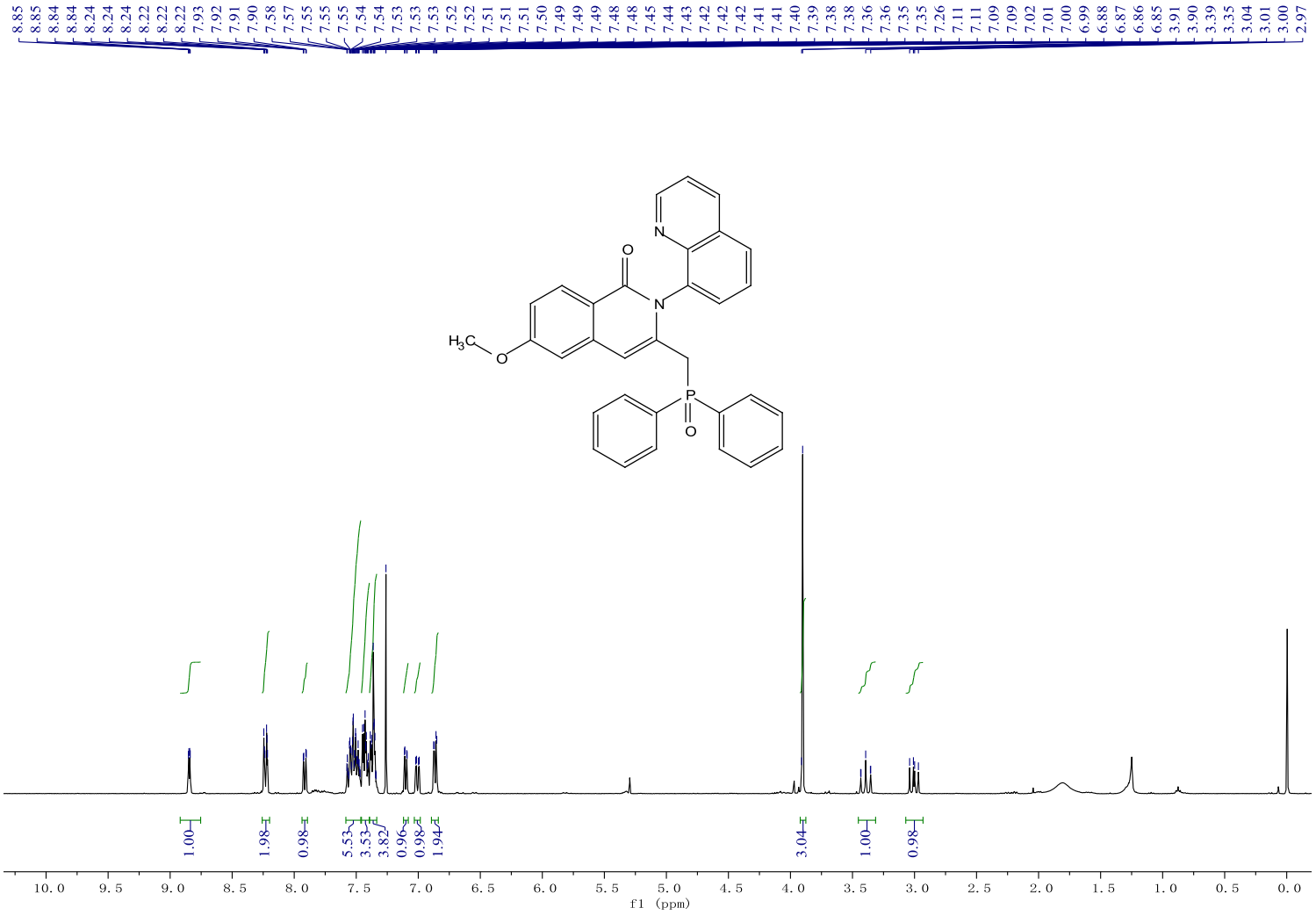
f1 (ppm)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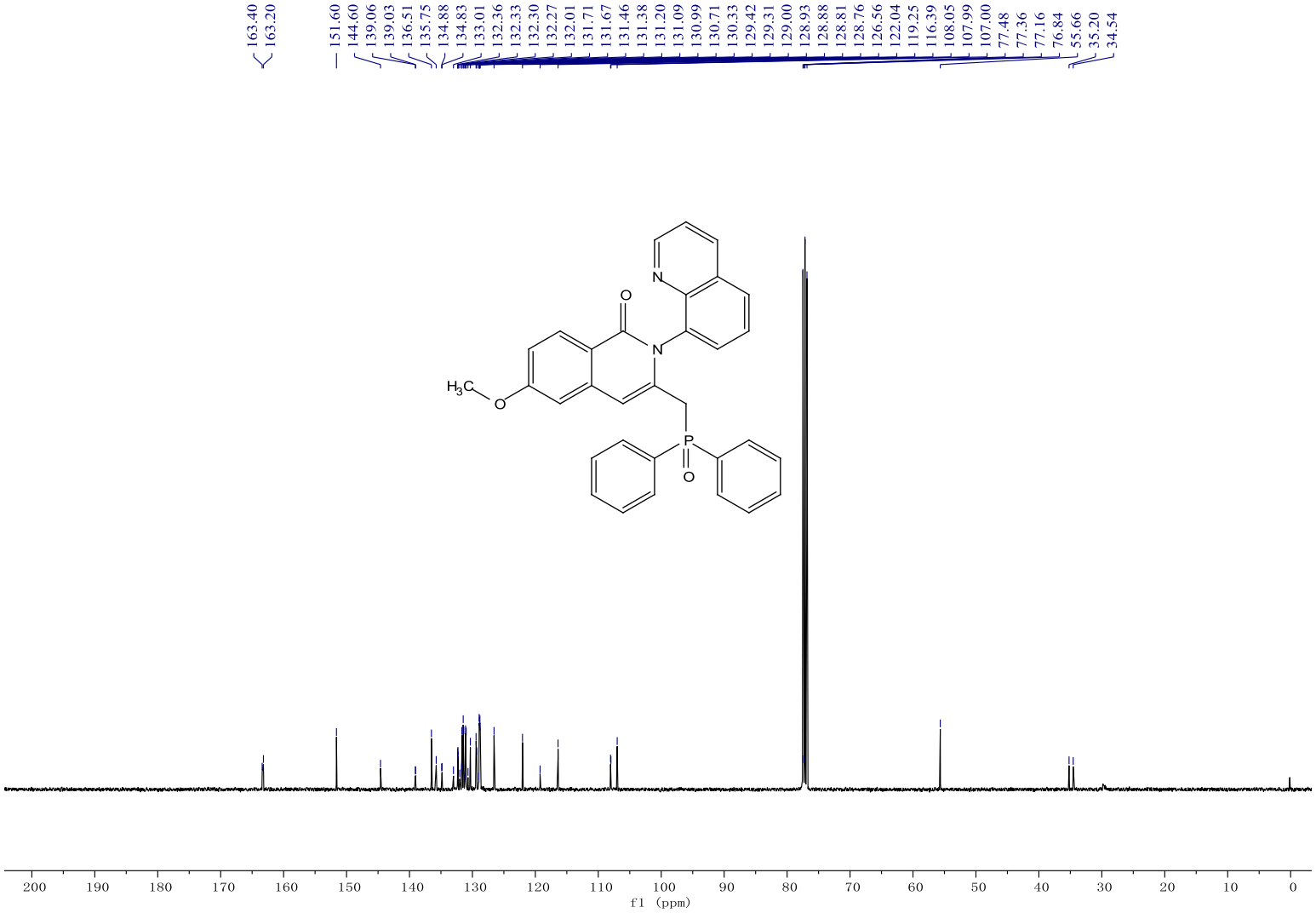
O
N
N
H3C
O
P
O
1.00 1.98 0.98 5.53 3.53 3.82 0.96 0.98 1.94 3.04 1.00 0.98
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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132.01
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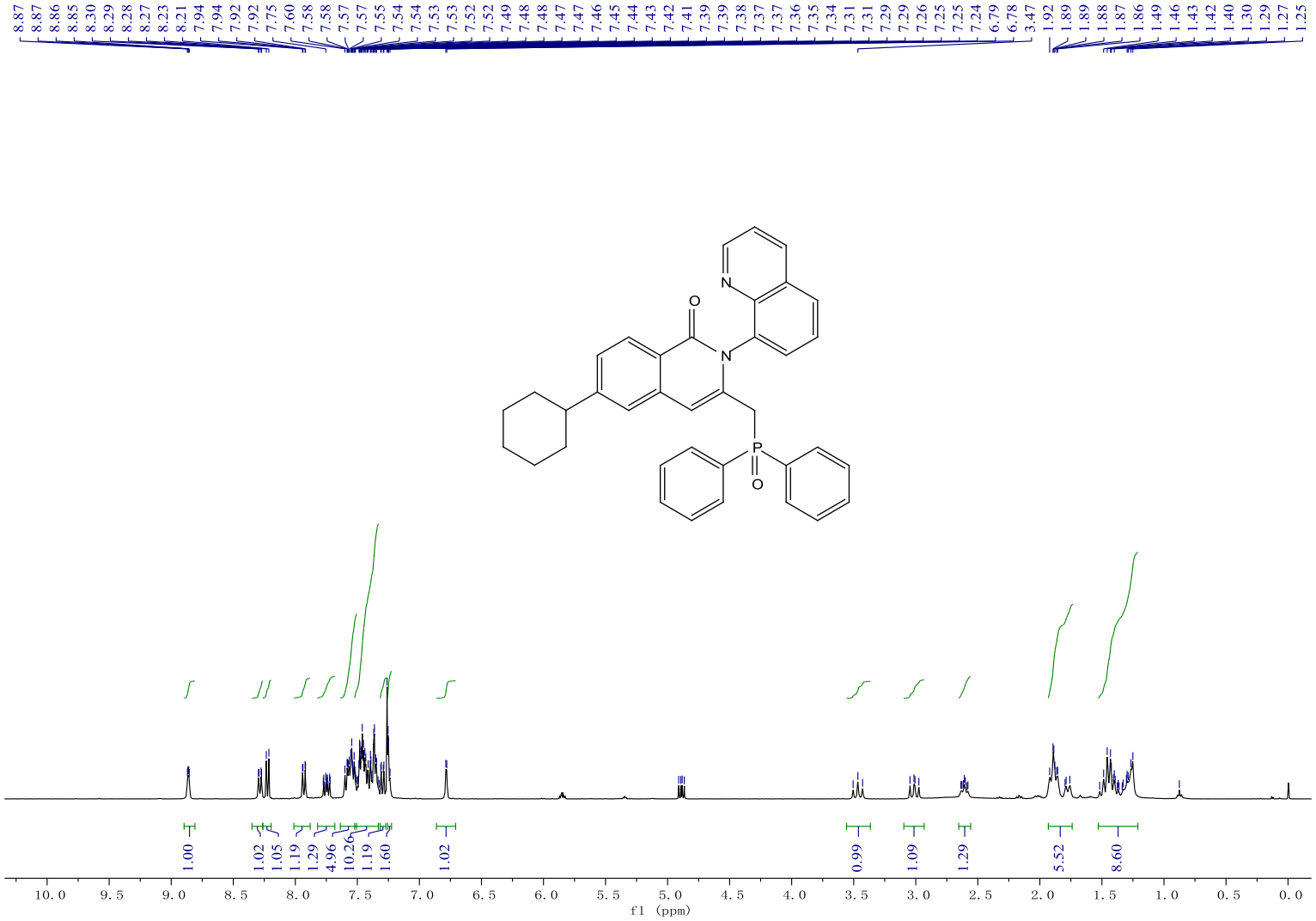
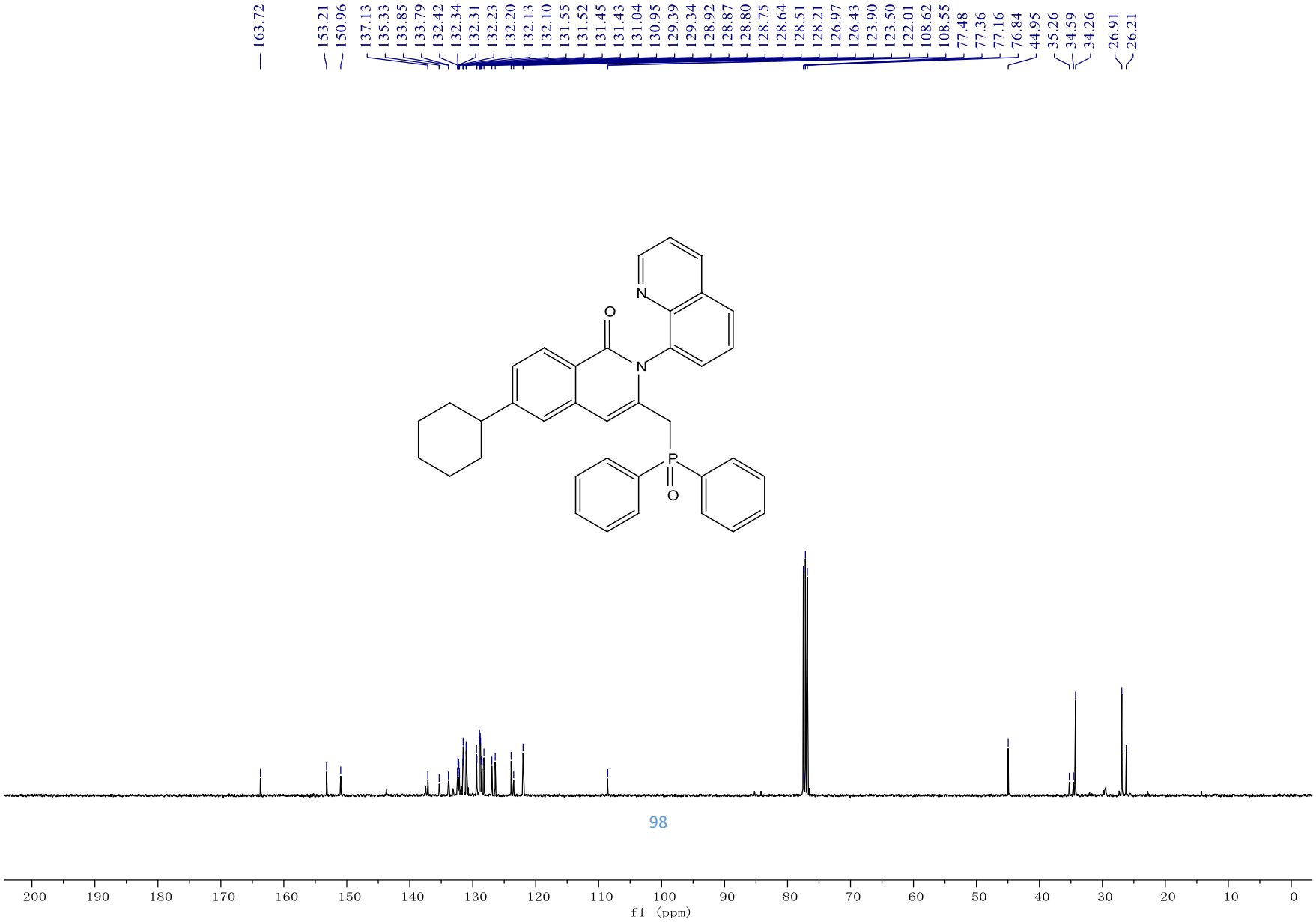
128.76
126.56
122.04
119.25
116.39
108.05
107.99
107.00
77.48
77.36
77.16
76.84
55.66
35.20
34.54
N
O
N
H3C
O
P
O
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


8.87 8.87 8.86 8.85 8.30 8.29 8.28 8.27 8.23 8.21 7.94 7.94 7.92 7.92 7.75 7.60 7.58 7.58 7.57 7.57 7.55 7.54 7.54 7.53 7.53 7.52 7.52 7.49 7.48 7.48 7.47 7.47 7.46 7.45 7.44 7.43 7.42 7.41 7.39 7.39 7.38 7.37 7.37 7.36 7.35 7.34 7.31 7.31 7.29 7.29 7.26 7.25 7.25 7.24 6.79 6.78 3.47 1.92 1.89 1.89 1.88 1.87 1.86 1.49 1.46 1.43 1.42 1.40 1.30 1.29 1.27 1.25
O
N
N
P
O
1.00 1.02 1.05 1.19 1.29 4.96 10.26 1.19 1.60 1.02 0.99 1.09 1.29 5.52 8.60
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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132.13
132.10
131.55
131.52
131.45
131.43
131.04
130.95
129.39
129.34
128.92
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128.80
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128.64
128.51
128.21
126.97
126.43
123.90
123.50
122.01
108.62
108.55
77.48
77.36
77.16
76.84
44.95
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34.26
26.91
26.21
O
N
N
P
O
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200
190
180
170
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150
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130
120
110
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90
80
70
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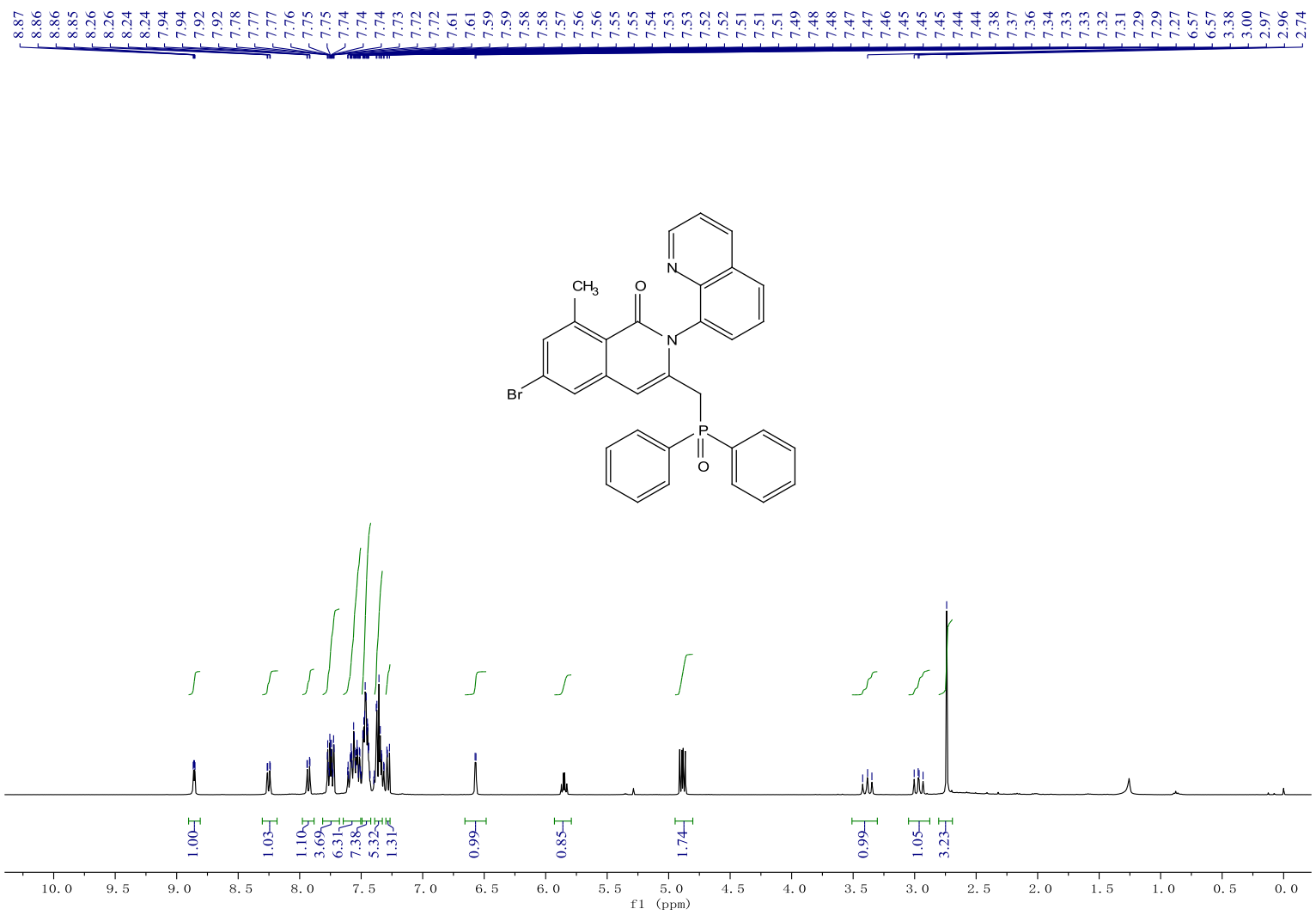
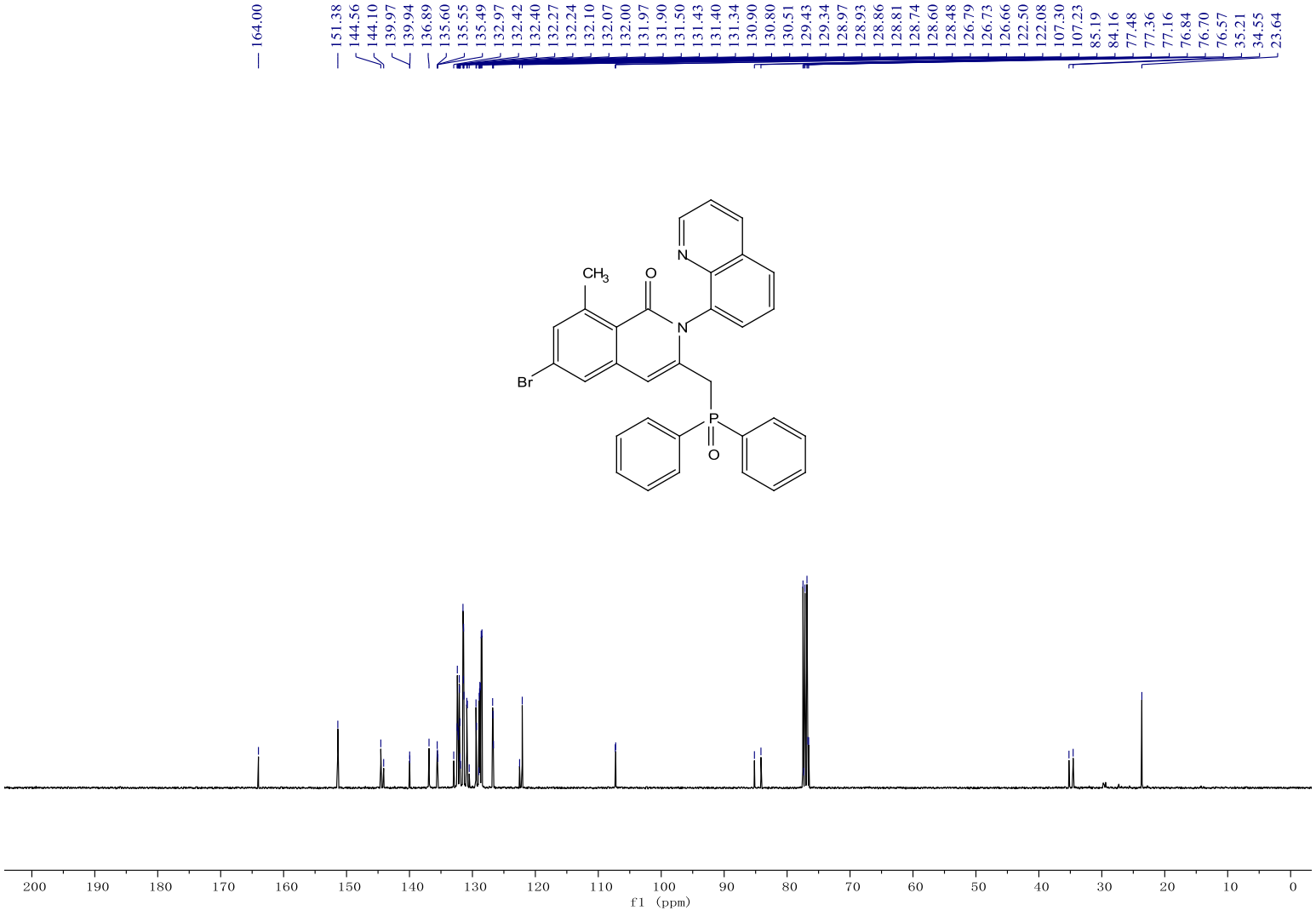
50
40
30
20
10
0
f1 (ppm)


8.87 8.86 8.86 8.85 8.26 8.26 8.24 8.24 7.94 7.94 7.92 7.92 7.78 7.77 7.77 7.76 7.75 7.75 7.74 7.74 7.74 7.73 7.72 7.72 7.61 7.61 7.59 7.59 7.58 7.58 7.57 7.56 7.56 7.55 7.55 7.54 7.53 7.53 7.52 7.52 7.51 7.51 7.51 7.49 7.48 7.48 7.47 7.47 7.46 7.45 7.45 7.45 7.44 7.44 7.38 7.37 7.36 7.34 7.33 7.33 7.32 7.31 7.29 7.29 7.27 6.57 6.57 3.38 3.00 2.97 2.96 2.74
CH3
O
N
N
Br
P
O
1.00 1.03 1.10 3.69 6.31 7.38 5.32 1.31 0.99 0.85 1.74 0.99 1.05 3.23
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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135.49
132.97
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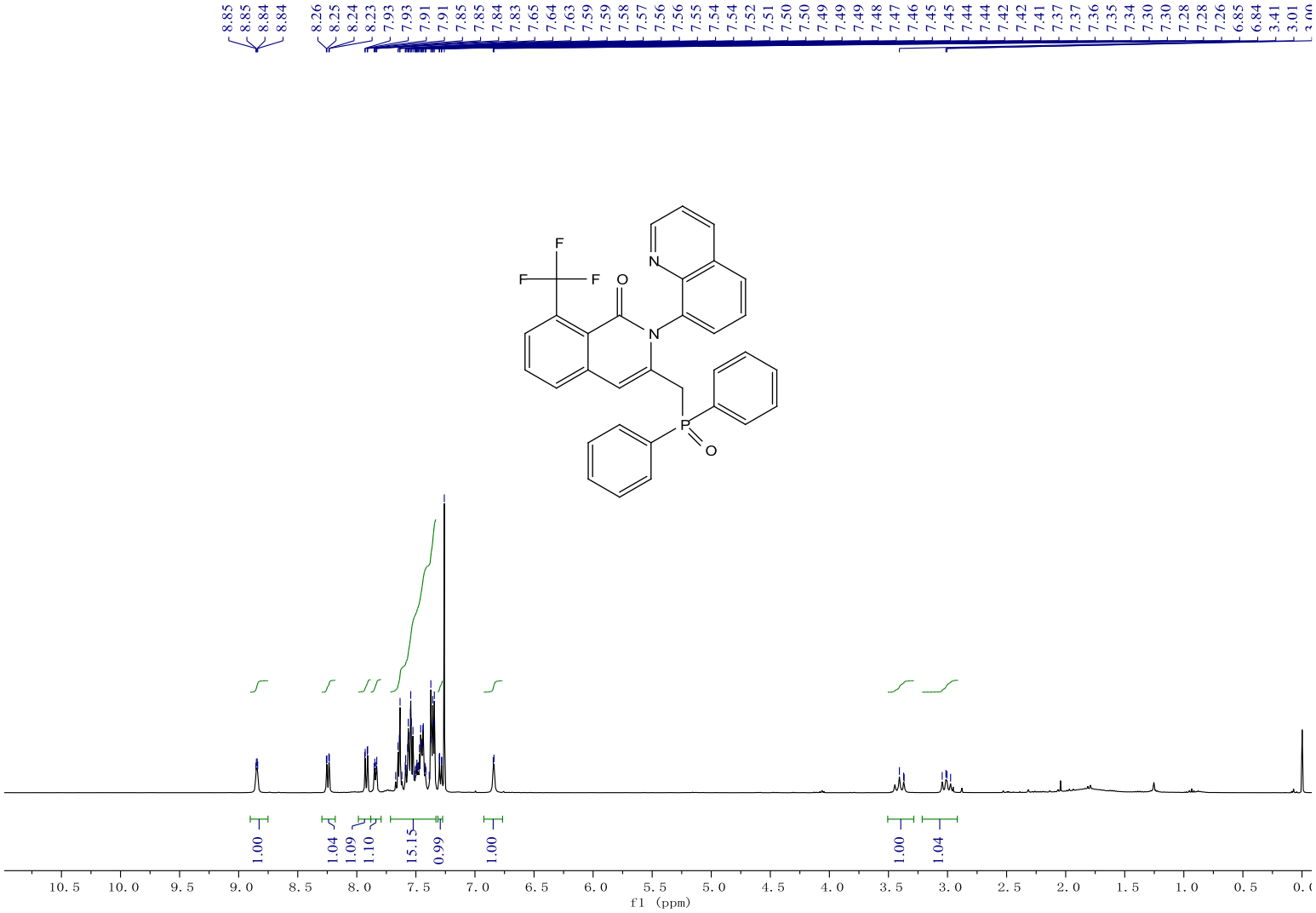
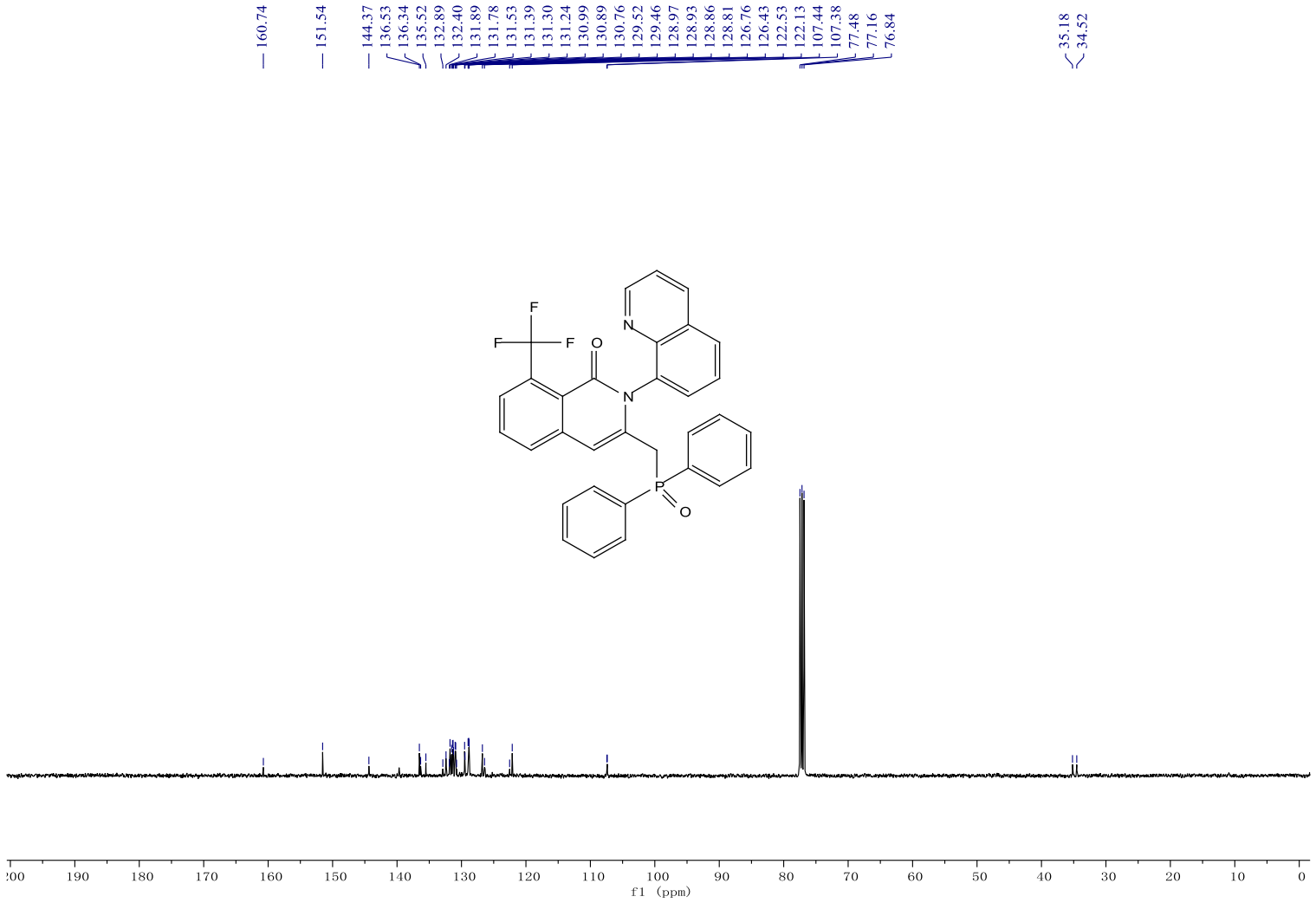
132.27
132.24
132.10
132.07
132.00
131.97
131.90
131.50
131.43
131.40
131.34
130.90
130.80
130.51
129.43
129.34
128.97
128.93
128.86
128.81
128.74
128.60
128.48
126.79
126.73
126.66
122.50
122.08
107.30
107.23
85.19
84.16
77.48
77.36
77.16
76.84
76.70
76.57
35.21
34.55
23.64
CH3
O
N
N
Br
P
O
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


8.85 8.85 8.84 8.84 8.26 8.25 8.24 8.23 7.93 7.93 7.91 7.91 7.85 7.85 7.84 7.83 7.65 7.64 7.63 7.59 7.59 7.58 7.57 7.56 7.56 7.55 7.54 7.54 7.52 7.51 7.50 7.50 7.49 7.49 7.49 7.48 7.47 7.46 7.45 7.45 7.44 7.44 7.42 7.42 7.41 7.37 7.37 7.36 7.35 7.34 7.30 7.30 7.28 7.28 7.26 6.85 6.84 3.41 3.01
F
F F O
N
N
P
O
1.00 1.04 1.09 1.10 15.15 0.99 1.00 1.00 1.04
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
f1 (ppm)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131.39
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131.24
130.99
130.89
130.76
129.52
129.46
128.97
128.93
128.86
128.81
126.76
126.43
122.53
122.13
107.44
107.38
77.48
77.16
76.84
35.18
34.52
F
F
F
O
N
N
P
O
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


8.83
8.83
8.82
8.82
8.47
8.45
8.28
8.27
8.26
8.25
8.24
8.16
8.15
8.14
8.13
7.97
7.95
7.63
7.61
7.60
7.60
7.59
7.58
7.58
7.57
7.56
7.55
7.49
7.48
7.47
7.46
7.45
7.45
7.44
7.44
7.43
7.37
7.36
7.35
7.34
7.34
7.26
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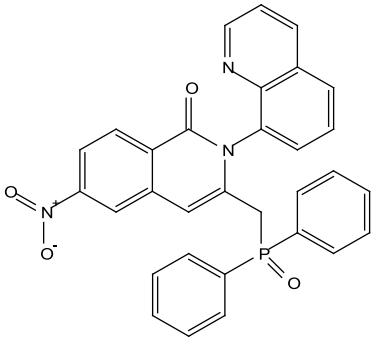
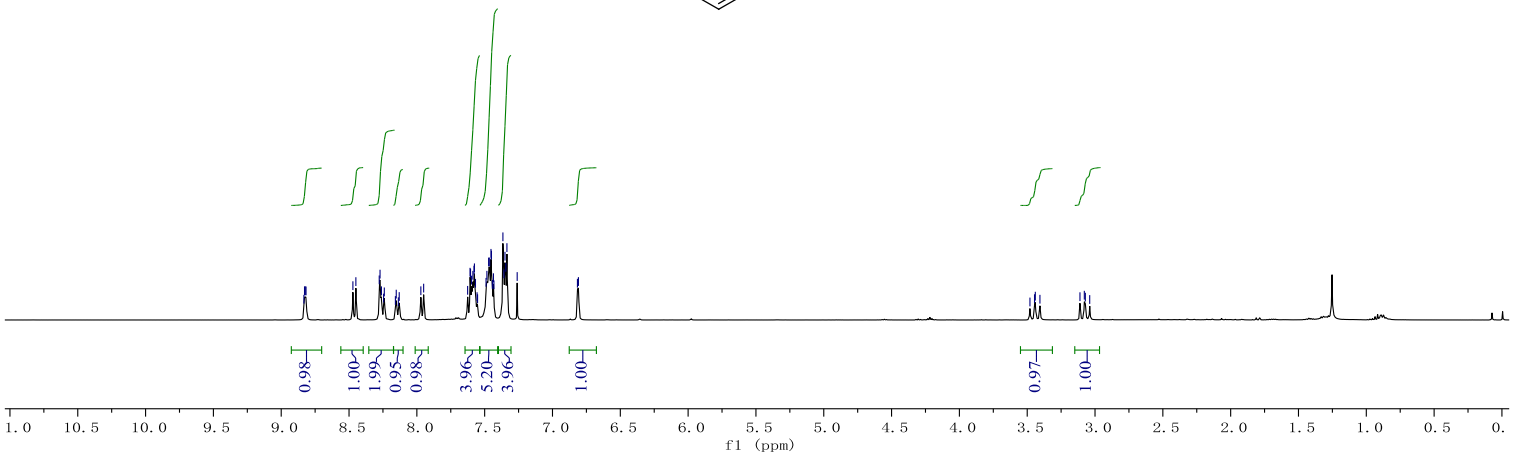
6.81
3.48
3.45
3.44
3.41
3.11
3.08
3.07
3.04


O
N
N
O
O
N+
O-
P
O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0.95
0.98
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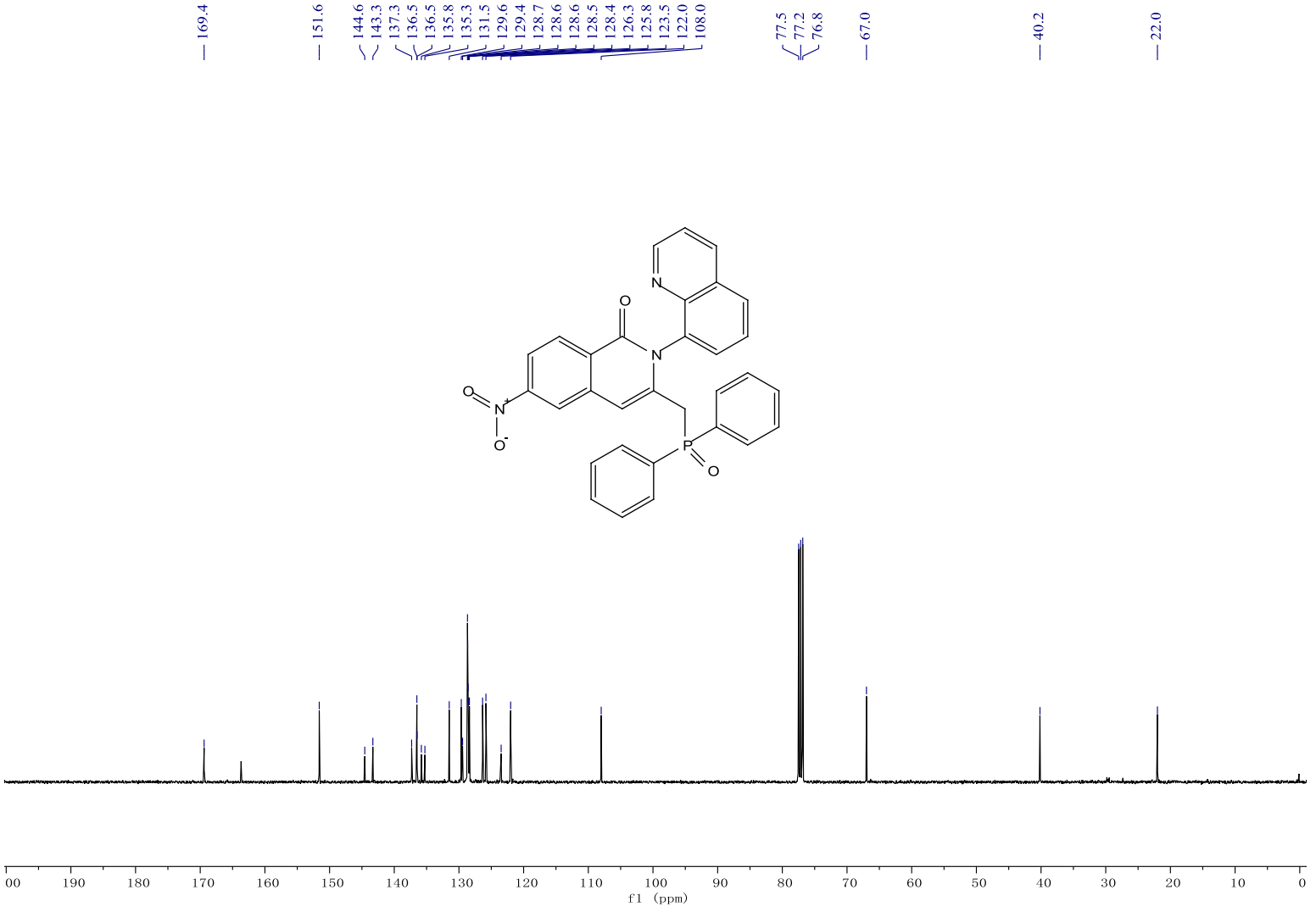
5.20
3.96
1.00
0.97
1.00
1.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.
f1 (ppm)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135.8
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131.5
129.6
129.4
128.7
128.6
128.6
128.5
128.4
126.3
125.8
123.5
122.0
108.0
77.5
77.2
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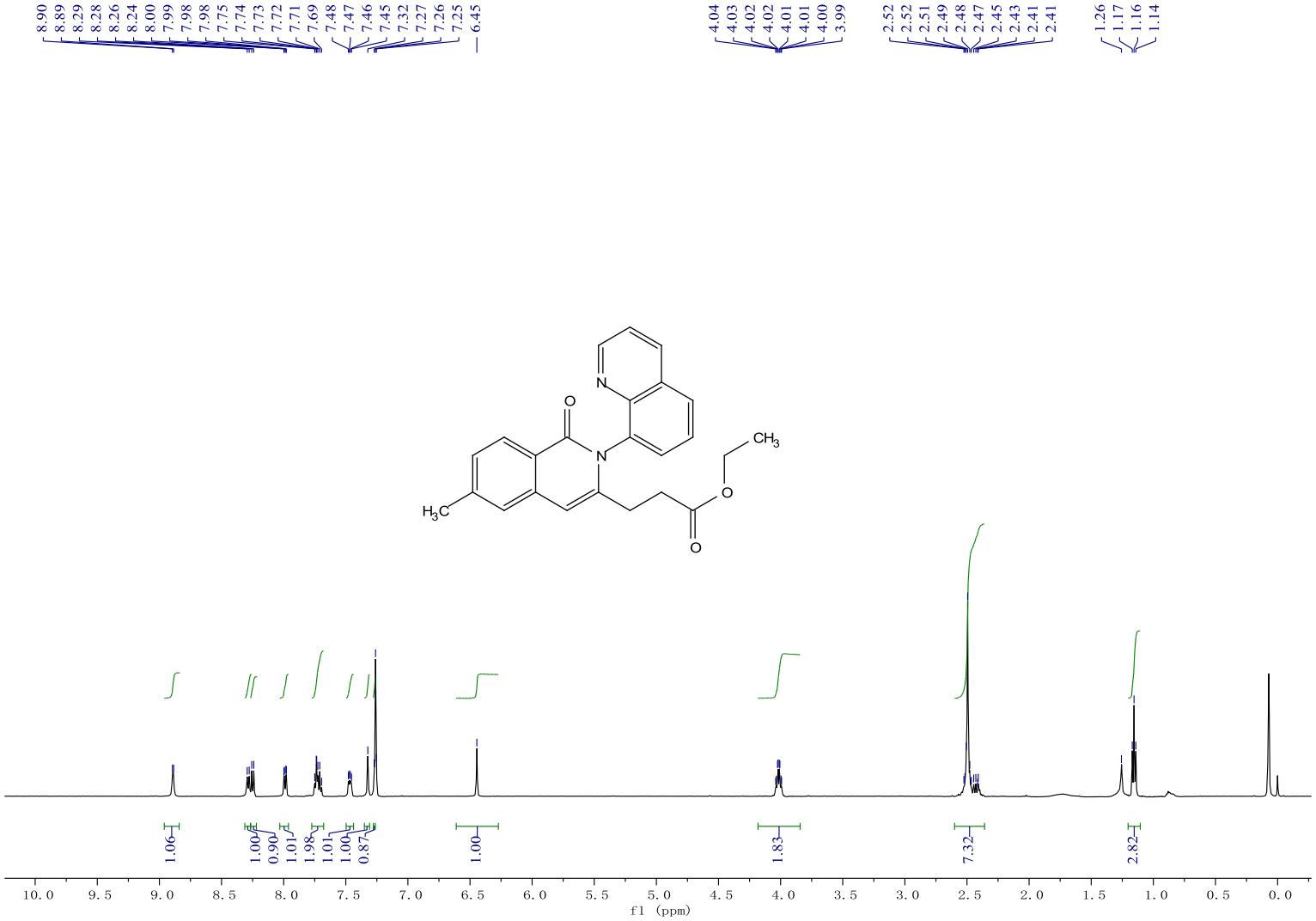
67.0
40.2
22.0
O
N
O
N
O
O
P
O
f1 (ppm)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7.75
7.74
7.73
7.72
7.71
7.69
7.48
7.47
7.46
7.45
7.32
7.27
7.26
7.25
6.45
4.04
4.03
4.02
4.02
4.01
4.01
4.00
3.99
2.52
2.52
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2.41
1.26
1.17
1.16
1.14
N
O
N
CH3
O
H3C
O
1.06
1.00
0.90
1.01
1.98
1.01
1.00
0.87
1.00
1.83
7.32
2.82
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
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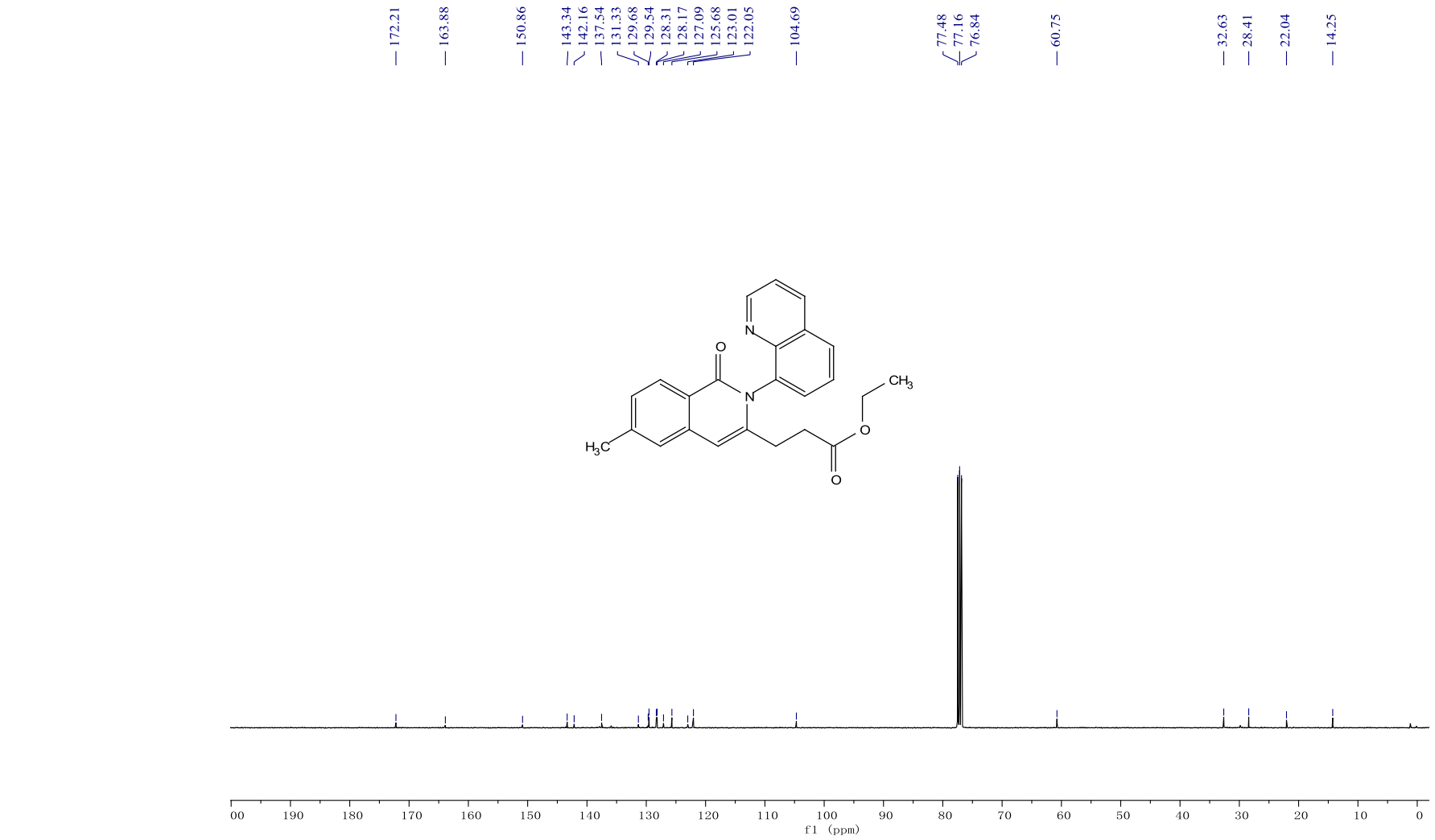
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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128.17
127.09
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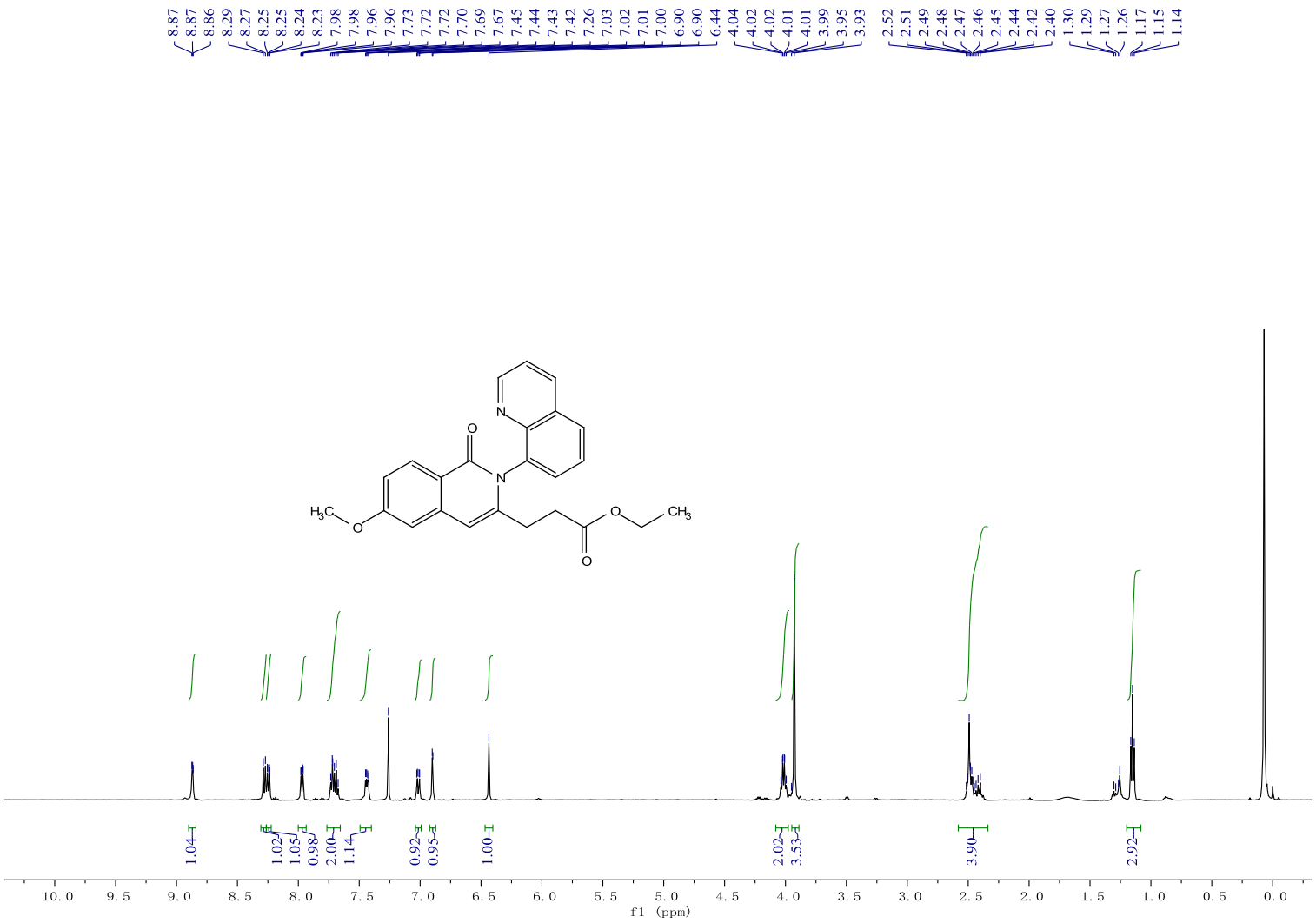
123.01
122.05
104.69
77.48
77.16
76.84
60.75
32.63
28.41
22.04
14.25
N
O
N
O
O
CH3
H3C
f1 (ppm)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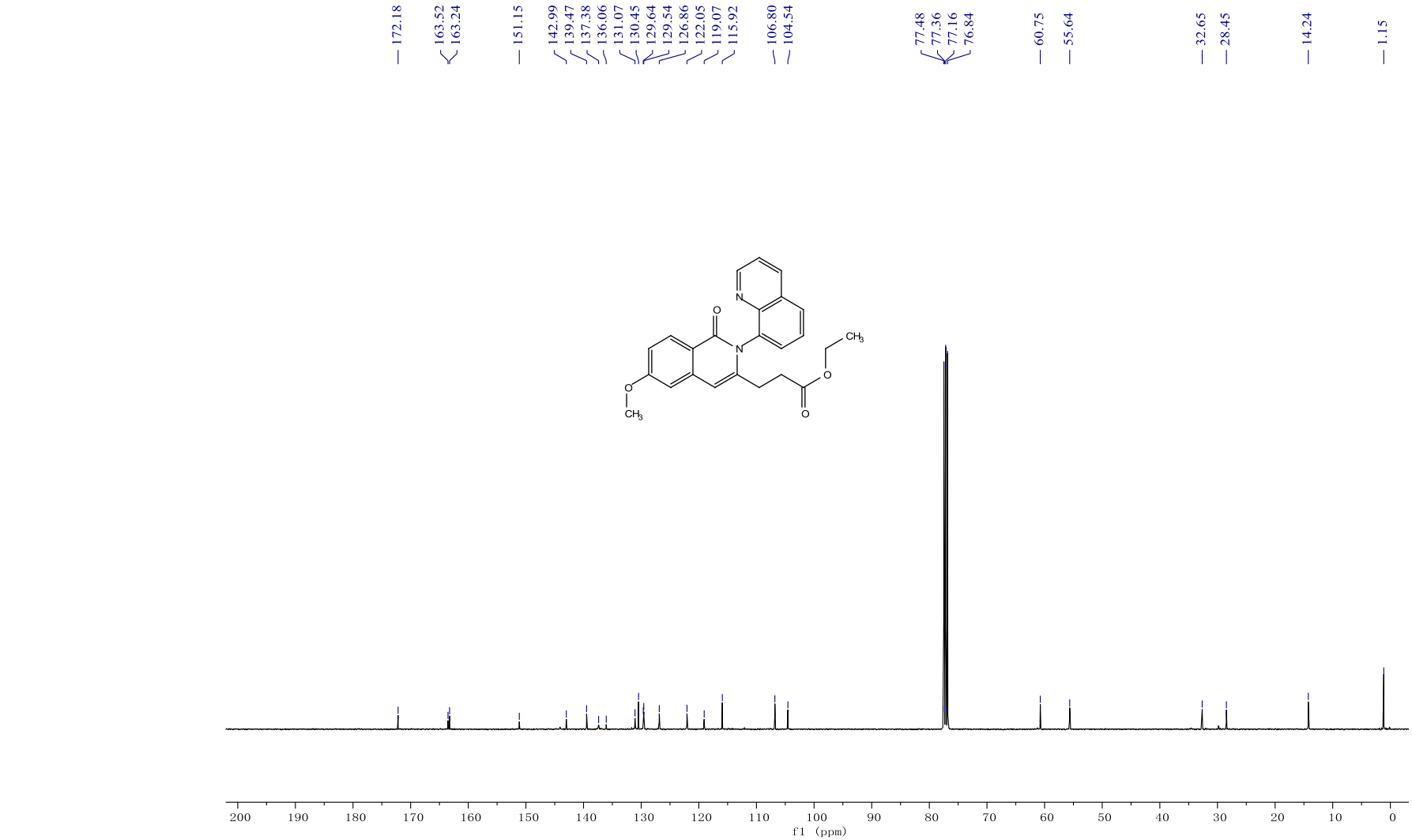
N
O
N
H3C
O
O
CH3
O
1.04 1.02 1.05 0.98 2.00 1.14 0.92 0.95 1.00 2.02 3.53 3.90 2.92
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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139.47
137.38
136.06
131.07
130.45
129.64
129.54
126.86
122.05
119.07
115.92
106.80
104.54
77.48
77.36
77.16
76.84
60.75
55.64
32.65
28.45
14.24
1.15
O
N
O
CH3
O
O
CH3
200
190
180
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150
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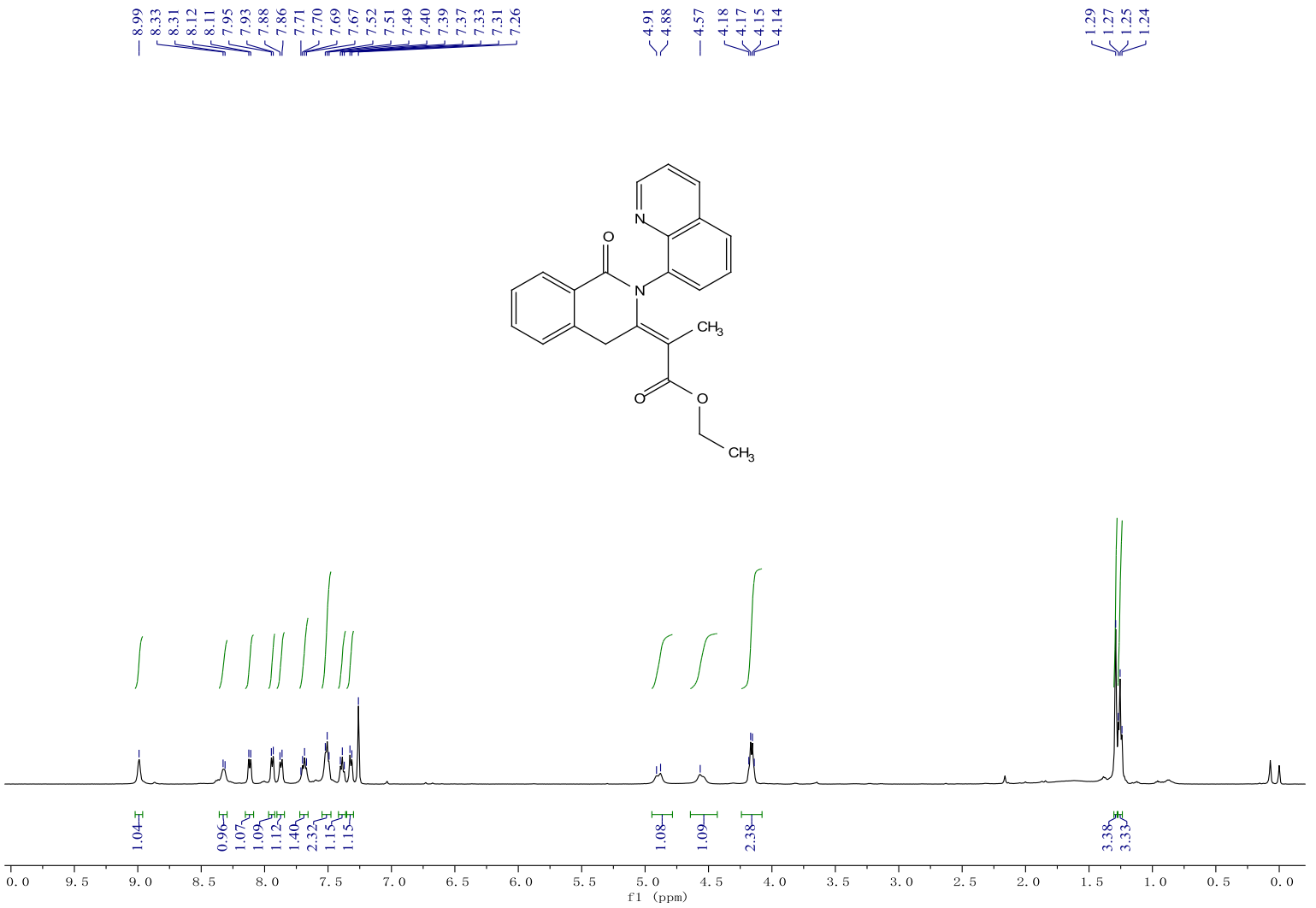
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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7.93
7.88
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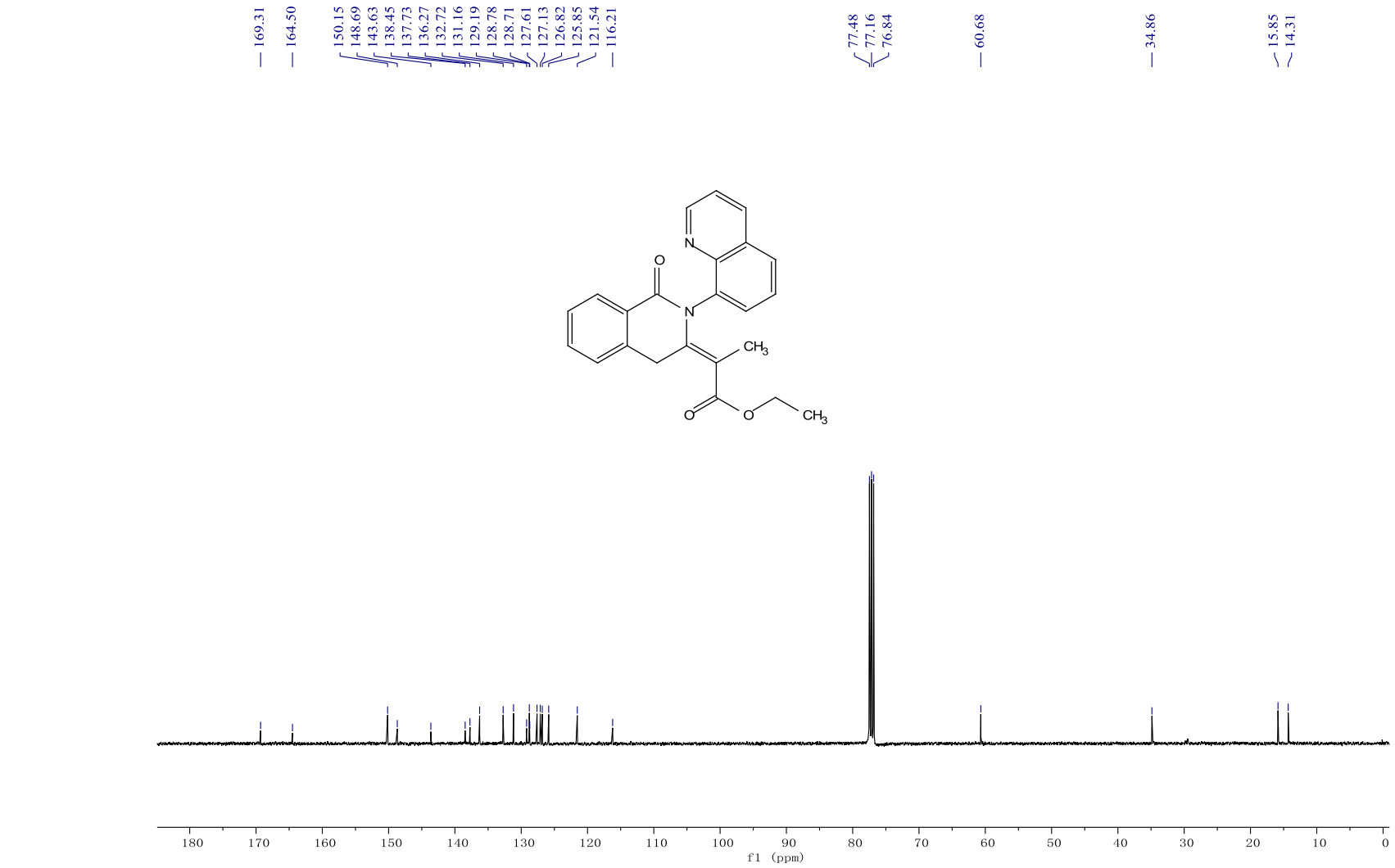
7.71
7.70
7.69
7.67
7.52
7.51
7.49
7.40
7.39
7.37
7.33
7.31
7.26
4.91
4.88
4.57
4.18
4.17
4.15
4.14
1.29
1.27
1.25
1.24
O
N
N
CH3
O
O
CH3
1.04
0.96
1.07
1.09
1.12
1.40
2.32
1.15
1.15
1.08
1.09
2.38
3.38
3.33
0.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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132.72
131.16
129.19
128.78
128.71
127.61
127.13
126.82
125.85
121.54
116.21
77.48
77.16
76.84
60.68
34.86
15.85
14.31
N
O
N
CH3
O
O
CH3
180
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130
120
110
100
90
80
70
60
50
40
30
20
10
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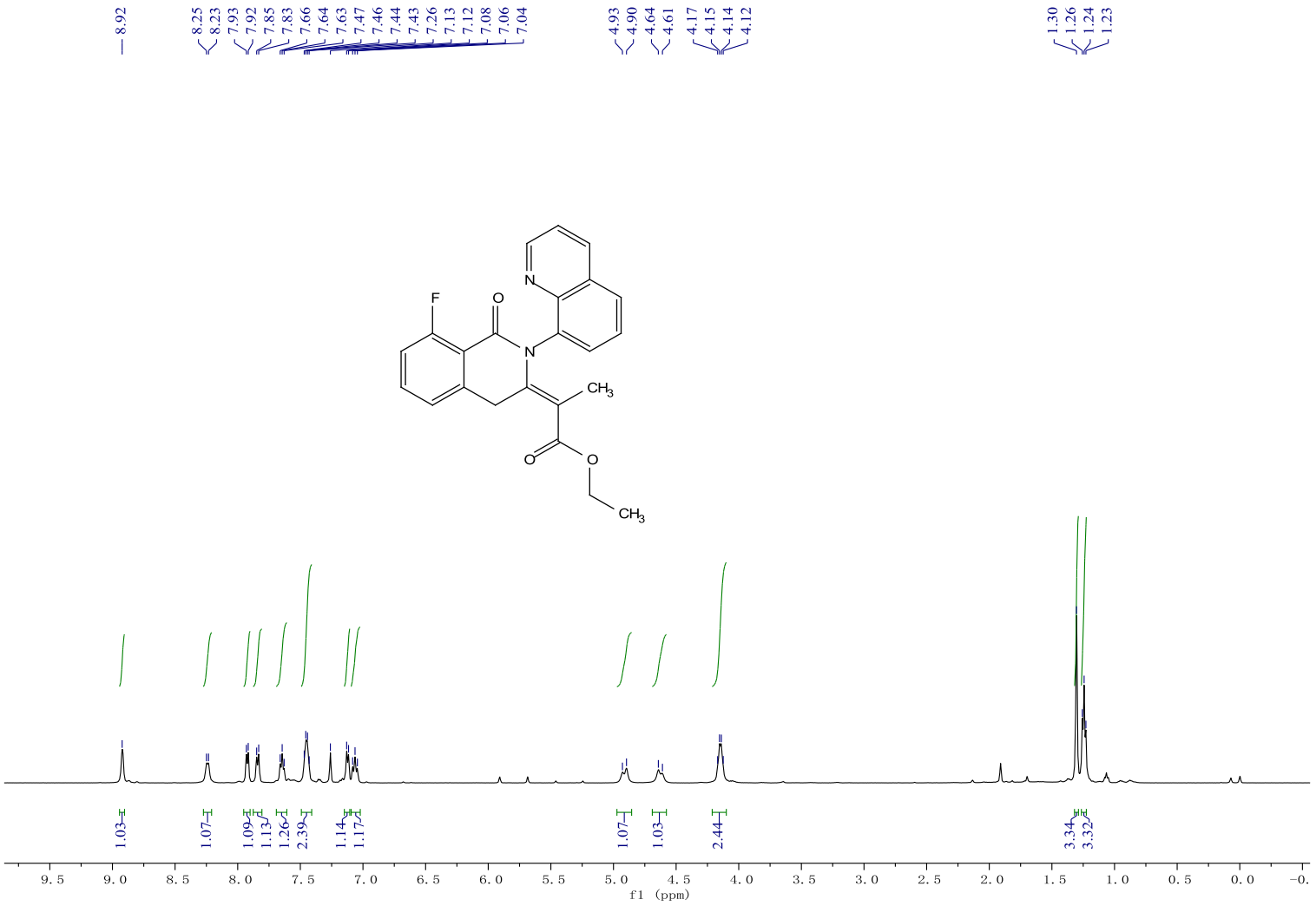
f1 (ppm)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7.63
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7.44
7.43
7.26
7.13
7.12
7.08
7.06
7.04
4.93
4.90
4.64
4.61
4.17
4.15
4.14
4.12
1.30
1.26
1.24
1.23
F
O
N
N
CH3
O
O
CH3
1.03
1.07
1.09
1.13
1.26
2.39
1.14
1.17
1.07
1.03
2.44
3.34
3.32
9.5
9.0
8.5
8.0
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7.0
6.5
6.0
5.5
5.0
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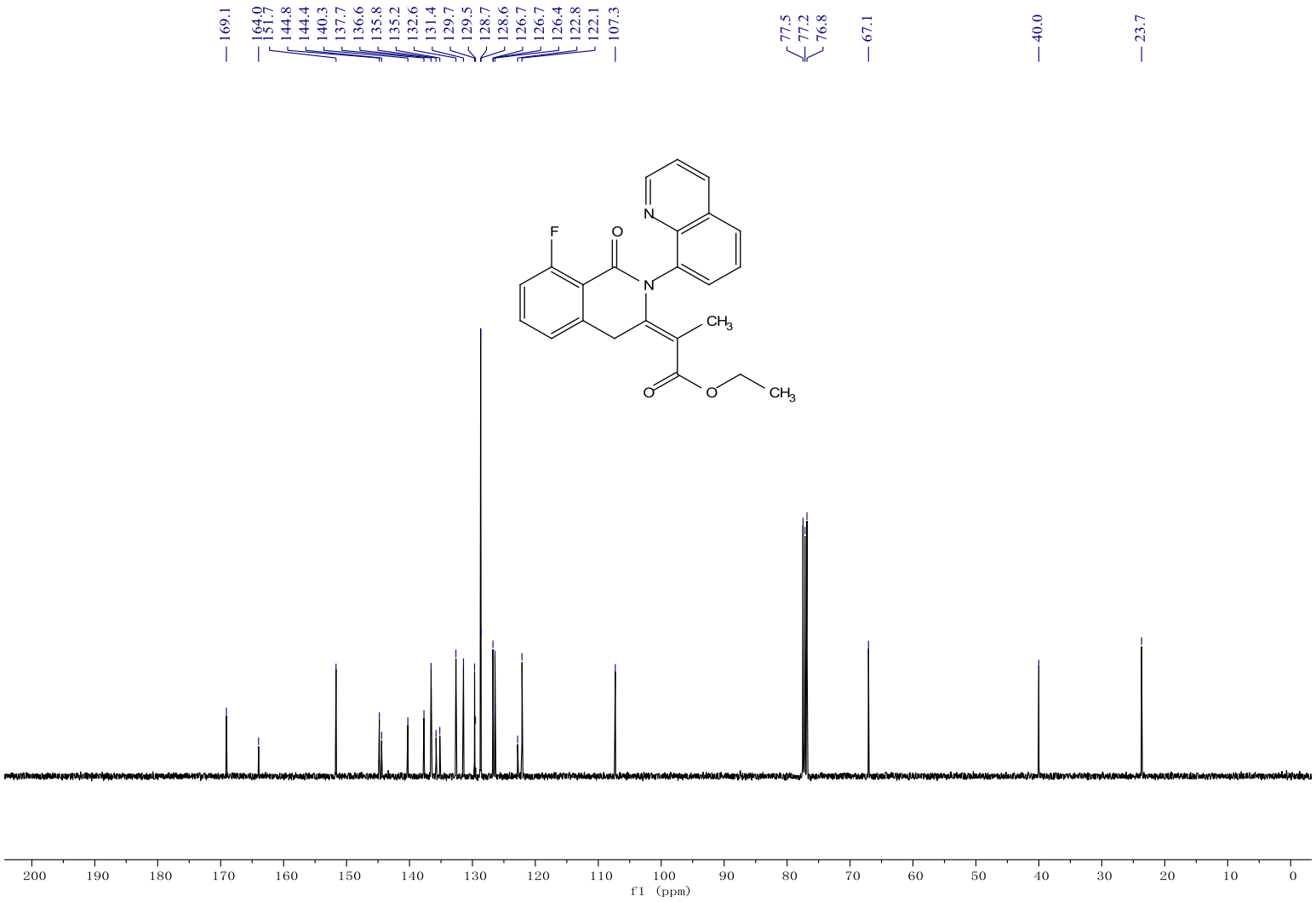
f1 (ppm)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135.2
132.6
131.4
129.7
129.5
128.7
128.6
126.7
126.4
122.8
122.1
107.3
77.5
77.2
76.8
67.1
40.0
23.7
F
O
N
N
CH3
O
O
CH3
200
190
180
170
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130
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110
100
90
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70
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50
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30
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10
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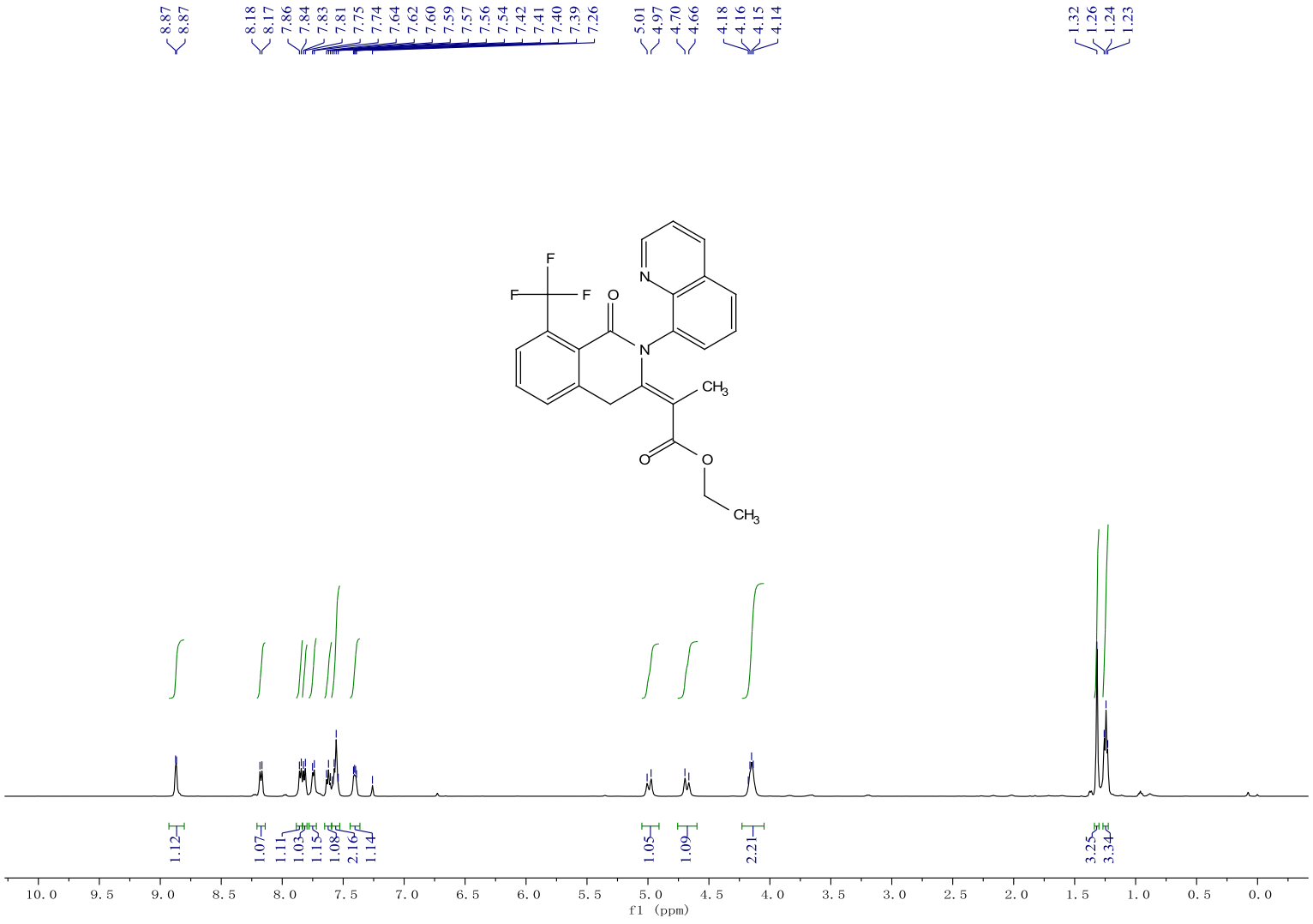
f1 (ppm)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7.83
7.81
7.75
7.74
7.64
7.62
7.60
7.59
7.57
7.56
7.54
7.42
7.41
7.40
7.39
7.26
5.01
4.97
4.70
4.66
4.18
4.16
4.15
4.14
1.32
1.26
1.24
1.23
F
F
F
O
N
N
CH3
O
O
CH3
1.12
1.07
1.11
1.03
1.15
1.08
2.16
1.14
1.05
1.09
2.21
3.25
3.34
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
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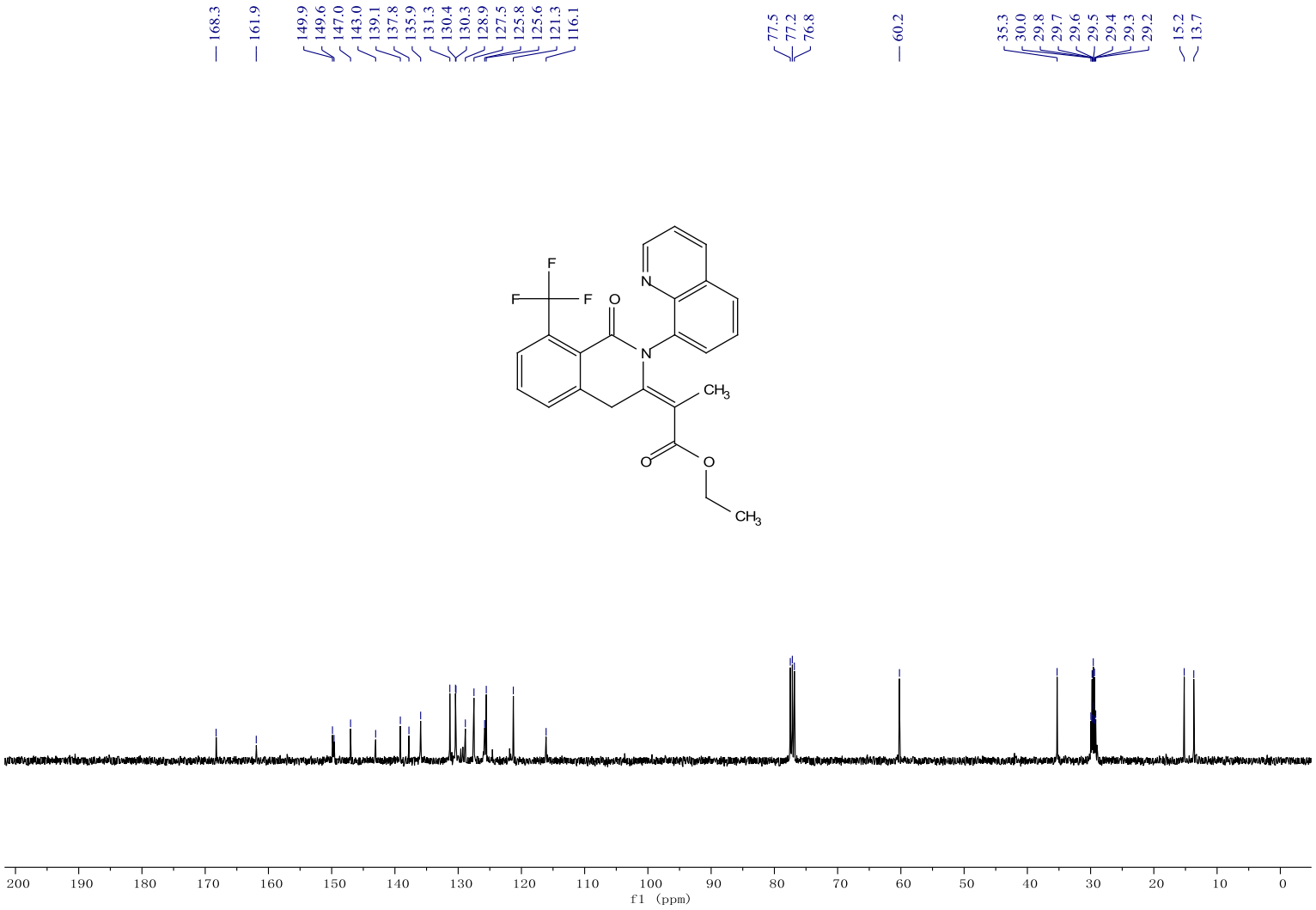
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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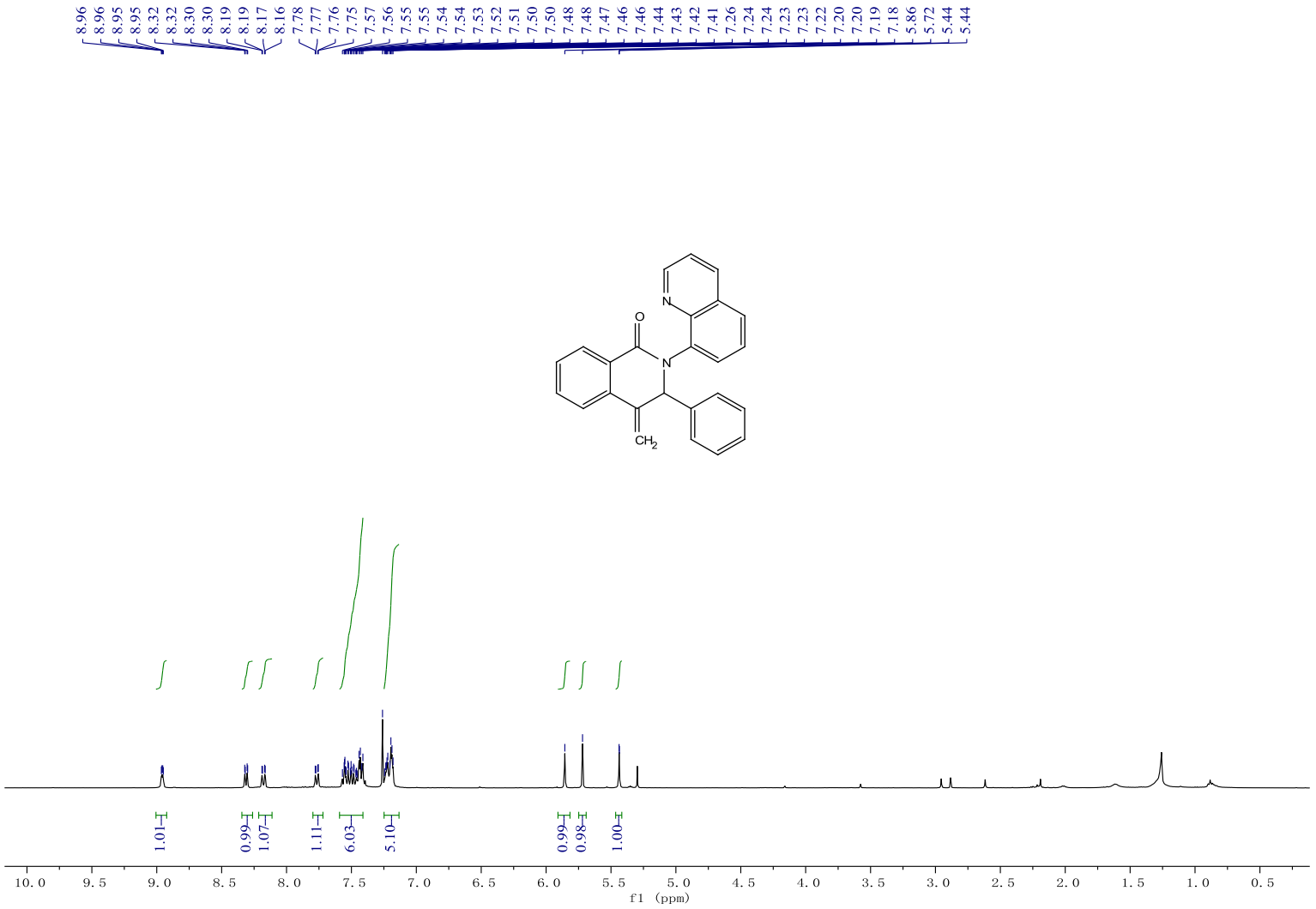
131.3
130.4
130.3
128.9
127.5
125.8
125.6
121.3
116.1
77.5
77.2
76.8
60.2
35.3
30.0
29.8
29.7
29.6
29.5
29.4
29.3
29.2
15.2
13.7
F
F
F
O
N
N
CH3
O
O
CH3
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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8.30
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8.19
8.17
8.16
7.78
7.77
7.76
7.75
7.57
7.56
7.55
7.55
7.54
7.54
7.53
7.52
7.51
7.50
7.50
7.48
7.48
7.47
7.46
7.46
7.44
7.43
7.42
7.41
7.26
7.24
7.24
7.23
7.23
7.22
7.20
7.20
7.19
7.18
5.86
5.72
5.44
5.44
O
N
N
CH2
1.01
0.99
1.07
1.11
6.03
5.10
0.99
0.98
1.00
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
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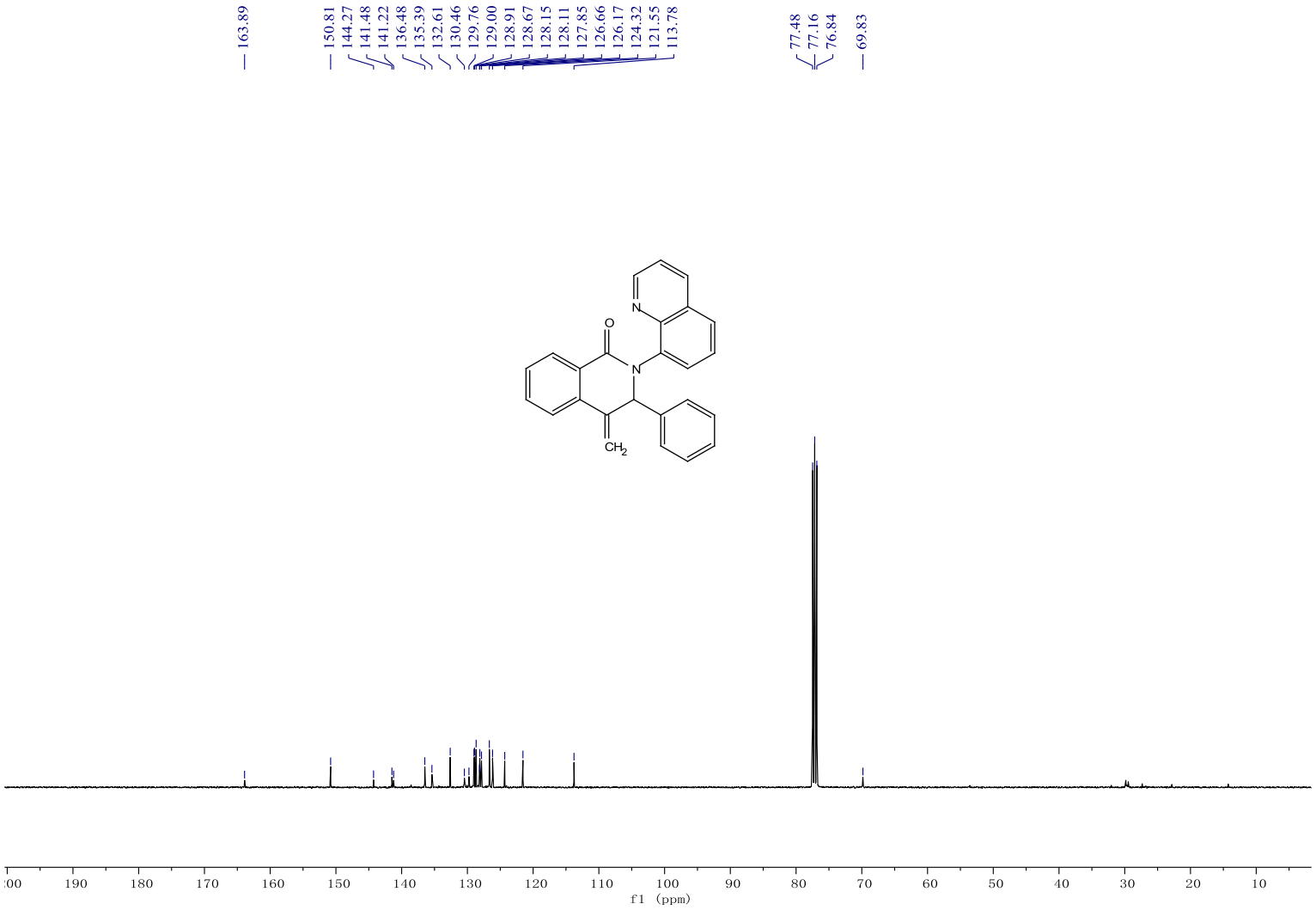
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
f1 (ppm)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144.27
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135.39
132.61
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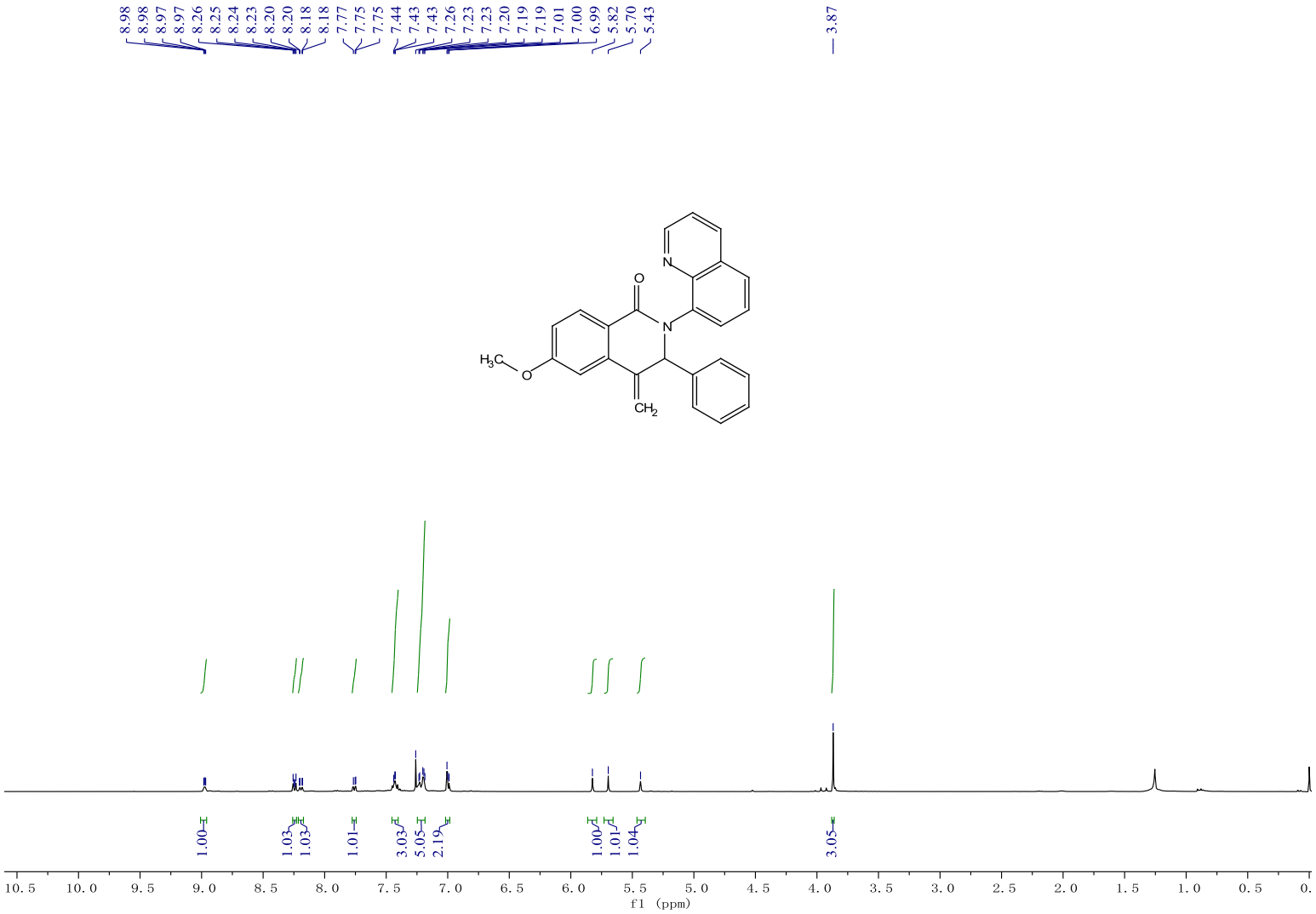
129.76
129.00
128.91
128.67
128.15
128.11
127.85
126.66
126.17
124.32
121.55
113.78
77.48
77.16
76.84
69.83
O
N
N
CH2
f1 (ppm)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8.97
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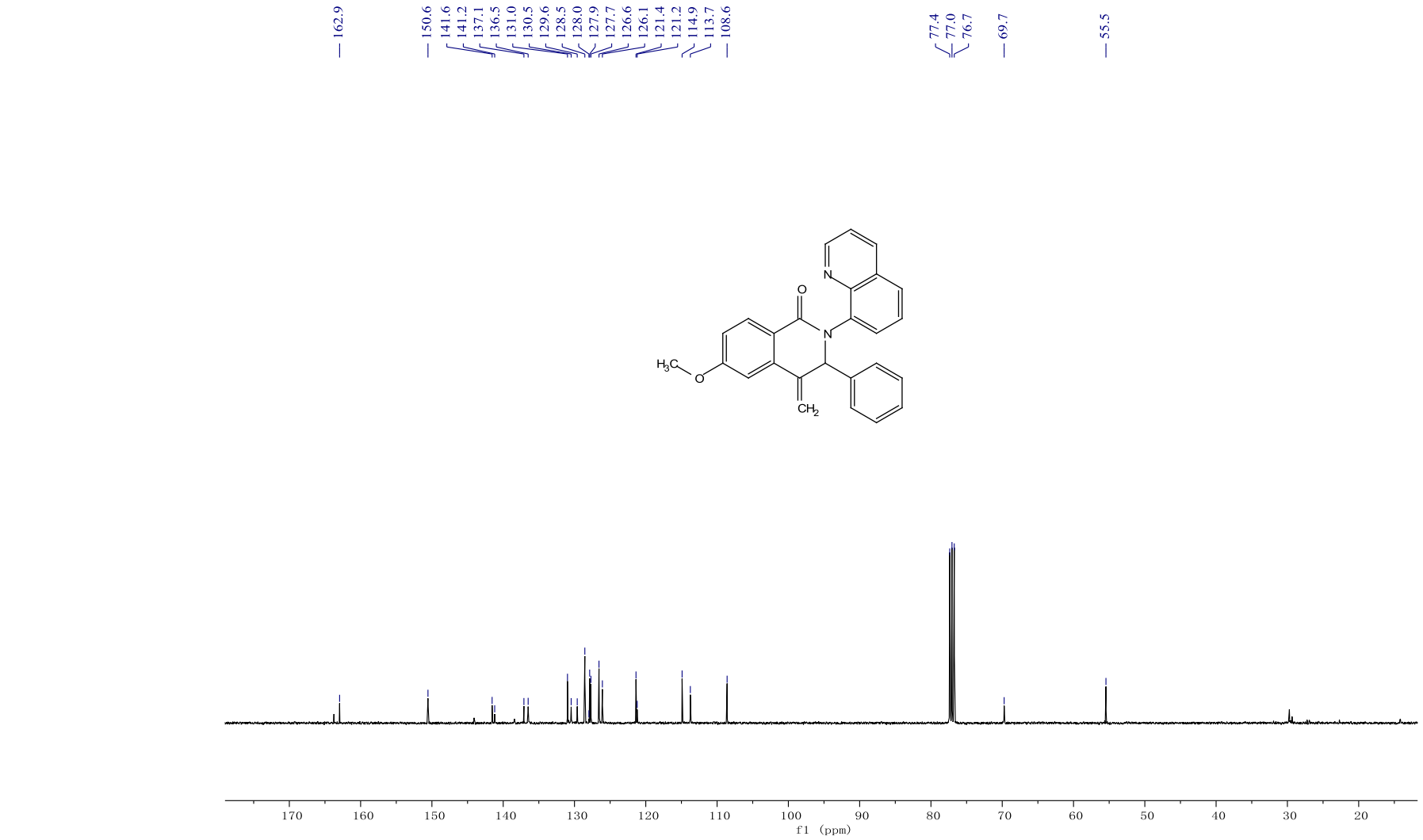
8.25
8.24
8.23
8.20
8.20
8.18
8.18
7.77
7.75
7.75
7.44
7.43
7.43
7.26
7.23
7.23
7.20
7.19
7.19
7.01
7.00
6.99
5.82
5.70
5.43
3.87
N
O
N
H3C
O
CH2
1.00
1.03
1.03
1.01
3.03
5.05
2.19
1.00
1.01
1.04
3.05
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.
f1 (ppm)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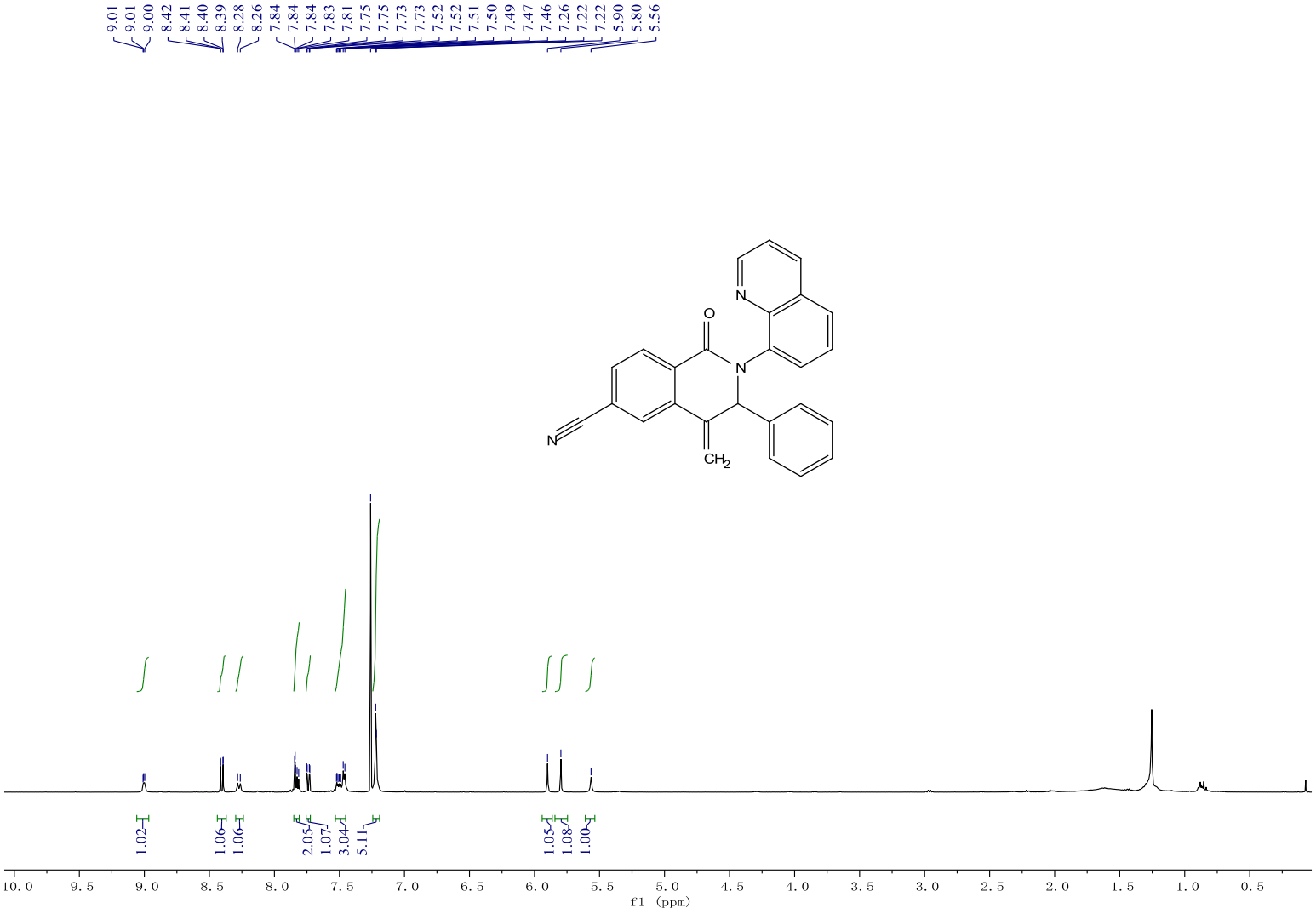
136.5
131.0
130.5
129.6
128.5
128.0
127.9
127.7
126.6
126.1
121.4
121.2
114.9
113.7
108.6
77.4
77.0
76.7
69.7
55.5
O
N
N
H3C
O
CH2
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
f1 (ppm)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9.00
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7.84
7.84
7.83
7.81
7.75
7.75
7.73
7.73
7.52
7.52
7.51
7.50
7.49
7.47
7.46
7.26
7.22
7.22
5.90
5.80
5.56
O
N
N
N
CH2
1.02
1.06
1.06
2.05
1.07
3.04
5.11
1.05
1.08
1.00
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
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5.0
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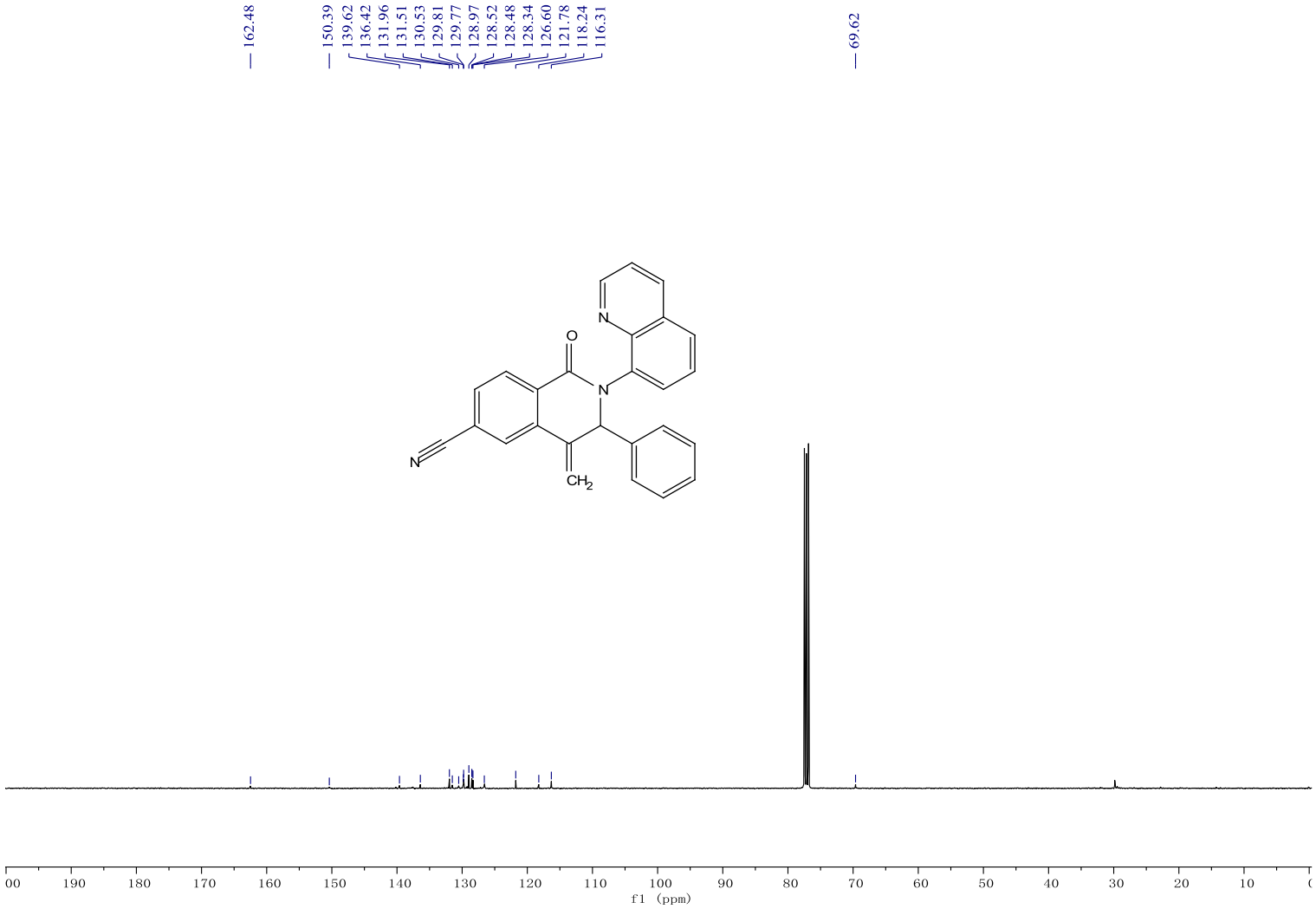
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
f1 (ppm)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128.97
128.52
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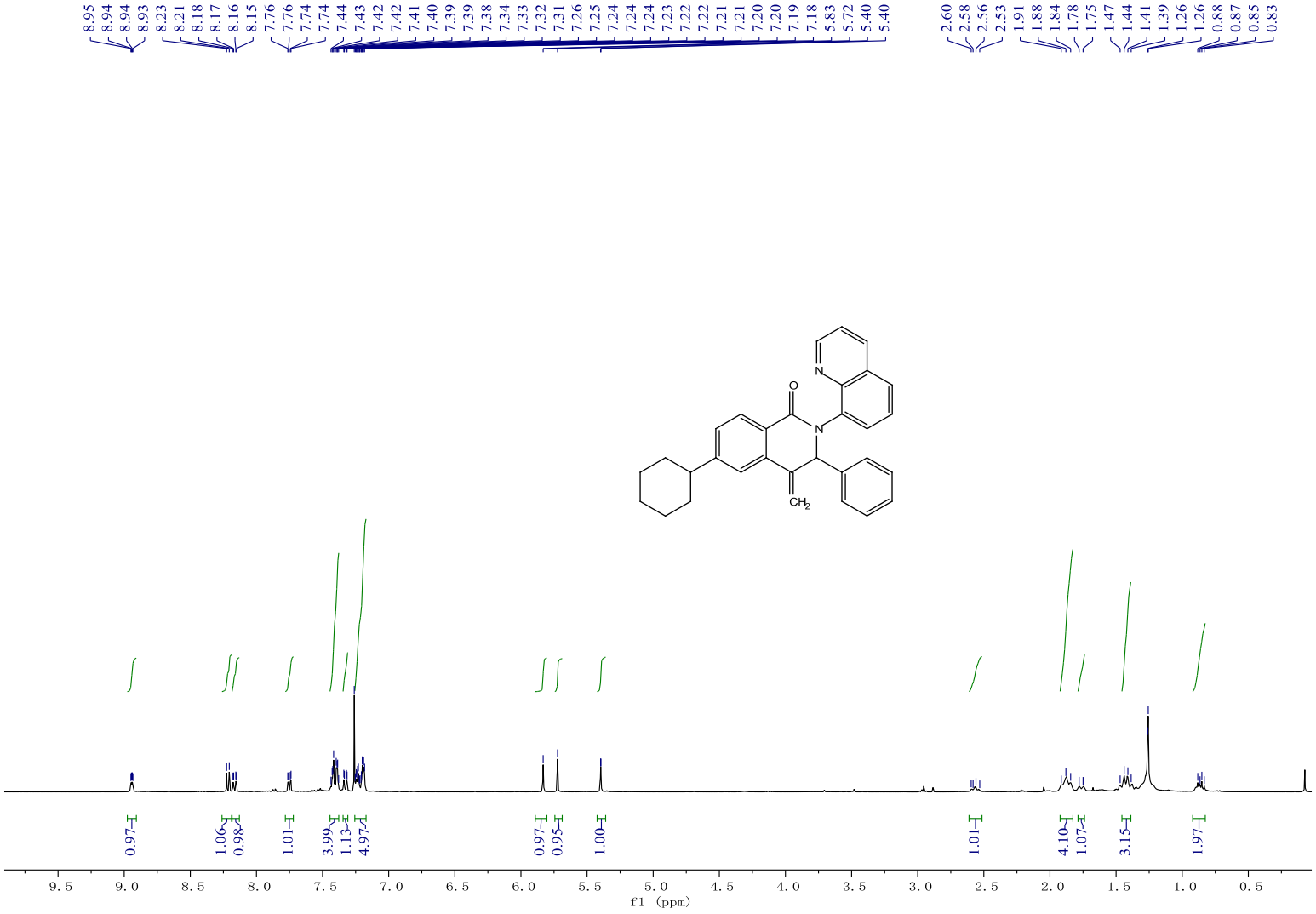
128.34
126.60
121.78
118.24
116.31
69.62
O
N
N
CH2
f1 (ppm)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8.94
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8.17
8.16
8.15
7.76
7.76
7.74
7.74
7.44
7.43
7.42
7.42
7.41
7.40
7.39
7.39
7.38
7.34
7.33
7.32
7.31
7.26
7.25
7.24
7.24
7.24
7.23
7.22
7.22
7.21
7.21
7.20
7.20
7.19
7.18
5.83
5.72
5.40
5.40
2.60
2.58
2.56
2.53
1.91
1.88
1.84
1.78
1.75
1.47
1.44
1.41
1.39
1.26
1.26
0.88
0.87
0.85
0.83
O
N
N
CH2
0.97
1.06
0.98
1.01
3.99
1.13
4.97
0.97
0.95
1.00
1.01
4.10
1.07
3.15
1.97
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
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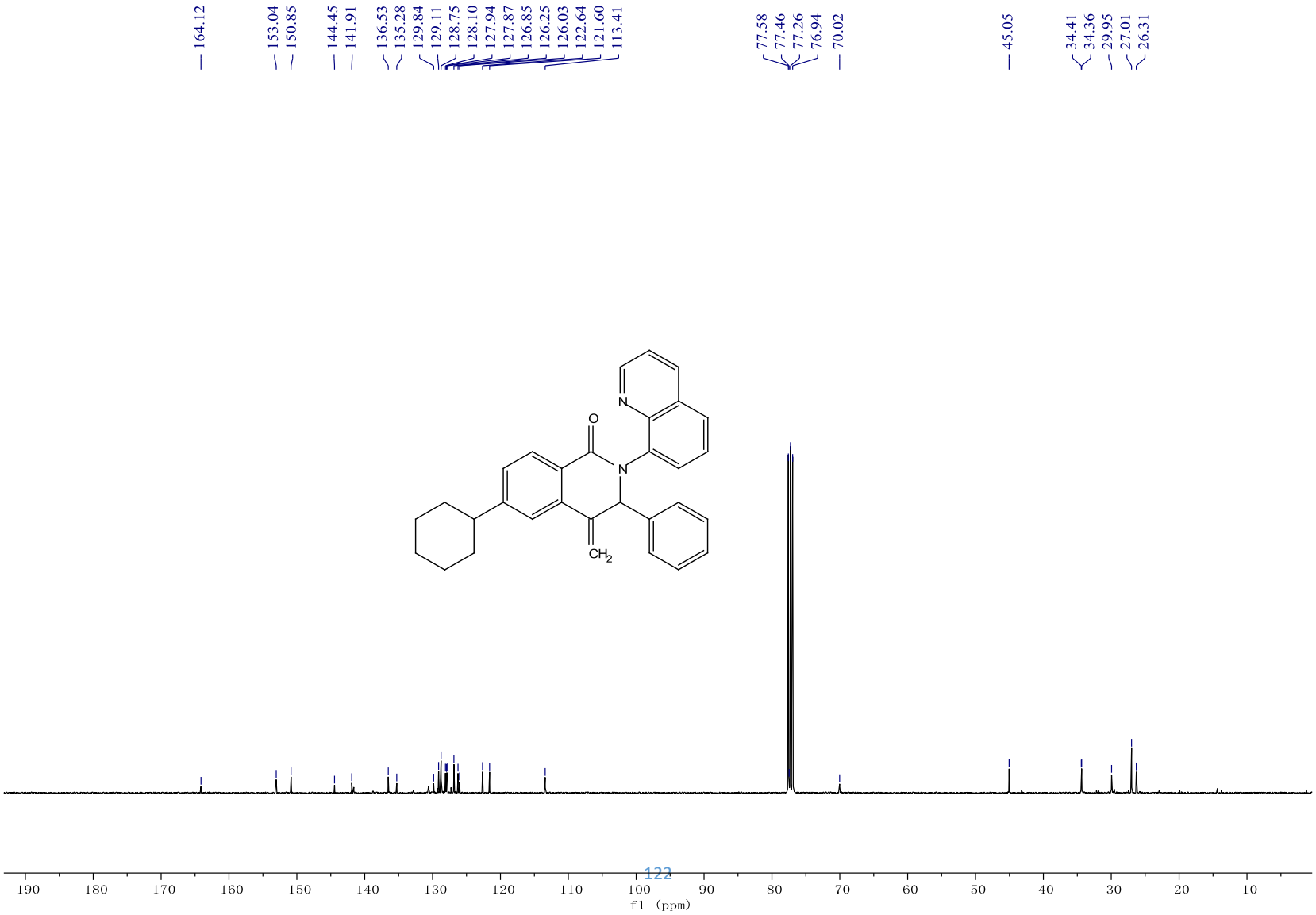
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
f1 (ppm)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153.04
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129.84
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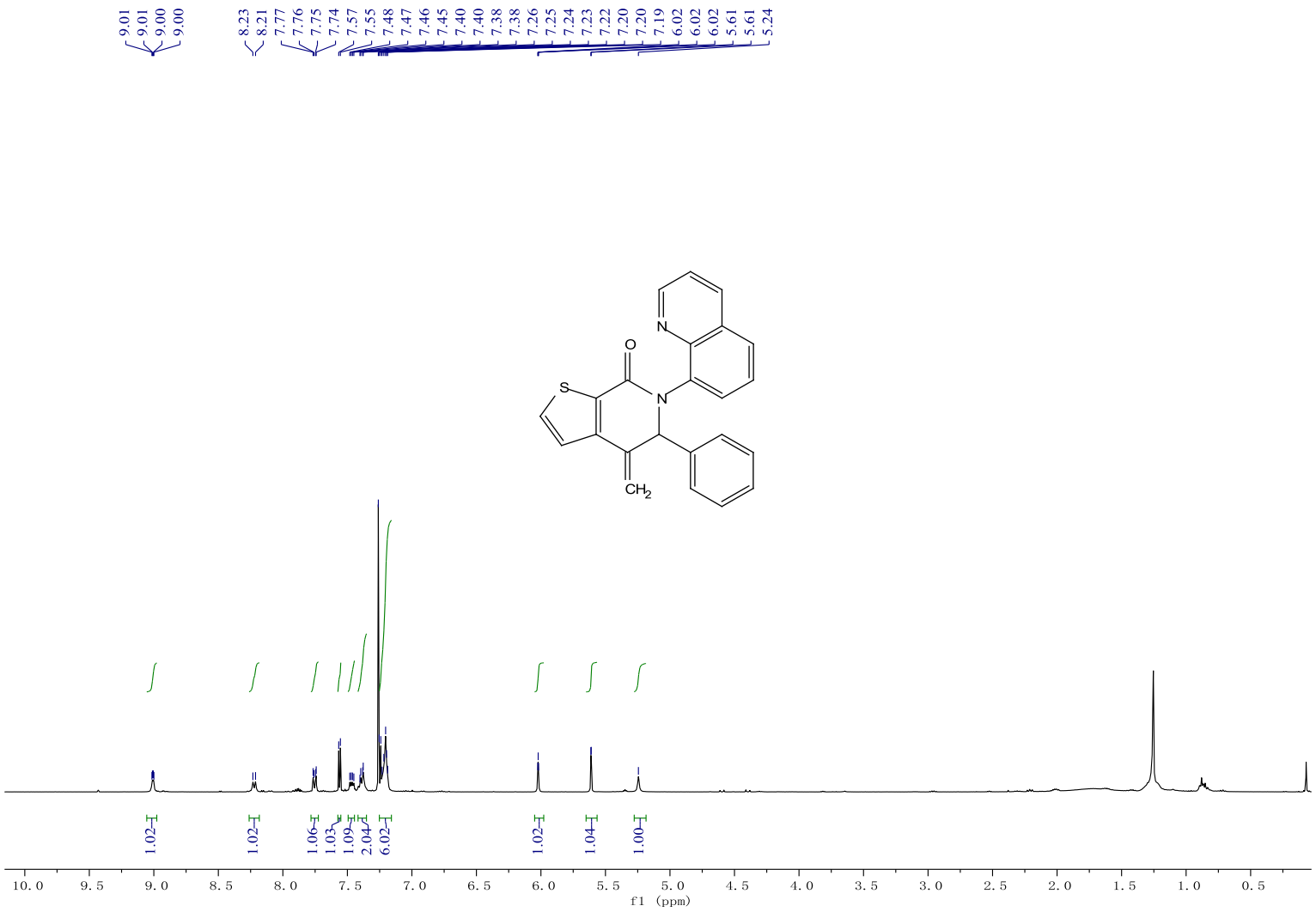
128.75
128.10
127.94
127.87
126.85
126.25
126.03
122.64
121.60
113.41
77.58
77.46
77.26
76.94
70.02
45.05
34.41
34.36
29.95
27.01
26.31
O
N
N
CH2
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)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9.00
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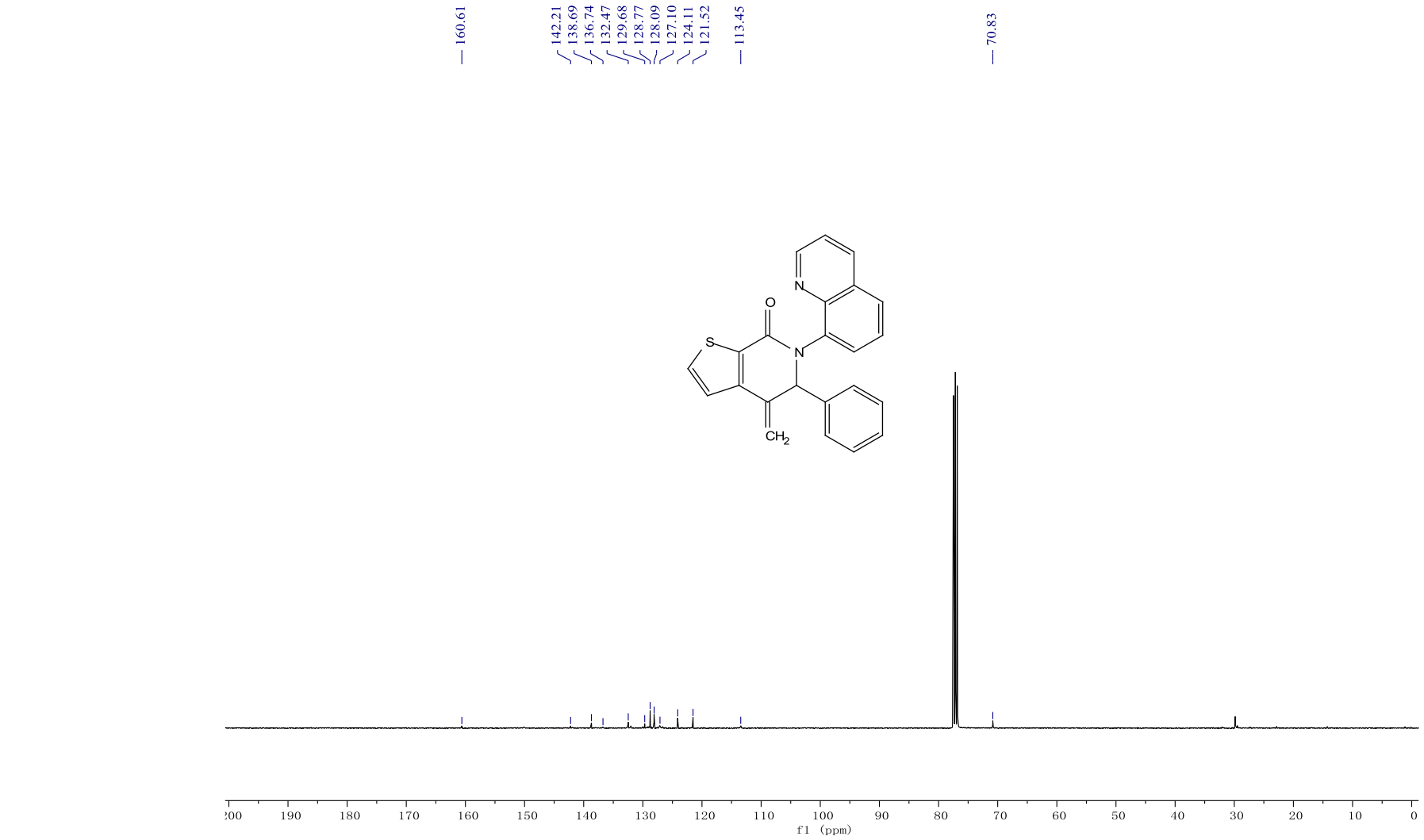
7.76
7.75
7.74
7.57
7.55
7.48
7.47
7.46
7.45
7.40
7.40
7.38
7.38
7.26
7.25
7.24
7.23
7.22
7.20
7.20
7.19
6.02
6.02
6.02
5.61
5.61
5.24
O
N
S
N
CH2
1.02
1.02
1.06
1.03
1.09
2.04
6.02
1.02
1.04
1.00
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
f1 (ppm)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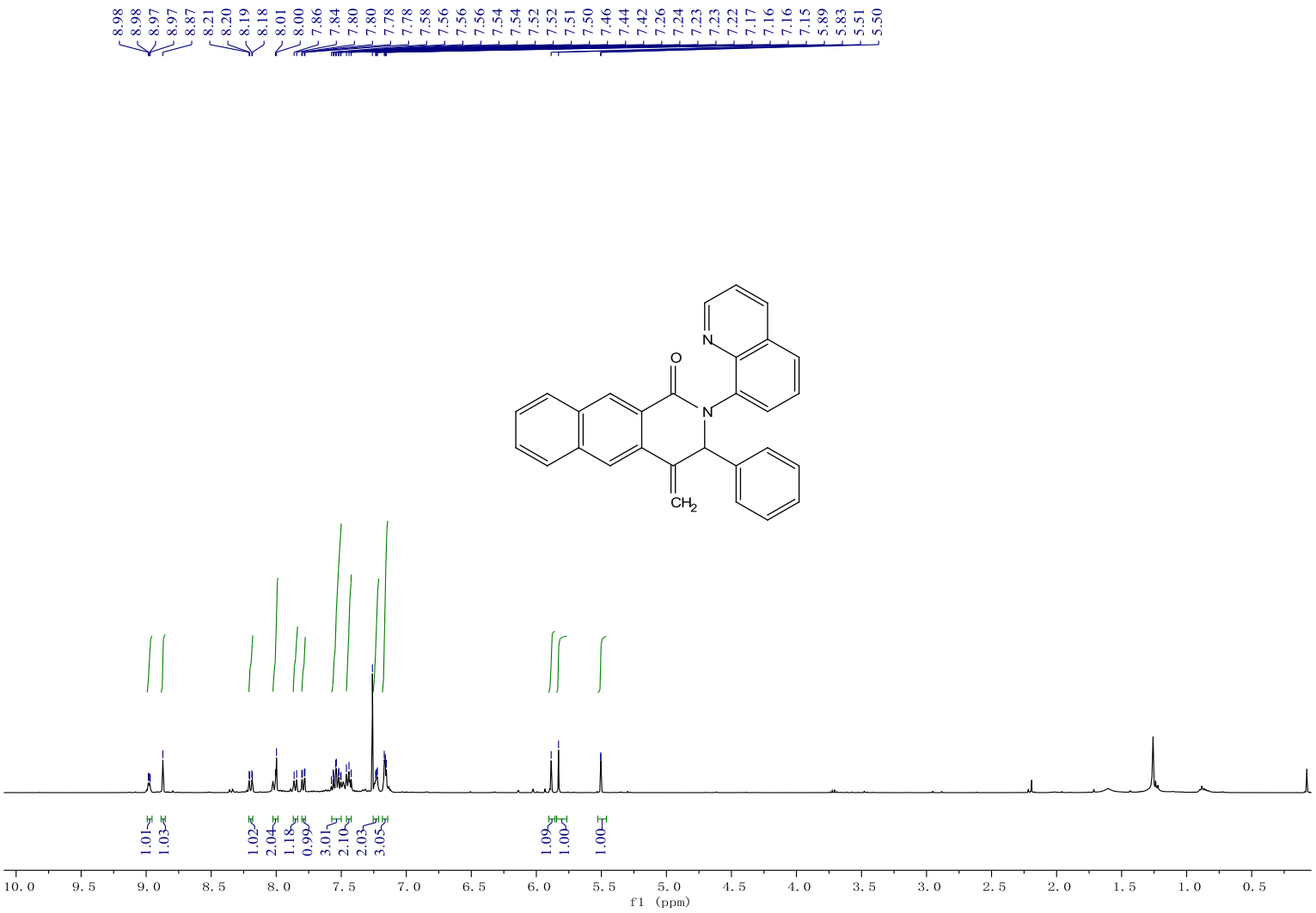
136.74
132.47
129.68
128.77
128.09
127.10
124.11
121.52
113.45
70.83
O
S
N
N
CH2
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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8.19
8.18
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7.56
7.56
7.54
7.54
7.52
7.52
7.51
7.50
7.46
7.44
7.42
7.26
7.24
7.23
7.23
7.22
7.17
7.16
7.16
7.15
5.89
5.83
5.51
5.50
O
N
N
CH2
1.01
1.03
1.02
2.04
1.18
0.99
3.01
2.10
2.03
3.05
1.09
1.00
1.00
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
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5.0
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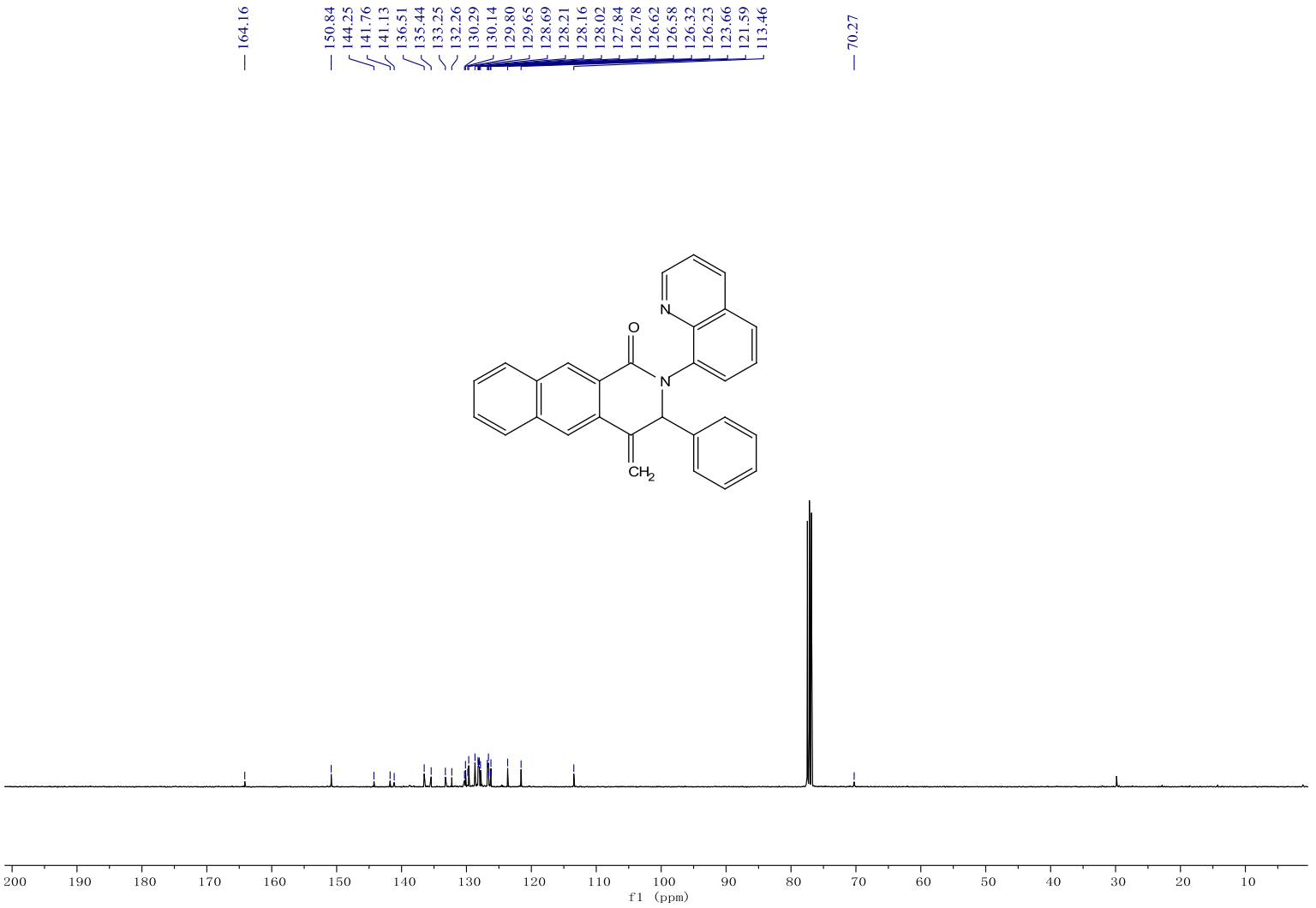
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
f1 (ppm)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133.25
132.26
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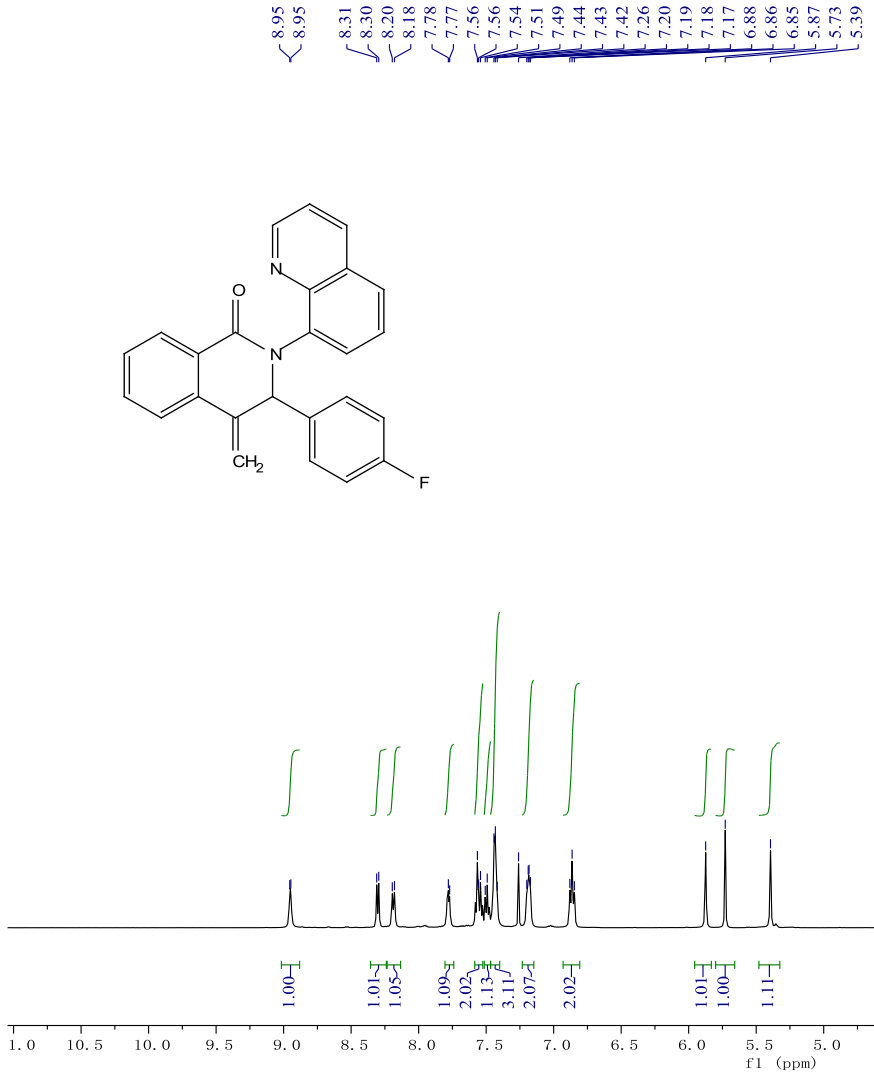
130.14
129.80
129.65
128.69
128.21
128.16
128.02
127.84
126.78
126.62
126.58
126.32
126.23
123.66
121.59
113.46
70.27
O
N
N
CH2
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)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8.18
7.78
7.77
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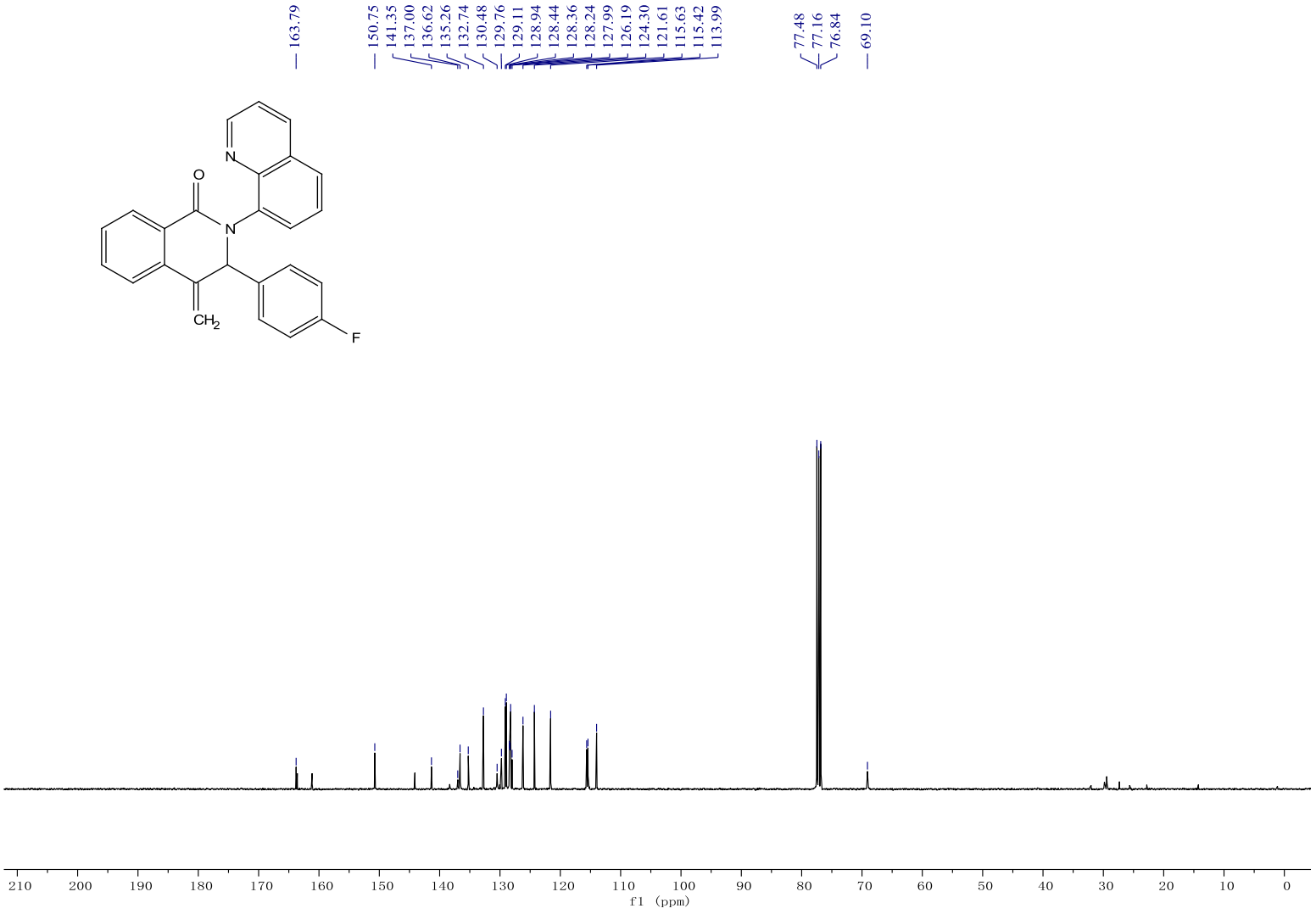
7.56
7.54
7.51
7.49
7.44
7.43
7.42
7.26
7.20
7.19
7.18
7.17
6.88
6.86
6.85
5.87
5.73
5.39
O
N
N
CH2
F
1.00
1.01
1.05
1.09
2.02
1.13
3.11
2.07
2.02
1.01
1.00
1.11
1.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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130.48
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129.11
128.94
128.44
128.36
128.24
127.99
126.19
124.30
121.61
115.63
115.42
113.99
77.48
77.16
76.84
69.10
O
N
N
CH2
F
210
200
190
180
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110
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90
80
70
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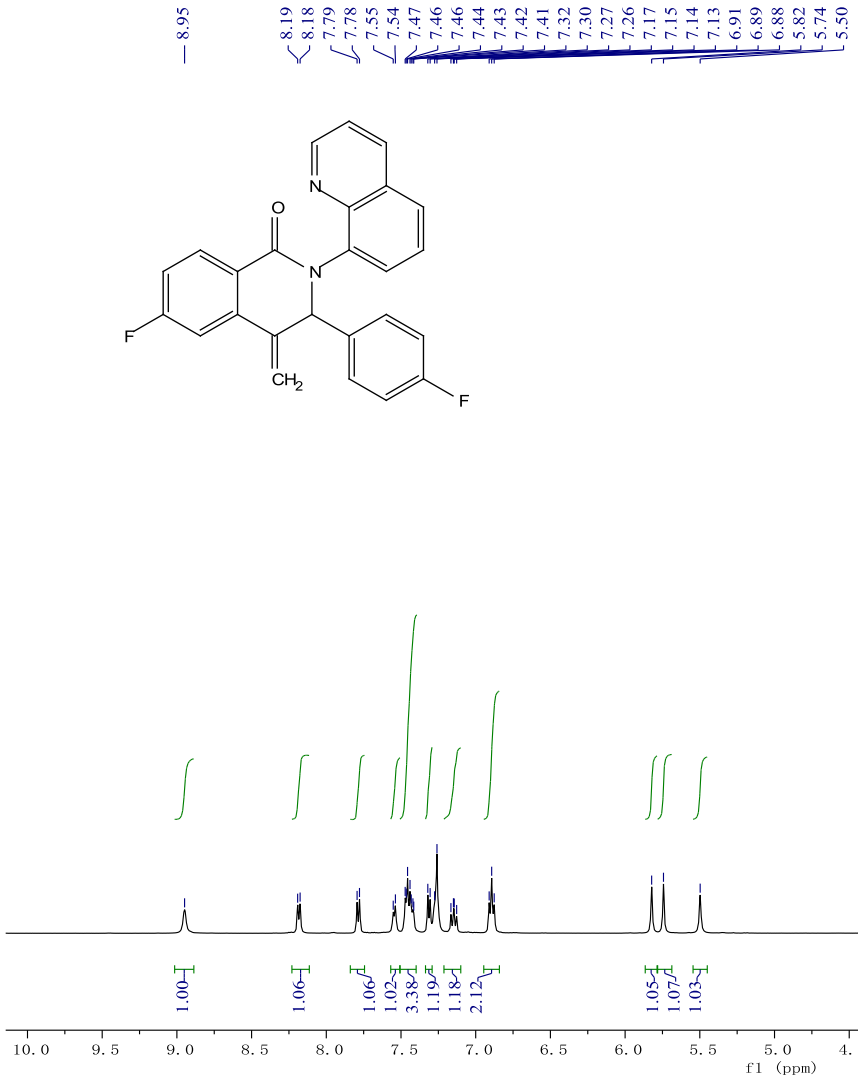
50
40
30
20
10
0
f1 (ppm)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7.54
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7.42
7.41
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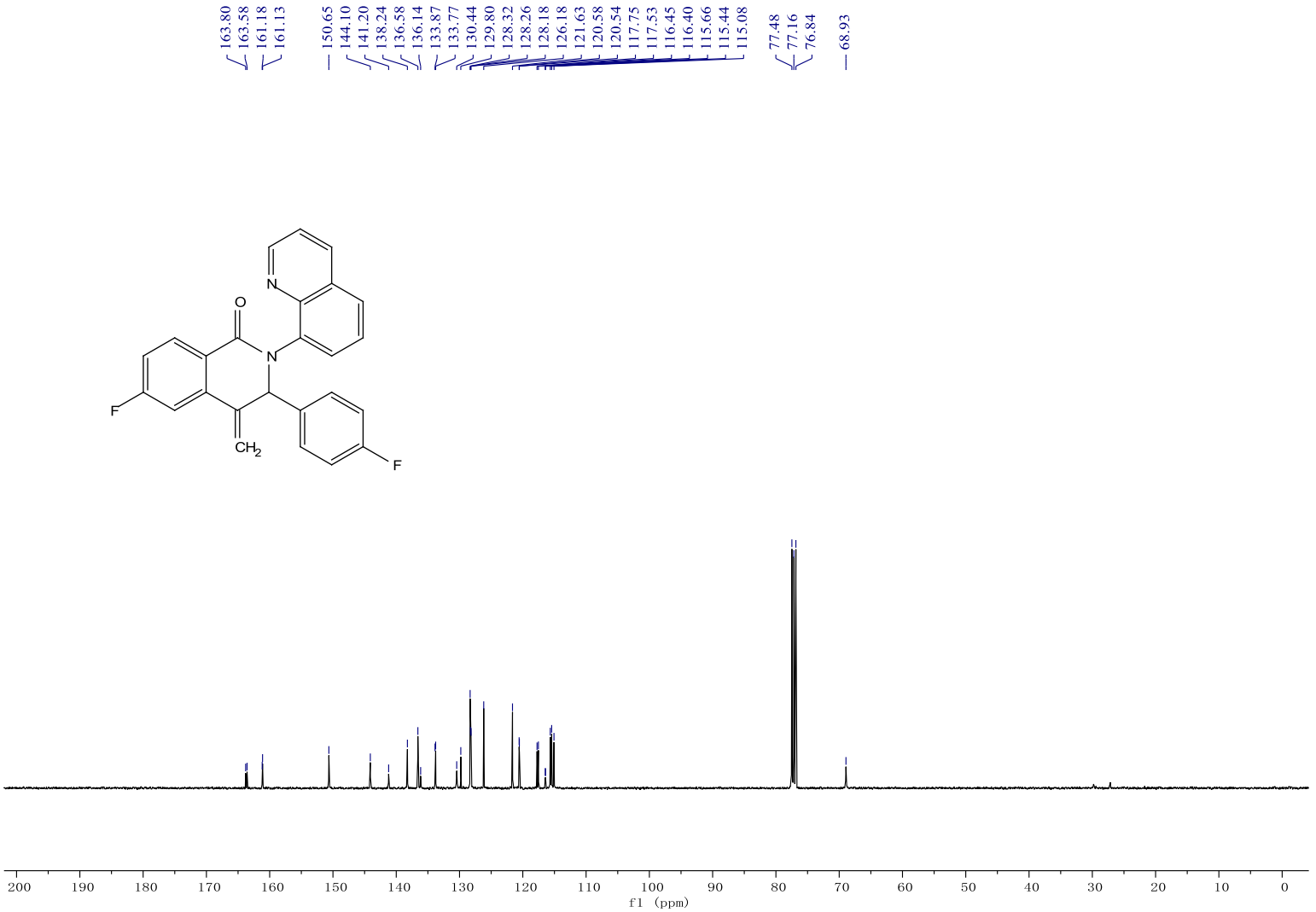
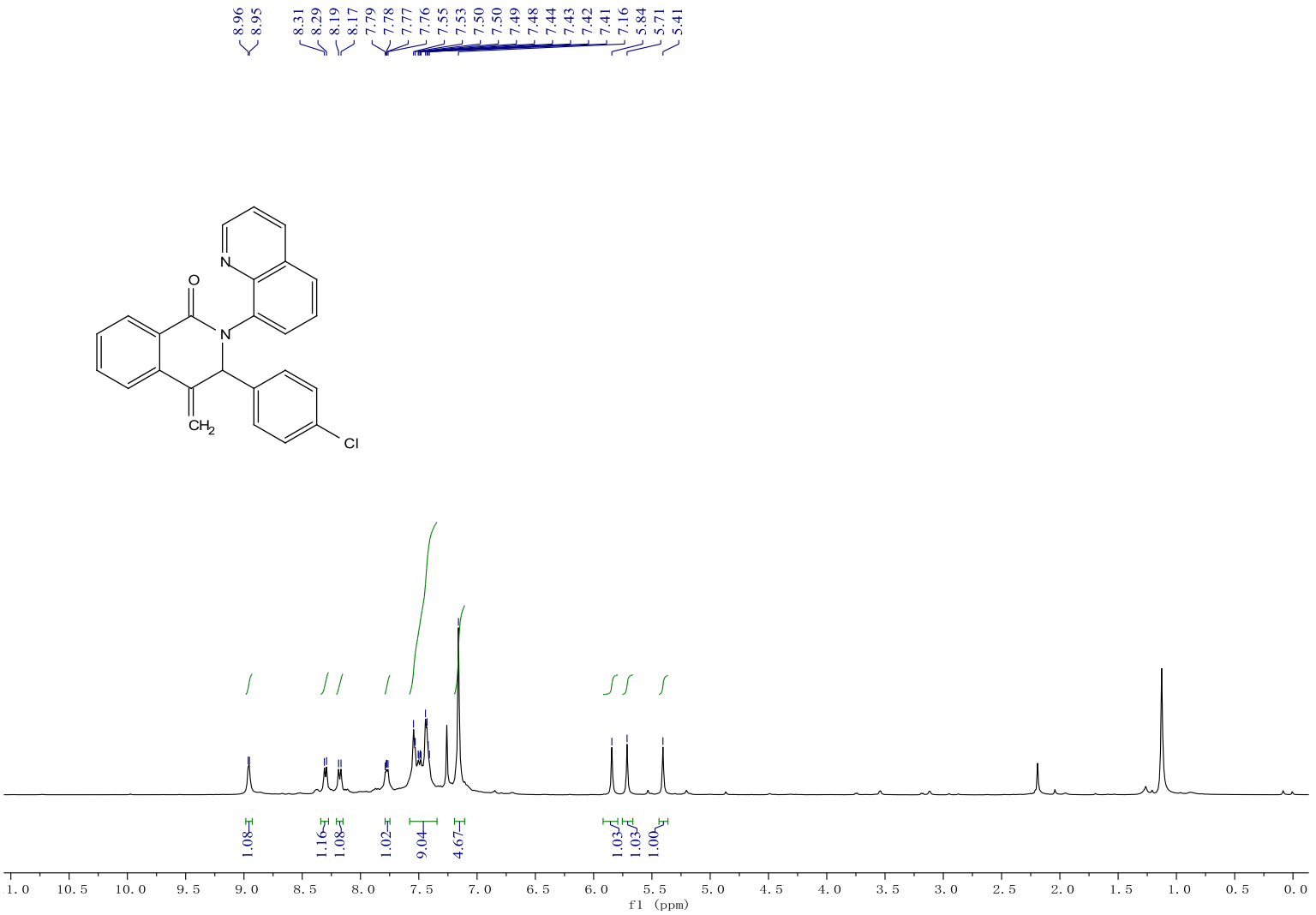
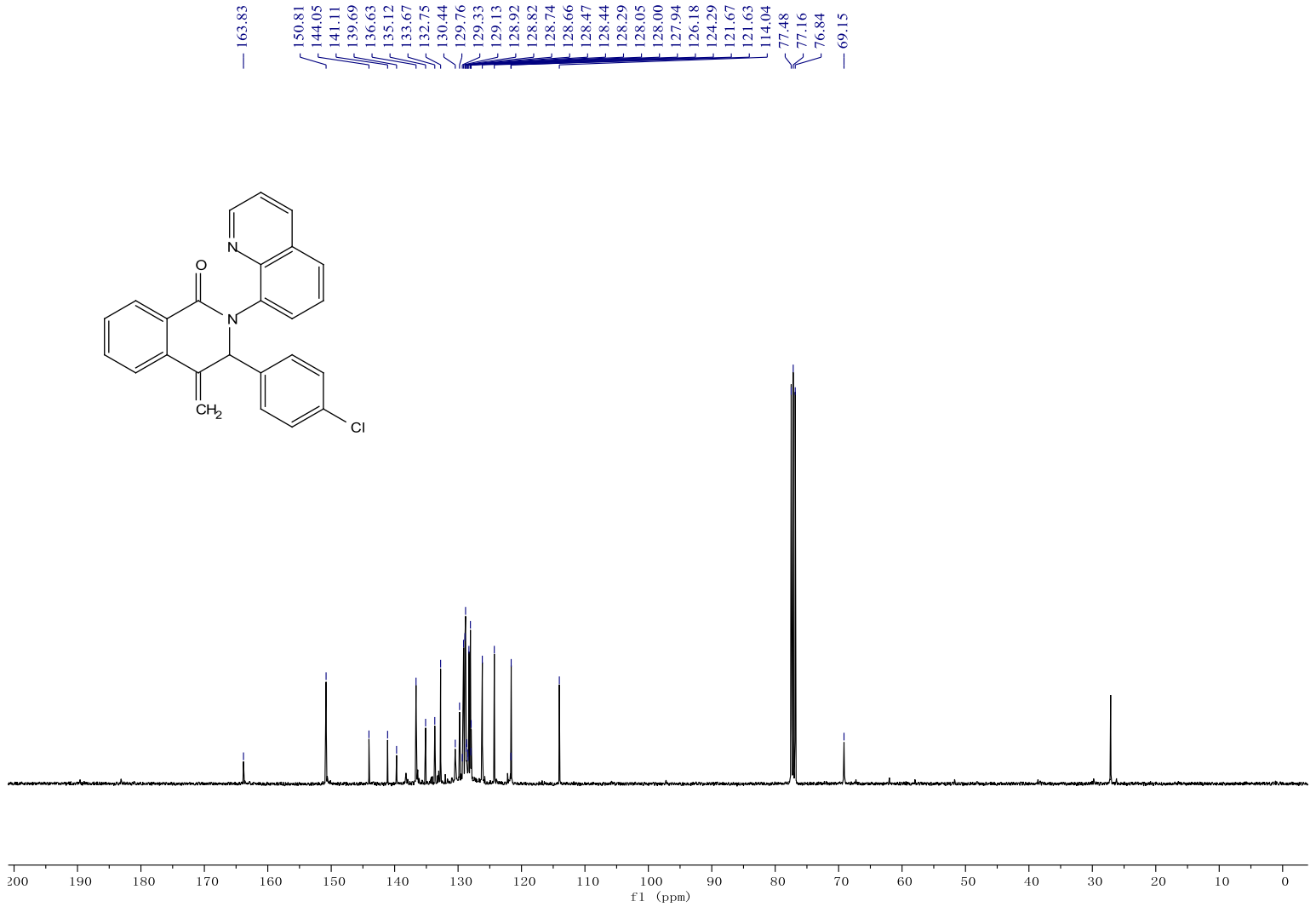
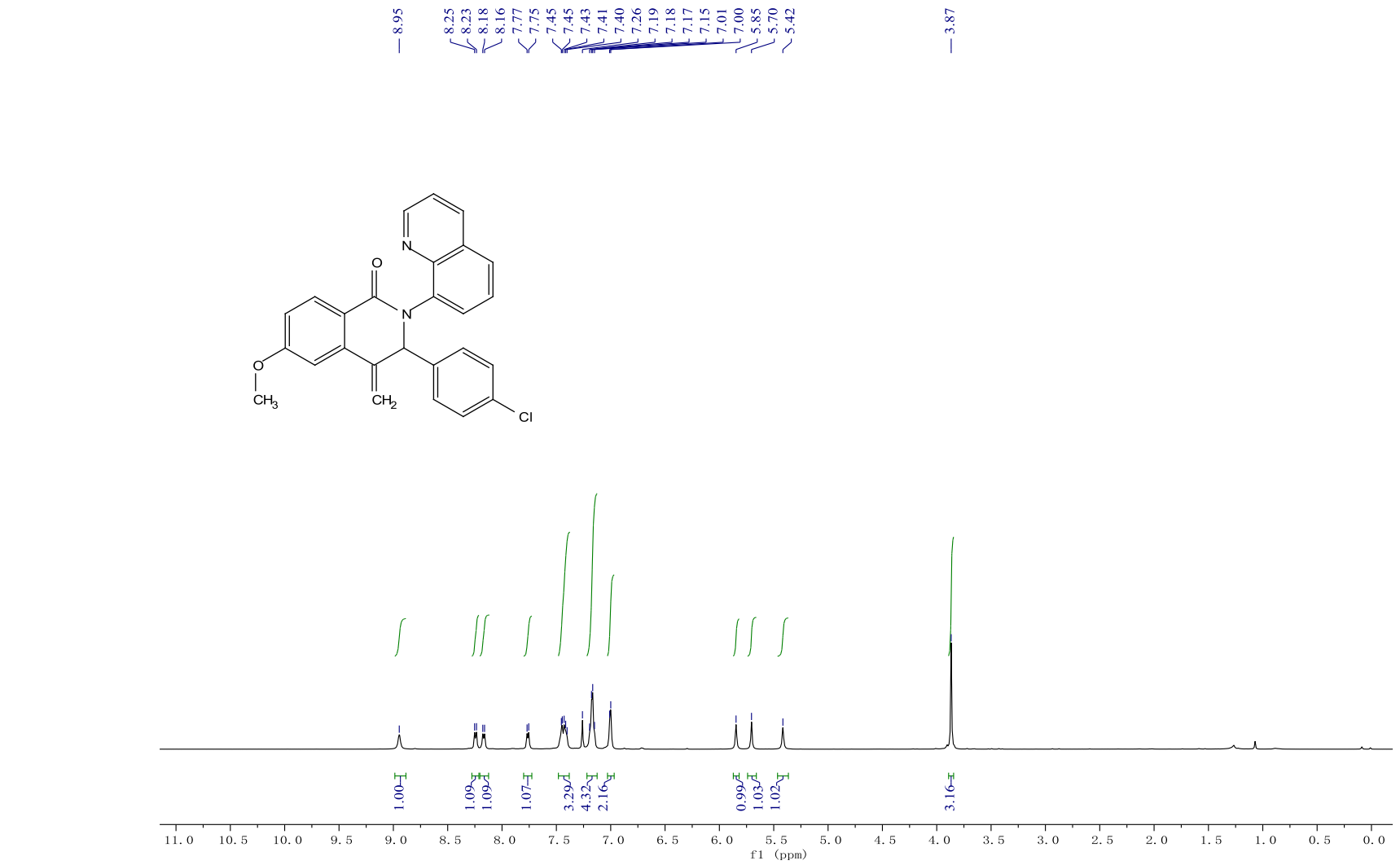
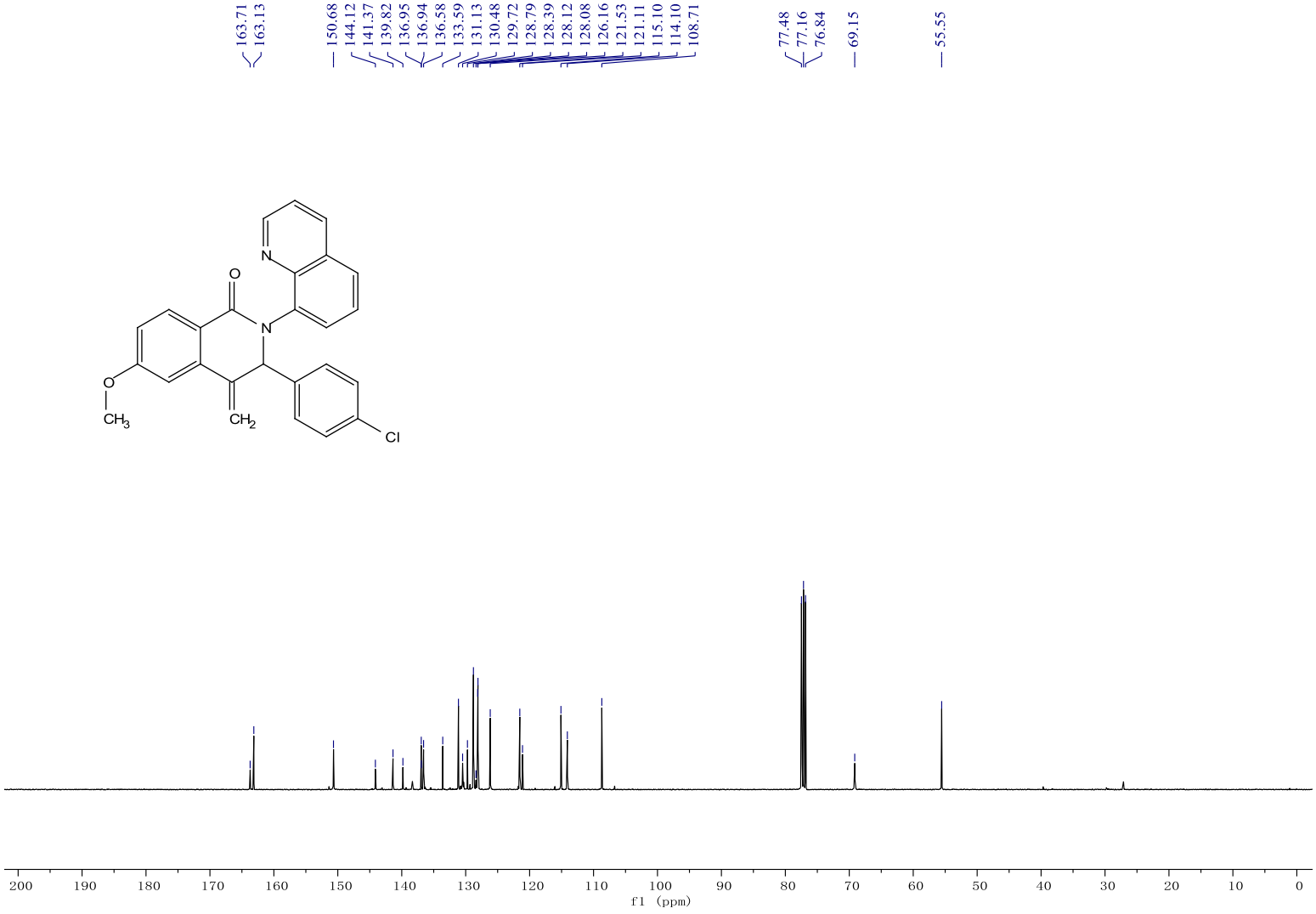
7.30
7.27
7.26
7.17
7.15
7.14
7.13
6.91
6.89
6.88
5.82
5.74
5.50
O
N
N
F
CH2
F
1.00
1.06
1.06
1.02
3.38
1.19
1.18
2.12
1.05
1.07
1.03
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

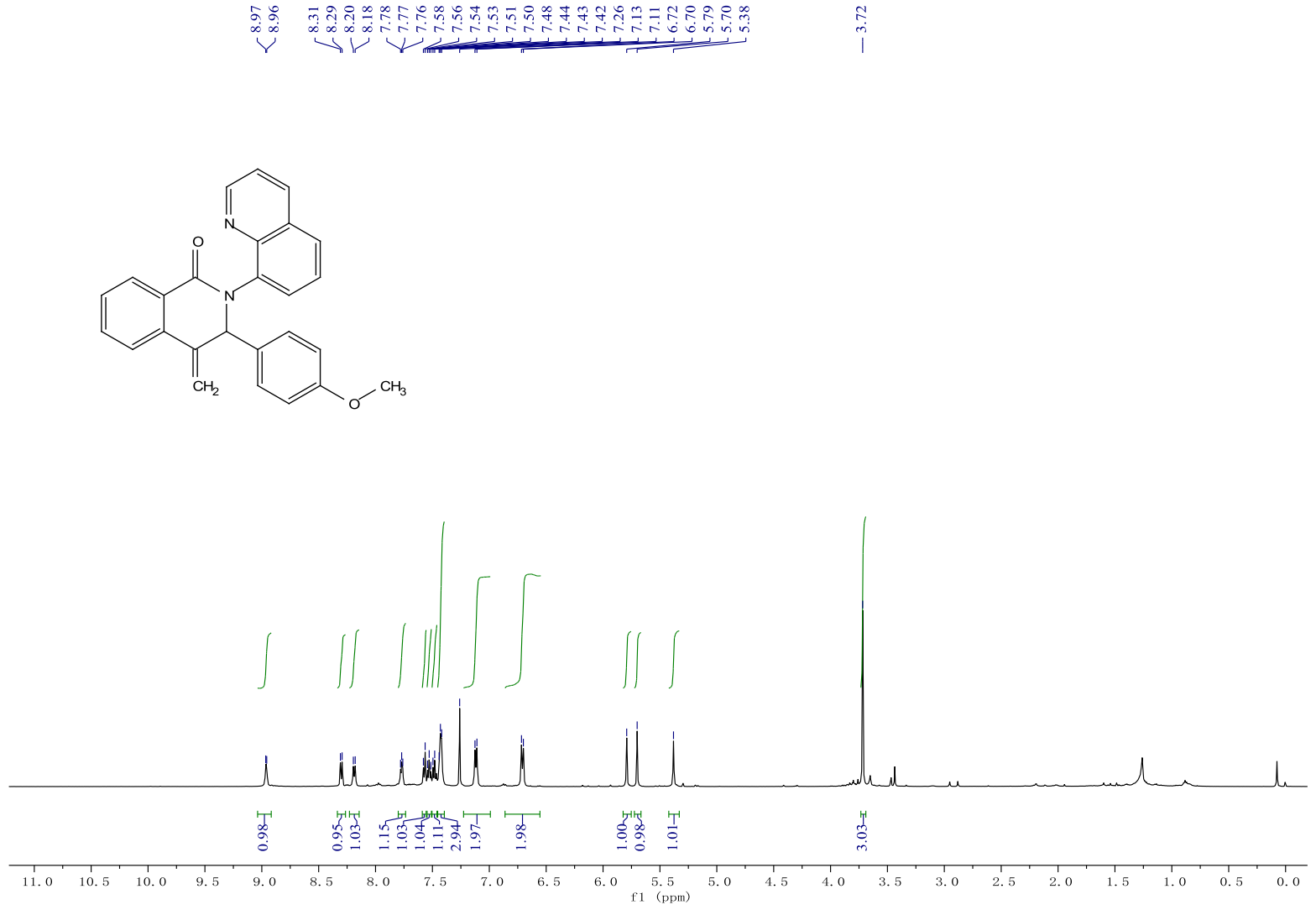

163.80
163.58
161.18
161.13
150.65
144.10
141.20
138.24
136.58
136.14
133.87
133.77
130.44
129.80
128.32
128.26
128.18
126.18
121.63
120.58
120.54
117.75
117.53
116.45
116.40
115.66
115.44
115.08
77.48
77.16
76.84
68.93
O
N
N
F
CH2
F
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

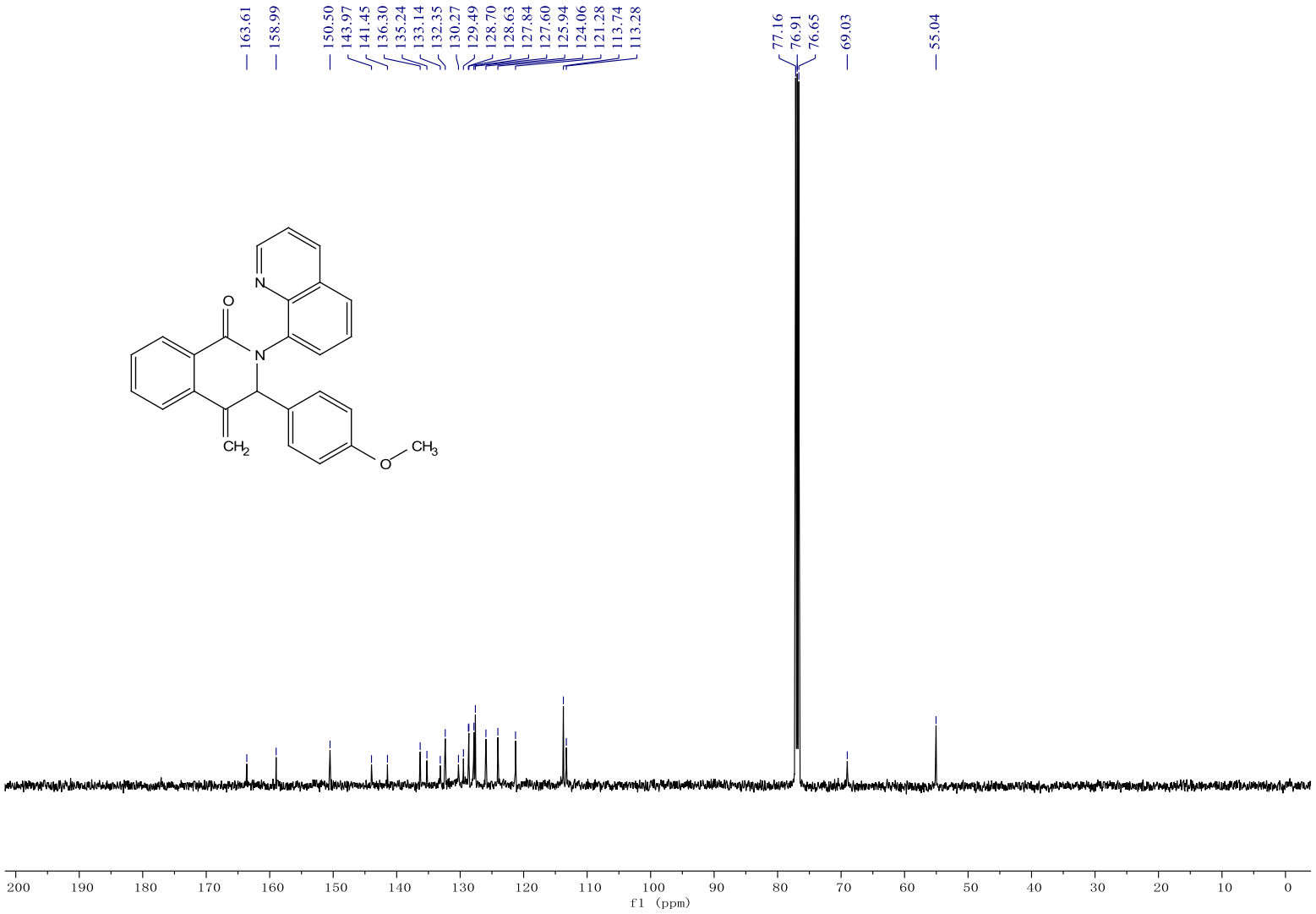

8.96
8.95
8.31
8.29
8.19
8.17
7.79
7.78
7.77
7.76
7.55
7.53
7.50
7.50
7.49
7.48
7.44
7.43
7.42
7.41
7.16
5.84
5.71
5.41
O
N
N
CH2
Cl
1.08
1.16
1.08
1.02
9.04
4.67
1.03
1.03
1.00
f1 (ppm)

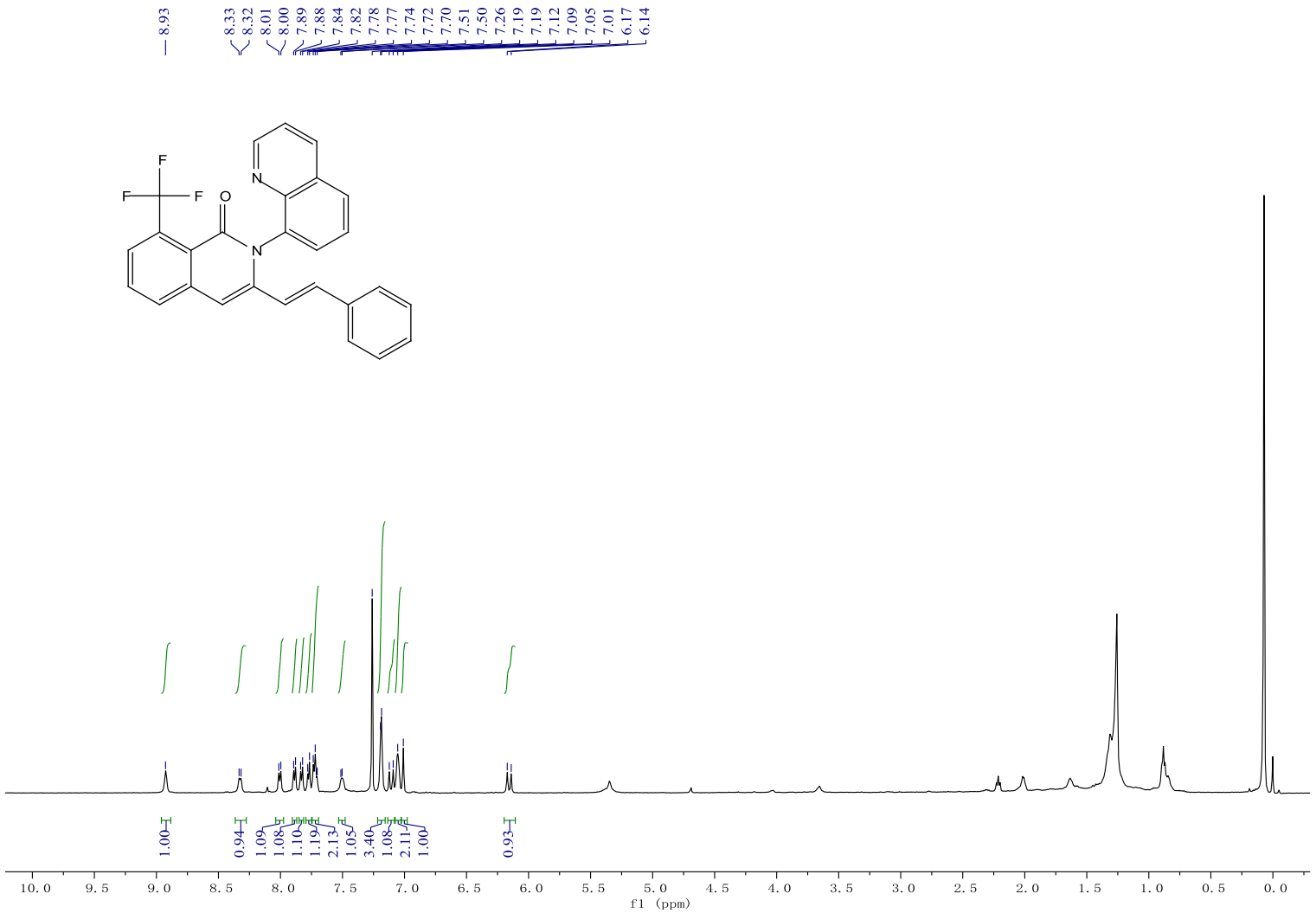

163.83
150.81
144.05
141.11
139.69
136.63
135.12
133.67
132.75
130.44
129.76
129.33
129.13
128.92
128.82
128.74
128.66
128.47
128.44
128.29
128.05
128.00
127.94
126.18
124.29
121.67
121.63
114.04
77.48
77.16
76.84
69.15
O
N
N
CH2
Cl
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

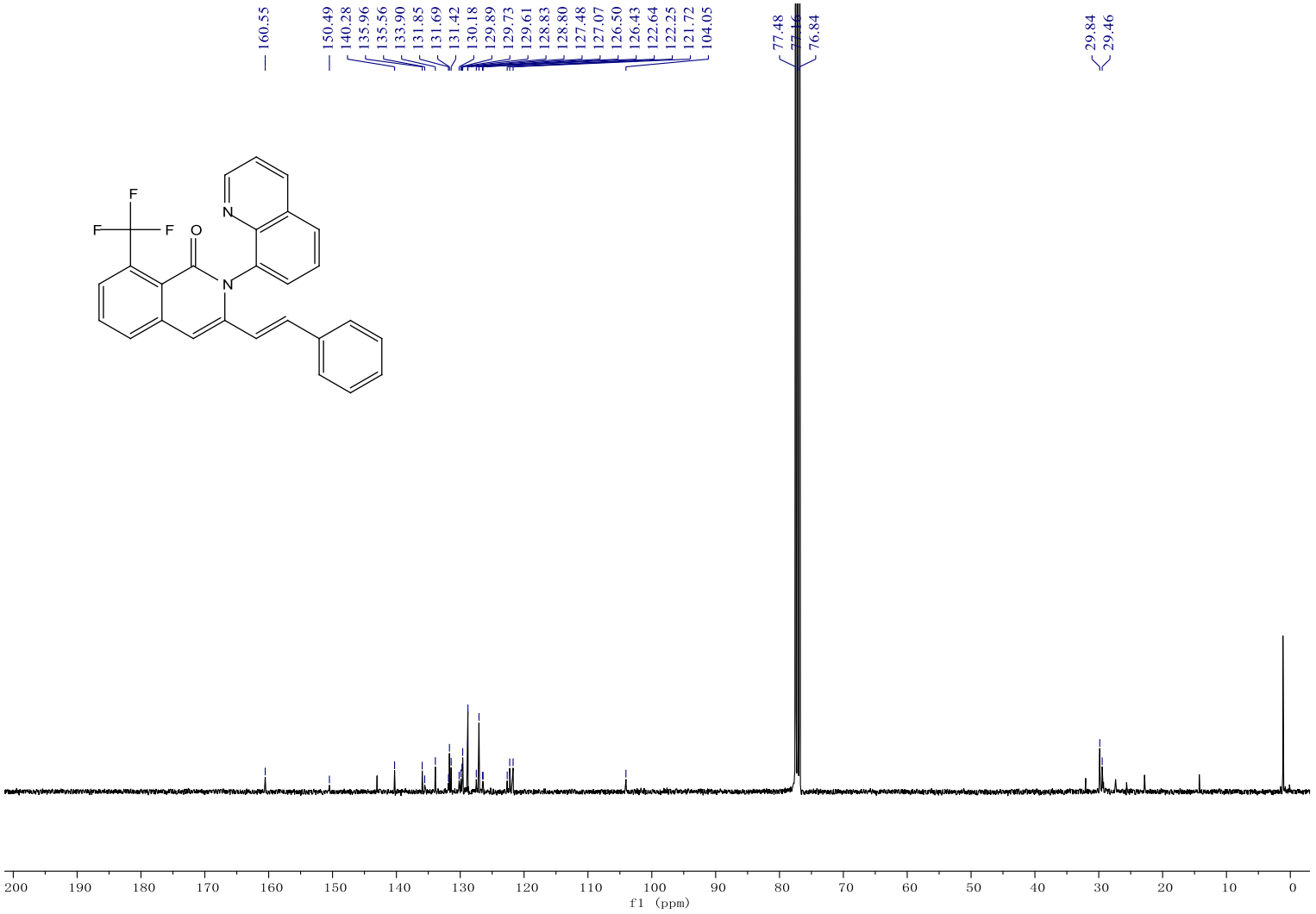

8.95
8.25
8.23
8.18
8.16
7.77
7.75
7.45
7.45
7.43
7.41
7.40
7.26
7.19
7.18
7.17
7.15
7.01
7.00
5.85
5.70
5.42
3.87
O
N
N
O
CH3
CH2
Cl
1.00
1.09
1.09
1.07
3.29
4.32
2.16
0.99
1.03
1.02
3.16
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

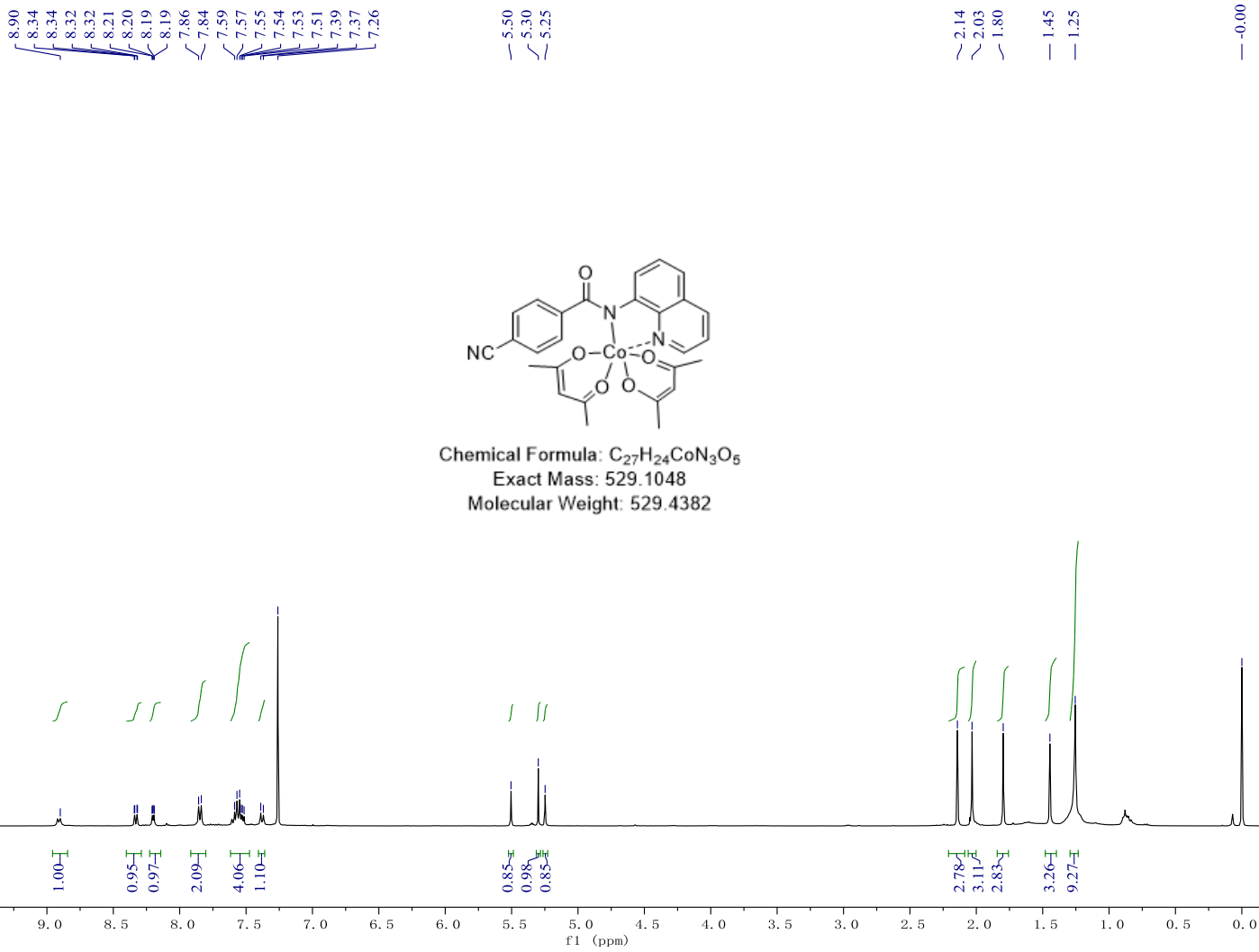

163.71
163.13
150.68
144.12
141.37
139.82
136.95
136.94
136.58
133.59
131.13
130.48
129.72
128.79
128.39
128.12
128.08
126.16
121.53
121.11
115.10
114.10
108.71
77.48
77.16
76.84
69.15
55.55
O
N
N
O
CH3
CH2
Cl
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

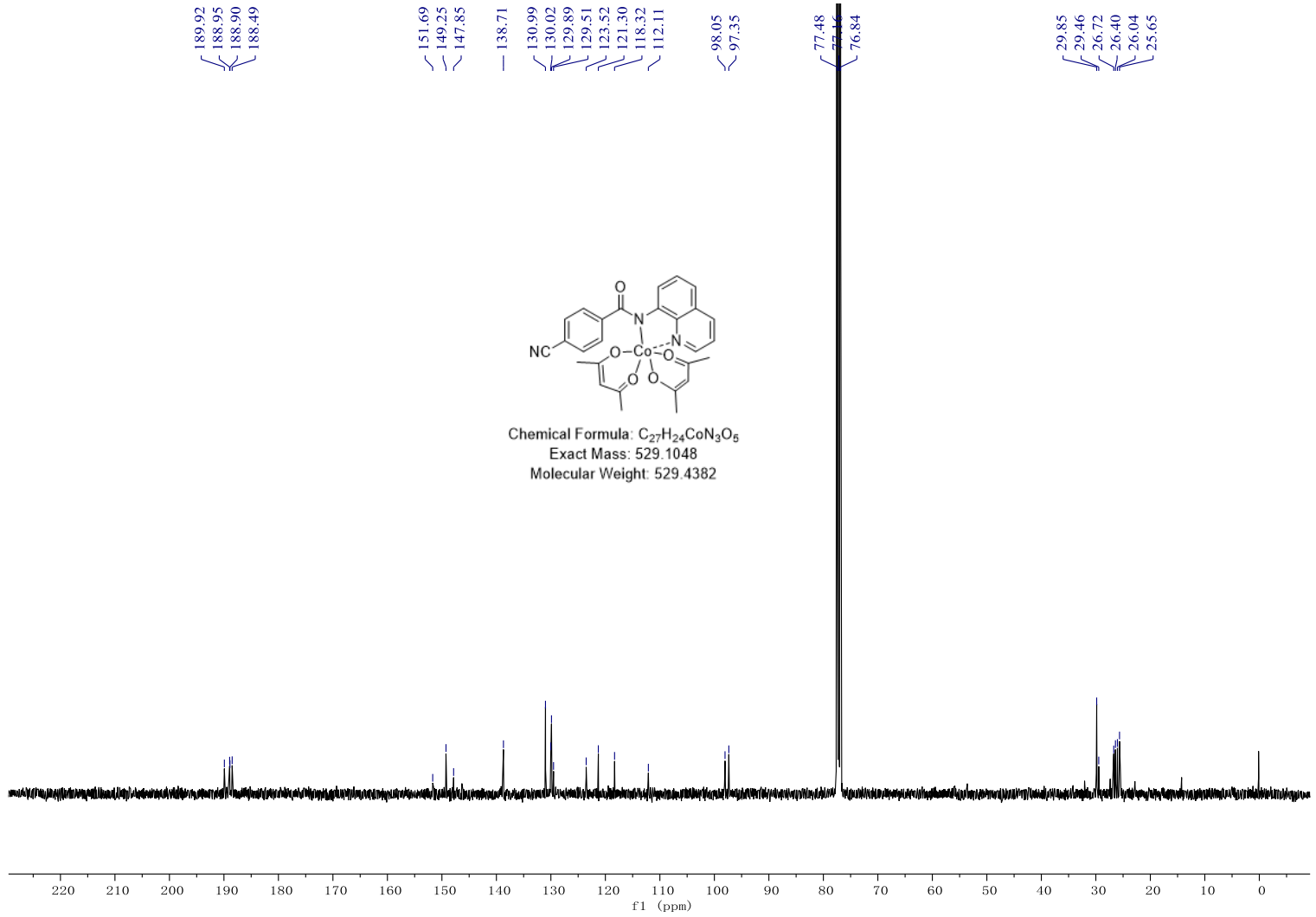

8.97
8.96
8.31
8.29
8.20
8.18
7.78
7.77
7.76
7.58
7.56
7.54
7.53
7.51
7.50
7.48
7.44
7.43
7.42
7.26
7.13
7.11
6.72
6.70
5.79
5.70
5.38
3.72
O
N
N
CH2
O
CH3
0.98
0.95
1.03
1.15
1.03
1.04
1.11
2.94
1.97
1.98
1.00
0.98
1.01
3.03
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

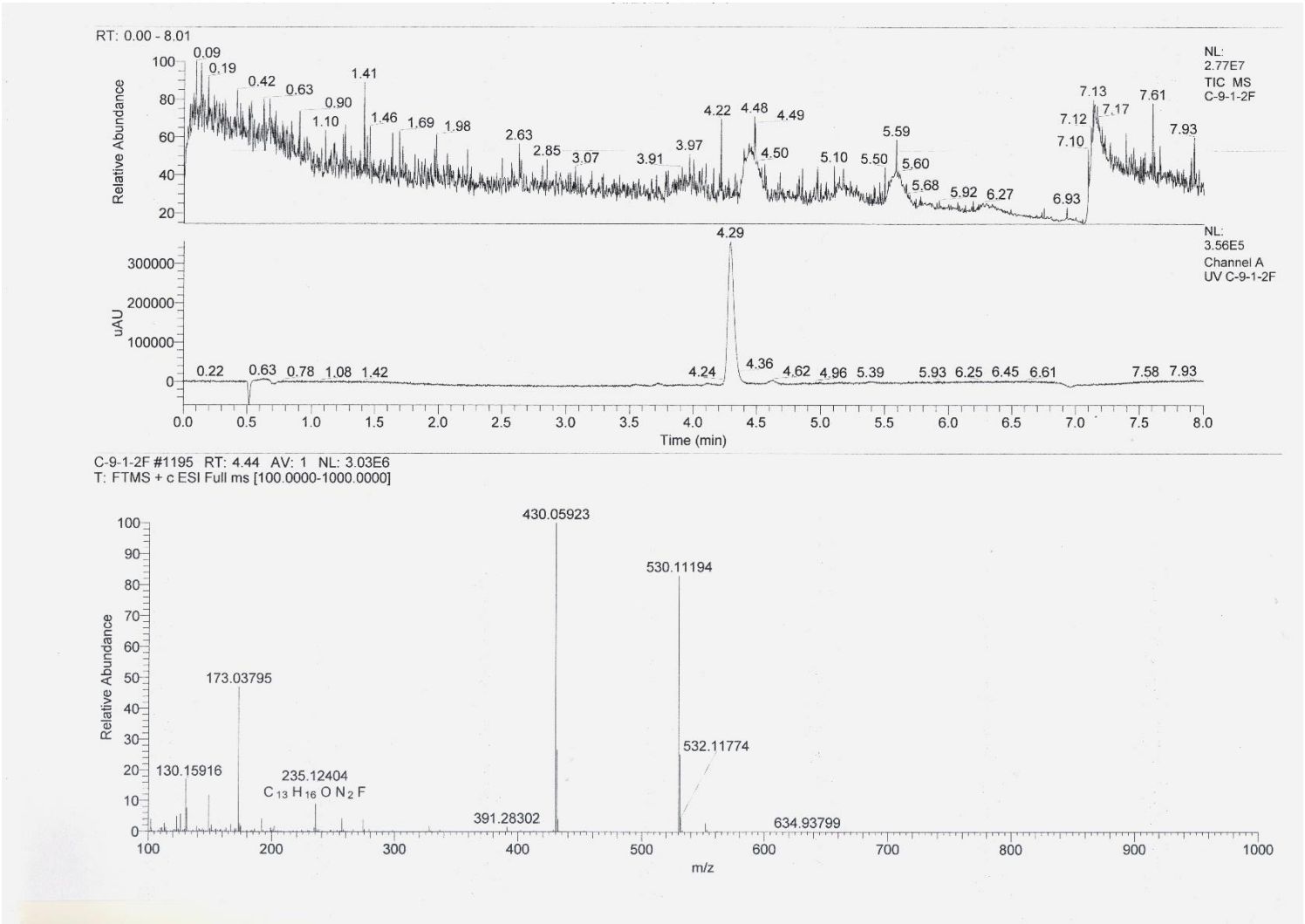

163.61
158.99
150.50
143.97
141.45
136.30
135.24
133.14
132.35
130.27
129.49
128.70
128.63
127.84
127.60
125.94
124.06
121.28
113.74
113.28
77.16
76.91
76.65
69.03
55.04
O
N
N
CH2
O
CH3
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

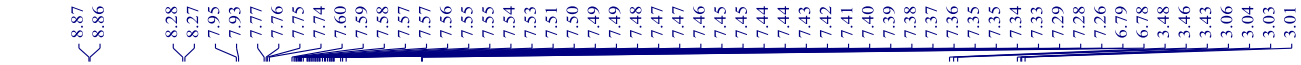

8.93
8.33
8.32
8.01
8.00
7.89
7.88
7.84
7.82
7.78
7.77
7.74
7.72
7.70
7.51
7.50
7.26
7.19
7.19
7.12
7.09
7.05
7.01
6.17
6.14
F
F
F
O
N
N
1.00
0.94
1.09
1.08
1.10
1.19
2.13
1.05
3.40
1.08
2.11
1.00
0.93
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

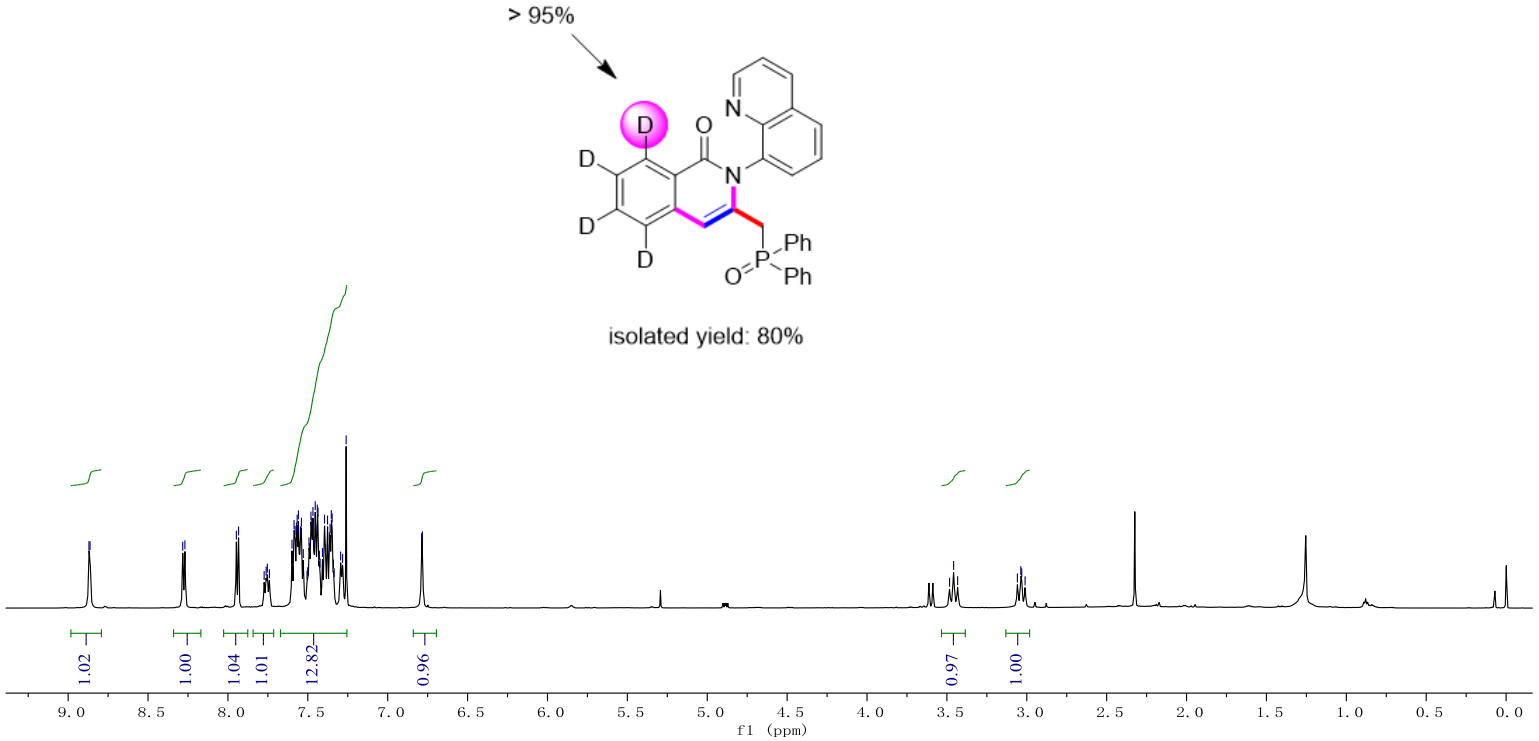

160.55
150.49
140.28
135.96
135.56
133.90
131.85
131.69
131.42
130.18
129.89
129.73
129.61
128.83
128.80
127.48
127.07
126.50
126.43
122.64
122.25
121.72
104.05
77.48
77.16
76.84
29.84
29.46
F
F
F
O
N
N
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

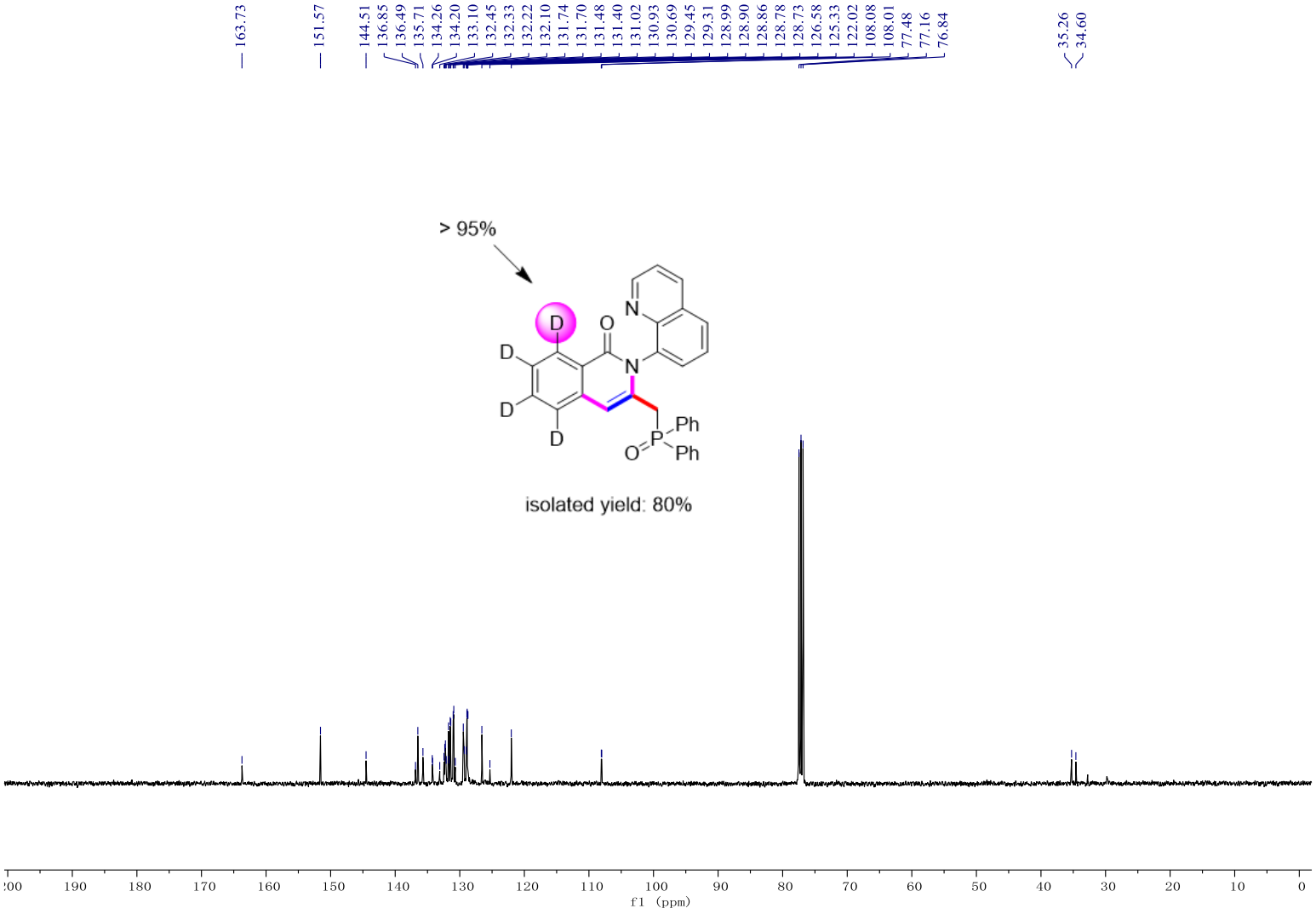

8.90
8.34
8.34
8.32
8.32
8.21
8.20
8.19
8.19
7.86
7.84
7.59
7.57
7.55
7.54
7.53
7.51
7.39
7.37
7.26
5.50
5.30
5.25
2.14
2.03
1.80
1.45
1.25
-0.00
NC
O
N
O
Co
N
O
O
O
O
Chemical Formula: C27H24CoN3O5
Exact Mass: 529.1048
Molecular Weight: 529.4382
1.00
0.95
0.97
2.09
4.06
1.10
0.85
0.98
0.85
2.78
3.11
2.83
3.26
9.27
f1 (ppm)

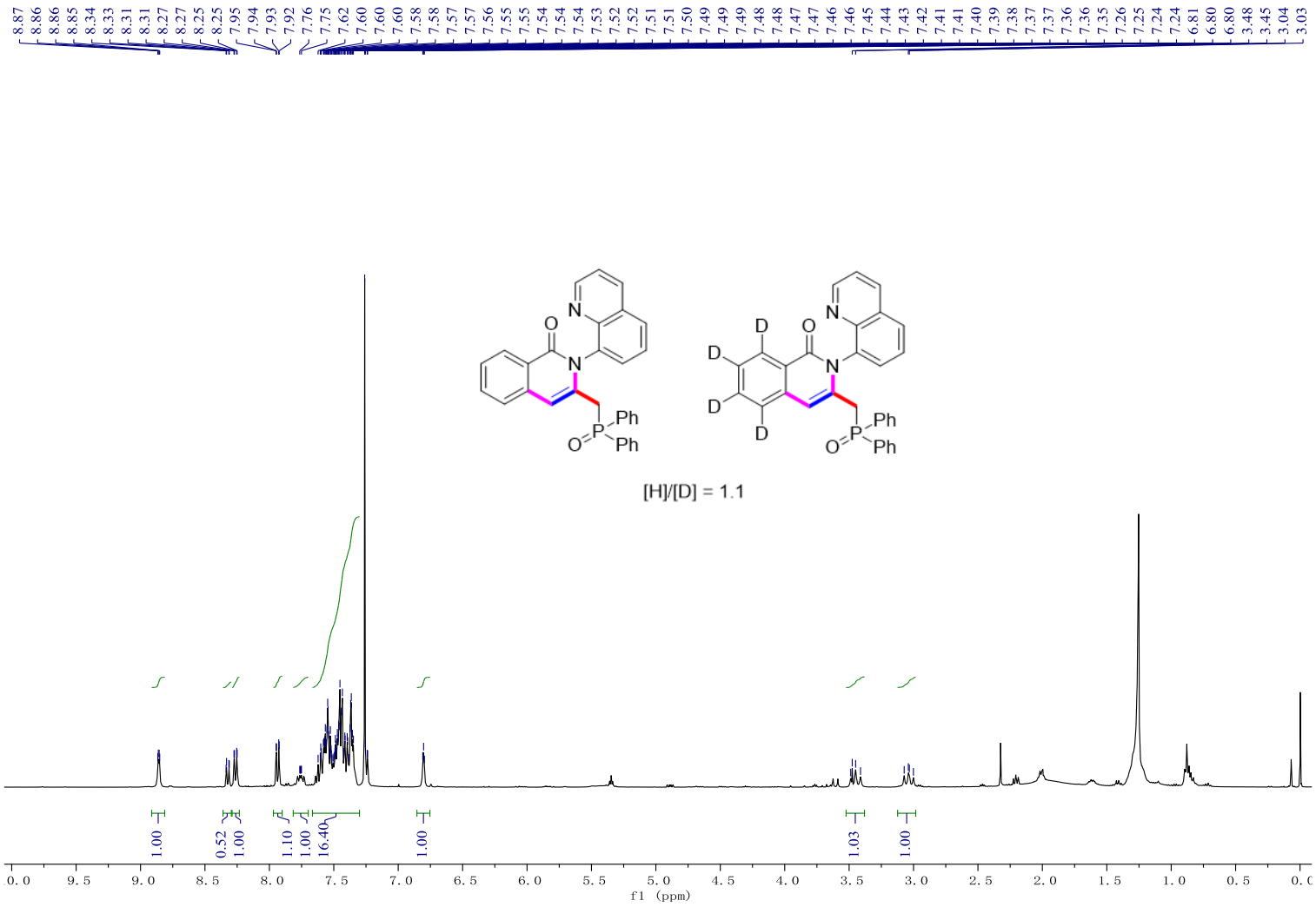

189.92
188.95
188.90
188.49
151.69
149.25
147.85
138.71
130.99
130.02
129.89
129.51
123.52
121.30
118.32
112.11
98.05
97.35
77.48
77.16
76.84
29.85
29.46
26.72
26.40
26.04
25.65
NC
O
N
Co
O
O
O
O
N
Chemical Formula: C27H24CoN3O5
Exact Mass: 529.1048
Molecular Weight: 529.4382
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


RT: 0.00 - 8.01
Relative Abundance
NL:
2.77E7
TIC MS
C-9-1-2F
NL:
3.56E5
Channel A
UV C-9-1-2F
uAU
Time (min)
C-9-1-2F #1195 RT: 4.44 AV: 1 NL: 3.03E6
T: FTMS + c ESI Full ms [100.0000-1000.0000]
430.05923
530.11194
173.03795
532.11774
130.15916
235.12404
C 13 H 16 O N 2 F
391.28302
634.93799
m/z


8.87
8.86
8.28
8.27
7.95
7.93
7.77
7.76
7.75
7.74
7.60
7.59
7.58
7.57
7.57
7.56
7.55
7.55
7.54
7.53
7.51
7.50
7.49
7.49
7.48
7.47
7.47
7.46
7.45
7.45
7.44
7.44
7.43
7.42
7.41
7.40
7.39
7.38
7.37
7.36
7.35
7.35
7.34
7.33
7.29
7.28
7.26
6.79
6.78
3.48
3.46
3.43
3.06
3.04
3.03
3.01


> 95%
D
O
N
N
D
D
D
P
Ph
Ph
O
isolated yield: 80%
1.02
1.00
1.04
1.01
12.82
0.96
0.97
1.00
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


163.73
151.57
144.51
136.85
136.49
135.71
134.26
134.20
133.10
132.45
132.33
132.22
132.10
131.74
131.70
131.48
131.40
131.02
130.93
130.69
129.45
129.31
128.99
128.90
128.86
128.78
128.73
126.58
125.33
122.02
108.08
108.01
77.48
77.16
76.84
35.26
34.60
> 95%
D
O
N
N
D
D
D
Ph
Ph
O
P
isolated yield: 80%
f1 (ppm)


8.87 8.86 8.86 8.85 8.34 8.33 8.31 8.31 8.27 8.27 8.25 8.25 7.95 7.94 7.93 7.92 7.76 7.75 7.62 7.60 7.60 7.60 7.58 7.58 7.57 7.57 7.56 7.55 7.55 7.54 7.54 7.54 7.53 7.52 7.52 7.51 7.51 7.50 7.49 7.49 7.49 7.48 7.48 7.47 7.47 7.46 7.46 7.45 7.44 7.43 7.42 7.41 7.41 7.40 7.39 7.38 7.37 7.37 7.36 7.36 7.35 7.26 7.25 7.24 7.24 6.81 6.80 6.80 3.48 3.45 3.04 3.03
O
N
N
Ph
P
O
Ph
D
D
D
D
[H]/[D] = 1.1
1.00
0.52
1.00
1.10
1.00
16.40
1.00
1.03
1.00
0.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
f1 (ppm)


8.85
8.84
8.47
8.46
8.28
8.27
8.16
8.16
8.15
8.14
7.98
7.97
7.77
7.75
7.75
7.73
7.63
7.62
7.61
7.61
7.59
7.58
7.57
7.54
7.53
7.52
7.50
7.49
7.48
7.47
7.47
7.46
7.45
7.45
7.37
7.36
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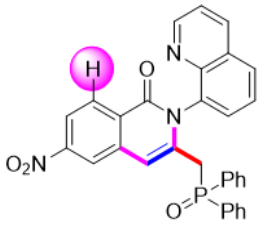
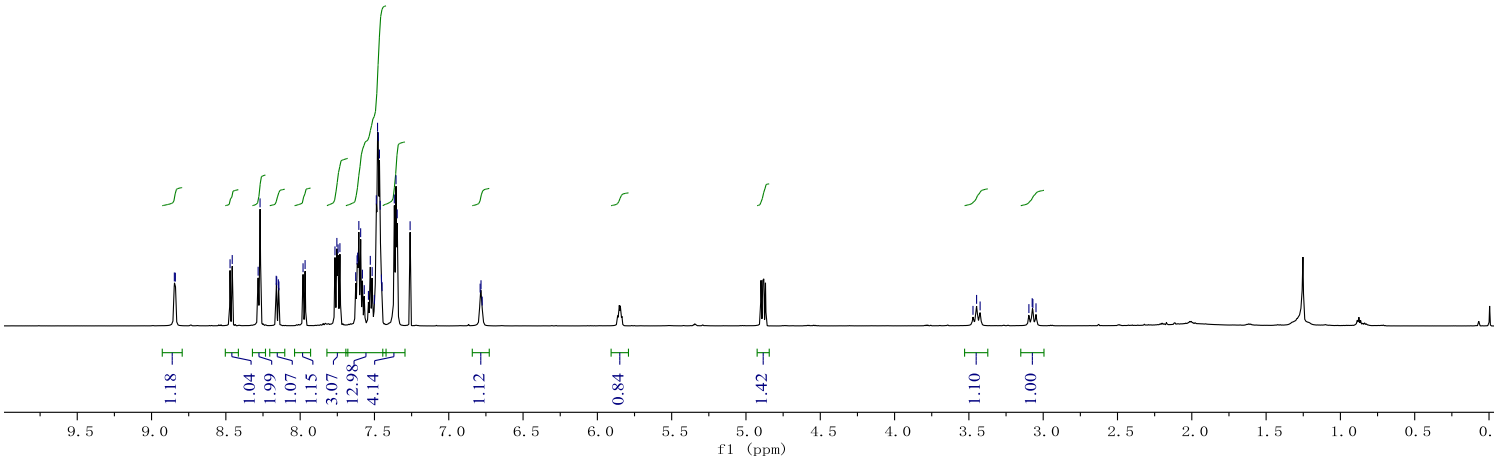
3.45
3.42
3.10
3.07
3.07
3.05


H
O
N
N
O2N
Ph
P
O
Ph


1.18
1.04
1.99
1.07
1.15
3.07
12.98
4.14
1.12
0.84
1.42
1.10
1.00
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.
f1 (ppm)