Supporting Information to

Cobalt-Promoted Selective Arylation of Benzamides and Acrylamides with Arylboronic Acids

Liang Hu,[ab] Qingwen Gui,[a] Xiang Chen,[a] Ze Tan[a,*] and Gangguo Zhu[b]

[a] *State Key Laboratory of Chemo/Biosensing and Chemometrics, College of Chemistry and Chemical Engineering, Hunan University, Changsha 410082, P. R. China. E-mail: ztanze@gmail.com.*

[b] *Department of Chemistry, Zhejiang Normal University, 688 Yingbin Road, Jinhua 321004, China. E-mail:gangguo@zjnu.cn*

Table of Contents

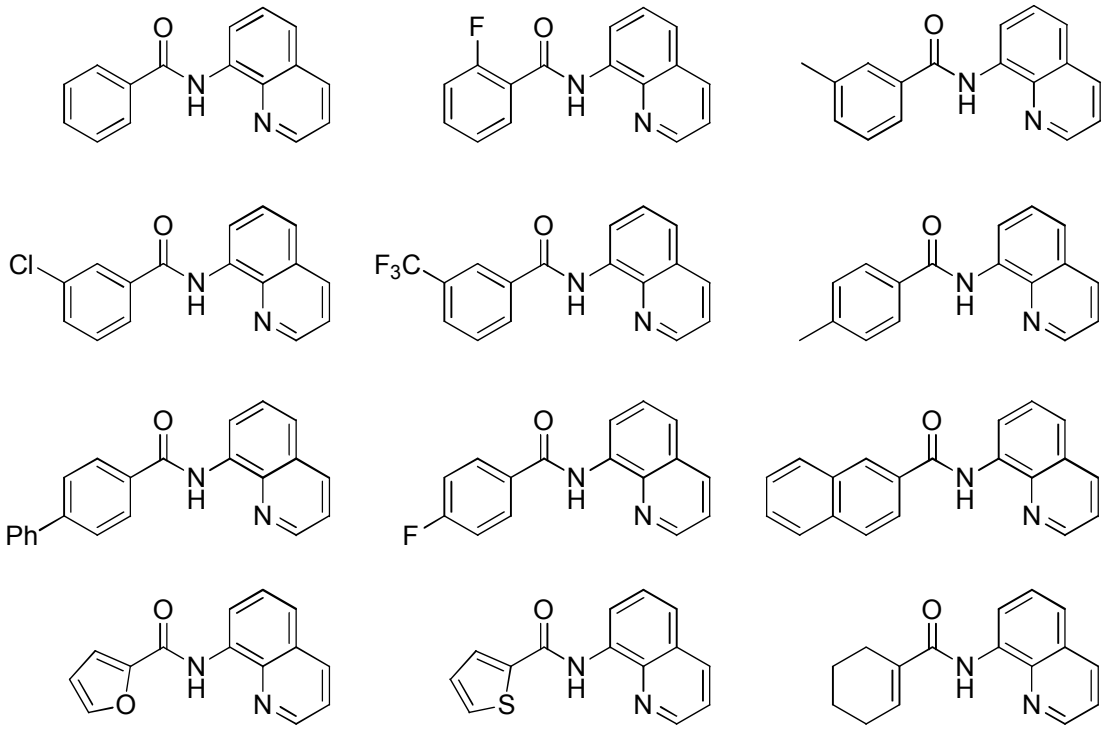
1. General information

^{1}H NMR, ^{13}C NMR and ^{19}F NMR were recorded in $CDCl_3$ at room temperature on the Varian INOVA-400 spectrometer (400 MHz, ^{1}H). The ^{1}H NMR chemical-shifts scale is based on internal TMS. The peak patterns are indicated as follows: s, singlet; d, doublet; t, triplet; q, quartet; m, multiplet; qui, quintet; sxt, sextet. The coupling constants, *J* are reported in Hertz (Hz). High-resolution mass spectral (HRMS) analyses were carried out using a TOF MS instrument with an ESI source.

Unless otherwise noted, all reagents were obtained from commercial suppliers and used without further purification. Anhydrous $Co(acac)_2$ was purchased from Alfa Aesar. All solvents were purified and dried according to standard methods prior to use. Products were purified by flash column chromatography on 200-300 mesh silica gel, SiO_2.

2. Typical procedure for the preparation of benzamides

All benzamides were synthesized from the corresponding benzoic acids or benzoyl chlorides and 8-aminoquinoline. The deuterated amides were synthesized according to a literature method, spectral properties are consistent with literature values.[1] The following amides were synthesized according to literature procedures.[2]



3. Co-promoted arylation of arylboronic acids

3.1 Optimization of reaction conditions

Scheme S1 ineffective directing groups

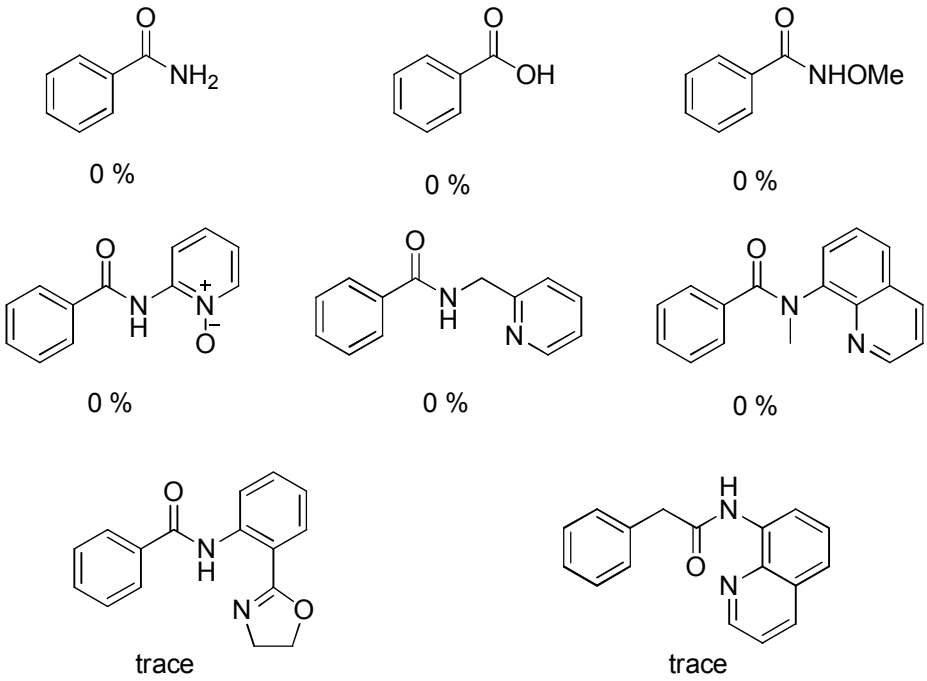
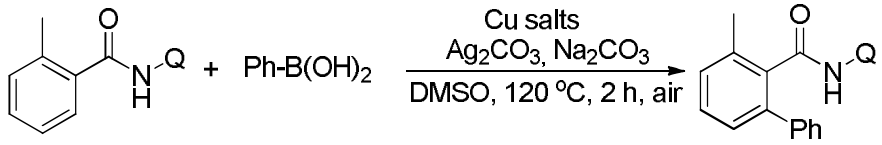


Table S1. screaning of Co salts [a]

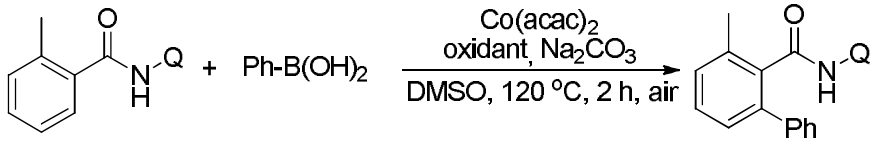


1a **2a** **3b**

Entry	Co salts	yield[b] (%)
1	$Co(OAc)_2$	trace
2	$Co(CO)_3$	trace
3	$CoCl_2$	ND
4	$CoBr_2$	ND
5	$CoSO_4$	ND
6	$Co(oxalate)_2$	trace
7	$Co(NO_3)_2.6H_2O$	ND
8	$Co(acac)_3$	21

[a] Reaction conditions: amide **1a** (0.2 mmol), **2a** (0.4 mmol), Co salt (0.2 mmol), Ag_2CO_3 (0.4 mmol), Na_2CO_3 (0.2 mmol), DMSO (1 mL), 120 °C, under air for 2h; [b] isolated yield.

Table S2. screaning of oxidant [a]

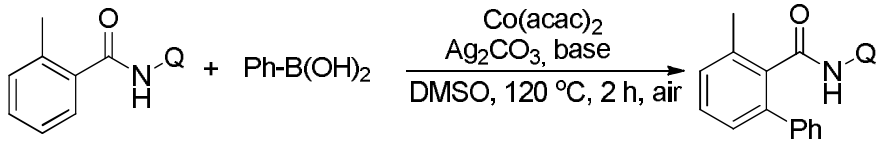


1a **2a** **3b**

Entry	oxidant	yield[b] (%)
1	$Mn(OAc)_2$	17
2	NMO	ND
3	O_2 (1 atm)	ND
4	Ag_2O	52
5	AgOAc	21
6	$AgCF_3CO_2$	14

[a] Reaction conditions: amide **1a** (0.2 mmol), **2a** (0.4 mmol), $Co(acac)_2$ (0.2 mmol), oxidant (0.4 mmol), Na_2CO_3 (0.2 mmol), DMSO (1 mL), 120 °C, under air for 2h; [b] isolated yield.

Table S3. screaning of base [a]

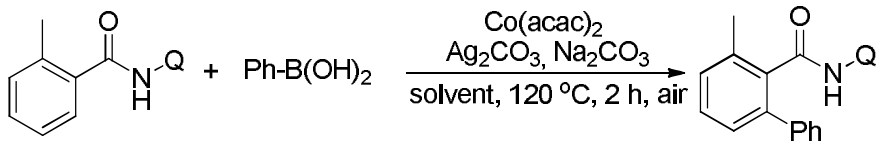


1a **2a** **3b**

Entry	base	yield[b] (%)
1	K_2CO_3	72
2	NaOPiv	53
3	$NaHCO_3$	82
4	Cs_2CO_3	54
5	*t*-BuONa	43

[a] Reaction conditions: amide **1a** (0.2 mmol), **2a** (0.4 mmol), $Co(acac)_2$ (0.2 mmol), Ag_2CO_3 (0.4 mmol), base (0.2 mmol), DMSO (1 mL), 120 °C, under air for 2h; [b] isolated yield.

Table S4. screaning of solvent [a]

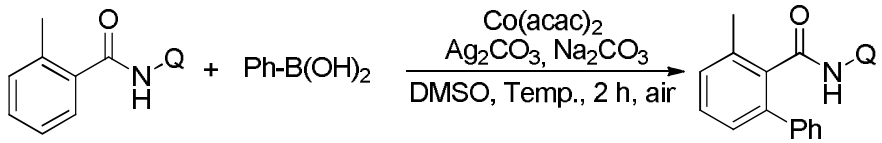


1a **2a** **3b**

Entry	solvent	yield[b] (%)
1	DMF	79
2	NMP	64
3	*t*-BuOH	ND
4	MeCN	trace
5	toluene	trace
6	dioxane	ND
7	DCE	ND

[a] Reaction conditions: amide **1a** (0.2 mmol), **2a** (0.4 mmol), $Co(acac)_2$ (0.2 mmol), Ag_2CO_3 (0.4 mmol), Na_2CO_3 (0.2 mmol), solvent (1 mL), 120 °C, under air for 2h; [b] isolated yield.

Table S5. screaning of temperature [a]

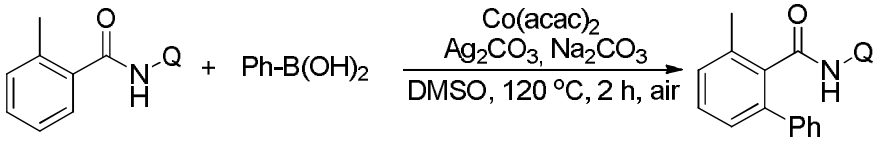


1a **2a** **3b**

Entry	Temp. (°C)	yield[b] (%)
1	R.T.	trace
2	60	<10
3	80	29
4	100	56
5	120	91
6	140	81

[a] Reaction conditions: amide **1a** (0.2 mmol), **2a** (0.4 mmol), $Co(acac)_2$ (0.2 mmol), Ag_2CO_3 (0.4 mmol), Na_2CO_3 (0.2 mmol), DMSO (1 mL), under air for 2h; [b] isolated yield.

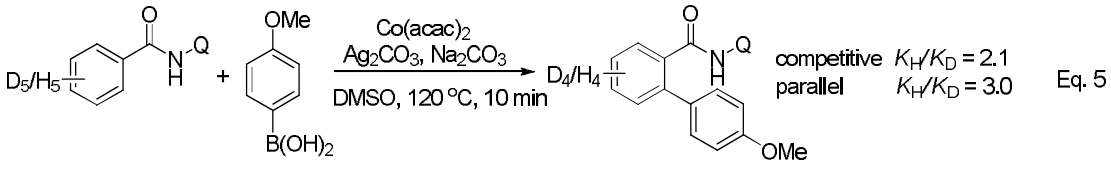
3.2 General procedure for Co-Promoted *ortho*-Arylation of Benzamides with Aryboronic Acids:



1a **2a** **3b**

Benzamide **1a** (0.2 mmol), anhydrous $Co(acac)_2$ (49 mg, 0.2 mmol), Ag_2CO_3 (110 mg, 0.4 mmol), Na_2CO_3 (21 mg, 0.2 mmol), arylboronic acid **2a** (0.4 mmol) and anhydrous DMSO (1 mL) were added to a 25-mL Schlenk flask equipped with a high-vacuum PTFE valve-to-glass seal. Then the flask was sealed under air and stirred at 120 °C for 2 h. After the completion of the reaction, the solvent was evaporated under reduced pressure. The mixture was extracted with ethyl acetate, and the combined organic layer was dried over sodium sulfate. Concentration in vacuo followed by silica gel column purification with petroleum ether/ethyl acetate elutent (8/1 to 6/1) gave the desired product **3a** as a colorless oil (62 mg, 91% yield).

3.3 Deuterium-labeling experiments:

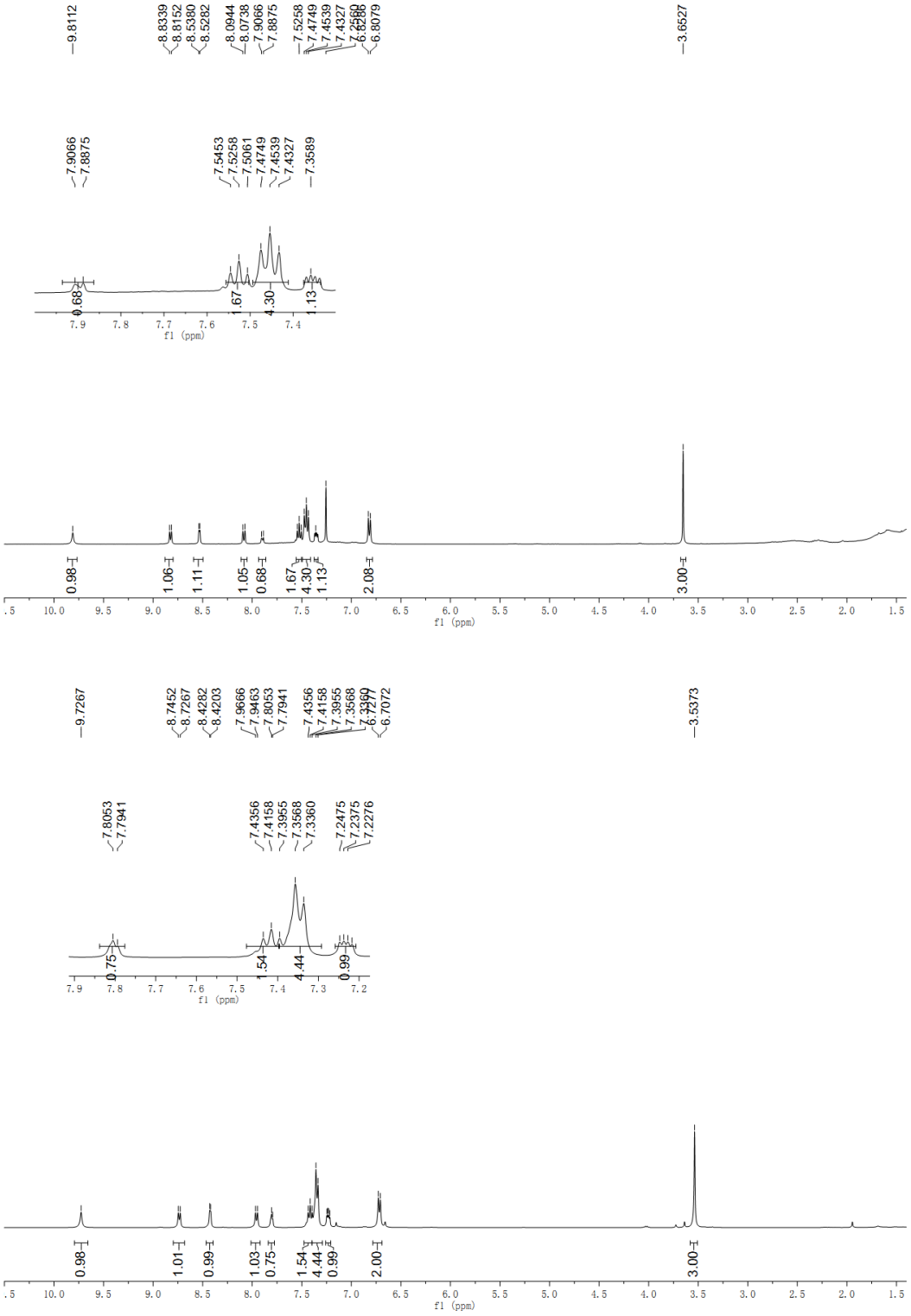


1a: 1a-d_5 = 1: 1

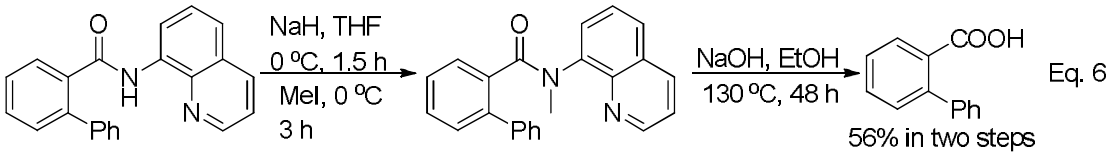
3a/3a-d_4

Intermolecular competition KIE Following general procedure: **1a** (50 mg, 0.2 mmol), **1a'-*d_5*** (51 mg, 0.2 mmol), $Co(acac)_2$ (98 mg, 0.4 mmol), Ag_2CO_3 (220 mg, 0.8 mmol), Na_2CO_3 (42 mg, 0.4 mmol), **2h** (122 mg, 0.8 mmol) and anhydrous DMSO (2 mL) were added to a 25-mL Schlenk flask equipped with a high-vacuum PTFE valve-to-glass seal. Then the flask was sealed under air and stirred at 120 °C for 10 min. The product was separated by column chromatography to give the desired product less than 13 % yield. The KIE value was calculated as $k_H/k_D = 2.1$.

Intermolecular parallel KIE Following general procedure:**1a** (50 mg, 0.2 mmol) or **1a'-*d_5*** (51 mg, 0.2 mmol), $Co(acac)_2$ (49 mg, 0.2 mmol), Ag_2CO_3 (110 mg, 0.4 mmol), Na_2CO_3 (21 mg, 0.2 mmol), **2h** (61 mg, 0.4 mmol) and anhydrous DMSO (1 mL) were added to a 25-mL Schlenk flask equipped with a high-vacuum PTFE valve-to-glass seal. Then the flask was sealed under air and stirred at 120 °C for 10 min. The product was separated by column chromatography to give the desired product less than 16 % yield. The KIE value was calculated as $k_H/k_D = 3.0$.



3.4 Removal of the 8-aminoquinoline Auxiliary:

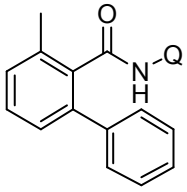


Eq. 6

N-(quinolin-8-yl)-[1,1'-biphenyl]-2-carboxamide **4a** (324 mg, 1 mmol) was dissolved in anhydrous THF (10 mL) and the resulting solution was cooled to 0°C. To this solution, NaH (80 mg, 2 mmol) was added in portions over 10 min. The resulting solution was allowed to stir for 1.5 h. MeI (710 mg, 5 mmol) was added dropwise over 5 min, and reaction mixture was stirred for additional 3 hours at 0 °C and stirred overnight at rt. After the reaction was quenched by addition water, the mixture was extracted with Et_2O, and the organic layer was dried by anhydrous Na_2SO_4. After remove the solvent, the residue was purified by column chromatography to give intermediate **7** as a yellow solid (271 mg, 80%).Intermediate **7** (169 mg, 0.5 mmol) and NaOH (307 mg, 7.5 mmol) were dissolved in EtOH (5 ml). The resulting mixture was stirred at 130 ^{o}C for 48 hours. After that, reaction mixture was diluted with EtOAc (100 mL) and 1N HCl (30mL) was added. Organic layer was washed with 1N HCl (5 x 20 mL), dried over anhydrous Na_2SO_4, filtered and the solvent was evaporated under vacuum affording pure product as a faint yellow solid (56%). Its spectral properties are consistent with literature values.[16]

4 Characterization data of products

3-Methyl-N-(quinolin-8-yl)-[1,1′-biphenyl]-2-carboxamide (**3a**)

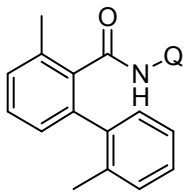


3a

91% yield (62 mg); colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.65 (s, 1H), 8.77 (d, J = 7.5 Hz, 1H), 8.55 (d, J = 4.0 Hz, 1H), 7.98 (d, J = 8.2 Hz, 1H), 7.53–7.51 (m, 2H), 7.49–7.45 (m, 1H), 7.41–7.36 (m, 2H), 7.31–7.26 (m, 3H), 7.19 (t, J = 7.7 Hz, 2H), 7.06 (t, J = 7.5 Hz, 1H), 2.52 (s, 3H); ^{13}C NMR (100 MHz , $CDCl_3$) δ 168.3, 147.9, 140.3, 139.6, 138.3, 136.7, 136.0, 135.7, 134.2, 129.4, 129.2, 128.6, 128.1, 127.7, 127.6, 127.2, 127.1, 121.7, 121.4, 116.4, 19.7; HRMS (ESI) calcd for $C_{23}H_{19}N_2O$ $(M + H)^+$ 339.1497,

found 339.1488.

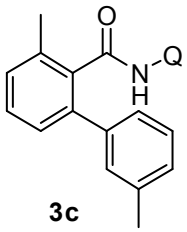
2′-Methyl-3-methyl-N-(quinolin-8-yl)-[1,1′-biphenyl]-2-carboxamide (**3b**)



3b

77% yield (54 mg); colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.64 (s, 1H), 8.67 (d, J = 4.6 Hz, 2H), 8.03 (d, J = 8.0 Hz, 1H), 7.41–7.33 (m, 4H), 7.30–7.27 (m, 2H), 7.14 (d, J = 7.5 Hz, 1H), 7.05–7.03 (m, 1H), 6.98–6.96 (m, 2H), 2.52 (s, 3H), 2.29 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.7, 147.8, 139.6, 139.2, 138.2, 137.4, 136.0, 135.8, 135.6, 134.2, 129.8, 129.6, 129.3, 128.7, 127.7, 127.6, 127.4, 127.2, 125.1, 121.4, 116.1, 20.3, 19.8; HRMS (ESI) calcd for $C_{24}H_{21}N_2O$ $(M + H)^+$ 353.1854, found 353.1857.

3′-Methyl-3-methyl-N-(quinolin-8-yl)-[1,1′-biphenyl]-2-carboxamide (**3c**)

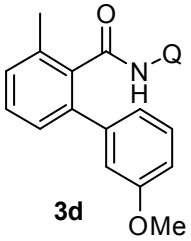


3c

71% yield (50 mg); colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.63 (s, 1H), 8.76 (d, J = 7.5 Hz, 1H), 8.59 (d, J = 4.0 Hz, 1H), 8.03 (d, J = 8.2 Hz, 1H), 7.50–7.46 (m, 1H), 7.43–7.41 (m, 1H), 7.38–7.36 (m, 1H), 7.34–7.26 (m, 5H), 7.06 (t, J = 7.6 Hz, 1H), 6.86 (d, J = 7.5 Hz, 1H), 2.53 (s, 3H), 2.16 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 168.3, 147.9, 140.3, 139.8, 138.3, 137.6, 136.8, 136.0, 135.7, 134.4, 129.4, 129.3, 129.1, 128.0, 127.9, 127.7, 127.5, 127.2, 125.6, 121.6, 121.4, 116.3, 21.2, 19.8; HRMS (ESI) calcd for $C_{24}H_{21}N_2O$ $(M + H)^+$ 353.1854, found 353.1848.

3′-Methoxy-3-methyl-N-(quinolin-8-yl)-[1,1′-biphenyl]-2-carboxamide (**3d**)

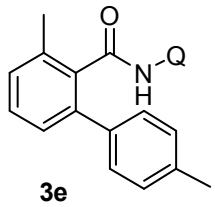
73% yield (54 mg); White solid, mp: 137–139 ^{o}C (from ethyl acetate/petroleum ether = 10:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.66 (s, 1H), 8.79 (dd,J = 7.5, 1.3 Hz, 1H), 8.59 (dd, J= 4.2, 1.6 Hz, 1H), 8.04 (dd, J = 8.3,



3d

1.5 Hz, 1H), 7.50 (t, J = 7.9 Hz, 1H), 7.44–7.37 (m, 2H), 7.34–7.30 (m, 3H), 7.10–7.09 (m, 3H), 6.63–6.60 (m, 1H), 3.63 (s, 3H), 2.53 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 168.3, 159.2, 147.9, 141.7, 139.5, 138.3, 136.7, 136.0, 135.8, 134.4, 129.5, 129.1, 127.7, 127.4, 127.1, 121.6, 121.4, 121.1, 116.3, 113.6, 55.0, 19.7; HRMS (ESI) calcd for $C_{24}H_{21}N_2O_2$ $[M + H]^+$ 369.1603, Found 369.1610.

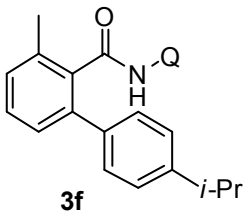
4′-Methyl-3-methyl-N-(quinolin-8-yl)-[1,1′-biphenyl]-2-carboxamide (**3e**)



3e

87% yield (61 mg); colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.65 (s, 1H), 8.78 (d, J = 7.3 Hz, 1H), 8.61 (d, J = 4.0 Hz, 1H), 8.07 (d, J = 8.2 Hz, 1H), 7.50 (t, J = 7.9 Hz, 1H), 7.46–7.39 (m, 4H), 7.37–7.33 (m, 1H), 7.29–7.24 (m, 2H), 7.01 (d, J = 7.9 Hz, 2H), 2.52 (s, 3H), 2.15 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 168.4, 147.9, 139.6, 138.4, 137.4, 136.9, 136.8, 136.0, 135.7, 134.4, 129.2, 129.1, 128.9, 128.5, 127.8, 127.6, 127.2, 121.6, 121.4, 116.5, 20.9, 19.8; HRMS (ESI) calcd for $C_{24}H_{21}N_2O$ $(M + H)^+$ 353.1654, found 353.1647.

4′-Isopropyl-3-methyl-N-(quinolin-8-yl)-[1,1′-biphenyl]-2-carboxamide (**3f**)

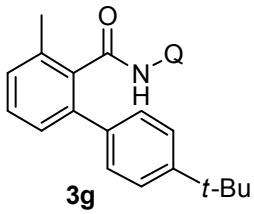


3f

83% yield (63 mg); White solid, mp: 132–134 ^{o}C (from ethyl acetate/petroleum ether = 12:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.58 (s, 1H), 8.76 (d, J = 7.6 Hz, 1H), 8.57 (d, J = 4.1 Hz, 1H), 8.03 (dd, J = 8.2, 1.2 Hz, 1H), 7.49 (t, J = 7.9 Hz, 1H), 7.43–7.41 (m, 3H), 7.39–7.37 (m, 1H), 7.33–7.24 (m, 3H), 7.02 (d, J = 8.0 Hz, 2H), 2.68–2.61 (m, 1H),2.54 (s, 3H), 0.95 (s, 3H), 0.93 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 168.4, 147.8,

147.7, 139.4, 138.3, 137.7, 136.7, 135.9, 134.4, 129.3, 129.2, 128.5, 127.6, 127.5, 127.2, 126.6, 126.1, 121.5, 121.3, 116.3, 33.5, 24.0, 23.6, 19.8; HRMS (ESI) calcd for $C_{26}H_{25}N_2O$ $(M + H)^+$ 381.1967, found 381.1975.

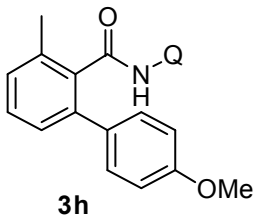
4′-Tertiary butyl-3-methyl-N-(quinolin-8-yl)-[1,1′-biphenyl]-2-carboxamide (**3g**)



3g

82% yield (65 mg); White solid, mp: 135–137 °C (from ethyl acetate/petroleum ether = 12:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.56 (s, 1H), 8.76 (d, J = 6.8 Hz, 1H), 8.54 (dd, J = 4.1,1.5 Hz, 1H), 8.01 (d, J = 8.2 Hz, 1H), 7.50–7.37 (m, 5H), 7.32–7.25 (m, 3H), 7.16 (d, J = 8.3 Hz, 2H), 2.54 (s, 3H), 1.01 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 168.4, 149.9, 147.7, 139.7, 138.2, 137.3, 136.7, 136.0, 135.9, 134.4, 129.3, 129.2, 128.3, 127.6, 127.4, 127.1, 124.9, 121.4, 121.3, 116.2, 34.1, 31.0, 19.8; HRMS (ESI) calcd for $C_{27}H_{27}N_2O[M + H]^+$ 395.2123, Found 395.2132.

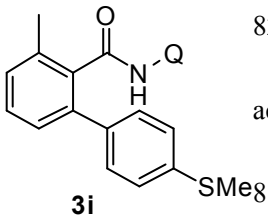
4′-Methoxy-3-methyl-N-(quinolin-8-yl)-[1,1′-biphenyl]-2-carboxamide (**3h**)



3h

92% yield (68 mg); White solid, mp: 141–143 °C (from ethyl acetate/petroleum ether = 10:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.65 (s, 1H), 8.79 (dd, J = 7.5, 1.2 Hz, 1H), 8.60 (dd, J = 4.2, 1.5 Hz, 1H), 8.04 (dd, J = 8.3, 1.5 Hz, 1H), 7.51–7.42 (m, 4H), 7.39–7.31 (m, 2H), 7.27–7.24 (m, 2H), 6.75 (d, J = 8.7 Hz, 2H), 3.60 (s, 3H), 2.51 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 168.5, 158.8, 147.9, 139.2, 138.3, 136.7, 136.0, 135.7, 134.4, 132.8, 129.7, 129.1, 129.0, 127.7, 127.5, 127.2, 121.6, 121.4, 116.4, 113.6, 55.0, 19.7; HRMS (ESI) calcd for $C_{24}H_{21}N_2O_2$ $(M + H)^+$ 369.1603, found 369.1600.

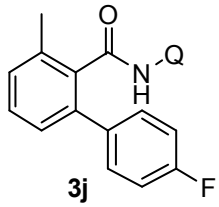
4′-Methylthio-3-methyl-N-(quinolin-8-yl)-[1,1′-biphenyl]-2-carboxamide (**3i**)



3i

82% yield (63 mg); White solid, mp: 135–137 ^{o}C (from ethyl acetate/petroleum ether = 12:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.64 (s, 1H), 8.78 (d, J = 7.3 Hz, 1H), 8.60 (d, J = 4.1 Hz, 1H), 8.07 (d, J = 8.3 Hz, 1H), 7.52–7.42 (m, 4H), 7.39–7.34 (m, 2H), 7.29–7.26 (m, 2H), 7.09 (d, J = 7.6 Hz, 2H), 2.52 (s, 3H), 2.28 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 168.3, 148.0, 139.0, 138.4, 137.5, 137.2, 136.7, 136.1, 135.9, 134.3, 129.5, 129.2, 129.0, 127.8, 127.5, 127.2, 126.4, 121.7, 121.5, 116.6, 19.8, 15.6; HRMS (ESI) calcd for $C_{24}H_{21}N_2OS$ $[M + H]^+$ 385.1375, Found 385.1379.

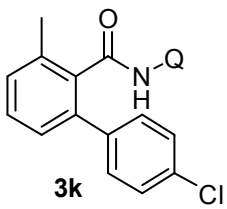
4′-Fluoro-3-methyl-N-(quinolin-8-yl)-[1,1′-biphenyl]-2-carboxamide (**3j**)



3j

83% yield (59 mg); colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.64 (s, 1H), 8.77 (dd, J = 7.4, 1.4 Hz, 1H), 8.60 (dd, J = 4.2, 1.6 Hz, 1H), 8.06 (dd, J = 8.3, 1.6 Hz, 1H), 7.51–7.46 (m, 4H), 7.41–7.33 (m, 2H), 7.29–7.24 (m, 2H), 6.90 (t, J = 8.7 Hz, 2H), 2.52 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 168.1, 162.2 (d, J = 244.9 Hz), 148.0, 138.4 (d, J = 19.8 Hz), 136.8, 136.1, 135.8, 134.1, 130.3, 130.2, 129.6, 129.2, 127.7, 127.5, 127.2, 121.8, 121.5, 116.4, 115.2, 114.9, 19.7; HRMS (ESI) calcd for $C_{23}H_{18}FN_2O$ $[M + H]^+$ 357.1403, Found 357.1399.

4′-Chloro-3-methyl-N-(quinolin-8-yl)-[1,1′-biphenyl]-2-carboxamide (**3k**)

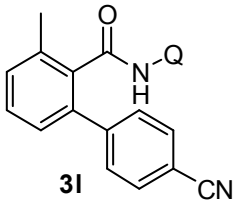


3k

82% yield (61 mg); colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.66 (s, 1H), 8.77 (d, J = 7.4 Hz, 1H), 8.59 (d, J = 4.0 Hz, 1H), 8.04 (d, J = 8.2 Hz, 1H), 7.49–7.45 (m, 4H), 7.40–7.36 (m, 1H), 7.34–7.31 (m, 1H), 7.29–7.22 (m, 2H), 7.19–7.16 (m, 2H), 2.52 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 168.0, 148.0, 138.8, 138.3, 138.2, 136.7, 136.1, 135.8, 134.1, 133.4, 129.9, 129.7,

129.5, 129.2, 128.3, 127.7, 127.4, 127.1, 121.9, 121.5, 120.1, 116.5, 19.7; HRMS (ESI) calcd for $C_{23}H_{18}ClN_2O$ $(M + H)^+$ 373.1108, found 373.1102.

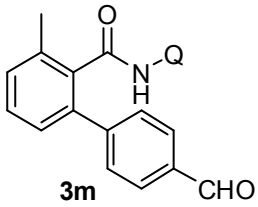
4'-cyano-3-methyl-N-(quinolin-8-yl)-[1,1'-biphenyl]-2-carboxamide (**3l**)



3l

63% yield (46 mg); White solid, mp: 133–135 °C (from ethyl acetate/petroleum ether = 10:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.64 (s, 1H), 8.73 (dd, J = 5.9, 3.0 Hz, 1H), 8.61 (dd, J = 4.2, 1.5 Hz, 1H), 8.13 (dd, J = 8.3, 1.5 Hz, 1H), 7.79–7.77 (m, 2H), 7.70–7.68 (m, 2H), 7.64–7.62(m, 2H), 7.53–7.50 (m, 2H), 7.41–7.38 (m, 1H), 7.28–7.26 (m, 1H), 2.54 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.5, 148.1, 145.1, 143.4, 138.2, 137.7, 136.3, 133.9, 132.8, 132.5, 131.9, 130.6, 129.5, 129.3, 127.8, 127.2, 127.1, 122.2, 121.6, 118.4, 116.6, 19.7; HRMS (ESI) calcd for $C_{24}H_{18}N_3O$ $[M + H]^+$ 364.1450, Found 364.1461.

4′-Aldehyde-3-methyl-N-(quinolin-8-yl)-[1,1′-biphenyl]-2-carboxamide (**3m**)

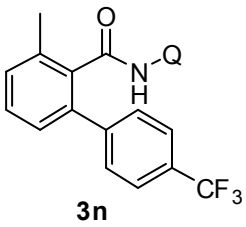


3m

54% yield (40 mg); White solid, mp: 138–140 °C (from ethyl acetate/petroleum ether = 10:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.82 (s, 1H), 9.66 (s, 1H), 8.75 (d, J = 7.1 Hz, 1H), 8.59 (d, J = 4.1 Hz, 1H), 8.07 (d, J = 8.3 Hz, 1H), 7.74–7.68 (m, 4H), 7.52–7.42 (m, 3H), 7.36–7.30 (m, 3H), 2.55 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 191.8, 167.7, 148.0, 146.7, 138.3, 136.7, 136.2, 136.1, 135.0, 134.0, 130.4, 129.6, 129.4, 129.3, 128.0, 127.7, 127.3, 127.2, 122.0, 121.5, 116.5, 19.7; HRMS (ESI) calcd for $C_{24}H_{19}N_2O_2$ $[M + H]^+$ 367.1447, Found 367.1450.

4′-Trifluoromethyl-3-methyl-N-(quinolin-8-yl)-[1,1′-biphenyl]-2-carboxamide (**3n**)

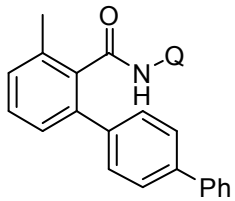
74% yield (60 mg); colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.65 (s, 1H), 8.74 (dd, J = 7.2, 1.4 Hz, 1H), 8.58 (dd, J = 4.1, 1.4 Hz, 1H), 8.07 (dd, J =



3n

8.3, 1.4 Hz, 1H), 7.64 (d, *J* = 8.1 Hz, 2H), 7.50–7.41 (m, 5H), 7.35–7.33 (m, 2H), 7.28 (d, *J* = 7.6 Hz, 1H), 2.55 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.8, 148.0, 144.0, 138.3, 138.1, 136.7, 136.1, 134.0, 130.2, 129.4, 129.0, 127.6 (q, *J* = 30.0 Hz), 127.4, 127.1, 125.1, 125.0, 124.0 (q, *J* = 270.4 Hz), 122.0, 121.5, 118.0, 116.6, 19.8; HRMS (ESI) calcd for $C_{24}H_{18}F_3N_2O$ $(M + H)^+$ 407.1371, found 407.1378.

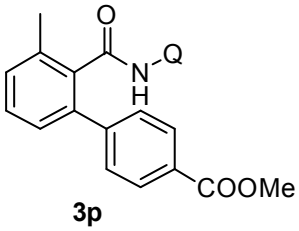
4′-Phenyl-3-methyl-N-(quinolin-8-yl)-[1,1′-biphenyl]-2-carboxamide (**3o**)



3o

80% yield (66 mg); White solid, mp: 143–145 ^{o}C (from ethyl acetate/petroleum ether = 12:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.70 (s, 1H), 8.79 (d, *J* = 7.4 Hz, 1H), 8.58 (d, *J* = 3.8 Hz, 1H), 8.01 (d, *J* = 7.1 Hz, 1H), 7.61–7.59 (m, 2H), 7.49–7.35 (m, 7H), 7.32–7.25 (m, 6H), 2.55 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 168.3, 147.9, 140.5, 139.9, 139.3, 139.2, 138.3, 136.7, 136.0, 135.9, 134.3, 129.5, 129.2, 129.0, 128.5, 127.7, 127.6, 127.5, 127.2, 127.1, 126.9, 121.7, 121.4, 116.5, 19.8; HRMS (ESI) calcd for $C_{29}H_{23}N_2O$ $[M + H]^+$ 415.1810, Found 415.1803.

Methyl-3′-methyl-N-(quinolin-8-yl)-[1,1′-biphenyl]-2-carboxamide (**3p**)

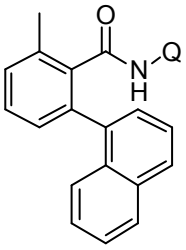


3p

74% yield (57 mg); White solid, mp: 131–133 ^{o}C (from ethyl acetate/petroleum ether = 8:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.67 (s, 1H), 8.76 (d, *J* = 7.4 Hz, 1H), 8.58 (dd, *J* = 4.1, 1.1 Hz, 1H), 8.03 (dd, *J* = 8.2, 1.2 Hz, 1H), 7.91–7.89 (m, 2H), 7.62–7.60 (m, 2H). 7.50–7.46 (m, 1H), 7.44–7.39 (m, 2H), 7.32–7.28 (m, 3H), 3.76 (s, 3H), 2.53 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.8, 166.6, 147.9, 145.0, 138.4, 138.2, 136.6, 136.0, 135.9, 134.0, 130.1, 129.4, 129.2, 128.8, 128.6, 127.7,

127.4, 127.1, 121.8, 121.4, 116.5, 51.8, 19.7; HRMS (ESI) calcd for $C_{25}H_{21}N_2O_3$ $(M + H)^+$ 397.1552, found 397.1548.

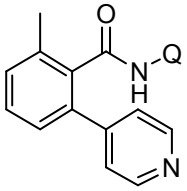
2-Methyl-N-(quinolin-8-yl)-6-(napht-1-yl)benzamide (**3q**)



3q

47% yield (32 mg); White solid, mp: 143–145 ^oC (from ethyl acetate/petroleum ether = 10:1); ^1H NMR (400 MHz, $CDCl_3$) δ 9.53 (s, 1H), 8.52 (dd, J = 7.2, 1.6 Hz, 1H), 8.29 (dd, J = 4.1, 1.5 Hz, 1H), 7.93–7.85 (m, 2H), 7.64 (d, J = 8.1 Hz, 1H), 7.54–7.36 (m, 6H), 7.32–7.26 (m, 4H), 7.22–7.19 (m, 1H), 2.58 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.6, 147.4, 138.1, 137.9, 137.8, 137.6, 136.1, 135.8, 134.0, 133.4, 132.2, 129.7, 128.7, 128.6, 128.0, 127.7, 127.4, 127.0, 126.9, 126.3, 125.9, 125.5, 124.9, 121.3, 121.1, 116.0, 19.9; HRMS (ESI) calcd for $C_{27}H_{19}N_2O$ $[M + H]^+$ 387.1497, Found 387.1501.

2-Methyl-N-(quinolin-8-yl)-6-(pyridin-8-yl)benzamide (**3r**)

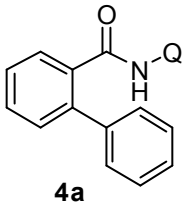


3r

65% yield (45 mg); colorless oil; ^1H NMR (400 MHz, $CDCl_3$) δ 9.67 (s, 1H), 8.76 (dd, J = 6.9, 2.0 Hz, 1H), 8.62 (d, J = 4.2 Hz, 1H), 8.44 (d, J = 5.2 Hz, 2H), 8.11 (dd, J = 8.3, 1.5 Hz, 1H), 7.55–7.50 (m, 2H), 7.48–7.45 (m, 3H), 7.39–7.36 (m, 2H), 7.31–7.29 (m, 1H), 2.55 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.5, 149.5, 148.3, 148.1, 138.3, 136.8, 136.6, 136.2, 134.0, 130.8, 129.5, 127.8, 127.2, 127.1, 123.5, 122.1, 121.6, 116.6, 19.7; HRMS (ESI) calcd for $C_{22}H_{16}N_3O$ $[M + H]^+$ 338.1293, Found 338.1294.

N-(quinolin-8-yl)-[1,1′-biphenyl]-2-carboxamide (**4a**)

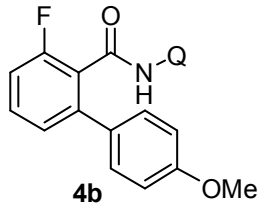
91% yield (59 mg); colorless oil; ^1H NMR (400 MHz, $CDCl_3$) δ 9.79 (s, 1H), 8.81 (d, J = 7.4 Hz, 1H), 8.51 (d, J = 2.6 Hz, 1H), 8.05 (d, J = 8.2 Hz, 1H),



4a

7.91 (d, *J* = 7.3 Hz, 1H), 7.57–7.45 (m, 6H), 7.37–7.33 (m, 1H), 7.30–7.26 (m, 2H), 7.18–7.16 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.8, 147.7, 140.5, 140.3, 138.4, 135.9, 134.5, 130.7, 130.5, 129.4, 129.1, 128.9, 128.7, 128.3, 128.1, 127.6, 127.3, 121.5, 121.4, 116.2; HRMS (ESI) calcd for $C_{22}H_{17}N_2O$ $(M + H)^+$ 325.1341, found 325.1355.

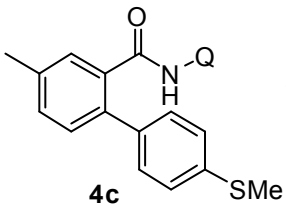
4′-Methoxy-3-fluoro-N-(quinolin-8-yl)-[1,1′-biphenyl]-2-carboxamide (**4b**)



4b

67% yield (50 mg); White solid, mp: 128–130 ^{o}C (from ethyl acetate/petroleum ether = 10:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.89 (s, 1H), 8.80 (d, *J* = 6.8 Hz, 1H), 8.66 (d, *J* = 4.2 Hz, 1H), 8.11 (d, *J* = 8.3 Hz, 1H), 7.53–7.51 (m, 1H), 7.48–7.40 (m, 3H), 7.39–7.38 (m, 1H), 7.27–7.24 (m, 2H), 7.19–7.14 (m, 1H), 6.80 (d, *J* = 8.3 Hz, 2H), 3.68 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 163.5, 160.6 (d, *J* = 249.8 Hz), 148.1, 142.0, 138.4, 136.2, 134.5, 134.2, 131.4, 130.9, 130.8, 129.7, 127.8, 127.3, 125.8, 121.9, 121.5, 116.7, 114.4 (d, *J* = 21.7 Hz), 113.9, 55.1; HRMS (ESI) calcd for $C_{23}H_{18}FN_2O_2$ $(M + H)^+$ 373.1352, found 373.1350.

4′-Methylthio-4-methyl-N-(quinolin-8-yl)-[1,1′-biphenyl]-2-carboxamide (**4c**)

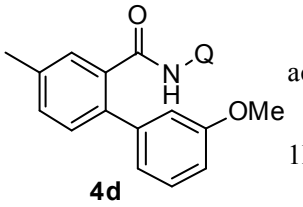


4c

72% yield (55 mg); White solid, mp: 127–129 ^{o}C (from ethyl acetate/petroleum ether = 12:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.78 (s, 1H), 8.81 (dd, *J* = 7.6, 1.1 Hz, 1H), 8.51 (dd, *J* = 4.2, 1.6 Hz, 1H), 8.04 (dd, *J* = 8.3, 1.6 Hz, 1H), 7.72 (s, 1H), 7.52–7.48 (m, 1H), 7.44–7.39 (m, 3H), 7.34–7.30 (m, 3H), 7.14–7.12 (m, 2H), 2.45 (s, 3H), 2.26 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.9, 147.7, 138.3, 137.7, 137.4, 136.6,

135.9, 135.6, 134.5, 131.3, 130.4, 129.8, 129.3, 127.6, 127.1, 126.5, 121.5, 121.3, 116.2, 21.0, 15.6; HRMS (ESI) calcd for $C_{24}H_{21}N_2OS$ $(M + H)^+$ 385.1375, found 385.1370.

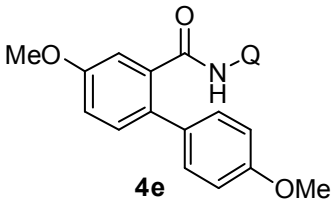
3′-Methoxy-4-chloro-N-(quinolin-8-yl)-[1,1′-biphenyl]-2-carboxamide (**4d**)



4d

79% yield (58 mg); White solid, mp: 132–134 °C (from ethyl acetate/petroleum ether = 10:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.77 (s, 1H), 8.82 (d, J = 7.6 Hz, 1H), 8.48 (dd, J = 4.2, 1.5 Hz, 1H), 7.97 (dd, J = 8.3, 1.4 Hz, 1H), 7.71 (s, 1H), 7.47–7.43 (m, 1H), 7.38–7.30 (m, 3H), 7.27–7.24 (m, 1H), 7.12–7.08 (m, 1H), 7.06–7.04 (m, 2H), 6.64 (d, J = 7.1 Hz, 1H), 3.63 (s, 3H), 2.43 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.9, 159.5, 147.6, 141.2, 138.2, 137.5, 137.1, 135.8, 134.5, 131.1, 130.3, 129.6, 129.2, 127.5, 127.0, 121.3, 121.3, 116.0, 114.0, 113.3, 55.0, 20.9; HRMS (ESI) calcd for $C_{24}H_{21}N_2O_2$ $(M + H)^+$ 369.1603, found 369.1609.

4,4'-dimethoxy-N-(quinolin-8-yl)-[1,1'-biphenyl]-2-carboxamide (**4e**)

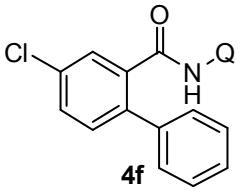


4e

84% yield (65 mg); White solid, mp: 141–143 °C (from ethyl acetate/petroleum ether = 8:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.79 (s, 1H), 8.82 (d, J = 7.5 Hz, 1H), 8.50 (d, J = 3.8 Hz, 1H), 8.07 (d, J = 8.2 Hz, 1H), 7.54–7.50 (m, 1H), 7.46–7.44 (m, 2H), 7.41–7.33 (m, 4H), 7.10–7.07 (m, 1H), 6.79 (d, J = 8.4 Hz, 2H), 3.90 (s, 3H), 3.63 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.7, 159.1, 158.8, 147.7, 138.5, 136.7, 135.9, 134.5, 132.4, 132.1, 131.9, 130.2, 127.7, 127.2, 121.5,

121.3, 117.1, 116.3, 113.9, 113.7, 55.6, 55.1; HRMS (ESI) calcd for $C_{24}H_{21}N_2O_3$ $(M + H)^+$ 385.1552, found 385.1546.

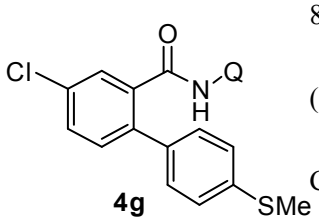
4-Chloro-N-(quinolin-8-yl)-[1,1′-biphenyl]-2-carboxamide (**4f**)



4f

55% yield (39 mg); colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.56 (s, 1H), 8.63 (d, J = 3.0 Hz, 1H), 8.35 (d, J = 7.2 Hz, 1H), 8.05 (d, J = 8.3 Hz, 1H), 7.65–7.63 (m, 1H), 7.53–7.51 (m, 2H), 7.45–7.41 (m, 3H), 7.38–7.34 (m, 1H), 7.26–7.22 (m, 3H), 7.17–7.15 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.0, 147.9, 139.3, 138.7, 138.7, 136.8, 136.0, 130.5, 130.3, 129.5, 129.4, 128.6, 128.3, 127.9, 127.8, 127.6, 127.1, 121.5, 121.4, 116.4; HRMS (ESI) calcd for $C_{22}H_{16}ClN_2O$ $(M + H)^+$ 359.0951, found 359.0947.

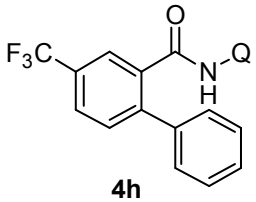
4′-Methylthio-4-chloro-N-(quinolin-8-yl)-[1,1′-biphenyl]-2-carboxamide (**4g**)



4g

71% yield (57 mg); White solid, mp: 121–123 ^{o}C (from ethyl acetate/petroleum ether = 12:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.80 (s, 1H), 8.77 (d, J = 7.3 Hz, 1H), 8.53 (d, J = 4.1 Hz, 1H), 8.08 (d, J = 8.3 Hz, 1H), 7.90 (d, J = 4.0 Hz, 1H), 7.52–7.47 (m, 3H), 7.40–7.37 (m, 4H), 7.16–7.14 (m, 2H), 2.29 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.2, 147.8, 138.7, 138.3, 137.9, 137.1, 136.0, 135.4, 134.2, 133.7, 131.8, 130.6, 129.3, 129.3, 127.7, 127.2, 126.5, 121.8, 121.5, 116.5, 15.5; HRMS (ESI) calcd for $C_{23}H_{18}ClN_2OS$ $(M + H)^+$ 405.0828, found 405.0834.

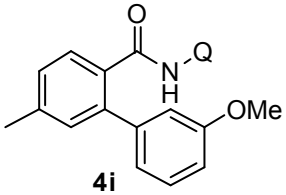
4-Trifluoro-N-(quinolin-8-yl)-[1,1′-biphenyl]-2-carboxamide (**4h**)



4h

77% yield (60 mg); White solid, mp: 123–125 ^{o}C (from ethyl acetate/petroleum ether = 12:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.78 (s, 1H), 8.78 (dd, J = 7.4, 1.2 Hz, 1H), 8.49 (dd, J = 4.2, 1.6 Hz, 1H), 8.20 (s, 1H), 8.05 (dd, J = 8.3, 1.5 Hz, 1H), 7.79 (d, J = 8.0 Hz, 1H), 7.59 (d, J = 8.2 Hz, 1H), 7.52–7.46 (m, 4H), 7.33–7.28 (m, 3H), 7.21–7.17 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.2, 147.8, 143.5, 138.5, 138.2, 136.5, 135.9, 134.0, 131.2, 130.2, 128.8, 128.6, 128.4, 127.5 (q, J = 24.1 Hz), 127.1, 127.0, 126.5, 121.9, 121.5, 118.9 (q, J = 276.2 Hz), 116.4; HRMS (ESI) calcd for $C_{23}H_{16}F_3N_2O$ $(M + H)^+$ 393.1215, found 393.1208.

3′-Methoxy-5-methyl-N-(quinolin-8-yl)-[1,1′-biphenyl]-2-carboxamide (**4i**)

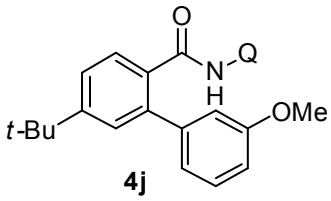


4i

73% yield (54 mg); White solid, mp: 131–133 ^{o}C (from ethyl acetate/petroleum ether = 10:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.77 (s, 1H), 8.81(d, J = 7.5 Hz, 1H), 8.49 (dd, J = 4.1, 1.5 Hz, 1H), 8.00 (dd, J = 8.3, 1.4 Hz, 1H), 7.83 (d, J = 8.4 Hz, 1H), 7.47 (t, J = 7.9 Hz, 1H), 7.40–7.38 (m, 1H), 7.30–7.27 (m, 3H), 7.15–7.11 (m, 1H), 7.07–7.05 (m, 2H), 6.67 (d, J = 8.8 Hz, 1H), 3.67 (s, 3H), 2.43 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.7, 159.5, 147.6, 141.5, 140.6, 140.1, 138.3, 135.8, 134.6, 133.2, 131.1, 129.3, 129.2, 128.3, 127.6, 127.1, 121.4, 121.3, 116.0, 114.0, 113.6, 55.1, 21.3; HRMS (ESI) calcd for $C_{24}H_{21}N_2O_2$ $(M + H)^+$ 369.1603, found 369.1601.

3′-Methoxy-5-tertbutyl-N-(quinolin-8-yl)-[1,1′-biphenyl]-2-carboxamide (**4j**)

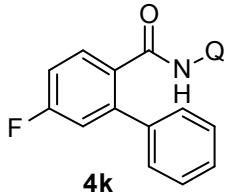
71% yield (58 mg); White solid, mp: 134–136 ^{o}C (from ethyl



4j

acetate/petroleum ether = 10:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.79 (s, 1H), 8.82 (d, J = 7.6 Hz, 1H), 8.51 (dd, J = 4.1, 1.5 Hz, 1H), 8.04 (dd, J = 8.3, 1.4 Hz, 1H), 7.87 (d, J = 8.1 Hz, 1H), 7.54–7.47 (m, 3H), 7.42–7.41 (m, 1H), 7.33–7.30 (m, 1H), 7.18–7.14 (m, 1H), 7.10–7.08 (m, 2H), 6.70 (d, J = 7.2 Hz, 1H), 3.69 (s, 3H), 1.39 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.8, 159.5, 153.8, 147.6, 141.9, 139.8, 138.4, 135.9, 134.6, 133.3, 129.3, 129.1, 127.6, 127.5, 127.2, 124.8, 121.5, 121.3, 116.1, 114.3, 113.4, 55.1, 34.9, 31.2; HRMS (ESI) calcd for $C_{27}H_{27}N_2O_2$ $(M + H)^+$ 411.2073, found 411.2069.

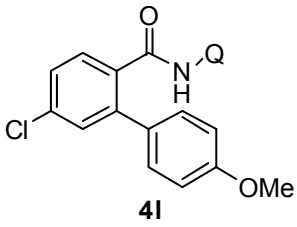
5-Fluoro-N-(quinolin-8-yl)-[1,1′-biphenyl]-2-carboxamide (**4k**)



4k

81% yield (55 mg); White solid, mp: 123–125 ^{o}C (from ethyl acetate/petroleum ether = 12:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.60 (s, 1H), 8.55 (dd, J = 4.2, 1.6 Hz, 1H), 8.49 (dd, J = 8.1, 1.4 Hz, 1H), 8.00 (dd, J = 8.3, 1.6 Hz, 1H), 7.54–7.51 (m, 3H), 7.38–7.37 (m, 1H), 7.36 (s, 1H), 7.31–7.28 (m, 1H), 7.25–7.21 (m, 3H), 7.17–7.15 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.7, 162.2 (d, J = 248.4 Hz), 147.8, 143.2, 143.1, 139.3, 138.1, 135.9, 134.1, 132.5, 128.8, 128.4, 128.3, 127.8, 127.5, 127.1, 121.6, 121.4 (d, J = 18.9 Hz), 116.3, 116.0 (d, J = 21.6 Hz); HRMS (ESI) calcd for $C_{22}H_{16}FN_2O$ $(M + H)^+$ 343.1247, found 343.1250.

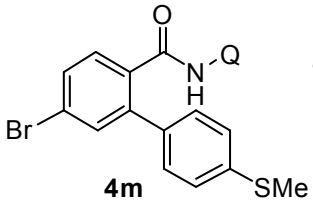
4′-Methoxy-5-chloro-N-(quinolin-8-yl)-[1,1′-biphenyl]-2-carboxamide (**4l**)



4l

57% yield (44 mg); White solid, mp: 124–126 ^{o}C (from ethyl acetate/petroleum ether = 10:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.60 (s, 1H), 8.58 (dd, J = 4.2, 1.6 Hz, 1H), 8.52 (d, J = 8.1 Hz, 1H), 8.04 (dd, J = 8.3, 1.6 Hz, 1H), 7.45–7.40 (m, 7H), 7.35–7.32 (m, 1H), 6.94 (d, J = 8 Hz, 2H), 3.65 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.0, 159.2, 149.2, 147.9, 141.9, 135.9, 134.7, 134.4, 134.1, 131.5, 129.7, 128.7, 127.5, 127.1, 126.8, 124.1, 121.4, 116.4, 114.2, 113.8, 55.1; HRMS (ESI) calcd for $C_{23}H_{18}ClN_2O_2$ $(M + H)^+$ 389.1057, found 389.1048.

4′-Methylthio-5-bromo-N-(quinolin-8-yl)-[1,1′-biphenyl]-2-carboxamide (**4m**)



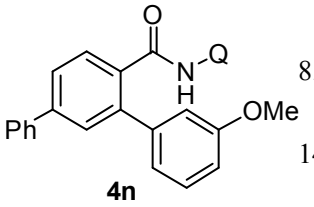
4m

70% yield (63 mg); White solid, mp: 127–129 ^{o}C (from ethyl acetate/petroleum ether = 12:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.87 (s, 1H), 8.83 (d, J = 7.6 Hz, 1H), 8.55 (dd, J = 4.1, 1.5 Hz, 1H), 8.09 (dd, J = 8.3, 1.4 Hz, 1H), 8.02 (d, J = 8.0 Hz, 1H), 7.68–7.66 (m, 2H), 7.50–7.46 (m, 4H), 7.37–7.34 (m, 1H), 7.20–7.18 (m, 2H), 2.30 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.4, 147.8, 143.5, 139.9, 138.3, 136.7, 135.9, 134.5, 130.1, 129.5, 129.3, 128.9, 127.9, 127.7, 127.2, 126.6, 126.2, 121.5, 121.4, 116.3, 15.6; HRMS (ESI) calcd for $C_{23}H_{18}BrN_2OS$ $(M + H)^+$ 449.0323, found 449.0320.

3′-Methoxy-5-Phenyl-N-(quinolin-8-yl)-[1,1′-biphenyl]-2-carboxamide (**4n**)

72% yield (62 mg); White solid, mp: 144–146 ^{o}C (from ethyl acetate/petroleum ether = 10:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.84 (s, 1H), 8.83 (d, J = 7.5 Hz, 1H), 8.54 (dd, J = 4.2, 1.6 Hz, 1H), 8.08 (dd, J

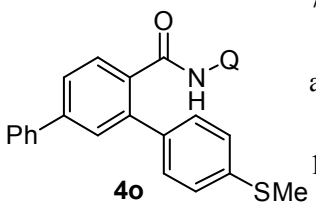
= 8.2, 1.4 Hz, 1H), 8.01 (d, *J* = 7.8 Hz, 1H), 7.74–7.67 (m, 4H), 7.52–7.47 (m, 5H), 7.37–7.34 (m, 1H), 7.20–7.12 (m, 3H), 6.73 (d, *J* = 8.2 Hz, 1H), 3.71 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.5, 159.7, 147.7, 143.4, 141.4, 140.7, 140.0, 138.4, 135.9, 134.8, 134.6, 129.9, 129.4, 129.3, 128.9, 127.9, 127.7, 127.3, 126.3, 121.5, 121.5, 121.4, 116.2, 114.2, 113.9, 55.2; HRMS (ESI) calcd for $C_{29}H_{23}N_2O_2$ $(M + H)^+$ 431.1760, found 431.1755.



4n

4′-Methylthio-5-Phenyl-N-(quinolin-8-yl)-[1,1′-biphenyl]-2-carboxamide (**4o**)

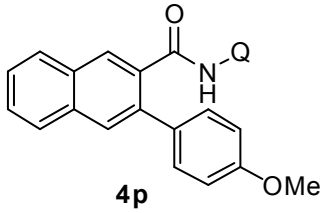
71% yield (63 mg); White solid, mp: 142–144 ^{o}C (from ethyl acetate/petroleum ether = 12:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.69 (s, 1H), 8.55 (dd, *J* = 4.0, 1.3 Hz, 2H), 8.02 (dd, *J* = 8.3, 1.5 Hz, 1H), 7.68–7.65 (m, 4H), 7.52–7.46 (m, 6H), 7.33–7.30 (m, 1H), 7.14–7.12 (m, 4H), 2.30 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.5, 147.8, 142.3, 140.6, 139.9, 138.3, 137.9, 136.9, 135.9, 134.6, 134.1, 130.3, 129.0, 128.9, 128.0, 127.9, 127.6, 127.2, 127.1, 126.3, 121.7, 121.4, 116.5, 116.1, 15.5; HRMS (ESI) calcd for $C_{29}H_{23}N_2OS$ $(M + H)^+$ 447.1531, found 447.1526.



4o

3-(4-methoxyphenyl)-N-(quinolin-8-yl)-2-naphthamide (**4p**)

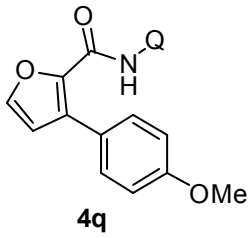
73% yield (59 mg); White solid, mp: 147–149 ^{o}C (from ethyl acetate/petroleum ether = 8:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.98 (s, 1H), 8.86 (d, *J* = 7.5 Hz, 1H), 8.57 (d, *J* = 4.0 Hz, 1H), 8.43 (s, 1H), 8.10 (d, *J* = 8.0 Hz, 1H), 7.97 (d, *J* = 8.0 Hz, 1H), 7.91–7.89 (m, 2H),



4p

7.59–7.53 (m, 4H), 7.50–7.46 (m, 2H), 7.37 (dd, J = 8.2, 4.2 Hz, 1H), 6.86 (d, J = 8.4 Hz, 2H), 3.69 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.8, 159.3, 147.8, 138.5, 137.0, 136.0, 134.7, 134.4, 134.1, 132.6, 131.8, 131.6, 130.3, 129.6, 129.6, 128.5, 127.7, 127.7, 127.3, 126.6, 121.5, 121.4, 116.4, 114.0, 55.2; HRMS (ESI) calcd for $C_{27}H_{21}N_2O_2$ $(M + H)^+$ 405.1603, found 405.1611.

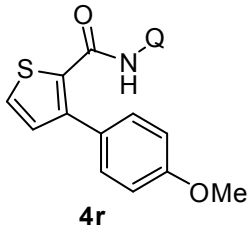
2-(4-methoxyphenyl)-N-(quinolin-8-yl)furan-3-carboxamide (**4q**)



4q

71% yield (49 mg); White solid, mp: 153–155 ^{o}C (from ethyl acetate/petroleum ether = 12:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.79 (s, 1H), 8.87 (d, J = 6.9 Hz, 1H), 8.83 (d, J = 4.1 Hz, 1H), 8.16 (d, J = 8.2 Hz, 1H), 7.74 (d, J = 8.5 Hz, 2H), 7.63 (s, 1H), 7.54–7.52 (m, 2H), 7.46 (dd, J = 8.3, 4.2 Hz, 1H), 6.99 (d, J = 8.5 Hz, 2H), 6.68 (s, 1H), 3.86 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.7, 157.0, 148.2, 143.3, 141.6, 138.8, 136.3, 134.5, 132.1, 130.8, 128.0, 127.4, 124.1, 121.6, 121.5, 116.7, 114.8, 113.7, 55.3; HRMS (ESI) calcd for $C_{21}H_{17}N_2O_3$ $(M + H)^+$ 345.1239, found 345.1245.

2-(4-methoxyphenyl)-N-(quinolin-8-yl)thiophene-3-carboxamide (**4r**)

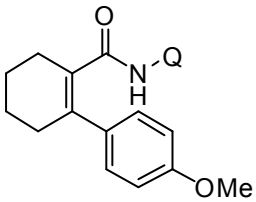


4r

70% yield (50 mg); White solid, mp: 137–139 ^{o}C (from ethyl acetate/petroleum ether = 10:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.14 (s, 1H), 8.83 (d, J = 7.6 Hz, 1H), 8.31 (d, J = 3.8 Hz, 1H), 8.04 (d, J = 8.2 Hz, 1H), 7.53–7.42 (m, 5H), 7.31 (dd, J = 8.2, 4.1 Hz, 1H), 7.08 (d, J = 5.0 Hz, 1H), 7.00–6.98 (m, 2H), 3.83 (s, 3H); ^{13}C NMR (100 MHz,

$CDCl_3$) δ 160.8, 160.1, 147.4, 142.9, 138.4, 135.8, 135.4, 134.6, 131.5, 130.8, 129.2, 127.7, 127.4, 127.3, 121.4, 121.3, 116.4, 114.6, 55.3; HRMS (ESI) calcd for $C_{21}H_{17}N_2O_2S$ $(M + H)^+$ 361.1011, found 361.1006.

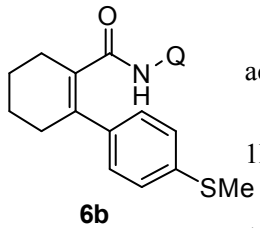
4'-methoxy-N-(quinolin-8-yl)-3,4,5,6-tetrahydro-[1,1'-biphenyl]-2-carboxamide (**6a**)



6a

77% yield (55 mg); White solid, mp: 123–125 °C (from ethyl acetate/petroleum ether = 12:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.37 (s, 1H), 8.70 (d, J = 7.5 Hz, 1H), 8.52 (d, J = 3.9 Hz, 1H), 8.02 (d, J = 8.2 Hz, 1H), 7.47–7.43 (m, 1H), 7.38 (d, J = 8.1 Hz, 1H), 7.31 (dd, J = 8.2, 4.2 Hz, 1H), 7.27–7.26 (m, 2H), 6.68 (d, J = 8.5 Hz, 2H), 3.54 (s, 3H), 2.63–2.58 (m, 2H), 2.50–2.45 (m, 2H), 1.84–1.76 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 169.9, 159.0, 147.5, 140.2, 138.4, 135.9, 134.7, 134.2, 132.5, 128.8, 127.7, 127.2, 121.2, 121.0, 116.0, 113.7, 55.0, 32.0, 27.2, 22.8, 22.2; HRMS (ESI) calcd for $C_{23}H_{23}N_2O_2$ $(M + H)^+$ 359.1760, found 359.1766.

4'-(methylthio)-N-(quinolin-8-yl)-3,4,5,6-tetrahydro-[1,1'-biphenyl]-2-carboxamide (**6b**)

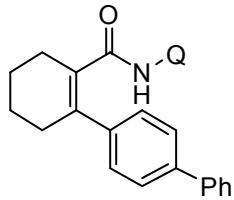


6b

81% yield (61 mg); White solid, mp: 113–115 °C (from ethyl acetate/petroleum ether = 12:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.37 (s, 1H), 8.68 (d, J = 7.5 Hz, 1H), 8.52 (d, J = 4.1 Hz, 1H), 8.03 (d, J = 8.2 Hz, 1H), 7.47–7.43 (m, 1H), 7.40–7.38 (m, 1H), 7.32 (dd, J = 8.2, 4.2 Hz, 1H), 7.27–7.23 (m, 2H), 7.03 (d, J = 8.1 Hz, 2H), 2.64–2.59 (m, 2H), 2.49–2.45 (m, 2H), 2.18 (s, 3H), 1.83–1.78 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 169.6, 147.6, 139.9, 138.6, 138.4, 137.5, 135.9, 134.5, 133.1, 128.1, 127.6,

127.2, 126.6, 121.2, 121.1, 116.1, 31.7, 27.2, 22.7, 22.1, 15.7; HRMS (ESI) calcd for $C_{23}H_{23}N_2OS$ $(M + H)^+$ 375.1531, found 375.1526.

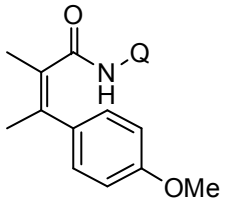
N-(quinolin-8-yl)-3,4,5,6-tetrahydro-[1,1':4',1''-terphenyl]-2-carboxamide (**6c**)



6c

63% yield (51 mg); White solid, mp: 144–146 ^oC (from ethyl acetate/petroleum ether = 12:1); ^1H NMR (400 MHz, $CDCl_3$) δ 9.41 (s, 1H), 8.70 (d, J = 7.6 Hz, 1H), 8.45 (d, J = 3.9 Hz, 1H), 7.97 (d, J = 8.2 Hz, 1H), 7.47–7.34 (m, 6H), 7.31–7.20 (m, 6H), 2.70–2,60 (m, 2H), 2.59–2.52 (m, 2H), 1.89–1.80 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 169.6, 147.5, 140.7, 140.6, 140.2, 140.2, 138.4, 135.8, 134.6, 133.2, 128.5, 128.1, 127.6, 127.2, 127.1, 126.9, 126.8, 121.2, 121.1, 116.1, 31.8, 27.2, 22.7, 22.1; HRMS (ESI) calcd for $C_{28}H_{25}N_2O$ $(M + H)^+$ 405.1967, found 405.1957.

(Z)-3-(4-methoxyphenyl)-2-methyl-N-(quinolin-8-yl)but-2-enamide (**6d**)

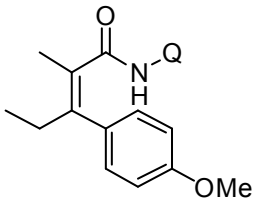


6d

63% yield (42 mg); colorless oil; ^1H NMR (400 MHz, $CDCl_3$) δ 9.99 (s, 1H), 8.90 (d, J = 7.4 Hz, 1H), 8.83 (d, J = 4.2 Hz, 1H), 8.19 (d, J = 8.3 Hz, 1H), 7.59–7.55 (m, 2H), 7.47 (dd, J = 8.2, 4.2 Hz, 1H), 7.26–7.22 (m, 2H), 6.94 (d, J = 8.4 Hz, 2H), 3.85 (s, 3H), 2.23 (s, 3H), 1.99 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 170.6, 158.6, 148.3, 138.6, 138.0, 137.6, 136.4, 134.7, 134.6, 129.6, 129.0, 128.0, 127.5, 121.6, 116.6, 113.7, 55.3, 22.7, 17.9; HRMS (ESI) calcd for $C_{21}H_{21}N_2O_2$ $(M + H)^+$ 333.1603, found 333.1600.

(Z)-3-(4-methoxyphenyl)-2-methyl-N-(quinolin-8-yl)pent-2-enamide (**6e**)

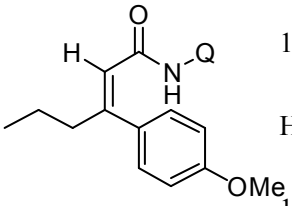
61% yield (42 mg); colorless oil; ^1H NMR (400 MHz, $CDCl_3$) δ 9.98 (s,



6e

1H), 8.91 (d, J = 7.3 Hz, 1H), 8.83 (d, J = 4.0 Hz, 1H), 8.19 (d, J = 8.2 Hz, 1H), 7.61–7.53 (m, 2H), 7.47 (dd, J = 8.2, 4.1 Hz, 1H), 7.18 (d, J = 8.2 Hz, 2H), 6.94 (d, J = 8.3 Hz, 2H), 3.85 (s, 3H), 2.58 (q, J = 7.2 Hz, 2H), 1.93 (s, 3H), 0.99 (t, J = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 170.7, 158.6, 148.2, 143.8, 138.5, 136.4, 134.7, 132.8, 129.6, 129.3, 128.0, 127.5, 121.6, 121.6, 116.6, 113.6, 55.2, 29.2, 17.9, 13.3; HRMS (ESI) calcd for $C_{22}H_{23}N_2O_2$ $(M + H)^+$ 347.1760, found 347.1751.

(Z)-3-(4-methoxyphenyl)-N-(quinolin-8-yl)hex-2-enamide (**6f**)



6f

65% yield (45 mg); colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.60 (s, 1H), 8.74 (d, J = 7.4 Hz, 1H), 8.51 (d, J = 3.6 Hz, 1H), 8.06 (d, J = 8.2 Hz, 1H), 7.48–7.41 (m, 3H), 7.34 (dd, J = 8.1, 4.2 Hz, 1H), 7.28–7.26 (m, 1H), 6.86 (d, J = 8.3 Hz, 2H), 6.11 (s, 1H), 3.72 (s, 3H), 2.50 (t, J = 7.4 Hz, 2H), 1.46 (q, J = 7.4 Hz, 2H), 0.95 (t, J = 7.3 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.2, 159.7, 153.6, 147.5, 138.4, 135.9, 134.8, 131.3, 129.2, 127.8, 127.4, 122.3, 121.3, 121.0, 116.3, 114.0, 55.1, 42.4, 20.8, 13.6; HRMS (ESI) calcd for $C_{22}H_{23}N_2O_2$ $(M + H)^+$ 347.1760, found 347.1755.

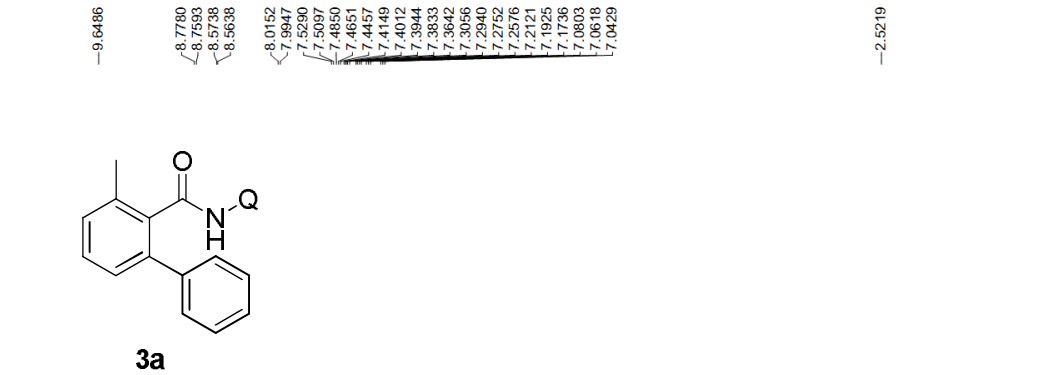
References

1. A. M. Suess, M. Z. Ertem, C. J. Cramer and S. S. Stahl, *J. Am. Chem. Soc.,* 2013, **135**, 9797.

2. (a) L. D. Tran, I. Popov and O. Daugulis, *J. Am. Chem. Soc.,* 2012, **134**, 18237; (b) T. Truong, K. Klimovica and O. Daugulis, *J. Am. Chem. Soc.,* 2013, **135**, 9342; (c) L. D. Tran, J. Roane and O. Daugulis, *Angew. Chem., Int. Ed.,* 2013, **52**, 6043; (d) J. Roane and O. Daugulis, *Org. Lett.,*

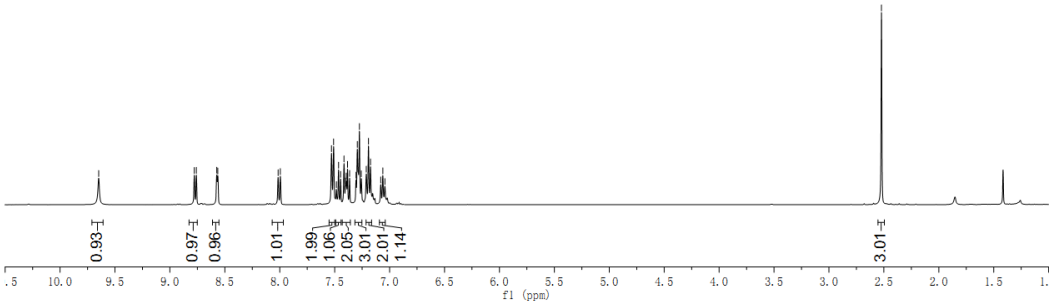
2013, **15**, 5842; (e) M. Nishino, K. Hirano, T. Satoh and M. Miura, *Angew. Chem., Int. Ed.,* 2013, **52**, 4457.

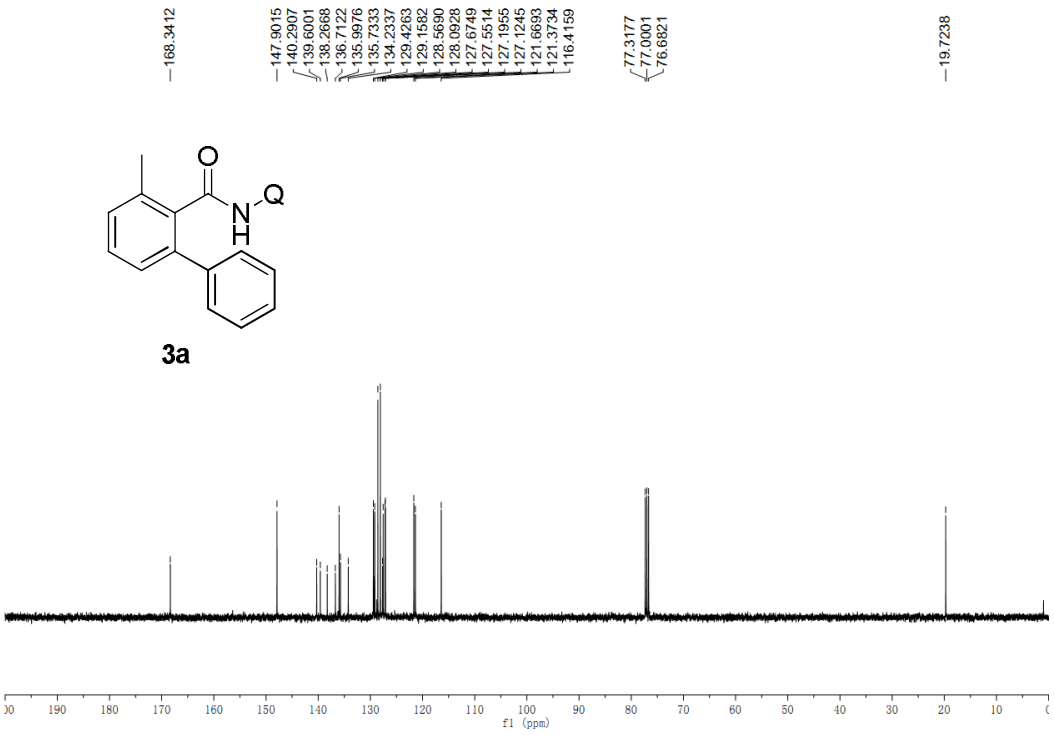
3. A. Yokota, Y. Aihara and N. Chatani, *J. Org. Chem.,* 2014, **79**, 11922.


9.6486
8.7780
8.7593
8.5738
8.5638
8.0152
7.9947
7.5290
7.5097
7.4850
7.4651
7.4457
7.4149
7.4012
7.3944
7.3833
7.3642
7.3056
7.2940
7.2752
7.2576
7.2121
7.1925
7.1736
7.0803
7.0618
7.0429
2.5219

O
N
H
Q

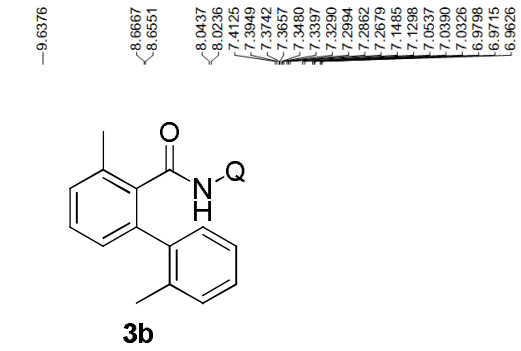
3a


0.93
0.97
0.96
1.01
1.99
1.06
2.05
3.01
2.01
1.14
3.01
f1 (ppm)

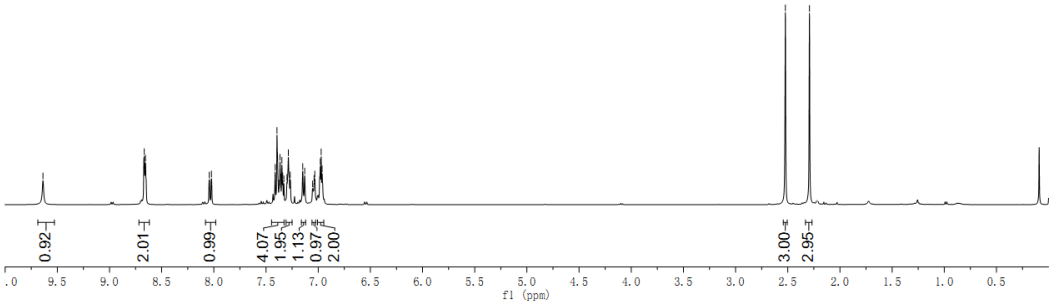

168.3412
147.9015
140.2907
139.6001
138.2668
136.7122
135.9976
135.7333
134.2337
129.4263
129.1582
128.5690
128.0928
127.6749
127.5514
127.1955
127.1245
121.6693
121.3734
116.4159
77.3177
77.0001
76.6821
19.7238
f1 (ppm)

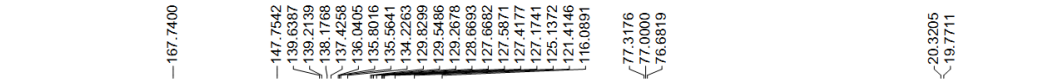
O
N
H
Q

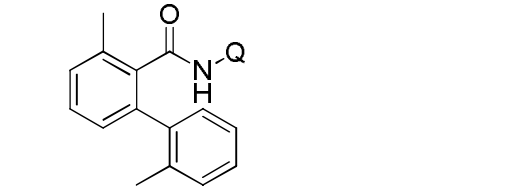
3a


9.6376
8.6667
8.6551
8.0437
8.0236
7.4125
7.3949
7.3742
7.3657
7.3480
7.3397
7.3290
7.2994
7.2862
7.2679
7.1485
7.1298
7.0537
7.0390
7.0326
6.9798
6.9715
6.9626
2.5233
2.2924
O
N
H
Q

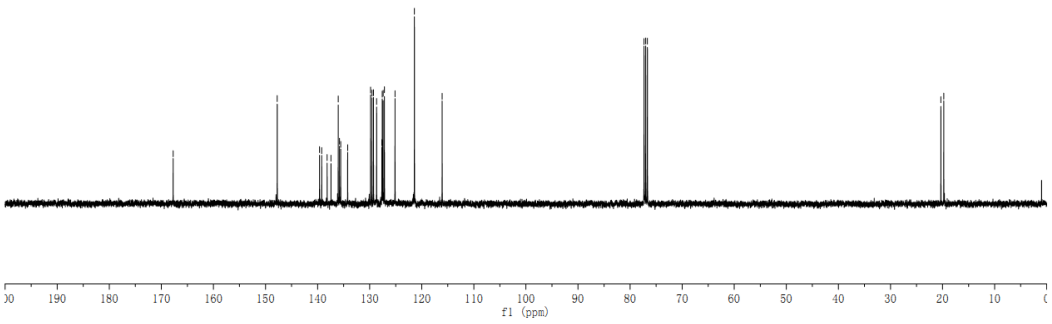
3b

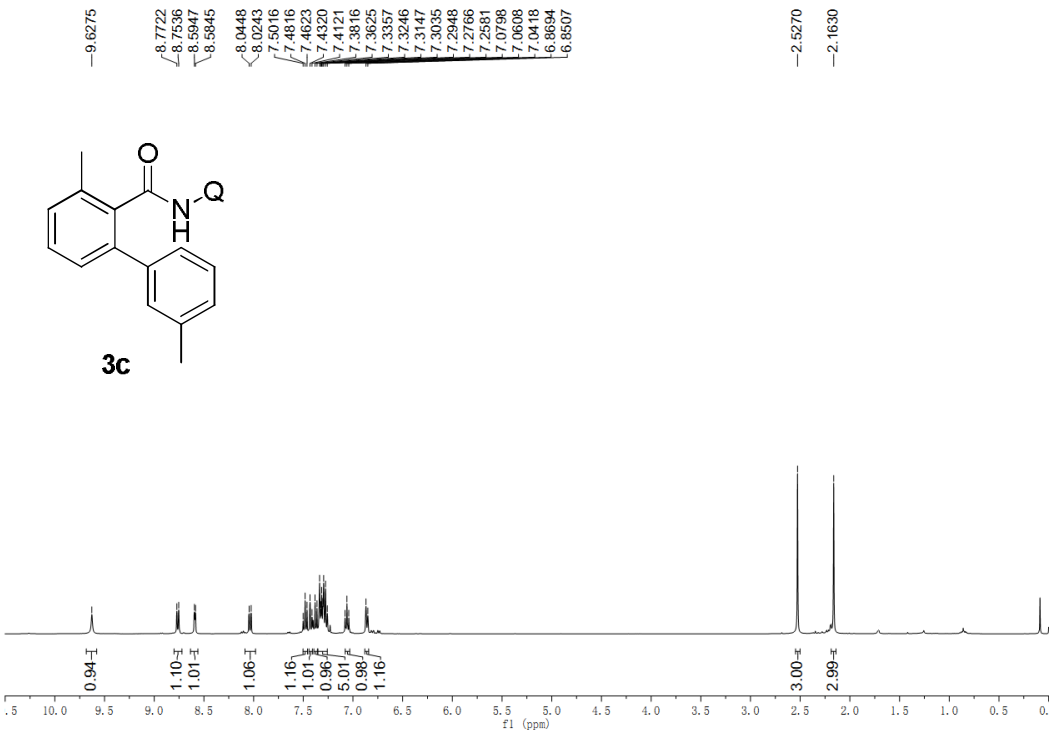

0.92
2.01
0.99
4.07
1.95
1.13
0.97
2.00
3.00
2.95
f1 (ppm)

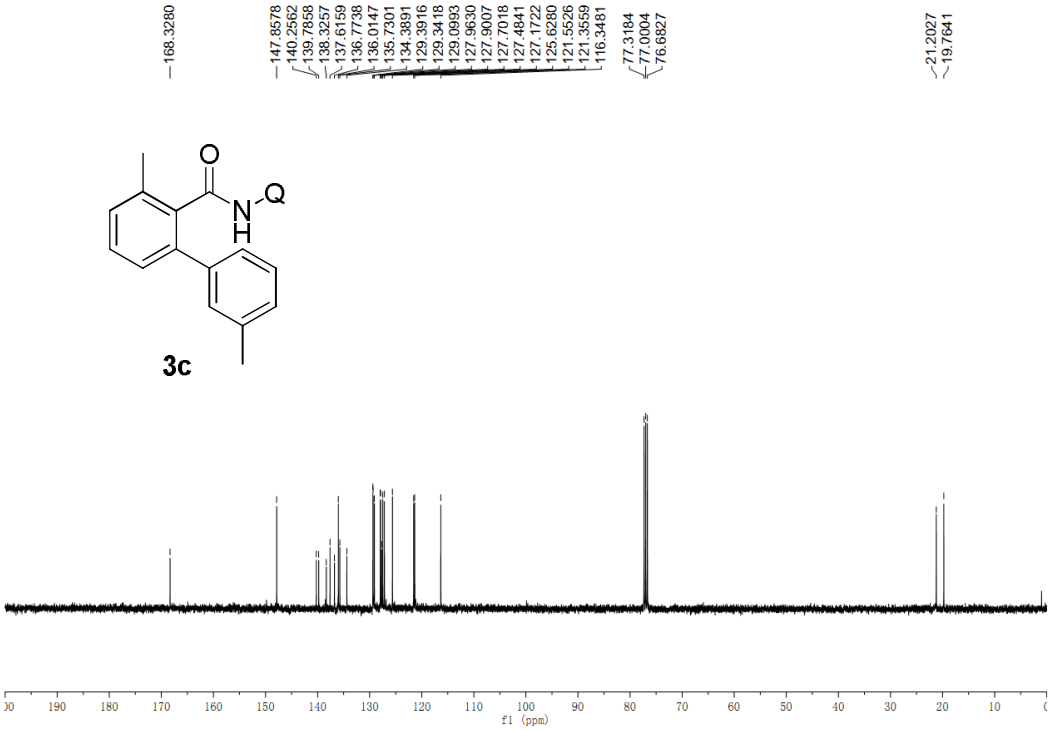

167.7400
147.7542
139.6387
139.2139
138.1768
137.4258
136.0405
135.8016
135.5641
134.2263
129.8299
129.5486
129.2678
128.6693
127.6682
127.5871
127.4177
127.1741
125.1372
121.4146
116.0891
77.3176
77.0000
76.6819
20.3205
19.7711

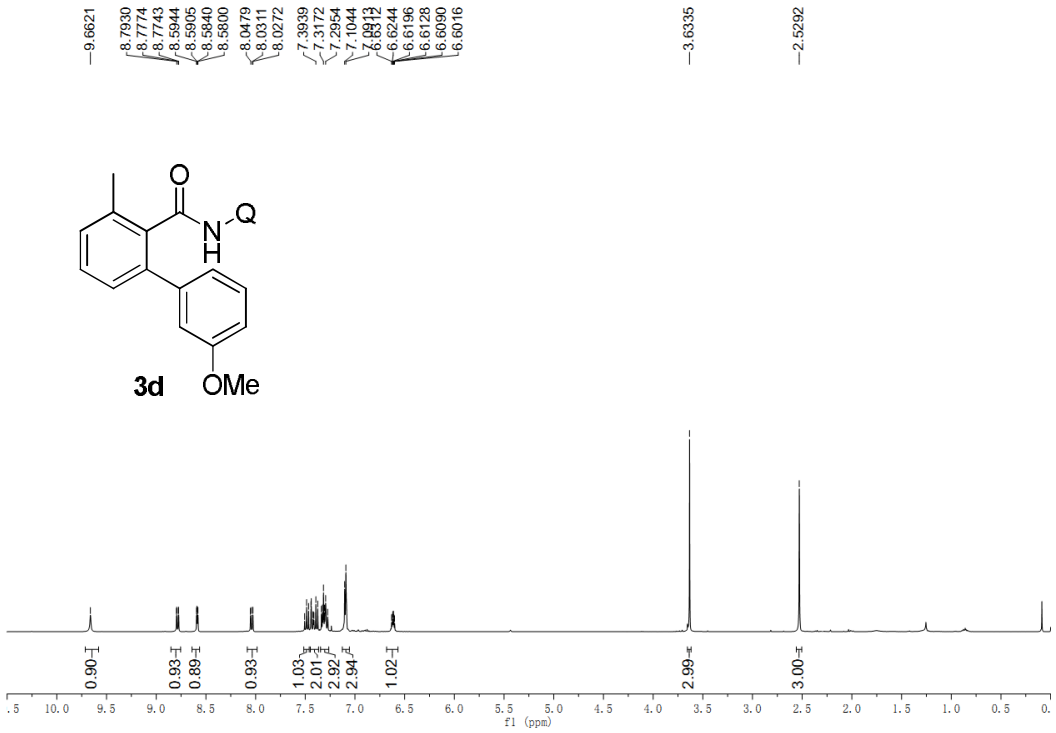

O
N
H
Q

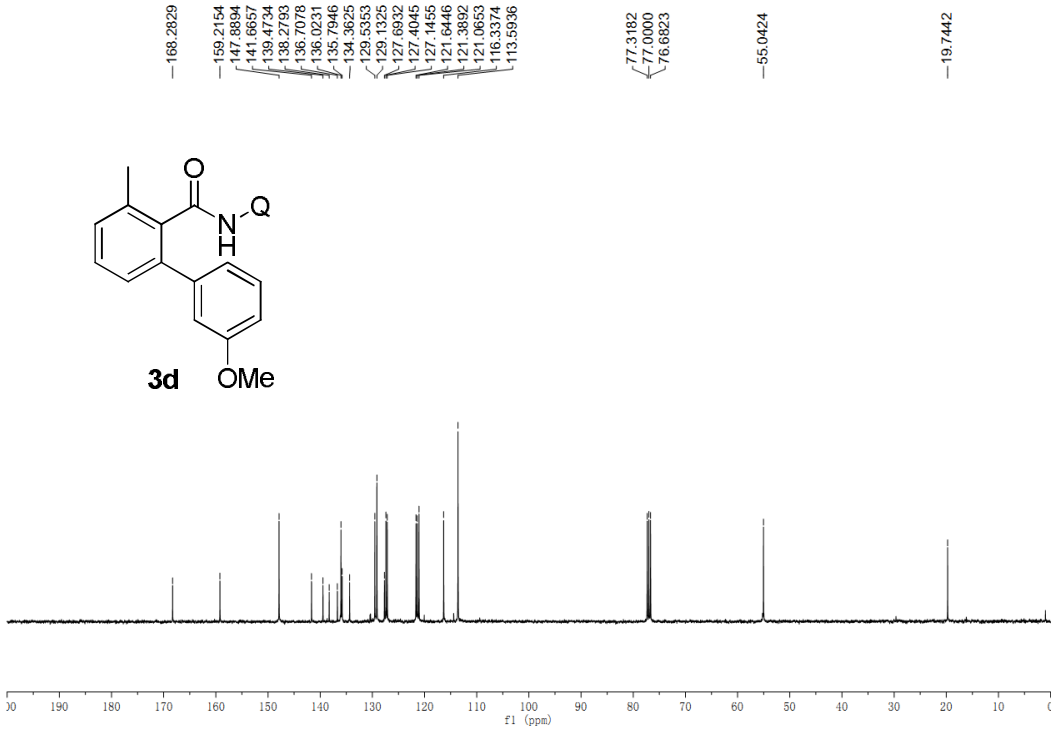
3b

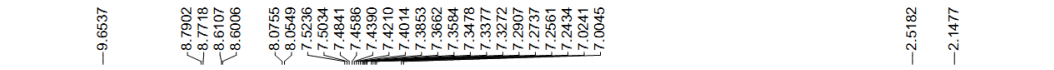

f1 (ppm)

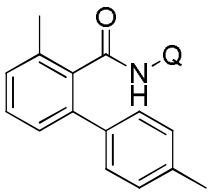

9.6275
8.7722
8.7536
8.5947
8.5845
8.0448
8.0243
7.5016
7.4816
7.4623
7.4320
7.4121
7.3816
7.3625
7.3357
7.3246
7.3147
7.3035
7.2948
7.2766
7.2581
7.0798
7.0608
7.0418
6.8694
6.8507
2.5270
2.1630
O
N
H
Q
3c
0.94
1.10
1.01
1.06
1.16
1.01
0.96
5.01
0.98
1.16
3.00
2.99
f1 (ppm)


168.3280
147.8578
140.2562
139.7858
138.3257
137.6159
136.7738
136.0147
135.7301
134.3891
129.3916
129.3418
129.0993
127.9630
127.9007
127.7018
127.4841
127.1722
125.6280
121.5526
121.3559
116.3481
77.3184
77.0004
76.6827
21.2027
19.7641
O
N
H
Q
3c
f1 (ppm)

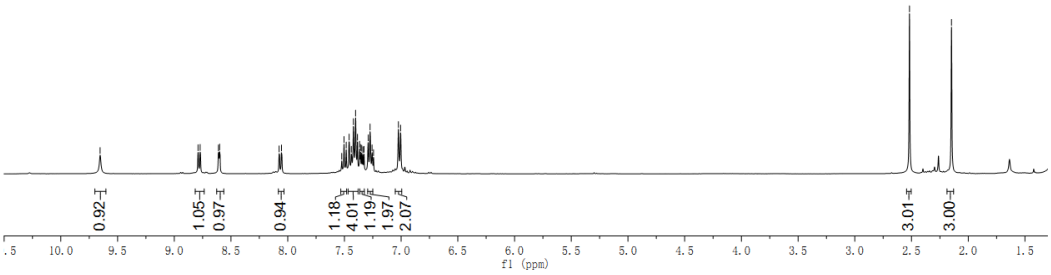

9.6621
8.7930
8.7774
8.7743
8.5944
8.5905
8.5840
8.5800
8.0479
8.0311
8.0272
7.3939
7.3172
7.2954
7.1044
6.8312
6.6244
6.6196
6.6128
6.6090
6.6016
3.6335
2.5292
O
N
H
Q
3d
OMe
0.90
0.93
0.89
0.93
1.03
2.01
2.92
2.94
1.02
2.99
3.00
f1 (ppm)

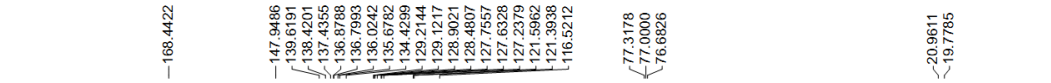

168.2829
159.2154
147.8894
141.6657
139.4734
138.2793
136.7078
136.0231
135.7946
134.3625
129.5353
129.1325
127.6932
127.4045
127.1455
121.6446
121.3892
121.0653
116.3374
113.5936
77.3182
77.0000
76.6823
55.0424
19.7442
O
N
H
Q
3d
OMe
f1 (ppm)

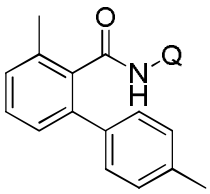

9.6537
8.7902
8.7718
8.6107
8.6006
8.0755
8.0549
7.5236
7.5034
7.4841
7.4586
7.4390
7.4210
7.4014
7.3853
7.3662
7.3584
7.3478
7.3377
7.3272
7.2907
7.2737
7.2561
7.2434
7.0241
7.0045
2.5182
2.1477


O
N
H
Q

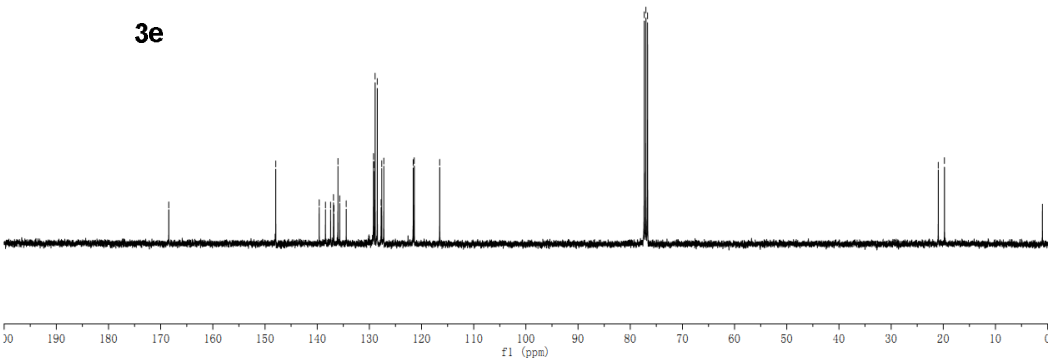
3e

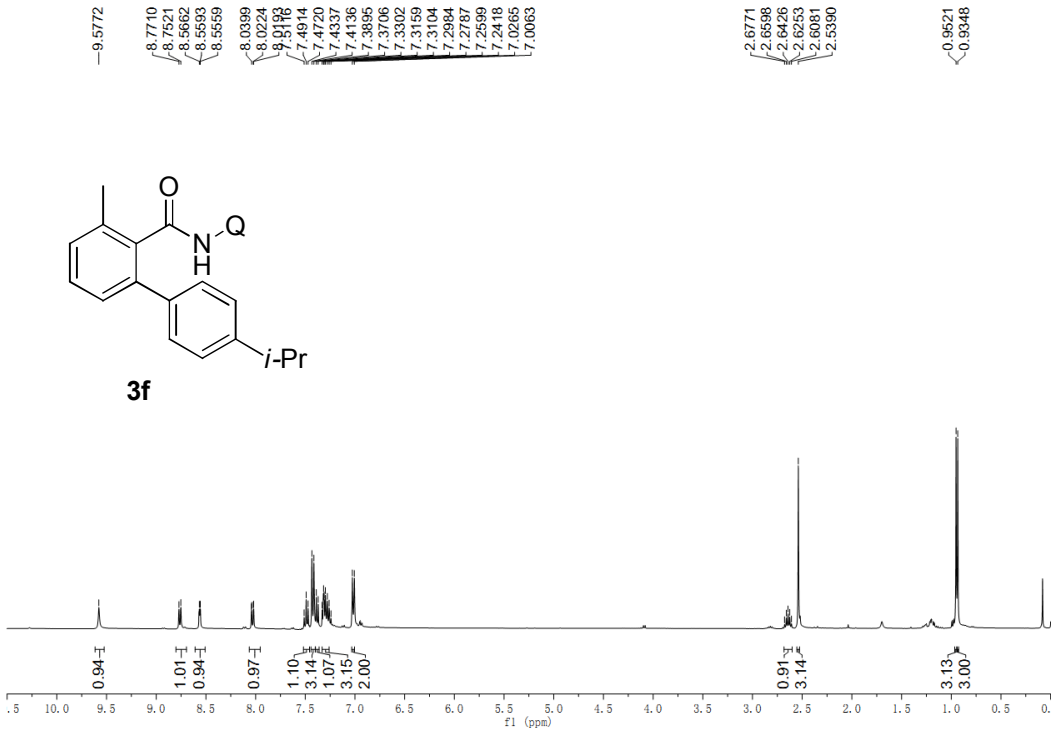

0.92
1.05
0.97
0.94
1.18
4.01
1.19
1.97
2.07
3.01
3.00
f1 (ppm)


168.4422
147.9486
139.6191
138.4201
137.4355
136.8788
136.7993
136.0242
135.6782
134.4299
129.2144
129.1217
128.9021
128.4807
127.7557
127.6328
127.2379
121.5962
121.3938
116.5212
77.3178
77.0000
76.6826
20.9611
19.7785

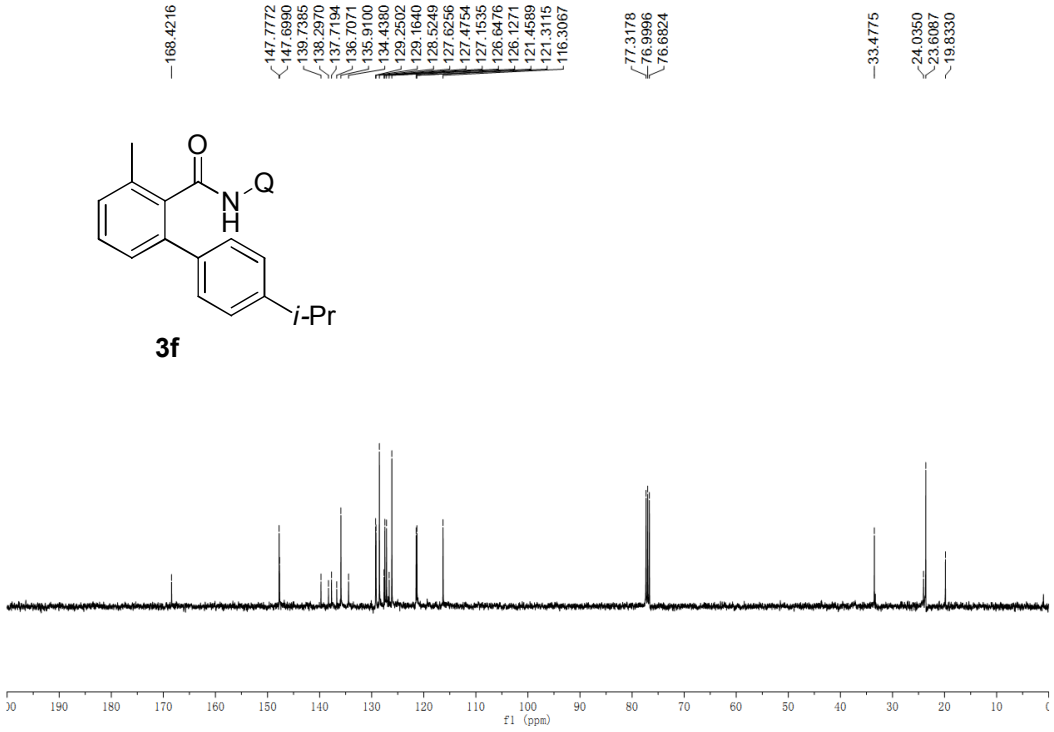

O
N
H
Q

3e

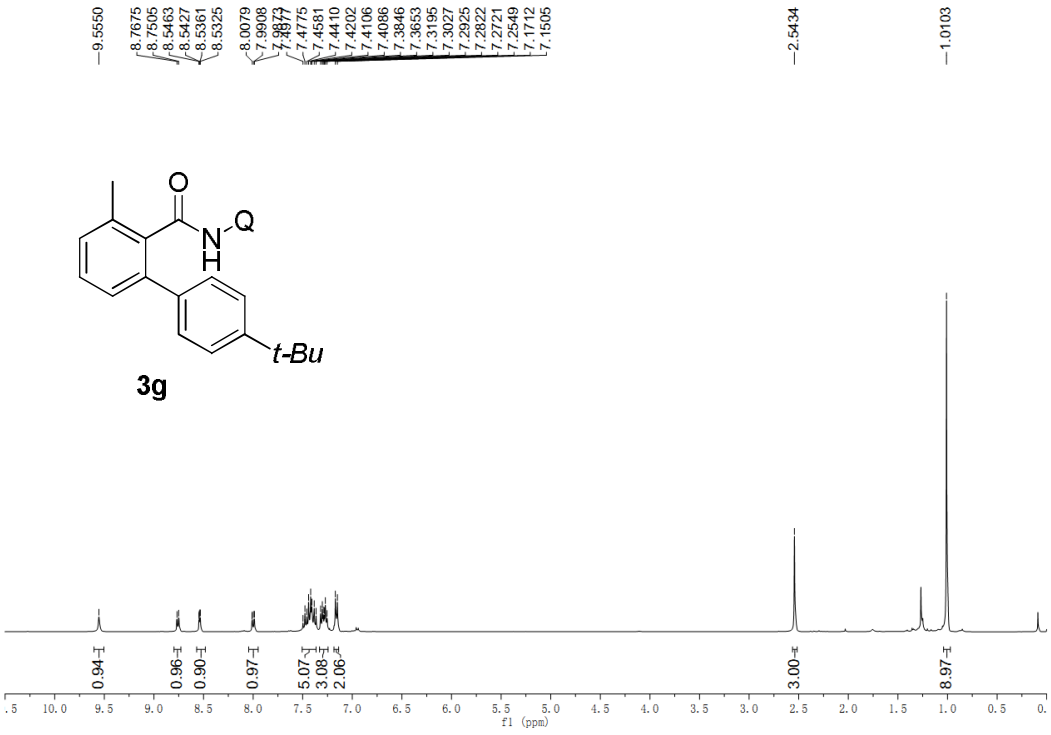

f1 (ppm)

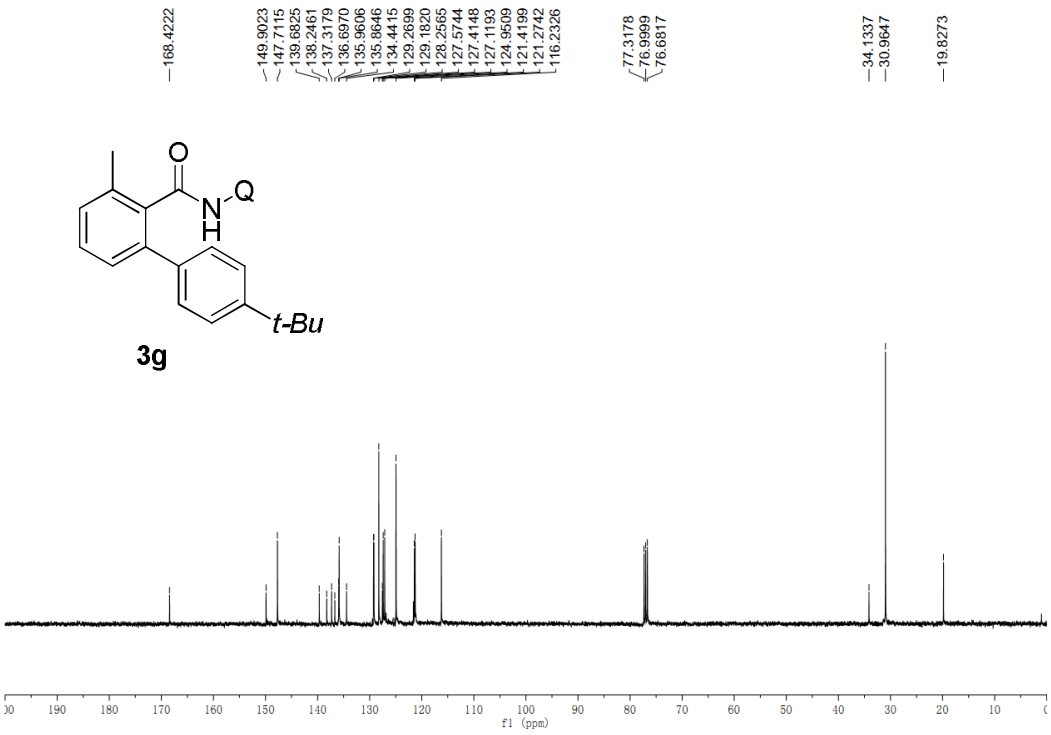

9.5772
8.7710
8.7521
8.5662
8.5593
8.5559
8.0399
8.0224
7.4914
7.4720
7.4337
7.4136
7.3895
7.3706
7.3302
7.3159
7.3104
7.2984
7.2787
7.2599
7.2418
7.0265
7.0063
2.6771
2.6598
2.6426
2.6253
2.6081
2.5390
0.9521
0.9348
O
N
H
Q
i-Pr
0.94
1.01
0.94
0.97
1.10
3.14
1.07
3.15
2.00
0.91
3.14
3.13
3.00
f1 (ppm)

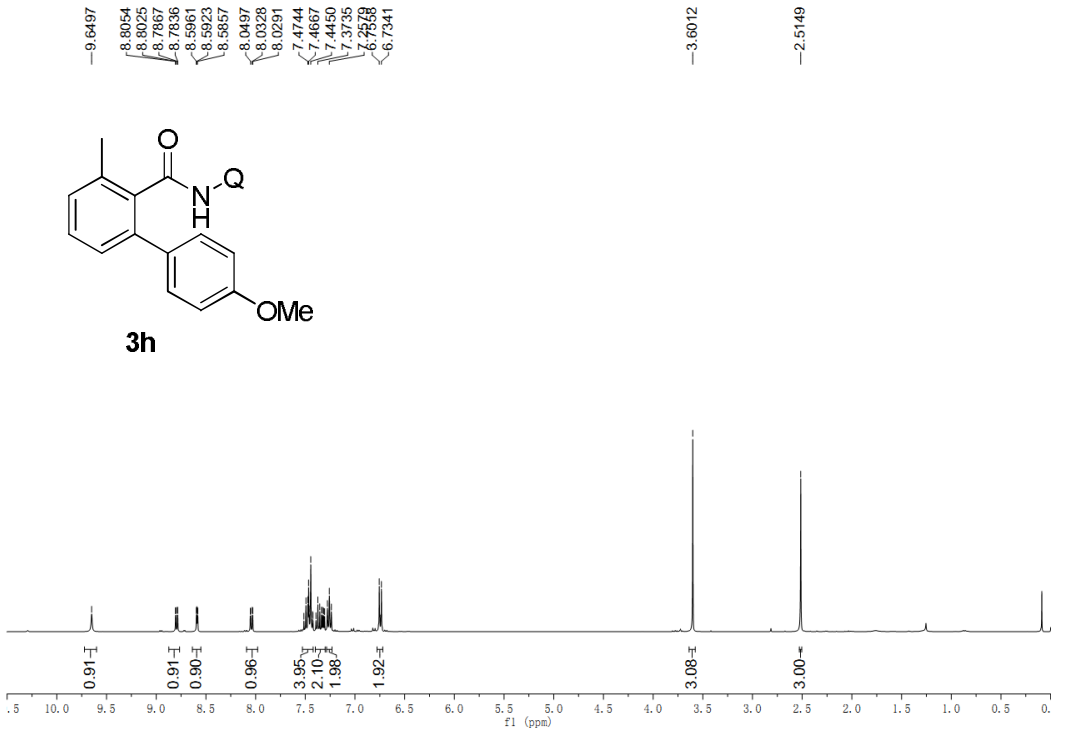
3f


168.4216
147.7772
147.6990
139.7385
138.2970
137.7194
136.7071
135.9100
134.4380
129.2502
129.1640
128.5249
127.6256
127.4754
127.1535
126.6476
126.1271
121.4589
121.3115
116.3067
77.3178
76.9996
76.6824
33.4775
24.0350
23.6087
19.8330
O
N
H
Q
i-Pr
f1 (ppm)

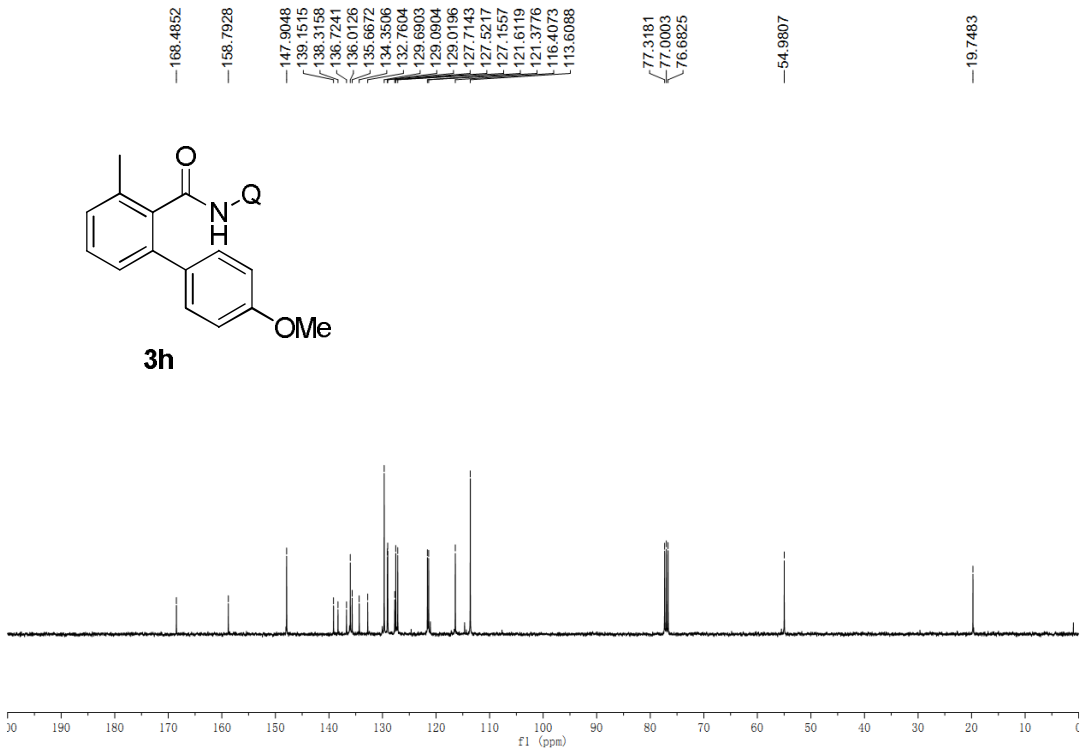
3f


9.5550
8.7675
8.7505
8.5463
8.5427
8.5361
8.5325
8.0079
7.9908
7.4775
7.4581
7.4410
7.4202
7.4106
7.4086
7.3846
7.3653
7.3195
7.3027
7.2925
7.2822
7.2721
7.2549
7.1712
7.1505
2.5434
1.0103
O
N
H
Q
t-Bu
3g
0.94
0.96
0.90
0.97
5.07
3.08
2.06
3.00
8.97
f1 (ppm)

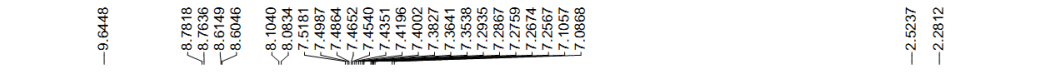

168.4222
149.9023
147.7115
139.6825
138.2461
137.3179
136.6970
135.9606
135.8646
134.4415
129.2699
129.1820
128.2565
127.5744
127.4148
127.1193
124.9509
121.4199
121.2742
116.2326
77.3178
76.9999
76.6817
34.1337
30.9647
19.8273
O
N
H
Q
t-Bu
3g
f1 (ppm)

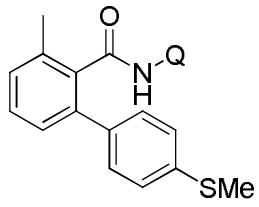

9.6497
8.8054
8.8025
8.7867
8.7836
8.5961
8.5923
8.5857
8.0497
8.0328
8.0291
7.4744
7.4667
7.4450
7.3735
6.7341
3.6012
2.5149
O
N
H
Q
OMe
0.91
0.91
0.90
0.96
3.95
2.10
1.98
1.92
3.08
3.00
f1 (ppm)

3h

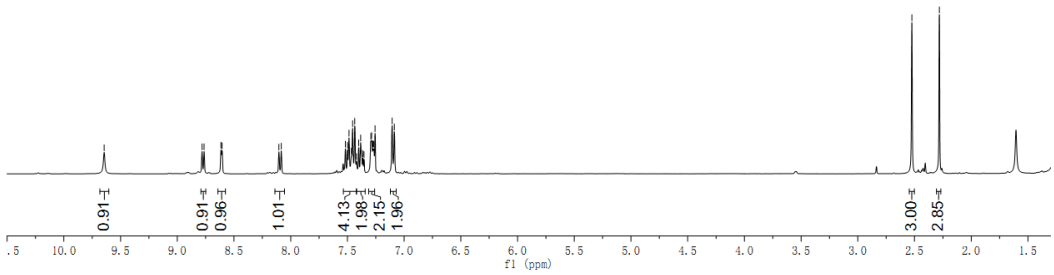

168.4852
158.7928
147.9048
139.1515
138.3158
136.7241
136.0126
135.6672
134.3506
132.7604
129.6903
129.0904
129.0196
127.7143
127.5217
127.1557
121.6119
121.3776
116.4073
113.6088
77.3181
77.0003
76.6825
54.9807
19.7483
O
N
H
Q
OMe
f1 (ppm)

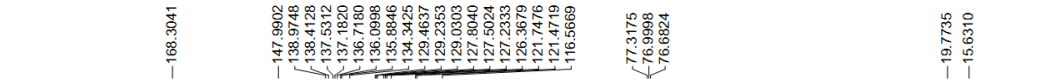
3h

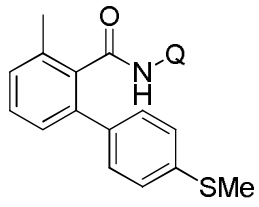

9.6448
8.7818
8.7636
8.6149
8.6046
8.1040
8.0834
7.5181
7.4987
7.4864
7.4652
7.4540
7.4351
7.4196
7.4002
7.3827
7.3641
7.3538
7.2935
7.2867
7.2759
7.2674
7.2567
7.1057
7.0868
2.5237
2.2812


O
N
H
Q
SMe

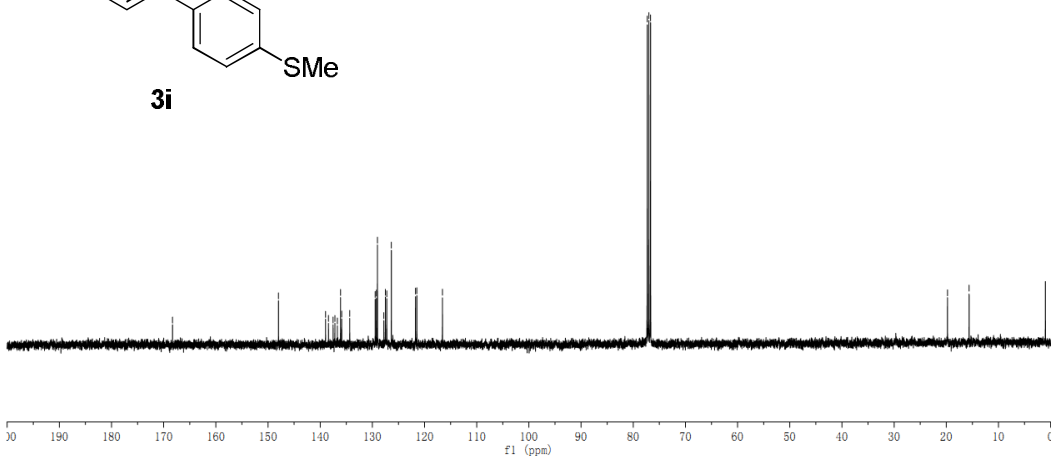
3i

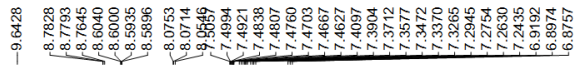

0.91
0.91
0.96
1.01
4.13
1.98
2.15
1.96
3.00
2.85
f1 (ppm)

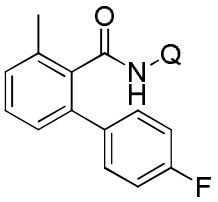

168.3041
147.9902
138.9748
138.4128
137.5312
137.1820
136.7180
136.0998
135.8846
134.3425
129.4637
129.2353
129.0303
127.8040
127.5024
127.2333
126.3679
121.7476
121.4719
116.5669
77.3175
76.9998
76.6824
19.7735
15.6310


O
N
H
Q
SMe

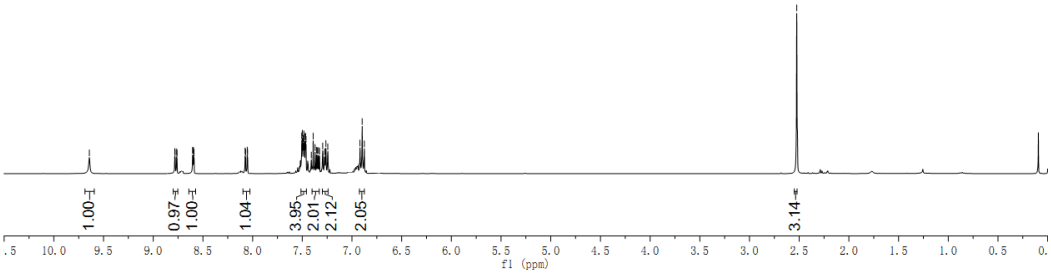
3i

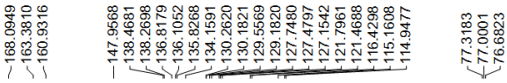

f1 (ppm)

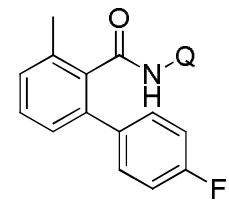

9.6428
8.7828
8.7793
8.7645
8.6040
8.6000
8.5935
8.5896
8.0753
8.0714
7.4994
7.4921
7.4838
7.4807
7.4760
7.4703
7.4667
7.4627
7.4097
7.3904
7.3712
7.3577
7.3472
7.3370
7.3265
7.2945
7.2754
7.2630
7.2435
6.9192
6.8974
6.8757
2.5248


O
N
H
Q
F

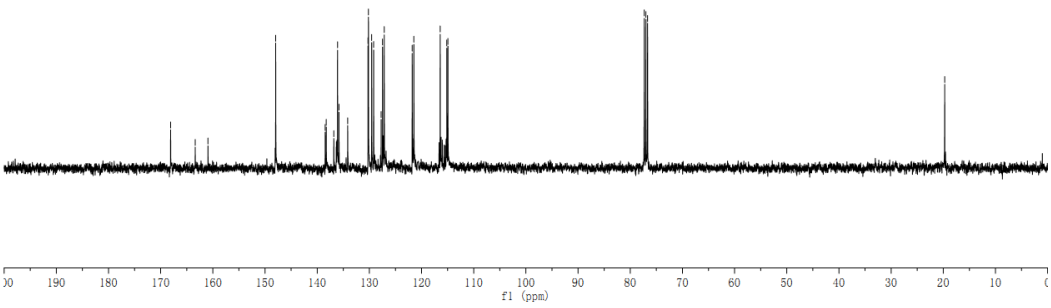
3j

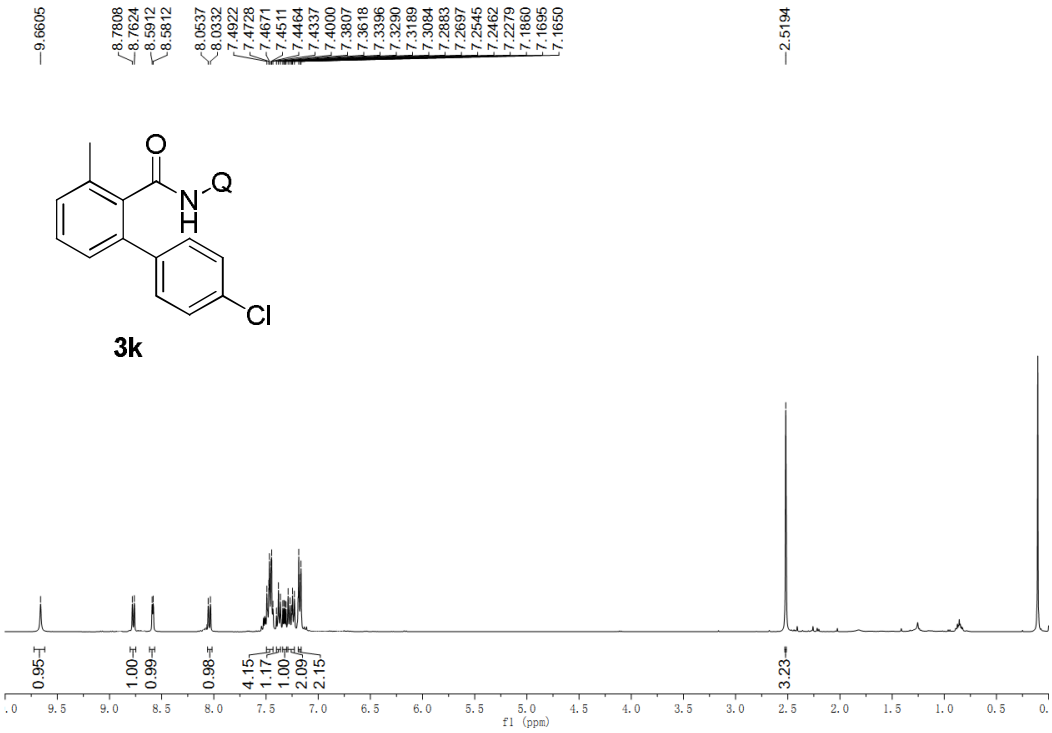

1.00
0.97
1.00
1.04
3.95
2.01
2.12
2.05
3.14
f1 (ppm)

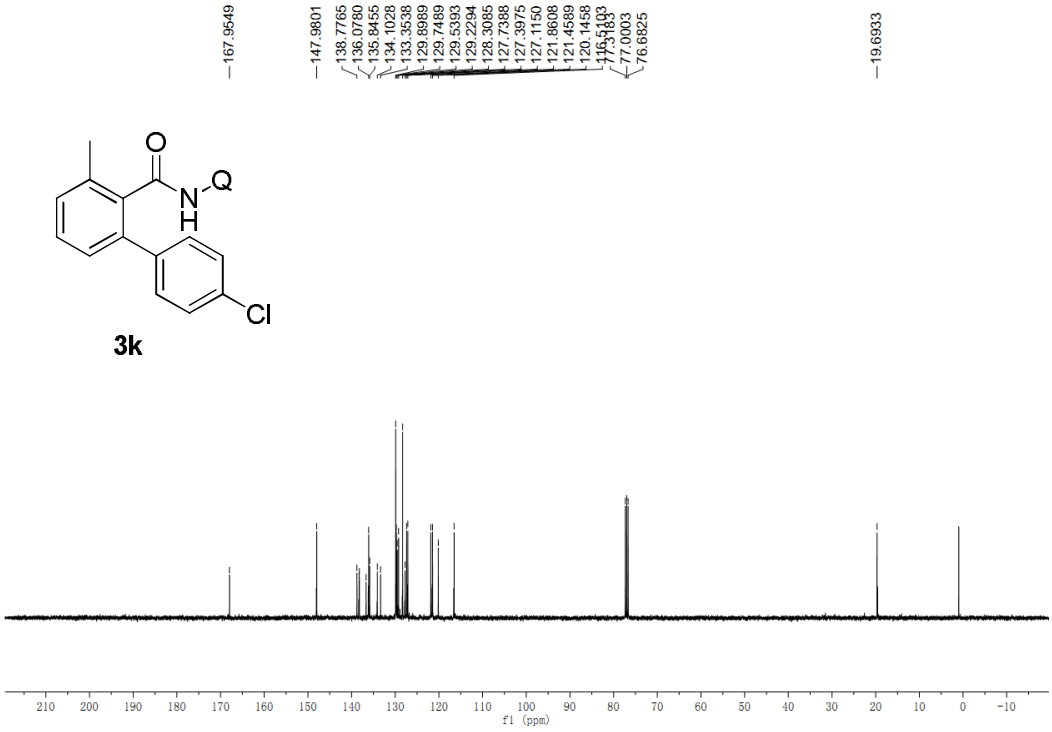

168.0949
163.3810
160.9316
147.9568
138.4681
138.2698
136.8179
136.1052
135.8268
134.1591
130.2620
130.1821
129.5569
129.1820
127.7480
127.4797
127.1542
121.7961
121.4688
116.4298
115.1608
114.9477
77.3183
77.0001
76.6823
19.7284

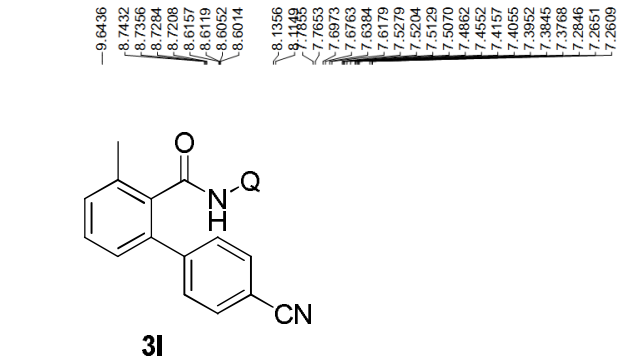

O
N
H
Q
F

3j

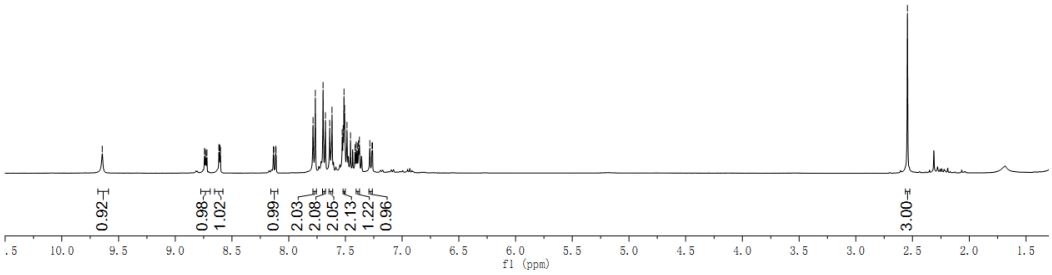

f1 (ppm)

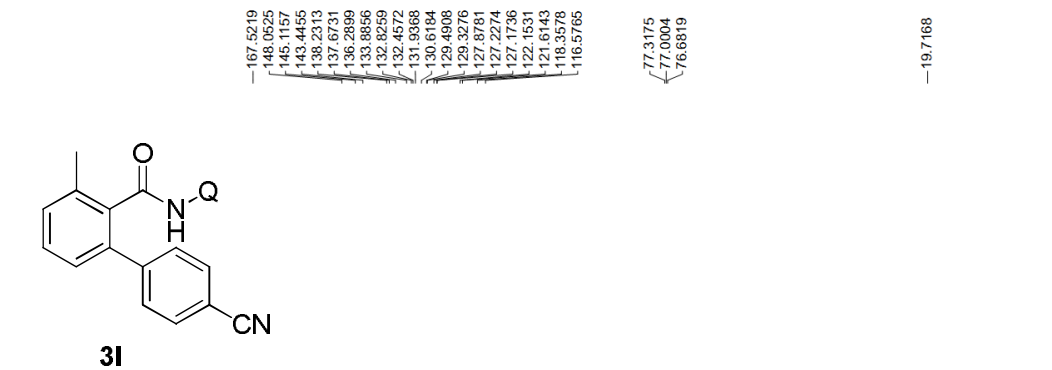

9.6605
8.7808
8.7624
8.5912
8.5812
8.0537
8.0332
7.4922
7.4728
7.4671
7.4511
7.4464
7.4337
7.4000
7.3807
7.3618
7.3396
7.3290
7.3189
7.3084
7.2883
7.2697
7.2545
7.2462
7.2279
7.1860
7.1695
7.1650
2.5194
O
N
H
Q
Cl
3k
0.95
1.00
0.99
0.98
4.15
1.17
1.00
2.09
2.15
3.23
f1 (ppm)


167.9549
147.9801
138.7765
136.0780
135.8455
134.1028
133.3538
129.8989
129.7489
129.5393
129.2294
128.3085
127.7388
127.3975
127.1150
121.8608
121.4589
120.1458
77.3833
77.0003
76.6825
19.6933
O
N
H
Q
Cl
3k
f1 (ppm)

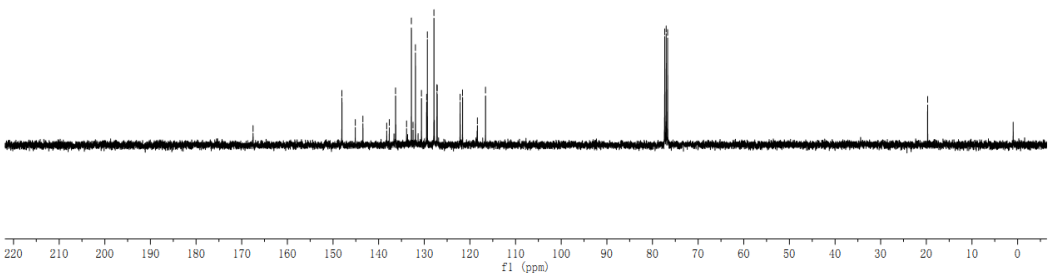

9.6436
8.7432
8.7356
8.7284
8.7208
8.6157
8.6119
8.6052
8.6014
8.1356
7.7653
7.6973
7.6763
7.6384
7.6179
7.5279
7.5204
7.5129
7.5070
7.4862
7.4552
7.4157
7.4055
7.3952
7.3845
7.3768
7.2846
7.2651
7.2609
2.5447
O
N
H
Q
CN

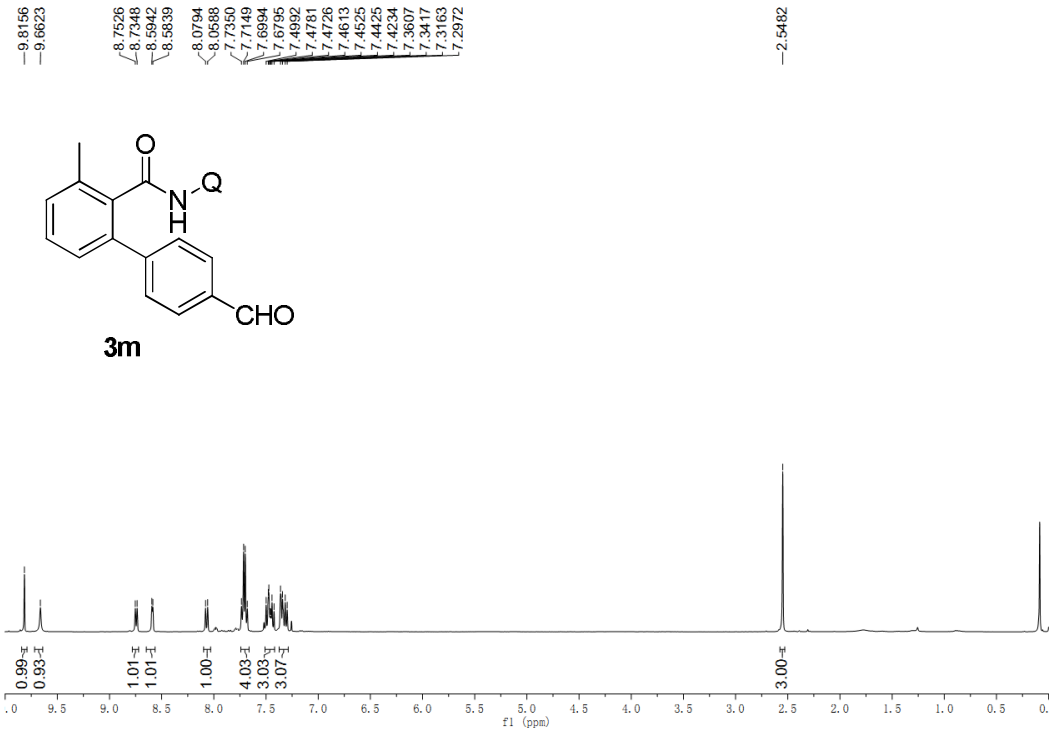
3l

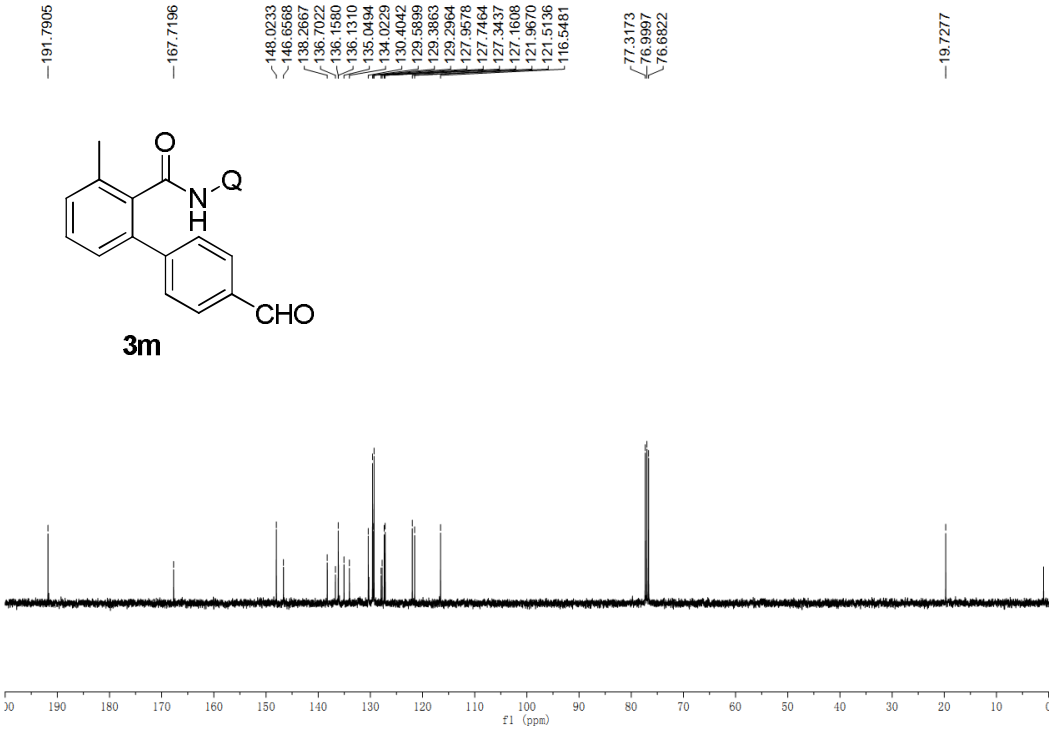

0.92
0.98
1.02
0.99
2.03
2.08
2.05
2.13
1.22
0.96
3.00
f1 (ppm)

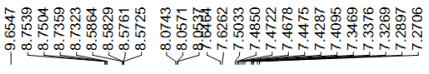

167.5219
148.0525
145.1157
143.4455
138.2313
137.6731
136.2899
133.8856
132.8259
132.4572
131.9368
130.6184
129.4908
129.3276
127.8781
127.2274
127.1736
122.1531
121.6143
118.3578
116.5765
77.3175
77.0004
76.6819
19.7168
O
N
H
Q
CN

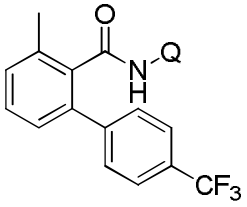
3l


f1 (ppm)

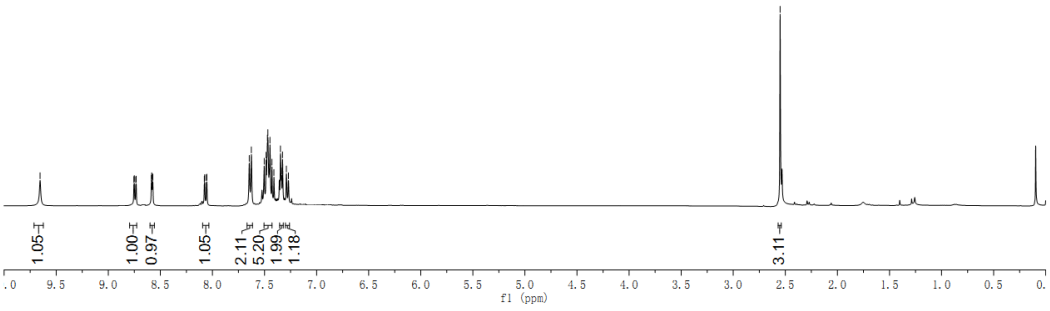

9.8156
9.6623
8.7526
8.7348
8.5942
8.5839
8.0794
8.0588
7.7350
7.7149
7.6994
7.6795
7.4992
7.4781
7.4726
7.4613
7.4525
7.4425
7.4234
7.3607
7.3417
7.3163
7.2972
2.5482
O
N
H
Q
CHO
3m
0.99
0.93
1.01
1.01
1.00
4.03
3.03
3.07
3.00
f1 (ppm)


191.7905
167.7196
148.0233
146.6568
138.2667
136.7022
136.1580
136.1310
135.0494
134.0229
130.4042
129.5899
129.3863
129.2964
127.9578
127.7464
127.3437
127.1608
121.9670
121.5136
116.5481
77.3173
76.9997
76.6822
19.7277
O
N
H
Q
CHO
3m
f1 (ppm)

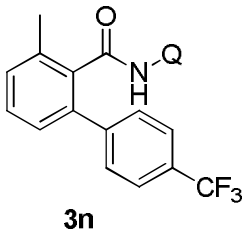

9.6547
8.7539
8.7504
8.7359
8.7323
8.5864
8.5829
8.5761
8.5725
8.0743
8.0571
7.6262
7.5033
7.4850
7.4722
7.4678
7.4475
7.4287
7.4095
7.3469
7.3376
7.3269
7.2897
7.2706
2.5500


O
N
H
Q
CF3

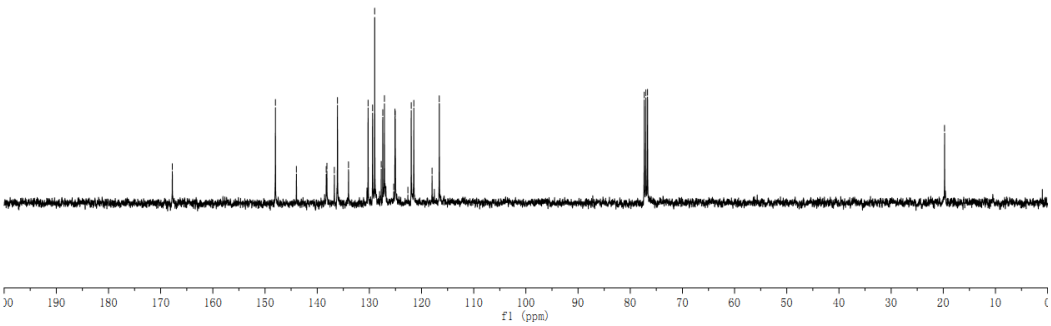
3n

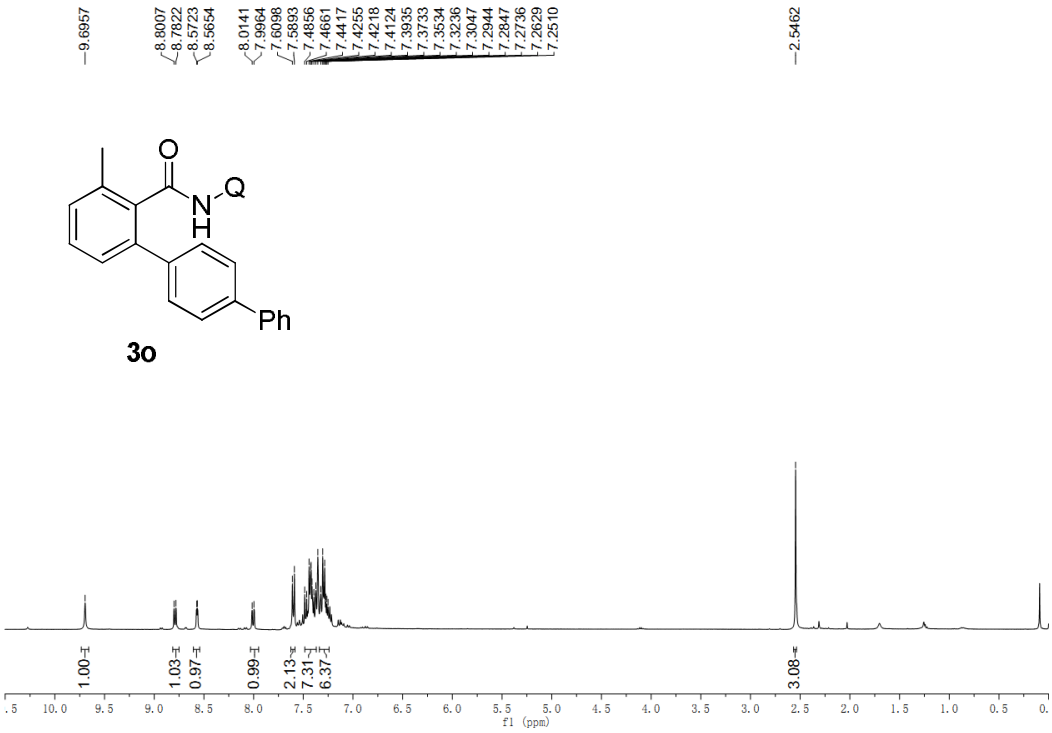

1.05
1.00
0.97
1.05
2.11
5.20
1.99
1.18
3.11
f1 (ppm)


167.7707
148.0038
143.9825
138.2746
138.1386
136.7149
136.1260
134.0035
130.2478
129.3902
128.9792
128.0383
127.7380
127.4379
127.1164
125.3285
125.0829
125.0483
122.6249
121.9823
121.4865
117.9841
116.5973
77.3183
77.0001
76.6819
19.7560

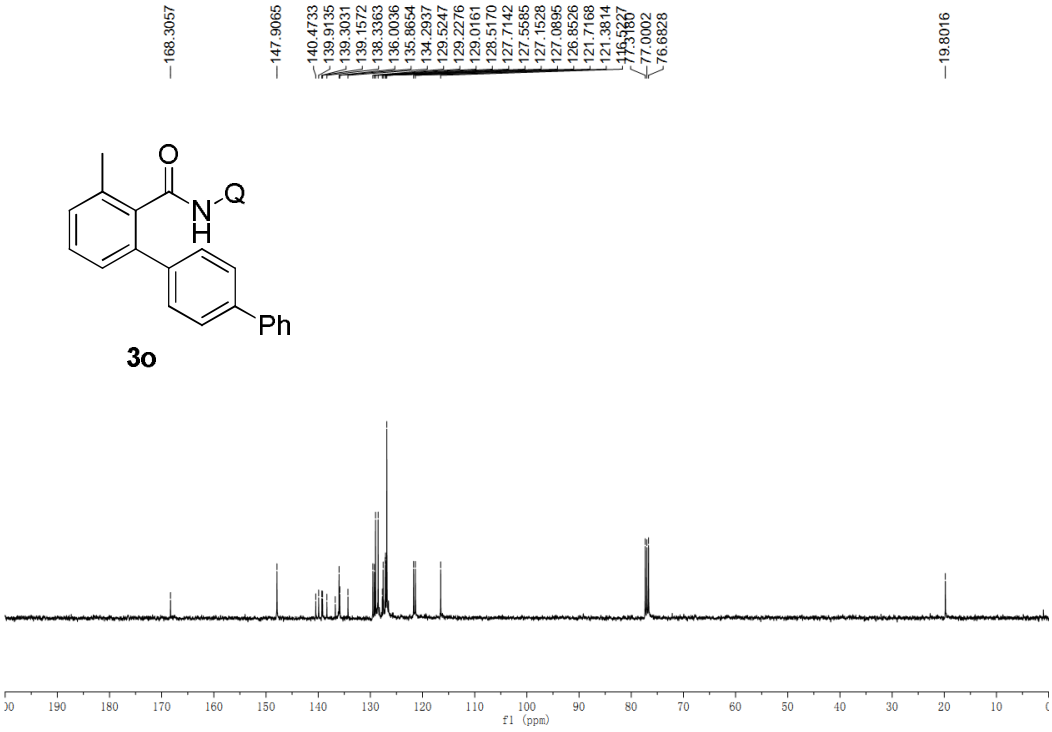

O
N
H
Q
CF3

3n

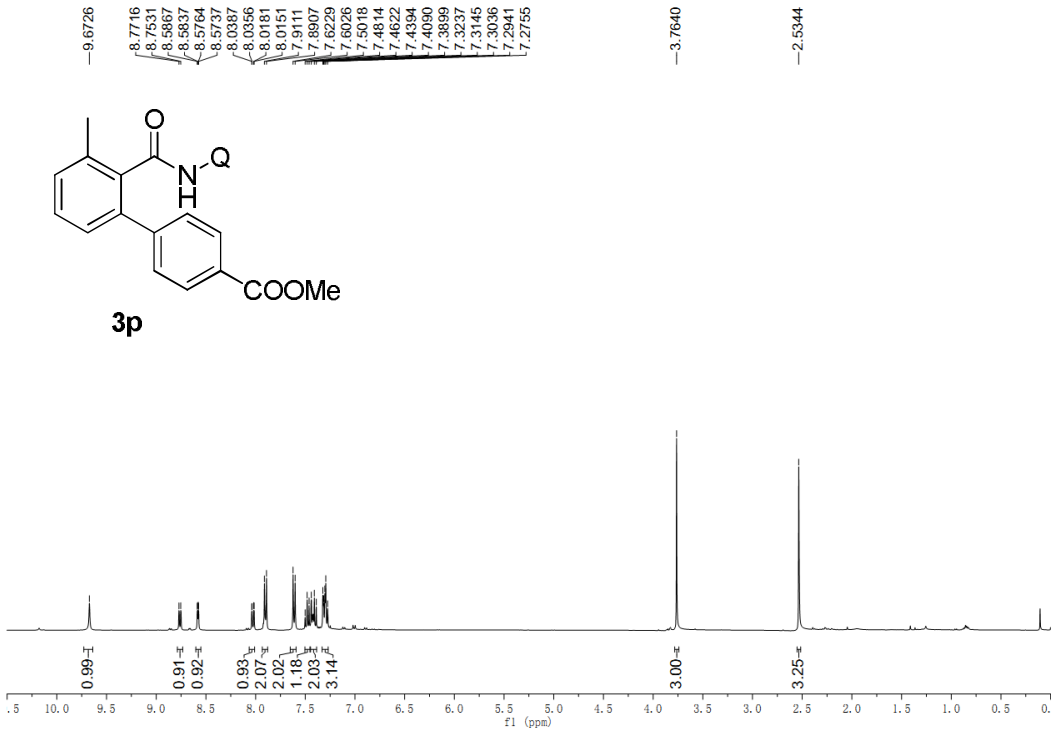

f1 (ppm)

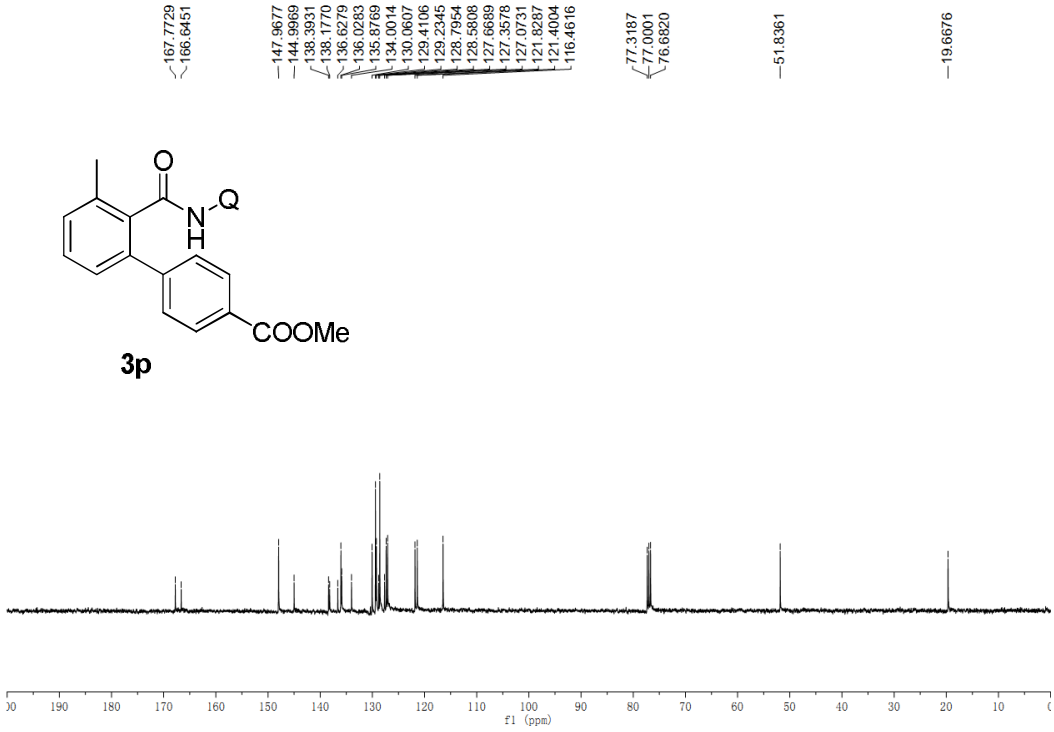

9.6957
8.8007
8.7822
8.5723
8.5654
8.0141
7.9964
7.6098
7.5893
7.4856
7.4661
7.4417
7.4255
7.4218
7.4124
7.3935
7.3733
7.3534
7.3236
7.3047
7.2944
7.2847
7.2736
7.2629
7.2510
2.5462
O
N
H
Q
Ph
1.00
1.03
0.97
0.99
2.13
7.31
6.37
3.08
f1 (ppm)

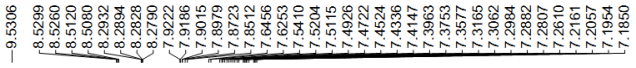
3o

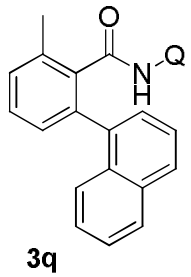

168.3057
147.9065
140.4733
139.9135
139.3031
139.1572
138.3363
136.0036
135.8654
134.2937
129.5247
129.2276
129.0161
128.5170
127.7142
127.5585
127.1528
127.0895
126.8526
121.7168
121.3814
116.5227
77.3180
77.0002
76.6828
19.8016
O
N
H
Q
Ph
f1 (ppm)

3o

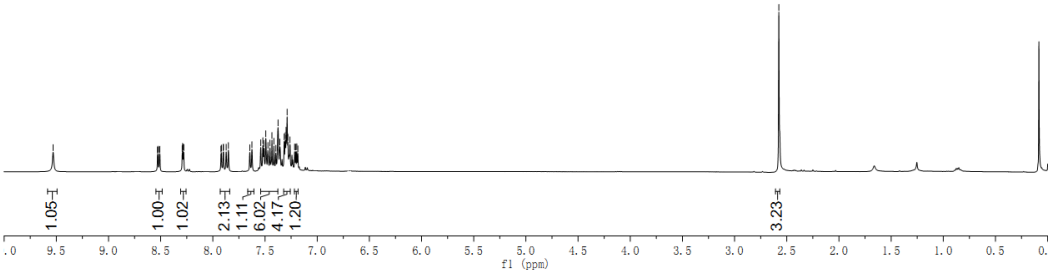

9.6726
8.7716
8.7531
8.5867
8.5837
8.5764
8.5737
8.0387
8.0356
8.0181
8.0151
7.9111
7.8907
7.6229
7.6026
7.5018
7.4814
7.4622
7.4394
7.4090
7.3899
7.3237
7.3145
7.3036
7.2941
7.2755
3.7640
2.5344
O
N
H
Q
COOMe
3p
0.99
0.91
0.92
0.93
2.07
2.02
1.18
2.03
3.14
3.00
3.25
f1 (ppm)

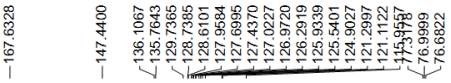

167.7729
166.6451
147.9677
144.9969
138.3931
138.1770
136.6279
136.0283
135.8769
134.0014
130.0607
129.4106
129.2345
128.7954
128.5808
127.6689
127.3578
127.0731
121.8287
121.4004
116.4616
77.3187
77.0001
76.6820
51.8361
19.6676
O
N
H
Q
COOMe
3p
f1 (ppm)

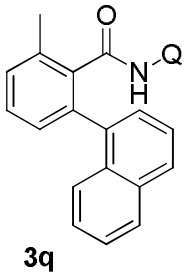

9.5306
8.5299
8.5260
8.5120
8.5080
8.2932
8.2894
8.2828
8.2790
7.9222
7.9186
7.9015
7.8979
7.8723
7.8512
7.6456
7.6253
7.5410
7.5204
7.5115
7.4926
7.4722
7.4524
7.4336
7.4147
7.3963
7.3753
7.3577
7.3165
7.3062
7.2984
7.2882
7.2807
7.2610
7.2161
7.2057
7.1954
7.1850
2.5760


O
N
H
Q

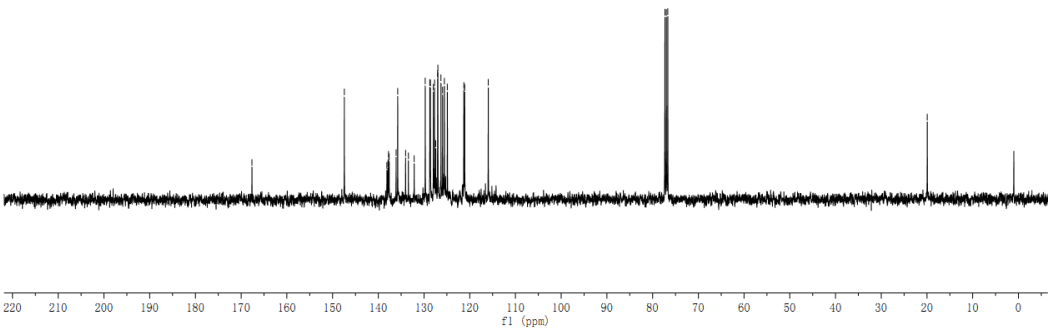
3q

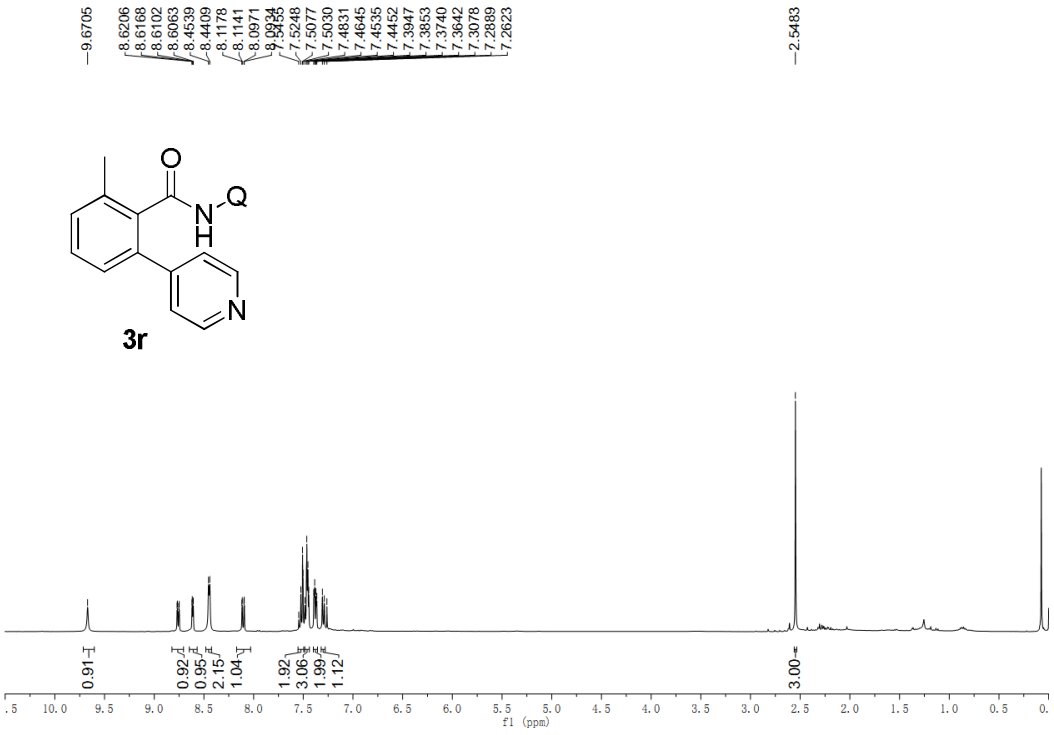

1.05
1.00
1.02
2.13
1.11
6.02
4.17
1.20
3.23
f1 (ppm)

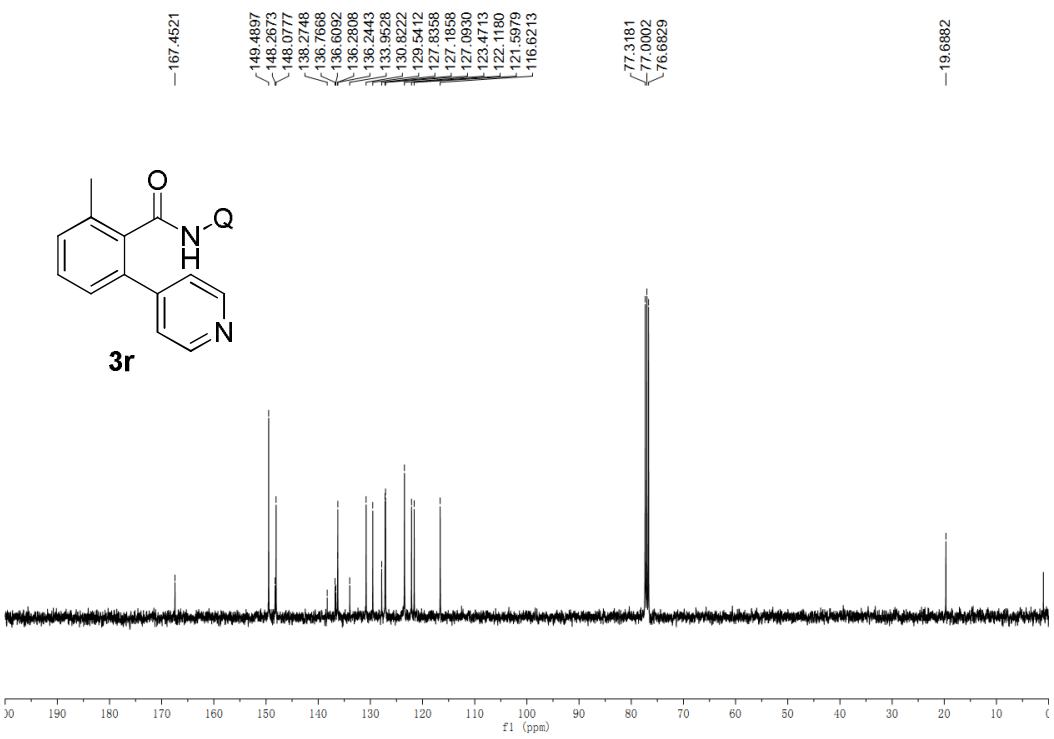

167.6328
147.4400
136.1067
135.7643
129.7365
128.7385
128.6101
127.9584
127.6995
127.4370
127.0227
126.9720
126.2919
125.9339
125.5401
124.9027
121.2997
121.1122
76.9999
76.6822
19.9361

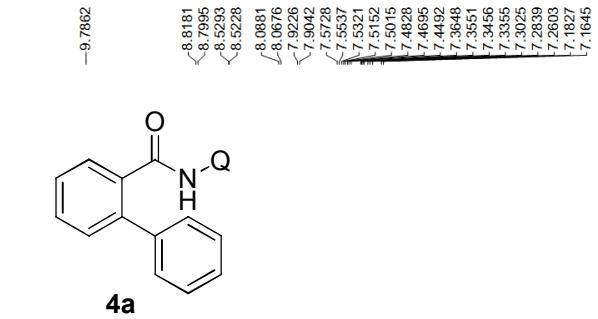

O
N
H
Q

3q

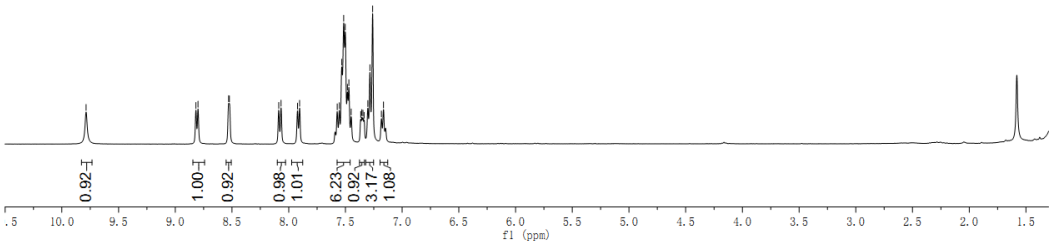

f1 (ppm)

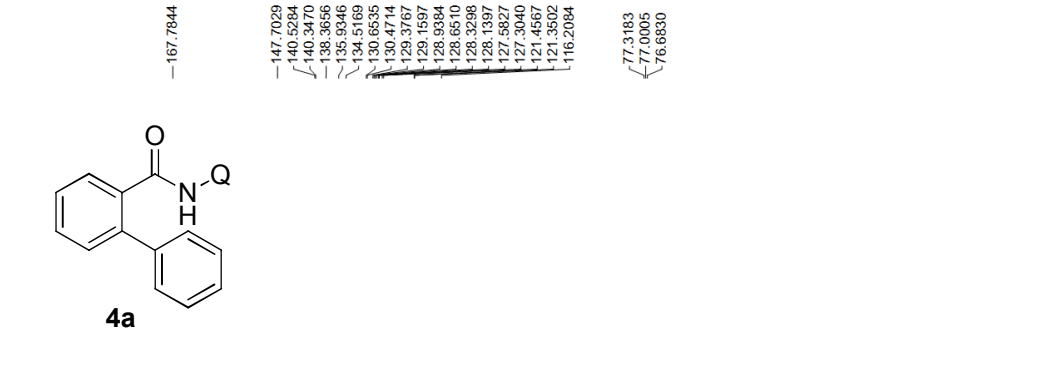

9.6705
8.6206
8.6168
8.6102
8.6063
8.4539
8.4409
8.1178
8.1141
8.0971
7.5248
7.5077
7.5030
7.4831
7.4645
7.4535
7.4452
7.3947
7.3853
7.3740
7.3642
7.3078
7.2889
7.2623
2.5483
O
N
H
Q
N
3r
0.91
0.92
0.95
2.15
1.04
1.92
3.06
1.99
1.12
3.00
f1 (ppm)


167.4521
149.4897
148.2673
148.0777
138.2748
136.7668
136.6092
136.2808
136.2443
133.9528
130.8222
129.5412
127.8358
127.1858
127.0930
123.4713
122.1180
121.5979
116.6213
77.3181
77.0002
76.6829
19.6882
O
N
H
Q
N
3r
f1 (ppm)

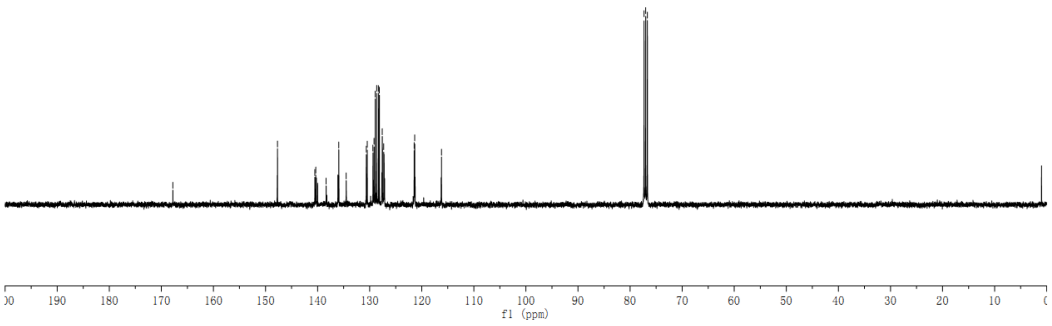

9.7862
8.8181
8.7995
8.5293
8.5228
8.0881
8.0676
7.9226
7.9042
7.5728
7.5537
7.5321
7.5152
7.5015
7.4828
7.4695
7.4492
7.3648
7.3551
7.3456
7.3355
7.3025
7.2839
7.2603
7.1827
7.1645
O
N
H
Q

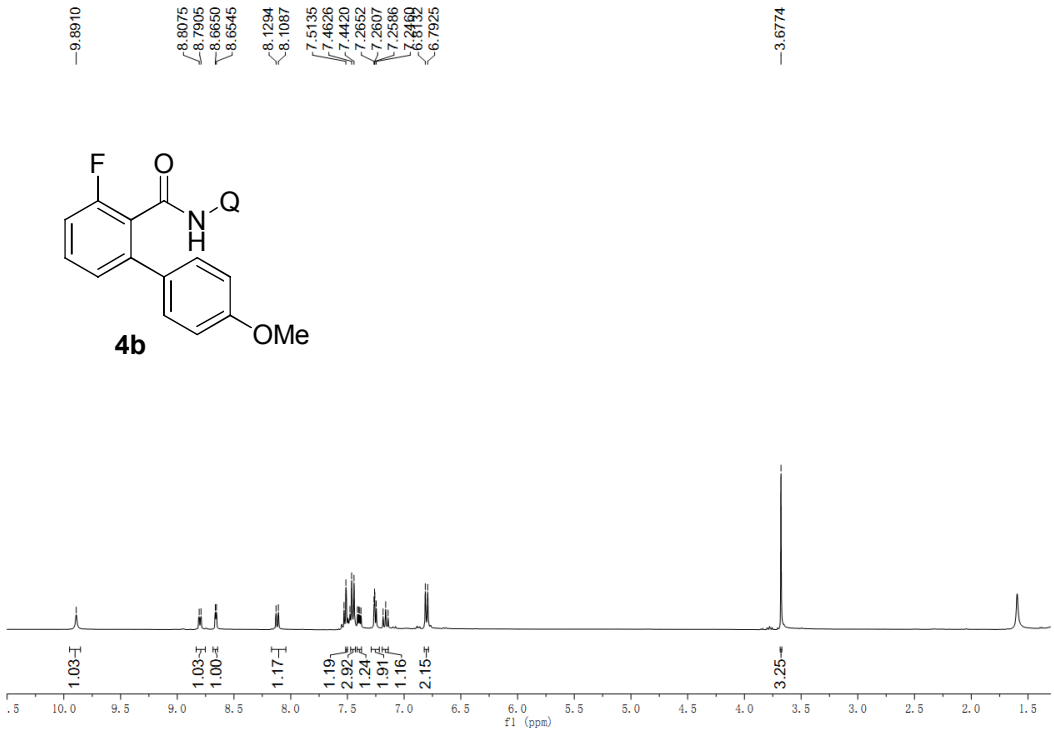
4a

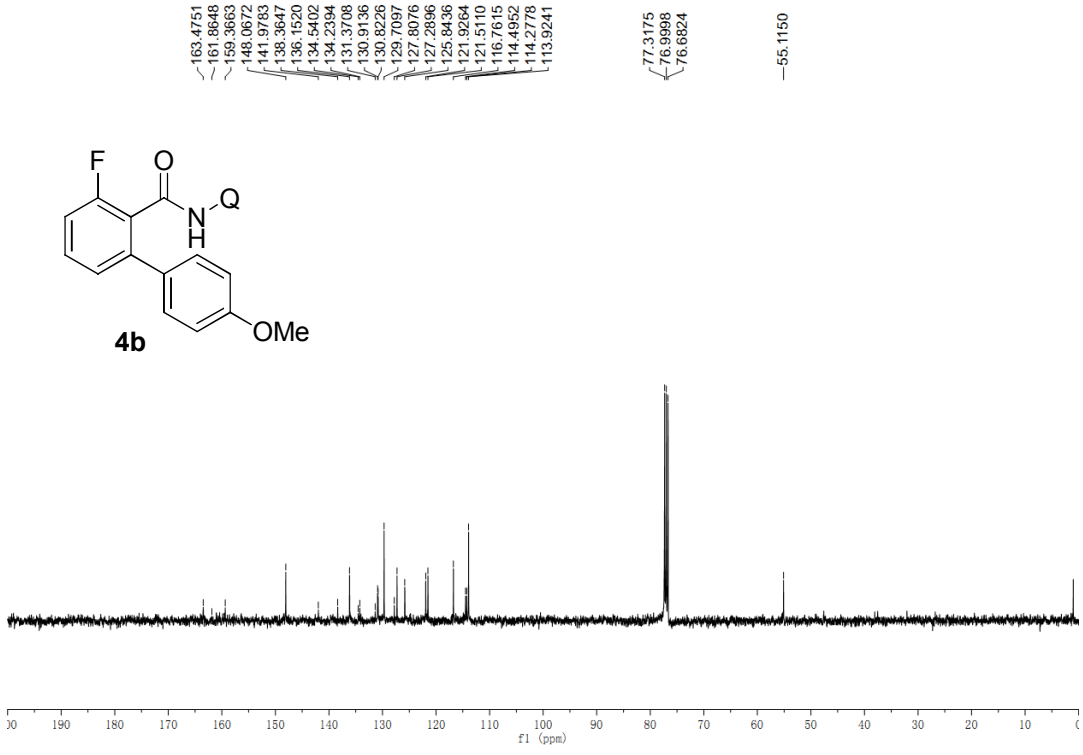

0.92
1.00
0.92
0.98
1.01
6.23
0.92
3.17
1.08
f1 (ppm)

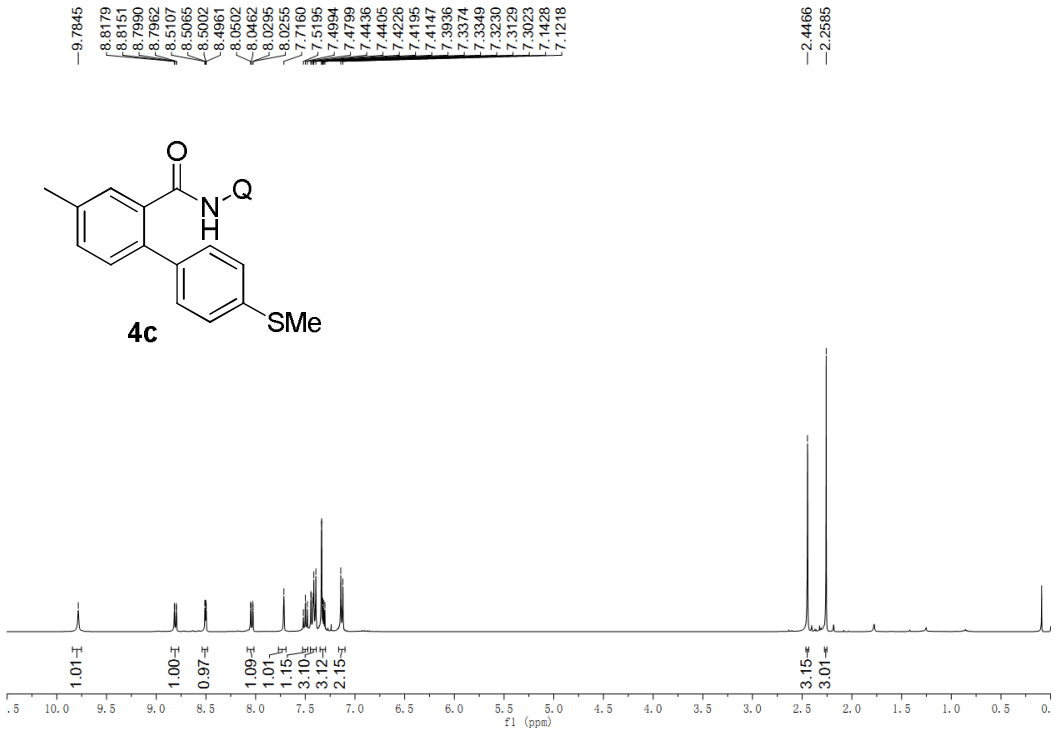

167.7844
147.7029
140.5284
140.3470
138.3656
135.9346
134.5169
130.6535
130.4714
129.3767
129.1597
128.9384
128.6510
128.3298
128.1397
127.5827
127.3040
121.4567
121.3502
116.2084
77.3183
77.0005
76.6830
O
N
H
Q

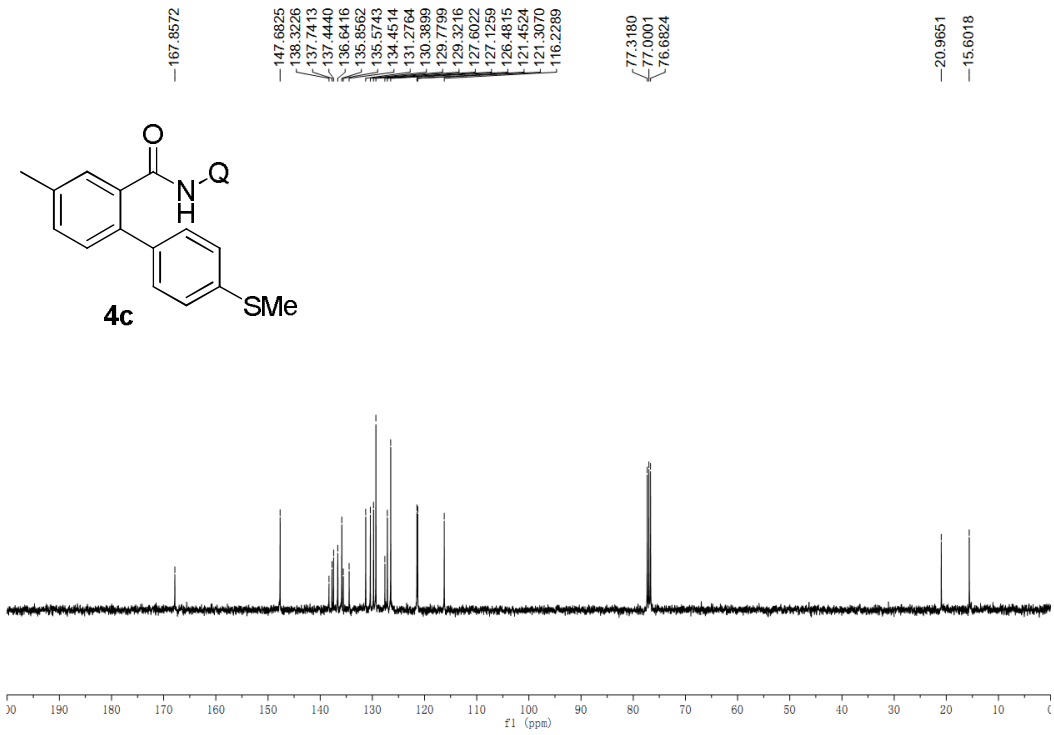
4a

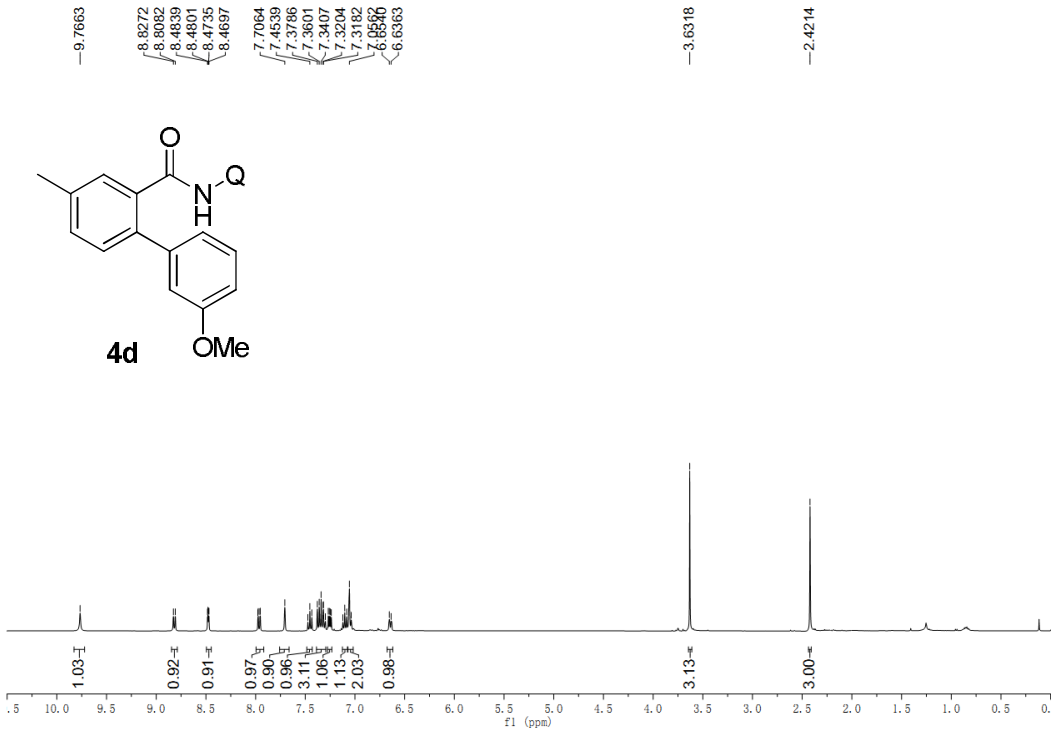

f1 (ppm)

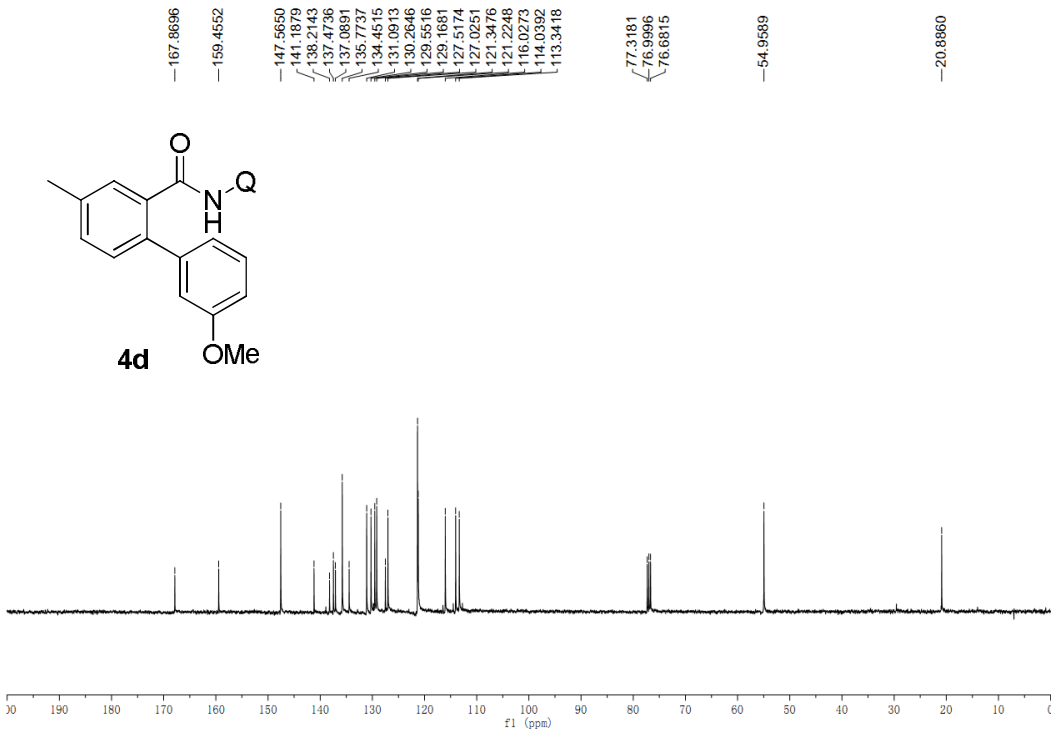

9.8910
8.8075
8.7905
8.6650
8.6545
8.1294
8.1087
7.5135
7.4626
7.4420
7.2652
7.2607
7.2586
6.8132
6.7925
3.6774
F
O
N
H
Q
OMe
4b
1.03
1.03
1.00
1.17
1.19
2.92
1.24
1.91
1.16
2.15
3.25
f1 (ppm)

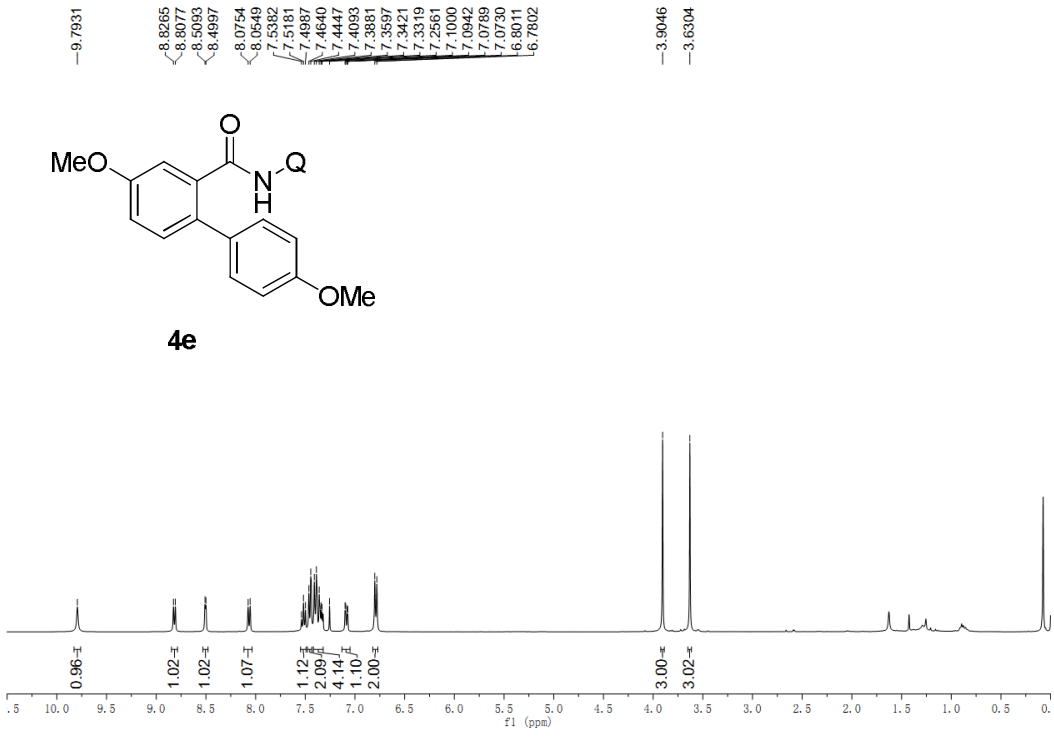

163.4751
161.8648
159.3663
148.0672
141.9783
138.3647
136.1520
134.5402
134.2394
131.3708
130.9136
130.8226
129.7097
127.8076
127.2896
125.8436
121.9264
121.5110
116.7615
114.4952
114.2778
113.9241
77.3175
76.9998
76.6824
55.1150
F
O
N
H
Q
OMe
4b
f1 (ppm)

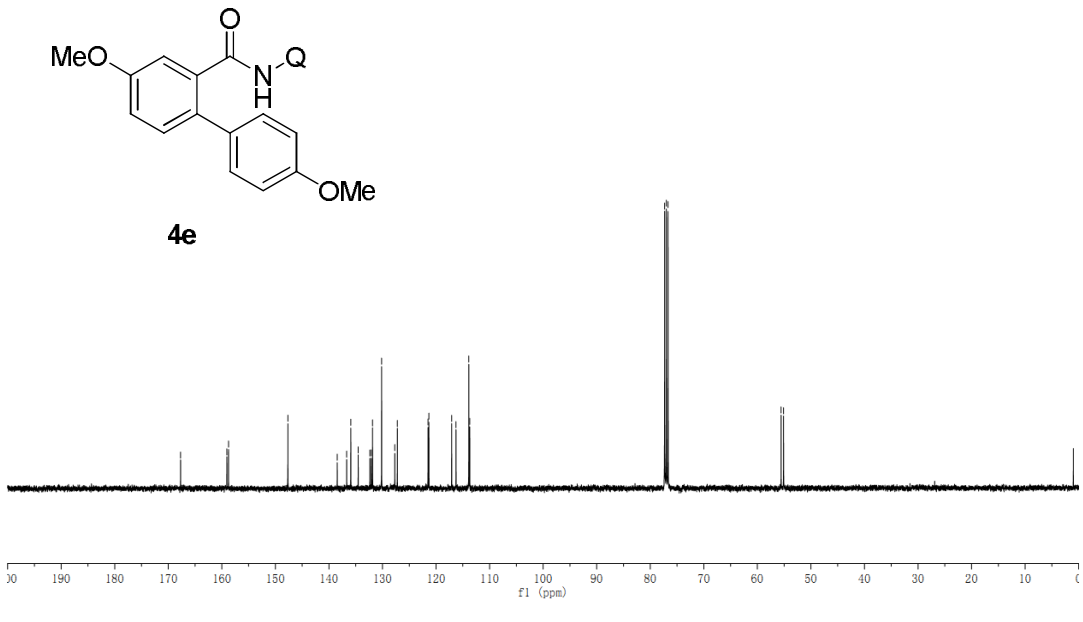

9.7845
8.8179
8.8151
8.7990
8.7962
8.5107
8.5065
8.5002
8.4961
8.0502
8.0462
8.0295
8.0255
7.7160
7.5195
7.4994
7.4799
7.4436
7.4405
7.4226
7.4195
7.4147
7.3936
7.3374
7.3349
7.3230
7.3129
7.3023
7.1428
7.1218
2.4466
2.2585
O
N
H
Q
SMe
4c
1.01
1.00
0.97
1.09
1.01
1.15
3.10
3.12
2.15
3.15
3.01
f1 (ppm)

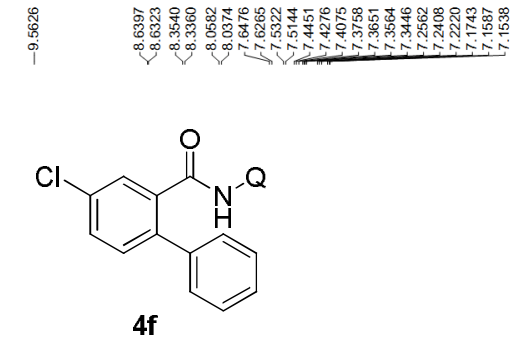

167.8572
147.6825
138.3226
137.7413
137.4440
136.6416
135.8562
135.5743
134.4514
131.2764
130.3899
129.7799
129.3216
127.6022
127.1259
126.4815
121.4524
121.3070
116.2289
77.3180
77.0001
76.6824
20.9651
15.6018
O
N
H
Q
SMe
4c
f1 (ppm)


9.7663
8.8272
8.8082
8.4839
8.4801
8.4735
8.4697
7.7064
7.4539
7.3786
7.3601
7.3407
7.3204
7.3182
7.0562
6.6540
6.6363
3.6318
2.4214
O
N
H
Q
OMe
4d
1.03
0.92
0.91
0.97
0.90
0.96
3.11
1.06
1.13
2.03
0.98
3.13
3.00
f1 (ppm)

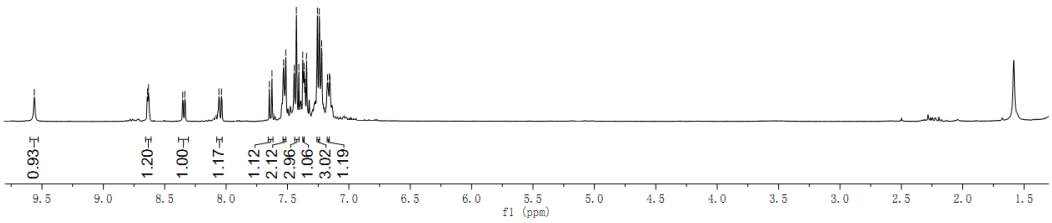

167.8696
159.4552
147.5650
141.1879
138.2143
137.4736
137.0891
135.7737
134.4515
131.0913
130.2646
129.5516
129.1681
127.5174
127.0251
121.3476
121.2248
116.0273
114.0392
113.3418
77.3181
76.9996
76.6815
54.9589
20.8860
O
N
H
Q
OMe
4d
f1 (ppm)

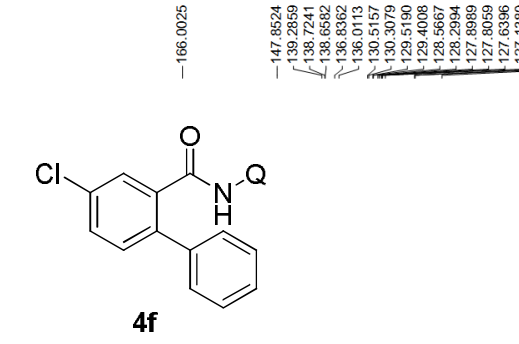

9.7931
8.8265
8.8077
8.5093
8.4997
8.0754
8.0549
7.5382
7.5181
7.4987
7.4640
7.4447
7.4093
7.3881
7.3597
7.3421
7.3319
7.2561
7.1000
7.0942
7.0789
7.0730
6.8011
6.7802
3.9046
3.6304
MeO
O
N
H
Q
OMe
4e
0.96
1.02
1.02
1.07
1.12
2.09
4.14
1.10
2.00
3.00
3.02
f1 (ppm)


167.7080
159.0645
158.7517
147.6652
138.4537
136.6857
135.9200
134.5404
132.3572
132.0877
131.8637
130.1679
127.6991
127.2267
121.4896
121.3368
117.0890
116.2759
113.8794
113.7135
77.3175
76.9999
76.6823
55.5652
55.1117
MeO
O
N
H
Q
OMe
4e
f1 (ppm)


9.5626
8.6397
8.6323
8.3540
8.3360
8.0582
8.0374
7.6476
7.6265
7.5322
7.5144
7.4451
7.4276
7.4075
7.3758
7.3651
7.3564
7.3446
7.2562
7.2408
7.2220
7.1743
7.1587
7.1538
Cl
O
N
H
Q

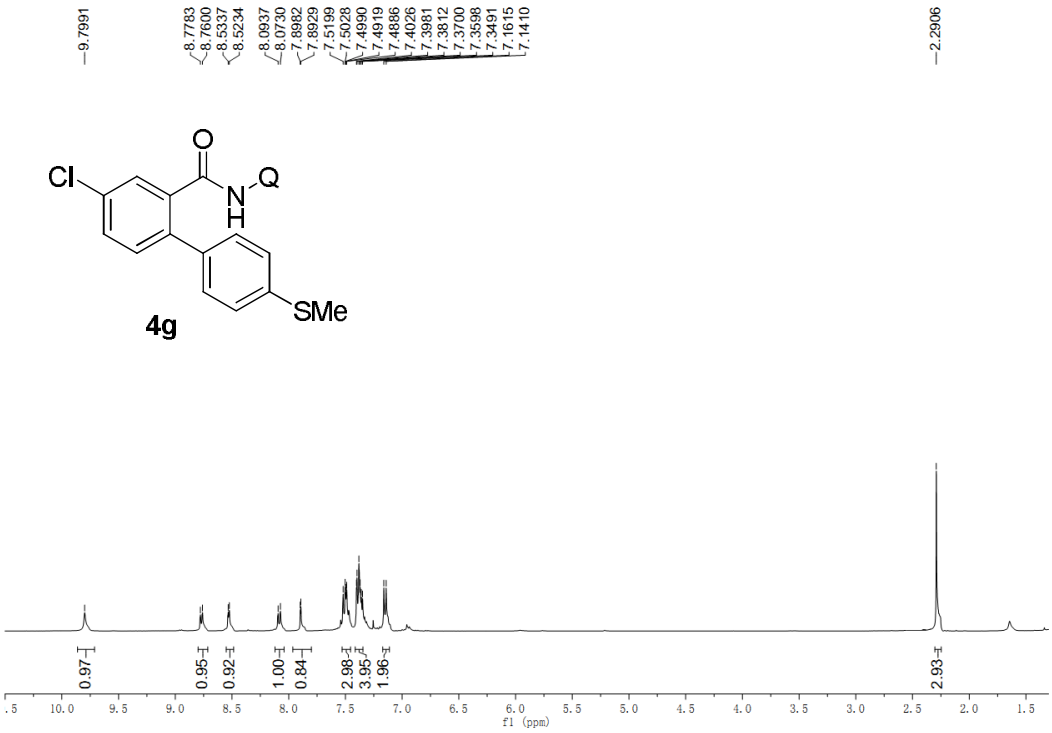
4f

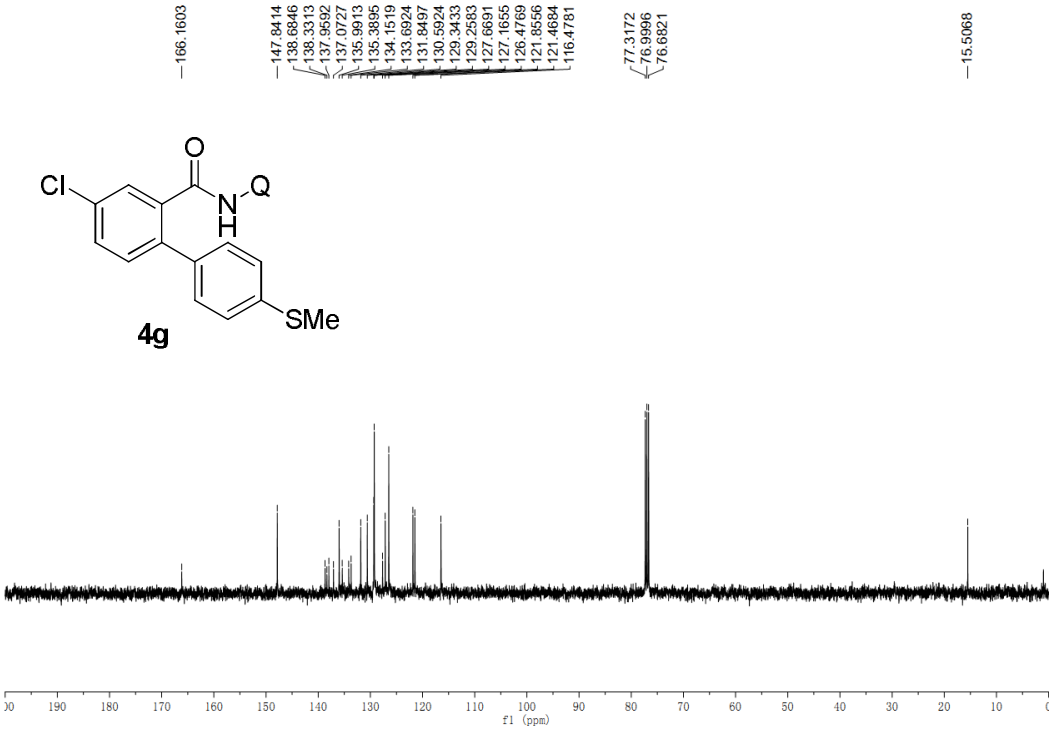

0.93
1.20
1.00
1.17
1.12
2.12
2.96
1.06
3.02
1.19
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5
f1 (ppm)

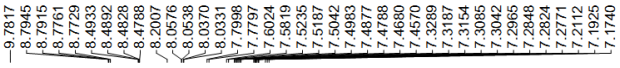

166.0025
147.8524
139.2859
138.7241
138.6582
136.8362
136.0113
130.5157
130.3079
129.5190
129.4008
128.5667
128.2994
127.8989
127.8059
127.6396
127.1380
121.5389
121.3913
116.2588
77.3178
77.0002
76.6827
Cl
O
N
H
Q

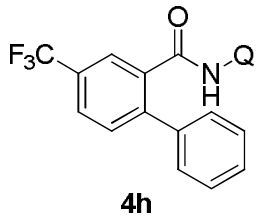
4f

190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)

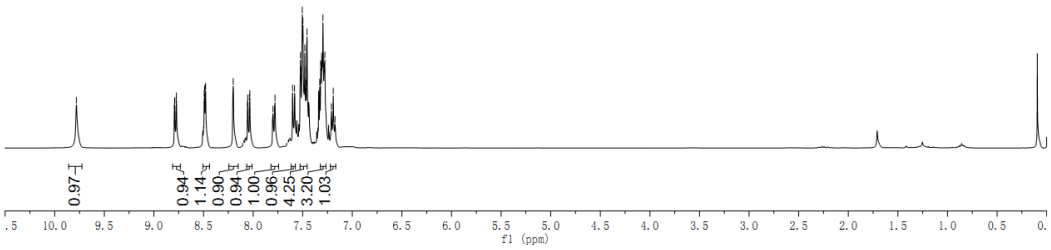

9.7991
8.7783
8.7600
8.5337
8.5234
8.0937
8.0730
7.8982
7.8929
7.5199
7.5028
7.4990
7.4919
7.4886
7.4026
7.3981
7.3812
7.3700
7.3598
7.3491
7.1615
7.1410
2.2906
Cl
O
N
H
Q
SMe
4g
0.97
0.95
0.92
1.00
0.84
2.98
3.95
1.96
2.93
f1 (ppm)

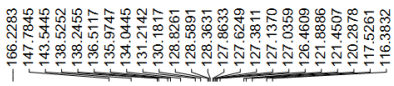

166.1603
147.8414
138.6846
138.3313
137.9592
137.0727
135.9913
135.3895
134.1519
133.6924
131.8497
130.5924
129.3433
129.2583
127.6691
127.1655
126.4769
121.8556
121.4684
116.4781
77.3172
76.9996
76.6821
15.5068
Cl
O
N
H
Q
SMe
4g
f1 (ppm)

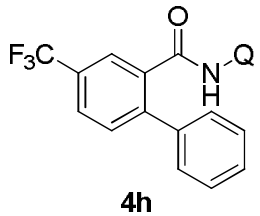

9.7817
8.7945
8.7915
8.7761
8.7729
8.4933
8.4892
8.4828
8.4788
8.2007
8.0576
8.0538
8.0370
8.0331
7.7998
7.7797
7.6024
7.5819
7.5235
7.5187
7.5042
7.4963
7.4877
7.4788
7.4680
7.4570
7.3289
7.3187
7.3154
7.3085
7.3042
7.2965
7.2848
7.2824
7.2771
7.2112
7.1925
7.1740


O
F3C
N
Q
H

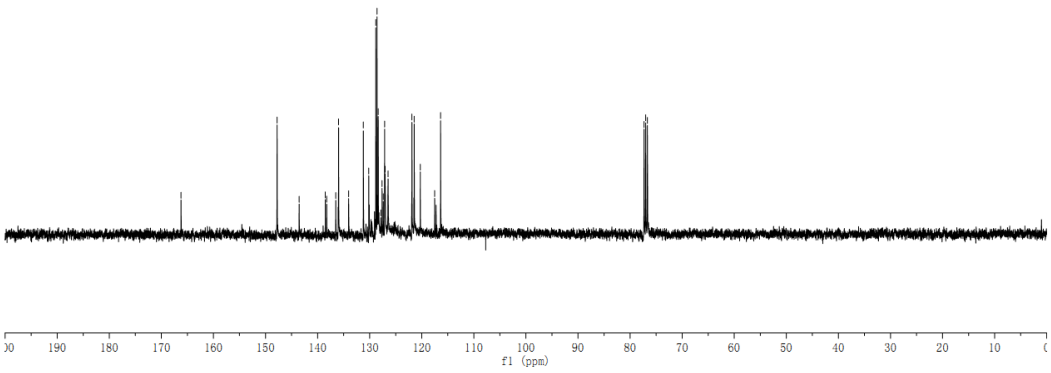
4h

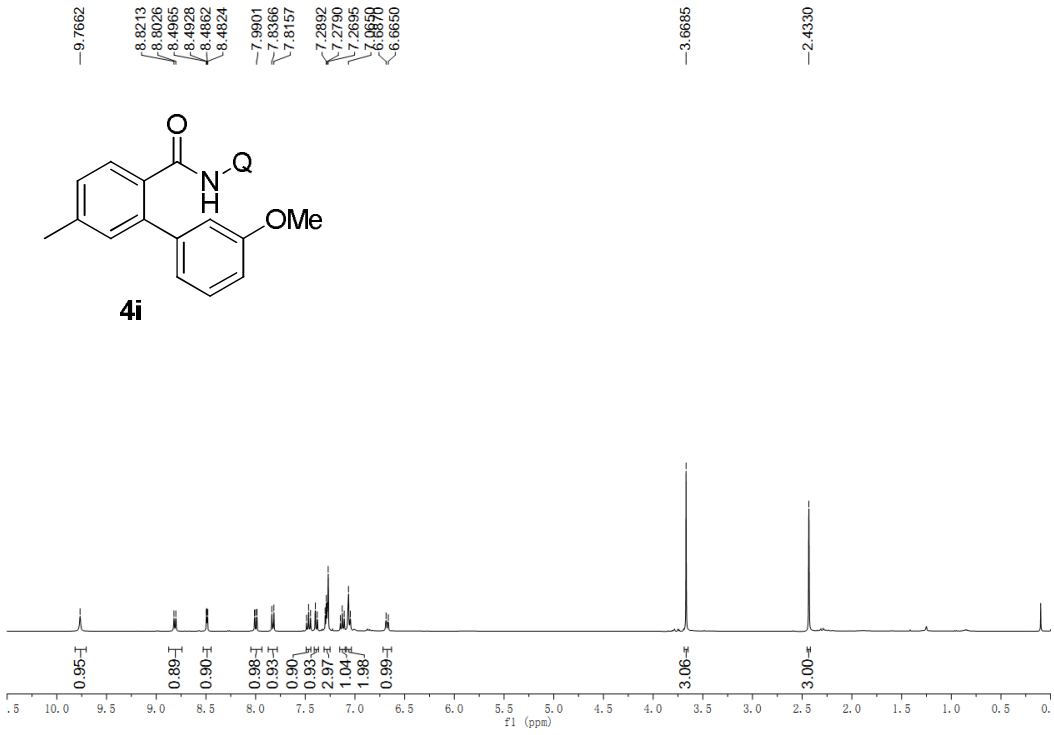

0.97
0.94
1.14
0.90
0.94
1.00
0.96
4.25
3.20
1.03
f1 (ppm)

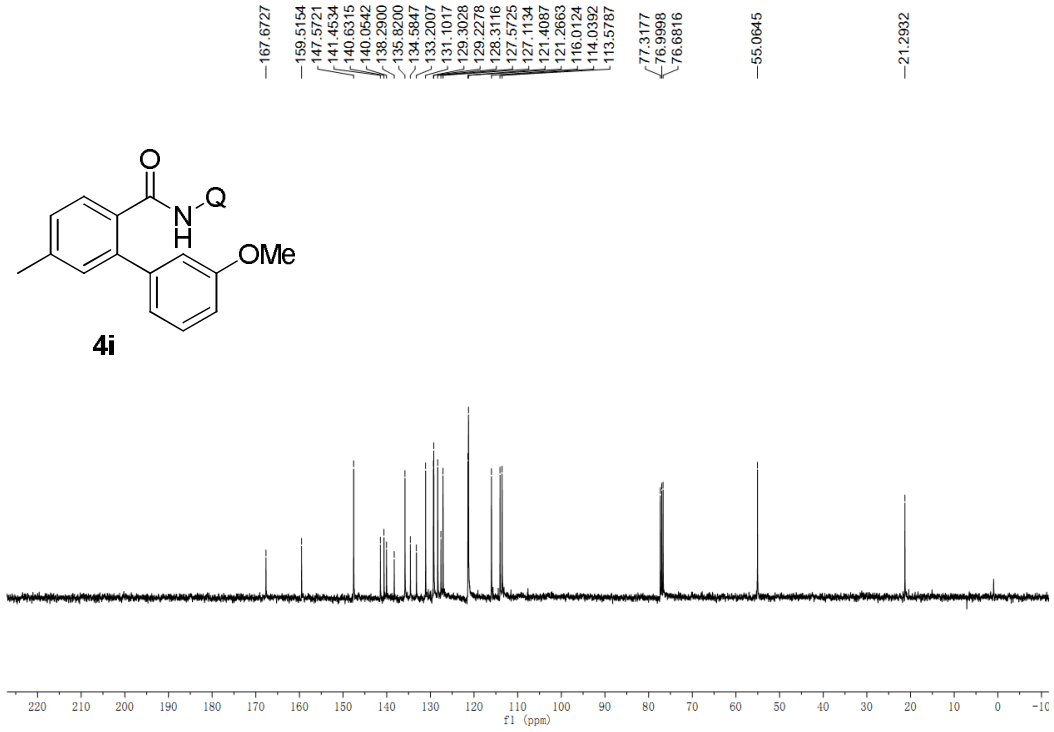

166.2283
147.7845
143.5445
138.5252
138.2455
136.5117
135.9747
134.0445
131.2142
130.1817
128.8261
128.5891
128.3631
127.8633
127.6249
127.3811
127.1370
127.0359
126.4609
121.8886
121.4507
120.2878
117.5261
116.3832
77.3181
76.9999
76.6826

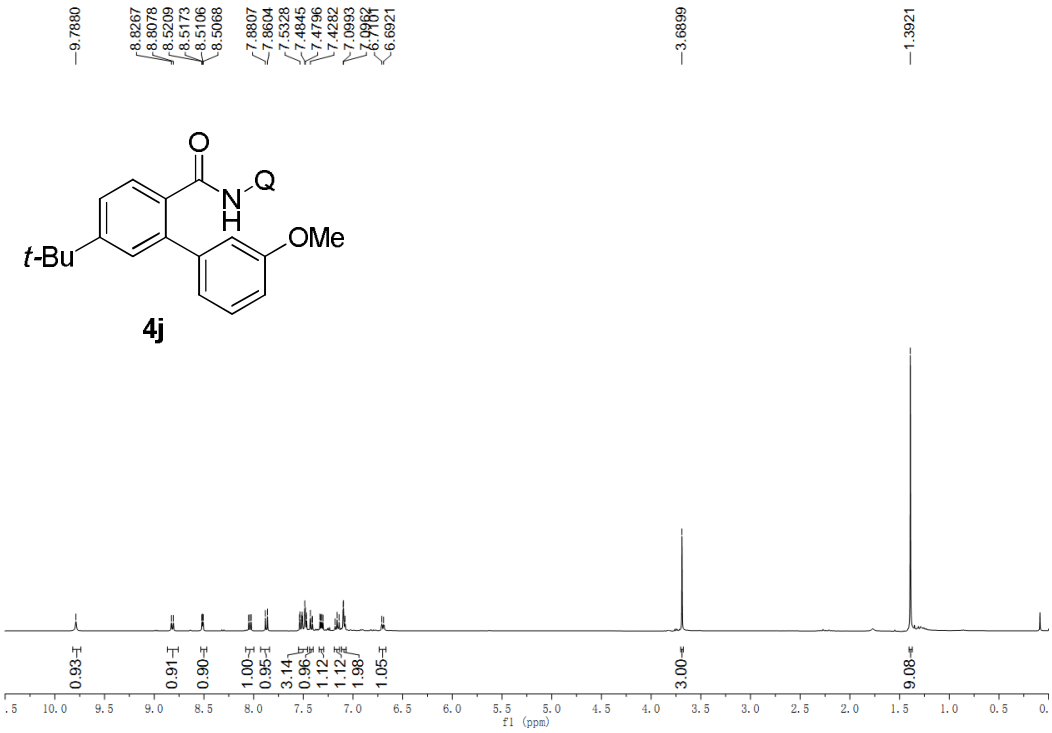

O
F3C
N
Q
H

4h

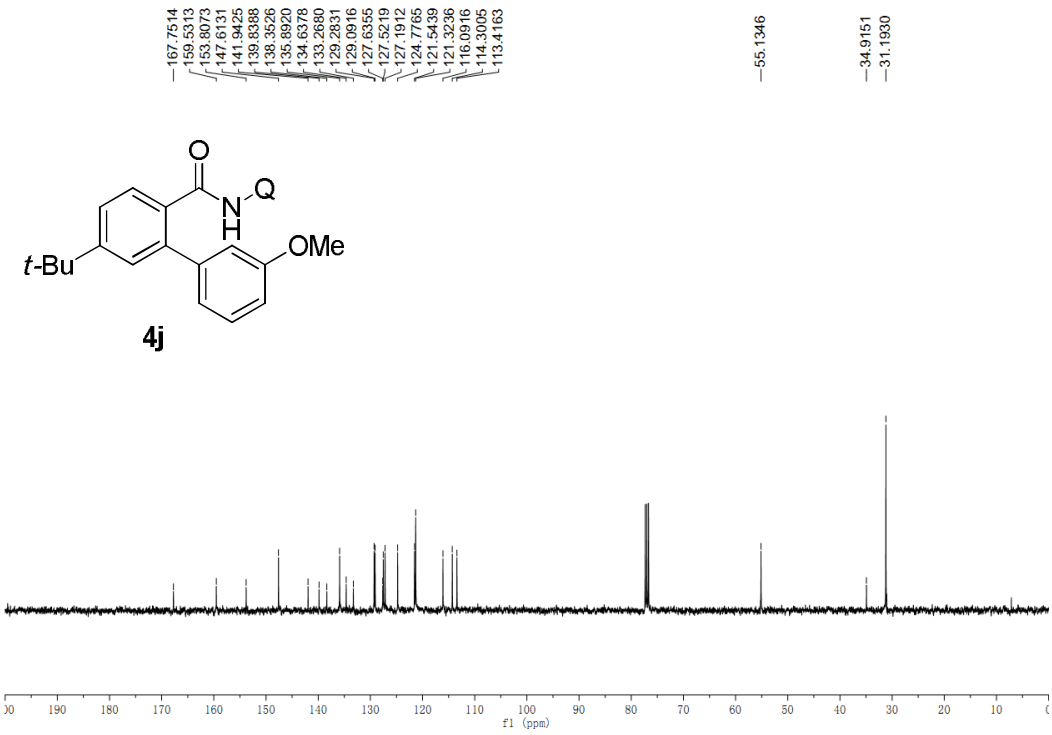

f1 (ppm)


9.7662
8.8213
8.8026
8.4965
8.4928
8.4862
8.4824
7.9901
7.8366
7.8157
7.2892
7.2790
7.2695
7.0650
6.8870
6.6650
3.6685
2.4330
O
N
H
Q
OMe
4i
0.95
0.89
0.90
0.98
0.93
0.90
0.93
2.97
1.04
1.98
0.99
3.06
3.00
f1 (ppm)

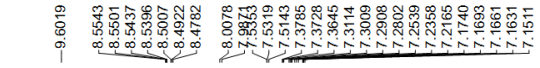

167.6727
159.5154
147.5721
141.4534
140.6315
140.0542
138.2900
135.8200
134.5847
133.2007
131.1017
129.3028
129.2278
128.3116
127.5725
127.1134
121.4087
121.2663
116.0124
114.0392
113.5787
77.3177
76.9998
76.6816
55.0645
21.2932
O
N
H
Q
OMe
4i
f1 (ppm)

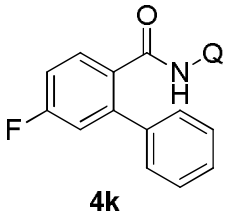

9.7880
8.8267
8.8078
8.5209
8.5173
8.5106
8.5068
7.8807
7.8604
7.5328
7.4845
7.4796
7.4282
7.0993
7.0962
6.7101
6.6921
3.6899
1.3921
O
N
H
Q
OMe
t-Bu
0.93
0.91
0.90
1.00
0.95
3.14
0.96
1.12
1.12
1.98
1.05
3.00
9.08
f1 (ppm)

4j

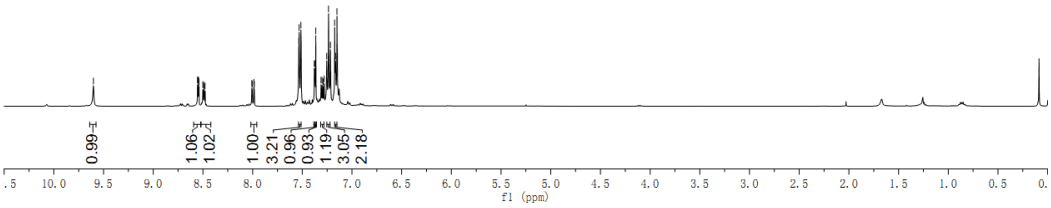

167.7514
159.5313
153.8073
147.6131
141.9425
139.8388
138.3526
135.8920
134.6378
133.2680
129.2831
129.0916
127.6355
127.5219
127.1912
124.7765
121.5439
121.3236
116.0916
114.3005
113.4163
55.1346
34.9151
31.1930
f1 (ppm)

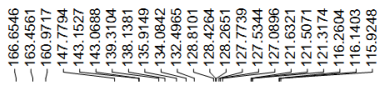
4j

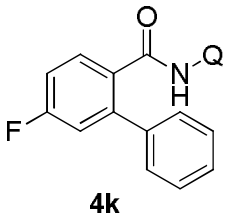

9.6019
8.5543
8.5501
8.5437
8.5396
8.5007
8.4922
8.4782
8.0078
7.5319
7.5143
7.3785
7.3728
7.3645
7.3114
7.3009
7.2908
7.2802
7.2539
7.2358
7.2165
7.1740
7.1693
7.1661
7.1631
7.1511


O
N
H
Q
F

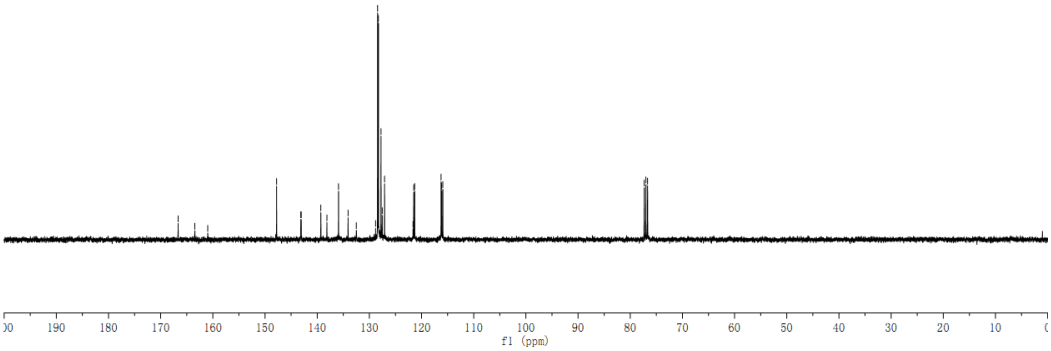
4k

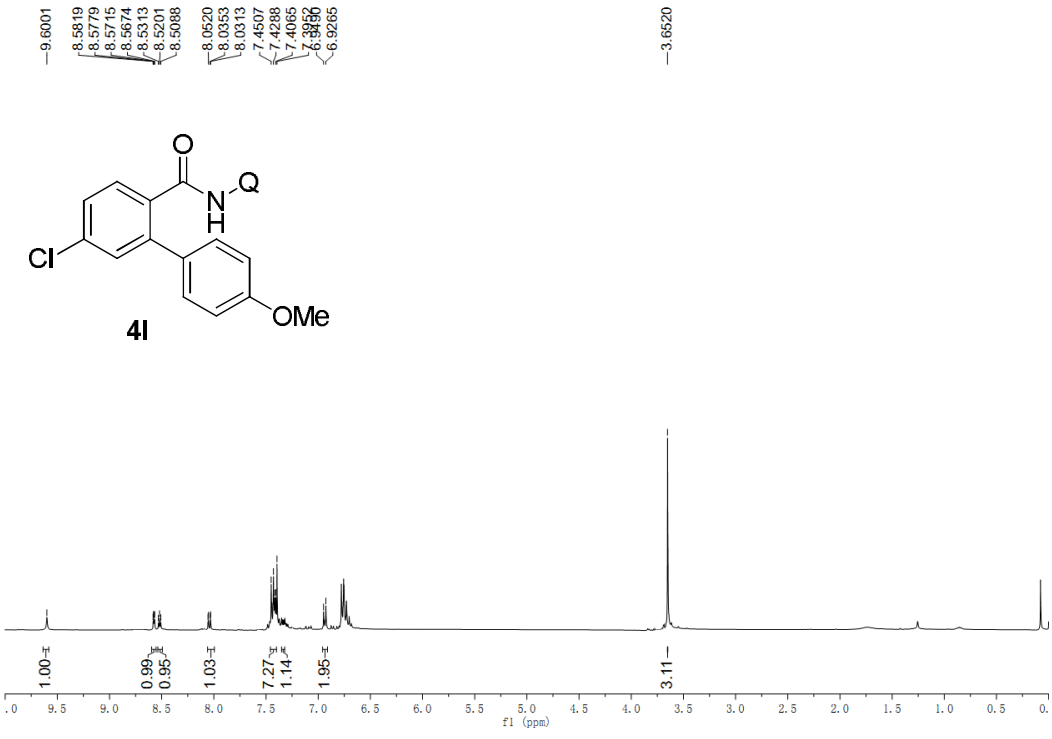

0.99
1.06
1.02
1.00
3.21
0.96
0.93
1.19
3.05
2.18
f1 (ppm)

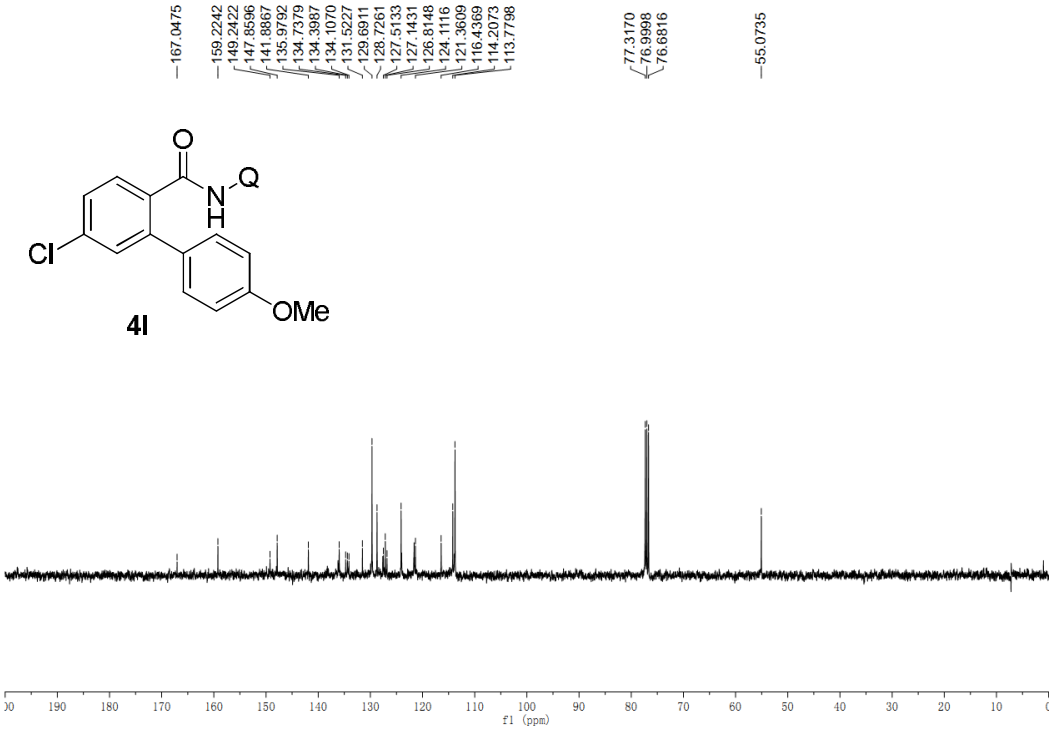

166.6546
163.4561
160.9717
147.7794
143.1527
143.0688
139.3104
138.1381
135.9149
134.0842
132.4965
128.8101
128.4264
128.2651
127.7739
127.5344
127.0896
121.6321
121.5071
121.3174
116.2604
116.1403
115.9248
77.3173
77.0005
76.6829

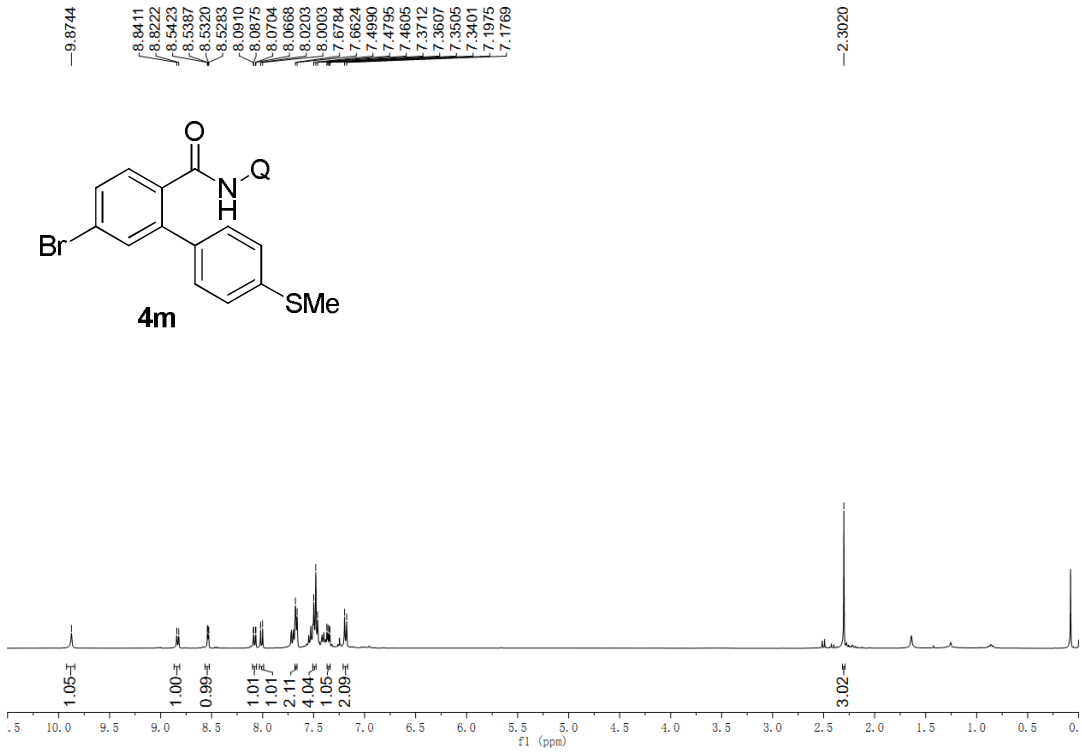

O
N
H
Q
F

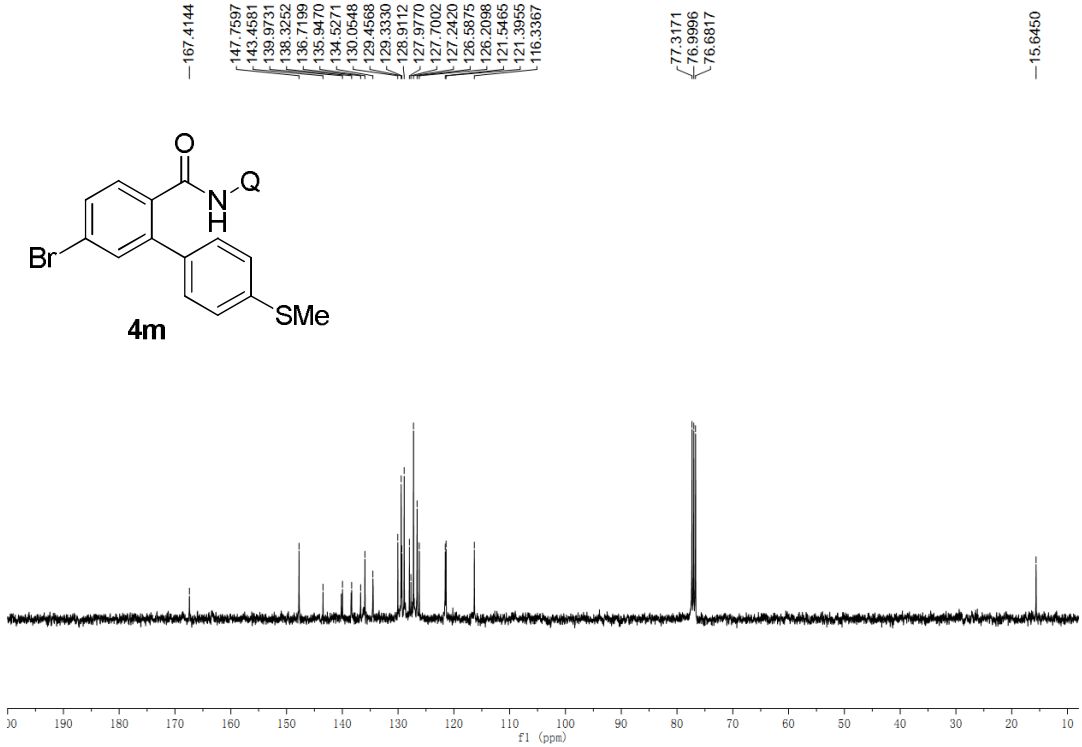
4k

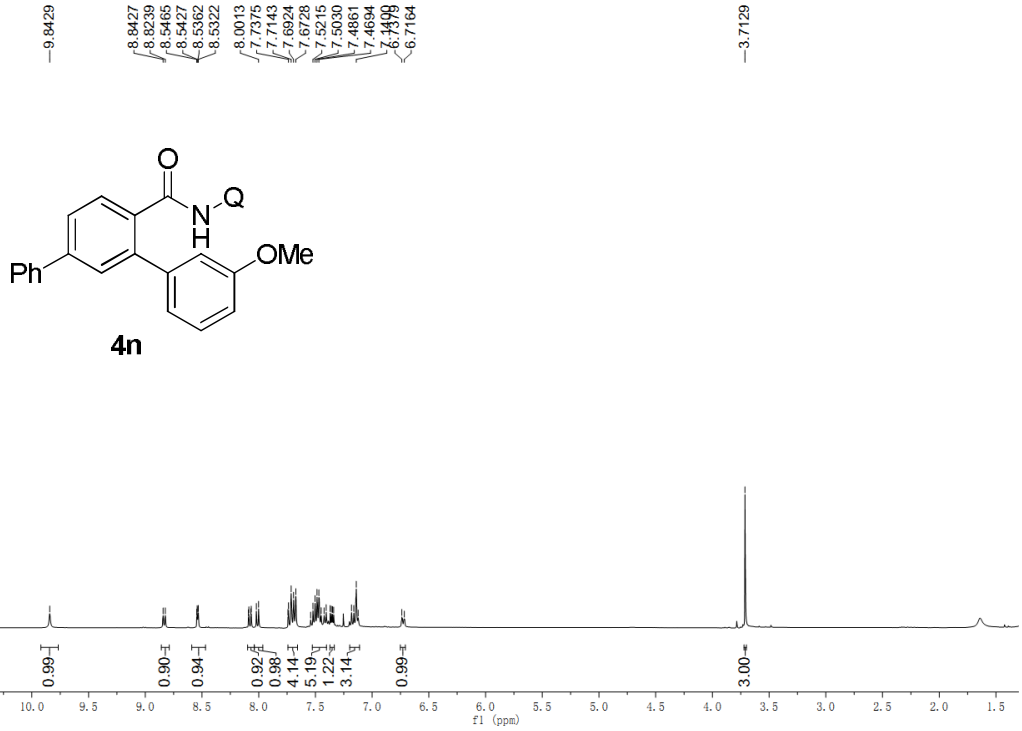

f1 (ppm)

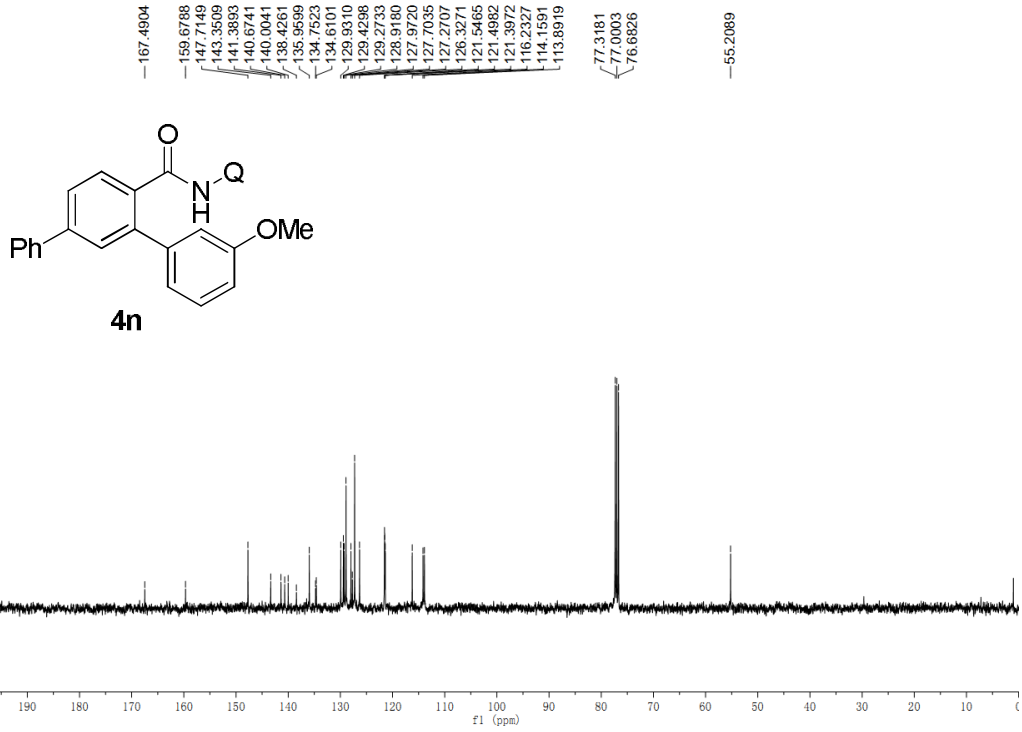

9.6001
8.5819
8.5779
8.5715
8.5674
8.5313
8.5201
8.5088
8.0520
8.0353
8.0313
7.4507
7.4288
7.4065
6.9265
3.6520
O
N
H
Q
Cl
OMe
4l
1.00
0.99
0.95
1.03
7.27
1.14
1.95
3.11
f1 (ppm)

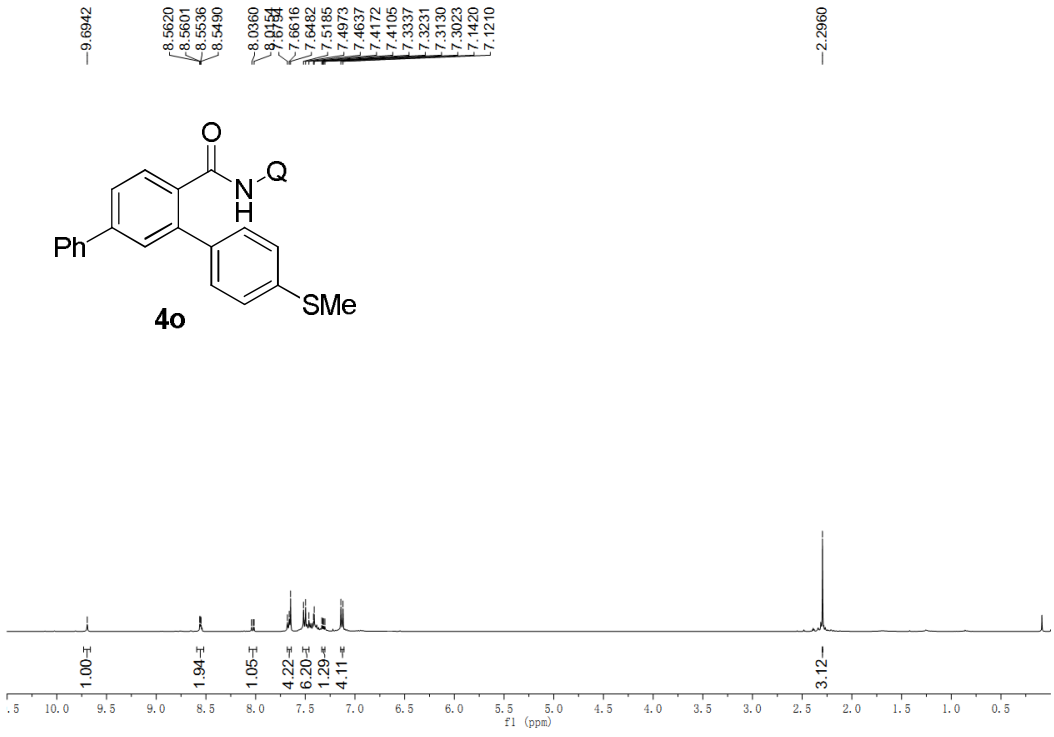

167.0475
159.2242
149.2422
147.8596
141.8867
135.9792
134.7379
134.3987
134.1070
131.5227
129.6911
128.7261
127.5133
127.1431
126.8148
124.1116
121.3609
116.4369
114.2073
113.7798
77.3170
76.9998
76.6816
55.0735
O
N
H
Q
Cl
OMe
4l
f1 (ppm)

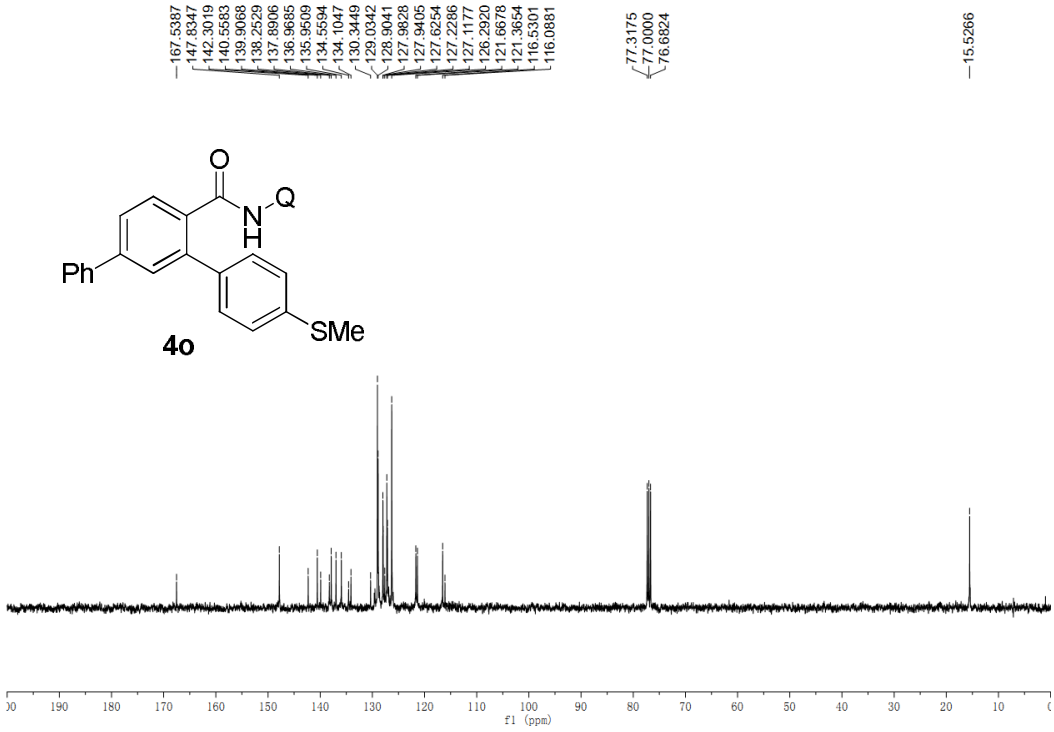

9.8744
8.8411
8.8222
8.5423
8.5387
8.5320
8.5283
8.0910
8.0875
8.0704
8.0668
8.0203
8.0003
7.6784
7.6624
7.4990
7.4796
7.4605
7.3712
7.3607
7.3505
7.3401
7.1975
7.1769
2.3020
O
N
H
Q
Br
SMe
4m
1.05
1.00
0.99
1.01
1.01
2.11
4.04
1.05
2.09
3.02
f1 (ppm)

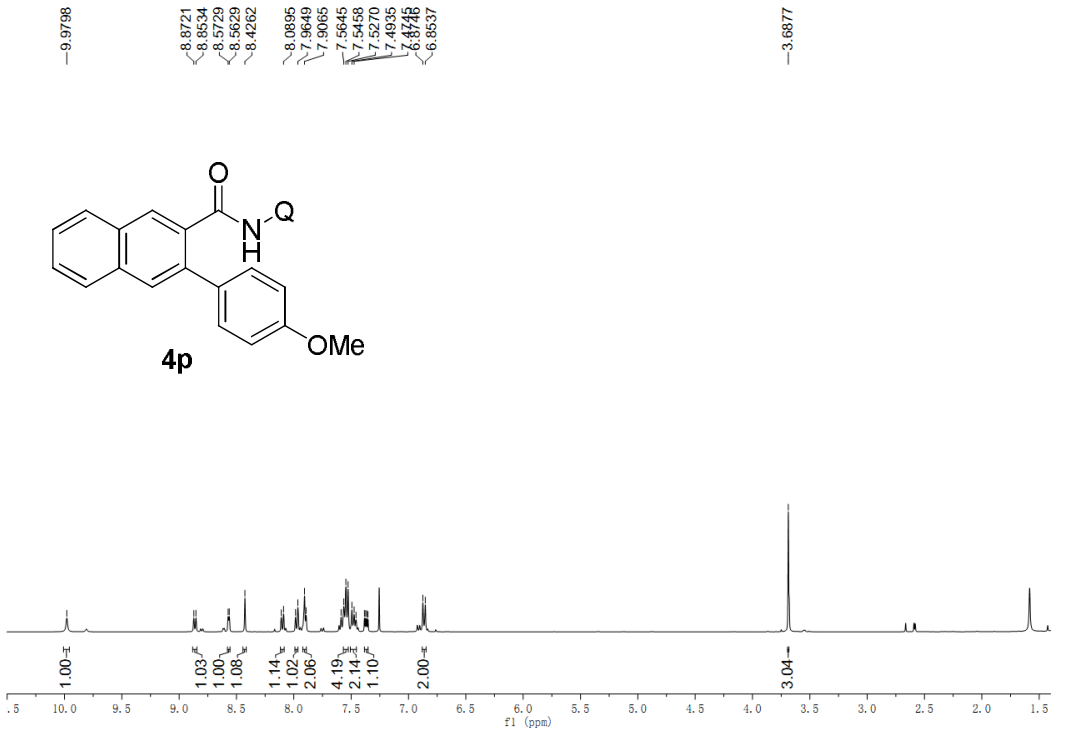

167.4144
147.7597
143.4581
139.9731
138.3252
136.7199
135.9470
134.5271
130.0548
129.4568
129.3330
128.9112
127.9770
127.7002
127.2420
126.5875
126.2098
121.5465
121.3955
116.3367
77.3171
76.9996
76.6817
15.6450
O
N
H
Q
Br
SMe
4m
f1 (ppm)

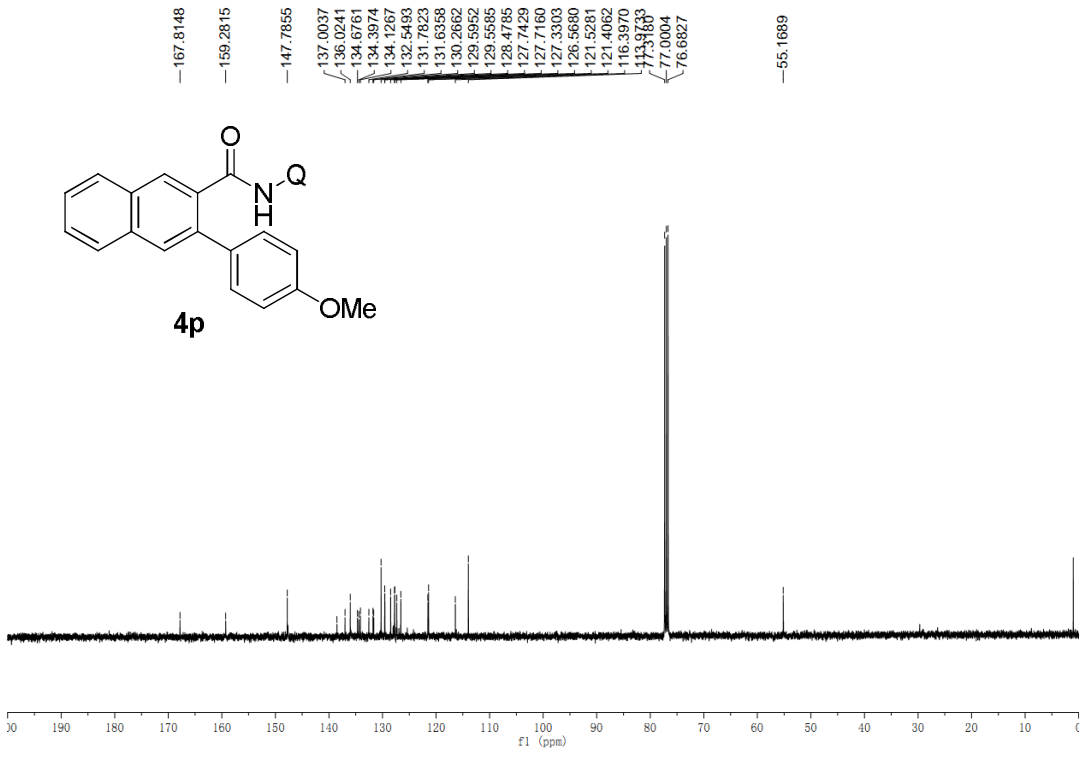

9.8429
8.8427
8.8239
8.5465
8.5427
8.5362
8.5322
8.0013
7.7375
7.7143
7.6924
7.6728
7.5215
7.5030
7.4861
7.4694
6.7164
3.7129
O
N
Q
H
Ph
OMe
4n
0.99
0.90
0.94
0.92
0.98
4.14
5.19
1.22
3.14
0.99
3.00
f1 (ppm)

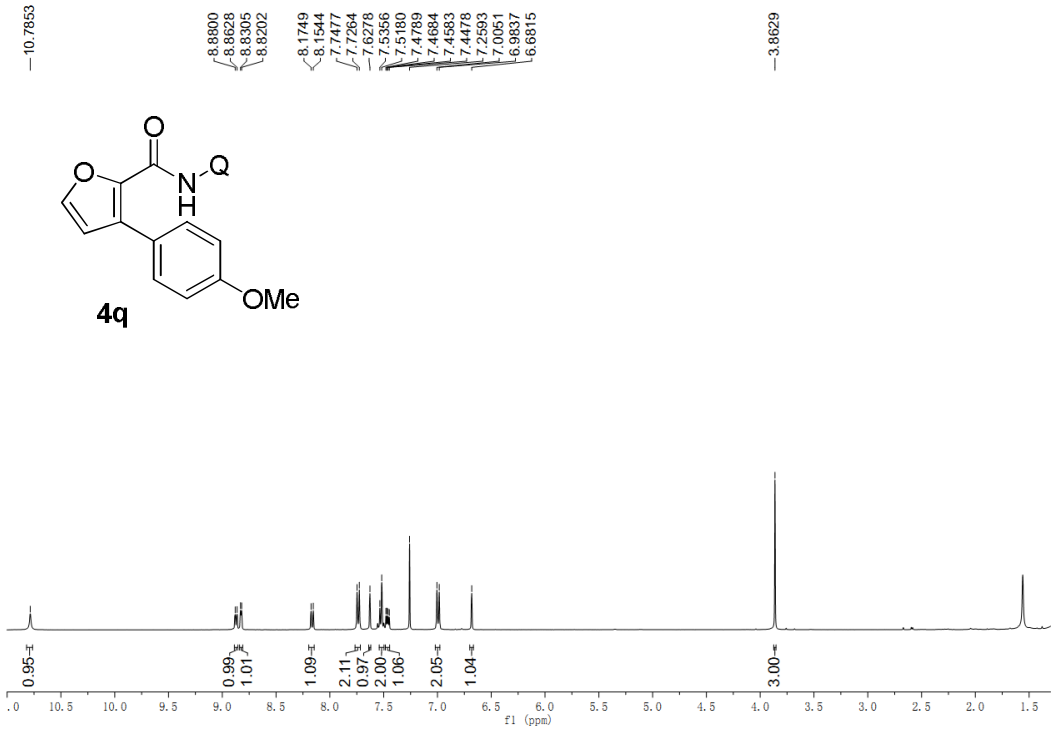

167.4904
159.6788
147.7149
143.3509
141.3893
140.6741
140.0041
138.4261
135.9599
134.7523
134.6101
129.9310
129.4298
129.2733
128.9180
127.9720
127.7035
127.2707
126.3271
121.5465
121.4982
121.3972
116.2327
114.1591
113.8919
77.3181
77.0003
76.6826
55.2089
O
N
Q
H
Ph
OMe
4n
f1 (ppm)

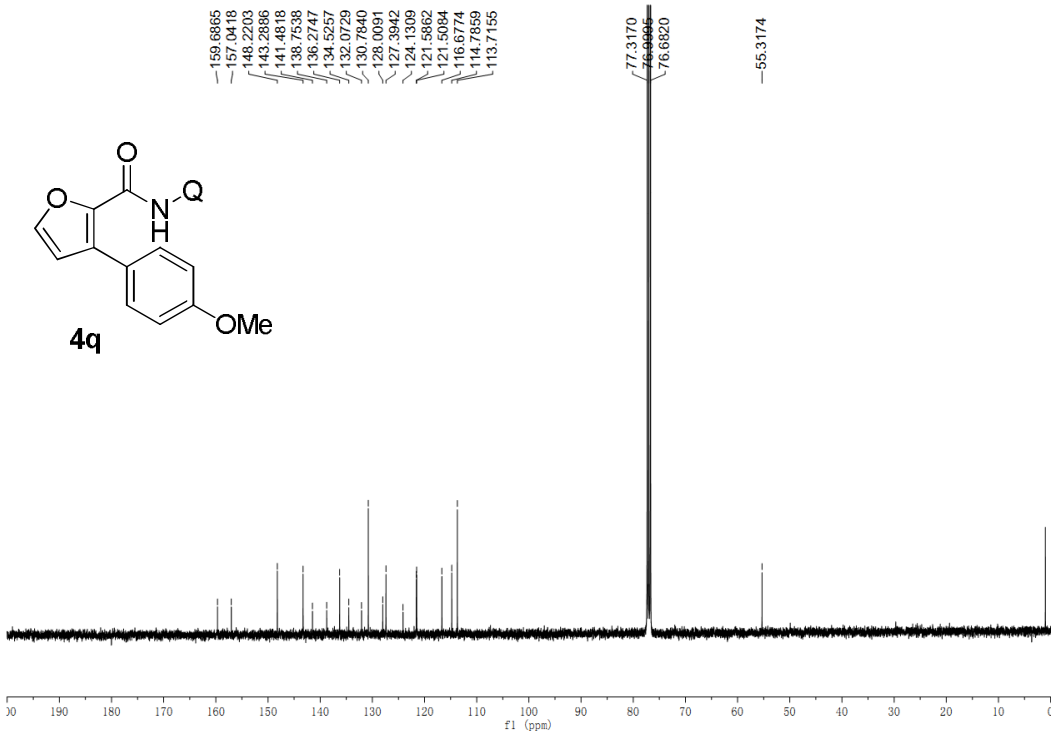

9.6942
8.5620
8.5601
8.5536
8.5490
8.0360
8.0154
7.8194
7.6616
7.6482
7.5185
7.4973
7.4637
7.4172
7.4105
7.3337
7.3231
7.3130
7.3023
7.1420
7.1210
2.2960
O
N
Q
H
Ph
SMe
4o
1.00
1.94
1.05
4.22
6.20
1.29
4.11
3.12
f1 (ppm)

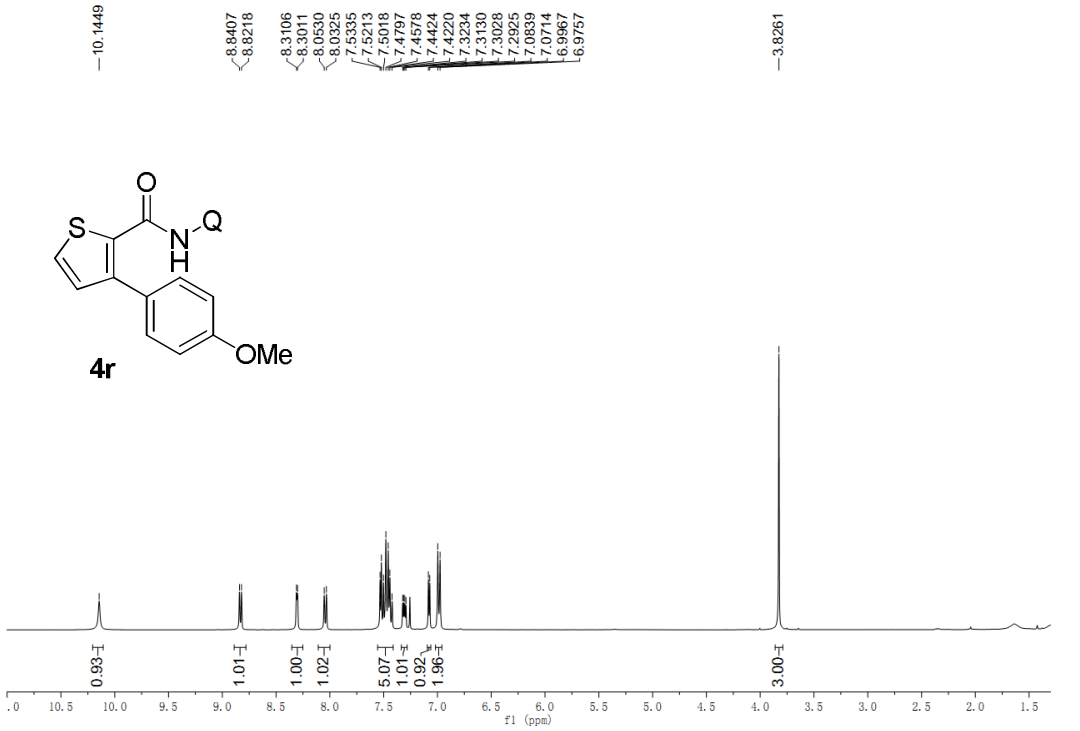

167.5387
147.8347
142.3019
140.5583
139.9068
138.2529
137.8906
136.9685
135.9509
134.5594
134.1047
130.3449
129.0342
128.9041
127.9828
127.9405
127.6254
127.2286
127.1177
126.2920
121.6678
121.3654
116.5301
116.0881
77.3175
77.0000
76.6824
15.5266
O
N
Q
H
Ph
SMe
4o
f1 (ppm)

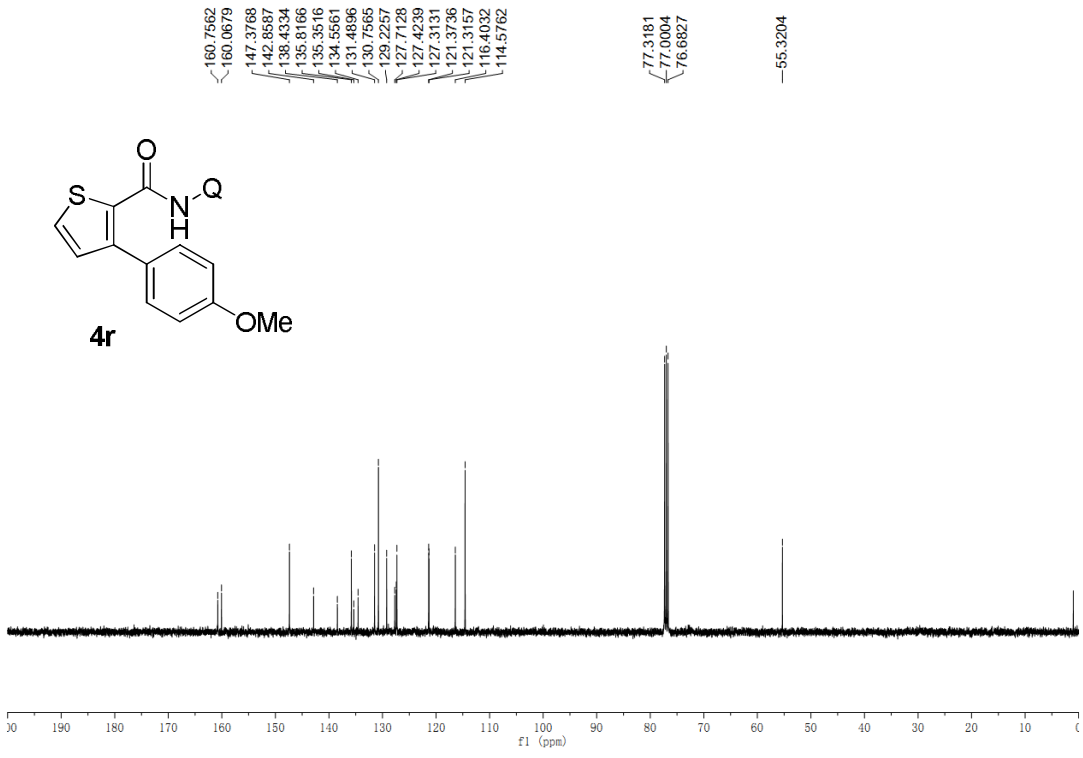

9.9798
8.8721
8.8534
8.5729
8.5629
8.4262
8.0895
7.9649
7.9065
7.5645
7.5458
7.5270
7.4935
6.8537
3.6877
O
N
H
Q
OMe
4p
1.00
1.03
1.00
1.08
1.14
1.02
2.06
4.19
2.14
1.10
2.00
3.04
f1 (ppm)

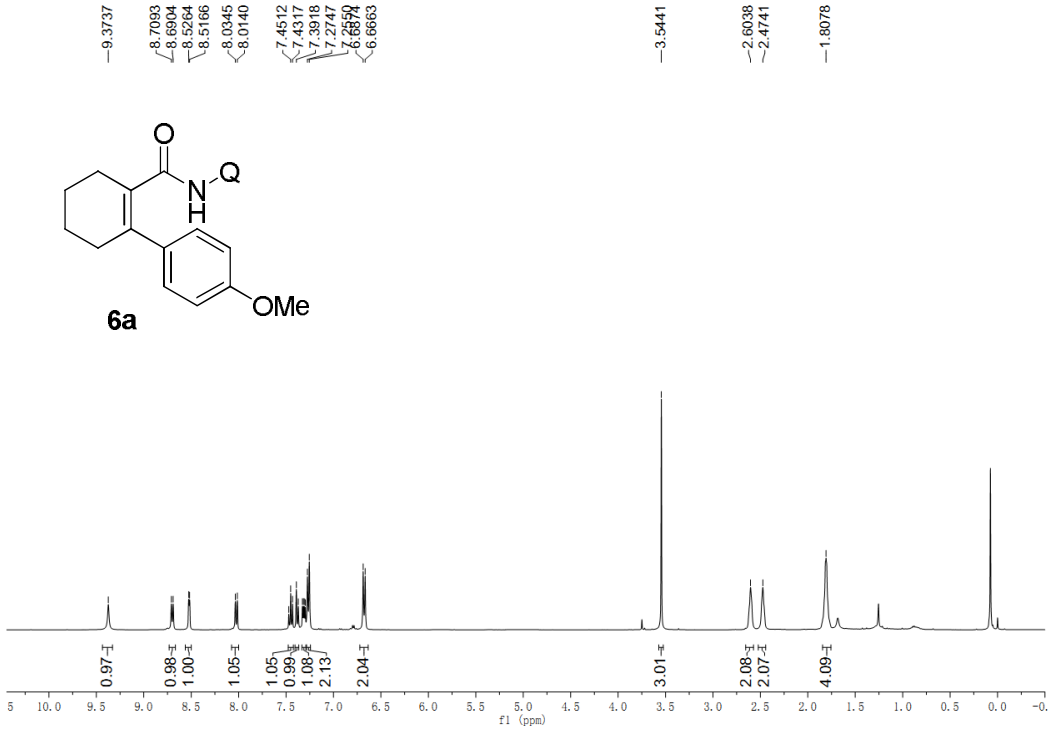

167.8148
159.2815
147.7855
137.0037
136.0241
134.6761
134.3974
134.1267
132.5493
131.7823
131.6358
130.2662
129.5952
129.5585
128.4785
127.7429
127.7160
127.3303
126.5680
121.5281
121.4062
116.3970
113.9733
77.3180
77.0004
76.6827
55.1689
O
N
H
Q
OMe
4p
f1 (ppm)

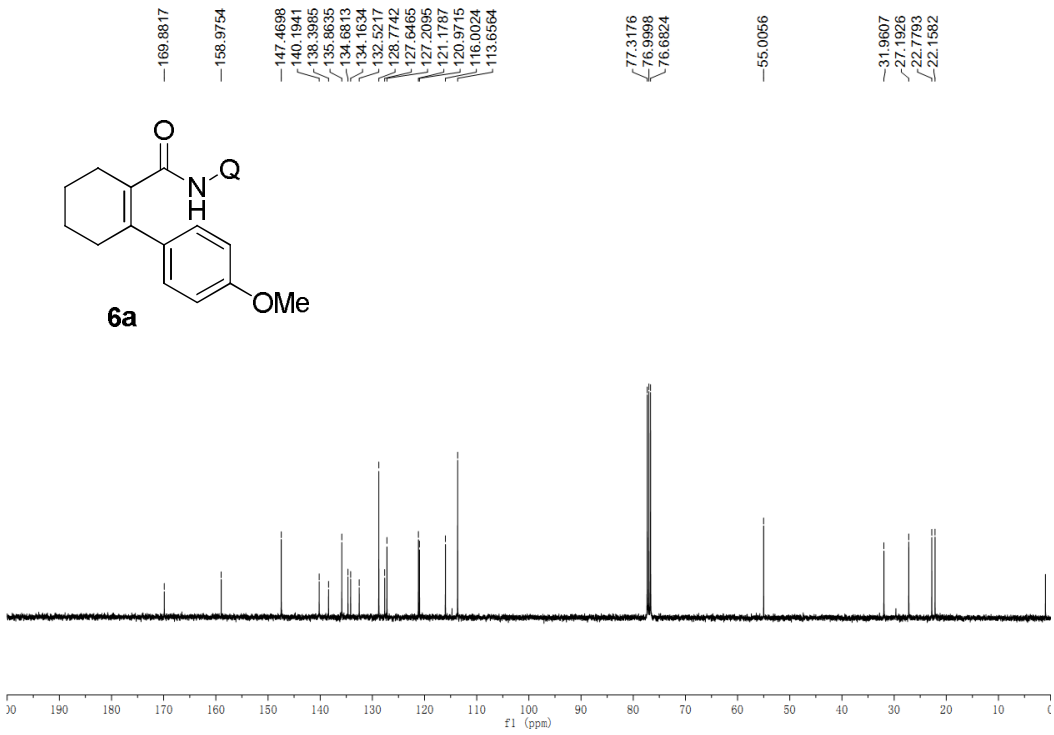

10.7853
8.8800
8.8628
8.8305
8.8202
8.1749
8.1544
7.7477
7.7264
7.6278
7.5356
7.5180
7.4789
7.4684
7.4583
7.4478
7.2593
7.0051
6.9837
6.6815
3.8629
O
O
N
H
Q
OMe
4q
0.95
0.99
1.01
1.09
2.11
0.97
2.00
1.06
2.05
1.04
3.00
f1 (ppm)

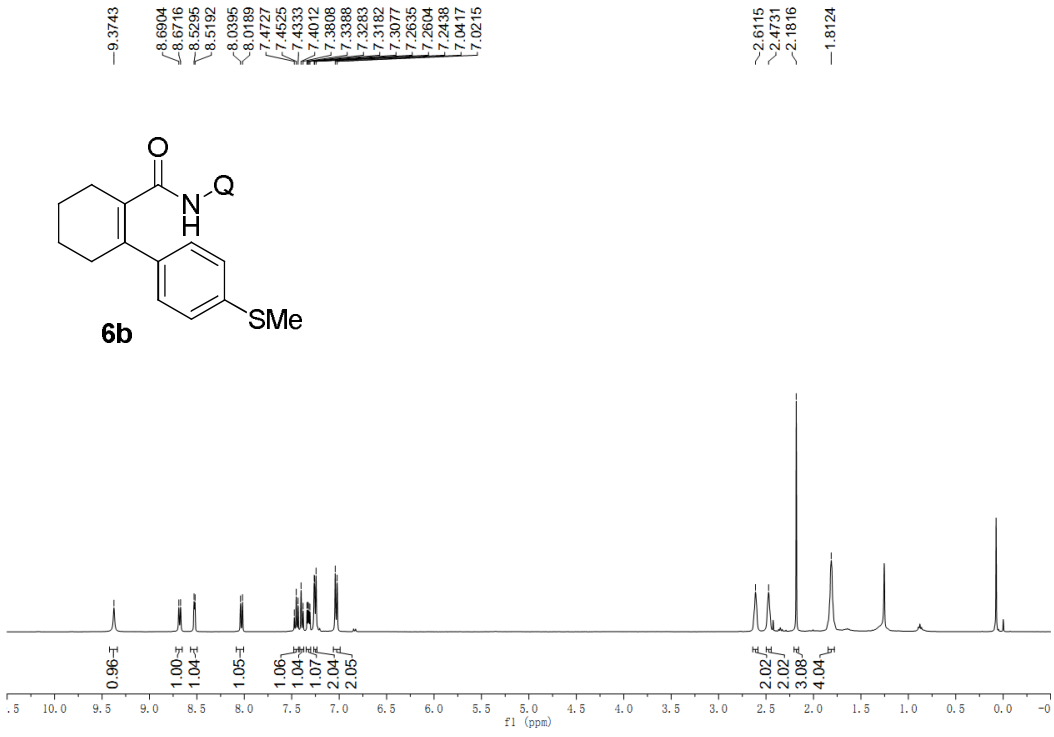

159.6865
157.0418
148.2203
143.2886
141.4818
138.7538
136.2747
134.5257
132.0729
130.7840
128.0091
127.3942
124.1309
121.5862
121.5084
116.6774
114.7859
113.7155
77.3170
77.0995
76.6820
55.3174
O
O
N
H
Q
OMe
4q
f1 (ppm)

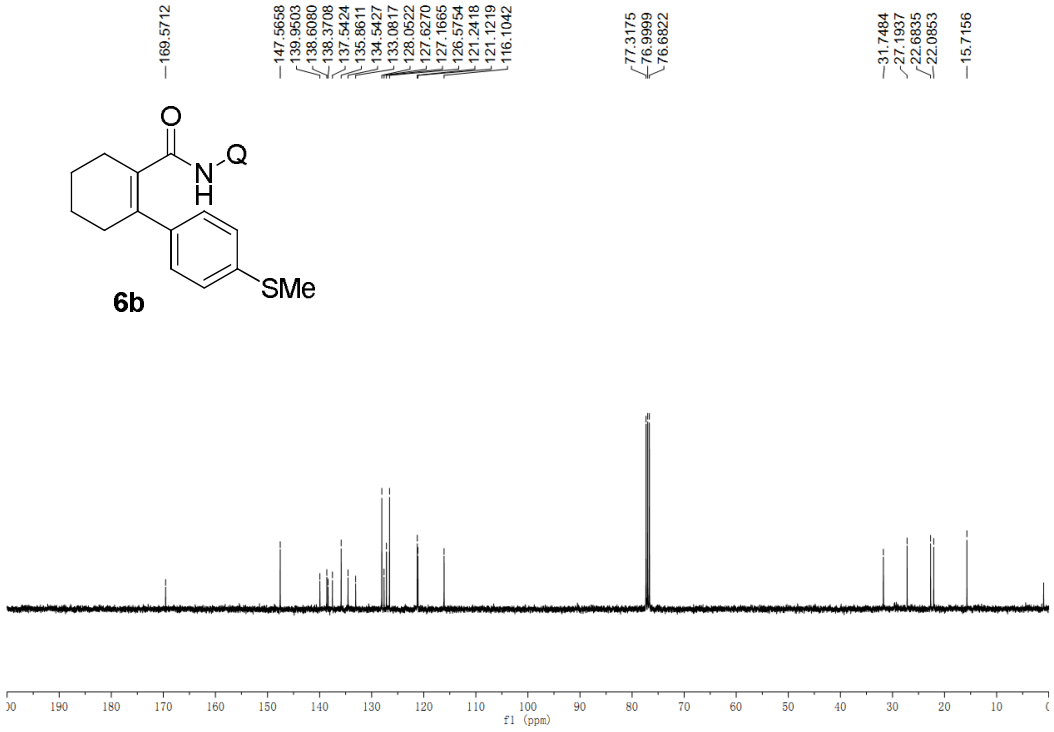

10.1449
8.8407
8.8218
8.3106
8.3011
8.0530
8.0325
7.5335
7.5213
7.5018
7.4797
7.4578
7.4424
7.4220
7.3234
7.3130
7.3028
7.2925
7.0839
7.0714
6.9967
6.9757
3.8261
O
S
N
H
Q
OMe
4r
0.93
1.01
1.00
1.02
5.07
1.01
0.92
1.96
3.00
f1 (ppm)

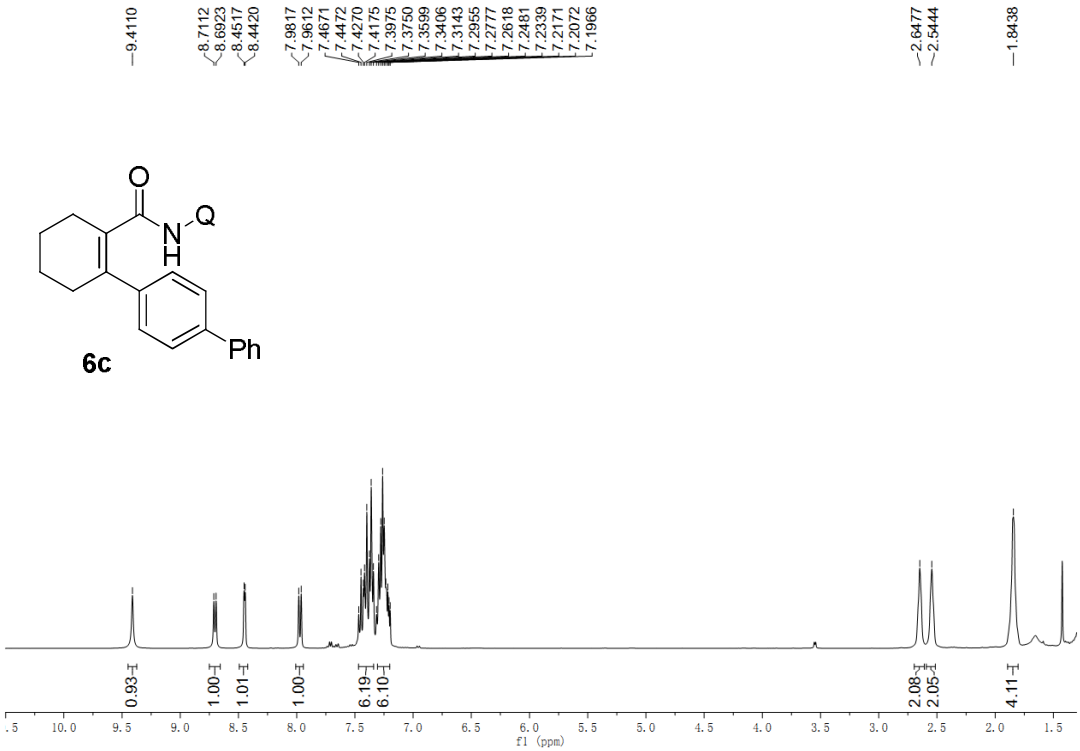

160.7562
160.0679
147.3768
142.8587
138.4334
135.8166
135.3516
134.5561
131.4896
130.7565
129.2257
127.7128
127.4239
127.3131
121.3736
121.3157
116.4032
114.5762
77.3181
77.0004
76.6827
55.3204
O
S
N
H
Q
OMe
4r
f1 (ppm)

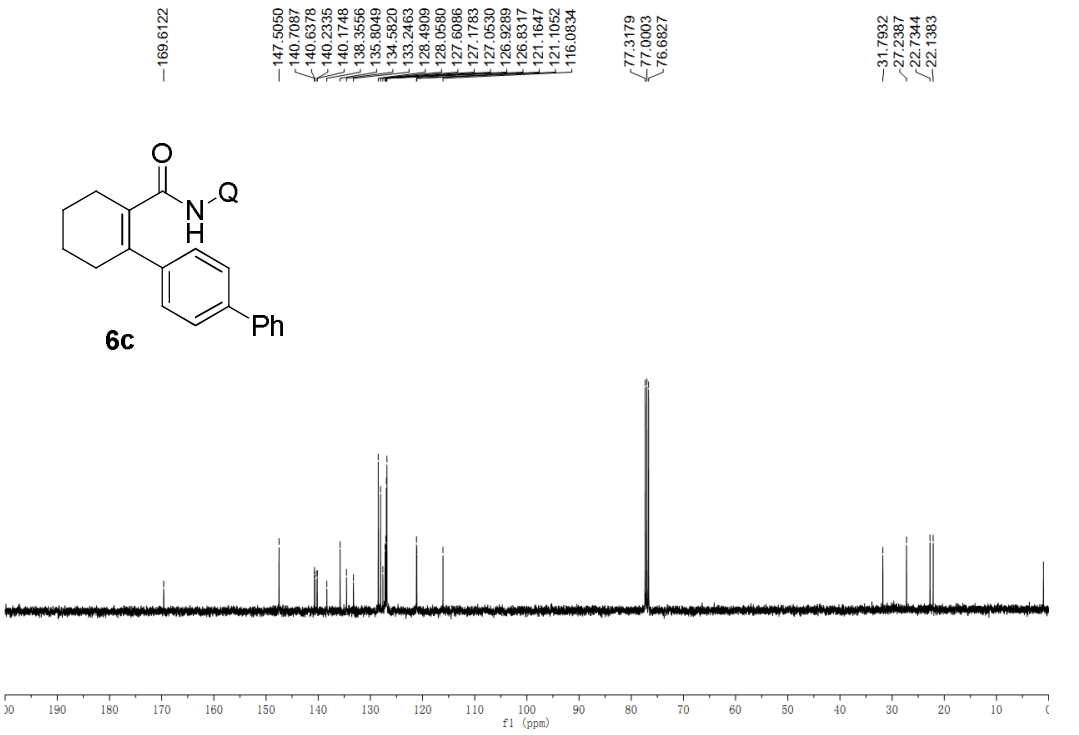

9.3737
8.7093
8.6904
8.5264
8.5166
8.0345
8.0140
7.4512
7.4317
7.3918
7.2747
7.2550
6.6874
6.6663
3.5441
2.6038
2.4741
1.8078
O
N
Q
H
OMe
6a
0.97
0.98
1.00
1.05
1.05
0.99
1.08
2.13
2.04
3.01
2.08
2.07
4.09
f1 (ppm)

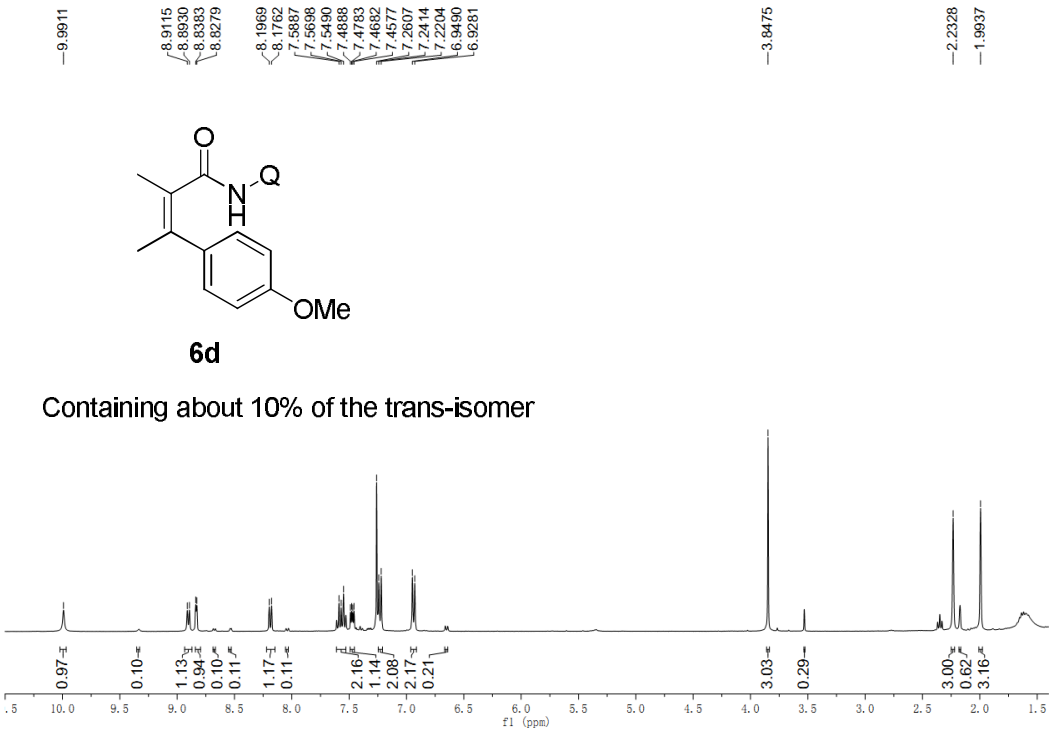

169.8817
158.9754
147.4698
140.1941
138.3985
135.8635
134.6813
134.1634
132.5217
128.7742
127.6465
127.2095
121.1787
120.9715
116.0024
113.6564
77.3176
76.9998
76.6824
55.0056
31.9607
27.1926
22.7793
22.1582
O
N
Q
H
OMe
6a
f1 (ppm)

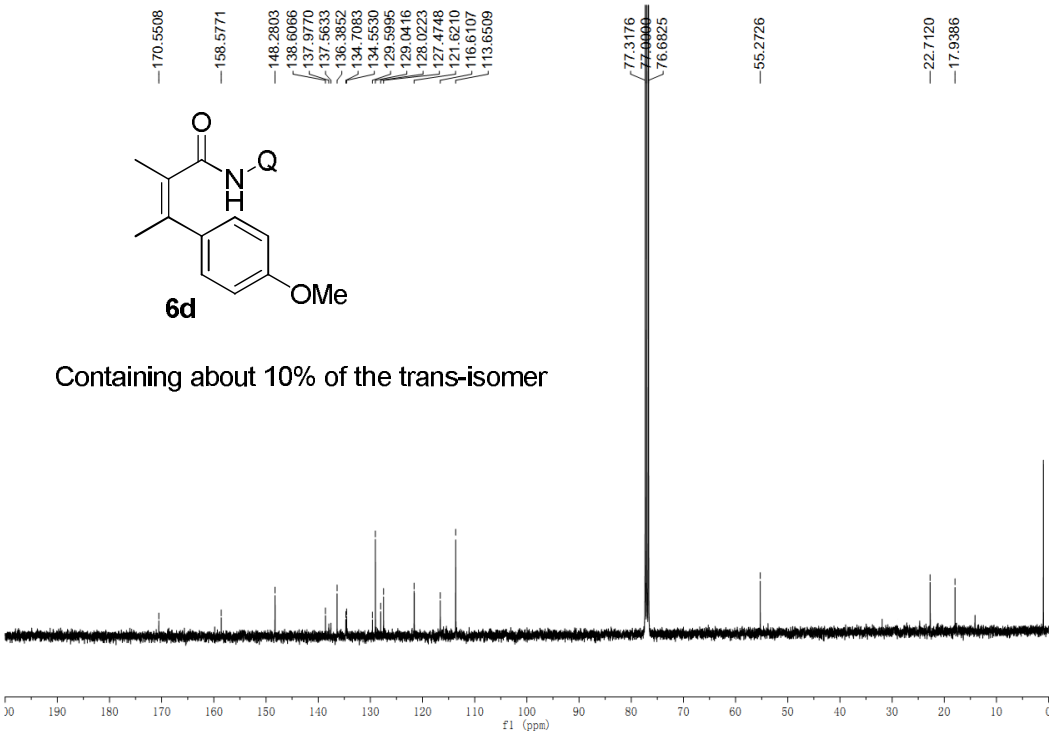

9.3743
8.6904
8.6716
8.5295
8.5192
8.0395
8.0189
7.4727
7.4525
7.4333
7.4012
7.3808
7.3388
7.3283
7.3182
7.3077
7.2635
7.2604
7.2438
7.0417
7.0215
2.6115
2.4731
2.1816
1.8124
O
N
H
Q
SMe
6b
0.96
1.00
1.04
1.05
1.06
1.04
1.07
2.04
2.05
2.02
2.02
3.08
4.04
f1 (ppm)

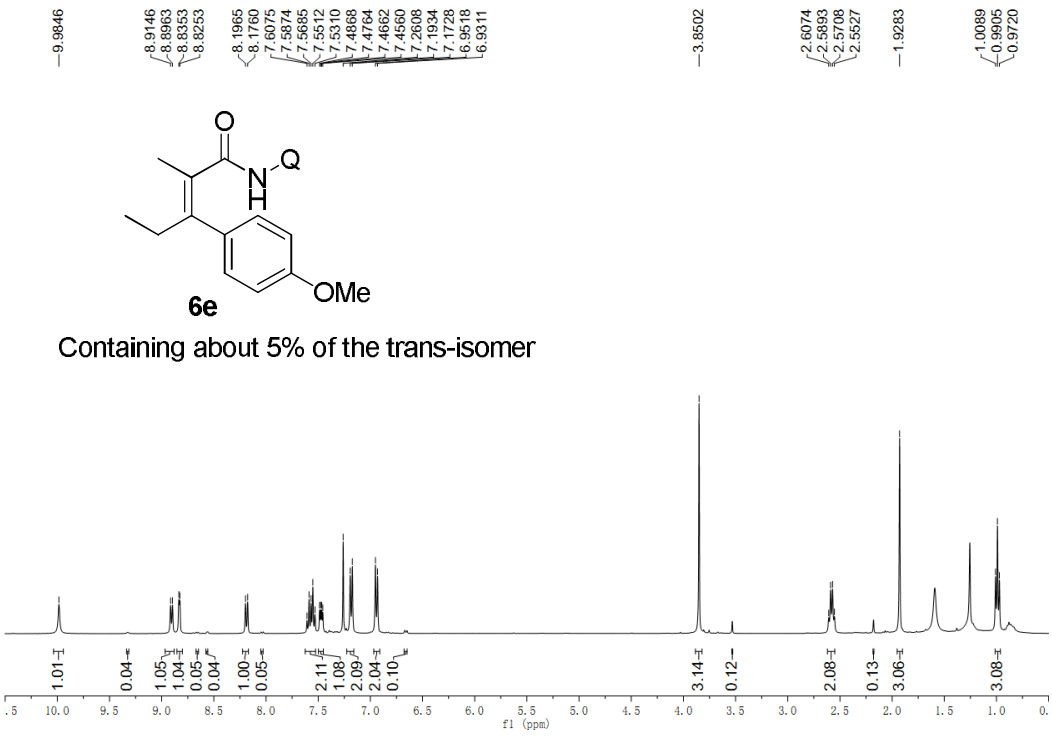

169.5712
147.5658
139.9503
138.6080
138.3708
137.5424
135.8611
134.5427
133.0817
128.0522
127.6270
127.1665
126.5754
121.2418
121.1219
116.1042
77.3175
76.9999
76.6822
31.7484
27.1937
22.6835
22.0853
15.7156
O
N
H
Q
SMe
6b
f1 (ppm)


9.4110
8.7112
8.6923
8.4517
8.4420
7.9817
7.9612
7.4671
7.4472
7.4270
7.4175
7.3975
7.3750
7.3599
7.3406
7.3143
7.2955
7.2777
7.2618
7.2481
7.2339
7.2171
7.2072
7.1966
2.6477
2.5444
1.8438
O
N
H
Q
Ph
6c
0.93
1.00
1.01
1.00
6.19
6.10
2.08
2.05
4.11
f1 (ppm)

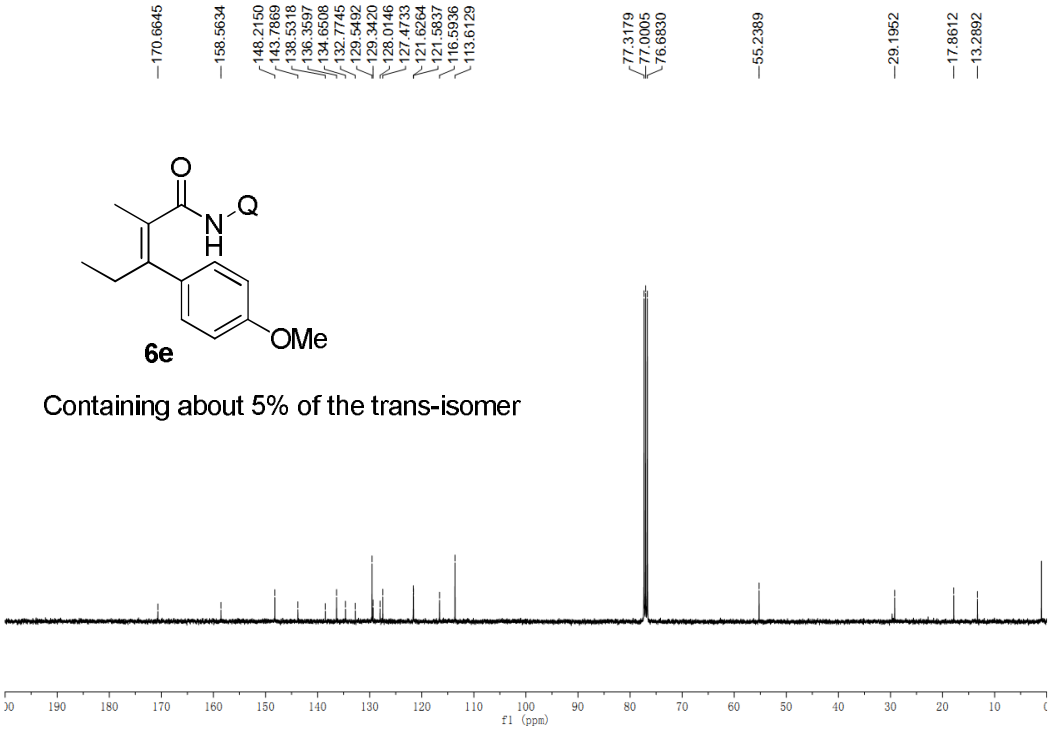

169.6122
147.5050
140.7087
140.6378
140.2335
140.1748
138.3556
135.8049
134.5820
133.2463
128.4909
128.0580
127.6086
127.1783
127.0530
126.9289
126.8317
121.1647
121.1052
116.0834
77.3179
77.0003
76.6827
31.7932
27.2387
22.7344
22.1383
O
N
H
Q
Ph
6c
f1 (ppm)


9.9911
8.9115
8.8930
8.8383
8.8279
8.1969
8.1762
7.5887
7.5698
7.5490
7.4888
7.4783
7.4682
7.4577
7.2607
7.2414
7.2204
6.9490
6.9281
3.8475
2.2328
1.9937
O
N
H
Q
OMe
6d
Containing about 10% of the trans-isomer
0.97
0.10
1.13
0.94
0.10
0.11
1.17
0.11
2.16
1.14
2.08
2.17
0.21
3.03
0.29
3.00
0.62
3.16
f1 (ppm)

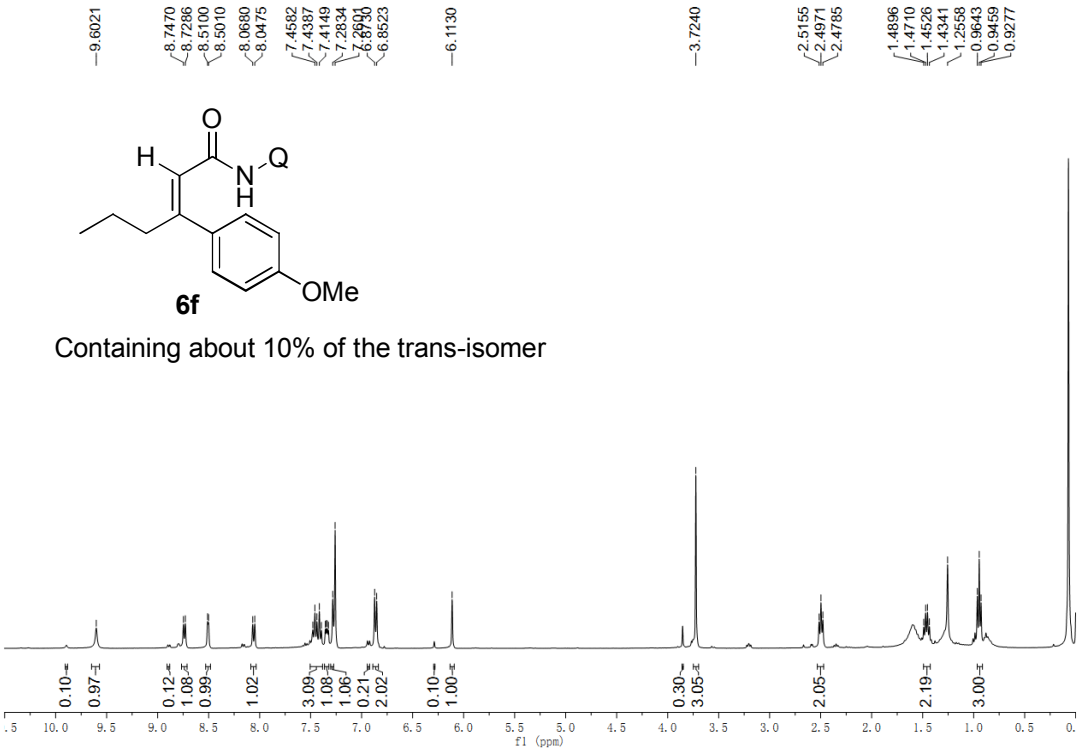

170.5508
158.5771
148.2803
138.6066
137.9770
137.5633
136.3852
134.7083
134.5530
129.5995
129.0416
128.0223
127.4748
121.6210
116.6107
113.6509
77.3176
77.0000
76.6825
55.2726
22.7120
17.9386
O
N
H
Q
OMe
6d
Containing about 10% of the trans-isomer
f1 (ppm)



Containing about 5% of the trans-isomer

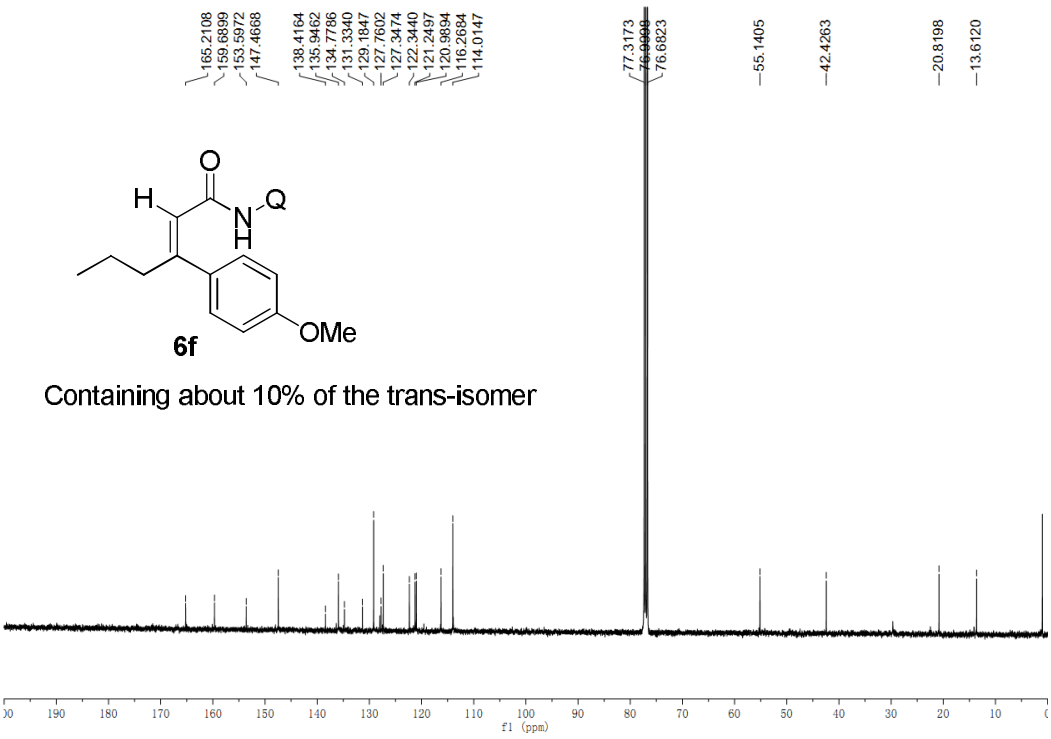


Containing about 5% of the trans-isomer



6f

Containing about 10% of the trans-isomer



6f

Containing about 10% of the trans-isomer

NOE of (Z)-**6f**: