Copper-mediated synthesis of quinazolin-4(3*H*)-ones from *N*-(quinolin-8-yl)benzamide and amidine hydrochlorides

1. General information

^{1}H NMR and ^{13}C NMR spectra were recorded on Bruker 300M and Mercury 400M in CD3SOCD3. All ^{1}H NMR and ^{13}C NMR chemical shifts were given as δ value (ppm) with reference to tetramethylsilane (TMS) as an internal standard. Copies of their ^{1}H NMR and ^{13}C NMR spectra were provided. Products were purified by flash chromatography on 200–300 mesh silica gels. All melting points were determined without correction. All reactions were carried out in oven-dried glassware, all reagents were obtained from commercial suppliers and used without further purification, unless otherwise noted.

2. Experimental procedures and characterizations of substrates

2.1. General procedure for preparation of 1 (1a as an example)

General procedure: To a solution of 8-aminoquinoline (3.00 g, 21 mmol) and ,*N*-dimethyl-4-aminopyridine (80 mg, 0.65 mmol) in anhydrous CH2Cl2 (30 mL) under nitrogen Et3N (3.3 mL, 24 mmol, 1.2 equiv) was added and resulting solution was cooled to 0 °C. Benzoyl chloride (2.3 mL, 20 mmol) was added dropwise and reaction mixture was stirred at room temperature overnight. The mixture was quenched with water (30 mL) and extracted with CH2Cl2 (3 x 20 mL). Combined organic phase was dried over MgSO4 and filtered. Concentration in vacuum followed by recrystallization from toluene afforded 4.6g (94%) of *N*-(quinolin-8-yl)benzamide as a white solid.

2.2. General procedure for preparation of 3 (3a as an example)

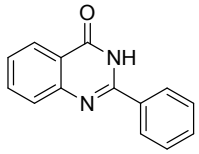
General procedure: A sealed tube was charged with *N*-(quinolin-8-yl）benzamide **1a** (25mg, 0.1mmol) ,benzamidine hydrochloride **2a** (24mg, 0.15 mmol), $Cu(OAc)_2$（4 mg, 20 mol %) and K_2CO_3(28 mg, 0.2 mmol) at room temperature, and then solvent DMSO (2mL) was added. The resulting mixture was stirred at 110° C under air. After disappearance of the reactant (monitored by TLC), added 20mL saturated NaCl(aq) solution to the mixture, extracted with EtOAc 3 times (3 × 20mL). The extract was dried over anhydrous Na_2SO_4 and concentrated under reduced pressure. The residue was purified by column chromatography on silica gel (Petroleum ether / ethyl acetate =4:1) to yield the desired product **3a** as a white solid (91% yield).

3. Futher optimization of the reaction conditions[a]

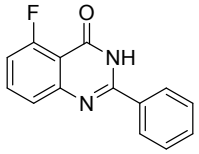
Entry	Catalyst	Base	Solvent	Yield(%)[b]
1	$Cu(OAc)_2$	EtONa	DMSO	18
2	$Cu(OAc)_2$	NaOAc	DMSO	27
3	$Cu(OAc)_2$	$NaHCO_3$	DMSO	63
4	$Cu(OAc)_2$	Et_3N	DMSO	nr
5	$Cu(OAc)_2$	K_3PO_4	DMSO	32
6	CuO	K_2CO_3	DMSO	50
7	CuBr	K_2CO_3	DMSO	45

8	$Cu(OAc)_2$	K_2CO_3	Toluene	27

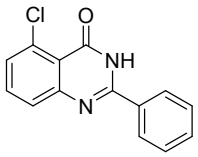
4.Spectral data of compounds



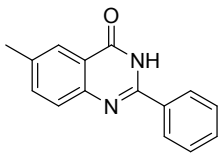
*2-phenylquinazolin-4(3H)-one (**3a**)* White solid; yield: 91% (20.0 mg), mp: 233-235 °C. ^{1}H NMR (300 MHz, DMSO-d_6): δ 12.56 (s, 1H), 8.23 – 8.07 (m, 3H), 7.88 – 7.78 (m, 1H), 7.74 (d, *J* = 7.6 Hz, 1H), 7.61 – 7.48 (m, 4H). ^{13}C NMR (75 MHz, DMSO-d_6) δ 162.03 (s), 152.06 (s), 148.51 (s), 134.32 (s), 132.48 (s), 131.13 (s), 128.34 (s), 127.53 (s), 127.27 (s), 126.31 (s), 125.62 (s), 120.75 (s). $C_{14}H_{10}N_2O$ HRMS $[M+H]^+$ calcd for 223.0866, found: 223.0871



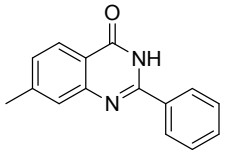
*5-fluoro-2-phenylquinazolin-4(3H)-one (**3b**)* White solid; yield: 52% (12.5 mg), mp: 308–310 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 12.55 (s, 1H), 8.22 – 8.11 (m, 2H), 7.82 – 7.73 (m, 1H), 7.59 – 7.50 (m, 4H), 7.24 (ddd, *J* = 10.9, 8.2, 0.8 Hz, 1H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 162.31 (s), 160.02 (s), 159.70 (s), 153.73-151.38 (d, *J*=235 Hz), 135.66-135.55 (d, *J*=10.0 Hz), 132.69 (s), 132.13 (s), 129.08 (s), 128.33 (s), 126.42 (s), 124.08 (s), 113.44-113.24 (d, *J*=20.0 Hz). $C_{14}H_9FN_2O$ HRMS $[M+H]^+$ calcd for 241.0772, found: 241.0776.



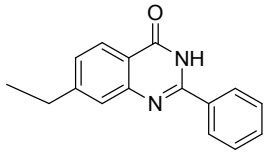
*5-chloro-2-phenylquinazolin-4(3H)-one (**3c**)* White solid; yield: 49% (12.6 mg)， mp:282-284°C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 12.49 (s, 1H), 8.10 (td, *J* = 7.8, 1.3 Hz, 3H), 7.79 – 7.72 (m, 1H), 7.67 (d, *J* = 8.1 Hz, 1H), 7.56 – 7.37 (m, 3H). ^{13}C NMR (75 MHz, DMSO-d_6) δ 162.99 (s), 153.03 (s), 149.34 (s), 135.26 (s), 133.40 (s), 132.06 (s), 129.27 (s), 128.44 (s), 128.10 (s), 127.24 (s), 126.53 (s), 121.64 (s). $C_{14}H_9ClN_2O$ HRMS $[M+H]^+$ calcd for 257.0476, found: 257.0476



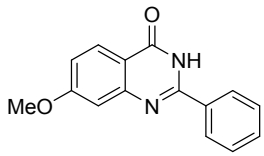
*6-methyl-2-phenylquinazolin-4(3H)-one (**3e**)* White solid; yield: 61% (14.5 mg); mp: 265−268 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 12.51 (s, 1H), 8.22 (dd, *J* = 7.8, 1.8 Hz, 2H), 8.00 (s, 1H), 7.69 (d, *J* = 1.2 Hz, 2H), 7.61 (dd, *J* = 7.5, 5.5 Hz, 3H), 2.50 (s, 3H). ^{13}C NMR (75 MHz, DMSO-d_6) δ 161.79 (s), 146.38 (s), 136.80 (s), 135.92 (s), 135.49 (s), 132.42 (s), 130.85 (s), 128.22 (s), 127.27 (s), 124.88 (s), 120.37 (s), 20.50 (s). $C_{15}H_{12}N_2O$ HRMS $[M+H]^+$ calcd for 237.1023, found: 237.1022.



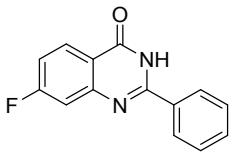
*7-methyl-2-phenylquinazolin-4(3H)-one (**3g**)* White solid; yield: 76% (18.1 mg); mp: 238-240 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 12.50 (s, 1H), 8.20 (dd, *J* = 8.1, 1.5 Hz, 2H), 8.06 (d, *J* = 8.1 Hz, 1H), 7.62 – 7.54 (m, 4H), 7.36 (dd, *J* = 8.1, 1.2 Hz, 1H), 2.49 (s, 3H). ^{13}C NMR (75 MHz, DMSO-d_6) δHRMS (ESI): m/z calcd for $C_{15}H_{13}N_2O$, 237.1028; found, 237.1019.162.78 (s), 152.97 (s), 149.51 (s), 145.72 (s), 133.43 (s), 132.00 (s), 129.26 (s), 128.68 (s), 128.36 (s), 127.81 (s), 126.37 (s), 119.24 (s), 22.04 (s). $C_{15}H_{12}N_2O$ HRMS $[M+H]^+$calcd for237.1023, found: 237.1021.



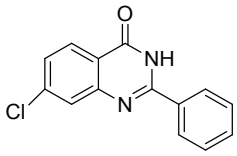
*7-ethyl-2-phenylquinazolin-4(3H)-one (**3h**)* White solid; yield: 81% (20.3 mg); mp: 250-252 °C ^{1}H NMR (400 MHz, DMSO-d_6) δ 12.49 (s, 1H), 8.19 (dd, *J* = 8.1, 1.5 Hz, 2H), 8.07 (d, *J* = 8.1 Hz, 1H), 7.56 (dd, *J* = 7.2, 4.5 Hz, 4H), 7.37 (dd, *J* = 8.1, 1.5 Hz, 1H), 2.76 (d, *J* = 7.6 Hz, 2H), 1.25 (t, *J* = 7.6 Hz, 3H). ^{13}C NMR (75 MHz, DMSO-d_6) δ 161.94 (s), 152.07 (s), 150.90 (s), 148.75 (s), 132.57 (s), 131.13 (s), 128.40 (s), 127.50 (s), 126.74 (s), 125.72 (s), 125.64 (s), 118.62 (s), 28.15 (s), 14.91 (s). $C_{16}H_{14}N_2O$ HRMS $[M+H]^+$ calcd for 251.1179, found: 251.1182.



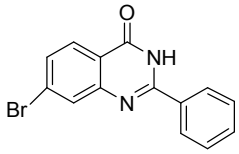
*7-methoxy-2-phenylquinazolin-4(3H)-one (**3i**)* White solid; yield: 68% (17.3 mg), mp: 235-236 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 12.45 (s, 1H), 8.21 (dt, *J* = 5.4, 1.4 Hz, 2H), 8.08 (dd, *J* = 8.8, 1.4 Hz, 1H), 7.65 – 7.52 (m, 3H), 7.21 (t, *J* = 1.9 Hz, 1H), 7.16 – 7.04 (m, 1H), 3.94 (d, *J* = 1.4 Hz, 3H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 164.63 (s), 162.23 (s), 153.32 (s), 151.44 (s), 133.17 (s), 131.85 (s), 129.04 (s), 128.20 (s), 127.89 (s), 116.65 (s), 114.86 (s), 108.96 (s), 56.16 (s). $C_{15}H_{12}N_2O_2$ HRMS $[M+H]^+$calcd for 253.0972, found: 253.0977.



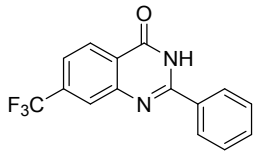
*7-fluoro-2-phenylquinazolin-4(3H)-one (**3j**)* White solid; yield: 82% (19.7 mg), mp >300 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 12.64 (s, 1H), 8.25 – 8.10 (m, 3H), 7.64 – 7.44 (m, 4H), 7.36 (td, *J* = 8.7, 2.5 Hz, 1H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 167.55 (s), 165.06 (s), 162.02 (s), 154.19 (s), 151.31 (s), 132.84 (s), 132.15 (s), 129.49-129.38 (d, *J*=11.0 Hz), 129.10-128.36 (d, *J*=74.0 Hz), 118.45 (s), 115.69-115.46 (d, *J*=23.0 Hz), 113.04-112.83 (d, *J*=21.0 Hz). $C_{14}H_9FN_2O$ HRMS $[M+H]^+$ calcd for241.0772, found: 241.0775.



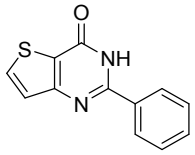
*7-chloro-2-phenylquinazolin-4(3H)-one (**3k**)* White solid; yield: 92% (23.6 mg) mp: 286–288 °C.^{1}H NMR (400 MHz, DMSO-d_6) δ 12.67 (s, 1H), 8.19 – 8.08 (m, 3H), 7.76 (d, *J* = 2.0 Hz, 1H), 7.61 – 7.49 (m, 4H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 162.14 (s), 154.24 (s), 150.32 (s), 139.63 (s), 132.82 (s), 132.18 (s), 129.10 (s), 128.37 (s), 127.25 (s), 127.02 (s), 120.25 (s). $C_{14}H_9ClN_2O$ HRMS $[M+H]^+$ calcd for 257.0476, found: 254.0478.



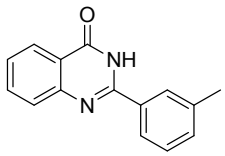
*7-bromo-2-phenylquinazolin-4(3H)-one (**3l**)* White solid; yield: 84% (25.3 mg); mp: 269–271°C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 12.64 (s, 1H), 8.19 – 8.09 (m, 2H), 8.03 (d, *J* = 8.5 Hz, 1H), 7.90 (d, *J* = 1.8 Hz, 1H), 7.64 (dd, White solid; yield: 84% (25.3 mg); *J* = 8.5, 1.9 Hz, 1H), 7.59 – 7.50 (m, 3H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 162.26 (s), 154.15 (s), 150.39 (s), 132.83 (s), 132.17 (s), 130.13 (s), 129.99 (s), 129.09 (s), 128.61 (s), 128.38 (s), 120.56 (s). $C_{14}H_9BrN_2O$ HRMS $[M+H]^+$ calcd for300.9971, found:300.9976.



*2-phenyl-7-(trifluoromethyl)quinazolin-4(3H)-one (**3m**)* White solid, yield: 67% (19.5 mg)，m.p. > 300 °C; ^{1}H NMR (300 MHz, DMSO-d_6) δ 12.78 (s, 1H), 8.29 (d, *J* = 8.2 Hz, 1H), 8.21 – 8.12 (m, 2H), 7.99 (s, 1H), 7.75 (d, *J* = 8.3 Hz, 1H), 7.60 – 7.49 (m, 3H). ^{13}C NMR (75 MHz, DMSO-d_6) δ 162.28 (s), 154.62 (s), 149.41 (s), 134.66 (s), 132.94 (s), 132.46 (s), 129.30-12853 (d, *J*=57.8 Hz), 128.33 (s), 125.15-124.44 (d, *J*=53.3 Hz), 122.81 (s). $C_{15}H_9F_3N_2O$ HRMS $[M+H]^+$ calcd for 291.0740, found: 291.0745

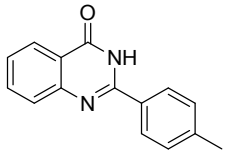


*2-phenylthieno[3,2-d]pyrimidin-4(3H)-one (**3n**)* Yellow solid, yield: 78% (17.8 mg). mp: 226 – 227 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 12.68 (s, 1H), 8.20 (d, *J* = 5.2 Hz, 1H), 8.15 – 8.08 (m, 2H), 7.59 – 7.49 (m, 3H), 7.46 (d, *J* = 5.2 Hz, 1H). ^{13}C NMR (75 MHz, DMSO-d_6) δ 159.22 (s), 158.62 (s), 154.98 (s), 136.06 (s), 133.20 (s), 131.99 (s), 129.30 (s), 128.51 (s), 126.12 (s), 121.92 (s). $C_{12}H_8N_2OS$ HRMS $[M+H]^+$ calcd for 229.0430, found: 229.0428.

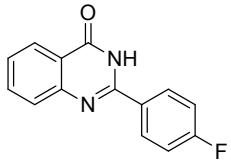


*2-(m-tolyl)quinazolin-4(3H)-one (**3q**)* White solid, yield: 45% (10.8 mg). mp: 210−212 °C. ^{1}H NMR

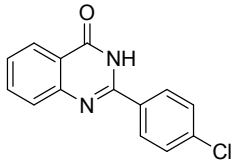
(400 MHz, DMSO-d_6) δ 12.60 (s, 1H), 8.26 – 8.22 (m, 1H), 8.11 (s, 1H), 8.06 (d, *J* = 7.3 Hz, 1H), 7.94 – 7.88 (m, 1H), 7.83 (d, *J* = 7.8 Hz, 1H), 7.63 – 7.56 (m, 1H), 7.54 – 7.46 (m, 2H), 2.49 (s,3H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 162.67 (s), 152.83 (s), 149.24 (s), 138.37 (s), 135.04 (s), 133.10 (s), 132.46 (s), 128.96 (s), 128.75 (s), 127.95 (s), 126.98 (s), 126.31 (s), 125.35 (s), 121.45 (s), 21.43 (s). $C_{15}H_{12}N_2O$ HRMS $[M+H]^+$calcd for 237.1023, found: 237.1028.



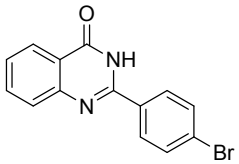
2-(p-tolyl)quinazolin-4(3H)-one (***3r***) White solid; yield: 61% (14.5 mg); mp: 261-263 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 12.45 (s, 1H), 8.21 – 8.01 (m, 2H), 7.83 – 7.76 (m, 1H), 7.72 – 7.66 (m, 1H), 7.49 (ddd, *J* = 8.1, 7.1, 1.2 Hz, 1H), 7.34 (d, *J* = 8.0 Hz, 2H), 2.38 (s, 5H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 162.71 (s), 152.71 (s), 149.29 (s), 141.93 (s), 135.04 (s), 130.37 (s), 129.67 (s), 128.15 (s), 127.88 (s), 126.86 (s), 126.31 (s), 121.36 (s), 21.46 (s). $C_{15}H_{12}N_2O$ HRMS $[M+H]^+$calcd for237.1023, found: 237.1025.



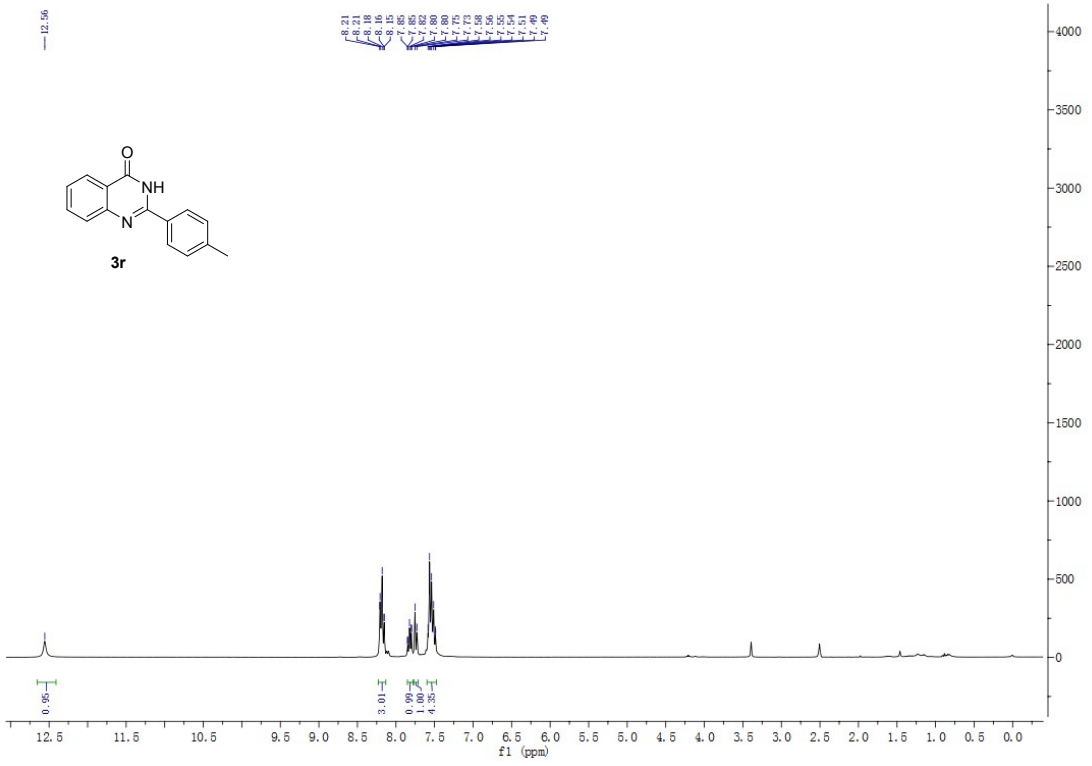
2-(4-fluorophenyl)quinazolin-4(3H)-one (***3s***) White solid; yield: 86% (20.7 mg); mp: 240−242 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 12.55 (s, 1H), 8.26 – 8.21 (m, 2H), 8.14 (dd, *J* = 7.9, 1.1 Hz, 1H), 7.84 – 7.79 (m, 1H), 7.72 (d, *J* = 8.0 Hz, 1H), 7.50 (dd, *J* = 13.3, 6.2 Hz, 1H), 7.37 (t, *J* = 8.8 Hz, 2H).^{13}C NMR (100 MHz, DMSO-d_6) δ 165.75 (s), 163.27 (s), 162.70 (s), 151.84 (s), 135.07 (s), 130.87-130.78 (d, *J*=9.0 Hz), 129.70-128.87 (d, *J*=83.0 Hz), 127.91 (s), 127.05 (s), 126.31 (s), 121.34 (s), 116.19-115.97 (d, *J*=22.0 Hz). HRMS (ESI): calcd. for $C_{14}H_9N_2OF$. $[M+H]^+$ 241.0772, found: 241.0773.

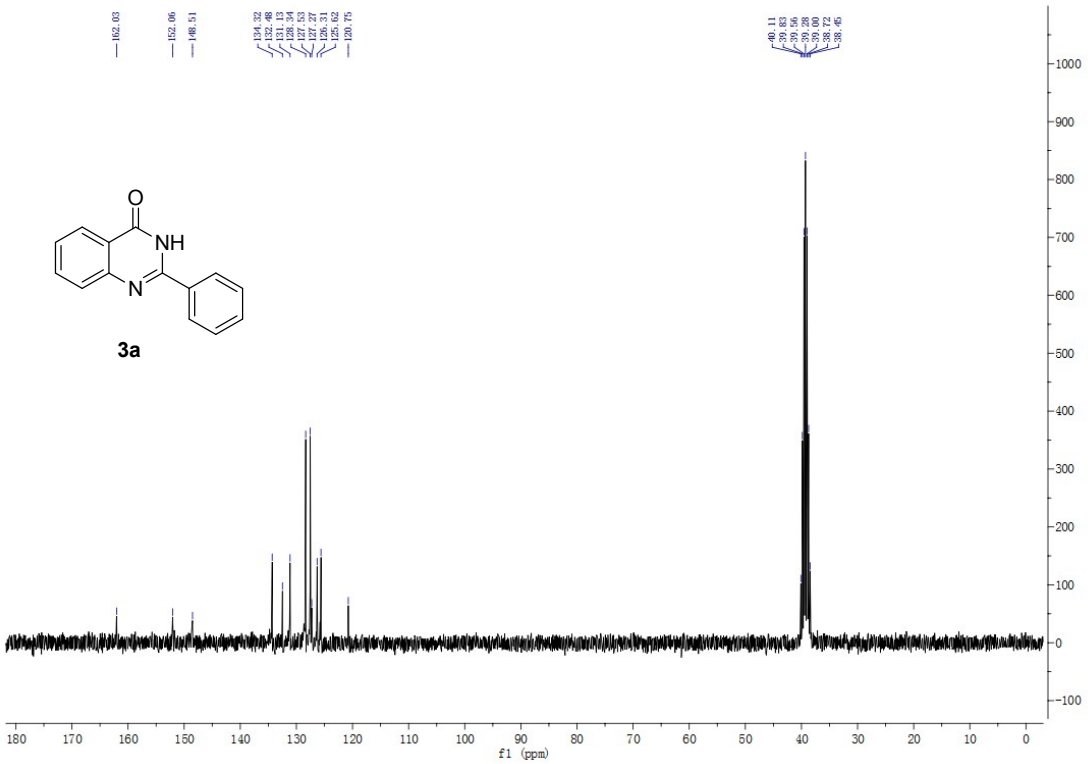


2-(4-chlorophenyl)quinazolin-4(3H)-one (***3t***) White solid; yield: 93% (23.9 mg) ;mp: 298−300 °C; ^{1}H NMR (300 MHz, DMSO-d_6 δ 12.62 (s, 1H), 8.16 (dd, *J* = 13.4, 8.5 Hz, 2H), 8.06 (d, *J* = 8.4 Hz, 2H), 7.57 (dd, *J* = 23.7, 8.1 Hz, 4H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 162.69 (s), 151.85 (s), 148.99 (s), 136.76 (s), 135.11 (s), 132.04 (s), 130.08 (s), 129.52 (s), 129.14 (s), 128.23 (s), 127.22 (s), 126.34 (s), 121.46 (s). $C_{14}H_9ClN_2O$ HRMS $[M+H]^+$ calcd for 257.0476, found: 254.0479.

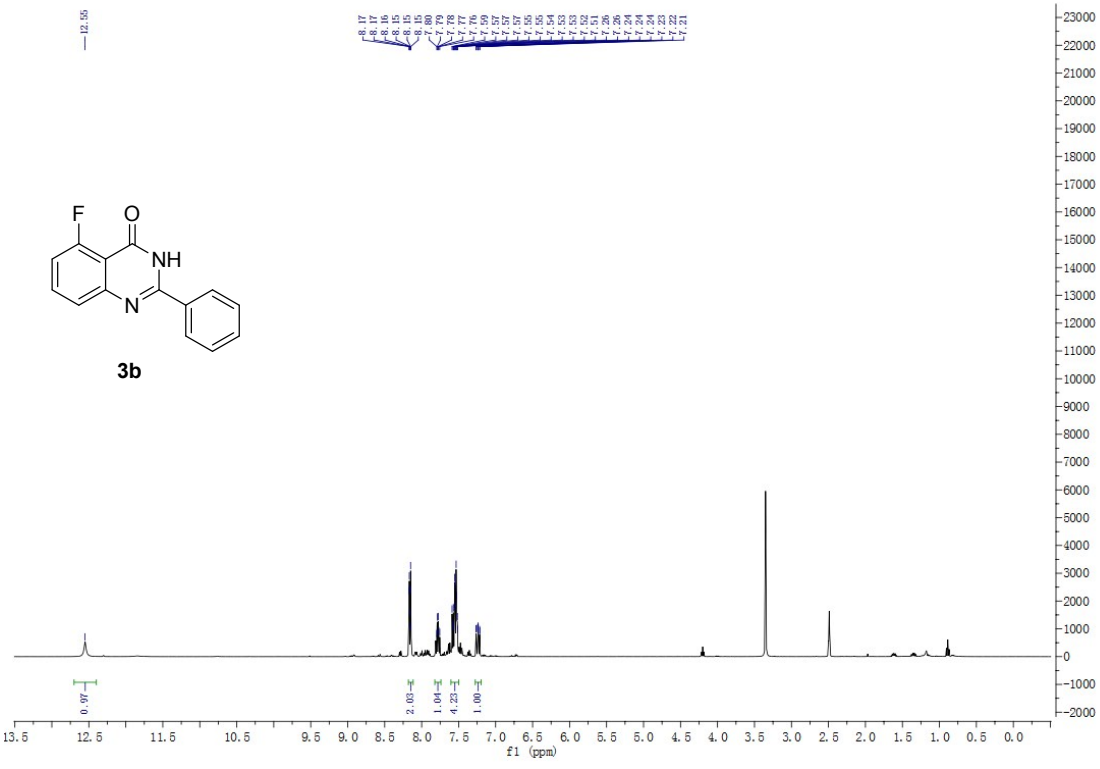


2-(4-bromophenyl)quinazolin-4(3H)-one (***3u***) White solid; yield: 89% (26.8 mg); mp: 292−295 °C; ^{1}H NMR (300 MHz, DMSO-d_6 δ 12.61 (s, 1H), 8.16 – 8.07 (m, 3H), 7.86 – 7.79 (m, 1H), 7.78 – 7.69 (m, 3H), 7.55 – 7.47 (m, 1H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 162.62 (s), 151.93 (s), 149.04 (s), 135.15 (s), 132.38 (s), 132.09 (s), 130.28 (s), 128.00 (s), 127.27 (s), 126.35 (s), 125.71 (s), 121.48 (s). $C_{14}H_9BrN_2O$ HRMS $[M+H]^+$ calcd for300.9971, found:300.9976.

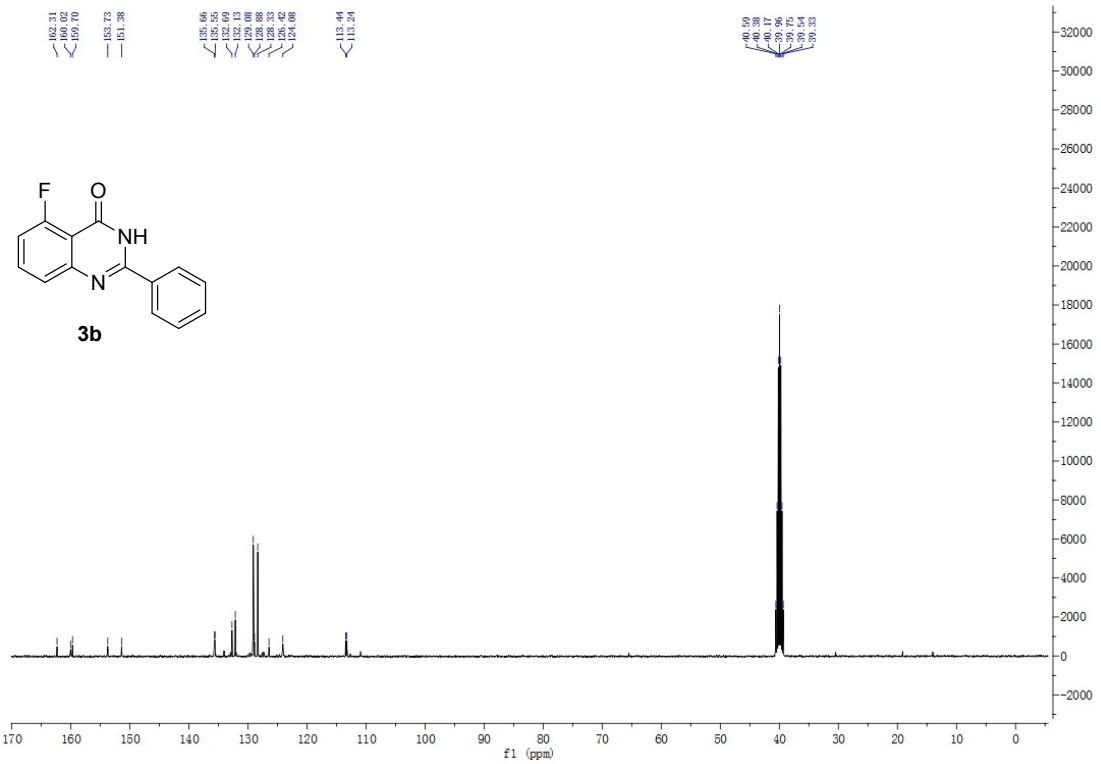

12.56
8.21
8.21
8.18
8.16
8.15
7.85
7.85
7.82
7.80
7.80
7.75
7.73
7.58
7.56
7.55
7.54
7.51
7.49
7.49
O
NH
N
3r
4000
3500
3000
2500
2000
1500
1000
500
0
0.95
3.01
0.99
1.00
4.35
12.5
11.5
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

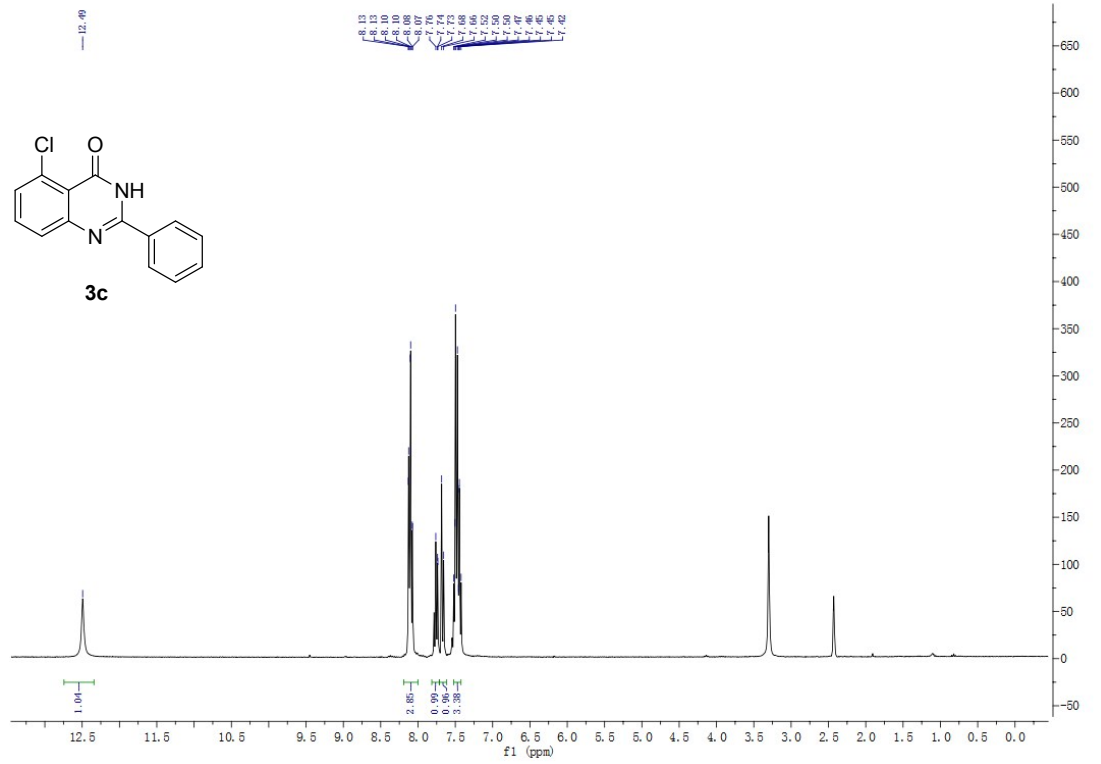

162.03
152.06
148.51
134.32
132.48
131.13
128.54
127.53
127.27
126.31
125.62
120.75
40.11
39.83
39.56
39.29
39.06
38.72
38.45
O
NH
N
f1 (ppm)

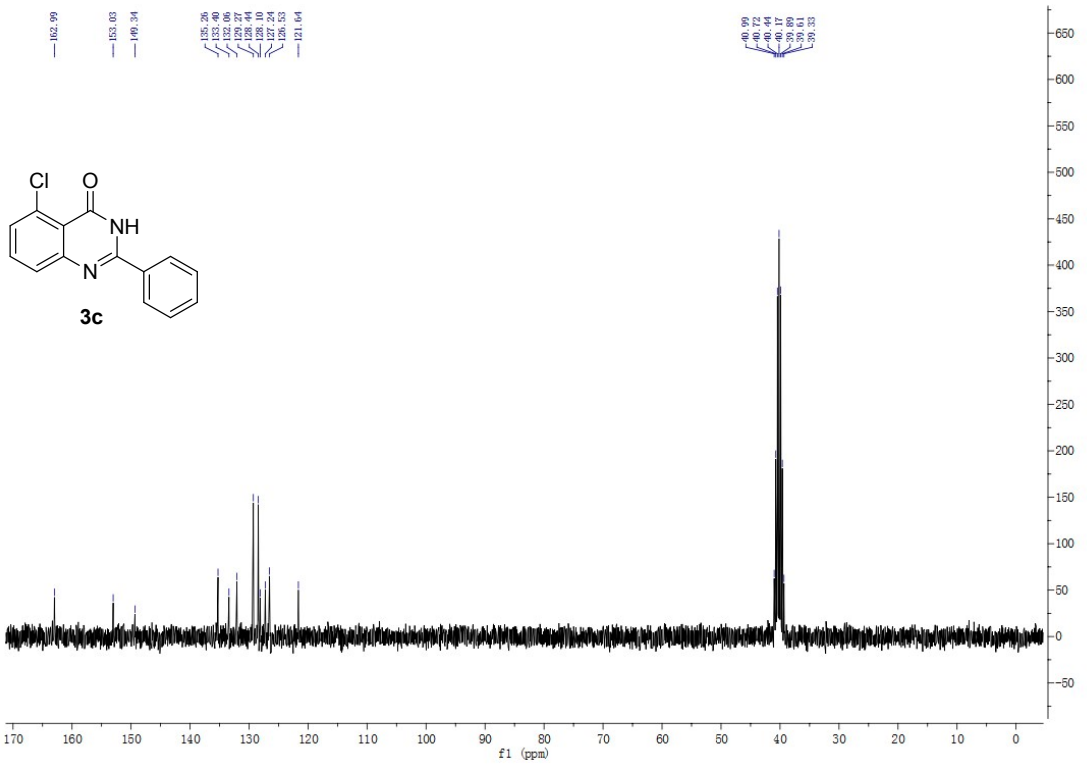
3a

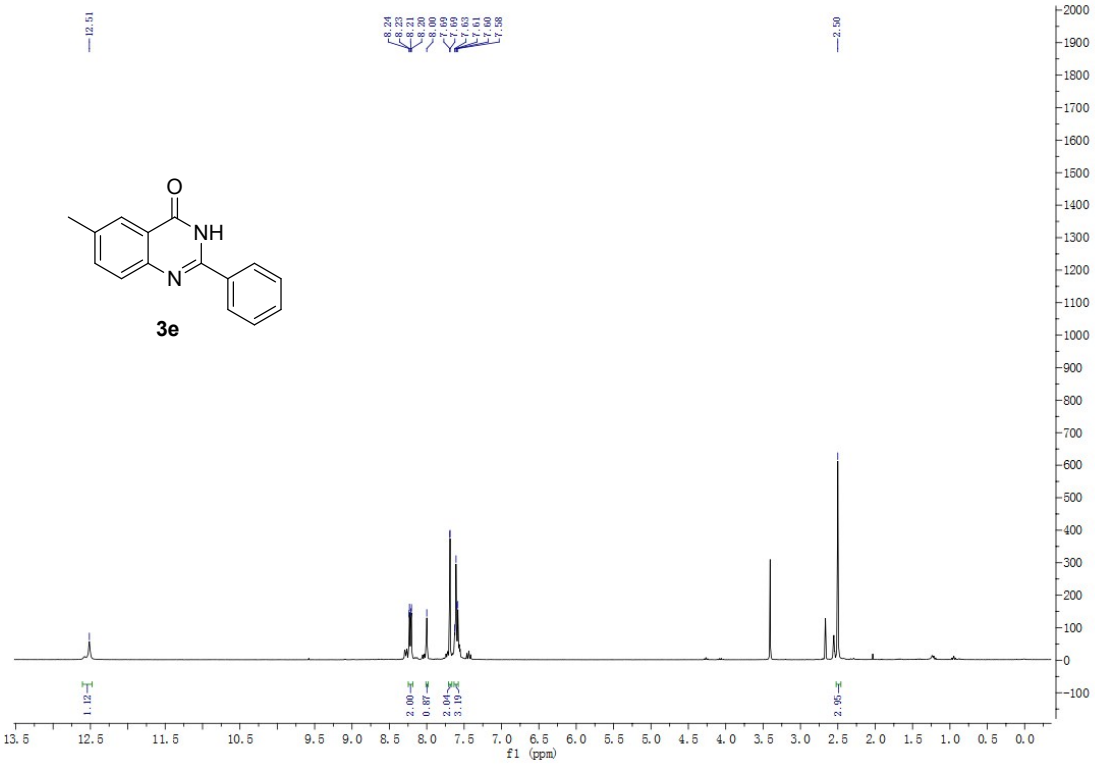

12.55
8.17
8.17
8.16
8.15
8.15
8.15
7.80
7.79
7.78
7.77
7.77
7.76
7.59
7.57
7.57
7.57
7.57
7.55
7.55
7.54
7.53
7.53
7.52
7.51
7.26
7.26
7.24
7.24
7.24
7.23
7.22
7.22
7.21
F
O
NH
N
0.97
2.03
1.04
4.23
1.00
f1 (ppm)

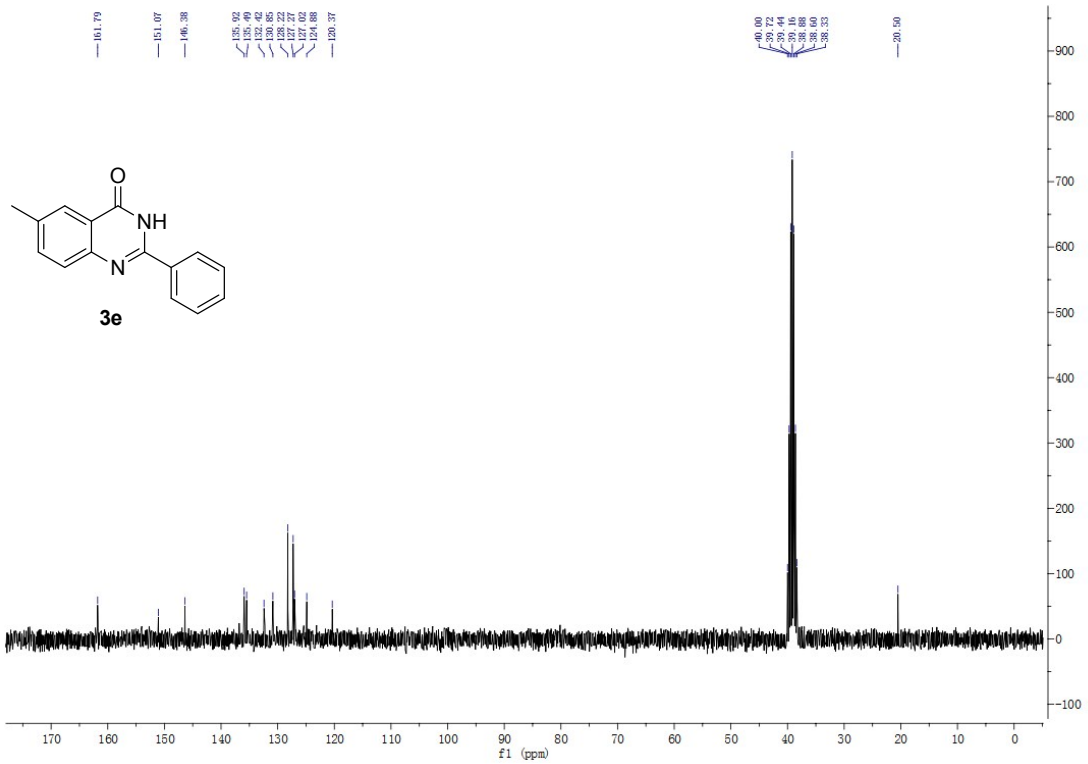
3b

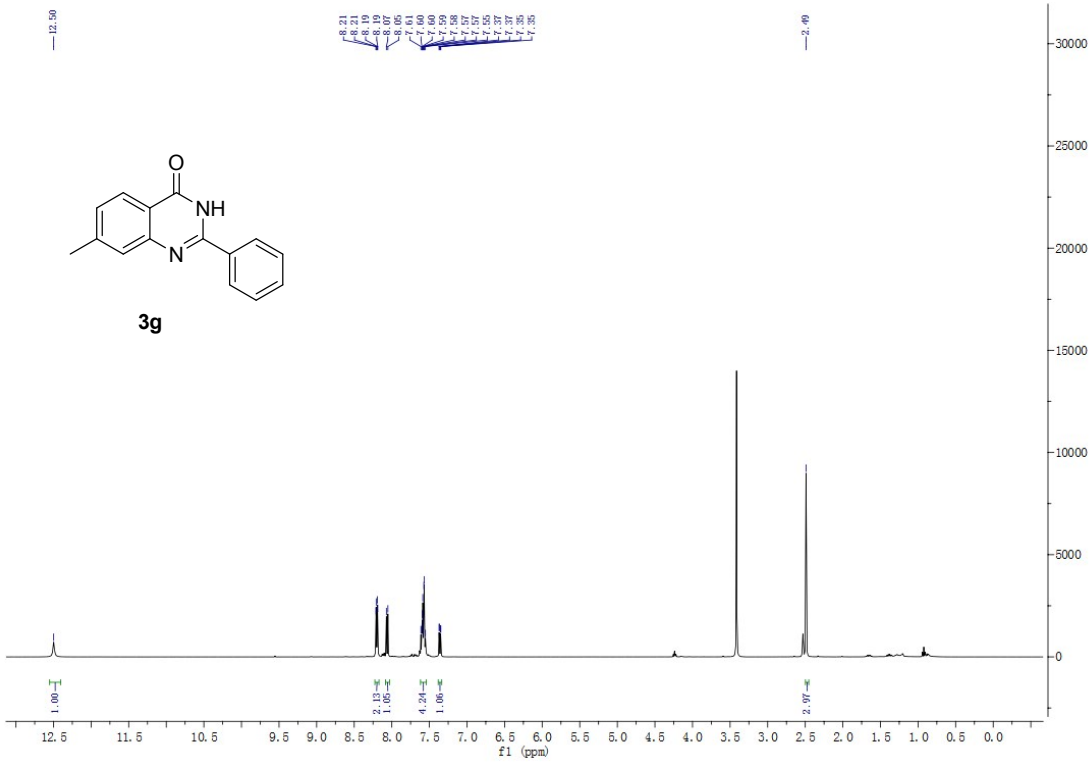

F
O
NH
N
3b
f1 (ppm)

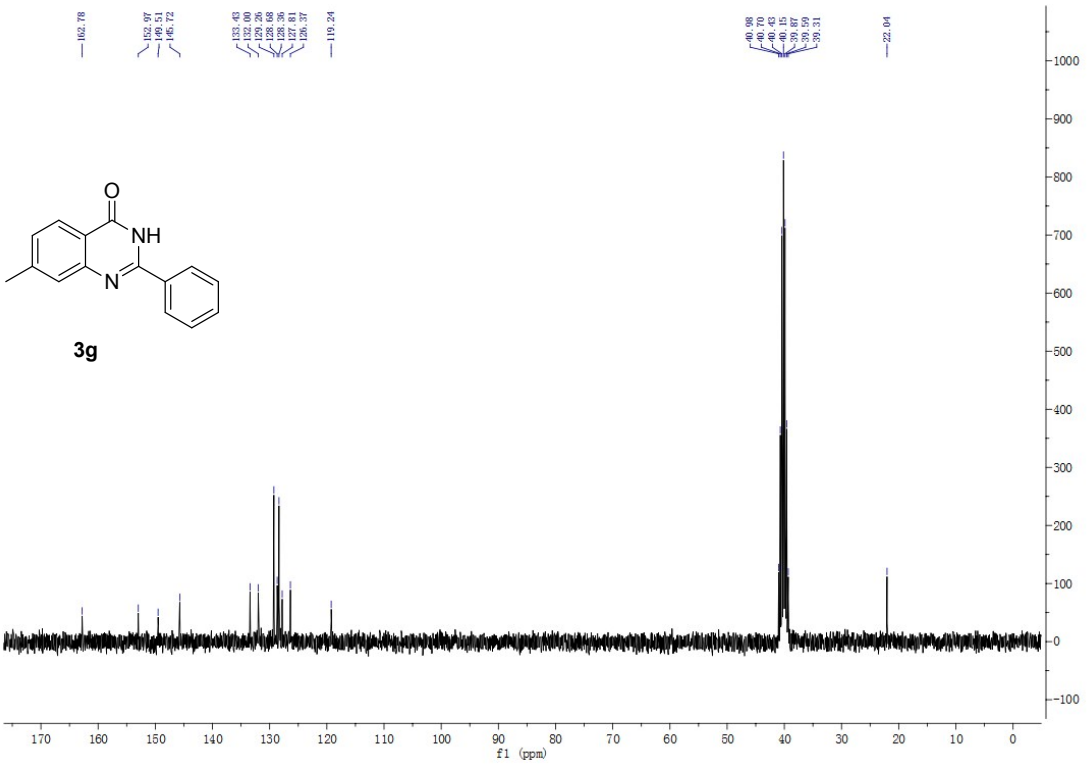

Cl
O
NH
N
3c
f1 (ppm)


Cl
O
NH
N
3c
162.99
153.63
149.34
135.26
133.40
132.06
129.27
128.44
128.10
127.24
126.53
121.64
40.99
40.72
40.44
40.17
39.89
39.61
39.33
f1 (ppm)

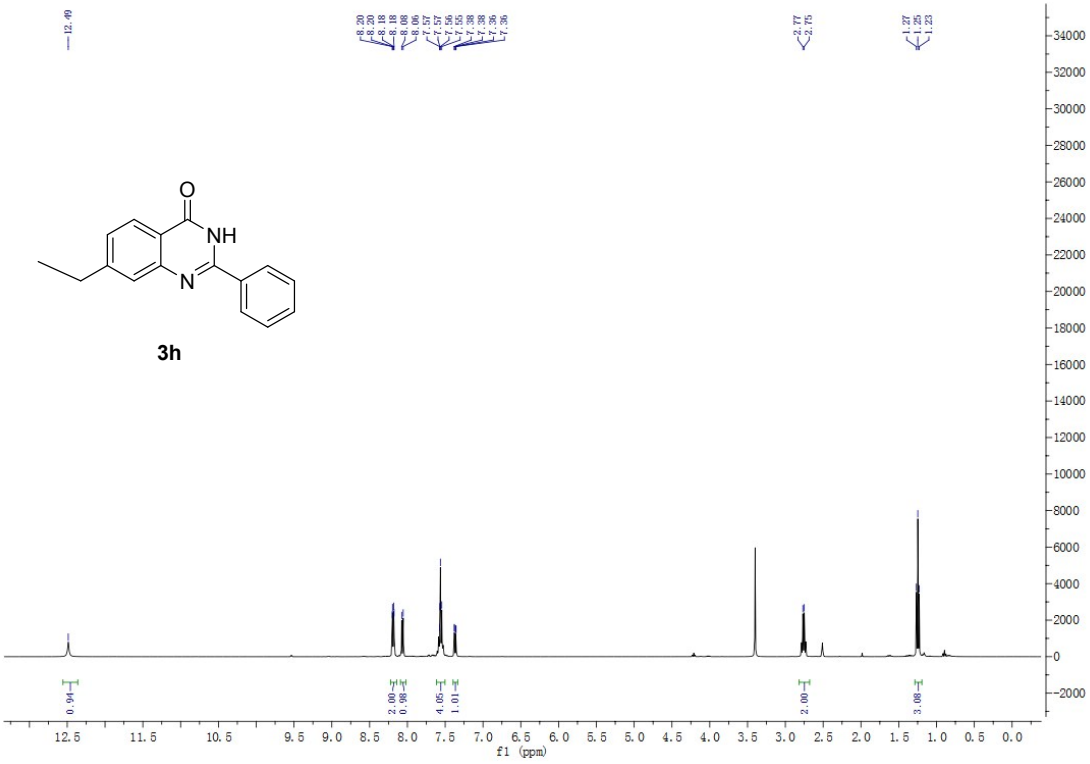

O
NH
N
3e
12.51
8.24
8.23
8.21
8.20
8.00
7.99
7.69
7.63
7.61
7.60
7.58
2.50
1.12
2.00
0.87
2.04
3.19
2.95
f1 (ppm)


161.79
151.07
146.38
135.92
135.49
132.42
130.85
128.22
127.27
127.02
124.88
120.37
40.00
39.72
39.44
39.16
38.88
38.60
38.33
20.50
O
NH
N
3e

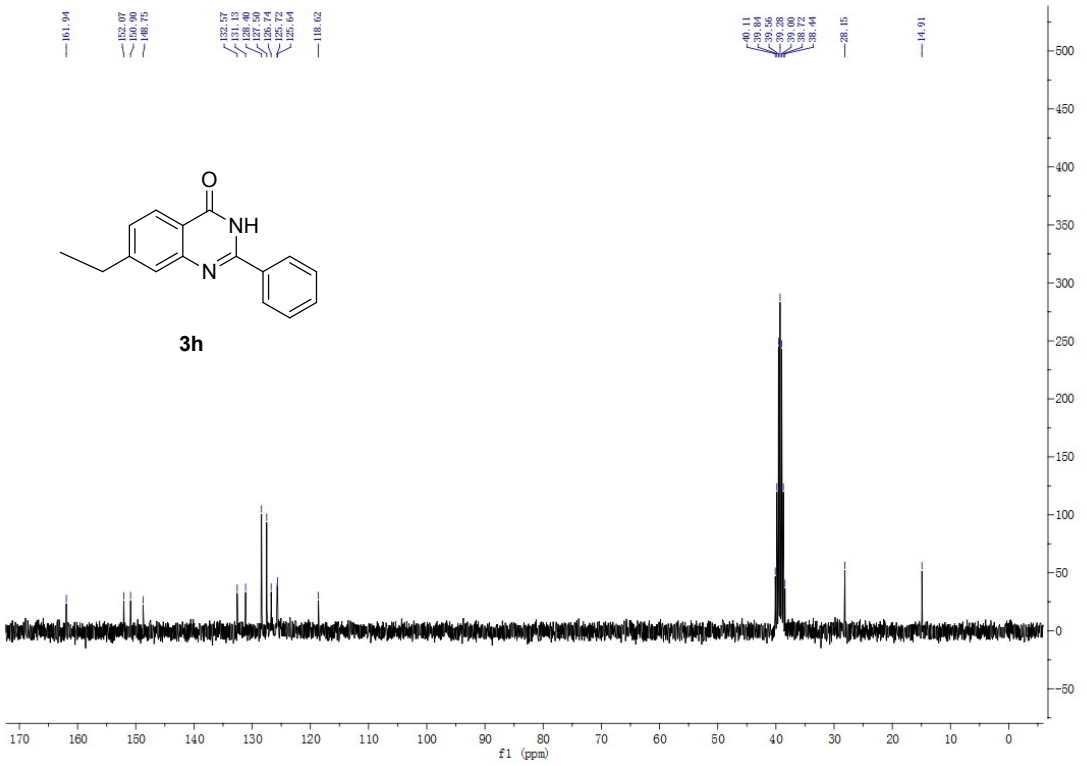

12.50
8.21
8.19
8.07
7.61
7.60
7.59
7.58
7.57
7.55
7.37
7.35
2.49
O
NH
N
3g
1.00
2.13
1.85
4.24
1.06
2.97
f1 (ppm)

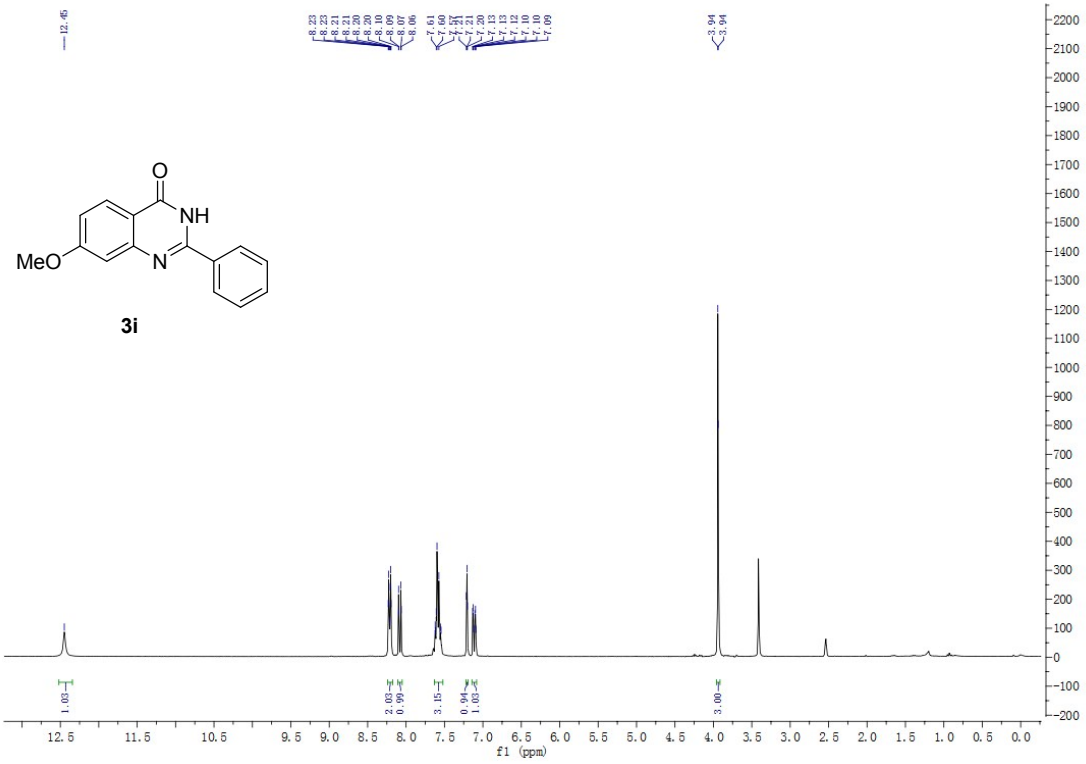

162.78
152.97
149.51
145.72
133.43
132.00
129.35
128.68
128.36
127.81
126.37
119.24
40.98
40.70
40.43
40.15
39.87
39.59
39.31
22.04
O
NH
N
f1 (ppm)

3g

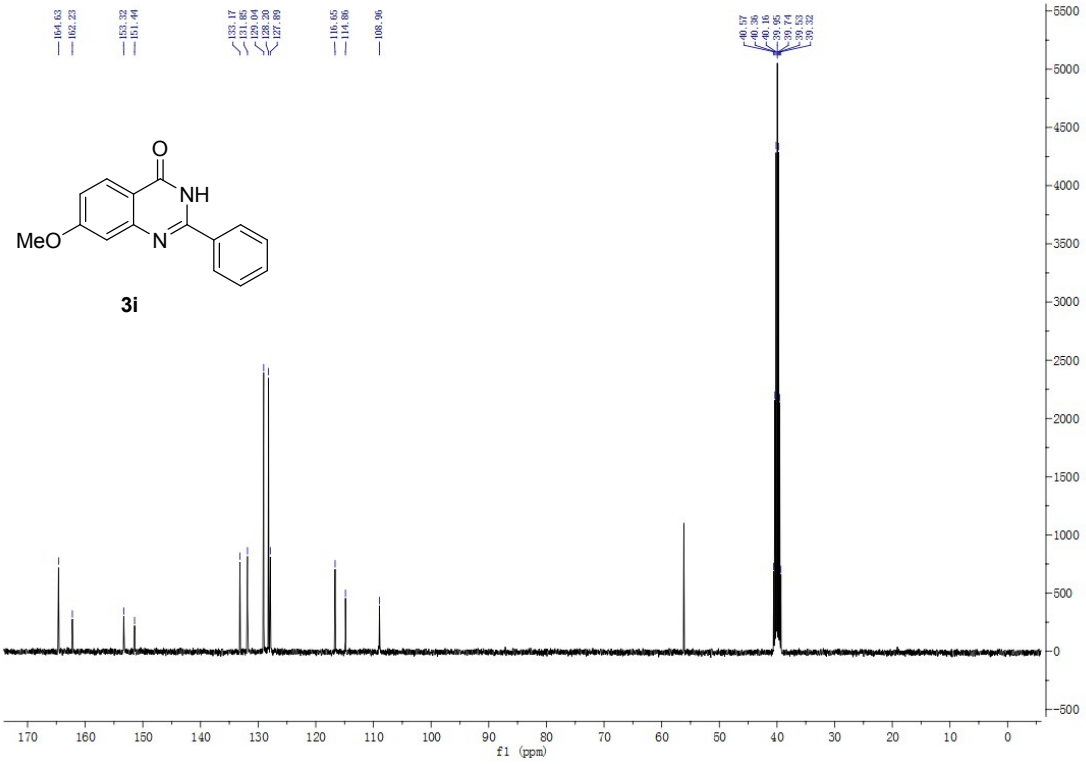

12.49
8.20
8.20
8.19
8.18
8.08
8.06
7.57
7.57
7.56
7.55
7.38
7.38
7.36
7.36
2.77
2.75
1.27
1.25
1.23
0.94
2.00
0.98
4.05
1.01
2.00
3.08
O
NH
N
f1 (ppm)

3h

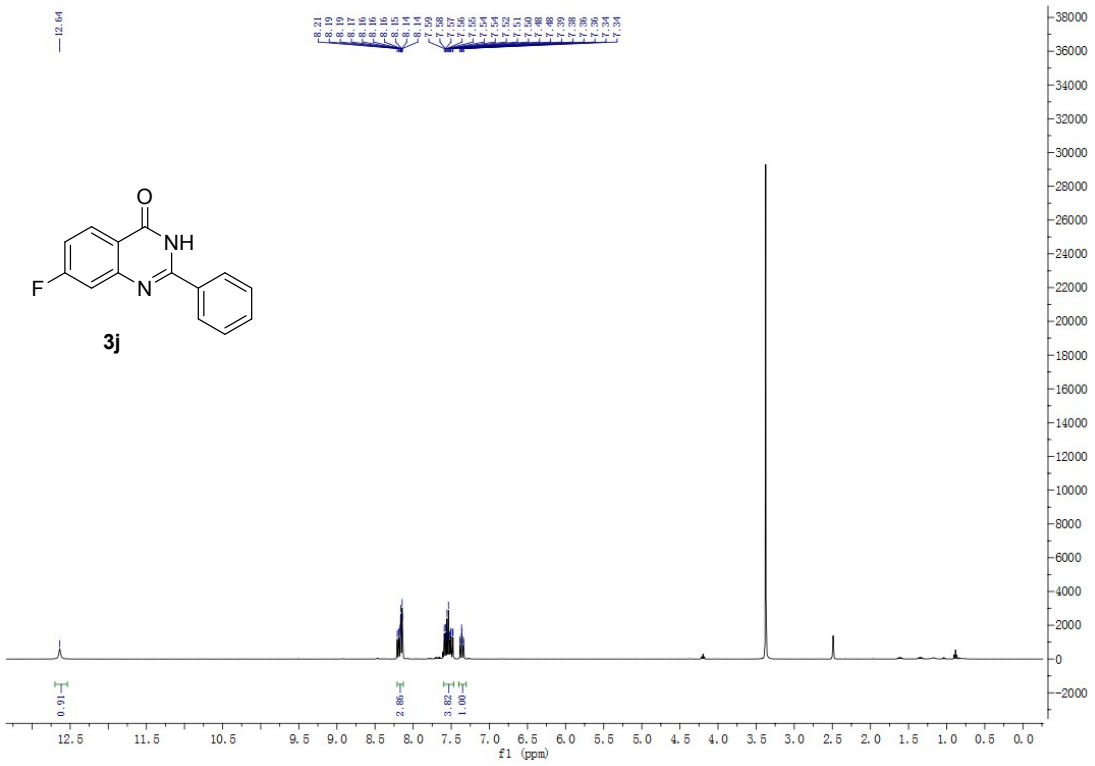

161.94
152.07
150.99
148.75
132.57
131.13
129.40
127.90
126.74
125.72
125.64
118.62
40.11
39.84
39.56
39.28
39.00
38.72
38.44
28.15
14.91
O
NH
N
3h
f1 (ppm)

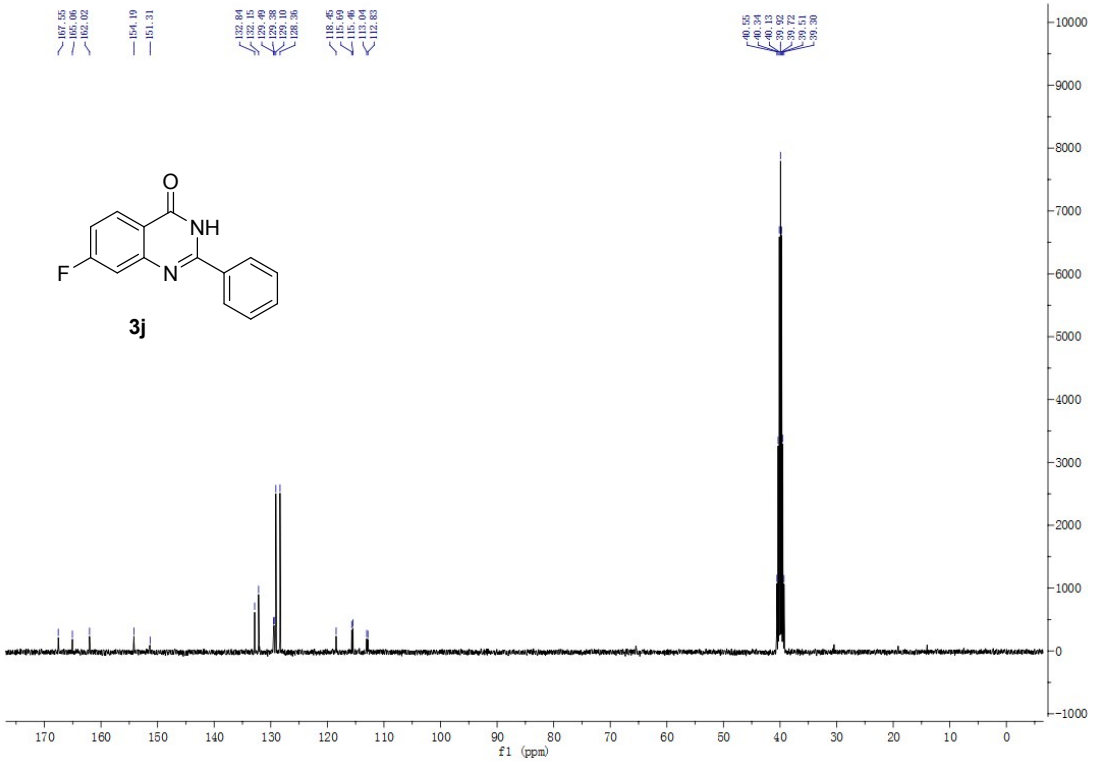

12.45
8.23
8.21
8.20
8.10
8.09
8.07
8.06
7.61
7.60
7.21
7.20
7.13
7.12
7.10
7.09
3.94
3.94
O
NH
MeO
N
1.03
2.03
0.99
3.15
0.94
1.03
3.00
f1 (ppm)

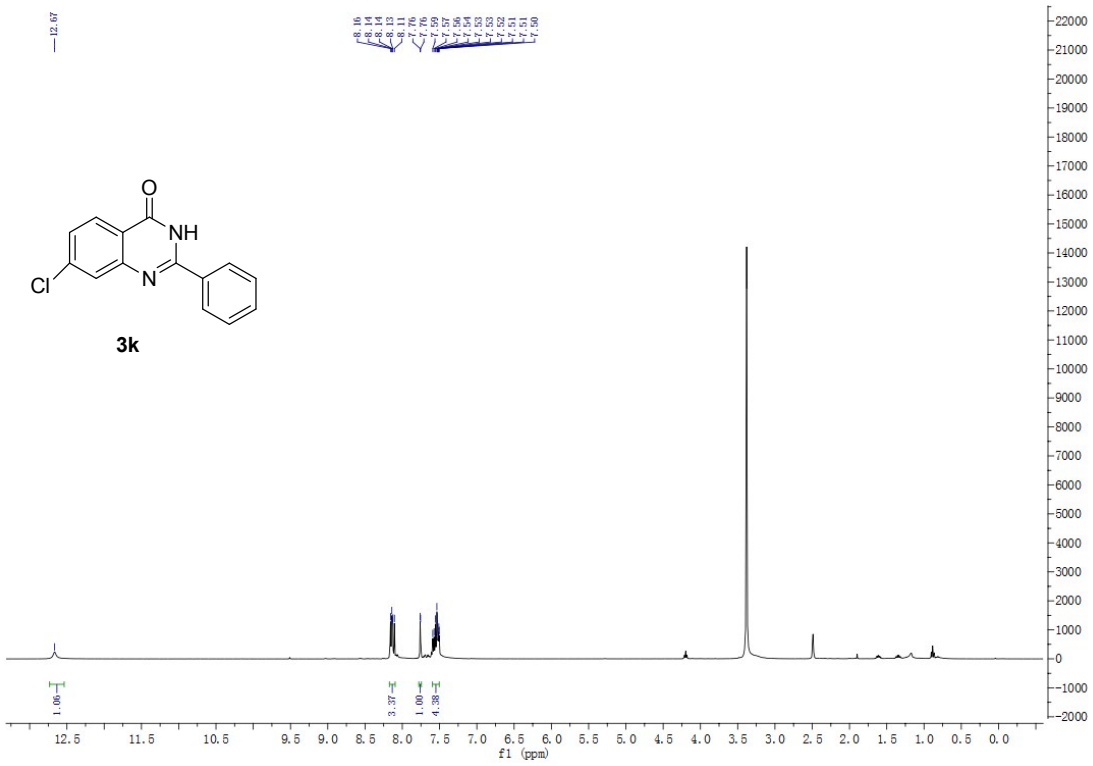
3i


164.63
162.23
153.32
151.44
133.17
131.85
129.04
128.20
127.89
116.65
114.86
108.96
40.57
40.36
40.16
39.95
39.74
39.53
39.32
O
NH
MeO
N
f1 (ppm)

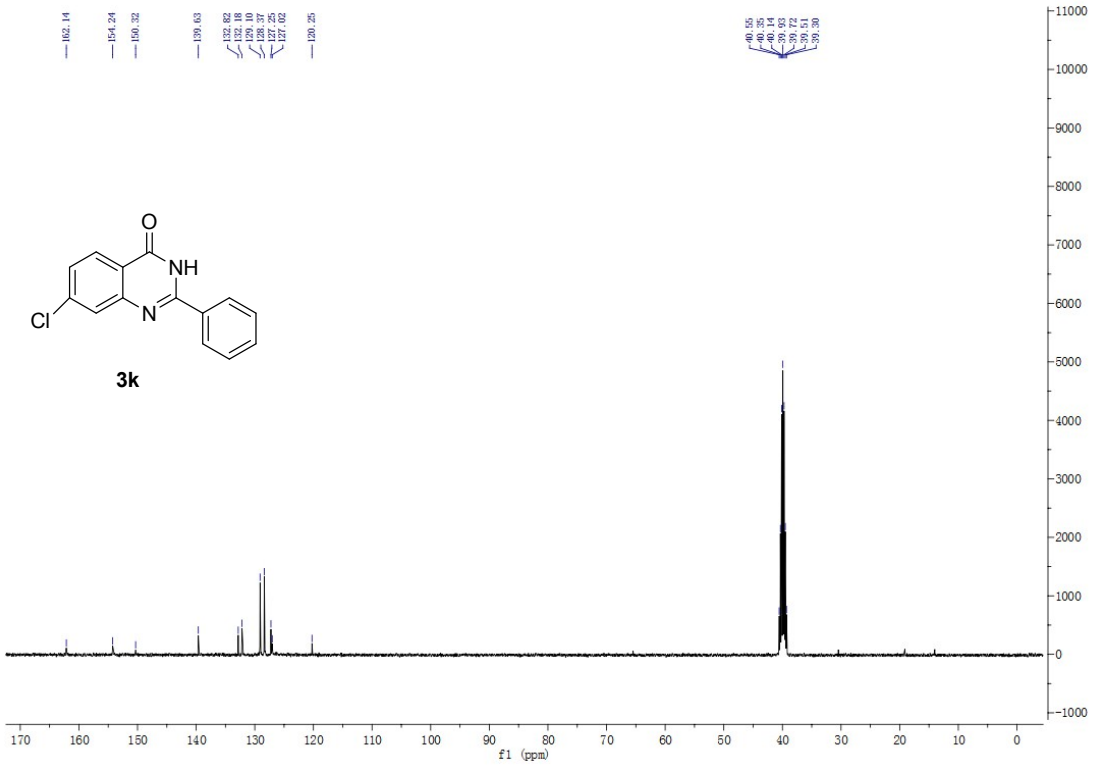
3i


12.64
8.21
8.19
8.19
8.17
8.16
8.16
8.16
8.15
8.14
8.14
7.59
7.58
7.57
7.56
7.55
7.54
7.54
7.52
7.51
7.50
7.48
7.39
7.38
7.36
7.36
7.34
7.34
O
NH
F
N
3j
0.91
2.86
3.82
1.00
f1 (ppm)

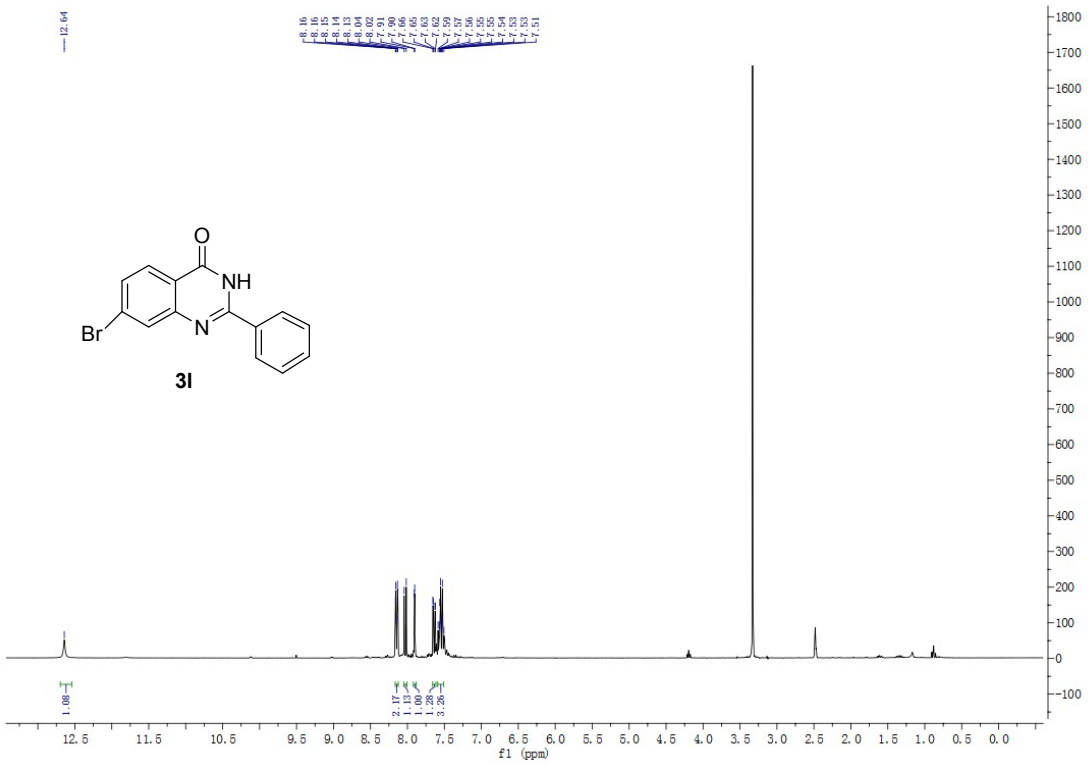

167.56
165.06
162.02
154.19
151.31
132.84
132.15
129.49
129.38
129.10
128.36
118.45
115.69
115.46
113.04
112.83
40.55
40.34
40.13
39.92
39.72
39.51
39.30
O
NH
F
N
3j
f1 (ppm)


12.67
8.16
8.14
8.14
8.13
8.11
7.76
7.76
7.59
7.57
7.57
7.56
7.54
7.53
7.53
7.52
7.51
7.51
7.50
O
NH
N
Cl
1.06
3.37
1.00
4.38
f1 (ppm)

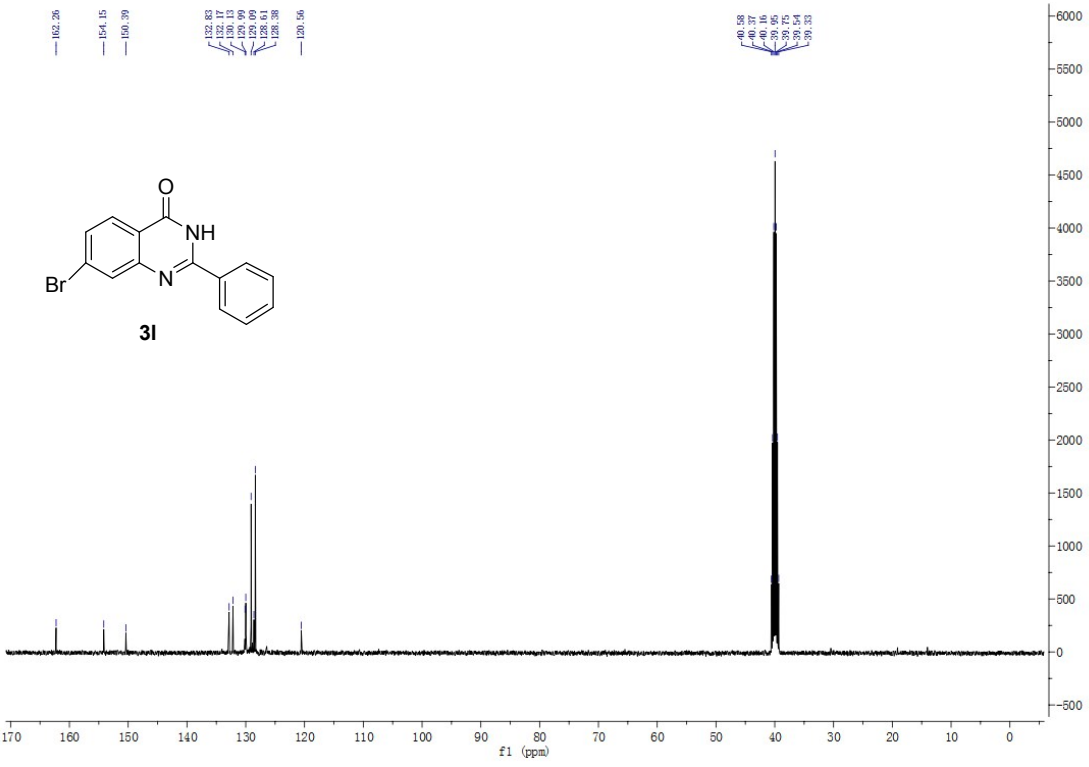
3k


162.14
154.24
150.32
139.63
132.82
132.18
129.10
128.57
128.25
127.25
127.02
120.25
40.55
40.35
40.14
39.93
39.72
39.51
39.30
O
NH
N
Cl
f1 (ppm)

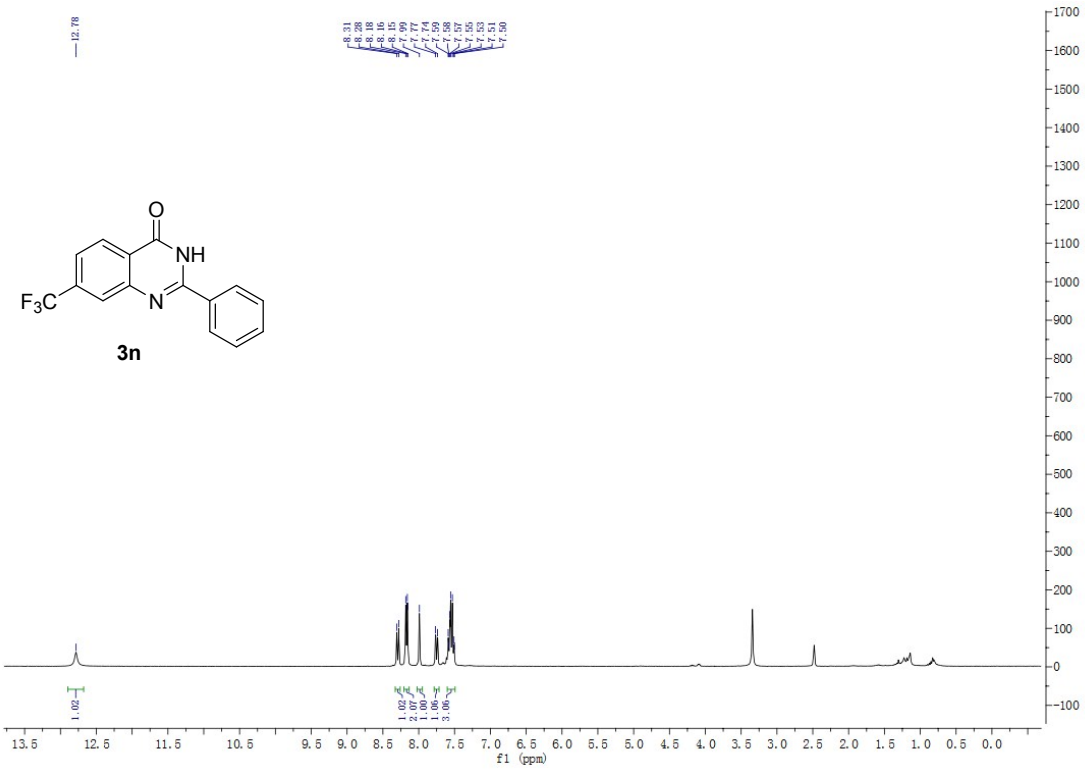
3k

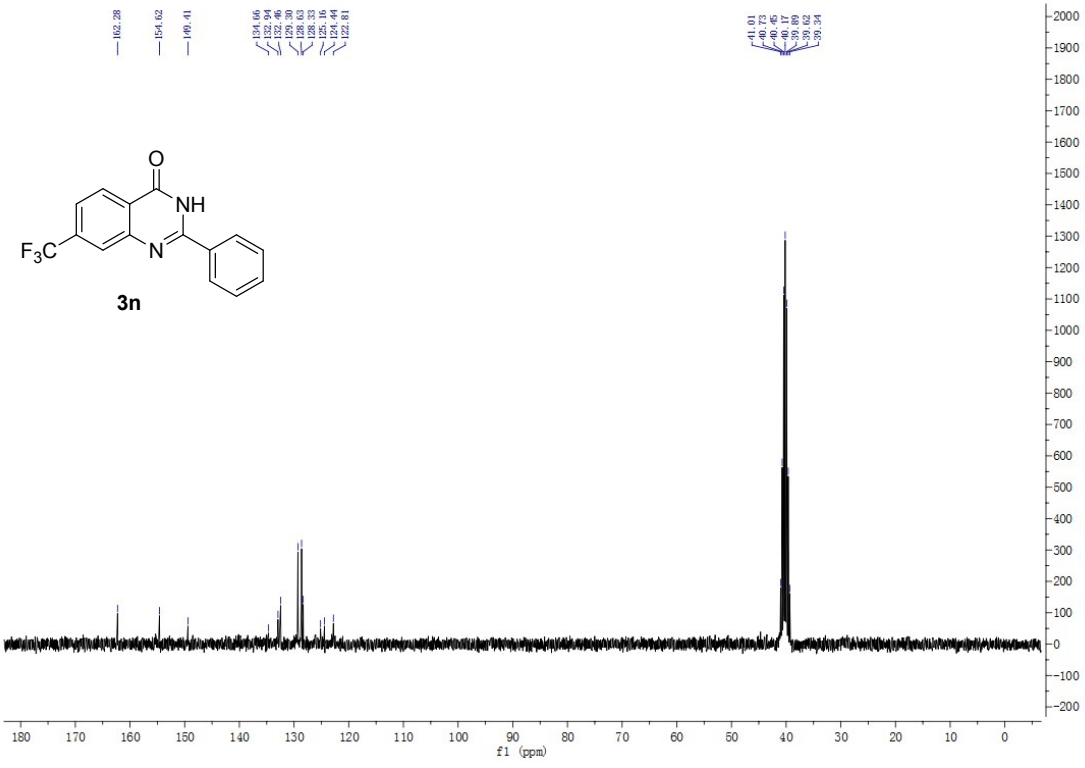

12.64
8.16
8.15
8.14
8.13
8.04
8.02
7.91
7.90
7.66
7.65
7.63
7.62
7.59
7.57
7.56
7.55
7.54
7.53
7.53
7.51
O
NH
N
Br
1.08
2.17
1.13
1.00
1.28
3.26
f1 (ppm)

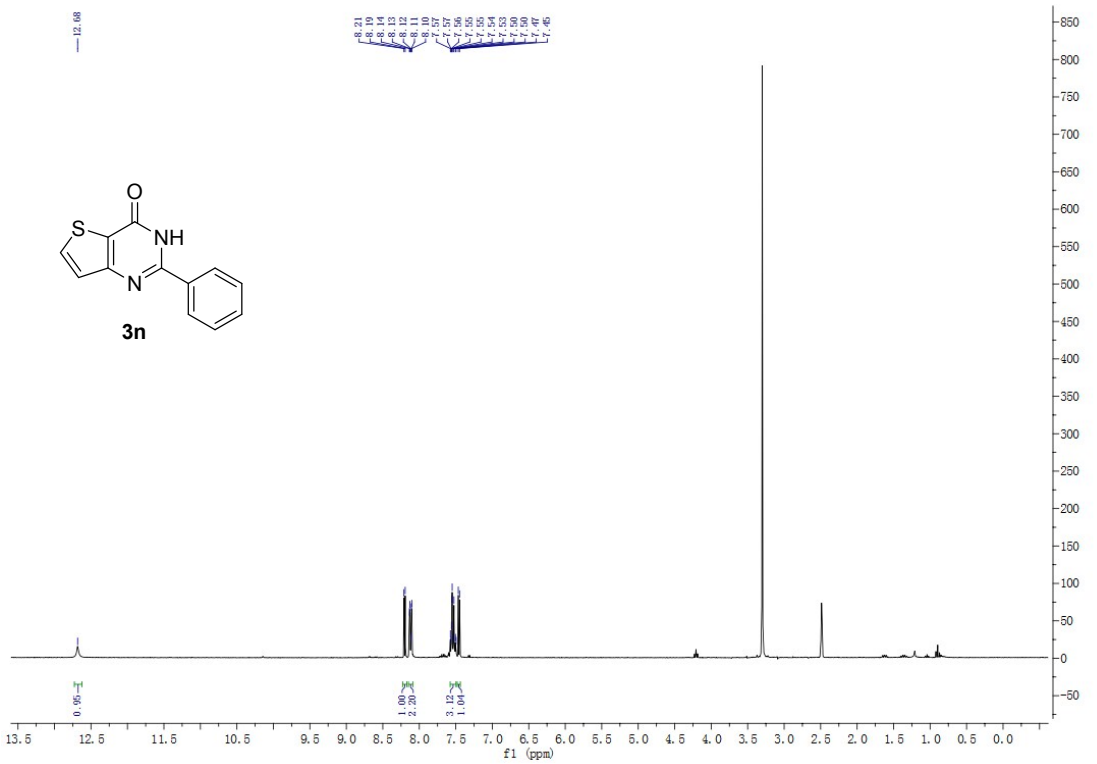
3l


162.26
154.15
150.39
132.83
132.17
130.15
129.99
129.09
128.61
128.38
120.56
40.58
40.37
40.16
39.95
39.75
39.54
39.33
O
NH
N
Br
f1 (ppm)

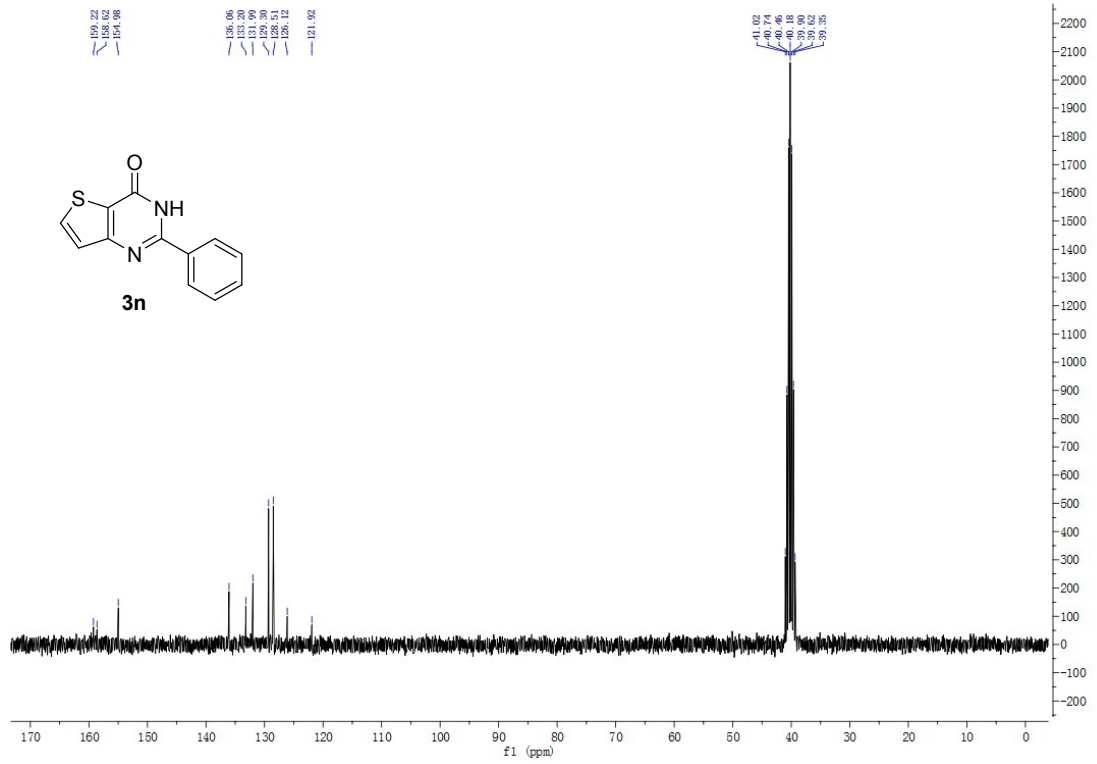
3l


12.78
8.31
8.28
8.18
8.16
8.15
7.99
7.77
7.74
7.59
7.58
7.57
7.55
7.53
7.51
7.50
O
NH
N
F3C
3n
1.02
1.02
2.07
1.08
1.06
3.06
f1 (ppm)

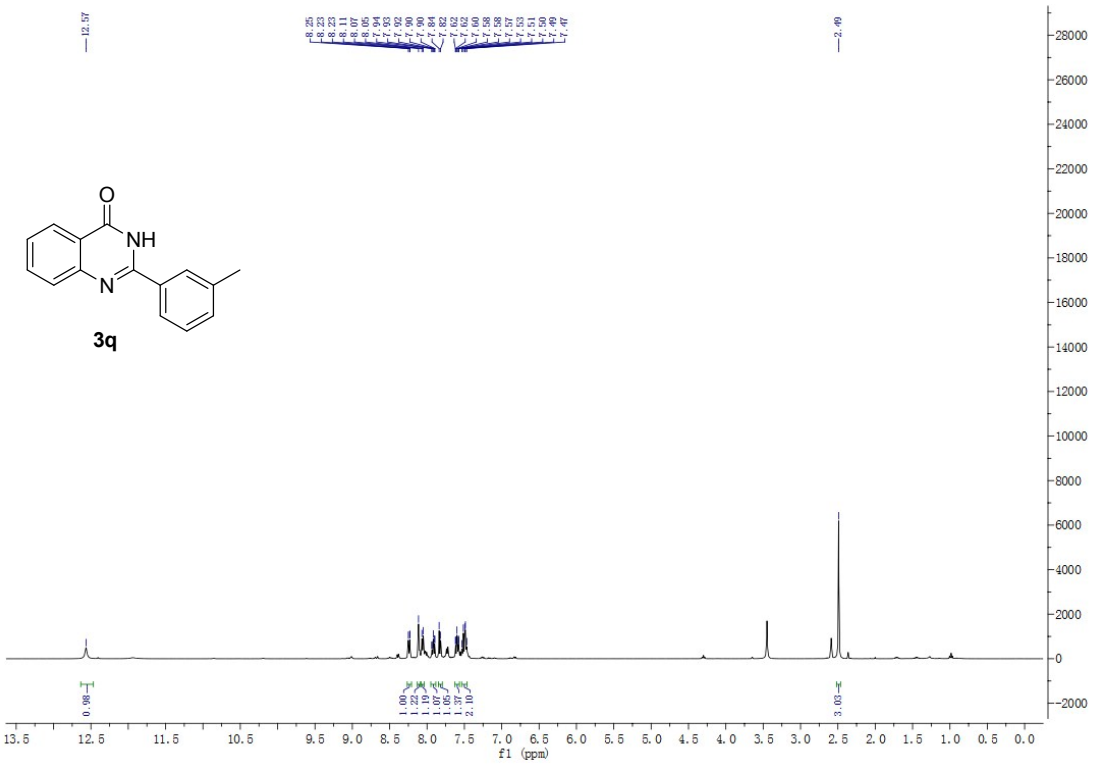

162.28
154.62
149.41
134.66
132.94
132.46
129.30
128.63
128.33
125.16
124.44
122.81
41.01
40.73
40.45
40.17
39.89
39.62
39.34
O
NH
N
F3C
3n
f1 (ppm)

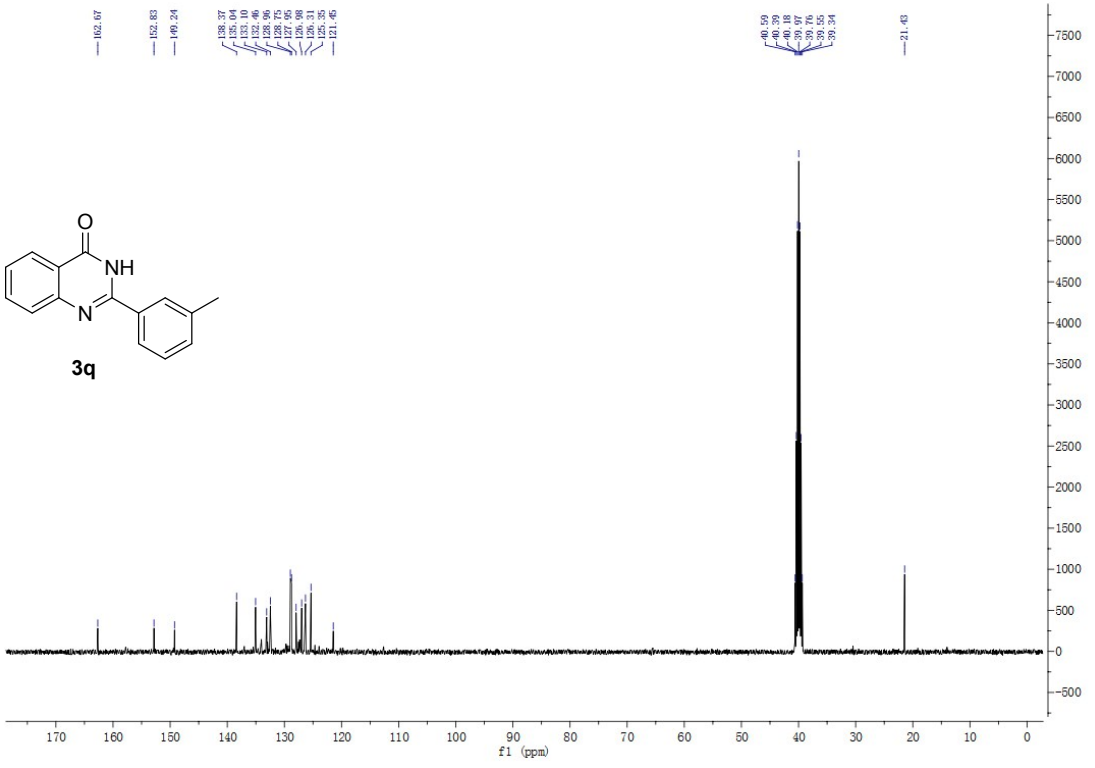

12.68
8.21
8.19
8.14
8.13
8.12
8.11
8.10
7.57
7.56
7.55
7.54
7.53
7.50
7.47
7.45
O
S
NH
N
0.95
1.00
2.20
3.12
1.04
f1 (ppm)

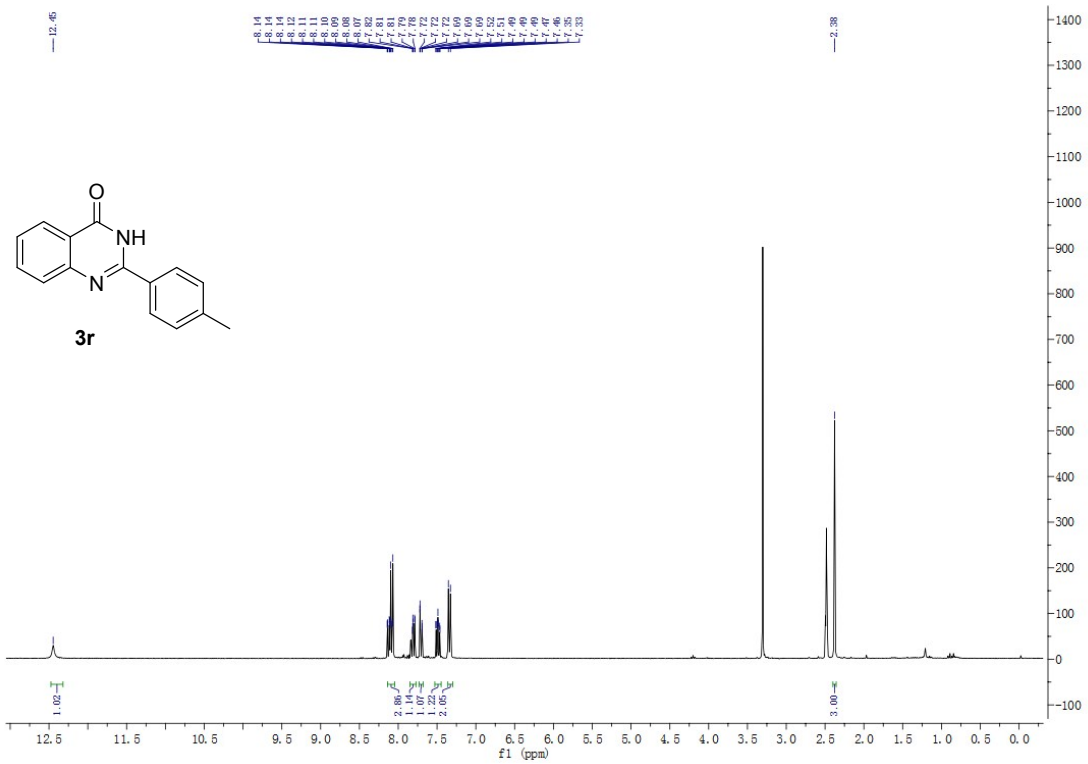
3n

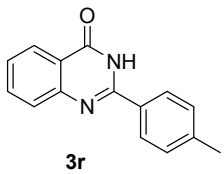

159.22
158.62
154.98
136.06
133.20
131.99
129.38
128.51
126.12
121.92
41.02
40.74
40.46
40.18
39.90
39.62
39.35
O
S
NH
N
f1 (ppm)

3n


12.57
8.25
8.23
8.23
8.11
8.11
8.05
7.94
7.93
7.90
7.90
7.84
7.82
7.62
7.62
7.60
7.58
7.58
7.57
7.53
7.51
7.50
7.49
7.47
2.49
O
NH
N
3q
0.98
1.00
1.23
1.19
1.07
1.05
1.37
2.10
3.03
f1 (ppm)


162.67
152.83
149.24
138.37
135.04
133.10
132.46
128.96
128.75
127.95
126.98
126.31
125.35
121.45
40.59
40.39
40.18
39.97
39.76
39.55
39.34
21.43
O
NH
N
3q
f1 (ppm)


12.45
8.14
8.14
8.14
8.12
8.11
8.11
8.10
8.09
8.08
8.07
7.82
7.81
7.81
7.79
7.78
7.72
7.72
7.72
7.69
7.69
7.69
7.52
7.51
7.49
7.49
7.49
7.47
7.46
7.35
7.33
2.38
1.02
2.86
1.14
1.07
1.22
2.05
3.00
f1 (ppm)

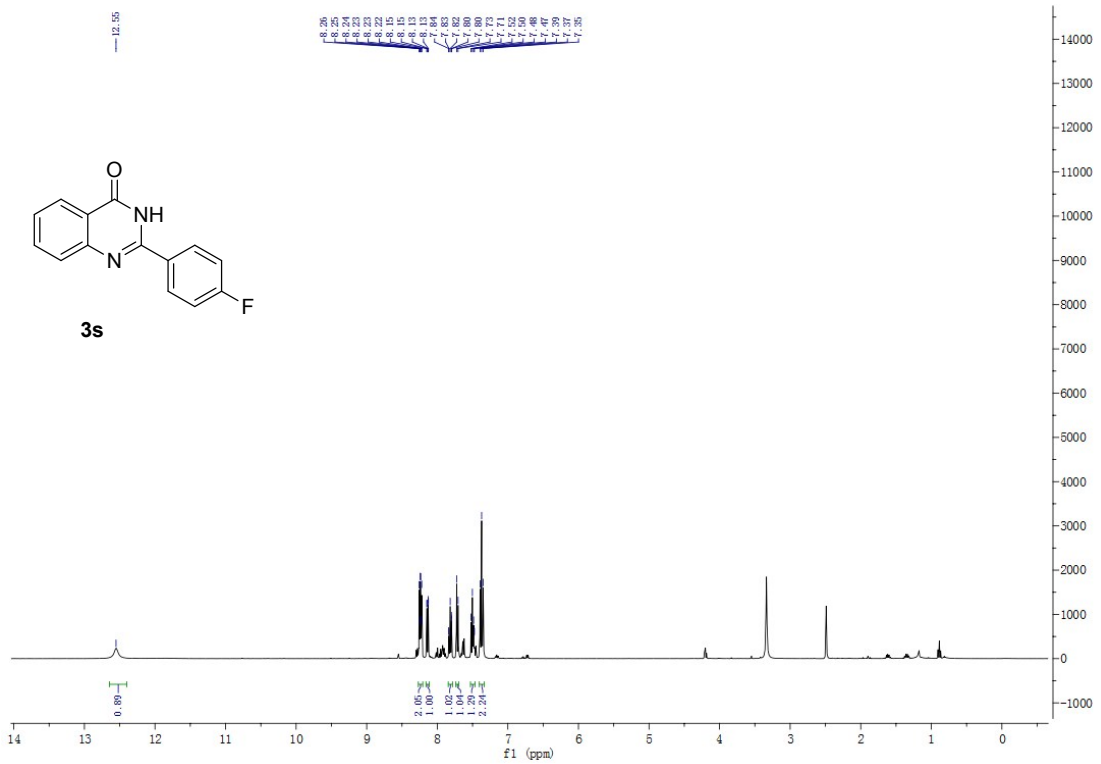

O
NH
N

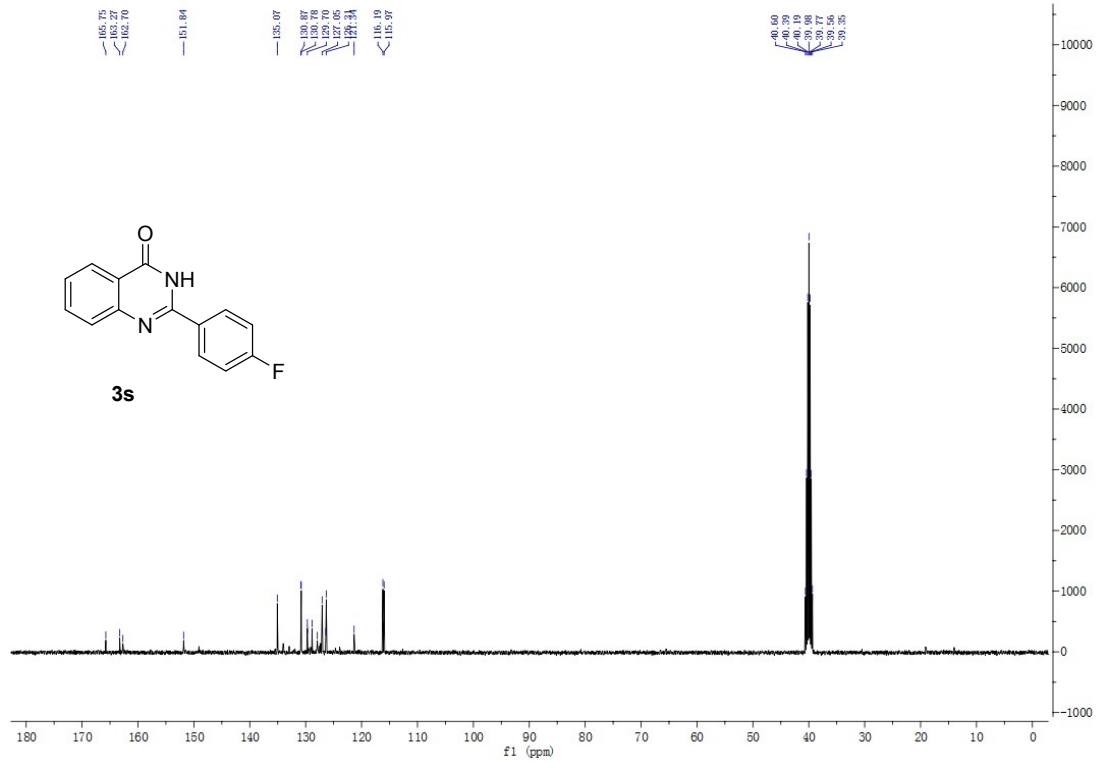
3r

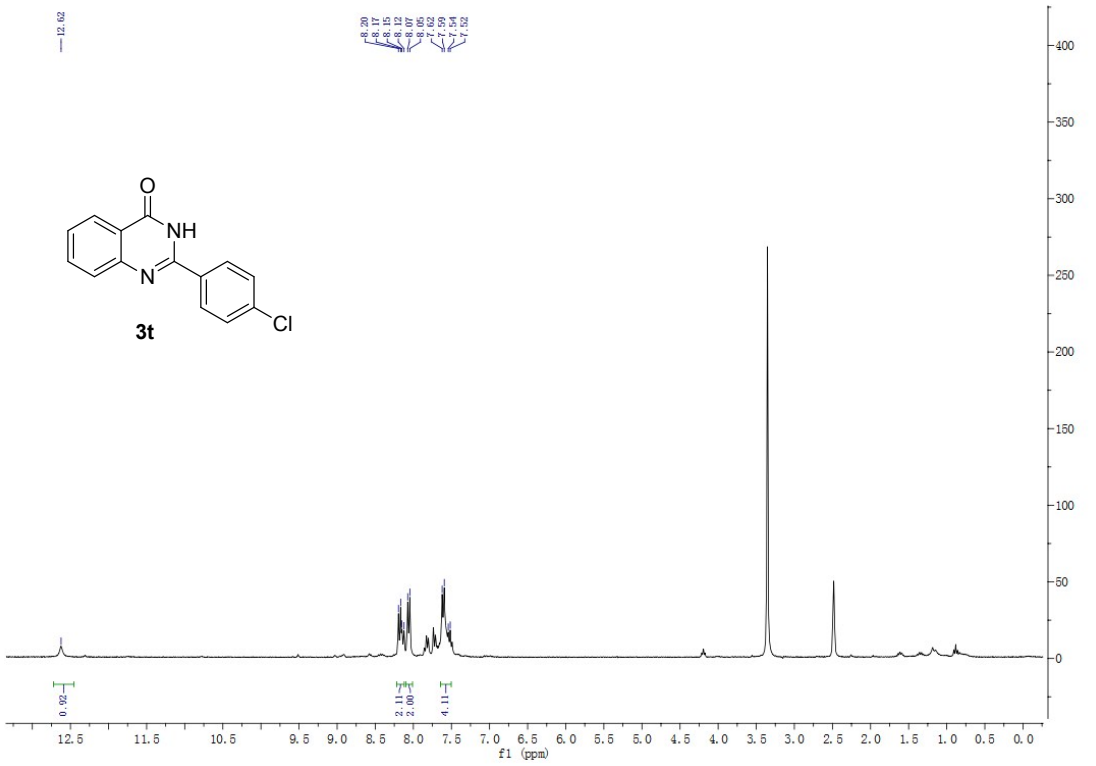
162.71
152.71
149.29
141.93
135.04
130.37
129.67
128.15
127.88
126.86
126.31
121.36
40.62
40.41
40.21
39.79
39.58
39.37
21.46
f1 (ppm)

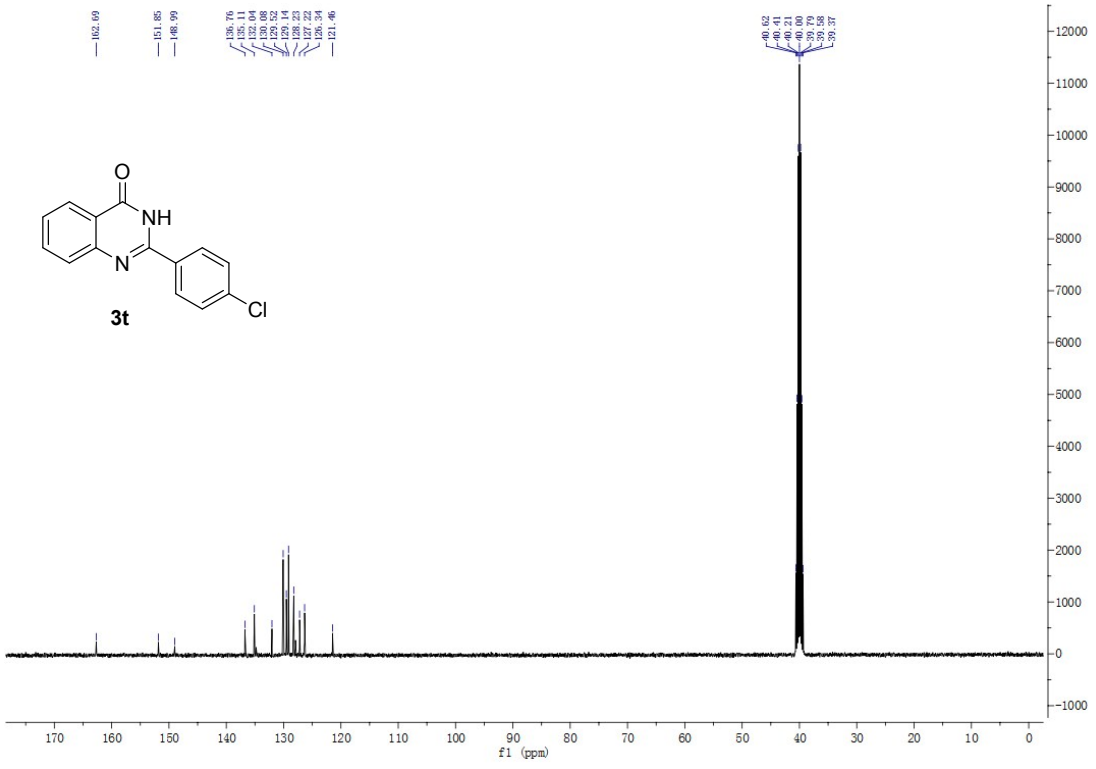
O
NH
N

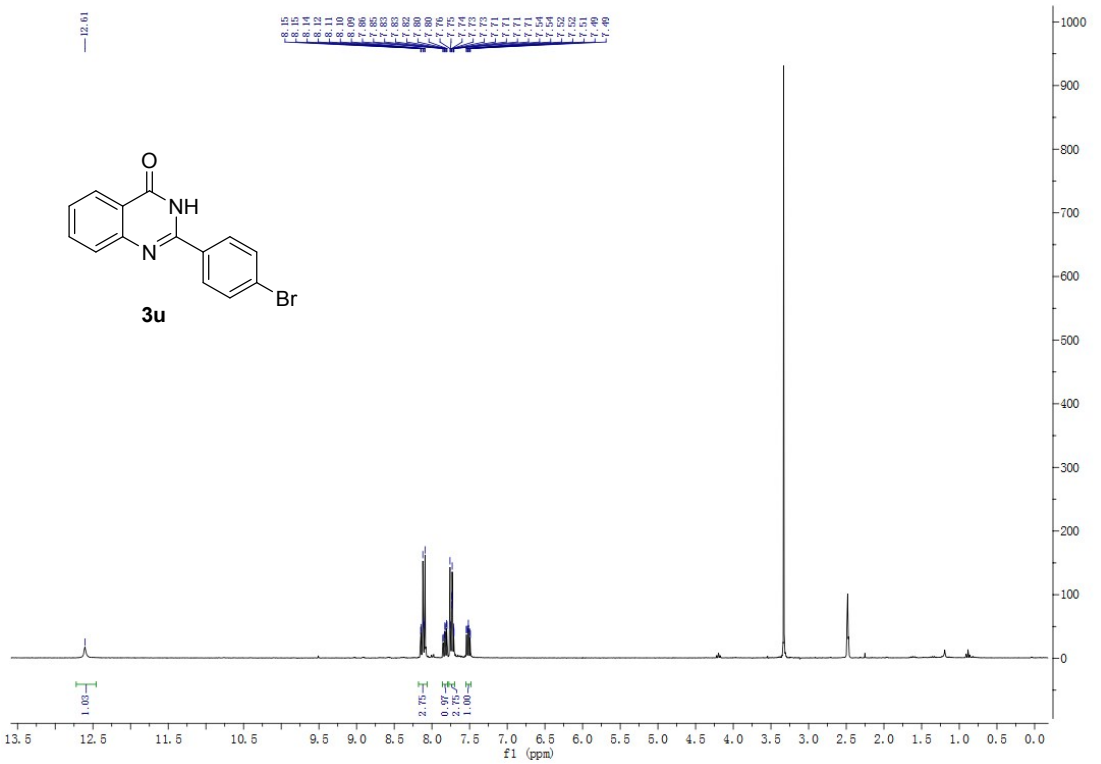
3r

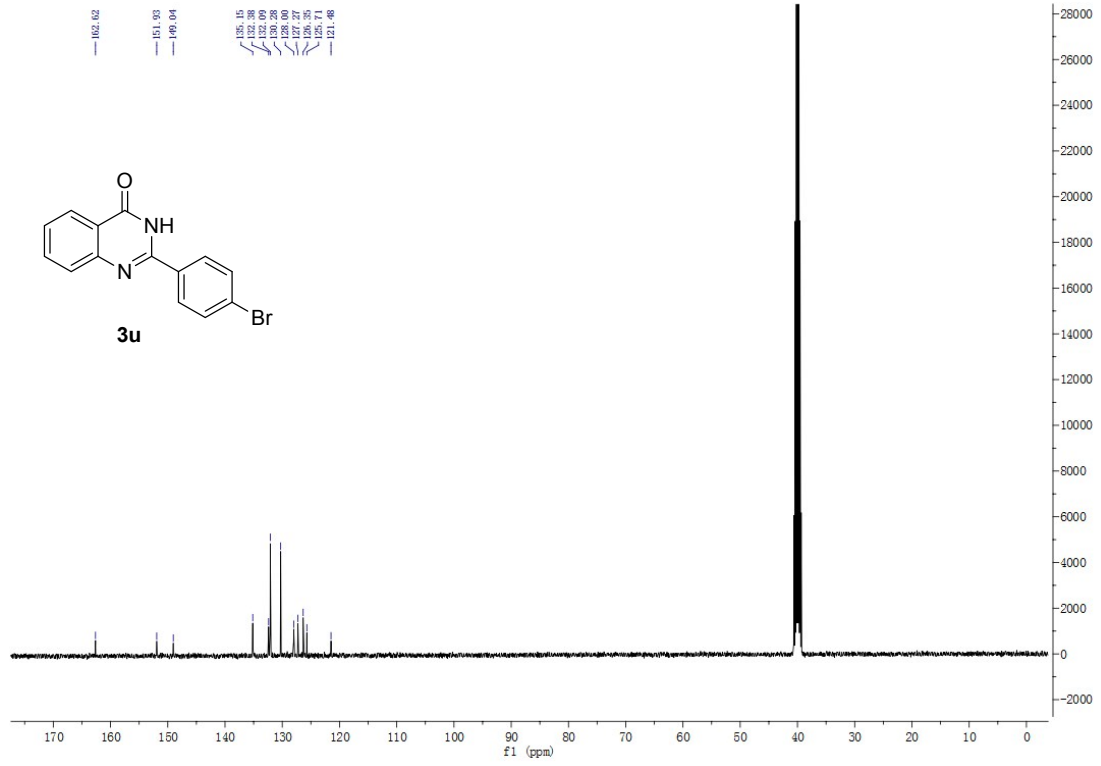

12.55
8.26
8.25
8.24
8.23
8.22
8.15
8.13
7.84
7.82
7.80
7.73
7.71
7.52
7.50
7.48
7.47
7.39
7.37
7.35
O
NH
N
F
3s
0.89
2.05
1.00
1.02
1.04
1.29
2.24
f1 (ppm)


165.75
163.27
162.70
151.84
135.07
130.87
130.78
129.70
127.05
121.34
116.19
115.97
40.60
40.39
40.19
39.98
39.77
39.56
39.35
O
NH
N
F
3s
f1 (ppm)


12.62
8.20
8.17
8.15
8.12
8.07
8.05
7.62
7.59
7.54
7.52
O
NH
N
Cl
3t
0.92
2.11
2.00
4.11
f1 (ppm)


162.69
151.85
148.99
136.76
135.11
132.04
130.98
129.52
129.14
128.23
127.22
126.34
121.46
40.62
40.41
40.21
40.00
39.79
39.58
39.37
O
NH
N
Cl
3t
f1 (ppm)


12.61
8.15
8.15
8.14
8.12
8.11
8.10
8.09
8.06
7.85
7.83
7.82
7.80
7.80
7.76
7.75
7.74
7.73
7.73
7.71
7.71
7.71
7.71
7.54
7.54
7.52
7.52
7.51
7.49
7.49
O
NH
N
Br
3u
1.03
2.75
0.97
2.75
1.00
f1 (ppm)


162.62
151.93
149.04
135.15
133.38
132.09
130.28
128.00
127.27
126.35
125.71
121.48
O
NH
N
Br
3u
f1 (ppm)