Electronic Supplementary Material (ESI) for Organic & Biomolecular Chemistry.
This journal is © The Royal Society of Chemistry 2023

Supporting Information

Synthesis of Quinazolinones via Cp*Co(III)-Catalyzed C-H Functionalization of Primary Amides with Oxadiazolones

Xuan Wu, Weiping Wu, Shuaixin Fan, Xuanzhen Han, Zhixin Wang, Hanxiao Xu, Baochen Wang, and Jin Zhu*

School of Chemistry and Chemical Engineering, State Key Laboratory of Coordination Chemistry, Nanjing University, Nanjing 210023, China

*E-mail: jinz@nju.edu.cn.

Content

General Information

All reactions were carried out under a dry nitrogen atmosphere using Schlenk techniques. All commercial reagents were used without additional purification, unless otherwise stated. Anhydrous solvent was purchased from commercial sources and transferred under an nitrogen atmosphere. Reaction temperature was reported corresponding to the oil bath temperature. Analytical thin-layer chromatography (TLC) was performed on Merck 60 F254 silica gel plates. Flash chromatography was performed using 40-63 μm silica gel (Si 60, Merck). ^{1}H and ^{13}C NMR spectra were recorded on Bruker 400 MHz or 500 MHz NMR spectrometer in the solvents indicated. The chemical shifts are expressed in ppm relative to TMS and coupling constants are given in Hz. Data for ^{1}H NMR are recorded as follows: chemical shift (ppm), multiplicity (s, singlet; d, doublet; t, triplet; q, quarter; m, multiplet; br, broad), coupling constant (Hz), integration. Data for ^{13}C NMR are reported in terms of chemical shift (δ, ppm). High-resolution mass spectrometric data were obtained on a Thermo Scientific Q Exactive HF Orbitrap-FTMS (ESI). The substrates of benzamides were purchased from commercial sources and oxadiazolones were obtained from our lab unless specifically stated.

Detailed Optimization of Reaction Conditions.

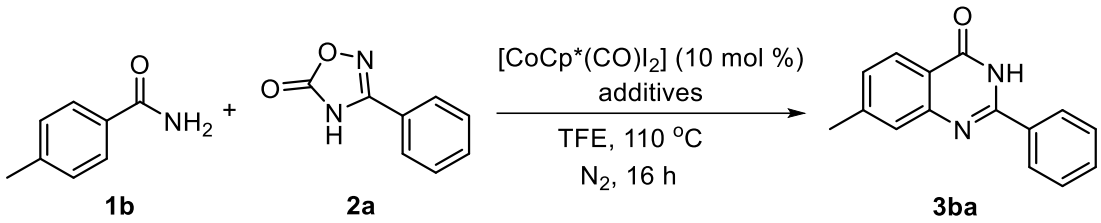


Table S1. Selected observations from detailed screening of additives. *[a,b]*

Entry	Additives (equiv)	Yield (%)
1	$AgSbF_6$ (0.2) + NaOAc (1.0)	trace
2	$AgSbF_6$ (0.2) + HOAc (1.0)	22
3	$AgSbF_6$ (0.5) + NaOAc (1.0)	trace
4	$AgSbF_6$ (0.5) + HOAc (1.0)	38
5	$AgSbF_6$ (0.5) + HOAc (1.0)	24
6	$AgSbF_6$ (2.0) + HOAc (1.0)	64
7	$AgSbF_6$ (0.2) + $BF_3{\cdot}Et_2O$ (1.0) + HOAc (0.2)	37

[a] Conditions: 1b (0.24 mmol, 1.2 equiv), 2a (0.2 mmol, 1.0 equiv) TFE (2 mL), N_2. [b] Isolated yields.

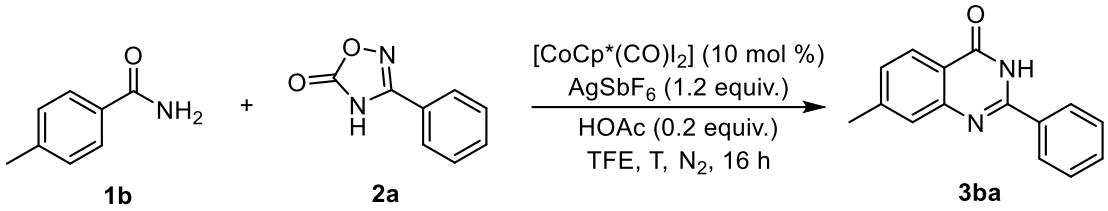


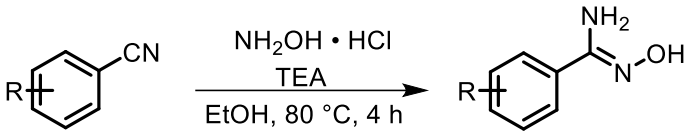
Table S2. Selected observations from detailed screening of temperature. *[a,b]*

Entry	Temperature (°C)	Yield (%)
1	80	30
2	100	42
3	120	50

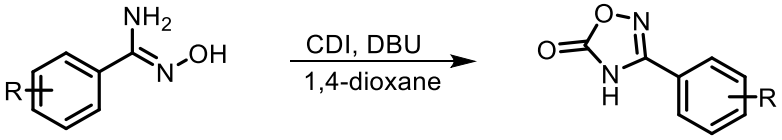
[a] Conditions: 1b (0.24 mmol, 1.2 equiv) 2a (0.2 mmol, 1.0 equiv), TFE (2 mL), N_2. [b] Isolated yields.

Synthesis of Substrates

General procedure for the synthesis of substrates[1]:

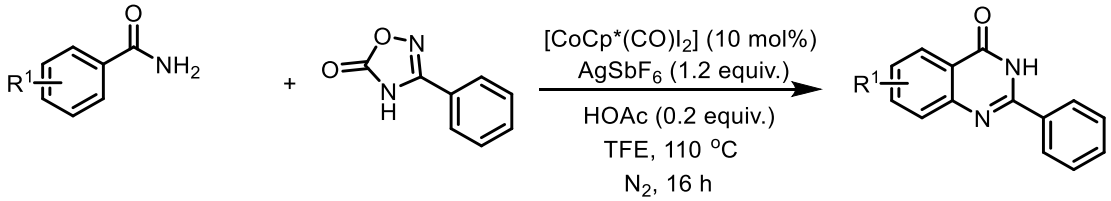


To a round bottom flask (100 mL) containing substituted benzonitrile (50.0 mmol) were added hydroxylamine hydrochloride (75.0 mmol) and Et_3N (75.0 mmol). Then, ethyl alcohol (50.0 ml) was sequentially added to the system and the reaction mixture was stirred at 80 °C for 4 h. After cooling to ambient temperature, the mixture was concentrated in vacuo. EtOAc was used to extract the product from the aqueous layer. The combined organic layer was washed with water (3 × 50 mL), dried over Na_2SO_4, filtered and concentrated to afford the crude product. This residue was pure enough for the further reaction as white solid.

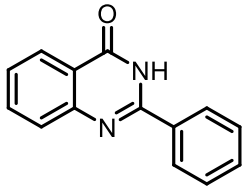


To a round bottom flask (100 mL) containing substituted (*Z*)-*N'*-hydroxybenzimidamide (30.0 mmol) were added CDI (*N*,*N'*-Carbonyldiimidazole) (36.0 mmol) and DBU (1,8-Diazabicyclo[5.4.0]undec-7-ene) (33.0 mmol). Then, 1,4-dioxane (30.0 mL) was sequentially added to the system and the reaction mixture was stirred at 100 °C for 3 h. After cooling to ambient temperature, the mixture was diluted with water, and adjusted to pH ≈ 2 with 3 M HCl and extracted with EtOAc. The combined organic layer was washed with water (3 × 50 mL), dried over Na_2SO_4, filtered and concentrated to afford the crude product. The crude product was filtered through a Buchner funnel and the precipitate was washed with cold $CHCl_3$ (3 × 10 mL). This residue was pure enough for the further reaction.

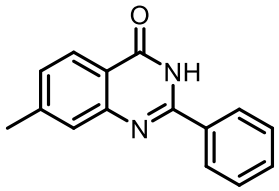
Synthesis and Characterization Data of Products



Taking **3ba** as an example, to a 10 mL schlenk tube equipped with magnetic bar was added 4-methylbenzamide (**1b**, 32.4 mg, 0.24 mmol, 1.2 equiv), 3-phenyl-1,2,4-oxadiazol-5(4*H*)-one (**2a**, 32.4 mg, 0.2 mmol, 1.0 equiv) and [CoCp*(CO)I_2] (9.6 mg, 0.02 mmol, 10 mol%). The tube was then transferred to a glovebox, and added with $AgSbF_6$ (82.2 mg, 0.24 mmol, 1.2 equiv). After the tube was removed from the glovebox, a solution of HOAc (2.4 μL, 0.04 mmol, 0.2 equiv) in 2 mL of CF_3CH_2OH was injected into the tube via syringe. The reaction mixture was placed in a pre-heated oil bath (110 ℃) and stirred for 16 h, during which time a constant checking by TLC was performed every three hours. The reaction mixture was cooled to rt and filtered over celite. The solvent was then removed under reduced pressure and the residue was purified by column chromatography on silica gel with PE/ EtOAc (2:1) as the eluent.

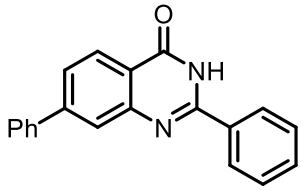


2-phenylquinazolin-4(3H)-one (3aa)[2]**:** Yield of 70% (31.1 mg); light yellow solid. **^{1}H NMR (500 MHz, $CDCl_3$)** δ 11.69 (s, 1H), 8.39 - 8.21 (m, 3H), 7.83 (ddd, *J* = 14.3, 7.5, 1.6 Hz, 2H), 7.59 (ddt, *J* = 5.7, 4.1, 1.6 Hz, 3H), 7.55 - 7.46 (m, 1H). **^{13}C NMR (126 MHz, $CDCl_3$)** δ 164.0, 151.9, 149.7, 135.0, 133.0, 131.8, 129.2, 128.1, 127.6, 126.9, 126.5, 121.0.

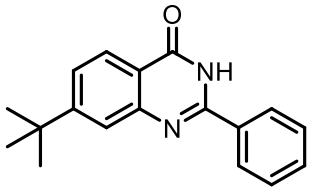


7-methyl-2-phenylquinazolin-4(3H)-one (3ba)[3]**:** Yield of 77% (36.4 mg); light yellow solid. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 11.41 (s, 1H), 8.32 - 8.14 (m, 3H), 7.67

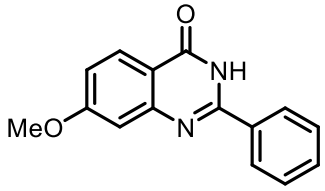
(s, 1H), 7.64 - 7.53 (m, 3H), 7.33 (dd, *J* = 8.2, 1.6 Hz, 1H), 2.54 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 163.7, 152.0, 149.5, 146.2, 132.8, 131.8, 129.2, 128.7, 127.7, 127.5, 126.4, 118.5, 22.2.



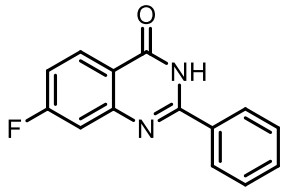
2,7-diphenylquinazolin-4(3H)-one (3ca): Yield of 40% (23.9 mg); light yellow solid. **^{1}H NMR (500 MHz, DMSO-d_6)** δ 12.57 (s, 1H), 8.27 - 8.18 (m, 3H), 8.00 (d, *J* = 1.8 Hz, 1H), 7.88 - 7.82 (m, 3H), 7.62 - 7.52 (m, 5H), 7.48 (d, *J* = 7.4 Hz, 1H). **^{13}C NMR (126 MHz, DMSO-d_6)** δ 162.1, 152.8, 149.3, 146.2, 138.8, 132.7, 131.5, 129.2, 128.7, 128.6, 127.8, 127.2, 126.6, 125.3, 125.0, 119.9. **HRMS (ESI, m/z)** $[M+H]^+$, calcd for $C_{20}H_{14}N_2O$, 299.1179; found, 299.1179.



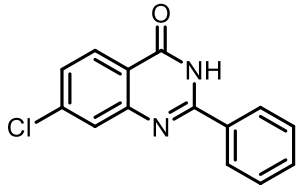
7-(tert-butyl)-2-phenylquinazolin-4(3H)-one (3da): Yield of 52% (28.9 mg); light yellow solid. **^{1}H NMR (500 MHz, $CDCl_3$)** δ 11.95 (s, 1H), 8.35 - 8.21 (m, 3H), 7.85 (d, *J* = 1.8 Hz, 1H), 7.68 - 7.52 (m, 4H), 1.43 (s, 9H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 164.1, 159.1, 152.1, 149.7, 133.1, 131.6, 129.1, 127.6, 126.1, 125.1, 124.3, 118.5, 35.6, 31.2. **HRMS (ESI, m/z)** $[M+H]^+$, calcd for $C_{18}H_{18}N_2O$, 279.1492; found, 279.1491.



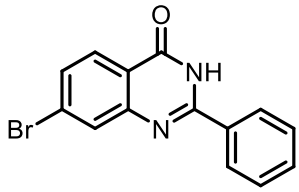
7-methoxy-2-phenylquinazolin-4(3H)-one (3ea)[4]: Yield of 52% (26.2 mg); light yellow solid. **^{1}H NMR (500 MHz, $CDCl_3$)** δ 11.42 (s, 1H), 8.22 (ddd, *J* = 7.7, 4.2, 2.6 Hz, 3H), 7.58 (dd, *J* = 5.1, 1.9 Hz, 3H), 7.25 (d, *J* = 2.5 Hz, 1H), 7.08 (dd, *J* = 8.8, 2.5 Hz, 1H), 3.96 (s, 3H). **^{13}C NMR (126 MHz, $CDCl_3$)** δ 165.2, 163.3, 152.7, 151.8, 132.9, 131.9, 129.2, 128.0, 127.5, 117.3, 114.4, 108.5, 55.9.



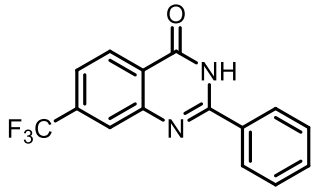
7-fluoro-2-phenylquinazolin-4(3H)-one (3fa)[5]: Yield of 42% (20.2 mg); light yellow solid. **^{1}H NMR (500 MHz, $CDCl_3$)** δ 11.26 (s, 1H), 8.35 (dd, *J* = 8.8, 6.1 Hz, 1H), 8.28 - 8.20 (m, 2H), 7.68 - 7.58 (m, 3H), 7.52 (dd, *J* = 9.7, 2.5 Hz, 1H), 7.24 - 7.22 (m, 1H). **^{13}C NMR (126 MHz, $CDCl_3$)** δ 168.1, 166.1, 162.9, 153.0, 151.7 (d, J = 12.6 Hz), 132.46, 132.23, 129.32, 129.24 (d, J = 10.0 Hz), 127.52, 115.85 (d, J = 23.8 Hz), 113.40 (d, J = 22.5 Hz). **^{19}F NMR (376 MHz, $CDCl_3$)** δ -102.5.



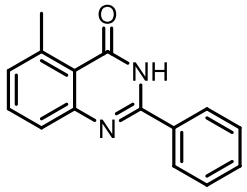
7-chloro-2-phenylquinazolin-4(3H)-one (3ga)[6]: Yield of 37% (19.0 mg); light yellow solid. **^{1}H NMR (400 MHz, DMSO-d_6)** δ 12.67 (s, 1H), 8.19 - 8.13 (m, 3H), 7.79 (d, J = 2.0 Hz, 1H), 7.63 - 7.53 (m, 4H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ161.7, 153.8, 149.9, 139.2, 132.4, 131.7, 128.6, 127.9, 127.9, 126.8, 126.6, 119.8.



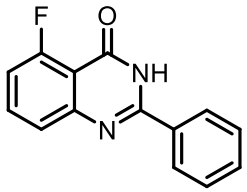
7-bromo-2-phenylquinazolin-4(3H)-one (3ha)[5]: Yield of 42% (25.3 mg); light yellow solid. **^{1}H NMR (500 MHz, DMSO-*d_6*)** δ 12.68 (s, 1H), 8.17 (dd, *J* = 7.3, 2.3 Hz, 2H), 8.07 (d, *J* = 8.5 Hz, 1H), 7.95 (d, *J* = 1.6 Hz, 1H), 7.69 (dd, *J* = 8.5, 1.9 Hz, 1H), 7.65 - 7.50 (m, 3H). **^{13}C NMR (126 MHz, DMSO-*d_6*)** δ 161.8, 153.8, 150.0, 132.4, 131.8, 129.7, 129.6, 128.7, 128.2, 128.0, 127.9, 120.1.



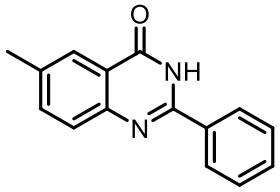
2-phenyl-7-(trifluoromethyl)quinazolin-4(3H)-one (3ia)[7]**:** Yield of 34% (19.7 mg); light yellow solid. **^{1}H NMR (400 MHz, DMSO-*d*$_6$)** δ 12.82 (s, 1H), 8.34 (d, *J* = 8.3 Hz, 1H), 8.26 - 8.16 (m, 2H), 8.04 (d, *J* = 1.7 Hz, 1H), 7.80 (dd, *J* = 8.3, 1.8 Hz, 1H), 7.67 - 7.52 (m, 3H). **^{13}C NMR (101 MHz, DMSO-*d*$_6$)** δ 161.6, 154.0, 148.8, 134.2 (d, J = 32.2 Hz), 132.1 (d, J = 45.9 Hz), 128.7, 128.0, 127.7, 124.9, 124.7 - 124.4 (m), 123.82, 122.3 - 122.1 (m). **^{19}F NMR (376 MHz, CDCl$_3$)** δ -63.0.



5-methyl-2-phenylquinazolin-4(3H)-one (3ja)[8]**:** Yield of 74% (35.0 mg); light yellow solid. **^{1}H NMR (500 MHz, DMSO-*d*$_6$)** δ 12.30 (s, 1H), 8.23 - 8.15 (m, 2H), 7.71 - 7.63 (m, 1H), 7.61 - 7.51 (m, 4H), 7.26 (d, *J* = 7.2 Hz, 1H), 2.82 (s, 3H). **^{13}C NMR (126 MHz, DMSO-*d*$_6$)** δ 163.0, 151.9, 150.3, 140.0, 133.6, 132.5, 131.3, 128.9, 128.6, 127.7, 125.7, 119.3, 22.5.

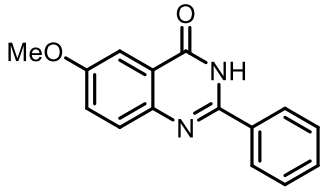


5-fluoro-2-phenylquinazolin-4(3H)-one (3ka)[9]**:** Yield of 56% (26.9 mg); light yellow solid. **^{1}H NMR (400 MHz, DMSO-*d*$_6$)** δ 12.54 (s, 1H), 8.20 - 8.15 (m, 2H), 7.80 (td, J = 8.2, 5.6 Hz, 1H), 7.63 - 7.52 (m, 4H), 7.25 (dd, J = 11.1, 8.1 Hz, 1H). **^{13}C NMR (101 MHz, DMSO-*d*$_6$)** δ 161.8, 159.4 (d, J = 29.6 Hz), 153.3, 150.9, 135.1 (d, J = 10.4 Hz), 132.2, 131.7, 128.6, 127.9, 123.58 (d, J = 3.1 Hz), 112.9 (d, J = 20.4 Hz), 110.4 (d, J = 6.5 Hz). **^{19}F NMR (376 MHz, DMSO-*d*$_6$)** δ -111.5.

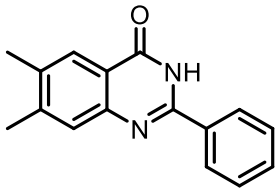


6-methyl-2-phenylquinazolin-4(3H)-one (3la)[5]**:** Yield of 48% (22.7 mg); light yellow solid. **^{1}H NMR (400 MHz, DMSO-*d*$_6$)** δ 12.45 (s, 1H), 8.19 - 8.15 (m, 2H), 7.95 (s,

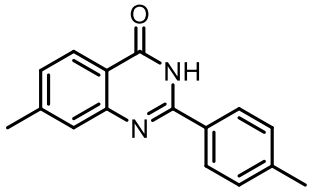
1H), 7.65 (s, 2H), 7.60 - 7.51 (m, 3H), 2.46 (s, 3H). **^{13}C NMR (101 MHz, DMSO-*d*$_6$)** δ 162.1, 151.4, 146.7, 136.3, 135.9, 132.8, 131.2, 128.6, 127.6, 127.4, 125.2, 120.7, 20.8.



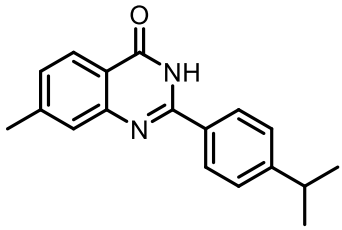
6-methoxy-2-phenylquinazolin-4(3H)-one (3ma)[5]**:** Yield of 50% (25.2 mg); light yellow solid. **^{1}H NMR (500 MHz, CDCl$_3$)** δ 8.08 - 8.05 (m, 2H), 7.80 (d, J = 8.8 Hz, 1H), 7.70 - 7.67 (m, 1H), 7.59 - 7.55 (m, 3H), 7.42 - 7.39 (m, 1H), 3.95 (s, 3H). **^{13}C NMR (101 MHz, CDCl$_3$)** δ 162.8, 158.7, 149.3, 144.1, 133.0, 131.6, 129.8, 129.3, 126.9, 125.3, 121.8, 106.0, 56.0.



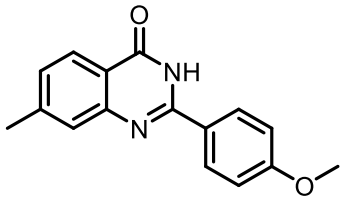
6,7-dimethyl-2-phenylquinazolin-4(3H)-one (3na)[10]**:** Yield of 52% (26.0 mg); light yellow solid. **^{1}H NMR (400 MHz, CDCl$_3$)** δ 8.15 (dd, *J* = 6.8, 2.9 Hz, 2H), 8.05 (s, 1H), 7.68 (s, 1H), 7.58 (d, *J* = 2.2 Hz, 2H), 7.57 (d, *J* = 1.5 Hz, 1H), 2.44 (d, *J* = 7.4 Hz, 6H). **^{13}C NMR (126 MHz, CDCl$_3$)** δ 163.3, 151.0, 147.8, 145.5, 136.8, 133.0, 131.7, 129.3, 128.2, 127.2, 126.4, 118.8, 20.7, 19.9.



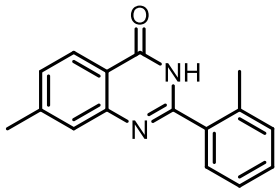
7-methyl-2-(p-tolyl)quinazolin-4(3H)-one (3bb)[11]**:** Yield of 54% (27.0 mg); light yellow solid. **^{1}H NMR (500 MHz, CDCl$_3$)** δ 10.64 (s, 1H), 8.19 (d, J = 8.1 Hz, 1H), 8.07 - 8.02 (m, 2H), 7.63 (s, 1H), 7.40 - 7.34 (m, 2H), 7.31 (dd, J = 8.1, 1.7 Hz, 1H), 2.53 (s, 3H), 2.46 (s, 3H). **^{13}C NMR (126 MHz, CDCl$_3$)** δ 163.6, 151.9, 149.8, 146.0, 142.3, 130.1, 129.9, 128.4, 127.8, 127.3, 126.3, 118.5, 22.2, 21.7.



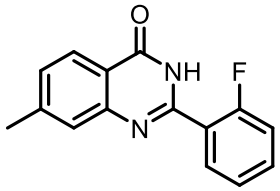
2-(4-isopropylphenyl)-7-methylquinazolin-4(3H)-one (3bc): Yield of 52% (28.9 mg); light yellow solid. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.23 - 8.18 (m, 3H), 7.64 (s, 1H), 7.45 - 7.40 (m, 2H), 7.31 (dd, J = 8.2, 1.6 Hz, 1H), 3.02 (hept, J = 7.1 Hz, 1H), 2.53 (s, 3H), 1.32 (d, J = 6.9 Hz, 6H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 164.1, 153.0, 152.1, 149.8, 146.0, 130.5, 128.3, 127.7, 127.6, 127.2, 126.3, 118.5, 34.3, 23.9, 22.1. **HRMS (ESI, m/z)** $[M+H]^+$, calcd for $C_{18}H_{18}N_2O$, 279.1492; found, 279.1492



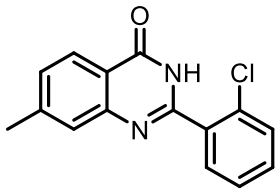
2-(4-methoxyphenyl)-7-methylquinazolin-4(3H)-one (3bd)[12]**:** Yield of 51% (27.2 mg); light yellow solid. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.19 (t, *J* = 8.3 Hz, 3H), 7.67 (s, 1H), 7.30 (dd, *J* = 8.1, 1.6 Hz, 1H), 7.11 - 7.01 (m, 2H), 3.91 (s, 3H), 2.53 (s, 3H). **^{13}C NMR (126 MHz, $CDCl_3$)** δ 163.8, 162.6, 151.7, 149.7, 146.1, 129.2, 128.2, 127.5, 126.3, 125.2, 118.3, 114.5, 55.7, 22.2.



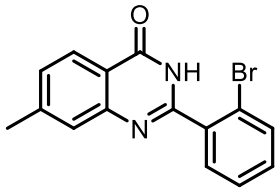
7-methyl-2-(o-tolyl)quinazolin-4(3H)-one (3be)[13]**:** Yield of 61% (30.5 mg); light yellow solid. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 11.07 (s, 1H), 8.09 (d, *J* = 8.1 Hz, 1H), 7.62 - 7.52 (m, 2H), 7.45 - 7.36 (m, 1H), 7.35 - 7.24 (m, 3H), 2.51 (s, 6H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 163.3, 153.8, 149.3, 146.0, 137.0, 133.8, 131.5, 130.5, 128.9, 128.6, 127.6, 126.3, 126.3, 118.4, 22.1, 20.2.



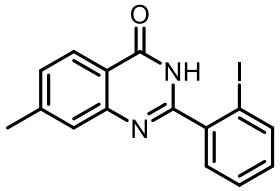
2-(2-fluorophenyl)-7-methylquinazolin-4(3H)-one (3bf)[14]**:** Yield of 59% (30.0 mg); light yellow solid. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 10.18 (s, 1H), 8.30 (td, J = 7.9, 1.9 Hz, 1H), 8.16 (d, J = 8.1 Hz, 1H), 7.61 (s, 1H), 7.56 - 7.49 (m, 1H), 7.35 - 7.30 (m, 2H), 7.21 (ddd, J = 12.3, 8.3, 1.2 Hz, 1H), 2.51 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 162.0 (d, J = 10.4 Hz), 159.6, 149.0, 148.6 (d, J = 1.8 Hz), 146.0, 133.6 (d, J = 9.1 Hz), 131.4 (d, J = 1.9 Hz), 128.9, 127.8, 126.5, 125.3 (d, J = 3.3 Hz), 120.3 (d, J = 9.2 Hz), 118.9, 116.7 (d, J = 23.4 Hz), 22.1. **^{19}F NMR (376 MHz, $CDCl_3$)** δ -115.3.



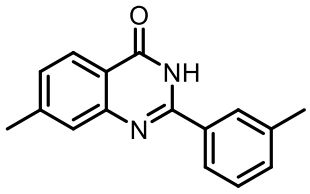
2-(2-chlorophenyl)-7-methylquinazolin-4(3H)-one (3bg)[11]**:** Yield of 46% (26.5 mg); light yellow solid. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 10.27 (s, 1H), 8.16 (d, *J* = 8.1 Hz, 1H), 7.81 (dd, *J* = 7.2, 2.1 Hz, 1H), 7.62 (s, 1H), 7.56 - 7.41 (m, 3H), 7.35 (dd, *J* = 8.1, 1.6 Hz, 1H), 2.53 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 162.1, 151.2, 149.1, 146.2, 132.8, 132.1, 132.1, 131.6, 130.7, 129.1, 127.8, 127.6, 126.5, 118.8, 22.1.



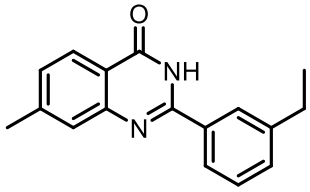
2-(2-bromophenyl)-7-methylquinazolin-4(3H)-one (3bh): Yield of 43% (27.1 mg); light yellow solid. **^{1}H NMR (400 MHz, DMSO-d_6)** δ 12.51 (s, 1H), 8.06 (d, J = 8.1 Hz, 1H), 7.76 (dd, J = 7.9, 1.0 Hz, 1H), 7.63 (dd, J = 7.5, 1.8 Hz, 1H), 7.55 - 7.44 (m, 3H), 7.38 (dd, J = 8.1, 1.2 Hz, 1H), 2.47 (s, 3H). **^{13}C NMR (101 MHz, DMSO-d_6)** δ 161.3, 153.3, 148.7, 145.1, 135.9, 132.6, 131.6, 130.7, 128.4, 127.6, 127.1, 125.7, 121.0, 118.9, 21.4. **HRMS (ESI, m/z)** $[M+H]^+$, calcd for $C_{15}H_{11}BrN_2O$, 315.0128; found, 315.0127.



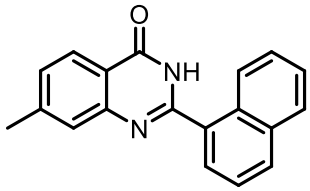
2-(2-iodophenyl)-7-methylquinazolin-4(3H)-one (3bi): Yield of 41% (29.7 mg); light yellow solid. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 10.96 (s, 1H), 8.11 (d, J = 8.1 Hz, 1H), 7.97 (d, J = 8.0 Hz, 1H), 7.63 - 7.58 (m, 2H), 7.52 - 7.47 (m, 1H), 7.34 (d, J = 8.1 Hz, 1H), 7.23 - 7.18 (m, 1H), 2.52 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 162.9, 154.0, 149.0, 146.2, 140.3, 139.0, 131.9, 130.3, 129.0, 128.6, 127.8, 126.4, 118.7, 95.1, 22.2. **HRMS (ESI, m/z)** $[M+H]^+$, calcd for $C_{15}H_{11}IN_2O$, 362.9989; found, 362.9988.



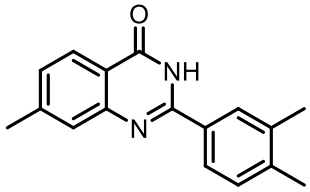
7-methyl-2-(m-tolyl)quinazolin-4(3H)-one (3bj)[13]**:** Yield of 58% (29.0 mg); light yellow solid. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 11.24 (s, 1H), 8.21 (d, J = 8.1 Hz, 1H), 8.05 (s, 1H), 7.99 (d, J = 7.7 Hz, 1H), 7.64 (s, 1H), 7.46 (t, J = 7.6 Hz, 1H), 7.39 (d, J = 7.6 Hz, 1H), 7.32 (d, J = 8.1 Hz, 1H), 2.53 (s, 3H), 2.51 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 163.7, 152.1, 149.8, 146.1, 139.0, 133.0, 132.5, 129.1, 128.5, 128.1, 127.9, 126.3, 124.5, 118.6, 22.1, 21.7.



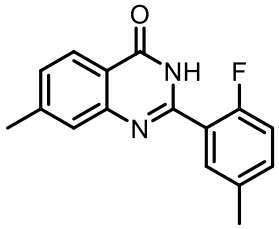
2-(3-ethylphenyl)-7-methylquinazolin-4(3H)-one (3bk): Yield of 60% (31.7 mg); light yellow solid. **^{1}H NMR (500 MHz, $CDCl_3$)** δ 11.84 (s, 1H), 8.20 (d, J = 8.0 Hz, 1H), 8.12 (s, 1H), 8.07 (d, J = 7.8 Hz, 1H), 7.66 (s, 1H), 7.49 (t, J = 7.6 Hz, 1H), 7.42 (d, J = 7.7 Hz, 1H), 7.32 (dd, J = 8.2, 1.2 Hz, 1H), 2.81 (q, J = 7.6 Hz, 2H), 2.53 (s, 3H), 1.36 (t, J = 7.6 Hz, 3H). **^{13}C NMR (126 MHz, $CDCl_3$)** δ 164.0, 152.4, 149.7, 146.0, 145.3, 132.9, 131.4, 129.1, 128.4, 127.7, 127.1, 126.2, 125.1, 118.5, 29.1, 22.1, 15.8. **HRMS (ESI, m/z)** $[M+H]^+$, calcd for $C_{17}H_{16}N_2O$, 265.1335; found, 265.1335.



7-methyl-2-(naphthalen-1-yl)quinazolin-4(3H)-one (3bl)[13]**:** Yield of 40% (22.9 mg); light yellow solid. **^{1}H NMR (400 MHz, DMSO-*d*$_6$)** δ 12.56 (s, 1H), 8.20 - 8.16 (m, 1H), 8.14 - 8.09 (m, 2H), 8.06 - 8.03 (m, 1H), 7.81 - 7.76 (m, 1H), 7.67 - 7.54 (m, 4H), 7.40 (dd, J = 8.2, 1.7 Hz, 1H), 2.49 (s, 3H). **^{13}C NMR (101 MHz, DMSO-*d*$_6$)** δ 161.8, 153.7, 148.8, 145.0, 133.1, 131.7, 130.3, 130.3, 128.3, 128.2, 127.6, 127.1, 127.0, 126.3, 125.7, 125.2, 125.1, 118.8, 21.4.

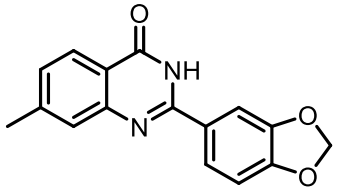


2-(3,4-dimethylphenyl)-7-methylquinazolin-4(3H)-one (3bm): Yield of 45% (23.8 mg); light yellow solid. **^{1}H NMR (500 MHz, CDCl$_3$)** δ 10.74 (s, 1H), 8.20 (d, J = 8.1 Hz, 1H), 7.97 (s, 1H), 7.87 (d, J = 7.9 Hz, 1H), 7.64 (s, 1H), 7.33 - 7.30 (m, 2H), 2.53 (s, 3H), 2.40 (s, 3H), 2.36 (s, 3H). **^{13}C NMR (126 MHz, CDCl$_3$)** δ 163.1, 155.1, 149.3, 146.1, 137.7, 131.7, 130.0, 129.4, 128.9, 128.4, 127.4, 127.2, 126.3, 118.4, 42.1, 22.1, 21.2. **HRMS (ESI, m/z)** $[M+H]^+$, calcd for $C_{17}H_{16}N_2O$, 265.1335; found, 265.1335.

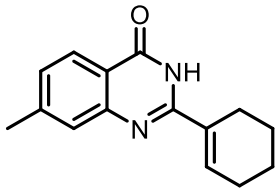


2-(2-fluoro-5-methylphenyl)-7-methylquinazolin-4(3H)-one (3bn): Yield of 47% (25.2 mg); light yellow solid. **^{1}H NMR (400 MHz, CDCl$_3$)** δ 9.97 (s, 1H), 8.17 (d, J = 8.1 Hz, 1H), 8.11 (dd, J = 7.6, 2.4 Hz, 1H), 7.62 (s, 1H), 7.34 - 7.29 (m, 2H), 7.10 (dd, J = 12.2, 8.4 Hz, 1H), 2.52 (s, 3H), 2.42 (s, 3H). **^{13}C NMR (101 MHz, CDCl$_3$)** δ 161.9, 160.4, 158.0, 148.9 (d, J = 34.1 Hz), 146.0, 135.1 (d, J = 3.2 Hz), 134.2 (d, J = 9.0 Hz), 131.3 (d, J = 1.8 Hz), 128.9, 127.8, 126.5, 119.6 (d, J = 9.0 Hz), 118.9, 116.5 (d, J = 23.6 Hz), 22.1, 20.8. **^{19}F NMR (376 MHz, CDCl$_3$)** δ -120.6. **HRMS (ESI, m/z)**

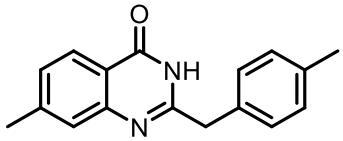
$[M+H]^+$, calcd for $C_{17}H_{16}N_2O$, 269.1085; found, 269.1084.



2-(benzo[d][1,3]dioxol-5-yl)-7-methylquinazolin-4(3H)-one (3bo): Yield of 55% (30.8 mg); light yellow solid. **^{1}H NMR (500 MHz, DMSO-*d*$_6$)** δ 12.26 (s, 1H), 8.00 (d, J = 8.1 Hz, 1H), 7.79 (dd, J = 8.2, 1.9 Hz, 1H), 7.72 (d, J = 1.9 Hz, 1H), 7.50 (s, 1H), 7.30 (dd, J = 8.0, 1.0 Hz, 1H), 7.06 (d, J = 8.2 Hz, 1H), 6.13 (s, 2H), 2.45 (s, 3H). **^{13}C NMR (126 MHz, DMSO-*d*$_6$)** δ162.1, 151.6, 150.0, 148.9, 147.7, 145.0, 127.7, 127.0, 126.6, 125.7, 122.7, 118.4, 108.2, 107.5, 101.8, 21.4. **HRMS (ESI, m/z)** $[M+H]^+$, calcd for $C_{16}H_{12}N_2O_3$, 281.0921; found, 281.0921.

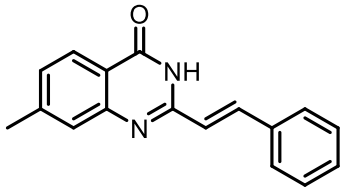


2-(cyclohex-1-en-1-yl)-7-methylquinazolin-4(3H)-one (3bp): Yield of 63% (30.3 mg); light yellow solid. **^{1}H NMR (400 MHz, CDCl$_3$)** δ 10.84 (s, 1H), 8.12 (d, J = 8.1 Hz, 1H), 7.53 (s, 1H), 7.27 - 7.23 (m, 1H), 6.96 - 6.89 (m, 1H), 2.62 - 2.57 (m, 2H), 2.49 (s, 3H), 2.38 - 2.33 (m, 2H), 1.84 - 1.77 (m, 2H), 1.75 - 1.68 (m, 2H). **^{13}C NMR (101 MHz, CDCl$_3$)** δ 163.4, 153.0, 149.5, 145.8, 134.2, 132.3, 128.1, 127.6, 126.2, 118.6, 26.2, 25.0, 22.4, 22.1, 21.8. **HRMS (ESI, m/z)** $[M+H]^+$, calcd for $C_{15}H_{16}N_2O$, 241.1335; found, 241.1335.

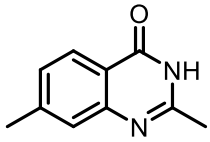


7-methyl-2-(4-methylbenzyl)quinazolin-4(3H)-one (3bq): Yield of 42% (22.2 mg); light yellow solid. **^{1}H NMR (400 MHz, CDCl$_3$)** δ 8.12 (d, *J* = 8.1 Hz, 1H), 7.55 (s, 1H), 7.30 - 7.24 (m, 3H), 7.15 (d, *J* = 7.8 Hz, 2H), 4.06 (s, 2H), 2.51 (s, 3H), 2.33 (s, 3H). **^{13}C NMR (126 MHz, CDCl$_3$)** δ 163.1, 155.1, 149.3, 146.1, 137.7, 131.7, 130.0,

129.4, 128.4, 127.2, 126.3, 118.4, 42.1, 22.1, 21.2. **HRMS (ESI, m/z)** $[M+H]^+$, calcd for $C_{17}H_{16}N_2O$, 265.1335; found, 265.1335.

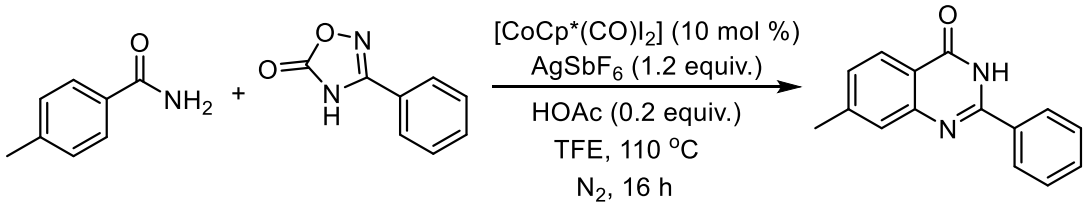


(E)-7-methyl-2-styrylquinazolin-4(3H)-one (3br): Yield of 53% (27.8 mg); light yellow solid. **^{1}H NMR (500 MHz, $CDCl_3$)** δ 8.21 (d, J = 8.1 Hz, 1H), 8.01 (d, J = 16.5 Hz, 1H), 7.69 - 7.65 (m, 2H), 7.57 (s, 1H), 7.47 - 7.38 (m, 3H), 7.31 (dd, J = 8.2, 1.6 Hz, 1H), 7.00 (d, J = 16.5 Hz, 1H), 2.52 (s, 3H). **^{13}C NMR (126 MHz, $CDCl_3$)** δ 163.9, 151.3, 149.6, 146.1, 139.0, 135.2, 129.9, 129.0, 128.4, 127.9, 127.2, 126.2, 121.2, 118.4, 22.0. **HRMS (ESI, m/z)** $[M+H]^+$, calcd for $C_{17}H_{14}N_2O$, 263.1179; found, 263.1179.



2,7-dimethylquinazolin-4(3H)-one (3bs)[15]**:** Yield of 60% (20.9 mg); light yellow solid. **^{1}H NMR (500 MHz, DMSO-*d*$_6$)** δ 12.09 (s, 1H), 7.95 (d, *J* = 8.1 Hz, 1H), 7.42 - 7.33 (m, 1H), 7.27 (dd, *J* = 8.2, 1.7 Hz, 1H), 2.43 (s, 3H), 2.33 (s, 3H). **^{13}C NMR (126 MHz, DMSO-*d*$_6$)** δ 161.6, 154.3, 149.1, 144.7, 127.3, 126.2, 125.5, 118.2, 21.4 (21.44), 21.4 (21.36).

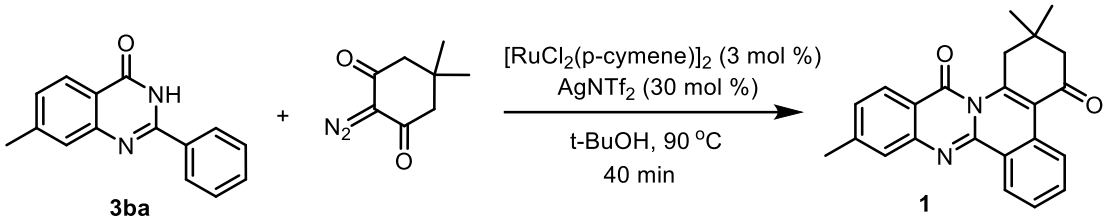
1mmol Scale Reaction



To a 25 mL schlenk tube equipped with magnetic bar was added 4-methylbenzamide (**1b**, 162 mg, 1.2 mmol, 1.2 equiv), 3-phenyl-1,2,4-oxadiazol-5(4*H*)-one (**2a**, 162 mg, 1.0 mmol, 1.0 equiv) and $[CoCp^*(CO)I_2]$ (48 mg, 0.1 mmol, 10 mol%). The tube was then transferred to a glovebox, and added with $AgSbF_6$ (411.0 mg, 1.2 mmol, 1.2 equiv). After the tube was removed from the glovebox, a soution of HOAc

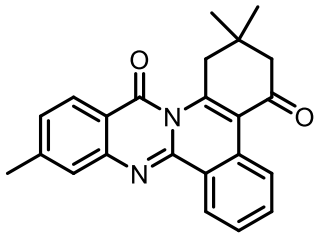
(12 μL, 0.2 mmol, 0.2 equiv) in 5 mL of CF_3CH_2OH was injected into the tube via syringe. The reaction mixture was placed in a pre-heated oil bath (110 ℃) and stirred for 16 h, during which time a constant checking by TLC was performed every three hours. The reaction mixture was cooled to rt and filtered over celite. The solvent was then removed under reduced pressure and the residue was purified by column chromatography on silica gel with PE / EtOAc (2:1) as the eluent. The yield is 65% (154.0 mg)

Diversified Transformations



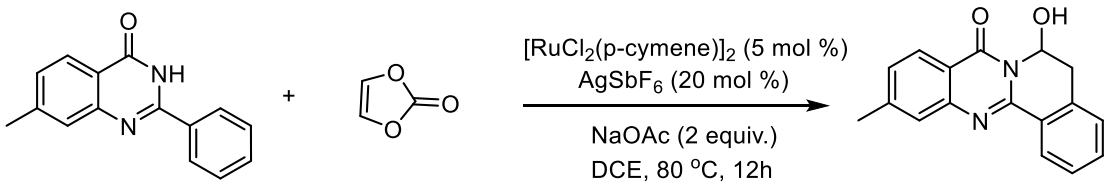
General Procedure for synthesis of **1**[16]

To a solution of **3ba** (47.3 mg, 0.2 mmol, 1.0 equiv) and [(*p*-cymene)$RuCl_2$]$_2$ (3.7 mg, 3 mol %) / $AgNTf_2$ (23.3 mg, 30 mol %) in t-BuOH (2 mL) at 90 °C was added portion wise a solution of 2-diazo-5,5-dimethylcyclohexane-1,3-dione (39.8 mg, 0.24 mmol, 1.2 equiv). After being stirred for another 40 min, the mixture was cooled to room temperature. The reaction was quenched with water, and the mixture was extracted with DCM three times. The combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated in vacuo. The residue was purified by by column chromatography, eluting with PE/EtOAc to afford 34.9 mg of **1** (41%) as light yellow solid.



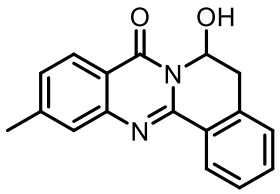
2,2,11-trimethyl-2,3-dihydro-4H-quinazolino[3,2-f]phenanthridine-4,14(1H)-dione (1): Yield of 41% (34.9 mg); light yellow solid. **^{1}H NMR (500 MHz, $CDCl_3$)** δ 9.04 (d, J = 8.2 Hz, 1H), 8.92 (d, J = 8.0 Hz, 1H), 8.17 (d, J = 8.1 Hz, 1H), 7.73 - 7.70

(m, 1H), 7.64 (s, 1H), 7.59 (t, J = 7.6 Hz, 1H), 7.32 (d, J = 8.1 Hz, 1H), 3.40 (s, 2H), 2.63 (s, 2H), 2.56 (s, 3H), 1.09 (s, 6H). **^{13}C NMR (126 MHz, $CDCl_3$)** δ 198.2, 162.3, 148.5, 147.4, 146.8, 146.3, 132.8, 129.6, 128.6, 128.3, 127.2, 127.1, 126.8, 126.7, 126.5, 117.9, 117.8, 52.8, 44.4, 33.5, 28.1, 22.3. **HRMS (ESI, m/z)** $[M+H]^+$, calcd for $C_{23}H_{20}N_2O_2$, 357.1598; found, 357.1597.

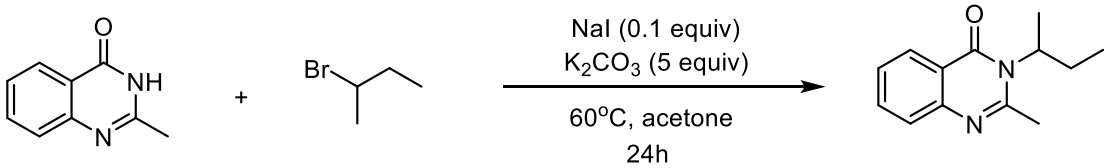


General Procedure for synthesis of **2**[17]

A solution of **3ba** (47.3 mg, 0.2 mmol, 1.0 equiv), 1,3-dioxol-2-one (25.0 mg, 0.3 mmol, 1.5 equiv), [Ru(p-cymene)Cl_2]$_2$ (6.1 mg, 5 mol%) and $AgSbF_6$ (13.7 mg, 20 mol%), and NaOAc (32.8 mg, 0.4 mmol) in DCE (1 mL) was stirred under nitrogen atmosphere in an oil bath heated at 80 °C for 12 h. After the reaction was complete (monitored by TLC), the solvent was removed under reduced pressure. The crude residue was purified by silica gel column chromatography (PE/EtOAc = 1:3) to afford 20.8 mg of **2** (41%) as light yellow solid.

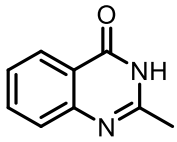


6-hydroxy-11-methyl-5,6-dihydro-8H-isoquinolino[1,2-b]quinazolin-8-one (2)[17]**:** Yield of 41% (20.8 mg); light yellow solid. **^{1}H NMR (500 MHz, DMSO-*d*$_6$)** δ 8.39 (dd, *J* = 8.0, 1.6 Hz, 1H), 8.09 (dd, *J* = 8.1, 1.7 Hz, 1H), 7.62 - 7.52 (m, 2H), 7.51 - 7.34 (m, 3H), 6.69 (dd, *J* = 26.3, 3.9 Hz, 2H), 3.17 (d, *J* = 16.5 Hz, 1H), 2.49 (s, 3H). **^{13}C NMR (126 MHz, DMSO-*d*$_6$)** δ 160.2, 148.3, 147.5, 145.4, 134.7, 131.8, 129.1, 128.4, 128.2, 127.1, 127.0, 126.9, 126.4, 118.3, 71.0, 34.4, 21.4.

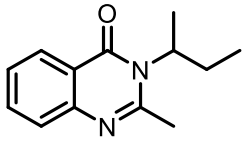


General Procedure for synthesis of **3**

A solution of **4as** (160.2 mg, 1.0 mmol, 1.0 equiv), 2-bromobutane (109.2 μL, 1 mmol, 1.0 equiv), NaI (15.0 mg, 0.1 mmol, 0.1 equiv), K_2CO_3 (691.0 mg, 5 mmol, 5.0 equiv) in acetone (4 mL) was stirred under nitrogen atmosphere in an oil bath heated at 60 °C for 24 h. After the reaction was complete (monitored by TLC), the solvent was removed under reduced pressure. The crude residue was purified by silica gel column chromatography (PE/EtOAc = 1:3) to afford 116.8 mg of **3** (54%) as yellow solid.

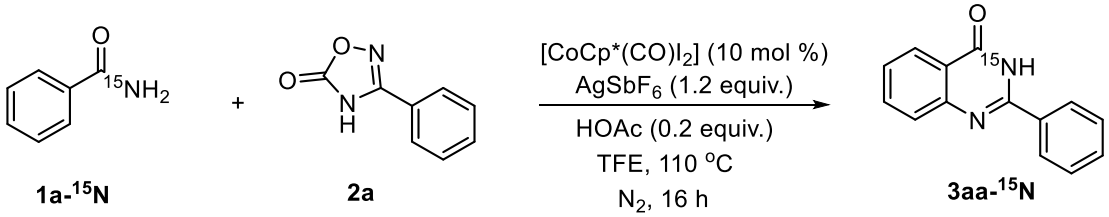


2-methylquinazolin-4(3H)-one (4as)[18]**:** Yield of 66% (21.1 mg); light yellow solid. **^{1}H NMR (400 MHz, DMSO-*d*$_6$)** δ 12.19 (s, 1H), 8.07 (dd, *J* = 7.9, 1.6 Hz, 1H), 7.77 (ddd, *J* = 8.4, 7.1, 1.6 Hz, 1H), 7.57 (dd, *J* = 8.3, 1.2 Hz, 1H), 7.45 (ddd, *J* = 8.1, 7.1, 1.2 Hz, 1H), 2.35 (s, 3H). **^{13}C NMR (101 MHz, DMSO-*d*$_6$)** δ 161.7, 154.3, 148.9, 134.2, 126.5, 125.8, 125.7, 120.6, 21.4.



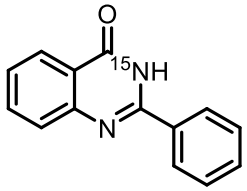
3-(sec-butyl)-2-methylquinazolin-4(3H)-one (3): Yield of 54% (116.8 mg); light yellow solid. **^{1}H NMR (400 MHz, CDCl$_3$)** δ 8.13 (dt, *J* = 8.2, 1.0 Hz, 1H), 7.83 (d, *J* = 8.3 Hz, 1H), 7.76 (ddd, *J* = 8.4, 6.8, 1.5 Hz, 1H), 7.46 (ddd, *J* = 8.2, 6.8, 1.3 Hz, 1H), 5.51 (h, *J* = 6.2 Hz, 1H), 2.71 (s, 3H), 1.90 - 1.75 (m, 2H), 1.42 (d, *J* = 6.2 Hz, 3H), 1.02 (t, *J* = 7.5 Hz, 3H). **^{13}C NMR (126 MHz, CDCl$_3$)** δ 166.5, 164.1, 151.5, 133.4, 126.9, 125.9, 123.6, 115.1, 74.4, 29.1, 26.7, 19.4, 9.9. **HRMS (ESI, m/z)** $[M+H]^+$, calcd for $C_{13}H_{16}N_2O$, 217.1335; found, 217.1335.

^{15}N-Labeling Experiment



1a-^{15}N **2a** **3aa-^{15}N**

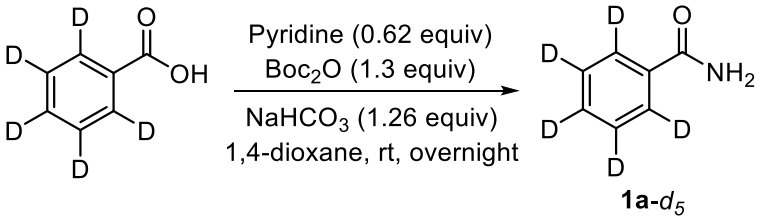
To a 10 mL schlenk tube equipped with magnetic bar was added benzamide-^{15}N (**1a-*^{15}N***, 29.3 mg, 0.24 mmol, 1.2 equiv), 3-phenyl-1,2,4-oxadiazol-5(4*H*)-one (2a, 32.4 mg, 0.2 mmol, 1.0 equiv) and [CoCp*(CO)I_2] (9.6 mg, 0.02 mmol, 10 mol%). The tube was then transferred to a glovebox, and added with $AgSbF_6$ (82.2 mg, 0.24 mmol, 1.2 equiv). After the tube was removed from the glovebox, a solution of HOAc (2.4 μL, 0.04 mmol, 0.2 equiv) in 2 mL of CF_3CH_2OH was injected into the tube via syringe. The reaction mixture was placed in a pre-heated oil bath (110 ℃) and stirred for 16 h, during which time a constant checking by TLC was performed every three hours. The reaction mixture was cooled to rt and filtered over celite. The solvent was then removed under reduced pressure and the residue was purified by column chromatography on silica gel with PE/ EtOAc (2:1) as the eluent to afford the **3aa-*^{15}N*** (68%, 30.4 mg).



2-phenylquinazolin-4(3*H*)-one-3-^{15}N (3aa-^{15}N): Yield of 68% (31.6 mg); light yellow solid. **^{1}H NMR (500 MHz, $CDCl_3$)** δ 11.70 (s, 1H), 8.34 - 8.32 (m, 1H), 8.28 - 8.25 (m, 2H), 7.86 - 7.79 (m, 2H), 7.60 - 7.57 (m, 3H), 7.53 - 7.49 (m, 1H). **^{13}C NMR (126 MHz, $CDCl_3$)** δ 164.0, 151.9, 149.7, 135.0, 133.0, 131.8, 129.2, 128.1, 127.6, 126.9, 126.5, 121.0. **^{15}N NMR (41 MHz, $CDCl_3$)** δ 96.5. **HRMS (ESI, m/z)** $[M+H]^+$, calcd for $C_{14}H_{10}N^{15}NO$, 224.0836; found, 224.0838.

KIE Experiment

Synthesis of 1a-d_5[19]



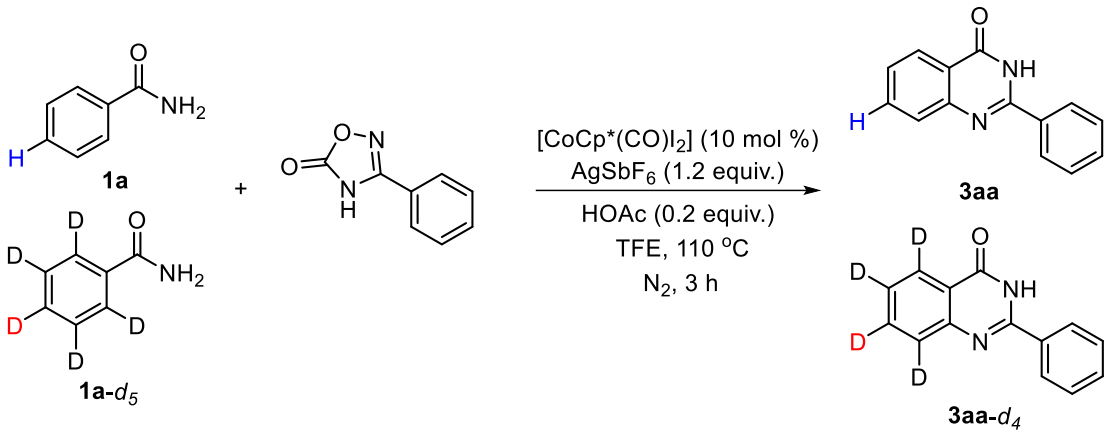
To a strirred solution of benzoic acid-d_5 (0.61 g, 5 mmol, 1.0 equiv.), pyridine (0.25 ml, 3.1 mmol, 0.62 equiv.), and Boc_2O (1.40 g, 6.5 mmol, 1.3 equiv.) in 1, 4-dioxane (10 ml) at room temperature was added ammonium bicarbonate (0.50 g, 6.3 mmol, 1.26

equiv.). The reaction was stirred overnight at room temperature and then partitioned between EtOAc (50 ml) and H_2O(50 ml). The organic layer was separated, washed consecutively with water (50 ml) and 0.6 N aqueous HCl (50 ml), dried ($NaSO_4$), and filtered. The filtrate was concentrated under reduced pressure to provide **1a**-d_5 as white solid in 83% yield (0.52 g).

Benzamide-d5 (1a-d_5)[20]

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82 (s, 0.1H), 7.53 (s, 0.02 H), 7.44 (s, 0.04 H), 6.28 (br, 2H).

Intermolecular competetion experiment



[**3aa**]/[**3aa**-d_4] = 0.79/(1.00-0.79) = 3.8

To a 10 mL schlenk tube equipped with magnetic bar was added benzamide (**1a**, 14.5 mg, 0.12 mmol, 0.6 equiv), benzamide-d_5 (**1a**-d_5, 15.1 mg, 0.12 mmol, 0.6 equiv), 3-phenyl-1,2,4-oxadiazol-5(4*H*)-one (**2a**, 32.4 mg, 0.2 mmol, 1.0 equiv) and [CoCp*(CO)I_2] (9.6 mg, 0.02 mmol, 10 mol%). The tube was then transferred to a glovebox, and added with $AgSbF_6$ (82.2 mg, 0.24 mmol, 1.2 equiv). After the tube was removed from the glovebox, a solution of HOAc (2.4 μL, 0.04 mmol, 0.2 equiv) in 2 mL of CF_3CH_2OH was injected into the tube via syringe. The reaction mixture was placed in a pre-heated oil bath (110 ℃) and stirred for 3 h, during which time a constant checking by TLC was performed every three hours. The reaction mixture was cooled to rt and filtered over celite. The solvent was then removed under reduced pressure and the residue was purified by column chromatography on silica gel with PE/ EtOAc (2:1) as the eluent to afford product. (8 mg)

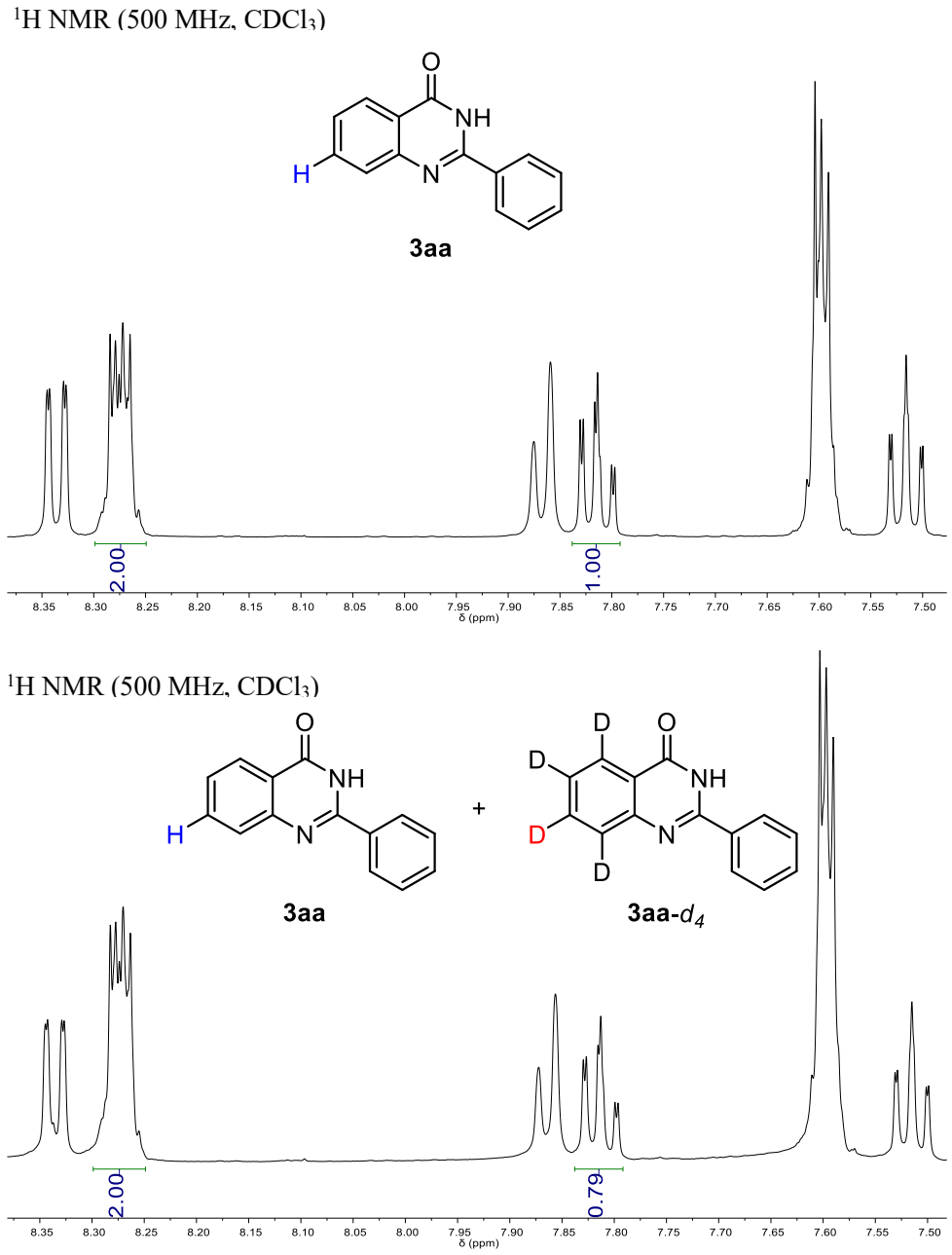
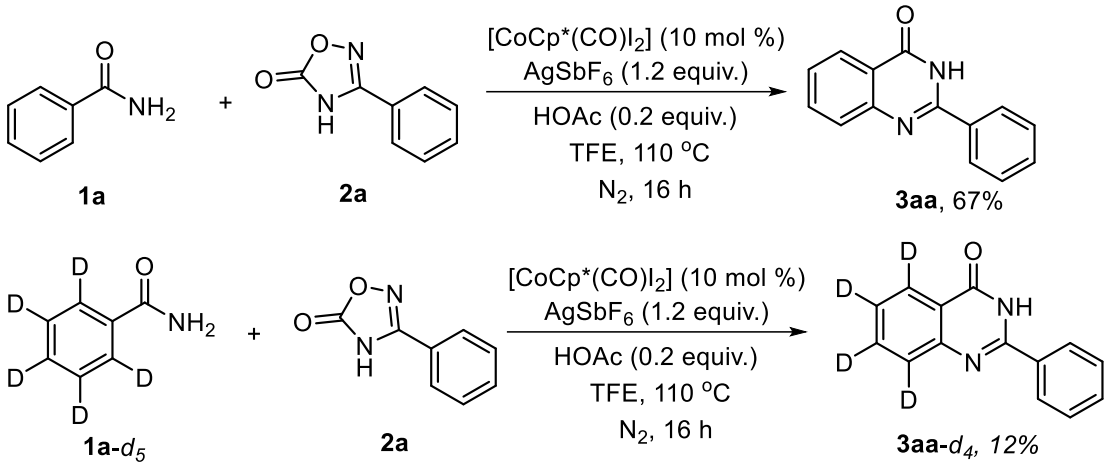


Figure S1. ^{1}H NMR spectra for the mixture of products and corresponding reference compound.

Parallel experiment



[**3aa**]/[**3aa**-d_4] = 5.6

To a 10 mL schlenk tube equipped with magnetic bar was added benzamide (**1a**, 29.0 mg, 0.24 mmol, 1.2 equiv), 3-phenyl-1,2,4-oxadiazol-5(4*H*)-one (**2a**, 32.4 mg, 0.2 mmol, 1.0 equiv) and [CoCp*(CO)I_2] (9.6 mg, 0.02 mmol, 10 mol%). The tube was then transferred to a glovebox, and added with $AgSbF_6$ (82.2 mg, 0.24 mmol, 1.2 equiv). After the tube was removed from the glovebox, a solution of HOAc (2.4 μL, 0.04 mmol, 0.2 equiv) in 2 mL of CF_3CH_2OH was injected into the tube via syringe. The reaction mixture was placed in a pre-heated oil bath (110 ℃) and stirred for 16 h, during which time a constant checking by TLC was performed every three hours. The reaction mixture was cooled to rt and filtered over celite. The solvent was then removed under reduced pressure and the residue was purified by column chromatography on silica gel with PE/ EtOAc (2:1) as the eluent to afford **3aa** in 67% yield as white solid (30.0 mg). **3aa**-d_4 was obtained according to above procedure in 12% yield as white solid (5.4 mg).

References

[1] X. Yu, K. Chen, F. Yang, S. Zha, J. Zhu, *Org. Lett*., 2016, **18**, 5412-5415.

[2] P. Marzullo, S. Vasto, S. Buscemi, A. Pace, D. Nuzzo, A. Piccionello, *Int. J. Mol. Sci*., 2021, **22**, 12301.

[3] J. Chen, K. Natte, H. Neumann, X. Wu, *Chem. Eur. J*. 2014, **20**, 16107 - 16110.

[4] R. Cheng, L. Tang, T. Guo, D. Negrerie, Y. Du, K. Zhao, *RSC Adv*. 2014, **4**, 26434.

[5] J. Chen, N. Liang, J. Shi, Y. Wu, K. Wen, X. Yao, X. Tang, *RSC Adv*. 2021, **11**, 4966.

[6] L. Wei, Y. Wei, J. Zhang, L. Xu, *Green Chem*. 2021, **23**, 4446.

[7] K. Wang, H. Chen, X. Dai, X. Huang, Z. Feng, *RSC Adv*., 2021, **11**, 13119.

[8] M. Shinde, U. Kshirsagar, *RSC Adv*. 2016, **6**, 52884.

[9] H. Wei, L. Zhou, Y. Zhou, Q. Zeng, *Toxical. Environ. Chem.*, 2015, **97**, 2-10.

[10] S. Maiti, J. Kim, J. Park, D. Nam, J. Lee, Y. Kim, J. Kee, J. Seo, K. Myung, J. Rohde, W. Choe, O. Kwon, S. Hong, *J. Org. Chem*. 2019, **84**, 6737-6751.

[11] Q. Wang, M. Lv, J. Liu, Y. Li, Q. Xu, X. Zhang, H. Cao, *ChemSusChem*. 2019, **12**, 3043 - 3048.

[12] S. Matcha, B. Karasala, S. Botsa, S. Vidavalur, *J Heterocyclic Chem*., **2021**, 58, 1955-1961.

[13] D. Khadka, G. Tran, S. Shin, H. Nguyen, H. Cao, C. Zhao, Y. Jin, H. Van, M. Chau, Y. Kwon, T. Le, W. Cho, *Eur. J. Med. Chem.,* 2015, **103**, 69-79.

[14] K. Manoranjan, S. Richa, B. Vinod, K. Neeraj, *Adv. Synth. Catal*., 2015, **357**, 2862 - 2868.

[15] İ. ŞENOL, İ. ÇELİK, İ. AVAN, *Turk J Chem.,* 2019, **49**, 1580 - 1596.

[16] P. Cai, E. Zhang, Y. Wu, T. Fang, Q. Li, C. Yang, J. Wang, Y. Shang, ACS Omega, 2018, **3**, 14575-14584.

[17] Z. Wang, H. Wang, H. Wang, L. Li, M. Zhou, *Org. Lett.,* 2021, **23**, 995-999.

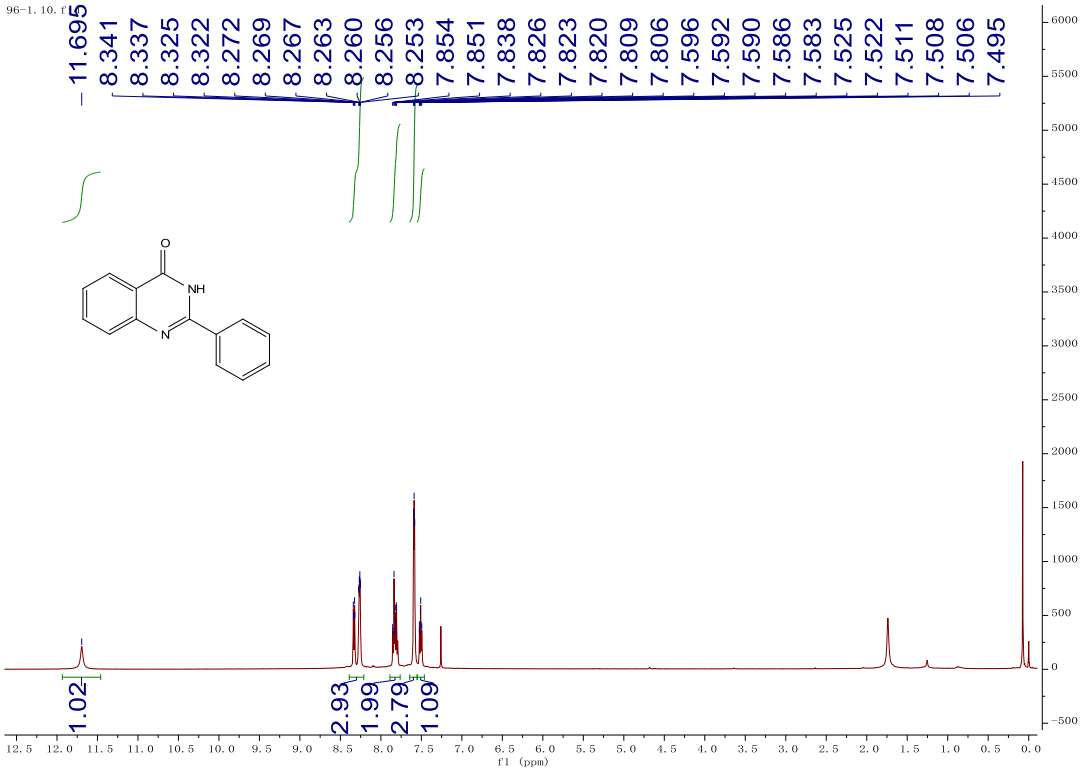
[18] B. Ma, Y. Wang, J. Peng, Q. Zhu, *J. Org. Chem.,* 2011, **76**, 6362- 6366.

[19] G. Zhang, C. C. Aldrich, *Acta Crystallogr.*, 2019, ***C75***, 1031-1035.

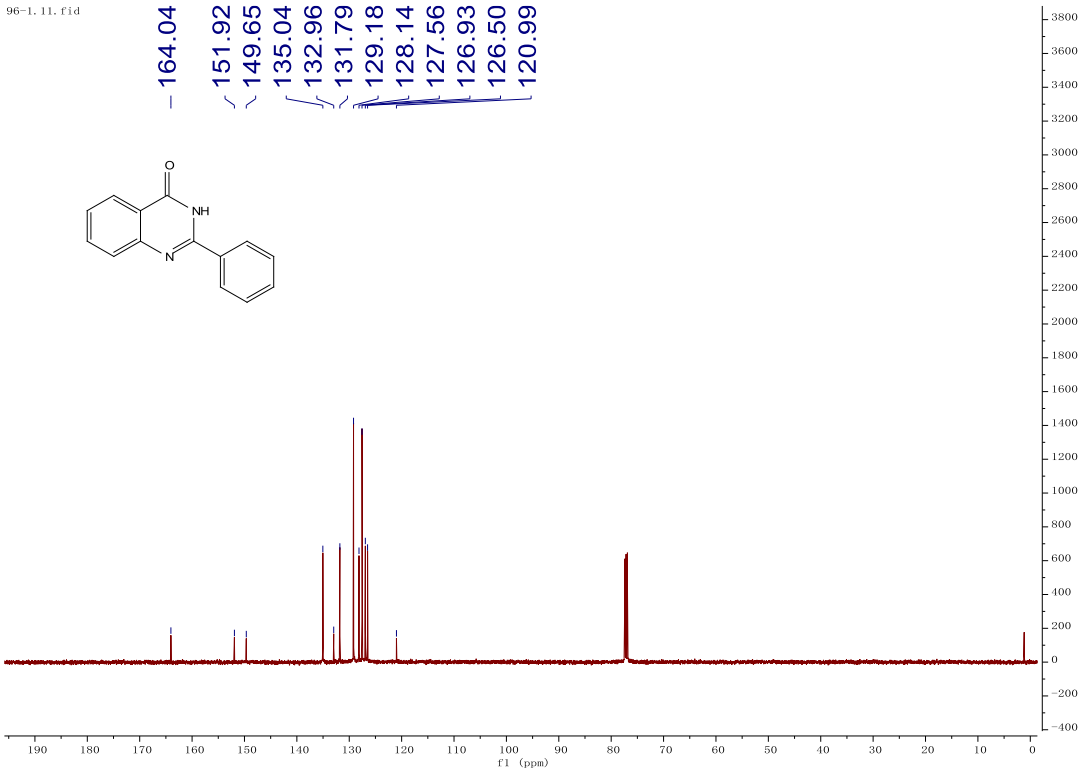
[20] K. Park, N. Ito, T. Yamada, H. Sajiki, *Bull. Chem. Soc. Jpn.*, 2021, **94**, 600-605.

NMR Spectra for Compounds

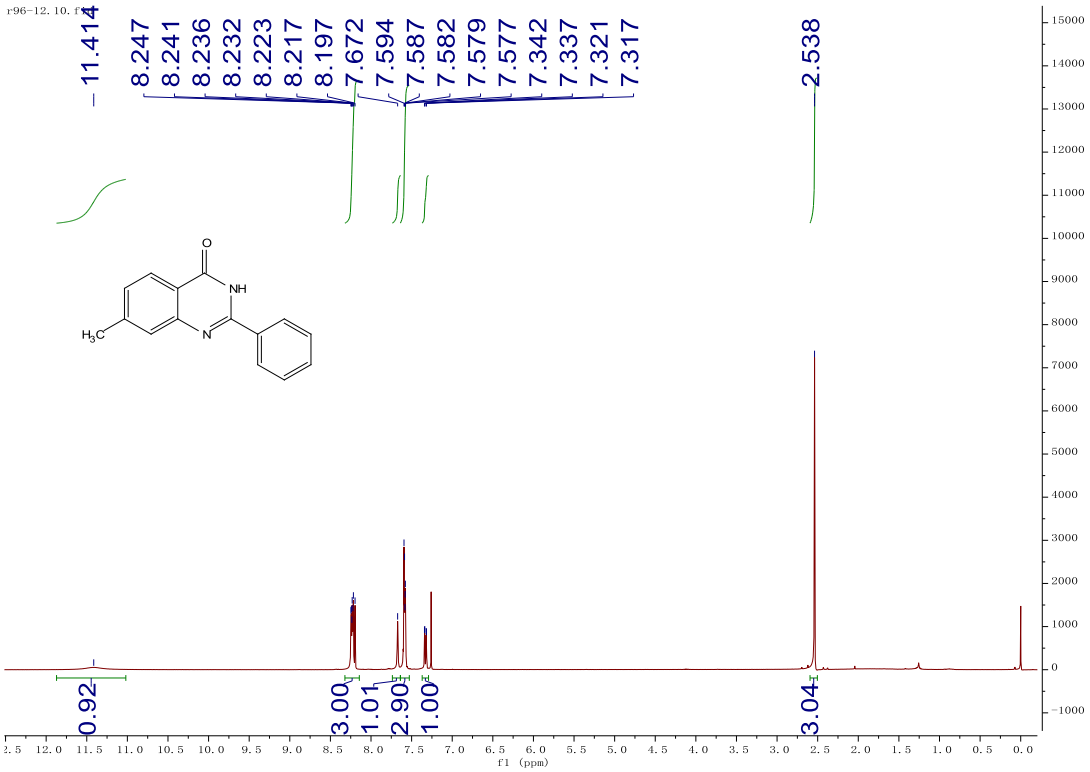
3aa (^{1}H, $CDCl_3$)



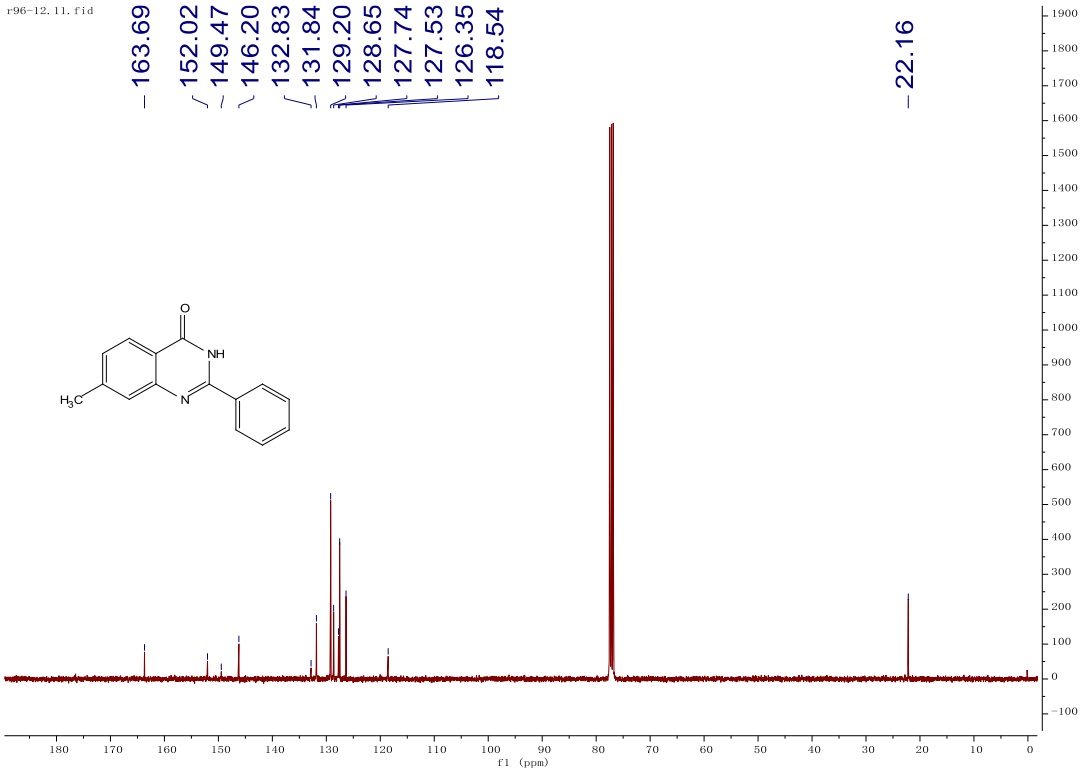
3aa (^{13}C, $CDCl_3$)



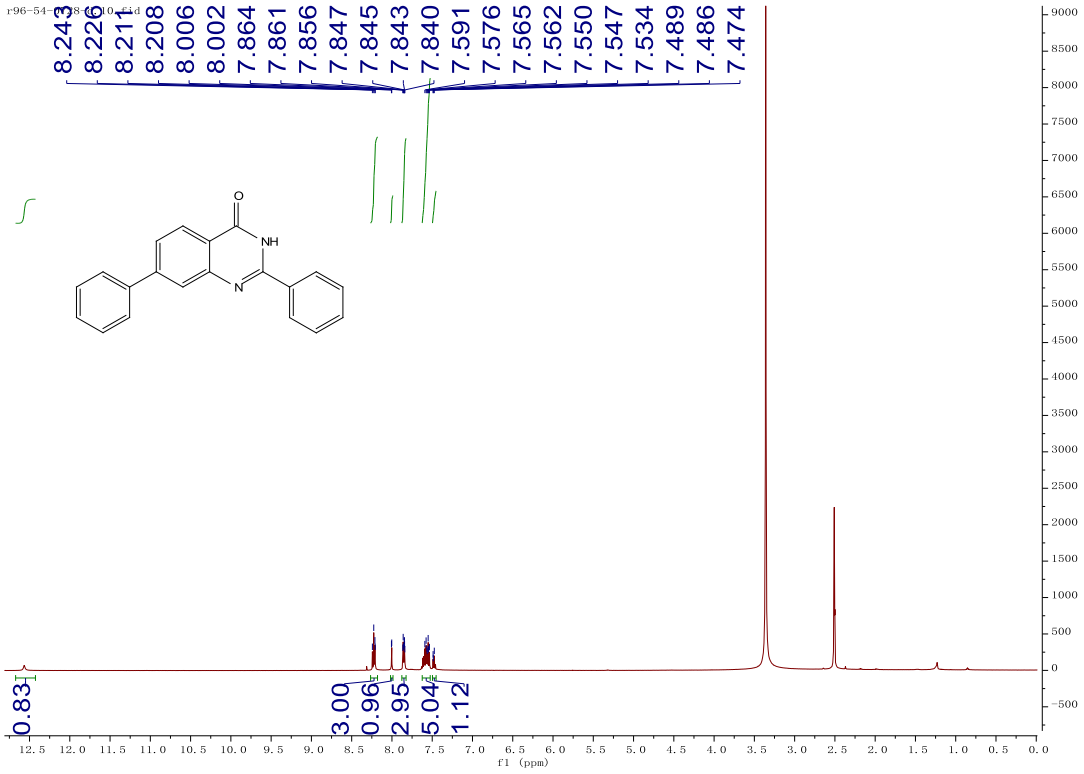
3ba (^{1}H, $CDCl_3$)



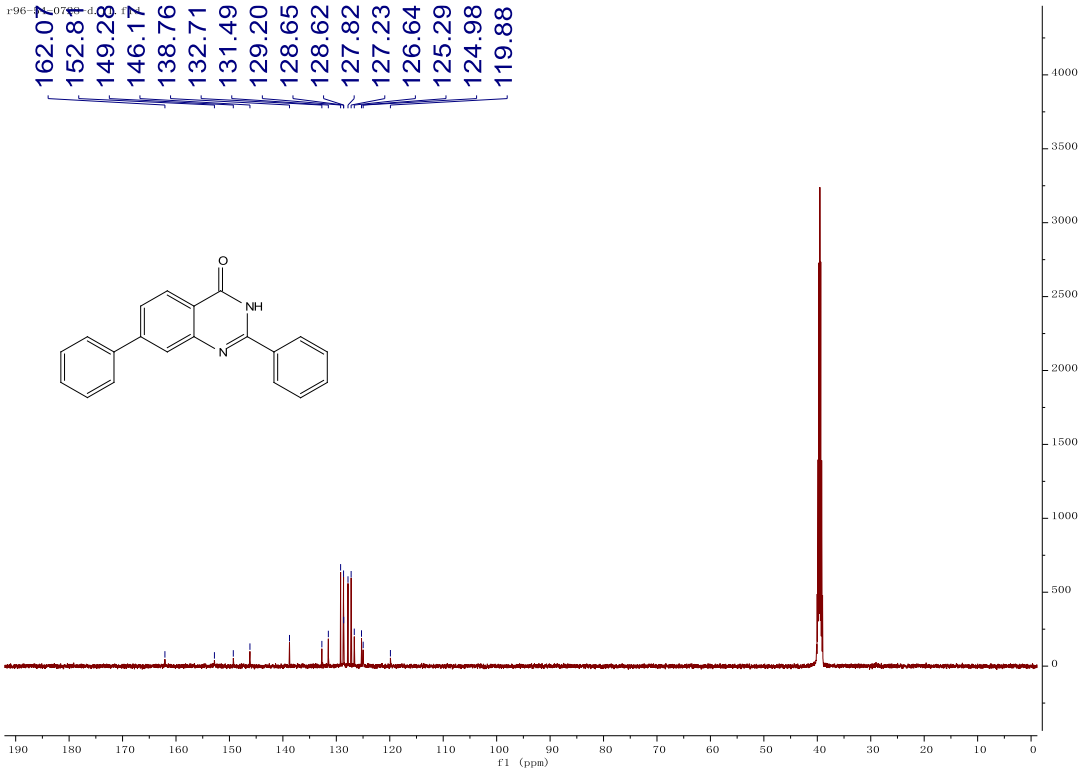
3ba (^{13}C, $CDCl_3$)



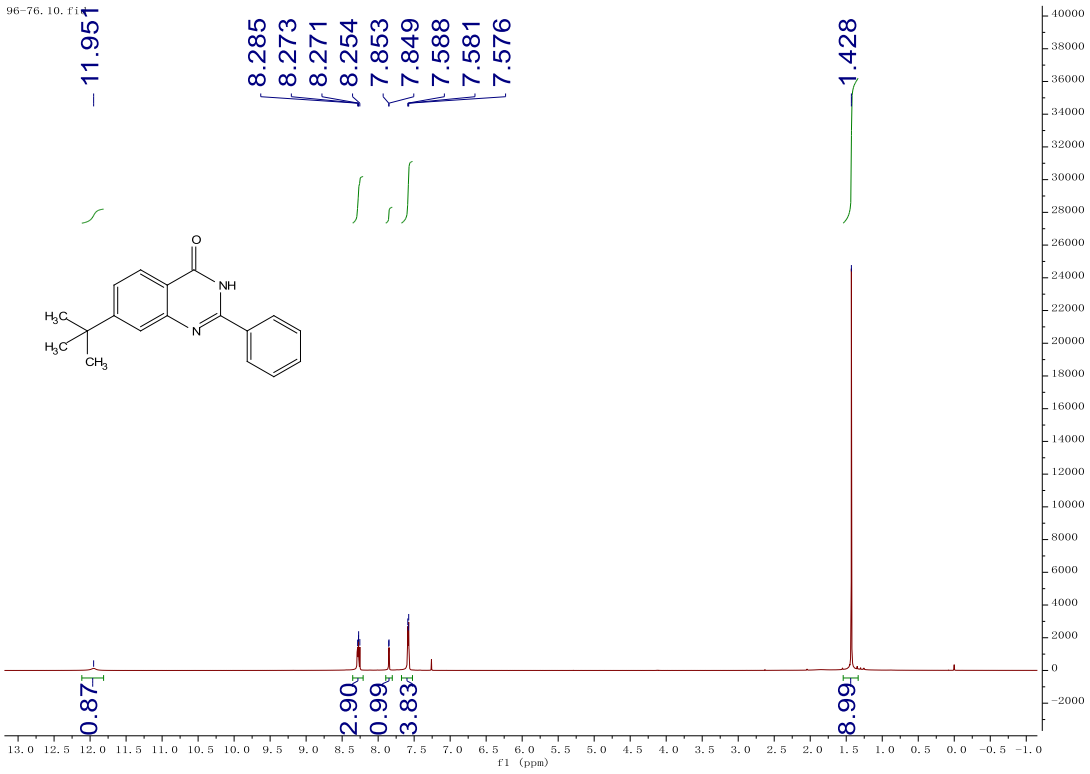
3ca (^{1}H, DMSO-d_6)



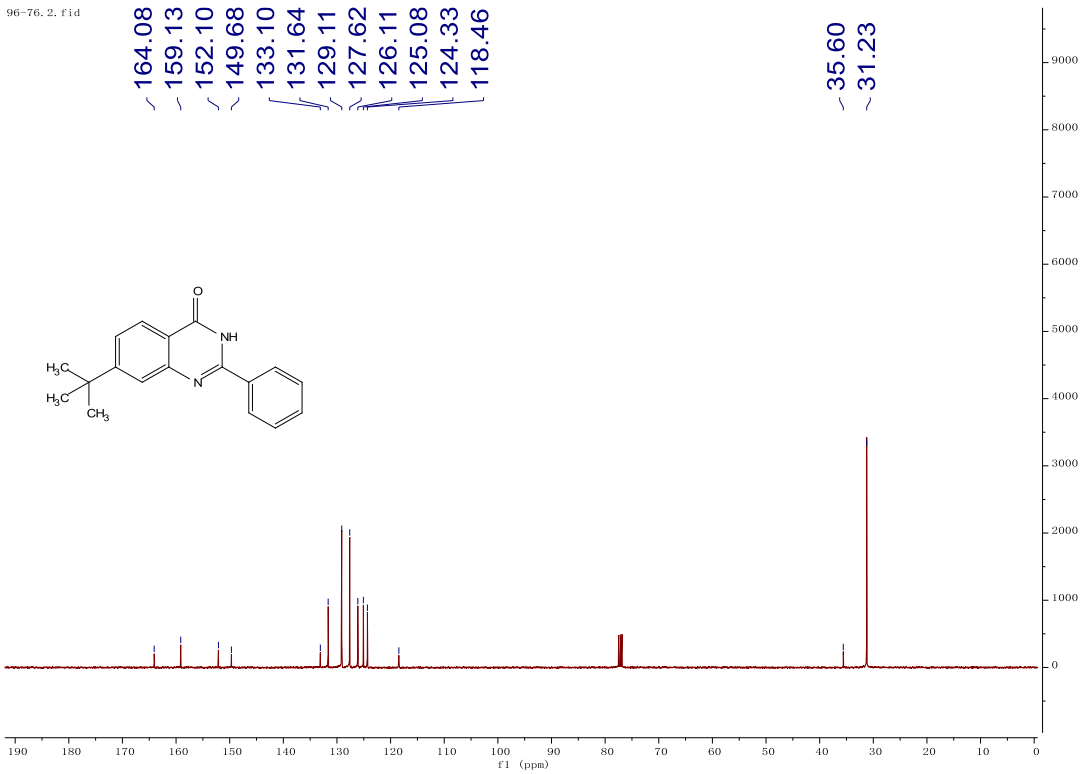
3ca (^{13}C, DMSO-d_6)



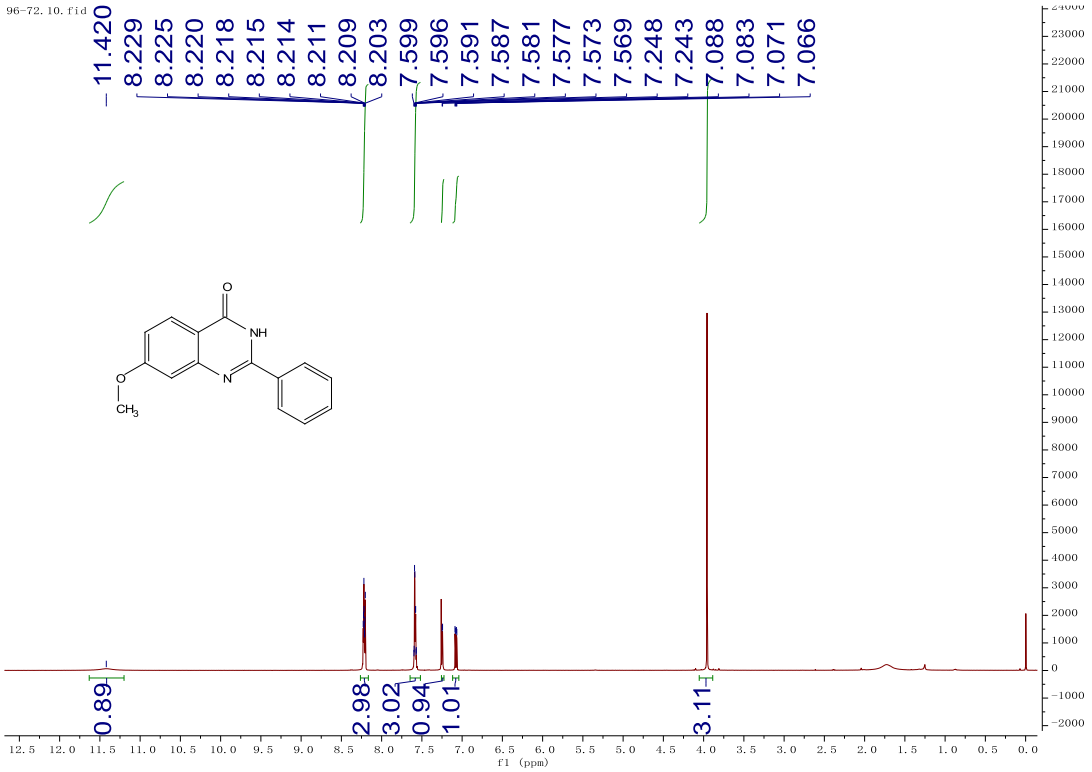
3da (^{1}H, $CDCl_3$)



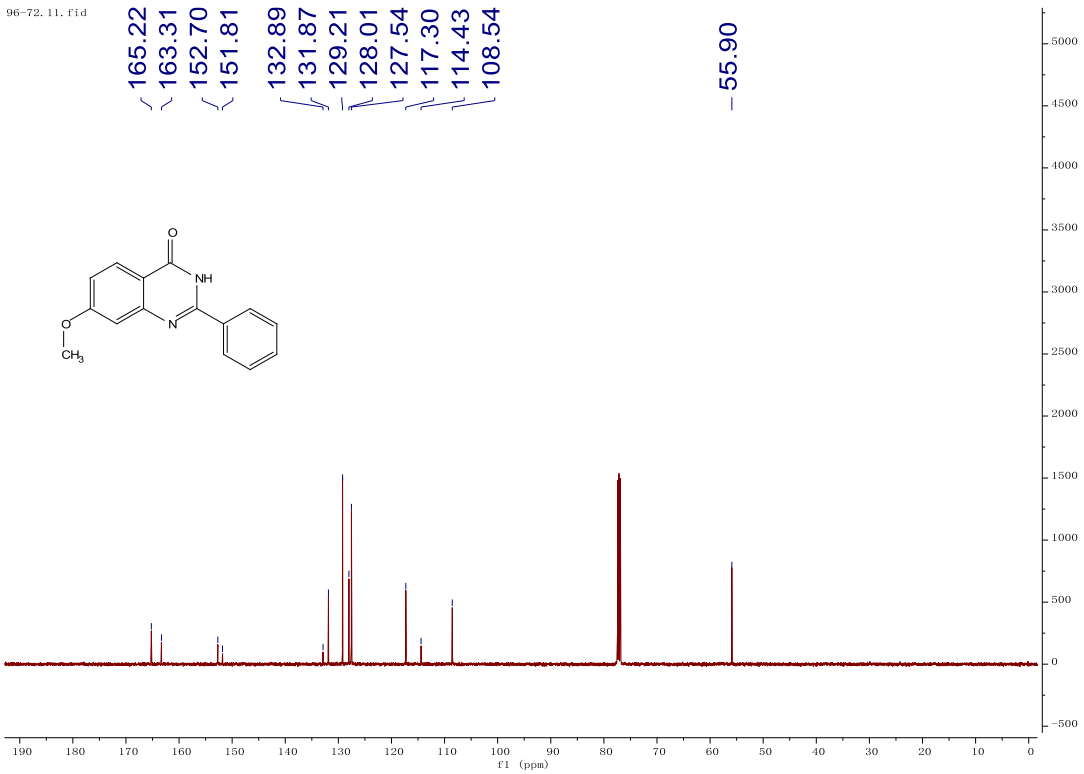
3da (^{13}C, $CDCl_3$)



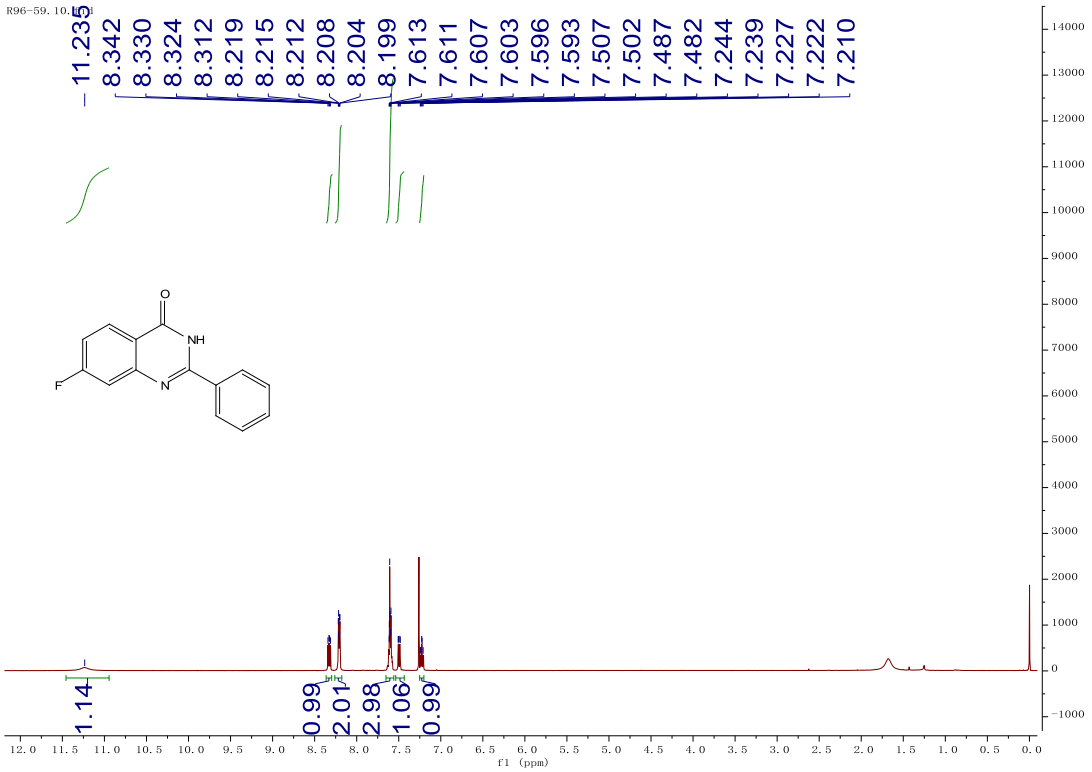
3ea (^{1}H, $CDCl_3$)



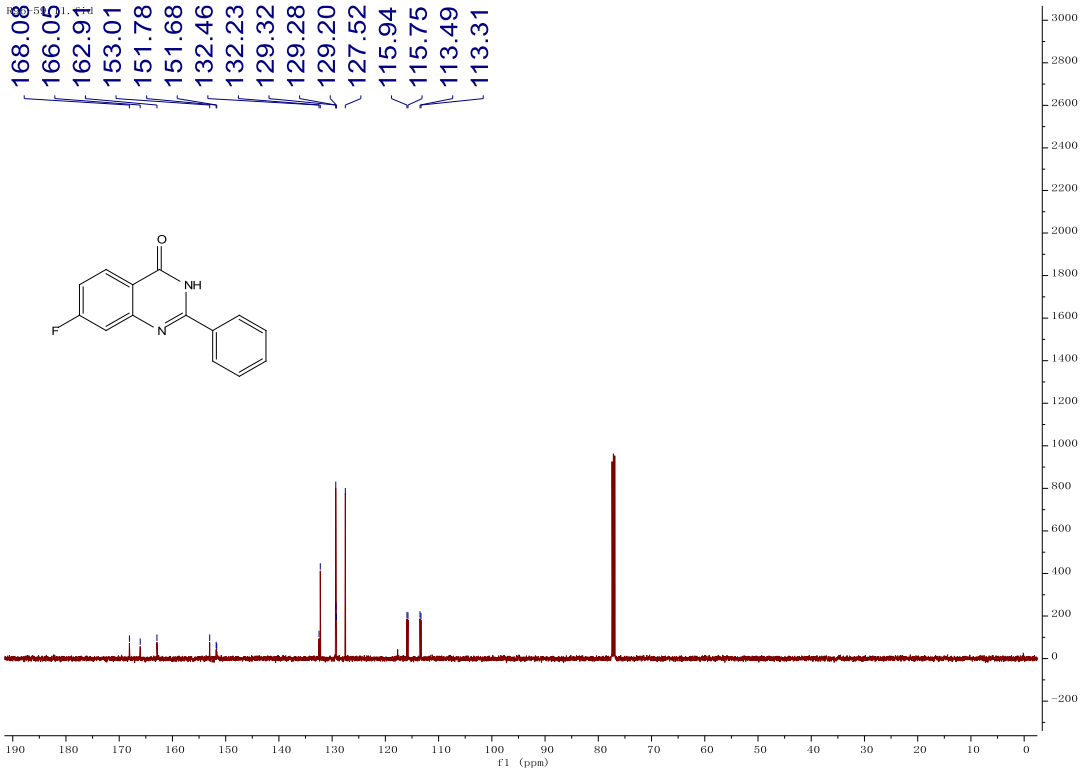
3ea (^{13}C, $CDCl_3$)



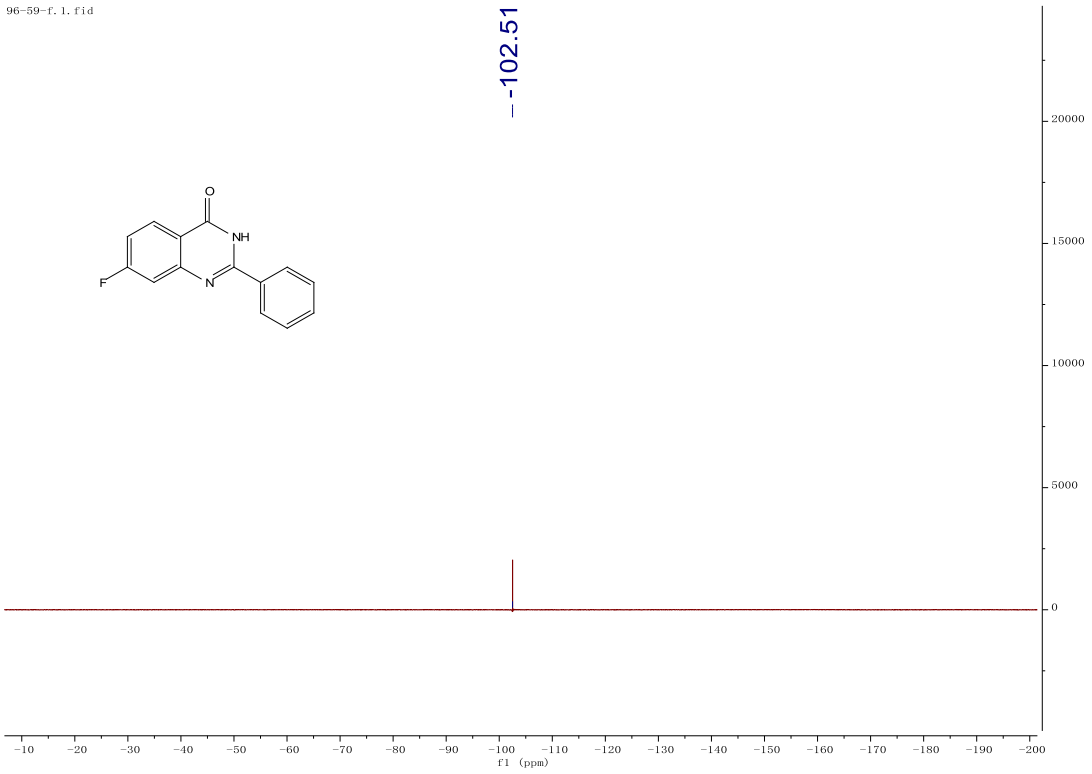
3fa (^{1}H, $CDCl_3$)



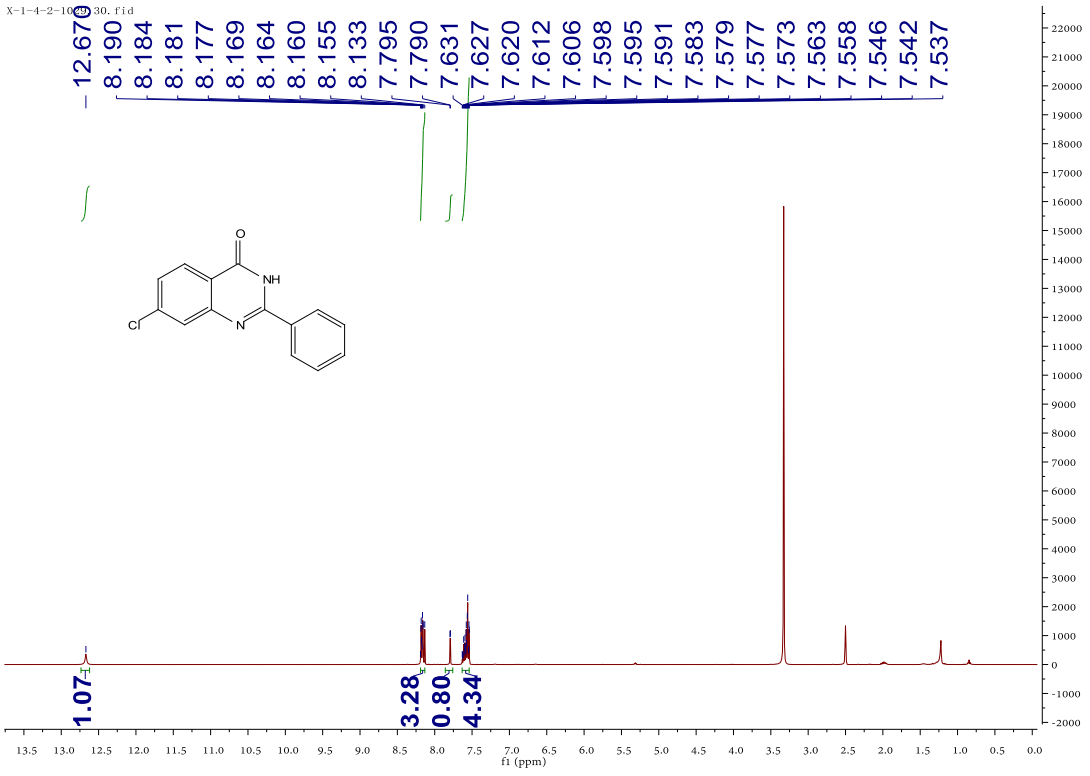
3fa (^{13}C, $CDCl_3$)



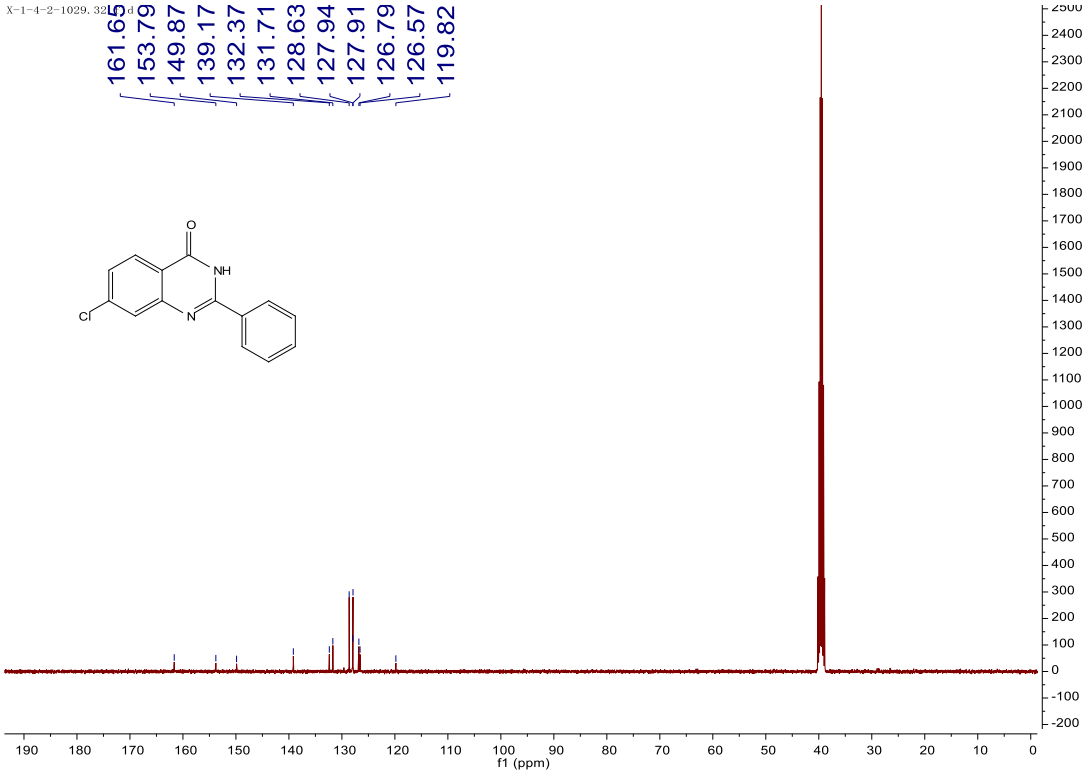
3fa (^{19}F, $CDCl_3$)



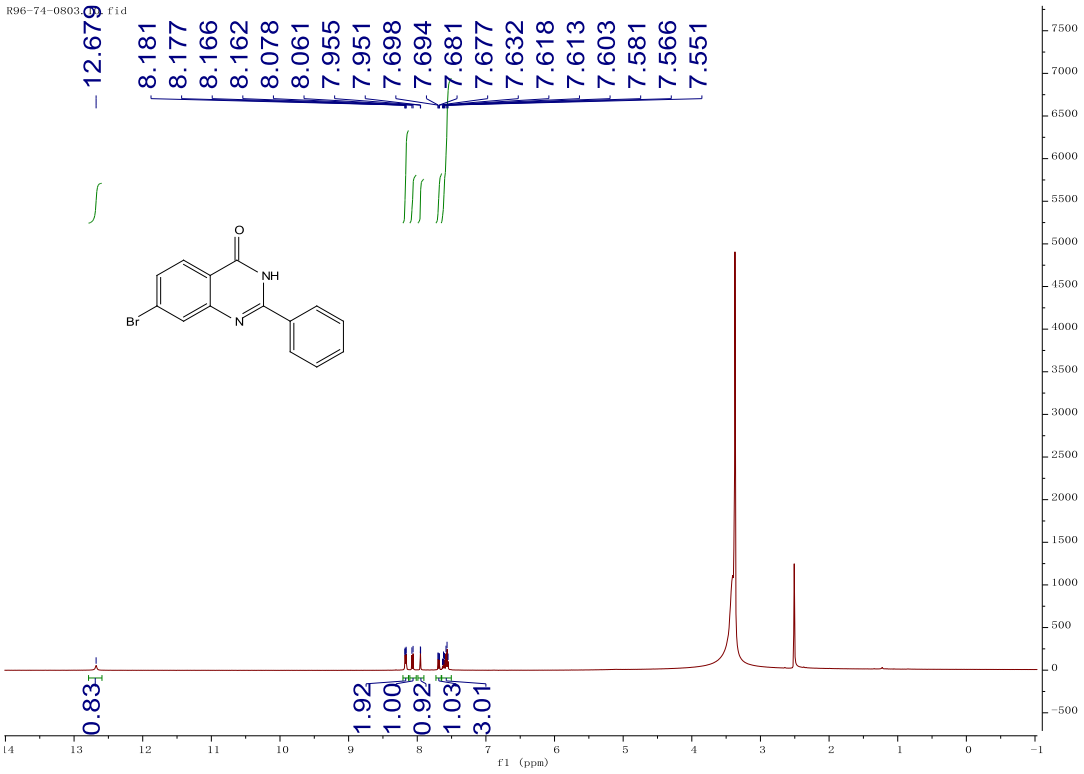
3ga (^{1}H, DMSO-d_6)



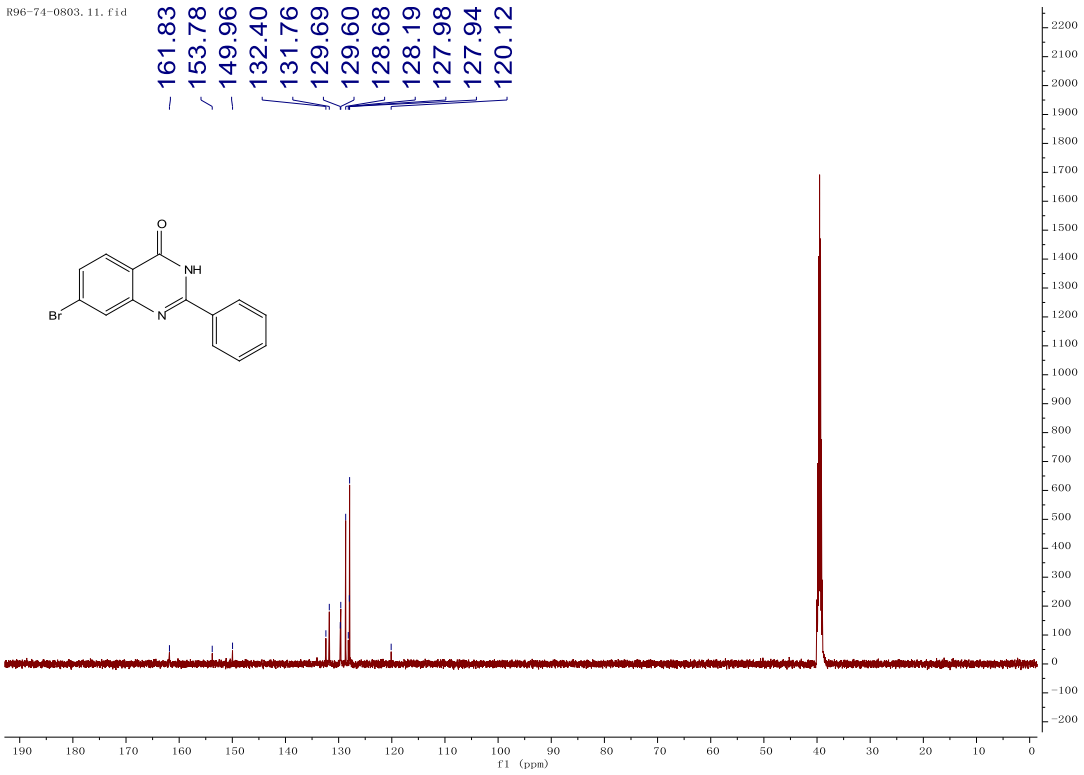
3ga (^{13}C, DMSO-d_6)



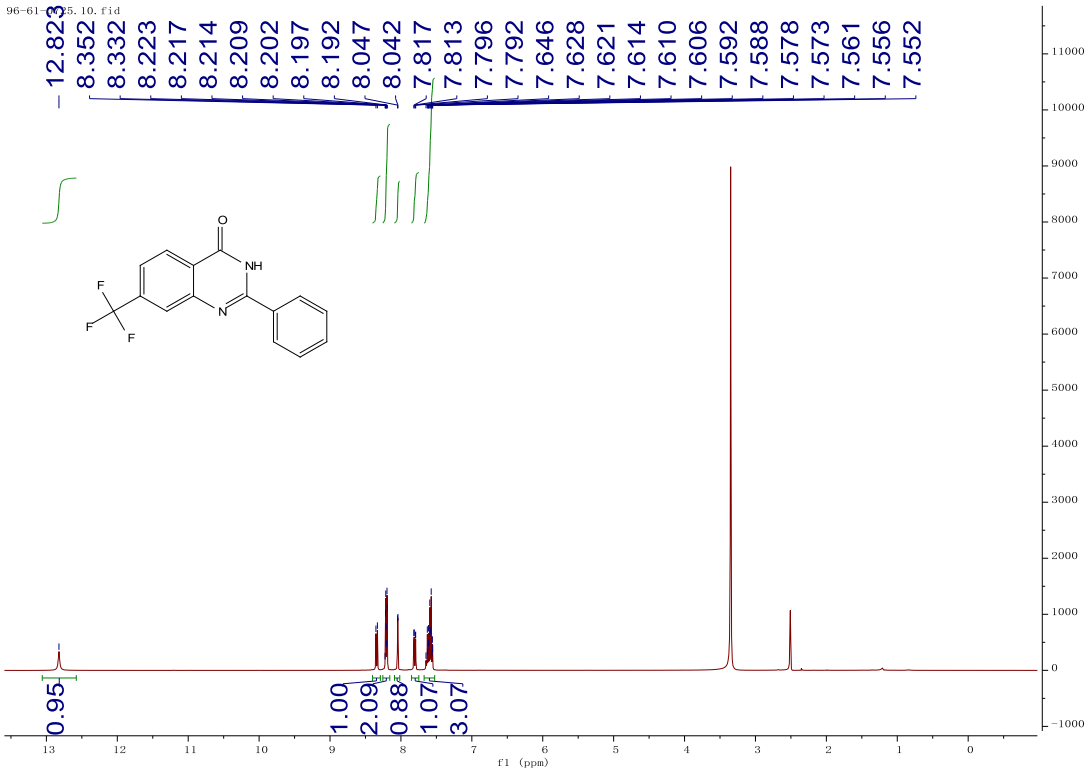
3ha (^{1}H, DMSO-d_6)



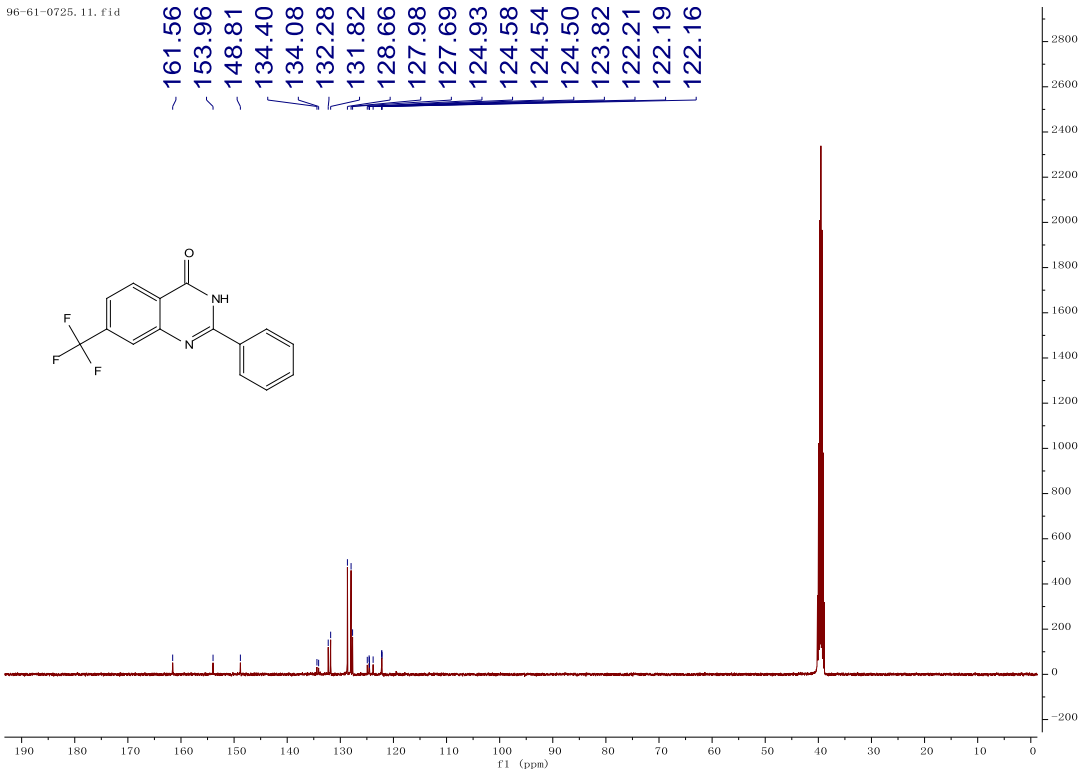
3ha (^{13}C, DMSO-d_6)



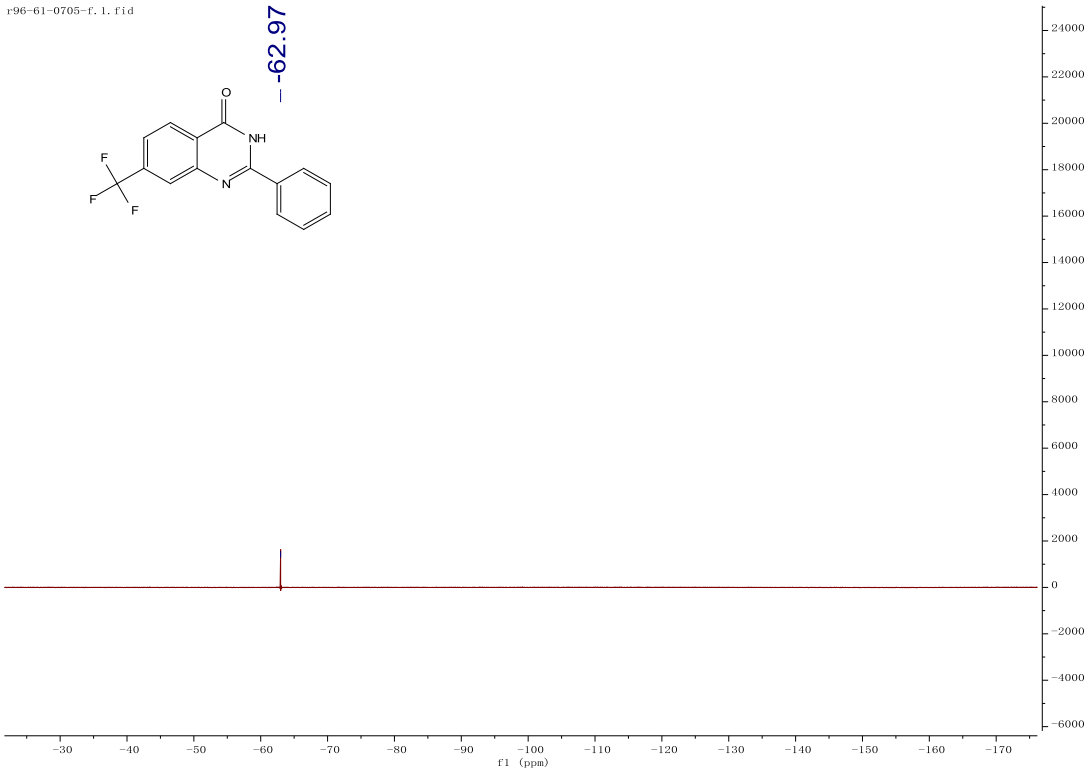
3ia (^{1}H, DMSO-d_6)



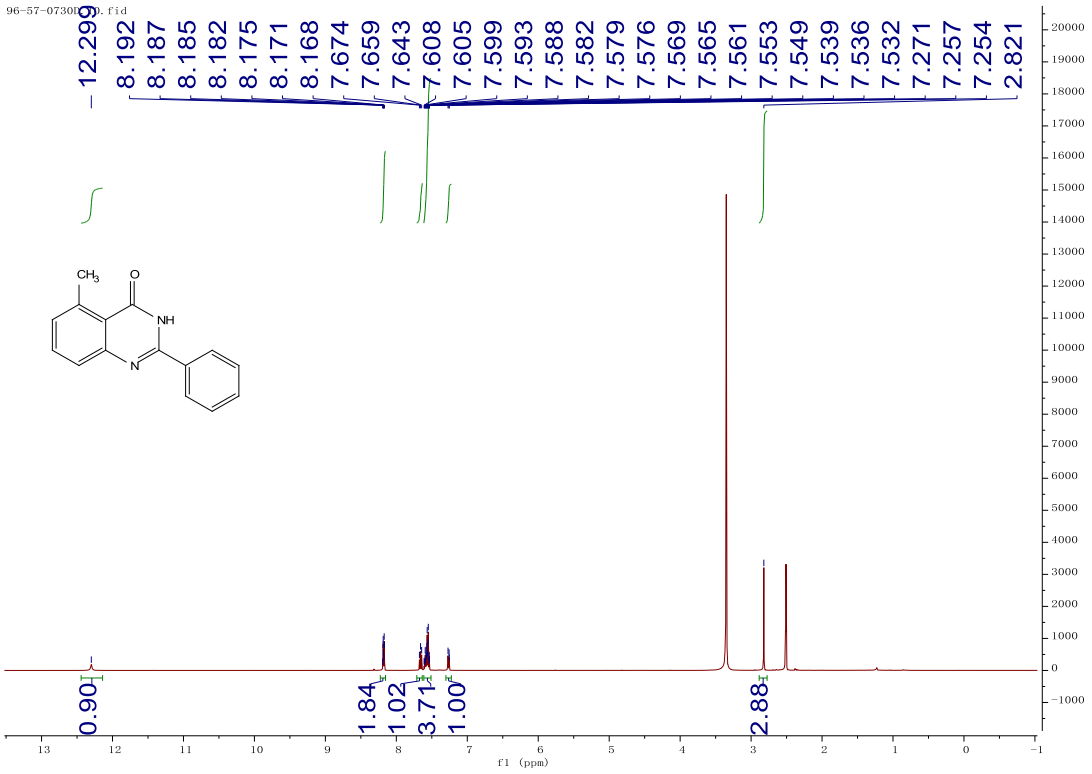
3ia (^{13}C, DMSO-d_6)



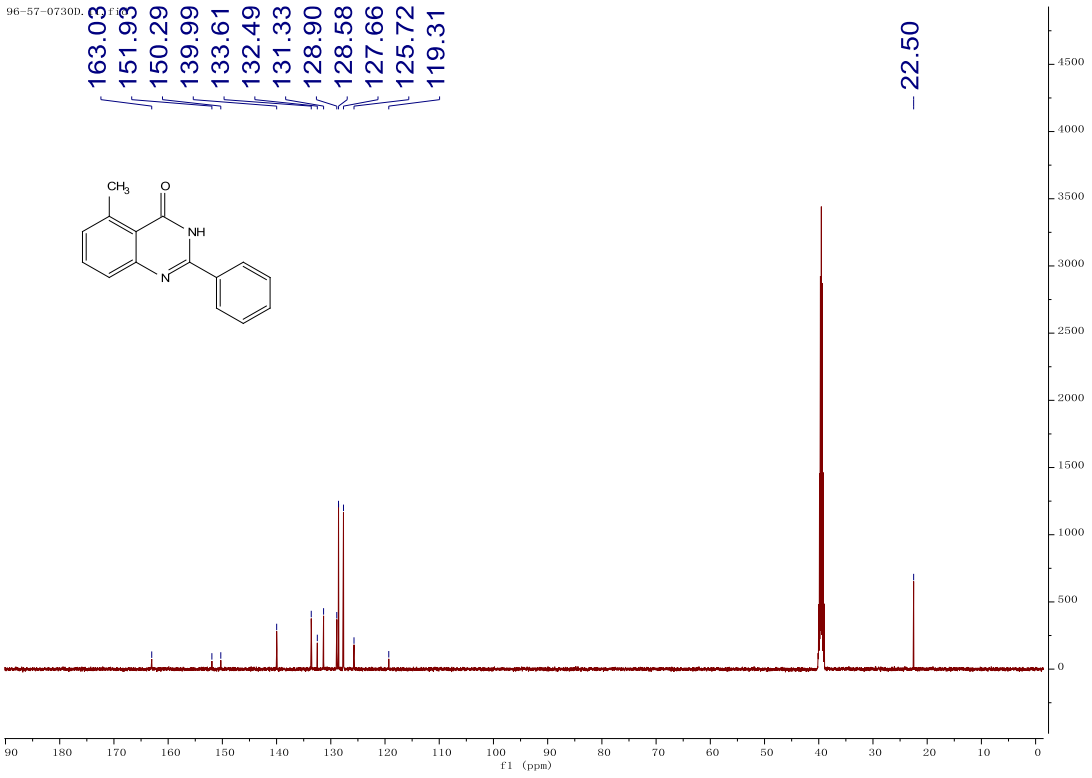
3ia (^{19}F, DMSO-d_6)



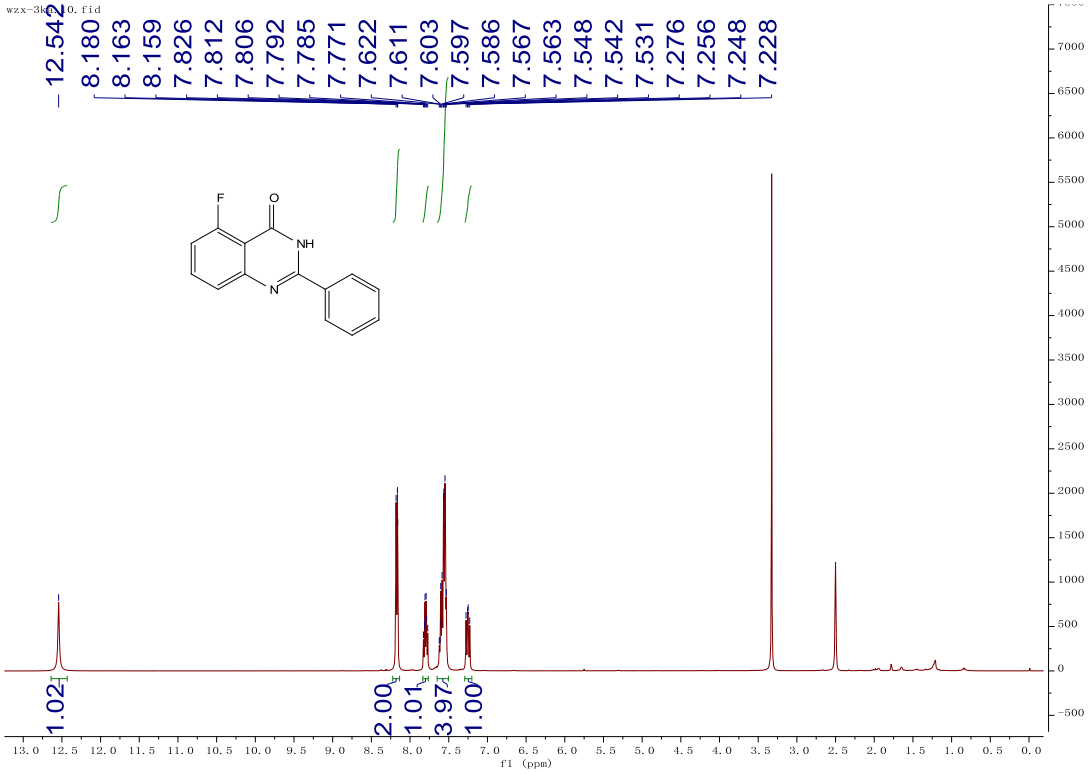
3ja (^{1}H, DMSO-d_6)



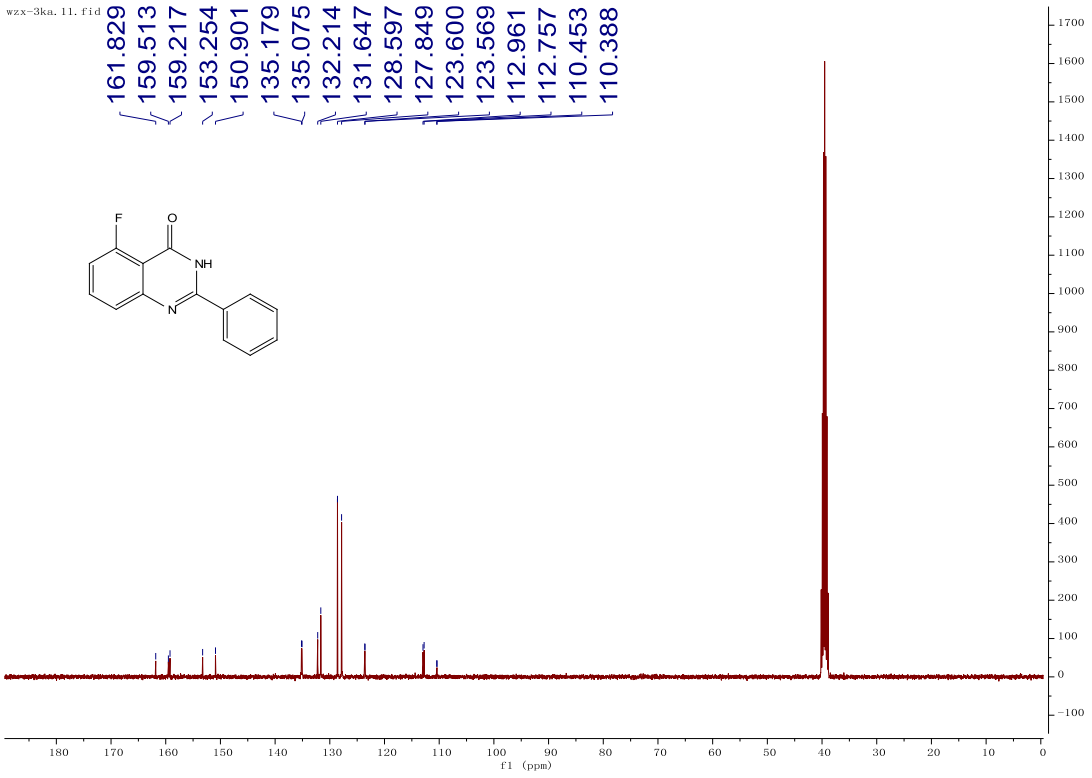
3ja (^{13}C, DMSO-d_6)



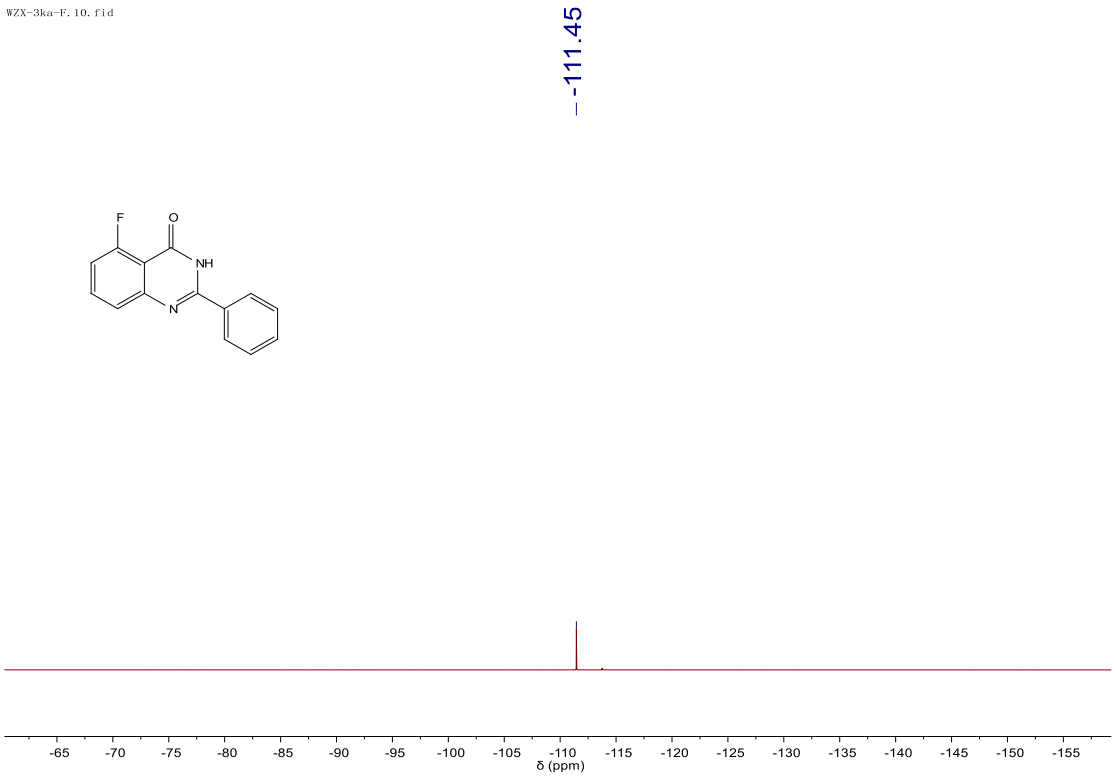
3ka (^{1}H, DMSO-d_6)



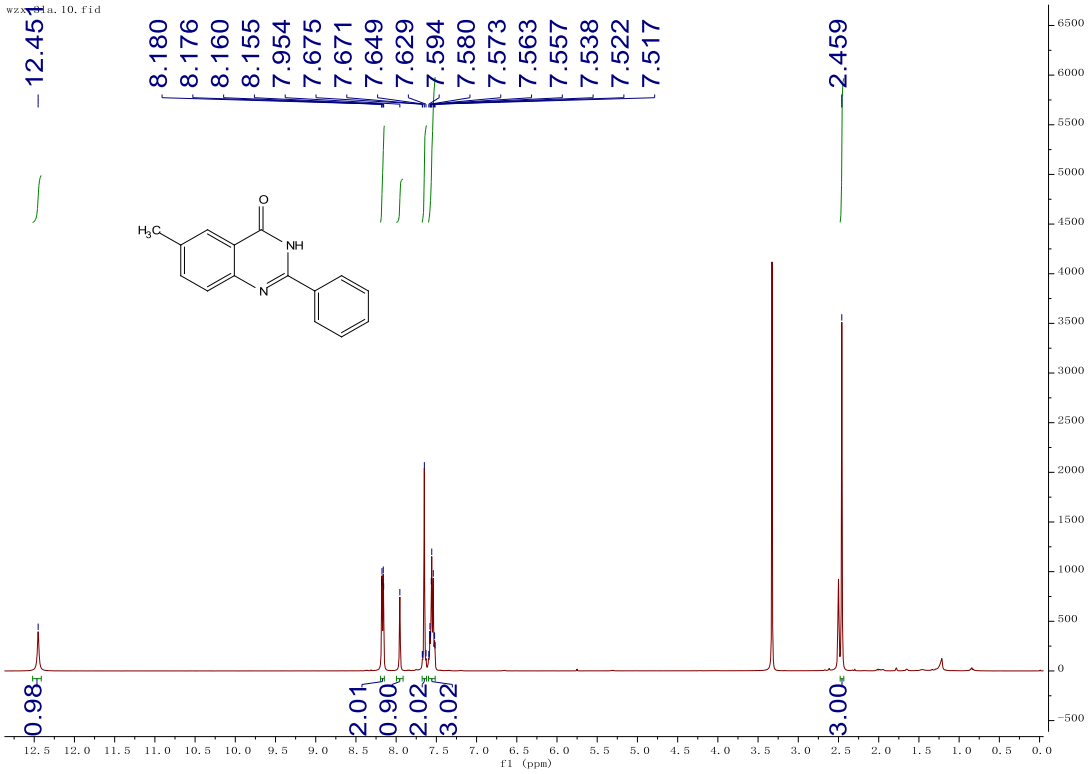
3ka (^{13}C, DMSO-d_6)



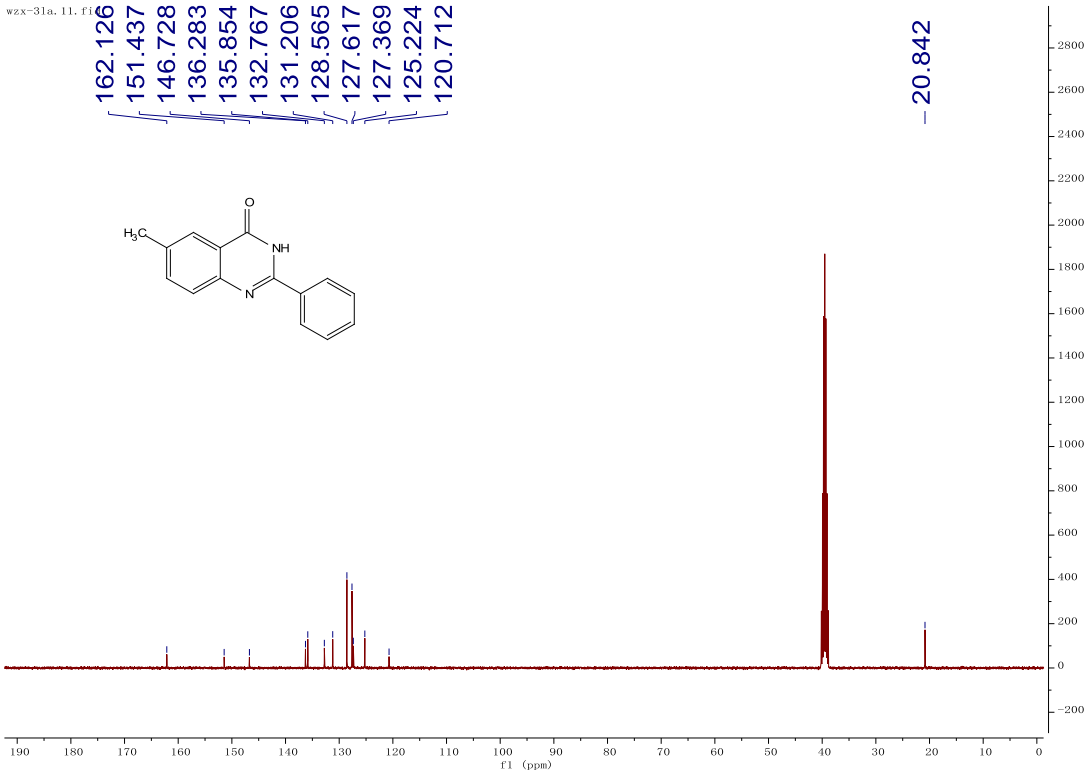
3ka (^{19}F, DMSO-d_6)



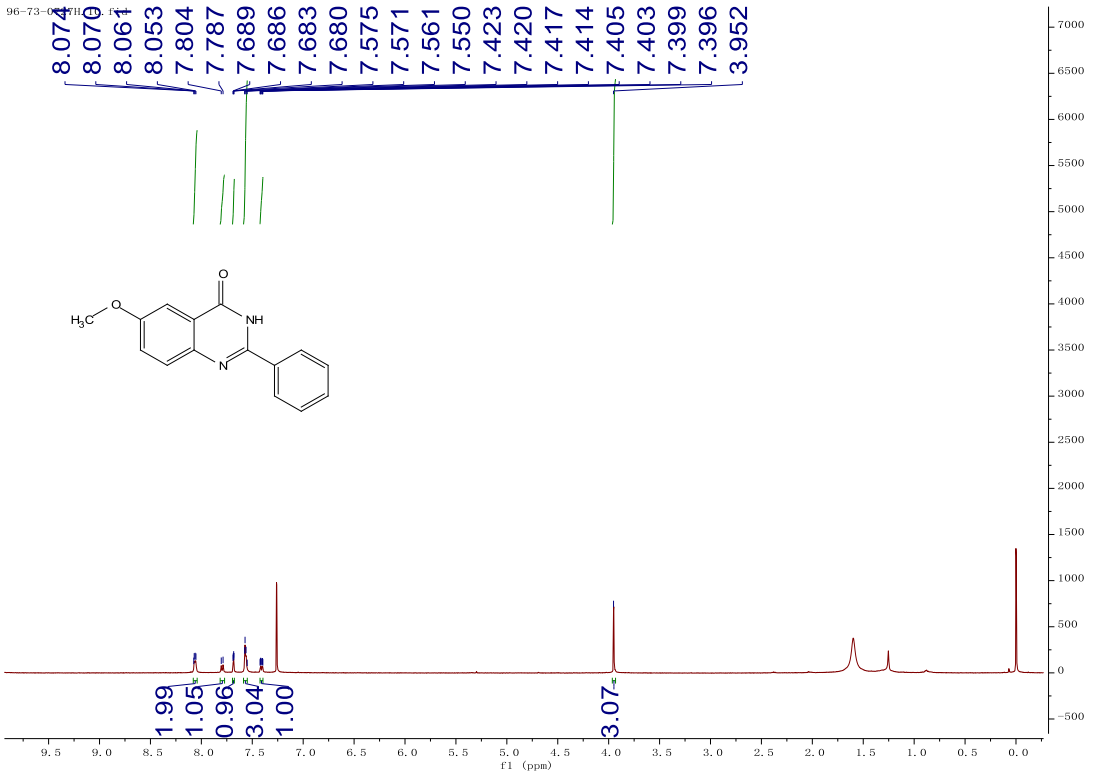
3la (^{1}H, DMSO-d_6)



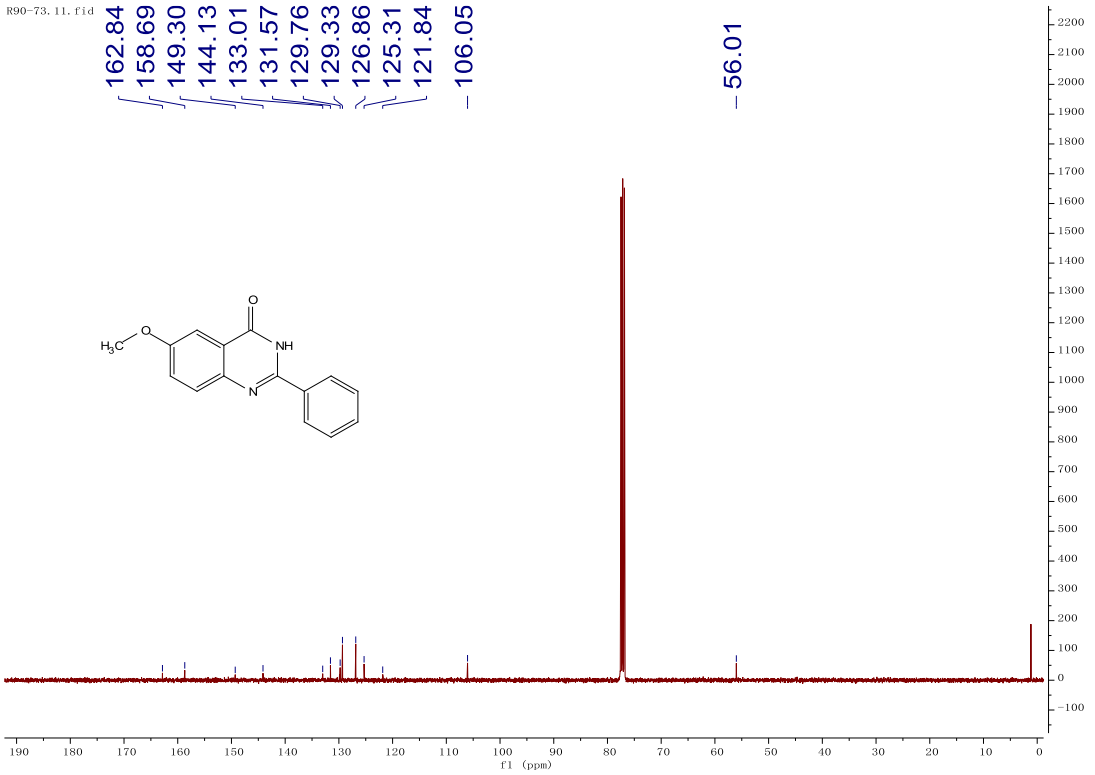
3la (^{13}C, DMSO-d_6)



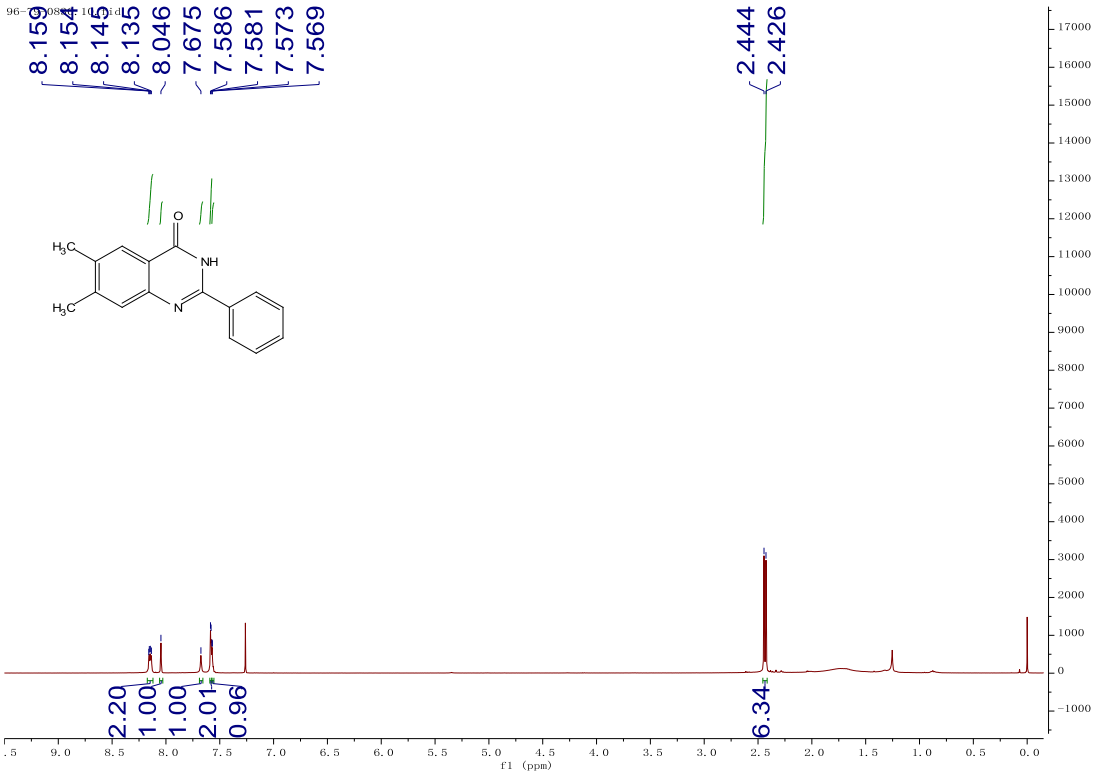
3ma (^{1}H, $CDCl_3$)



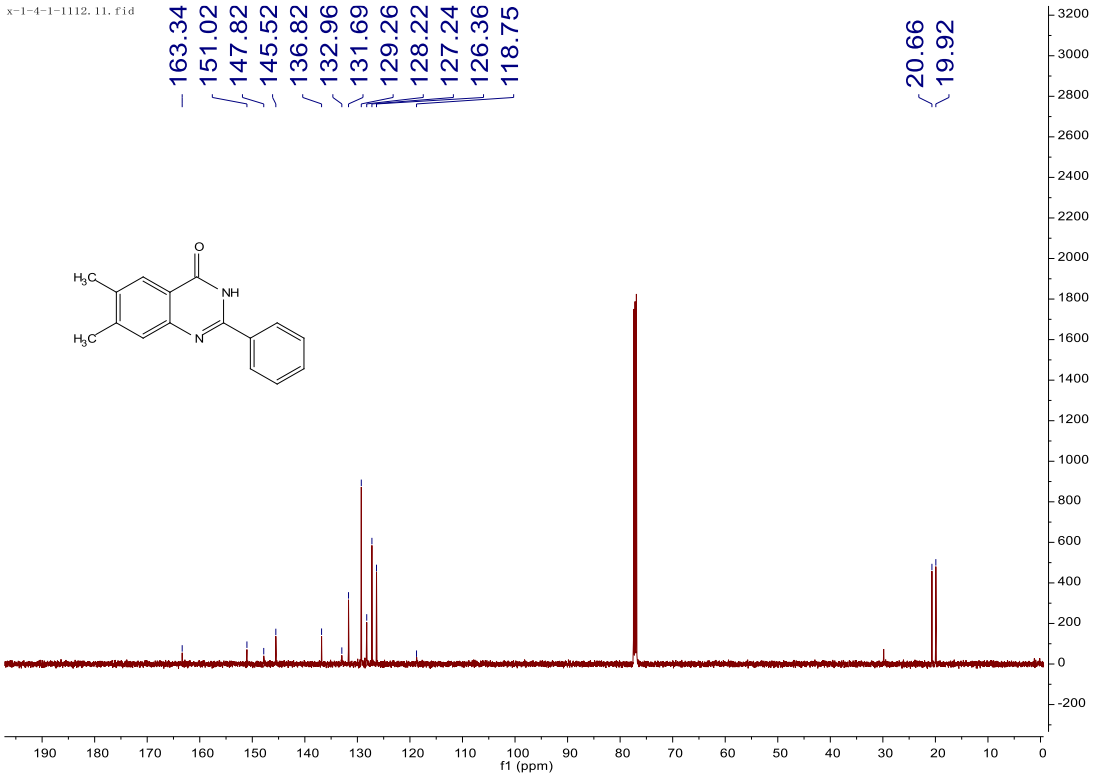
3ma (^{13}C, $CDCl_3$)



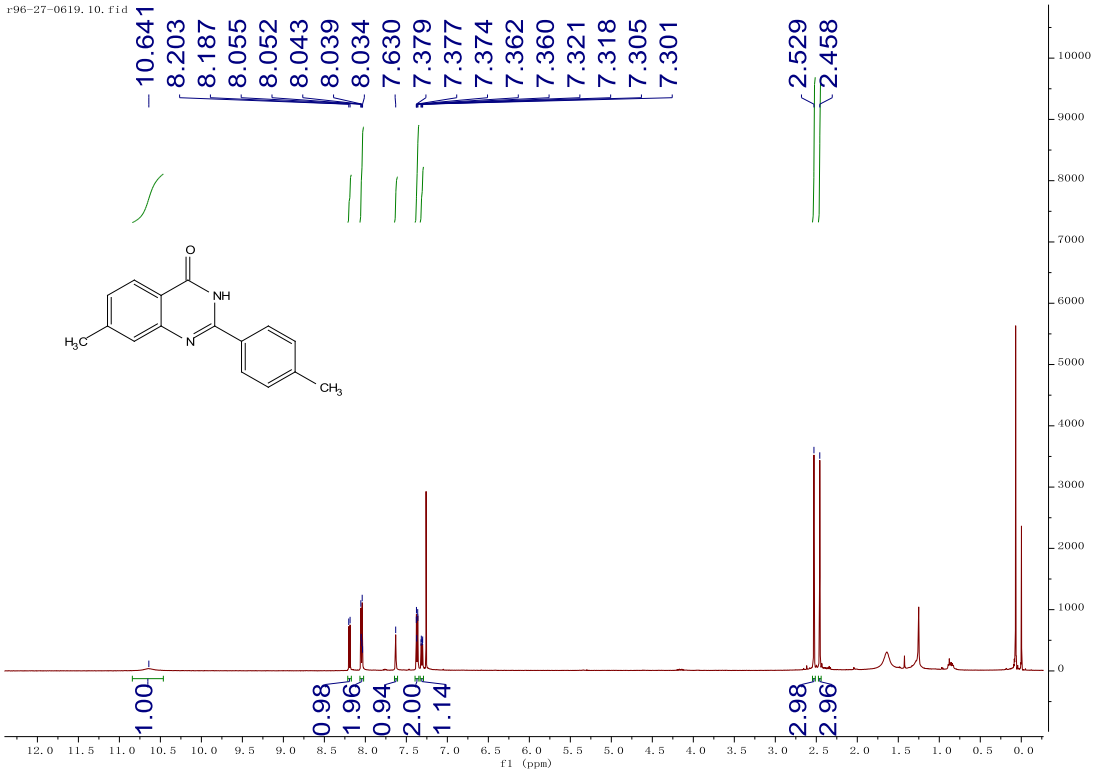
3na (^{1}H, $CDCl_3$)



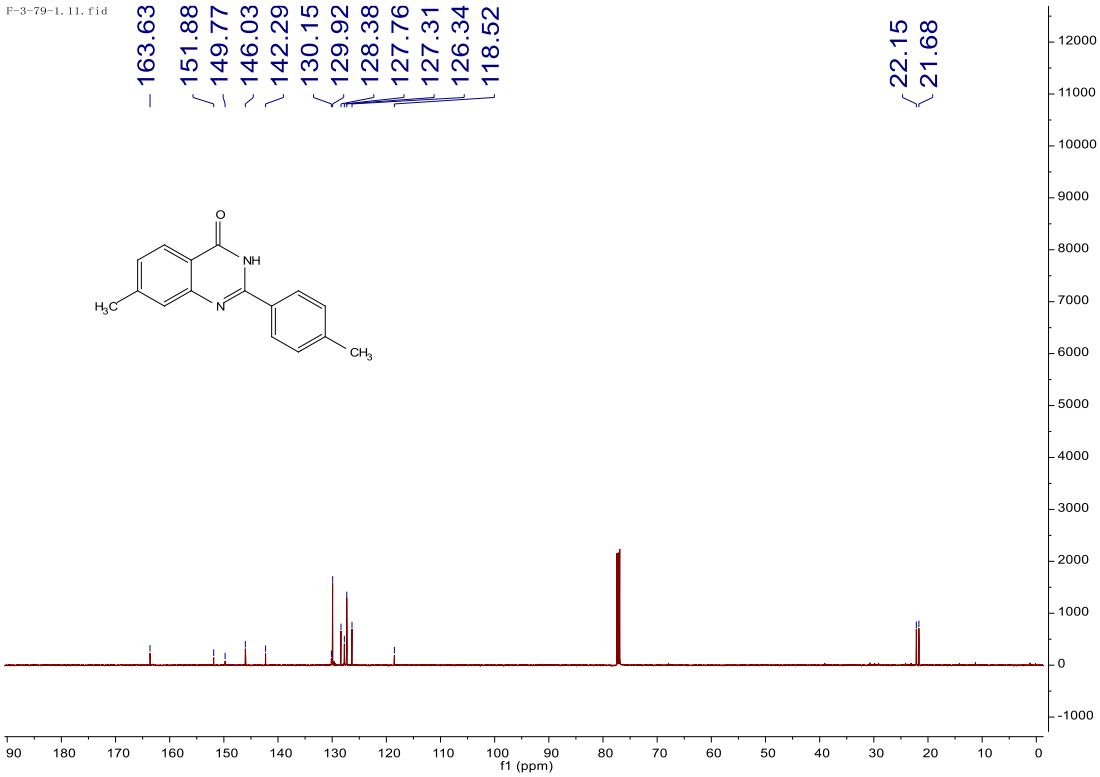
3na (^{13}C, $CDCl_3$)



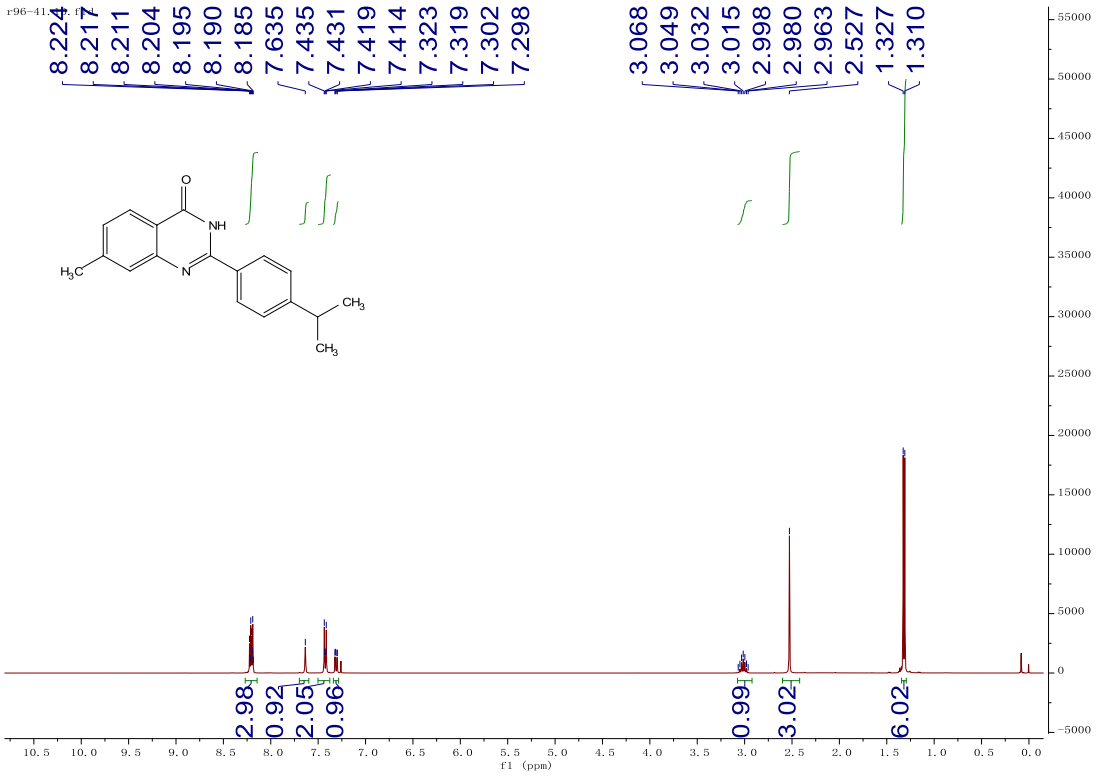
3bb (^{1}H, $CDCl_3$)



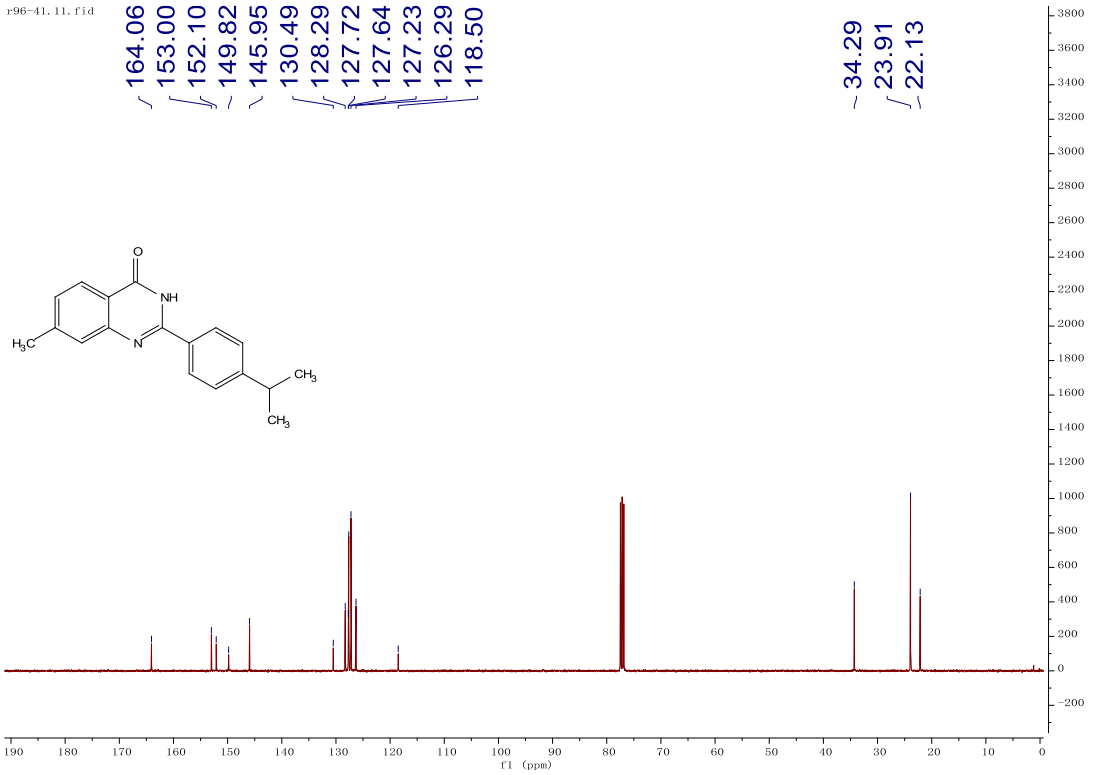
3bb (^{13}C, $CDCl_3$)



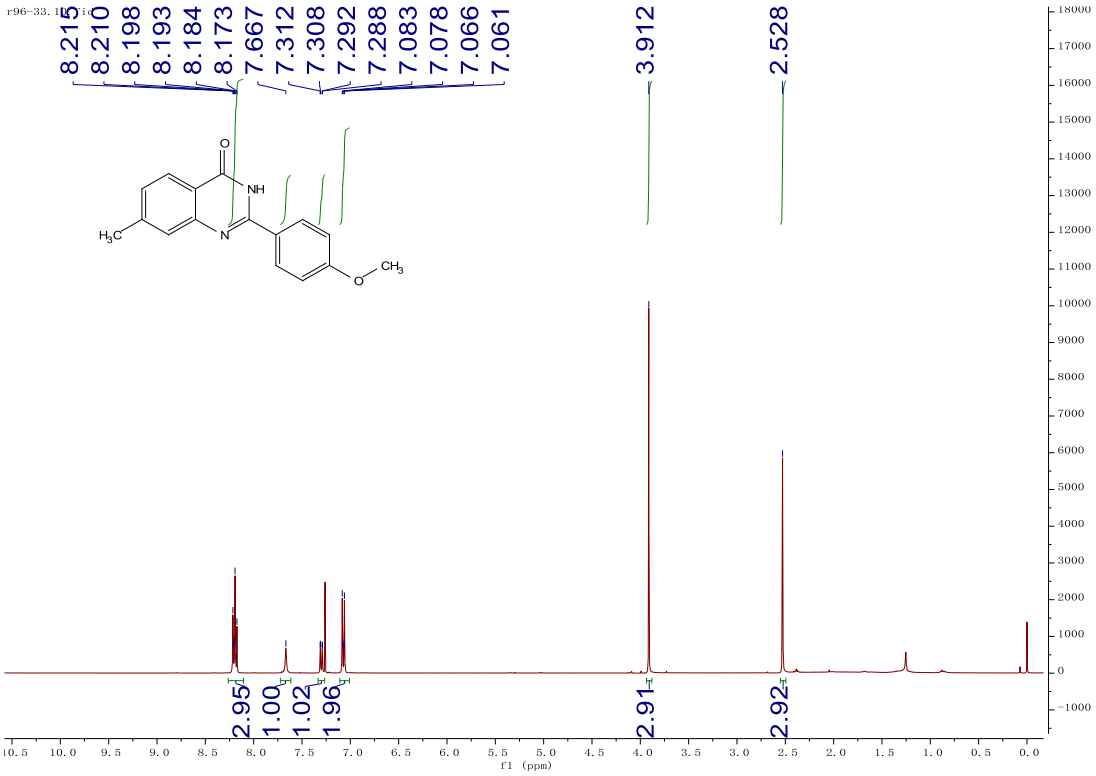
3bc (^{1}H, $CDCl_3$)



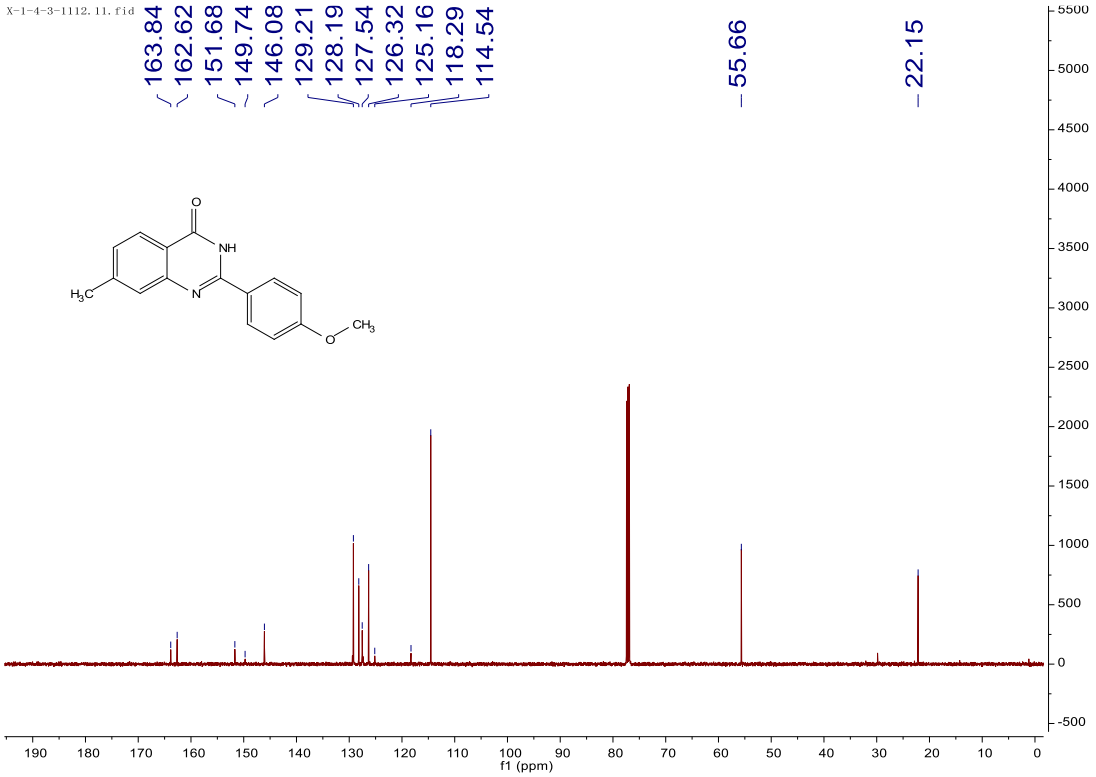
3bc (^{13}C, $CDCl_3$)



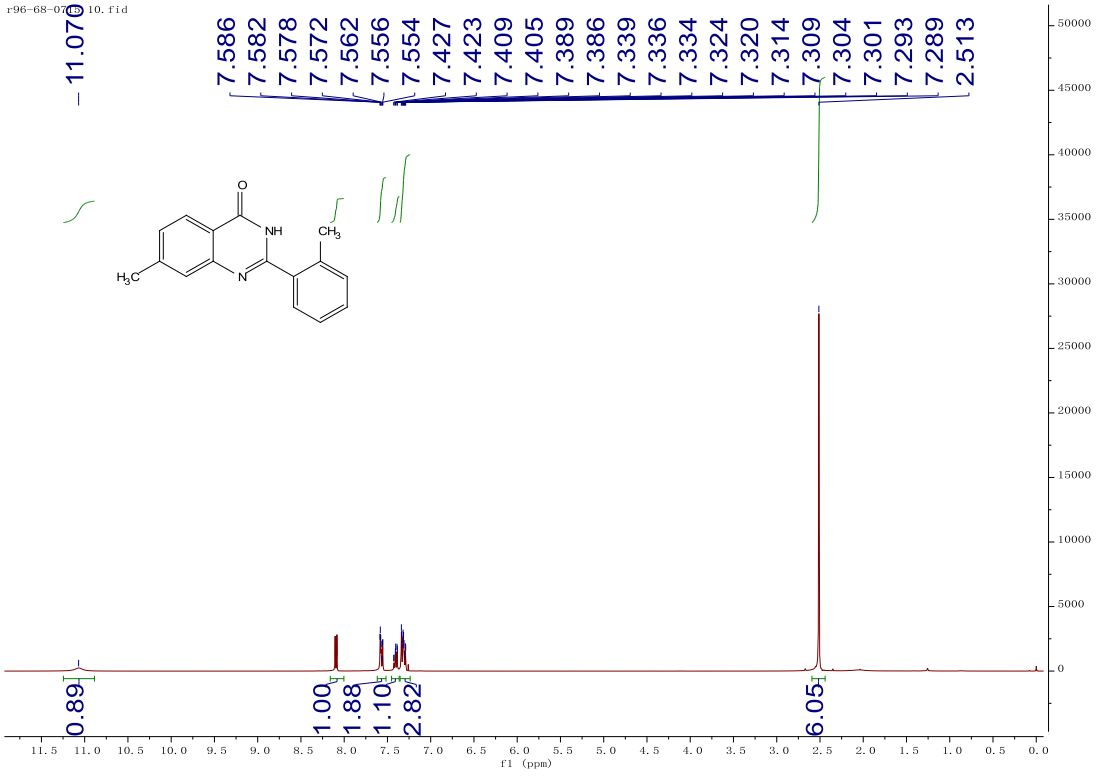
3bd (^{1}H, $CDCl_3$)



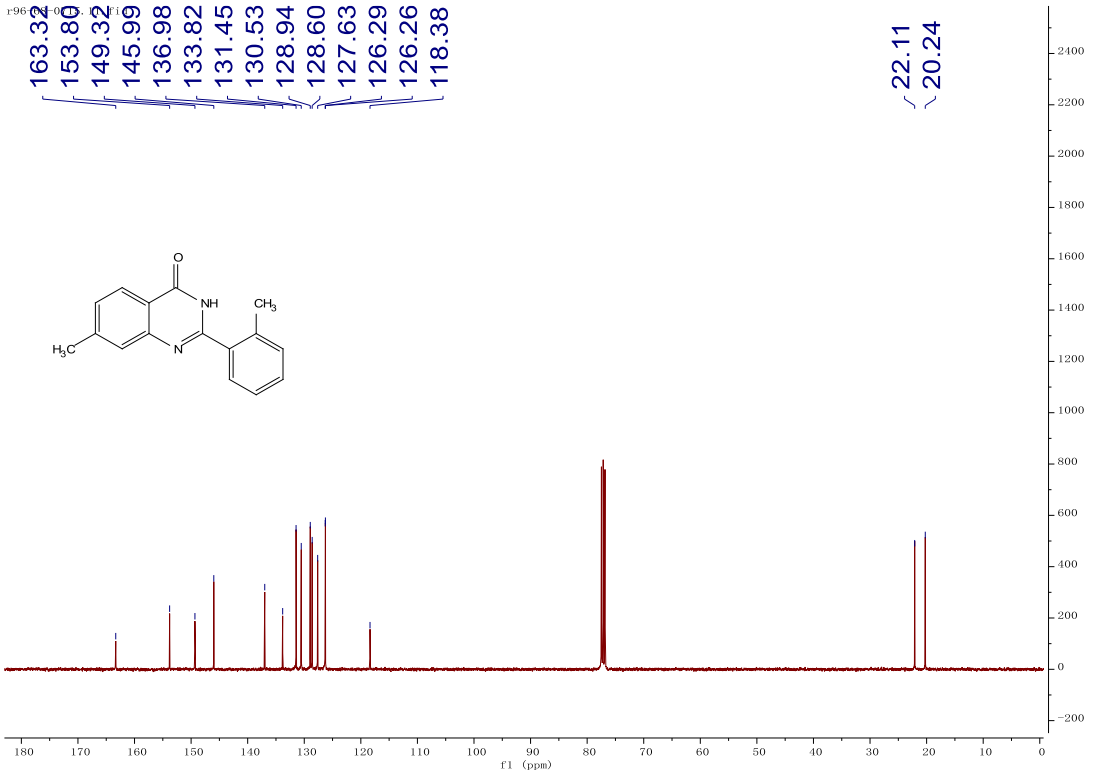
3bd (^{13}C, $CDCl_3$)



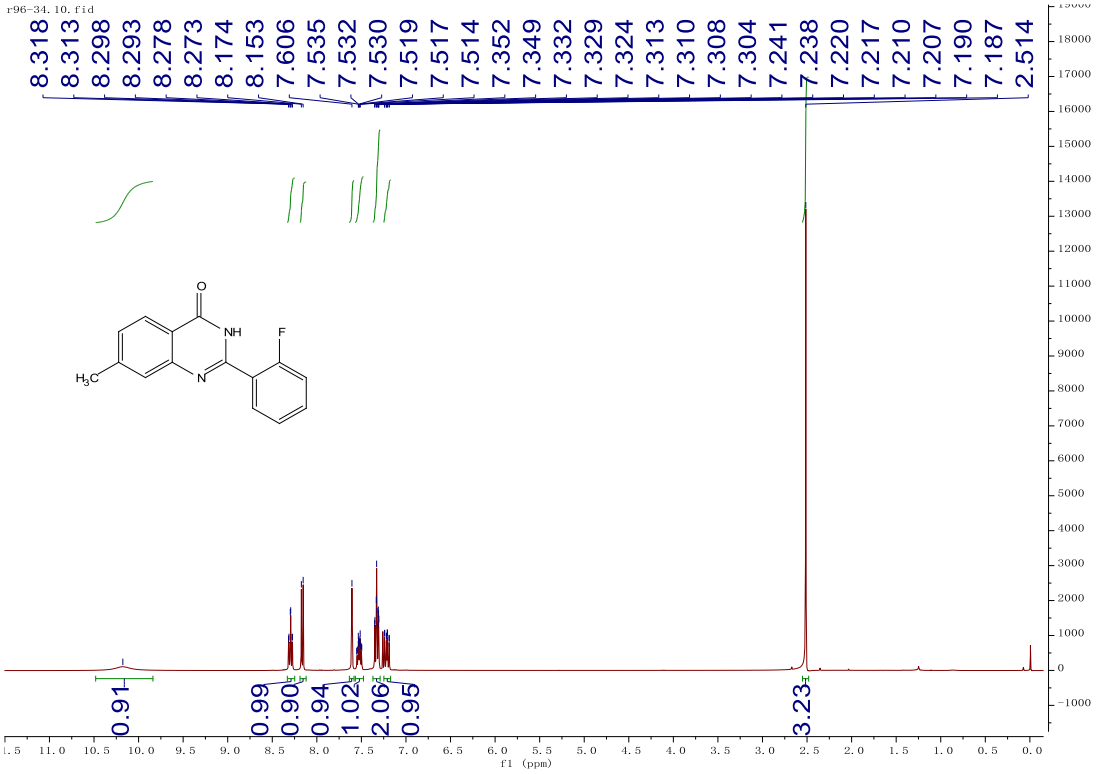
3be (^{1}H, $CDCl_3$)



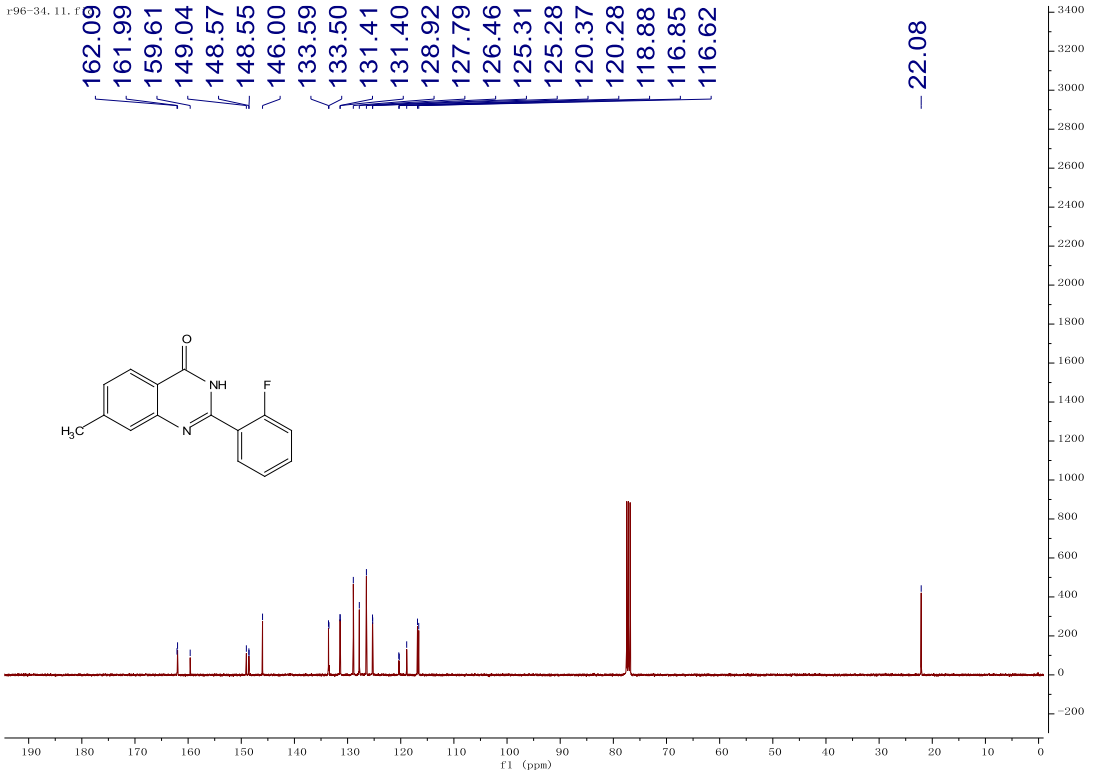
3be (^{13}C, $CDCl_3$)



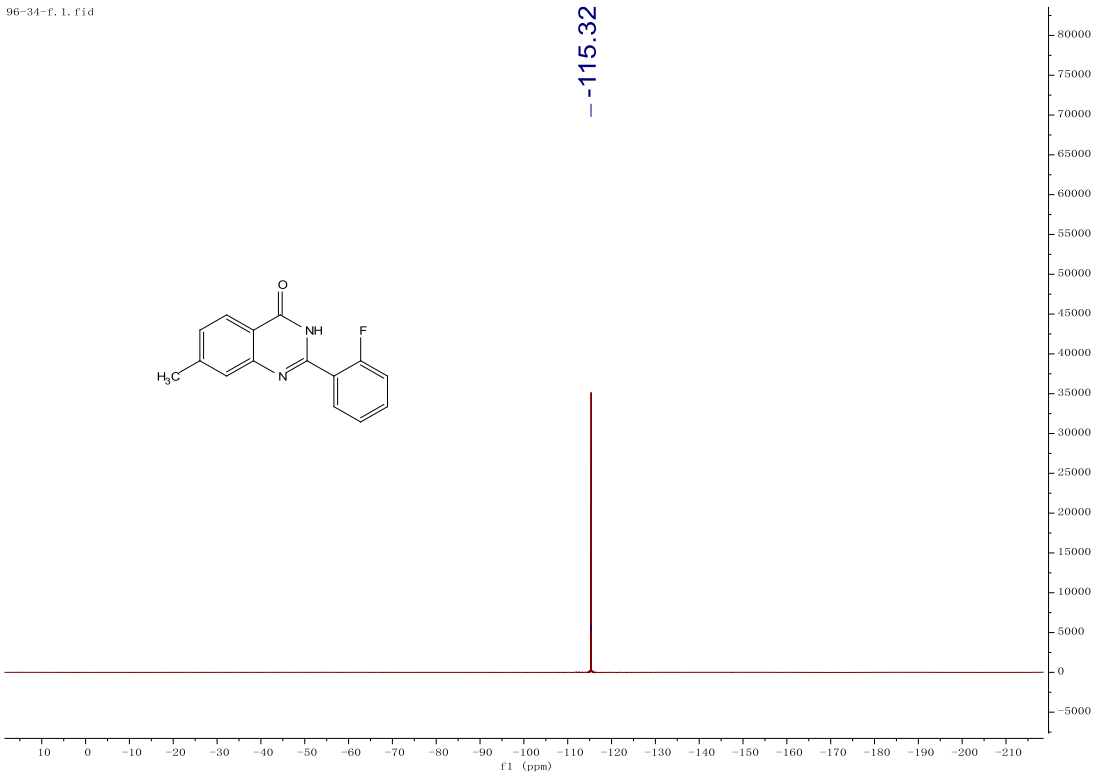
3bf (^{1}H, $CDCl_3$)



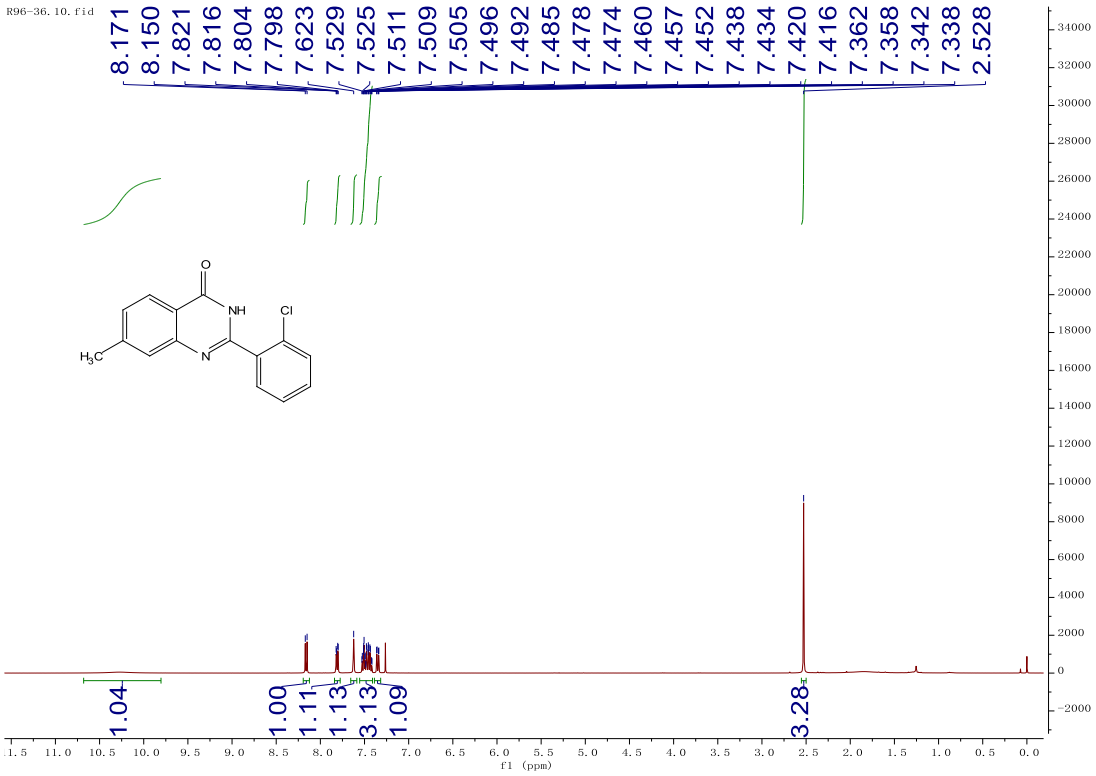
3bf (^{13}C, $CDCl_3$)



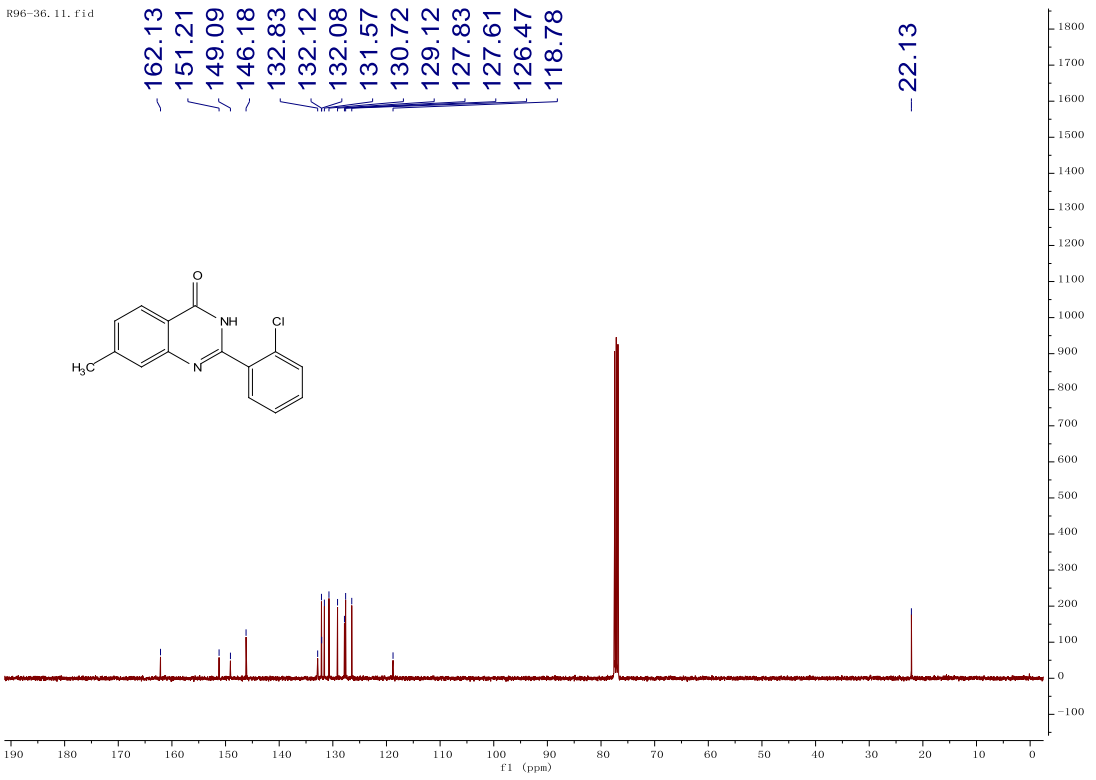
3bf (^{19}F, $CDCl_3$)



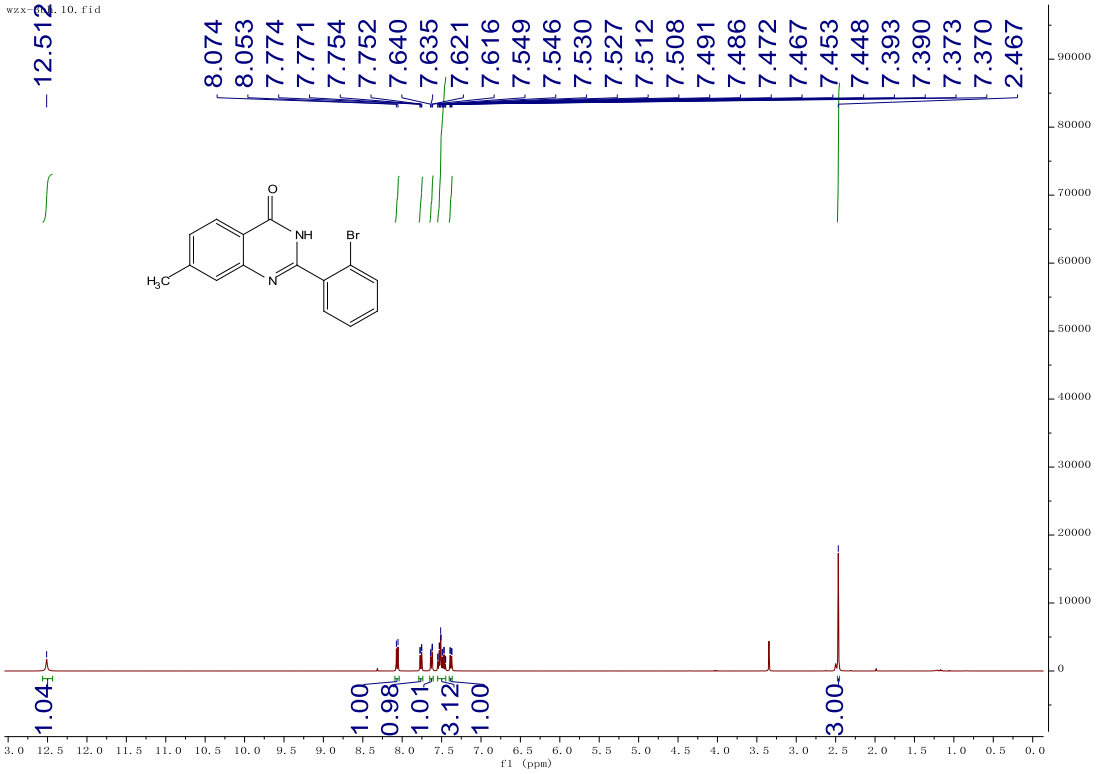
3bg (^{1}H, $CDCl_3$)



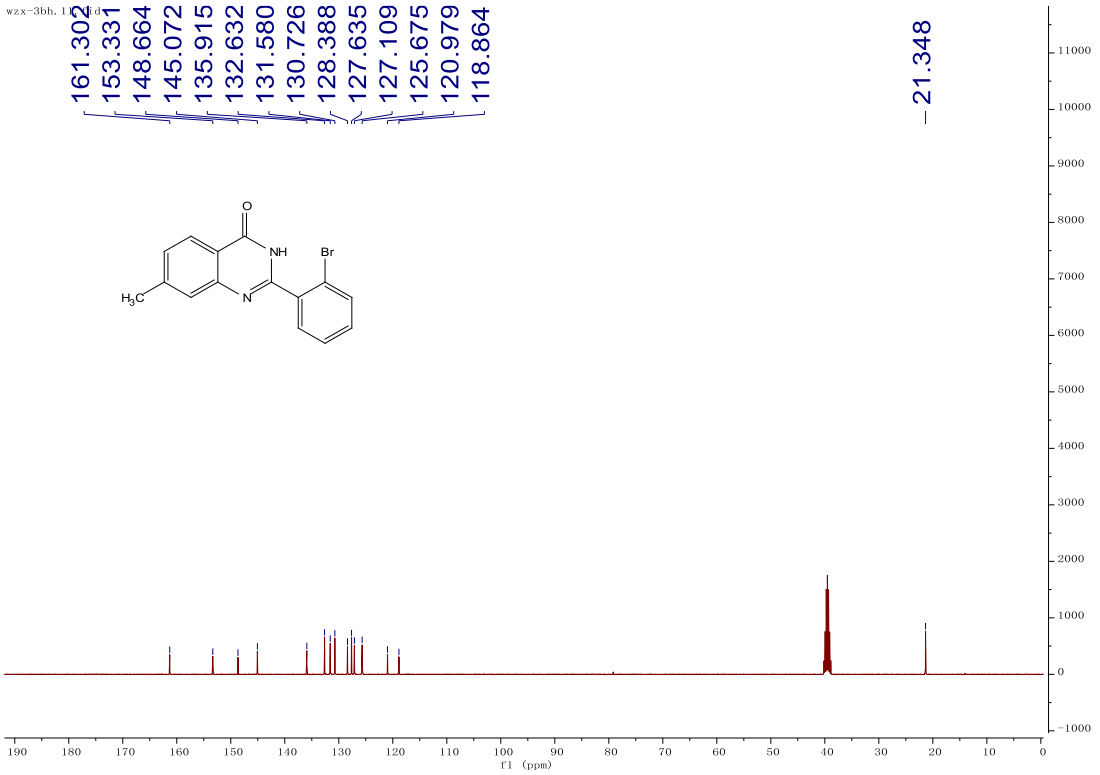
3bg (^{13}C, $CDCl_3$)



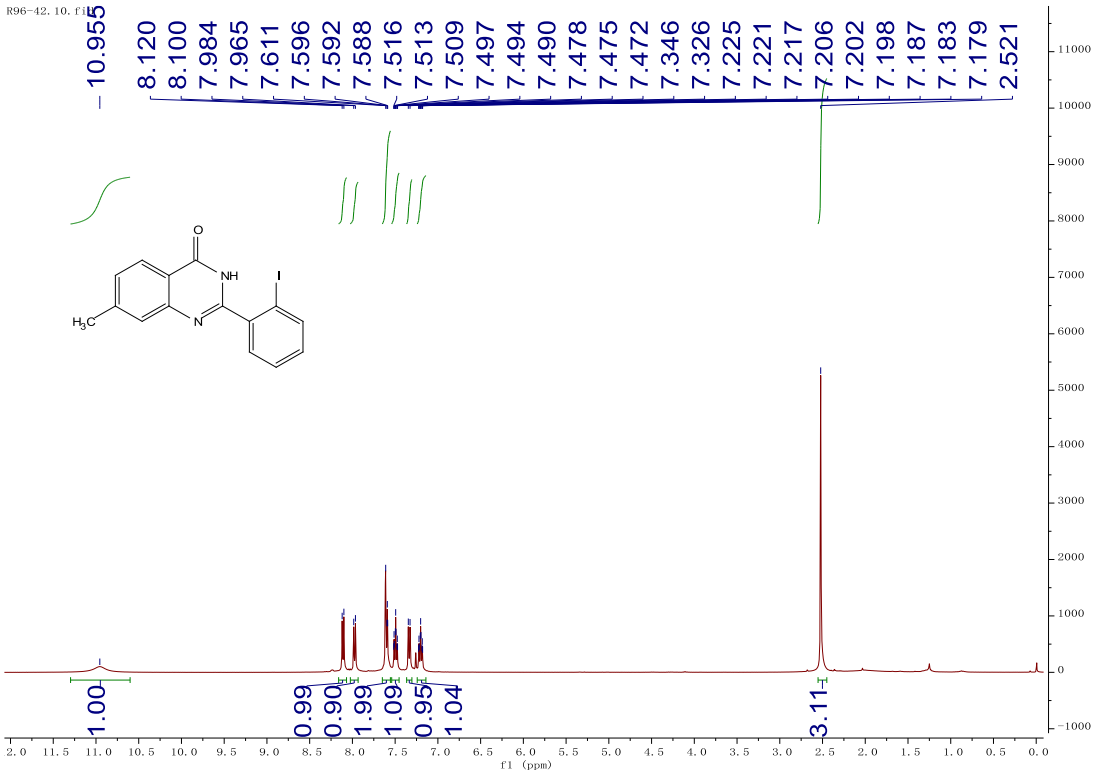
3bh (^{1}H, DMSO-d$_6$)



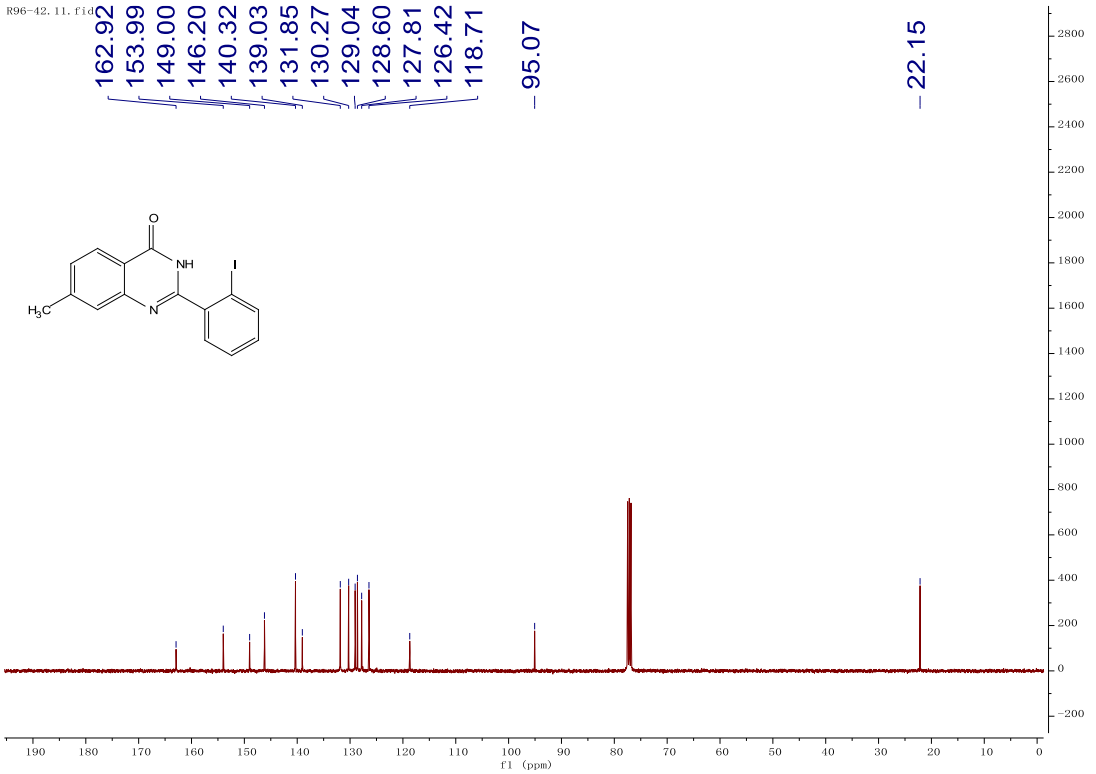
3bh (^{13}C, DMSO-d$_6$)



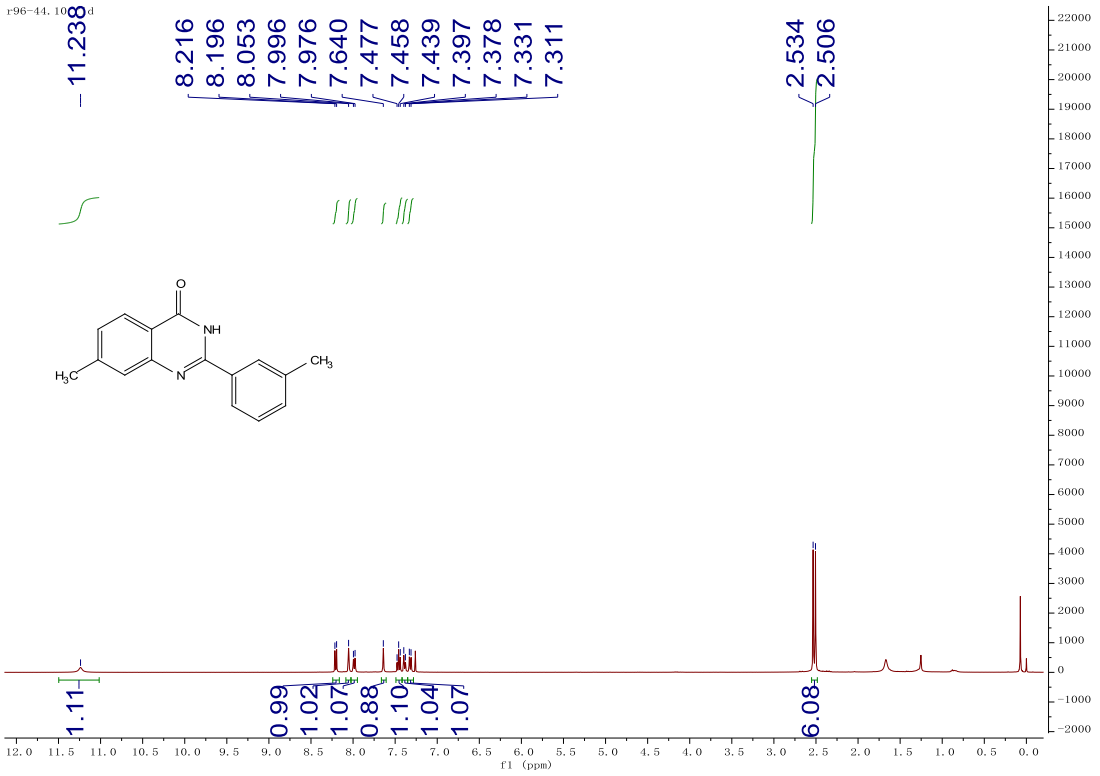
3bi (^{1}H, $CDCl_3$)



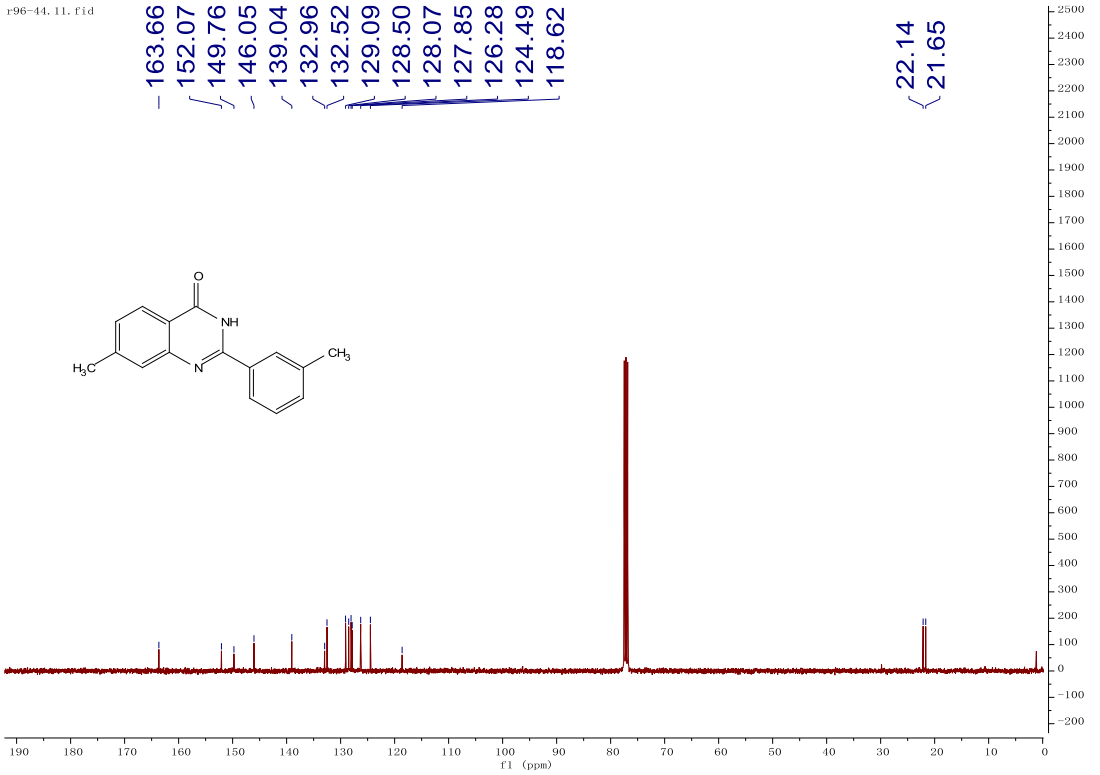
3bi (^{13}C, $CDCl_3$)



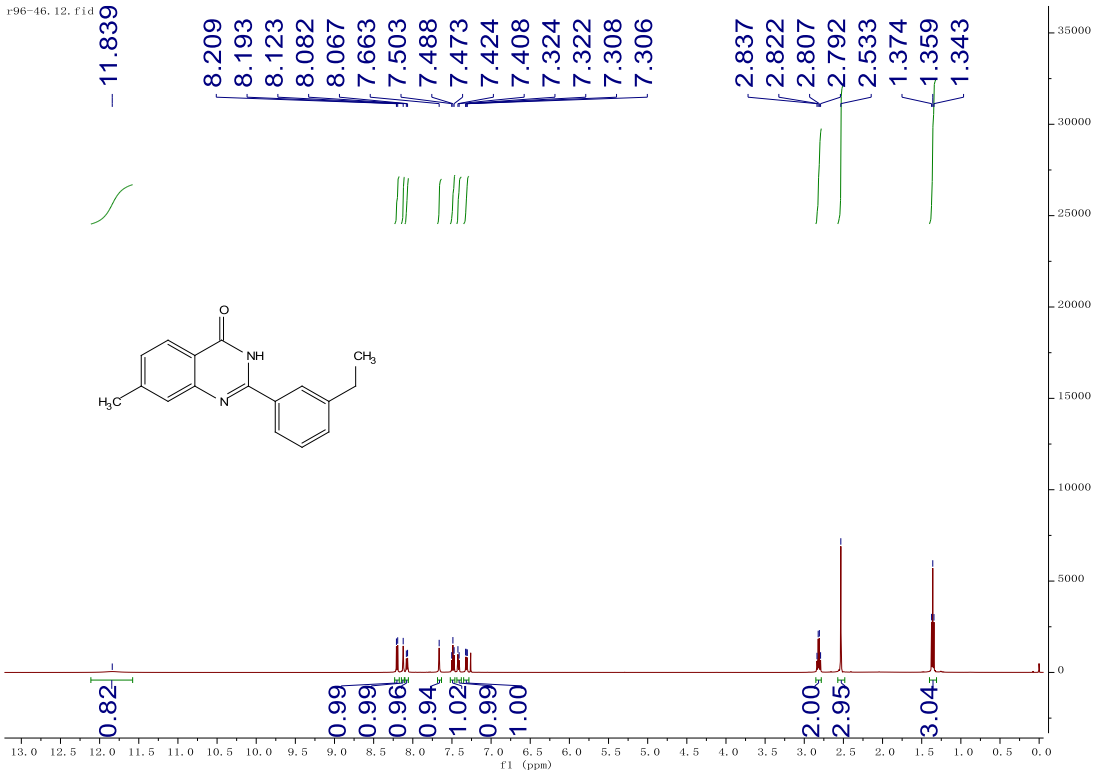
3bj (^{1}H, $CDCl_3$)



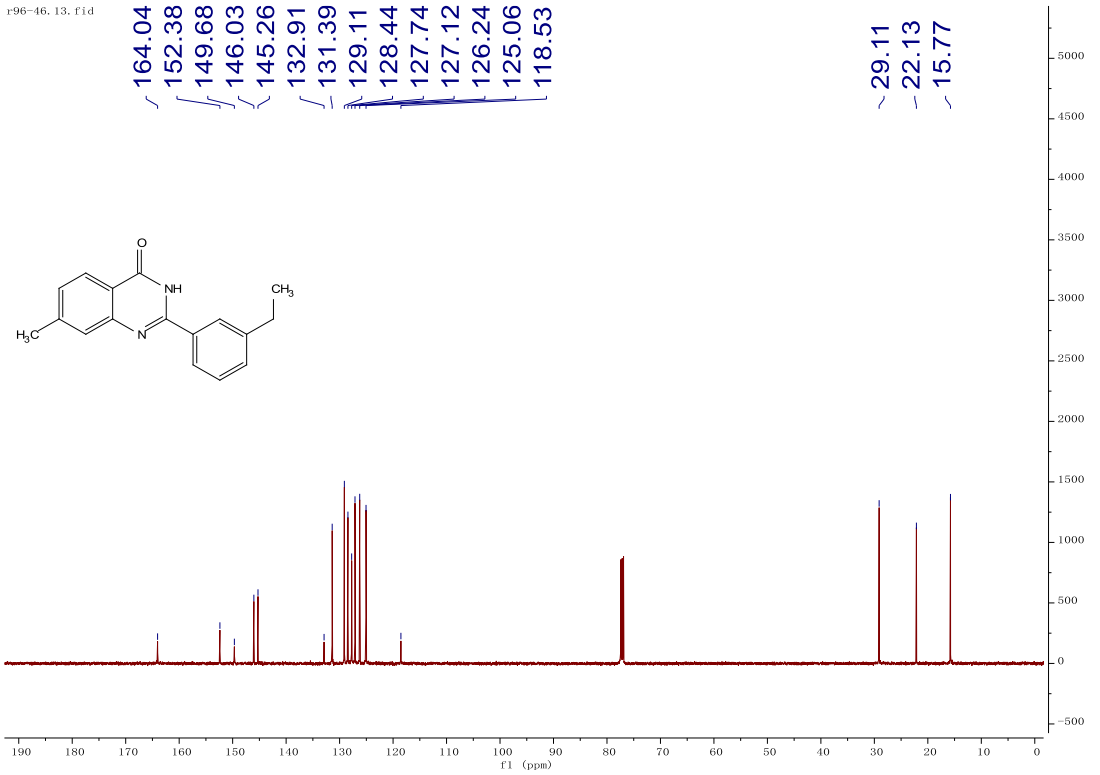
3bj (^{13}C, $CDCl_3$)



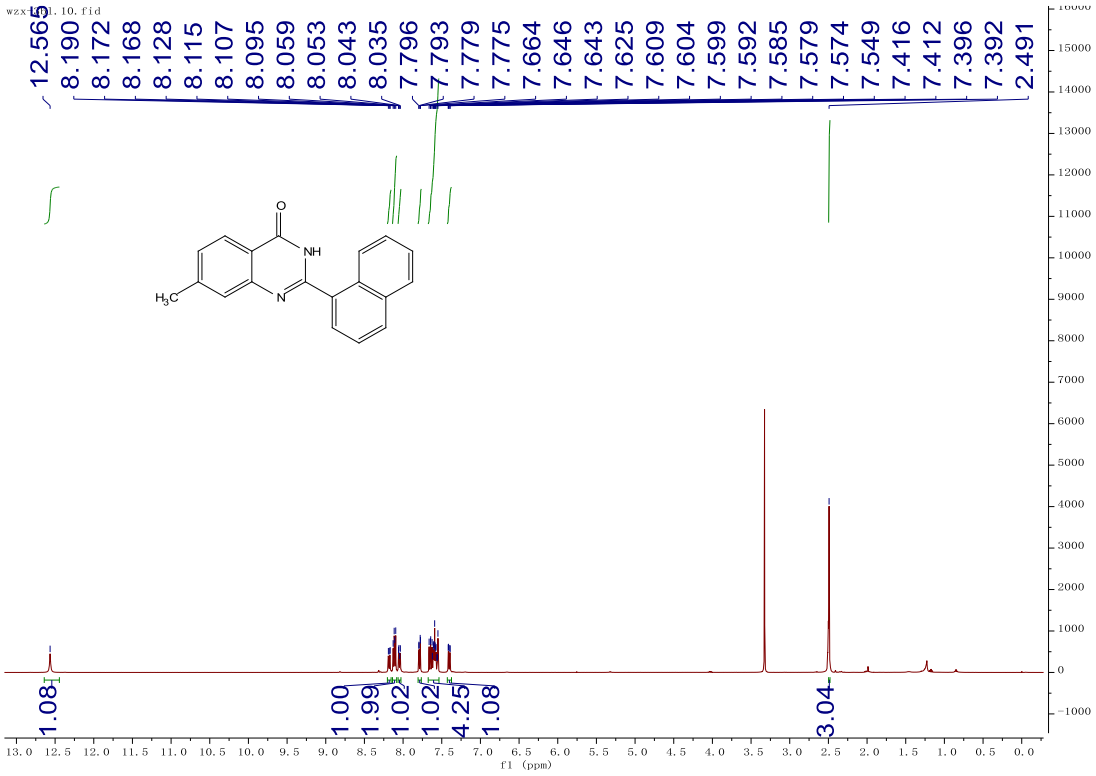
3bk (^{1}H, $CDCl_3$)



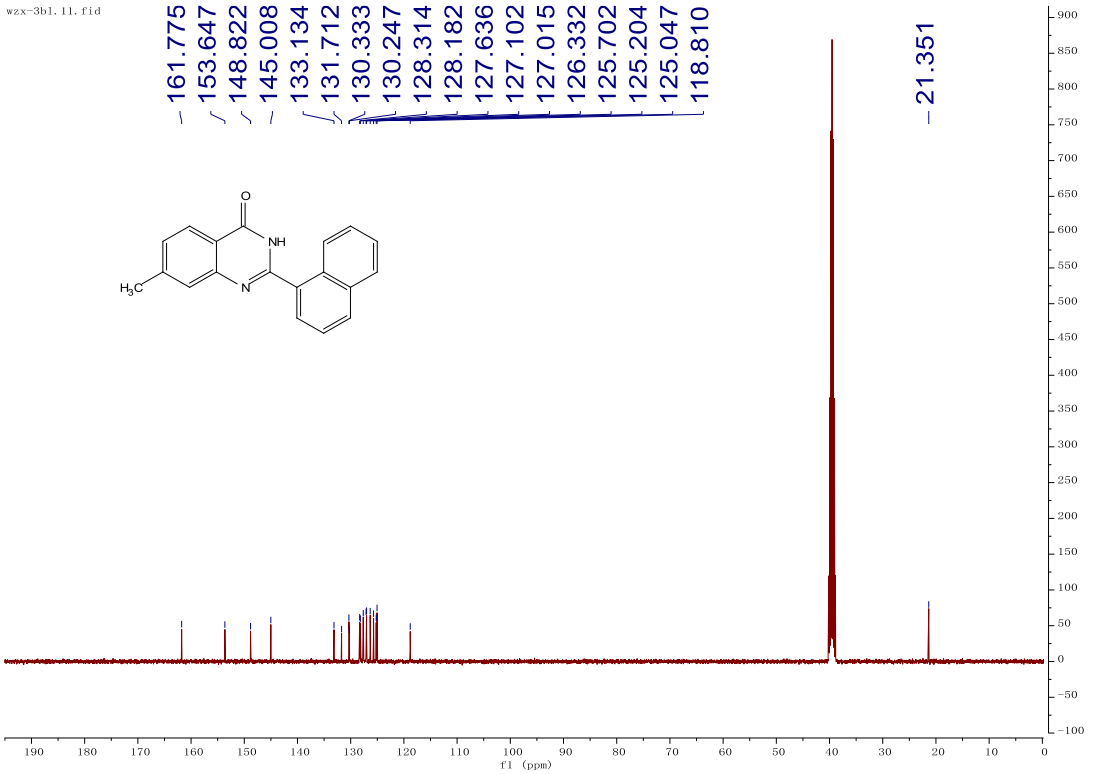
3bk (^{13}C, $CDCl_3$)



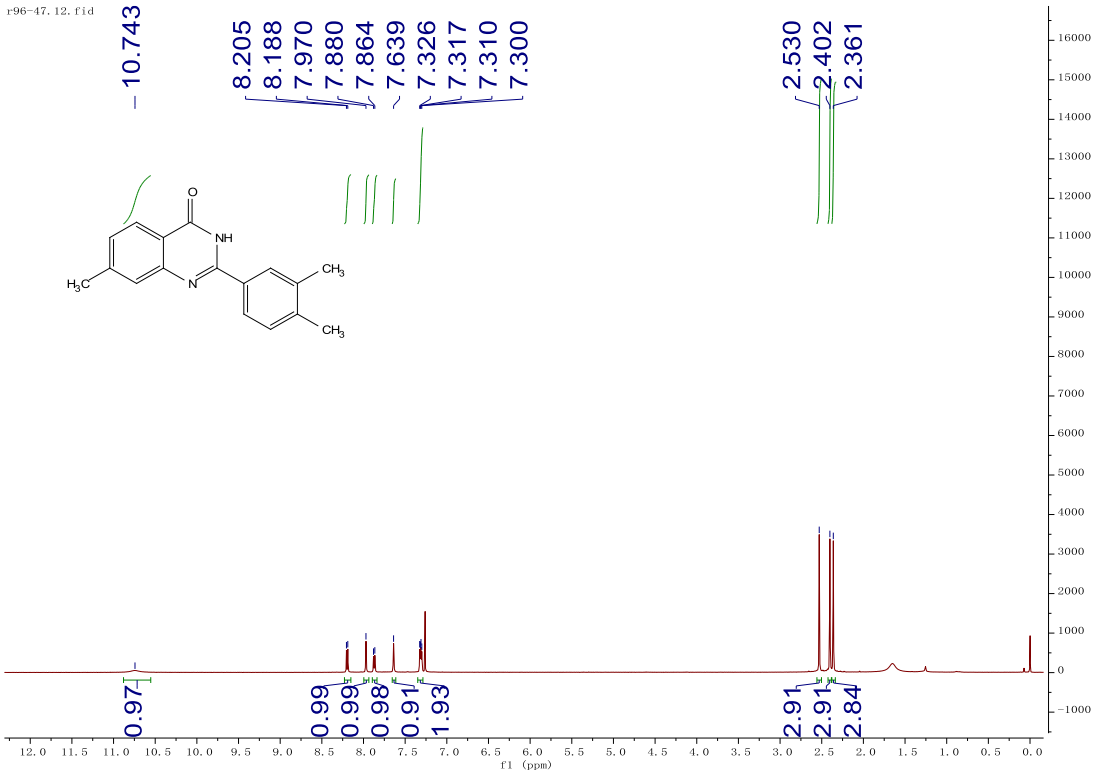
3bl (^{1}H, DMSO-d_6)



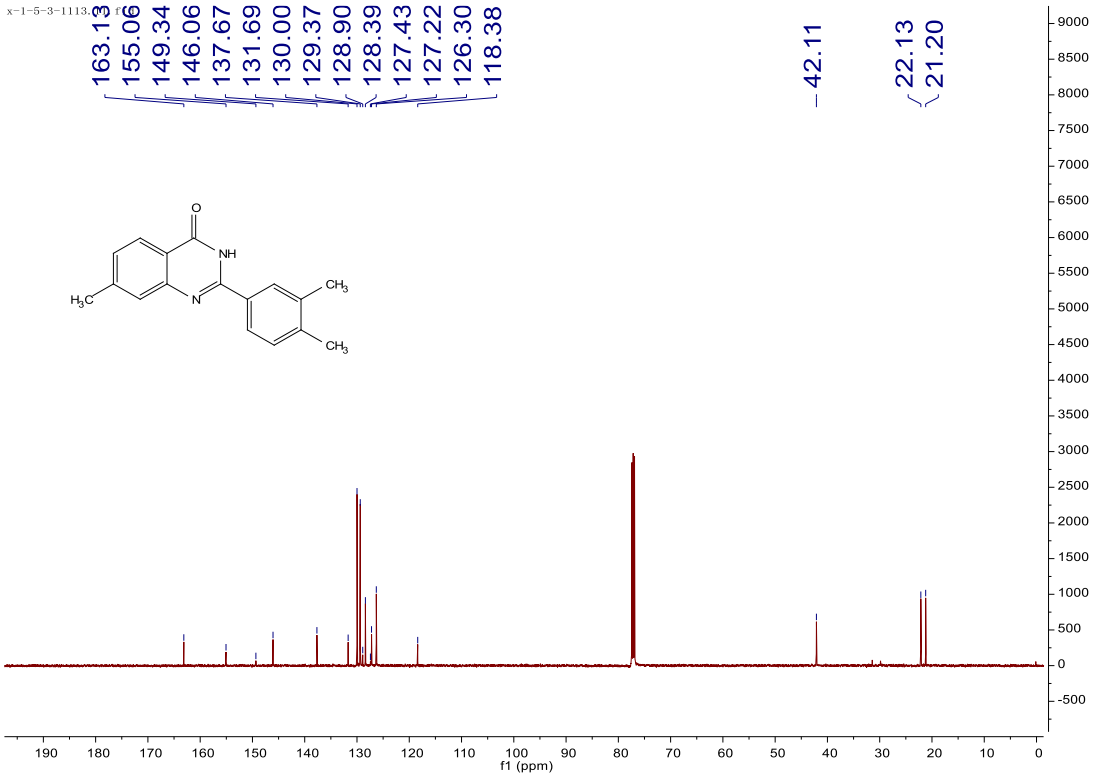
3bl (^{13}C, DMSO-d_6)



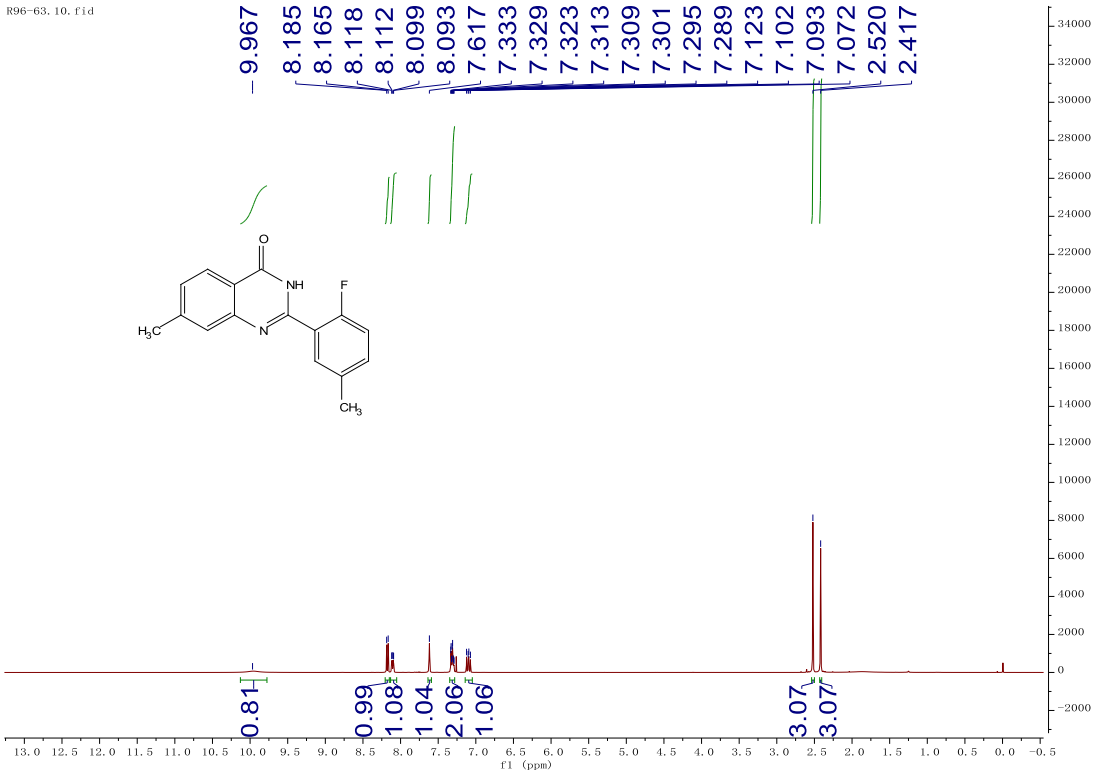
3bm (^{1}H, $CDCl_3$)



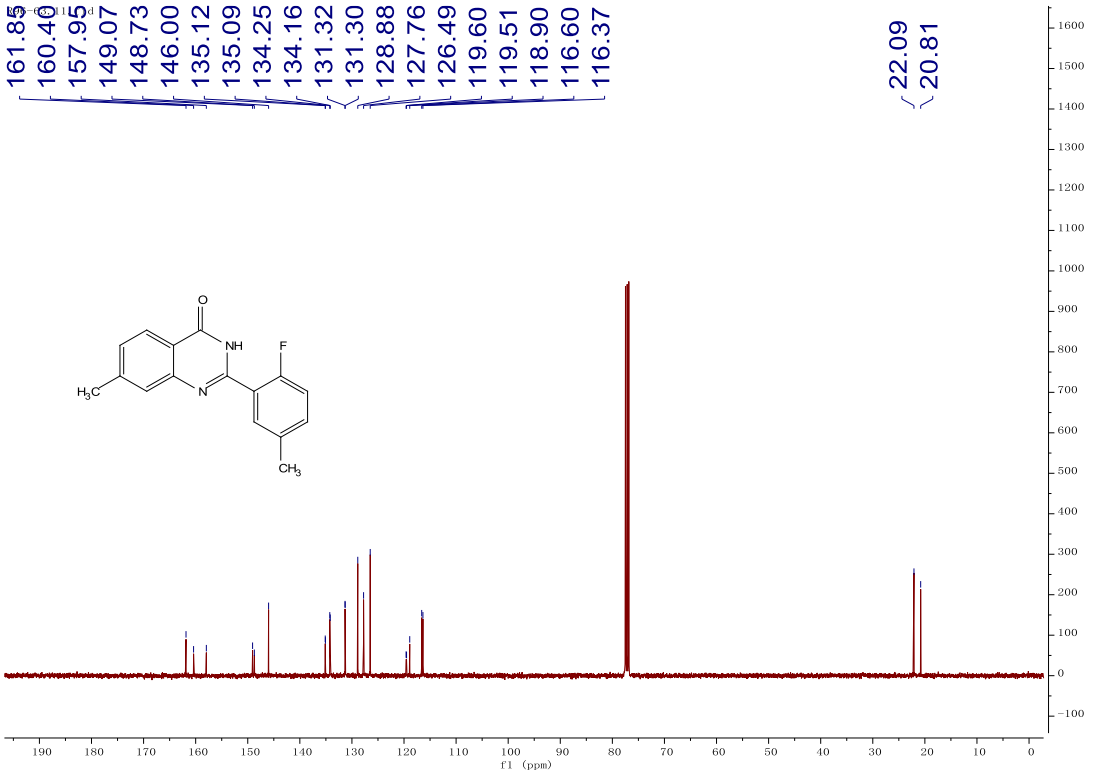
3bm (^{13}C, $CDCl_3$)



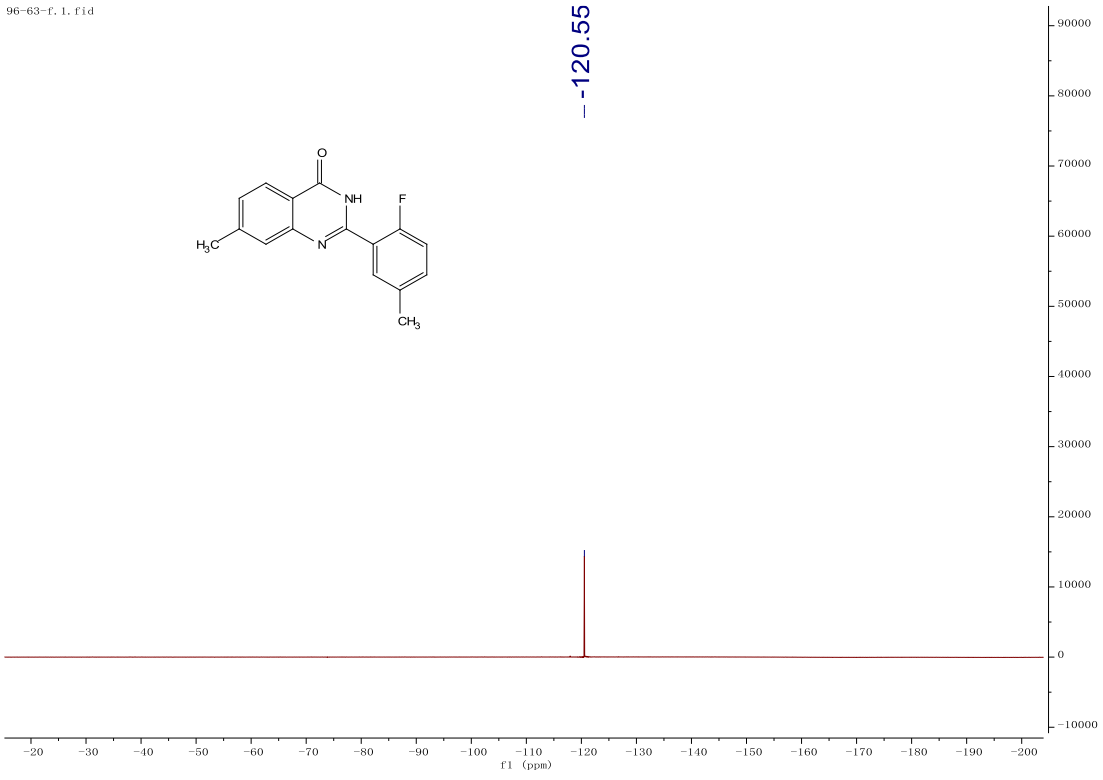
3bn (^{1}H, $CDCl_3$)



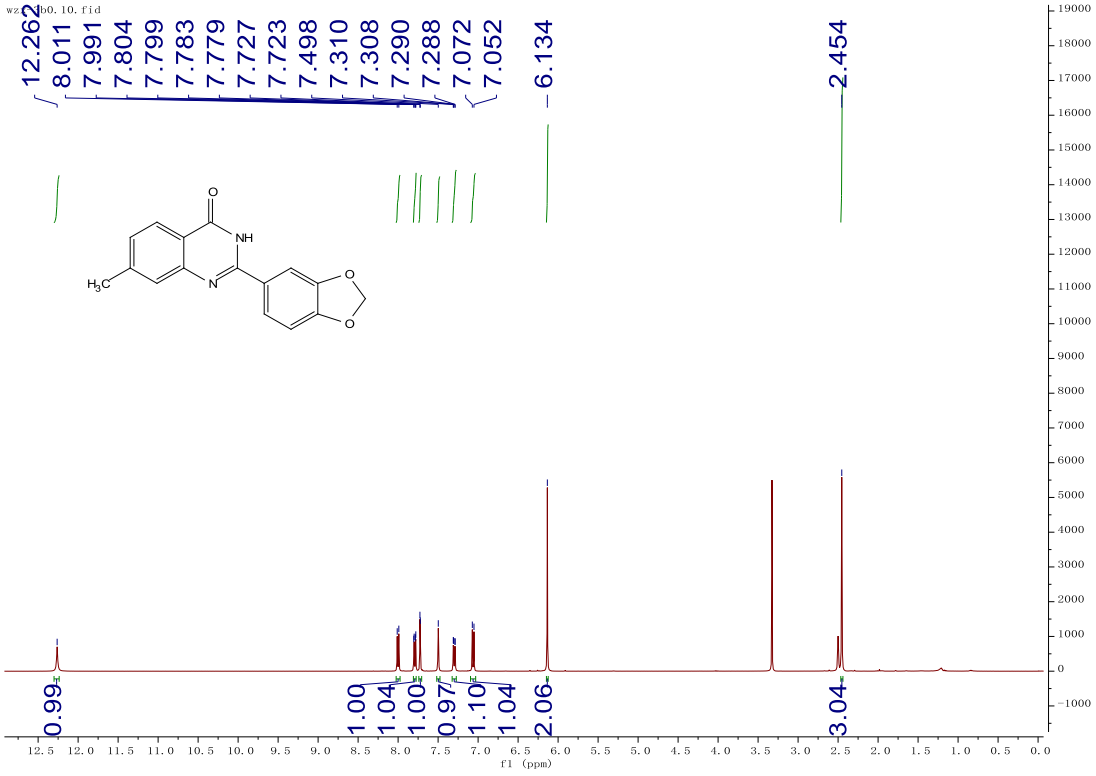
3bn (^{13}C, $CDCl_3$)



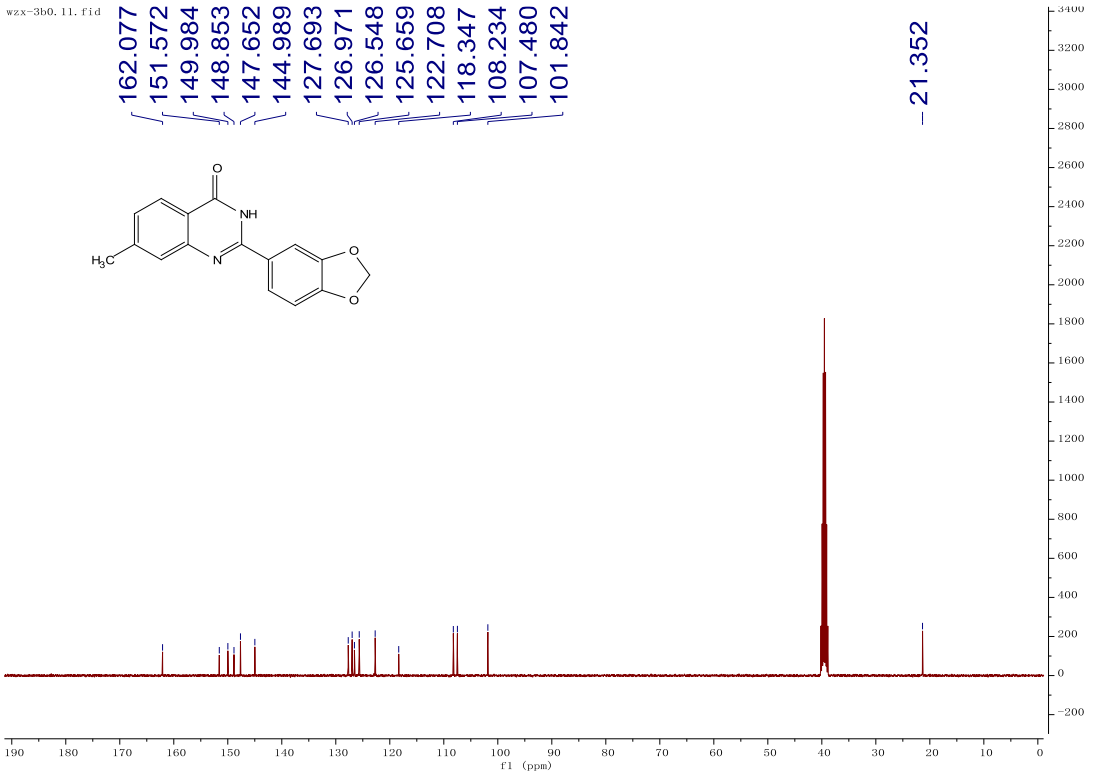
3bn (^{19}F, $CDCl_3$)



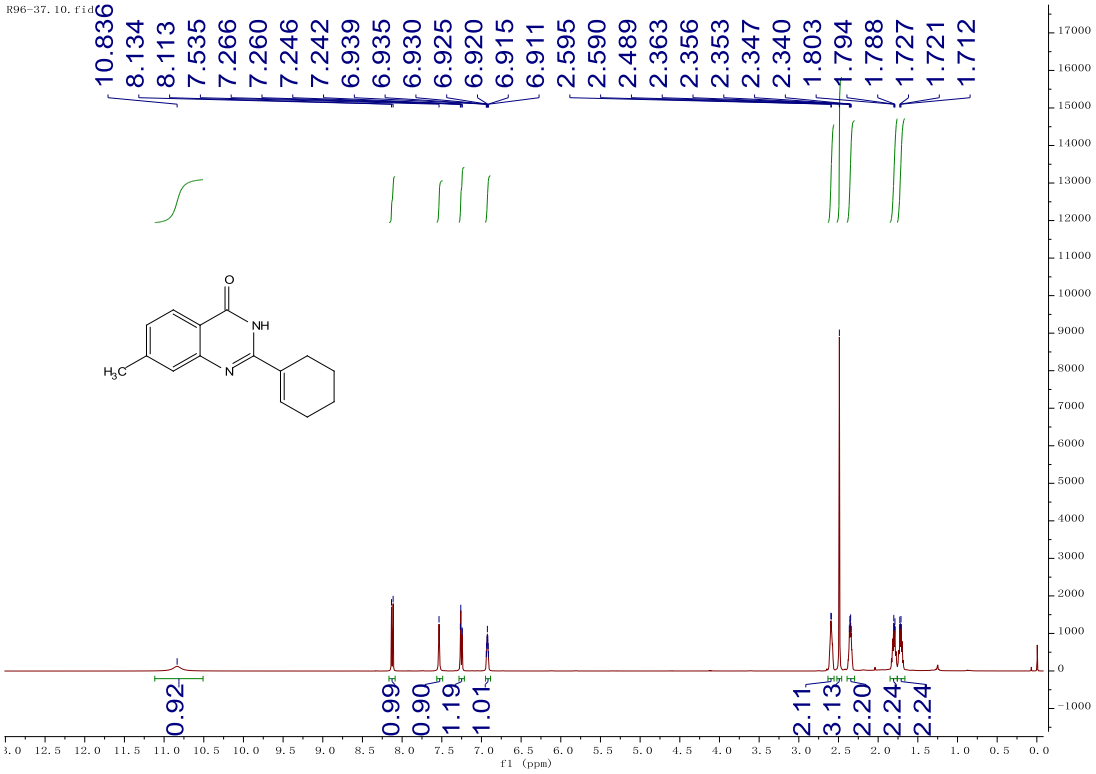
3bo (^{1}H, DMSO-d_6)



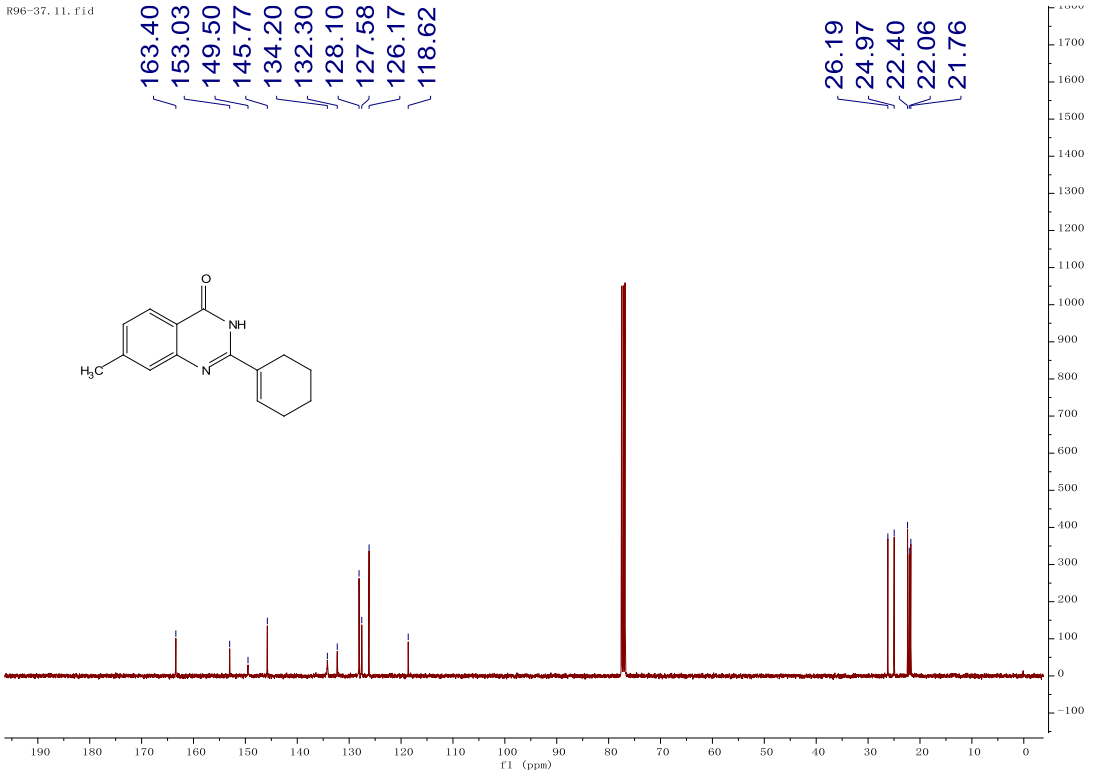
3bo (^{13}C, DMSO-d_6)



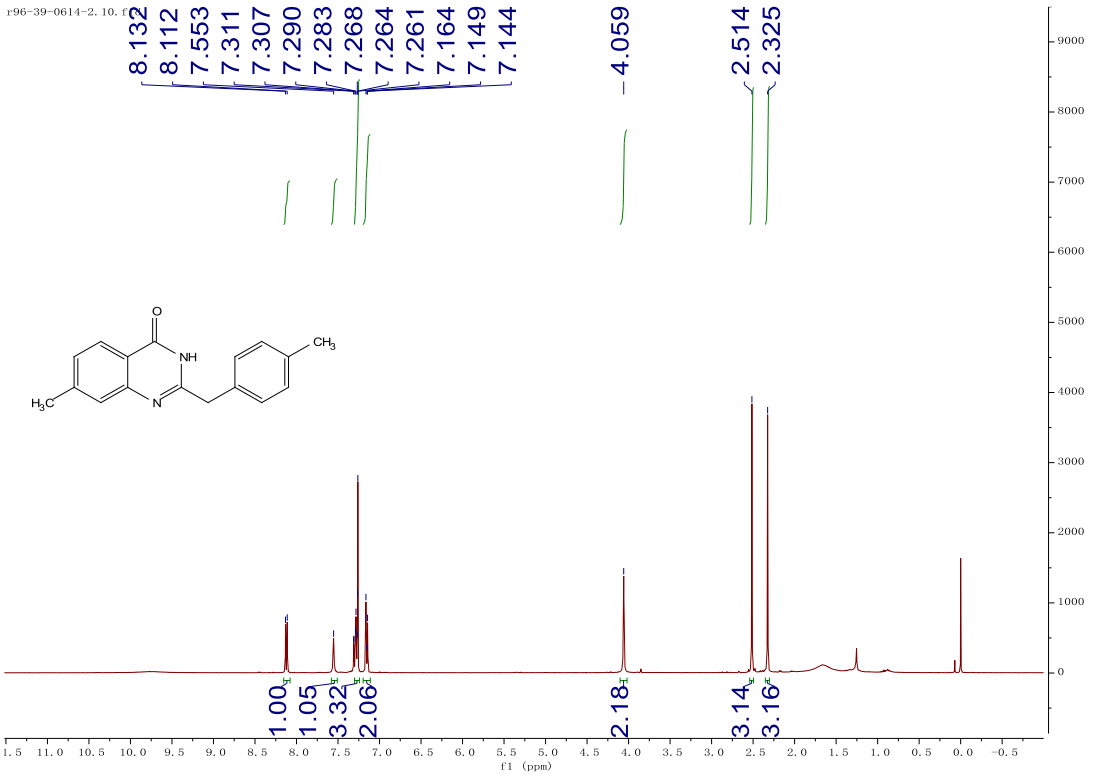
3bp (^{1}H, $CDCl_3$)



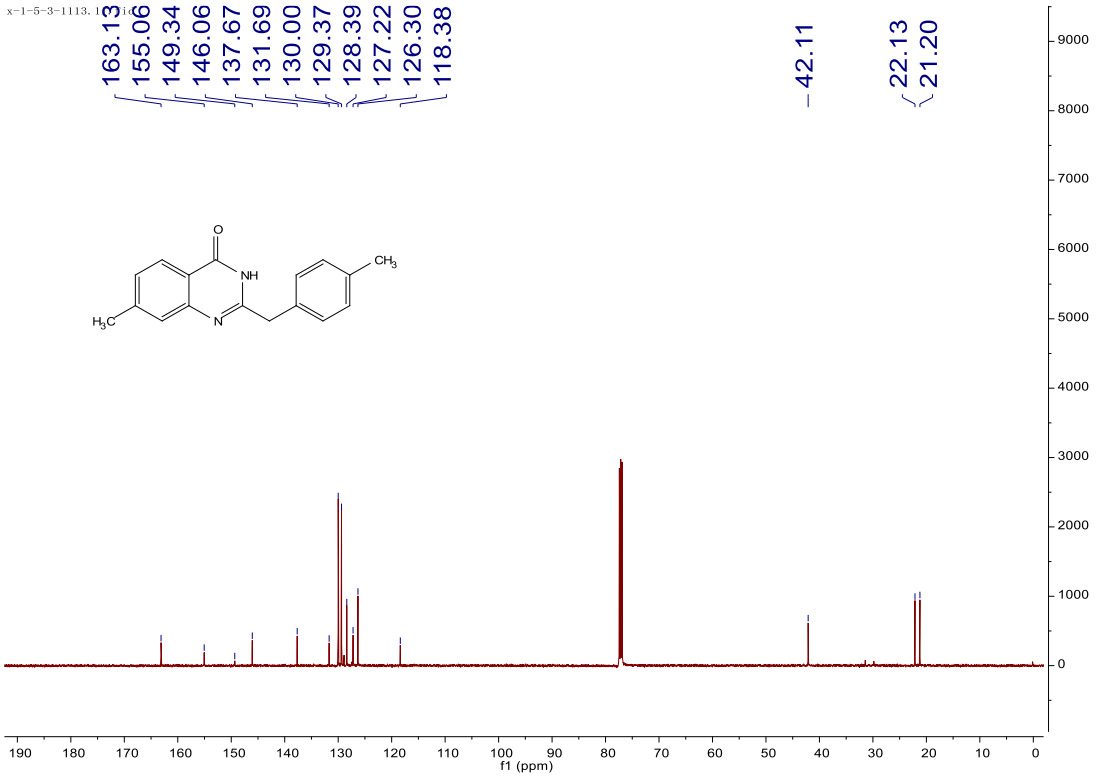
3bp (^{13}C, $CDCl_3$)



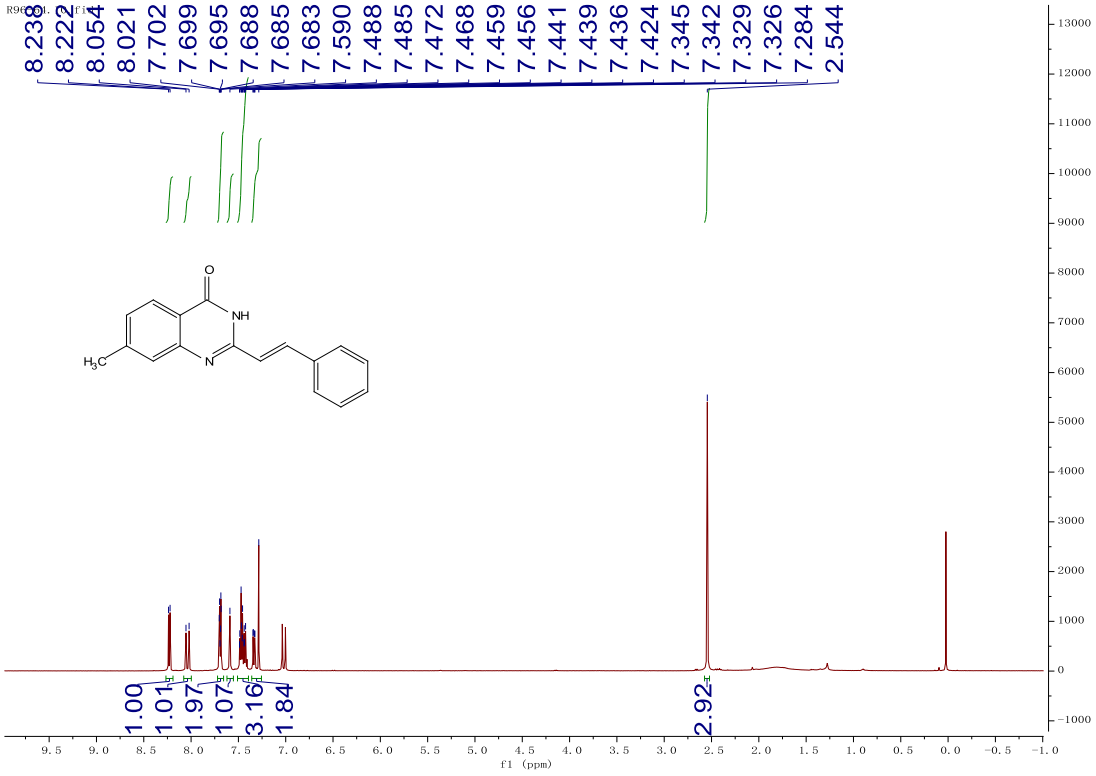
3bq (^{1}H, $CDCl_3$)



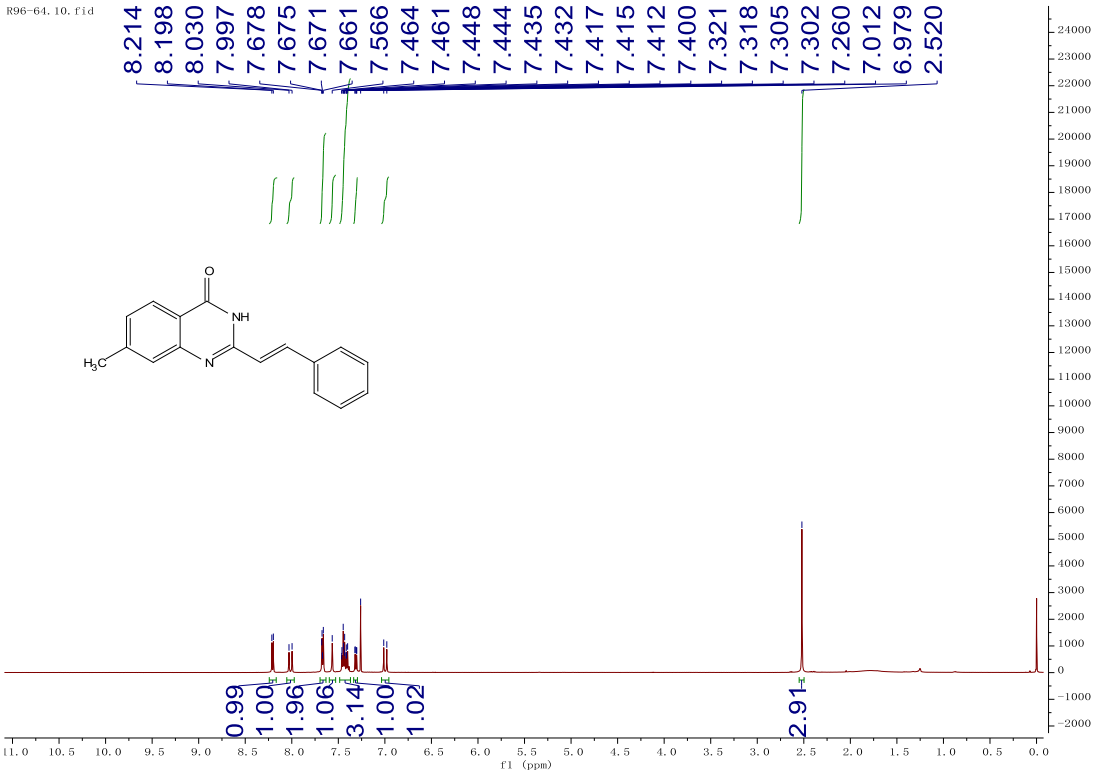
3bq (^{13}C, $CDCl_3$)



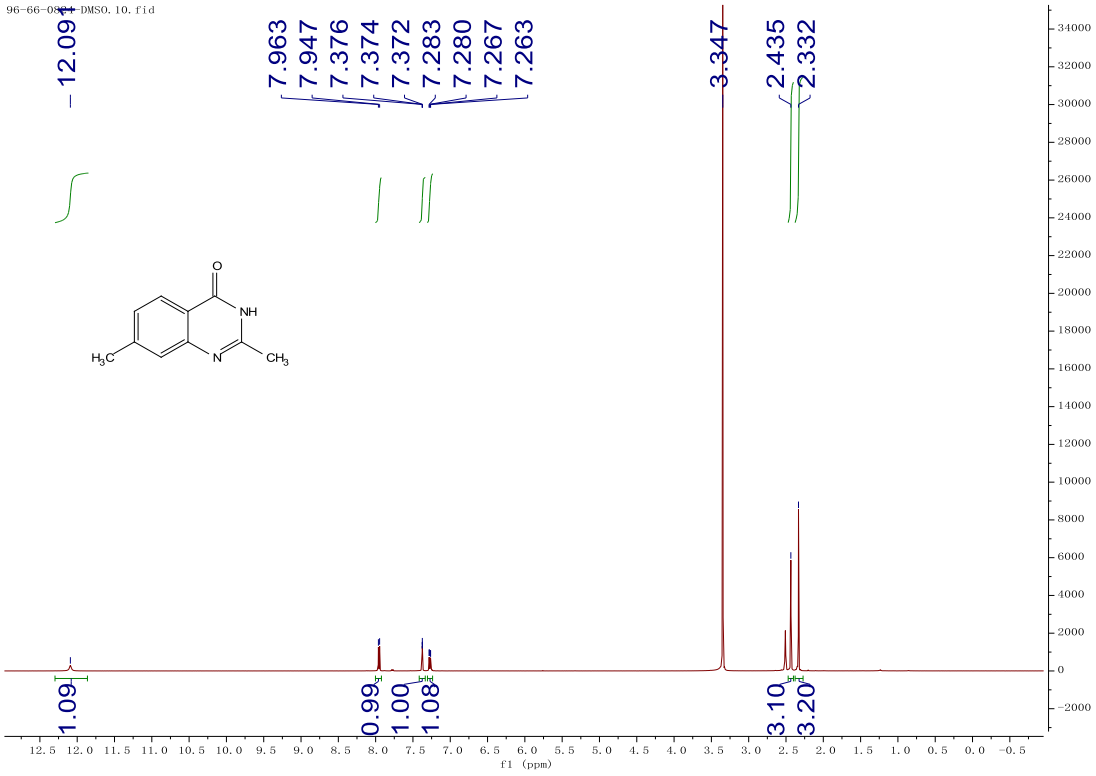
3br (^{1}H, $CDCl_3$)



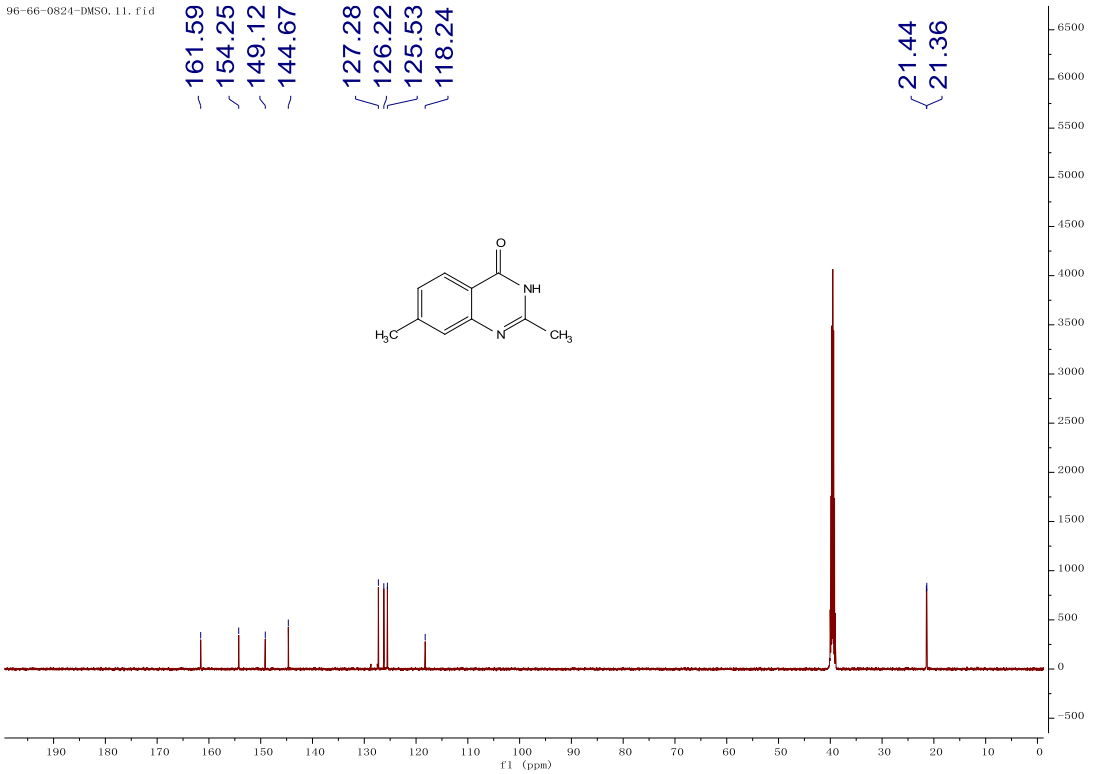
3br (^{13}C, $CDCl_3$)



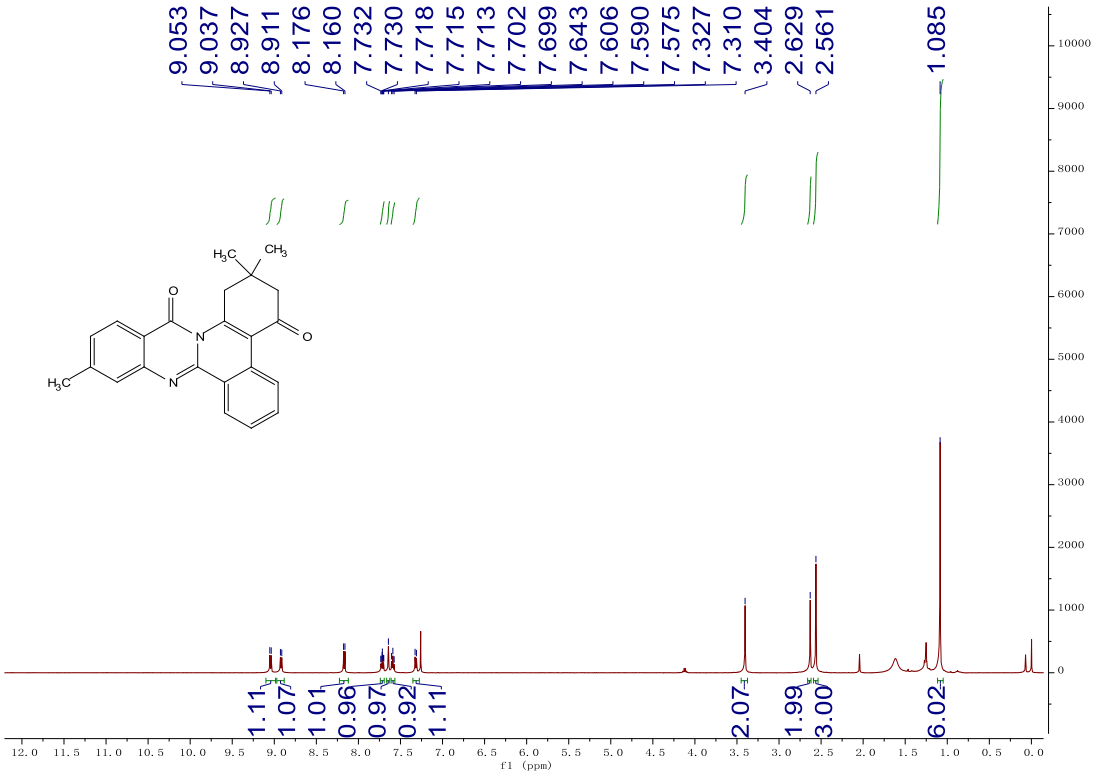
3bs (^{1}H, DMSO-d$_6$)



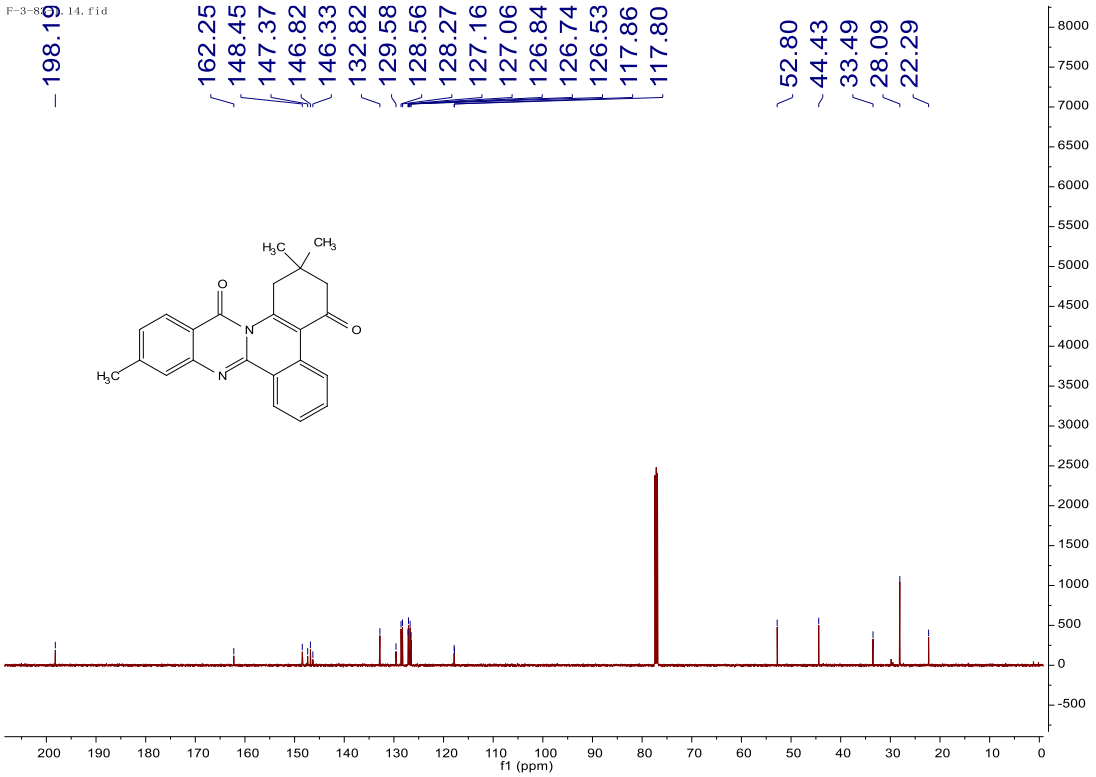
3bs (^{13}C, DMSO-d$_6$)



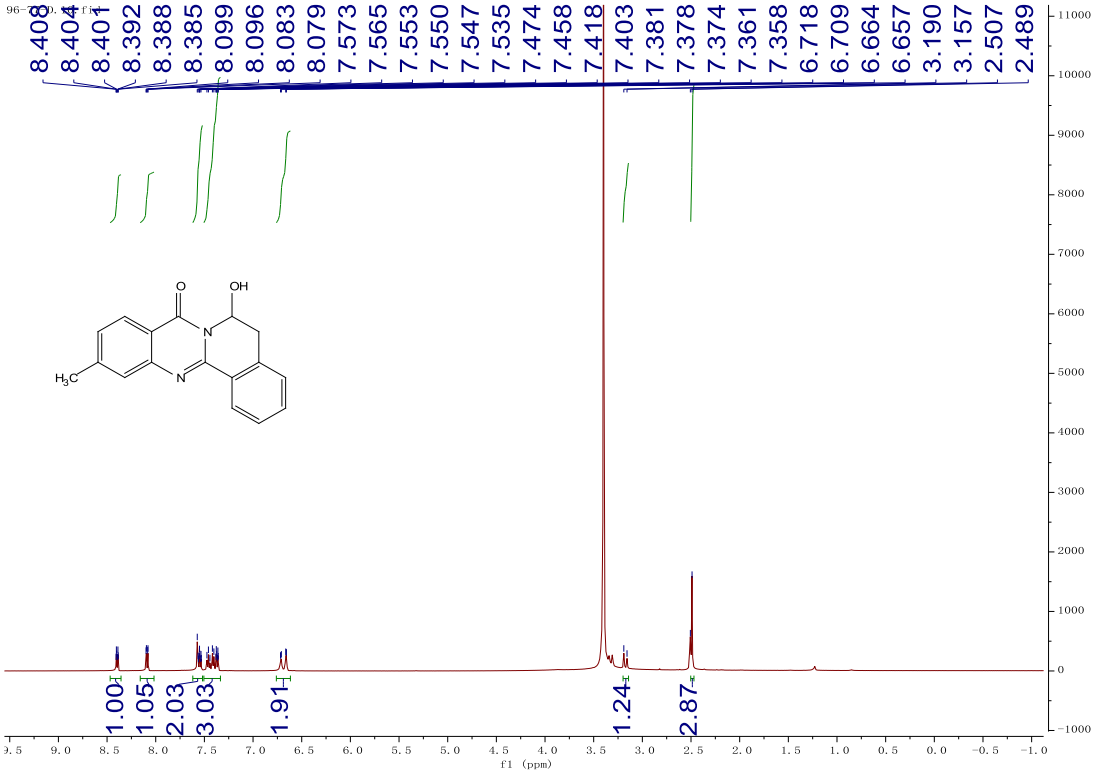
1 (^{1}H, $CDCl_3$)



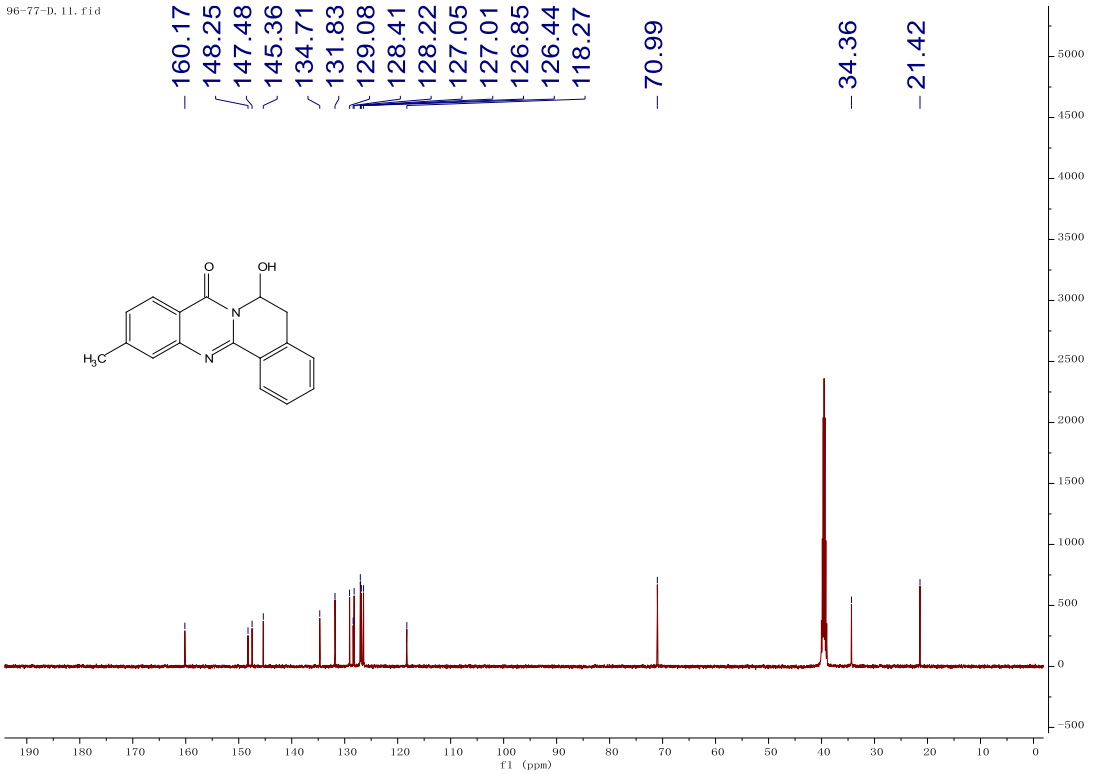
1 (^{13}C, $CDCl_3$)



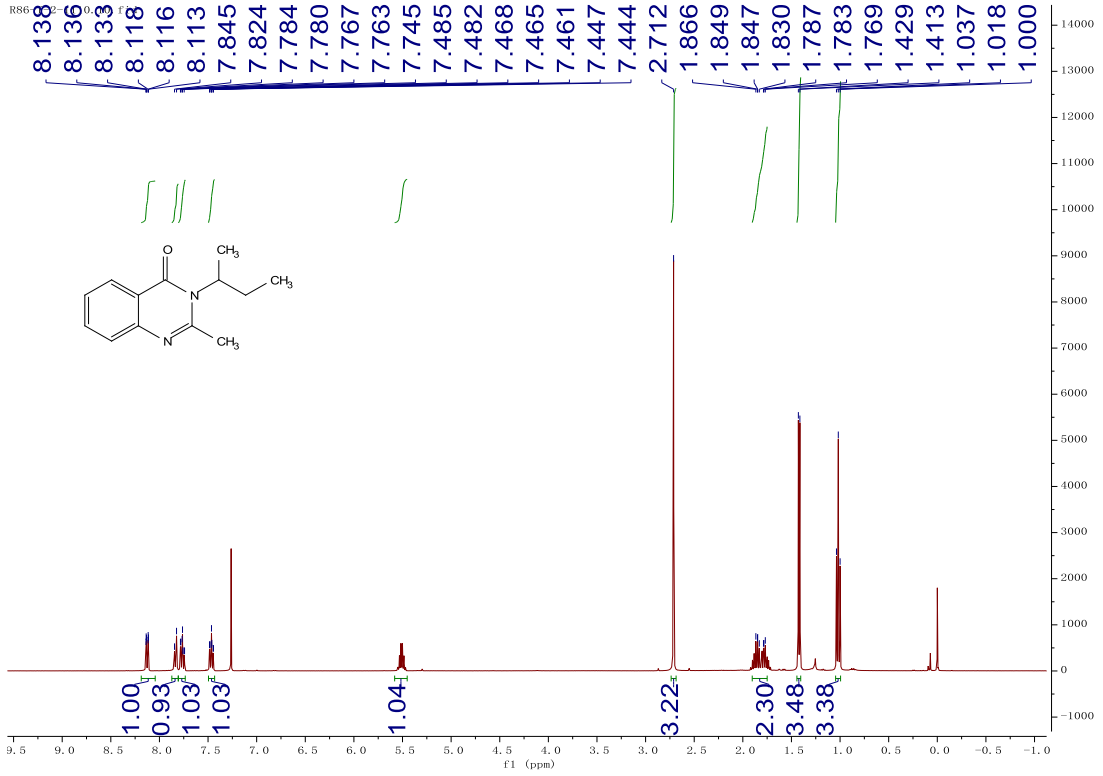
2 (^{1}H, DMSO-d_6)



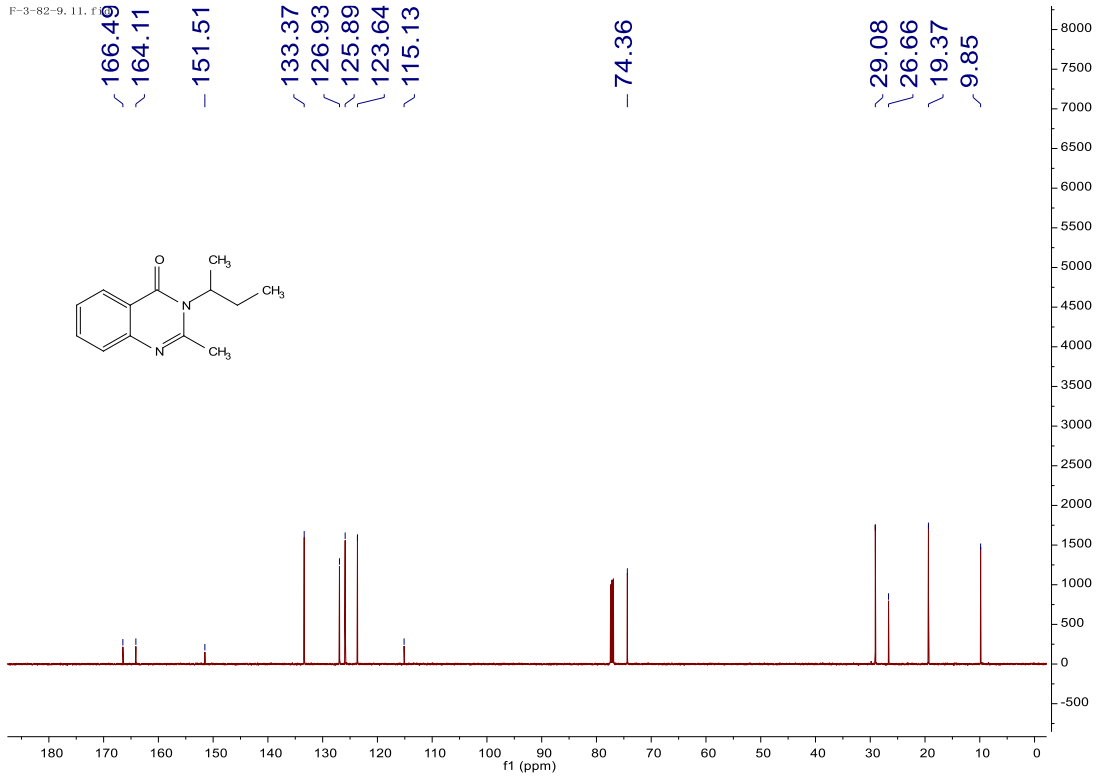
2 (^{13}C, DMSO-d_6)



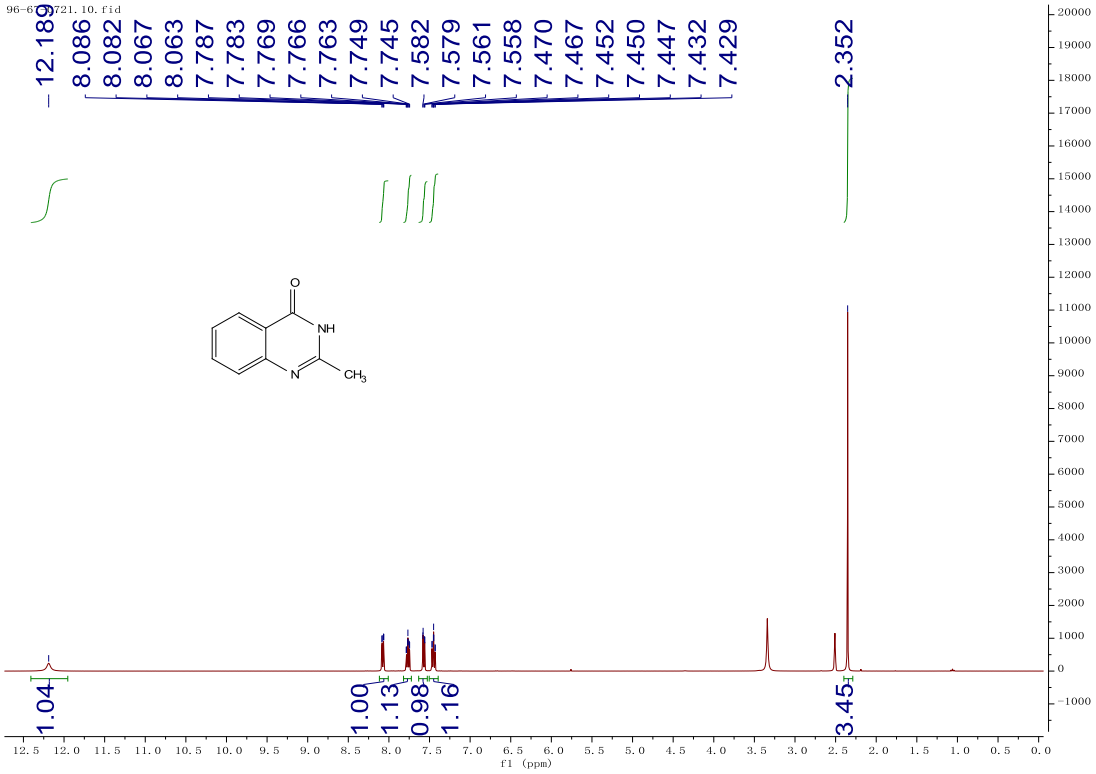
3 (^{1}H, $CDCl_3$)



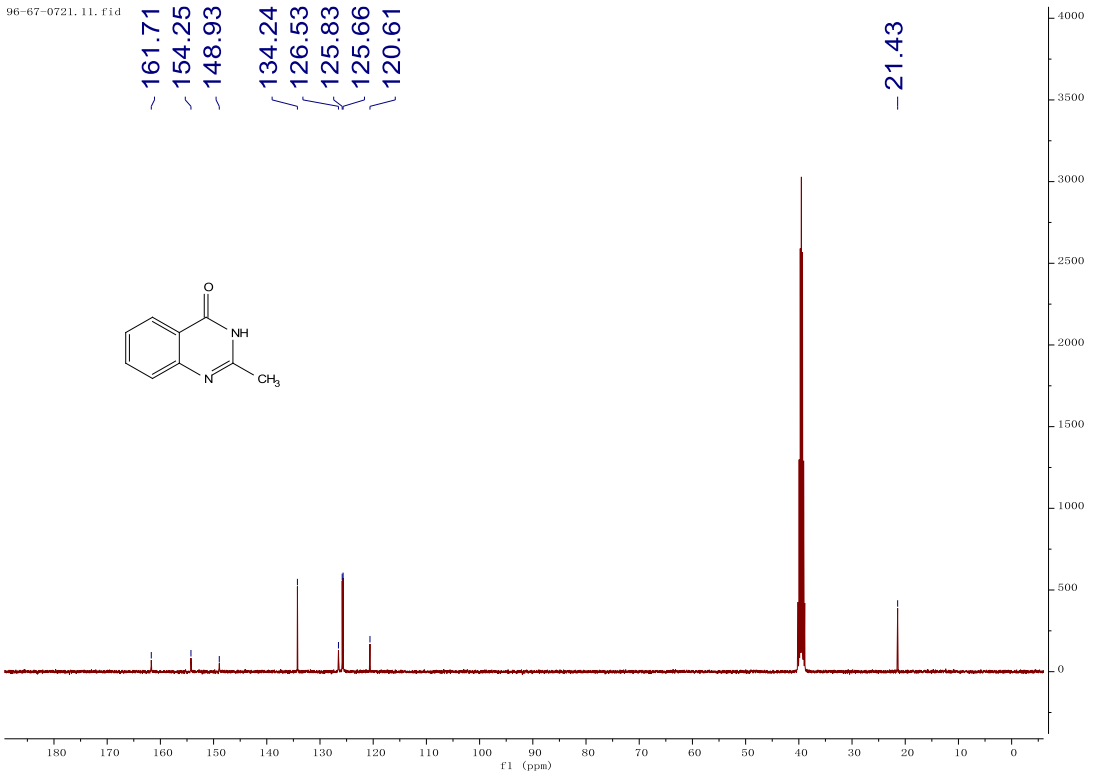
3 (^{13}C, $CDCl_3$)



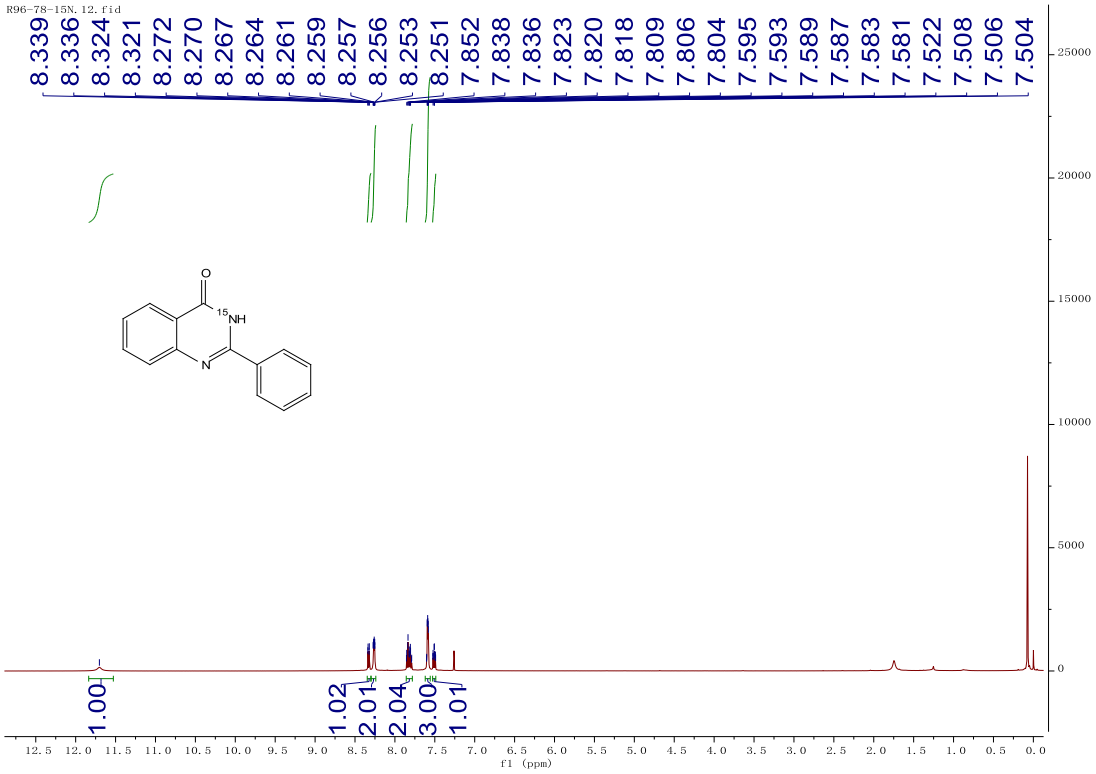
4as (^{1}H, DMSO-d_6)



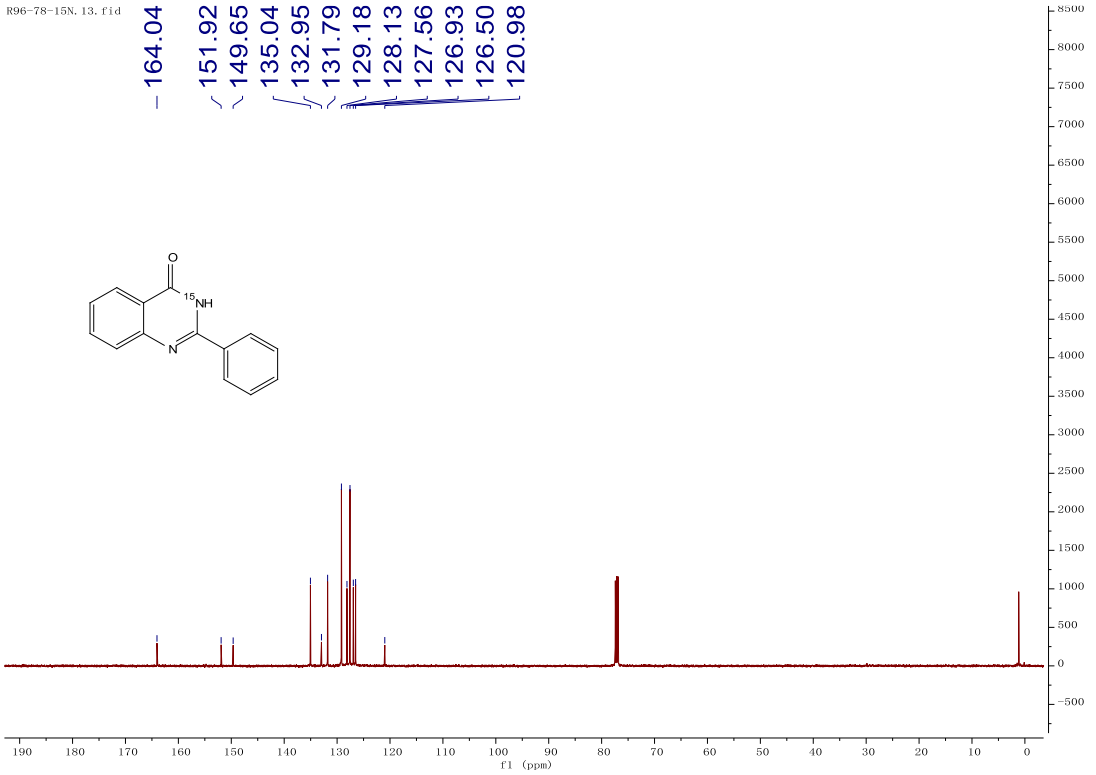
4as (^{13}C, DMSO-d_6)



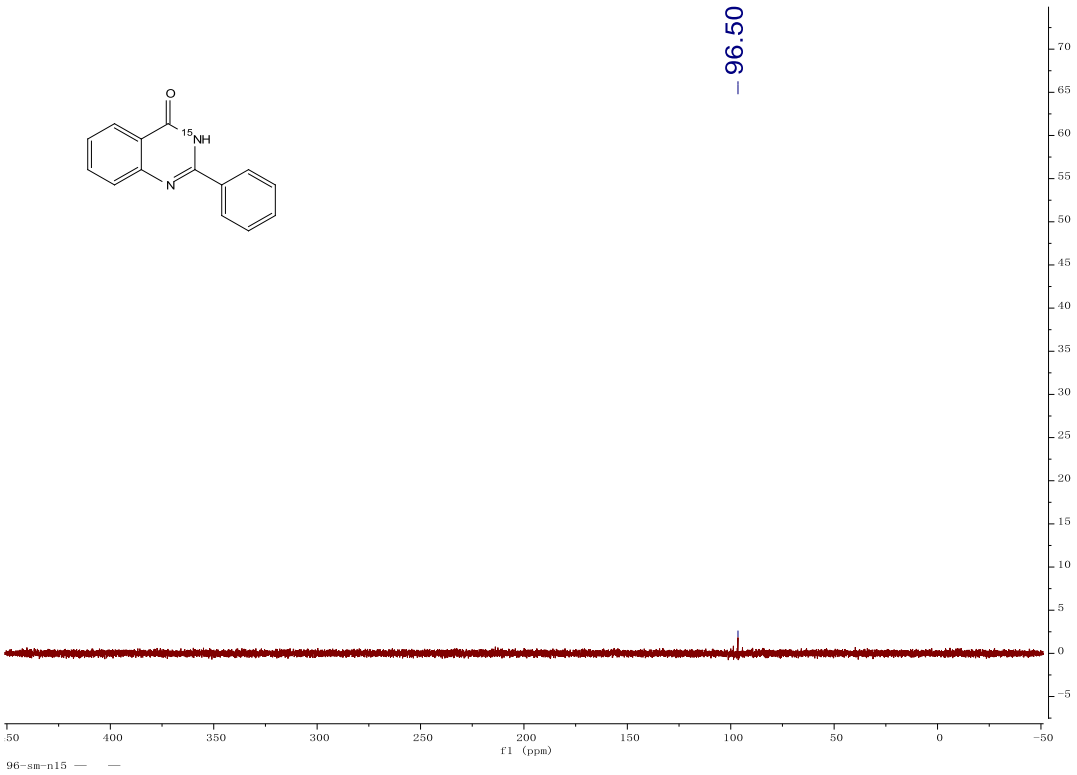
3aa-^{15}N (^{1}H, $CDCl_3$)



3aa-^{15}N (^{13}C, $CDCl_3$)



3aa-^{15}N (^{15}N, $CDCl_3$)



1a-d_5 (^{1}H, $CDCl_3$)