Supplementary Information

Iron mediated divergent reductive coupling reactions of heteroarenes with alkenes

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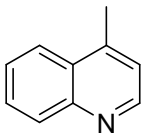
Table of Contents

1. General Information

Unless otherwise noted, all reagents were obtained from commercial suppliers (Adamas-beta) and used without further purification. The reaction product was isolated by column chromatography on a silica gel (236–400 mesh) column using petroleum ether (PE) with a boiling range from 60 to 90 ℃and EtOAc. ^{1}H, ^{13}C NMR and ^{19}F NMR spectra were recorded on 400, 101, 376 MHz NMR spectrometers using $CDCl_3$ and DMSO-d_6 as solvent. In addition, ^{1}H, and ^{13}C NMR spectra used tetramethylsilane as the internal standard and the ^{19}F NMR spectra used trifluoroacetic acid as the internal standard. HRMS were made by means of ESI. Unless otherwise noted, all reagents were weighed and handled in air, and all reactions were performed in air.

2. Substrate Structures



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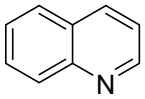

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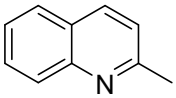

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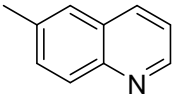

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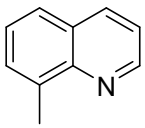

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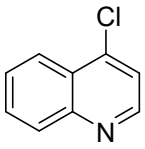

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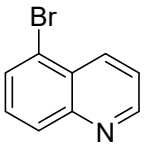

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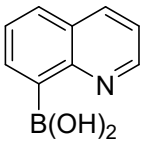

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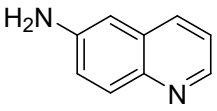

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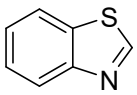

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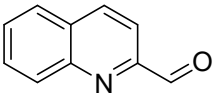

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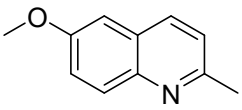

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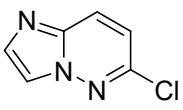

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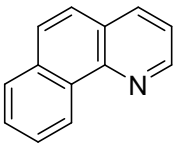

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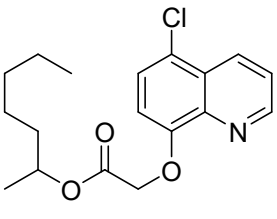
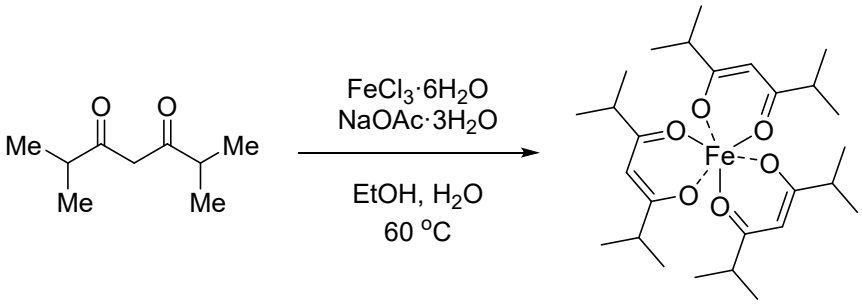


1p

Scheme S1. Substrate Structures

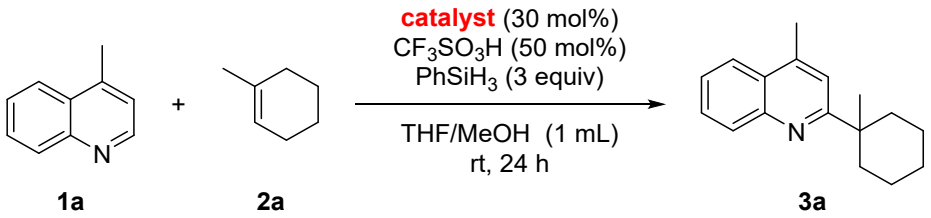
3. Preparation of $Fe(dibm)_3$



Iron(III) diisobutyrylmethane. To a biphasic mixture of 2,6-dimethylheptane-3,5-dione (2.60 g, 16.6 mmol, 3.0 equiv) and NaOAc (1.36 g, 16.6 mmol, 3.0 equiv) in an aqueous solution of EtOH (1:1 EtOH:H_2O, 42 mL) was added ground $FeCl_3$•$6H_2O$ (1.50 g, 5.55 mmol, 1.0 equiv). A red slurry formed and the reaction mixture was heated at 60 °C with stirring for 1 h. The slurry was cooled at room temperature over 10 min, cooled at 0 °C for 15 min, and then filtered to give an orange powder. The orange powder was rinsed with H_2O, collected, placed in an Erlenmeyer flask, and heated with an aqueous solution of EtOH (9:1 EtOH:H_2O, 30 mL) using a heat gun until fully dissolved to give a red, homogenous solution. The solution was cooled to room temperature and then to 0 °C to give red crystals, which were filtered and rinsed with a –78 °C aqueous solution of EtOH (9:1 EtOH:H_2O, 10 mL) to furnish $Fe(dibm)_3$ as a red crystalline solid (1.20 g, 2.31 mmol, 14%).[1]

4. Optimization of C2 Alkylation

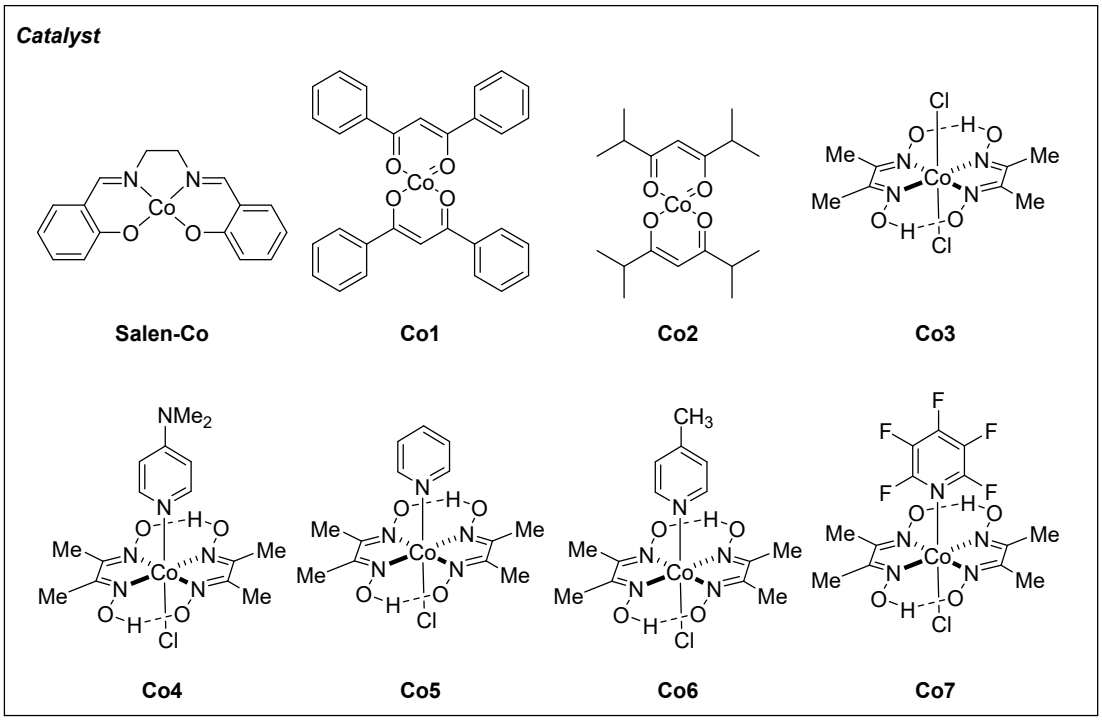
Table S1. Screening of Catalyst[a]



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

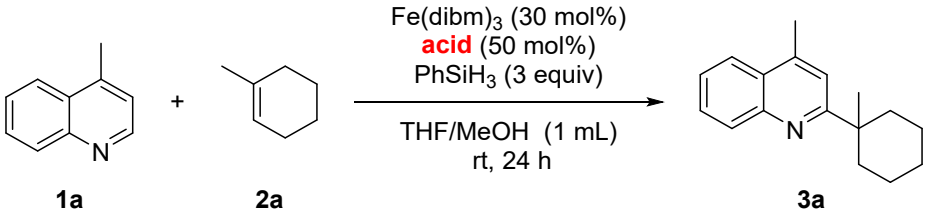
Entry	Catalyst	Yield(%)[b]
1	$Fe(acac)_3$	29
2	$Fe(dibm)_3$	45
3	$Fe(dpm)_3$	31
4	$Mn(dpm)_3$	20
5	$Co(acac)_2$(II)	N.R
6	$Co(acac)_2$(III)	N.R
7	$Ni(acac)_2$	N.R
8	Salen-Co	N.R
9	Co 1	N.R
10	Co 2	13
11	Co 3	N.R
12	Co 4	N.R
13	Co 5	N.R
14	Co 6	N.R
15	Co 7	N.R

[a]Reaction conditions: **1a** (0.2 mmol, 1.0 equiv), **2a** (0.6 mmol, 3.0 equiv), catalyst (30 mol%), CF_3SO_3H (50 mol%) and $PhSiH_3$ (3 equiv) was added in 1 mL of THF/MeOH (4:1) under air for 24 h. [b]Isolated products. N.R.=No reaction.



Scheme S2. Catalysts

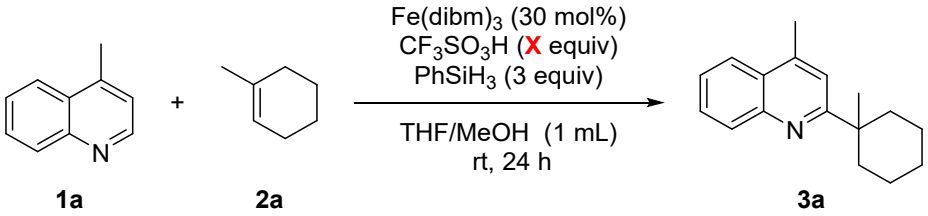
Table S2. Screening of Acid Additives[a]



Entry	Acid	Yield(%)[b]
1	CF_3SO_3H	45
2	CF_3COOH	12
3	$ClCH_2COOH$	<5
4	CH_3COOH	<5
5	C_6H_5COOH	37
6	$TsOH•H_2O$	37
7	HFIP	<5

[a]Reaction conditions: **1a** (0.2 mmol, 1.0 equiv), **2a** (0.6 mmol, 3.0 equiv), $Fe(dibm)_3$ (30 mol%), acid (50 mol%) and $PhSiH_3$ (3 equiv) was added in 1 mL of THF/MeOH (4:1) under air 24 h. [b]Isolated products. N.R.=No reaction.

Table S3. The Amount of Acid[a]

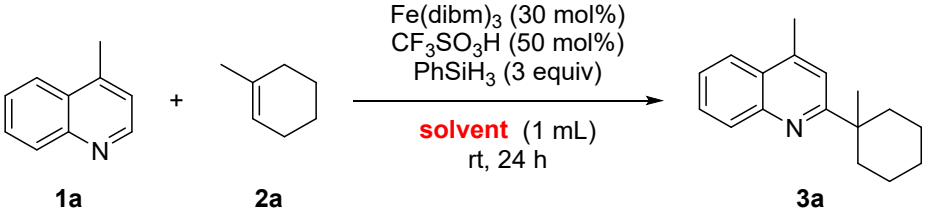


1a **2a** **3a**

Entry	CF_3SO_3H (equiv)	Yield(%)[b]
1	0.8	24
2	0	6
3	0.5	45

[a]Reaction conditions: **1a** (0.2 mmol, 1.0 equiv), **2a** (0.6 mmol, 3.0 equiv), $Fe(dibm)_3$ (30 mol%), CF_3SO_3H (X equiv) and $PhSiH_3$ (3 equiv) was added in 1 mL of THF/MeOH (4:1) under air 24 h. [b]Isolated products. N.R.=No reaction.

Table S4. Screening of Solvent[a]

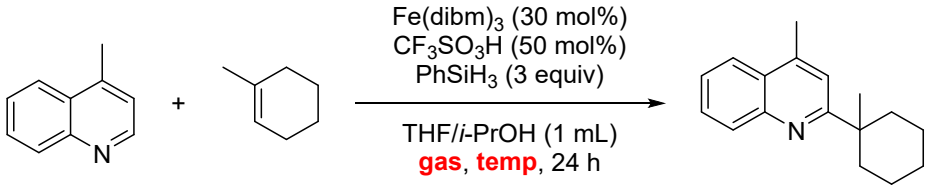


1a **2a** **3a**

Entry	Solvent	Yield(%)[b]
1	THF/EtOH (4:1)	49
2	EtOH	37
3	HFIP	15
4	THF/HFIP (4:1)	14
5	THF/MeOH (4:1)	45
6	THF/TBA (4:1)	25
7	TBA	14
8	THF	13
9	*i*-PrOH	43
10	THF/*i*-PrOH (4:1)	63
11	THF/*i*-PrOH (8:1)	67
12	THF/*i*-PrOH (6:1)	69
13	THF/*i*-PrOH (2:1)	62
14	THF/*i*-PrOH (1:1)	69

[a]Reaction conditions: **1a** (0.2 mmol, 1.0 equiv), **2a** (0.6 mmol, 3.0 equiv), $Fe(dibm)_3$ (30 mol%), CF_3SO_3H (50 mol%) and $PhSiH_3$ (3 equiv) was added in 1 mL of solvent under air 24 h. [b]Isolated products. N.R.=No reaction. TBA= tert-butanol. HFIP= 1,1,1,3,3,3-hexafluoro-2-propanol. THF= tetrahydrofuran.

Table S5. Screening of Temperature and Gas Environment[a]



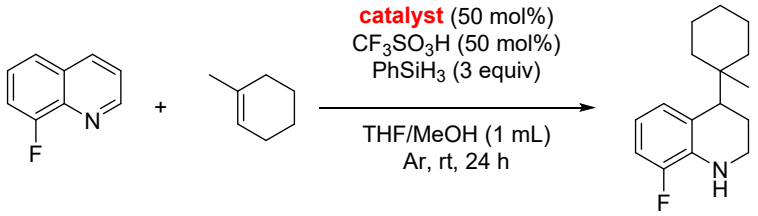
1a **2a** **3a**

Entry	Temp(°C)	Gas	Yield(%)[b]
1	20	Ar	47
2	20	Air	69
3	40	Air	64
4	60	Air	53

[a]Reaction conditions: **1a** (0.2 mmol, 1.0 equiv), **2a** (0.6 mmol, 3.0 equiv), $Fe(dibm)_3$ (30 mol%), CF_3SO_3H (50 mol%) and $PhSiH_3$ (3 equiv) was added in 1 mL of THF/*i*-PrOH (6:1) under gas environment 24 h. [b]Isolated products. N.R.=No reaction.

5. Optimization of Reductive Alkylation

Table S6. Screening of Catalyst[a]

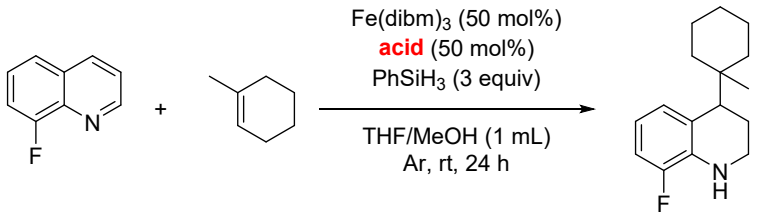


1i **2a** **5j**

Entry	Catalyst	Yield(%)[b]
1	$Fe(acac)_3$	72
2	$Fe(dibm)_3$	77
3	$Fe(dpm)_3$	37
4	$Mn(dpm)_3$	33
5	$Co(acac)_2$(II)	N.R
6	$Co(acac)_2$(III)	N.R
7	$Ni(acac)_2$	N.R
8	Salen-Co	N.R
9	Co 2	N.R
10	Co 5	N.R

[a]Reaction conditions: **1i** (0.2 mmol, 1.0 equiv), **2a** (0.6 mmol, 3.0 equiv), catalyst (50 mol%), CF_3SO_3H (50 mol%) and $PhSiH_3$ (3 equiv) was added in 1 mL of THF/MeOH (4:1) under Ar reaction for 24 h. [b]Isolated products. N.R.=No reaction.

Table S7. Screening of Acid Additives[a]

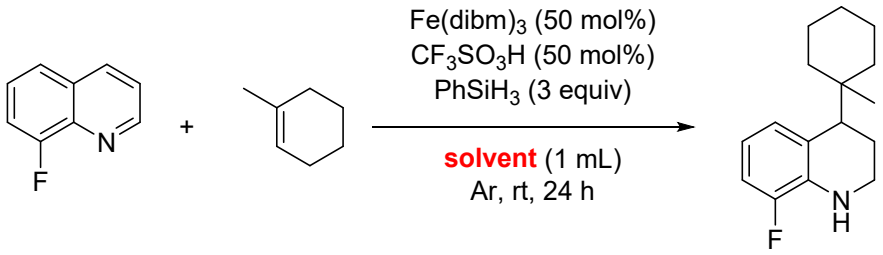


1i **2a** **5j**

Entry	Acid	Yield(%)[b]
1	CF_3SO_3H	77
2	CF_3COOH	N.R
3	$ClCH_2COOH$	N.R
4	CH_3COOH	N.R
5	C_6H_5COOH	N.R
6	$TsOH•H_2O$	29

[a]Reaction conditions: **1i** (0.2 mmol, 1.0 equiv), **2a** (0.6 mmol, 3.0 equiv), $Fe(dibm)_3$ (50 mol%), acid (50 mol%) and $PhSiH_3$ (3 equiv) was added in 1 mL of THF/MeOH (4:1) under Ar reaction for 24 h. [b]Isolated products. N.R.=No reaction.

Table S8. Screening of Solvent[a]



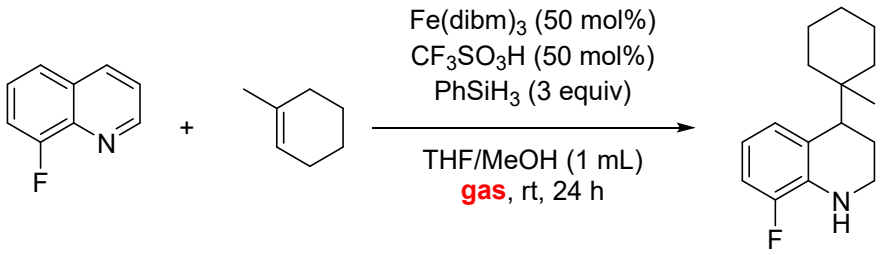
1i **2a** **5j**

Entry	Solvent	Yield(%)[b]
1	THF/MeOH (4:1)	77
2	THF/HFIP (4:1)	N.R
3	THF/TFE (4:1)	21
4	THF/*i*-PrOH (4:1)	61
5	THF/*i*-PrOH (6:1)	37

[a]Reaction conditions: **1i** (0.2 mmol, 1.0 equiv), **2a** (0.6 mmol, 3.0 equiv), $Fe(dibm)_3$ (50 mol%), CF_3SO_3H (50 mol%) and $PhSiH_3$ (3 equiv) was added in 1 mL of solvent under Ar reaction for 24 h. [b]Isolated products. N.R.=No reaction.

THF= tetrahydrofuran. TFE= trifluoroethanol.

Table S9. Screening of Gas Environment[a]



1i **2a** **5j**

Entry	Gas	Yield(%)[b]
1	O_2	N.R
2	Ar	77
3	Air	30

[a]Reaction conditions: **1i** (0.2 mmol, 1.0 equiv), **2a** (0.6 mmol, 3.0 equiv), Fe(dibm)$_3$ (50 mol%), CF_3SO_3H (50 mol%) and $PhSiH_3$ (3 equiv) was added in 1 mL of THF/MeOH (4:1) under Ar reaction for 24 h. [b]Isolated products. N.R.=No reaction.

6. General Procedures for Synthesis of Compounds

6.1 Procedures for Synthesis of Compounds (3a-3u)

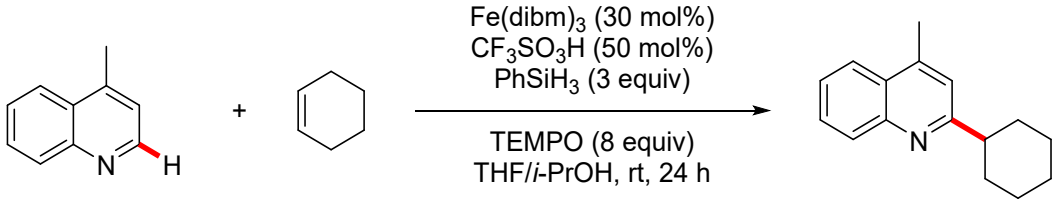
A Schlenk flask was charged with heterocycle **1** (0.2 mmol, 1.0 equiv), Fe(dibm)$_3$ (30 mol%), and olefin **2** (3 equiv), THF/*i*-PrOH (6:1, 1 mL), CF_3SO_3H (neat, 50 mol%) and $PhSiH_3$ (3 equiv) was added sequentially, and the mixture was stirred vigorously at rt in air for 24 h. The reaction mixture was then cooled to rt and quenched with saturated aqueous solution of $NaHCO_3$. The organic layer was separated and the aqueous layer was extracted with EtOAc. The organic layers were combined, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The solvent was evaporated in vacuo and the residue was purified by column chromatography on silica gel to give the pure product.

6.2 Procedures for Synthesis of Compounds (4a-4b and 5a-5m)

A Schlenk flask was charged with heterocycle **1** (0.2 mmol, 1.0 equiv), Fe(dibm)$_3$ (50 mol%), and olefin **2** (3 equiv). The flask was evacuated and backfilled with argon for 3 times. THF/MeOH (4:1, 1 mL), CF_3SO_3H (neat, 50 mol%) and $PhSiH_3$ (3 equiv) was added sequentially, and the mixture was stirred vigorously at rt for 24 h. The reaction mixture was then cooled to rt and quenched with saturated aqueous solution of $NaHCO_3$. The organic layer was separated and the aqueous layer was extracted with EtOAc. The organic layers were combined, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The solvent was evaporated in vacuo and the residue was purified by column chromatography on silica gel to give the pure product.

7. Cyclohexyl Radical Capture Experiment

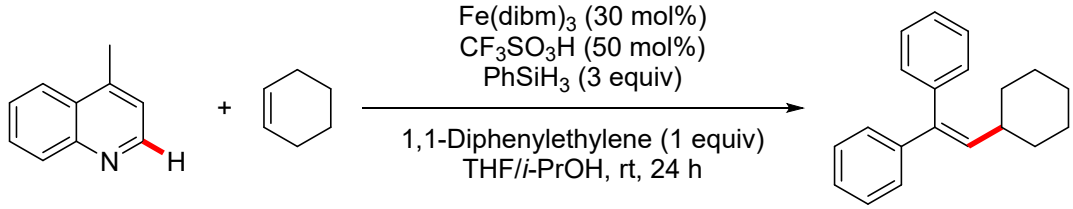
7.1 TEMPO Inhibition Experiment



1a **3b**, < 5%

A Schlenk flask was charged with heterocycle **1a** (0.2 mmol, 1.0 equiv), $Fe(dibm)_3$ (30 mol%), TEMPO (1.6 mmol, 8.0 equiv) and olefin **2** (3 equiv), THF/*i*-PrOH (6:1, 1 mL), CF_3SO_3H (neat, 50 mol%) and $PhSiH_3$ (3 equiv) was added sequentially, and the mixture was stirred vigorously at rt in air for 24 h. The target product yield is inhibited.

7.2 1,1-Diphenylethylene Inhibition Experiment



1a **6,** 16%

A Schlenk flask was charged with heterocycle **1a** (0.2 mmol, 1.0 equiv), $Fe(dibm)_3$ (30 mol%), 1,1-diphenylethylene (0.2 mmol, 1.0 equiv) and olefin **2** (3 equiv), THF/*i*-PrOH (6:1, 1 mL), CF_3SO_3H (neat, 50 mol%) and $PhSiH_3$ (3 equiv) was added sequentially, and the mixture was stirred vigorously at rt in air for 24 h. Product **6** was obtained with a yield of 16%. The structure of **6** is confirmed by ^1H NMR analysis as follows.

8. Prove the Formation of Ph(*i*-PrO)SiH_2

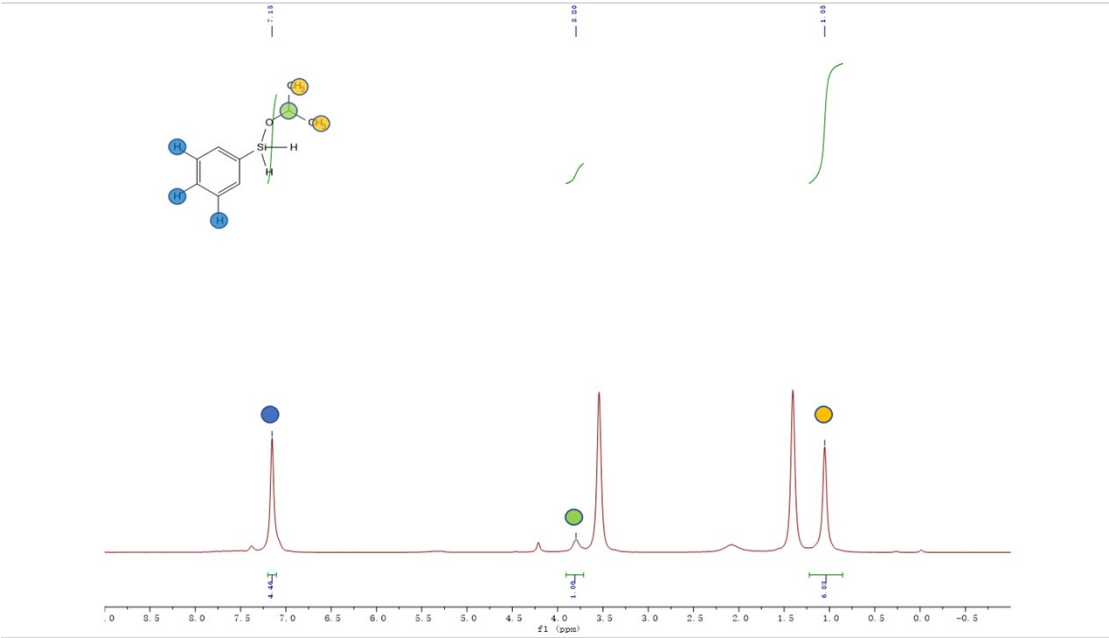
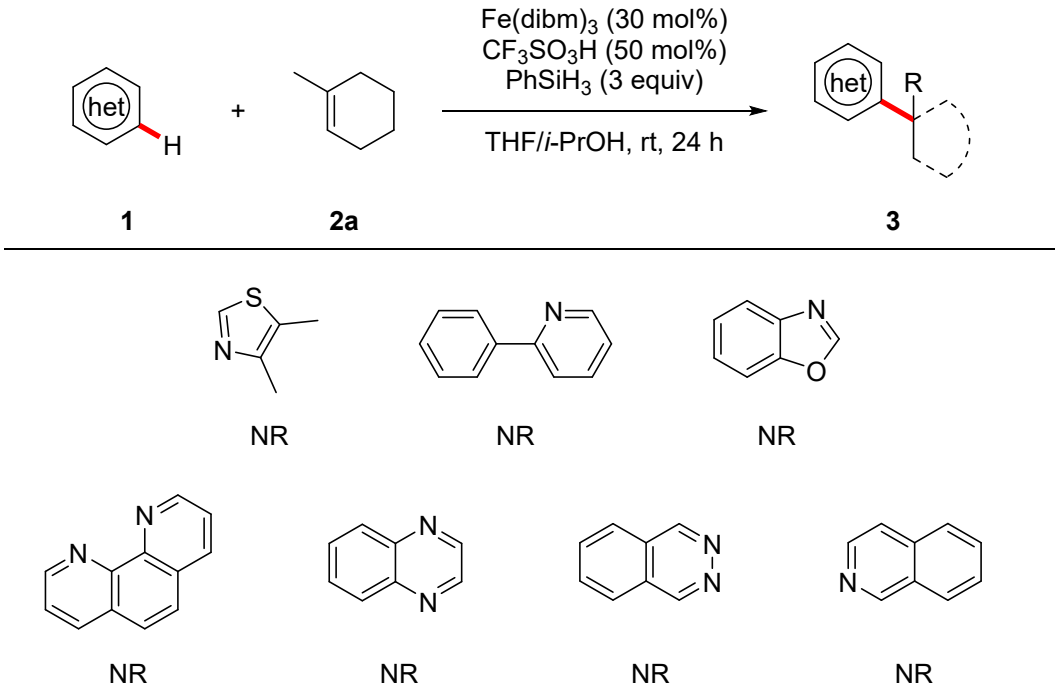


Figure S1. Prove the Formation of Ph(*i*-PrO)SiH_2

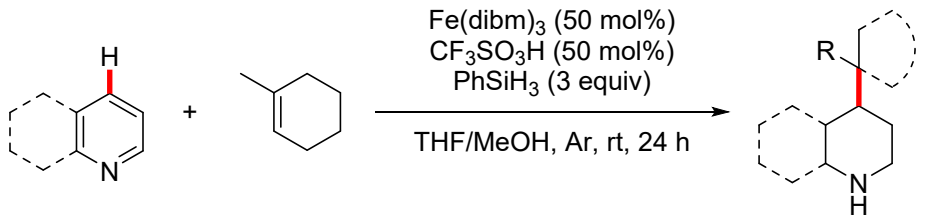
9. Unsuccessful Substrates

Table S10. Unsuccessful Substrates of C2-Alkylation[a,b]

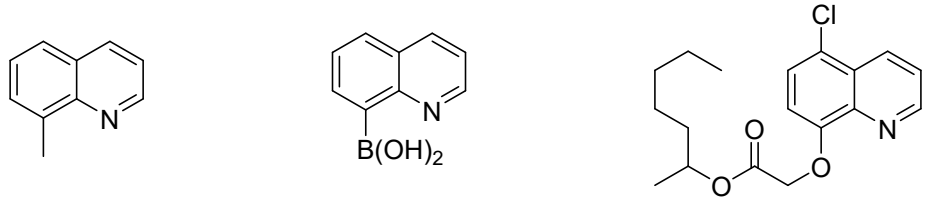


[a]Reaction conditions: **1** (0.2 mmol, 1.0 equiv), **2a** (0.6 mmol, 3.0 equiv), Fe(dibm)$_3$ (30 mol%), CF_3SO_3H (50 mol%) and $PhSiH_3$ (3 equiv) was added in 1 mL of THF/*i*-PrOH (6:1) under air 24 h. [b]Isolated products. N.R.=No reaction.

Table S11. Unsuccessful C4 Reductive Alkylation[a,b]



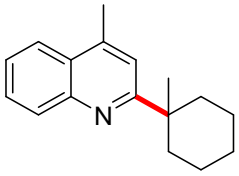
1 **2a** **5**



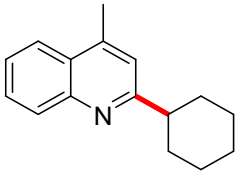
NR NR 10%

[a]Reaction conditions: **1** (0.2 mmol, 1.0 equiv), **2a** (0.6 mmol, 3.0 equiv), $Fe(dibm)_3$ (50 mol%), CF_3SO_3H (50 mol%) and $PhSiH_3$ (3 equiv) was added in 1 mL of THF/MeOH (4:1) under Ar reaction for 24 h. [b]Isolated products. N.R.=No reaction.

10. Characterization Data of the Compounds

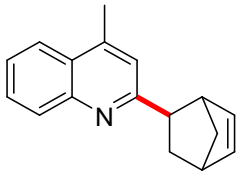


4-methyl-2-(1-methylcyclohexyl)quinoline (3a): Eluent: 100% petroleum ether (PE); Yellow Oil, 69% yield, 32.9 mg; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.05 (d, *J* = 8.4 Hz, 1H), 7.94 (d, *J* = 8.0 Hz, 1H), 7.65 (t, *J* = 7.6 Hz, 1H), 7.50 (t, *J* = 8.0 Hz, 1H), 7.32 (s, 1H), 2.69 (s, 3H), 2.35 (dd, *J* = 13.1, 7.9 Hz, 2H), 1.66 – 1.54 (m, 4H), 1.46 (s, 4H), 1.29 (s, 3H).**^{13}C NMR** (101 MHz, $CDCl_3$) δ 168.2, 147.6, 143.5, 130.0, 128.5, 126.5, 125.3, 123.4, 119.3, 77.3, 77.0, 76.7, 41.3, 37.2, 26.4, 22.9, 19.4, 19.0. **HRMS (ESI)** m/z calcd for $C_{17}H_{22}N^+$ $[M+H]^+$: 240.1747; found: 240.1745.

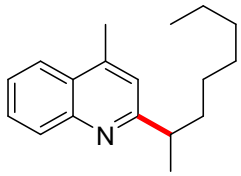


2-cyclohexyl-4-methylquinoline (3b): Eluent: PE/EtOAc (50:1); Colorless oil, 43% yield, 19.5 mg; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.06 (d, *J* = 8.4 Hz, 1H), 7.95 (d, *J* = 8.3 Hz, 1H), 7.68 (t, *J* = 7.6 Hz, 1H),

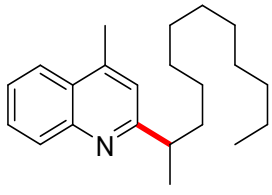
7.50 (t, J = 7.6 Hz, 1H), 7.18 (s, 1H), 2.94 – 2.84 (m, 1H), 2.70 (s, 3H), 2.03 (d, J = 12.0 Hz, 2H), 1.91 (d, J = 12.8 Hz, 2H), 1.81 (d, J = 12.7 Hz, 1H), 1.70 – 1.57 (m, 2H), 1.55 – 1.30 (m, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 166.5, 147.6, 144.3, 129.5, 129.0, 127.1, 125.4, 123.6, 120.3, 77.4, 77.1, 76.7, 47.6, 32.9, 26.6, 26.2, 18.9. **HRMS (ESI)** m/z calcd for $C_{16}H_{20}N^+$ $[M+H]^+$: 226.1590; found: 226.1587.



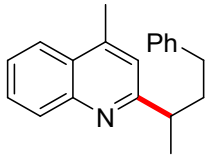
2-(bicyclo[2.2.1]hept-5-en-2-yl)-4-methylquinoline (3c): Eluent: PE/EtOAc (100:1); Colorless oil, 82% yield, 38.6 mg; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 8.01 (d, J = 8.2 Hz, 1H), 7.91 (d, J = 8.3 Hz, 1H), 7.68 (t, J = 7.6 Hz, 1H), 7.53 (t, J = 7.5 Hz, 1H), 7.35 (s, 1H), 6.29 (dd, J = 5.8, 3.0 Hz, 1H), 6.23 (dd, J = 5.7, 2.8 Hz, 1H), 2.98 (s, 2H), 2.88 (dd, J = 8.5, 4.3 Hz, 1H), 2.64 (s, 3H), 2.34 (dt, J = 11.4, 3.9 Hz, 1H), 1.76 (d, J = 8.0 Hz, 1H), 1.45 (ddd, J = 11.2, 8.8, 2.2 Hz, 1H), 1.24 (d, J = 7.9 Hz, 1H). **^{13}C NMR** (101 MHz, DMSO-d_6) δ 164.6, 147.4, 144.2, 138.4, 137.3, 129.7, 129.5, 126.9, 126.0, 124.4, 123.1, 48.9, 46.5, 45.5, 42.1, 40.6, 40.4, 40.2, 40.0, 39.8, 39.6, 39.4, 31.3, 18.6. **HRMS (ESI)** m/z calcd for $C_{17}H_{18}N^+$ $[M+H]^+$: 236.1434; found: 236.1433.



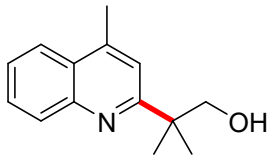
4-methyl-2-(octan-2-yl)quinoline (3d): Eluent: PE/EtOAc (100:1); Yellow oil, 59% yield, 29.9 mg; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.08 (d, J = 8.4 Hz, 1H), 7.96 (d, J = 8.2 Hz, 1H), 7.68 (t, J = 7.6 Hz, 1H), 7.51 (t, J = 7.5 Hz, 1H), 7.15 (s, 1H), 3.05 (q, J = 7.1 Hz, 1H), 2.70 (s, 3H), 1.83 (tdd, J = 13.4, 9.0, 5.9 Hz, 1H), 1.67 (dq, J = 19.1, 6.1 Hz, 1H), 1.37 (d, J = 6.9 Hz, 3H), 1.33 – 1.15 (m, 8H), 0.87 (t, J = 6.7 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 167.0, 147.6, 144.2, 129.6, 128.9, 127.0, 125.4, 123.6, 120.2, 77.4, 77.1, 76.7, 43.0, 37.1, 31.8, 29.5, 27.7, 22.6, 20.8, 18.9, 14.1. **HRMS (ESI)** m/z calcd for $C_{18}H_{26}N^+$ $[M+H]^+$: 256.2060; found: 256.2056.



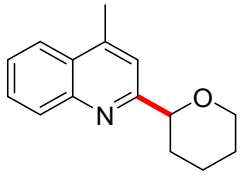
2-(dodecan-2-yl)-4-methylquinoline (3e): Eluent: PE/EtOAc (50:1); Colorless oil, 49% yield, 30.5 mg; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.07 (d, *J* = 8.3 Hz, 1H), 7.96 (d, *J* = 8.3 Hz, 1H), 7.68 (t, *J* = 7.0 Hz, 1H), 7.51 (t, *J* = 7.6 Hz, 1H), 7.15 (s, 1H), 3.05 (q, *J* = 7.1 Hz, 1H), 2.70 (s, 3H), 1.82 (qd, *J* = 10.1, 9.1, 6.3 Hz, 1H), 1.67 (tt, *J* = 13.3, 6.0 Hz, 1H), 1.39 – 1.19 (m, 19H), 0.88 (t, *J* = 6.8 Hz, 3H).**^{13}C NMR** (101 MHz, $CDCl_3$) δ 167.0, 147.7, 144.1, 129.6, 128.9, 127.0, 125.3, 123.6, 120.2, 77.3, 77.0, 76.7, 43.0, 37.1, 31.9, 29.8, 29.6, 29.6, 29.6, 29.3, 27.7, 22.7, 20.8, 18.8, 14.1. **HRMS (ESI)** m/z calcd for $C_{22}H_{34}N^+$ $[M+H]^+$:312.2686; found: 312.2683.



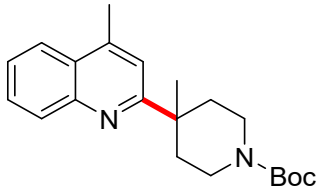
4-methyl-2-(4-phenylbutan-2-yl)quinoline (3f): Eluent: PE/EtOAc (20:1); Colorless oil, 45% yield, 24.9 mg; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 8.04 (d, *J* = 8.1 Hz, 1H), 7.96 (d, *J* = 8.3 Hz, 1H), 7.70 (t, *J* = 7.6 Hz, 1H), 7.56 (t, *J* = 7.5 Hz, 1H), 7.32 (s, 1H), 7.25 (t, *J* = 7.5 Hz, 2H), 7.16 (t, *J* = 7.4 Hz, 3H), 3.01 (q, *J* = 7.0 Hz, 1H), 2.67 (s, 3H), 2.57 (ddd, *J* = 14.0, 10.0, 6.2 Hz, 1H), 2.45 (dq, *J* = 10.2, 5.7, 4.9 Hz, 1H), 2.12 (dddd, *J* = 13.6, 9.8, 6.0, 4.1 Hz, 1H), 1.91 (ddt, *J* = 12.9, 9.9, 6.3 Hz, 1H), 1.32 (d, *J* = 6.9 Hz, 3H). **^{13}C NMR** (101 MHz, DMSO-d_6) δ 166.2, 147.6, 144.8, 142.6, 129.6, 129.5, 128.7, 127.1, 126.1, 126.0, 124.5, 121.2, 41.8, 40.6, 40.4, 40.2, 40.0, 39.8, 39.6, 39.4, 38.5, 33.7, 21.1, 18.7. **HRMS (ESI)** m/z calcd for $C_{20}H_{22}N^+$ $[M+H]^+$: 276.1747; found: 276.1745.



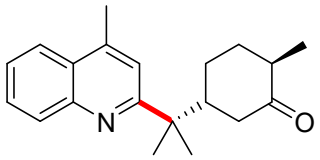
2-methyl-2-(4-methylquinolin-2-yl)propan-1-ol (3g): Eluent: PE/EtOAc (9:1); Colorless oil, 57% yield, 24.5 mg; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 8.01 (d, *J* = 8.1 Hz, 1H), 7.92 (d, *J* = 8.3 Hz, 1H), 7.68 (t, *J* = 7.1 Hz, 1H), 7.54 (t, *J* = 7.2 Hz, 1H), 7.48 (s, 1H), 4.73 (t, *J* = 5.6 Hz, 1H), 3.65 (d, *J* = 5.6 Hz, 2H), 2.65 (s, 3H), 1.33 (s, 6H). **^{13}C NMR** (101 MHz, DMSO-d_6) δ 167.3, 147.0, 144.1, 129.7, 129.4, 126.7, 126.1, 124.3, 120.3, 70.8, 43.3, 40.6, 40.4, 40.2, 40.0, 39.8, 39.6, 39.4, 25.2, 18.9. **HRMS (ESI)** m/z calcd for $C_{14}H_{18}NO^+$ $[M+H]^+$: 216.1383; found: 216.1382.



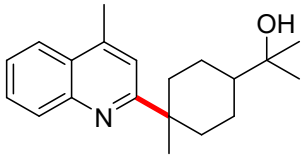
4-methyl-2-(tetrahydro-2H-pyran-2-yl)quinoline (3h): Eluent: PE/EtOAc (9:1); Colorless oil, 61% yield, 27.6 mg; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 8.04 (d, J = 8.2 Hz, 1H), 7.93 (d, J = 8.3 Hz, 1H), 7.71 (t, J = 7.6 Hz, 1H), 7.57 (t, J = 7.6 Hz, 1H), 7.46 (s, 1H), 4.48 (dd, J = 11.0, 2.4 Hz, 1H), 4.06 (d, J = 11.1 Hz, 1H), 3.64 – 3.52 (m, 1H), 2.67 (s, 3H), 2.03 – 1.93 (m, 1H), 1.92 – 1.83 (m, 1H), 1.75 – 1.44 (m, 4H). **^{13}C NMR** (101 MHz, DMSO-d_6) δ 162.3, 147.1, 145.1, 129.7, 129.6, 127.5, 126.5, 124.6, 119.2, 80.9, 68.3, 40.6, 40.4, 40.2, 40.0, 39.8, 39.6, 39.4, 32.5, 26.0, 23.6, 18.8. **HRMS (ESI)** m/z calcd for $C_{15}H_{18}NO^+$ $[M+H]^+$: 228.1383; found: 228.1380.



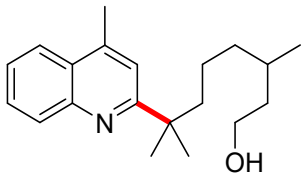
tert-butyl 4-methyl-4-(4-methylquinolin-2-yl)piperidine-1-carboxylate (3i): Eluent: PE/EtOAc (9:1); Colorless oil, 63% yield, 42.8 mg; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.13 – 7.87 (m, 2H), 7.77 – 7.62 (m, 1H), 7.61 – 7.46 (m, 1H), 7.40 – 7.22 (m, 1H), 3.73 (s, 2H), 3.25 (s, 2H), 2.73 (d, J = 13.3 Hz, 3H), 2.49 (s, 2H), 1.74 (s, 2H), 1.48 (d, J = 12.9 Hz, 9H), 1.37 (d, J = 13.1 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 166.0, 155.1, 147.4, 144.2, 130.0, 128.9, 126.6, 125.7, 123.5, 119.2, 79.2, 41.4, 39.8, 36.2, 29.1, 28.5, 19.1. **HRMS (ESI)** m/z calcd for $C_{21}H_{29}N_2O_2^+$ $[M+H]^+$: 341.2224; found: 341.2220.



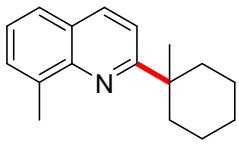
(2*R*,5*S*)-2-methyl-5-(2-(4-methylquinolin-2-yl)propan-2-yl)cyclohexan-1-one (3j): Eluent: PE/EtOAc (20:1); Colorless oil, 33% yield, 19.2 mg; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 8.03 (d, J = 8.0 Hz, 1H), 7.93 (d, J = 8.2 Hz, 1H), 7.70 (t, J = 7.1 Hz, 1H), 7.57 (t, J = 7.2 Hz, 1H), 7.49 (s, 1H), 2.68 (s, 3H), 2.36 (dt, J = 12.7, 6.3 Hz, 1H), 2.29 – 2.15 (m, 2H), 1.98 (ddd, J = 12.5, 5.8, 3.0 Hz, 1H), 1.89 (d, J = 11.5 Hz, 1H), 1.63 – 1.46 (m, 2H), 1.37 (d, J = 12.7 Hz, 6H), 1.22 – 1.11 (m, 1H), 0.84 (d, J = 6.5 Hz, 3H). **^{13}C NMR** (101 MHz, DMSO-d_6) δ 212.6, 167.5, 146.9, 144.4, 129.9, 129.5, 126.6, 126.2, 124.3, 119.9, 49.2, 44.2, 43.8, 43.7, 40.6, 40.4, 40.2, 40.0, 39.8, 39.6, 39.4, 34.7, 26.7, 24.8, 24.0, 18.9, 14.8. **HRMS (ESI)** m/z calcd for $C_{20}H_{26}NO^+$ $[M+H]^+$: 296.2009; found: 296.2007.



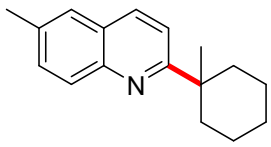
2-(4-methyl-4-(4-methylquinolin-2-yl)cyclohexyl)propan-2-ol (3k): Eluent: PE/EtOAc (9:1); Yellow oil, 46% yield, 27.3 mg; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 8.01 (d, J = 8.2 Hz, 1H), 7.93 (d, J = 8.4 Hz, 1H), 7.69 (t, J = 7.6 Hz, 1H), 7.55 (d, J = 7.1 Hz, 1H), 7.51 (d, J = 6.4 Hz, 1H), 4.07 (s, 1H), 2.66 (s, 3H), 1.94 (d, J = 12.6 Hz, 2H), 1.77 (t, J = 11.7 Hz, 4H), 1.33 (d, J = 9.8 Hz, 5H), 1.22 (dd, J = 13.2, 9.5 Hz, 1H), 1.09 (s, 6H). **^{13}C NMR** (101 MHz, DMSO-d_6) δ 169.9, 147.0, 144.3, 129.8, 129.3, 126.7, 126.0, 124.3, 119.4, 71.1, 48.9, 40.6, 40.4, 40.2, 40.0, 39.8, 39.6, 39.4, 36.9, 27.6, 23.1, 23.0, 18.9. **HRMS (ESI)** m/z calcd for $C_{20}H_{28}NO^+$ $[M+H]^+$: 298.2165; found: 298.2162.



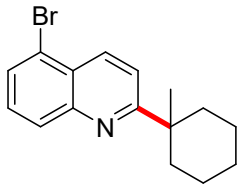
3,7-dimethyl-7-(4-methylquinolin-2-yl)octan-1-ol (3l): Eluent: PE/EtOAc (9:1); Colorless oil, 65% yield, 38.7 mg; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.07 (d, J = 8.4 Hz, 1H), 7.94 (d, J = 8.2 Hz, 1H), 7.65 (t, J = 7.6 Hz, 1H), 7.49 (t, J = 7.5 Hz, 1H), 7.29 (s, 1H), 3.60 (qd, J = 10.4, 9.9, 3.6 Hz, 2H), 2.68 (s, 3H), 1.80 – 1.73 (m, 2H), 1.54 – 1.40 (m, 8H), 1.33 – 1.03 (m, 6H), 0.79 (d, J = 6.4 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 168.2, 147.3, 143.6, 129.9, 128.7, 126.5, 125.4, 123.4, 119.3, 77.4, 77.1, 76.8, 61.1, 43.5, 41.0, 39.8, 37.8, 29.2, 27.9, 22.1, 19.6, 19.1. **HRMS (ESI)** m/z calcd for $C_{20}H_{30}NO^+$ $[M+H]^+$: 300.2322; found: 300.2321.



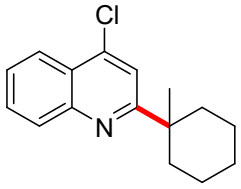
8-methyl-2-(1-methylcyclohexyl)quinoline (3m): Eluent: PE/EtOAc (100:1); Colorless oil, 50% yield, 23.8 mg; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.04 (d, J = 8.7 Hz, 1H), 7.61 (d, J = 8.1 Hz, 1H), 7.50 (dd, J = 16.5, 7.8 Hz, 2H), 7.36 (t, J = 7.5 Hz, 1H), 2.81 (s, 3H), 2.49 – 2.37 (m, 2H), 1.66 – 1.54 (m, 4H), 1.53 – 1.41 (m, 4H), 1.29 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 166.9, 146.4, 137.5, 136.0, 128.9, 126.1, 125.3, 125.1, 118.4, 77.4, 77.0, 76.7, 41.8, 37.4, 30.0, 26.5, 23.0, 17.8. **HRMS (ESI)** m/z calcd for $C_{17}H_{22}N^+$ $[M+H]^+$: 240.1747; found: 240.1745.



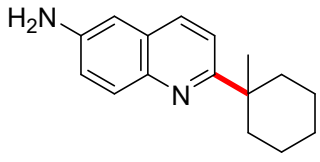
6-methyl-2-(1-methylcyclohexyl)quinoline (3n): Eluent: PE/EtOAc (50:1);Yellow oil, 66% yield, 31.6 mg; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.98 (dd, *J* = 11.2, 8.9 Hz, 2H), 7.58 – 7.41 (m, 3H), 2.54 (s, 3H), 2.37 (dd, *J* = 11.9, 6.4 Hz, 2H), 1.73 – 1.58 (m, 4H), 1.48 (s, 4H), 1.32 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 167.6, 146.3, 135.3, 135.2, 131.1, 129.1, 126.3, 126.1, 118.7, 77.4, 77.1, 76.7, 41.4, 37.3, 29.2, 26.4, 22.9, 21.5. **HRMS (ESI)** m/z calcd for $C_{17}H_{22}N^+$ $[M+H]^+$: 240.1747; found: 240.1743.



5-bromo-2-(1-methylcyclohexyl)quinoline (3o)： Eluent: PE/EtOAc (50:1); Colorless oil, 43% yield, 26.0 mg； **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.43 (d, *J* = 8.9 Hz, 1H), 8.02 (d, *J* = 8.5 Hz, 1H), 7.74 (d, *J* = 7.5 Hz, 1H), 7.59 (d, *J* = 8.9 Hz, 1H), 7.51 (t, *J* = 8.0 Hz, 1H), 2.36 (dd, *J* = 12.2, 6.9 Hz, 2H), 1.63 (d, *J* = 12.6 Hz, 4H), 1.45 (s, 4H), 1.30 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 169.4, 148.5, 135.3, 129.4, 129.3, 129.1, 125.8, 121.6, 120.0, 77.4, 77.0, 76.7, 41.5, 37.1, 29.3, 26.3, 22.9. **HRMS (ESI)** m/z calcd for $C_{16}H_{19}BrN^+$ $[M+H]^+$: 304.0695; found: 304.0693.

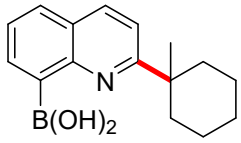


4-chloro-2-(1-methylcyclohexyl)quinoline (3p)： Eluent: PE/EtOAc (100:1); Colorless oil, 53% yield, 27.3 mg； **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.19 (d, *J* = 8.3 Hz, 1H), 8.09 (d, *J* = 8.4 Hz, 1H), 7.73 (t, *J* = 7.6 Hz, 1H), 7.59 (d, *J* = 4.4 Hz, 2H), 2.35 (dd, *J* = 12.3, 6.3 Hz, 3H), 1.70 – 1.58 (m, 8H), 1.48 (s, 4H), 1.32 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 168.7, 148.6, 142.4, 129.8, 129.8, 126.6, 124.6, 123.7, 119.0, 77.3, 77.0, 76.7, 41.7, 37.1, 29.2, 26.2, 22.9. **HRMS (ESI)** m/z calcd for $C_{16}H_{19}ClN^+$ $[M+H]^+$: 260.1201; found: 260.1200.

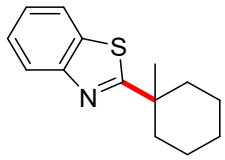


2-(1-methylcyclohexyl)quinolin-6-amine (3q): Eluent: PE/EtOAc (4:1); Brown oil, 43% yield, 20.8 mg; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 7.84 (d, *J* = 8.7 Hz, 1H), 7.60 (d, *J* = 8.9 Hz, 1H), 7.36 (d, *J* = 8.7 Hz, 1H), 7.08 (d, *J* = 11.1 Hz, 1H), 6.74 (s, 1H), 5.43 (s, 2H), 2.24 (d, *J* = 8.6 Hz, 2H), 1.58 – 1.40 (m,

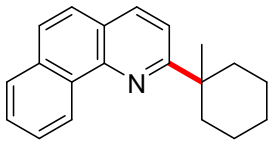
4H), 1.41 – 1.29 (m, 4H), 1.17 (s, 3H). **^{13}C NMR** (101 MHz, DMSO-d_6) δ 162.6, 146.9, 141.5, 133.9, 129.9, 128.2, 121.6, 118.9, 105.3, 41.0, 40.6, 40.4, 40.2, 40.0, 39.7, 39.6, 39.3, 37.2, 29.9, 26.3, 23.0. **HRMS (ESI)** m/z calcd for $C_{16}H_{21}N_2^+$ $[M+H]^+$: 241.1699; found: 241.1697.



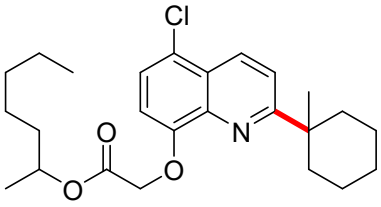
(2-(1-methylcyclohexyl)quinolin-8-yl)boronic acid (3r): Eluent: PE/EtOAc (4:1); Yellow oil, 44% yield, 23.5 mg; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.91 (s, 2H), 8.39 (d, J = 6.9 Hz, 1H), 8.21 (d, J = 8.6 Hz, 1H), 7.92 (d, J = 8.1 Hz, 1H), 7.59 (t, J = 8.7 Hz, 2H), 2.29 (dd, J = 11.3, 6.8 Hz, 2H), 1.82 – 1.65 (m, 4H), 1.52 (d, J = 7.9 Hz, 4H), 1.35 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 171.4, 167.9, 151.2, 137.9, 137.8, 130.4, 126.1, 125.9, 118.7, 77.4, 77.0, 76.7, 41.7, 37.3, 29.2, 26.2, 22.8. **HRMS (ESI)** m/z calcd for $C_{16}H_{21}BNO_2^+$ $[M+H]^+$: 270.1660; found: 270.1656.



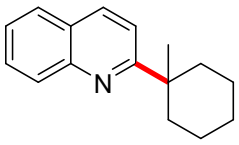
2-(1-methylcyclohexyl)benzo[d]thiazole (3s): Eluent: PE/EtOAc (100:1); Colorless oil, 43% yield, 19.8 mg; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.00 (d, J = 8.1 Hz, 1H), 7.86 (d, J = 7.9 Hz, 1H), 7.44 (t, J = 7.7 Hz, 1H), 7.33 (t, J = 7.6 Hz, 1H), 2.31 – 2.14 (m, 2H), 1.74 – 1.47 (m, 8H), 1.41 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 181.7, 153.3, 134.9, 125.6, 124.5, 122.7, 121.5, 77.4, 77.0, 76.7, 42.1, 38.5, 29.8, 25.8, 22.7. **HRMS (ESI)** m/z calcd for $C_{14}H_{18}NS^+$ $[M+H]^+$: 232.1154; found: 232.1151.



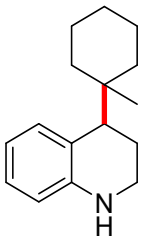
2-(1-methylcyclohexyl)benzo[h]quinoline (3t): Eluent: 100% petroleum ether (PE); Colorless oil, 58% yield, 31.8 mg; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 9.42 (d, J = 8.0 Hz, 1H), 8.12 (d, J = 8.4 Hz, 1H), 7.92 (d, J = 7.7 Hz, 1H), 7.81 – 7.66 (m, 4H), 7.62 (d, J = 8.4 Hz, 1H), 2.54 (dd, J = 10.9, 6.3 Hz, 2H), 1.79 – 1.64 (m, 4H), 1.61 – 1.47 (m, 4H), 1.39 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 167.2, 145.3, 135.8, 133.7, 132.0, 127.7, 127.6, 126.7, 126.6, 125.1, 124.7, 123.9, 119.0, 77.4, 77.1, 76.7, 41.8, 37.5, 30.1, 26.5, 23.0. **HRMS (ESI)** m/z calcd for $C_{20}H_{22}N^+$ $[M+H]^+$: 276.1747; found: 276.1743.



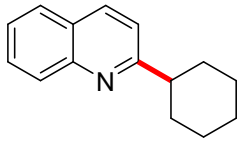
heptan-2-yl 2-((5-chloro-2-(1-methylcyclohexyl)quinolin-8-yl)oxy)acetate (3u): Eluent: PE/EtOAc (50:1); Colorless oil, 63% yield, 54.1 mg; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 8.40 (d, J = 9.0 Hz, 1H), 7.79 (d, J = 9.0 Hz, 1H), 7.56 (d, J = 8.4 Hz, 1H), 7.09 (d, J = 8.4 Hz, 1H), 5.15 – 4.99 (m, 2H), 4.86 (q, J = 6.2 Hz, 1H), 2.28 (s, 2H), 1.60 – 1.48 (m, 4H), 1.44 – 1.29 (m, 6H), 1.23 – 1.07 (m, 12H), 0.76 (t, J = 6.5 Hz, 3H). **^{13}C NMR** (101 MHz, DMSO-d_6) δ 168.8, 168.1, 153.1, 140.0, 133.2, 126.1, 125.0, 122.4, 120.9, 112.6, 71.9, 67.0, 41.9, 40.6, 40.4, 40.2, 39.9, 39.7, 39.5, 39.3, 37.0, 35.6, 31.5, 29.5, 26.2, 24.7, 22.8, 22.4, 20.2, 14.3. **HRMS (ESI)** m/z calcd for $C_{25}H_{35}ClNO_3^+$ $[M+H]^+$: 432.2300; found: 432.2298.



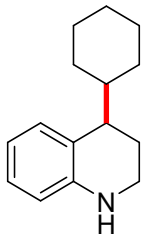
2-(1-methylcyclohexyl)quinoline (4a): Eluent: PE/EtOAc (100:1); Yellow oil, 39% yield, 17.4 mg; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.13 – 8.01 (m, 2H), 7.77 (d, J = 8.0 Hz, 1H), 7.70 – 7.63 (m, 1H), 7.55 – 7.42 (m, 2H), 2.37 (dd, J = 12.0, 6.5 Hz, 2H), 1.69 – 1.57 (m, 4H), 1.46 (s, 4H), 1.30 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 168.6, 147.7, 135.8, 129.4, 128.9, 127.2, 126.3, 125.6, 118.7, 77.4, 77.0, 76.7, 41.6, 37.2, 29.2, 26.4, 22.9. **HRMS (ESI)** m/z calcd for $C_{16}H_{20}N^+$ $[M+H]^+$: 226.1590; found: 226.1589.



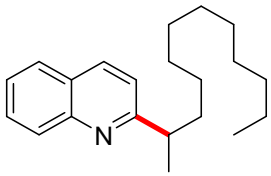
4-(1-methylcyclohexyl)-1,2,3,4-tetrahydroquinoline (4b): Eluent: PE/EtOAc (100:1); Yellow oil, 30% yield, 13.6 mg; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 6.83 (t, J = 7.5 Hz, 1H), 6.75 (d, J = 7.3 Hz, 1H), 6.41 (d, J = 7.9 Hz, 1H), 6.33 (t, J = 7.2 Hz, 1H), 5.60 (d, J = 3.5 Hz, 1H), 3.21 (ddt, J = 16.5, 12.2, 4.9 Hz, 2H), 2.50 (d, J = 11.0 Hz, 2H), 2.08 (d, J = 13.7 Hz, 1H), 1.57 – 1.24 (m, 10H), 0.69 (s, 3H). **^{13}C NMR** (101 MHz, DMSO-d_6) δ 146.0, 130.9, 127.1, 120.8, 113.8, 113.2, 40.6, 40.3, 40.1, 39.9, 39.7, 39.5, 39.3, 38.9, 37.4, 37.0, 35.8, 26.4, 22.6, 22.2, 21.8. **HRMS (ESI)** m/z calcd for $C_{16}H_{24}N^+$ $[M+H]^+$: 230.1903; found: 230.1900.



2-cyclohexylquinoline (5a-C2): Eluent: PE/EtOAc (100:1); Yellow oil, 46% yield, 19.3 mg; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.06 (t, *J* = 8.4 Hz, 2H), 7.76 (d, *J* = 8.1 Hz, 1H), 7.67 (t, *J* = 7.6 Hz, 1H), 7.46 (t, *J* = 7.5 Hz, 1H), 7.32 (d, *J* = 8.5 Hz, 1H), 2.92 (tt, *J* = 12.0, 3.3 Hz, 1H), 2.02 (d, *J* = 11.9 Hz, 2H), 1.89 (d, *J* = 12.8 Hz, 2H), 1.79 (d, *J* = 12.5 Hz, 1H), 1.63 (qd, *J* = 12.4, 2.6 Hz, 2H), 1.47 (qd, *J* = 12.7, 2.9 Hz, 2H), 1.33 (qt, *J* = 12.8, 3.1 Hz, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 166.9, 147.8, 136.3, 129.3, 129.0, 127.5, 127.0, 125.6, 119.6, 77.4, 77.1, 76.8, 47.7, 32.9, 26.6, 26.1. **HRMS (ESI)** m/z calcd for $C_{15}H_{18}N^+$ $[M+H]^+$: 212.1434; found: 212.1430.

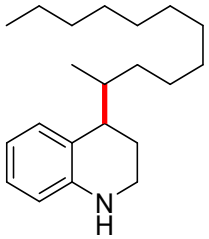


4-cyclohexyl-1,2,3,4-tetrahydroquinoline (5a): Eluent: PE/EtOAc (100:1); Yellow oil, 29% yield, 12.5 mg; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 6.85 – 6.70 (m, 2H), 6.48 – 6.24 (m, 2H), 5.59 (s, 1H), 3.18 – 3.06 (m, 2H), 2.37 (dt, *J* = 8.3, 4.6 Hz, 1H), 1.93 – 1.79 (m, 1H), 1.76 – 1.47 (m, 6H), 1.47 – 1.33 (m, 1H), 1.21 – 0.73 (m, 5H). **^{13}C NMR** (101 MHz, DMSO-d_6) δ 145.3, 129.7, 126.9, 122.6, 114.5, 113.7, 41.5, 40.6, 40.4, 40.2, 40.0, 39.8, 39.5, 39.3, 38.1, 31.8, 29.3, 26.7, 26.7, 26.6, 23.0. **HRMS (ESI)** m/z calcd for $C_{15}H_{22}N^+$ $[M+H]^+$: 216.1747; found: 216.1745.

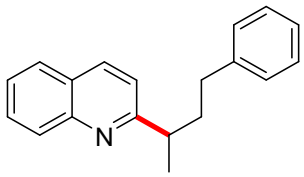


2-(dodecan-2-yl)quinoline (5b-C2): Eluent: PE/EtOAc (50:1); Yellow oil, 33% yield, 19.9 mg; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.10 – 8.02 (m, 2H), 7.77 (d, *J* = 8.0 Hz, 1H), 7.67 (t, *J* = 7.7 Hz, 1H), 7.47 (t, *J* = 7.4 Hz, 1H), 7.30 (d, *J* = 8.6 Hz, 1H), 3.08 (h, *J* = 7.0 Hz, 1H), 1.88 – 1.73 (m, 1H), 1.72 – 1.60 (m, 1H), 1.36 (d, *J* = 6.9 Hz, 4H), 1.24 (d, *J* = 16.7 Hz, 15H), 0.86 (t, *J* = 6.8 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 167.3, 147.8, 136.3, 129.2, 129.0, 127.5, 127.0, 125.6, 119.6, 77.4, 77.1, 76.7, 43.1, 37.2,

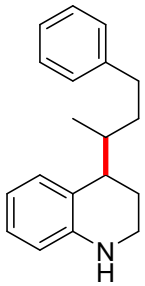
31.9, 29.8, 29.6, 29.6, 29.6, 29.4, 27.7, 22.7, 20.9, 14.2. **HRMS (ESI)** m/z calcd for $C_{21}H_{32}N^+$ $[M+H]^+$: 298.2529; found: 298.2528.



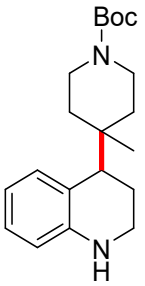
4-(dodecan-2-yl)-1,2,3,4-tetrahydroquinoline (5b): Eluent: PE/EtOAc (50:1); Yellow oil, 34% yield, 20.3 mg; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 6.83 (dd, J = 27.3, 7.5 Hz, 2H), 6.39 (t, J = 7.1 Hz, 2H), 5.54 (s, 1H), 3.12 (d, J = 6.9 Hz, 2H), 2.58 (d, J = 6.2 Hz, 1H), 1.84 (s, 1H), 1.65 (dq, J = 17.3, 6.0, 5.2 Hz, 2H), 1.34 (s, 1H), 1.22 (s, 17H), 0.83 (t, J = 6.7 Hz, 3H), 0.70 (d, J = 6.7 Hz, 3H). **^{13}C NMR** (101 MHz, DMSO-d_6) δ 146.2, 128.4, 126.6, 123.3, 115.2, 114.0, 40.6, 40.4, 40.2, 40.0, 39.8, 39.6, 39.3, 35.1, 34.8, 31.8, 29.8, 29.5, 29.5, 29.2, 27.4, 22.6, 22.5, 15.7, 14.4. **HRMS (ESI)** m/z calcd for $C_{21}H_{36}N^+$ $[M+H]^+$: 302.2842; found: 302.2840.



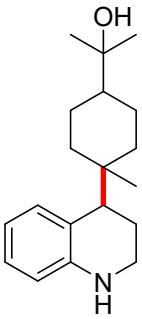
2-(4-phenylbutan-2-yl)quinoline (5c-C2): Eluent: PE/EtOAc (9:1); Colorless oil, 49% yield, 25.6 mg; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.13 – 8.07 (m, 2H), 7.79 (d, J = 8.0 Hz, 1H), 7.73 – 7.67 (m, 1H), 7.50 (t, J = 7.5 Hz, 1H), 7.32 (d, J = 8.5 Hz, 1H), 7.26 (t, J = 7.5 Hz, 2H), 7.17 (t, J = 6.1 Hz, 3H), 3.17 (h, J = 6.9 Hz, 1H), 2.66 (m, J = 13.7, 10.4, 6.1 Hz, 1H), 2.54 (m, J = 10.5, 5.4 Hz, 1H), 2.21 (m, J = 10.4, 8.2, 5.5 Hz, 1H), 2.02 (m, J = 13.2, 10.5, 6.3 Hz, 1H), 1.42 (d, J = 7.0 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 166.6, 147.9, 142.5, 136.5, 129.3, 129.1, 128.4, 128.3, 127.5, 127.0, 125.8, 125.7, 119.7, 77.4, 77.1, 76.8, 42.6, 38.8, 34.0, 21.0. **HRMS (ESI)** m/z calcd for $C_{19}H_{20}N^+$ $[M+H]^+$: 262.1590; found: 262.1587.



4-(4-phenylbutan-2-yl)-1,2,3,4-tetrahydroquinoline (5c): Eluent: PE/EtOAc (9:1); Colorless oil, 25% yield, 13.3 mg; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 7.30 – 7.20 (m, 2H), 7.15 (d, J = 6.4 Hz, 3H), 6.86 – 6.75 (m, 2H), 6.39 (dd, J = 11.6, 7.7 Hz, 2H), 5.55 (s, 1H), 3.19 – 3.06 (m, 2H), 2.65 (dq, J = 12.3, 6.1, 5.7 Hz, 2H), 2.52 (d, J = 6.7 Hz, 1H), 1.91 (dt, J = 12.2, 6.7 Hz, 1H), 1.68 (ddq, J = 17.3, 11.3, 6.7, 6.2 Hz, 3H), 1.57 – 1.41 (m, 1H), 0.78 (d, J = 6.7 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 145.2, 142.8, 128.4, 128.3, 128.3, 126.6, 125.7, 124.5, 117.1 114.4, 77.3, 77.0, 76.7, 40.6 39.6, 36.9, 35.1, 34.1 22.6 15.1. **HRMS (ESI)** m/z calcd for $C_{19}H_{24}N^+$ $[M+H]^+$: 266.1903; found: 266.1902.

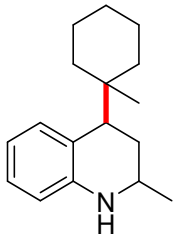


tert-butyl 4-methyl-4-(1,2,3,4-tetrahydroquinolin-4-yl)piperidine-1-carboxylate (5d): Eluent: PE/EtOAc (9:1); Yellow solid, 73% yield, 48.0 mg, m.p. 115.1-116.6 °C; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 6.89 – 6.81 (m, 1H), 6.76 (d, J = 7.4 Hz, 1H), 6.42 (d, J = 7.6 Hz, 1H), 6.33 (t, J = 7.4 Hz, 1H), 5.63 (d, J = 4.4 Hz, 1H), 3.63 (d, J = 13.3 Hz, 2H), 3.20 (ddt, J = 25.1, 12.3, 5.6 Hz, 2H), 2.93 (s, 1H), 2.45 (d, J = 6.9 Hz, 1H), 2.08 (d, J = 13.8 Hz, 1H), 1.56 – 1.10 (m, 15H), 0.78 (s, 3H). **^{13}C NMR** (101 MHz, DMSO-d_6) δ 154.4, 146.1, 131.1, 127.4, 120.1, 113.9, 113.3, 78.8, 60.2, 45.0, 40.6, 40.4, 40.1, 39.9, 39.7, 39.5, 39.3, 38.8, 35.9, 28.6, 22.5, 20.2, 14.6. **HRMS (ESI)** m/z calcd for $C_{20}H_{31}N_2O_2^+$ $[M+H]^+$: 331.2380; found: 331.2378.

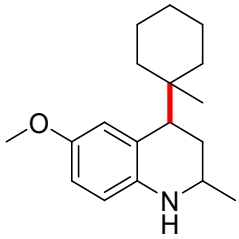


2-(4-methyl-4-(1,2,3,4-tetrahydroquinolin-4-yl)cyclohexyl)propan-2-ol (5e): Eluent: PE/EtOAc (9:1); Yellow solid, 38% yield, 21.7 mg, m.p. 103.9-104.6 °C; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 6.83 (t, J = 7.5 Hz, 1H), 6.78 (d, J = 7.3 Hz, 1H), 6.40 (d, J = 8.0 Hz, 1H), 6.32 (t, J = 7.2 Hz, 1H), 5.67 – 5.52 (m, 1H), 3.94 (s, 1H), 3.26 – 3.17 (m, 2H), 2.33 – 2.26 (m, 1H), 2.13 (d, J = 13.7 Hz, 1H), 1.51 (dq, J = 30.9, 10.2, 5.8 Hz, 5H), 1.34 – 1.02 (m, 5H), 0.97 (s, 6H), 0.73 (s, 3H). **^{13}C NMR** (101 MHz, DMSO-d_6)

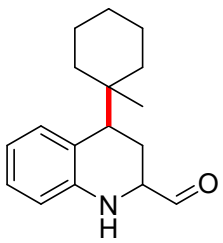
δ 146.0, 131.2, 127.2, 120.8, 113.8, 113.3, 71.0, 49.1, 47.7, 40.6, 40.4, 40.2, 40.0, 39.8, 39.6, 39.4, 37.3, 37.0, 36.2, 27.6, 23.3, 22.7, 20.0. **HRMS (ESI)** m/z calcd for $C_{19}H_{30}NO^+$ $[M+H]^+$: 288.2322; found: 288.2320.



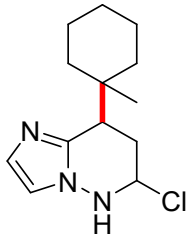
2-methyl-4-(1-methylcyclohexyl)-1,2,3,4-tetrahydroquinoline (5f): Eluent: PE/EtOAc (100:1); Yellow solid, 45% yield, 21.7 mg, m.p. 49.4-51.0 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.13 (d, *J* = 7.6 Hz, 1H), 6.99 (t, *J* = 7.5 Hz, 1H), 6.69 (t, *J* = 7.4 Hz, 1H), 6.58 (d, *J* = 7.8 Hz, 1H), 3.05 – 2.85 (m, 2H), 2.01 (ddd, *J* = 13.1, 10.0, 3.0 Hz, 1H), 1.64 (dq, *J* = 12.6, 7.9 Hz, 2H), 1.40 (ddd, *J* = 41.0, 20.5, 9.0 Hz, 10H), 1.21 (d, *J* = 6.1 Hz, 3H), 0.68 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 149.9, 131.2, 126.3, 126.0, 117.7, 115.4, 77.4, 77.0, 76.7, 49.9, 38.5, 37.0, 36.3, 35.7, 26.4, 22.4, 22.2, 19.6. **HRMS (ESI)** m/z calcd for $C_{17}H_{26}N^+$ $[M+H]^+$: 244.2060; found: 244.2057.



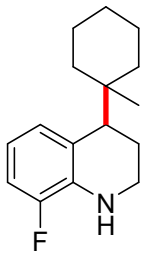
6-methoxy-2-methyl-4-(1-methylcyclohexyl)-1,2,3,4-tetrahydroquinoline (5g): Eluent: PE/EtOAc (4:1); Yellow oil, 47% yield, 25.5 mg; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 7.09 (d, *J* = 8.5 Hz, 1H), 6.77 (dd, *J* = 8.5, 2.8 Hz, 1H), 6.64 (d, *J* = 2.9 Hz, 1H), 5.23 (d, *J* = 4.8 Hz, 1H), 3.98 (d, *J* = 4.9 Hz, 1H), 3.72 (s, 3H), 2.54 (s, 1H), 2.49 (s, 1H), 2.14 (s, 3H), 1.53 – 0.91 (m, 11H), 0.59 (s, 3H). **^{13}C NMR** (101 MHz, DMSO-d_6) δ 167.4, 157.0, 138.4, 127.7, 126.9, 118.1, 111.9, 63.4, 55.6, 40.6, 40.4, 40.1, 39.9, 39.7, 39.5, 39.3, 36.1, 36.0, 35.3, 26.2, 25.4, 21.9, 21.8. **HRMS (ESI)** m/z calcd for $C_{18}H_{28}NO^+$ $[M+H]^+$: 274.2165; found: 274.2161.



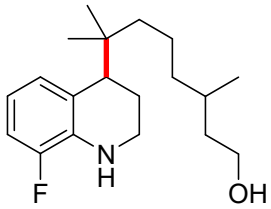
4-(1-methylcyclohexyl)-1,2,3,4-tetrahydroquinoline-2-carbaldehyde (5h): Eluent: PE/EtOAc (100:1); Yellow solid, 47% yield, 24.3 mg, m.p. 141.2-142.1 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 9.33 (s, 1H), 7.16 (t, *J* = 7.6 Hz, 1H), 7.04 (d, *J* = 7.4 Hz, 1H), 6.93 (t, *J* = 7.4 Hz, 1H), 6.77 (d, *J* = 7.9 Hz, 1H), 6.40 (s, 1H), 5.83 – 5.63 (m, 1H), 3.55 (d, *J* = 6.2 Hz, 1H), 1.68 – 1.49 (m, 4H), 1.42 (dq, *J* = 25.2, 15.9, 13.0 Hz, 6H), 1.30 – 1.08 (m, 2H), 0.76 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 186.3, 140.3, 130.7, 127.2, 121.1, 119.4, 114.6, 77.4, 77.0, 76.7, 48.7, 42.2, 34.9, 34.4, 26.4, 22.0, 21.9, 19.7. **HRMS (ESI)** m/z calcd for $C_{17}H_{24}NO^+$ $[M+H]^+$: 258.1852; found: 258.1850.



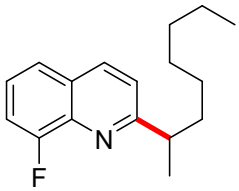
6-chloro-8-(1-methylcyclohexyl)-5,6,7,8-tetrahydroimidazo[1,2-b]pyridazine (5i): Eluent: PE/EtOAc (9:1); Colorless oil, 56% yield, 28.3 mg; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.13 (d, *J* = 1.5 Hz, 1H), 6.98 (d, *J* = 1.5 Hz, 1H), 3.11 – 3.04 (m, 1H), 3.02 – 2.97 (m, 2H), 1.64 – 1.38 (m, 10H), 1.25 (s, 1H), 0.85 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 155.5, 136.4, 126.3, 117.6, 77.3, 77.0, 76.7, 37.9, 35.4, 35.1, 32.2, 25.9, 21.8, 21.6. **HRMS (ESI)** m/z calcd for $C_{13}H_{21}ClN_3^+$ $[M+H]^+$: 254.1419; found: 254.1416.



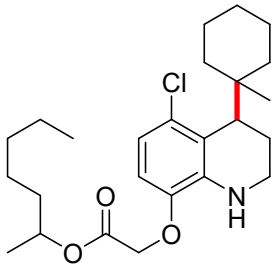
8-fluoro-4-(1-methylcyclohexyl)-1,2,3,4-tetrahydroquinoline (5j): Eluent: PE/EtOAc (100:1); Colorless oil, 77% yield, 38.1 mg; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 6.86 (dd, *J* = 10.9, 8.5 Hz, 1H), 6.76 (d, *J* = 7.6 Hz, 1H), 6.47 (q, *J* = 7.7 Hz, 1H), 4.04 (s, 1H), 3.45 (dd, *J* = 11.5, 3.7 Hz, 2H), 2.70 (s, 1H), 2.31 – 2.18 (m, 1H), 1.77 – 1.48 (m, 7H), 1.45 – 1.22 (m, 4H), 0.81 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 150.6 (d, *J* = 236.2 Hz), 133.4 (d, *J* = 11.3 Hz), 126.2 (d, *J* = 2.8 Hz), 124.4 (d, *J* = 3.4 Hz), 113.4 (d, *J* = 7.4 Hz), 112.2 (d, *J* = 18.1 Hz), 77.4, 77.0, 76.7, 39.0, 37.5, 37.2, 36.0, 26.3, 22.3, 22.3, 21.9. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -64.12. **HRMS (ESI)** m/z calcd for $C_{16}H_{23}FN^+$ $[M+H]^+$: 248.1809; found: 248.1808.



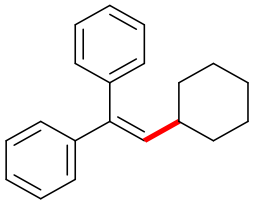
7-(8-fluoro-1,2,3,4-tetrahydroquinolin-4-yl)-3,7-dimethyloctan-1-ol (5k): Eluent: PE/EtOAc (9:1); Colorless oil, 36% yield, 22.2 mg; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 6.81 (dd, J = 11.3, 8.2 Hz, 1H), 6.65 (d, J = 7.5 Hz, 1H), 6.33 (q, J = 7.7 Hz, 1H), 5.54 (s, 1H), 4.31 (t, J = 5.0 Hz, 1H), 3.41 (m, 2H), 3.32 – 3.17 (m, 2H), 2.58 (s, 1H), 2.05 (d, J = 13.5 Hz, 1H), 1.48 (m, 3H), 1.35 – 1.12 (m, 6H), 1.06 (d, J = 8.7 Hz, 1H), 0.83 (d, J = 7.9 Hz, 6H), 0.76 (s, 3H). **^{13}C NMR** (101 MHz, DMSO-d_6) δ 150.4 (d, J = 235.0 Hz), 134.0 (d, J = 11.5 Hz), 126.5 (d, J = 2.0 Hz), 123.9 (d, J = 3.6 Hz), 112.7 (d, J = 7.3 Hz), 112.5, 59.3, 42.5, 41.2, 40.6, 40.4, 40.4, 40.1, 39.9, 39.7, 39.5, 39.3, 38.3, 38.2, 37.4, 29.5, 27.7, 27.7, 26.1, 22.9, 21.3, 20.1. **^{19}F NMR** (376 MHz, DMSO-d_6) δ -62.16. **HRMS (ESI)** m/z calcd for $C_{19}H_{31}FNO^+$ $[M+H]^+$: 308.2384; found: 308.2380.



8-fluoro-2-(octan-2-yl)quinoline (5l): Eluent: PE/EtOAc (100:1); Colorless oil, 40% yield, 21.0 mg; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 8.33 (d, J = 9.9 Hz, 1H), 7.78 – 7.70 (m, 1H), 7.57 – 7.45 (m, 3H), 3.04 (q, J = 6.9 Hz, 1H), 1.75 (dq, J = 13.5, 9.2, 6.8 Hz, 1H), 1.59 (dq, J = 13.5, 7.7, 7.0 Hz, 1H), 1.27 (d, J = 6.9 Hz, 3H), 1.23 – 1.09 (m, 8H), 0.78 (t, J = 6.6 Hz, 3H). **^{13}C NMR** (101 MHz, DMSO-d_6) δ 167.5, 157.5 (d, J = 254.2 Hz), 137.5 (d, J = 11.5 Hz), 136.8, 128.9 (d, J = 2.7 Hz), 126.1 (d, J = 7.5 Hz), 124.2, 121.8, 114.1 (d, J = 18.0 Hz), 113.9, 42.5, 40.6, 40.4, 40.2, 40.0, 39.8, 39.6, 39.3, 36.8, 31.6, 29.2, 27.5, 22.5, 21.0, 14.3. **^{19}F NMR** (376 MHz, DMSO-d_6) δ -50.13. **HRMS (ESI)** m/z calcd for $C_{17}H_{23}FN^+$ $[M+H]^+$: 260.1809; found: 260.1807.



heptan-2-yl 2-((5-chloro-4-(1-methylcyclohexyl)-1,2,3,4-tetrahydroquinolin-8-yl)oxy)acetate (5m): PE/EtOAc (50:1); Yellow oil, 10% yield, 8.7 mg; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 6.53 (d, *J* = 8.5 Hz, 1H), 6.45 (d, *J* = 8.4 Hz, 1H), 5.03 (h, *J* = 6.5 Hz, 1H), 4.68 (s, 1H), 4.57 – 4.54 (m, 2H), 3.03 – 2.93 (m, 2H), 2.60 (ddd, *J* = 17.4, 12.6, 5.8 Hz, 1H), 2.07 – 1.99 (m, 1H), 1.64 – 1.19 (m, 22H), 0.95 (s, 3H), 0.87 (t, J = 6.7 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 168.6, 143.1, 137.5, 127.4, 119.4, 114.8, 110.3, 77.4, 77.4, 77.0, 76.7, 72.5, 66.6, 59.7, 35.8, 34.8, 34.6, 31.6, 26.4, 25.4, 25.0, 22.5, 21.7, 21.5, 20.0, 18.3, 14.0. **HRMS (ESI)** m/z calcd for $C_{25}H_{39}ClNO_3^+$ $[M+H]^+$: 436.2613; found: 436.2611.



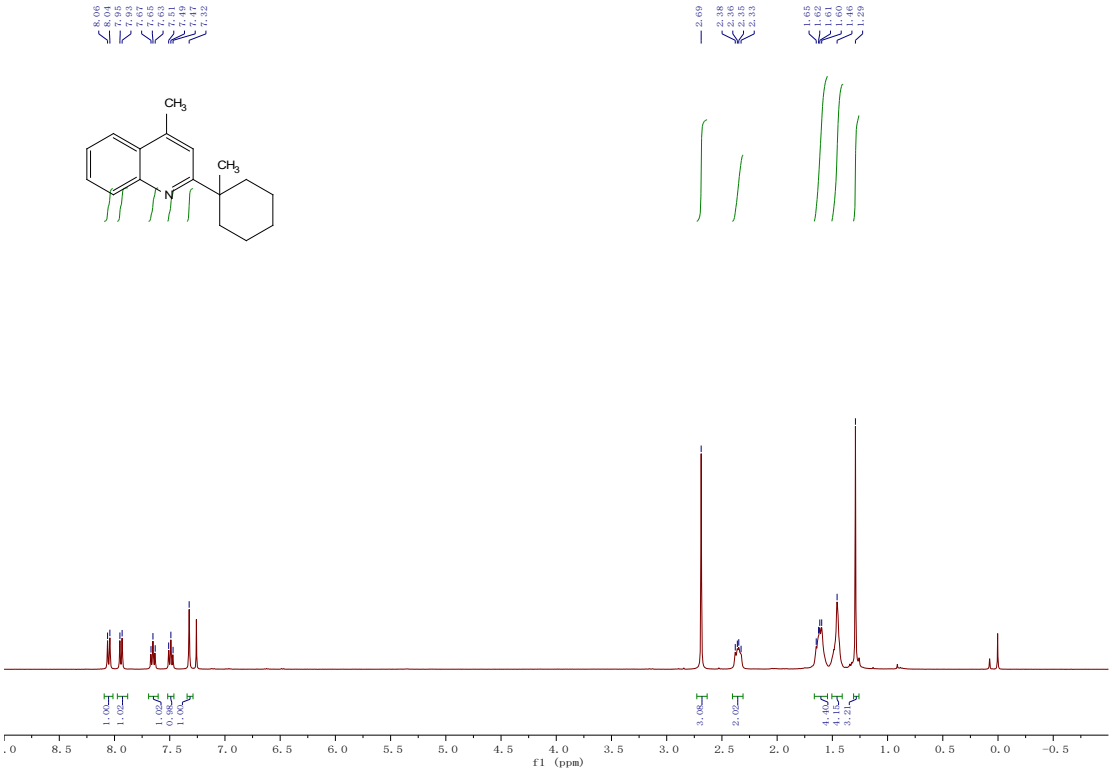
(2-cyclohexylethene-1,1-diyl)dibenzene (6): Eluent: PE; Colorless oil, 16% yield, 8.2 mg; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.36 (dt, *J* = 16.7, 7.1 Hz, 3H), 7.27 – 7.14 (m, 7H), 5.92 (d, *J* = 10.0 Hz, 1H), 2.18 – 2.11 (m, 1H), 1.69 (d, *J* = 5.2 Hz, 5H), 1.28 – 1.13 (m, 5H). **HRMS (ESI)** m/z calcd for $C_{20}H_{23}^+$ $[M+H]^+$: 263.1794; found: 263.1791.

11. Reference

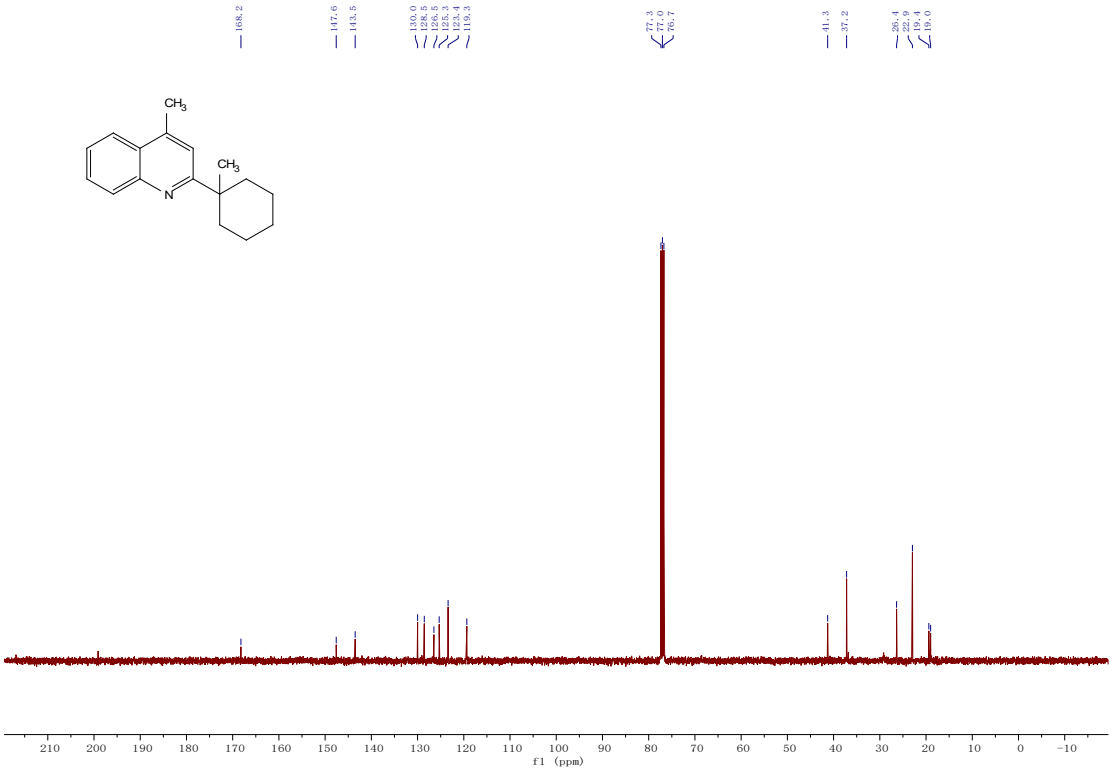
1. J. C. Lo, J. Gui, Y. Yabe, C. M. Pan and P. S. Baran, Functionalized olefin cross-coupling to construct carbon-carbon bonds, *Nature*, 2014, **516**, 343-348.

12. Copies of ^{1}H and ^{13}C NMR Spectra

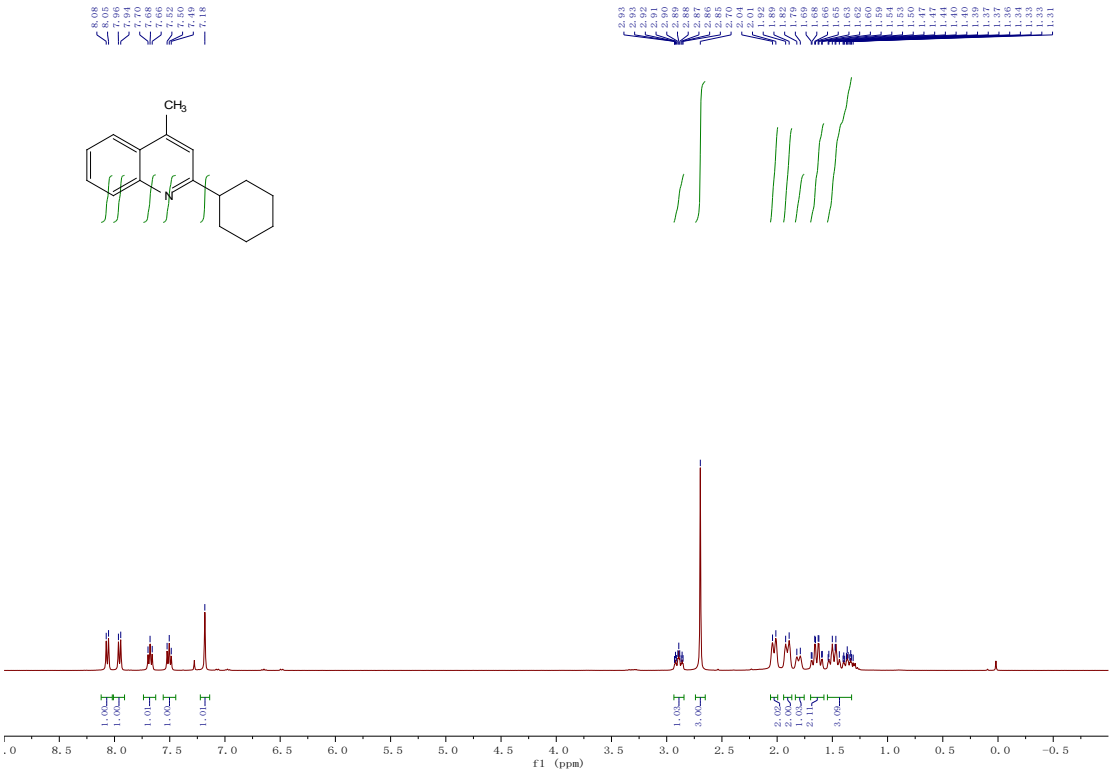
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of **3a**



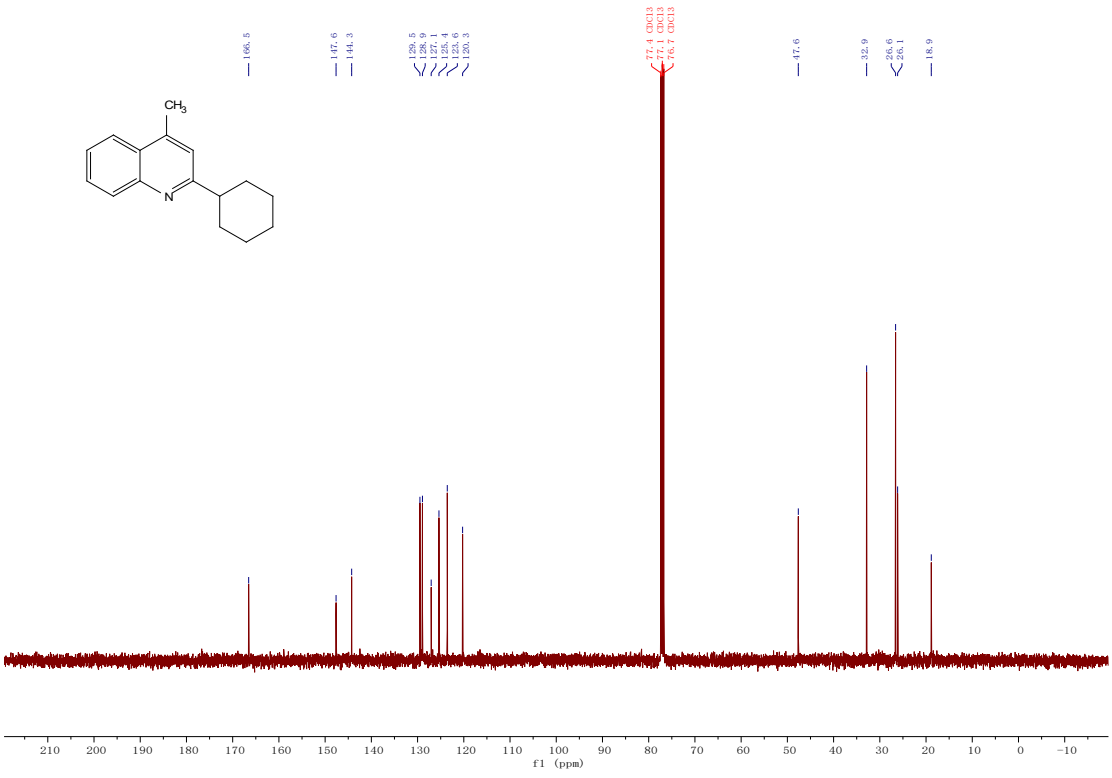
^{13}C NMR spectrum (101 MHz, $CDCl_3$) of **3a**



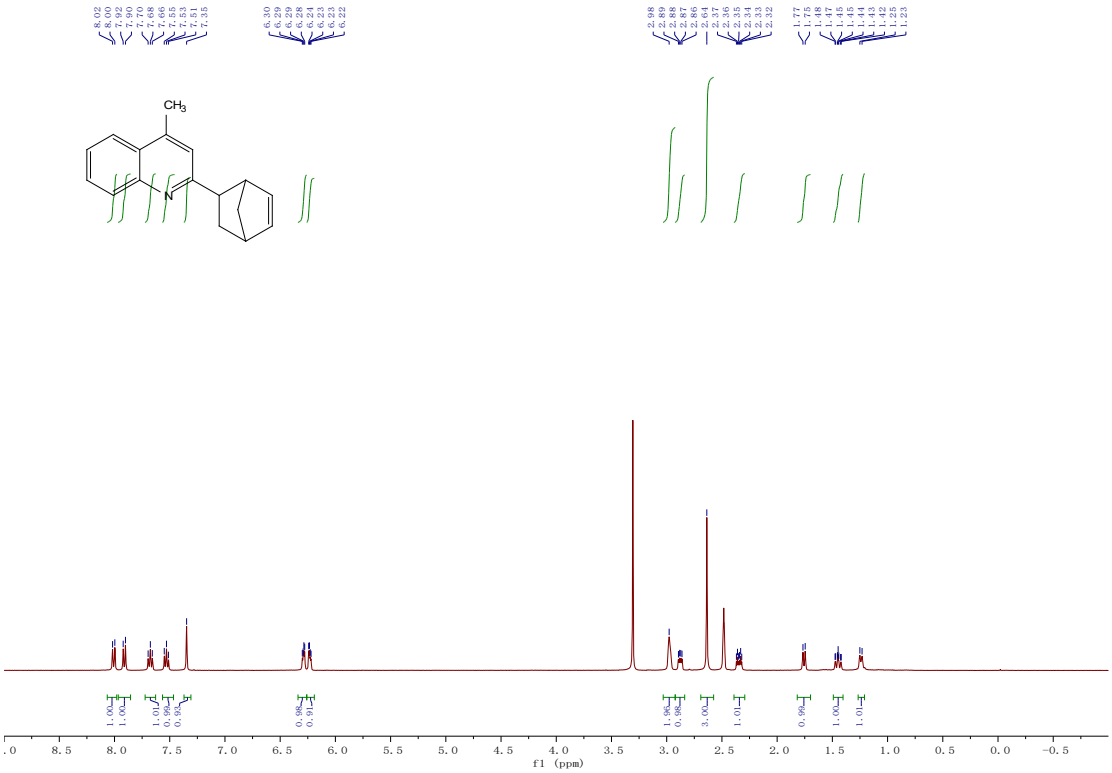
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of **3b**



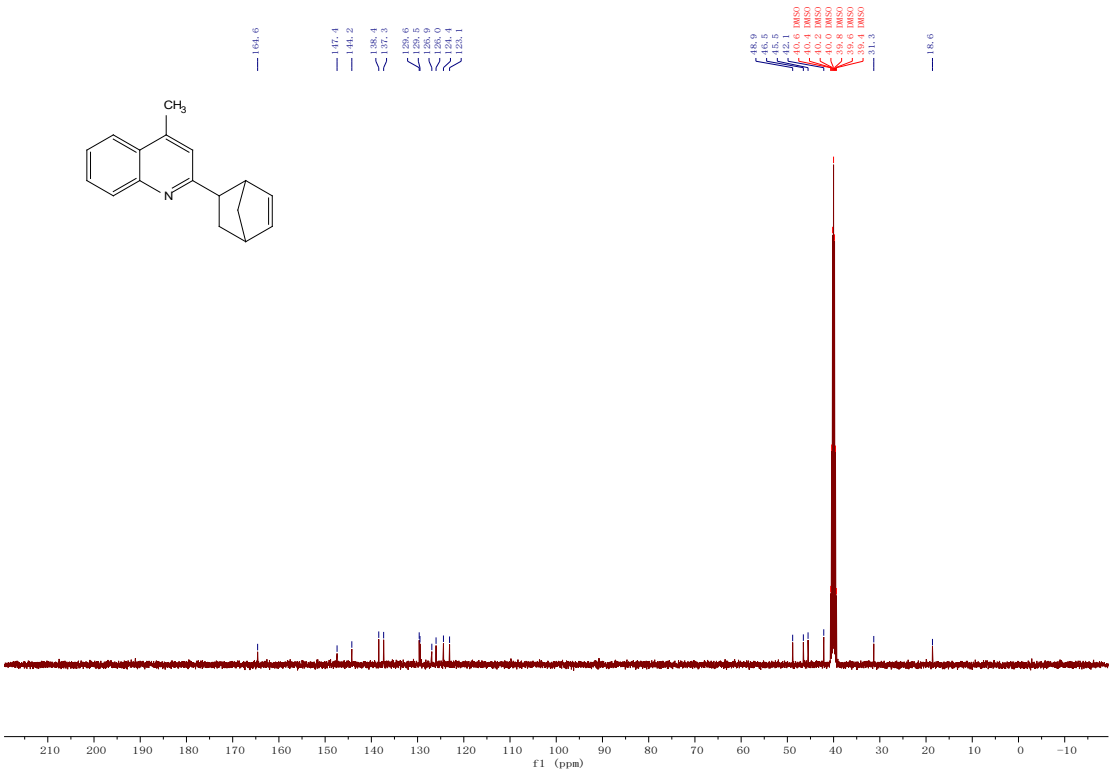
^{13}C NMR spectrum (101 MHz, $CDCl_3$) of **3b**



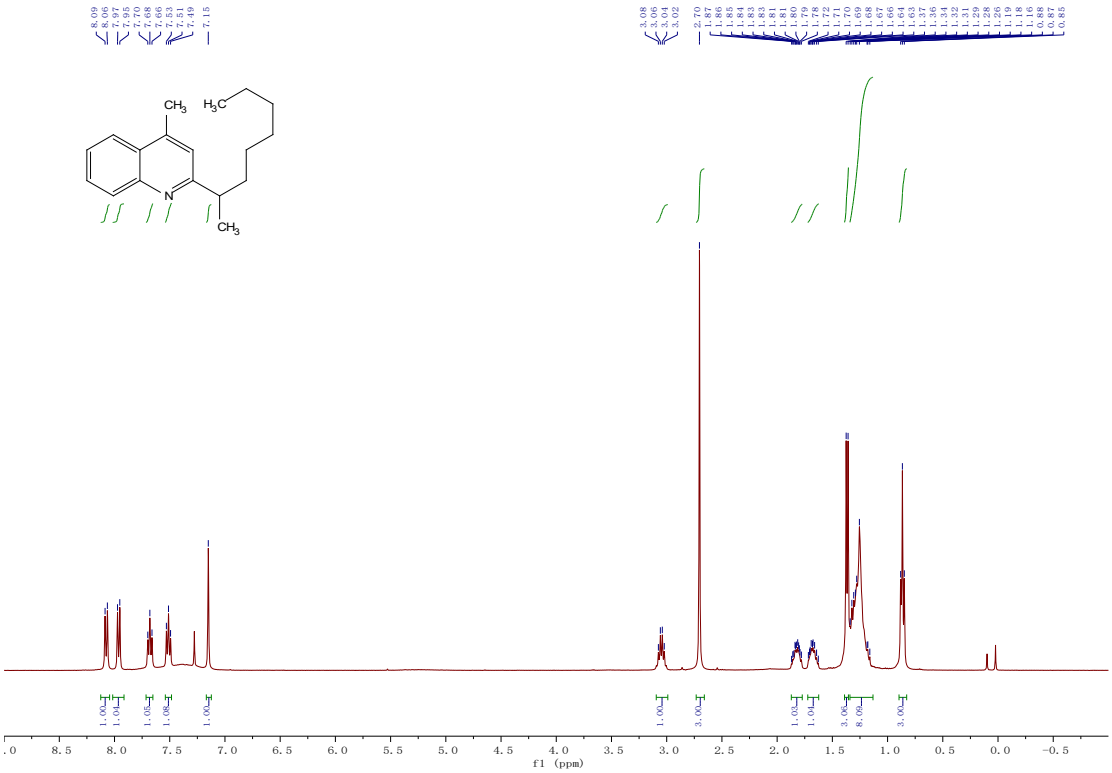
^{1}H NMR spectrum (400 MHz, DMSO-d_6) of **3c**



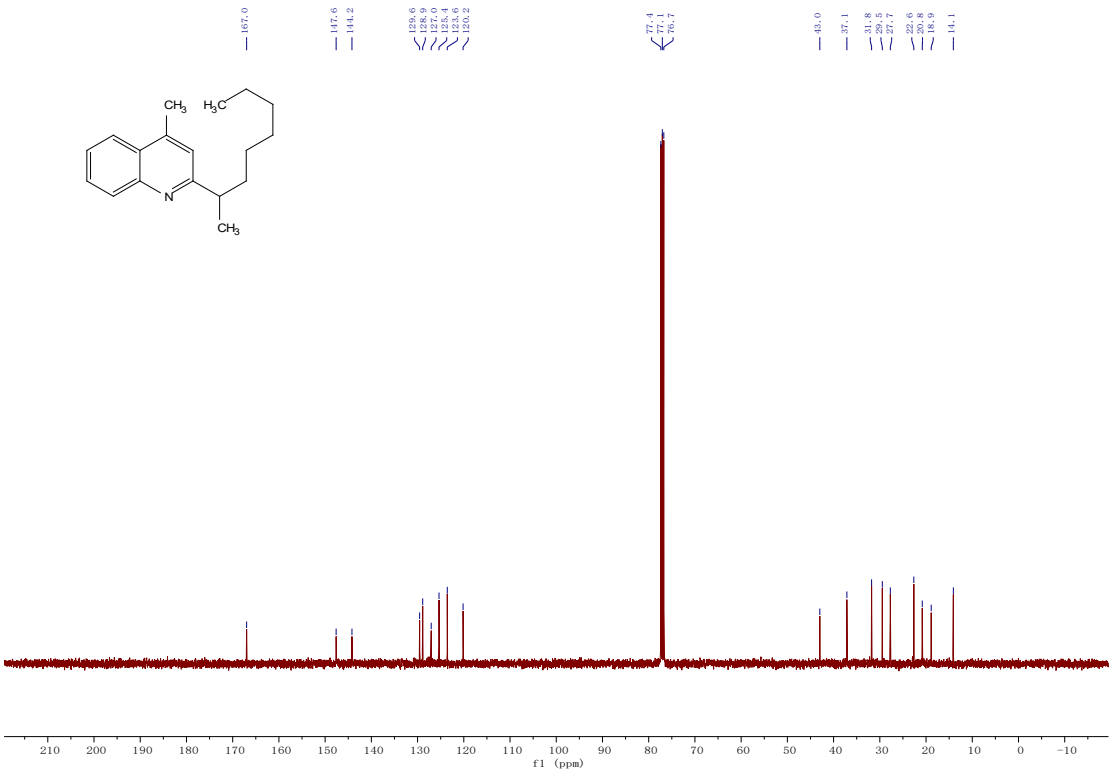
^{13}C NMR spectrum (101 MHz, DMSO-d_6) of **3c**



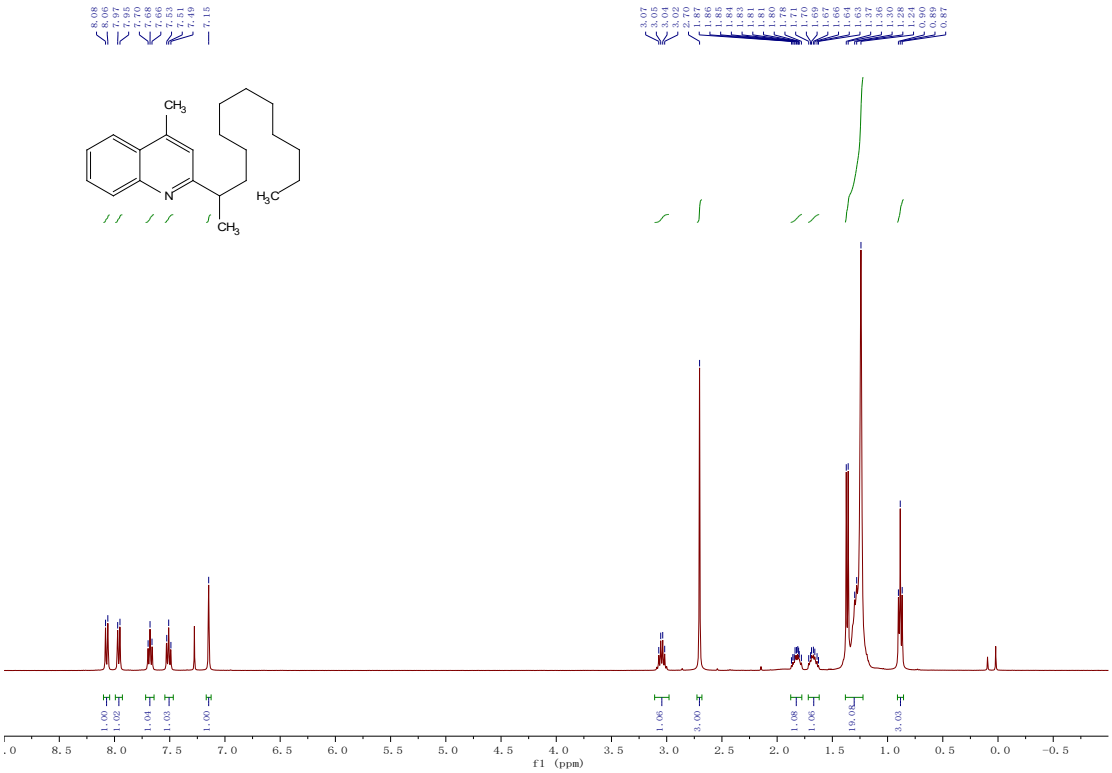
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of **3d**



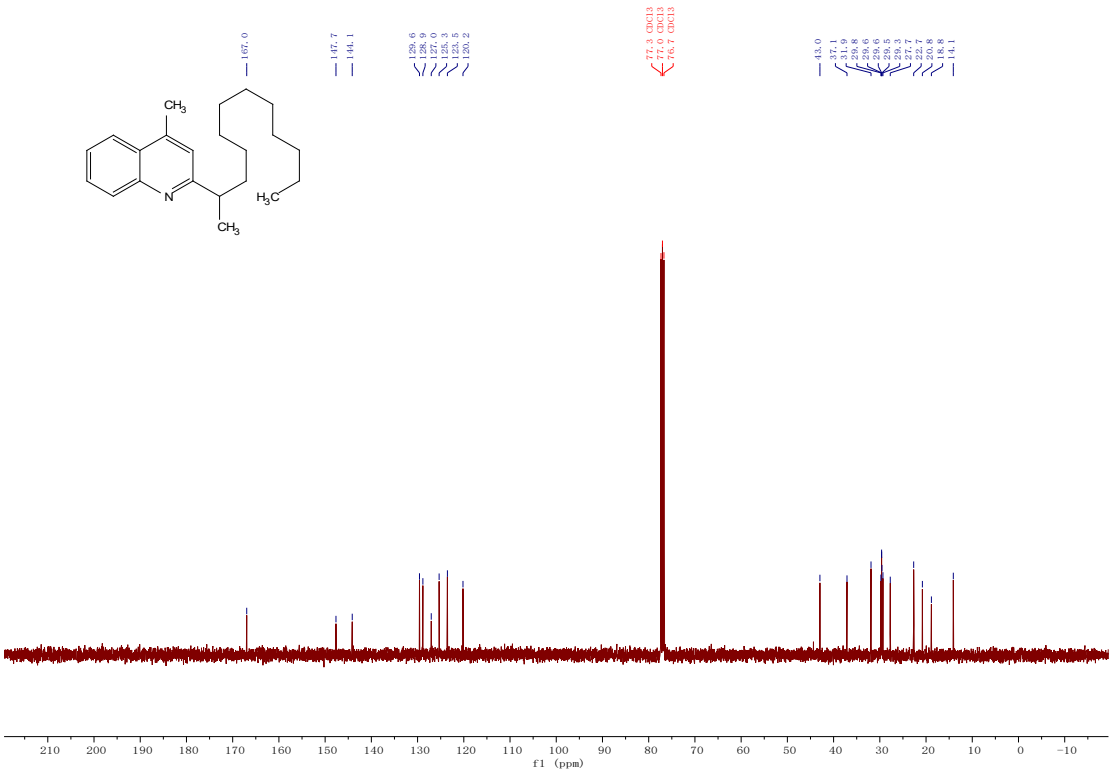
^{13}C NMR spectrum (101 MHz, $CDCl_3$) of **3d**



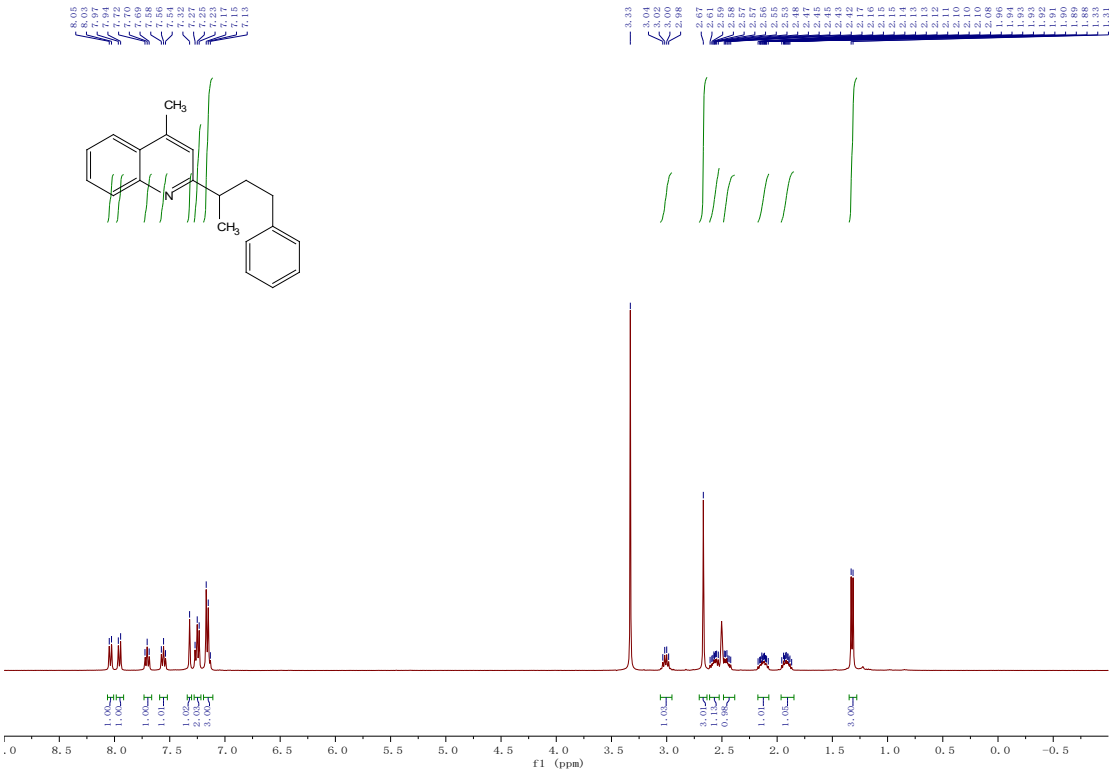
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of **3e**



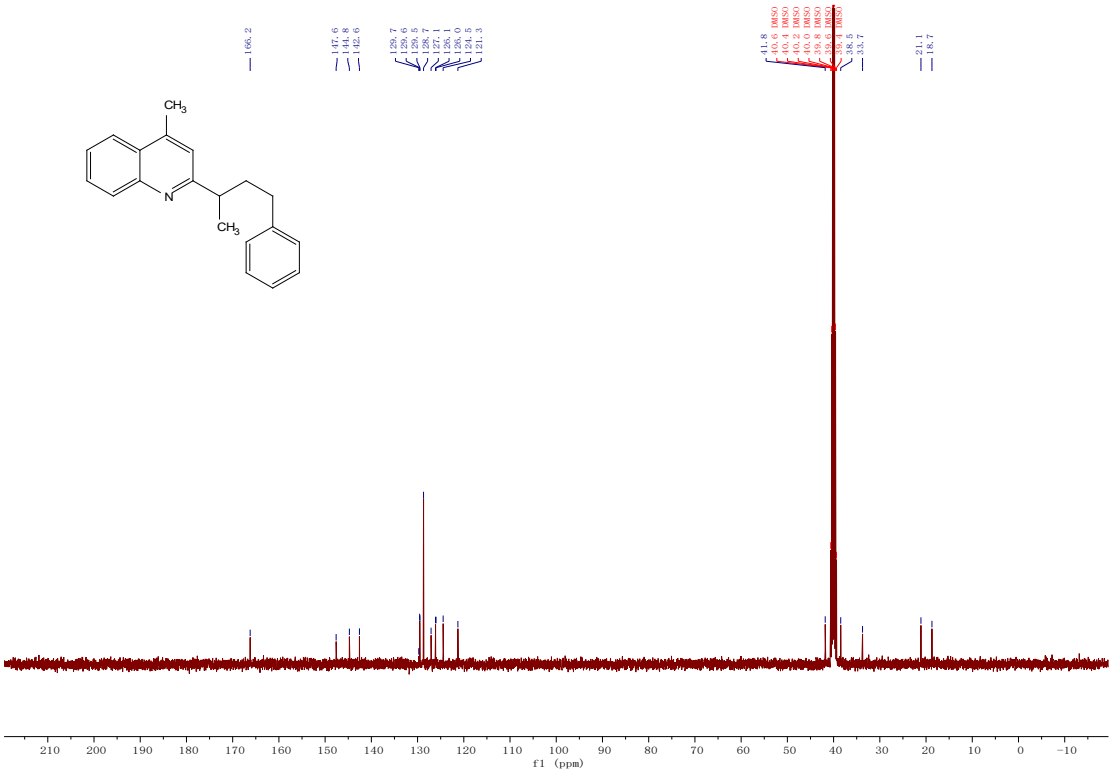
^{13}C NMR spectrum (101 MHz, $CDCl_3$) of **3e**



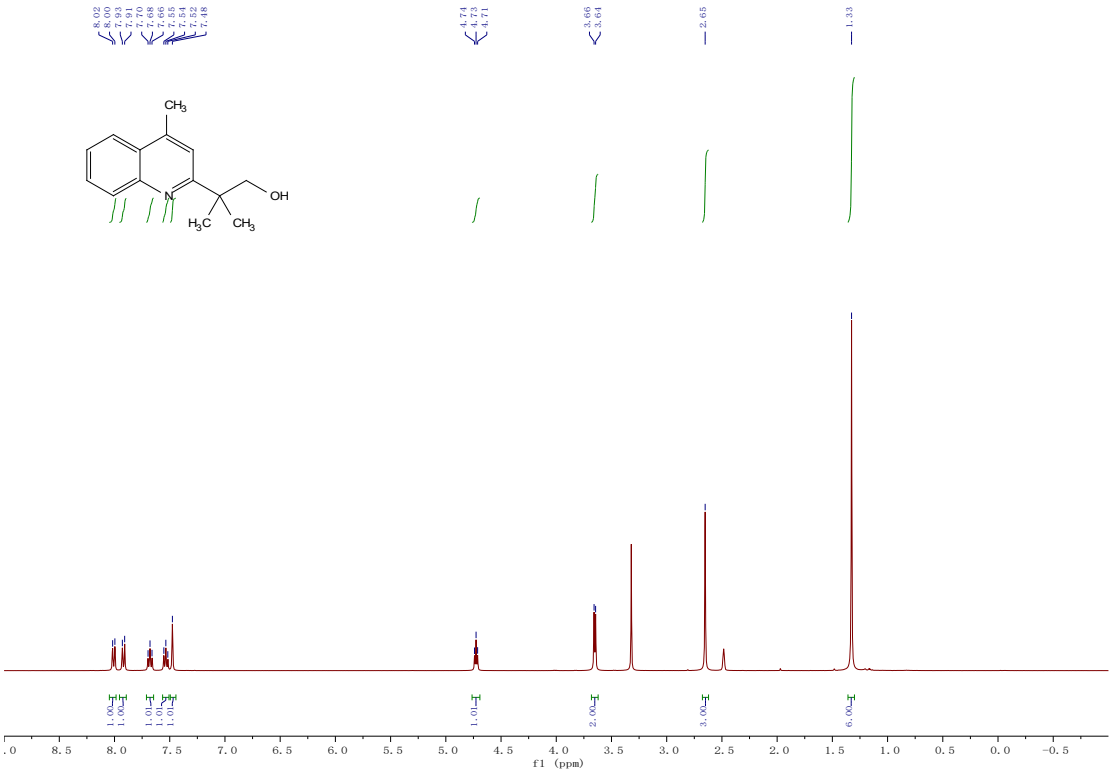
^{1}H NMR spectrum (400 MHz, DMSO-d_6) of **3f**



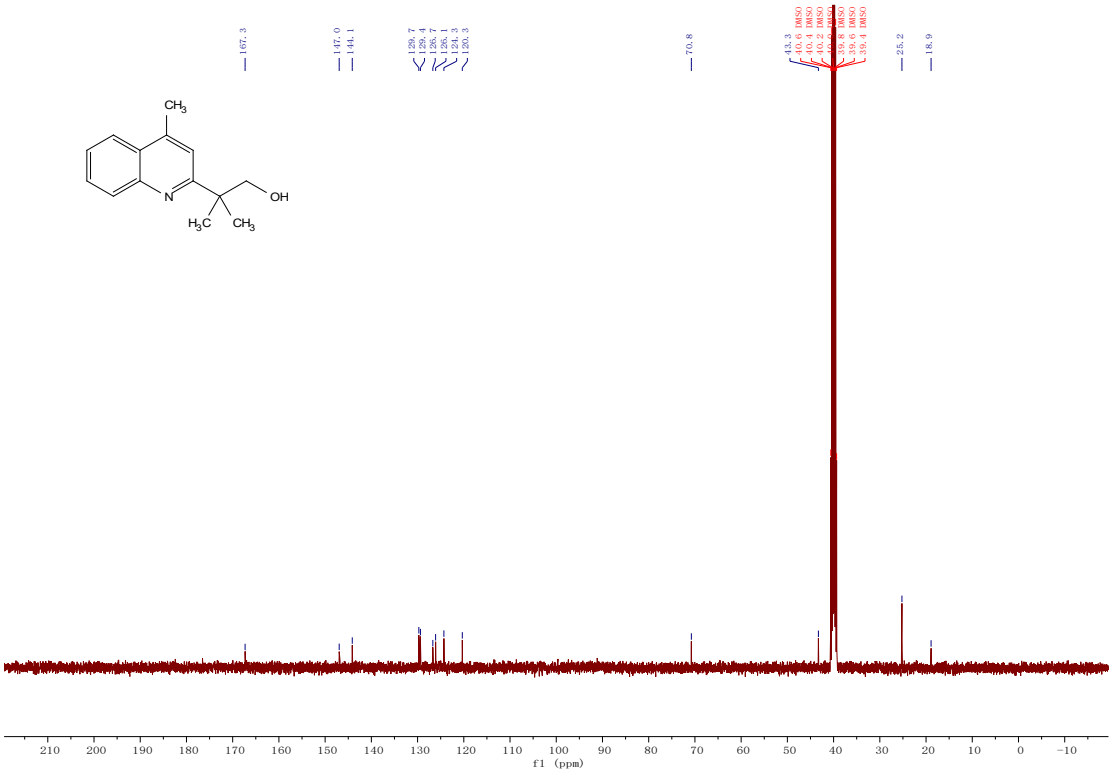
^{13}C NMR spectrum (101 MHz, DMSO-d_6) of **3f**



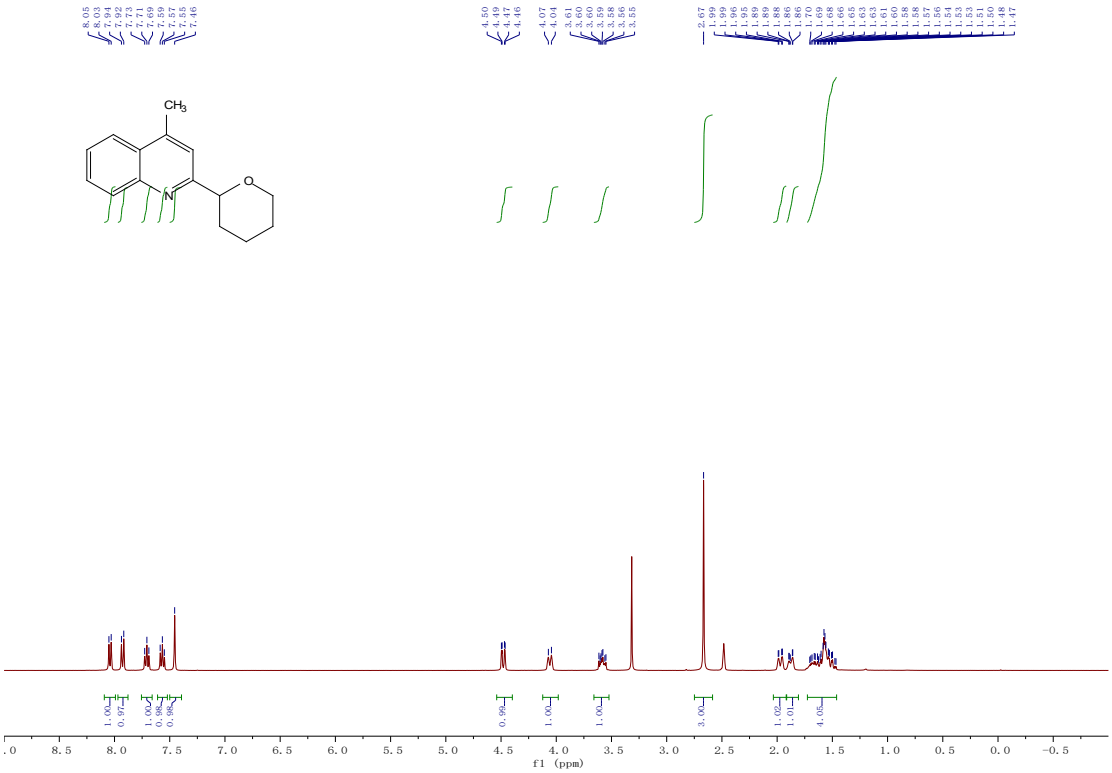
^{1}H NMR spectrum (400 MHz, DMSO-d_6) of **3g**



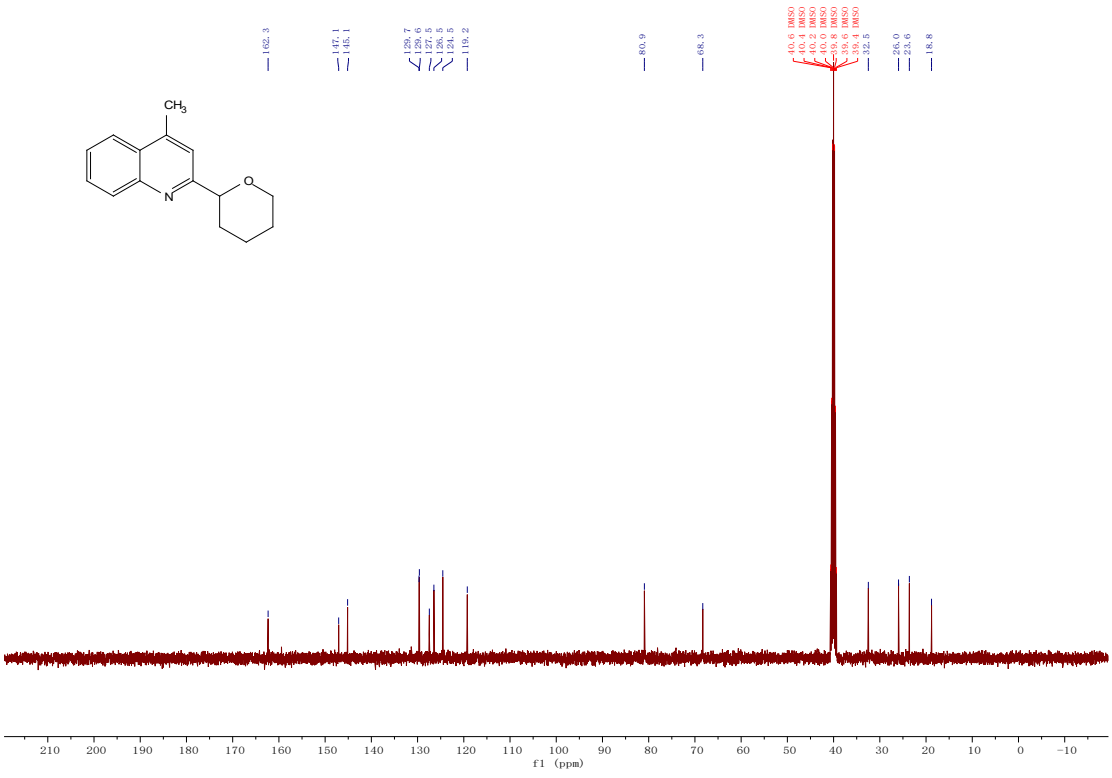
^{13}C NMR spectrum (101 MHz, DMSO-d_6) of **3g**



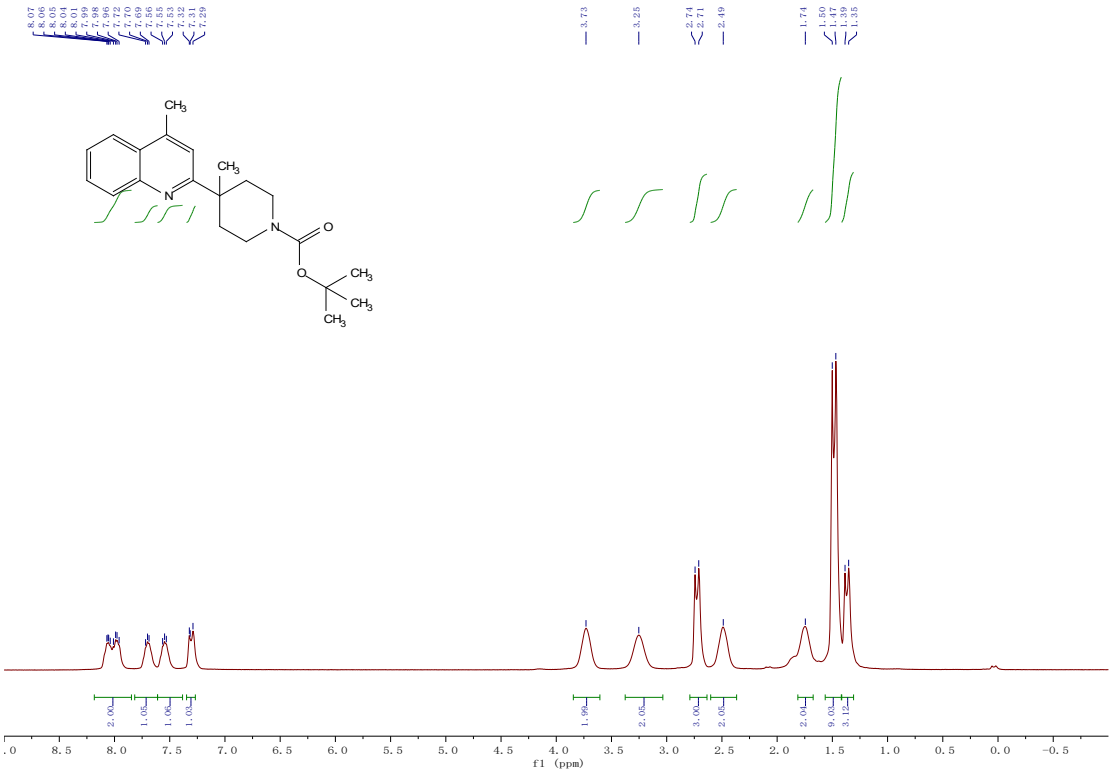
^{1}H NMR spectrum (400 MHz, DMSO-d_6) of **3h**



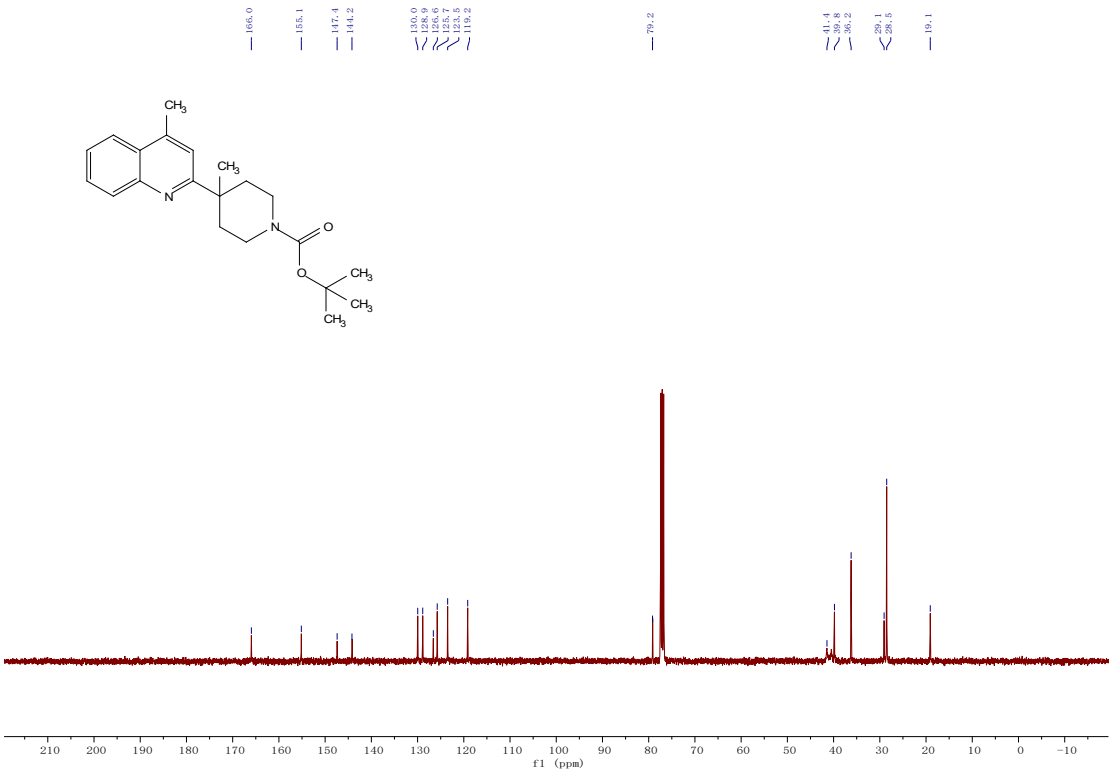
^{13}C NMR spectrum (101 MHz, DMSO-d_6) of **3h**



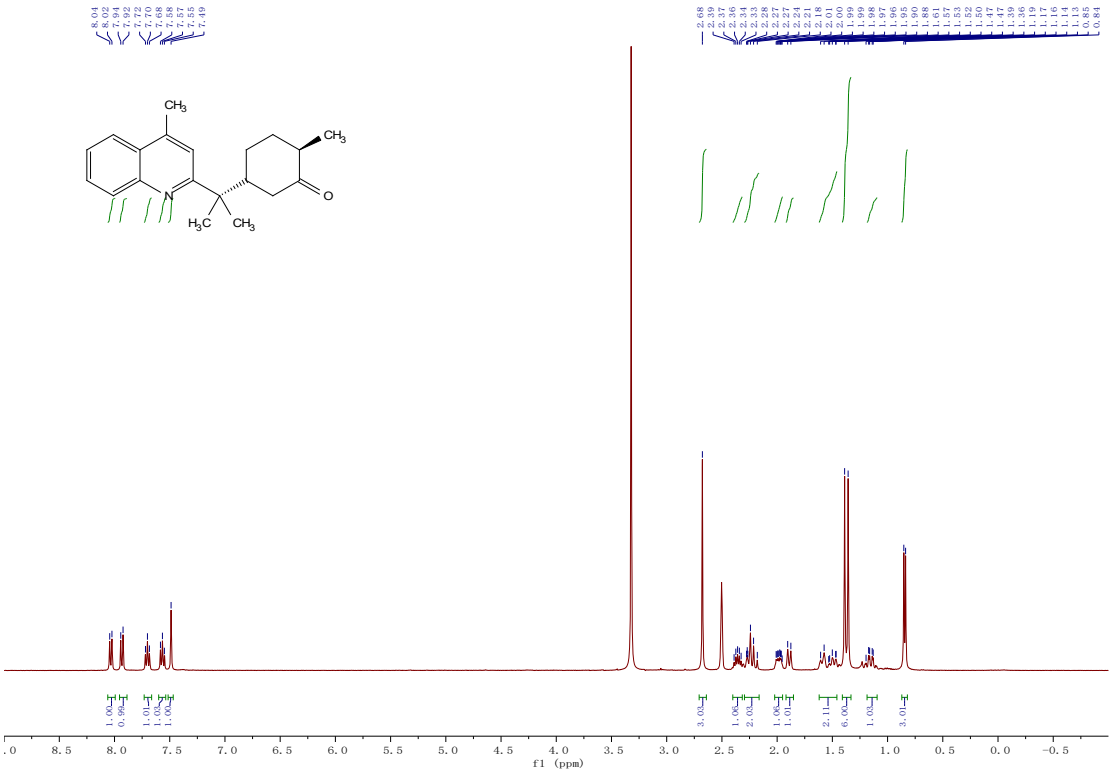
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of **3i**



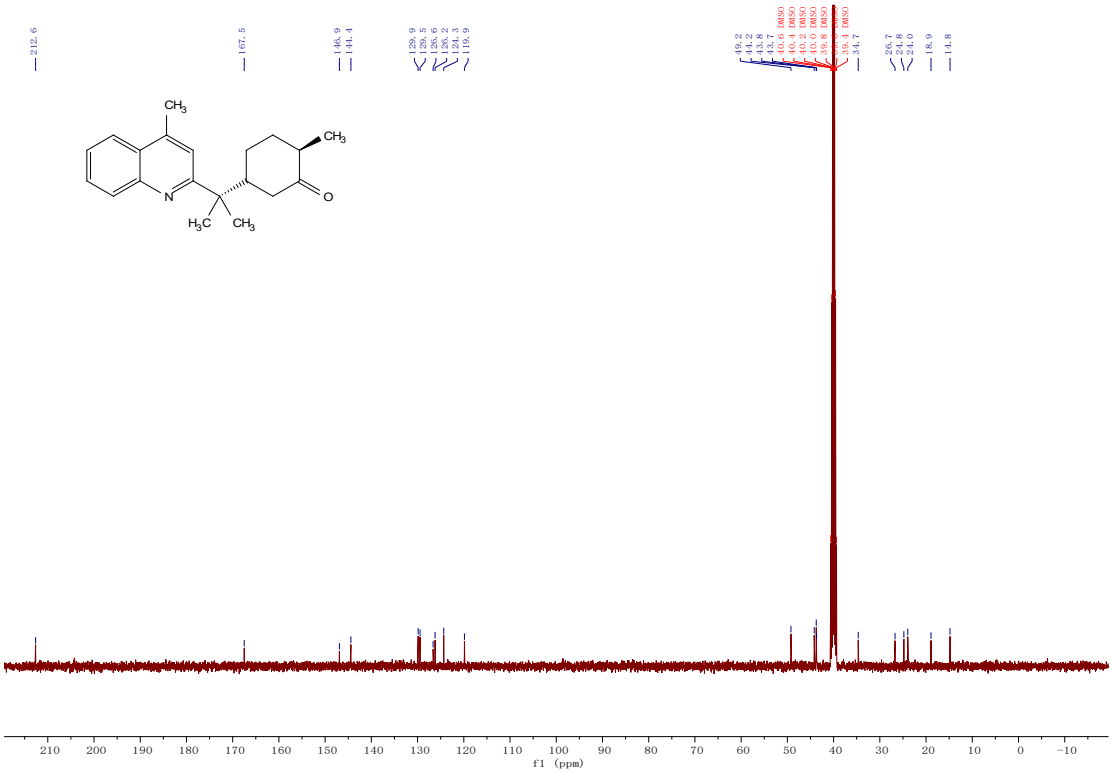
^{13}C NMR spectrum (101 MHz, $CDCl_3$) of **3i**



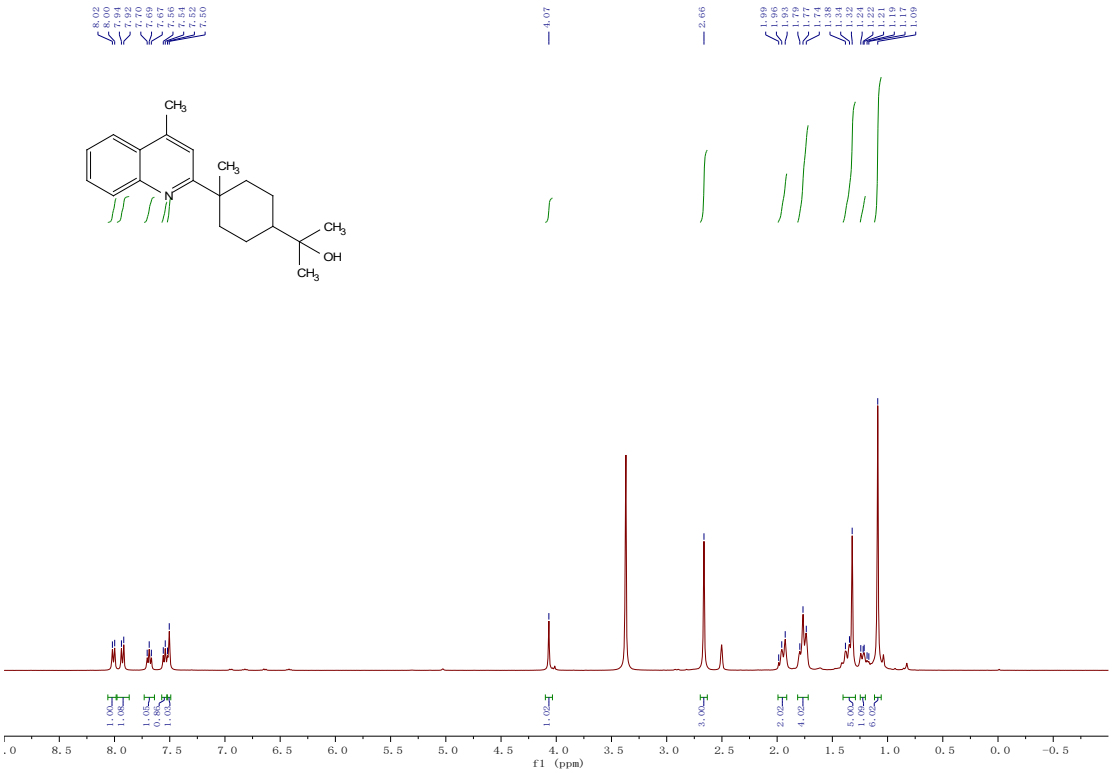
^{1}H NMR spectrum (400 MHz, DMSO-d_6) of **3j**



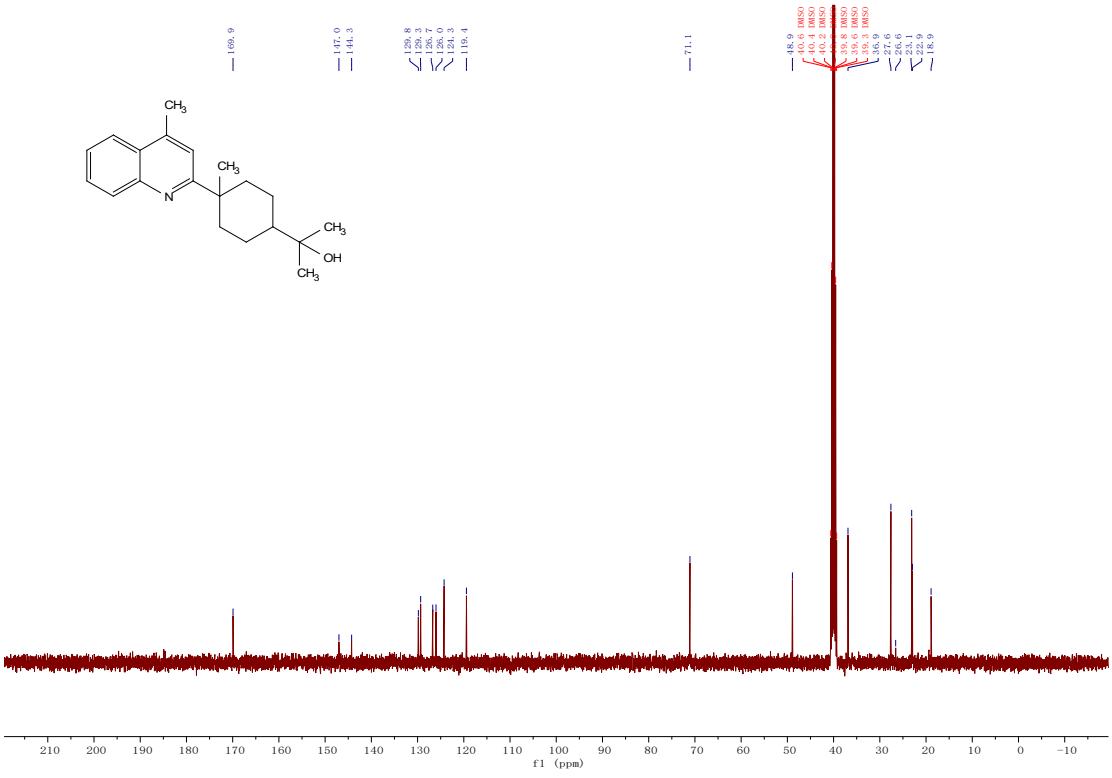
^{13}C NMR spectrum (101 MHz, DMSO-d_6) of **3j**



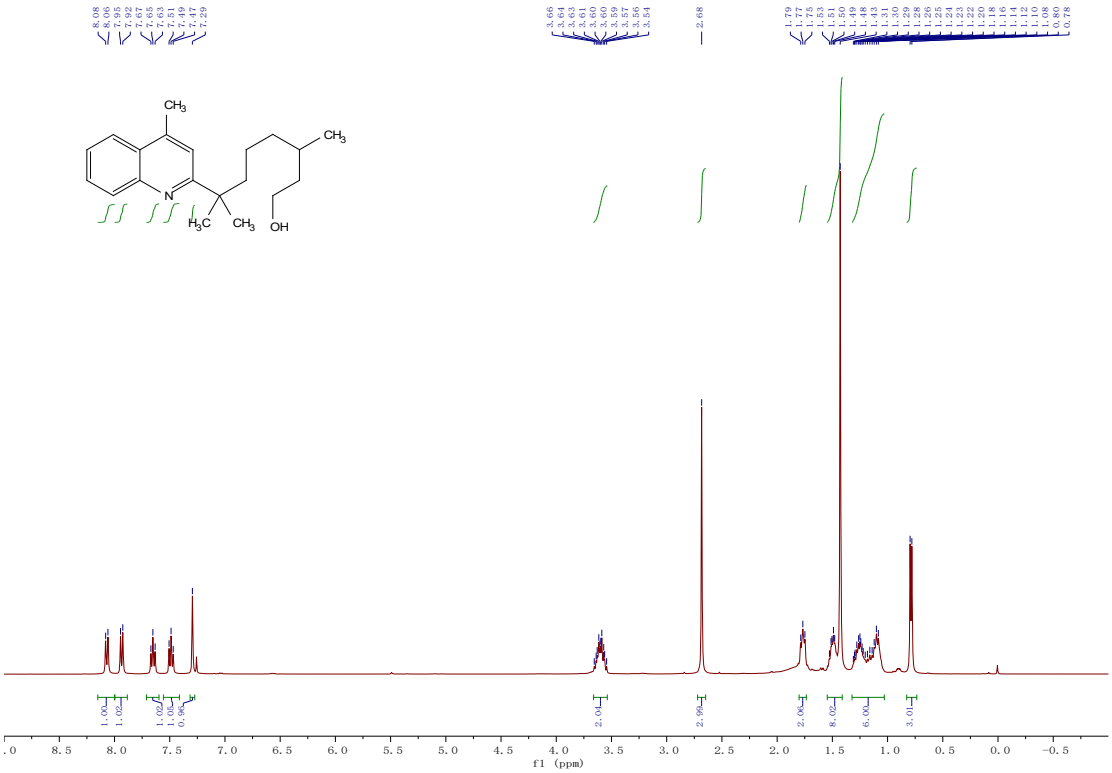
^{1}H NMR spectrum (400 MHz, DMSO-d_6) of **3k**



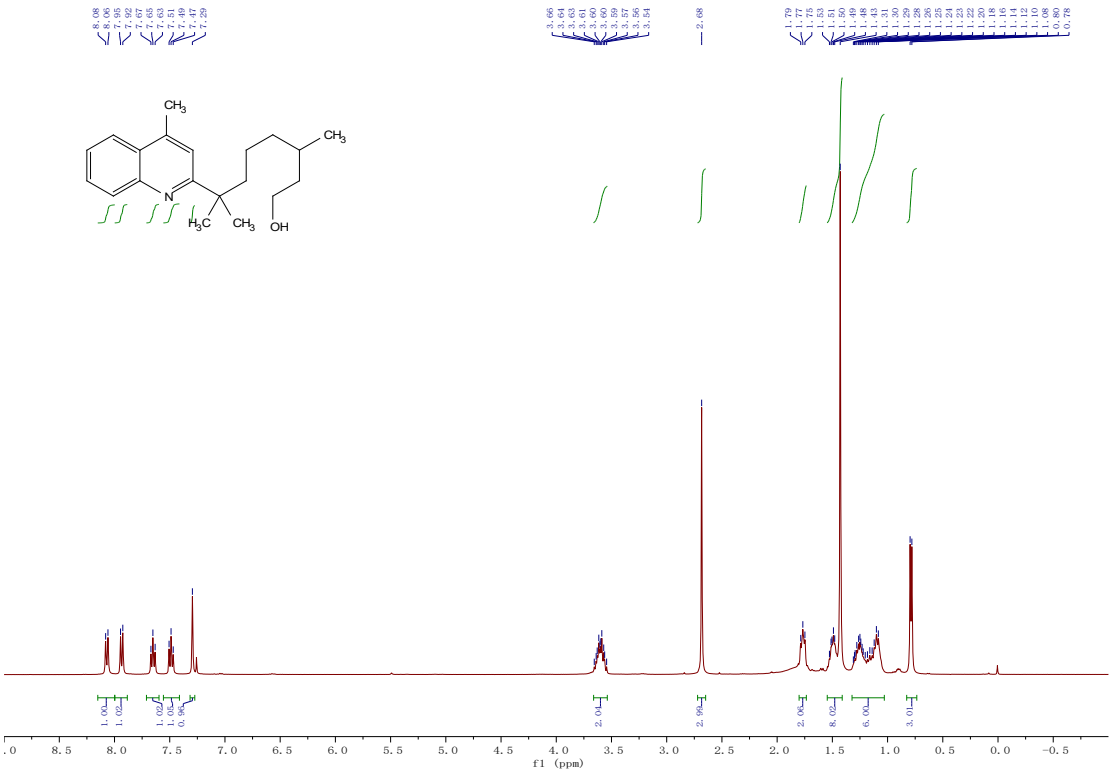
^{13}C NMR spectrum (101 MHz, DMSO-d_6) of **3k**



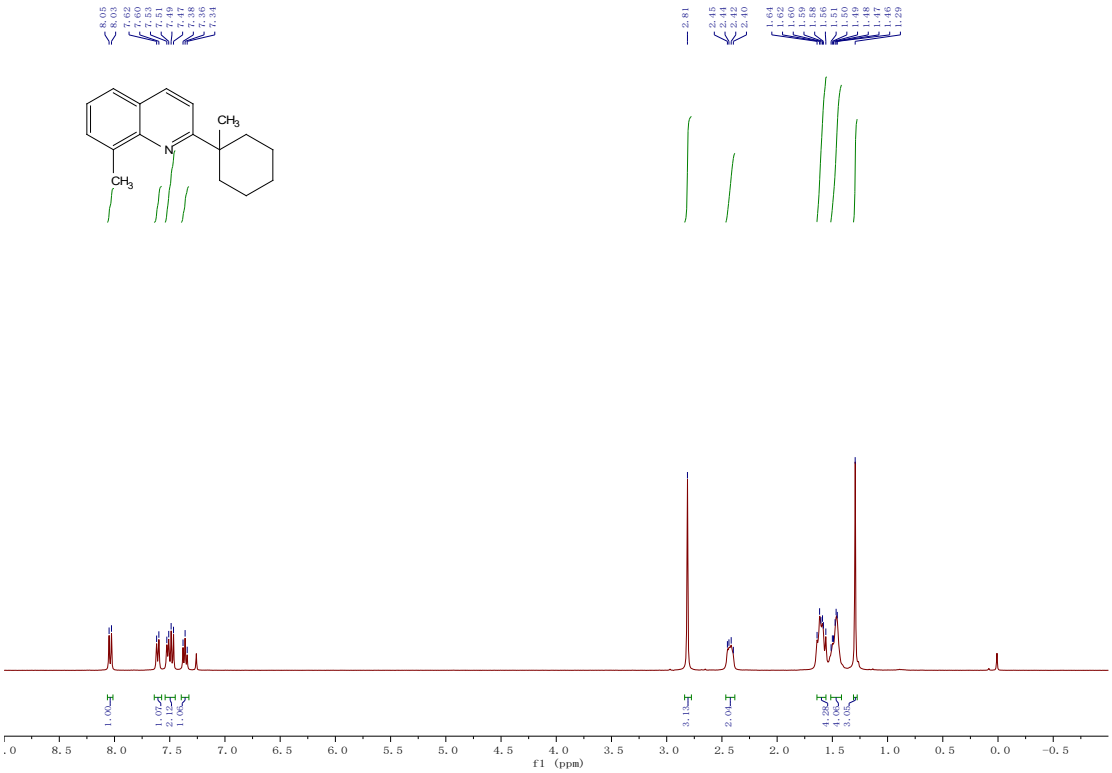
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of **3l**



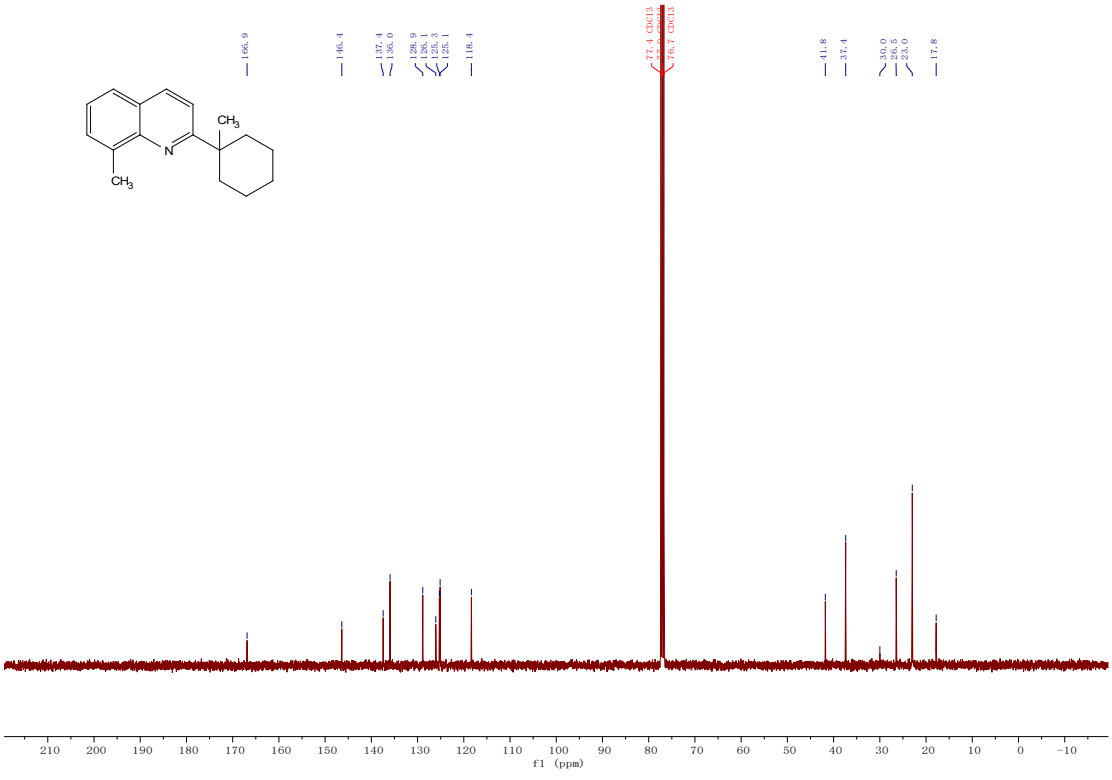
^{13}C NMR spectrum (101 MHz, $CDCl_3$) of **3l**



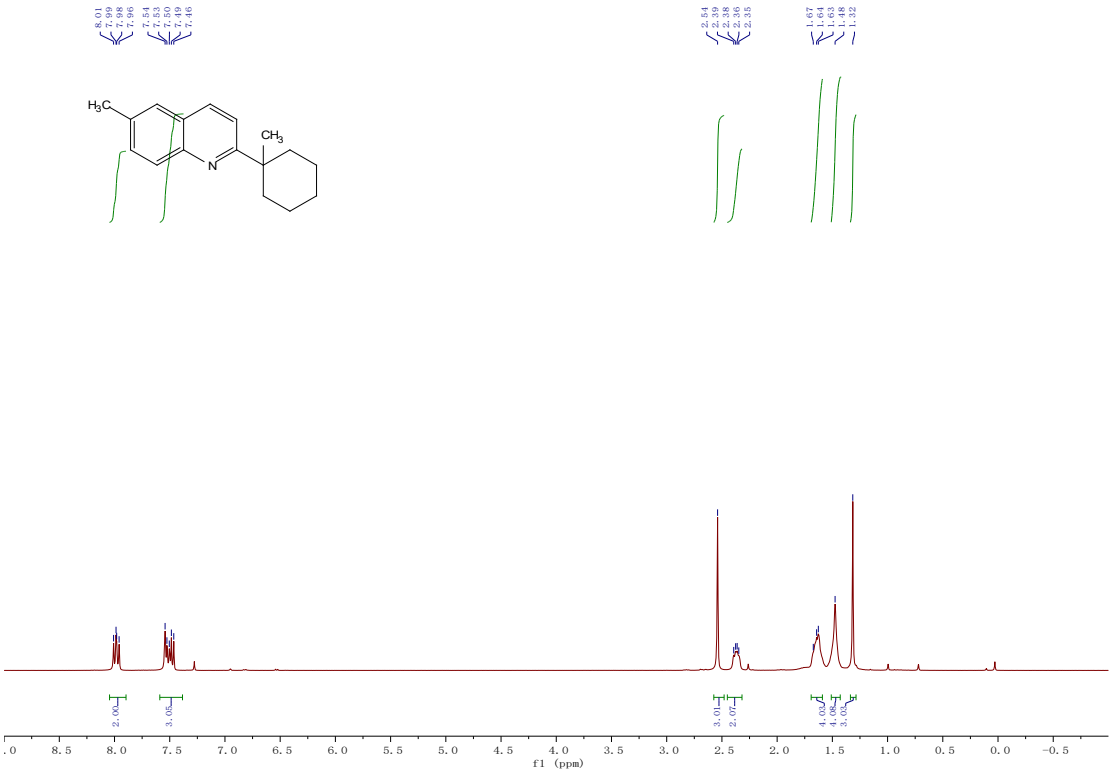
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of **3m**



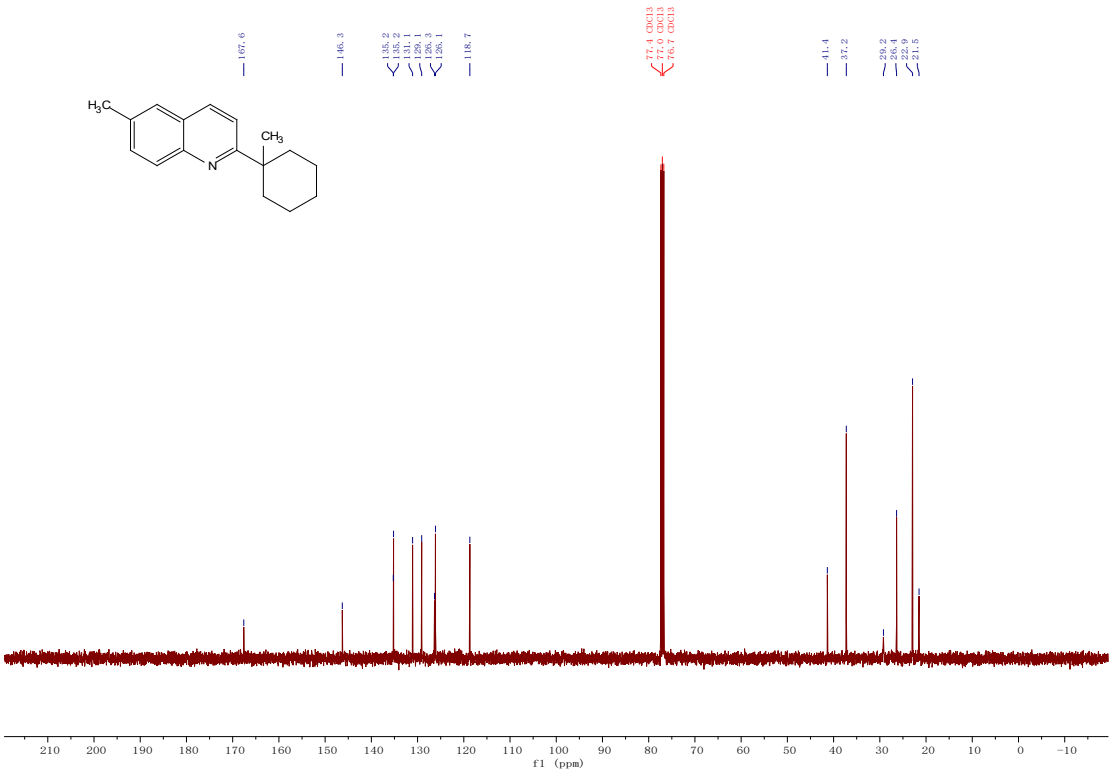
^{13}C NMR spectrum (101 MHz, $CDCl_3$) of **3m**



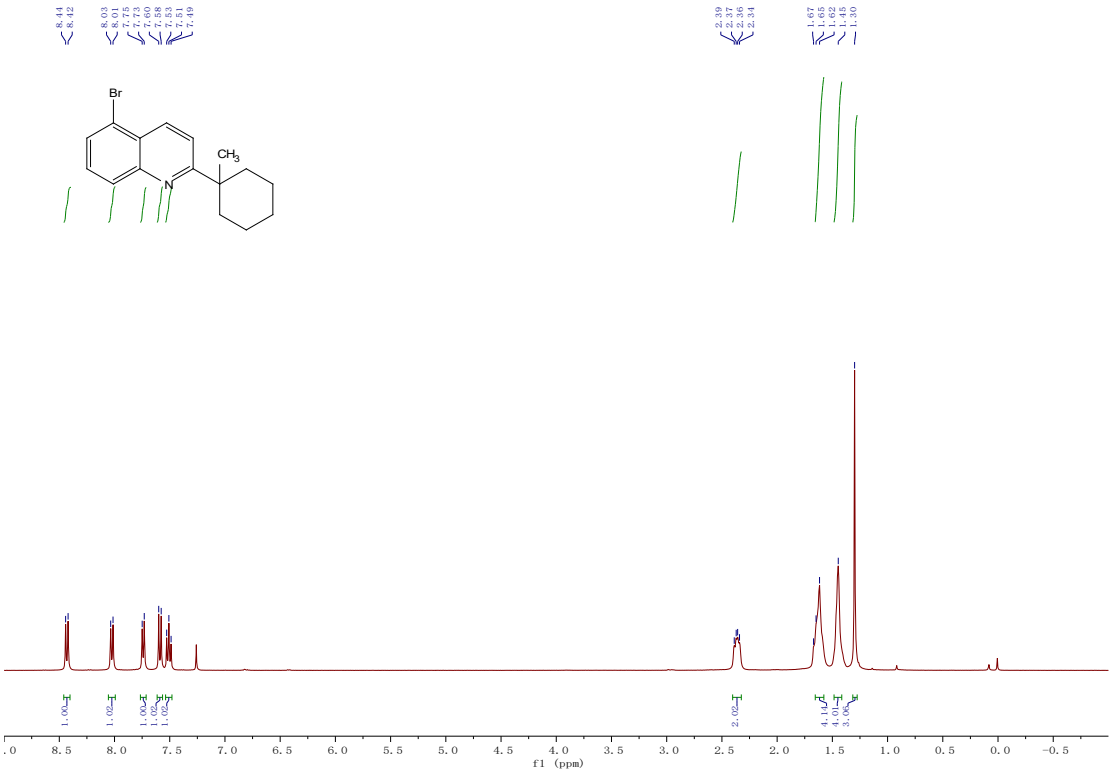
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of **3n**



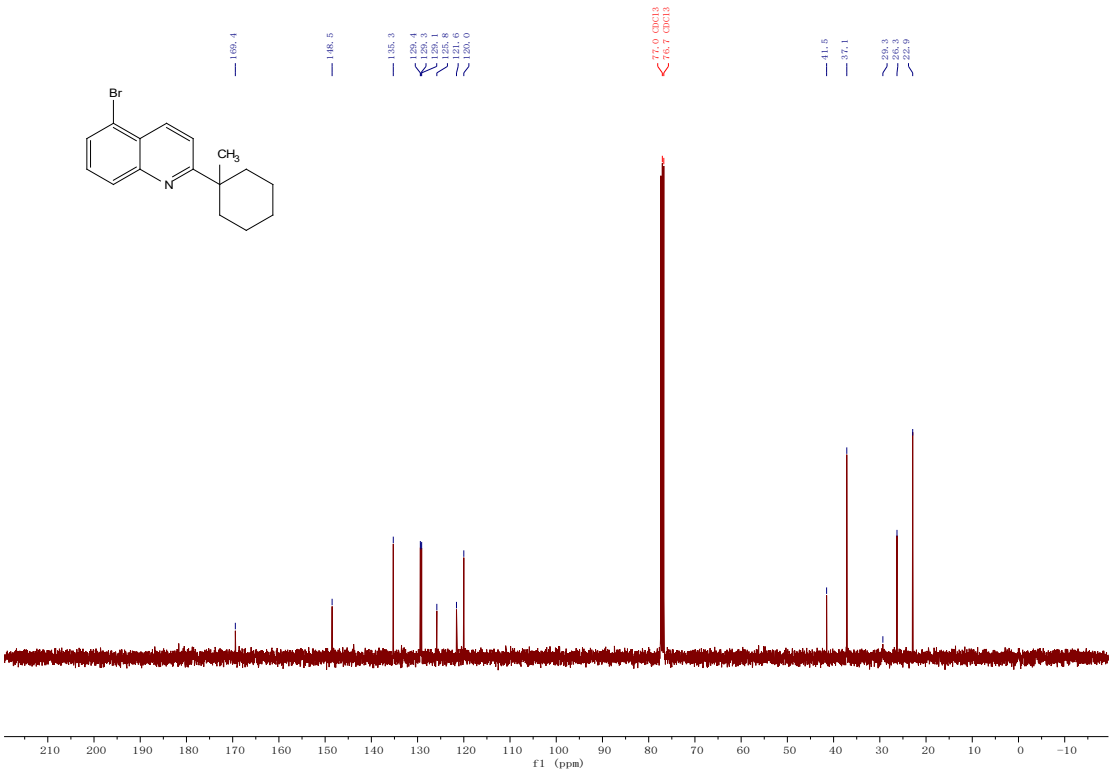
^{13}C NMR spectrum (101 MHz, $CDCl_3$) of **3n**



^{1}H NMR spectrum (400 MHz, $CDCl_3$) of **3o**

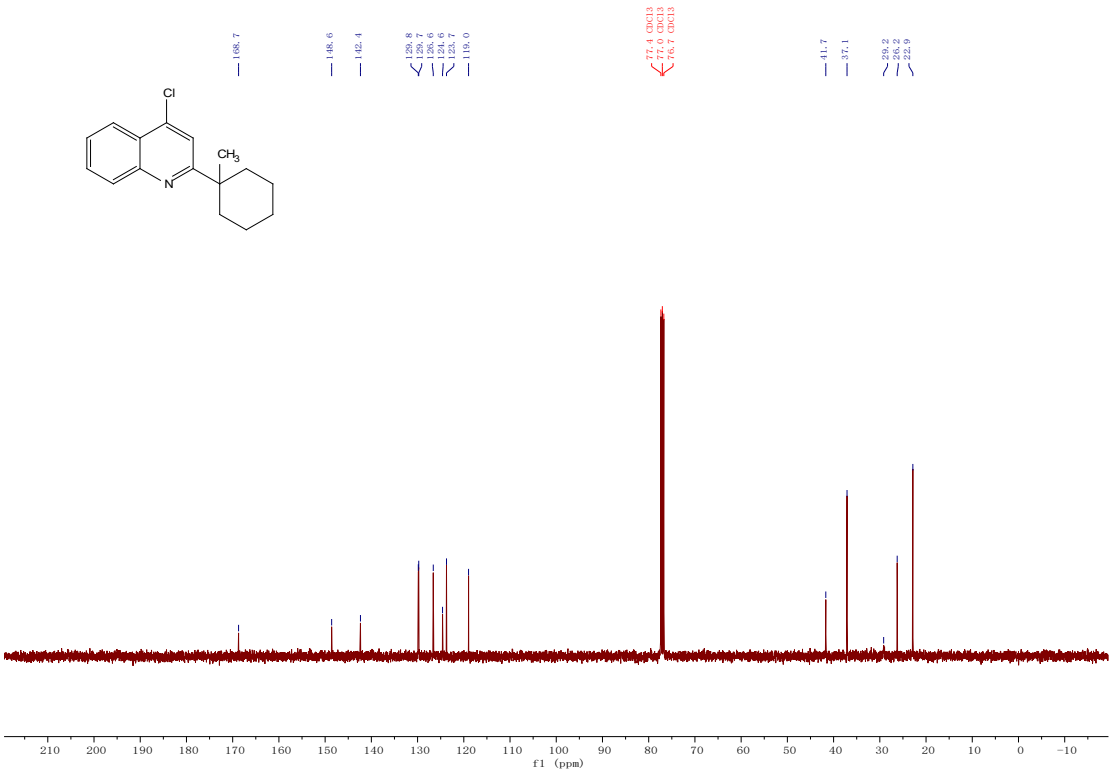


^{13}C NMR spectrum (101 MHz, $CDCl_3$) of **3o**

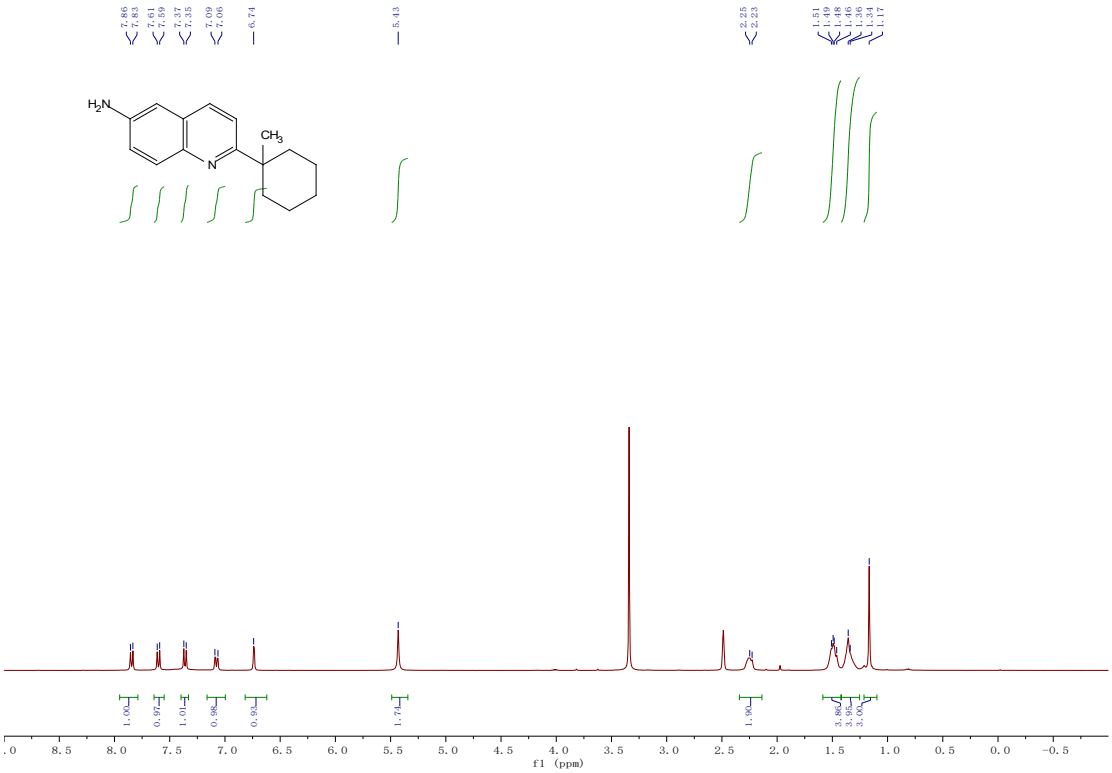


^{1}H NMR spectrum (400 MHz, $CDCl_3$) of **3p**

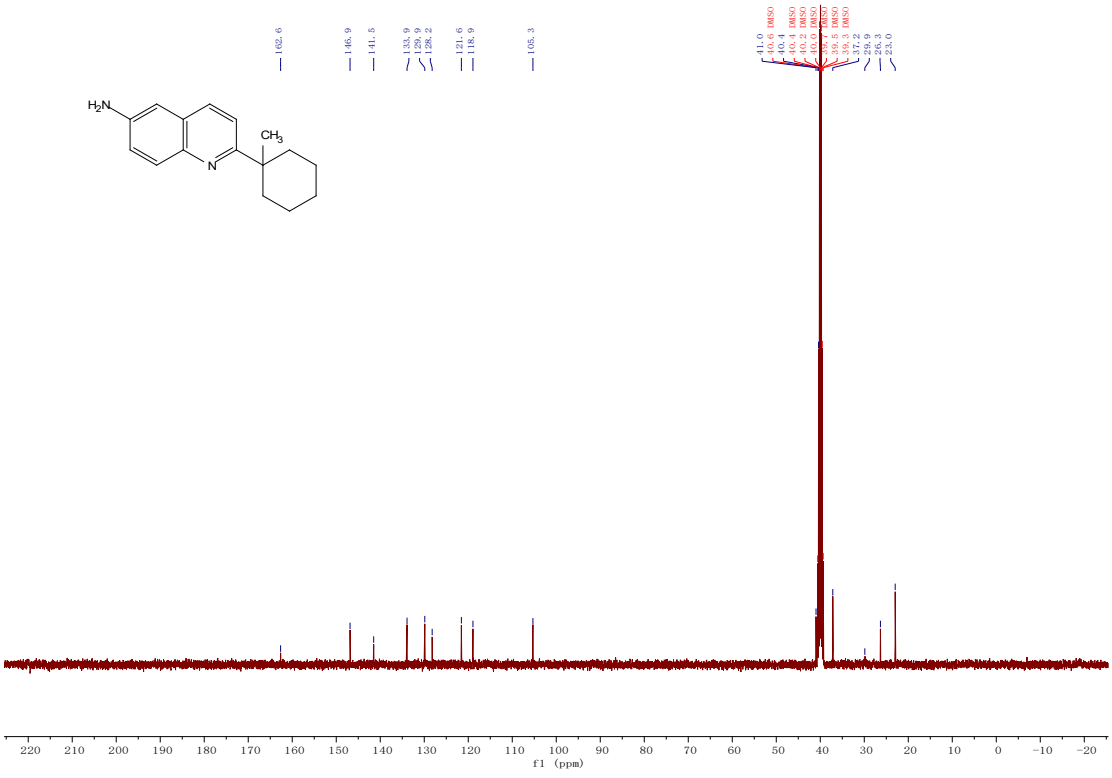
^{13}C NMR spectrum (101 MHz, $CDCl_3$) of **3p**



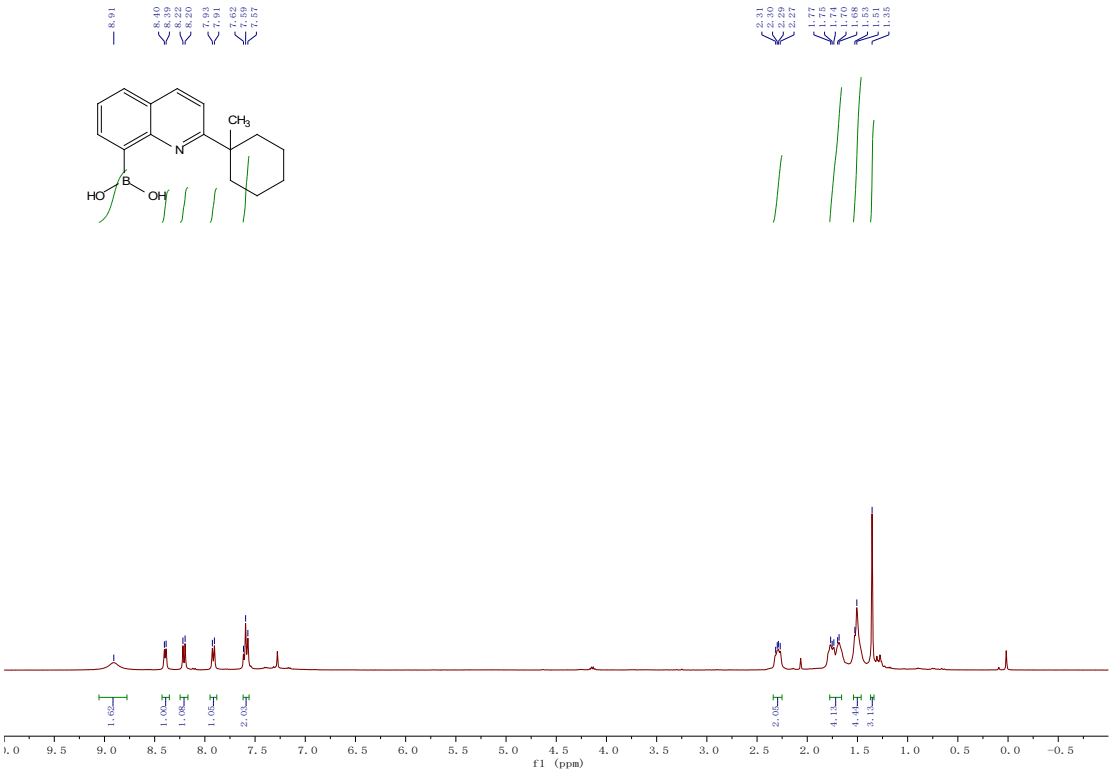
^{1}H NMR spectrum (400 MHz, DMSO-d_6) of **3q**



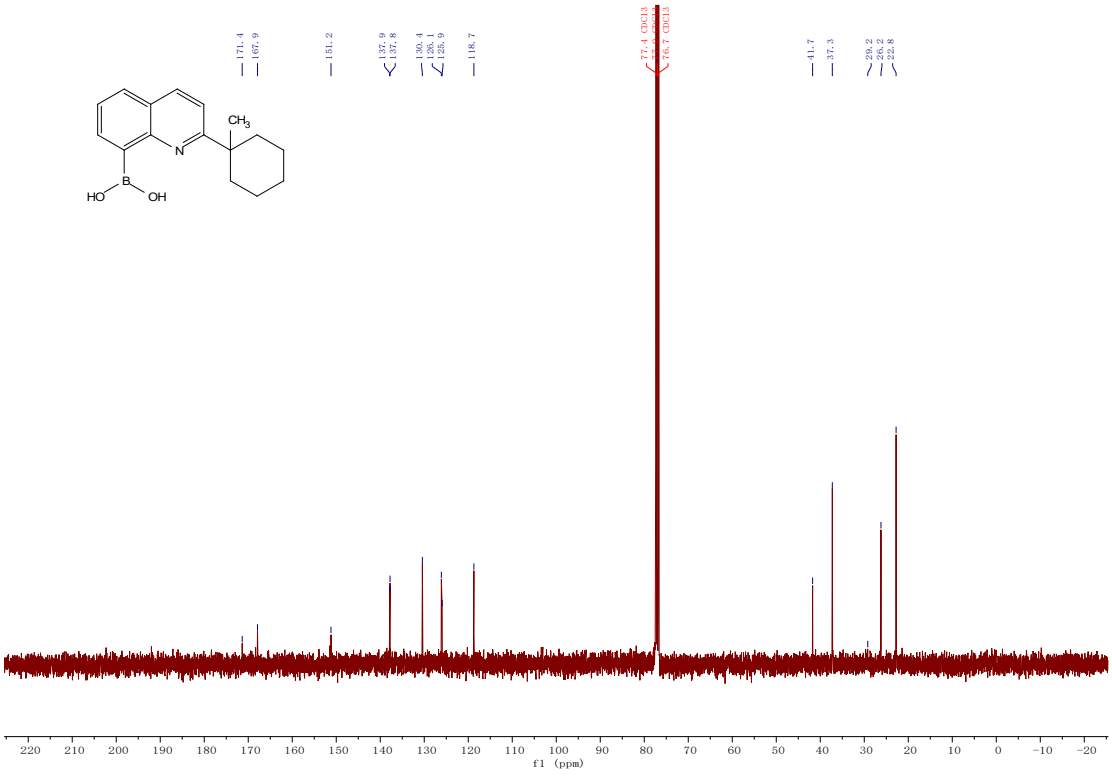
^{13}C NMR spectrum (101 MHz, DMSO-d_6) of **3q**



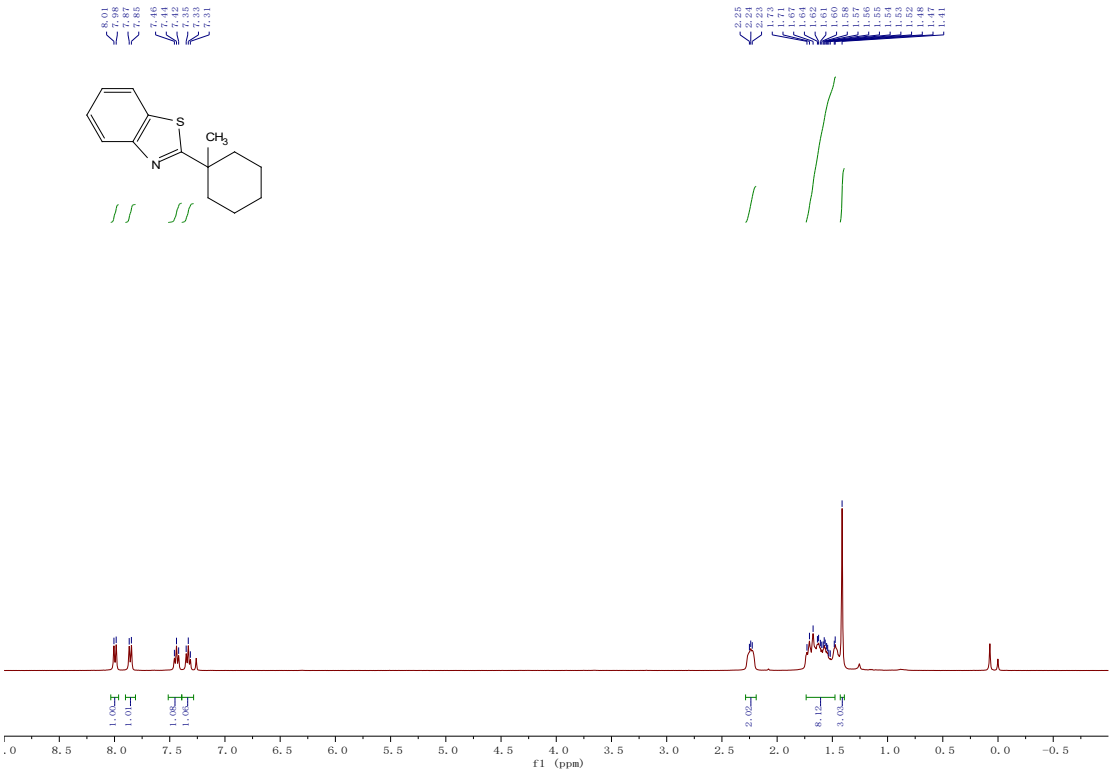
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of **3r**



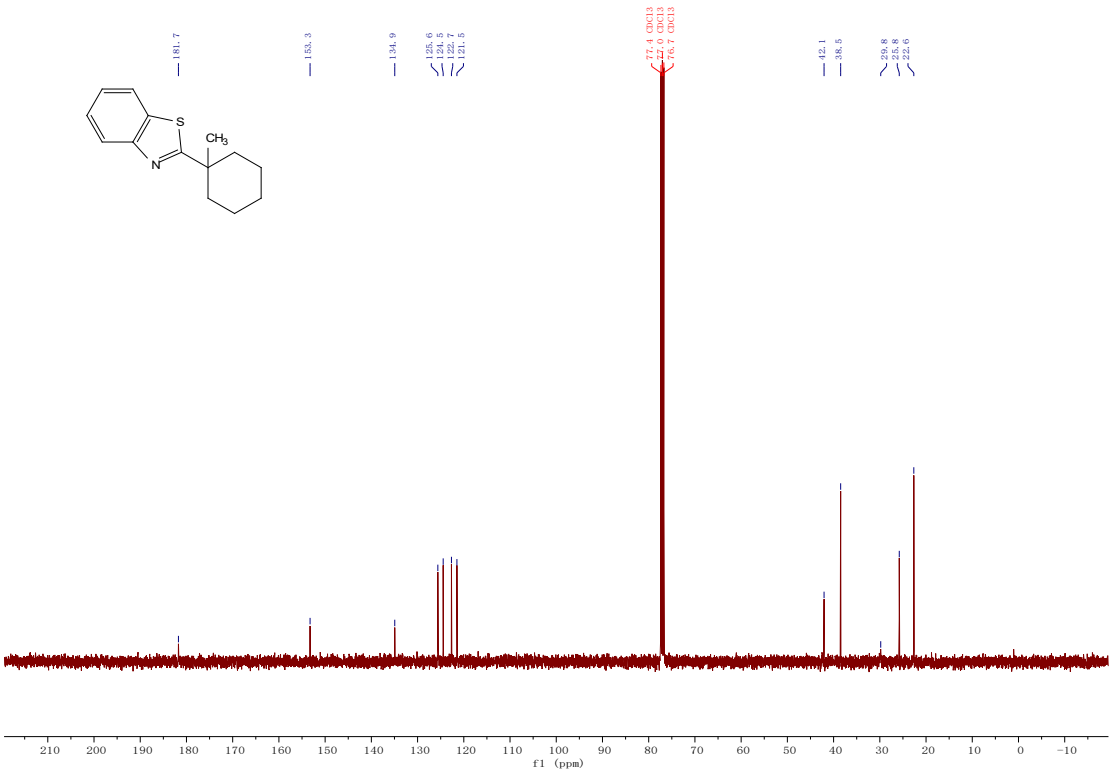
^{13}C NMR spectrum (101 MHz, $CDCl_3$) of **3r**



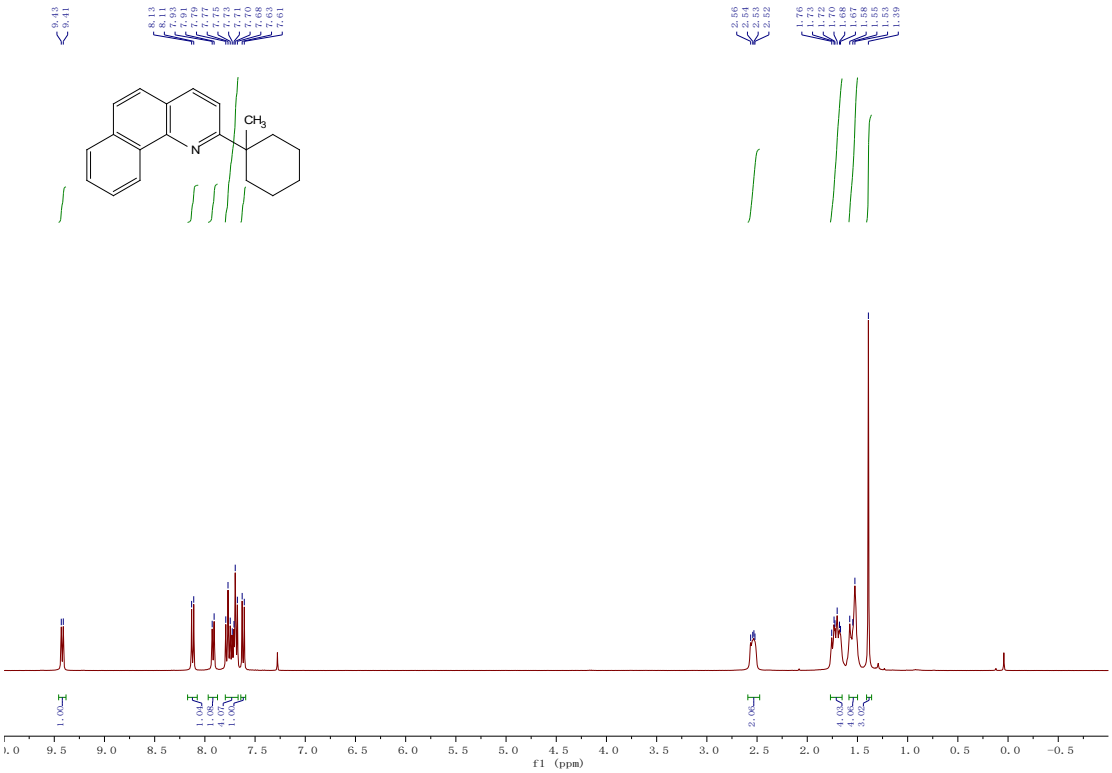
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of **3s**



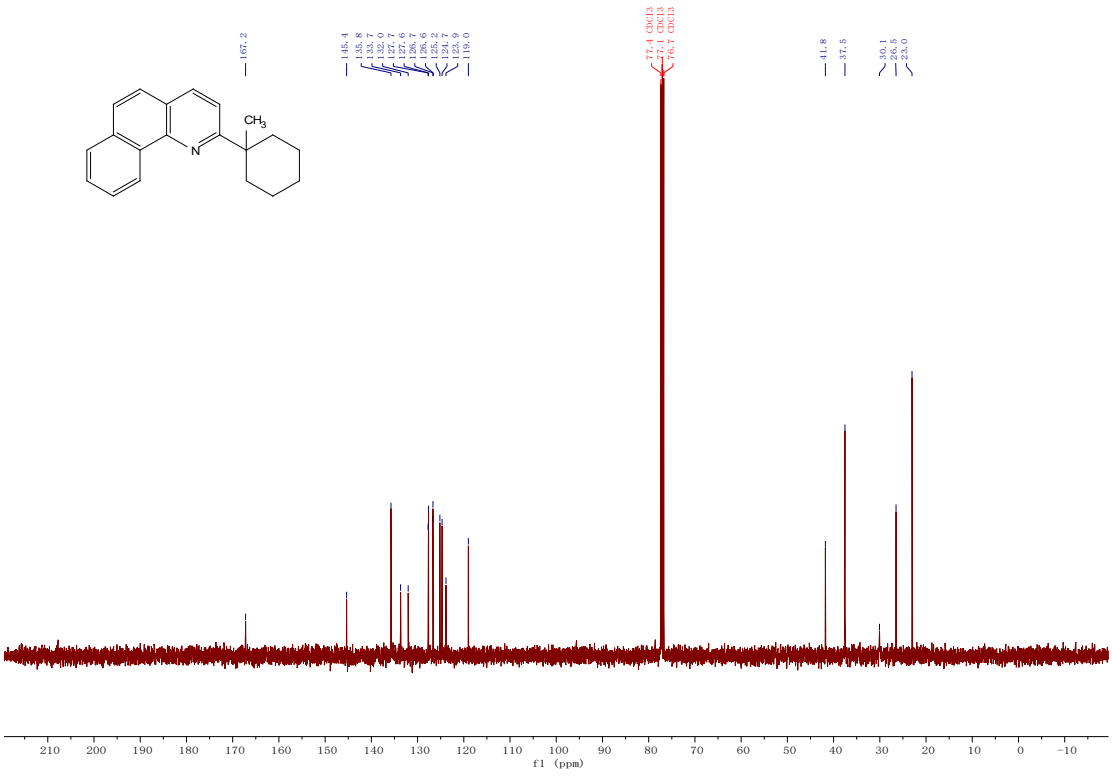
^{13}C NMR spectrum (101 MHz, $CDCl_3$) of **3s**



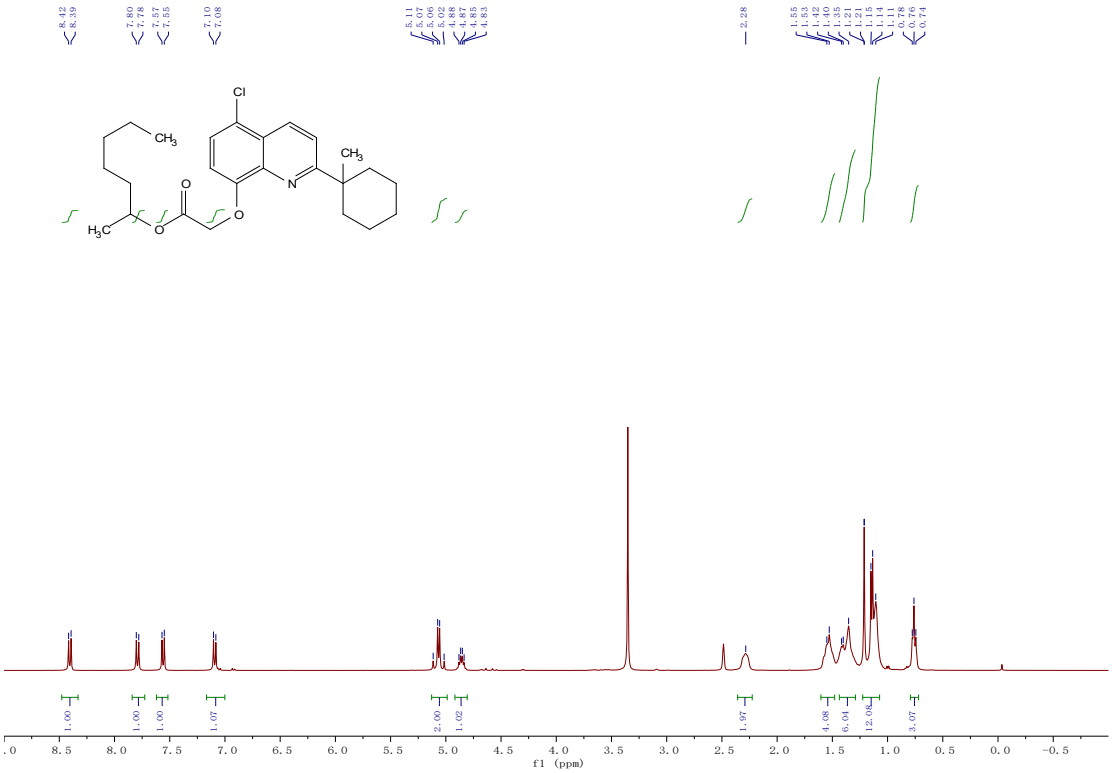
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of **3t**



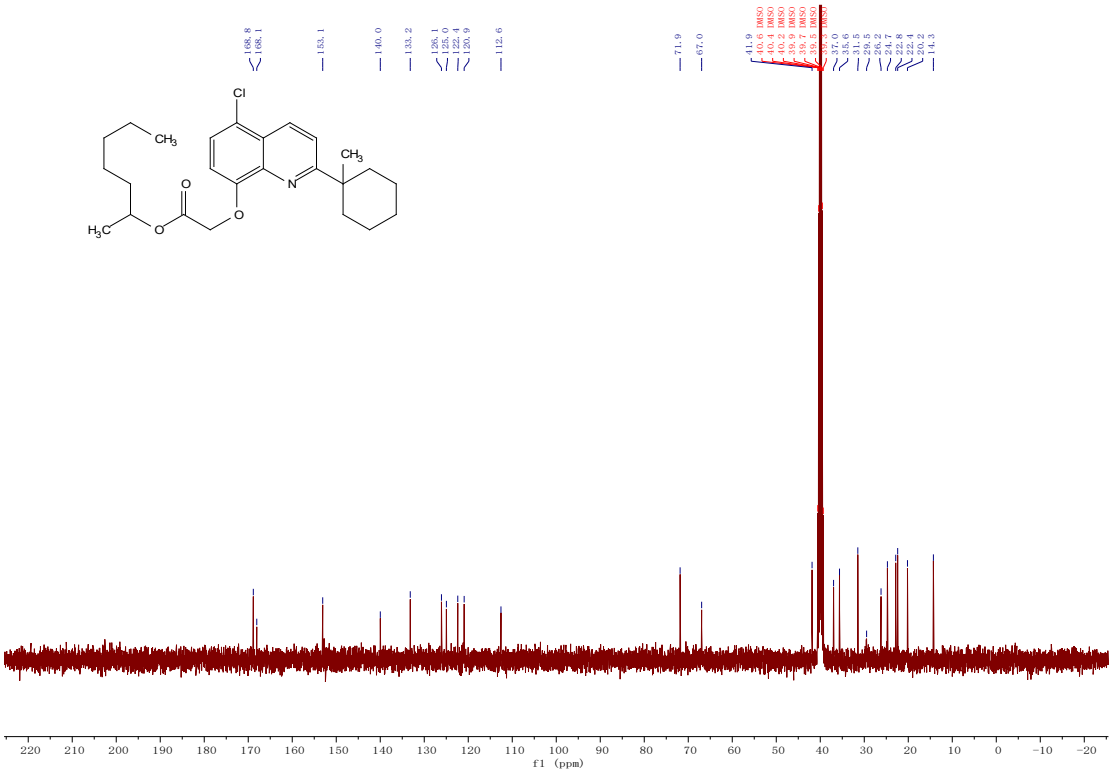
^{13}C NMR spectrum (101 MHz, $CDCl_3$) of **3t**



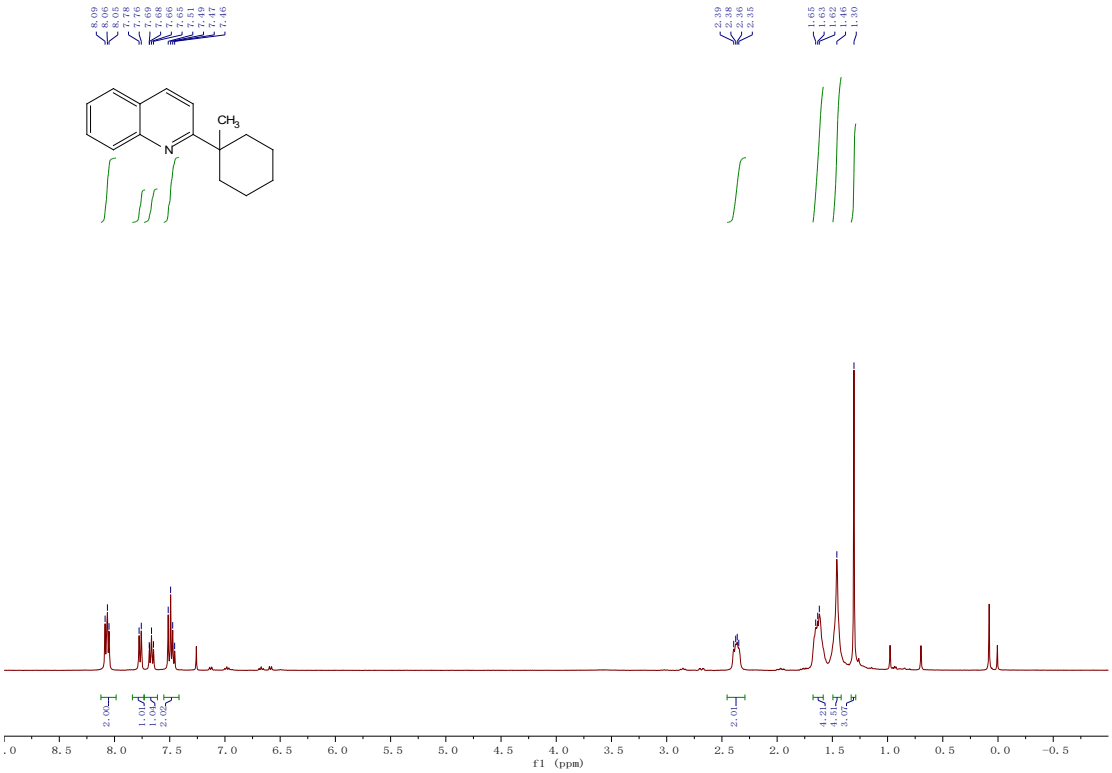
^{1}H NMR spectrum (400 MHz, DMSO-d_6) of **3u**



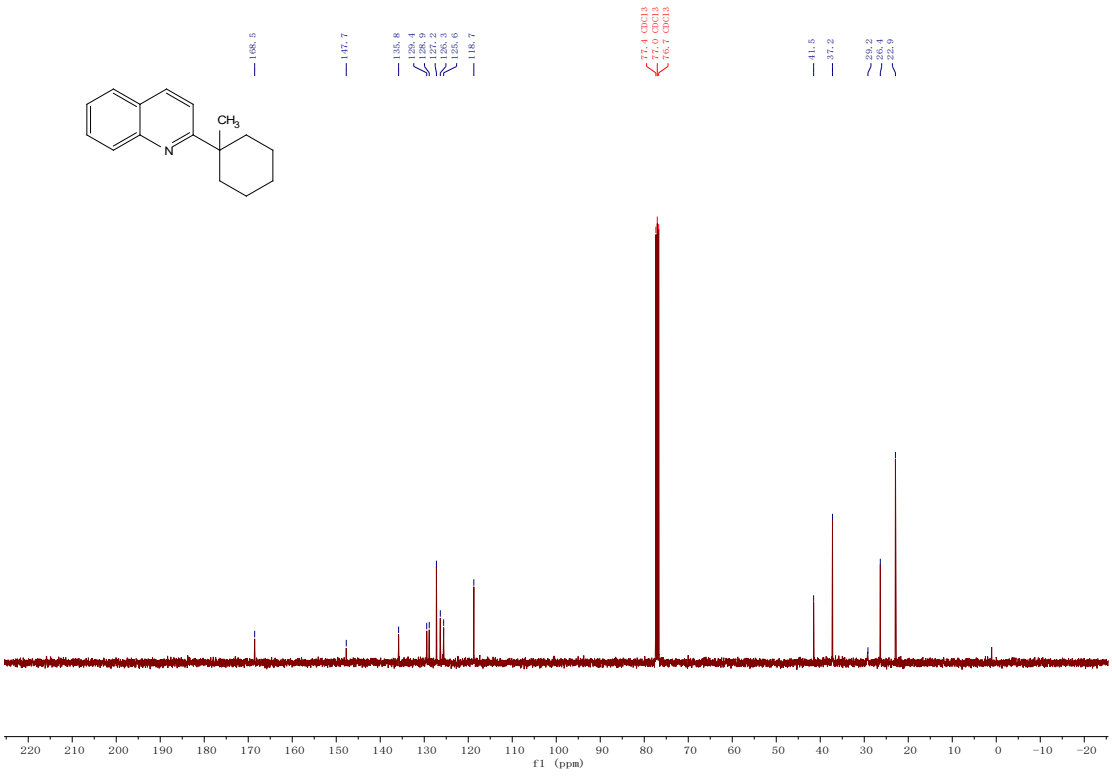
^{13}C NMR spectrum (101 MHz, DMSO-d_6) of **3u**



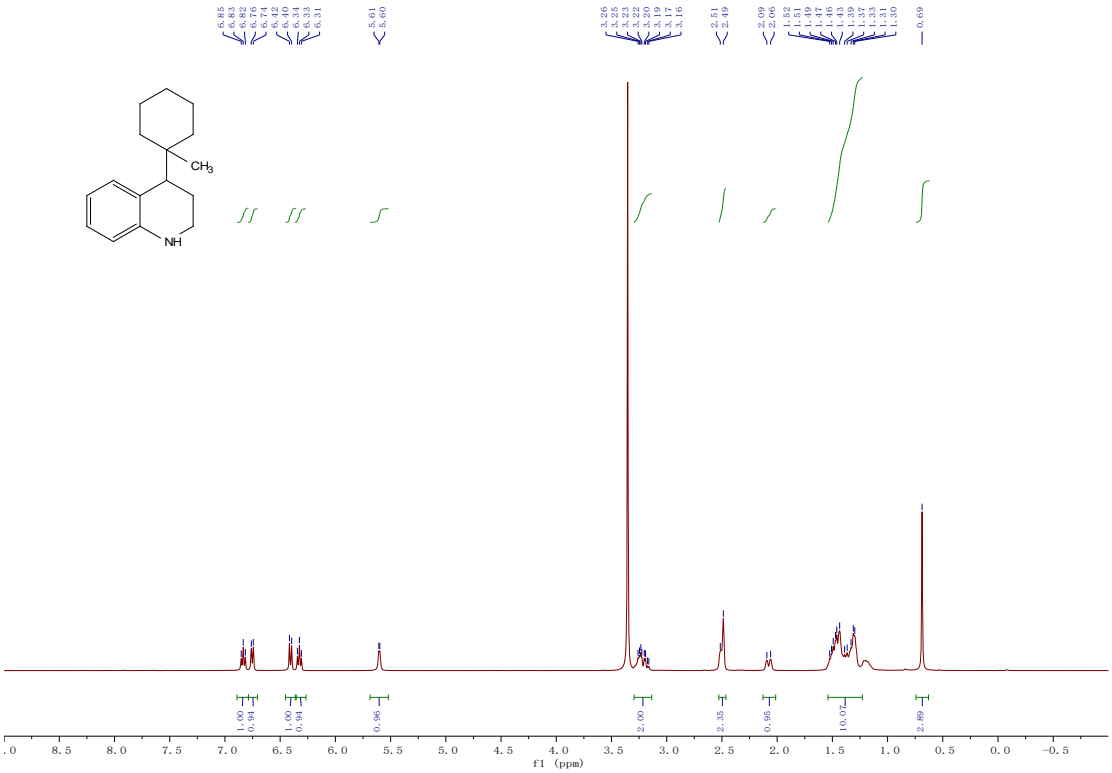
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of **4a**



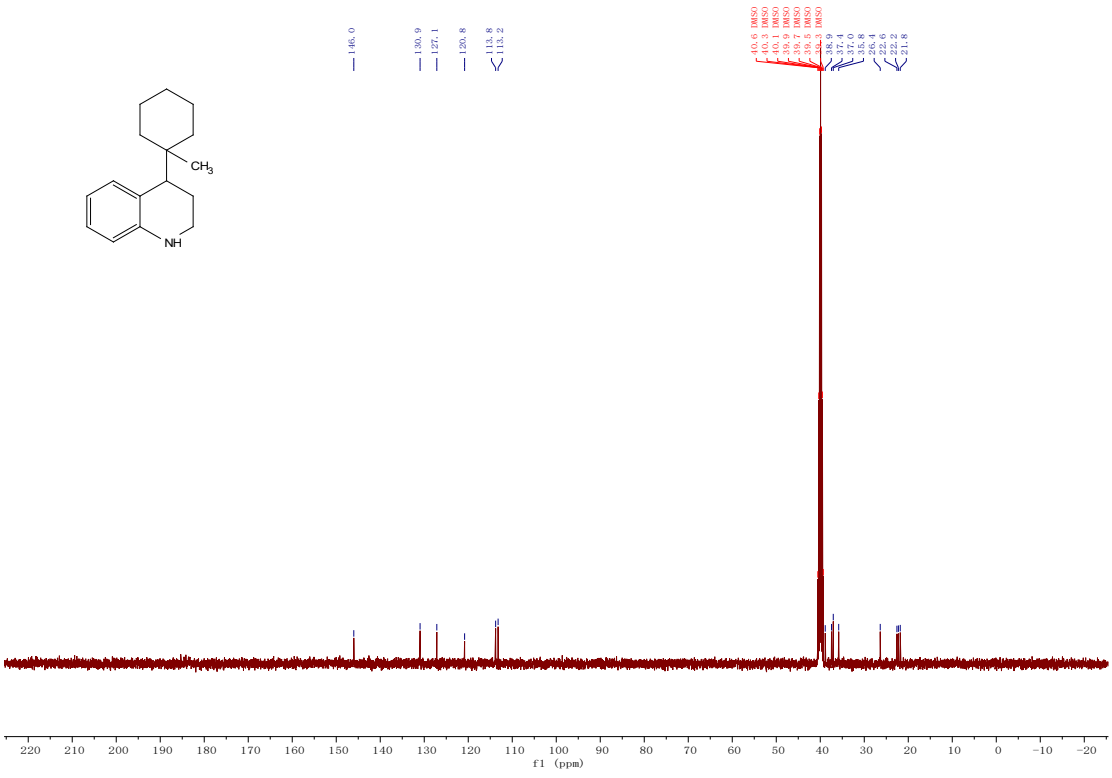
^{13}C NMR spectrum (101 MHz, $CDCl_3$) of **4a**



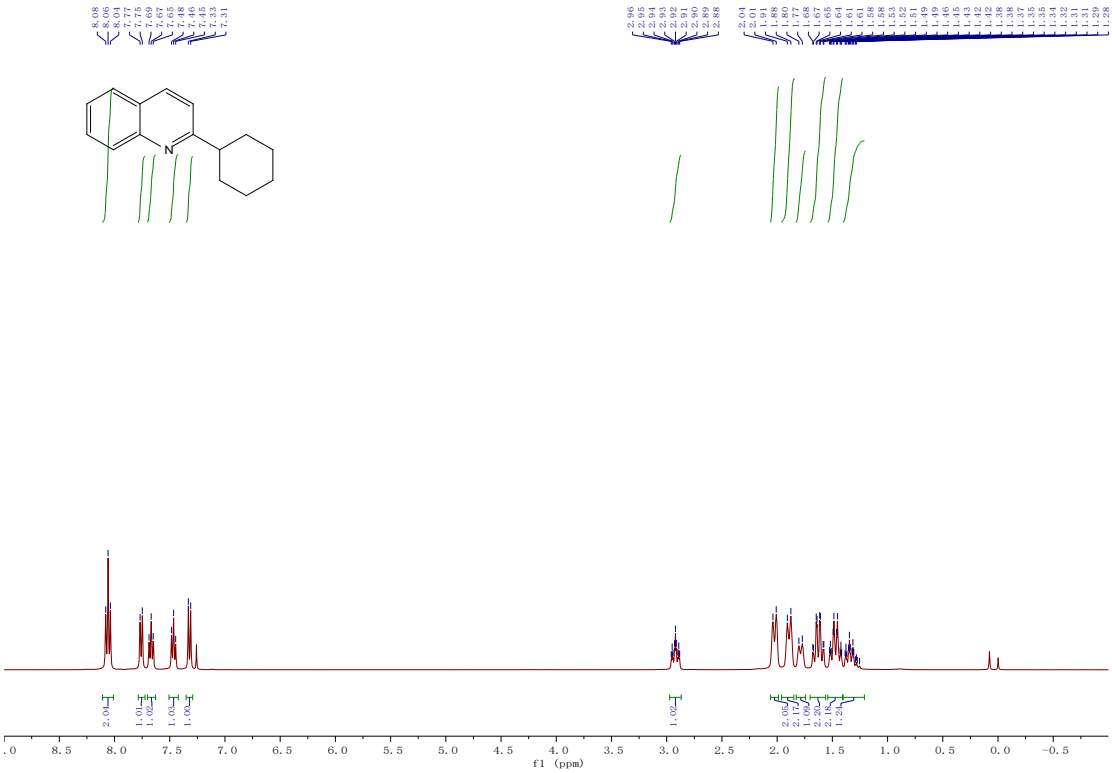
^{1}H NMR spectrum (400 MHz, DMSO-d_6) of **4b**



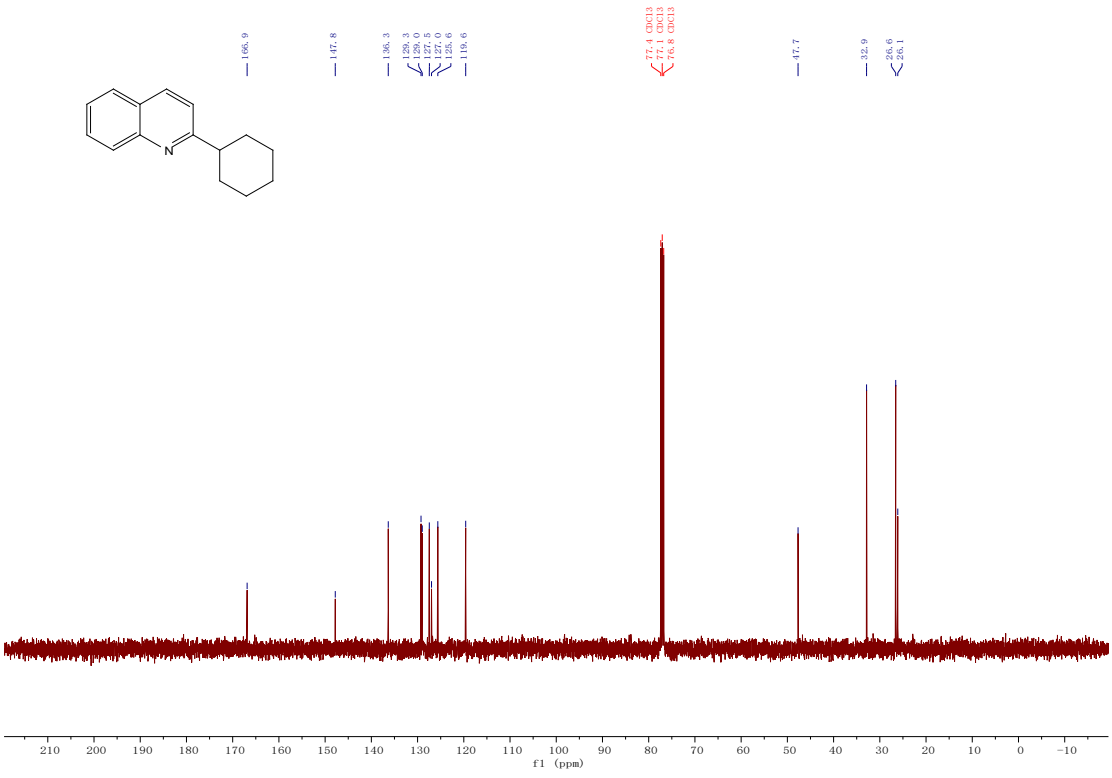
^{13}C NMR spectrum (101 MHz, DMSO-d_6) of **4b**



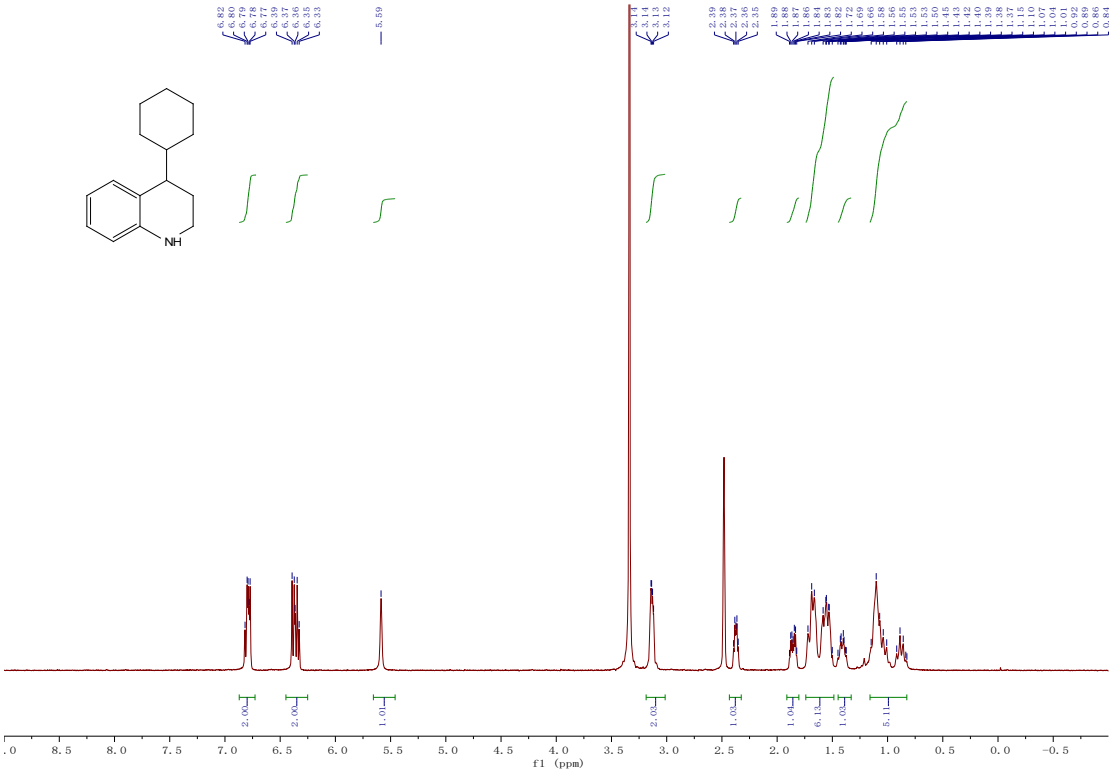
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of (**5a-C2)**



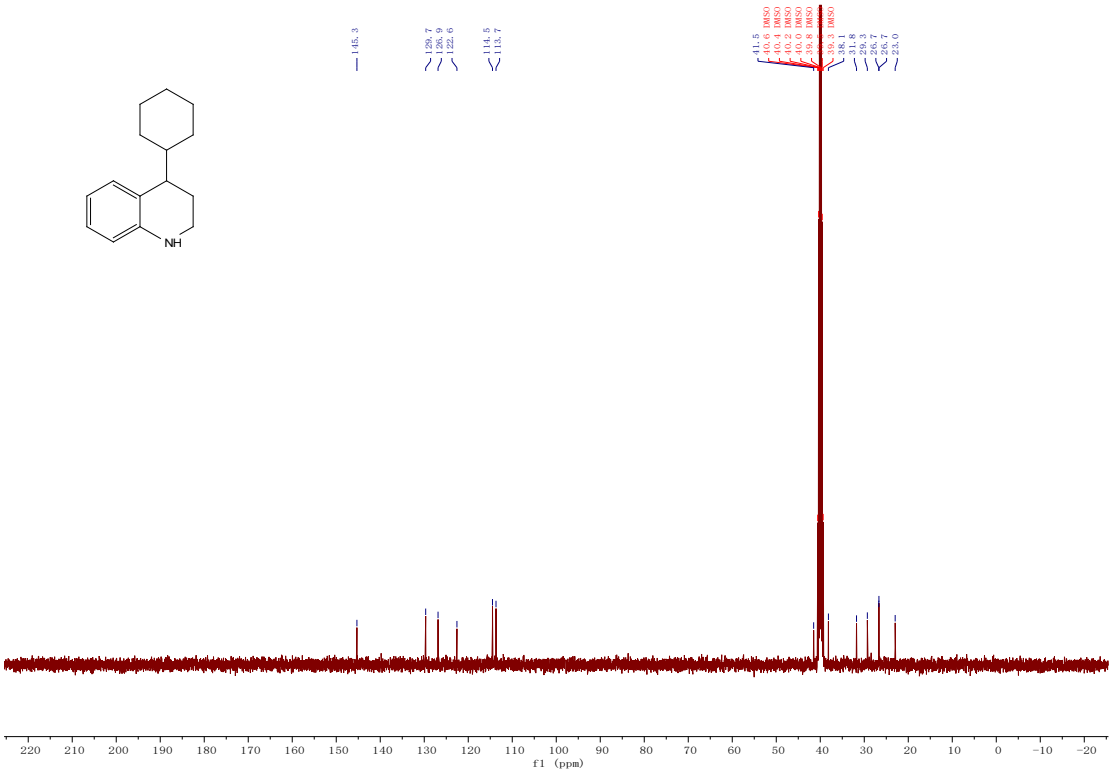
^{13}C NMR spectrum (101 MHz, $CDCl_3$) of (**5a-C2)**



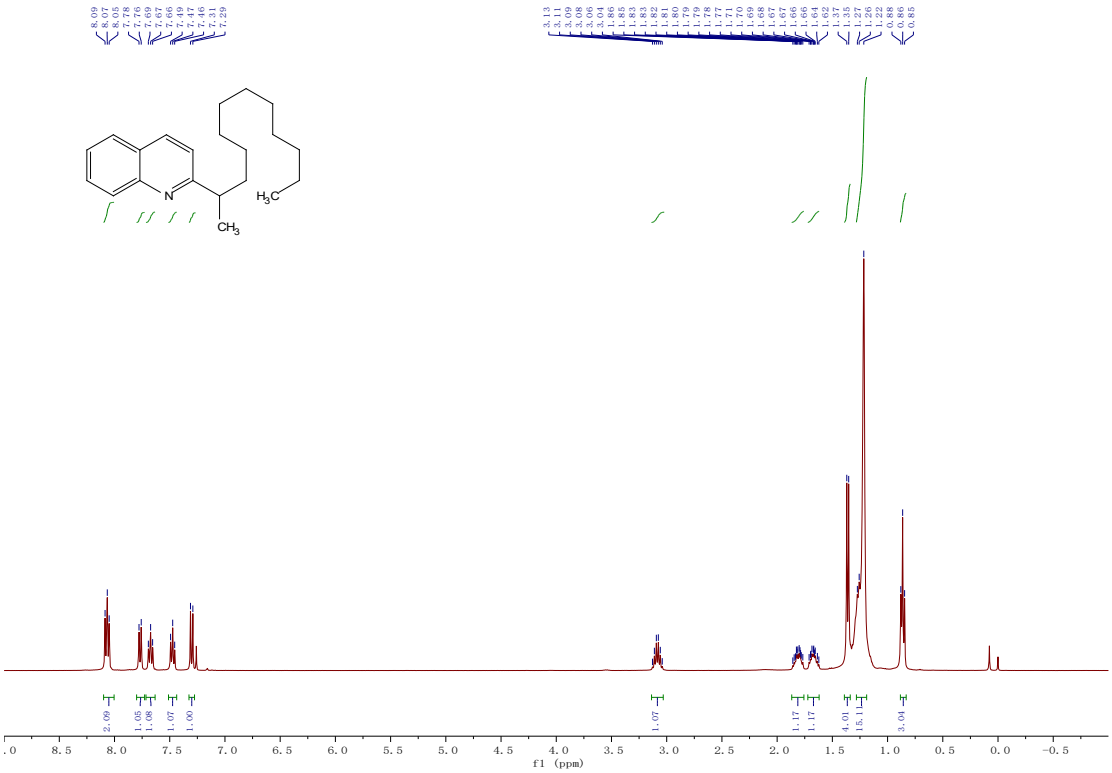
^{1}H NMR spectrum (400 MHz, DMSO-d_6) of **5a**



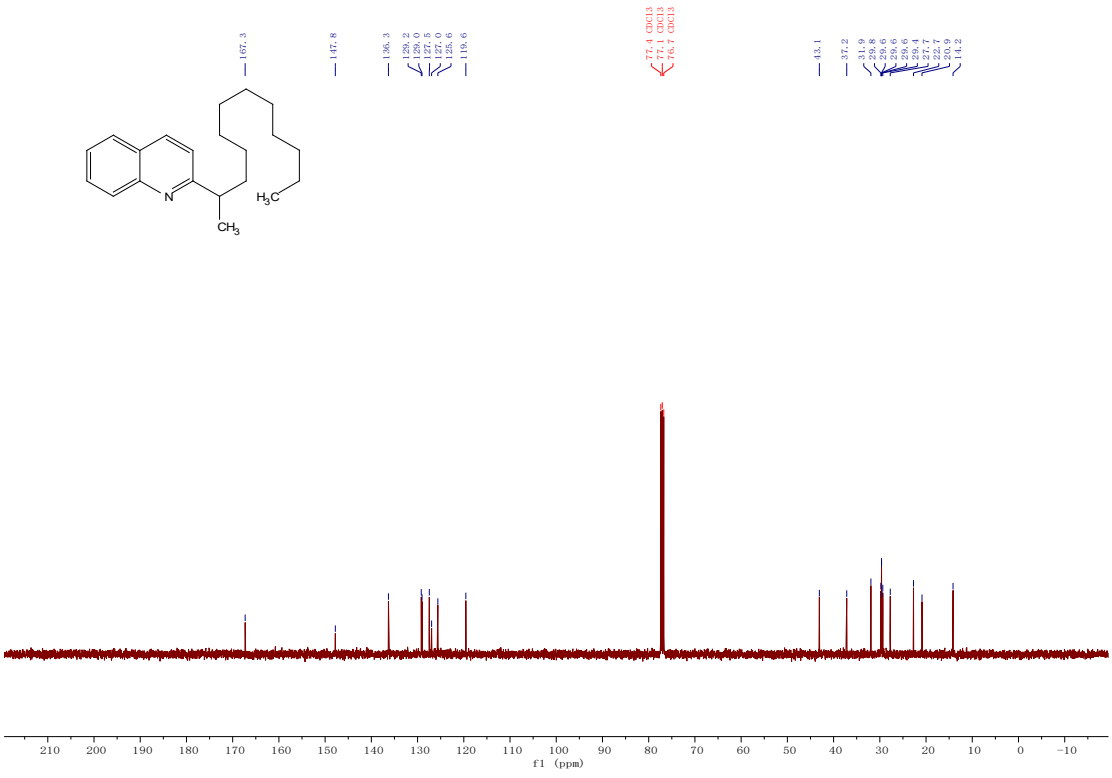
^{13}C NMR spectrum (101 MHz, DMSO-d_6) of **5a**



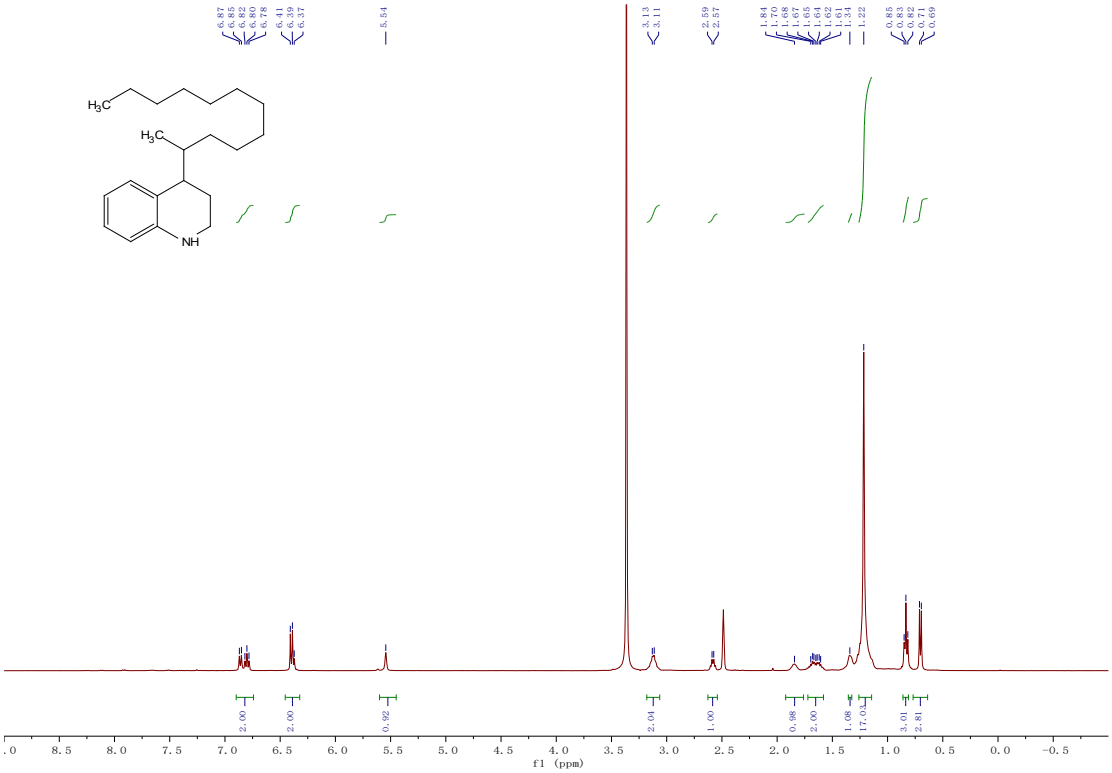
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of (**5b-C2)**



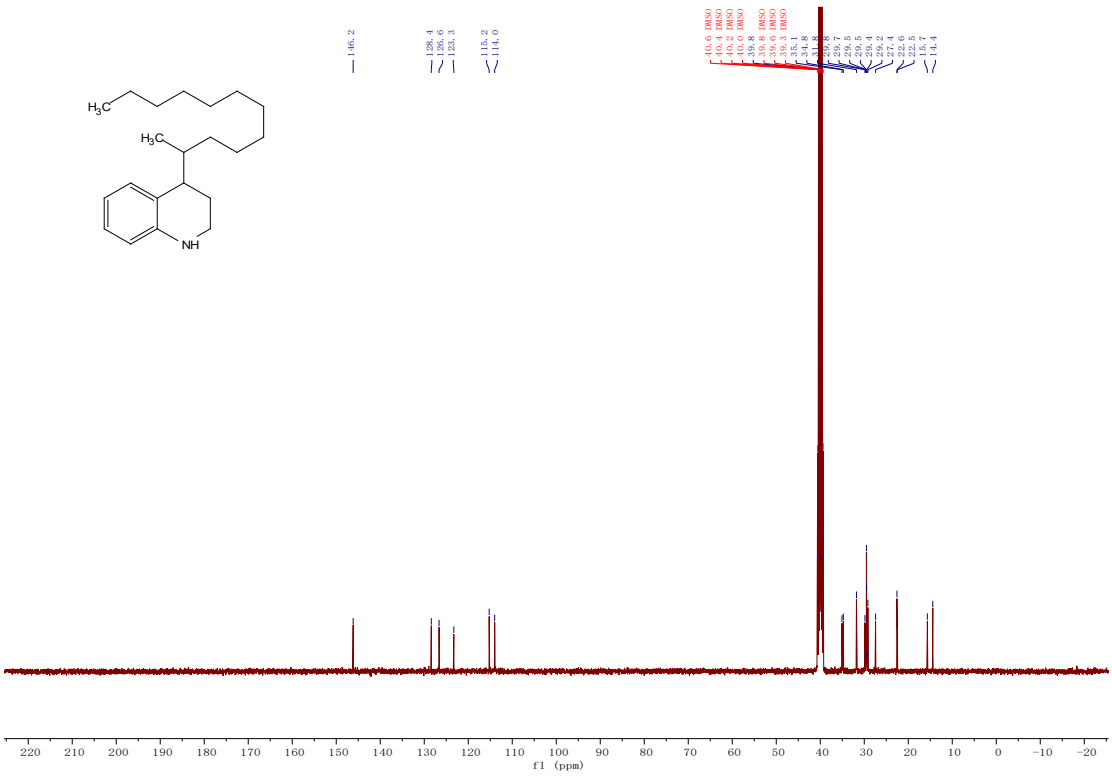
^{13}C NMR spectrum (101 MHz, $CDCl_3$) of (**5b-C2)**



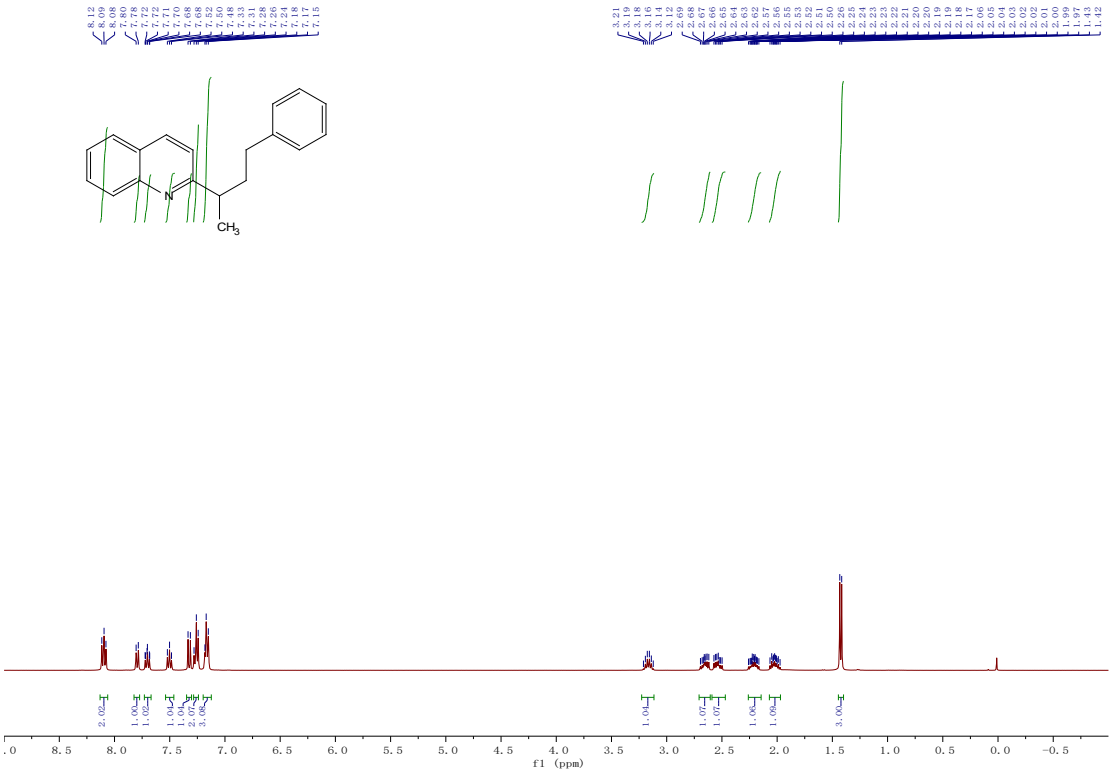
^{1}H NMR spectrum (400 MHz, DMSO-d_6) of **5b**



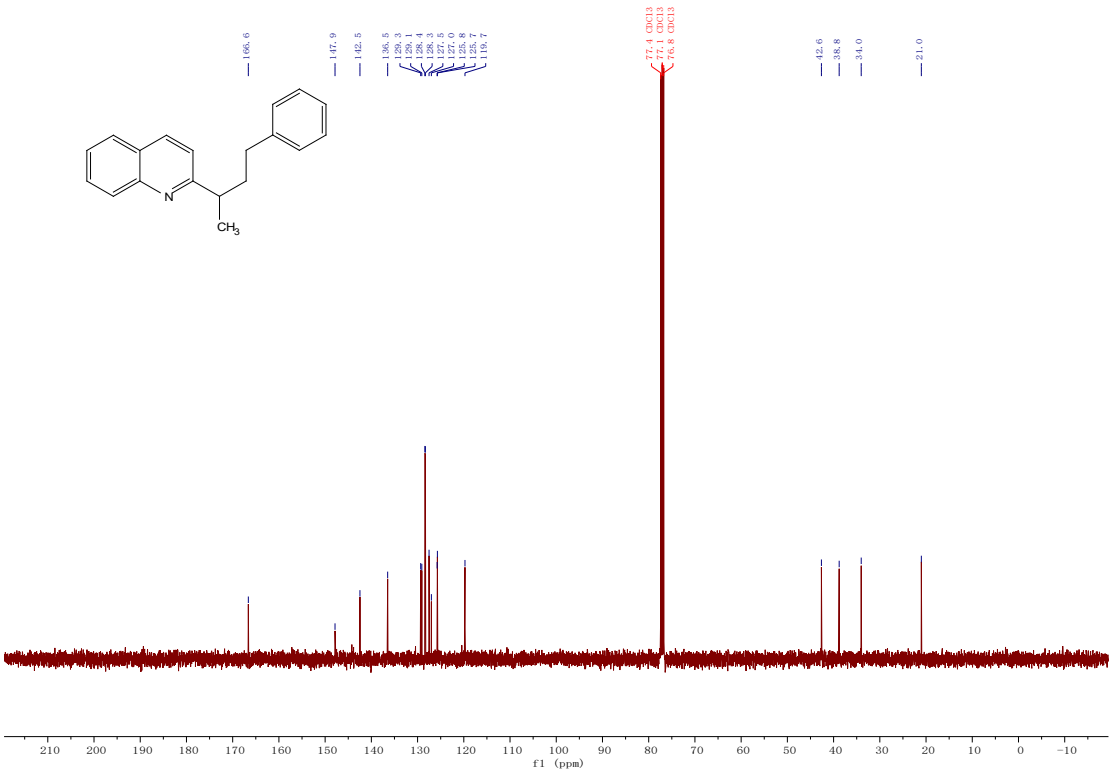
^{13}C NMR spectrum (101 MHz, DMSO-d_6) of **5b**



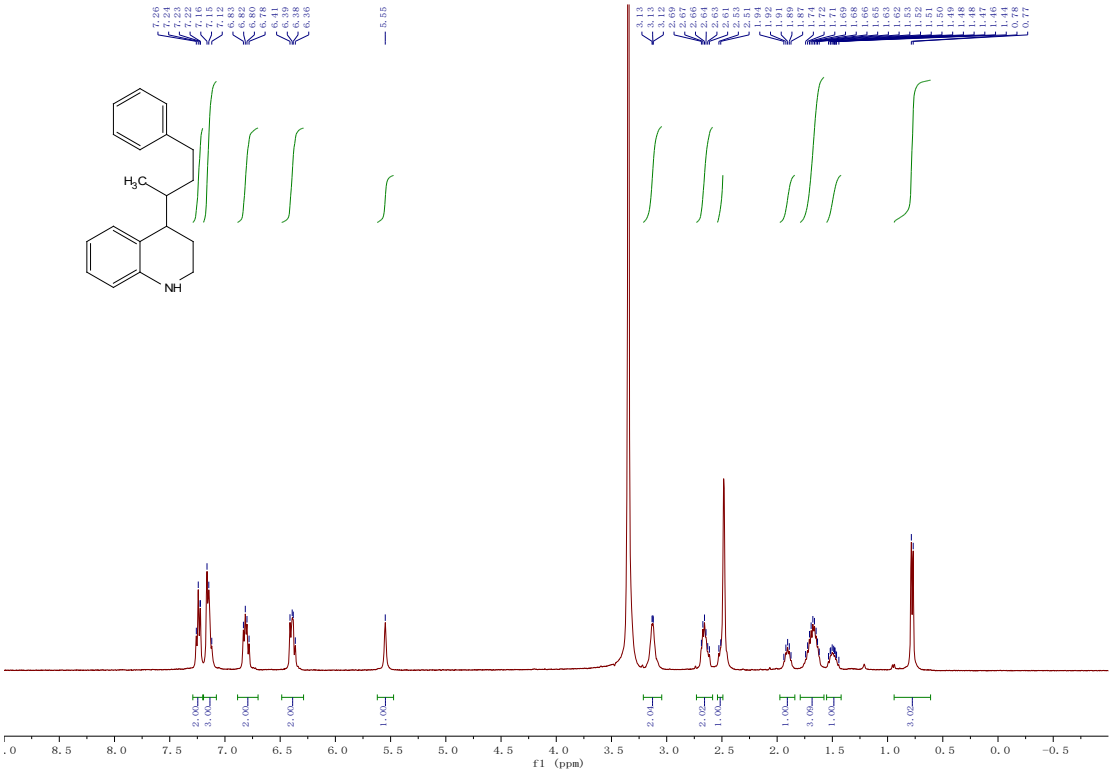
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of (**5c-C2)**



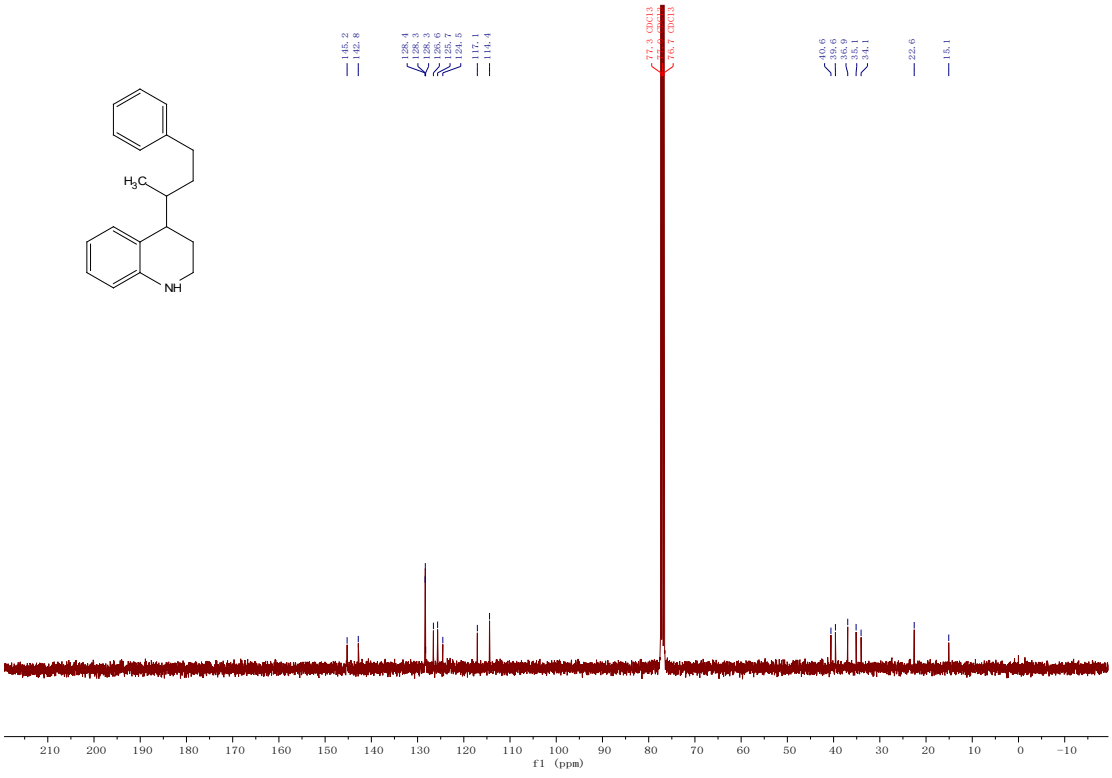
^{13}C NMR spectrum (101 MHz, $CDCl_3$) of (**5c-C2)**



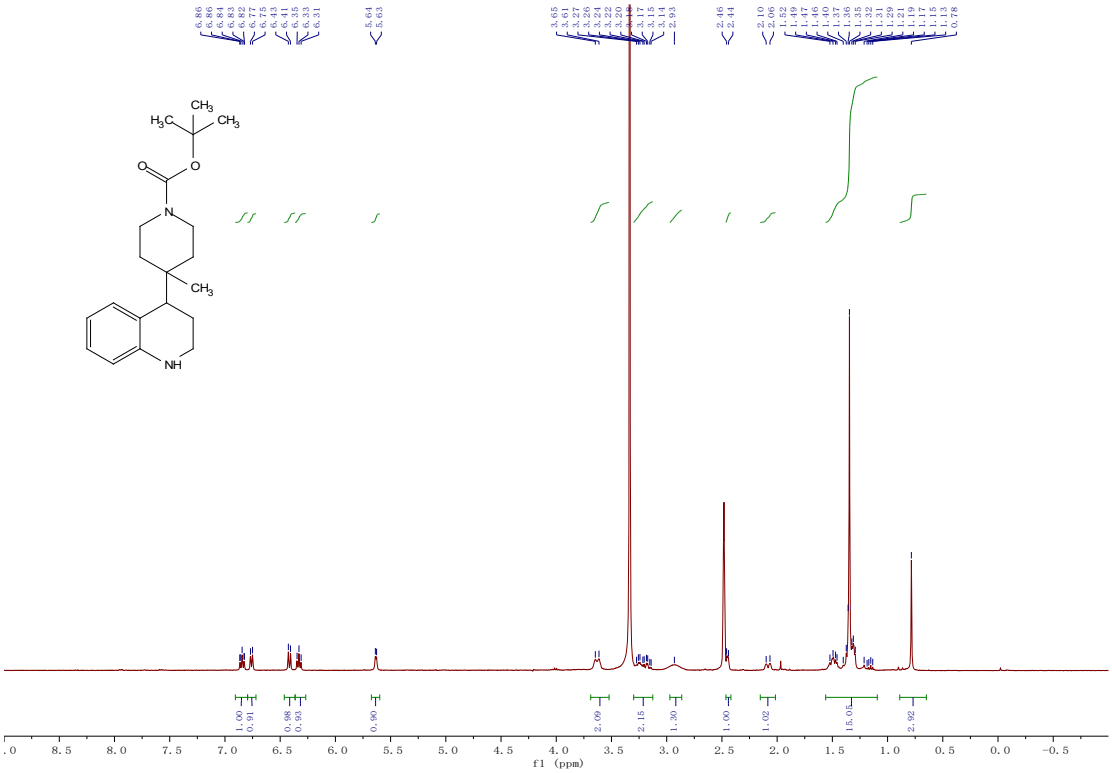
^{1}H NMR spectrum (400 MHz, DMSO-d_6) of **5c**



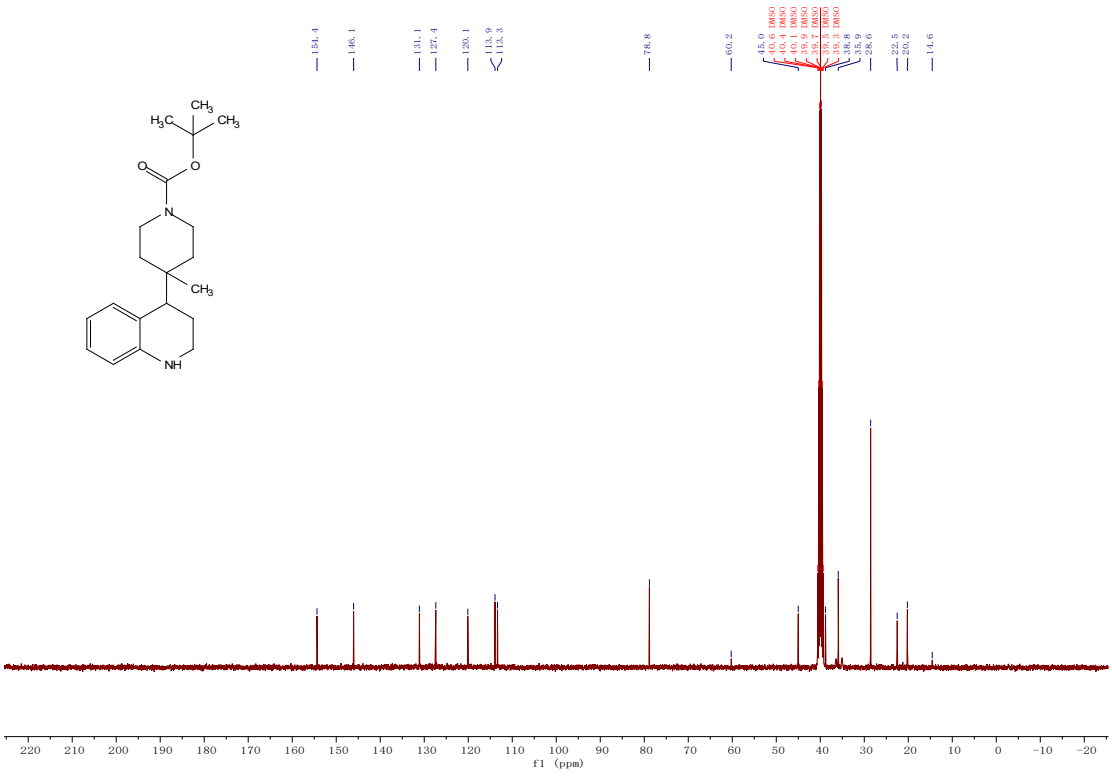
^{13}C NMR spectrum (101 MHz, $CDCl_3$) of **5c**



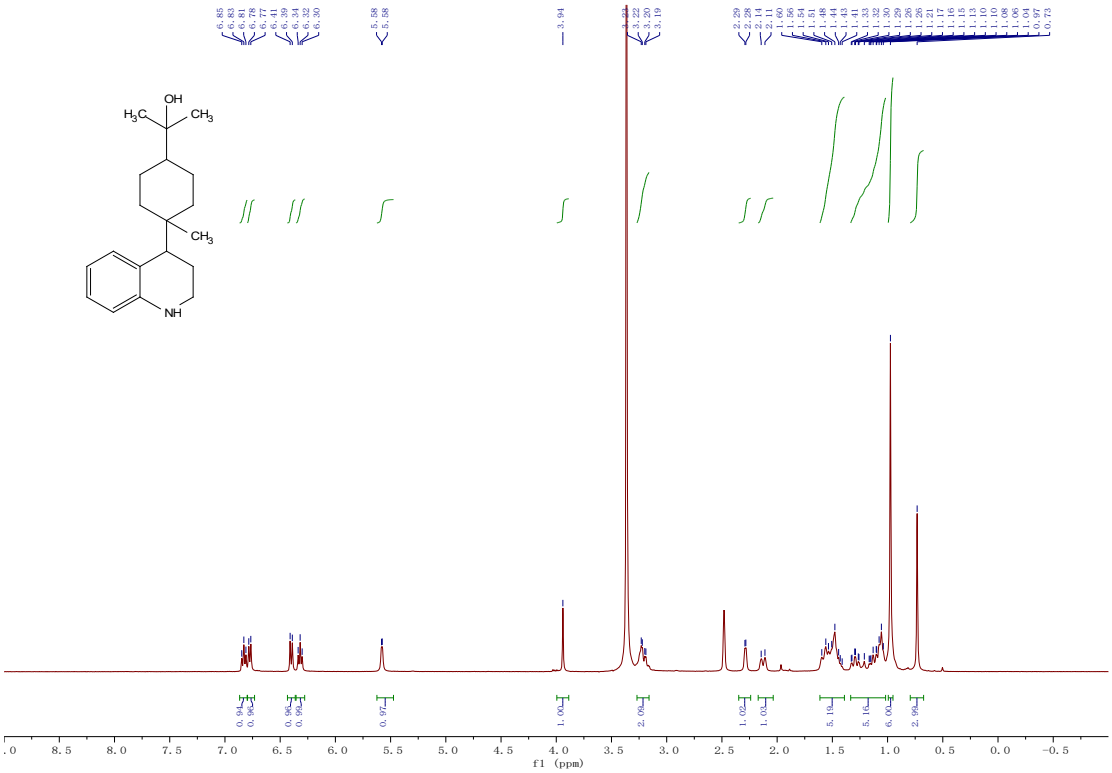
^{1}H NMR spectrum (400 MHz, DMSO-d_6) of **5d**



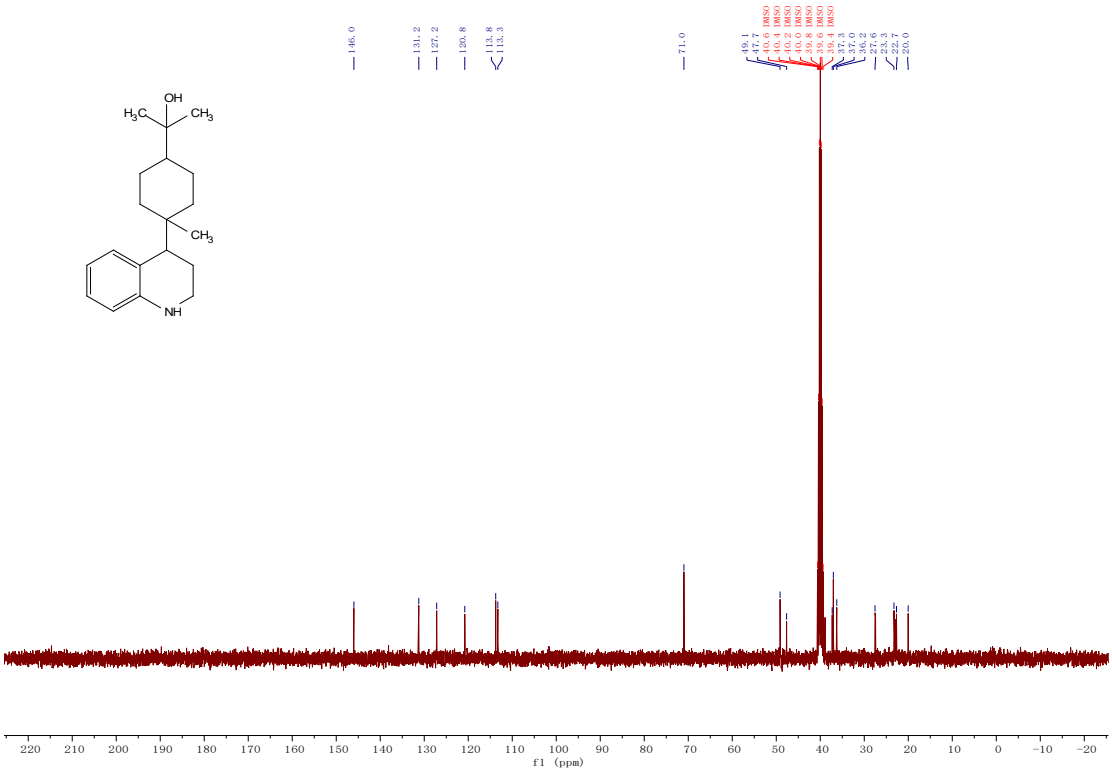
^{13}C NMR spectrum (101 MHz, DMSO-d_6) of **5d**



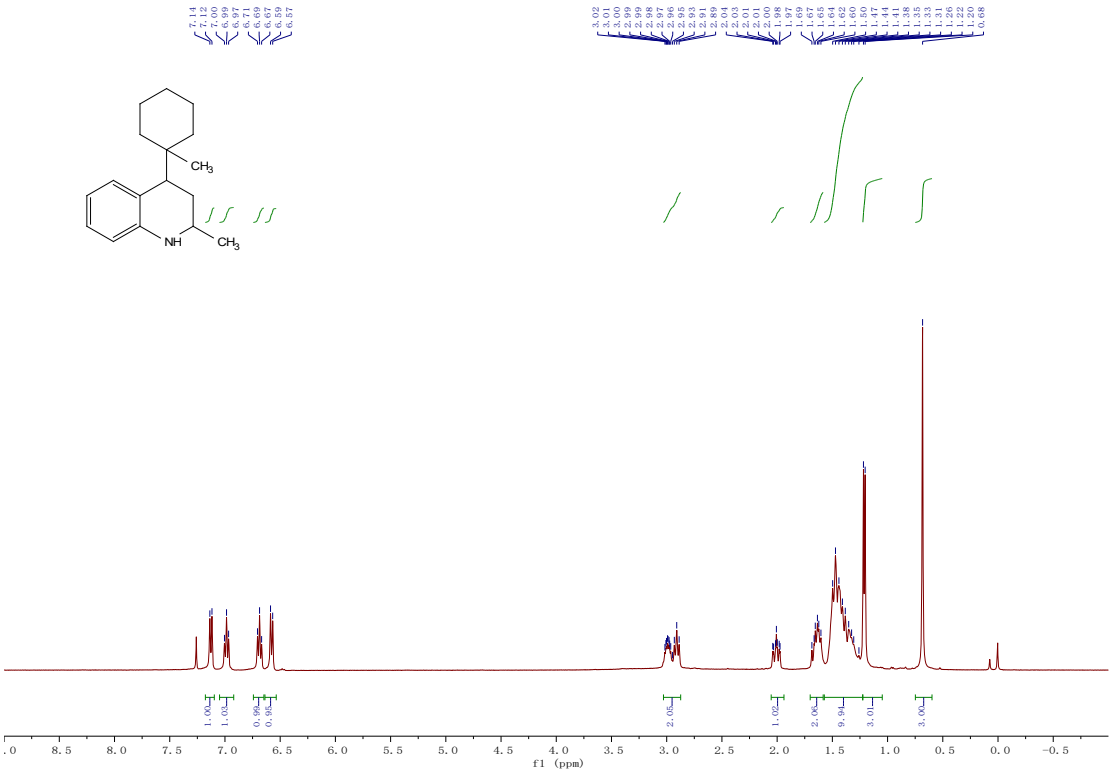
^{1}H NMR spectrum (400 MHz, DMSO-d_6) of **5e**



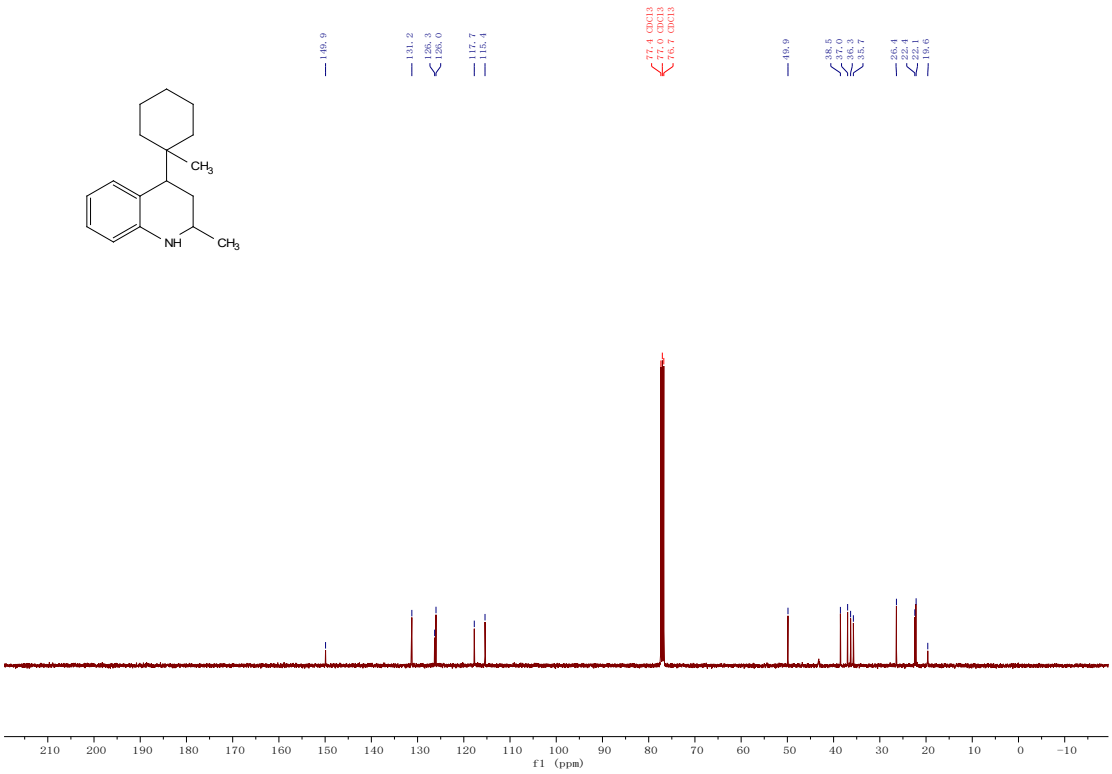
^{13}C NMR spectrum (101 MHz, DMSO-d_6) of **5e**



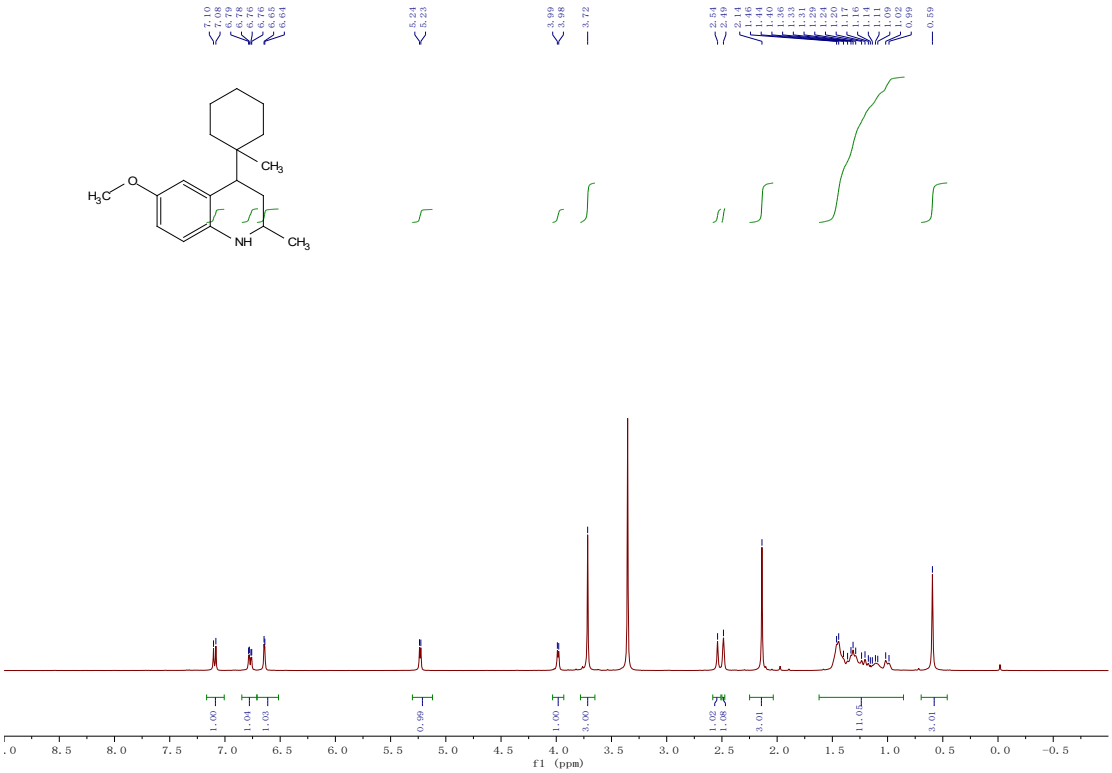
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of **5f**



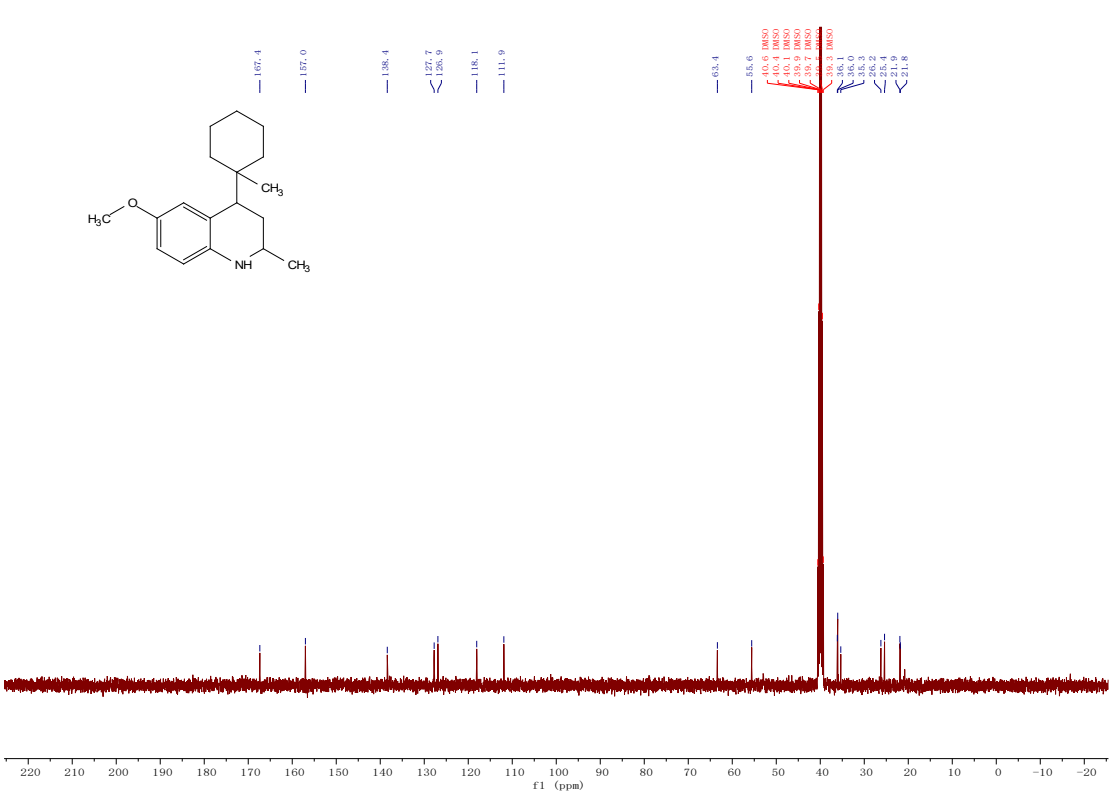
^{13}C NMR spectrum (101 MHz, $CDCl_3$) of **5f**



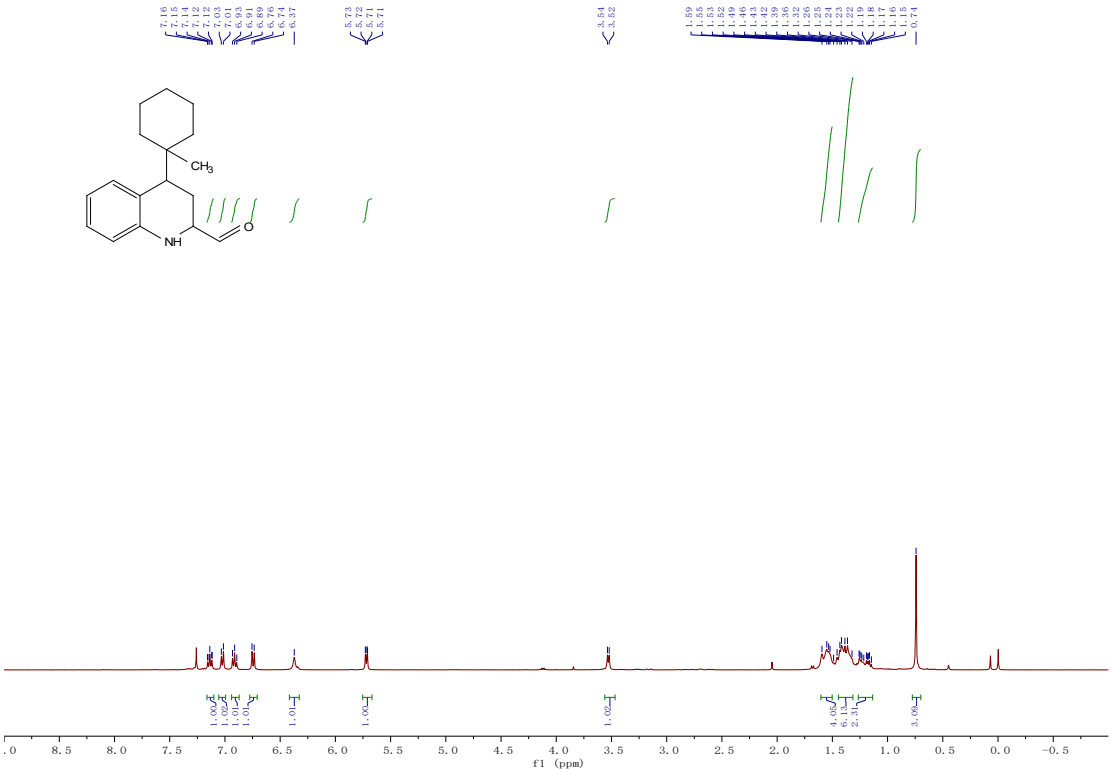
^{1}H NMR spectrum (400 MHz, DMSO-d_6) of **5g**



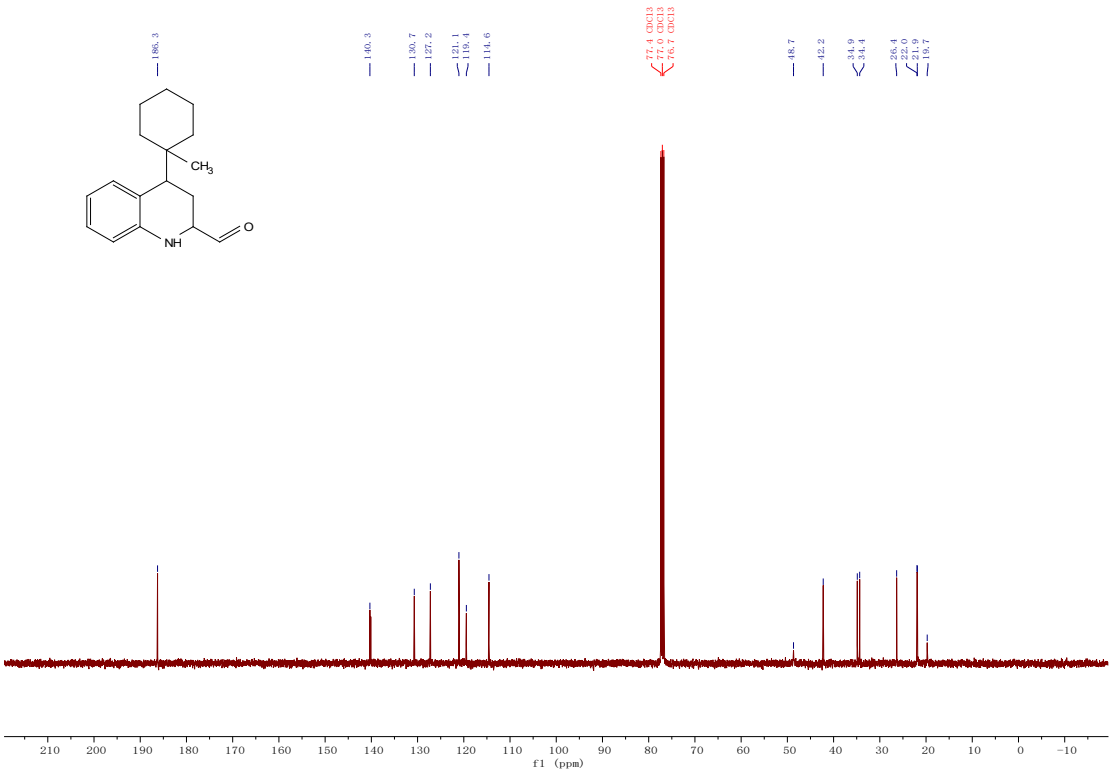
^{13}C NMR spectrum (101 MHz, DMSO-d_6) of **5g**



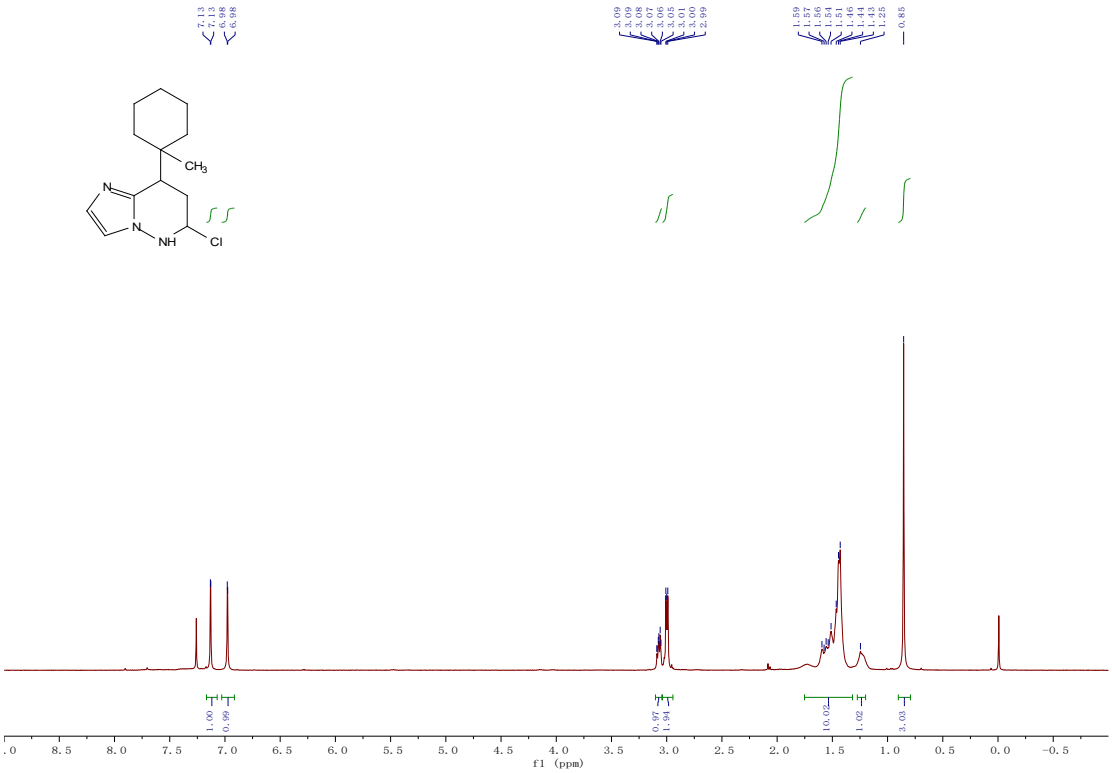
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of **5h**



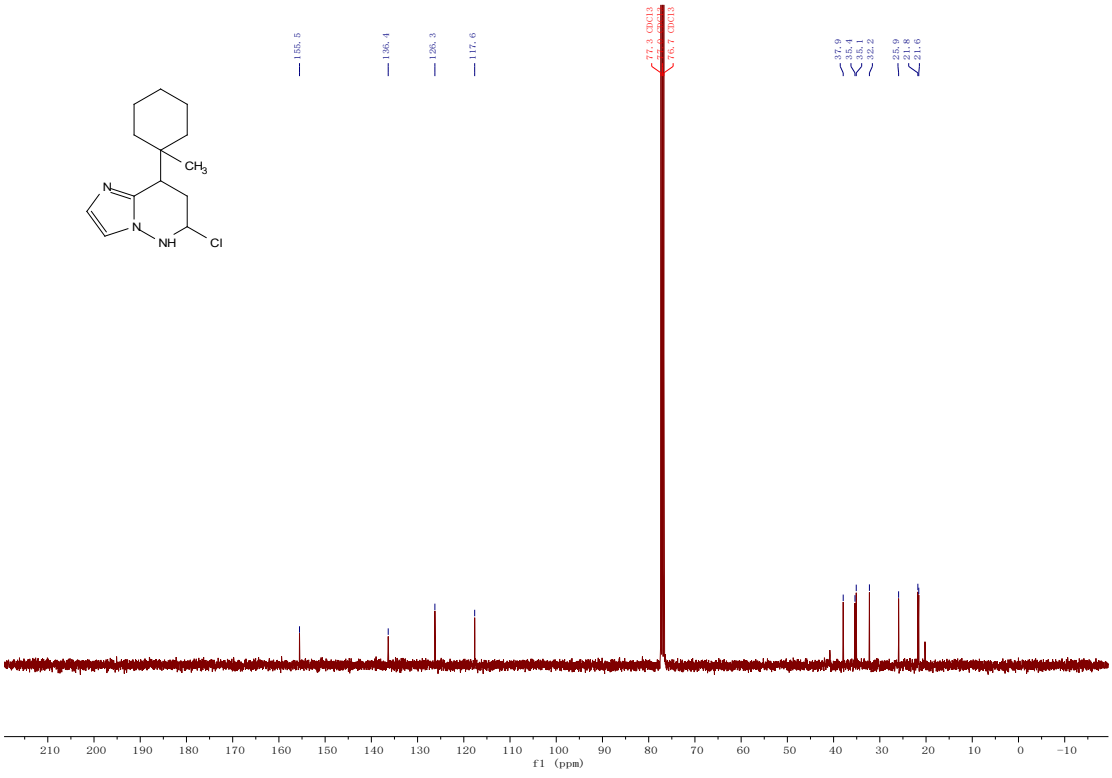
^{13}C NMR spectrum (101 MHz, $CDCl_3$) of **5h**



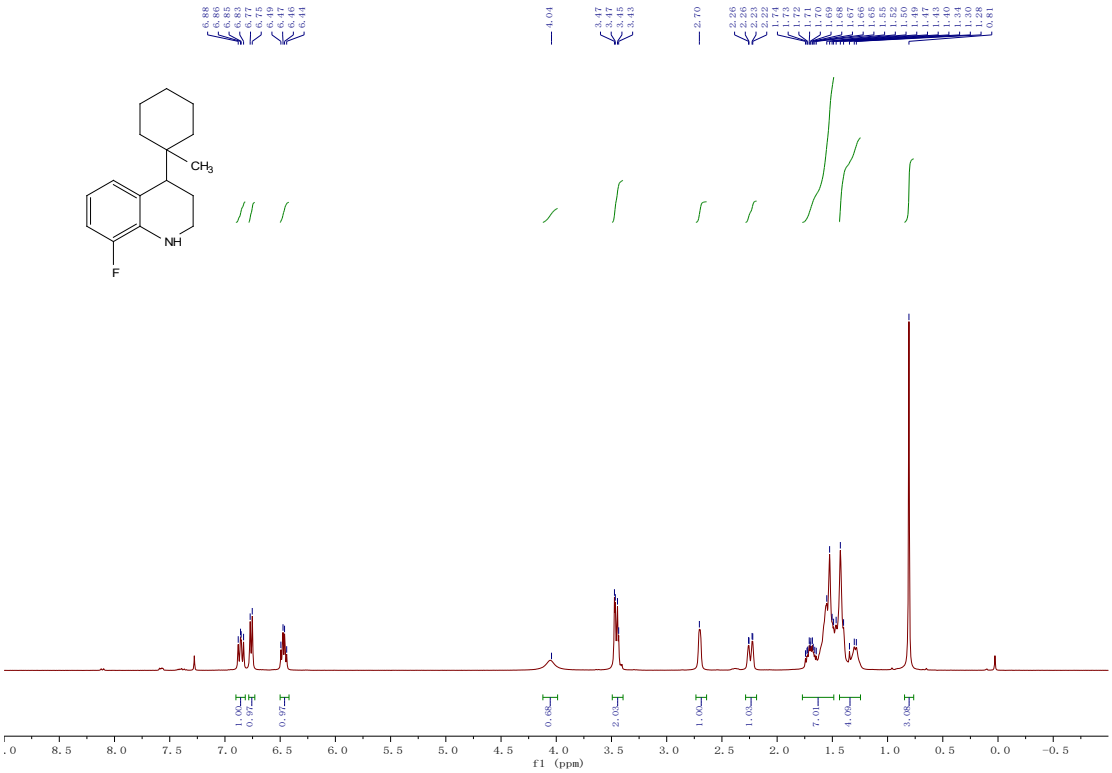
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of **5i**



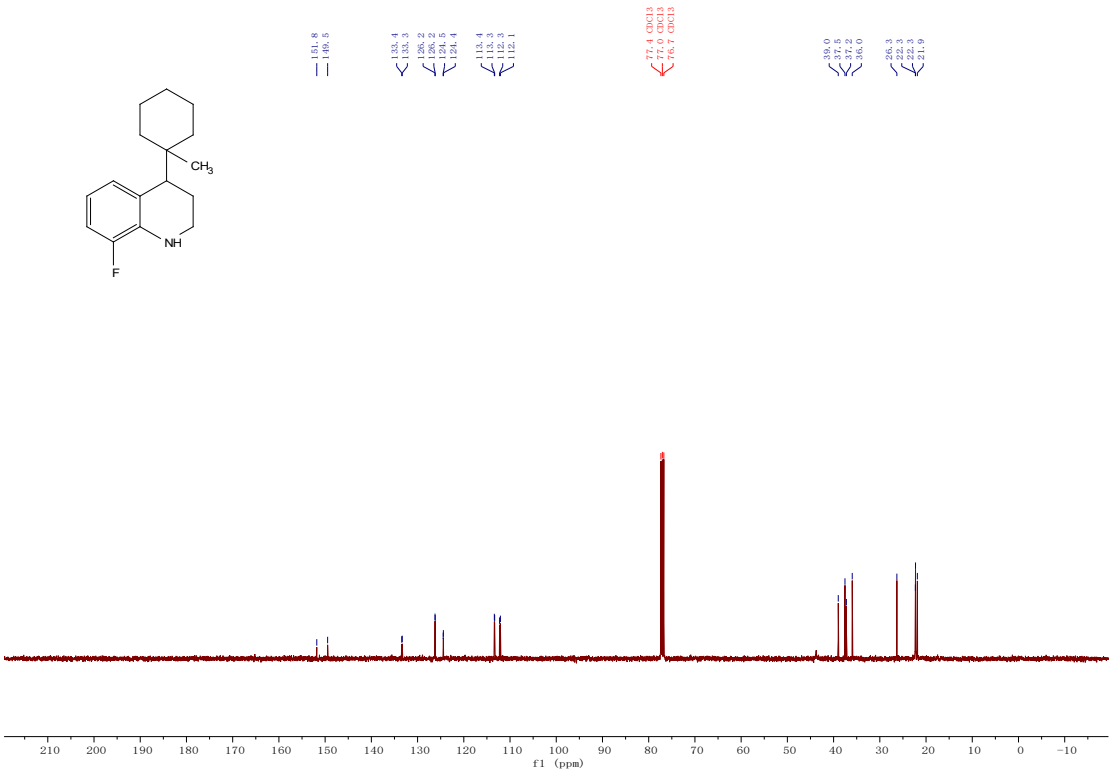
^{13}C NMR spectrum (101 MHz, $CDCl_3$) of **5i**



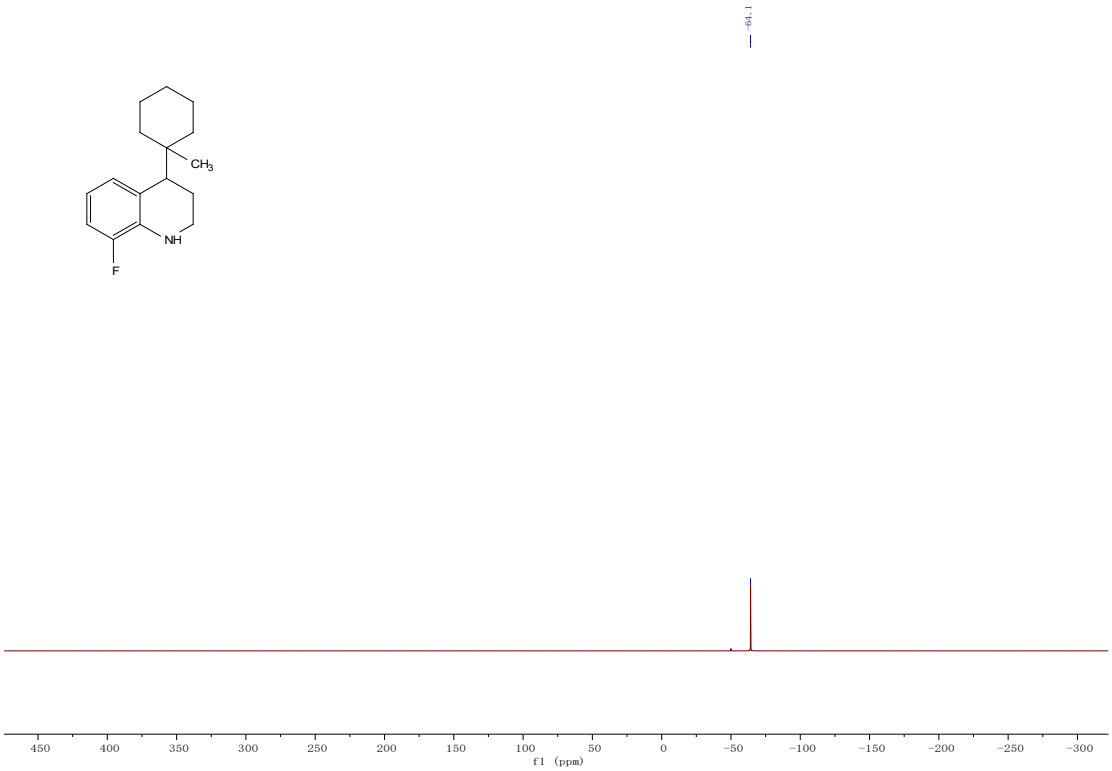
^{1}H NMR spectrum (400 MHz, $CDCl_3$) of **5j**



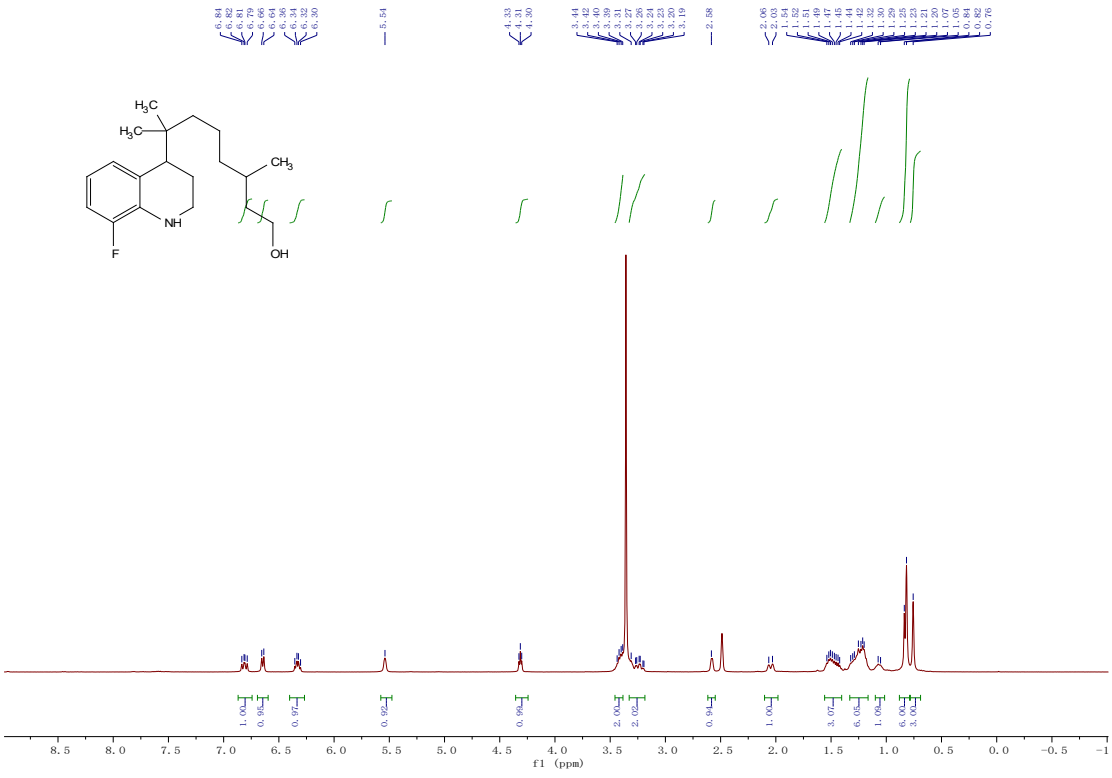
^{13}C NMR spectrum (101 MHz, $CDCl_3$) of **5j**



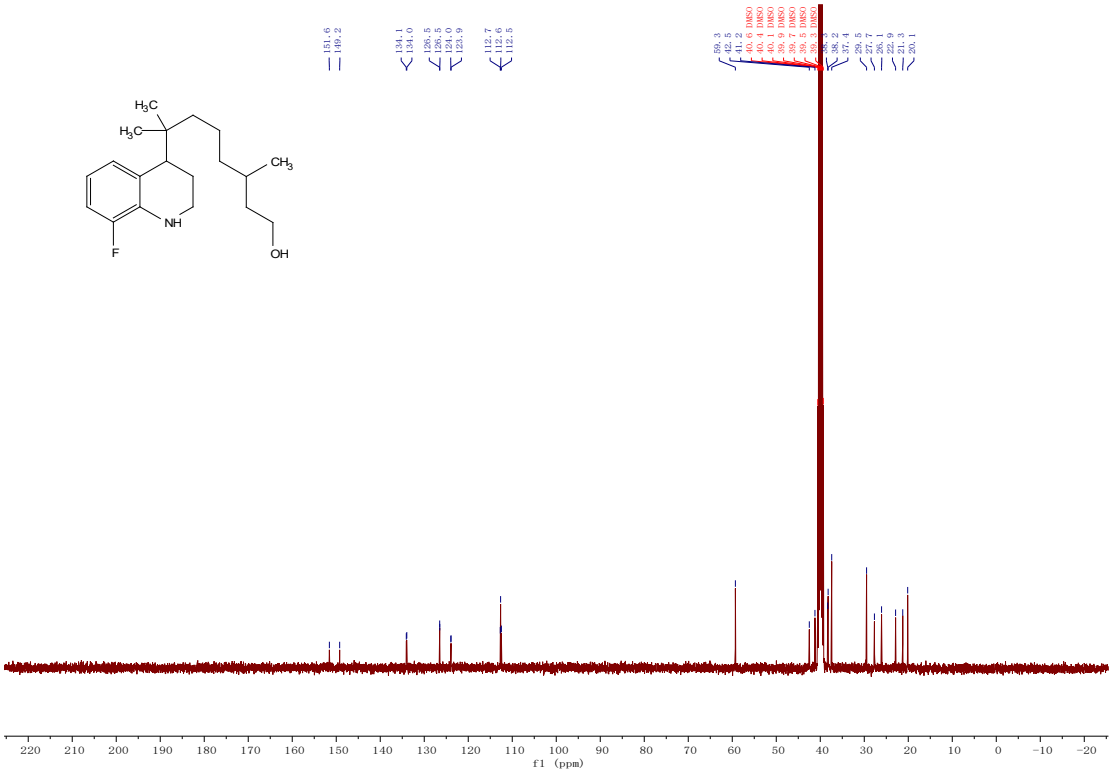
^{19}F NMR spectrum (376 MHz, $CDCl_3$) of **5j**



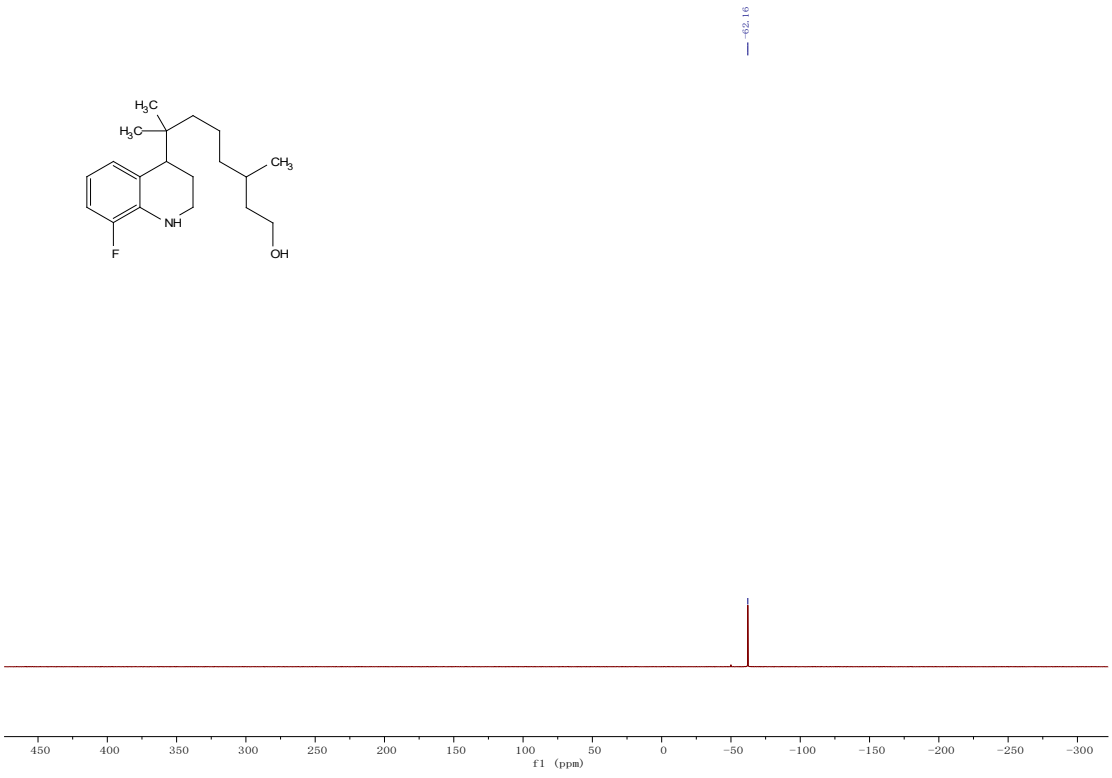
^{1}H NMR spectrum (400 MHz, DMSO-d_6) of **5k**



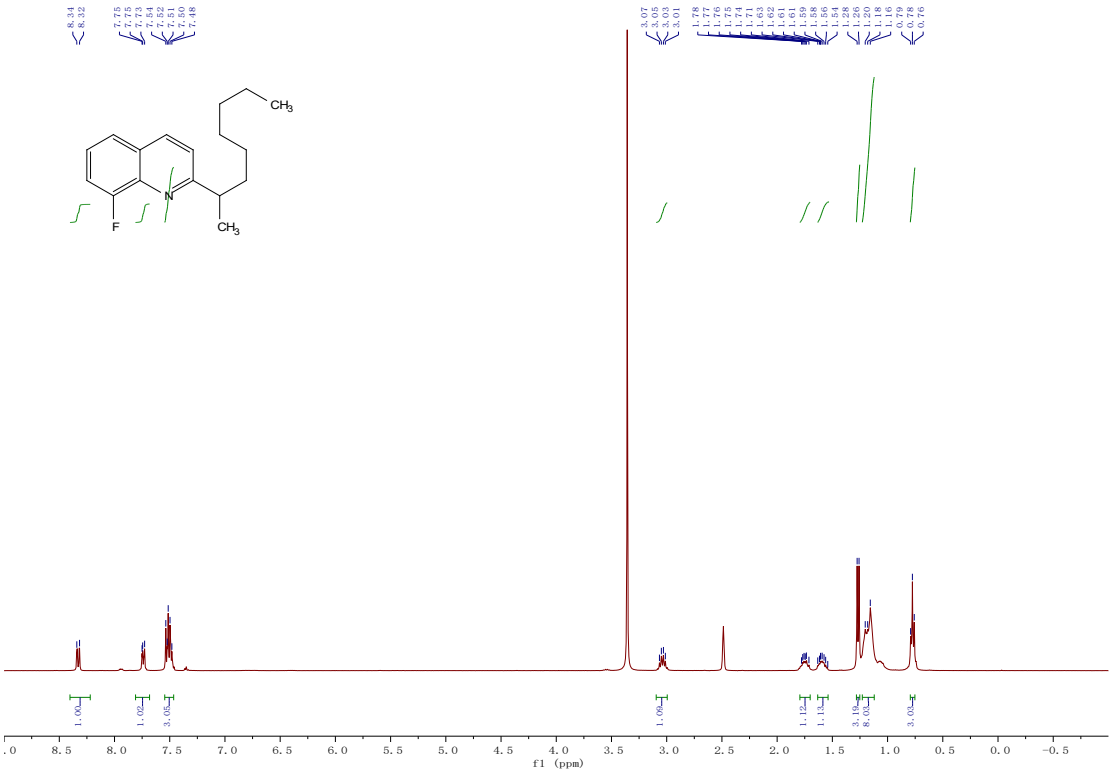
^{13}C NMR spectrum (101 MHz, DMSO-d_6) of **5k**



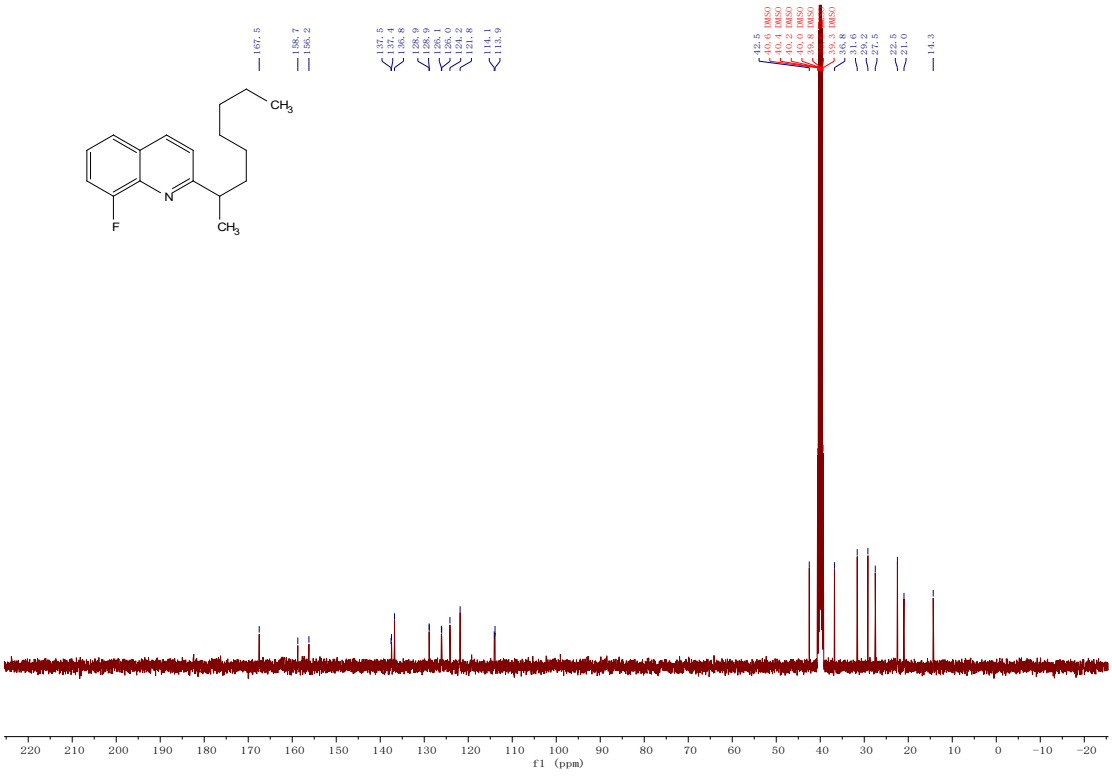
^{19}F NMR spectrum (376 MHz, DMSO-d_6) of **5k**



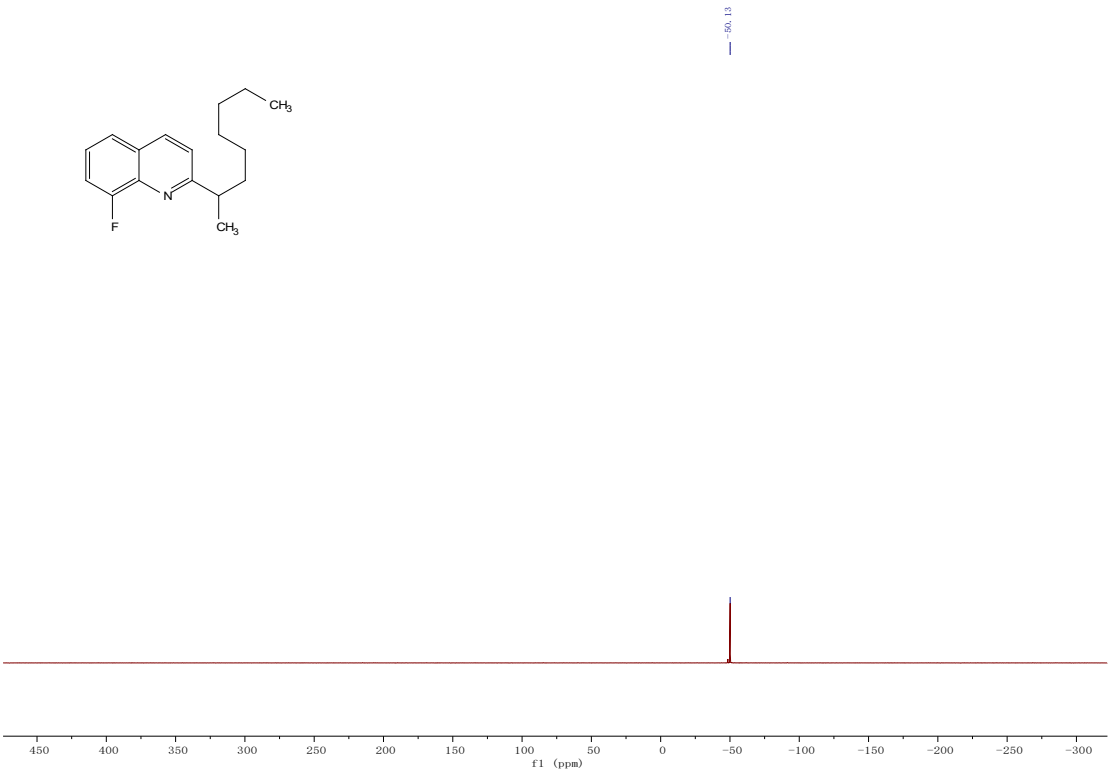
^{1}H NMR spectrum (400 MHz, DMSO-d_6) of **5l**



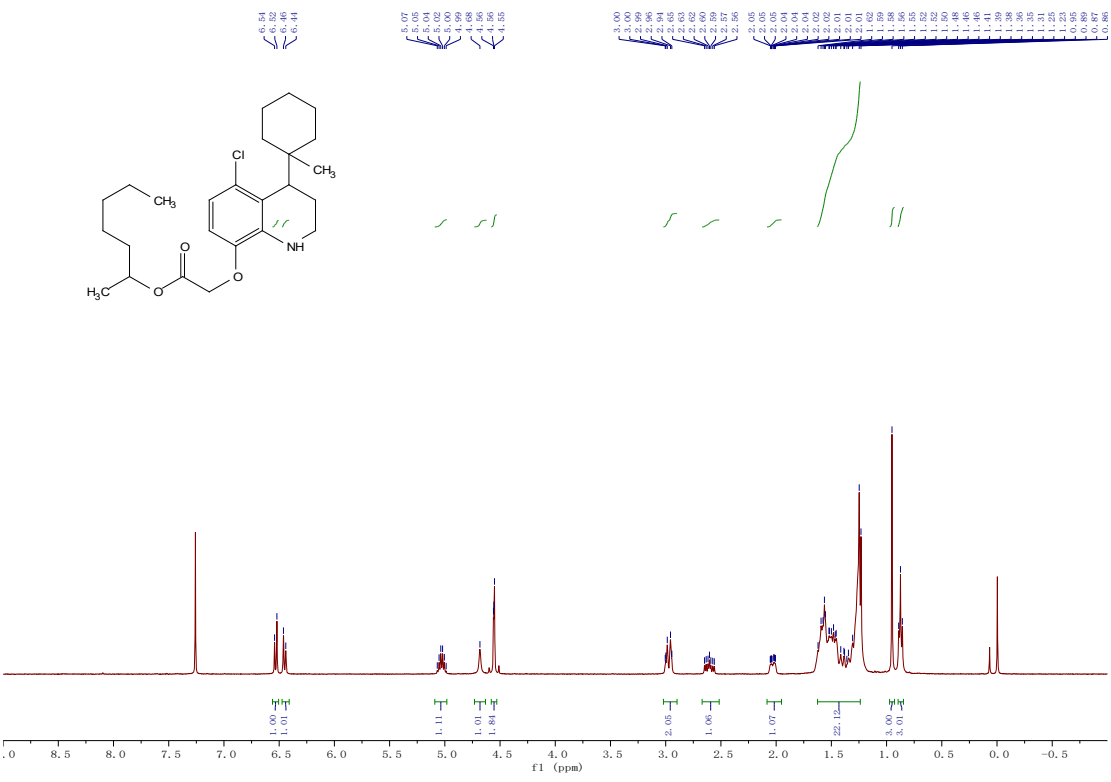
^{13}C NMR spectrum (101 MHz, DMSO-d_6) of **5l**



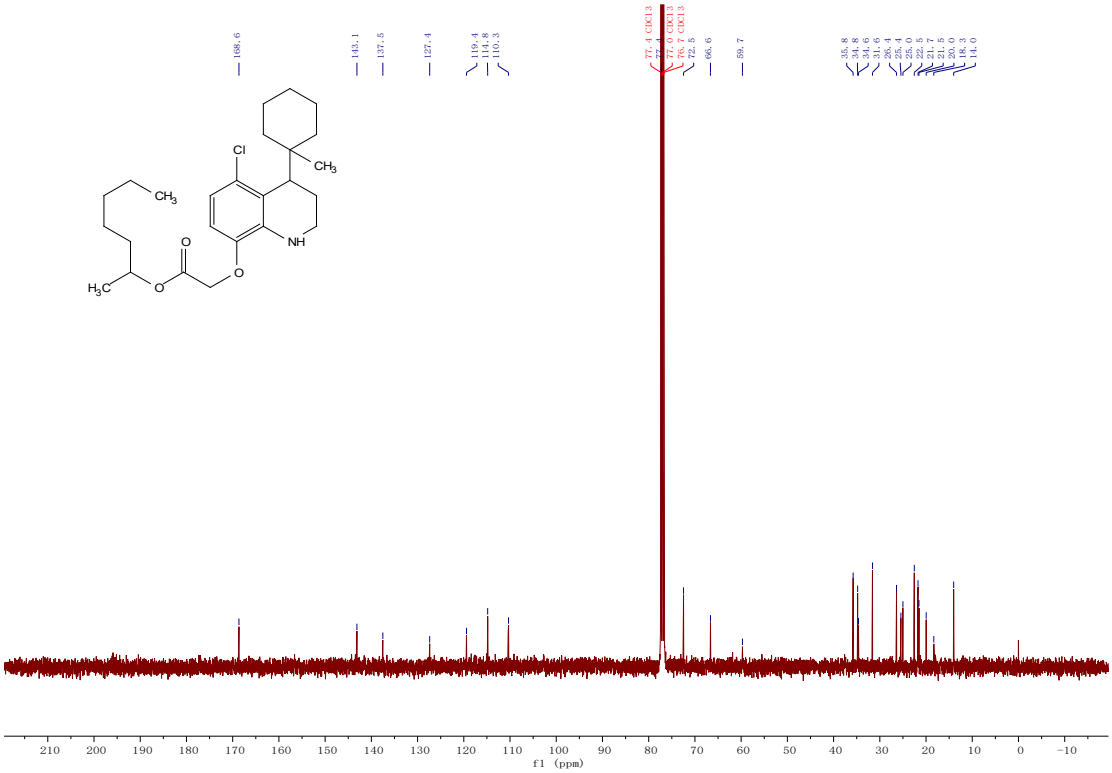
^{19}F NMR spectrum (376 MHz, DMSO-d_6) of **5l**



^{1}H NMR spectrum (400 MHz, $CDCl_3$) of **5m**



^{13}C NMR spectrum (101 MHz, $CDCl_3$) of **5m**



^{1}H NMR spectrum (400 MHz, $CDCl_3$) of **6**