Electronic Supplementary Material (ESI) for ChemComm.

Supporting Information

Visible-Light-Induced Dehydrogenative Amidation of Aldehydes Enabled by Iron Salts

Han Gao,[a] Lin Guo,[a] Yining Zhu,[a] Chao Yang,[a]* and Wujiong Xia[a,b]*

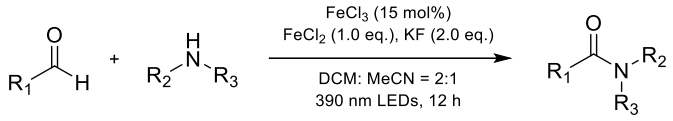
[a] State Key Lab of Urban Water Resource and Environment, School of Science, Harbin Institute of Technology (Shenzhen), Shenzhen 518055, China
[b] School of Chemistry and Chemical Engineering, Henan Normal University, Xinxiang, Henan 453007, China
E-mail: xyyang@hit.edu.cn; xiawj@hit.edu.cn

Table Content

1. General Information

Unless otherwise mentioned, all reagents were purchased from commercial sources and used as received. 1,3,5-trimethoxybenzene was purchased and re-purified by chromatography. The visible-light mediated reactions were performed on WPTEC-1020L instruments which are purchased from WATTCAS, China. All yields of products refer to the isolated yields after chromatography. ^{1}H NMR (400, 500 or 600 MHz), ^{13}C NMR (101, 126 or 151 MHz) and ^{19}F NMR (376 MHz) spectra were recorded on a Bruker AV-400 spectrometer or a Quantum-I Plus 400 in $CDCl_3$ or DMSO-d_6. For ^{1}H NMR, $CDCl_3$ (δ 7.26 ppm), DMSO-d_6 (δ 2.50 ppm) or tetramethylsilane (TMS, δ 0 ppm) serves as the internal standard; for ^{13}C NMR, $CDCl_3$ (δ 77.16 ppm) or DMSO-d_6 (δ 39.52 ppm) serves as the internal standard. Data are reported as follows: chemical shift (in ppm), multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, p = quintet, hept = heptet, m = multiplet, br = broad), coupling constant (in Hz), and integration. GC analysis was performed on a 7890B/Agilent, while GC-MS analysis was performed on a 7890A-5975C/Agilent. HR-MS spectra were recorded on a Waters Xevo G2QTOF/UPLC mass spectrometer using electrospray ionization.

2. General Synthetic Procedure



General procedure: To an oven-dried 25 mL quartz vial equipped with a magnetic stir bar were sequentially added the corresponding $FeCl_3$ (4.8 mg, 15 mol%), KF (23.2 mg, 2.0 eq.), $FeCl_2$ (25.2 mg, 1.0 eq.), dry MeCN (0.67 mL), aldehyde (0.6 mmol), amine (0.2 mmol). The vial was degassed, backfilled with nitrogen three times, and then was added dry DCM (1.33 mL). The vial was then put into the reactor and was irradiated and stirred under 10 W 390 nm LEDs for 12 h at room temperature. After the reaction was complete, the crude system was filtered, and all volatiles were removed in vacuo and the crude product was purified by column chromatography (1:5 to 5:1 EtOAc:petroleum ether, varied from structures) to obtain corresponding product.

Note: basic workup procedure was found to be viable in order to quench the generated HF: the crude system was quenched by saturated aqueous Na_2CO_3, filtered, and then extracted by DCM; combined organic layer was then concentrated, purified by column chromatography. The results showed that similar yields were afforded with and without basic workup.

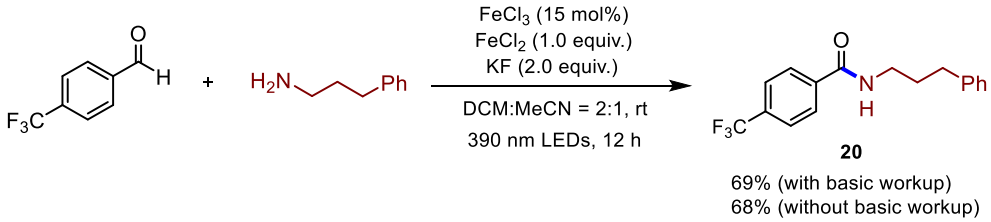
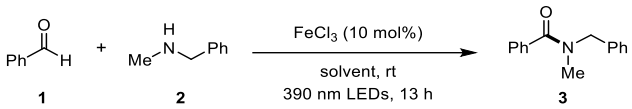


Figure S1. Photoreactor Setup

Figure S2. 390 nm LED chip

3. Optimization of Reaction Conditions

Table S1. Optimization of solvents

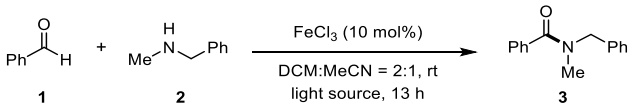


1 2 3

Entry	Solvent	Yield%[a]
1	Acetone	trace
2	Dry MeCN	33
3	DCE	trace
4	EA	23
5	CPME	trace
6	Dry DCM	35
7	Toluene	31
8	HFIP	N.R.
9	Dry THF	np
10	Dry Dioxane	nd
11	DCM:MeCN 1:9	25
12	DCM:MeCN 1:4	27
13	DCM:MeCN 1:2	35
14	DCM:MeCN 1:1	28
15	DCM:MeCN 2:1	46
16	DCM:MeCN 4:1	27
17	DCM:MeCN 9:1	13

[a] conditions: **1** (0.3 mmol), **2** (0.1 mmol), $FeCl_3$ (10 mol%), under 10 W 390 nm LEDs for 13 h, room temperature. The isolated yield was calculated after chromatogram. N.R.: no reaction; np: no product; nd: nothing detected.

Table S2. Optimization of light sources

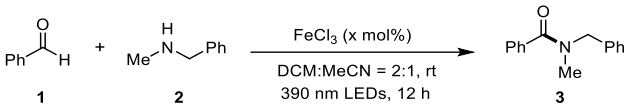


1 2 3

Entry	Light scource	Yield%[a]
1	370 nm 10 W	10
2	380 nm 10 W	34
3	400 nm 10 W	15
4	410 nm 10 W	28
5	420 nm 10 W	7
6	450 nm 10W	trace

[a] conditions: **1** (0.3 mmol), **2** (0.1 mmol), $FeCl_3$ (10 mol%) in DCM:MeCN = 2:1 under 10 W LEDs for 12 h, room temperature. The isolated yield was calculated after chromatogram.

Table S3. Optimization on loadings of tervalent Fe salt

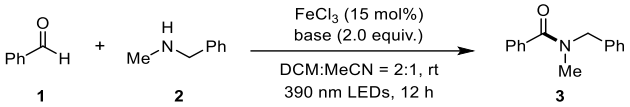


1 2 3

Entry	x	Yield%[a]
1	0.05	27
2	0.15	50

[a] conditions: **1** (0.3 mmol), **2** (0.1 mmol), $FeCl_3$ in DCM:MeCN = 2:1 under 10 W 390 nm LEDs for 12 h, room temperature. The isolated yield was calculated after chromatogram.

Table S4. Optimization of bases

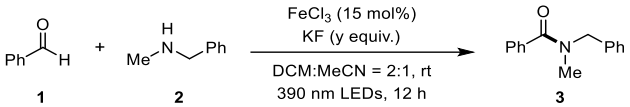


1 2 3

Entry	Base	Yield%[a]
1	$NaHCO_3$	36
2	K_3PO_4	32
3	Na_2CO_3	trace
4	K_2CO_3	trace
5	Cs_2CO_3	trace
6	$KHCO_3$	trace
7	K_2HPO_4	trace
8	Na_2HPO_4	trace
9	CsF	trace
10	KF	60
11	$LiOCH_3$	trace
12	Li_2CO_3	trace
13	KOtBu	N.R.
14	NaOtBu	N.R.
15	NaF	38
16	NaOAc	trace
17	KOAc	trace
18	KBF_4	40
19	KPF_6	32
20	$NaNO_2$	N.R.
21	NaOTf	N.R.

[a] conditions: **1** (0.3 mmol), **2** (0.1 mmol), $FeCl_3$ (15 mol%), base (2.0 eq.) in DCM:MeCN = 2:1 under 10 W 390 nm LEDs for 12 h, room temperature. The isolated yield was calculated after chromatogram. N.R.: no reaction.

Table S5. Optimization on loadings of base

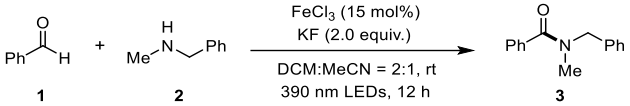


1 2 3

Entry	y	Yield%[a]
1	1.0	38
2	1.5	40
3	2.0	60
4	3.0	39

[a] conditions: **1** (0.3 mmol), **2** (0.1 mmol), $FeCl_3$ (15 mol%), KF in DCM:MeCN = 2:1 under 10 W 390 nm LEDs for 12 h, room temperature. The isolated yield was calculated after chromatogram.

Table S6. Optimization on loadings of aldehyde

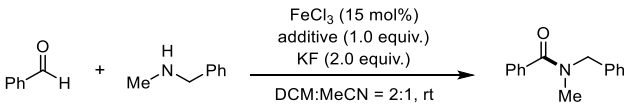


1 2 3

Entry	Equiv. of aldehyde	Yield%[a]
1	2	31
2	1	16

[a] conditions: **1**, **2** (0.1 mmol), $FeCl_3$ (15 mol%), KF (2.0 eq.) in DCM:MeCN = 2:1 under 10 W 390 nm LEDs for 12 h, room temperature. The isolated yield was calculated after chromatogram.

Table S7. Optimization of additives

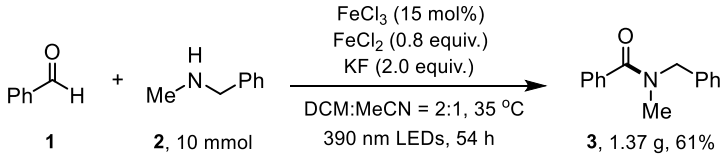


1 2 3

Entry	Additive	Yield%[a]
1	LiCl	34
2	$FeCl_2$	73
3	NH_4Cl	33
4	NEt_4Cl	27
5	NBu_4Cl	40
6	$FeCl_2$	35[b]
7	$FeCl_2$ (0.5 eq.)	65
8	$FeCl_2$ (0.2 eq.)	50
9	$FeCl_2$ (0.1 eq.)	49

[a] conditions: **1** (0.3 mmol), **2** (0.1 mmol), $FeCl_3$ (15 mol%), KF (2.0 eq.), additive (1.0 eq.) in DCM:MeCN = 2:1 under 10 W 390 nm LEDs for 12 h, room temperature. The isolated yield was calculated after chromatogram. [b] w/o the addition of $FeCl_3$.

4. Gram Scale Reaction



General procedure: To an oven-dried 250 mL flask equipped with a magnetic stir bar were sequentially added the corresponding $FeCl_3$ (243 mg, 15 mol%), KF (1.1 g, 2.0 eq.), $FeCl_2$ (1.0 g, 0.8 eq.). The vial was degassed, backfilled with nitrogen three times and equipped with a N_2 balloon, and then was added dry DCM (67 mL), dry MeCN (33 mL), aldehyde (30 mmol), amine (10 mmol). The flask was then put under the 4*10 W 390 nm light source and was irradiated and stirred for 54 h at around 35 ℃ by TLC monitored. After the reaction was complete, the crude system was filtered, and all volatiles were removed in vacuo and the crude product was purified by column chromatography (1:10 to 1:3 EtOAc:petroleum ether). After removal of solvents, the purified amide product was obtained in 1.37 g, 61% yield.

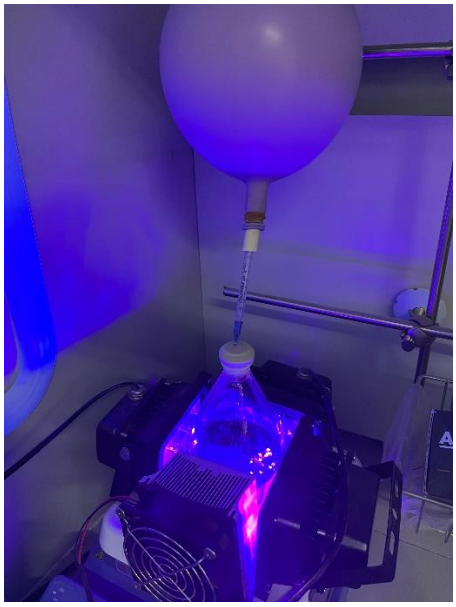
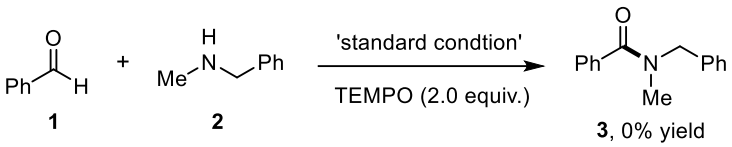
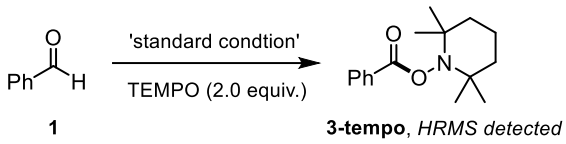


Figure S3. Gram-scale setup

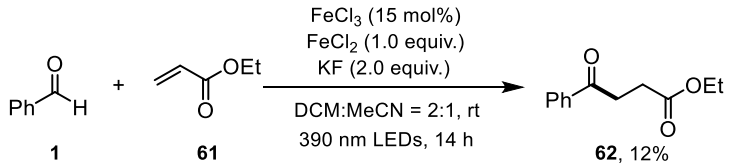
5. Mechanistic studies



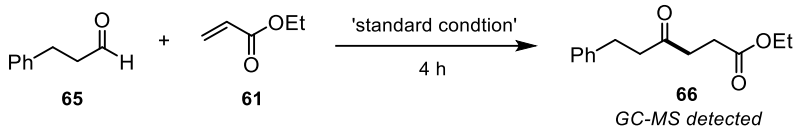
General procedure: To an oven-dried 250 mL quartz vial equipped with a magnetic stir bar were sequentially added the corresponding $FeCl_3$ (4.8 mg, 15 mol%), KF (23.2 mg, 2.0 eq.), $FeCl_2$ (25.2 mg, 1.0 eq.), 2,2,6,6-tetramethyl-1-piperidinyloxy (TEMPO) (62.4 mg, 2.0 eq.), dry MeCN (0.67 mL), aldehyde **1** (0.6 mmol), amine **2** (0.2 mmol). The vial was degassed, backfilled with nitrogen three times, and then was added dry DCM (1.33 mL). The vial was then put into the reactor and was irradiated and stirred under 10 W 390 nm LEDs for 12 h at room temperature, TLC and GC-MS monitored.



General procedure: To an oven-dried 25 mL quartz vial equipped with a magnetic stir bar were sequentially added the corresponding $FeCl_3$ (4.8 mg, 15 mol%), KF (23.2 mg, 2.0 eq.), $FeCl_2$ (25.2 mg, 1.0 eq.), TEMPO (62.4 mg, 2.0 eq.), dry MeCN (0.67 mL), aldehyde **1** (0.6 mmol). The vial was degassed, backfilled with nitrogen three times, and then was added dry DCM (1.33 mL). The vial was then put into the reactor and was irradiated and stirred under 10 W 390 nm LEDs for 12 h at room temperature, TLC and GC-MS monitored. After 12 h, the crude system was diluted, filtered, and then tested under HRMS. The radical-capture product was detected by HRMS (ESI) m/z $[M+H]^+$; calcd for $C_{16}H_{24}NO_2$ 262.1807; found 262.1802.



General procedure: To an oven-dried 25 mL quartz vial equipped with a magnetic stir bar were sequentially added the corresponding $FeCl_3$ (4.8 mg, 15 mol%), KF (23.2 mg, 2.0 eq.), $FeCl_2$ (25.2 mg, 1.0 eq.), dry MeCN (0.67 mL), benzaldehyde **1** (61 μL, 0.6 mmol) and ethyl acrylate **61** (21.7 μL, 0.2 mmol). The vial was degassed, backfilled with nitrogen three times, and then was added dry DCM (1.33 mL). The vial was then put into the reactor and was irradiated and stirred under 10 W 390 nm LEDs for 14 h at room temperature. After the reaction was complete, the crude system was filtered, and all volatiles were removed in vacuo and the crude product was purified by column chromatography (1:15 EtOAc:petroleum ether). After removal of solvents, the purified product was obtained in 4.8 mg, 12% yield.



General procedure: To an oven-dried 25 mL quartz vial equipped with a magnetic stir bar were sequentially added the corresponding $FeCl_3$ (4.8 mg, 15 mol%), KF (23.2 mg, 2.0 eq.), $FeCl_2$ (25.2 mg, 1.0 eq.), dry MeCN (0.67 mL), phenylpropyl aldehyde **65** (79 μL, 0.6 mmol) and ethyl acrylate **61** (21.7 μL, 0.2 mmol). The vial was degassed, backfilled with nitrogen three times, and then was added dry DCM (1.33 mL). The vial was then put into the reactor and was irradiated and stirred under 10 W 390 nm LEDs for 4 h at room temperature. The vial was then diluted by MeCN, filtered through Celite. Then the filtrate was put onto GC-MS analysis.

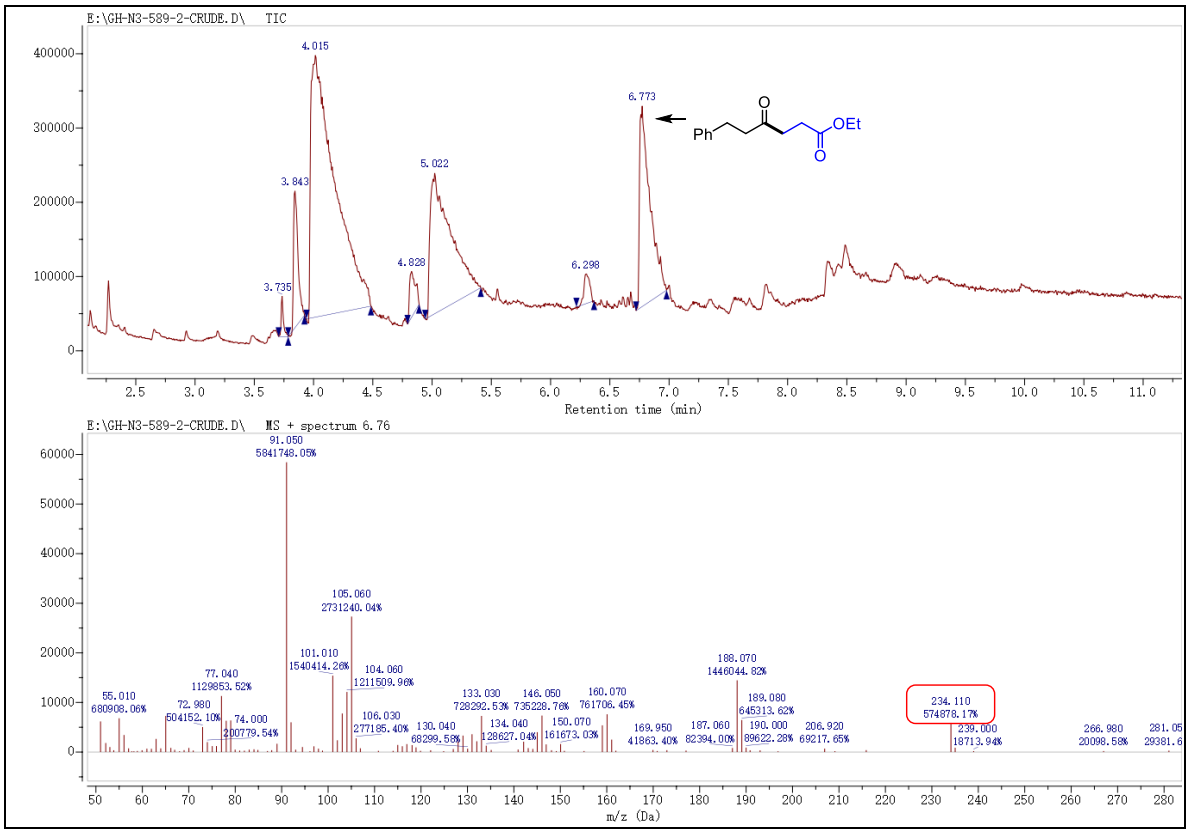
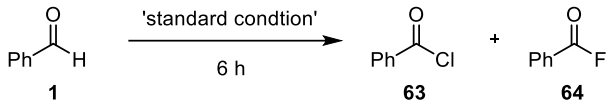


Figure S3. GC-MS spectrum of **66**



General procedure: To an oven-dried 25 mL quartz vial equipped with a magnetic stir bar were sequentially added the corresponding $FeCl_3$ (4.8 mg, 15 mol%), KF (23.2 mg, 2.0 eq.), $FeCl_2$ (25.2 mg, 1.0 eq.), dry MeCN (0.67 mL), benzaldehyde **1** (61 μL, 0.6 mmol). The vial was degassed, backfilled with nitrogen three times, and then was added dry DCM (1.33 mL). The vial was then put into the reactor and was irradiated and stirred under 10 W 390 nm LEDs for 6 h at room temperature. The vial was then diluted by MeCN, filtered through Celite. Then the filtrate was put onto GC-MS analysis. Further filtration was delivered in order to test HRMS. The crude system was detected by HRMS (ESI) m/z $[M+H]^+$; calcd for C_7H_6ClO 141.0107, found 141.0106; calcd for C_7H_6FO 125.0402, found 125.0399. HRMS results further proved the existence of intermediates.

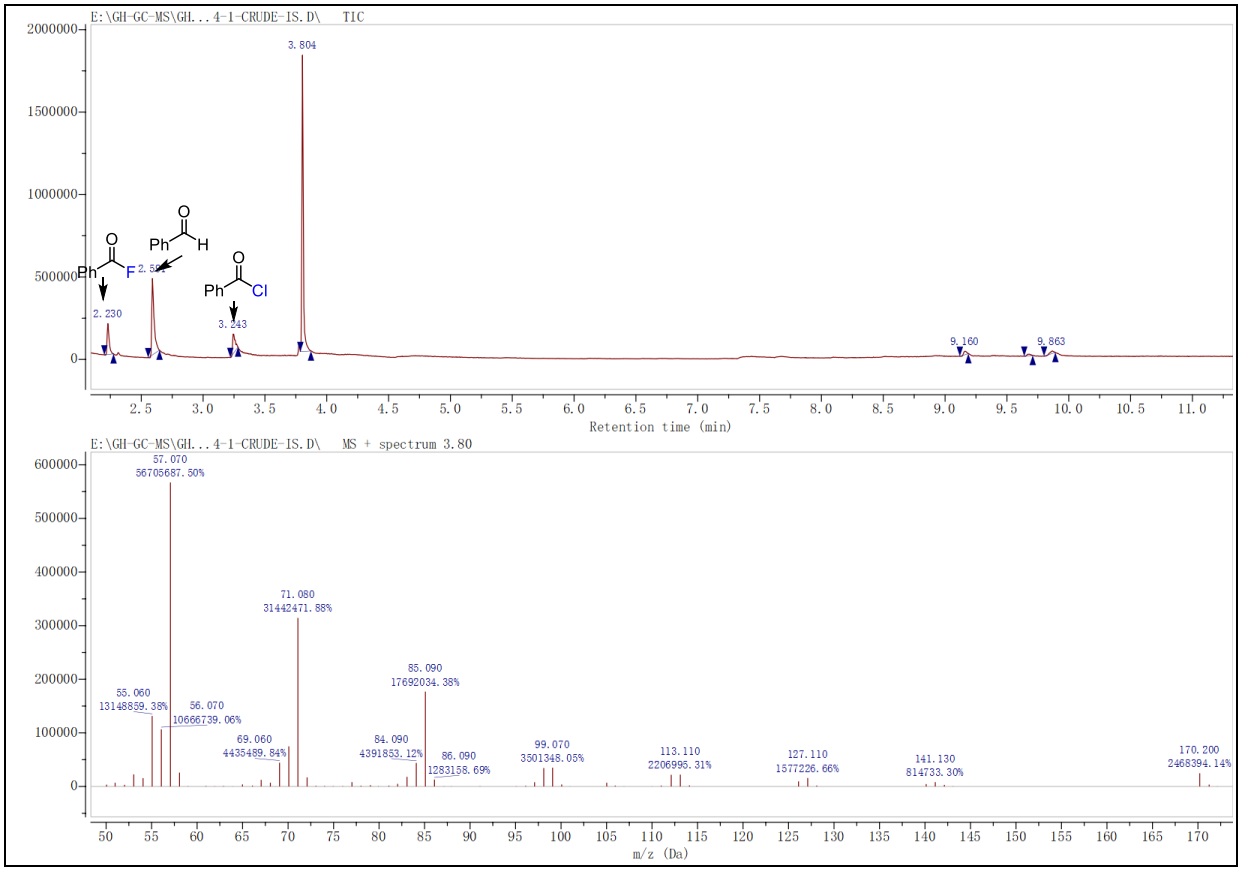


Figure S4. GC-MS spectrum of crude system

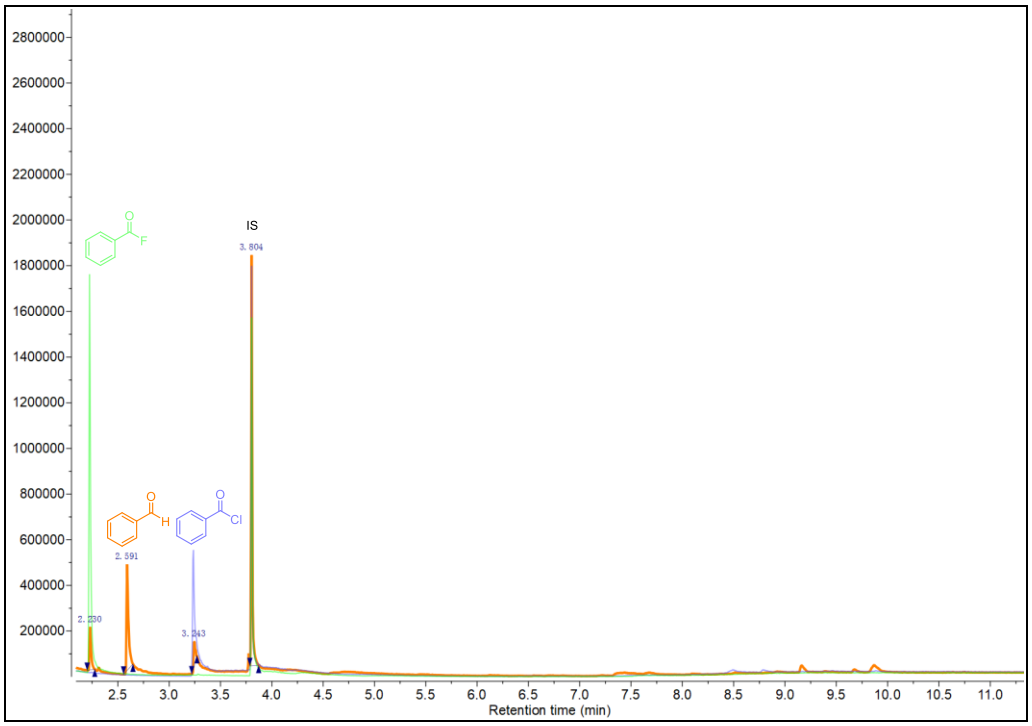
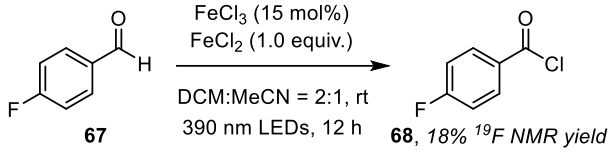
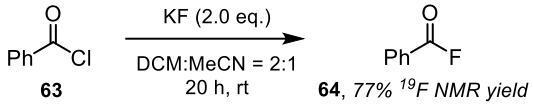


Figure S5. Stacked GC-MS spectrum



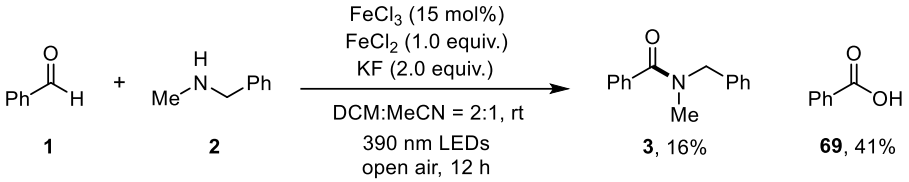
67 **68**, *18% ^{19}F NMR yield*

General procedure: To an oven-dried 25 mL quartz vial equipped with a magnetic stir bar were sequentially added the corresponding $FeCl_3$ (4.8 mg, 15 mol%), KF (23.2 mg, 2.0 eq.), $FeCl_2$ (25.2 mg, 1.0 eq.), dry MeCN (0.67 mL), *p*-fluorobenzaldehyde **67** (64.5 µL, 0.6 mmol). The vial was degassed, backfilled with nitrogen three times, and then was added dry DCM (1.33 mL). The vial was then put into the reactor and was irradiated and stirred under 10 W 390 nm LEDs for 12 h at room temperature. The yield was determined using 4-bromobenzotrifluoride as internal standard.

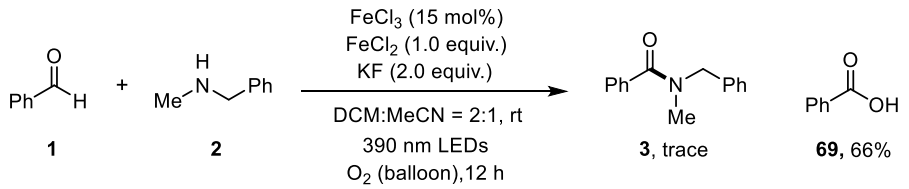


63 **64**, *77% ^{19}F NMR yield*

General procedure: To an oven-dried 25 mL quartz vial equipped with a magnetic stir bar were sequentially added the corresponding KF (116 mg, 2.0 eq.), dry DCM (6.7 mL), dry MeCN (3.3 mL), benzoyl chloride (116 µL, 10 mmol, 1.0 eq.). The vial was stirred 20 h at room temperature. The yield was determined using 4-bromobenzotrifluoride as internal standard.

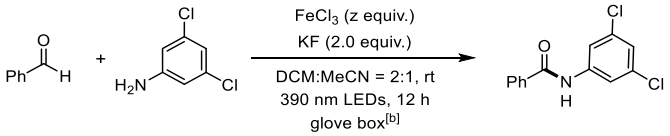


General procedure: To an oven-dried 25 mL quartz vial equipped with a magnetic stir bar were sequentially added the corresponding $FeCl_3$ (4.8 mg, 15 mol%), KF (23.2 mg, 2.0 eq.), $FeCl_2$ (25.2 mg, 1.0 eq.), dry MeCN (0.67 mL), dry DCM (1.33 mL), aldehyde **1** (0.6 mmol) and amine **2** (0.2 mmol). The vial was open air, then was put into the reactor and was irradiated and stirred under 10 W 390 nm LEDs for 12 h at room temperature, TLC monitored. After the reaction was complete, the crude system was filtered, and all volatiles were removed in vacuo and the crude product was purified by column chromatography (1:5 to 1:1 EtOAc:petroleum ether). Target amine product was obtained in 7.2 mg, 16% yield, and benzoic acid byproduct **69** was obtained in 10 mg, 41% yield.



General procedure: To an oven-dried 25 mL quartz vial equipped with a magnetic stir bar were sequentially added the corresponding $FeCl_3$ (4.8 mg, 15 mol%), KF (23.2 mg, 2.0 eq.), $FeCl_2$ (25.2 mg, 1.0 eq.), dry MeCN (0.67 mL), aldehyde **1** (0.6 mmol), amine **2** (0.2 mmol). The vial was degassed, backfilled by O_2 three times and equipped with a O_2 balloon, then was added dry DCM (1.33 mL). The vial was then put into the reactor and was irradiated and stirred under 10 W 390 nm LEDs for 12 h at room temperature, TLC monitored. After the reaction was complete, the crude system was filtered, and all volatiles were removed in vacuo and the crude product was purified by column chromatography (1:5 to 1:1 EtOAc:petroleum ether). Benzoic acid byproduct **69** was obtained in 16.1 mg, 66% yield.

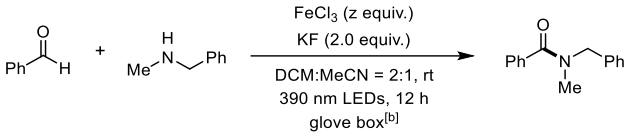
Table S8. Stoichiometric Fe (III) setup in glove box with 3,5-dichloroaniline[a]



Entry	z	Yield%[c]
1	1.0	36
3	2.0	34

[a] Reaction conditions: **1** (0.3 mmol), **2** (0.1 mmol), $FeCl_3$, KF (2.0 equiv.), in DCM:MeCN = 2:1, 10 W 390 nm LEDs at room temperature for 12 hours. [b] Oxygen less than 2 ppm. [c] Yields of isolated product. N.R.: no reaction.

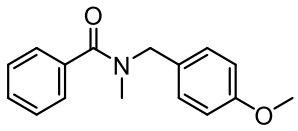
Table S9. Stoichiometric test of Fe (III) in glove box with N-methyl benzylamine[a]



Entry	z	Yield%[c]
1	1.0	33
2	1.5	50
3	2.0	19

[a] Reaction conditions: **1** (0.3 mmol), **2** (0.1 mmol), $FeCl_3$, KF (2.0 equiv.), in DCM:MeCN = 2:1, 10 W 390 nm LEDs at room temperature for 12 hours. [b] Oxygen less than 2 ppm. [c] Yields of isolated product. N.R.: no reaction.

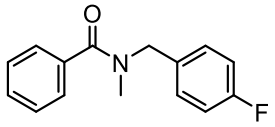
6. Product Characterization



4

N-(4-methoxybenzyl)-N-methylbenzamide (4)

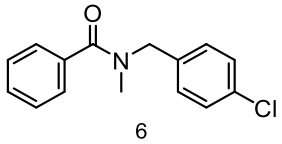
White solid, 30 mg, 41% yield. 1H NMR (400 MHz, CDCl3) δ 7.47 – 7.39 (m, 5H), 7.31 – 7.29 (m, 1H), 7.30 (d, *J* = 8.0 Hz, 1H), 7.08 (d, *J* = 8.0 Hz, 1H), 6.94 – 6.84 (m, 2H), 4.69 (s, 1H), 4.44 (s, 1H), 3.81 (d, J = 1.8 Hz, 3H), 2.92 (d, J = 66.1 Hz, 3H). ^{13}C NMR (101 MHz, CDCl3) δ 172.3, 171.6, 159.2, 136.5, 129.7, 129.3, 128.6, 128.2, 127.1, 127.0, 114.3, 114.2, 55.4, 54.7, 50.3, 36.9, 33.1. HRMS (ESI, m/z): calcd for $[M+H]^+$ 256.1337, found 256.1341.



5

N-(4-fluorobenzyl)-N-methylbenzamid (5)

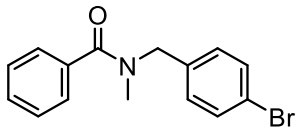
Colorless oil, 28.3 mg, 58% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.47 – 7.29 (m, 6H), 7.12 (s, 1H), 7.04 (t, *J* = 8.6 Hz, 2H), 4.72 (s, 1H), 4.48 (s, 1H), 2.93 (d, *J* = 59.1 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 171.7, 163.6, 161.1, 136.2, 133.0, 130.0, 129.8, 128.6, 127.1, 115.8, 54.6, 50.2, 37.0, 33.2. ^{19}F NMR (376 MHz, $CDCl_3$) δ -114.6, -115.0. calcd for $[M+H]^+$ 244.1137, found 244.1133.



6

N-(4-chlorobenzyl)-N-methylbenzamide (6)

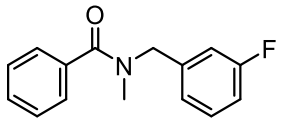
Colorless oil, 40 mg, 73% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 – 7.28 (m, 8H), 7.48 – 7.28 (m, 8H), 7.21 – 6.98 (m, 1H), 4.71 (s, 1H), 4.47 (s, 1H), 2.94 (d, J = 61.9 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.3, 171.7, 136.0, 135.7, 135.2, 133.4, 129.8, 129.7, 128.9, 128.5, 128.1, 127.0, 126.8, 54.6, 50.3, 37.1, 33.2. calcd for $[M+H]^+$ 260.0842, found 260.0842.



7

N-(4-bromobenzyl)-N-methylbenzamide (7)

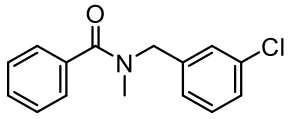
Colorless oil, 31.1 mg, 51% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.51 – 7.30 (m, 8H), 7.24 (d, J = 8.1 Hz, 1H), 7.07 (dd, J = 23.0, 7.8 Hz, 1H), 4.58 (d, J = 95.9 Hz, 2H), 2.94 (d, J = 62.0 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.3, 171.7, 136.2, 136.0, 135.7, 133.4, 131.9, 130.0, 129.8, 129.7, 128.9, 128.5, 128.1, 127.0, 126.8, 121.5, 54.6, 50.3, 37.1, 33.2. calcd for $[M+H]^+$ 304.0337, found 304.0341.



8

N-(3-fluorobenzyl)-N-methylbenzamide (8)

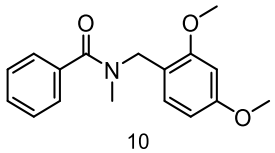
Colorless oil, 26.7 mg, 55% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 – 7.27 (m, 6H), 7.18 – 6.82 (m, 3H), 4.62 (d, *J* = 97.9 Hz, 2H), 2.96 (d, *J* = 59.8 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 171.8, 164.5, 162.0, 139.7, 136.0, 130.4, 129.9, 128.6, 127.1, 126.9, 123.8, 122.4, 114.7, 54.8, 50.5, 37.2, 33.4. ^{19}F NMR (376 MHz, $CDCl_3$) δ -112.1, -112.8. calcd for $[M+H]^+$ 244.1137, found 244.1140.



9

N-(3-chlorobenzyl)-N-methylbenzamide (9)

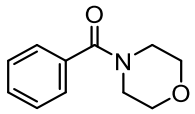
Colorless oil, 34.7 mg, 67% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.47 – 7.22 (m, 8H), 7.10 (d, *J* = 36.4 Hz, 1H), 4.73 (s, 1H), 4.49 (s, 1H), 2.96 (d, *J* = 59.6 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 171.8, 139.2, 136.0, 134.7, 130.2, 129.9, 128.7, 128.6, 128.3, 127.9, 127.1, 126.8, 126.4, 124.9, 54.8, 50.5, 37.2, 33.4. calcd for $[M+H]^+$ 260.0842, found 260.0844.



10

N-(2,4-dimethoxybenzyl)-N-methylbenzamide (10)

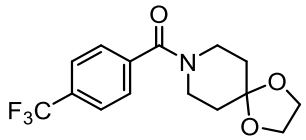
White solid, 28.6 mg, 50% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49 – 7.32 (m, 5H), 7.26 (m, 0.5H), 7.04 (m, 0.5H), 6.51 – 6.39 (m, 2H), 4.73 (s, 1H), 4.43 (s, 1H), 3.86 – 3.79 (m, 4.5H), 3.71 (s, 1.5H), 2.99 (s, 1.5H), 2.84 (s, 1.5H). 13C NMR (101 MHz, CDCl3) δ 172.6, 171.6, 160.6, 158.9, 158.4, 136.8, 136.6, 130.6, 130.1, 129.6, 128.8, 128.4, 127.1, 117.6, 117.1, 104.4, 104.0, 98.6, 55.5, 55.2, 50.4, 45.1, 37.2, 33.1. calcd for [M+H]+ 286.1443, found 286.1445.



11

morpholino(phenyl)methanone (11)

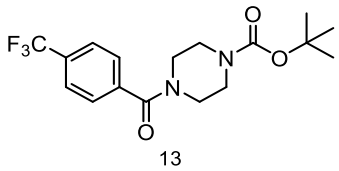
32.5 mg, 85% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.41 (d, *J* = 1.5 Hz, 5H), 3.91 – 3.37 (m, 8H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 170.6, 135.4, 130.0, 128.7, 127.2, 67.0, 48.3, 42.7. calcd for $[M+H]^+$ 192.1024, found 192.1026.



12

(1,4-dioxa-8-azaspiro[4.5]decan-8-yl)(4-(trifluoromethyl)phenyl)methanone (12)

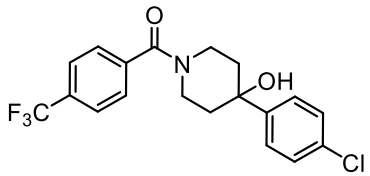
White solid, 39 mg, 62% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.68 (d, *J* = 8.0 Hz, 2H), 7.52 (d, *J* = 8.0 Hz, 2H), 3.99 (d, *J* = 4.1 Hz, 4H), 3.87 (t, *J* = 5.7 Hz, 2H), 3.45 (t, *J* = 5.7 Hz, 2H), 1.87 – 1.59 (m, 4H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 169.0, 139.7, 131.9, 131.6, 127.3, 125.8, 125.8, 125.8, 125.7, 125.2, 122.5, 106.9, 64.7, 45.8, 40.5, 35.8, 34.8. ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.9. calcd for $[M+H]^+$ 316.1160, found 316.1161.



13

tert-butyl 4-(4-(trifluoromethyl)benzoyl)piperazine-1-carboxylate (13)

White solid, 32.9 mg, 46% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.70 (d, *J* = 8.0 Hz, 2H), 7.52 (d, *J* = 8.0 Hz, 2H), 3.76 (s, 2H), 3.46 (d, *J* = 58.5 Hz, 6H), 1.47 (s, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 169.2, 154.6, 139.1, 132.0 (q, *J* = 32.7 Hz), 127.5, 125.9, 125.8, 125.8, 125.8, 123.7 (q, *J* = 273.6 Hz), 80.6, 47.5, 43.7, 42.2, 28.4. ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.9. calcd for $[M+H]^+$ 359.1582, found 359.1578.

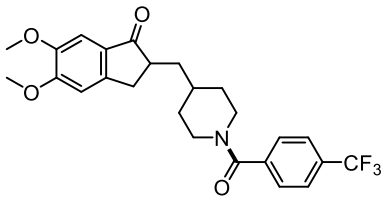


14

(4-(4-chlorophenyl)-4-hydroxypiperidin-1-yl)(4-(trifluoromethyl)phenyl)methanone (14)

White solid, 40,7 mg, 53% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.68 (d, *J* = 8.0 Hz, 2H), 7.52 (d, *J* = 8.0 Hz, 2H), 7.44 – 7.37 (m, 2H), 7.37 – 7.30 (m, 2H), 4.67 (d, *J* = 13.2 Hz, 1H), 3.58 – 3.54 (m, 2H), 3.37 – 3.27 (m,

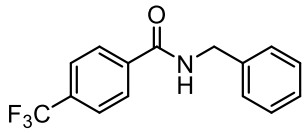
1H), 2.17 – 2.07 (m, 1H), 2.02 (s, 1H), 1.87 (d, *J* = 13.7 Hz, 2H), 1.70 (d, *J* = 16.9 Hz, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 169.1, 146.0, 139.4, 133.4, 132.0, 131.6, 130.4, 128.8, 127.4, 127.3, 126.1, 125.8, 125.8, 125.8, 125.7, 125.1, 122.4, 71.2, 44.0, 38.9, 38.5, 37.7. ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.8. calcd for $[M+H]^+$ 384.0978, found 384.0974.



15

5,6-dimethoxy-2-((1-(4-(trifluoromethyl)benzoyl)piperidin-4-yl)methyl)-2,3-dihydro-1H-inden-1-one (15)

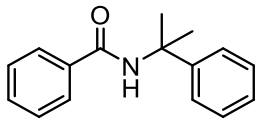
White soild, 32.3 mg, 35% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.68 (d, *J* = 8.0 Hz, 2H), 7.51 (d, *J* = 8.0 Hz, 2H), 7.17 (s, 1H), 6.87 (s, 1H), 4.78 – 4.68 (m, 1H), 3.97 (s, 3H), 3.91 (s, 3H), 3.66 (s, 1H), 3.28 (dd, *J* = 17.2, 7.9 Hz, 1H), 3.11 – 3.00 (m, 1H), 2.89 – 2.78 (m, 1H), 2.76 – 2.65 (m, 2H), 1.98 – 1.66 (m, 3H), 1.47 – 1.14 (m, 4H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 207.4, 168.9, 155.7, 149.6, 148.7, 139.9, 131.5 (q, *J* = 33.2 Hz), 129.2, 127.3, 125.7, 125.7, 125.7, 123.8 (q, *J* = 273.7 Hz), 107.4, 104.5, 56.3, 56.2, 48.0, 45.0, 42.5, 38.7, 38.5, 34.7, 33.4, 32.5, 31.5. ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.8. calcd for $[M+H]^+$ 462.1892, found 462.1893.



16

N-benzyl-4-(trifluoromethyl)benzamide (16)

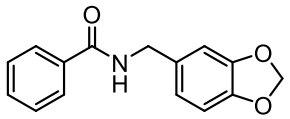
White solid, 18.9 mg, 34% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.90 (d, *J* = 8.1 Hz, 2H), 7.69 (d, *J* = 8.1 Hz, 2H), 7.42 – 7.29 (m, 5H), 4.66 (d, *J* = 5.6 Hz, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 166.4, 137.8, 137.7, 133.6, 133.3, 129.0, 128.0, 128.0, 127.6, 127.5, 127.4, 125.8, 125.8, 125.2, 125.1, 44.4. ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.9. calcd for $[M+H]^+$ 280.0949, found 280.0951.



17

N-(2-phenylpropan-2-yl)benzamide (17)

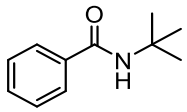
White solid, 25.8 mg, 54% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76 (d, *J* = 7.2 Hz, 2H), 7.51 – 7.38 (m, 5H), 7.38 – 7.31 (m, 2H), 7.27 – 7.22 (m, 1H), 1.82 (d, *J* = 0.8 Hz, 6H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 166.6, 146.9, 135.5, 128.7, 128.6, 127.0, 124.9, 56.4, 29.3. calcd for $[M+H]^+$ 240.1388, found 240.1335.



18

N-(benzo[d][1,3]dioxol-5-ylmethyl)benzamide (18)

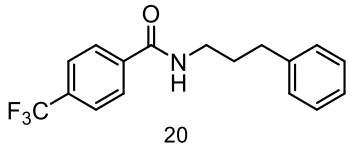
White solid, 16.4 mg, 32% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83 – 7.75 (m, 2H), 7.54 – 7.37 (m, 3H), 6.88 – 6.74 (m, 3H), 6.45 (s, 1H), 5.94 (s, 2H), 4.54 (d, *J* = 5.6 Hz, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 167.5, 148.1, 147.2, 134.4, 132.1, 131.7, 128.7, 127.1, 121.4, 108.6, 108.5, 101.2, 44.1. calcd for $[M+H]^+$ 256.0973, found 256.0975.



19

N-(tert-butyl)benzamide (19)

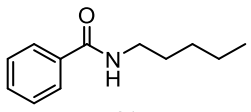
White solid, 16.2 mg, 46% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.74 – 7.69 (m, 2H), 7.43 (dtd, *J* = 17.1, 7.2, 1.8 Hz, 3H), 5.95 (s, 1H), 1.47 (s, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 167.1, 136.0, 131.2, 128.6, 126.8, 51.7, 29.0. calcd for $[M+H]^+$ 178.1232, found 178.1229.



20

N-(3-phenylpropyl)-4-(trifluoromethyl)benzamide (20)

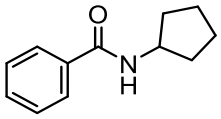
Yellow solid, 41.8 mg, 68% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72 (d, *J* = 8.1 Hz, 2H), 7.63 (d, *J* = 8.1 Hz, 2H), 7.34 – 7.16 (m, 5H), 6.33 (d, *J* = 6.2 Hz, 1H), 3.50 (q, *J* = 6.6 Hz, 2H), 2.72 (t, *J* = 7.4 Hz, 2H), 1.97 (p, *J* = 7.2 Hz, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 166.3, 141.5, 133.2 (q, J = 32.7 Hz), 128.8, 128.5, 127.4, 126.3, 125.7, 125.6, 125.6, 125.6, 125.1, 122.4, 40.2, 33.7, 31.0. ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.9. calcd for $[M+H]^+$ 308.1262, found 308.1263.



21

N-pentylbenzamide (21)

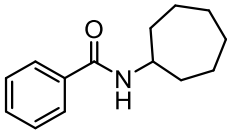
Colorless oil, 17.2 mg, 45% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.79 – 7.75 (m, 2H), 7.50 – 7.45 (m, 1H), 7.44 – 7.38 (m, 2H), 6.39 (s, 1H), 3.43 (td, *J* = 7.3, 5.8 Hz, 3H), 1.66 – 1.55 (m, 3H), 1.40 – 1.32 (m, 4H), 0.94 – 0.87 (m, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 167.7, 134.9, 131.5, 131.4, 128.6, 128.6, 127.0, 127.0, 40.2, 29.4, 29.2, 22.5, 14.1. calcd for $[M+H]^+$ 192.1388, found 192.1386.



22

N-cyclopentylbenzamide (22)

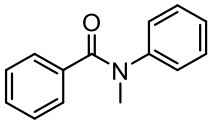
Colorless oil, 17.8 mg, 47% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.75 (dt, *J* = 7.0, 1.5 Hz, 2H), 7.53 – 7.37 (m, 3H), 6.15 (s, 1H), 4.40 (q, *J* = 7.0 Hz, 1H), 2.15 – 2.05 (m, 2H), 1.78 – 1.60 (m, 4H), 1.57 – 1.44 (m, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 167.4, 135.0, 131.4, 128.6, 127.0, 51.8, 33.3, 23.9. calcd for $[M+H]^+$, found . calcd for $[M+H]^+$ 190.1232, found 190.1230.



23

N-cycloheptylbenzamide (23)

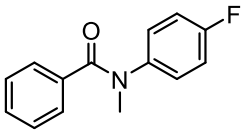
White solid, 17.3 mg, 40% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.74 (dd, *J* = 7.0, 1.8 Hz, 2H), 7.53 – 7.39 (m, 3H), 6.09 (s, 1H), 4.22 – 4.06 (m, 1H), 2.11 – 1.95 (m, 2H), 1.71 – 1.46 (m, 10H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 166.5, 135.2, 131.3, 128.6, 126.9, 51.0, 35.3, 28.2, 24.3. calcd for $[M+H]^+$ 218.1545, found 218.1545.



24

N-methyl-N-phenylbenzamide (24)

Yellow oil, 27.9 mg, 66% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.32 – 7.10 (m, 8H), 7.07 – 7.00 (m, 2H), 3.50 (d, *J* = 1.9 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 170.8, 145.0, 136.0, 129.7, 129.2, 128.8, 127.8, 127.0, 126.6, 38.5. calcd for $[M+H]^+$ 212.1075, found 212.1078.

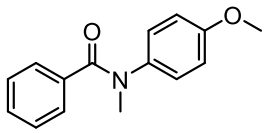


25

N-(4-fluorophenyl)-N-methylbenzamide (25)

Colorless oil, 28.9 mg. 63% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.30 – 7.23 (m, 3H), 7.18 (dd, *J* = 8.0, 6.5 Hz, 2H), 7.04 – 6.98 (m, 2H), 6.91 (t, *J* = 8.5 Hz, 2H), 3.47 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 170.9, 162.1,

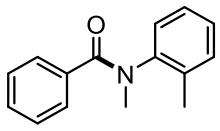
159.7, 141.1, 135.8, 129.8, 128.7, 128.6, 128.0, 116.3, 116.1, 38.7. ^{19}F NMR (376 MHz, $CDCl_3$) δ -114.8. calcd for $[M+H]^+$ 230.0981, found 230.0977.



26

N-(4-methoxyphenyl)-N-methylbenzamide (26)

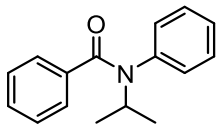
Yellow oil, 31.8 mg, 66% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.28 (dd, J = 7.2, 5.5 Hz, 2H), 7.24 – 7.12 (m, 3H), 6.95 (d, J = 8.6 Hz, 2H), 6.76 – 6.70 (m, 2H), 3.73 (s, 3H), 3.45 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 170.8, 158.0, 137.9, 136.2, 129.5, 128.7, 128.3, 128.1, 127.9, 127.8, 114.4, 55.4, 38.7. calcd for $[M+H]^+$ 242.1181, found 242.1179.



27

N-methyl-N-(o-tolyl)benzamide (27)

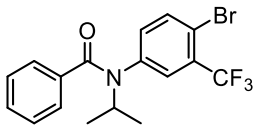
Colorless oil, 24.7 mg, 55% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.30 – 7.25 (m, 1H), 7.20 (t, *J* = 7.4 Hz, 1H), 7.15 – 7.01 (m, 6H), 3.38 (s, 3H), 2.21 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 171.0, 143.6, 136.0, 134.9, 131.4, 129.8, 128.7, 128.4, 127.8, 127.7, 127.1, 37.6, 17.9. calcd for $[M+H]^+$ 226.1232, found 226.1228.



28

N-isopropyl-N-phenylbenzamide (28)

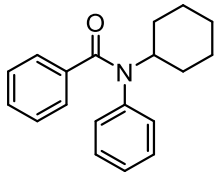
Colorless oil, 32.5 mg, 68% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.27 – 7.08 (m, 8H), 7.05 – 6.98 (m, 2H), 5.09 (s, 1H), 1.20 (d, *J* = 6.7 Hz, 6H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 170.8, 139.6, 137.4, 130.7, 129.0, 128.7, 128.2, 127.7, 127.5, 47.8, 21.2. calcd for $[M+H]^+$ 240.1388, found 240.1383.



29

N-(4-bromo-3-(trifluoromethyl)phenyl)-N-isopropylbenzamide (29)

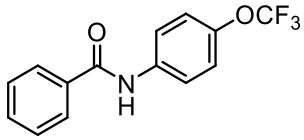
White solid, 33.2 mg, 43% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.57 (d, *J* = 8.4 Hz, 1H), 7.34 (d, *J* = 2.6 Hz, 1H), 7.25 – 7.17 (m, 5H), 7.06 – 7.01 (m, 1H), 5.06 – 4.96 (m, 1H), 1.21 (d, *J* = 6.8 Hz, 6H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 170.8, 139.4, 136.4, 135.5, 134.9, 132.0, 130.9, 130.6, 129.8, 129.7, 129.7, 128.2, 128.0, 123.7, 121.0, 118.9, 48.6, 21.3. ^{19}F NMR (376 MHz, $CDCl_3$) δ -63.0. calcd for $[M+H]^+$ 386.0367, found 386.0371.



30

N-cyclohexyl-N-phenylbenzamide (30)

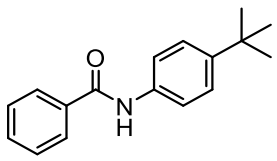
White solid, 21.2 mg, 38% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.24 – 7.06 (m, 8H), 7.04 – 6.97 (m, 2H), 4.71 (s, 1H), 1.97 (d, *J* = 12.2 Hz, 2H), 1.78 (d, *J* = 12.9 Hz, 2H), 1.61 (d, *J* = 13.5 Hz, 1H), 1.45 (q, *J* = 13.5 Hz, 2H), 1.23 (qd, *J* = 12.4, 3.7 Hz, 2H), 1.04 – 0.90 (m, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 170.8, 140.0, 137.4, 130.9, 128.9, 128.6, 128.1, 127.7, 127.5, 55.6, 31.8, 26.0, 25.5. calcd for $[M+H]^+$ 280.1701, found 280.1702.



31

N-(4-(trifluoromethoxy)phenyl)benzamide (31)

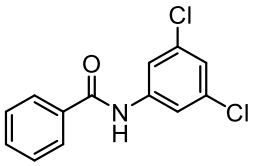
White solid, 26.4 mg, 47% yield. ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.45 (s, 1H), 7.99 – 7.95 (m, 2H), 7.94 – 7.89 (m, 2H), 7.63 – 7.58 (m, 1H), 7.53 (d, *J* = 8.2 Hz, 2H), 7.36 (d, *J* = 8.6 Hz, 2H). ^{13}C NMR (101 MHz, DMSO) δ 165.8, 143.9, 138.5, 134.7, 131.8, 128.5, 127.8, 121.7, 121.5. ^{19}F NMR (376 MHz, DMSO) δ -57.1. calcd for $[M+H]^+$ 282.0742, found 282.0742.



32

N-(4-(tert-butyl)phenyl)benzamide (32)

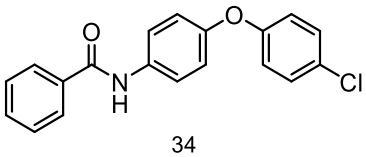
White solid, 15.2 mg, 30% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.93 (s, 1H), 7.88 – 7.82 (m, 2H), 7.58 – 7.49 (m, 3H), 7.45 (t, *J* = 7.7 Hz, 2H), 7.37 (d, *J* = 8.3 Hz, 2H), 1.32 (d, *J* = 1.1 Hz, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.9, 147.7, 135.4, 135.2, 131.8, 128.8, 127.2, 126.0, 120.2, 34.5, 31.5. calcd for $[M+H]^+$ 254.1545, found 254.1544.



33

N-(3,5-dichlorophenyl)benzamide (33)

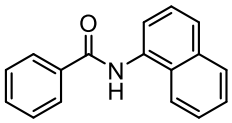
White solid, 32 mg, 60% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94 (s, 1H), 7.85 – 7.81 (m, 2H), 7.62 (d, *J* = 1.8 Hz, 2H), 7.60 – 7.55 (m, 1H), 7.51 – 7.46 (m, 2H), 7.13 (t, *J* = 1.8 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 166.3, 139.8, 135.3, 134.1, 132.4, 128.9, 127.2, 124.6, 118.7. calcd for $[M+H]^+$ 266.0139, found 266.0139.



34

N-(4-(4-chlorophenoxy)phenyl)benzamide (34)

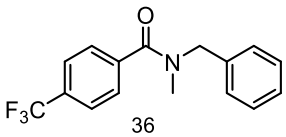
White solid, 46.6 mg, 72% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.03 (s, 1H), 7.85 (dd, *J* = 7.2, 1.9 Hz, 2H), 7.63 – 7.57 (m, 2H), 7.53 (td, *J* = 7.4, 1.8 Hz, 1H), 7.45 (td, *J* = 7.6, 1.9 Hz, 2H), 7.30 – 7.25 (m, 1H), 6.95 (ddt, *J* = 26.8, 6.6, 2.0 Hz, 4H), 6.88 – 6.81 (m, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 166.0, 156.3, 153.4, 134.9, 133.9, 132.0, 129.8, 129.7, 128.9, 128.2, 127.2, 122.3, 119.8, 119.8. calcd for $[M+H]^+$ 324.0791, found 324.0795.



35

N-(naphthalen-1-yl)benzamide (35)

White solid, 30.7 mg, 62% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.30 (s, 1H), 7.97 – 7.83 (m, 5H), 7.71 (d, *J* = 8.2 Hz, 1H), 7.56 (t, *J* = 7.3 Hz, 1H), 7.51 – 7.43 (m, 5H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 166.5, 134.9, 134.3, 132.5, 132.0, 128.9, 128.9, 127.7, 127.3, 126.5, 126.3, 126.2, 125.9, 121.6, 121.0. calcd for $[M+H]^+$ 248.1075, found 248.1075.

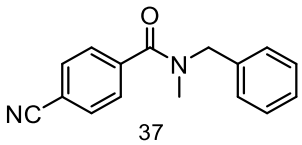


36

N-benzyl-N-methyl-4-(trifluoromethyl)benzamide (36)

Colorless oil, 42.1 mg, 72% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.66 (dd, *J* = 18.1, 8.0 Hz, 2H), 7.57 (d, *J* = 8.0 Hz, 2H), 7.42 – 7.28 (m, 4H), 7.16 (d, *J* = 7.4 Hz, 1H), 4.77 (s, 1H), 4.48 (s, 1H), 3.07 (s, 1.5H), 2.85 (s,

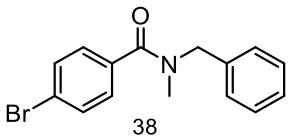
1.5H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 171.0, 170.3, 139.9, 136.7, 136.2, 131.9, 131.6, 131.3, 130.8, 129.1, 128.9, 128.4, 128.0, 127.9, 127.5, 127.3, 126.7, 125.7, 55.2, 51.0, 37.0, 33.4. ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.8, -62.9. calcd for $[M+H]^+$ 294.1105, found 294.1100.



37

N-benzyl-4-cyano-N-methylbenzamide (37)

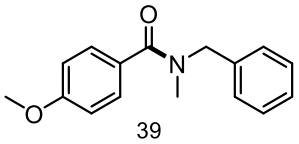
Yellow oil, 39.2 mg, 78% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.73 (dd, *J* = 21.7, 7.9 Hz, 2H), 7.62 – 7.55 (m, 2H), 7.45 – 7.31 (m, 4H), 7.17 (d, *J* = 7.4 Hz, 1H), 4.78 (s, 1H), 4.49 (s, 1H), 3.10 (s, 1.5H), 2.87 (s, 1.5H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 170.3, 169.6, 140.7, 140.6, 136.5, 135.9, 132.5, 129.2, 128.9, 128.4, 128.1, 127.9, 127.8, 127.6, 126.6, 118.2, 113.5, 55.1, 50.9, 36.9, 33.5. calcd for $[M+H]^+$ 251.1184, found 251.1183.



38

N-benzyl-4-bromo-N-methylbenzamide (38)

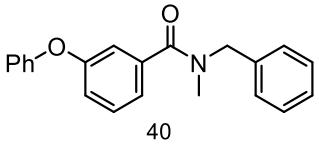
Colorless oil, 40.6 mg, 67% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.58 – 7.47 (m, 2H), 7.43 – 7.27 (m, 6H), 7.15 (d, *J* = 7.2 Hz, 1H), 4.62 (d, *J* = 97.8 Hz, 2H), 2.94 (d, *J* = 70.5 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 171.4, 170.7, 136.8, 136.3, 135.1, 131.8, 129.0, 128.9, 128.6, 128.3, 127.8, 126.7, 124.1, 55.2, 51.0, 37.1, 33.5. calcd for $[M+H]^+$ 304.0337, found 304.0336.



39

N-benzyl-4-methoxy-N-methylbenzamide (39)

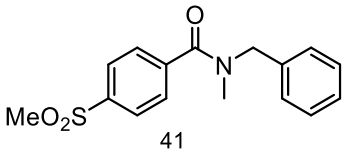
Colorless oil, 34.8 mg, 68% yield. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.47 – 7.41 (m, 2H), 7.39 – 7.16 (m, 5H), 6.93 – 6.85 (m, 2H), 4.80 – 4.51 (m, 2H), 3.81 (s, 3H), 2.96 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 160.8, 128.9, 128.3, 127.6, 113.8, 55.4. calcd for $[M+H]^+$ 256.1337, found 256.1338.



40

N-benzyl-N-methyl-3-phenoxybenzamide (40)

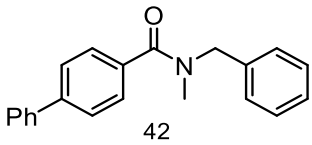
Colorless oil, 29.7 mg, 47% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.39 – 7.27 (m, 7H), 7.20 – 6.93 (m, 7H), 4.61 (d, *J* = 95.0 Hz, 2H), 2.92 (d, *J* = 54.6 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 171.6, 157.8, 137.9, 136.9, 136.5, 130.0, 129.0, 128.3, 127.7, 126.8, 123.9, 121.7, 121.2, 119.7, 119.6, 119.3, 117.3, 116.6, 55.2, 50.9, 37.0, 33.2. calcd for $[M+H]^+$ 318.1494, found 318.1496.



41

N-benzyl-N-methyl-4-(methylsulfonyl)benzamide (41)

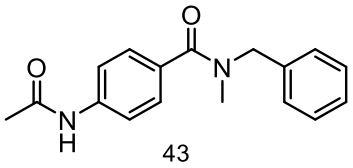
White solid, 40.6 mg, 67% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.98 (dd, *J* = 21.1, 8.0 Hz, 2H), 7.64 (d, *J* = 8.1 Hz, 2H), 7.41 – 7.30 (m, 4H), 7.14 (d, *J* = 7.4 Hz, 1H), 4.76 (s, 1H), 4.46 (s, 1H), 3.09 – 3.06 (m, 3H), 3.04 (s, 1.5H), 2.84 (s, 1.5H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 170.3, 169.6, 141.7, 141.6, 141.4, 136.4, 135.8, 129.1, 128.9, 128.3, 127.9, 127.8, 127.7, 126.6, 55.0, 50.8, 44.4, 36.8, 33.4. calcd for $[M+H]^+$ 304.1007, found 304.1004.



42

N-benzyl-N-methyl-[1,1'-biphenyl]-4-carboxamide (42)

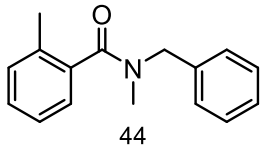
White solid, 30.2 mg, 50% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.66 – 7.51 (m, 6H), 7.48 – 7.28 (m, 8H), 7.20 (d, *J* = 7.5 Hz, 1H), 4.68 (d, *J* = 80.7 Hz, 2H), 2.99 (d, *J* = 51.3 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.3, 171.6, 142.7, 140.3, 137.1, 136.7, 135.0, 129.0, 128.9, 128.3, 127.9, 127.7, 127.5, 127.3, 127.2, 126.8, 55.4, 51.0, 37.2, 33.4. calcd for $[M+H]^+$ 302.1545, found 302.1544.



43

4-acetamido-N-benzyl-N-methylbenzamide (43)

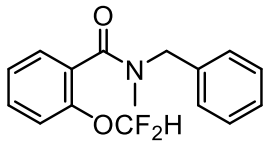
Colorless oil, 21.4 mg, 38% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.51 (d, *J* = 23.4 Hz, 1H), 7.46 (d, *J* = 8.5 Hz, 2H), 7.40 – 7.28 (m, 6H), 7.15 (d, *J* = 7.7 Hz, 1H), 4.64 (d, *J* = 83.0 Hz, 2H), 2.96 (d, *J* = 49.7 Hz, 3H), 2.12 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 169.3, 139.9, 131.2, 129.0, 127.8, 126.8, 119.8, 55.4, 51.1, 37.4, 33.5, 24.5. calcd for $[M+H]^+$ 283.1446, found 283.1448.



44

N-benzyl-N,2-dimethylbenzamide (44)

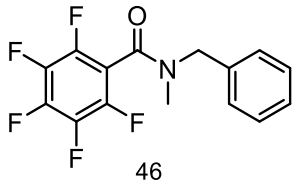
Yellow oil, 28.1 mg, 59% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37 (d, *J* = 2.9 Hz, 1H), 7.35 – 7.22 (m, 4H), 7.22 – 7.14 (m, 3H), 7.11 (dd, *J* = 7.1, 1.6 Hz, 1H), 4.78 (s, 1H), 4.35 (s, 1H), 3.05 (s, 1.5H), 2.70 (s, 1.5H), 2.32 (d, *J* = 12.7 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.1, 171.7, 137.1, 136.6, 136.3, 136.3, 134.4, 134.0, 130.6, 130.5, 129.0, 128.9, 128.8, 128.8, 128.4, 127.8, 127.6, 127.2, 126.0, 126.0, 125.8, 54.6, 50.2, 35.8, 32.5, 19.2, 19.0. calcd for $[M+H]^+$ 240.1388, found 240.1392.



45

N-benzyl-2-(difluoromethoxy)-N-methylbenzamide (45)

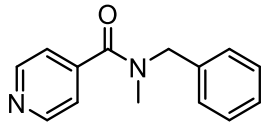
Colorless oil, 30.2 mg, 52% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.44 – 7.27 (m, 7H), 7.25 – 7.13 (m, 2H), 6.57 (td, *J* = 74.1, 2.9 Hz, 1H), 4.38 (m, 2H), 3.03 (s, 1H), 2.76 (s, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 168.3, 168.1, 147.1, 136.6, 136.1, 130.7, 130.7, 129.8, 129.7, 128.9, 128.8, 128.3, 128.3, 128.1, 127.9, 127.6, 127.2, 126.1, 120.4, 119.9, 118.9, 116.4, 116.3, 113.7, 54.8, 50.5, 35.9, 32.6. ^{19}F NMR (376 MHz, $CDCl_3$) δ -78.8, -79.0, -79.2, -79.4, -82.2, -82.4, -82.6, -82.8. calcd for $[M+H]^+$ 292.1149, found 292.1149.



46

N-benzyl-2,3,4,5,6-pentafluoro-N-methylbenzamide (46)

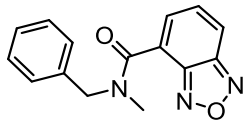
Yellow oil, 34.9 mg, 55% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.41 – 7.29 (m, 4H), 7.16 – 7.11 (m, 1H), 4.79 (s, 1H), 4.42 (s, 1H), 3.05 (s, 1.5H), 2.84 (s, 1.5H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 173.2, 159.0, 135.7, 134.8, 129.2, 129.0, 128.4, 128.1, 127.1, 54.8, 50.9, 35.5, 33.0. ^{19}F NMR (376 MHz, $CDCl_3$) δ -140.1, -140.2, -140.2, -140.2, -140.2, -140.2, -140.8, -140.9, -140.9, -140.9, -140.9, -140.9, -151.7, -151.7, -151.8, -151.8, -151.9, -151.9, -159.5, -159.5, -159.5, -159.5, -159.5, -159.6, -159.6, -159.6, -159.6, -159.7, -159.7, -159.7, -159.7, -159.7, -159.8, -159.8, -159.8, -159.8. calcd for $[M+H]^+$ 316.0761, found 316.0762.



47

N-benzyl-N-methylisonicotinamide (47)

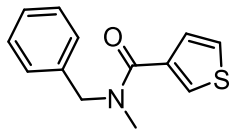
Colorless oil, 34.8 mg, 77% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.73 – 8.60 (m, 2H), 7.40 – 7.29 (m, 6H), 7.14 (d, *J* = 7.3 Hz, 1H), 4.75 (s, 1H), 4.45 (s, 1H), 3.06 (s, 1.5H), 2.83 (s, 1.5H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 169.7, 169.0, 150.3, 150.3, 143.9, 143.8, 136.4, 135.8, 129.1, 128.9, 128.3, 128.0, 127.8, 126.6, 121.2, 121.0, 54.8, 50.7, 36.6, 33.2. calcd for $[M+H]^+$ 227.1184, found 227.1186.



48

N-benzyl-N-methylbenzo[c][1,2,5]oxadiazole-4-carboxamide (48)

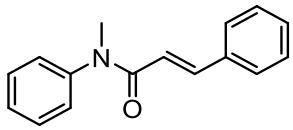
Yellow oil, 24.3 mg, 46% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.96 – 7.86 (m, 1H), 7.60 (d, *J* = 6.5 Hz, 1H), 7.55 – 7.47 (m, 1H), 7.47 – 7.38 (m, 2H), 7.37 – 7.25 (m, 2H), 7.16 (d, *J* = 7.3 Hz, 1H), 4.86 (s, 1H), 4.46 (s, 1H), 3.11 (s, 1.5H), 2.85 (s, 1.5H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 166.3, 148.9, 136.3, 135.7, 131.3, 131.2, 130.9, 130.2, 129.1, 128.9, 128.2, 128.1, 127.8, 127.1, 118.0, 55.1, 51.1, 36.6, 33.3. calcd for $[M+H]^+$ 268.1086, found 268.1082.



49

N-benzyl-N-methylthiophene-3-carboxamide (49)

Colorless oil, 31 mg, 67% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 – 7.49 (m, 1H), 7.42 – 7.17 (m, 7H), 4.67 (d, *J* = 32.9 Hz, 2H), 3.02 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 136.9, 129.0, 128.3, 127.7, 127.4, 126.6, 125.9, 55.2, 51.2, 37.0, 33.8. calcd for $[M+H]^+$ 232.0796, found 232.0792.

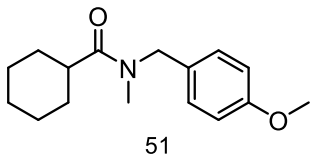


50

N-methyl-N-phenylcinnamamide (50)

Yellow oil, 17.6 mg, 37% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.68 (d, *J* = 15.5 Hz, 1H), 7.47 – 7.41 (m, 2H), 7.39 – 7.21 (m, 7H), 6.37 (d, *J* = 15.6 Hz, 1H), 3.41 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 166.3, 143.7,

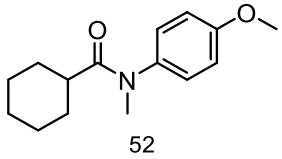
141.8, 135.3, 129.7, 129.6, 129.1, 128.9, 128.8, 128.0, 127.9, 127.7, 127.4, 118.8, 37.7. calcd for $[M+H]^+$ 238.1232, found 238.1235.



51

N-(4-methoxybenzyl)-N-methylcyclohexanecarboxamide (51)

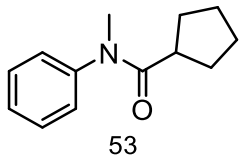
Colorless oil, 15.6 mg, 30% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.17 – 7.05 (m, 2H), 6.92 – 6.81 (m, 2H), 4.50 (d, *J* = 7.7 Hz, 2H), 3.80 (d, *J* = 8.3 Hz, 3H), 2.90 (d, *J* = 13.8 Hz, 3H), 2.58 – 2.46 (m, 1H), 1.87 – 1.50 (m, 6H), 1.33 – 1.16 (m, 4H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 176.9, 176.3, 159.2, 158.9, 129.9, 129.4, 129.0, 127.7, 114.4, 114.0, 55.4, 55.4, 52.6, 50.2, 41.0, 40.9, 34.5, 33.8, 29.8, 29.3, 26.0, 25.9, 25.9. calcd for $[M+H]^+$ 262.1807, found 262.1805.



52

N-(4-methoxyphenyl)-N-methylcyclohexanecarboxamide (52)

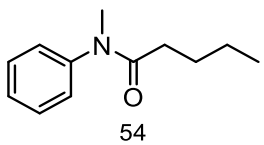
Yellow oil, 16.9 mg, 34% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.13 – 7.04 (m, 2H), 6.92 (d, *J* = 9.1 Hz, 2H), 3.84 (d, *J* = 1.2 Hz, 3H), 3.20 (d, *J* = 1.1 Hz, 3H), 2.23 – 2.13 (m, 1H), 1.69 – 1.45 (m, 7H), 1.34 – 1.10 (m, 2H), 1.05 – 0.89 (m, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 176.9, 158.9, 137.2, 128.4, 114.9, 55.6, 41.3, 37.7, 29.5, 25.7. calcd for $[M+H]^+$ 248.1650, found 248.1652.



53

N-methyl-N-phenylcyclopentanecarboxamide (53)

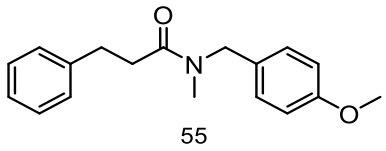
Yellow oil, 20.7 mg, 51% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.42 (t, *J* = 7.5 Hz, 3H), 7.34 (t, *J* = 7.4 Hz, 1H), 7.19 (d, *J* = 7.9 Hz, 2H), 3.26 (s, 3H), 2.55 (t, *J* = 8.1 Hz, 1H), 1.90 – 1.54 (m, 8H), 1.39 (q, *J* = 5.4, 4.8 Hz, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 177.0, 144.5, 129.8, 127.7, 127.6, 42.0, 37.7, 31.3, 26.3. calcd for $[M+H]^+$ 204.1388, found 204.1384.



54

N-methyl-N-phenylpentanamide (54)

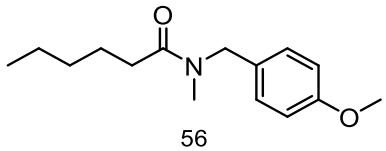
Yellow oil, 16.7 mg, 44% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.55 – 7.48 (m, 3H), 7.34 (d, *J* = 8.4 Hz, 1H), 7.22 (t, *J* = 7.5 Hz, 1H), 3.75 (s, 3H), 2.63 (t, *J* = 7.6 Hz, 2H), 1.69 (q, *J* = 7.4 Hz, 4H), 1.01 (t, *J* = 7.3 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 162.7, 139.1, 135.1, 134.1, 129.4, 128.1, 122.1, 120.9, 114.0, 33.3, 29.8, 21.6, 14.1. calcd for $[M+H]^+$ 192.1388, found 192.1390.



55

N-(4-methoxybenzyl)-N-methyl-3-phenylpropanamide (55)

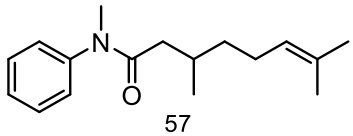
Colorless oil, 21.5 mg, 38% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.31 – 7.12 (m, 6H), 6.99 (d, *J* = 8.5 Hz, 1H), 6.87 – 6.82 (m, 2H), 4.52 (s, 1H), 4.39 (s, 1H), 3.79 (s, 3H), 3.04 – 2.97 (m, 2H), 2.92 (s, 1H), 2.82 (s, 2H), 2.72 – 2.63 (m, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.6, 172.3, 159.1, 159.0, 141.5, 141.4, 129.6, 129.5, 128.6, 128.5, 127.7, 126.2, 114.4, 114.0, 55.4, 55.4, 52.8, 50.3, 35.5, 35.1, 34.6, 33.8, 31.7, 31.5. calcd for $[M+H]^+$ 284.1650, found 284.1653.



56

N-(4-methoxybenzyl)-N-methylhexanamide (56)

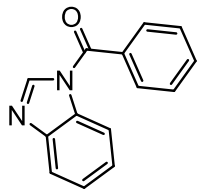
Colorless oil, 12.9 mg, 26% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.17 (d, *J* = 8.3 Hz, 1H), 7.08 (d, *J* = 8.2 Hz, 1H), 6.87 (dd, *J* = 17.4, 8.5 Hz, 2H), 4.49 (d, *J* = 21.5 Hz, 2H), 3.80 (d, *J* = 6.2 Hz, 3H), 2.90 (d, *J* = 7.3 Hz, 3H), 2.36 (dt, *J* = 10.9, 7.6 Hz, 2H), 1.72 – 1.63 (m, 2H), 1.32 (m, 4H), 0.90 (dt, *J* = 10.9, 6.6 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 173.7, 173.4, 159.2, 159.0, 129.9, 129.5, 128.8, 127.7, 114.4, 114.0, 55.4, 55.4, 52.9, 50.2, 34.7, 33.7, 33.3, 31.8, 25.3, 25.0, 22.6, 22.6, 14.1, 14.1. calcd for $[M+H]^+$ 250.1807, found 250.1807.



57

N,3,7-trimethyl-N-phenyloct-6-enamide (57)

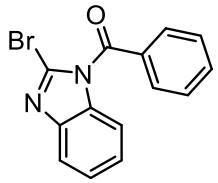
Yellow oil, 28.5 mg, 55% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.21 – 7.15 (m, 2H), 7.10 – 7.04 (m, 1H), 6.63 – 6.55 (m, 2H), 2.95 (s, 3H), 2.86 (td, *J* = 10.7, 3.4 Hz, 1H), 2.30 – 2.23 (m, 1H), 1.97 – 1.89 (m, 1H), 1.81 – 1.73 (m, 1H), 1.33 – 1.25 (m, 4H), 1.13 (qd, *J* = 12.5, 3.4 Hz, 1H), 1.00 – 0.92 (m, 7H), 0.91 – 0.82 (m, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 145.9, 133.6, 127.0, 123.9, 115.7, 112.4, 59.4, 47.8, 42.0, 36.8, 35.1, 34.5, 31.6, 25.8, 24.9, 24.4, 22.5. calcd for $[M+H]^+$ 260.2014, found 260.2014.



58

(1H-benzo[d]imidazol-1-yl)(phenyl)methanone (58)

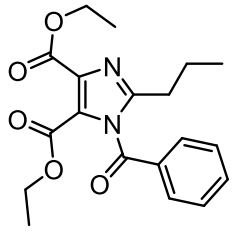
White solid, 19.6 mg, 44% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.24 – 8.17 (m, 2H), 7.82 (ddd, *J* = 14.2, 7.6, 1.5 Hz, 3H), 7.72 – 7.67 (m, 1H), 7.59 (t, *J* = 7.7 Hz, 2H), 7.48 – 7.40 (m, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 167.2, 144.2, 143.20 133.3, 133.0, 132.2, 129.7, 129.2, 125.9, 125.4, 120.7, 115.6. calcd for $[M+H]^+$ 223.0871, found 223.0874.



59

(2-bromo-1H-benzo[d]imidazol-1-yl)(phenyl)methanone (59)

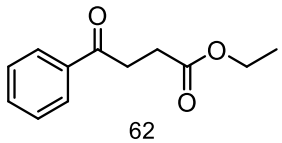
White solid, 16.3 mg, 27% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.85 – 7.78 (m, 2H), 7.73 (tt, *J* = 8.8, 1.2 Hz, 2H), 7.58 – 7.52 (m, 2H), 7.38 – 7.32 (m, 1H), 7.29 – 7.25 (m, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 167.1, 141.6, 139.6, 134.8, 134.6, 132.6, 130.6, 129.2, 125.1, 124.8, 119.9, 113.2. calcd for $[M+H]^+$ 300.9976, found 300.9979.



60

Diethyl 1-benzoyl-2-propyl-1H-imidazole-4,5-dicarboxylate (60)

Colorless oil, 24.4 mg, 34% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72 – 7.65 (m, 3H), 7.51 (dd, *J* = 8.4, 7.1 Hz, 2H), 4.43 (q, *J* = 7.1 Hz, 2H), 3.99 (q, *J* = 7.1 Hz, 2H), 2.74 (dd, *J* = 9.0, 6.3 Hz, 2H), 1.73 (h, *J* = 7.4 Hz, 2H), 1.40 (t, *J* = 7.1 Hz, 3H), 1.06 (t, *J* = 7.2 Hz, 3H), 0.91 (t, *J* = 7.4 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 167.5, 162.1, 158.9, 151.7, 135.5, 135.3, 132.5, 130.1, 129.4, 126.6, 62.1, 61.8, 30.0, 21.8, 14.3, 13.9, 13.7. calcd for $[M+H]^+$ 359.1607, found 359.1621.



62

Ethyl 4-oxo-4-phenylbutanoate (62)

Colorless oil, 4.8 mg, 12% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.99 (dd, *J* = 8.4, 1.4 Hz, 2H), 7.62 – 7.53 (m, 1H), 7.47 (dd, *J* = 8.2, 6.9 Hz, 2H), 4.17 (q, *J* = 7.1 Hz, 2H), 3.32 (t, *J* = 6.7 Hz, 2H), 2.76 (t, *J* = 6.7 Hz, 2H), 1.27 (t, *J* = 7.1 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 198.3, 173.1, 136.7, 133.4, 128.8, 128.2, 60.8, 33.5, 28.4, 14.3.

7. References

[1] S. M. Treacy and T. Rovis, *J. Am. Chem. Soc.*, 2021**, 143**, 2729.

[2] X. Liu and K. F. Jensen, *Green Chem.*, 2012**, 14**, 1471.

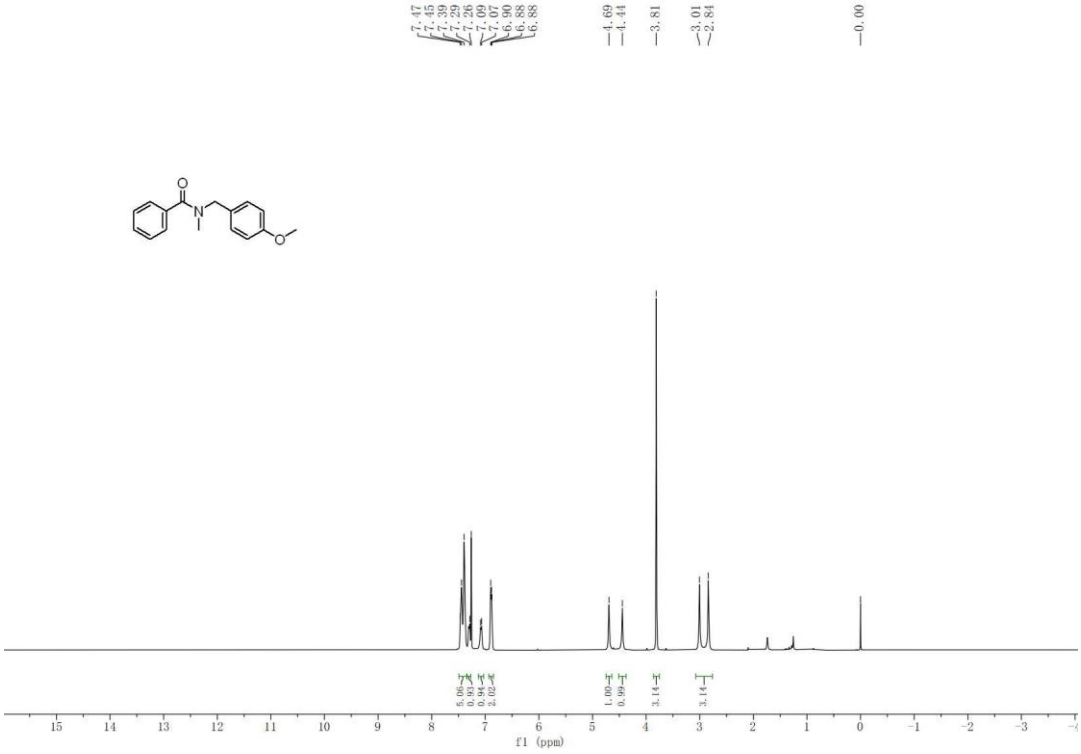
[3] A. M. Whittaker and V. M. Dong, *Angew. Chem. Int. Ed.*, 2015**, 54**, 1312.

[4] H.-Y. Lan, X.-T. Zhou and H.-B Ji, *Tetrahedron*, 2013, **69**, 4241.

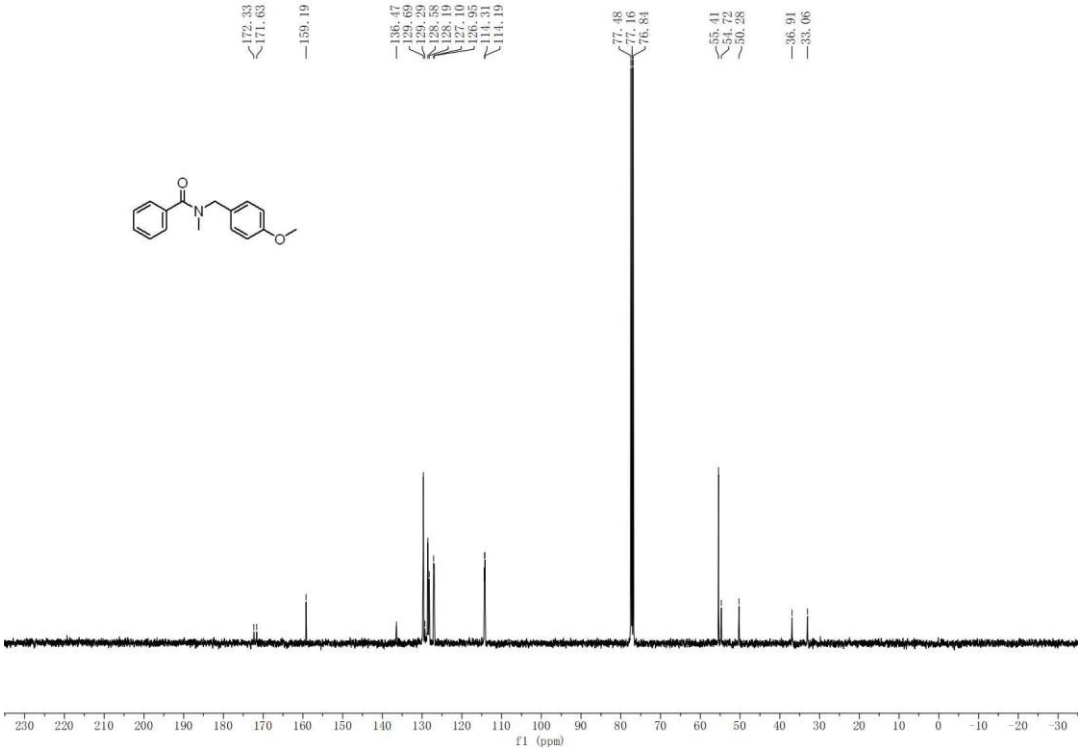
[5] N. Xiong, Y. Dong, B. Xu, Y. Li and R. Zeng, *Org. Lett.*, 2022, **24**, 4766.

[6] S. Pagoti, S. Surana, A. Chauhan, B. Parasar and J. Dash, *Catal. Sci. Tech.*, 2013, **3**, 584.

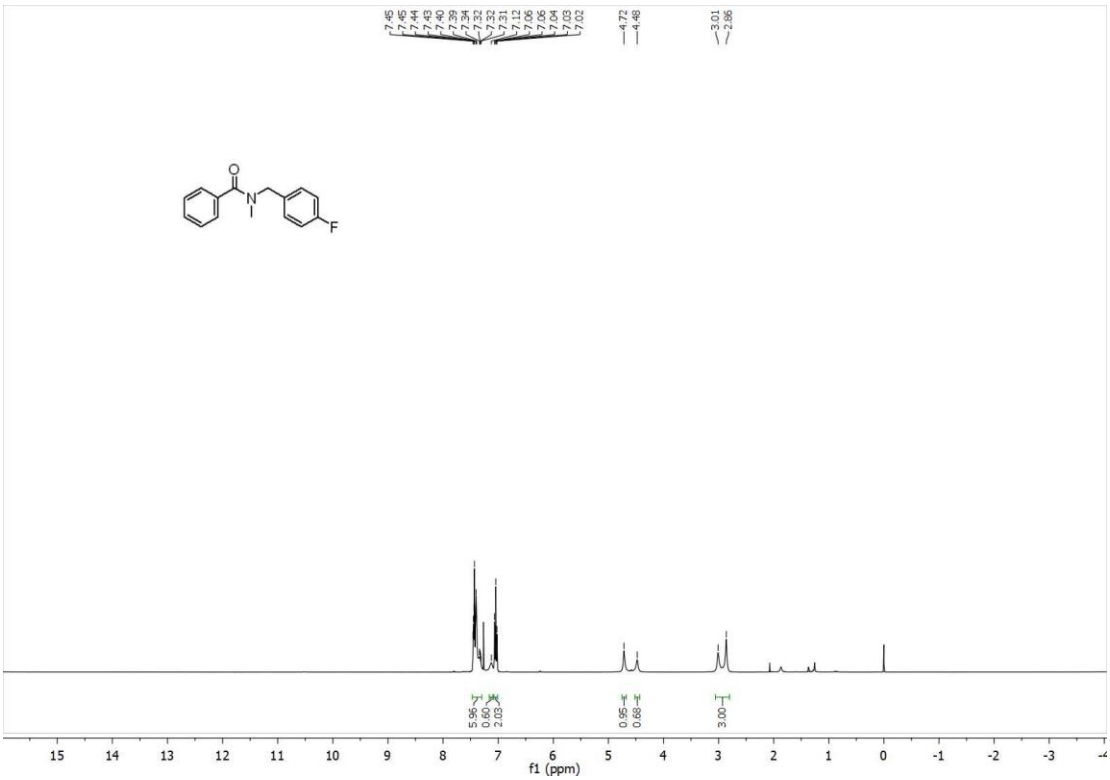
8. Copies of ^{1}H, ^{13}C and ^{19}F NMR Spectra for Products



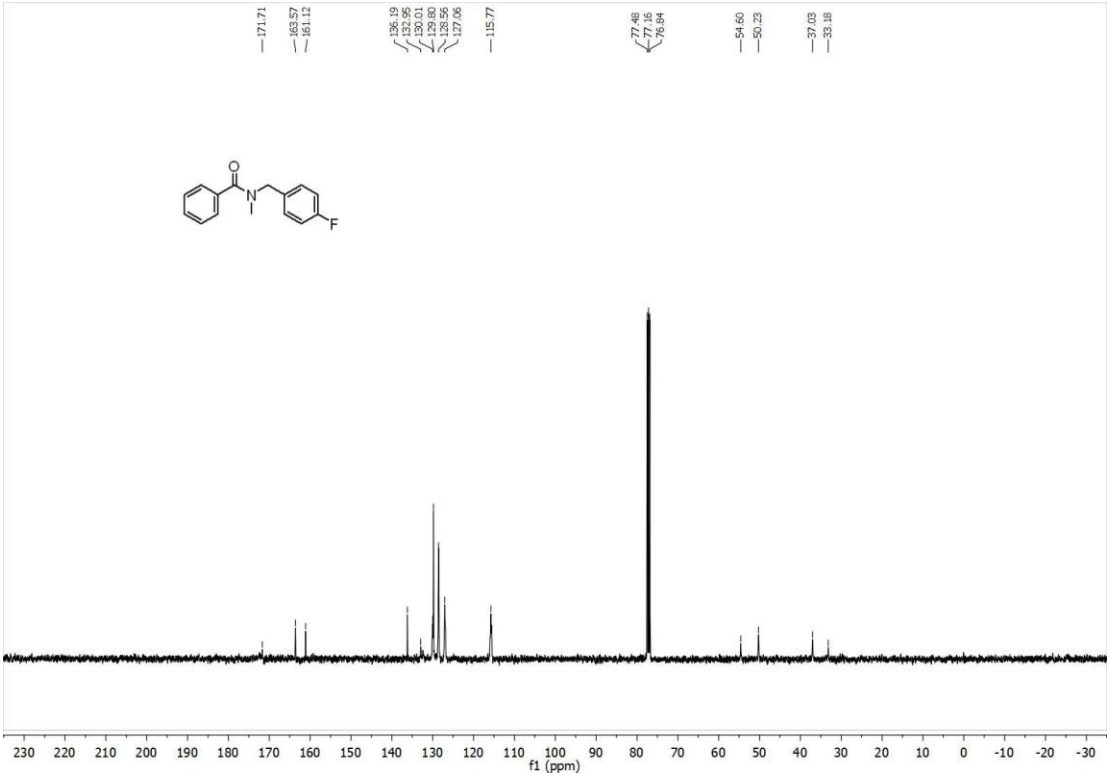
^{1}H NMR Spectrum of Compound 4 (400 MHz, $CDCl_3$)



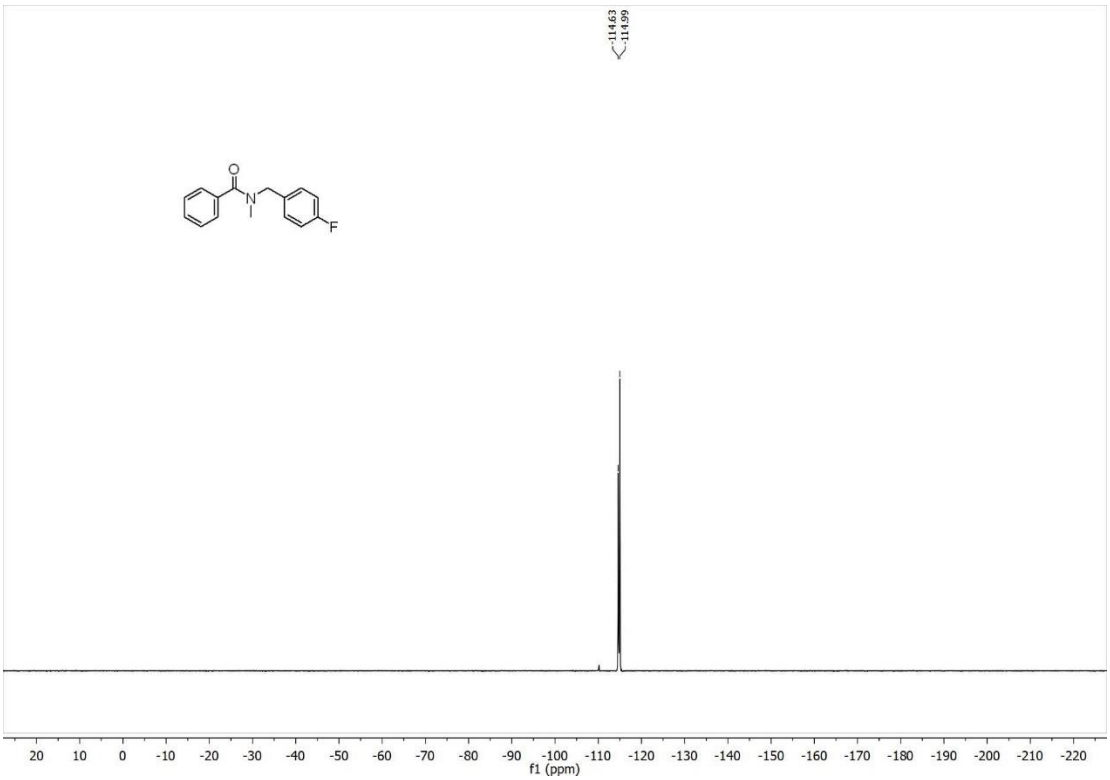
^{13}C NMR Spectrum of Compound 4 (101 MHz, $CDCl_3$)



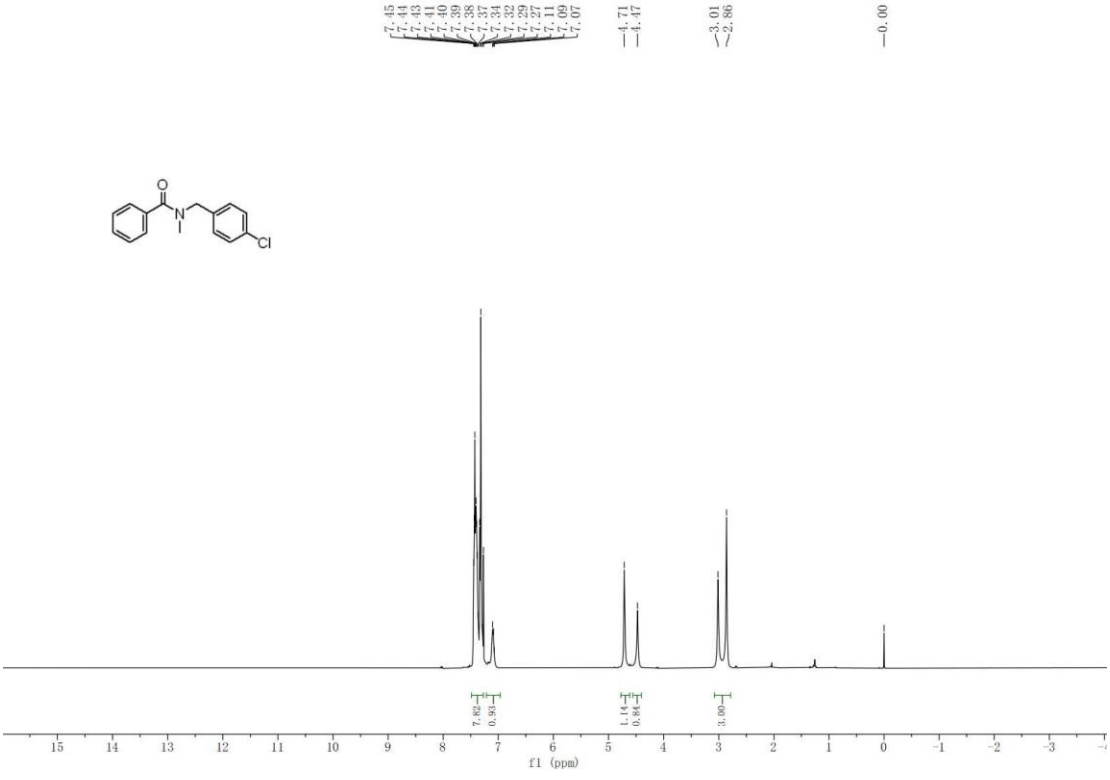
^{1}H NMR Spectrum of Compound 5 (400 MHz, $CDCl_3$)



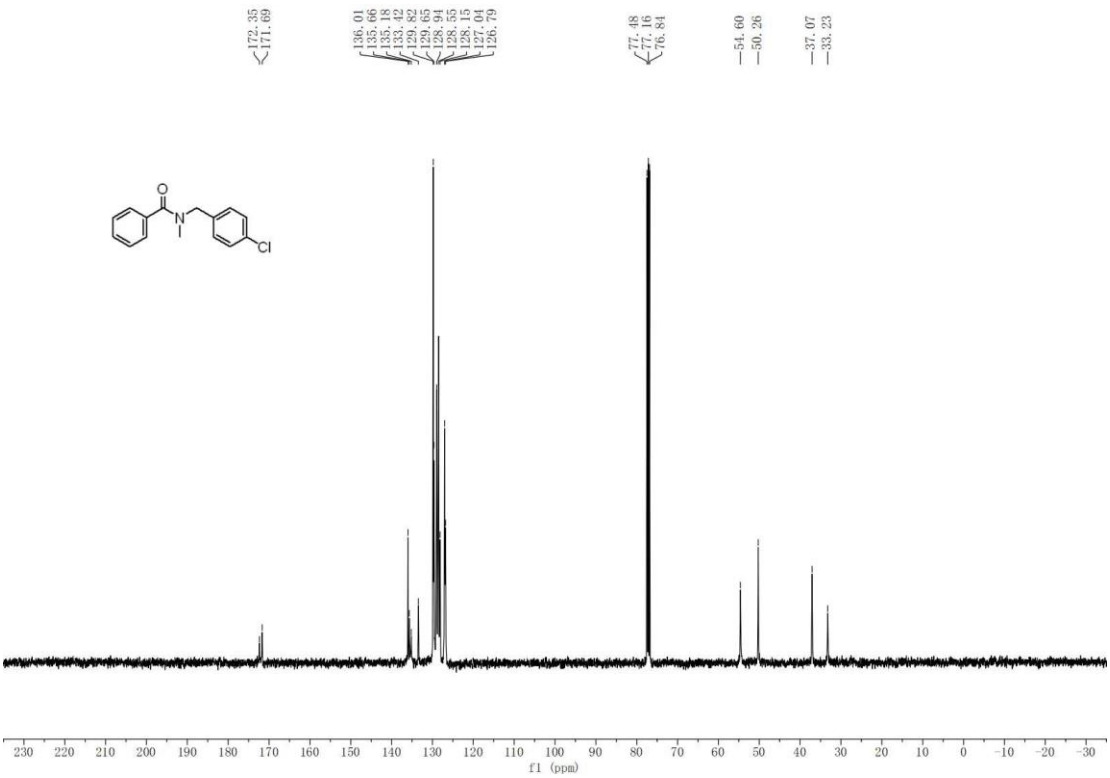
^{13}C NMR Spectrum of Compound 5 (101 MHz, $CDCl_3$)



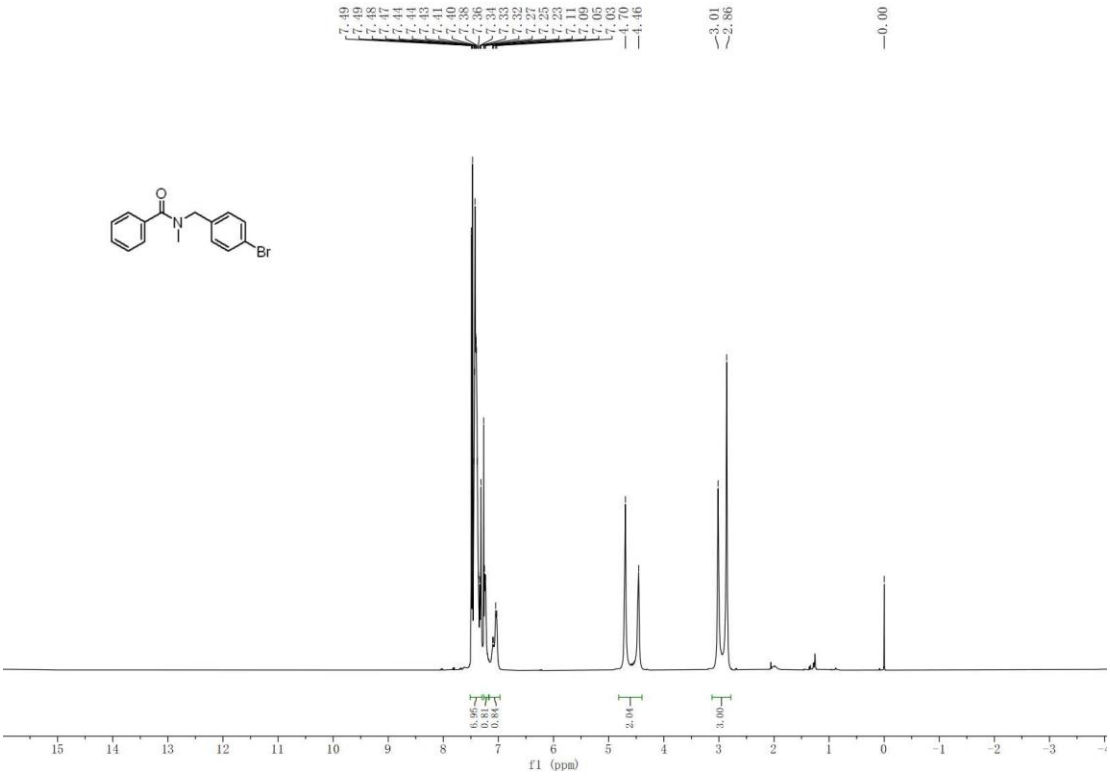
^{19}F NMR Spectrum of Compound 5 (376 MHz, $CDCl_3$)



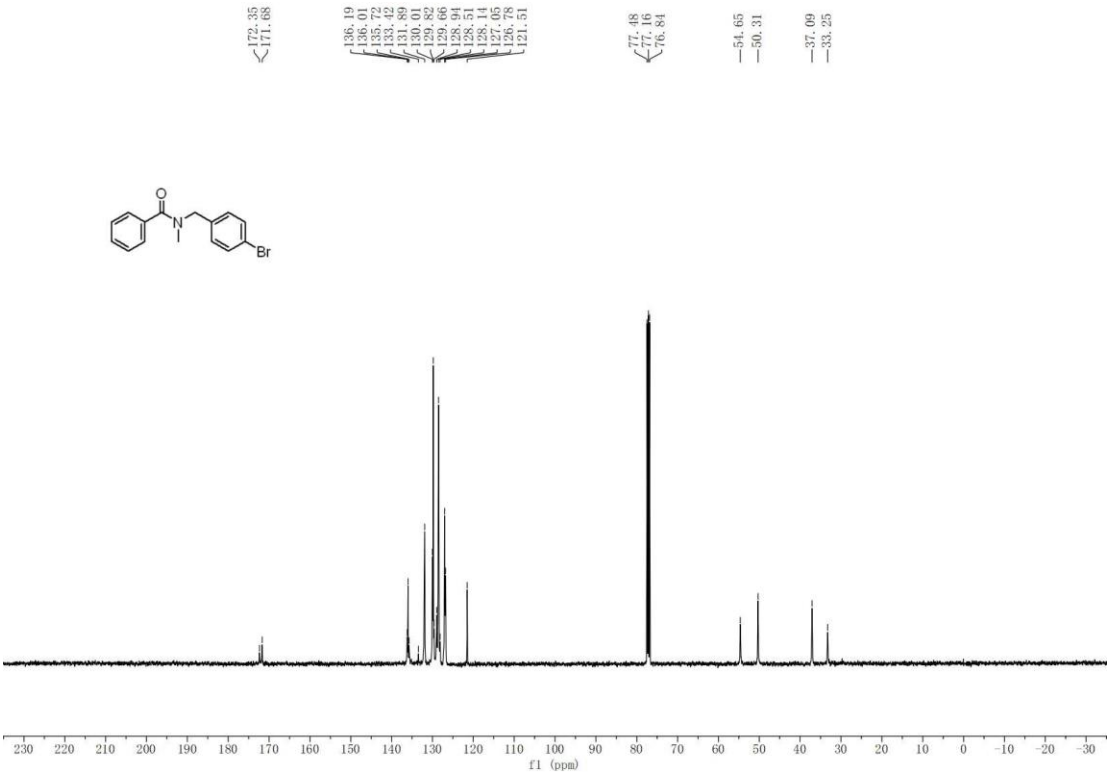
^{1}H NMR Spectrum of Compound 6 (400 MHz, $CDCl_3$)



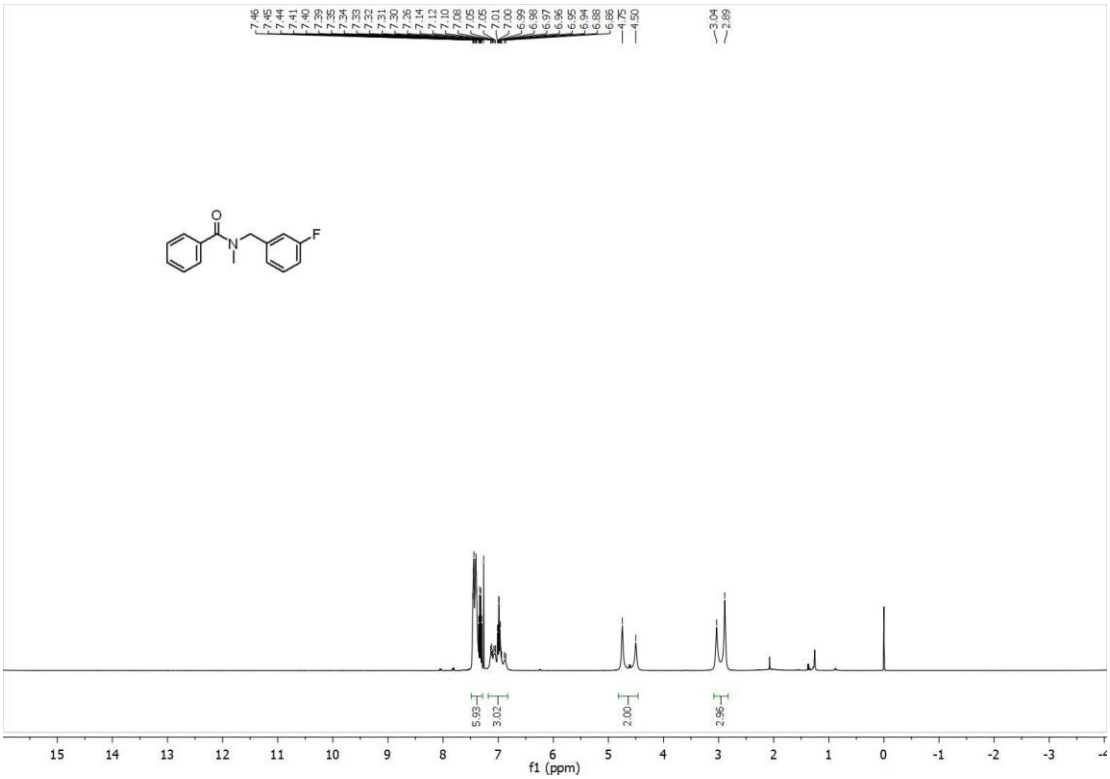
^{13}C NMR Spectrum of Compound 6 (101 MHz, $CDCl_3$)



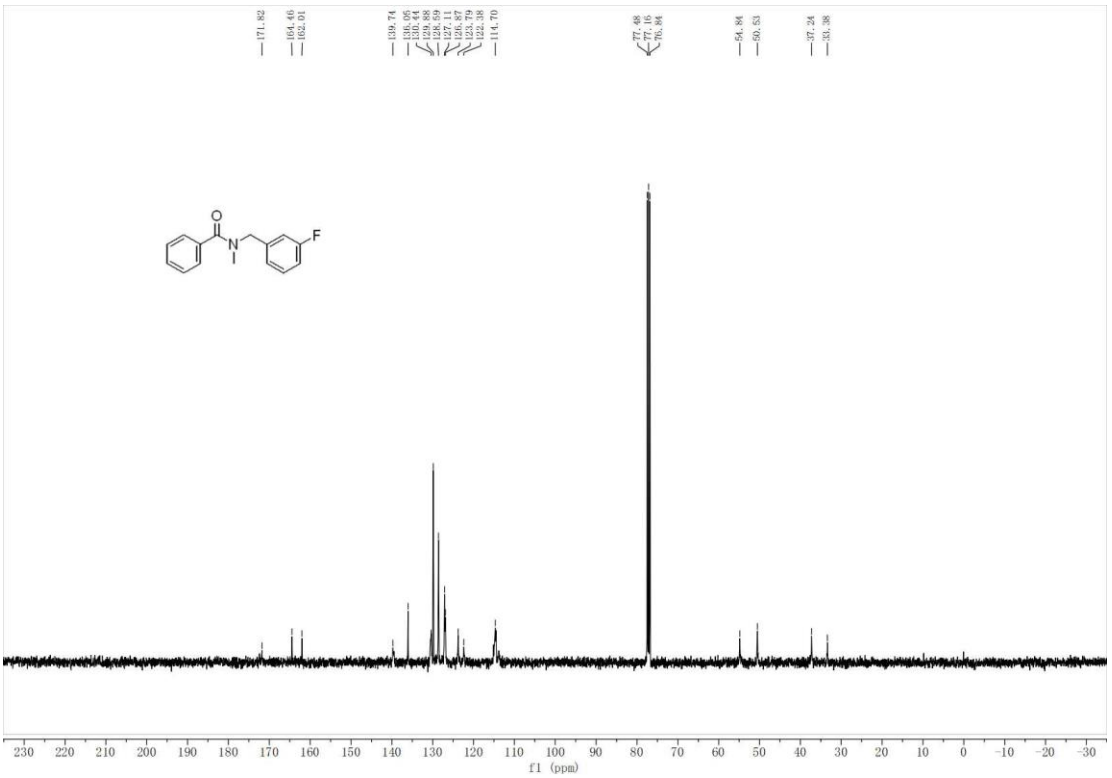
^{1}H NMR Spectrum of Compound 7 (400 MHz, $CDCl_3$)



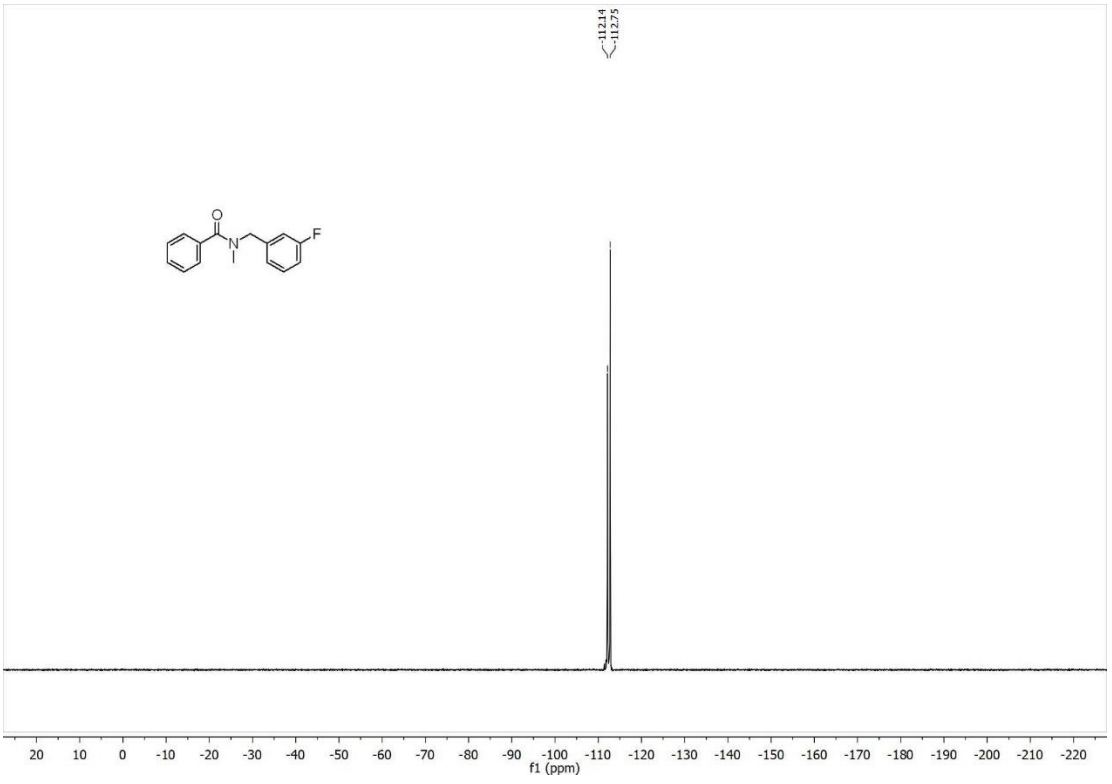
^{13}C NMR Spectrum of Compound 7 (101 MHz, $CDCl_3$)



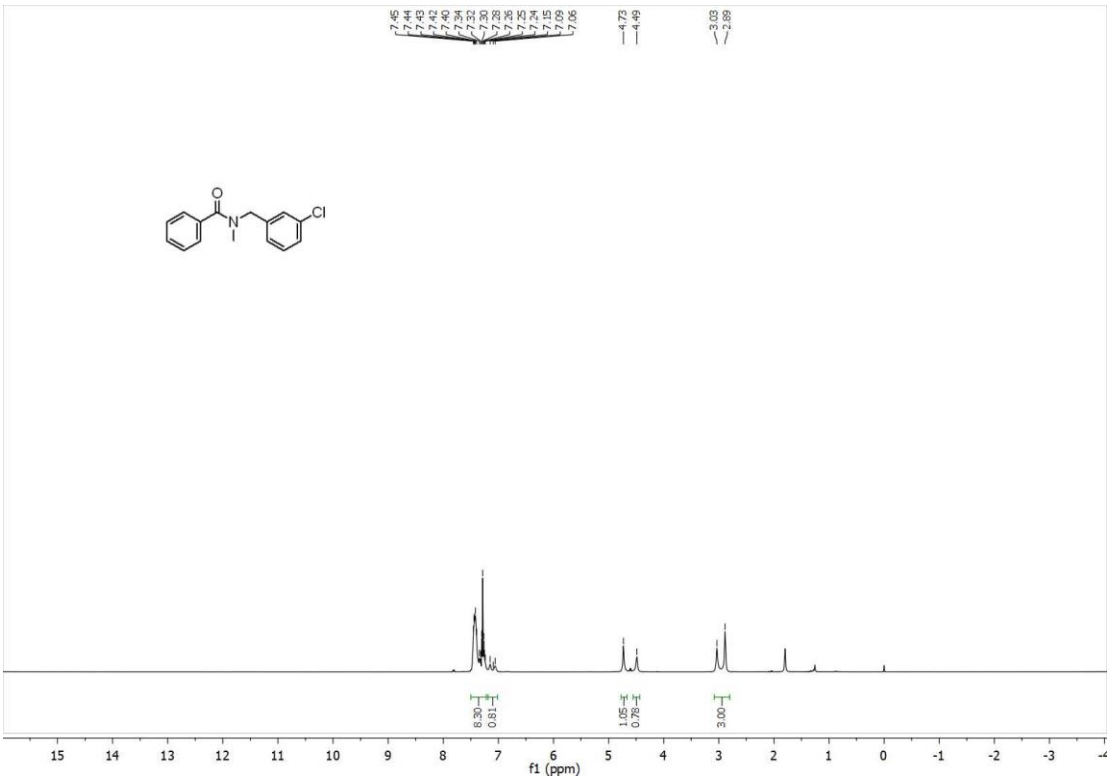
^{1}H NMR Spectrum of Compound 8 (400 MHz, $CDCl_3$)



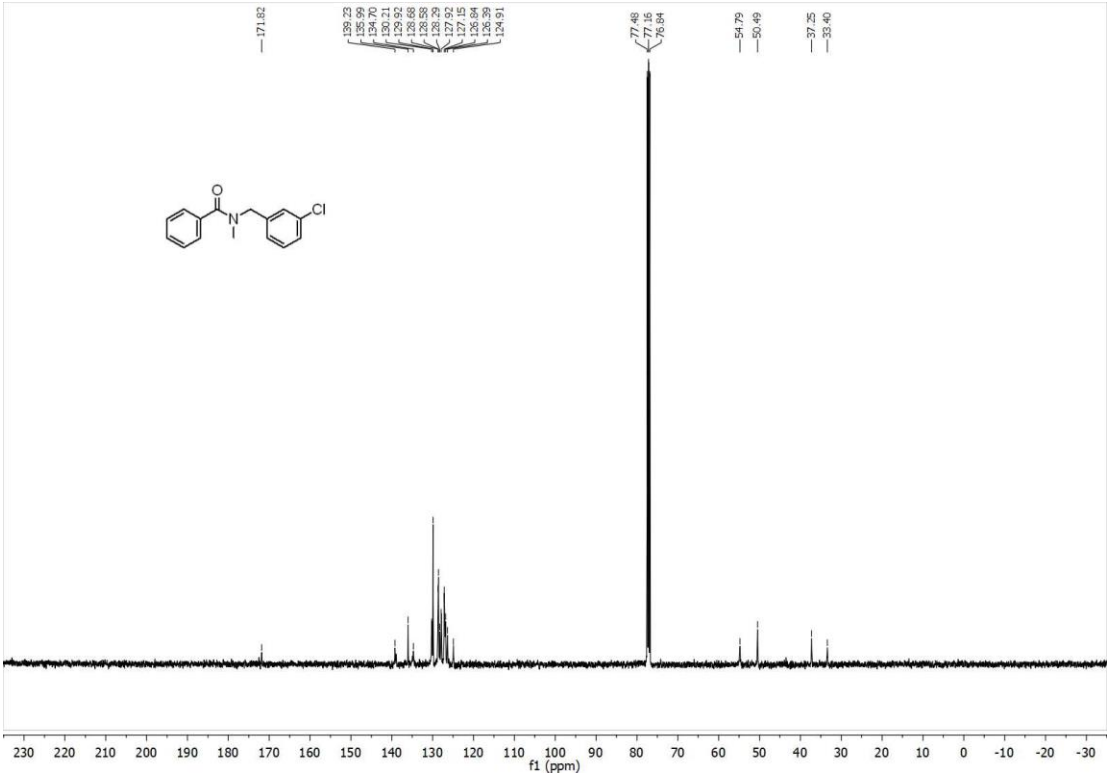
^{13}C NMR Spectrum of Compound 8 (101 MHz, $CDCl_3$)



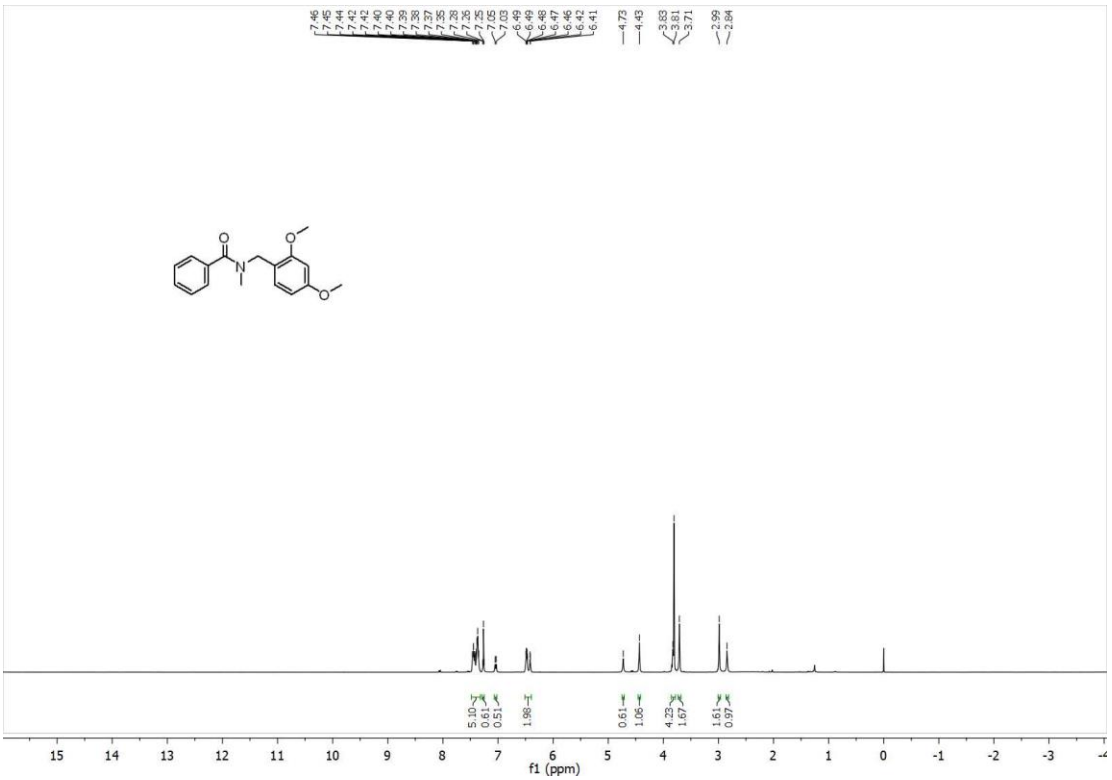
^{19}F NMR Spectrum of Compound 8 (376 MHz, $CDCl_3$)



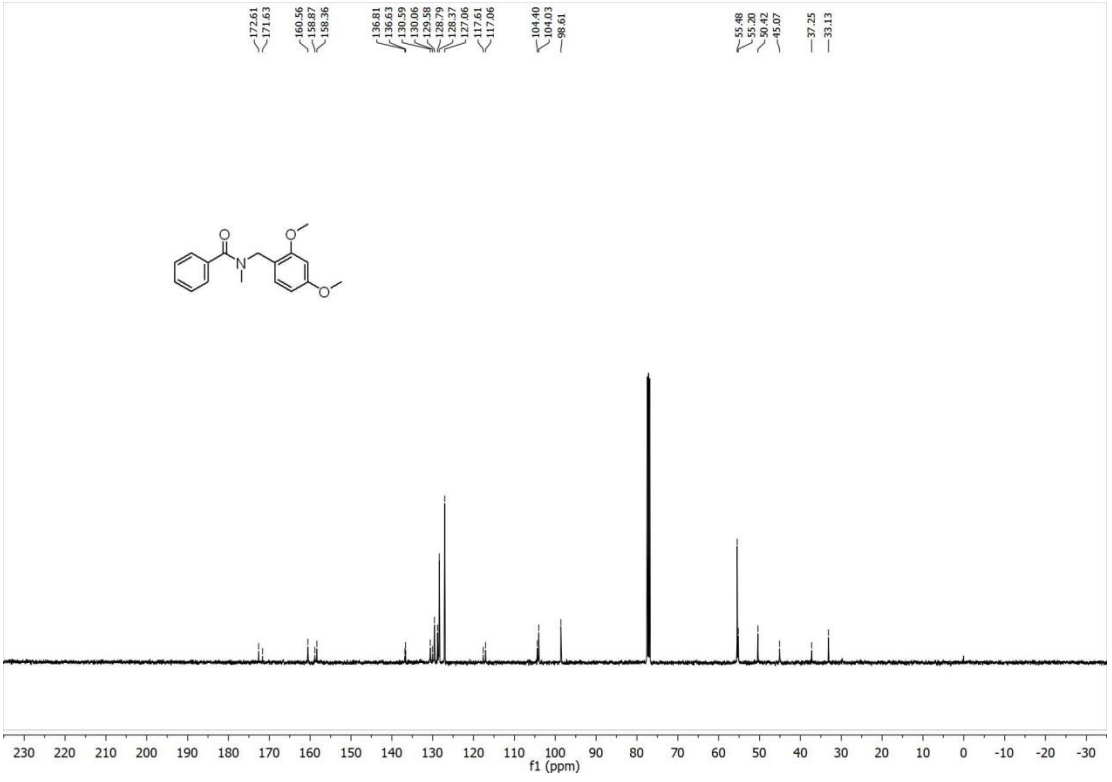
^{1}H NMR Spectrum of Compound 9 (400 MHz, $CDCl_3$)



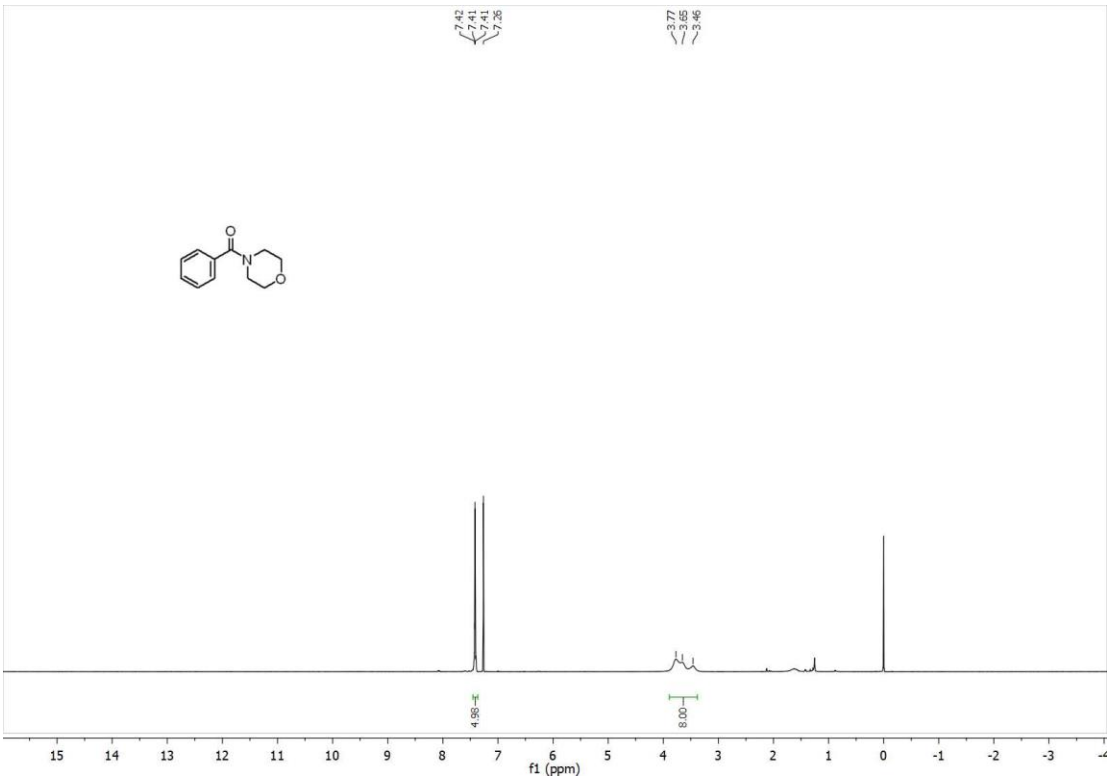
^{13}C NMR Spectrum of Compound 9 (101 MHz, $CDCl_3$)



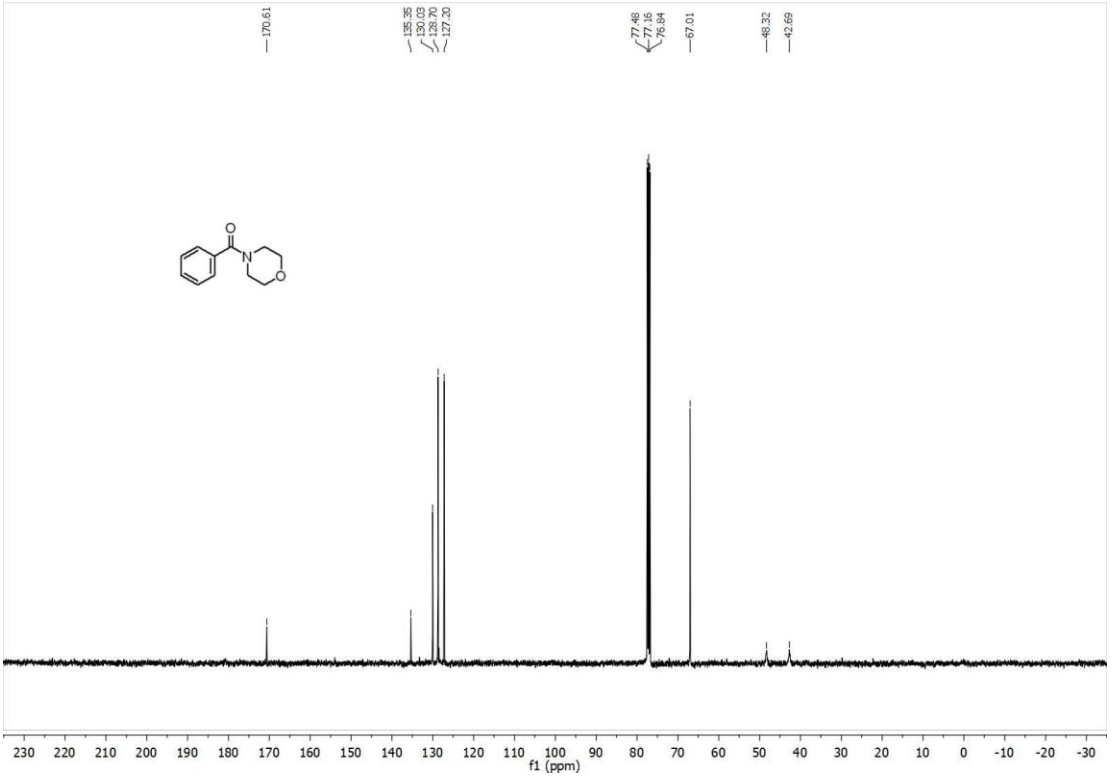
^{1}H NMR Spectrum of Compound 10 (400 MHz, $CDCl_3$)



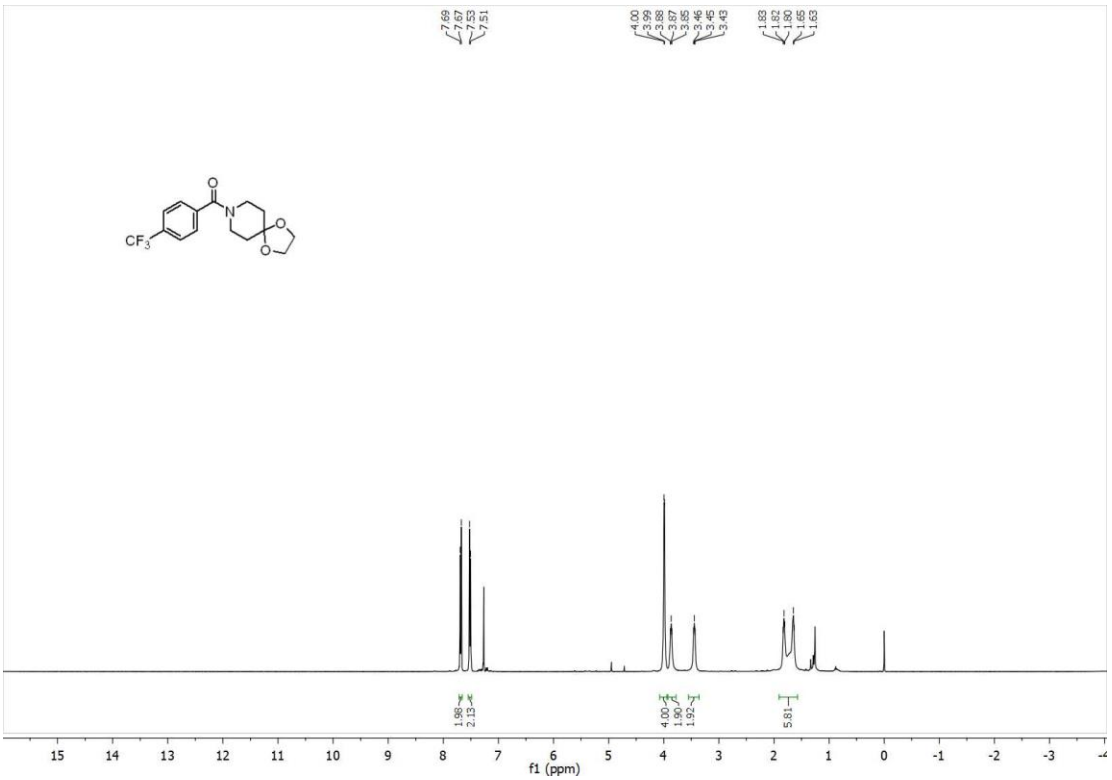
^{13}C NMR Spectrum of Compound 10 (101 MHz, $CDCl_3$)



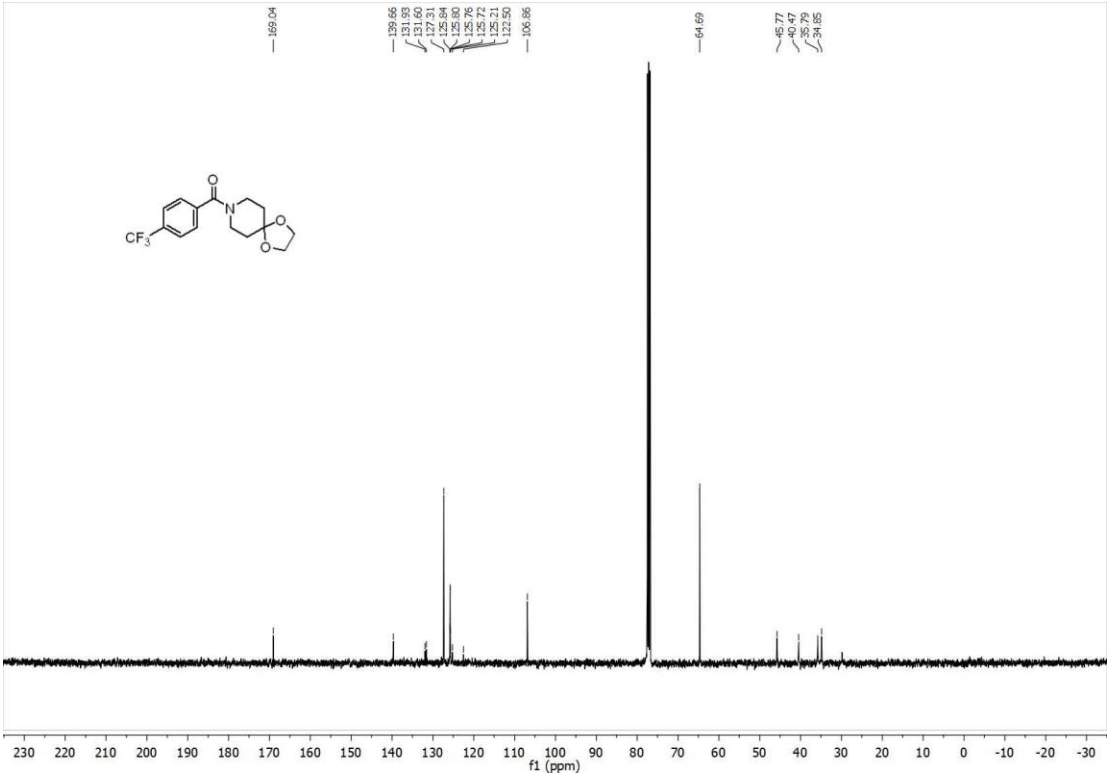
^{1}H NMR Spectrum of Compound 11 (400 MHz, $CDCl_3$)



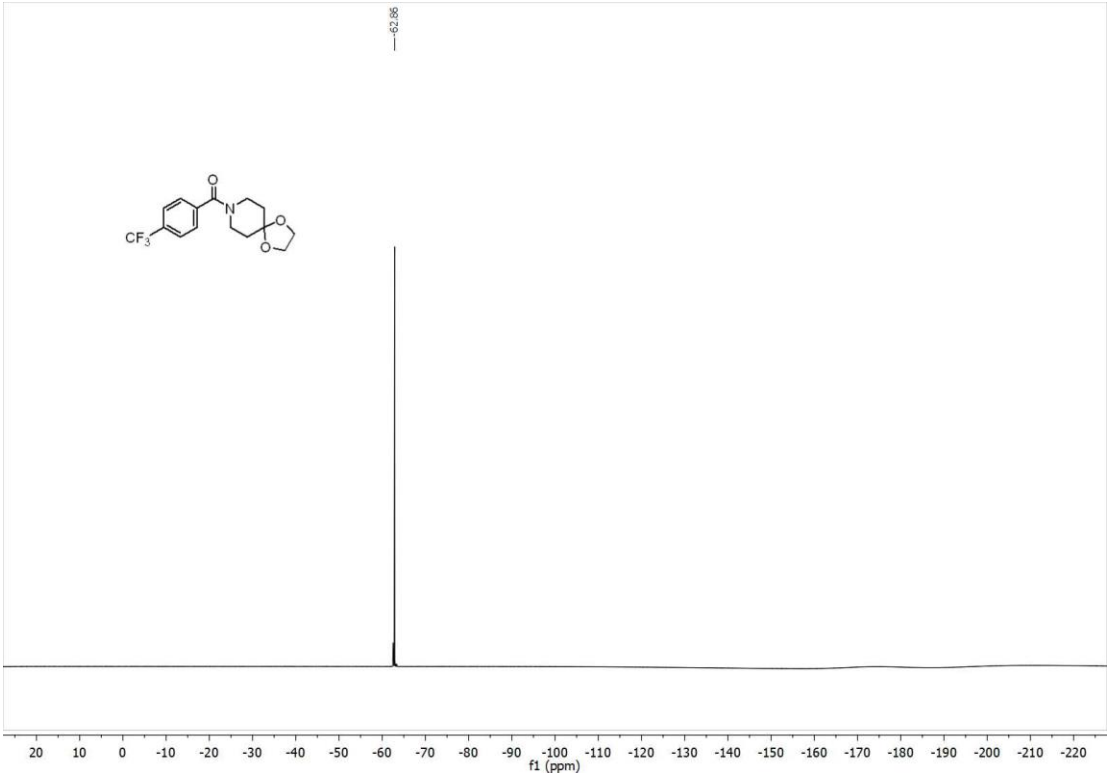
^{13}C NMR Spectrum of Compound 11 (101 MHz, $CDCl_3$)



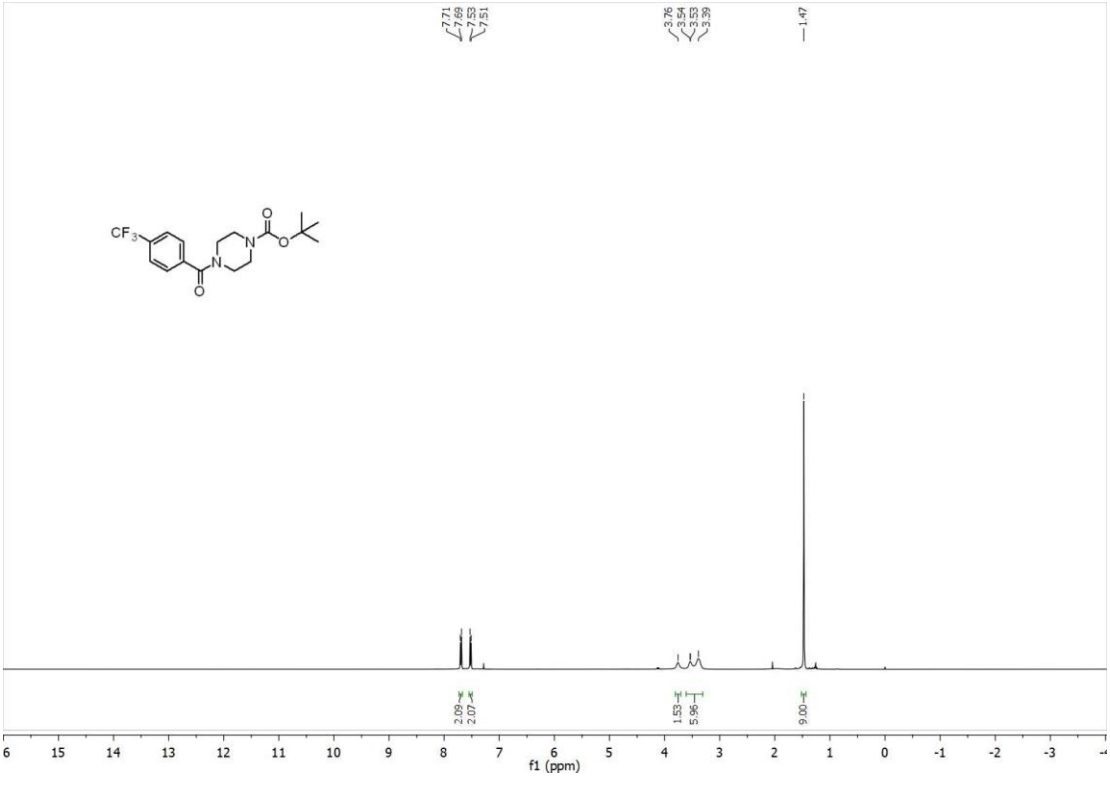
^{1}H NMR Spectrum of Compound 12 (400 MHz, $CDCl_3$)



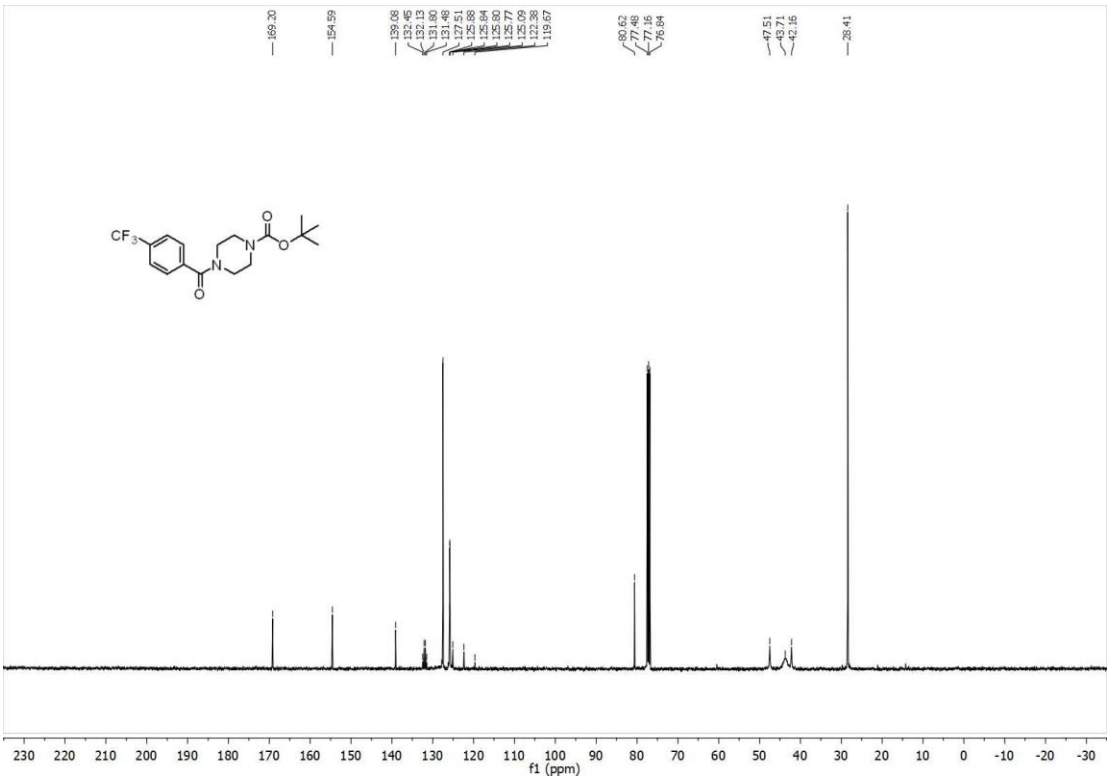
^{13}C NMR Spectrum of Compound 12 (101 MHz, $CDCl_3$)



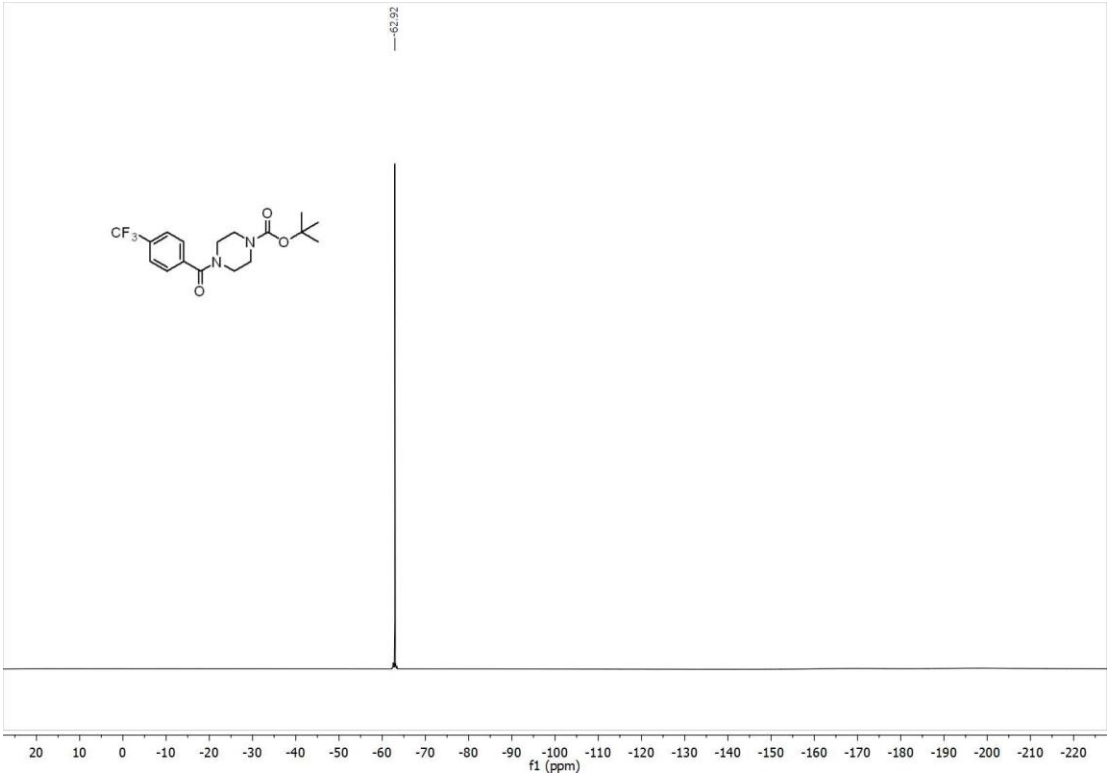
^{19}F NMR Spectrum of Compound 12 (376 MHz, $CDCl_3$)



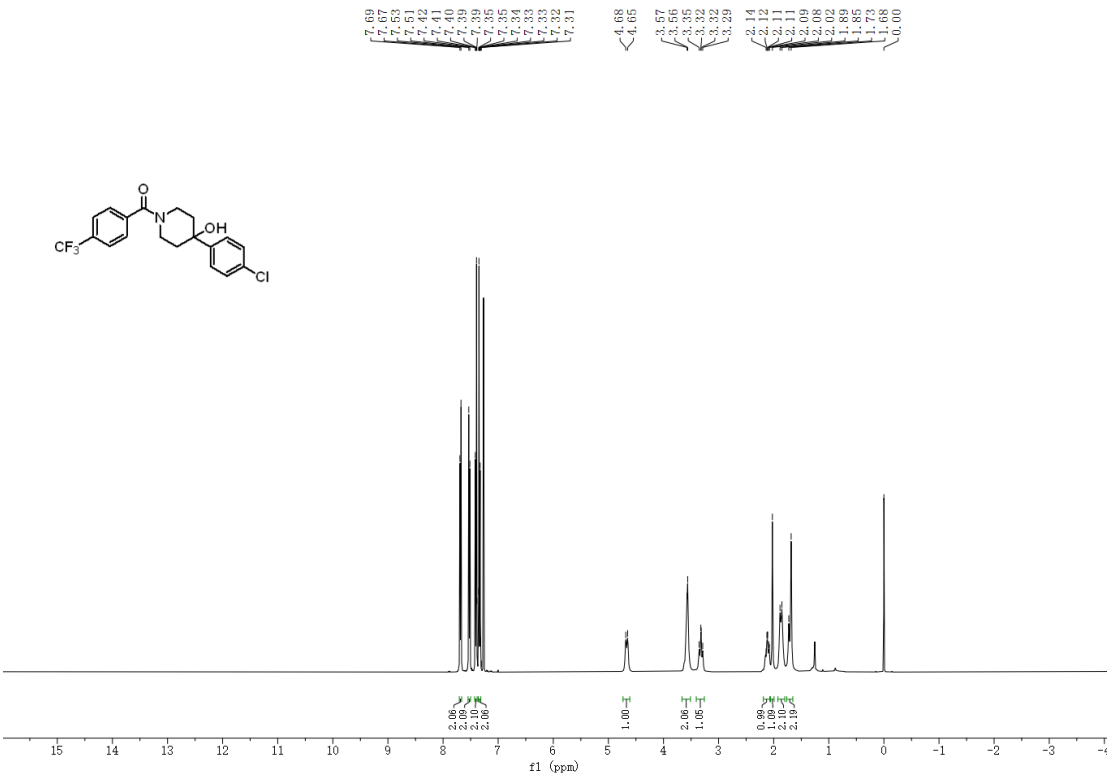
^{1}H NMR Spectrum of Compound 13 (400 MHz, $CDCl_3$)



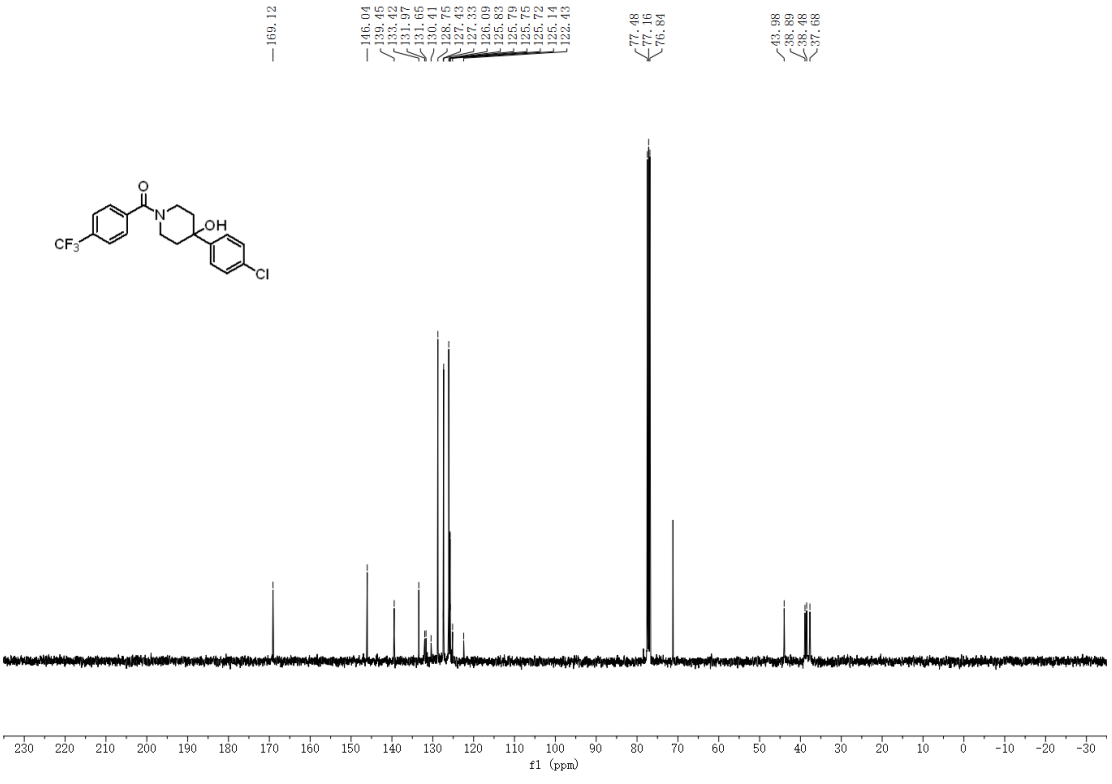
^{13}C NMR Spectrum of Compound 13 (101 MHz, $CDCl_3$)



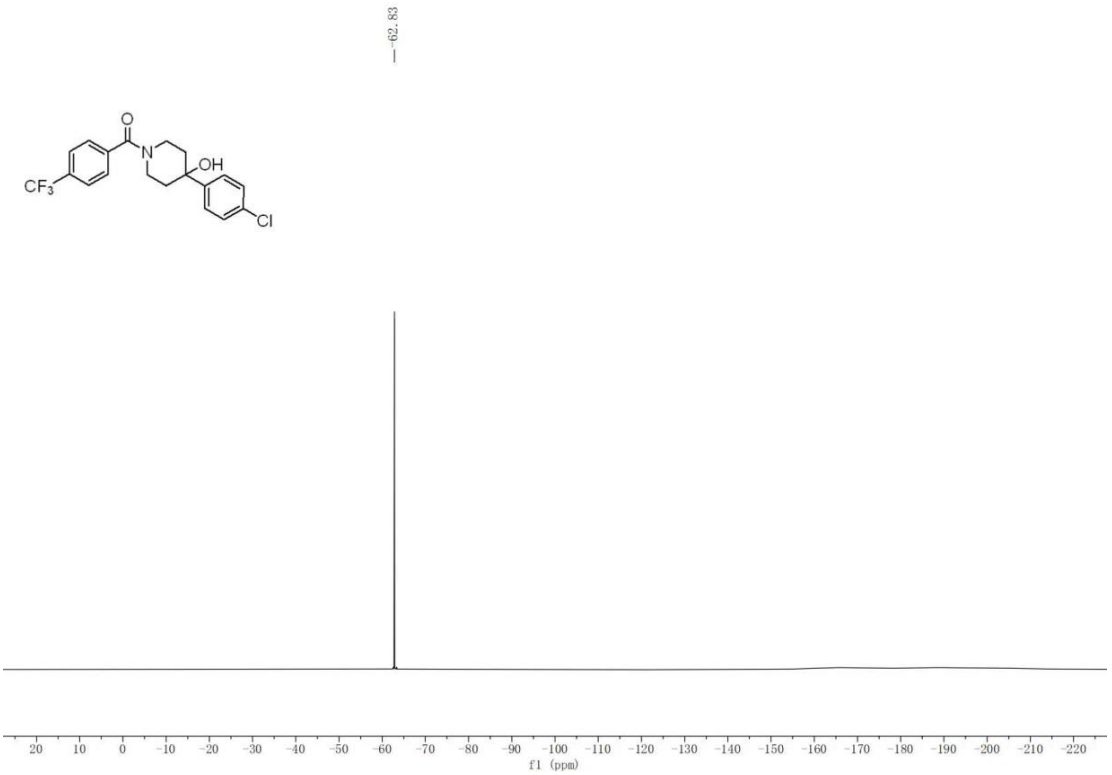
^{19}F NMR Spectrum of Compound 13 (376 MHz, $CDCl_3$)



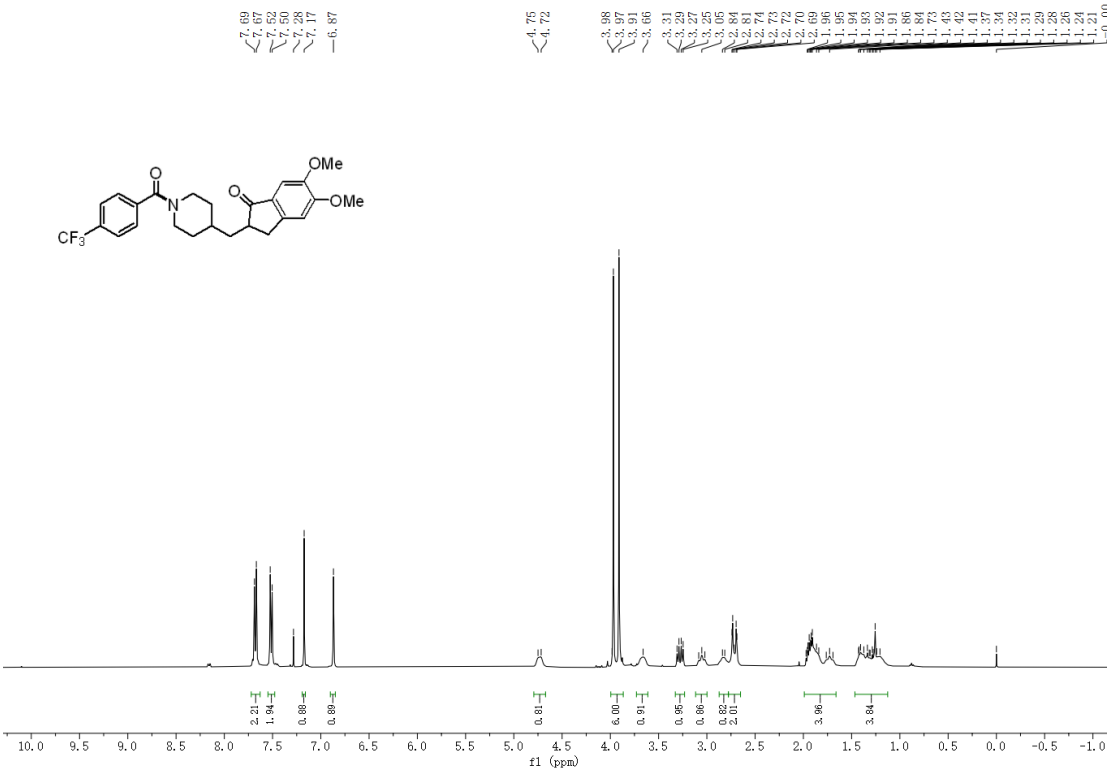
^{1}H NMR Spectrum of Compound 14 (400 MHz, $CDCl_3$)



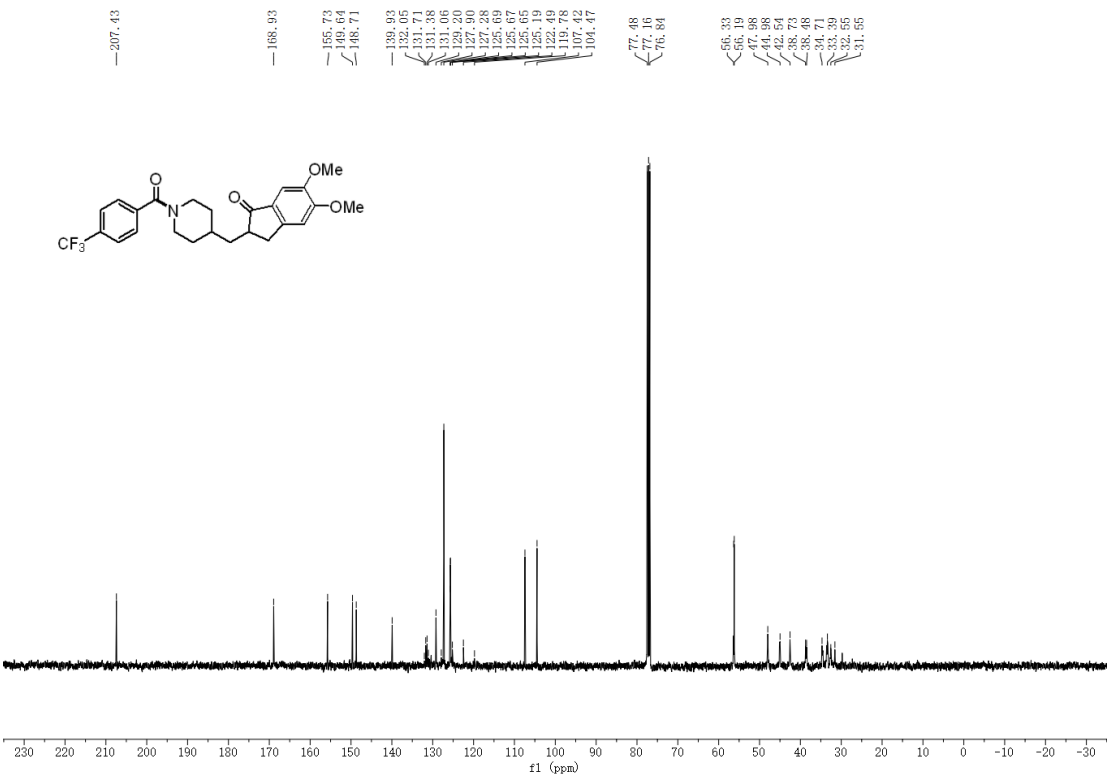
^{13}C NMR Spectrum of Compound 14 (101 MHz, $CDCl_3$)



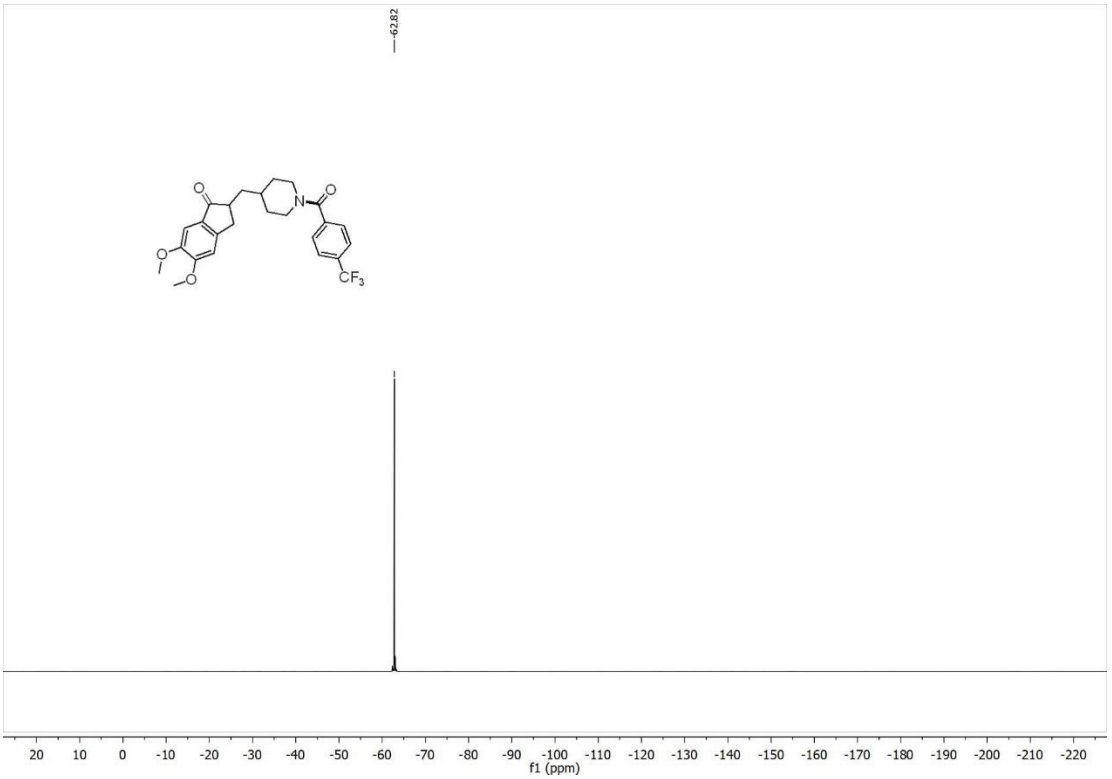
^{19}F NMR Spectrum of Compound 14 (376 MHz, $CDCl_3$)



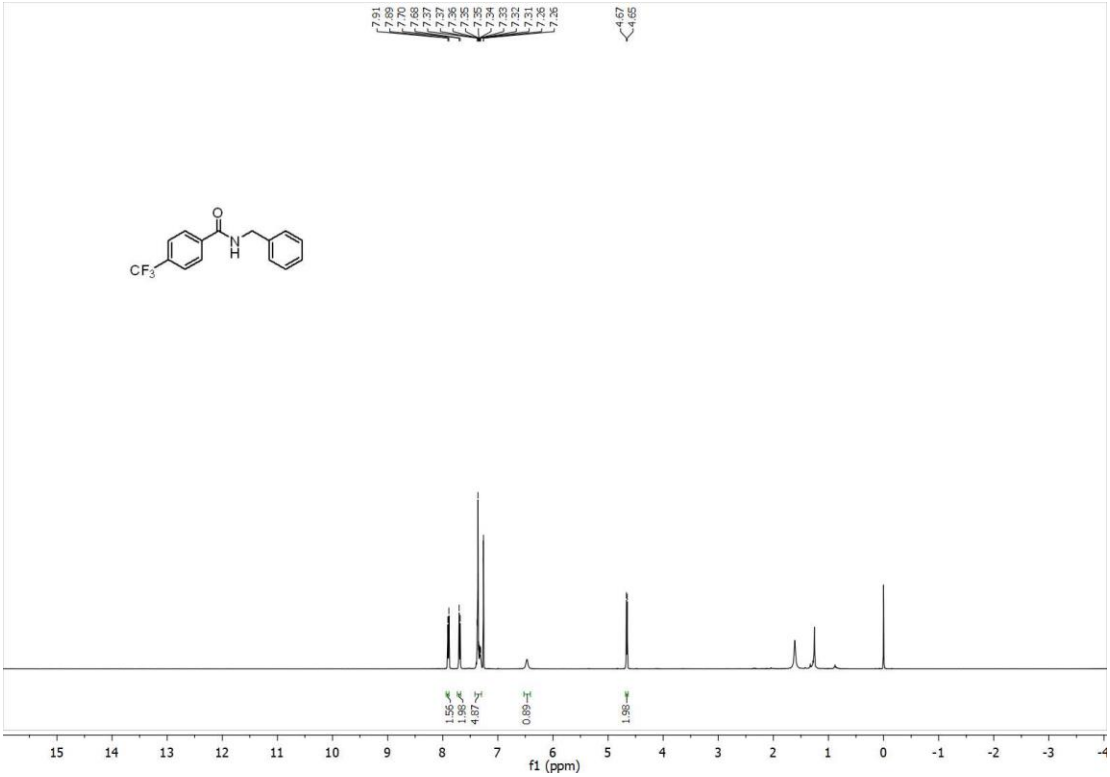
^{1}H NMR Spectrum of Compound 15 (400 MHz, $CDCl_3$)



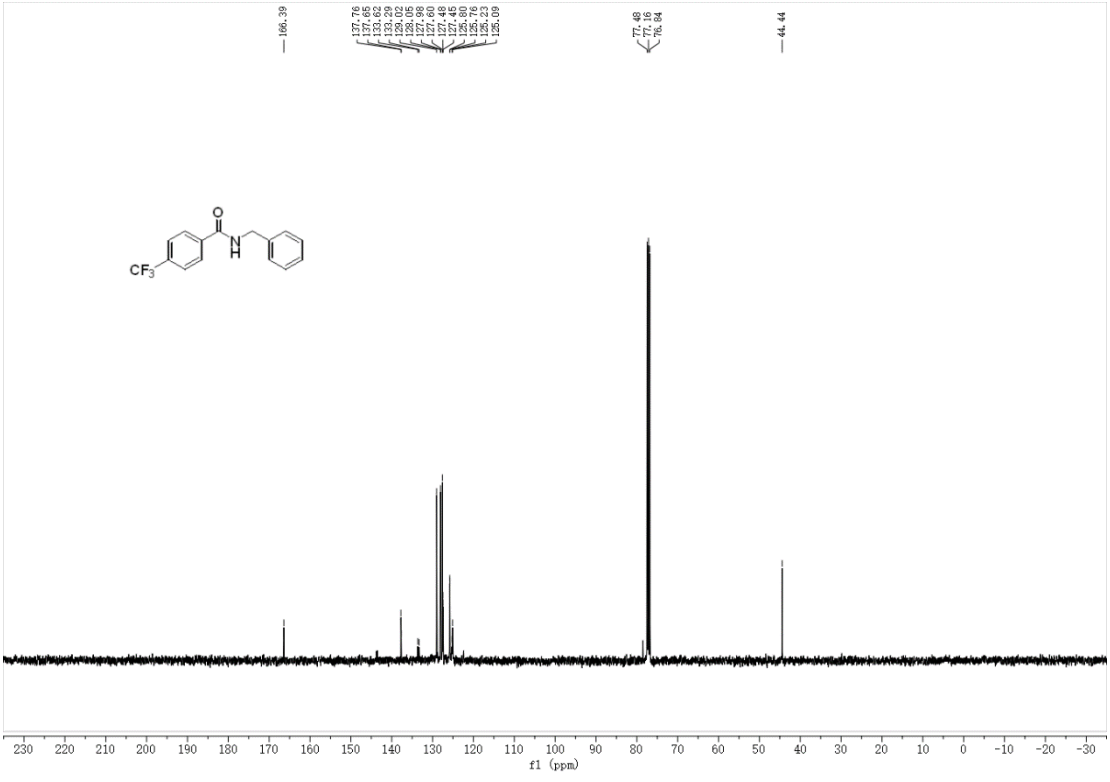
^{13}C NMR Spectrum of Compound 15 (101 MHz, $CDCl_3$)



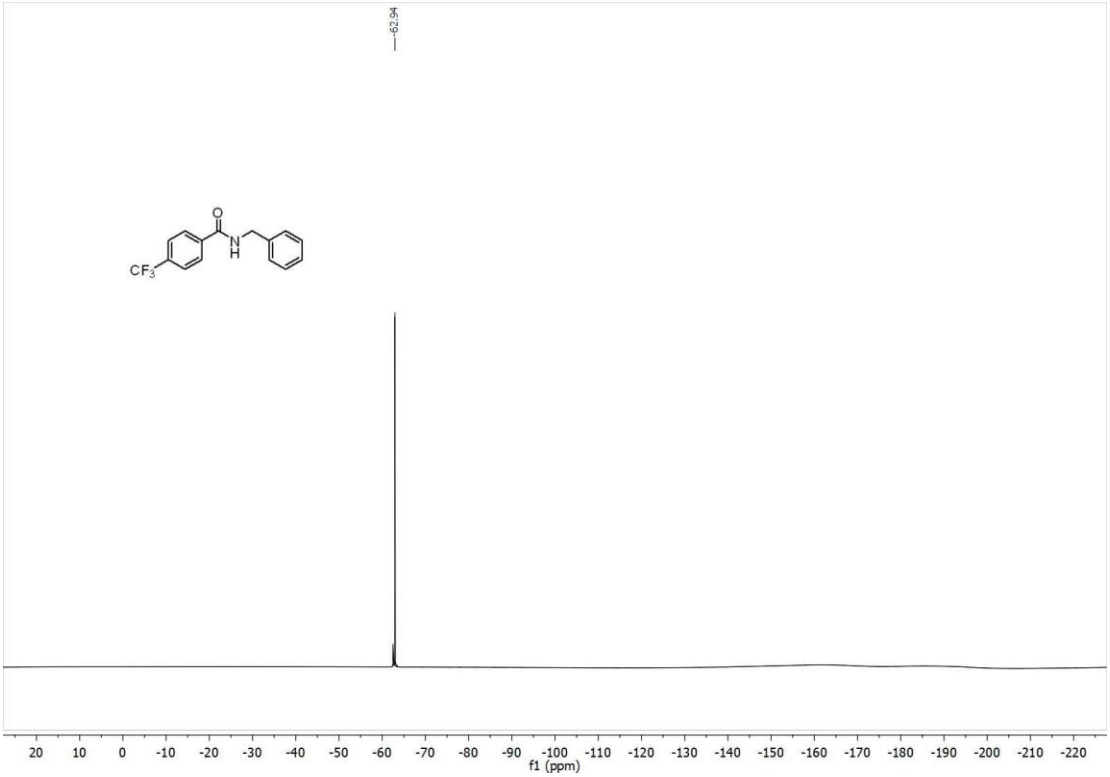
^{19}F NMR Spectrum of Compound 15 (376 MHz, $CDCl_3$)



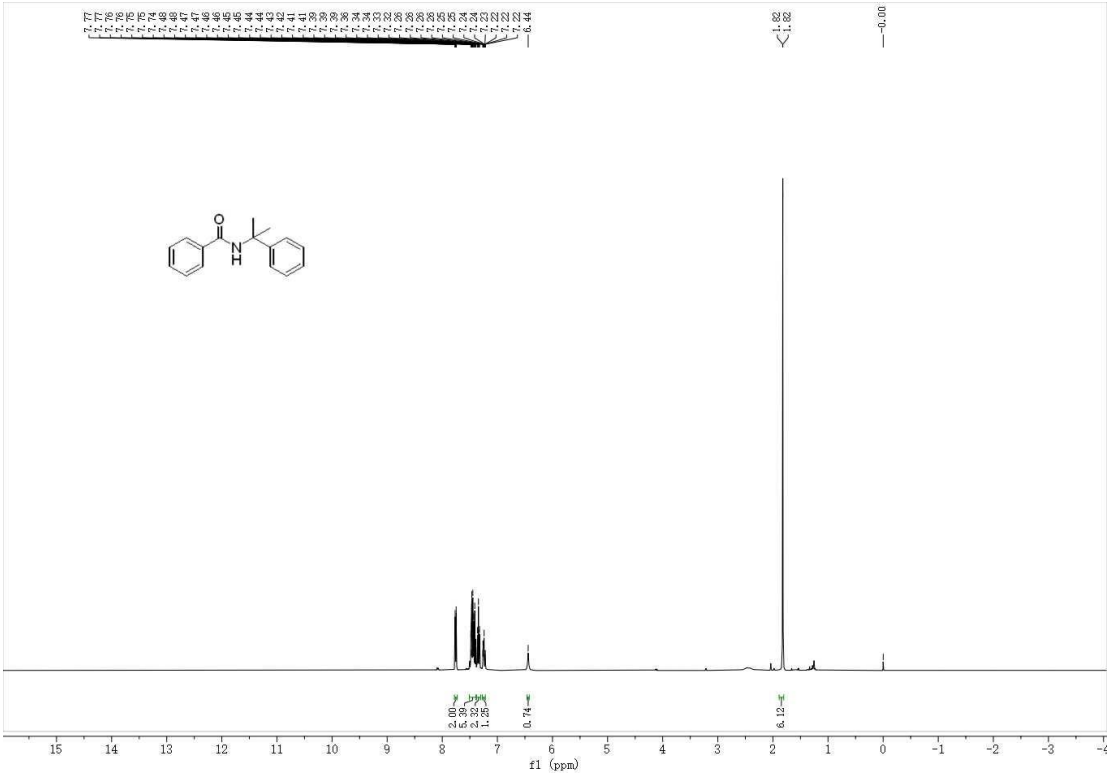
^{1}H NMR Spectrum of Compound 16 (400 MHz, $CDCl_3$)



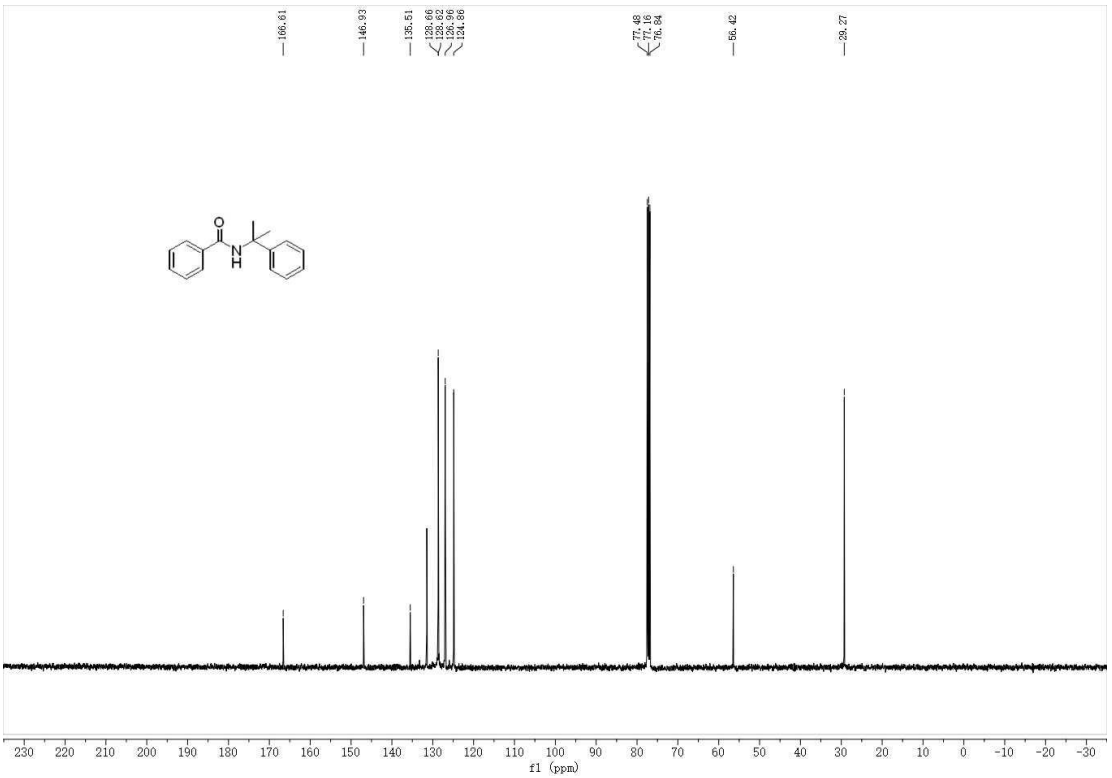
^{13}C NMR Spectrum of Compound 16 (101 MHz, $CDCl_3$)



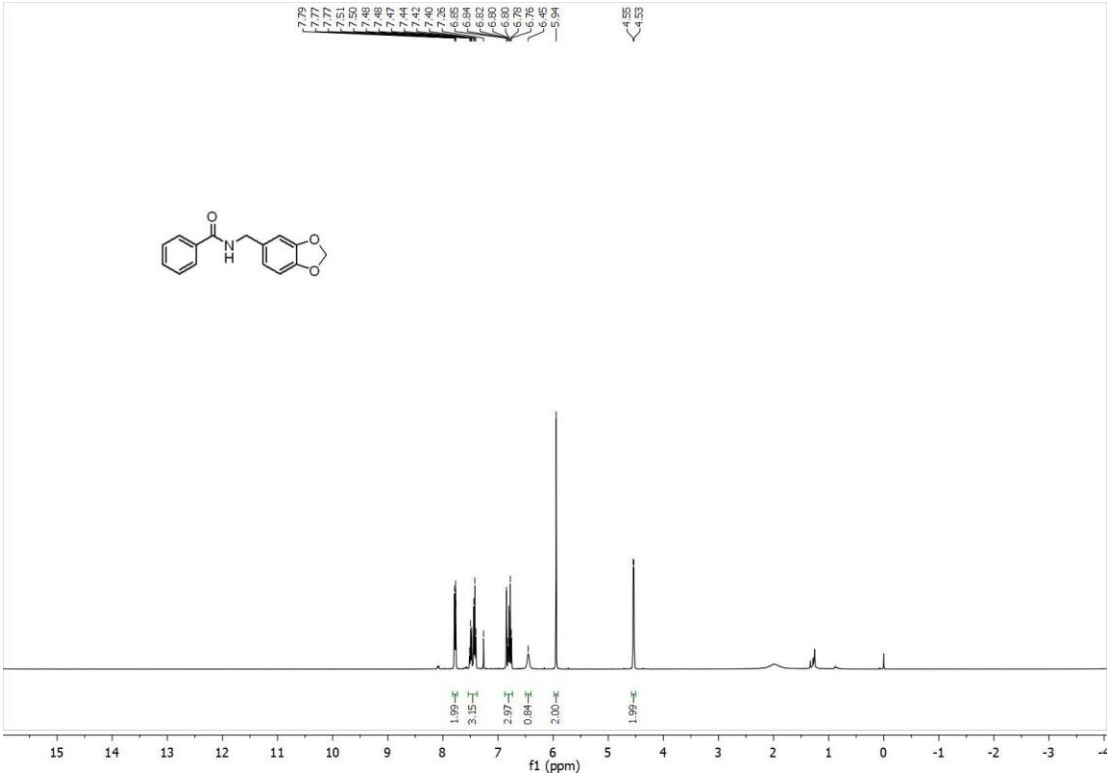
^{13}C NMR Spectrum of Compound 16 (376 MHz, $CDCl_3$)



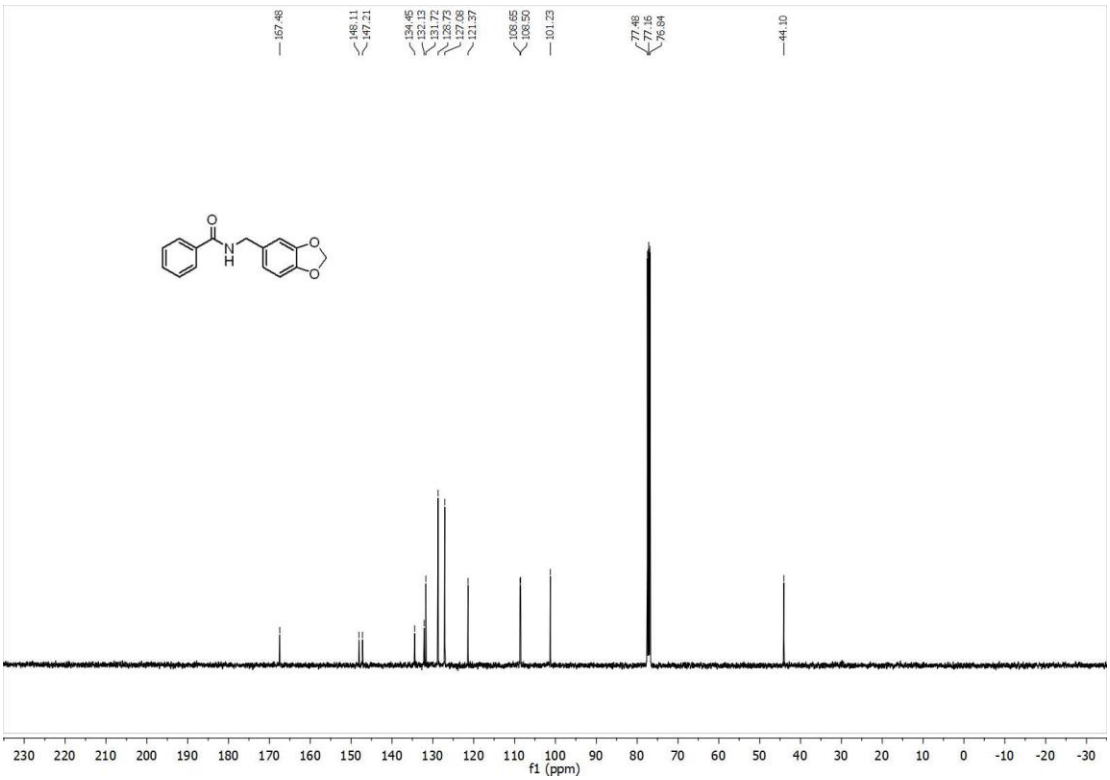
^{1}H NMR Spectrum of Compound 17 (400 MHz, $CDCl_3$)



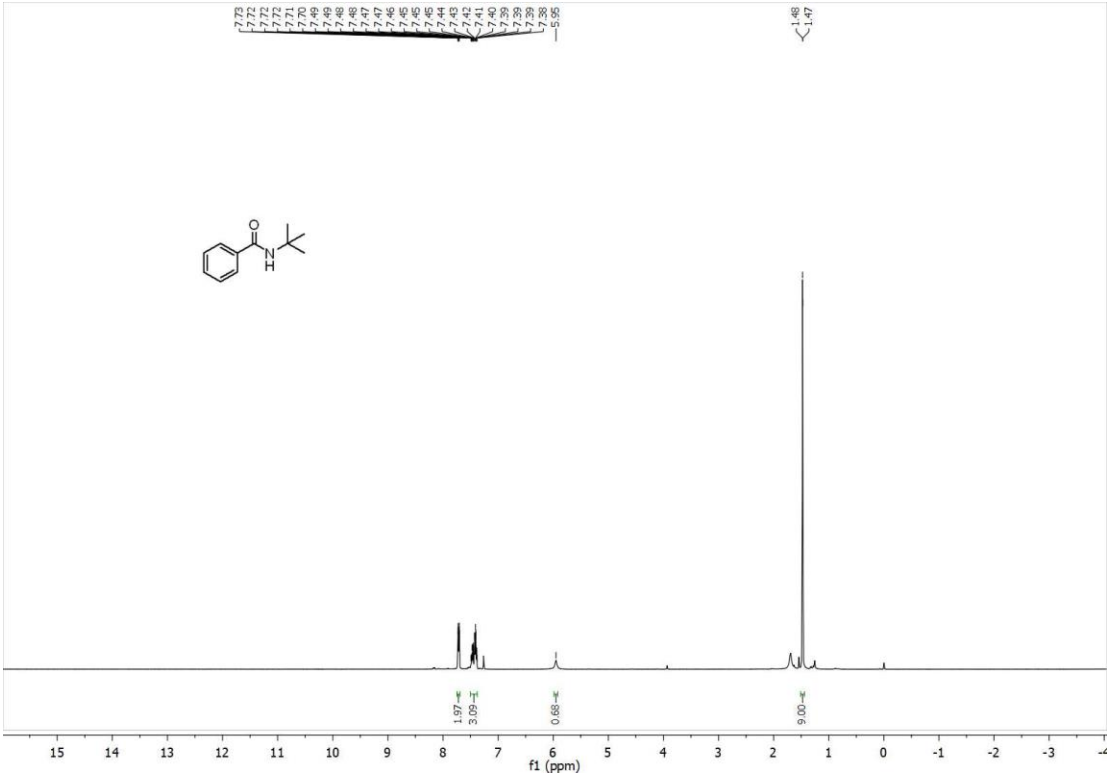
^{13}C NMR Spectrum of Compound 17 (101 MHz, $CDCl_3$)



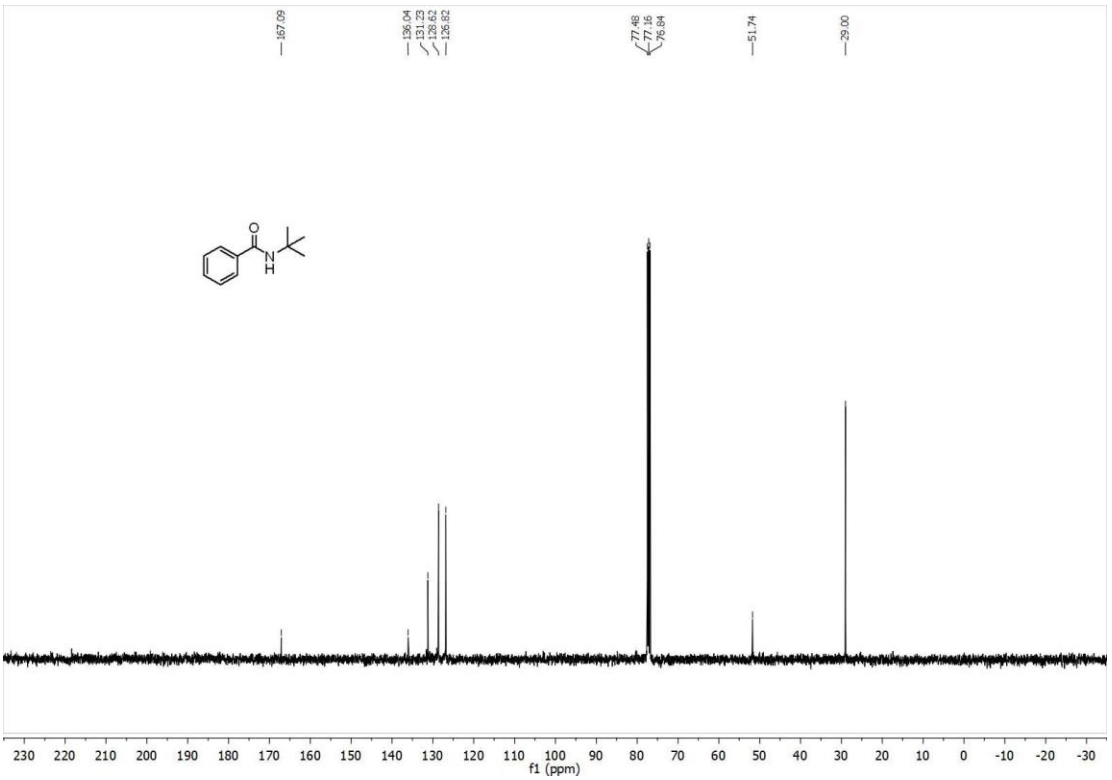
^{1}H NMR Spectrum of Compound 18 (400 MHz, $CDCl_3$)



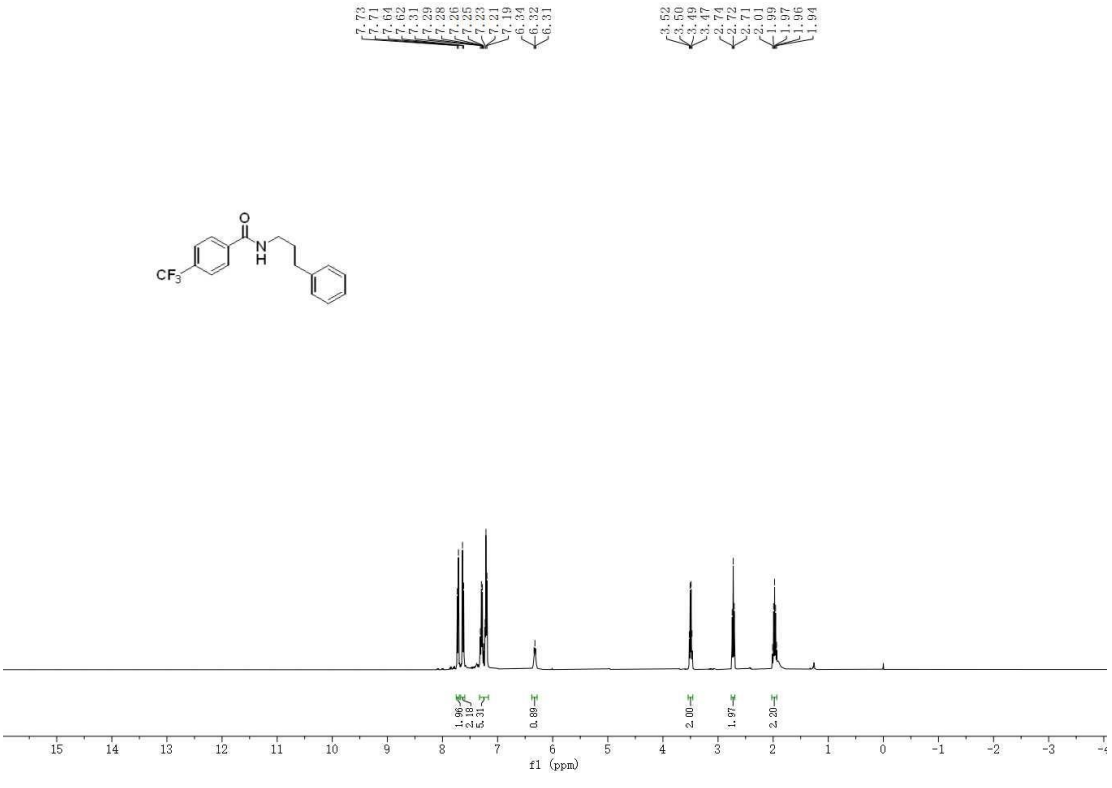
^{13}C NMR Spectrum of Compound 18 (101 MHz, $CDCl_3$)



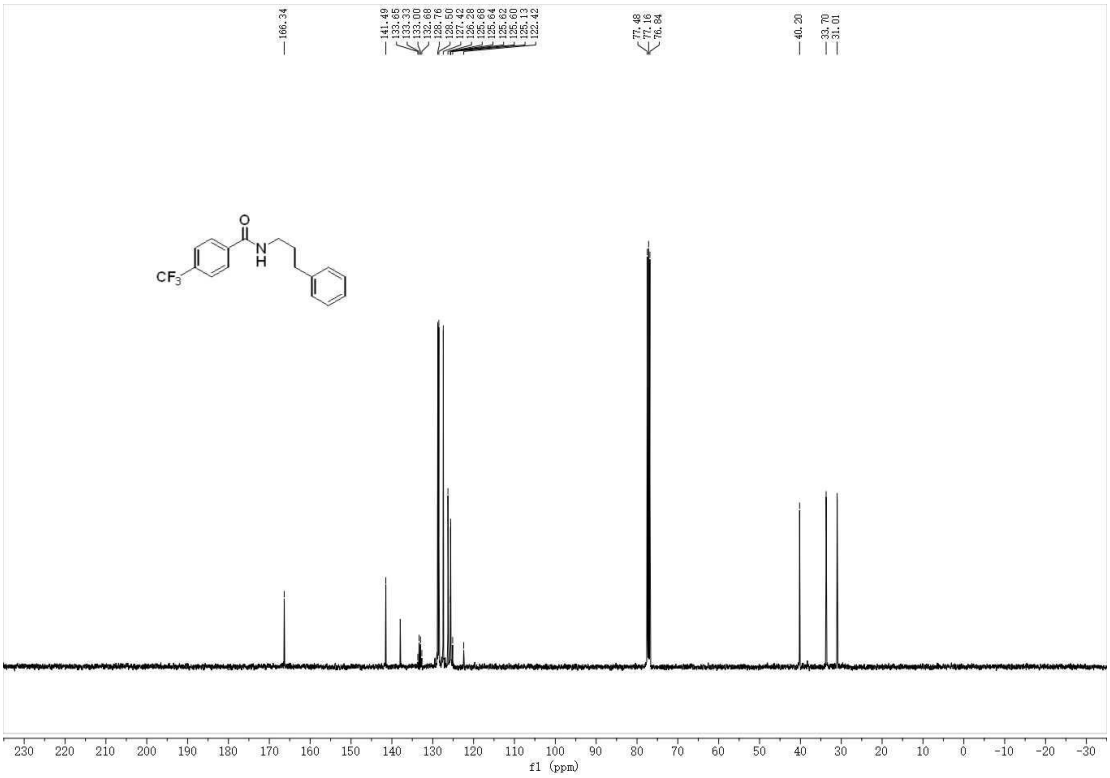
^{1}H NMR Spectrum of Compound 19 (400 MHz, $CDCl_3$)



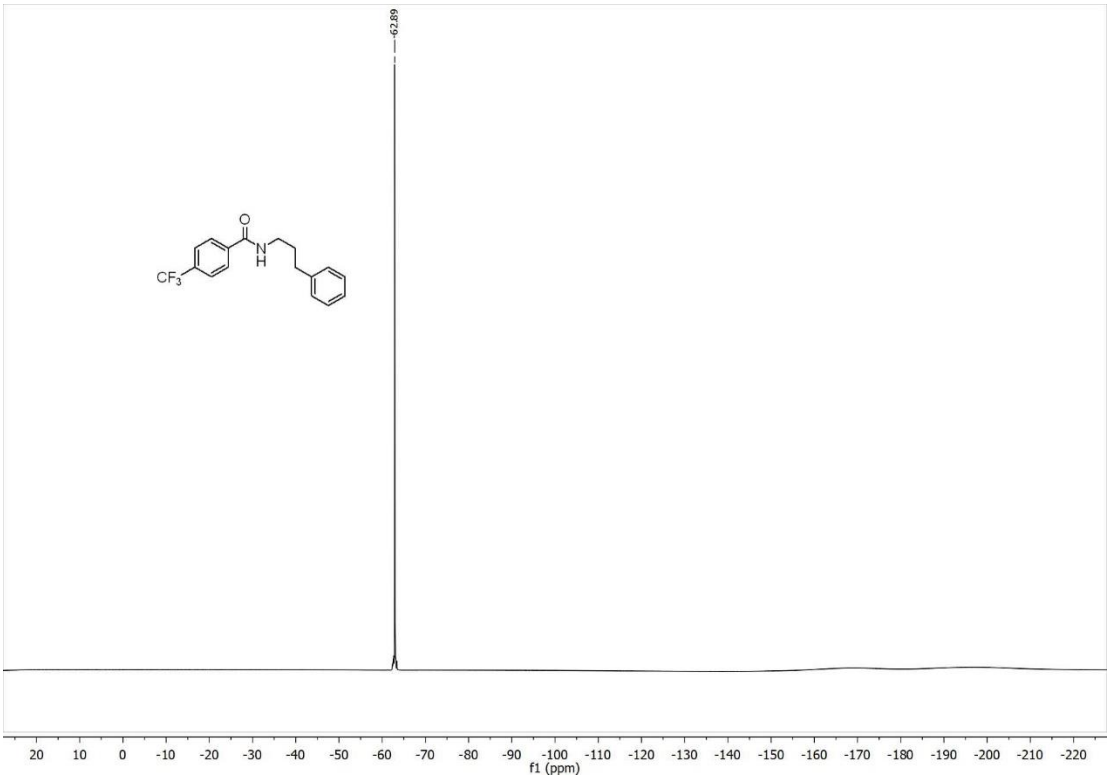
^{13}C NMR Spectrum of Compound 19 (101 MHz, $CDCl_3$)



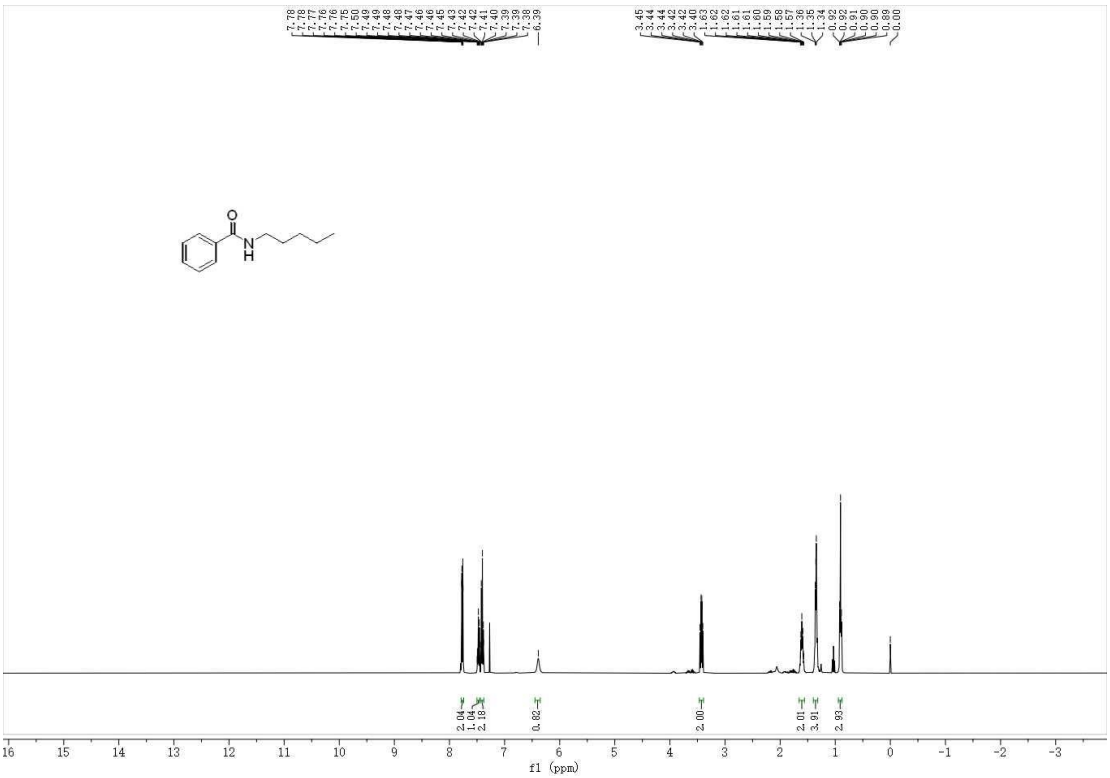
^{1}H NMR Spectrum of Compound 20 (400 MHz, $CDCl_3$)



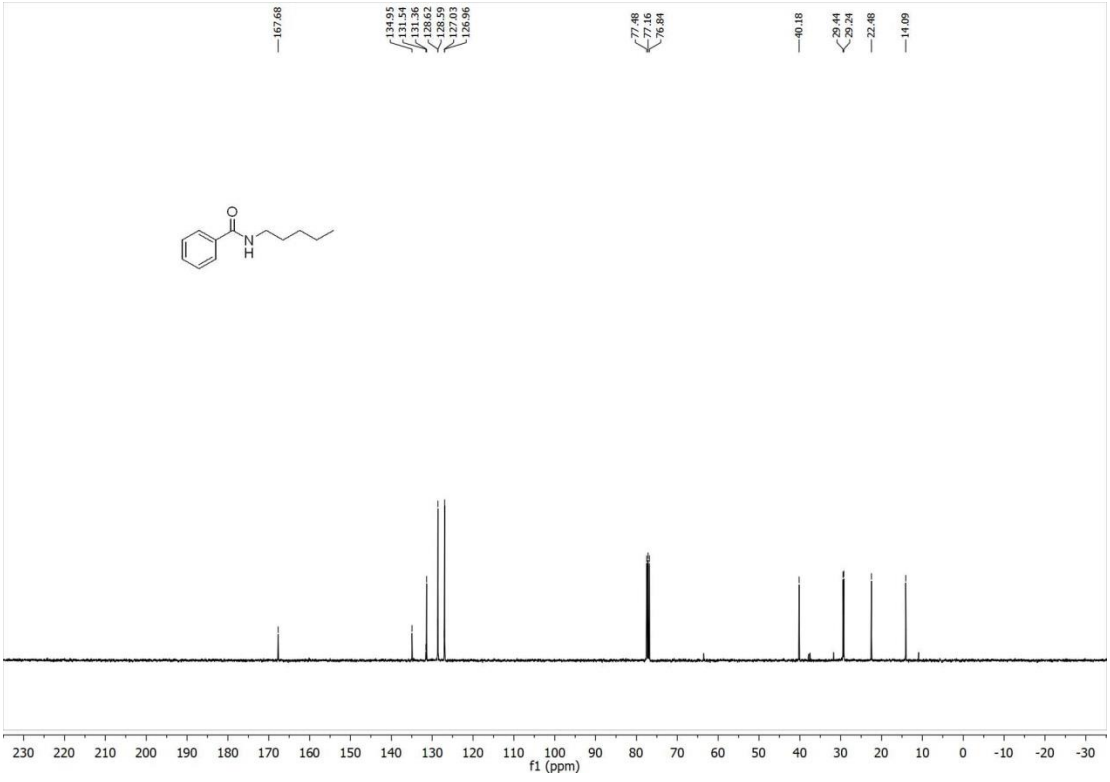
^{13}C NMR Spectrum of Compound 20 (101 MHz, $CDCl_3$)



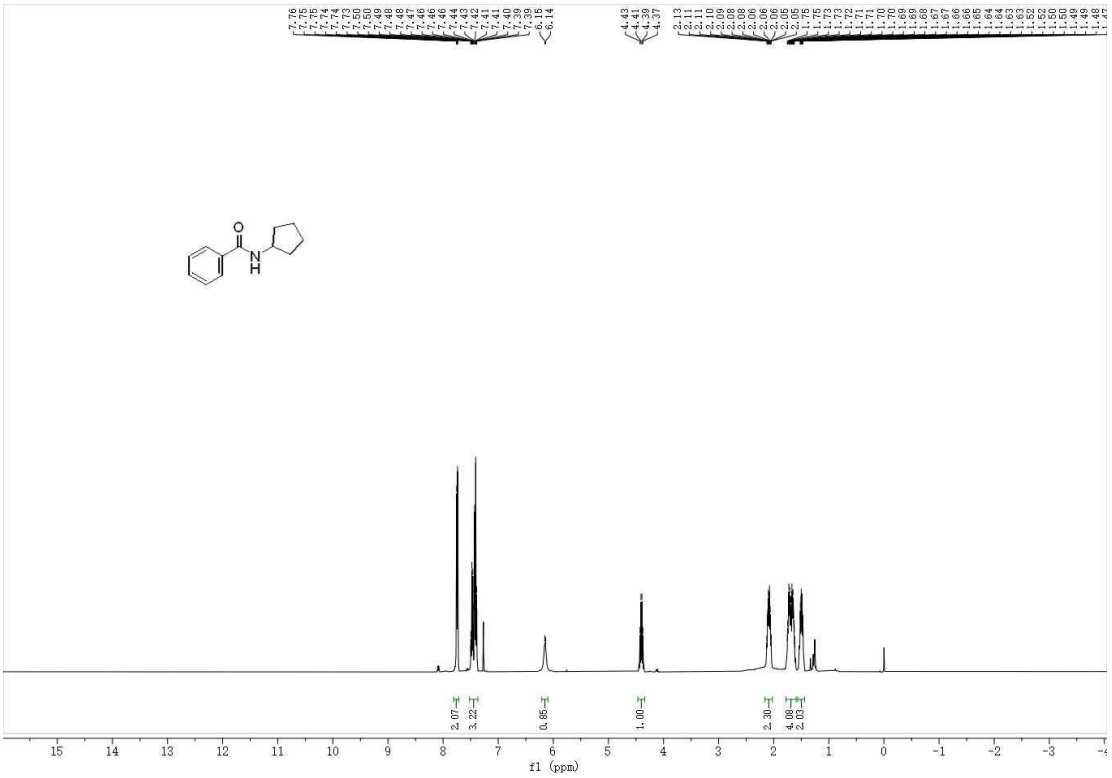
^{19}F NMR Spectrum of Compound 20 (376 MHz, $CDCl_3$)



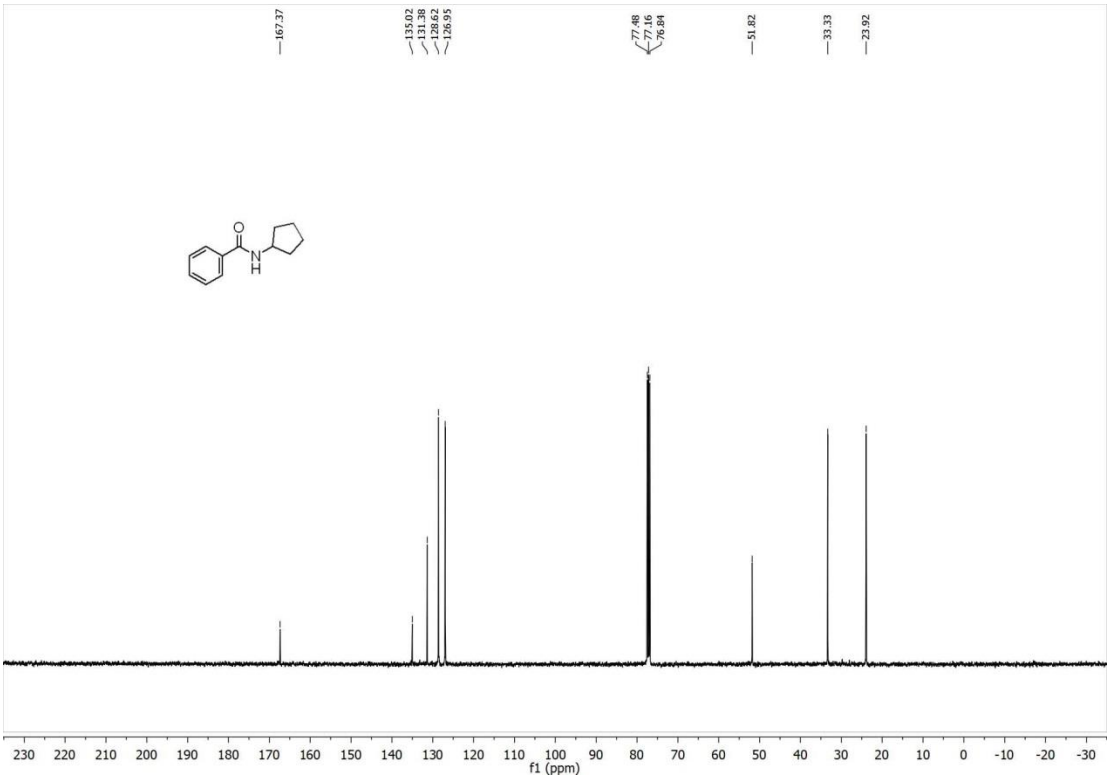
^{1}H NMR Spectrum of Compound 21 (400 MHz, $CDCl_3$)



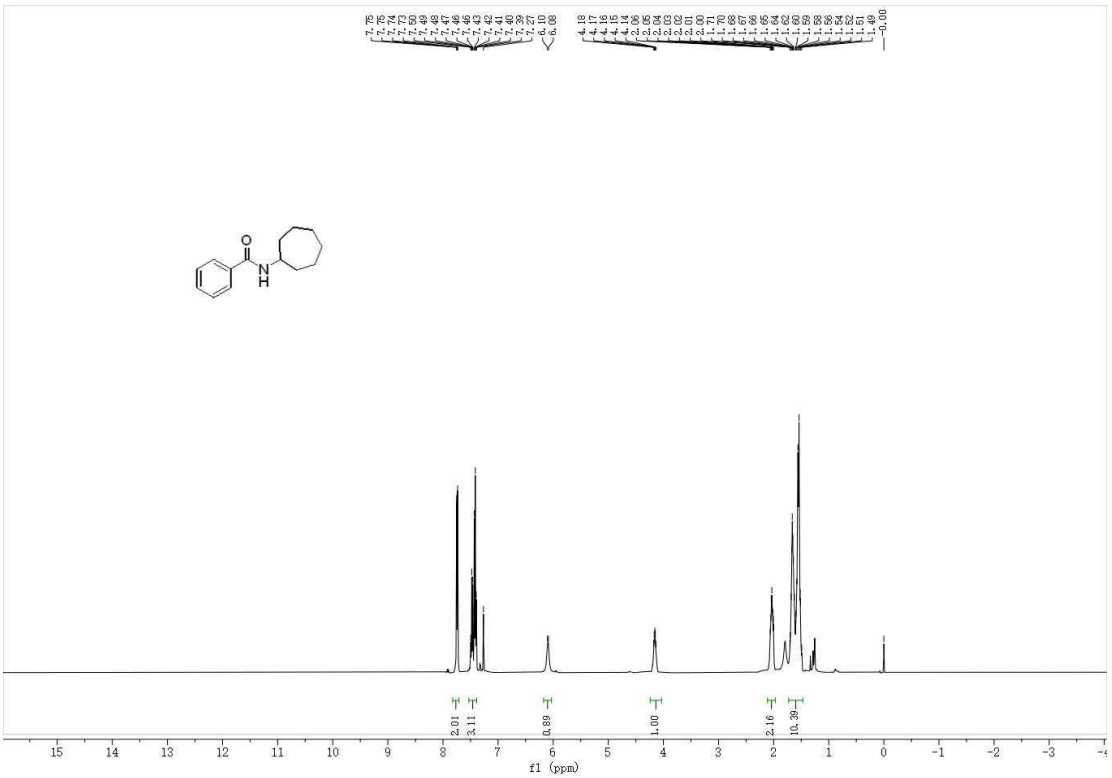
^{13}C NMR Spectrum of Compound 21 (101 MHz, $CDCl_3$)



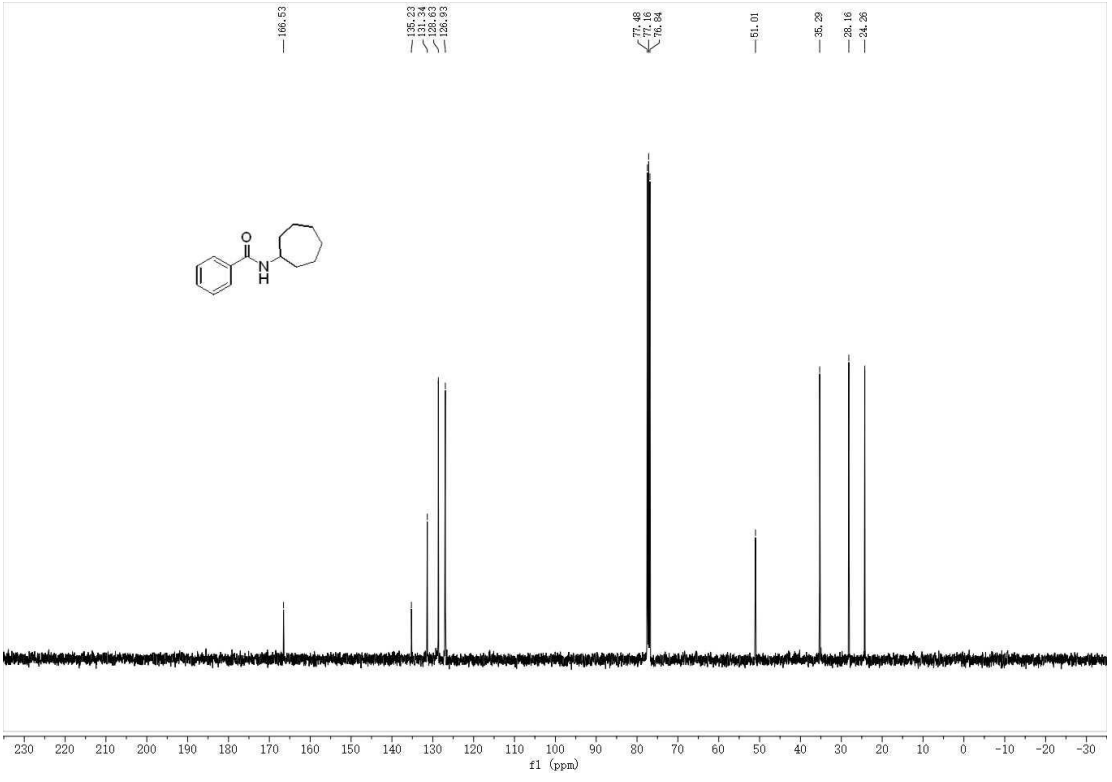
^{1}H NMR Spectrum of Compound 22 (400 MHz, $CDCl_3$)



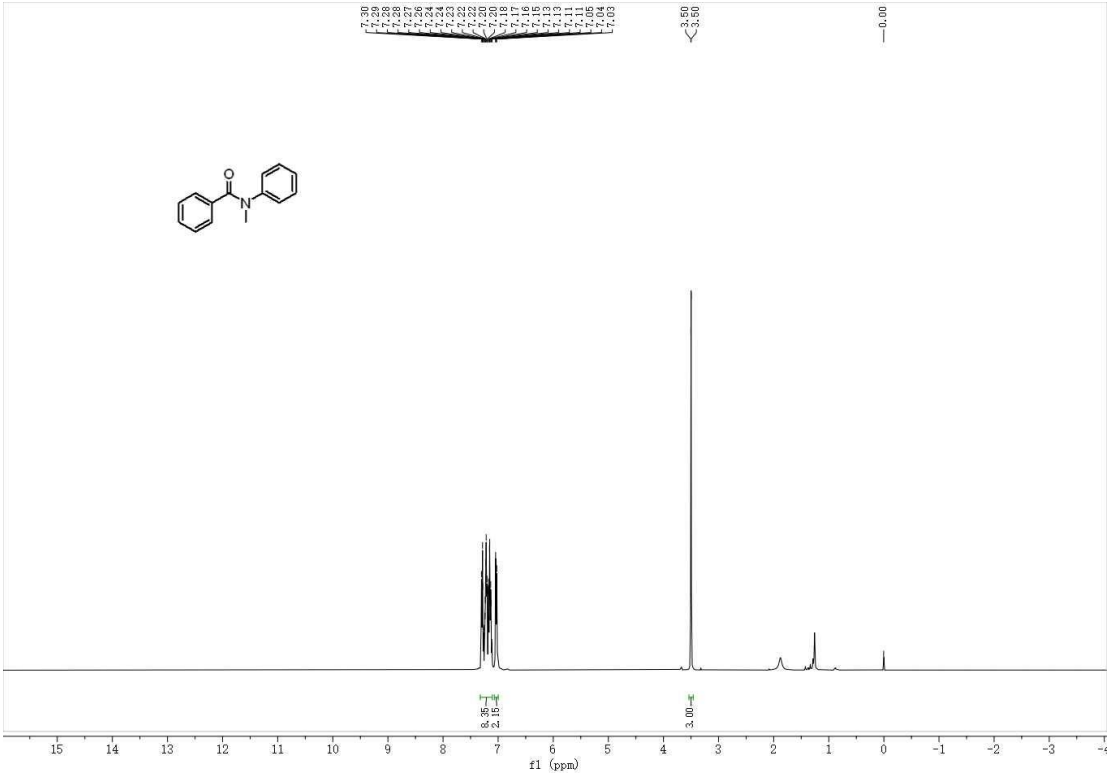
^{13}C NMR Spectrum of Compound 22 (101 MHz, $CDCl_3$)



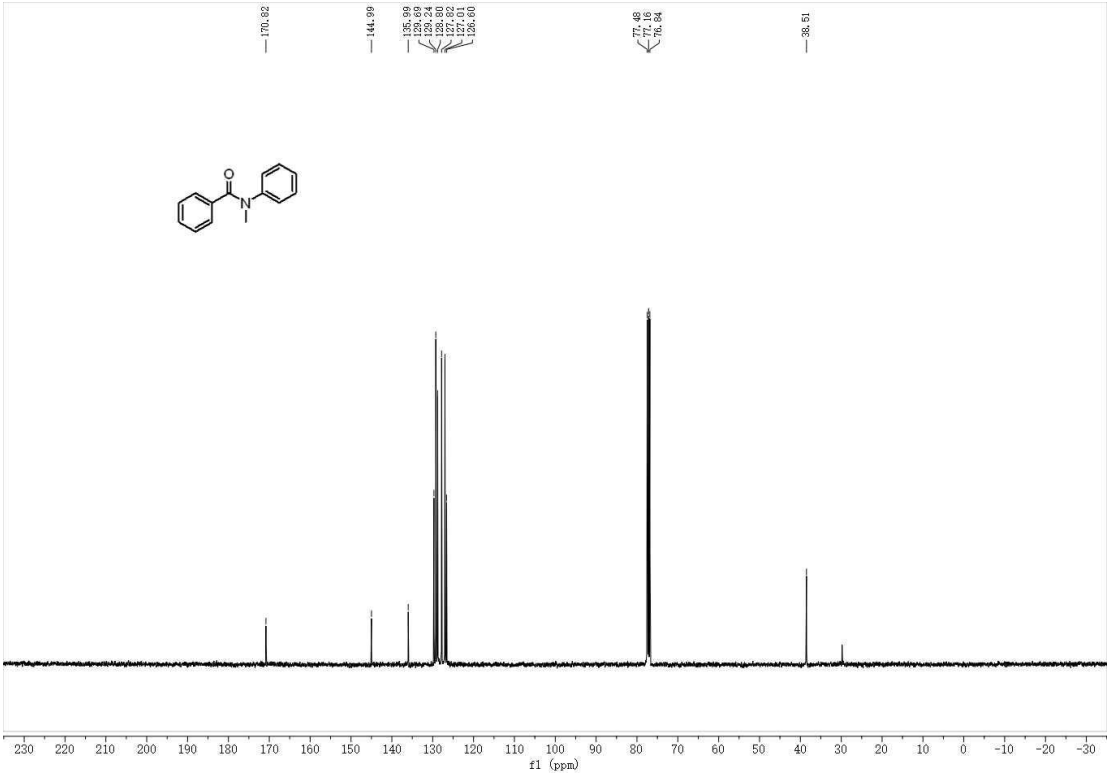
^{1}H NMR Spectrum of Compound 23 (400 MHz, $CDCl_3$)



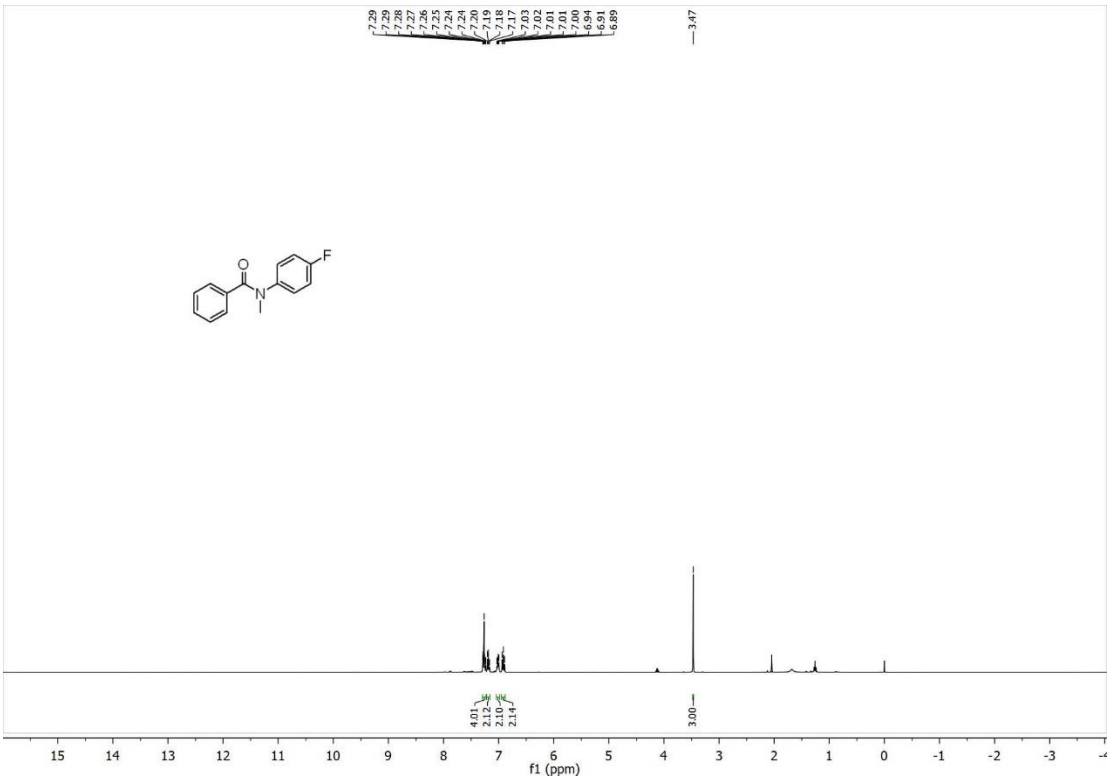
^{13}C NMR Spectrum of Compound 23 (101 MHz, $CDCl_3$)



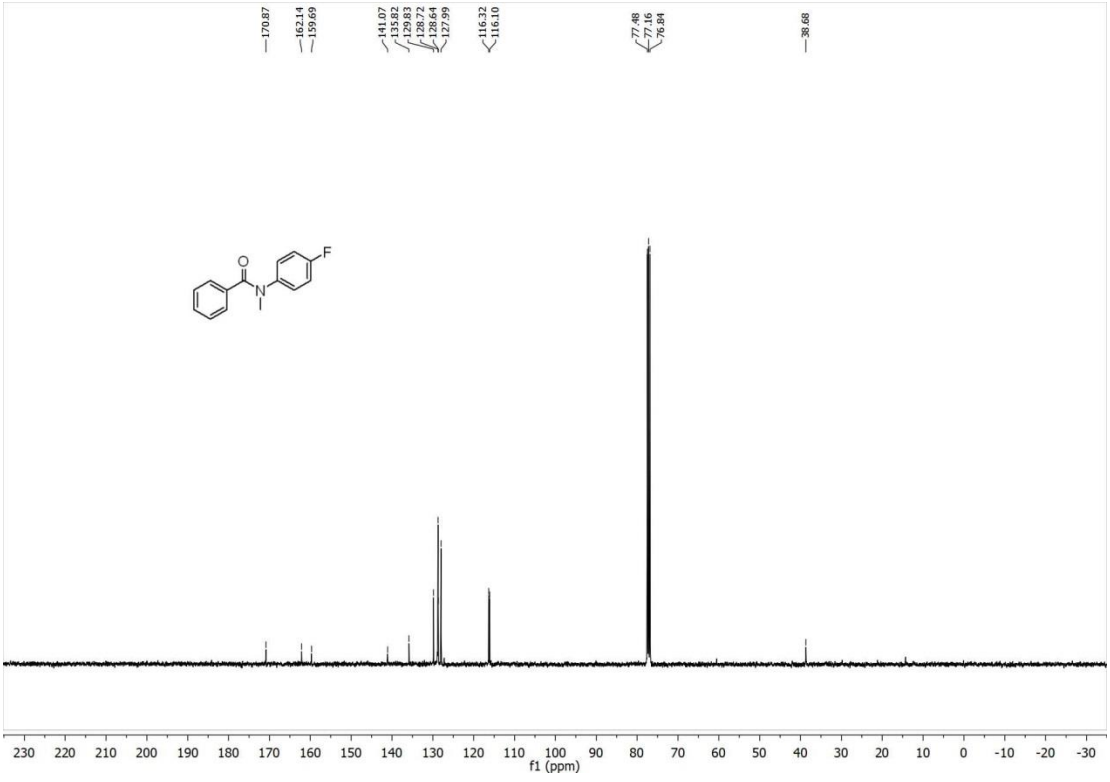
^{1}H NMR Spectrum of Compound 24 (400 MHz, $CDCl_3$)



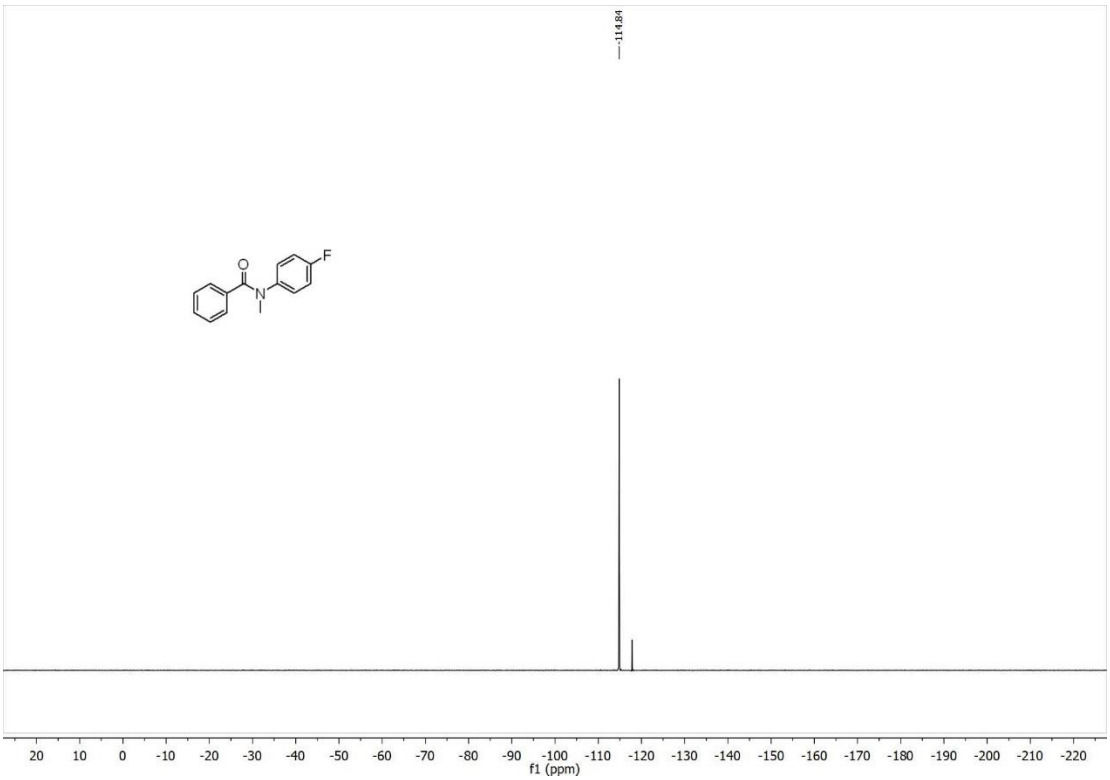
^{13}C NMR Spectrum of Compound 24 (101 MHz, $CDCl_3$)



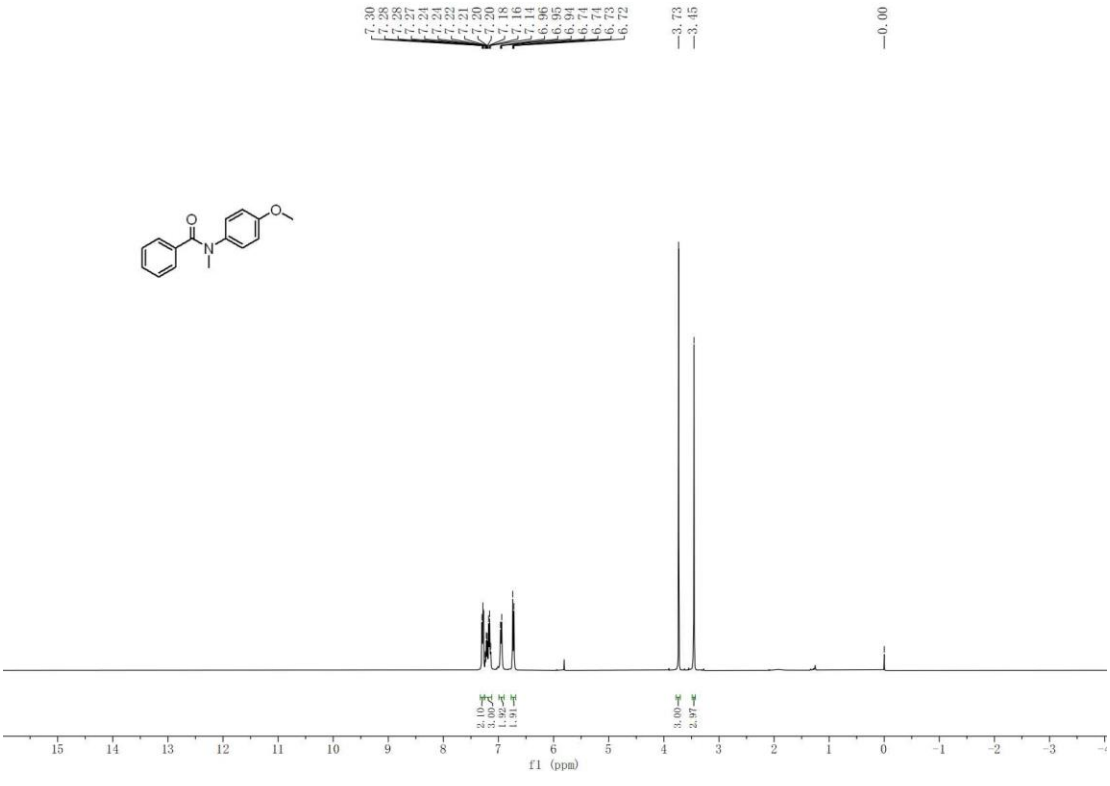
[1]H NMR Spectrum of Compound 25 (400 MHz, $CDCl_3$)



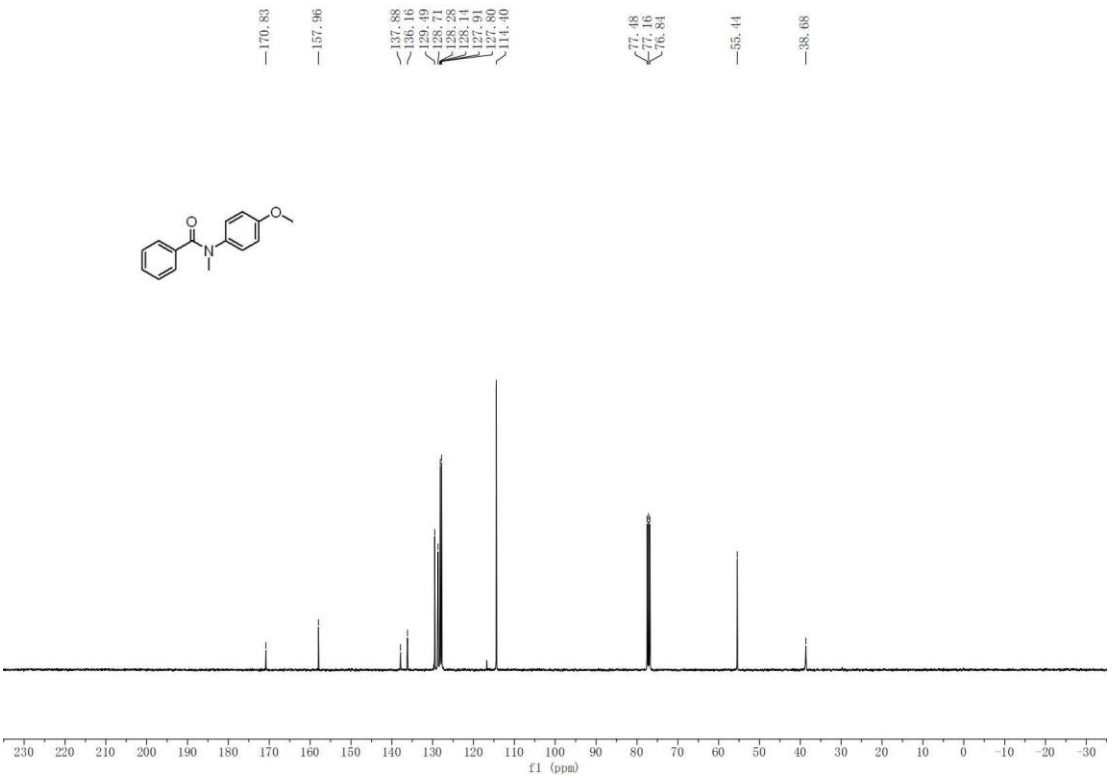
[13]C NMR Spectrum of Compound 25 (101 MHz, $CDCl_3$)



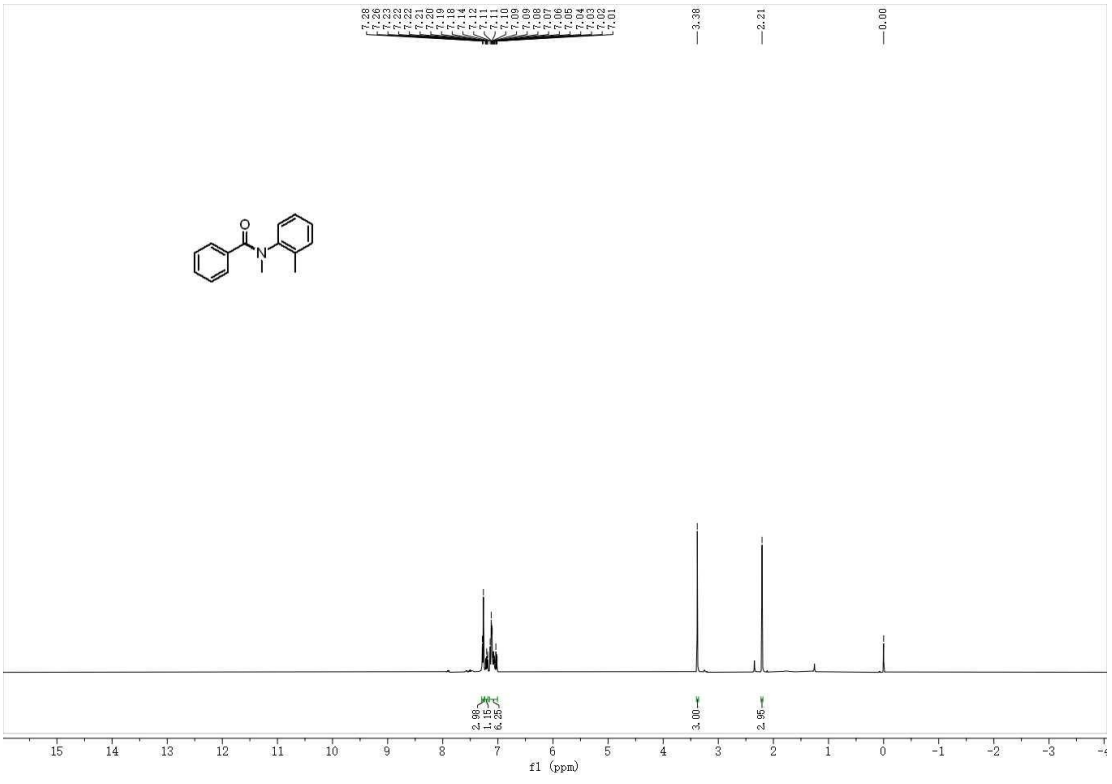
^{19}F NMR Spectrum of Compound 25 (376 MHz, $CDCl_3$)



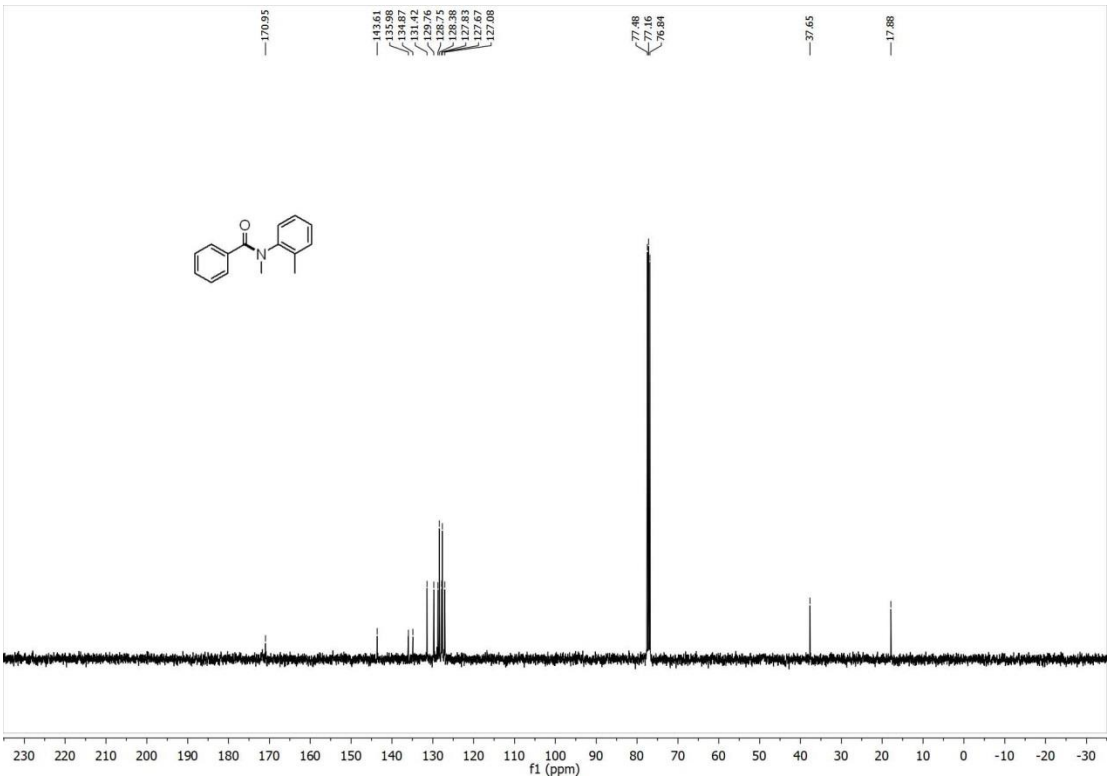
^{1}H NMR Spectrum of Compound 26 (400 MHz, $CDCl_3$)



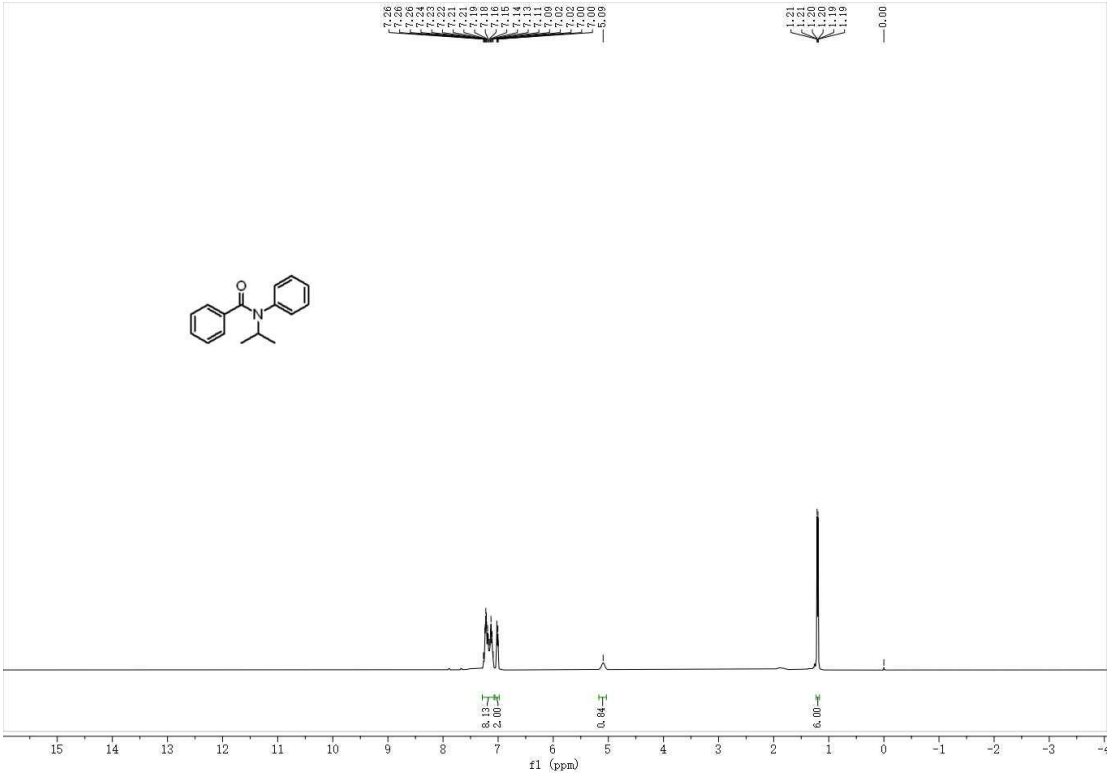
^{13}C NMR Spectrum of Compound 26 (101 MHz, $CDCl_3$)



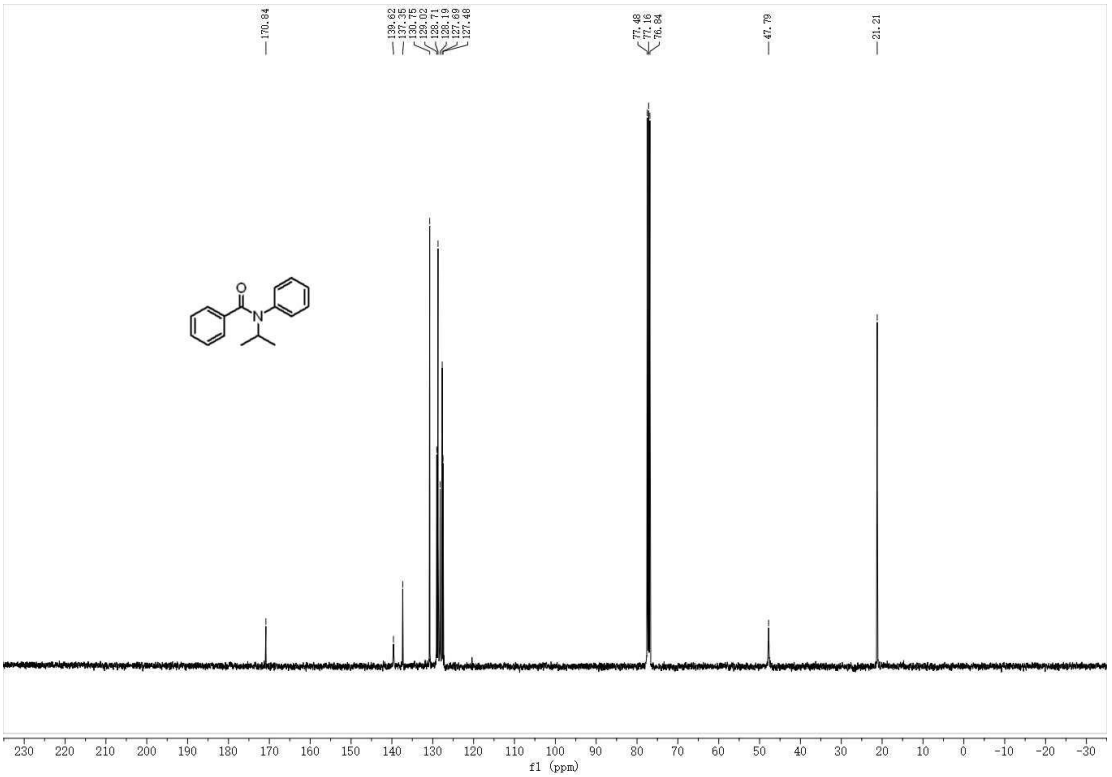
^{1}H NMR Spectrum of Compound 27 (400 MHz, $CDCl_3$)



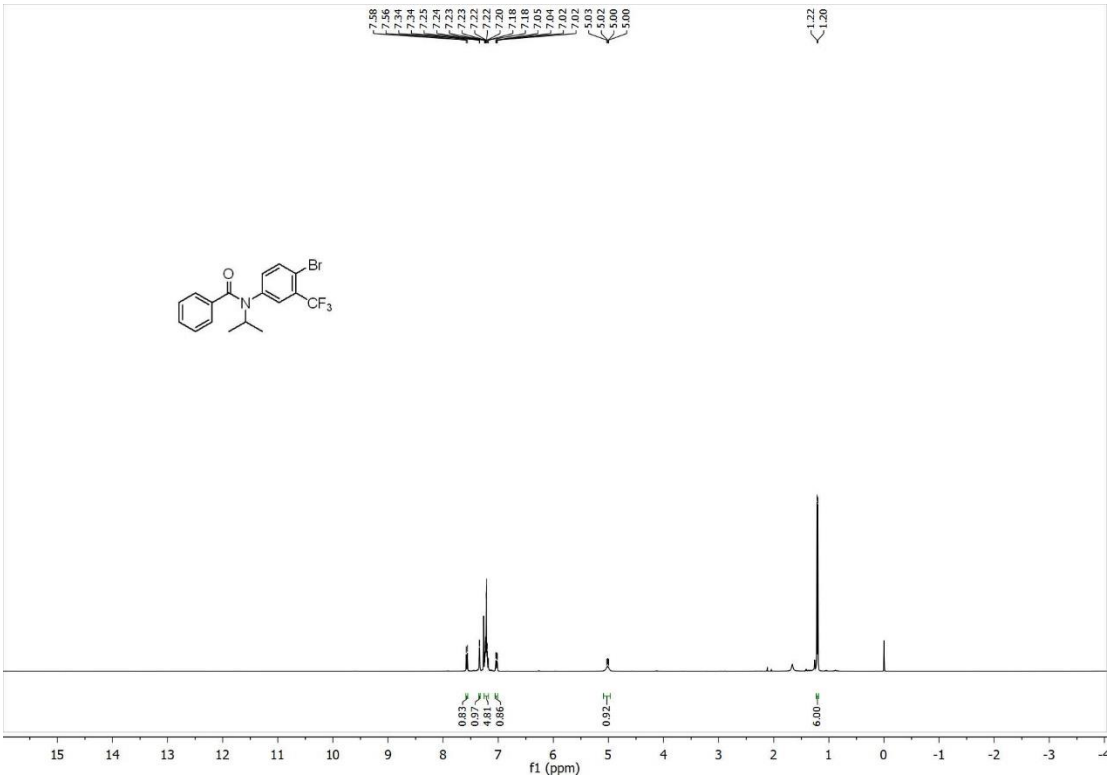
^{13}C NMR Spectrum of Compound 27 (101 MHz, $CDCl_3$)



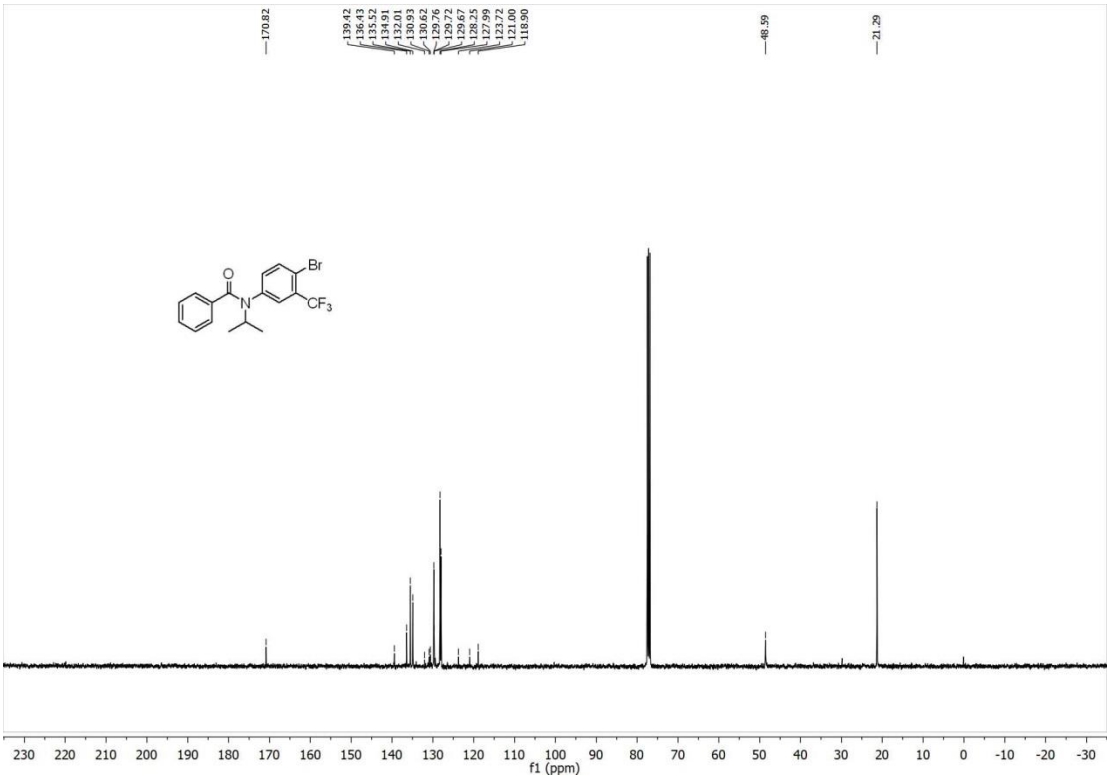
^{1}H NMR Spectrum of Compound 28 (400 MHz, $CDCl_3$)



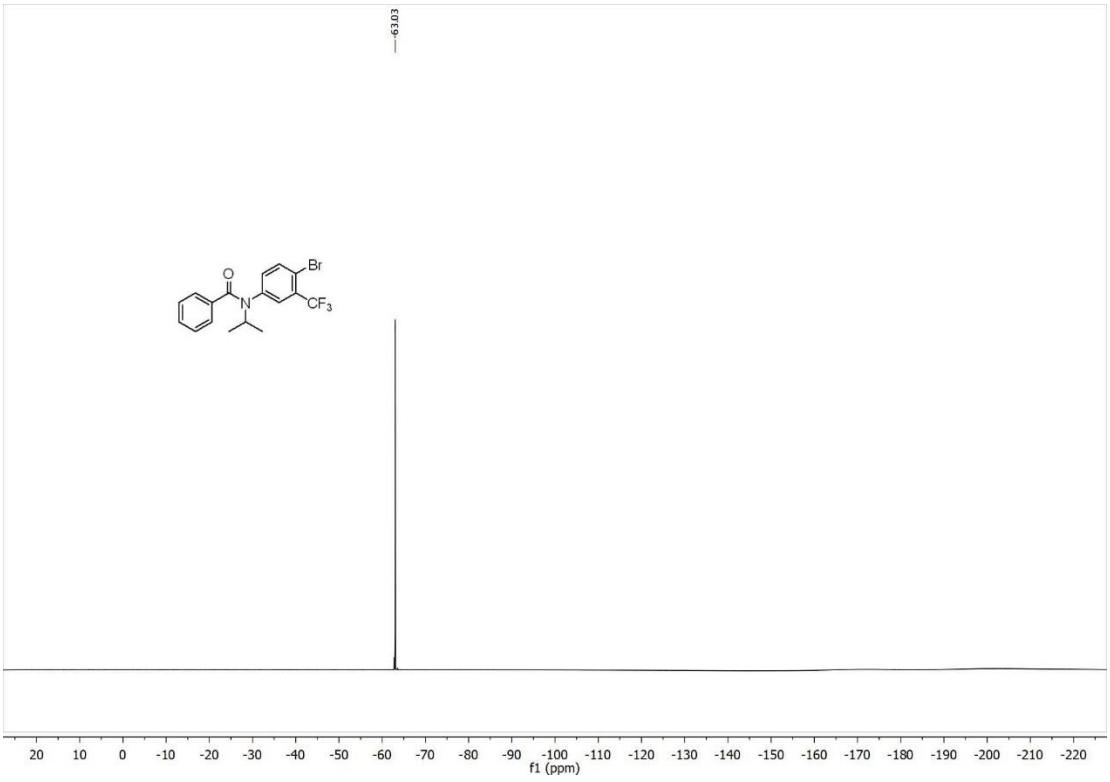
^{13}C NMR Spectrum of Compound 28 (101 MHz, $CDCl_3$)



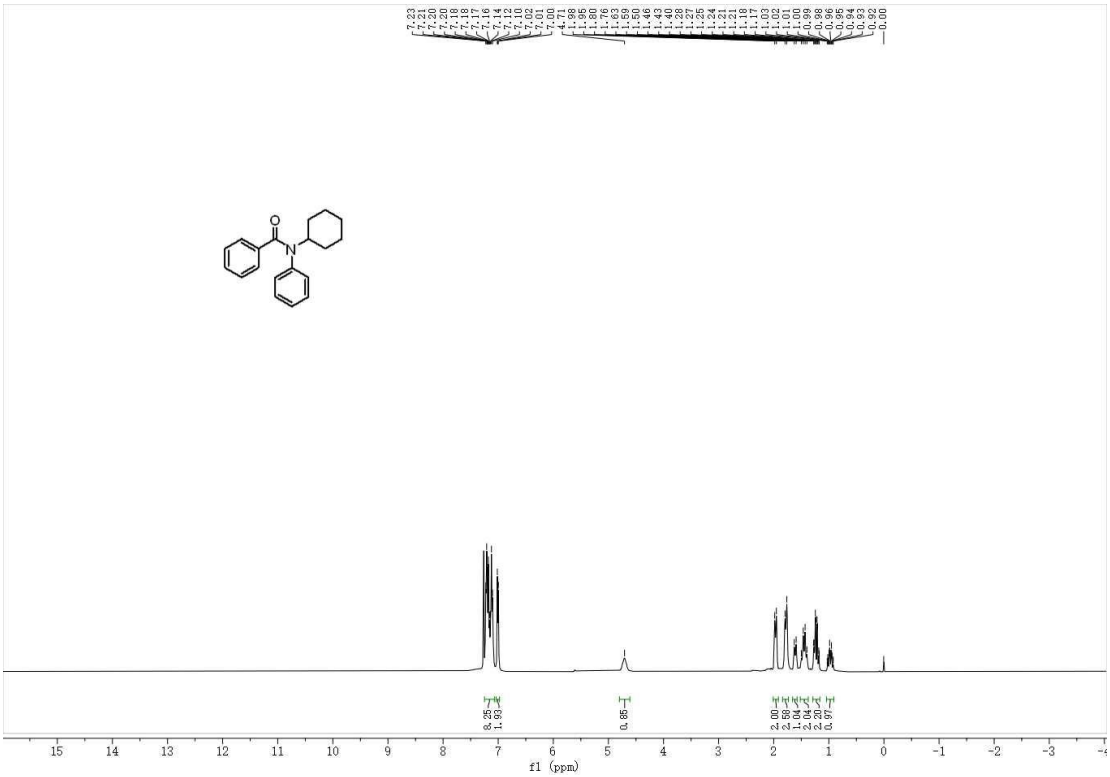
^{1}H NMR Spectrum of Compound 29 (400 MHz, $CDCl_3$)



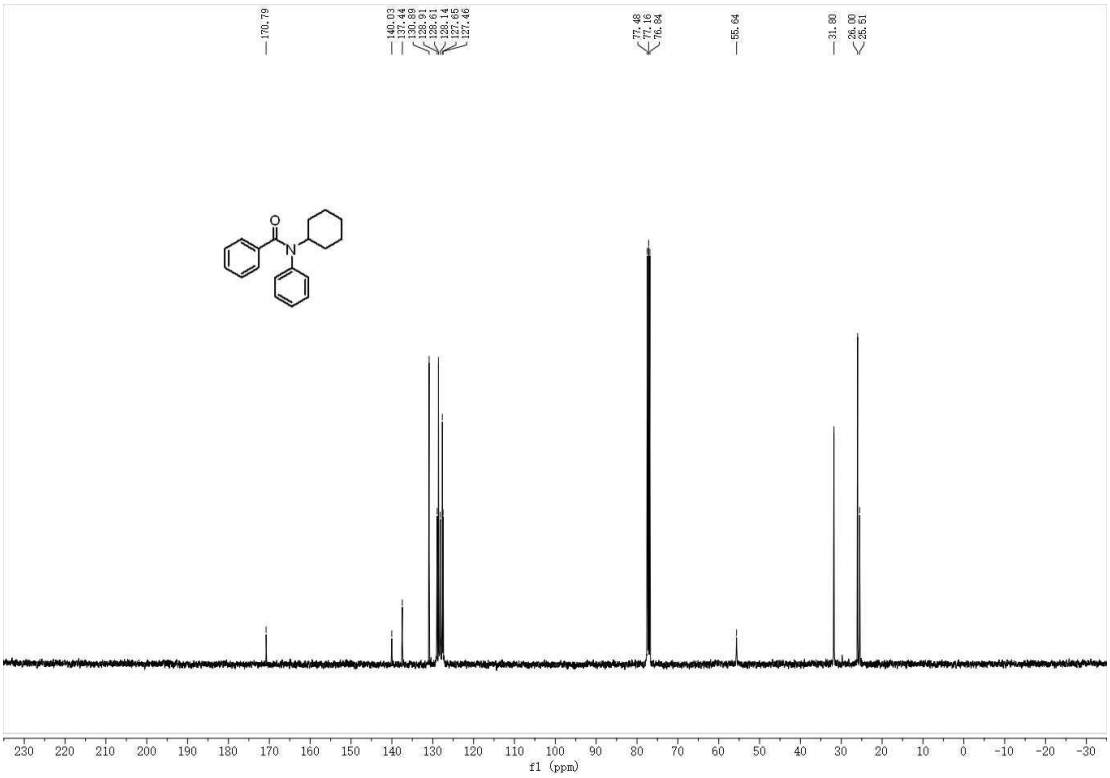
^{13}C NMR Spectrum of Compound 29 (101 MHz, $CDCl_3$)



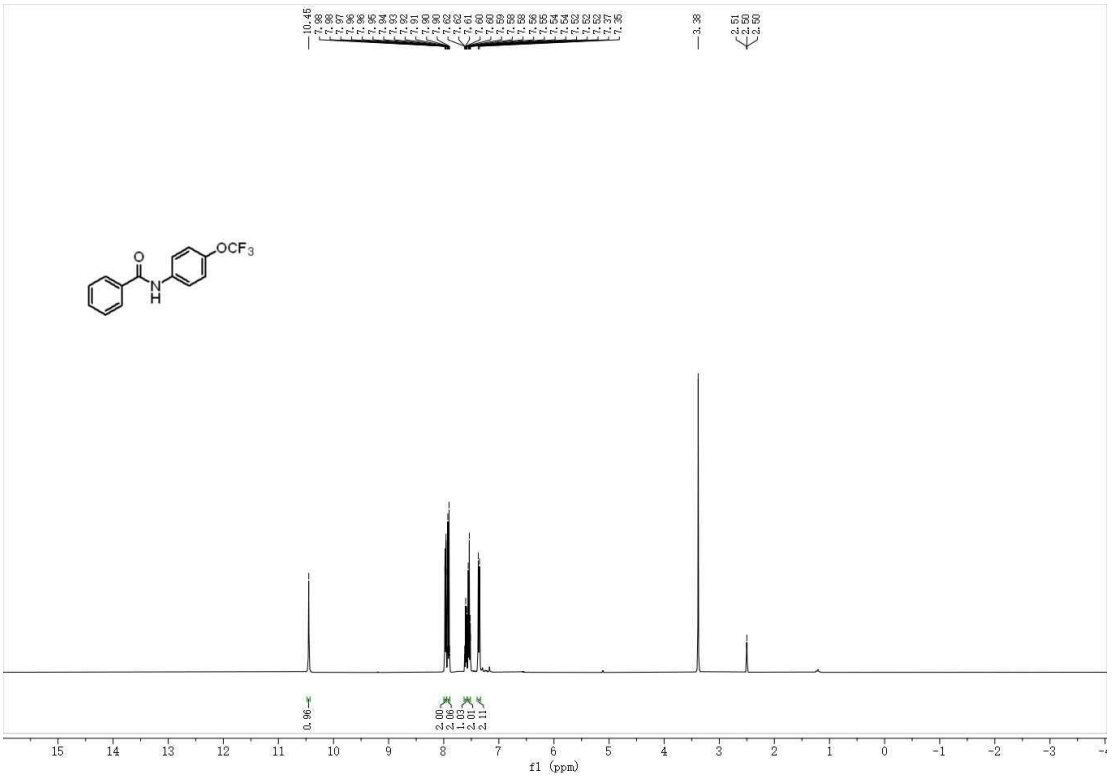
^{19}F NMR Spectrum of Compound 29 (376 MHz, $CDCl_3$)



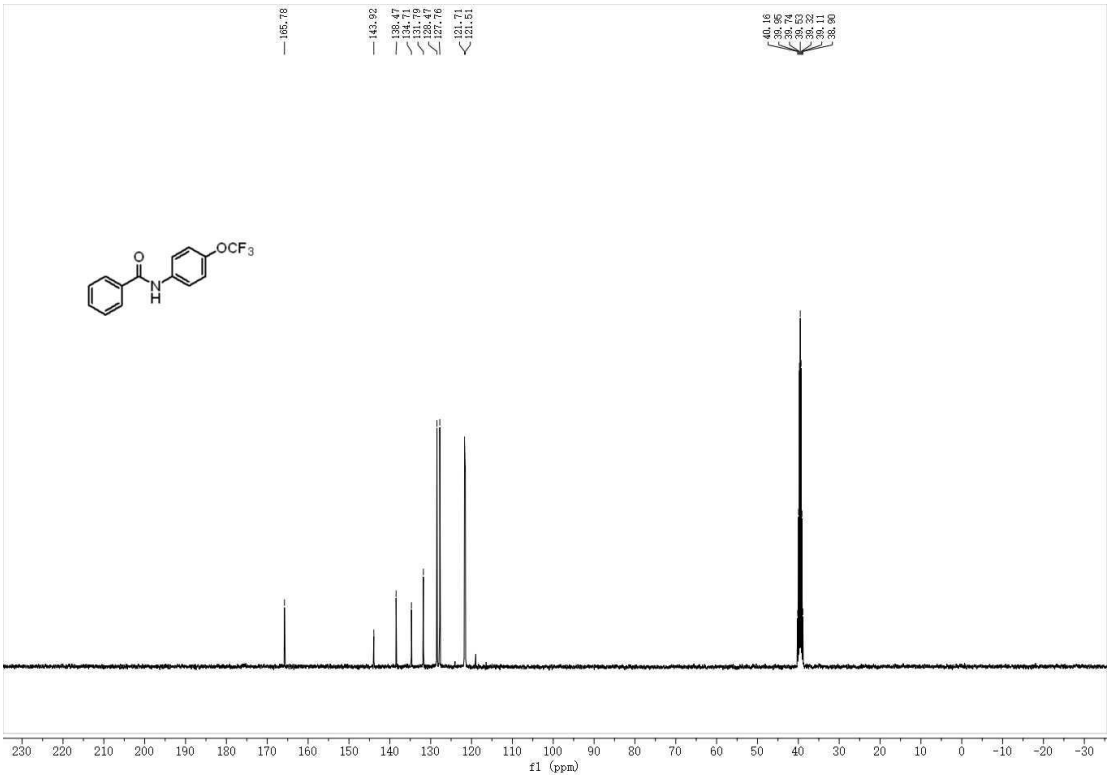
^{1}H NMR Spectrum of Compound 30 (400 MHz, $CDCl_3$)



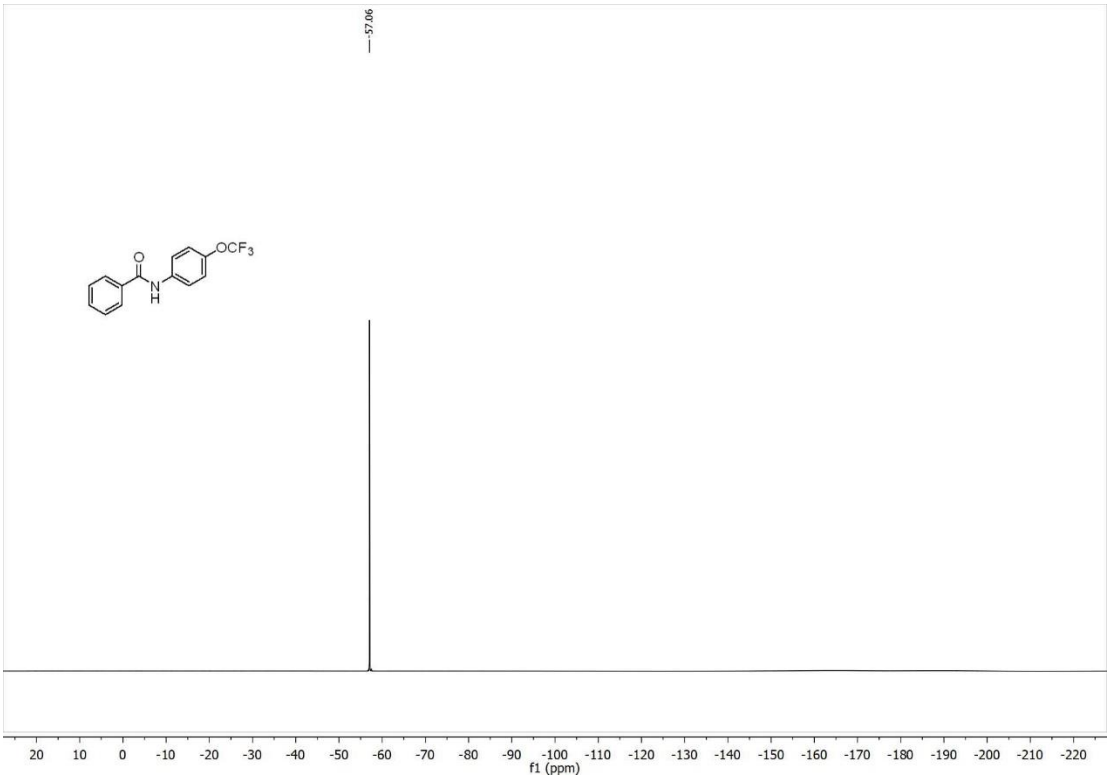
^{13}C NMR Spectrum of Compound 30 (101 MHz, $CDCl_3$)



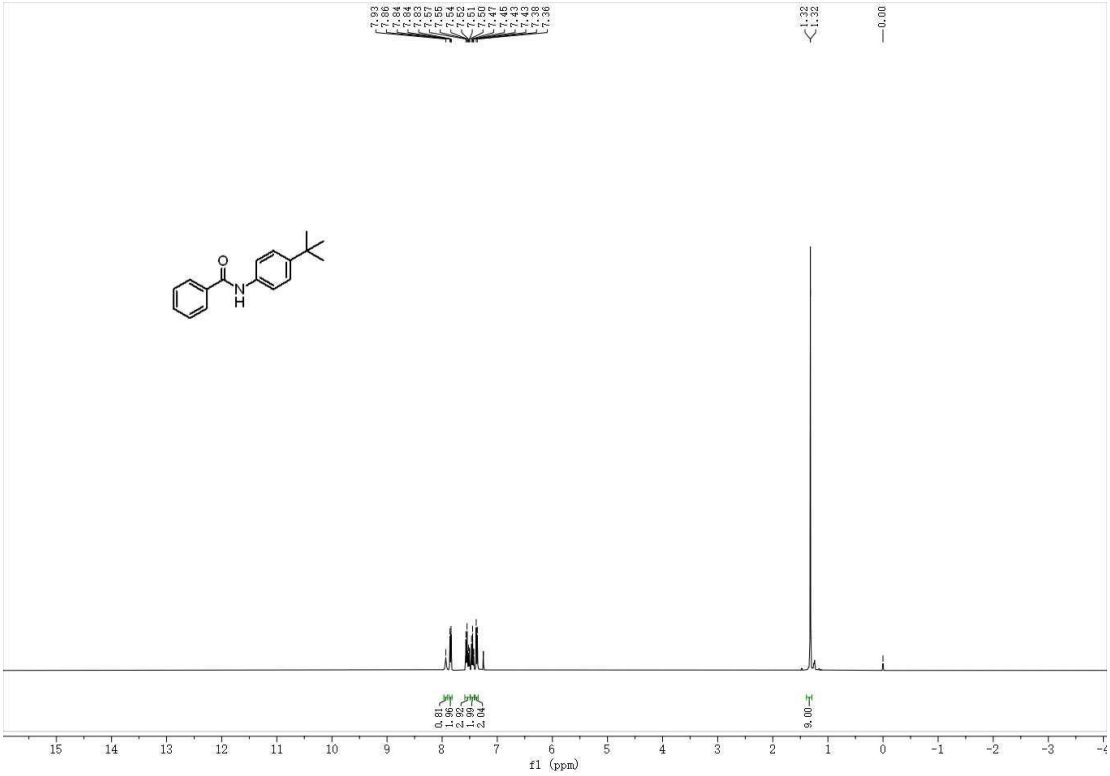
^{1}H NMR Spectrum of Compound 31 (400 MHz, DMSO-d_6)



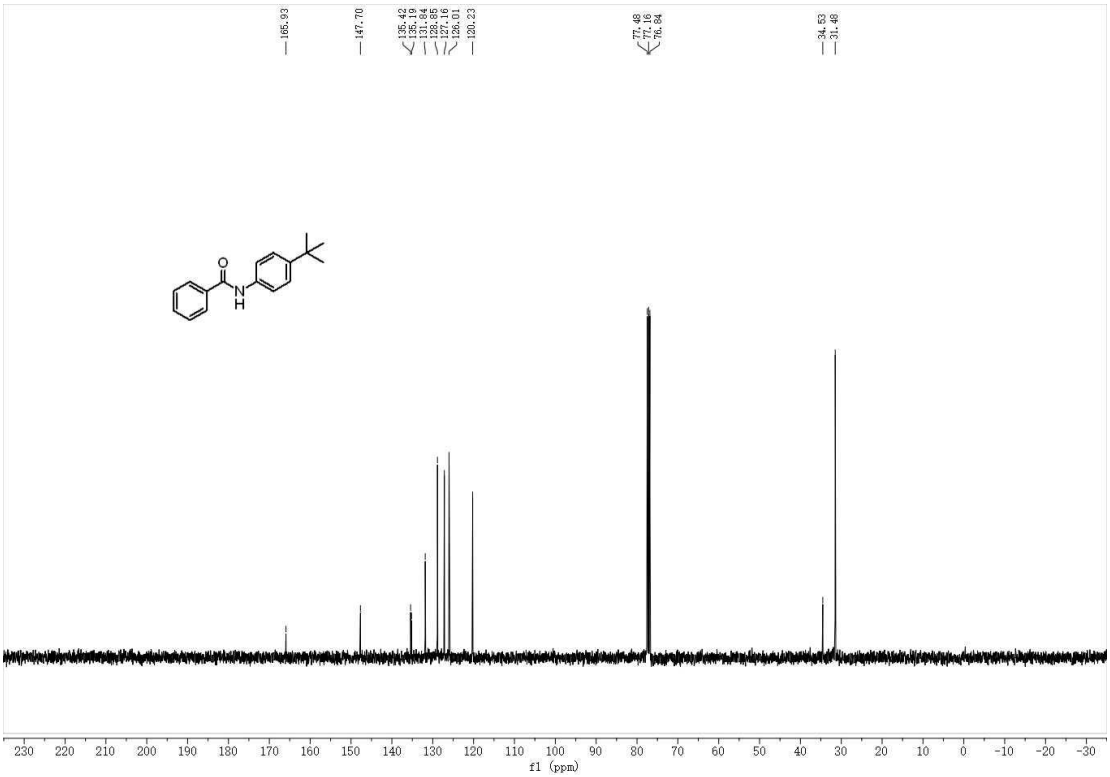
^{13}C NMR Spectrum of Compound 31 (101 MHz, DMSO-d_6)



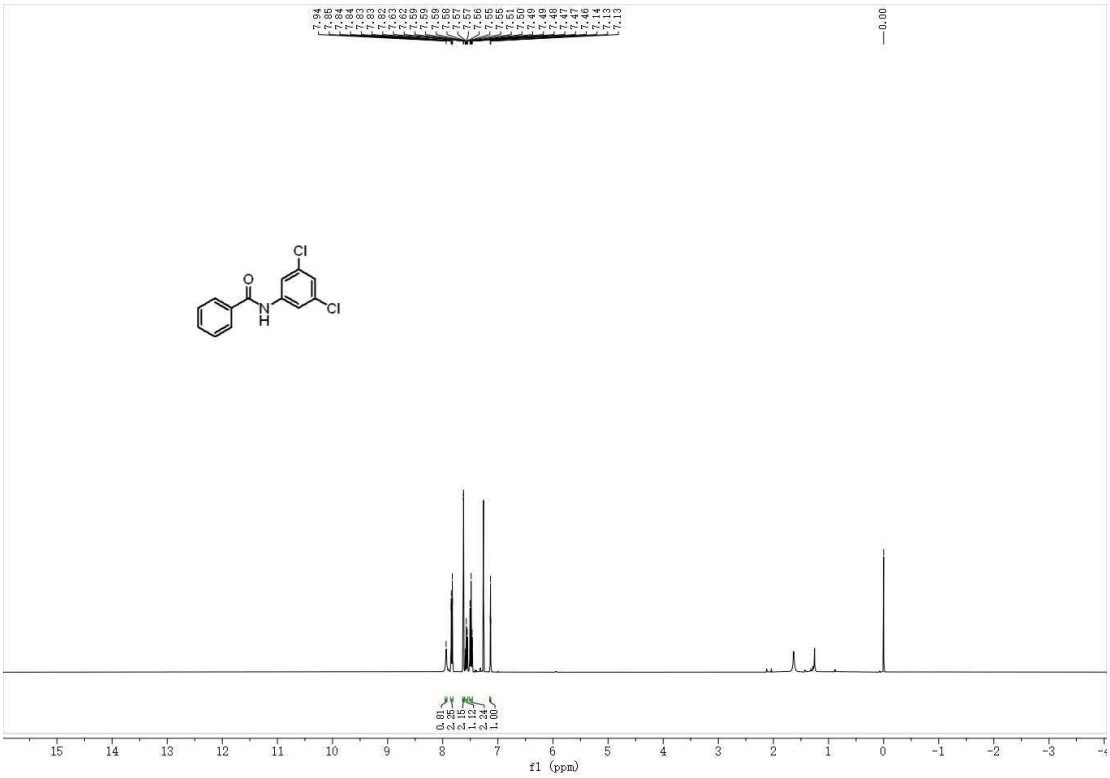
^{19}F NMR Spectrum of Compound 31 (376 MHz, DMSO-d_6)



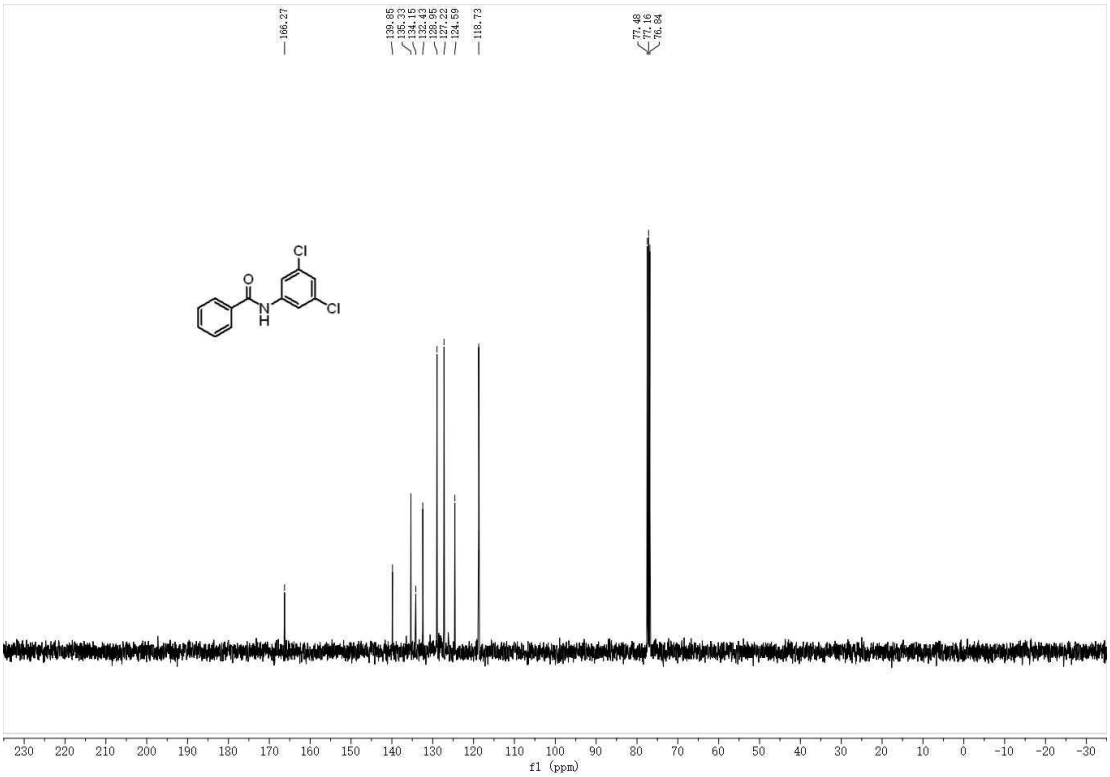
^{1}H NMR Spectrum of Compound 32 (400 MHz, $CDCl_3$)



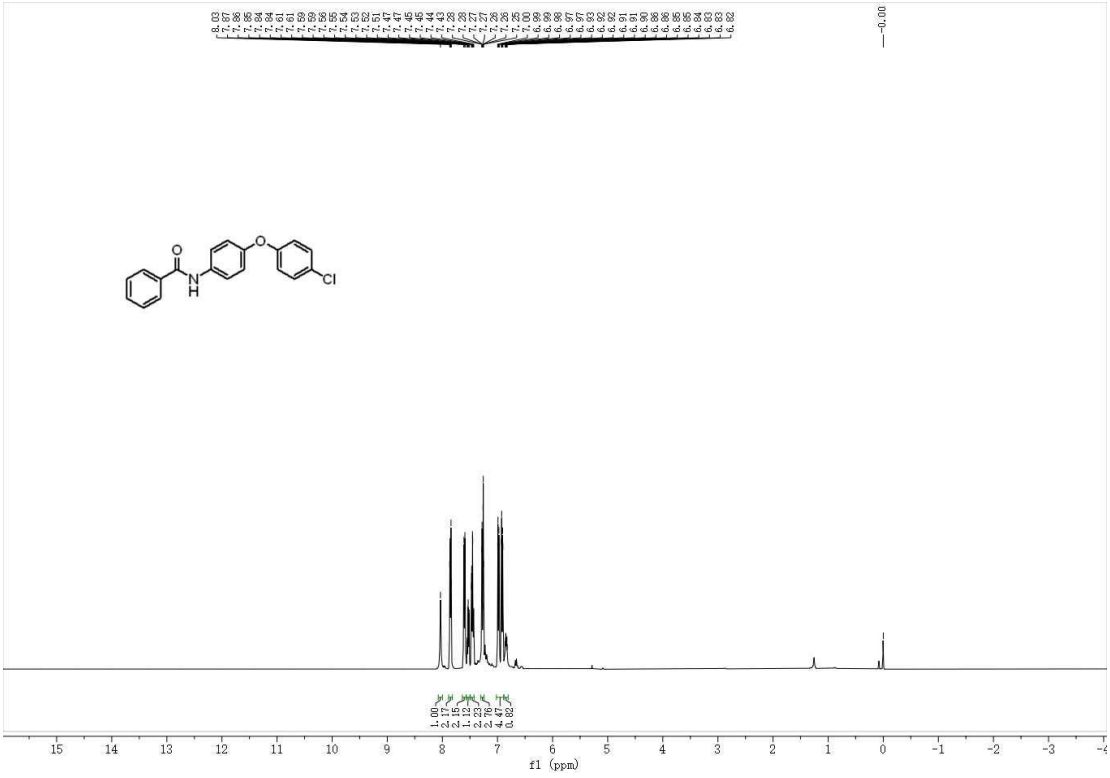
^{13}C NMR Spectrum of Compound 32 (101 MHz, $CDCl_3$)



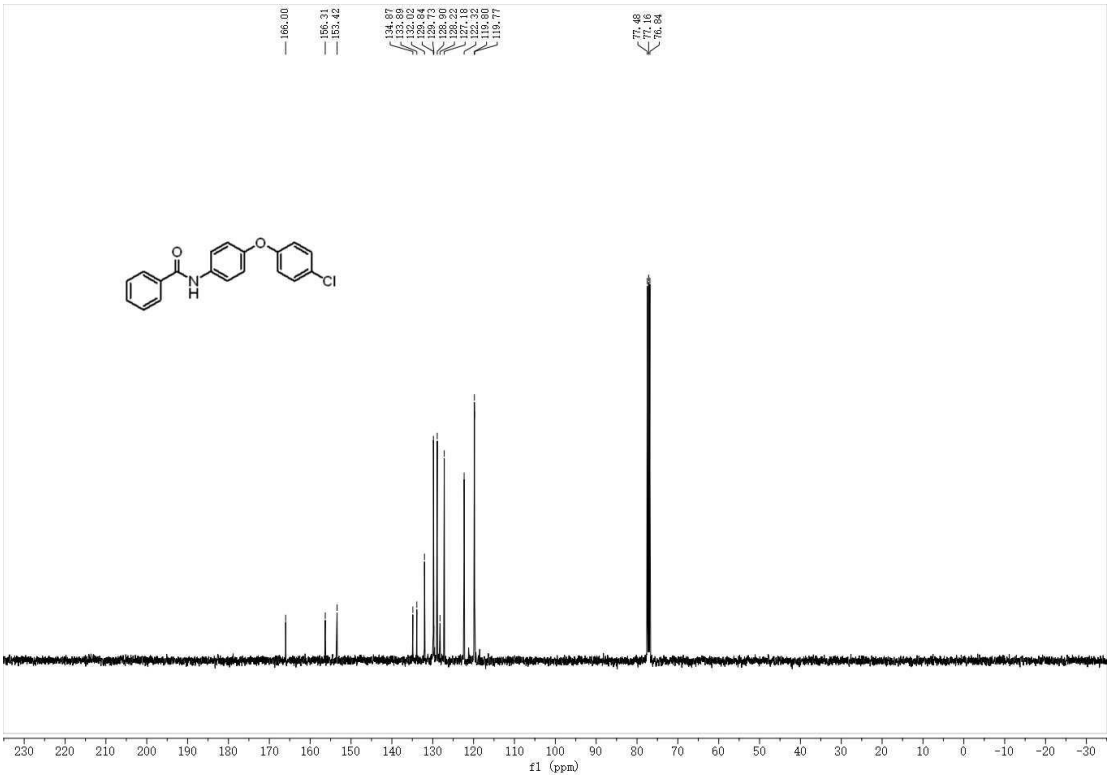
^{1}H NMR Spectrum of Compound 33 (400 MHz, $CDCl_3$)



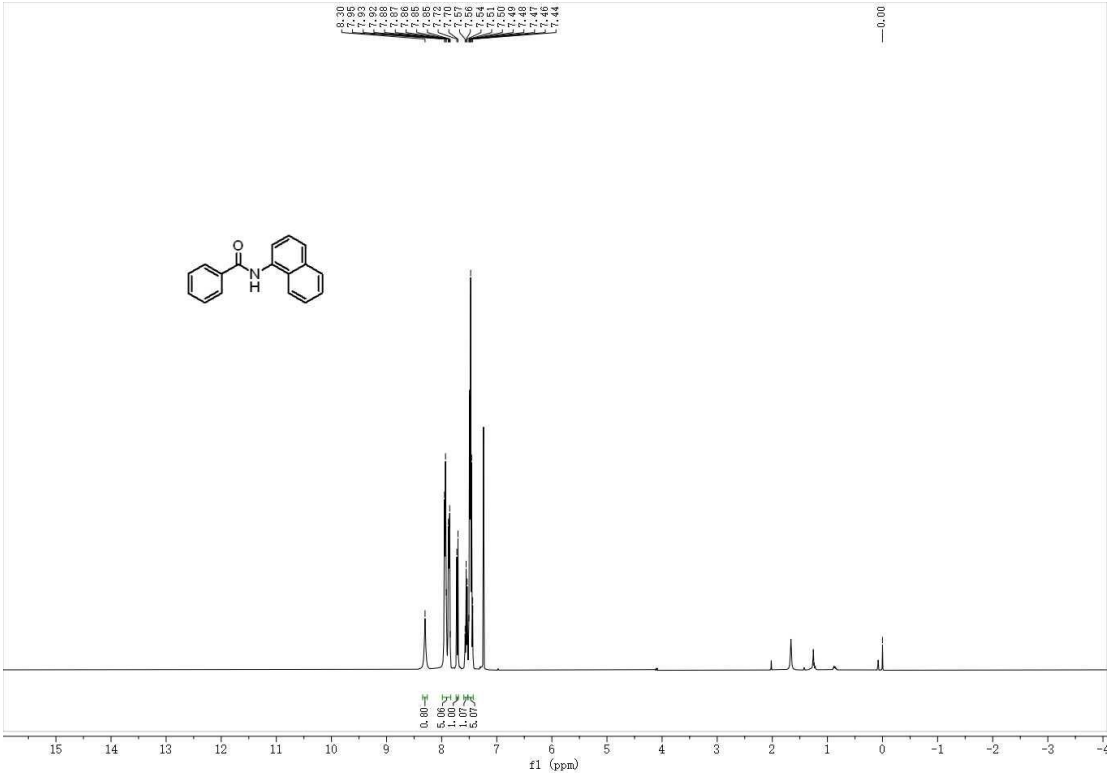
^{13}C NMR Spectrum of Compound 33 (101 MHz, $CDCl_3$)



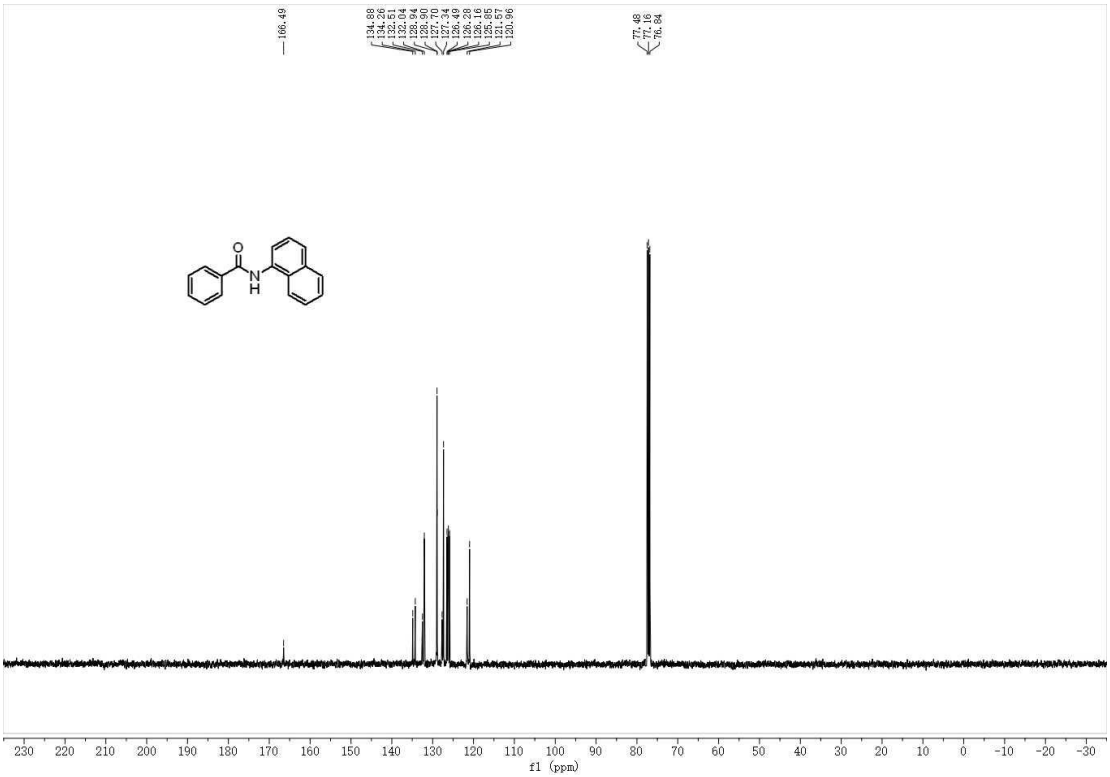
^{1}H NMR Spectrum of Compound 34 (400 MHz, $CDCl_3$)



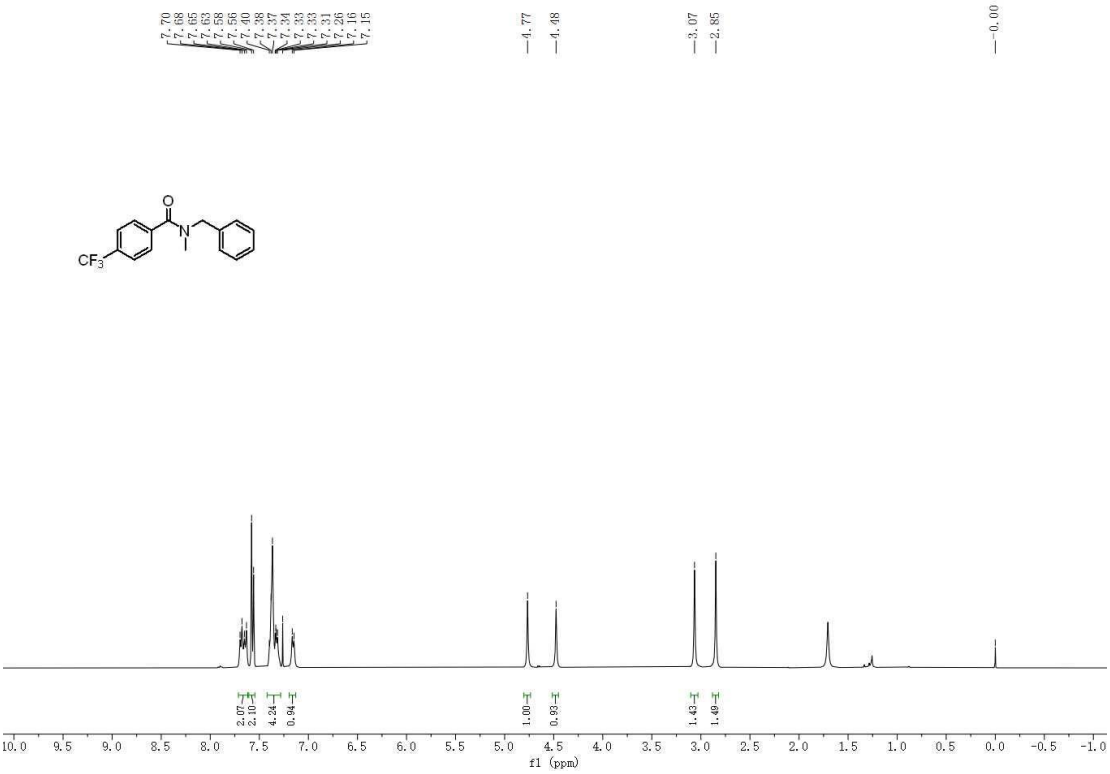
^{13}C NMR Spectrum of Compound 34 (101 MHz, $CDCl_3$)



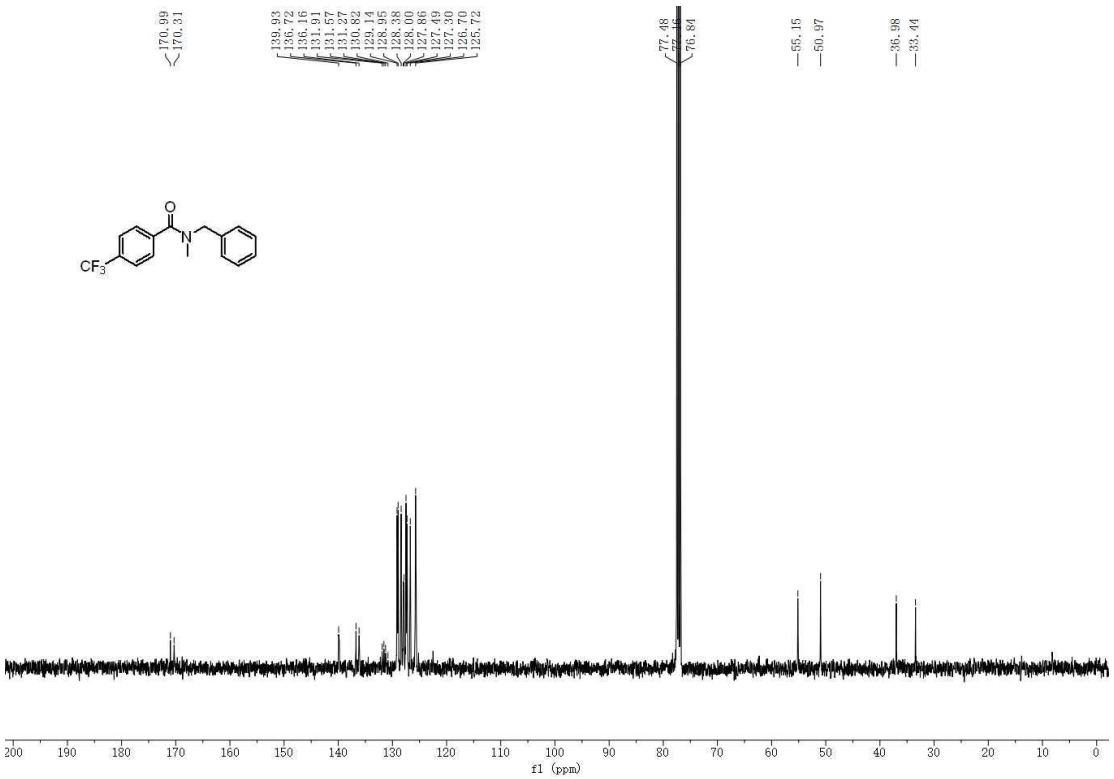
^{1}H NMR Spectrum of Compound 35 (400 MHz, $CDCl_3$)



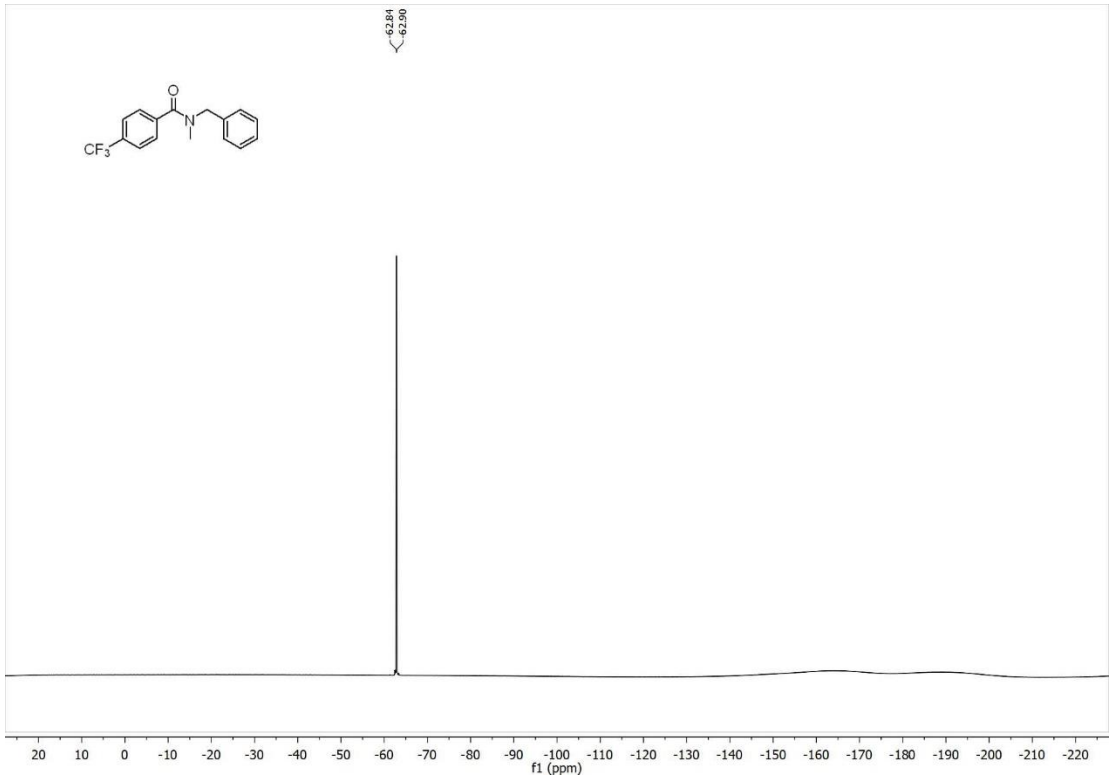
^{13}C NMR Spectrum of Compound 35 (101 MHz, $CDCl_3$)



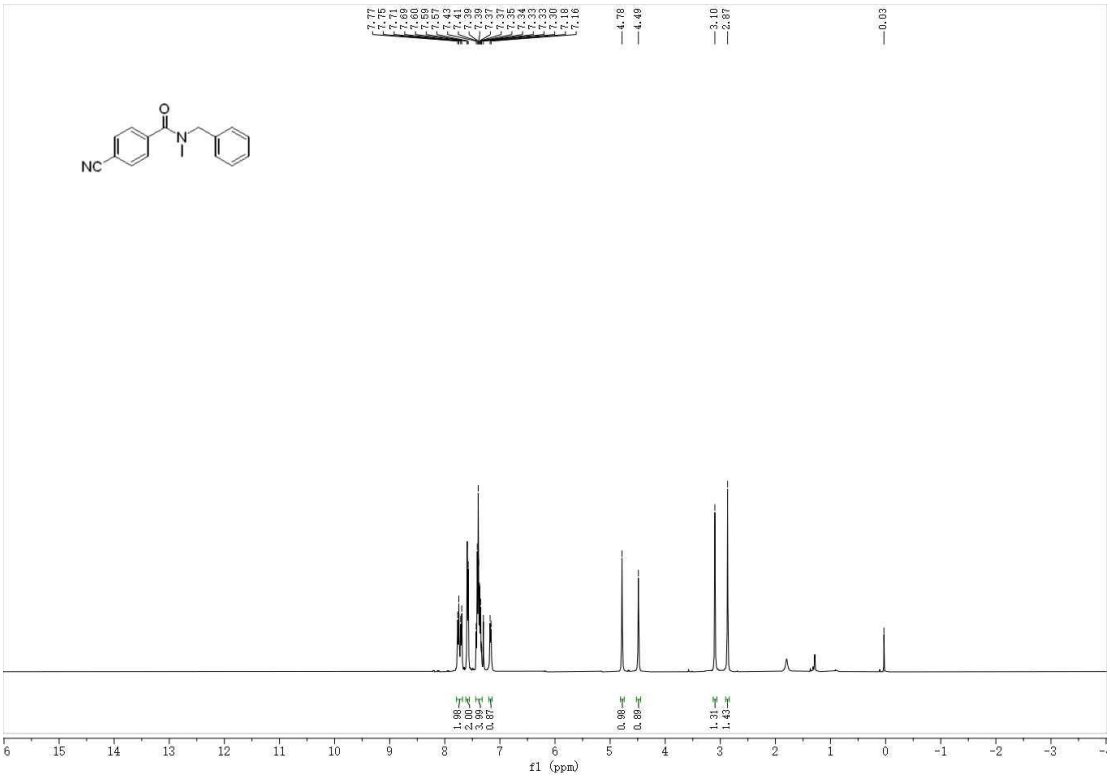
^{1}H NMR Spectrum of Compound 36 (400 MHz, $CDCl_3$)



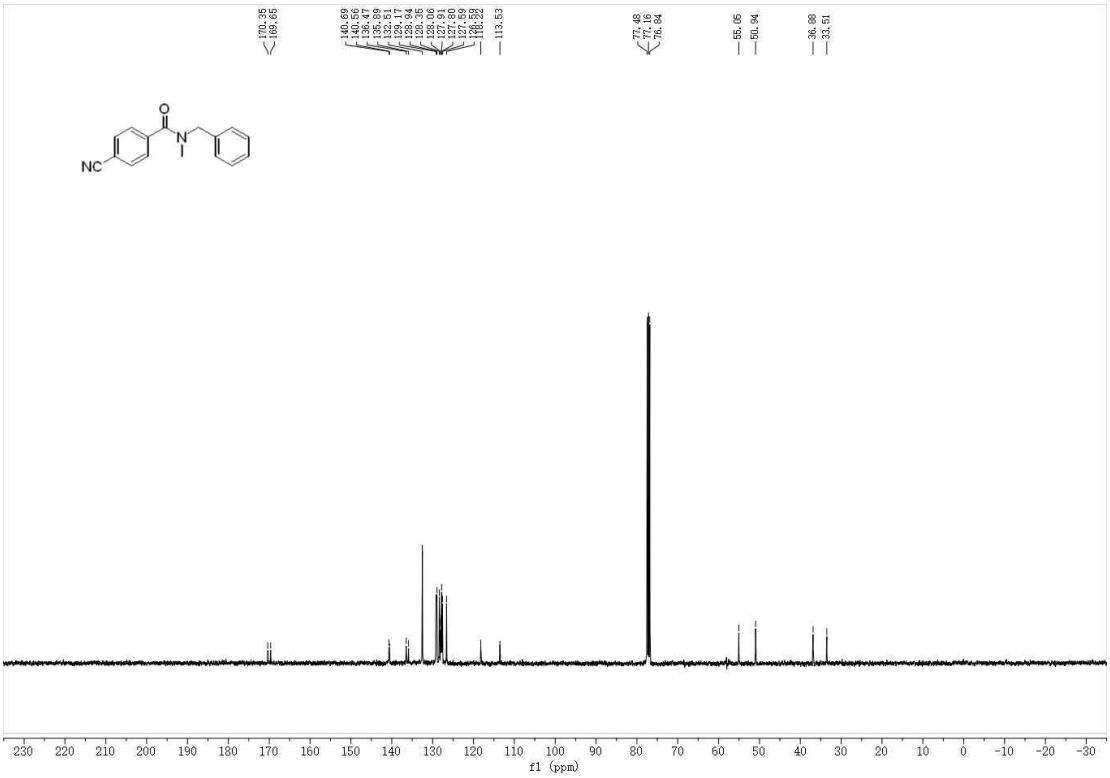
^{13}C NMR Spectrum of Compound 36 (101 MHz, $CDCl_3$)



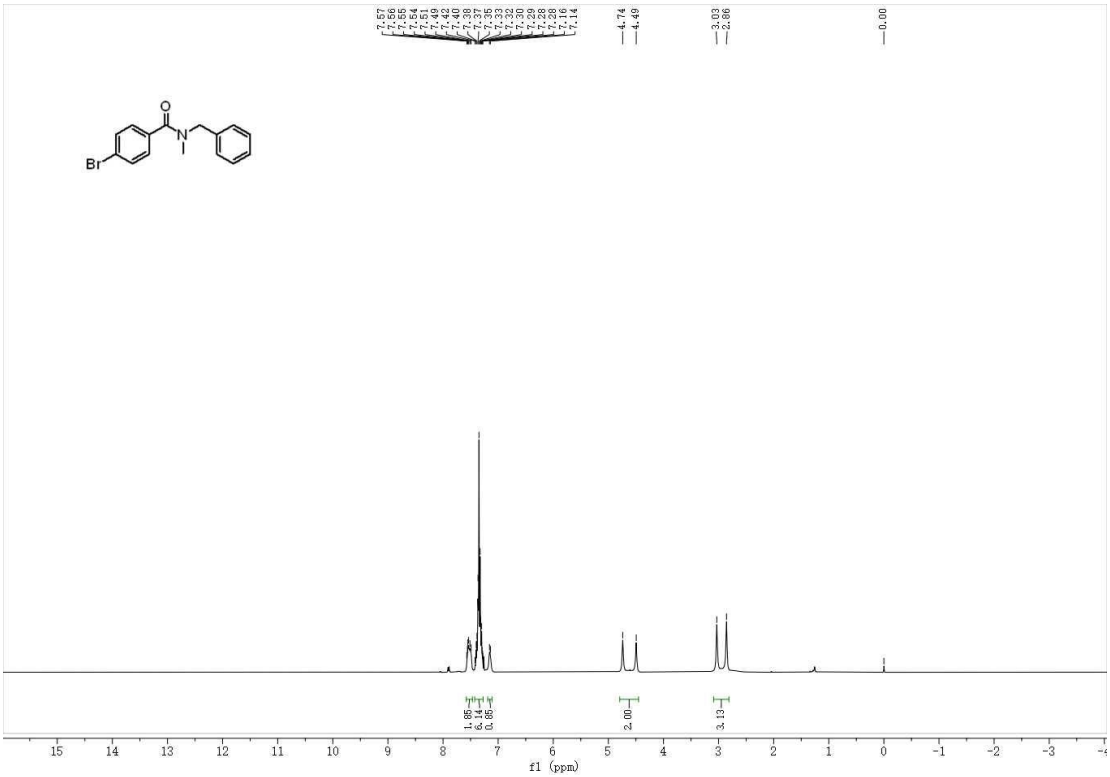
^{19}F NMR Spectrum of Compound 36 (376 MHz, $CDCl_3$)



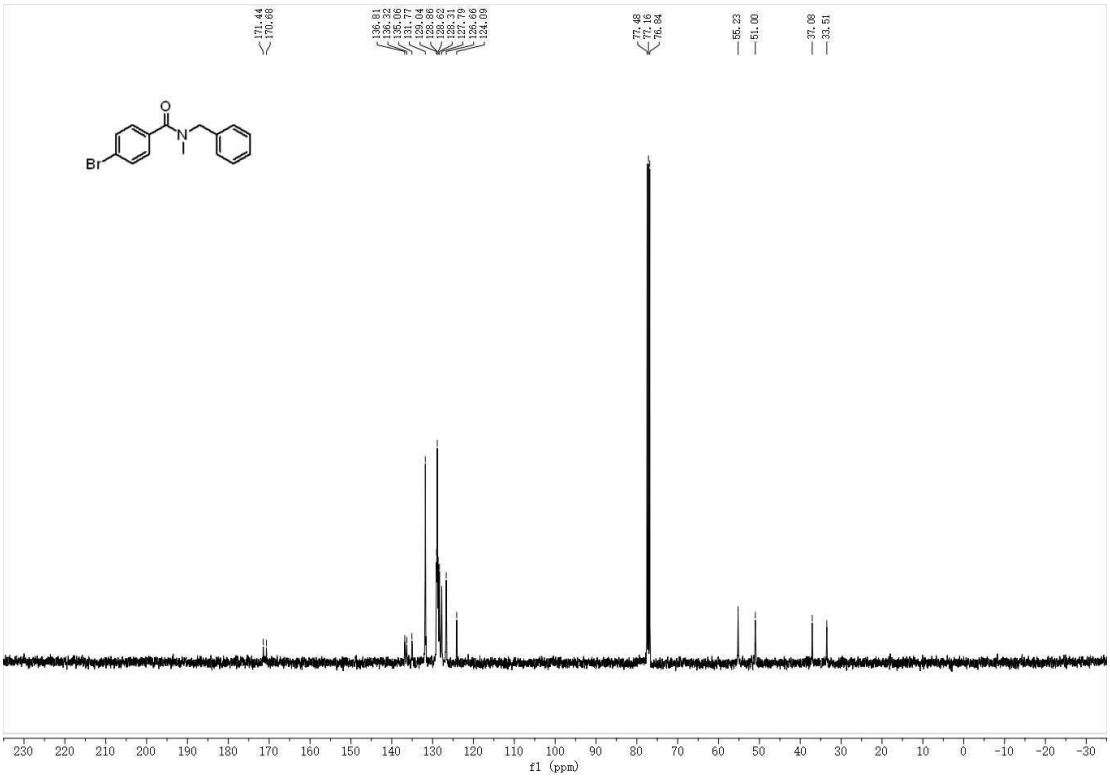
^{1}H NMR Spectrum of Compound 37 (400 MHz, $CDCl_3$)



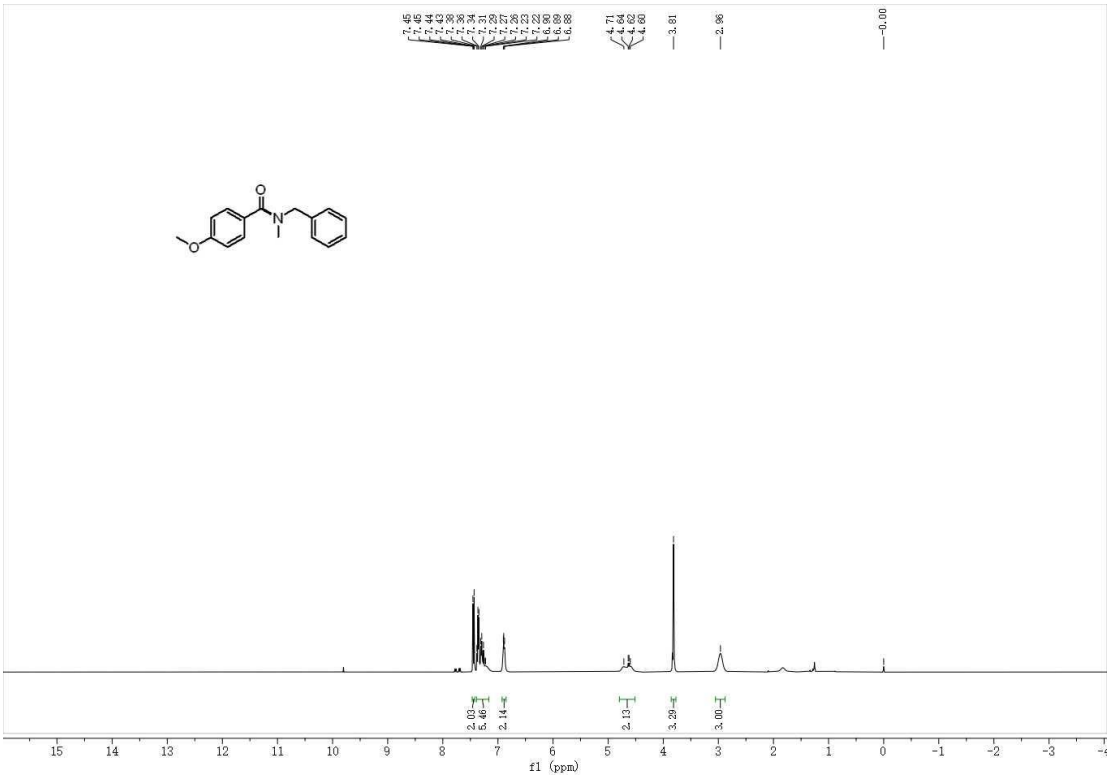
^{13}C NMR Spectrum of Compound 37 (101 MHz, $CDCl_3$)



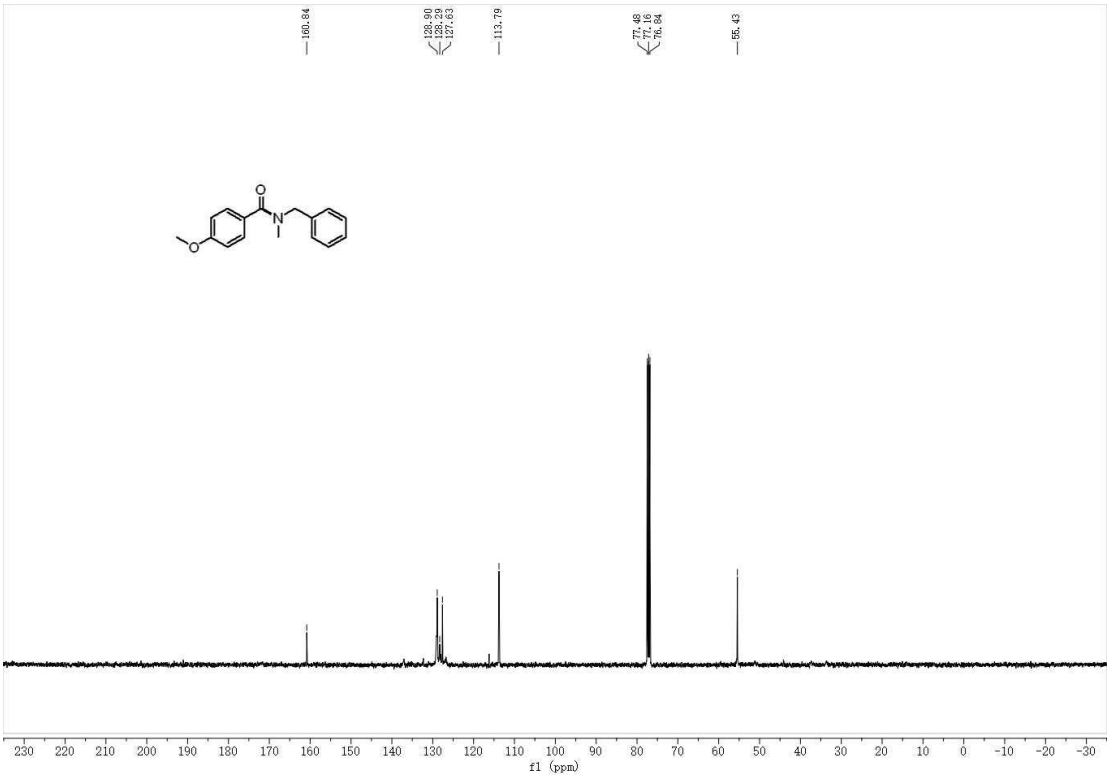
^{1}H NMR Spectrum of Compound 38 (400 MHz, $CDCl_3$)



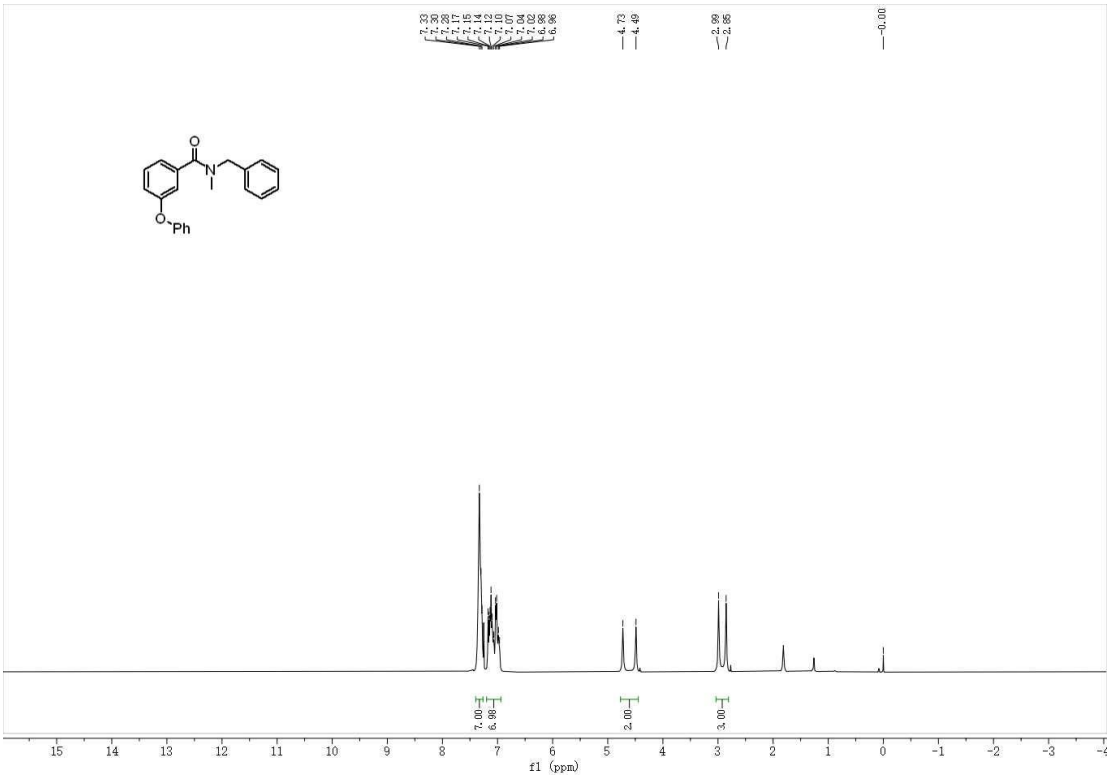
^{13}C NMR Spectrum of Compound 38 (101 MHz, $CDCl_3$)



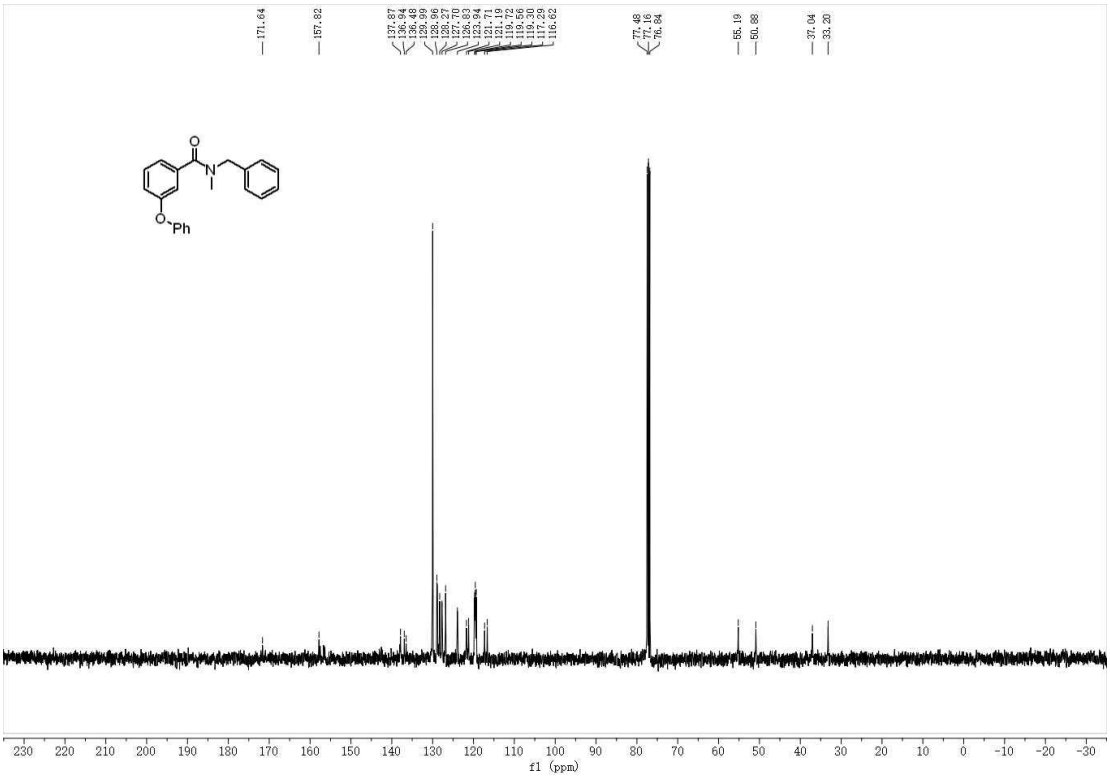
^{1}H NMR Spectrum of Compound 39 (400 MHz, $CDCl_3$)



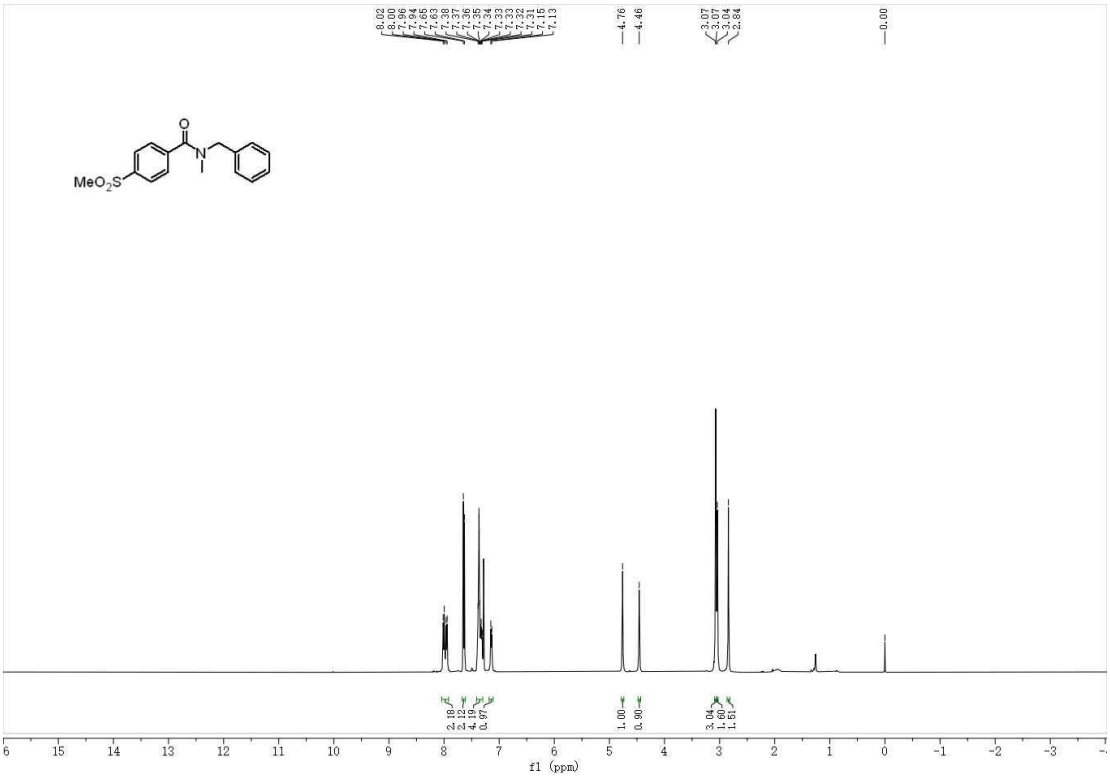
^{13}C NMR Spectrum of Compound 39 (101 MHz, $CDCl_3$)



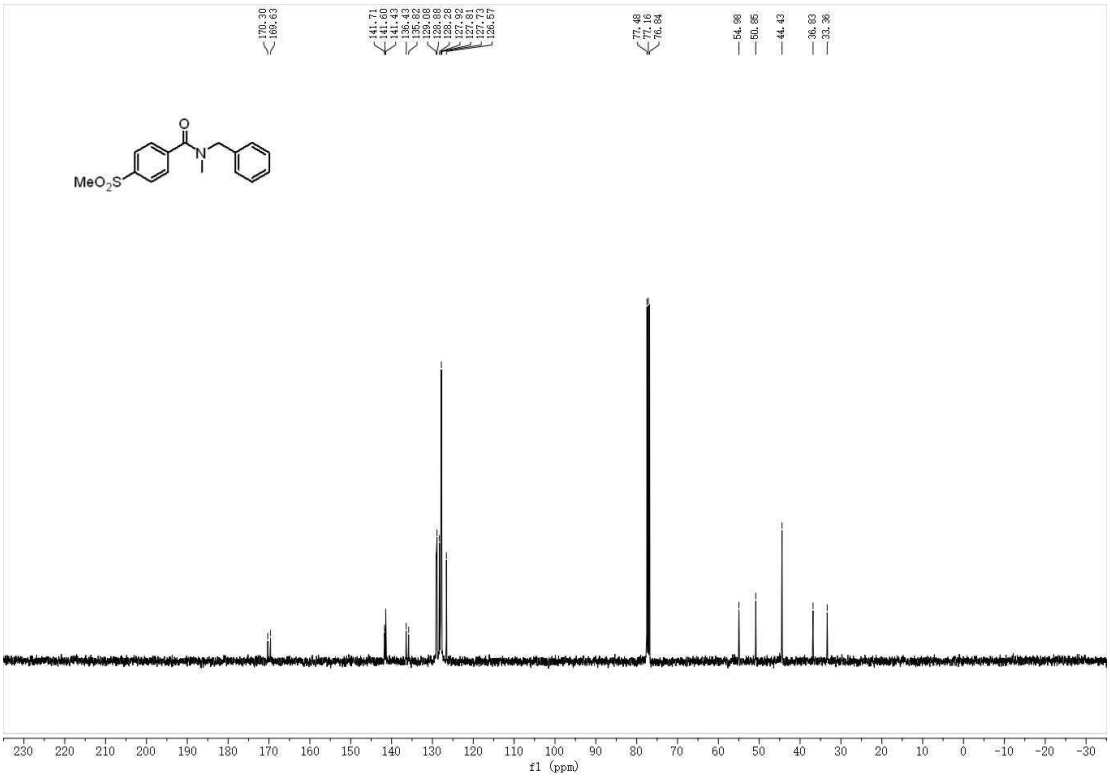
^{1}H NMR Spectrum of Compound 40 (400 MHz, $CDCl_3$)



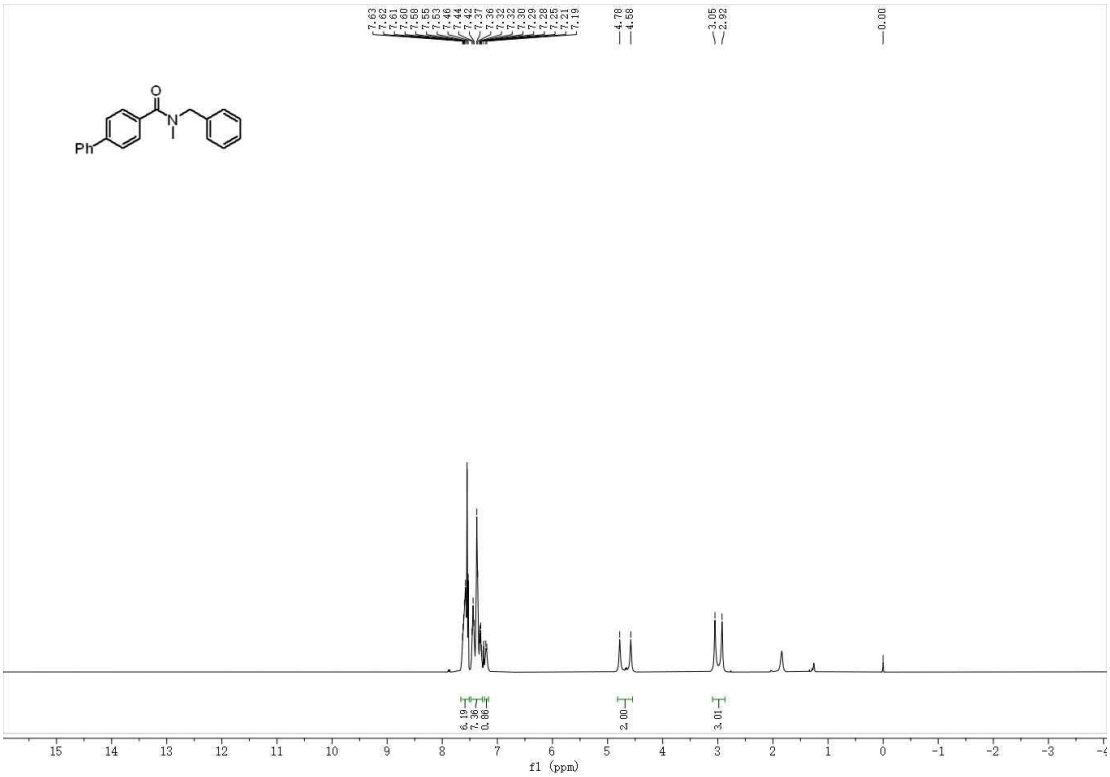
^{13}C NMR Spectrum of Compound 40 (101 MHz, $CDCl_3$)



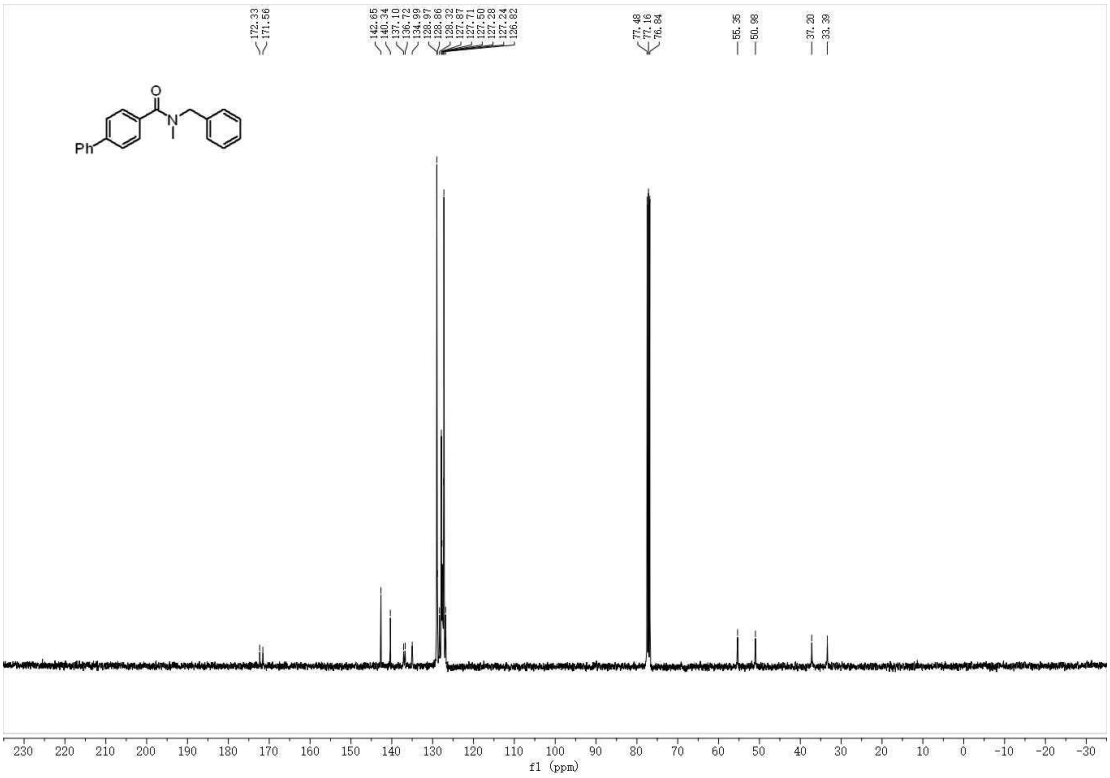
^{1}H NMR Spectrum of Compound 41 (400 MHz, $CDCl_3$)



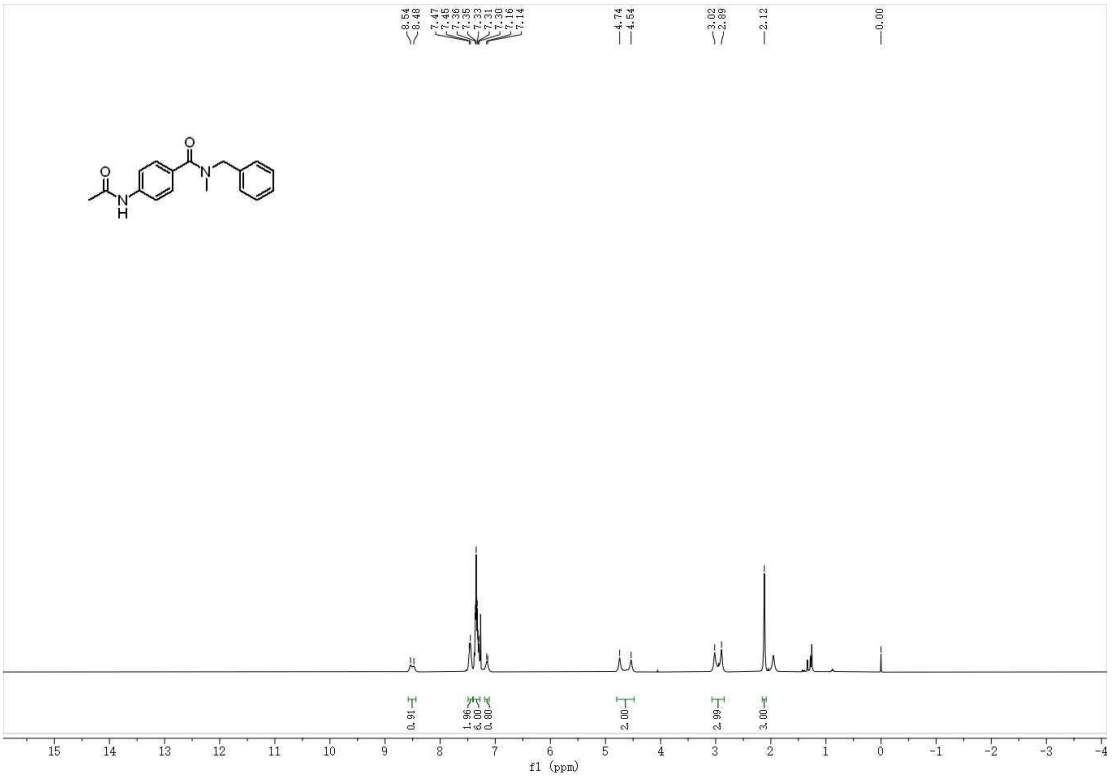
^{13}C NMR Spectrum of Compound 41 (101 MHz, $CDCl_3$)



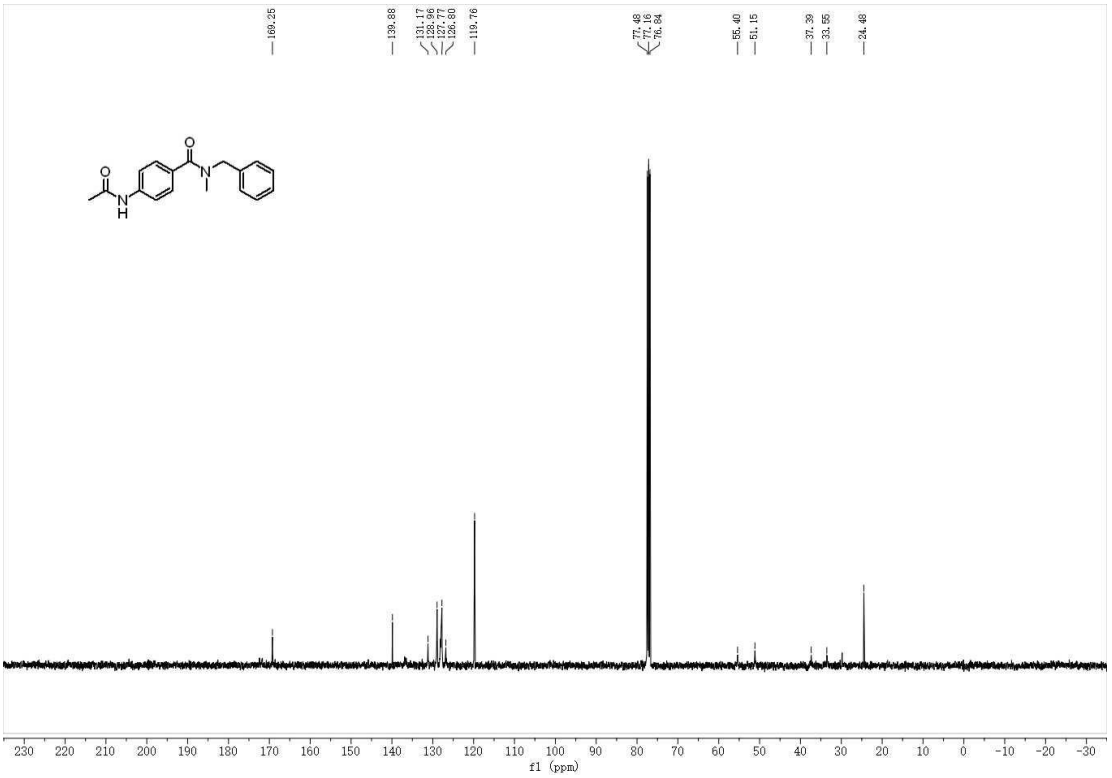
^{1}H NMR Spectrum of Compound 42 (400 MHz, $CDCl_3$)



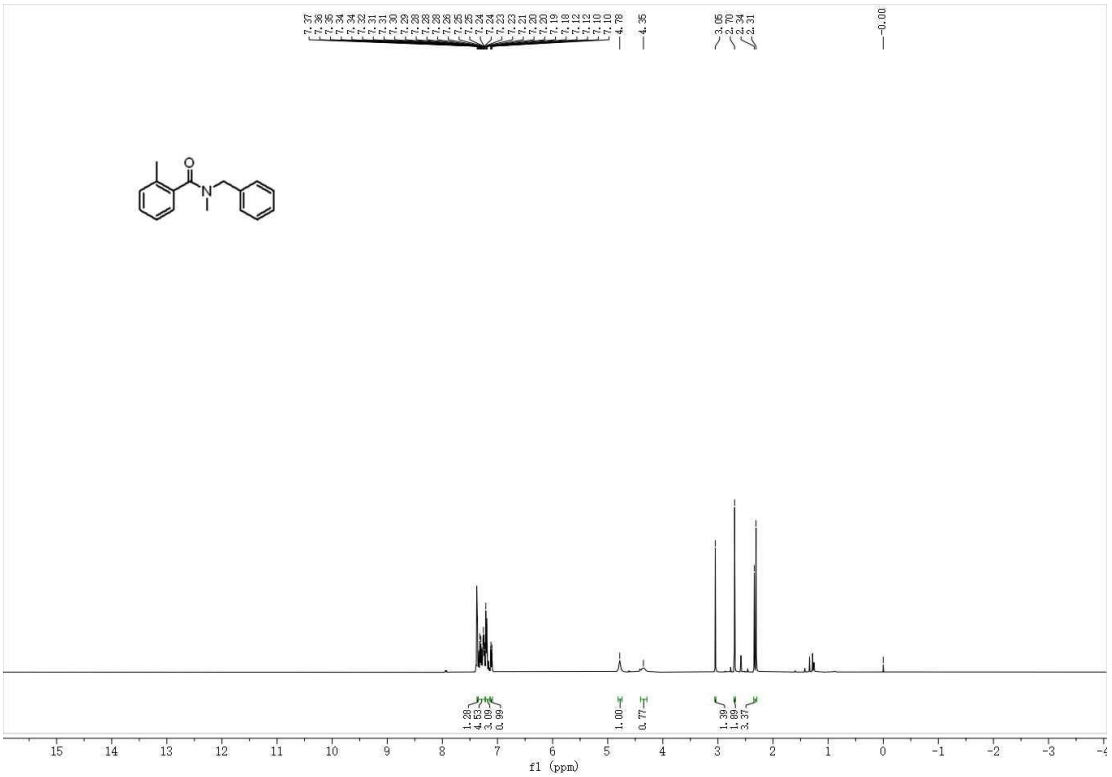
^{13}C NMR Spectrum of Compound 42 (101 MHz, $CDCl_3$)



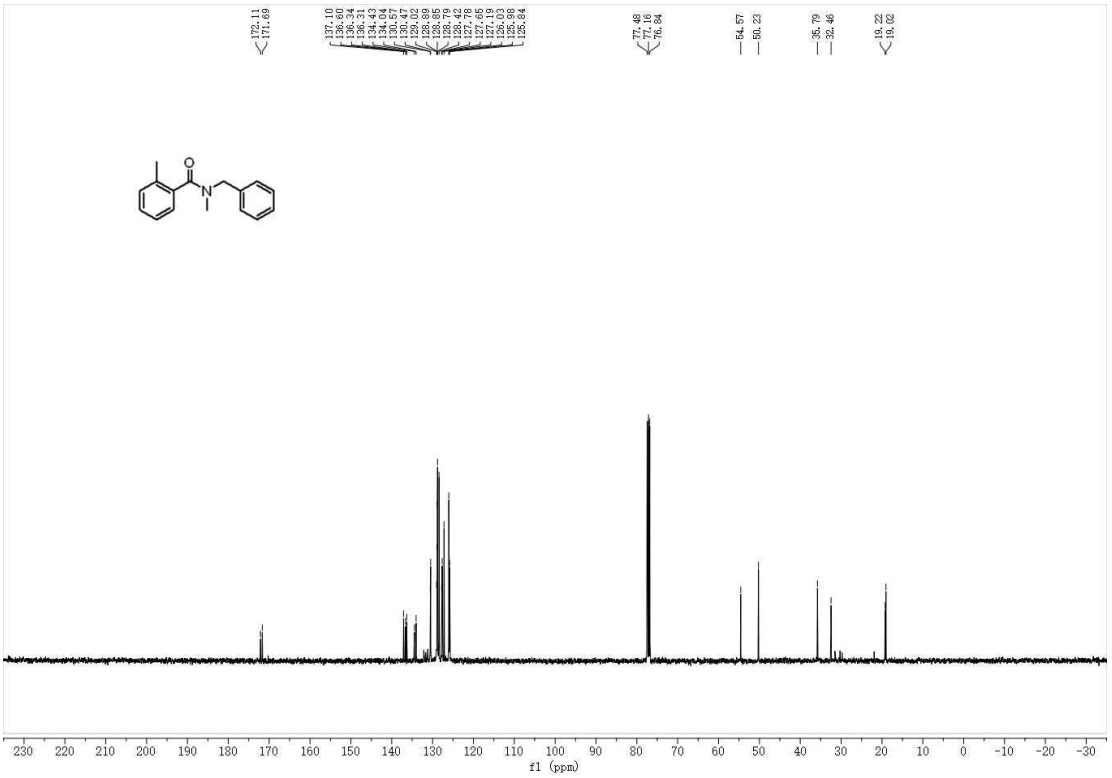
^{1}H NMR Spectrum of Compound 43 (400 MHz, $CDCl_3$)



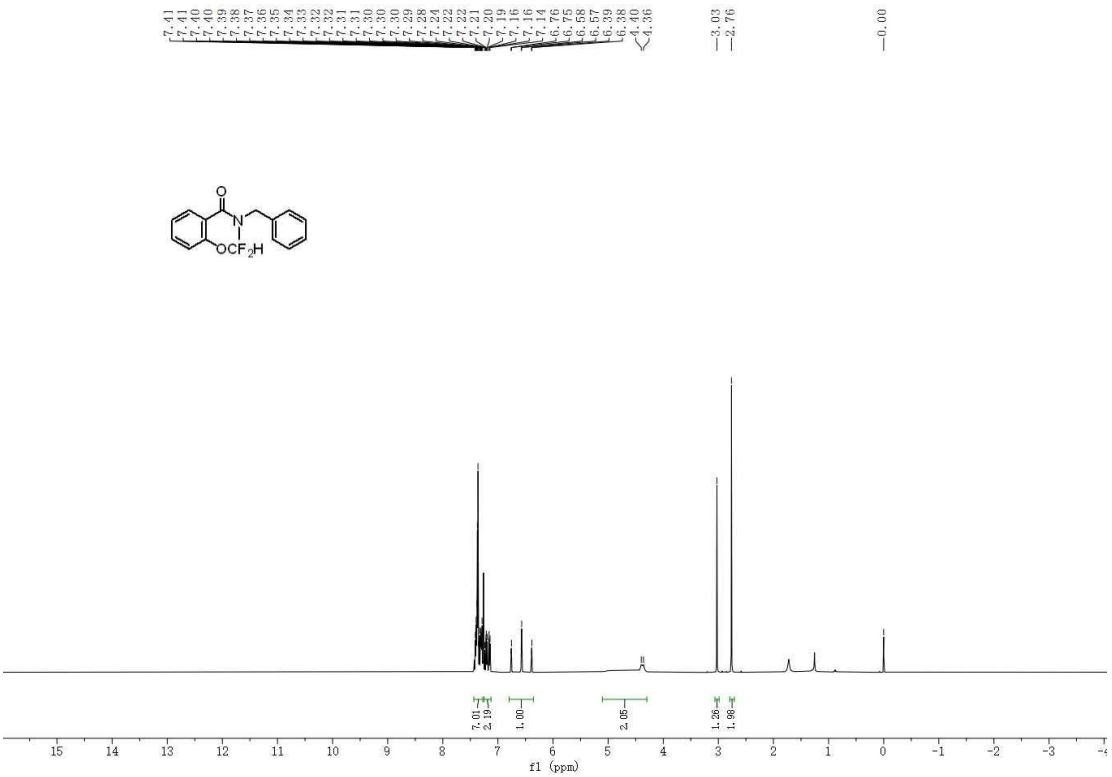
^{13}C NMR Spectrum of Compound 43 (101 MHz, $CDCl_3$)



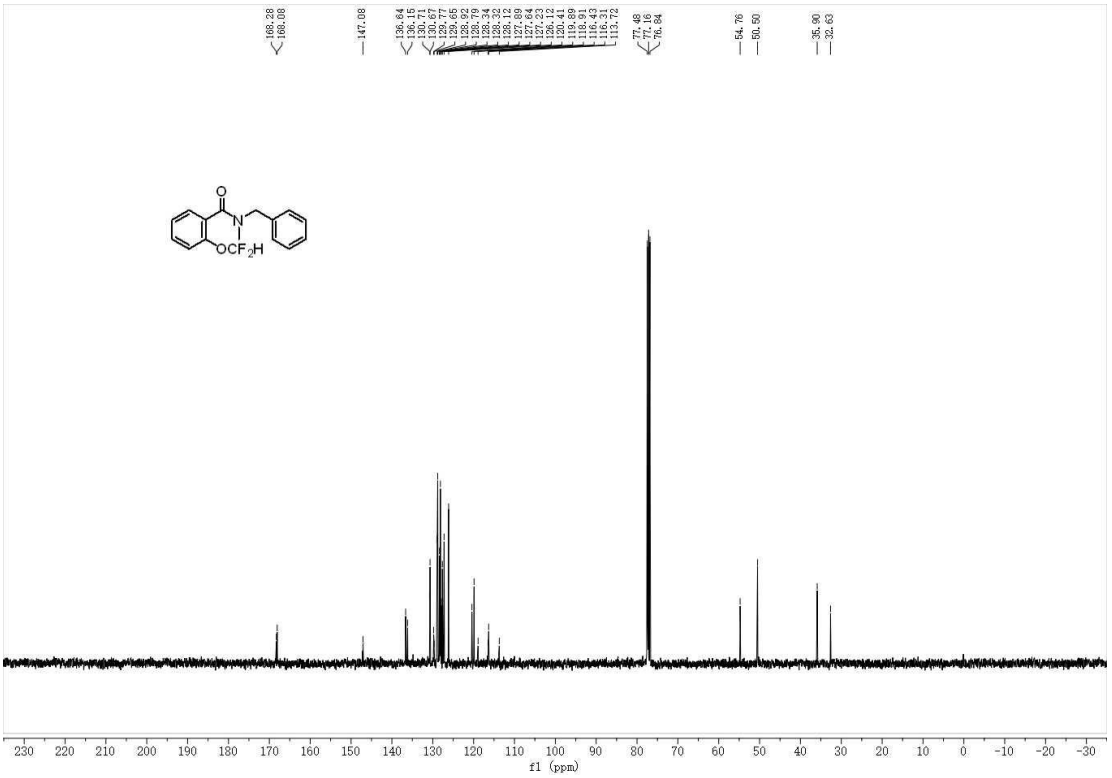
^{1}H NMR Spectrum of Compound 44 (400 MHz, $CDCl_3$)



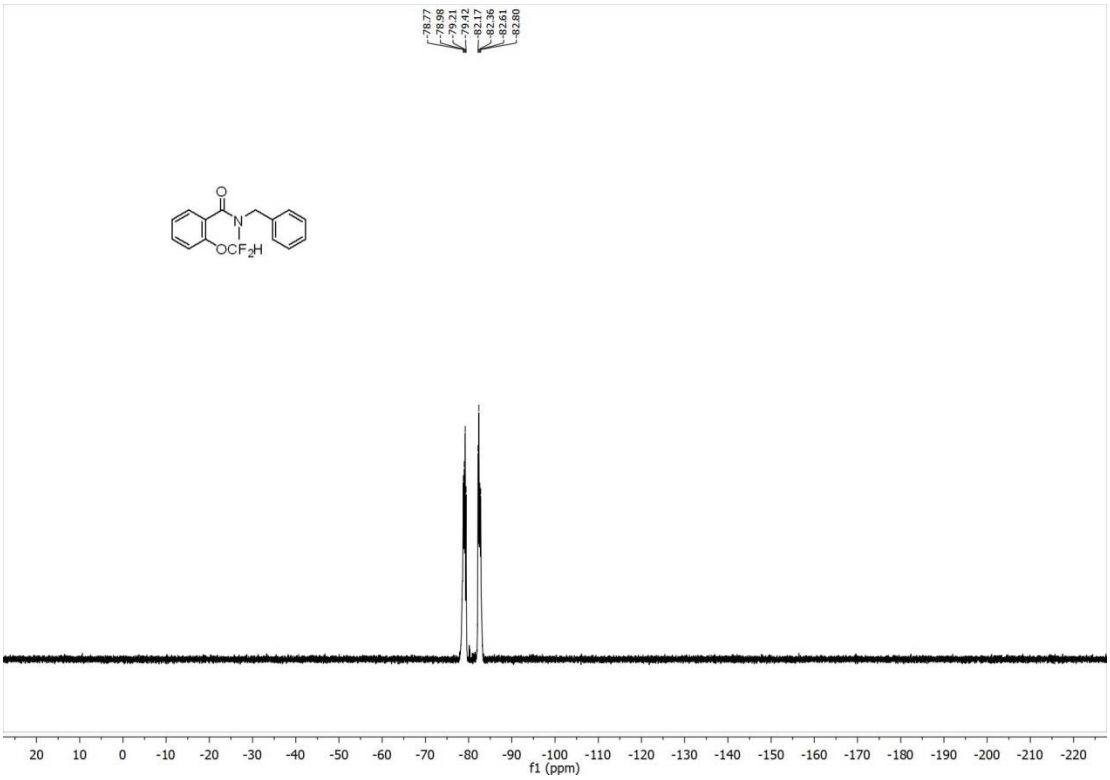
^{13}C NMR Spectrum of Compound 44 (101 MHz, $CDCl_3$)



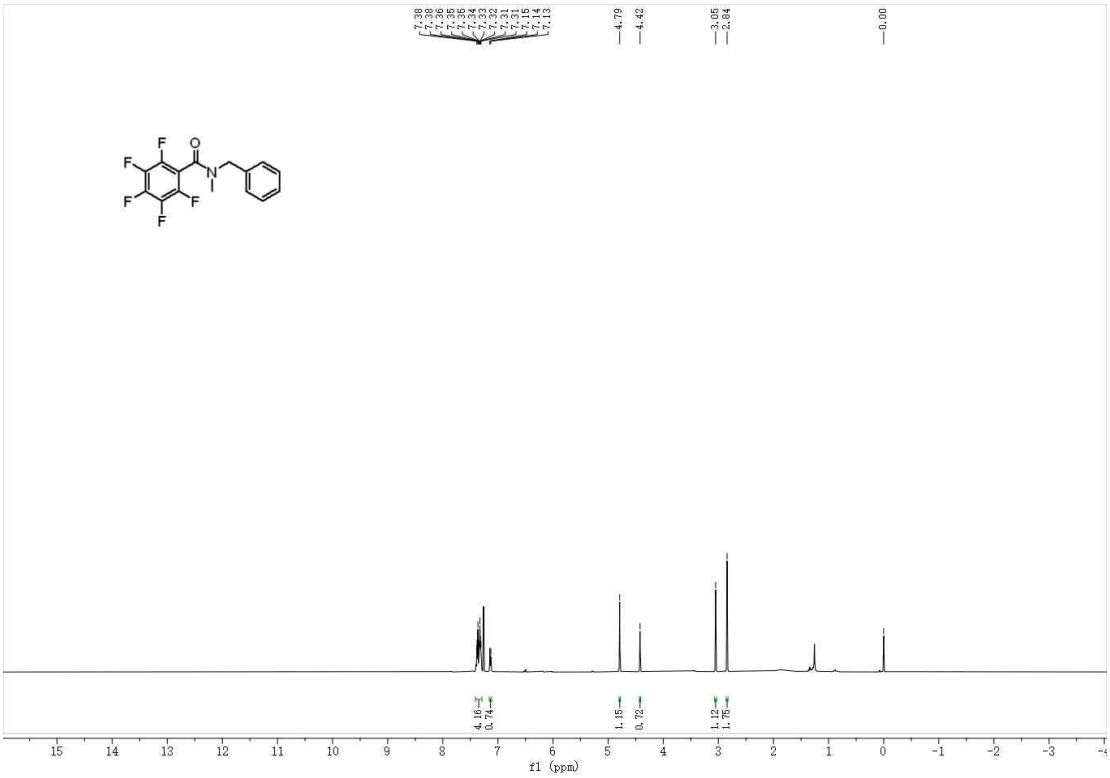
^{1}H NMR Spectrum of Compound 45 (400 MHz, $CDCl_3$)



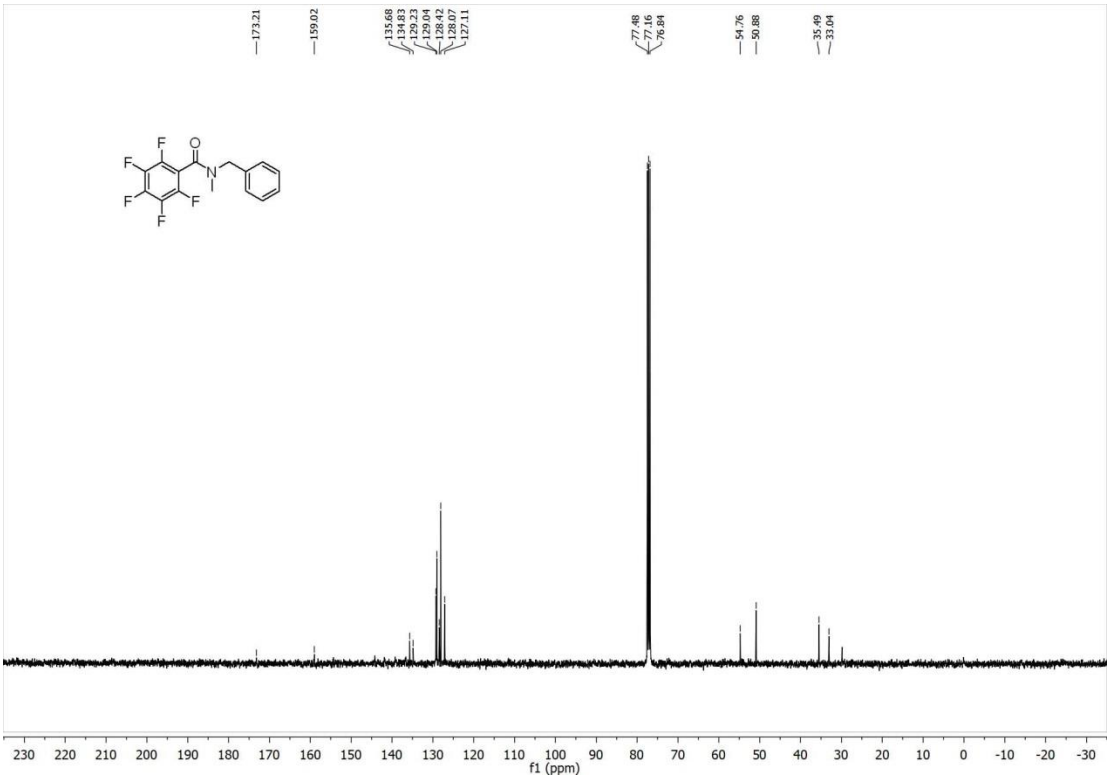
^{13}C NMR Spectrum of Compound 45 (101 MHz, $CDCl_3$)



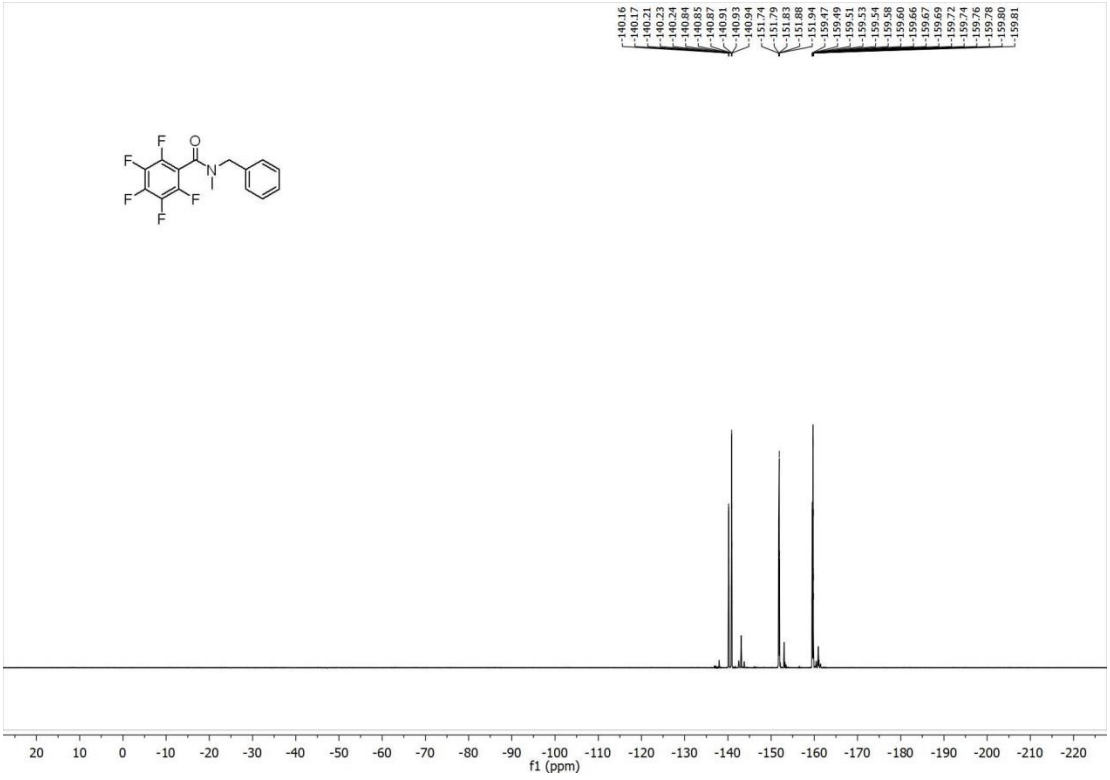
^{19}F NMR Spectrum of Compound 45 (376 MHz, $CDCl_3$)



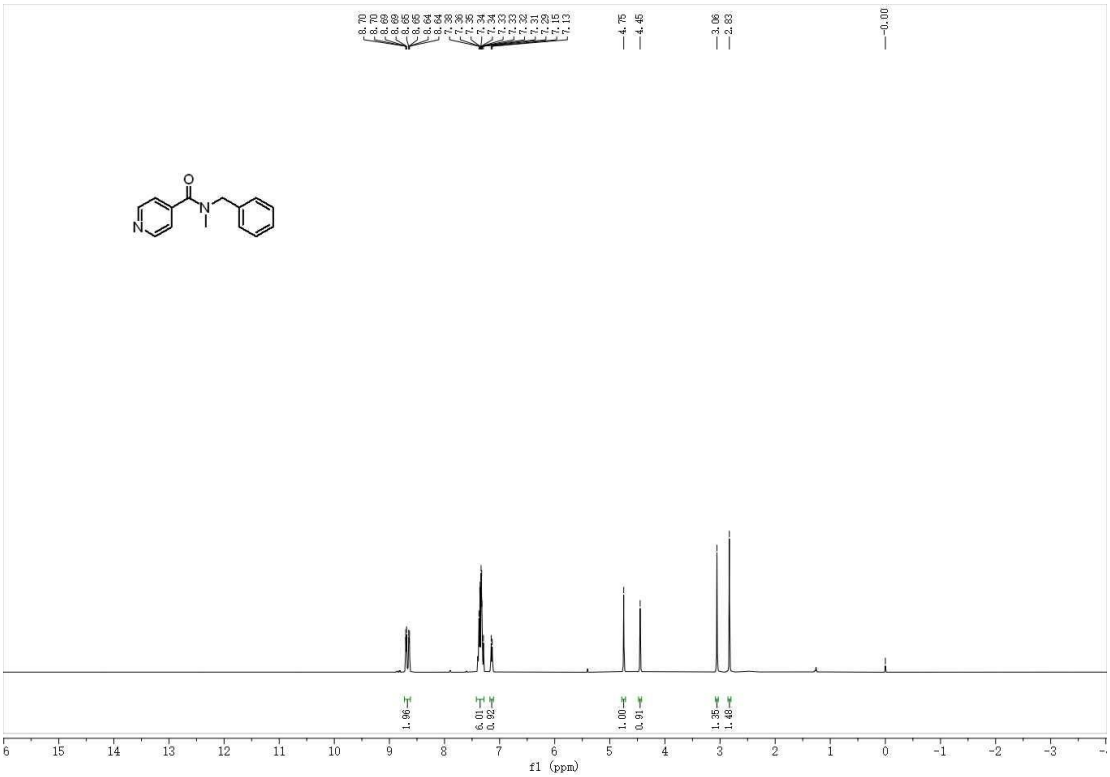
^{1}H NMR Spectrum of Compound 46 (400 MHz, $CDCl_3$)



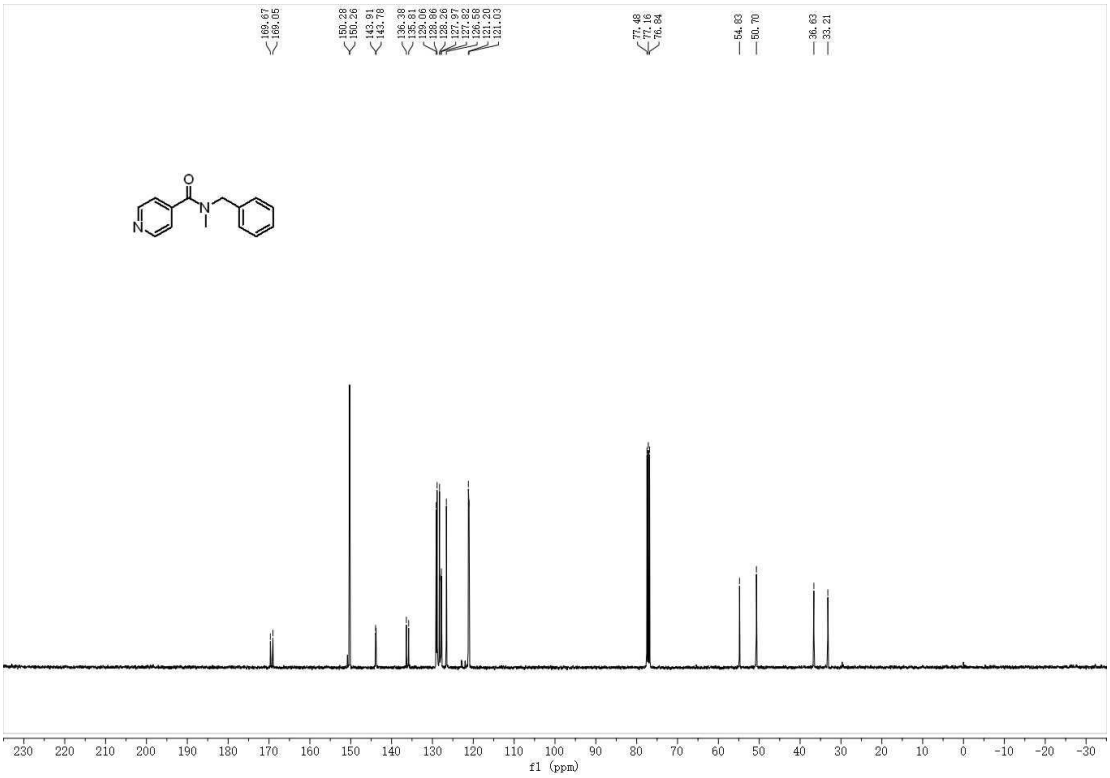
^{13}C NMR Spectrum of Compound 46 (101 MHz, $CDCl_3$)



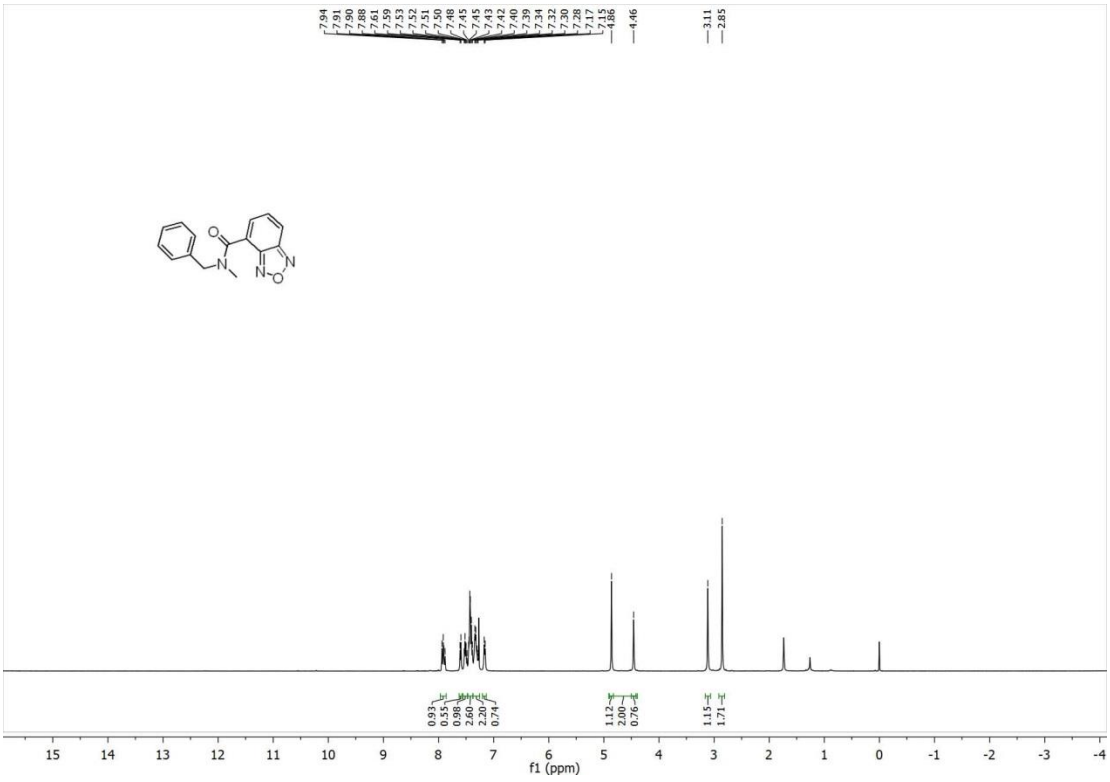
^{19}F NMR Spectrum of Compound 46 (376 MHz, $CDCl_3$)



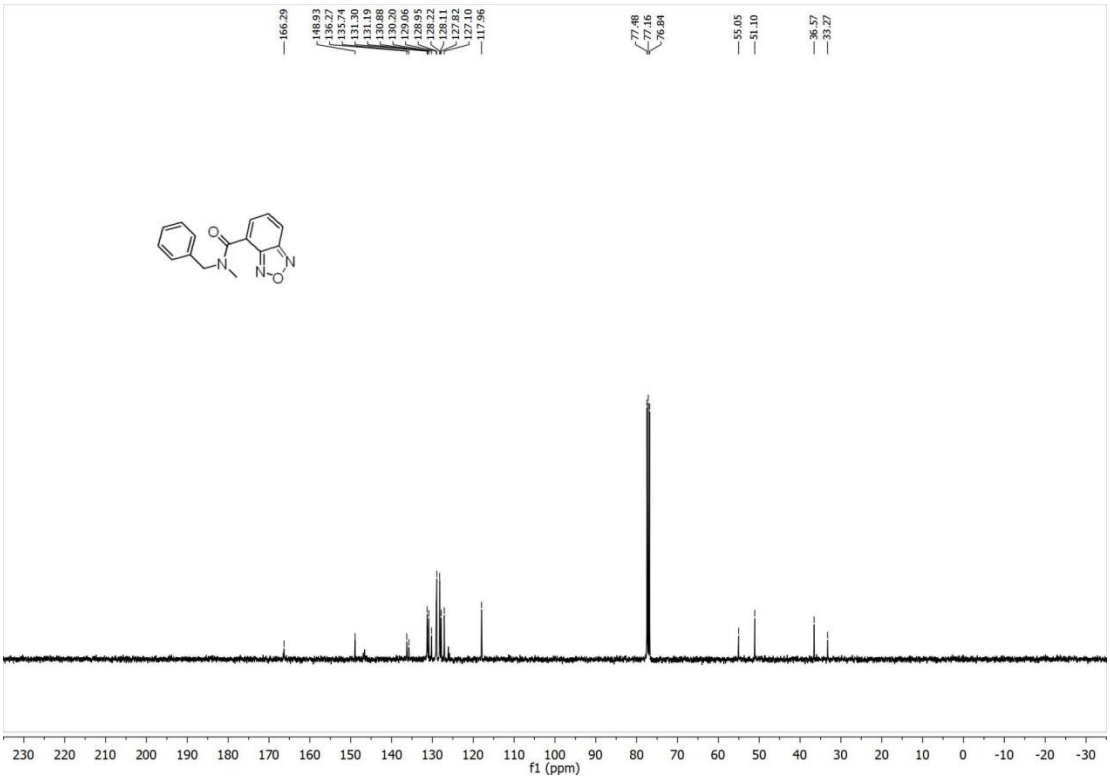
^{1}H NMR Spectrum of Compound 47 (400 MHz, $CDCl_3$)



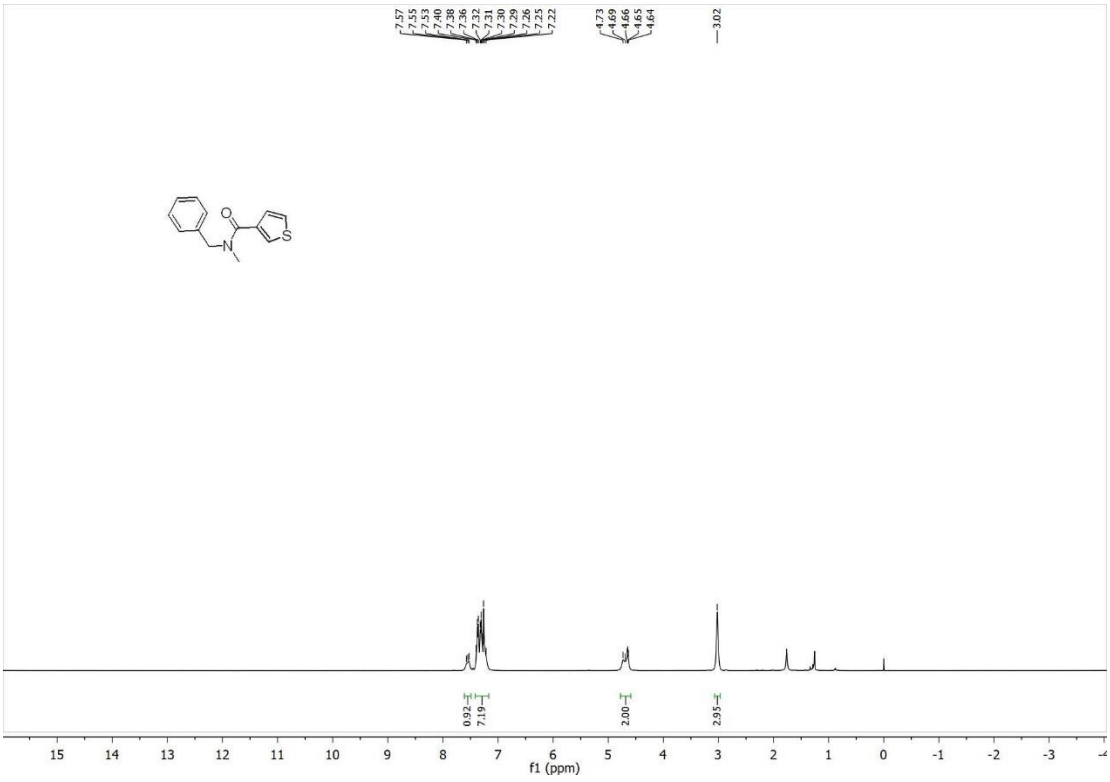
^{13}C NMR Spectrum of Compound 47 (101 MHz, $CDCl_3$)



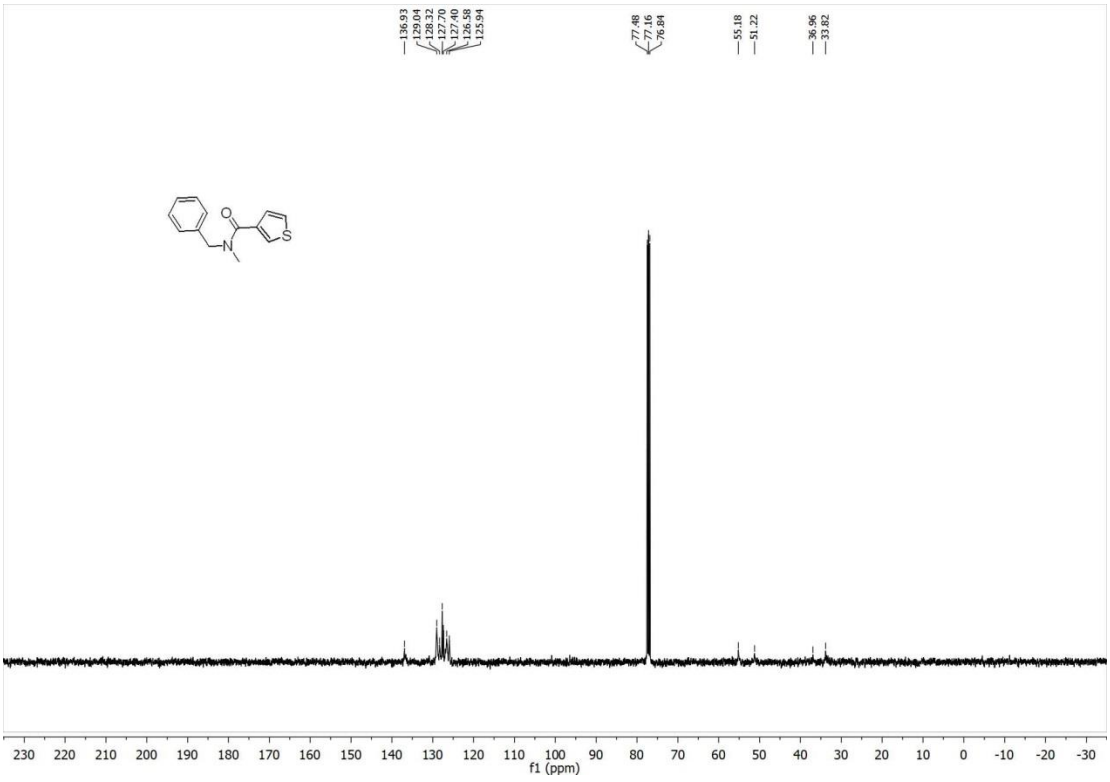
^{1}H NMR Spectrum of Compound 48 (400 MHz, $CDCl_3$)



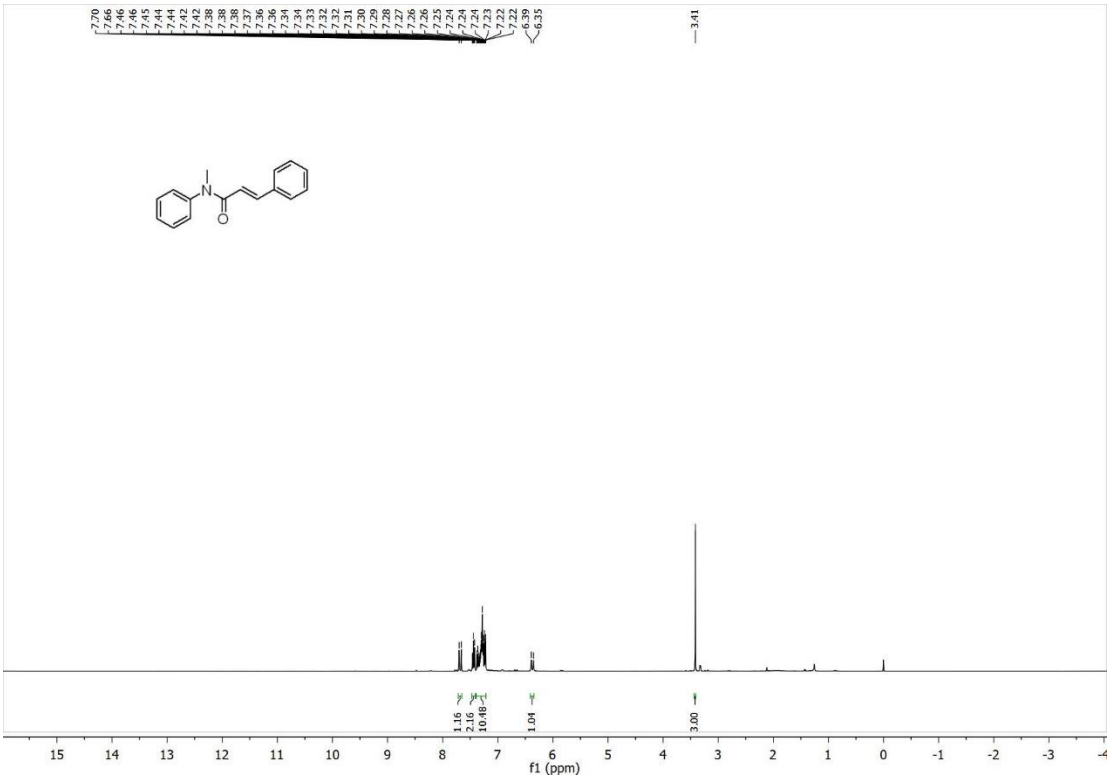
^{13}C NMR Spectrum of Compound 48 (101 MHz, $CDCl_3$)



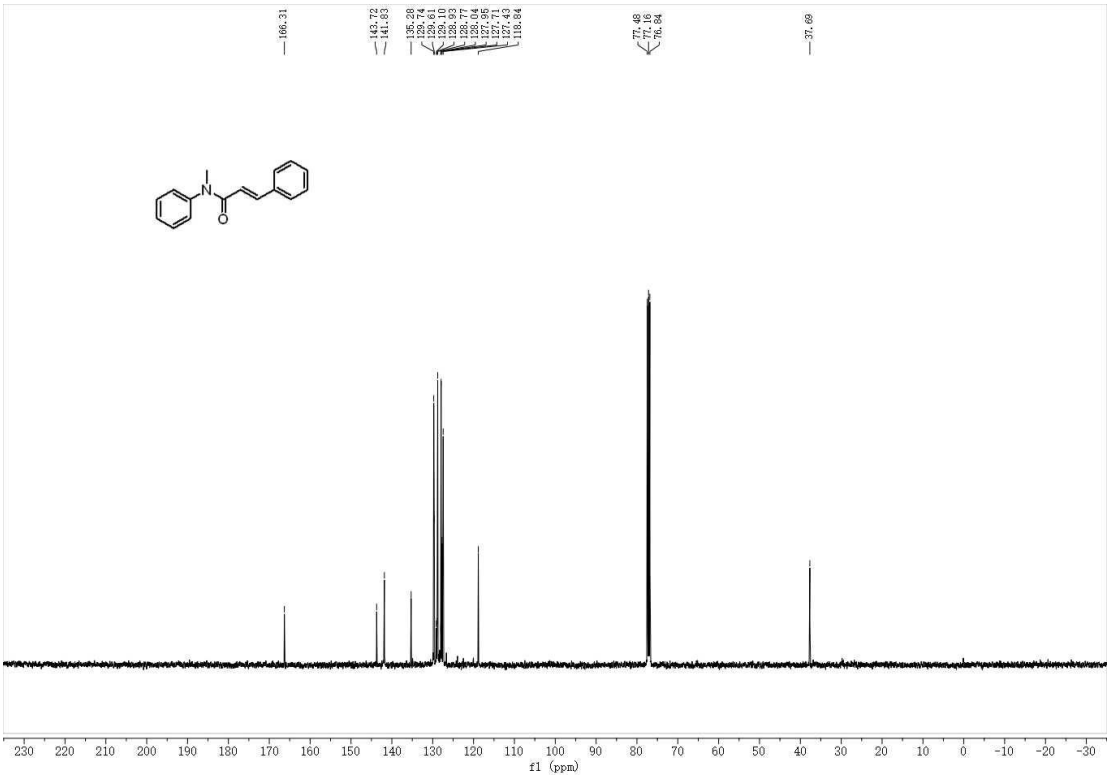
^{1}H NMR Spectrum of Compound 49 (400 MHz, $CDCl_3$)



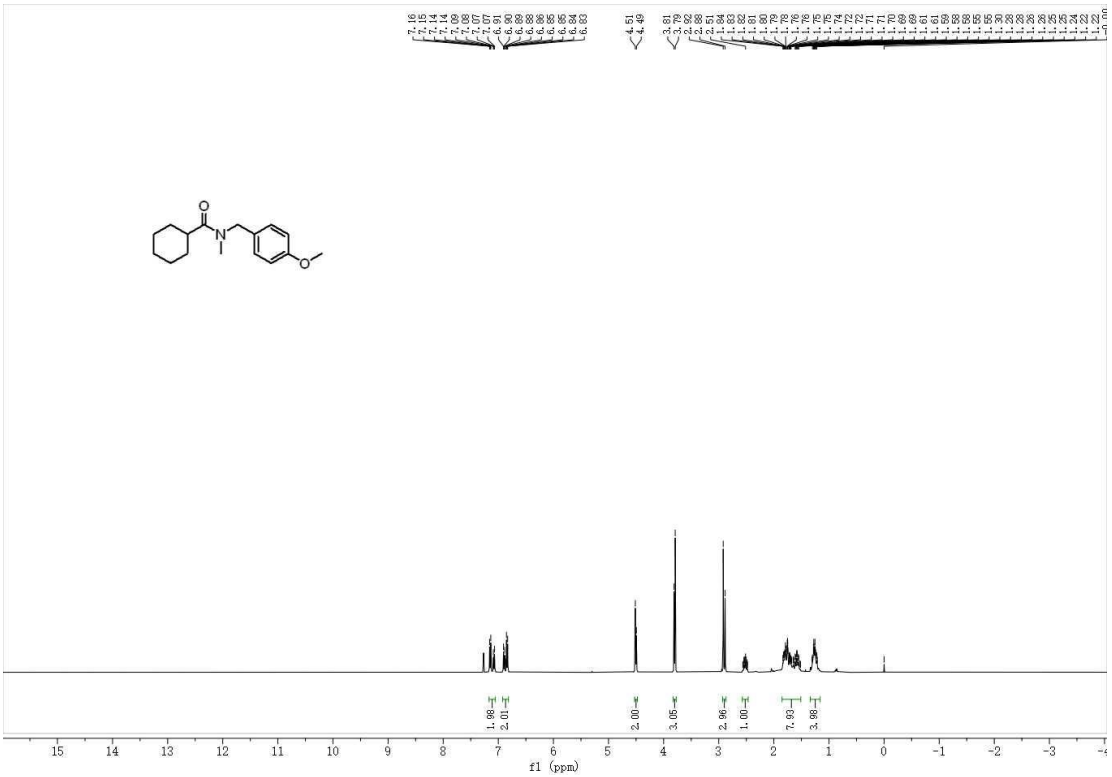
^{13}C NMR Spectrum of Compound 49 (101 MHz, $CDCl_3$)



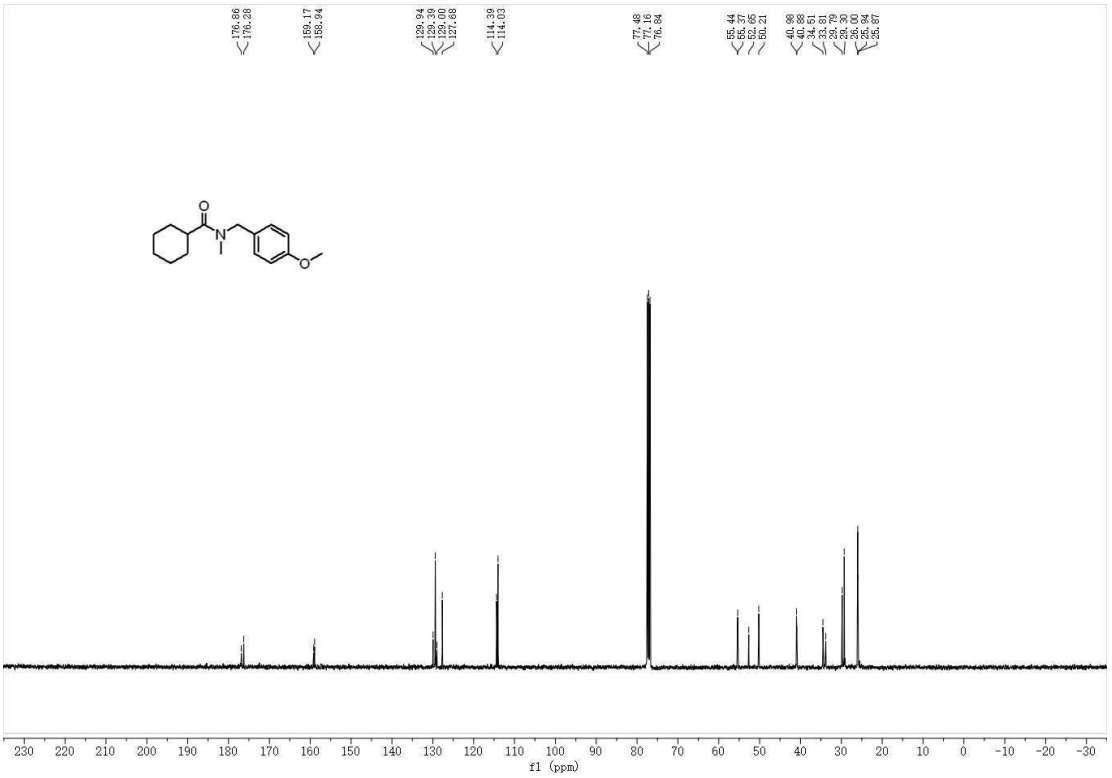
^{1}H NMR Spectrum of Compound 50 (400 MHz, $CDCl_3$)



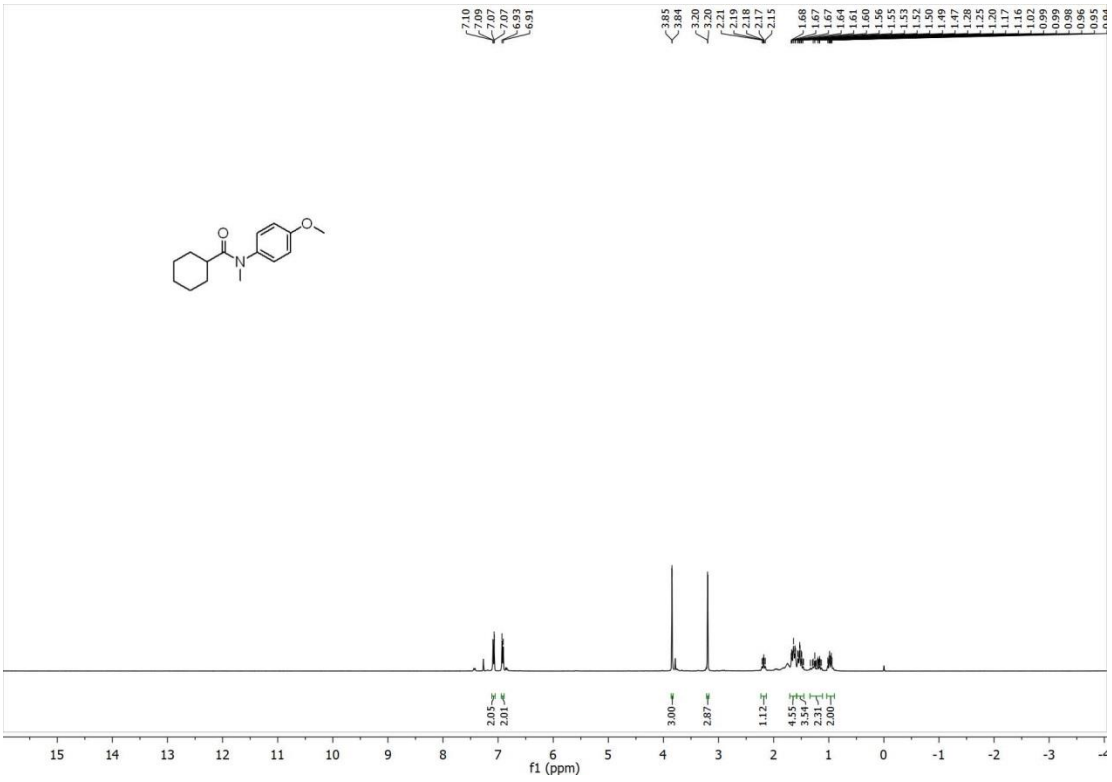
^{13}C NMR Spectrum of Compound 50 (101 MHz, $CDCl_3$)



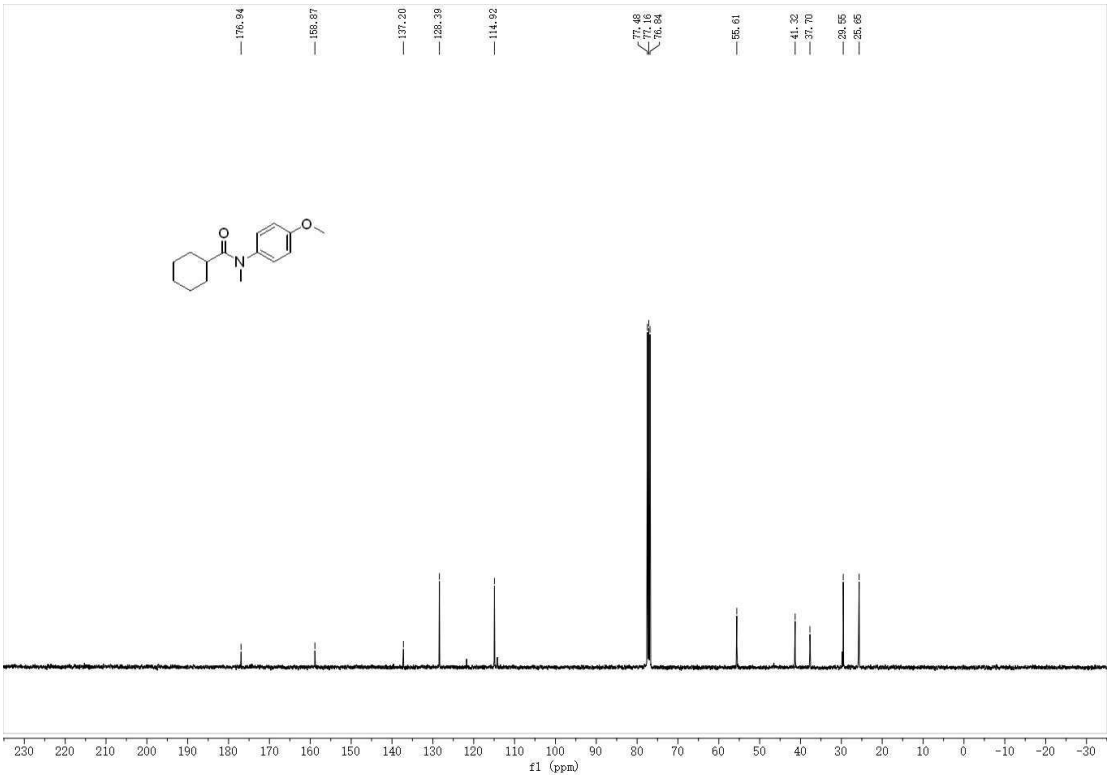
^{1}H NMR Spectrum of Compound 51 (400 MHz, $CDCl_3$)



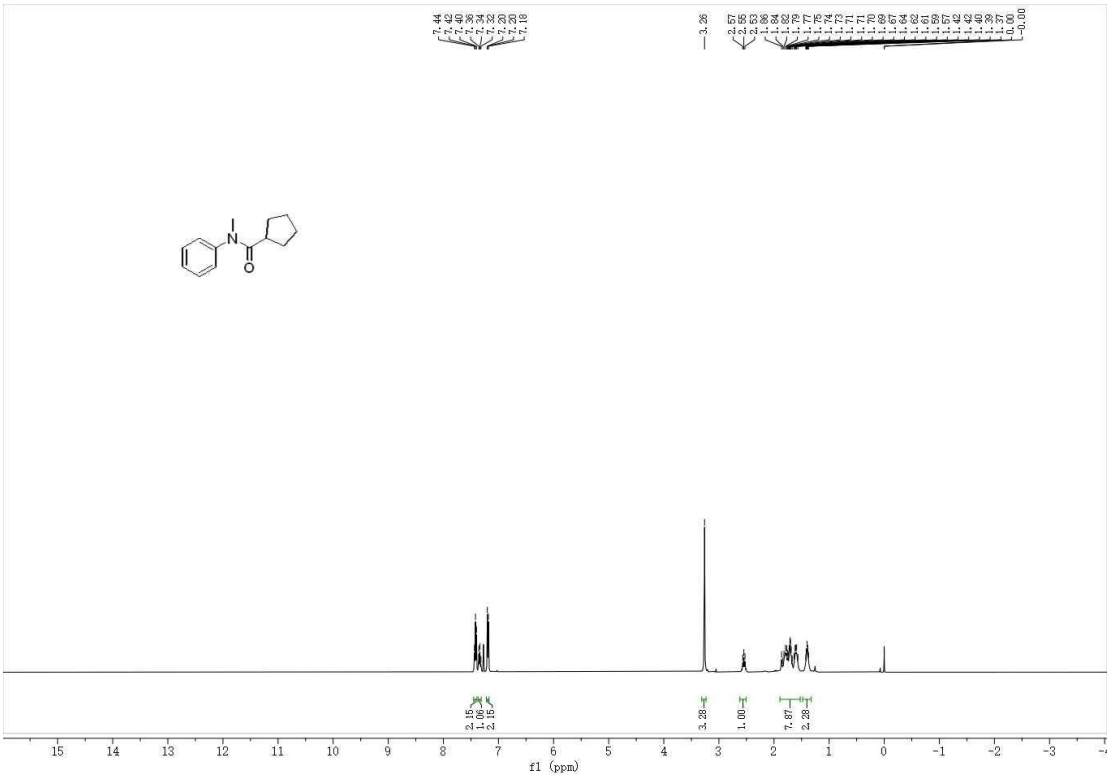
^{13}C NMR Spectrum of Compound 51 (101 MHz, $CDCl_3$)



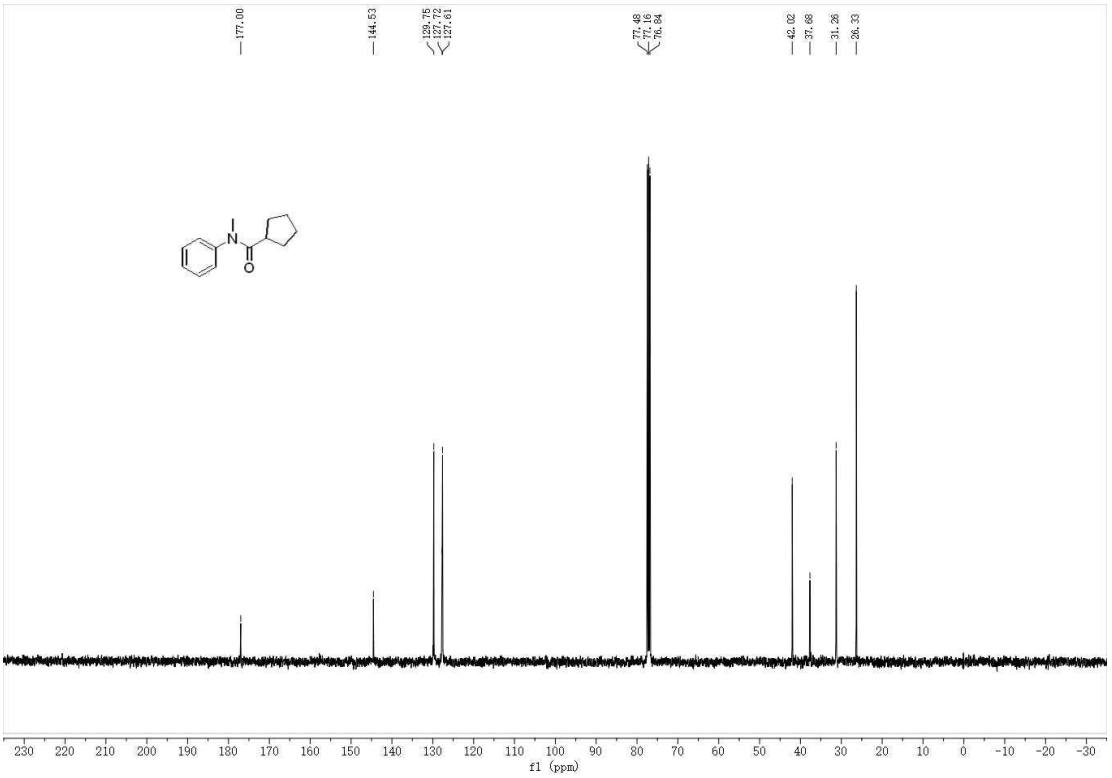
^{1}H NMR Spectrum of Compound 52 (400 MHz, $CDCl_3$)



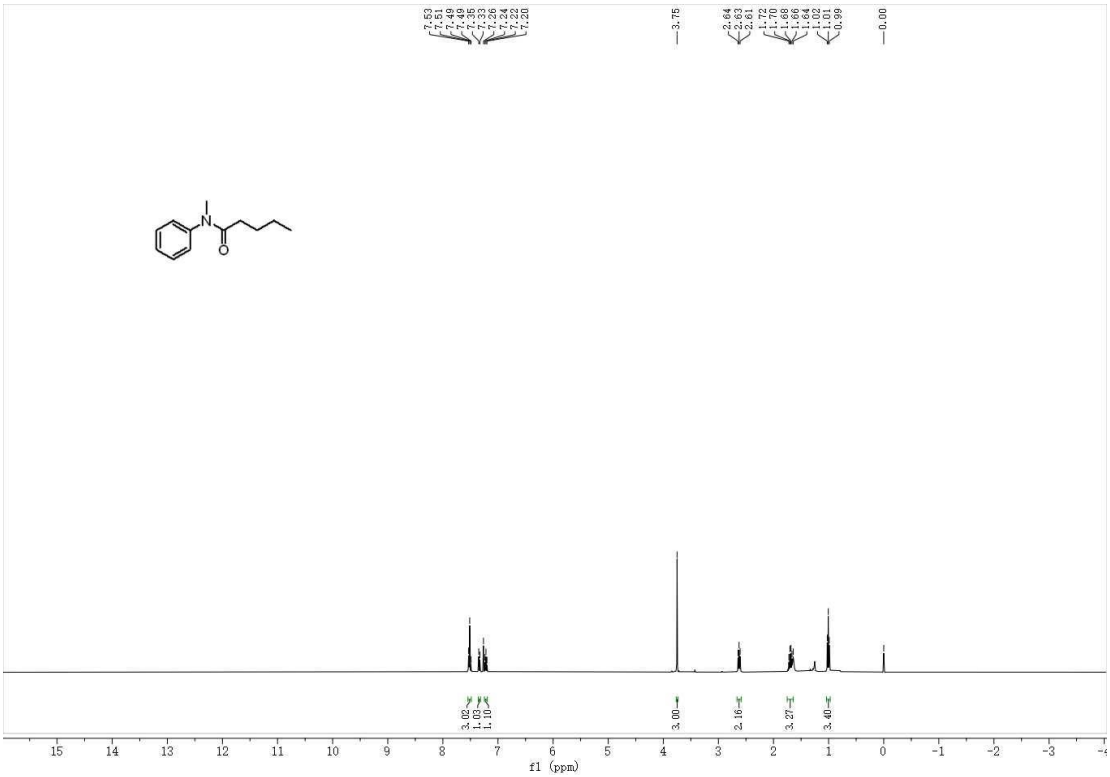
^{13}C NMR Spectrum of Compound 52 (101 MHz, $CDCl_3$)



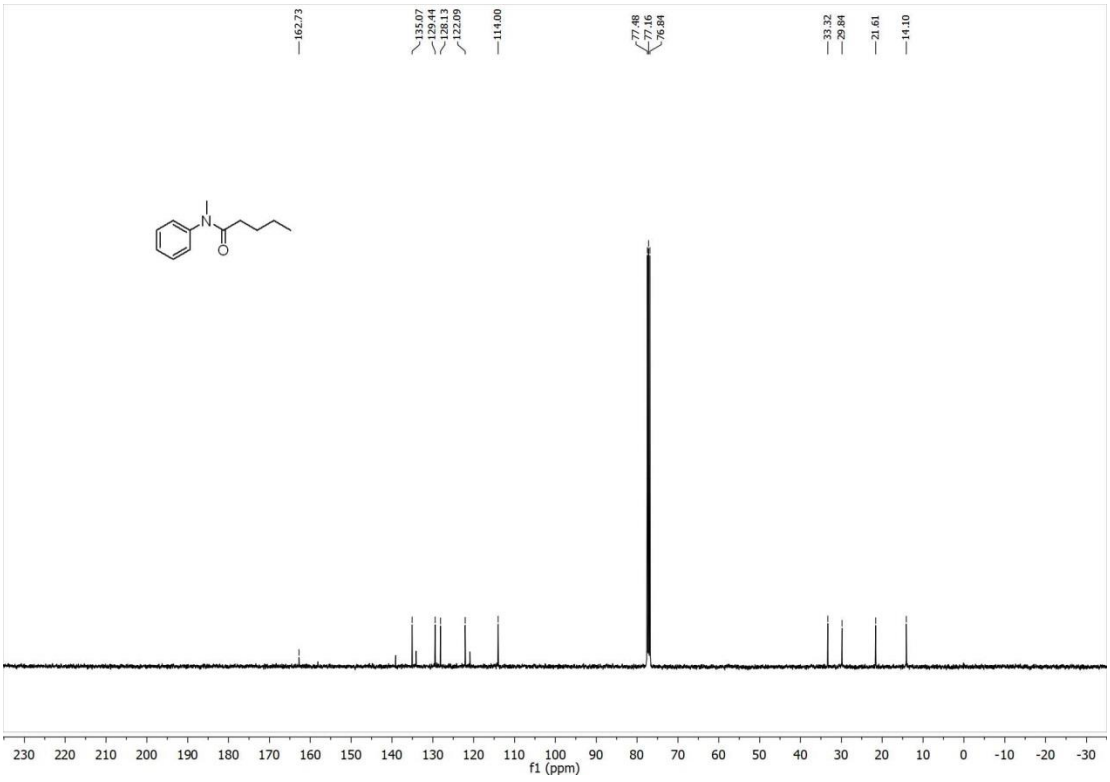
^{1}H NMR Spectrum of Compound 53 (400 MHz, $CDCl_3$)



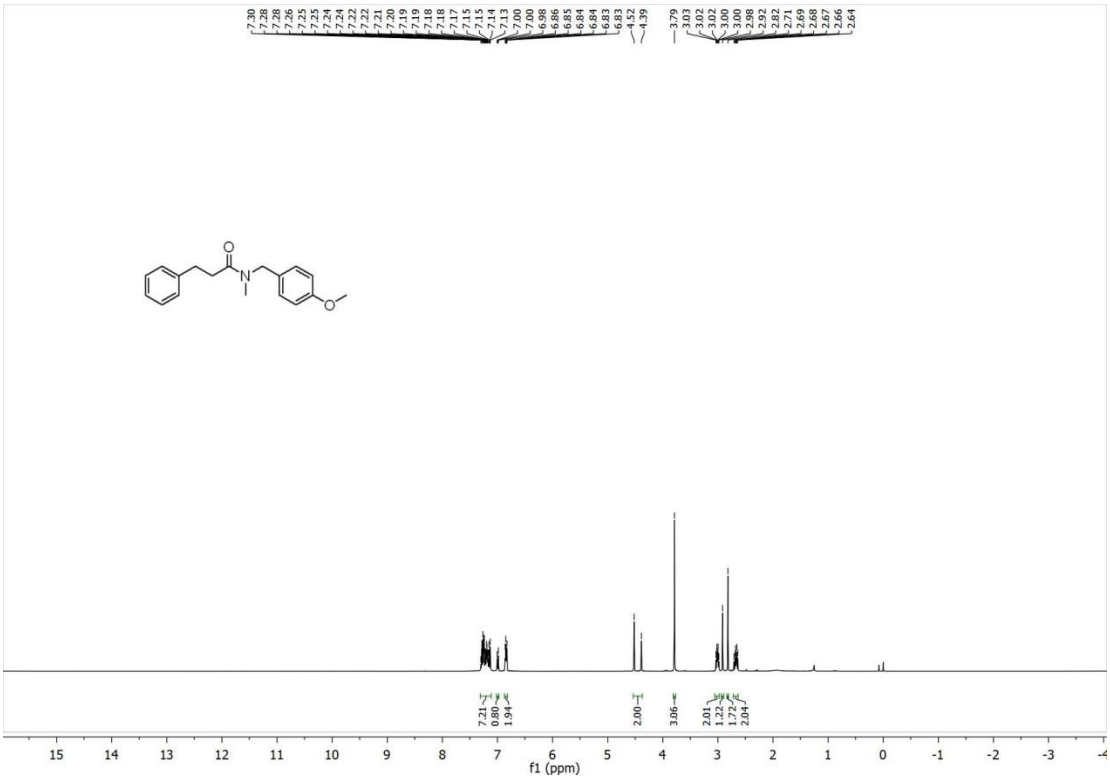
^{13}C NMR Spectrum of Compound 53 (101 MHz, $CDCl_3$)



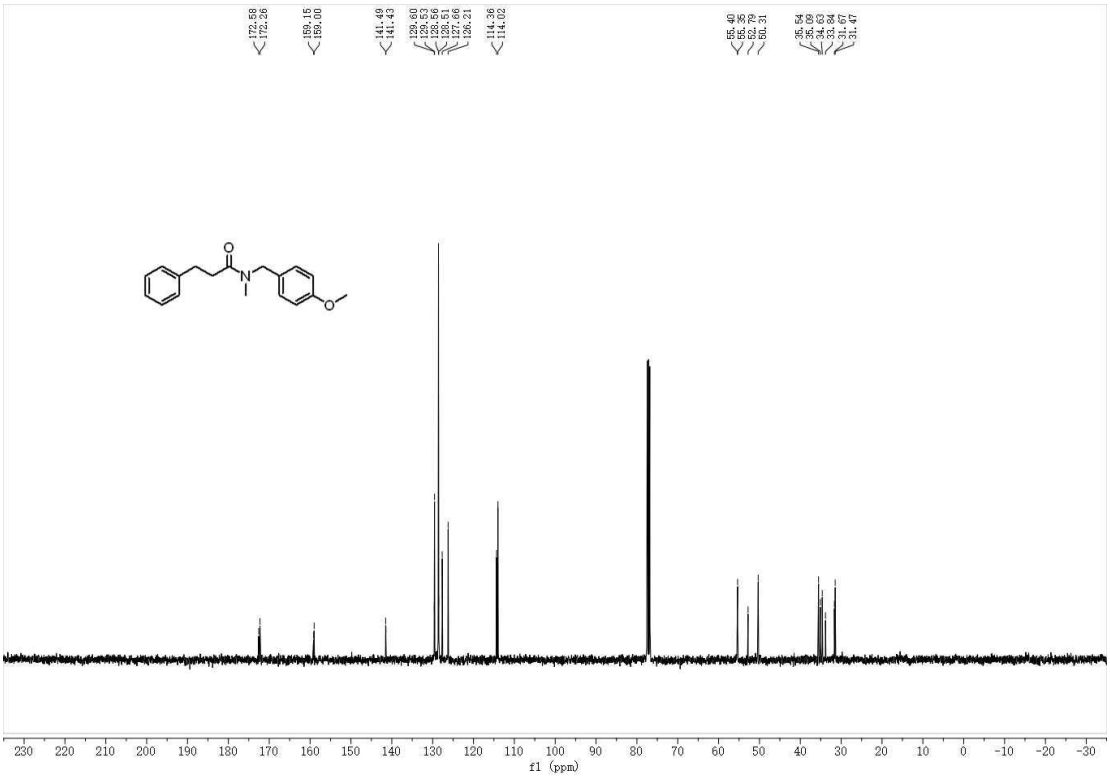
^{1}H NMR Spectrum of Compound 54 (400 MHz, $CDCl_3$)



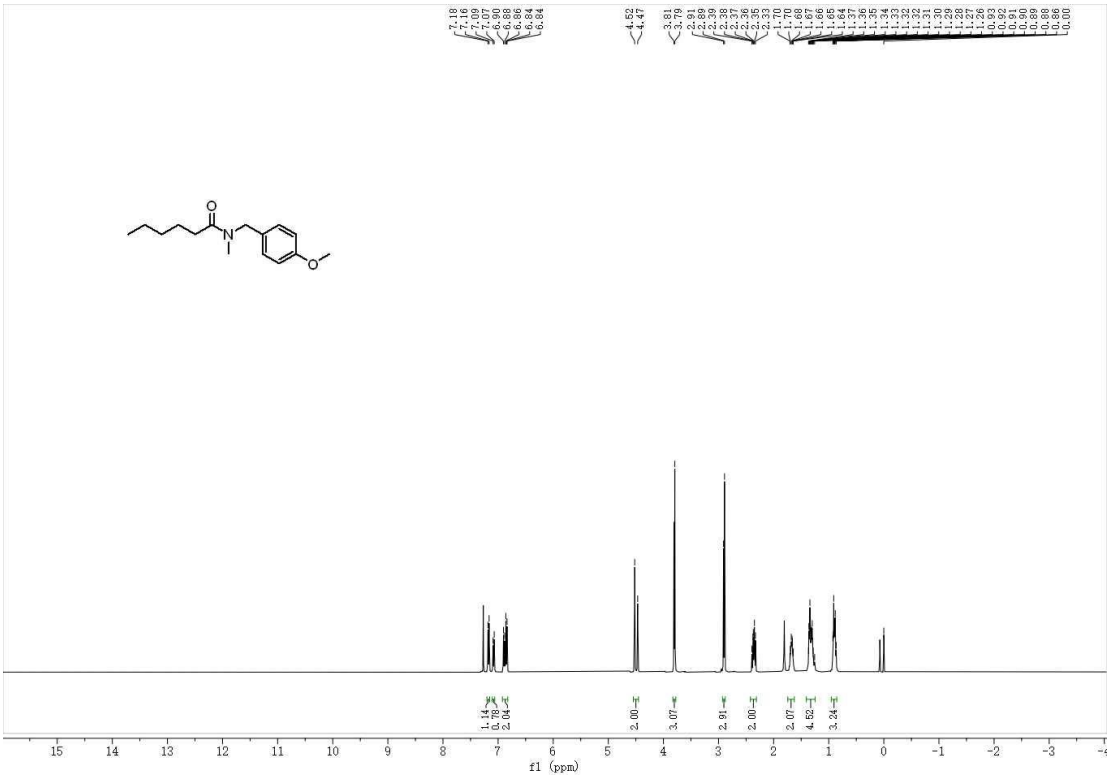
^{13}C NMR Spectrum of Compound 54 (101 MHz, $CDCl_3$)



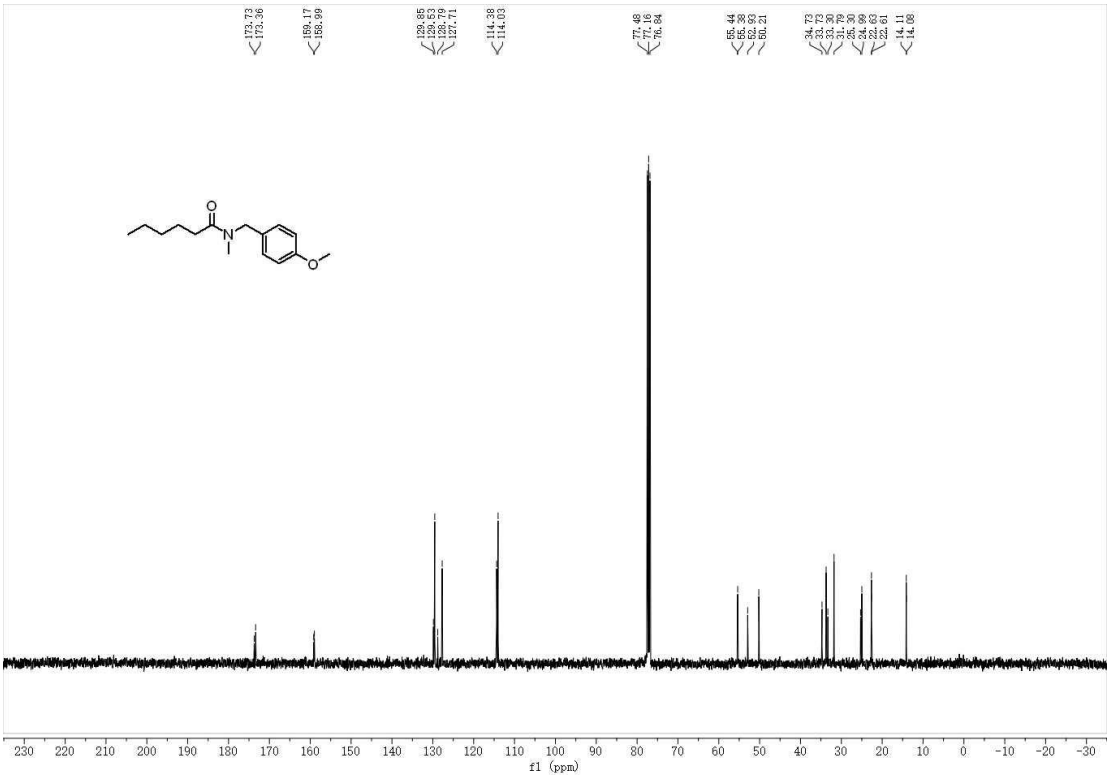
^{1}H NMR Spectrum of Compound 55 (400 MHz, $CDCl_3$)



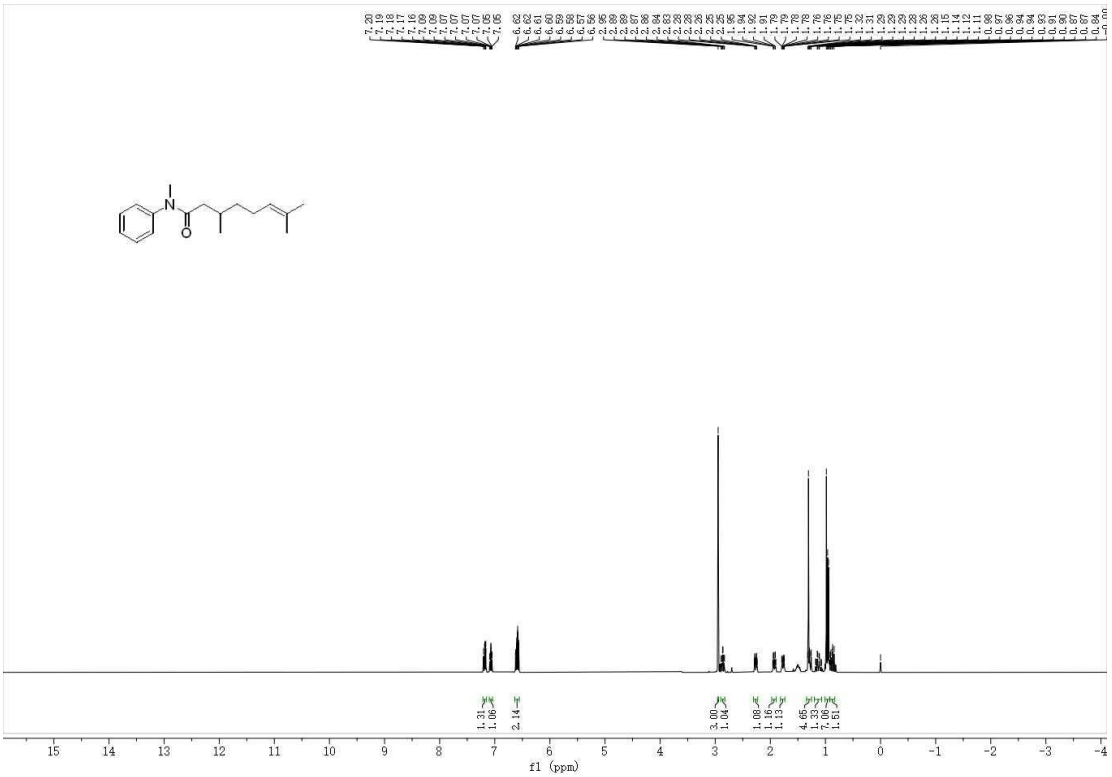
^{13}C NMR Spectrum of Compound 55 (101 MHz, $CDCl_3$)



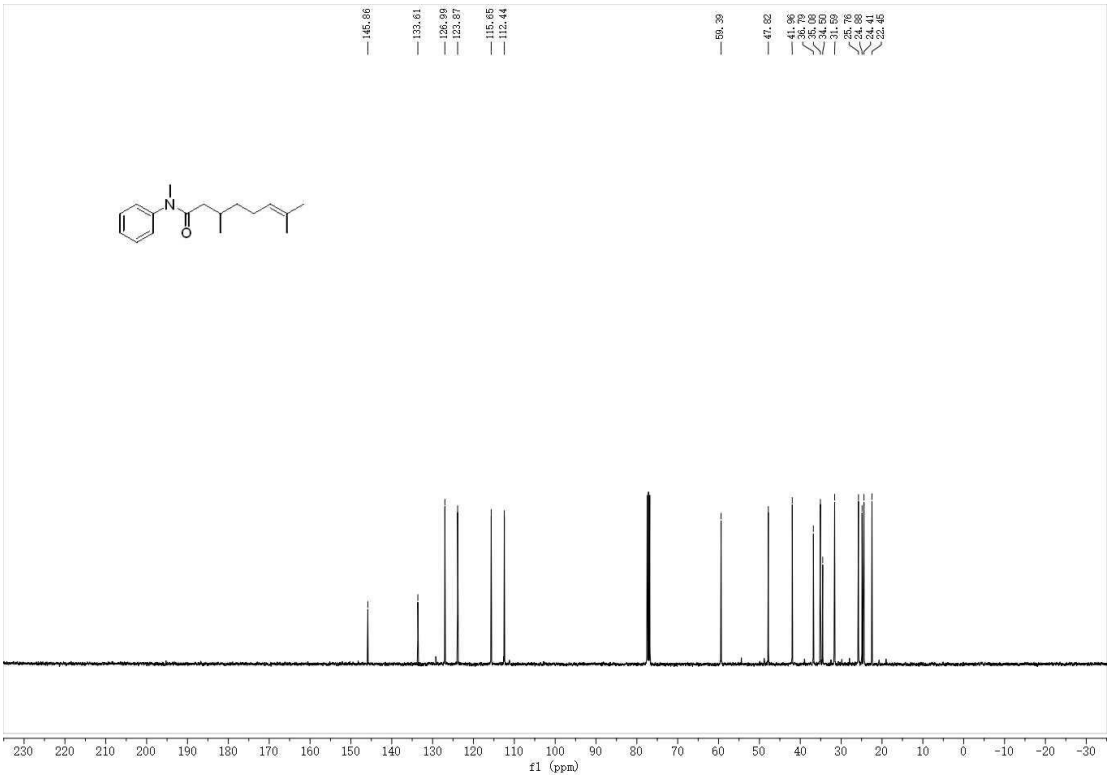
^{1}H NMR Spectrum of Compound 56 (400 MHz, $CDCl_3$)



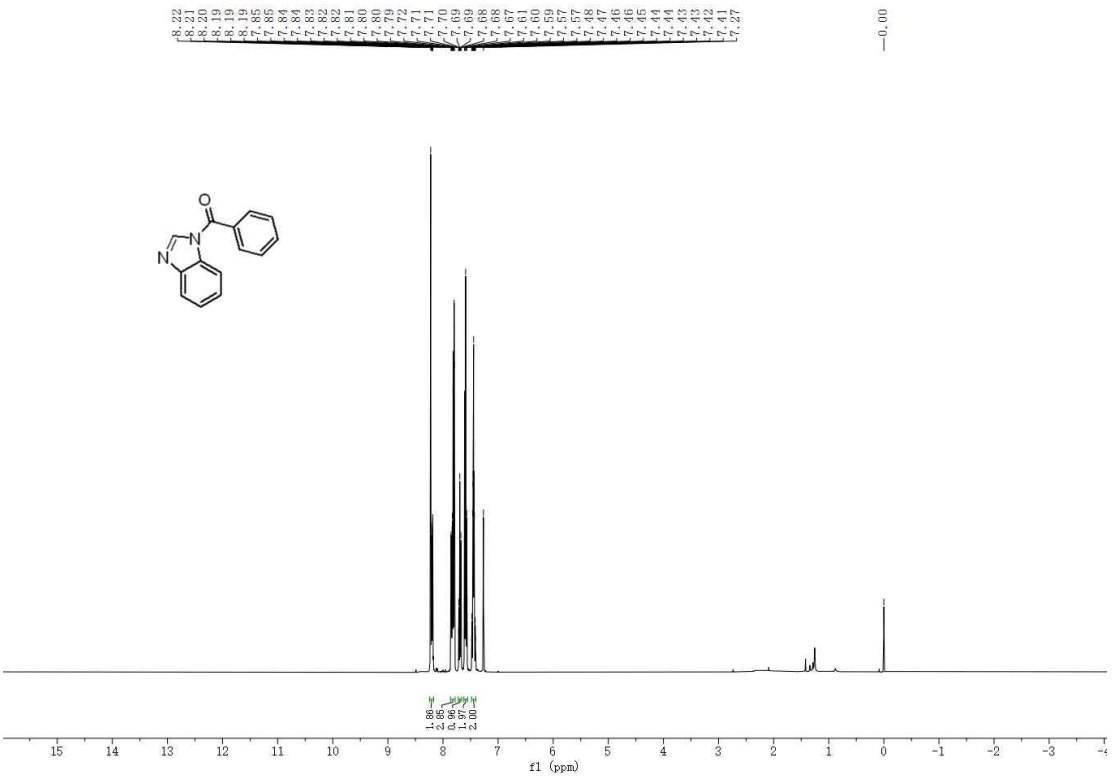
^{13}C NMR Spectrum of Compound 56 (101 MHz, $CDCl_3$)



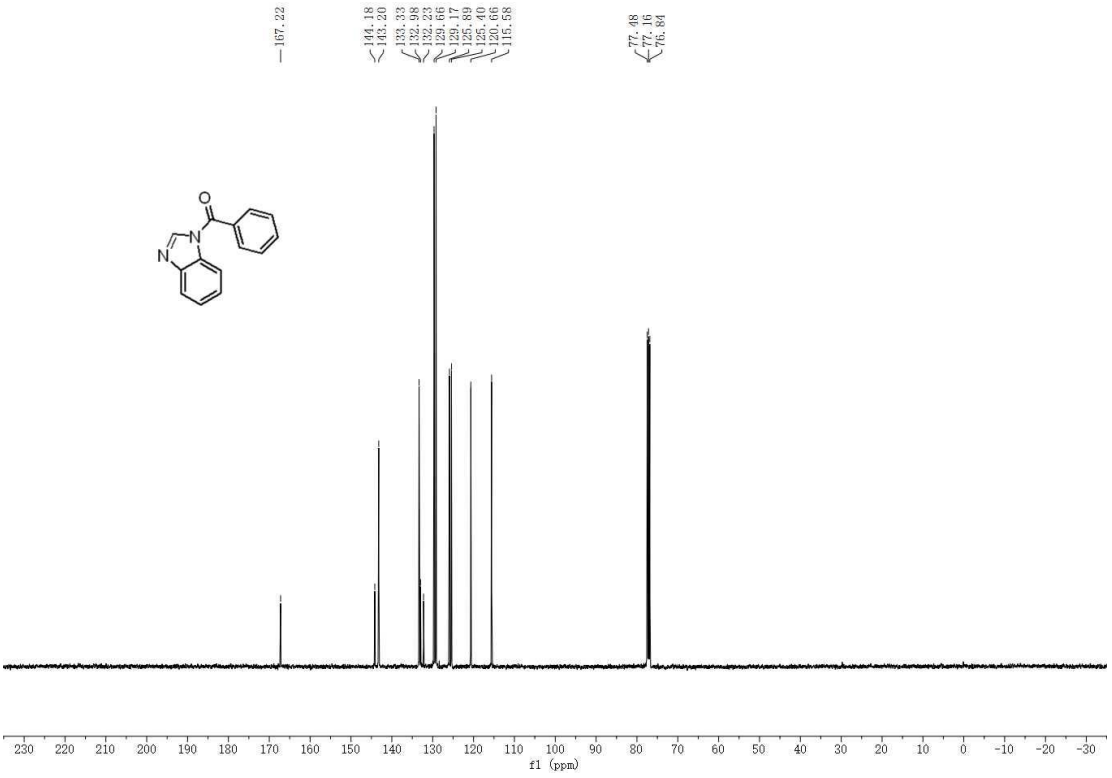
^{1}H NMR Spectrum of Compound 57 (400 MHz, $CDCl_3$)



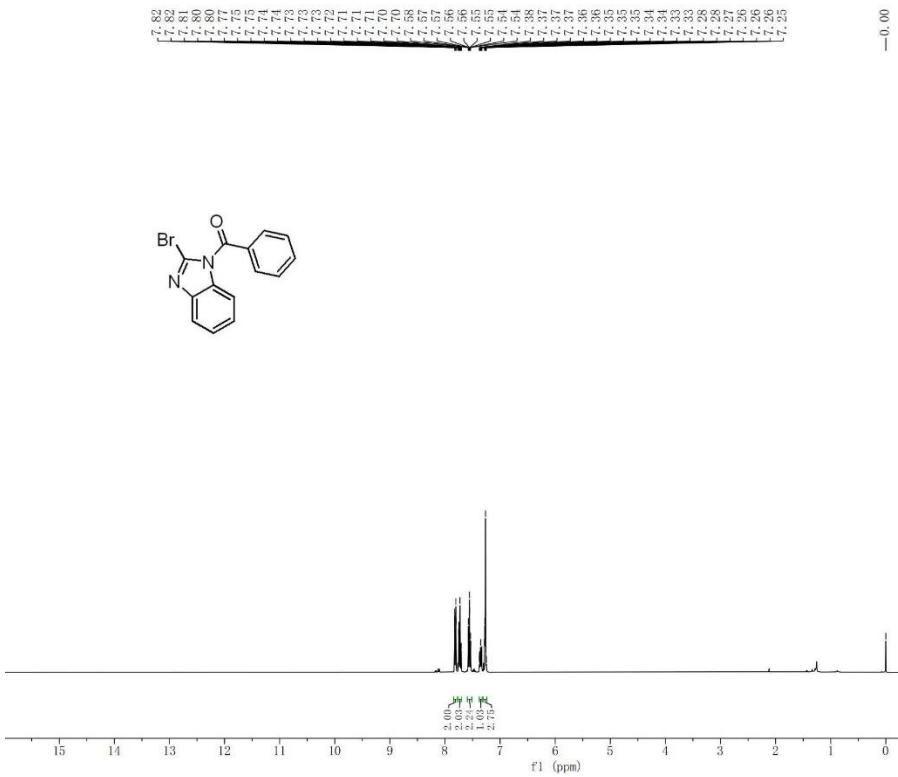
^{13}C NMR Spectrum of Compound 57 (101 MHz, $CDCl_3$)



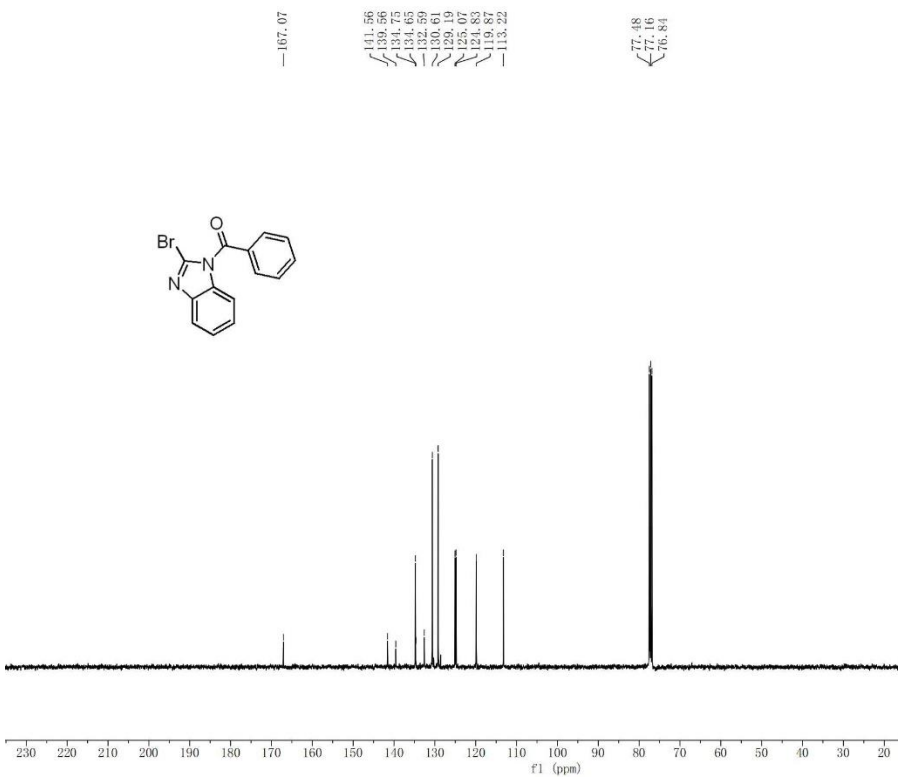
^{1}H NMR Spectrum of Compound 58 (400 MHz, $CDCl_3$)



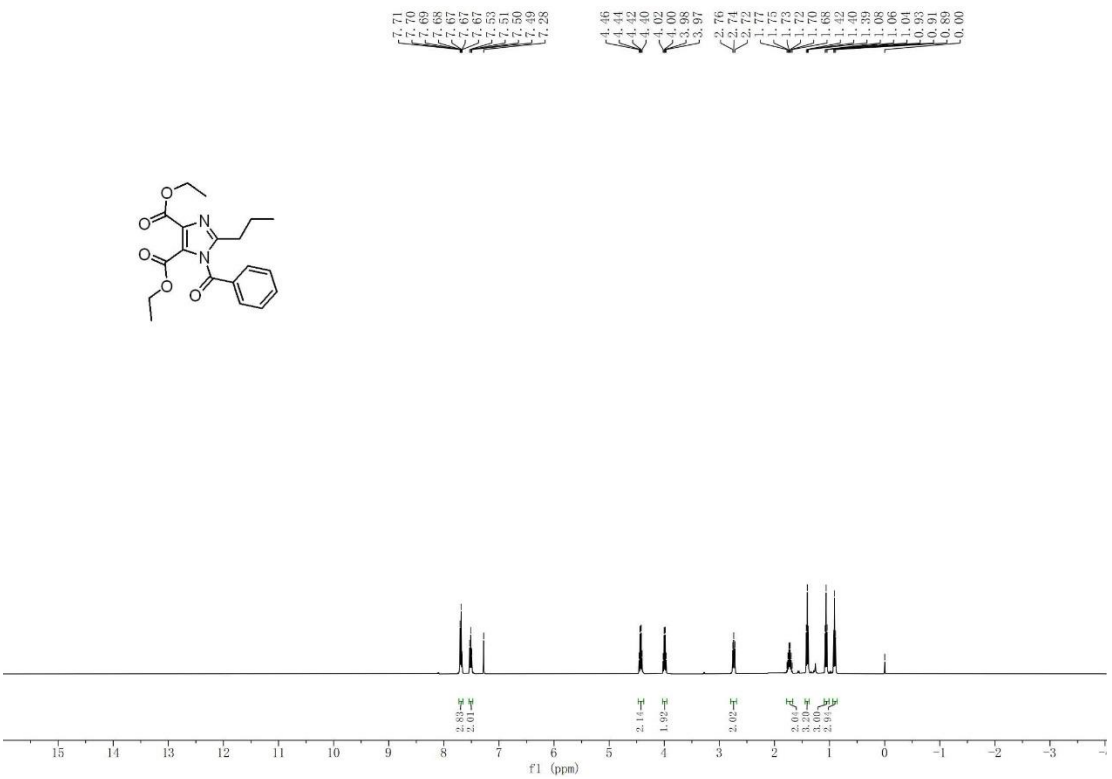
^{13}C NMR Spectrum of Compound 58 (101 MHz, $CDCl_3$)



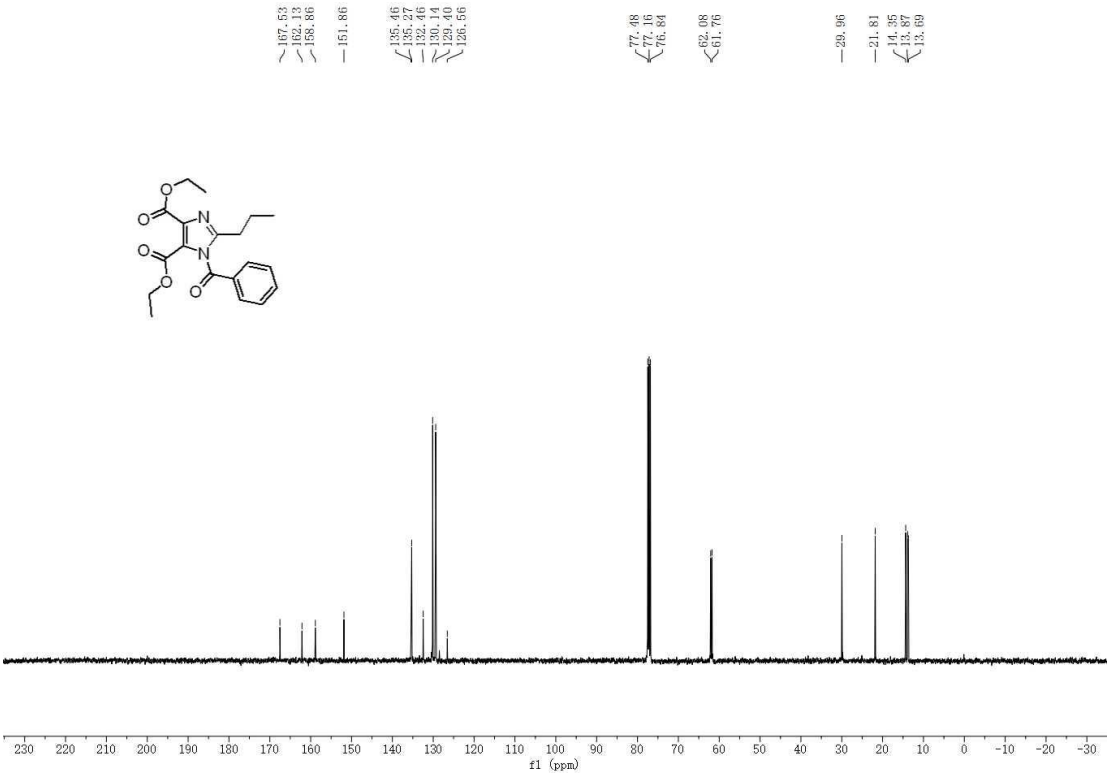
^{1}H NMR Spectrum of Compound 59 (400 MHz, $CDCl_3$)



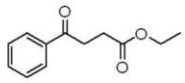
^{13}C NMR Spectrum of Compound 59 (101 MHz, $CDCl_3$)

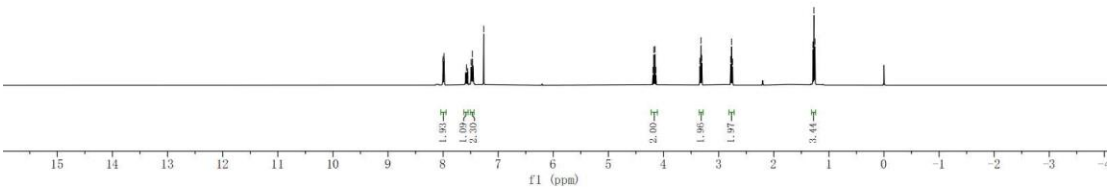


^{1}H NMR Spectrum of Compound 60 (400 MHz, $CDCl_3$)

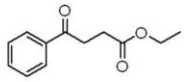


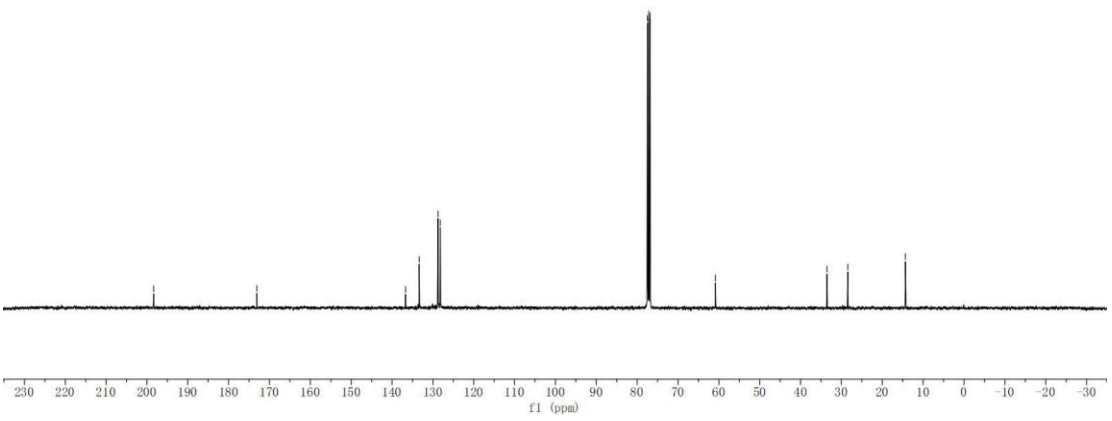
^{13}C NMR Spectrum of Compound 60 (101 MHz, $CDCl_3$)





^{1}H NMR Spectrum of Compound 62 (400 MHz, $CDCl_3$)





^{13}C NMR Spectrum of Compound 62 (101 MHz, $CDCl_3$)