Supporting Information

Photocatalytic Synthesis of 2,3-Diamines from Anilines and DIPEA via C-N Bond Cleavage and C-C Bond Formation

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1. General information

The reactions via general procedure was carried out under an atmosphere of argon unless otherwise noted. Column chromatography was performed with silica gel (200-300 mesh) with petroleum ether/ethyl acetate and ethyl acetate as eluents.Unless otherwise noted, all other reagents were obtained from commercial suppliers and used without further purification, all solvents was dried. ^{1}H NMR spectra were recorded using a Bruker 400 MHz instrument with tetramethylsilane (TMS) as an internal standard. ^{13}C NMR spectra were obtained at 100 MHz and referenced to the internal solvent signals. Mass spectra were measured on Agilent 5977 GC-MS instrument (EI). The structures of known compounds were further corroborated by comparing their ^{1}H NMR, ^{13}C NMR date and MS date with those in literature. Some new compounds for HRMS were tested on a Q-TOF time-of-flight with Dual ESI mass spectrometer. Some high-resolution mass spectra (HRMS) were obtained by fast atom bombardment (FAB) using a double focusing magnetic sector mass spectrometer and electron impact (EI) ionization technique. Stea-state emission spectra were recorded using a Cary Eclipse Fluorescence spectrophotometer (Agilent Techonologies). The light source was 20 W blue LED (454 nm, 1 W*20, 30-50 cd/m^2, made in Everlight Electronics., Ltd.); borosilicate glass Schlenk tube was used as the irradiation vessel; the distance from the light source to the irradiation vessel; 2-3 cm and no filter was used. The organic photocatalyst 4CzIPN was synthesized using reported procedures.[1]

2. General procedure for the diamine reaction

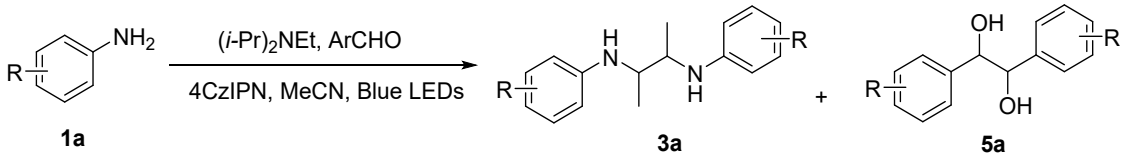


Figure S1

Under the protection of argon, a 25 mL Schlenk tube equipped with a magnetic stir bar was charged with 4CzIPN (23.7 mg, 0.03 mmol, 10 mol%), aniline (27.9 mg, 0.3 mmol, 1.0 equiv), (*i*-Pr)$_2$NEt (77.6 mg, 0.6 mmol, 2.0 equiv), and aromatic aldehydes (31.8 mg, 0.3 mmol, 1.0 equiv), in 2.0 mL acetonitrile. The resulting mixture was stirred for 20 h under irradiation with a 20 W blue LEDs at room temperature, and cooled by a fan to keep the temperature relatively constant. The reaction was monitored by TLC. The resulting solution was concentrated in vacuum and the residue was purified by chromatography on silica gel, eluting with the mixture of ethyl acetate/petroleum ether/ethyl acetate to give the product **3a** and **5a.**

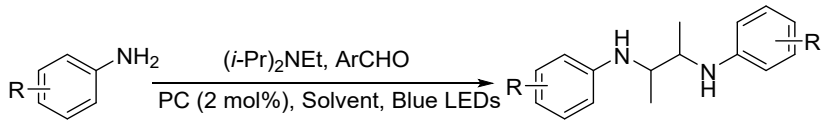
Scale-up experiment

12 mmol scale reaction: Under the protection of argon, a 100 mL oven-dried reaction vessel equipped with a magnetic stir bar was charged with 4CzIPN (189.4 mg, 0.3 mmol, 2 mol%), aniline (1.1 g, 12 mmol, 1.0 equiv), (*i*-Pr)$_2$NEt (3.1 g, 24 mmol, 2.0 equiv), and aromatic aldehydes (1.3 g, 12 mmol, 1.0 equiv), in 50.0 mL acetonitrile. The resulting mixture was stirred

for 20 h under irradiation with a 20 W blue LEDs at room temperature, and cooled by a fan to keep the temperature relatively constant. The reaction was monitored by TLC. The resulting solution was concentrated in vacuum and the residue was purified by chromatography on silica gel, eluting with the mixture of ethyl acetate/petroleum ether/ethyl acetate to give the product **3a** (748.8mg, 52% yield) and **5a** (590.6 mg, 46% yield)

3. Optimization of reaction conditions

Table S1. Conditions for the optimization of solvent and PC [a]



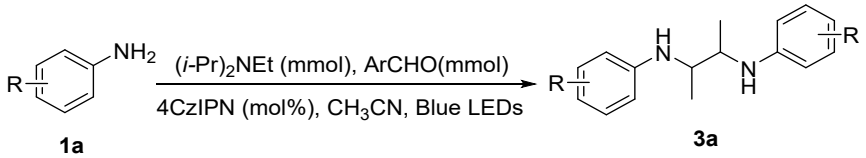
1a **3a**

entry	solvent	PC (2 mol%)	Time (h)	Yield (%)[b]
1	THF	4CzIPN	24	34
2	CH_3CN	4CzIPN	24	69
3	acetone	4CzIPN	24	58
4	DMF	4CzIPN	24	52
5	toluene	4CzIPN	24	trace
6	DMSO	4CzIPN	24	trace
7	1,4-dioxane	4CzIPN	24	50
8	DCE	4CzIPN	24	65
9	DCM	4CzIPN	24	64
10	EA	4CzIPN	24	28
11	EtOH	4CzIPN	24	trace
12	HFIP	4CzIPN	24	n.d.
13	CH_3CN	4CzPN	24	42
14	CH_3CN	4CzTPN	24	55
15	CH_3CN	4*t*-BuCzIPN	24	61
16	CH_3CN	4DP-IPN	24	56
17	CH_3CN	*fac*-Ir(ppy)$_3$	24	53
18	CH_3CN	BP	24	trace
19	CH_3CN	Eosin Y	24	trace
20	CH_3CN	DDQ	24	trace

21	CH_3CN	$Ru(bpy)_3Cl_2$	24	n.d.
22	CH_3CN	Riboflavine	24	n.d.
23	CH_3CN	Rhodamine B	24	trace
24	CH_3CN	Xanthone	24	n.d.
25	CH_3CN	1,4-Dicyanbenzene	24	n.d.
26 [c]	CH_3CN	4CzIPN	48	n.d.
27 [d]	CH_3CN	4CzIPN	48	n.d.
28 [e]	CH_3CN	4CzIPN	48	trace

[a] Reaction conditions*:* **1a** (0.3 mmol), **(*i*-Pr)$_2$NEt** (0.6 mmol), **ArCHO** (0.3 mmol) and photocatalyst (2 mol%) in solvent (2 mL) at room temperature in argon under a 20 W blue LEDs (460-470 nm) irradiation, unless otherwise noted. [b] Isolated yields, *dr* = diastereomeric ratio. [c] The reaction was carried out in dark. [d] The reaction was carried out at 70 ℃. [e] The reaction was carried out under air atmosphere.

Table S2. Conditions for the optimization of 4CzIPN (mmol), (*i*-Pr)$_2$Net (mmol) and ArCHO (mmol).[a]



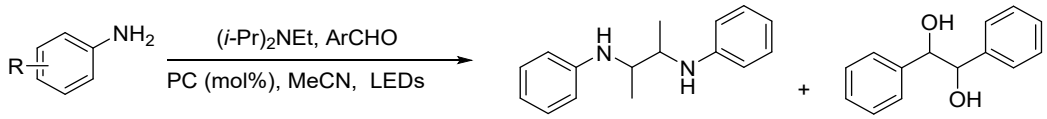
1a **3a**

entry	**4CzIPN (mol%)**	**(*i*-Pr)$_2$Net (mmol)**	**Time (h)**	**Yield (%)**[b]
1	—	0.6 mmol	48	n.d.
2	2 mol%	0.6 mmol	24	69
3	4 mol%	0.6 mmol	20	72
4	6 mol%	0.6 mmol	20	78
5	8 mol%	0.6 mmol	20	78
6	**10 mol%**	**0.6 mmol**	**15**	**82**
7	12 mol%	0.6 mmol	20	62
8	10 mol%	—	48	n.d.
9	10 mol%	0.3 mmol	20	42
10	10 mol%	0.45 mmol	20	66
11	10 mol%	0.9 mmol	20	62
12 [c]	10 mol%	0.6 mmol	48	52

13 [d]	10 mol%	0.6 mmol	20	67
14 [e]	10 mol%	0.6 mmol	20	59
15 [f]	10 mol%	0.6 mmol	20	19

[a] Reaction conditions: **1a** (0.3 mmol), **(*i*-Pr)$_2$NEt**, **ArCHO** (0.3 mmol), and 4CzIPN in CH_3CN (2 mL) at room temperature in argon under a 20 W blue LEDs (460-470 nm) irradiation, unless otherwise noted. [b] Isolated yields, dr = diastereomeric ratio. [c] no ArCHO was added. [d] 0.15 mmol ArCHO was added. [e] 0.45 mmol ArCHO was added. [f] 0.60 mmol ArCHO was added.

Table S3. Screening of LEDs, photocatalyst (PC), and the amount of photocatalyst [a].

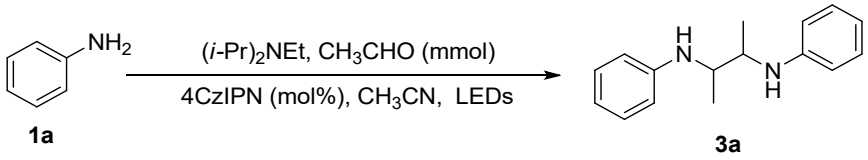


1a 3a 5a

entry	LEDs[b]	PC	PC (mol%)	Diamine yield (%) [c]	Diol yield (%) [c]
1	Blue LEDs	4CzIPN	10 mol%	82	78
2	Purple LEDs	4CzIPN	10 mol%	53	74
3	Purple LEDs	4CzIPN	5 mol%	61	69
4	Purple LEDs	4CzIPN	2 mol%	53	66
5	Purple LEDs	4CzIPN	1 mol%	47	63
6	Purple LEDs	4DPAIPN	1 mol%	50	60
7	Purple LEDs	4DPAIPN	2 mol%	54	58
8	Purple LEDs	4DPAIPN	5 mol%	56	55
9	Purple LEDs	$Ir(ppy)_3$	2 mol%	61	69
10	Purple LEDs	PTH	2 mol%	50	66
11	Purple LEDs	BP	2 mol%	47	63

[a] Reaction conditions: **1a** (0.3 mmol), **(*i*-Pr)$_2$NEt** (0.6 mmol), and **ArCHO** (0.3 mmol) and PC in CH_3CN (2 mL) at room temperature in argon under a LEDs irradiation, unless otherwise noted. [b] 20 W blue LED (460-470 nm), 20 W Purple LEDs (365 nm) [c] Isolated yields.

Table S4. Screening of LEDs, the amount of CH_3CHO and 4CzIPN. [a]

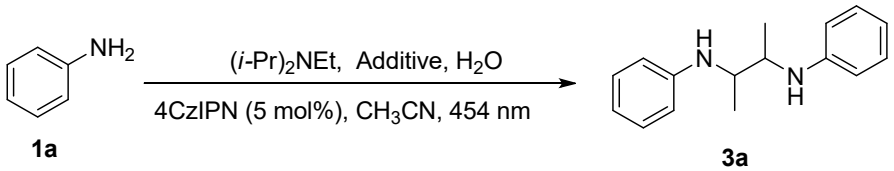


1a **3a**

entry	LEDs[b]	4CzIPN (mol%)	CH_3CHO (mmol)	Yield (%)[c]
1	Blue LEDs	2 mol%	0.3 mmol	54
2	Blue LEDs	5 mol%	0.3 mmol	72
3	**Blue LEDs**	**10 mol%**	**0.3 mmol**	**85**
4	Blue LEDs	10 mol%	0.15 mmol	55
5	Blue LEDs	10 mol%	0.6 mmol	48
6[d]	Blue LEDs	10 mol%	0.6 mmol	NR
7	Purple LEDs	2 mol%	0.3 mmol	41
8	Purple LEDs	5 mol%	0.3 mmol	46
9	Purple LEDs	10 mol%	0.3 mmol	55

[a] Reaction conditions*:* **1a** (0.3 mmol), **(*i*-Pr)$_2$NEt** (0.6 mmol) **CH_3CHO** and 4CzIPN in CH_3CN (2 mL) at room temperature in argon under a irradiation, unless otherwise noted. [b] 20 W blue LED (460-470 nm), 20 W Purple LEDs (365 nm) [c] Isolated yields. [d] no (*i*-Pr)$_2$NEt was added.

Table S5. Optimization conditions for additive and H_2O[a].



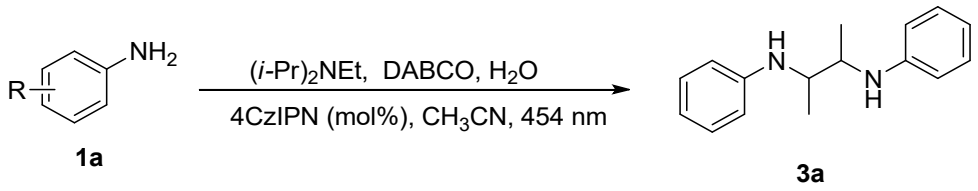
1a **3a**

entry	Additive	H_2O	Time (h)	Yield (%)[b]
1	KPF_6	/	48	30.
2	CuI	/	48	42
3	$Cu(OTf)_2$	/	48	NR
4	Bu_4NBr	/	48	45
5	Cs_2CO_3	0.6 mmol	48	NR

6	^{t}BuOK	0.6 mmol	48	NR
7	**DABCO**	**0.6 mmol**	**40**	**70**
8	quinuclidine	/	60	36.
9	LiBr	/	60	18
10	N-Methylpiperidine	/	60	26
11	DBU	/	60	NR

[a] Reaction conditions: **1a** (0.3 mmol), **(*i*-Pr)$_2$NEt** (0.6 mmol), **additive** (0.6 mmol), **H$_2$O** (0.6 mmol) and **4CzIPN** (5 mol%) in CH_3CN (2 mL) at room temperature in argon under a 20 W blue LEDs (460-470 nm) irradiation, unless otherwise noted. [b] Isolated yields.

Table S6. Screening of the amount of DACBO, H_2O and 4CzIPN [a]

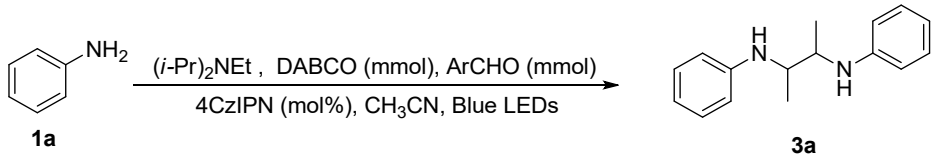


1a **3a**

Entry	4CzIPN (mol%)	DABCO (mmol)	H_2O (mmol)	Diamine (yield %)[b]
1	2	0.6	/	44
2	5	0.6	/	25
3	10	0.6	/	trace
4	10	0.3	/	28
5	10	0.15	/	50
6	2	0.6	0.3	35
7	2	0.6	0.6	28
8	5	0.6	0.3	45
9	**5**	**0.6**	**0.6**	**70**
10	10	0.6	0.3	15
11	10	0.6	0.6	20

[a] Reaction conditions: **1a** (0.3 mmol), **(*i*-Pr)$_2$NEt** (0.6 mmol), **DABCO**, **H$_2$O** and **4CzIPN** (5 mol%) in CH_3CN (2 mL) at room temperature in argon under a 20 W blue LEDs (460-470 nm) irradiation, unless otherwise noted. [b] Isolated yields.

Table S7. Screening of the amount of DACBO, ArCHO and 4CzIPN [a]

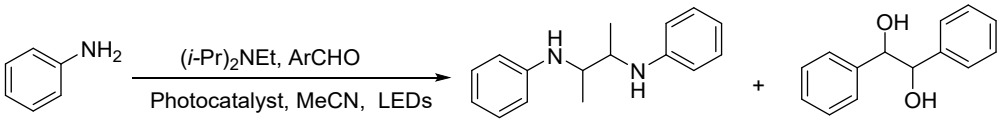


1a 3a

Entry	4CzIPN (mol%)	DABCO (mmol)	ArCHO (mmol)	Diamine (yield %)[b]
1	2	0.3	0.15	44
2	2	0.6	0.3	64
3	2	0.6	0.06	31
4	4	0.6	0.06	70
5	6	0.6	0.06	56
6	2	0.6	0.15	70
7	**5**	**0.3**	**0.15**	**75**
8	5	0.6	0.15	67
9	**5**	**0.6**	**0.06**	**75**

[a] Reaction conditions: **1a** (0.3 mmol), **(*i*-Pr)$_2$NEt** (0.6 mmol), **DABCO**, **H$_2$O** and **4CzIPN** in CH_3CN (2 mL) at room temperature in argon under a 20 W blue LEDs (460-470 nm) irradiation, unless otherwise noted. [b] Isolated yields.

Table S8. Effect of photocatalyst, solvent and temperature on d.r. value. [a]



1a 3a 5a

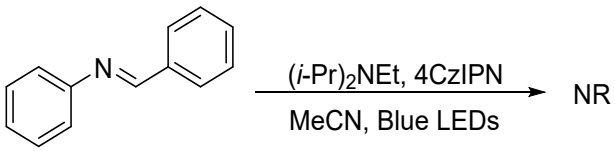
entry	Solvent	PC	Time (h)	Yield (%)[b]	*d.r.*[c]
1	THF	4CzIPN	24	55	2:1
2	CH_3CN	4CzIPN	30	70	2:3
3	CH_3COCH_3	4CzIPN	24	58	1:1
4	DMF	4CzIPN	24	52	2:3
5	DMA	4CzIPN	24	41	2:3
6	DCE	4CzIPN	24	65	1:2
7	DMF:MeCN=1:1	4CzIPN	24	55	2:3
8	DMA:MeCN=1:1	4CzIPN	24	50	2:3

9	CH_3CN	4CzPN	48	42	1:1
10	CH_3CN	4CzTPN	37	55	1:1
11	CH_3CN	*4t*BuCzIPN	48	42	1:1
12	CH_3CN	*fac*-Ir(ppy)$_3$	48	53	1:1
13	CH_3CN	[Ir(dF(CF$_3$ppy)$_2$)(5,5'-CF$_3$-bpy)]PF$_6$	48	50	1:1
14[d]	CH_3CN	4CzIPN	48	NR	
15[e]	CH_3CN	4CzIPN	48	20%	1:1

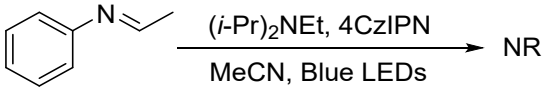
[a] Reaction conditions*:* **1a** (0.3 mmol), **(*i*-Pr)$_2$NEt** (0.6 mmol), **ArCHO** (0.3 mmol) and **PC** (2 mol%) in solvent (2 mL) at room temperature in argon under a 20 W blue LEDs (460-470 nm) irradiation, unless otherwise noted. [b] Isolated yields, [c] *dr* = diastereomeric ratio. [d] T = -20 – 0℃. [e] T = 40 – 60℃.

Mechanistic studies

4.1. Control experiment



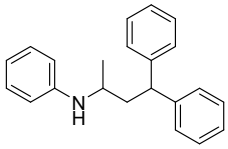
Under the protection of argon, N-benzylideneaniline (54.4 mg, 0.3 mmol, 1.0 equiv), 4CzIPN (23.7 mg, 0.03 mmol, 10 mol%), and (*i*-Pr)$_2$NEt (77.6 mg, 0.6 mmol, 2.0 equiv), in 2.0 mL acetonitrile. were added sequentially to a 25 mL Schlenk tube equipped with a magnetic stir bar. When reaction mixture was stirred under 20 W blue LEDs irradiation at room temperature, and cooled by a fan to keep the temperature relatively constant. The reaction was monitored by TLC. The product was not detected.

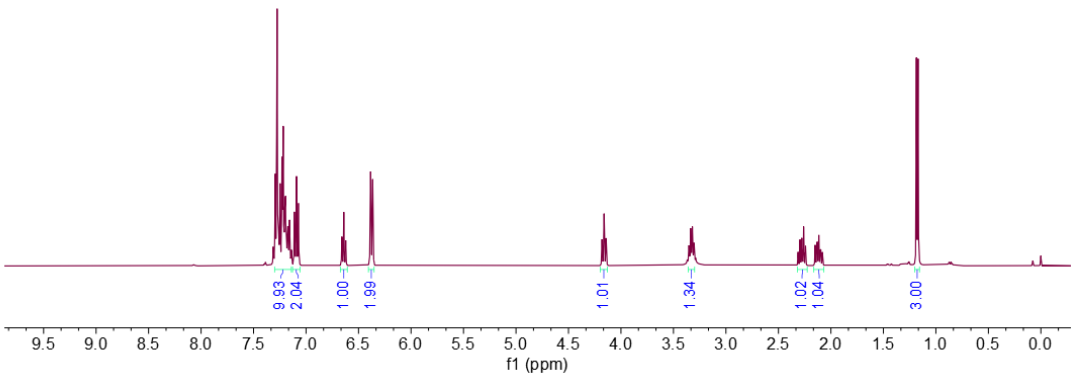


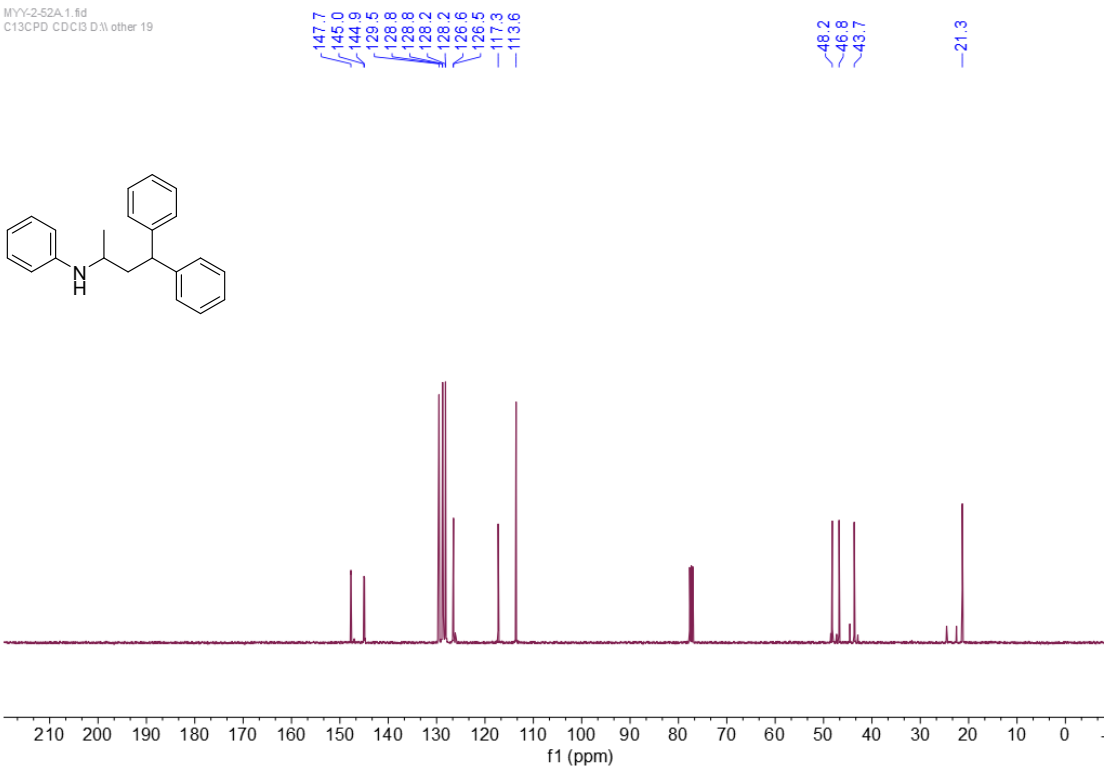
Under the protection of argon, N-phenylethanimine (35.7 mg, 0.3 mmol, 1.0 equiv), 4CzIPN (23.7 mg, 0.03 mmol, 10 mol%), and (*i*-Pr)$_2$NEt (77.6 mg, 0.6 mmol, 2.0 equiv), in 2.0 mL acetonitrile. were added sequentially to a 25 mL Schlenk tube equipped with a magnetic stir bar. When reaction mixture was stirred under 20 W blue LEDs irradiation at room temperature, and cooled by a fan to keep the temperature relatively constant. The reaction was monitored by TLC. The products was not detected.

4.2. Radical-trapping experiment with 1,1-Diphenylethylene

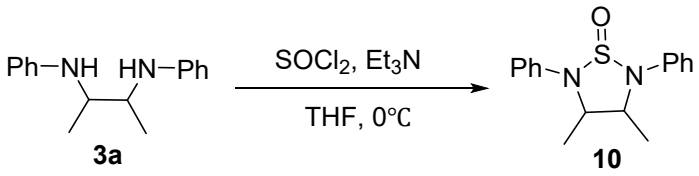
According to general procedure **2**, When 1,1-Diphenylethylene was added, the product **3a** was only a trace amount of the product **3a** was detected by GC-MS analysis, the trapped product was obtained as main product, and purified by silica gel chromatography (PE/EA = 50:1) as White solid (MW = 301.4, 58.8 mg, 0.20 mmol, 65% yield, mp:52-53 °C). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.30 – 7.14 (m, 10H), 7.09 (dd, *J* = 8.6, 7.2 Hz, 2H), 6.64 (tt, *J* = 7.3, 1.2 Hz, 1H), 6.41 – 6.35 (m, 2H), 4.16 (t, *J* = 7.8 Hz, 1H), 3.33 (q, *J* = 6.4 Hz, 1H), 2.32 – 2.23 (m, 1H), 2.13 (dd, *J* = 8.1, 6.0 Hz, 1H), 1.18 (d, *J* = 6.2 Hz, 3H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 147.7, 145.0, 144.9, 129.5, 128.8, 128.8, 128.2, 128.2, 126.6, 126.5, 117.3, 113.6, 48.2, 46.8, 43.7, 21.3. HRMS (ESI) calcd for $C_{12}H_{23}N$, $[M+H]^+$ m/z 302.1903; Found: 302.1906.



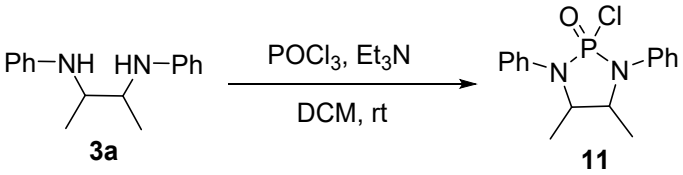




4. Product derivatizations



Under the protection of argon, 1,2-diamines (72.0 mg, 0.3 mmol, 1.0 equiv), $SOCl_2$ (48 mg, 0.4 mmol, 1.5 equiv), and EtN_3 (60.6 mg, 0.6 mmol, 2.0 equiv), in 2.0 mL THF. were added sequentially to a 25 mL Schlenk tube equipped with a magnetic stir bar. The resulting solution was stirred at 0 °C under argon atmosphere with TLC monitoring. The resulting solution was concentrated in vacuum and the residue was purified by chromatography on silica gel, eluting with the mixture of ethyl acetate/petroleum ether/ethyl acetate to give the product **10** (35 mg, 40% yield) [2]

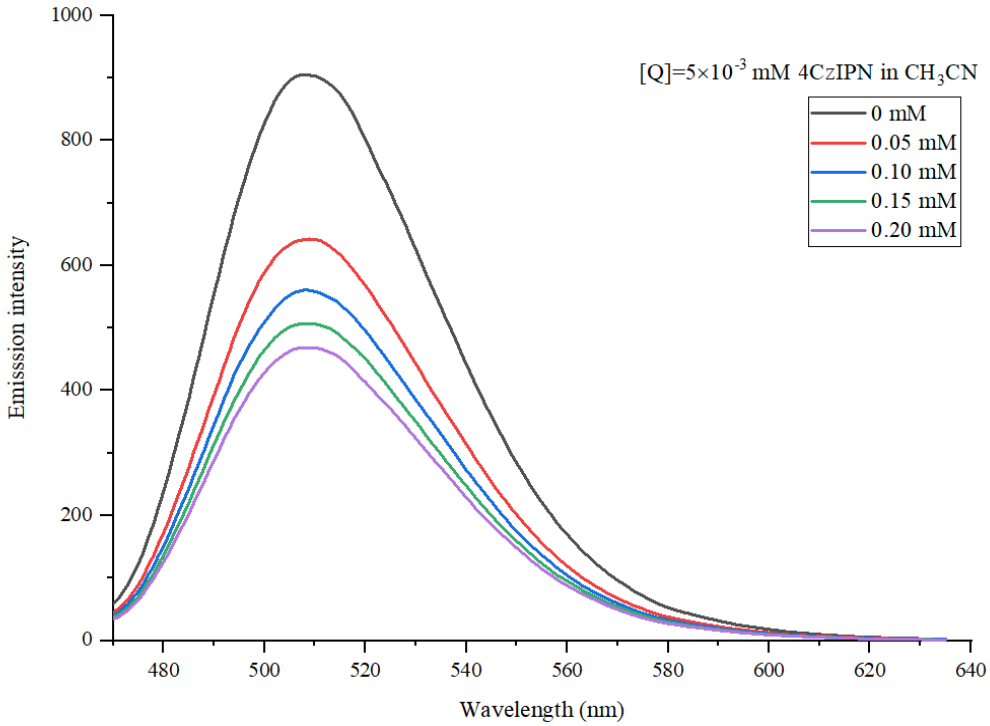


Under the protection of argon, 1,2-diamines (72.0 mg, 0.3 mmol, 1.0 equiv), $POCl_2$ (61.2 mg, 0.4 mmol, 1.5 equiv), and EtN_3 (60.6 mg, 0.6 mmol, 2.0 equiv), in 2.0 mL DCM. were added sequentially to a 25 mL Schlenk tube equipped with a magnetic stir bar. The resulting solution was stirred at room temperature under argon atmosphere with TLC monitoring. The resulting

solution was concentrated in vacuum and the residue was purified by chromatography on silica gel, eluting with the mixture of ethyl acetate/petroleum ether/ethyl acetate to give the product **11** (20 mg, 21% yield) [3]

5. Stern-Volmer experiment

Formulation solution: N,N-Diisopropylethylamine was dissolved in CH_3CN in a 5 mL volumetric flask to set the concentration to be 0.05 mM, 0.10 mM, 0.15 mM, 0.20 mM. Photocatalyst 4CzIPN was dissolved in CH_3CN (50 mL) to set the concentration to be 0.1 mM. **Experimental procedure:** Steady-state emission spectra were recorded using a Cary Ecipse Fluorescence Spectrophotomer (Agilent Techonologies) **(Figure S2)**. N,N-Diisopropylethylamine was added to an CH_3CN solution of 4CzIPN (0.1 mM) and made to a fixed concentration in a volumetric flask. The solutions were then transferred to a septum topped quarts cuvette. Samples were irradiated at 440 nm and area under the graph was calculated and used for determig the Stern-Volmer quenching values. A pre-weighed amount of N,N-Diisopropylethylamine was dissolved in CH_3CN solution of 4CzIPN (0.1 mM) and made to fixed concentration in a volumetric flask. The solution were then transferred to a septum topped quarts cuvette. Due to competing absorption of the imine substrate, samples were irradiated at 440 nm and the emission intensity at 510 nm was used to determine the Stern-Volmer quenching values.



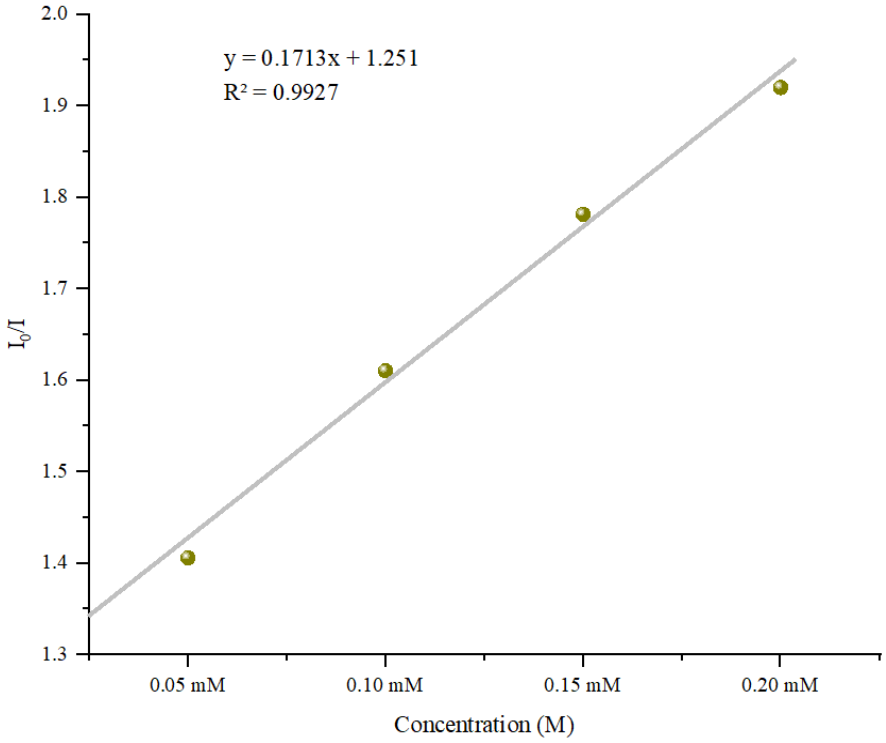
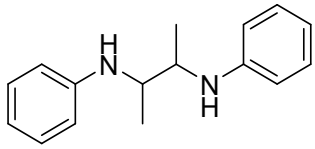


Figure 2. Emission quenching of 4CzIPN with (*i*-Pr)$_2$NEt in CH_3CN

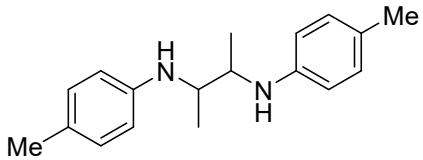
6. Characterization data of products

N^2, N^3-diphenylbutane-2,3-diamine (3a)



Purified by silica gel chromatography (petroleum ether/ethyl acetate = 20:1, v/v), the desired product **3a** was obtained as a colourless oil. (30 mg, 82% yield). *meso/dl* 1:1; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.18 (dtd, *J* = 14.3, 7.2, 1.9 Hz, 4H), 6.76 – 6.59 (m, 6H), 3.78 – 3.71 (m, 1H), 3.60 (dt, *J* = 6.1, 4.3 Hz, 1H), 1.26 – 1.18 (m, 6H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 147.6, 147.6, 129.5, 129.4, 117.7, 117.6, 113.8, 113.6, 52.6, 52.3, 17.0, 16.3. HRMS (ESI) calcd for $C_{16}H_{20}N_2$, $[M+H]^+$ m/z 241.1699; Found: 241.1692.

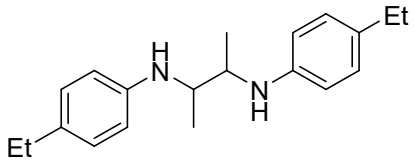
N^2, N^3-di-p-tolylbutane-2,3-diamine (3b)



Purified by silica gel chromatography (petroleum ether/ethyl acetate = 30:1, v/v), the desired product **3b** was obtained as a colourless oil. (31 mg, 77% yield). *meso/dl* 1:1.5; ^{1}H NMR (400

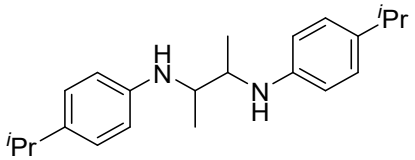
MHz, Chloroform-*d*) δ 7.03 – 6.93 (m, 4H), 6.59 – 6.49 (m, 4H), 3.72 – 3.62 (m, 1H), 3.51 (ddd, *J* = 9.8, 7.1, 4.9 Hz, 2H), 2.24 (d, *J* = 4.4 Hz, 6H), 1.21 – 1.14 (m, 6H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 145.3, 145.2, 129.9, 129.8, 126.9, 126.8, 114.1, 113.9, 52.9, 52.7, 29.7, 20.4, 16.9, 16.2. HRMS (ESI) calcd for $C_{18}H_{24}N_2$, $[M+H]^+$ m/z 269.2012; Found: 269.2011.

N^2, N^3-bis(4-ethylphenyl)butane-2,3-diamine (3c)



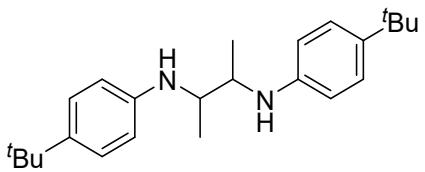
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 30:1, v/v), the desired product **3c** was obtained as a yellow oil. (34 mg, 80% yield). *meso/dl* 1:1.5; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.05 – 6.96 (m, 4H), 6.61 – 6.52 (m, 4H), 3.72 – 3.63 (m, 1H), 3.52 (dt, *J* = 5.9, 4.2 Hz, 1H), 2.54 (qd, *J* = 7.6, 4.2 Hz, 4H), 1.23 – 1.13 (m, 12H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 145.6, 145.5, 133.5, 133.4, 128.8, 128.7, 114.1, 113.8, 52.9, 52.7, 28.0, 17.1, 16.3, 16.0. HRMS (ESI) calcd for $C_{20}H_{28}N_2$, $[M+H]^+$ m/z 297.2325; Found: 297.2327.

N^2, N^3-bis(4-isopropylphenyl)butane-2,3-diamine (3d)



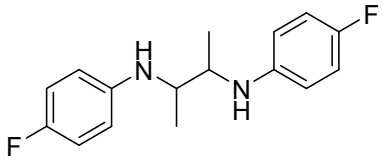
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 30:1, v/v), the desired product **3d** was obtained as a colourless oil. (37 mg, 76% yield). *meso/dl* 1:2; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.09 – 6.96 (m, 4H), 6.62 – 6.51 (m, 4H), 3.70 – 3.61 (m, 1H), 3.50 (dt, *J* = 5.9, 4.2 Hz, 2H), 2.85 – 2.73 (m, 2H), 1.21 – 1.12 (m, 18H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 145.6, 145.5, 138.1, 138.0, 127.2, 127.2, 113.8, 113.6, 52.9, 52.7, 33.1, 33.1, 24.2, 17.1, 16.3,. HRMS (ESI) calcd for $C_{22}H_{32}N_2$, $[M+Na]^+$ m/z 347.2458; Found: 347.2453.

N^2, N^3-bis(4-(tert-butyl)phenyl)butane-2,3-diamine (3e)



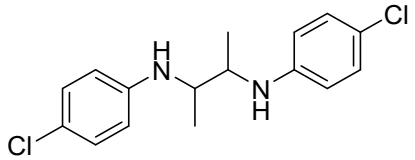
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 30:1, v/v), the desired product **3e** was obtained as a colourless oil. (35 mg, 66% yield). *meso/dl* 1:1.7; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.25 – 7.16 (m, 4H), 6.65 – 6.53 (m, 4H), 3.73 – 3.66 (m, 1H), 3.53 (dt, *J* = 5.9, 4.2 Hz, 2H), 1.29 (d, *J* = 3.5 Hz, 18H), 1.24 – 1.15 (m, 6H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 145.3, 145.2, 140.4, 140.3, 126.2, 126.1, 113.5, 113.3, 52.9, 52.6, 33.9, 33.9, 31.6, 17.2, 16.4. HRMS (ESI) calcd for $C_{24}H_{36}N_2$, $[M+H]^+$ m/z 353.2951; Found: 353.2950.

N^2, N^3-bis(4-fluorophenyl)butane-2,3-diamine (3f)



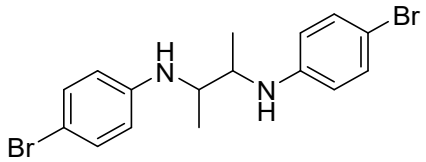
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 15:1, v/v), the desired product **3f** was obtained as a yellow oil. (30 mg, 72% yield). *meso/dl* 1:1.5; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 6.94 – 6.78 (m, 4H), 6.60 – 6.46 (m, 4H), 3.66 – 3.56 (m, 1H), 3.44 (dd, *J* = 4.6, 1.8 Hz, 2H), 1.23 – 1.11 (m, 6H). ^{119}F NMR (376 MHz, Chloroform-*d*) δ -119.14 – -135.60 (m). ^{113}C NMR (101 MHz, Chloroform-*d*) δ 155.9 (dd, *J* = 235.4, 6.3 Hz), 143.9 (dd, *J* = 4.2, 2.0 Hz), 121.1 – 102.1 (m), 53.6, 53.0, 17.0, 16.1. HRMS (ESI) calcd for $C_{16}H_{18}F_2N_2$, $[M+H]^+$ m/z 277.1511; Found: 277.1510.

N^2,N^3-bis(4-chlorophenyl)butane-2,3-diamine (3g)



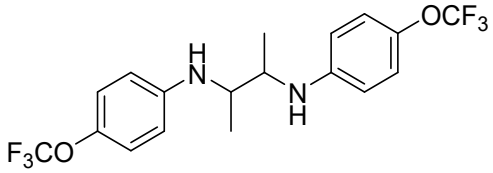
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 15:1, v/v), the desired product **3g** was obtained as a yellow oil. (32 mg, 70% yield). *meso/dl* 1:1.2; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.16 – 7.06 (m, 4H), 6.59 – 6.46 (m, 4H), 3.67 (q, *J* = 6.0 Hz, 1H), 3.61 (s, 2H), 3.51 (dt, *J* = 5.9, 4.2 Hz, 1H), 1.19 (dd, *J* = 11.0, 6.0 Hz, 6H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 146.1, 146.0, 129.3, 129.2, 129.1, 122.2, 122.1, 114.8, 114.6, 52.8, 52.3, 17.0, 16.2. HRMS (ESI) calcd for $C_{16}H_{18}Cl_2N_2$, $[M+H]^+$ m/z 309.0920; Found: 309.0924.

N^2, N^3-bis(4-bromophenyl)butane-2,3-diamine (3h)



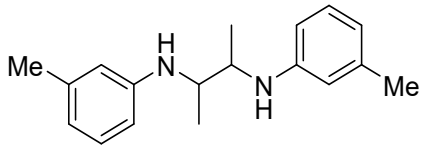
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 15:1, v/v), the desired product **3h** was obtained as a yellow oil. (36 mg, 60% yield). *meso/dl* 1.4:1; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.09 (dtd, *J* = 13.5, 8.1, 6.7 Hz, 2H), 6.45 – 6.24 (m, 6H), 3.69 (q, *J* = 5.9 Hz, 1H), 3.59 – 3.50 (m, 1H), 1.21 (dd, *J* = 11.0, 6.0 Hz, 6H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 146.5, 146.5, 132.1, 132.1, 115.3, 115.1, 109.2, 109.1, 52.7, 52.2, 16.9, 16.2. HRMS (ESI) calcd for $C_{16}H_{18}Br_2N_2$, $[M+H]^+$ m/z 398.9890; Found: 398.9886.

N^2, N^3-bis(4-(trifluoromethoxy)phenyl)butane-2,3-diamine (3i)



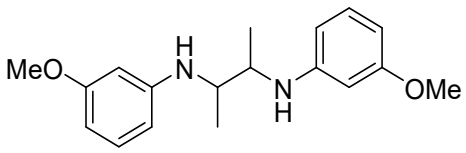
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 7:1, v/v), the desired product **3i** was obtained as a colourless oil. (34 mg, 56% yield). *meso/dl* 2.5:1; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.07 – 6.97 (m, 4H), 6.61 – 6.50 (m, 4H), 3.73 – 3.63 (m, 3H), 3.52 (dd, *J* = 4.5, 1.8 Hz, 1H), 1.21 (dd, *J* = 13.1, 5.9 Hz, 6H). ^{19}F NMR (376 MHz, Chloroform-*d*) δ -58.5. ^{13}C NMR (100 MHz, Chloroform-*d*) δ 146.3, 146.3, 122.6, 122.6, 114.0, 113.7, 53.0, 52.4, 17.1, 16.1. HRMS (ESI) calcd for $C_{18}H_{18}F_6N_2O_2$, $[M+H]^+$ m/z 409.1345; Found: 409.1342.

N^2, N^3-di-m-tolylbutane-2,3-diamine (3j)



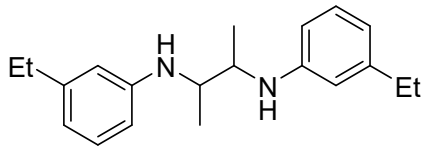
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 30:1, v/v), the desired product **3j** was obtained as a colourless oil. (35 mg, 88% yield). *meso/dl* 1:1.4; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.10 – 7.01 (m, 2H), 6.57 – 6.39 (m, 6H), 3.71 (dt, *J* = 7.1, 1.7 Hz, 1H), 3.58 (dt, *J* = 5.8, 4.3 Hz, 2H), 2.26 (d, *J* = 17.7 Hz, 6H), 1.22 – 1.15 (m, 6H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 147.7, 147.6, 139.2, 139.2, 129.3, 129.3, 118.6, 118.5, 114.6, 114.4, 111.0, 110.8, 52.4, 52.2, 21.7, 21.7, 16.9, 16.4. HRMS (ESI) calcd for $C_{18}H_{24}N_2$, $[M+H]^+$ m/z 269.2012; Found: 269.2018.

N^2, N^3-bis(3-methoxyphenyl)butane-2,3-diamine (3k)



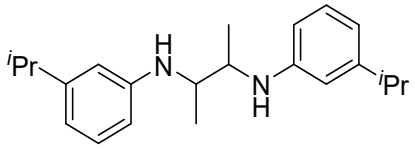
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 10:1, v/v), the desired product **3k** was obtained as a yellow oil. (29 mg, 65% yield). *meso/dl* 1:1; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.09 (dt, *J* = 14.0, 8.1 Hz, 2H), 6.36 – 6.13 (m, 6H), 3.79 (s, 3H), 3.73 (s, 3H), 3.68 (s, 1H), 3.63 – 3.56 (m, 1H), 1.22 (dd, *J* = 11.3, 5.9 Hz, 6H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 160.9, 160.9, 149.0, 148.9, 130.1, 130.1, 106.7, 106.6, 103.0, 102.9, 99.4, 55.1, 55.0, 52.5, 52.2, 29.7, 17.0, 16.3. HRMS (ESI) calcd for $C_{18}H_{24}O_2N_2$, $[M+H]^+$ m/z 301.1910; Found: 301.1909.

N^2, N^3-bis(3-ethylphenyl)butane-2,3-diamine (3l)



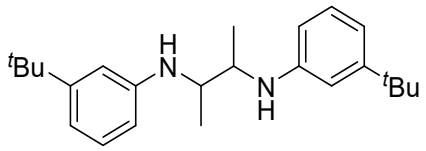
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 30:1, v/v), the desired product **3l** was obtained as a yellow oil. (36 mg, 85% yield). *meso/dl* 1:2.5; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.15 – 7.03 (m, 2H), 6.61 – 6.39 (m, 6H), 3.72 (d, *J* = 6.0 Hz, 1H), 3.62 – 3.56 (m, 1H), 2.55 (dq, *J* = 17.9, 7.6 Hz, 4H), 1.20 (dt, *J* = 15.4, 7.4 Hz, 12H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 147.8, 147.7, 145.7, 145.6, 129.4, 129.3, 117.4, 117.3, 113.6, 113.3, 111.1, 110.9, 52.4, 52.3, 29.2, 29.1, 16.9, 16.4, 15.7, 15.6. HRMS (ESI) calcd for $C_{20}H_{28}N_2$, $[M+H]^+$ m/z 297.2325; Found: 297.2324.

N^2, N^3-bis(3-isopropylphenyl)butane-2,3-diamine (3m)



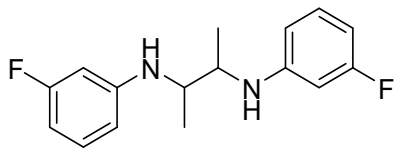
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 30:1, v/v), the desired product **3m** was obtained as a colourless oil. (43 mg, 88% yield). *meso/dl* 1:1.4; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.18 – 7.03 (m, 2H), 6.65 – 6.36 (m, 6H), 3.77 – 3.52 (m, 3H), 2.85 – 2.71 (m, 2H), 1.22 (ddd, *J* = 15.0, 7.0, 2.0 Hz, 18H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 150.3, 150.2, 147.6, 147.5, 129.3, 129.2, 115.9, 115.8, 112.2, 112.0, 111.0, 110.8, 52.3, 52.3, 34.3, 34.2, 24.0, 24.0, 16.8, 16.3. HRMS (ESI) calcd for $C_{18}H_{24}N_2$, $[M+H]^+$ m/z 325.2638; Found: 325.2636.

N^2, N^3-bis(3-(tert-butyl)phenyl)butane-2,3-diamine (3n)



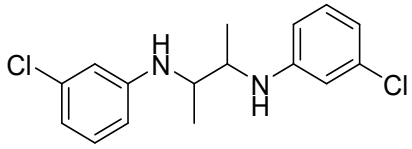
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 30:1, v/v), the desired product **3n** was obtained as a colourless oil. (41 mg, 78% yield). *meso/dl* 1:1.7; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.16 – 7.06 (m, 2H), 6.83 – 6.61 (m, 4H), 6.47 (dddd, *J* = 20.7, 8.0, 2.4, 1.2 Hz, 2H), 3.76 – 3.69 (m, 1H), 3.68 – 3.54 (m, 2H), 1.31 – 1.17 (m, 24H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 152.5, 152.5, 147.4, 147.3, 129.1, 129.0, 115.0, 114.9, 111.5, 111.4, 110.5, 110.2, 52.6, 52.4, 34.7, 34.6, 31.4, 31.4, 17.0, 16.3. HRMS (ESI) calcd for $C_{24}H_{36}N_2$, $[M+H]^+$ m/z 353.2951; Found: 353.2950.

N^2, N^3-bis(3-fluorophenyl)butane-2,3-diamine (3o)



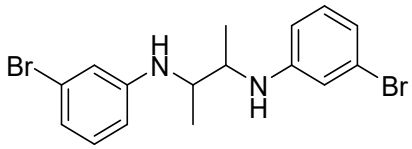
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 15:1, v/v), the desired product **3o** was obtained as a yellow oil. (32 mg, 76% yield). *meso/dl* 2:1; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.09 (dtd, *J* = 13.4, 8.2, 6.7 Hz, 2H), 6.43 – 6.24 (m, 6H), 3.71 – 3.65 (m, 1H), 3.56 – 3.50 (m, 1H), 1.24 – 1.17 (m, 6H). ^{19}F NMR (376 MHz, Chloroform-*d*) δ -112.62 (d, *J* = 43.2 Hz). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 164.1 (dd, *J* = 243.0, 2.4 Hz), 149.2 (d, *J* = 10.8 Hz), 130.5 (dd, *J* = 10.3, 4.0 Hz), 116.1 – 95.7 (m), 52.6, 52.1, 17.1, 16.2. HRMS (ESI) calcd for $C_{16}H_{18}F_2N_2$, $[M+H]^+$ m/z 277.1511; Found: 277.1508.

N^2, N^3-bis(3-chlorophenyl)butane-2,3-diamine (3p)



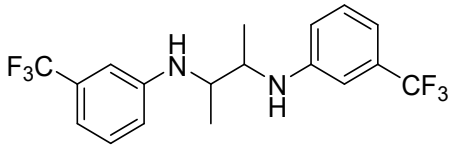
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 15:1, v/v), the desired product **3p** was obtained as a yellow oil. (38 mg, 81% yield). *meso/dl* 1:1.2; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.07 (dt, *J* = 13.8, 8.0 Hz, 2H), 6.68 (td, *J* = 7.7, 1.9 Hz, 2H), 6.59 (dt, *J* = 22.2, 2.2 Hz, 2H), 6.47 (ddd, *J* = 23.0, 8.2, 2.4 Hz, 2H), 3.73 – 3.67 (m, 2H), 3.54 (dd, *J* = 4.7, 1.7 Hz, 1H), 1.20 (dd, *J* = 10.0, 6.1 Hz, 6H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 148.5, 135.2, 135.1, 130.4, 130.3, 117.5, 117.5, 113.2, 113.1, 112.0, 111.8, 52.5, 52.0, 17.0, 16.2. HRMS (ESI) calcd for $C_{16}H_{18}Cl_2N_2$, $[M+H]^+$ m/z 309.0920; Found: 309.0920.

N^2, N^3-bis(3-bromophenyl)butane-2,3-diamine (3q)



Purified by silica gel chromatography (petroleum ether/ethyl acetate = 15:1, v/v), the desired product **3q** was obtained as a yellow oil. (50 mg, 84% yield). *meso/dl* 1.4:1; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.01 (dt, *J* = 14.3, 8.0 Hz, 2H), 6.85 – 6.76 (m, 3H), 6.72 (t, *J* = 2.1 Hz, 2H), 6.56 – 6.46 (m, 2H), 3.72 – 3.65 (m, 2H), 3.53 (dt, *J* = 5.9, 4.3 Hz, 1H), 1.21 – 1.16 (m, 6H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 148.7, 130.7, 130.7, 123.4, 123.4, 120.5, 120.4, 116.1, 116.0, 112.3, 112.2, 52.4, 52.0, 17.0, 16.2. HRMS (ESI) calcd for $C_{16}H_{18}Br_2N_2$, $[M+H]^+$ m/z 398.9890; Found: 398.9886.

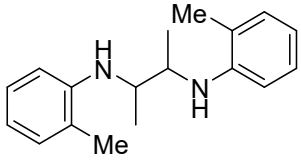
N^2, N^3-bis(3-(trifluoromethyl)phenyl)butane-2,3-diamine (3r)



Purified by silica gel chromatography (petroleum ether/ethyl acetate = 8:1, v/v), the desired product **3r** was obtained as a colourless oil. (34 mg, 60% yield). *meso/dl* 1:1; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.31 – 7.24 (m, 2H), 6.96 (t, *J* = 8.0 Hz, 2H), 6.88 – 6.70 (m, 4H), 3.84 (s, 1H), 3.80 (d,

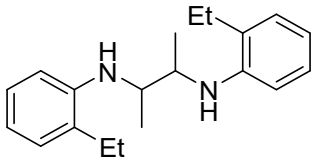
J = 6.3 Hz, 1H), 3.65 (dt, *J* = 6.1, 4.4 Hz, 1H), 1.26 (dd, *J* = 8.4, 6.0 Hz, 6H). ^{19}F NMR (376 MHz, Chloroform-*d*) δ -62.88 (d, *J* = 5.5 Hz). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 147.5, 129.9 (d, *J* = 4.3 Hz), 116.4 (d, *J* = 13.6 Hz), 114.1, 109.7 (d, *J* = 10.2 Hz), 52.4, 52.0, 17.0, 16.2. HRMS (ESI) calcd for $C_{18}H_{18}F_6N_2$, $[M+H]^+$ m/z 377.1447; Found: 377.1444.

N^2, N^3-di-o-tolylbutane-2,3-diamine (3s)



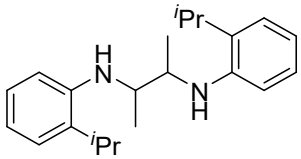
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 50:1, v/v), the desired product **3s** was obtained as a colourless oil. (21 mg, 51% yield). *meso/dl* 1:3.5; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.18 – 6.99 (m, 4H), 6.76 – 6.59 (m, 4H), 3.84 (tdd, *J* = 8.3, 6.6, 2.9 Hz, 1H), 3.68 (dt, *J* = 6.0, 4.3 Hz, 1H), 3.57 (s, 1H), 2.07 (d, *J* = 14.4 Hz, 6H), 1.29 – 1.23 (m, 6H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 145.4, 130.4, 130.4, 127.2, 127.2, 122.5, 117.1, 110.9, 110.6, 52.6, 17.6, 17.6, 17.3, 16.6. HRMS (ESI) calcd for $C_{18}H_{24}N_2$, $[M+H]^+$ m/z 269.2012; Found: 269.2018.

N^2,N^3-bis(2-ethylphenyl)butane-2,3-diamine (3t)



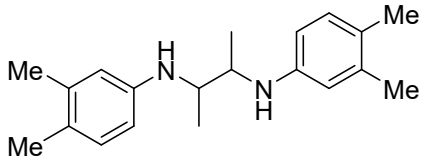
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 30:1, v/v), the desired product **3t** was obtained as a yellow oil. (25 mg, 60% yield). *meso/dl* 1:3; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.04 (dt, *J* = 29.1, 7.8 Hz, 4H), 6.63 (dt, *J* = 22.3, 7.9 Hz, 4H), 3.77 (d, *J* = 6.1 Hz, 1H), 3.61 (q, *J* = 5.1 Hz, 3H), 2.34 (dq, *J* = 14.7, 7.5 Hz, 4H), 1.22 – 1.10 (m, 12H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 143.8, 143.8, 127.2, 127.0, 126.0, 126.0, 116.2, 116.1, 110.1, 109.8, 51.5, 51.0, 22.9, 22.9, 22.7, 16.4, 15.4, 11.9. HRMS (ESI) calcd for $C_{20}H_{28}N_2$, $[M+H]^+$ m/z 297.2325; Found: 297.2325.

N^2,N^3-bis(2-isopropylphenyl)butane-2,3-diamine (3u)



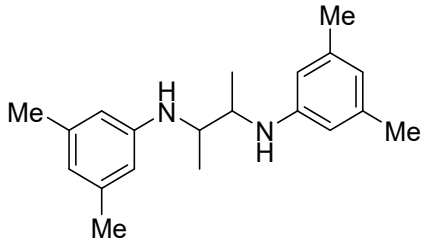
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 30:1, v/v), the desired product **3u** was obtained as a colourless oil. (25 mg, 52% yield). *meso/dl* 1:1.4; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.03 (td, *J* = 7.4, 1.7 Hz, 4H), 6.67 – 6.55 (m, 4H), 3.73 (q, *J* = 5.8 Hz, 1H), 3.68 (s, 1H), 3.60 – 3.52 (m, 1H), 2.68 (dq, *J* = 14.2, 6.9 Hz, 2H), 1.18 – 1.06 (m, 19H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 143.1, 143.1, 131.7, 131.7, 125.7, 125.7, 124.2, 124.2, 116.4, 116.3, 110.7, 110.3, 51.8, 51.3, 26.2, 26.2, 21.4, 21.4, 21.3, 21.1, 16.5, 15.3. HRMS (ESI) calcd for $C_{18}H_{24}N_2$, $[M+Na]^+$ m/z 347.2458; Found: 347.2453

N^2,N^3-bis(3,4-dimethylphenyl)butane-2,3-diamine (3v)



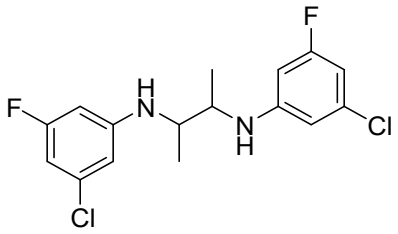
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 20:1, v/v), the desired product **3v** was obtained as a colourless oil. (25 mg, 57% yield). *meso/dl* 1:1.5; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 6.93 (dd, *J* = 12.7, 8.0 Hz, 2H), 6.51 – 6.34 (m, 4H), 3.66 (td, *J* = 6.2, 4.4 Hz, 1H), 3.53 (dt, *J* = 5.9, 4.3 Hz, 1H), 2.22 – 2.12 (m, 12H), 1.17 (dd, *J* = 11.5, 6.0 Hz, 6H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 148.7, 130.7, 130.7, 123.5, 123.4, 120.5, 120.4, 116.1, 116.0, 112.4, 112.2, 52.4, 52.2, 52.0, 17.0, 16.2. HRMS (ESI) calcd for $C_{20}H_{28}N_2$, $[M+H]^+$ m/z 297.2325; Found: 297.2328.

N^2,N^3-bis(3,5-dimethylphenyl)butane-2,3-diamine (3w)



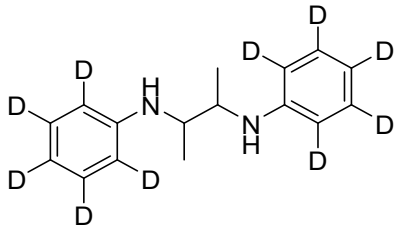
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 20:1, v/v), the desired product **3w** was obtained as a colourless oil. (30 mg, 67% yield). *meso/dl* 1:1.5; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 6.36 (d, *J* = 10.3 Hz, 2H), 6.25 (d, *J* = 26.5 Hz, 4H), 3.68 (d, *J* = 5.9 Hz, 1H), 3.57 (dt, *J* = 5.9, 3.0 Hz, 2H), 2.21 (d, *J* = 15.9 Hz, 12H), 1.16 (t, *J* = 6.6 Hz, 6H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 147.7, 147.5, 139.1, 139.0, 119.6, 119.4, 111.7, 111.4, 52.1, 52.0, 21.5, 21.5, 16.5, 16.4. HRMS (ESI) calcd for $C_{20}H_{28}N_2$, $[M+H]^+$ m/z 297.2325; Found: 297.2323.

N^2,N^3-bis(3-chloro-5-fluorophenyl)butane-2,3-diamine (3x)



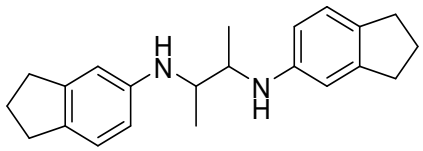
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 8:1, v/v), the desired product **3x** was obtained as a colourless oil. (26 mg, 51% yield). *meso/dl* 1.4:1; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 6.96 (dt, *J* = 12.2, 8.8 Hz, 2H), 6.62 (ddd, *J* = 22.2, 6.1, 2.9 Hz, 2H), 6.44 (ddt, *J* = 21.5, 8.9, 3.3 Hz, 2H), 3.62 (q, *J* = 5.8 Hz, 2H), 3.49 (s, 1H), 3.44 (dt, *J* = 5.9, 4.2 Hz, 1H), 1.20 (dd, *J* = 13.1, 6.0 Hz, 6H). ^{19}F NMR (376 MHz, Chloroform-*d*) δ -130.60 (d, *J* = 31.8 Hz). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 151.1 (dd, *J* = 238.2, 7.5 Hz), 144.3 (d, *J* = 2.2 Hz), 121.2 (dd, *J* = 18.4, 4.5 Hz), 117.2 – 110.3 (m), 53.3, 52.7, 31.5, 31.5, 30.2, 30.6, 17.0, 16.1. HRMS (ESI) calcd for $C_{16}H_{16}Cl_2F_2N_2$, $[M+H]^+$ m/z 345.0731; Found: 345.0729.

N^2,N^3-bis(phenyl-d5)butane-2,3-diamine (3y)



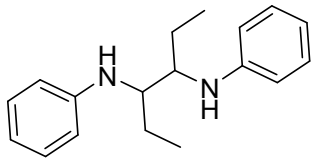
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 20:1, v/v), the desired product **3y** was obtained as a colourless oil. (30 mg, 83% yield). *meso/dl* 1:2.5; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 3.76 – 3.69 (m, 1H), 3.62 – 3.54 (m, 2H), 1.28 – 1.16 (m, 6H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 52.6, 52.2, 17.0, 16.3. HRMS (ESI) calcd for $C_{16}H_{10}D_{10}N_2$, $[M+H]^+$ m/z 251.2325; Found: 251.2327.

N^2,N^3-bis(2,3-dihydro-1H-inden-5-yl)butane-2,3-diamine (3z)



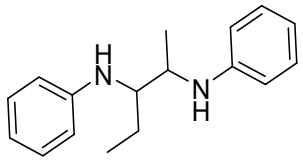
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 20:1, v/v), the desired product **3z** was obtained as a colourless oil. (34 mg, 70% yield). *meso/dl* 1:1; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.02 (dd, *J* = 12.0, 8.0 Hz, 2H), 6.56 (dd, *J* = 20.8, 2.3 Hz, 2H), 6.44 (ddd, *J* = 12.7, 8.0, 2.3 Hz, 2H), 3.68 (dt, *J* = 7.1, 1.8 Hz, 1H), 3.54 (dd, *J* = 4.6, 1.7 Hz, 1H), 2.87 – 2.76 (m, 8H), 2.04 (pd, *J* = 7.4, 4.9 Hz, 4H), 1.22 – 1.15 (m, 6H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 146.4, 146.3, 145.6, 145.6, 133.4, 133.3, 125.0, 124.9, 112.4, 112.2, 110.2, 109.9, 53.0, 52.9, 33.2, 33.2, 32.0, 25.8, 17.0, 16.3. HRMS (ESI) calcd for $C_{22}H_{28}N_2$, $[M+H]^+$ m/z 321.2325; Found: 321.2328.

N^3,N^4-diphenylhexane-3,4-diamine (6)



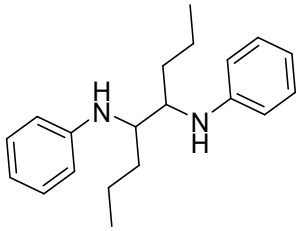
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 50:1, v/v), the desired product **6** was obtained as a colourless oil. (9 mg, 22% yield). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.14 (dtd, *J* = 18.7, 7.3, 1.9 Hz, 4H), 6.72 – 6.60 (m, 4H), 6.57 – 6.51 (m, 2H), 3.47 (d, *J* = 26.0 Hz, 4H), 1.77 – 1.60 (m, 2H), 1.47 (dt, *J* = 14.7, 7.3 Hz, 2H), 0.97 (dt, *J* = 15.2, 7.4 Hz, 6H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 148.6, 129.4, 129.3, 117.1, 117.1, 113.4, 113.1, 58.0, 57.7, 25.6, 24.6, 11.4, 11.1. HRMS (ESI) calcd for $C_{18}H_{24}N_2$, $[M+H]^+$ m/z 269.2012; Found: 269.2015.

N^2,N^3-diphenylpentane-2,3-diamine (7)



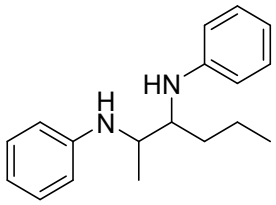
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 20:1, v/v), the desired product **7** was obtained as a colourless oil. (15 mg, 38% yield). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.23 – 7.14 (m, 4H), 6.73 – 6.59 (m, 6H), 3.66 (qd, *J* = 6.4, 4.1 Hz, 1H), 3.39 (dt, *J* = 8.4, 4.3 Hz, 1H), 1.76 (ddp, *J* = 14.9, 7.5, 4.3, 3.8 Hz, 1H), 1.47 (dt, *J* = 15.1, 7.6 Hz, 1H), 1.21 (d, *J* = 6.4 Hz, 3H), 0.96 (t, *J* = 7.4 Hz, 3H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 148.9, 148.5, 147.8, 147.5, 129.5, 129.4, 117.5, 117.5, 117.4, 117.3, 113.7, 113.6, 113.3, 59.0, 58.8, 51.2, 50.9, 25.9, 24.6, 17.8, 15.2, 11.5, 10.8. HRMS (ESI) calcd for $C_{17}H_{22}N_2$, $[M+H]^+$ m/z 255.1856; Found: 255.1862.

N^4,N^5-diphenyloctane-4,5-diamine (8)



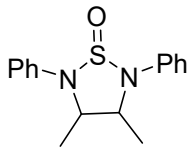
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 50:1, v/v), the desired product **8** was obtained as a colourless oil. (19 mg, 42% yield). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.14 (dtd, *J* = 21.5, 7.3, 1.9 Hz, 4H), 6.71 – 6.59 (m, 4H), 6.55 – 6.46 (m, 2H), 3.58 (dd, *J* = 8.0, 3.2 Hz, 1H), 3.50 (d, *J* = 8.3 Hz, 3H), 1.59 – 1.29 (m, 8H), 0.90 (dt, *J* = 15.9, 7.0 Hz, 6H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 148.8, 148.5, 147.8, 147.5, 129.5, 129.4, 129.4, 129.2, 117.5, 117.4, 117.3, 117.0, 113.7, 113.6, 113.2, 57.1, 56.9, 51.6, 51.4, 51.2, 35.3, 34.2, 20.0, 19.6, 17.7, 15.2, 14.3, 14.2. HRMS (ESI) calcd for $C_{20}H_{28}N_2$, $[M+H]^+$ m/z 297.2325; Found: 297.2330.

N^2,N^3-diphenylhexane-2,3-diamine (9)



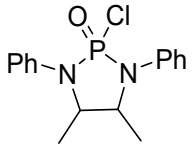
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 20:1, v/v), the desired product **9** was obtained as a colourless oil. (10 mg, 25% yield). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.18 (ddd, *J* = 9.1, 7.2, 2.2 Hz, 4H), 6.68 (dd, *J* = 22.0, 7.7 Hz, 6H), 3.66 (qd, *J* = 6.4, 3.9 Hz, 1H), 3.49 (dt, *J* = 8.2, 4.1 Hz, 1H), 1.68 – 1.62 (m, 1H), 1.50 – 1.40 (m, 2H), 1.35 (td, *J* = 7.7, 4.2 Hz, 1H), 1.20 (d, *J* = 6.4 Hz, 3H), 0.89 (t, *J* = 7.1 Hz, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 148.3, 129.4, 129.4, 117.7, 117.3, 113.8, 113.2, 57.0, 51.6, 34.1, 19.5, 17.5, 14.2. HRMS (ESI) calcd for $C_{18}H_{24}N_2$, $[M+K]^+$ m/z 307.1571; Found: 307.1575.

3,4-dimethyl-2,5-diphenyl-1,2,5-thiadiazolidine 1-oxide (10)



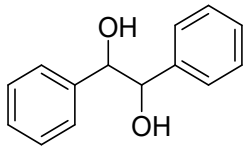
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 5:1, v/v), the desired product **10** was obtained as a white solid (35 mg, 40% yield). mp 126 - 128°C, ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.45 – 7.32 (m, 4H), 7.28 – 7.19 (m, 5H), 7.14 – 7.06 (m, 1H), 4.44 – 4.33 (m, 1H), 3.99 – 3.86 (m, 1H), 1.48 (d, *J* = 6.1 Hz, 3H), 1.28 (d, *J* = 6.0 Hz, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 141.1, 138.5, 129.6, 129.5, 126.4, 126.1, 123.4, 118.8, 63.6, 61.1, 17.6, 16.5. HRMS (ESI) calcd for $C_{16}H_{18}N_2OS$, $[M+H]^+$ m/z 287.1213; Found: 287.1211.

2-chloro-4,5-dimethyl-1,3-diphenyl-1,3,2-diazaphospholidine 2-oxide (11)



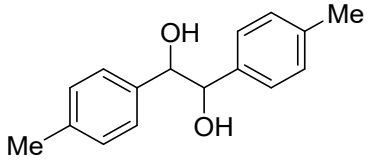
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 7:1, v/v), the desired product **11** was obtained as a white solid. (20 mg, 21% yield). mp 130 - 132°C ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.47 – 7.32 (m, 8H), 7.25 – 7.13 (m, 2H), 4.00 (dqd, *J* = 12.6, 6.3, 4.6 Hz, 1H), 3.93 – 3.82 (m, 1H), 1.40 (dd, *J* = 6.2, 2.8 Hz, 6H). ^{31}P NMR (162 MHz, Chloroform-*d*) δ 13.31. ^{13}C NMR (101 MHz, Chloroform-*d*) δ 138.0, 137.9, 137.3, 137.2, 129.6, 129.6, 125.2, 125.2, 124.4, 122.6, 122.5, 121.2, 121.1, 58.4, 58.2, 57.8, 57.6, 18.7, 18.7, 17.8, 17.8. HRMS (ESI) calcd for $C_{16}H_{18}ClN_2OP$, $[M+H]^+$ m/z 321.0918; Found: 321.0915.

1,2-diphenylethane-1,2-diol (5a)



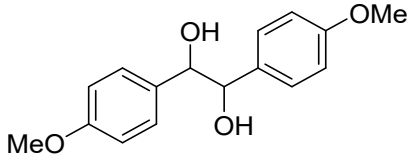
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 7:1, v/v), the desired product **5a** was obtained as a white solid. (25 mg, 78% yield). *meso/dl* 1:1.7; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.20 – 6.97 (m, 8H), 6.94 – 6.90 (m, 2H), 4.63 (s, 1H), 4.47 (s, 1H), 3.40 (s, 1H), 2.71 (s, 1H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 140.0, 140.0, 128.1, 128.1, 128.0, 127.9, 127.2, 127.1, 79.1.

1,2-di-p-tolylethane-1,2-diol (5b)



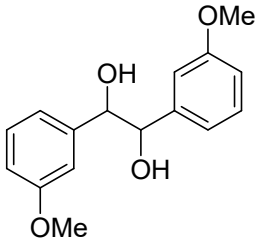
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 7:1, v/v), the desired product **5b** was obtained as a white solid. (29 mg, 80% yield). *meso/dl* 1:1.1; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.13 (q, *J* = 8.2 Hz, 4H), 7.05 – 6.97 (m, 4H), 4.71 (s, 1H), 4.62 (s, 1H), 2.90 (s, 1H), 2.31 (d, *J* = 17.3 Hz, 6H), 2.18 (s, 1H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 137.8, 137.5, 137.0, 137.0, 129, 128.8, 127.1, 126.9, 78.8, 78.0, 21.2, 21.2.

1,2-bis(4-methoxyphenyl)ethane-1,2-diol (5c)



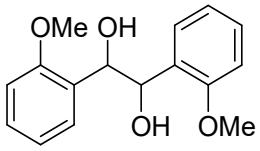
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 3:1, v/v), the desired product **5c** was obtained as a white solid. (26 mg, 63% yield). *meso/dl* 1:1.7; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.21 – 7.16 (m, 2H), 7.05 – 6.99 (m, 2H), 6.88 – 6.82 (m, 2H), 6.77 – 6.72 (m, 2H), 4.72 (s, 1H), 4.61 (s, 1H), 3.77 (d, *J* = 15.3 Hz, 6H), 2.89 (s, 1H), 2.18 (s, 1H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 159.4, 159.2, 132.1, 132.1, 128.3, 128.2, 113.7, 113.5, 78.8, 55.3, 55.2.

1,2-bis(3-methoxyphenyl)ethane-1,2-diol (5d)



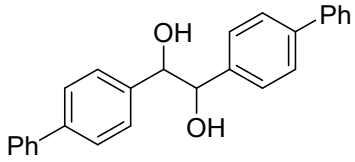
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 3:1, v/v), the desired product **5d** was obtained as a white solid. (32 mg, 73% yield). *meso/dl* 1.1:10; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.63 – 8.48 (m, 2H), 8.21 – 8.03 (m, 6H), 6.13 (s, 1H), 6.00 (s, 1H), 5.08 (d, *J* = 11.5 Hz, 6H), 4.43 (s, 1H), 3.79 (s, 1H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 159.5, 159.4, 141.5, 141.4, 129.3, 129.2, 119.5, 119.3, 114.0, 113.7, 112.3, 112.2, 78.9, 78.0, 55.2, 55.2.

1,2-bis(2-methoxyphenyl)ethane-1,2-diol (5e)



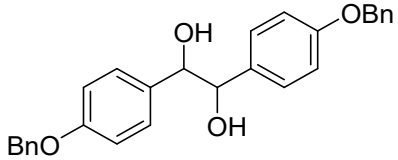
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 5:1, v/v), the desired product **5e** was obtained as a white solid. (36 mg, 82% yield). *meso/dl* 1:1.1; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.26 – 7.13 (m, 4H), 6.86 (dtd, *J* = 15.9, 7.5, 1.1 Hz, 2H), 6.79 (dd, *J* = 8.2, 1.1 Hz, 1H), 6.76 – 6.72 (m, 1H), 5.24 (d, *J* = 4.6 Hz, 1H), 5.03 (d, *J* = 3.5 Hz, 1H), 3.70 – 3.61 (m, 6H), 3.47 (d, *J* = 3.9 Hz, 1H), 3.13 (s, 1H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 156.97, 157.0, 128.6, 128.5, 128.5, 128.3, 120.5, 120.5, 110.3, 110.2, 74.5, 73.7, 73.7, 55.3, 55.2.

1,2-di([1,1'-biphenyl]-4-yl)ethane-1,2-diol (5f)



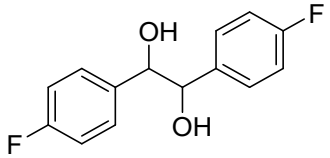
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 5:1, v/v), the desired product **5f** was obtained as a white solid. (24 mg, 43% yield). *meso/dl* 1:1.2 ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.62 – 7.04 (m, 18H), 4.82 (s, 1H), 2.90 (s, 1H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 140.8, 140.6, 139.0 128.8, 127.4, 127.4, 127.0, 126.9, 78.8. HRMS (ESI) calcd for $C_{26}H_{22}O_2$, $[M+Na]^+$ m/z 389.1512; Found: 389.1516.

1,2-bis(4-(benzyloxy)phenyl)ethane-1,2-diol (5g)



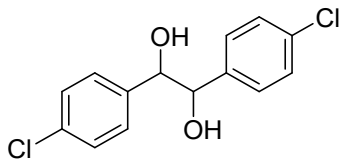
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 3:1, v/v), the desired product **5g** was obtained as a white solid. (30 mg, 47% yield). *meso/dl* 1:1.5; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.45 – 7.30 (m, 10H), 7.21 – 7.15 (m, 2H), 7.04 – 6.99 (m, 2H), 6.92 (d, *J* = 8.7 Hz, 2H), 6.85 – 6.79 (m, 2H), 5.02 (d, *J* = 16.7 Hz, 4H), 4.71 (s, 1H), 4.60 (s, 1H), 2.86 (s, 1H), 2.16 (s, 1H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 158.7, 158.4, 136.9, 132.4, 128.6, 128.6, 128.4, 128.2, 128.0, 128.0, 127.5, 114.7, 114.5, 70.0, 70.0.

1,2-bis(4-fluorophenyl)ethane-1,2-diol (5h)



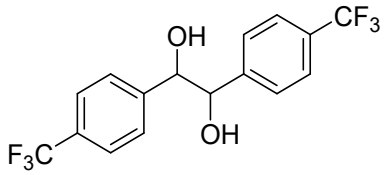
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 5:1, v/v), the desired product **5h** was obtained as a white solid. (27 mg, 71% yield). *meso/dl* 1:1.5; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.17 – 7.09 (m, 2H), 7.07 – 6.86 (m, 6H), 4.80 (s, 1H), 4.60 (s, 1H), 3.02 (s, 1H), 2.42 (s, 1H). ^{19}F NMR (376 MHz, Chloroform-*d*) δ -114.05 (d, *J* = 30.5 Hz). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 162.4 (d, *J* = 246.4 Hz), 135.4 (d, *J* = 3.2 Hz), 128.7 (dd, *J* = 8.1, 6.6 Hz), 115.1 (dd, *J* = 21.4, 2.4 Hz), 78.7.

1,2-bis(4-chlorophenyl)ethane-1,2-diol (5i)



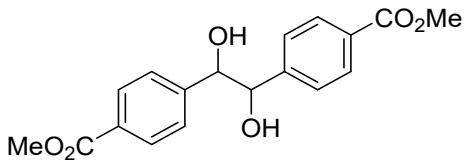
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 3:1, v/v), the desired product **5i** was obtained as a white solid. (25 mg, 59% yield). *meso/dl* 1.2:1; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.27 – 7.15 (m, 4H), 7.10 – 6.94 (m, 4H), 4.78 (s, 1H), 4.56 (s, 1H), 3.12 (s, 1H), 2.58 (s, 1H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 138.0, 137.8, 133.8, 133.8, 128.4, 128.3, 128.3.

1,2-bis(4-(trifluoromethyl)phenyl)ethane-1,2-diol (5j)



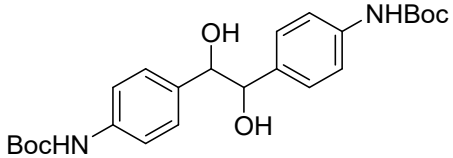
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 3:1, v/v), the desired product **5j** was obtained as a white solid. (35 mg, 67% yield). *meso/dl* 1:1.2; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.52 (t, *J* = 9.0 Hz, 4H), 7.24 (dd, *J* = 23.4, 8.0 Hz, 4H), 4.94 (s, 1H), 4.72 (s, 1H), 3.12 (s, 1H), 2.62 (s, 1H). ^{19}F NMR (376 MHz, Chloroform-*d*) δ -62.54 (d, *J* = 13.1 Hz). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 143.3 (d, *J* = 16.1 Hz), 130.4 (dd, *J* = 32.5, 11.1 Hz), 134.2 – 120.8 (m), 122.6 (d, *J* = 6.1 Hz), 78.4.

dimethyl 4,4'-(1,2-dihydroxyethane-1,2-diyl)dibenzoate (5k)



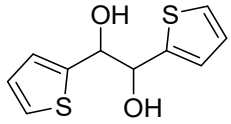
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 3:1, v/v), the desired product **5k** was obtained as a white solid. (25 mg, 51% yield). *meso/dl* 1:1.3; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.27 – 7.19 (m, 2H), 7.15 – 7.08 (m, 2H), 7.04 – 6.91 (m, 4H), 4.76 (s, 1H), 4.63 (s, 1H), 3.11 (s, 1H), 2.54 (s, 1H), 2.27 (d, *J* = 6.4 Hz, 6H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 169.6, 169.4, 150.3, 150.2, 137.4, 137.4, 128.2, 128.0, 121.3, 121.3, 21.1.

di-tert-butyl ((1,2-dihydroxyethane-1,2-diyl)bis(4,1-phenylene))dicarbamate (5l)



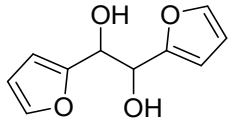
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 2:1, v/v), the desired product **5l** was obtained as a white solid. (55 mg, 82% yield). mp 183 - 185°C *meso/dl* 1:1.3; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.28 – 7.10 (m, 6H), 6.99 (d, *J* = 8.3 Hz, 2H), 6.54 (d, *J* = 16.8 Hz, 2H), 4.72 (s, 1H), 4.57 (s, 1H), 1.50 (d, *J* = 5.2 Hz, 18H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 152. 8, 138.1, 137.9, 134.5, 134.4, 127.8, 127.7, 118.2, 118.1, 78.7, 77.6, 60.4, 28.4, 14.2. HRMS (ESI) calcd for $C_{24}H_{32}N_2O_6$, $[M+H]^+$ m/z 445.2333; Found: 445.2335.

1,2-di(thiophen-2-yl)ethane-1,2-diol (5m)



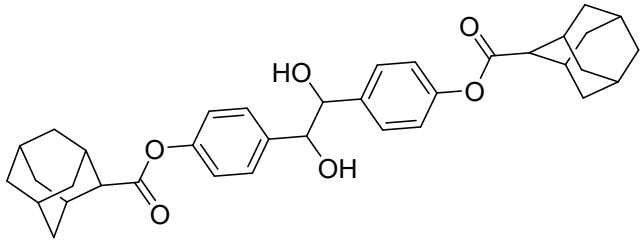
Purified by silica gel chromatography (petroleum ether/ethyl acetate = 7:1, v/v), the desired product **5m** was obtained as a white solid. (11 mg, 32% yield). *meso/dl* 1:1.4; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.31 (ddd, *J* = 11.7, 5.0, 1.2 Hz, 1H), 7.26 – 7.23 (m, 1H), 7.04 – 6.96 (m, 2H), 6.91 (dd, *J* = 5.1, 3.5 Hz, 1H), 6.83 (dd, *J* = 3.5, 1.2 Hz, 1H), 5.12 (s, 1H), 5.05 (s, 1H), 3.04 (s, 1H), 2.53 (s, 1H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 152.6, 142.5, 142.4, 110.4, 110.3, 108.2, 108.0, 70.1, 69.9.

1,2-di(furan-2-yl)ethane-1,2-diol (5n)



Purified by silica gel chromatography (petroleum ether/ethyl acetate = 7:1, v/v), the desired product **5n** was obtained as a white solid. (11 mg, 36% yield). *meso/dl* 1:1.3; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.38 (ddd, *J* = 12.9, 1.9, 0.9 Hz, 2H), 6.37 – 6.21 (m, 4H), 5.03 (s, 1H), 5.01 (s, 1H), 2.85 (s, 1H), 2.51 (s, 1H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 152.8, 152.6, 142.5, 142.4, 110.4, 110.3, 108.2, 108.0, 70.1, 70.0.

4-(2-(4-(((1S,2R,5R)-adamantane-2-carbonyl)oxy)phenyl)-1,2-dihydroxyethyl) phenyl (1r,3r,5r,7r)-adamantane-2-carboxylate (5o)



Purified by silica gel chromatography (petroleum ether/ethyl acetate = 3:1, v/v), the desired product **5o** was obtained as a white solid. (48 mg, 56% yield). mp 195 - 197°C *meso/dl* 1:1.7; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 6.02 – 5.89 (m, 2H), 5.82 (d, *J* = 8.0 Hz, 2H), 5.67 (dd, *J* = 21.3, 8.1 Hz, 4H), 3.49 (d, *J* = 2.7 Hz, 1H), 3.33 (d, *J* = 3.2 Hz, 1H), 1.94 (s, 1H), 1.38 (d, *J* = 16.4 Hz, 1H), 0.79 (dt, *J* = 18.0, 3.2 Hz, 17H), 0.50 (t, *J* = 3.4 Hz, 11H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 176.2, 137.1, 128.1, 128.0, 121.3, 41.0, 41.0, 38.8, 36.5, 27.9. HRMS (ESI) calcd for $C_{36}H_{42}O_6$, $[M+H]^+$ m/z 571.3054; Found: 571.3055.

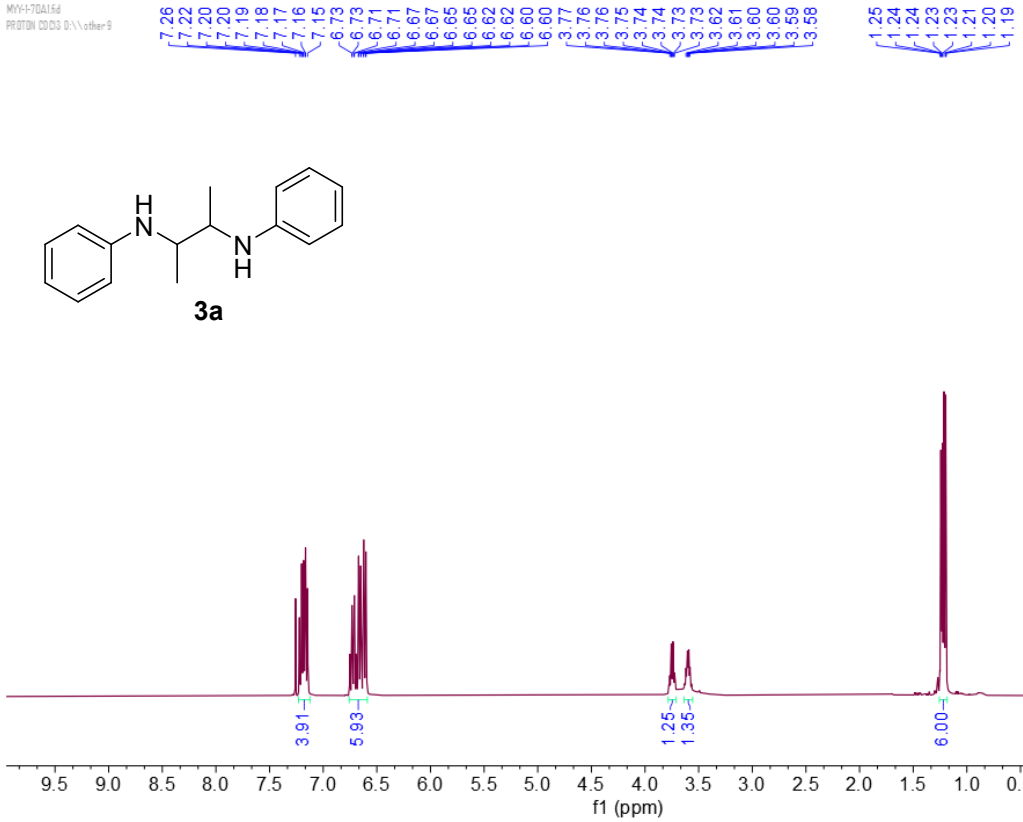
7. Reference

(1) (a) J. Luo and J. Zhang, *ACS Catal*., 2020, **10**, 14302-14303; (b) E. Speckmeier, T. G. Fischer and K. Zeitler, *J. Am. Chem. Soc*., 2018, **140**, 15353-15365.

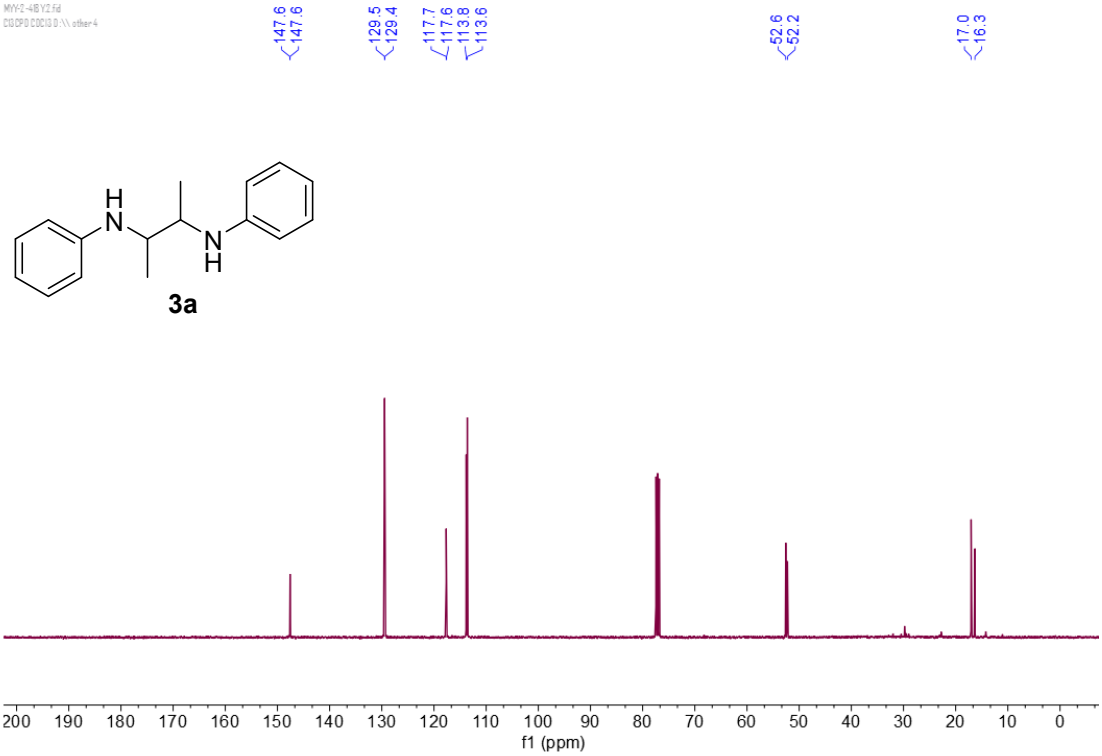
(2) J. L. Li, D. Zhang, J. H. Chen, C. Q. Ma, and W. H. Hu, *ACS Catal.,* 2020, **10**, 4559–4565.
(3) D. V. Hrishikesh, R. A. Annadate and S. V. Pansare, *ACS Omega.,* 2023, **8**, 3190-3197.

8. NMR spectra

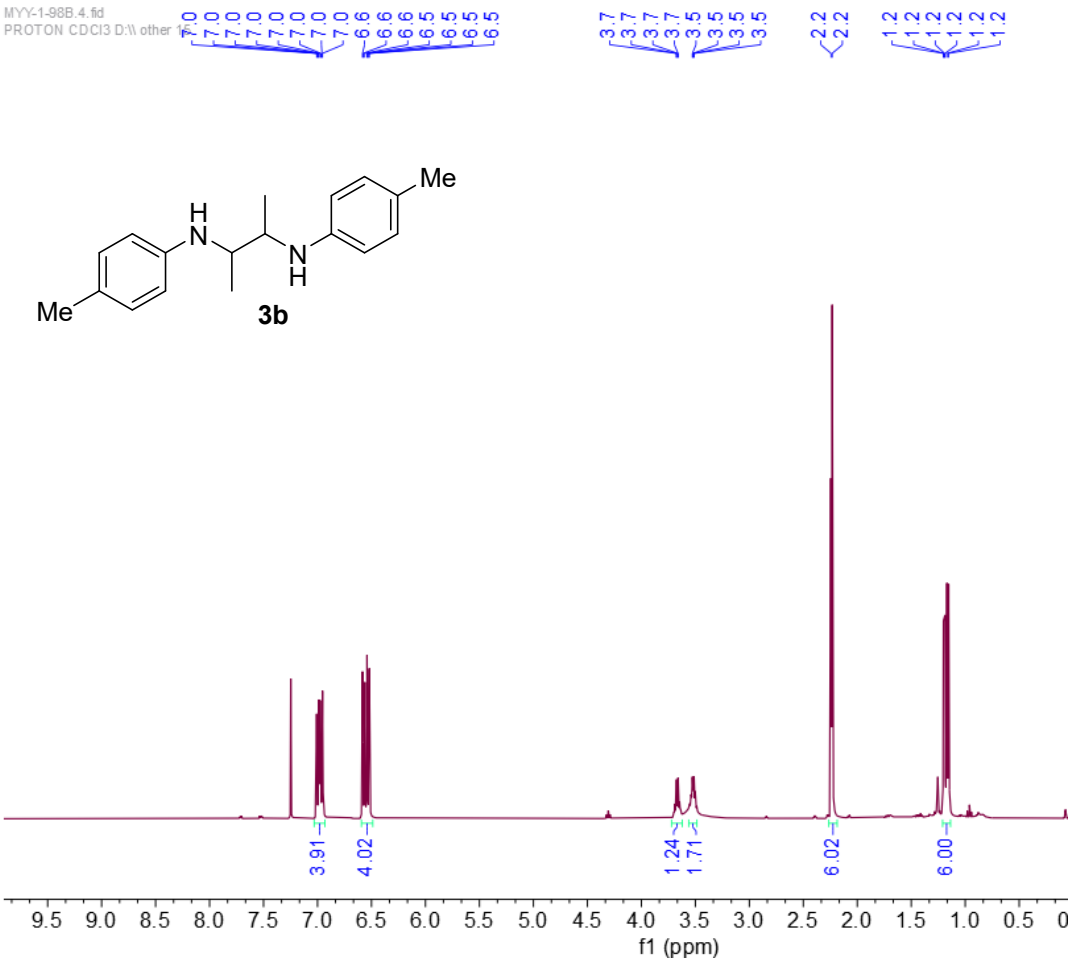
^{1}H-NMR spectrum of **3a** ($CDCl_3$, 400 MHz)



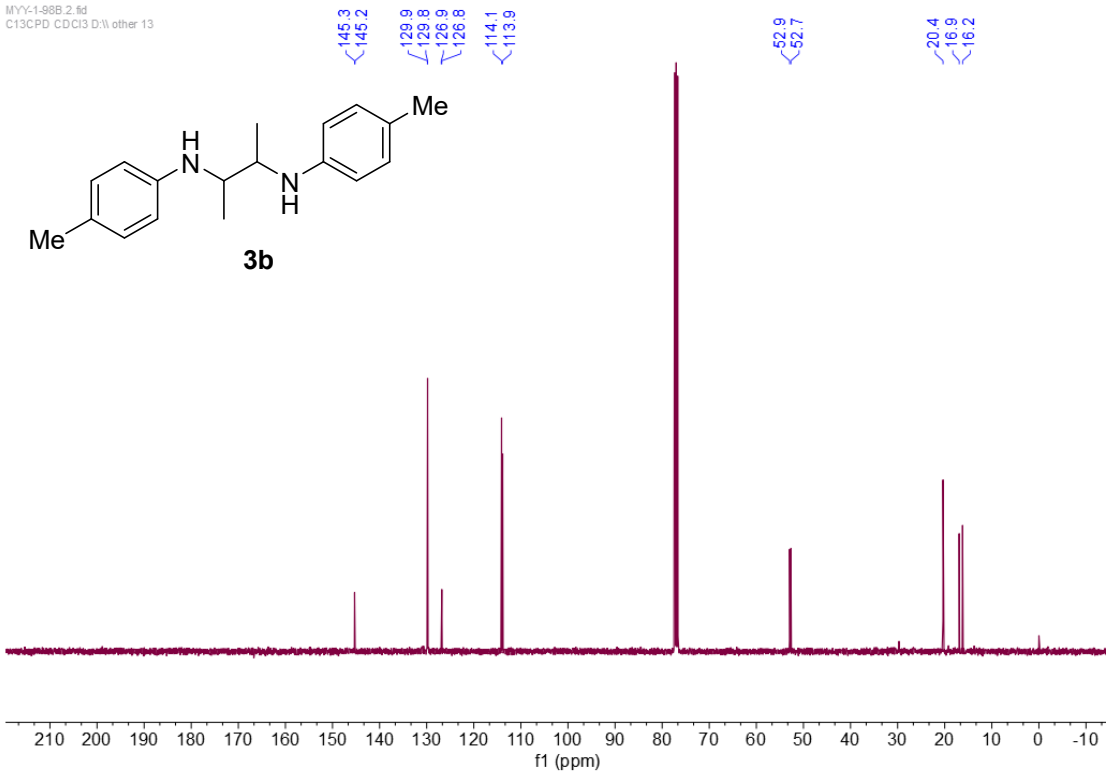
^{13}C-NMR spectrum of **3a** ($CDCl_3$, 100 MHz)



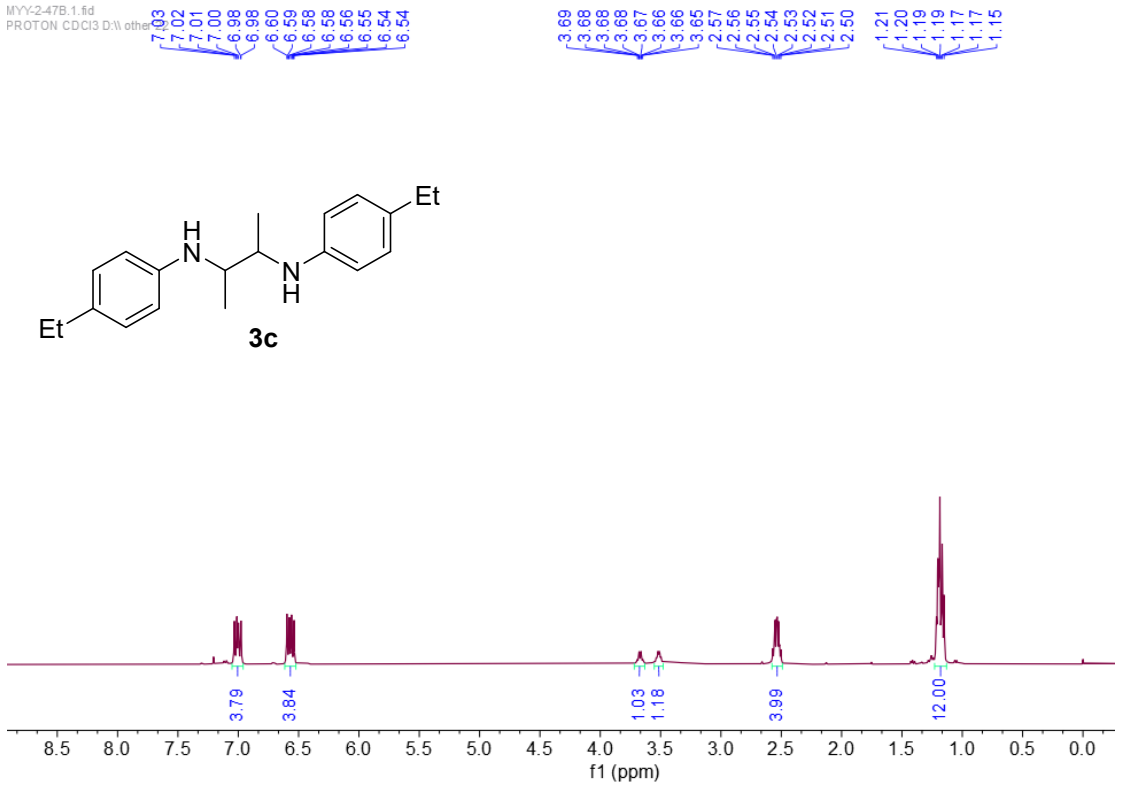
^{1}H-NMR spectrum of **3b** ($CDCl_3$, 400 MHz)



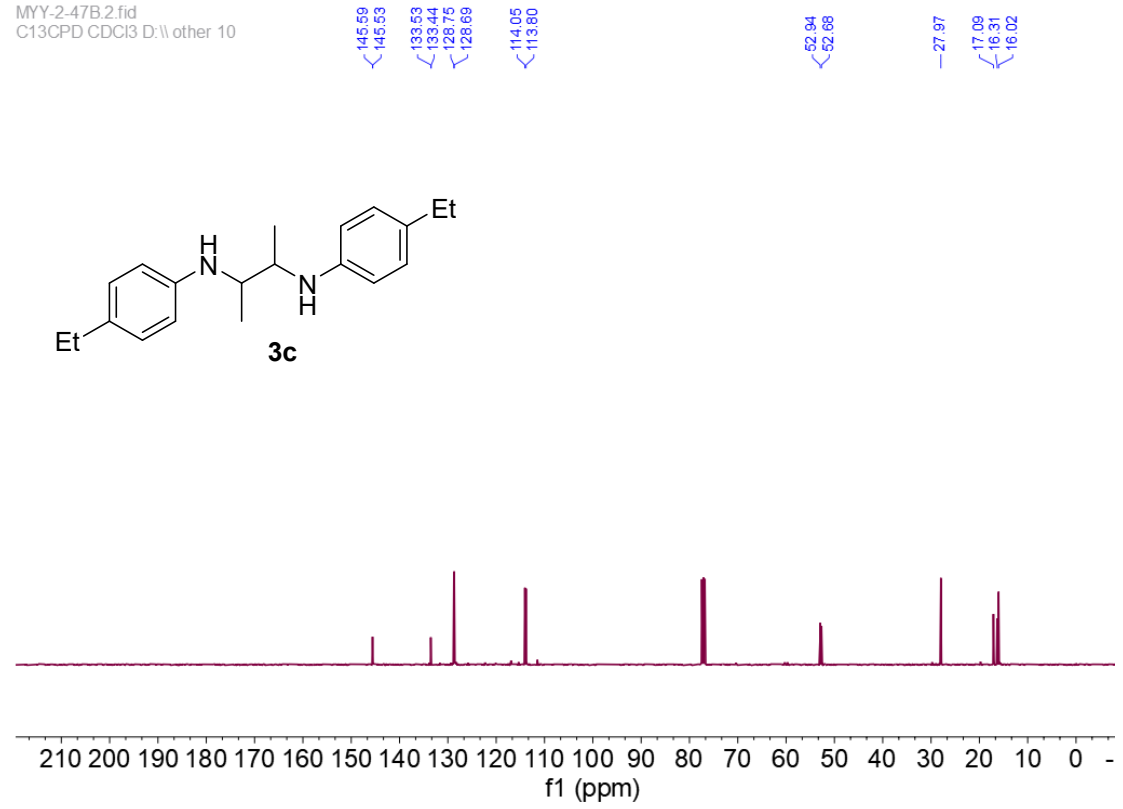
^{13}C-NMR spectrum of **3b** ($CDCl_3$, 100 MHz)



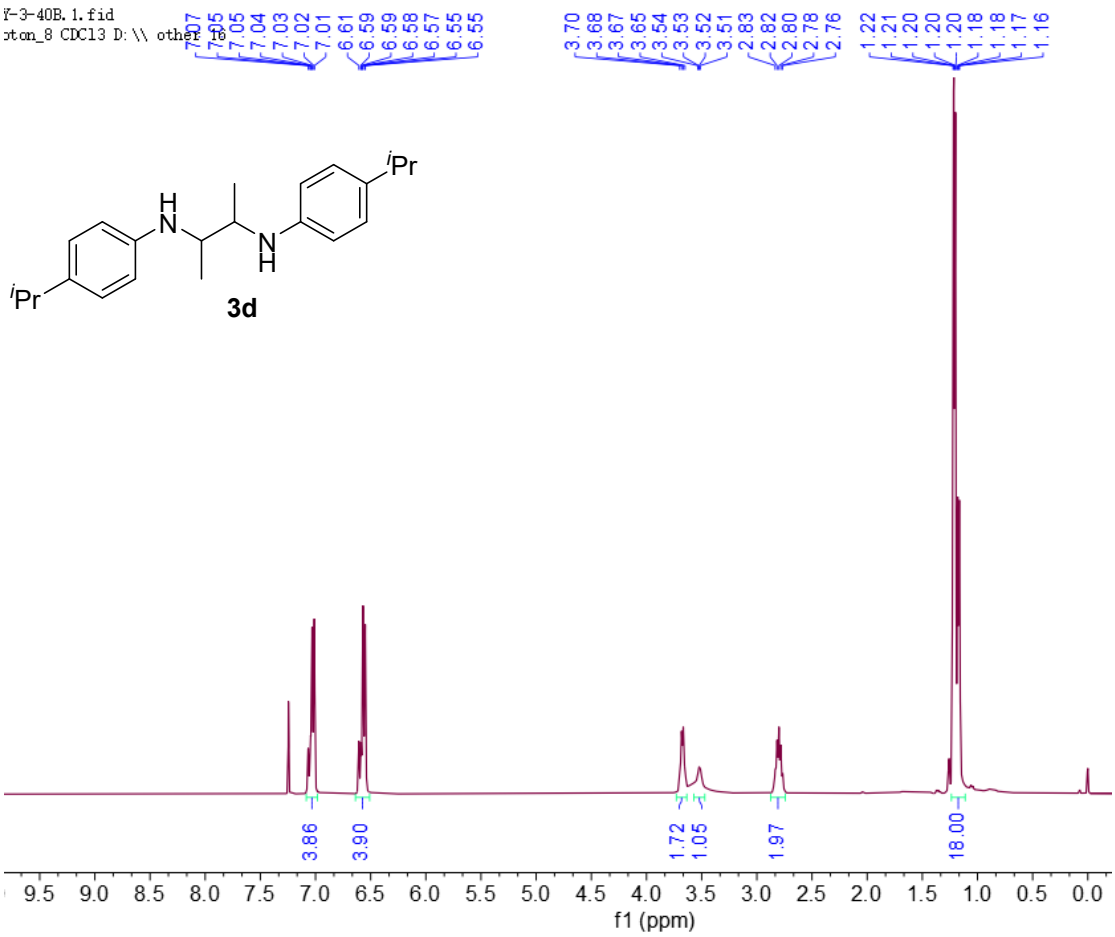
^{1}H-NMR spectrum of **3c** ($CDCl_3$, 400 MHz)



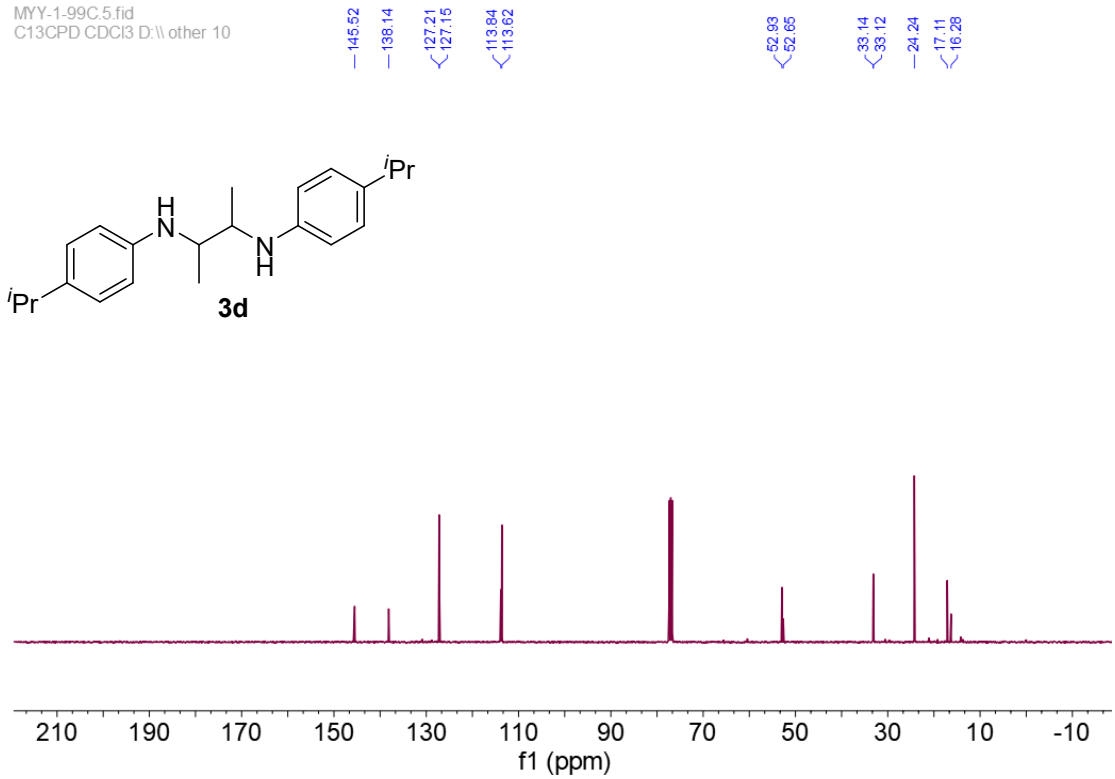
^{13}C-NMR spectrum of **3c** ($CDCl_3$, 100 MHz)



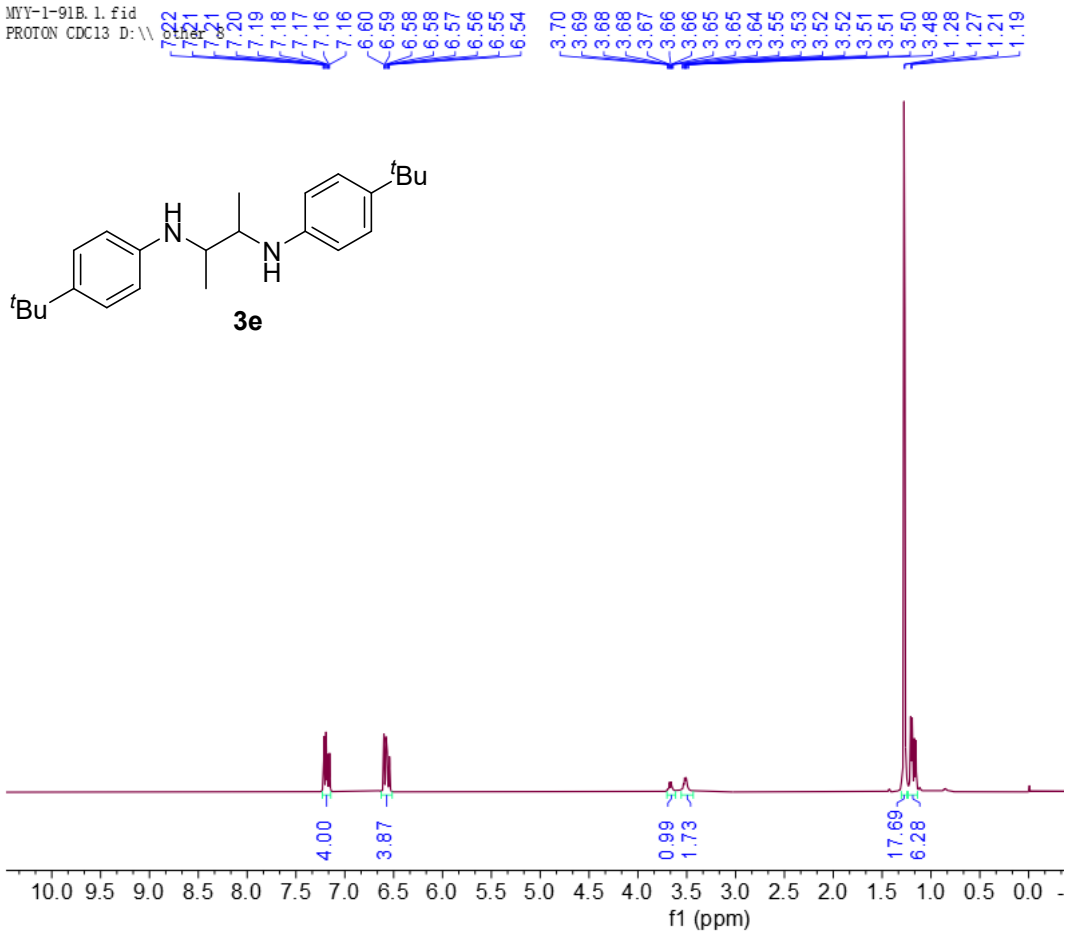
^{1}H-NMR spectrum of **3d** ($CDCl_3$, 400 MHz)



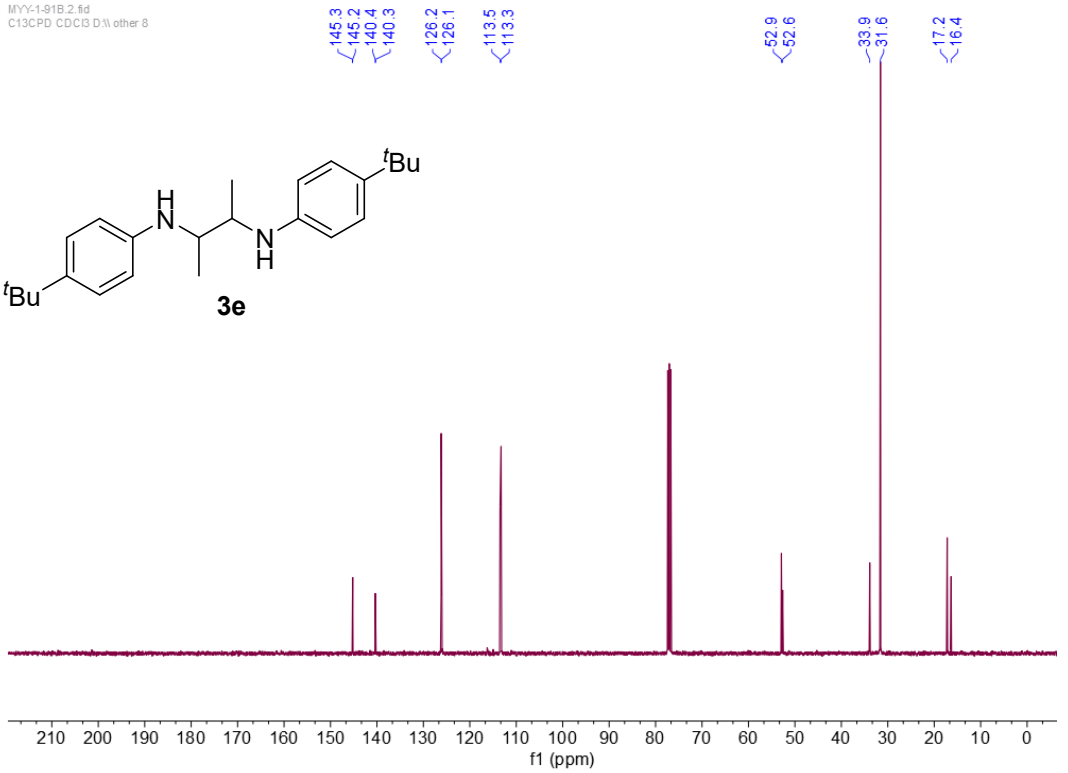
^{13}C-NMR spectrum of **3d** ($CDCl_3$, 100 MHz)



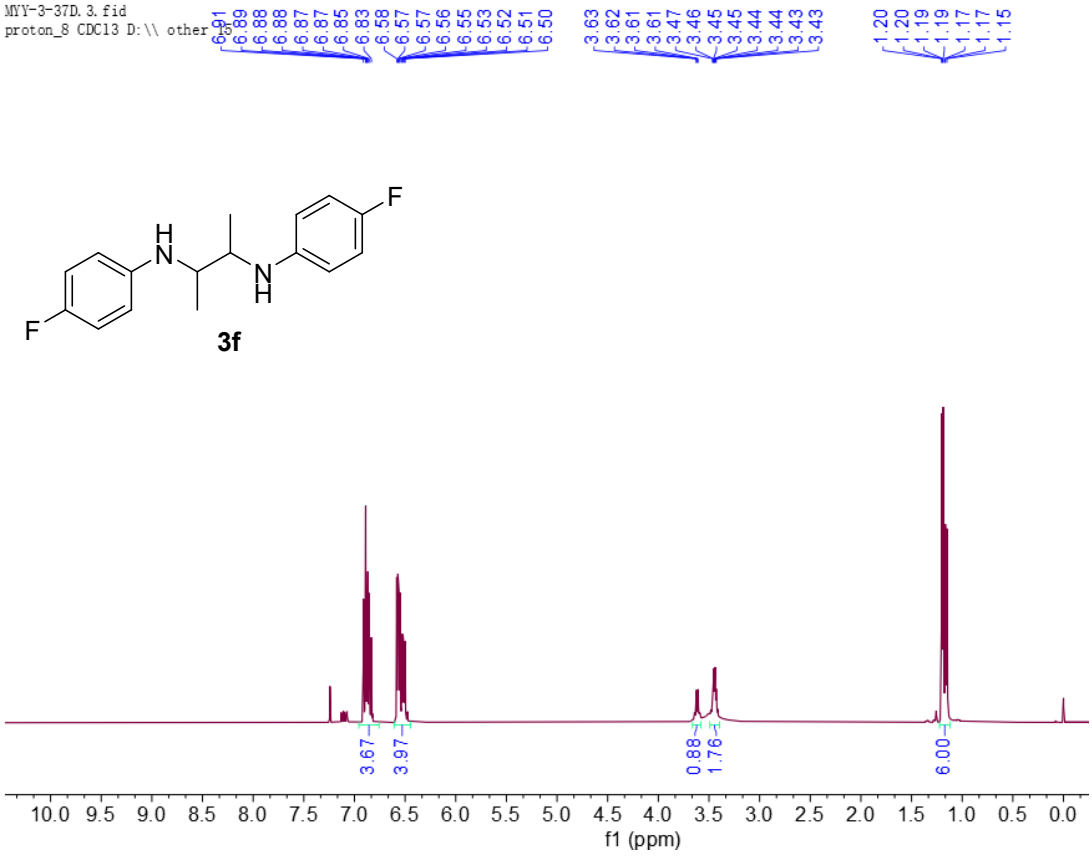
^{1}H-NMR spectrum of **3e** ($CDCl_3$, 400 MHz)



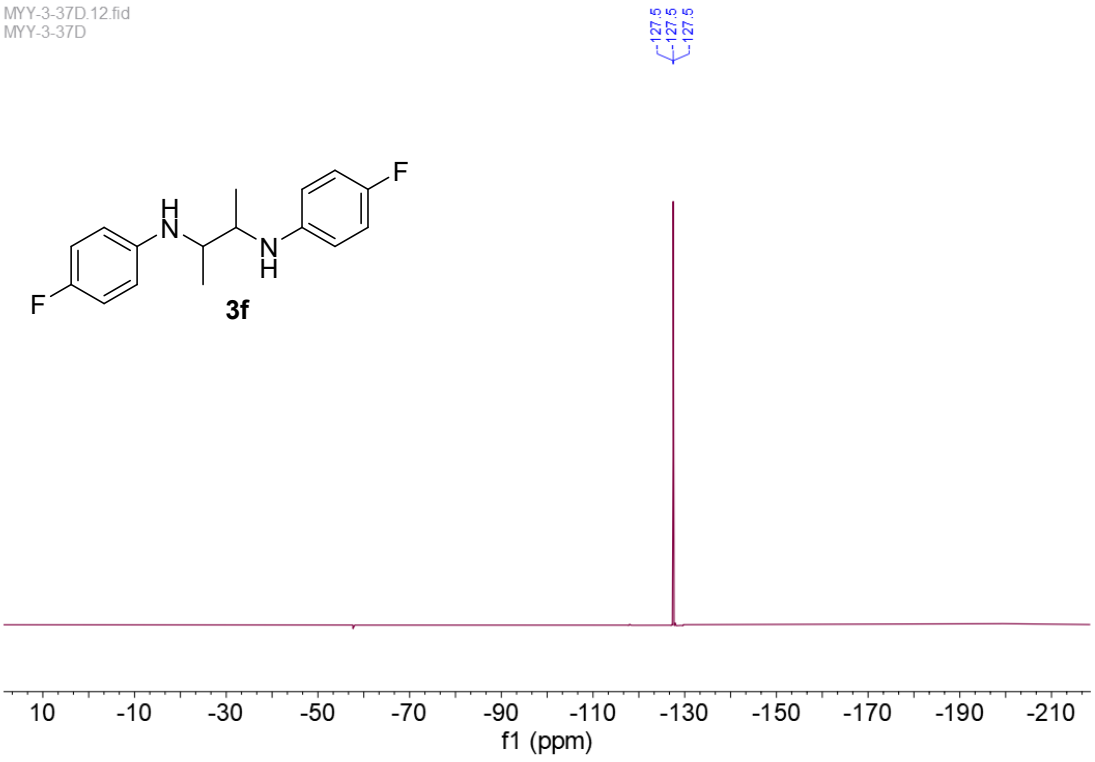
^{13}C-NMR spectrum of **3e** ($CDCl_3$, 100 MHz)



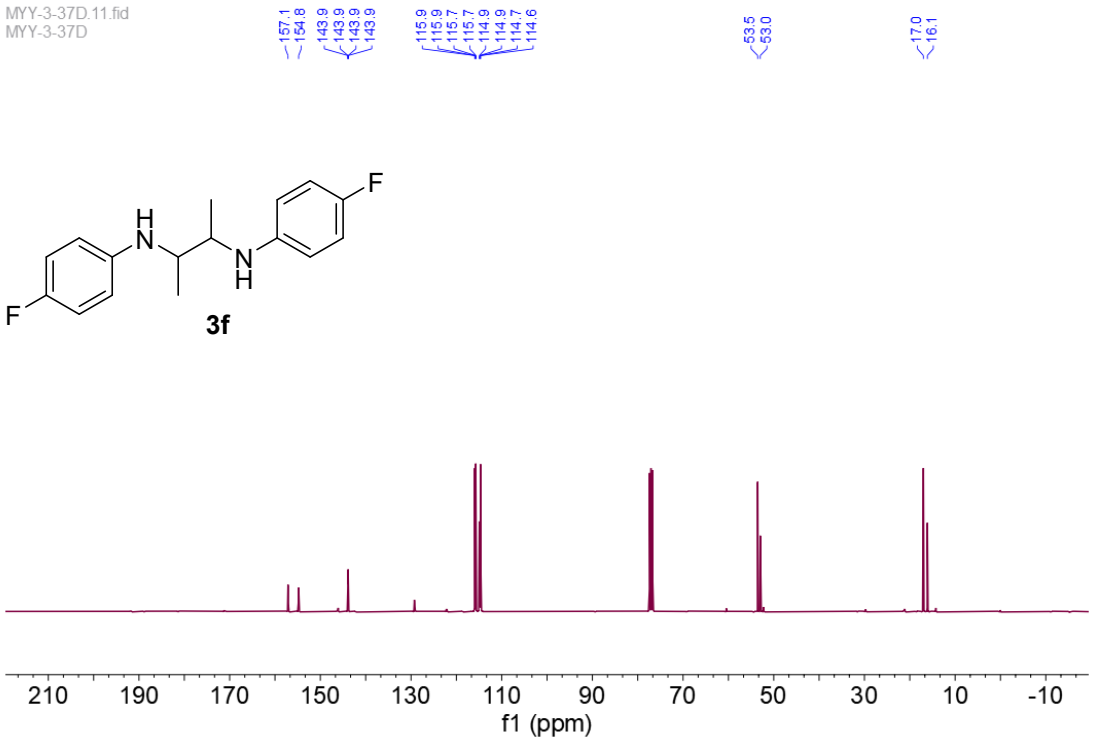
^{1}H-NMR spectrum of **3f** ($CDCl_3$, 400 MHz)



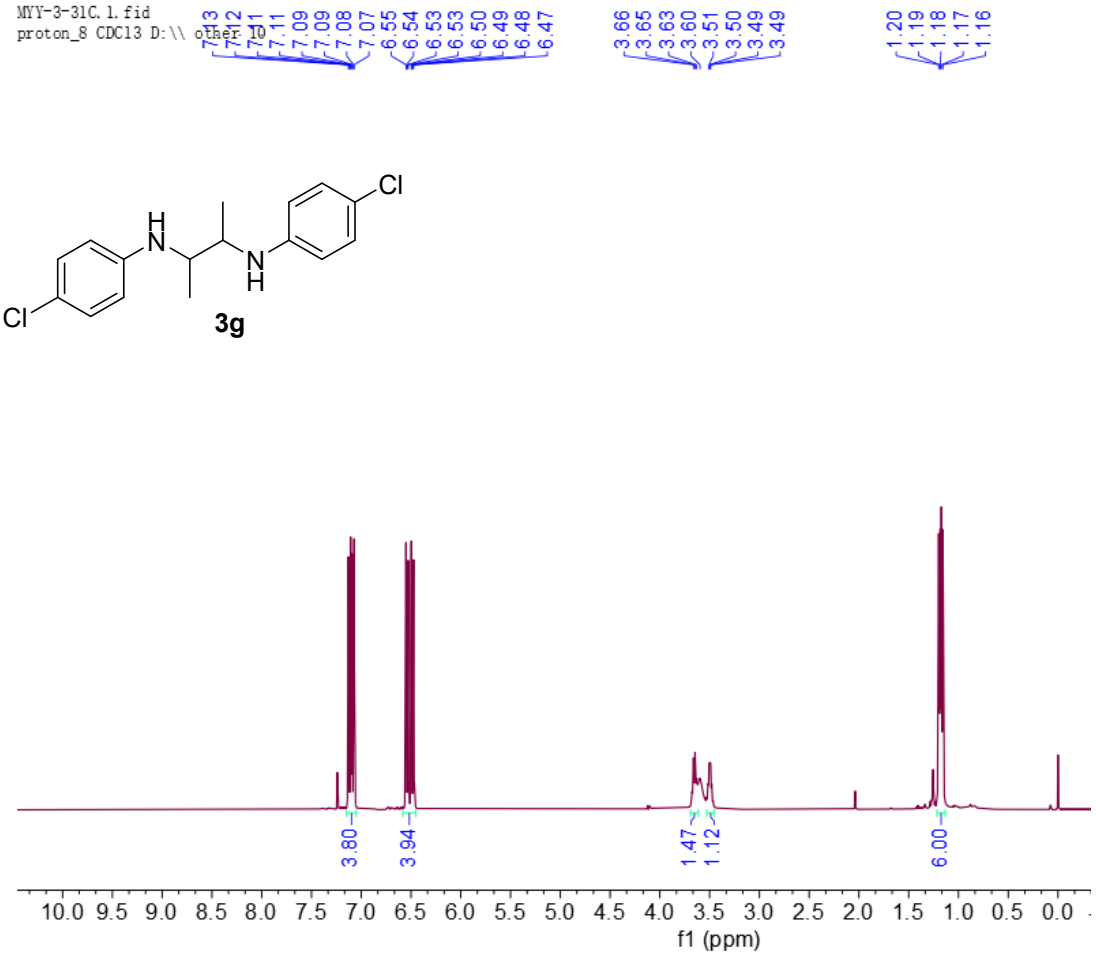
^{19}F-NMR spectrum of **3f** ($CDCl_3$, 376 MHz)



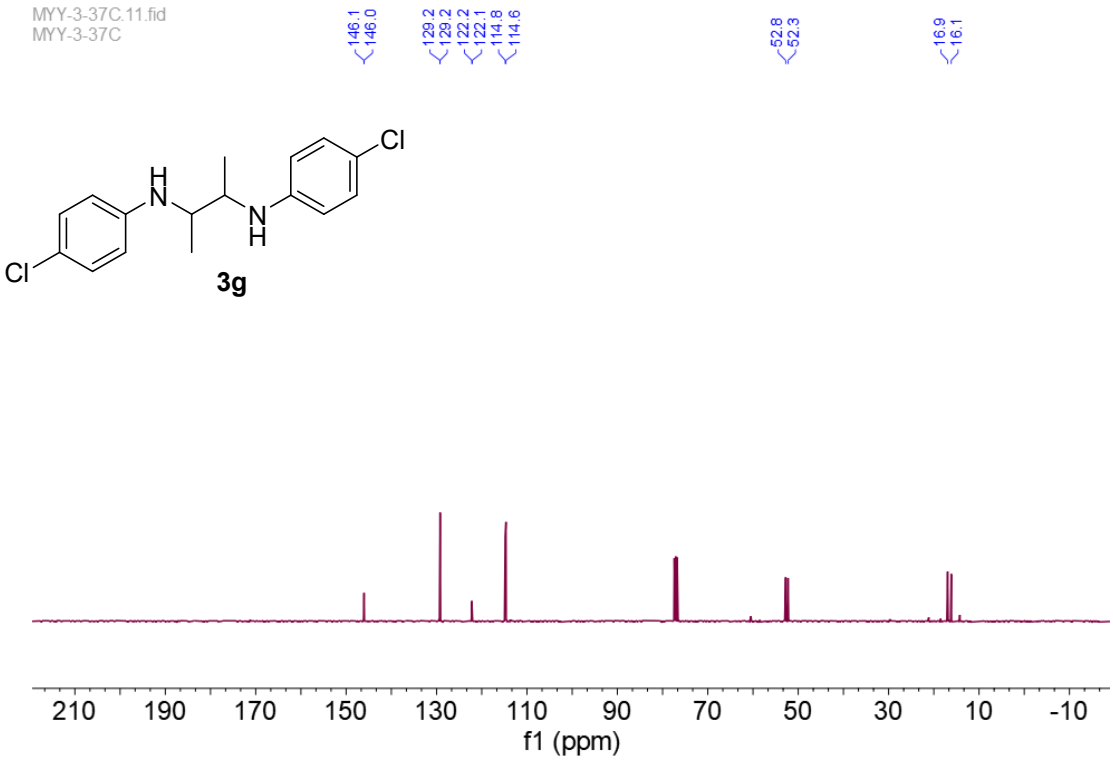
^{13}C-NMR spectrum of **3f** ($CDCl_3$, 100 MHz)



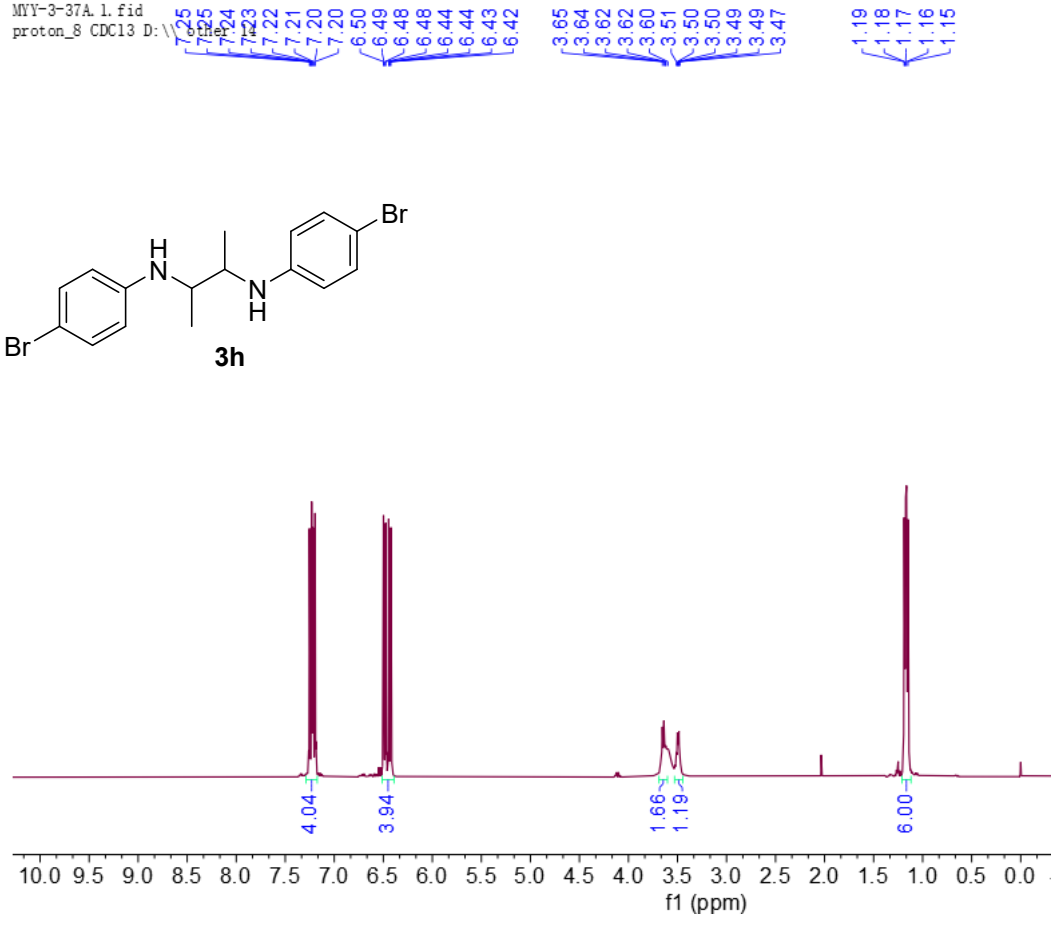
^{1}H-NMR spectrum of **3g** ($CDCl_3$, 400 MHz)



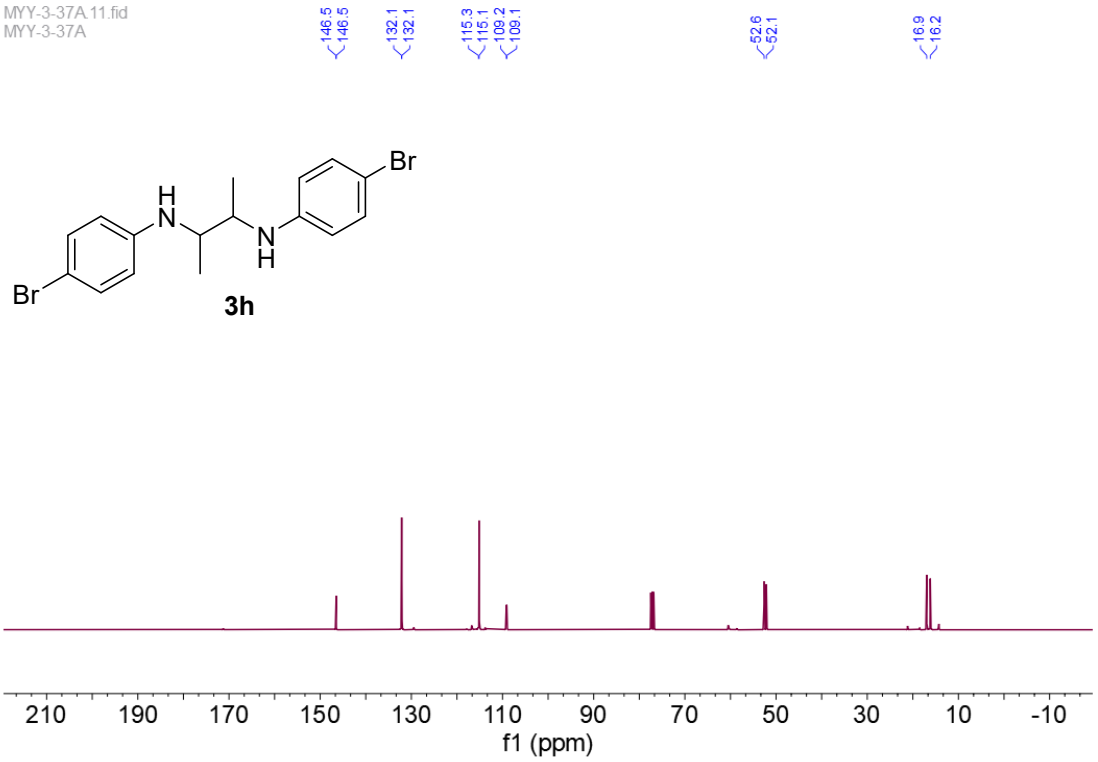
^{13}C-NMR spectrum of **3g** ($CDCl_3$, 100 MHz)



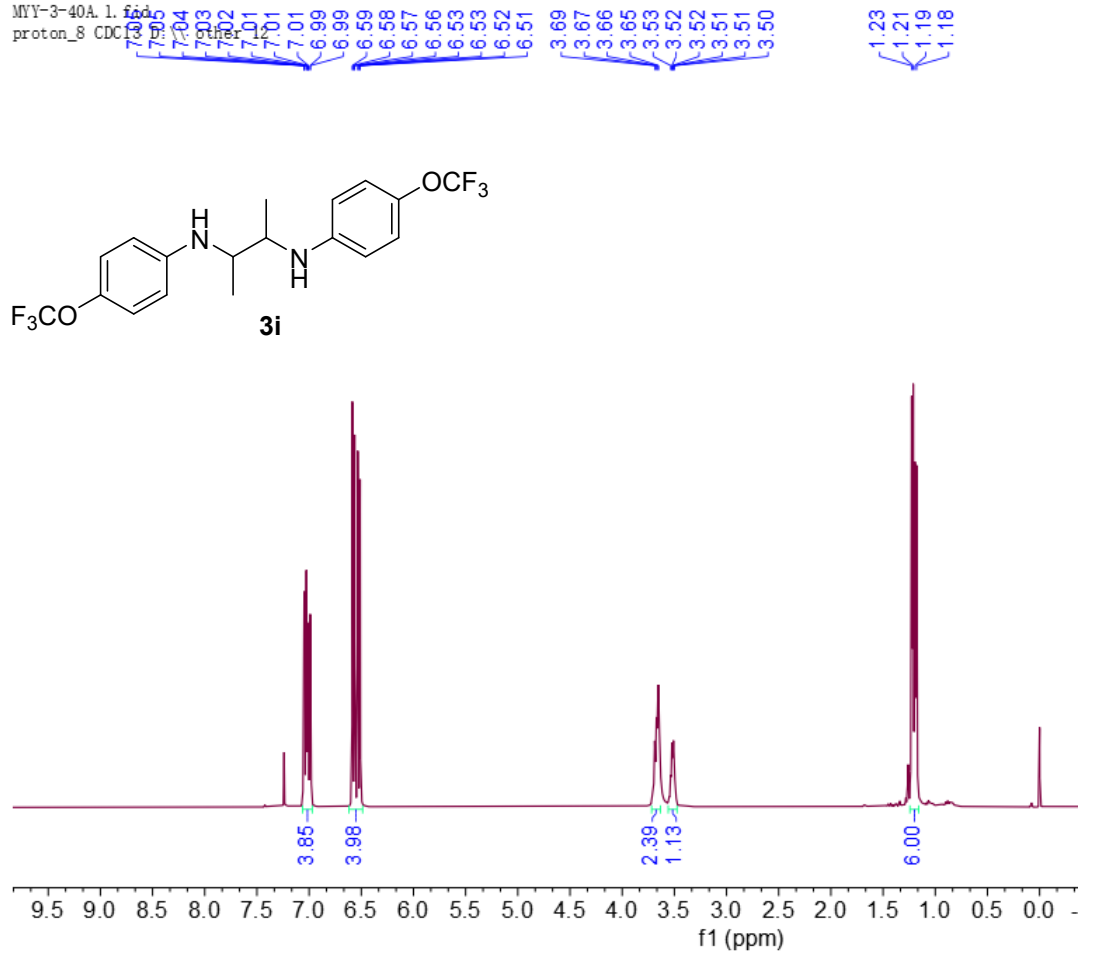
^{1}H-NMR spectrum of **3h** ($CDCl_3$, 400 MHz)



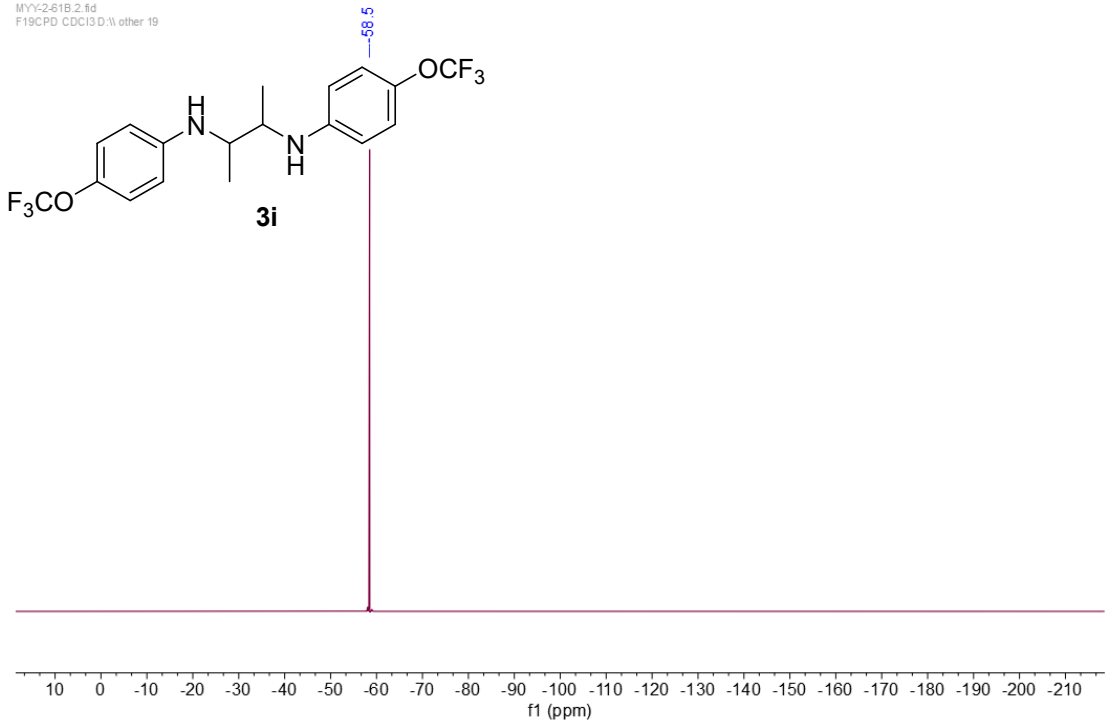
^{13}C-NMR spectrum of **3h** ($CDCl_3$, 100 MHz)



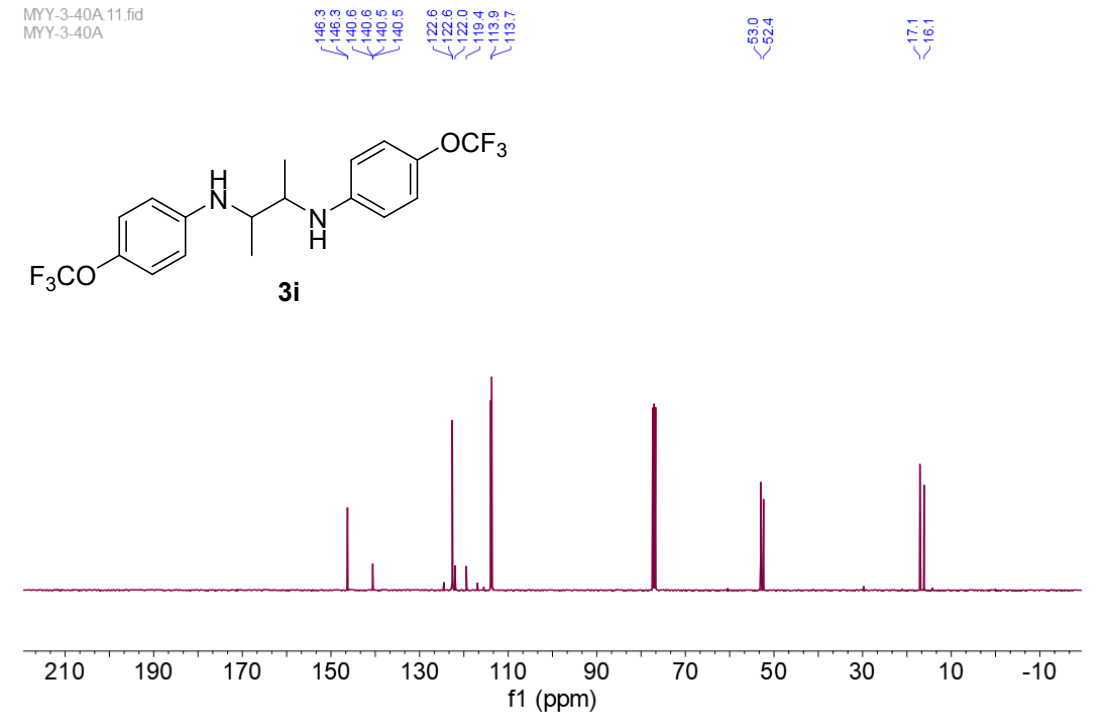
^{1}H-NMR spectrum of **3i** ($CDCl_3$, 400 MHz)



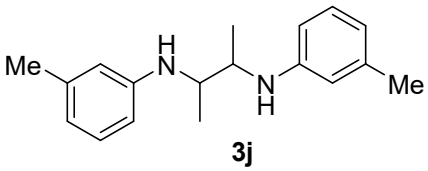
^{19}F-NMR spectrum of **3i** ($CDCl_3$, 376 MHz)



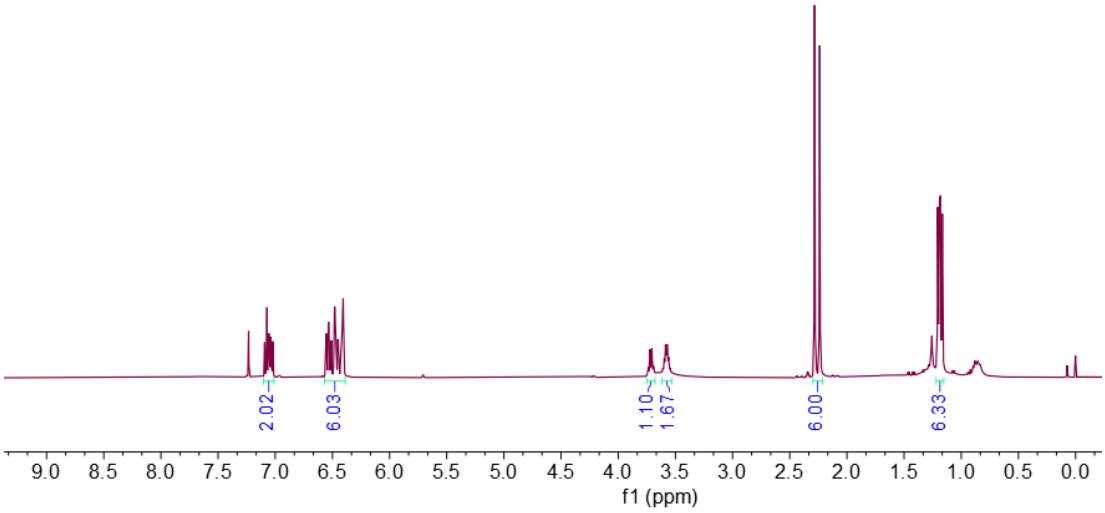
^{13}C-NMR spectrum of **3i** ($CDCl_3$, 100 MHz)



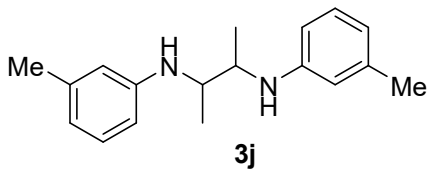
^{1}H-NMR spectrum of **3j** ($CDCl_3$, 400 MHz)



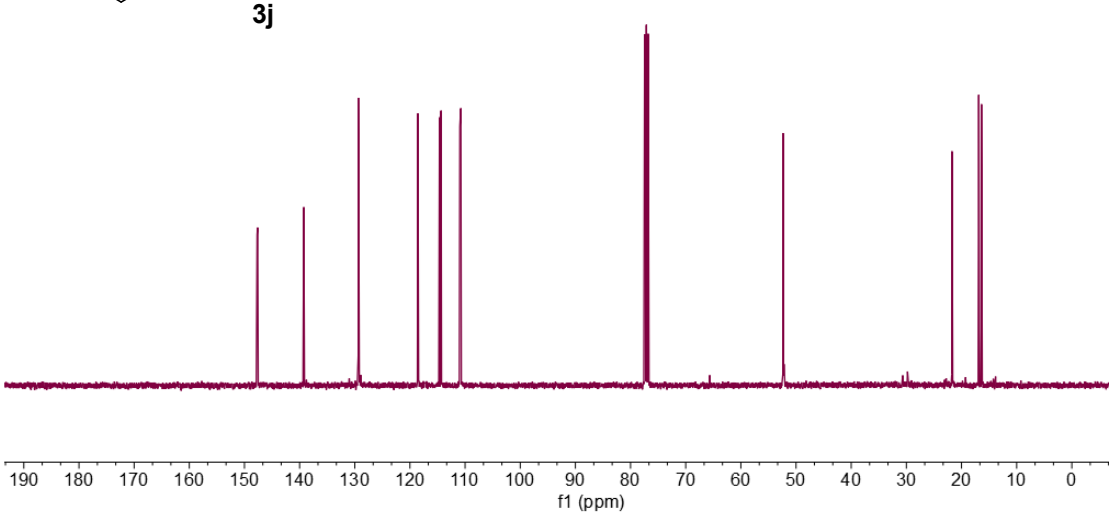
3j



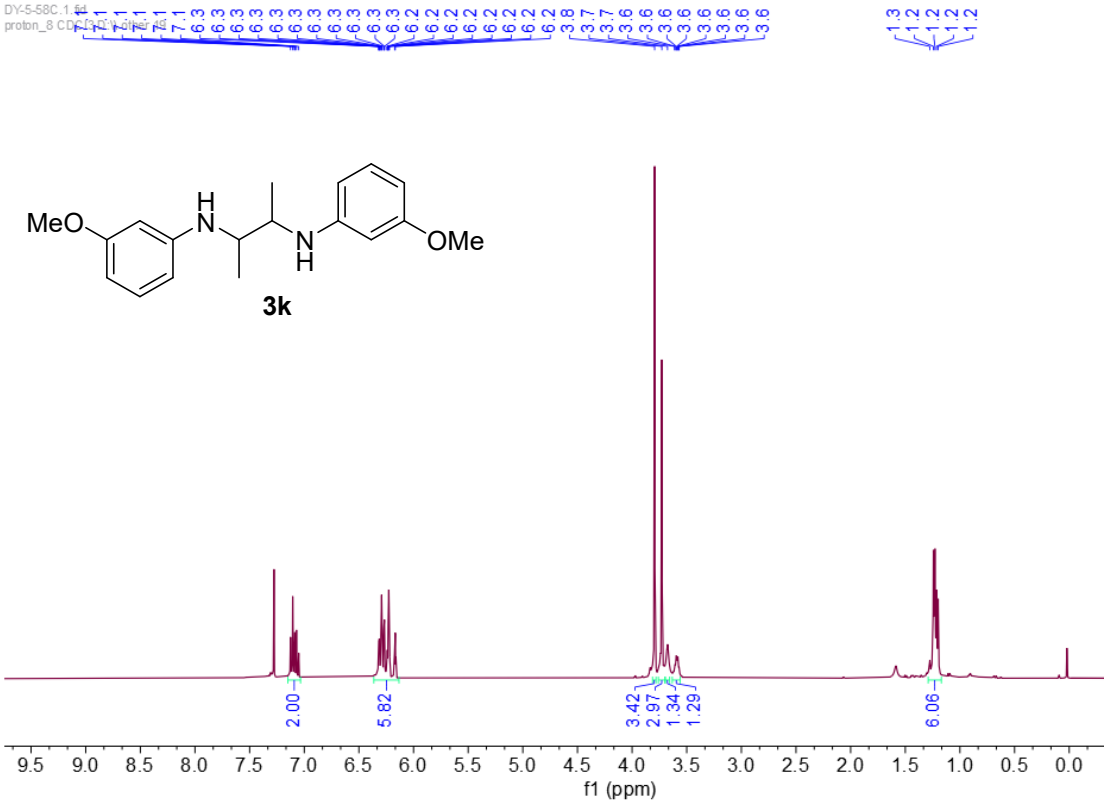
^{13}C-NMR spectrum of **3j** ($CDCl_3$, 100 MHz)



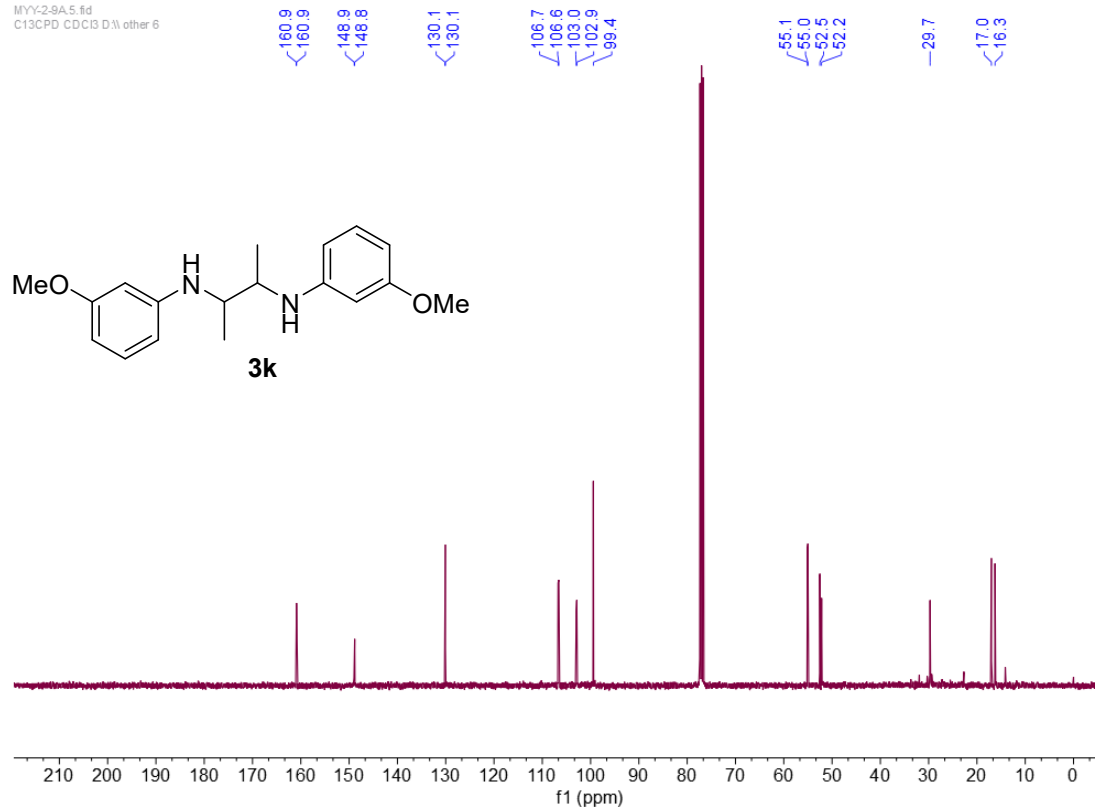
3j



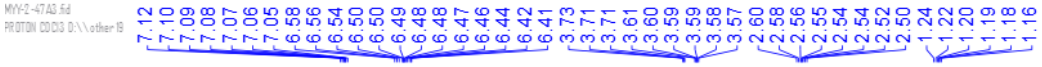
^{1}H-NMR spectrum of **3k** ($CDCl_3$, 400 MHz)

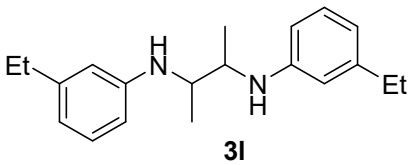


^{13}C-NMR spectrum of **3k** ($CDCl_3$, 100 MHz)

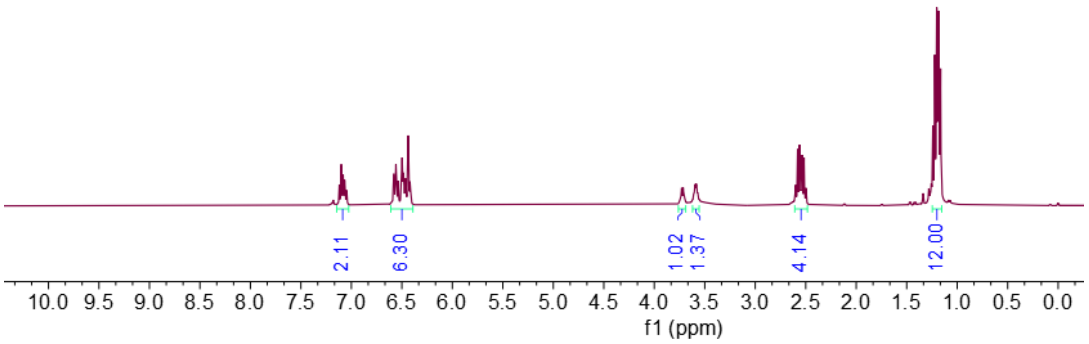


^{1}H-NMR spectrum of **3l** ($CDCl_3$, 400 MHz)

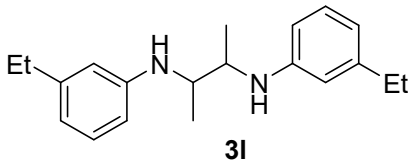




3l

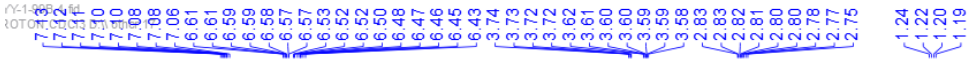


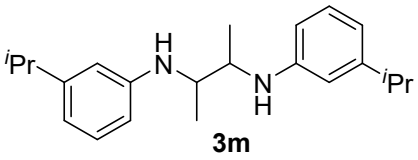
^{13}C-NMR spectrum of **3l** ($CDCl_3$, 100 MHz)



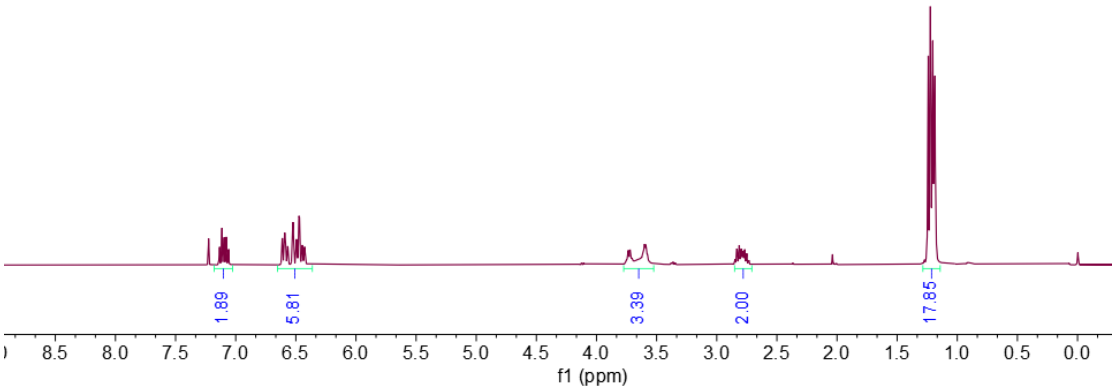
3l

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

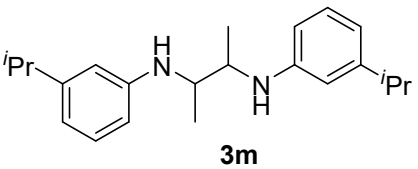




3m

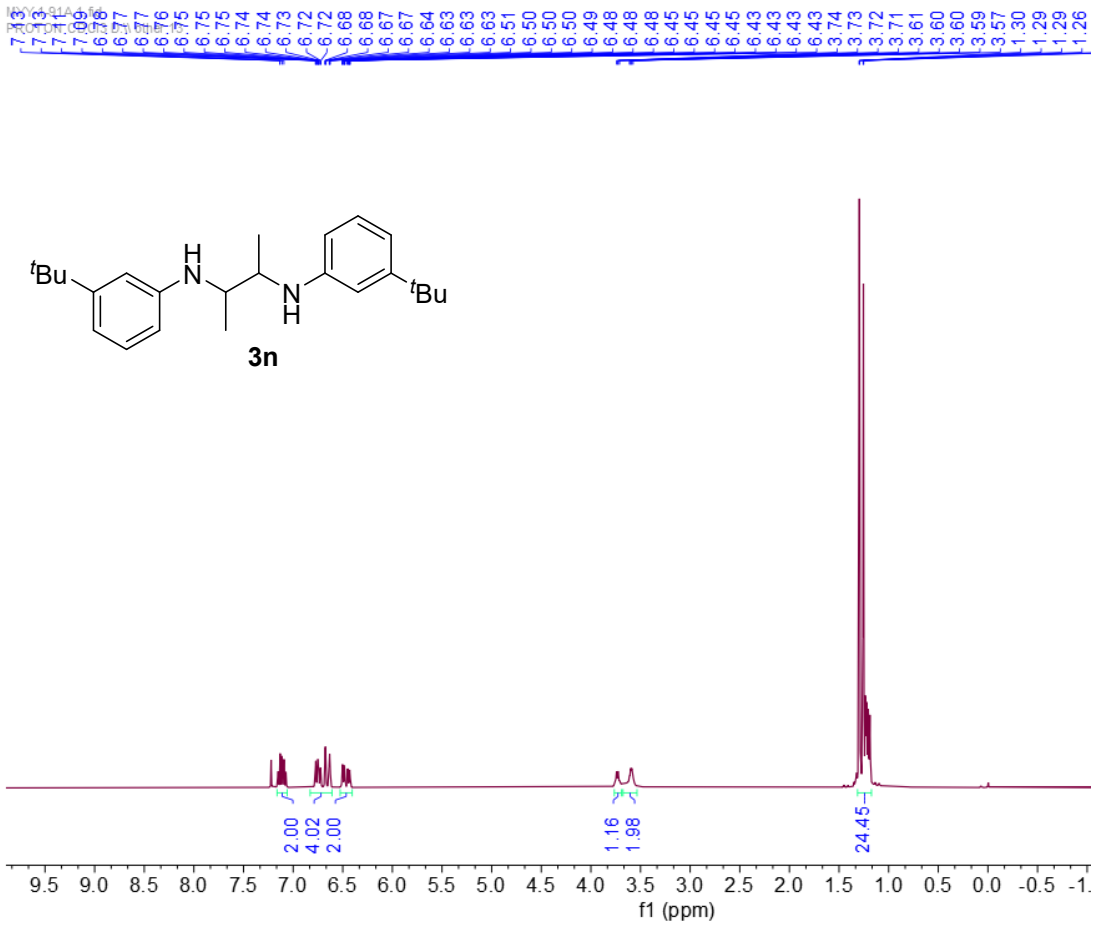


^{13}C-NMR spectrum of **3m** ($CDCl_3$, 100 MHz)

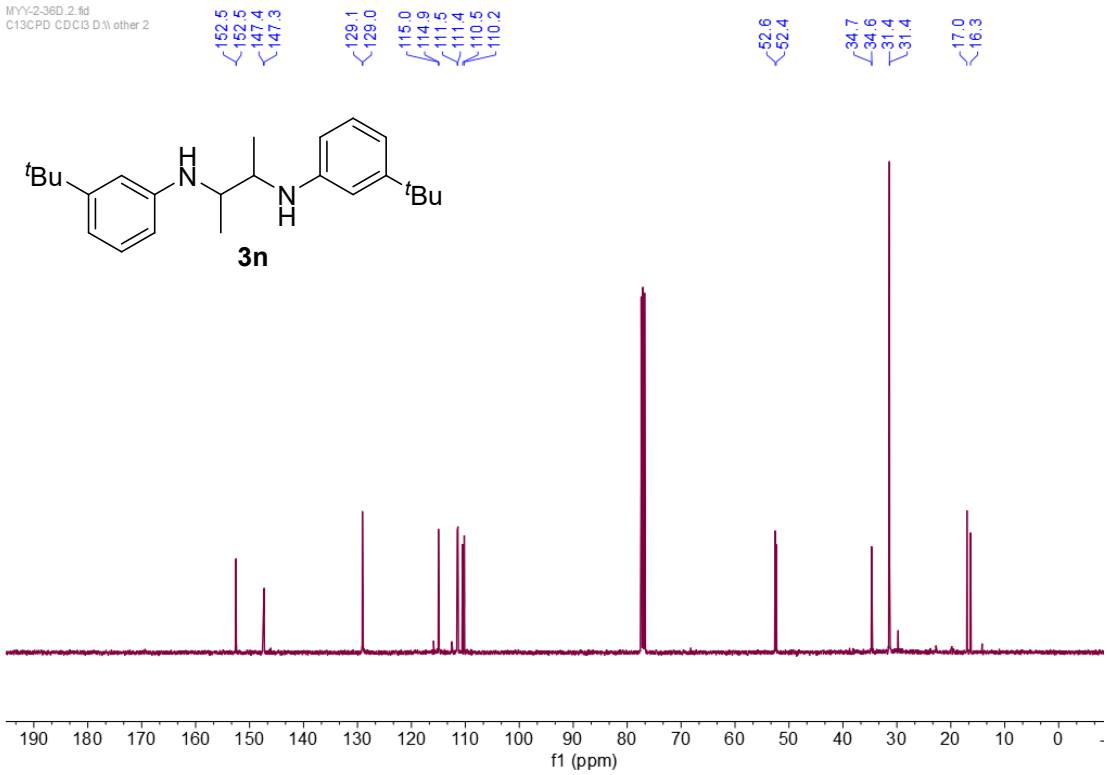


3m

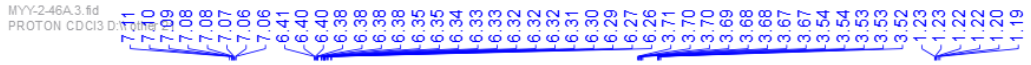
^{1}H-NMR spectrum of **3n** ($CDCl_3$, 400 MHz)

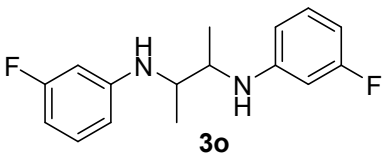


^{13}C-NMR spectrum of **3n** ($CDCl_3$, 100 MHz)

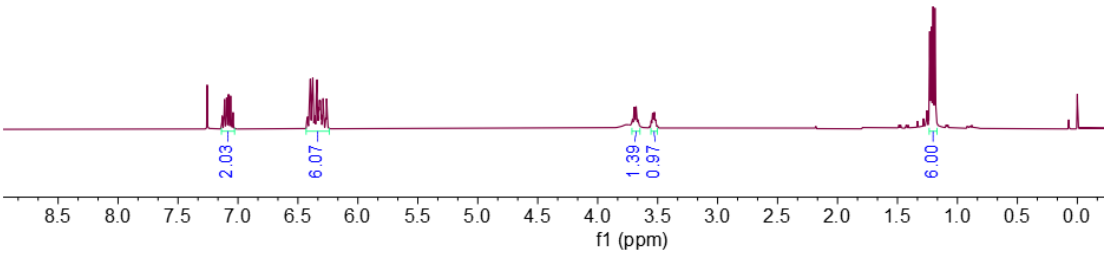


^{1}H-NMR spectrum of **3o** ($CDCl_3$, 400 MHz)

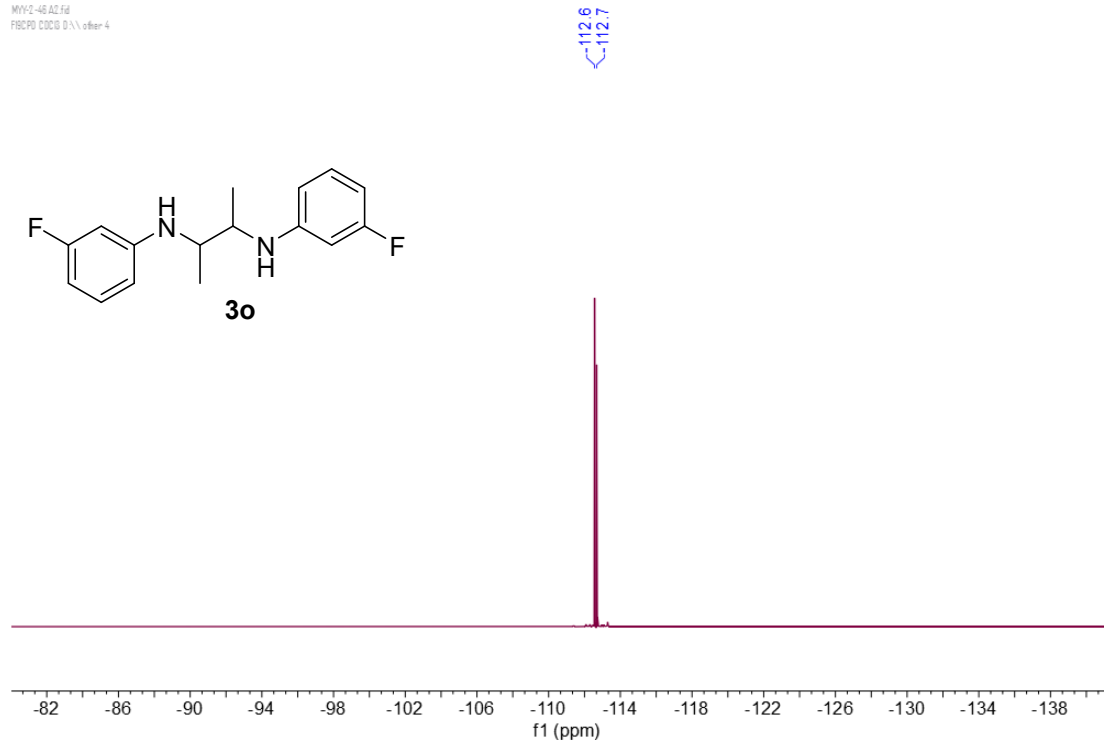




3o

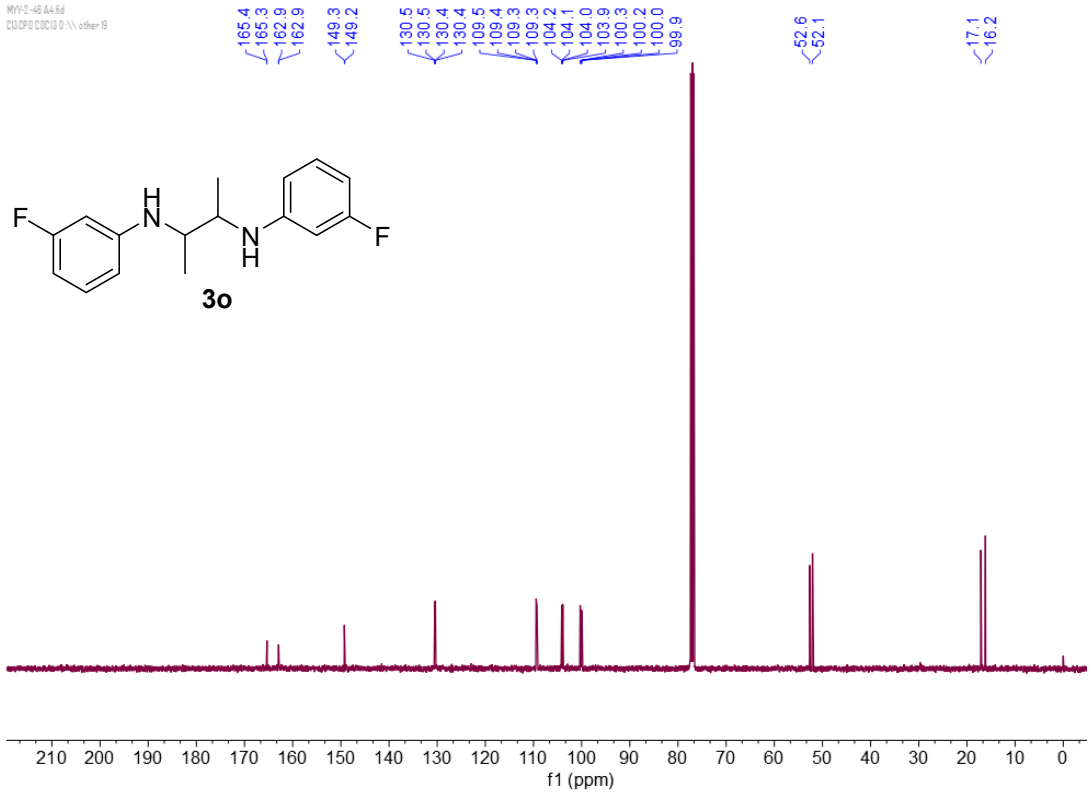


^{19}F-NMR spectrum of **3o** ($CDCl_3$, 376 MHz)

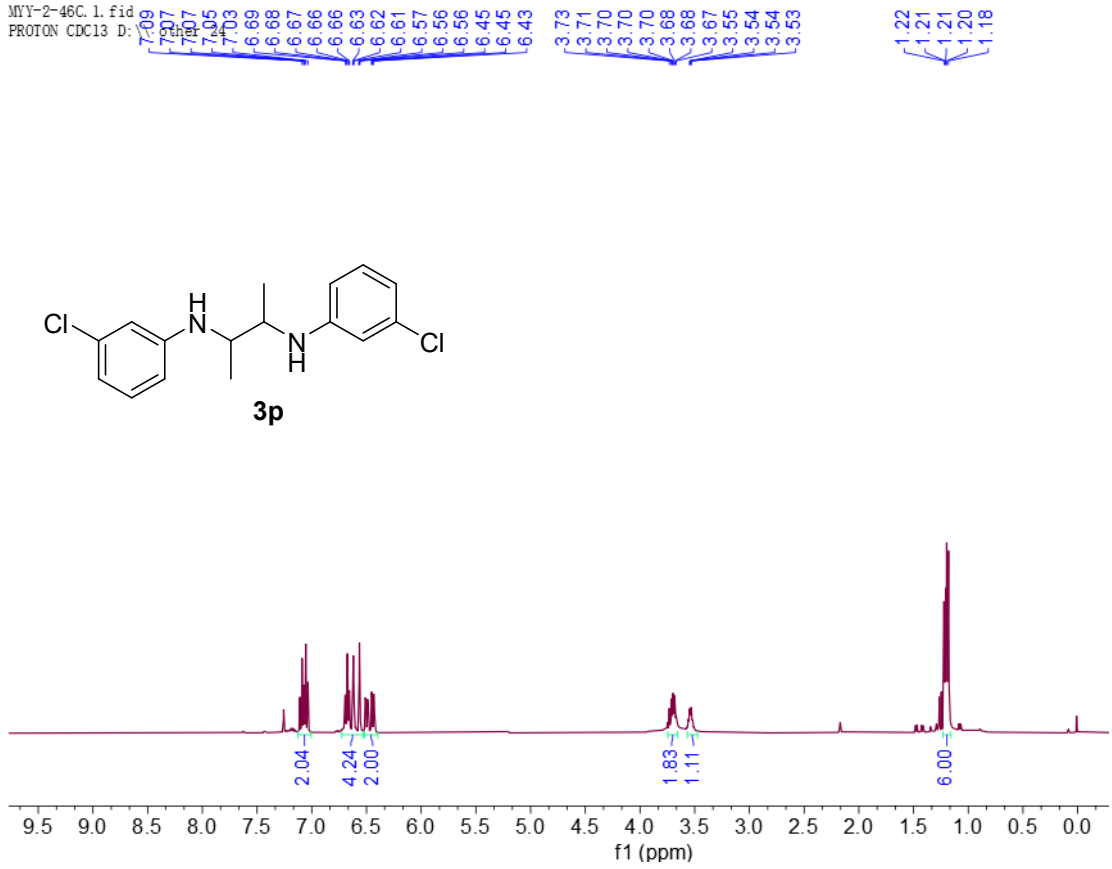


3o

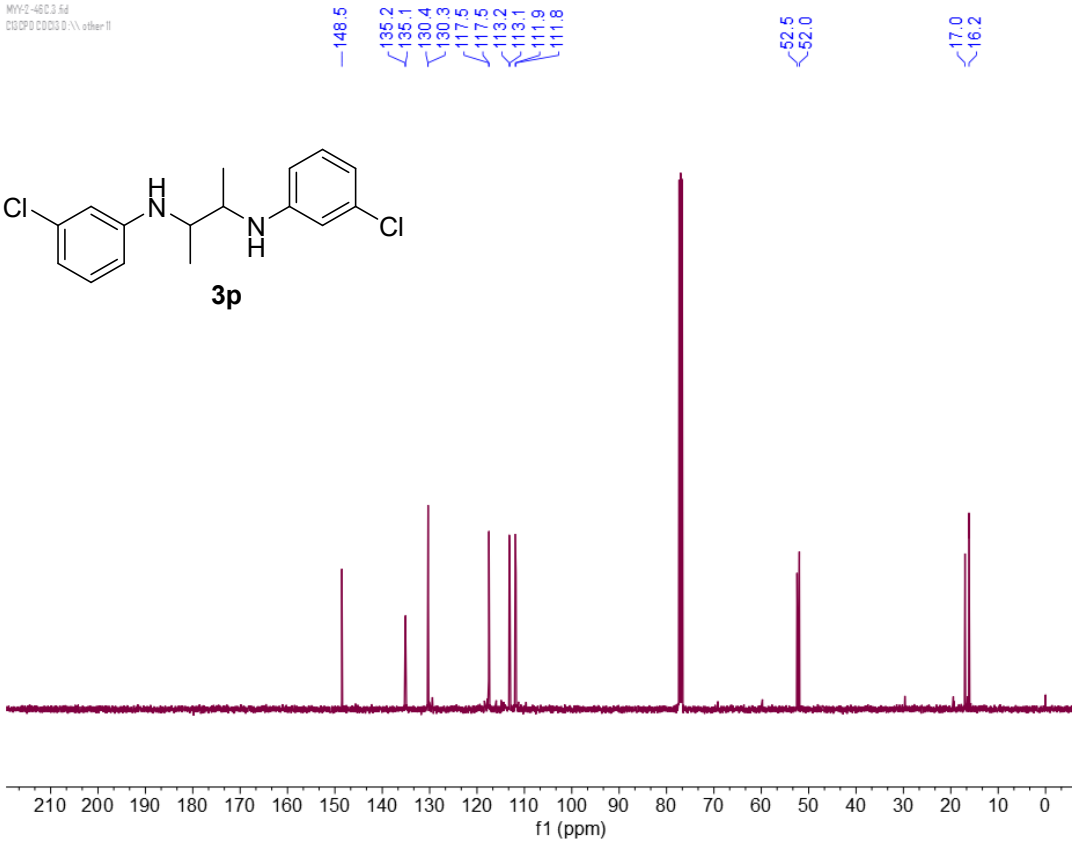
^{13}C-NMR spectrum of **3o** ($CDCl_3$, 100 MHz)



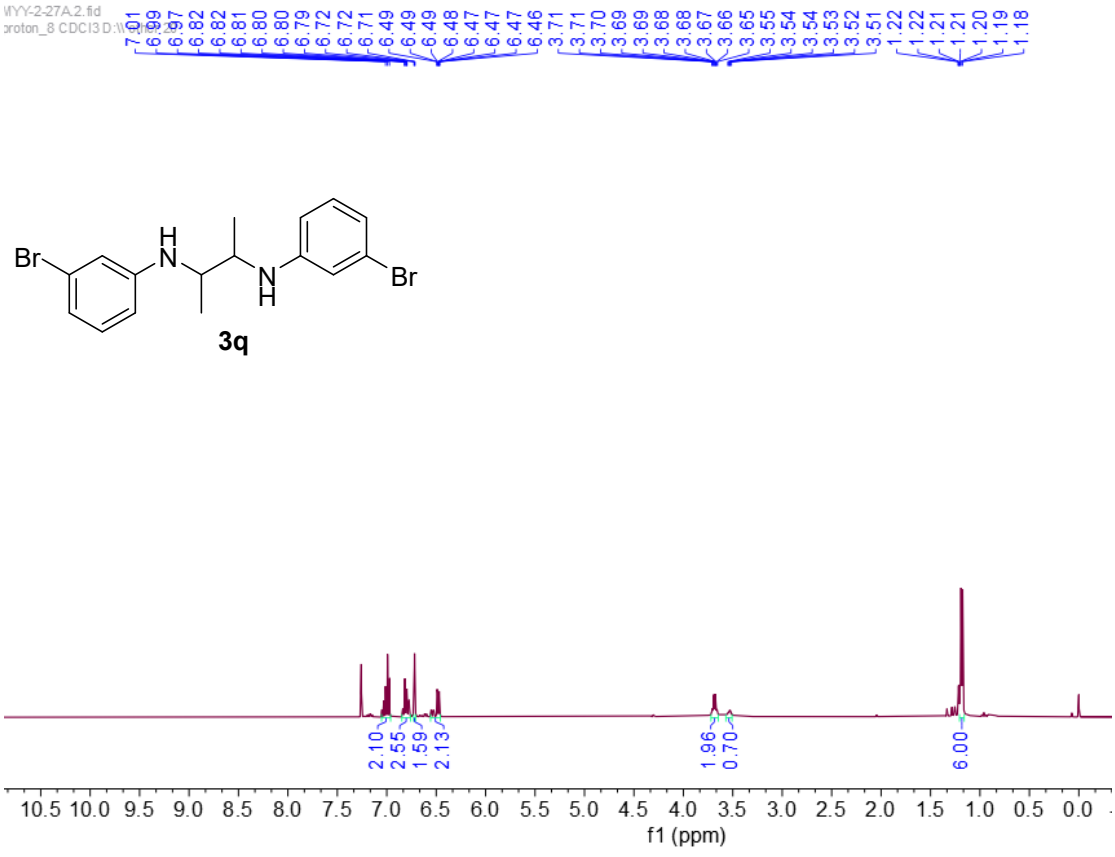
^{1}H-NMR spectrum of **3p** ($CDCl_3$, 400 MHz)



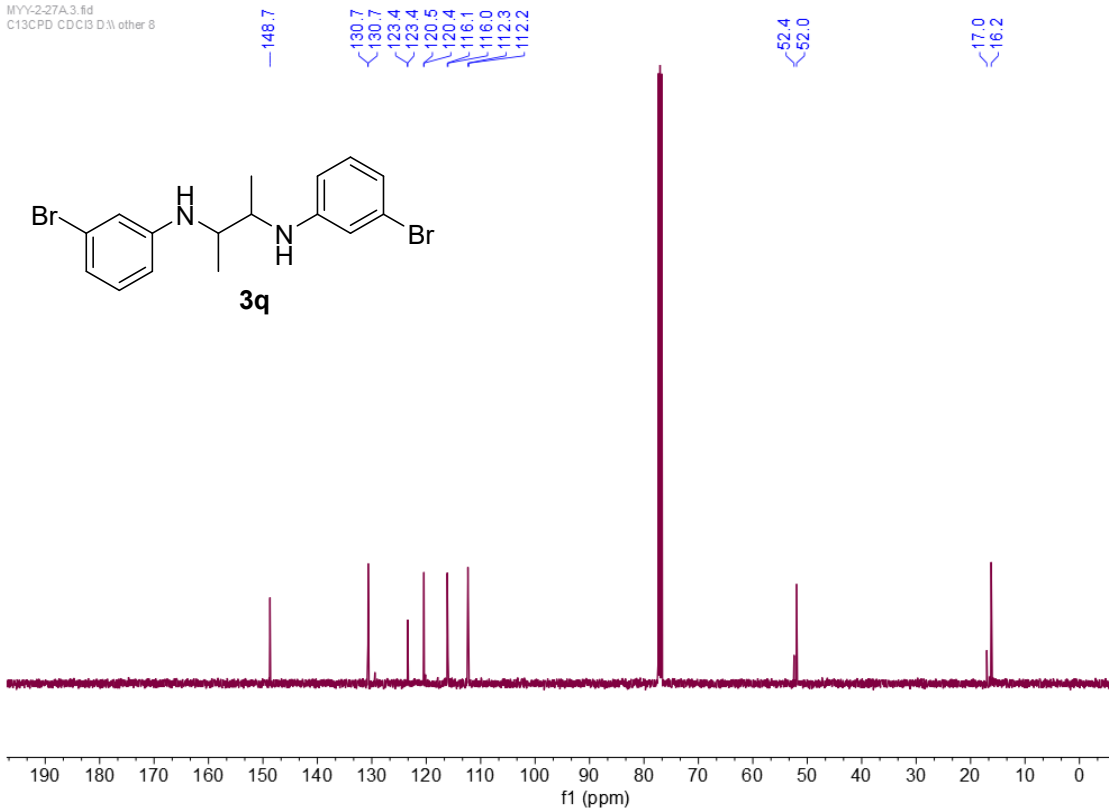
^{13}C-NMR spectrum of **3p** ($CDCl_3$, 100 MHz)



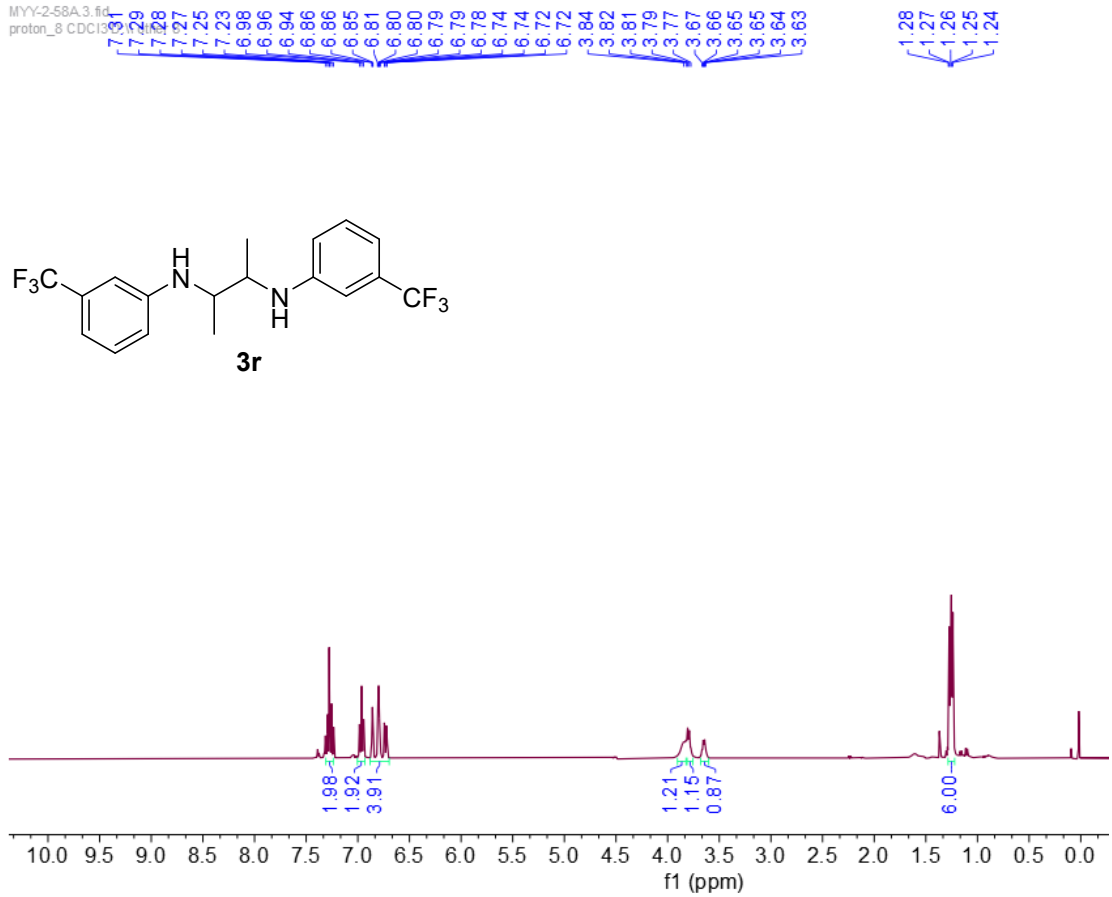
^{1}H-NMR spectrum of **3q** ($CDCl_3$, 400 MHz)



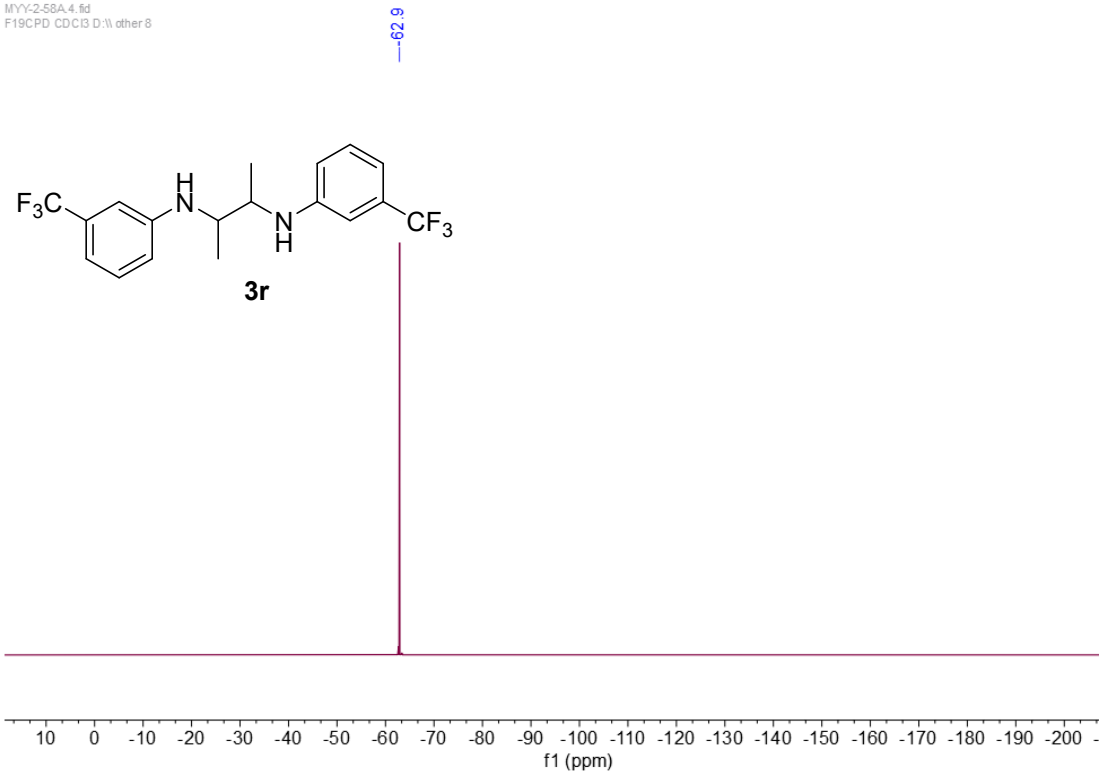
^{13}C-NMR spectrum of **3q** ($CDCl_3$, 100 MHz)



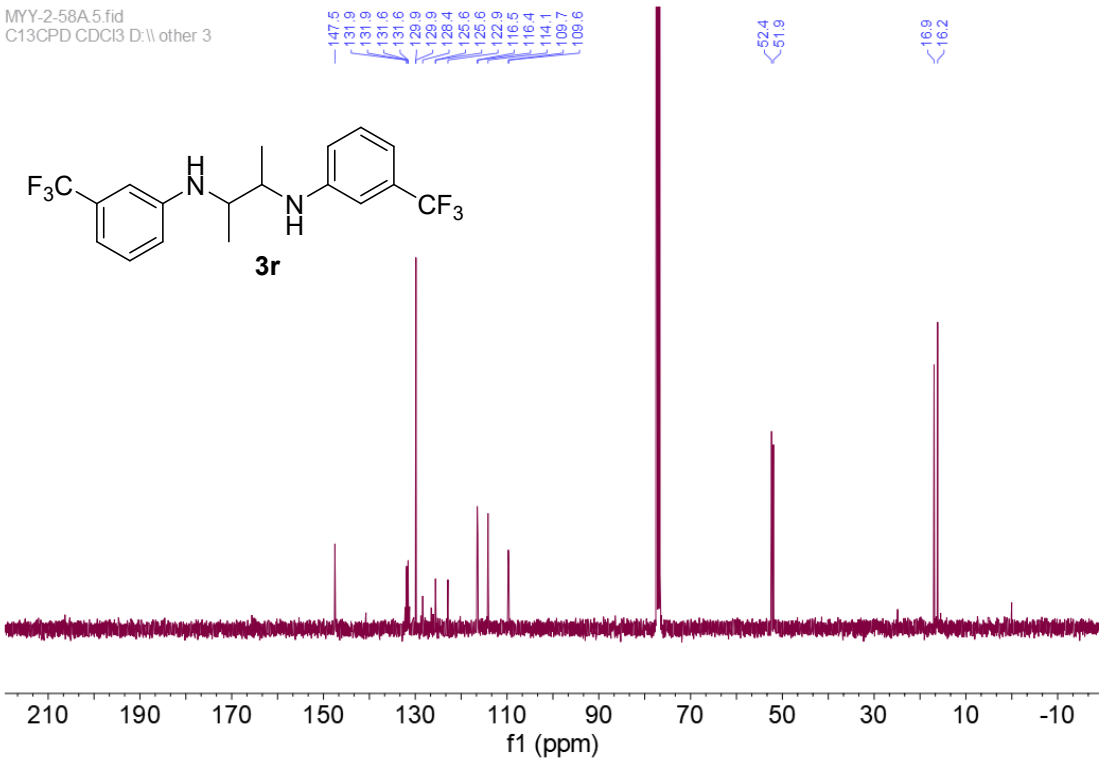
^{1}H-NMR spectrum of **3r** ($CDCl_3$, 400 MHz)



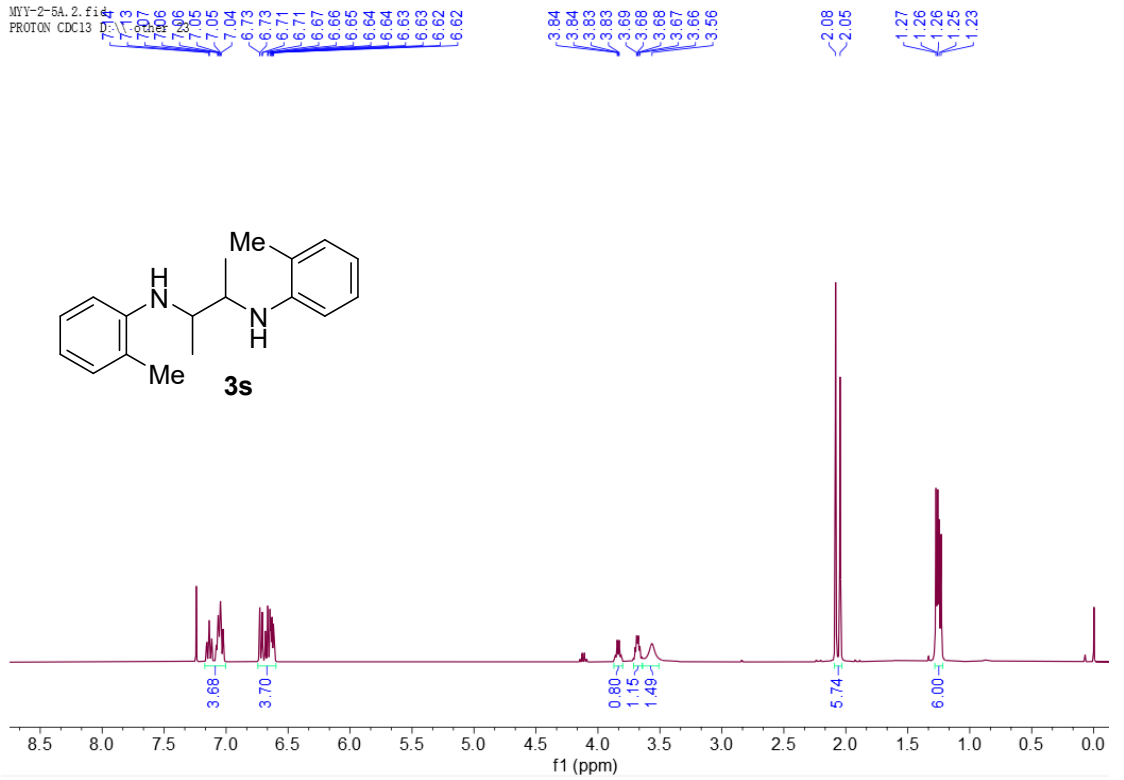
^{19}F-NMR spectrum of **3r** ($CDCl_3$, 376 MHz)



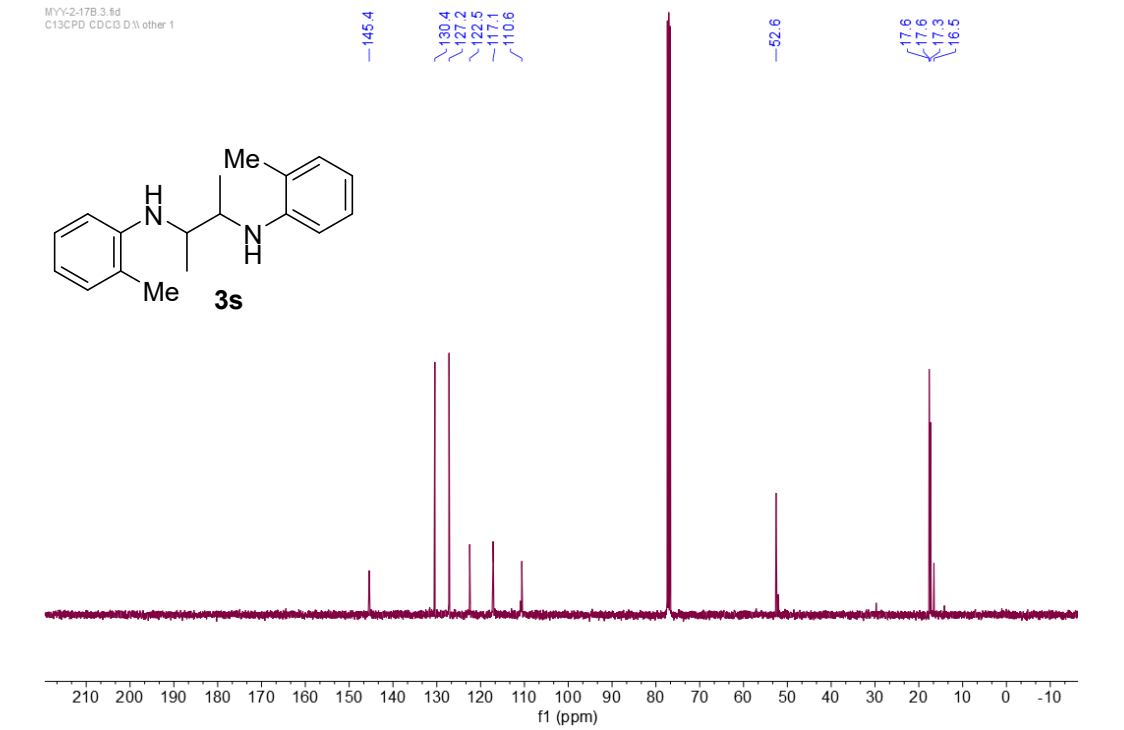
^{13}C-NMR spectrum of **3r** ($CDCl_3$, 100 MHz)



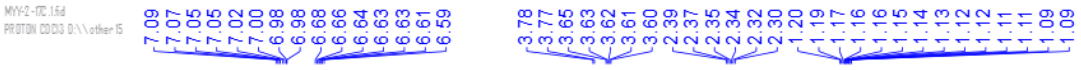
^{1}H-NMR spectrum of **3s** ($CDCl_3$, 400 MHz)

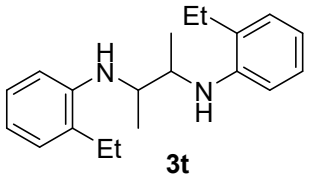


^{13}C-NMR spectrum of **3s** ($CDCl_3$, 100 MHz)

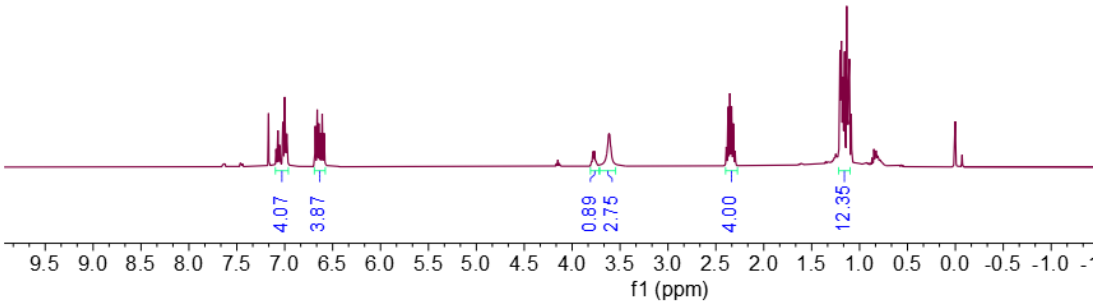


^{1}H-NMR spectrum of **3t** ($CDCl_3$, 400 MHz)

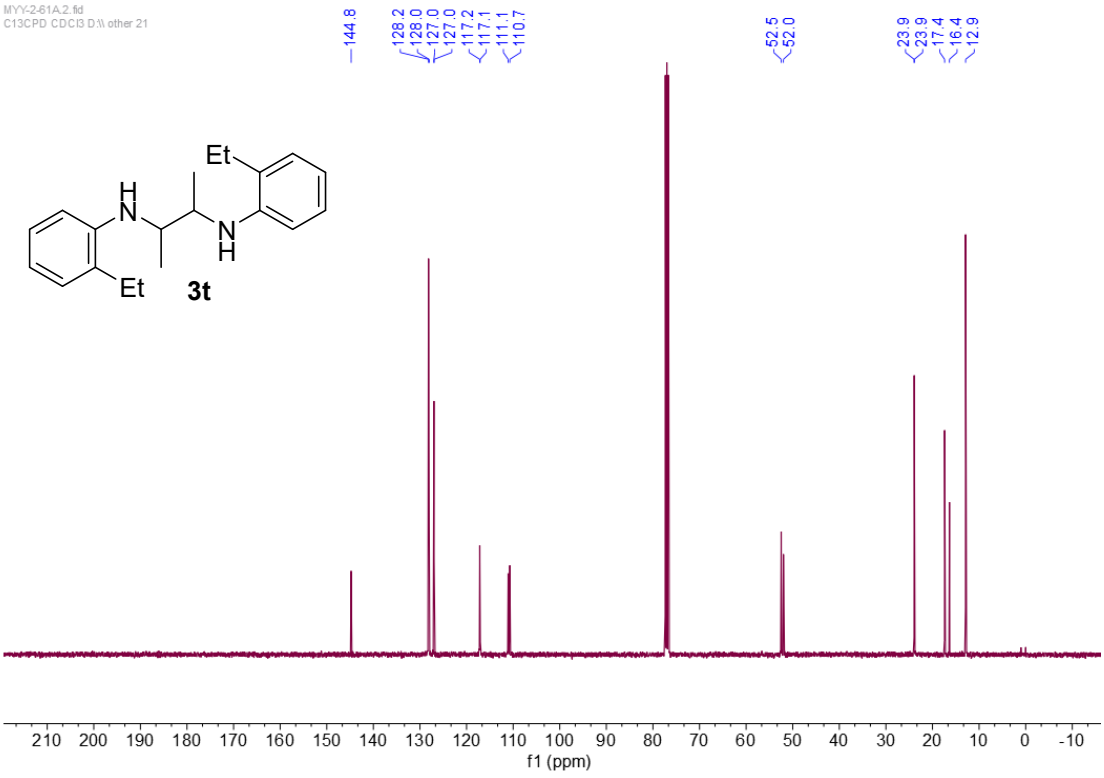




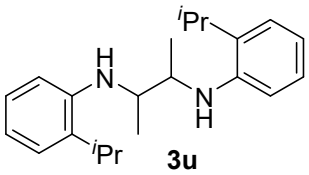
3t



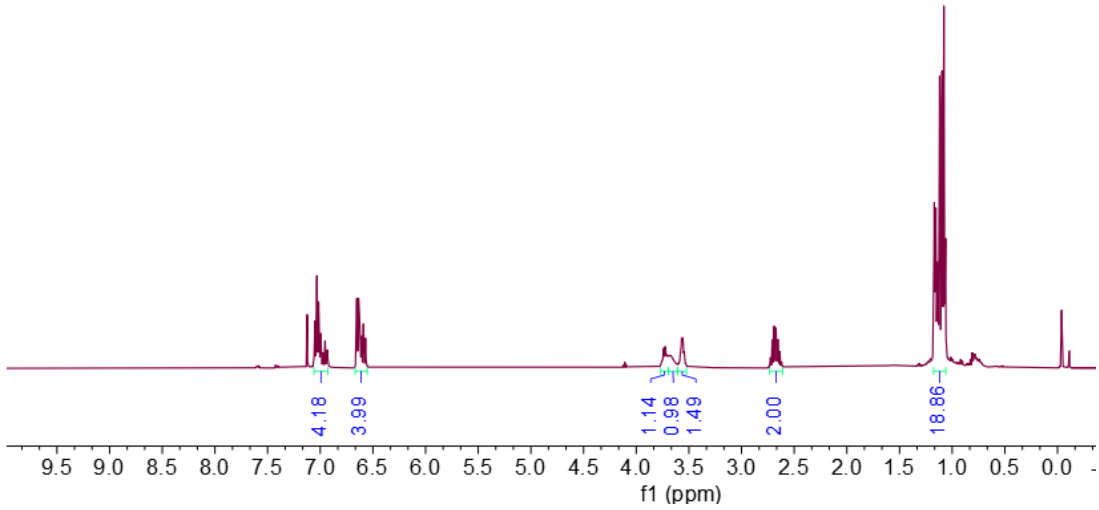
^{13}C-NMR spectrum of **3t** ($CDCl_3$, 100 MHz)



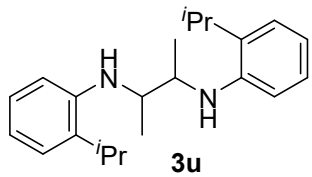
^{1}H-NMR spectrum of **3u** ($CDCl_3$, 400 MHz)



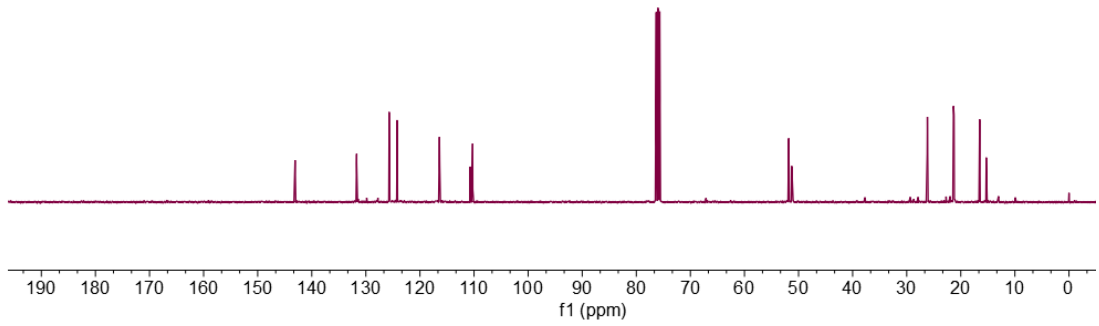
3u



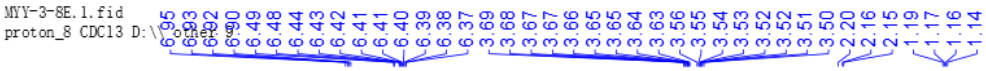
^{13}C-NMR spectrum of **3u** ($CDCl_3$, 100 MHz)

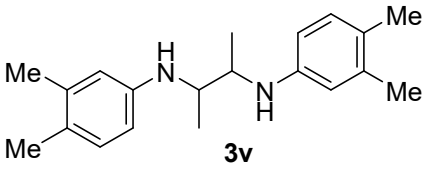


3u

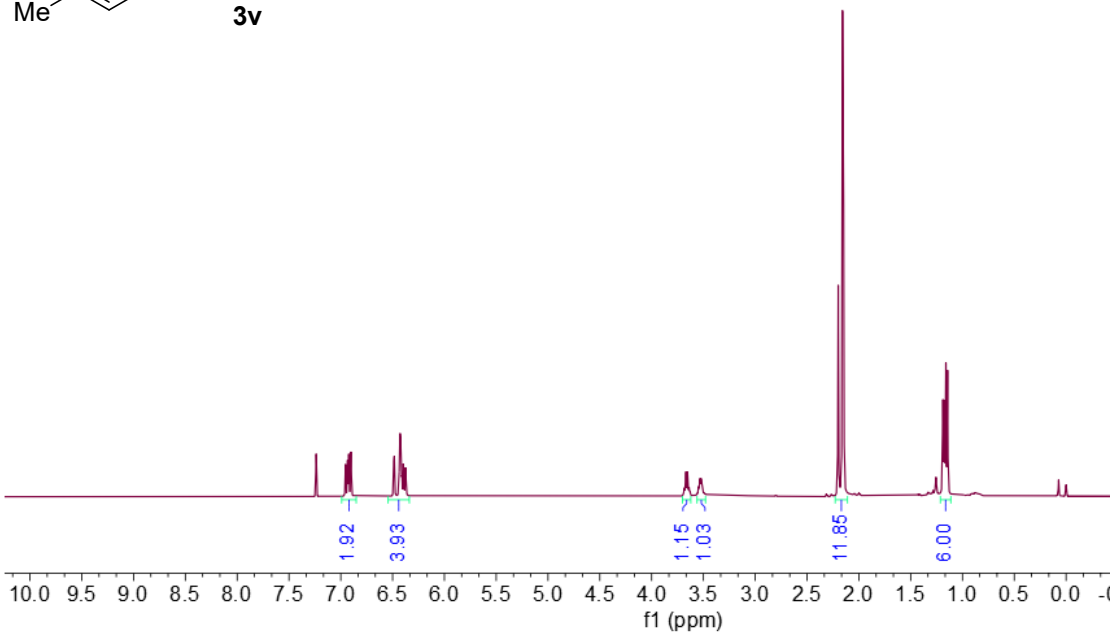


^{1}H-NMR spectrum of **3v** ($CDCl_3$, 400 MHz)

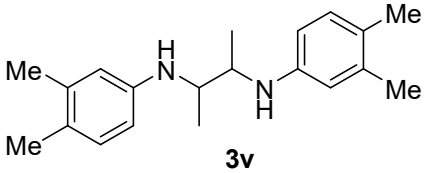




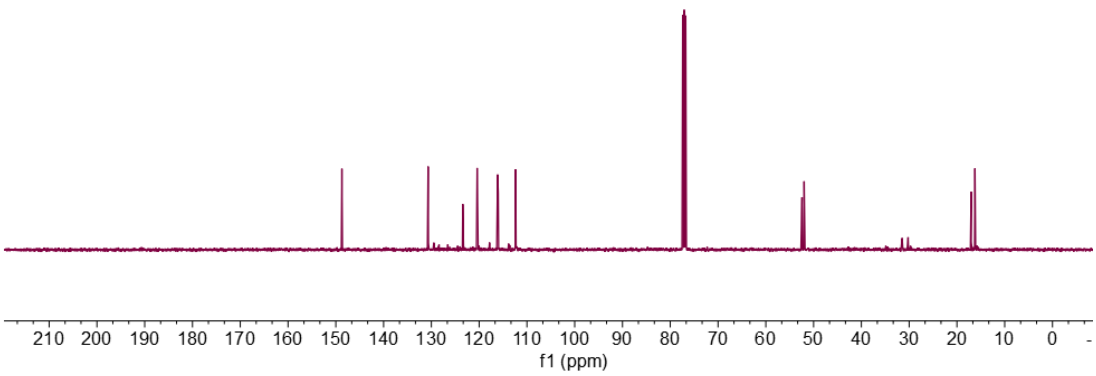
3v



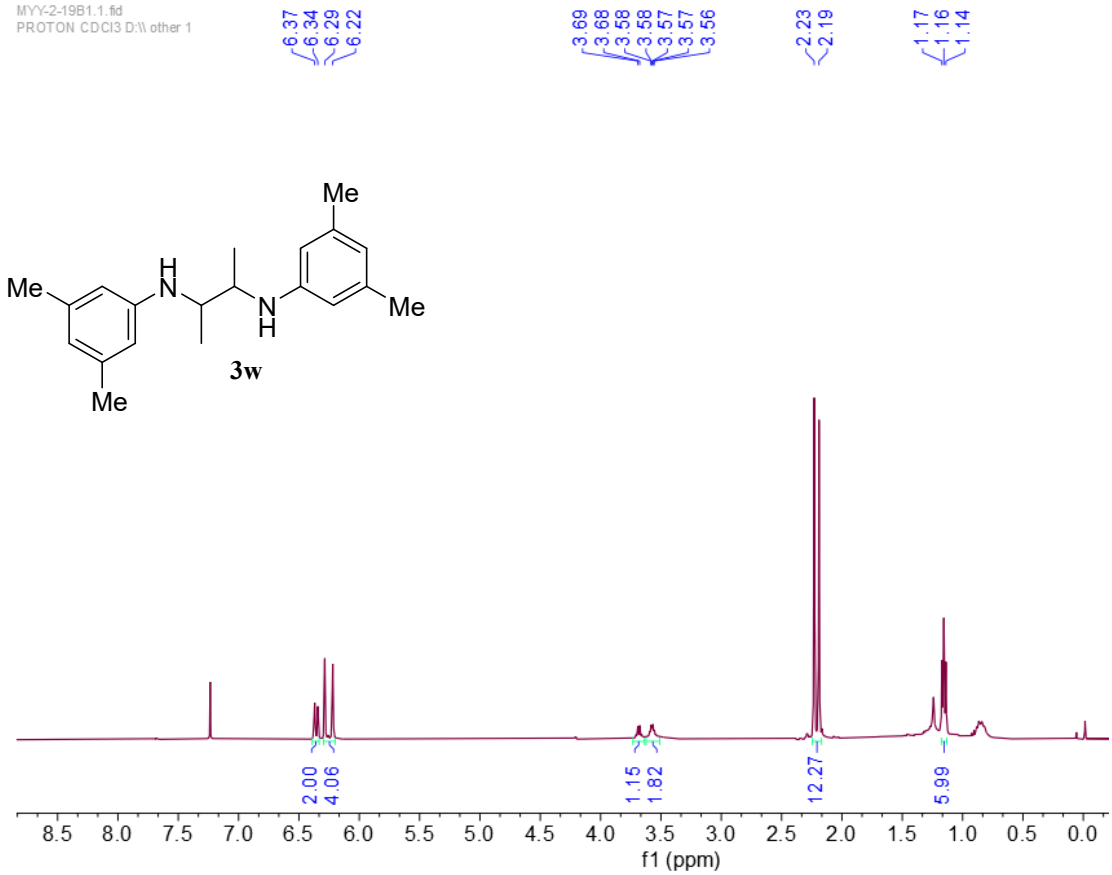
^{13}C-NMR spectrum of **3v** ($CDCl_3$, 100 MHz)



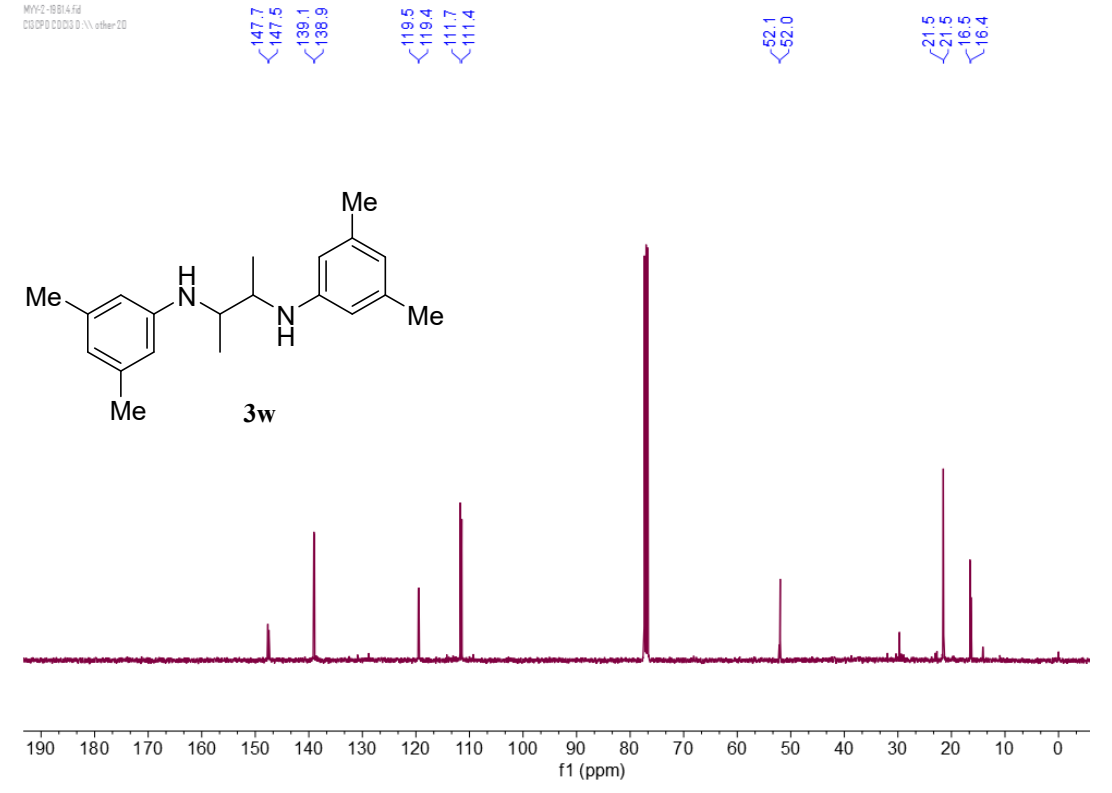
3v



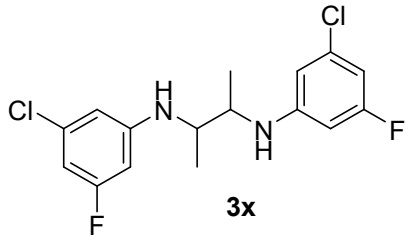
^{1}H-NMR spectrum of **3w** ($CDCl_3$, 400 MHz)



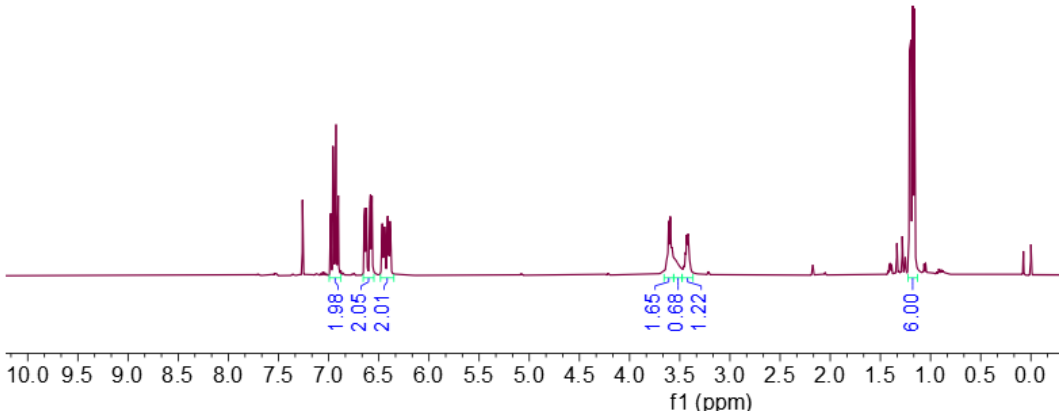
^{13}C-NMR spectrum of **3w** ($CDCl_3$, 100 MHz)



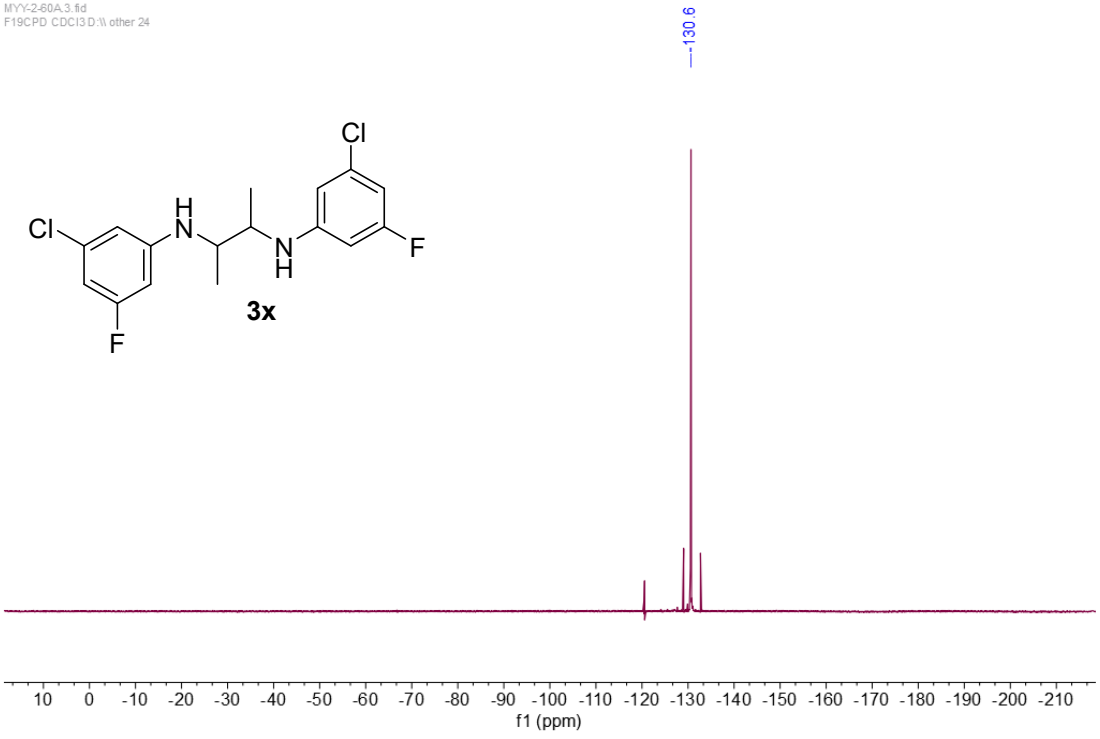
^{1}H-NMR spectrum of **3x** ($CDCl_3$, 400 MHz)



3x

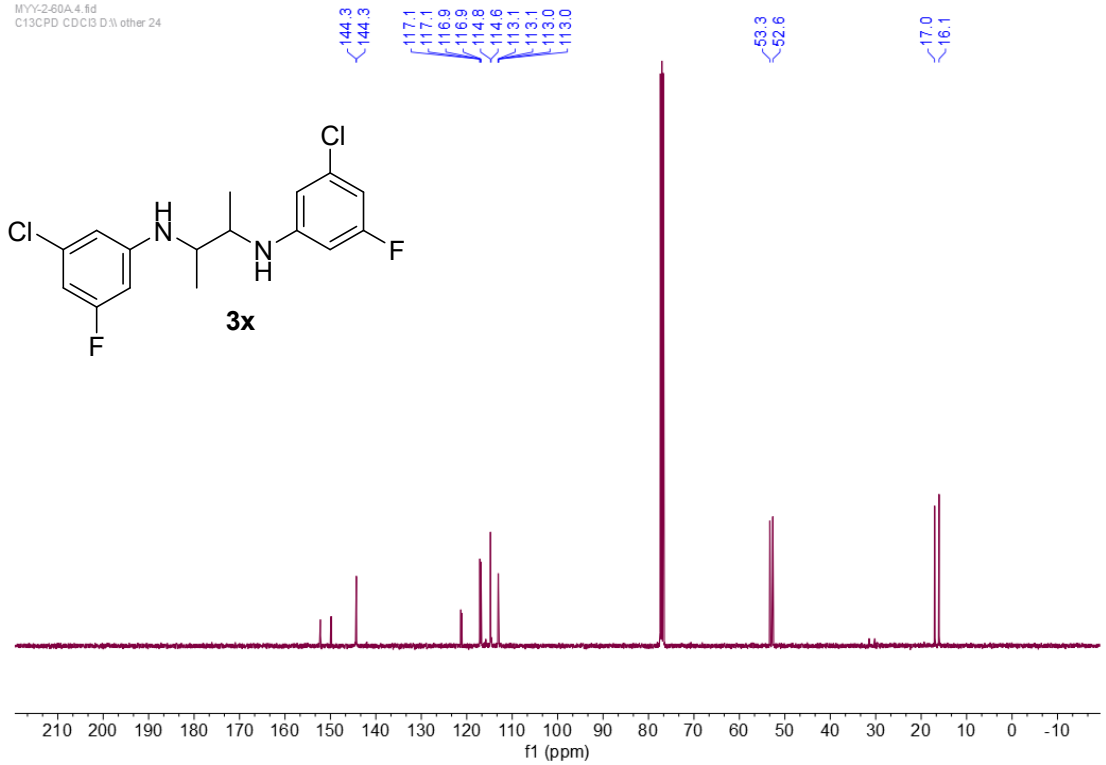


^{19}F-NMR spectrum of **3x** ($CDCl_3$, 376 MHz)

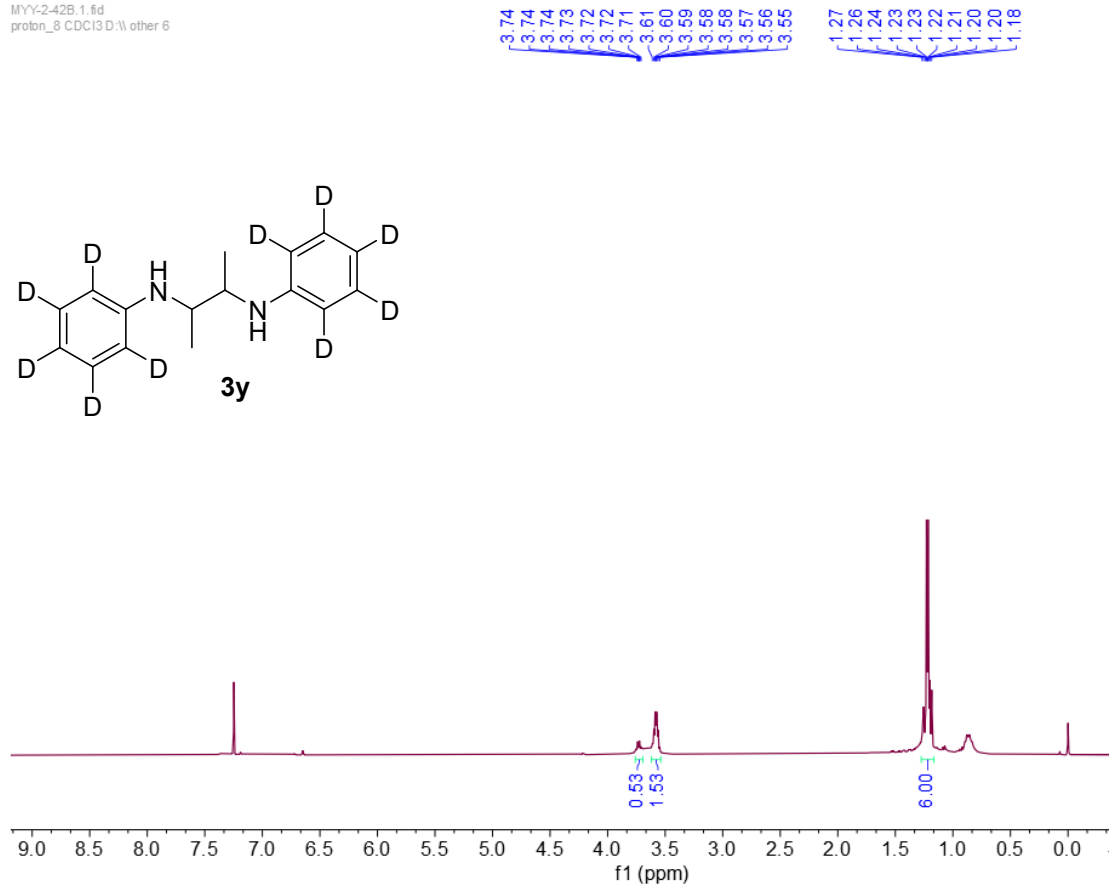


3x

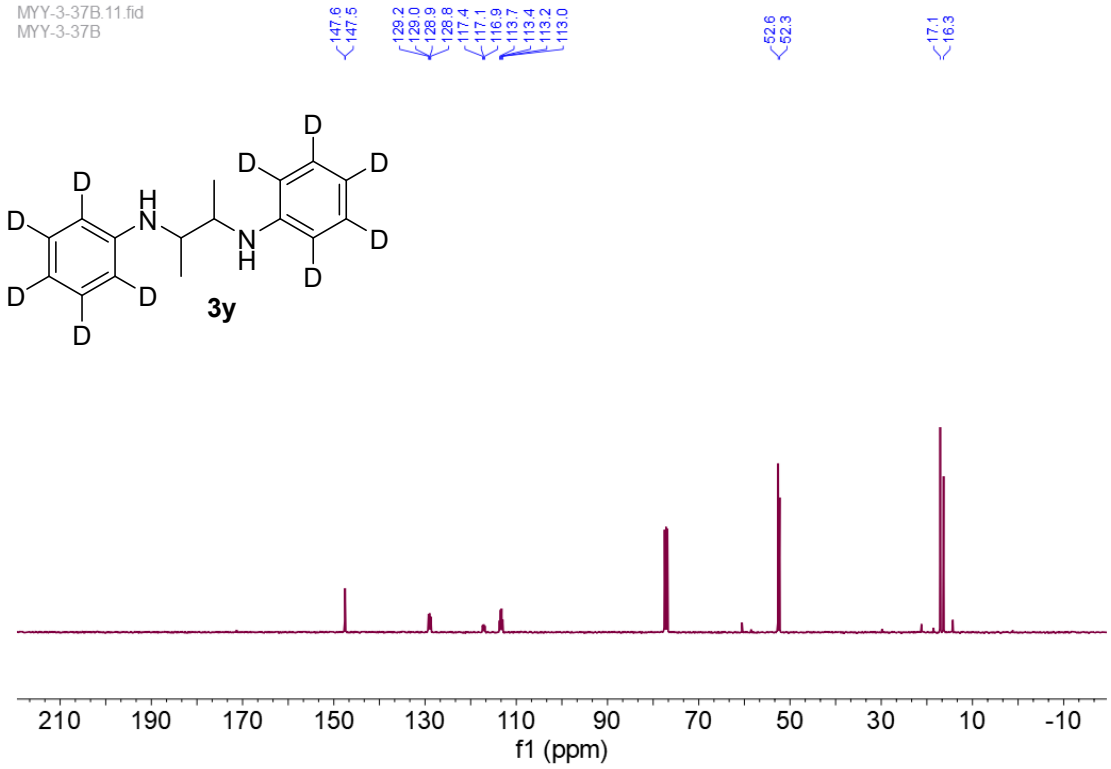
^{13}C-NMR spectrum of **3x** ($CDCl_3$, 100 MHz)



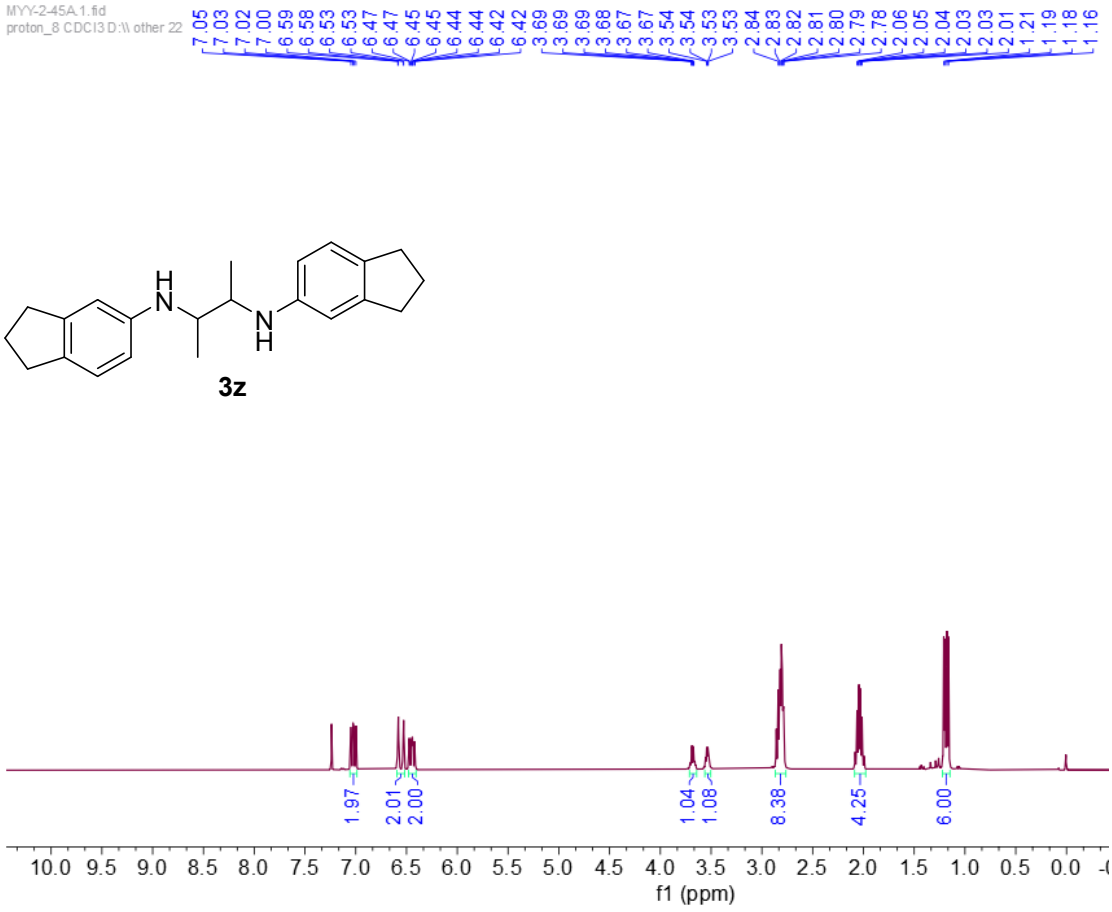
^{1}H-NMR spectrum of **3y** ($CDCl_3$, 400 MHz)



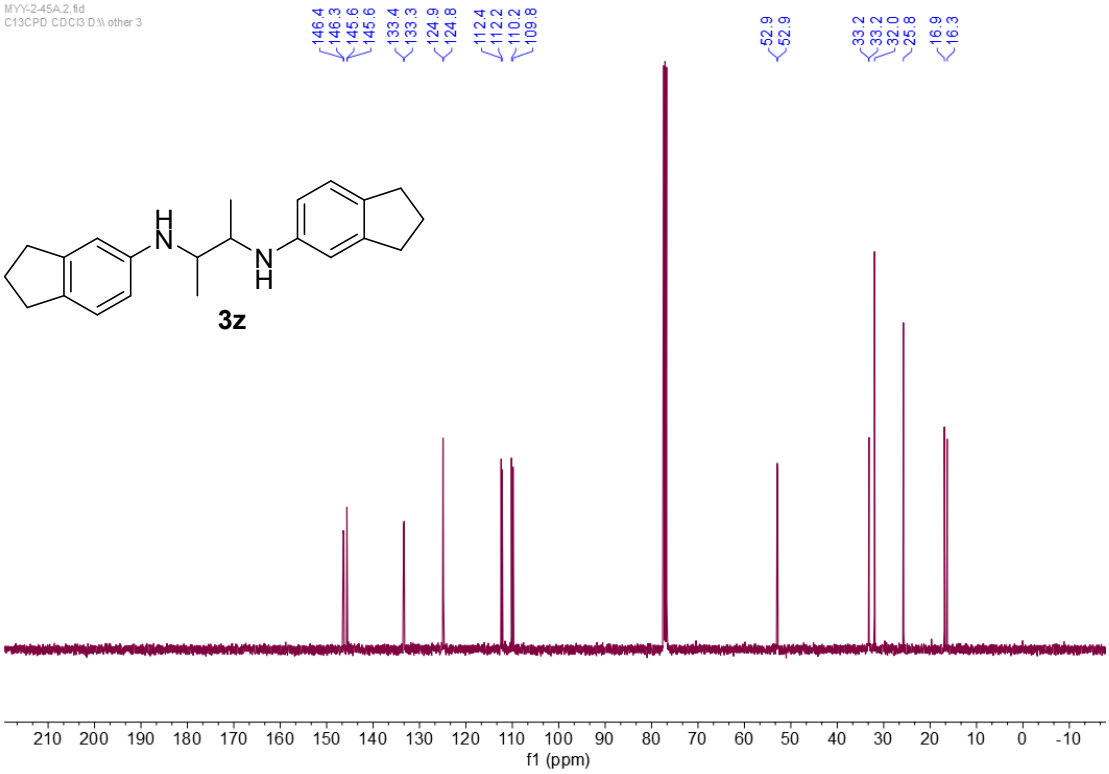
^{13}C-NMR spectrum of **3y** ($CDCl_3$, 100 MHz)



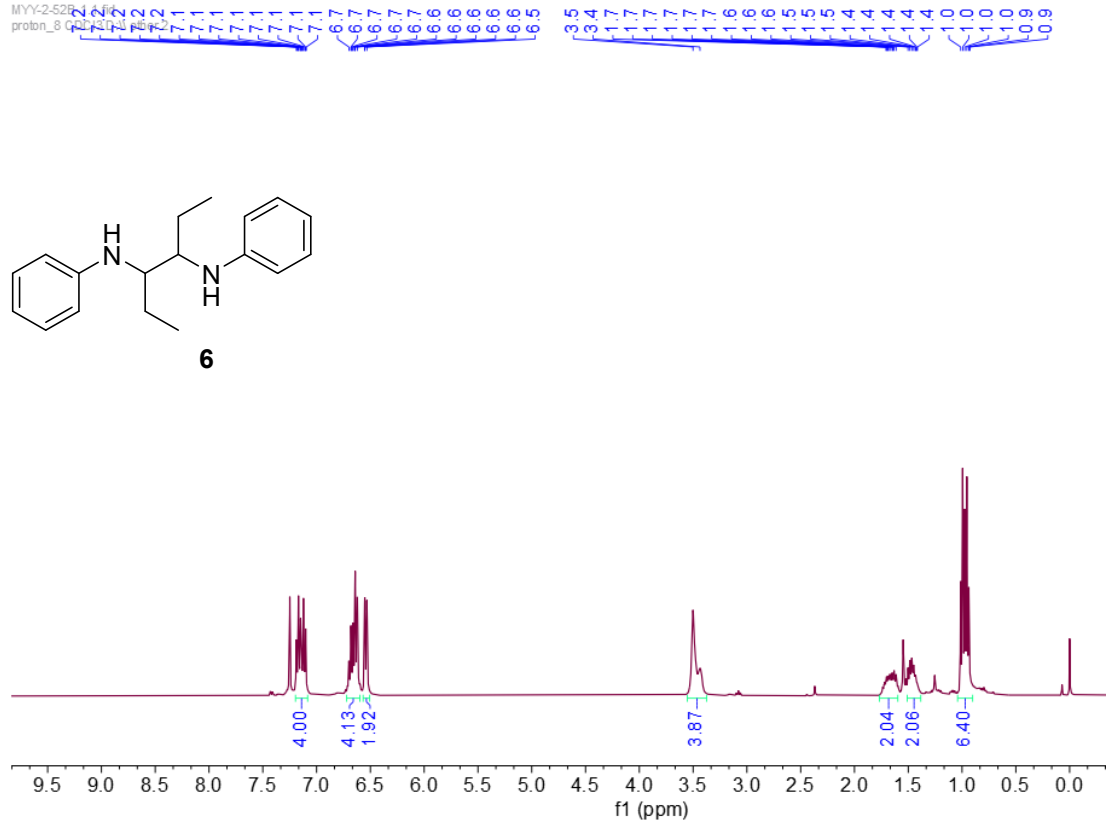
^{1}H-NMR spectrum of **3z** ($CDCl_3$, 400 MHz)



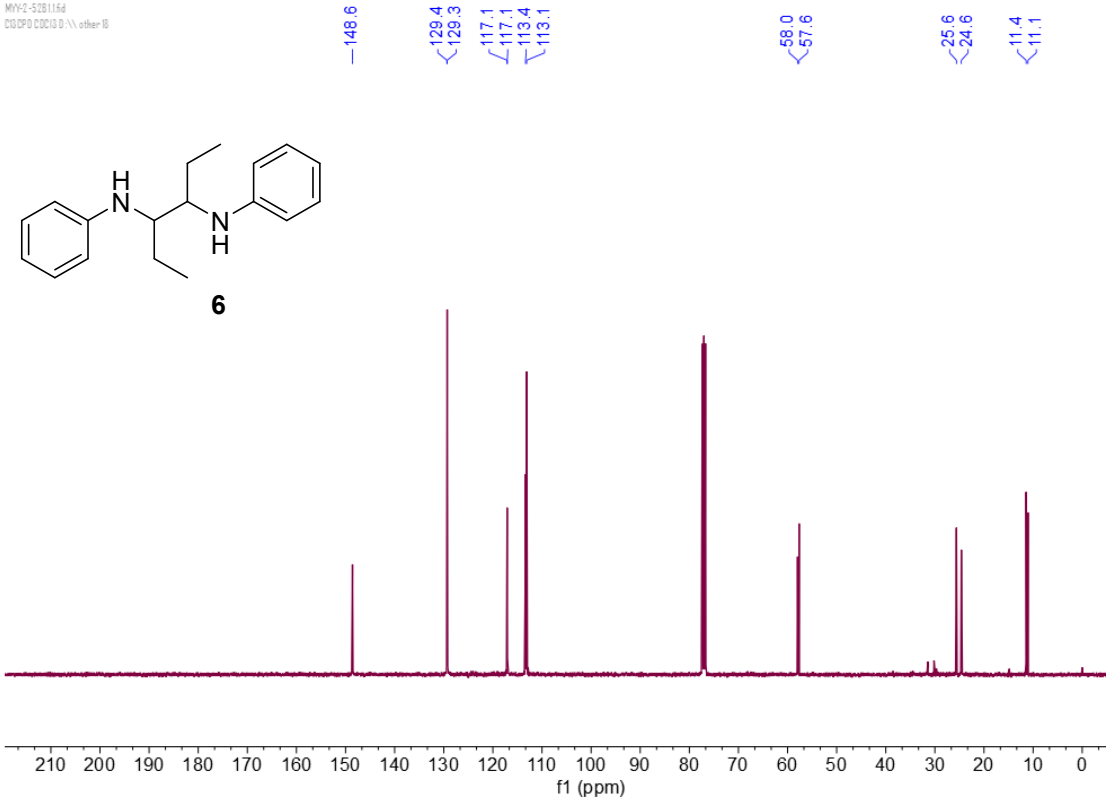
^{13}C-NMR spectrum of **3z** ($CDCl_3$, 100 MHz)



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

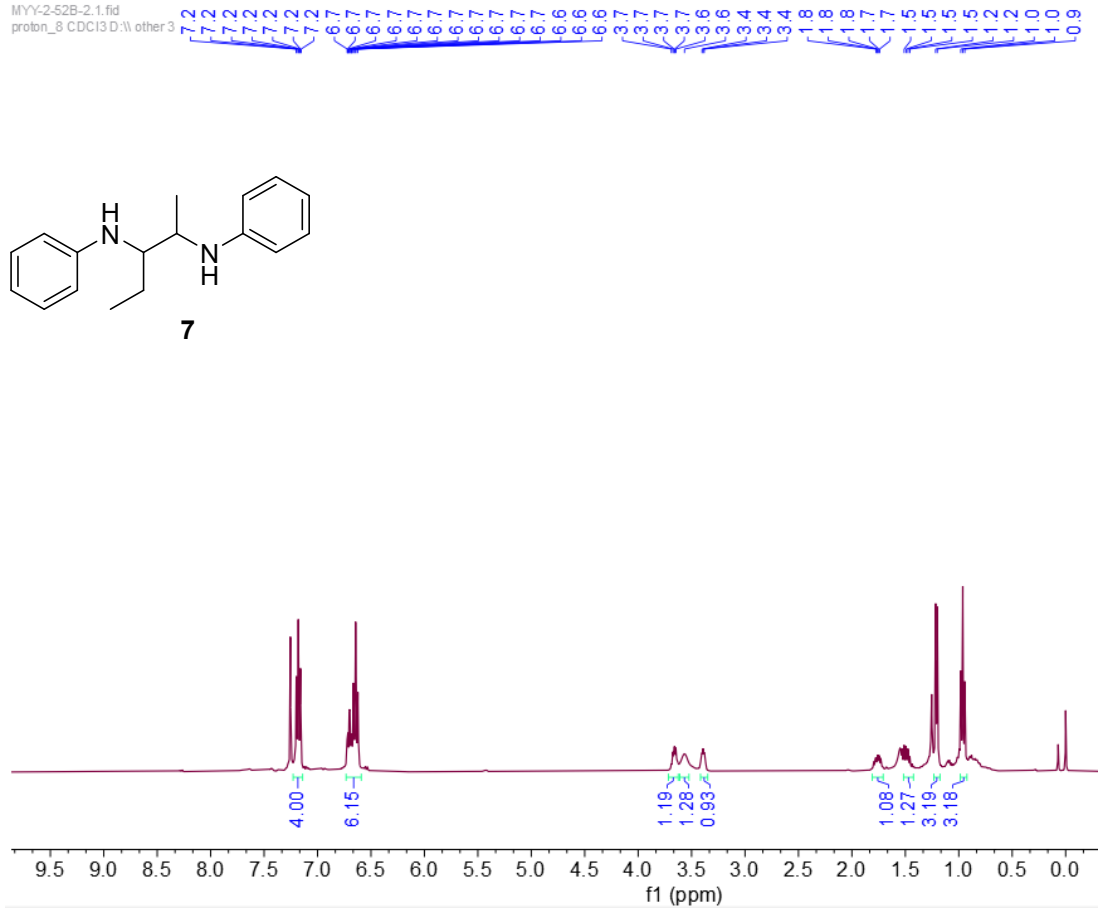


^{13}C-NMR spectrum of **6** ($CDCl_3$, 100 MHz)



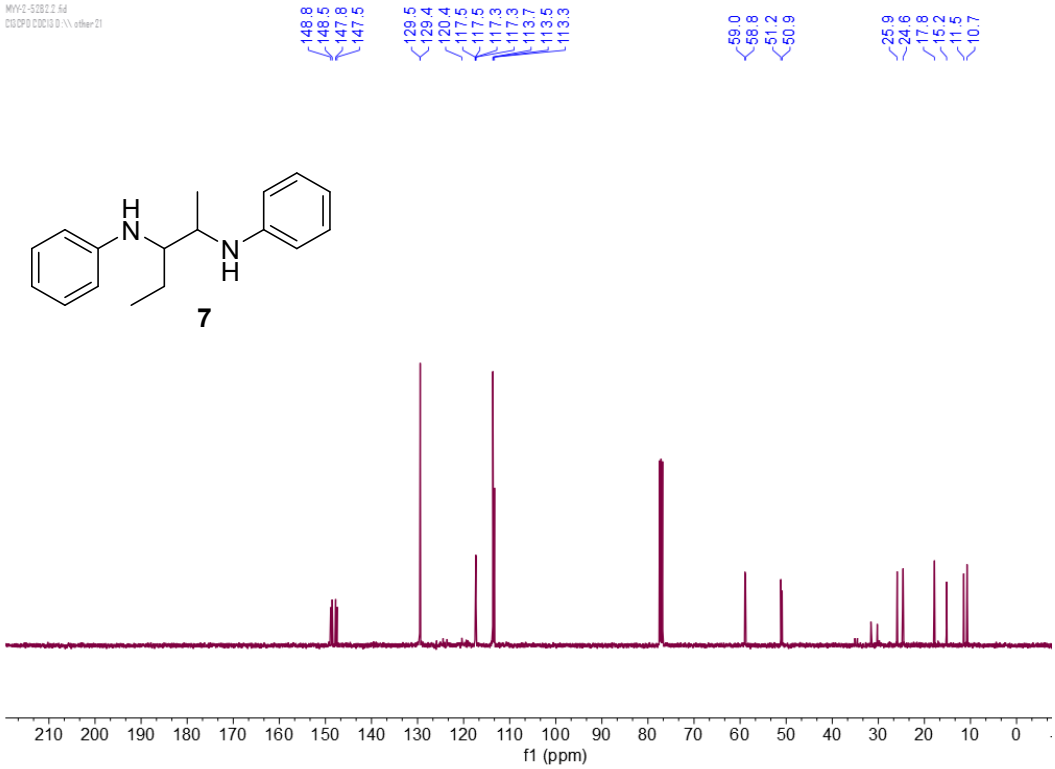
6

^{1}H-NMR spectrum of **7** ($CDCl_3$, 400 MHz)

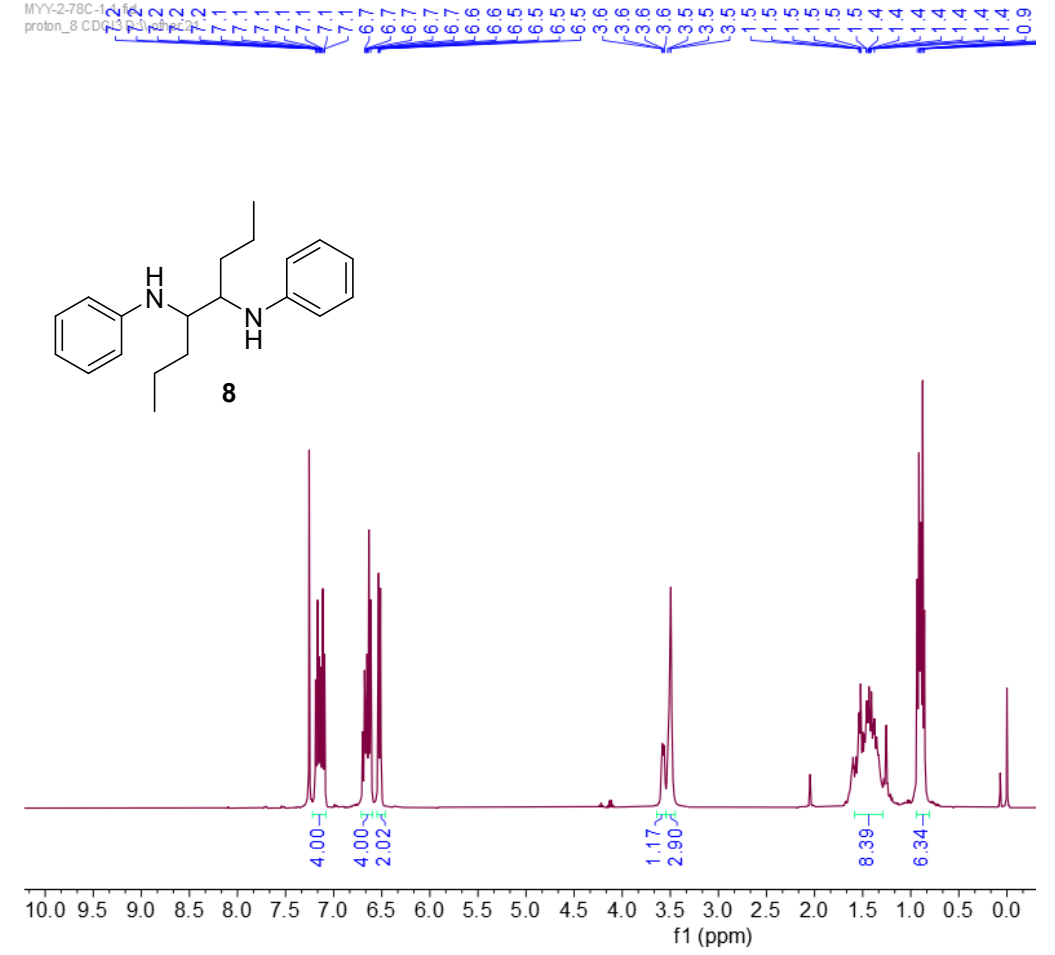


7

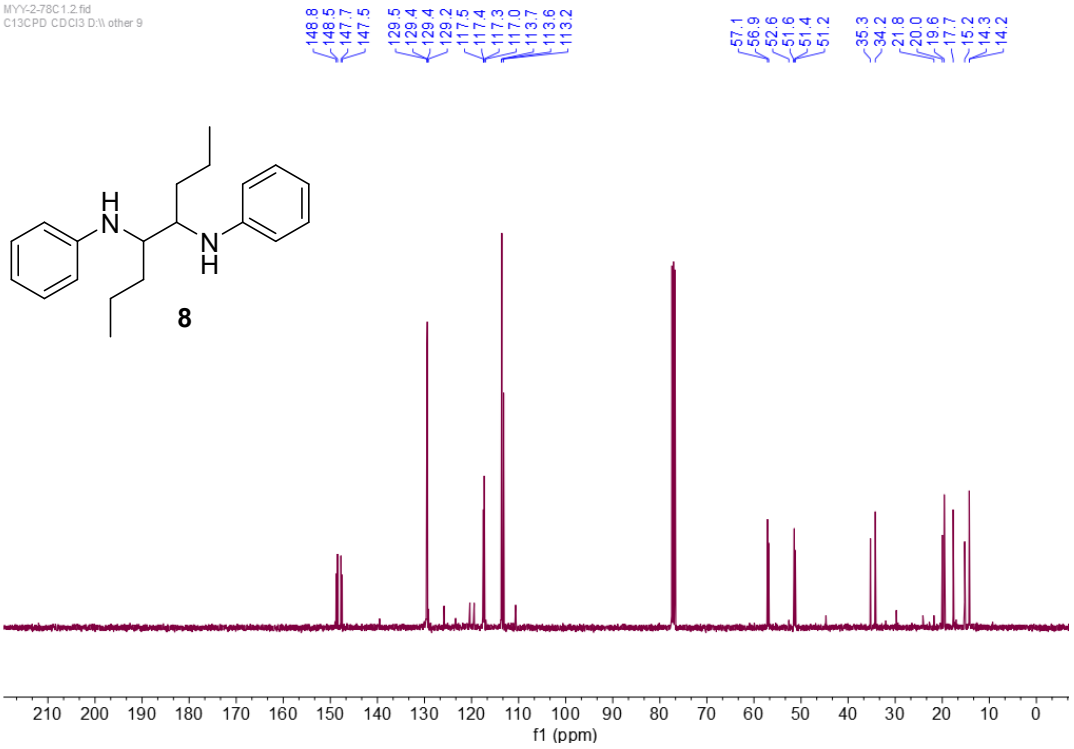
^{13}C-NMR spectrum of **7** ($CDCl_3$, 100 MHz)



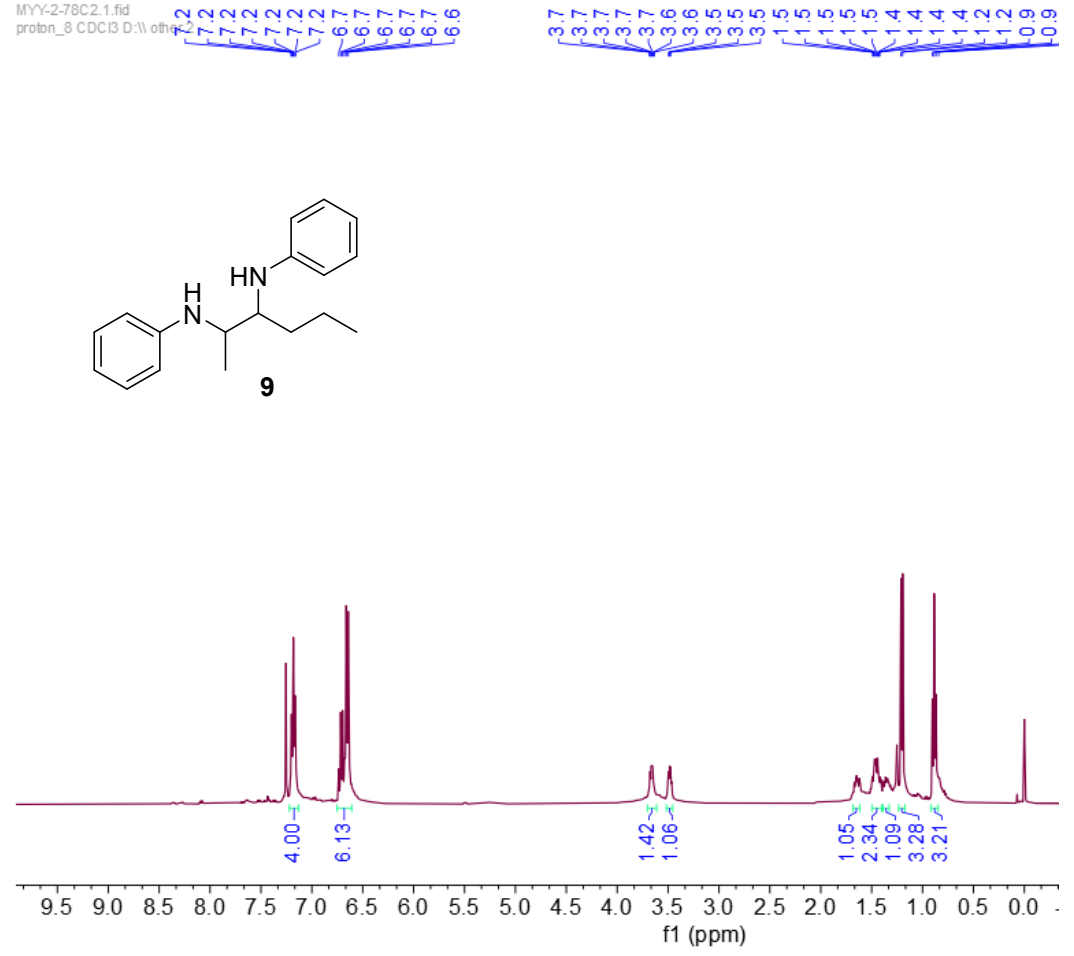
^{1}H-NMR spectrum of **8** ($CDCl_3$, 400 MHz)



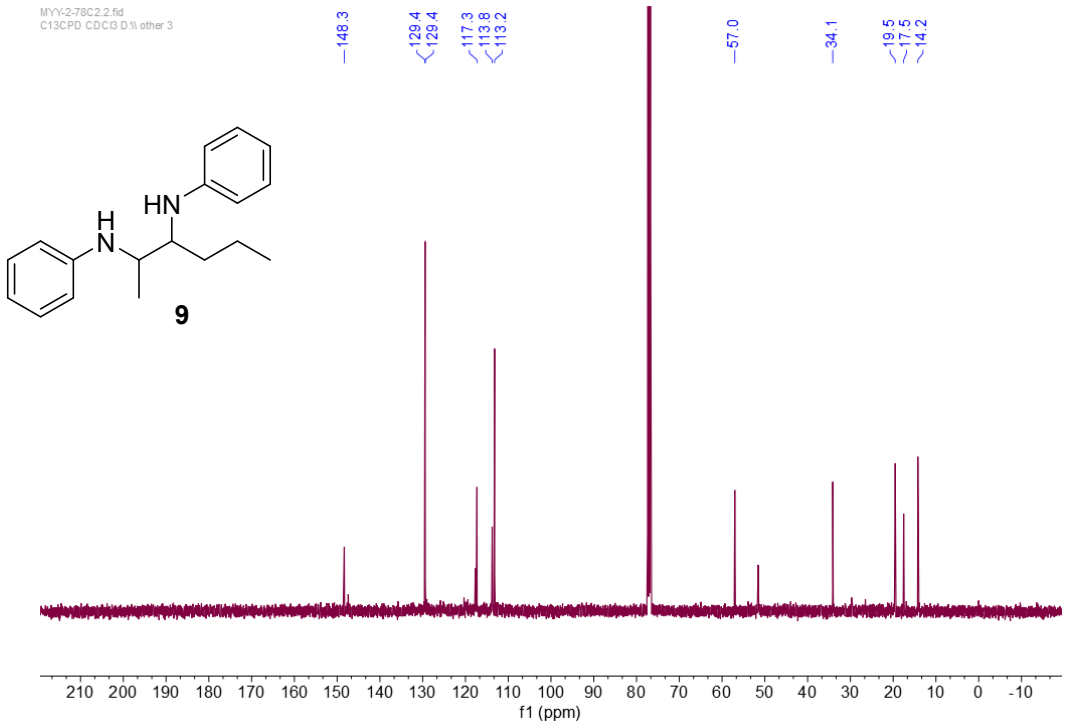
^{13}C-NMR spectrum of **8** ($CDCl_3$, 100 MHz)



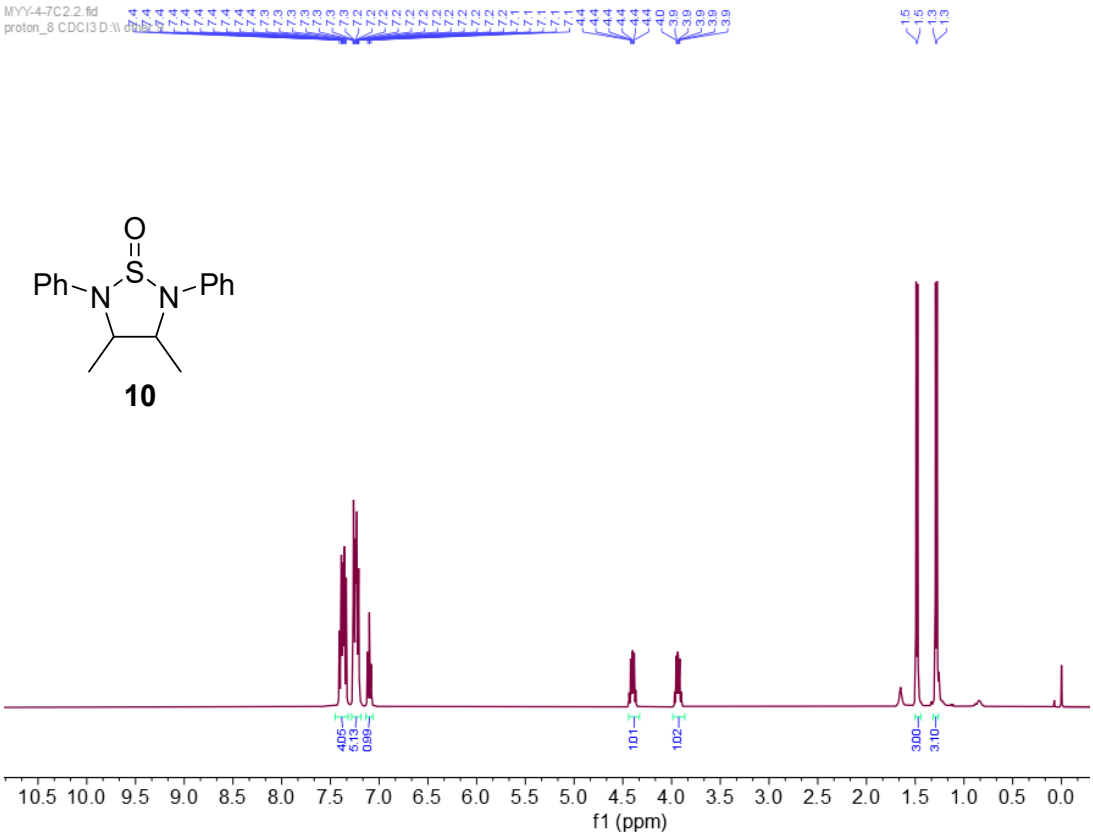
^{1}H-NMR spectrum of **9** ($CDCl_3$, 400 MHz)



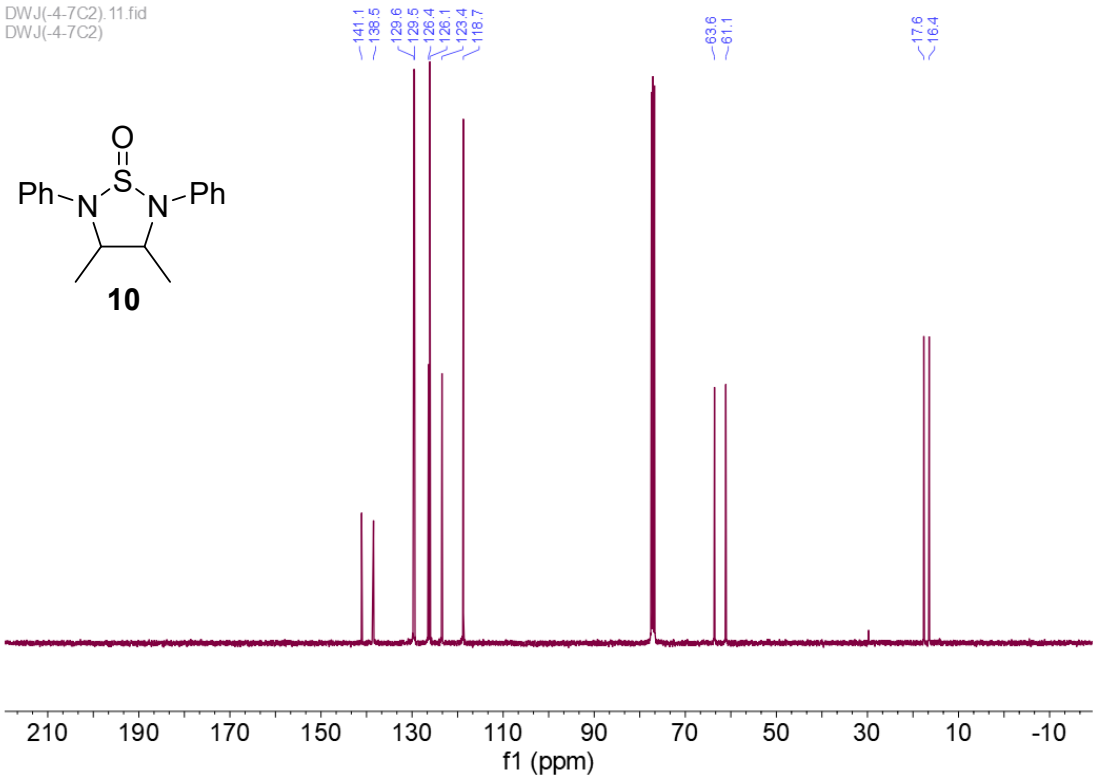
^{13}C-NMR spectrum of **9** ($CDCl_3$, 100 MHz)



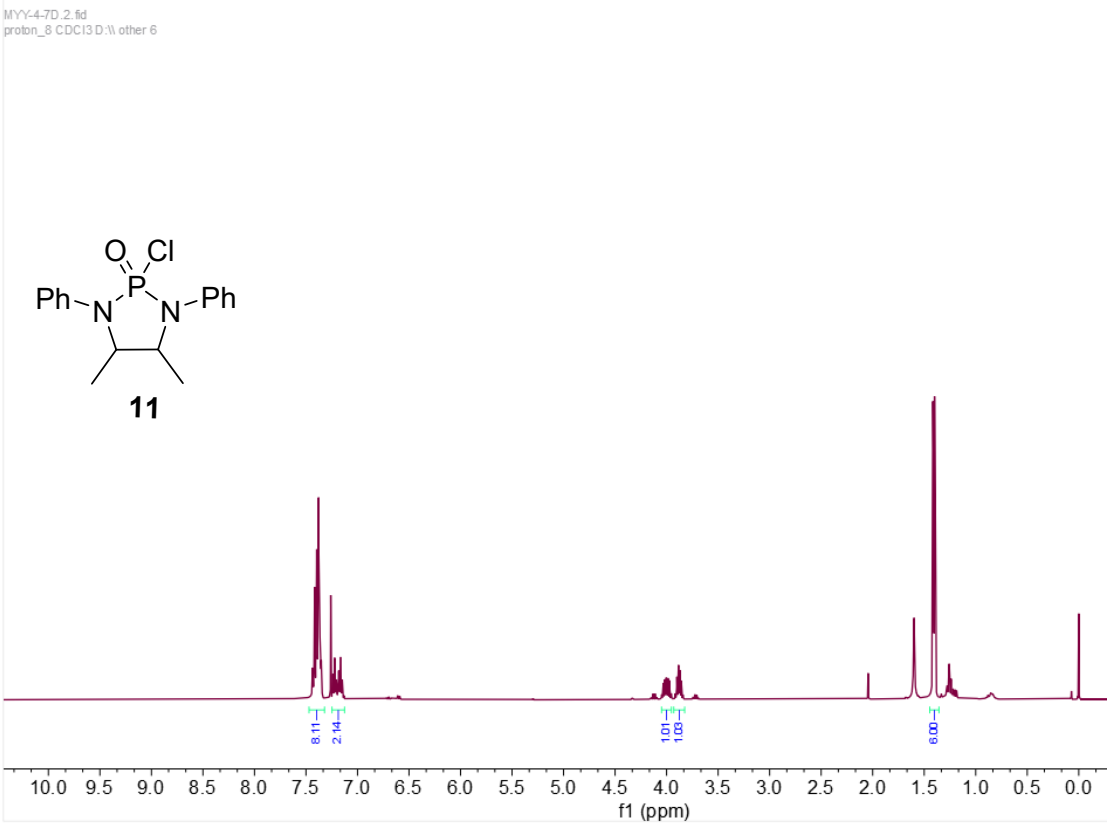
^{1}H-NMR spectrum of **10** ($CDCl_3$, 400 MHz)



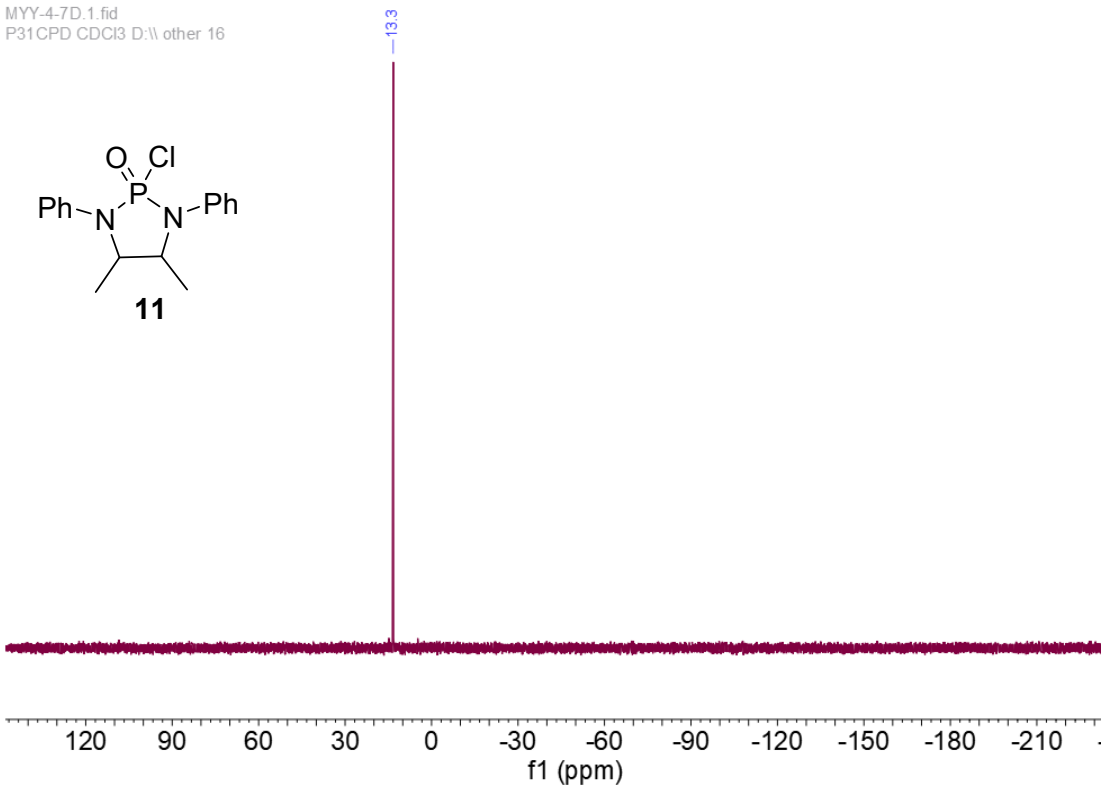
^{13}C-NMR spectrum of **10** ($CDCl_3$, 100 MHz)



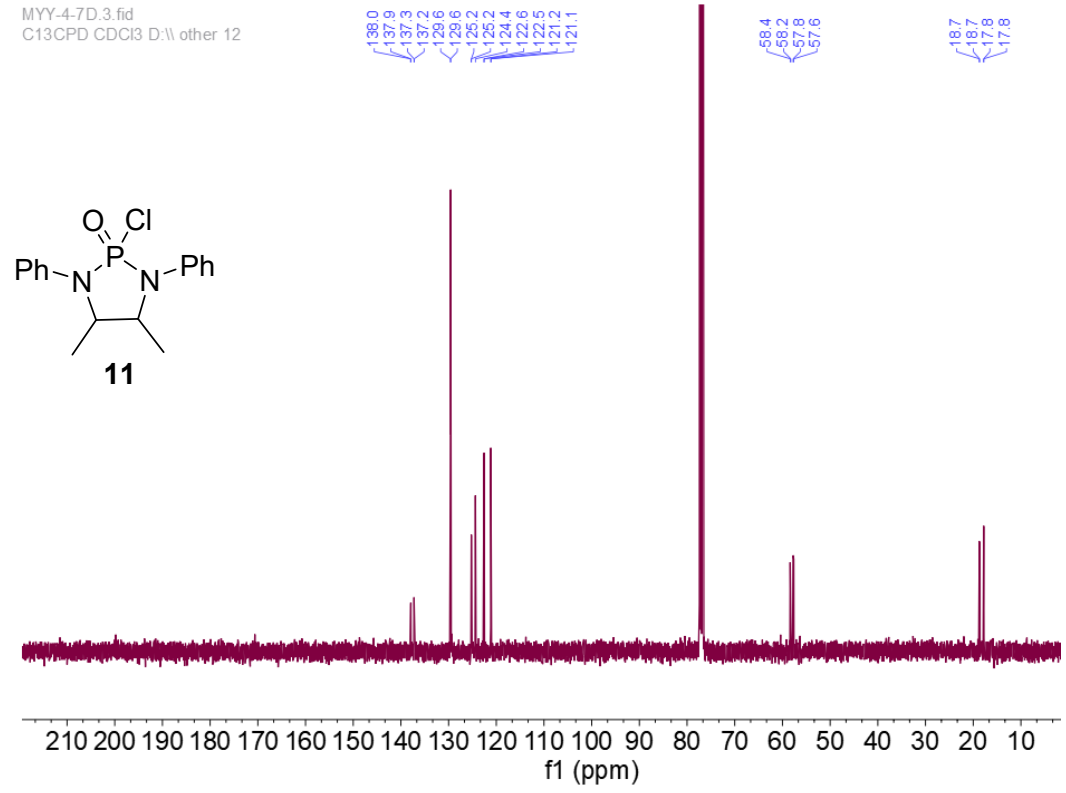
^{1}H-NMR spectrum of **11** ($CDCl_3$, 400 MHz)



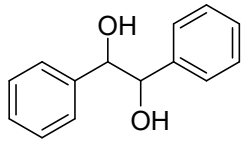
^{31}P-NMR spectrum of **11** ($CDCl_3$, 162 MHz)



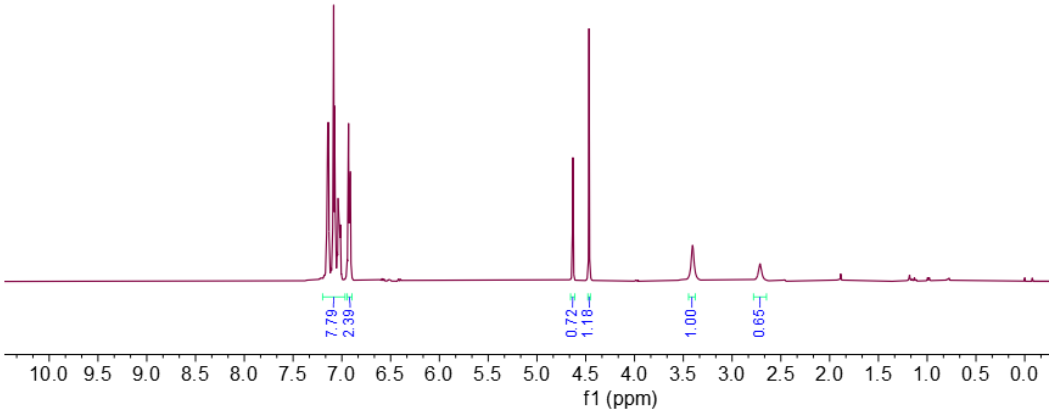
^{13}C-NMR spectrum of **11** ($CDCl_3$, 100 MHz)



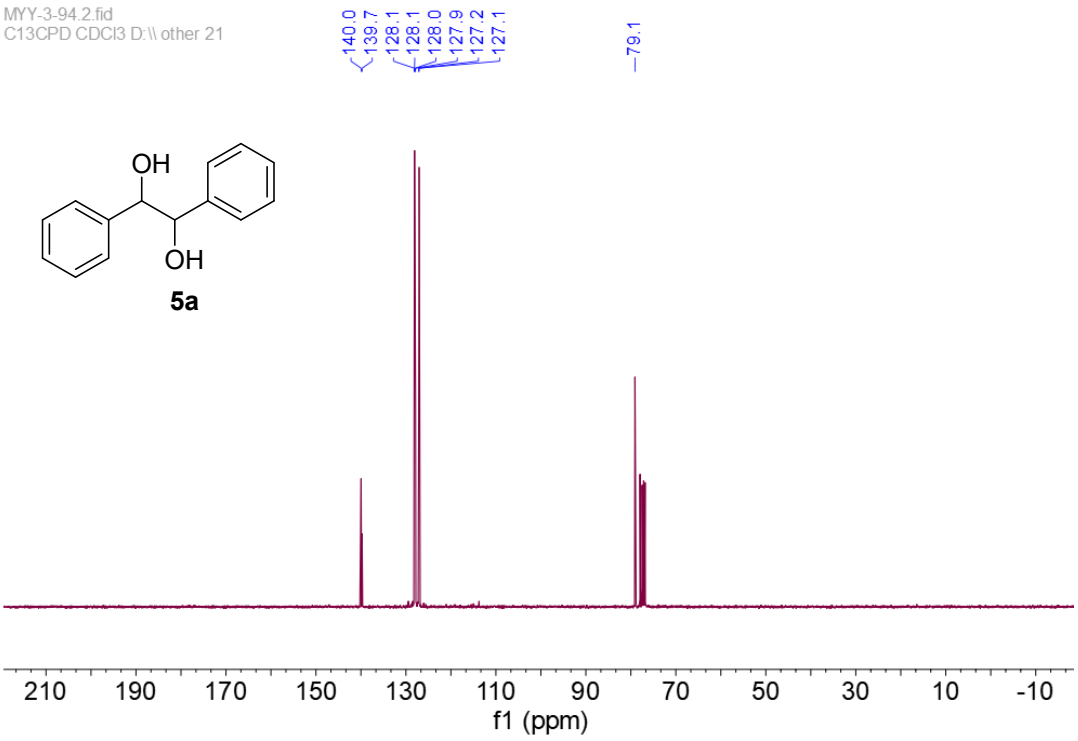
^{1}H-NMR spectrum of **5a** ($CDCl_3$, 400 MHz)



5a

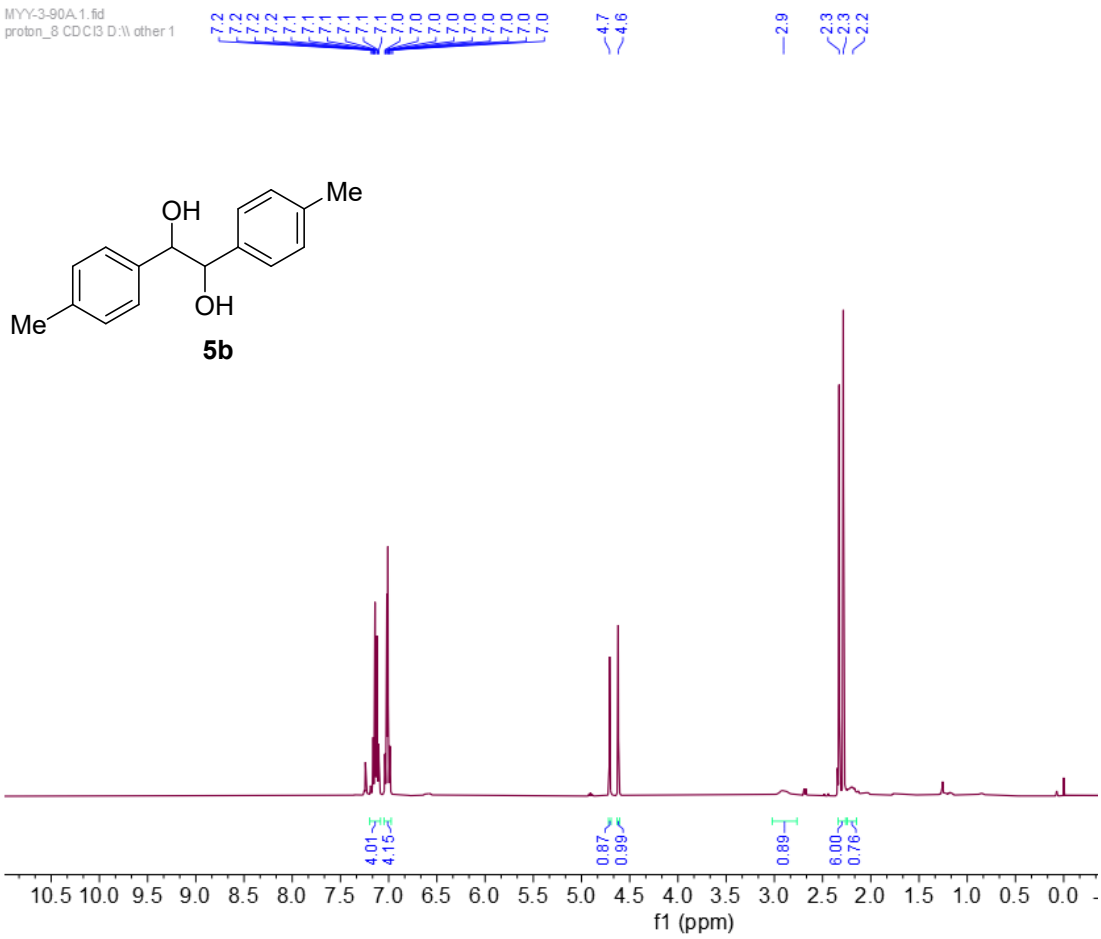


^{13}C-NMR spectrum of **5a** ($CDCl_3$, 100 MHz)

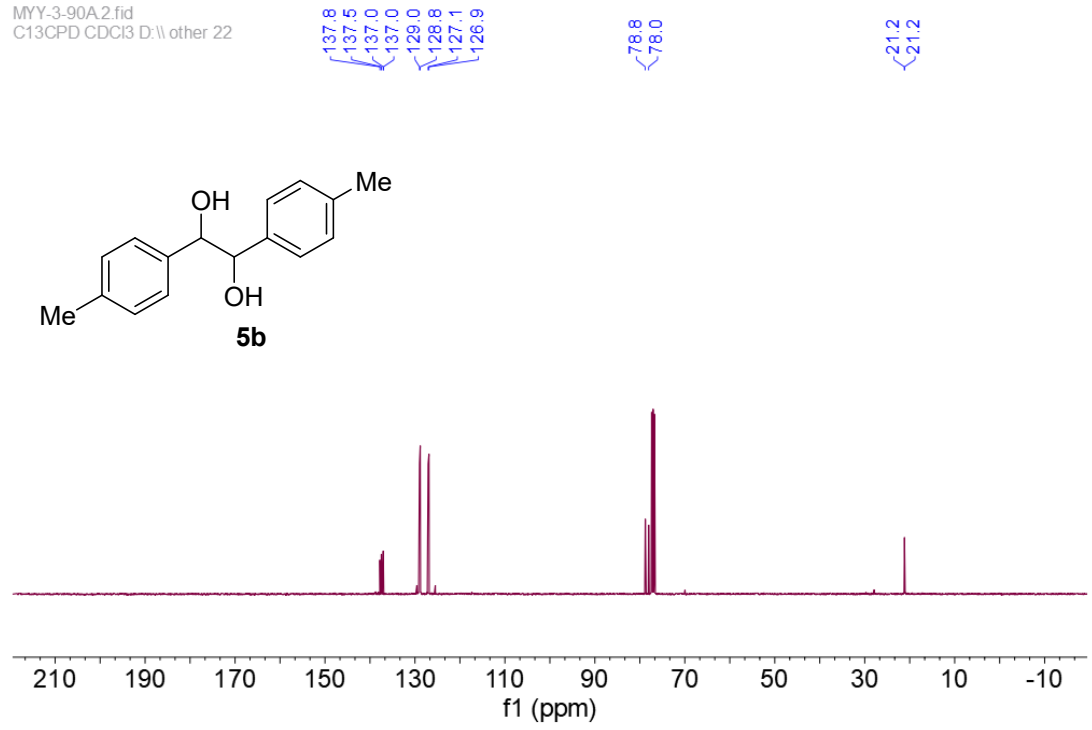


5a

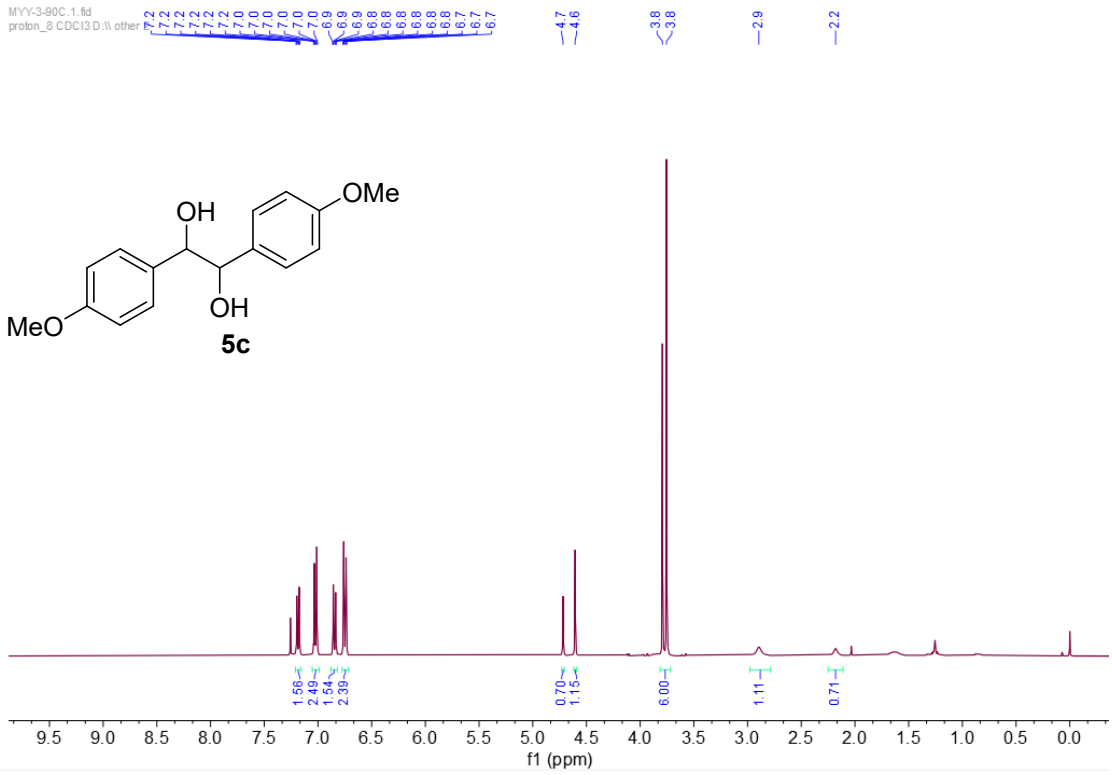
^{1}H-NMR spectrum of **5b** ($CDCl_3$, 400 MHz)



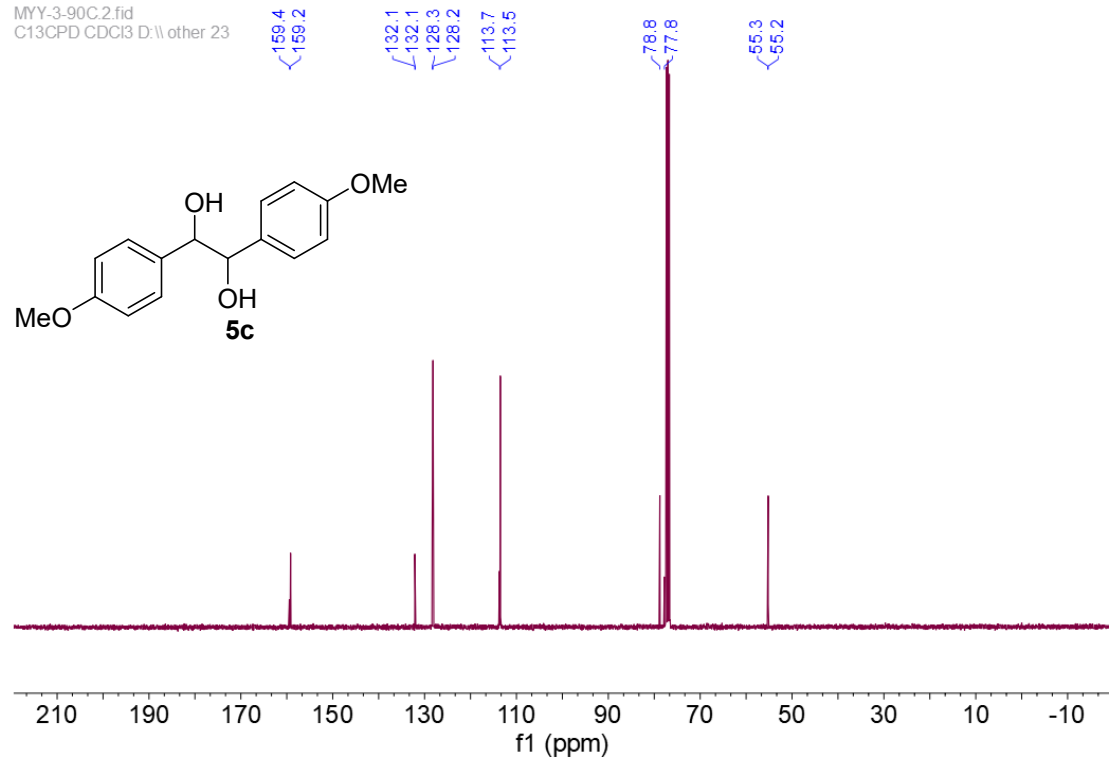
^{13}C-NMR spectrum of **5b** ($CDCl_3$, 100 MHz)



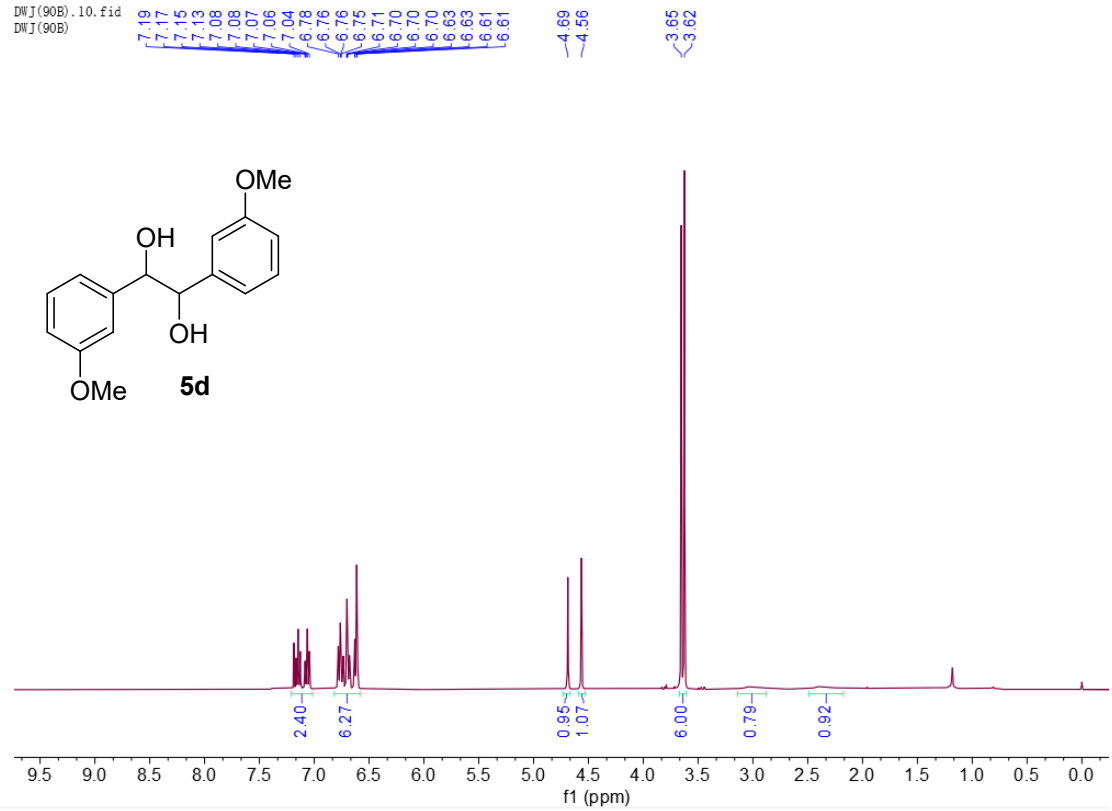
^{1}H-NMR spectrum of **5c** ($CDCl_3$, 400 MHz)



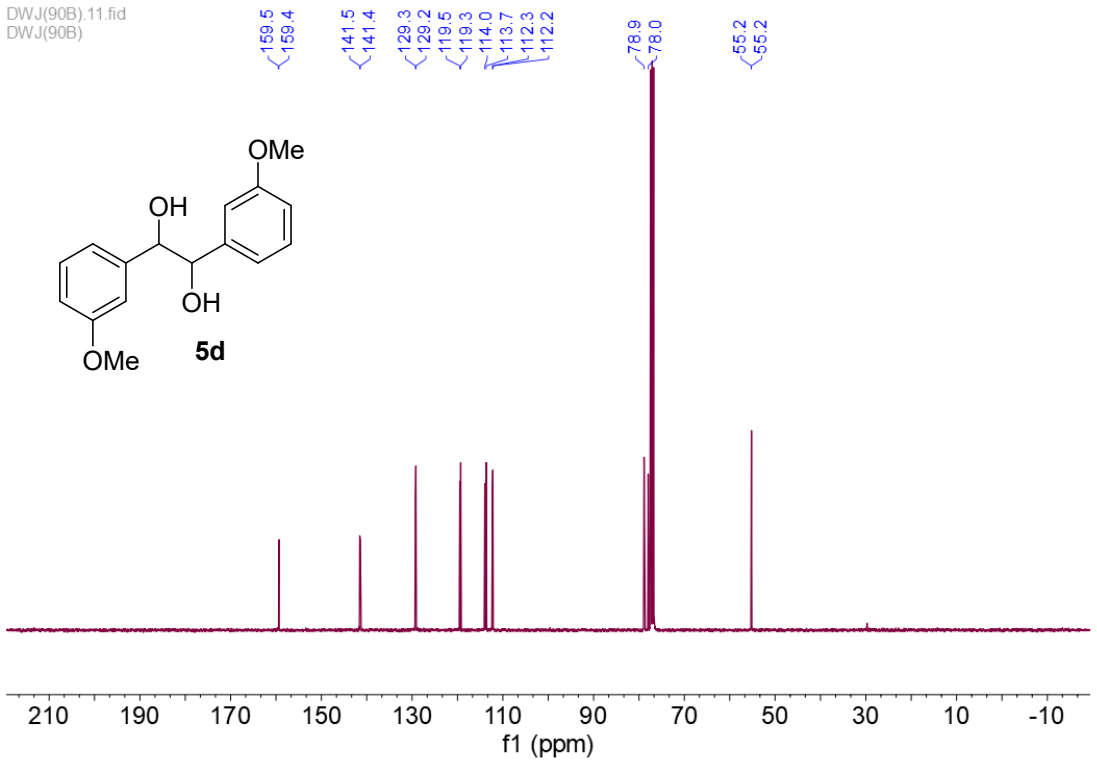
^{13}C-NMR spectrum of **5c** ($CDCl_3$, 100 MHz)



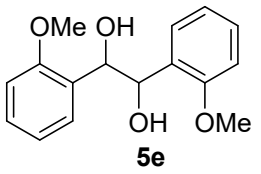
^{1}H-NMR spectrum of **5d** ($CDCl_3$, 400 MHz)



^{13}C-NMR spectrum of **5d** ($CDCl_3$, 100 MHz)

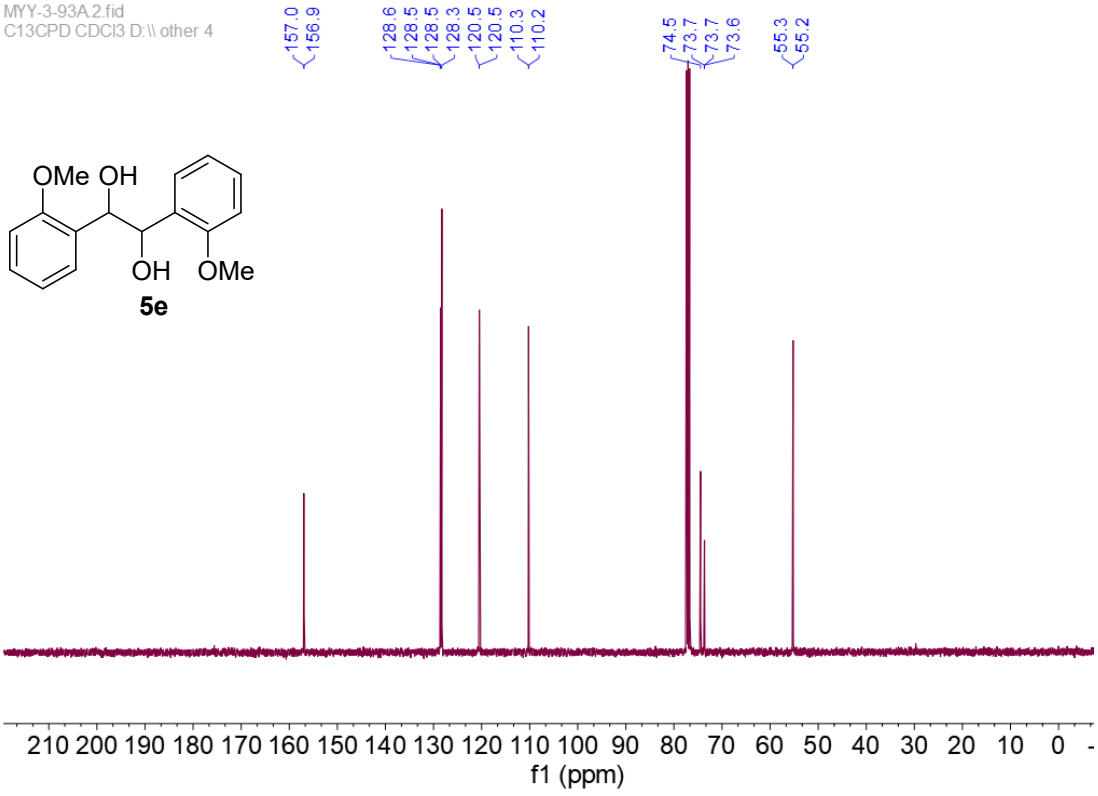


^{1}H-NMR spectrum of **5e** ($CDCl_3$, 400 MHz)



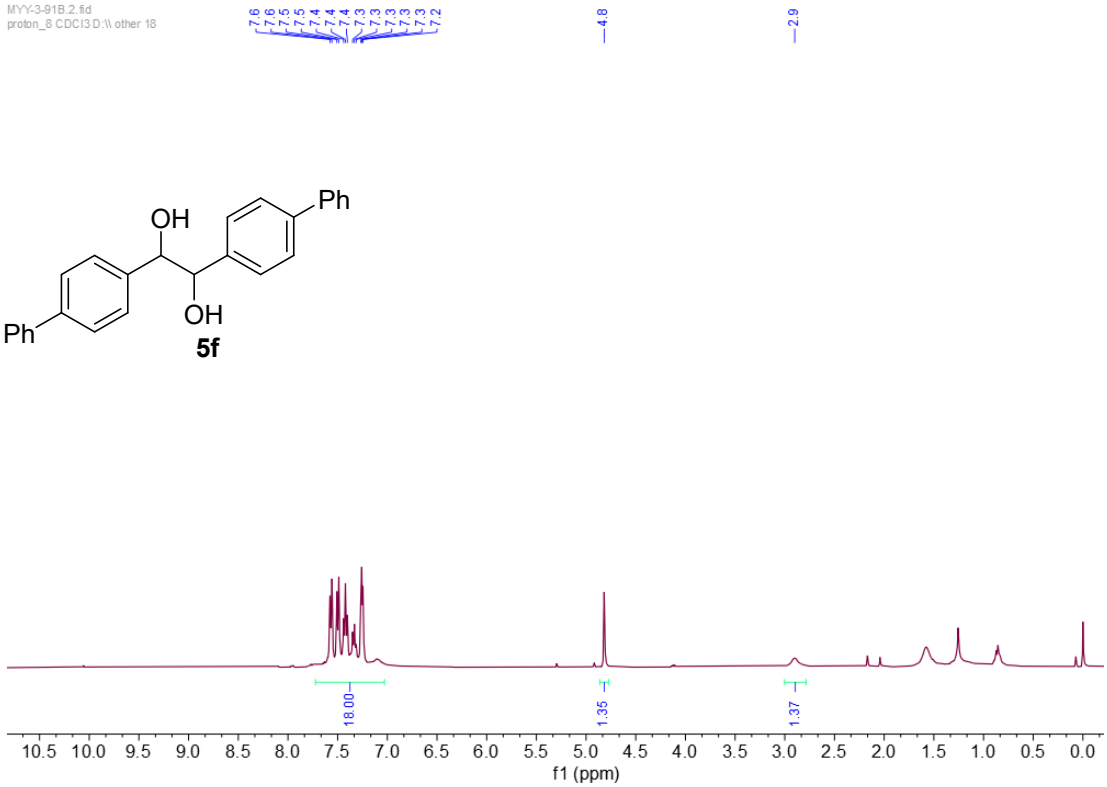
5e

^{13}C-NMR spectrum of **5e** ($CDCl_3$, 100 MHz)

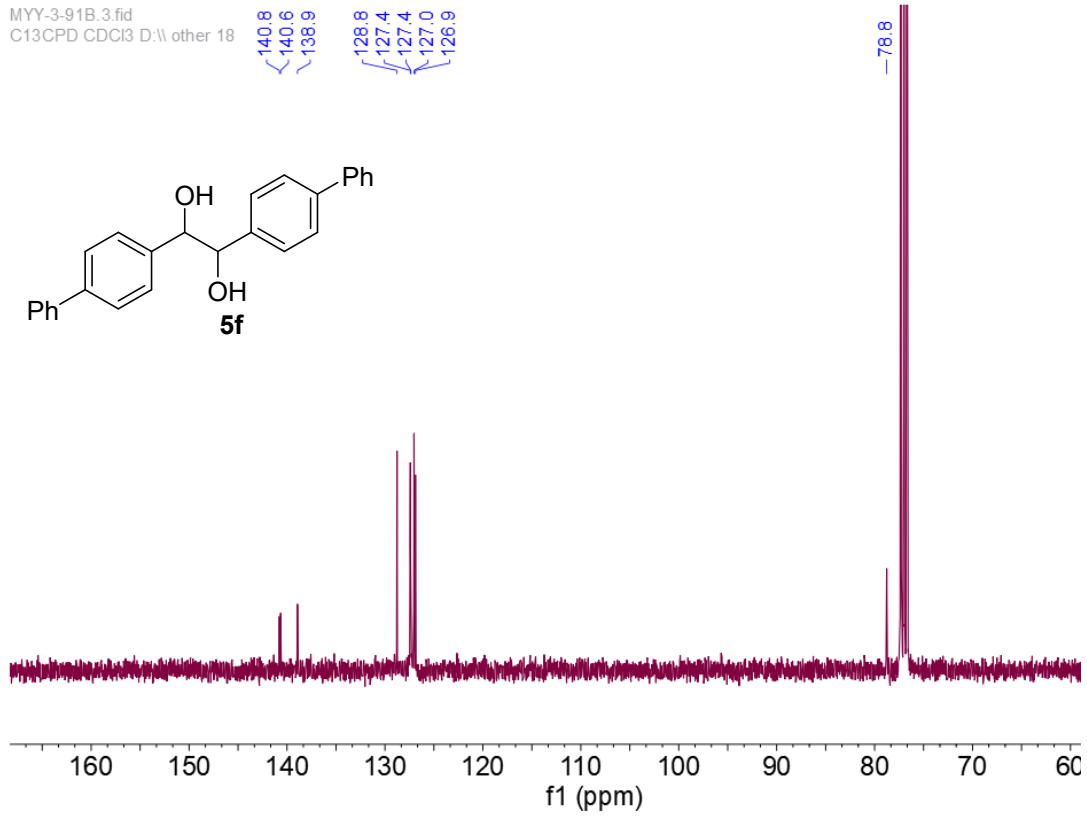


5e

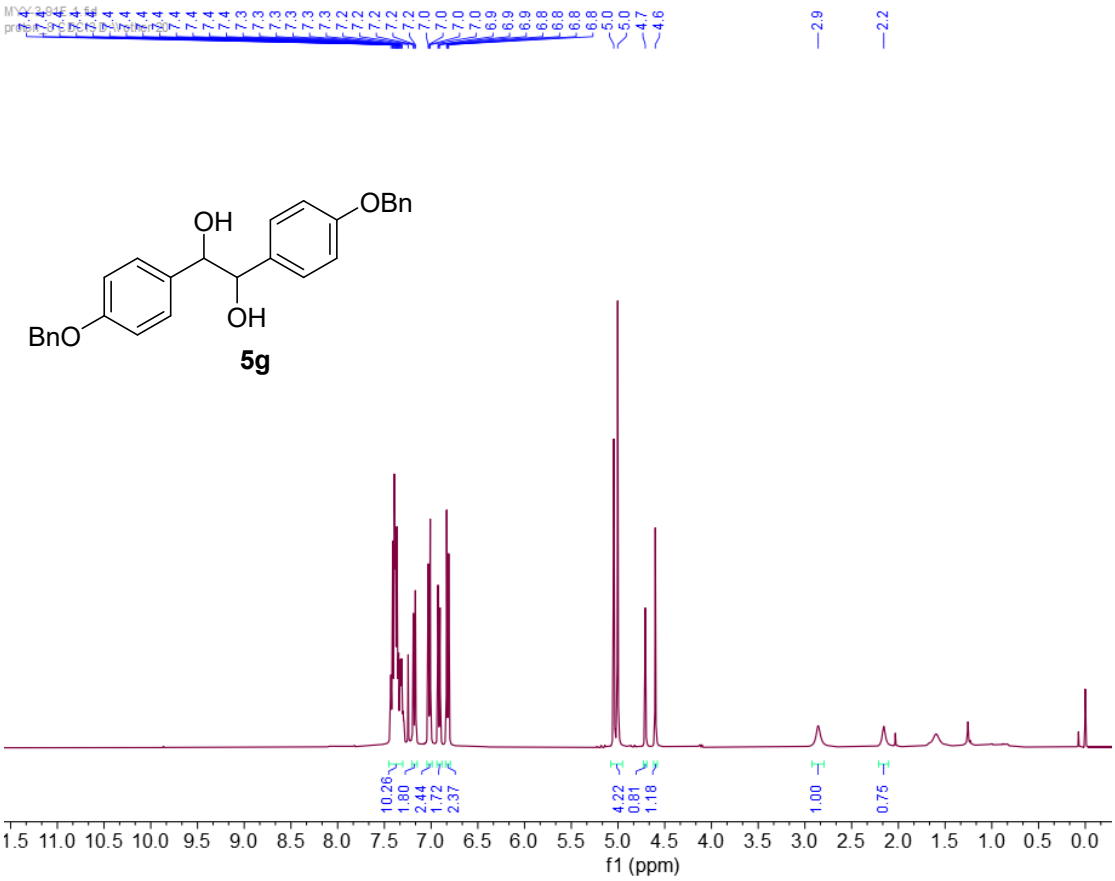
^{1}H-NMR spectrum of **5f** ($CDCl_3$, 400 MHz)



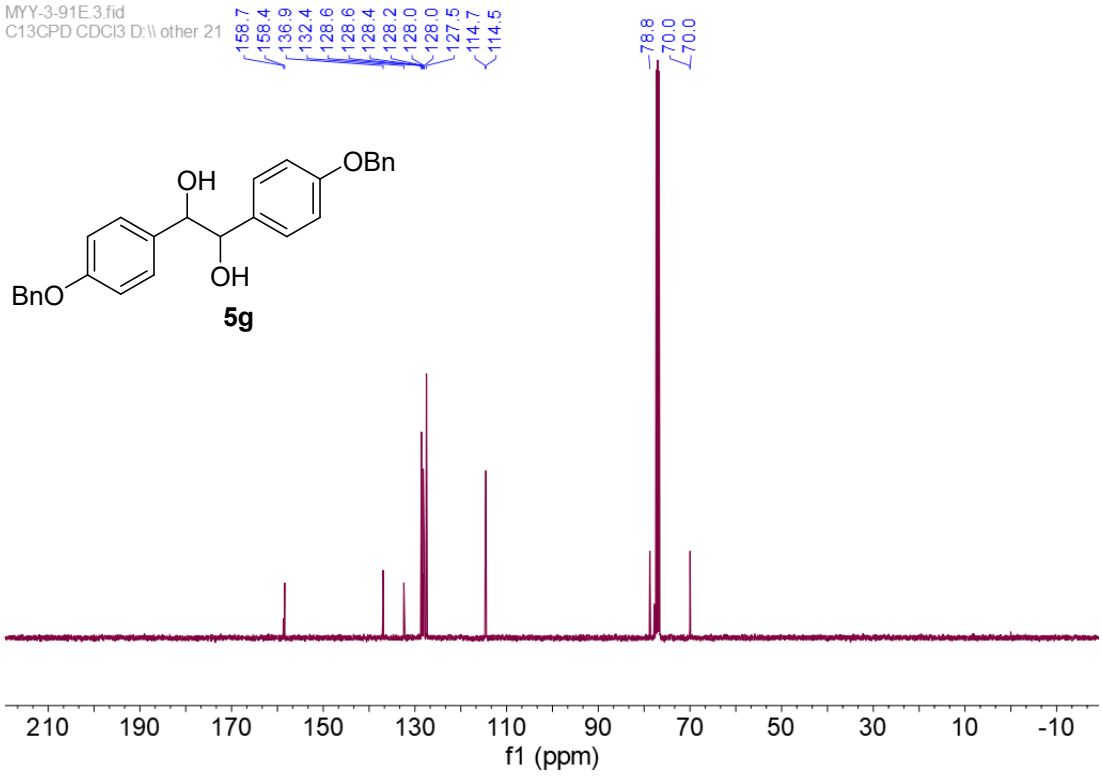
^{13}C-NMR spectrum of **5f** ($CDCl_3$, 100 MHz)



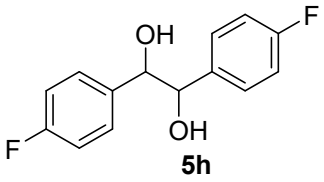
^{1}H-NMR spectrum of **5g** ($CDCl_3$, 400 MHz)



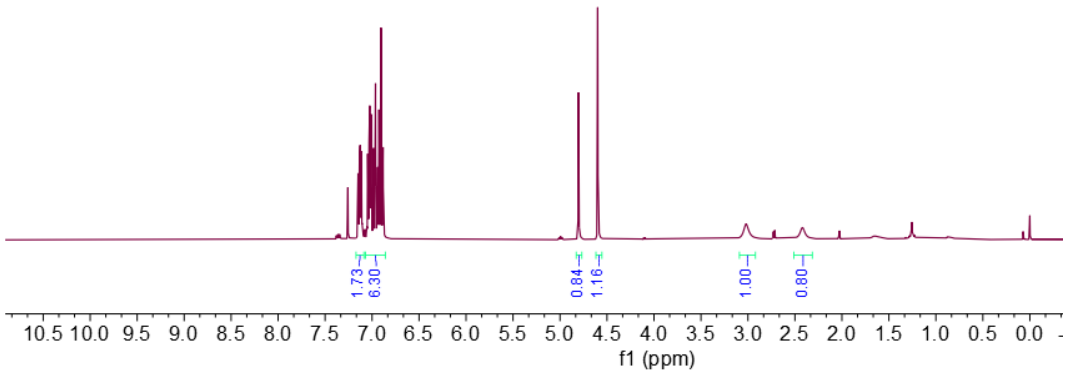
^{13}C-NMR spectrum of **5g** ($CDCl_3$, 100 MHz)



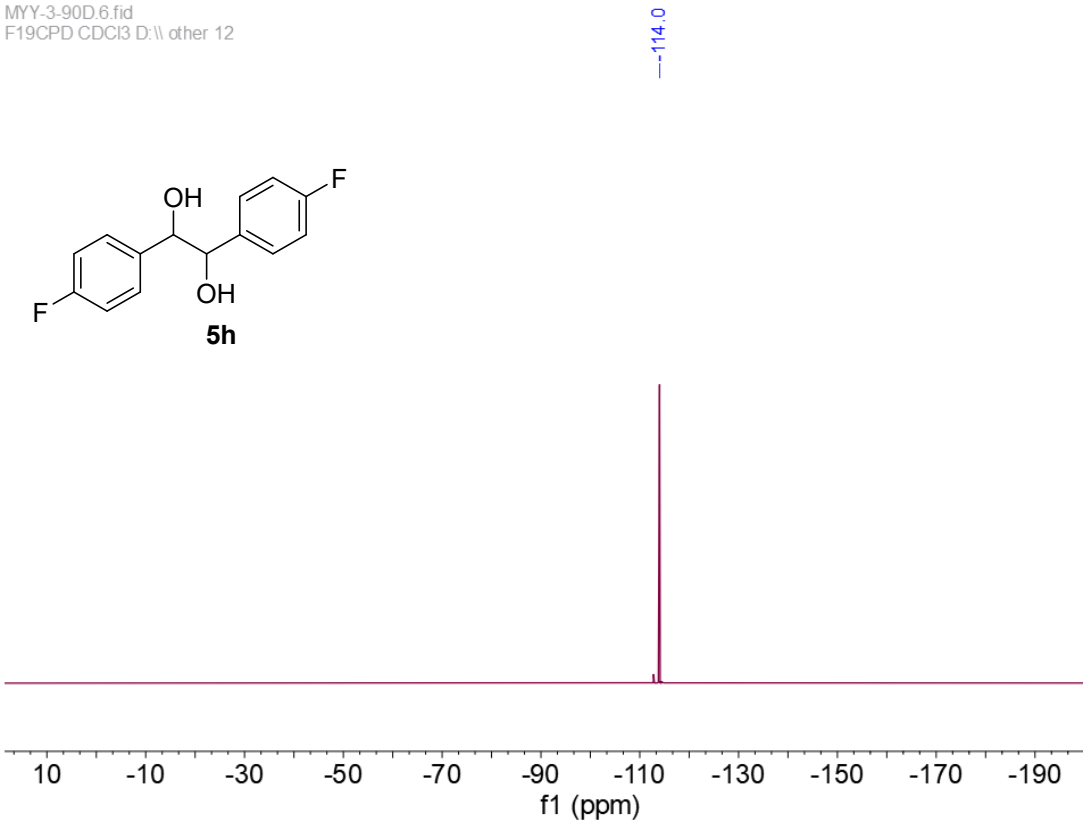
^{1}H-NMR spectrum of **5h** ($CDCl_3$, 400 MHz)



5h

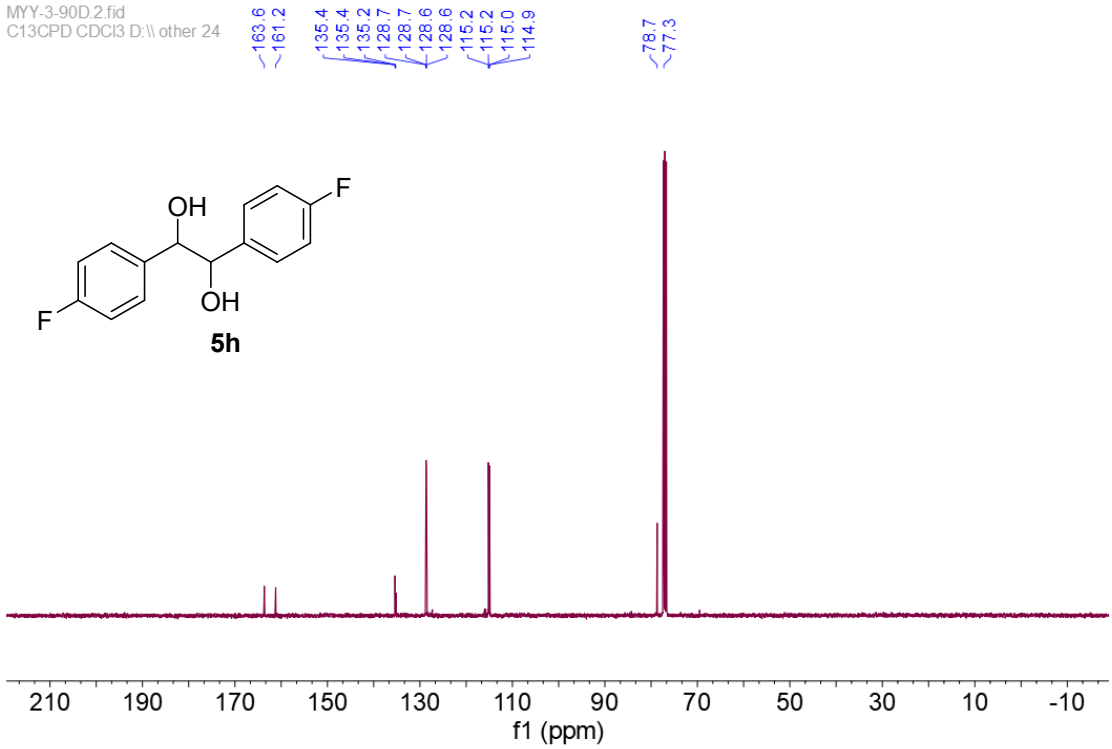


^{19}F-NMR spectrum of **5h** ($CDCl_3$, 376 MHz)

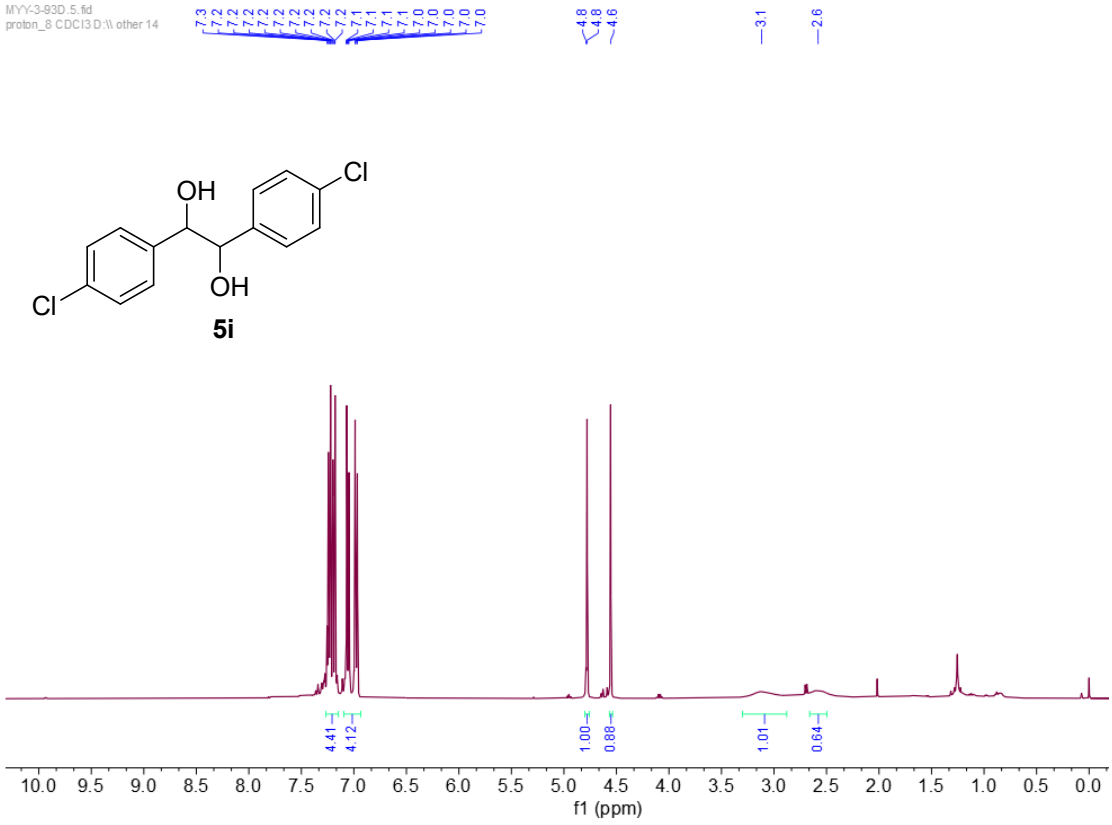


5h

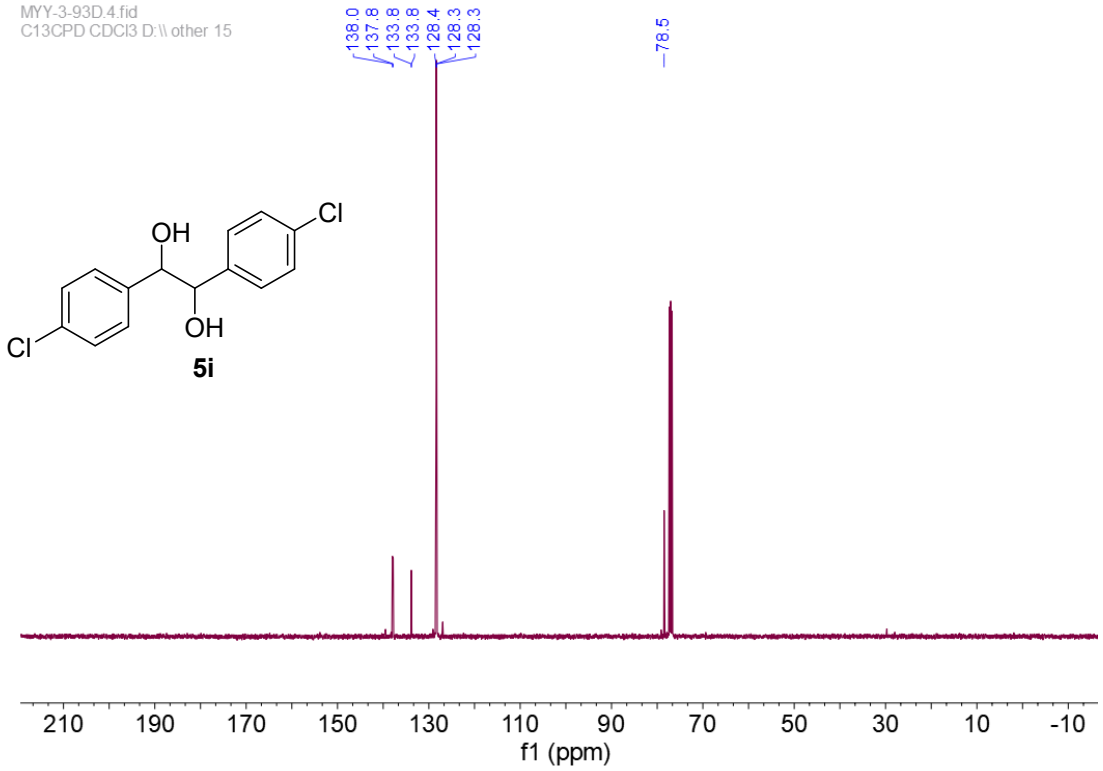
^{13}C-NMR spectrum of **5h** ($CDCl_3$, 100 MHz)



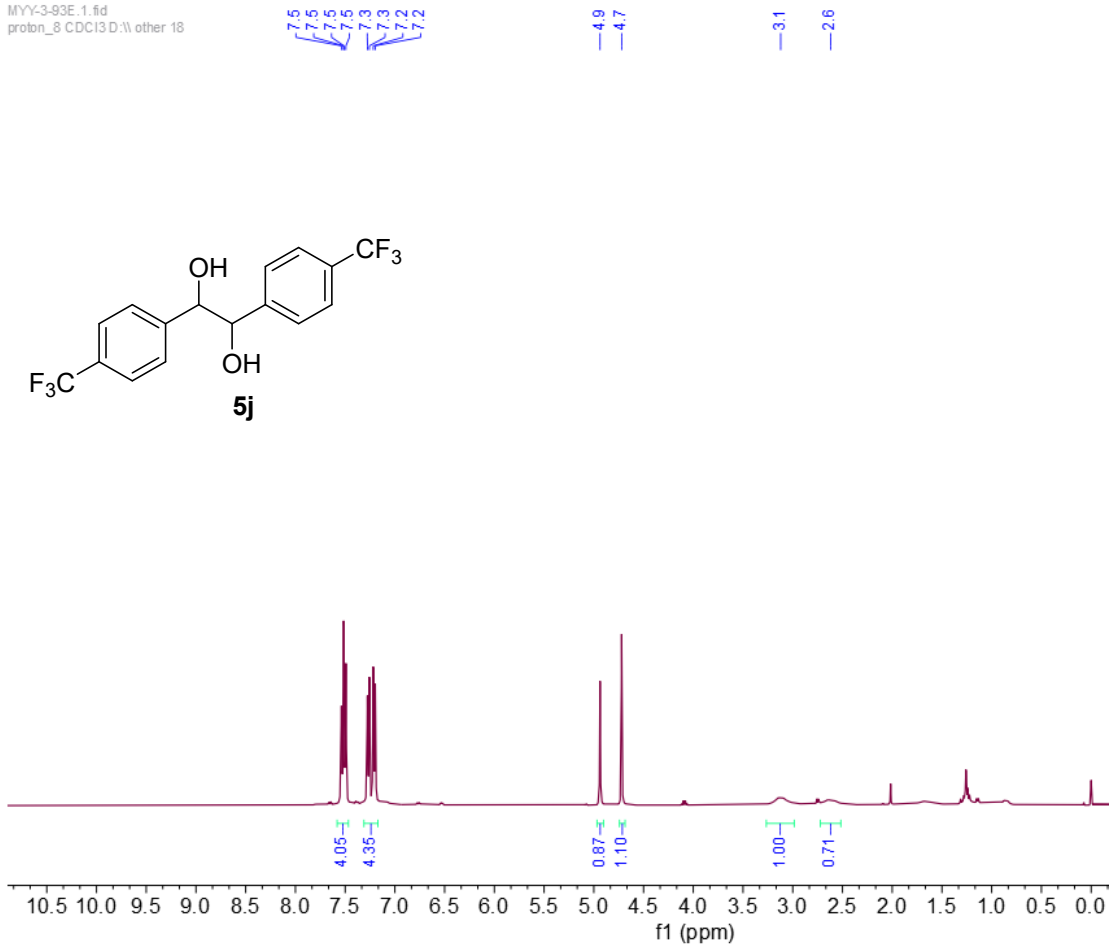
^{1}H-NMR spectrum of **5i** ($CDCl_3$, 400 MHz)



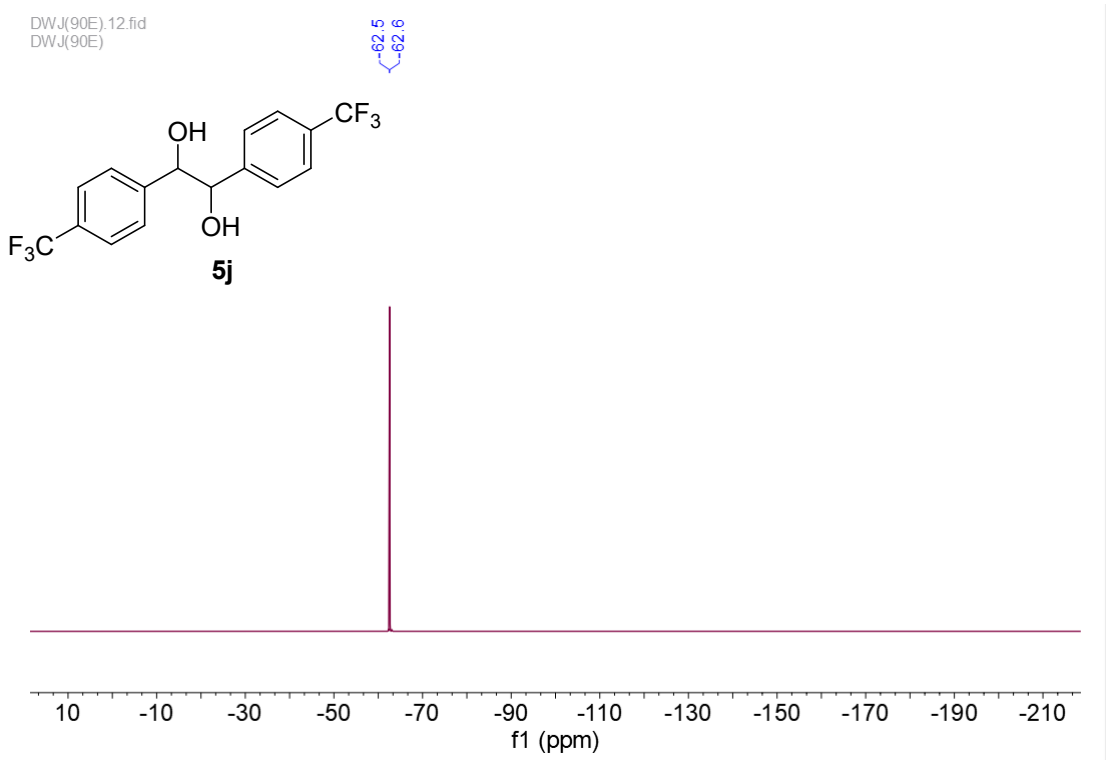
^{13}C-NMR spectrum of **5i** ($CDCl_3$, 100 MHz)



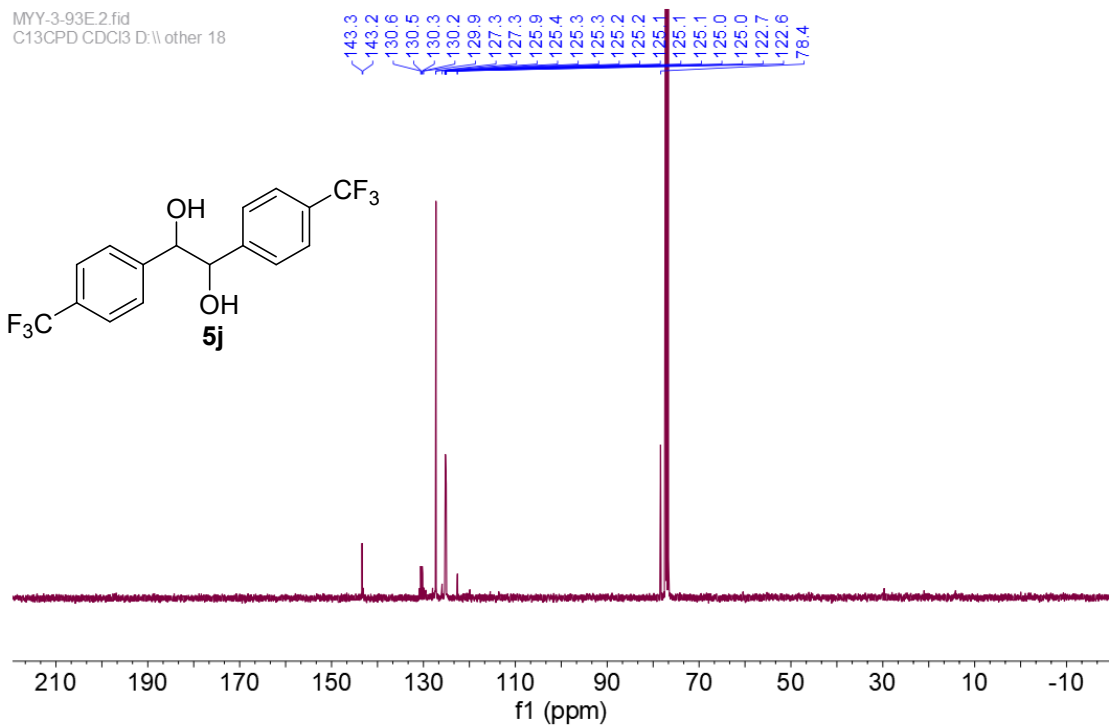
^{1}H-NMR spectrum of **5j** ($CDCl_3$, 400 MHz)



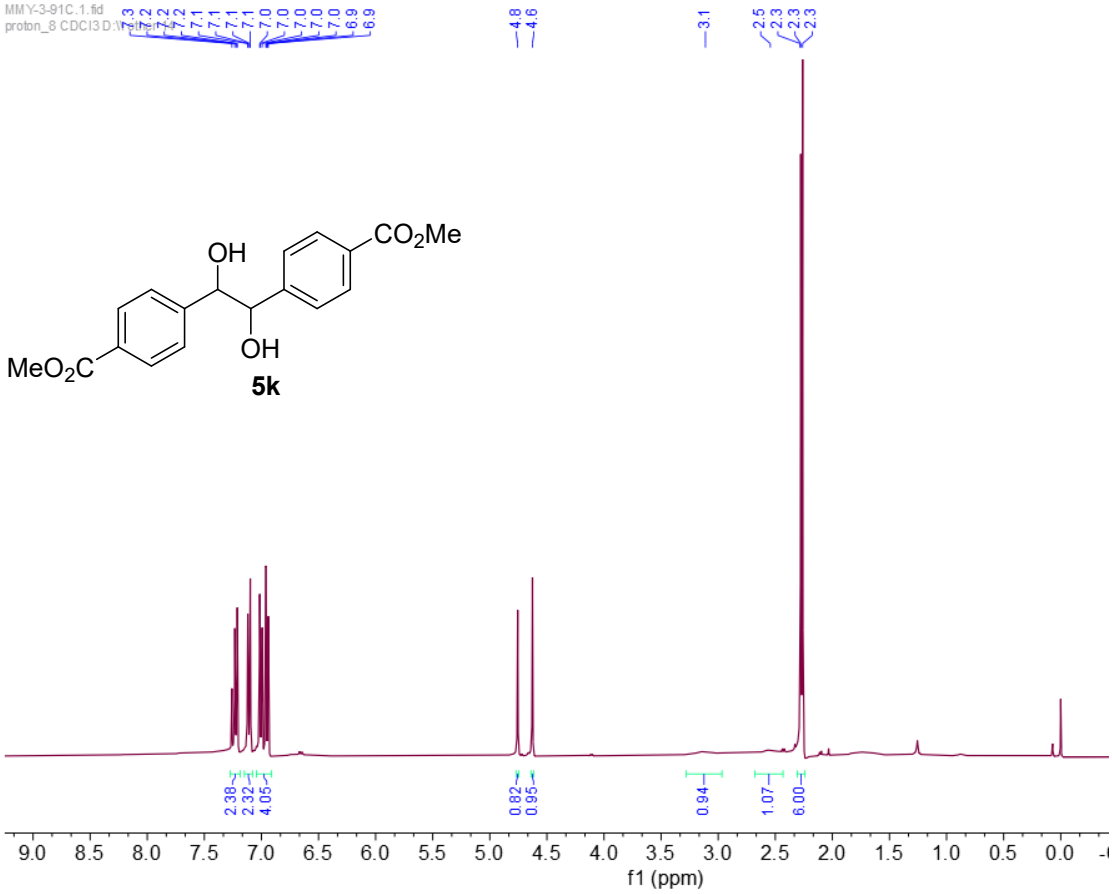
^{19}F-NMR spectrum of **5j** ($CDCl_3$, 376 MHz)



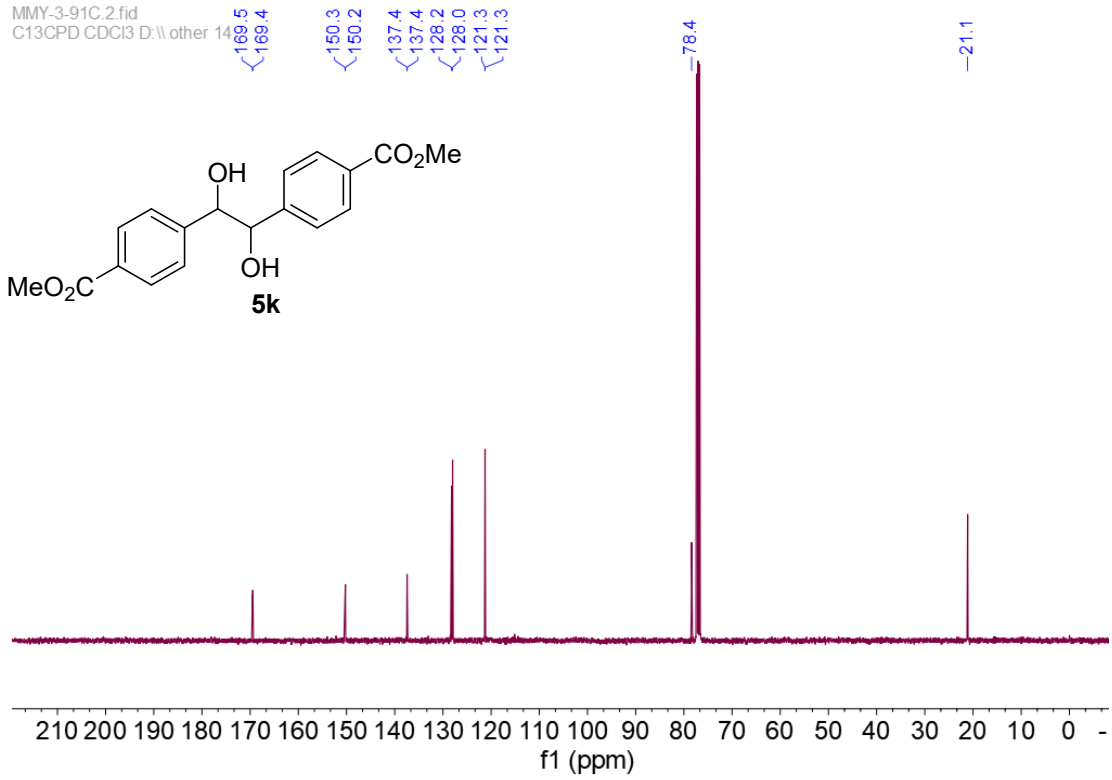
^{13}C-NMR spectrum of **5j** ($CDCl_3$, 100 MHz)



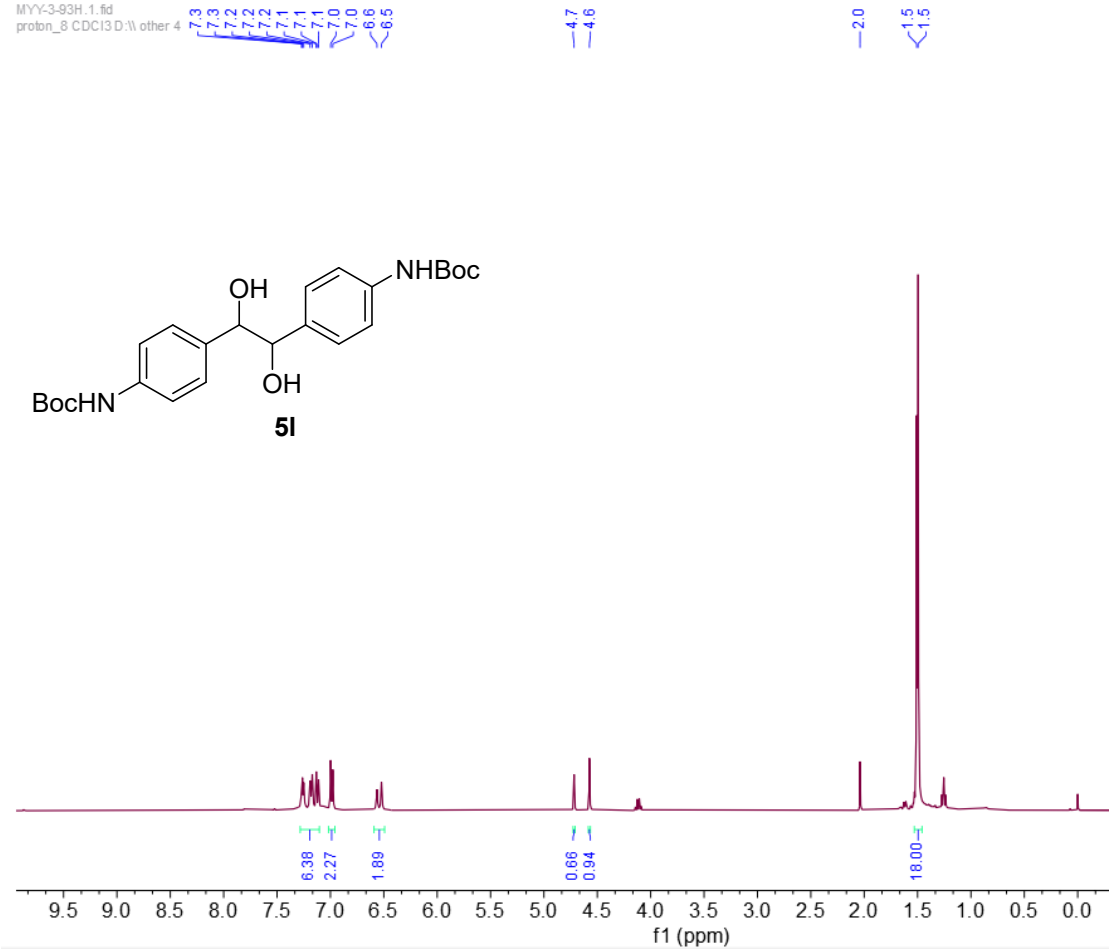
^{1}H-NMR spectrum of **5k** ($CDCl_3$, 400 MHz)



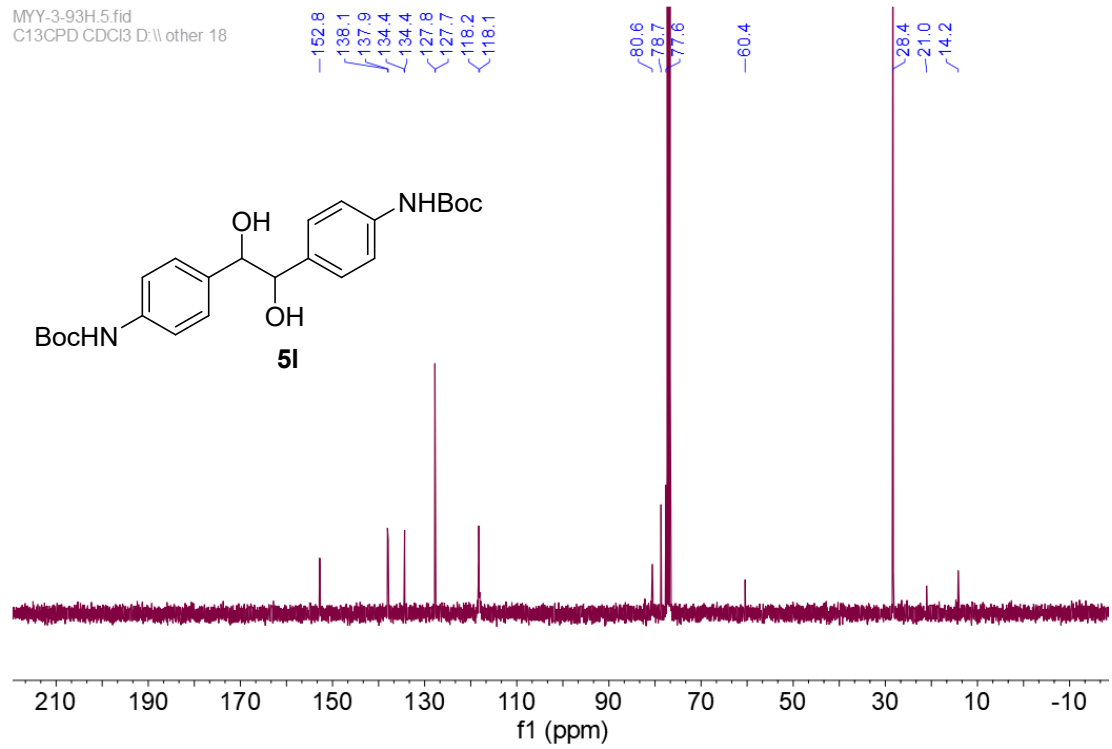
^{13}C-NMR spectrum of **5k** ($CDCl_3$, 100 MHz)



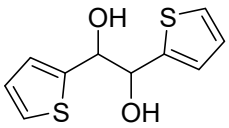
[1]H-NMR spectrum of **5l** ($CDCl_3$, 400 MHz)



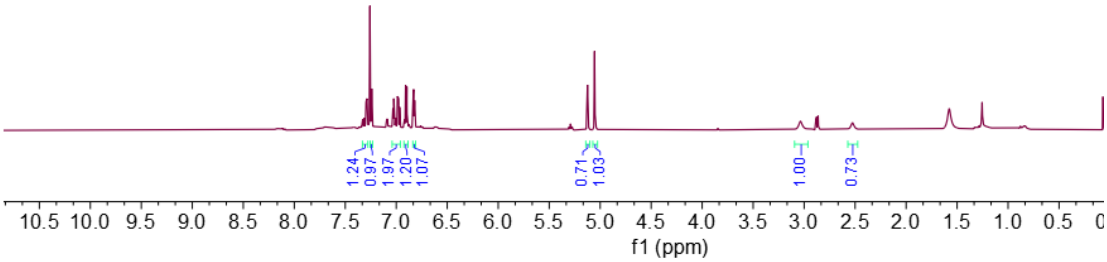
[13]C-NMR spectrum of **5l** ($CDCl_3$, 100 MHz)



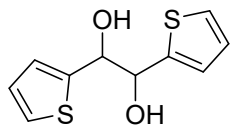
^{1}H-NMR spectrum of **5m** ($CDCl_3$, 400 MHz)



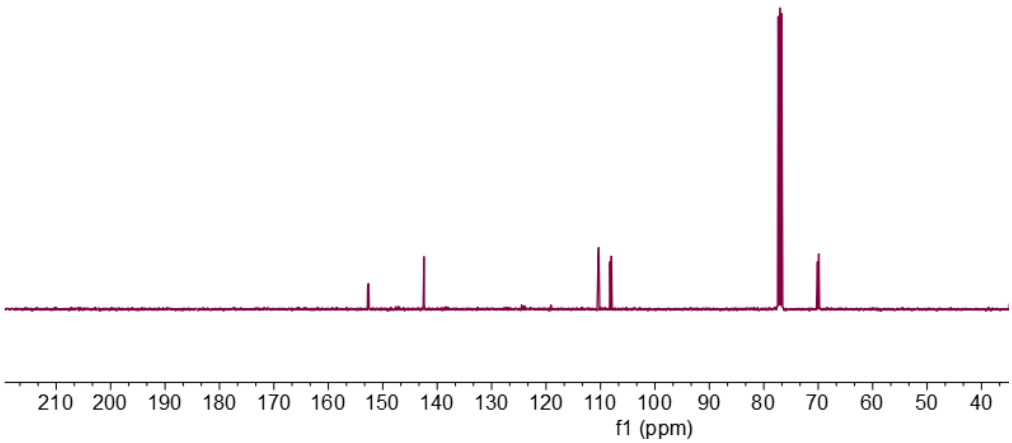
5m



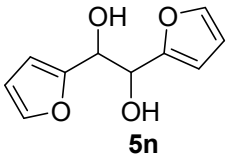
^{13}C-NMR spectrum of **5m** ($CDCl_3$, 100 MHz)



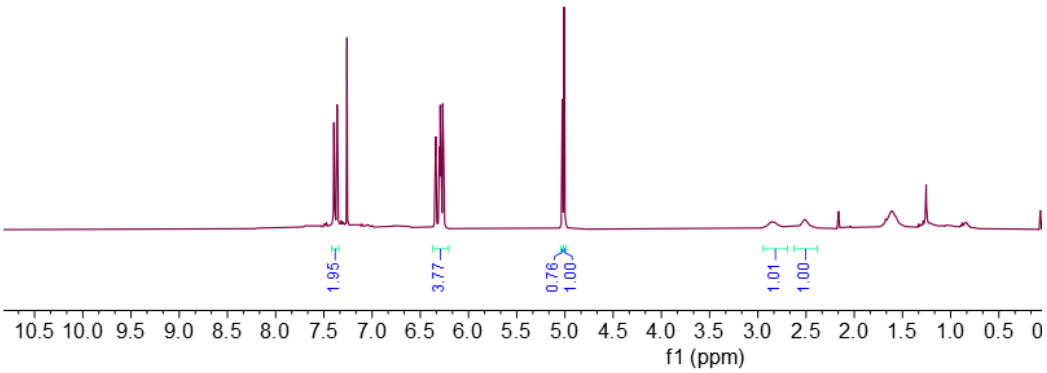
5m



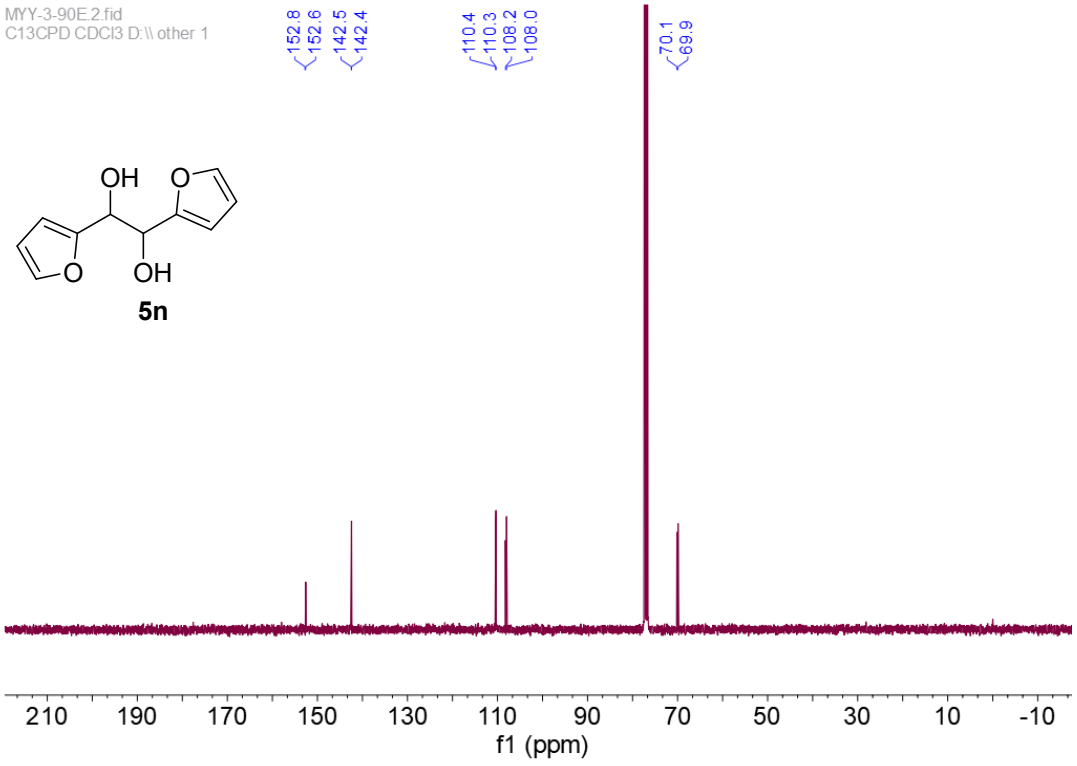
^{1}H-NMR spectrum of **5n** ($CDCl_3$, 400 MHz)



5n

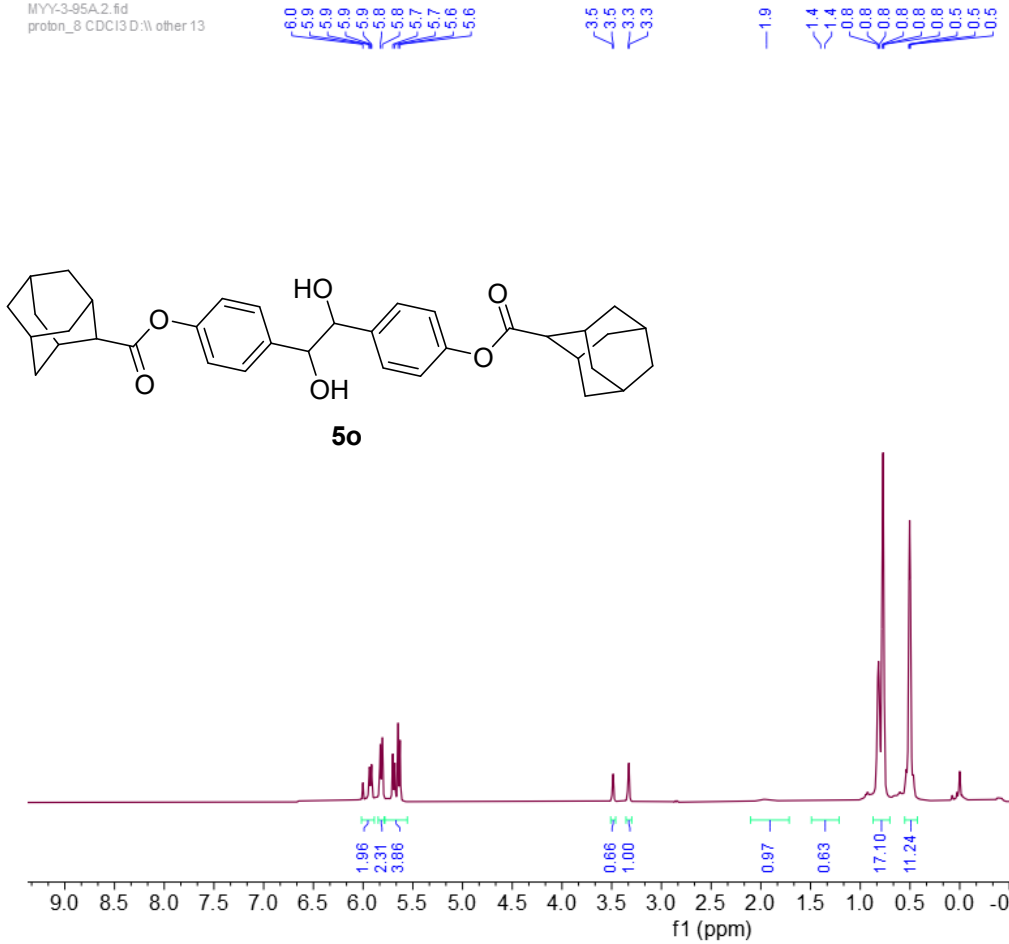


^{13}C-NMR spectrum of **5n** ($CDCl_3$, 100 MHz)



5n

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



^{13}C-NMR spectrum of **5o** ($CDCl_3$, 100 MHz)