Supporting Information

From one to two CO_2 molecules: controllable divergent synthesis of formate esters and carbonates

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A. General methods

^{1}H and ^{13}C NMR spectra were recorded by using a 400 MHz NMR spectrometer using $CDCl_3$ or DMSO-d_6 as solvent and TMS as an internal standard. The data of HRMS was carried out on a high-resolution mass spectrometer (LCMS-IT-TOF). GC-Mass analyses were conducted on a gas chromatograph-mass spectrometer (Trace 1300 ISQ) at an ionization voltage of 70 eV and equipped with a DB-WAX capillary column (internal diameter: 0.25 mm, length: 30 m). Melting points were determined with a digital melting point measuring instrument and are uncorrected. All the reaction temperatures reported are oil bath temperatures. All substrates and reagents were purchased from commercial sources and used directly without further treatment.

B. General procedure for the synthesis of formate esters 2

An oven-dried Schlenk tube (25 mL) was charged with a mixture of **1** (0.2 mmol, 1 equiv), K_2CO_3 (0.1 mmol, 0.5 equiv), anhydrous NMP (1.0 mL), and a magnetic stir bar. The tube was capped with a rubber septum, evacuated, and refilled with CO_2 (1 atm) three times. Then, $PhSiH_3$ (0.12 mmol, 0.6 equiv) in anhydrous NMP (1.0 mL) was added dropwise, and the mixture was stirred at 28 °C for 3 h. After the reaction was complete, the mixture was quenched with saturated brine (5 mL) and extracted with ethyl acetate (3 × 10 mL). The combined organic layers were dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure. The crude residue was purified by column chromatography on silica gel using petroleum ether/ethyl acetate as eluent to afford the desired product **2**.

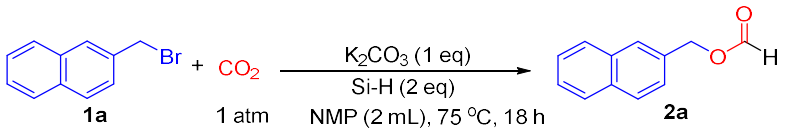
C. General procedure for the synthesis of methyl carbonate 3

An oven-dried Schlenk tube (25 mL) was charged with Cs_2CO_3 (0.7 mmol, 3.5 equiv), TBAI (0.02 mmol, 0.1 equiv), and a magnetic stir bar. The tube was capped with a rubber septum, evacuated, and refilled with CO_2 (1 atm) three times. Then, $PhSiH_3$ (0.9 mmol, 4.5 equiv) in anhydrous DMF (0.5 mL) was added dropwise, and the mixture was stirred at 90 °C for 3 h. Subsequently, **1** (0.2 mmol, 1 equiv) in anhydrous PhMe (1.5 mL) was added dropwise, and the mixture was stirred at 90 °C for 2 h. After the reaction was complete, the mixture was quenched with saturated brine (5 mL) and extracted with ethyl acetate (3 × 10 mL). The combined organic layers were dried over

anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure. The crude residue was purified by column chromatography on silica gel using petroleum ether/ethyl acetate as eluent to afford the desired product **3**.

D. Optimization of the reaction conditions for the synthesis of 2a

Table S1. The effect of silane on the reaction[a]

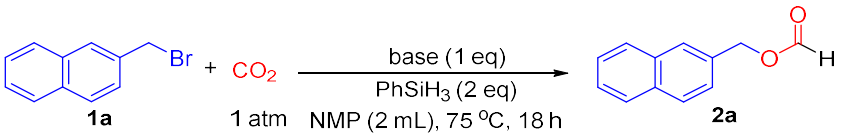


1a 2a

Entry	Si-H	Conversion of **1a** [%][b]	Yield of **2a** [%][b]
1	None	67	0
2	$PhSiH_3$	＞99	97
3	Ph_2SiH_2	＞99	90
4	Ph_3SiH	69	0
5	$(CH_3O)_3SiH$	70	0
6	$Ph(CH_3)_2SiH$	71	0

[a]Reaction conditions: **1a** (0.2 mmol), K_2CO_3 (1.0 eq), silane (2.0 eq), CO_2 (1 atm), NMP (2 mL), 75 °C, 18 h. [b]Determind by ^1H NMR with CH_2Br_2 as internal standard.

Table S2. The effect of bases on the reaction[a]

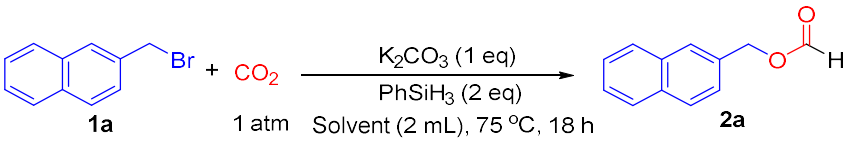


1a 2a

Entry	Base	Conversion of **1a** [%][b]	Yield of **2a** [%][b]
1	none	＜5	0
2	NEt_3	54	26
3	DBU	85	63
4	^tBuOK	43	7
5	$NaHCO_3$	＞99	90
6	Cs_2CO_3	＞99	93
7	KOH	＞99	95
8	K_2CO_3	＞99	97

[a]Reaction conditions: **1a** (0.2 mmol), base (1.0 equiv.), $PhSiH_3$ (2.0 equiv.), CO_2 (1 atm), NMP (2 mL), 75 °C, 18 h. [b]Determind by ^1H NMR with CH_2Br_2 as internal standard.

Table S3. The effect of solvents on the reaction[a]

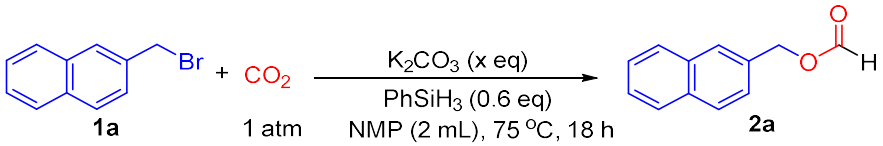


1a 2a

Entry	Solvent	Conversion of **1a** [%][b]	Yield of **2a** [%][b]
1	NMP	>99	97
2	THF	>99	0
3	CH_3CN	>99	0
4	DMA	>99	95
5	DMF	>99	82
6	DMSO	>99	83

[a]Reaction conditions: **1a** (0.2 mmol), K_2CO_3 (1.0 eq), $PhSiH_3$ (2.0 eq), CO_2 (1 atm), solvent (2 mL), 75 °C, 18 h. [b]Determind by ^1H NMR with CH_2Br_2 as internal standard.

Table S4. The effect of the loading of K_2CO_3 on the reaction[a]

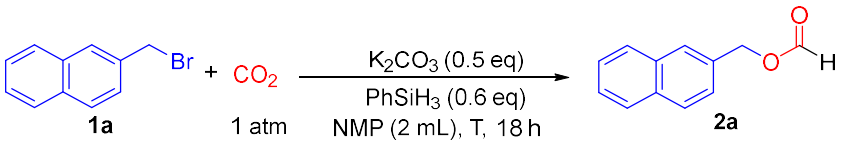


1a 2a

Entry	K_2CO_3	Conversion of **1a** [%][b]	Yield of **2a** [%][b]
1	1 eq.	>99	90
2	0.5 eq.	>99	92
3	0.4 eq.	87	84
4	0.2 eq.	52	Trace

[a]Reaction conditions: the mixture of **1a** (0.2 mmol), K_2CO_3 (x equiv.), $PhSiH_3$ (0.6 equiv.), CO_2 (1 atm) in NMP (2 mL), 75 °C, 18 h. [b]Determind by ^1H NMR with CH_2Br_2 as internal standard.

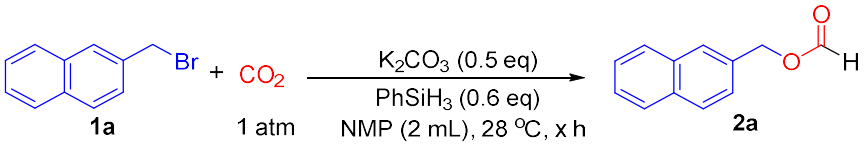
Table S5. The effect of temperatures on the reaction[a]



Entry	Temp./°C	Conversion of **1a** [%][b]	Yield of **2a** [%][b]
1	90	>99	86
2	75	>99	88
3	60	>99	88
4	40	>99	89
5	28	>99	95

[a]Reaction conditions: **1a** (0.2 mmol), K_2CO_3 (0.5 eq), $PhSiH_3$ (0.6 eq), CO_2 (1 atm), NMP (2 mL), 18 h. [b]Determind by ^{1}H-NMR with CH_2Br_2 as internal standard.

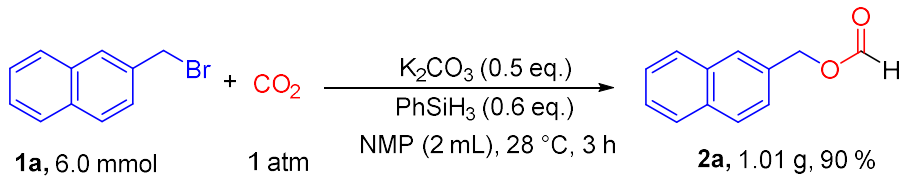
Table S6. The effect of times on the reaction[a]



Entry	Time/h	Conversion of **1a** [%][b]	Yield of **2a** [%][b]
1	18	>99	95
2	12	>99	96
3	3	>99	97 (93)[c]
4	2	>99	88
5	1	>99	72

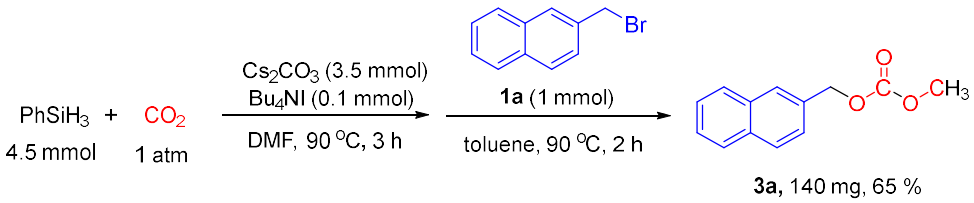
[a]Reaction conditions: **1a** (0.2 mmol), K_2CO_3 (0.5 eq), $PhSiH_3$ (0.6 eq), CO_2 (1 atm), NMP (2 mL), 28 °C. [b]Determind by ^{1}H NMR with CH_2Br_2 as internal standard. [c]Isolated yields.

E. Procedure for the synthesis of 2a on a 6 mmol scale



An oven-dried Schlenk tube (125 mL) was charged with a mixture of **1a** (6.0 mmol, 1 equiv), K_2CO_3 (3.0 mmol, 0.5 equiv), anhydrous NMP (10.0 mL), and a magnetic stir bar. The tube was capped with a rubber septum, evacuated, and refilled with CO_2 (1 atm) three times. Then, $PhSiH_3$ (3.6 mmol, 0.6 equiv) in anhydrous NMP (10.0 mL) was added dropwise, and the mixture was stirred at 28 °C for 3 h. After the reaction was complete, the mixture was quenched with saturated brine (10 mL) and extracted with ethyl acetate (3 × 10 mL). The combined organic layers were dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure. The crude residue was purified by column chromatography on silica gel using petroleum ether/ethyl acetate as eluent to afford the desired product **2a** (1.01 g, 90% yield).

F. Procedure for the synthesis of 3a on a 1 mmol scale

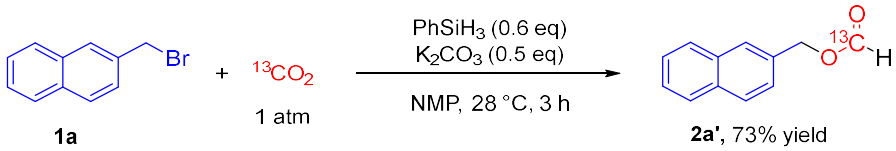


An oven-dried Schlenk tube (125 mL) was charged with Cs_2CO_3 (3.5 mmol, 3.5 equiv), TBAI (0.1 mmol, 0.1 equiv), and a magnetic stir bar. The tube was capped with a rubber septum, evacuated, and refilled with CO_2 (1 atm) three times. Then, $PhSiH_3$ (4.5 mmol, 4.5 equiv) in anhydrous DMF (2.5 mL) was added dropwise, and the mixture was stirred at 90 °C for 3 h. Subsequently, **1a** (1.0 mmol, 1 equiv) in anhydrous PhMe (7.5 mL) was added dropwise, and the mixture was stirred at 90 °C for 2 h. After the reaction was complete, the mixture was quenched with saturated brine (10 mL) and extracted with ethyl acetate (3 × 10 mL). The combined organic layers were dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure. The crude residue was purified by column chromatography on silica gel using petroleum ether/ethyl acetate as eluent to afford the desired product **3a** (140 mg, 65% yield).

G. Mechanistic studies

(1) For the synthesis of formate esters 2

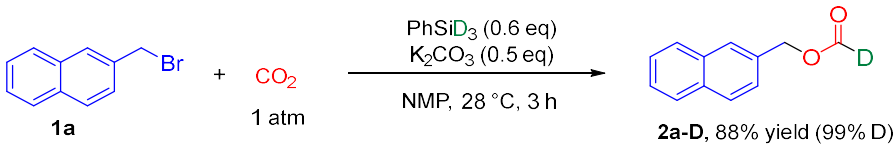
i) ^{13}C-labeling experiment



1a **2a'**, 73% yield

An oven dried Schlenk tube (25 mL) was charged with the mixture of **1a** (0.2 mmol, 1 equiv), K_2CO_3 (0.1mmol, 0.5 equiv), anhydrous NMP (1.0 mL), and a magnetic stirring bar. The tube was capped with a rubber septum, the tube was then evacuated, refilled with $^{13}CO_2$ (1 atm) three times. Then $PhSiH_3$ (0.6 equiv) in the solvent of anhydrous NMP (1.0 mL) was added dropwise and stirred at 28 °C for 3 h. After the reaction was completed, the reaction mixture was quenched with saturated brine water (5 mL) and extracted with ethyl acetate (3×10 mL) three times. The organic layer was dried over anhydrous Na_2SO_4, and then filtered and concentrated under reduced pressure. The crude residue was separated by column chromatography on a silica gel column using petroleum ether/ethyl acetate (10:1) as eluent to give the desired product **2a'** (27.3 mg, 73% yield). ^1H NMR (400 MHz, $CDCl_3$) δ 8.20 (d, J = 226.4 Hz, 1H), 7.89 – 7.80 (m, 4H), 7.55 – 7.47 (m, 3H), 5.38 (d, J = 3.2 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.8, 133.1, 133.1, 132.5 (d, J = 2.1 Hz), 128.5, 128.0, 127.7, 127.5, 126.4, 126.4, 125.7, 65.8 (d, J = 2.8 Hz); HRMS (ESI): m/z $[M-H]^+$ calcd for $C_{11}{}^{13}CH_9O_2^+$: 186.0642; found: 186.0635.

ii) Deuterium-labeling experiment

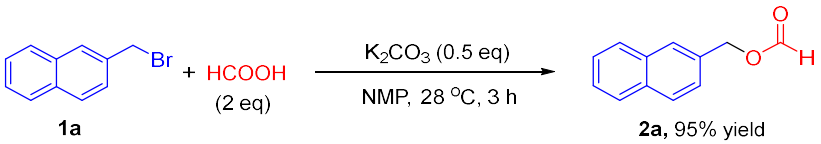


1a **2a-D**, 88% yield (99% D)

An oven dried Schlenk tube (25 mL) was charged with the mixture of **1a** (0.2 mmol, 1 equiv), K_2CO_3 (0.1 mmol, 0.5 equiv), anhydrous NMP (1.0 mL), and a magnetic stirring bar. The tube was capped with a rubber septum, the tube was then evacuated, refilled with CO_2 (1 atm) three times. Then $PhSiD_3$ (0.12 mmol, 0.6 equiv) in the solvent of anhydrous NMP (1.0 mL) was added dropwise and stirred at 28 °C for 3 h. After the reaction was completed, the reaction mixture was quenched with saturated brine water (5 mL) and extracted with ethyl acetate (3×10 mL) three times. The organic layer was dried over anhydrous Na_2SO_4, and then filtered and concentrated

under reduced pressure. The crude residue was separated by column chromatography on a silica gel column using petroleum ether/ethyl acetate (10:1) as eluent to give the desired product **2a-D** (32.9 mg, 88% yield). ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.96 – 7.89 (m, 4H), 7.56 – 7.48 (m, 3H), 5.34 (s, 2H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 162.3 (t, J = 34.6 Hz), 133.8, 133.2, 133.1, 128.6, 128.3, 128.1, 127.4, 126.9, 126.8, 126.4, 65.4.

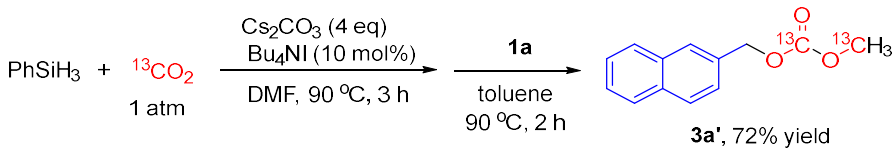
iii) Control experiment



An oven-dried Schlenk tube (25 mL) was charged with a mixture of **1a** (0.2 mmol, 1 equiv), K_2CO_3 (0.1 mmol, 0.5 equiv), HCOOH (0.4 mmol, 2.0 equiv), anhydrous NMP (2.0 mL), and a magnetic stir bar. The tube was capped with a rubber septum, and the mixture was stirred at 28 °C for 3 h. After the reaction was complete, the mixture was quenched with saturated brine (5 mL) and extracted with ethyl acetate (3 × 10 mL). The combined organic layers were dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure. The crude residue was purified by column chromatography on silica gel using petroleum ether/ethyl acetate (10:1) as eluent to afford the desired product **2a** in 95% yield.

(2) For the synthesis of carbonates 3

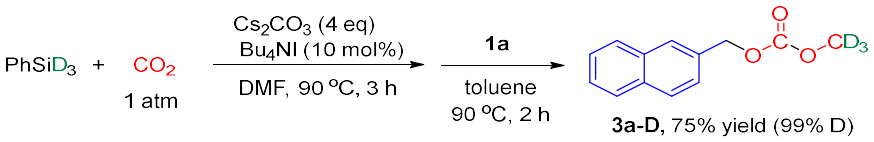
i) ^{13}C labeling experiment



An oven-dried Schlenk tube (25 mL) was charged with Cs_2CO_3 (0.7 mmol, 3.5 equiv), TBAI (0.02 mmol, 0.1 equiv), and a magnetic stir bar. The tube was capped with a rubber septum, evacuated, and refilled with $^{13}CO_2$ (1 atm) three times. Then, $PhSiH_3$ (0.9 mmol, 4.5 equiv) in anhydrous DMF (0.5 mL) was added dropwise, and the mixture was stirred at 90 °C for 3 h. Subsequently, **1a** (0.2 mmol, 1 equiv) in anhydrous PhMe (1.5 mL) was added dropwise, and the mixture was stirred at 90 °C for 2 h. After the reaction was complete, the mixture was quenched with saturated brine (5 mL) and extracted with ethyl acetate (3 × 10 mL). The combined organic layers were dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure. The crude

residue was purified by column chromatography on silica gel using petroleum ether/ethyl acetate (10:1) as eluent to afford the desired product **3a'** (31.4 mg, 72% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.90 – 7.81 (m, 4H), 7.55 – 7.45 (m, 3H), 5.38 – 5.25 (m, 2H), 4.02 – 3.59 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.7 (d, J = 1.6 Hz), 133.2, 133.1, 132.6, 128.4, 128.0, 127.7, 127.5, 126.3(9), 126.3(7), 125.7, 69.7, 54.8 (d, J = 1.5 Hz); HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{11}{}^{13}C_2H_{12}O_3^+$: 218.0854; found: 218.0845.

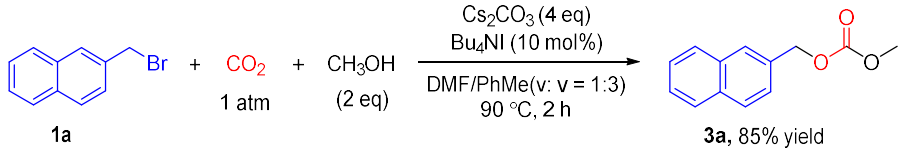
ii) Deuterium-labeling experiment



3a-D, 75% yield (99% D)

An oven-dried Schlenk tube (25 mL) was charged with Cs_2CO_3 (0.7 mmol, 3.5 equiv), TBAI (0.02 mmol, 0.1 equiv), and a magnetic stir bar. The tube was capped with a rubber septum, evacuated, and refilled with CO_2 (1 atm) three times. Then, $PhSiD_3$ (0.9 mmol, 4.5 equiv) in anhydrous DMF (0.5 mL) was added dropwise, and the mixture was stirred at 90 °C for 3 h. Subsequently, 1a (0.2 mmol, 1 equiv) in anhydrous PhMe (1.5 mL) was added dropwise, and the mixture was stirred at 90 °C for 2 h. After the reaction was complete, the mixture was quenched with saturated brine (5 mL) and extracted with ethyl acetate (3 × 10 mL). The combined organic layers were dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure. The crude residue was purified by column chromatography on silica gel using petroleum ether/ethyl acetate (10:1) as eluent to afford the desired product **3a-D** (32.8 mg, 75% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86 (d, J = 8.0 Hz, 4H), 7.50 (m, 3H), 5.34 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.7, 133.2, 133.1, 132.6, 128.4, 128.0, 127.7, 127.4, 126.3(4), 126.2(9), 125.7, 69.7.

iii) Control experiment



1a

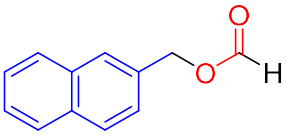
3a, 85% yield

An oven-dried Schlenk tube (25 mL) was charged with a mixture of **1a** (0.2 mmol, 1 equiv), Cs_2CO_3 (0.7 mmol, 3.5 equiv), TBAI (0.02 mmol, 0.1 equiv), and a magnetic stir bar. The tube was capped with a rubber septum, evacuated, and refilled with CO_2 (1 atm) three times. Then, CH_3OH (0.4 mmol, 2.0 equiv) in a mixed solvent of anhydrous DMF (0.5 mL) and PhMe (1.5 mL) was added dropwise, and the mixture was stirred at 90 °C for 2 h. After the reaction was complete,

the mixture was quenched with saturated brine (5 mL) and extracted with ethyl acetate (3 × 10 mL). The combined organic layers were dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure. The crude residue was purified by column chromatography on silica gel using petroleum ether/ethyl acetate (10:1) as eluent to afford the desired product **3a** in 85% yield.

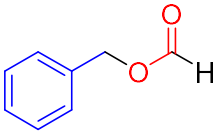
H. Analytical data

Naphthalen-2-ylmethyl formate (2a)[1]



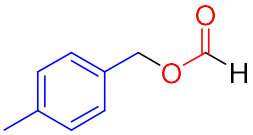
Eluent: PE : EA = 10:1; White solid, 34.6 mg, 93% yield. m.p. 83-84 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.20 (s, 1H), 7.92 – 7.81 (m, 4H), 7.57 – 7.45 (m, 3H), 5.38 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.8, 133.1(4), 133.1(1), 132.5, 128.5, 128.0, 127.7, 127.5, 126.4, 126.4, 125.7, 65.8.

Benzyl formate (2b)[2]



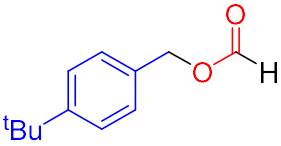
Eluent: PE : EA = 20:1; Colorless oil, 23.1 mg, 85% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.15 (s, 1H), 7.41 – 7.35 (m, 5H), 5.22 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.7, 135.1, 128.6, 128.4, 128.3, 65.6.

4-Methylbenzyl formate (2c)[1]



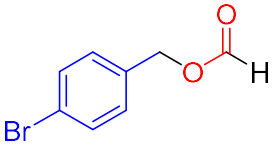
Eluent: PE : EA = 20:1; Colorless oil, 26.4 mg, 88% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.13 (s, 1H), 7.28 (d, J = 8.0 Hz, 2H), 7.19 (d, J = 7.9 Hz, 2H), 5.18 (s, 2H), 2.37 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.8, 138.4, 132.2, 129.3, 128.5, 65.6, 21.2.

4-Tertbutylbenzyl formate (2d)[3]



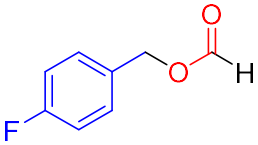
Eluent: PE : EA = 20:1; Yellow oil, 35.4 mg, 92% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.15 (s, 1H), 7.43 (d, J = 8.3 Hz, 2H), 7.34 (d, J = 8.3 Hz, 2H), 5.20 (s, 2H), 1.35 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.8, 151.6, 132.2, 128.3, 125.5, 65.5, 34.6, 31.2.

4-Bromobenzyl formate (2e)[2]



Eluent: PE : EA = 20:1; Colorless oil, 36.8 mg, 86% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.15 (s, 1H), 7.53 (d, J = 8.4 Hz, 2H), 7.27 (d, J = 8.5 Hz, 2H), 5.17 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.6, 134.2, 131.8, 130.0, 122.5, 64.8.

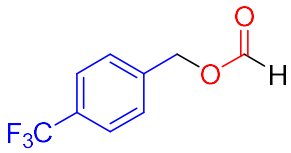
4-Fluorobenzyl formate (2f)[3]



Eluent: PE : EA = 10:1; Colorless oil, 26.2 mg, 85% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.12 (s, 1H), 7.36 (dd, J = 8.3, 5.5 Hz, 2H), 7.06 (t, J = 8.6 Hz, 2H), 5.17 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 162.8 (d, J

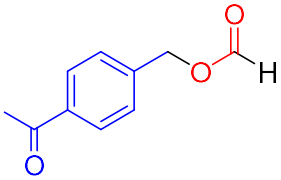
= 247.4 Hz), 160.7, 131.0 (d, J = 3.4 Hz), 130.4 (d, J = 8.3 Hz), 115.6 (d, J = 21.6 Hz), 65.0.

4-(Trifluoromethyl)benzyl formate (2g)[4]



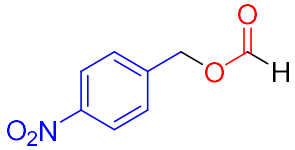
Eluent: PE : EA = 10:1; Colorless oil, 37.1 mg, 91% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.16 (s, 1H), 7.64 (d, J = 8.1 Hz, 2H), 7.49 (d, J = 8.0 Hz, 2H), 5.26 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.5, 139.1, 130.8, 128.2, 125.59 (q, J = 3.8 Hz),122.6, 64.6.

4-Acetylbenzyl formate (2h)



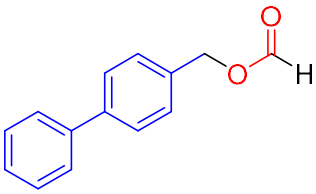
Eluent: PE : EA = 5:1; Yellow solid, 32.8 mg, 92% yield. m.p. 51 - 53 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.16 (s, 1H), 7.95 (d, 2H), 7.45 (d, J = 8.4 Hz, 2H), 5.25 (s, 2H), 2.60 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 197.5, 160.5, 140.3, 137.0, 128.6, 128.0, 64.8, 26.6; HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{10}H_{11}O_3^+$: 179.0703; found: 179.0698.

4-Nitrobenzyl formate (2i)[4]



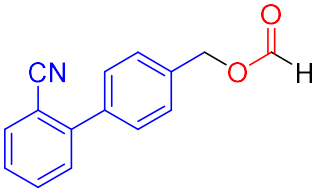
Eluent: PE : EA = 5:1; Yellow oil, 31.8 mg, 88% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.24 (d, J = 8.6 Hz, 2H), 8.18 (s, 1H), 7.54 (d, J = 8.6 Hz, 2H), 5.30 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.3, 147.7, 142.3, 128.4, 123.7, 64.0.

[1,1'-Biphenyl]-4-methyl formate (2j)[4]



Eluent: PE : EA = 10:1; White solid, 40.3 mg, 95% yield. m.p. 54 - 55 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.18 (s, 1H), 7.63 – 7.59 (m, 4H), 7.48 – 7.44 (m, 4H), 7.39 – 7.35 (m, 1H), 5.26 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.8, 141.5, 140.5, 134.1, 128.8(4), 128.8(0), 127.5, 127.4, 127.1, 65.4.

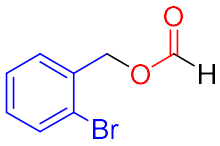
[1,1'-Biphenyl]-2'-cyano-4-methyl formate (2k)



Eluent: PE : EA = 5:1; White solid, 43.6 mg, 92% yield. m.p. 115 - 117 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.17 (s, 1H), 7.76 (dd, J = 7.7, 1.0 Hz, 1H), 7.67 – 7.62 (m, 1H), 7.60 – 7.56 (m, 2H), 7.50 (d, J = 7.9 Hz, 3H), 7.45 (td, J = 7.6, 1.2 Hz, 1H), 5.27 (s, 2H);^{13}C

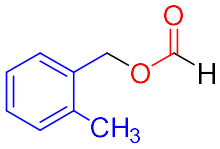
NMR (100 MHz, $CDCl_3$) δ 160.6, 144.7, 138.2, 135.7, 133.7, 132.8, 129.9, 128.9, 128.5, 127.7, 118.5, 111.2, 65.0; HRMS (ESI): m/z $[M+Na]^+$ calcd for $C_{15}H_{11}NO_2Na^+$: 260.0682; found: 260.0676.

2-Bromobenzyl formate (2l)[5]



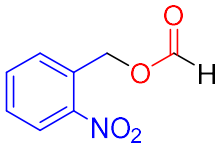
Eluent: PE : EA = 10:1; Umber oil, 37.2 mg, 87% yield. ^1H NMR (400 MHz, $CDCl_3$) δ 8.20 (s, 1H), 8.14 (d, J = 8.3 Hz, 1H), 7.71 – 7.62 (m, 2H), 7.52 (t, J = 7.6 Hz, 1H), 5.62 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.1, 133.8, 131.3, 129.2, 129.0, 125.2, 62.4.

2-Methylbenzyl formate (2m)[3]



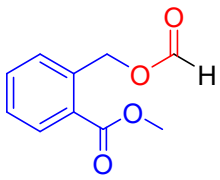
Eluent: PE : EA = 20:1; Colorless oil, 27.3 mg, 91% yield. ^1H NMR (400 MHz, $CDCl_3$) δ 8.15 (s, 1H), 7.35 (d, J = 7.0 Hz, 1H), 7.28 (t, J = 7.1 Hz, 1H), 7.22 (d, J = 4.6 Hz, 2H), 5.23 (s, 2H), 2.38 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.8, 137.1, 133.1, 130.4, 129.4, 128.8, 126.1, 64.1, 18.8.

2-Nitrobenzyl formate (2n)[6]



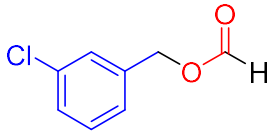
Eluent: PE : EA = 5:1; Yellow oil, 32.6 mg, 90% yield. ^1H NMR (400 MHz, $CDCl_3$) δ 8.19 (s, 1H), 8.12 (d, J = 8.2 Hz, 1H), 7.69 – 7.61 (m, 2H), 7.54 – 7.48 (m, 1H), 5.61 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.1, 147.4, 133.8, 131.2, 129.1, 129.0, 125.1, 62.3.

Methyl 2-((formyloxy)methyl)benzoate (2o)



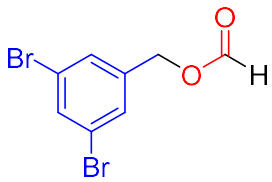
Eluent: PE : EA = 5:1; Colorless oil, 29.1 mg, 75% yield. ^1H NMR (400 MHz, $CDCl_3$) δ 8.19 (s, 1H), 8.01 (d, J = 8.3 Hz, 1H), 7.57 – 7.51 (m, 2H), 7.43 – 7.37 (m, 1H), 5.63 (s, 2H), 3.91 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.0, 160.6, 136.9, 132.5, 131.0, 128.6, 128.1, 127.7, 64.0, 52.2; HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{10}H_{11}O_4^+$: 195.0652; found: 195.0647.

3-Chlorobenzyl formate (2p)[2]



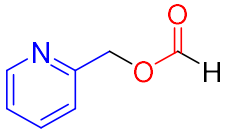
Eluent: PE : EA = 20:1; Colorless oil, 30.3 mg, 89% yield. ^1H NMR (400 MHz, $CDCl_3$) δ 8.16 (s, 1H), 7.39 (s, 1H), 7.33 (d, J = 5.3 Hz, 2H), 7.27 (d, 1H), 5.19 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.5, 137.2, 134.5, 129.9, 128.6, 128.2, 126.2, 64.7.

3,5-Bromobenzyl formate (2q)



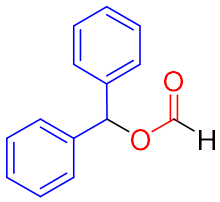
Eluent: PE : EA = 10:1; Yellow oil, 52.3 mg, 90% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.14 (s, 1H), 7.63 (t, J = 1.7 Hz, 1H), 7.45 (d, J = 1.7 Hz, 2H), 5.13 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.2, 139.0, 134.0, 129.7, 123.1, 63.7; HRMS (ESI): m/z $[M+H]^+$ calcd for $C_8H_5Br_2O_2^+$: 292.8641; found: 292.8643.

Pyridin-2-ylmethyl formate (2r)[7]



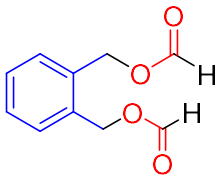
Eluent: PE : EA = 5:1; Yellow oil, 13.7 mg, 50% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.60 (d, J = 4.7 Hz, 1H), 8.20 (s, 1H), 7.74 – 7.68 (m, 1H), 7.36 (d, J = 7.8 Hz, 1H), 7.26 – 7.21 (m, 1H), 5.31 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.5, 155.0, 149.5, 136.8, 123.1, 121.9, 66.1.

Benzhydryl formate (2s)[4]



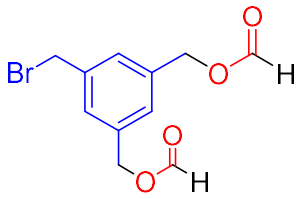
Eluent: PE : EA = 10:1; Colorless oil, 23.3 mg, 55% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.25 (s, 1H), 7.42 – 7.33 (m, 10H), 7.05 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.9, 139.5, 128.5, 128.1, 127.1, 76.5.

1,2-Phenylenebis(methylene) diformate (2t)



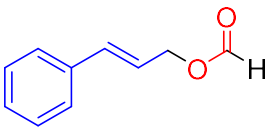
Eluent: PE : EA = 5:1; Colorless oil, 31.0 mg, 80% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.12 (s, 2H), 7.45 – 7.41 (m, 2H), 7.40 – 7.36 (m, 2H), 5.31 (s, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.5, 133.8, 130.0, 129.0, 63.0; HRMS (ESI): m/z $[M+Na]^+$ calcd for $C_{10}H_{10}O_4Na^+$: 217.0471; found: 217.0467.

(5-(Bromomethyl)-1,3-phenylene)bis(methylene) diformate (2u)



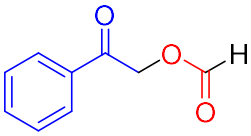
Eluent: PE : EA = 3:1; Yellow oil, 49.2 mg, 86% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.15 (s, 2H), 7.38 (s, 2H), 7.31 (s, 1H), 5.20 (s, 4H), 4.48 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.6, 138.8, 136.5, 128.8, 127.9, 64.8, 32.4; HRMS (ESI): m/z $[M+Na]^+$ calcd for $C_{11}H_{11}BrO_4Na^+$: 308.9733; found: 308.9727.

Cinnamyl formate (2v)[1]



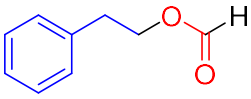
Eluent: PE : EA = 5:1; Colorless oil, 24.3 mg, 75% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.13 (s, 1H), 7.40 (d, J = 7.4 Hz, 2H), 7.34 (t, J = 7.4 Hz, 2H), 7.29 (t, J = 7.1 Hz, 1H), 6.70 (d, J = 15.9 Hz, 1H), 6.36 – 6.24 (m, 1H), 4.84 (d, J = 6.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.7, 136.0, 134.8, 128.6, 128.2, 126.6, 122.4, 64.4.

2-Oxo-2-phenylethyl formate (2w)[8]



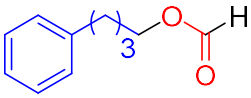
Eluent: PE : EA = 10:1; Yellow oil, 29.5 mg, 90% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.26 (s, 1H), 7.94 – 7.91 (m, 2H), 7.63 (t, J = 7.4 Hz, 1H), 7.50 (t, J = 7.7 Hz, 2H), 5.44 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 191.1, 160.0, 134.1, 133.9, 128.9, 127.8, 65.3.

Phenethyl formate (2x)[9]



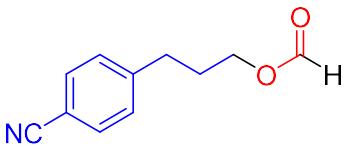
Eluent: PE : EA = 20:1; Light yellow oil, 18.3 mg, 61% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.04 (s, 1H), 7.32 (t, 2H), 7.25 (t, J = 7.4 Hz, 3H), 4.40 (t, J = 7.0 Hz, 2H), 2.99 (t, J = 7.0 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.9, 137.4, 128.8, 128.6, 126.7, 64.4, 34.9.

4-Phenylbutyl formate (2y)[4]



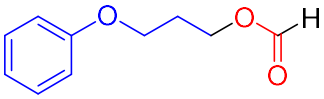
Eluent: PE : EA = 30:1; Yellow oil, 33.1 mg, 93% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.06 (s, 1H), 7.29 (t, J = 7.4 Hz, 2H), 7.20 (t, J = 7.5 Hz, 3H), 4.20 (t, 2H), 2.66 (t, 2H), 1.76 – 1.68 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 161.1, 141.8, 128.3(4), 128.2(7), 125.9, 35.3, 28.1, 27.6.

3-(4-Cyanophenyl)propyl formate (2z)



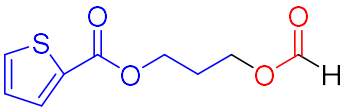
Eluent: PE : EA = 5:1; Colorless oil, 27.6 mg, 73 % yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.06 (s, 1H), 7.57 (d, J = 8.2 Hz, 2H), 7.29 (d, J = 8.2 Hz, 2H), 4.17 (t, J = 6.4 Hz, 2H), 2.76 (t, 2H), 2.04 – 1.96 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.9, 146.5, 132.3, 129.1, 118.8, 110.1, 62.7, 32.2, 29.5; HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{11}H_{12}NO_2^+$: 190.0863; found: 190.0857.

3-Phenoxypropyl formate (2aa)



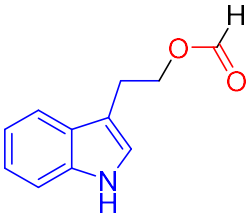
Eluent: PE : EA = 20:1; Colorless oil, 20.5 mg, 57% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.07 (s, 1H), 7.32 – 7.27 (m, 2H), 6.94 (dd, J = 25.1, 7.6 Hz, 3H), 4.39 (t, J = 6.2 Hz, 2H), 4.07 (t, J = 6.1 Hz, 2H), 2.16 (p, J = 6.2 Hz, 2H);^{13}C NMR (100 MHz, $CDCl_3$) δ 160.9, 158.7, 129.5, 120.9, 114.5, 63.9, 60.8, 28.5; HRMS (ESI): m/z $[M+Na]^+$ calcd for $C_{10}H_{12}O_3Na^+$: 203.0679; found: 203.0675.

3-(Formyloxy)propyl thiophene-2-carboxylate (2ab)



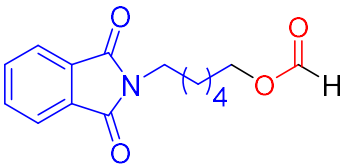
Eluent: PE : EA = 8:1; Yellow oil, 30.8 mg, 72 % yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.06 (s, 1H), 7.79 (dd, J = 3.7, 1.2 Hz, 1H), 7.55 (dd, J = 5.0, 1.2 Hz, 1H), 7.09 (dd, J = 4.9, 3.8 Hz, 1H), 4.39 (t, J = 6.2 Hz, 2H), 4.31 (t, J = 6.2 Hz, 2H), 2.14 – 2.08 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 162.0, 160.8, 134.1, 133.5, 132.5, 127.7, 61.4, 60.5, 27.9; HRMS (ESI): m/z $[M+H]^+$ calcd for $C_9H_{11}O_4S^+$: 215.0373; found: 215.0367.

2-(1*H*-Indol-3-yl)ethyl formate (2ac)



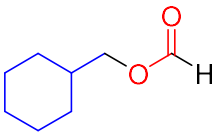
Eluent: PE : EA = 3:1; Yellow oil, 21.0 mg, 56 % yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.10 (s, 1H), 7.67 (d, J = 7.9 Hz, 1H), 7.37 (d, J = 8.0 Hz, 1H), 7.26 – 7.22 (m, 1H), 7.18 (td, J = 7.5, 7.1, 1.1 Hz, 1H), 7.05 (d, J = 2.3 Hz, 1H), 4.49 (t, J = 7.5 Hz, 2H), 3.17 (t, J = 7.1 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 161.1, 136.1, 127.2, 122.2, 122.1, 119.4, 118.6, 111.4, 111.2, 64.0, 24.6; HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{11}H_{12}NO_2^+$: 190.0863; found: 190.0857.

3-(1,3-Dioxoisoindolin-2-yl)propyl formate (2ad)



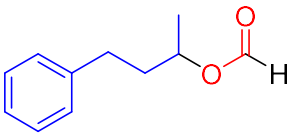
Eluent: PE : EA = 3:1; Colorless oil, 35.7 mg, 65% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.02 (s, 1H), 7.82 (dd, J = 5.4, 3.1 Hz, 2H), 7.69 (dd, J = 5.4, 3.0 Hz, 2H), 4.13 (t, J = 6.6 Hz, 2H), 3.67 (t, J = 7.2 Hz, 2H), 1.72 – 1.61 (m, 4H), 1.43 – 1.34 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 168.4, 161.1, 133.8, 132.1, 123.1, 63.8, 37.8, 28.4, 28.3, 26.3, 25.4; HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{15}H_{18}NO_4^+$: 276.1230; found: 276.1224.

Cyclohexylmethyl Formate (2ae)[10]



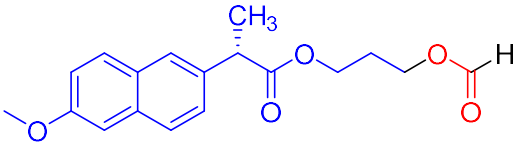
Eluent: PE : EA = 100:1; Colorless oil, 11.9 mg, 42% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.05 (s, 1H), 3.96 (d, J = 6.5 Hz, 2H), 1.76 – 1.63 (m, 6H), 1.26 – 1.12 (m, 3H), 0.96 (q, J = 11.5 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 161.2, 69.0, 36.9, 29.5, 26.2, 25.5.

4-Phenylbutan-2-yl formate (2af)



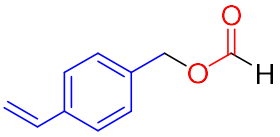
Eluent: PE : EA = 20:1; Colorless oil, 14.2 mg, 40 % yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.08 (s, 1H), 7.29 (t, J = 7.3 Hz, 2H), 7.22 – 7.16 (m, 3H), 5.06 (dq, J = 11.8, 5.8 Hz, 1H), 2.74 – 2.58 (m, 2H), 2.01 – 1.81 (m, 2H), 1.30 (d, J = 6.3 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.8, 141.2, 128.5, 128.3, 126.0, 70.5, 37.5, 31.6, 20.0; HRMS (ESI): m/z $[M+H]^-$ calcd for $C_{18}H_{19}O_5^-$: 179.1067; found: 179.1066.

3-(Formyloxy)propyl (S)-2-(6-methoxynaphthalen-2-yl)propanoate (2ah)



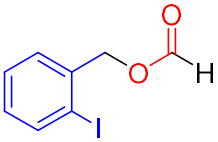
Eluent: PE : EA = 5:1; Colorless oil, 30.5 mg, 48 % yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94 (s, 1H), 7.72 – 7.66 (m, 3H), 7.40 (dd, J = 8.4, 1.6 Hz, 1H), 7.17 – 7.12 (m, 2H), 4.18 (t, J = 6.2 Hz, 2H), 4.16 – 4.11 (m, 2H), 3.91 (s, 3H), 3.89 – 3.83 (m, 1H), 1.94 (p, J = 6.2 Hz, 2H), 1.59 (d, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 174.5, 160.7, 157.6, 135.5, 133.7, 129.2, 128.9, 127.1, 126.1, 125.9, 119.0, 105.6, 61.0, 60.4, 55.2, 45.4, 27.7, 18.4; HRMS (ESI): m/z $[M+H]^-$ calcd for $C_{18}H_{19}O_5^-$: 315.1238; found: 315.1235.

4-Vinylbenzyl formate (2ai)



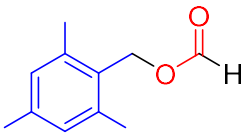
Eluent: PE : EA = 10:1; Colorless oil, 28.8 mg, 89% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.14 (s, 1H), 7.42 (d, J = 8.1 Hz, 2H), 7.34 (d, J = 8.0 Hz, 2H), 6.72 (q, J = 17.6, 10.9 Hz, 1H), 5.77 (d, J = 17.6 Hz, 1H), 5.28 (d, J = 10.9 Hz, 1H), 5.19 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.7, 137.8, 136.2, 134.6, 128.6, 126.4, 114.5, 65.4; HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{10}H_{11}O_2^+$: 163.0754; found: 163.0752.

2-Iodobenzyl formate (2aj)[4]



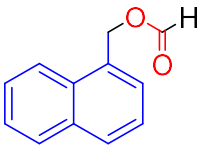
Eluent: PE : EA = 10:1; Colorless oil, 40.9 mg, 78% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.18 (s, 1H), 7.87 (d, J = 7.9 Hz, 1H), 7.43 – 7.34 (m, 2H), 7.04 (t, J = 8.2 Hz, 1H), 5.23 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.4, 139.5, 137.5, 130.1, 129.6, 128.4, 98.3, 69.4.

2,4,6-Trimethylbenzyl formate (2ak)



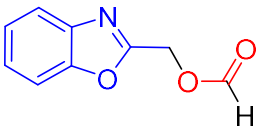
Eluent: PE : EA = 10:1; Colorless oil, 28.5 mg, 80% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.13 (s, 1H), 6.91 (s, 2H), 5.29 (s, 2H), 2.38 (s, 6H), 2.31 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 161.0, 138.7, 138.2, 129.1, 128.3, 60.3, 21.0, 19.4; HRMS (ESI): m/z $[M+Na]^+$ calcd for $C_{11}H_{14}O_2Na^+$: 201.0886; found: 201.0881.

Naphthalen-1-ylmethyl formate (2al)[4]



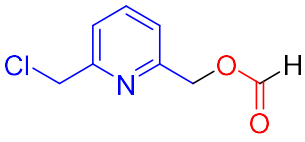
Eluent: PE : EA = 10:1; Yellow oil, 33.5 mg, 90% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.19 (s, 1H), 8.04 (d, J = 8.3 Hz, 1H), 7.90 (t, J = 8.8 Hz, 2H), 7.61 – 7.54 (m, 3H), 7.50 – 7.45 (m, 1H), 5.68 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.9, 133.8, 131.6, 130.7, 129.7, 128.8, 127.8, 126.8, 126.1, 125.3, 123.4, 64.0.

Benzo[*d*]oxazol-2-ylmethyl formate (2am)



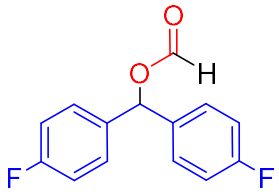
Eluent: PE : EA = 3:1; Colorless oil, 21.2 mg, 60% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.22 (s, 1H), 7.77 – 7.74 (m, 1H), 7.57 – 7.54 (m, 1H), 7.40 – 7.37 (m, 2H), 5.44 (s, 2H);^{13}C NMR (100 MHz, $CDCl_3$) δ 159.7, 150.9, 140.7, 134.2, 125.8, 124.8, 120.5, 110.9, 57.5; HRMS (ESI): m/z $[M+H]^+$ calcd for $C_9H_8NO_3^+$: 178.0499; found: 178.0496.

(6-(Chloromethyl)pyridin-2-yl)methyl formate (2an)



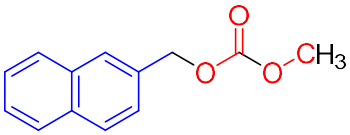
Eluent: PE : EA = 3:1; Yellow oil, 19.6 mg, 53% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.21 (s, 1H), 7.74 (t, J = 7.8 Hz, 1H), 7.45 (d, J = 7.7 Hz, 1H), 7.32 (d, J = 7.7 Hz, 1H), 5.30 (s, 2H), 4.66 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.4, 156.6, 154.7, 137.9, 122.1, 121.1, 65.9, 46.4; HRMS (ESI): m/z $[M+H]^+$ calcd for $C_8H_9ClNO_2^+$: 186.0316; found: 186.0312.

Bis(4-fluorophenyl)methyl formate (2ao)



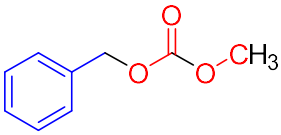
Eluent: PE : EA = 10:1; Colorless oil, 22.3 mg, 45% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.21 (s, 1H), 7.34 – 7.29 (m, 4H), 7.05 (t, J = 8.6 Hz, 4H), 6.97 (s, 1H);^{13}C NMR (100 MHz, Chloroform-*d*) δ 162.5 (d, J = 247.4 Hz), 159.8, 135.1 (d, J = 3.3 Hz), 128.9 (d, J = 8.3 Hz), 115.6 (d, J = 21.7 Hz), 75.1; HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{14}H_{11}F_2O_2^+$: 249.0722; found: 249.0725.

Methyl (naphthalen-2-ylmethyl) carbonate (3a)[11]



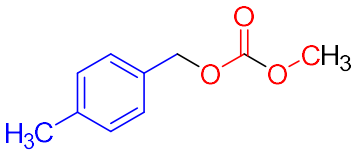
Eluent: PE : EA =10:1; White solid, 35.8 mg, 83% yield. m.p. 49 - 51 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.88 – 7.83 (m, 4H), 7.52 – 7.47 (m, 3H), 5.34 (s, 2H), 3.82 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.7, 133.2, 133.1, 132.6, 128.4, 128.0, 127.7, 127.5, 126.4, 126.3, 125.7, 69.7, 54.9.

Benzyl methyl carbonate (3b)[12]



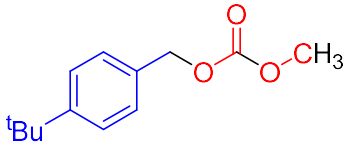
Eluent: PE : EA = 20:1; Yellow oil, 23.2 mg, 70% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 – 7.33 (m, 5H), 5.17 (s, 2H), 3.80 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.7, 135.2, 128.6, 128.5, 128.3, 69.6, 54.8.

Methyl (4-methylbenzyl) carbonate (3c)[13]



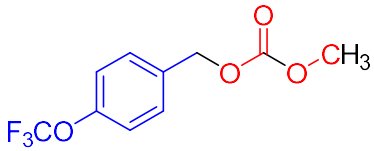
Eluent: PE : EA = 20:1; Yellow oil, 26.3 mg, 73% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.28 (d, J = 8.0 Hz, 2H), 7.18 (d, J = 7.9 Hz, 2H), 5.13 (s, 2H), 3.79 (s, 3H), 2.35 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.7, 138.4, 132.2, 129.2, 128.5, 69.6, 54.8, 21.2.

4-(Tert-butyl)benzyl methyl carbonate (3d)[14]



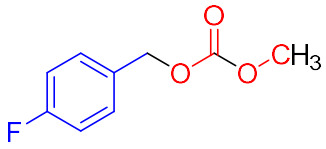
Eluent: PE : EA = 10:1; Colorless oil, 30.2 mg, 68% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.41 (d, J = 8.4 Hz, 2H), 7.34 (d, J = 8.3 Hz, 2H), 5.15 (s, 2H), 3.80 (s, 3H), 1.33 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.7, 151.6, 132.2, 128.2, 125.5, 69.5, 54.8, 34.6, 31.2.

Methyl (4-(trifluoromethoxy)benzyl) carbonate (3e)



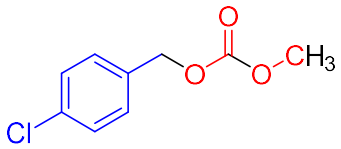
Eluent: PE : EA = 5:1; Yellow oil, 34.0 mg, 68% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.43 (d, J = 8.7 Hz, 2H), 7.22 (d, J = 8.1 Hz, 2H), 5.16 (s, 2H), 3.81 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.6, 149.2 (d, J = 1.9 Hz), 134.0 (d, J = 19.0 Hz), 129.8, 127.7 (d, J = 5.5 Hz), 121.1, 68.6, 55.0; HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{10}H_9F_3O_4^+$: 250.0453; found: 250.0462.

4-Fluorobenzyl methyl carbonate (3f)



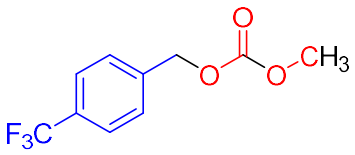
Eluent: PE : EA = 10:1; Colorless oil, 25.4 mg, 69% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37 (dd, J = 8.4, 5.4 Hz, 2H), 7.05 (t, J = 8.6 Hz, 2H), 5.12 (s, 2H), 3.79 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 162.8 (d, J = 247.2 Hz), 155.6, 131.1 (d, J = 3.3 Hz), 130.4 (d, J = 8.4 Hz), 115.5 (d, J = 21.6 Hz), 68.9, 54.9; HRMS (ESI): m/z $[M+NH_3]^+$ calcd for $C_9H_{13}F_1O_3N_1^+$: 202.08714; found: 202.0871.

4-Chlorobenzyl methyl carbonate (3g)



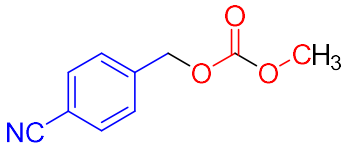
Eluent: PE : EA = 10:1; Colorless oil, 28.8 mg, 72% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.33 (d, J = 2.5 Hz, 4H), 5.12 (s, 2H), 3.80 (s, 3H);^{13}C NMR (100 MHz, $CDCl_3$) δ 155.6, 134.5, 133.7, 129.7, 128.8, 68.7, 55.0; HRMS (ESI): m/z $[M+H]^+$ calcd for $C_9H_8ClO_3^+$: 199.0167; found: 199.0161.

Methyl (4-(trifluoromethyl)benzyl) carbonate (3h)



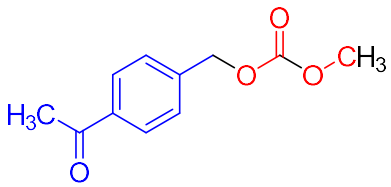
Eluent: PE : EA = 3:1; Colorless oil, 23.4 mg, 50% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.64 (d, J = 8.1 Hz, 2H), 7.50 (d, J = 8.0 Hz, 2H), 5.22 (s, 2H), 3.82 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.6, 139.2, 134.1, 128.1, 127.7, 125.6 (q, J = 3.8 Hz), 68.51, 55.08; HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{10}H_{10}F_3O_3^+$: 233.0431; found: 233.0426.

4-Cyanobenzyl methyl carbonate (3i)[14]



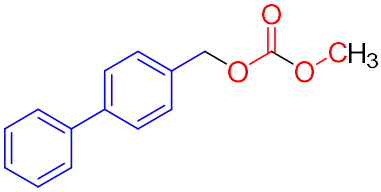
Eluent: PE : EA = 3:1; White solid, 24.9 mg, 65% yield. m.p. 95 - 97 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.66 (d, J = 8.3 Hz, 2H), 7.48 (d, J = 8.3 Hz, 2H), 5.20 (s, 2H), 3.81 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.4, 140.5, 132.4, 128.2, 118.5, 112.3, 68.2, 55.2.

4-Acetylbenzyl methyl carbonate (3j)



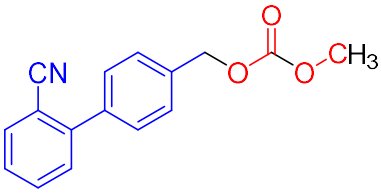
Eluent: PE : EA =5:1; Colorless oil, 20.0 mg, 48% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.96 (d, J = 8.2 Hz, 2H), 7.46 (d, J = 8.2 Hz, 2H), 5.21 (s, 2H), 3.81 (s, 3H), 2.60 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 197.6, 155.6, 140.4, 137.0, 128.6, 127.9, 68.7, 55.0, 26.6; HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{11}H_{13}O_4^+$: 209.0808; found: 209.0807.

[1,1'-Biphenyl]-4-ylmethyl methyl carbonate (3k)



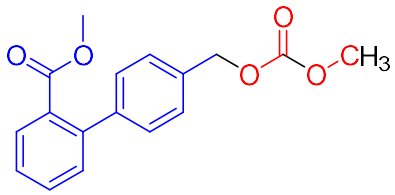
Eluent: PE : EA =5:1; Yellow solid, 34.8 mg, 72% yield. m.p. 91 - 93 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.64 – 7.61 (m, 4H), 7.49 (dd, J = 7.6, 5.2 Hz, 4H), 7.41 – 7.38 (m, 1H), 5.24 (s, 2H), 3.84 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.7, 141.4, 140.5, 134.2, 134.1, 128.7, 127.4, 127.3, 127.1, 69.3, 54.8; HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{15}H_{13}O_3^+$: 241.0870; found: 241.0869.

(2'-Cyano-[1,1'-biphenyl]-4-yl)methyl methyl carbonate (3l)



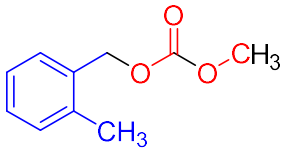
Eluent: PE : EA =5:1; Colorless oil, 31.5 mg, 59% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.78 – 7.75 (m, 1H), 7.66 – 7.62 (m, 1H), 7.57 (d, J = 8.3 Hz, 2H), 7.50 (dd, J = 8.1, 3.8 Hz, 3H), 7.47 – 7.43 (m, 1H), 5.23 (s, 2H), 3.82 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.6, 144.8, 138.2, 135.7, 133.7, 132.8, 130.0, 129.0, 128.5, 127.7, 118.5, 111.1, 69.0, 54.9; HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{16}H_{12}NO_3^+$: 266.0823; found: 266.0822.

Methyl 4'-(((methoxycarbonyl)oxy)methyl)-[1,1'-biphenyl]-2-carboxylate (3m)



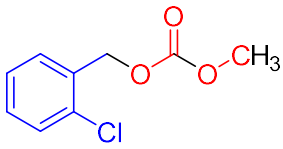
Eluent: PE : EA =5:1; Colorless oil, 21.2 mg, 55% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.85 (dd, J = 7.7, 1.1 Hz, 1H), 7.52 (td, J = 7.6, 1.4 Hz, 1H), 7.42 (d, J = 8.0 Hz, 3H), 7.36 – 7.31 (m, 3H), 5.22 (s, 2H), 3.81 (s, 3H), 3.65 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 168.7, 155.6, 141.9, 141.5, 134.1, 131.3, 130.6(4), 130.5(5), 129.8, 128.5, 127.9, 127.2, 69.3, 54.8, 51.9; HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{17}H_{15}O_5^+$: 299.0925; found: 299.0922.

Methyl (2-methylbenzyl) carbonate (3n)[15]



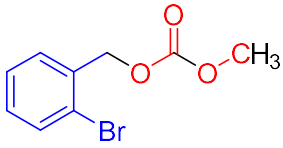
Eluent: PE : EA =15:1; Colorless oil, 28.8 mg, 80% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.38 – 7.34 (m, 1H), 7.29 – 7.24 (m, 1H), 7.21 (t, J = 5.5 Hz, 2H), 5.20 (s, 2H), 3.80 (s, 3H), 2.38 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.7, 137.0, 133.2, 130.3, 129.3, 128.8, 126.0, 68.0, 54.8, 18.8.

2-Chlorobenzyl methyl carbonate (3o)



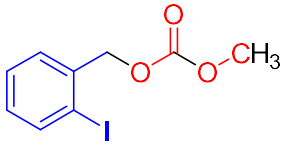
Eluent: PE : EA = 10:1; Yellow oil, 23.3 mg, 58% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.47 – 7.43 (m, 1H), 7.41 – 7.38 (m, 1H), 7.30 – 7.26 (m, 2H), 5.29 (s, 2H), 3.82 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.5, 133.6, 133.0, 129.8, 129.7, 129.6, 126.9, 66.8, 55.0; HRMS (ESI): m/z $[M+H]^+$ calcd for $C_9H_{10}ClO_3^+$: 201.0313; found: 201.0311.

2-Bromobenzyl methyl carbonate (3p)



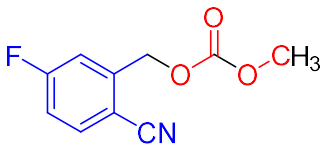
Eluent: PE : EA = 10:1; Brown oil, 31.7 mg, 65% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.58 (d, J = 8.0 Hz, 1H), 7.44 (d, J = 7.4 Hz, 1H), 7.32 (t, J = 7.5 Hz, 1H), 7.20 (t, J = 7.7 Hz, 1H), 5.26 (s, 2H), 3.82 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.5, 134.6, 132.8, 129.9, 129.7, 127.5, 123.2, 68.9, 55.0; HRMS (ESI): m/z $[M+H]^+$ calcd for $C_9H_{10}BrO_3^+$: 244.9808; found: 244.9806.

2-Iodobenzyl methyl carbonate (3q)



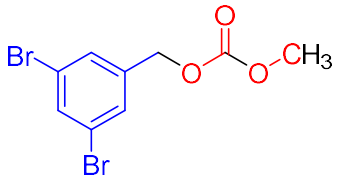
Eluent: PE : EA = 8:1; Colorless oil, 36.2 mg, 58% yield.^{1}H NMR (400 MHz, $CDCl_3$) δ 7.85 (d, J = 7.7 Hz, 1H), 7.41 (d, J = 7.5 Hz, 1H), 7.35 (t, J = 7.4 Hz, 1H), 7.03 (t, J = 7.6 Hz, 1H), 5.19 (s, 2H), 3.83 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.4, 139.5, 137.7, 130.0, 129.3, 128.4, 98.0, 73.1, 55.0; HRMS (ESI): m/z $[M+H]^+$ calcd for $C_9H_{10}IO_3^+$: 292.9669; found: 292.9668.

2-Cyano-5-fluorobenzyl methyl carbonate (3r)



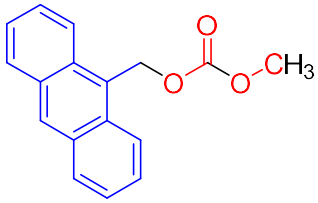
Eluent: PE : EA =5:1; Colorless oil, 27.6 mg, 66% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.70 (dd, J = 8.6, 5.3 Hz, 1H), 7.29 (dd, J = 8.9, 2.5 Hz, 1H), 7.14 (td, J = 8.2, 2.5 Hz, 1H), 5.34 (s, 2H), 3.84 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.0 (d, J = 257.4 Hz), 155.1, 142.2 (d, J = 9.0 Hz), 135.3 (d, J = 9.5 Hz), 116.5 (d, J = 3.2 Hz), 116.3 (d, J = 4.4 Hz), 116.0, 107.5 (d, J = 3.6 Hz), 66.1 (d, J = 1.4 Hz), 55.4; HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{10}H_9FNO_3^+$: 210.0561; found: 210.0560.

3,5-Bromobenzyl methyl carbonate (3s)



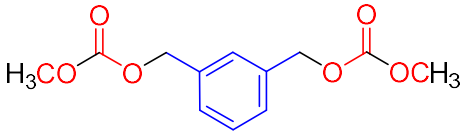
Eluent: PE : EA = 5:1; White solid, 32.8 mg, 51% yield. m.p. 69 - 71 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.63 (t, J = 1.7 Hz, 1H), 7.46 (d, J = 1.6 Hz, 2H), 5.08 (s, 2H), 3.82 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.4, 139.0, 134.2, 134.1, 129.8, 129.6, 123.1, 67.6, 55.2; HRMS (ESI): m/z $[M+H]^+$ calcd for $C_9H_7Br_2O_3^+$: 322.8747; found: 322.8745.

Anthracen-9-ylmethyl methyl carbonate (3t)



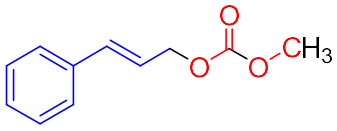
Eluent: PE : EA =5:1; Yellow solid, 15.9 mg, 30% yield. m.p. 88 - 90 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.51 (s, 1H), 8.40 (d, J = 8.9 Hz, 2H), 8.02 (d, J = 8.4 Hz, 2H), 7.62 – 7.57 (m, 2H), 7.53 – 7.47 (m, 2H), 6.23 (s, 2H), 3.81 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 156.0, 131.3, 131.1, 129.5, 129.0, 126.8, 125.3, 125.1, 123.8, 62.3, 54.9; HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{17}H_{14}O_3^+$: 266.0943; found: 266.0937.

1,3-Phenylenebis(methylene) dimethyl bis(carbonate) (3u)



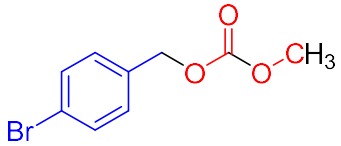
Eluent: PE : EA =5:1; Yellow oil, 27.9 mg, 55% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 (s, 1H), 7.37 (d, J = 4.0 Hz, 3H), 5.16 (s, 4H), 3.80 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.6, 135.7, 128.9, 128.3, 128.0, 69.2, 54.9; HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{12}H_{15}O_6^+$: 255.0863; found: 255.0862.

Cinnamyl methyl carbonate (3v)[16]



Eluent: PE : EA =5:1; Colorless oil, 21.2 mg, 55% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 (d, J = 7.1 Hz, 2H), 7.33 (t, J = 7.3 Hz, 2H), 7.29 – 7.26 (m, 1H), 6.70 (d, J = 15.9 Hz, 1H), 6.34 – 6.27 (m, 1H), 4.80 (d, J = 7.7 Hz, 2H), 3.81 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.6, 136.0, 134.8, 128.6, 128.2, 126.7, 122.4, 68.4, 54.8.

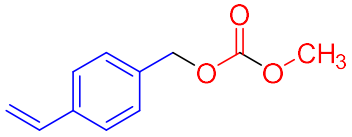
4-Bromobenzyl methyl carbonate (3w)



Eluent: PE : EA =10:1; White solid, 23.9 mg, 49% yield. m.p. 49 - 52 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49 (d, J = 8.3 Hz, 2H), 7.27 (s, 1H), 7.24 (d, J = 4.9 Hz, 1H), 5.10 (s, 2H), 3.80 (s, 3H);

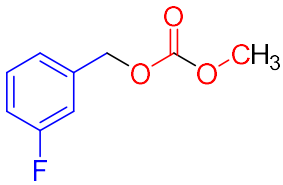
^{13}C NMR (100 MHz, $CDCl_3$) δ 155.6, 134.2, 131.7, 129.9, 122.6, 68.7, 55.0; HRMS (ESI): m/z $[M+H]^+$ calcd for $C_9H_8BrO_3^+$: 242.9662; found: 242.9655.

Methyl (4-vinylbenzyl) carbonate (3x)



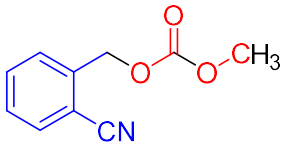
Eluent: PE : EA =5:1; Colorless oil, 17.3 mg, 45% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.41 (d, J = 8.1 Hz, 2H), 7.35 (d, J = 8.1 Hz, 2H), 6.72 (dd, J = 17.6, 10.9 Hz, 1H), 5.77 (d, J = 17.6 Hz, 1H), 5.27 (d, J = 10.9 Hz, 1H), 5.15 (s, 2H), 3.80 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.8, 137.9, 136.3, 134.7, 128.6, 126.4, 114.5, 69.4, 54.9; HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{11}H_{13}O_3^+$: 193.0859; found: 193.0858.

3-Fluorobenzyl methyl carbonate (3y)[17]



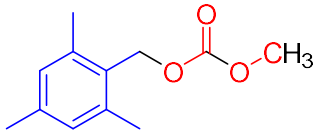
Eluent: PE : EA =10:1; Yellow oil, 18.4 mg, 50% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35 – 7.32 (m, 1H), 7.15 (d, J = 7.7 Hz, 1H), 7.10 (d, J = 9.5 Hz, 1H), 7.05 – 7.01 (m, 1H), 5.15 (s, 2H), 3.81 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 162.8 (d, J = 246.6 Hz), 155.6, 137.7 (d, J = 7.5 Hz), 130.2 (dd, J = 8.2, 3.2 Hz), 123.6 (dd, J = 5.9, 3.1 Hz), 115.4 (d, J = 21.1 Hz), 115.0 (d, J = 22.0 Hz), 68.7 (d, J = 2.0 Hz), 55.0.

2-Cyanobenzyl methyl carbonate (3z)



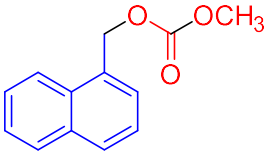
Eluent: PE : EA =5:1; Colorless oil, 23.9 mg, 60% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.69 (d, J = 7.7 Hz, 1H), 7.62 (t, J = 7.6 Hz, 1H), 7.57 (t, J = 7.1 Hz, 1H), 7.45 (t, J = 8.1 Hz, 1H), 5.35 (s, 2H), 3.83 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.3, 138.6, 134.1, 133.0 (d, J = 1.8 Hz), 129.1 (d, J = 22.4 Hz), 127.7, 116.8, 112.0, 66.8, 55.2; HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{10}H_{10}NO_3^+$: 192.0655; found: 192.0654.

Methyl (2,4,6-trimethylbenzyl) carbonate (3aa)



Eluent: PE : EA =10:1; Yellow oil, 29.9 mg, 72% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.88 (s, 2H), 5.25 (s, 2H), 3.78 (s, 3H), 2.38 (s, 6H), 2.27 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.9, 138.7, 138.3, 129.0, 128.3, 64.5, 54.7, 21.0, 19.5; HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{12}H_{15}O_3^+$: 207.1027; found: 207.1022.

Methyl (naphthalen-1-ylmethyl) carbonate (3ab)



Eluent: PE : EA =10:1; Yellow oil, 31.1 mg, 72% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.07 (d, J = 8.3 Hz, 1H), 7.90 (t, J = 8.1 Hz, 2H), 7.61 – 7.53 (m, 3H), 7.47 (t, 1H), 5.66 (s, 2H), 3.82 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.8, 133.8, 131.6, 130.8, 129.7, 128.8, 127.8, 126.8, 126.1, 125.3, 123.5, 68.0, 55.0; HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{13}H_{12}O_3^+$: 216.0786; found: 216.0781.

I. Reference

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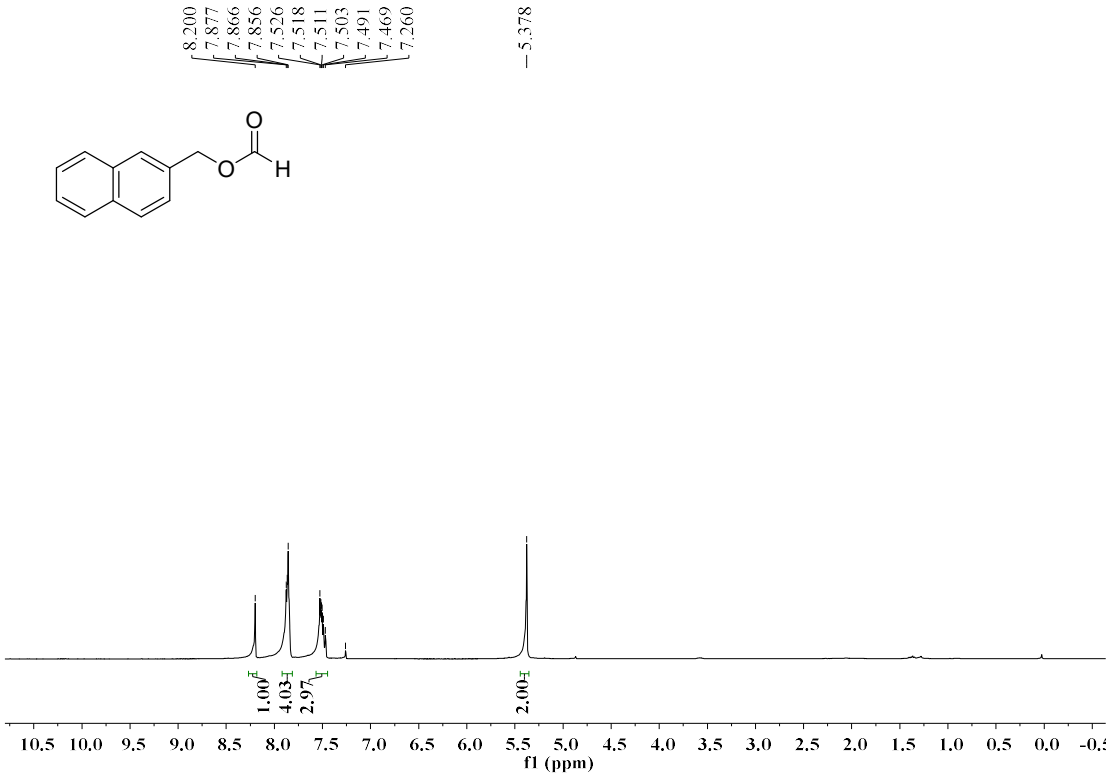
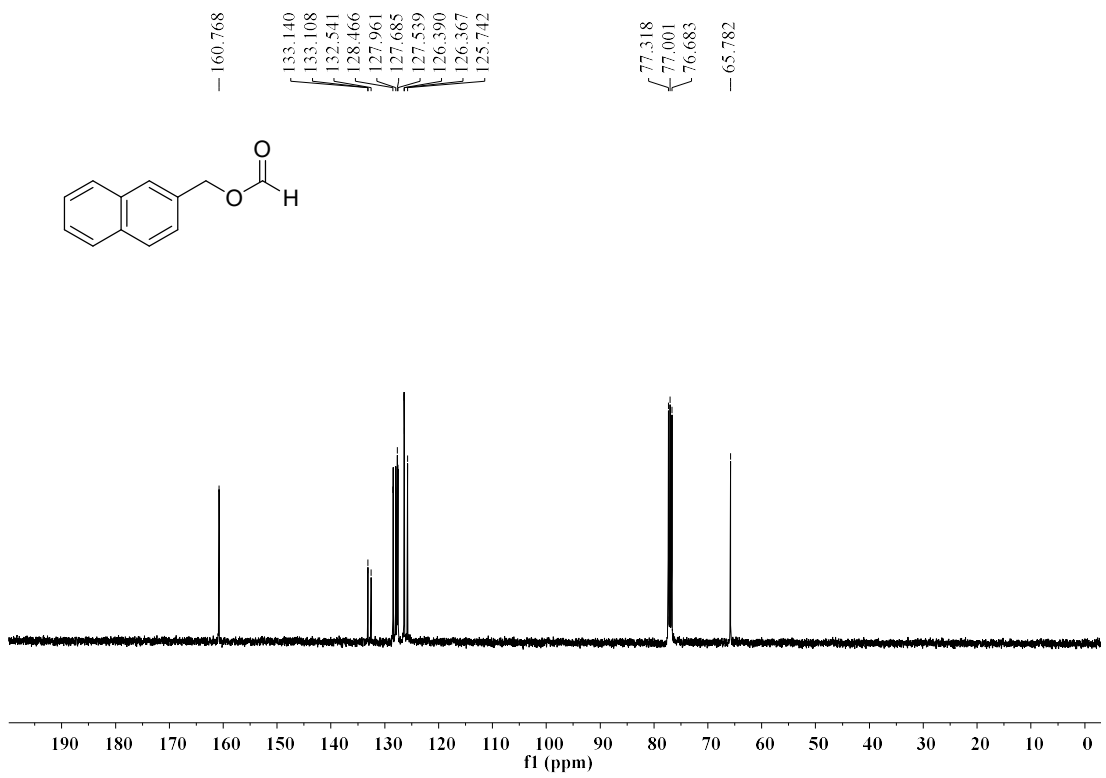
J. NMR spectra of products

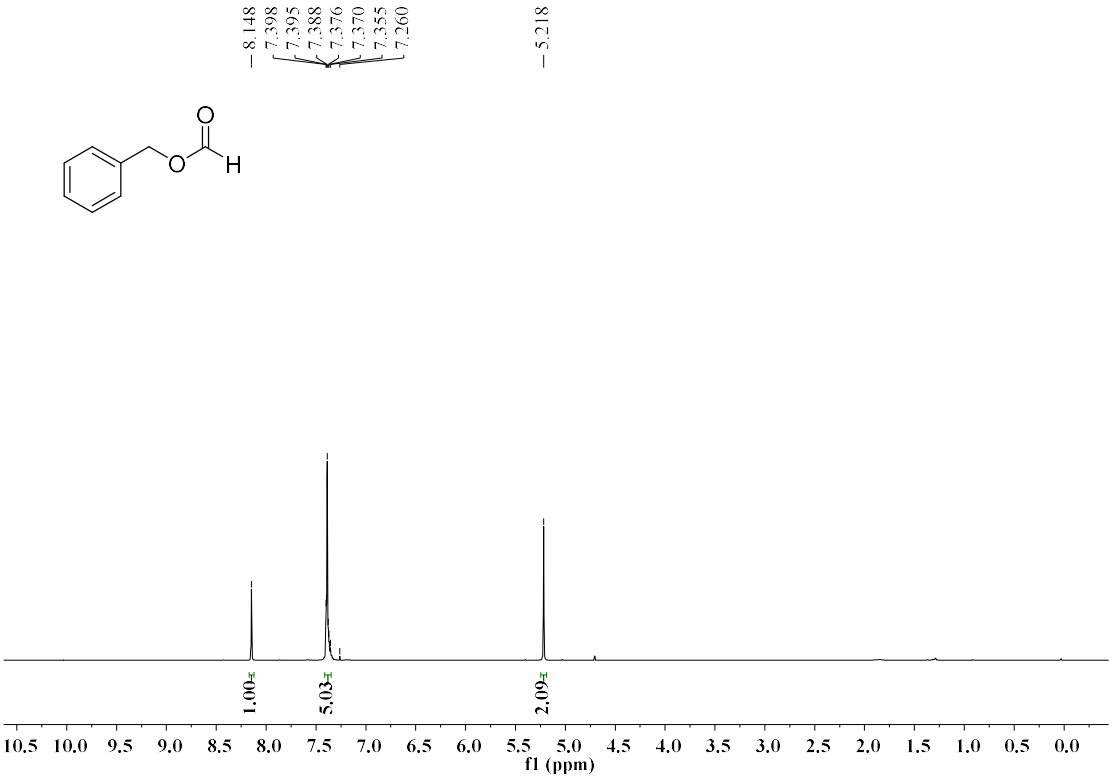
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2a



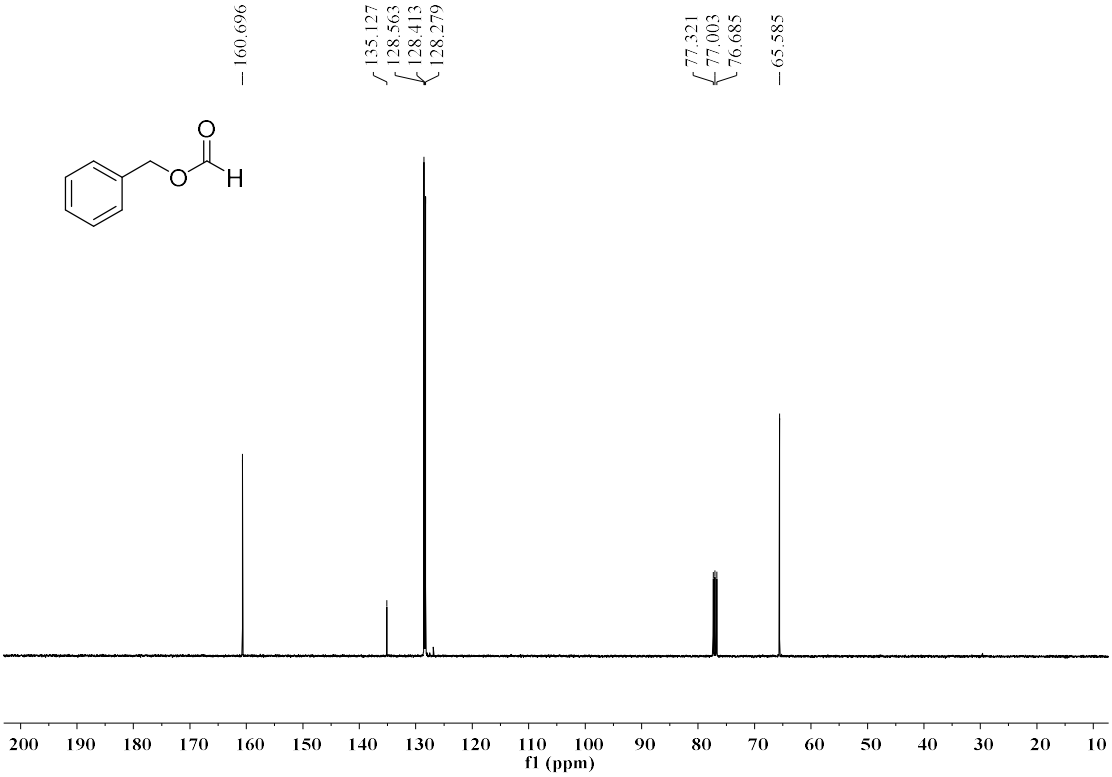
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2a



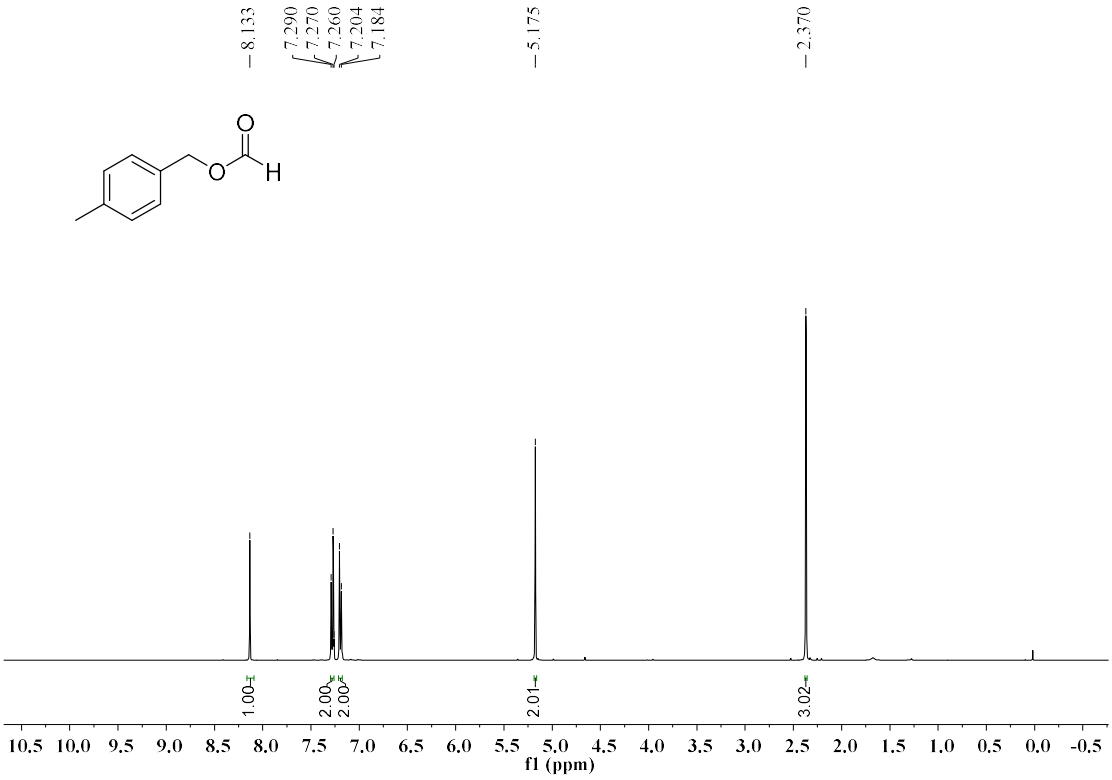
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2b



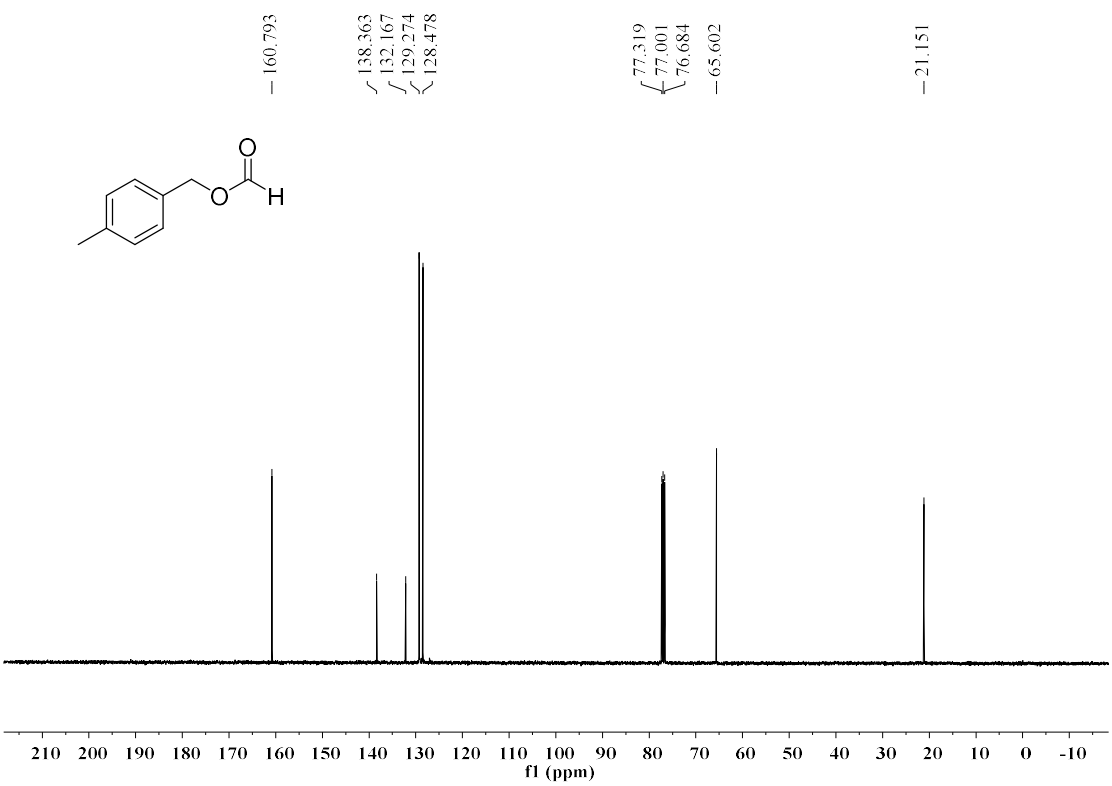
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2b



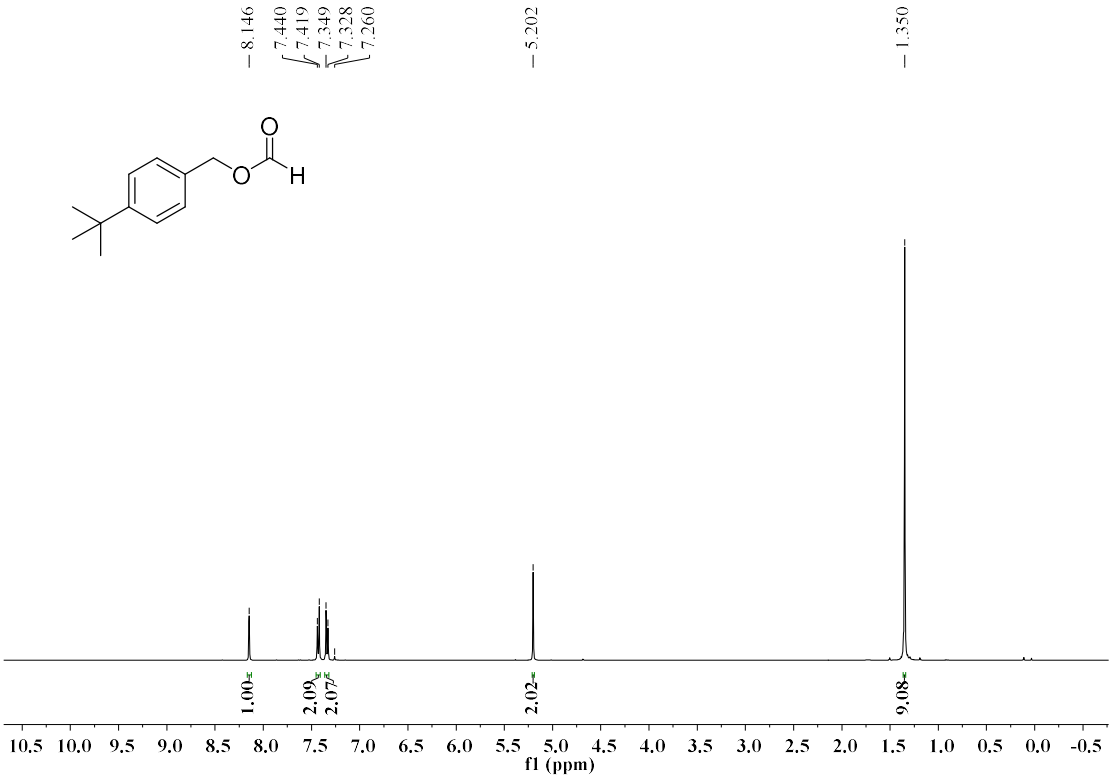
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2c



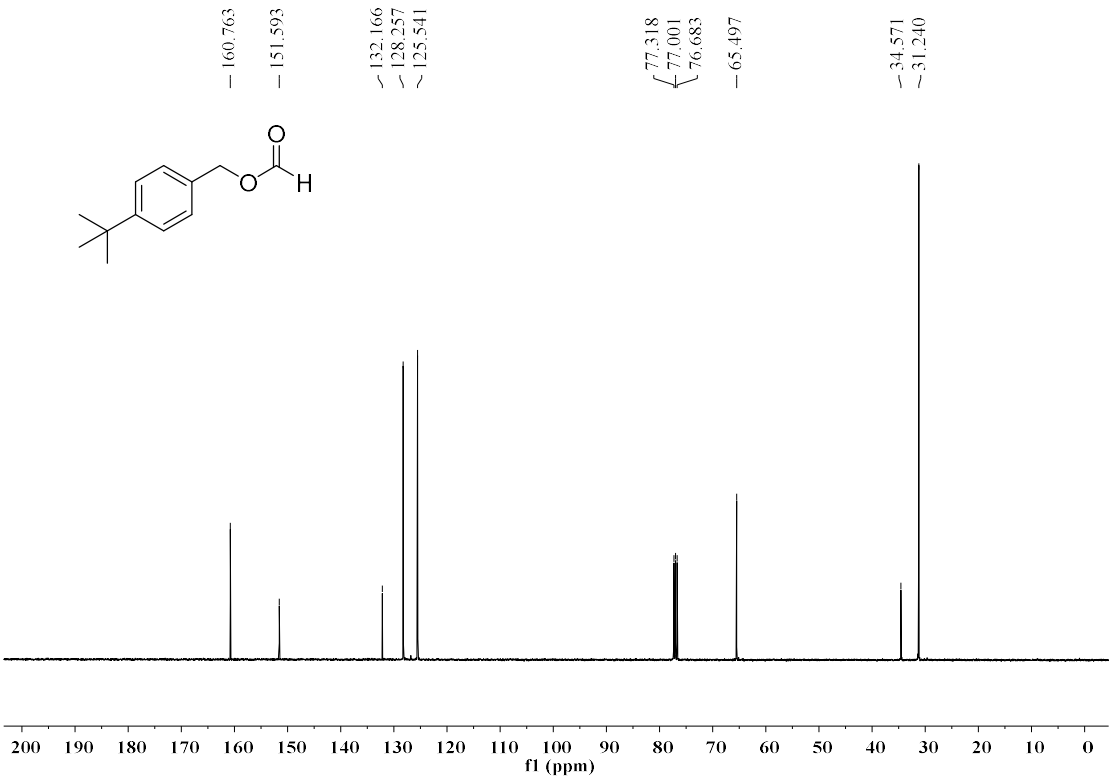
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2c



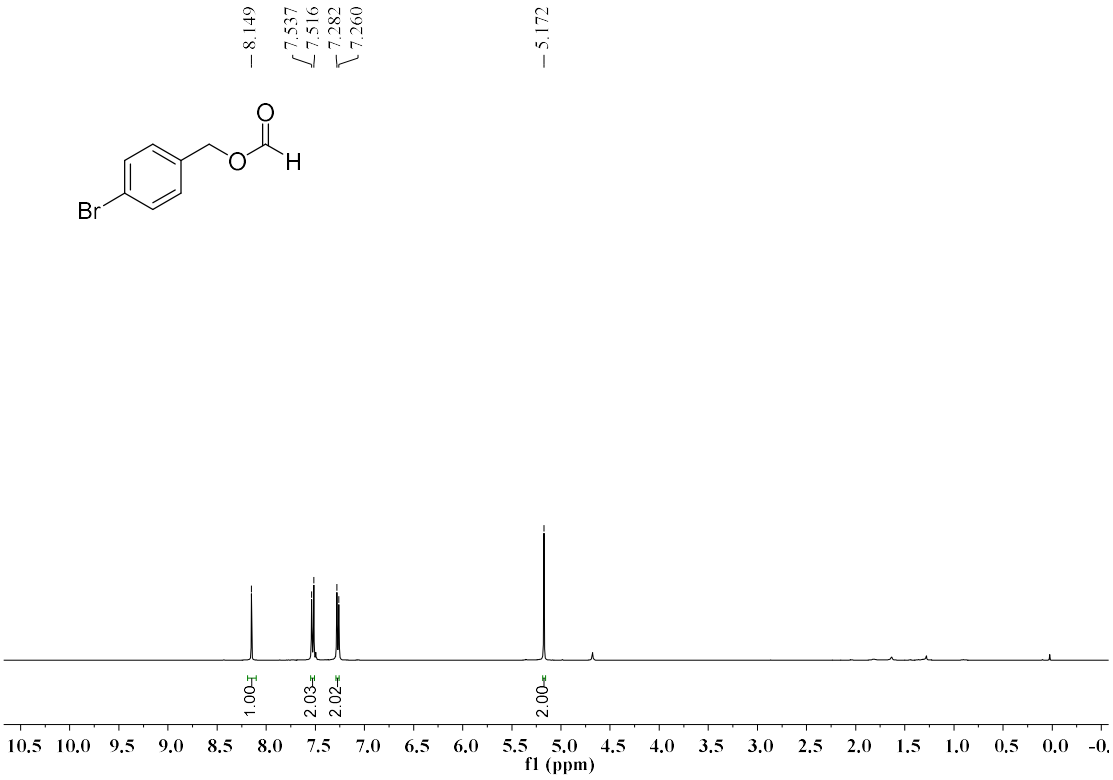
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2d



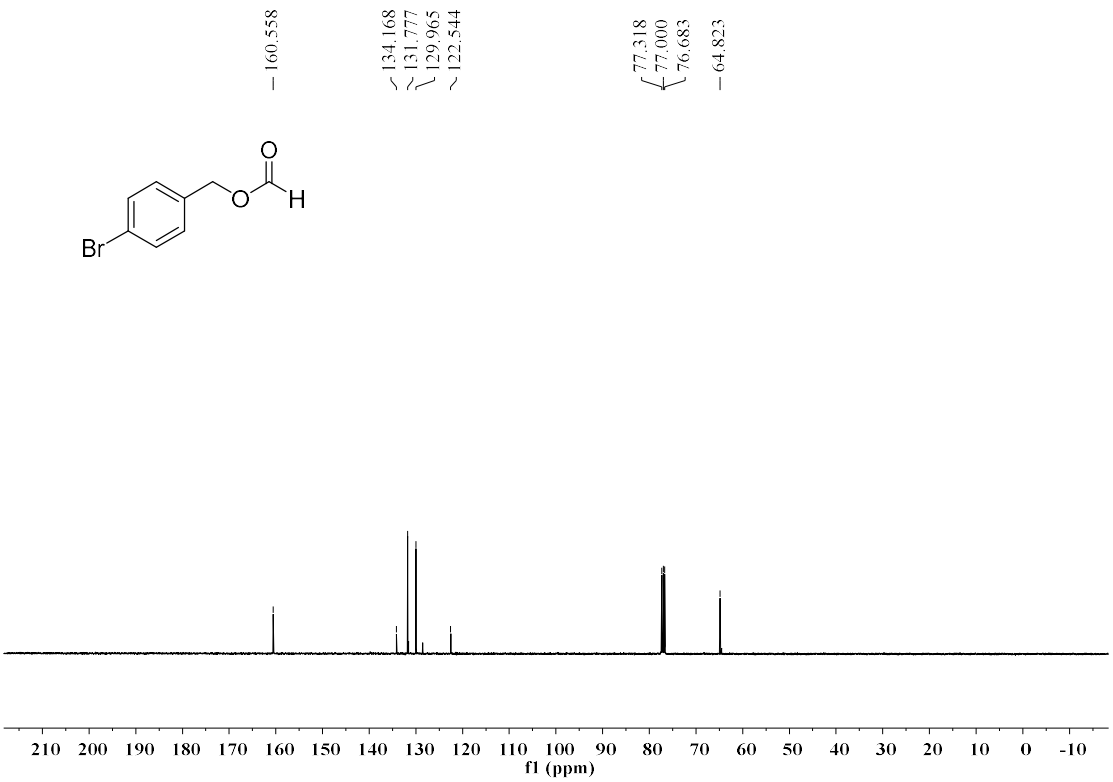
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2d



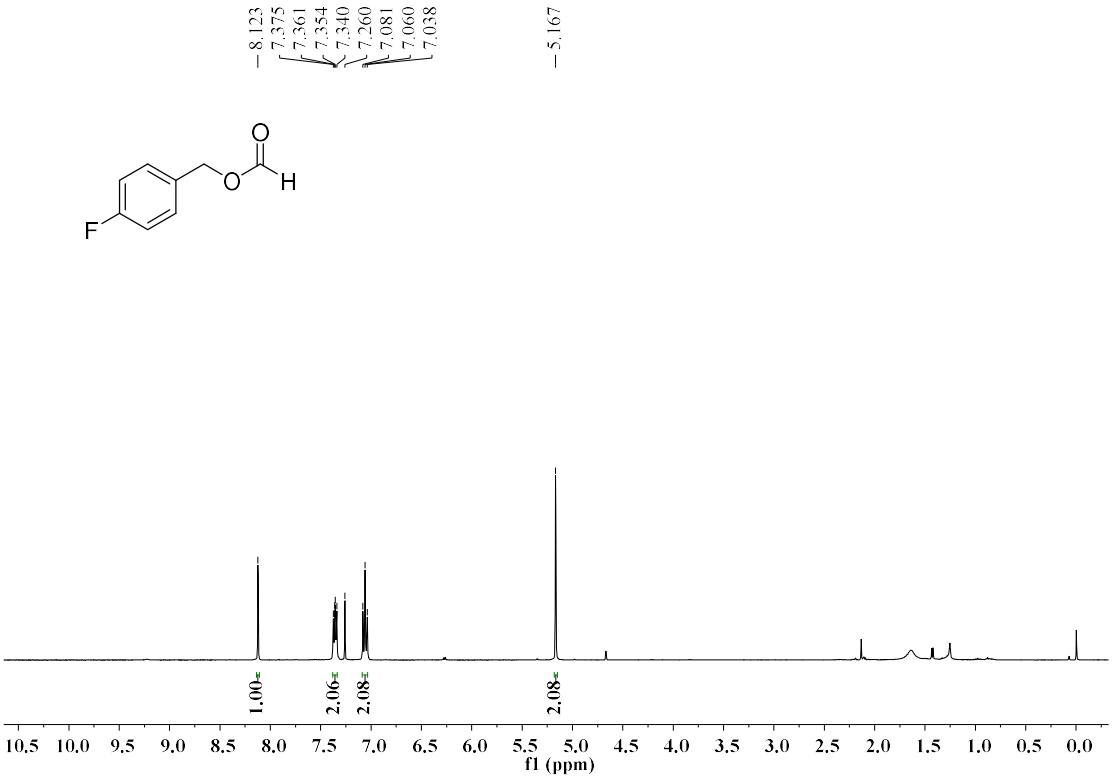
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2e



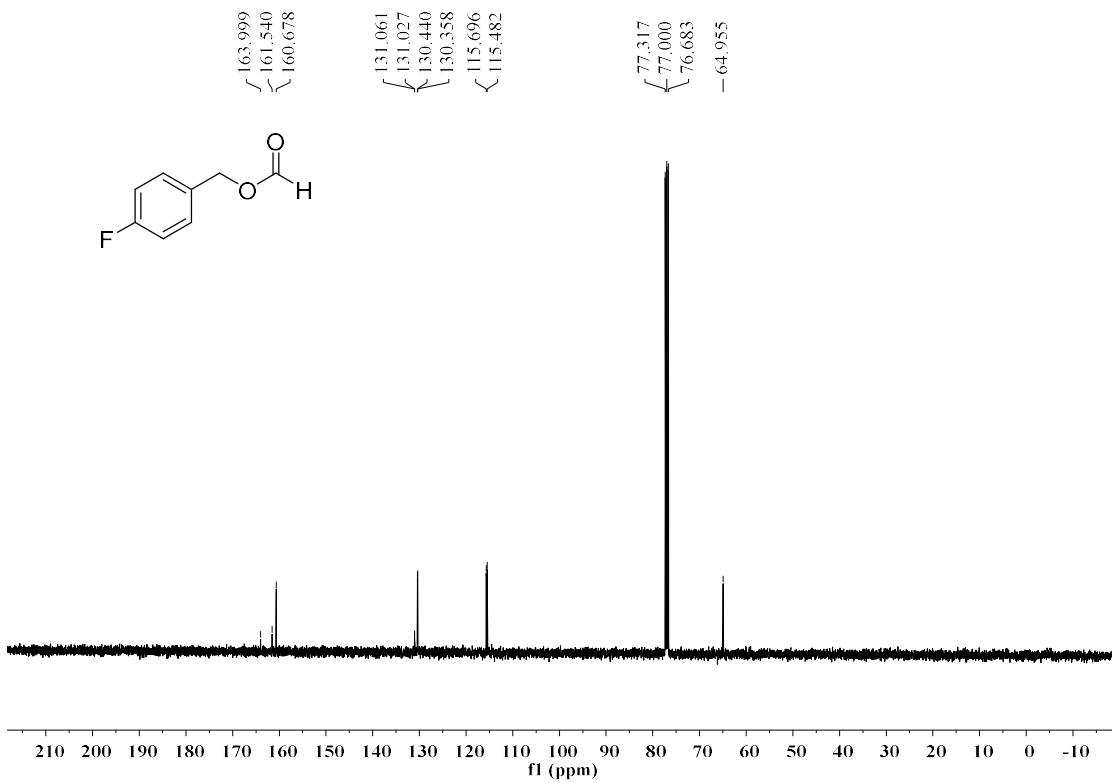
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2e



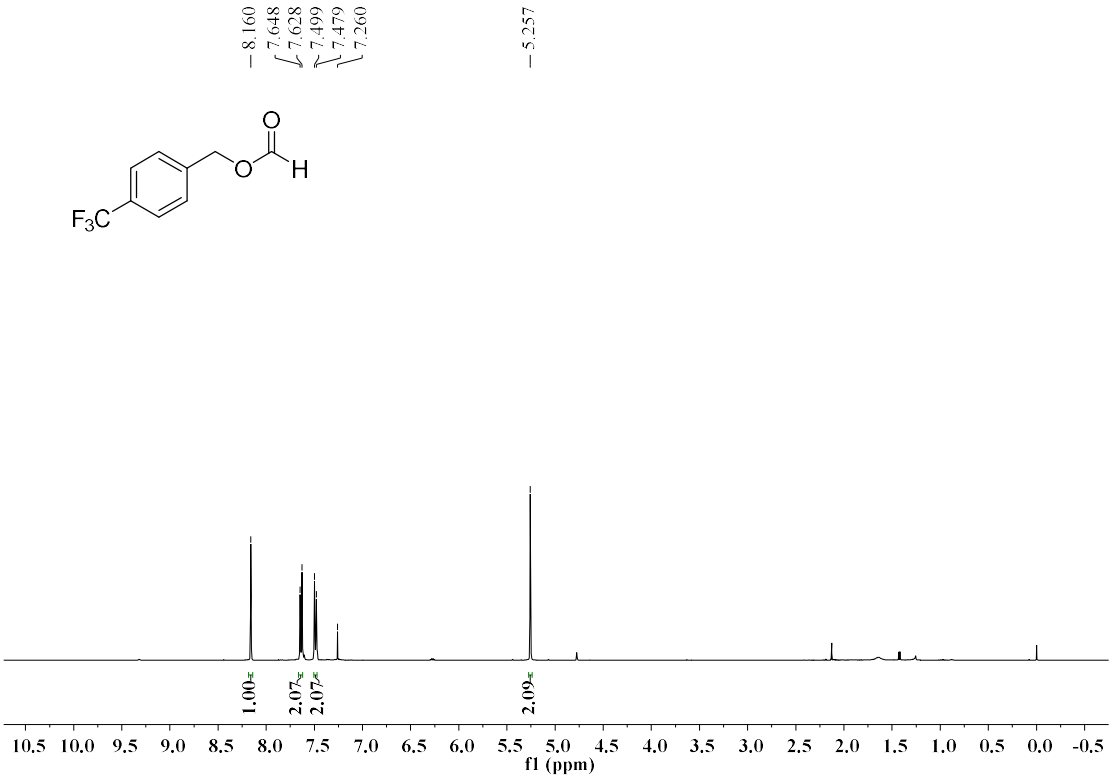
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2f



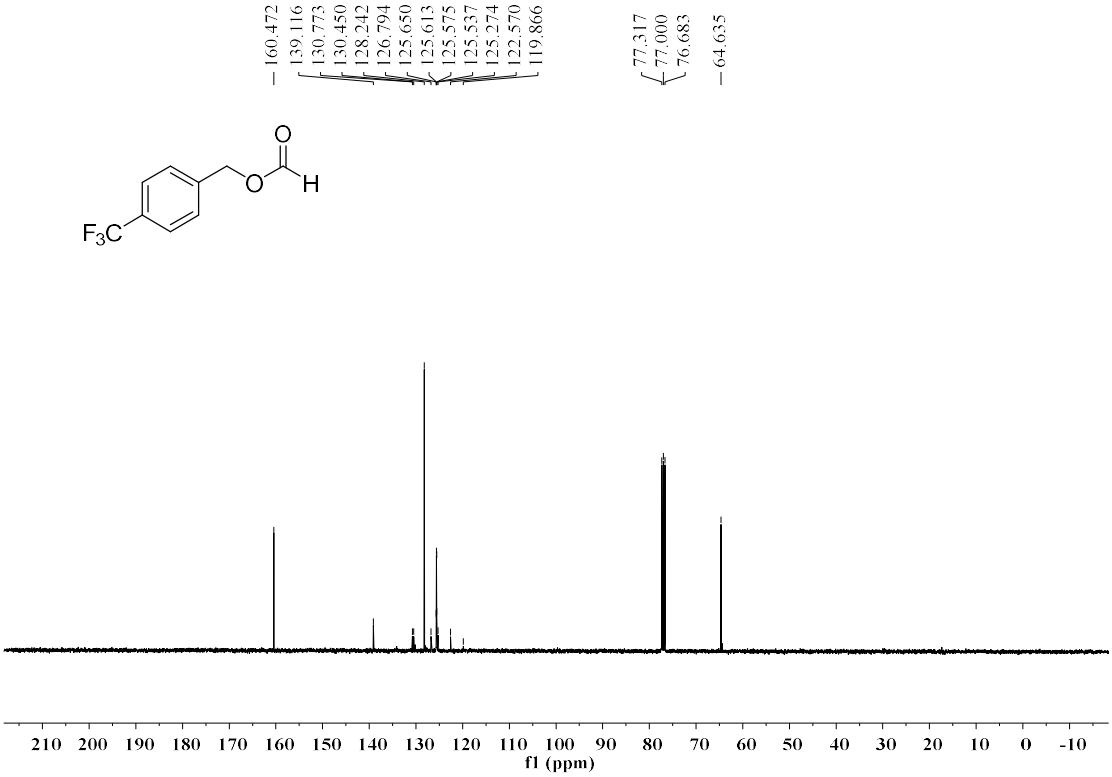
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2f



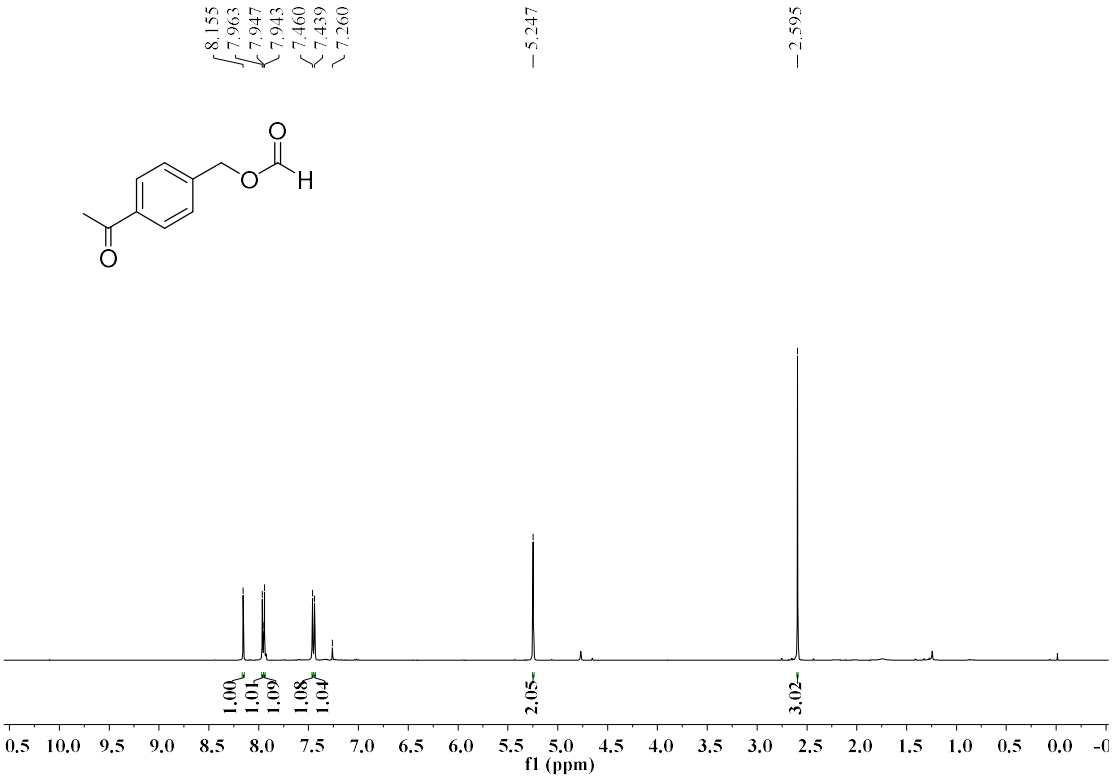
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2g



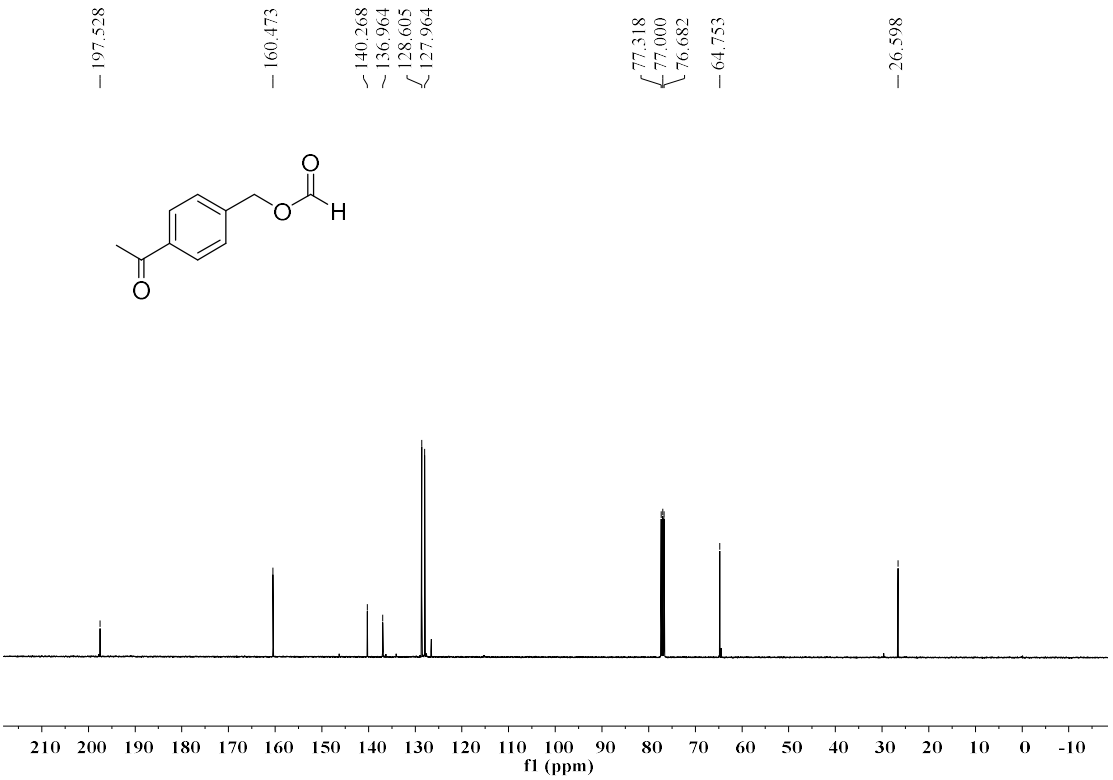
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2g



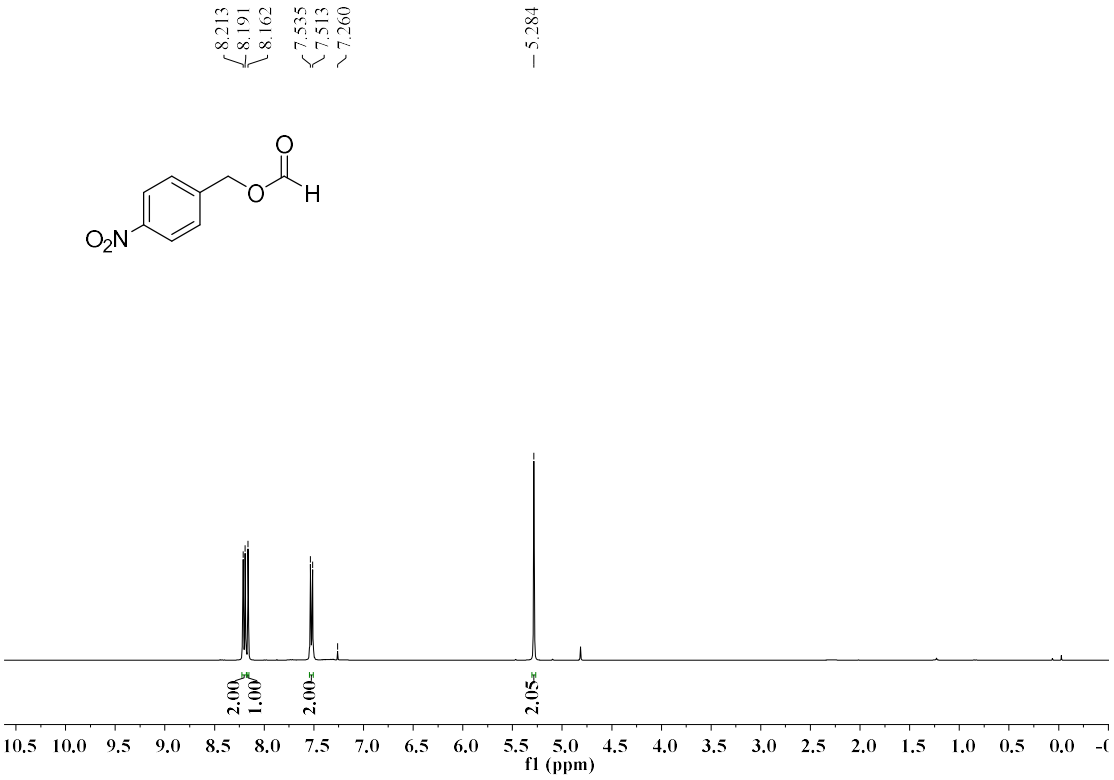
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2h



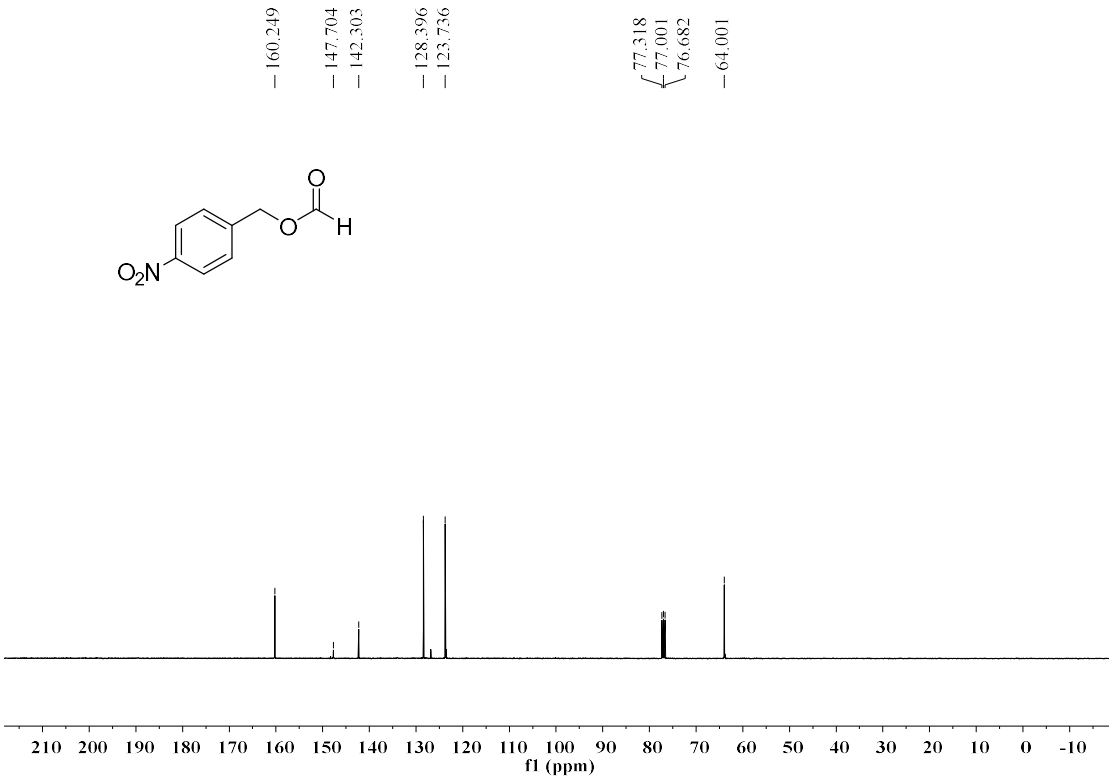
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2h



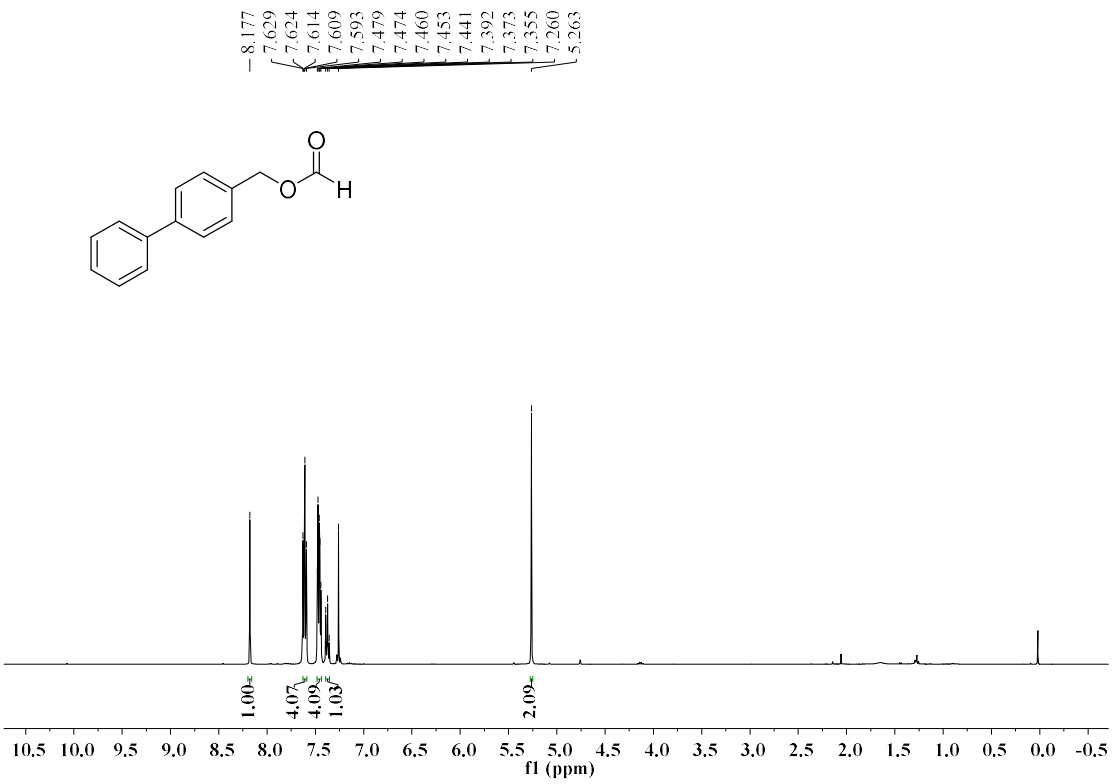
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2i



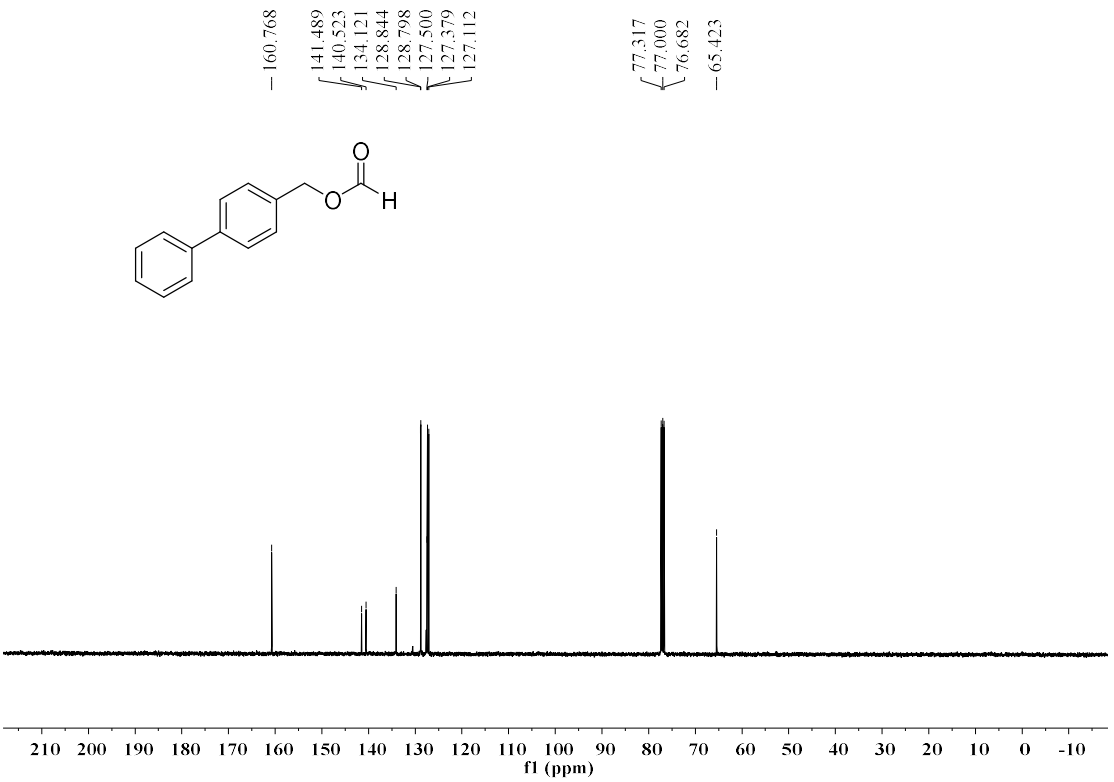
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2i



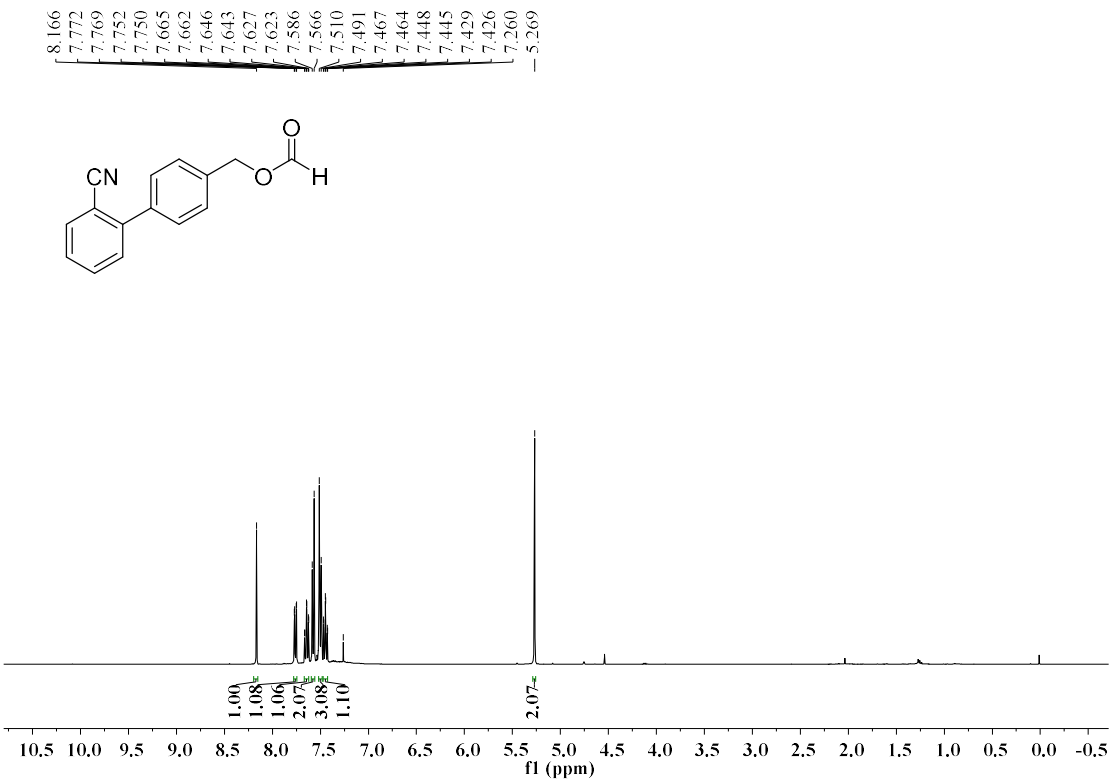
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2j



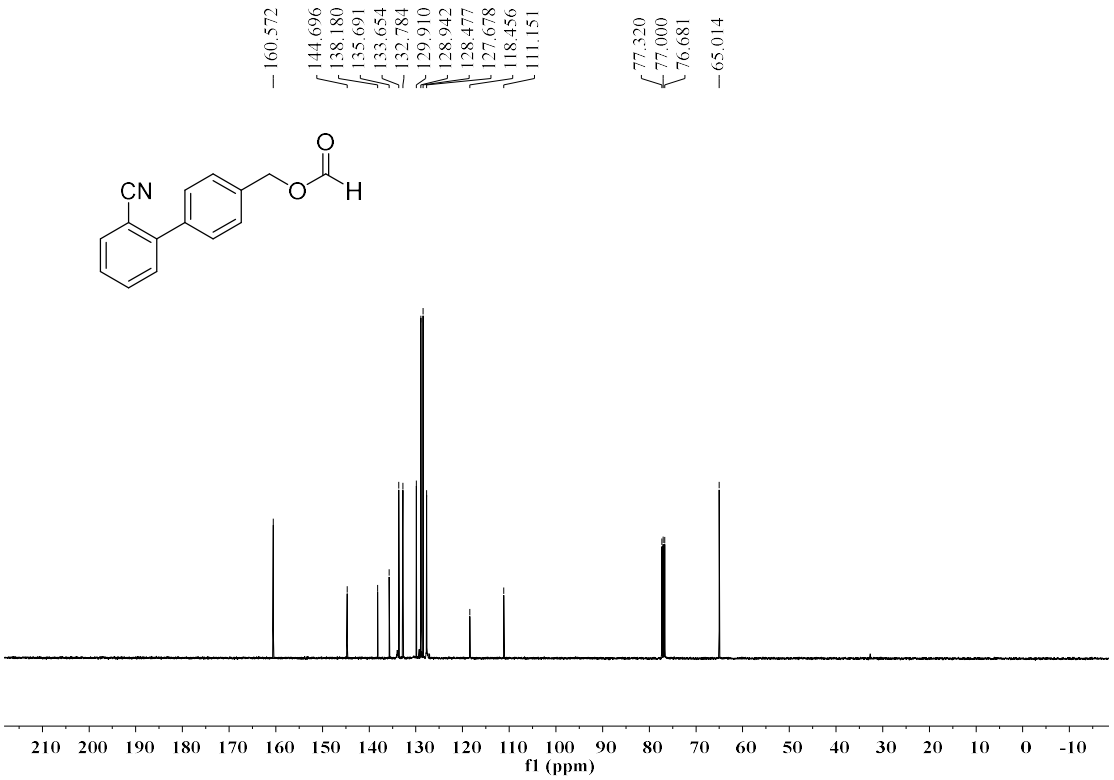
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2j



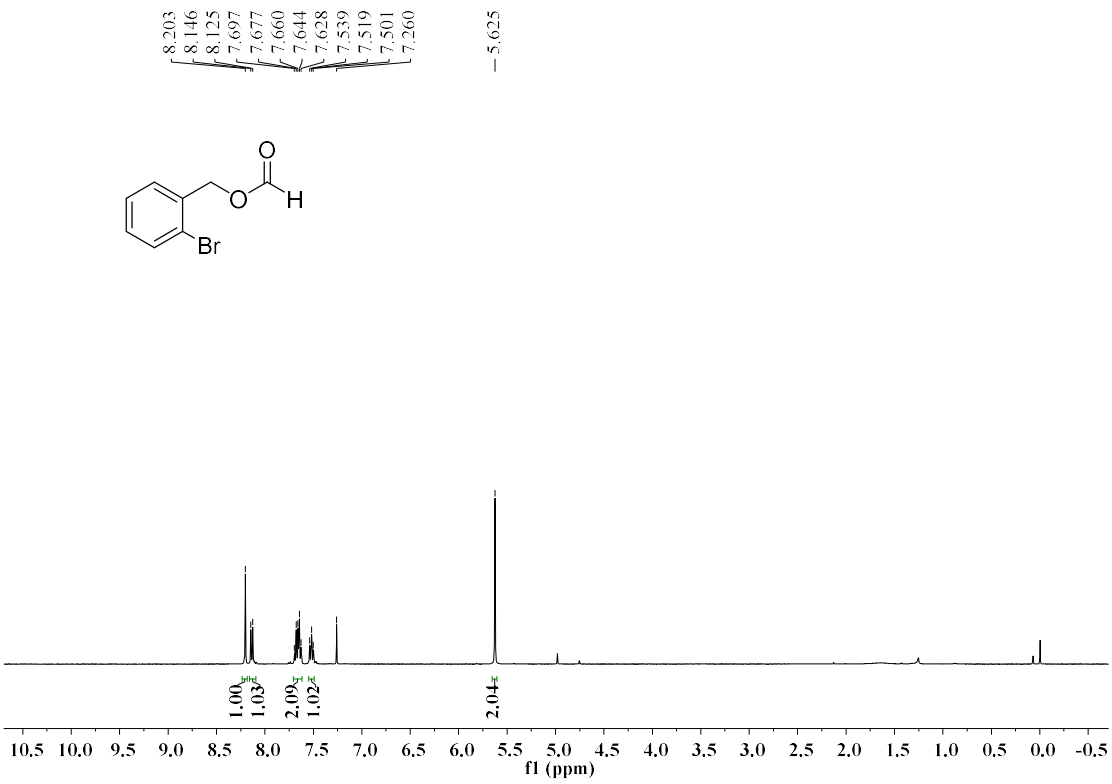
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2k



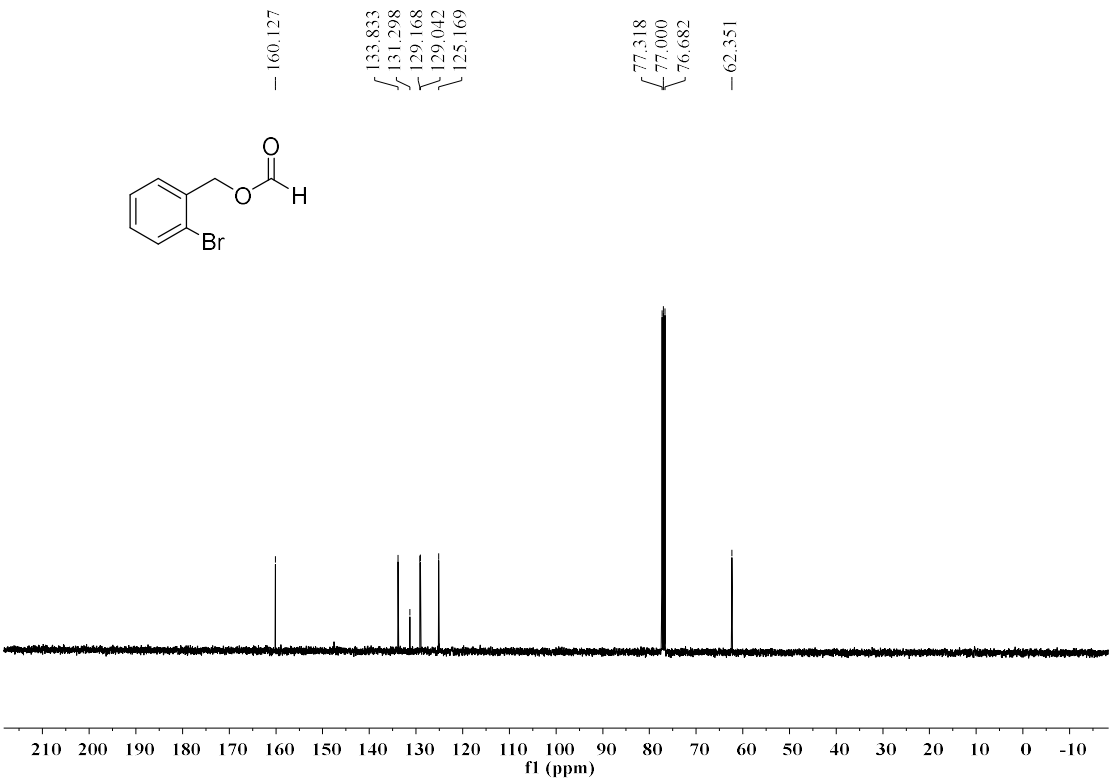
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2k



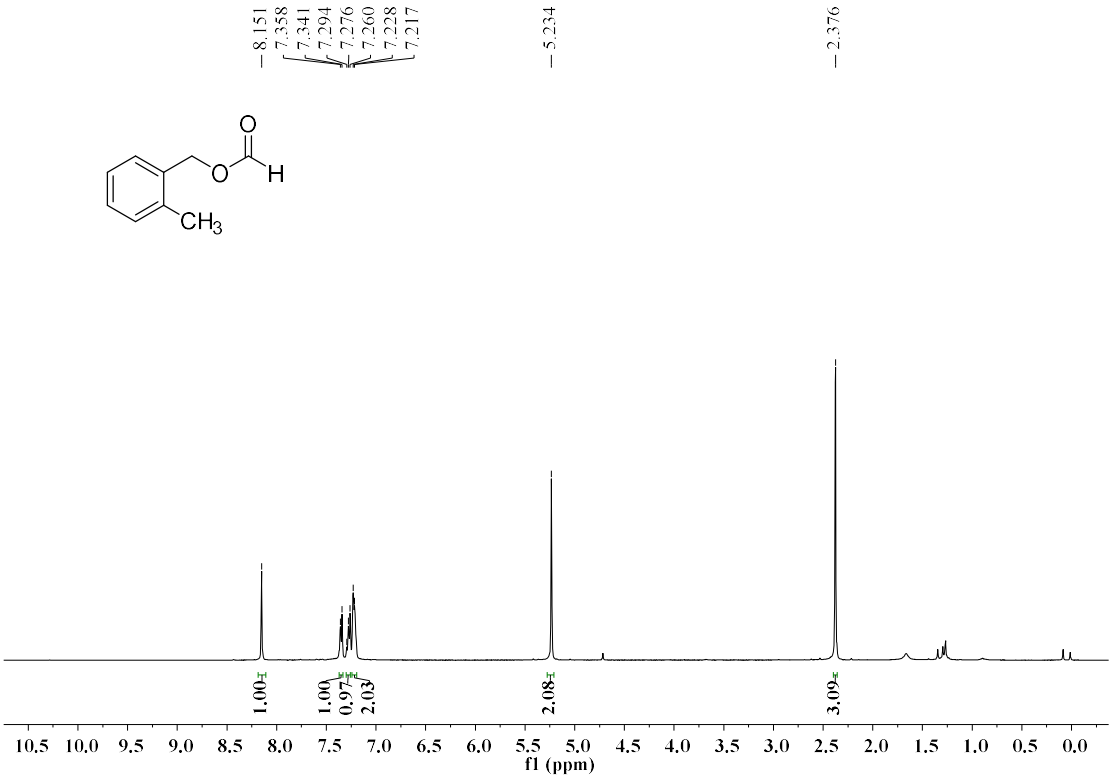
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2l



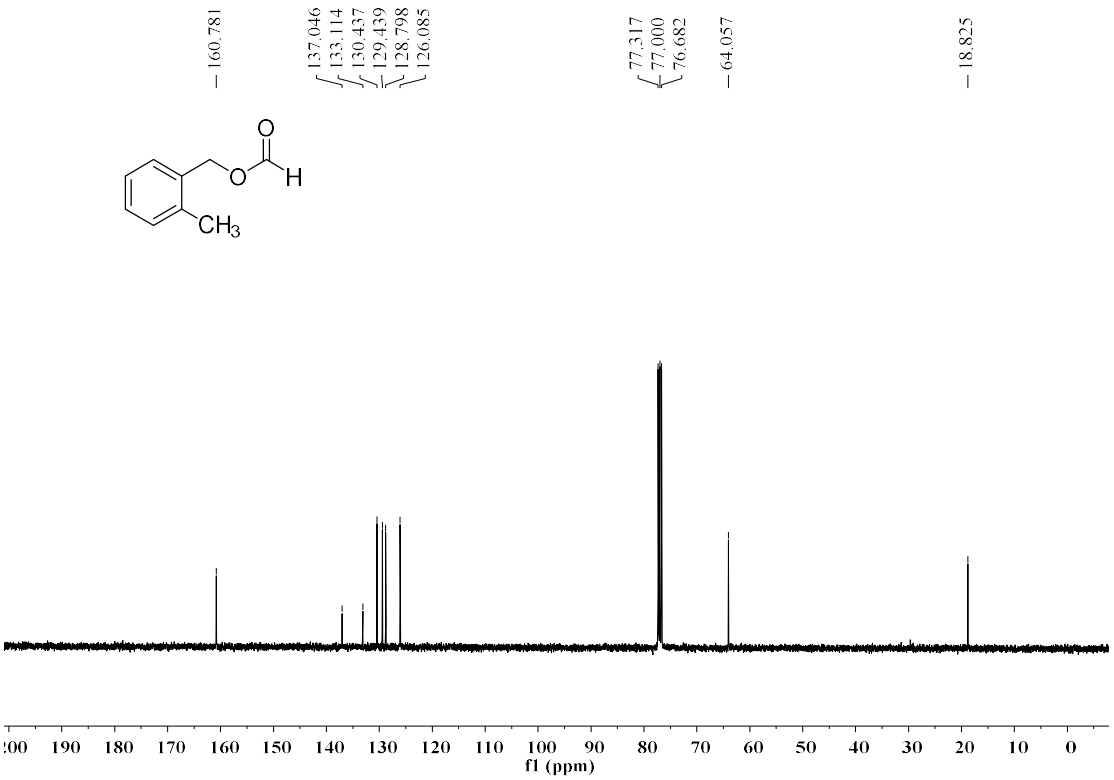
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2l



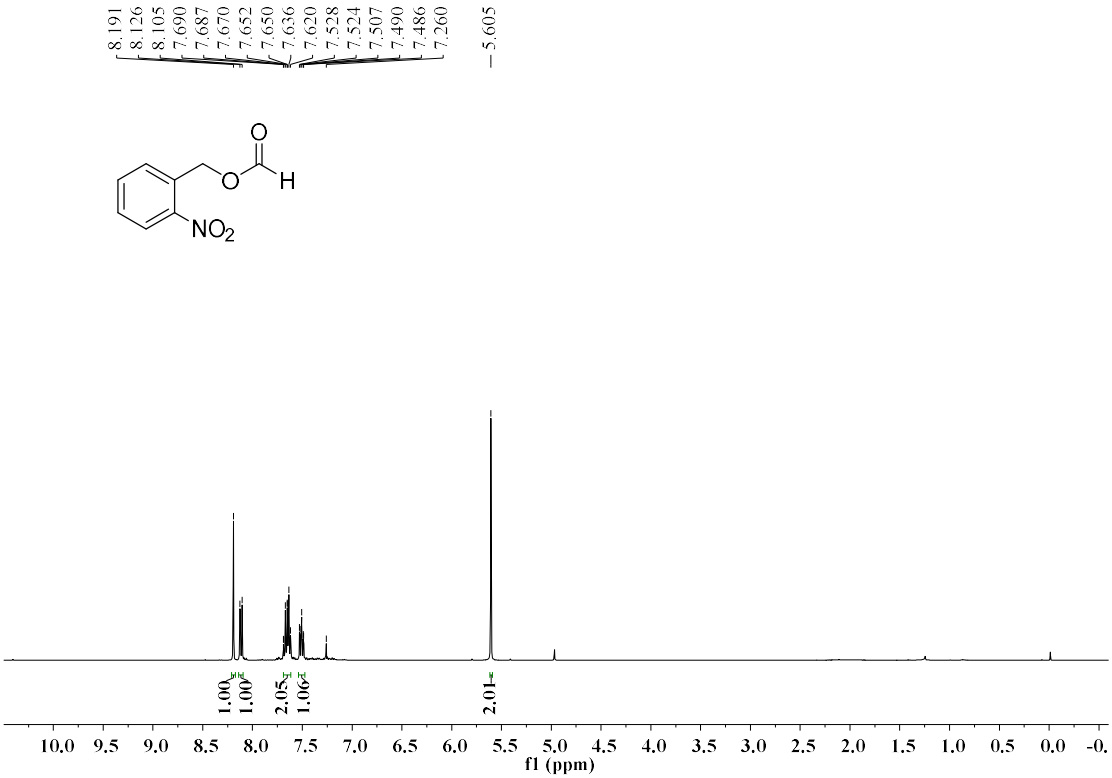
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2m



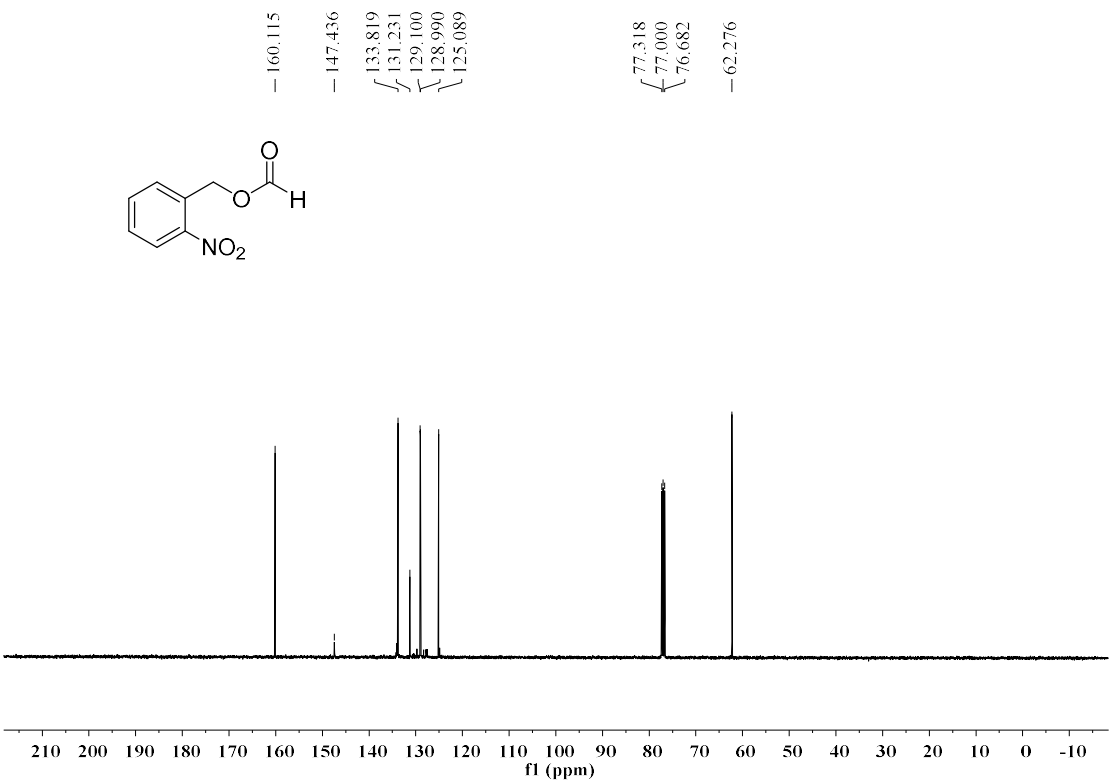
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2m



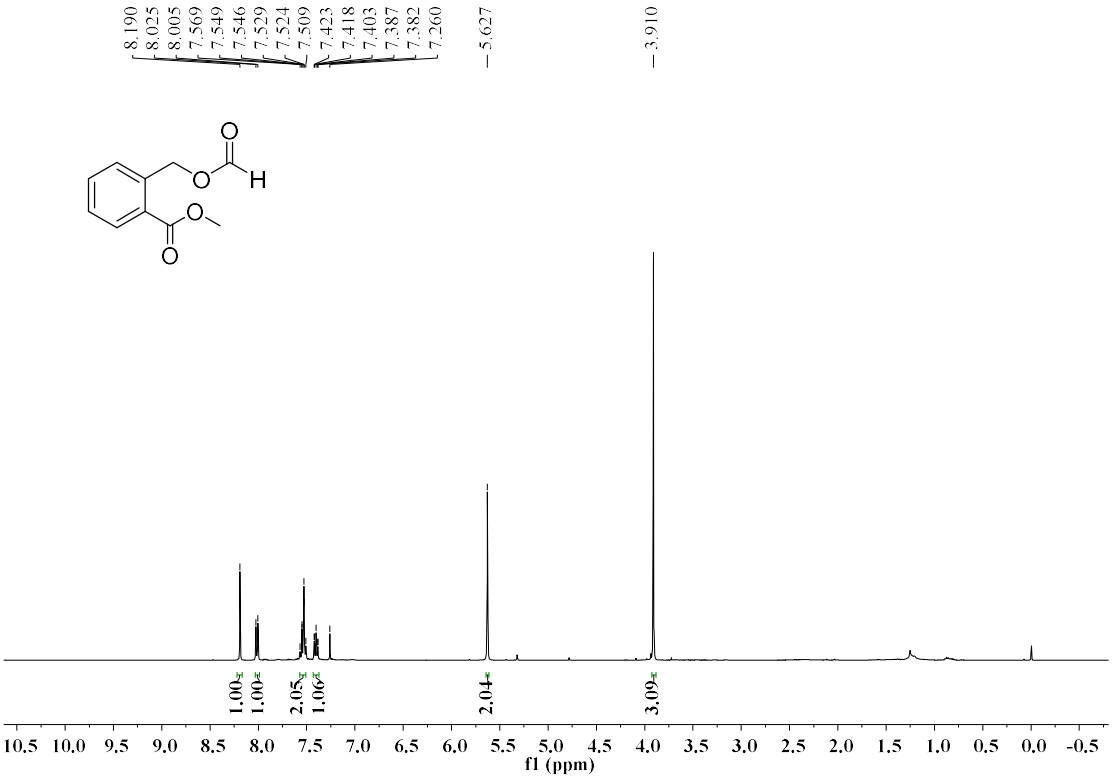
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2n



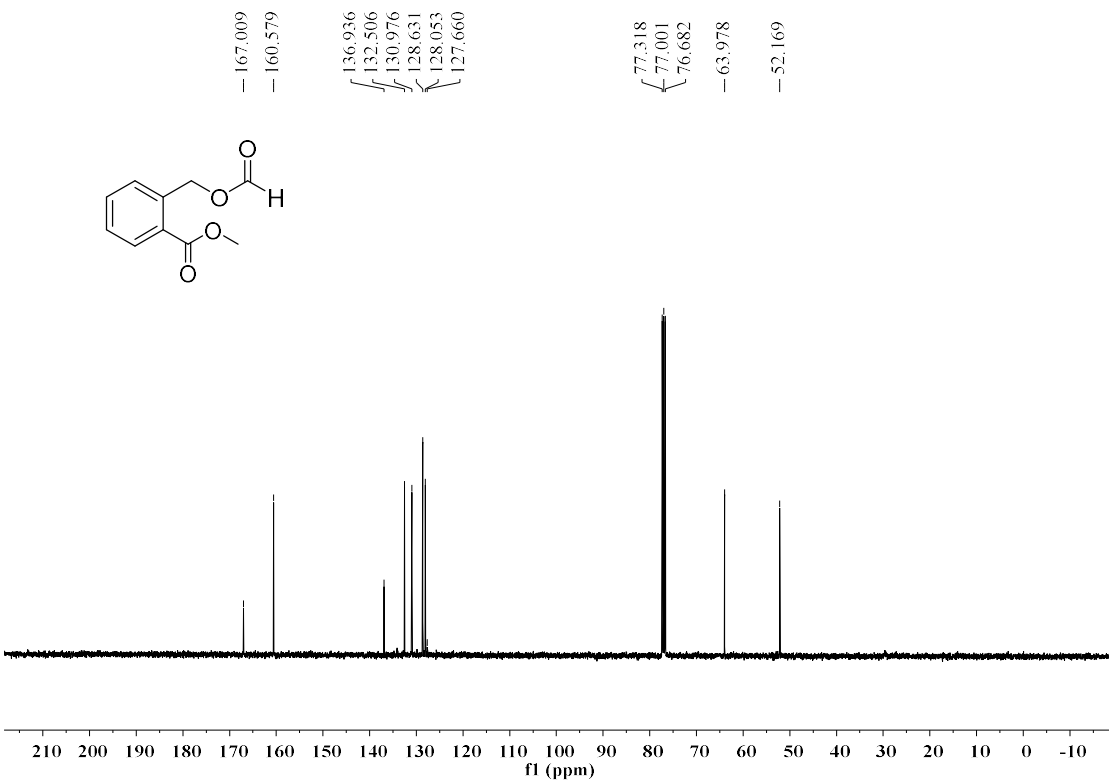
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2n



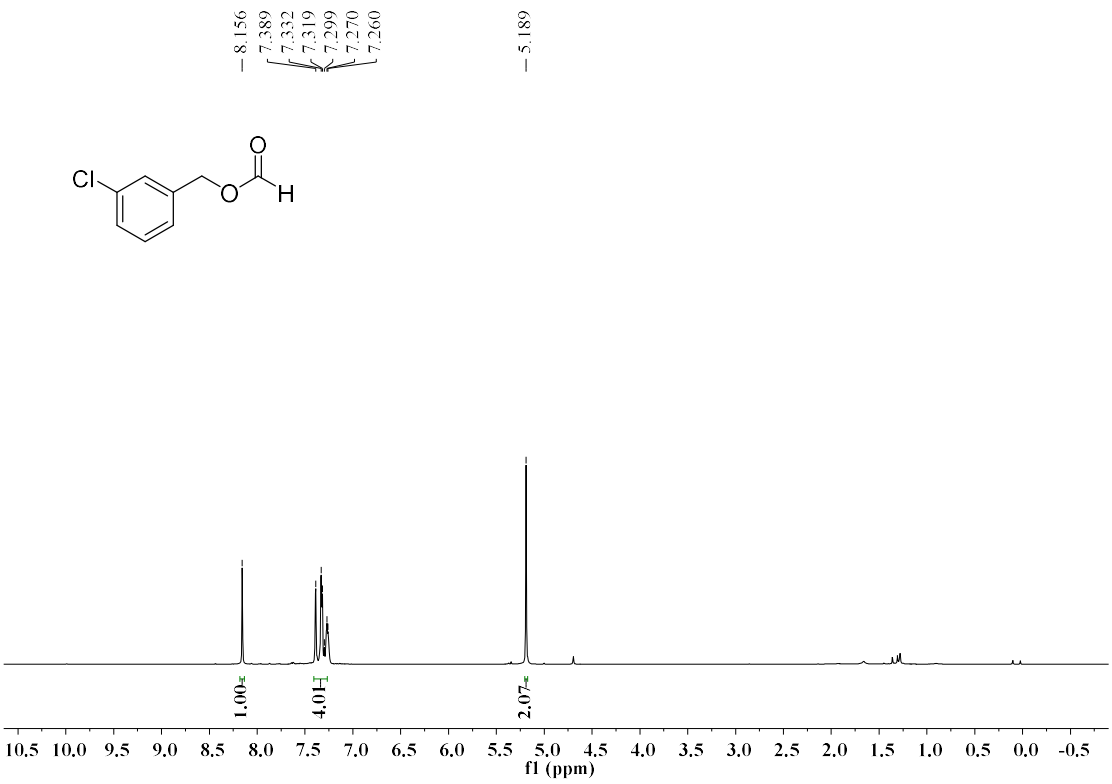
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2o



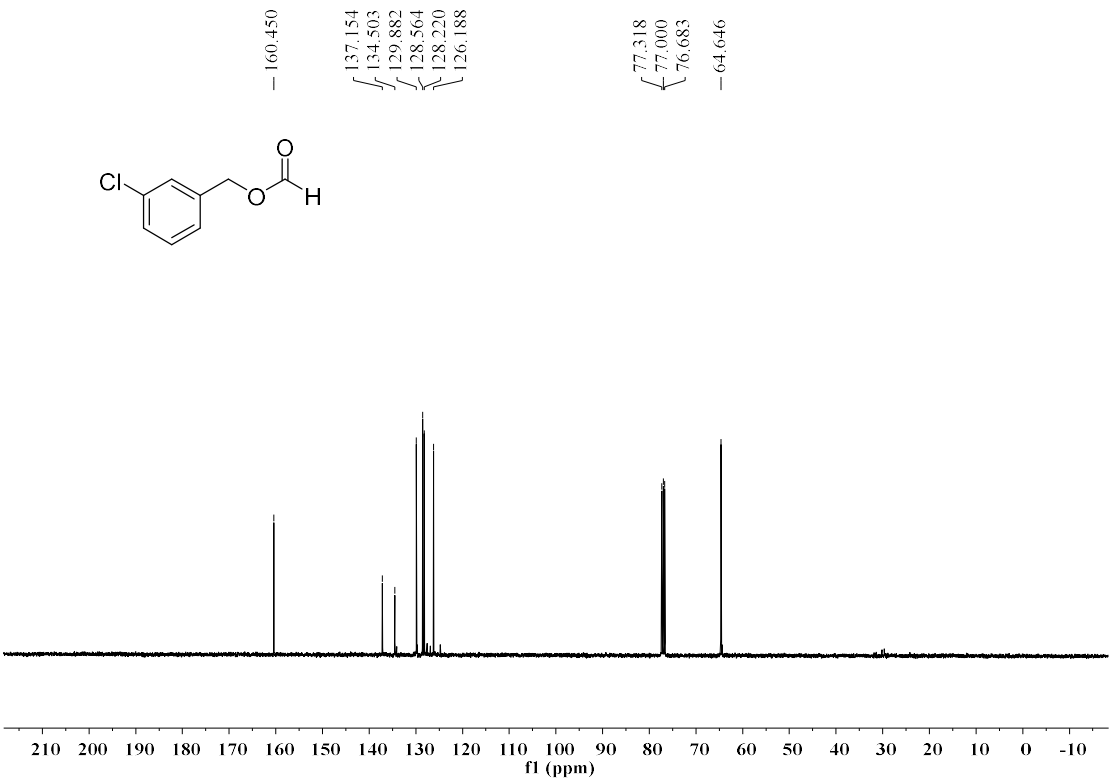
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2o



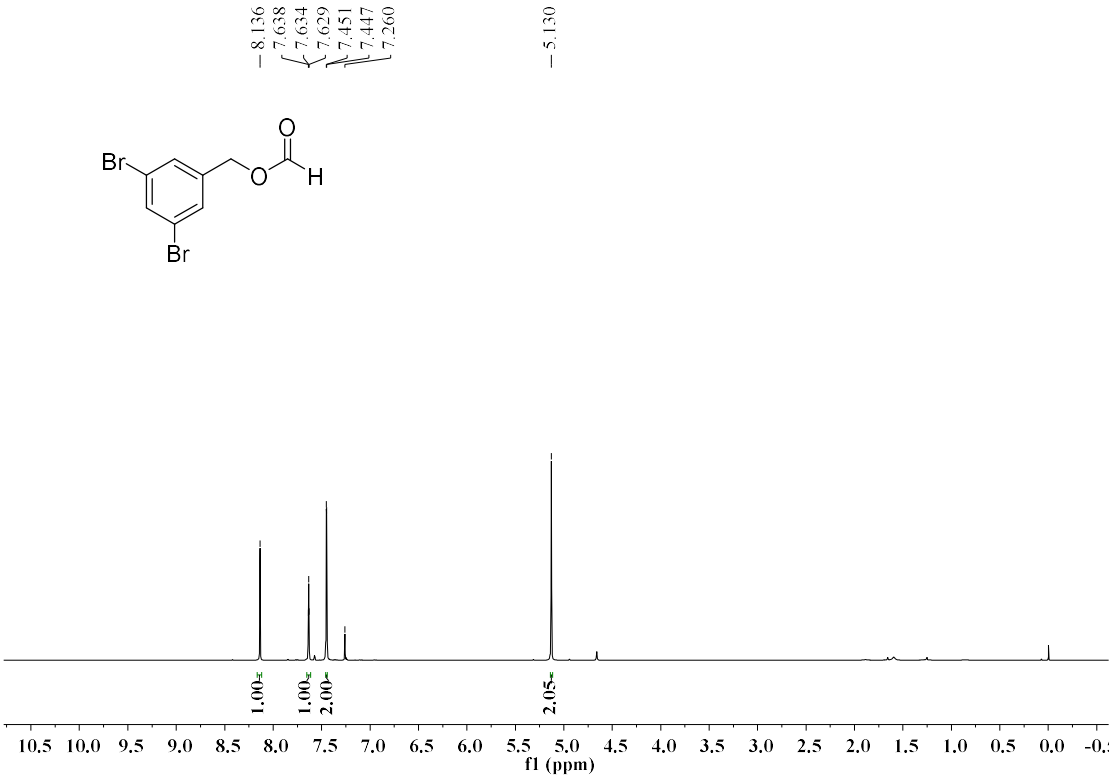
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2p



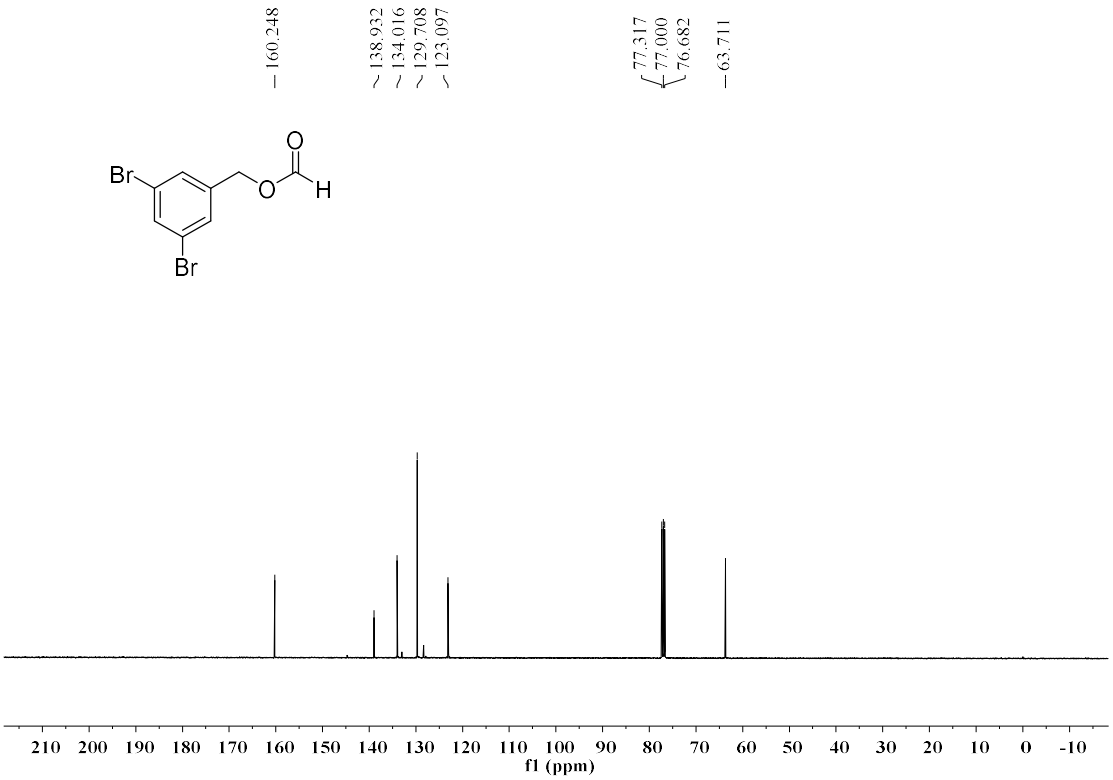
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2p



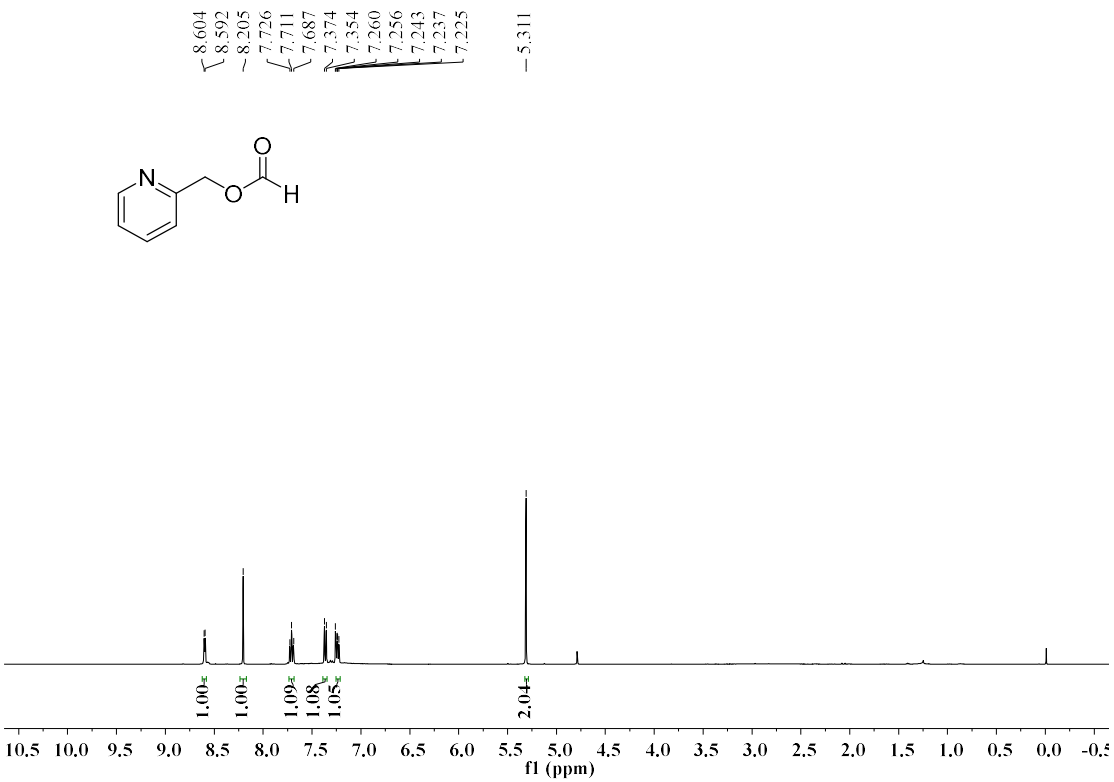
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2q



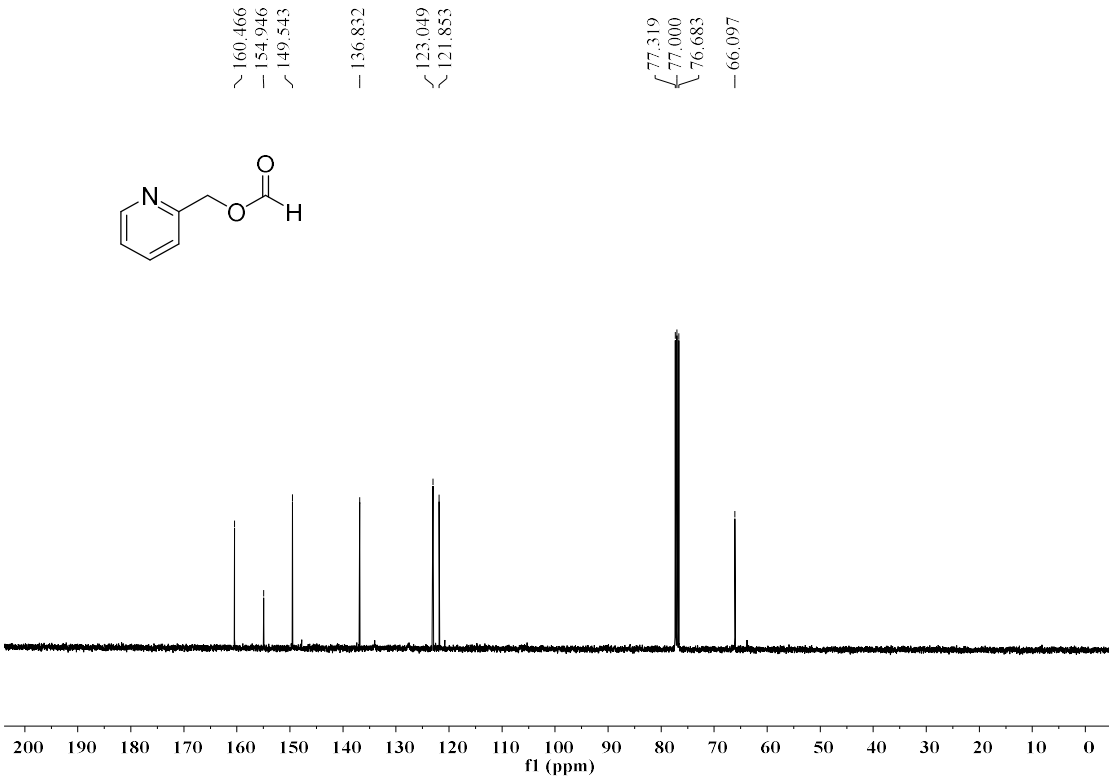
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2q



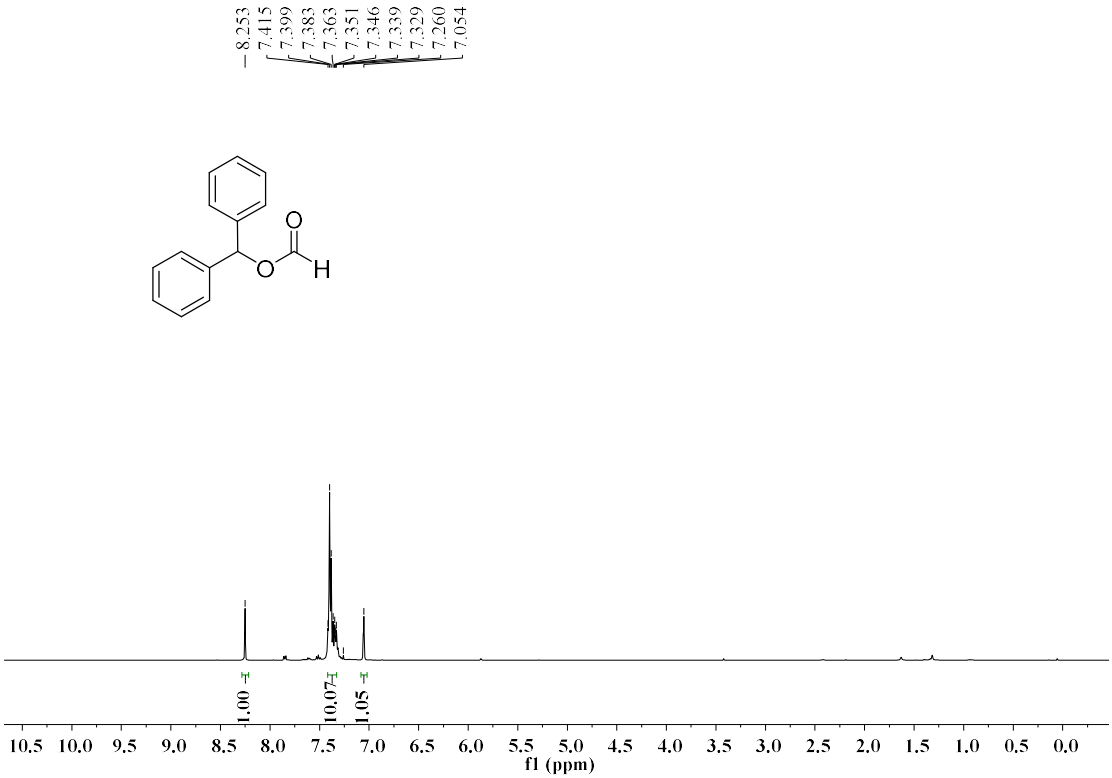
H NMR (400 MHz, $CDCl_3$) spectrum of 2r



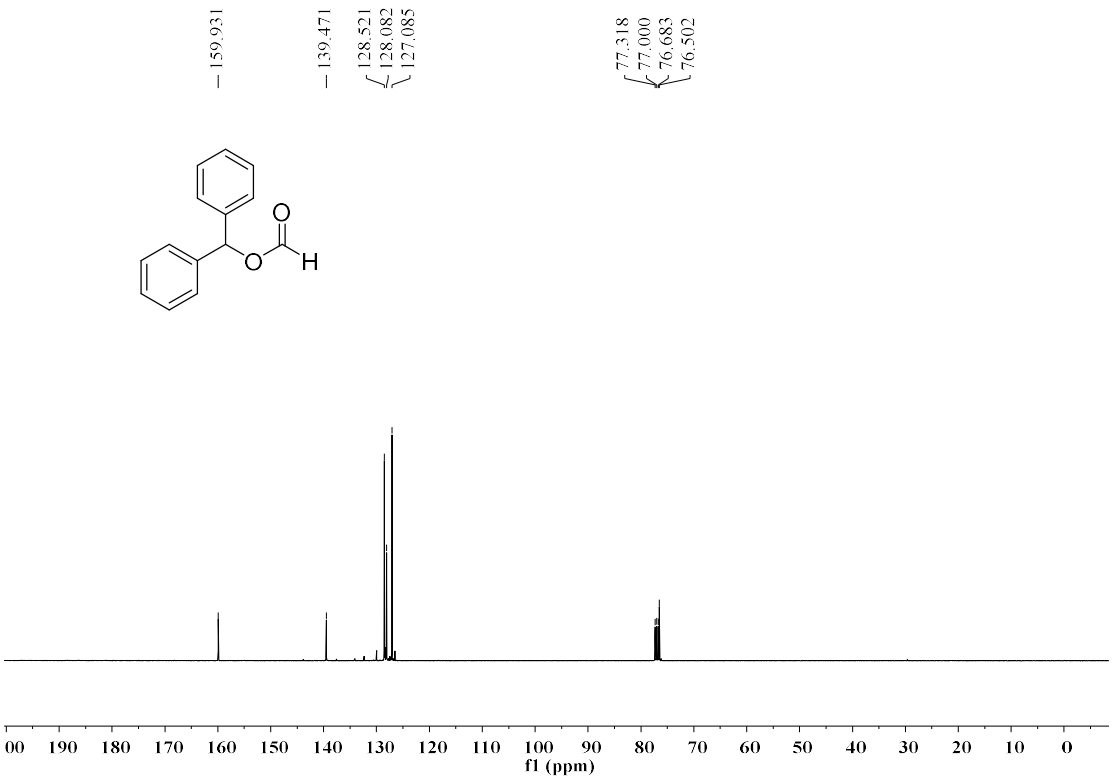
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2r



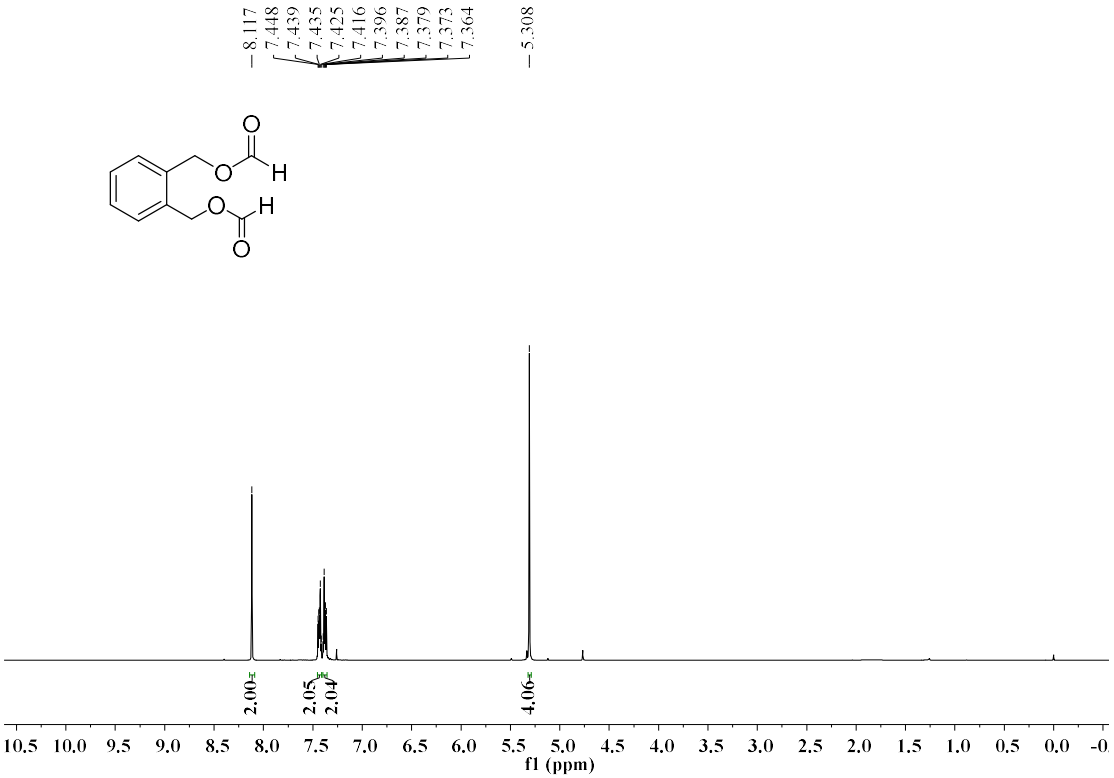
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2s



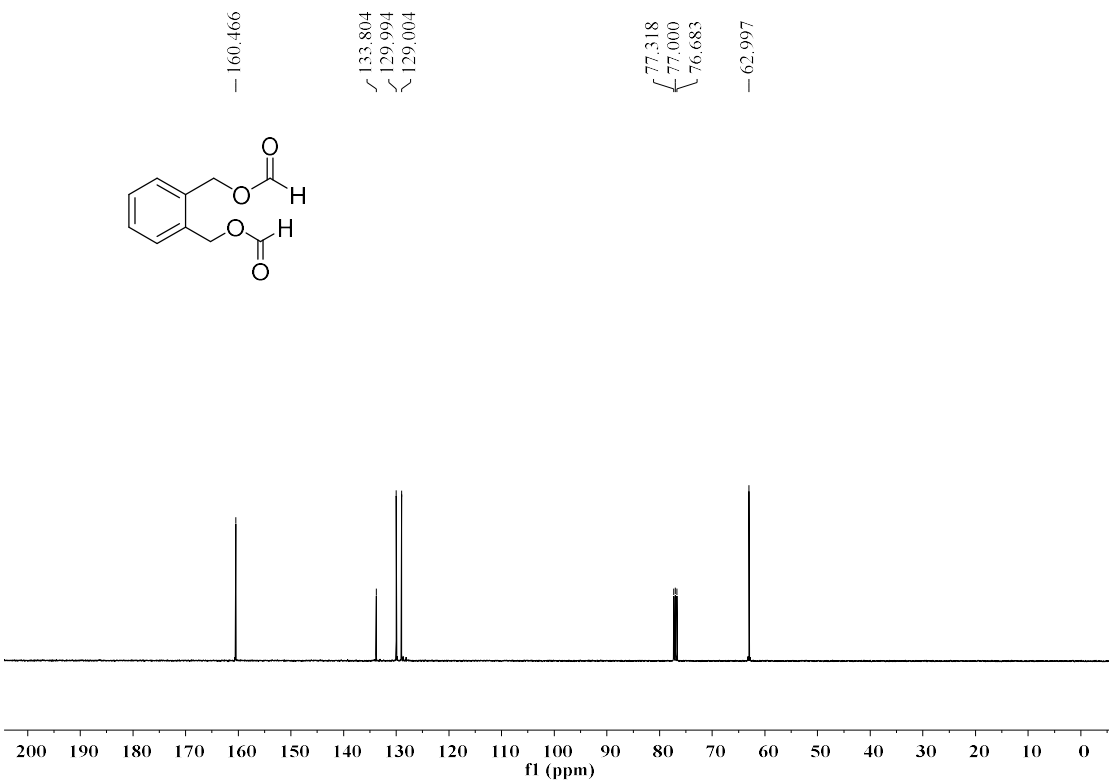
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2s



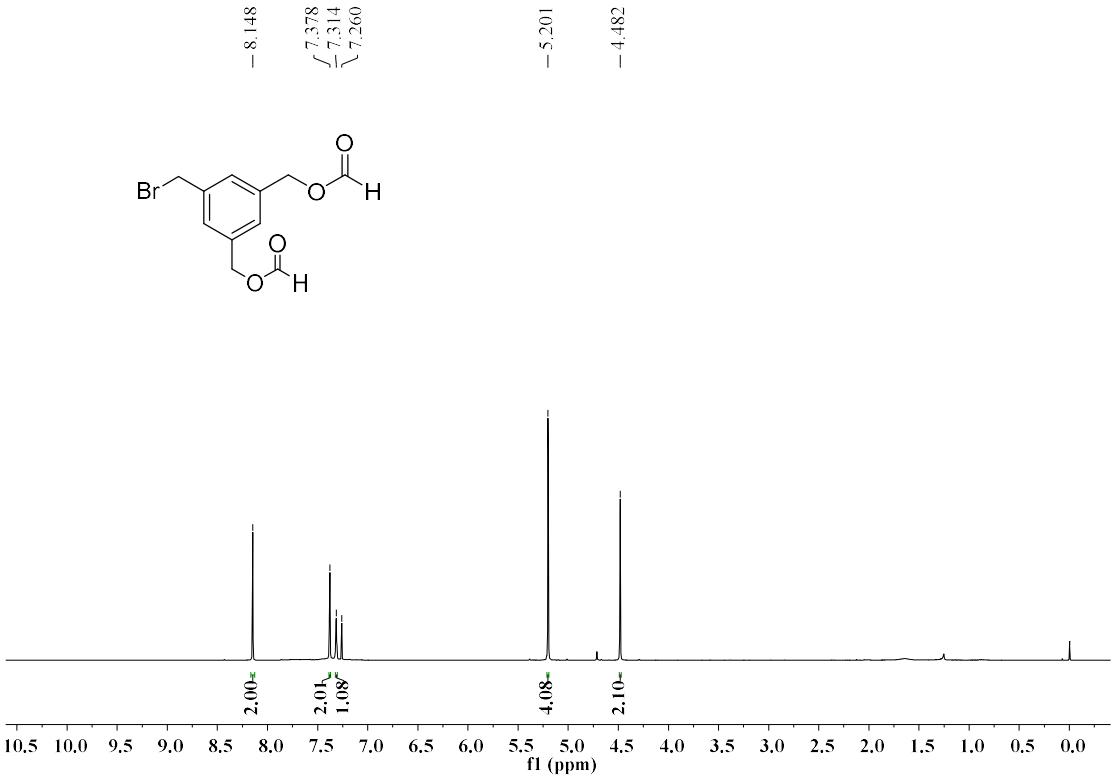
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2t



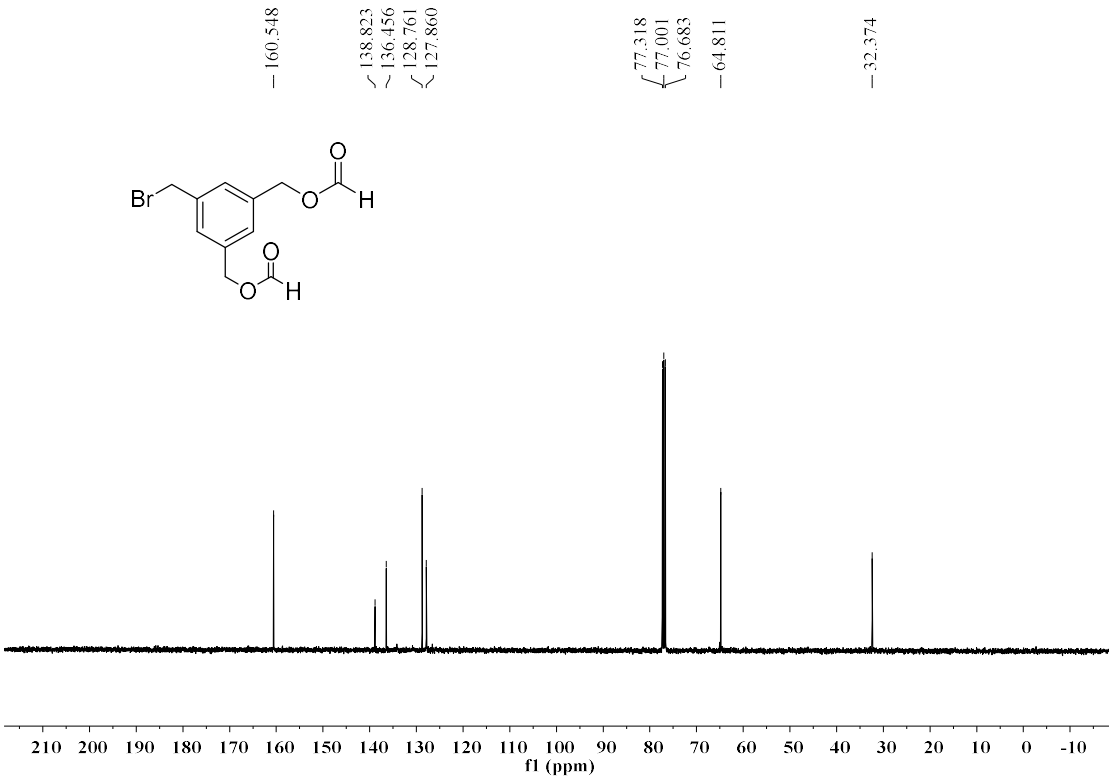
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2t



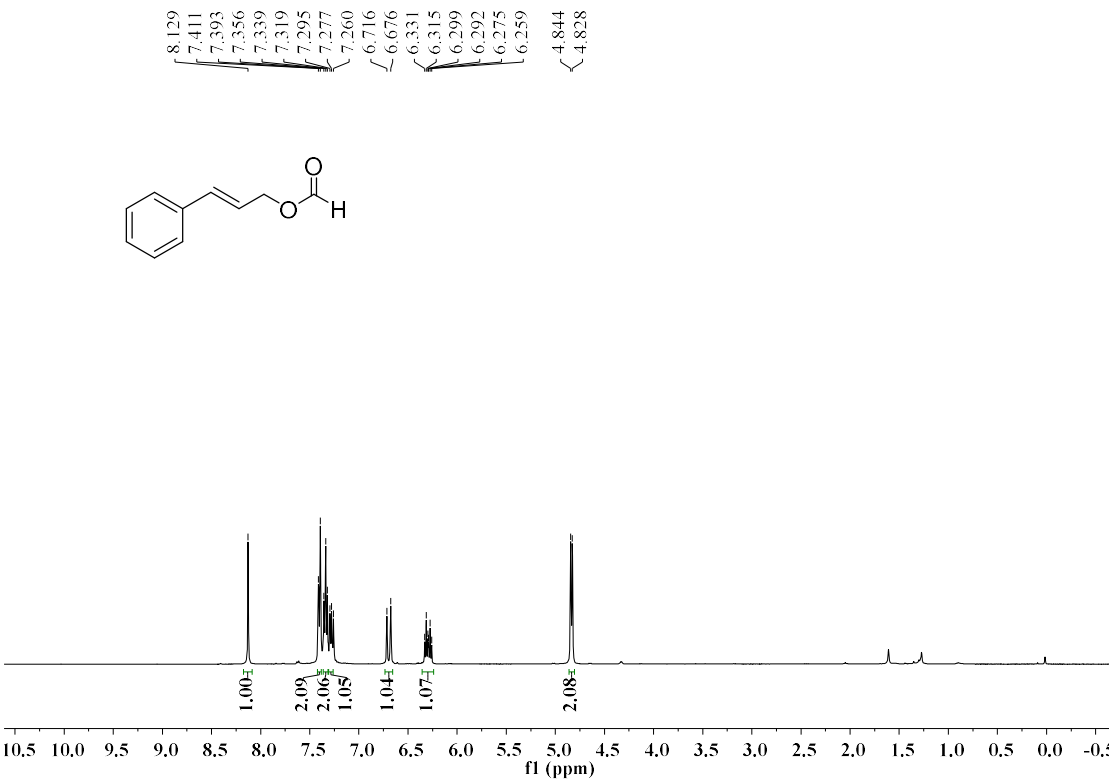
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2u



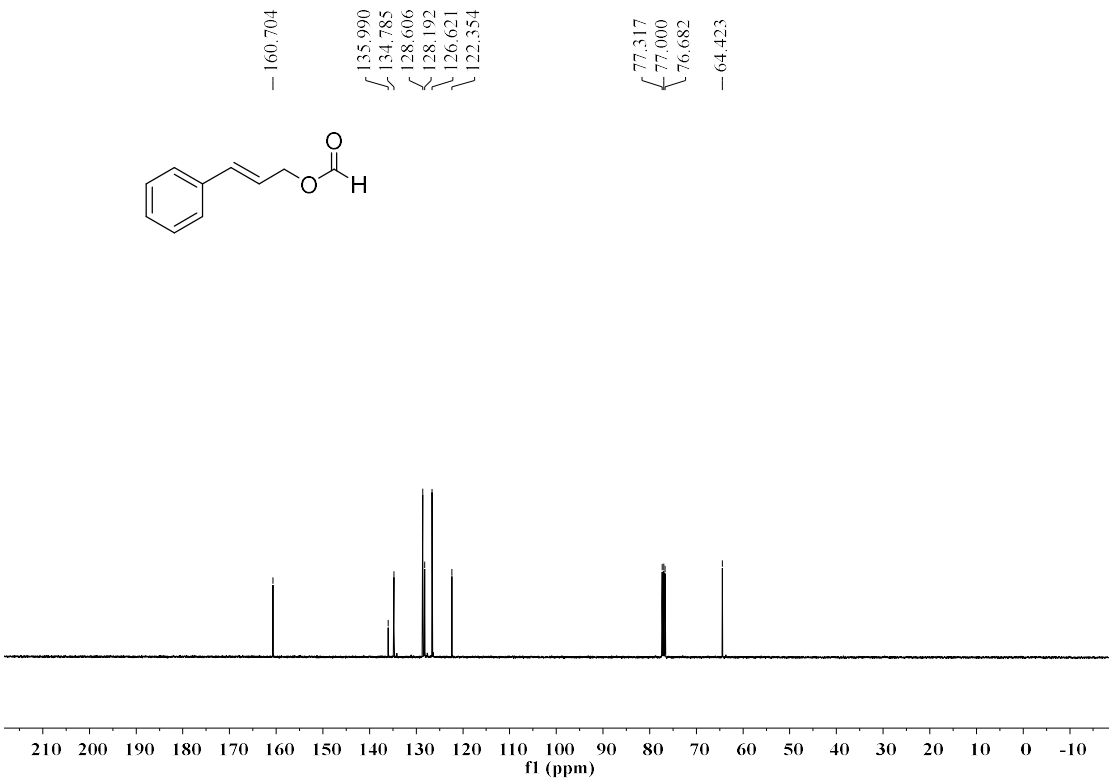
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2u



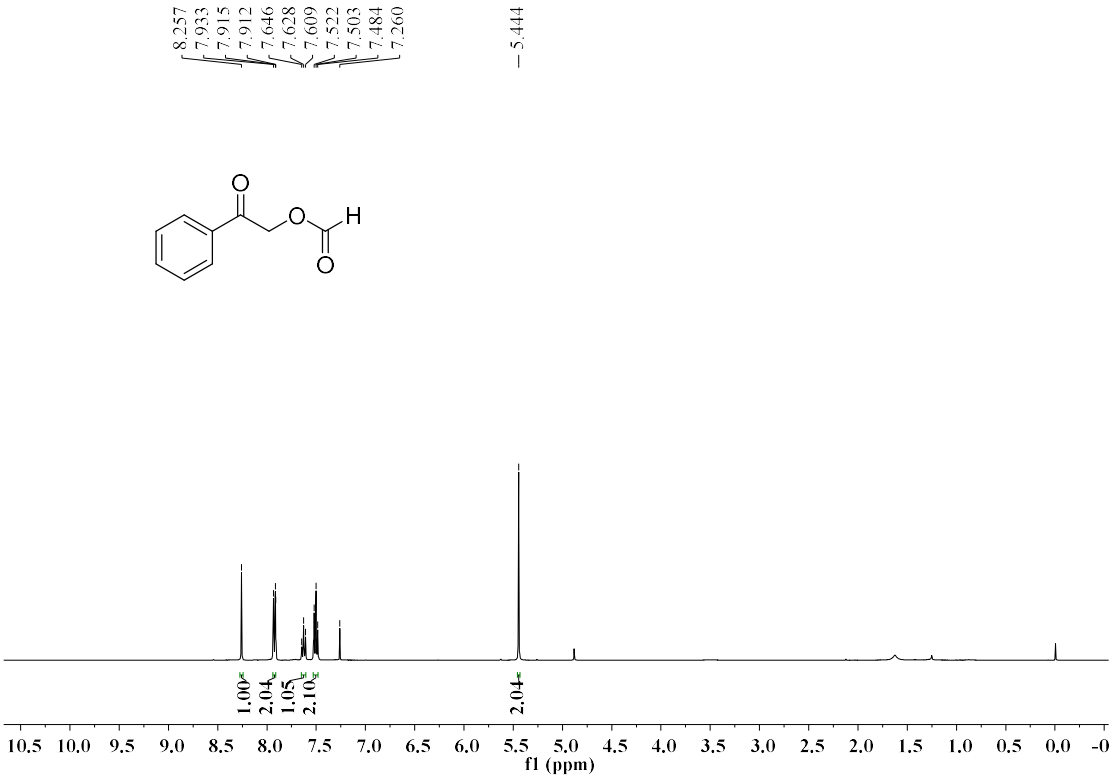
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2v



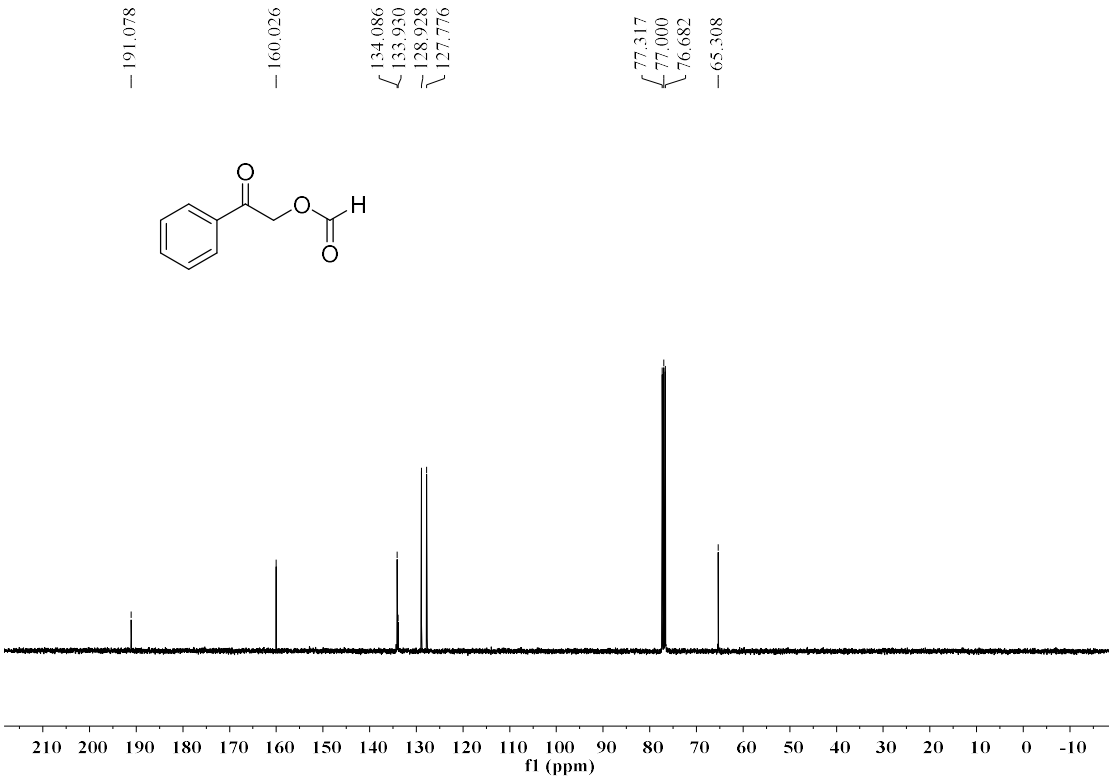
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2v



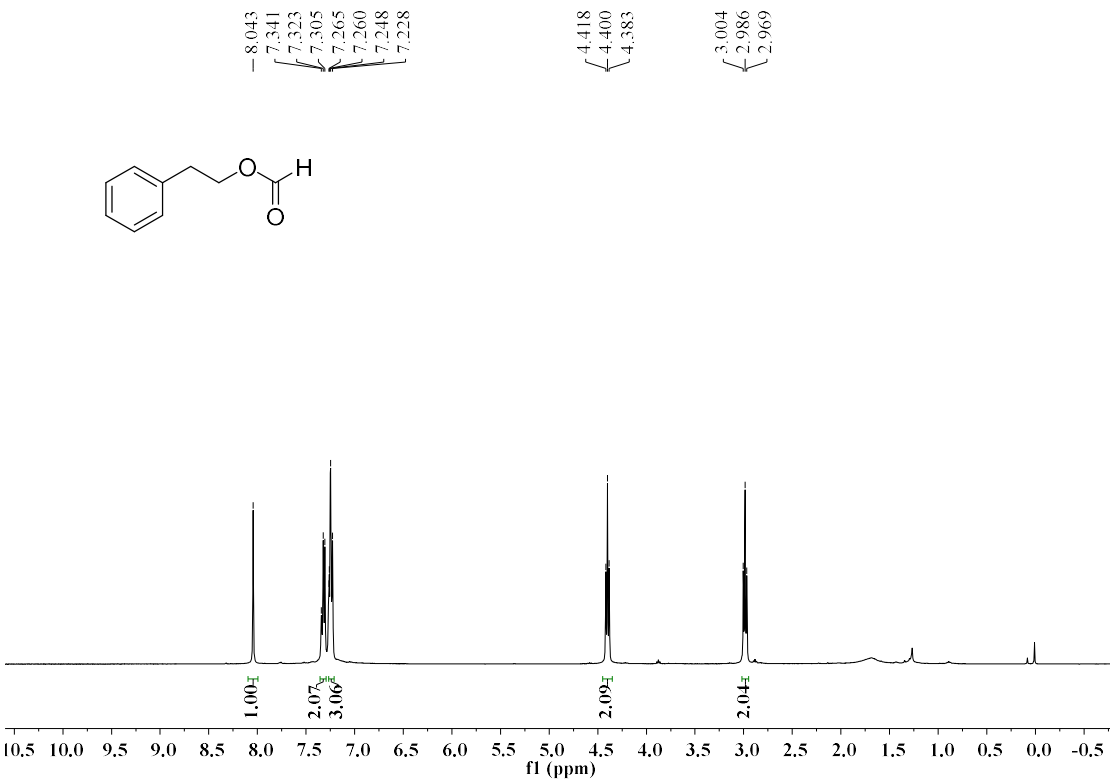
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2w



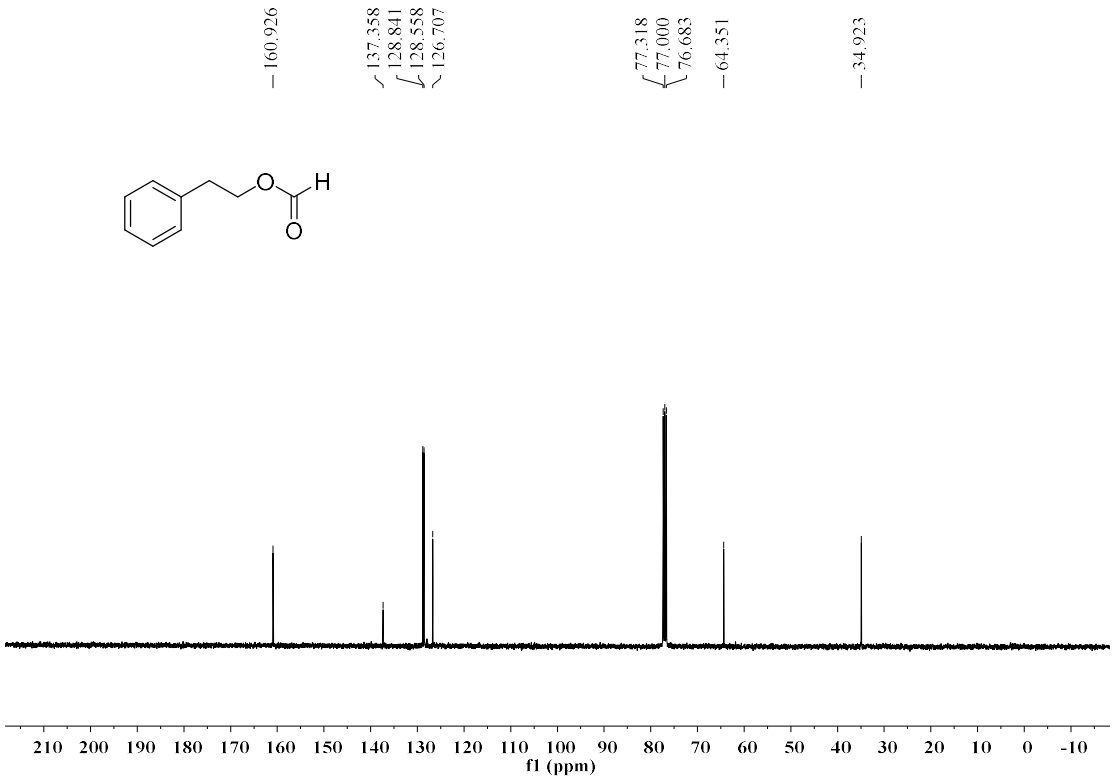
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2w



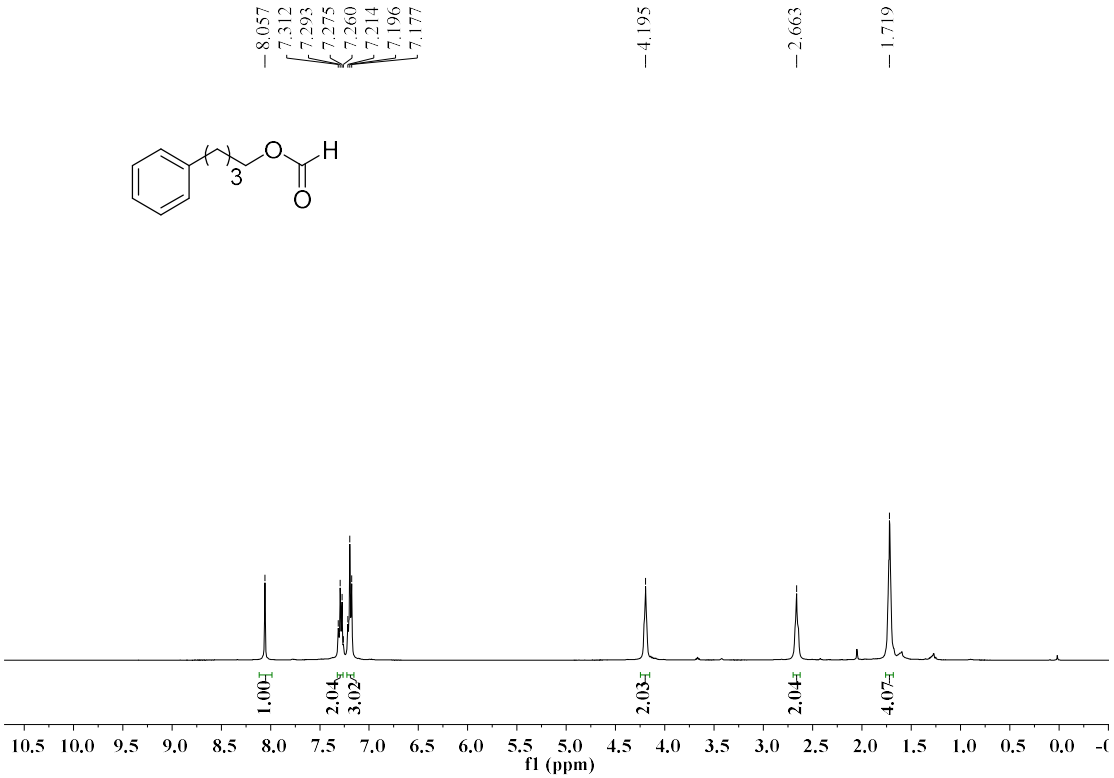
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2x



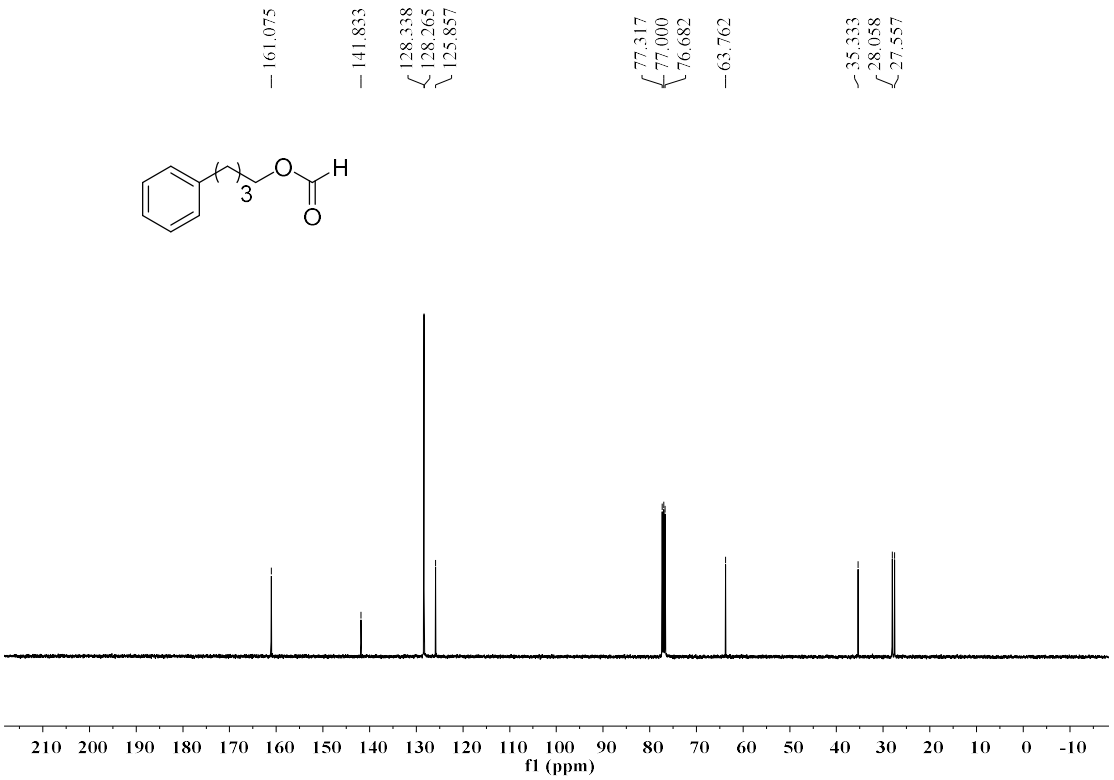
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2x



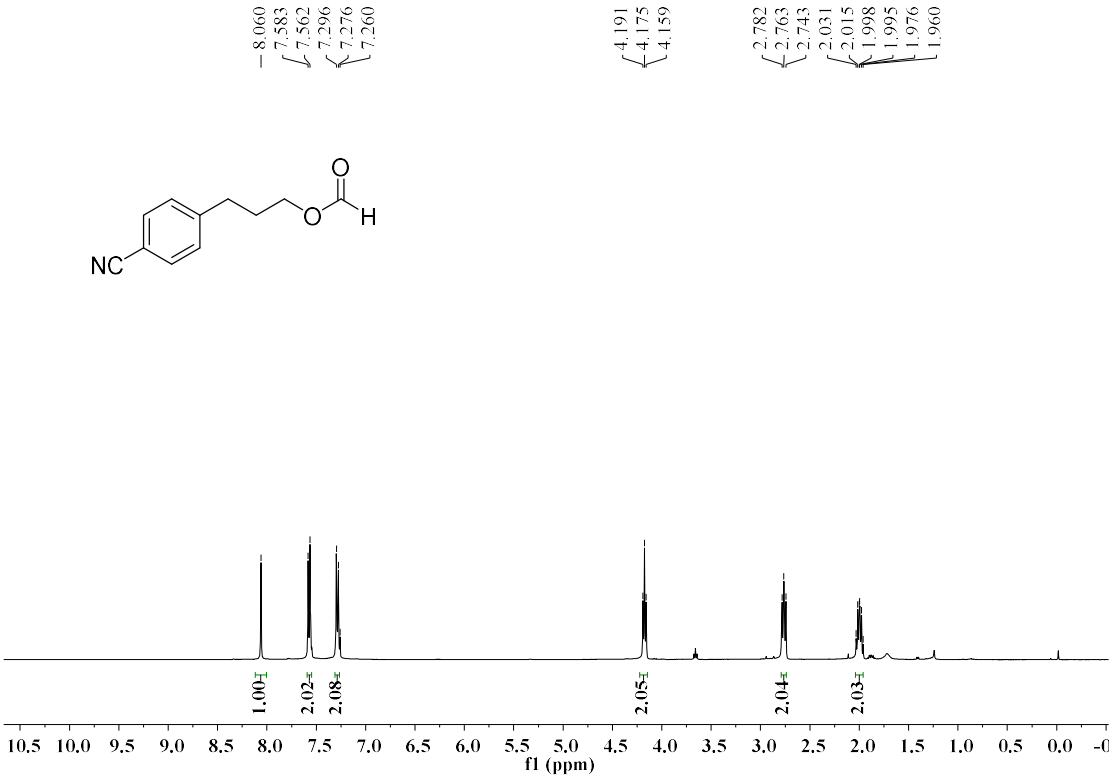
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2y



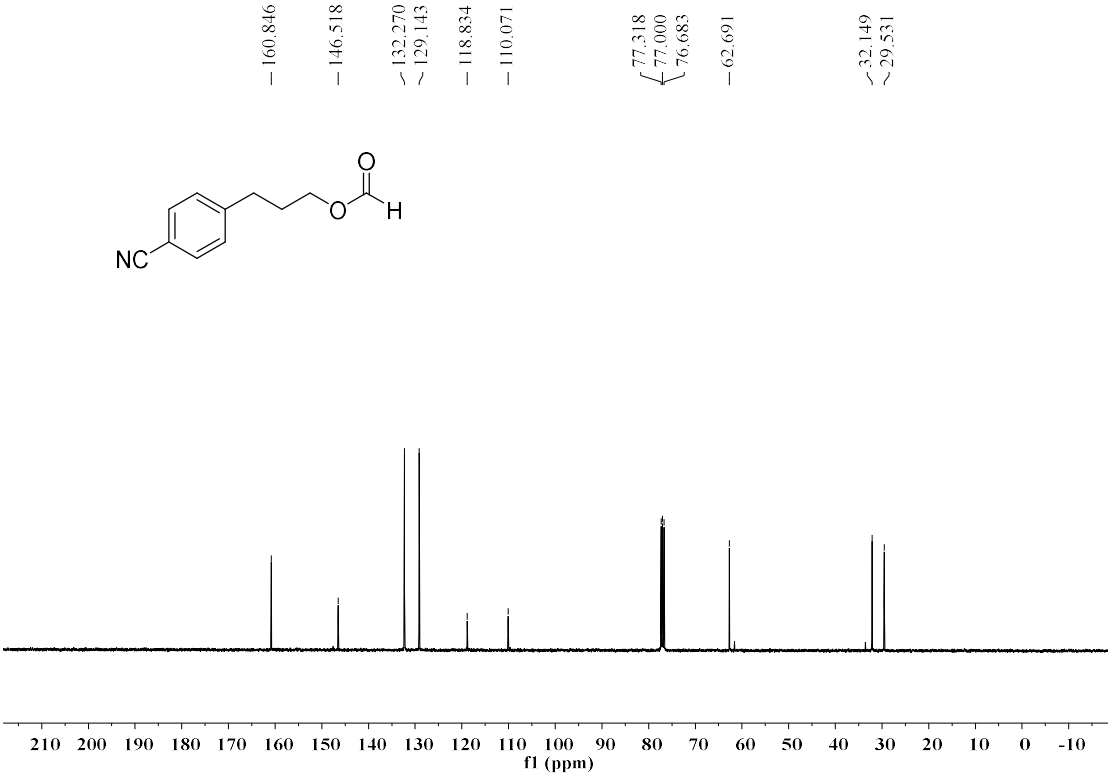
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2y



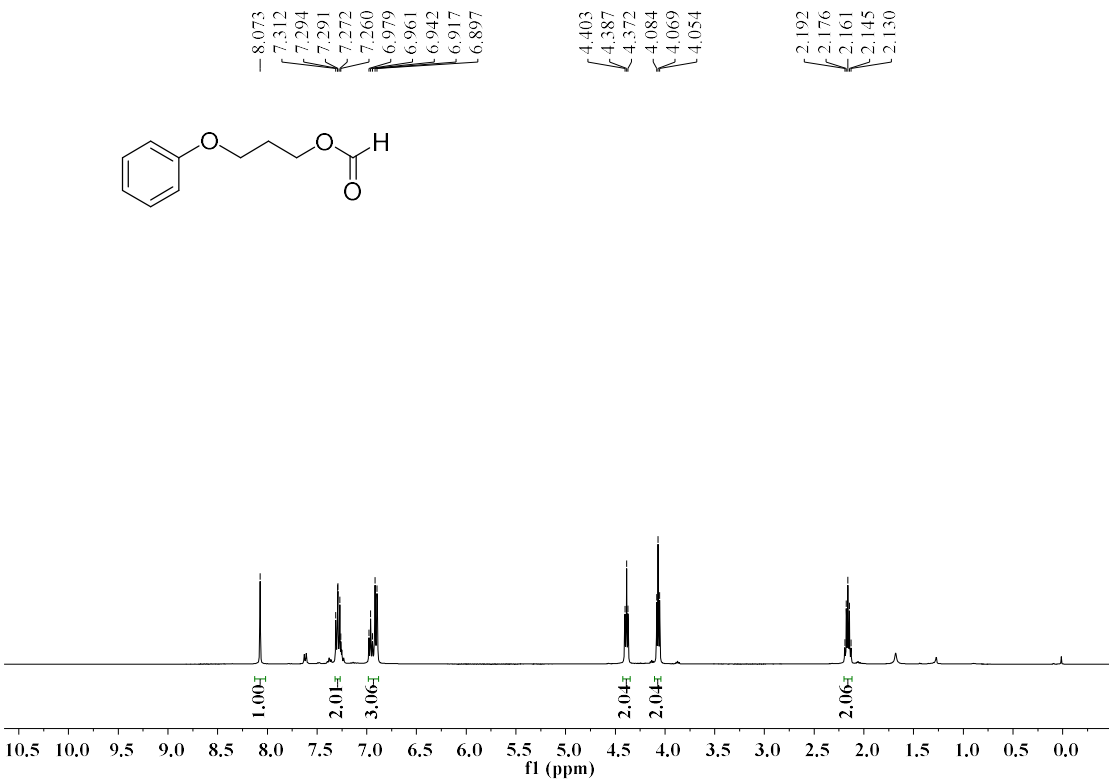
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2z



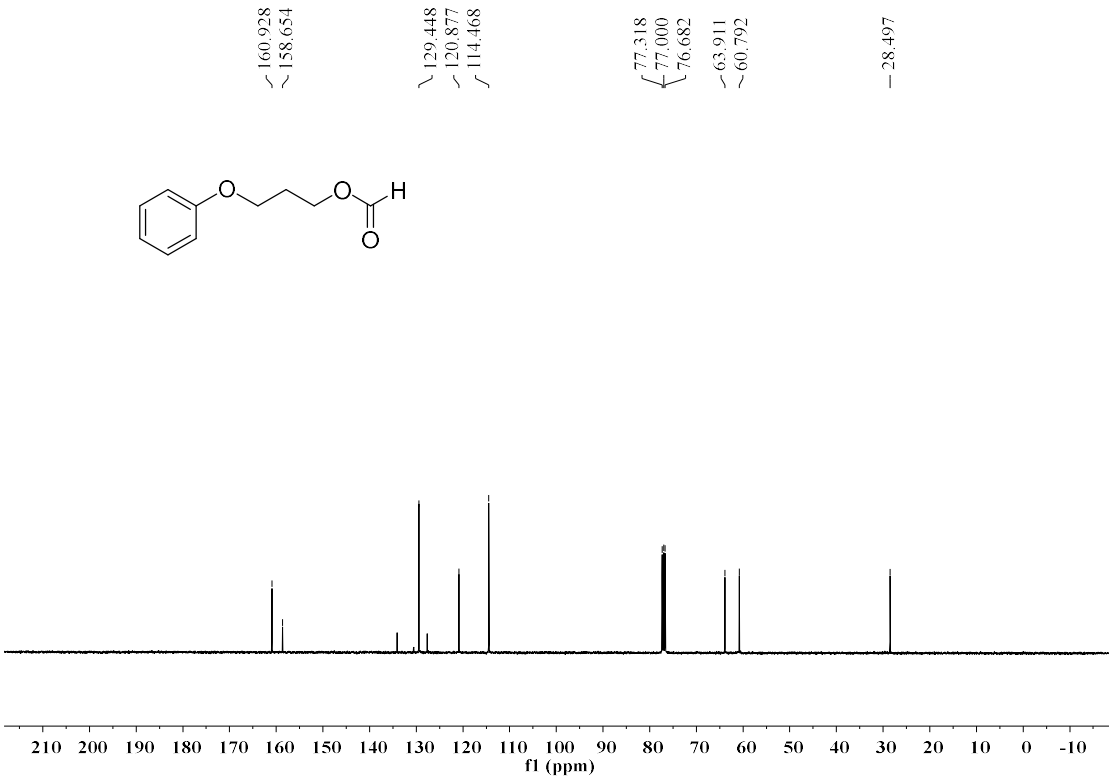
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2z



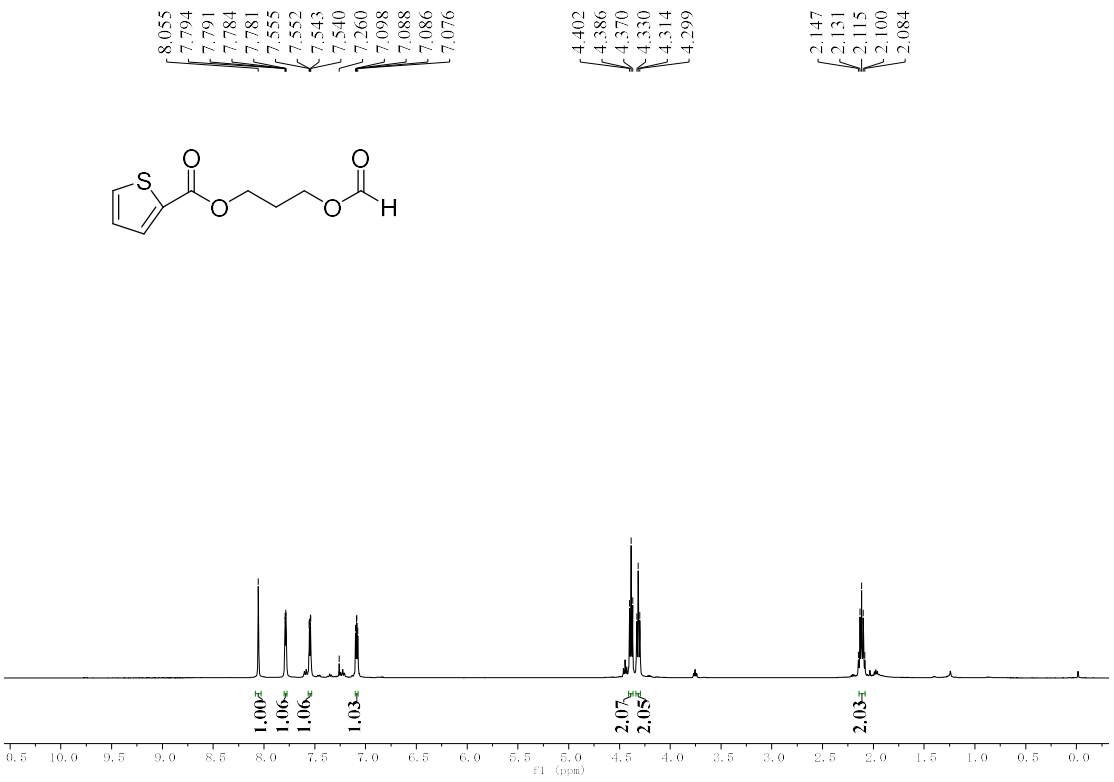
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2aa



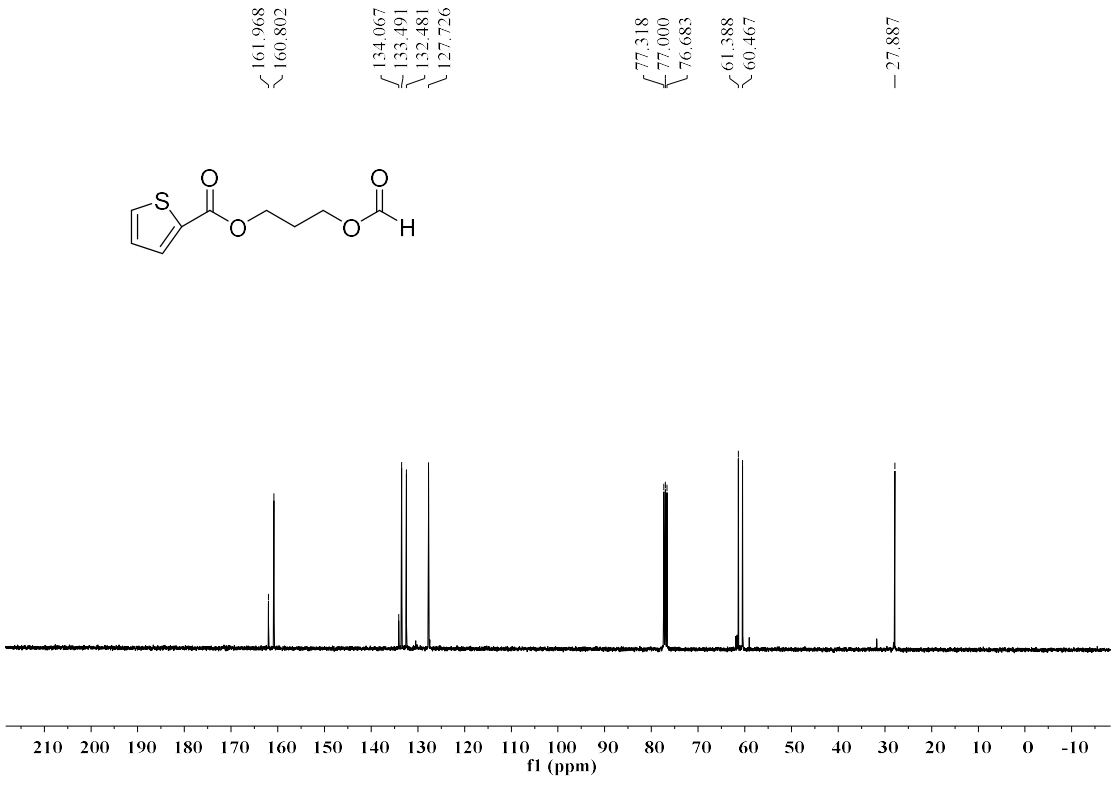
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2aa



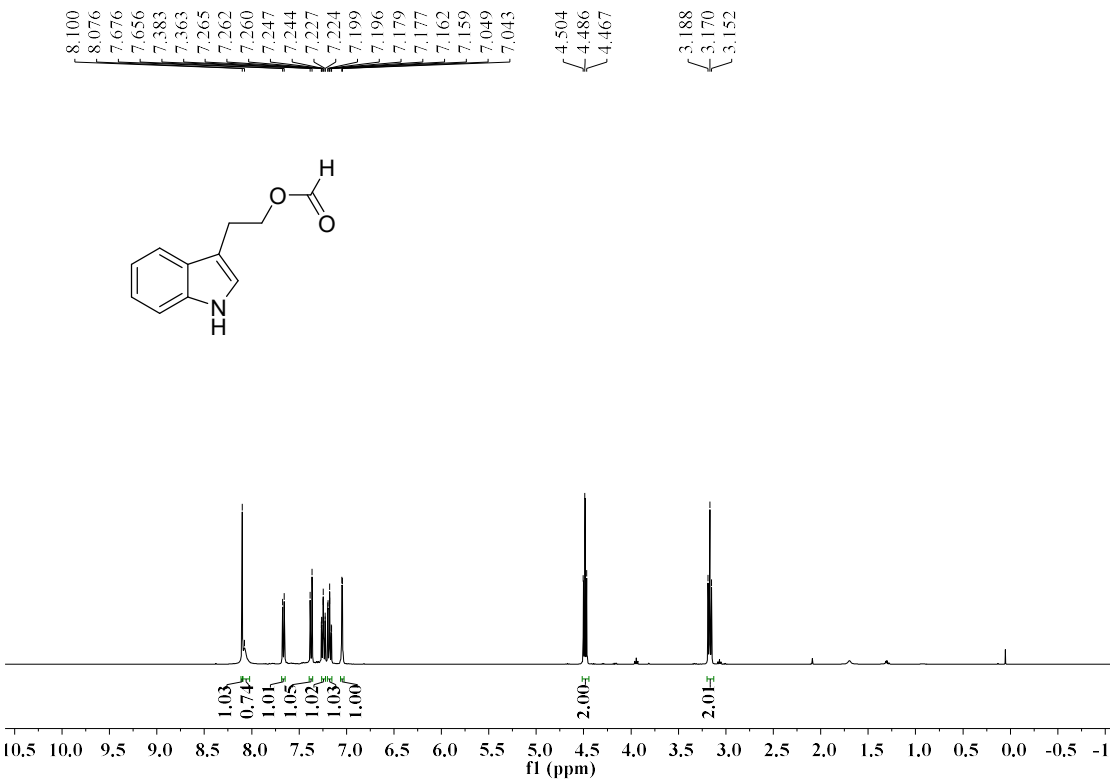
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2ab



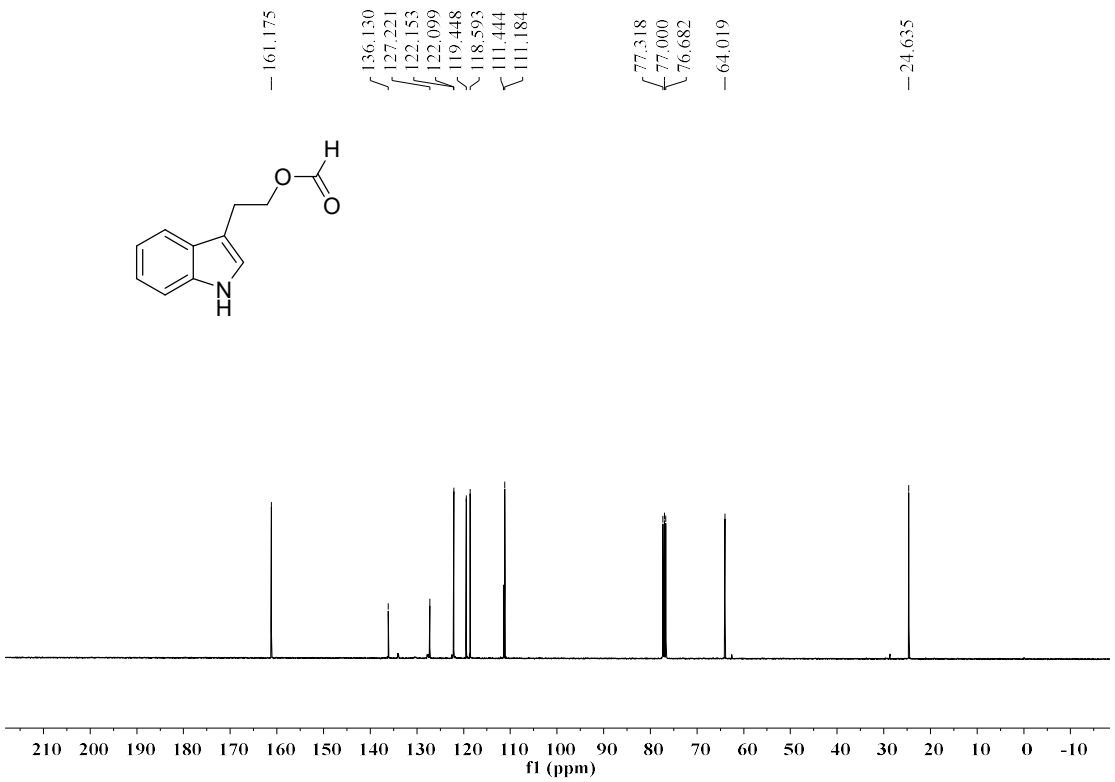
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2ab



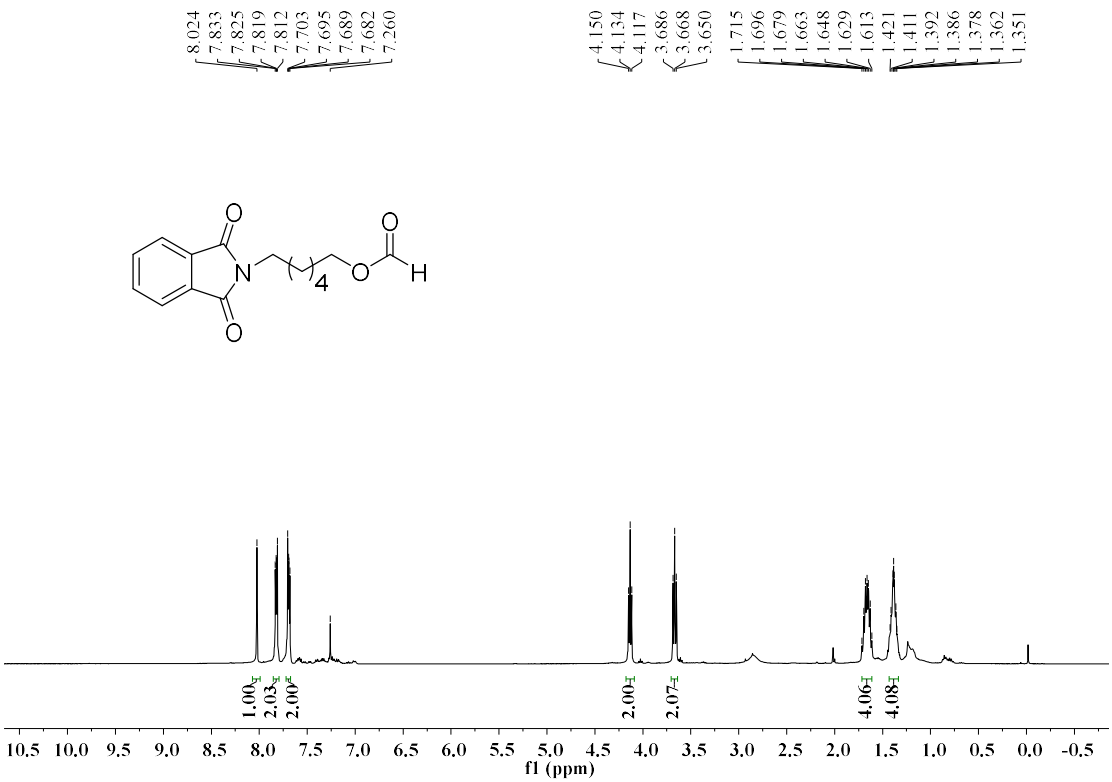
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2ac



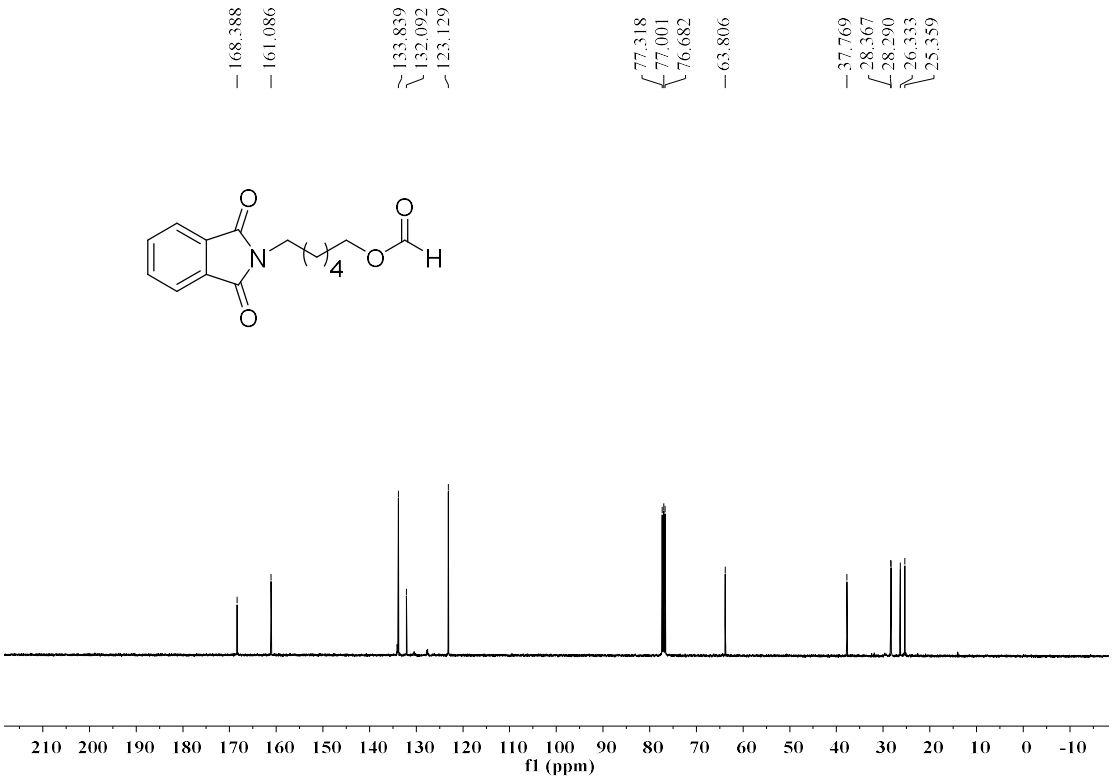
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2ac



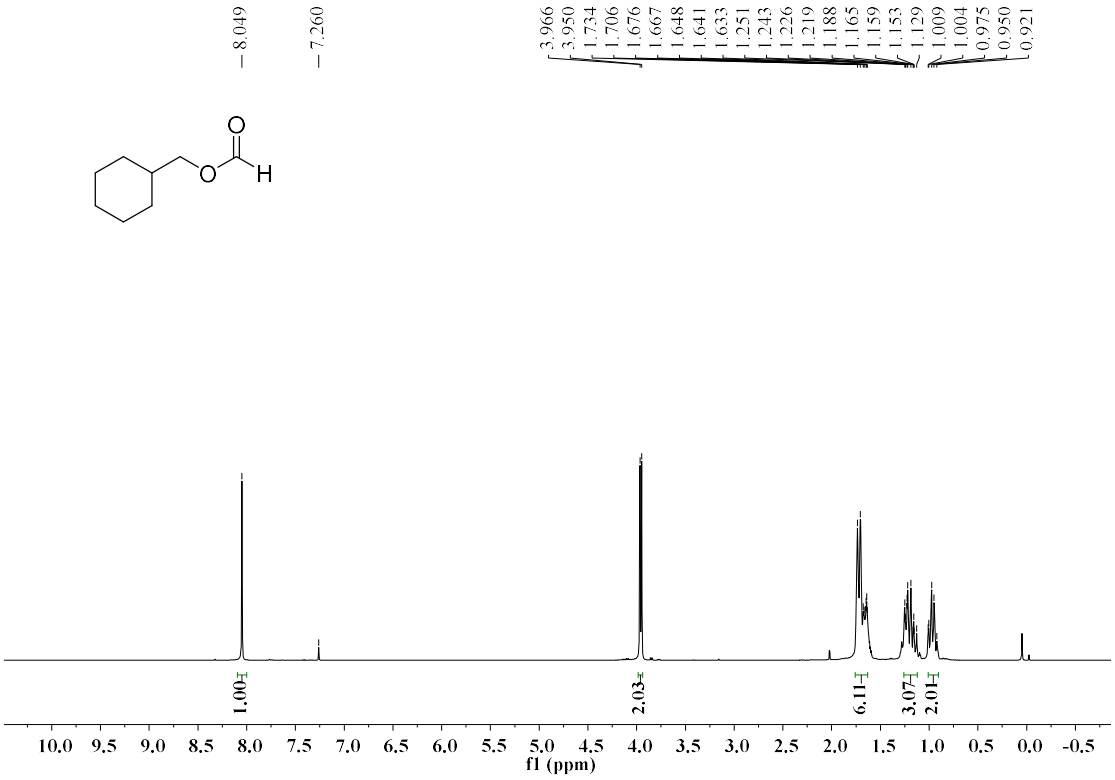
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2ad



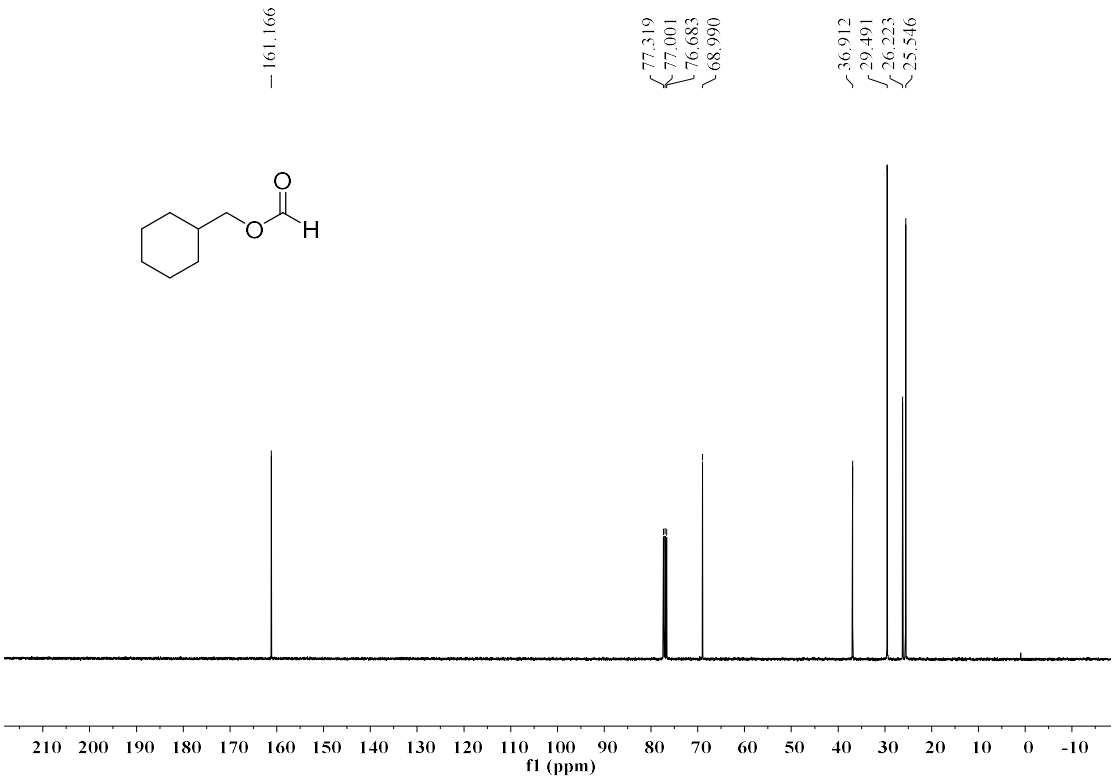
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2ad



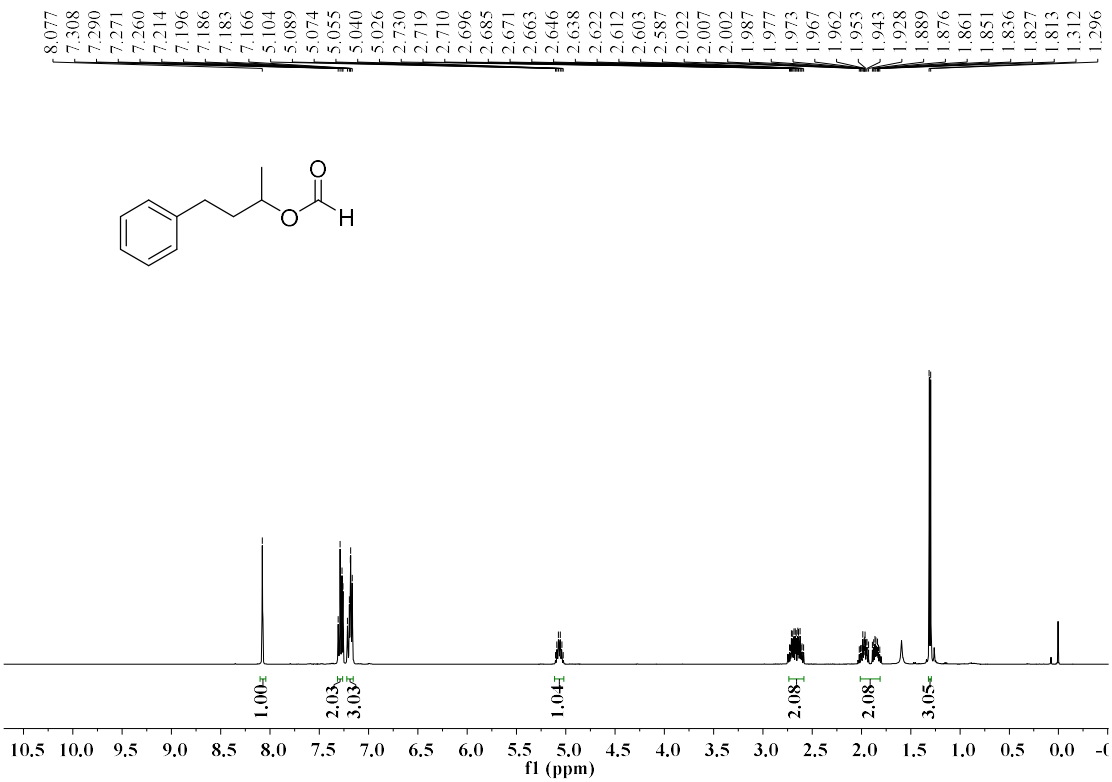
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2ae



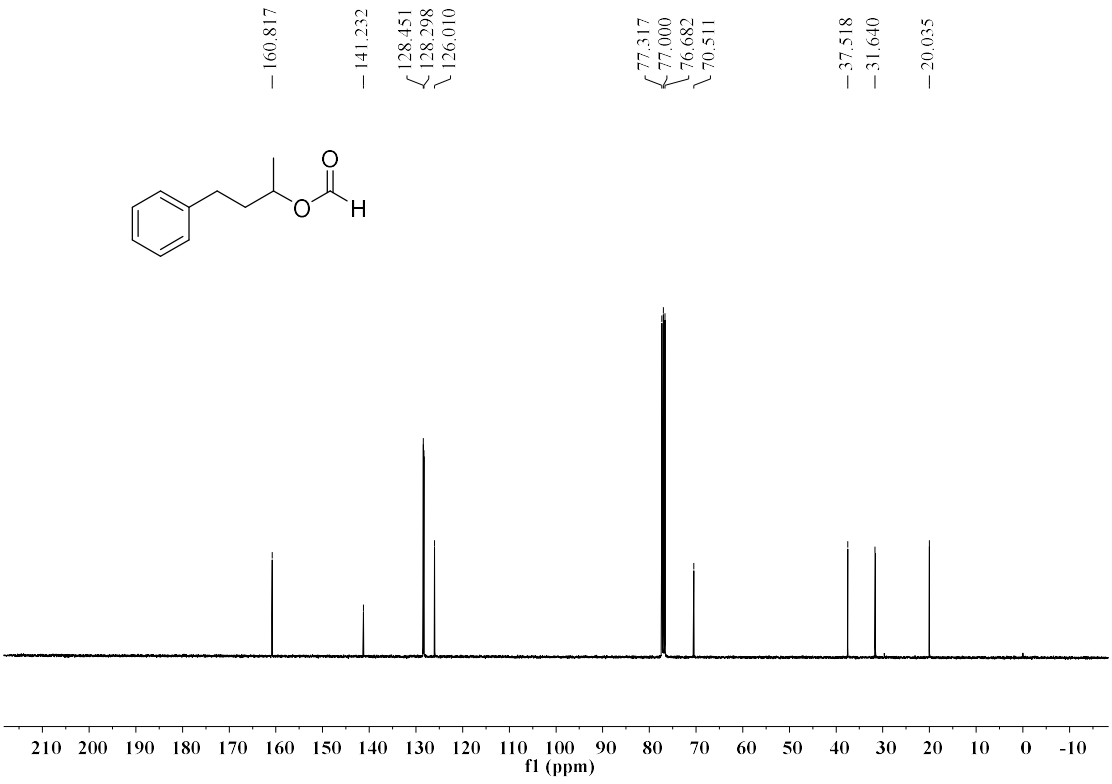
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2ae



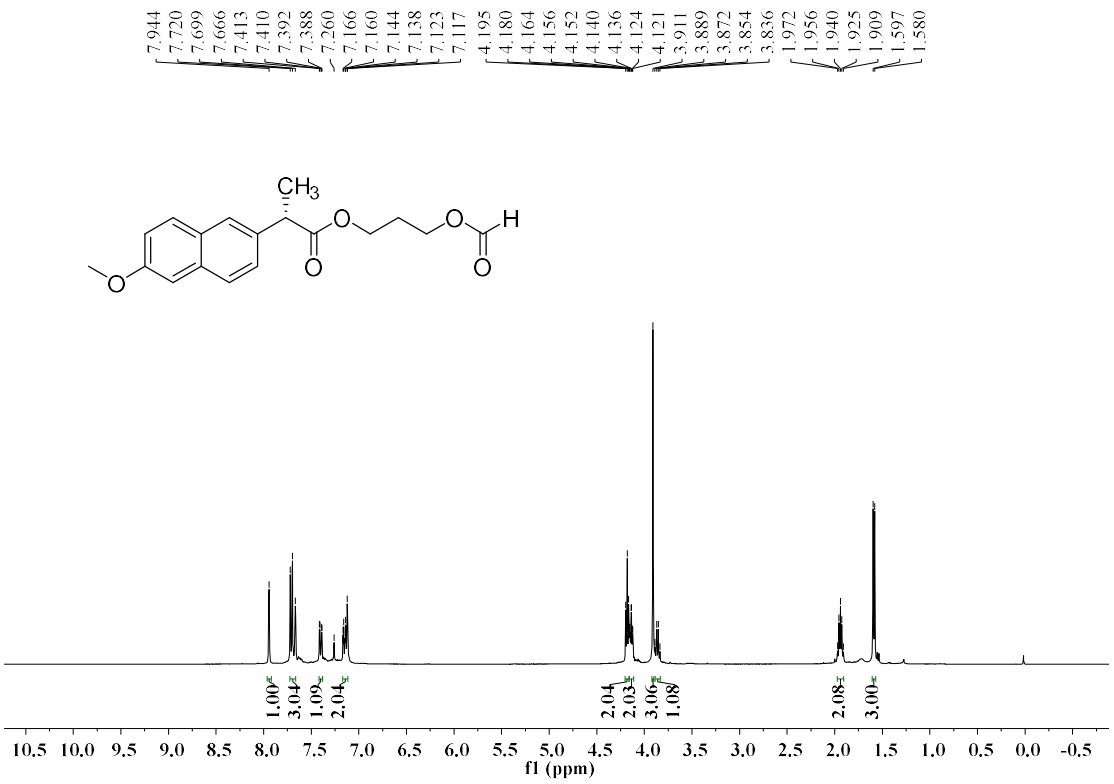
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2af



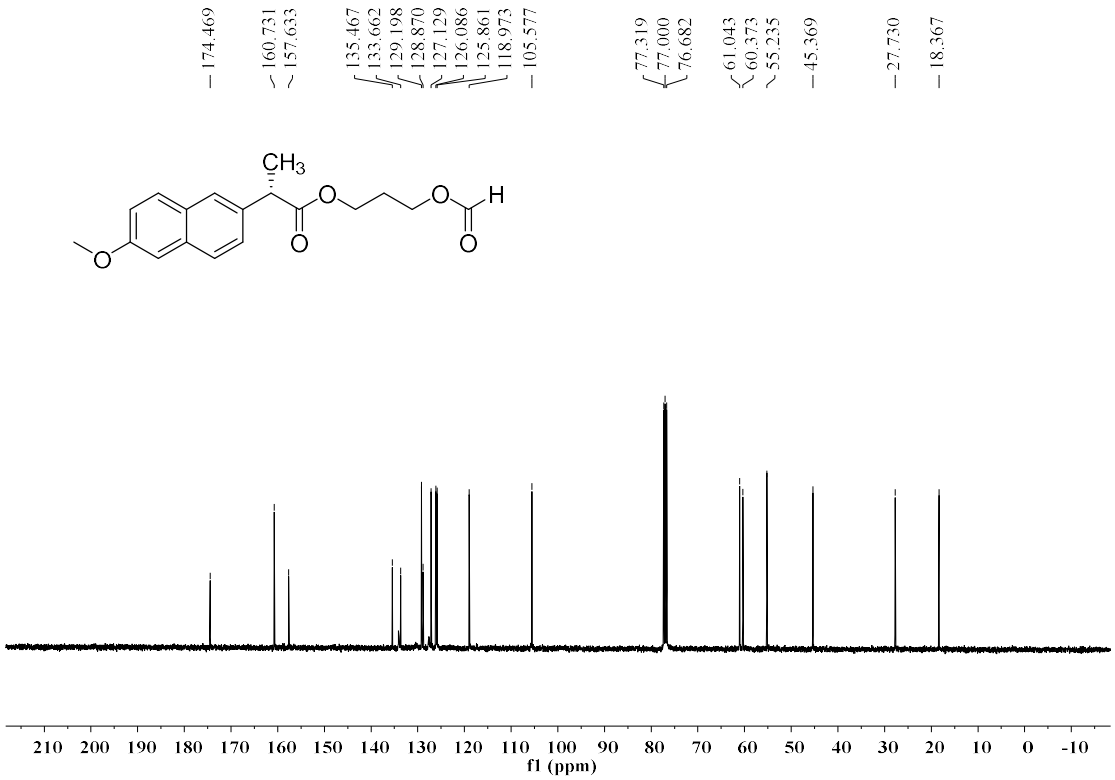
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2af



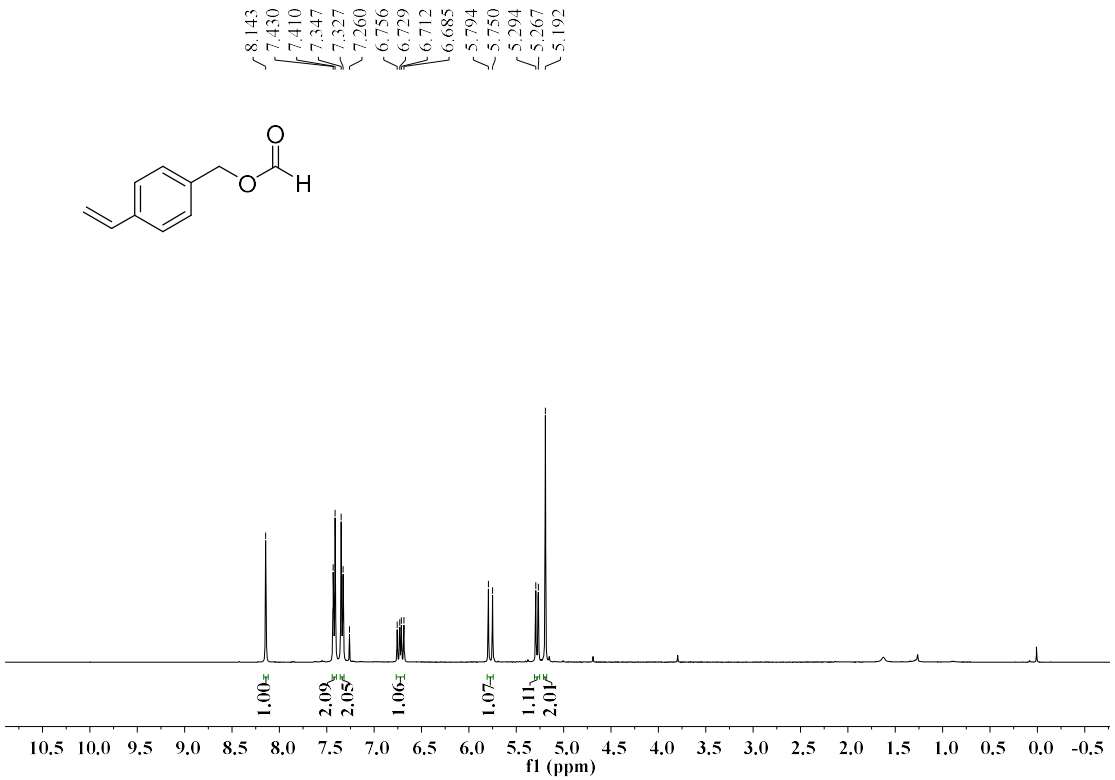
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2ah



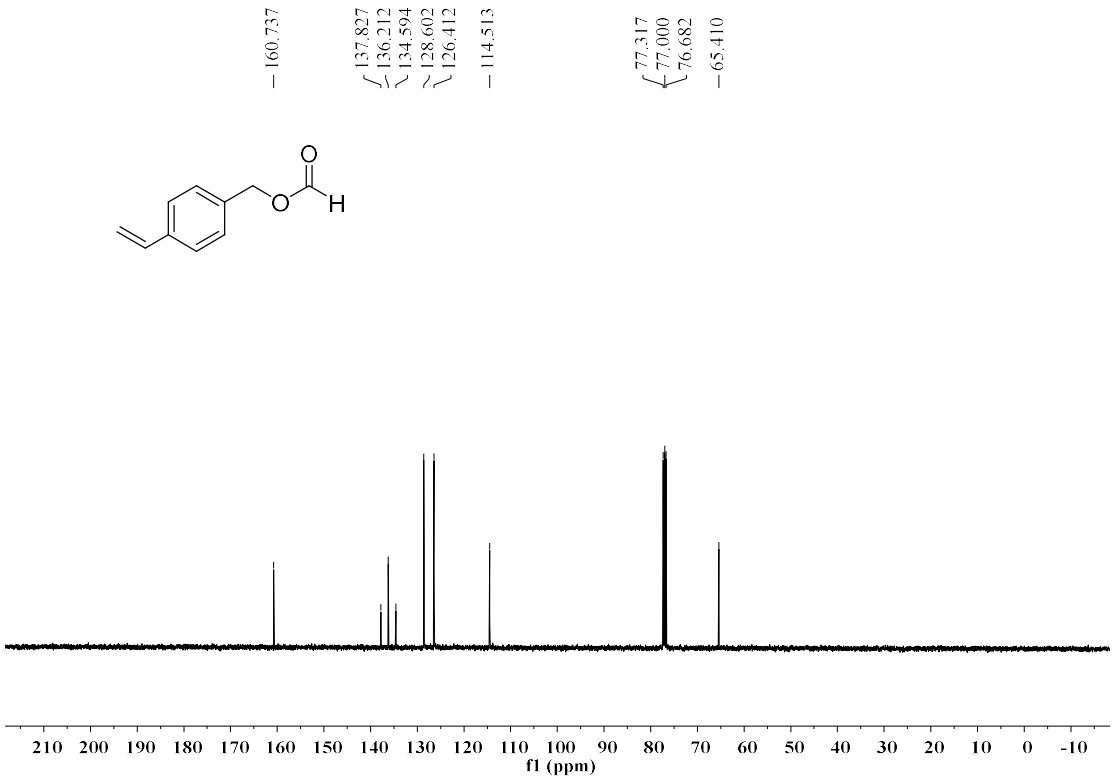
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2ah



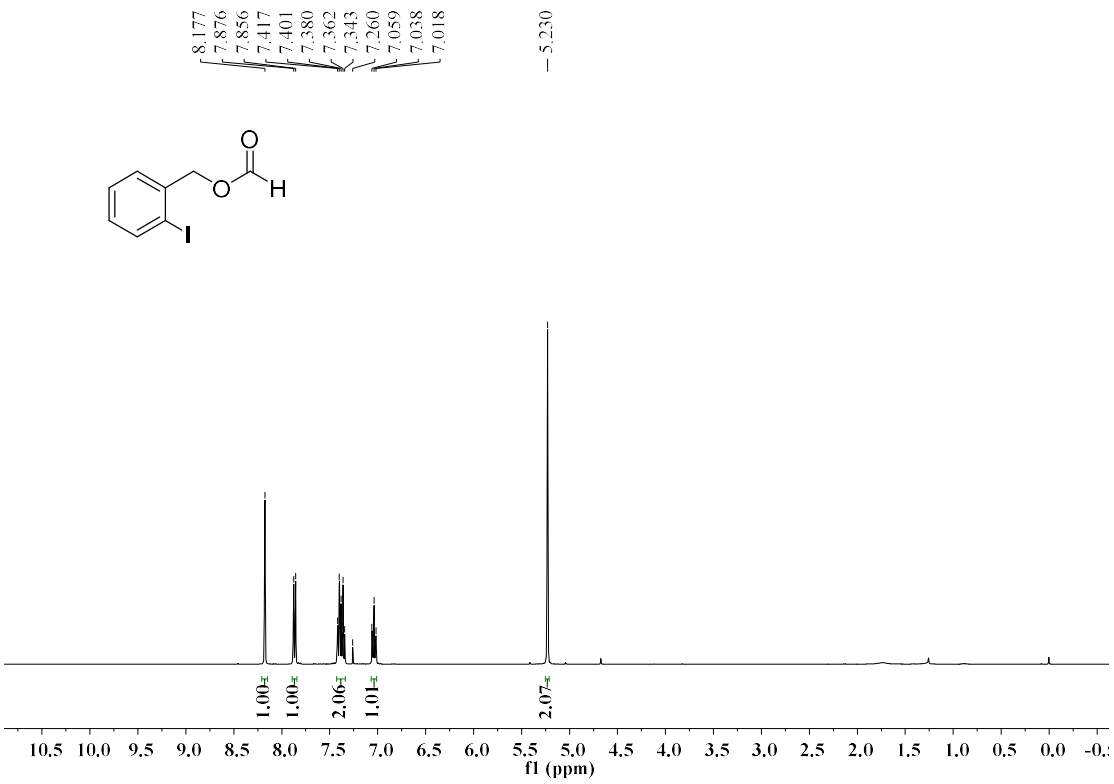
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2ai



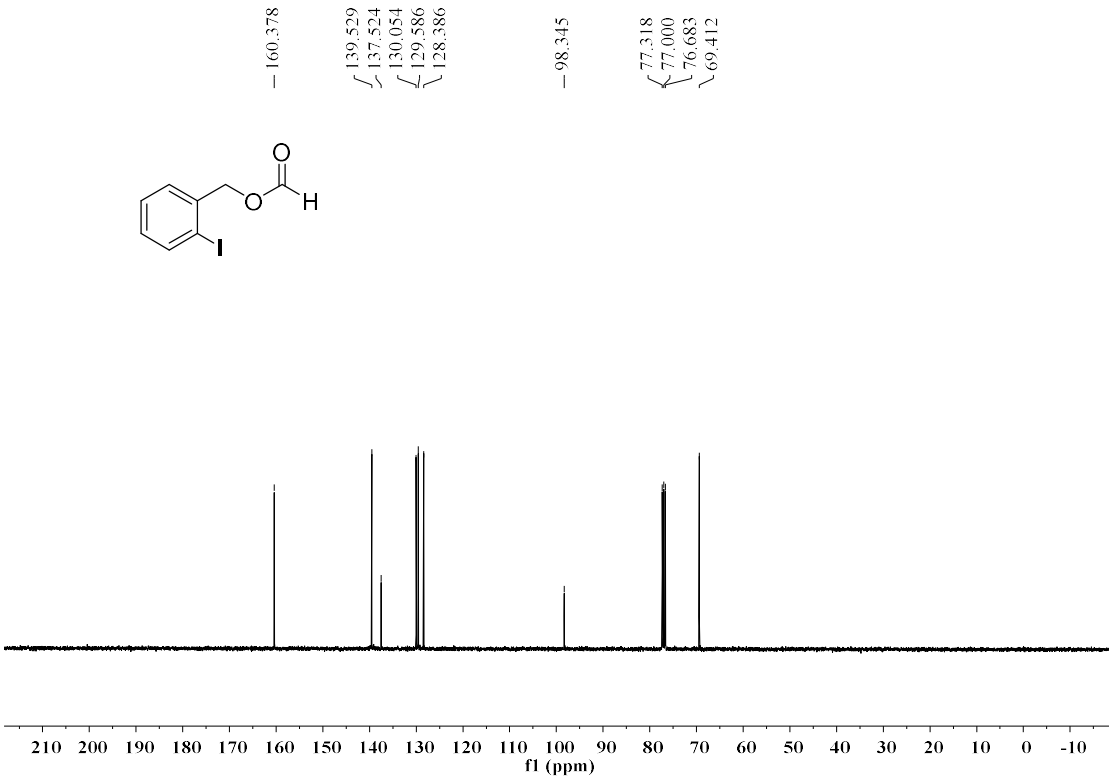
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2ai



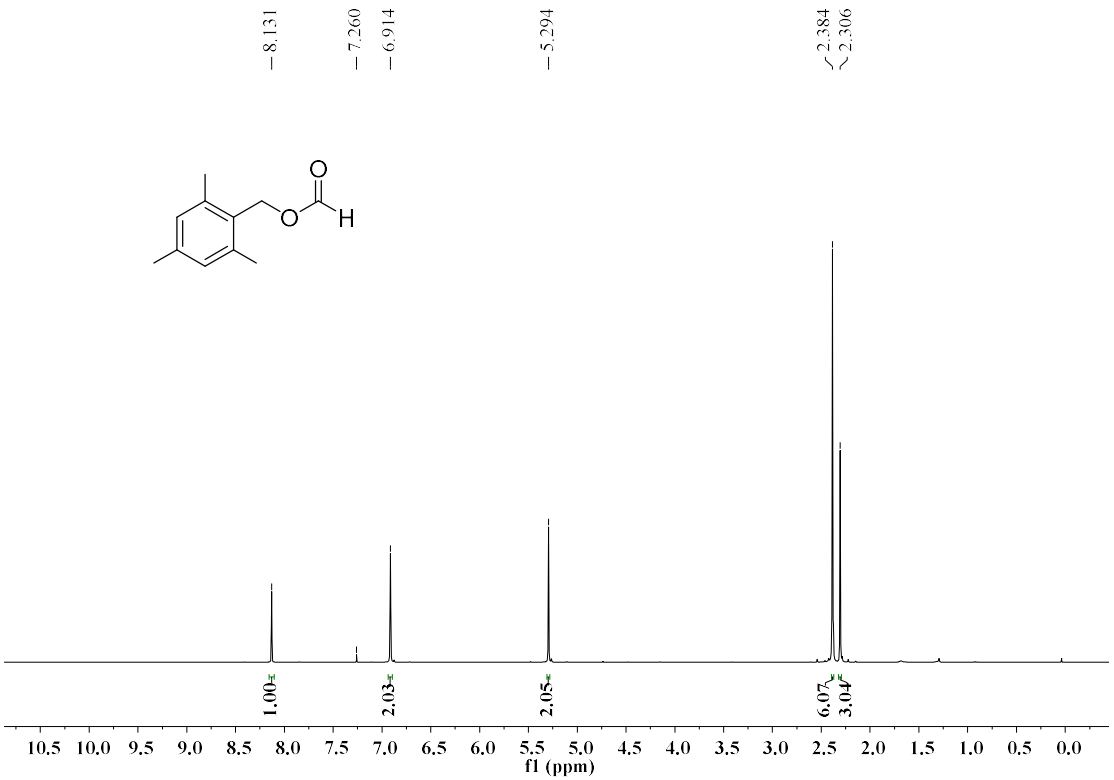
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2aj



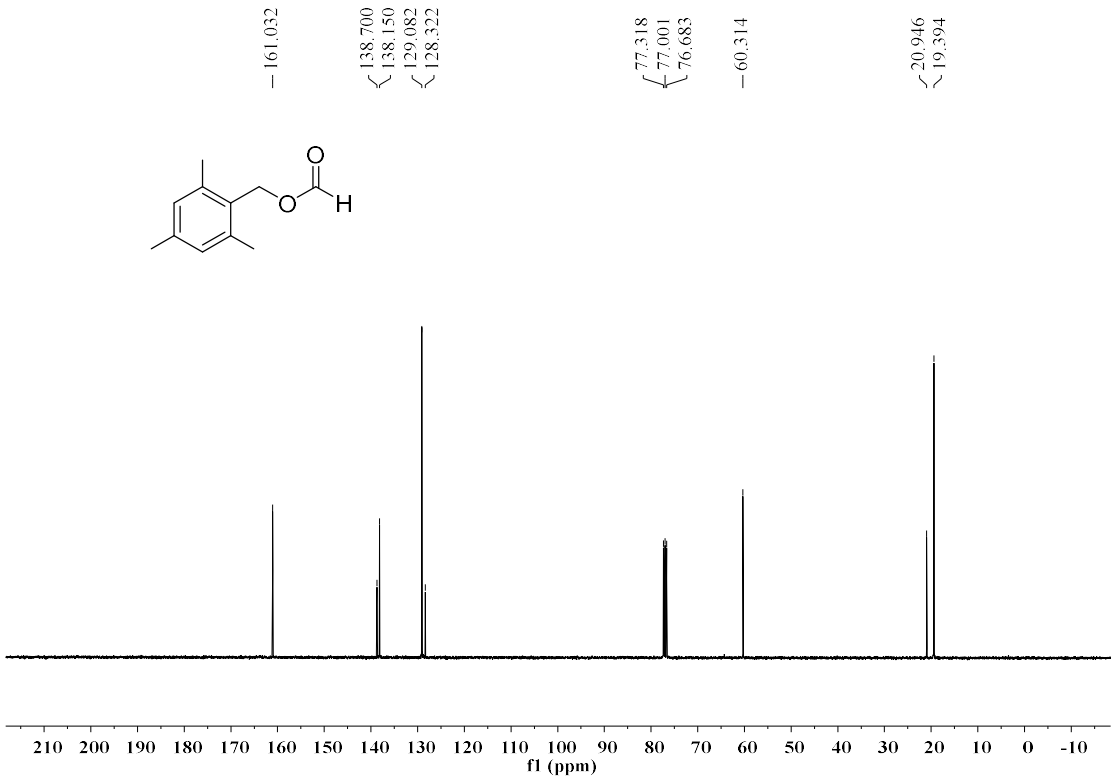
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2aj



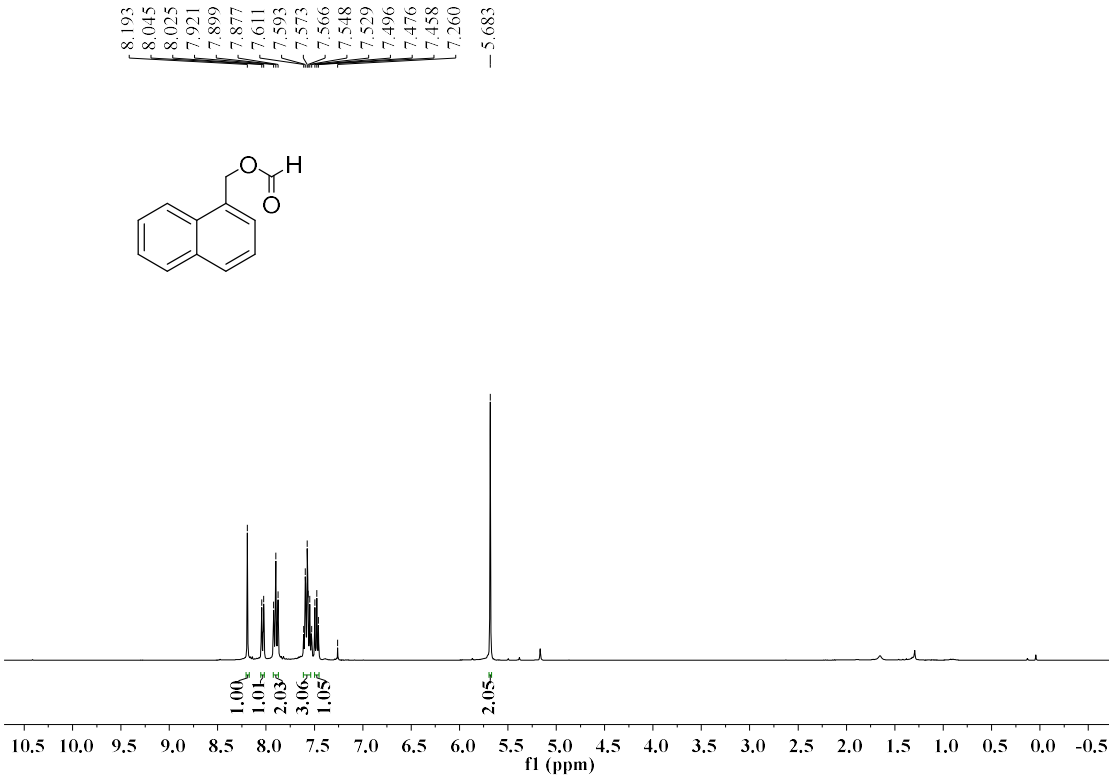
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2ak



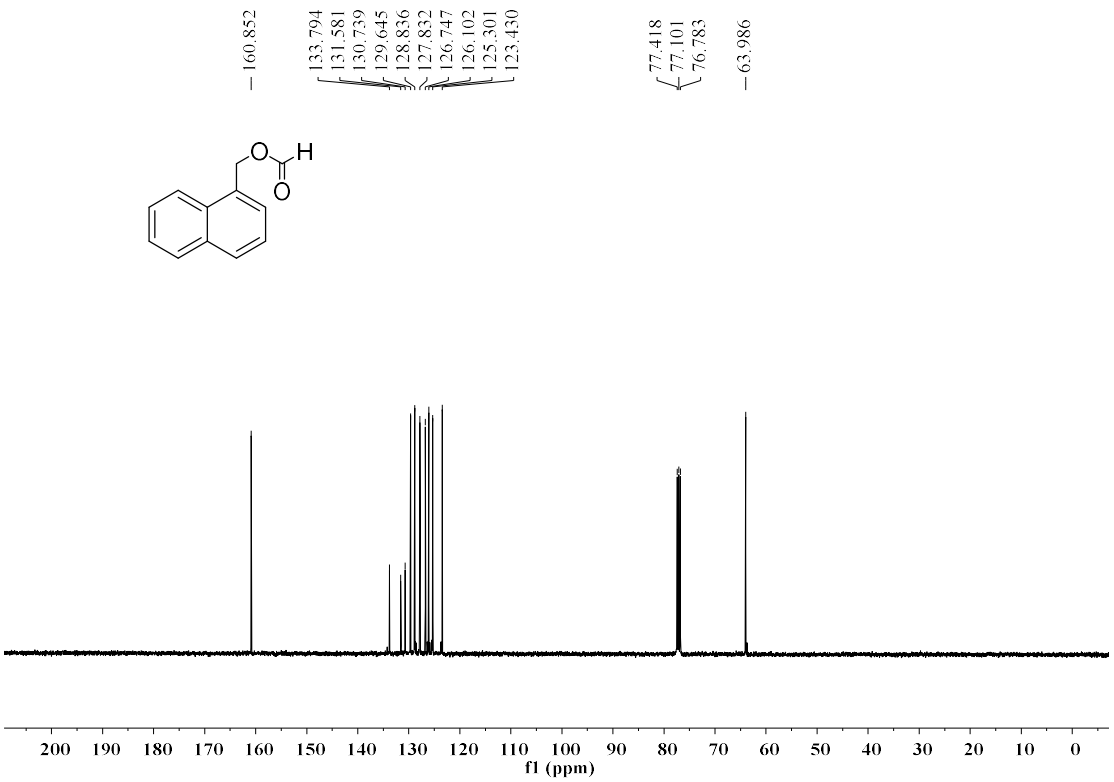
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2ak



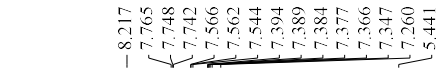
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2al

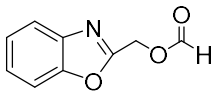


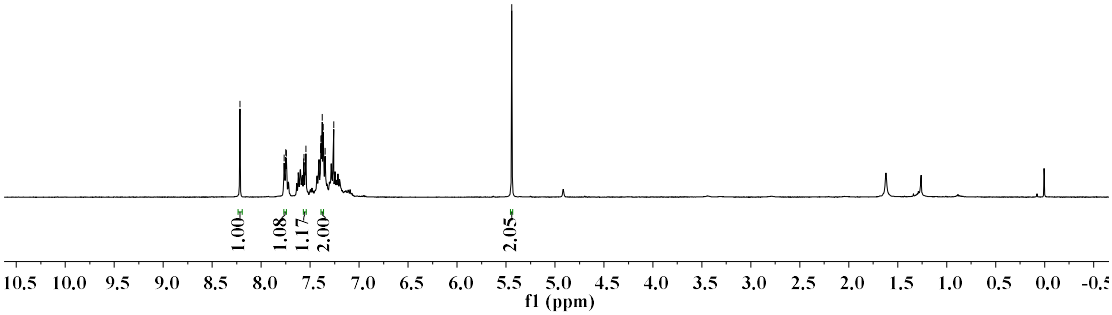
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2al



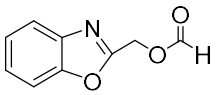
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2am

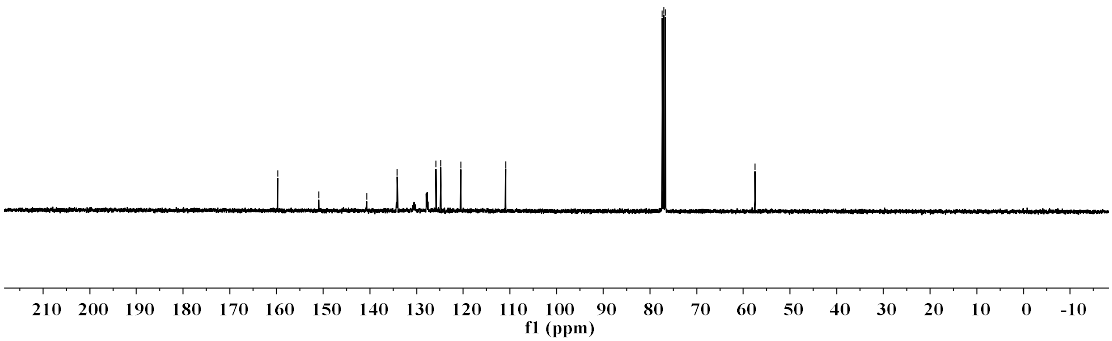




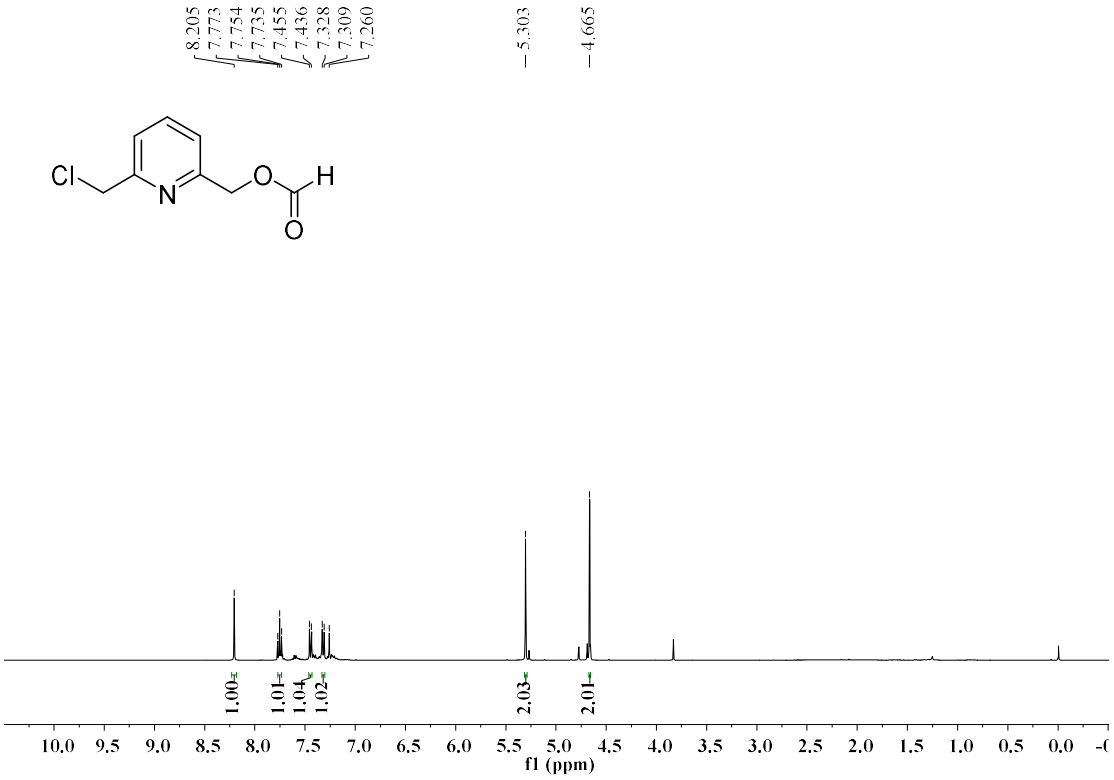


^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2am

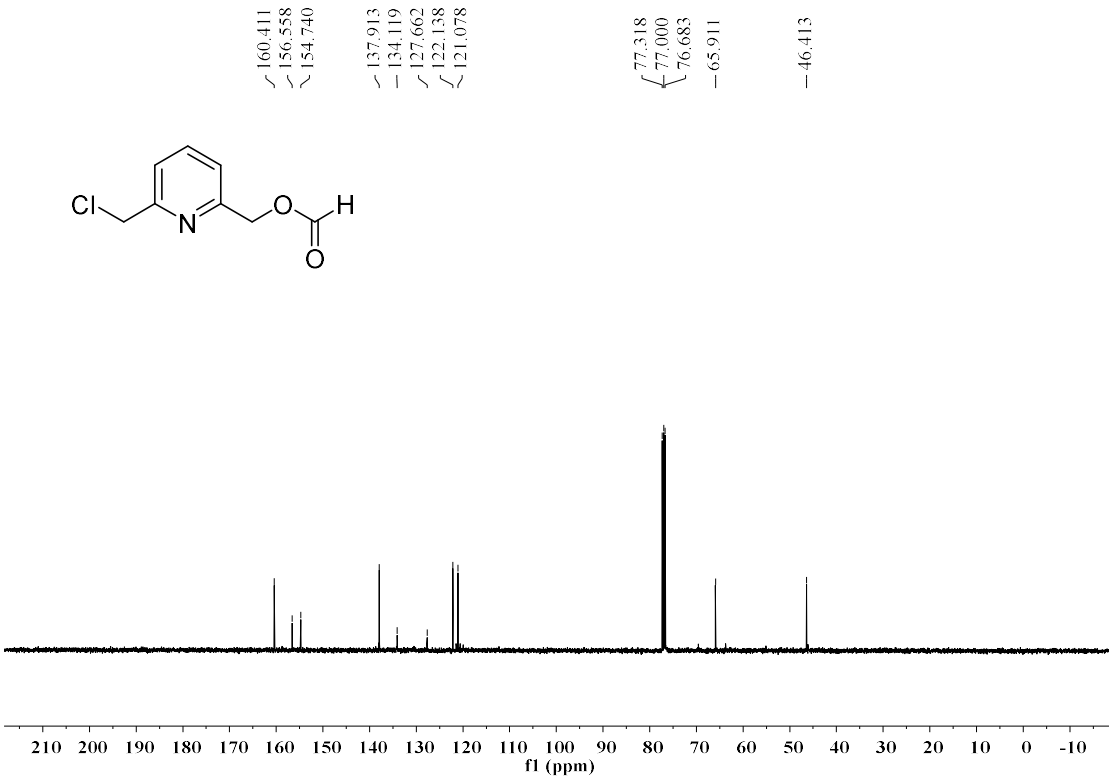




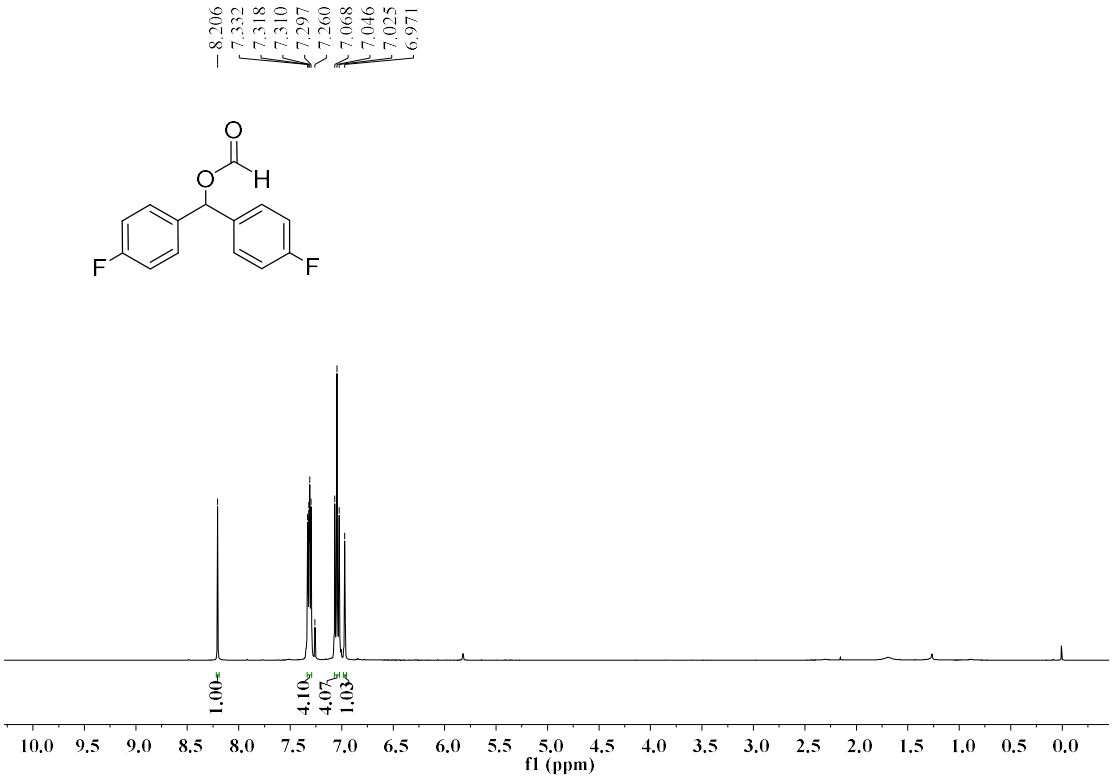
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2an



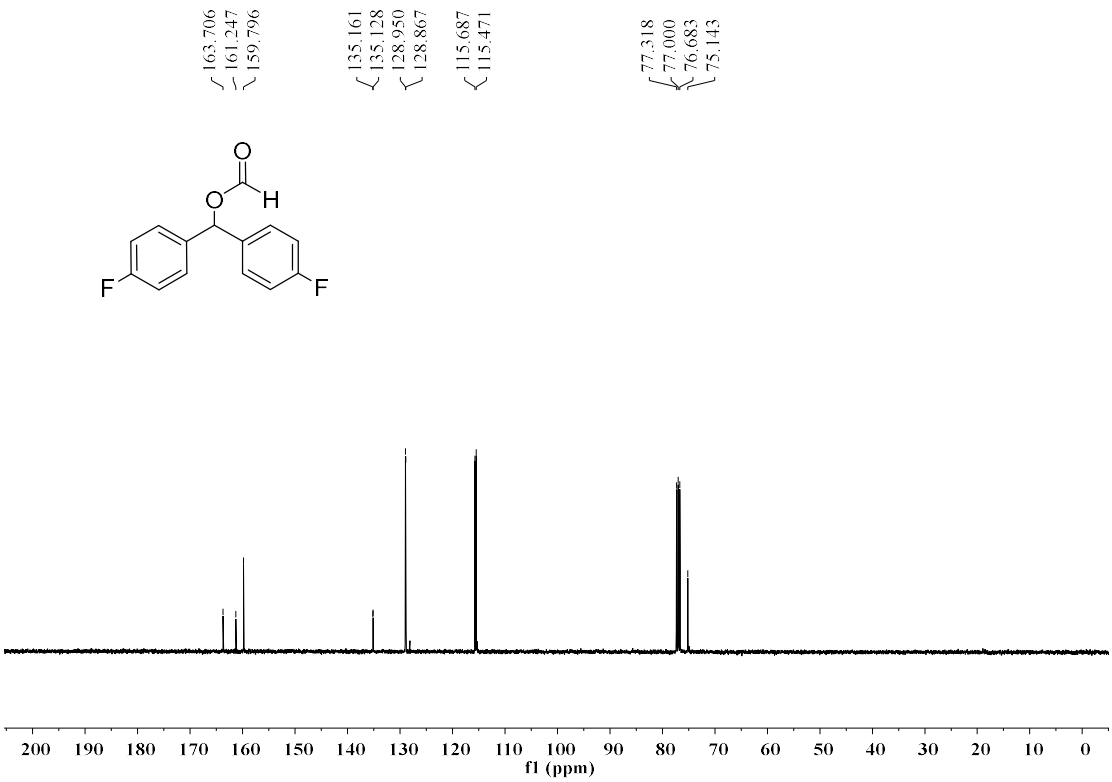
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2an



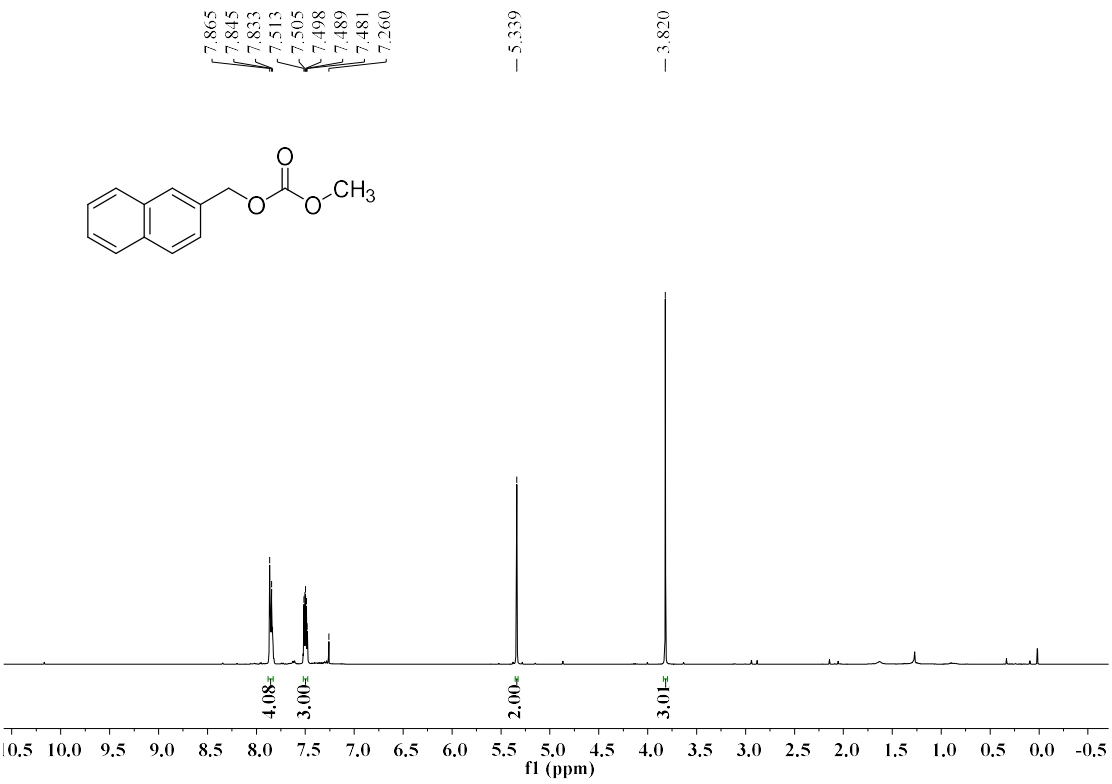
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2ao



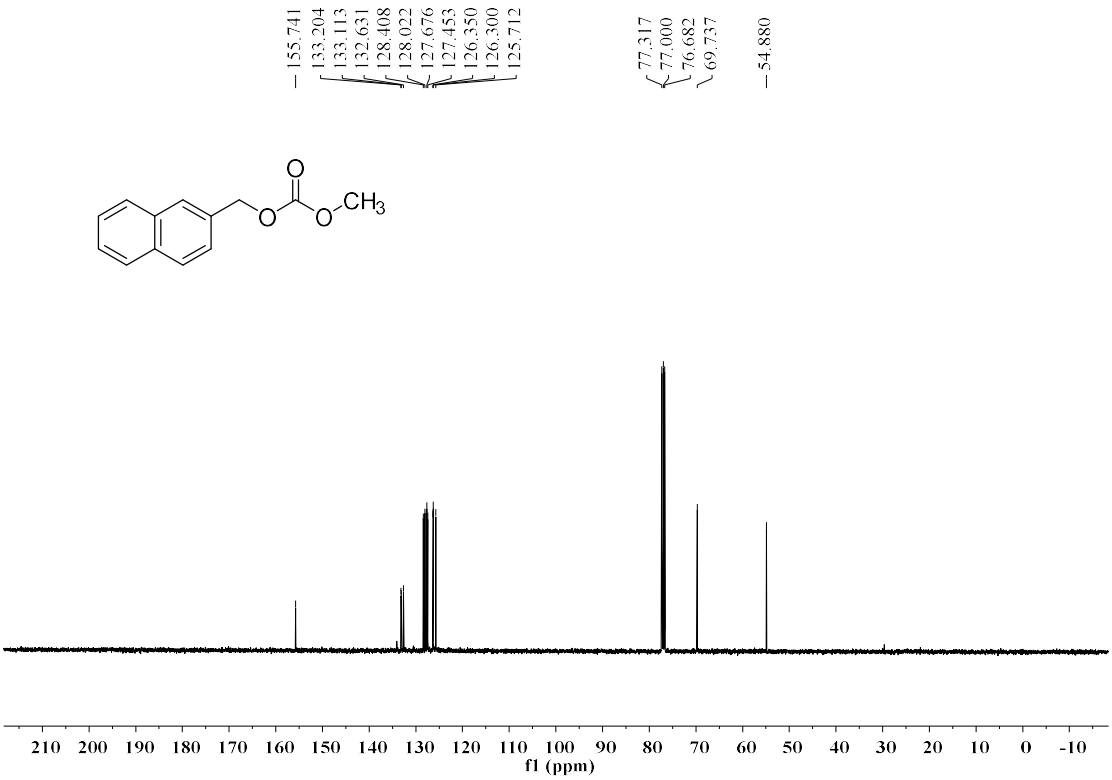
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2ao



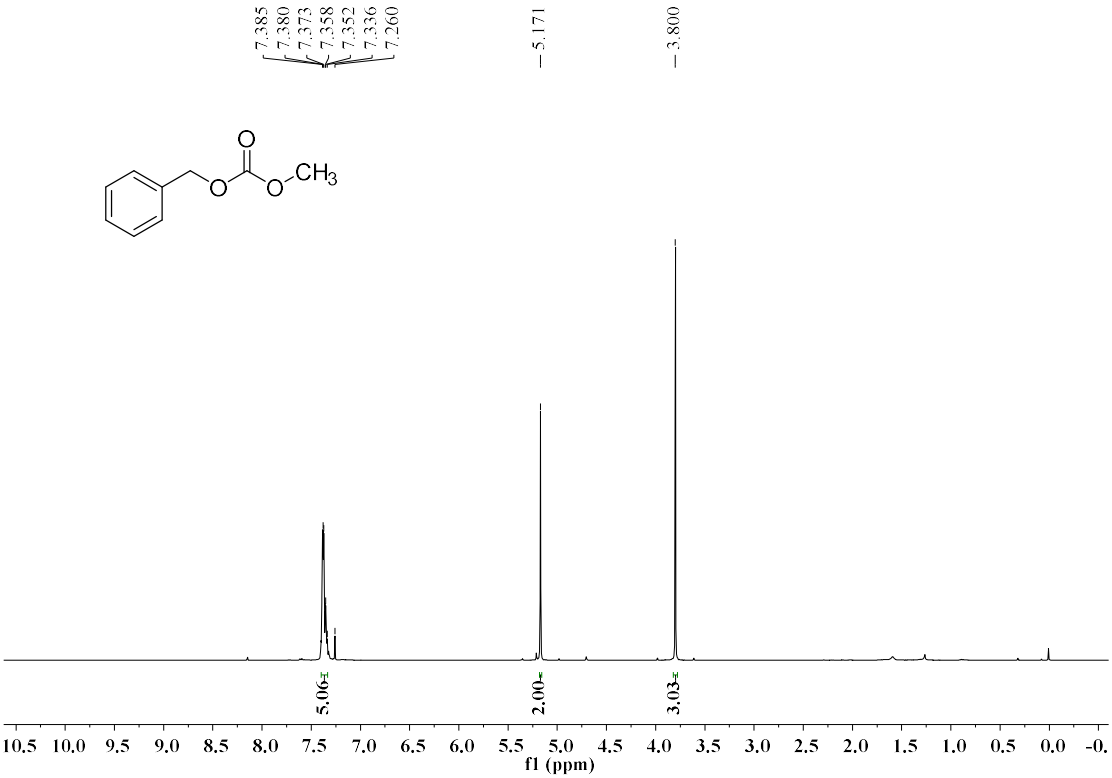
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 3a



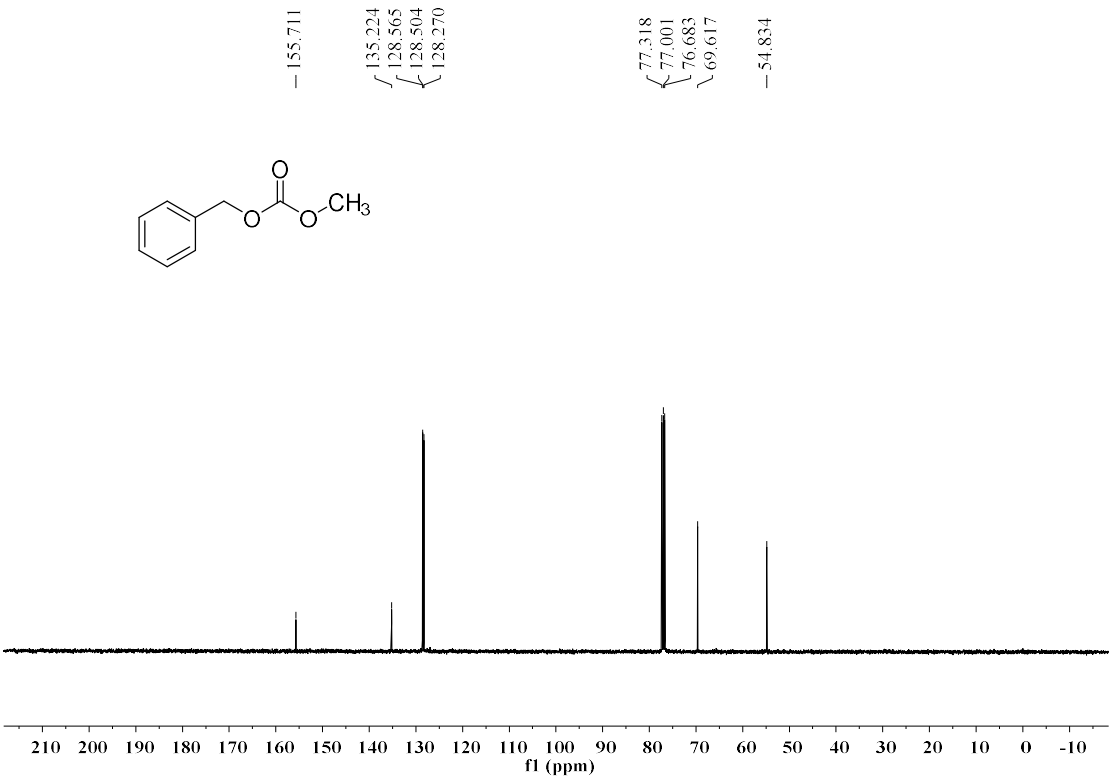
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 3a



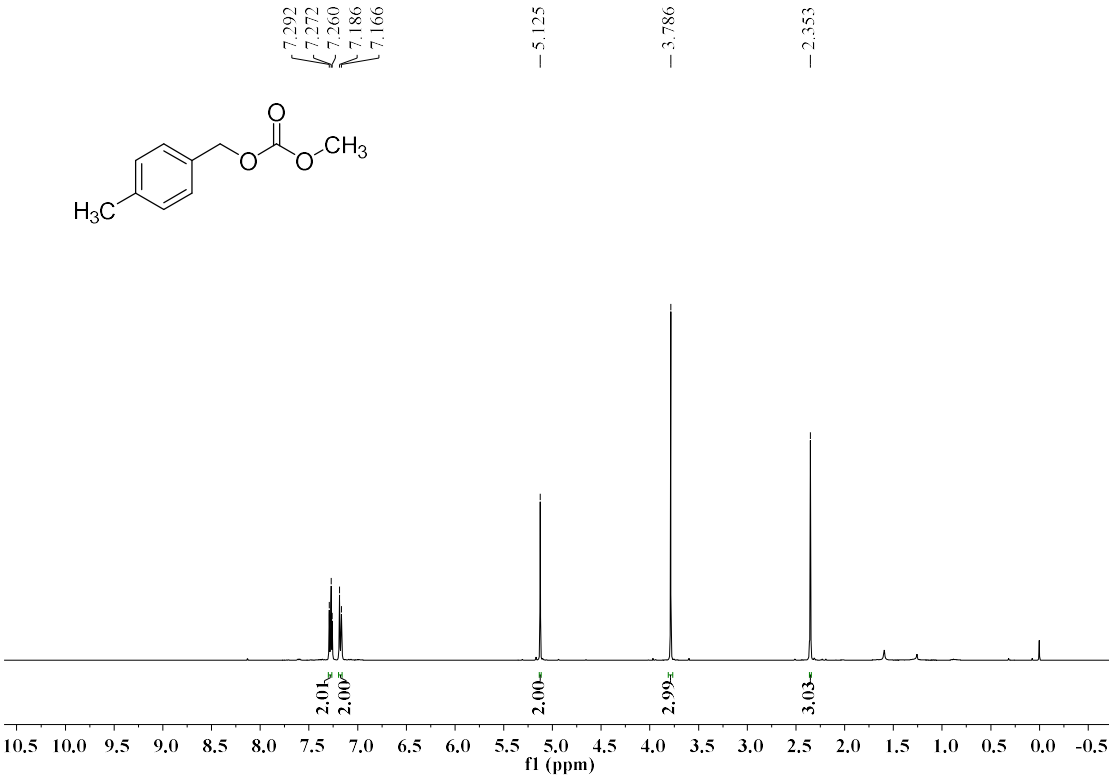
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 3b



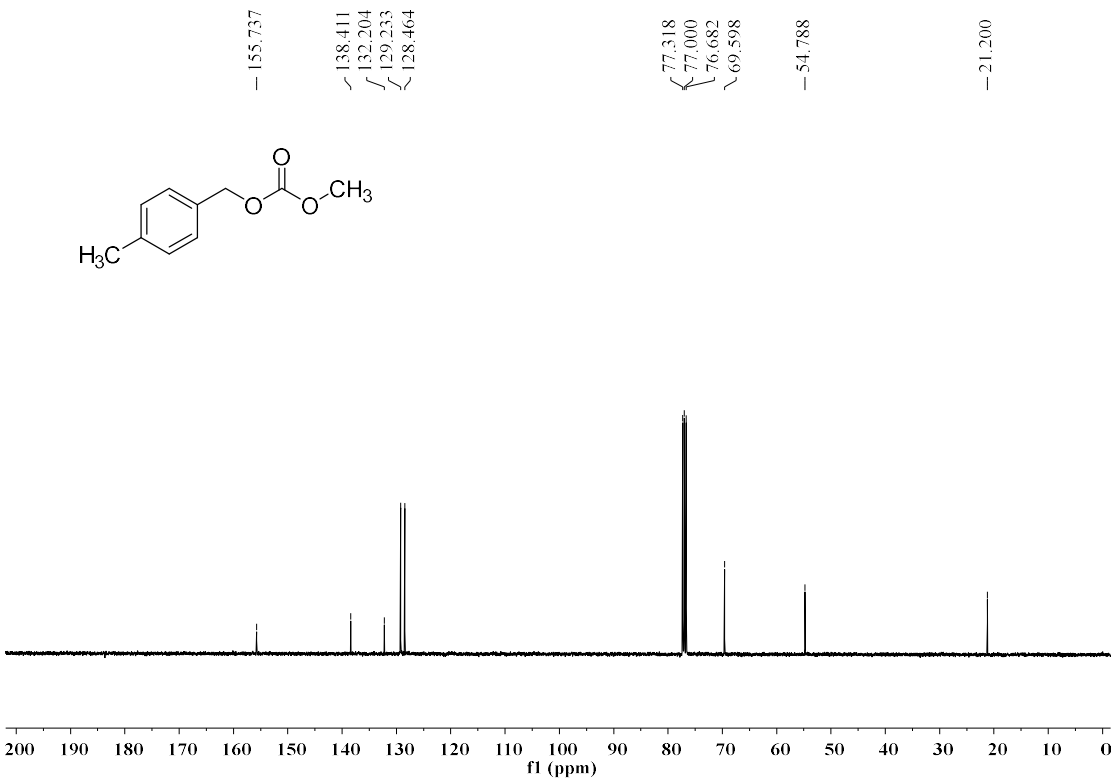
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 3b



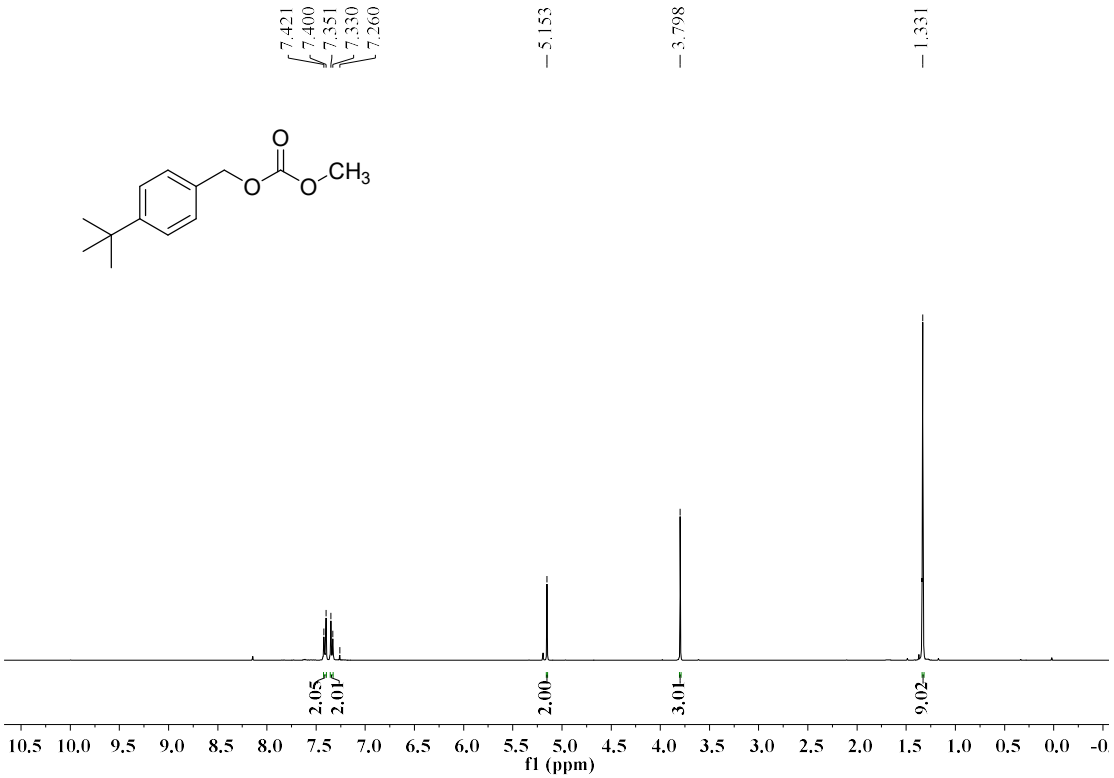
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 3c



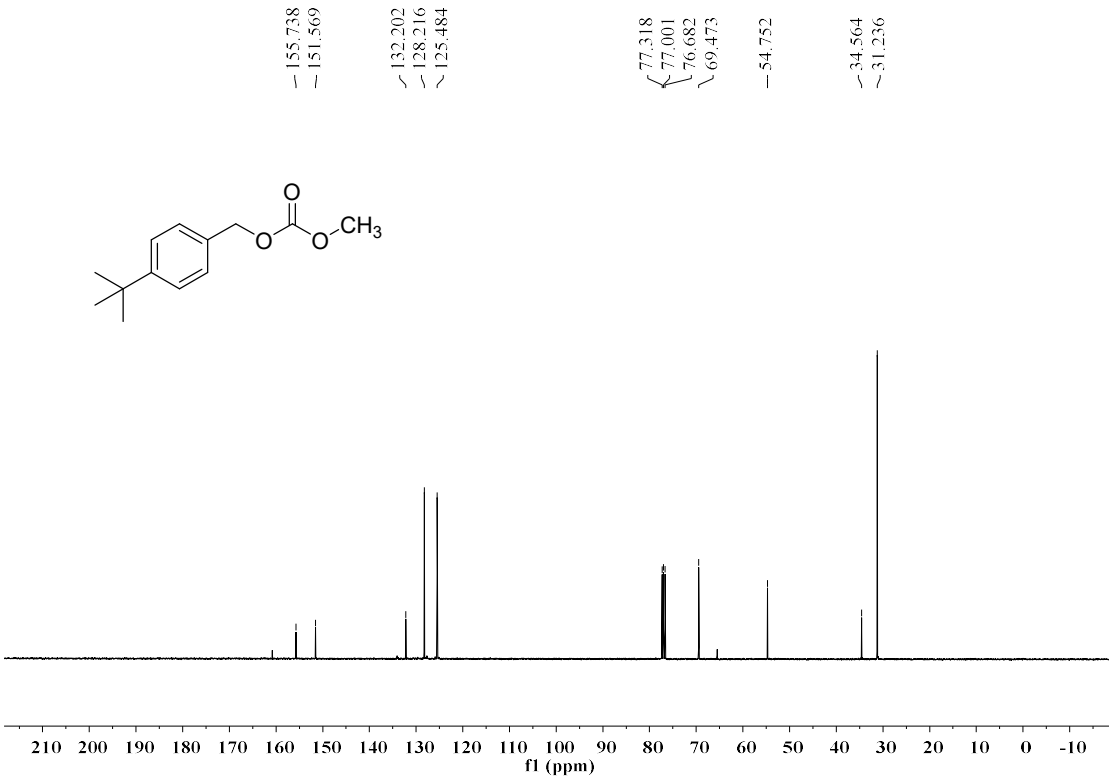
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 3c



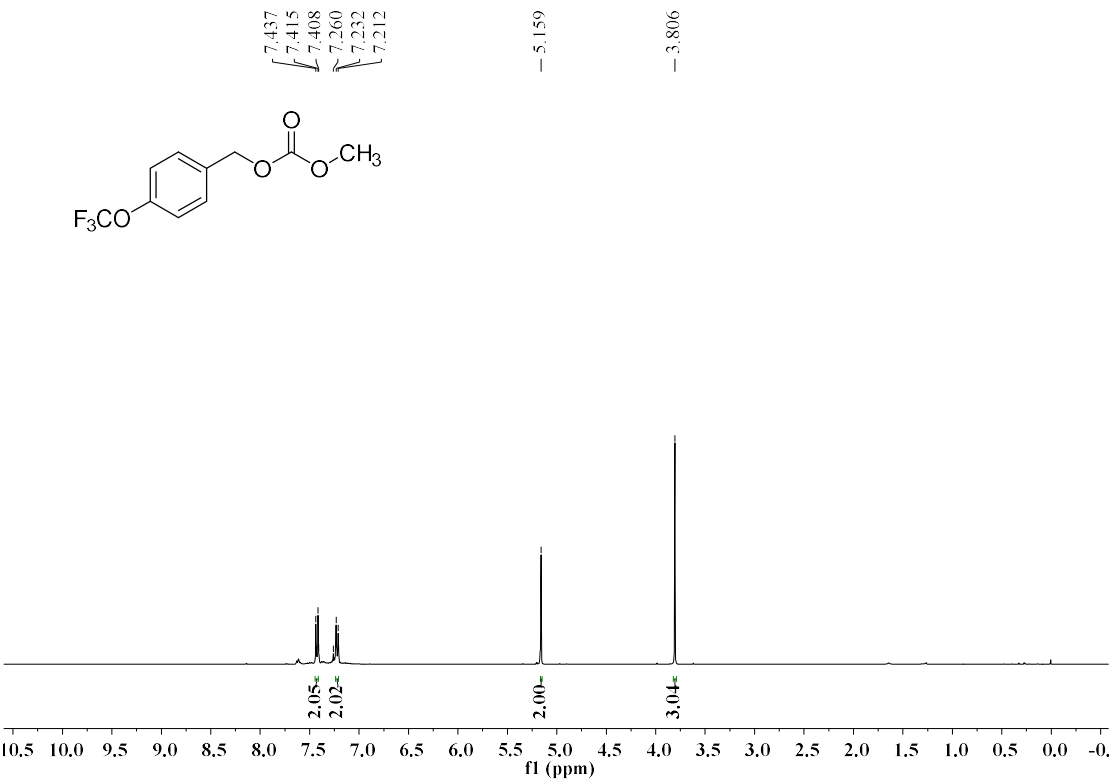
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 3d



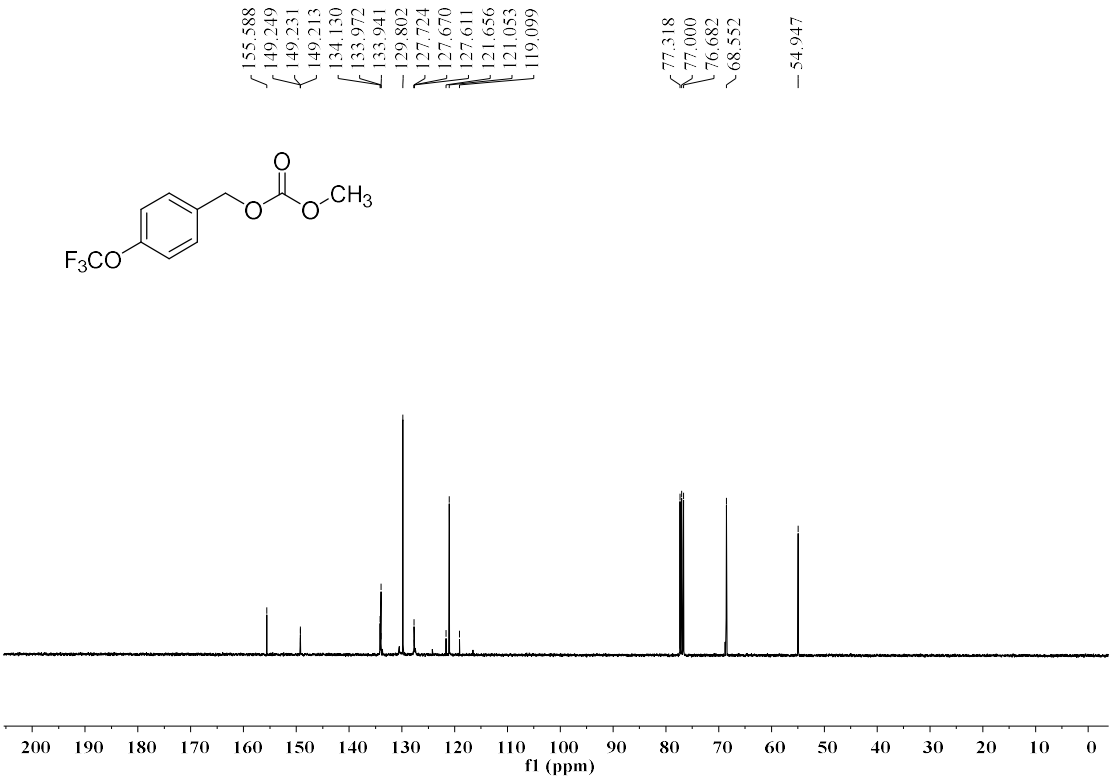
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 3d



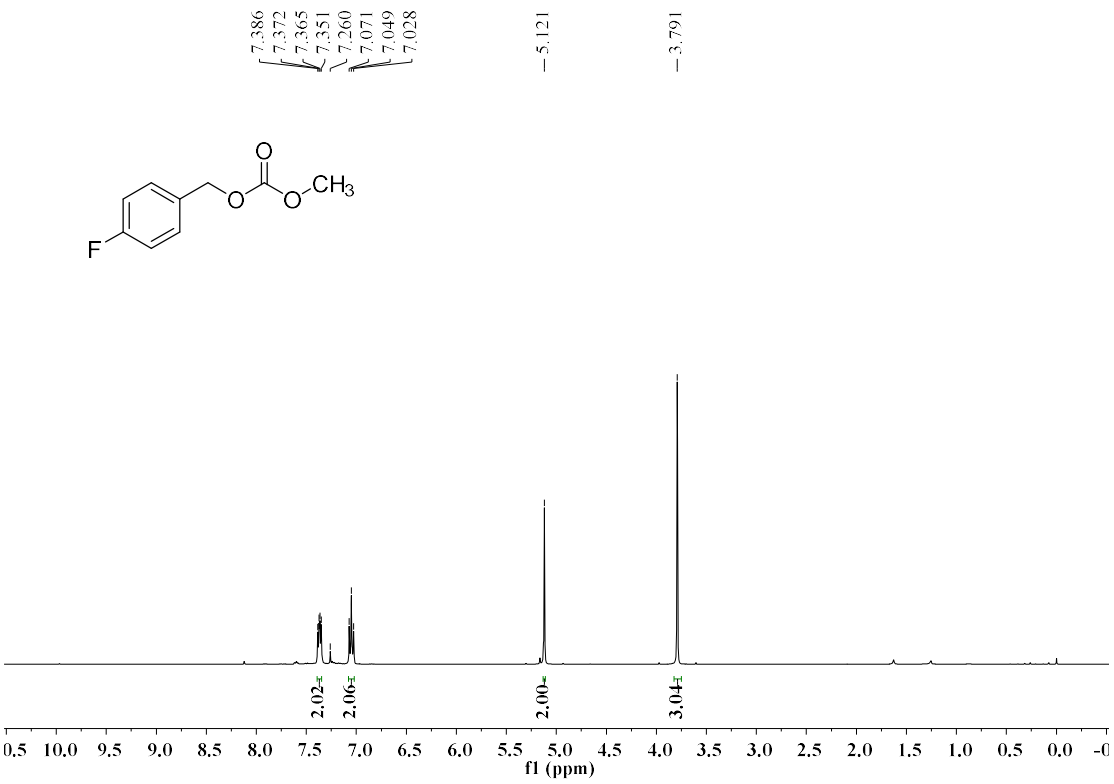
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 3e



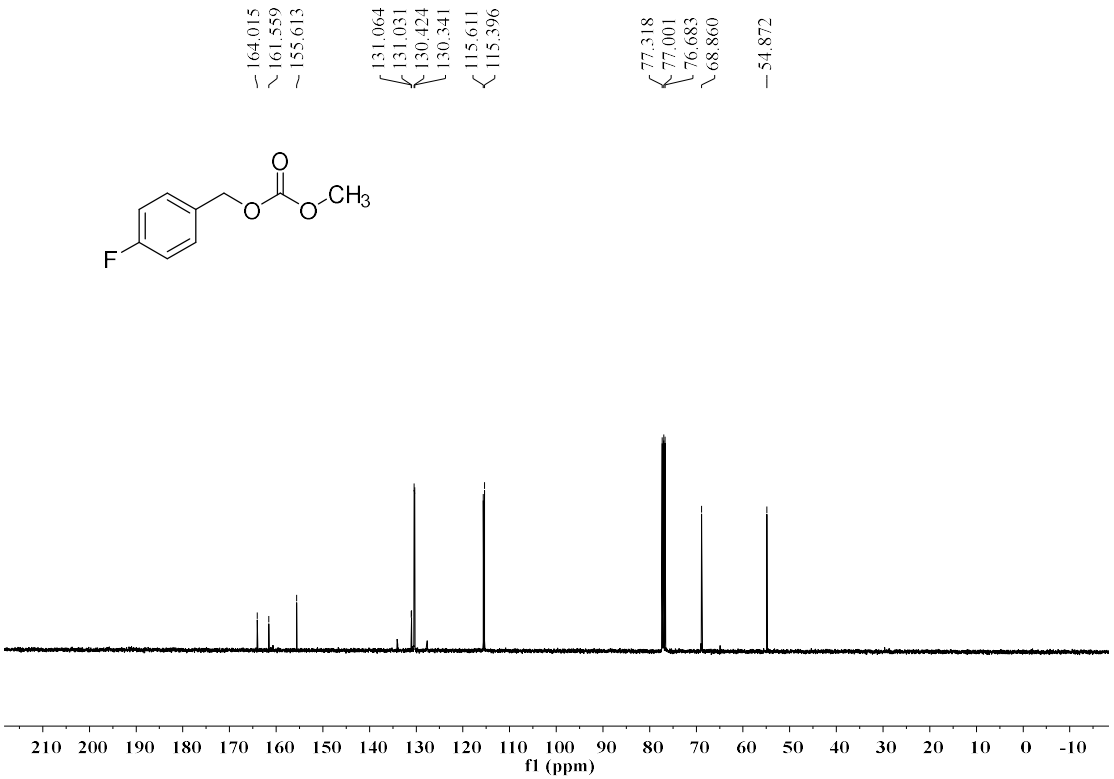
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 3e



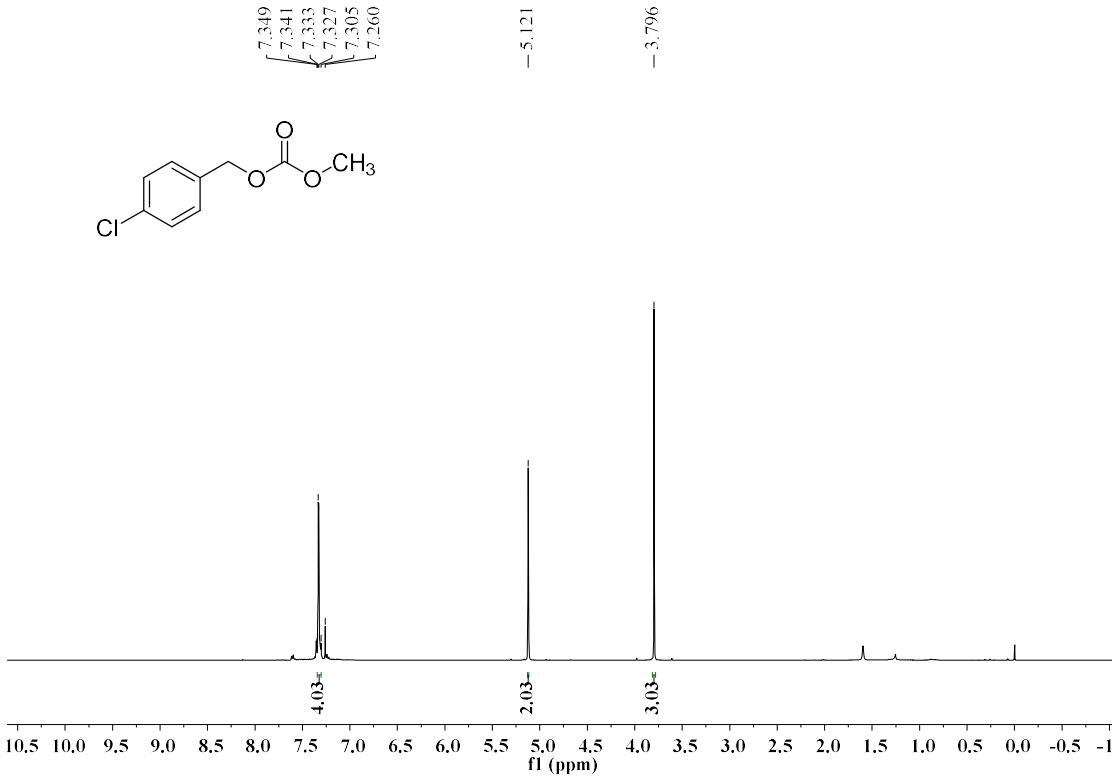
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 3f



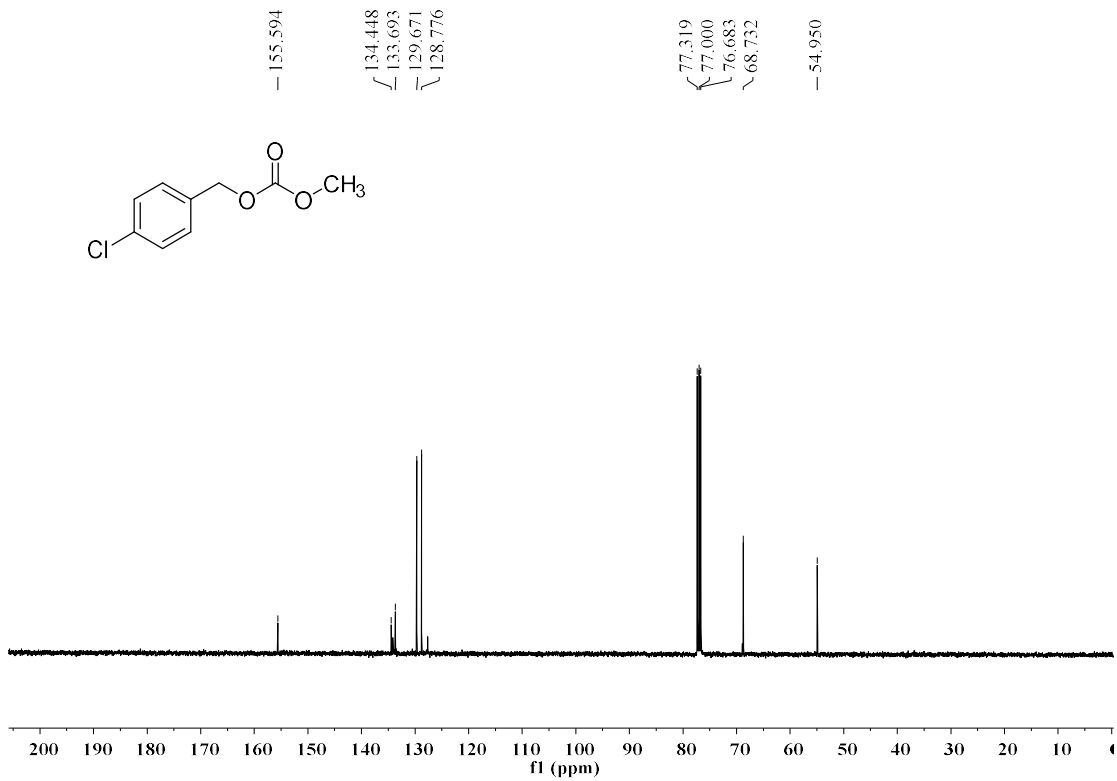
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 3f



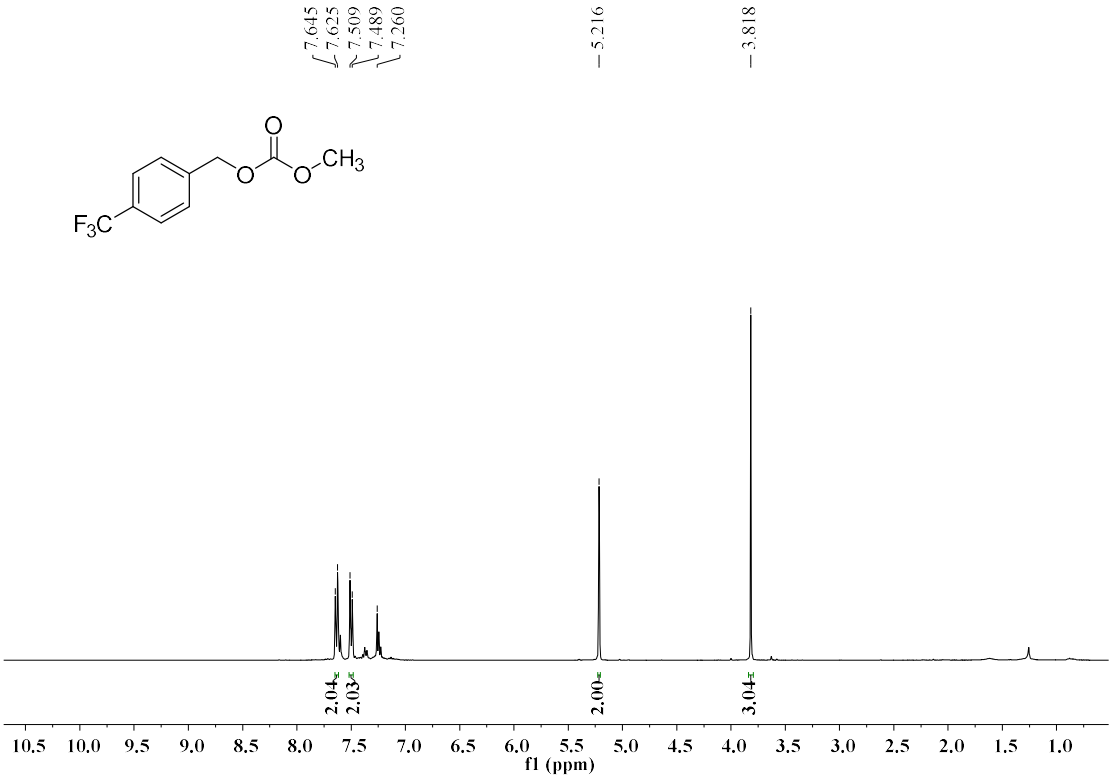
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 3g



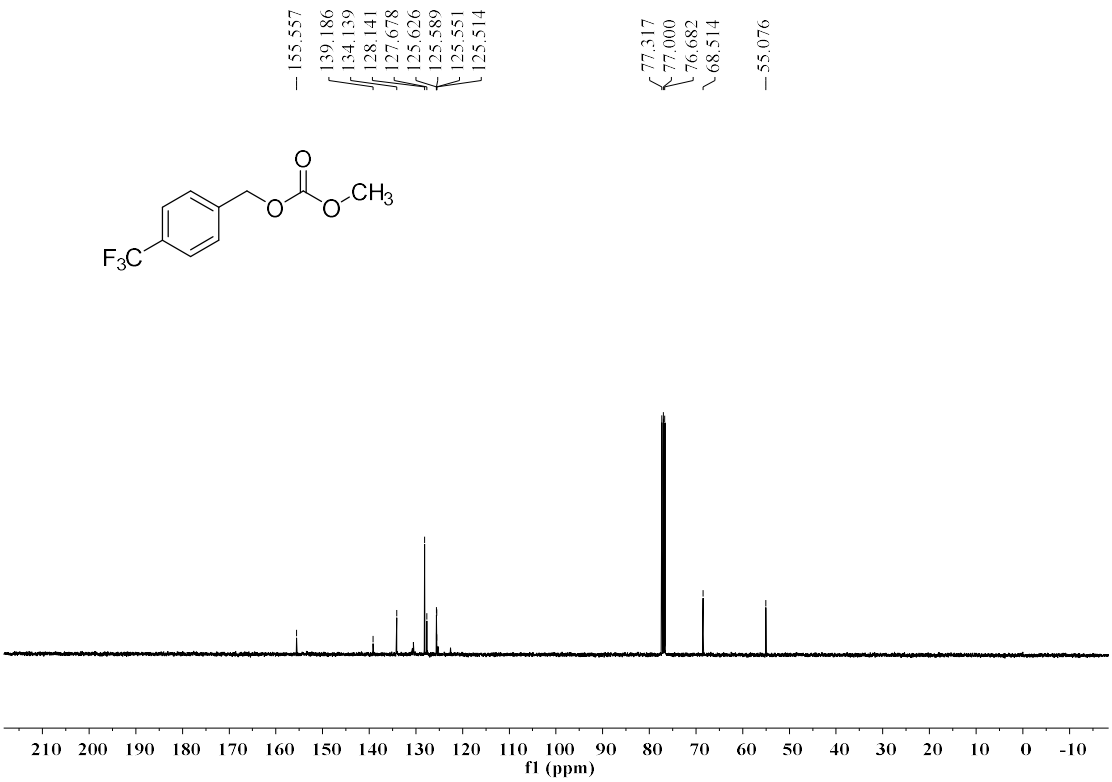
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 3g



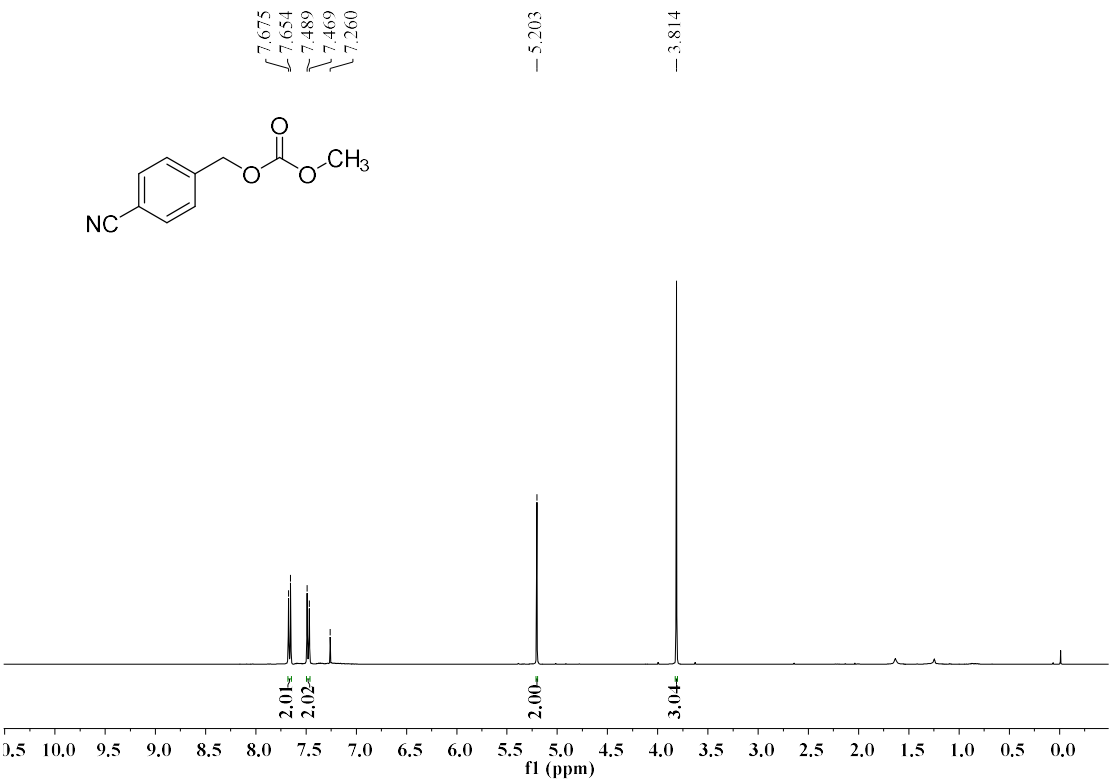
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 3h



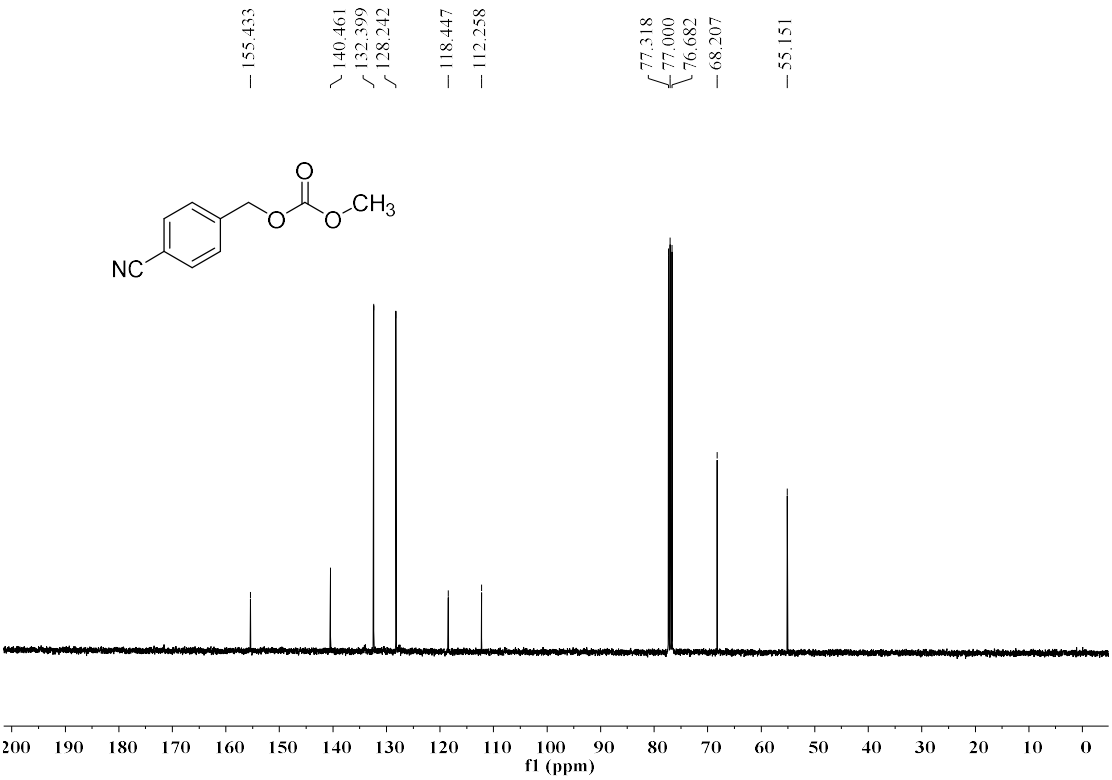
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 3h



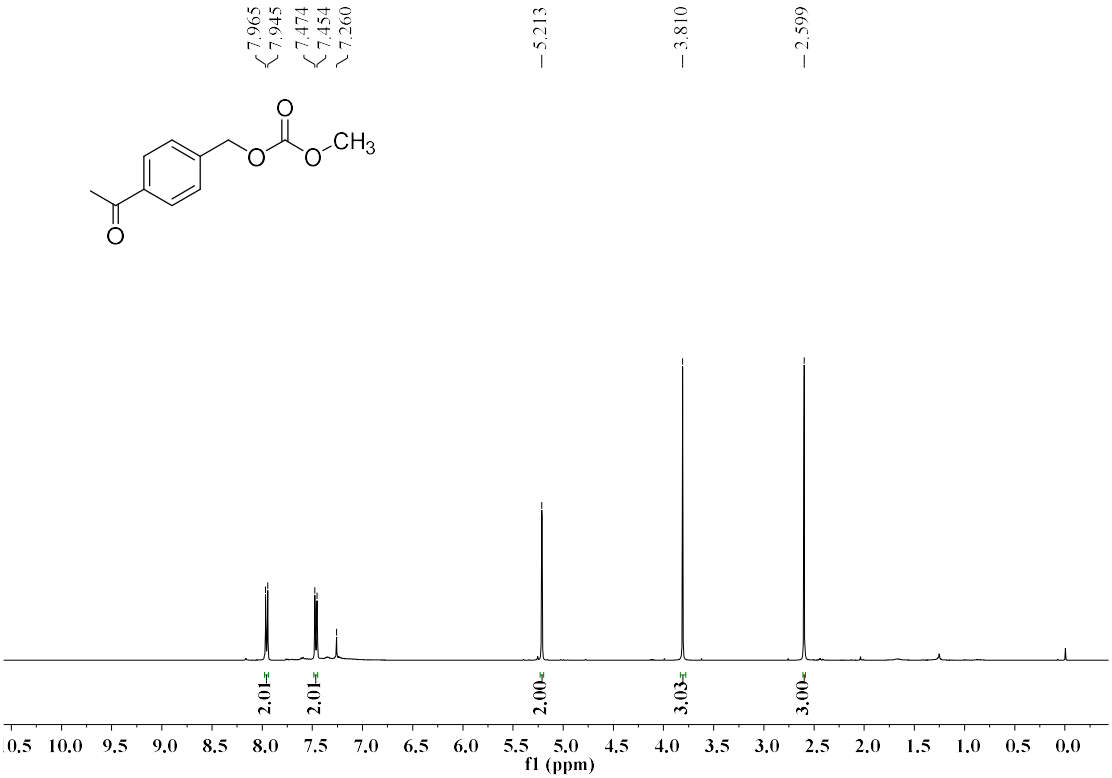
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 3i



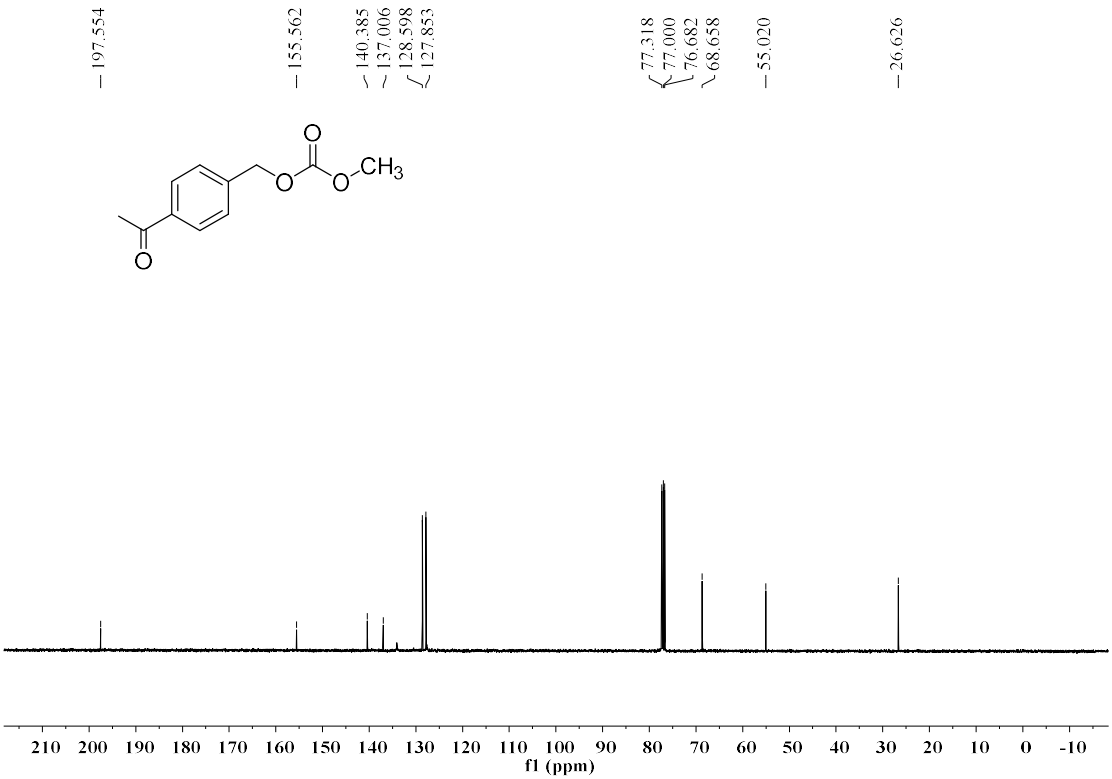
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 3i



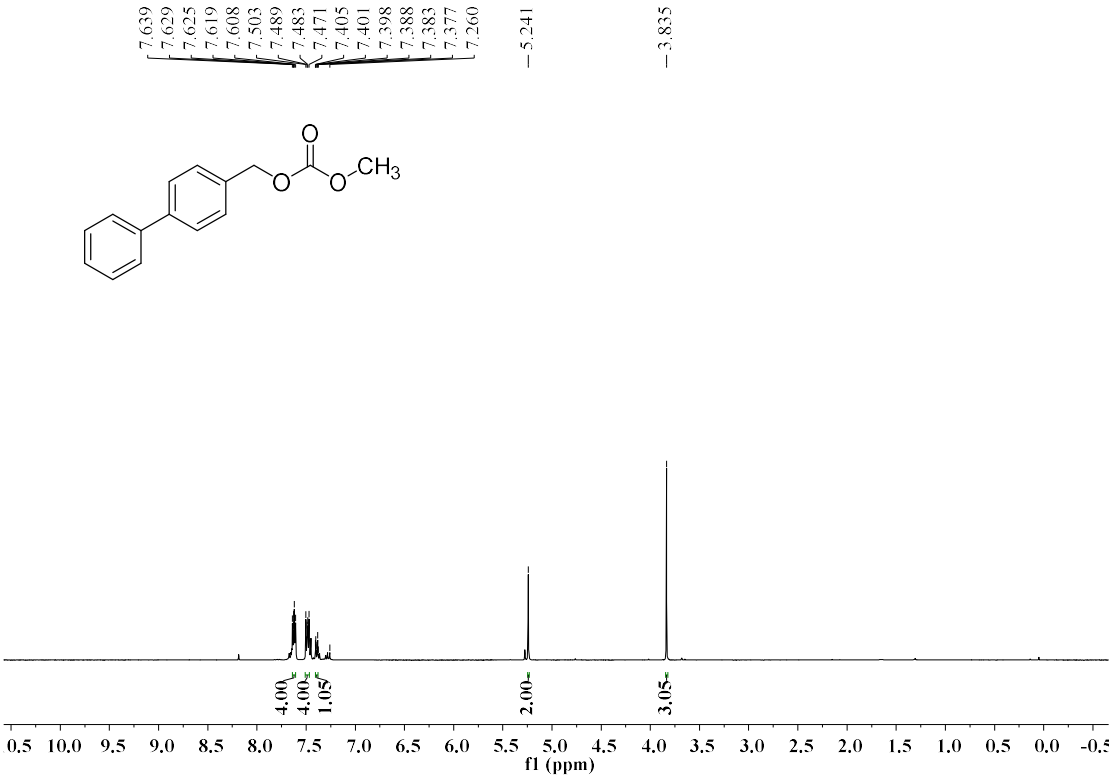
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 3j



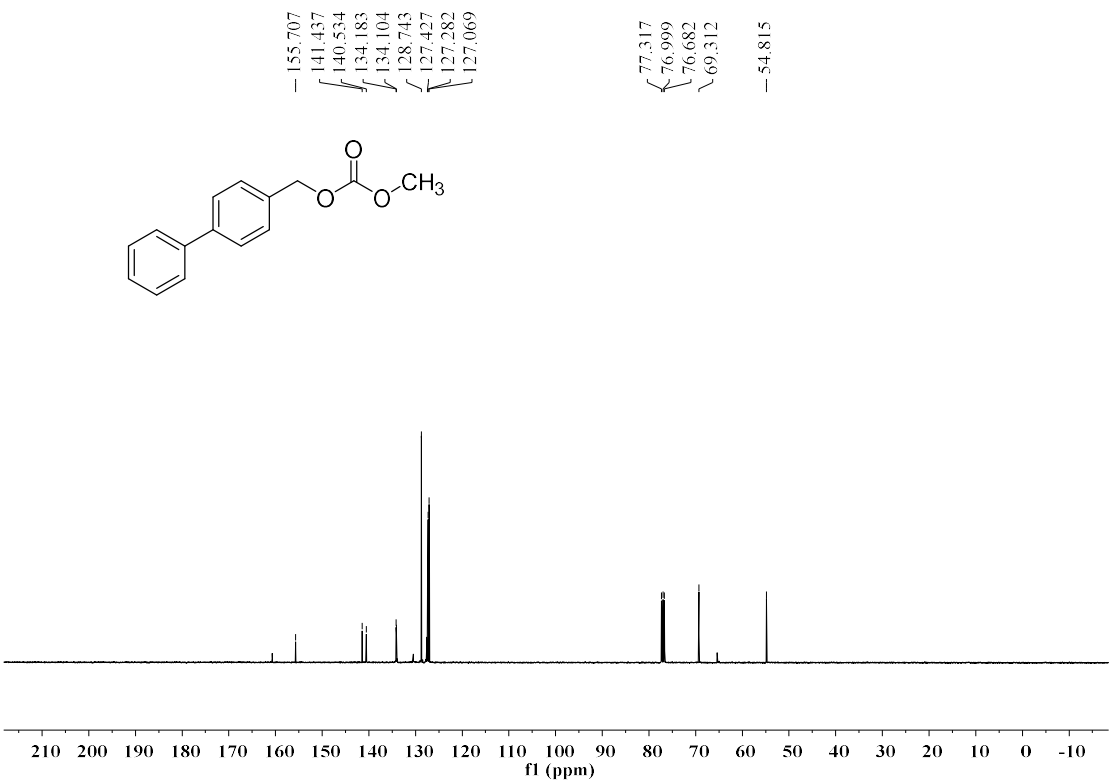
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 3j



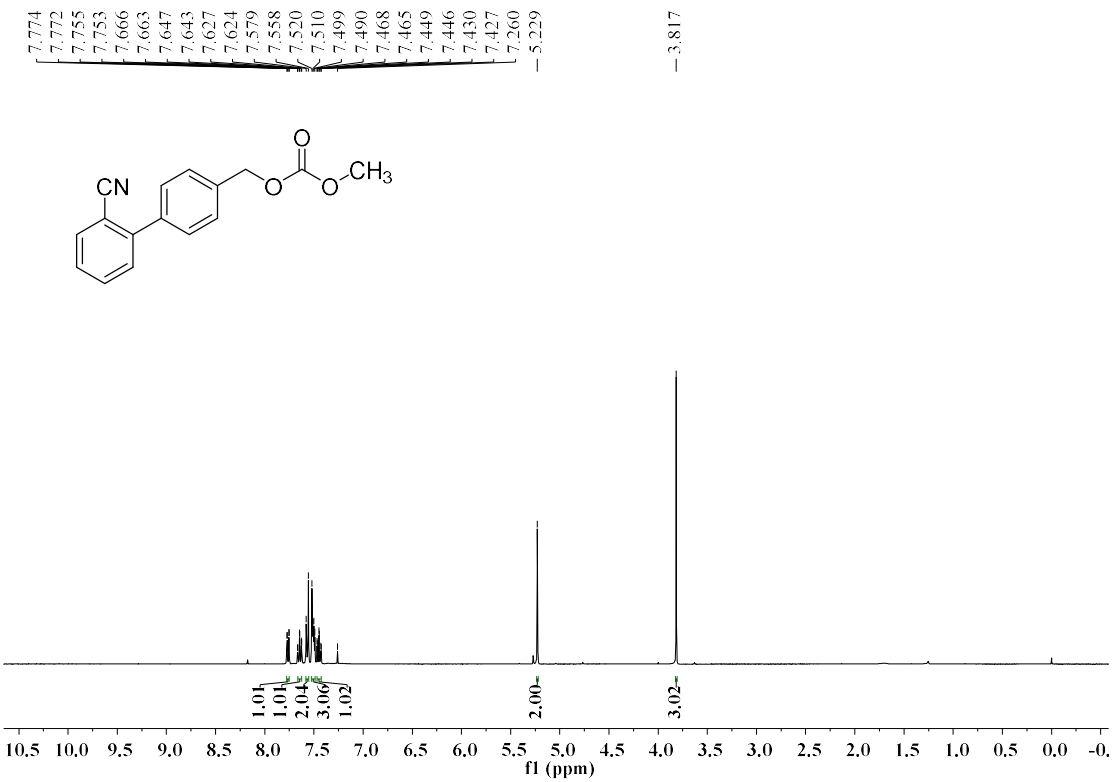
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 3k



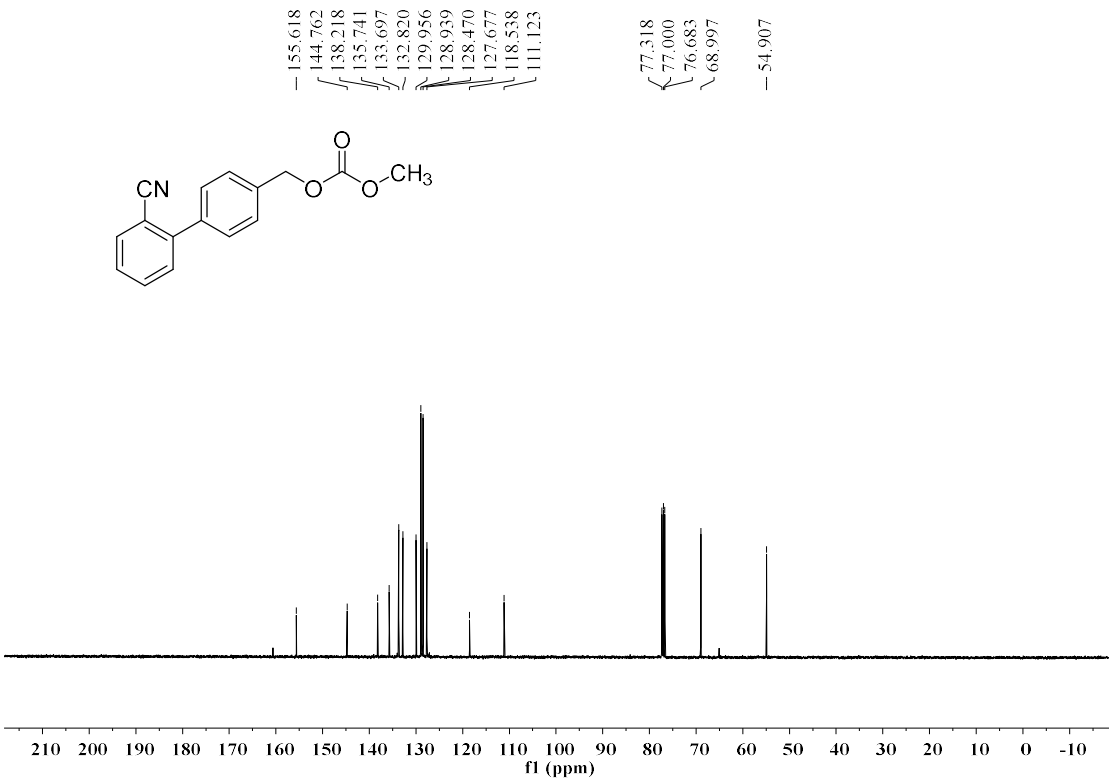
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 3k



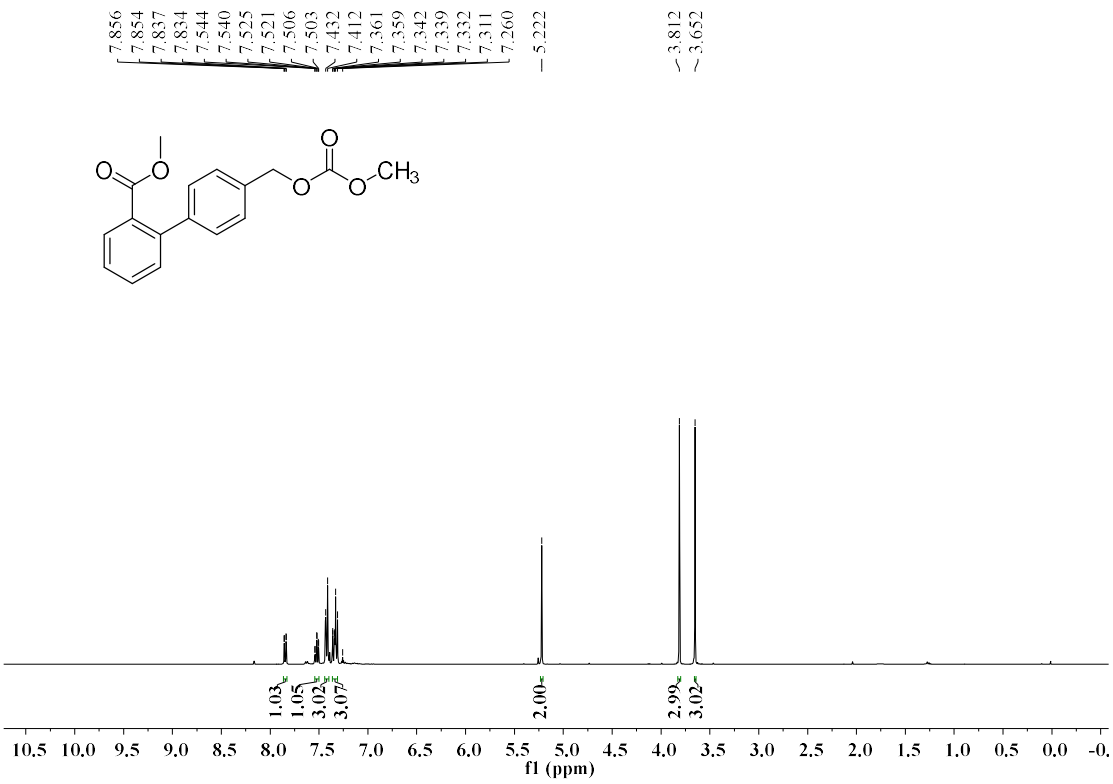
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 3l



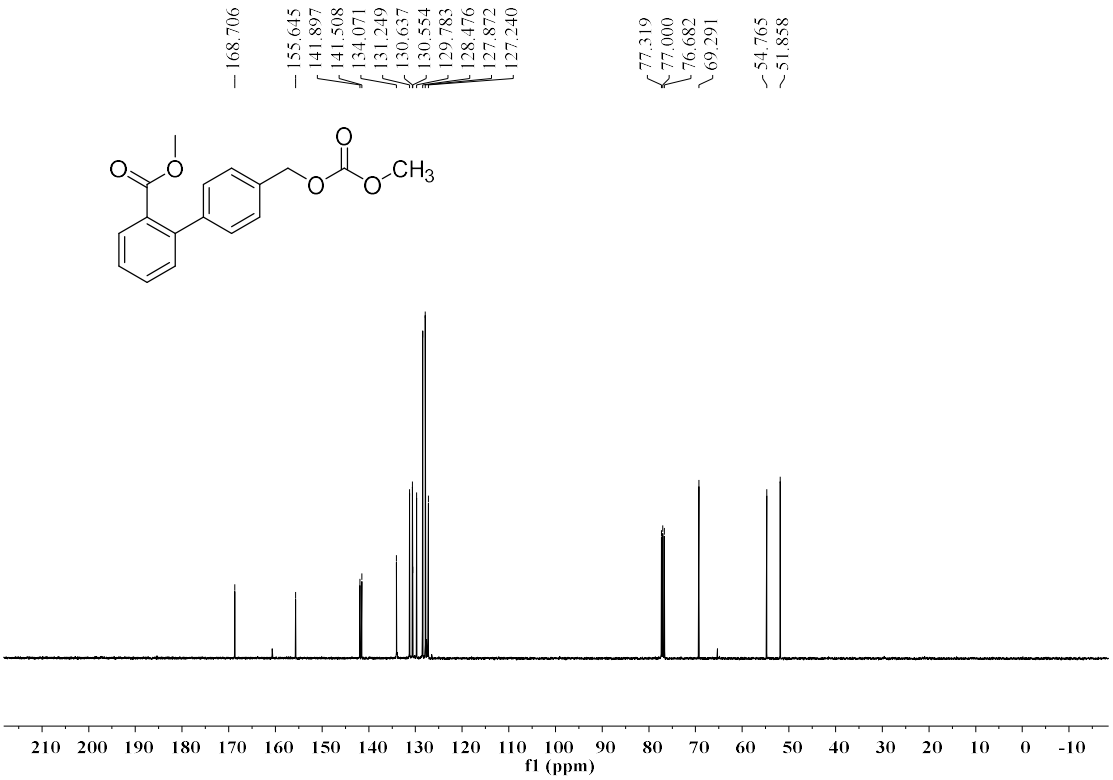
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 3l



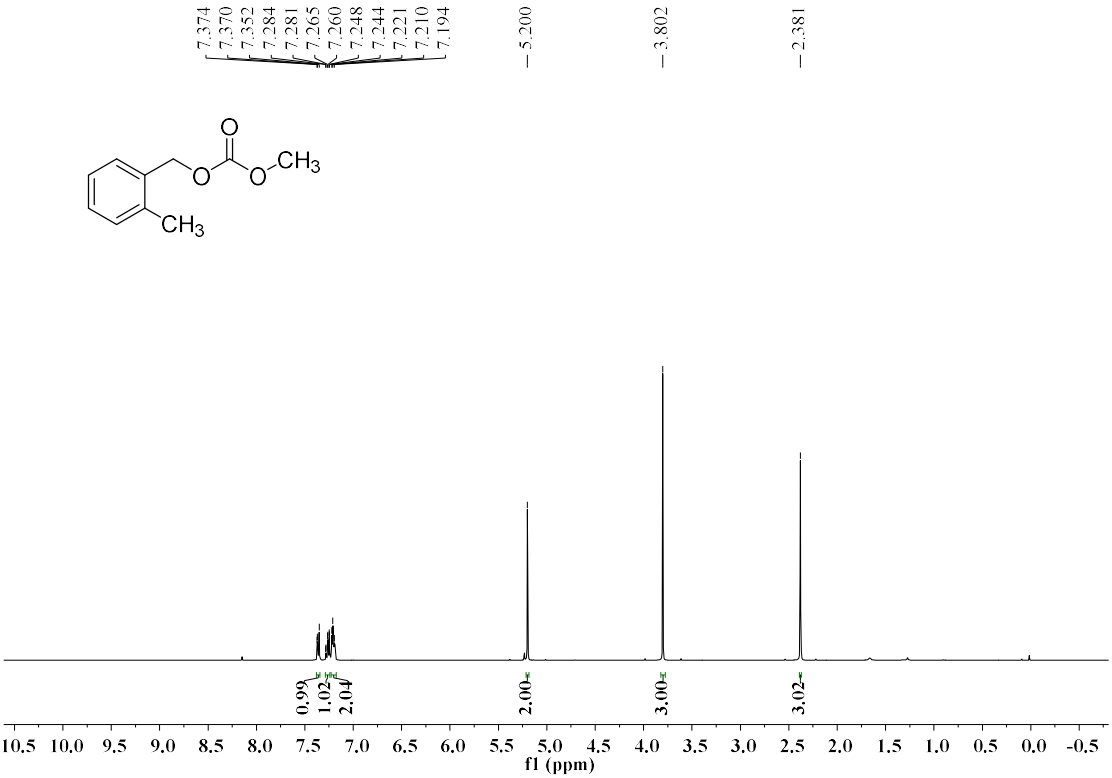
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 3m



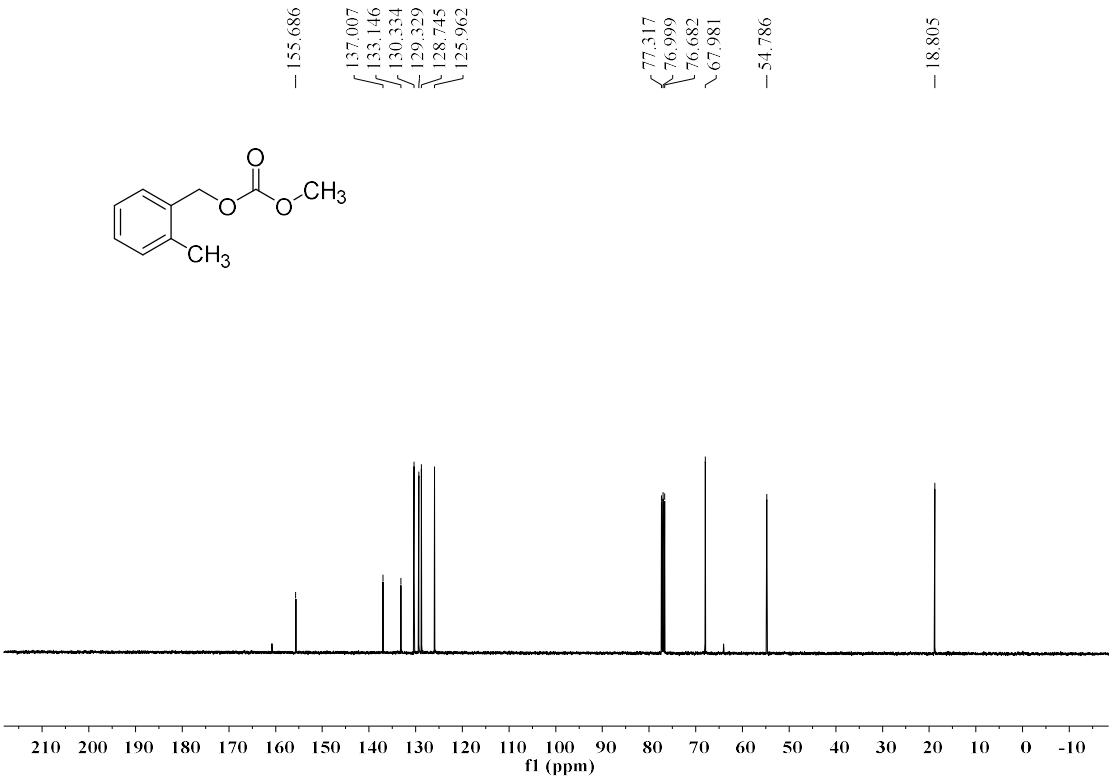
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 3m



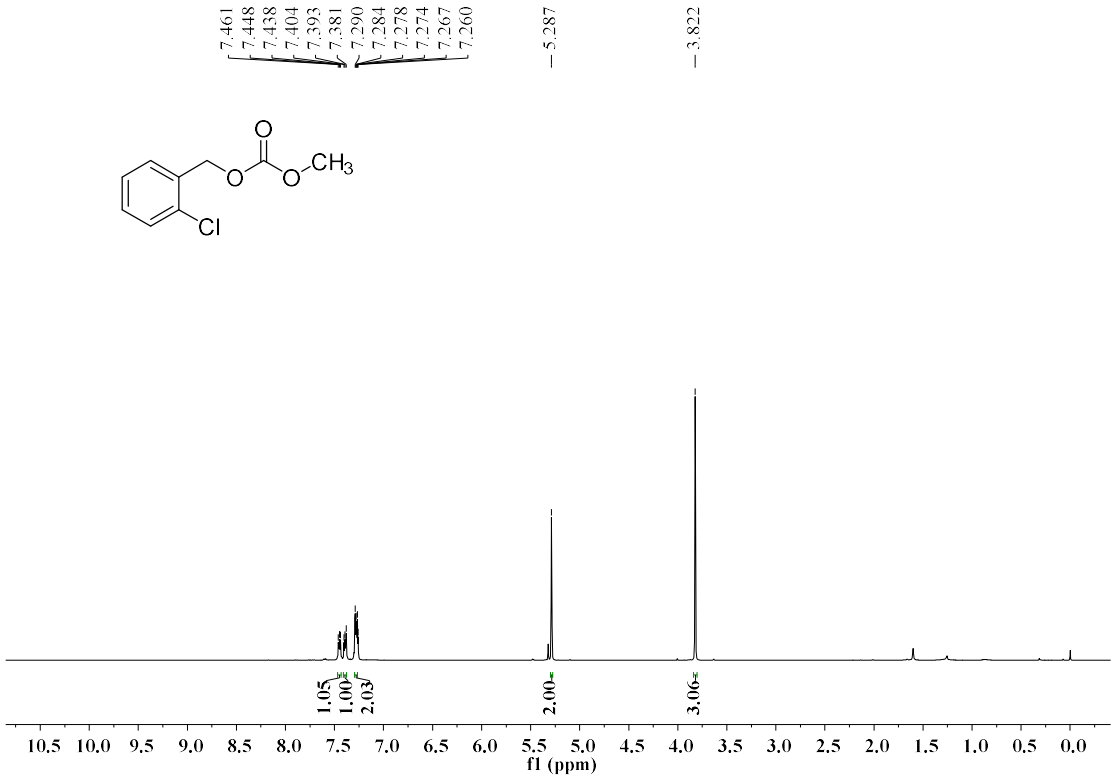
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 3n



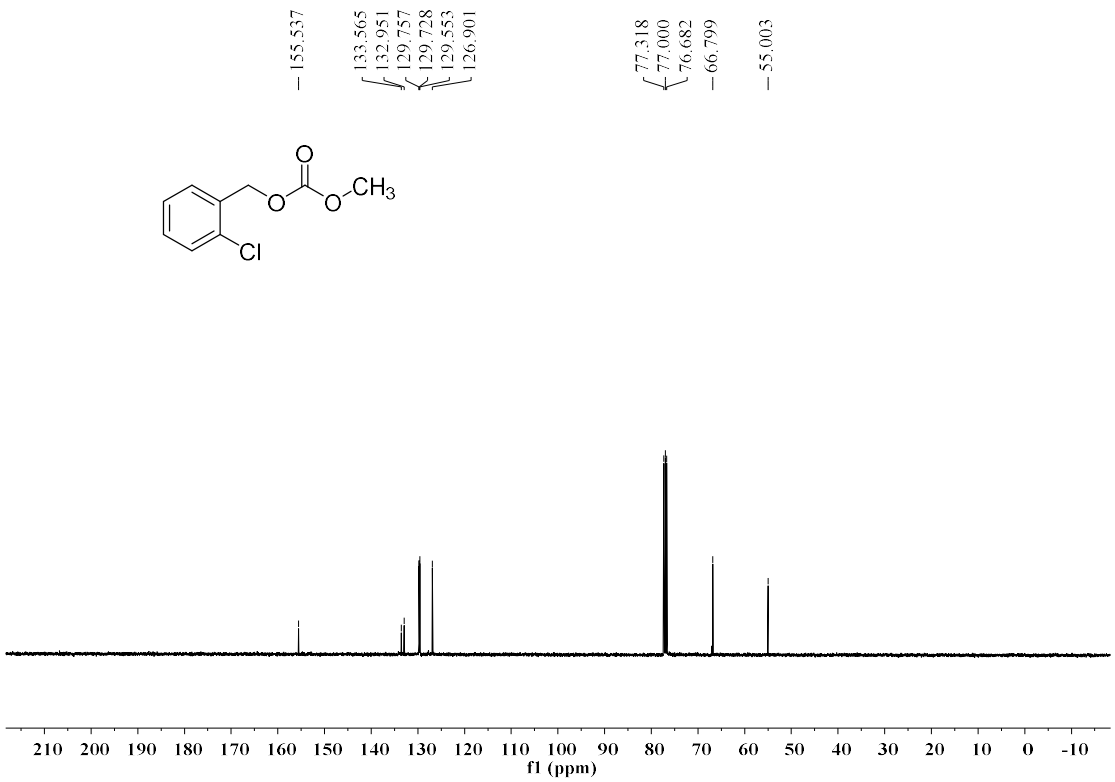
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 3n



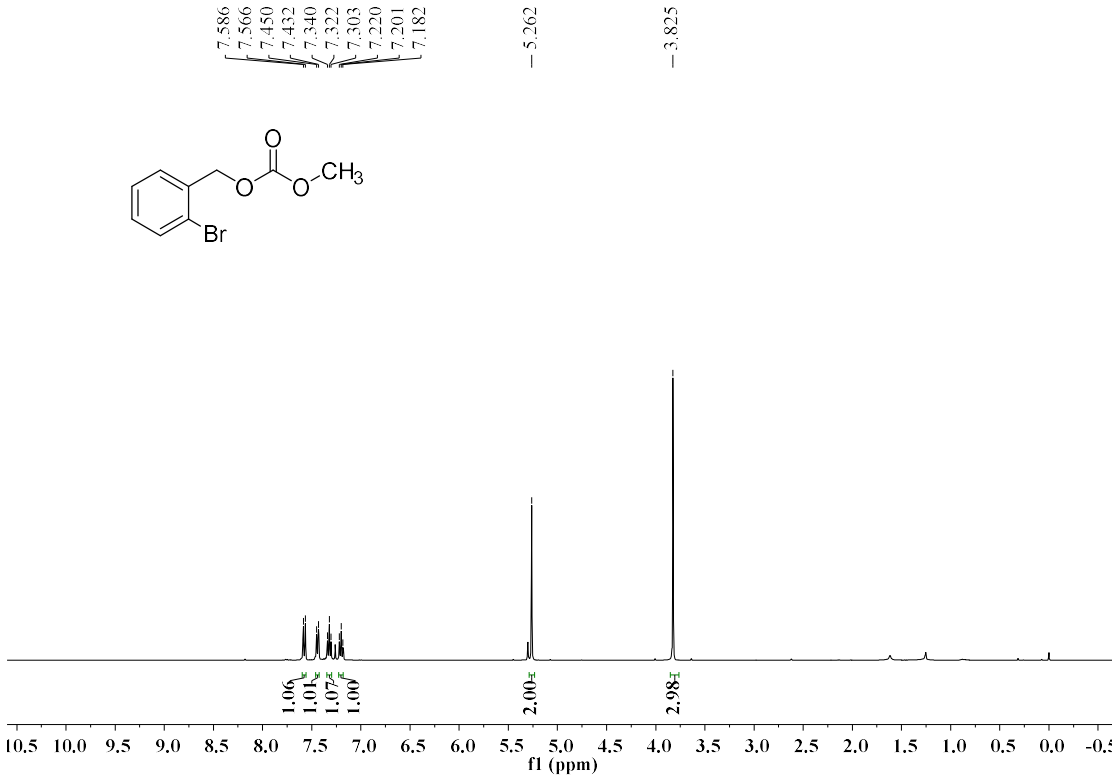
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 3o



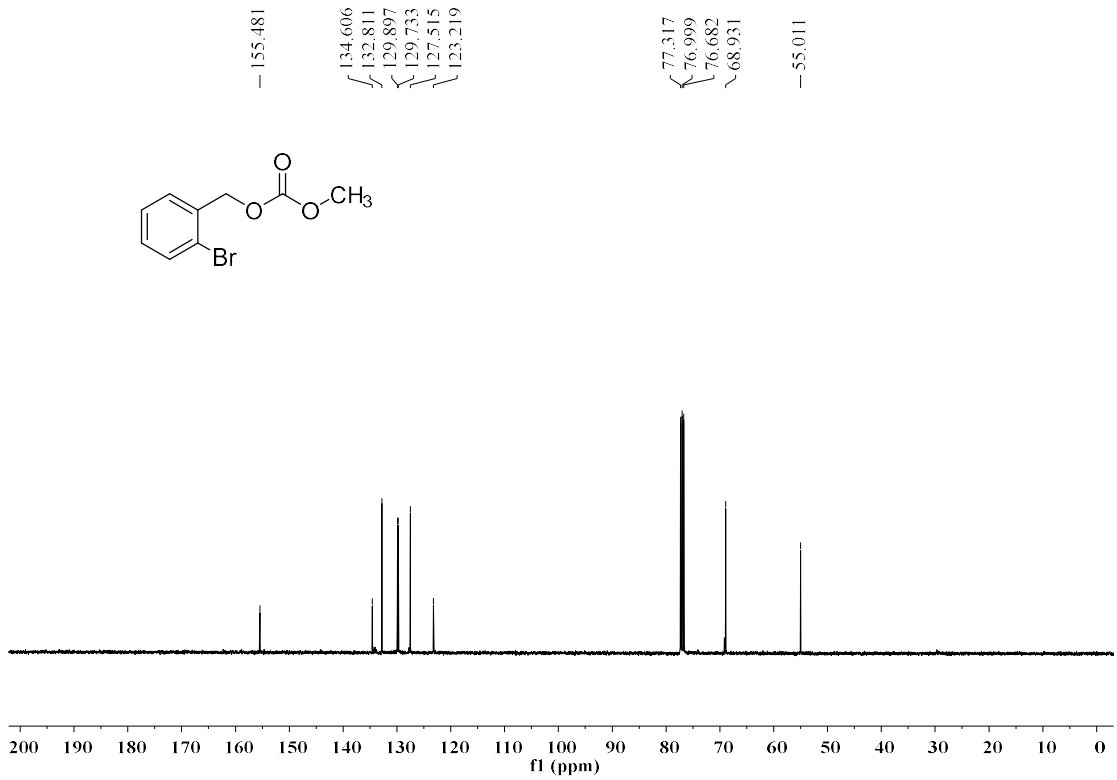
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 3o



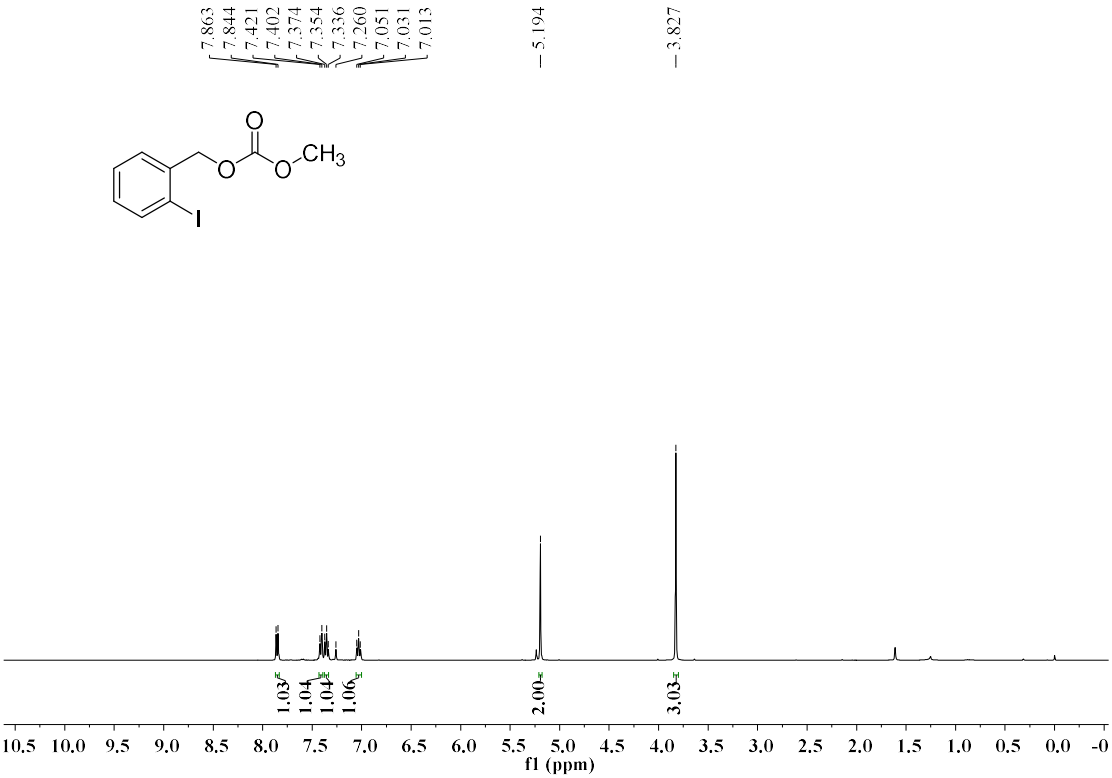
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 3p



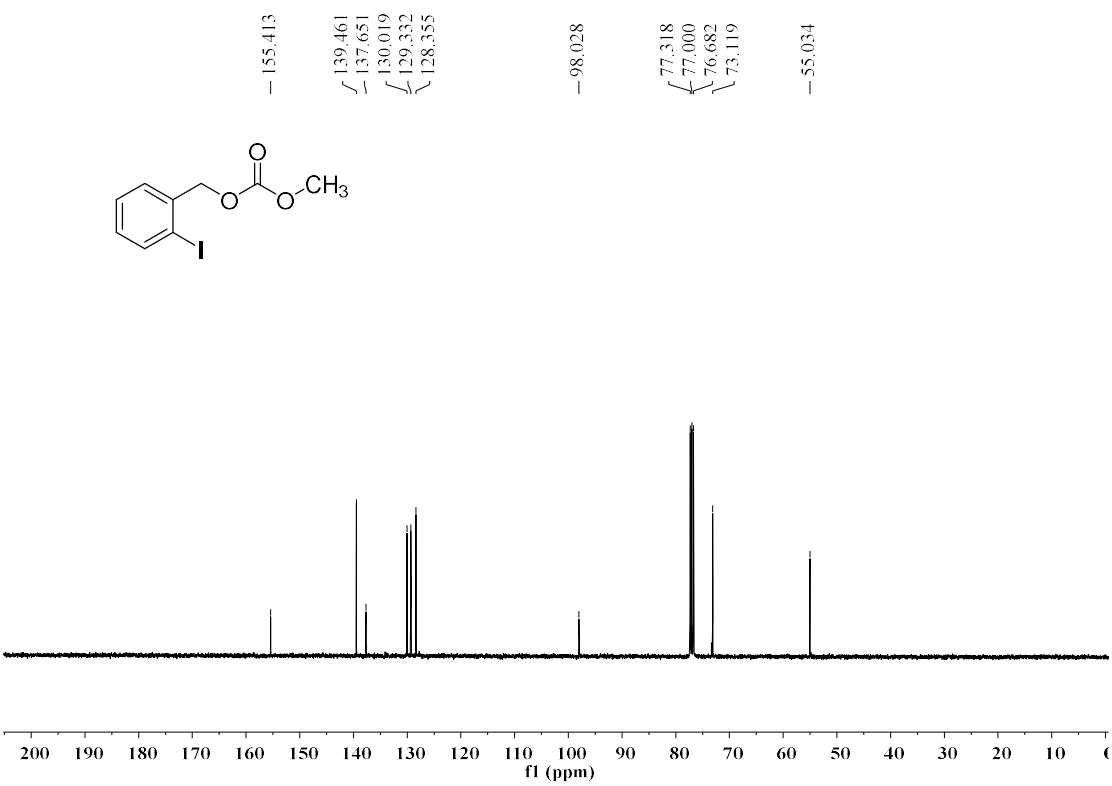
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 3p



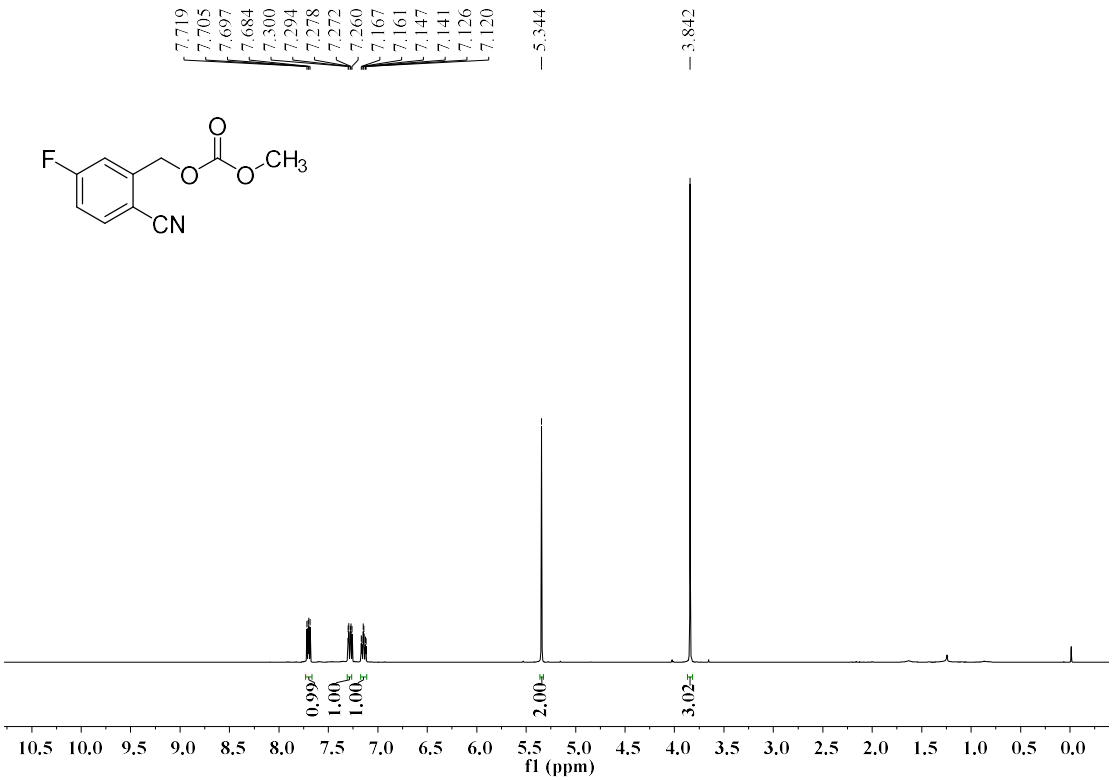
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 3q



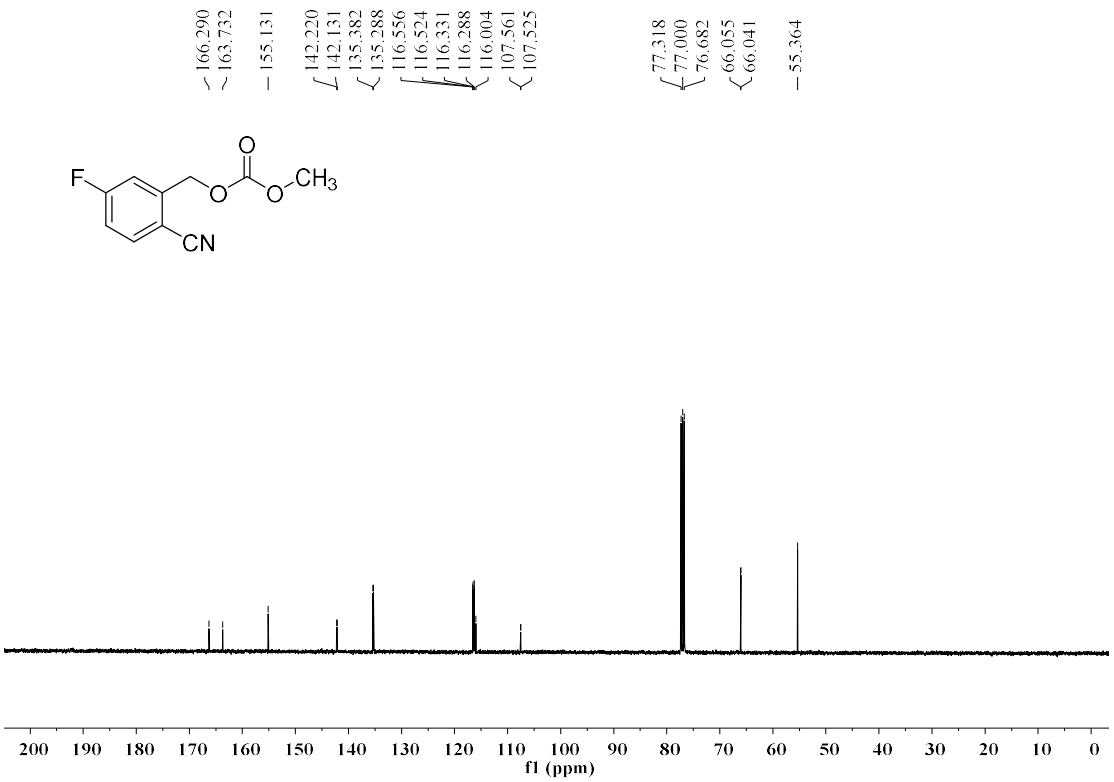
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 3q



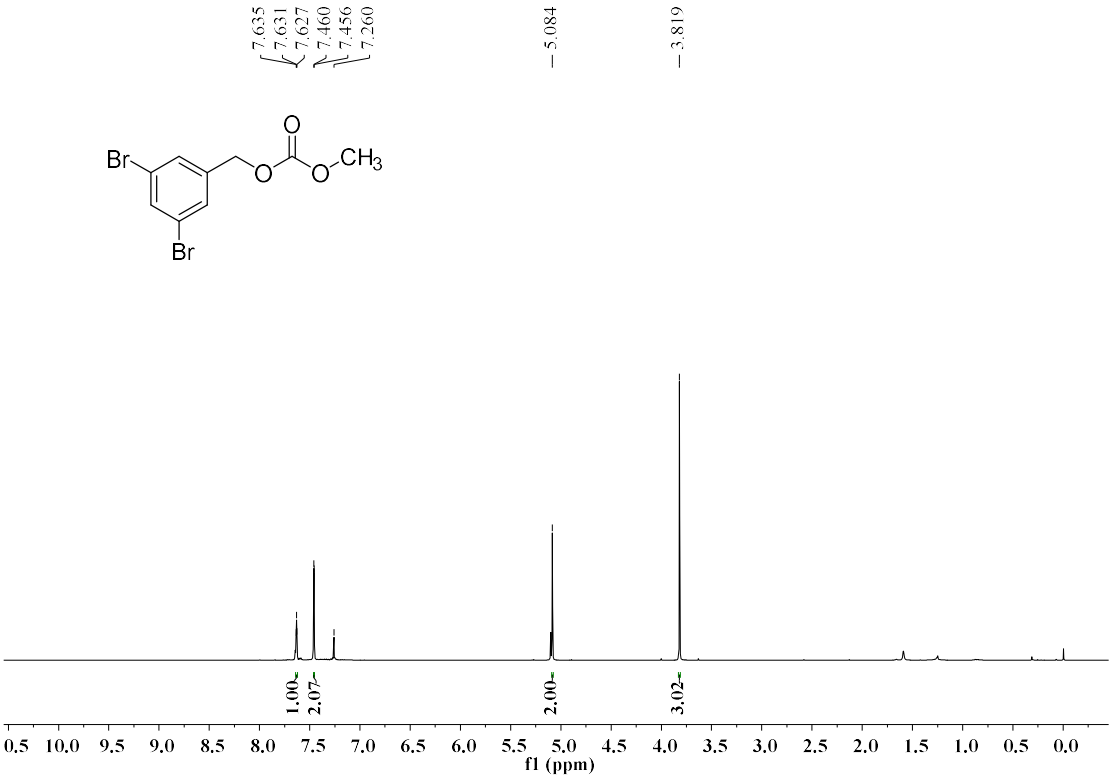
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 3r



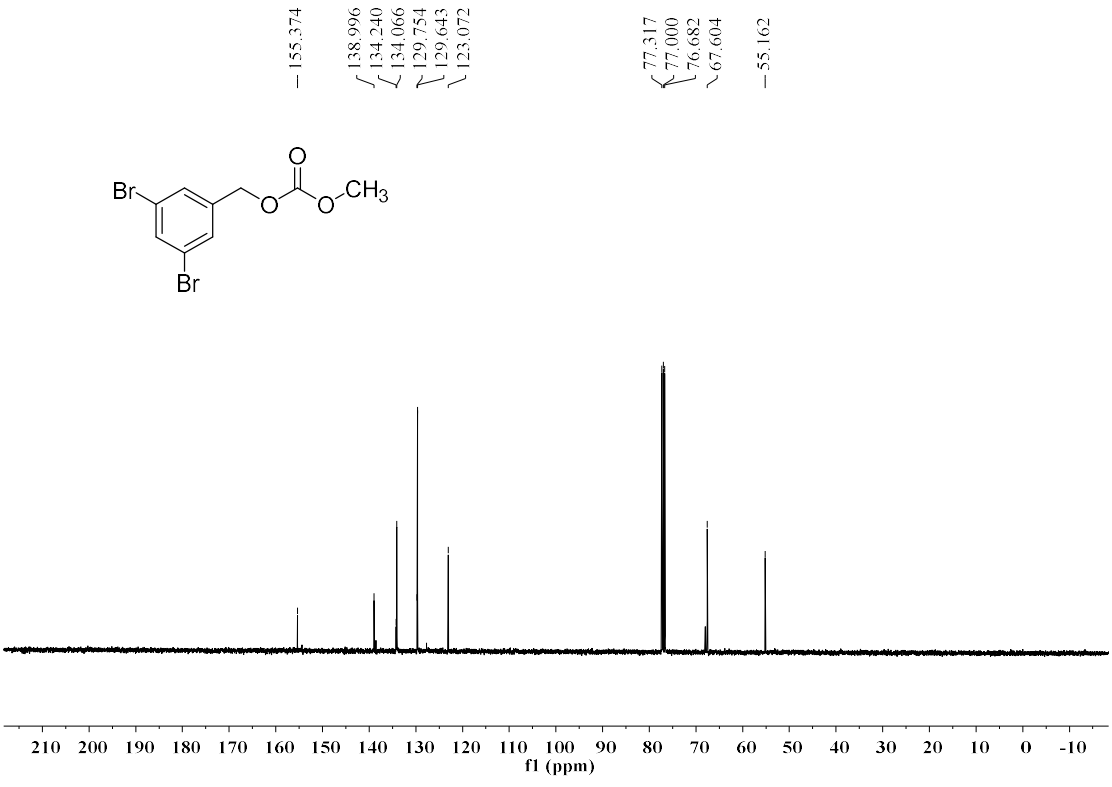
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 3r



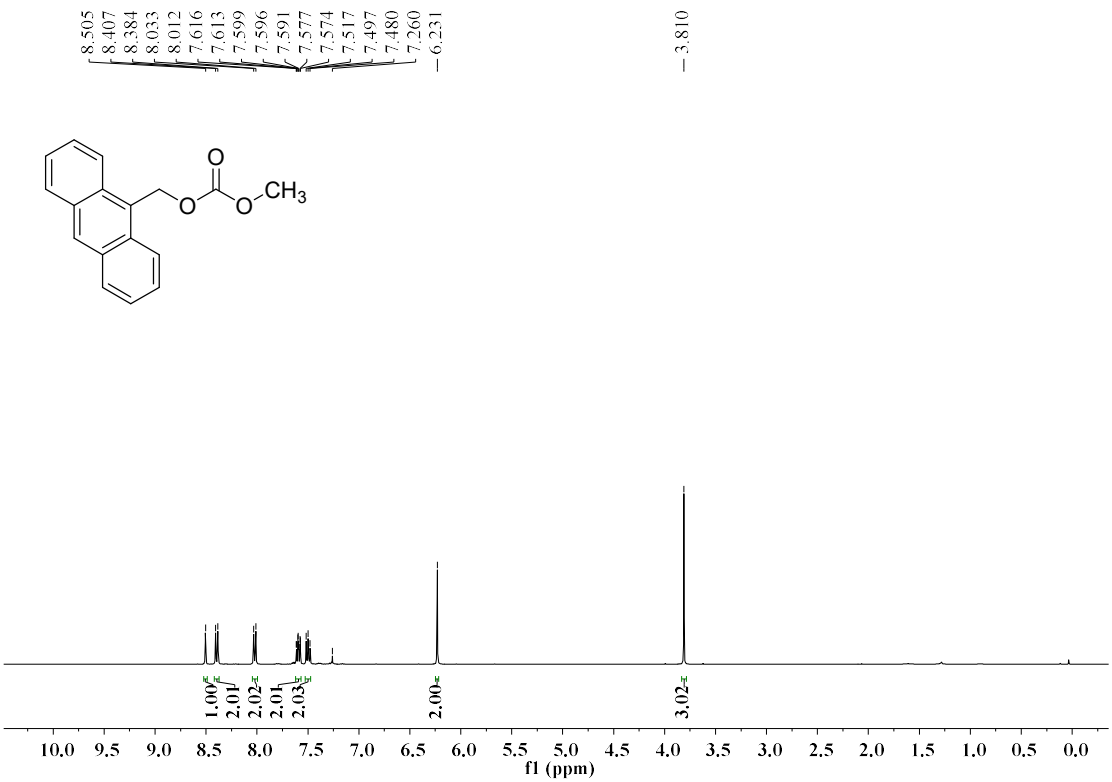
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 3s



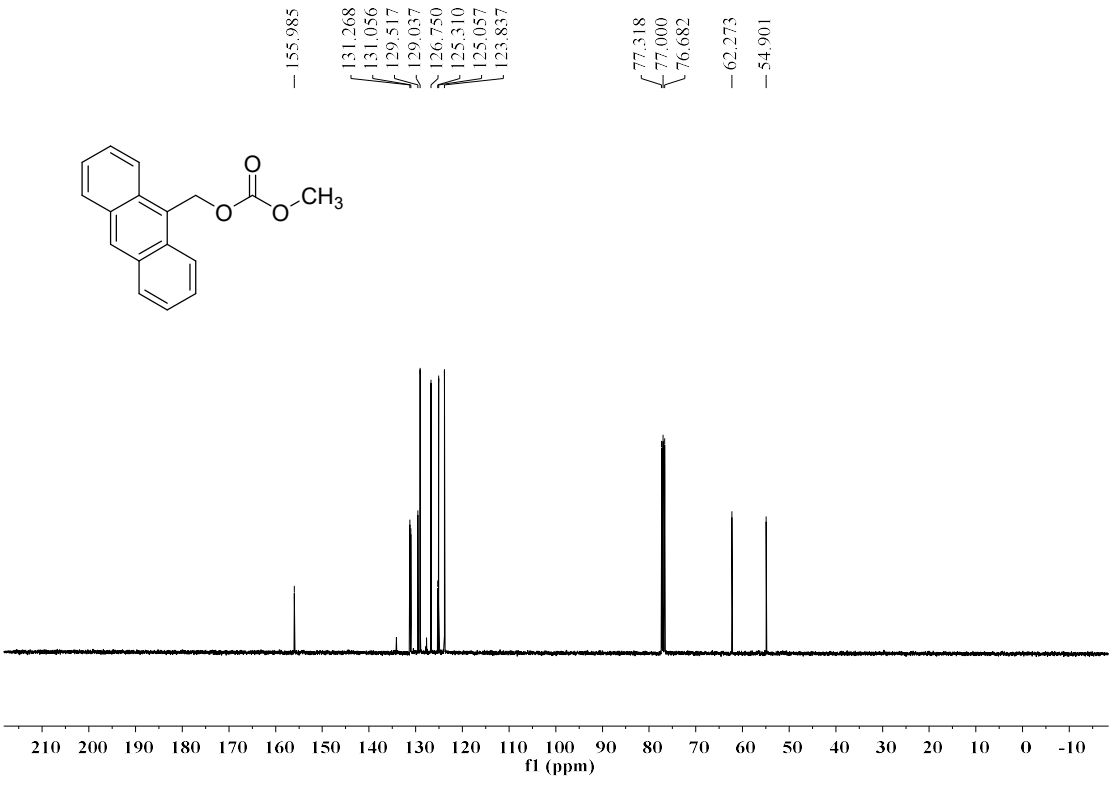
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 3s



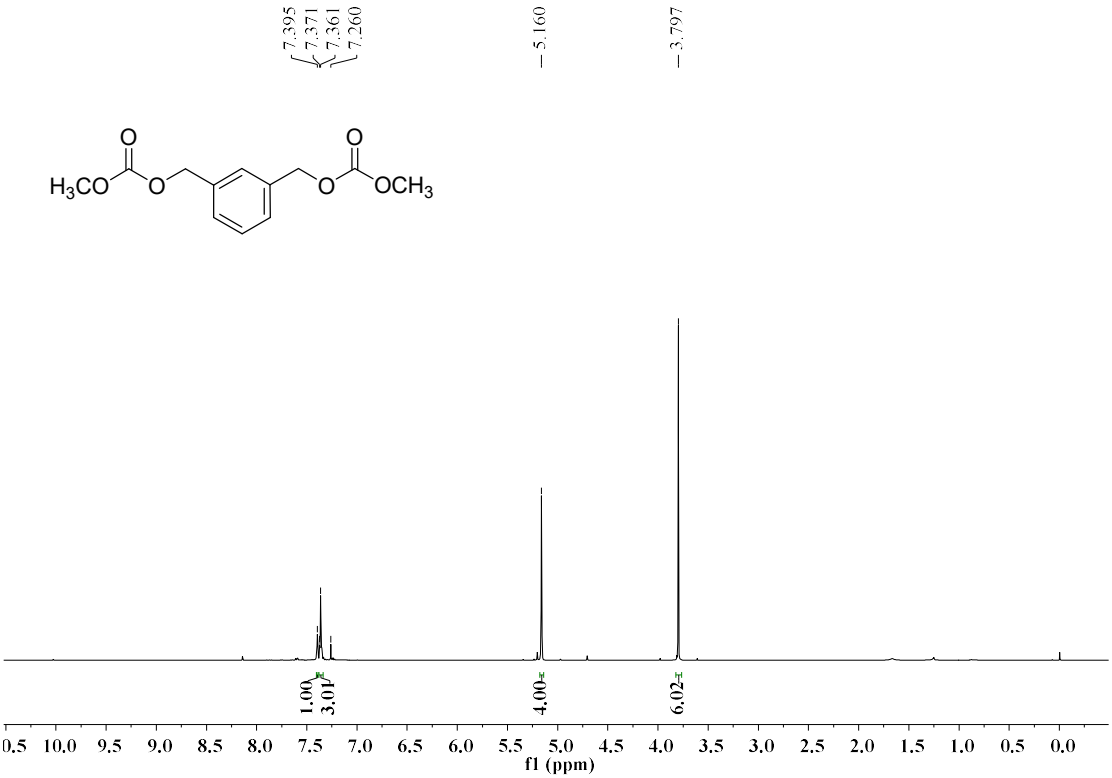
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 3t



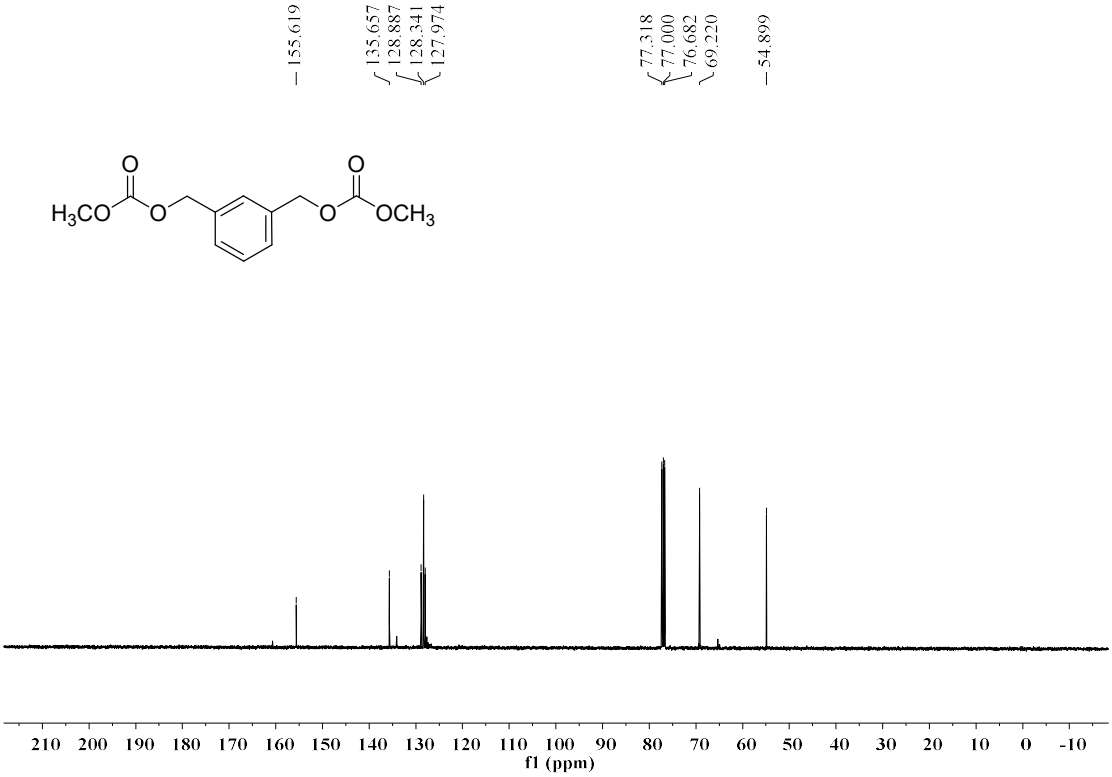
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 3t



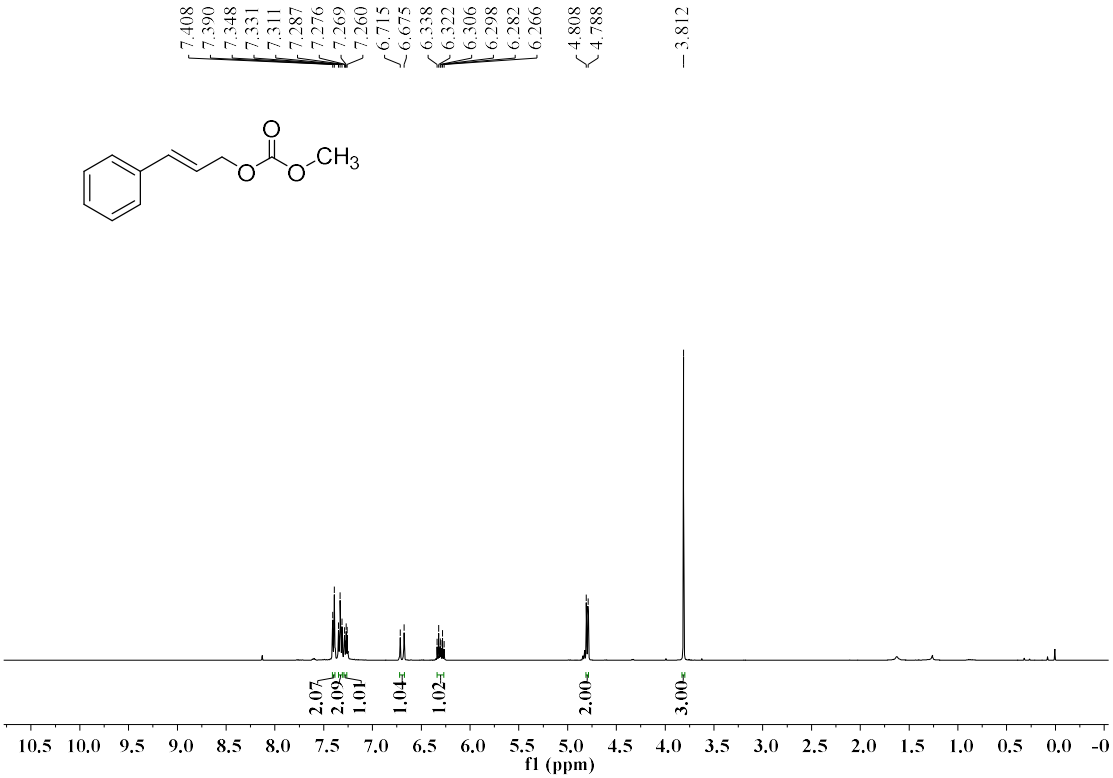
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 3u



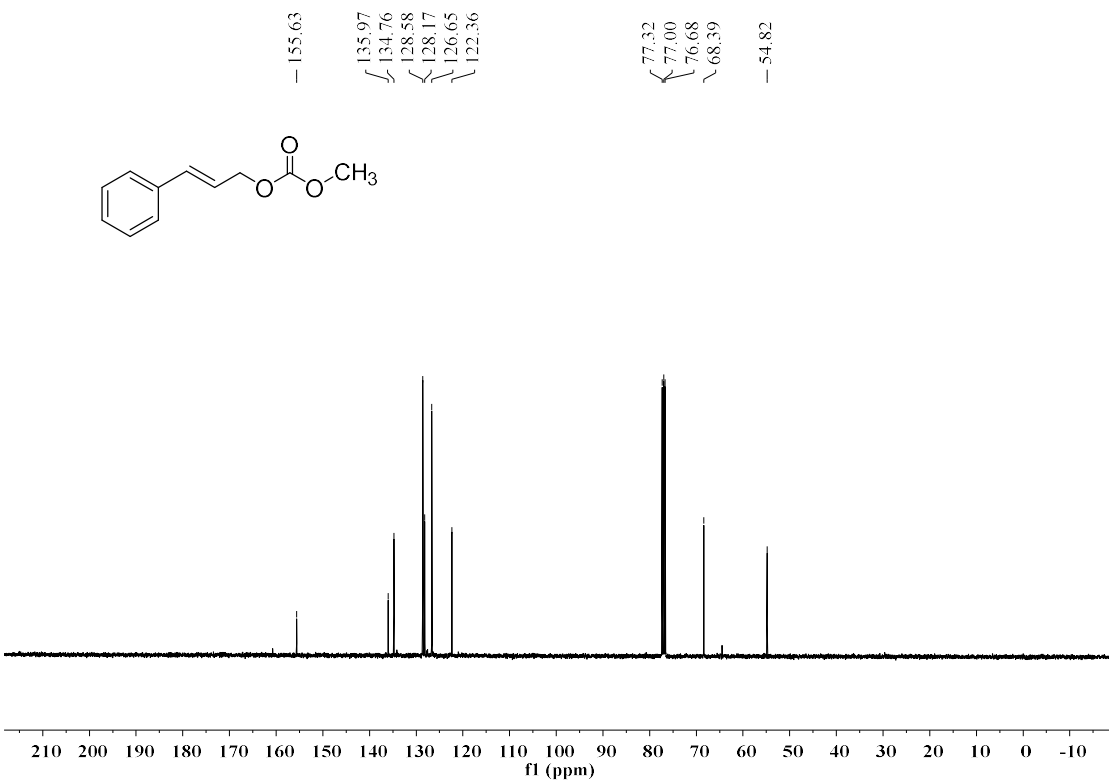
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 3u



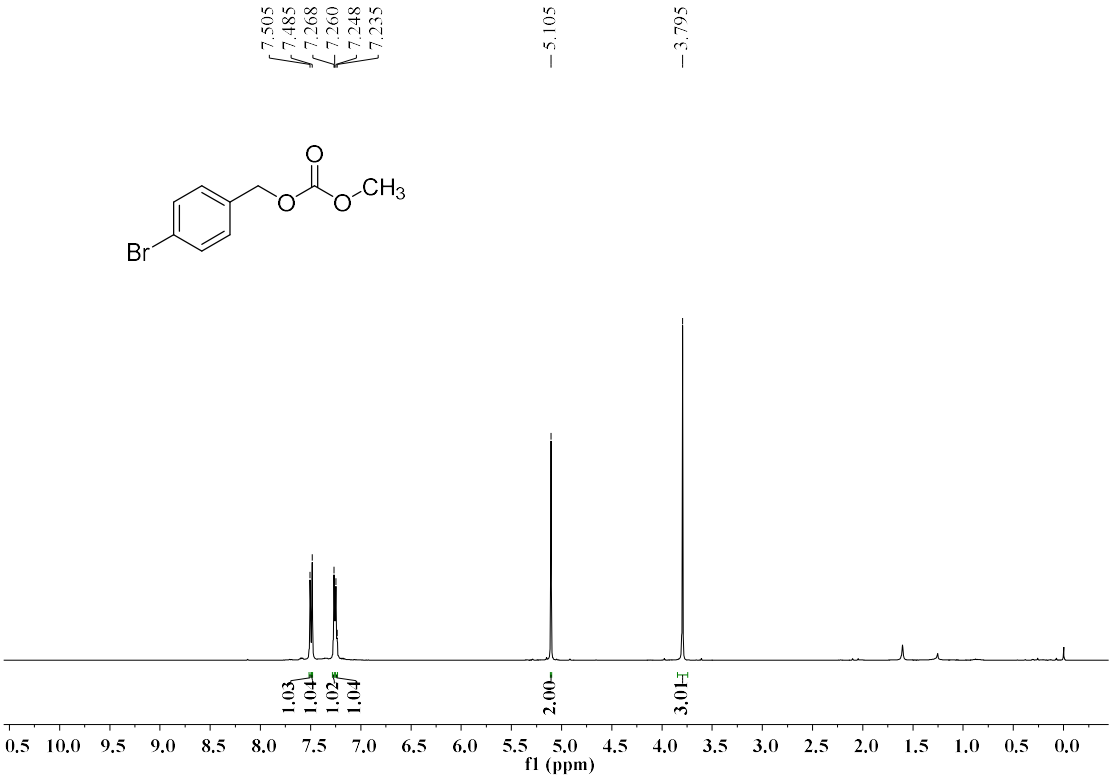
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 3v



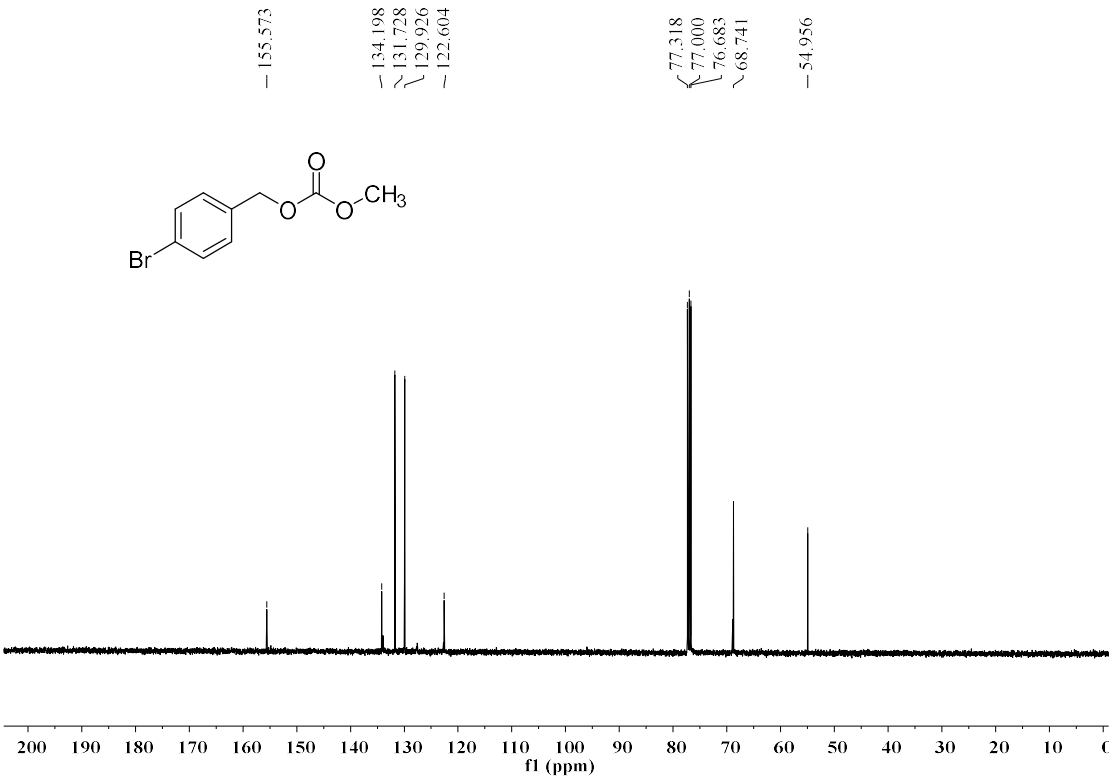
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 3v



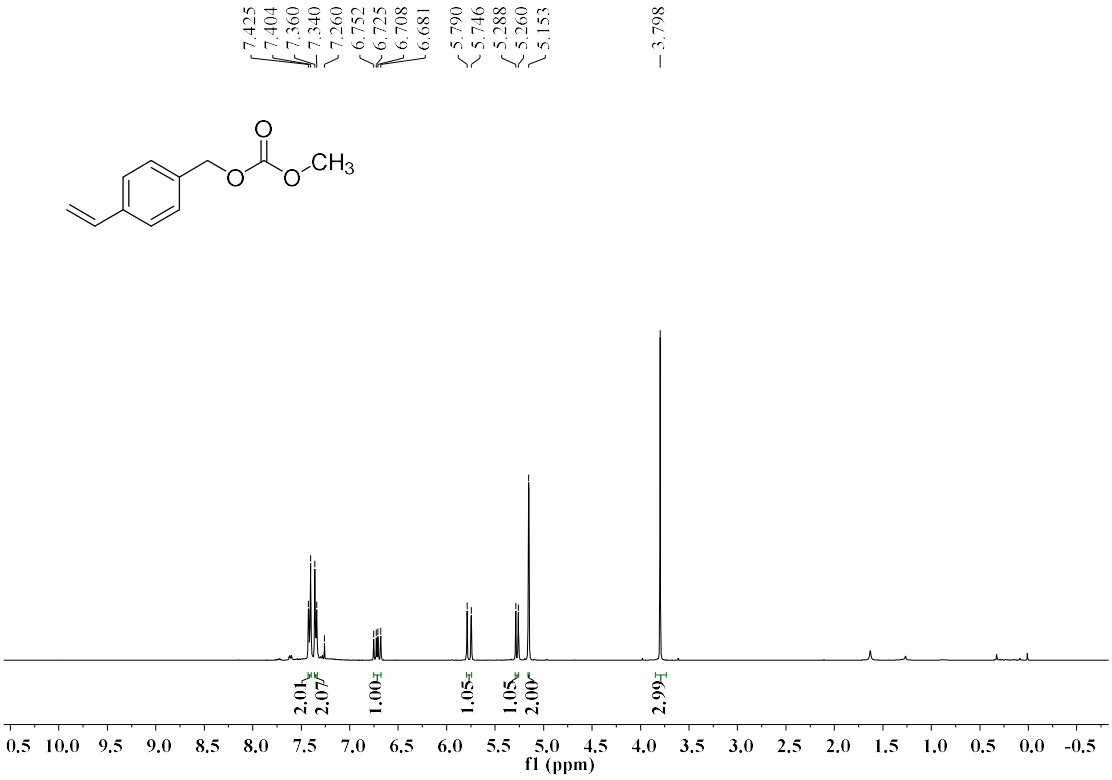
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 3w



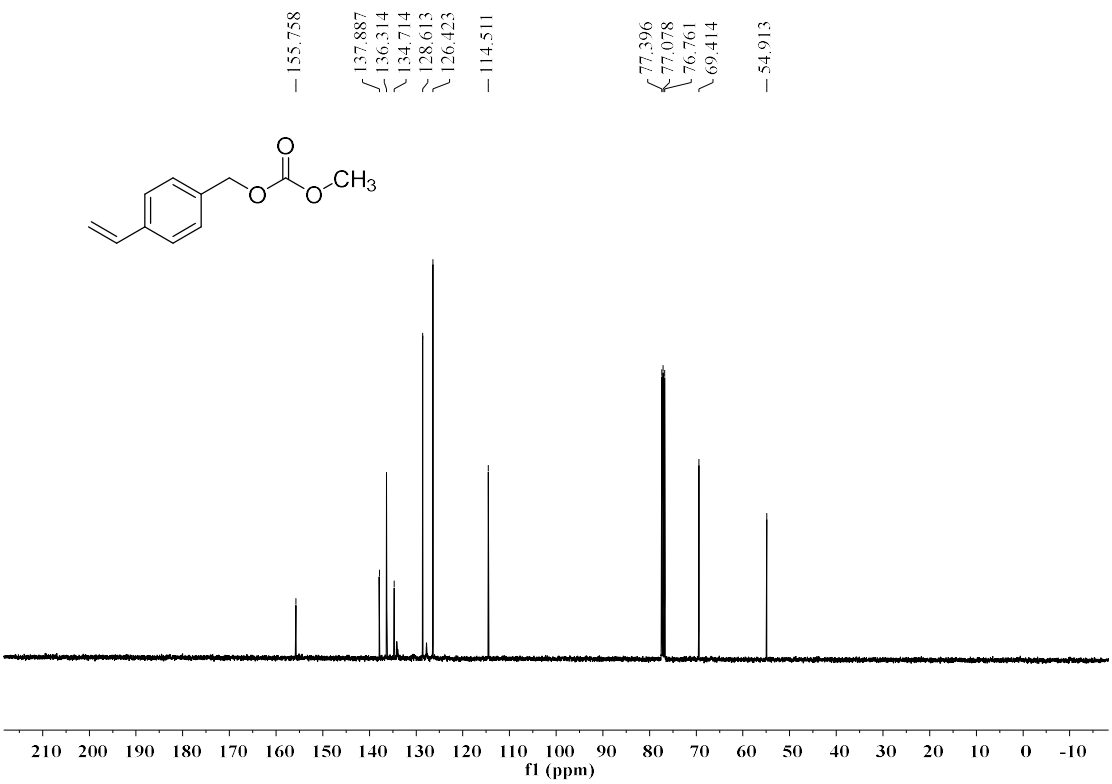
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 3w



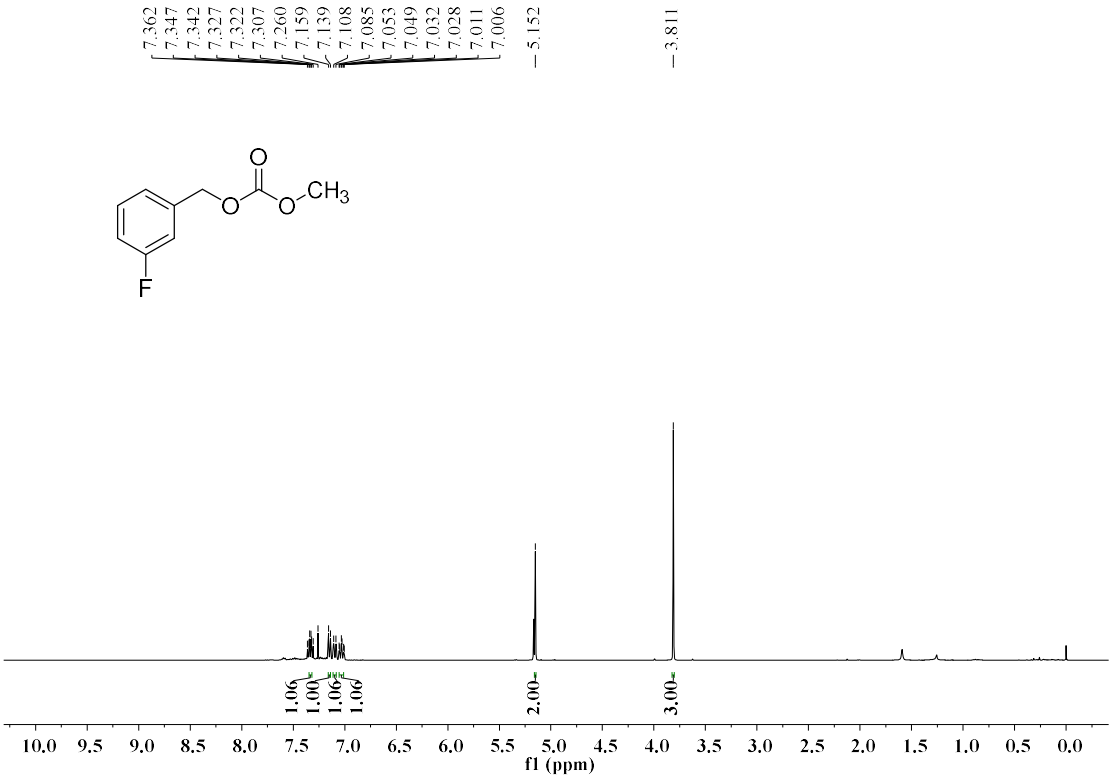
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 3x



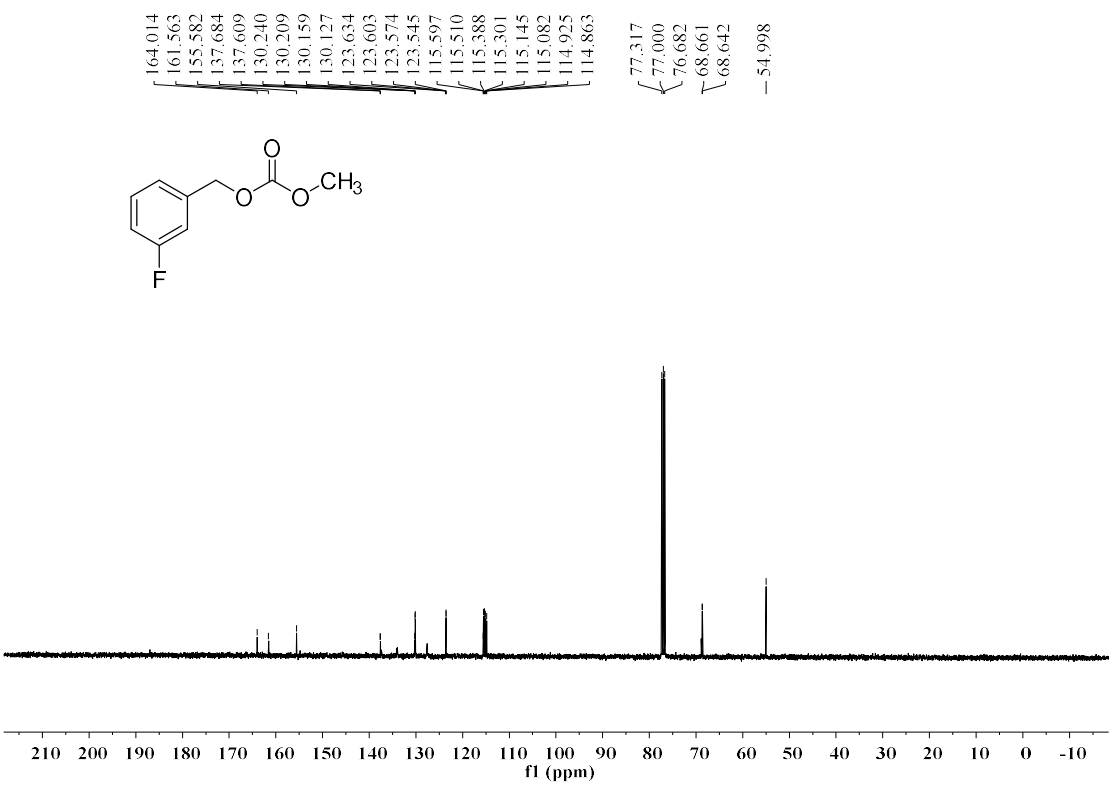
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 3x



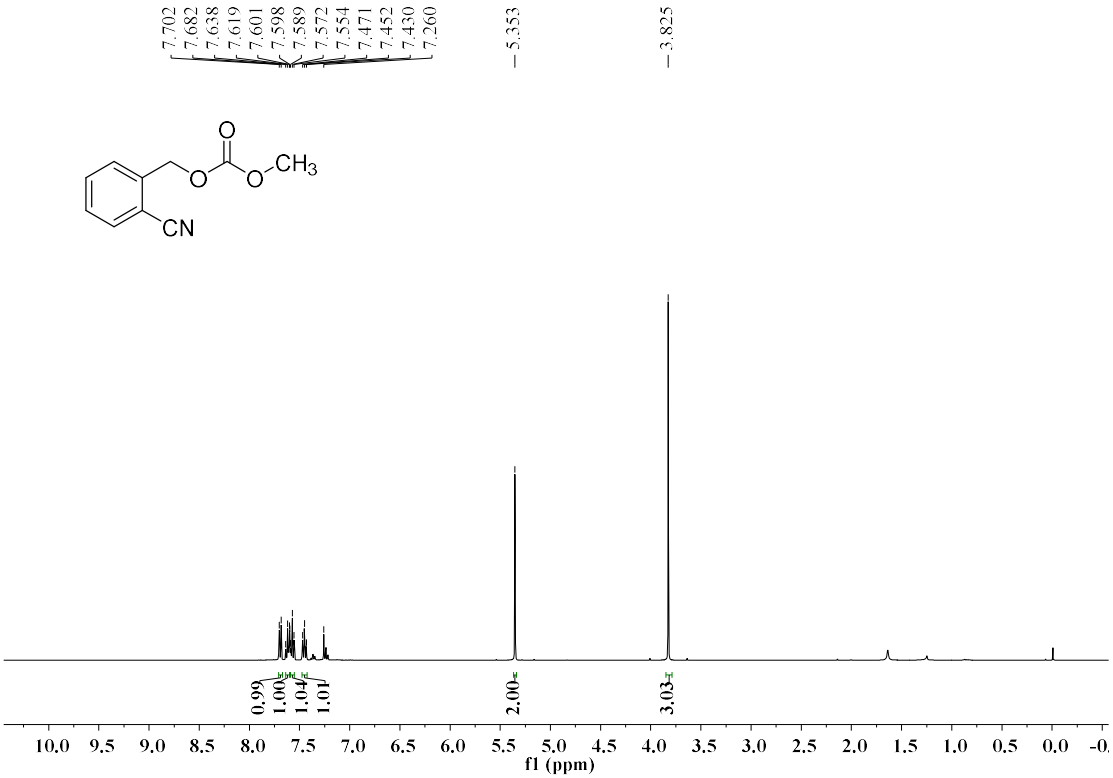
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 3y



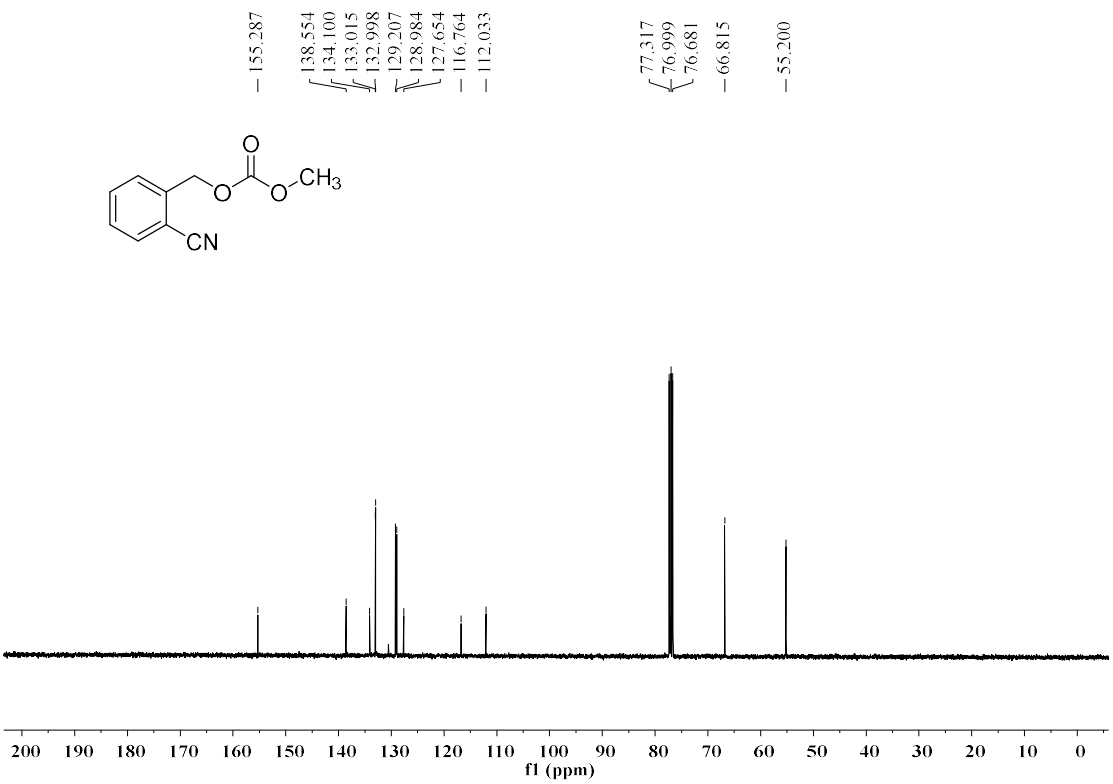
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 3y



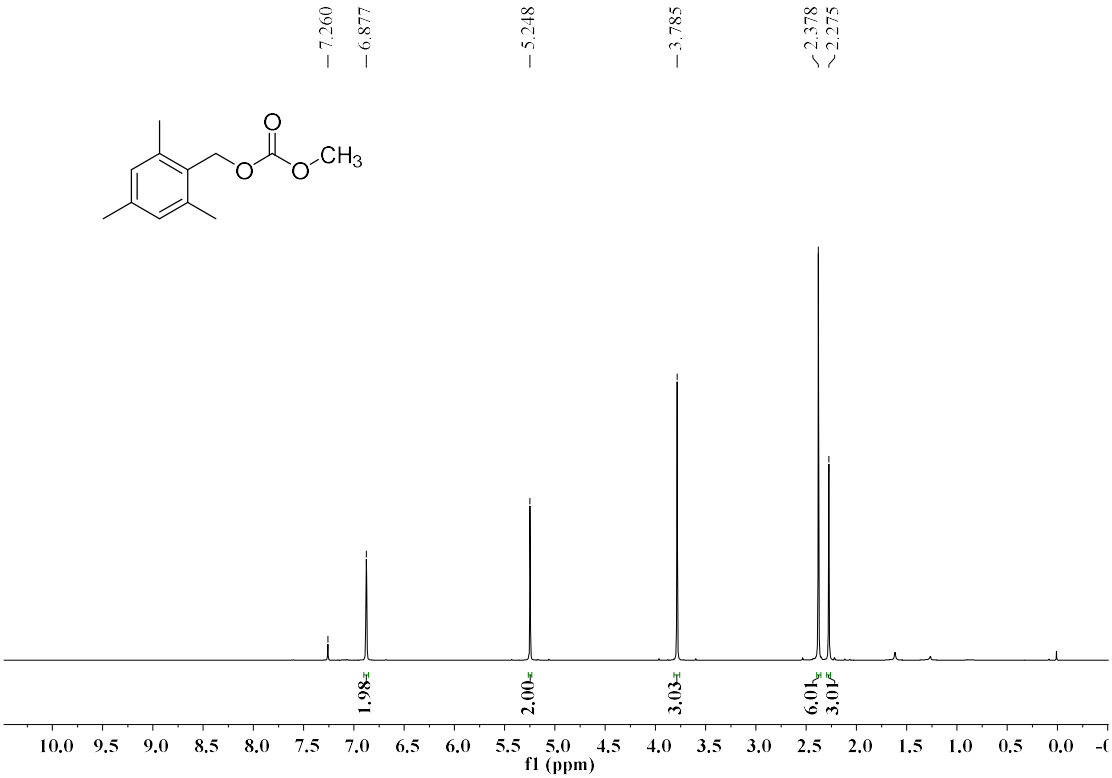
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 3z



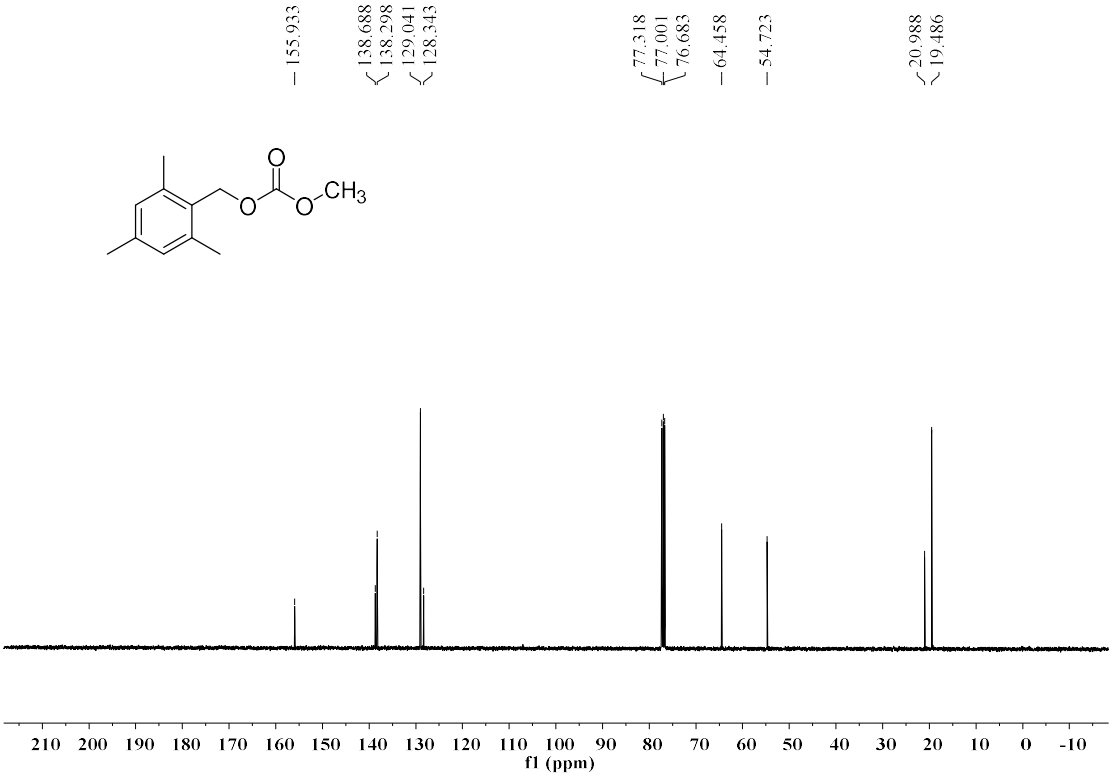
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 3z



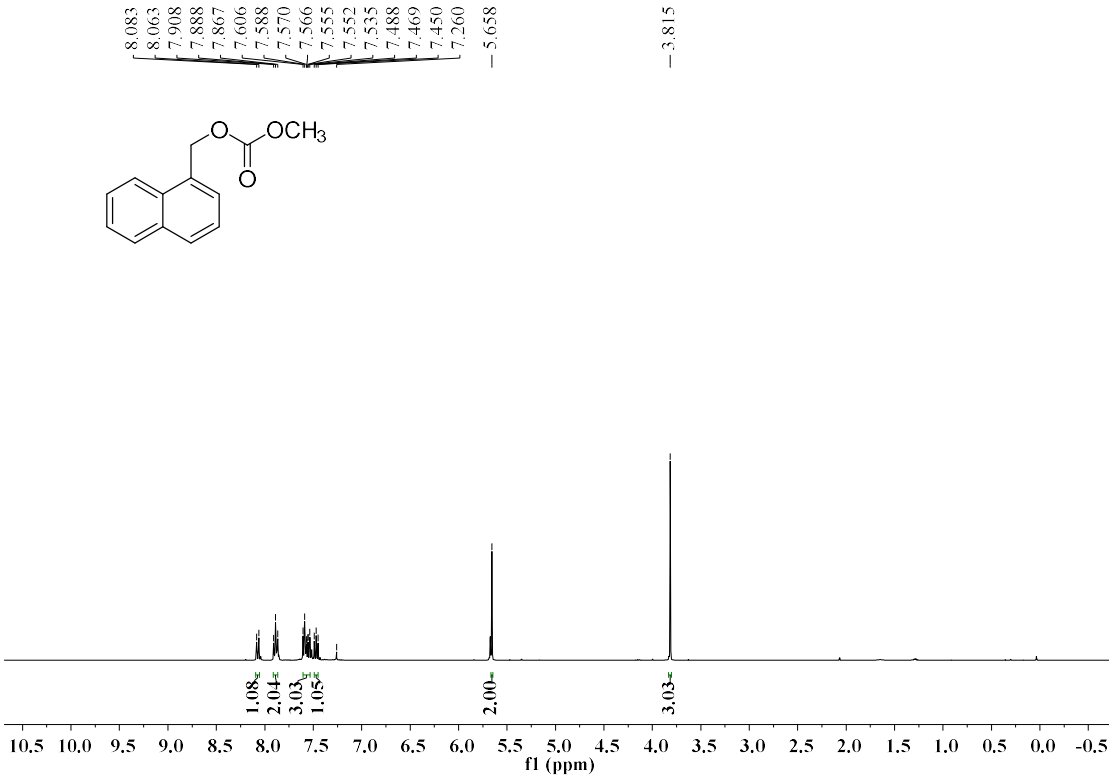
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 3aa



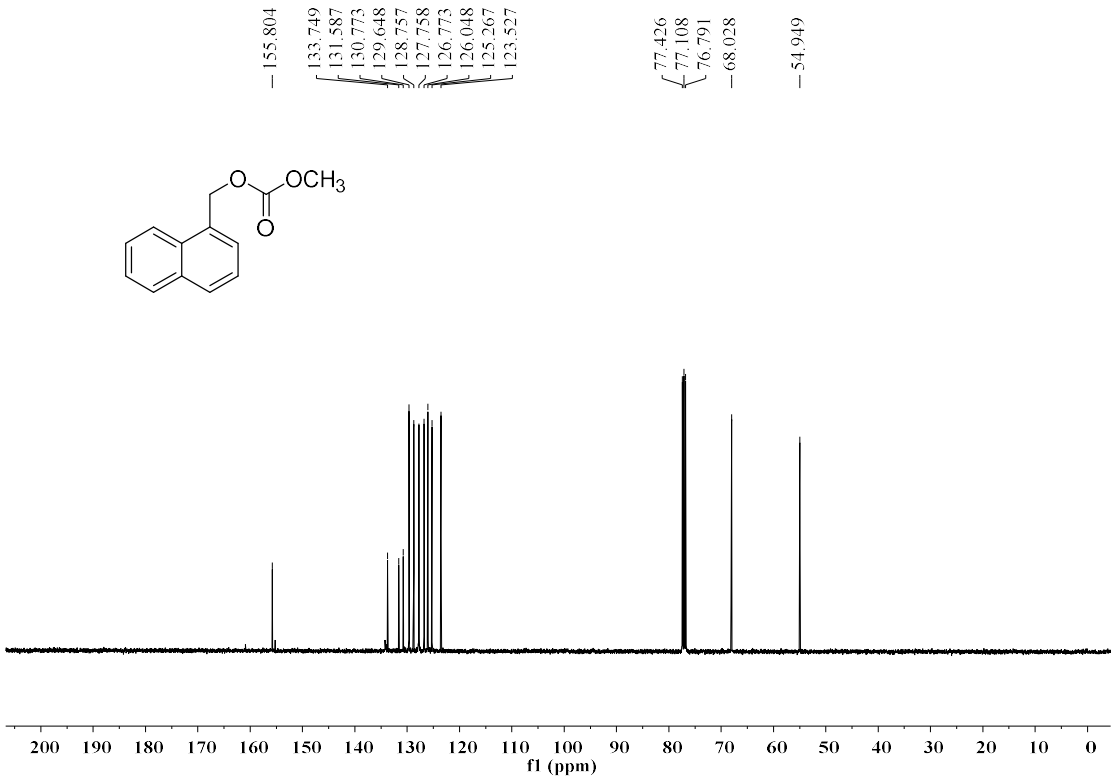
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 3aa



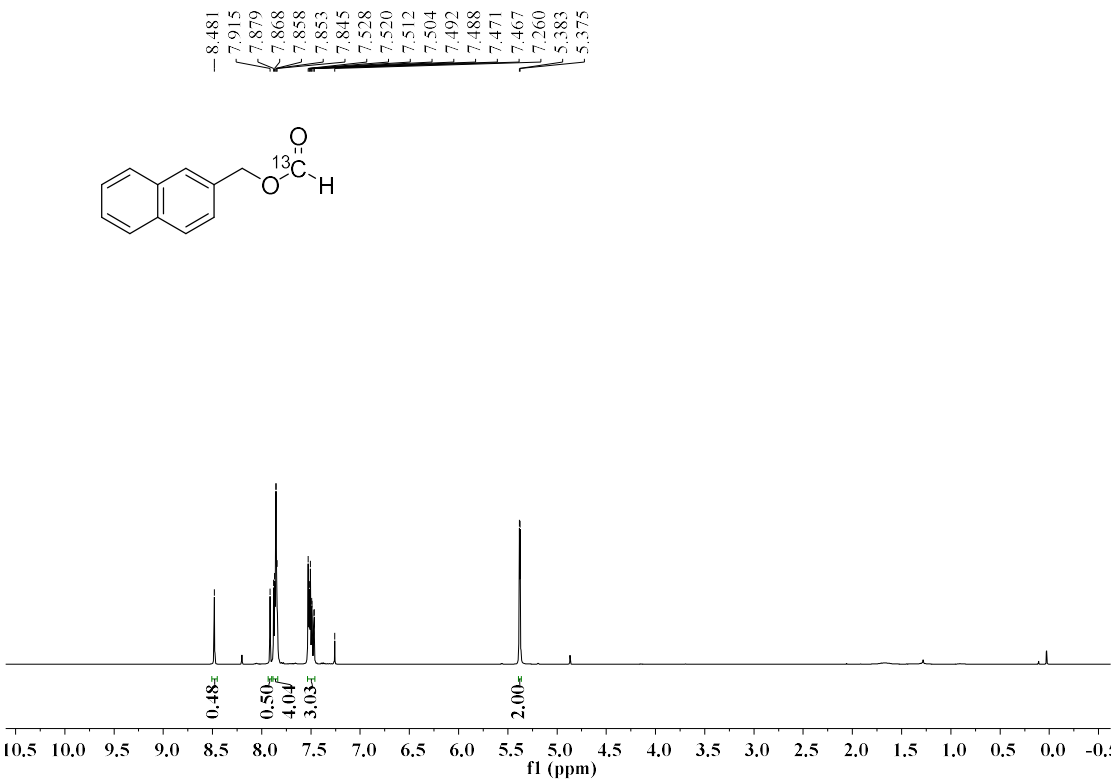
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 3ab



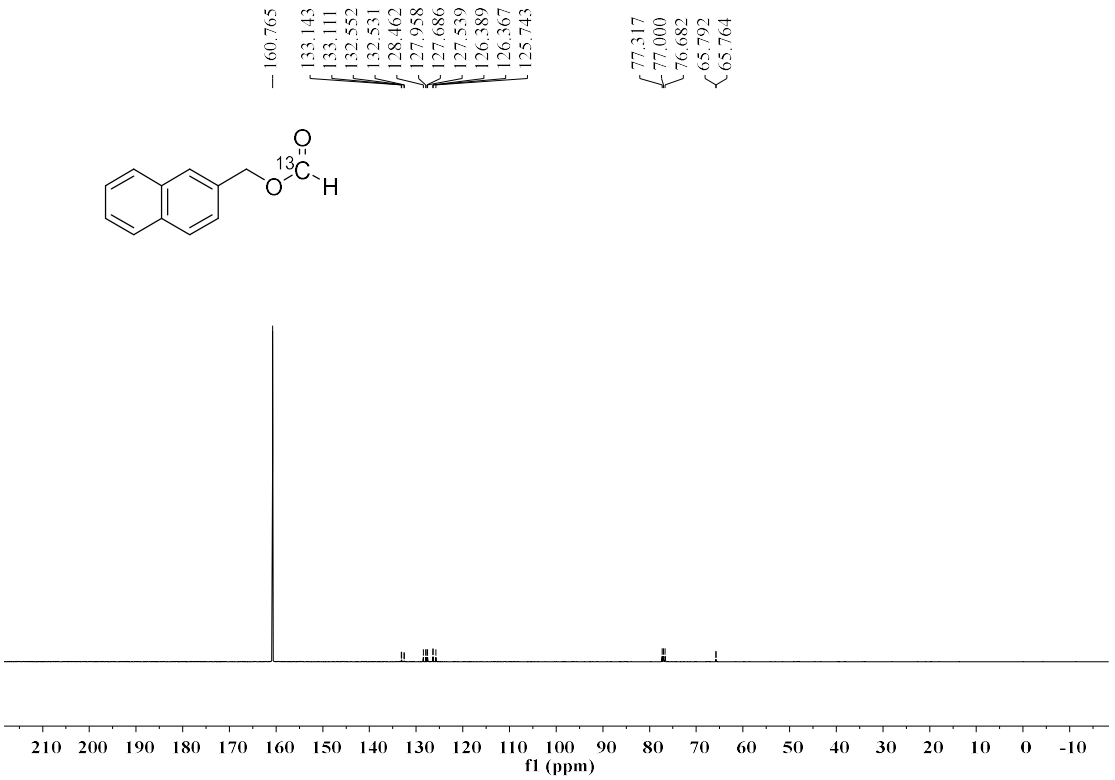
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 3ab



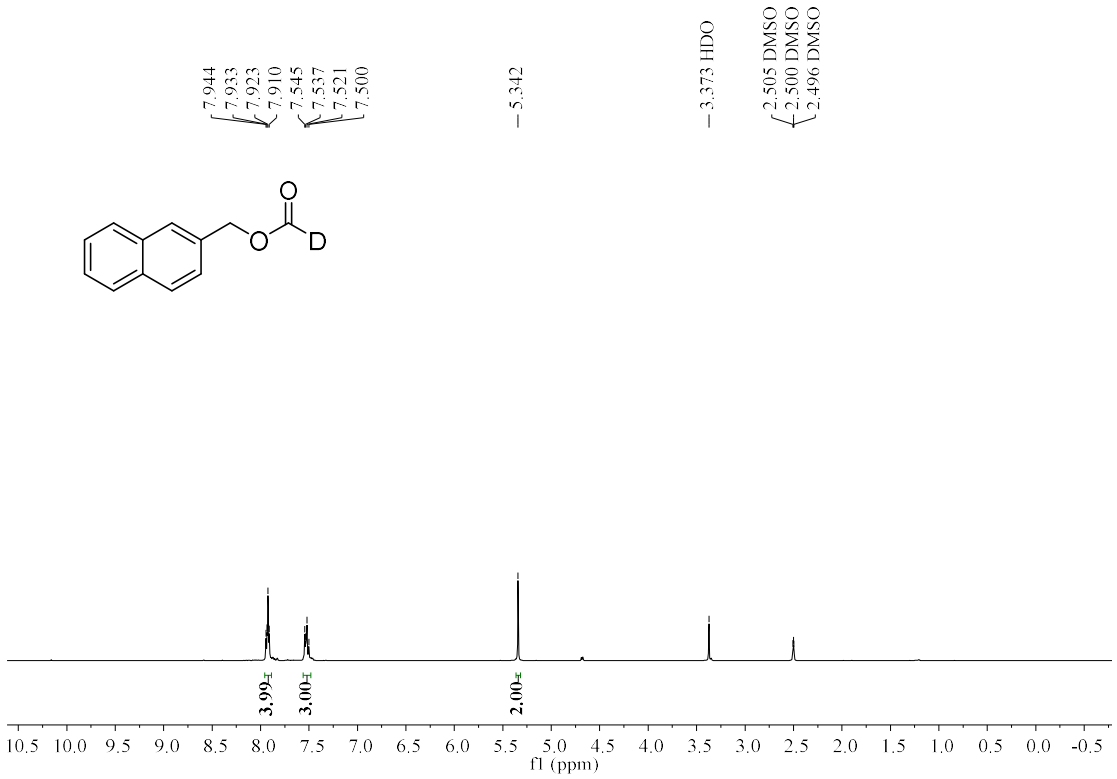
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2a'



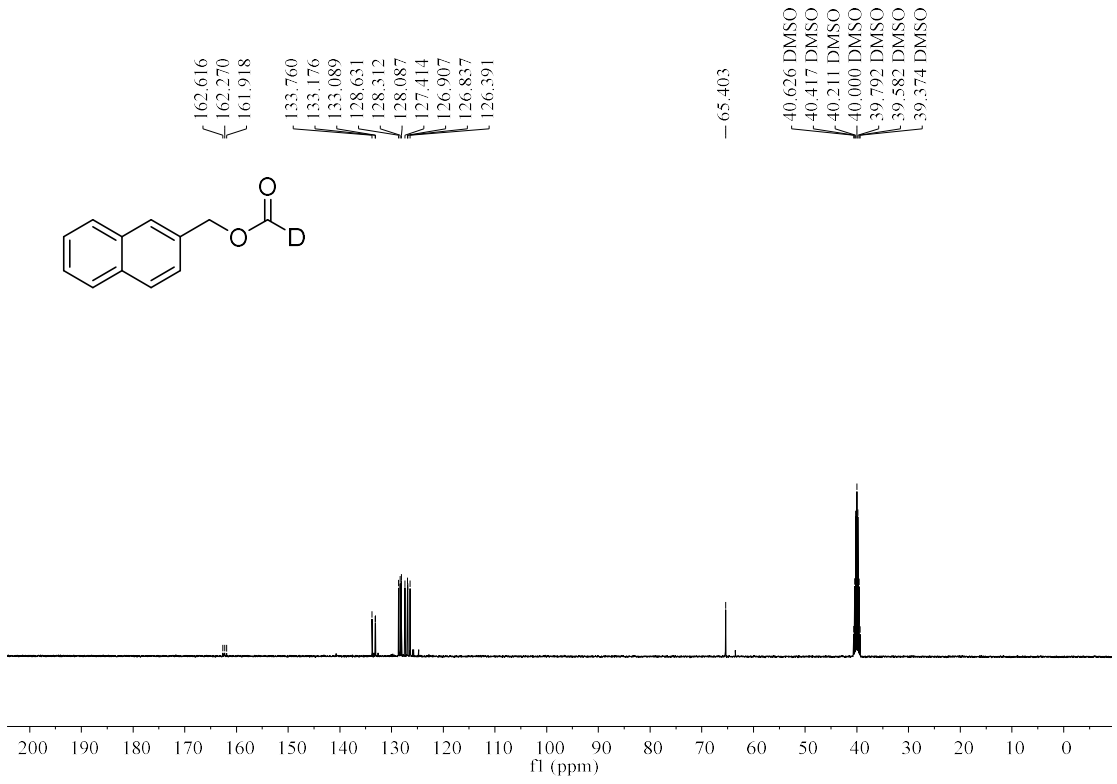
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2a'



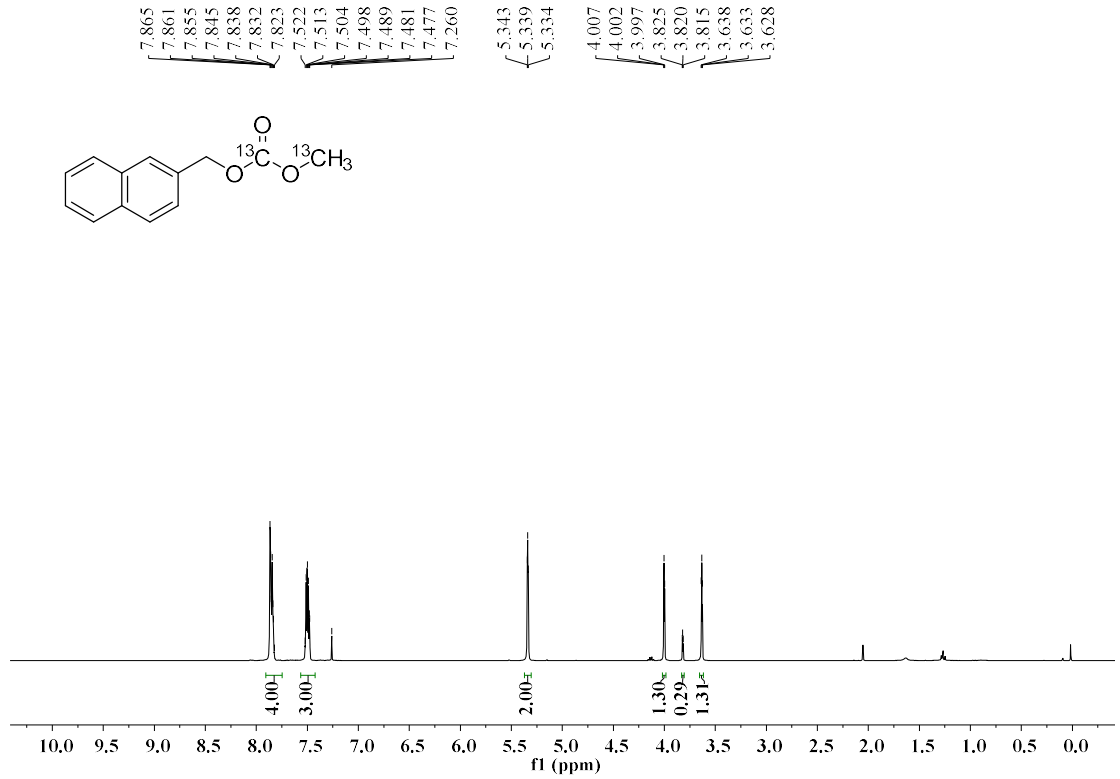
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 2a-D



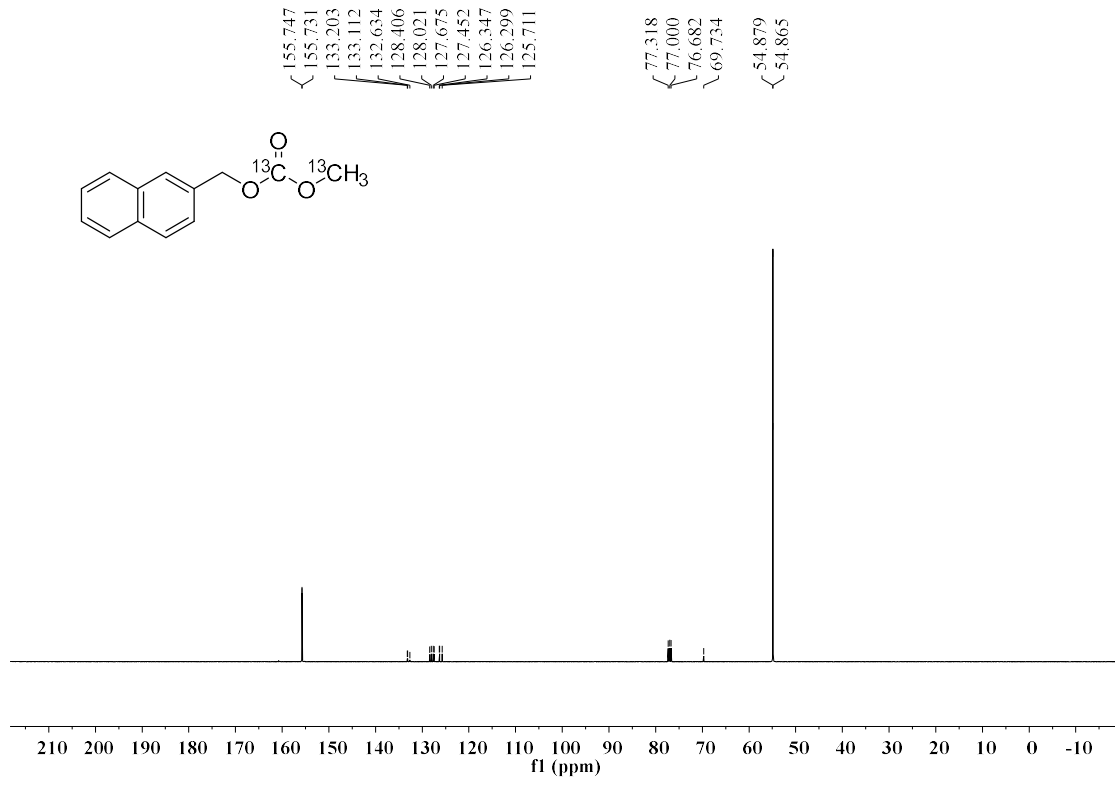
^{13}C NMR (100 MHz, $CDCl_3$) spectrum of 2a-D



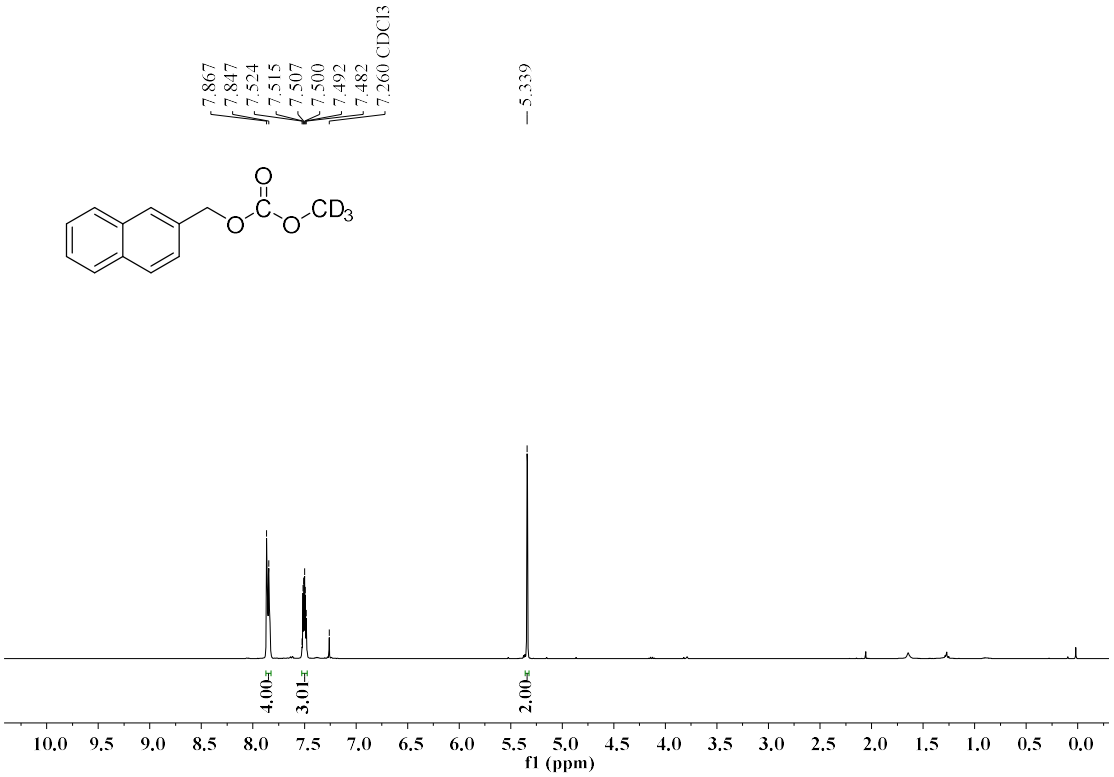
^{1}H NMR (400 MHz, $CDCl_3$) spectrum of 3a'



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



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



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