Electronic Supplementary Material (ESI) for Green Chemistry.

Supporting Information for

Selective *N*-Formylation / *N*-Methylation of Amines and *N*-Formylation of Amides and Carbamates with Carbon Dioxide and Hydrosilanes: Promotion of Basic Counter Anion of the Zinc Catalyst

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Contents

Experimental section

Materials

CO_2 was purchased from SHOWA DENKO GAS PRODUCTS CO. LTD. All of the other chemicals were purchased from Sigma-Aldrich, Tokyo Chemical Industry (TCI), or FUJIFILM Wako Pure Chemical Corporation in the best grade, stored under N_2, and used without further purification.

Caution: High pressure CO_2 gas cylinders should be handled with care and located in an open area with fresh air, although we did not encounter any accident.

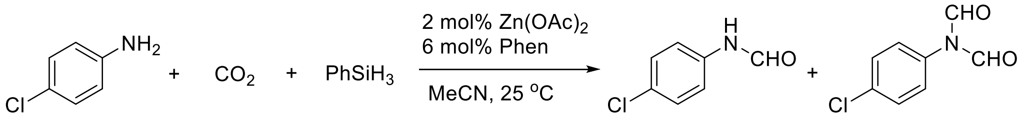
Instruments

The catalytic reactions were carried out in a 10 mL stainless-steel autoclave with a gas-pressure monitor (max. 25 MPa). All of the oxygen-free operations were done in a glovebox. If required, reaction mixtures were heated in Sibata Chemi-300 Synthesizer. ^{1}H, ^{13}C {^{1}H} and ^{29}Si {^{1}H} NMR spectra were recorded with a 400 MHz Bruker NMR Spectrometer at room temperature. Products were isolated with a Yamazen AI-580 Single Channel Automated Flash Chromatography System by using n-hexane and ethyl acetate as eluents. Molecular weights were determined with a Shimadzu GCMS-QP2010 Plus Gas Chromatograph Mass Spectrometer (GC–MS) with electron ionization mode.

General procedure for the synthesis of 1a

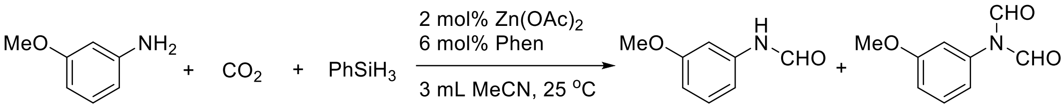
To a 10 mL steel autoclave, $Zn(OAc)_2$ (3.7 mg, 0.02 mmol), phen (10.8 mg, 0.06 mmol), MeCN (3 mL), *N*-methylaniline (10.7 mg, 1 mmol), and $PhSiH_3$ (108 mg, 1 mmol) were added in a glove box. The autoclave was sealed tightly and filled with CO_2 to 5 bar at room temperature. After 4 h reaction in a 25°C, CO_2 was released slowly. The solvent was removed in vacuo and re-dissolved in 30 mL dichloromethane washed with water (30 mL, 3 times). Isolated product was purified with automated flash chromatography with *n*-hexane and ethyl acetate as the eluents. A colorless liquid (124 mg, 92%) was obtained after dried in vacuo. The product was characterized with ^{1}H NMR, ^{13}C {^{1}H} NMR, and GC–MS, consistent with authentic chemical. Other products were synthesized in the same way, and consistent with either authentic materials or literatures.

Reaction condition screening of the synthesis of mono-*N*-formylation products.



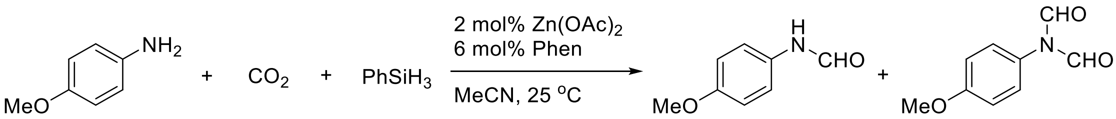
1 mmol 5 bar 2 mmol **3b** **3c**

1 h	30%	N.D.
2 h	48%	4%
3 h	68%	7%
4 h	48%	9%



1 mmol 5 bar 2 mmol **4b** **4c**

1 h	58%	N.D.
2 h	52%	8%
3 h	45%	9%
4 h	44%	10%



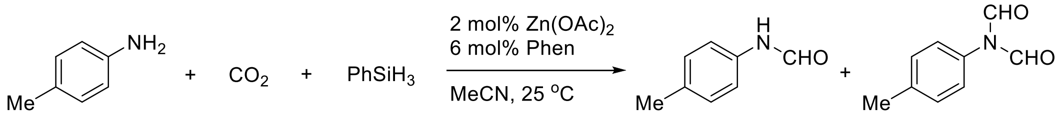
1 mmol 5 bar X mmol **5b** **5c**

X = 1.5

1 h	42%	N.D.
2 h	54%	trace
3 h	57%	5%
4 h	65%	30%

X = 2

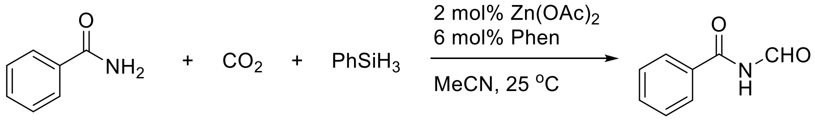
1 h	54%	4%
2 h	66%	8%
3 h	42%	24%
4 h	40%	39%



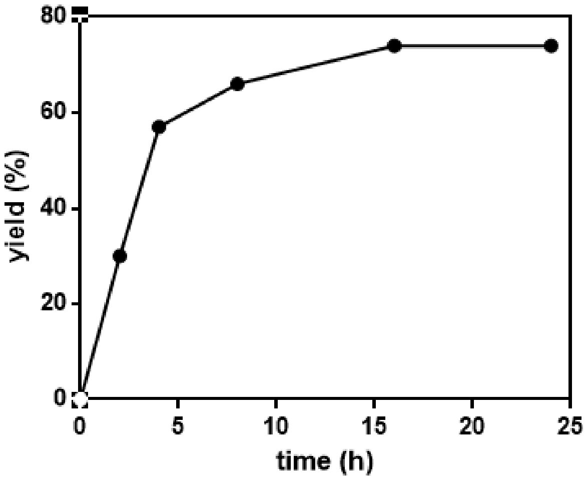
1 mmol　5 bar　2 mmol　**6b**　**6c**

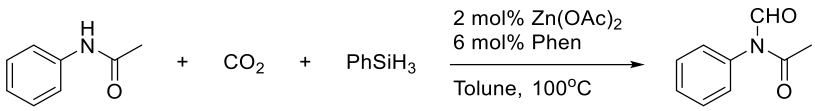
1 h	52%	3%
2 h	64%	15%
3 h	58%	16%
4 h	24%	49%

Time dependent reactions for the *N*-formylation of amides.

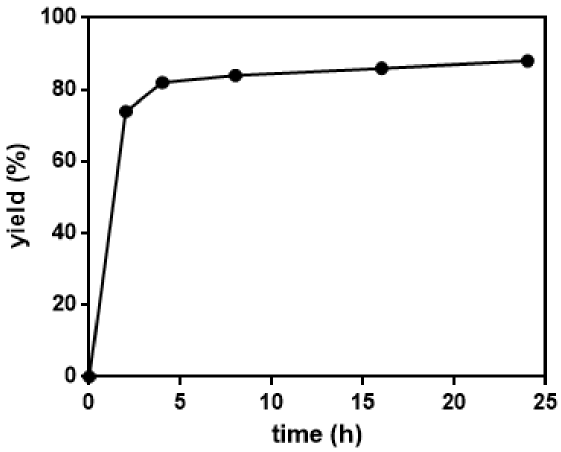


0.5 mmol 5 bar 1 mmol **1e**

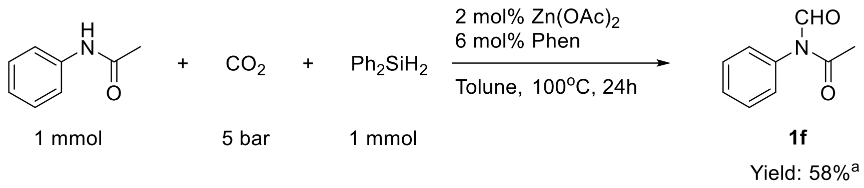




1 mmol 5 bar 1 mmol **1f**



N-Formylation of acetanilide with CO_2 and Ph_2SiH_2



[a] The yield was determined by ^{1}H NMR in $CDCl_3$ using mesitylene as the internal standard.

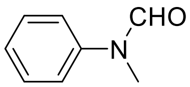
Synthesis of $Ph_2Si(OCHO)_2$[S1]

HCOONa (28 mmol) + Ph_2SiCl_2 (10 mmol) $\xrightarrow{\text{10 mL } CH_2Cl_2\text{, 25 °C, 24h}}$ $Ph_2Si(OCHO)_2$

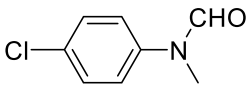
Isolated yield, 1.85g (6.80 mmol), 68%

NMR / MS data and NMR spectra
N-Formylation of secondary amines

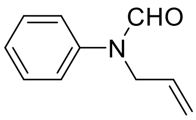
(Products **1a-13a** contain conformational isomers.)[S2-S5]



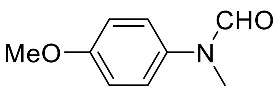
Product **1a**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.47 (s, 1H), 7.41 (t, *J* = 7.5 Hz, 2H), 7.26 (t, *J* = 7.5 Hz, 1H), 7.16 (d, *J* = 8.0 Hz, 2H), 3.31 (s, 3H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 162.4, 142.2, 129.6, 126.4, 122.4, 32.1. GC-MS (*m/z*): 135 [M^+] for C_8H_9NO (yield, 124 mg (0.92 mmol), 92%).



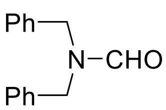
Product **2a**. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.41, 8.31 (s, total 1H), 7.40-7.29 (m, 2H), 7.12-7.07 (m, 2H), 3.30, 3.26 (s, total 3H). ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 162.0, 140.8, 132.0, 129.8, 123.5, 32.0. GC-MS (*m/z*): 169 [M^+] for C_8H_8ClNO (yield, 125 mg (0.74 mmol), 74%).



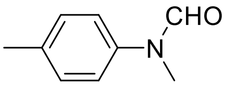
Product **3a**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.51, 8.40 (s, total 1H), 7.44-7.37 (m, 2H), 7.33-7.28 (m, 1H), 7.23-7.20 (m, 2H), 5.92-5.82 (m, 1H), 5.25-5.18(m, 2H), 4.44, 4.31 (d, *J* = 5.8 Hz, total 2H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 162.0, 141.2, 132.5, 129.6, 126.7, 123.5, 117.6, 47.9; GC-MS (*m/z*): 161 [M^+] for $C_{10}H_{11}NO$ (yield, 128 mg (0.80 mmol), 80%).



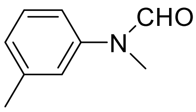
Product **4a**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.25 (s, 1H), 7.01 (d, *J* = 9.1 Hz, 2H), 6.84 (d, *J* = 9.1 Hz, 2H), 3.72 (s, 3H), 3.17 (s, 3H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 162.4, 158.2, 135.2, 124.5, 114.7, 55.5, 32.6. GC-MS (*m/z*): 165 [M^+] for $C_9H_{11}NO_2$ (yield, 140 mg (0.85 mmol), 85%).



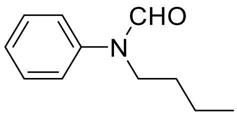
Product **5a**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.42 (s, 1H), 7.40-7.18 (m, 10H), 4.42 (s, 2H), 4.26 (s, 2H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 162.9, 136.0, 135.6, 128.9, 128.7, 128.5, 128.2, 127.7, 127.6, 50.3, 44.7. GC-MS (*m/z*): 225 [M^+] for $C_{15}H_{15}NO$ (yield, 164 mg (0.73 mmol), 73%).



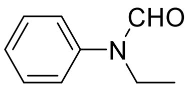
Product **6a**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.41 (s, 1H), 7.20 (d, *J* = 8.2 Hz, 2H), 7.05 (d, *J* = 8.4 Hz, 2H), 3.28 (s, 3H), 2.36 (s, 3H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 162.4, 139.7, 136.4, 130.2, 122.6, 32.3, 20.9. GC-MS (*m/z*): 149 [M^+] for $C_9H_{11}NO$ (yield, 143 mg (0.96 mmol), 96%).



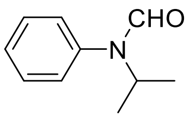
Product **7a**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.43 (s, 1H), 7.30-7.22 (m, 1H), 7.09-7.03 (m, 1H), 6.97-6.92 (m, 2H), 3.28 (s, 3H), 2.36 (s, 3H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 162.3, 142.2, 139.7 129.4, 127.2, 123.1, 119.4, 32.0, 21.4. GC-MS (*m/z*): 149 [M^+] for $C_9H_{11}NO$ (yield, 141 mg (0.95 mmol) 95%).



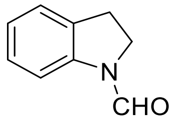
Product **8a**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.37 (s, 1H), 7.44-7.39 (m, 2H), 7.32-7.27 (m, 1H), 7.19-7.15 (m, 2H), 3.82 (t, *J* = 7.6 Hz, 2H), 1.57-1.48 (m, 2H), 1.37-1.26 (m, 2H), 0.92-0.86 (m, 3H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 162.4, 141.1, 129.6, 126.8, 124.2, 44.8, 29.7, 20.0, 13.7. GC-MS (*m/z*): 177 [M^+] for $C_{11}H_{15}NO$ (yield,141 mg (0.80 mmol), 80%).



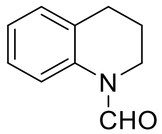
Product **9a**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.35 (s, 1H), 7.43-7.38 (m, 2H), 7.32-7.26 (m, 1H), 7.18-7.15 (m, 2H), 3.86 (q, *J* = 7.2 Hz, 2H), 1.6 (t, *J* = 7.2 Hz, 3H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 162.1, 140.8, 129.7, 126.9, 124.3, 40.1, 13.1. GC-MS (*m/z*): 149 [M^+] for $C_9H_{11}NO$ (yield, 140 mg (0.94 mmol), 94%,).



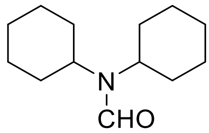
Product **10a**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.37, 8.12 (s, and s, total 1H), 7.41-7.29 (m, 3H), 7.13-7.08 (m, 2H), 4.75, 4.01 (hept, *J* = 6.8 Hz, and hept, *J* = 6.8 Hz, total 1H), 1.23, 1.15 (d, *J* = 6.8 Hz, and d, *J* = 6.8 Hz, total 6H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 162.5, 138.4, 129.2, 128.9, 128.1, 45.8, 20.9. GC-MS (*m/z*): 163 [M^+] for $C_{10}H_{13}NO$ (yield, 107 mg (0.66 mmol), 66%).



Product **11a**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.88 (s, 1H), 7.24-7.09 (m, 3H), 7.05-6.99 (m, 1H), 4.10-3.97 (m, 2H), 3.17-3.05 (m, 2H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 157.5, 141.0, 131.9, 127.5, 126.0, 124.2, 109.4, 44.6. 27.1. GC-MS (*m/z*): 147 [M$^+$] for C_9H_9NO (yield, 107 mg (0.73 mmol), 73%).



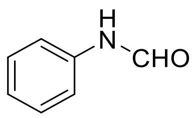
Product **12a**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.73 (s, 1H), 7.20-6.99 (m, 4H), 3.75, 3.60 (t, *J* = 6.2 Hz, and t, *J* = 6.2 Hz, total 2H), 2.76, 2.84 (t, *J* = 6.4 Hz, and t, *J* = 6.4 Hz, total 2H), 2.01-1.93, (m, 2H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 161.1, 137.2, 129.6, 128.9, 127.1, 124.6, 117.0, 40.3, 27.1, 22.3. GC-MS (*m/z*): 161 [M$^+$] for $C_{10}H_{11}NO$ (yield, 140 mg (0.87 mmol), 87%).



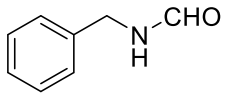
Product **13a**. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.21 (s, 1H), 3.99-3.89 (m, 1H), 3.11-3.00 (m, 1H), 1.91-1.05 (m, 20H). ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 161.7, 55.1, 52.6, 34.6, 30.4, 26.3, 25.9, 25.4, 25.3. GC-MS (*m/z*): 209 [M$^+$] for $C_{13}H_{23}NO$ (yield, 196 mg (0.94 mmol), 94%).

Mono-*N*-formylation of primary amines

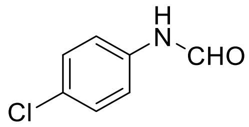
(Products **1b-6b** contains conformational isomers.)[S3,S6,S7]



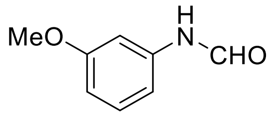
Product **1b**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 9.35, 8.74 (br and br, total 1H), 8.71, 8.31 (d, *J* = 11.6, and d, *J* = 1.8, total 1H), 7.61-7.56 (m, 1H), 7.36-7.55 (m, 2H), 7.20-7.08 (m, 2H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 163.4, 160.0, 137.2, 137.0, 129.7, 129.1, 125.3, 124.8, 120.3, 118.8. GC-MS (*m/z*): 121 [M$^+$] for C_7H_7NO (yield, 89 mg (0.74 mmol), 74%).



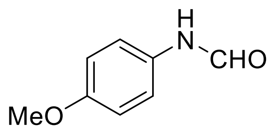
Product **2b**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.23, 8.15 (s, and d, *J* = 11.8, total 1H), 7.40-7.22 (m, 5H), 6.07 (br, 1H), 4.46, 4.39 (d, *J* = 6.45, and d, *J* = 6.45, total 2H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 161.0, 137.6, 128.8, 127.8, 127.7, 42.2. GC-MS (*m/z*): 135 [M^+] for C_8H_9NO (yield, 131 mg (0.97 mmol), 97%).



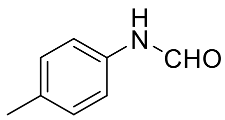
Product **3b**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.64, 8.37 (d, *J* = 11.44 Hz, and s, total 1H), 7.49 (d, *J* = 8.92, 1H), 7.35-7.27 (m, 2H), 7.02 (d, *J* = 8.77, 1H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 162.5, 159.1, 135.4, 135.3, 130.8, 129.9, 129.9, 129.2, 121.2, 120.1. GC-MS (*m/z*): 155 [M^+] for C_7H_6ClNO (yield, 105 mg (0.68 mmol), 68%).



Product **4b**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.63, 8.26 (s, and d, *J* = 1.73 Hz, total 1H), 8.61, 7.81(br, and br, total 1H) 7.26-7.09 (m, 1.5H), 6.97-6.93 (m, 0.5H), 6.66-6.53 (m, 2H), 3.71 (d, *J* = 2.30, 3H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 162.3, 160.7, 160.1, 159.4, 138.2, 138.0, 130.6, 129.8, 112.2, 110.9, 110.5, 110.4, 106.0, 104.9, 55.4, 55.3. GC-MS (*m/z*): 151 [M^+] for $C_8H_9NO_2$ (yield, 87 mg (0.58 mmol), 58%).

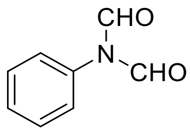


Product **5b**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.51, 8.31 (d, *J* = 11.54 Hz, and d, *J* = 1.87 Hz, total 1H), 7.44 (d, *J* = 9.13, 1H), 7.03 (d, *J* = 8.91, 1H), 6.90-6.83 (m, 2H), 3.79 (d, *J* = 6.00, 3H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 163.2, 159.0, 157.6, 156.7, 130.0, 129.6, 121.8, 121.6, 114.9, 114.2, 55.6, 55.5. GC-MS (*m/z*): 151 [M^+] for $C_8H_9NO_2$ (yield, 98 mg (0.65 mmol), 65%).

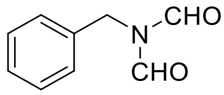


Product **6b**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.62, 8.35 (d, *J* = 11.35 Hz, and br, total 1H), 7.42 (d, *J* = 8.72, 1H), 7.15 (t, *J* = 8.54, 2H), 6.97 (d, *J* = 8.01, 1H), 2.32 (d, *J* = 6.47, 3H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 162.9, 159.3, 135.2, 134.6, 134.2, 134.1, 130.2, 129.6, 120.2, 119.2, 20.9, 20.8. GC-MS (*m/z*): 135 [M^+] for C_8H_9NO (yield, 86 mg (0.64 mmol), 64%).

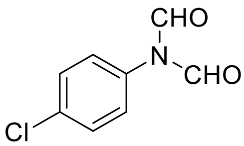
Double-*N*-formylation of primary amines



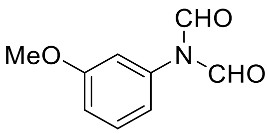
Product **1c**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.98 (br, 2H), 7.52-7.38 (m, 3H), 7.22-7.13 (m, 2H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 163.3, 129.6, 129.3, 127.3. GC-MS (*m/z*): 149 [M$^+$] for $C_8H_7NO_2$ (yield, 67 mg (0.45 mmol), 90%).



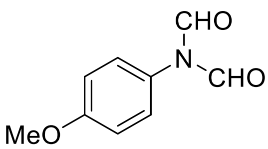
Product **2c**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.79 (s, 2H), 7.39-7.23 (m, 5H), 4.76(s, 2H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 164.2, 135.6, 128.8, 128.7, 128.0, 42.1. GC-MS (*m/z*): 163 [M$^+$] for $C_9H_9NO_2$ (yield, 69 mg (0.42 mmol), 85%).



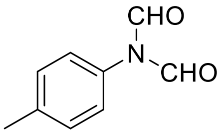
Product **3c**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 9.02 (br, 2H), 7.44 (d, *J* = 8.1, 2H), 7.14 (d, *J* = 7.9, 2H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 162.7, 135.3, 129.8, 128.7. GC-MS (*m/z*): 183 [M$^+$] for $C_8H_6ClNO_2$ (yield, 67 mg (0.37 mmol), 73%).



Product **4c**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 9.09 (br, 2H), 7.40 (d, *J* = 8.23, 1H), 7.01-6.97 (m, 1H), 6.82-6.79 (d, *J* = 7.92, 1H), 7.76 (br, 1H), 3.82 (s, 3H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 162.8, 160.5, 130.4, 119.4, 115.0, 113.2, 55.5. GC-MS (*m/z*): 179 [M$^+$] for $C_9H_9NO_3$ (yield, 74 mg (0.41 mmol), 83%).

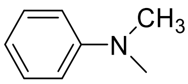


Product **5c**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 9.06 (br, 2H), 7.13 (d, *J* = 8.78, 2H), 6.99 (d, *J* = 8.94, 2H), 3.83 (s, 3H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 163.2, 160.1, 128.5, 114.9, 55.6. GC-MS (*m/z*): 179 [M$^+$] for $C_9H_9NO_3$ (yield, 79 mg (0.45 mmol), 89%).

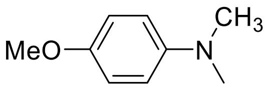


Product **6c**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 9.01 (br, 2H), 7.28 (d, *J* = 8.72, 1H), 7.08 (d, *J* = 8.25, 2H), 2.38 (s, 3H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 163.3, 139.5, 130.3, 127.1, 21.2. GC-MS (*m/z*): 163 [M^+] for $C_9H_9NO_2$ (yield, 75 mg (0.46 mmol), 92%).

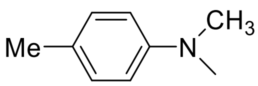
***N*-Methylation of secondary amines**



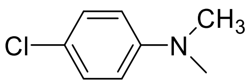
Product **1d**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.30 (t, *J* = 7.6 Hz, 2H), 6.80 (m, 3H), 7.16 (d, *J* = 8.0 Hz, 2H), 2.99 (s, 6H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 150.6, 129.4, 116.8, 112.8, 40.7. GC-MS (*m/z*): 121 [M^+] for $C_8H_{11}N$ (yield, 110 mg (0.92 mmol), 92%).



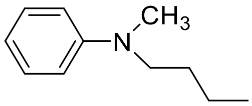
Product **2d**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 6.87-6.82 (m, 2H), 6.78-6.73 (m, 2H), 3.76 (s, 3H), 2.87 (s, 6H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 152.0, 145.8, 114.9, 114.7, 55.8, 41.8. GC-MS (*m/z*): 151 [M^+] for $C_9H_{13}NO$ (yield, 139 mg (0.92 mmol), 92%).



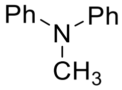
Product **3d**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.06 (d, *J* = 8.5 Hz, 2H), 6.71 (d, *J* = 8.5 Hz, 2H), 2.91 (s, 6H), 2.27 (s, 3H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 148.9, 129.7, 126.3, 113.4, 41.2, 20.3. GC-MS (*m/z*): 135 [M^+] for $C_9H_{13}N$ (yield, 119 mg (0.88 mmol), 88%).



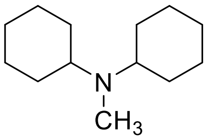
Product **4d**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.17 (d, *J* = 9.2 Hz, 2H), 6.64 (d, *J* = 9.2 Hz, 2H), 2.92 (s, 6H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 149.2, 128.8, 121.4, 113.7, 40.7. GC-MS (*m/z*): 155 [M^+] for $C_8H_{10}ClN$ (yield, 97 mg (0.63 mmol), 63%).



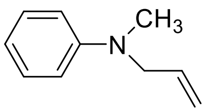
Product **5d**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.25 (m, 2H), 6.74-6.67 (m, 3H), 3.33 (t, *J* = 7.5 Hz, 2H), 2.95 (s, 3H), 1.62-1.55 (m, 2H), 1.42-1.33 (m, 2H), 0.98 (t, *J* = 7.3 Hz, 3H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 149.4, 129.1, 115.7, 112.1, 52.5, 38.3, 28.9, 20.4, 14.0. GC-MS (*m/z*): 163 [M^+] for $C_{11}H_{17}N$ (yield, 161 mg (0.99 mmol), 99%).



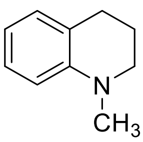
Product **6d**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.46-6.90 (m, 10H), 3.38 (s, 3H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 149.0, 129.3, 121.3, 120.5, 40.3. GC-MS (*m/z*): 183 [M^+] for $C_{13}H_{13}N$ (yield, 141 mg (0.77 mmol), 77%).



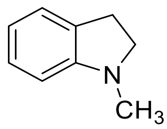
Product **7d**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 2.53-2.41 (m, 2H), 2.21 (s, 3H), 1.81-1.71 (m, 8H), 1.62-1.55 (m, 2H), 1.27-1.00 (m, 10H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 59.4, 32.9, 30.5, 26.3, 26.2. GC-MS (*m/z*): 195 [M^+] for $C_{13}H_{25}N$ (yield, 156 mg (0.80 mmol), 80%).



Product **8d**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.32-7.25 (m, 2H), 6.82–6.73 (m, 3H), 5.97-5.85 (m, 1H), 5.27-5.17 (m, 2H), 3.99-3.94 (t, 2H), 2.99 (s, 3H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 149.5, 133.7, 129.1, 116.5, 116.2, 112.5, 55.3, 38.0, GC-MS (*m/z*): 147 [M^+] for $C_{10}H_{13}N$ (yield, 123 mg (0.84 mmol), 84%).

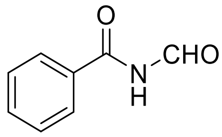


Product **9d**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.12 (t, *J*=7.8, 1H), 6.99 (d, *J*=7.5, 1H), 6.68–6.62 (m, 2H), 3.28 (t, *J*=5.7, 2H), 2.93 (s, 3H), 2.81 (t, *J*=6.5, 2H), 2.07–1.99 (m, 2H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 146.8, 128.9, 127.1, 122.9, 116.3, 111.0, 51.3, 39.2, 27.9, 22.5, GC-MS (*m/z*): 147 [M^+] for $C_{10}H_{13}N$ (yield, 116 mg (0.79 mmol), 79%).

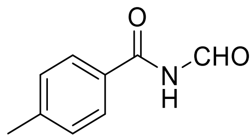


Product **10d**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.12-7.07 (m, 2H), 6.69 (t, *J* = 7.3, 1H), 6.51 (d, *J* = 8.0, 1H), 3.30 (t, *J* = 8.2, 2H), 2.95 (t, *J* = 8.2, 2H), 2.77 (m, 3H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 153.4, 130.3, 127.3, 124.3, 117.8, 107.2, 56.2, 36.3, 28.8. GC-MS (*m/z*): 133 [M^+] for $C_9H_{11}N$ (yield, 86 mg (0.65 mmol), 65%).

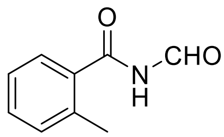
N-Formylation of primary amides



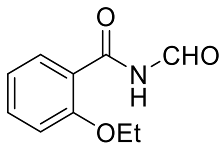
Product **1e**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 9.86 (s, 1H), δ 9.41 (d, *J* = 5.3 Hz, 1H), 7.98 (d, *J* = 3.7 Hz, 2H), 7.70-7.63 (m, 2H), 7.57-7.51 (m, 2H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 166.8, 165.1, 134.0, 131.1, 129.1, 128.2. GC-MS (*m/z*): 149 [M^+] for $C_8H_7NO_2$ (yield, 55 mg (0.37 mmol), 74%).



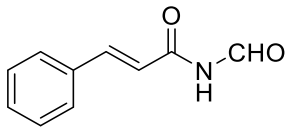
Product **2e**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 9.89 (d, *J* = 4.7 Hz, 1H), 9.38 (d, *J* = 4.7 Hz, 1H), 7.89-7.85 (m, 2H), 7.35-7.31 (m, 2H), 2.44 (s, 3H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 166.6, 164.8, 145.0, 129.8, 128.3, 128.2, 21.7. GC-MS (*m/z*): 163 [M^+] for $C_9H_9NO_2$ (yield, 61 mg (0.37 mmol), 75%).



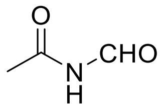
Product **3e**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 9.24 (d, *J* = 10.1 Hz, 1H), 8.57 (br, 1H), 7.51-7.43 (m, 2H), 7.34-7.28 (m, 2H), 2.53 (s, 3H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 168.6, 163.3, 138.4, 132.2, 132.0, 132.0, 127.3, 126.2, 20.3. GC-MS (*m/z*): 163 [M^+] for $C_9H_9NO_2$ (yield, 60 mg (0.37 mmol), 74%).



Product **4e**. [1]H NMR ($CDCl_3$, 400 MHz) δ 10.34 (br, 1H), 9.38 (d, *J* = 9.9 Hz, 1H), 8.19 (dd, *J* = 8.0 and 1.9), 7.57-7.52 (m, 1H), 7.13-7.07 (m, 1H), 7.00 (d, *J* = 8.7 Hz, 1H), 4.25 (q, *J* = 7.0 Hz, 2H), 1.56 (t, *J* = 7.0 Hz, 3H); ^{13}C {^1H} NMR ($CDCl_3$, 100 MHz) δ 165.3, 163.1, 157.9, 135.4, 132.7, 121.7, 118.9, 112.7, 65.3, 14.6. GC-MS (*m/z*): 193 [M^+] for $C_{10}H_{11}NO_3$ (yield, 68 mg (0.35 mmol), 71%).

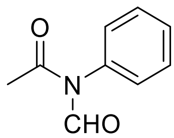


Product **5e**. [1]H NMR ($CDCl_3$, 400 MHz) δ 9.29 (d, *J* = 4.8 Hz, 1H), 9.13 (s, 1H), 7.88 (d, *J* = 7.8 Hz, 1H), 7.61-7.56 (m, 2H), 7.48-7.40 (m, 3H), 6.51 (d, *J* = 7.8 Hz, 1H); ^{13}C {^1H} NMR ($CDCl_3$, 100 MHz) δ 156.5, 164.5, 146.6, 133.7, 131.2, 129.1, 128.6, 118.0. GC-MS (*m/z*): 175 [M^+] for $C_{10}H_9NO_2$ (yield, 48 mg (0.27 mmol), 55%).

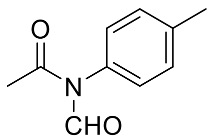


Product **6e**. [1]H NMR ($CDCl_3$, 400 MHz) δ 9.08 (d, *J* = 9.2 Hz, 1H), 8.90 (br, 1H), 2.20 (s, 3H); ^{13}C {^1H} NMR ($CDCl_3$, 100 MHz) δ 170.5, 162.3, 23.7. GC-MS (*m/z*): 87 [M^+] for $C_3H_5NO_2$ (yield, 37 mg (0.43 mmol), 86%).

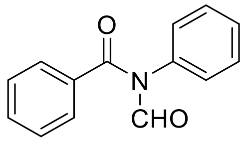
***N*-Formylation of secondary amides**



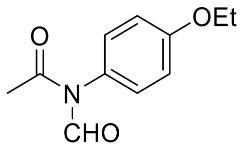
Product **1f**. [1]H NMR ($CDCl_3$, 400 MHz) δ 9.57 (s, 1H), 7.52-7.43 (m, 3H), 7.18-7.14 (m, 2H), 2.06 (s, 2H); ^{13}C {^1H} NMR ($CDCl_3$, 100 MHz) δ 172.9, 162.5, 135.6, 130.0, 129.5, 128.4, 24.4. GC-MS (*m/z*): 163 [M^+] for $C_9H_9NO_2$ (yield, 142 mg (0.87 mmol), 87%).



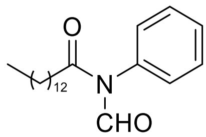
Product **2f**. [1]H NMR ($CDCl_3$, 400 MHz) δ 9.57 (s, 1H), 7.34-7.30 (m, 2H), 7.08-7.04 (m, 2H), 2.43 (s, 3H), 2.09 (s, 3H); ^{13}C {^1H} NMR ($CDCl_3$, 100 MHz) δ 173.1, 162.6, 139.6, 132.9, 130.6, 128.1, 24.4, 21.2. GC-MS (*m/z*): 177 [M^+] for $C_{10}H_{11}NO_2$ (yield, 161 mg (0.91 mmol), 91%).



Product **3f**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 9.46 (s, 1H), 7.58-7.13 (m, 10H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 171.8, 163.4, 135.6, 133.2, 132.3, 129.4, 128.5, 128.1. GC-MS (*m/z*): 225 [M^+] for $C_{14}H_{11}NO_2$ (yield, 196 mg (0.87 mmol), 87%).

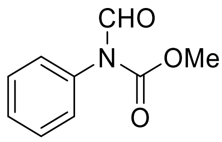


Product **4f**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 9.56 (s, 1H), 7.07-7.02 (m, 2H), 6.99-6.94 (m, 2H), 4.05 (q, *J* = 7.0 Hz, 2H), 2.06 (s, 3H), 1.43 (t, *J* = 7.0 Hz, 3H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 173.4, 162.6, 159.5, 129.4, 127.8, 115.6, 63.8, 24.3, 14.7. GC-MS (*m/z*): 207 [M^+] for $C_{11}H_{13}NO_3$ (yield, 167 mg (0.81 mmol), 81%).

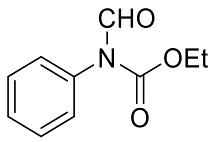


Product **5f**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 9.60 (s, 1H), 7.53-7.45 (m, 3H), 7.17-7.13 (m, 2H), 2.22 (t, *J* = 7.3 Hz, 2H),1.65-1.56 (m, 2H), 1.29-1.19 (m, 20H), 0.88 (t, *J* = 6.8 Hz, 3H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 175.7, 162.6, 135.3, 130.0, 129.4, 128.6, 36.1, 31.9, 29.7, 29.6, 29.6, 29.5, 29.4, 29.4, 29.3, 28.9, 24.1, 22.7, 14.1. GC-MS (*m/z*): 331 [M^+] for $C_{21}H_{33}NO_2$ (yield, 327 mg (0.99 mmol), 99%).

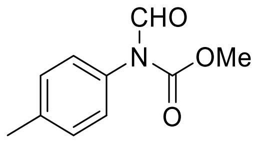
N-Formylation of carbamates



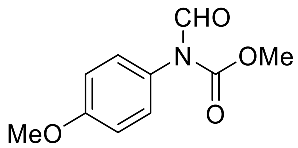
Product **1g**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 9.47 (s, 1H), 7.48-7.39 (m, 3H), 7.17-7.13 (m, 2H), 3.86 (s, 3H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 162.7, 154.5, 134.0, 129.3, 128.9, 128.2, 54.2. GC-MS (*m/z*): 179 [M^+] for $C_9H_9NO_3$ (yield, 130 mg (0.73 mmol), 73%).



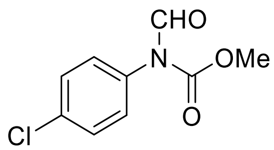
Product **2g**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 9.47 (s, 1H), 7.49-7.39 (m, 3H), 7.17-7.13 (m, 2H), 4.33 (q, *J* = 7.0 Hz, 2H), 1.29 (t, *J* = 7.0 Hz, 3H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 162.8, 153.9, 134.1, 129.2, 128.8, 128.2, 63.7, 14.2. GC-MS (*m/z*): 193 [M^+] for $C_{10}H_{11}NO_3$ (yield, 121 mg (0.63 mmol), 63%).



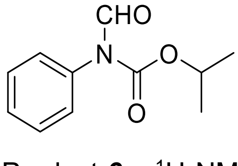
Product **3g**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 9.46 (s, 1H), 7.26 (d, *J* = 8.0, 2H), 7.03 (d, *J* = 8.0, 2H), 3.86 (s, 3H), 2.39 (s, 3H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 162.9, 154,7, 139.0, 131.3, 130.1, 129.6, 127.9, 54.2, 21.2. GC-MS (*m/z*): 193 [M^+] for $C_{10}H_{11}NO_3$ (yield, 152 mg (0.79 mmol), 79%).



Product **4g**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 9.45 (s, 1H), 7.08-7.04 (m, 2H), 6.97-6.93 (m, 2H), 3.85 (s, 3H),3.82 (s, 3H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 163.0, 159.7, 154.8, 129.2, 126.5, 114.6, 114.3, 55.5, 54.2. GC-MS (*m/z*): 209 [M^+] for $C_{10}H_{11}NO_4$ (yield, 175 mg (0.84 mmol), 84%).

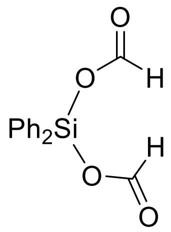


Product **5g**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 9.45 (s, 1H), 7.45-7.41 (m, 2H), 7.11-7.07 (m, 2H), 3.87 (s, 3H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 162.5, 154.1, 134.9, 132.4, 129.6, 129.6, 54.3. GC-MS (*m/z*): 213 [M^+] for $C_9H_8ClNO_3$ (yield, 157 mg (0.74 mmol), 74%).



Product **6g**. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 9.46 (s, 1H), 7.48-7.37 (m, 3H), 7.16-7.12 (m, 2H), 5.13 (sept, *J* = 6.3 Hz, 1H), 1.28 (d, *J* = 6.3 Hz, 6H); ^{13}C {^{1}H} NMR ($CDCl_3$, 100 MHz) δ 162.9, 153.4, 134.2, 129.1, 128.6, 128.2, 72.1, 21.7. GC-MS (*m/z*): 207 [M^+] for $C_{11}H_{13}NO_3$ (yield, 159 mg (0.77 mmol), 77%).

Data of $Ph_2Si(OCHO)_2$[S1]



^{1}H NMR (CD_3CN, 400 MHz) δ 8.28 (s, 1H), 7.80 (d, *J* = 8.0 Hz, 4H), 7.61 (t, *J* = 8.0 Hz, 2H), 7.52 (t, *J* = 8.0 Hz, 4H); ^{13}C {^{1}H} NMR (CD_3CN, 100 MHz) δ 160.5, 135.8, 133.0, 129.4, 129.2; ^{29}Si {^{1}H} NMR (CD_3CN, 79.5 MHz): δ –27.7. GC-MS (*m/z*): 272 [M^+] for $C_{14}H_{12}O_4Si$.

References

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S2. Z.-W. Xu, W.-Y. Xu, X.-J. Pei, F. Tang and Y.-S. Feng, *Tetrahedron Lett.*, 2019, **60**, 1254-1258.
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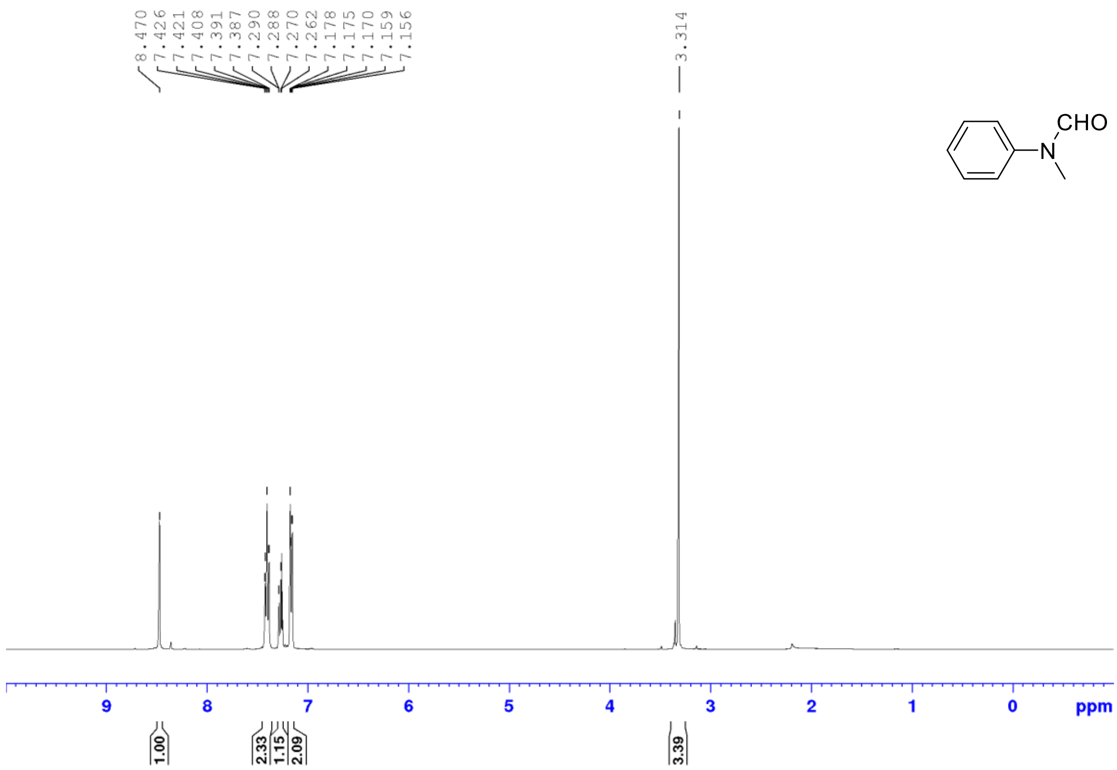
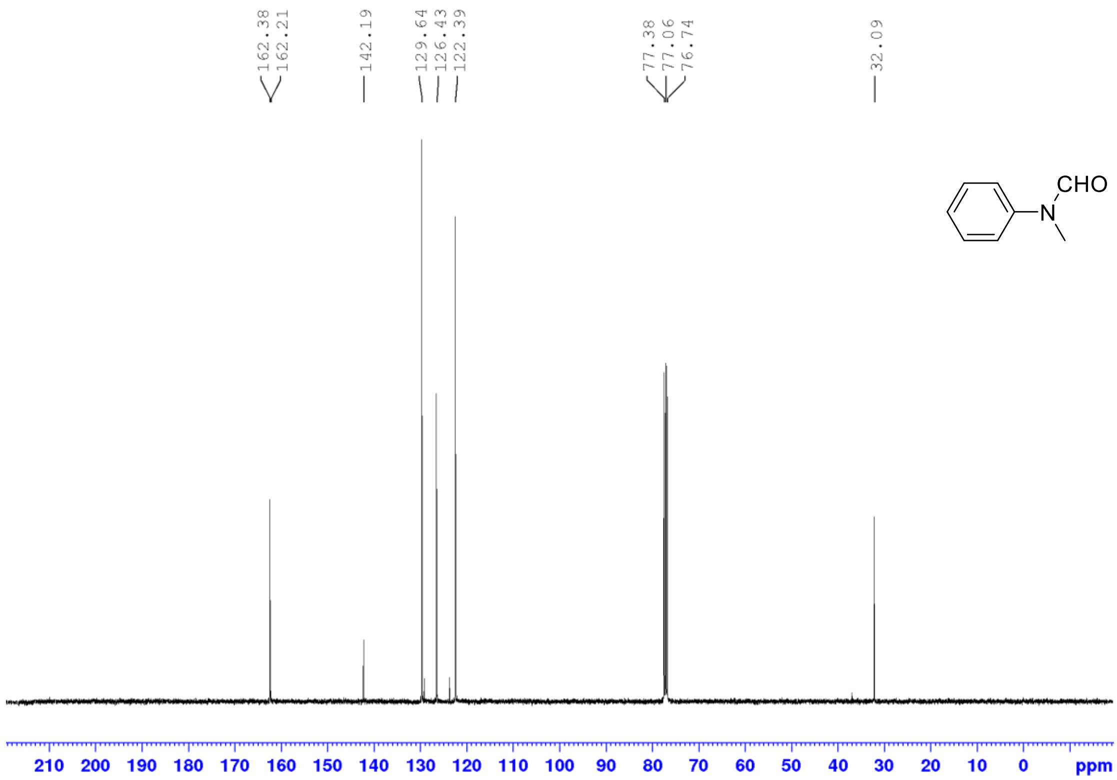
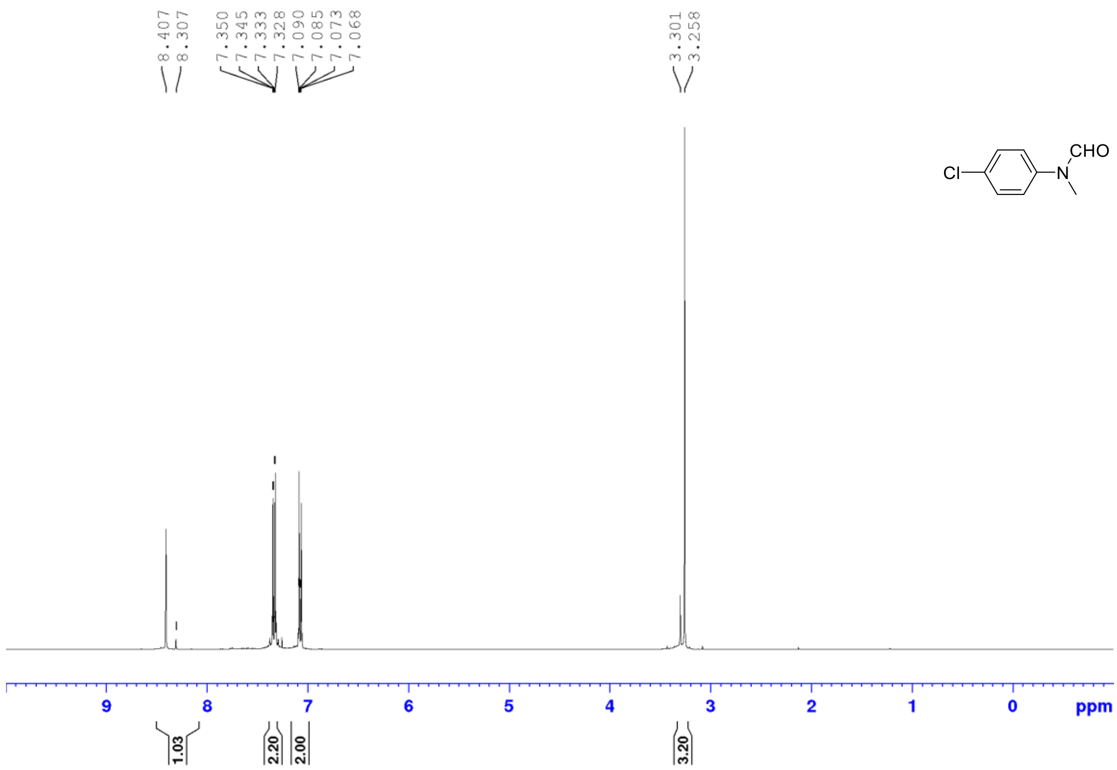
S5. C. Du and Y. Chen, *Chin. J. Chem.*, 2020, **38**, 1057-1064.
S6. J. Chen, J. Jia, Z. Guo, J. Zhang and M. Xie, *Tetrahedron Lett.,* 2019, **60,** 1426-1429.
S7. R. B. Sonawane, N. K. Rasal, D. S. Bhange and S. V. Jagtap, *ChemCatChem*, 2018, **10**, 3907-3913.



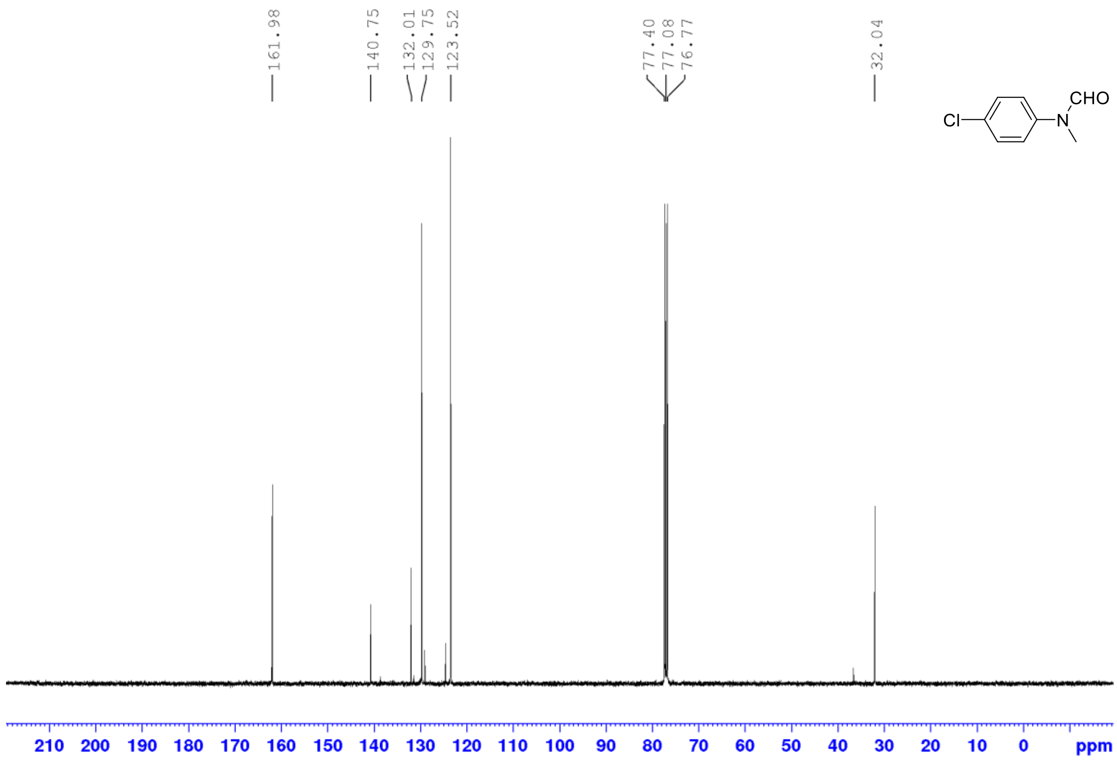
[1]H NMR of **1a**. (400 MHz, $CDCl_3$)



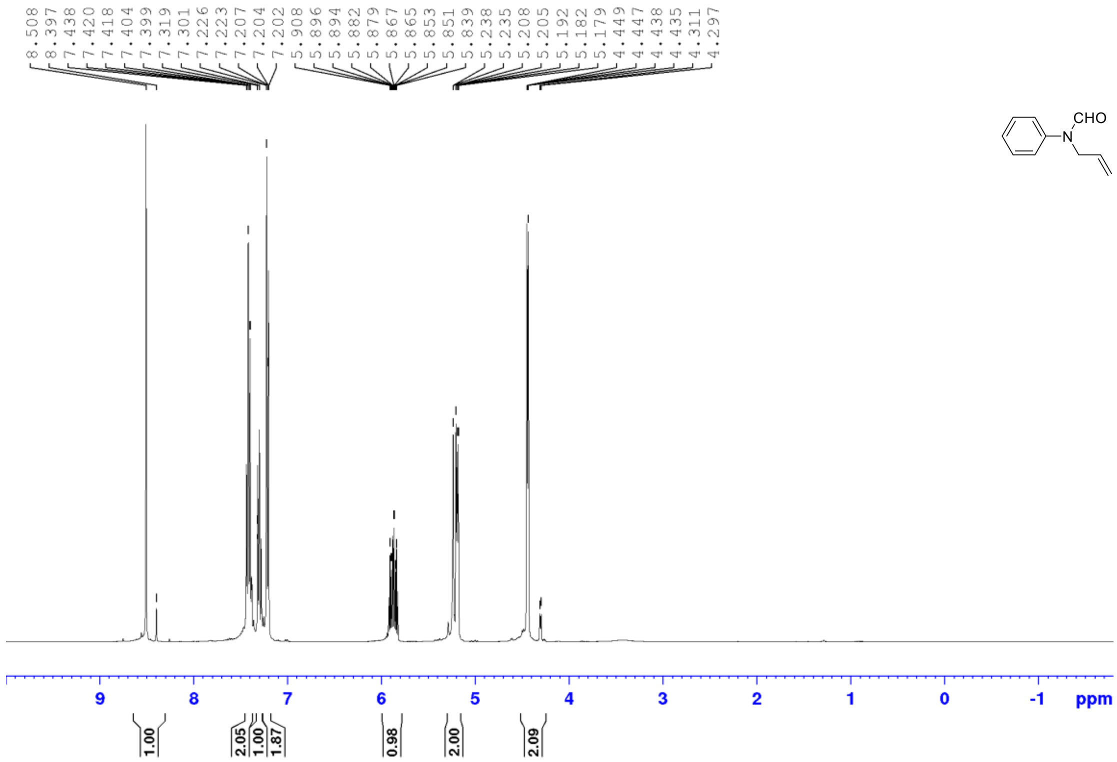
[13]C {[1]H} NMR of **1a**. (100 MHz, $CDCl_3$)



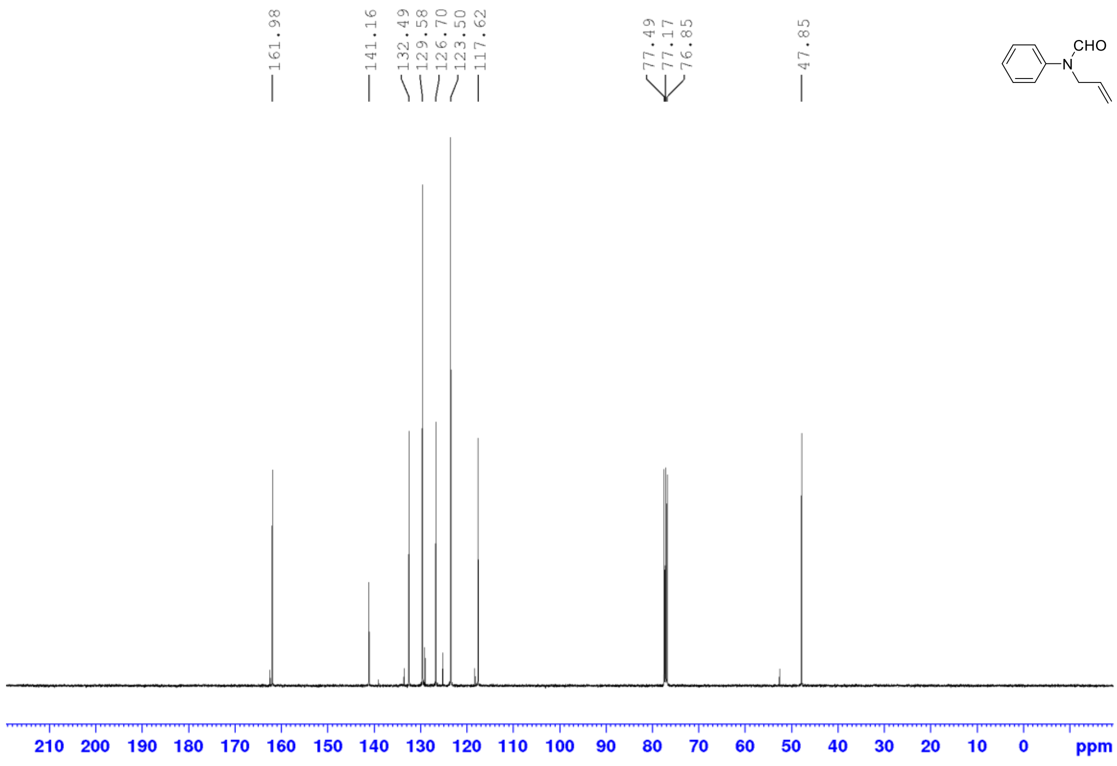
^{1}H NMR of **2a**. (400 MHz, $CDCl_3$)



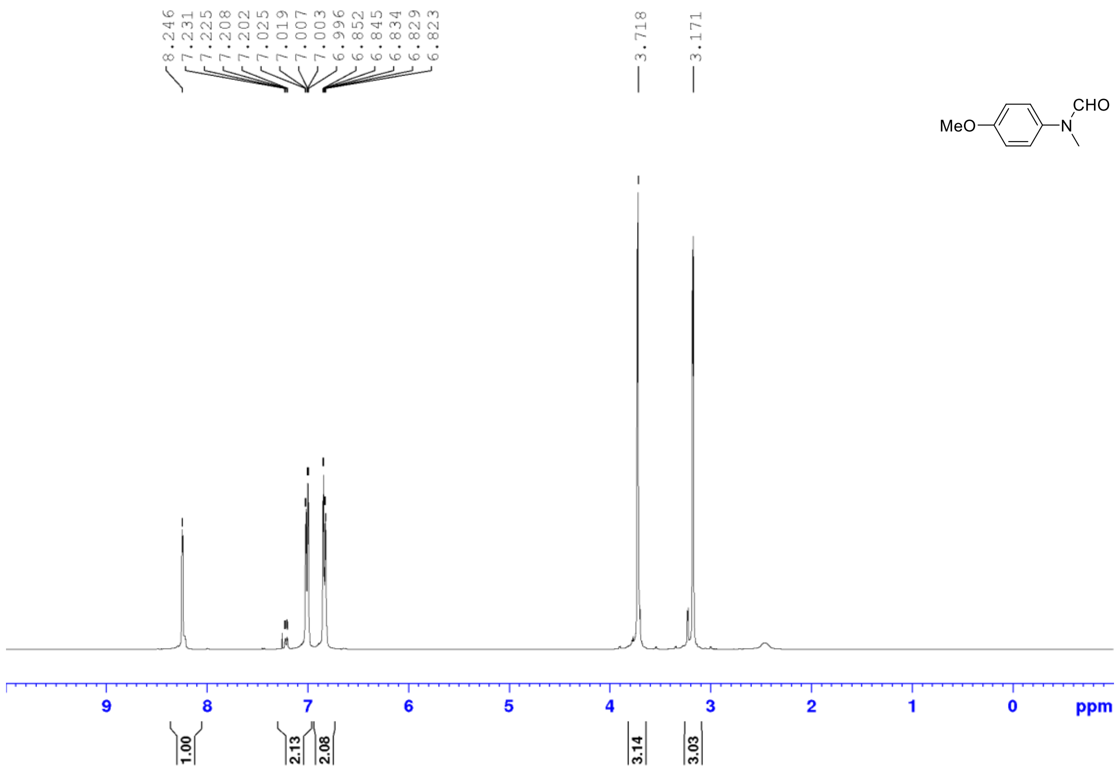
^{13}C {^{1}H} NMR of **2a**. (100 MHz, $CDCl_3$)



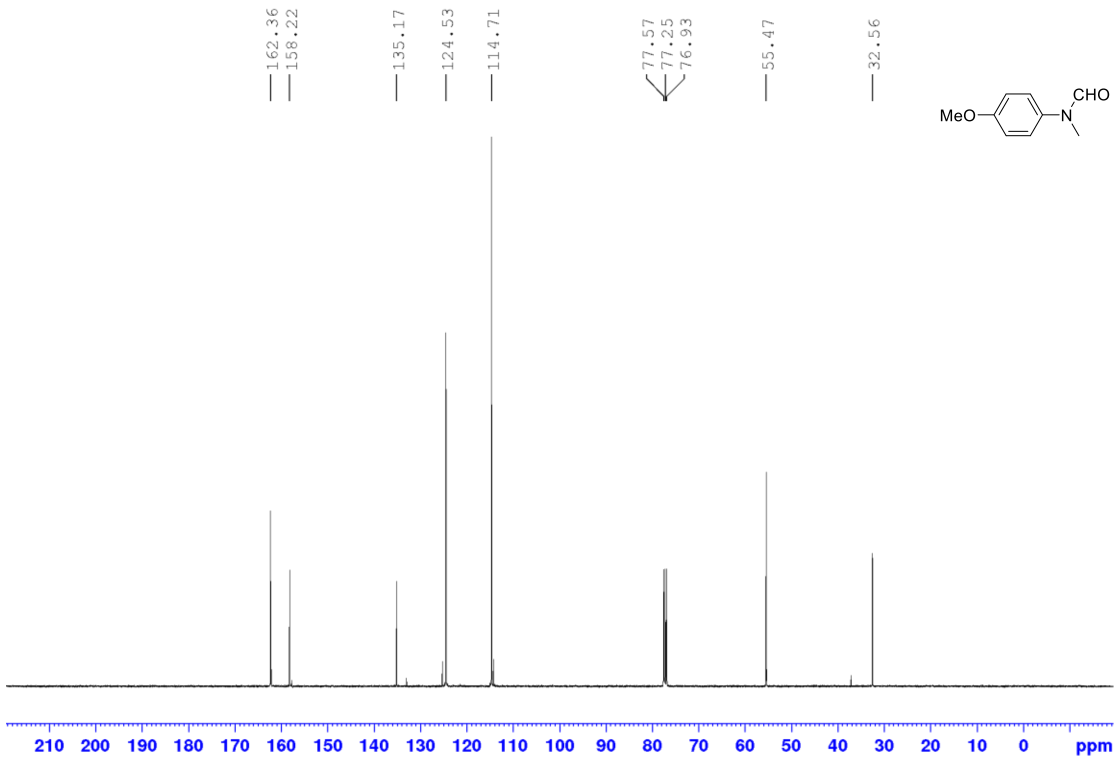
^{1}H NMR of **3a**. (400 MHz, $CDCl_3$)



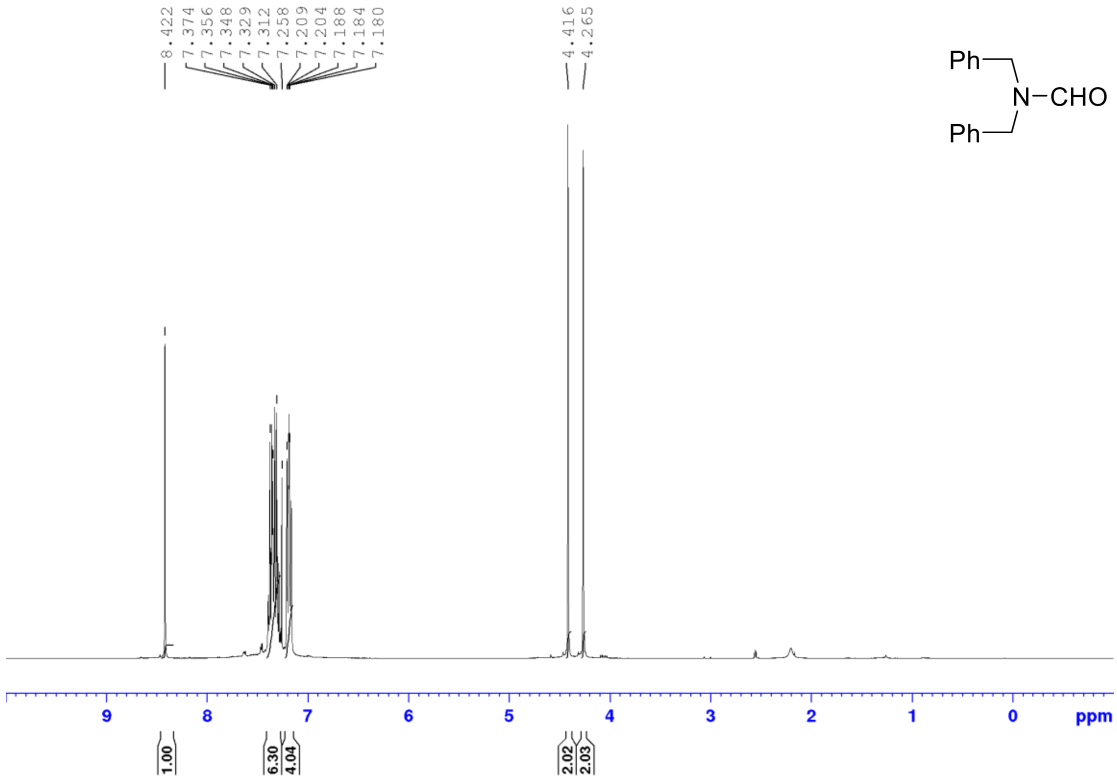
^{13}C {^{1}H} NMR of **3a**. (100 MHz, $CDCl_3$)



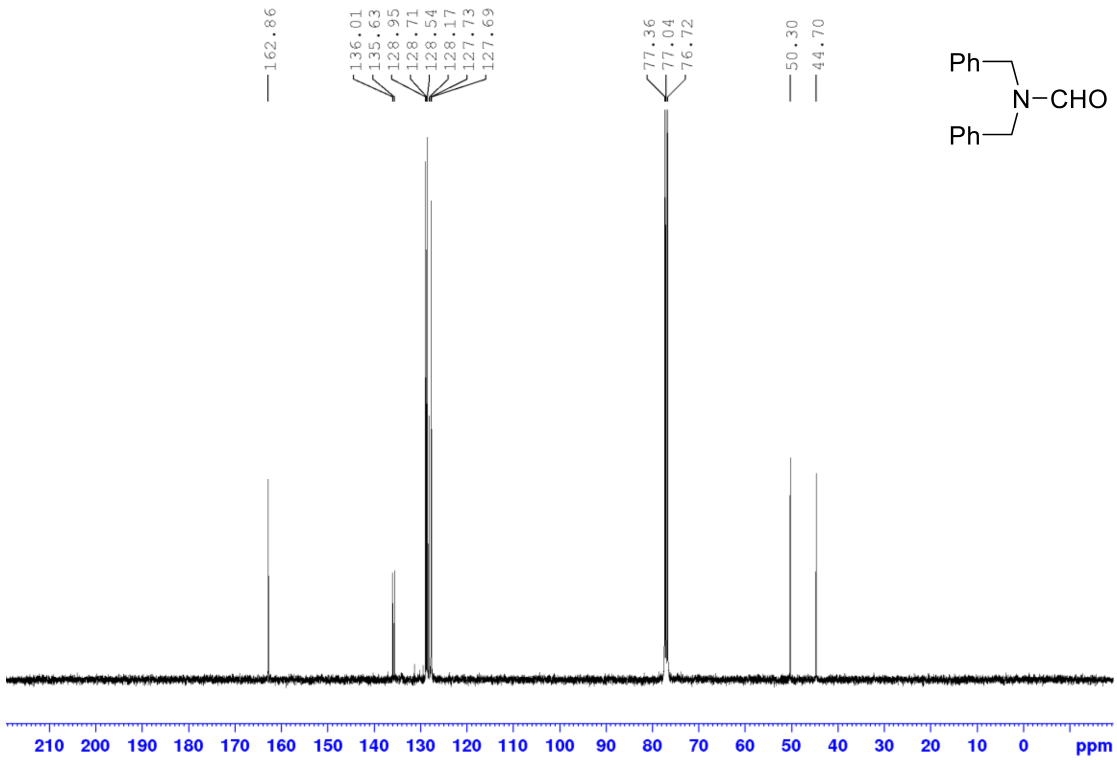
^{1}H NMR of **4a**. (400 MHz, $CDCl_3$)



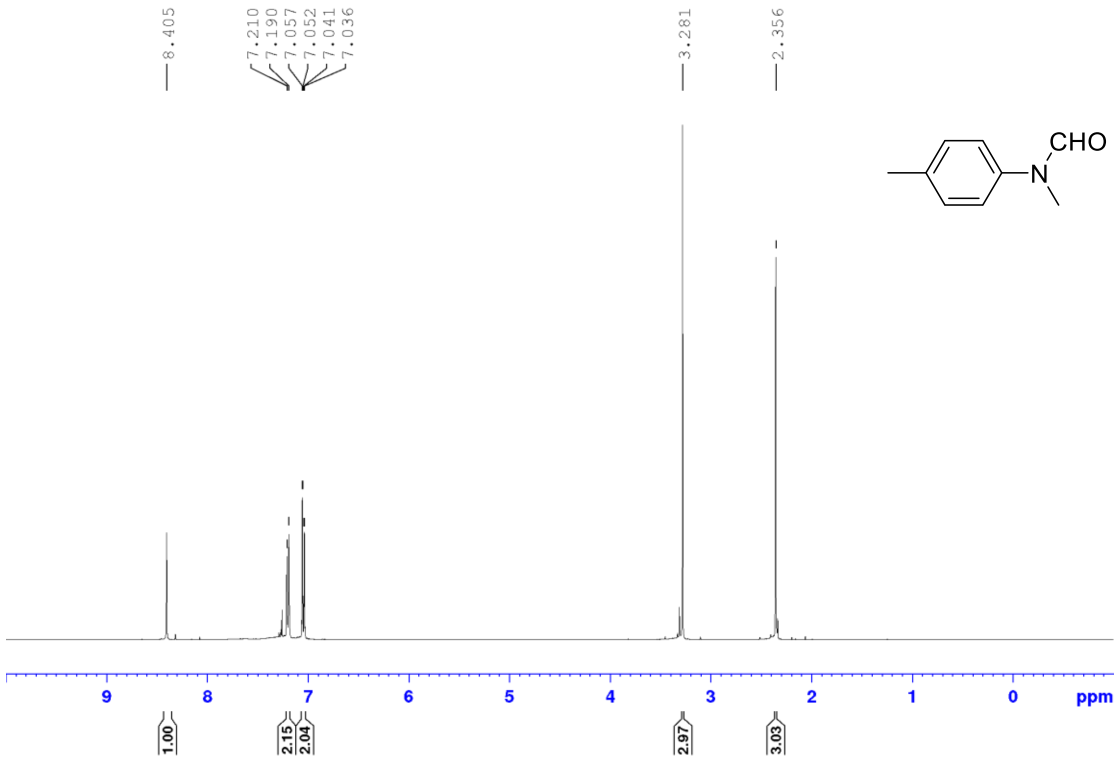
^{13}C {^{1}H} NMR of **4a**. (100 MHz, $CDCl_3$)



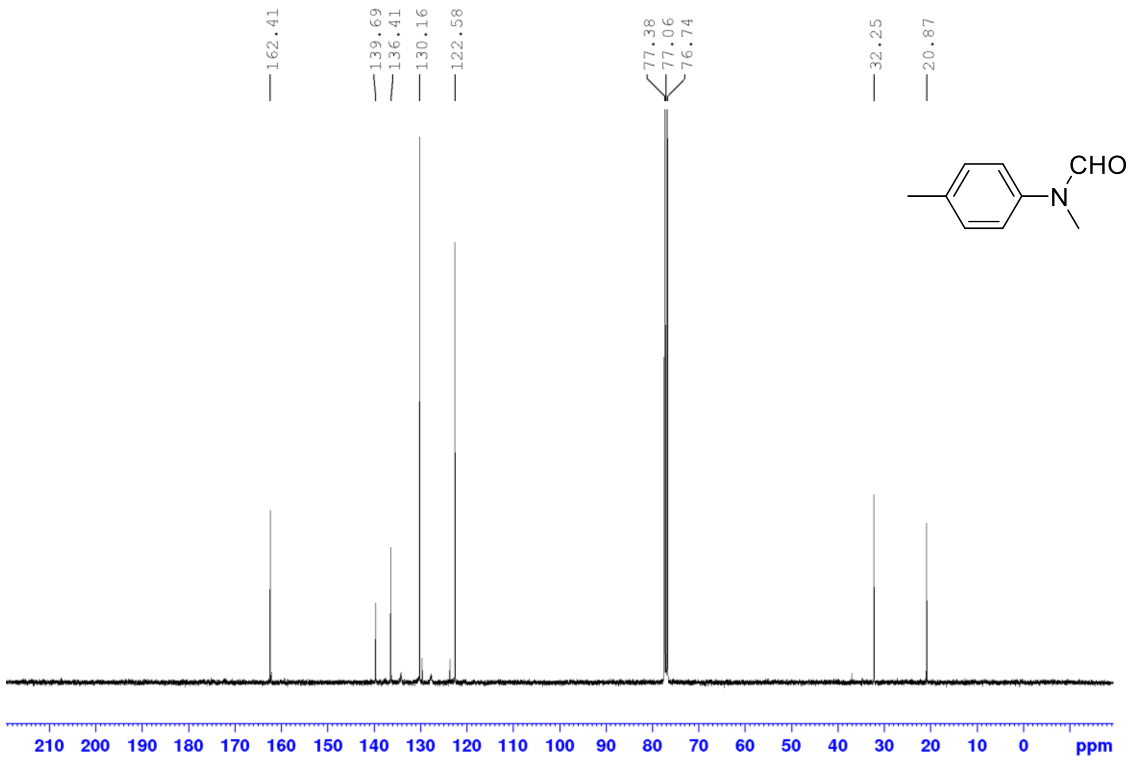
[1]H NMR of **5a**. (400 MHz, $CDCl_3$)



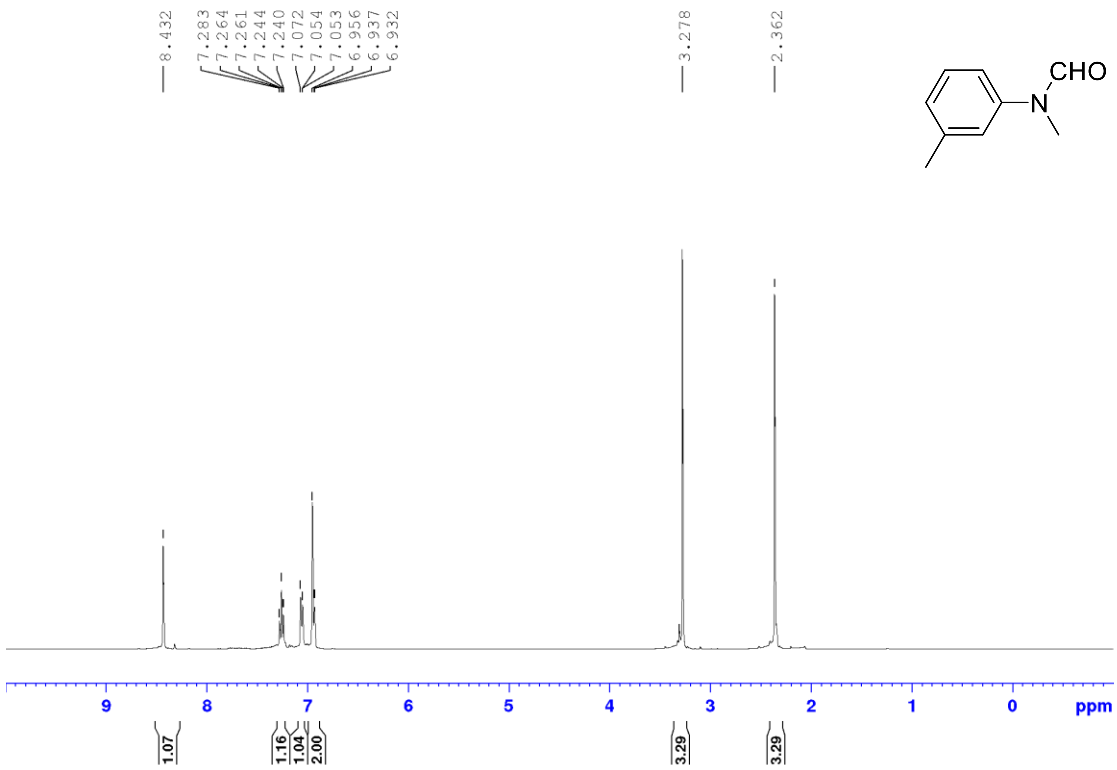
[13]C {[1]H} NMR of **5a**. (100 MHz, $CDCl_3$)



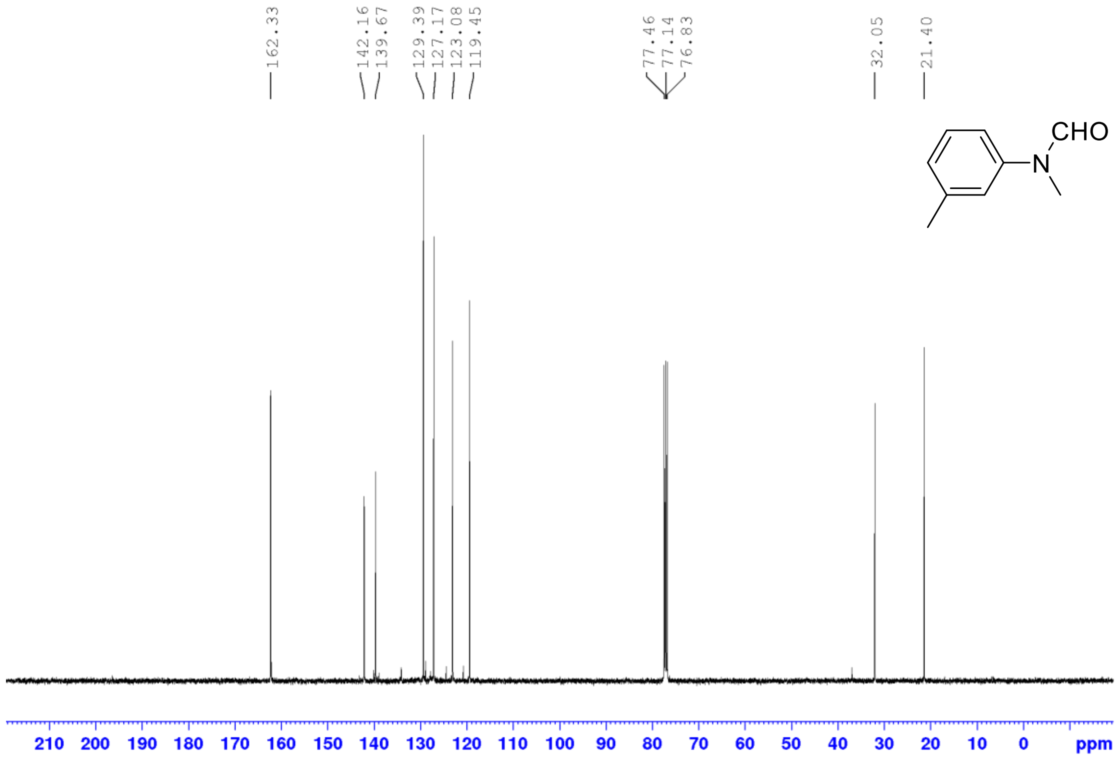
^{1}H NMR of **6a**. (400 MHz, $CDCl_3$)



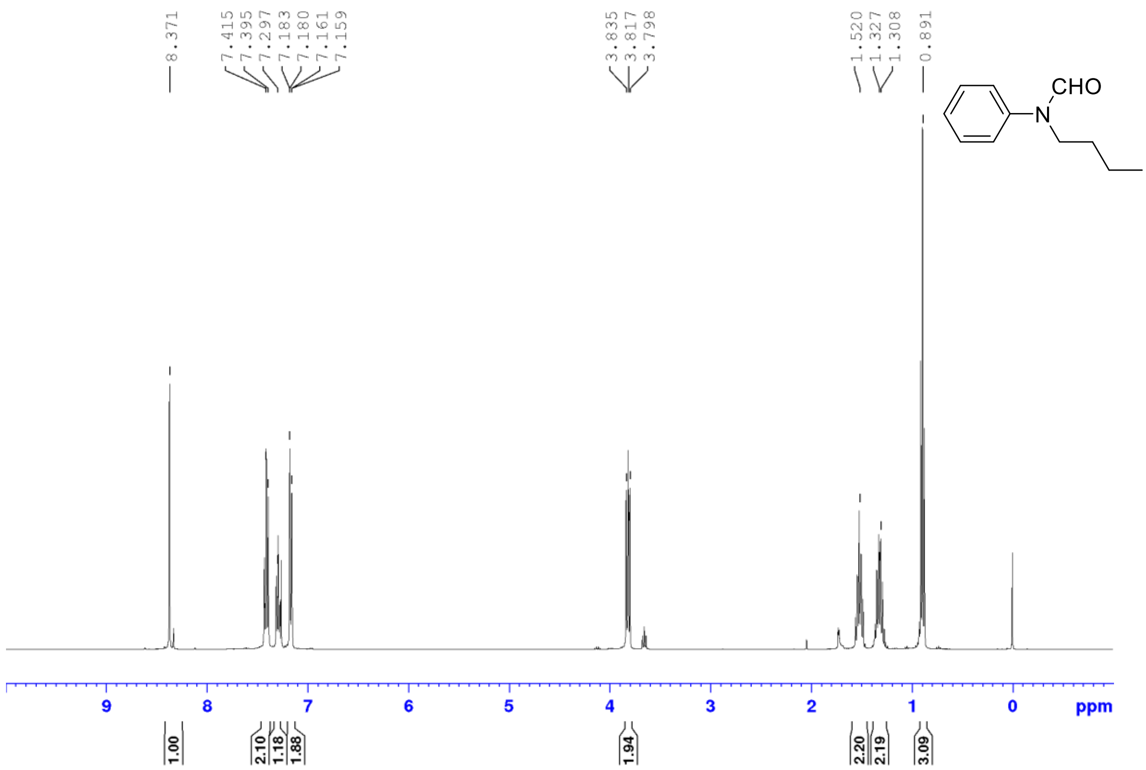
^{13}C {^{1}H} NMR of **6a**. (100 MHz, $CDCl_3$)



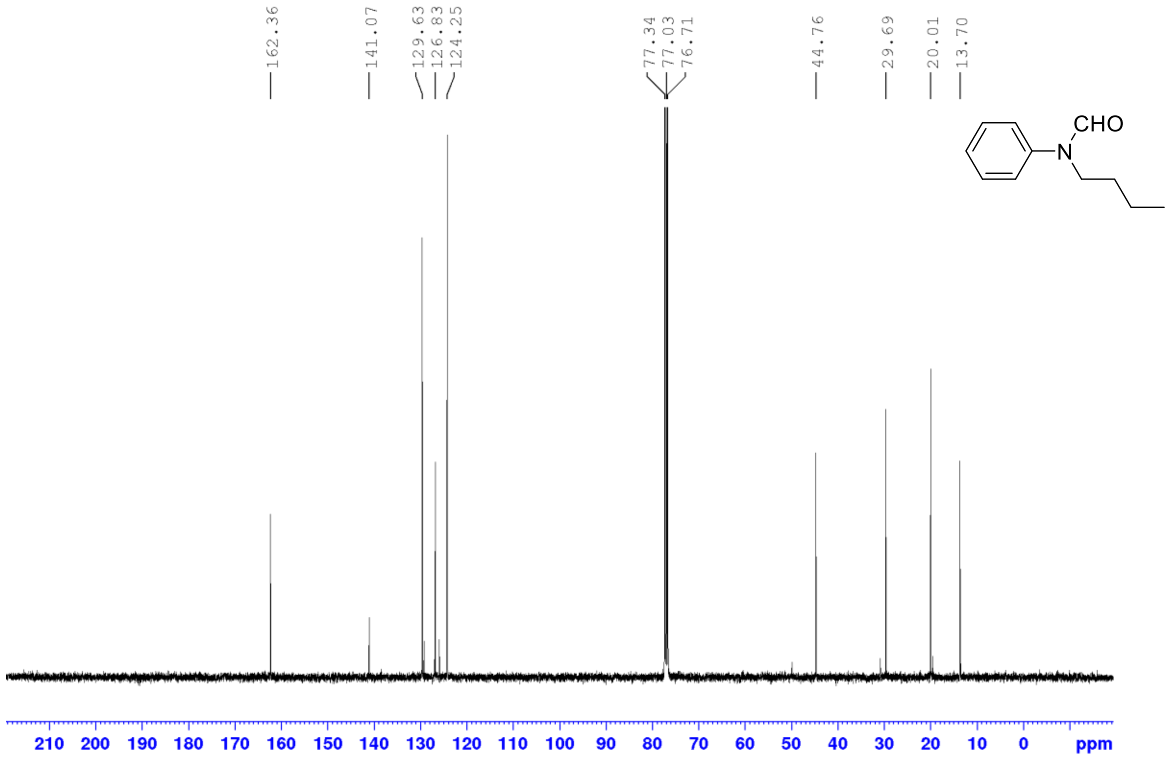
^{1}H NMR of **7a**. (400 MHz, $CDCl_3$)



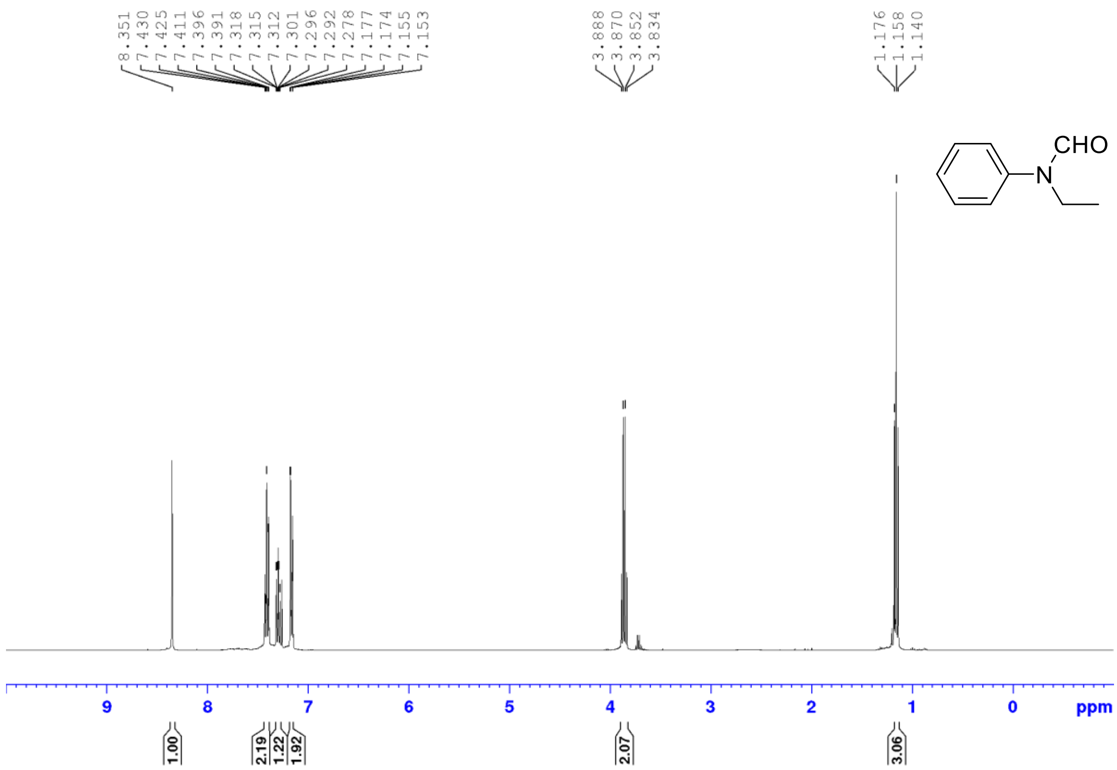
^{13}C {^{1}H} NMR of **7a**. (100 MHz, $CDCl_3$)



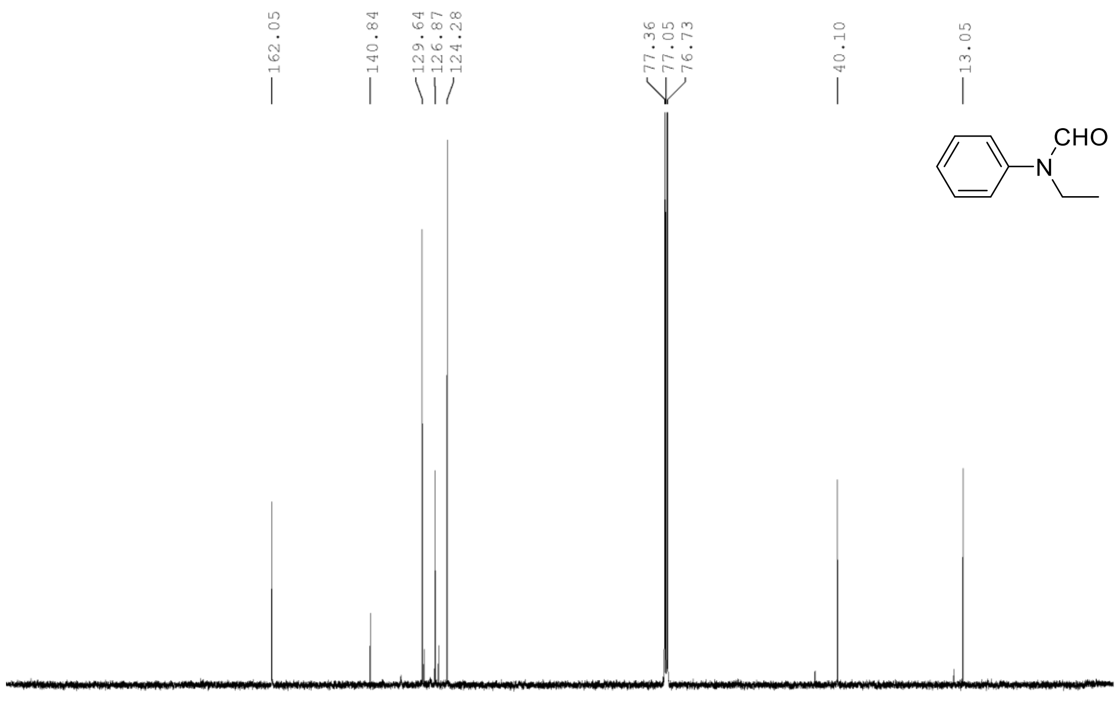
^{1}H NMR of **8a**. (400 MHz, $CDCl_3$)



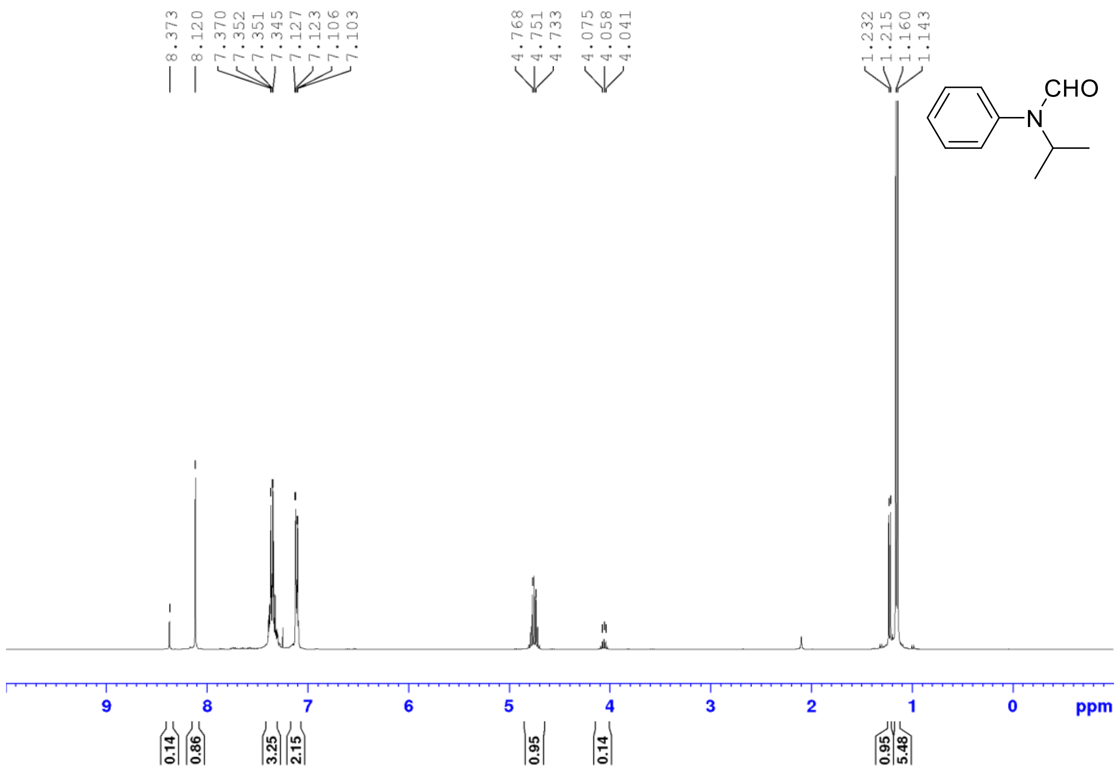
^{13}C {^{1}H} NMR of **8a**. (100 MHz, $CDCl_3$)



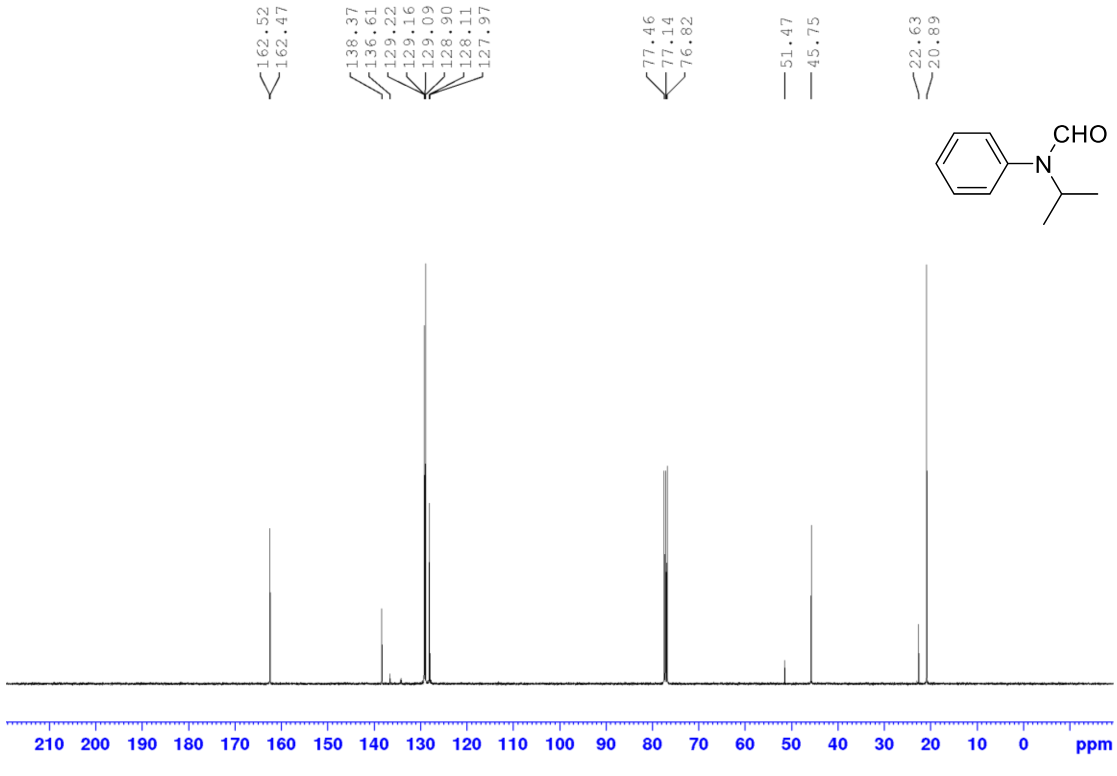
[1]H NMR of **9a**. (400 MHz, $CDCl_3$)



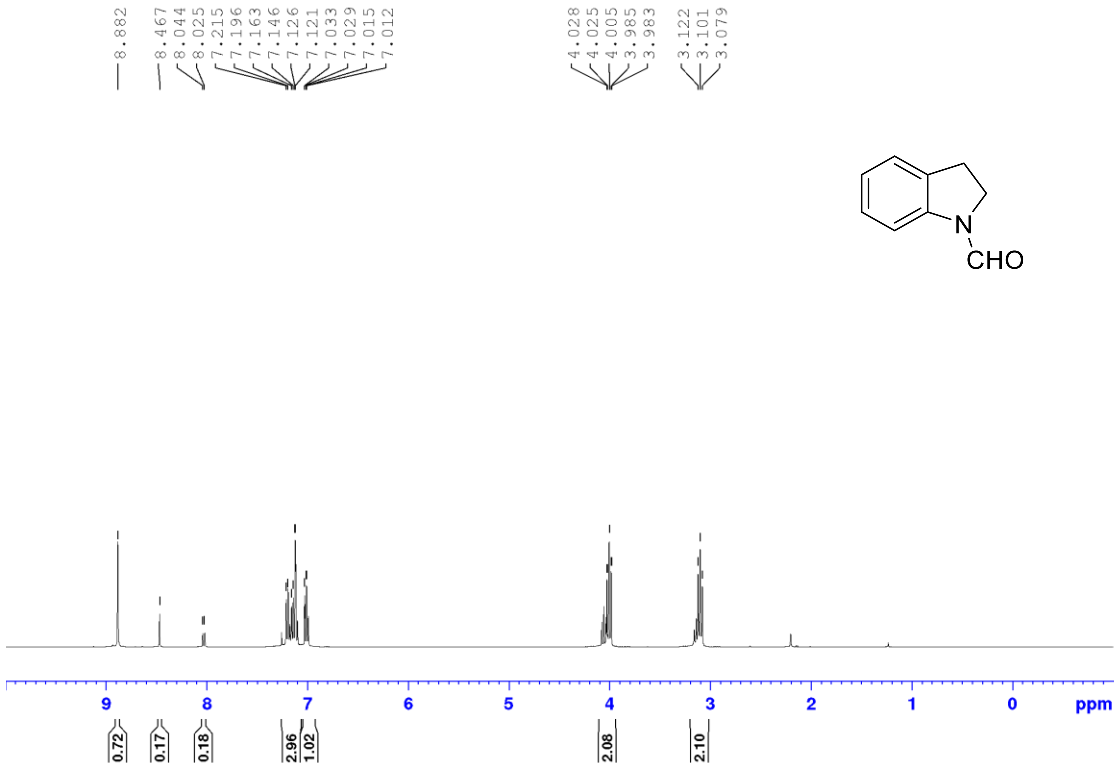
[13]C {[1]H} NMR of **9a**. (100 MHz, $CDCl_3$)



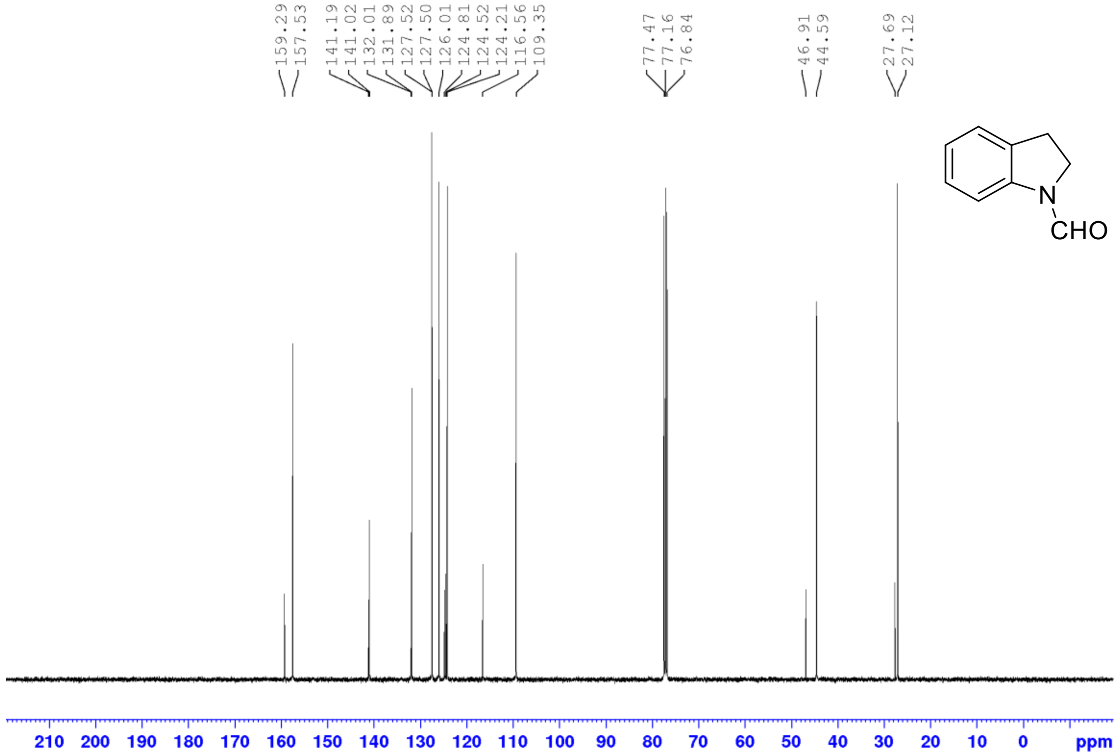
^{1}H NMR of **10a**. (400 MHz, $CDCl_3$)



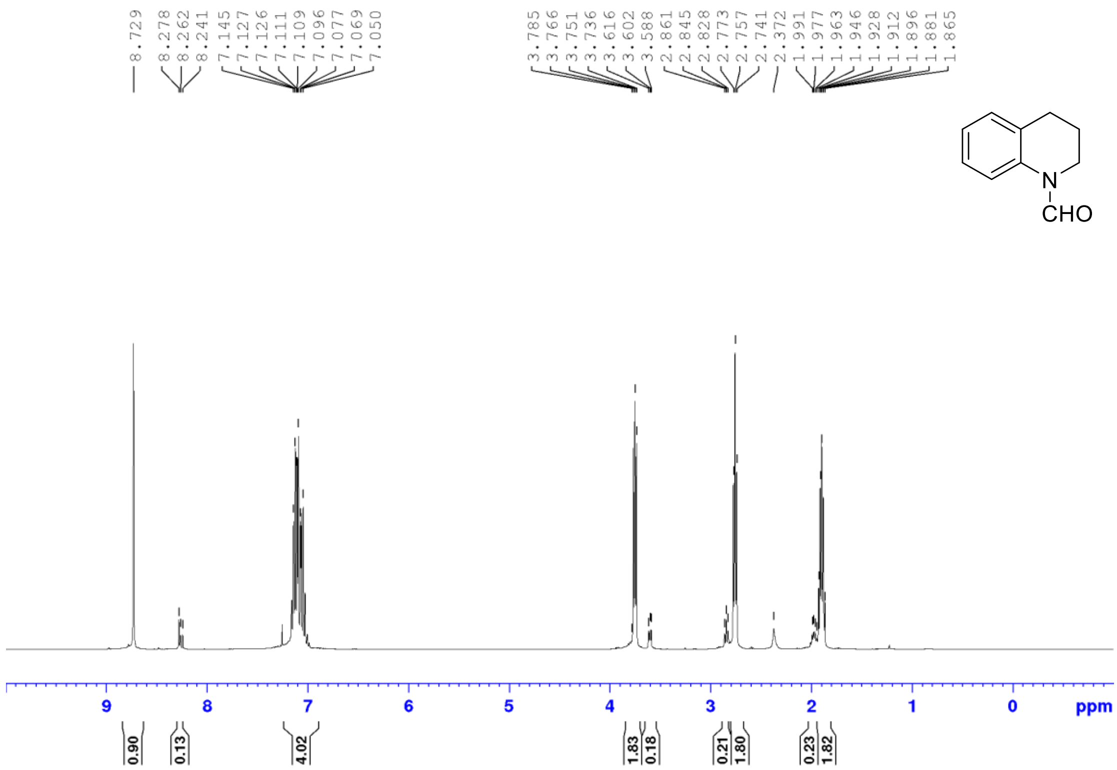
^{13}C {^{1}H} NMR of **10a**. (100 MHz, $CDCl_3$)



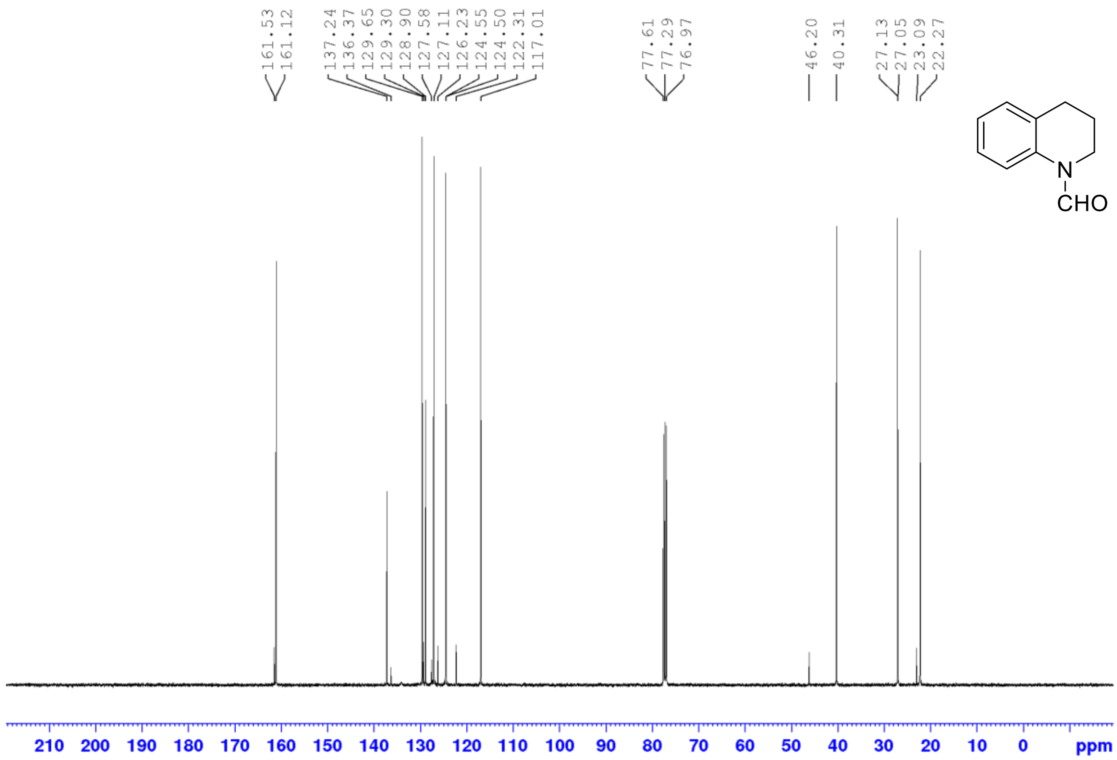
^{1}H NMR of **11a**. (400 MHz, $CDCl_3$)



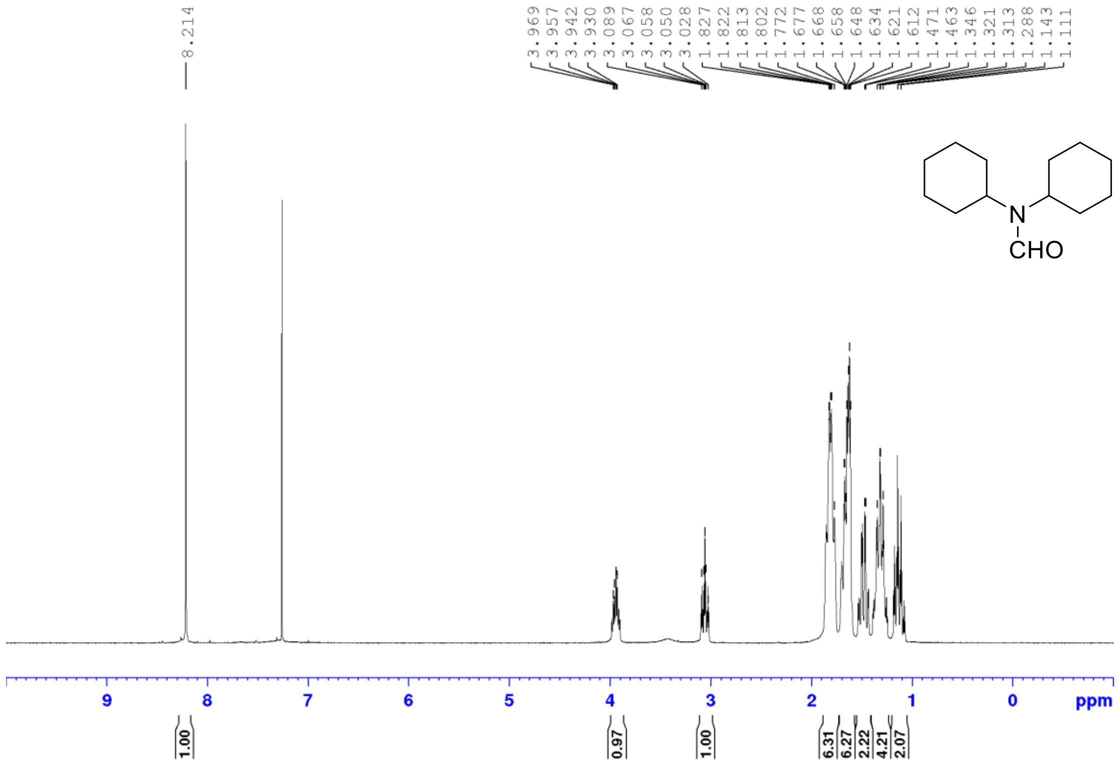
^{13}C {^{1}H} NMR of **11a**. (100 MHz, $CDCl_3$)



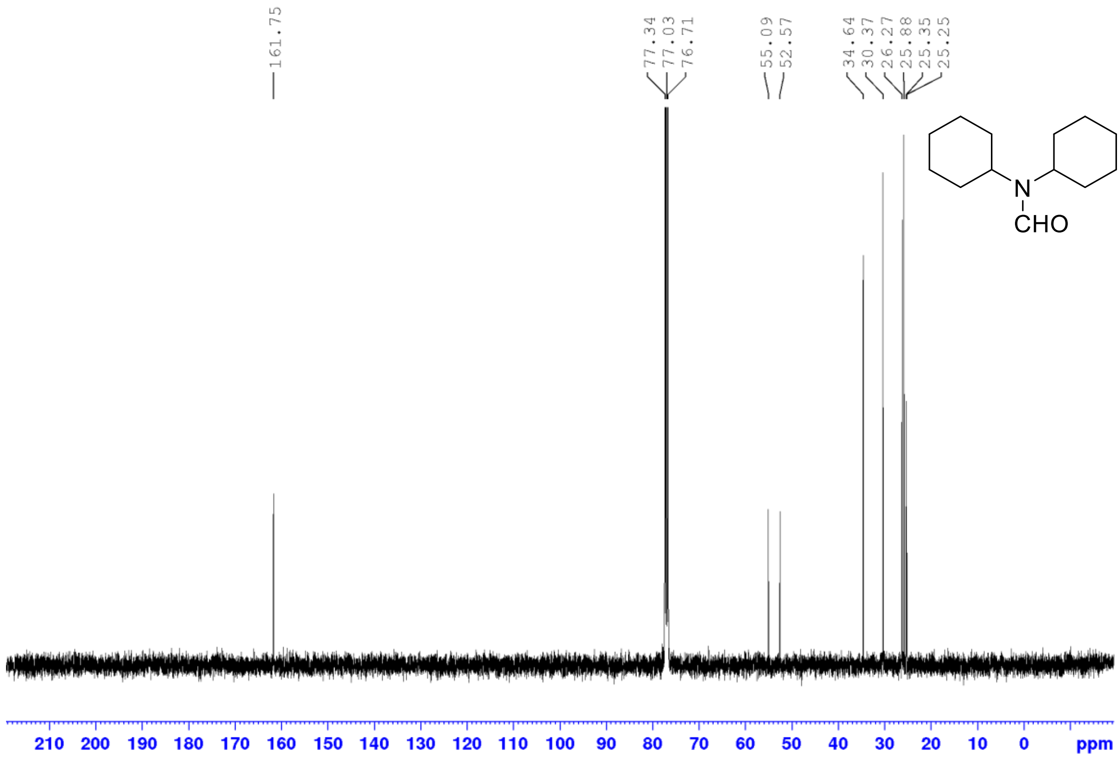
[1]H NMR of **12a**. (400 MHz, $CDCl_3$)



[13]C {[1]H} NMR of **12a**. (100 MHz, $CDCl_3$)



^{1}H NMR of **13a**. (400 MHz, $CDCl_3$)



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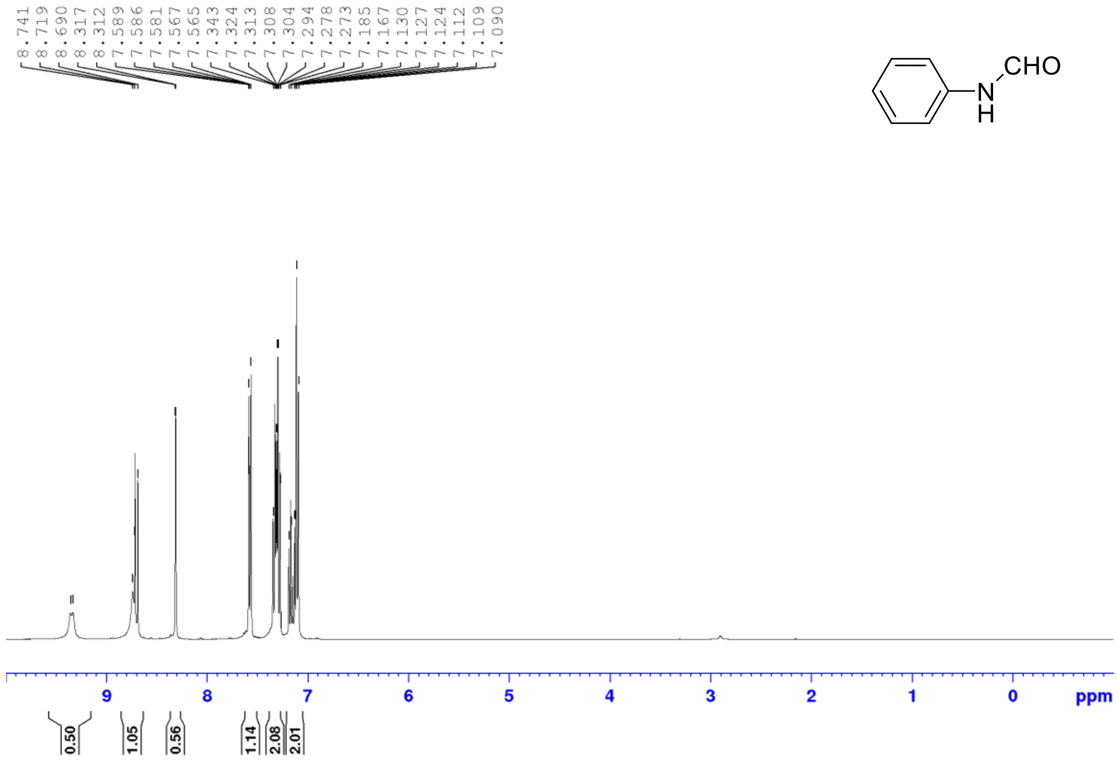
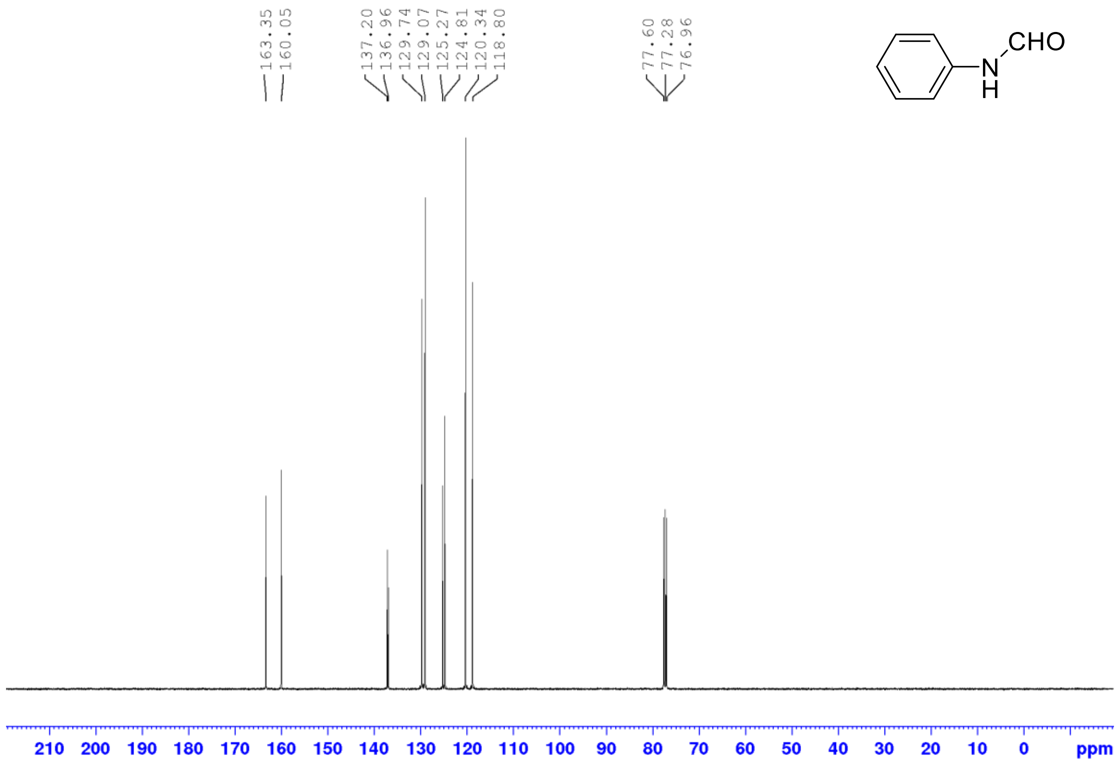
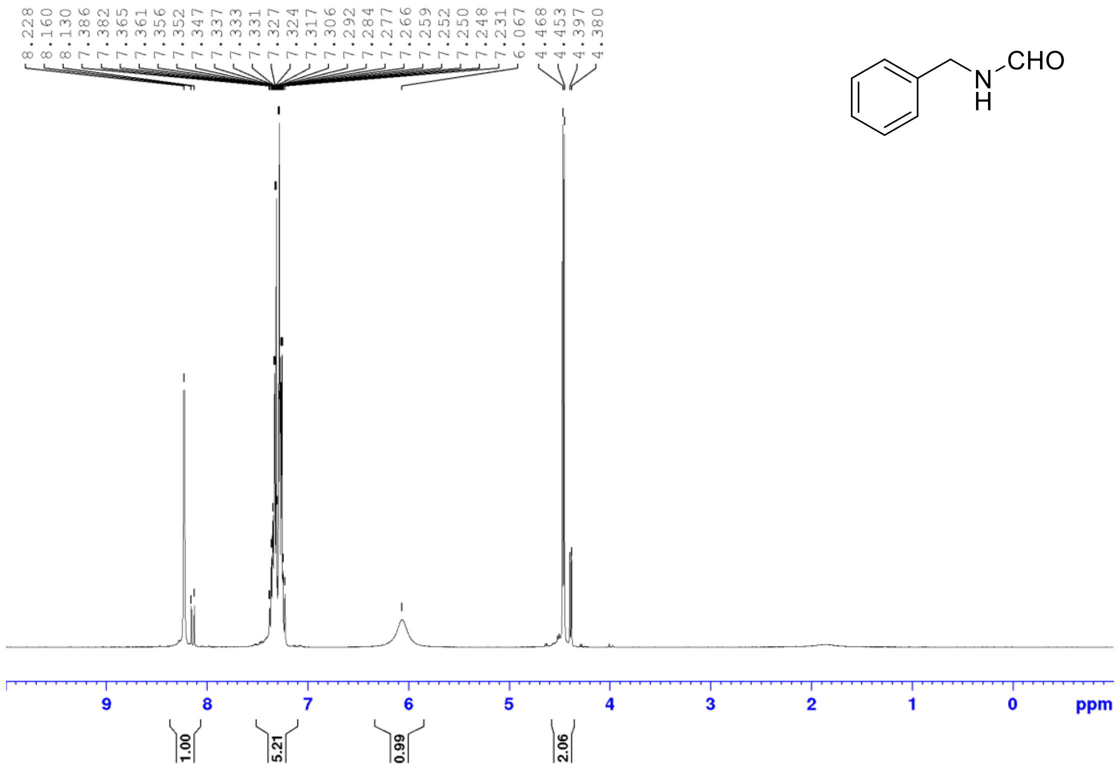


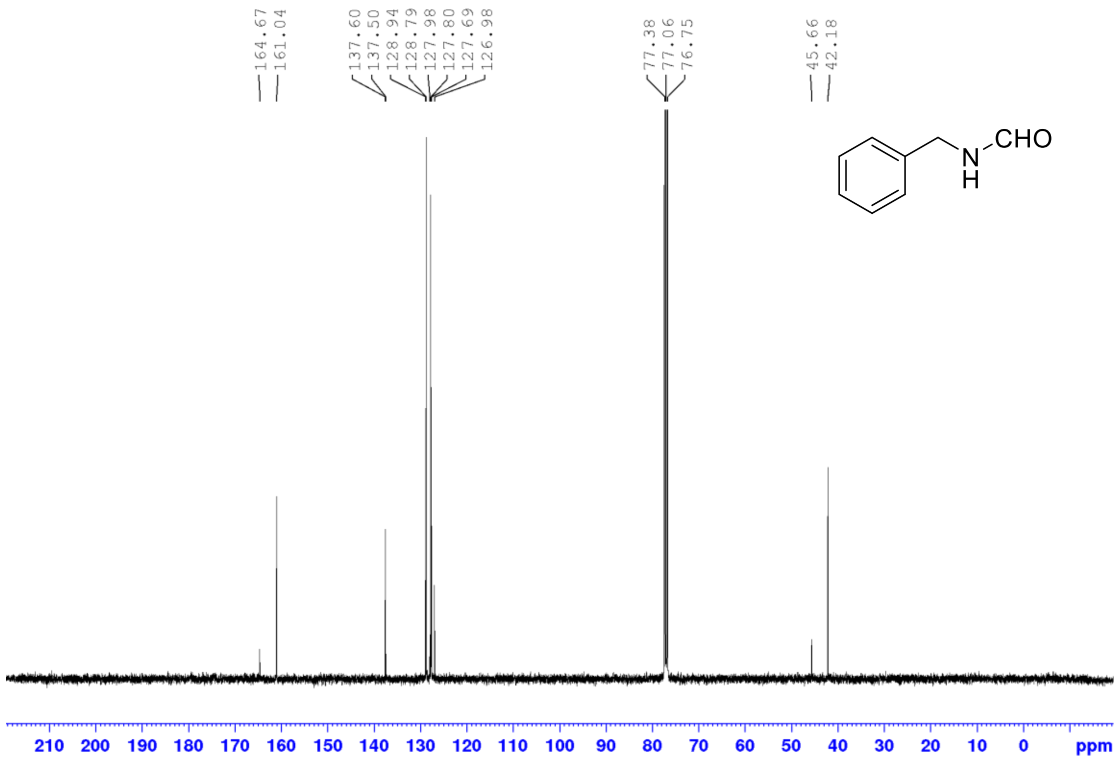
^{1}H NMR of **1b**. (400 MHz, $CDCl_3$)



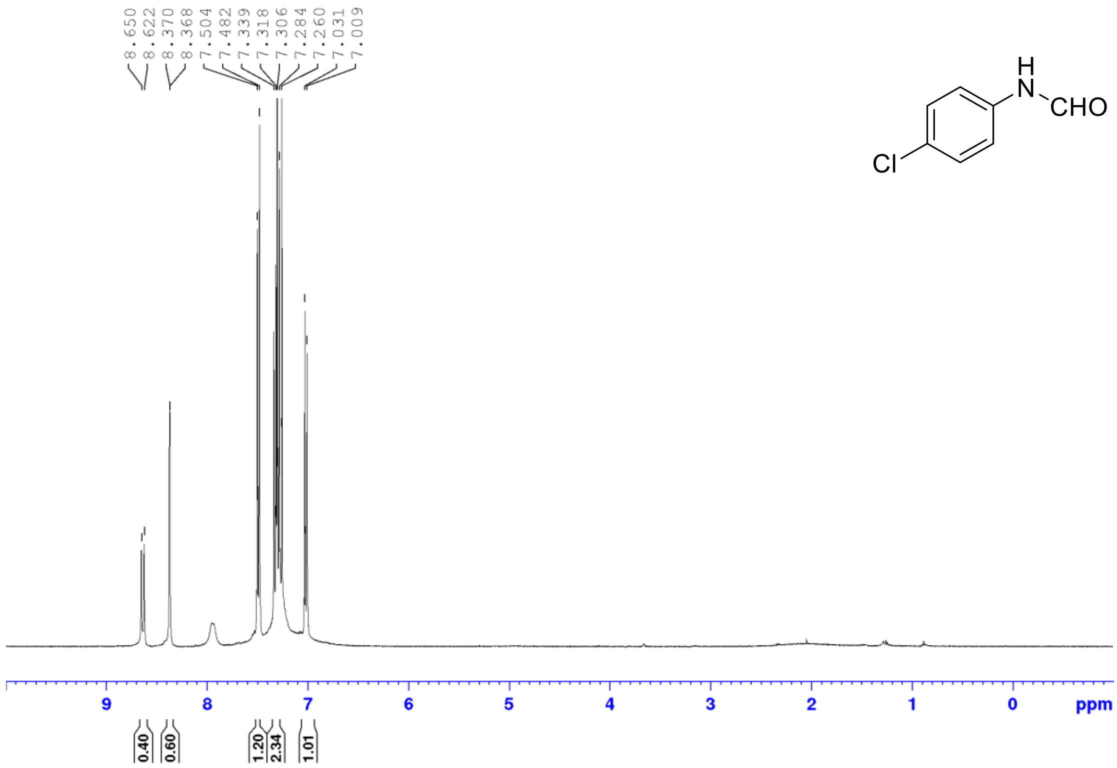
^{13}C {^{1}H} NMR of **1b**. (100 MHz, $CDCl_3$)



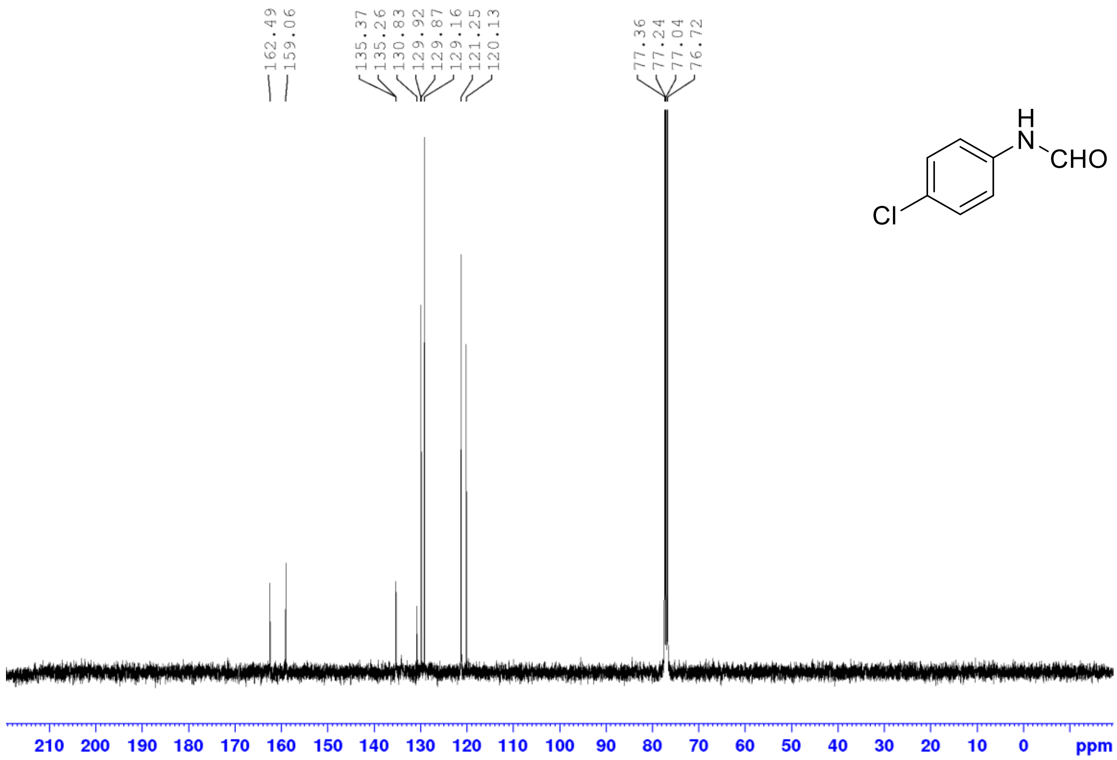
^{1}H NMR of **2b**. (400 MHz, $CDCl_3$)



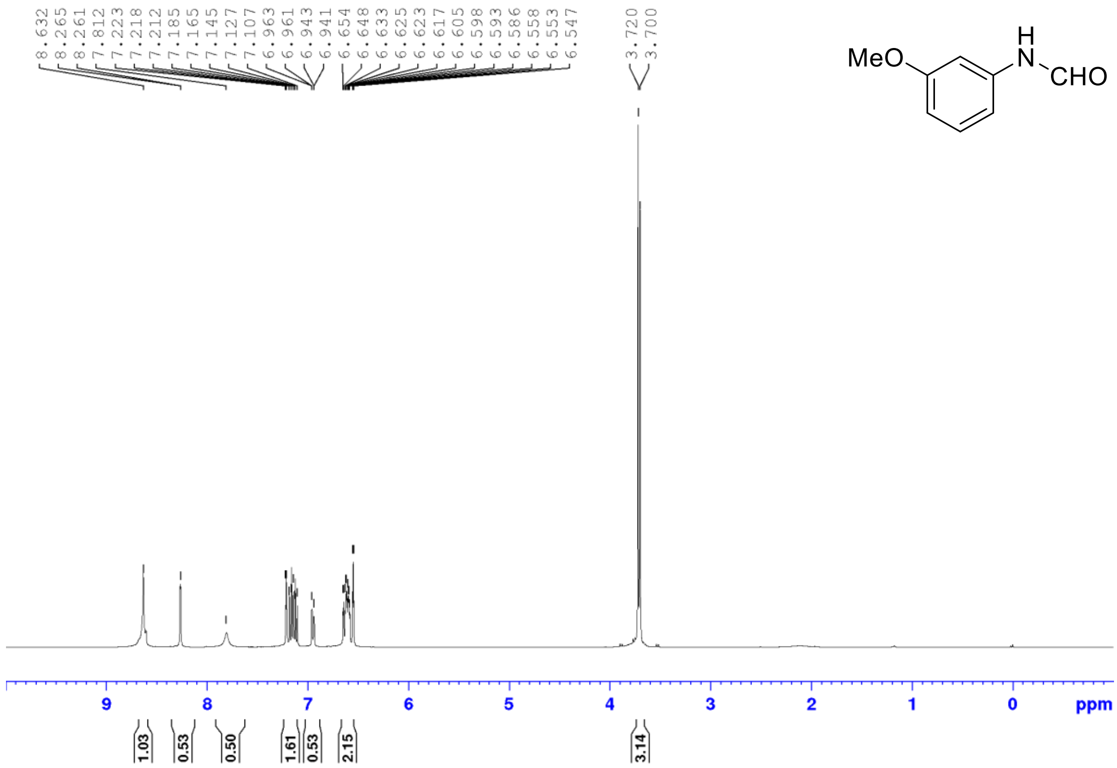
^{13}C {^{1}H} NMR of **2b**. (100 MHz, $CDCl_3$)



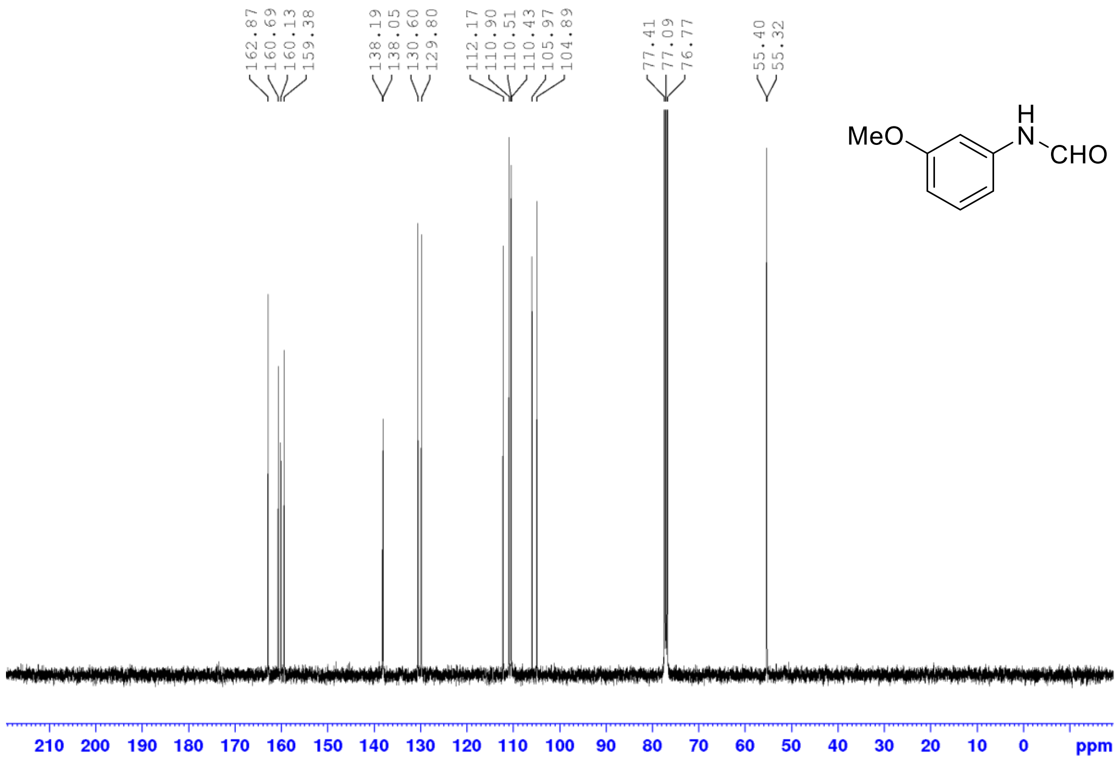
^{1}H NMR of **3b**. (400 MHz, $CDCl_3$)



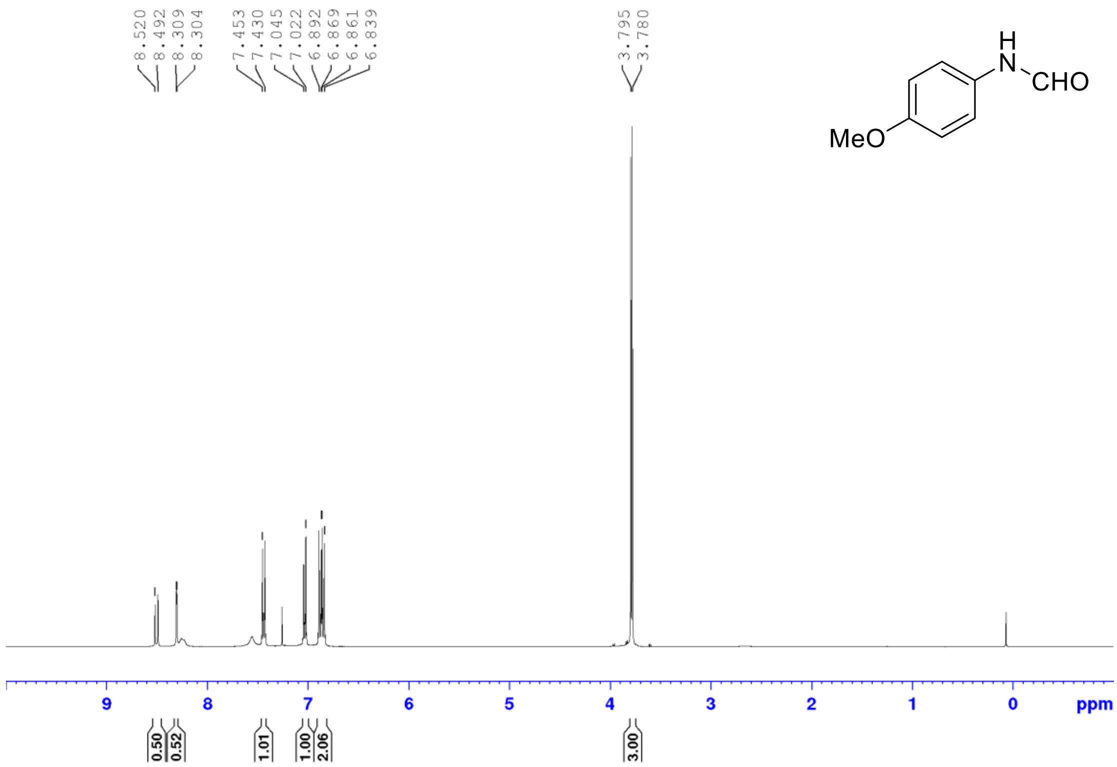
^{13}C {^{1}H} NMR of **3b**. (100 MHz, $CDCl_3$)



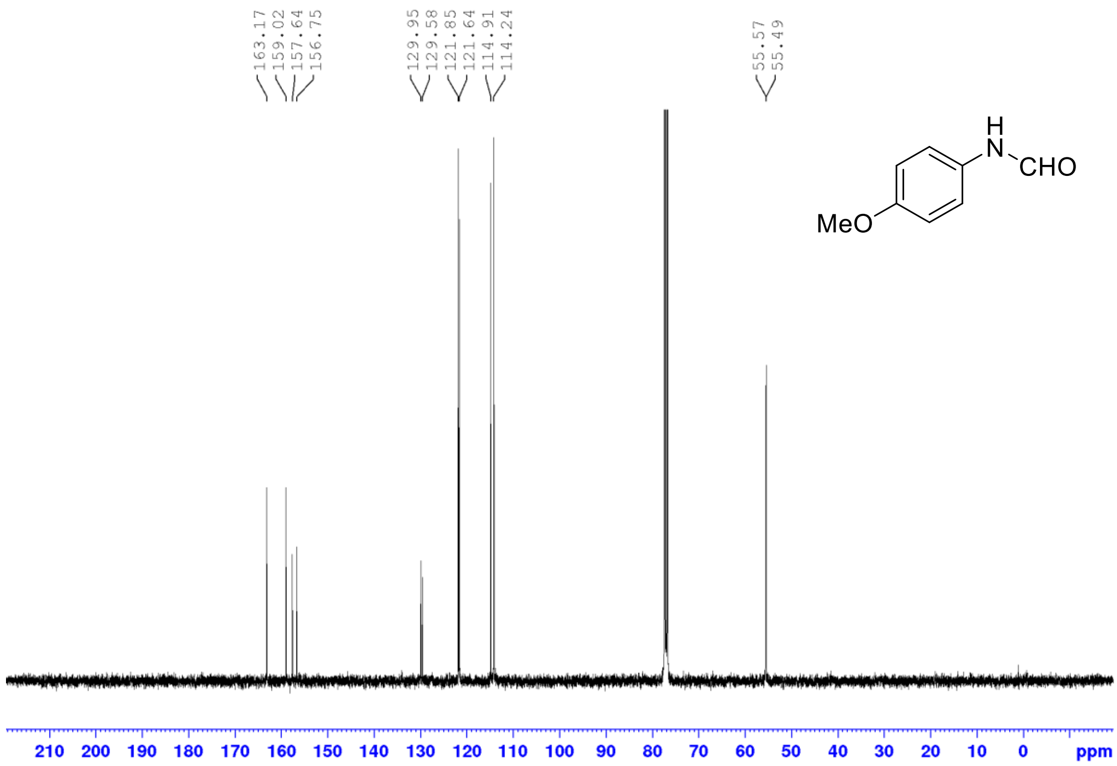
[1]H NMR of **4b**. (400 MHz, $CDCl_3$)



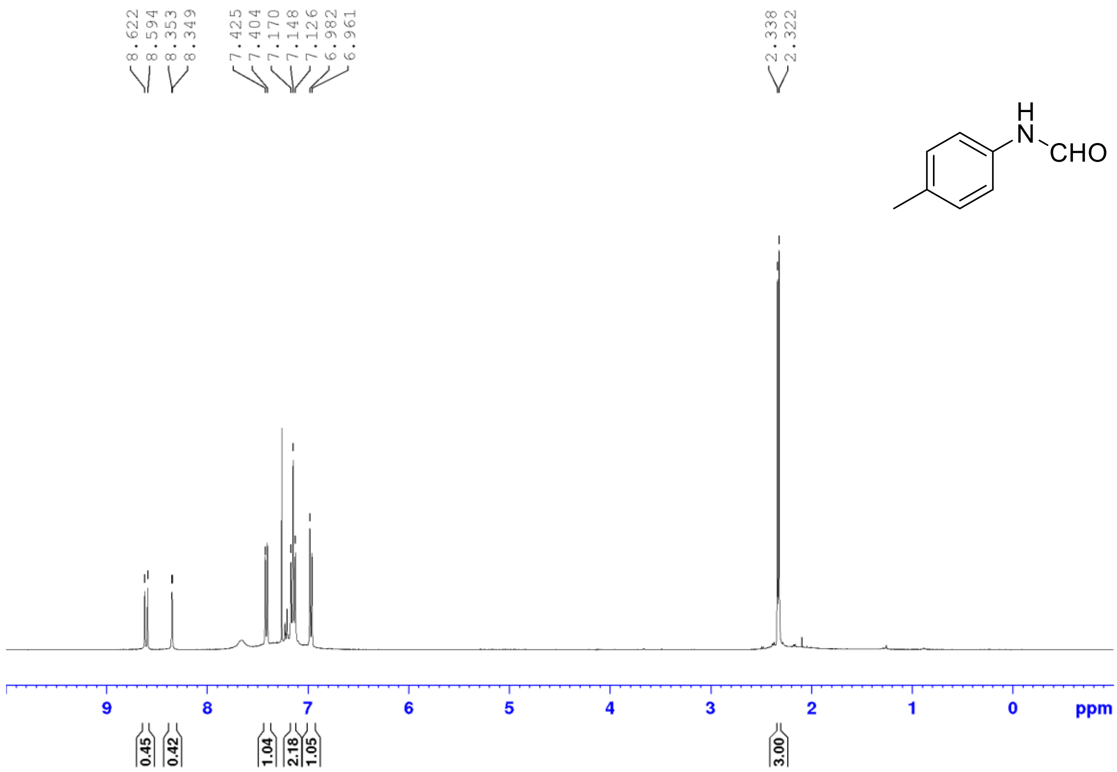
[13]C {[1]H} NMR of **4b**. (100 MHz, $CDCl_3$)



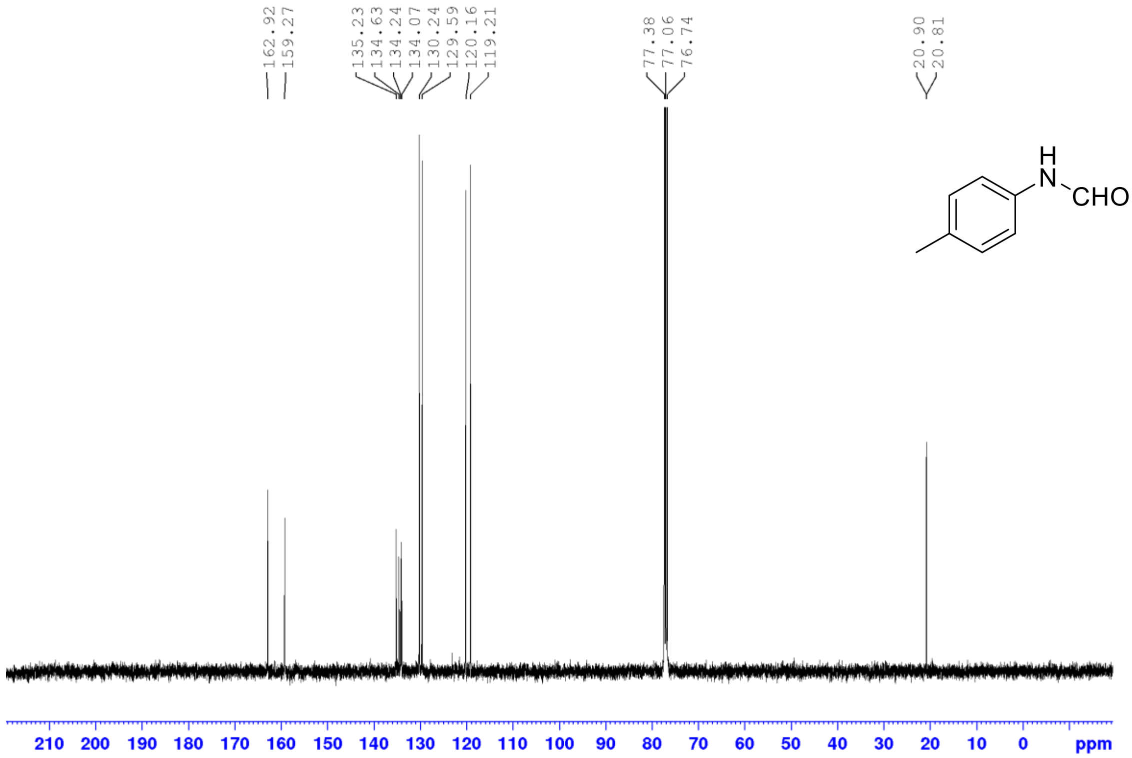
^{1}H NMR of **5b**. (400 MHz, $CDCl_3$)



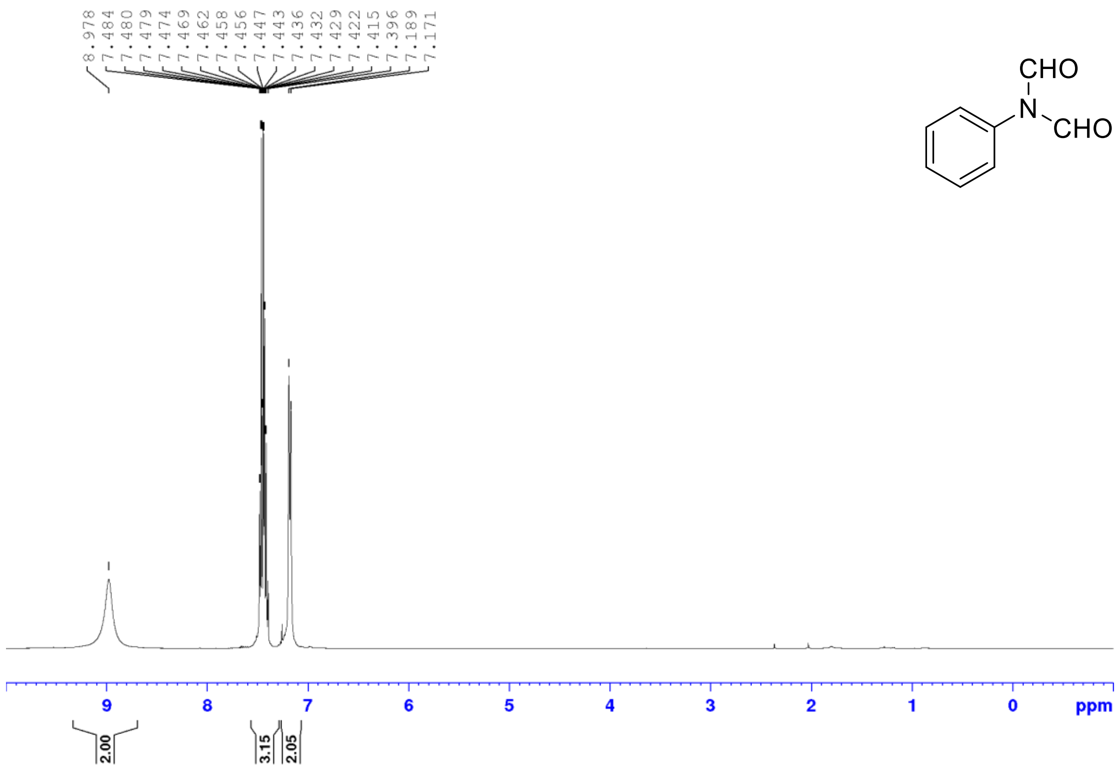
^{13}C {^{1}H} NMR of **5b**. (100 MHz, $CDCl_3$)



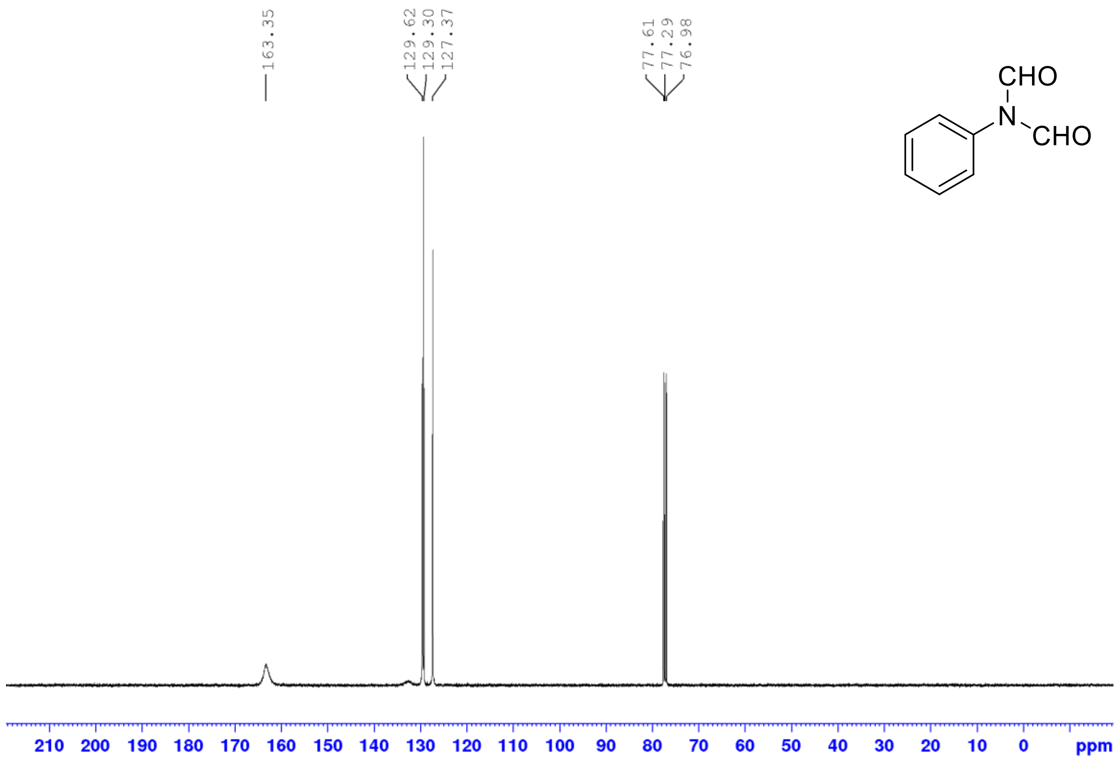
[1]H NMR of **6b**. (400 MHz, $CDCl_3$)



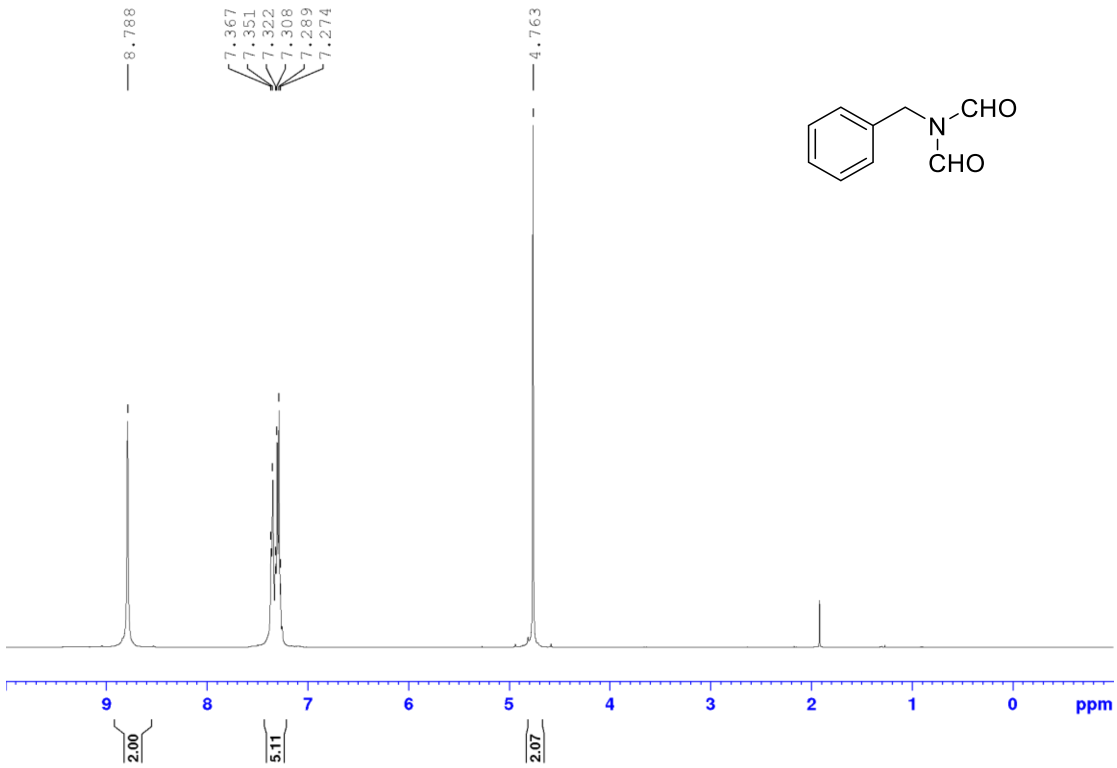
[13]C {[1]H} NMR of **6b**. (100 MHz, $CDCl_3$)



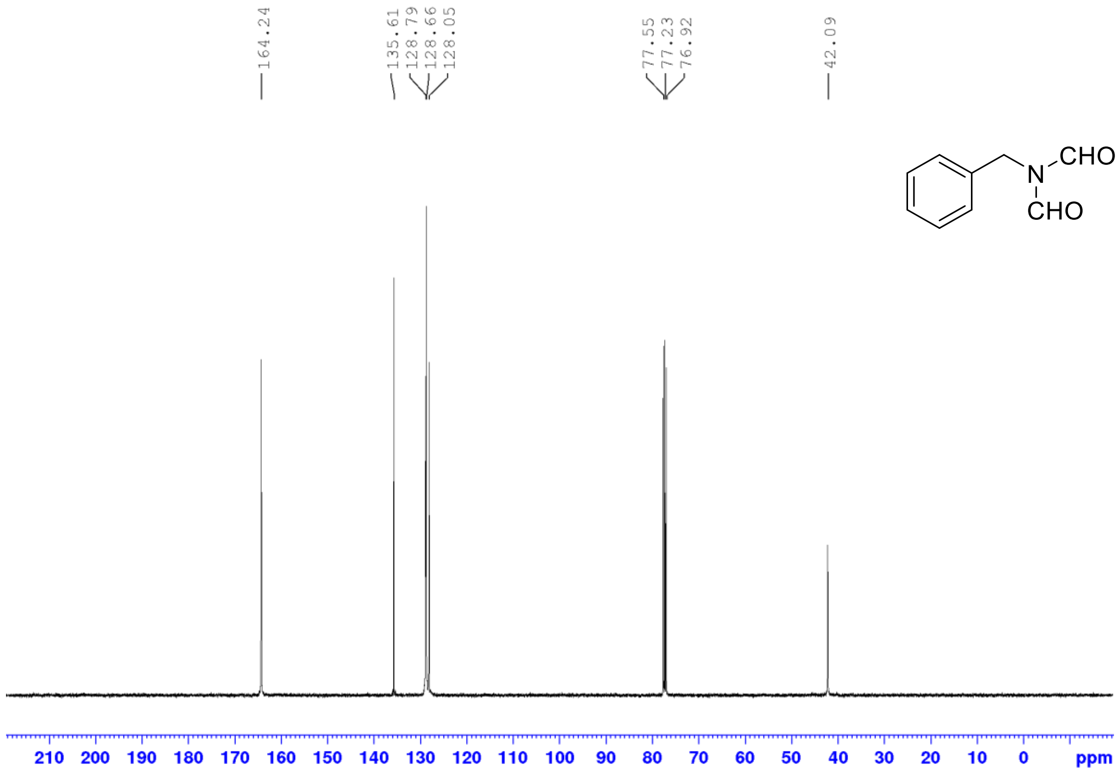
^{1}H NMR of **1c**. (400 MHz, $CDCl_3$)



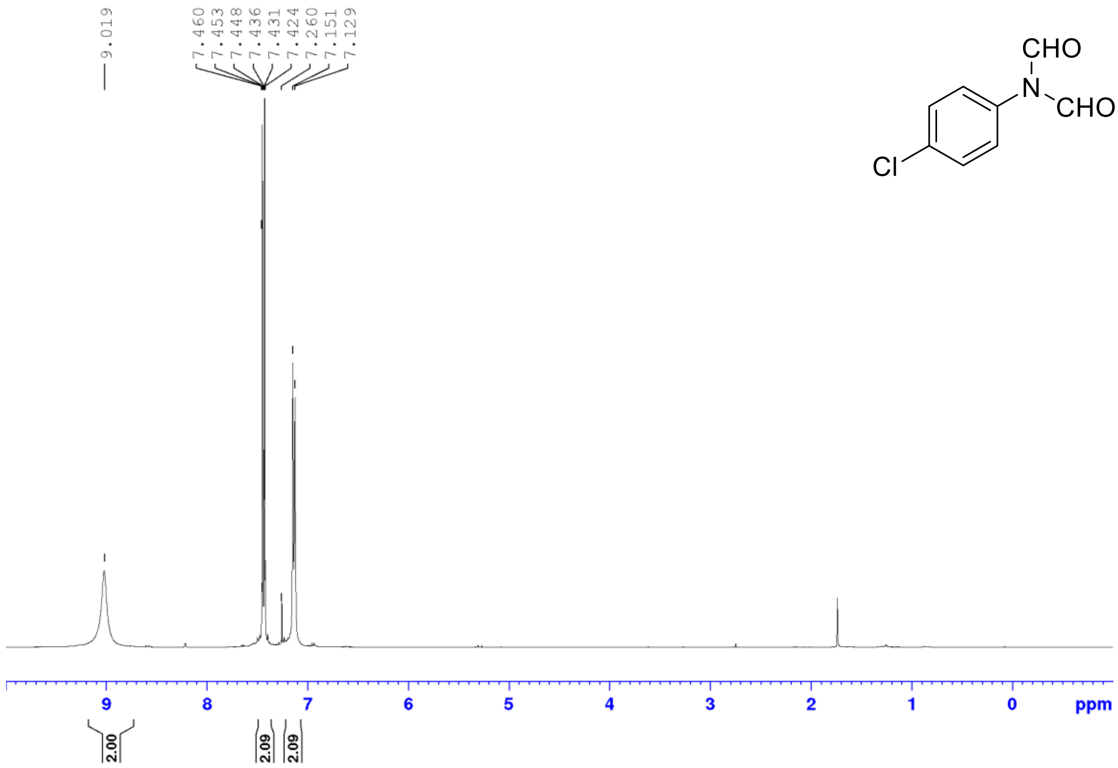
^{13}C {^{1}H} NMR of **1c**. (100 MHz, $CDCl_3$)



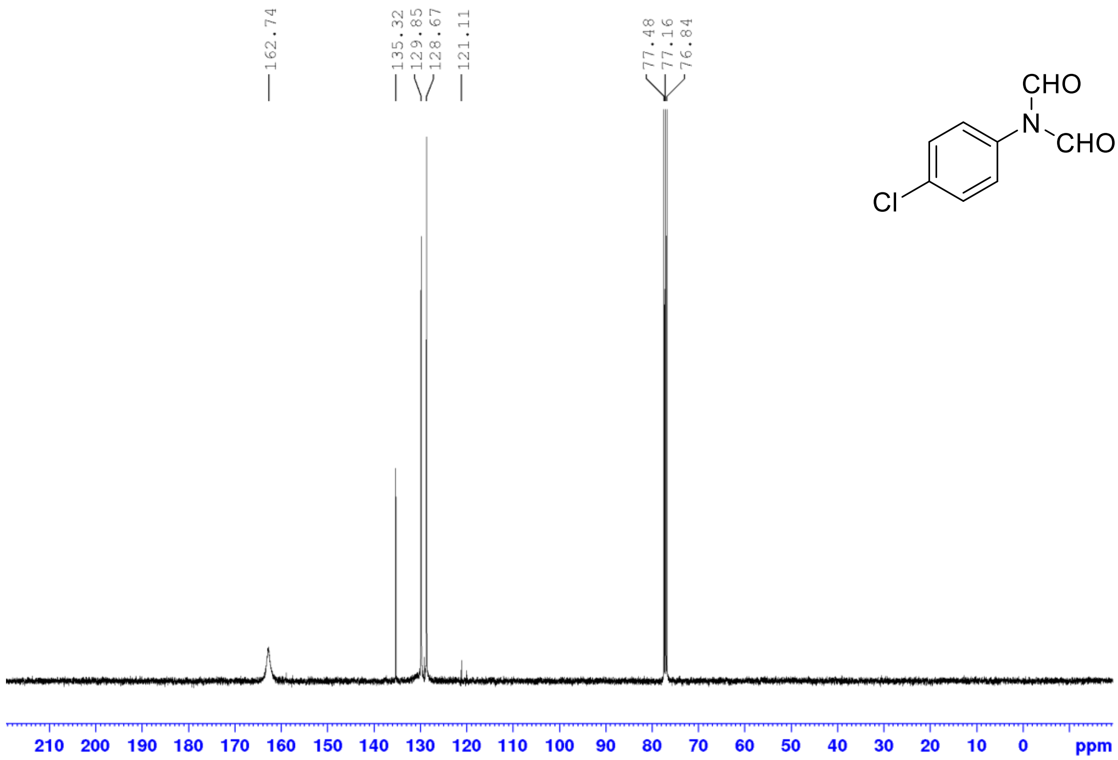
^{1}H NMR of **2c**. (400 MHz, $CDCl_3$)



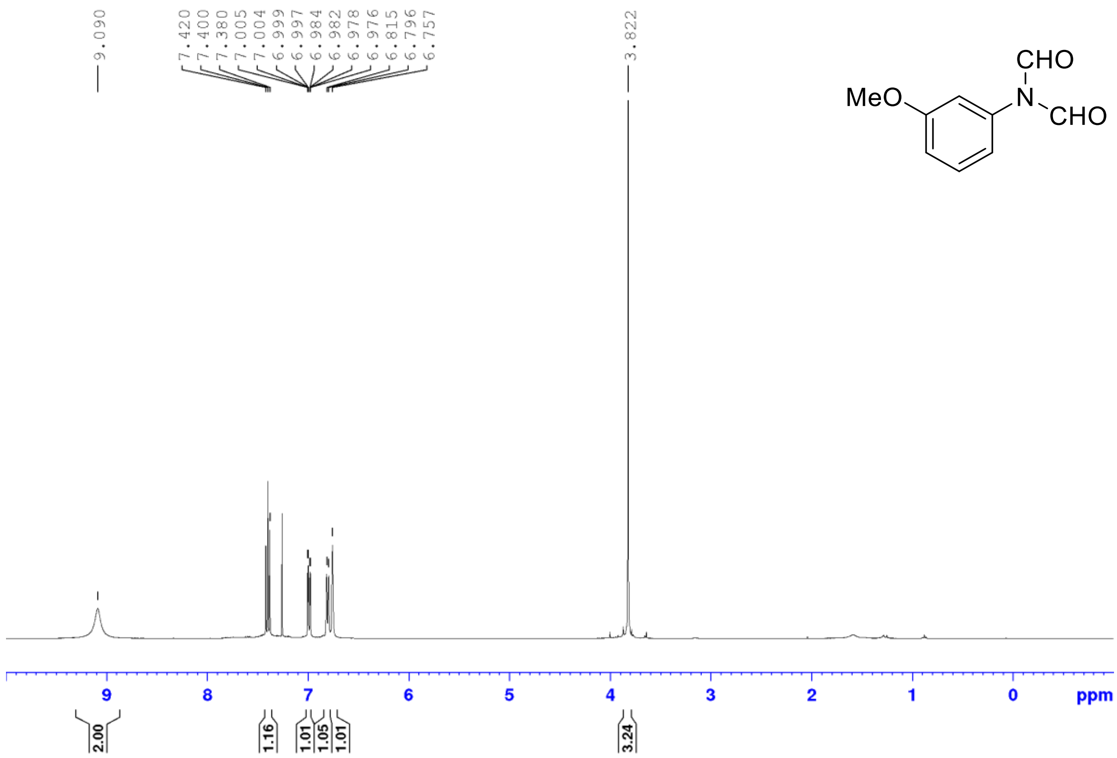
^{13}C {^{1}H} NMR of **2c**. (100 MHz, $CDCl_3$)



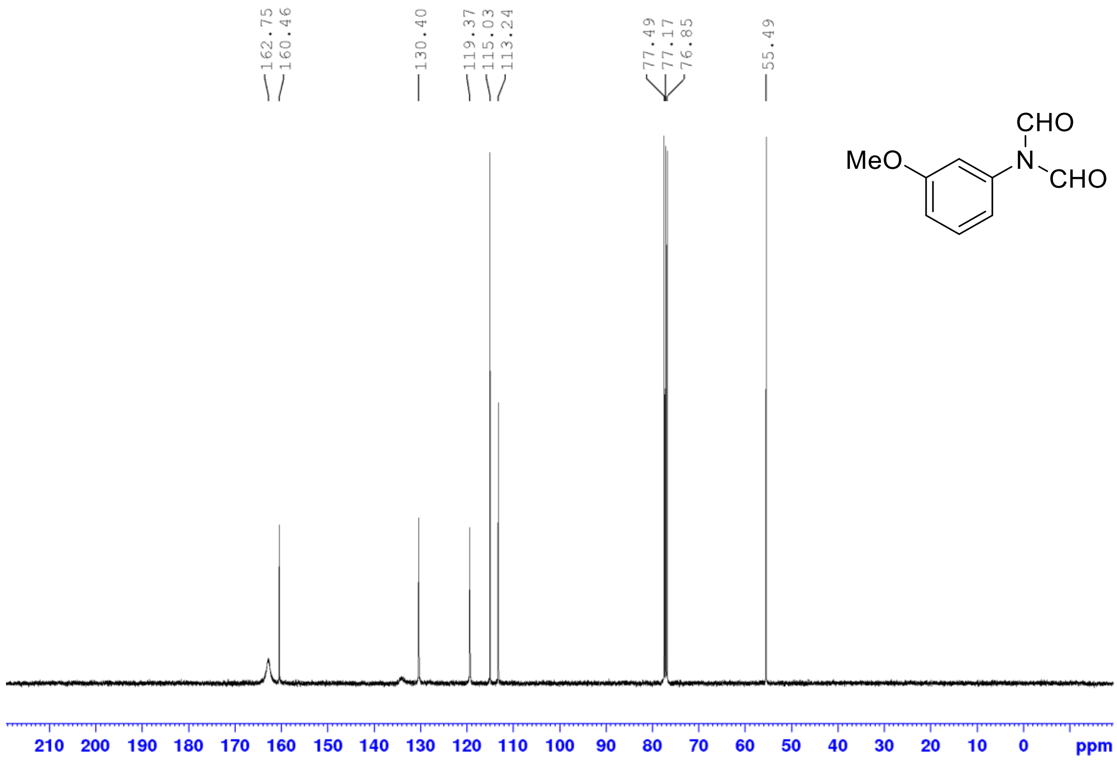
^{1}H NMR of **3c**. (400 MHz, $CDCl_3$)



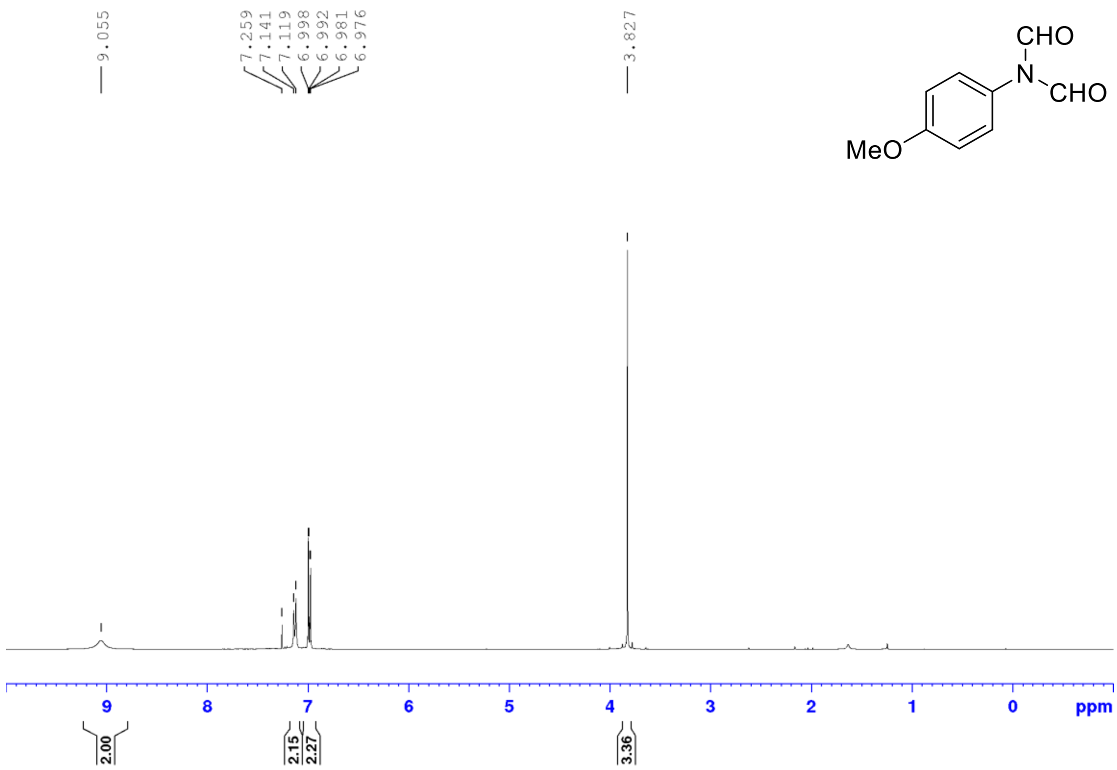
^{13}C {^{1}H} NMR of **3c**. (100 MHz, $CDCl_3$)



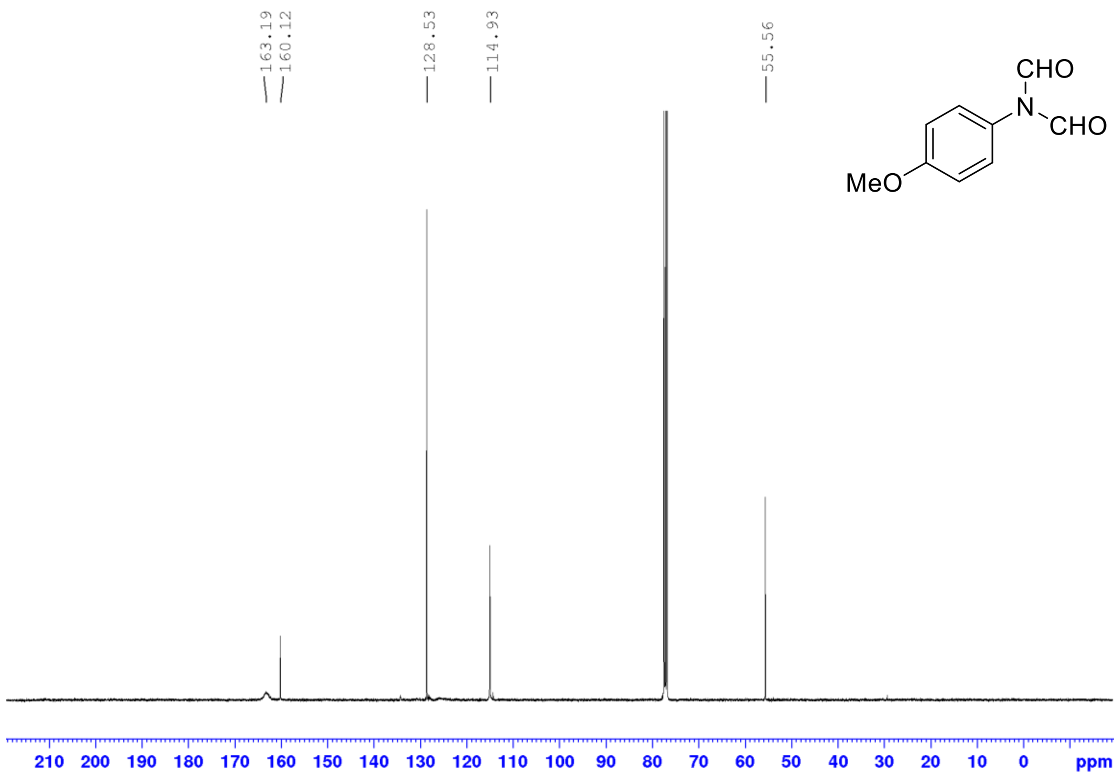
[1]H NMR of **4c**. (400 MHz, $CDCl_3$)



[13]C {[1]H} NMR of **4c**. (100 MHz, $CDCl_3$)

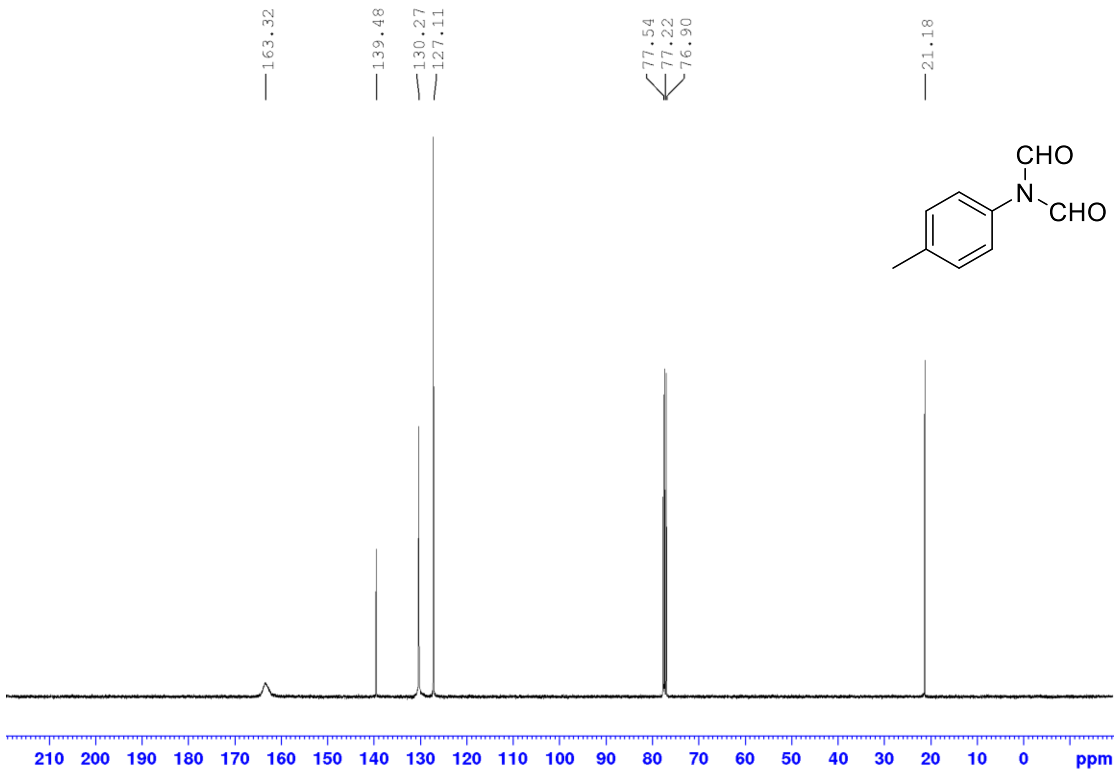


^{1}H NMR of **5c**. (400 MHz, $CDCl_3$)

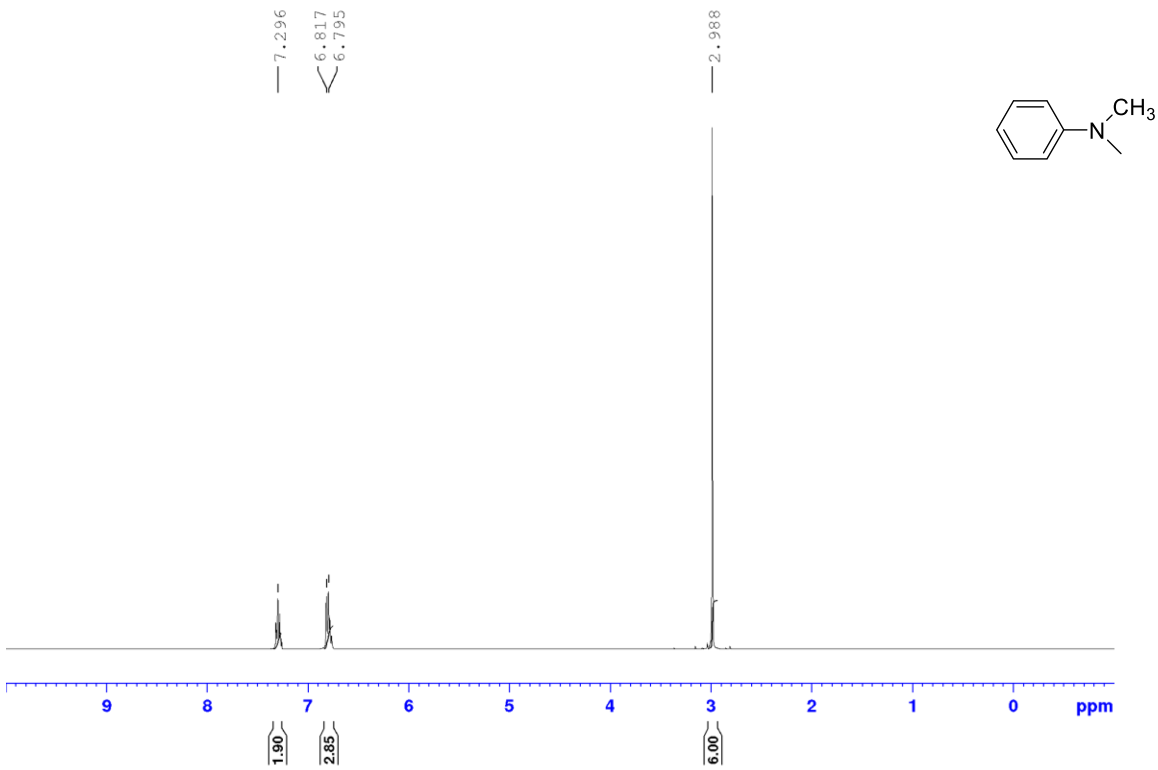


^{13}C {^{1}H} NMR of **5c**. (100 MHz, $CDCl_3$)

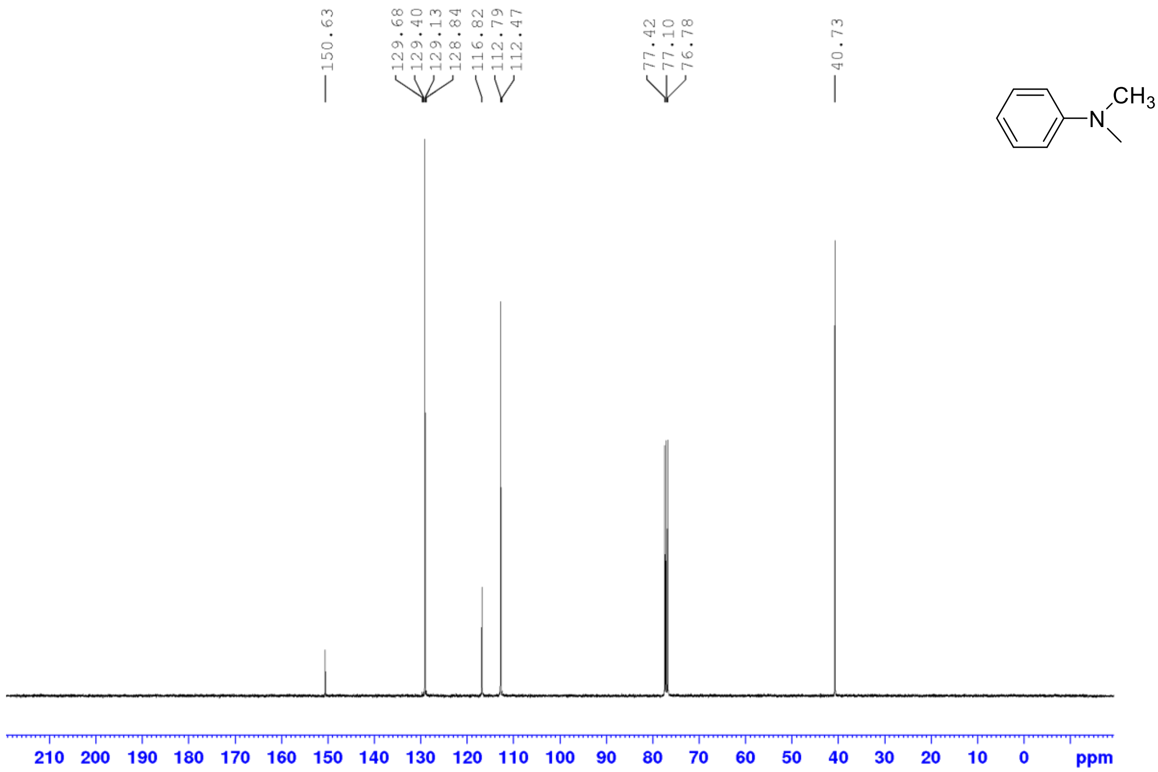
^{1}H NMR of **6c**. (400 MHz, $CDCl_3$)



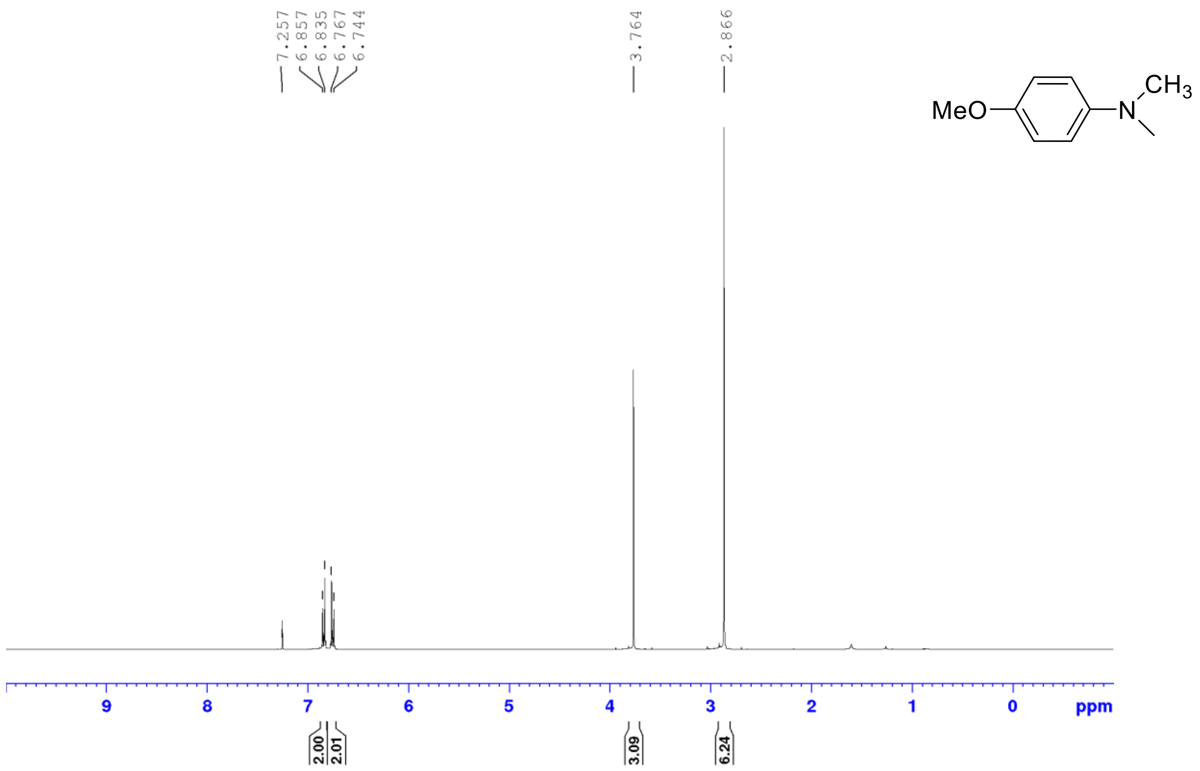
^{13}C {^{1}H} NMR of **6c**. (100 MHz, $CDCl_3$)



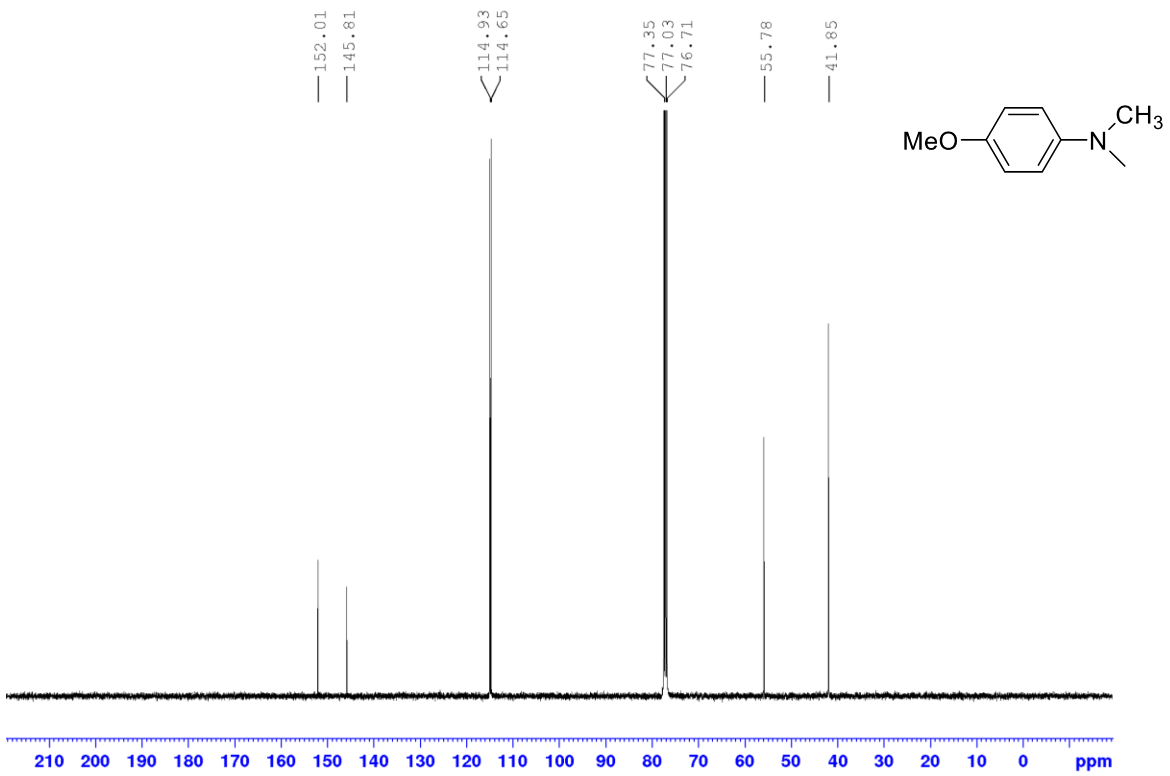
^{1}H NMR of **1d**. (400 MHz, $CDCl_3$)



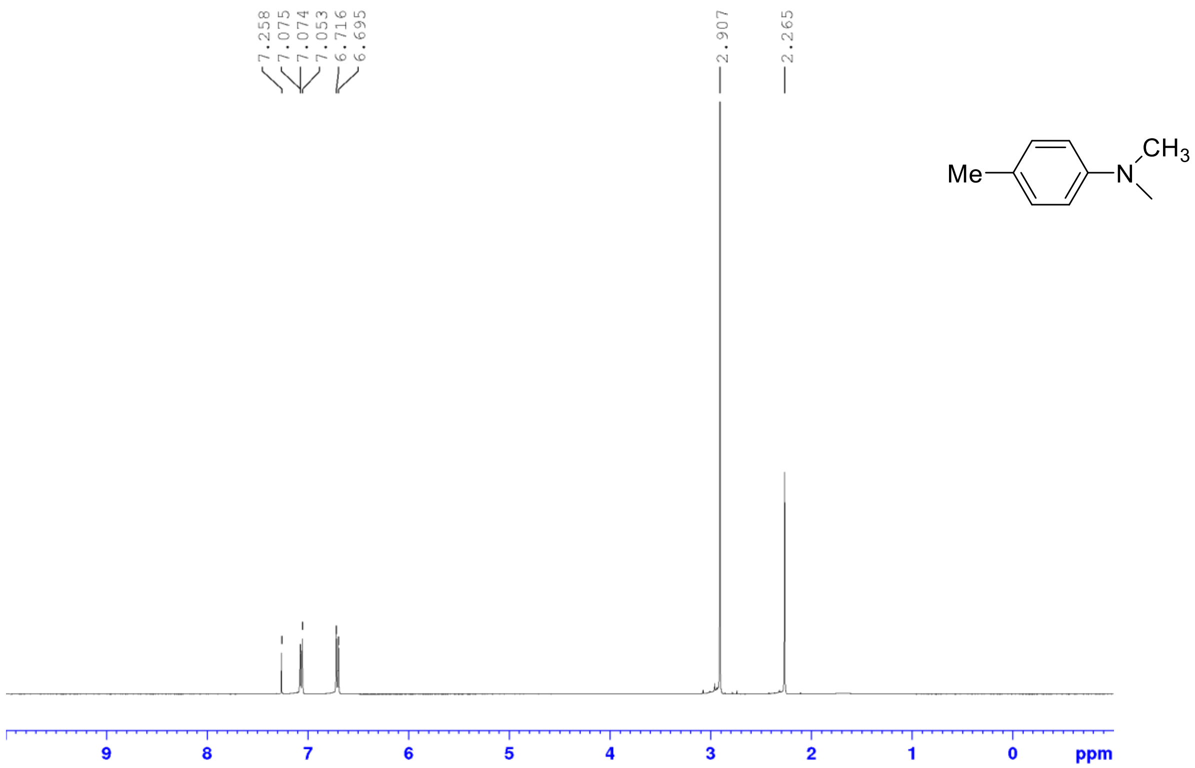
^{13}C {^{1}H} NMR of **1d**. (100 MHz, $CDCl_3$)



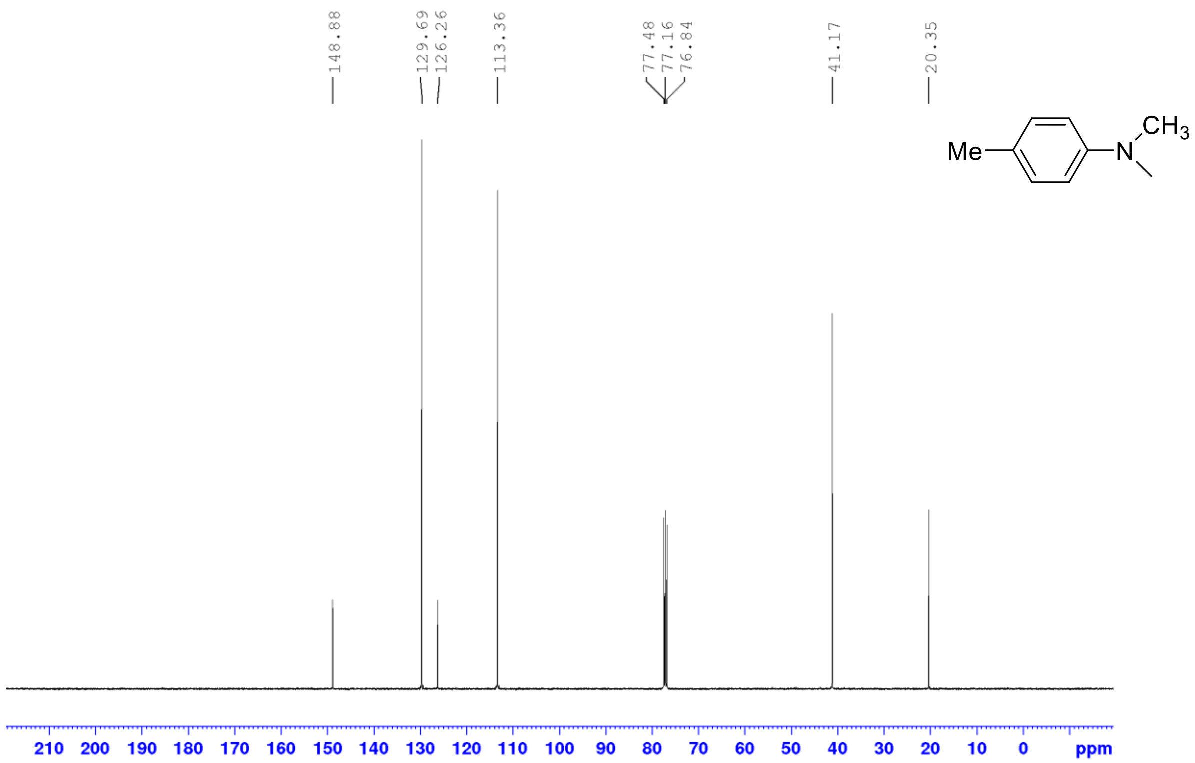
^{1}H NMR of **2d**. (400 MHz, $CDCl_3$)



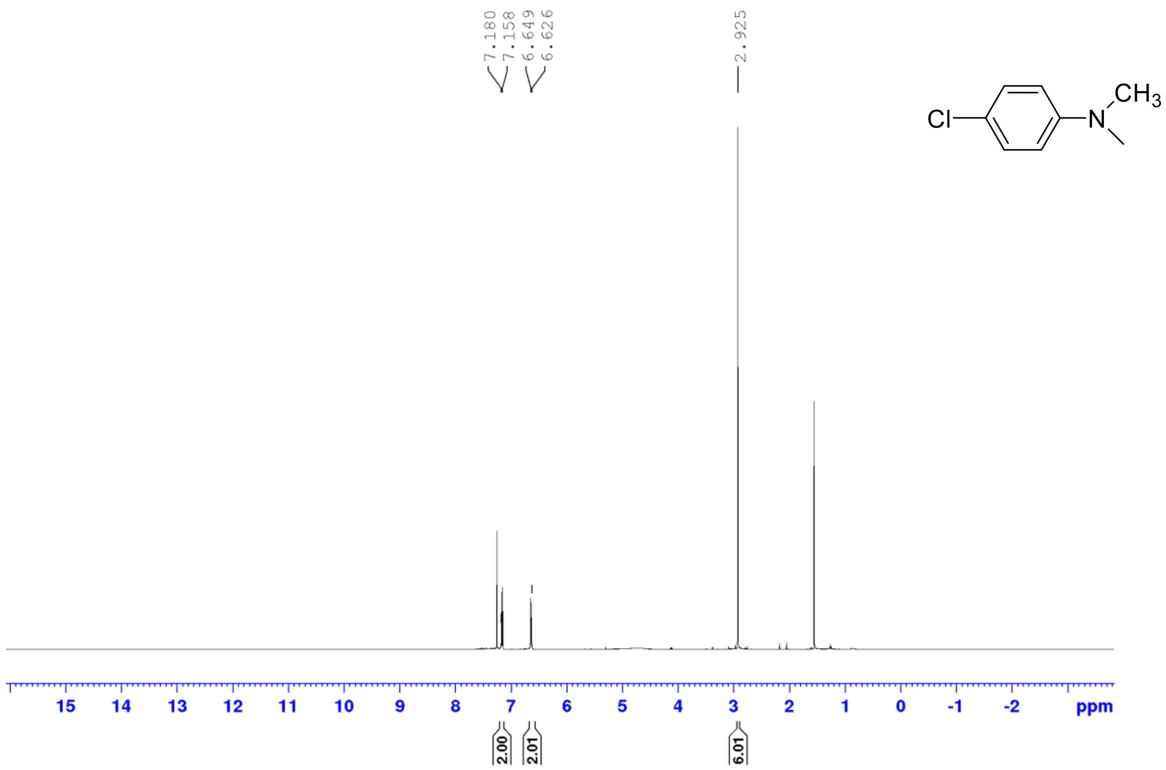
^{13}C {^{1}H} NMR of **2d**. (100 MHz, $CDCl_3$)



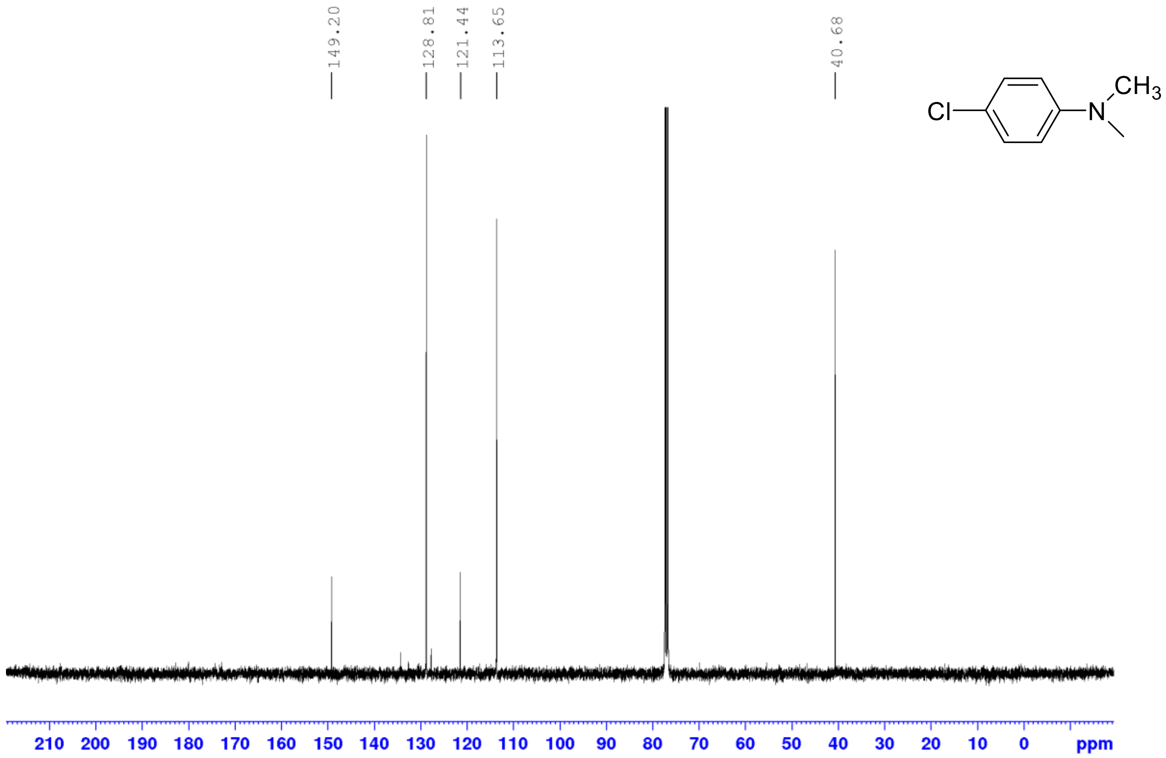
^{1}H NMR of **3d**. (400 MHz, $CDCl_3$)



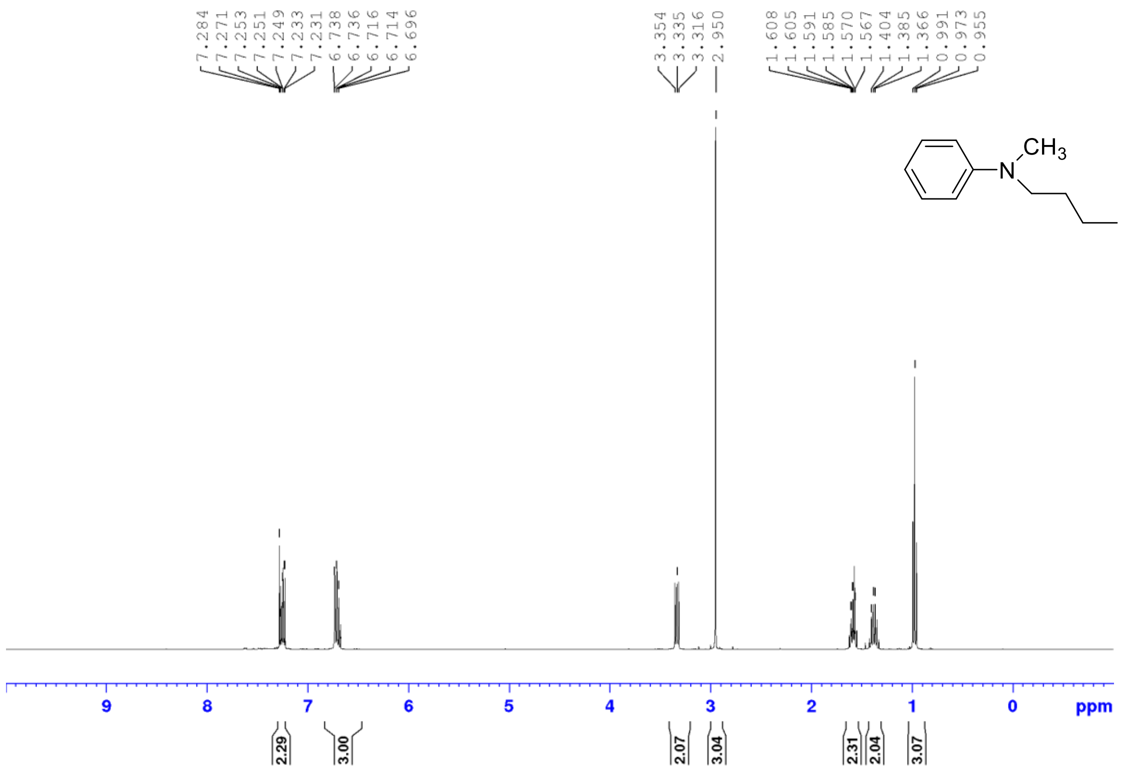
^{13}C {^{1}H} NMR of **3d**. (100 MHz, $CDCl_3$)



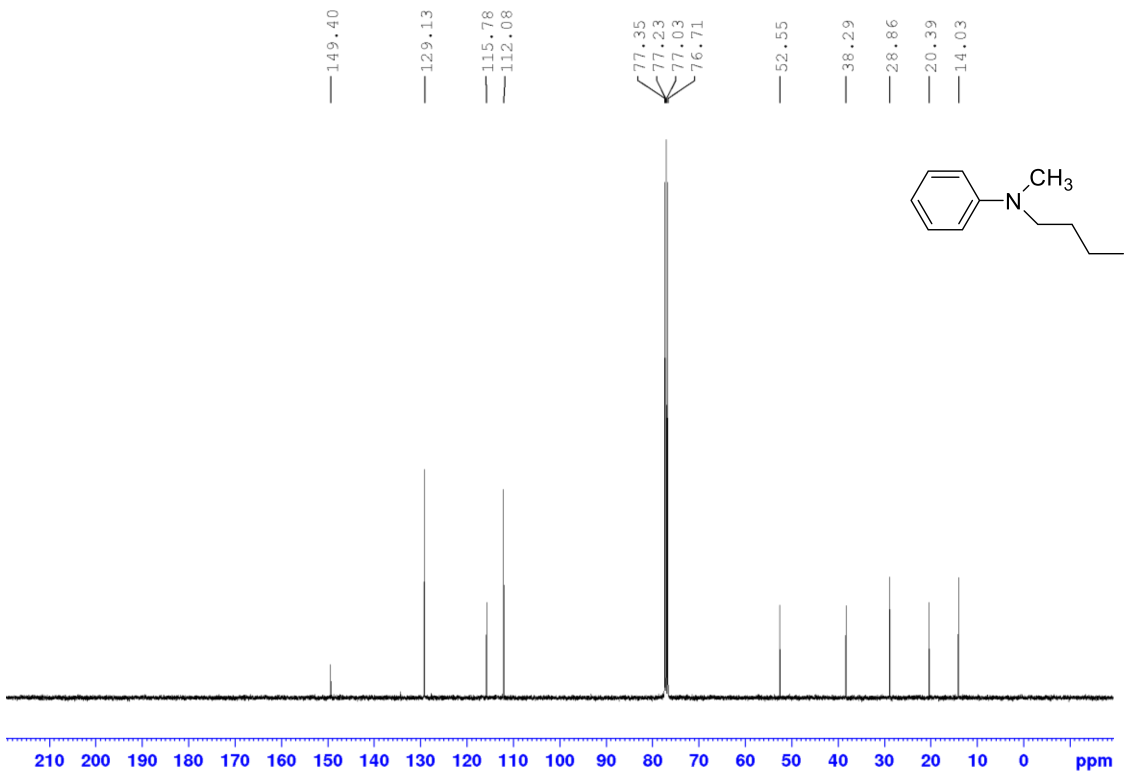
^{1}H NMR of **4d**. (400 MHz, $CDCl_3$)



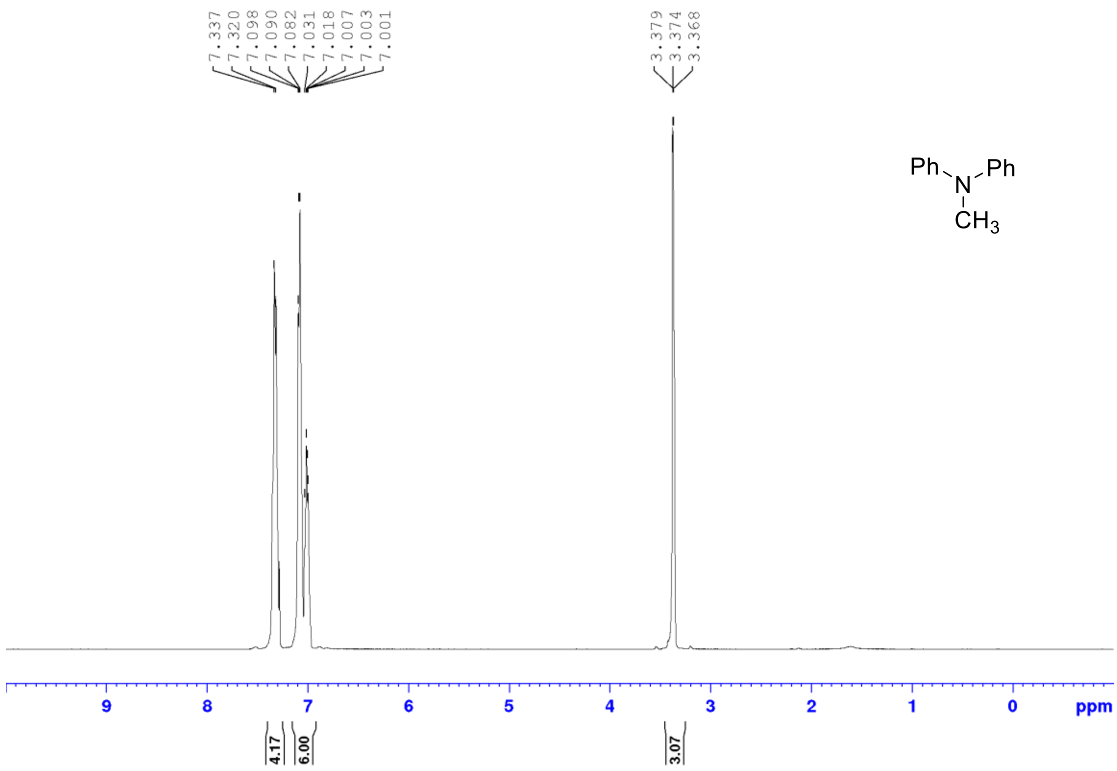
^{13}C {^{1}H} NMR of **4d**. (100 MHz, $CDCl_3$)



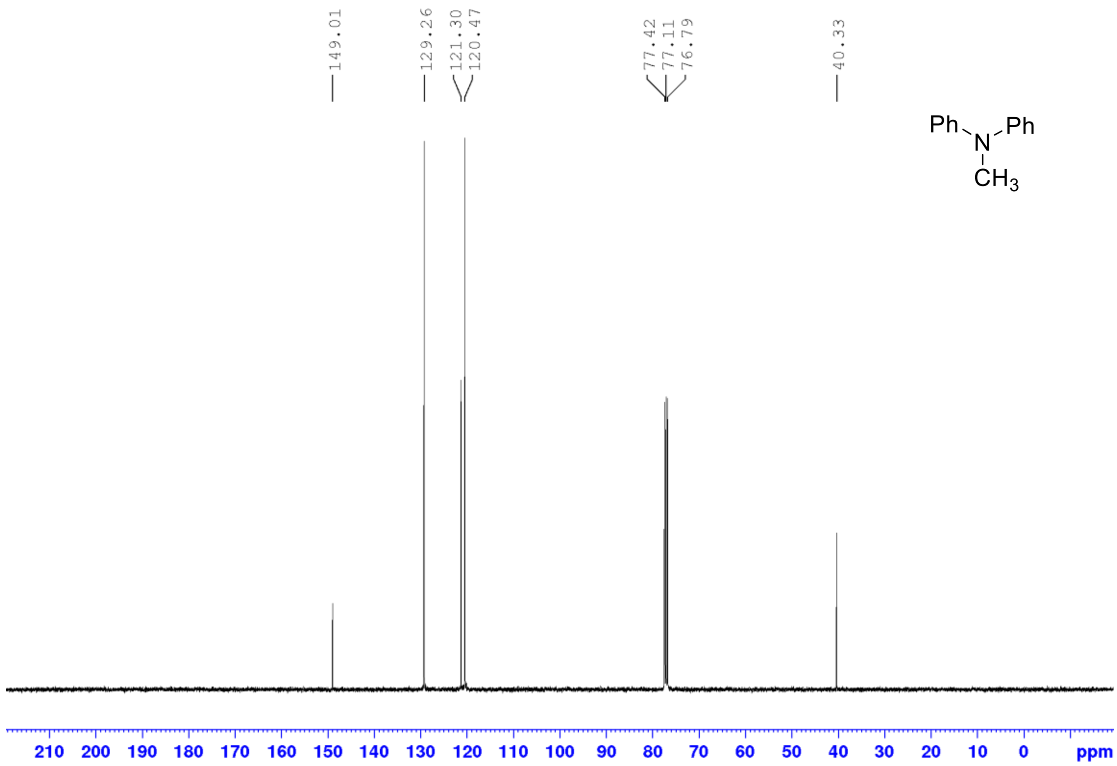
^{1}H NMR of **5d**. (400 MHz, $CDCl_3$)



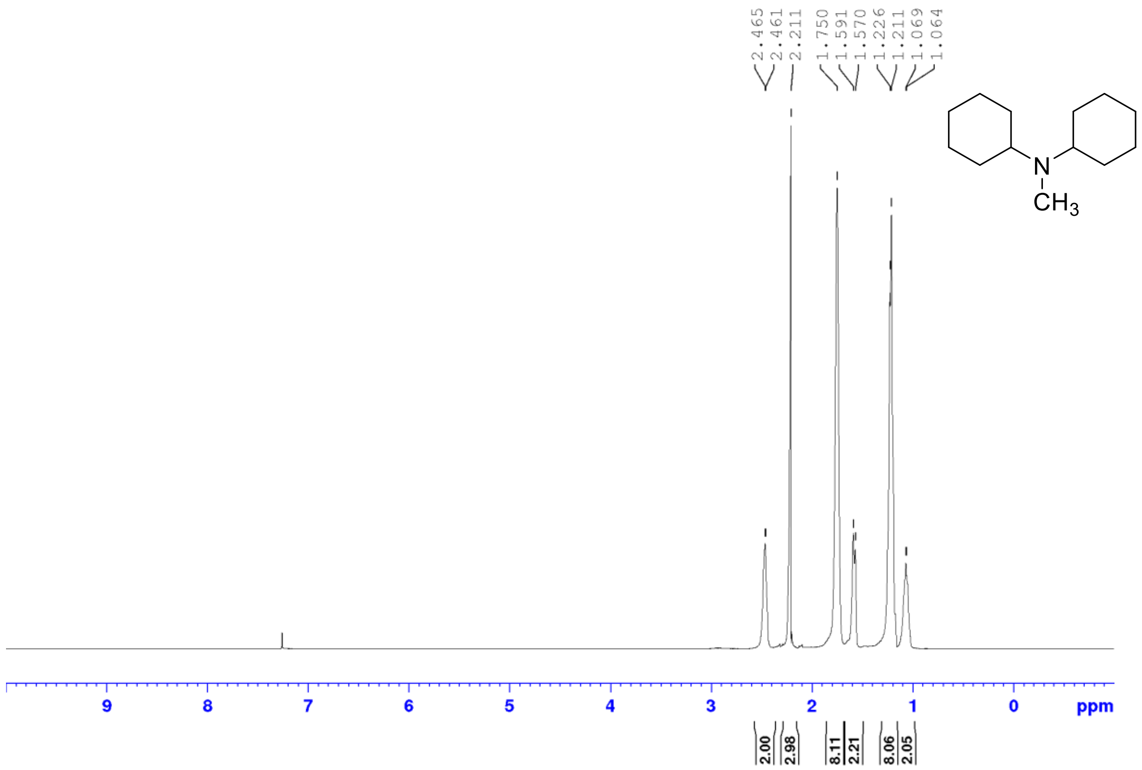
^{13}C {^{1}H} NMR of **5d**. (100 MHz, $CDCl_3$)



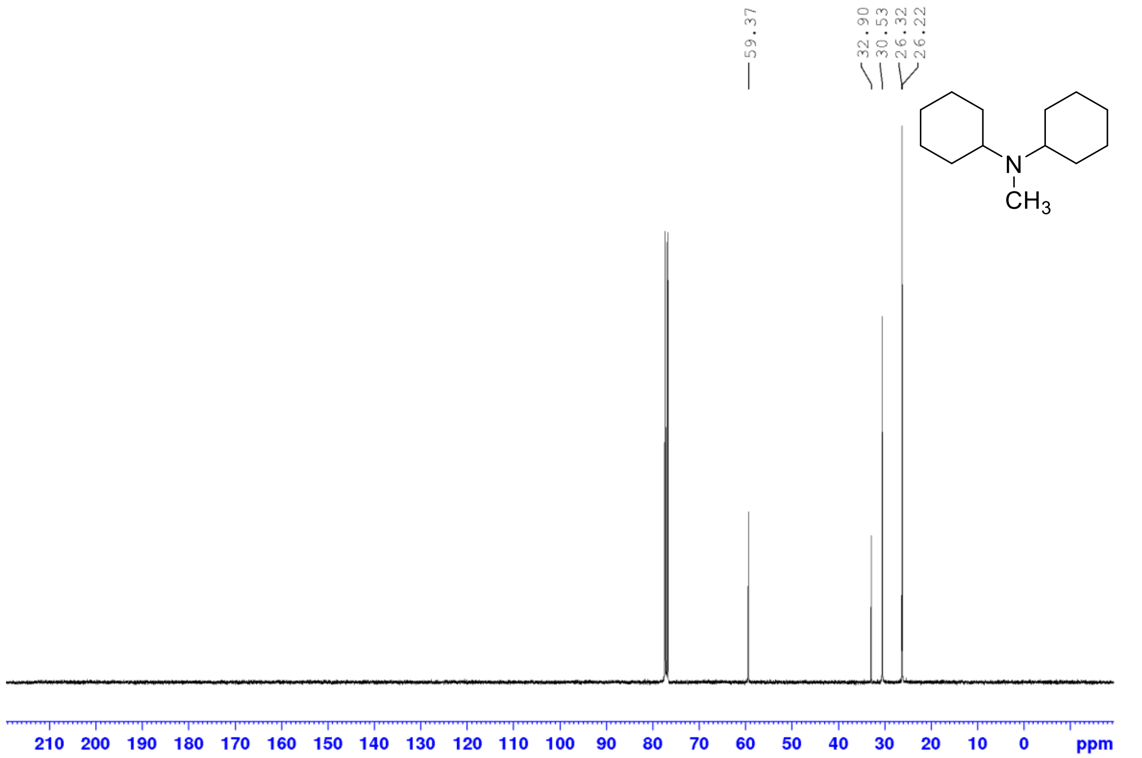
^{1}H NMR of **6d**. (400 MHz, $CDCl_3$)



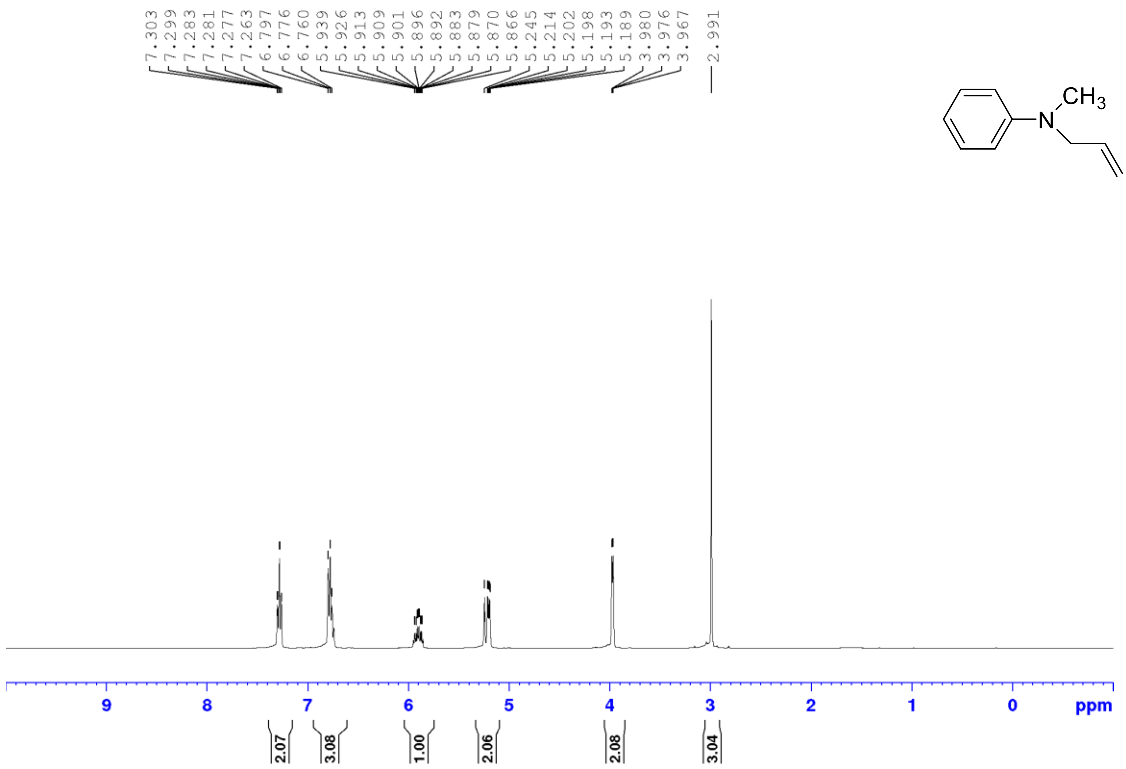
^{13}C {^{1}H} NMR of **6d**. (100 MHz, $CDCl_3$)



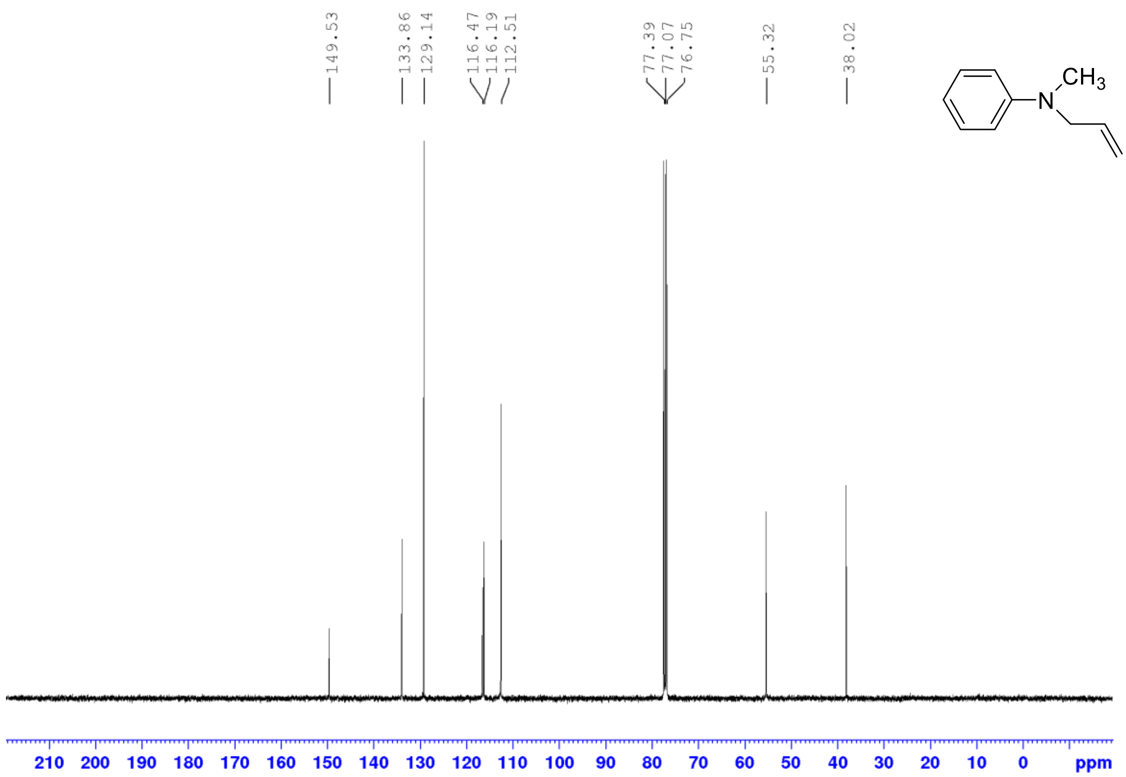
[1]H NMR of **7d**. (400 MHz, $CDCl_3$)



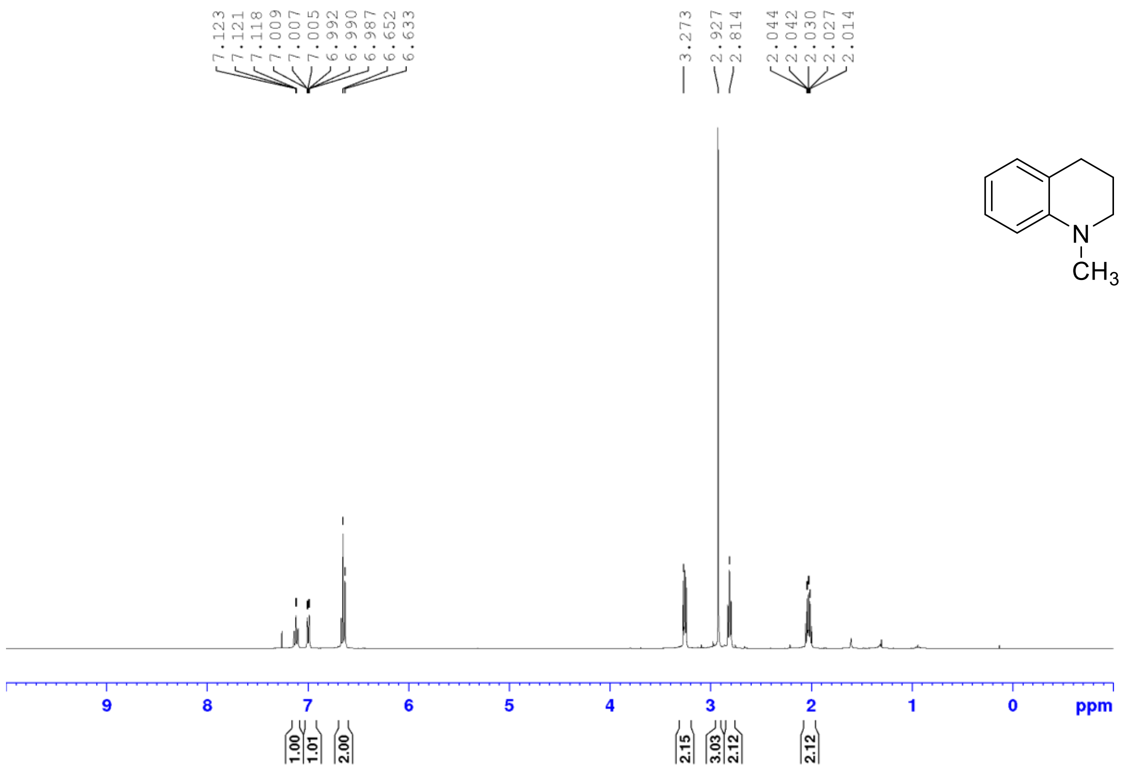
[13]C {[1]H} NMR of **7d**. (100 MHz, $CDCl_3$)



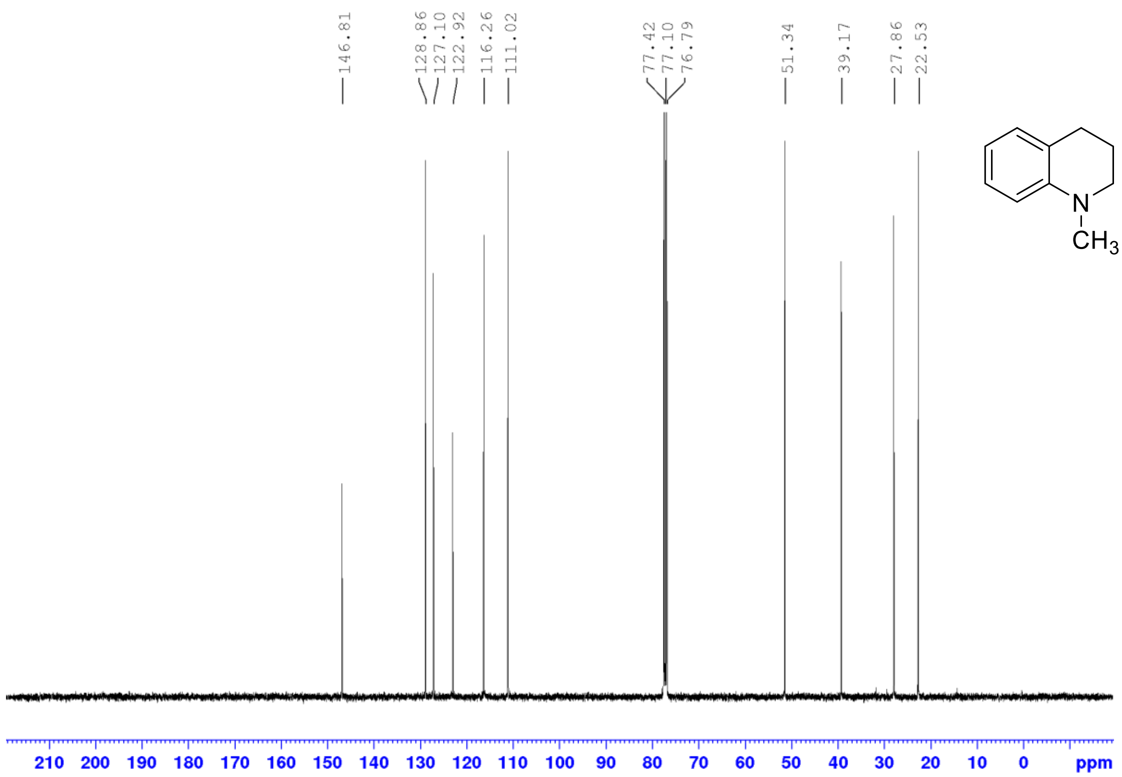
[1]H NMR of **8d**. (400 MHz, $CDCl_3$)



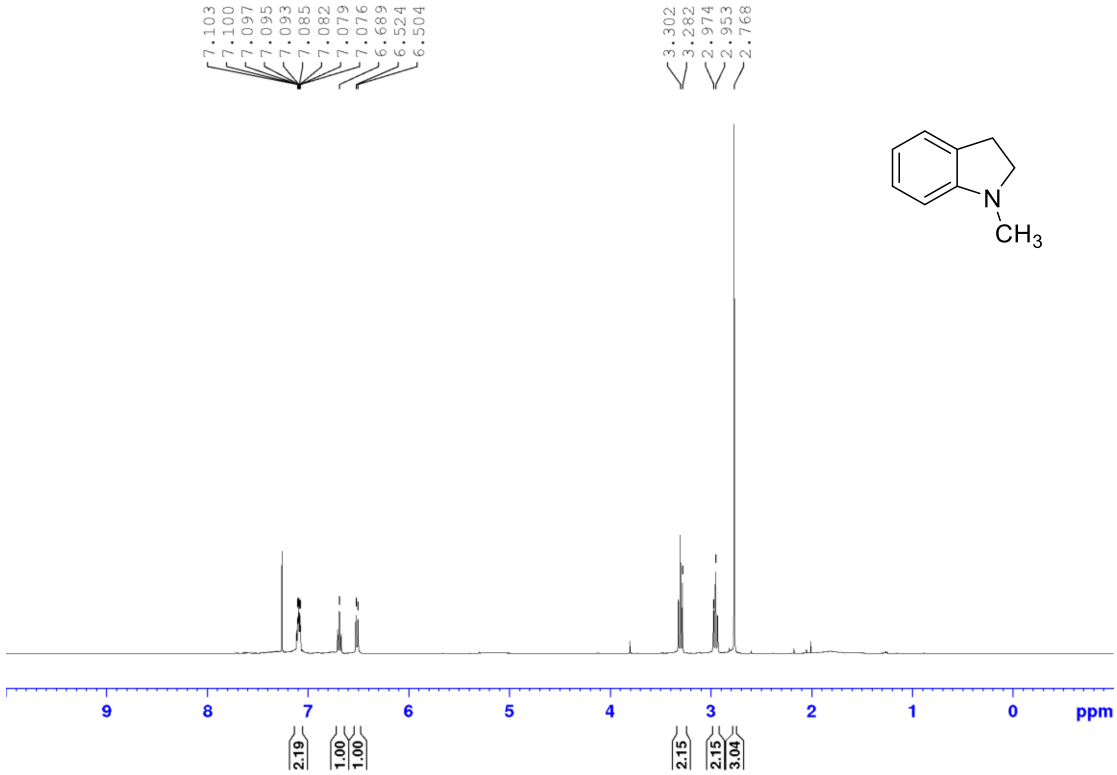
[13]C {[1]H} NMR of **8d**. (100 MHz, $CDCl_3$)



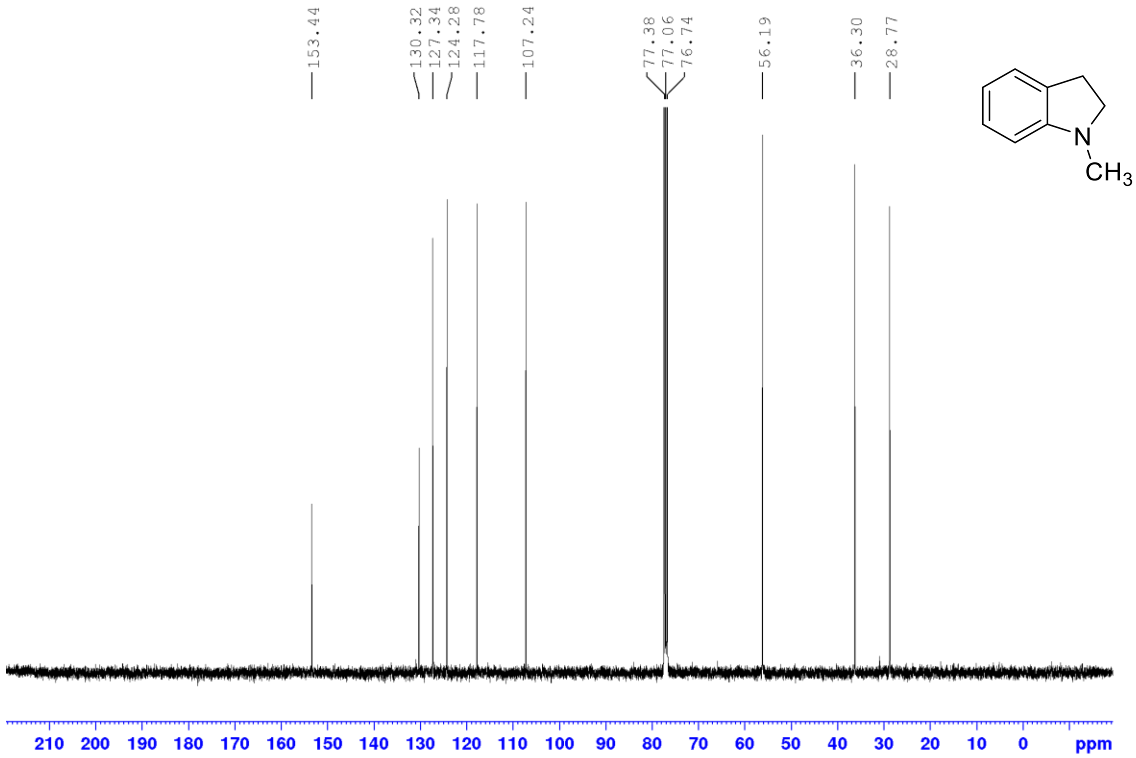
[1]H NMR of **9d**. (400 MHz, $CDCl_3$)



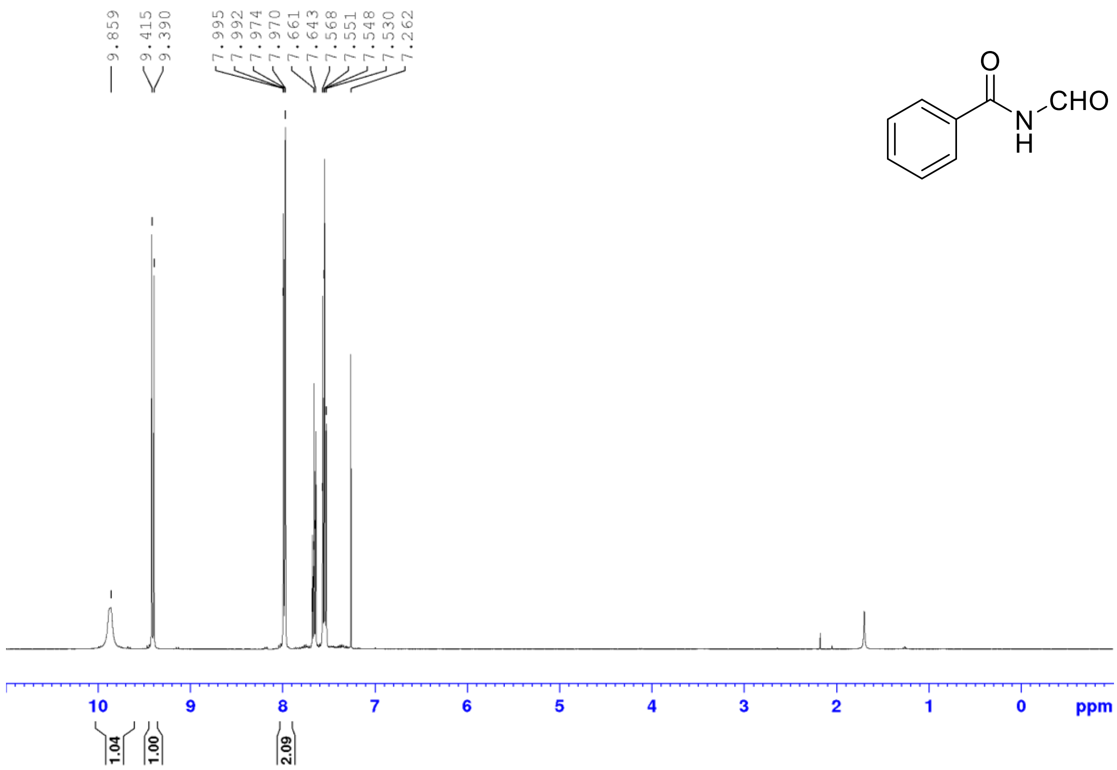
[13]C {[1]H} NMR of **9d**. (100 MHz, $CDCl_3$)



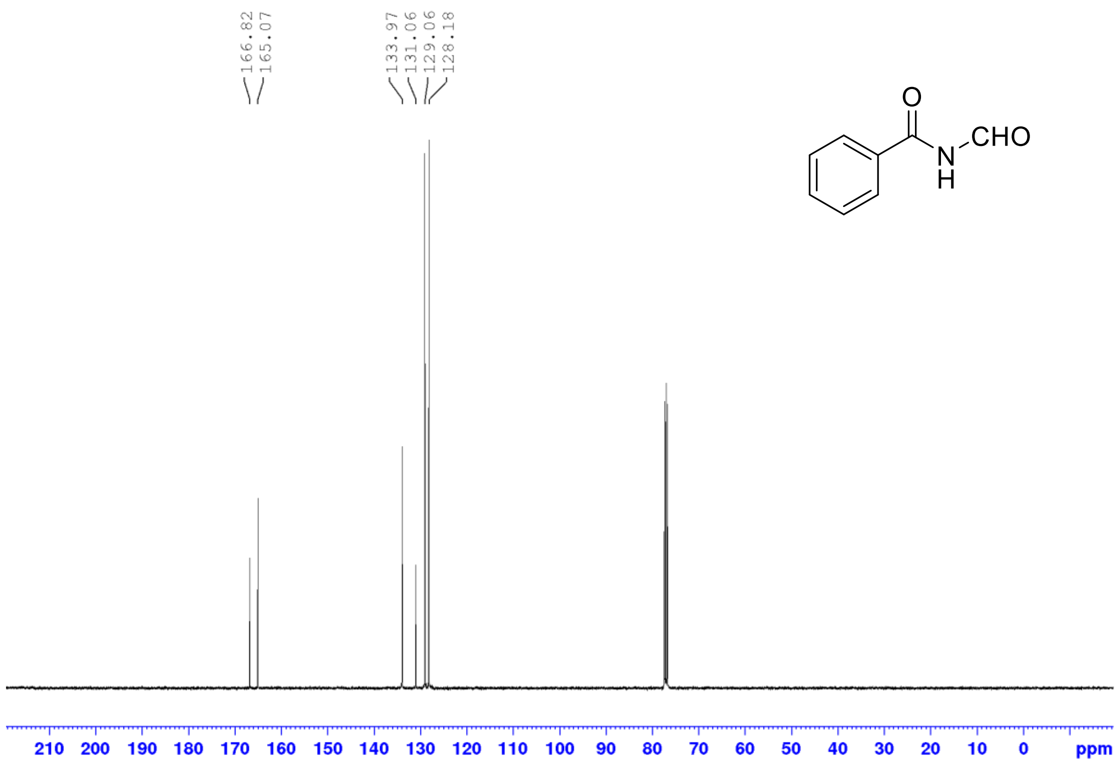
^{1}H NMR of **10d**. (400 MHz, $CDCl_3$)



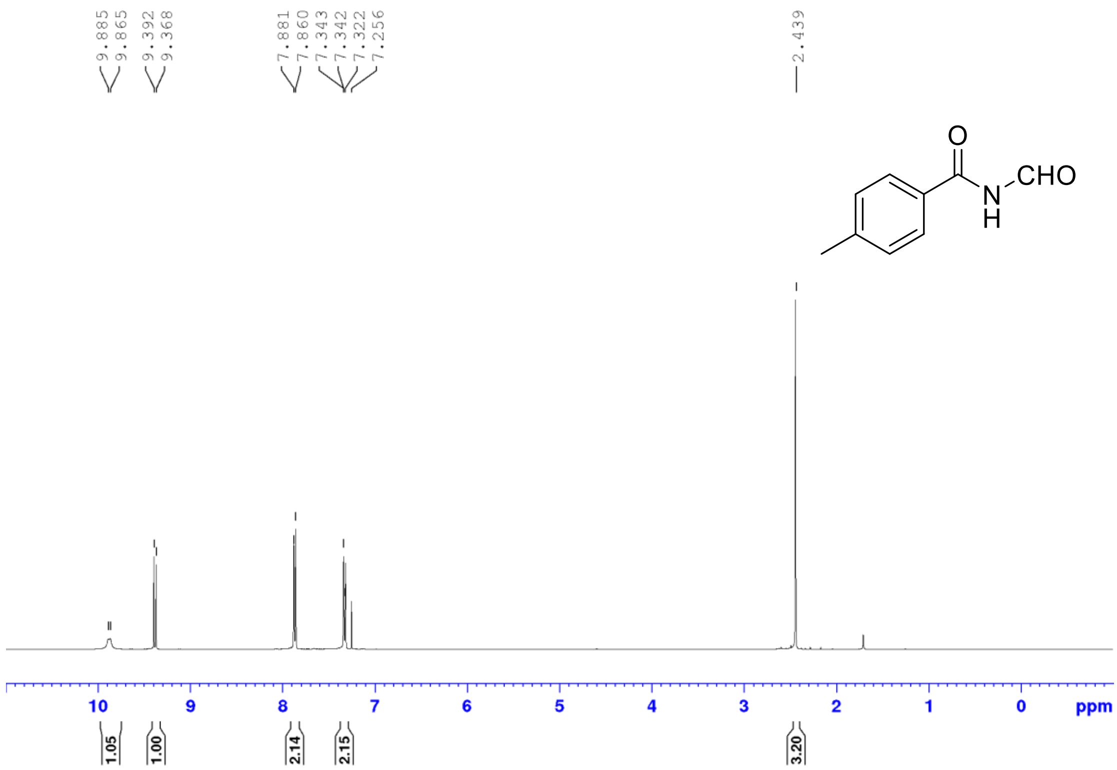
^{13}C {^{1}H} NMR of **10d**. (100 MHz, $CDCl_3$)



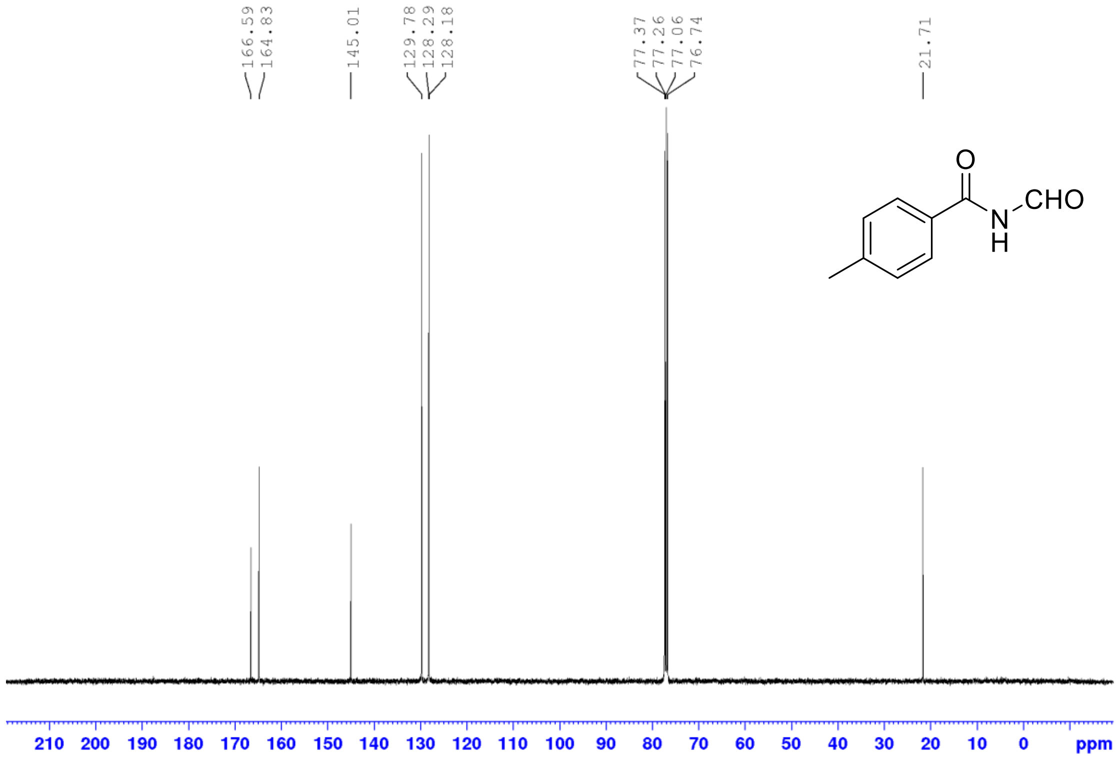
[1]H NMR of **1e**. (400 MHz, $CDCl_3$)



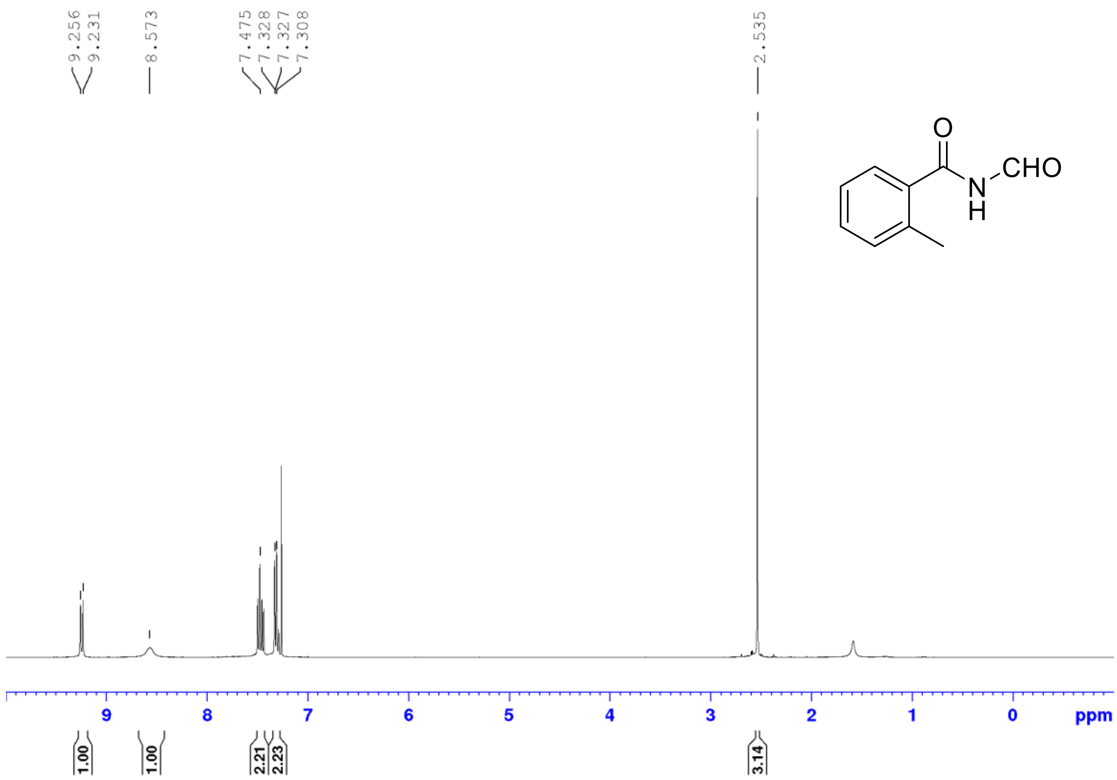
[13]C {[1]H} NMR of **1e**. (100 MHz, $CDCl_3$)



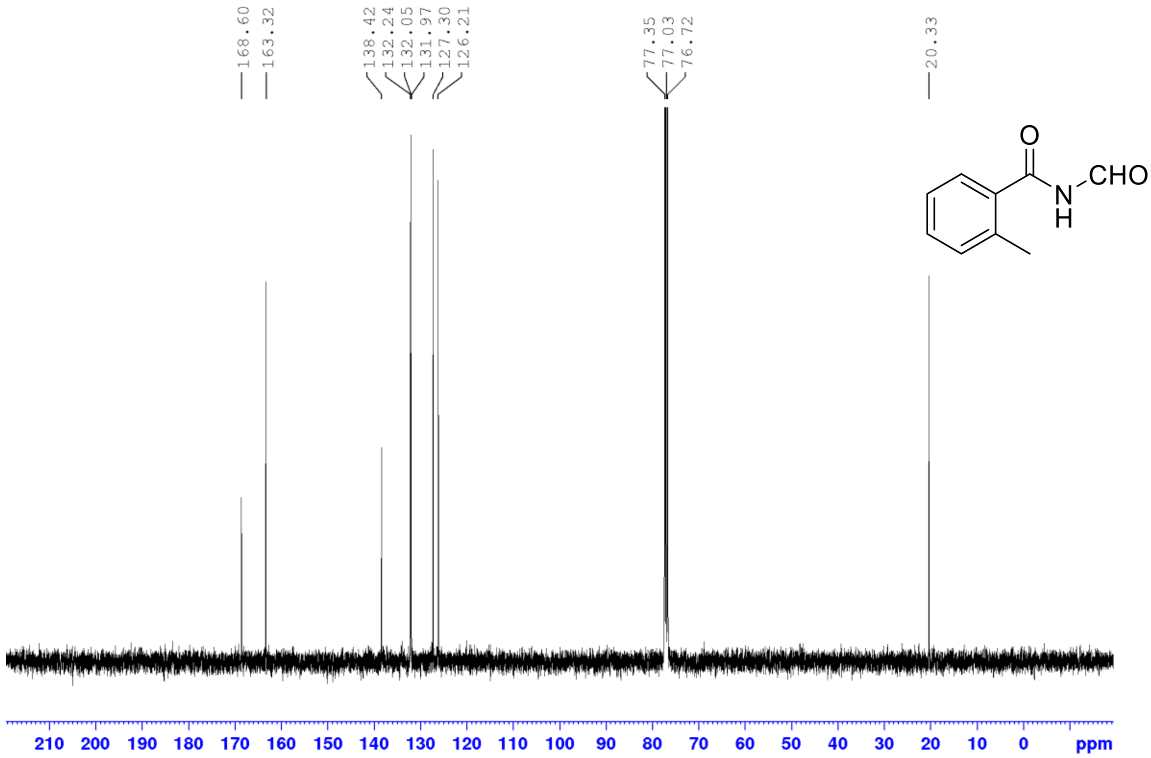
^{1}H NMR of **2e**. (400 MHz, $CDCl_3$)



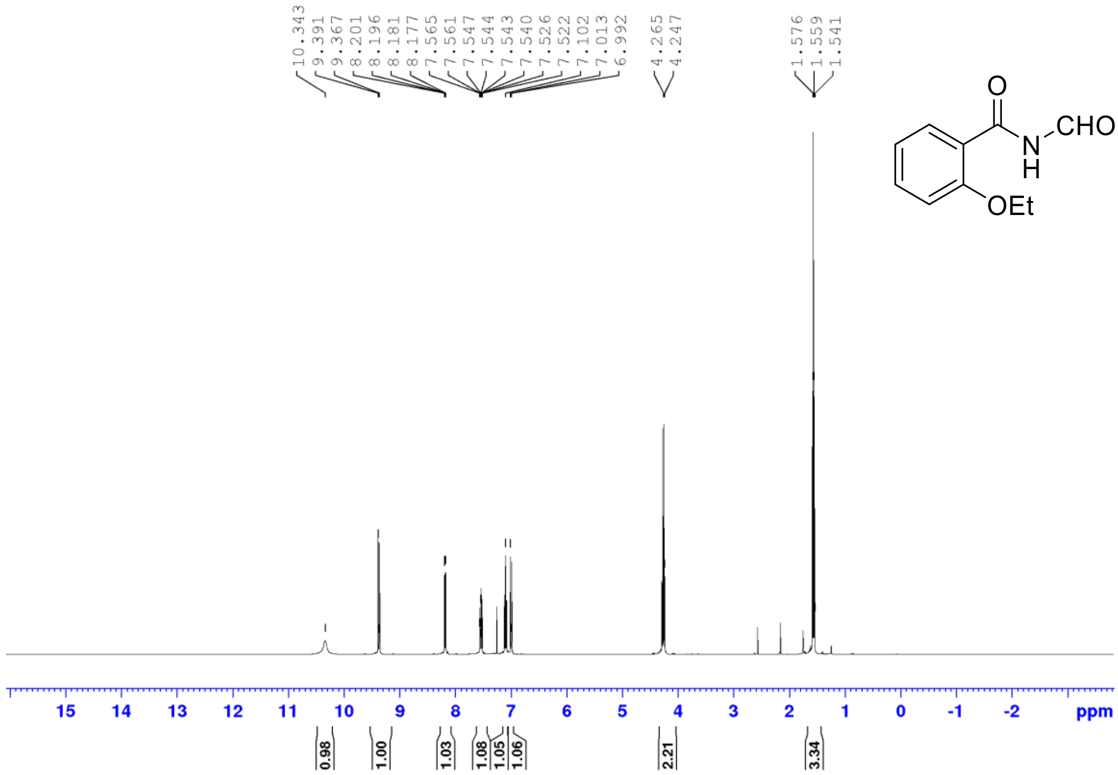
^{13}C {^{1}H} NMR of **2e**. (100 MHz, $CDCl_3$)



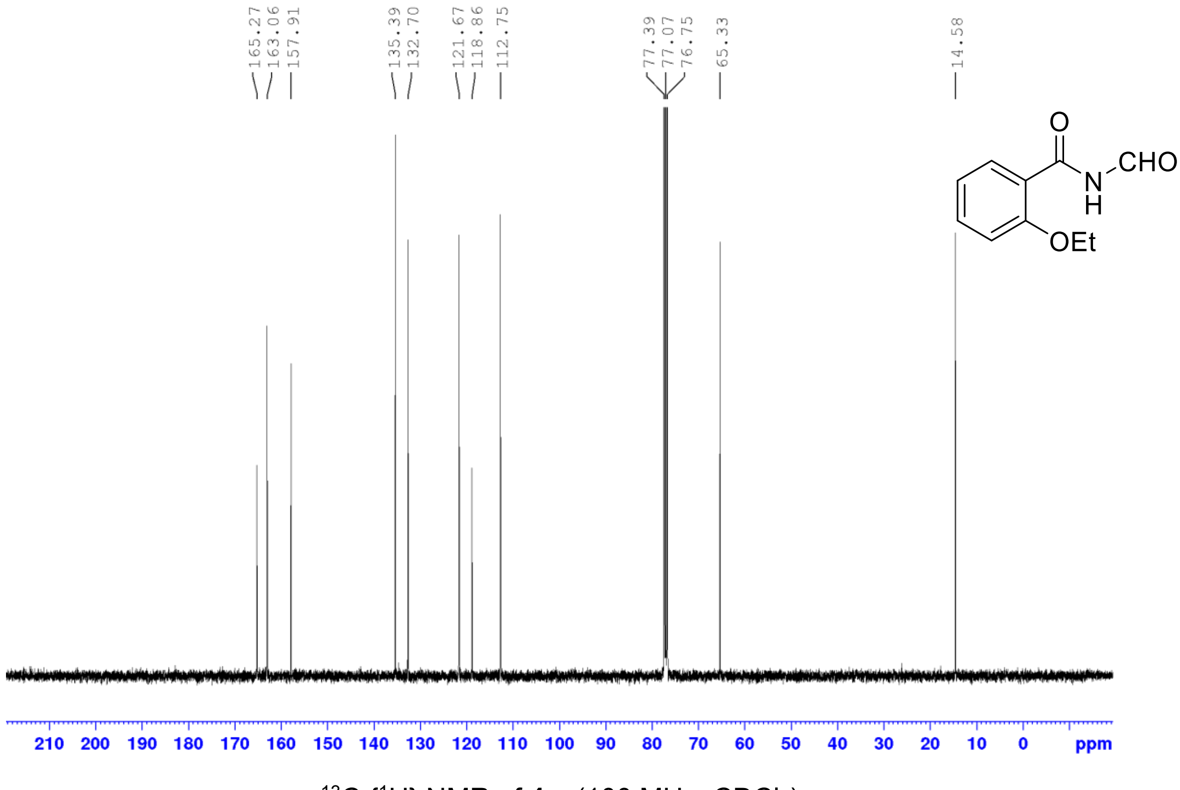
^{1}H NMR of **3e**. (400 MHz, $CDCl_3$)



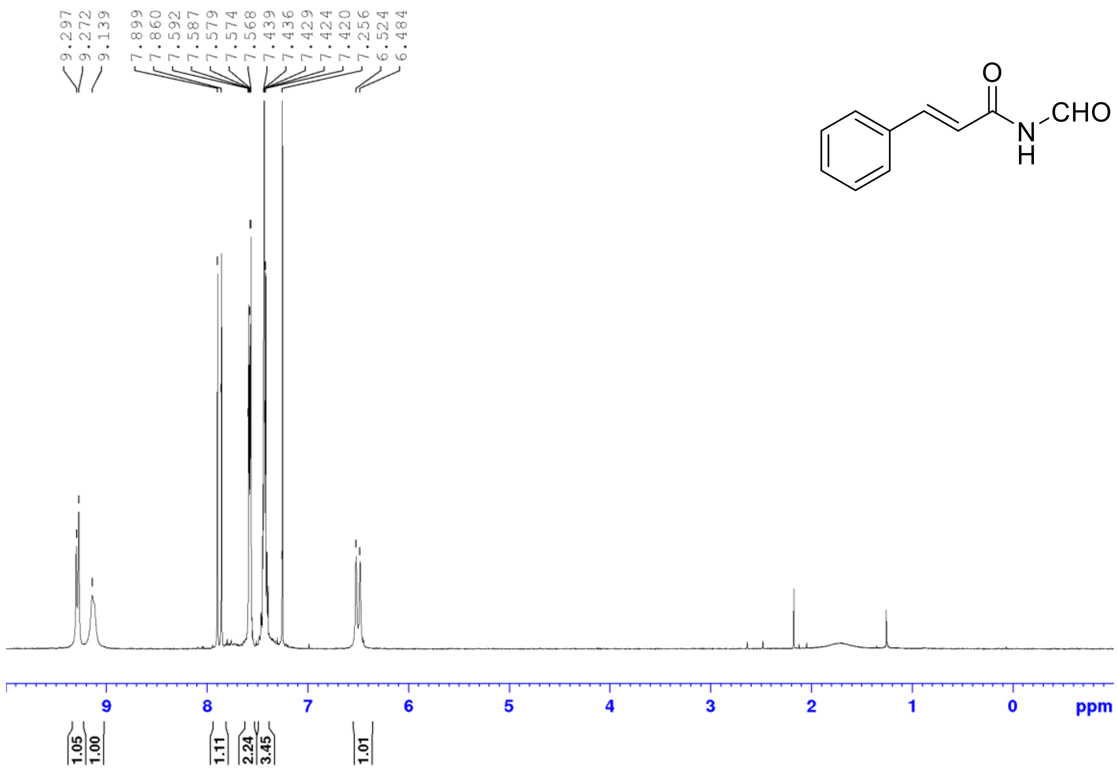
^{13}C {^{1}H} NMR of **3e**. (100 MHz, $CDCl_3$)



[1]H NMR of **4e**. (400 MHz, $CDCl_3$)

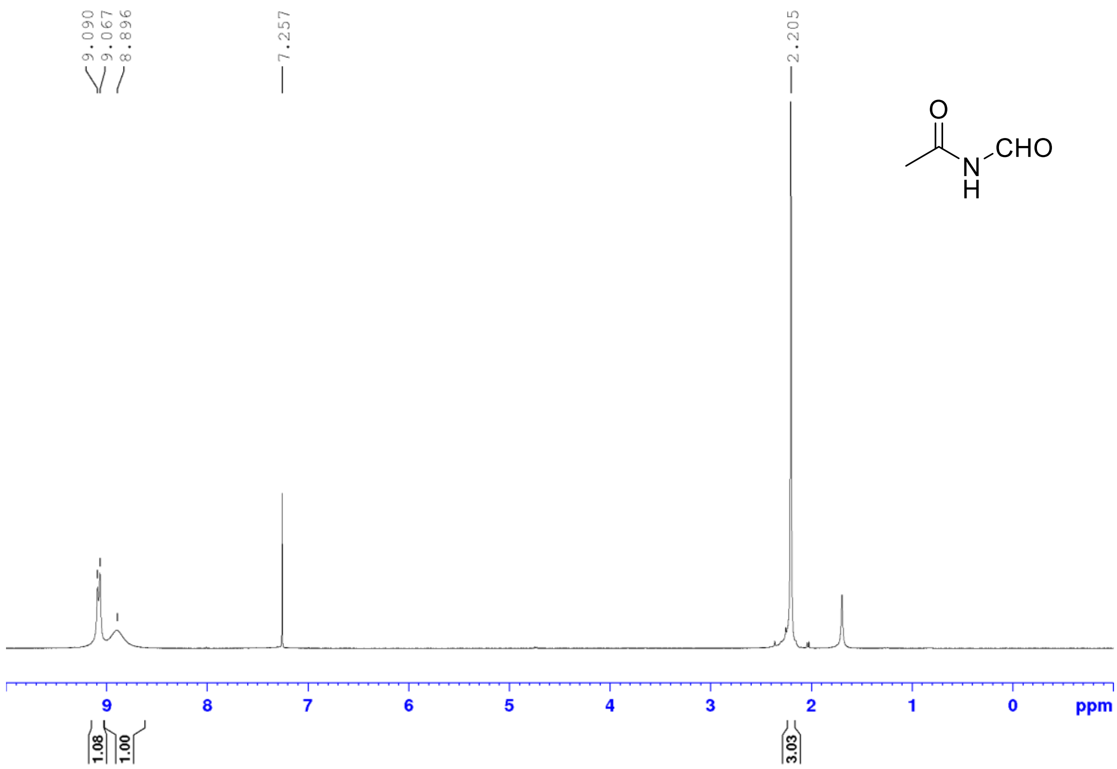


[13]C {[1]H} NMR of **4e**. (100 MHz, $CDCl_3$)

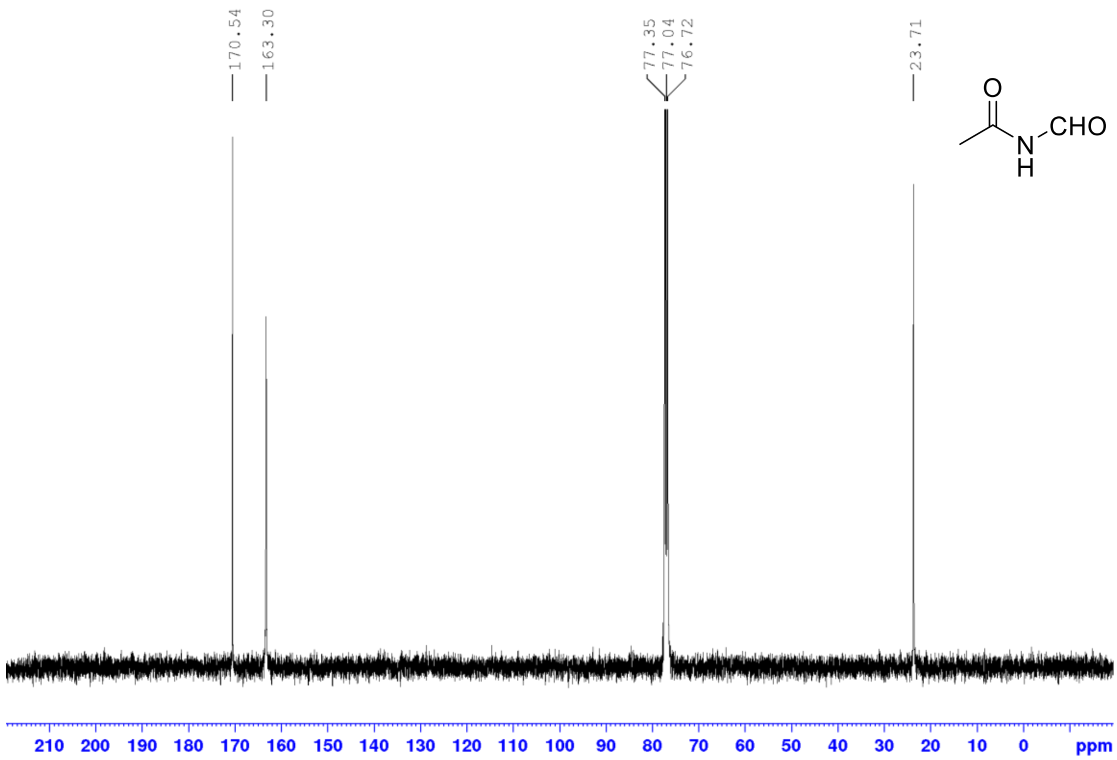


^{1}H NMR of **5e**. (400 MHz, $CDCl_3$)

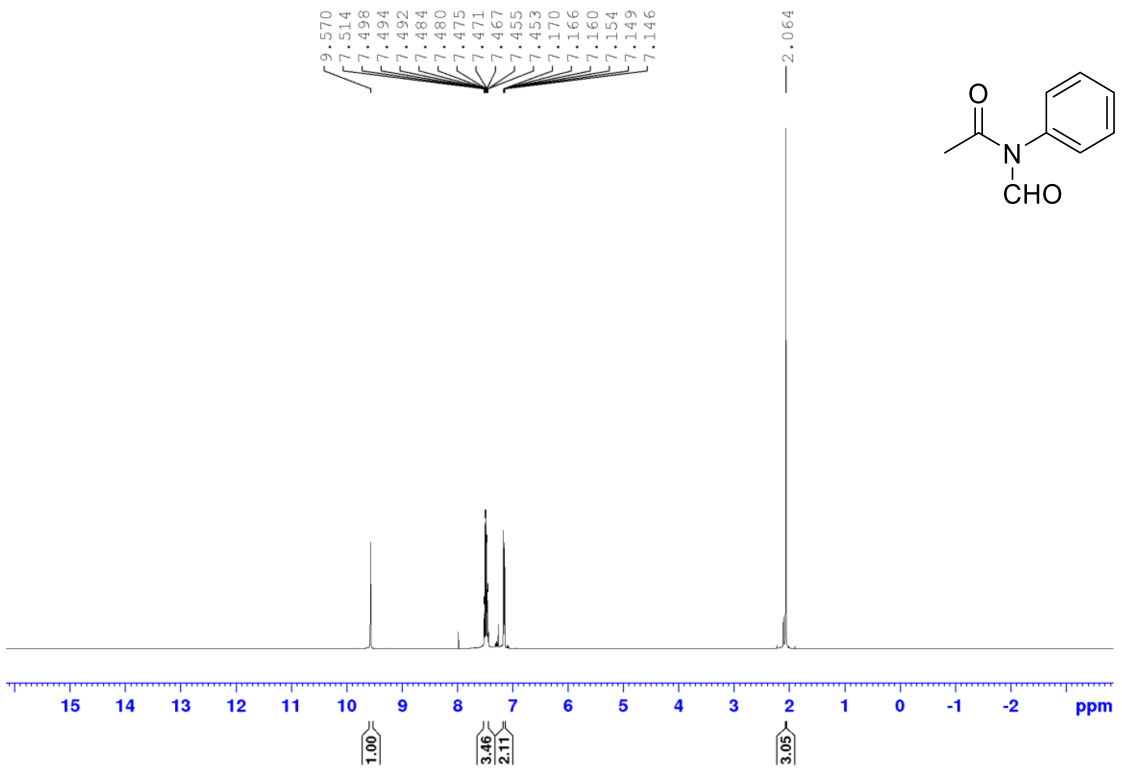
^{13}C {^{1}H} NMR of **5e**. (100 MHz, $CDCl_3$)



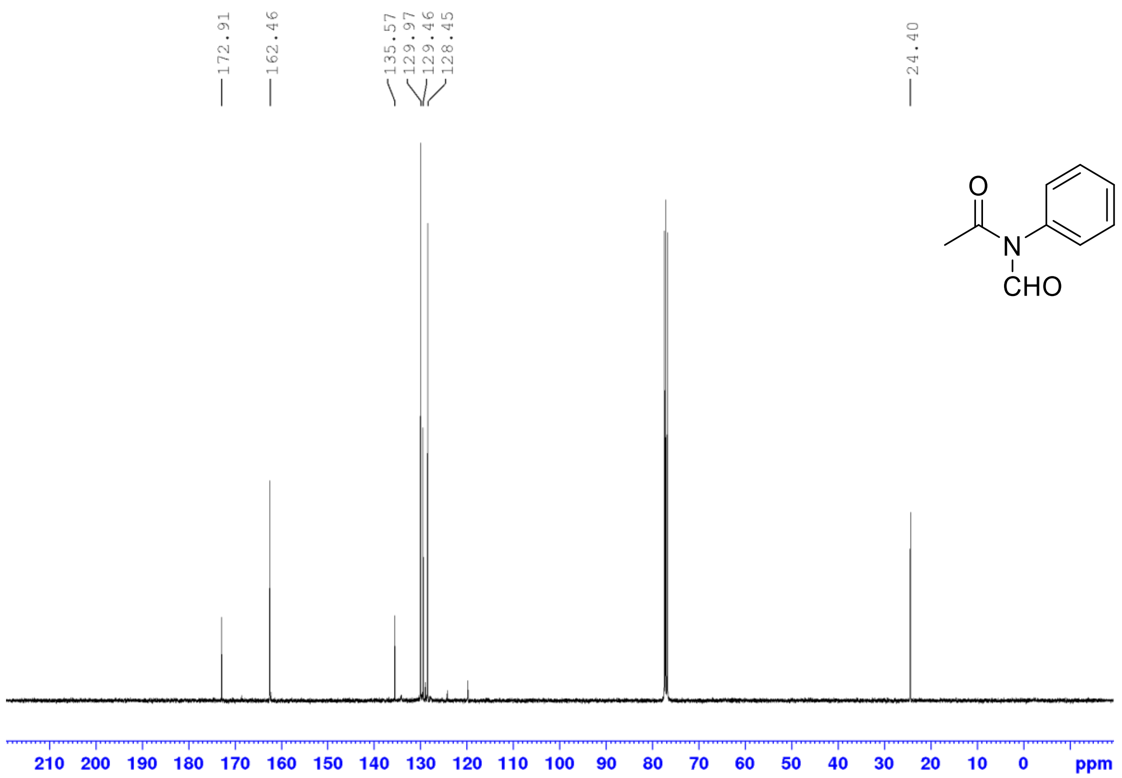
^{1}H NMR of **6e**. (400 MHz, $CDCl_3$)



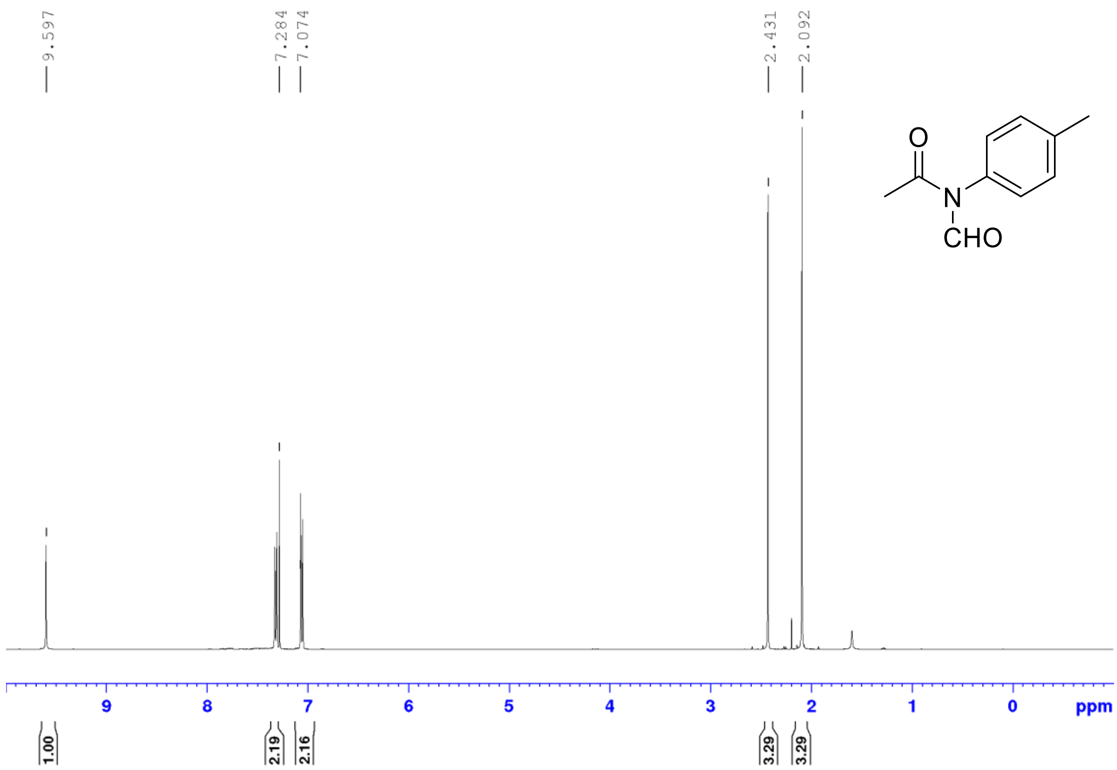
^{13}C $\{^{1}H\}$ NMR of **6e**. (100 MHz, $CDCl_3$)



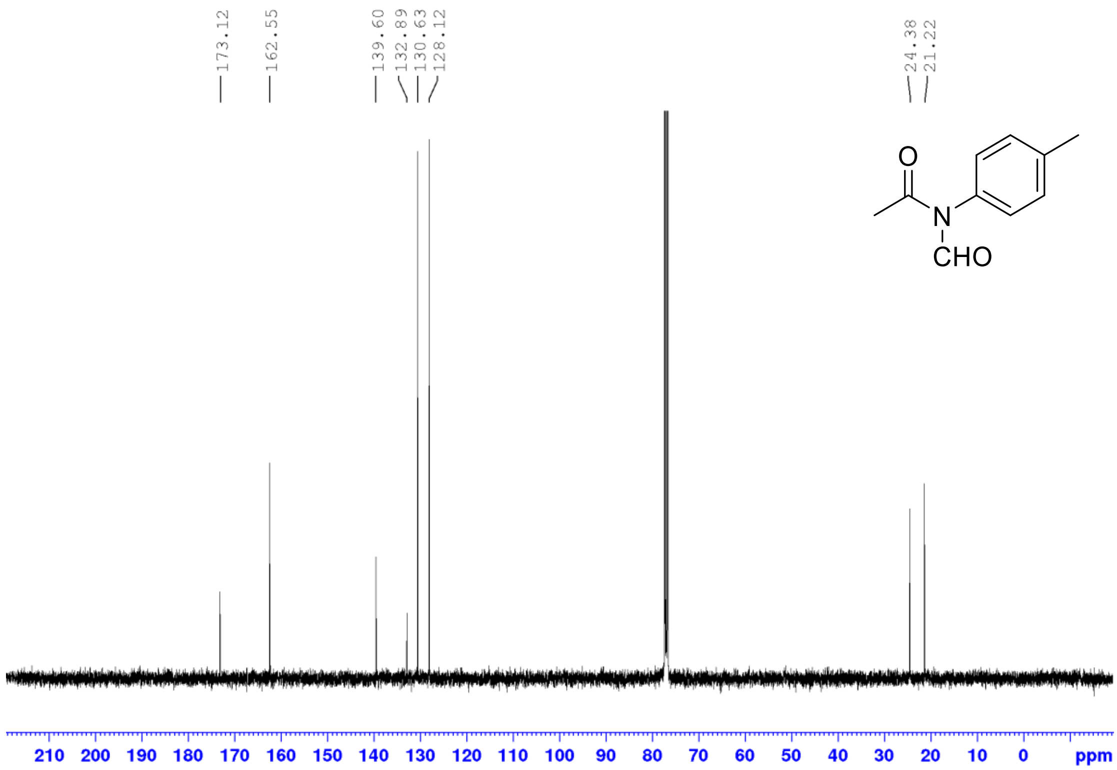
^{1}H NMR of **1f**. (400 MHz, $CDCl_3$)



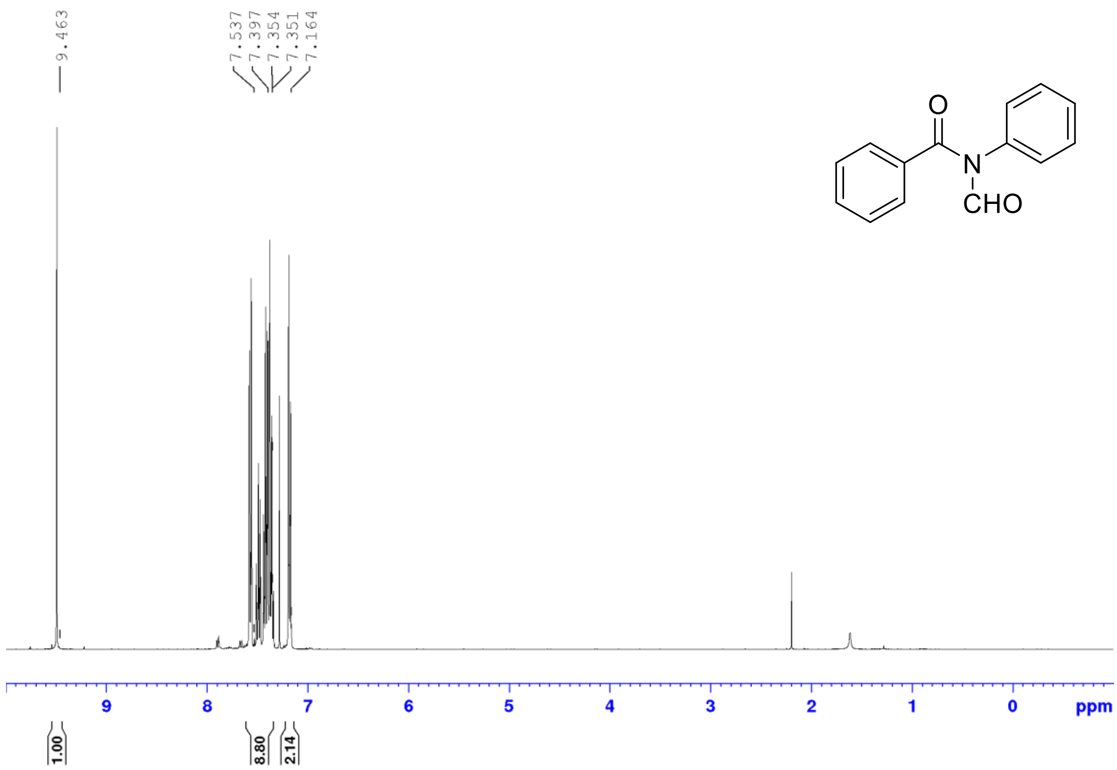
^{13}C {^{1}H} NMR of **1f**. (100 MHz, $CDCl_3$)



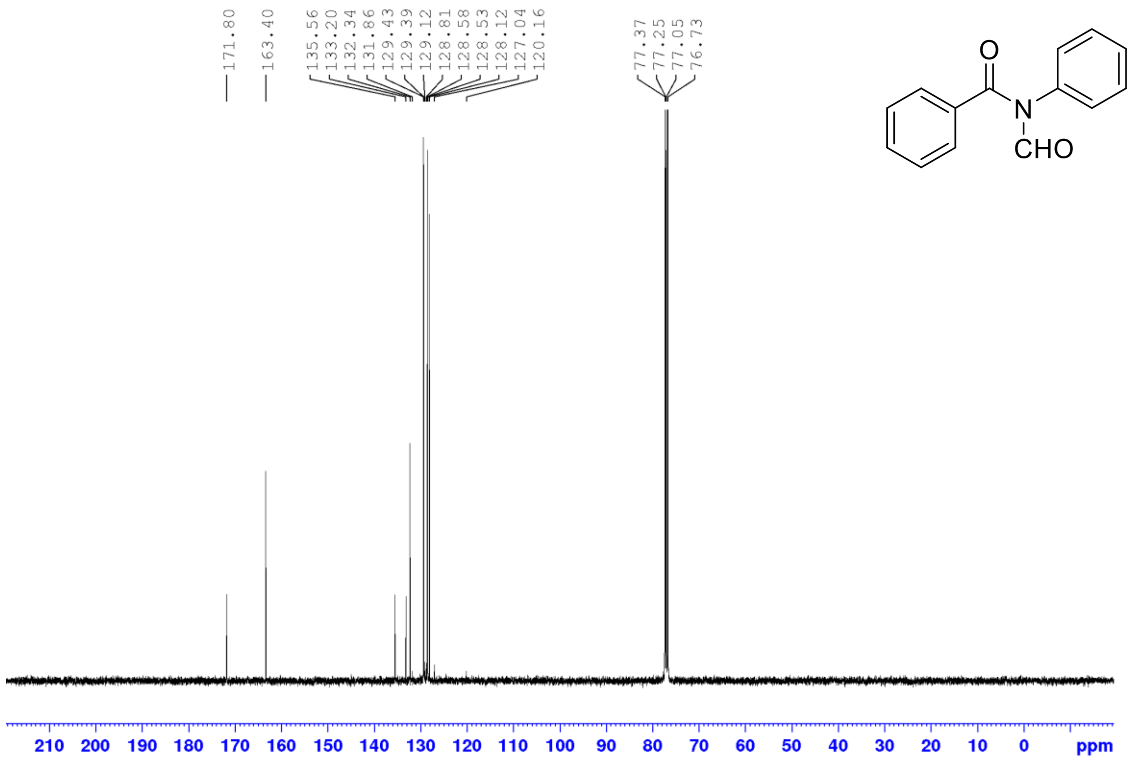
^{1}H NMR of **2f**. (400 MHz, $CDCl_3$)



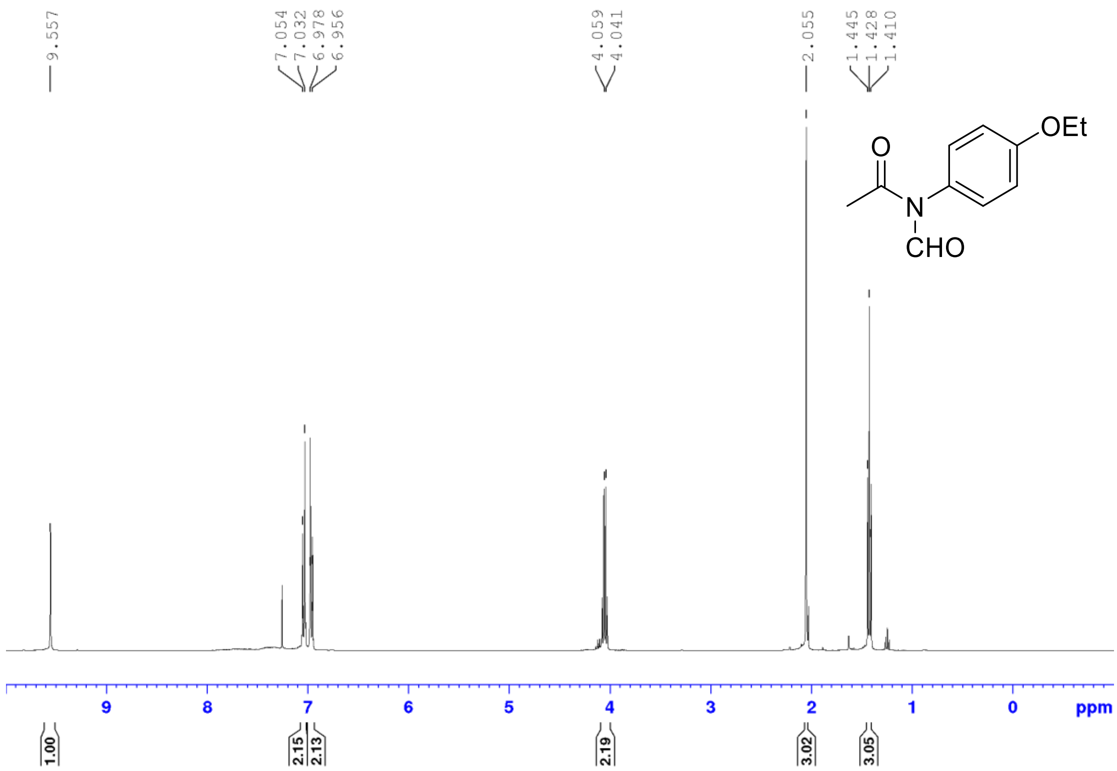
^{13}C {^{1}H} NMR of **2f**. (100 MHz, $CDCl_3$)



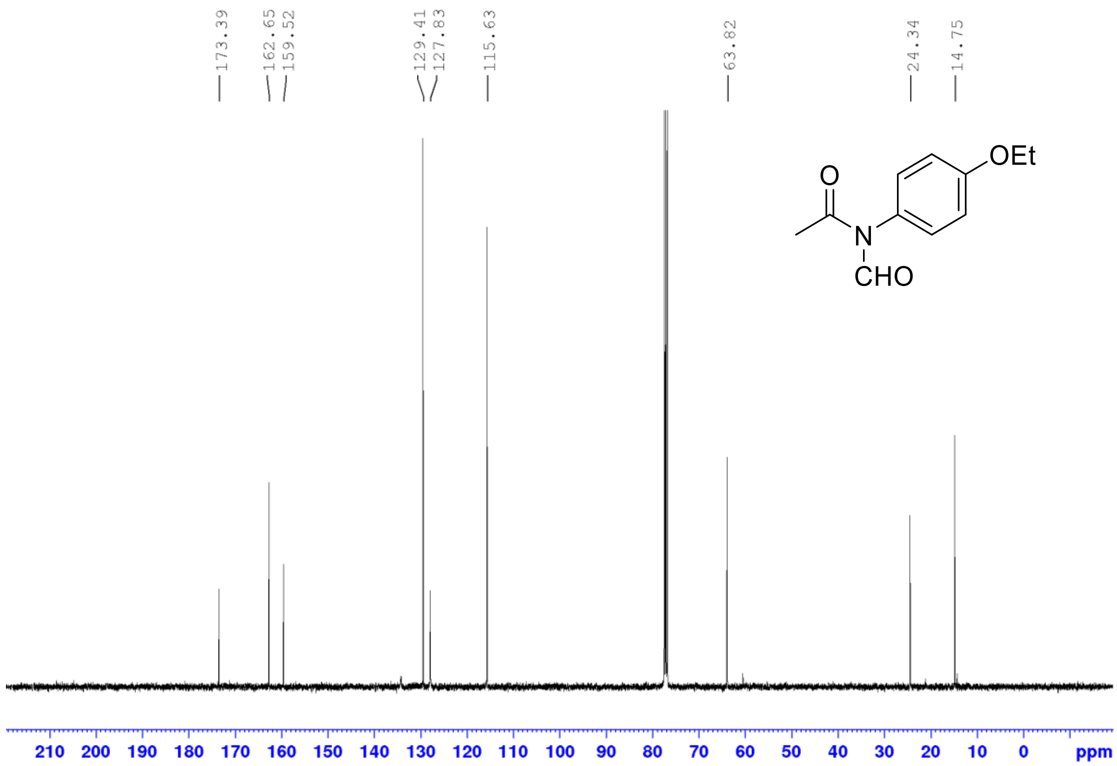
^{1}H NMR of **3f**. (400 MHz, $CDCl_3$)



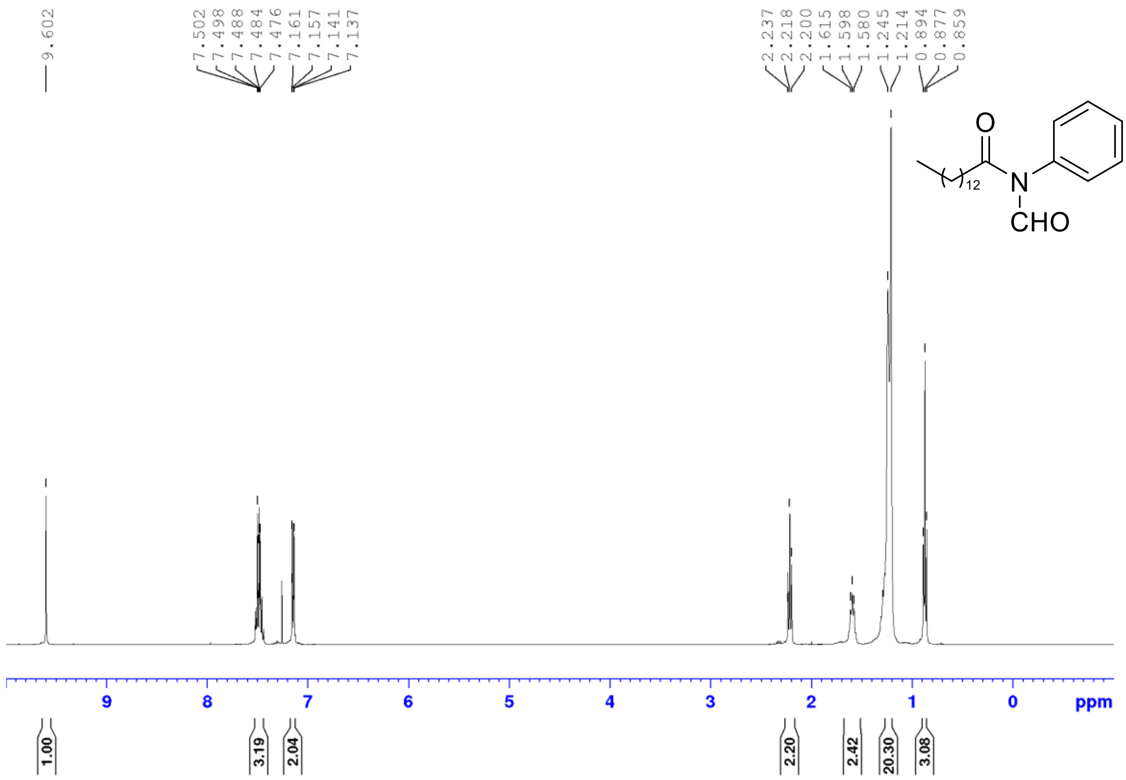
^{13}C {^{1}H} NMR of **3f**. (100 MHz, $CDCl_3$)



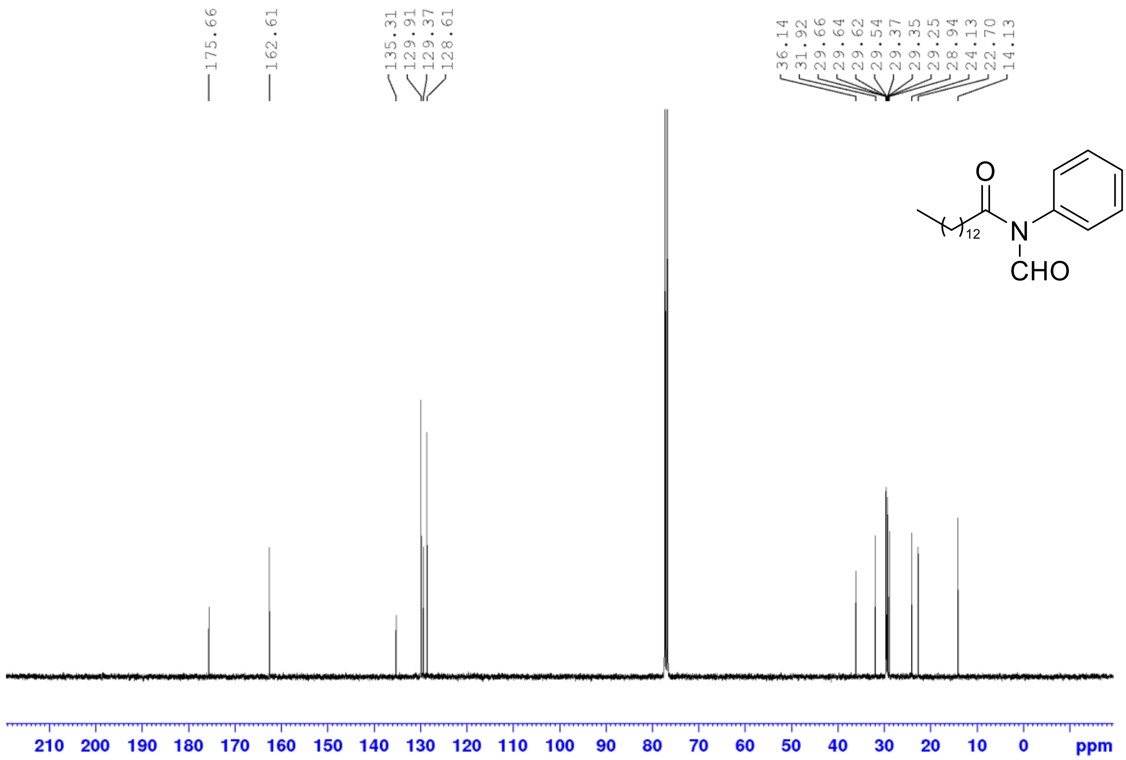
^{1}H NMR of **4f**. (400 MHz, $CDCl_3$)



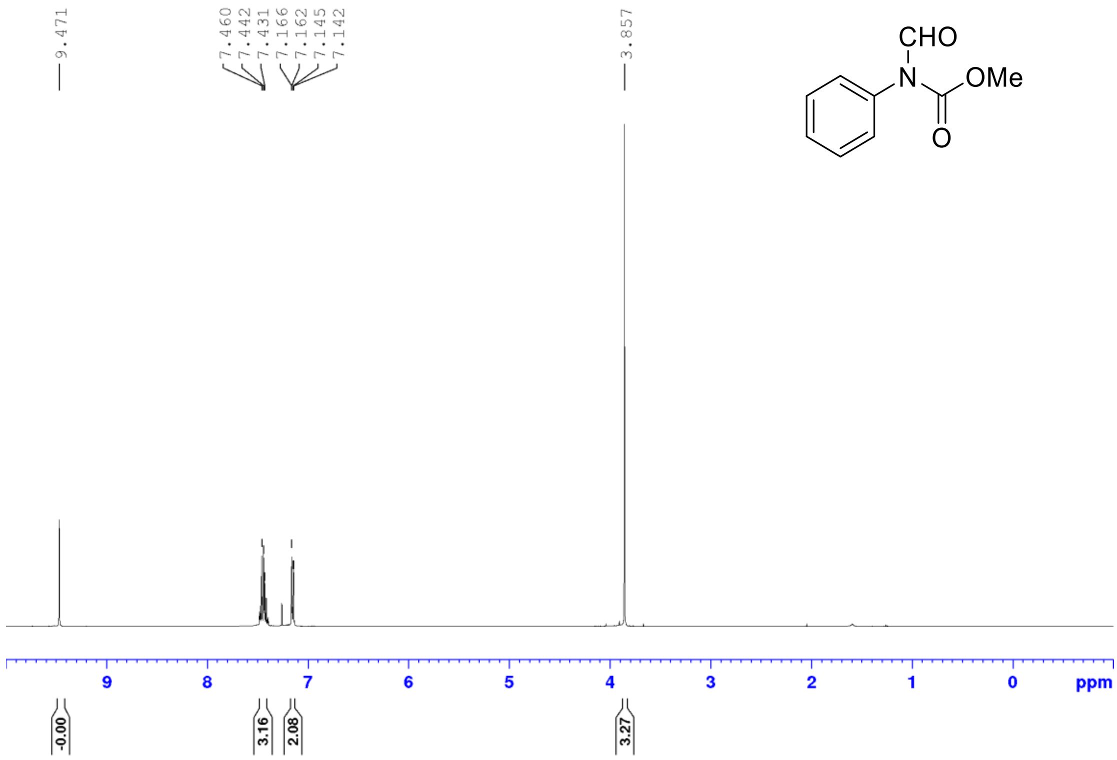
^{13}C {^{1}H} NMR of **4f**. (100 MHz, $CDCl_3$)



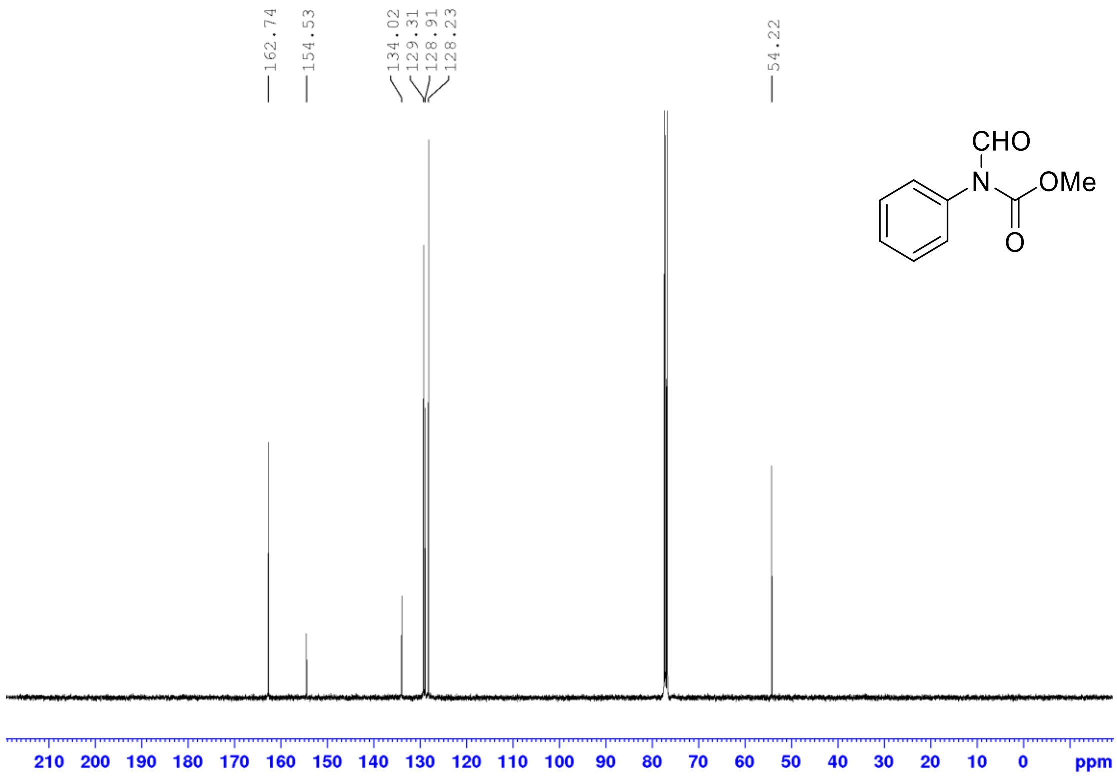
^{1}H NMR of **5f**. (400 MHz, $CDCl_3$)



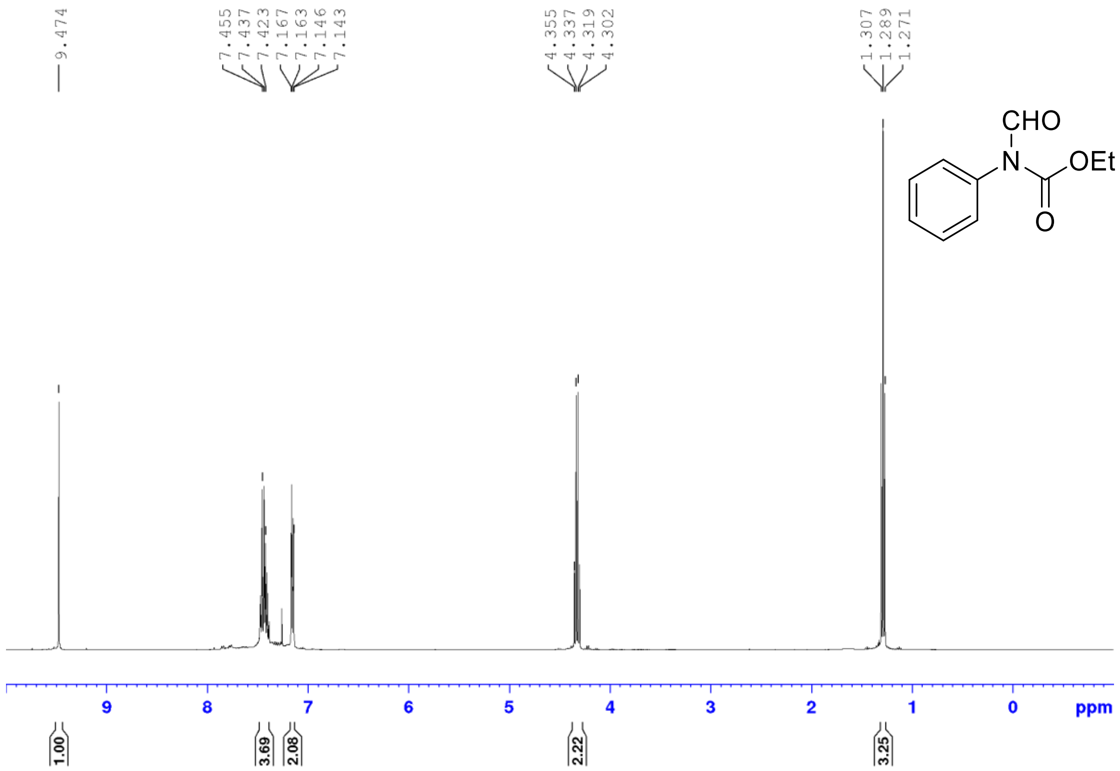
^{13}C {^{1}H} NMR of **5f**. (100 MHz, $CDCl_3$)



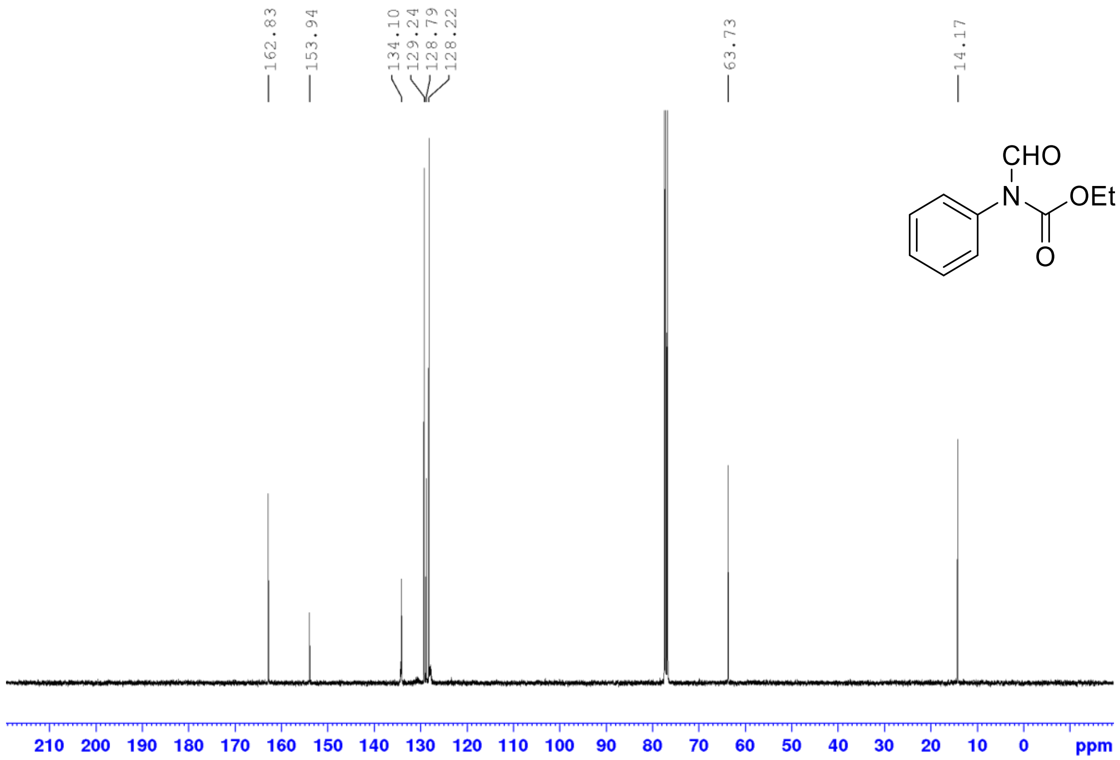
^{1}H NMR of **1g**. (400 MHz, $CDCl_3$)



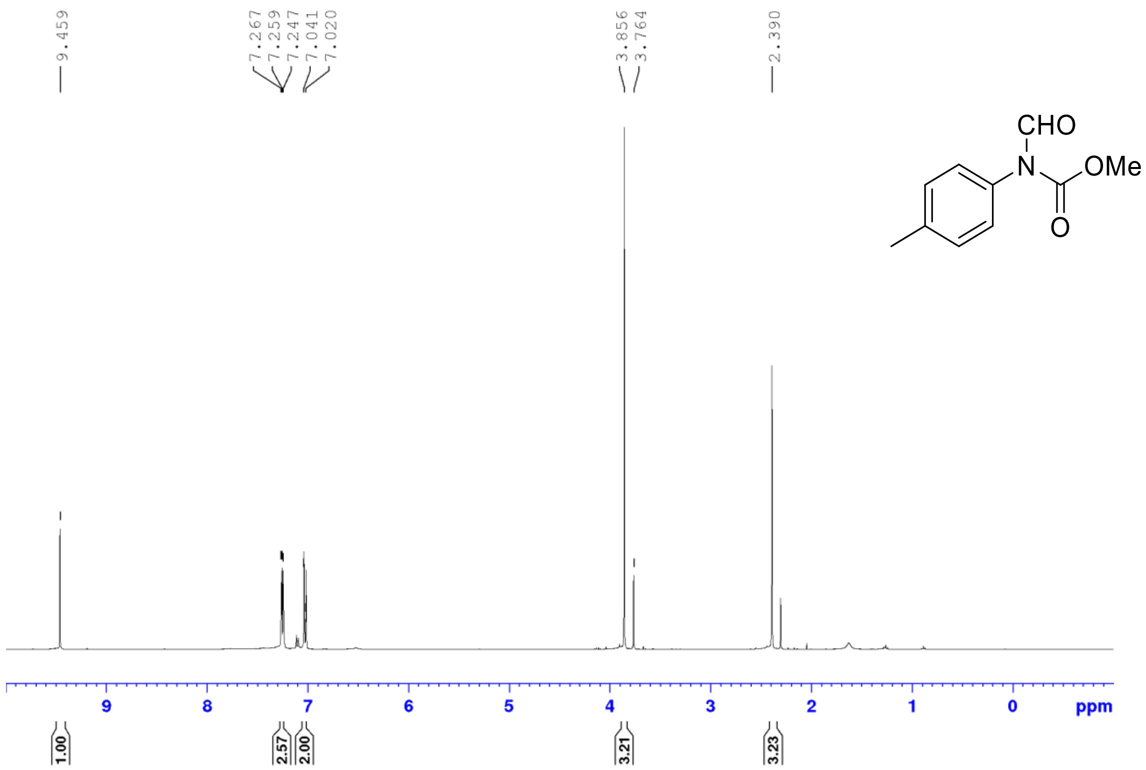
^{13}C {^{1}H} NMR of **1g**. (100 MHz, $CDCl_3$)



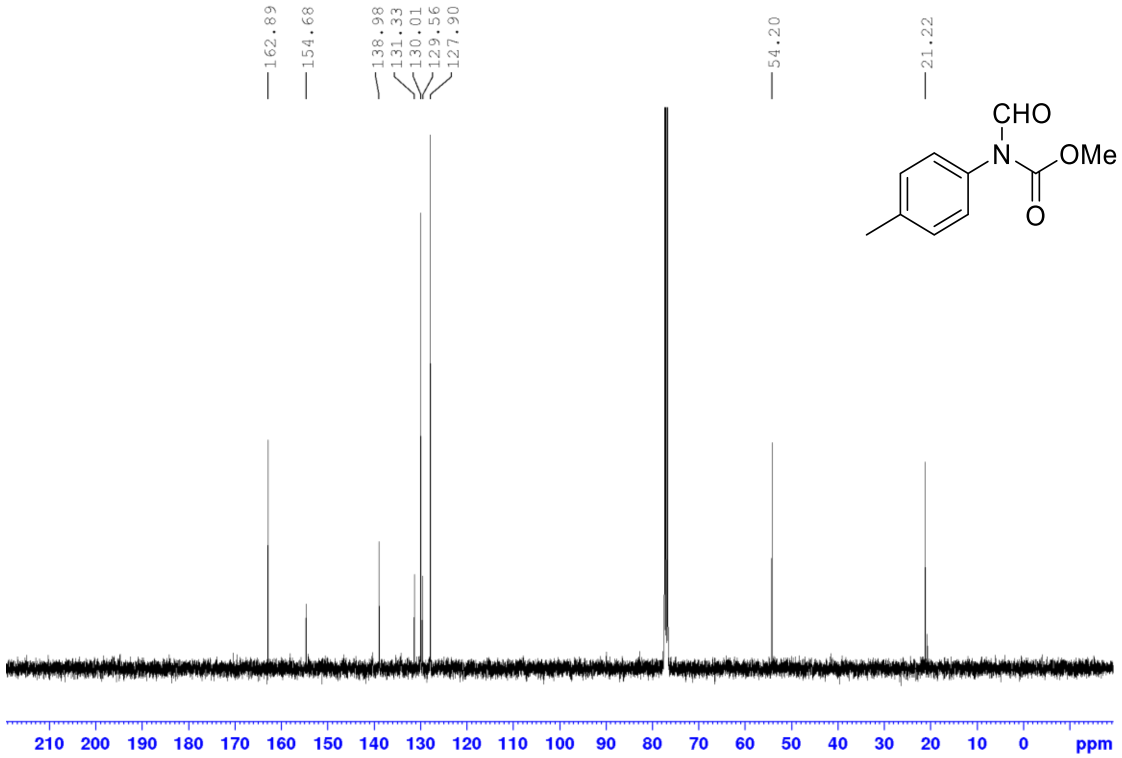
^{1}H NMR of **2g**. (400 MHz, $CDCl_3$)



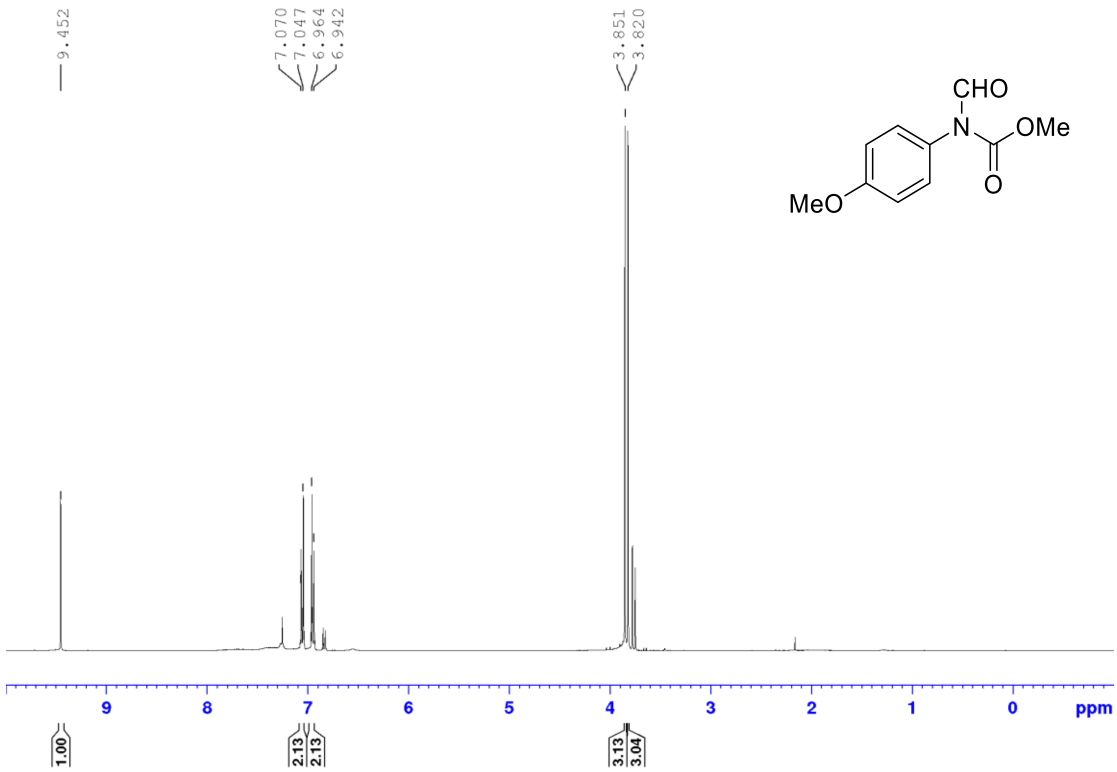
^{13}C {^{1}H} NMR of **2g**. (100 MHz, $CDCl_3$)



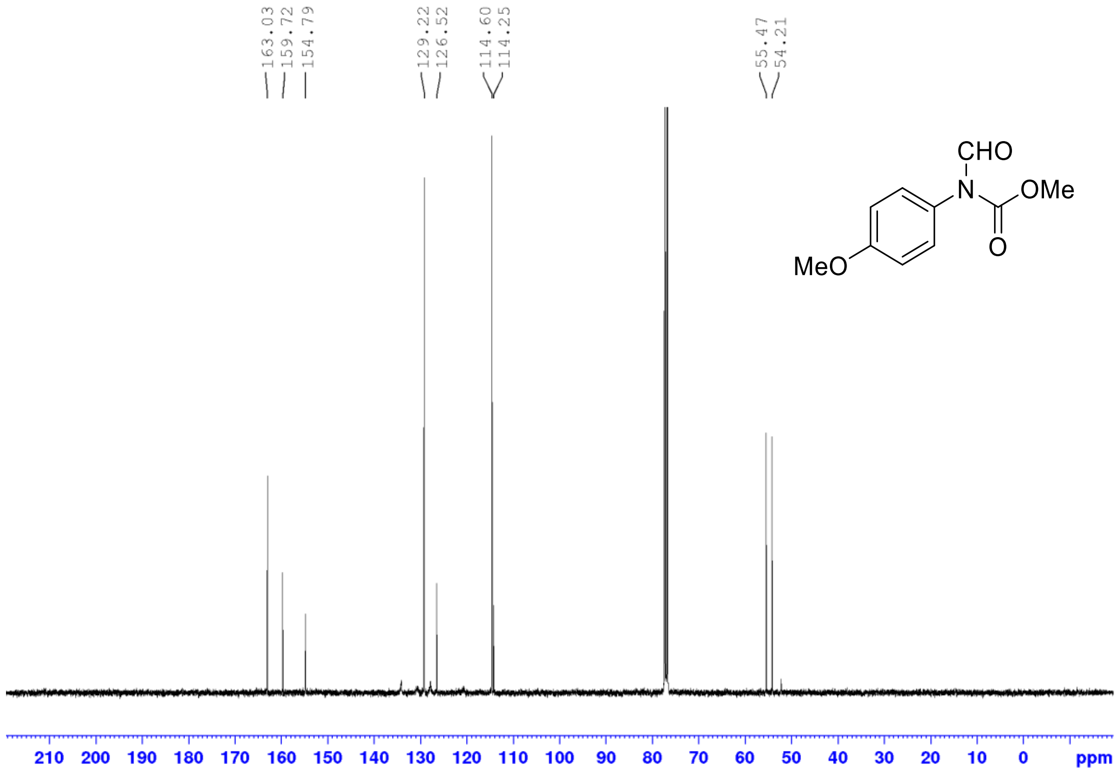
^1H NMR of **3g**. (400 MHz, $CDCl_3$)



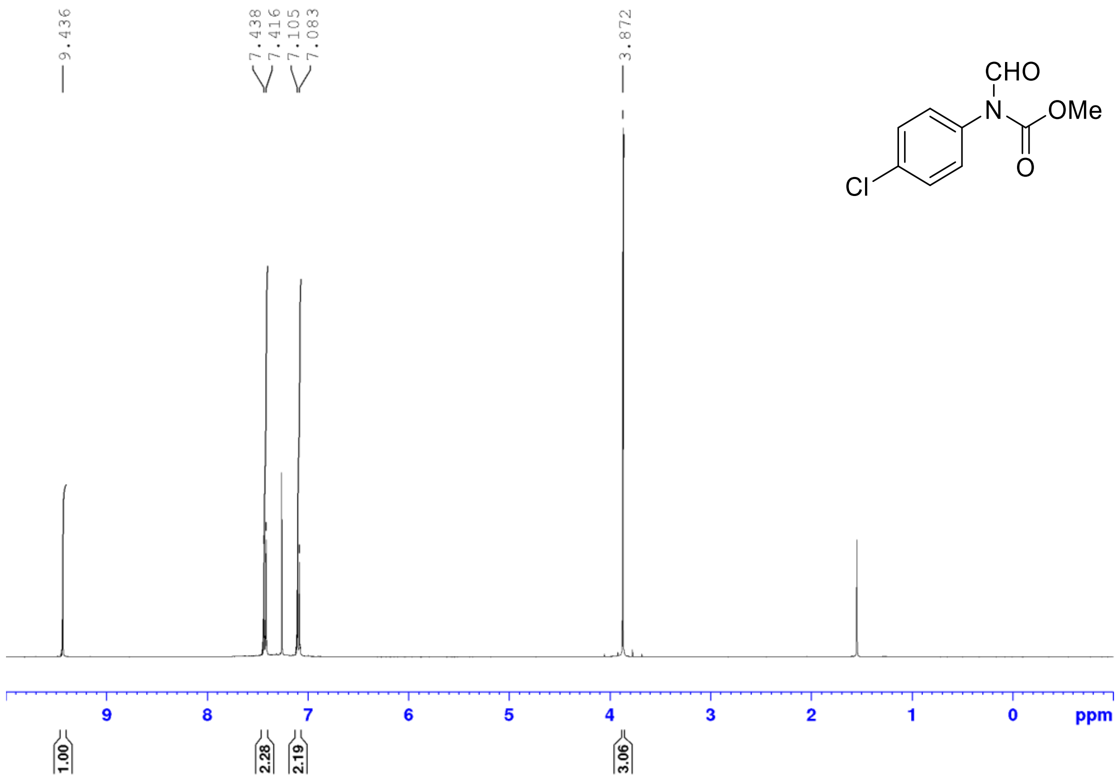
^{13}C {^1H} NMR of **3g**. (100 MHz, $CDCl_3$)



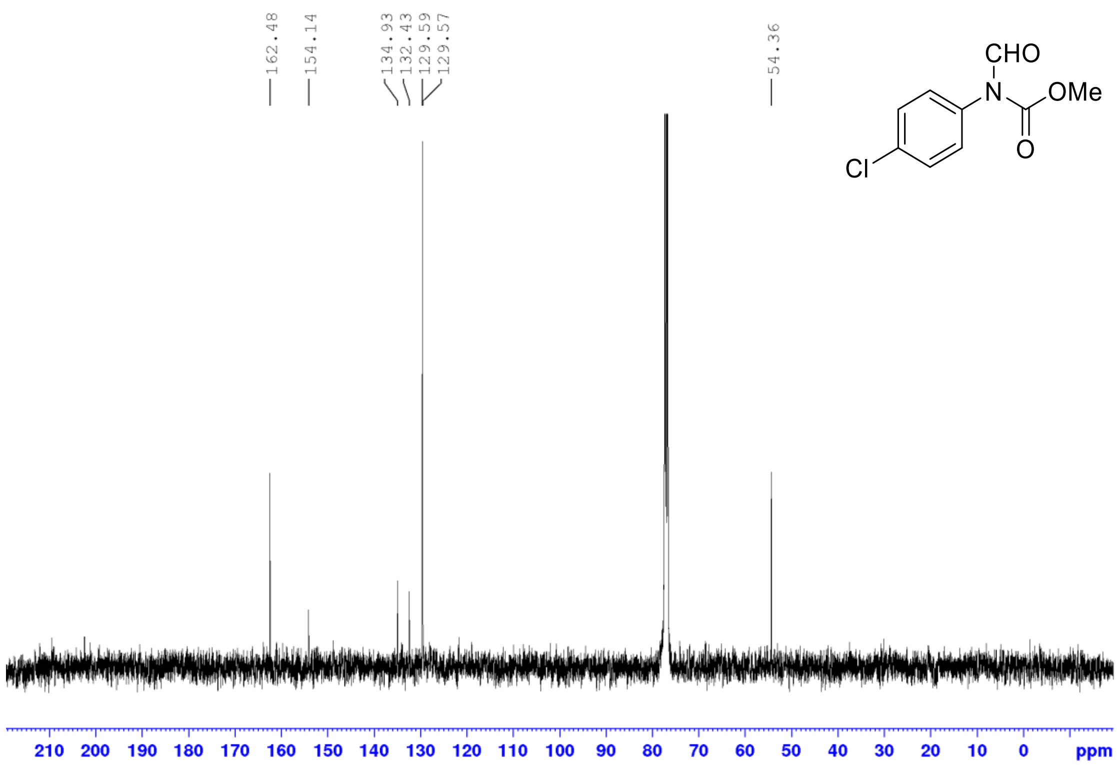
^{1}H NMR of **4g**. (400 MHz, $CDCl_3$)



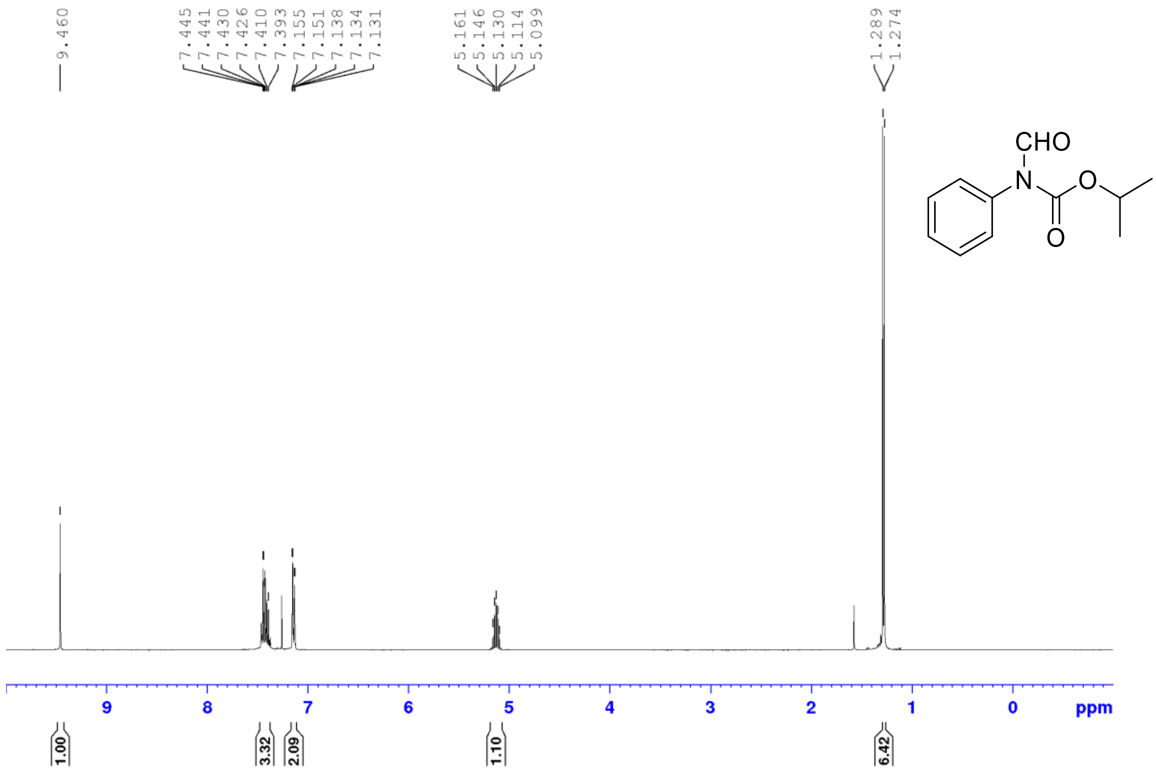
^{13}C {^{1}H} NMR of **4g**. (100 MHz, $CDCl_3$)



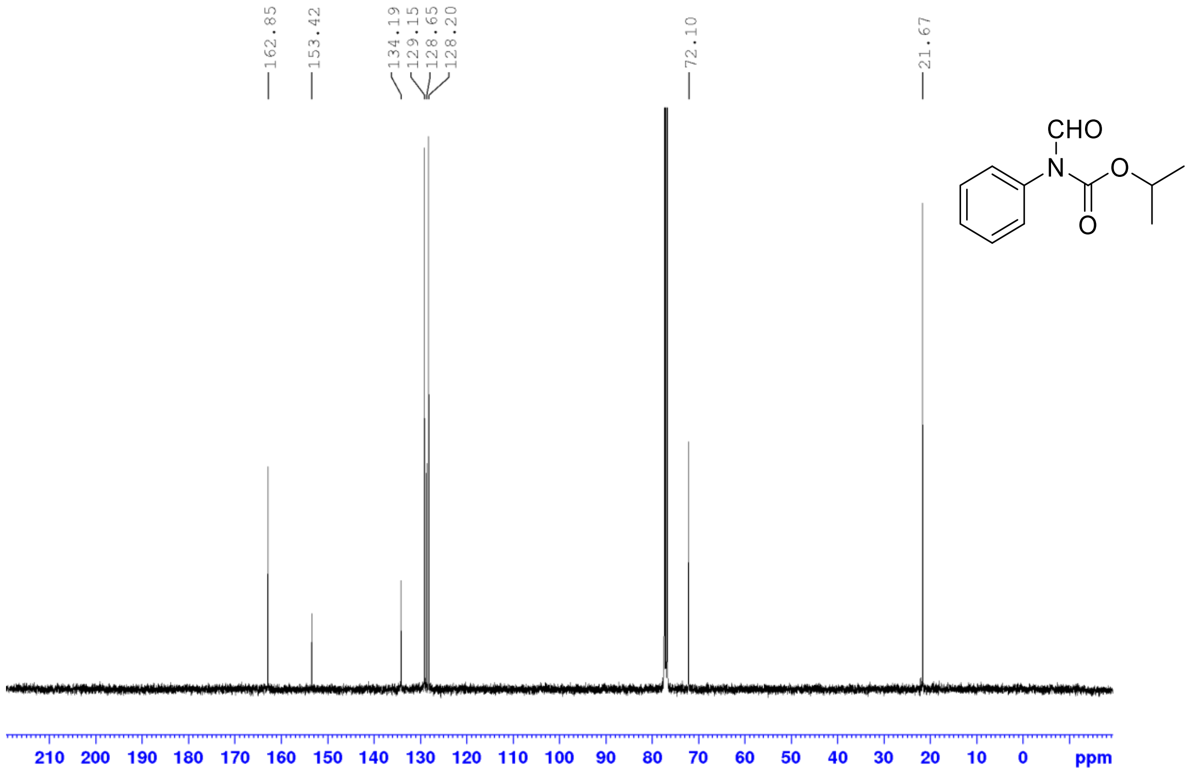
^{1}H NMR of **5g**. (400 MHz, $CDCl_3$)



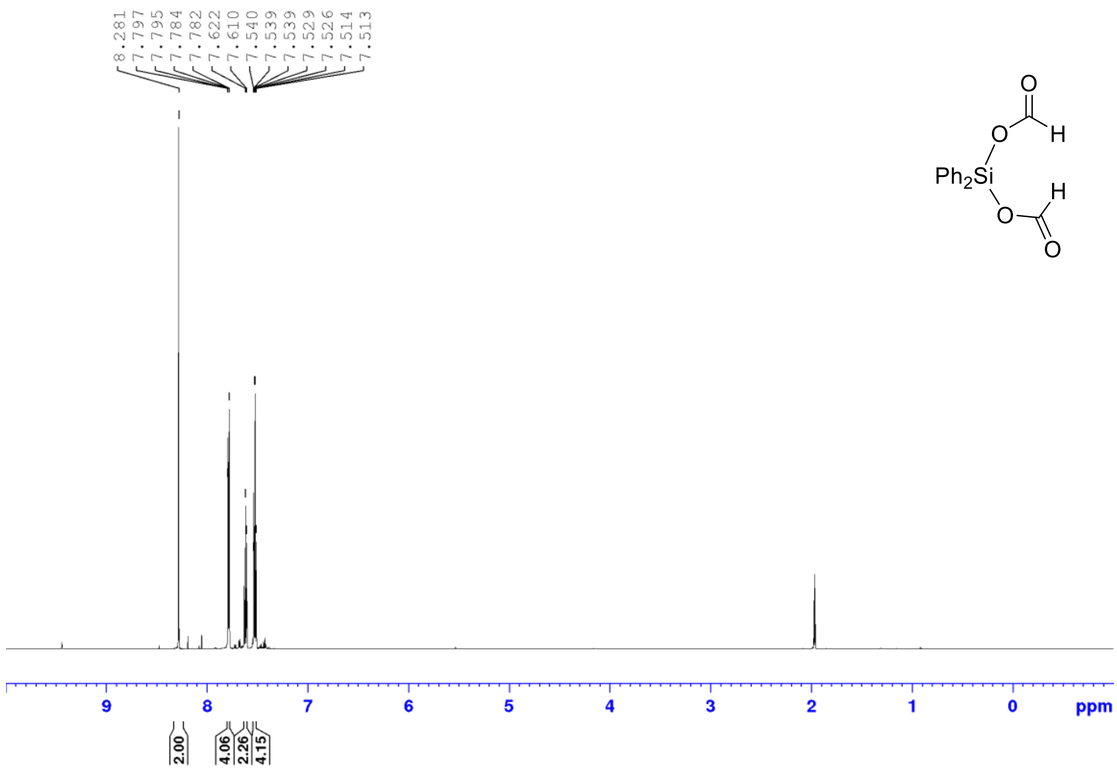
^{13}C {^{1}H} NMR of **5g**. (100 MHz, $CDCl_3$)



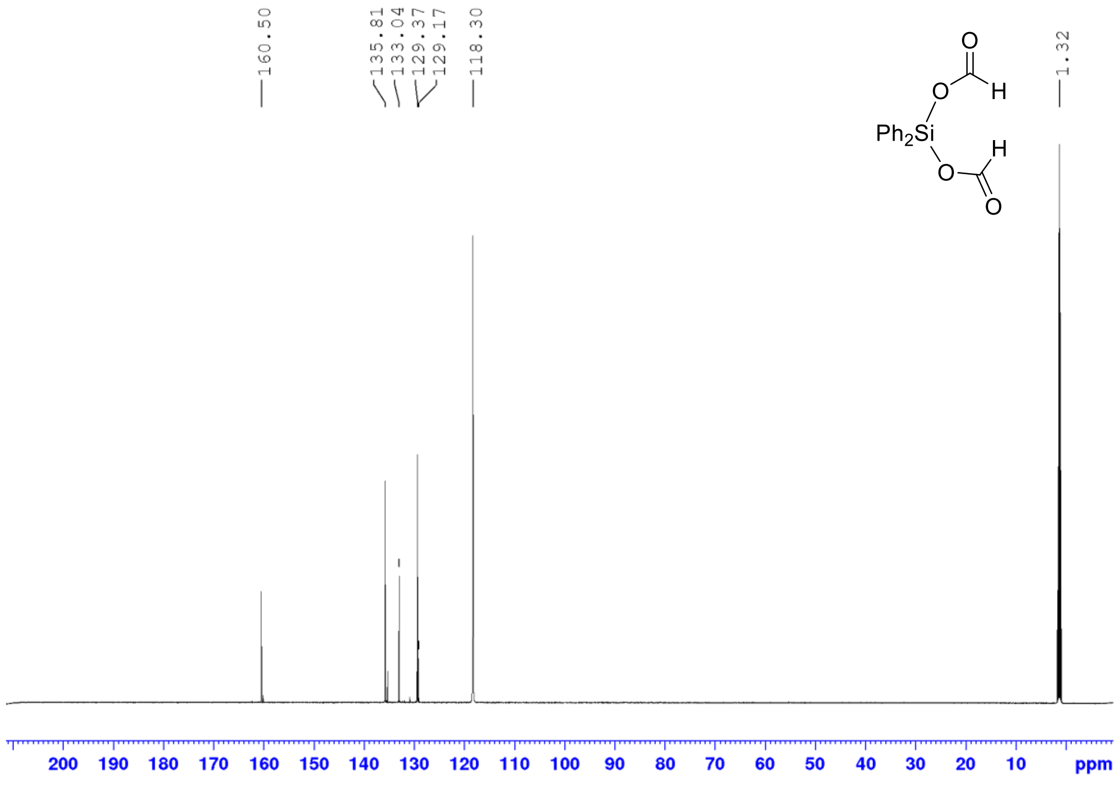
^{1}H NMR of **6g**. (400 MHz, $CDCl_3$)



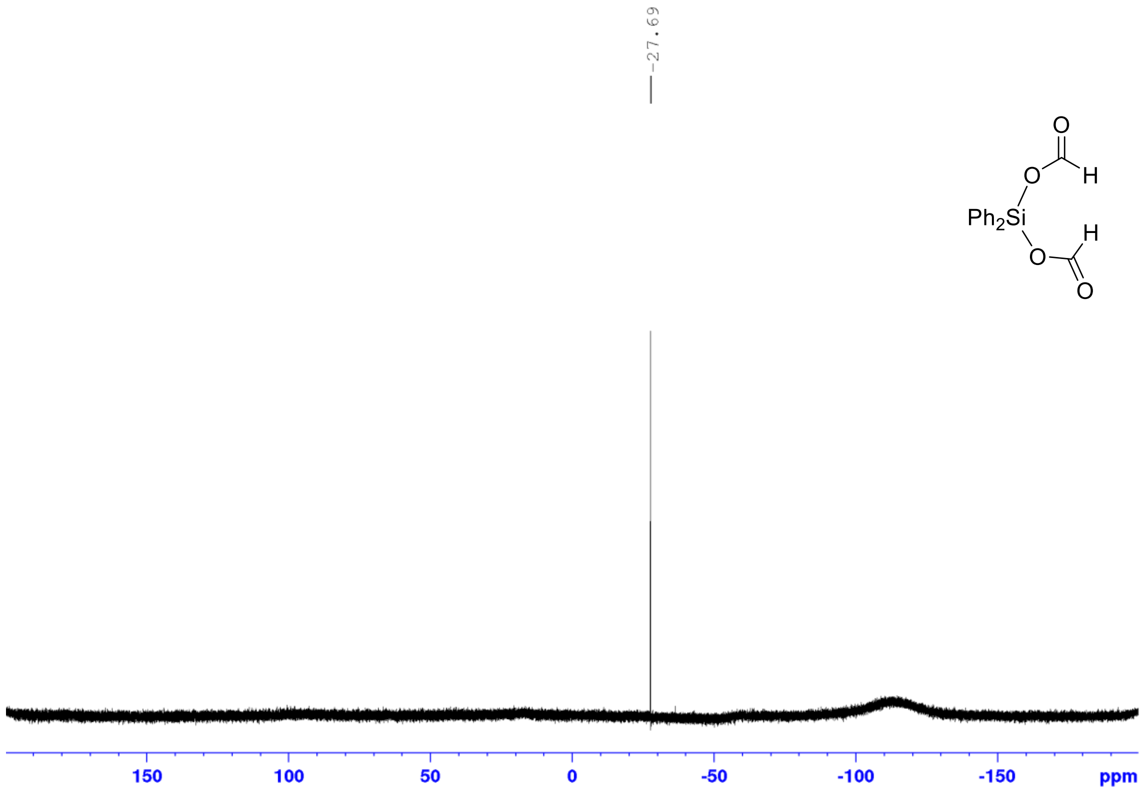
^{13}C {^{1}H} NMR of **6g**. (100 MHz, $CDCl_3$)



[1]H NMR of **$Ph_2Si(OCHO)_2$**. (400 MHz, CD_3CN)



[13]C {[1]H} NMR of **$Ph_2Si(OCHO)_2$**. (100 MHz, CD_3CN)



^{29}Si {^{1}H} NMR of **$Ph_2Si(OCHO)_2$**. (79.5 MHz, CD_3CN)