Supporting Information

Bis(trialkylsilyl) peroxides as alkylating agents in the copper-catalyzed selective mono-*N*-alkylation of primary amides

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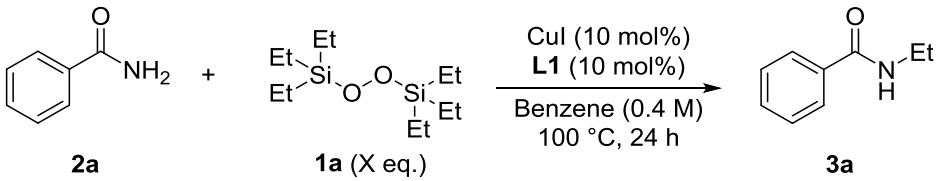
General Information

^{1}H NMR spectra were measured on JEOL JNM-ECA500 (500 MHz) spectrometer. Data were reported as follows: chemical shifts in ppm from tetramethylsilane as an internal standard in $CDCl_3$, integration, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, br = broad), coupling constants (Hz), and assignment. ^{13}C NMR spectra were measured on JEOL JNM-ECA500 (125 MHz) spectrometer with complete proton decoupling. Chemical shifts were reported in ppm from the residual solvent as an internal standard. ^{29}Si NMR spectra were measured on JEOL JNM-ECA500 (100 MHz) spectrometer. Infrared (IR) spectra were recorded on a Thermo Scientific Nicolet iS5 spectrometer. High-resolution mass spectra (HRMS) were performed on Thermo Exactive plus. The products were purified by flash column chromatography (silica gel 60, Merck, 230-400 mesh) or preparative thin layer chromatography silica gel (PLC 60 F254. 0.5 mm). Commercially available reagents were purchased from Wako, Sigma-Aldrich, TCI and Alfa-aesar chemicals and used as received. Benzene was used after the distillation from CaH_2.

Optimization of Reaction Conditions of *N*-Ethylation of Benzamide 2a with 1a.

Table S1. The effect of the amount of peroxide [a]

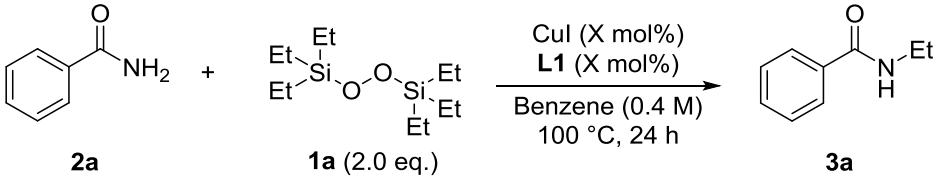


2a **1a** (X eq.) **3a**

Entry	**X**	**3a** (%) [b]	**2a** (%) [b]
1	1.0	37	56
2	2.0	60	23
3	3.0	66	24
4 [c]	2.0+2.0	81	4

[a] Reaction conditions: bezamide **2a** (0.1 mmol, 1.0 eq.), **1a** (X eq.), CuI (10 mol%), **L1** (10 mol%), benzene (0.25 mL, 0.4 M), 100 °C, 24 h. [b] Yield was determined by ^{1}H NMR spectroscopy using DMF as an internal standard. [c] **1a** (0.2 mmol, 2.0 eq.) was added to the reaction mixture after stirring for 1h.

Table S2. The effect of the amount of catalyst and ligand [a]

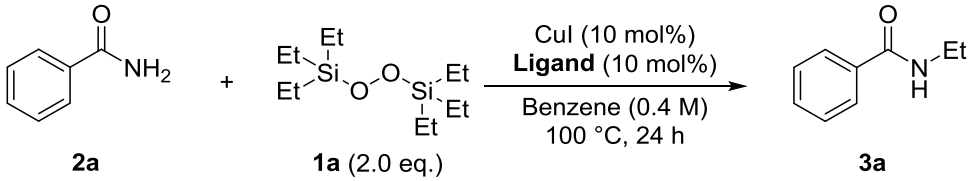


2a **1a** (2.0 eq.) **3a**

Entry	**X**	Yield of **3a** (%) [b]
1	5	55
2	10	60
3	20	62

[a] Reaction conditions: bezamide **2a** (0.1 mmol, 1.0 eq.), **1a** (0.2 mmol, 2.0 eq.), CuI (X mol%), bipyrimidine (X mol%), benzene (0.25 mL, 0.4 M), 100 °C, 24 h. [b] Yield was determined by ^{1}H NMR spectroscopy using DMF as an internal standard.

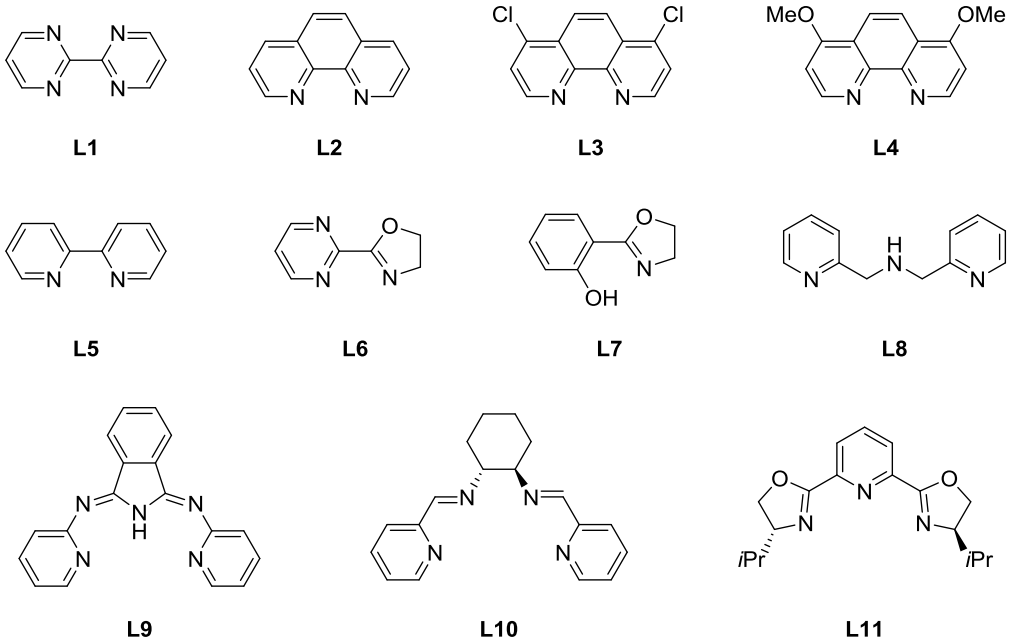
Table S3. The effect of ligand [a]



2a + **1a** (2.0 eq.) → **3a**

Entry	**Ligand**	Yield of **3a** (%) [b]
1	none	45
2	**L1**	60
3	**L2**	71
4	**L3**	61
5	**L4**	71
6	**L5**	57
7	**L6**	50
8	**L7**	53
9	**L8**	39
10	**L9**	0
11	**L10**	44
12	**L11**	38

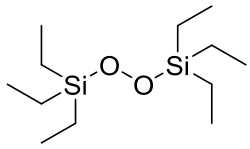
[a] Reaction conditions: bezamide **2a** (0.1 mmol, 1.0 eq.), **1a** (0.2 mmol, 2.0 eq.), CuI (10 mol%), ligand (10 mol%), benzene (0.25 mL, 0.4 M), 100 °C, 24 h. [b] Yield was determined by ^{1}H NMR spectroscopy using DMF as an internal standard.



General Procedure for the Synthesis of Bis(trialkylsilyl) Peroxide (1)

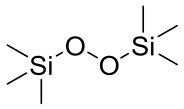
To a solution of 1,4-diazabicyclo[2.2.2]octane（1.12 g, 10.0 mmol, 1.0 eq.) and H_2O_2·urea complex (941 mg, 10.0 mmol, 1.0 eq.) in dry dichloromethane (20 mL) was added a trialkylsilyl chloride (1.0 eq.) slowly at 0 ˚C under argon atmosphere. After 3 h of stirring at room temperature, to the reaction mixture was added pentane (20 mL), and the white precipitate was removed by filtration. Solvent was evaporated and the residue was purified by flash column chromatography on silica gel (eluting with pentane) to afford a corresponding product.

Bis(triethylsilyl) peroxide (1a) [1]



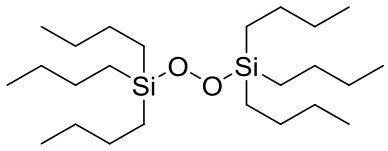
Colorless oil.
^{1}H NMR (500 MHz, $CDCl_3$) δ 0.98 (18H, t, J = 7.9 Hz, CH_3), 0.68 (12H, q, J = 7.9 Hz, SiCH_2); ^{13}C NMR (125 MHz, $CDCl_3$) δ 6.92, 4.01; ^{29}Si NMR (100 MHz, $CDCl_3$) δ 28.62.

Bis(trimethylsilyl) peroxide (1b) [2]



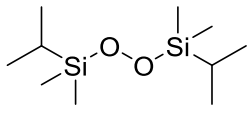
Colorless oil.
^{1}H NMR (500 MHz, $CDCl_3$) δ 0.19 (18H, s, SiCH_3); ^{13}C NMR (125 MHz, $CDCl_3$) δ –1.16; ^{29}Si NMR (100 MHz, $CDCl_3$) δ 27.86.

Bis(tributylsilyl) peroxide (1c)



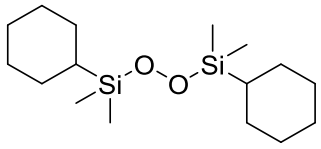
Colorless oil.
^{1}H NMR (500 MHz, $CDCl_3$) δ 1.35-1.32 (24H, m), 0.89 (18H, t, J = 6.8 Hz, CH_3), 0.69-0.65 (12H, m, SiCH_2); ^{13}C NMR (125 MHz, $CDCl_3$) δ 26.7, 25.6, 13.9, 12.8; ^{29}Si NMR (100 MHz, $CDCl_3$) δ 26.51; HRMS calculated for $C_{24}H_{54}O_2NaSi_2$: *m/z* 453.3555 ([M + Na]$^+$), found: *m/z* 453.3545 ([M + Na]$^+$); IR (neat) 2956, 2922, 1465, 1195, 1081, 884, 782 cm^{-1}.

Bis(dimethylisopropylsilyl) peroxide (1d)



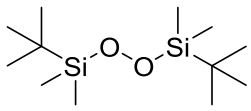
Colorless oil.
^{1}H NMR (500 MHz, $CDCl_3$) δ 0.98-0.97 (14H, m), 0.12 (12H, s, SiCH_3); ^{13}C NMR (125 MHz, $CDCl_3$) δ 17.2, 13.9, –4.82; ^{29}Si NMR (100 MHz, $CDCl_3$) δ 28.84; HRMS calculated for $C_{10}H_{26}O_2NaSi_2$: *m/z* 257.1364 ([M + Na]$^+$), found: *m/z* 257.1360 ([M + Na]$^+$); IR (neat) 2944, 2867, 1463, 1249, 1000, 813, 778 cm^{-1}.

Bis(dicyclohexylmethylsilyl) peroxide (1e)



Colorless oil.
^{1}H NMR (500 MHz, $CDCl_3$) δ 1.73-1.66 (10H, m, CH_2), 1.23-1.12 (10H, m, CH_2), 0.85-0.80 (2H, m, CH_2), 0.12 (12H, m, SiCH_3); ^{13}C NMR (125 MHz, $CDCl_3$) δ 28.1, 28.0, 27.1,27.0, 25.9, –1.41, –4.46; ^{29}Si NMR (100 MHz, $CDCl_3$) δ 26.88; HRMS calculated for $C_{16}H_{34}O_2NaSi_2$: *m/z* 337.1990 ([M + Na]$^+$), found: *m/z* 337.1983 ([M + Na]$^+$); IR (neat) 2918, 2848, 1446, 1247, 818, 778 cm^{-1}.

Bis(*tert*-butyldimethylmethylsilyl) peroxide (1f)

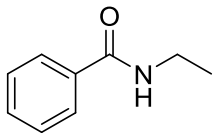


Colorless oil.
^{1}H NMR (500 MHz, $CDCl_3$) δ 0.93 (18H, s, CH_3), 0.14 (12H, s, SiCH_3); ^{13}C NMR (125 MHz, $CDCl_3$) δ 26.4, 18.5, –5.59; ^{29}Si NMR (100 MHz, $CDCl_3$) δ 29.30; HRMS calculated for $C_{12}H_{30}O_2NaSi_2$: *m/z* 285.1677 ([M + Na]$^+$), found: *m/z* 285.1674 ([M + Na]$^+$); IR (neat) 2955, 2878, 1458, 1238, 1005, 782, 725 cm^{-1}.

General Procedure for Mono-*N*-Alkylation of Amide (2) with Disilyl Peroxide (1)

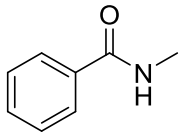
To a solution of amide **2** (0.2 mmol, 1.0 eq.), CuI (3.8 mg, 10 mol%) and 1,10-phenanthroline (3.6 mg, 10 mol%) in benzene (0.5 mL) was added disilyl peroxide **1** (0.4 mmol, 2.0 eq.) under argon atmosphere. The reaction mixture was stirred at 100 ˚C for 1 h. After cooling to room temperature, the reaction mixture was quenched with H_2O, extracted with Et_2O for three times. The combined organic layer was washed with brine, dried over Na_2SO_4 and concentrated. The residue was purified by flash column chromatography on silica gel (eluting with ethyl acetate/hexane = 2/3) to afford a corresponding product.

***N*-Ethylbenzamide (3a)** [3]



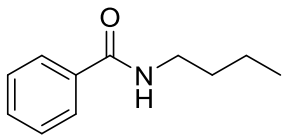
White solid, 18.6 mg, 62% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.77-7.75 (2H,), 7.49-7.47 (1H, m, ArH), 7.44-7.40 (2H, m, ArH), 6.14 (1H, br, NH), 3.53-3.47 (2H, m, NCH_2), 1.25 (3H, t, J = 7.4 Hz, CH_3); ^{13}C NMR (125 MHz, $CDCl_3$) δ 167.6, 134.9, 131.5, 128.7, 127.0, 35.1, 15.0.

_N_-Methylbenzamide (3b) [4]



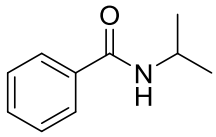
$Me_3SiO\text{-}OSiMe_3$ (**1b**) (4.0 eq.) was used for the reaction.
White solid, 10.0 mg, 37% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.76-7.75 (2H, m, Ar*H*), 7.51-7.48 (1H, m, Ar*H*), 7.44-7.41 (2H, m, Ar*H*), 6.13 (1H, br, N*H*), 3.02 (3H, d, NCH_3, J = 4.8 Hz); ^{13}C NMR (125 MHz, $CDCl_3$) δ 168.5, 134.8, 131.5, 128.7, 127.0, 27.0.

_N_-Butylbenzamide (3c) [5]



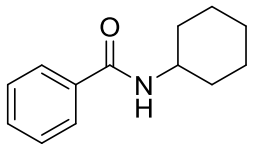
$n Bu_3SiO\text{-}OSi n Bu_3$ (**1c**) (4.0 eq.) was used for the reaction.
White solid, 20.2 mg, 57% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.76-7.75 (2H, m, Ar*H*), 7.51-7.47 (1H, m, Ar*H*), 7.44-7.41 (2H, m, Ar*H*), 6.08 (1H, br, N*H*), 3.49-3.45 (2H, m, NCH_2), 1.62-1.58 (2H, m, CH_2), 1.45-1.40 (2H, m, CH_2), 0.97 (3H, t, J = 7.4 Hz, CH_3); ^{13}C NMR (125 MHz, $CDCl_3$) δ 167.7, 134.8, 131.0, 128.2, 127.0, 39.8, 31.6, 20.1, 13.7.

_N_-Isopropylbenzamide (3d) [6]



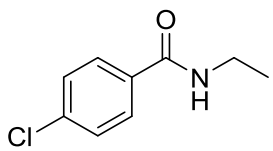
White solid, 20.6 mg, 63% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.76-7.74 (2H, m, Ar*H*), 7.50-7.47 (1H, m, Ar*H*), 7.44-7.41 (2H, m, Ar*H*), 5.89 (1H, br, N*H*), 4.33-4.26 (1H, m, NC*H*), 1.27 (6H, d, J = 6.5 Hz, CH_3); ^{13}C NMR (125 MHz, $CDCl_3$) δ 166.8, 135.2, 131.4, 128.7, 126.9, 42.0, 23.0.

_N_-Cyclohexylbenzamide (3e) [7]



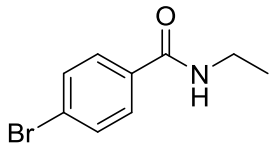
White solid, 24.8 mg, 61% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.76-7.74 (2H, m, Ar*H*), 7.49-7.47 (1H, m, Ar*H*), 7.44-7.42 (2H, m, Ar*H*), 5.94 (1H, br, N*H*), 4.02-3.96 (1H, m, NC*H*), 2.06-2.02 (2H, m, CH_2), 1.77-1.74 (2H, m, CH_2), 1.68-1.64 (1H, m, CH_2), 1.48-1.40 (2H, m, CH_2), 1.28-1.20 (3H, m, CH_2); ^{13}C NMR (125 MHz, $CDCl_3$) δ 166.8, 135.3, 131.4, 128.7, 127.0, 48.8, 33.4, 25.7, 25.1.

4-Chloro-_N_-ethylbenzamide (4a) [8]



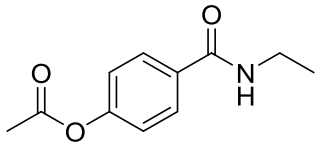
Pale yellow solid, 23.2 mg, 63% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.71-7.69 (2H, m, Ar*H*), 7.41-7.39 (2H, m, Ar*H*), 6.03 (1H, br, N*H*), 3.52-3.47 (2H, m, NCH_2), 1.26 (3H, t, J = 7.4 Hz, CH_3); ^{13}C NMR (125 MHz, $CDCl_3$) δ 166.5, 137.7, 133.3, 128.9, 128.4, 35.2, 15.0.

4-Bromo-*N*-ethylbenzamide (4b) [9]



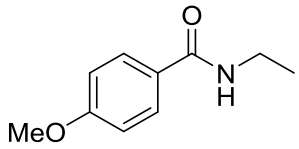
Pale yellow solid, 27.4 mg, 60% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.64-7.62 (2H, m, Ar*H*), 7.58-7.56 (2H, m, Ar*H*), 6.02 (1H, br, N*H*), 3.52-3.47 (2H, m, NCH_2), 1.26 (3H, t, J = 7.4 Hz, CH_3); ^{13}C NMR (125 MHz, $CDCl_3$) δ 166.6, 133.8, 131.9, 128.6, 126.1, 35.2, 15.0.

4-Acetoxy-*N*-ethylbenzamide (4c)



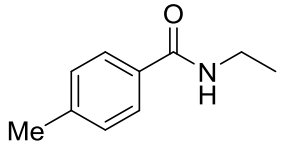
Et_3SiO-$OSiEt_3$ (**1a**) (4.0 eq.) was used for the reaction.
White solid, 19.9 mg, 48% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.78 (2H, d, J = 8.8 Hz, Ar*H*), 7.16 (2H, d, J = 8.8 Hz, Ar*H*), 6.00 (1H, br, N*H*), 3.53-3.47 (2H, m, NCH_2), 2.32 (3H, s, CH_3), 1.25 (3H, t, J = 7.4 Hz, CH_3); ^{13}C NMR (125 MHz, $CDCl_3$) δ 169.2, 166.7, 153.1, 132.6, 128.4, 121.9, 35.1, 21.3, 15.0; HRMS calculated for $C_{11}H_{13}O_3NNa$: *m/z* 230.0788 ([M + Na]$^+$), found: *m/z* 230.0787 ([M + Na]$^+$); IR (neat) 3305, 2921, 1749, 1634, 1540, 1255, 1198 cm^{-1}.

***N*-Ethyl-4-methoxybenzamide (4d)** [8]



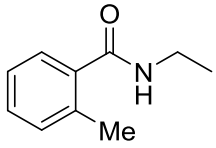
White solid, 20.1 mg, 56% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.74-7.72 (2H, m, Ar*H*), 6.93-6.91 (2H, m, Ar*H*), 5.98 (1H, br, N*H*), 3.85 (1H, s, OCH_3), 3.52-3.46 (2H, m, NCH_2), 1.25 (3H, t, J = 7.4 Hz, CH_3); ^{13}C NMR (125 MHz, $CDCl_3$) δ 167.1, 162.2, 128.7, 127.3, 113.9, 55.5, 35.0, 15.2.

***N*-Ethyl-4-methylbenzamide (4e)** [8]



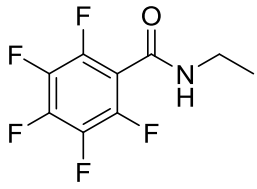
White solid, 19.6 mg, 60% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.66 (2H, d, J = 8.2 Hz, Ar*H*), 7.23 (2H, d, J = 8.2 Hz, Ar*H*), 6.03 (1H, br, N*H*), 3.52-3.47 (2H, m, NCH_2), 2.39 (3H, s, ArCH_3), 1.25 (3H, t, J = 7.1 Hz, CH_3); ^{13}C NMR (125 MHz, $CDCl_3$) δ 167.5, 141.8, 132.1, 129.3, 127.0, 35.0, 21.6, 15.1.

***N*-Ethyl-2-methylbenzamide (4f)** [9]



White solid, 19.9 mg, 61% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.35-7.34 (1H, m, Ar*H*), 7.31-7.28 (1H, m, Ar*H*), 7.22-7.18 (2H, m, Ar*H*), 5.70 (1H, br, N*H*), 3.51-3.46 (2H, m, NCH_2), 2.45 (3H, s, ArCH_3), 1.25 (3H, t, J = 7.4 Hz, CH_3); ^{13}C NMR (125 MHz, $CDCl_3$) δ 170.2, 136.9, 136.1, 131.1, 129.9, 126.7, 125.8, 34.8, 19.8, 15.1.

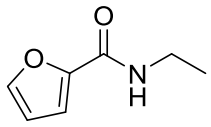
***N*-Ethyl-2,3,4,5,6-pentafluorobenzamide (4g)**



White solid, 30.1 mg, 63% yield.

^{1}H NMR (500 MHz, $CDCl_3$) δ 5.88 (1H, br, N*H*), 3.55-3.49 (2H, m, NCH_2), 1.27 (3H, t, J = 7.4 Hz, CH_3); ^{13}C NMR (125 MHz, $CDCl_3$) δ 157.3, 145.3(m), 143.3-143.2 (m), 141.3 (m), 138.9-138.7 (m), 136.9-136.7 (m), 35.5, 14.7; HRMS calculated for $C_9H_6ONF_5Na$: *m/z* 262.0262 ([M + Na]$^+$), found: *m/z* 262.0263 ([M + Na]$^+$); IR (neat) 1655, 1502, 1326, 1265, 991, 735 cm^{-1}.

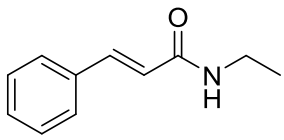
***N*-Ethyl-2-furancarboxamide (4h)** [8]



Pale yellow oil, 14.8 mg, 53% yield.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.42-7.41 (1H, m, Ar*H*), 7.10-7.09 (1H, m, Ar*H*), 6.50-6.48 (1H, m, Ar*H*), 6.32 (1H, br, N*H*), 3.50-3.44 (2H, m, NCH_2), 1.24 (3H, t, J = 7.4 Hz, CH_3); ^{13}C NMR (125 MHz, $CDCl_3$) δ 158.4, 148.3, 143.7, 113.8, 112.1, 34.1, 15.0.

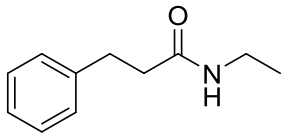
(*E*)-*N*-Ethyl-3-phenyl-2-propenamide (4i)



White solid, 14.0 mg, 40% yield.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.62 (1H, d, J = 15.6 Hz, C*H*), 7.51-7.49 (2H, m, Ar*H*), 7.37-7.34 (3H, m, Ar*H*), 6.37 (1H, d, J = 15.6 Hz, C*H*), 5.55 (1H, br, N*H*), 3.47-3.41 (2H, m, NCH_2), 1.22 (3H, t, J = 7.4 Hz, CH_3); ^{13}C NMR (125 MHz, $CDCl_3$) δ 166.0, 140.9, 135.1, 129.7, 128.9, 127.9, 121.1, 34.7, 15.0; HRMS calculated for $C_{11}H_{13}ONNa$: *m/z* 198.0889 ([M + Na]$^+$), found: *m/z* 198.0893 ([M + Na]$^+$); IR (neat) 3273, 1655, 1616, 1549, 1336, 1225, 977 cm^{-1}.

***N*-Ethyl-3-phenylpropanamide (4j)** [10]

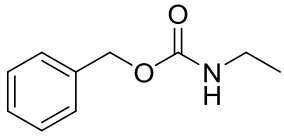


Et_3SiO-$OSiEt_3$ (**1a**) (2.0 eq.) was added to the reaction mixture after 1 h of stirring at 100 ˚C, and then the reaction mixture was stirred at 100 ˚C for another 1 h.

White solid, 18.1 mg, 51% yield.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.30-7.27 (2H, m, Ar*H*), 7.21-7.19 (3H, m, Ar*H*), 5.29 (1H, br, N*H*), 3.27-3.24 (2H, m, NCH_2), 2.96 (2H, t, J = 7.4 Hz, CH_2), 2.45 (2H, t, J = 7.9 Hz, CH_2), 1.06 (3H, t, J = 7.4 Hz, CH_3); ^{13}C NMR (125 MHz, $CDCl_3$) δ 172.0, 141.1, 128.6, 128.5, 126.3, 38.7, 34.4, 31.9, 14.9.

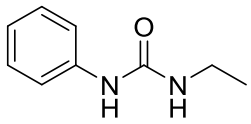
Benzyl *N*-ehylcarbamate (4k) [11]



White solid, 16.9 mg, 47% yield.

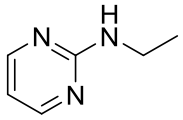
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.39-7.29 (5H, m, Ar*H*), 5.10 (2H, s, OCH_2), 4.68 (1H, br, N*H*), 3.27-3.22 (2H, m, NCH_2), 1.15 (3H, t, J = 7.4 Hz, CH_3); ^{13}C NMR (125 MHz, $CDCl_3$) δ 156.4, 136.7, 128.5-128.0(3 peaks overlap), 66.5, 35.9, 15.2.

1-Ethyl-3-phenylurea (4l) [12]



White solid, 14.5 mg, 44% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.34-7.31 (2H, m, Ar*H*), 7.28-7.27 (2H, m, Ar*H*), 7.12-7.10 (1H, m, Ar*H*), 6.17 (1H, br, N*H*) , 4.63 (1H, br, N*H*), 3.33-3.28 (2H, m, NCH_2), 1.16 (3H, t, J = 7.1 Hz, CH_3); ^{13}C NMR (125 MHz, $CDCl_3$) δ 156.5, 139.1, 129.2, 123.4, 120.7, 35.2, 15.5.

2-Ethylaminopyrimidine (4n) [13]



Et_3SiO-$OSiEt_3$ (**1a**) (4.0 eq.) was used for the reaction.
Pale yellow solid, 9.9 mg, 40% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.21 (2H, d, J = 4.8 Hz, Ar*H*), 6.44 (1H, t, J = 4.8 Hz, Ar*H*), 5.72 (1H, br, N*H*), 3.42-3.36 (2H, m, NCH_2), 1.19 (3H, t, J = 7.1 Hz, CH_3); ^{13}C NMR (125 MHz, $CDCl_3$) δ 162.4, 158.0, 110.2, 36.2, 14.9.

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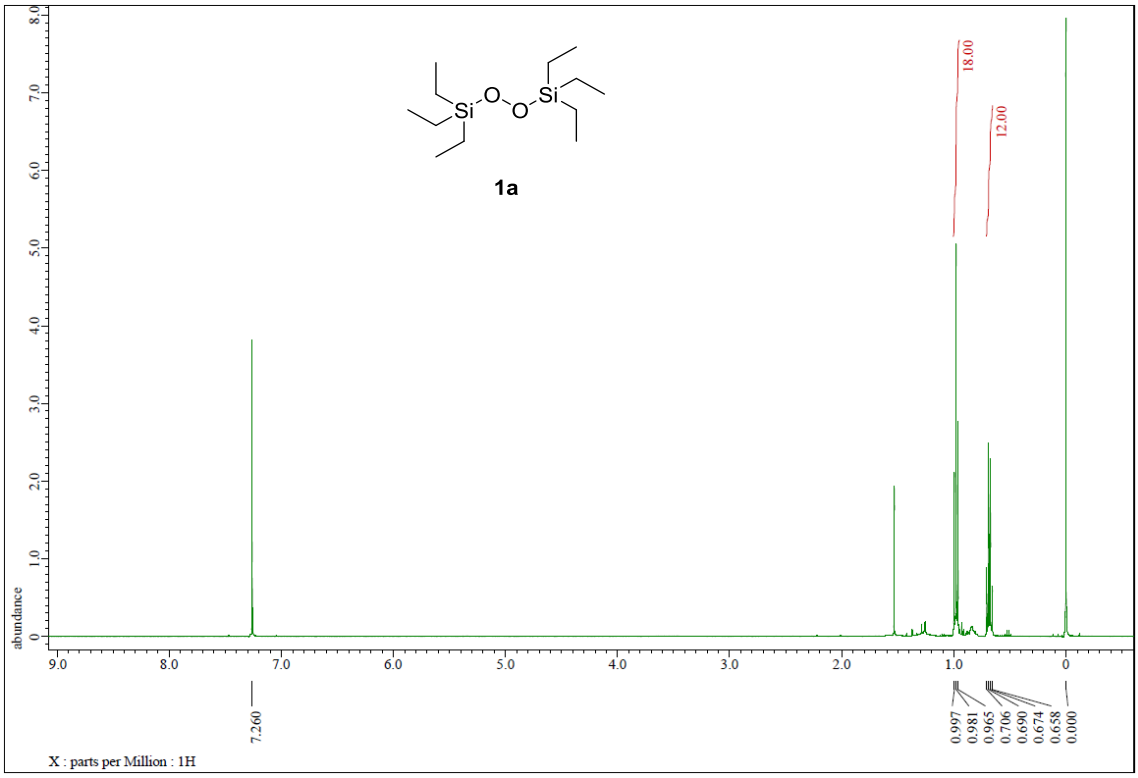
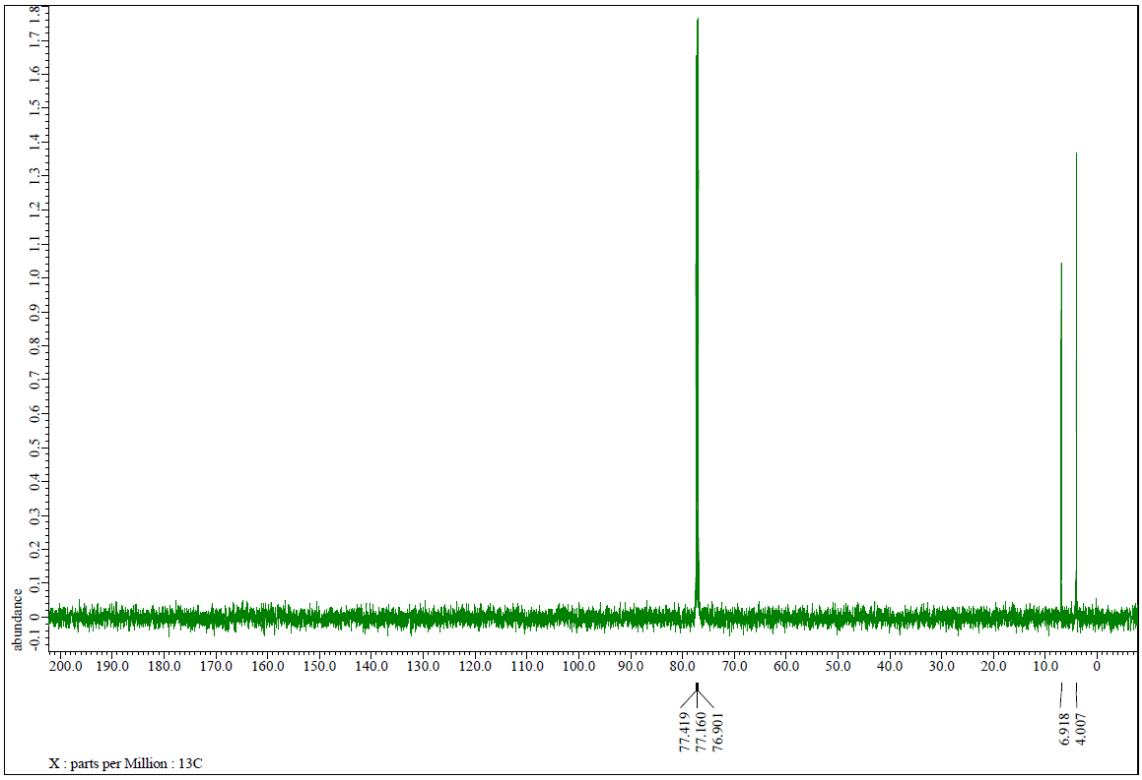
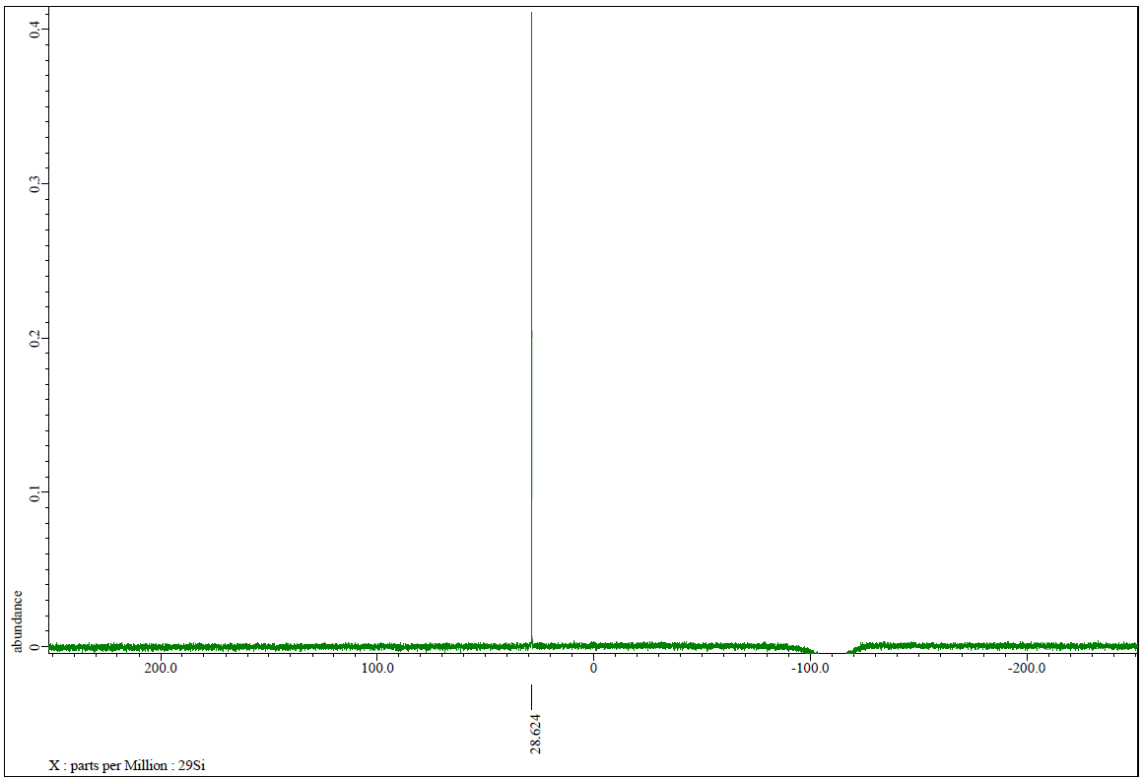
^{1}H NMR spectrum of **1a** ($CDCl_3$, 500 MHz)



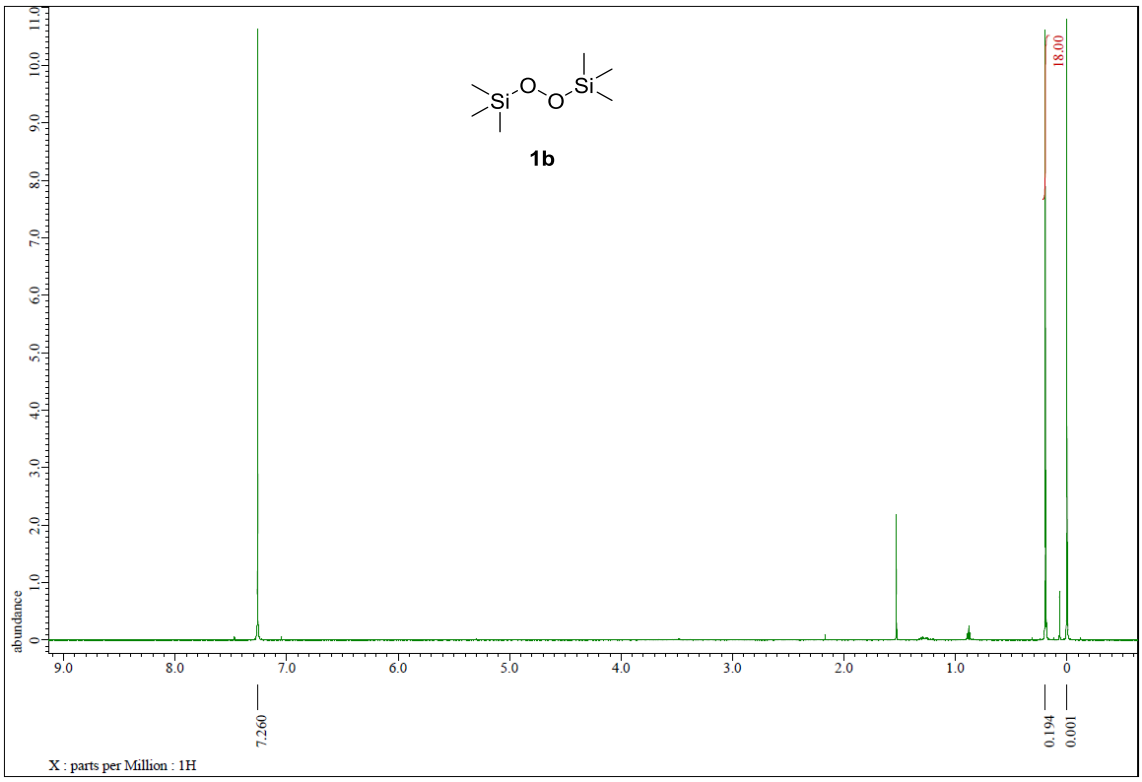
^{13}C NMR spectrum of **1a** ($CDCl_3$, 125 MHz)



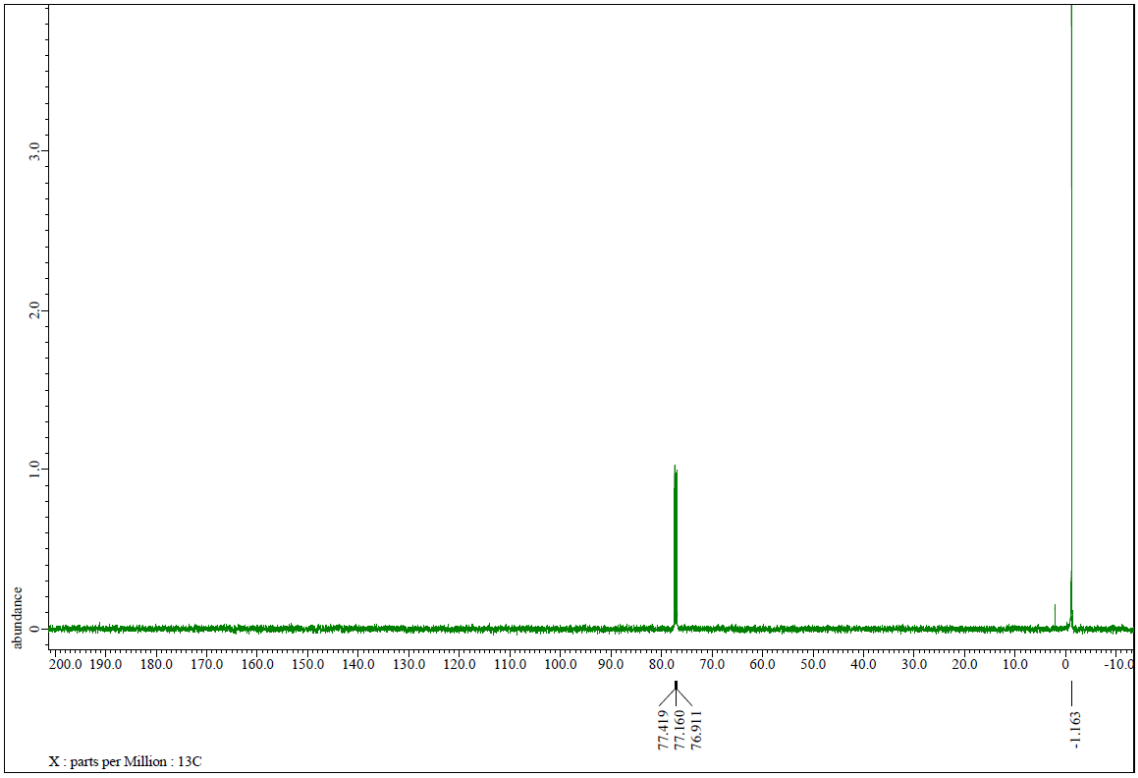
^{29}Si NMR spectrum of **1a** ($CDCl_3$, 100 MHz)



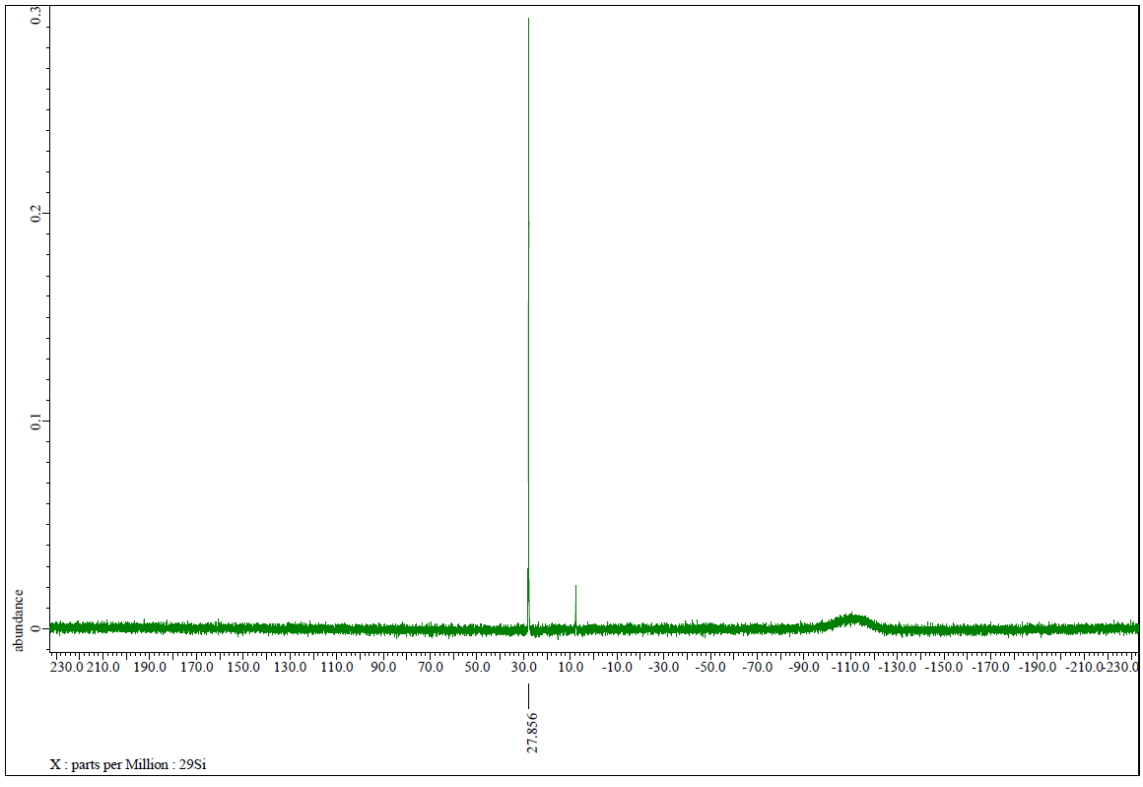
^{1}H NMR spectrum of **1b** ($CDCl_3$, 500 MHz)



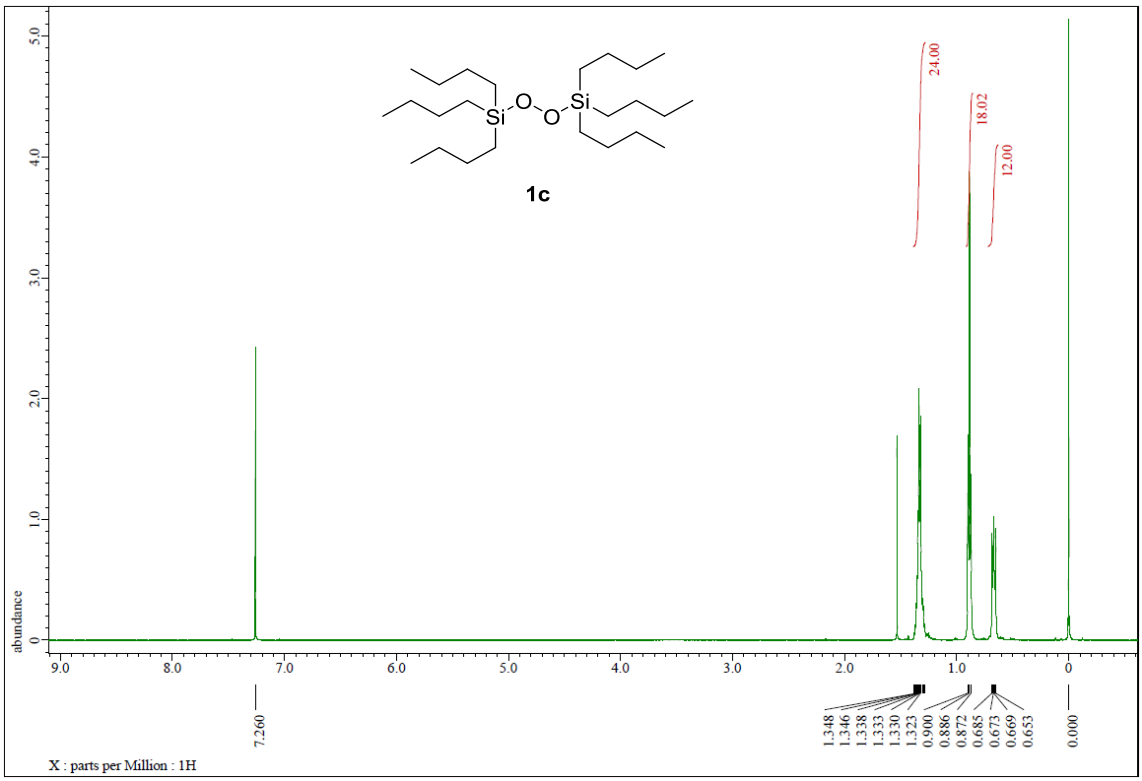
^{13}C NMR spectrum of **1b** ($CDCl_3$, 125 MHz)



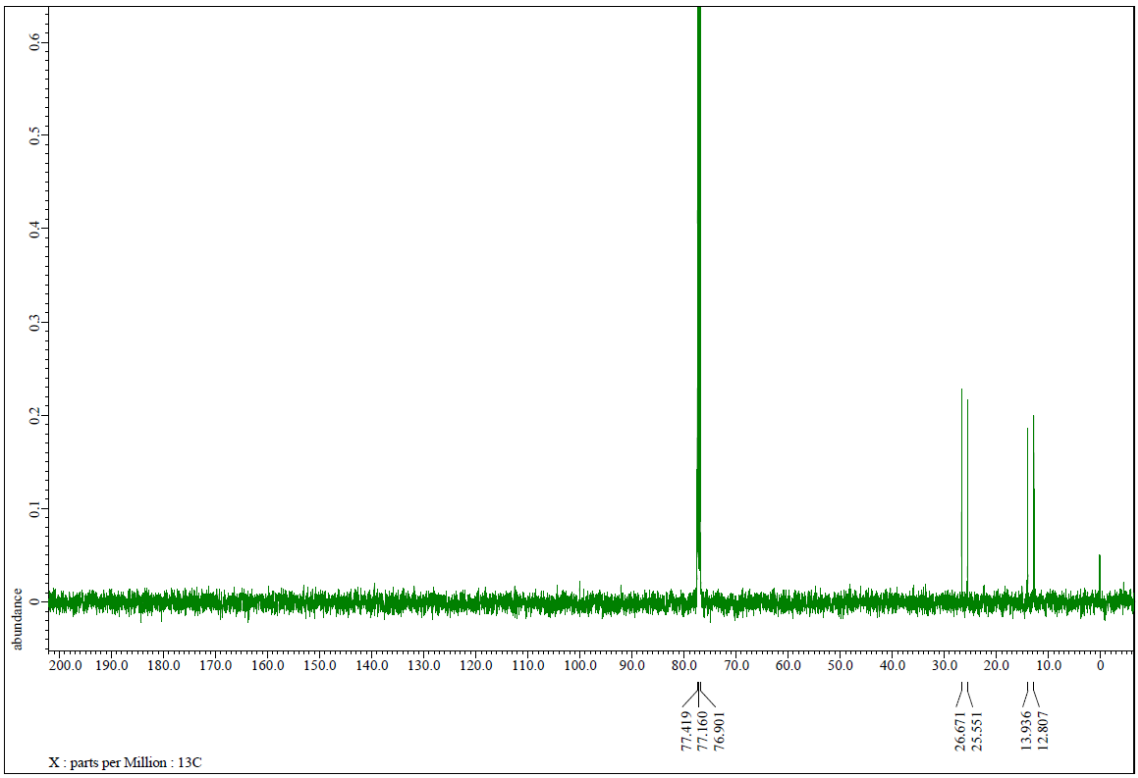
^{29}Si NMR spectrum of **1b** ($CDCl_3$, 100 MHz)



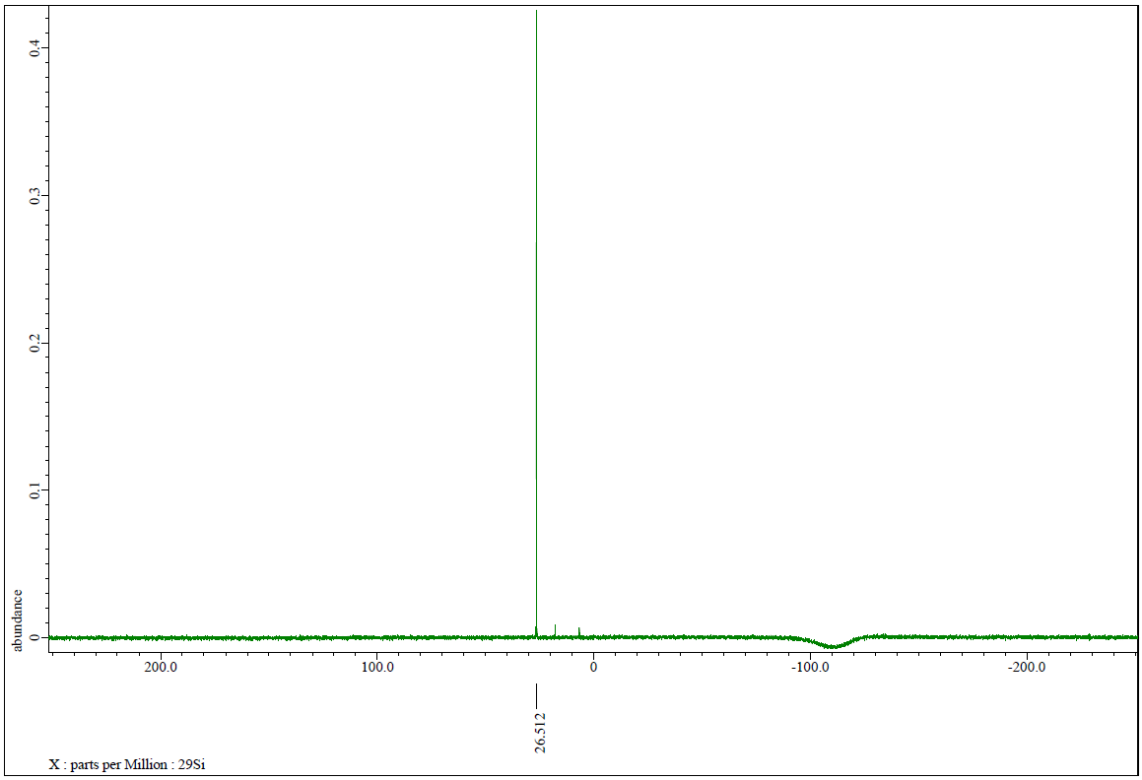
^{1}H NMR spectrum of **1c** ($CDCl_3$, 500 MHz)



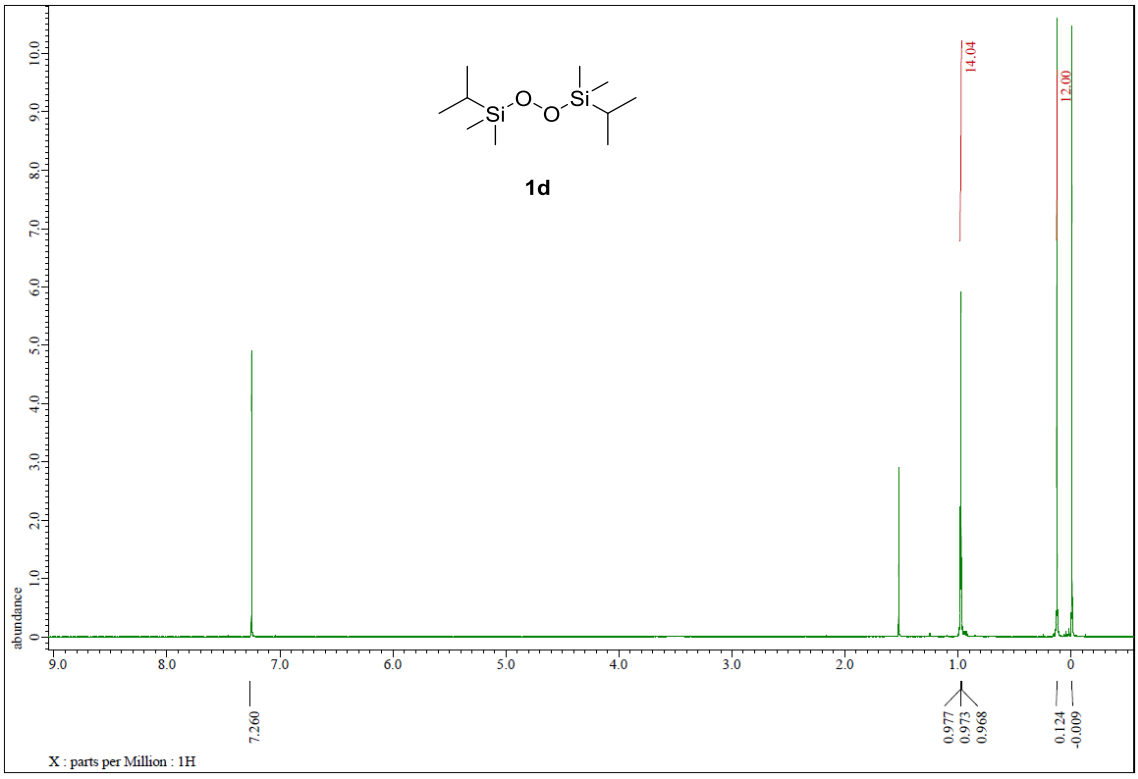
^{13}C NMR spectrum of **1c** ($CDCl_3$, 125 MHz)



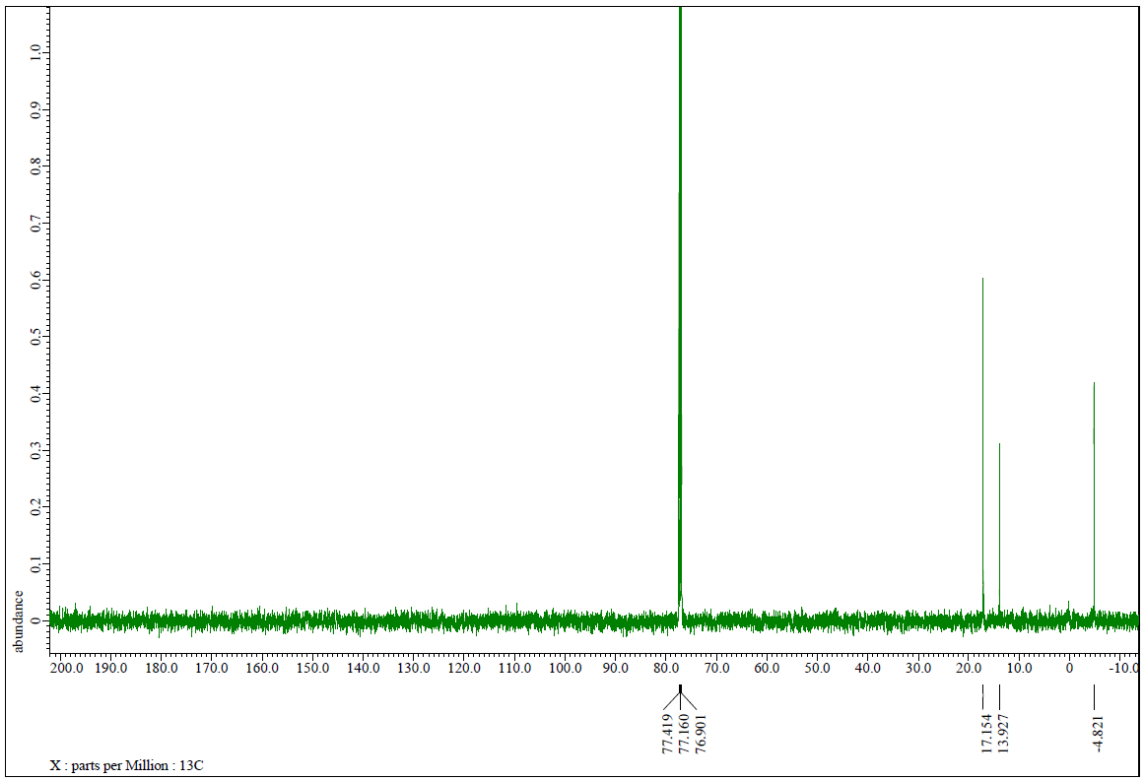
^{29}Si NMR spectrum of **1c** ($CDCl_3$, 100 MHz)



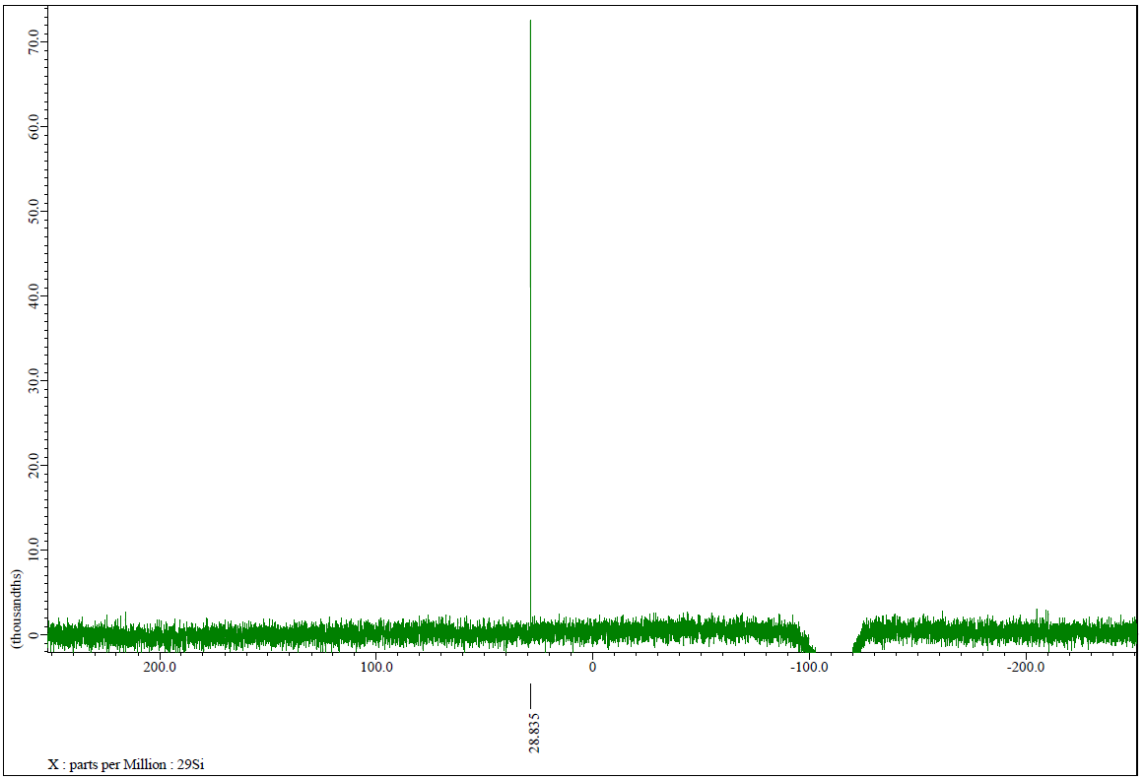
^{1}H NMR spectrum of **1d** ($CDCl_3$, 500 MHz)



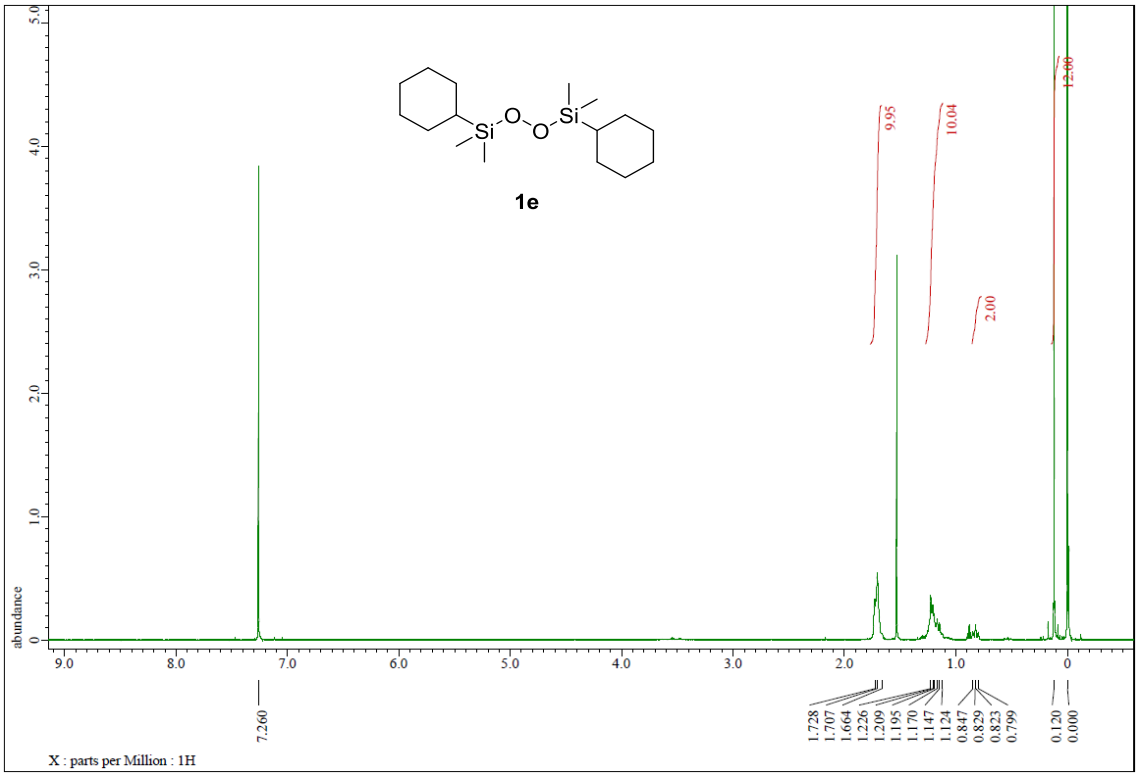
^{13}C NMR spectrum of **1d** ($CDCl_3$, 125 MHz)



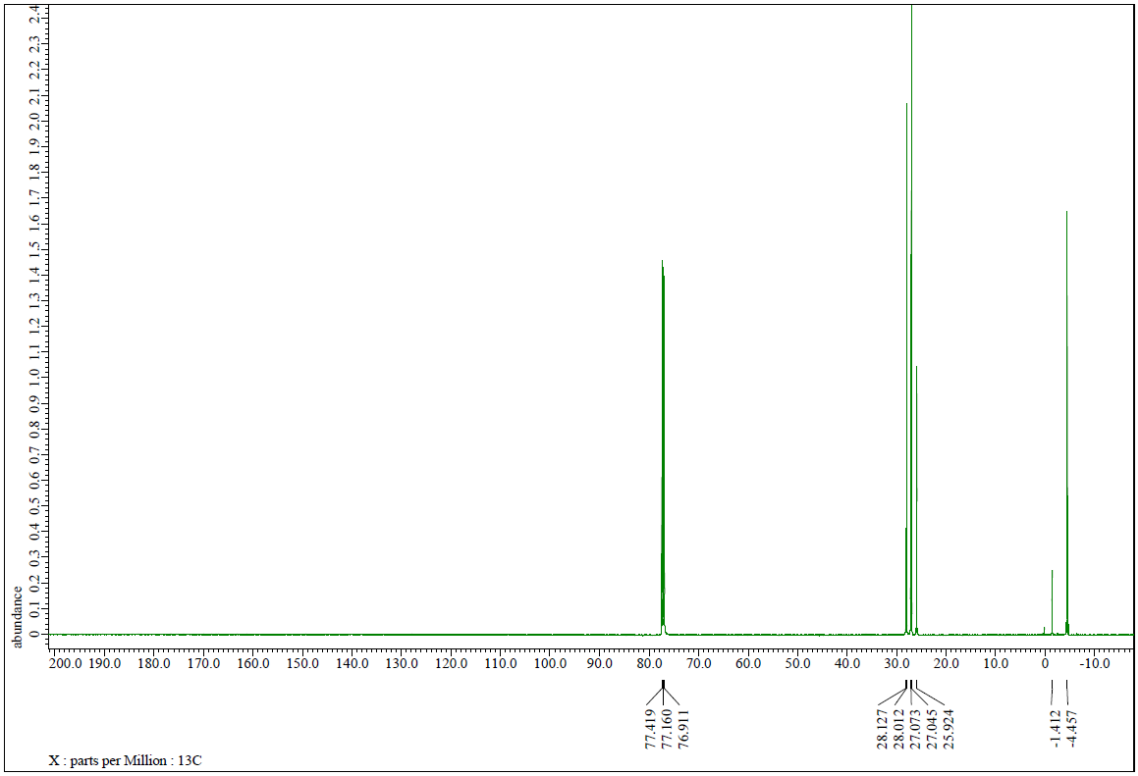
^{29}Si NMR spectrum of **1d** ($CDCl_3$, 100 MHz)



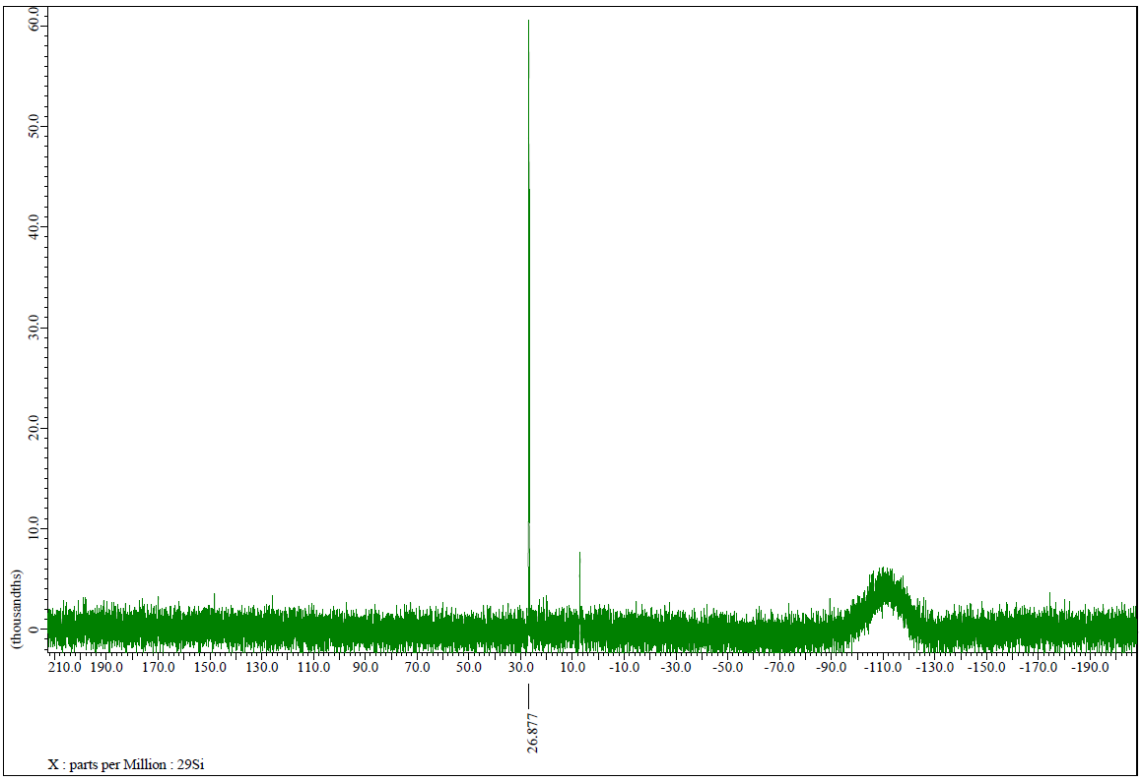
^{1}H NMR spectrum of **1e** ($CDCl_3$, 500 MHz)



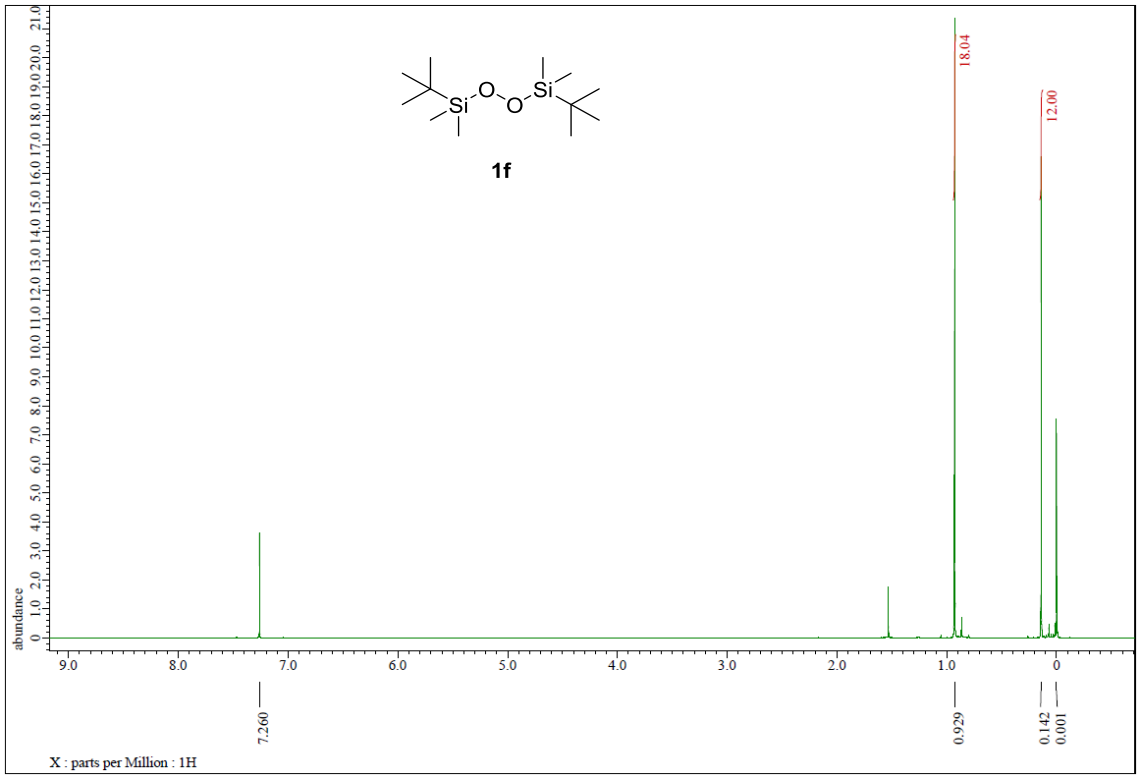
^{13}C NMR spectrum of **1e** ($CDCl_3$, 125 MHz)



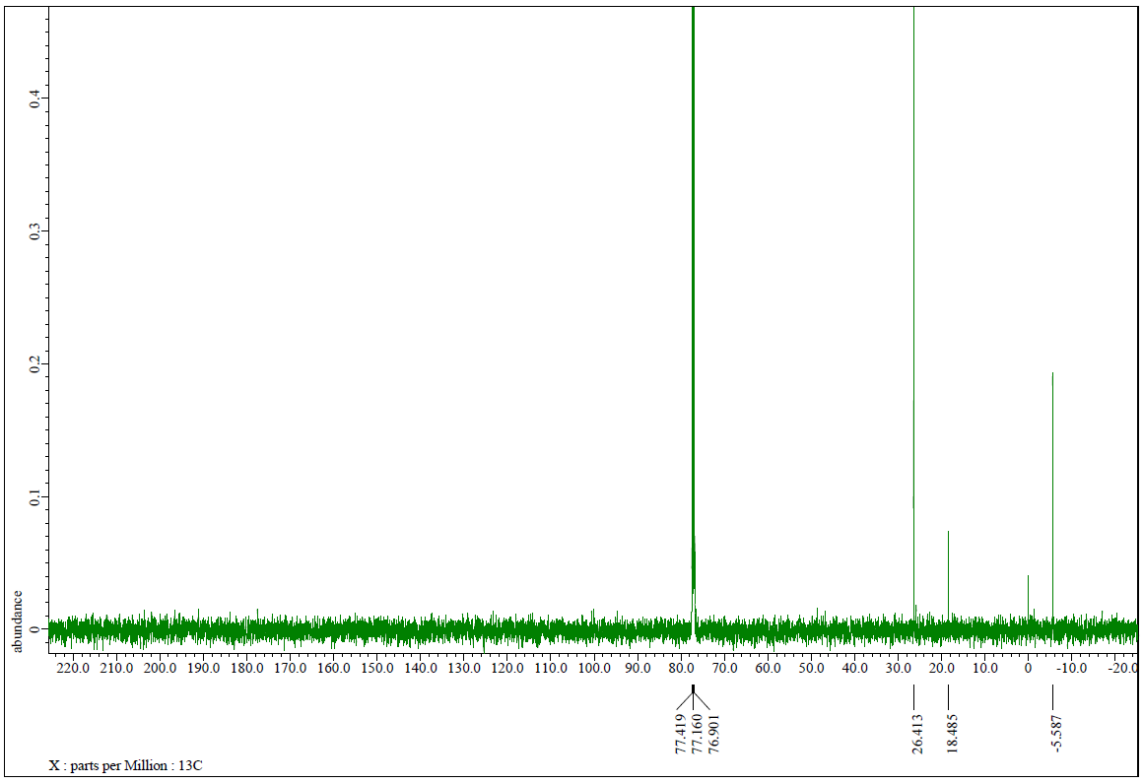
^{29}Si NMR spectrum of **1e** ($CDCl_3$, 100 MHz)



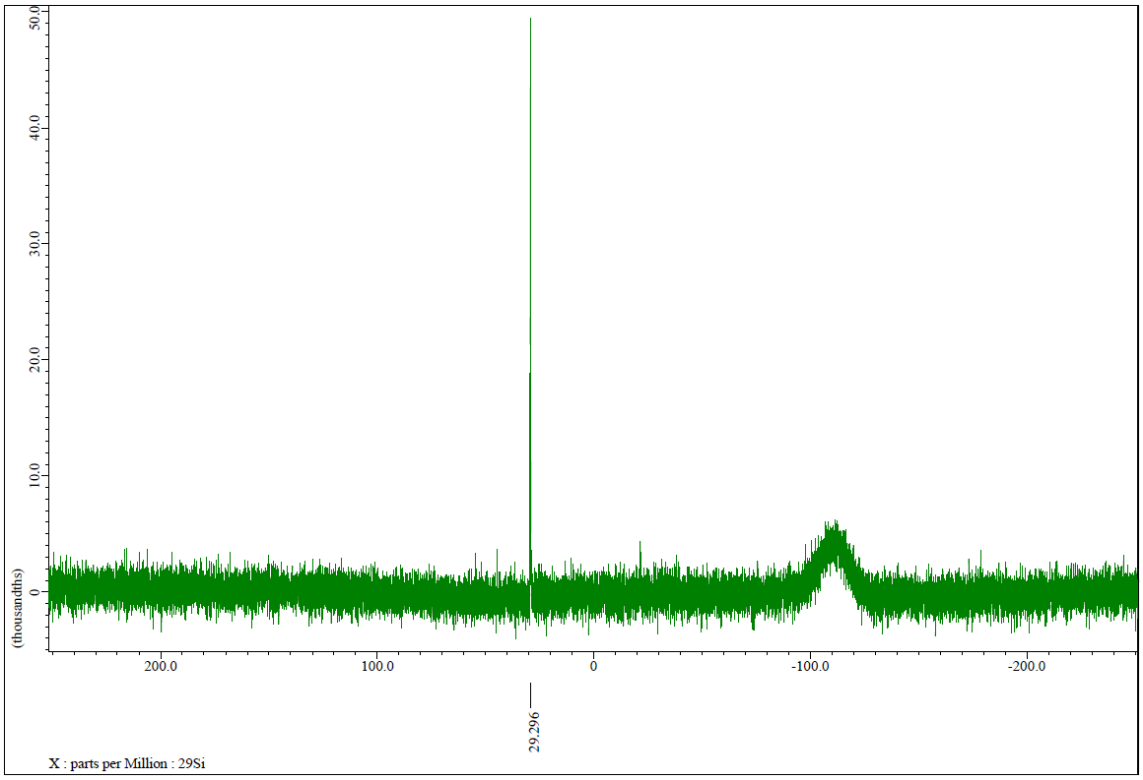
^{1}H NMR spectrum of **1f** ($CDCl_3$, 500 MHz)



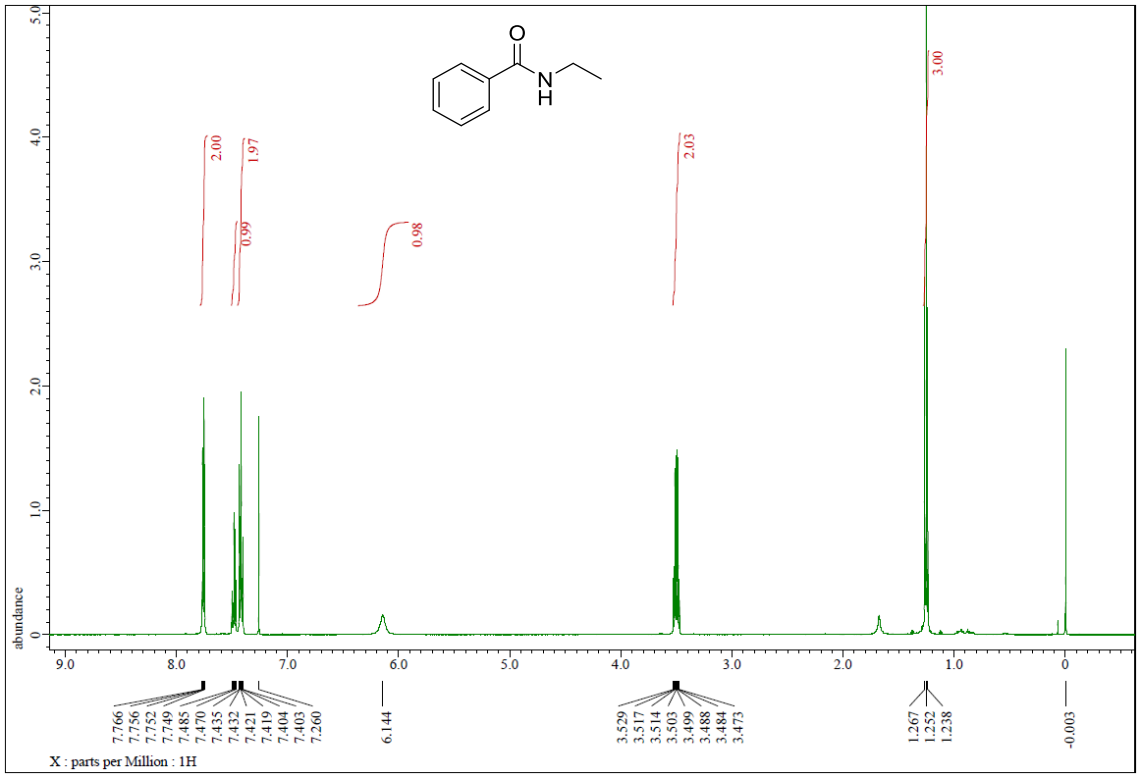
^{13}C NMR spectrum of **1f** ($CDCl_3$, 125 MHz)



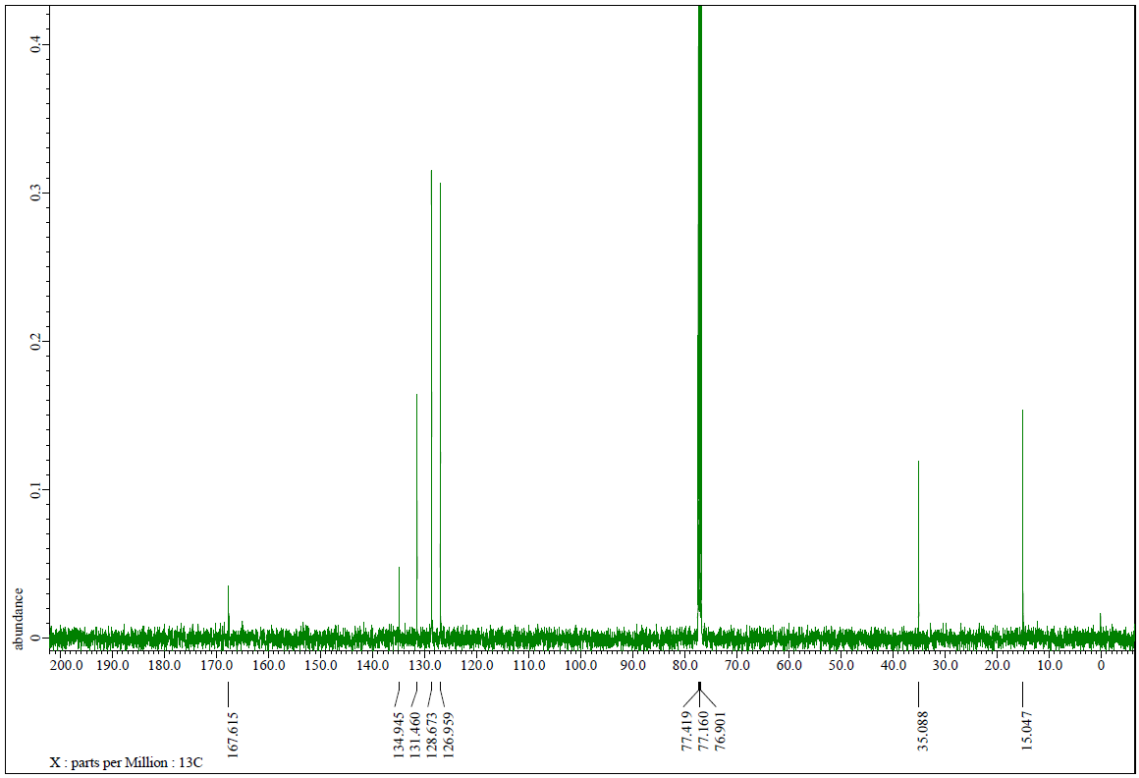
^{29}Si NMR spectrum of **1f** ($CDCl_3$, 100 MHz)



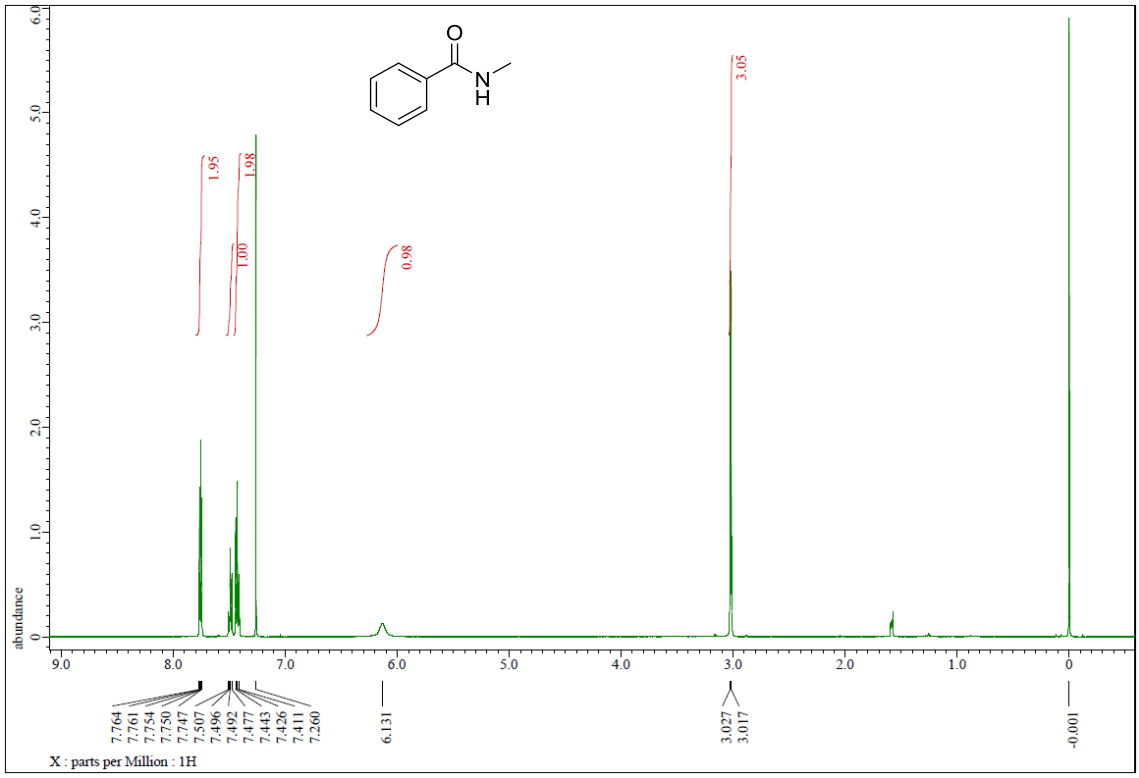
^{1}H NMR spectrum of **3a** ($CDCl_3$, 500 MHz)



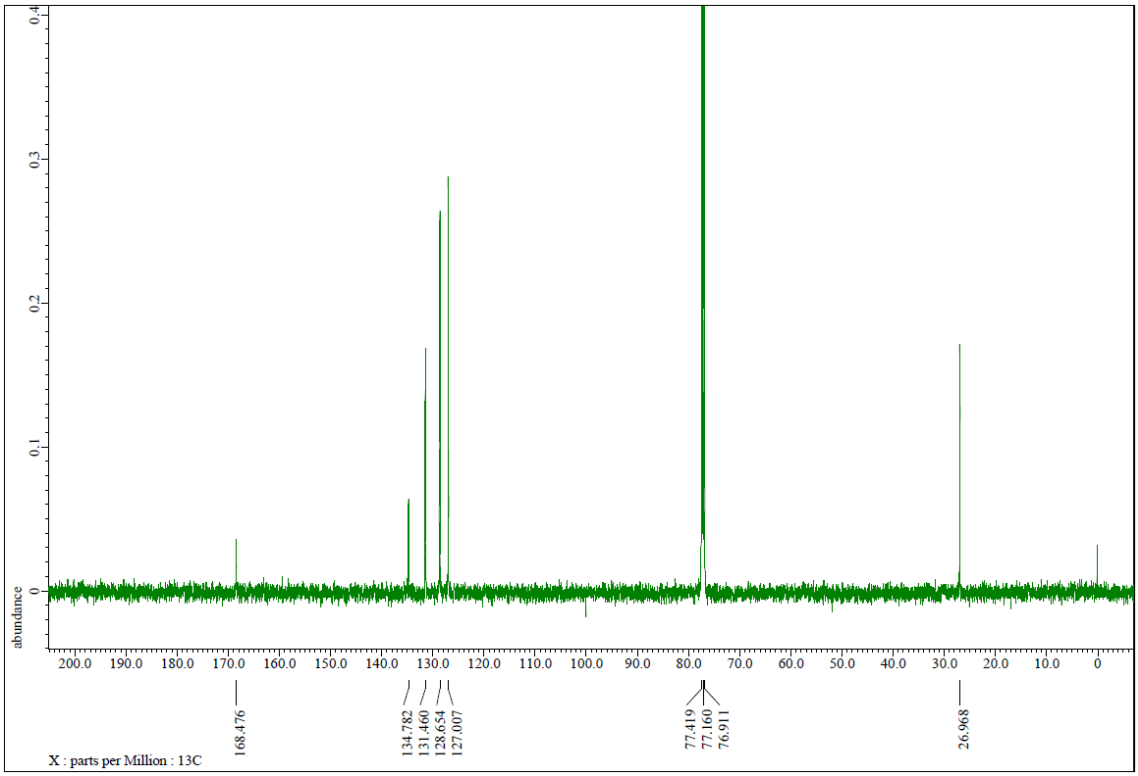
^{13}C NMR spectrum of **3a** ($CDCl_3$, 125 MHz)



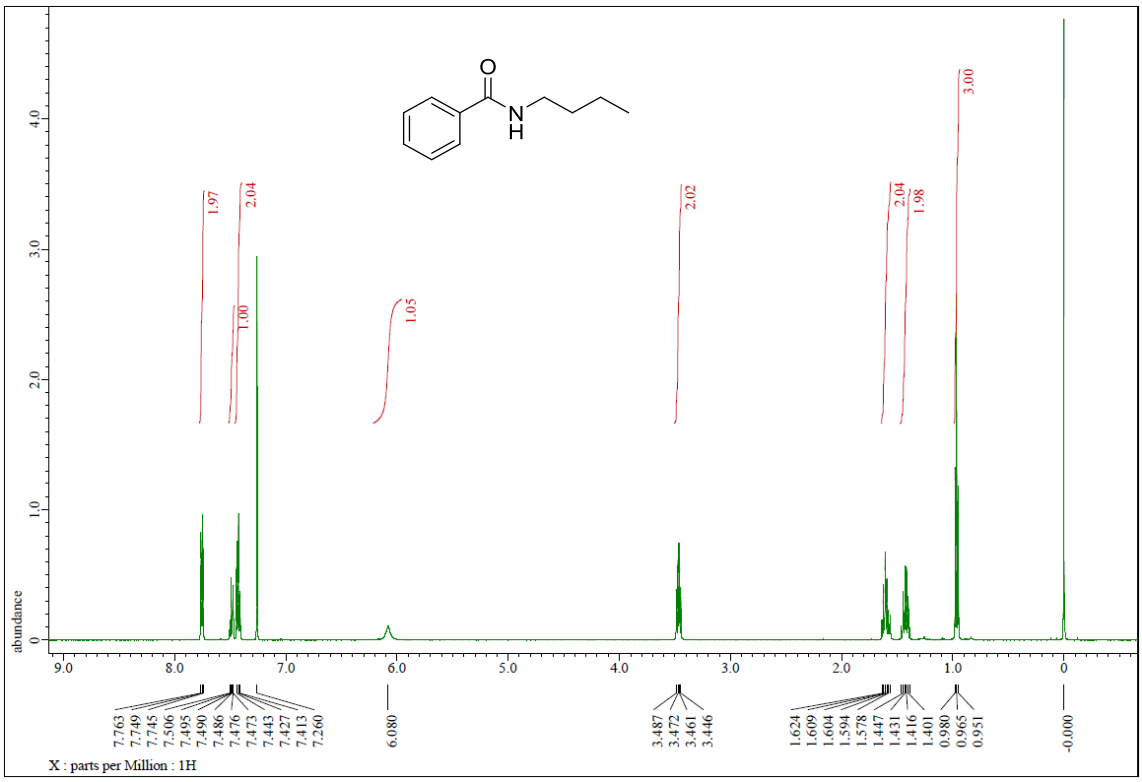
^{1}H NMR spectrum of **3b** ($CDCl_3$, 500 MHz)



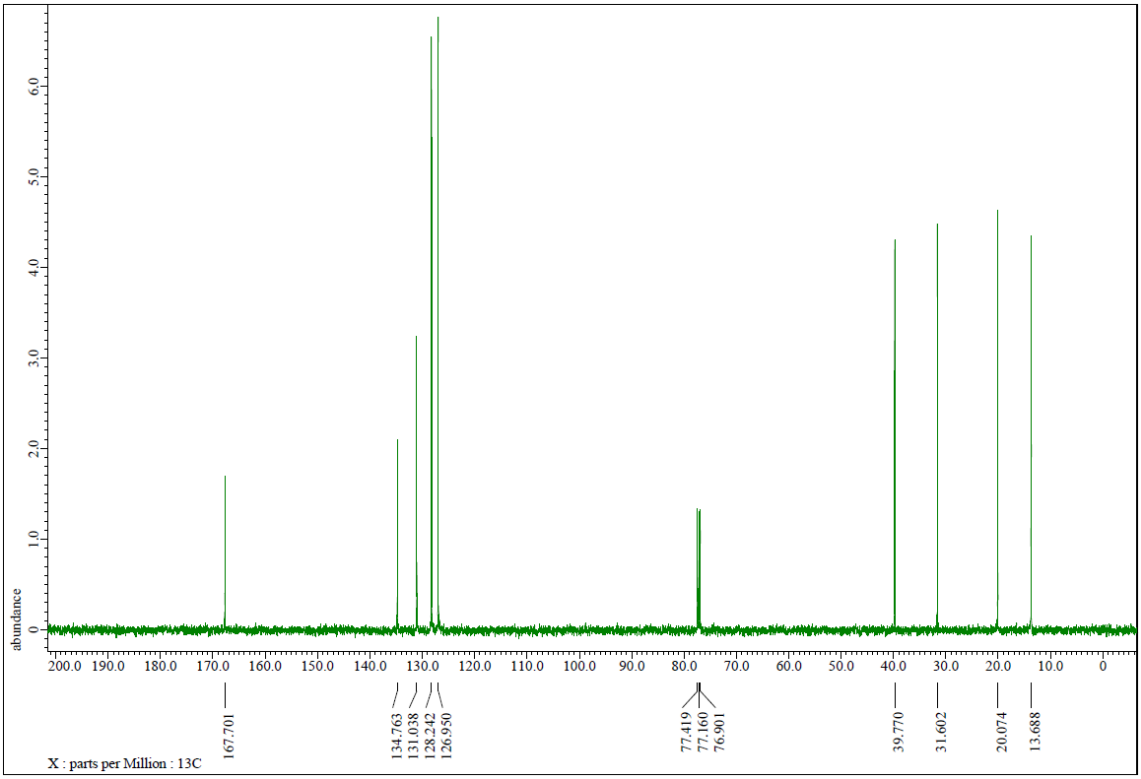
^{13}C NMR spectrum of **3b** ($CDCl_3$, 125 MHz)



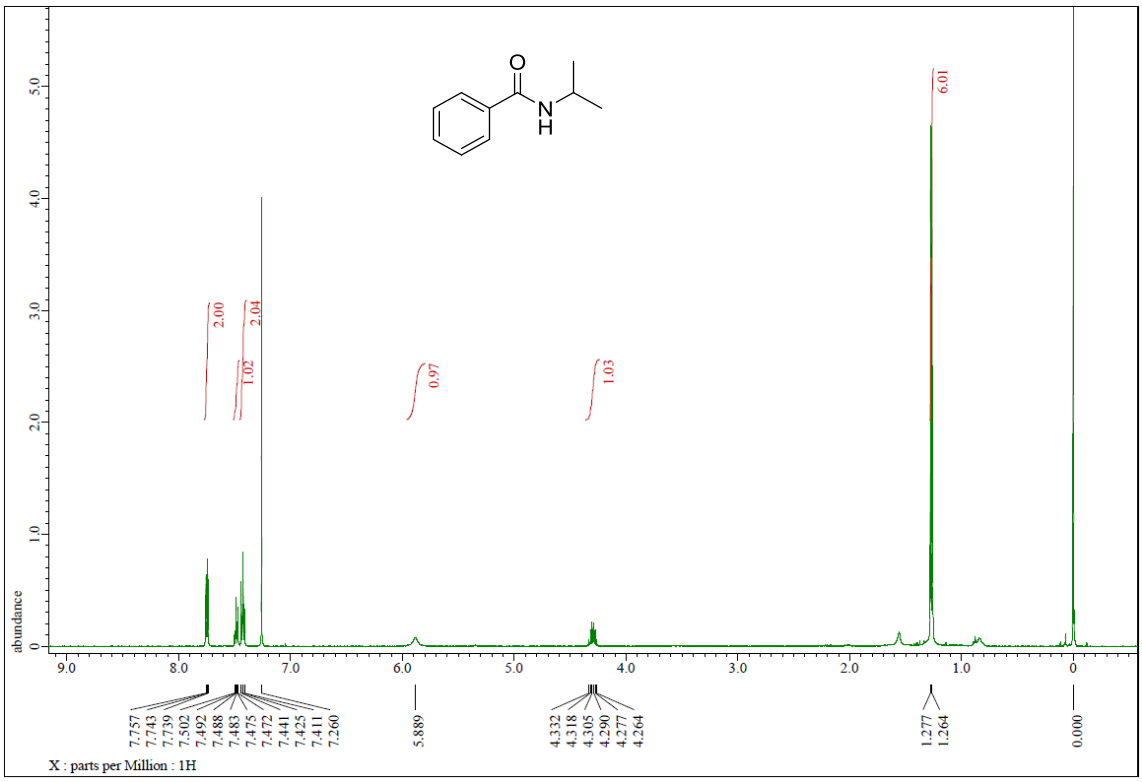
^{1}H NMR spectrum of **3c** ($CDCl_3$, 500 MHz)



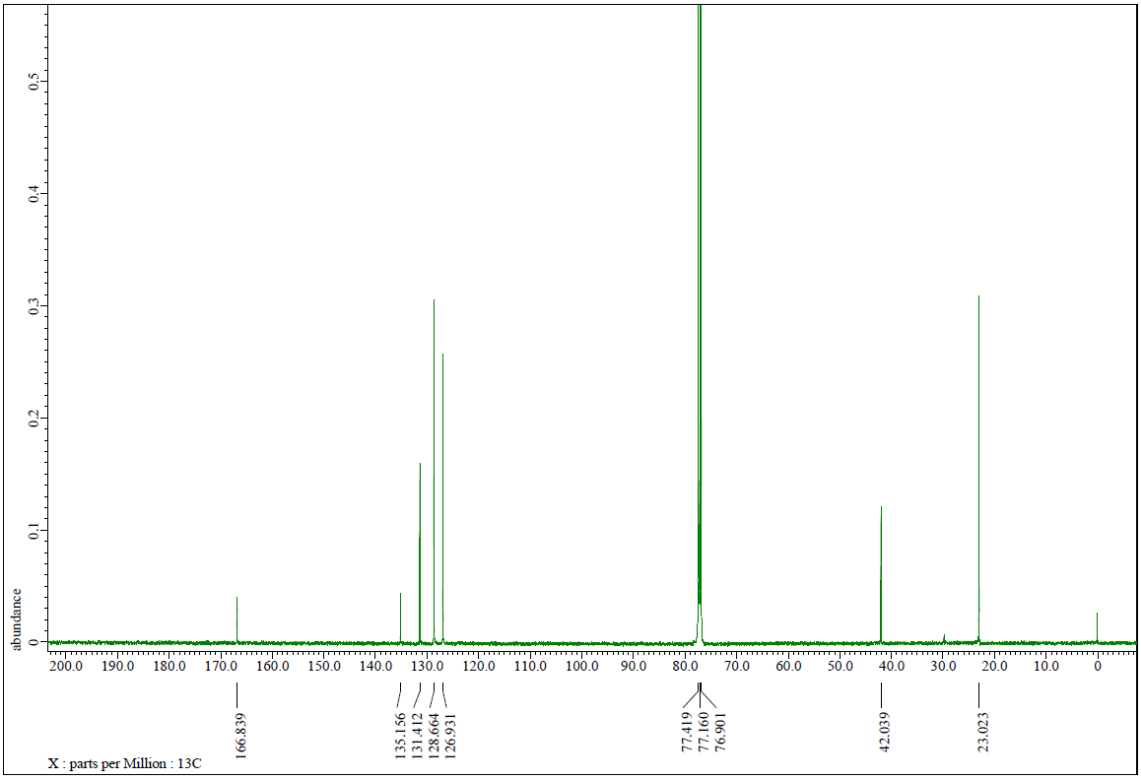
^{13}C NMR spectrum of **3c** ($CDCl_3$, 125 MHz)



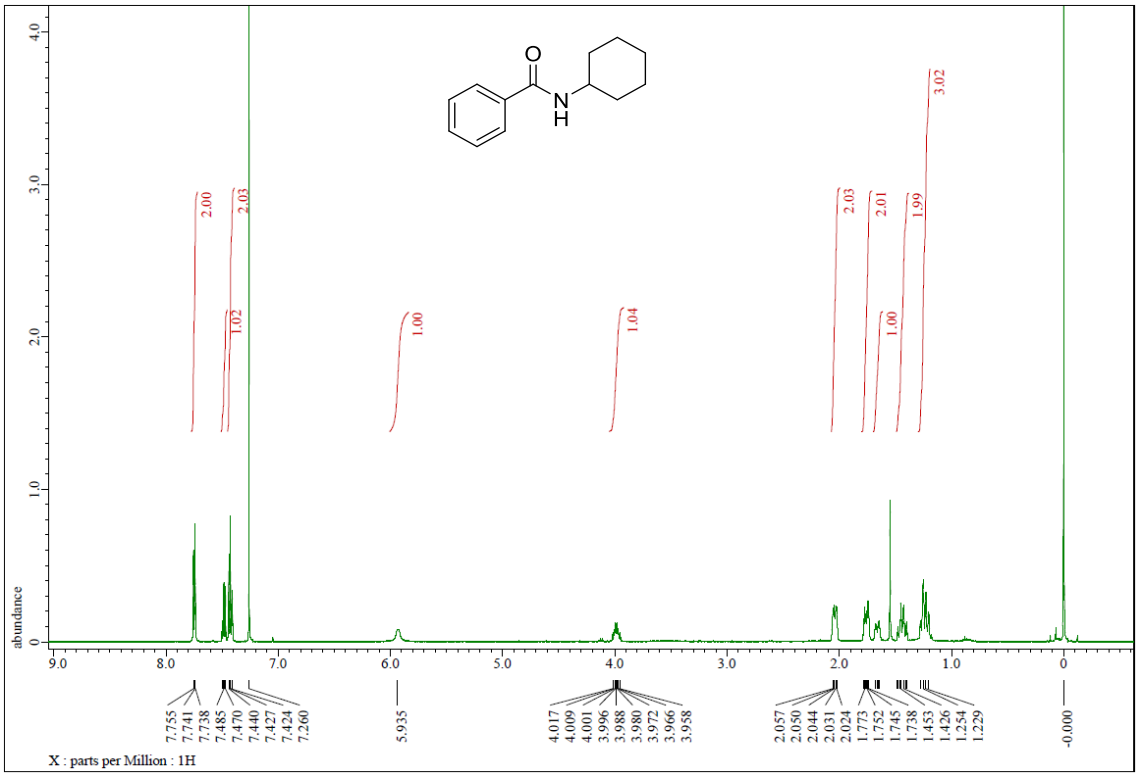
^{1}H NMR spectrum of **3d** ($CDCl_3$, 500 MHz)



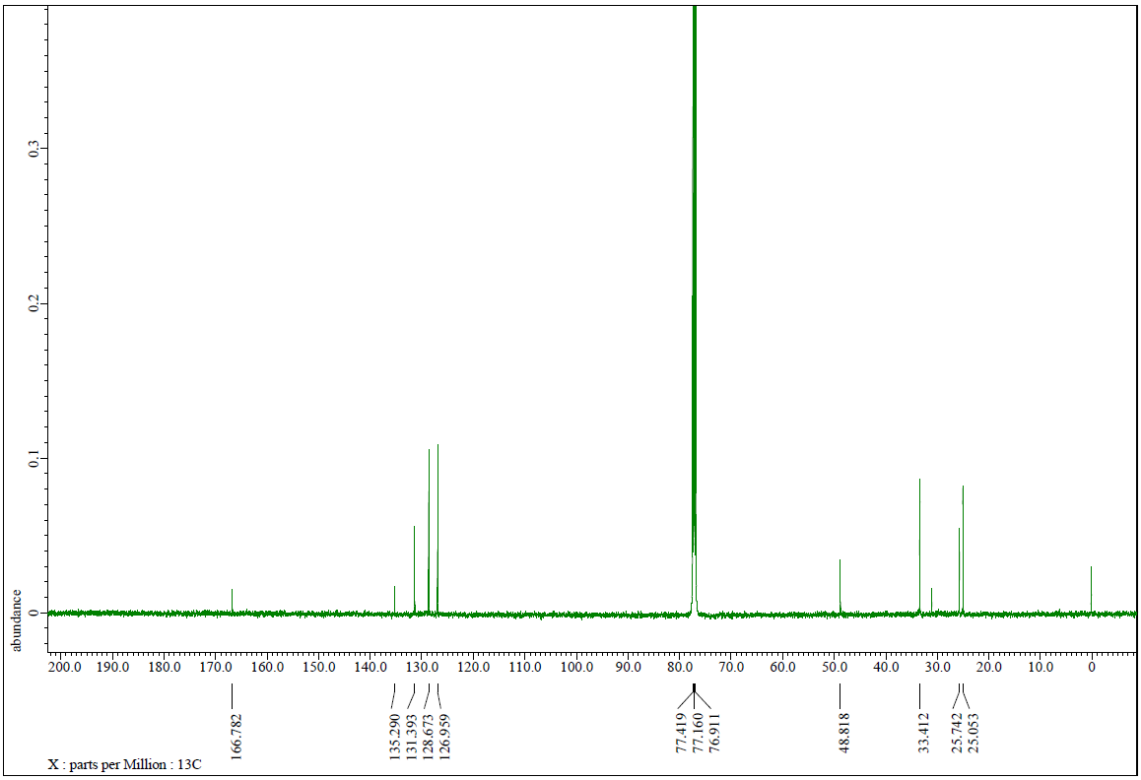
^{13}C NMR spectrum of **3d** ($CDCl_3$, 125 MHz)



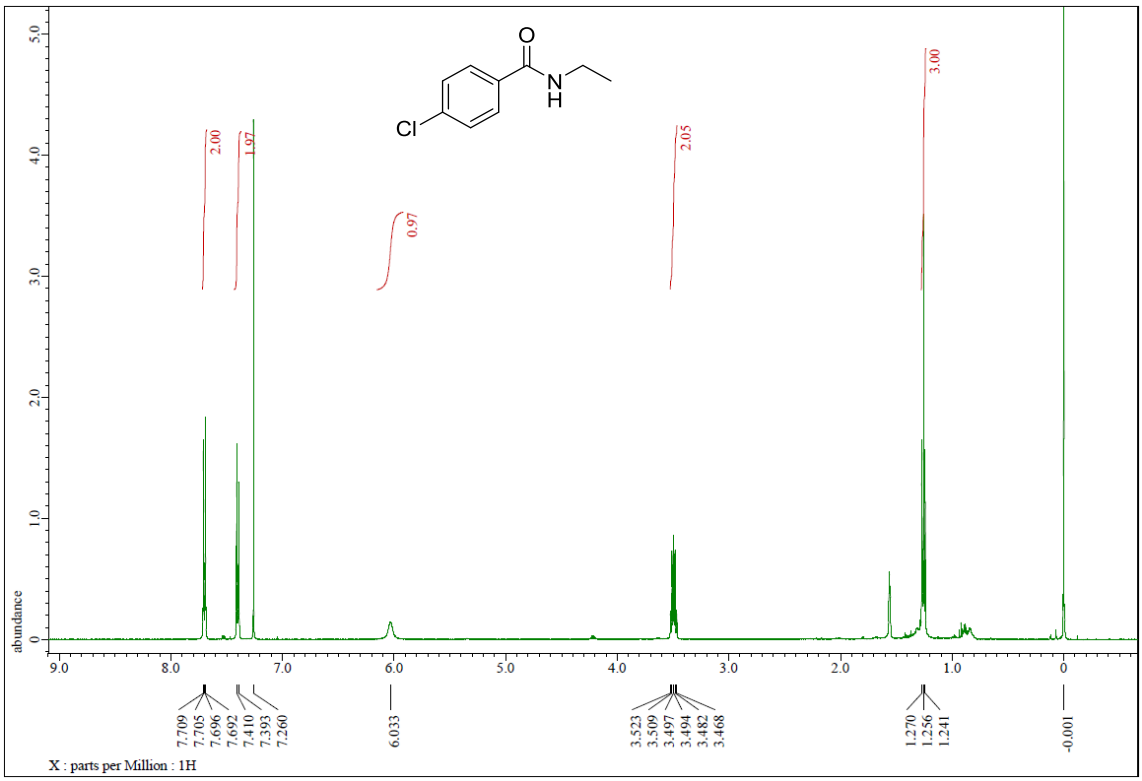
^{1}H NMR spectrum of **3e** ($CDCl_3$, 125 MHz)



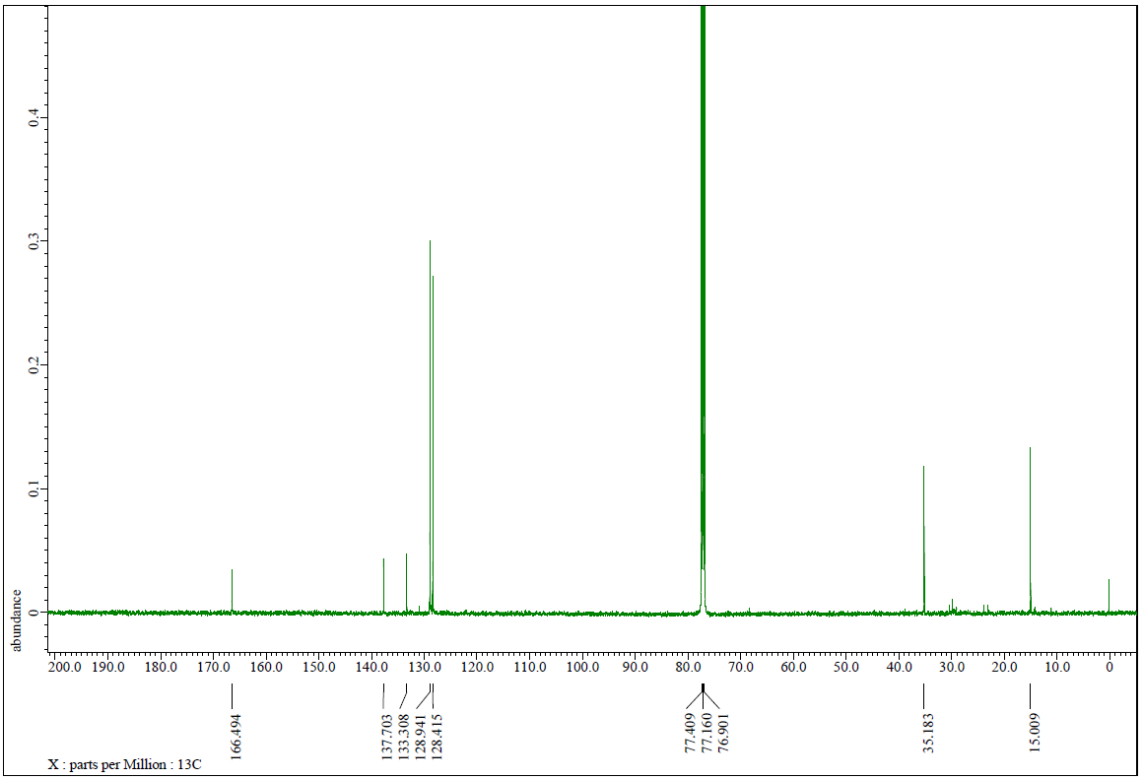
^{13}C NMR spectrum of **3e** ($CDCl_3$, 125 MHz)



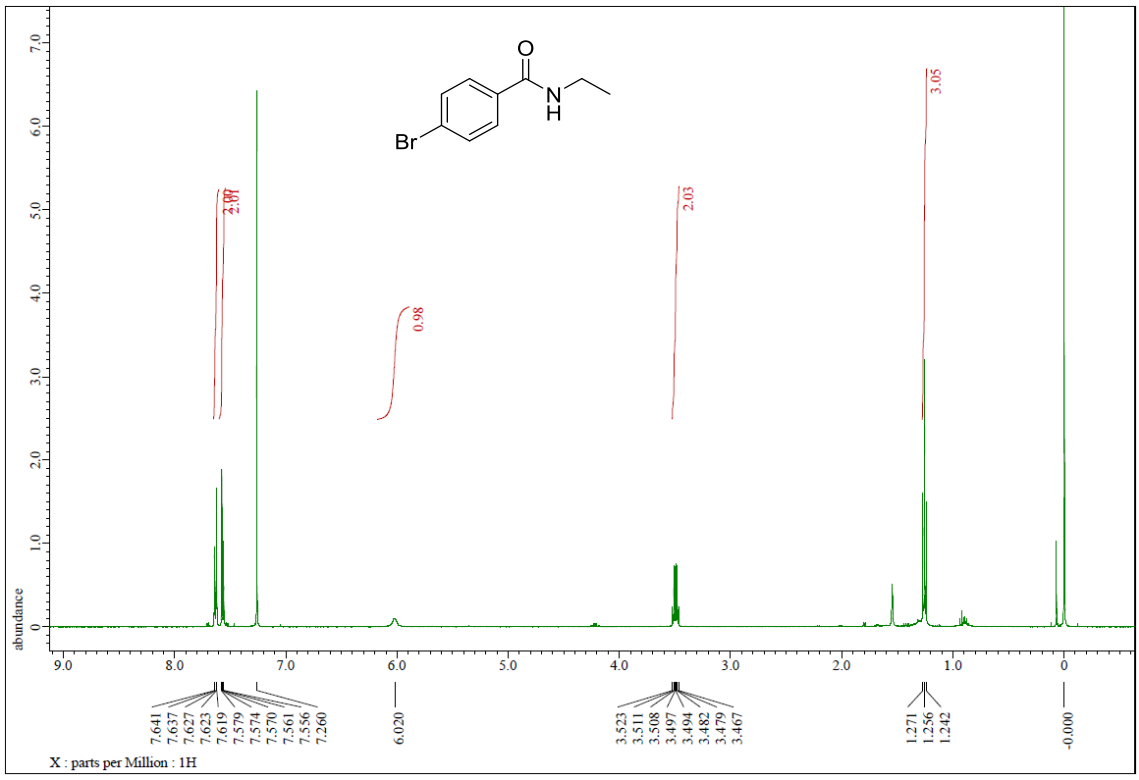
^{1}H NMR spectrum of **4a** ($CDCl_3$, 500 MHz)



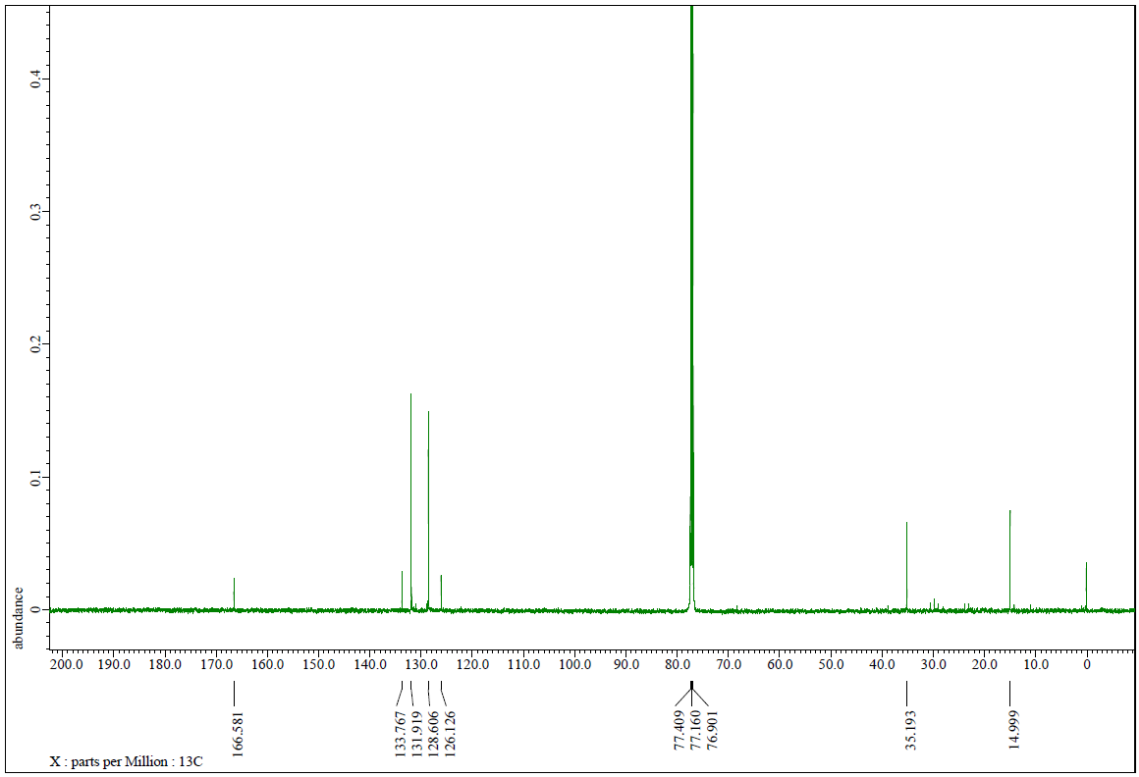
^{13}C NMR spectrum of **4b** ($CDCl_3$, 125 MHz)



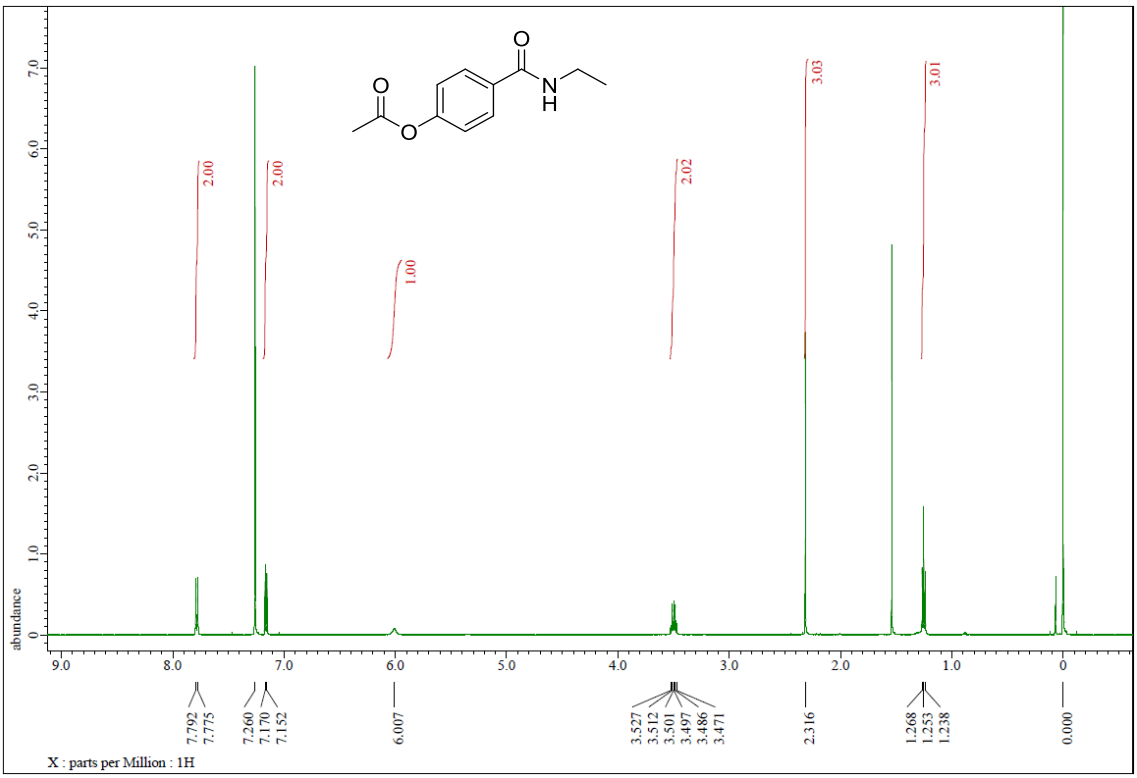
^{1}H NMR spectrum of **4b** ($CDCl_3$, 500 MHz)



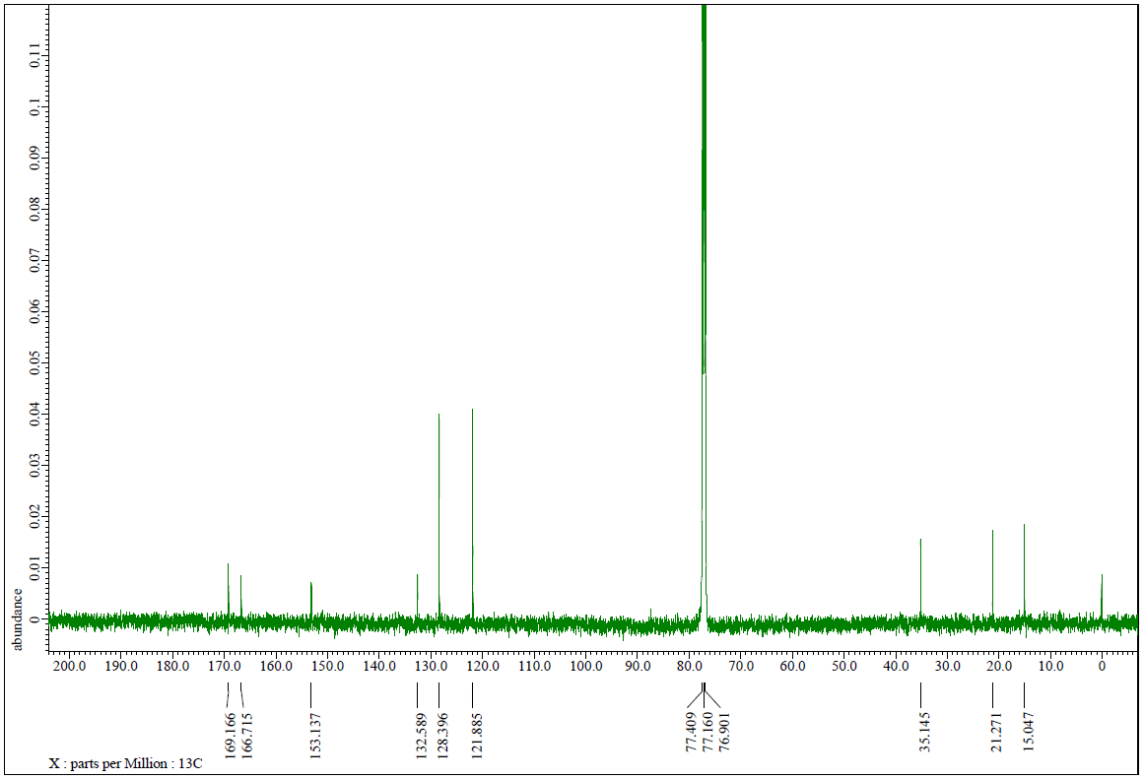
^{13}C NMR spectrum of **4b** ($CDCl_3$, 125 MHz)



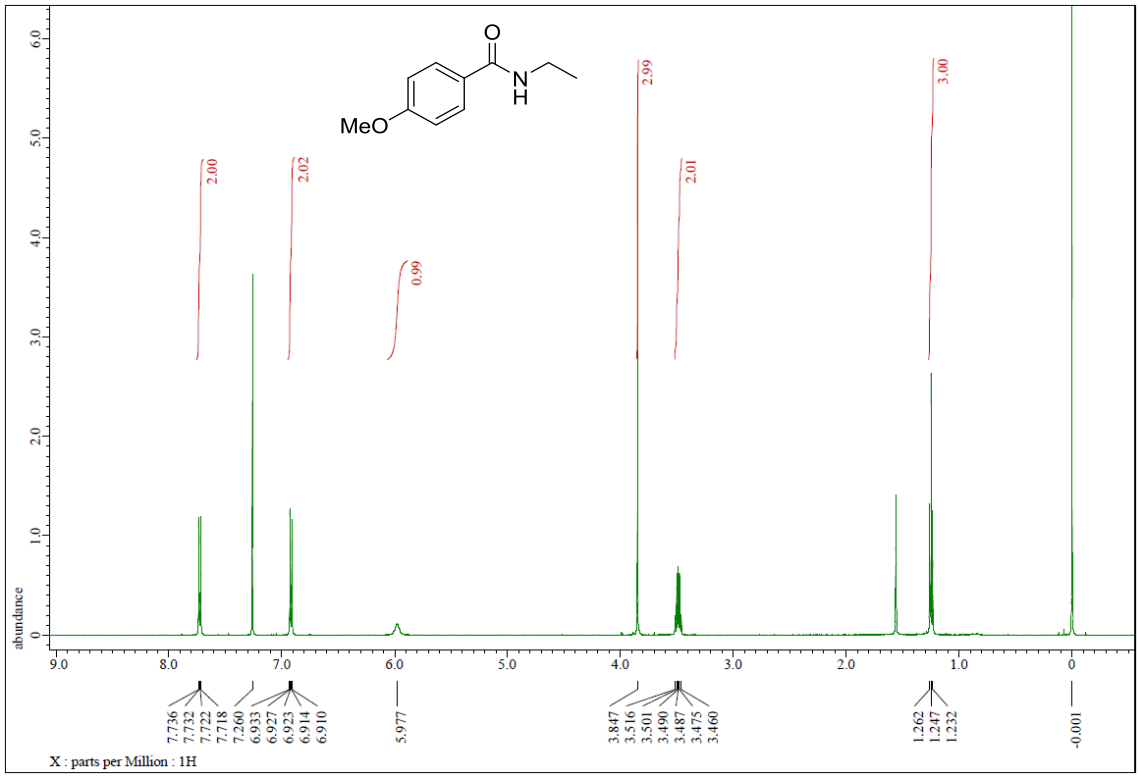
^{1}H NMR spectrum of **4c** ($CDCl_3$, 500 MHz)



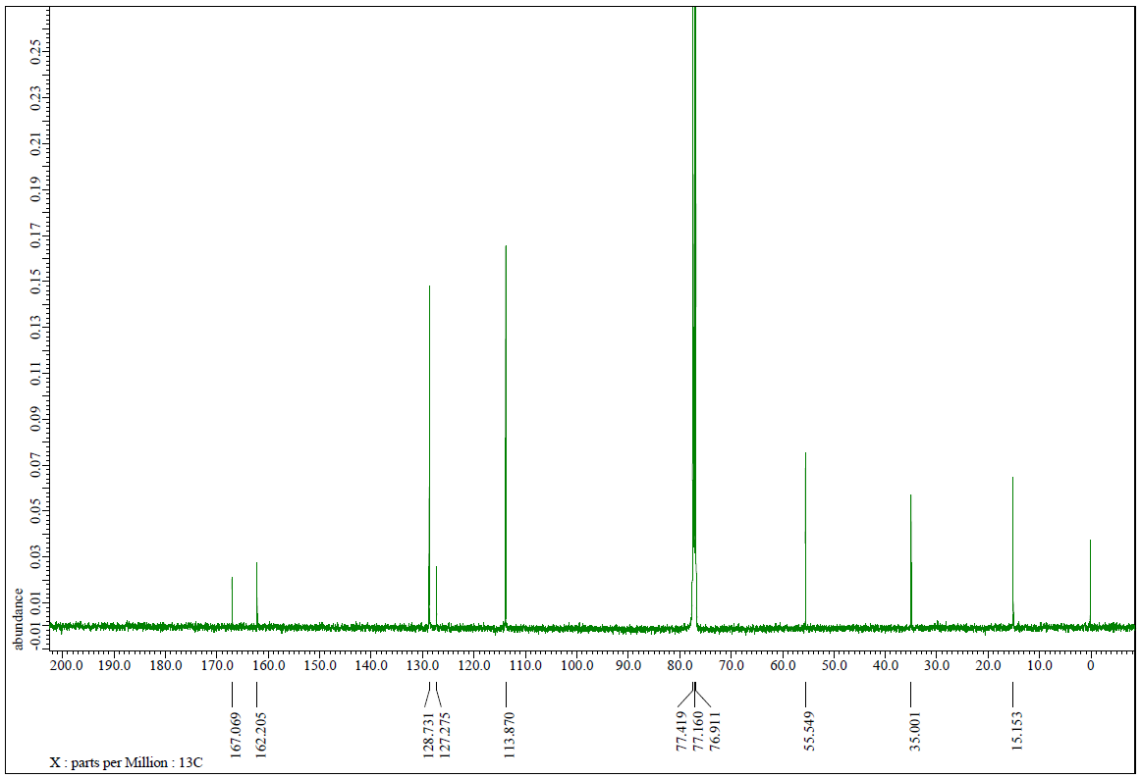
^{13}C NMR spectrum of **4c** ($CDCl_3$, 125 MHz)



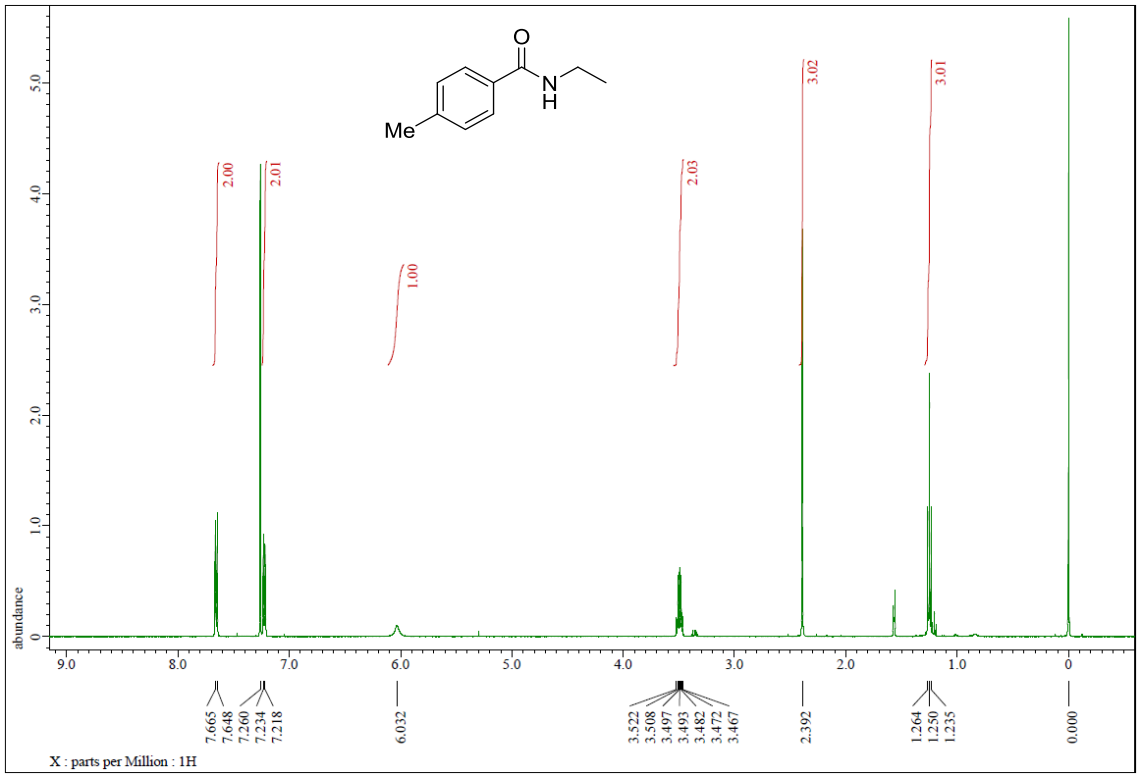
^{1}H NMR spectrum of **4d** ($CDCl_3$, 500 MHz)



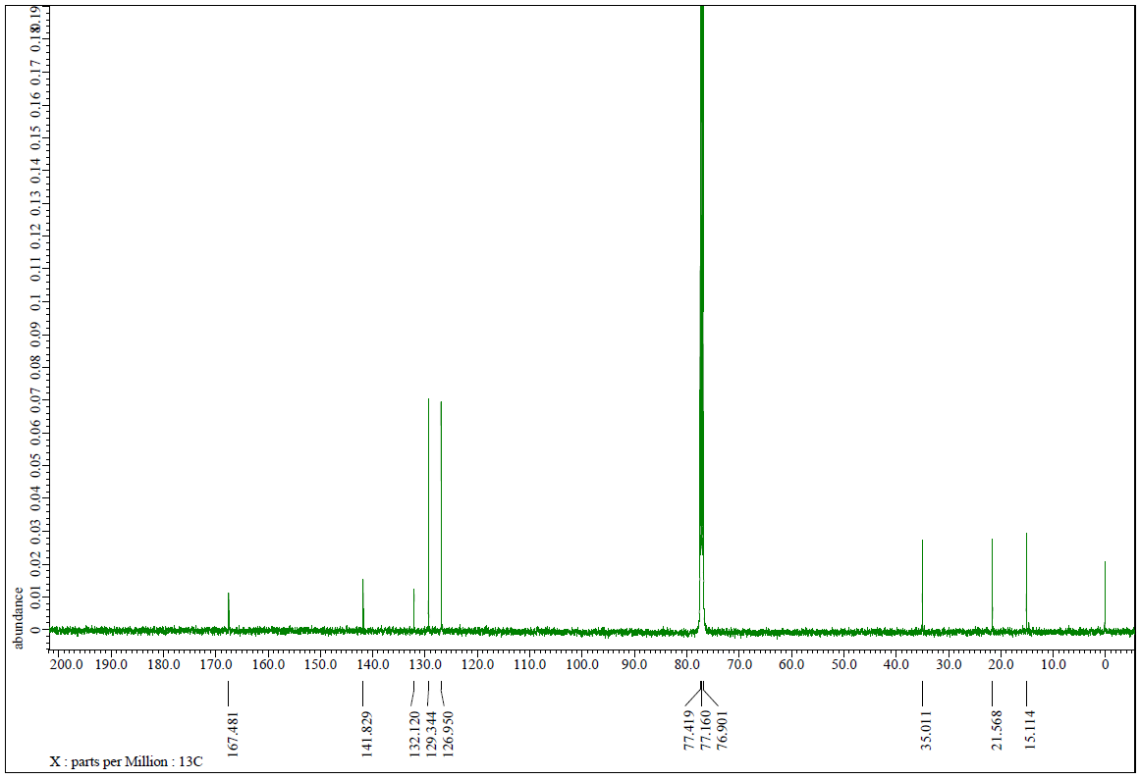
^{13}C NMR spectrum of **4d** ($CDCl_3$, 500 MHz)



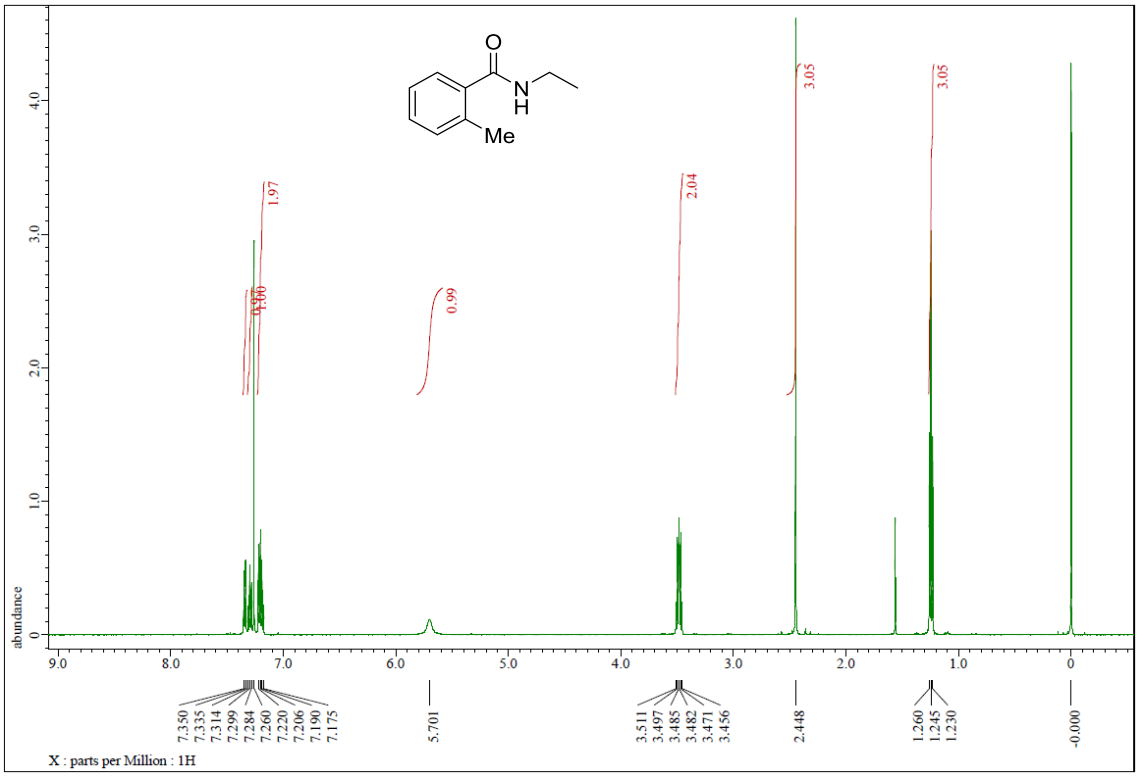
^{1}H NMR spectrum of **4e** ($CDCl_3$, 500 MHz)



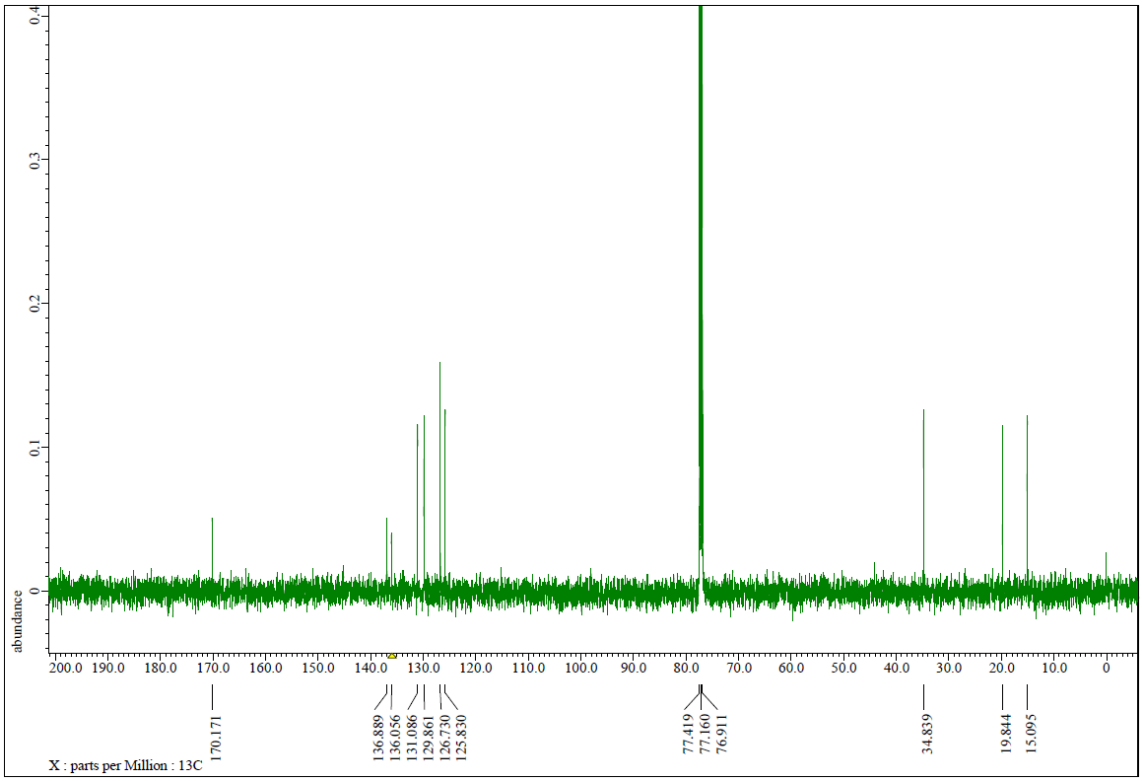
^{13}C NMR spectrum of **4e** ($CDCl_3$, 125 MHz)



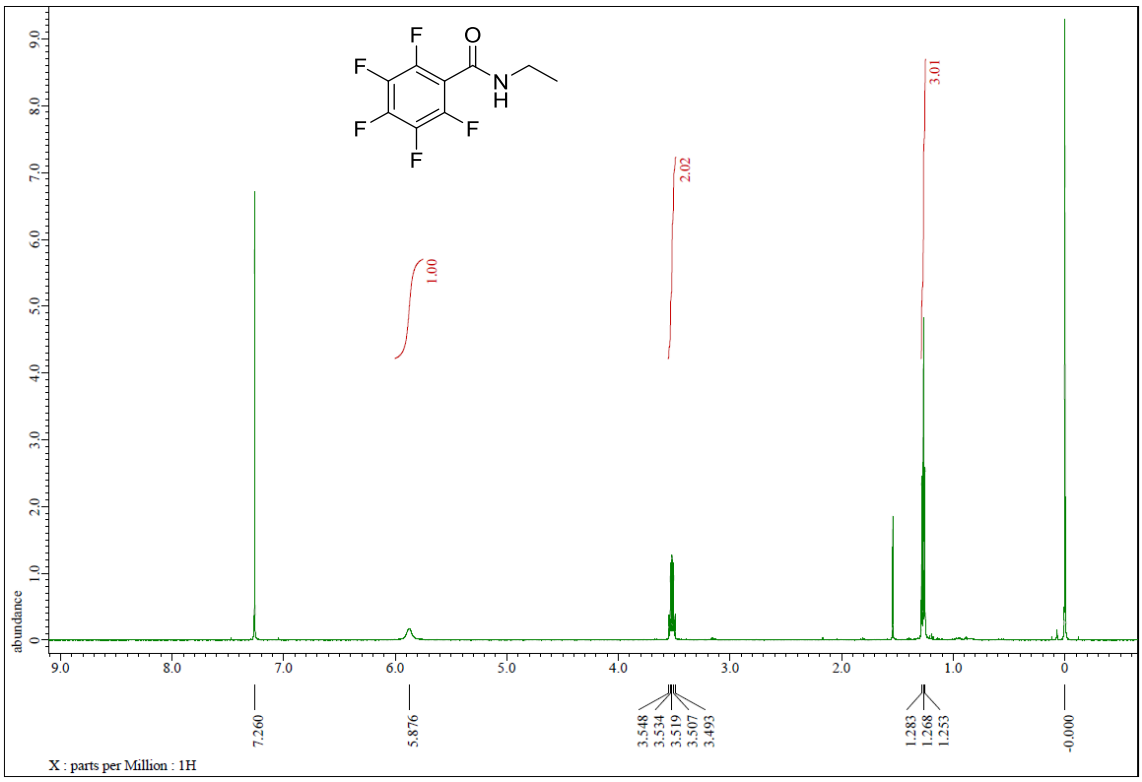
^{1}H NMR spectrum of **4f** ($CDCl_3$, 500 MHz)



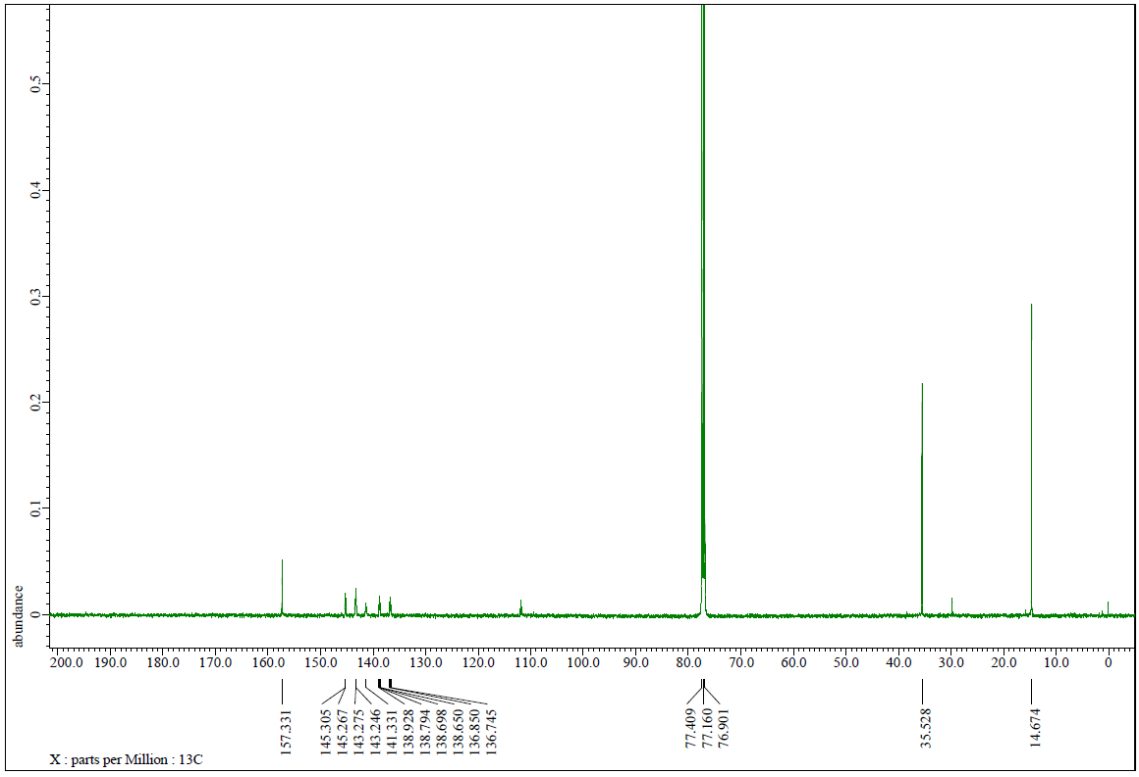
^{13}C NMR spectrum of **4f** ($CDCl_3$, 500 MHz)



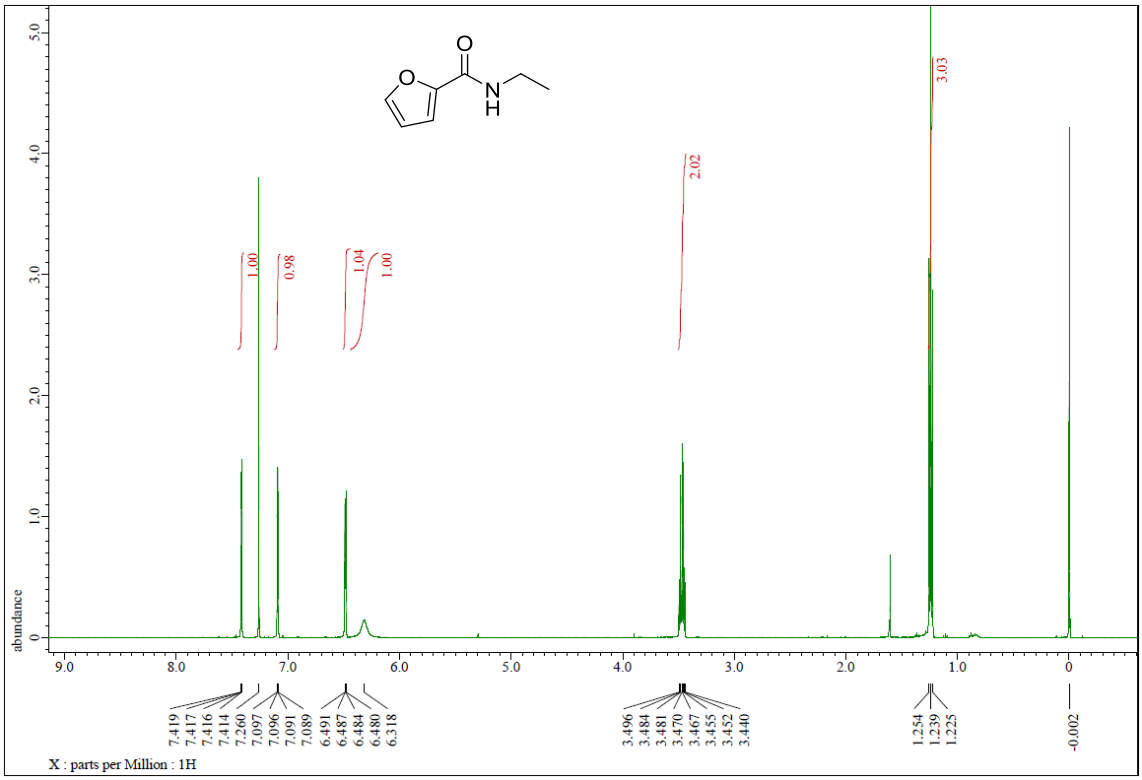
^{1}H NMR spectrum of **4g** ($CDCl_3$, 500 MHz)



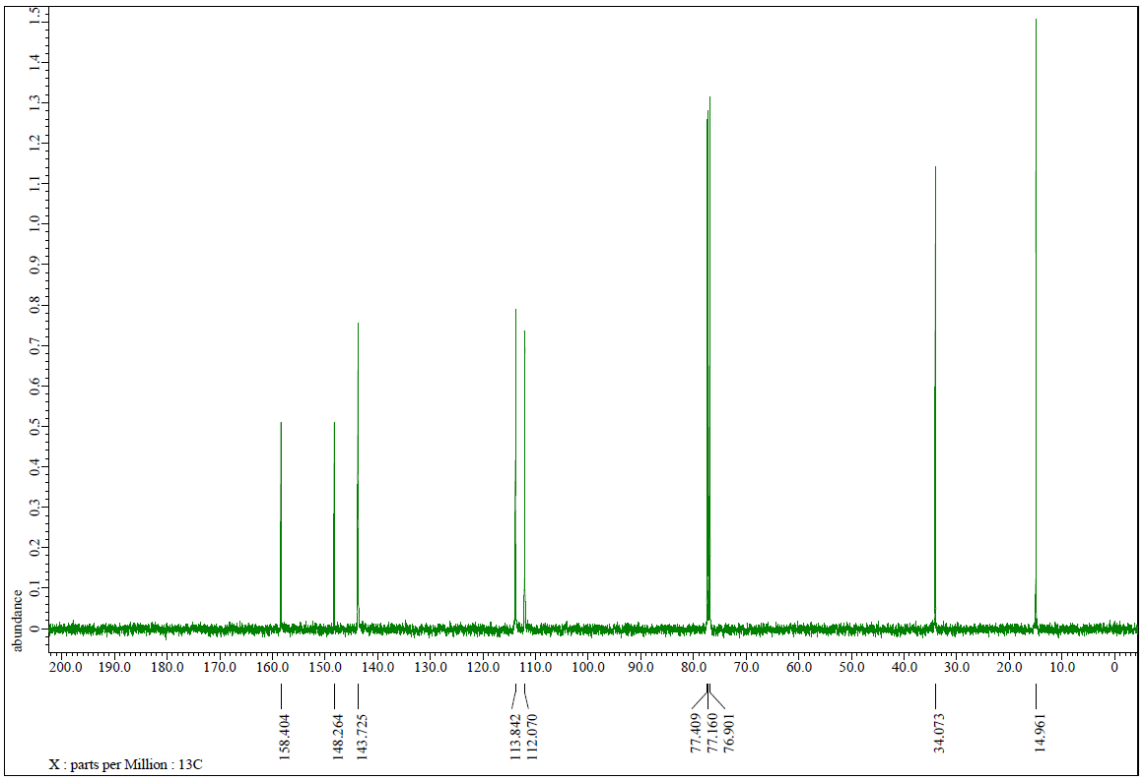
^{13}C NMR spectrum of **4g** ($CDCl_3$, 125 MHz)



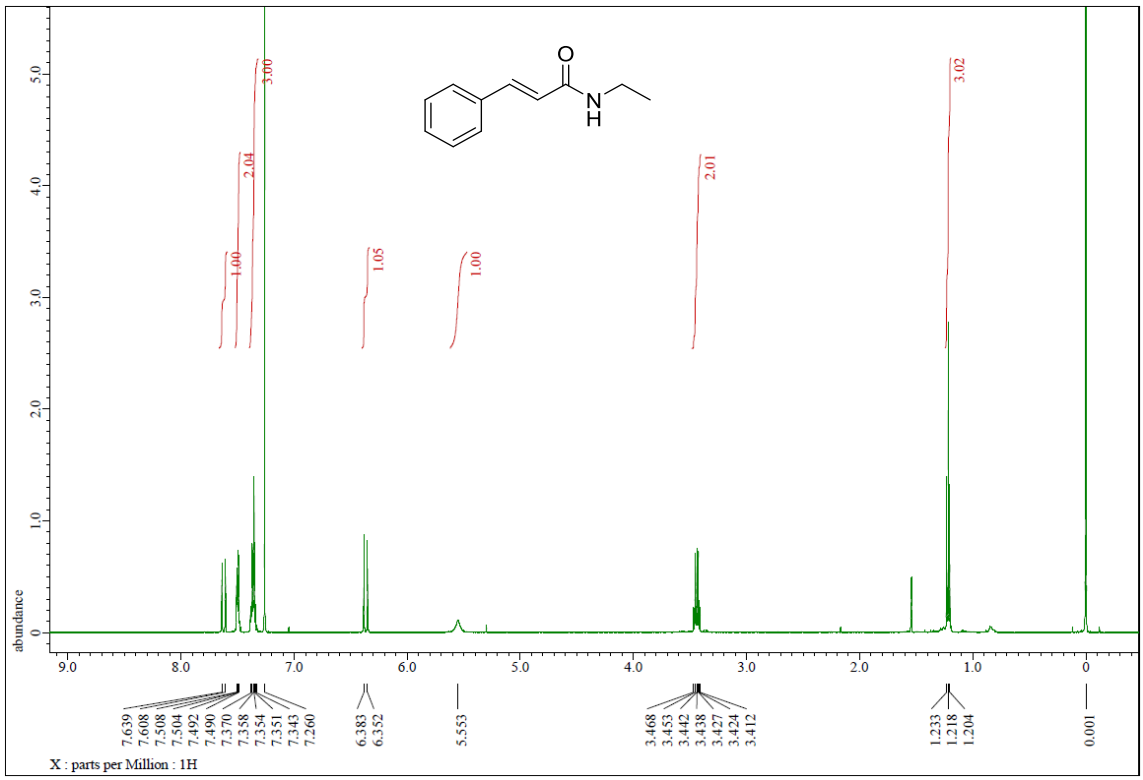
^{1}H NMR spectrum of **4h** ($CDCl_3$, 500 MHz)



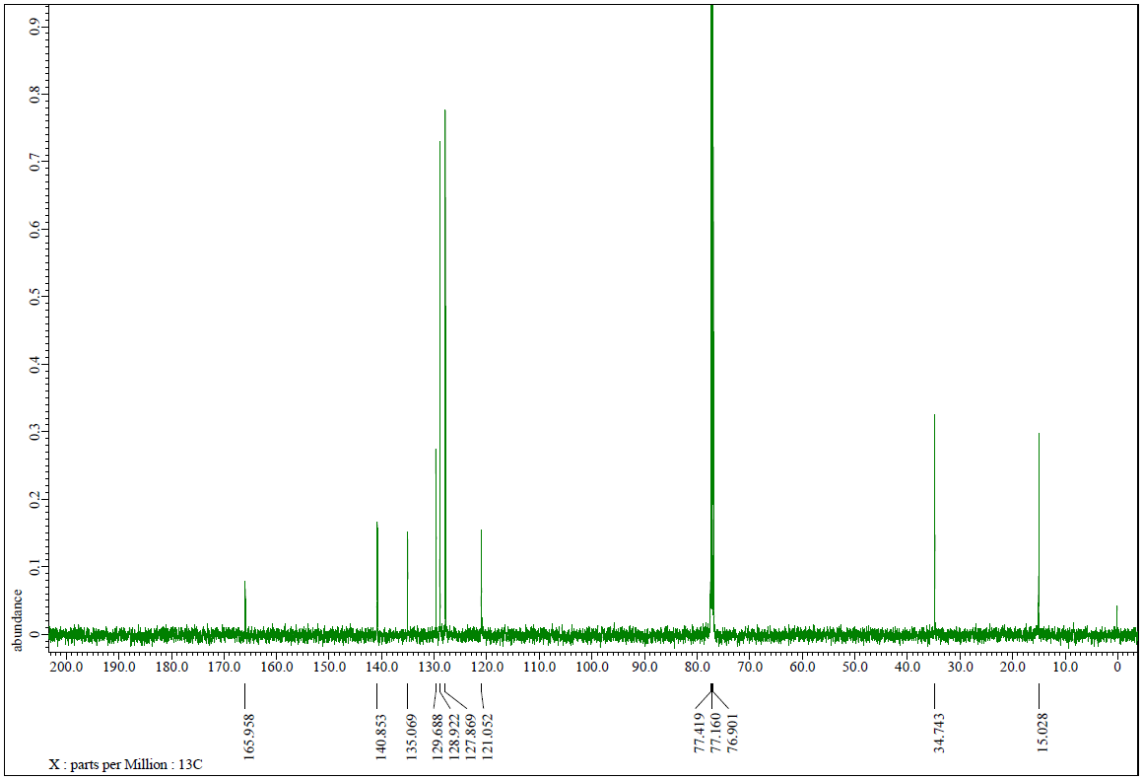
^{13}C NMR spectrum of **4h** ($CDCl_3$, 125 MHz)



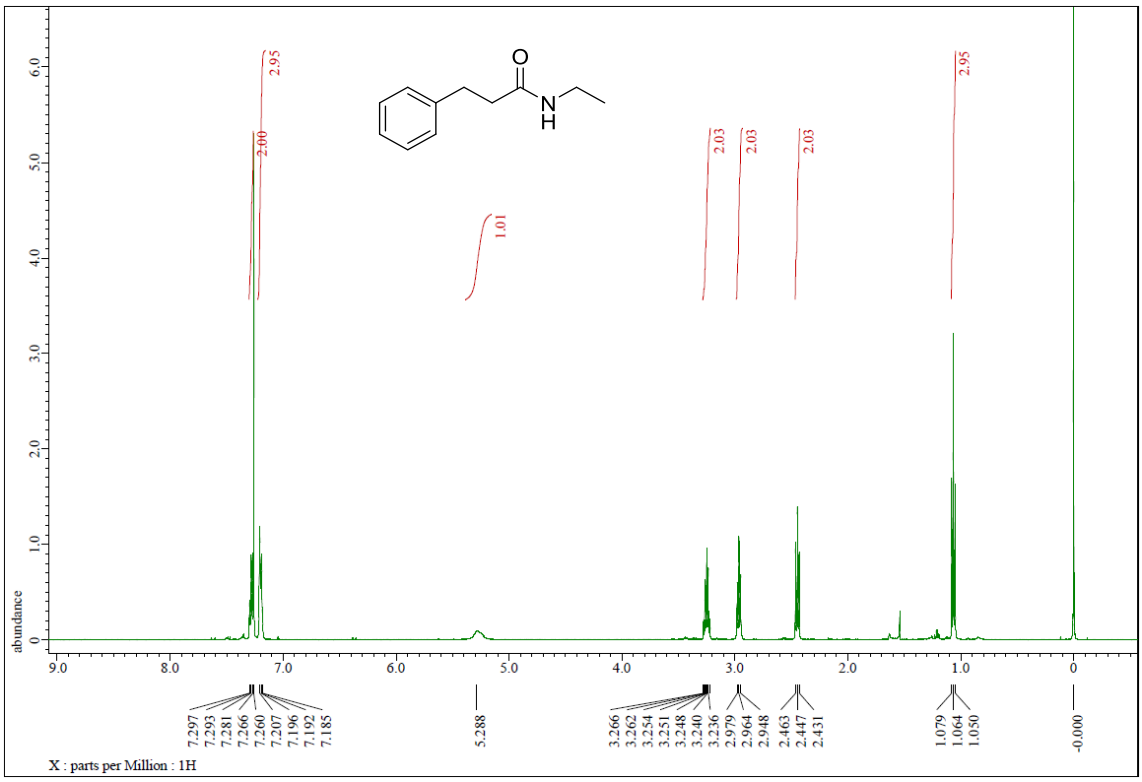
^{1}H NMR spectrum of **4i** ($CDCl_3$, 500 MHz)



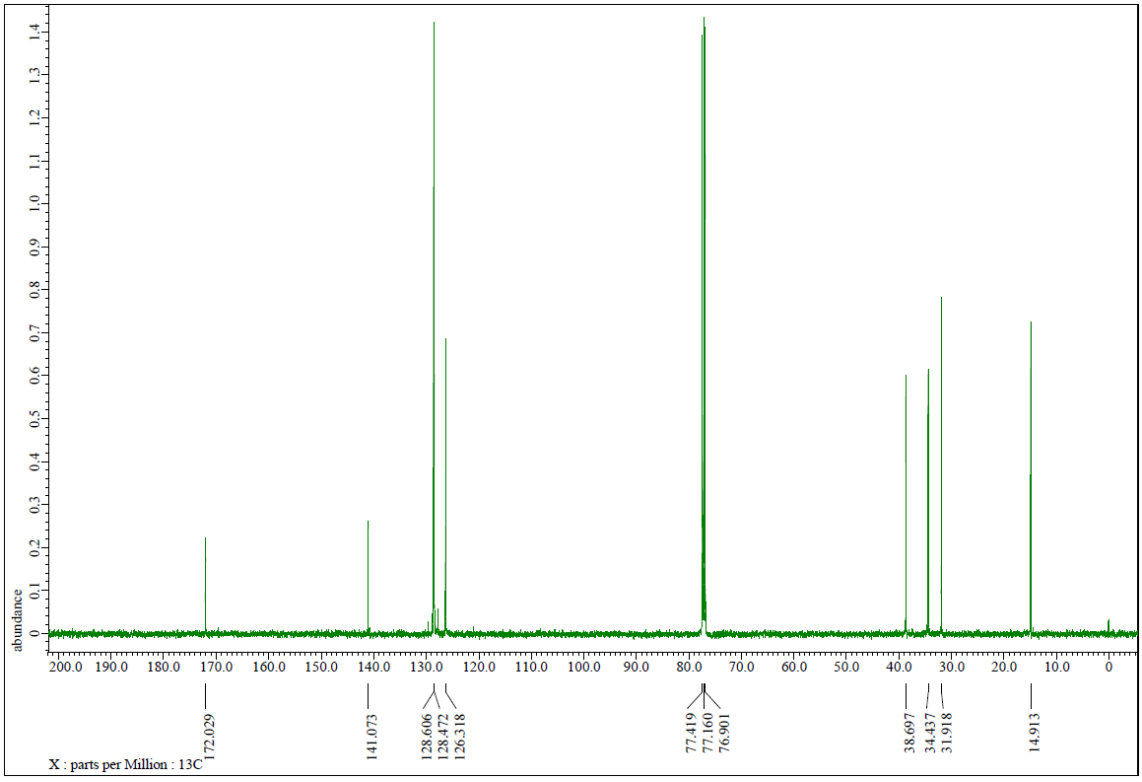
^{13}C NMR spectrum of **4i** ($CDCl_3$, 125 MHz)



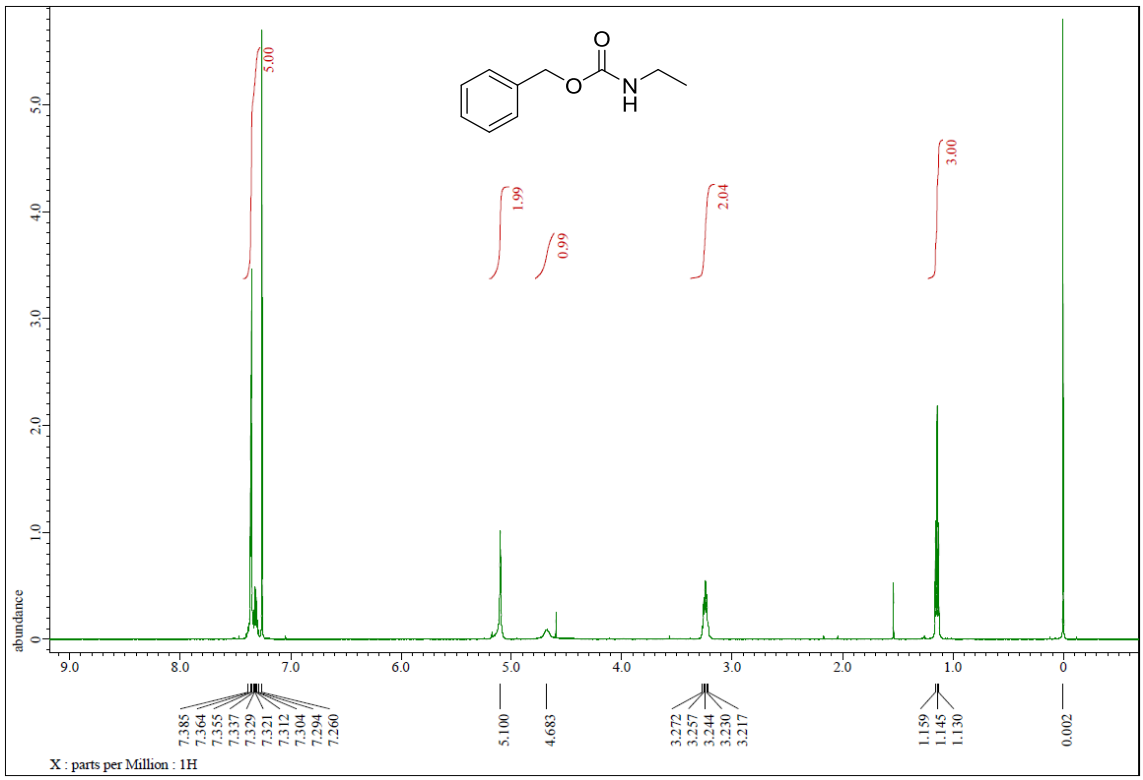
^{1}H NMR spectrum of **4j** ($CDCl_3$, 500 MHz)



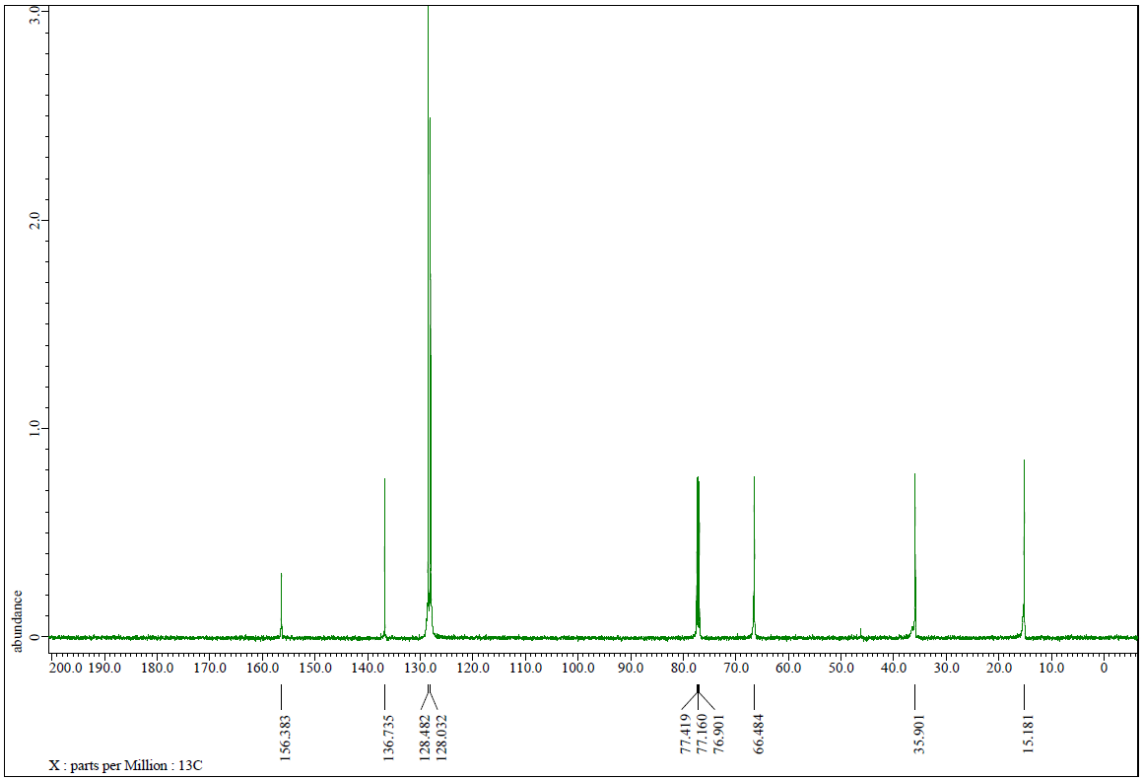
^{13}C NMR spectrum of **4j** ($CDCl_3$, 125 MHz)



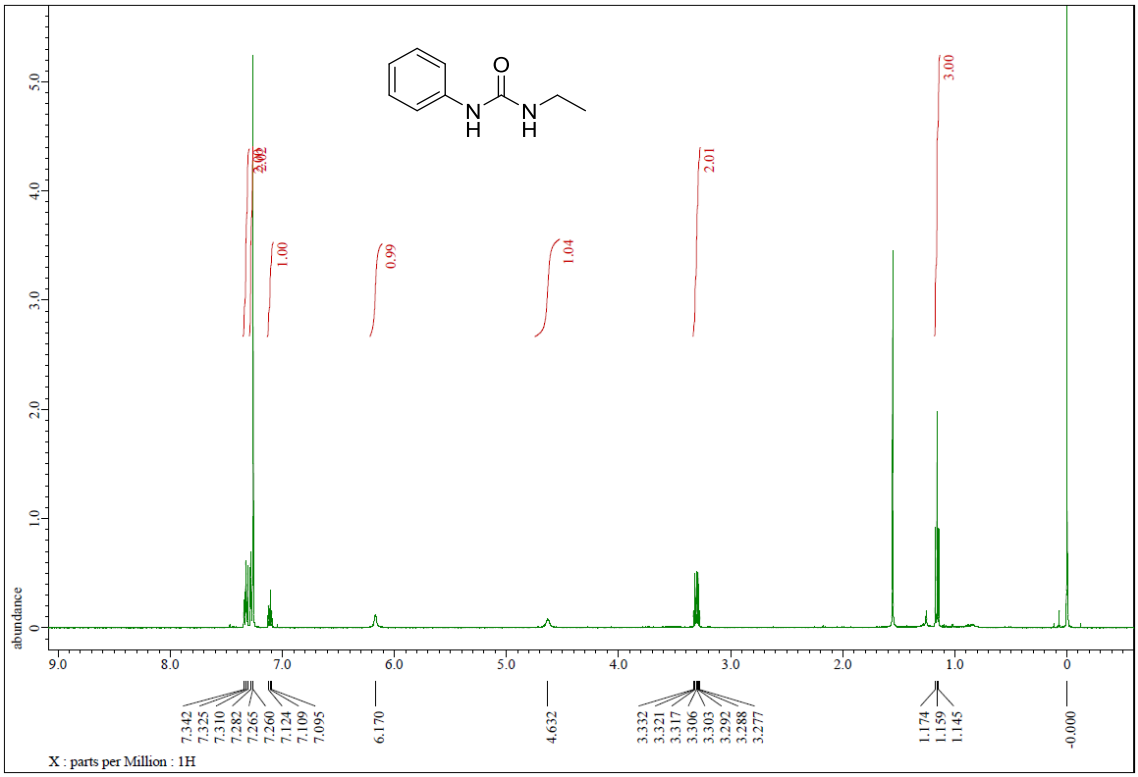
^{1}H NMR spectrum of **4k** ($CDCl_3$, 500 MHz)



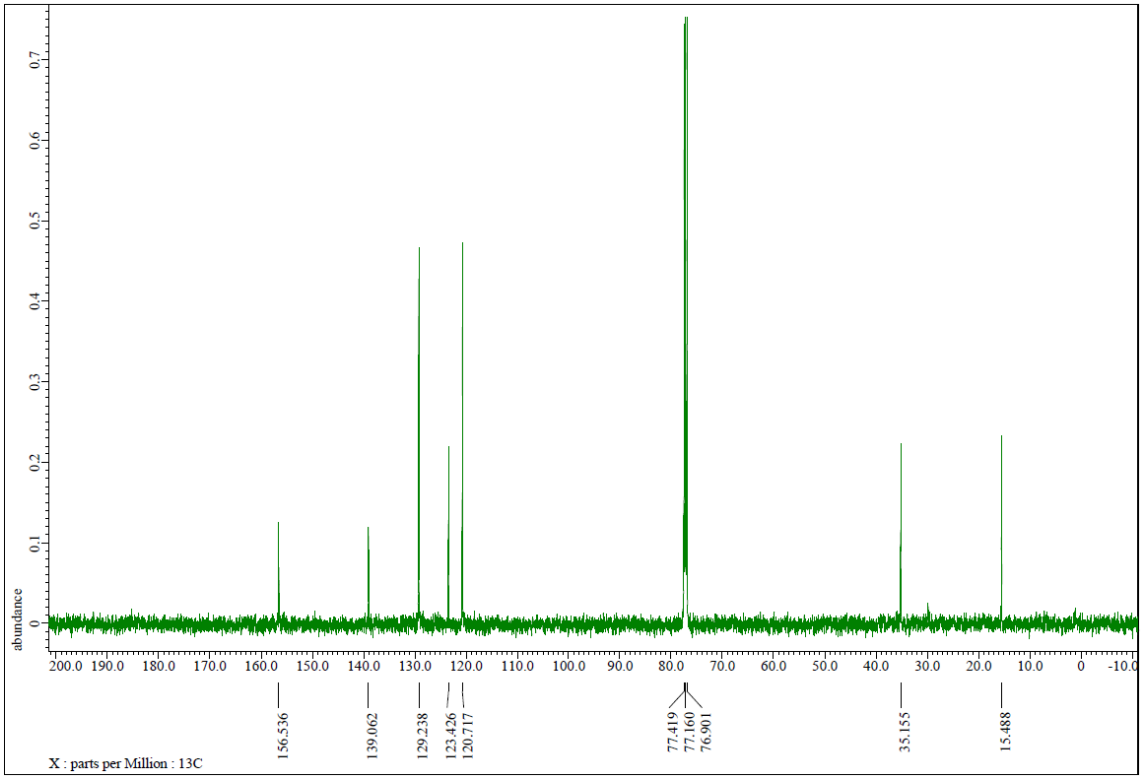
^{13}C NMR spectrum of **4k** ($CDCl_3$, 125 MHz)



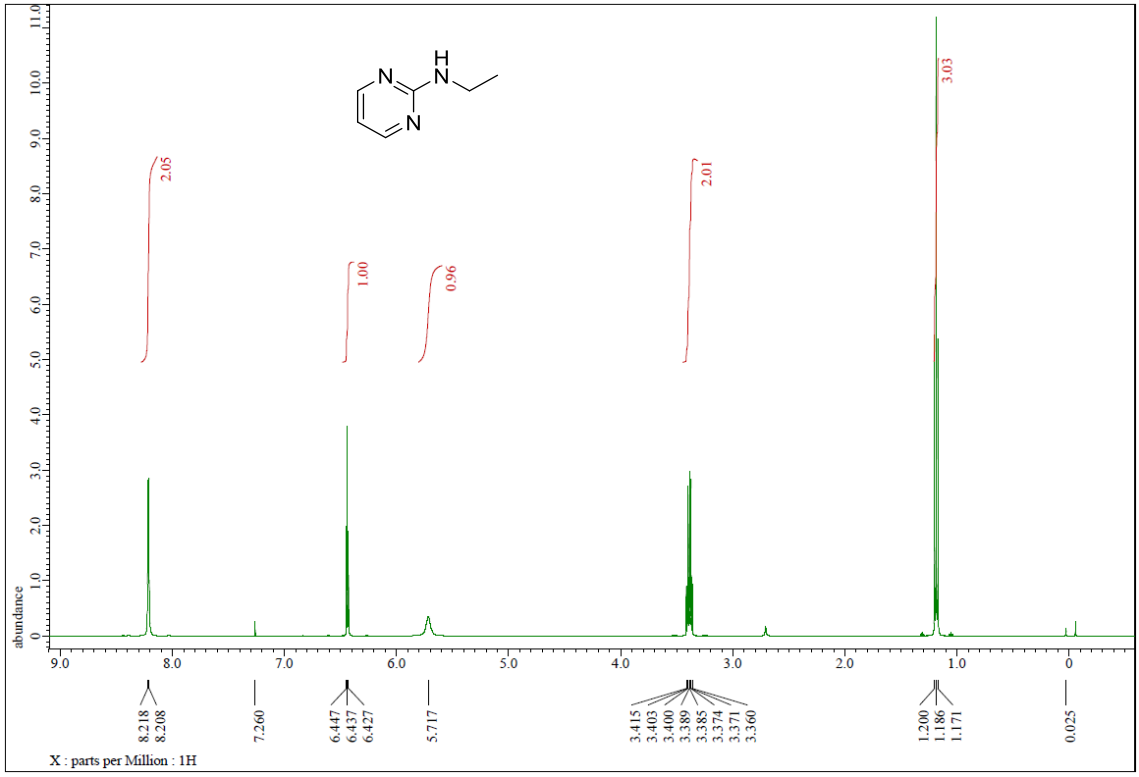
^{1}H NMR spectrum of **4l** ($CDCl_3$, 500 MHz)



^{13}C NMR spectrum of **4l** ($CDCl_3$, 125 MHz)



^{1}H NMR spectrum of **4n** ($CDCl_3$, 500 MHz)



^{13}C NMR spectrum of **4n** ($CDCl_3$, 125 MHz)