Electronic Supplementary Material (ESI) for RSC Advances.
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General Experimental

Chemicals

All reagents were purchased from Aldrich or AlfaAesar and were used as received without further purification unless otherwise stated.

Solvents

Where described below, Petrol refers to petroleum ether (b.p. 40-60 °C).

Chromatography

All reactions were monitored by thin-layer chromatography (TLC) on pre-coated silica gel plates. Silica get plates were initially examined under short wave UV light and then developed using aqueous potassium permanganate stain. Flash column chromatography was carried out with pre-loaded GraceResolvTM flash cartridges on a Biotage® Isolera Spektra One flash chromatography system.

Spectroscopy

Quoted yields refer to chromatographically and spectroscopically pure compounds unless otherwise stated. ^{1}H NMR spectra were recorded at 600 MHz and ^{13}C NMR at 150 MHz on a Bruker AMX600 spectrometer. The chemical shifts (δ) for ^{1}H and ^{13}C are quoted relative to residual signals of the solvent on the parts per million (ppm) scale. In the case of multiple rotamers, only the major has been assigned. Coupling constants (*J* values) are reported in Hertz (Hz) and are reported as $J_{H\text{-}H}$ unless otherwise stated. Signal multiplicities in ^{13}C NMR were determined using the distortionless enhancement by polarisation transfer (DEPT) spectral editing technique. Where applicable, only the peaks for the major rotamers of acyl hydrazides are assigned in the ^{1}H and ^{13}C spectra.

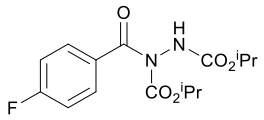
Miscellaneous

Melting points were measured with a Gallenkamp apparatus and are uncorrected.

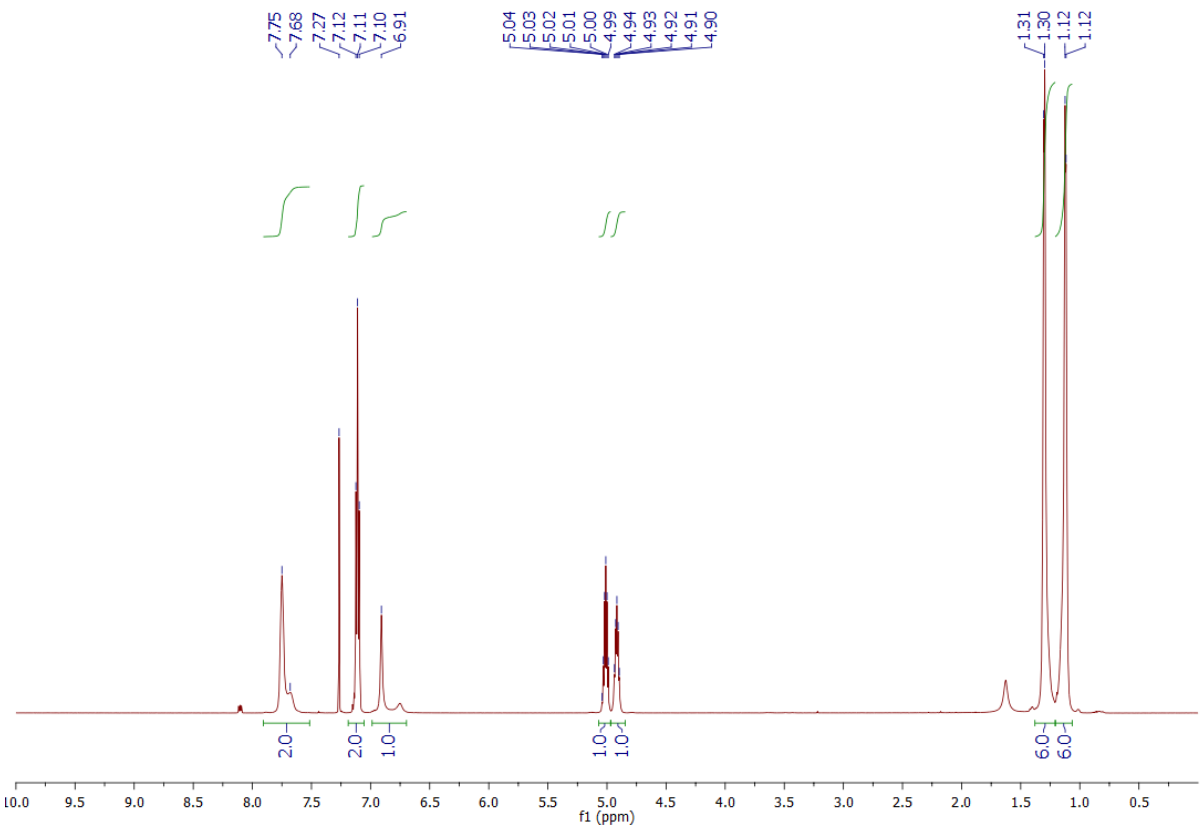
General experimental for the formation of acyl hydrazides – Method A

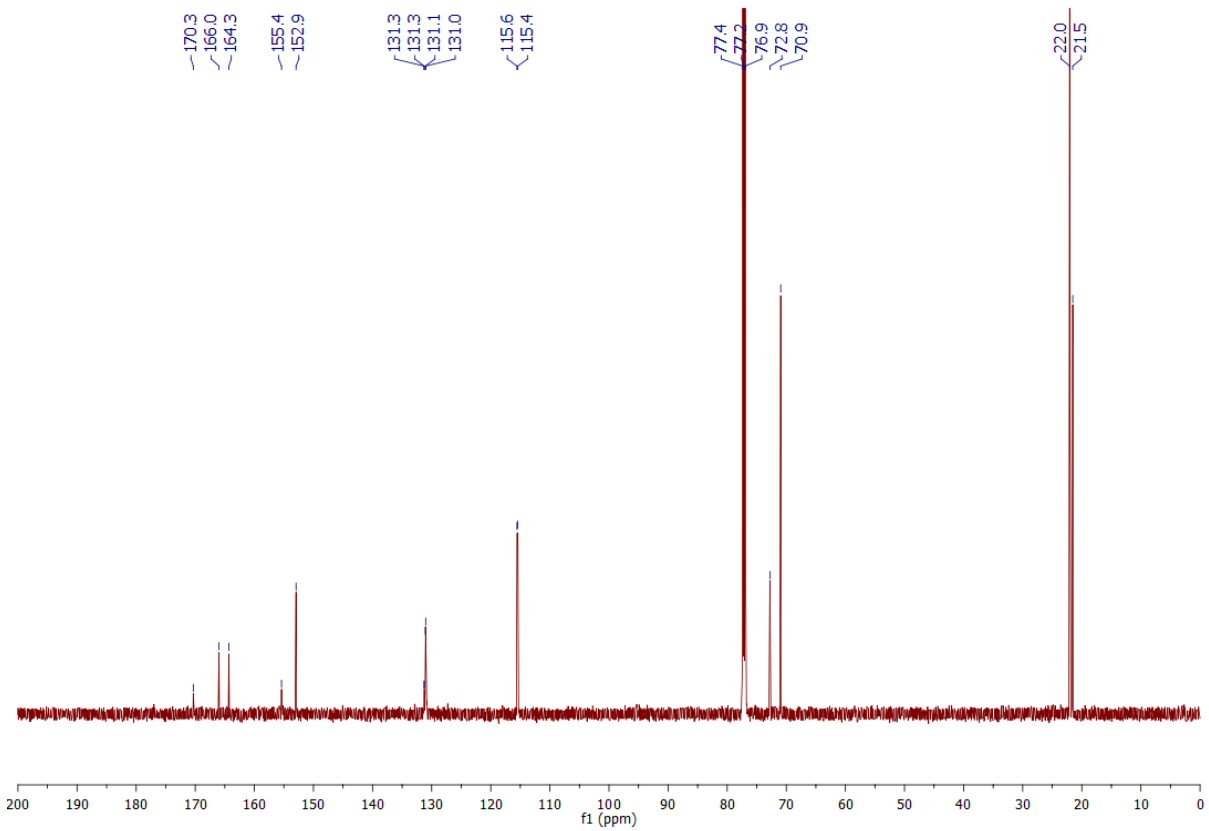
To a solution of azodicarboxylate (6.00 mmol) on H_2O (1 mL) was added aldehyde (5.00 mmol). The reaction mixture stirred at 21 °C for 48 h. The resulting solution was extracted with EtOAc (3 × 15 mL). The combined extracts were dried ($MgSO_4$), filtered and the solvent was evaporated *in vacuo*. The resultant crude residue was purified as described below.

Diisopropyl 1-(4-fluorobenzoyl)hydrazine-1,2-dicarboxylate[1] 1a

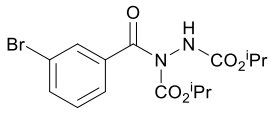


Compound prepared according to method A. Purification by column chromatography (10%-50% EtOAc/Petrol) afforded diisopropyl 1-(4-fluorobenzoyl)hydrazine-1,2-dicarboxylate as a white solid (1.21 g, 3.70 mmol, 74%). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.80-7.62 (m, 2H), 7.11 (t, J = 8.5 Hz, 2H), 6.95-6.70 (m, NH, 1H), 5.02 (septet, J = 6.1 Hz, 1H), 4.92 (septet, J = 6.1 Hz, 1H), 1.30 (d. J = 5.2 Hz, 6H), 1.12 (d, J = 5.0 Hz, 6H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 170.3 (C), 165.2 (d, $J_{C\text{-}F}$ = 253.4 Hz, C), 155.4 (C), 152.9 (C), 131.3 (d, $J_{C\text{-}F}$ = 2.7 Hz, CH), 131.1 (d, $J_{C\text{-}F}$ = 9.8 Hz, CH), 115.5 (d, $J_{C\text{-}F}$ = 22.1 Hz, CH), 72.8 (CH), 70.9 (CH), 22.0 (CH_3), 21.5 (CH_3); IR (solid) 3306, 2984, 2939, 1704, 1602, 1507 cm^{-1}.

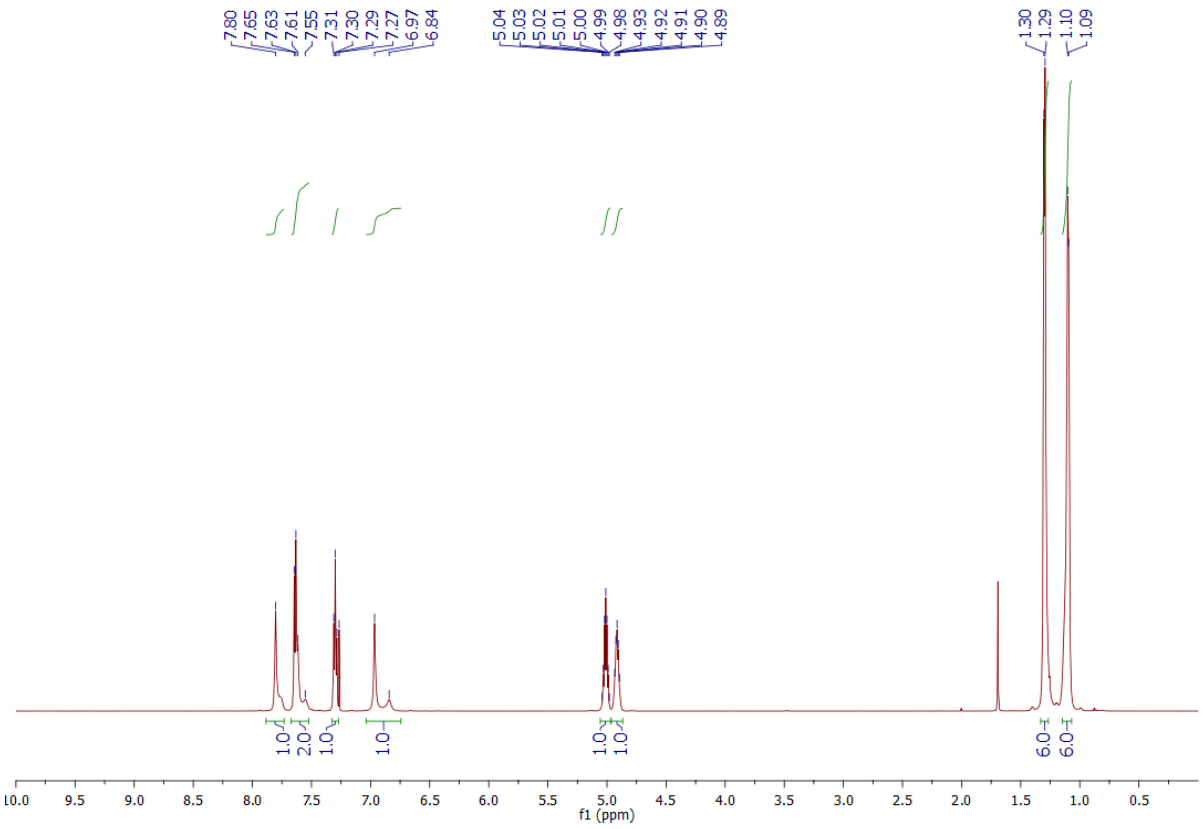


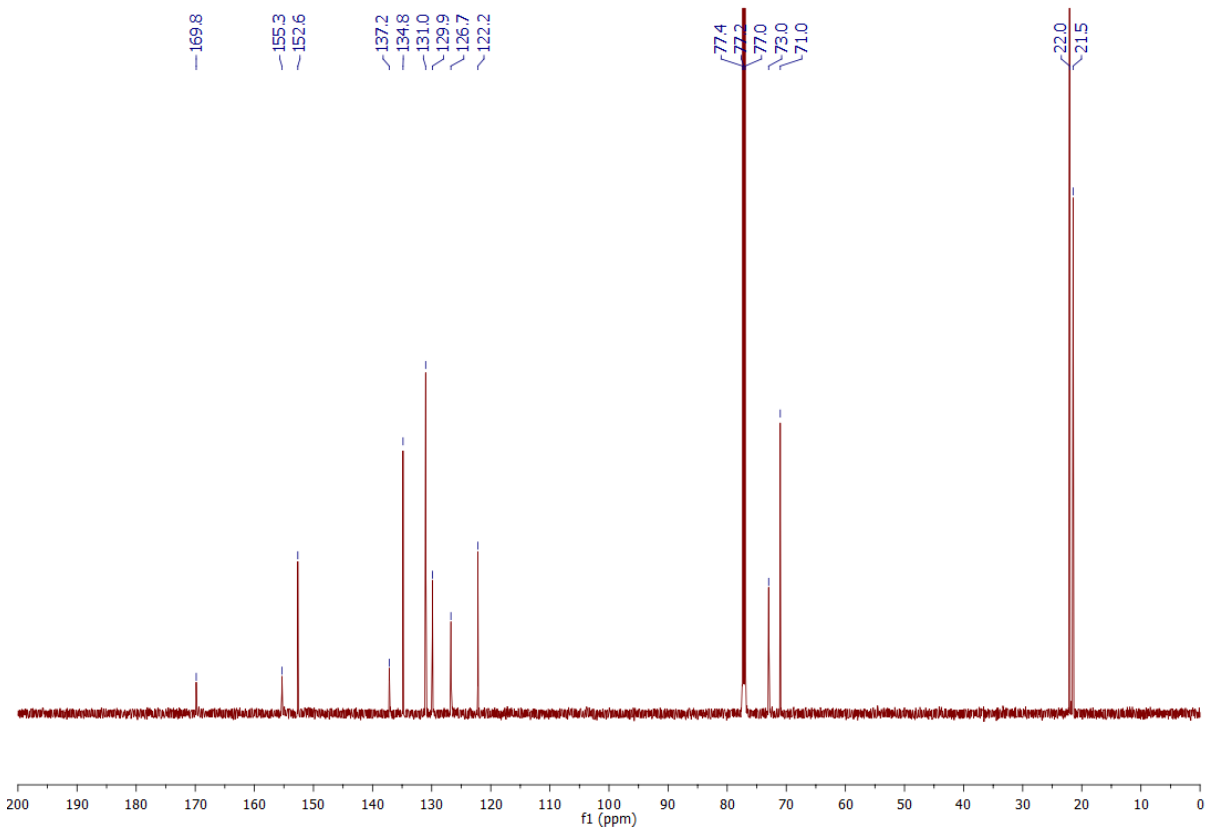

170.3
166.0
164.3
155.4
152.9
131.3
131.3
131.1
131.0
115.6
115.4
77.4
77.2
76.9
72.8
70.9
22.0
21.5
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

Diisopropyl 1-(3-bromobenzoyl)hydrazine-1,2-dicarboxylate[2] 1c

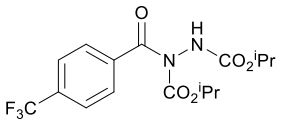


Compound prepared according to method A. Purification by column chromatography (10%-50% EtOAc/Petrol) afforded diisopropyl 1-(3-bromobenzoyl)hydrazine-1,2-dicarboxylate as a white solid (1.20 g, 3.10 mmol, 62%). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.84-7.73 (m, 1H), 7.67-7.52 (m, 2H), 7.30 (t, *J* = 7.8 Hz, 1H), 6.99-6.80 (m, NH, 1H), 5.01 (septet, *J* = 6.0 Hz, 1H), 4.91 (septet, *J* = 6.0 Hz, 1H), 1.30 (d, *J* = 5.8 Hz, 6H), 1.10 (d, *J* = 5.1 Hz, 6H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 169.8 (C), 155.3 (C), 152.6 (C), 137.2 (C), 134.8 (CH), 131.0 (CH), 129.9 (CH), 126.7 (CH), 122.2 (C), 73.0 (CH), 71.0 (CH), 22.0 (CH_3), 21.5 (CH_3); IR (solid) 3303, 2983, 2938, 1707, 1568 cm^{-1}.

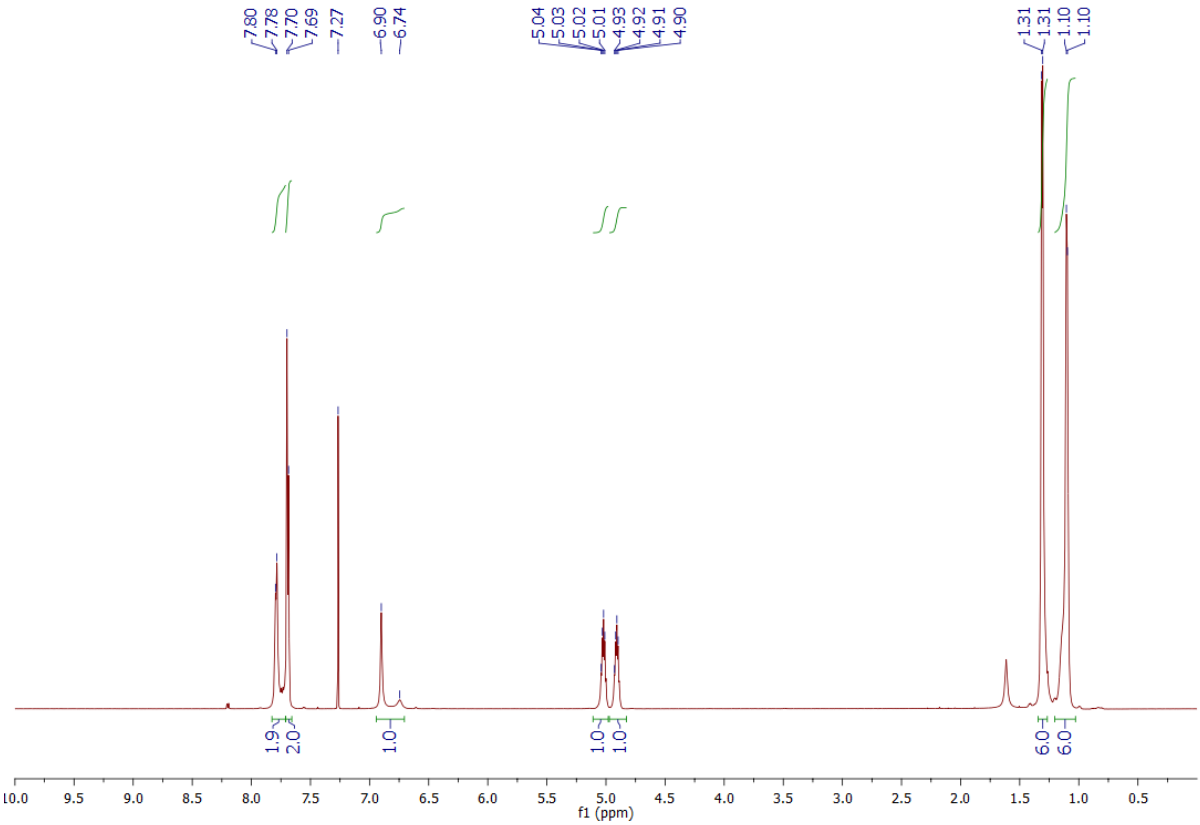


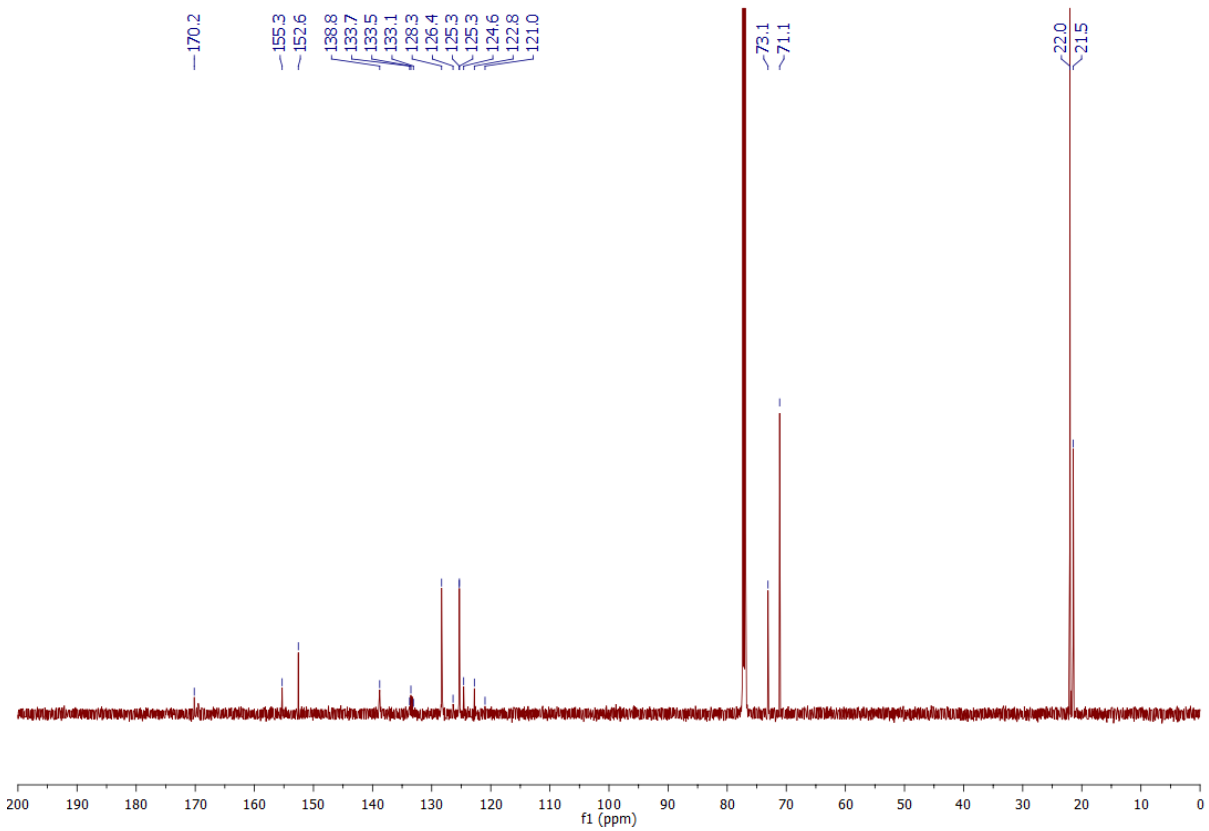

169.8
155.3
152.6
137.2
134.8
131.0
129.9
126.7
122.2
77.4
77.2
77.0
73.0
71.0
22.0
21.5
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Diisopropyl 1-(4-(trifluoromethyl)benzoyl)hydrazine-1,2-dicarboxylate[2] 1d

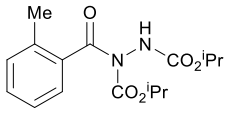


Compound prepared according to method A. Purification by column chromatography (10%-50% EtOAc/Petrol) afforded diisopropyl 1-(4-(trifluoromethyl)benzoyl)hydrazine-1,2-dicarboxylate as a white solid (1.17 g, 3.10 mmol, 62%). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.82-7.74 (m, 2H), 7.73-7.67 (m, 2H), 6.95-6.70 (m, NH, 1H), 5.03 (septet, J = 6.1 Hz, 1H), 4.91 (septet, J = 6.1 Hz, 1H), 1.31 (d, J = 5.8 Hz, 6H), 1.10 (d, J = 5.1 Hz, 6H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 170.2 (C), 155.3 (C), 152.6 (C), 138.8 (C), 133.4 (q, $J_{C\text{-}F}$ = 31.9 Hz, C), 128.3 (CH), 125.3 (q, $J_{C\text{-}F}$ = 3.0 Hz, CH), 123.7 (q, $J_{C\text{-}F}$ = 272.6 Hz, CH), 73.1 (CH), 71.1 (CH), 22.0 (CH_3), 21.5 (CH_3); IR (solid) 3308, 2985, 2941, 1709, 1619, 1514 cm^{-1}.

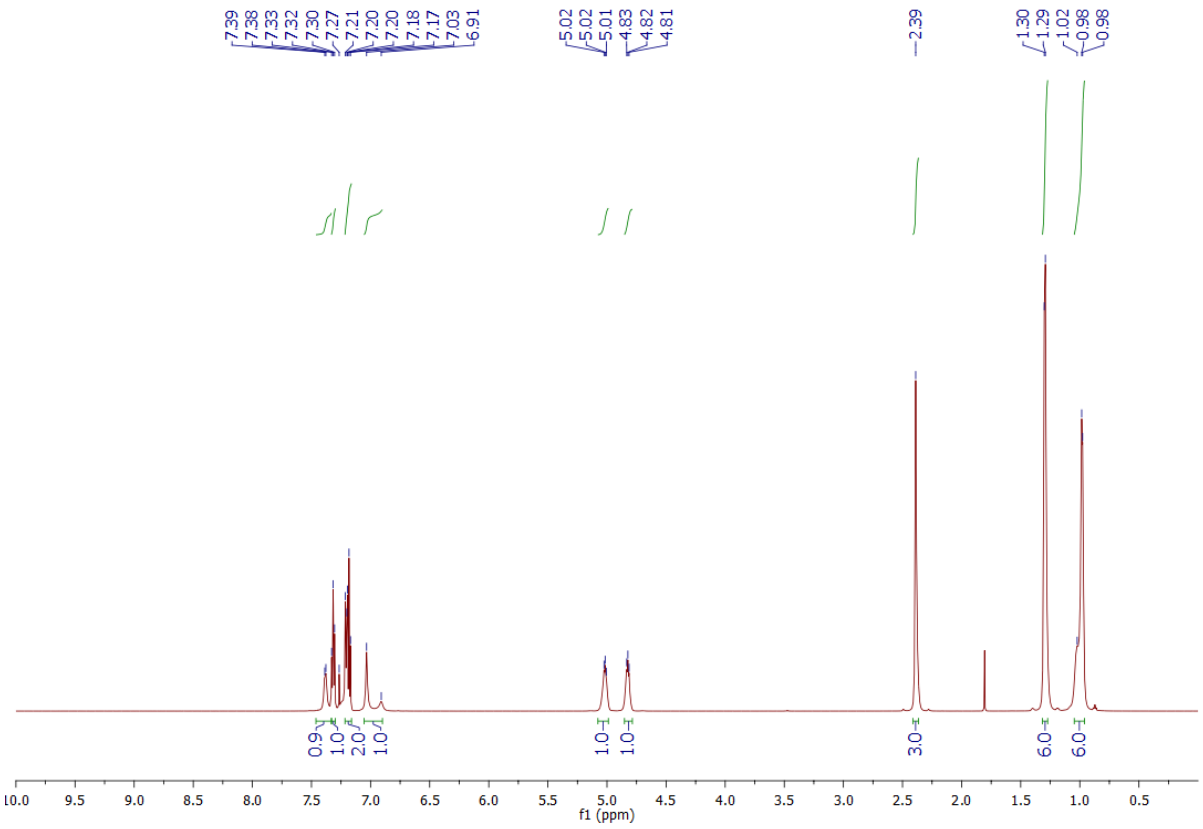


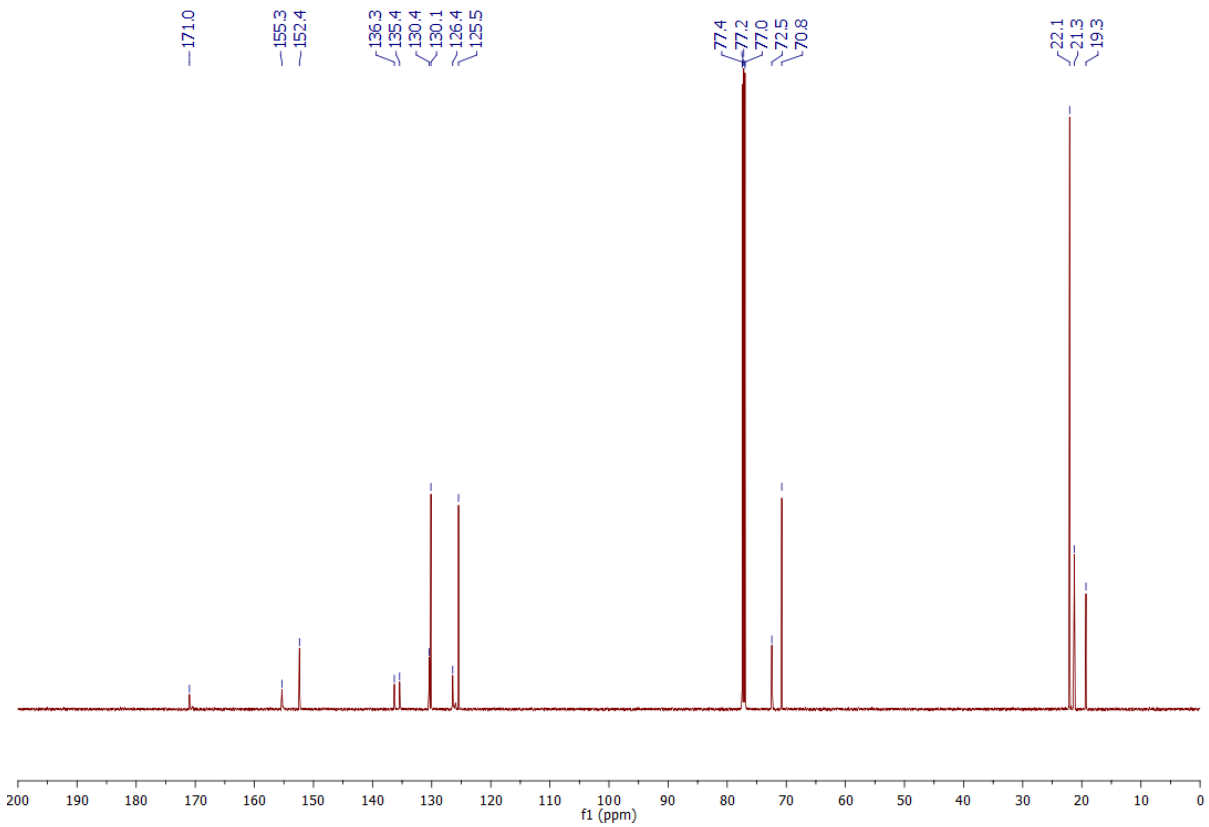

170.2
155.3
152.6
138.8
133.7
133.5
133.1
128.3
126.4
125.3
125.3
124.6
122.8
121.0
73.1
71.1
22.0
21.5
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Diisopropyl 1-(2-methylbenzoyl)hydrazine-1,2-dicarboxylate[2] 1e

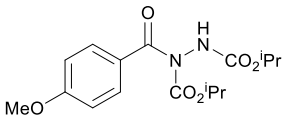


Compound prepared according to method A. Purification by column chromatography (10%-50% EtOAc/Petrol) afforded diisopropyl 1-(2-methylbenzoyl)hydrazine-1,2-dicarboxylate as a white solid (887 mg, 2.75 mmol, 55%). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.43-7.34 (m, 1H), 7.32 (t, *J* = 7.5 Hz 1H), 7.23-7.16 (m, 2H), 7.06-6.86 (m, NH, 1H), 5.02 (septet, *J* = 5.7 Hz, 1H), 4.82 (septet, *J* = 5.9 Hz, 1H), 2.39 (s, 3H), 1.30 (d, *J* = 5.7 Hz, 6H), 1.05-0.95 (m, 6H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 171.0 (C), 155.3 (C), 152.4 (C), 136.3 (C), 135.4 (C), 130.4 (CH), 130.1 (CH), 126.4 (CH), 125.5 (CH), 72.5 (CH), 70.8 (CH), 22.1 (CH_3), 21.3 (CH_3), 19.3 (CH_3); IR (solid) 3308, 2983, 2938, 1705, 1602 cm^{-1}.

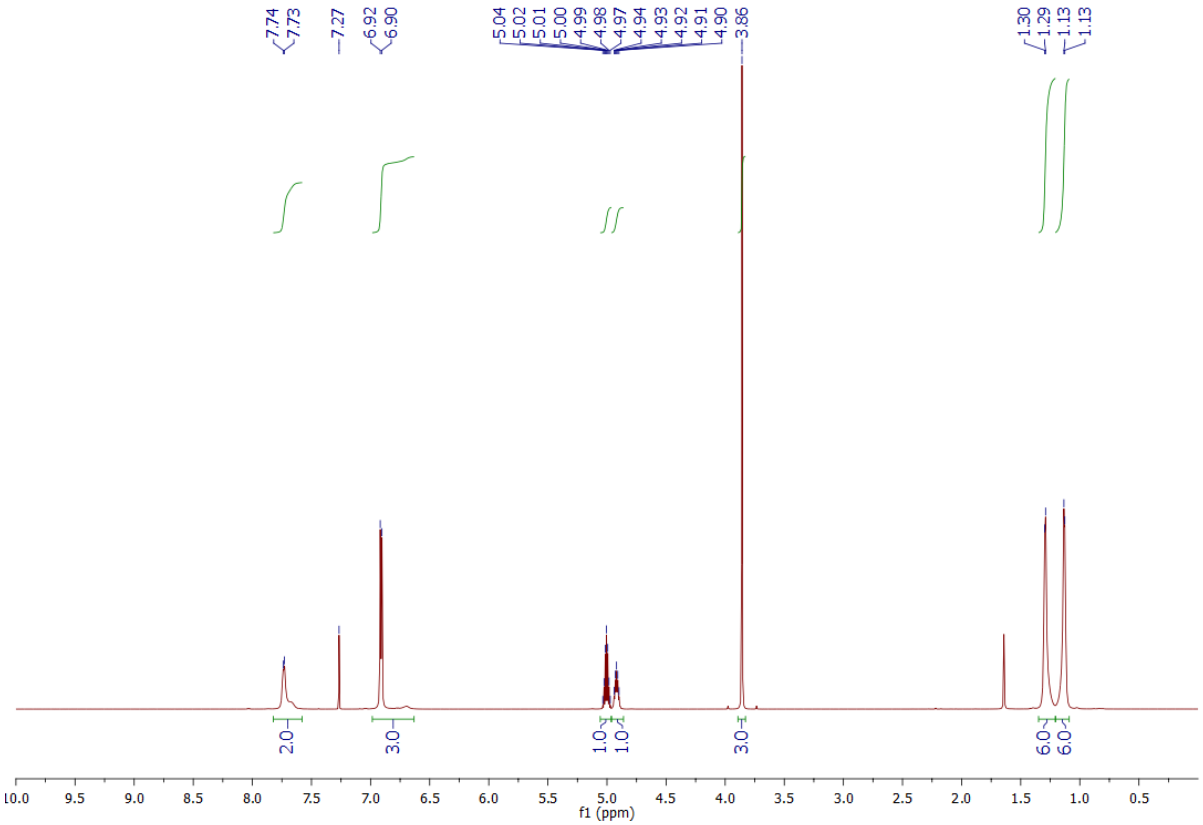


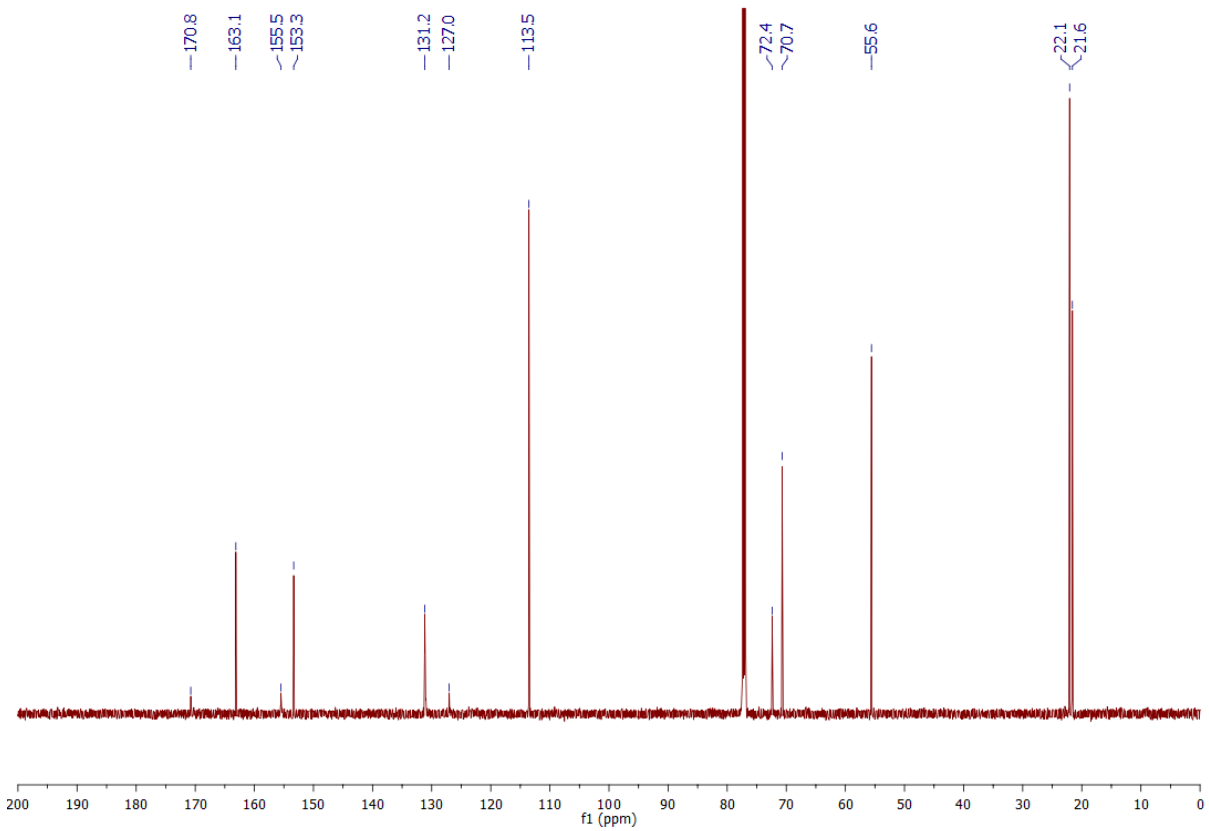

171.0
155.3
152.4
136.3
135.4
130.4
130.1
126.4
125.5
77.4
77.2
77.0
72.5
70.8
22.1
21.3
19.3
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Diisopropyl 1-(4-methoxybenzoyl)hydrazine-1,2-dicarboxylate[3] 1f



Compound prepared according to method A. Purification by column chromatography (10%-50% EtOAc/Petrol) afforded diisopropyl 1-(4-methoxybenzoyl)hydrazine-1,2-dicarboxylate as a white solid (1.03 g, 3.05 mmol, 61%). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.76-7.62 (m, 2H), 6.98-6.64 (m, 3H), 5.00 (septet, *J* = 6.2 Hz, 1H), 4.92 (septet, *J* = 6.2 Hz, 1H), 3.86 (s, 3H), 1.29 (d, *J* = 4.5 Hz, 6H), 1.13 (d, *J* = 4.5 Hz, 6H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 170.8 (C), 163.1 (C), 155.5 (C), 153.3 (C), 131.2 (CH), 127.0 (C), 113.5 (CH), 72.4 (CH), 70.7 (CH), 55.6 (CH_3), 22.1 (CH_3), 21.6 (CH_3); IR (solid) 3310, 2982, 2938, 1733, 1699, 1604, 1510 cm^{-1}.




170.8
163.1
155.5
153.3
131.2
127.0
113.5
72.4
70.7
55.6
22.1
21.6
200
190
180
170
160
150
140
130
120
110
100
90
80
70
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40
30
20
10
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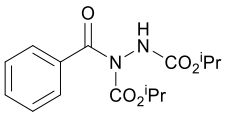
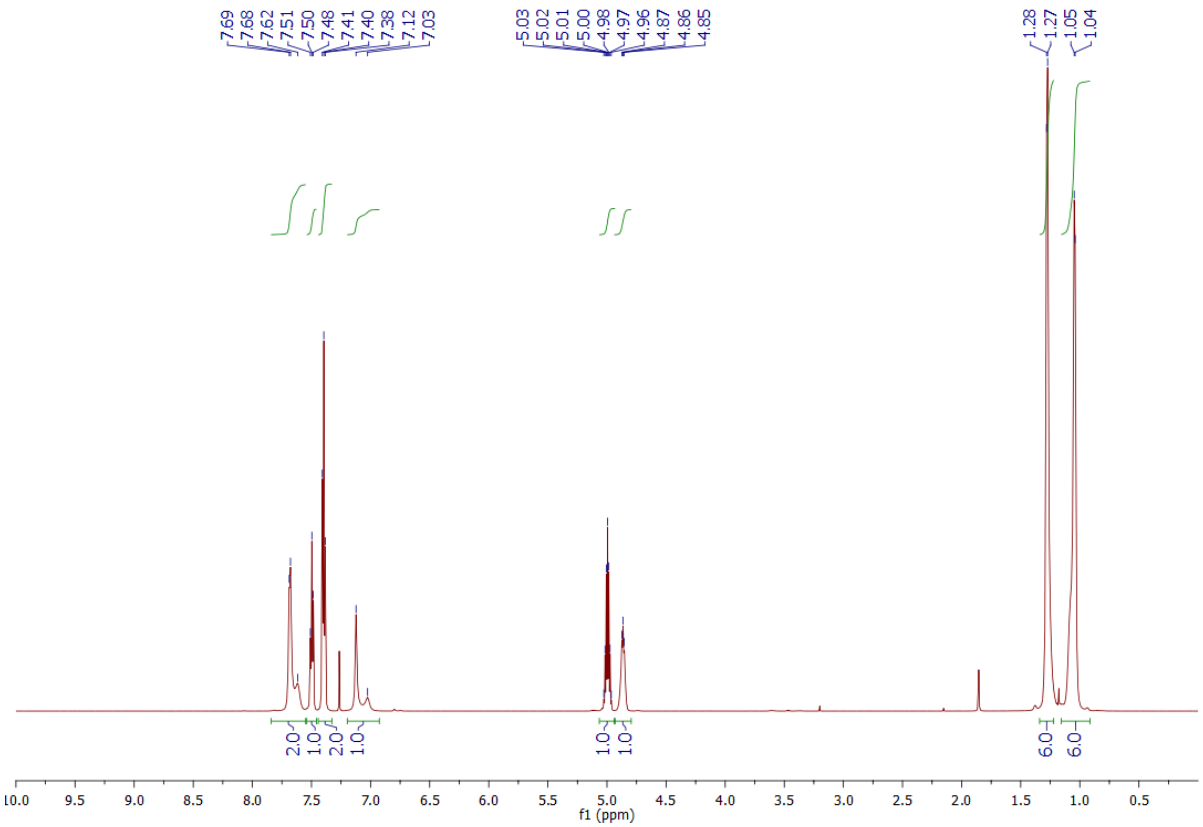
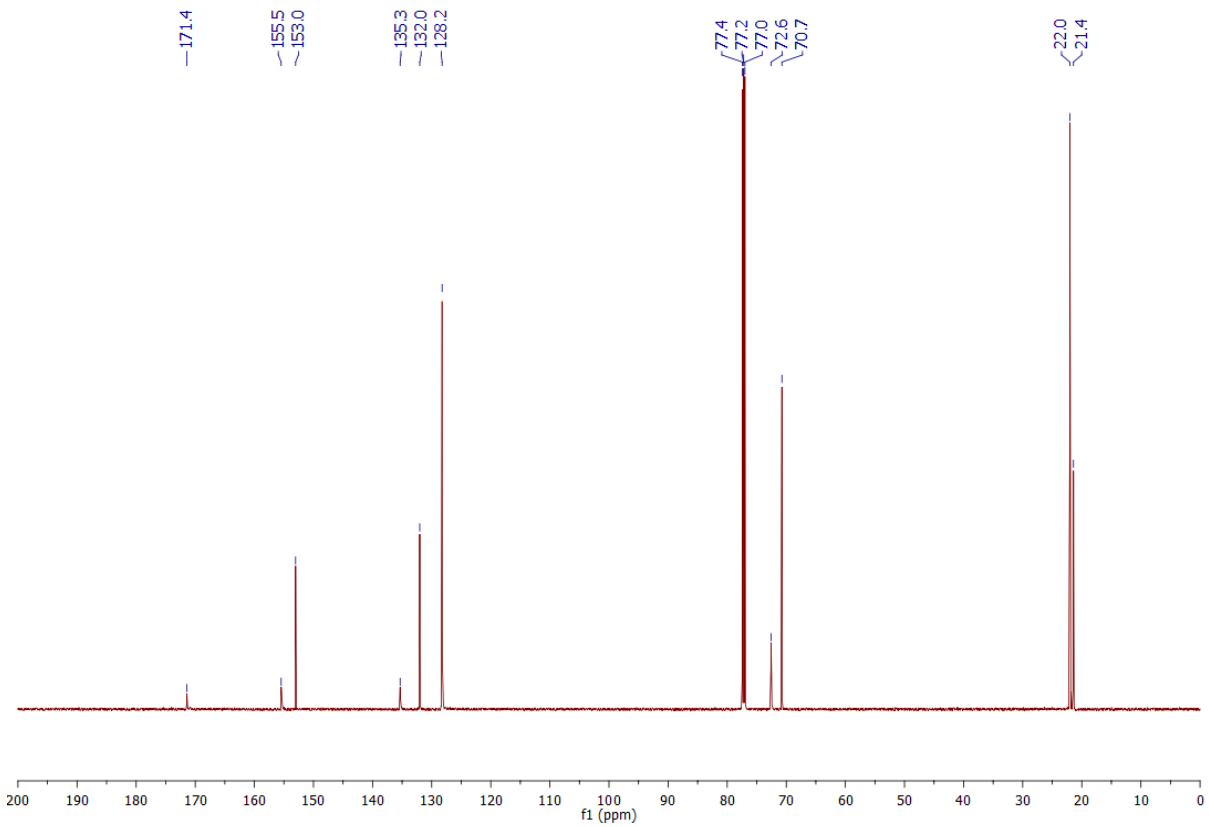
f1 (ppm)

Diisopropyl 1-benzoylhydrazine-1,2-dicarboxylatedicarboxylate[4] 1g



Compound prepared according to method A. Purification by column chromatography (10%-50% EtOAc/Petrol) afforded diisopropyl 1-benzoylhydrazine-1,2-dicarboxylatedicarboxylate as a white solid (1.02 g, 3.30 mmol, 66%). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.72-7.58 (m, 2H), 7.50 (t, *J* = 7.4 Hz, 1H), 7.40 (t, *J* = 7.6 Hz, 2H), 7.15-6.99 (m, NH, 1H), 5.00 (septet, *J* = 6.3 Hz, 1H), 4.87 (septet, *J* = 5.9 Hz, 1H), 1.28 (d, *J* = 5.5 Hz, 6H), 1.04 (d, *J* = 4.7 Hz, 6H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 171.4 (C), 155.5 (C), 153.0 (C), 135.3 (CH), 132.0 (CH), 128.2 (CH), 72.6 (CH), 70.7 (CH), 22.0 (CH_3), 21.4 (CH_3); IR (solid) 3308, 2983, 2938, 1705, 1601 cm^{-1}.




171.4
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77.2
77.0
72.6
70.7
22.0
21.4
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
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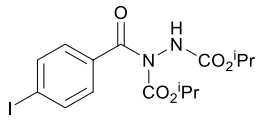
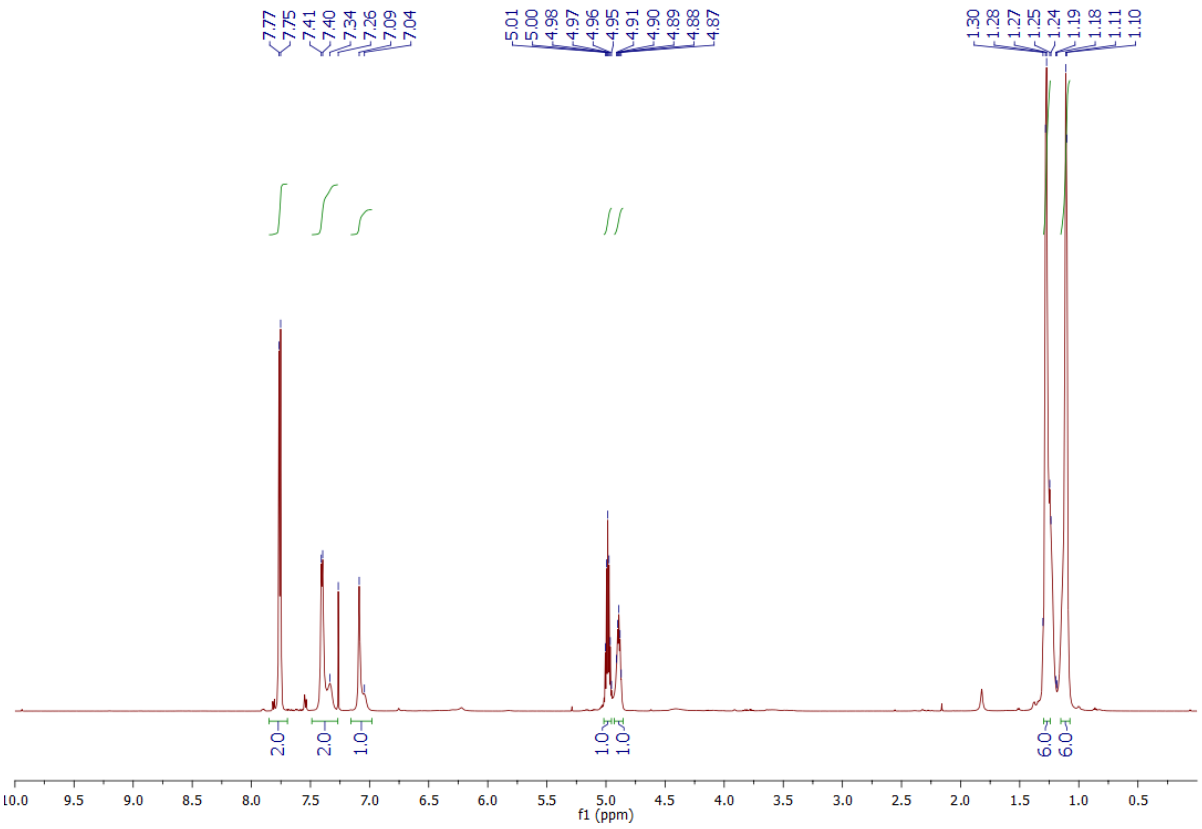
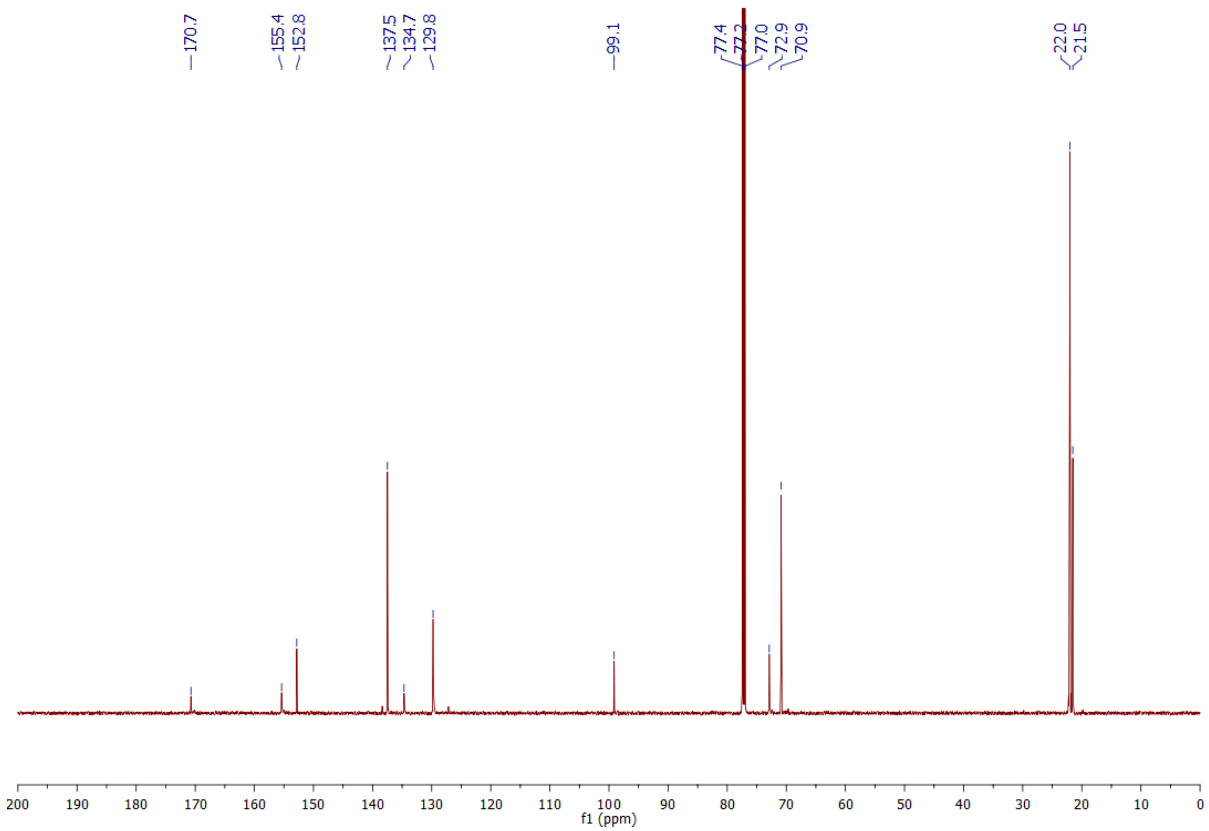
f1 (ppm)

Diisopropyl 1-(4-iodobenzoyl)hydrazine-1,2-dicarboxylate[5] 1h



Compound prepared according to method A. Purification by column chromatography (10%-50% EtOAc/Petrol) afforded diisopropyl 1-(4-iodobenzoyl)hydrazine-1,2-dicarboxylate as a white solid (1.28 g, 2.95 mmol, 59%). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.76 (d, 2H, *J* = 8.2 Hz), 7.43-7.30 (m, 2H), 7.11-7.03 (m, NH, 1H), 4.98 (septet, *J* = 6.2 Hz, 1H), 4.89 (septet, *J* = 6.0 Hz, 1H), 1.30-1.21 (m, 6H), 1.17-1.08 (m, 6H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 170.7 (C), 155.4 (C), 152.8 (C), 137.5 (CH), 134.7 (C), 129.8 (CH), 99.1 (C), 72.9 (CH), 70.9 (CH), 22.0 (CH_3), 21.5 (CH_3); IR (solid) 3302, 2982, 2937, 1705, 1585 cm^{-1}.

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137.5
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129.8
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77.4
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77.0
72.9
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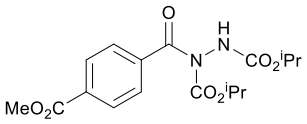
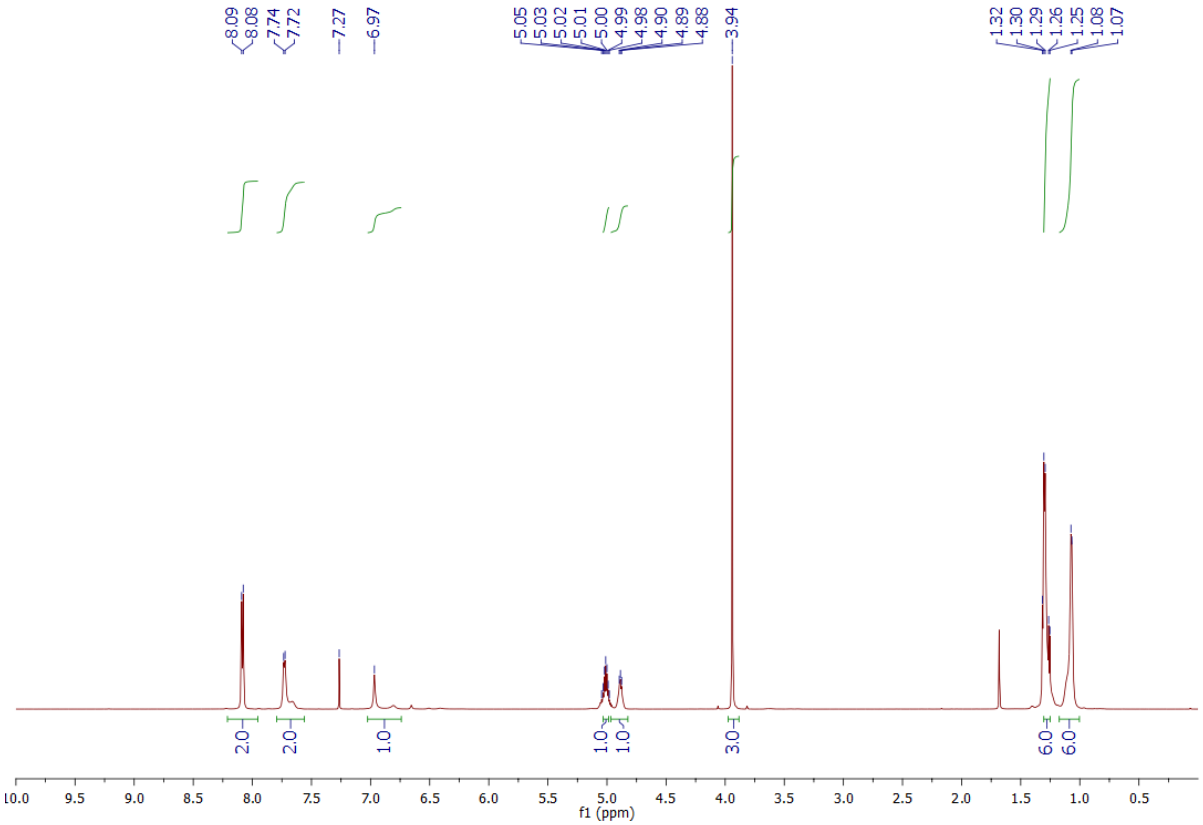
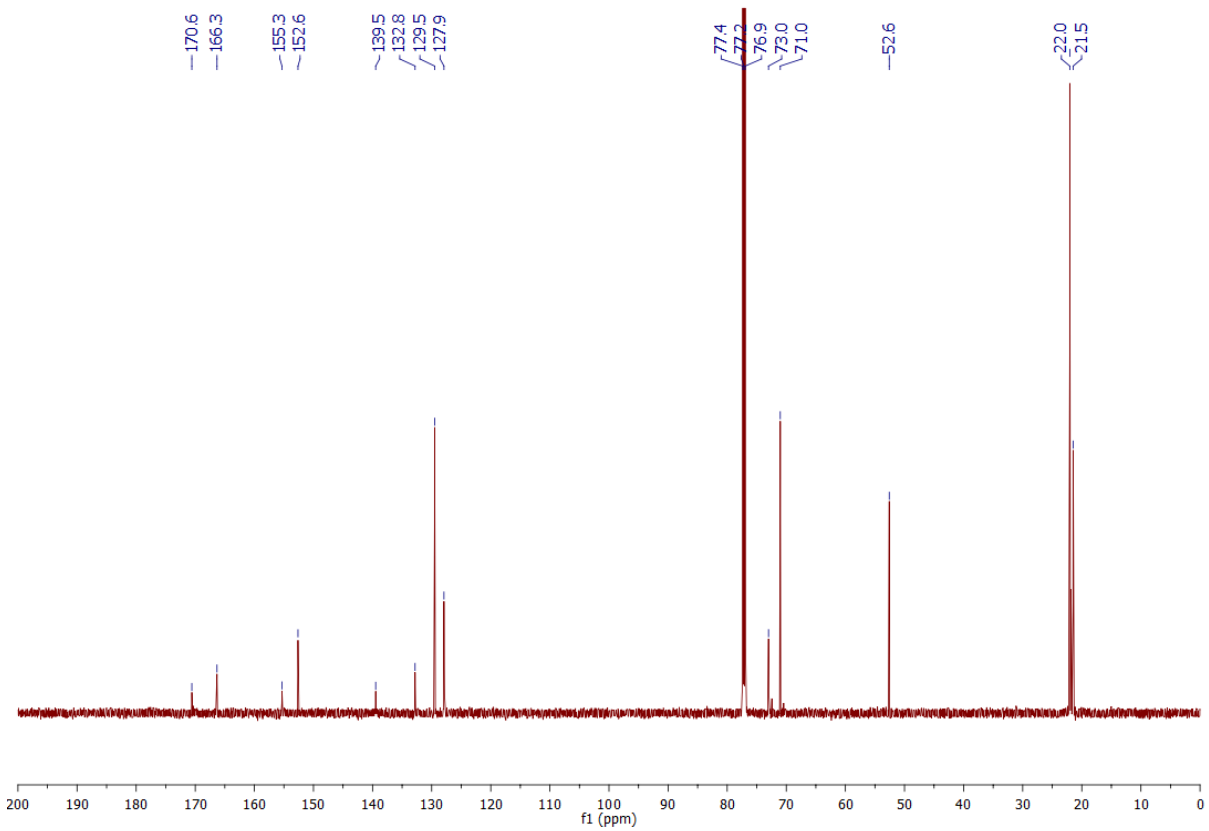
22.0
21.5
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Diisopropyl 1-(4-(methoxycarbonyl)benzoyl)hydrazine-1,2-dicarboxylate 1i



Compound prepared according to method A. Purification by column chromatography (10%-50% EtOAc/Petrol) afforded diisopropyl 1-(4-(methoxycarbonyl)benzoyl)hydrazine-1,2-dicarboxylate as a white solid (898 mg, 2.45 mmol, 49%). m.p. 106-108 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.08 (d, 2H, *J* = 8.1 Hz), 7.75-7.62 (m, 2H), 7.00-6.76 (m, NH, 1H), 5.03 (septet, *J* = 6.2 Hz, 1H), 4.89 (septet, *J* = 6.0 Hz, 1H), 3.94 (s, 3H), 1.33-1.24 (m, 6H), 1.13-1.05 (m, 6H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 170.6 (C), 166.3 (C), 155.3 (C), 152.6 (C), 139.5 (C), 132.8 (C), 129.5 (CH), 127.9 (CH), 73.0 (CH), 71.0 (CH), 52.6 (CH_3), 22.0 (CH_3), 21.5 (CH_3); IR (solid) 3301, 2980, 2936, 1706, 1571 cm^{-1}; LRMS (ESI) 367 (100, $[M+H]^+$), 163 (20, $[M-C_8H_{15}N_2O_4+H]^+$); HRMS (ESI) calcd for $C_{17}H_{23}N_2O_7$ $[M+H]^+$ 367.1500; observed 367.1503.




170.6
166.3
155.3
152.6
139.5
132.8
129.5
127.9
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77.2
76.9
73.0
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52.6
22.0
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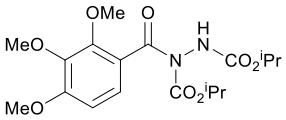
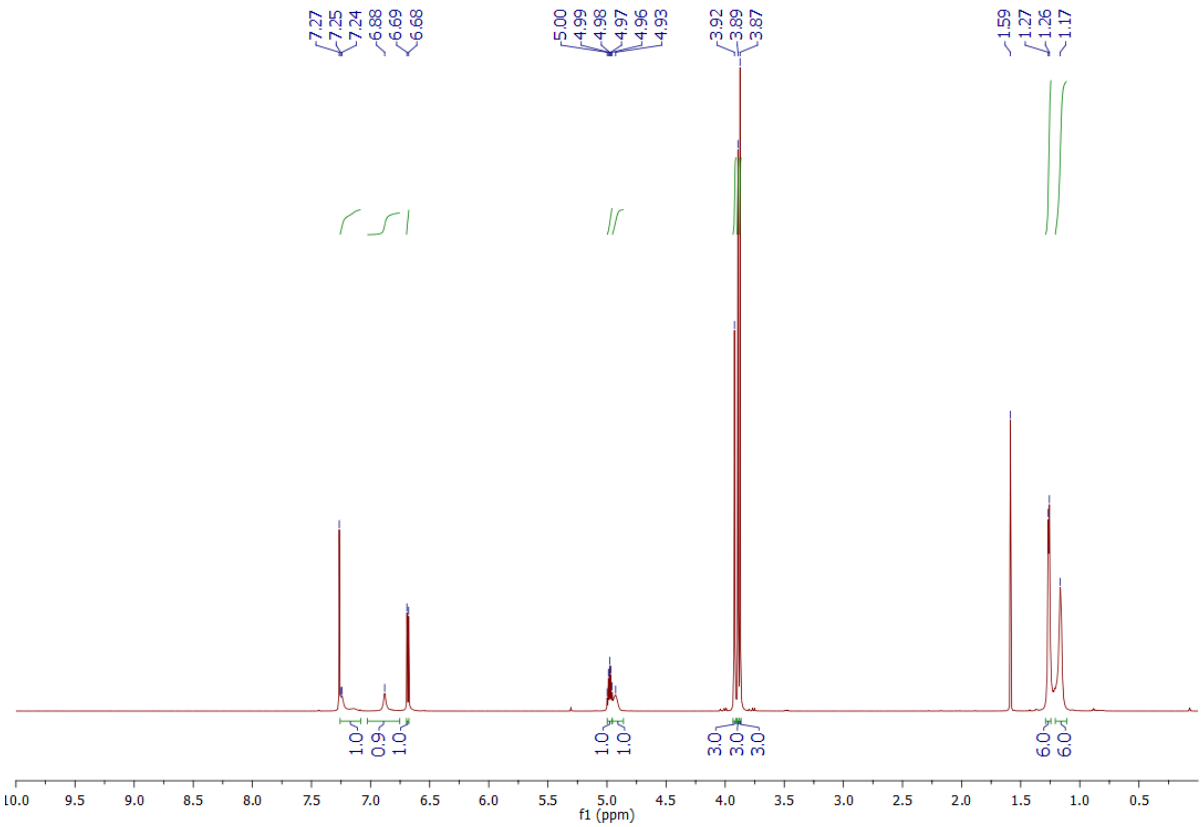
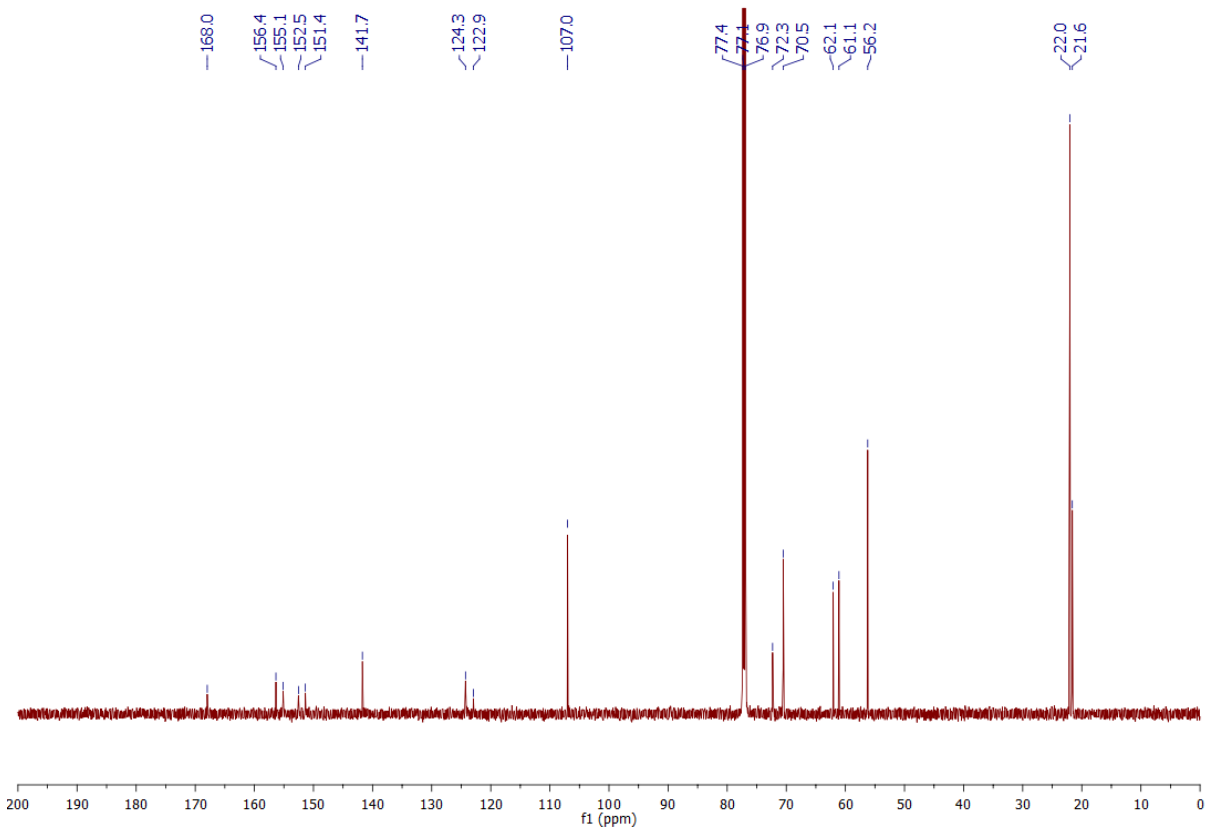
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Diisopropyl 1-(2,3,4-trimethoxybenzoyl)hydrazine-1,2-dicarboxylate 1j

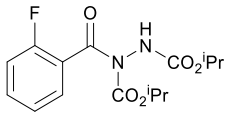


Compound prepared according to method A. Purification by column chromatography (10%-50% EtOAc/Petrol) afforded diisopropyl 1-(2,3,4-trimethoxybenzoyl)hydrazine-1,2-dicarboxylate as a white solid (797 mg, 2.00 mmol, 40%). m.p. 110-112 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.25-7.08 (m, 1H), 6.88 (s, NH, 1H), 6.69 (d, *J* = 8.7 Hz, 1H), 5.00-4.88 (m, 2H), 3.92 (s, 3H), 3.89 (s, 3H), 3.87 (s, 3H), 1.26 (d, *J* = 5.8 Hz, 6H), 1.20-1.012 (m, 6H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 168.0 (C), 156.4 (C), 155.1 (C), 152.5 (C), 151.4 (C), 141.7 (C), 124.3 (CH), 122.9 (C), 107.0 (CH), 72.3 (CH), 70.5 (CH), 62.1 (CH_3), 61.1 (CH_3), 56.2 (CH_3), 22.0 (CH_3), 21.6 (CH_3); IR (solid) 3310, 2982, 2940, 1737, 1710, 1596 cm^{-1}; LRMS (ESI) 399 (30, $[M+H]^+$), 195 (100, $[M-C_8H_{15}N_2O_4+H]^+$); HRMS (ESI) calcd for $C_{18}H_{27}N_2O_8$ $[M+H]^+$ 399.1762; observed 399.1760.

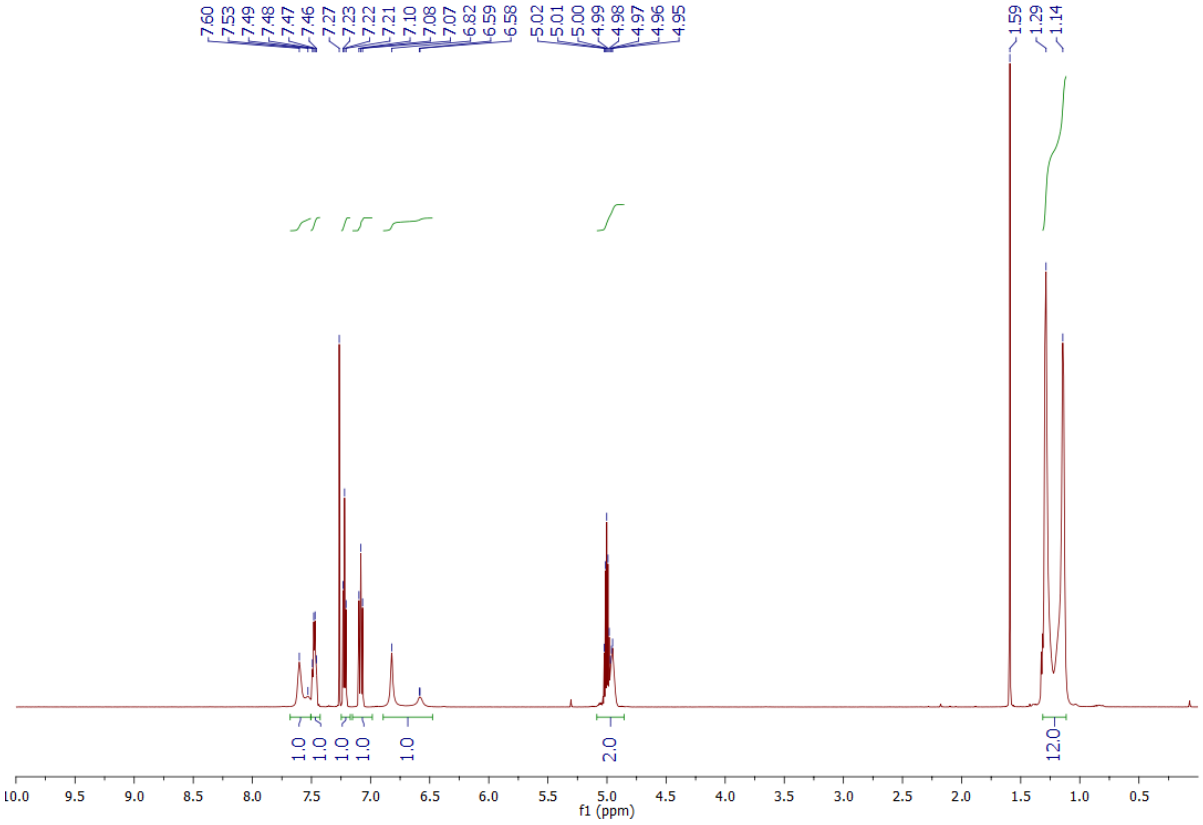


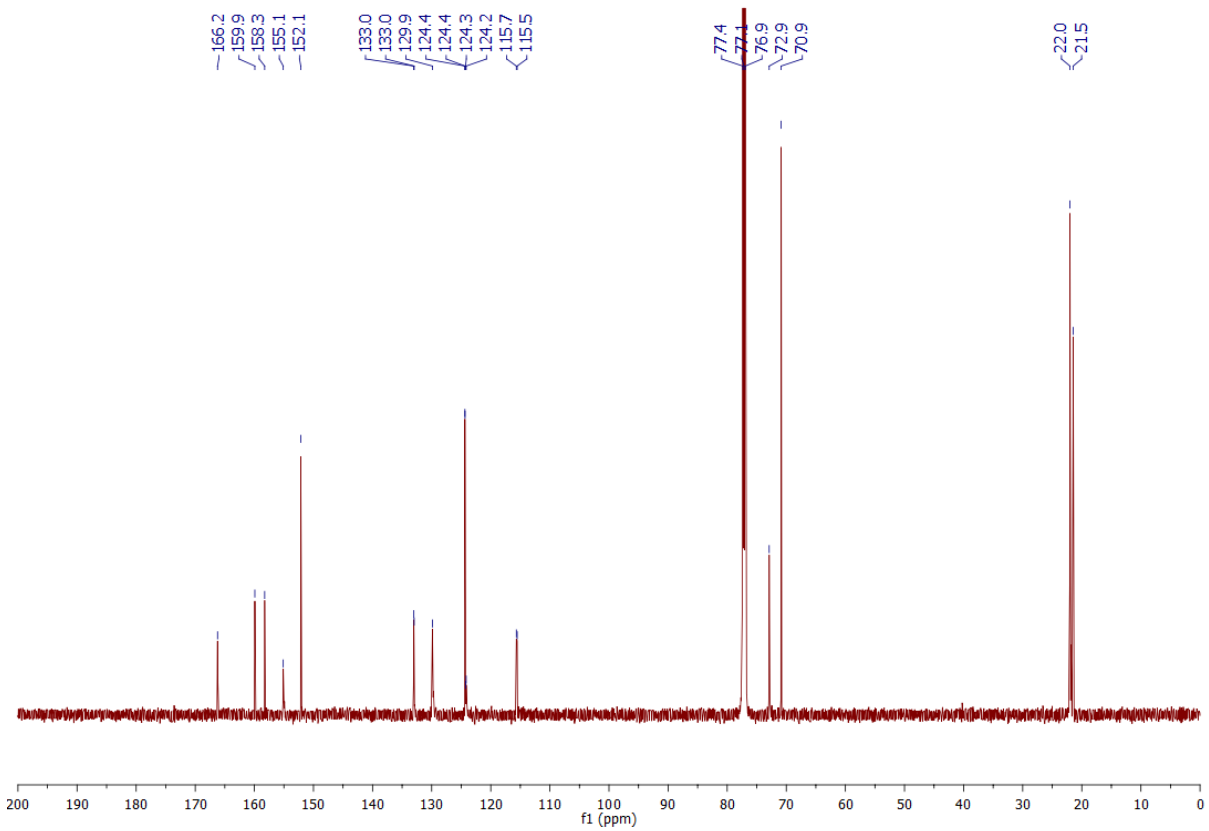

168.0
156.4
155.1
152.5
151.4
141.7
124.3
122.9
107.0
77.4
77.1
76.9
72.3
70.5
62.1
61.1
56.2
22.0
21.6
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Diisopropyl 1-(2-fluorobenzoyl)hydrazine-1,2-dicarboxylate[2] 1k

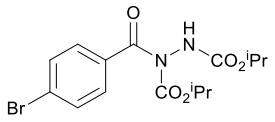


Compound prepared according to method A. Purification by column chromatography (10%-50% EtOAc/Petrol) afforded diisopropyl 1-(2-fluorobenzoyl)hydrazine-1,2-dicarboxylate as a white solid (979 mg, 3.00 mmol, 60%). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.64-7.50 (m, 1H), 7.48 (m, 1H), 7.22 (t, J = 7.5 Hz, 1H), 7.11-7.06 (m, 1H), 6.82-6.52 (m, NH, 1H), 5.04-4.92 (m, 2H), 1.32-1.11 (m, 12H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 166.2 (C), 159.1 (d, $J_{C\text{-}F}$ = 251.1 Hz, C), 155.1 (C), 152.1 (C), 133.0 (d, $J_{C\text{-}F}$ = 7.7 Hz, CH), 129.9 (CH), 124.4 (d, $J_{C\text{-}F}$ = 3.3 Hz, CH), 124.2 (d, $J_{C\text{-}F}$ = 15.6 Hz, C), 115.6 (d, $J_{C\text{-}F}$ = 21.0 Hz, CH), 72.9 (CH), 70.9 (CH), 22.0 (CH_3), 21.5 (CH_3); IR (solid) 3306, 2984, 2943, 2857, 1739, 1714, 1614, 1581, 1563 cm^{-1}.

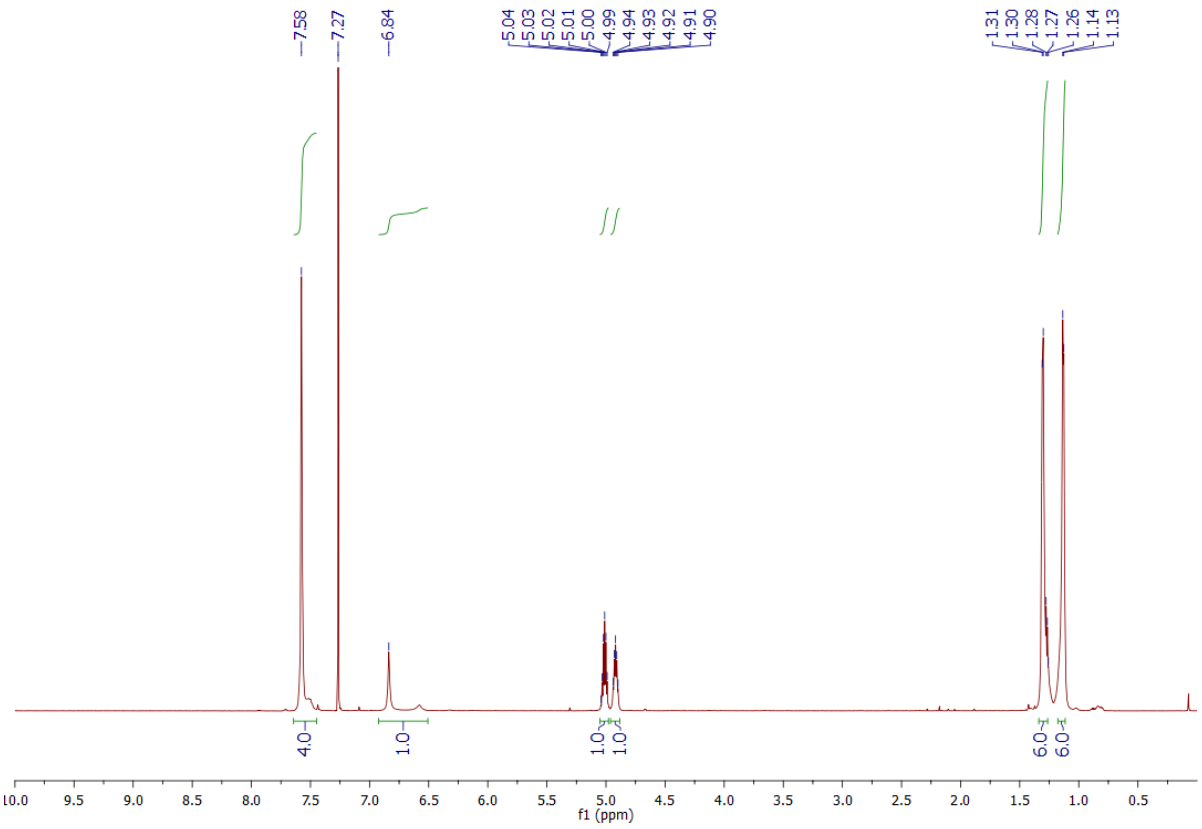


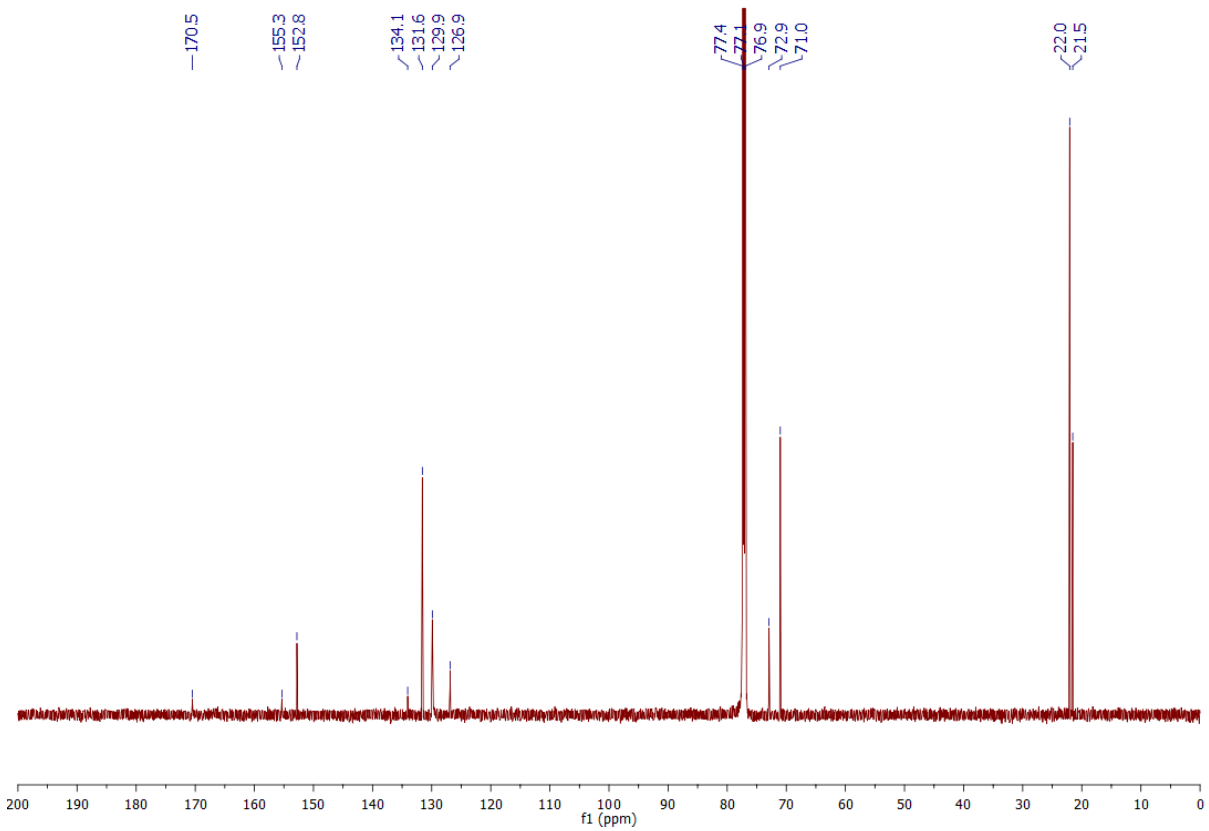

166.2
159.9
158.3
155.1
152.1
133.0
133.0
129.9
124.4
124.4
124.3
124.2
115.7
115.5
77.4
77.1
76.9
72.9
70.9
22.0
21.5
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Diisopropyl 1-(4-bromobenzoyl)hydrazine-1,2-dicarboxylate[3] 1l

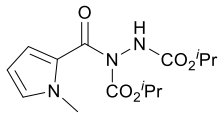


Compound prepared according to method A. Purification by column chromatography (10%-50% EtOAc/Petrol) afforded diisopropyl 1-(4-bromobenzoyl)hydrazine-1,2-dicarboxylate as a white solid (1.20 g, 3.10 mmol, 62%). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.63-7.48 (m, 4H), 6.88-6.53 (m, NH, 1H), 5.01 (septet, J = 6.2 Hz, 1H), 4.92 (septet, J = 6.0 Hz, 1H), 1.33-1.24 (m, 6H), 1.18-1.11 (m, 6H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 170.5 (C), 155.3 (C), 152.8 (C), 134.1 (C), 131.6 (CH), 129.9 (CH), 126.9 (C), 72.9 (CH), 71.0 (CH), 22.0 (CH_3), 21.5 (CH_3); IR (solid) 3294, 2979, 2934, 1737, 1711, 1588 cm^{-1}.

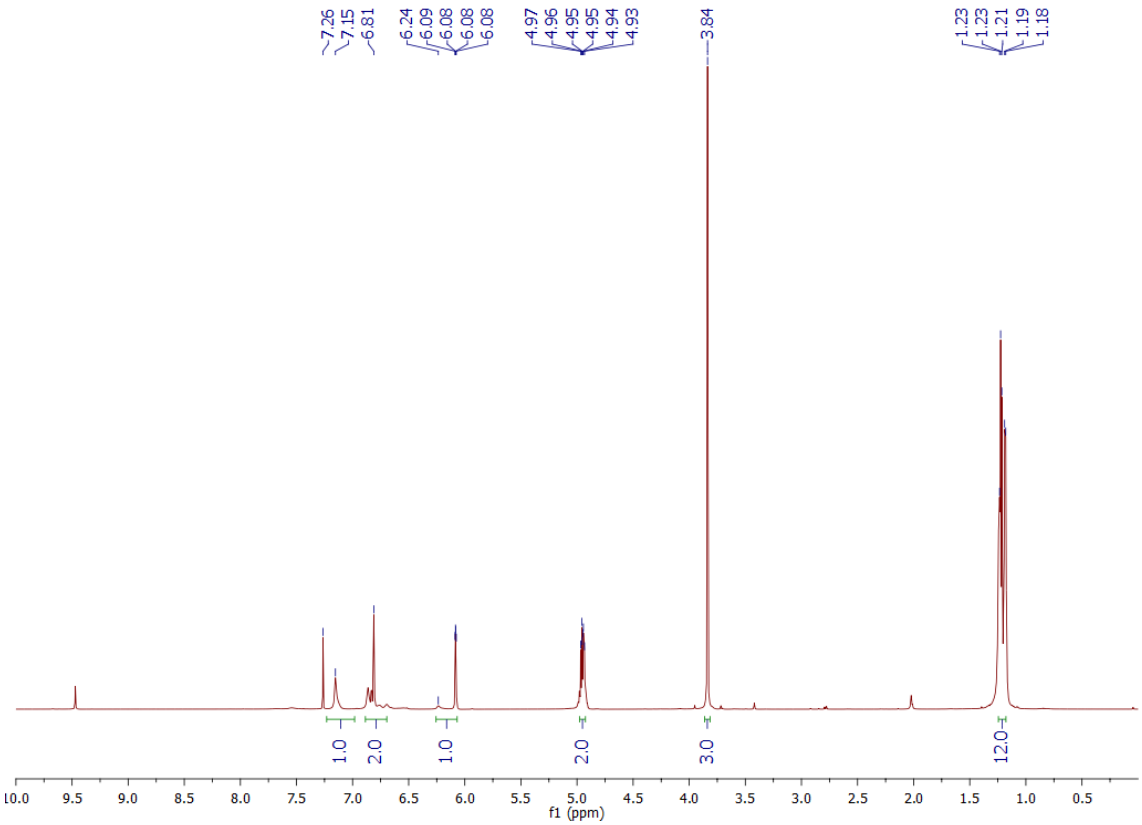


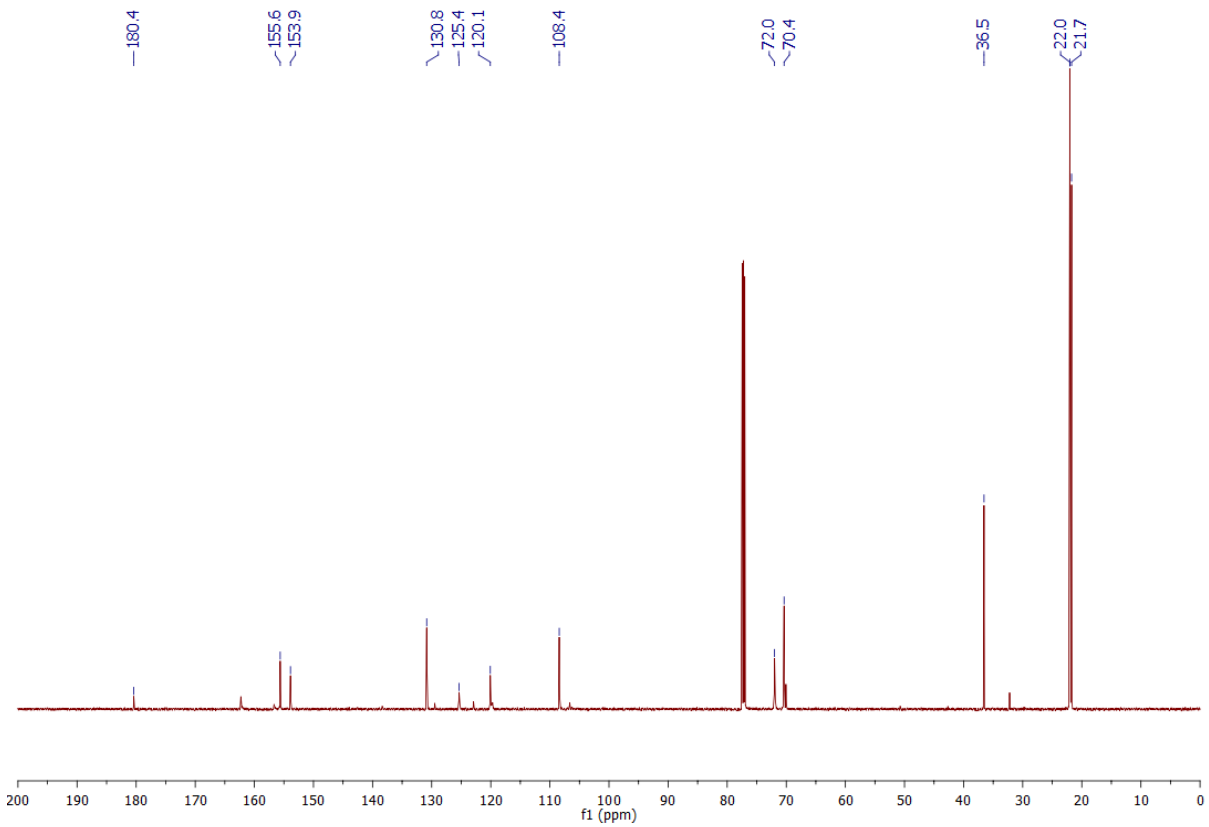

170.5
155.3
152.8
134.1
131.6
129.9
126.9
77.4
77.1
76.9
72.9
71.0
22.0
21.5
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Diisopropyl 1-(1-methyl-1*H*-pyrrole-2-carbonyl)hydrazine-1,2-dicarboxylate[6] 1m

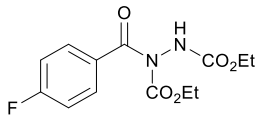


Compound prepared according to method A. Purification by column chromatography (10%-50% EtOAc/Petrol) afforded diisopropyl 1-(1-methyl-1*H*-pyrrole-2-carbonyl)hydrazine-1,2-dicarboxylate as a pale-yellow solid (716 mg, 2.30 mmol, 46%). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.18-7.10 (m, 1H), 6.88-6.70 (m, 2H), 6.25-6.05 (m, 1H), 4.99-4.91 (m, 2H), 3.84 (s, 3H), 1.25-1.16 (m, 12H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 180.4 (C), 155.6 (C), 153.9 (C), 153.5 (C), 130.8 (CH), 125.4 (C), 120.1 (CH), 108.4 (CH), 72.0 (CH), 70.4 (CH), 36.5 (CH_3), 22.0 (CH_3), 21.7 (CH_3); IR (solid) 3305, 2984, 2939, 1729, 1685, 1528 cm^{-1}.

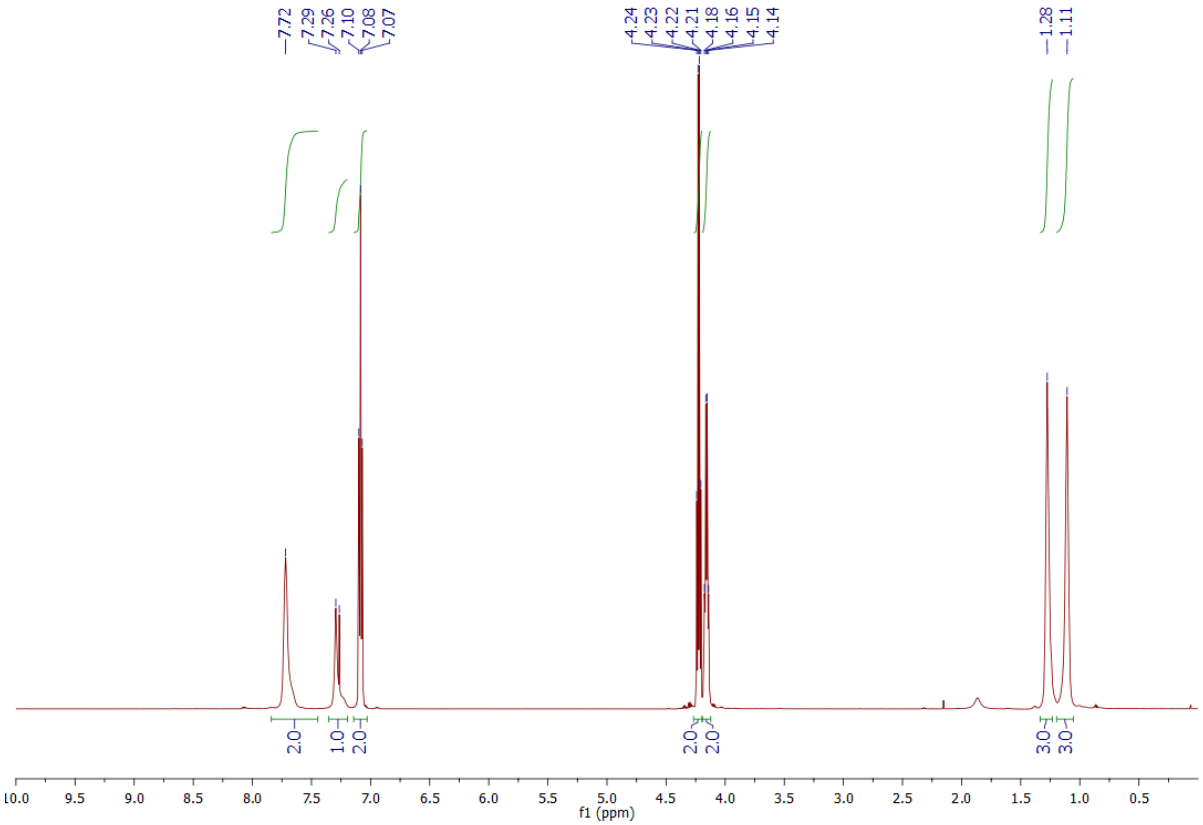


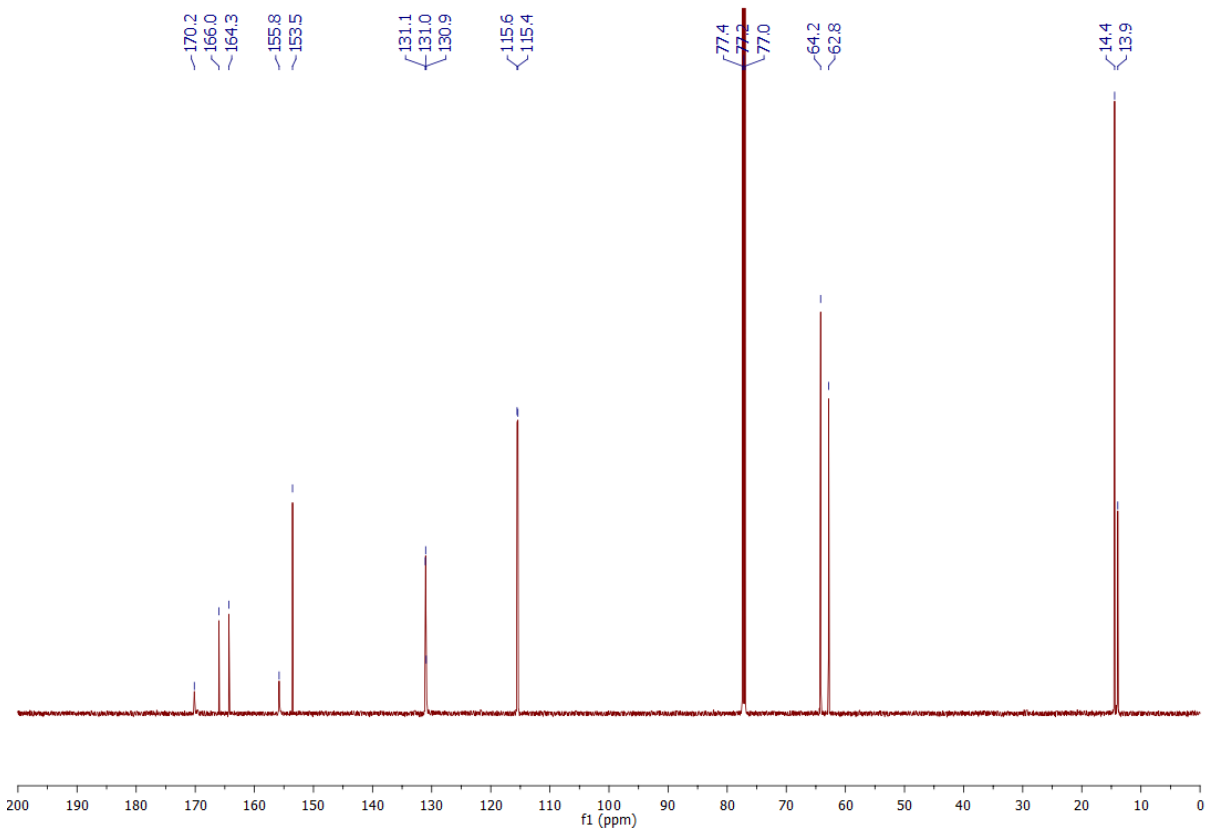

180.4
155.6
153.9
130.8
125.4
120.1
108.4
72.0
70.4
36.5
22.0
21.7
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Diethyl 1-(4-fluorobenzoyl)hydrazine-1,2-dicarboxylate[7] 1b

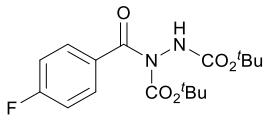


Compound prepared according to method A. Purification by column chromatography (10%-50% EtOAc/Petrol) afforded diethyl 1-(4-fluorobenzoyl)hydrazine-1,2-dicarboxylate as a white solid (1.07 g, 3.60 mmol, 72%). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.72 (m, 2H), 7.29-7.20 (m, NH, 1H), 7.08 (t, J = 8.6 Hz, 2H), 4.22 (q, J = 7.1 Hz, 2H), 4.16 (q, J = 7.0 Hz, 6H), 1.28 (m, 3H), 1.11 (m, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 170.2 (C), 165.2 (d, $J_{C\text{-}F}$ = 253.5 Hz, C), 155.8 (C), 153.5 (C), 131.1 (d, $J_{C\text{-}F}$ = 8.9 Hz, CH), 130.9 (C), 115.5 (d, $J_{C\text{-}F}$ = 22.2 Hz, CH), 64.2 (CH_2), 62.8 (CH_2), 14.4 (CH_3), 13.9 (CH_3); IR (solid) 3302, 2985, 2940, 1737, 1706, 1603, 1507 cm^{-1}.

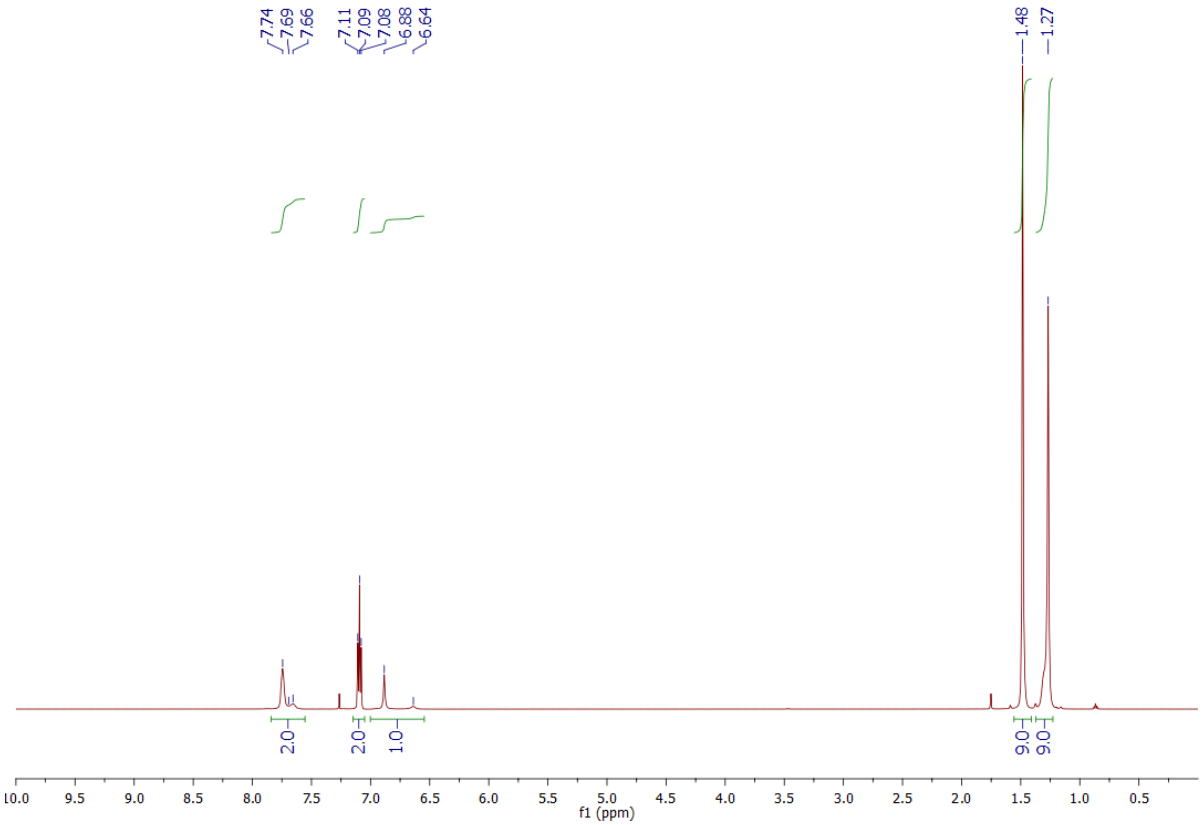


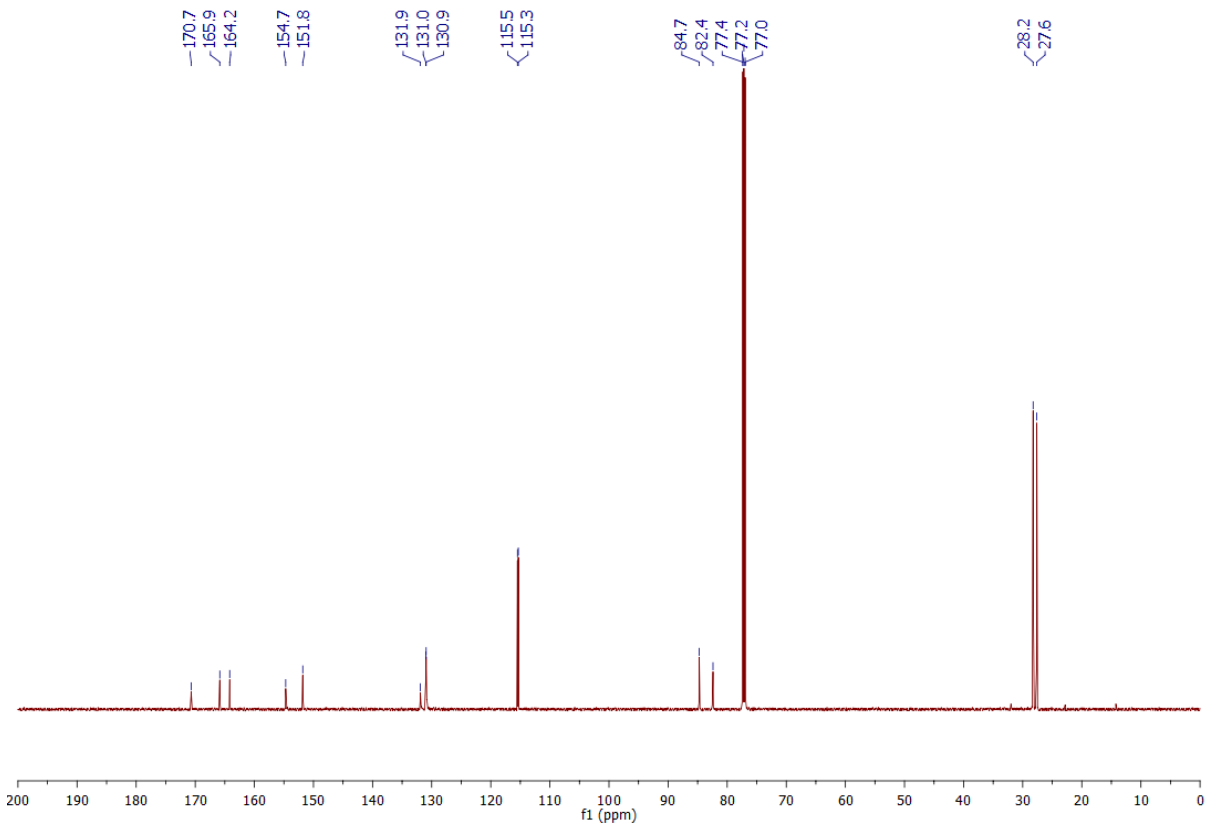

170.2
166.0
164.3
155.8
153.5
131.1
131.0
130.9
115.6
115.4
77.4
77.2
77.0
64.2
62.8
14.4
13.9
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

Di-*tert*-butyl 1-(4-fluorobenzoyl)hydrazine-1,2-dicarboxylate 1n

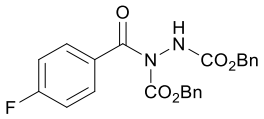


Compound prepared according to method A except in that the reaction duration was 120 h. Purification by column chromatography (10%-50% EtOAc/Petrol) afforded di-*tert*-butyl 1-(4-fluorobenzoyl)hydrazine-1,2-dicarboxylate as a white solid (921 mg, 2.60 mmol, 52%). m.p. 104-106 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.78-7.61 (m, 2H), 7.09 (t, J = 8.6 Hz, 2H), 6.90-6.60 (s, NH, 1H), 1.48 (s, 9H), 1.34-1.24 (m, 9H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 170.7 (C), 165.0 (d, $J_{C\text{-}F}$ = 253.1 Hz, C), 154.7 (C), 151.8 (C), 131.9 (C), 131.0 (d, $J_{C\text{-}F}$ = 8.9 Hz, CH), 115.4 (d, $J_{C\text{-}F}$ = 22.1 Hz, CH), 84.7 (C), 82.4 (C), 28.2 (CH_3), 27.6 (CH_3); IR (solid) 3335, 3007, 2974, 2937 1756, 1702, 1603, 1506 cm^{-1}.

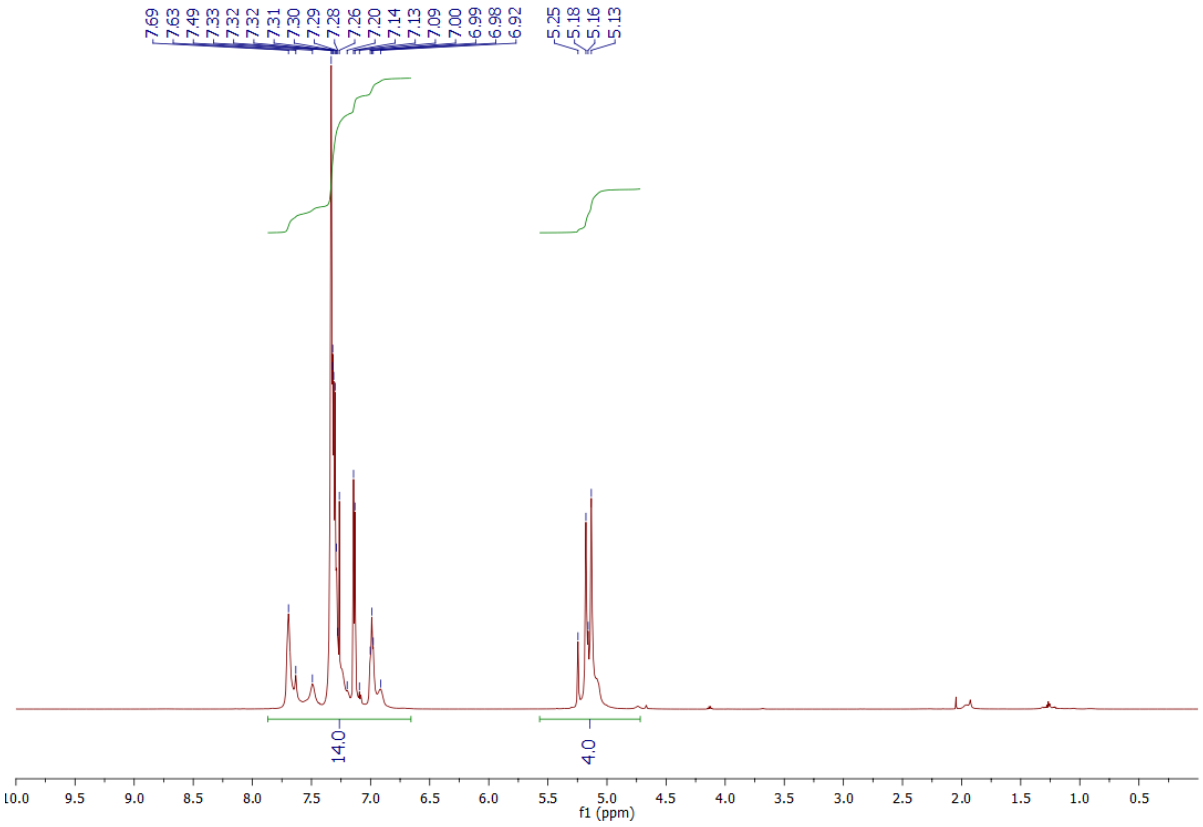


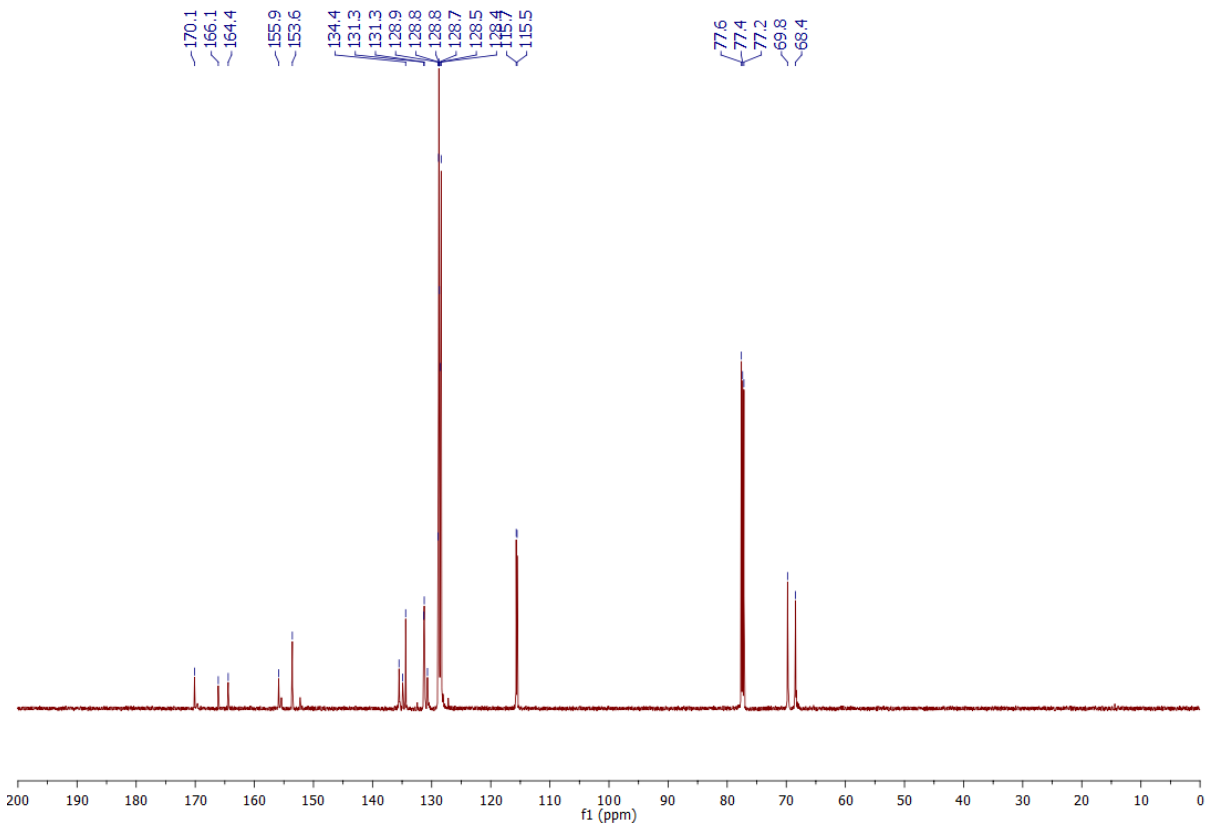

170.7
165.9
164.2
154.7
151.8
131.9
131.0
130.9
115.5
115.3
84.7
82.4
77.4
77.2
77.0
28.2
27.6
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

Dibenzyl 1-(4-fluorobenzoyl)hydrazine-1,2-dicarboxylate 1o

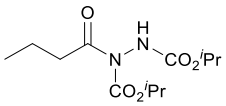


Compound prepared according to method A. Purification by column chromatography (10%-50% EtOAc/Petrol) afforded dibenzyl 1-(4-fluorobenzoyl)hydrazine-1,2-dicarboxylate as a colourless oil (1.29 g, 3.05 mmol, 61%). m.p. 115-119 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.71-6.90 (m, 14H), 5.26-5.05 (m, 4H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 170.1 (C), 165.2 (d, $J_{C\text{-}F}$ = 253.3 Hz, C), 155.9 (C), 153.5 (C), 135.5 (C), 134.9 (C), 134.4 (C), 131.3 (d, $J_{C\text{-}F}$ = 8.5 Hz, CH), 130.7 (C), 128.9 (CH), 128.8 (C), 128.8 (CH), 128.7 (CH), 128.5 (CH), 128.4 (CH), 115.6 (d, $J_{C\text{-}F}$ = 22.2 Hz, CH), 69.8 (CH_2), 68.4 (CH_2); IR (solid) 3396, 3067, 2969, 1738, 1707, 1596 cm^{-1}; LRMS (CI) 440 (100, $[M+NH_4]^+$), 423 (15, $[M+H]^+$); HRMS (ESI) calcd for $C_{23}H_{20}FN_2O_5$ $[M+H]^+$ 423.1352; observed 423.1351.

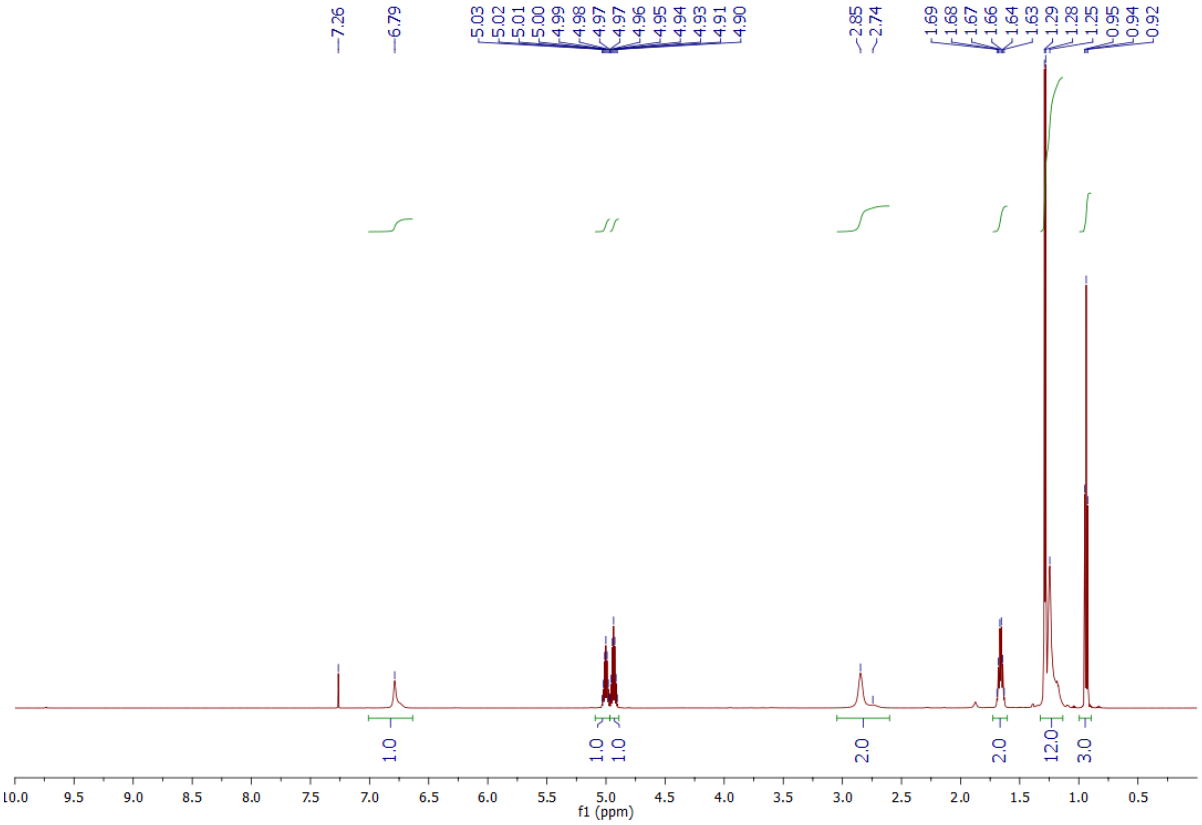


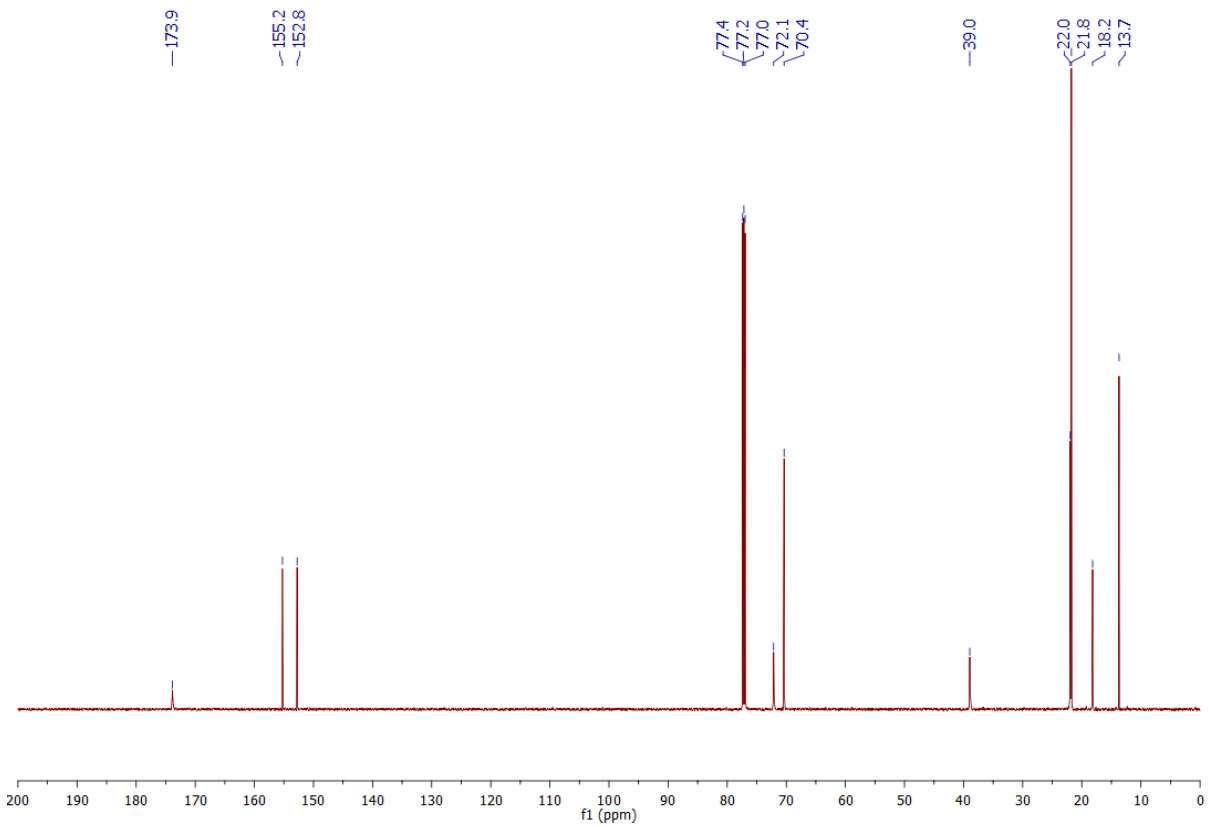

170.1
166.1
164.4
155.9
153.6
134.4
131.3
131.3
128.9
128.8
128.8
128.7
128.5
128.4
115.7
115.5
77.6
77.4
77.2
69.8
68.4
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Diisopropyl 1-butyrylhydrazine-1,2-dicarboxylate[7] 1p

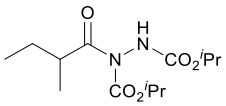


Compound prepared according to method A. Purification by column chromatography (10%-50% EtOAc/Petrol) afforded diisopropyl 1-butyrylhydrazine-1,2-dicarboxylate as a colourless oil (1.19 g, 4.35 mmol, 87%). ^{1}H NMR (600 MHz, $CDCl_3$) δ 6.79 (br s, NH, 1H), 5.00 (septet, *J* = 6.3 Hz, 1H), 4.94 (septet, *J* = 6.3 Hz, 1H), 2.92-2.67 (m, 2H), 1.66 (sextet, *J* = 7.4 Hz, 2H), 1.30-1.14 (m, 12H), 0.94 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 173.9 (C), 155.2 (C), 152.8 (C), 130.9 (C), 72.1 (CH), 70.4 (CH), 39.0 (CH_2), 18.2 (CH_2), 13.7 (CH_3); IR (thin film) 3319, 3022, 2984, 2938 1785, 1729 cm^{-1}.

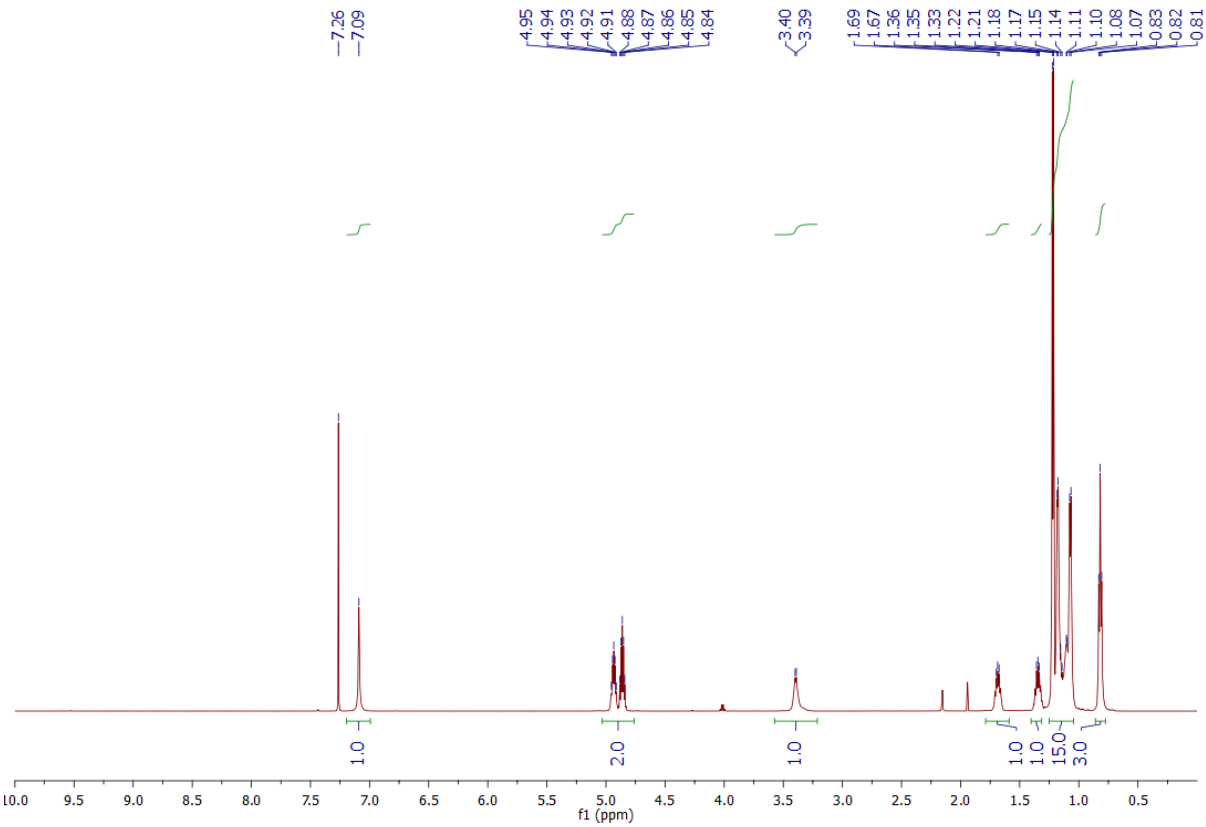


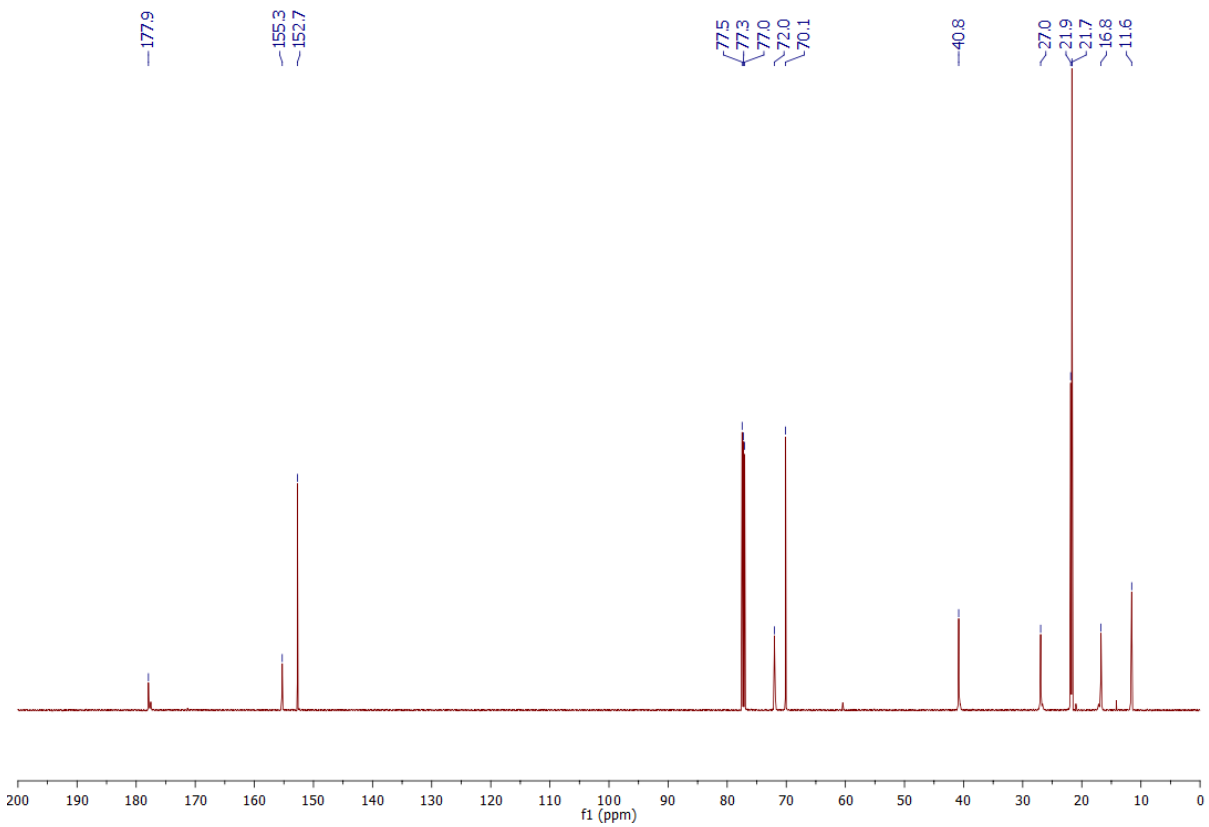

173.9
155.2
152.8
77.4
77.2
77.0
72.1
70.4
39.0
22.0
21.8
18.2
13.7
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

Diisopropyl 1-(2-methylbutanoyl)hydrazine-1,2-dicarboxylate[8] 1q

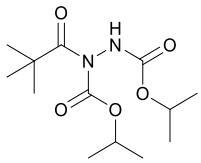


Compound prepared according to method A. Purification by column chromatography (10%-50% EtOAc/Petrol) afforded diisopropyl 1-(2-methylbutanoyl)hydrazine-1,2-dicarboxylate as a colourless oil (1.14 g, 3.95 mmol, 79%). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.09 (br s, NH, 1H), 4.93 (septet, *J* = 6.2 Hz, 1H), 4.87 (septet, *J* = 6.2 Hz, 1H), 3.43-3.34 (m, 1H), 1.69 (septet, *J* = 6.7 Hz, 1H), 1.35 (septet, *J* = 6.7 Hz, 1H), 1.23-1.05 (m, 15H), 0.82 (t, *J* = 7.3 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.9 (C), 155.3 (C), 152.7 (C), 72.0 (CH), 70.1 (CH), 40.8 (CH), 27.0 (CH_2), 21.9 (CH_3), 21.7 (CH_3), 16.8 (CH_2), 11.6 (CH_3); IR (thin film) 3315, 3023, 2982, 2938, 1784, 1722 cm^{-1}.

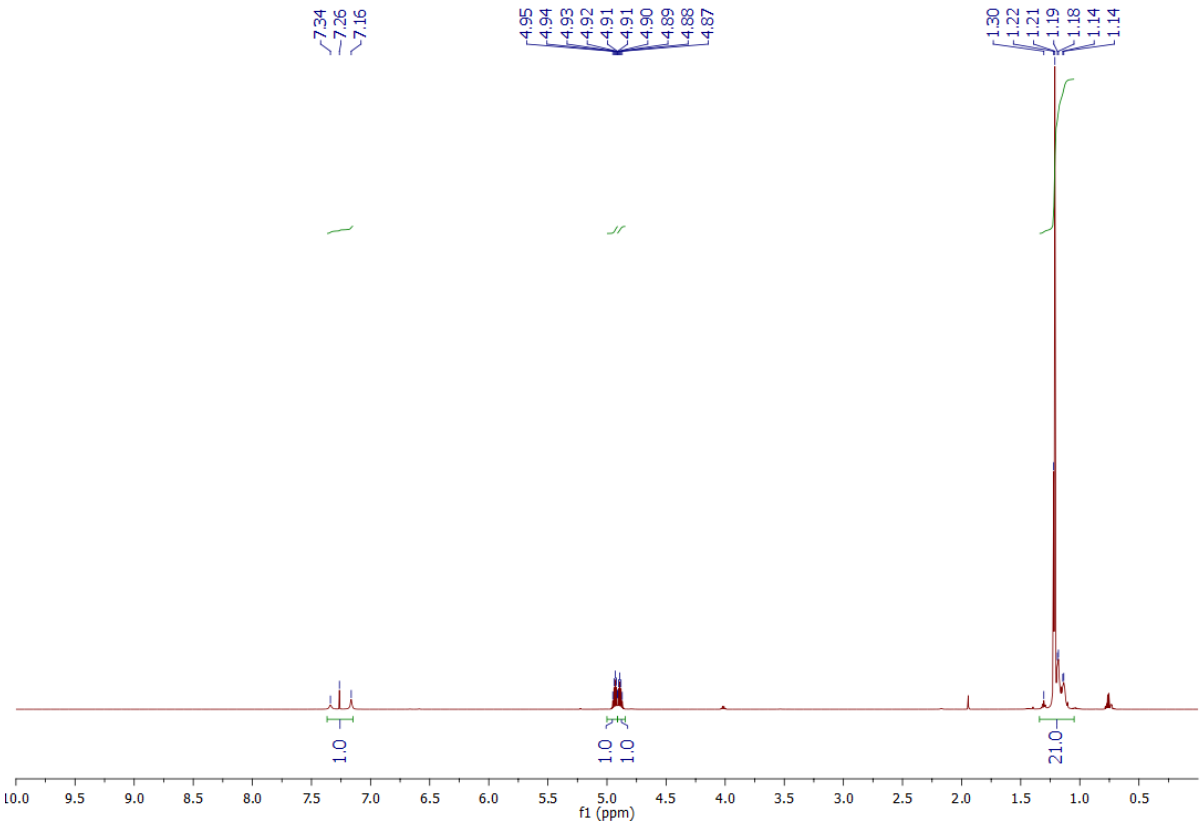


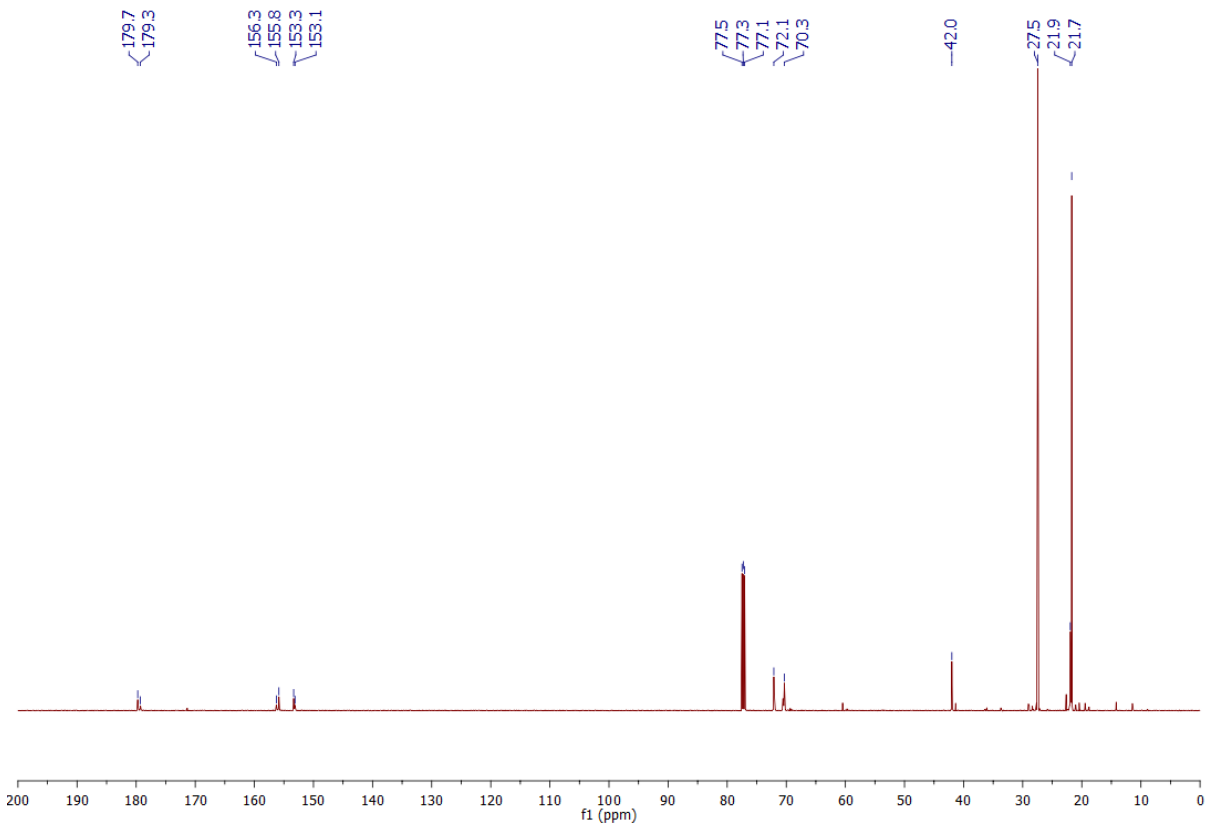

177.9
155.3
152.7
77.5
77.3
77.0
72.0
70.1
40.8
27.0
21.9
21.7
16.8
11.6
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Diisopropyl 1-pivaloylhydrazine-1,2-dicarboxylate[7] 1r



Purification by column chromatography (10%-50% EtOAc/Petrol) afforded diisopropyl 1-pivaloylhydrazine-1,2-dicarboxylate as a colourless oil (937 mg, 3.25 mmol, 65%). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.36-7.14 (m, NH, 1H), 4.93 (septet, *J* = 6.3 Hz, 1H), 4.89 (septet, *J* = 6.3 Hz, 1H), 1.33-1.09 (m, 21H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 179.7 (C), 179.3 (C), 156.3 (C), 155.8 (C), 153.3 (C), 153.1 (C), 72.1 (CH), 70.3 (CH), 42.0 (C), 27.5 (CH_3), 21.9 (CH_3) 21.7 (CH_3); IR (solid) 3295, 2982, 2937, 2876, 1775, 1722, 1506 cm^{-1}.

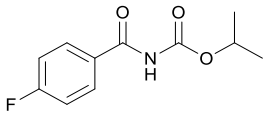



179.7
179.3
156.3
155.8
153.3
153.1
77.5
77.3
77.1
72.1
70.3
42.0
27.5
21.9
21.7
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

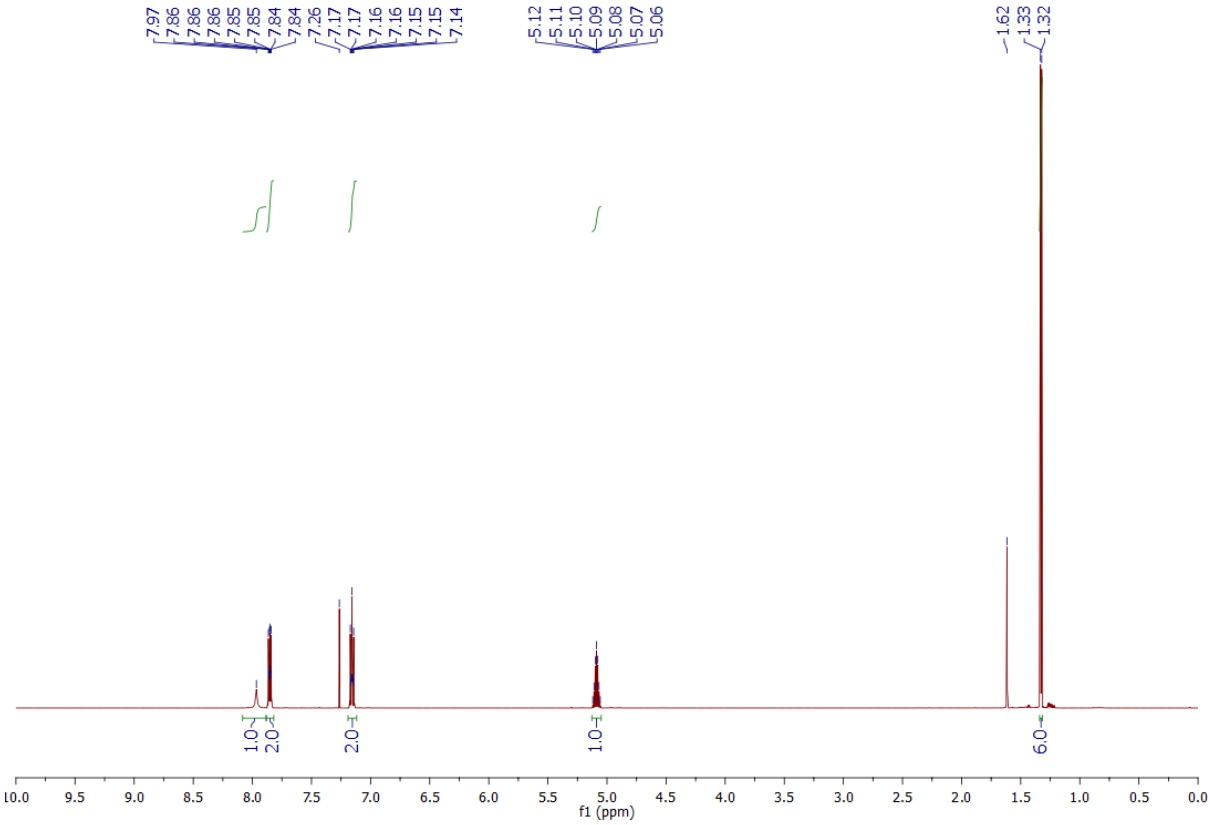
General experimental for the formation of aryl acyl carbamates – Method B

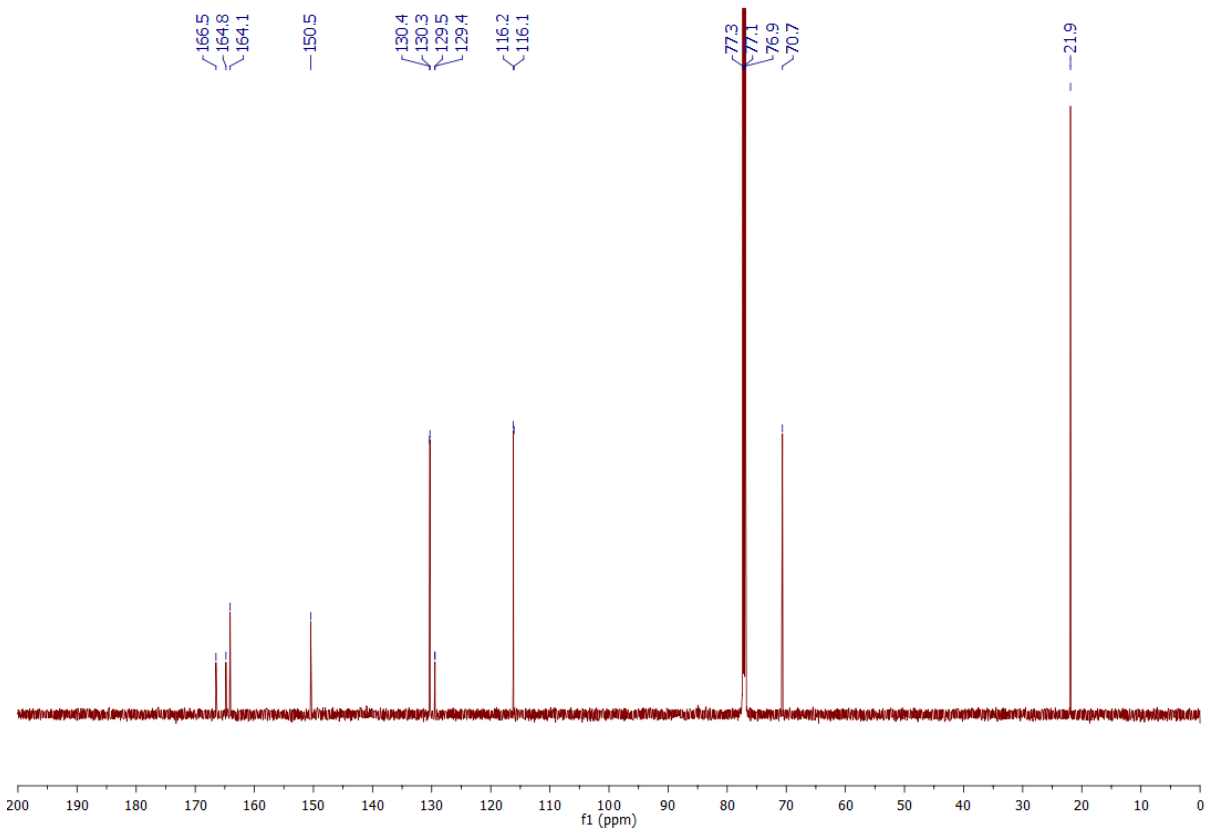
To a stirring solution of sodium hydride (60% mineral oil dispersion, 200 mg, 5.00 mmol, 5 eq.) in anhydrous THF (0.5 mL) was added dropwise a solution of acyl hydrazide (1.00 mmol, 1 eq.) pre-dissolved in anhydrous THF (1.5 mL) under an atmosphere of argon and the reaction mixture stirred for 5 minutes. After this time, to the reaction mixture was added dropwise *tert*-butyl bromoacetate (162 μL, 1.10 mmol, 1.1 eq.) pre-dissolved in anhydrous THF (0.5 mL). The reaction mixture was then stirred at 25 °C for 16 h and then poured over saturated aqueous NH_4Cl (10 mL). The resulting solution was extracted with EtOAc (3 × 15 mL). The combined extracts were dried ($MgSO_4$), filtered and the solvent evaporated *in vacuo*. The resultant crude residue was purified as described below.

Isopropyl (4-fluorobenzoyl)carbamate 3a

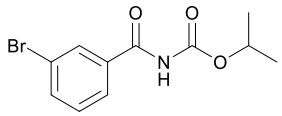


Compound prepared according to method B. Purification by column chromatography (10%-50% EtOAc/Petrol) yielded isopropyl (4-fluorobenzoyl)carbamate as a white solid (187 mg, 0.83 mmol, 83%). m.p. 112-114 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.97 (br s, NH, 1H), 7.87-7.83 (m, 2H), 7.21-7.10 (m, 2H), 5.09 (septet, J = 6.3 Hz, 1H), 1.33 (d, J = 6.3 Hz, 6H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 165.7 (d, $J_{C\text{-}F}$ = 254.7 Hz, C), 164.1 (C), 150.5 (C), 130.3 (d, $J_{C\text{-}F}$ = 9.3 Hz, CH), 129.5 (d, $J_{C\text{-}F}$ = 3.1 Hz, C), 116.1 (d, $J_{C\text{-}F}$ = 22.1 Hz, CH), 70.7 (CH), 21.9 (CH_3); IR (solid) 3268, 2979, 2934, 1746, 1682, 1601, 1526 cm^{-1}; LRMS (CI) 243 (100, $[M+NH_4]^+$), 226 (20, $[M+H]^+$); HRMS (ESI) calcd for $C_{11}H_{13}FNO_3$ $[M+H]^+$ 226.0874; observed 226.0875.

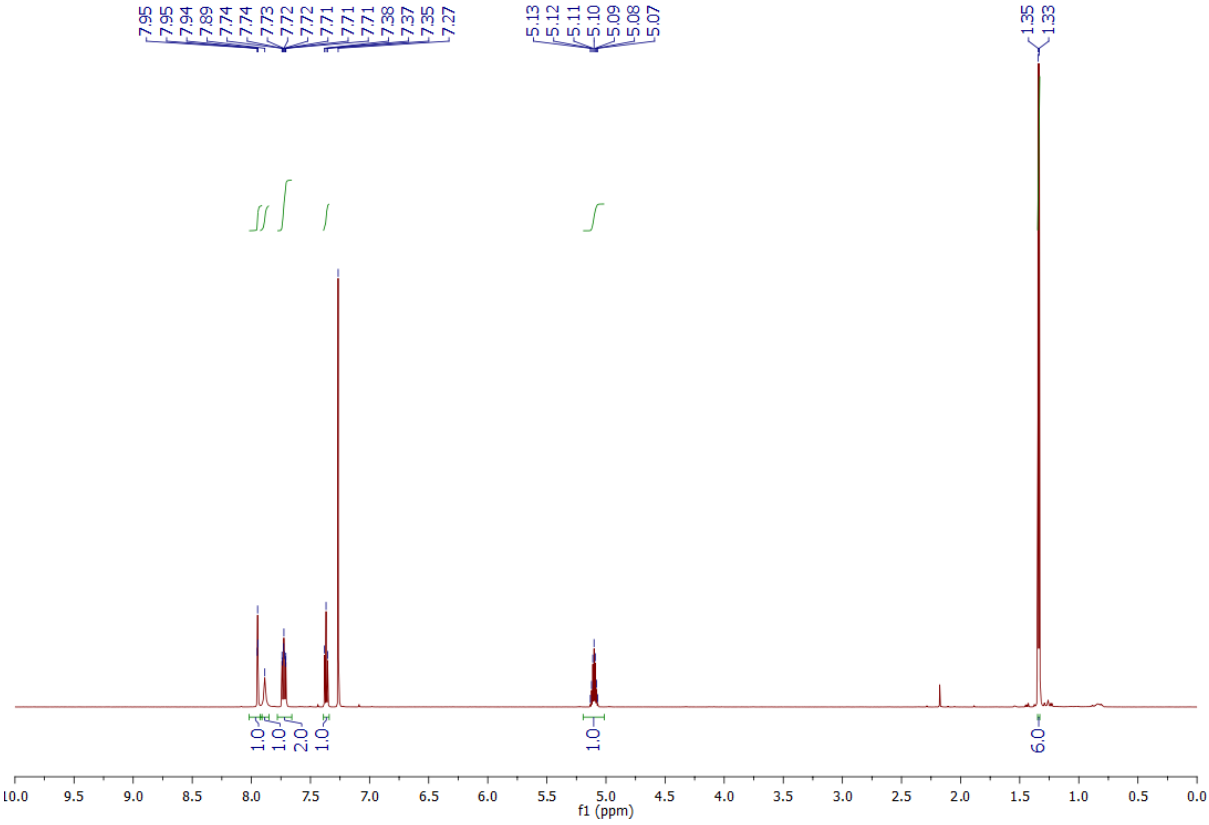


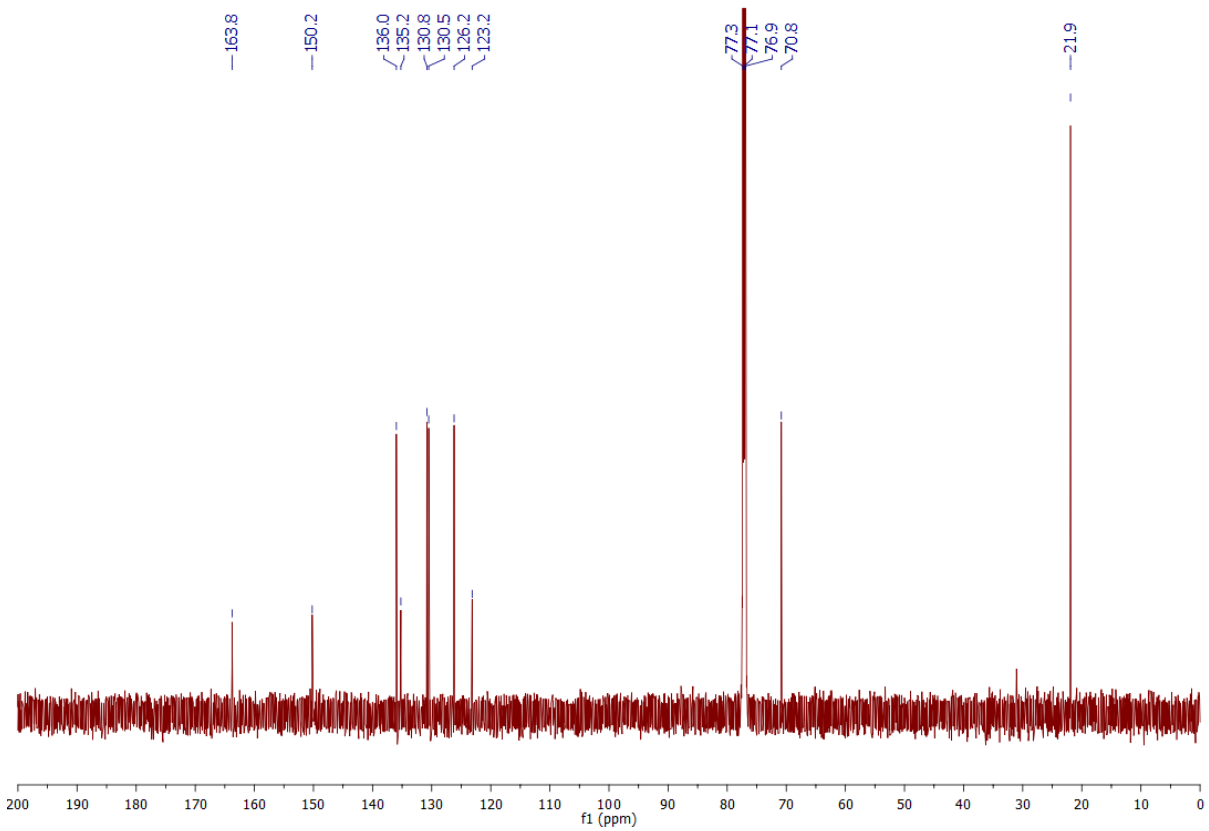

166.5
164.8
164.1
150.5
130.4
130.3
129.5
129.4
116.2
116.1
77.3
77.1
76.9
70.7
21.9
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Isopropyl (3-bromobenzoyl)carbamate 3c

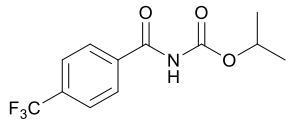


Compound prepared according to method B. Purification by column chromatography (10%-50% EtOAc/Petrol) yielded isopropyl (3-bromobenzoyl)carbamate as a white solid (244 mg, 0.850 mmol, 85%). m.p. 134-135 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.95 (t, *J* = 1.7 Hz, 1H), 7.89 (br s, NH, 1H), 7.79-7.67 (m, 2H), 7.37 (t, *J* = 7.9 Hz, 1H), 5.10 (septet, *J* = 6.3 Hz, 1H), 1.34 (d, *J* = 6.3 Hz, 6H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 163.8 (C), 150.2 (C), 136.0 (CH), 135.2 (C), 130.8 (CH), 130.5 (CH), 126.2 (CH), 123.2 (C), 70.8 (CH), 21.9 (CH_3); IR (solid) 3250, 3187, 2979, 1764, 1746, 1684, 1594, 1567, 1520 cm^{-1}; LRMS (ESI) 288 (97, $[M^{81}Br+H]^+$), 286 (100, $[M^{79}Br+H]^+$); HRMS (ESI) calcd for $C_{11}H_{13}NO_3Br$ $[M^{79}Br+H]^+$ 286.0079; observed 286.0078.

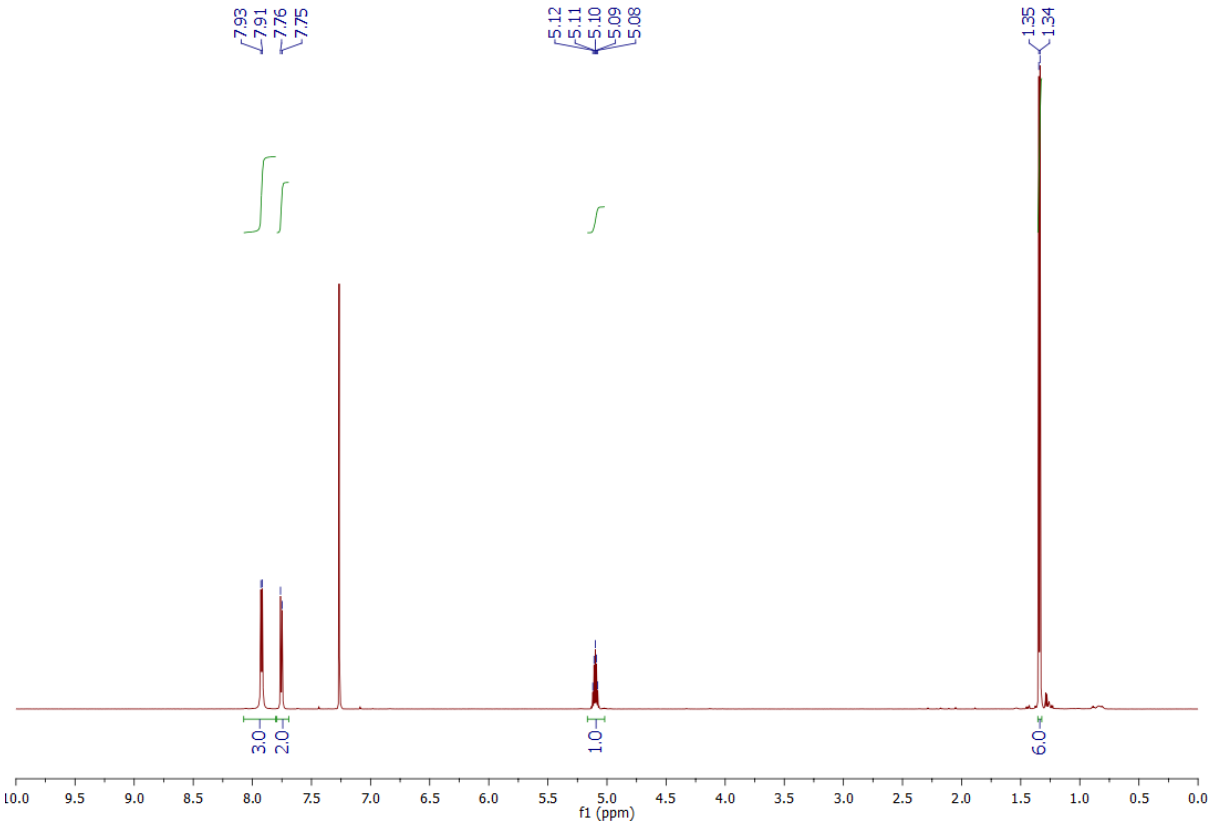


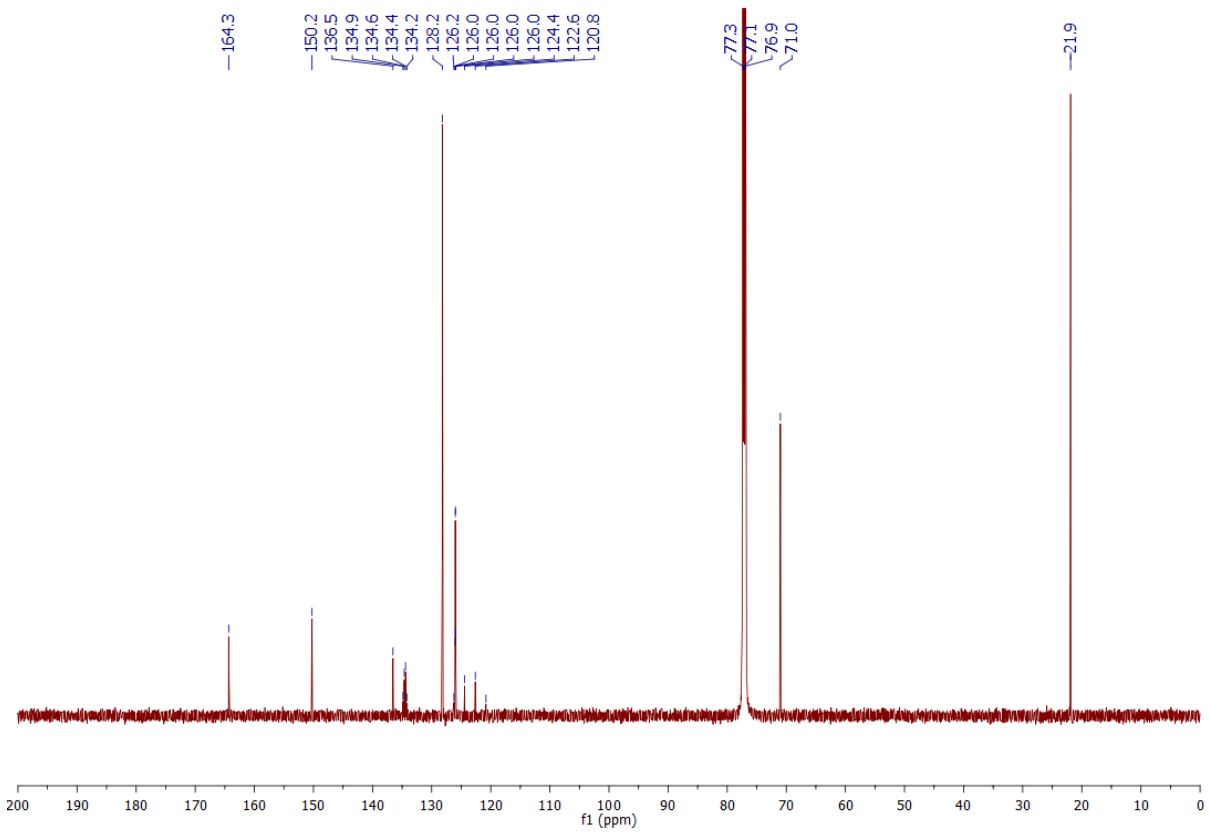

163.8
150.2
136.0
135.2
130.8
130.5
126.2
123.2
77.3
77.1
76.9
70.8
21.9
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Isopropyl (4-(trifluoromethyl)benzoyl)carbamate 3d

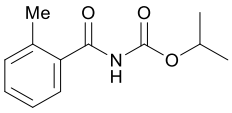


Compound prepared according to method B. Purification by column chromatography (10%-50% EtOAc/Petrol) yielded isopropyl (4-(trifluoromethyl)benzoyl)carbamate as a white solid (195 mg, 0.710 mmol, 71%). m.p. 100-102 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.98-7.86 (m, 3H), 7.75 (d, J = 8.2 Hz, 2H), 5.10 (septet, J = 6.3 Hz, 1H), 1.34 (d, J = 6.3 Hz, 6H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 164.3 (C), 150.2 (C), 136.5 (C), 134.5 (q, $J_{C\text{-}F}$ = 33.0 Hz, C), 128.2 (CH), 126.0 (q, $J_{C\text{-}F}$ = 3.7 Hz, CH), 123.5 (q, $J_{C\text{-}F}$ = 272.8 Hz, C), 71.0 (CH), 21.9 (CH_3); IR (solid) 3273, 2984, 2942, 1753, 1611, 1528 cm^{-1}; LRMS (ESI) 274 (100, [M-H]$^-$); HRMS (ESI) calcd for $C_{12}H_{11}NO_3F_3$ [M-H]$^-$ 274.0691; observed 274.0696.

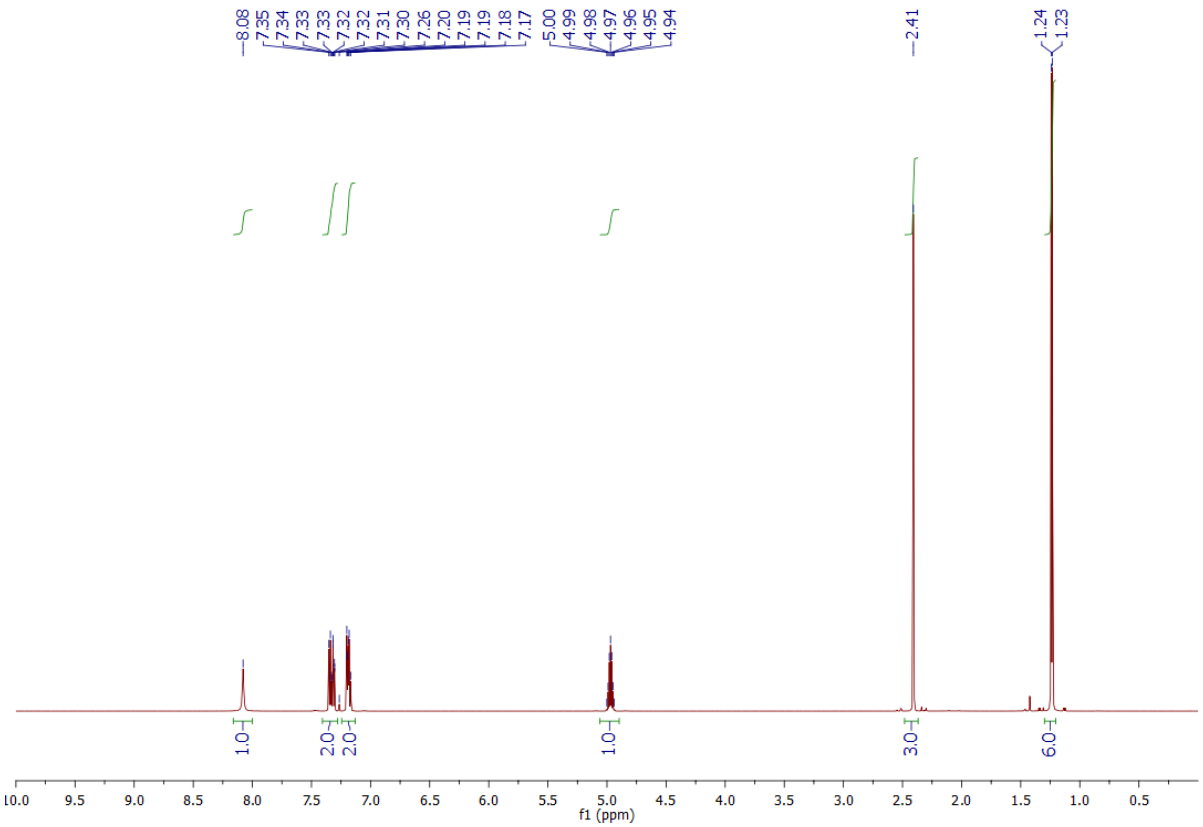


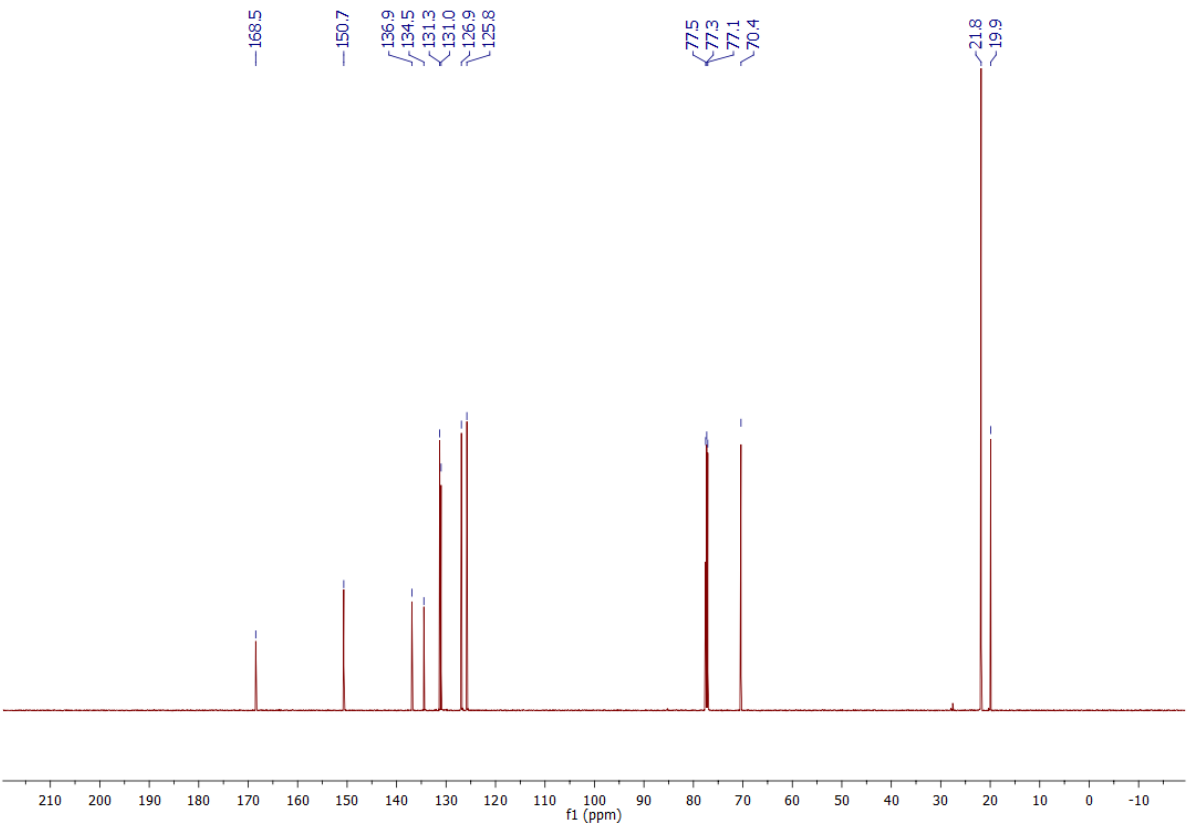

164.3
150.2
136.5
134.9
134.6
134.4
134.2
128.2
126.2
126.0
126.0
126.0
126.0
124.4
122.6
120.8
77.3
77.1
76.9
71.0
21.9
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Isopropyl (2-methylbenzoyl)carbamate 3e

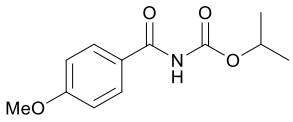


Compound prepared according to method B. Purification by column chromatography (10%-50% EtOAc/Petrol) yielded isopropyl (2-methylbenzoyl)carbamate as a white solid (155 mg, 0.700 mmol, 70%). m.p. 94-97 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.08 (br s, NH, 1H), 7.36-7.29 (m, 2H), 7.21-7.16 (m, 2H), 4.97 (septet, *J* = 6.3 Hz, 1H), 2.41 (s, 3H), 1.24 (d, *J* = 6.3 Hz, 6H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 168.5 (C), 150.7 (C), 136.9 (C), 134.5 (C), 131.3 (CH), 131.0 (CH), 126.9 (CH), 125.8 (CH), 70.4 (CH), 21.8 (CH_3), 19.9 (CH_3); IR (solid) 3271, 2981, 2933, 1757, 1696, 1600, 1574 cm^{-1}; LRMS (ESI) 222 (100, $[M+H]^+$); HRMS (ESI) calcd for $C_{12}H_{16}NO_3$ $[M+H]^+$ 222.1125; observed 222.1125.

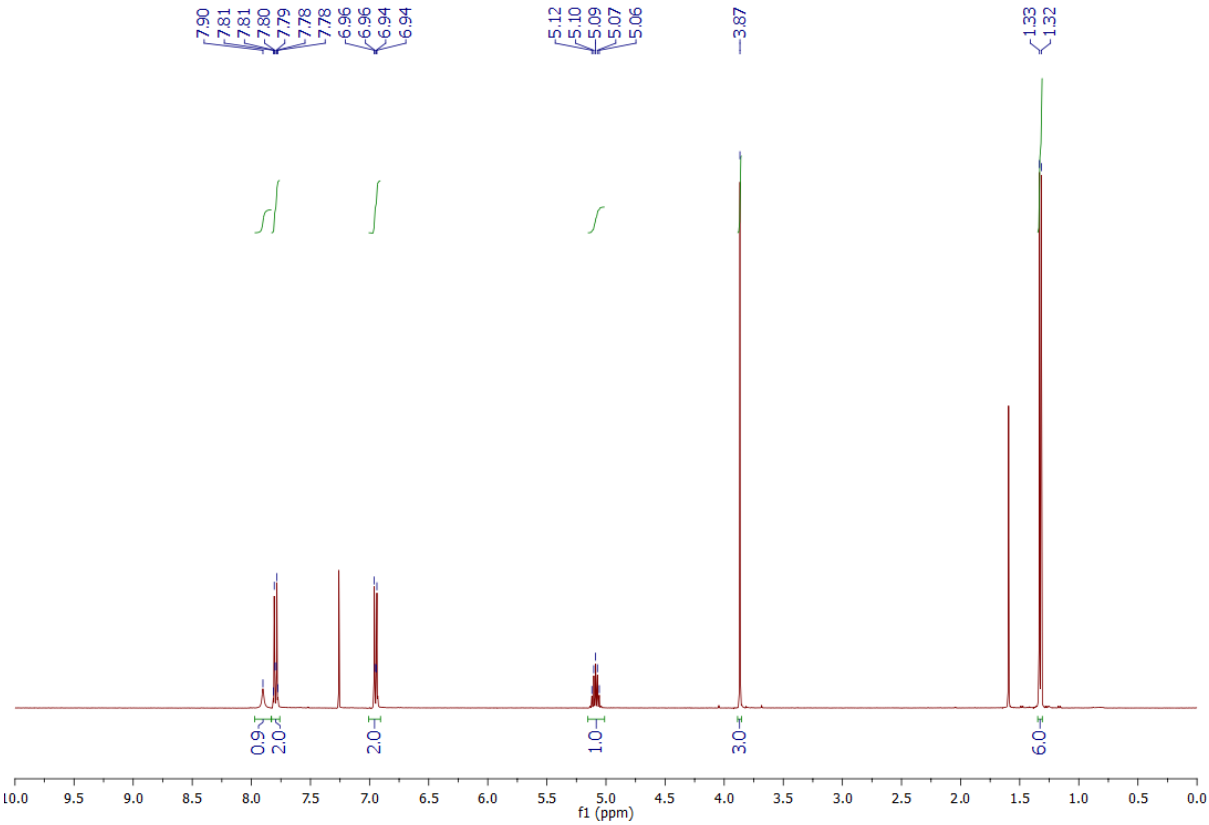


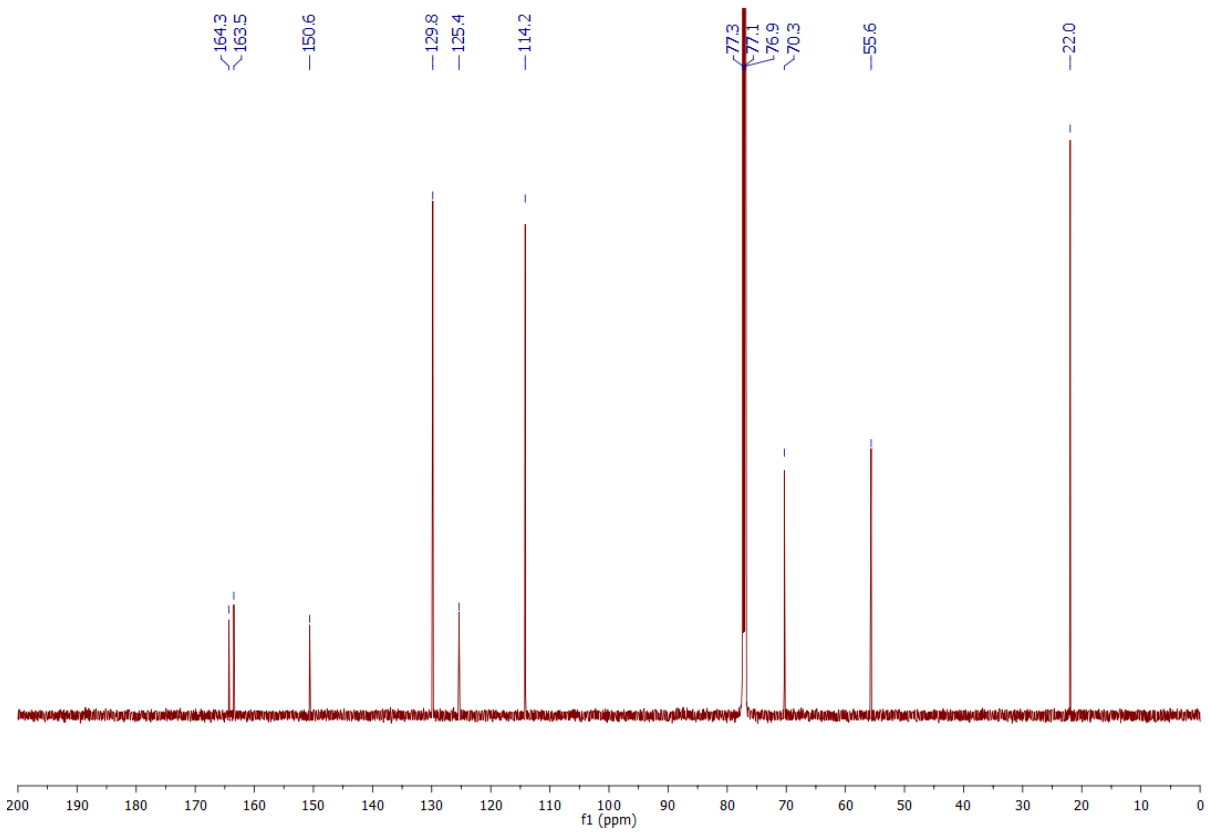

168.5
150.7
136.9
134.5
131.3
131.0
126.9
125.8
77.5
77.3
77.1
70.4
21.8
19.9
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

Isopropyl (4-methoxybenzoyl)carbamate 3f

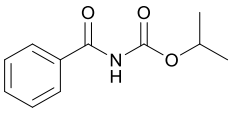


Compound prepared according to method B. Purification by column chromatography (10%-50% EtOAc/Petrol) yielded isopropyl (4-methoxybenzoyl)carbamate as a white solid (204 mg, 0.860 mmol, 86%). m.p. 120-124 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.90 (br s, 1H), 7.81-7.78 (m, 2H), 6.96-6.94 (m, 2H), 5.09 (septet, *J* = 6.3 Hz, 1H), 3.87 (s, 3H), 1.33 (d, *J* = 6.3 Hz, 6H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 164.3 (C), 163.5 (C), 150.6 (C), 129.8 (CH), 125.4 (C), 114.2 (CH), 70.3 (CH), 55.6 (CH_3), 22.0 (CH_3); IR (solid) 3314, 2982, 2937, 1738, 1703, 1606, 1579 cm^{-1}; LRMS (ESI) 238 (100, $[M+H]^+$); HRMS (ESI) calcd for $C_{12}H_{16}NO_4$ $[M+H]^+$ 238.1079; observed 238.1080.

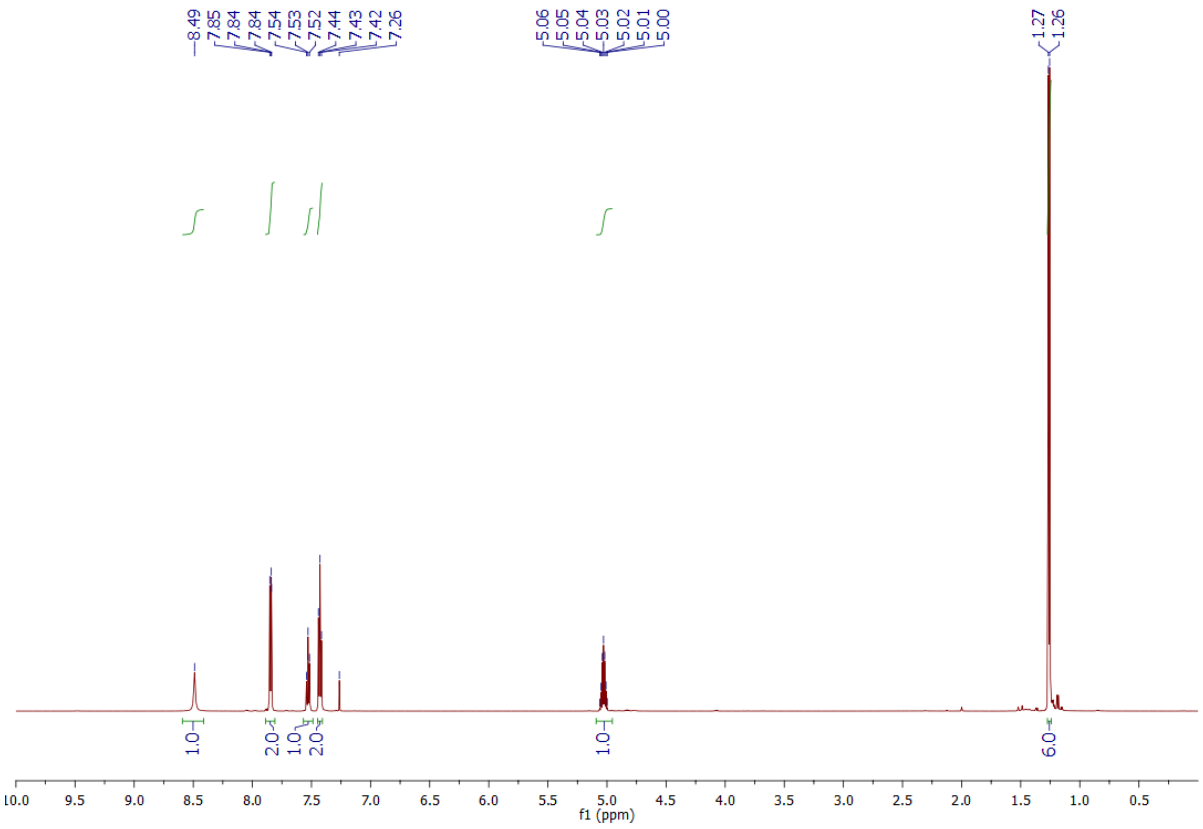


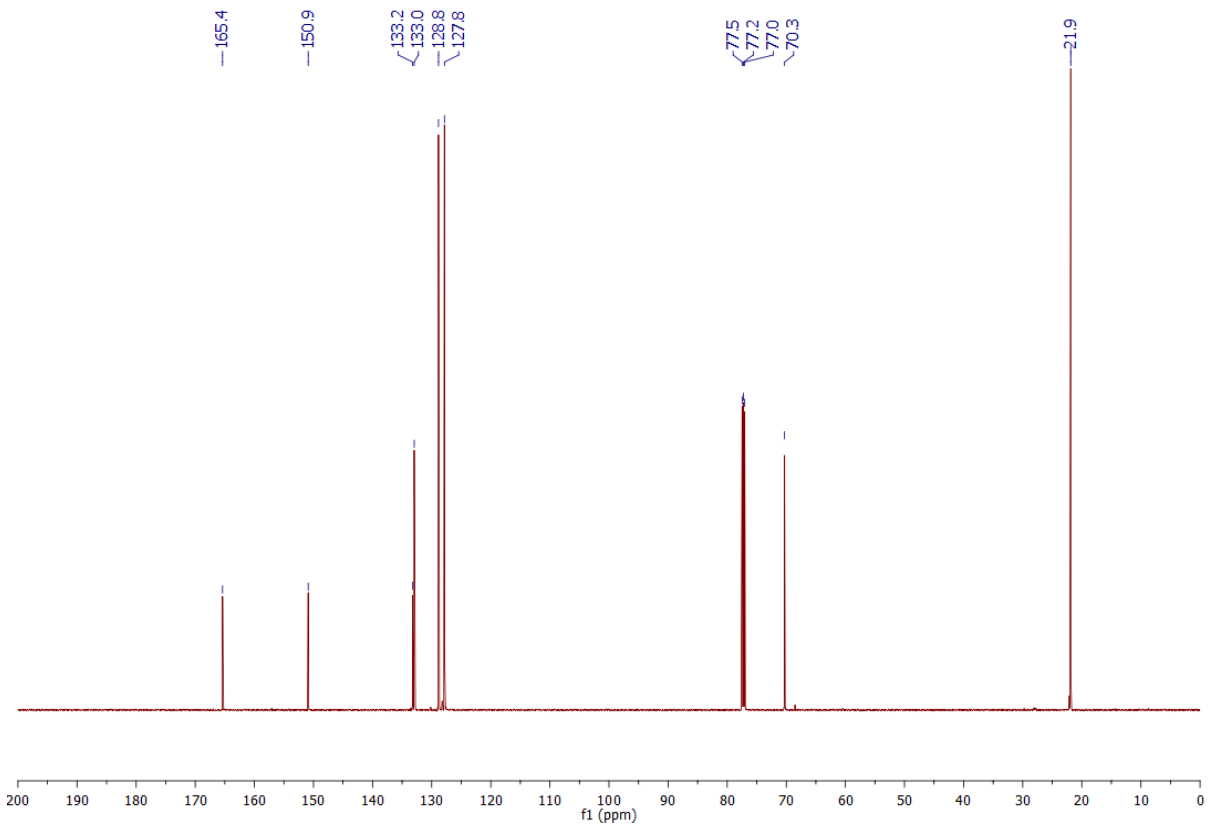

164.3
163.5
150.6
129.8
125.4
114.2
77.3
77.1
76.9
70.3
55.6
22.0
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Isopropyl benzoylcarbamate 3g

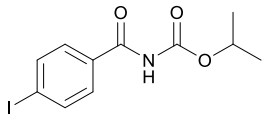


Compound prepared according to method B. Purification by column chromatography (10%-50% EtOAc/Petrol) yielded isopropyl benzoylcarbamate as a white solid (157 mg, 0.760 mmol, 76%). m.p. 129-133 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.49 (br s, NH, 1H), 7.84 (dd, *J* = 7.4 Hz, 1.1 Hz, 2H), 7.53 (t, *J* = 7.4 Hz, 1H), 7.43 (t, *J* = 7.8 Hz, 2H), 5.03 (septet, *J* = 6.3 Hz, 1H), 1.26 (d, *J* = 6.3 Hz, 6H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 165.4 (C), 150.9 (C), 133.2 (C), 133.0 (CH), 128.8 (CH), 127.8 (CH), 70.3 (CH), 21.9 (CH_3); IR (solid) 3272, 2979, 2934, 1743, 1682, 1600, 1582, 1510 cm^{-1}; LRMS (ESI) 206 (100, $[M+H]^+$); HRMS (ESI) calcd for $C_{11}H_{14}NO_3$ $[M+H]^+$ 206.0968; observed 206.0967.

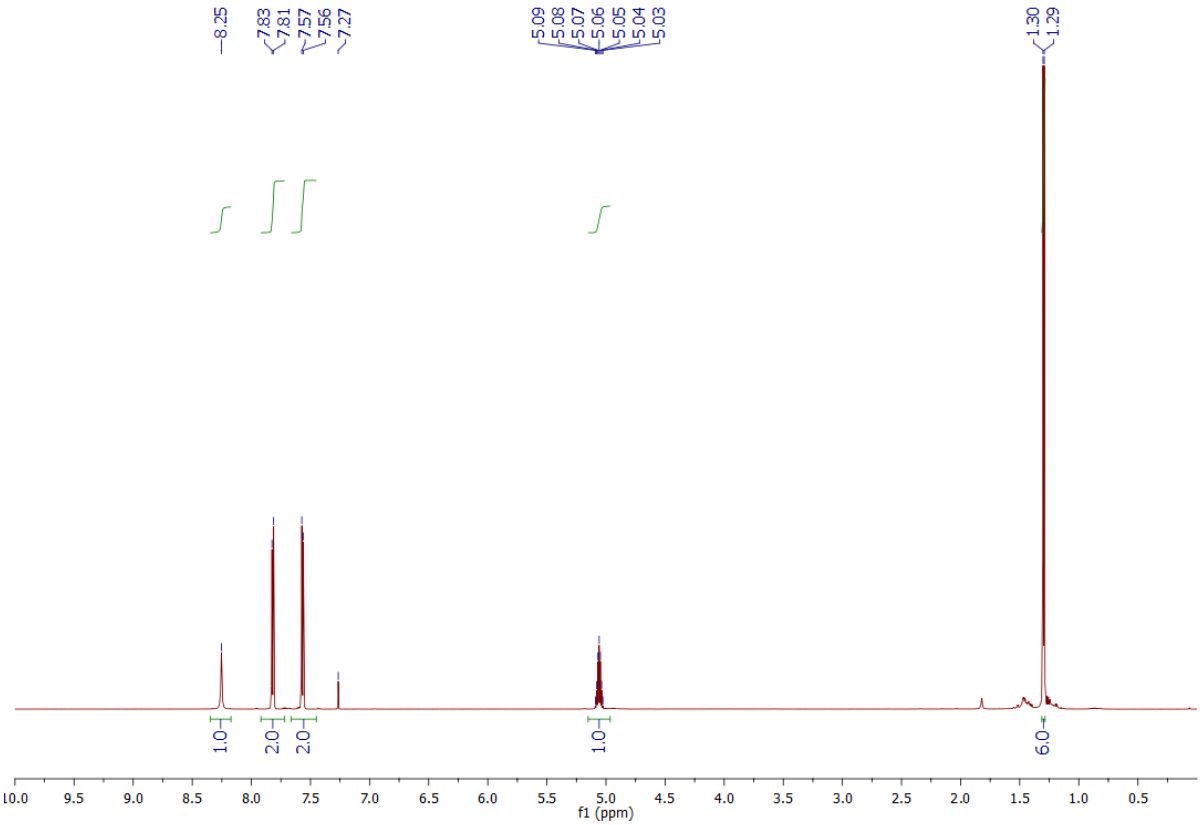


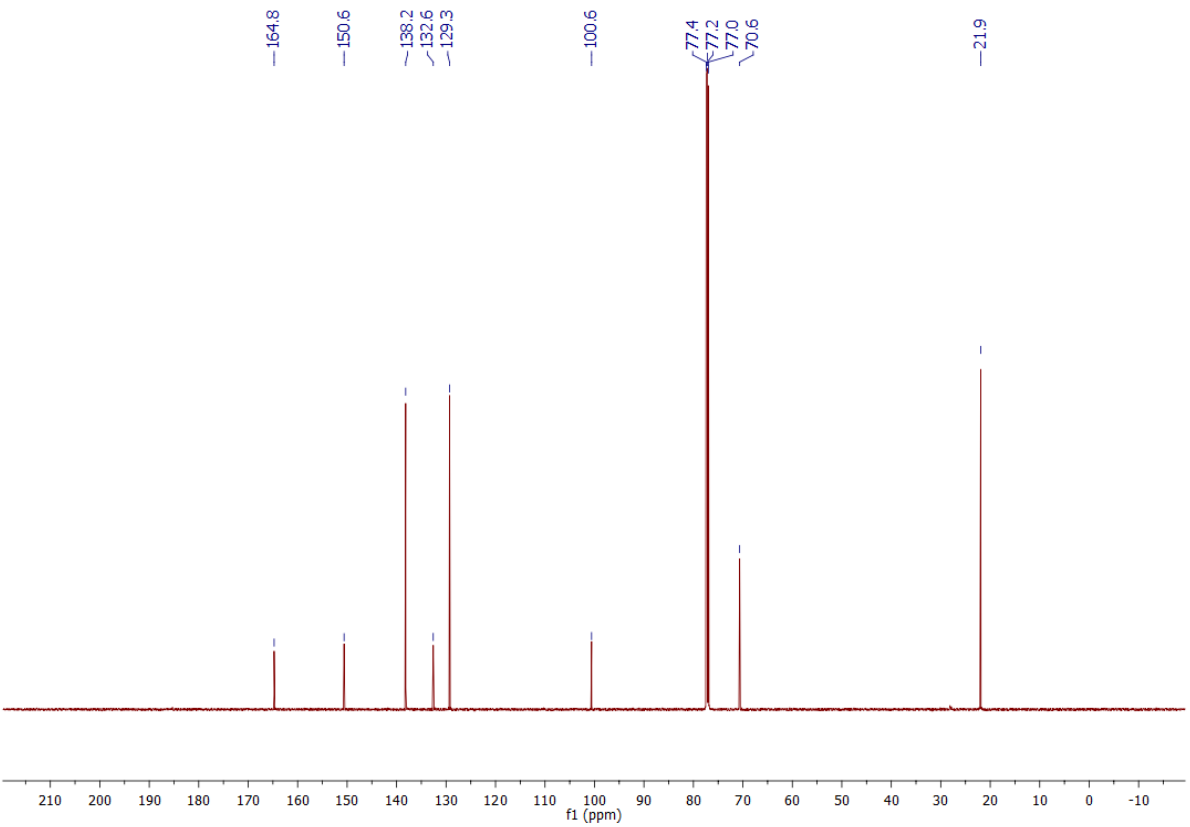

165.4
150.9
133.2
133.0
128.8
127.8
77.5
77.2
77.0
70.3
21.9
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Isopropyl (4-iodobenzoyl)carbamate 3h

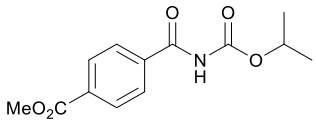


Compound prepared according to method B. Purification by column chromatography (10%-50% EtOAc/Petrol) yielded isopropyl (4-iodobenzoyl)carbamate as a white solid (290 mg, 0.870 mmol, 87%). m.p. 119-122 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.25 (br s, NH, 1H), 7.82 (d, *J* = 8.2 Hz, 2H), 7.57 (d, *J* = 8.2 Hz, 2H), 5.06 (septet, *J* = 6.3 Hz, 1H), 1.30 (d, *J* = 6.3 Hz, 6H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 164.8 (C), 150.6 (C), 138.2 (CH), 132.6 (C), 129.3 (CH), 100.6 (C). 70.6 (CH), 21.9 (CH_3); IR (solid) 3266, 2980, 2935, 1746, 1685, 1586, 1517 cm^{-1}; LRMS (ESI) 334 (100, $[M+H]^+$), 292 (60, $[M+H]^+$), 231 (20, $[M-C_4H_8NO_2+H]^+$); HRMS (ESI) calcd for $C_{11}H_{13}INO_3$ $[M+H]^+$ 333.9935; observed 333.9934.

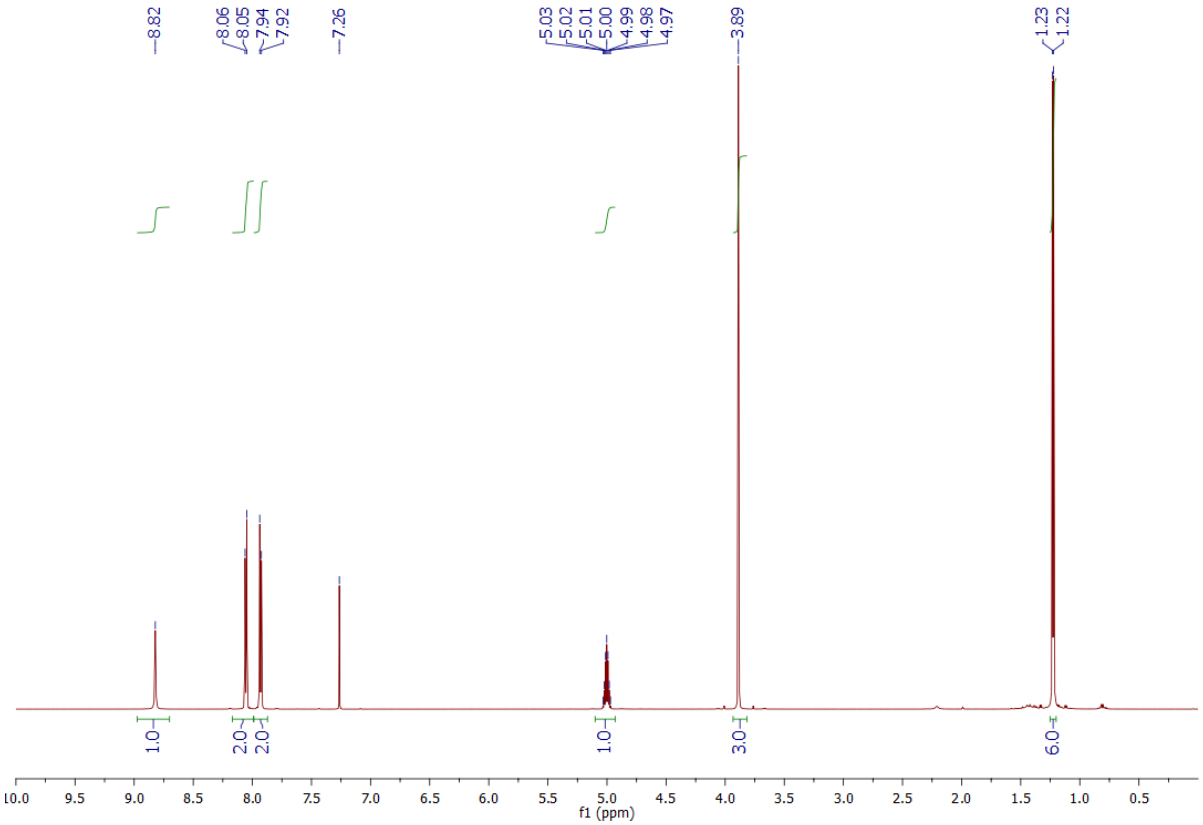


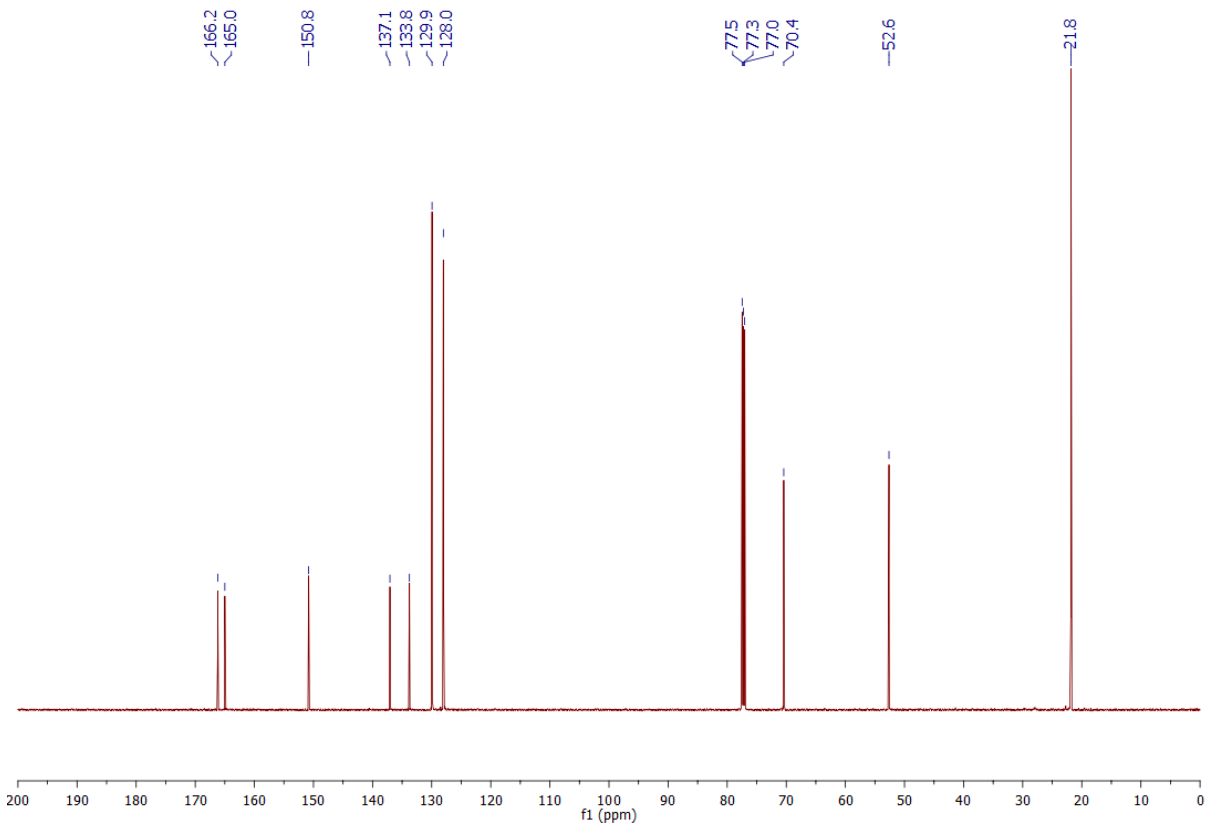

164.8
150.6
138.2
132.6
129.3
100.6
77.4
77.2
77.0
70.6
21.9
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

Methyl 4-((isopropoxycarbonyl)carbamoyl)benzoate 3i

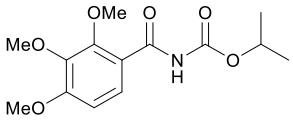


Compound prepared according to method B. Purification by column chromatography (10%-50% EtOAc/Petrol) yielded methyl 4-((isopropoxycarbonyl)carbamoyl)benzoate as a white solid (191 mg, 0.720 mmol, 72%). m.p. 112-125 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.82 (br s, NH, 1H), 8.05 (d, *J* = 8.5 Hz, 2H), 7.93 (d, *J* = 8.5 Hz, 2H), 5.00 (septet, *J* = 6.3 Hz, 1H), 3.89 (s, 3H), 1.23 (d, *J* = 6.3 Hz, 6H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 166.2 (C), 165.0 (C), 150.8 (C), 137.1 (C), 133.8 (C), 129.9 (CH), 128.0 (CH). 70.4 (CH), 52.6 (CH_3), 21.9 (CH_3); IR (solid) 3272, 2980, 2943, 1757, 1715, 1677, 1613, 1572, 1515 cm^{-1}; LRMS (ESI) 266 (100, $[M+H]^+$); HRMS (ESI) calcd for $C_{13}H_{16}NO_5$ $[M+H]^+$ 266.1023; observed 266.1025.

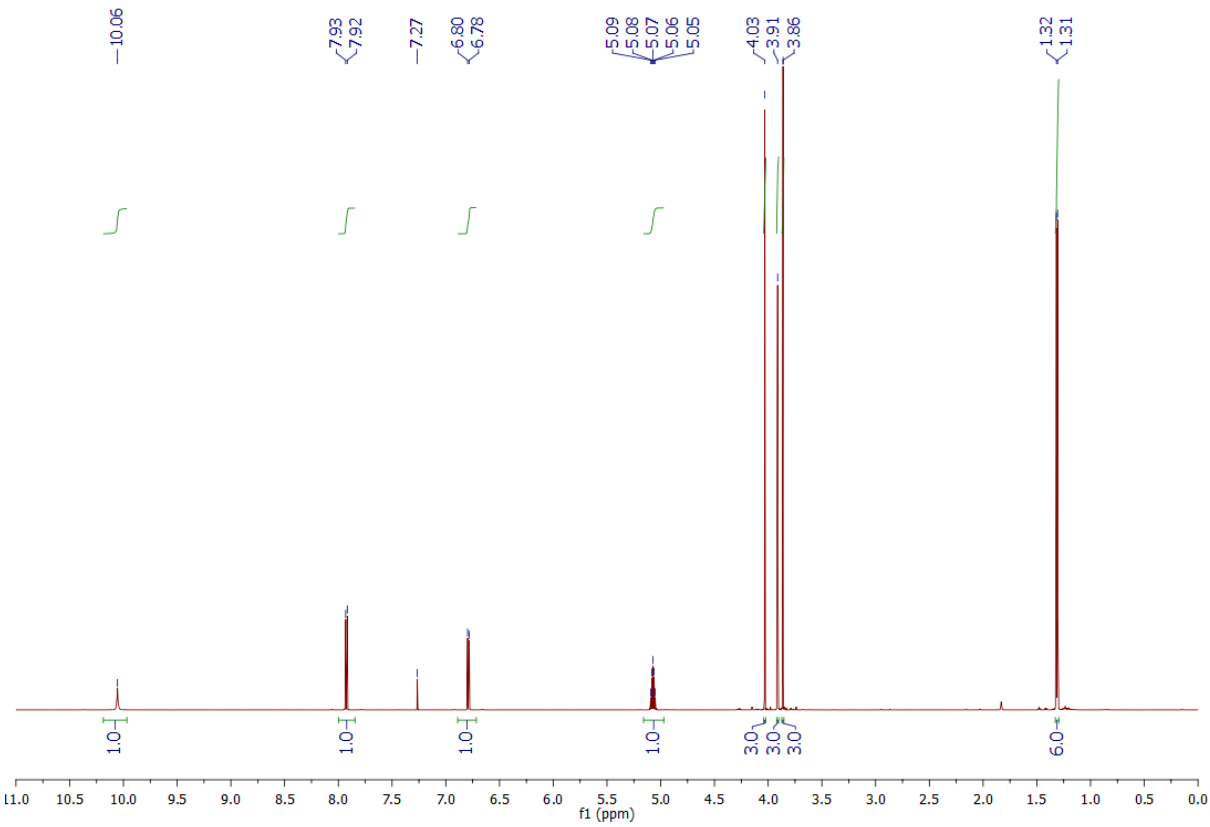


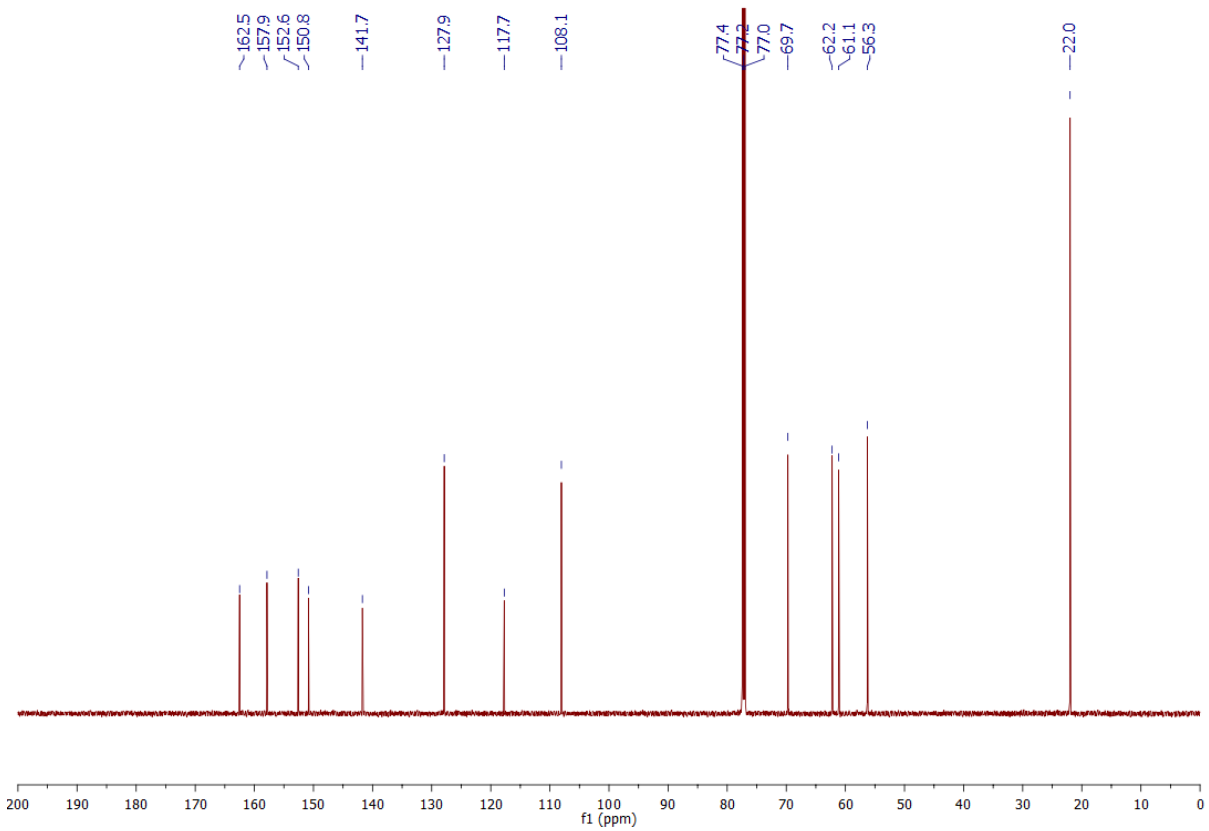

166.2
165.0
150.8
137.1
133.8
129.9
128.0
77.5
77.3
77.0
70.4
52.6
21.8
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Isopropyl (2,3,4-trimethoxybenzoyl)carbamate 3j

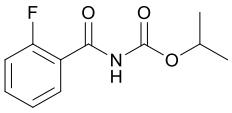


Compound prepared according to method B. Purification by column chromatography (10%-50% EtOAc/Petrol) yielded isopropyl (2,3,4-trimethoxybenzoyl)carbamate as a white solid (202 mg, 0.680 mmol, 68%). m.p. 122-124 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 10.06 (br s, NH, 1H), 7.92 (d, *J* = 9.0 Hz, 1H), 6.79 (d, *J* = 9.0 Hz, 2H), 5.07 (septet, *J* = 6.3 Hz, 1H), 4.03 (s, 3H), 3.91 (s, 3H), 3.86 (s, 3H), 1.31 (d, *J* = 6.3 Hz, 6H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 162.5 (C), 157.9 (C), 152.6 (C), 150.8 (C), 141.7 (C), 127.9 (CH), 117.7 (C), 108.1 (CH), 67.9 (CH), 62.2 (CH_3), 61.1 (CH_3), 56.3 (CH_3), 22.0 (CH_3); IR (solid) 3537, 2982, 2940, 1776, 1705, 1595 cm^{-1}; LRMS (ESI) 914 (20, $[3M+Na]^+$), 617 (50, $[2M+Na]^+$), 298 (100, $[M+H]^+$); HRMS (ESI) calcd for $C_{14}H_{20}NO_6$ $[M+H]^+$ 298.1291; observed 298.1293.

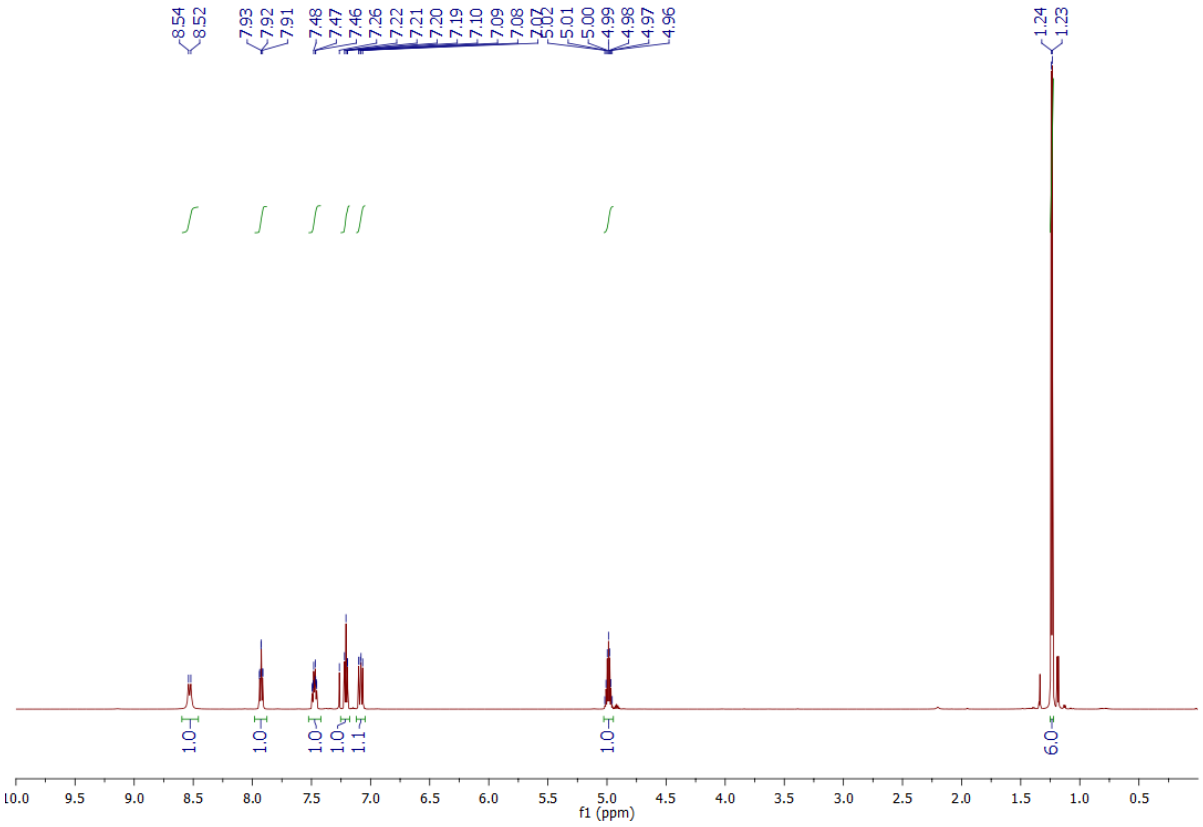


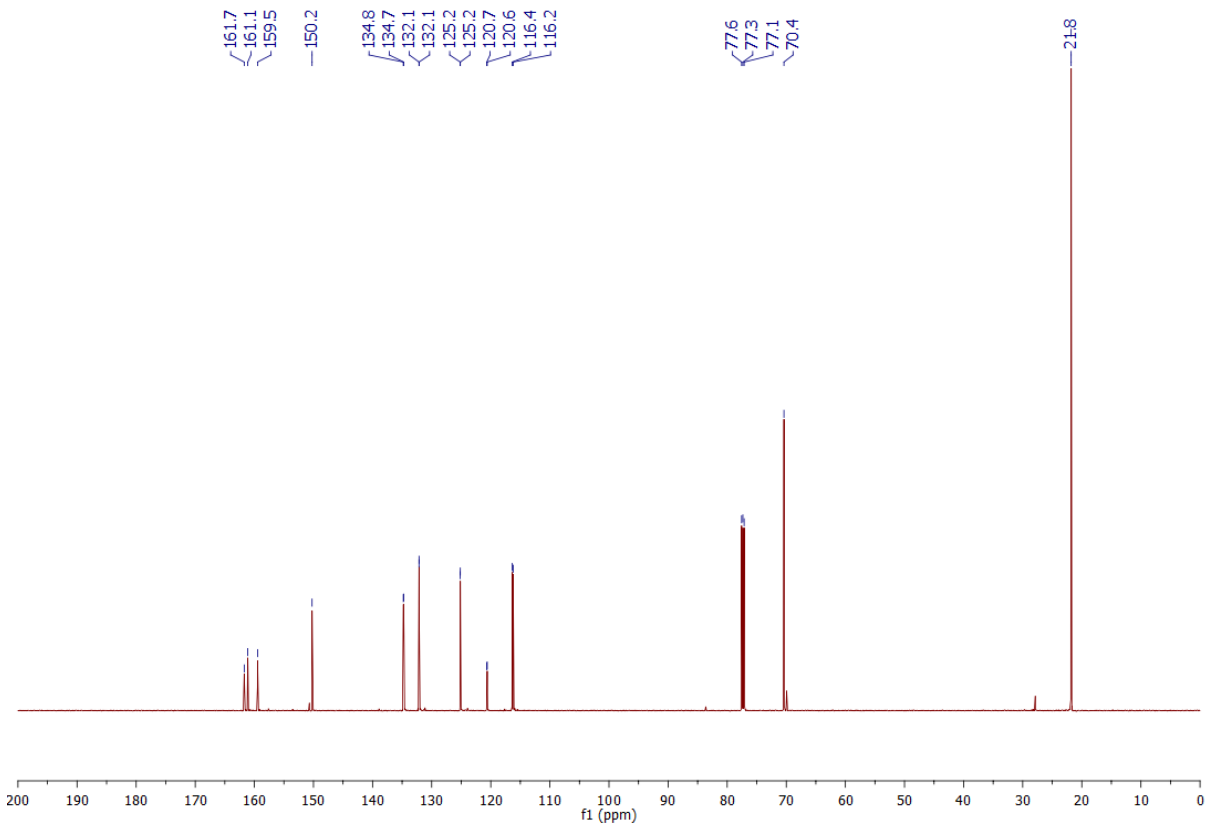

162.5
157.9
152.6
150.8
141.7
127.9
117.7
108.1
77.4
77.2
77.0
69.7
62.2
61.1
56.3
22.0
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Isopropyl (2-fluorobenzoyl)carbamate 3k

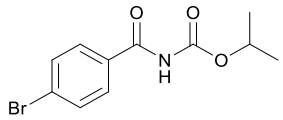


Compound prepared according to method B. Purification by column chromatography (10%-50% EtOAc/Petrol) yielded isopropyl (2-fluorobenzoyl)carbamate as a white solid (235 mg, 0.740 mmol, 74%). m.p. 129-131 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.53 (app. d, J = 11.8 Hz, NH, 1H), 7.93 (td, J = 7.8, 1.7 Hz, 1H), 7.50-7.45 (m, 1H), 7.21 (t, J = 7.6 Hz, 1H), 7.08 (dd, J = 11.8, 8.4 Hz, 1H), 4.99 (septet, J = 6.3 Hz, 1H), 1.24 (d, J = 6.3 Hz, 6H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 161.7 (C), 160.3 (d, $J_{C\text{-}F}$ = 248.8 Hz, C) 150.2 (C), 134.8 (d, $J_{C\text{-}F}$ = 9.4 Hz, CH), 132.1 (d, $J_{C\text{-}F}$ = 1.3 Hz, CH), 125.2 (d, $J_{C\text{-}F}$ = 3.2 Hz, CH), 120.6 (d, $J_{C\text{-}F}$ = 11.4 Hz, C), 116.3 (d, $J_{C\text{-}F}$ = 24.2 Hz, CH), 70.4 (CH), 21.8 (CH_3); IR (solid) 3266, 2980, 2935, 1760, 1691, 1612, 1581 cm^{-1}; LRMS (ESI) 226 (100, $[M+H]^+$); HRMS (ESI) calcd for $C_{11}H_{13}FNO_3$ $[M+H]^+$ 226.0874; observed 226.0872.

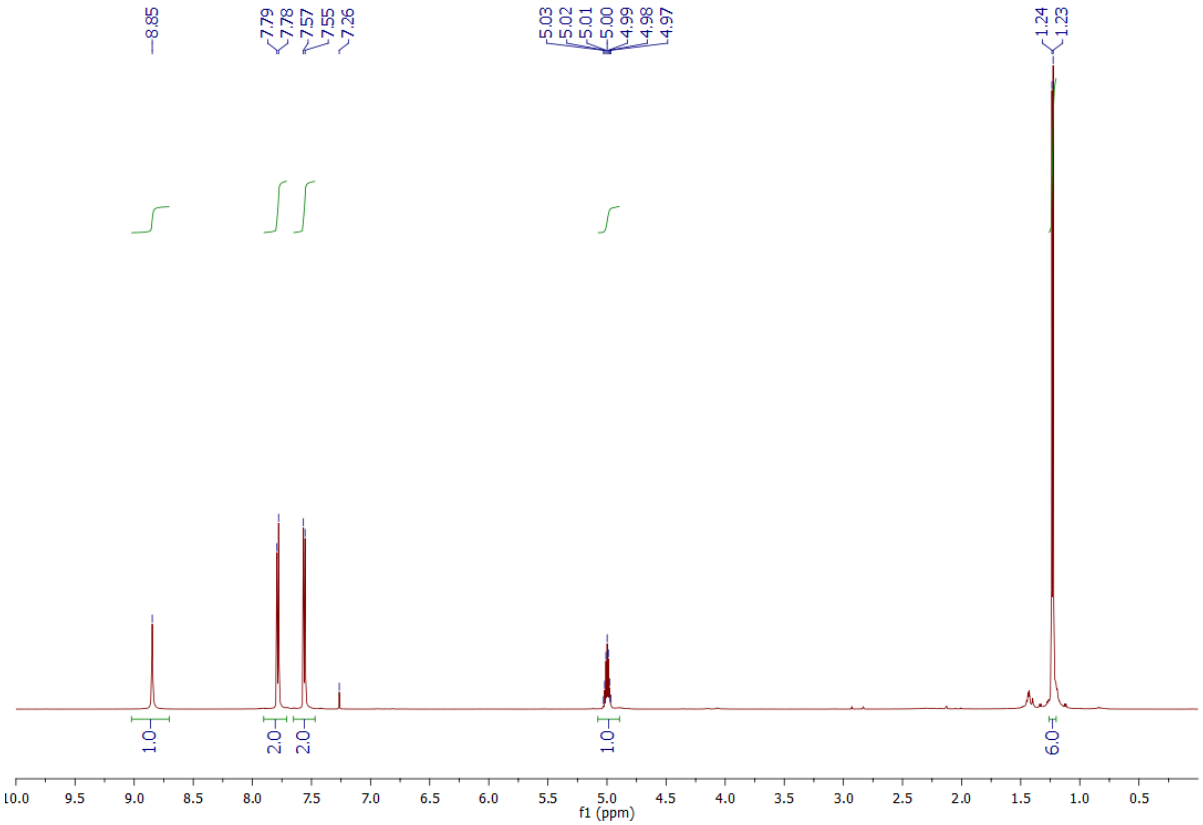


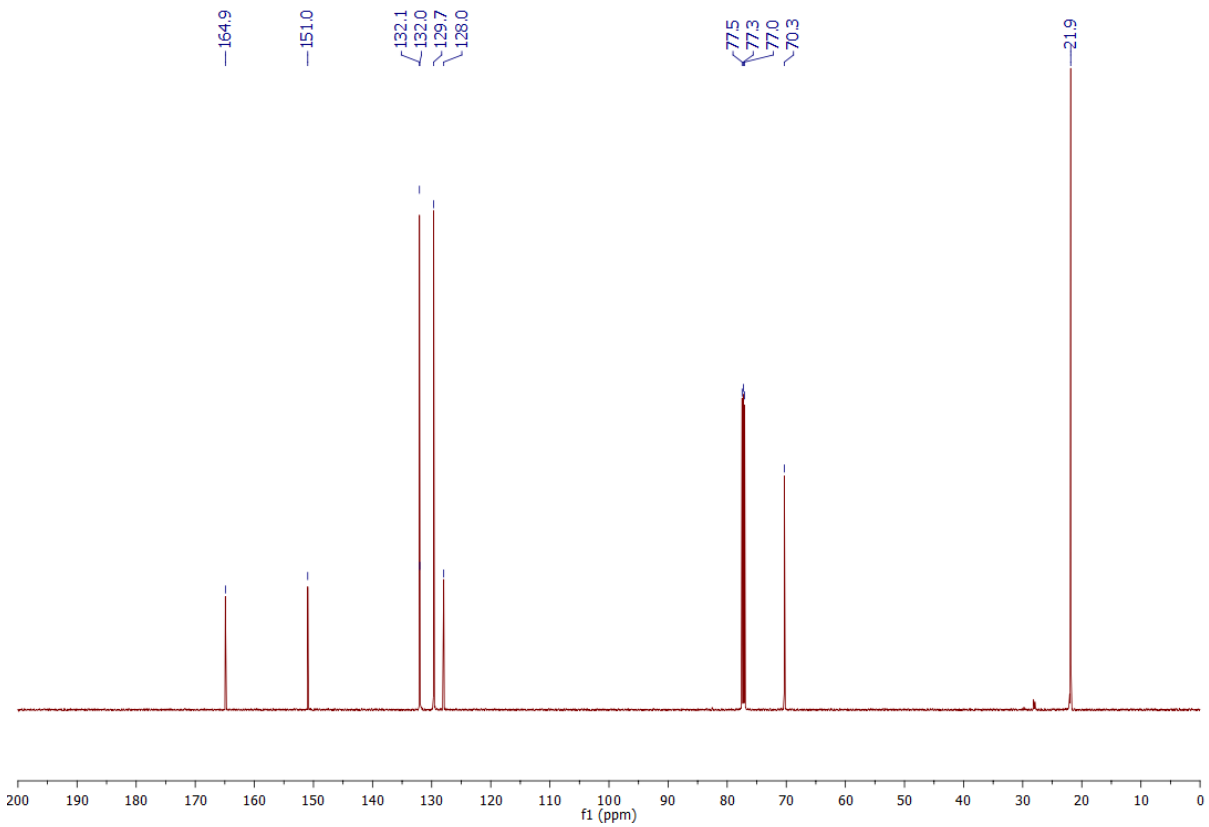

161.7
161.1
159.5
150.2
134.8
134.7
132.1
132.1
125.2
125.2
120.7
120.6
116.4
116.2
77.6
77.3
77.1
70.4
21.8
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Isopropyl (4-bromobenzoyl)carbamate 3l

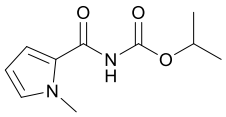


Compound prepared according to method B. Purification by column chromatography (10%-50% EtOAc/Petrol) yielded isopropyl (4-bromobenzoyl)carbamate as a white solid (229 mg, 0.800 mmol, 80%). m.p. 125-127 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.85 (br s, NH, 1H), 7.79 (d, *J* = 8.6 Hz, 2H), 7.56 (d, *J* = 8.6 Hz, 2H), 5.00 (septet, *J* = 6.3 Hz, 1H), 1.23 (d, *J* = 6.3 Hz, 6H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 164.9 (C), 151.0 (C), 132.1 (CH), 132.0 (C), 129.7 (CH), 128.0 (C), 70.3 (CH), 21.9 (CH_3); IR (solid) 3274, 2981, 2946, 1760, 1716, 1677, 1613, 1572, 1517 cm^{-1}; LRMS (ESI) 288 (95, $[M^{81}Br+H]^+$), 286 (100, $[M^{79}Br+H]^+$); HRMS (ESI) calcd for $C_{11}H_{13}BrNO_3$ $[M+H]^+$ 286.0078; observed 286.0073.

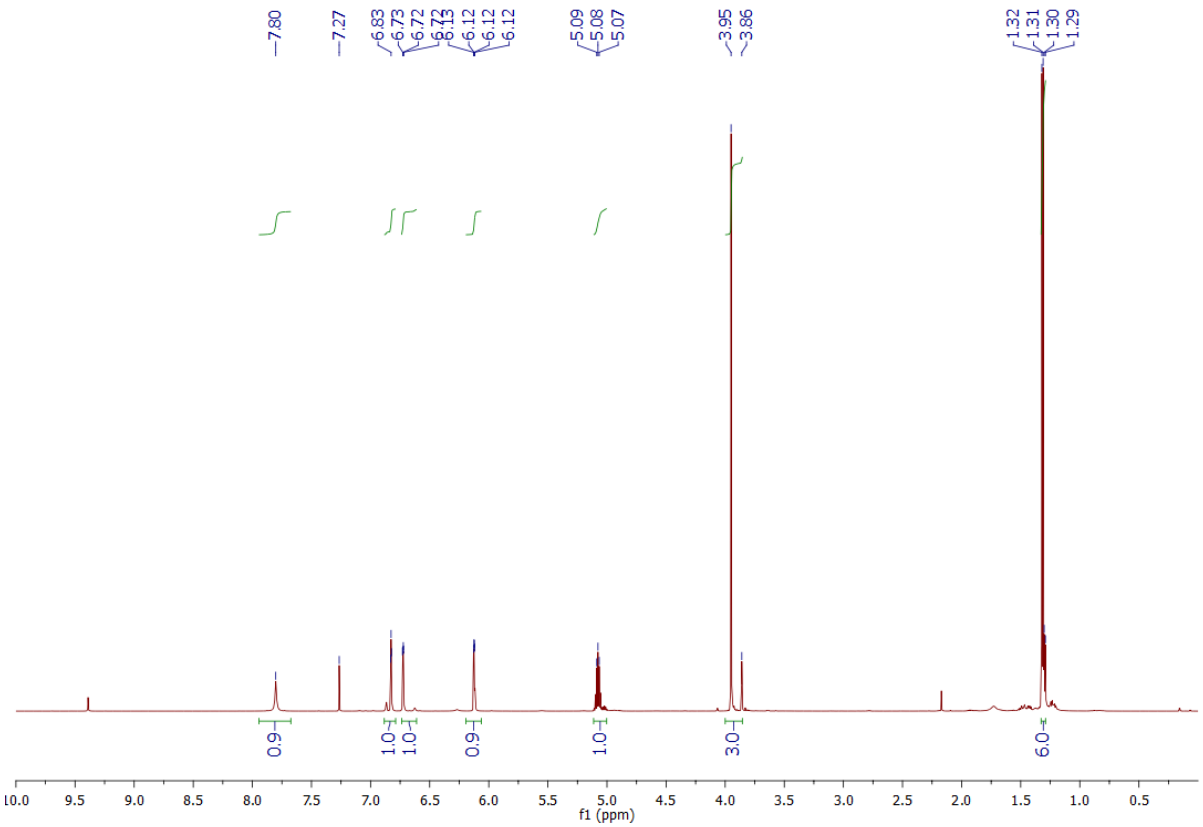


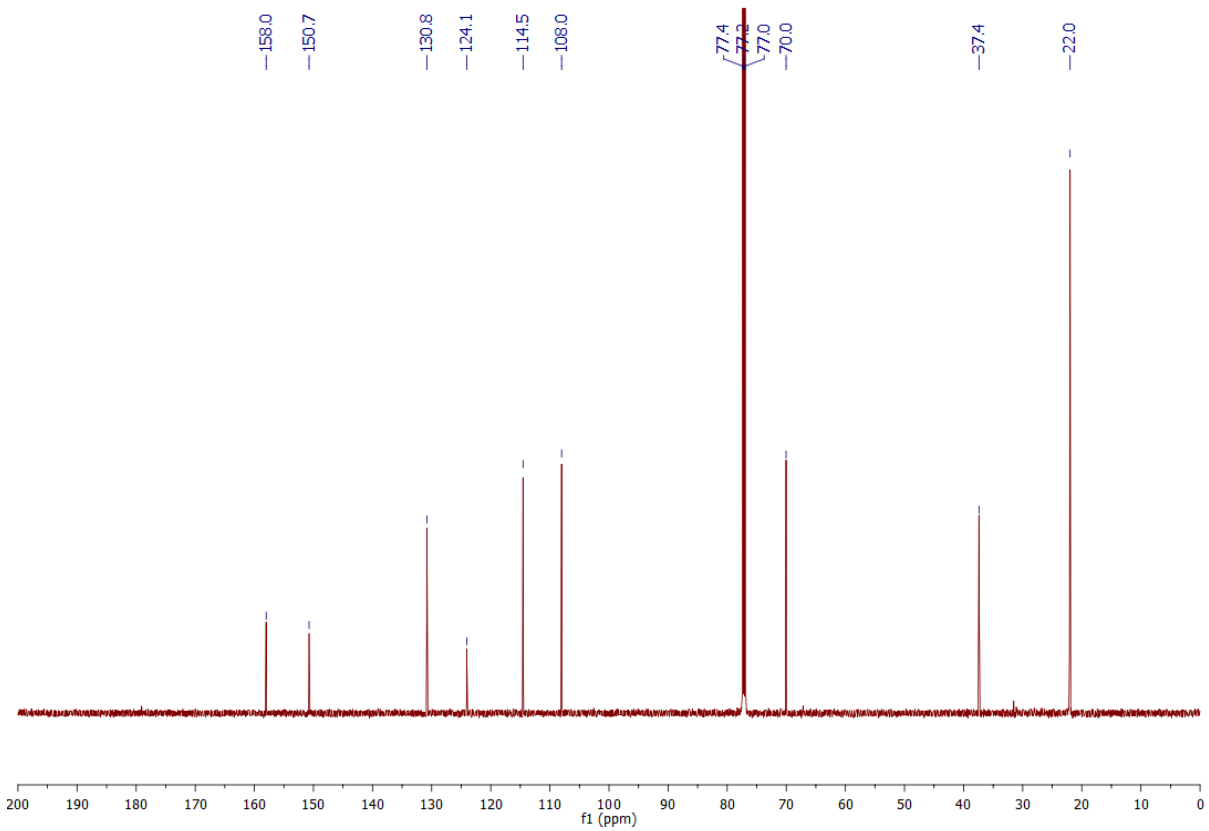

164.9
151.0
132.1
132.0
129.7
128.0
77.5
77.3
77.0
70.3
21.9
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Isopropyl (1-methyl-1*H*-pyrrole-2-carbonyl)carbamate 3m

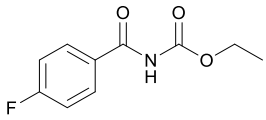


Compound prepared according to method B. Purification by column chromatography (10%-50% EtOAc/Petrol) yielded isopropyl (1-methyl-1*H*-pyrrole-2-carbonyl)carbamate as a brown solid (128 mg, 0.610 mmol, 61%). m.p. 105-109 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.80 (br s, NH, 1H), 6.88-6.82 (m, 1H), 6.73 (dd, *J* = 4.1, 1.6 Hz, 1H), 6.12 (dd, *J* = 4.1, 2.5 Hz, 1H), 5.08 (septet, *J* = 6.3 Hz, 1H), 3.95 (s, 3H), 1.32 (d, *J* = 6.3 Hz, 6H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 158.0 (C), 150.7 (C), 130.8 (CH), 124.1 (C), 114.5 (CH), 108.0 (CH), 70.0 (CH), 22.0 (CH_3); IR (solid) 3273, 3119, 2980, 2938, 1921, 1897, 1869, 1741, 1673, 1567, 1531 cm^{-1}.

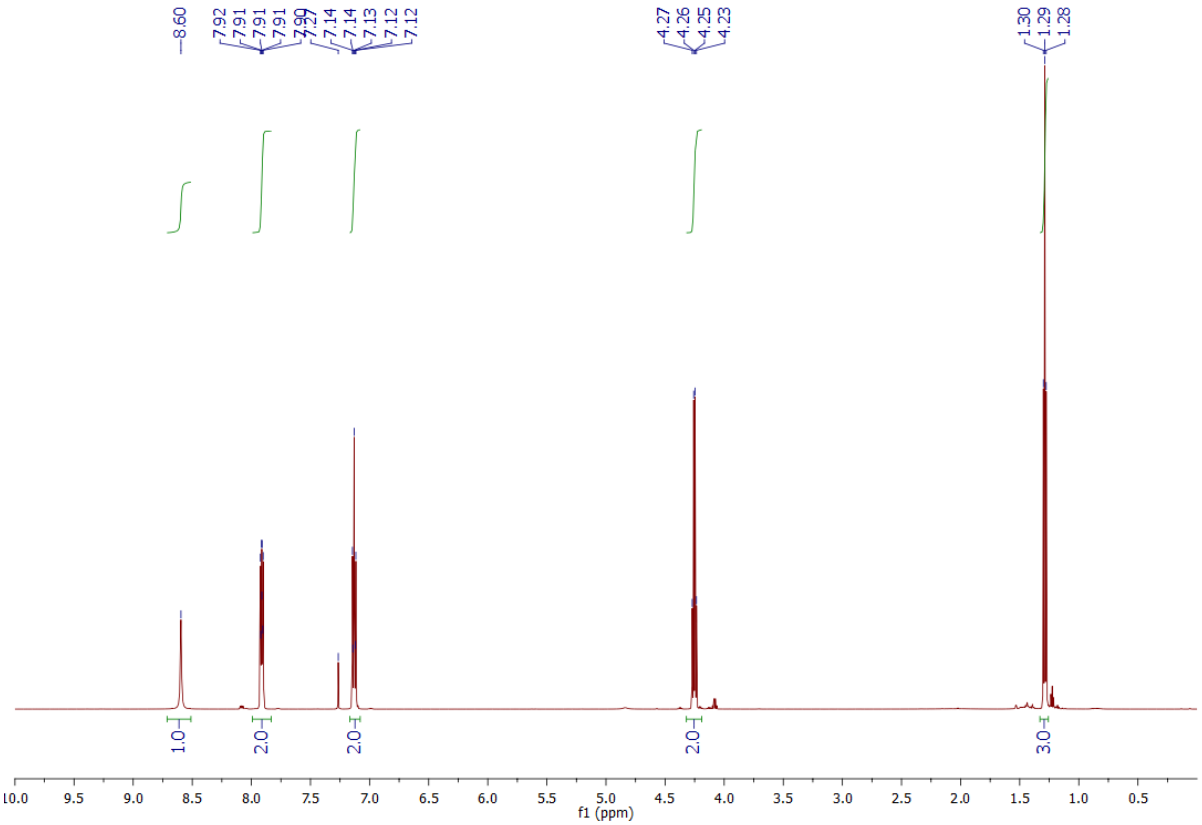


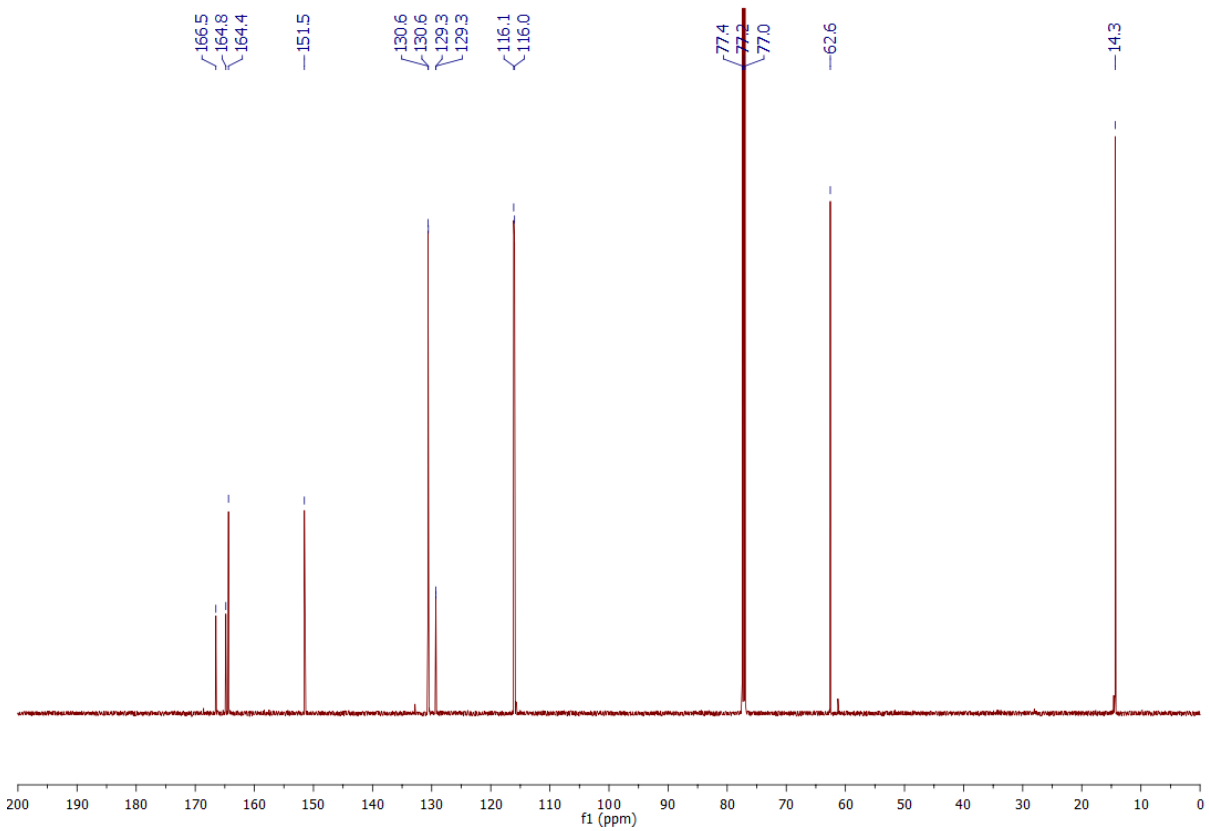

158.0
150.7
130.8
124.1
114.5
108.0
77.4
77.2
77.0
70.0
37.4
22.0
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Ethyl (4-fluorobenzoyl)carbamate 3b

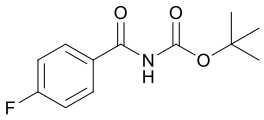


Compound prepared according to method B. Purification by column chromatography (10%-50% EtOAc/Petrol) yielded ethyl (4-fluorobenzoyl)carbamate as a white solid (152 mg, 0.720 mmol, 72%). m.p. 87-90 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.60 (br s, NH, 1H), 7.93-7.89 (m, 2H), 7.15-7.11 (m, 2H), 4.25 (q, J = 7.1 Hz, 2H) 1.29 (t, J = 7.1 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 165.7 (d, $J_{C\text{-}F}$ = 254.5 Hz, C), 164.4 (C), 151.5 (C), 130.6 (d, $J_{C\text{-}F}$ = 9.3 Hz, CH), 129.2 (d, $J_{C\text{-}F}$ = 3.0 Hz, C), 116.1 (d, $J_{C\text{-}F}$ = 22.1 Hz, CH), 62.6 (CH_2), 14.3 (CH_3); IR (solid) 3274, 2983, 2938, 1751, 1686, 1602, 1525 cm^{-1}; LRMS (ESI) 212 (100, $[M+H]^+$); HRMS (ESI) calcd for $C_{10}H_{11}FNO_4$ $[M+H]^+$ 212.0717; observed 212.0717.

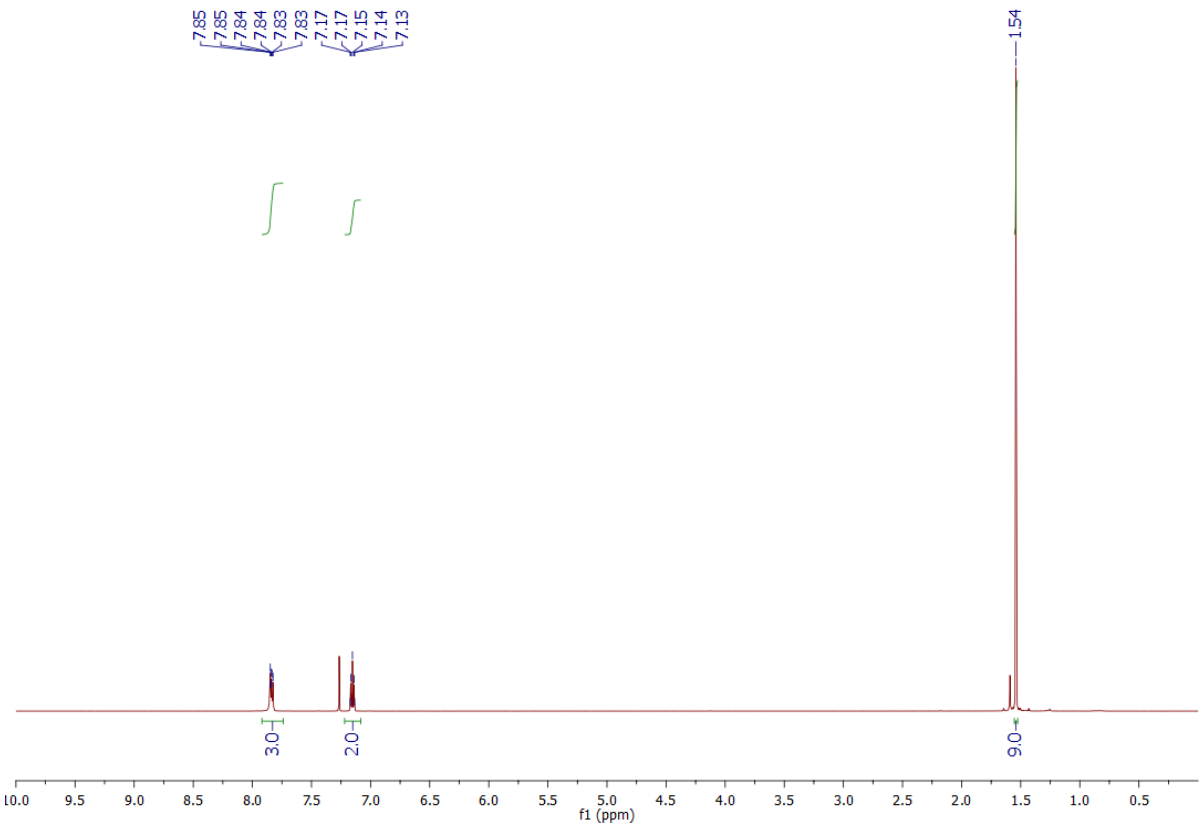


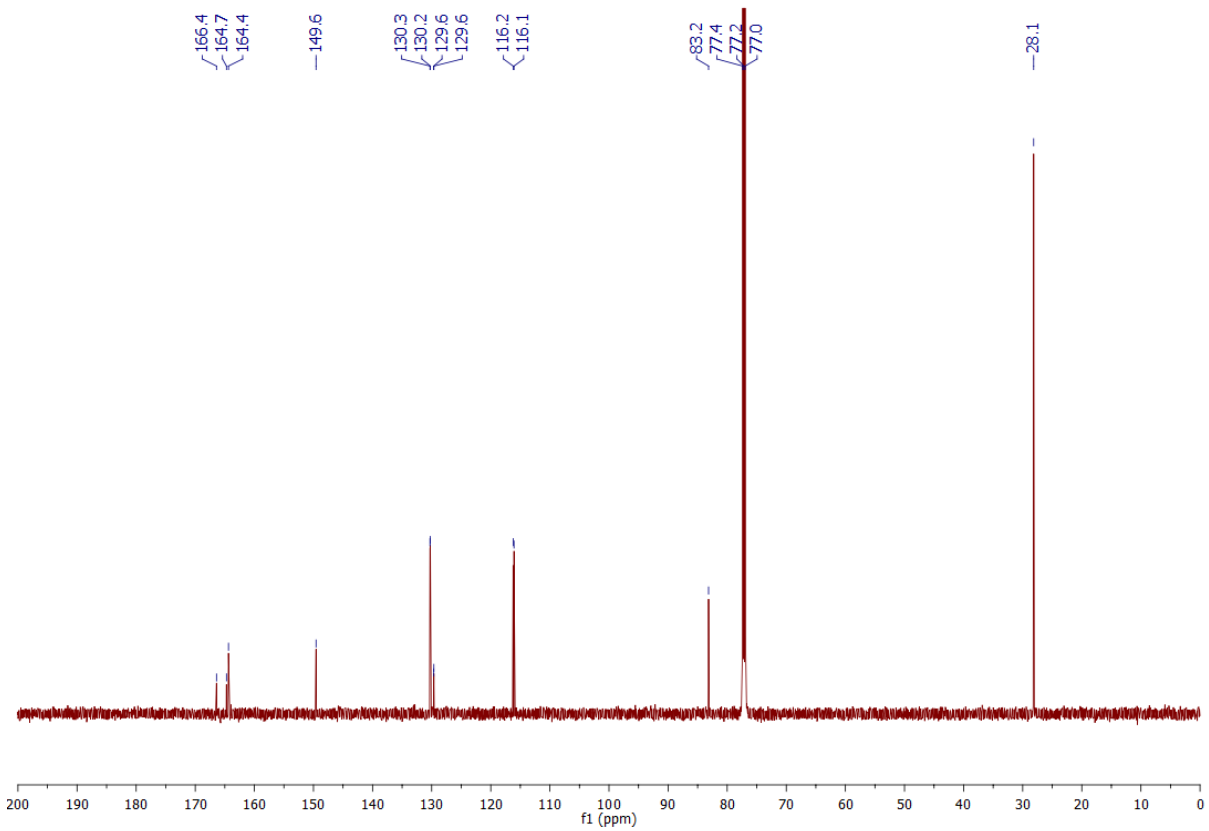

166.5
164.8
164.4
151.5
130.6
130.6
129.3
129.3
116.1
116.0
77.4
77.2
77.0
62.6
14.3
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

***tert*-Butyl (4-fluorobenzoyl)carbamate 3n**

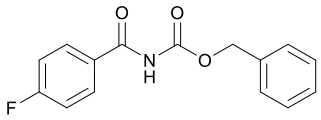


Compound prepared according to method B. Purification by column chromatography (10%-50% EtOAc/Petrol) yielded *tert*-butyl (4-fluorobenzoyl)carbamate as a white solid (177 mg, 0.740 mmol, 74%). m.p. 116-118 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.92-7.74 (m, 3H), 7.18-7.13 (m, 2H), 1.54 (s, 9H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 166.4 (d, $J_{C\text{-}F}$ = 254.4 Hz, C), 164.4 (C), 149.6 (C), 130.3 (d, $J_{C\text{-}F}$ = 9.3 Hz, CH), 129.6 (d, $J_{C\text{-}F}$ = 3.0 Hz, C), 116.1 (d, $J_{C\text{-}F}$ = 22.1 Hz, CH), 83.2 (C) 28.1 (CH_3); IR (solid) 3268, 2980, 2931, 1748, 1682, 1603, 1526, 1501 cm^{-1}.

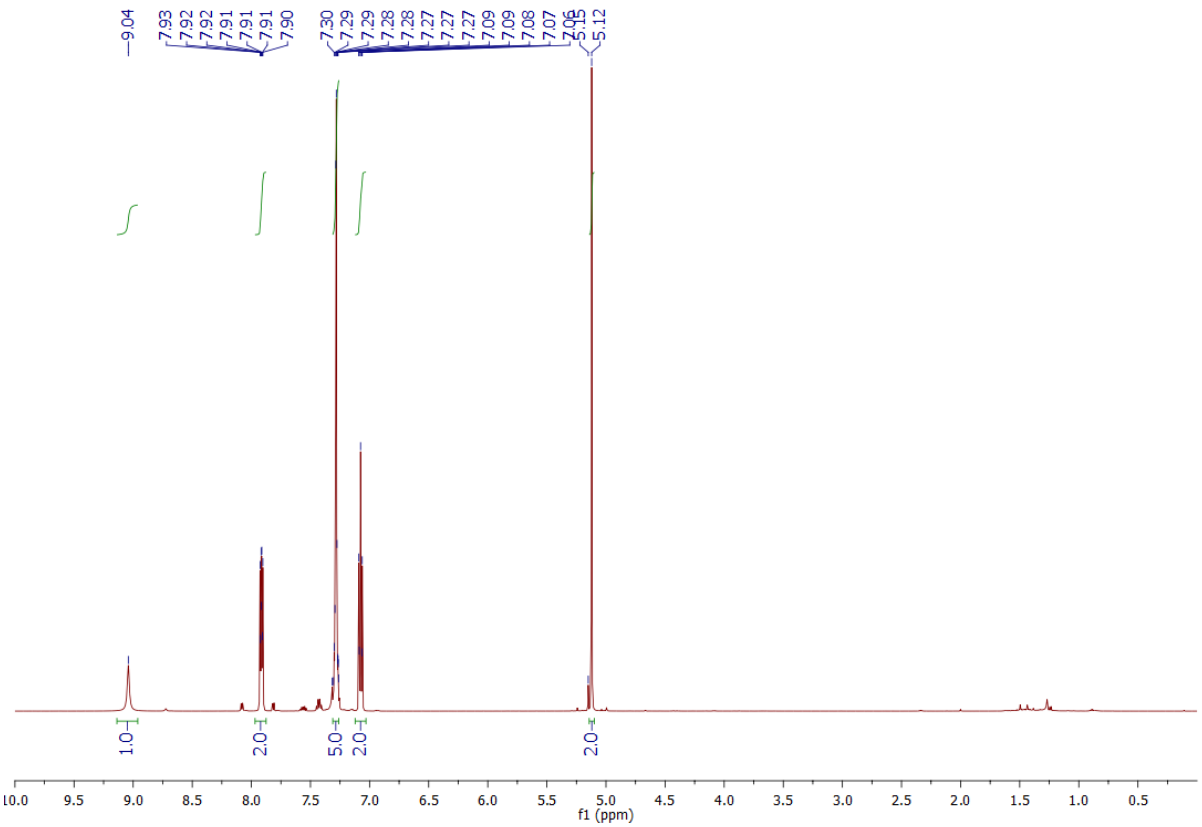


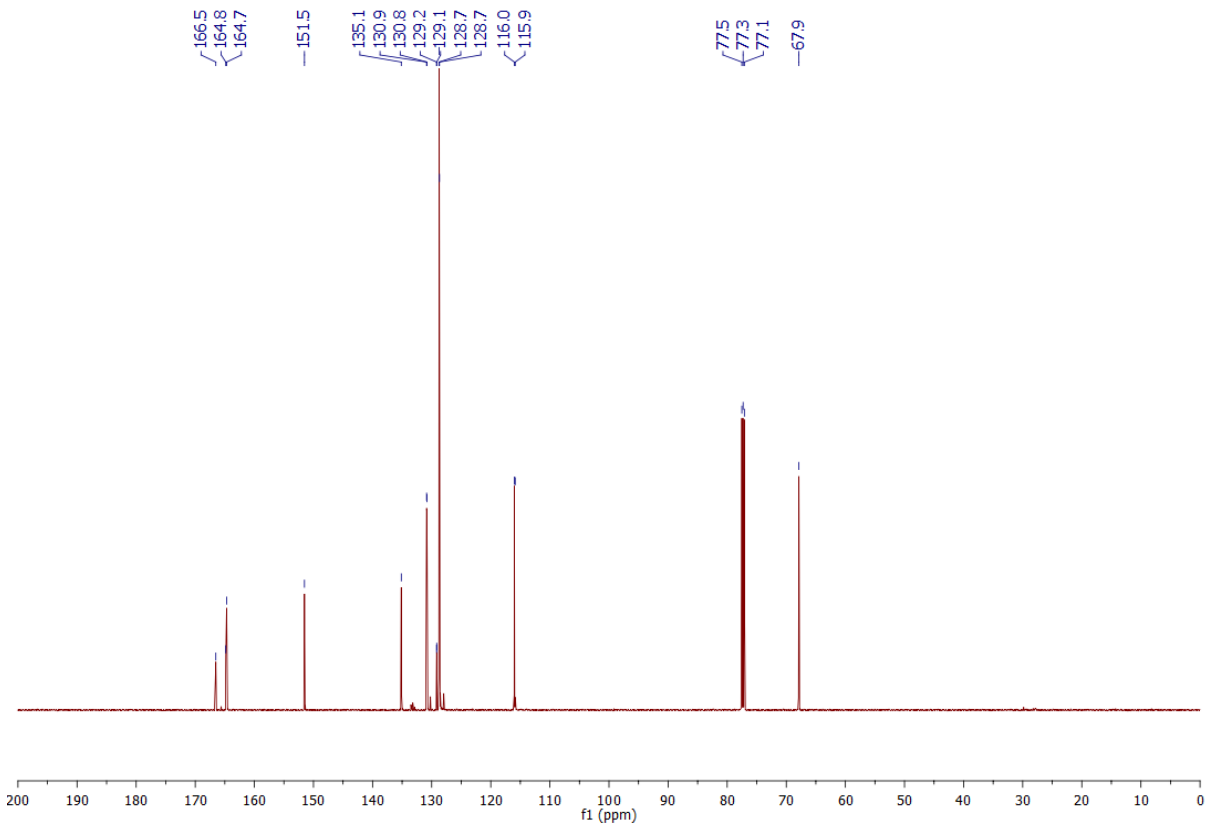

166.4
164.7
164.4
149.6
130.3
130.2
129.6
129.6
116.2
116.1
83.2
77.4
77.2
77.0
28.1
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Benzyl (4-fluorobenzoyl)carbamate 3o

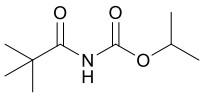


Compound prepared according to method B. Purification by column chromatography (10%-50% EtOAc/Petrol) yielded benzyl (4-fluorobenzoyl)carbamate as a white solid (189 mg, 0.690 mmol, 69%). m.p. 125-130 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 9.04 (br s, NH, 1H), 7.94-7.89 (m, 2H), 7.33-7.26 (m, 5H), 7.10-7.05 (m, 2H), 5.12 (s, 2H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 165.7 (d, $J_{C\text{-}F}$ = 254.3 Hz, C), 164.7 (C), 151.5 (C), 135.1 (C), 130.9 (d, $J_{C\text{-}F}$ = 9.3 Hz, CH), 129.2 (d, $J_{C\text{-}F}$ = 2.9 Hz, C), 128.7 (CH), 128.7 (CH), 115.9 (d, $J_{C\text{-}F}$ = 22.1 Hz, CH), 67.9 (CH_2); IR (solid) 3273, 2982, 2937, 1761, 1736, 1681, 1599, 1582, 1508 cm^{-1}.

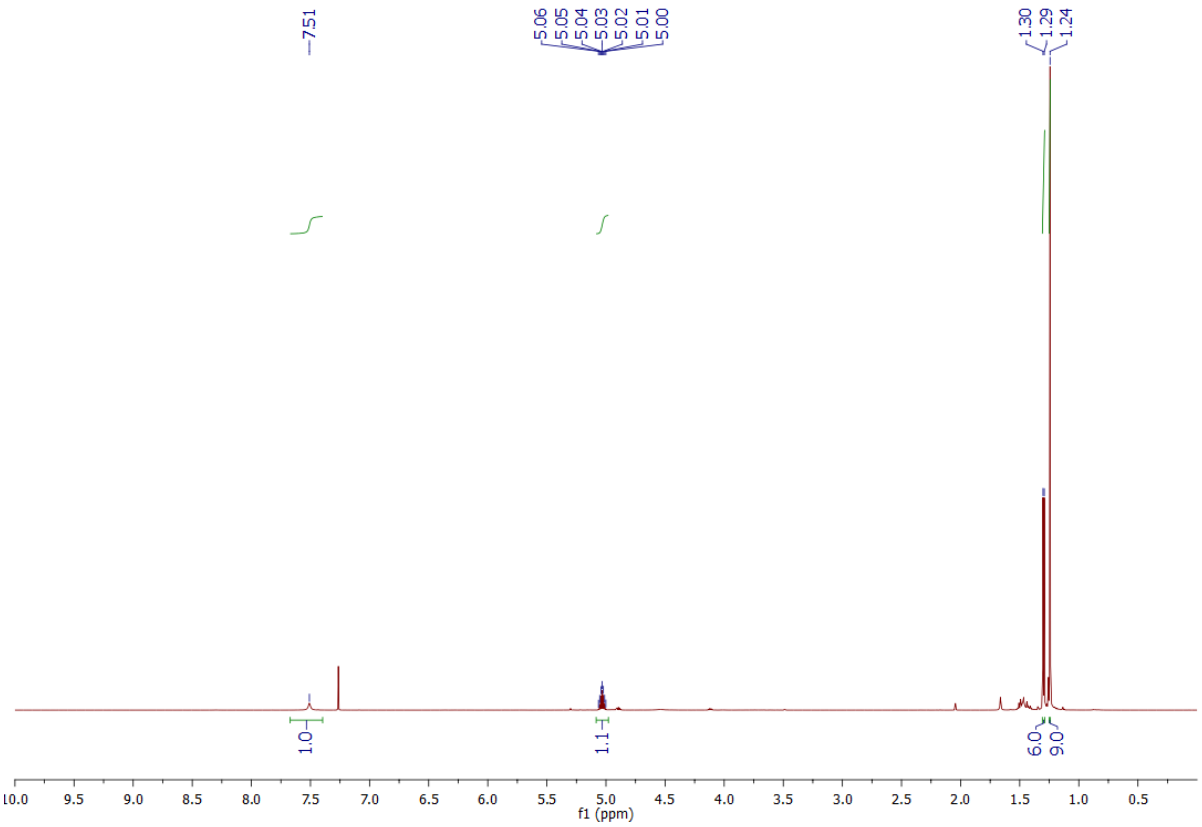


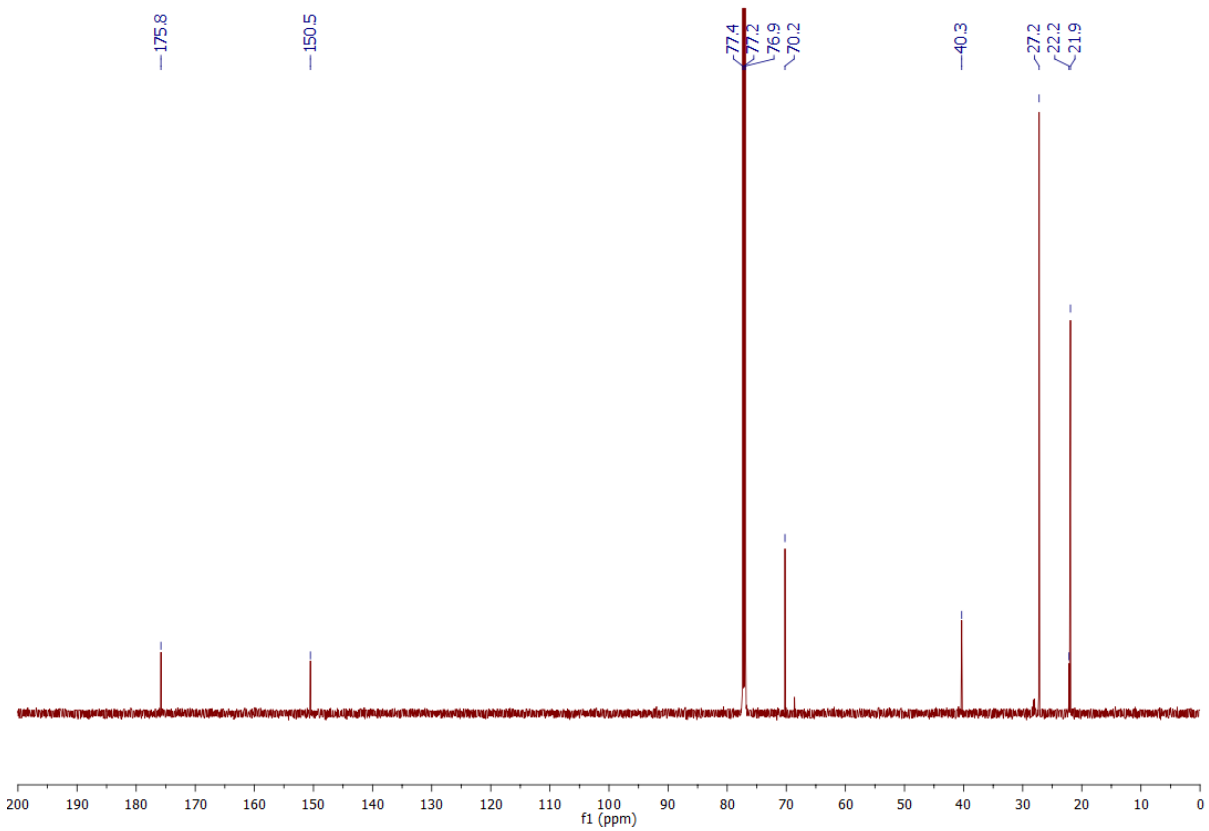

166.5
164.8
164.7
151.5
135.1
130.9
130.8
129.2
129.1
128.7
128.7
116.0
115.9
77.5
77.3
77.1
67.9
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Isopropyl pivaloylcarbamate 3r

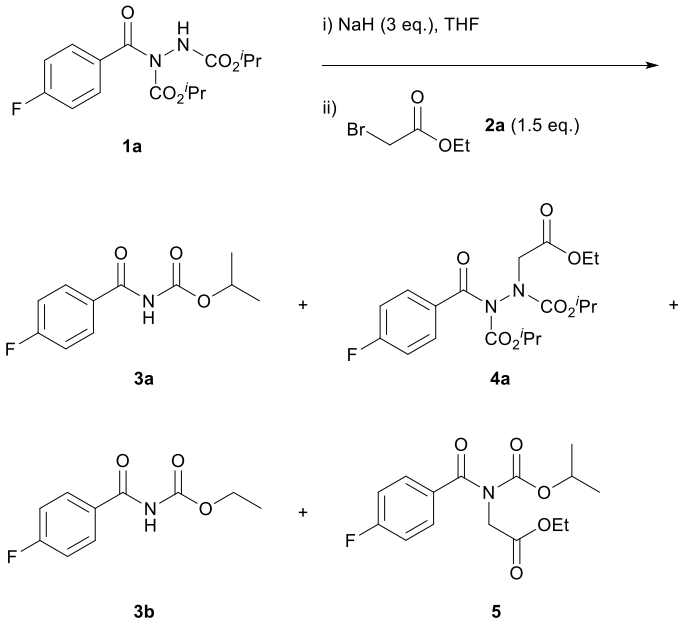


Purification by column chromatography (10%-50% EtOAc/Petrol) afforded isopropyl pivaloylcarbamate as a white solid (152 mg, 0.810 mmol, 81%). m.p. 80-84 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.51 (br s, NH, 1H), 5.03 (septet, *J* = 6.3 Hz, 1H), 1.30 (d, *J* = 6.3 Hz, 6H), 1.24 (s, 9H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 175.8 (C), 150.5 (C), 70.2 (CH), 40.3 (C), 27.2 (CH_3), 22.2 (CH_3) 21.9 (CH_3); IR (solid) 3267, 3193, 2979, 2937, 1771, 1758, 1509 cm^{-1}.




175.8
150.5
77.4
77.2
76.9
70.2
40.3
27.2
22.2
21.9
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

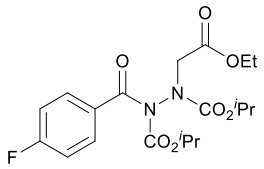
Optimisation of reaction of acyl hydrazide 1a and bromoacteate 2a



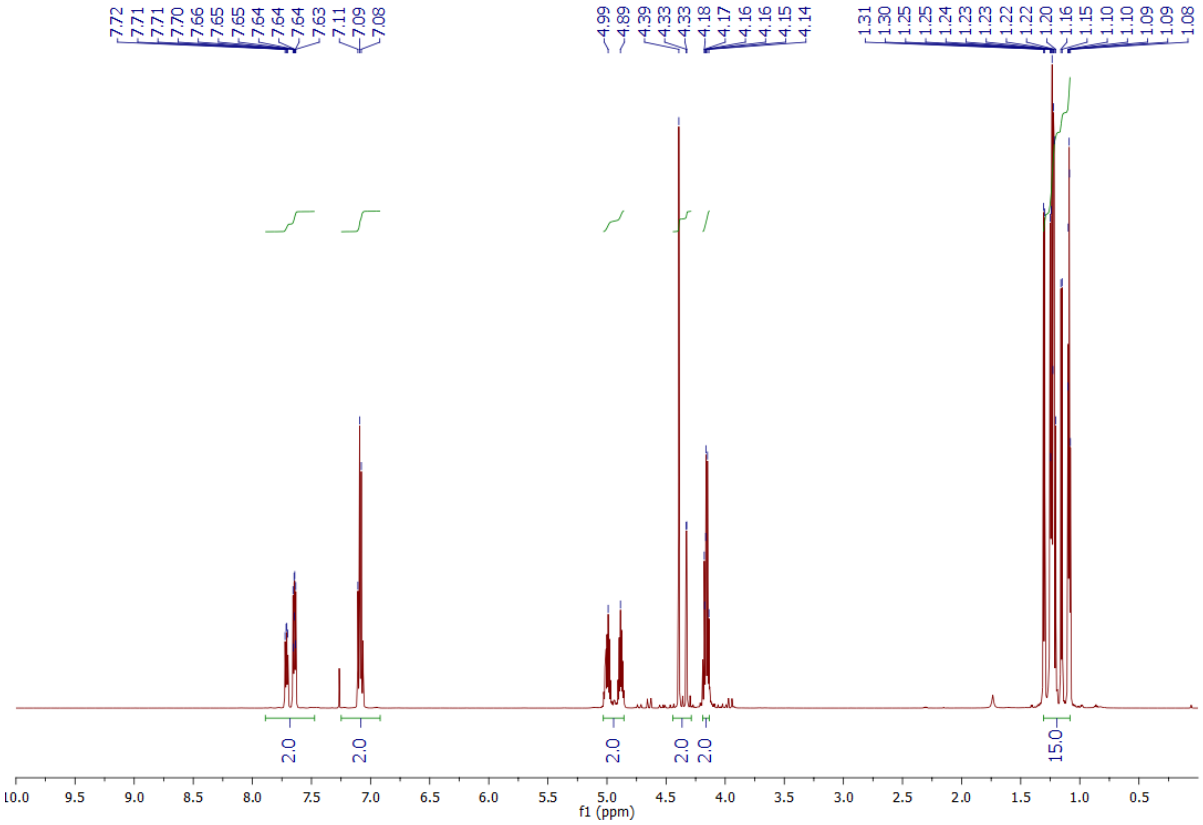
To a stirring solution of sodium hydride (60% mineral oil dispersion, 120 mg, 3.00 mmol, 3 eq.) in anhydrous THF (0.5 mL) was added dropwise a solution of diisopropyl 1-(4-fluorobenzoyl)hydrazine-1,2-dicarboxylate **1a** (326 mg, 1.00 mmol, 1 eq.) in anhydrous THF (1.5 mL) under an atmosphere of argon and the reaction mixture stirred for 5 minutes. After this time, to the reaction mixture was added dropwise ethyl bromoacetate **2a** (167 μL, 1.50 mmol, 1.5 eq.) pre-dissolved in anhydrous THF (0.5 mL). The reaction was stirred at 25 °C for 16 h and poured over stirring saturated, aqueous NH_4Cl (10 mL). The resulting solution was extracted with EtOAc (3 × 15 mL). The combined extracts were dried ($MgSO_4$), filtered and the solvent was evaporated *in vacuo*. Purification by column chromatography (10%-50% EtOAc/Petrol) yielded isopropyl (4-fluorobenzoyl)carbamate **3a** as a white solid (56.0 mg, 0.250 mmol, 25%); diisopropyl 1-(2-ethoxy-2-oxoethyl)-2-(4-fluorobenzoyl)hydrazine-1,2-dicarboxylate **4a** as a colourless oil (157 mg, 0.380 mmol, 38%); ethyl (4-fluorobenzoyl)carbamate **3b** as a white solid (34.0 mg, 0.160 mmol, 16%) and ethyl *N*-(4-fluorobenzoyl)-*N*-(isopropoxycarbonyl)glycinate **5** as a colourless oil (34.0 mg, 0.110 mmol, 11%).

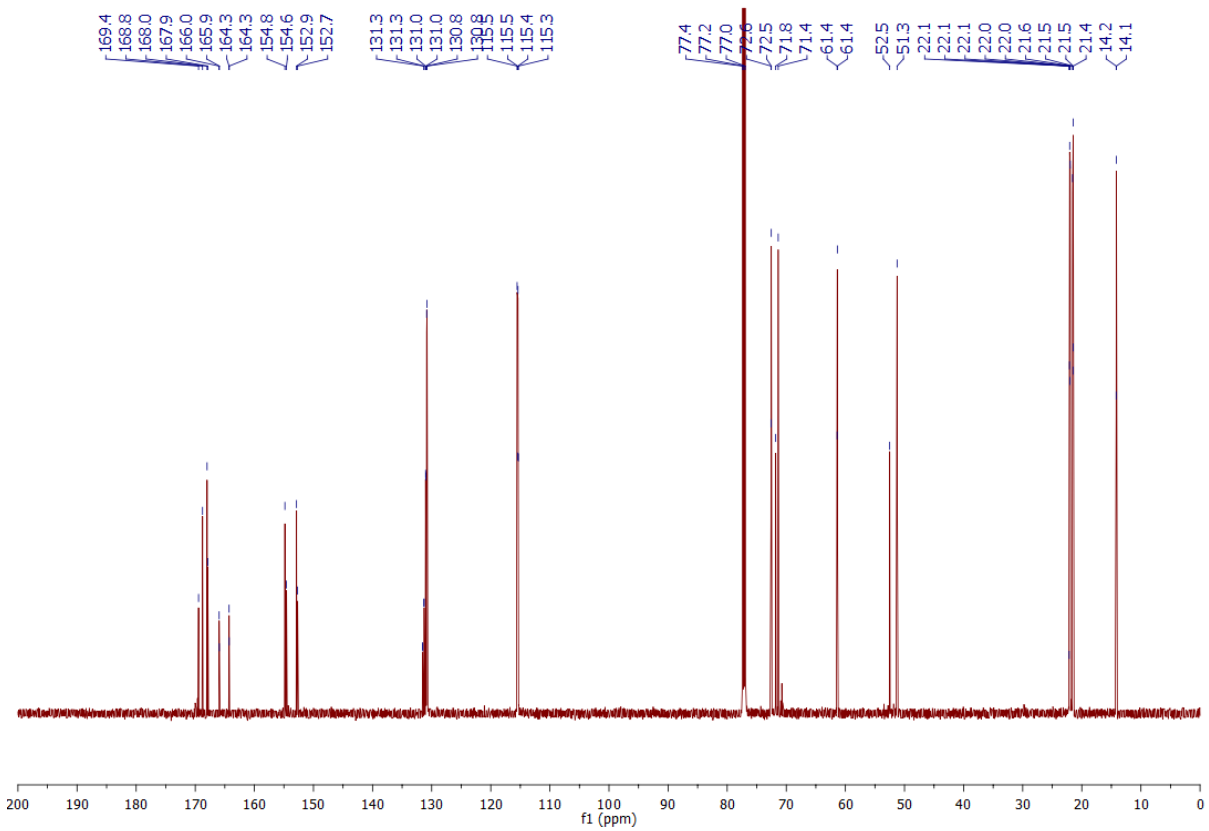
Data for isopropyl (4-fluorobenzoyl)carbamate **3a** and ethyl (4-fluorobenzoyl)carbamate **3b** matched that given above.

Diisopropyl 1-(2-ethoxy-2-oxoethyl)-2-(4-fluorobenzoyl)hydrazine-1,2-dicarboxylate 4a

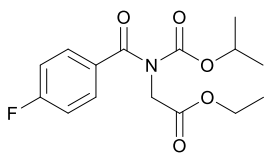


^{1}H NMR (600 MHz, $CDCl_3$) δ 7.71-7.69 (m, 2H), 7.10-7.05 (m, 2H), 5.01-4.95 (m, 1H), 4.90-4.84 (m, 1H), 4.41-4.29 (m, 2H), 4.17-4.12 (m, 2H), 1.29-1.06 (m, 15H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 169.4 (C), 168.8 (C), 168.0 (C), 167.9 (C), 165.4 (d, $J_{C\text{-}F}$ = 253.3 Hz, C), 164.8 (d, $J_{C\text{-}F}$ = 253.3 Hz, C), 154.8 (C), 154.6 (C), 152.9 (C), 152.7 (C), 131.5 (d, $J_{C\text{-}F}$ = 3.2 Hz, C), 131.3 (d, $J_{C\text{-}F}$ = 3.2 Hz, C), 131.0 (d, $J_{C\text{-}F}$ = 9.1 Hz, CH), 130.8 (d, $J_{C\text{-}F}$ = 9.1 Hz, CH), 115.5 (d, $J_{C\text{-}F}$ = 22.1 Hz, CH), 115.4 (d, $J_{C\text{-}F}$ = 22.1 Hz, CH), 72.6 (CH), 72.5 (CH), 71.8 (CH), 71.4 (CH), 61.4 (CH_2), 61.4 (CH_2), 52.5 (CH_2), 51.3 (CH_2), 22.1 (CH_3), 22.1 (CH_3), 22.0 (CH_3) 22.0 (CH_3), 21.6 (CH_3), 21.5 (CH_3) 21.5 (CH_3), 21.4 (CH_3), 14.2 (CH_3), 14.1 (CH_3); IR (thin film) 2984, 2939, 1753, 1725, 1603, 1508 cm^{-1}; LRMS (ESI) 413 (100, $[M+H]^+$); HRMS (ESI) calcd for $C_{19}H_{26}N_2O_7F$ $[M+H]^+$ 413.1724; observed 413.1726.

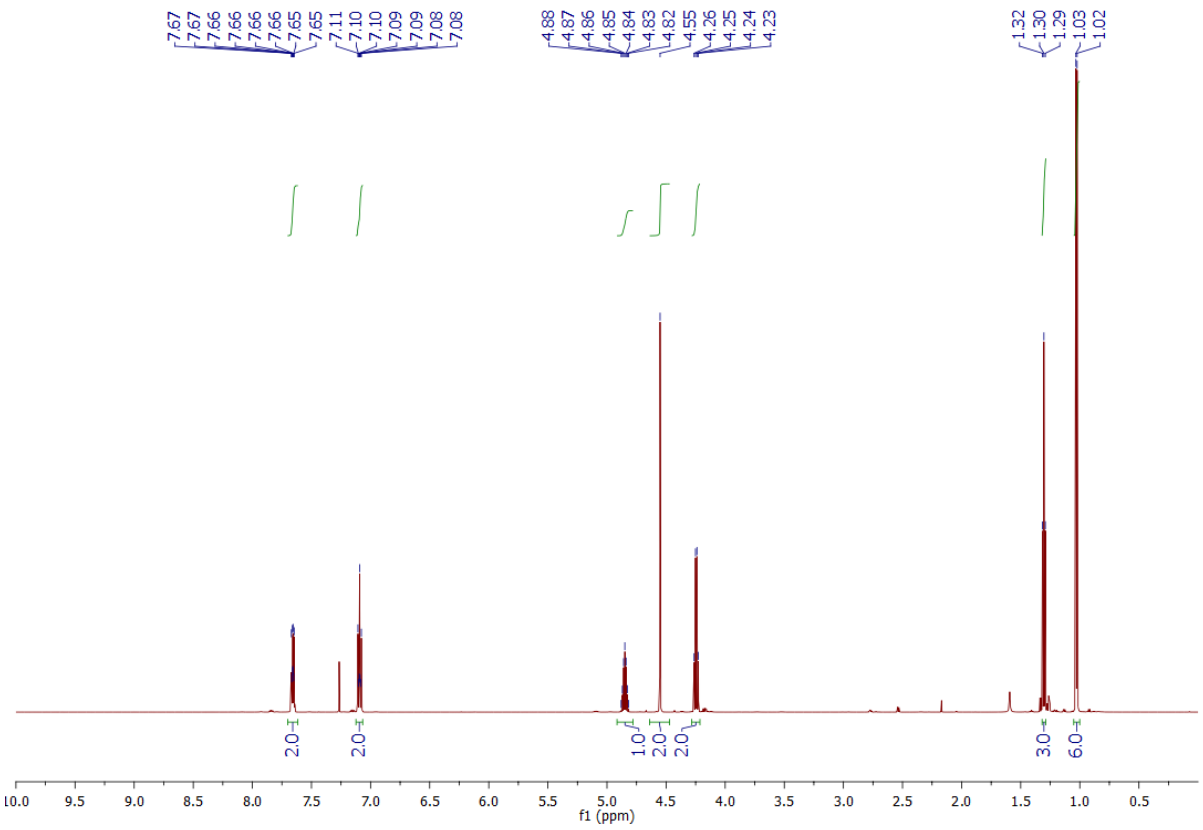




Ethyl *N*-(4-fluorobenzoyl)-*N*-(isopropoxycarbonyl)glycinate 5



^{1}H NMR (600 MHz, $CDCl_3$) δ 7.75-7.57 (m, 2H), 7.17-7.04 (m, 2H), 4.85 (septet, J = 6.2 Hz, 1H), 4.55 (s, 2H), 4.25 (q, J = 7.1 Hz, 2H), 1.30 (t, J = 7.1 Hz, 3H), 1.03 (d, J = 6.3 Hz, 6H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 171.8 (C), 168.9 (C), 164.8 (d, $J_{C\text{-}F}$ = 252.2 Hz, C), 153.7 (C), 132.9 (d, $J_{C\text{-}F}$ = 3.3 Hz, C), 130.4 (d, $J_{C\text{-}F}$ = 9.0 Hz, CH), 115.3 (d, $J_{C\text{-}F}$ = 22.2 Hz, CH), 71.9 (CH), 61.7 (CH_2), 46.7 (CH_2), 21.4 (CH_3), 14.3 (CH_3); IR (thin film) 2982, 2939, 1732, 1678, 1602, 1508 cm^{-1}; LRMS (ESI) 312 (100, $[M+H]^+$); HRMS (ESI) calcd for $C_{15}H_{19}FNO_5$ $[M+H]^+$ 312.1242; observed 312.1241.


7.67
7.67
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7.11
7.10
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7.08
7.08
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4.87
4.86
4.85
4.84
4.83
4.82
4.55
4.26
4.25
4.24
4.23
1.32
1.30
1.29
1.03
1.02
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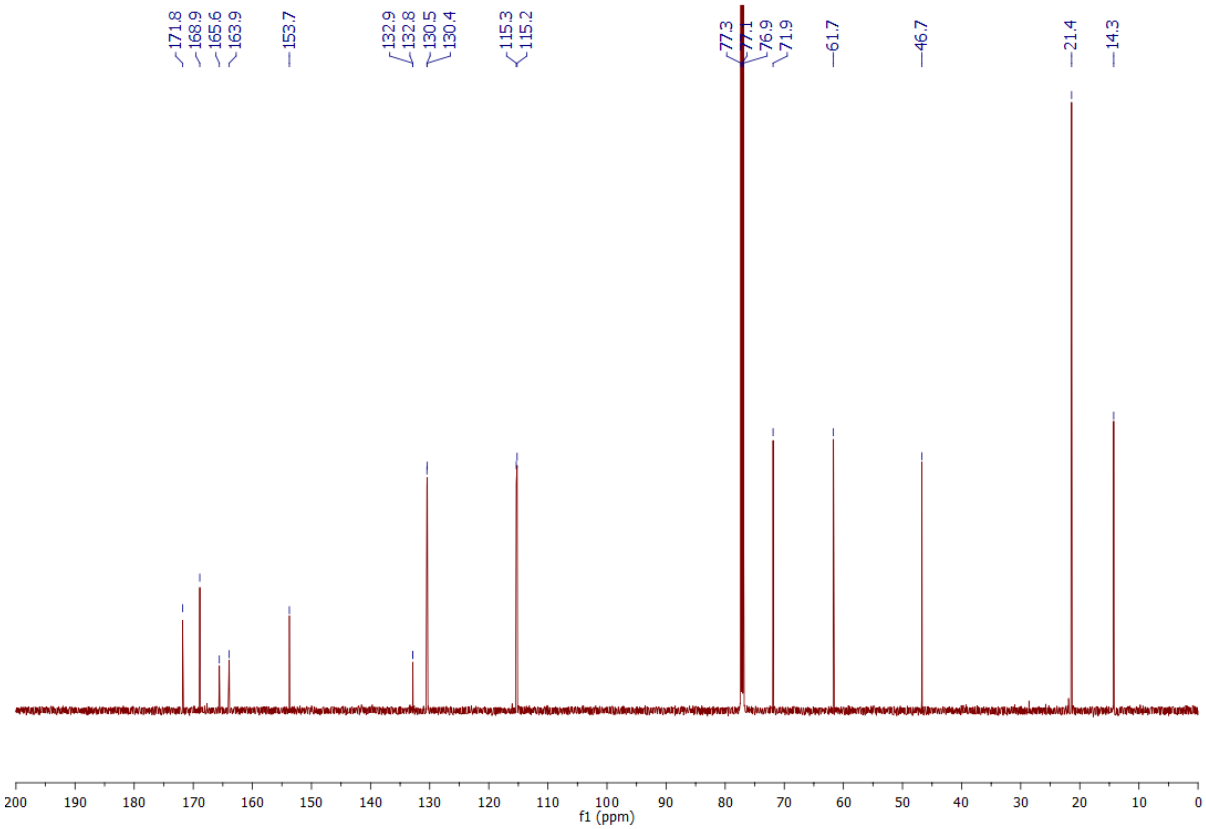
1.0
2.0
2.0
3.0
6.0
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
f1 (ppm)


171.8
168.9
165.6
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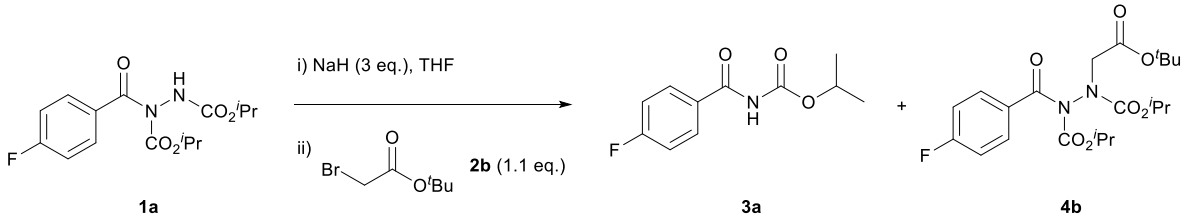
132.8
130.5
130.4
115.3
115.2
77.3
77.1
76.9
71.9
61.7
46.7
21.4
14.3
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

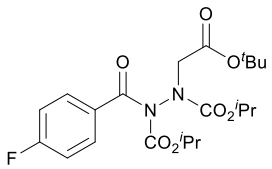
Optimisation of reaction of acyl hydrazide 1a and bromoacteate 2b



To a stirring solution of sodium hydride (60% mineral oil dispersion, 120 mg, 3.00 mmol, 3 eq.) in anhydrous THF (0.5 mL) was added dropwise a solution of diisopropyl 1-(4-fluorobenzoyl)hydrazine-1,2-dicarboxylate **1a** (326 mg, 1.00 mmol, 1 eq.) in anhydrous THF (1.5 mL) under an atmosphere of argon and the reaction mixture stirred for 5 minutes. After this time, to the reaction mixture was added dropwise *tert*-butyl bromoacetate **2b** (162 μL, 1.10 mmol, 1.1 eq.) pre-dissolved in anhydrous THF (0.5 mL). The reaction was stirred at 25 °C for 16 h and poured over stirring saturated, aqueous NH_4Cl (10 mL). The resulting solution was extracted with EtOAc (3 × 15 mL). The combined extracts were dried ($MgSO_4$), filtered and the solvent was evaporated *in vacuo*. Purification by column chromatography (10%-50% EtOAc/Petrol) yielded isopropyl (4-fluorobenzoyl)carbamate **3a** as a white solid (131 mg, 0.580 mmol, 58%) and diisopropyl 1-(2-(*tert*-butoxy)-2-oxoethyl)-2-(4-fluorobenzoyl)hydrazine-1,2-dicarboxylate **4b** as a colourless oil (110 mg, 0.250 mmol, 25%).

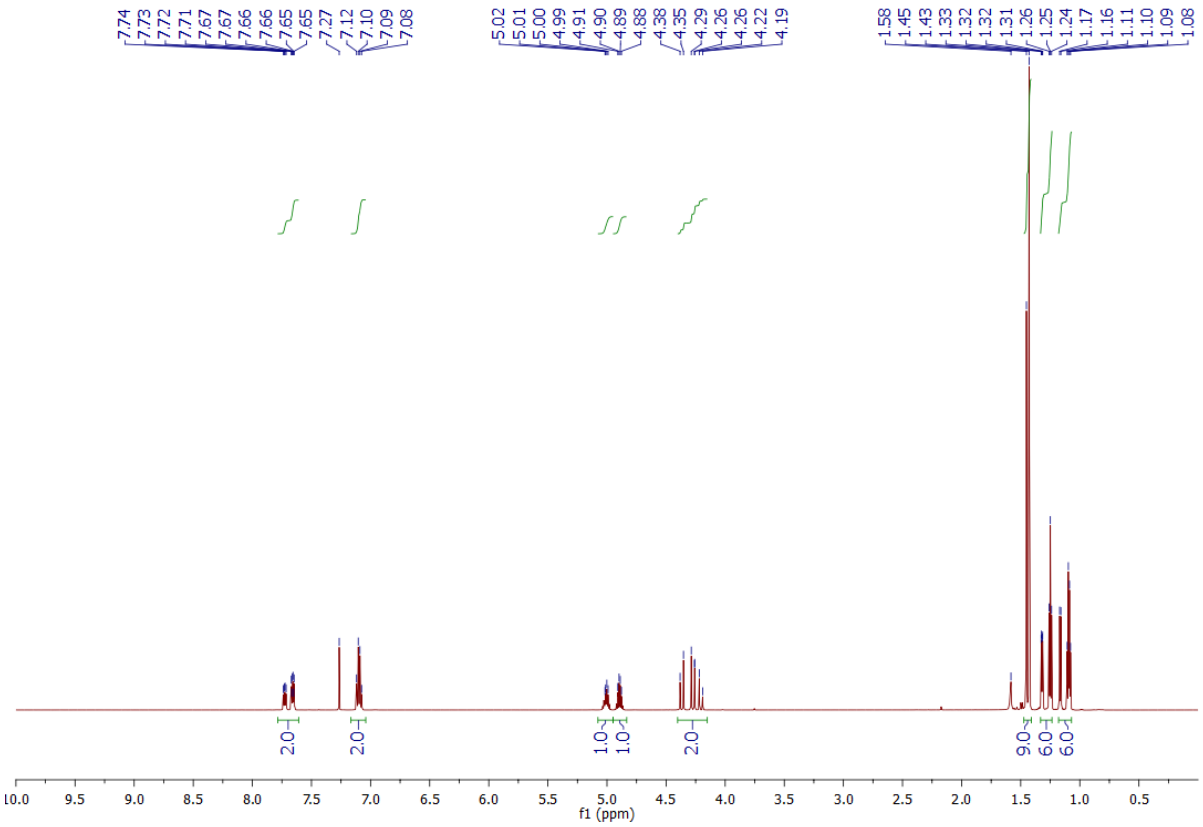
Data for isopropyl (4-fluorobenzoyl)carbamate **3a** matched that given above.

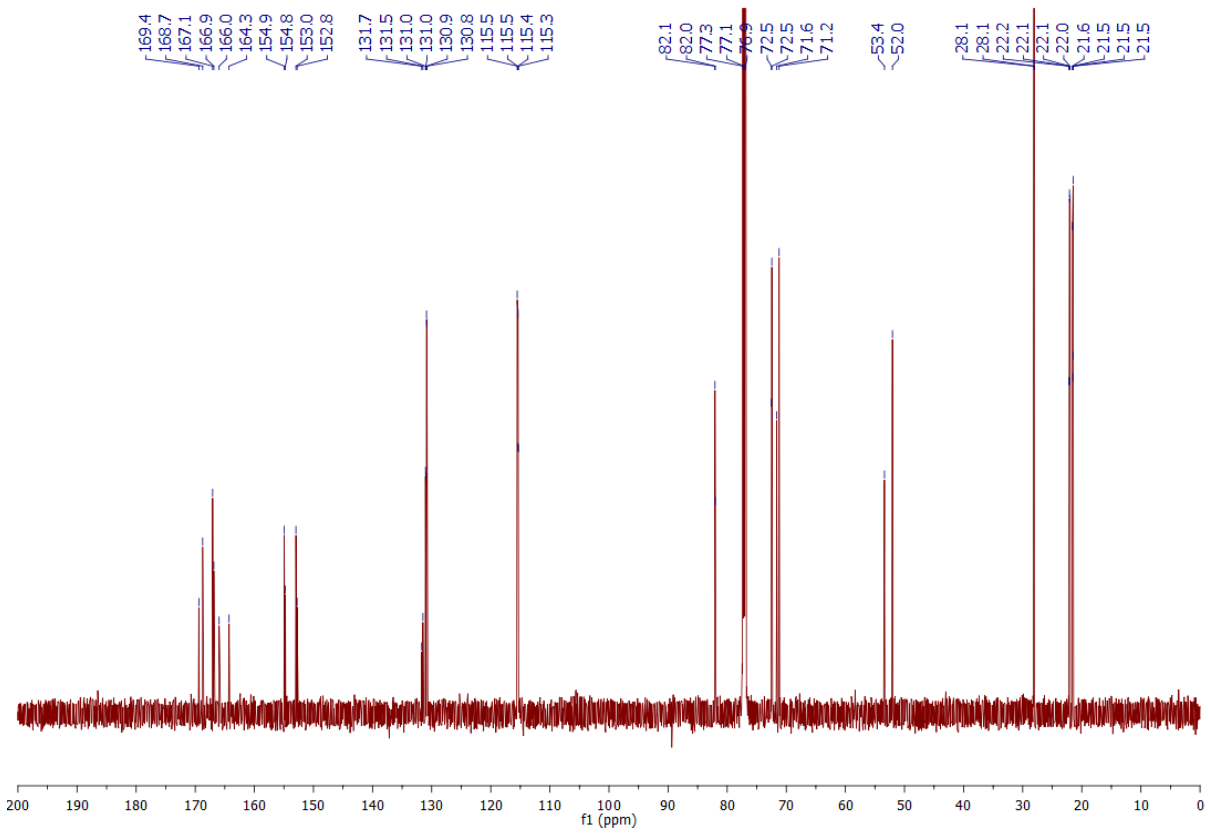
Diisopropyl 1-(2-(*tert*-butoxy)-2-oxoethyl)-2-(4-fluorobenzoyl)hydrazine-1,2-dicarboxylate 4b



^{1}H NMR (600 MHz, $CDCl_3$) δ 7.75-7.64 (m, 2H), 7.13-7.07 (m, 2H), 5.05-4.96 (m, 1H), 4.93-4.85 (m, 1H), 4.40-4.17 (m, 2H), 1.47-1.41 (m, 9H), 1.33-1.23 (m, 6H), 1.18-1.07 (m, 6H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 169.4 (C), 168.7 (C), 167.1 (C), 166.9 (C), 165.1 (d, $J_{C\text{-}F}$ = 253.3 Hz, C), 165.1 (d, $J_{C\text{-}F}$ = 253.0 Hz, C), 154.9 (C), 154.8 (C), 153.0 (C), 152.8 (C), 131.7 (d, $J_{C\text{-}F}$ = 3.2 Hz, C), 131.5 (d, $J_{C\text{-}F}$ = 3.2 Hz, C), 131.0 (d, $J_{C\text{-}F}$ = 9.1 Hz, CH), 130.8 (d, $J_{C\text{-}F}$ = 9.1 Hz, CH), 115.5 (d, $J_{C\text{-}F}$ = 22.2 Hz, CH), 115.4 (d, $J_{C\text{-}F}$ = 22.2 Hz, CH), 82.1 (C), 82.0 (C), 72.5 (CH), 72.5 (CH), 71.6 (CH), 71.2 (CH), 53.4 (CH_2), 52.0 (CH_2), 28.1 (CH_3),

28.1 (CH_3), 28.1 (CH_3), 22.2 (CH_3), 22.1 (CH_3), 22.1 (CH_3), 22.0 (CH_3), 21.6 (CH_3), 21.5 (CH_3), 21.5 (CH_3), 21.5 (CH_3); IR (thin film) 2978, 2933, 2876, 1748, 1720, 1601, 1506 cm^{-1}; LRMS (ESI) 441 (100, $[M+H]^+$); HRMS (ESI) calcd for $C_{21}H_{30}FN_2O_7$ $[M+H]^+$ 441.2032; observed 441.2031.




169.4
168.7
167.1
166.9
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164.3
154.9
154.8
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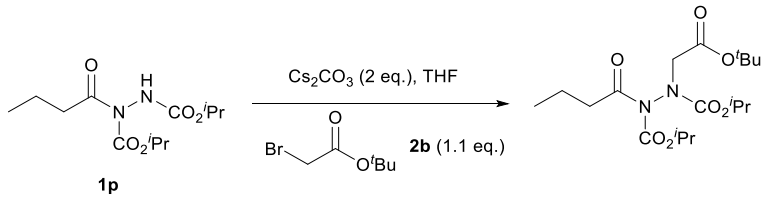
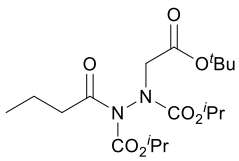
152.8
131.7
131.5
131.0
131.0
130.9
130.8
115.5
115.5
115.4
115.3
82.1
82.0
77.3
77.1
76.9
72.5
72.5
71.6
71.2
53.4
52.0
28.1
28.1
22.2
22.1
22.1
22.0
21.6
21.5
21.5
21.5
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

Reaction of alkyl acyl hydrazides with bromoacetate 2b

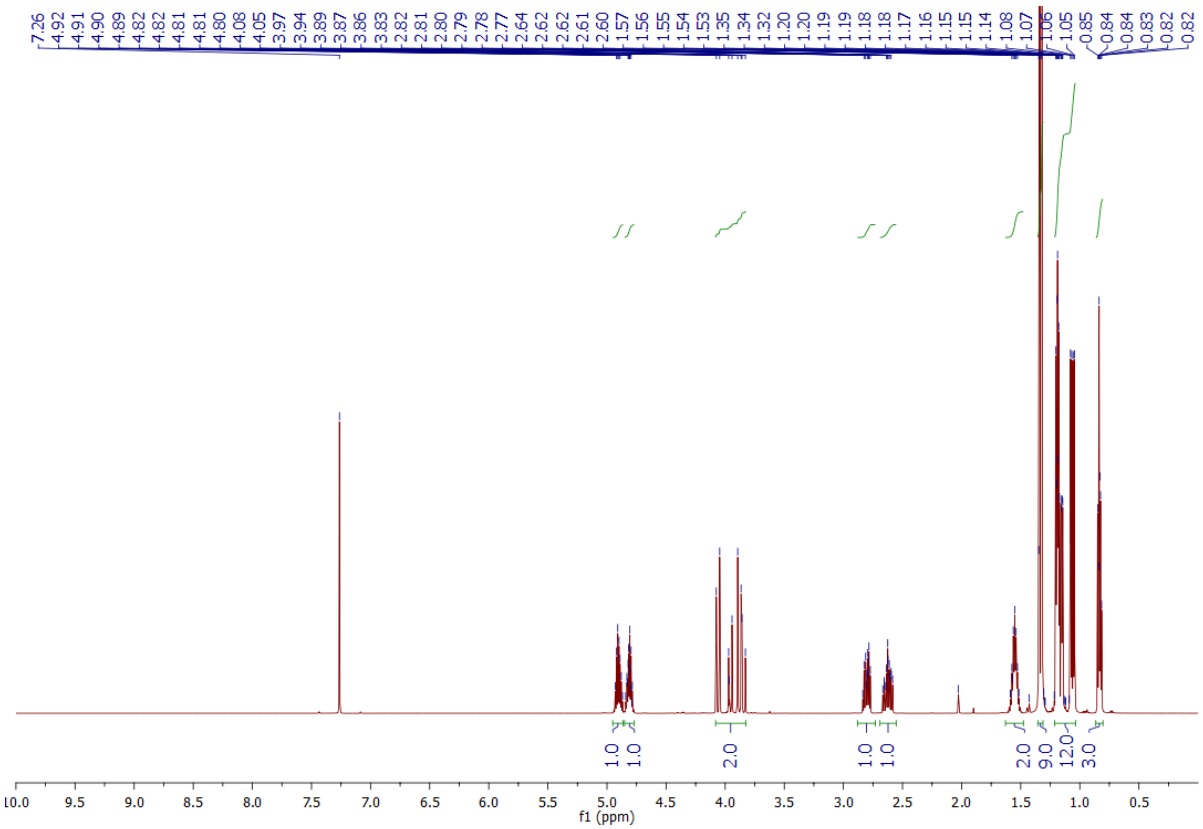


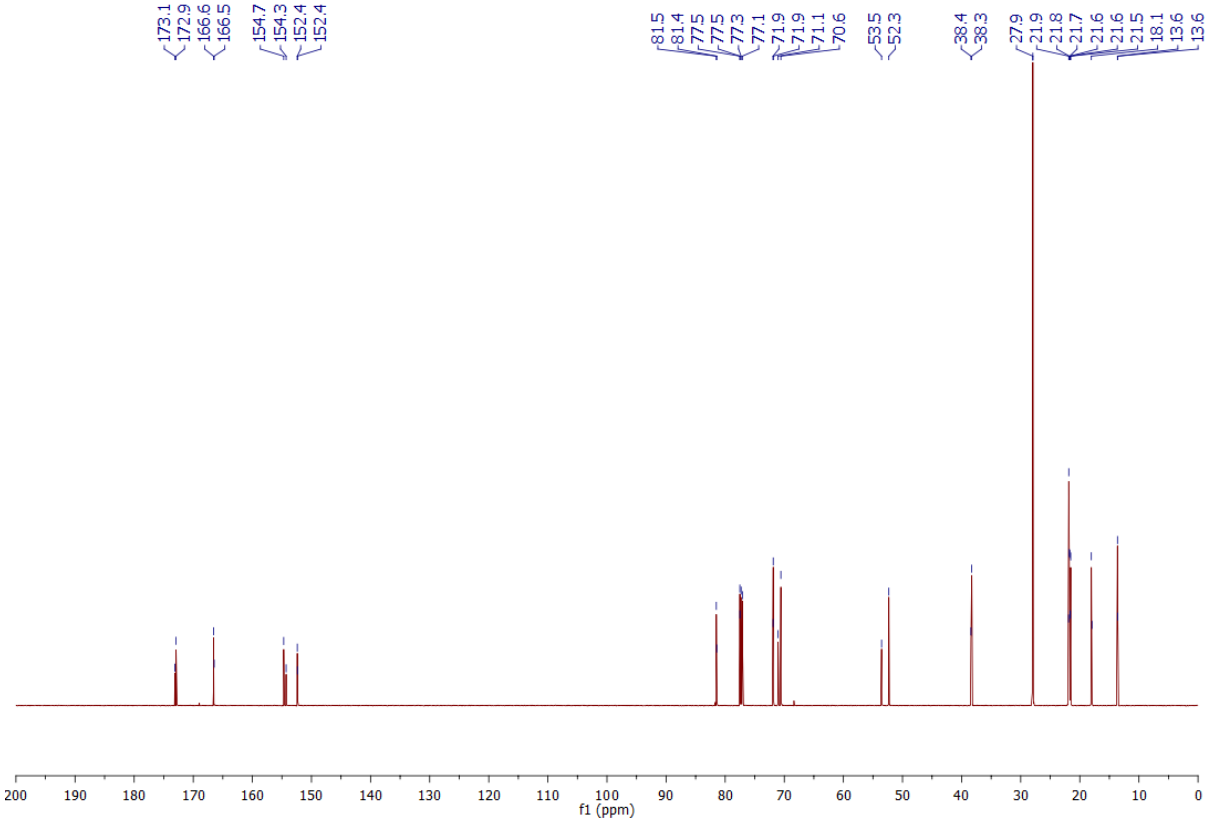
To a stirring solution of cesium carbonate (652 mg, 2.00 mmol, 2 eq.) in anhydrous THF (0.5 mL) was added dropwise a solution of diisopropyl 1-butyrylhydrazine-1,2-dicarboxylate **1p** (274 mg, 1.00 mmol) in anhydrous THF (1.5 mL) under an atmosphere of argon and the reaction mixture stirred for 5 minutes. After this time, to the reaction mixture was added dropwise *tert*-butyl bromoacetate **2b** (162 μL, 1.10 mmol, 1.1 eq.) pre-dissolved in anhydrous THF (0.5 mL). The reaction was stirred at 25 °C for 16 h and poured over stirring saturated, aqueous NH_4Cl (10 mL). The resulting solution was extracted with EtOAc (3 × 15 mL). The combined extracts were dried ($MgSO_4$), filtered and the solvent was evaporated *in vacuo*.

Diisopropyl 1-(2-(*tert*-butoxy)-2-oxoethyl)-2-butyrylhydrazine-1,2-dicarboxylate



Purification by column chromatography (10%-50% EtOAc/Petrol) afforded diisopropyl 1-(2-(*tert*-butoxy)-2-oxoethyl)-2-butyrylhydrazine-1,2-dicarboxylate as a colourless oil (357 mg, 0.920 mmol, 92%). ^{1}H NMR (600 MHz, $CDCl_3$) δ 4.94-4.87 (m, 1H), 4.85-4.77 (m, 1H), 4.08-3.82 (m, 2H), 2.84-2.76 (m, 1H), 2.67-2.57 (m, 1H), 1.61-1.49 (m, 2H), 1.35-1.31 (m, 9H), 1.21-1.04 (m, 12H), 0.86-0.81 (m, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 173.1 (C), 172.9 (C), 166.6 (C), 166.5 (C), 154.7 (C), 154.3 (C), 152.4 (C), 152.4 (C), 81.5 (C), 81.4 (C), 71.9 (CH), 71.9 (CH), 71.1 (CH), 70.6 (CH), 53.5 (CH_2), 52.3 (CH_2), 38.4 (CH_2), 38.3 (CH_2), 27.9 (CH_3), 21.9 (CH_3), 21.9 (CH_3), 21.8 (CH_3), 21.7 (CH_3), 21.6 (CH_3), 21.6 (CH_3), 21.5 (CH_3), 18.1 (CH_2), 17.9 (CH_2), 13.6 (CH_3) 13.6 (CH_3); IR (solid) 3023, 2981, 2937, 1790, 1725 cm^{-1}.


7.26 4.92 4.91 4.90 4.89 4.82 4.82 4.81 4.81 4.80 4.08 4.05 3.97 3.94 3.89 3.87 3.86 3.83 2.82 2.81 2.80 2.79 2.78 2.77 2.64 2.62 2.62 2.61 2.60 1.57 1.56 1.55 1.54 1.53 1.35 1.34 1.32 1.20 1.20 1.19 1.19 1.18 1.18 1.17 1.16 1.15 1.15 1.14 1.08 1.07 1.06 1.05 0.85 0.84 0.84 0.83 0.82 0.82
1.0 1.0 2.0 1.0 1.0 2.0 9.0 12.0 3.0
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
f1 (ppm)


173.1 172.9 166.6 166.5 154.7 154.3 152.4 152.4
81.5 81.4 77.5 77.5 77.3 77.1 71.9 71.9 71.1 70.6 53.5 52.3 38.4 38.3 27.9 21.9 21.8 21.7 21.6 21.6 21.5 18.1 13.6 13.6
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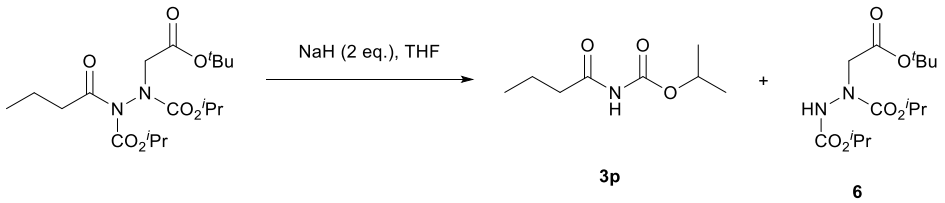
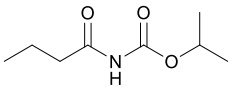
f1 (ppm)

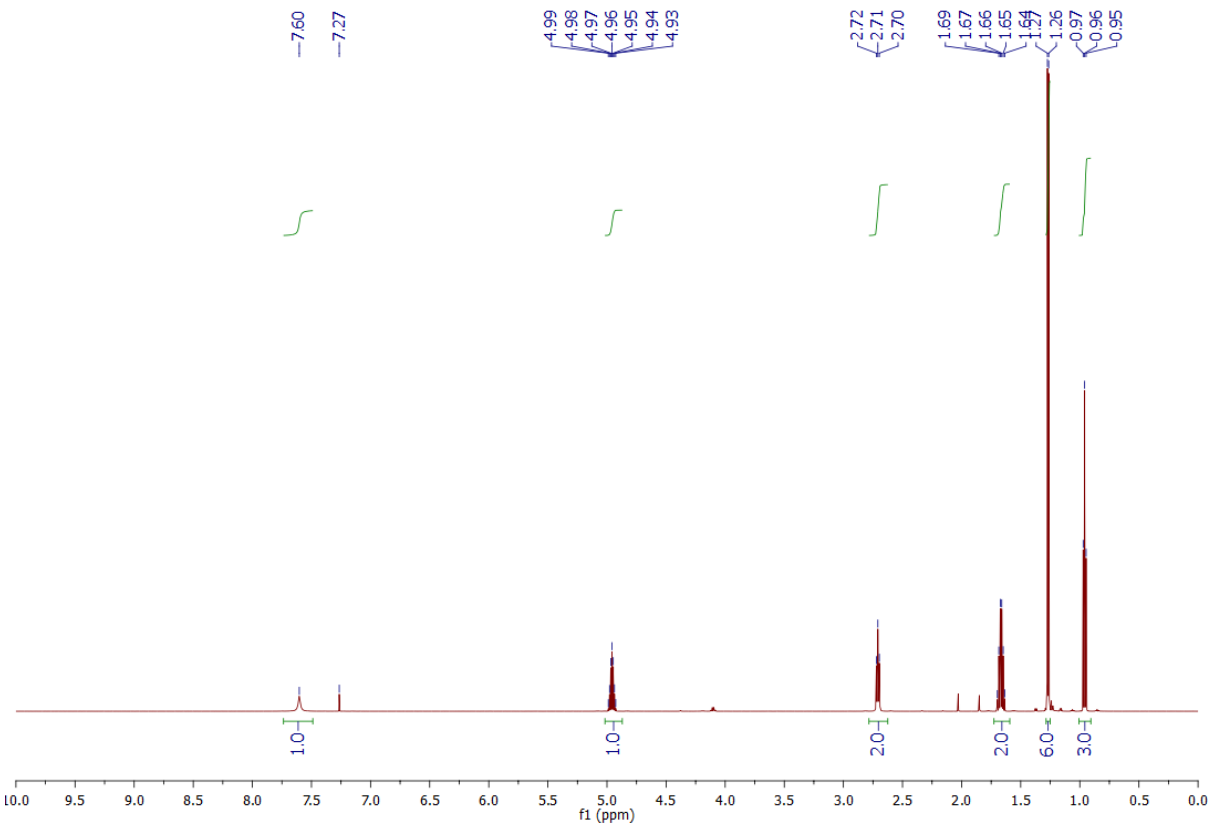


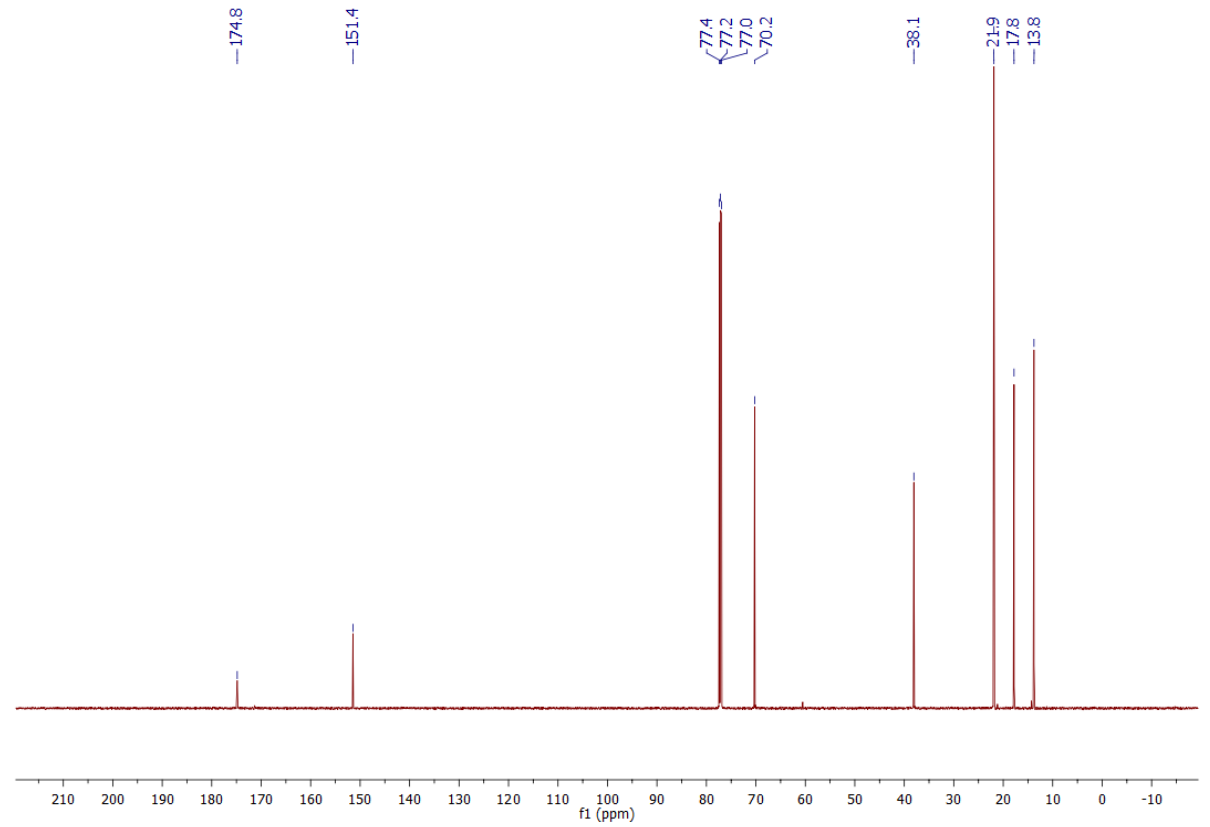
To a stirring solution of sodium hydride (60% mineral oil dispersion, 73.6 mg, 1.84 mmol, 2 eq.) in anhydrous THF (0.5 mL) was added dropwise a solution of diisopropyl 1-(2-(*tert*-butoxy)-2-oxoethyl)-2-butyrylhydrazine-1,2-dicarboxylate (357 mg, 0.920 mmol, 1 eq.) pre-dissolved in anhydrous THF (1.5 mL) under an atmosphere of argon. The reaction was stirred at 25 °C for 16 h and poured over stirring saturated, aqueous NH_4Cl (10 mL). The resulting solution was extracted with EtOAc (3 × 15 mL). The combined extracts were dried ($MgSO_4$), filtered and the solvent was evaporated *in vacuo*. Purification by column chromatography (10%-50% EtOAc/Petrol) afforded isopropyl butyrylcarbamate **3p** as a white solid (90.0 mg, 0.520 mmol, 56%) and diisopropyl 1-(2-(*tert*-butoxy)-2-oxoethyl)hydrazine-1,2-dicarboxylate **6** as a white solid (118 mg, 0.370 mmol, 40%).

Isopropyl butyrylcarbamate 3p

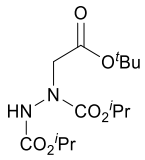


m.p. 65-67 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.60 (br s, NH, 1H), 4.96 (septet, *J* = 6.3 Hz, 1H), 2.71 (t, *J* = 7.4 Hz, 2H), 1.67 (sextet, *J* = 7.4 Hz. 2H), 1.27 (d, *J* = 6.3 Hz, 6H), 0.96 (t, *J* = 7.4 Hz, 2H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 174.8 (C), 151.4 (C), 70.2 (CH), 38.1 (CH_2), 21.9 (CH_3), 17.8 (CH_2), (CH_3); IR (thin film) 3275, 2966, 2936, 2876, 1756, 1697 cm^{-1}; LRMS (ESI) 196 (100, $[M+Na]^+$), 174 (90, $[M+H]^+$); HRMS (ESI) calcd for $C_8H_{16}NO_3$ $[M+H]^+$ 174.1130; observed 174.1134.

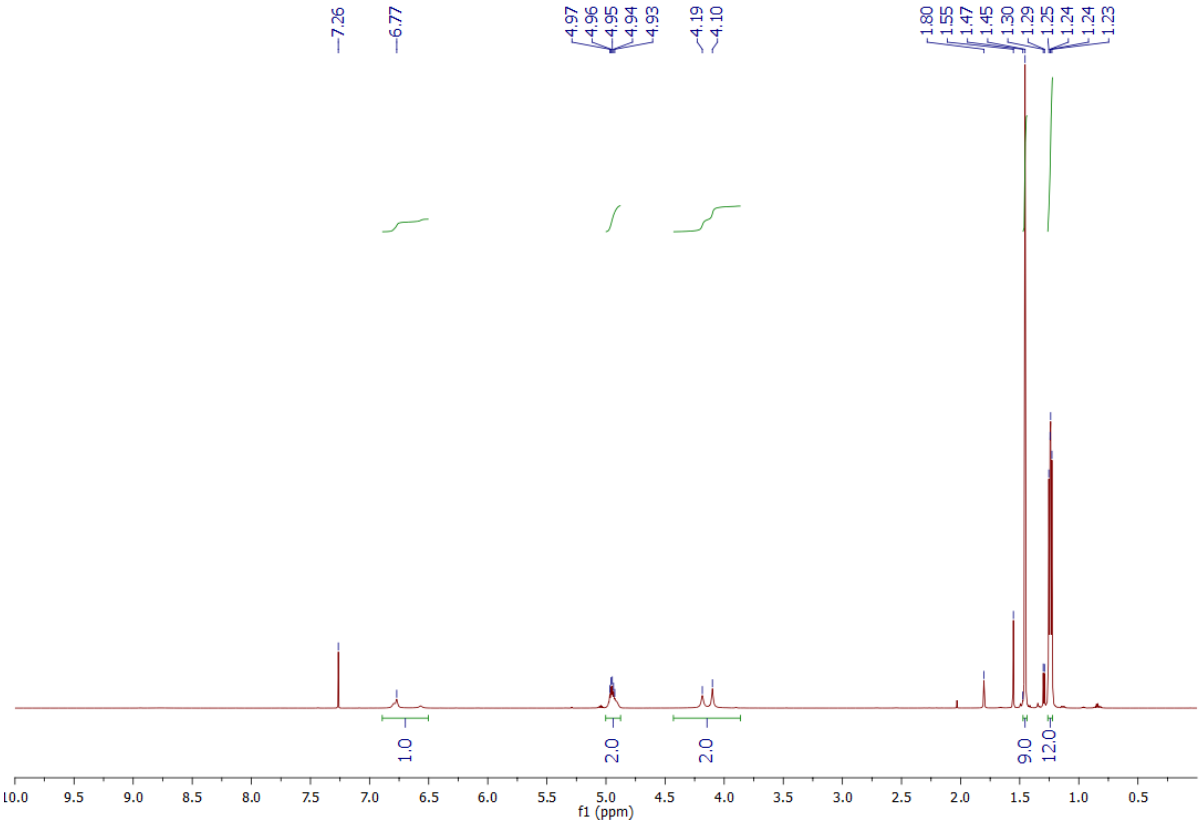

7.60
7.27
4.99
4.98
4.97
4.96
4.95
4.94
4.93
2.72
2.71
2.70
1.69
1.67
1.66
1.65
1.64
1.27
1.26
0.97
0.96
0.95
1.0
1.0
2.0
2.0
6.0
3.0
f1 (ppm)

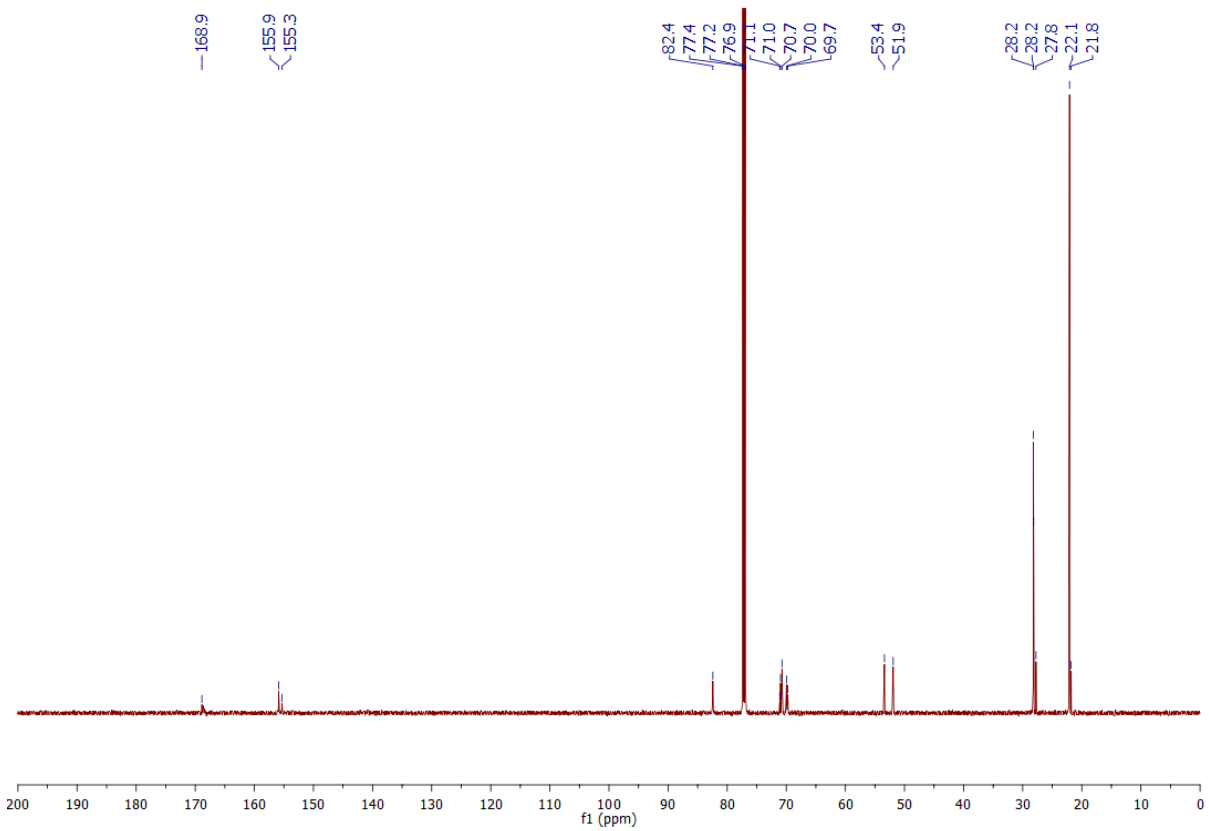

174.8
151.4
77.4
77.2
77.0
70.2
38.1
21.9
17.8
13.8
f1 (ppm)

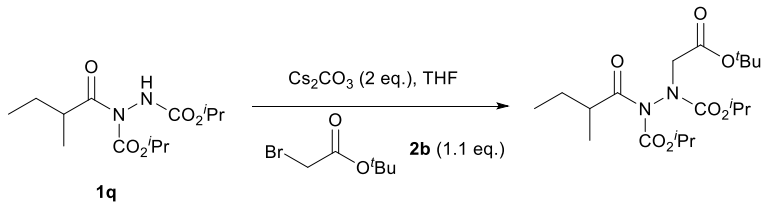
Diisopropyl 1-(2-(*tert*-butoxy)-2-oxoethyl)hydrazine-1,2-dicarboxylate 6



m.p. 100-105 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 6.85-6.50 (m, NH, 1H), 5.00-4.87 (m, 2H), 4.22-4.06 (m, 2H), 1.45 (s, 9H), 1.26-1.22 (m, 12H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 168.9 (C), 155.9 (C), 155.3 (C), 82.4 (C), 71.1 (CH), 71.0 (CH), 70.7 (CH), 70.0 (CH), 69.7 (CH), 53.4 (CH_2), 51.9 (CH_2), 28.2 (CH_3), 28.2 (CH_3), 27.8 (CH_3), 22.1 (CH_3), 21.8 (CH_3); IR (solid) 3321, 2981, 2937, 1726 cm^{-1}.

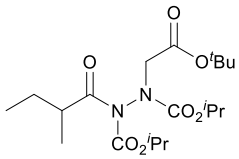



168.9
155.9
155.3
82.4
77.4
77.2
76.9
71.1
71.0
70.7
70.0
69.7
53.4
51.9
28.2
28.2
27.8
22.1
21.8
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

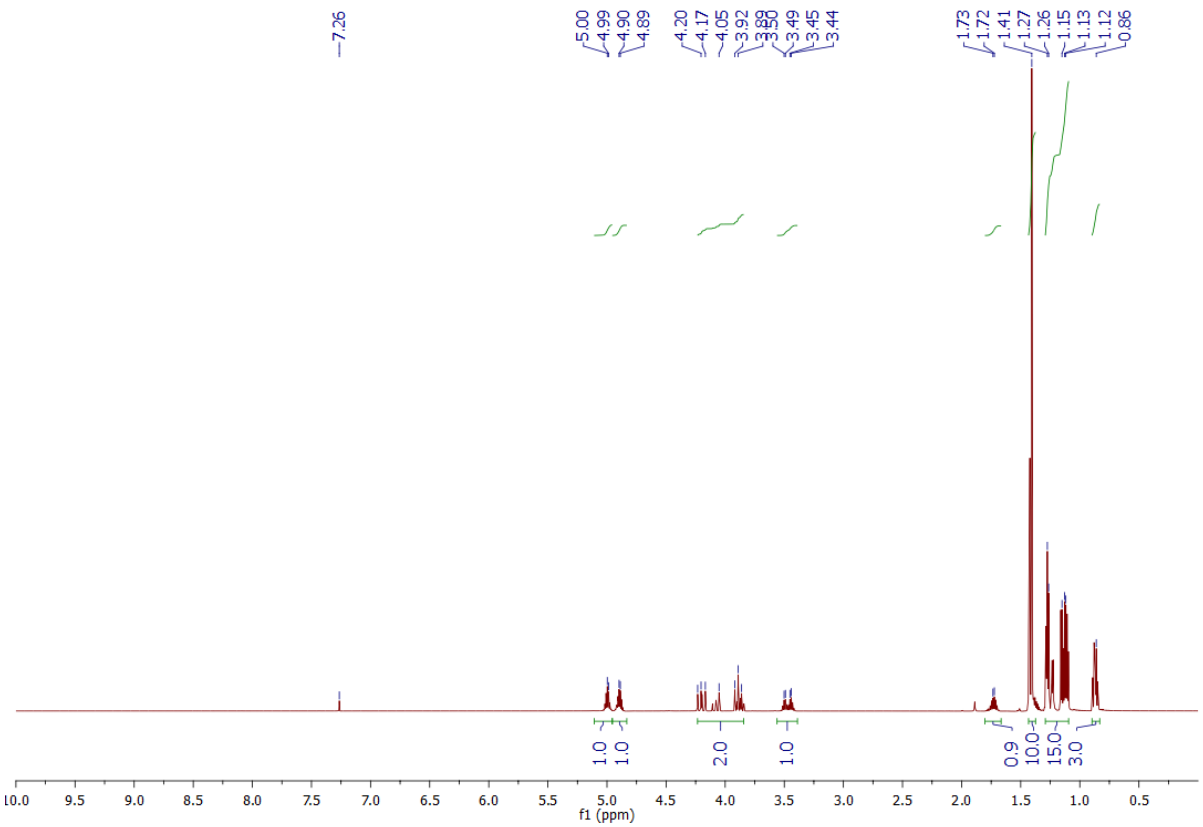


To a stirring solution of cesium carbonate (652 mg, 2.00 mmol, 2 eq.) in anhydrous THF (0.5 mL) was added dropwise a solution of diisopropyl 1-(2-methylbutanoyl)hydrazine-1,2-dicarboxylate **1q** (288 mg, 1.00 mmol) in anhydrous THF (1.5 mL) under an atmosphere of argon and the reaction mixture stirred for 5 minutes. After this time, to the reaction mixture was added dropwise *tert*-butyl bromoacetate (162 μL, 1.10 mmol, 1.1 eq.) pre-dissolved in anhydrous THF (0.5 mL). The reaction was stirred at 25 °C for 16 h and poured over stirring saturated, aqueous NH_4Cl (10 mL). The resulting solution was extracted with EtOAc (3 × 15 mL). The combined extracts were dried ($MgSO_4$), filtered and the solvent was evaporated *in vacuo*.

Diisopropyl 1-(2-(tert-butoxy)-2-oxoethyl)-2-(2-methylbutanoyl)hydrazine-1,2-dicarboxylate



Purification by column chromatography (10%-50% EtOAc/Petrol) afforded diisopropyl 1-(2-(*tert*-butoxy)-2-oxoethyl)-2-(2-methylbutanoyl)hydrazine-1,2-dicarboxylate as a colourless oil (322 mg, 0.800 mmol, 80%). ^{1}H NMR (600 MHz, $CDCl_3$) δ 5.03-4.96 (m, 1H), 4.93-4.85 (m, 1H), 4.24-3.84 (m, 2H), 3.53-3.41 (m, 1H), 1.80-1.68 (m, 1H), 1.44-1.34 (m, 10H), 1.29-1.09 (m, 15H), 0.90-0.84 (m, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.3 (C), 177.2 (C), 176.9 (C), 176.8 (C), 166.7 (C), 166.6 (C), 166.6 (C), 154.9 (C), 154.4 (C), 154.4 (C), 152.7 (C), 152.6 (C), 152.6 (C), 81.9 (C), 81.6 (C), 81.6 (C), 81.5 (C), 72.1 (CH), 72.0 (CH), 71.1 (CH), 70.7 (CH), 70.7 (CH), 68.5 (CH), 53.6 (CH_2), 53.6 (CH_2), 52.4 (CH_2), 52.4 (CH_2), 40.7 (CH), 40.6 (CH), 40.4 (CH), 40.3 (CH), 28.1 (CH_3), 28.1 (CH_3), 27.1 (CH_2), 27.0 (CH_2), 27.0 (CH_2), 26.9 (CH_2), 22.0 (CH_3), 22.0 (CH_3), 21.9 (CH_3), 21.9 (CH_3), 21.8 (CH_3), 21.8 (CH_3), 21.7 (CH_3), 21.7 (CH_3), 21.7 (CH_3), 21.6 (CH_3), 17.0 (CH_3), 16.9 (CH_3), 16.8 (CH_3), 11.8 (CH_3), 11.7 (CH_3), 11.7 (CH_3), 11.6 (CH_3); IR (thin film) 3021, 2982, 2937, 1784, 1722 cm^{-1}.


7.26
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4.99
4.90
4.89
4.20
4.17
4.05
3.92
3.49
3.45
3.44
1.73
1.72
1.41
1.27
1.26
1.15
1.13
1.12
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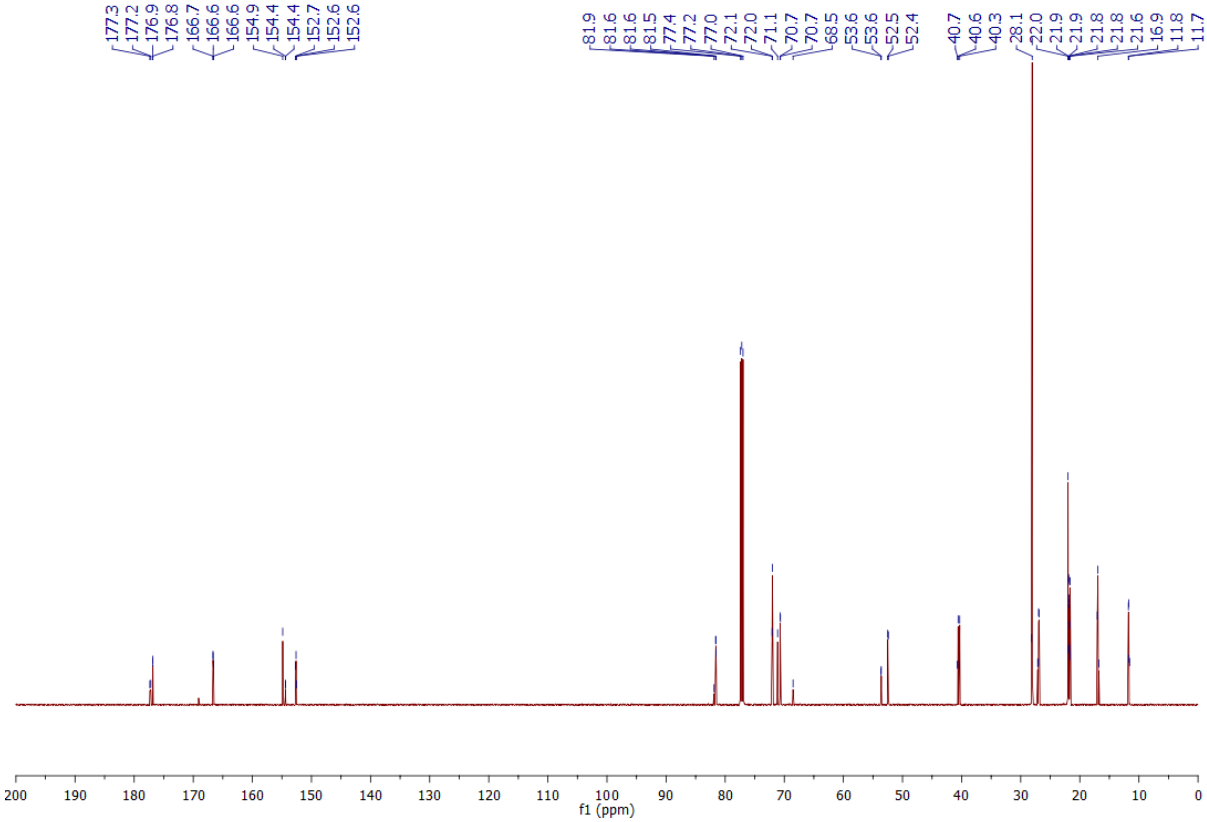
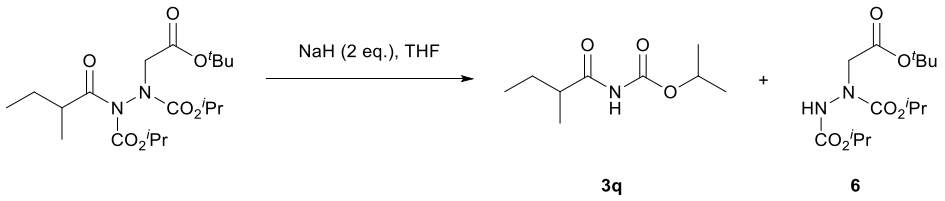
1.0
1.0
2.0
1.0
0.9
10.0
15.0
3.0
f1 (ppm)

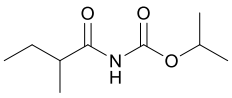

177.3
177.2
176.9
176.8
166.7
166.6
166.6
154.9
154.4
154.4
152.7
152.6
152.6
81.9
81.6
81.6
81.5
77.4
77.2
77.0
72.1
72.0
71.1
70.7
70.7
68.5
53.6
53.6
52.5
52.4
40.7
40.6
40.3
28.1
22.0
21.9
21.9
21.8
21.8
21.6
16.9
11.8
11.7
f1 (ppm)



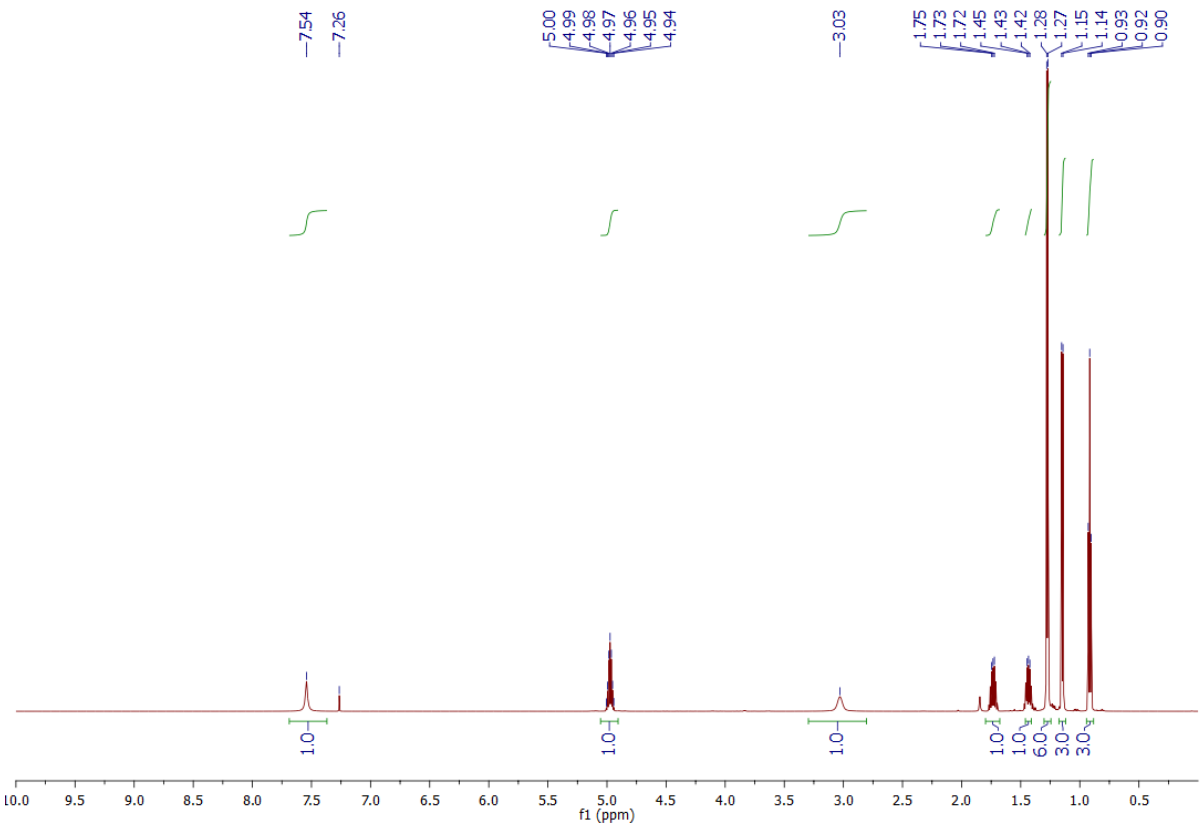
To a stirring solution of sodium hydride (60% mineral oil dispersion, 64.0 mg, 1.60 mmol, 2 eq.) in anhydrous THF (0.5 mL) was added dropwise a solution of diisopropyl 1-(2-(*tert*-butoxy)-2-oxoethyl)-2-(2-methylbutanoyl)hydrazine-1,2-dicarboxylate (322 mg, 0.800 mmol, 1 eq.) pre-dissolved in anhydrous THF (1.5 mL) under an atmosphere of argon. The reaction was stirred at 25 °C for 16 h and poured over stirring saturated, aqueous NH_4Cl (10 mL). The resulting solution was extracted with EtOAc (3 × 15 mL). The combined extracts were dried ($MgSO_4$), filtered and the solvent was evaporated *in vacuo*. Purification by column chromatography (10%-50% EtOAc/Petrol) afforded isopropyl (2-methylbutanoyl)carbamate as a white solid **3q** (101 mg, 0.540 mmol, 67%) and diisopropyl 1-(2-(*tert*-butoxy)-2-oxoethyl)hydrazine-1,2-dicarboxylate **6** as a white solid (51.0 mg, 0.160 mmol, 20%).

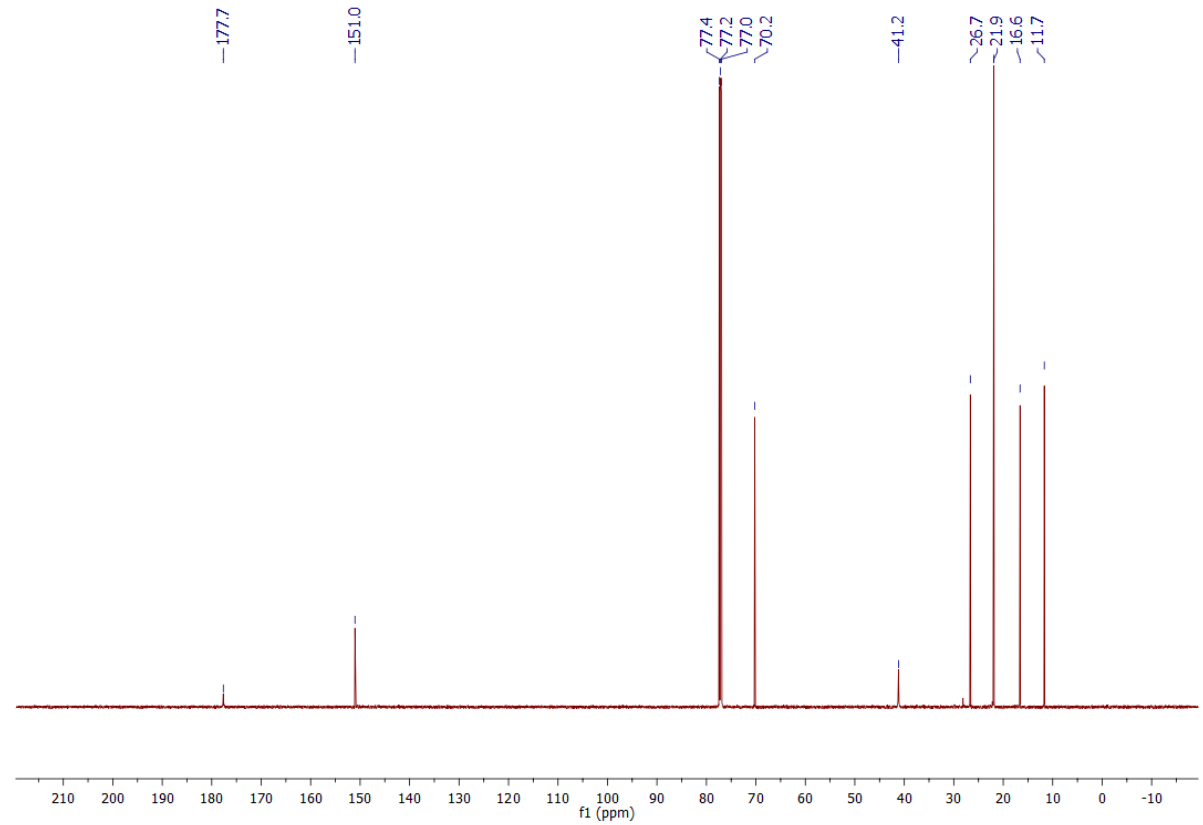
Data for diisopropyl 1-(2-(*tert*-butoxy)-2-oxoethyl)hydrazine-1,2-dicarboxylate **6** matched that given above.

Isopropyl (2-methylbutanoyl)carbamate 3q



m.p. 73-77 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.54 (br s, NH, 1H), 4.97 (septet, *J* = 6.3 Hz, 1H), 3.03 (m, 1H), 1.73 (septet, *J* = 6.9 Hz, 1H), 1.43 (septet, *J* = 6.9 Hz, 1H), 1.27 (d, *J* = 6.3 Hz, 6H), 1.15 (d, *J* = 6.9 Hz, 3H), 0.92 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.7 (C), 151.0 (C), 70.2 (CH), 41.2 (CH), 26.7 (CH_2), 21.9 (CH_3), 16.6 (CH_3), 11.7 (CH_3); IR (solid) 3271, 3198, 2973, 2936, 2877, 1772, 1752, 1525 cm^{-1}.


7.54
7.26
5.00
4.99
4.98
4.97
4.96
4.95
4.94
3.03
1.75
1.73
1.72
1.45
1.43
1.42
1.28
1.27
1.15
1.14
0.93
0.92
0.90
1.0
1.0
1.0
1.0
1.0
6.0
3.0
3.0
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
f1 (ppm)


177.7
151.0
77.4
77.2
77.0
70.2
41.2
26.7
21.9
16.6
11.7
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

References

1 A. Maruani, M. T. W. Lee, G. Watkins, A. R. Akhbar, H. Baggs, A. Shamsabadi, D. A. Richards and V. Chudasama, *RSC Adv.*, 2016, **6**, 3372–3376.

2 A. R. Akhbar, V. Chudasama, R. J. Fitzmaurice, L. Powell and S. Caddick, *Chem. Commun.*, 2014, **50**, 743–746.

3 S. M. Inamdar, V. K. More and S. K. Mandal, *Chem. Lett.*, 2012, **41**, 1484–1486.

4 Y. Qin, Q. Peng, J. Song and D. Zhou, *Tetrahedron Lett.*, 2011, **52**, 5880–5883.

5 O. Sugimoto, T. Arakaki, H. Kamio and K. Tanji, *Chem. Commun.*, 2014, **50**, 7314.

6 A. Mariappan, K. Rajaguru, S. Muthusubramanian and N. Bhuvanesh, *Tetrahedron Lett.*, 2015, **56**, 338–341.

7 V. Chudasama, J. M. Ahern, D. V Dhokia, R. J. Fitzmaurice and S. Caddick, *Chem. Commun.*, 2011, **47**, 3269–3271.

8 G. N. Papadopoulos and C. G. Kokotos, *Chem. - A Eur. J.*, 2016, **22**, 6964–6967.