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Supporting Information

Lewis- and Brønsted-Acid Cooperative Catalytic Radical Coupling of Aldehydes and Azodicarboxylate

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1. General Information

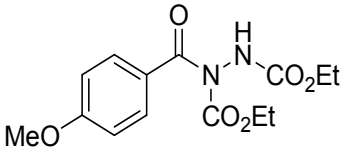
Chemicals and solvents were either purchased from commercial suppliers or purified by standard procedures as specified in *Purification of Laboratory Chemicals*, 4th Ed (Armarego, W. L. F.; Perrin, D. D. Butterworth Heinemann: 1997). All reactions were carried out in carousel tubes (15 cm × 2 cm) equipped with an octagon-shaped magnetic stirrer bar (12.7 mm × 3 mm). All reactions were monitored by thin-layer chromatography (TLC) on pre-coated silica gel plates (254 μm). Flash column chromatography was carried out with (200–300 mesh) silica gel. ^{1}H NMR spectra were recorded at 400 MHz and ^{13}C NMR at 100 MHz on Bruker AM-400 spectrometers at ambient temperature in $CDCl_3$. HRMS were performed on Bruker maXis 4G mass instrument (ESI) or Thermo ORBITRAP ELITE (ESI). IR spectra were recorded using Nicolet NEXUS 670 FT-IR instrument.

2. General Procedure for the functionalization of aldehyde with DEAD

Azodicarboxylate (0.2 mmol), $CoCO_3$ (2.4 mg, 0.02 mmol) and CH_2Cl_2 (0.2 mL) were added to a test tube, the aldehyde (0.24 mmol) was then added to the mixture. After that, 8 μL solution of TFA (50 μL) and CH_2Cl_2 (0.5 mL) mixture was added to the reaction mixture. The reaction mixture was stirred at 300 rpm at 21 °C in a stoppered carousel tube for the time specified below. The solvent was removed *in vacuo* and the product was purified as specified below.

3. Analytical Data

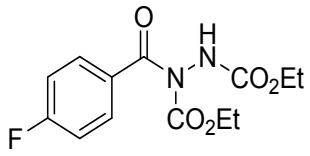
Diethyl-2-yl 1-(4-methoxybenzoyl)hydrazine-1,2-dicarboxylate 2a



The reaction was stirred for 12 h. Purification by column chromatography (20% EtOAc/Petrol) gave diethyl-2-yl 1-(4-methoxybenzoyl)hydrazine-1,2-dicarboxylate as a colorless oil (57.0 mg, 0.18 mmol, 92%); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.73-7.71 (m, 2H), 7.33 (br s, 1H), 6.89 (d, J = 8.8 Hz, 2H), 4.25 (q, J = 7.0 Hz, 2H), 4.17 (q, J = 7.0 Hz, 2H), 3.85 (s, 3H), 1.31-1.27 (t, J = 7.2 Hz ,3H), 1.14-1.11

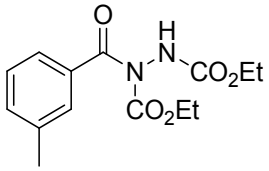
(t, J = 7.2 Hz ,3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 170.3, 163.0, 155.6, 153.4, 131.1, 126.4, 113.5, 63.7, 62.4, 55.3, 14.2, 13.8; IR (thin film) 3312, 2984, 2938, 1743, 1704, 1606, 1578 cm^{-1}; HRMS (FTMS) calculated for $C_{14}H_{18}N_2O_6$ $[M+H]^+$ 311.1238, found 311.1231.

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



The reaction was stirred for 12 h. Purification by column chromatography (20% EtOAc/Petrol) gave diethyl 1-(4-fluorobenzoyl)hydrazine-1,2-dicarboxylate as a colorless oil (56.0 mg, 0.18 mmol, 94%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.73 (m, 2H), 7.37 (br s, 1H), 7.12-7.08 (m, 2H), 4.25 (q, J = 7.0 Hz, 2H), 4.17 (q, J = 7.0 Hz, 2H), 1.31-1.27 (t, J = 7.2 Hz ,3H), 1.14-1.11 (t, J = 7.2 Hz ,3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 169.9, 166.2, 163.7, 155.6 (d, $J_{C\text{-}F}$ = 230 Hz,), 132.0 (d, $J_{C\text{-}F}$ = 8 Hz,), 130.9 (d, $J_{C\text{-}F}$ = 9 Hz,), 115.4 (d, $J_{C\text{-}F}$ = 22 Hz,), 64.0, 62.6, 14.2, 13.7; IR (thin film) 3315, 2985, 2938, 1746, 1714, 1603, 1508 cm^{-1}; HRMS (FTMS) calculated for $C_{13}H_{15}N_2O_5F$ $[M+Na]^+$ 321.0857, found 321.0853.

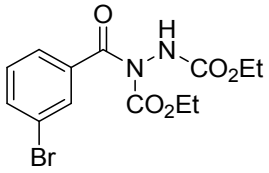
Diethyl 1-(3-methylbenzoyl)hydrazine-1,2-dicarboxylate 2c



The reaction was stirred for 12 h. Purification by column chromatography (20% EtOAc/petrol) gave diethyl 1-(3-methylbenzoyl)hydrazine-1,2-dicarboxylate as a colorless oil (54.1 mg, 0.18 mmol, 92%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49 (m, 2H), 7.33-7.27 (m, 3H), 4.29 (q, J = 7.0 Hz, 2H), 4.21 (q, J = 7.0 Hz, 2H), 2.37 (s, 3H), 1.31-1.27 (t, J = 7.2 Hz ,3H), 1.08-1.05 (t, J = 7.2 Hz

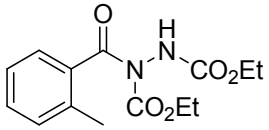
,3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.1, 155.6, 153.4, 137.9, 134.7, 132.7, 128.5, 127.9, 125.2, 63.7, 62.5, 21.1, 14.2, 13.6; IR (thin film) 3312, 2984, 2937, 1745, 1711 cm^{-1}; HRMS (FTMS) calculated for $C_{14}H_{18}N_2O_5$ $[M+H]^+$ 295.1288, found 295.1284.

Diethyl 1-(3-bromobenzoyl)hydrazine-1,2-dicarboxylate 2d



The reaction was stirred for 12 h. Purification by column chromatography (20% EtOAc/petrol) gave diethyl 1-(3-bromobenzoyl)hydrazine-1,2-dicarboxylate as a colorless oil (66.8 mg, 0.18 mmol, 93%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.80 (s, 1H), 7.65-7.60 (m, 2H), 7.31-7.27 (m, 2H), 4.29 (q, *J* = 7.0 Hz, 2H), 4.21 (q, *J* = 7.0 Hz, 2H), 1.31-1.27 (t, *J* = 7.2 Hz ,3H), 1.08-1.05 (t, *J* = 7.2 Hz ,3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 169.5, 155.6, 153.0, 136.6, 134.7, 130.8, 129.6, 126.5, 122.0, 64.1, 62.5, 14.3, 13.7; IR (thin film) 3313, 2984, 2938, 1747, 1714 cm^{-1}; HRMS (FTMS) calculated for $C_{13}H_{15}N_2O_5Br$ $[M+H]^+$ 359.0237, found 359.0236.

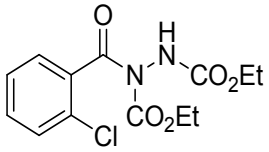
Diethyl 1-(2-methylbenzoyl)hydrazine-1,2-dicarboxylate 2e



The reaction was stirred for 12 h. Purification by column chromatography (20% EtOAc/Petrol) gave diethyl 1-(2-methylbenzoyl)hydrazine-1,2-dicarboxylate as a colorless oil (47 mg, 0.16 mmol, 80%); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37-7.31 (m, 2H), 7.26-7.18 (m, 2H), 7.06 (br s, 1H), 4.25 (q, *J* = 7.0 Hz, 2H), 4.10 (q, *J* = 7.0 Hz, 2H), 2.40 (s, 3H), 1.33-1.29 (t, *J* = 7.2 Hz ,3H), 1.04-1.01 (t, *J* = 7.2 Hz ,3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.0, 155.5, 152.8, 135.7, 135.3, 130.3, 130.1, 126.3, 125.3, 64.0, 62.7, 19.1, 14.3, 13.6; IR (thin film) 3310, 2985, 2936, 1744, 1711, cm^{-1}; HRMS (FTMS) calculated for $C_{14}H_{18}N_2O_5$ $[M+H]^+$ 295.1288,

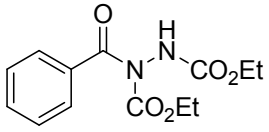
found 295.1281.

Diethyl 1-(2-chlorobenzoyl)hydrazine-1,2-dicarboxylate 2f



The reaction was stirred for 12 h. Purification by column chromatography (20% EtOAc/Petrol) gave diethyl 1-(2-chlorobenzoyl)hydrazine-1,2-dicarboxylate as a colorless oil (48.5 mg, 0.15 mmol, 77%); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.45-7.26 (m, 4H), 6.96 (br s, 1H), 4.25 (q, *J* = 7.0 Hz, 2H), 4.10 (q, *J* = 7.0 Hz, 2H), 1.33-1.29 (t, *J* = 7.2 Hz ,3H), 1.04-1.01 (t, *J* = 7.2 Hz ,3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.4, 155.2, 152.2, 135.7, 131.0, 130.2, 129.3, 127.9, 126.7, 64.2, 62.8, 14.3, 13.7; IR (thin film) 3308, 2984, 2930, 1743, 1717 cm^{-1}; HRMS (FTMS) calculated for $C_{13}H_{15}N_2O_6Cl$ $[M+H]^+$ 315.0742, found 315.0734.

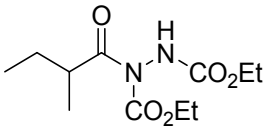
Diethyl-2-yl 1-benzoylhydrazine-1,2-dicarboxylate 2g



The reaction was stirred for 12 h. Purification by column chromatography (20% EtOAc/Petrol) gave diethyl-2-yl 1-benzoylhydrazine-1,2-dicarboxylate as a colorless oil (52.6 mg, 0.18 mmol, 94%); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.69-7.68 (m, 2H), 7.53-7.39 (m 3H), 7.24 (br s, 1H), 4.29 (q, *J* = 7.0 Hz, 2H), 4.21 (q, *J* = 7.0 Hz, 2H), 1.31-1.27 (t, *J* = 7.2 Hz ,3H), 1.08-1.05 (t, *J* = 7.2 Hz ,3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 170.1, 155.6, 153.4, 134.8, 131.9, 130.1, 128.4, 128.1, 128.0, 63.9, 62.5, 14.3, 14.1; IR (thin film) 3310, 2985, 1743, 1712, 1601, 1508 cm^{-1}; HRMS (FTMS) calculated for $C_{13}H_{16}N_2O_5$ $[M+H]^+$ 281.1132, found

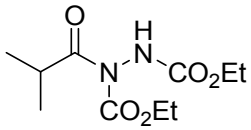
281.1130.

Diethyl-2-yl 1-2-methylbutanoyl hydrazine-1,2-dicarboxylate 2h



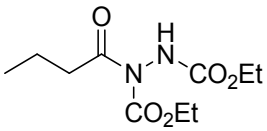
The reaction was stirred for 12 h. Purification by column chromatography (20% EtOAc/Petrol) gave diethyl-2-yl 1-2-methylbutanoyl hydrazine-1,2-dicarboxylate as a colorless oil (50 mg, 0.19 mmol, 96%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.92 (br s, 1H), 4.31 (q, J = 7.2 Hz, 2H), 4.21 (q, J = 7.2 Hz, 2H), 3.52-3.50 (m, 1H), 1.80 (doublet of quintets, J = 14.5, 7.2 Hz, 1H), 1.46 (doublet of quintets, J = 14.5, 7.0 Hz, 1H), 1.35-1.28 (m, 6H), 1.19 (t, J = 7.0 Hz, 3H), 0.93 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 177.7, 155.6, 153.1, 63.8, 62.4, 40.8, 26.9, 16.7, 14.3, 14.1, 11.5; IR (thin film) 3315, 2978, 2938, 1786, 1746 cm^{-1}; HRMS (FTMS) calculated for $C_{11}H_{20}N_2O_5$ $[M+H]^+$ 261.1445, found 261.1444

Diethyl 1-(2-methylpropanoyl)hydrazine-1,2-dicarboxylate 2i



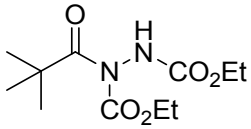
The reaction was stirred for 12 h. Purification by column chromatography (20% EtOAc/petrol) gave diethyl 1-(2-methylpropanoyl)hydrazine-1,2-dicarboxylate as a colorless oil (46.7 mg, 0.19 mmol, 95%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.90 (br s, 1H), 4.29 (q, *J* = 7.0 Hz, 2H), 4.21 (q, *J* = 7.0 Hz, 2H), 3.65 (m, *J* = 6.8 Hz, 1H), 1.35-1.28 (m, 6H), 1.20 (d, *J* = 6.8 Hz, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 178.2, 155.6, 153.0, 63.8, 62.4, 34.2, 19.1, 18.8, 14.3, 14.0; IR (thin film) 3316, 2983, 2938, 1787, 1746 cm^{-1}; HRMS (FTMS) calculated for $C_{10}H_{18}N_2O_5$ $[M+H]^+$ 247.1288, found 247.1288.

Diethyl 1-butanoylhydrazine-1,2-dicarboxylate 2j



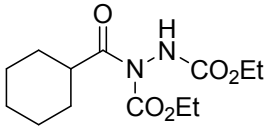
The reaction was stirred for 12 h. Purification by column chromatography (20% EtOAc/petrol) gave diethyl 1-butanoylhydrazine-1,2-dicarboxylate as a colorless oil (47.2 mg, 0.19 mmol, 96%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.03 (br s, 1H), 4.28 (q, *J* = 7.0 Hz, 2H), 4.21 (q, *J* = 7.0 Hz, 2H), 2.90-2.80 (m, 2H), 1.68 (sextet, *J* = 7.2 Hz, 2H), 1.35-1.20 (m, 6H), 0.97 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 173.7, 155.6, 153.1, 63.7, 62.4, 38.7, 17.9, 14.2, 14.0, 13.5; IR (thin film) 3317, 2970, 2877, 1787, 1748 cm^{-1}; HRMS (FTMS) calculated for $C_{10}H_{18}N_2O_5$ $[M+H]^+$ 247.1288, found 247.1286

Diethyl 1-(2,2-dimethylpropanoyl)hydrazine-1,2-dicarboxylate 2k



The reaction was stirred for 12 h. Purification by column chromatography (20% EtOAc/petrol) gave diethyl 1-(2,2-dimethylpropanoyl)hydrazine-1,2-dicarboxylate as a colorless oil (48.9 mg, 0.18 mmol, 94%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.04 (br s, 1H), 4.32 (q, *J* = 7.0 Hz, 2H), 4.23 (q, *J* = 7.0 Hz, 2H), 1.36-1.32 (m, 15H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 180.0, 156.0, 154.0, 64.0, 62.6, 42.0, 27.3, 27.0, 14.3, 14.0; IR (thin film) 3301, 2982, 2938, 1780, 1740, cm^{-1}; HRMS (FTMS) calculated for $C_{11}H_{20}N_2O_5$ $[M+Na]^+$ 283.1264, found 283.1258.

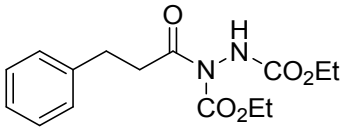
Diethyl 1- cyclohexylhydrazine-1,2-dicarboxylate 2l



The reaction was stirred for 12 h. Purification by column chromatography (20% EtOAc/petrol) gave diethyl 1- cyclohexylhydrazine-1,2-dicarboxylate as a colorless oil (53.8 mg,0.18 mmol, 94%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.88 (br s,

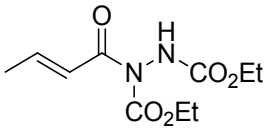
1H), 4.31 (q, *J* = 7.0 Hz, 2H), 4.21 (q, *J* = 7.0 Hz, 2H), 3.38 (t, *J* = 7.2 Hz, 1H), 1.93 (m, 2H), 1.80 (m, 2H), 1.70 (doublet of quintets, 1H), 1.50 (m, 2H), 1.40-1.28 (doublet of quintets, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 177.0, 155.6, 153.1, 63.7, 62.4, 43.9, 29.3, 25.7, 25.5, 14.3, 14.0; IR (thin film) 3316, 2983, 2933, 2856, 1785, 1743 cm^{-1}; HRMS (FTMS) calculated for $C_{13}H_{22}N_2O_5$ $[M+H]^+$ 287.1601, found 287.1597.

Diethyl 1-(3-phenylpropanoyl)hydrazine-1,2-dicarboxylate 2m



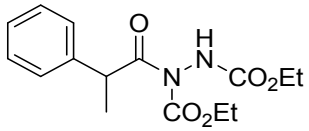
The reaction was stirred for 12 h. Purification by column chromatography (20% EtOAc/petrol) gave diethyl 1-(3-phenylpropanoyl)hydrazine-1,2-dicarboxylate as a colorless oil (59.1 mg, 0.19 mmol, 96%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.81 (d, *J* = 15.6 Hz, 1H), 7.38-7.60 (m, 6H), 6.97 (br s, 1H), 4.33 (q, *J* = 7.0 Hz, 2H), 4.23 (q, *J* = 7.0 Hz, 2H), 1.38-1.30 (m, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.6, 155.5, 153.4, 146.2, 134.6, 132.0, 130.5, 128.8, 128.4, 128.0, 118.6, 64.2, 62.6, 14.3, 14.1; IR (thin film) 3625, 3316, 2983, 1788, 1746, cm^{-1}; HRMS (FTMS) calculated for $C_{15}H_{20}N_2O_5$ $[M+H]^+$ 309.1445, found 309.1440.

(E)-diethyl 1-(but-2-enoyl)hydrazine-1,2-dicarboxylate 2n



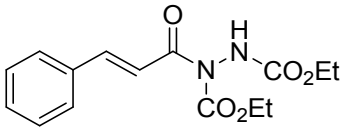
The reaction was stirred for 12 h. Purification by column chromatography (20% EtOAc/petrol) gave (E)-diethyl 1-(but-2-enoyl)hydrazine-1,2-dicarboxylate as a colorless oil (46.4 mg, 0.19 mmol, 95%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.14 (m, 1H), 6.90 (m, 2H), 4.29 (q, *J* = 7.0 Hz, 2H), 4.21 (q, *J* = 7.0 Hz, 2H), 1.94 (d, *J* = 7.2 Hz, 3H), 1.36-1.29 (m, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.6, 155.6, 153.3, 146.6, 123.1, 63.9, 62.5, 18.5, 14.3, 14.1; IR (thin film) 3308, 2984, 2939, 1745 cm^{-1}; HRMS (FTMS) calculated for $C_{10}H_{16}N_2O_5$ $[M+H]^+$ 245.1132, found 245.1133.

Diethyl 1-(2-phenylpropanoyl)hydrazine-1,2-dicarboxylate 2o



The reaction was stirred for 12 h. Purification by column chromatography (20% EtOAc/Petrol) gave diethyl 1-(2-phenylpropanoyl)hydrazine-1,2-dicarboxylate as a colorless oil (31.4 mg, 0.10 mmol, 51%); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.30-7.17 (m, 5H), 6.86 (br s, 1H), 4.29 (q, *J* = 7.0 Hz, 2H), 4.22 (q, *J* = 7.0 Hz, 2H), 3.24-2.97 (m, 4H), 1.33-1.26 (m, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 172.9, 155.5, 153.1, 140.5, 128.4, 128.3, 126.1, 63.9, 62.5, 38.6, 30.5, 14.3, 14.1, IR (thin film) 3308, 2983, 2936, 1744, 1603 cm^{-1}; HRMS (FTMS) calculated for $C_{15}H_{20}N_2O_5$ $[M+Na]^+$ 331.1264, found 331.1256.

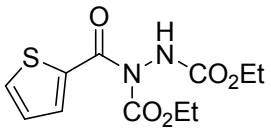
Diethyl 1-cinnamoylhydrazine-1,2-dicarboxylate 2p



The reaction was stirred for 12 h. Purification by column chromatography (20% EtOAc/Petrol) gave diethyl 1-cinnamoylhydrazine-1,2-dicarboxylate as a colorless oil (31.8 mg, 0.10 mmol, 52%); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83-7.79 (d, *J* = 8.5 Hz, 1H), 7.60-7.56 (m, 3H), 7.41-7.38 (m, 3H), 6.97 (br s, 1H), 4.29 (q, *J* = 7.0 Hz, 2H), 4.21 (q, *J* = 7.0 Hz, 2H), 1.38-1.29 (m, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.5, 155.6, 153.4, 146.21, 134.6, 132.0, 130.5, 128.8, 128.4, 128.1,

118.6, 64.0, 62.6, 14.3, 14.1; IR (thin film) 3306, 2984, 2937, 1743, 1621 cm^{-1}; HRMS (FTMS) calculated for $C_{15}H_{18}N_2O_5$ $[M+H]^+$ 307.1288, found 307.1281.

Diethyl 1-(thiophene-2-carbonyl)hydrazine-1,2-dicarboxylate 2q



The reaction was stirred for 12 h. Purification by column chromatography (20% EtOAc/Petrol) gave diethyl 1-(thiophene-2-carbonyl)hydrazine-1,2-dicarboxylate as a colorless oil (44.0 mg, 0.15 mmol, 77%); ^1H NMR (400 MHz, $CDCl_3$) δ 7.88 (d, J = 2.8 Hz, 1H), 7.66 (d, J = 22 Hz, 1H), 7.28-7.11 (m, 1H), 4.30-4.26 (m, 4H) 1.34-1.27 (m, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.9, 135.7, 133.8, 127.2, 64.2, 62.9, 13.9; IR (thin film) 3497, 3301, 2985, 2937, 1768, 1517 cm^{-1}; HRMS (FTMS) calculated for $C_{11}H_{14}N_2O_5S$ $[M+H]^+$ 287.0696, found 287.0689.

4. EPR Experiment and Spectra

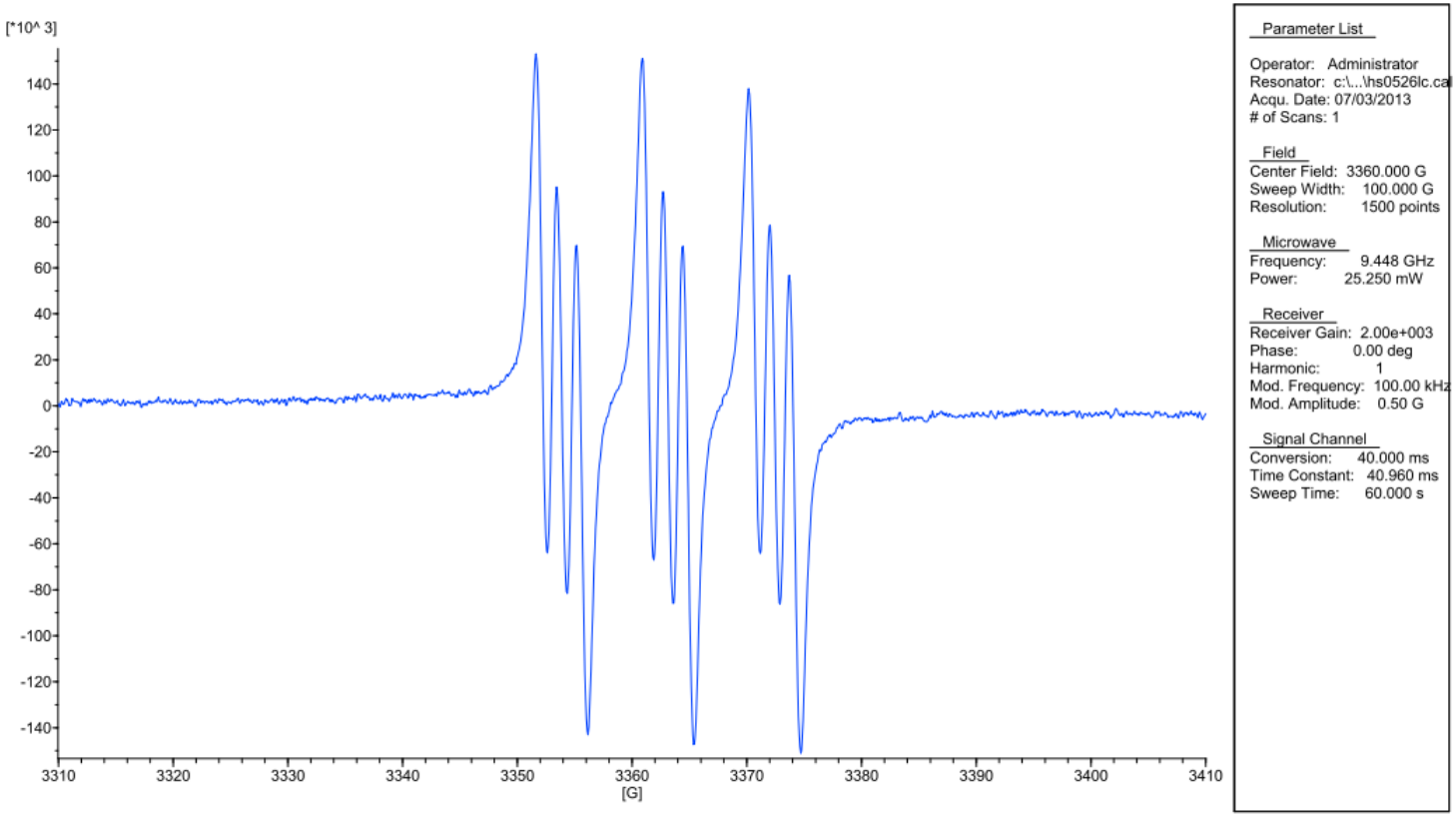
The EPR experiment was performed as following procedure. Diethyl azodicarboxylate (34.8 mg, 0.2 mmol), $CoCO_3$ (2.4 mg, 0.02 mmol) and CH_2Cl_2 (0.2 mL) were added to a test tube, the 2-methylbutanal (26 μL, 0.24 mmol) was then added to the mixture. After that, 8 μL solution of TFA (50 μL) and CH_2Cl_2 (0.5 mL) mixture was added to the reaction mixture. The reaction mixture was stirred at 300 rpm at 21 °C in a stoppered carousel tube. After 5 minutes, extract upper clear liquid to EPR experiment.

EPR Spectra

WinEPR Acquisition

Date: 07/03/2013 Time: 15:59

FileName: C:\Documents and Settings\Administrator\Desktop\zhifangquan.par



Parameter List

Operator: Administrator
Resonator: c:\...\hs0526lc.cal
Acqu. Date: 07/03/2013
# of Scans: 1

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Center Field: 3360.000 G
Sweep Width: 100.000 G
Resolution: 1500 points

Microwave
Frequency: 9.448 GHz
Power: 25.250 mW

Receiver
Receiver Gain: 2.00e+003
Phase: 0.00 deg
Harmonic: 1
Mod. Frequency: 100.00 kHz
Mod. Amplitude: 0.50 G

Signal Channel
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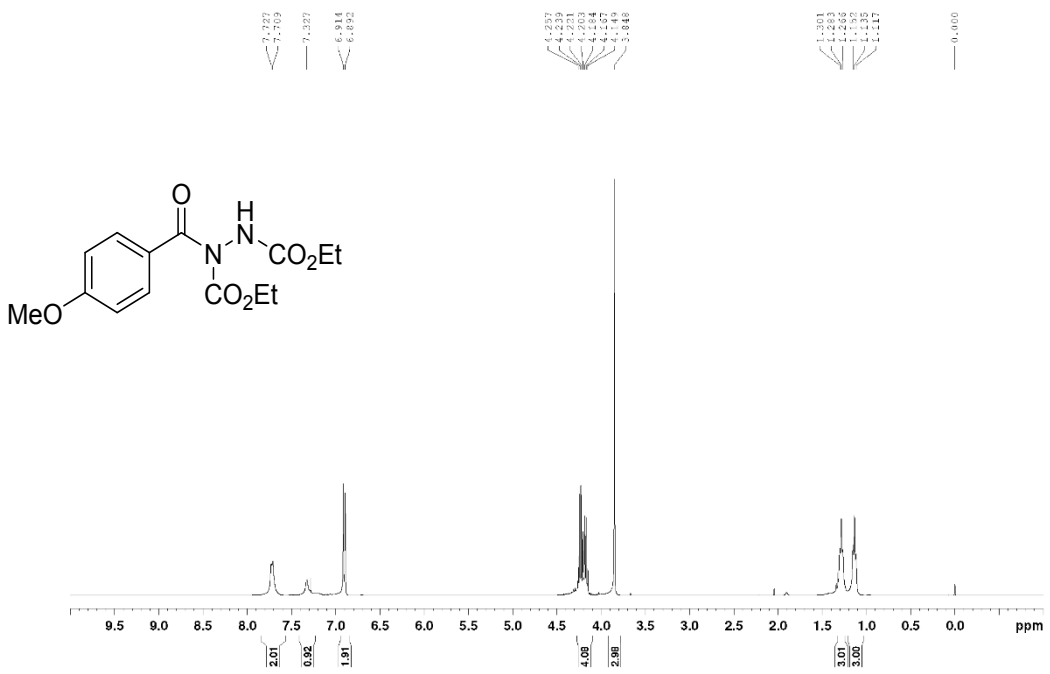
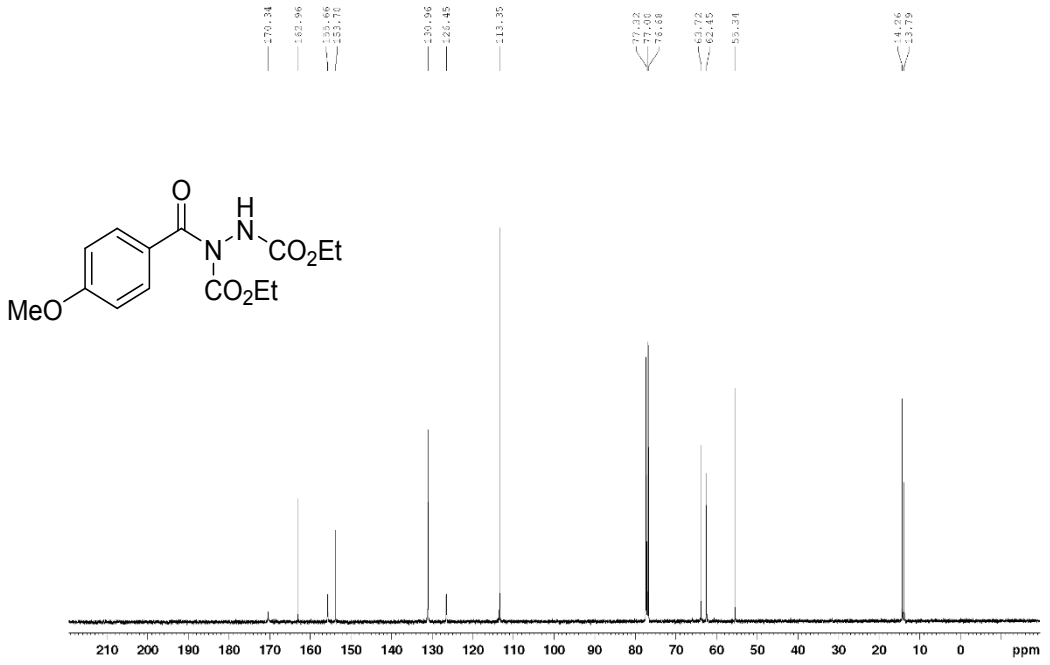
Time Constant: 40.960 ms
Sweep Time: 60.000 s

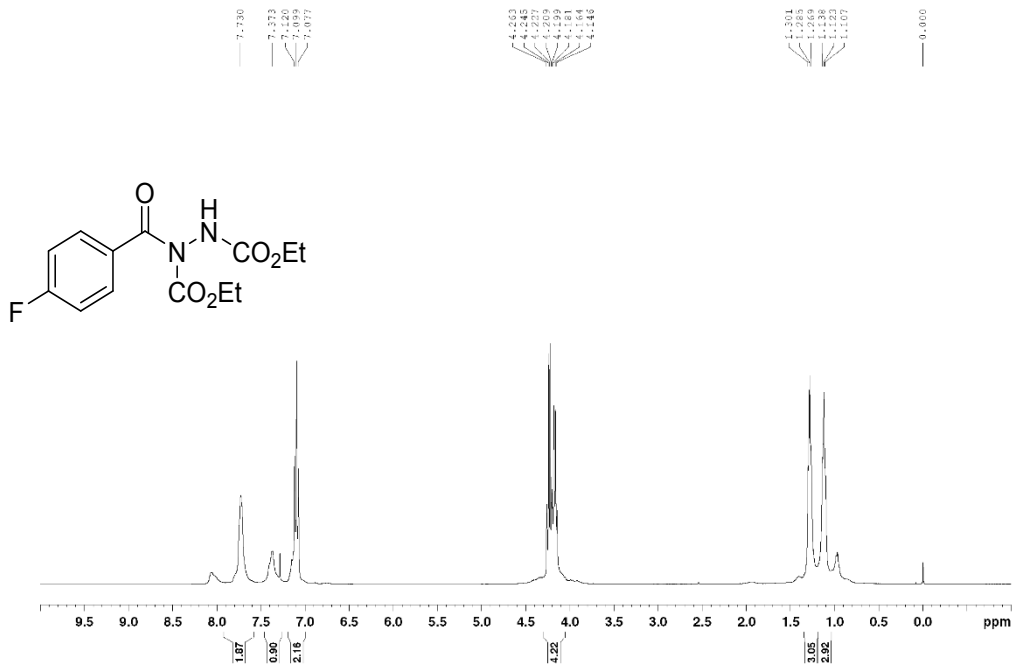
^{1}H NMR spectrum of compound 2a ($CDCl_3$, 400 MHz)



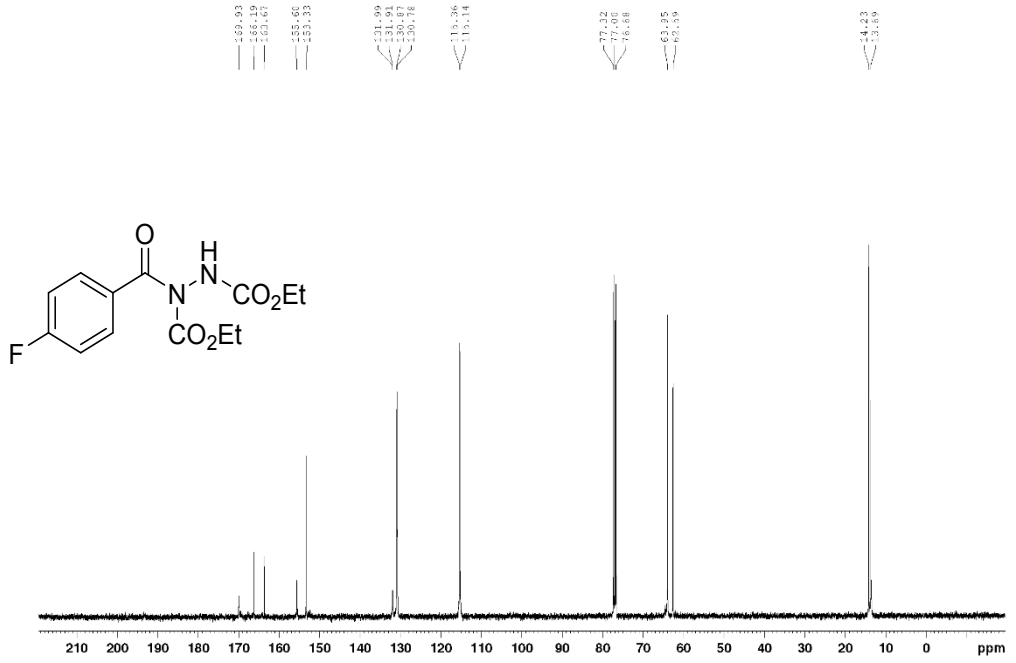
^{13}C NMR spectrum of compound 2a ($CDCl_3$, 100 MHz)



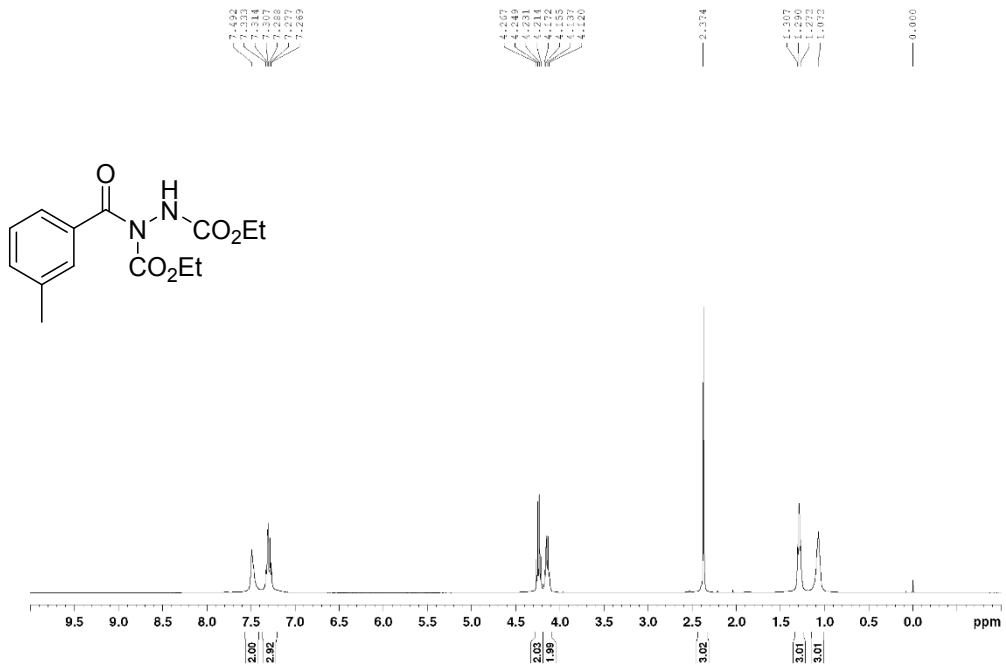
^{1}H NMR spectrum of compound 2b ($CDCl_3$, 400 MHz)



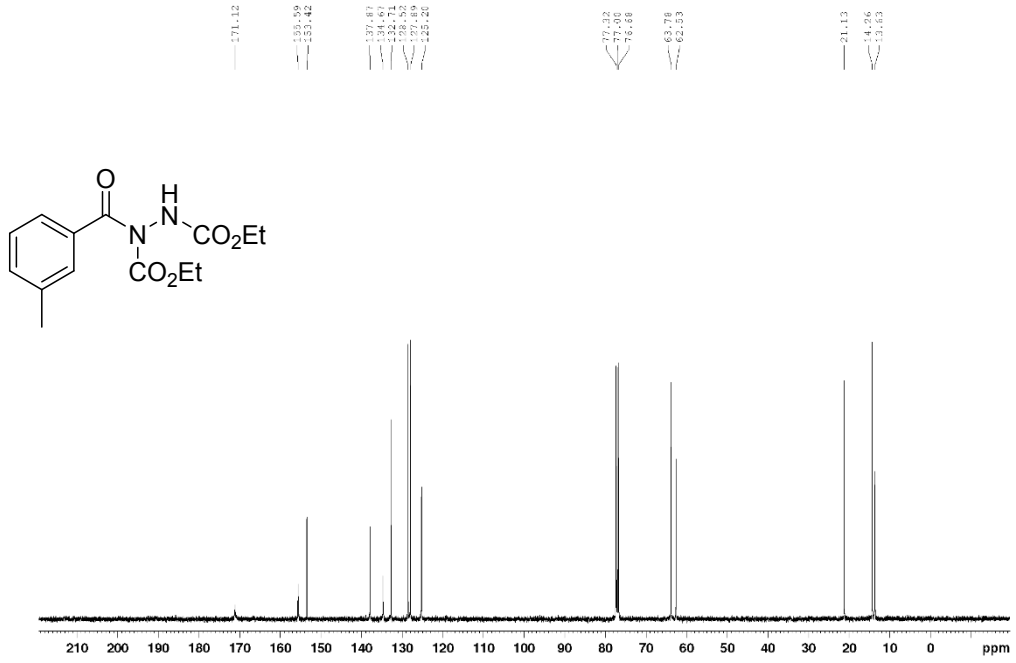
^{13}C NMR spectrum of compound 2b ($CDCl_3$, 100 MHz)



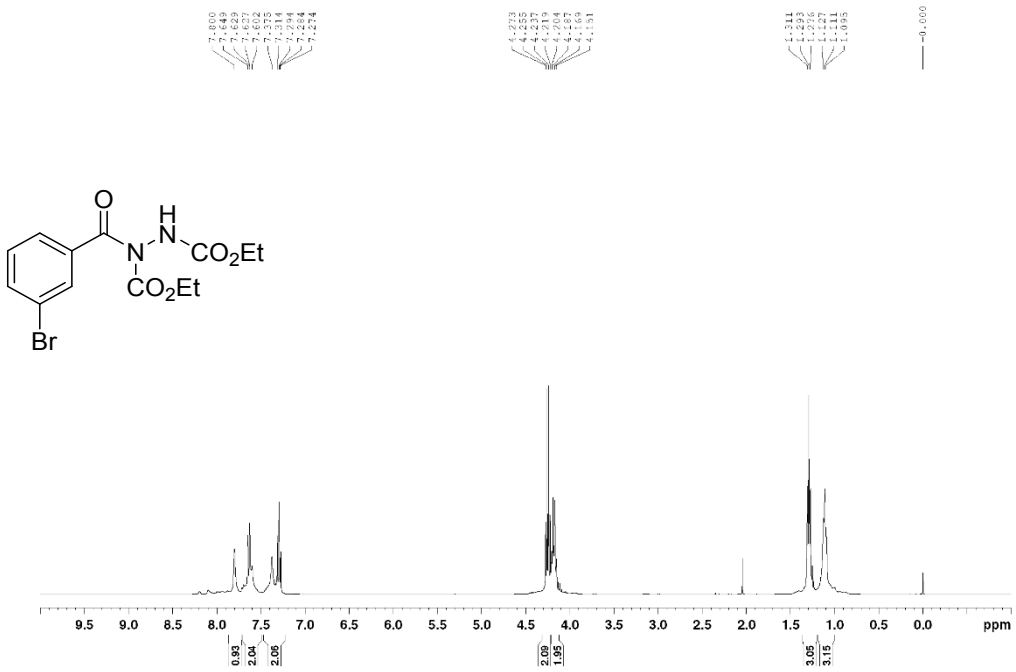
^{1}H NMR spectrum of compound 2c ($CDCl_3$, 400 MHz)



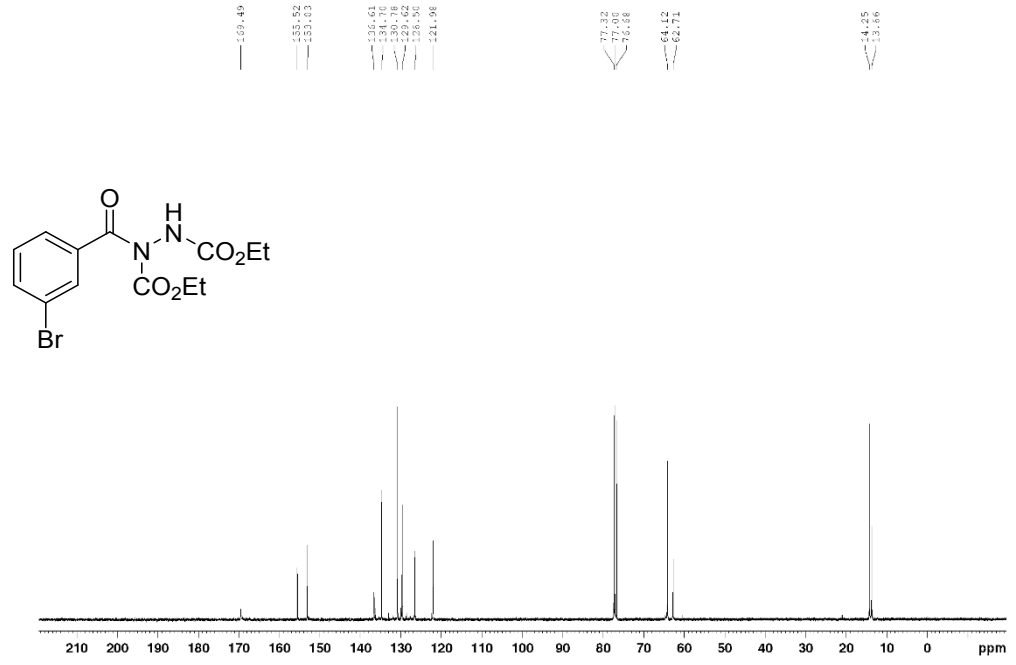
^{13}C NMR spectrum of compound 2c ($CDCl_3$, 100 MHz)



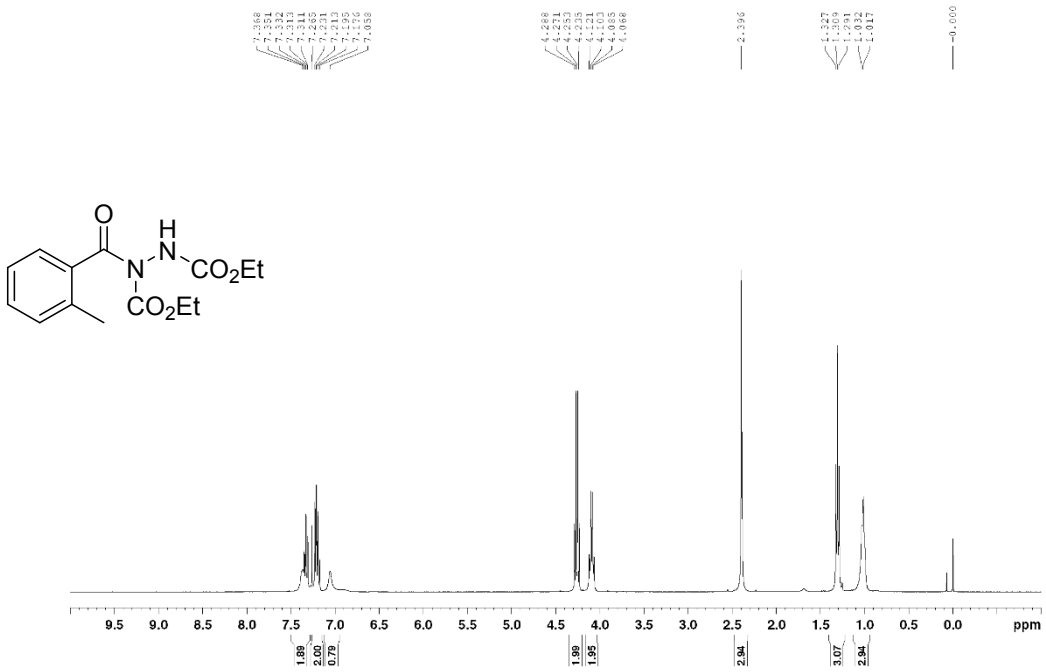
^{1}H NMR spectrum of compound 2d ($CDCl_3$, 400 MHz)



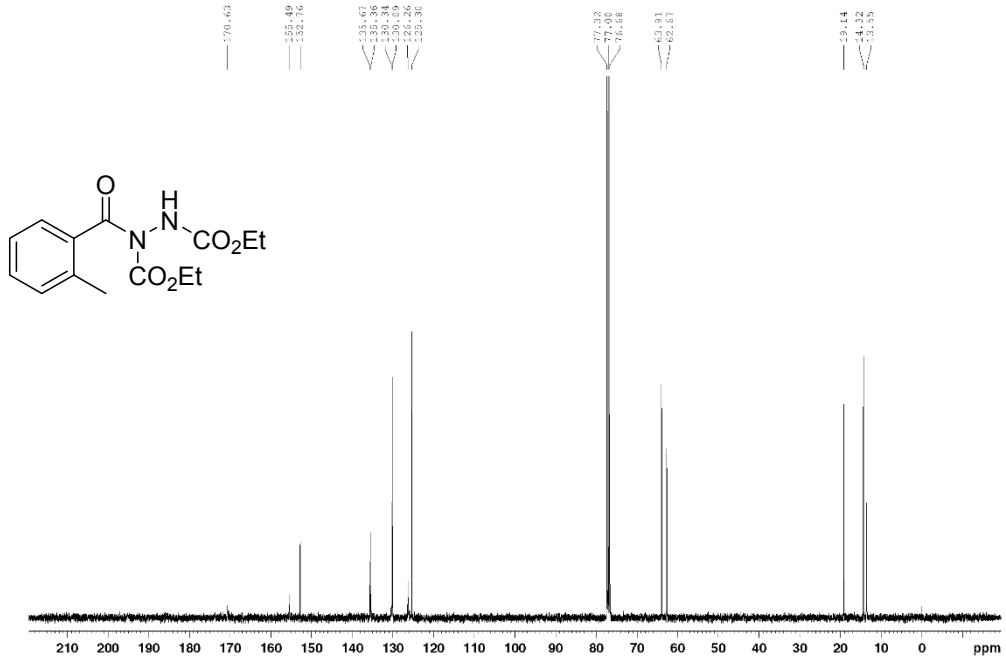
^{13}C NMR spectrum of compound 2d ($CDCl_3$, 100 MHz)



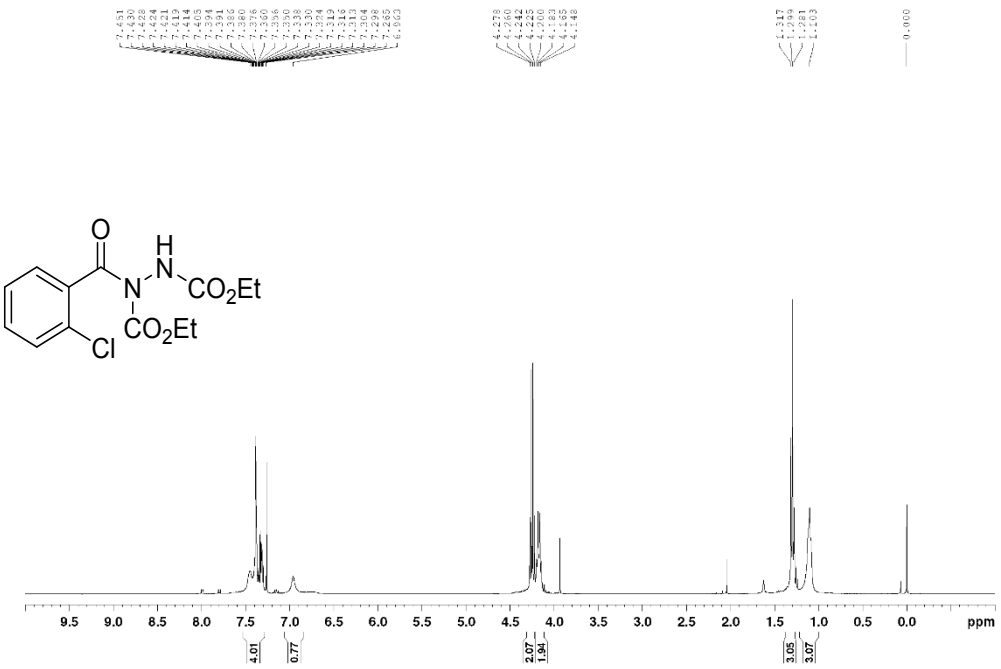
^{1}H NMR spectrum of compound 2e ($CDCl_3$, 400 MHz)



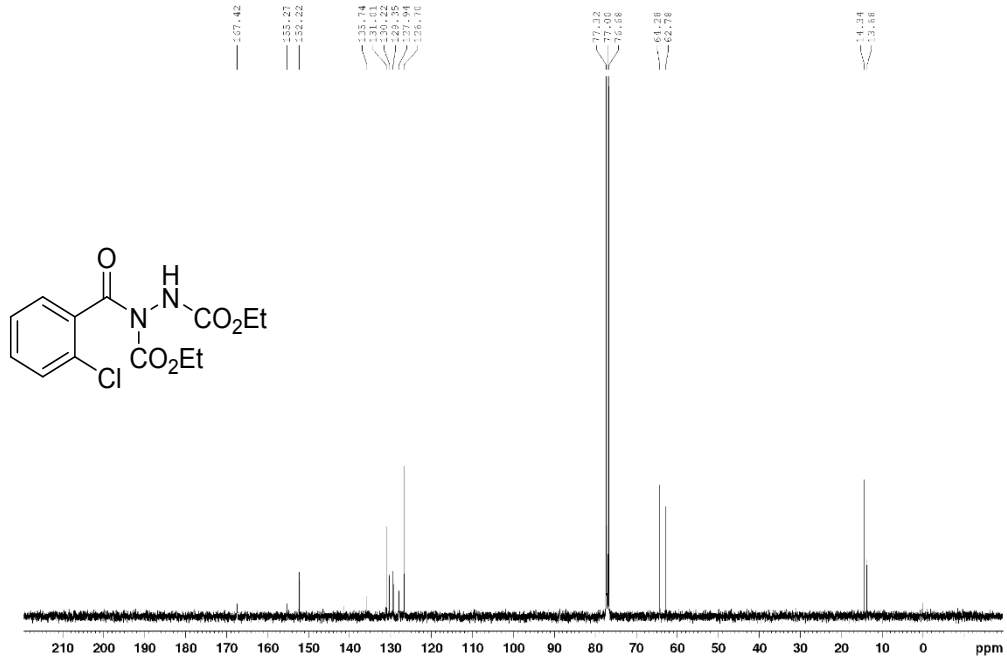
^{13}C NMR spectrum of compound 2e ($CDCl_3$, 100 MHz)



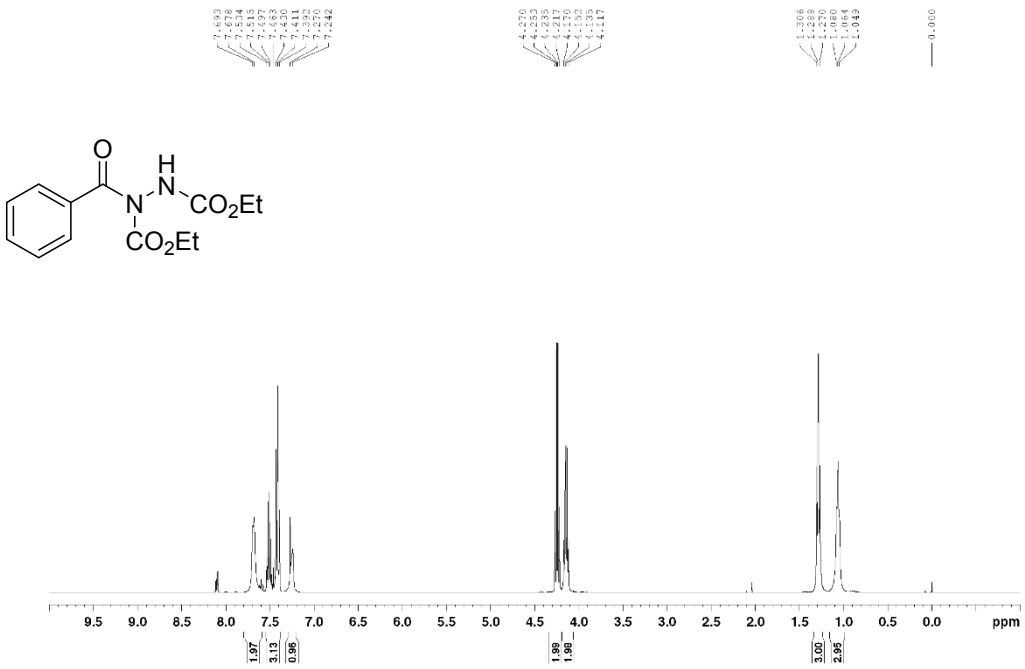
^{1}H NMR spectrum of compound 2f ($CDCl_3$, 400 MHz)



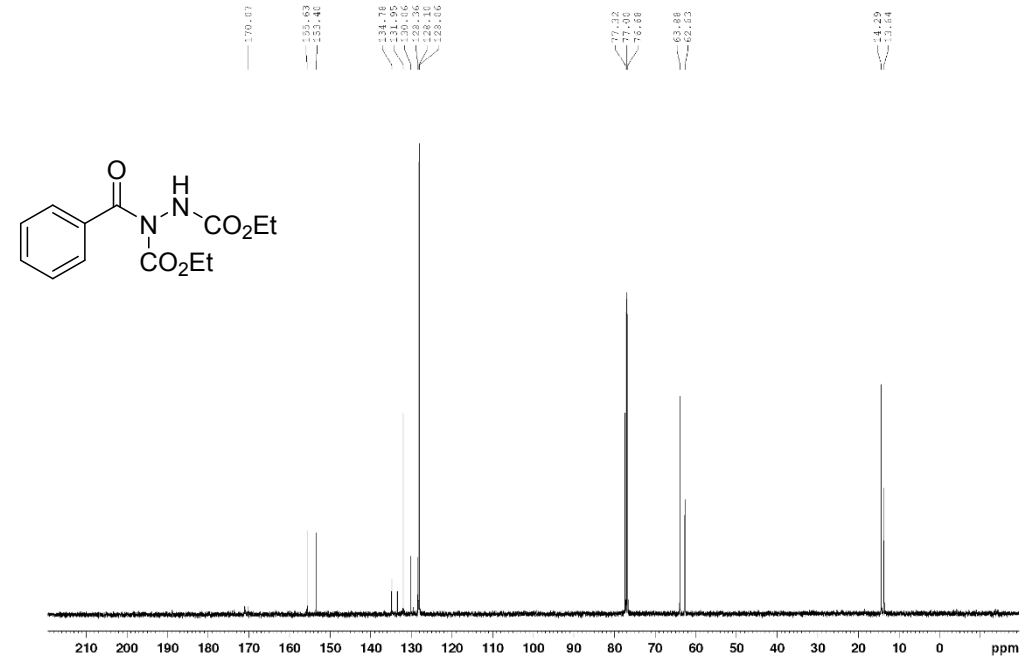
^{13}C NMR spectrum of compound 2f ($CDCl_3$, 100 MHz)



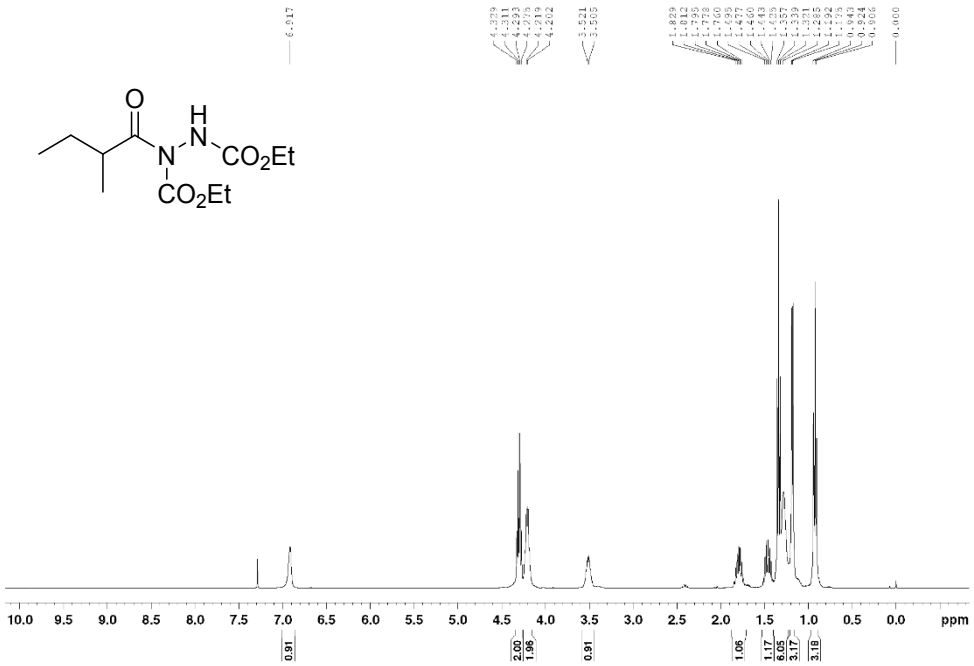
^{1}H NMR spectrum of compound 2g ($CDCl_3$, 400 MHz)



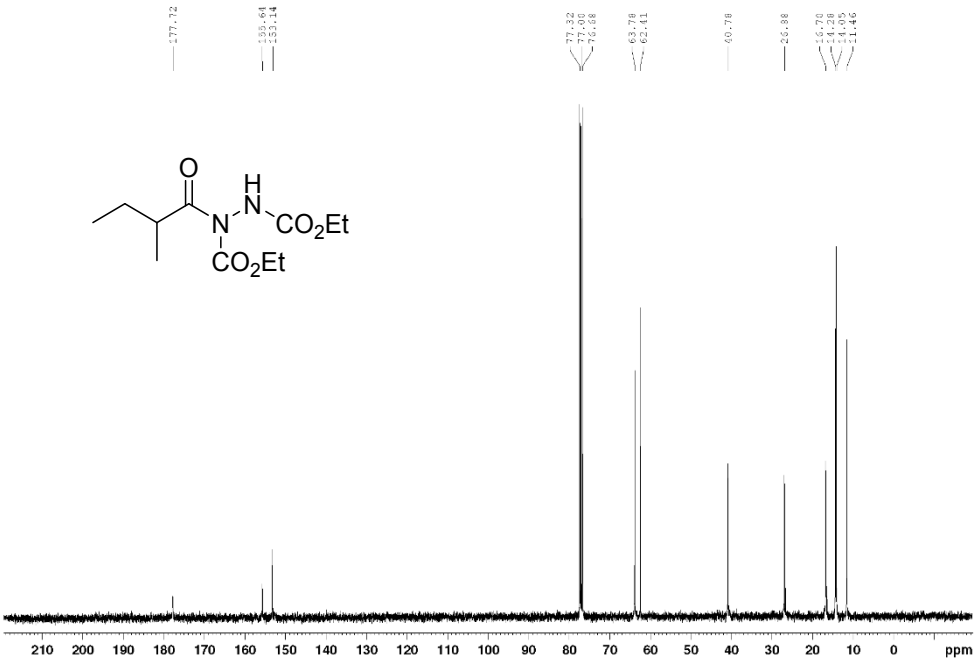
^{13}C NMR spectrum of compound 2g ($CDCl_3$, 100 MHz)



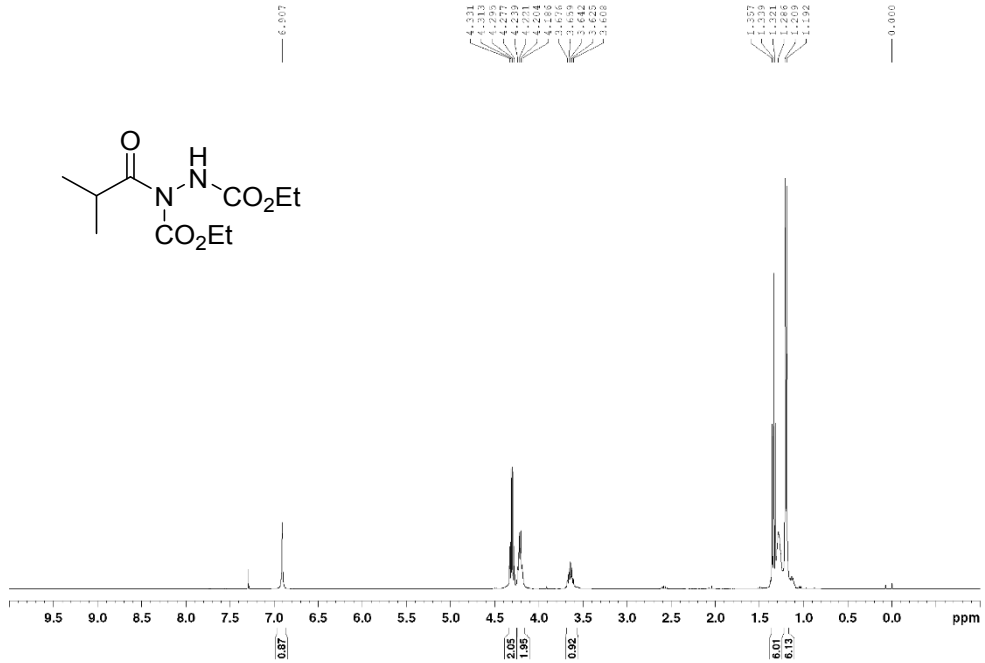
^{1}H NMR spectrum of compound 2h ($CDCl_3$, 400 MHz)



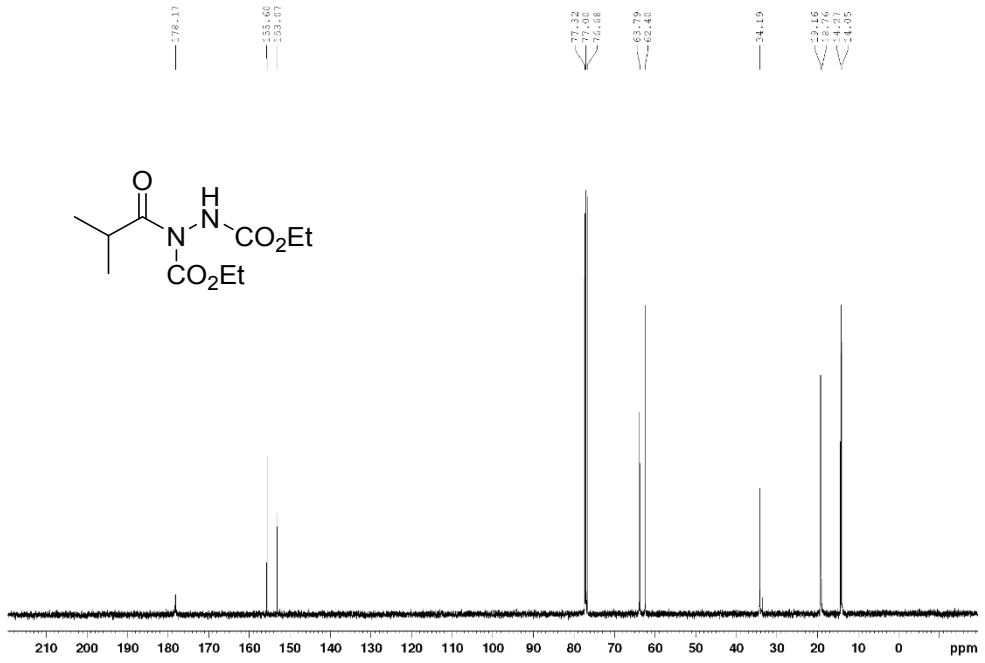
^{13}C NMR spectrum of compound 2h ($CDCl_3$, 100 MHz)



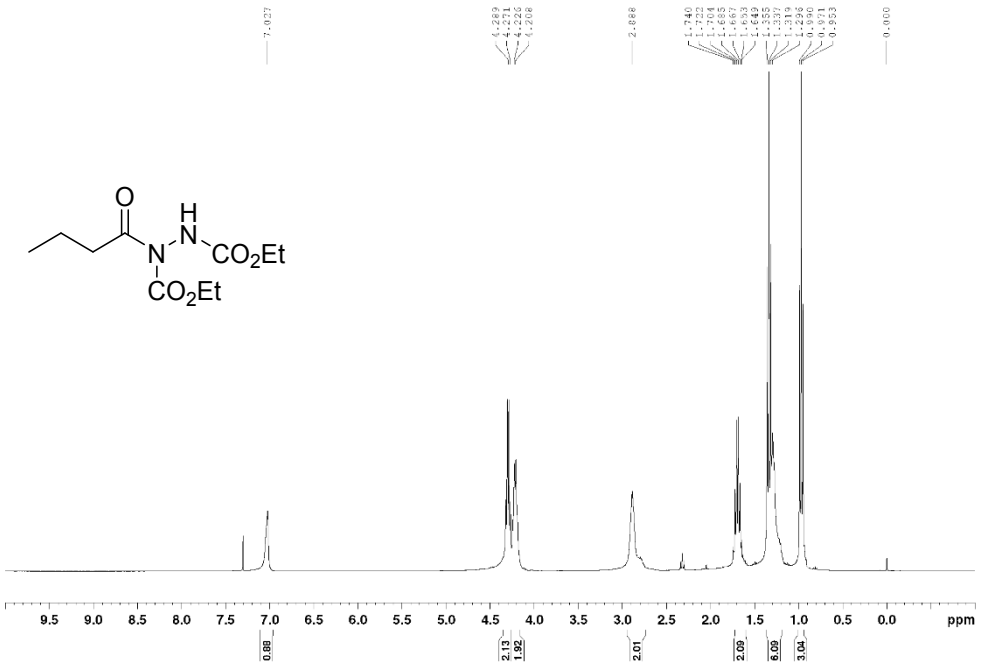
^{1}H NMR spectrum of compound 2i ($CDCl_3$, 400 MHz)



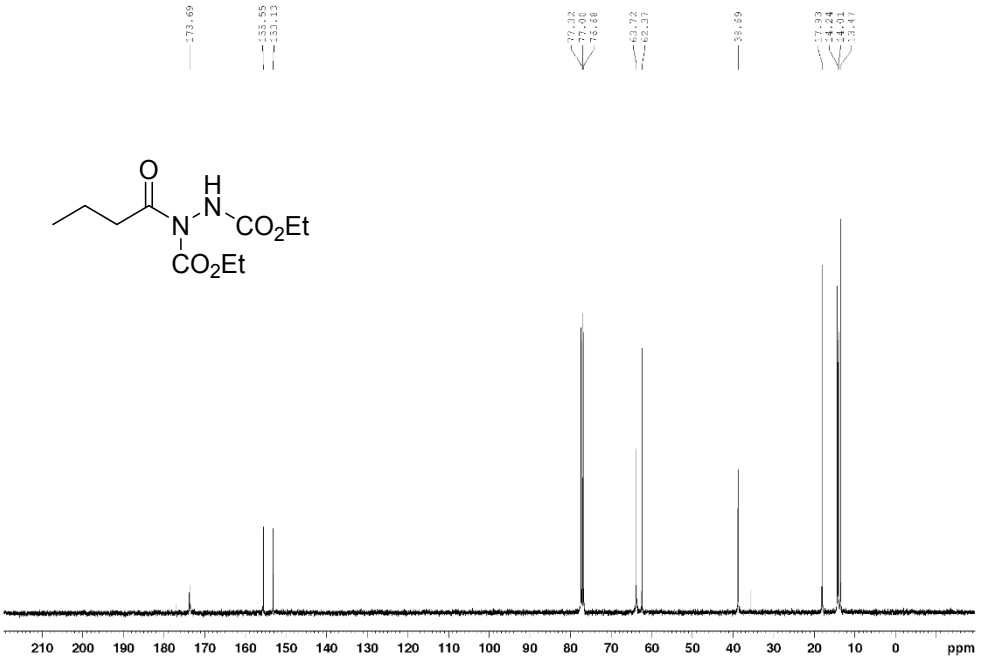
^{13}C NMR spectrum of compound 2i ($CDCl_3$, 100 MHz)



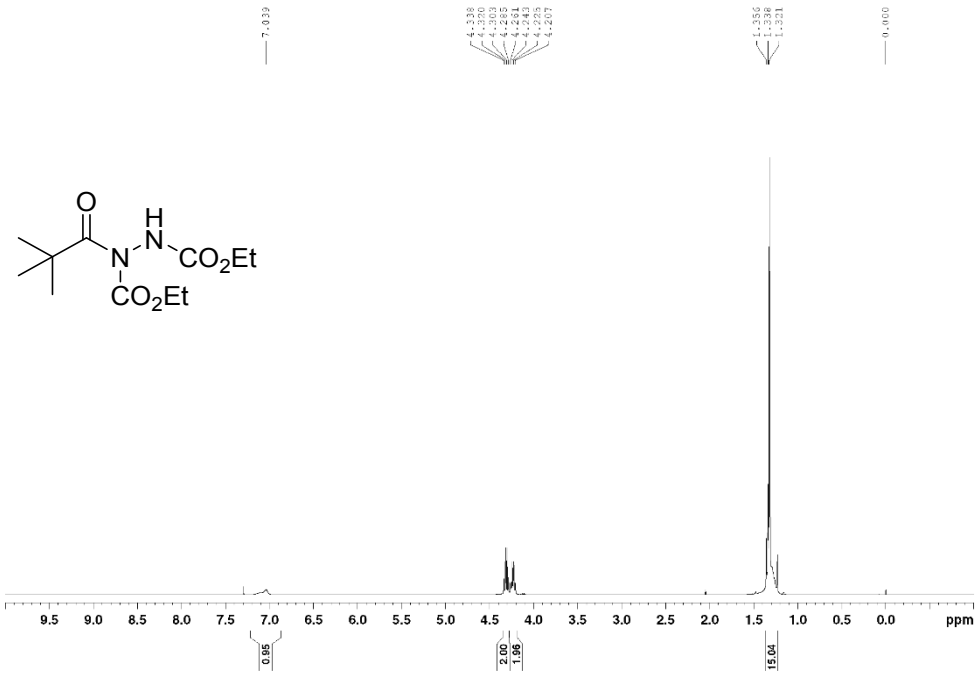
^{1}H NMR spectrum of compound 2j ($CDCl_3$, 400 MHz)



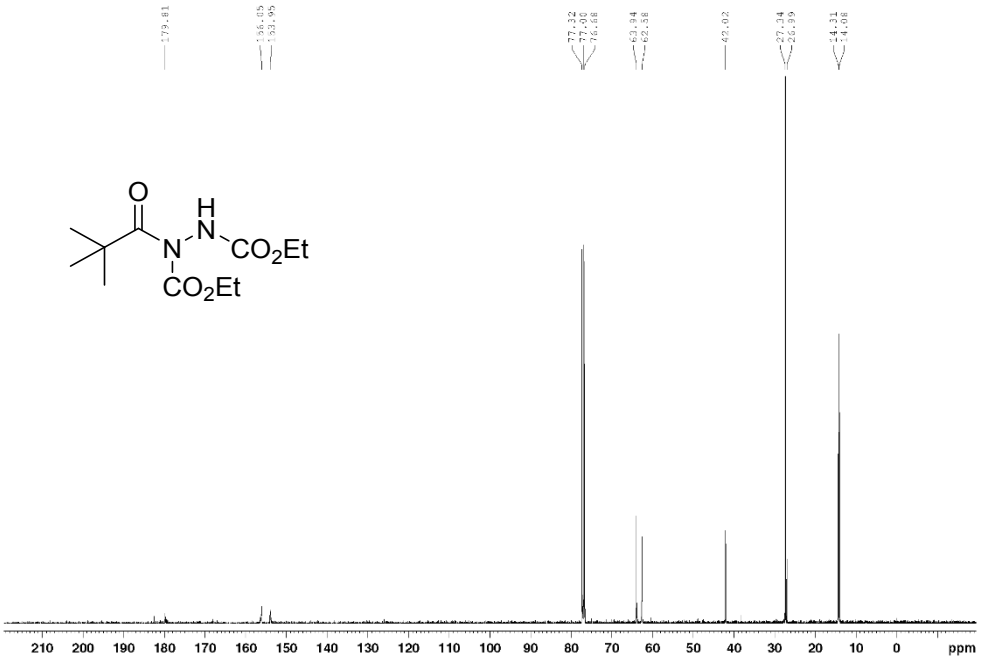
^{13}C NMR spectrum of compound 2j ($CDCl_3$, 100 MHz)



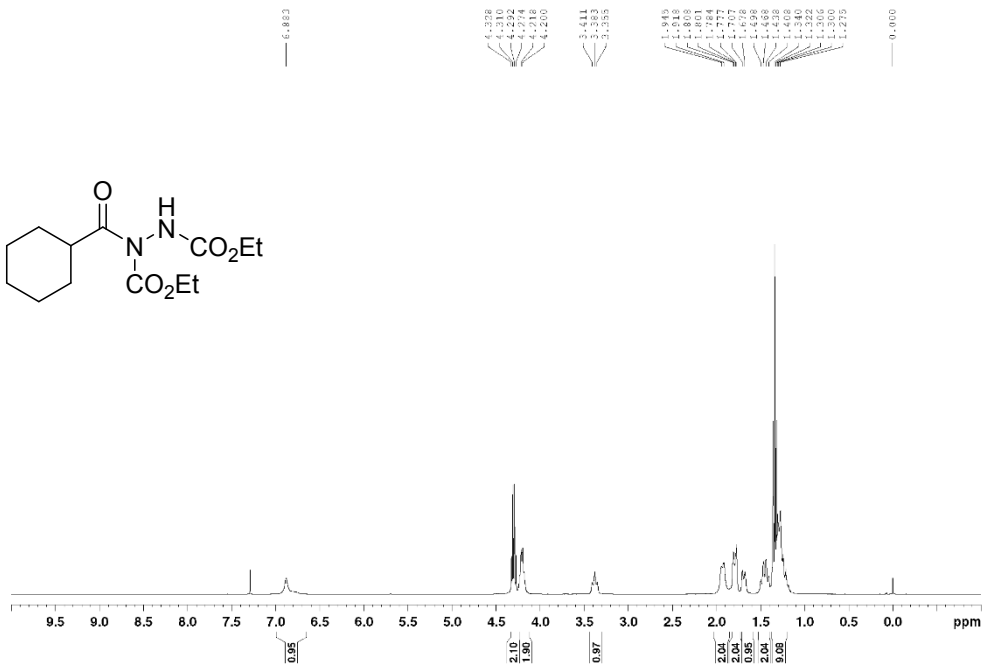
^{1}H NMR spectrum of compound 2k ($CDCl_3$, 400 MHz)



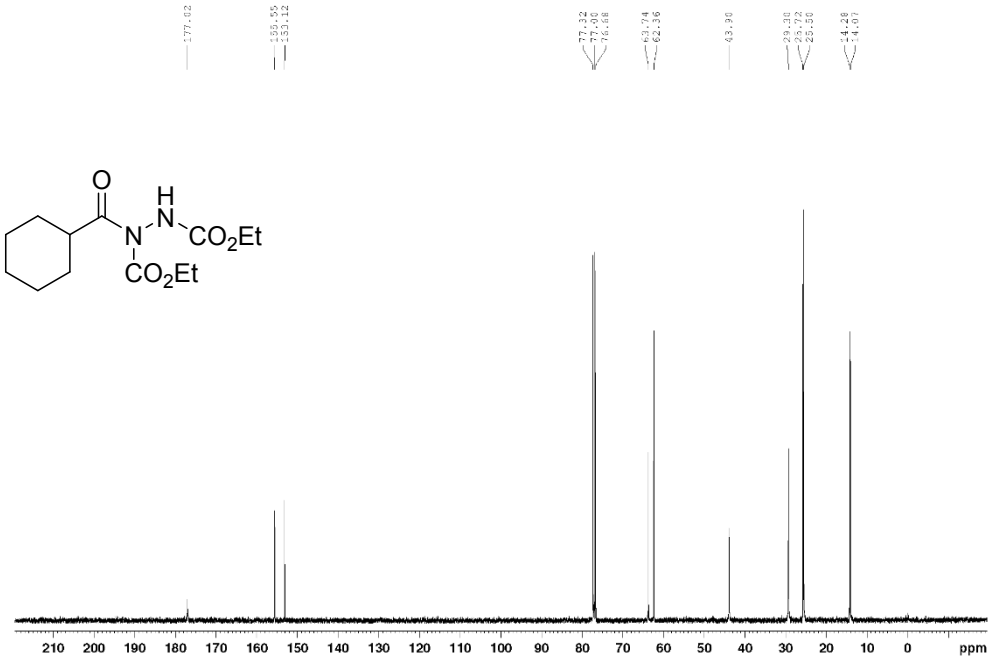
^{13}C NMR spectrum of compound 2k ($CDCl_3$, 100 MHz)



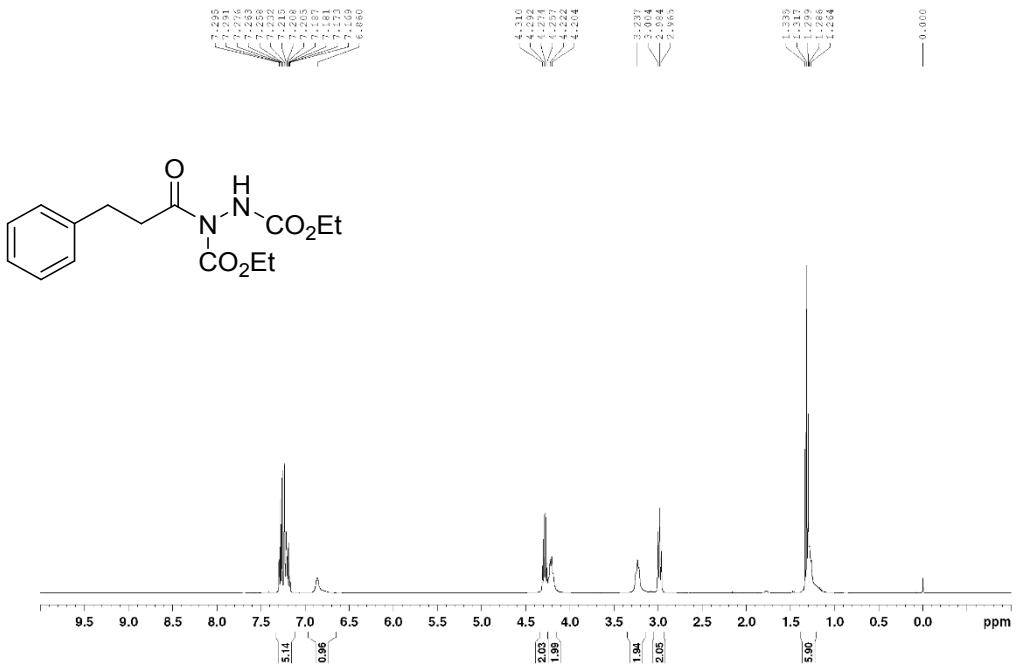
^{1}H NMR spectrum of compound 2l ($CDCl_3$, 400 MHz)



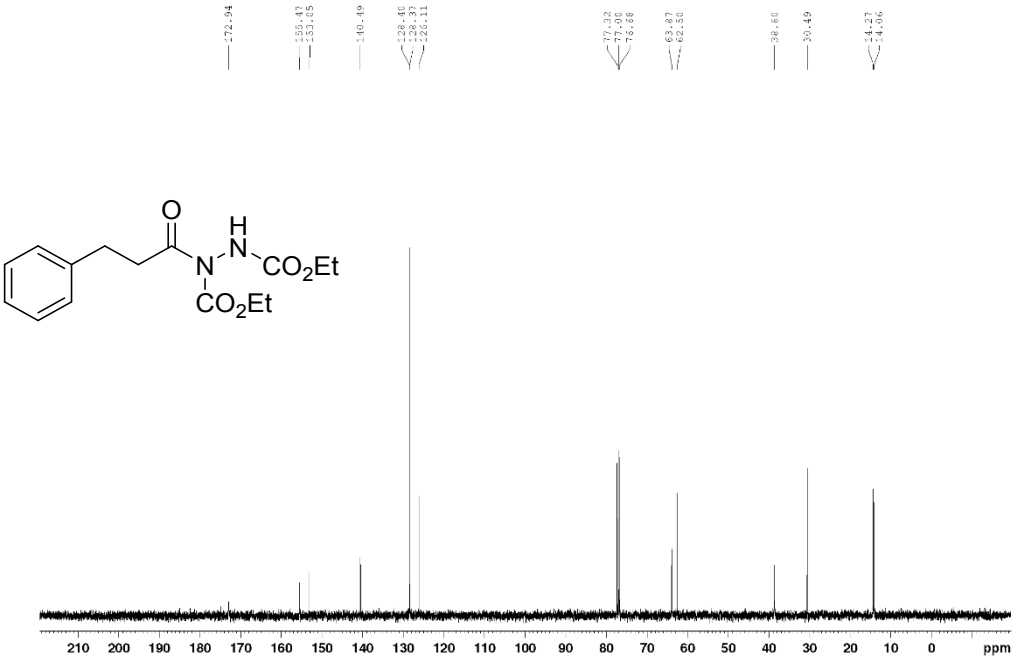
^{13}C NMR spectrum of compound 2l ($CDCl_3$, 100 MHz)



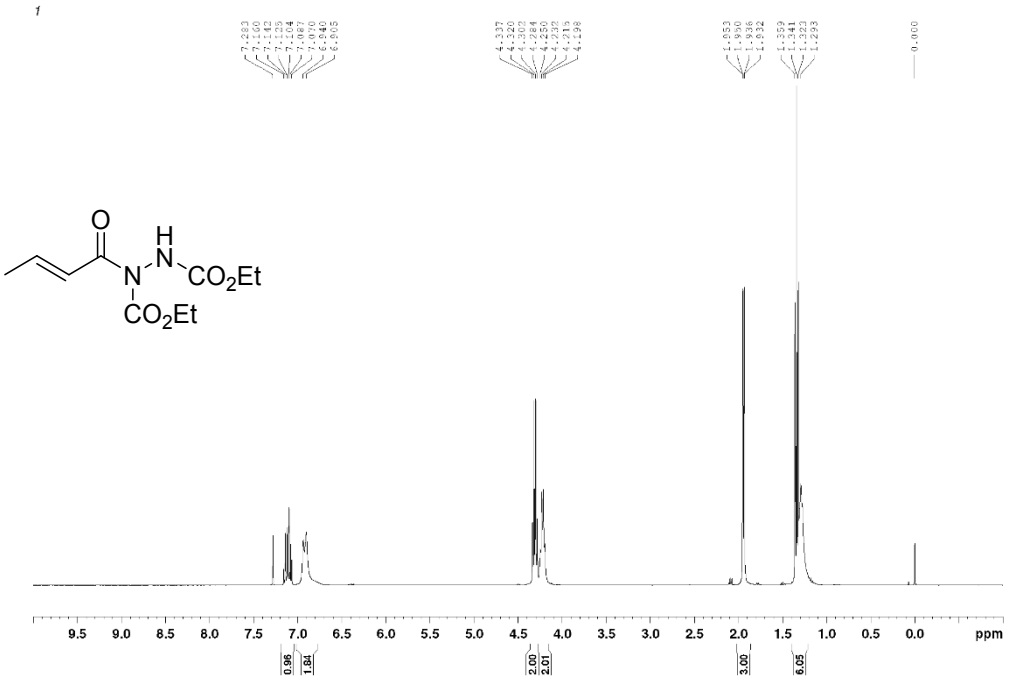
^{1}H NMR spectrum of compound 2m ($CDCl_3$, 400 MHz)



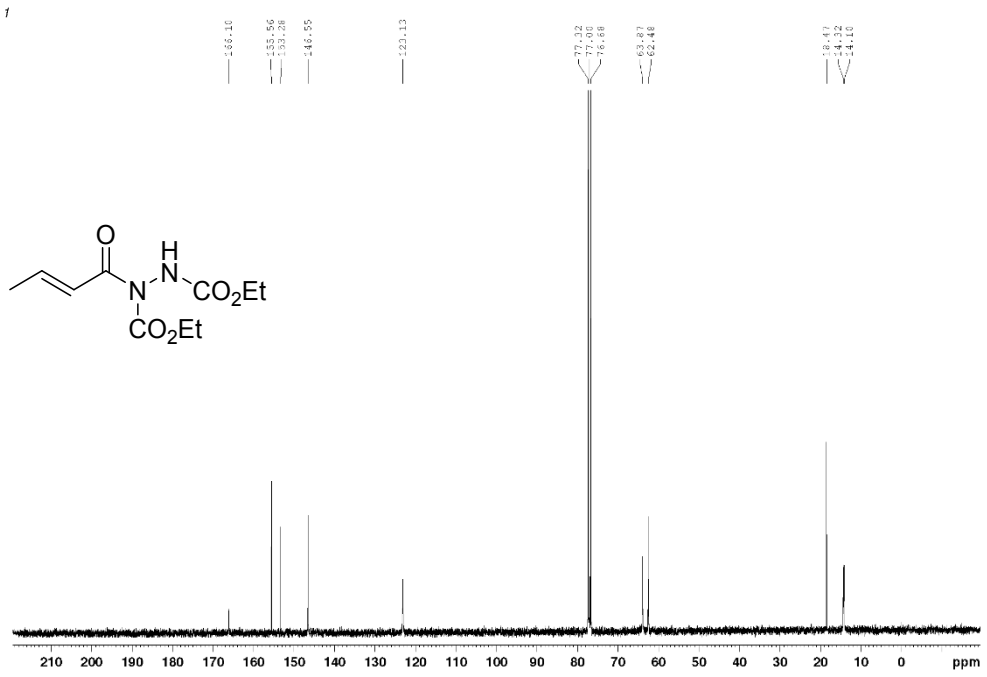
^{13}C NMR spectrum of compound 2m ($CDCl_3$, 100 MHz)



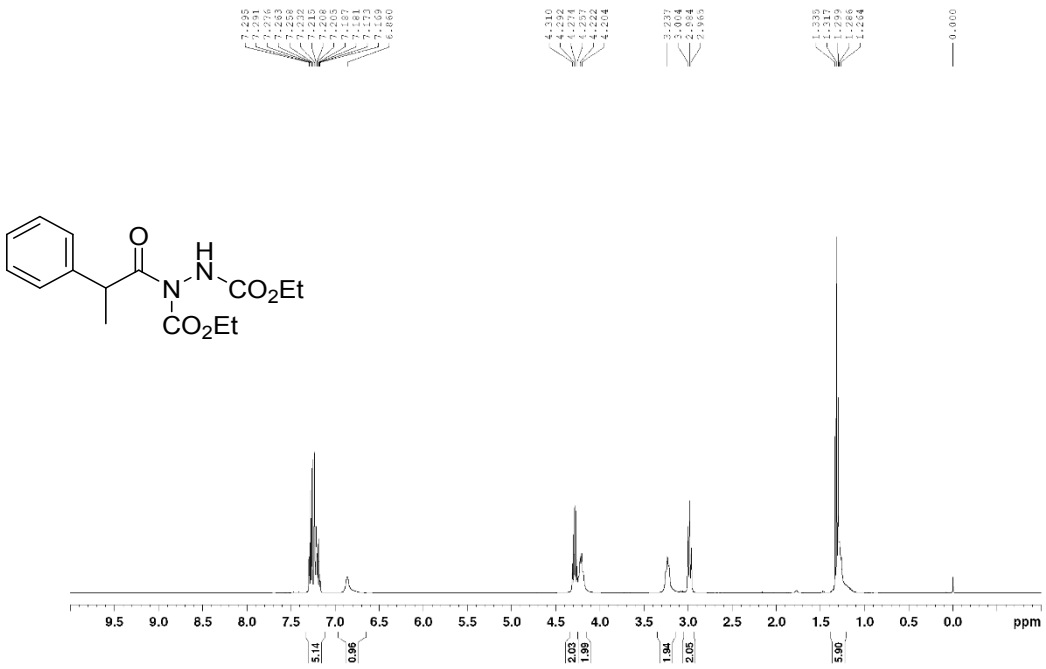
^{1}H NMR spectrum of compound 2n ($CDCl_3$, 400 MHz)



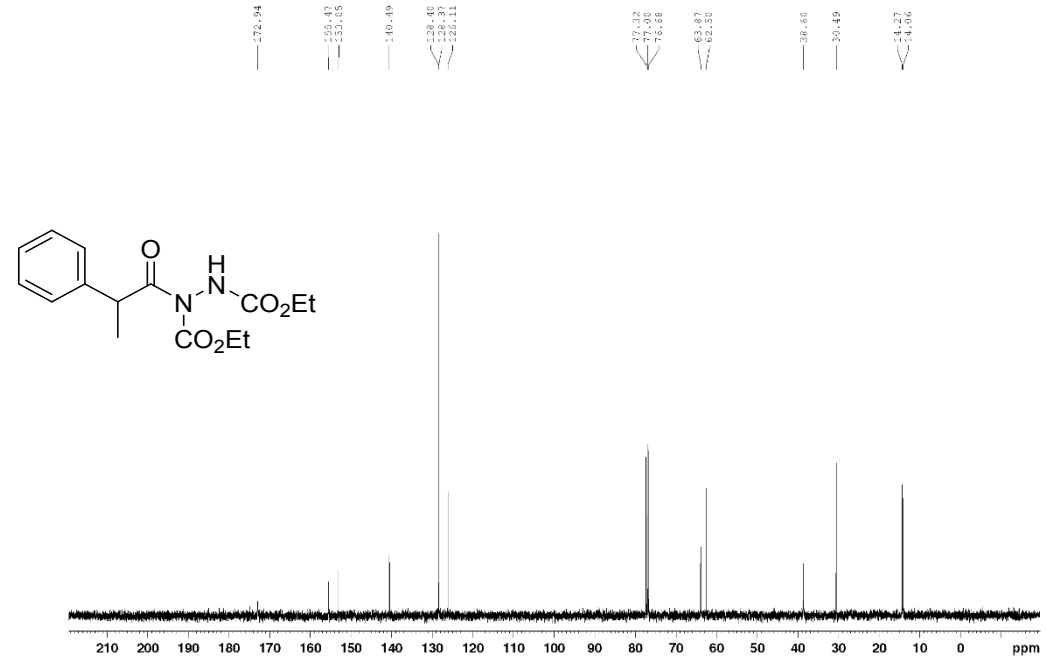
^{13}C NMR spectrum of compound 2n ($CDCl_3$, 100 MHz)



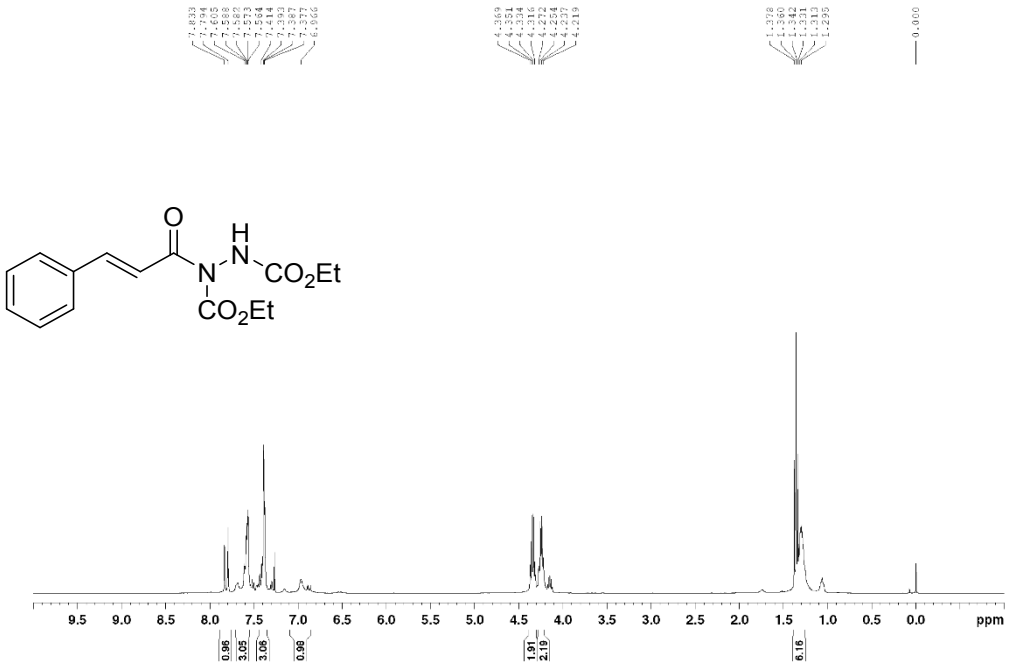
^{1}H NMR spectrum of compound 2o ($CDCl_3$, 400 MHz)



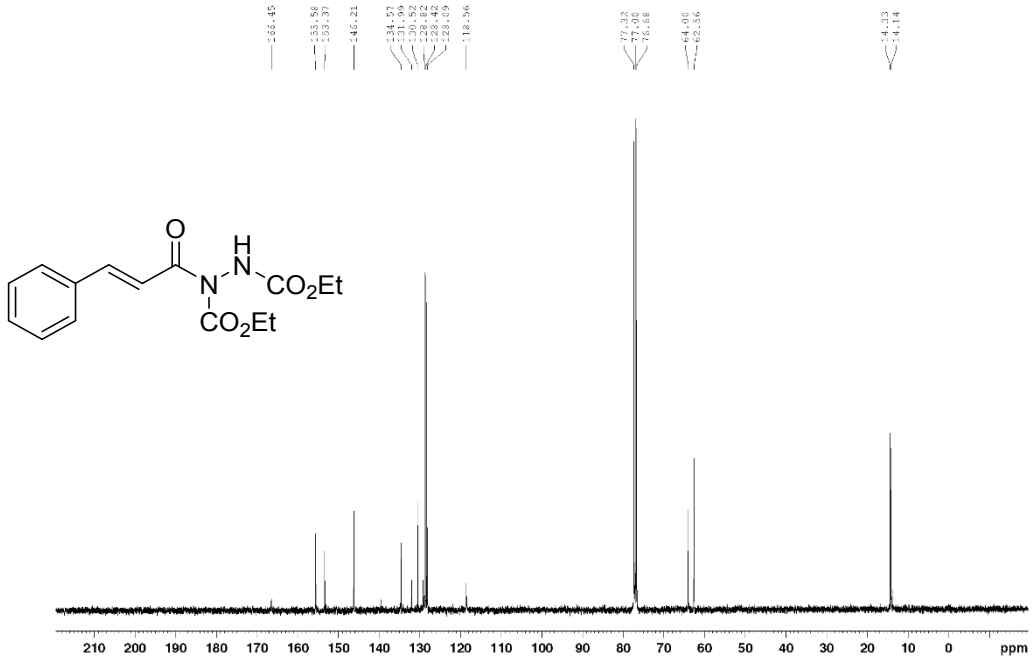
^{13}C NMR spectrum of compound 2o ($CDCl_3$, 100 MHz)



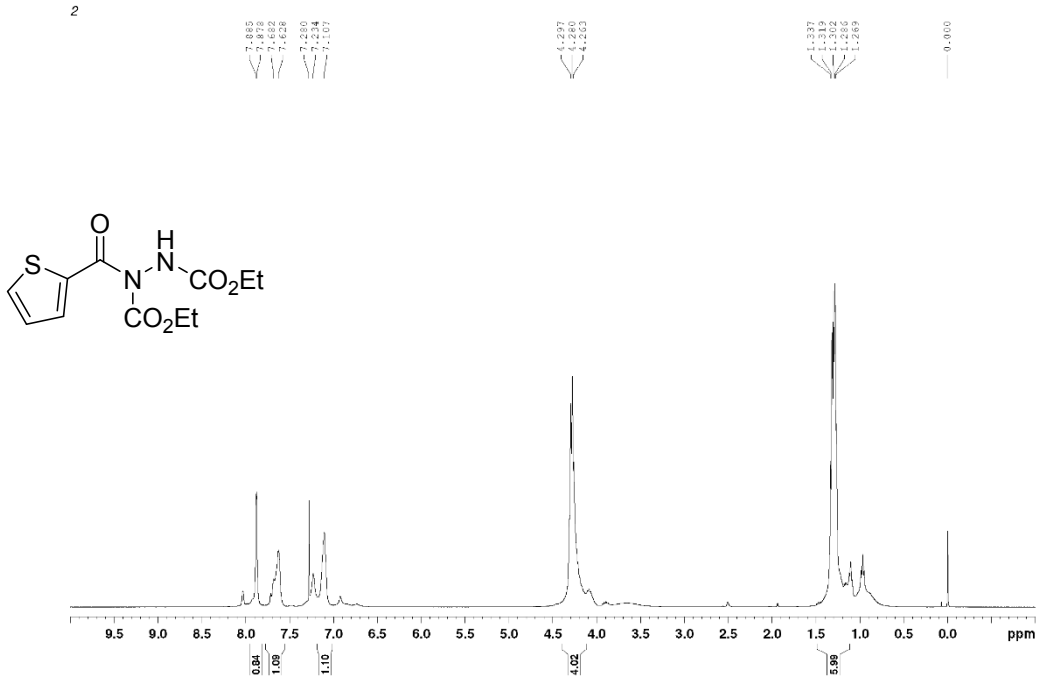
^{1}H NMR spectrum of compound 2p ($CDCl_3$, 400 MHz)



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



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



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