Supporting Information

Methyl ketone break-and-rebuild: a strategy for full α-heterofunctionalization of acetophenones

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General information

Reagents were obtained from commercial supplier and used without further purification. Analytical thin layer chromatography (TLC) was purchased from Merck KGaA (silica gel 60 F254). Visualization of the chromatogram was performed by UV light (254 nm or 365 nm) or phosphomolybdic acid or vanilline stains. Flash column chromatography was carried out using kieselgel 35-70 µm particle sized silica gel (230-400 mesh). NMR Chemical shifts are reported in (δ) ppm relative to tetramethylsilane (TMS) with the residual solvent as internal reference ($CDCl_3$, δ 7.26 ppm for ^1H and δ 77.0 ppm for ^{13}C). Data are reported as follows: chemical shift, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet), coupling constants (Hz) and integration.

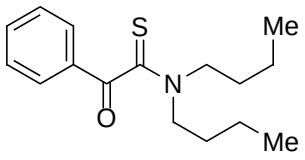
General procedure for iron-catalyzed aerobic Willgerodt reaction between acetophenones (1), amine (2) and sulfur

A mixture of acetophenone **1** (1 mmol), amine **2** (2 mmol), elemental sulfur (64 mg, 2 mmol) and $FeCl_2 \cdot 4H_2O$ (10 mg, 0.05 mmol) was stirred under an oxygen atmosphere (balloon) in a 7 mL-tube at 60-80 ºC for 16 h (see Table 1 and Schemes 3-5 of the manuscript). Although the reactions were performed under solvent-free conditions, the reaction mixtures were always liquid at the reaction temperatures. The stirring was effective with classical magnetic stirring.

The black reaction mixture was dissolved in a minimum amount of CH_2Cl_2 and purified by column chromatography on silica gel (eluent heptane:ethyl acetate or dichloromethane:methanol) to provide the product as bright yellow solids or yellow oils which crystallize slowly on standing at rt.

Characterization of benzoxazole products

***N*,*N*-Dibutyl-2-phenyl-2-oxoethanethioamide (3a)**[1]



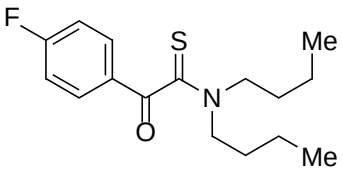
Eluent: heptane:ethyl acetate 3:1. Yellow crystal. mp 66-67 °C (lit. 67.5 - 68.5 °C).[1] 215 mg (78%).

^{1}H NMR (300 MHz, $CDCl_3$) δ 7.93 (d, J = 8.0 Hz, 2H), 7.55 (t, J = 8.0 Hz, 1H), 7.43 (t, J = 8.0 Hz, 2H), 3.95 (t, J = 7.5 Hz, 2H), 3.34 (t, J = 7.5 Hz, 2H), 1.80 (quintet, J = 7.5 Hz, 2H), 1.59 (quintet, J = 7.5 Hz, 2H), 1.42 (sextet, J = 7.5 Hz, 2H), 1.15 (sextet, J = 7.5 Hz, 2H), 0.99 (t, J = 7.5 Hz, 3H), 0.77 (t, J = 7.5 Hz, 3H).

^{13}C NMR (75 MHz, $CDCl_3$) δ 196.0, 187.6, 134.1, 133.7, 130.0, 128.8, 53.5, 50.0, 30.4, 28.1, 20.4, 19.9, 14.0, 13.6.

HRMS (ESI$^+$) calcd for $C_{16}H_{24}NOS$ $[M + H]^+$ 278.1579. Found 278.1567.

***N*,*N*-Dibutyl-2-(4-fluorophenyl)-2-oxoethanethioamide (3b)**



Eluent: heptane:ethyl acetate 3:1. Yellow crystal. mp 50-51 °C. 213 mg (72%).

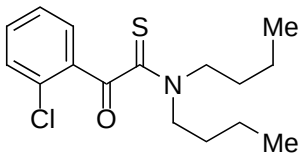
^{1}H NMR (300 MHz, $CDCl_3$) δ 7.98 (dd, J = 8.5, 5.2 Hz, 2H), 7.12 (d, J = 8.5 Hz, 2H), 3.95 (t, J = 7.5 Hz, 2H), 3.35 (t, J = 7.5 Hz, 2H), 1.80 (quintet, J = 7.5 Hz, 2H), 1.59 (quintet, J = 7.5 Hz, 2H), 1.43 (sextet, J = 7.5 Hz, 2H), 1.18 (sextet, J = 7.5 Hz, 2H), 1.00 (t, J = 7.5 Hz, 3H), 0.80 (t, J = 7.5 Hz, 3H).

^{13}C NMR (75 MHz, $CDCl_3$) δ 195.6, 186.1, 166.3 (d, J = 257 Hz), 132.8 (d, J = 9.7 Hz), 130.3 (d, J = 3.3 Hz), 116.2 (d, J = 11.2 Hz), 53.5, 50.1, 30.5, 28.2, 20.4, 20.0, 14.0, 13.6.

^{19}F NMR (272 MHz, $CDCl_3$) δ -103.2.

HRMS (ESI$^+$) calcd for $C_{16}H_{23}FNOS$ $[M + H]^+$ 296.1484. Found 296.1464.

***N*,*N*-Dibutyl-2-(2-chlorophenyl)-2-oxoethanethioamide (3c)**



[1] T. Matsuda, and Y. Takada, *Phosphorus Sulfur Relat. Elem.*, 1976, **1**, 75.

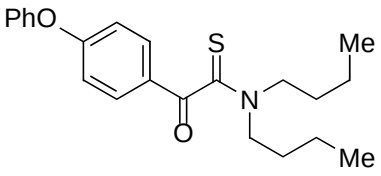
Eluent: heptane:ethyl acetate 3:1. Yellow oil. 200 mg (64%).

^{1}H NMR (300 MHz, $CDCl_3$) δ 7.91 (dd, J = 7.4, 1.7 Hz, 1H), 7.46-7.31 (m, 3H), 3.91-3.86 (m, 2H), 3.52-3.46 (m, 2H), 1.82-1.70 (m, 4H), 1.41 (sextet, J = 7.4 Hz, 2H), 1.28 (sextet, J = 7.4 Hz, 2H), 0.97 (t, J = 7.4 Hz, 3H), 0.89 (t, J = 7.4 Hz, 3H).

^{13}C NMR (75 MHz, $CDCl_3$) δ 195.7, 185.0, 134.7, 133.6, 132.8, 131.1, 131.0, 127.2, 54.4, 50.5, 30.1, 27.1, 20.5, 20.2, 14.0, 13.8.

HRMS (ESI^+) calcd for $C_{16}H_{23}ClNOS$ $[M + H]^+$ 312.1189. Found 312.1172.

***N*,*N*-Dibutyl-2-oxo-2-(4-phenoxyphenyl)ethanethioamide (3d)**



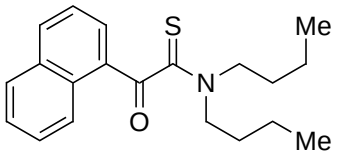
Eluent: heptane:ethyl acetate 5:1 to 3:1. Brown oil. 249 mg (67%).

^{1}H NMR (300 MHz, $CDCl_3$) δ 7.91 (d, J = 8.6 Hz, 2H), 7.38 (t, J = 8.4 Hz, 2H), 7.20 (t, J = 8.4 Hz, 1H), 7.06 (d, J = 8.4 Hz, 2H), 6.97 (d, J = 8.6 Hz, 2H), 3.97-3.91 (m, 2H), 3.39-3.34 (m, 2H), 1.79 (quintet, J = 7.4 Hz, 2H), 1.61 (quintet, J = 7.4 Hz, 2H), 1.42 (sextet, J = 7.4 Hz, 2H), 1.18 (sextet, J = 7.4 Hz, 2H), 0.98 (t, J = 7.4 Hz, 3H), 0.81 (t, J = 7.4 Hz, 3H).

^{13}C NMR (75 MHz, $CDCl_3$) δ 196.2, 186.8, 163.0, 155.2, 132.4, 130.3, 128.1, 125.1, 120.6, 117.4, 53.5, 50.0, 30.5, 28.1, 20.4, 20.0, 14.0, 13.7.

HRMS (ESI^+) calcd for $C_{22}H_{28}NO_2S$ $[M + H]^+$ 370.1841. Found 370.1826.

***N*,*N*-Dibutyl-2-(naphthalen-1-yl)-2-oxoethanethioamide (3e)**



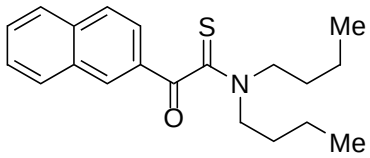
Eluent: heptane:ethyl acetate 4:1 to 3:1. Brown oil. 196 mg (60%).

^{1}H NMR (300 MHz, $CDCl_3$) δ 9.18 (d, J = 8.7 Hz, 1H), 8.04 (d, J = 8.7 Hz, 1H), 7.98 (dd, J = 8.7, 1.2 Hz, 1H), 7.88 (dd, J = 8.7, 1.2 Hz, 1H), 7.69-7.63 (m, 1H), 7.58-7.52 (m, 1H), 7.47 (t, J = 7.9 Hz, 1H), 4.03-3.97 (m, 2H), 3.50-3.44 (m, 2H), 1.91-1.81 (m, 2H), 1.72-1.62 (m, 2H), 1.46 (sextet, J = 7.3 Hz, 2H), 1.16 (sextet, J = 7.3 Hz, 2H), 1.02 (t, J = 7.3 Hz, 3H), 0.78 (t, J = 7.3 Hz, 3H).

^{13}C NMR (75 MHz, $CDCl_3$) δ 197.0, 189.3, 135.1, 134.2, 132.9, 131.7, 129.7, 129.0, 128.8, 126.9, 126.2, 124.3, 53.8, 50.1, 30.4, 28.0, 20.4, 20.0, 14.0, 13.6.

HRMS (ESI^+) calcd for $C_{20}H_{26}NOS$ $[M + H]^+$ 328.1735. Found 328.1723.

***N*,*N*-Dibutyl-2-(naphthalen-2-yl)-2-oxoethanethioamide (3f)**



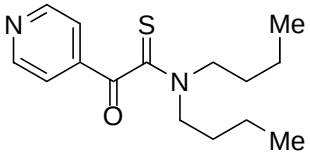
Eluent: heptane:ethyl acetate 4:1 to 3:1. Brown oil. 215 mg (66%).

^{1}H NMR (300 MHz, $CDCl_3$) δ 8.48 (s, 1H), 8.01 (dd, J = 8.6, 1.6 Hz, 1H), 7.92 (d, J = 9.4 Hz, 1H), 7.86 (d, J = 9.4 Hz, 1H), 7.62-7.50 (m, 2H), 4.05-4.00 (m, 2H), 3.43-3.37 (m, 2H), 1.92-1.81 (m, 2H), 1.68-1.57 (m, 2H), 1.48 (sextet, J = 7.4 Hz, 2H), 1.16 (sextet, J = 7.4 Hz, 2H), 1.03 (t, J = 7.4 Hz, 3H), 0.76 (t, J = 7.4 Hz, 3H).

^{13}C NMR (75 MHz, $CDCl_3$) δ 196.2, 187.8, 136.2, 132.6, 132.5, 131.1, 130.0, 129.3, 128.9, 128.1, 127.2, 124.8, 53.6, 50.1, 30.5, 28.2, 20.5, 20.0, 14.1, 13.6.

HRMS (ESI$^+$) calcd for $C_{20}H_{26}NOS$ $[M + H]^+$ 328.1735. Found 328.1727.

***N*,*N*-Dibutyl-2-oxo-2-(pyridin-4-yl)ethanethioamide (3g)**



Eluent: 1% MeOH in CH_2Cl_2. Brown oil. 209 mg (75%).

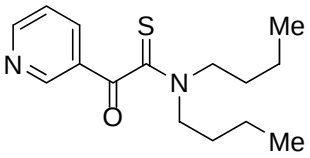
^{1}H NMR (300 MHz, $CDCl_3$) δ 8.80-8.78 (m, 2H), 7.75-7.73 (m, 2H), 3.98-3.93 (m, 2H), 3.39-3.34 (m, 2H), 1.86-1.75 (m, 2H), 1.66-1.55 (m, 2H), 1.44 (sextet, J = 7.3 Hz, 2H), 1.20 (sextet, J = 7.3 Hz, 2H),

1.00 (t, J = 7.3 Hz, 3H), 0.81 (t, J = 7.3 Hz, 3H).

^{13}C NMR (75 MHz, $CDCl_3$) δ 194.2, 185.0, 151.2, 151.1, 140.6, 122.6, 53.6, 50.3, 30.7, 28.3, 20.5, 20.0, 14.0, 13.7.

HRMS (ESI$^+$) calcd for $C_{15}H_{23}N_2OS$ $[M + H]^+$ 279.1531. Found 279.1516.

***N*,*N*-Dibutyl-2-oxo-2-(pyridin-3-yl)ethanethioamide (3h)**



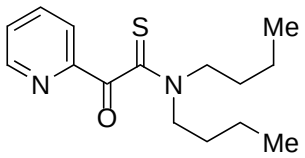
Eluent: 1% MeOH in CH_2Cl_2. Brown oil. 205 mg (74%).

^{1}H NMR (300 MHz, $CDCl_3$) δ 9.09-9.05 (m, 1H), 8.75-8.69 (m, 1H), 8.20-8.18 (m, 1H), 7.39-7.35 (m, 1H), 3.92-3.87 (m, 2H), 3.35-3.30 (m, 2H), 1.79-1.69 (m, 2H), 1.60-1.50 (m, 2H), 1.37 (sextet, J = 7.8 Hz, 2H), 1.13 (sextet, J = 7.8 Hz, 2H), 0.93 (t, J = 7.5 Hz, 3H), 0.73 (t, J = 7.5 Hz, 3H).

^{13}C NMR (75 MHz, $CDCl_3$) δ 194.2, 185.4, 153.9, 151.3, 136.9, 129.7, 123.7, 53.4, 50.0, 30.5, 28.0, 20.3, 19.8, 13.9, 13.5.

HRMS (ESI$^+$) calcd for $C_{15}H_{23}N_2OS$ $[M + H]^+$ 279.1531. Found 279.1536.

***N*,*N*-Dibutyl-2-oxo-2-(pyridin-2-yl)ethanethioamide (3i)**



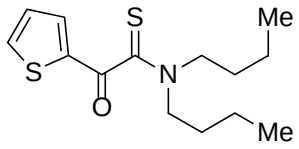
Eluent: 1% MeOH in CH_2Cl_2. Brown oil. 215 mg (77%).

^{1}H NMR (300 MHz, $CDCl_3$) δ 8.63-8.61 (m, 1H), 8.11-8.08 (m, 1H), 7.84-7.79 (m, 1H), 7.43-7.39 (m, 1H), 3.98-3.93 (m, 2H), 3.42-3.37 (m, 2H), 1.85-1.74 (m, 2H), 1.70-1.59 (m, 2H), 1.43 (sextet, J = 7.8 Hz, 2H), 1.17 (sextet, J = 7.8 Hz, 2H), 0.96 (t, J = 7.8 Hz, 3H), 0.77 (t, J = 7.8 Hz, 3H).

^{13}C NMR (75 MHz, $CDCl_3$) δ 196.8, 185.9, 152.5, 149.6, 137.1, 127.3, 124.1, 53.8, 49.9, 30.2, 28.2, 20.3, 19.9, 14.0, 13.6.

HRMS (ESI$^+$) calcd for $C_{15}H_{23}N_2OS$ $[M + H]^+$ 279.1531. Found 279.1539.

***N*,*N*-Dibutyl-2-oxo-2-(thiophen-2-yl)ethanethioamide (3j)**



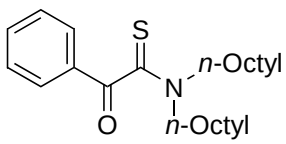
Eluent: heptane:ethyl acetate 3:1. Brown oil. 231 mg (82%).

^{1}H NMR (300 MHz, $CDCl_3$) δ 7.71-7.66 (m, 2H), 7.10 (dd, J = 4.9, 3.9 Hz, 1H), 3.91 (t, J = 8.0 Hz, 2H), 3.39 (t, J = 8.0 Hz, 2H), 1.81-1.71 (m, 2H), 1.64-1.54 (m, 2H), 1.41 (sextet, J = 7.5 Hz, 2H), 1.17 (sextet, J = 7.5 Hz, 2H), 0.97 (t, J = 7.5 Hz, 3H), 0.79 (t, J = 7.5 Hz, 3H).

^{13}C NMR (75 MHz, $CDCl_3$) δ 194.7, 181.0, 140.8, 135.6, 135.4, 128.6, 53.5, 50.1, 30.5, 28.0, 20.3, 19.9, 14.0, 13.6.

HRMS (ESI$^+$) calcd for $C_{14}H_{22}NOS_2$ $[M + H]^+$ 284.1143. Found 284.1135.

***N*,*N*-Dioctyl-2-oxo-2-phenylethanethioamide (3k)**



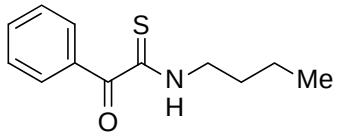
Eluent: heptane:ethyl acetate 7:1 to 4:1. Brown oil. 232 mg (60%).

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.96 (d, J = 7.4 Hz, 2H), 7.56 (t, J = 7.4 Hz, 1H), 7.44 (t, J = 7.4 Hz, 2H), 3.95 (t, J = 7.9 Hz, 2H), 3.35 (t, J = 7.9 Hz, 2H), 1.82 (quintet, J = 7.9 Hz, 2H), 1.60 (quintet, J = 7.9 Hz, 2H), 1.43-1.10 (m, 20 H), 0.88 (t, J = 6.9 Hz, 3H), 0.83 (t, J = 6.9 Hz, 3H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 196.2, 187.7, 134.1, 133.9, 130.1, 128.9, 53.8, 50.3, 32.0, 31.8, 29.5, 29.4, 29.1, 29.1, 28.4, 27.2, 26.7, 26.1, 22.8, 22.8, 14.3, 14.2.

HRMS (ESI$^+$) calcd for $C_{24}H_{40}NOS$ $[M + H]^+$ 390.2831. Found 390.2845.

***N*-Butyl-2-oxo-2-phenylethanethioamide (3l)**



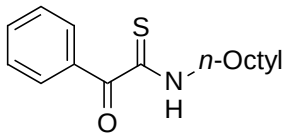
Eluent: heptane:ethyl acetate 3:1. Brown solid. mp 70-71 °C. 135 mg (61%).

^{1}H NMR (300 MHz, $CDCl_3$) δ 8.60 (broad s, 1H), 7.94 (d, J = 7.4 Hz, 2H), 7.52 (t, J = 7.4 Hz, 1H), 7.37 (t, J = 7.4 Hz, 2H), 3.77-3.70 (m, 2H), 1.76-1.65 (m, 2H), 1.49-1.37 (m, 2H), 0.96 (t, J = 7.3 Hz, 3H).

^{13}C NMR (75 MHz, $CDCl_3$) δ 194.1, 188.4, 134.0, 133.7, 130.7, 128.3, 45.1, 29.9, 20.3, 13.8.

HRMS (ESI$^+$) calcd for $C_{12}H_{16}NOS$ $[M + H]^+$ 222.0953. Found: 222.0946.

***N*-Octyl-2-oxo-2-phenylethanethioamide (3m)**



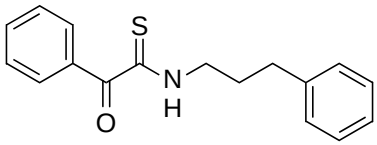
Eluent: heptane:ethyl acetate 4:1. Brown oil. 150 mg (54%).

^{1}H NMR (300 MHz, $CDCl_3$) δ 8.30 (broad s, 1H), 8.04-8.00 (m, 2H), 7.58-7.53 (m, 1H), 7.41 (t, J = 7.8 Hz, 2H), 3.78-3.71 (m, 2H), 1.74 (quintet, J = 7.3 Hz, 2H), 1.46-1.20 (m, 10H), 0.89-0.85 (m, 3H).

^{13}C NMR (75 MHz, $CDCl_3$) δ 193.5, 187.9, 134.0, 134.0, 130.9, 128.3, 45.6, 32.0, 29.4, 29.3, 28.0, 27.2, 22.8, 14.3.

HRMS (ESI$^+$) calcd for $C_{16}H_{24}NOS$ $[M + H]^+$ 278.1579. Found 278.1598.

2-Oxo-2-phenyl-*N*-(3-phenylpropyl)ethanethioamide (3n)



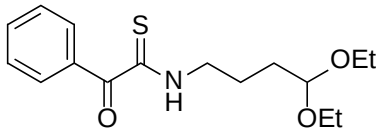
Eluent: heptane:ethyl acetate 4:1. Brown oil. 130 mg (46%).

^{1}H NMR (300 MHz, $CDCl_3$) δ 8.35 (broad s, 1H), 8.00-7.98 (m, 2H), 7.59-7.16 (m, 8H), 3.78 (q, J = 6.7 Hz, 2H), 2.75 (t, J = 6.7 Hz, 2H), 2.09 (quintet, J = 6.7 Hz, 2H).

^{13}C NMR (75 MHz, $CDCl_3$) δ 193.8, 188.0, 140.8, 134.0, 133.9, 130.9, 128.8, 128.6, 128.4, 126.5, 45.0, 33.5, 29.4.

HRMS (ESI$^+$) calcd for $C_{17}H_{18}NOS$ $[M + H]^+$ 284.1093. Found 284.1109.

***N*-(4,4-Diethoxybutyl)-2-oxo-2-phenylethanethioamide (3o)**



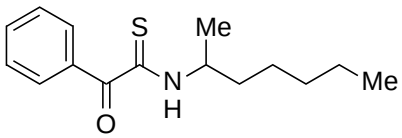
Eluent: heptane:ethyl acetate 4:1 to 3:1. Brown oil. 145 mg (47%).

^{1}H NMR (300 MHz, $CDCl_3$) δ 9.17 (broad s, 1H), 7.99 (d, J = 7.8 Hz, 2H), 7.52 (t, J = 7.8 Hz, 1H), 7.39 (t, J = 7.8 Hz, 2H), 4.62 (t, J = 4.8 Hz, 1H), 3.85-3.80 (m, 2H), 3.71-3.61 (m, 2H), 3.53-3.43 (m, 2H), 2.04-1.98 (m, 2H), 1.16 (t, J = 7.1 Hz, 6H).

^{13}C NMR (75 MHz, $CDCl_3$) δ 193.4, 188.0, 133.9, 133.8, 130.7, 128.2, 102.6, 62.7, 41.5, 31.4, 15.3.

HRMS (ESI$^+$) calcd for $C_{16}H_{24}NO_3S$ $[M + H]^+$ 310.1477. Found: 310.1456.

_N_-(Heptan-2-yl)-2-oxo-2-phenylethanethioamide (3p)



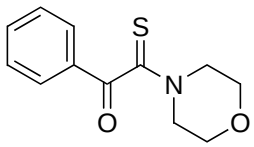
Eluent: heptane:ethyl acetate 3:1. Brown oil. 154 mg (59%).

^{1}H NMR (300 MHz, $CDCl_3$) δ 8.23 (broad d, J = 7.7 Hz, 1H), 8.01 (d, J = 8.0 Hz, 2H), 7.58 (t, J = 8.0 Hz, 1H), 7.43 (t, J = 8.0 Hz, 2H), 4.76-4.62 (m, 1H), 1.81-1.59 (m, 3H), 1.47-1.32 (m, 5H), 1.36 (d, J = 6.4 Hz, 3H), 0.92 (t, J = 6.7 H2, 3H).

^{13}C NMR (75 MHz, $CDCl_3$) δ 192.9, 188.2, 134.0, 133.9, 130.8, 128.3, 51.0, 35.7, 31.7, 25.8, 22.7, 19.3, 14.2.

HRMS (ESI$^+$) calcd for $C_{15}H_{22}NOS$ $[M + H]^+$ 264.1422. Found 264.1431.

2-Morpholino-1-phenyl-2-thioxoethan-1-one (3q)[2]

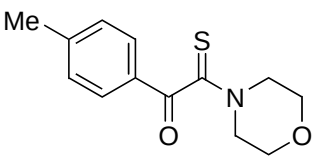


Eluent: heptane:ethyl acetate 3:1. Yellow solid. mp 112-113 °C (lit. 113-116 °C).[2] 179 mg (76%).

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.96 (d, J = 7.5 Hz, 2H), 7.59 (t, J = 7.5 Hz, 1H), 7.46 (t, J = 7.5 Hz, 2H), 4.30 (t, J = 5.0 Hz, 2H), 3.87 (t, J = 5.0 Hz, 2H), 3.67-3.65 (m, 2H), 3.58-3.56 (m, 2H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 195.9, 188.0, 134.6, 133.4, 130.0, 129.1, 66.6, 66.5, 52.1, 47.3.

2-Morpholino-2-thioxo-1-(*p*-tolyl)ethan-1-one (3r)[2]



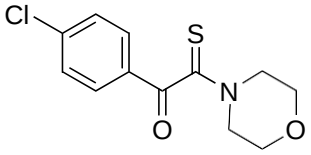
[2] H. Li, W. Xue, and A. Wu, *Tetrahedron*, 2014, **70**, 4645.

Eluent: heptane:ethyl acetate 3:1. Yellow crystal. mp 117-118 °C (lit 115-117 °C).[2] 181 mg (73%).

^{1}H NMR (300 MHz, $CDCl_3$) δ 7.86 (d, J = 8.2 Hz, 2H), 7.26 (d, J = 8.2 Hz, 2H), 4.30 (t, J = 5.0 Hz, 2H), 3.87 (t, J = 5.0 Hz, 2H), 3.67-3.65 (m, 2H), 3.57-3.55 (m, 2H), 2.40 (s, 3H).

^{13}C NMR (75 MHz, $CDCl_3$) δ 196.1, 188.0, 145.9, 130.8, 130.1, 129.8, 66.6, 66.5, 52.0, 47.2, 22.0.

1-(4-Chlorophenyl)-2-morpholino-2-thioxoethan-1-one (3s)[2]

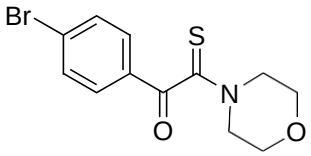


Eluent: heptane:ethyl acetate 3:1. Yellow solid. mp 153-154 °C (lit. 153-155 °C).[3] 187 mg (69%).

^{1}H NMR (300 MHz, $CDCl_3$) δ 7.91 (d, J = 8.5 Hz, 2H), 7.45 (d, J = 8.5 Hz, 2H), 4.29 (t, J = 5.0 Hz, 2H), 3.87 (t, J = 5.0 Hz, 2H), 3.69-3.66 (m, 2H), 3.58-3.55 (m, 2H).

^{13}C NMR (75 MHz, $CDCl_3$) δ 195.1, 186.6, 141.2, 131.9, 131.3, 129.5, 66.7, 66.5, 52.1, 47.3

1-(4-Bromophenyl)-2-morpholino-2-thioxoethan-1-one (3t)[4]

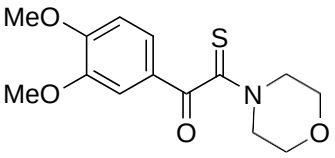


Eluent: heptane:ethyl acetate 1:1. White solid. mp 161-162 °C (lit 157-159 °C).[4] 210 mg (67%).

^{1}H NMR (300 MHz, $CDCl_3$) δ 7.82 (d, J = 8.5 Hz, 2H), 7.60 (d, J = 8.5 Hz, 2H), 4.28 (t, J = 5.0 Hz, 2H), 3.85 (t, J = 5.0 Hz, 2H), 3.68-3.64 (m, 2H), 3.58-3.54 (m, 2H).

^{13}C NMR (75 MHz, $CDCl_3$) δ 194.9, 186.7, 132.4, 132.3, 131.3, 130.0, 66.6, 66.5, 52.1, 47.3.

1-(3,4-Dimethoxyphenyl)-2-morpholino-2-thioxoethan-1-one (3u)[5]



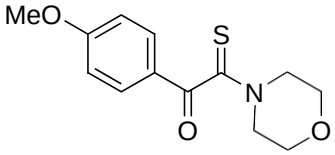
Eluent: heptane:ethyl acetate 1:1 to 1:2. Yellow solid. mp 143-144 °C (lit 144-146 °C).[5] 201 mg (68%).

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.46 (dd, J = 8.2, 2.2 Hz, 1H), 7.44 (d, J = 2.2 Hz, 1H), 6.81(d, J = 8.2 Hz, 1H), 4.21 (t, J = 5.0 Hz, 2H), 3.84 (s, 3H), 3.80 (s, 3H), 3.77 (t, J = 5.0 Hz, 2H), 3.58-3.56 (m, 2H), 3.50-3.46 (m, 2H).

[3] F. M. Moghaddam, Z. Mirjafary, H. Saeidian and M. J. Javan, *Synlett* 2008, **6**, 892.
[4] S. Ravez, C. Corbet, Q. Spillier, A. Dutu, A. D. Robin, E. Mullarky, L. C. Cantley, O. Feron and R. Frédérick, *J. Med. Chem.* 2017, **60**, 1591.
[5] B. Eftekhari-Sis, S. V. Khajeh and O. Bueyuekguengoer, *Synlett* 2013, **24**, 977.

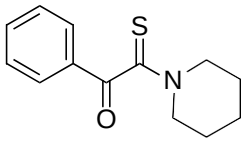
^{13}C NMR (125 MHz, $CDCl_3$) δ 195.8, 187.2, 154.4, 149.3, 126.0, 125.5, 110.7, 110.4, 66.4, 66.2, 56.2, 56.0, 51.8, 47.1.

1-(4-Methoxyphenyl)-2-morpholino-2-thioxoethan-1-one (3v)[2]



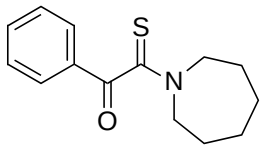
Eluent: heptane:ethyl acetate 1:1. Yellow solid. mp 118-119 °C (lit 120-123 °C).[2] 185 mg (70%).
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.88 (d, J = 8.8 Hz, 2H), 6.89 (d, J = 8.8 Hz, 2H), 4.24 (t, J = 5.0 Hz, 2H), 3.82 (t, J = 5.0 Hz, 2H), 3.80 (s, 3H), 3.62-3.60 (m, 2H), 3.53-3.51 (m, 2H).
^{13}C NMR (125 MHz, $CDCl_3$) δ 196.0, 187.2, 164.6, 132.2, 125.9, 114.3, 66.5, 66.3, 55.7, 51.9, 47.1.

1-Phenyl-2-(piperidin-1-yl)-2-thioxoethan-1-one (3w)[2]



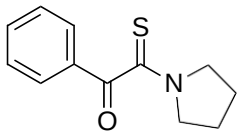
Eluent: heptane:ethyl acetate 3:1. Yellow solid. mp 76-77 °C (lit 70-74 °C).[2] 177 mg (76%).
^{1}H NMR (300 MHz, $CDCl_3$) δ 7.97-7.93 (m, 2H), 7.60-7.54 (m, 1H), 7.48-7.42 (m, 2H), 4.21 (t, J = 5.4 Hz, 2H), 3.49 (t, J = 5.4 Hz, 2H), 1.83-1.69 (m, 4H), 1.61-1.53 (m, 2H).
^{13}C NMR (75 MHz, $CDCl_3$) δ 194.1, 187.9, 134.1, 133.3, 129.6, 128.8, 52.9, 48.0, 26.3, 25.3, 23.9.

2-(Azepan-1-yl)-1-phenyl-2-thioxoethan-1-one (3x)



Eluent: heptane:ethyl acetate 3:1. Brown oil. 182 mg (74%).
^{1}H NMR (300 MHz, $CDCl_3$) δ 7.97-7.94 (m, 2H), 7.58-7.53 (m, 1H), 7.47-7.41 (m, 2H), 4.14-4.10 (m, 2H), 3.58-3.54 (m, 2H), 1.99-1.91 (m, 2H), 1.73-1.53 (m, 4H).
^{13}C NMR (75 MHz, $CDCl_3$) δ 196.1, 187.8, 134.1, 133.6, 130.0, 128.9, 54.1, 51.4, 28.6, 27.6, 26.3, 25.6.
HRMS (ESI^+) calcd for $C_{10}H_{12}N_3$ $[M + H]^+$ 248.1109. Found 248.1125.

1-Phenyl-2-(pyrrolidin-1-yl)-2-thioxoethan-1-one (3y)[5]

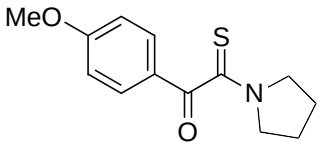


Eluent: heptane:ethyl acetate 2:1. Yellow solid. mp 115 °C (lit. 117 °C).[6] 160 mg (73%).

^{1}H NMR (300 MHz, $CDCl_3$) δ 7.99 (d, J = 8.1 Hz, 2H), 7.57 (t, J = 8.1 Hz, 1H), 7.45 (t, J = 8.1 Hz, 2H), 3.91 (t, J = 6.9 Hz, 2H), 3.48 (t, J = 6.9 Hz, 2H), 2.03-1.99 (m, 4H).

^{13}C NMR (75 MHz, $CDCl_3$) δ 192.6, 188.7, 134.2, 132.7, 130.0, 128.8, 51.3, 51.1, 26.1, 23.8.

1-(4-Methoxyphenyl)-2-(pyrrolidin-1-yl)-2-thioxoethan-1-one (3z)[5]



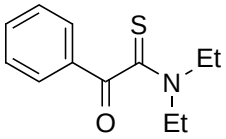
Eluent: heptane:ethyl acetate 1:1. Yellow solid. mp 118 °C (112-114 °C).[7] 174 mg (70%).

^{1}H NMR (300 MHz, $CDCl_3$) δ 7.92 (d, J = 8.7 Hz, 2H), 6.89 (d, J = 8.7 Hz, 2H), 3.87 (t, J = 6.8 Hz, H),

3.81 (s, 3H), 3.46 (t, J = 6.8 Hz, 2H), 2.05-1.92 (m, 4H).

^{13}C NMR (75 MHz, $CDCl_3$) δ 193.2, 188.2, 164.6, 132.6, 125.7, 114.3, 55.7, 51.3, 51.2, 26.2, 24.0.

***N*,*N*-Diethyl-2-oxo-2-phenylethanethioamide (3aa)**



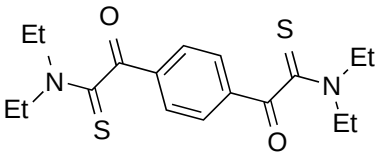
Eluent: heptane:ethyl acetate 1:4. Orange oil.182 mg (82%).

^{1}H NMR (300 MHz, $CDCl_3$) δ 7.91 (d, J = 7.8 Hz, 2H), 7.54 (t, J = 7.8 Hz, 1H), 7.41 (t, J = 7.8 Hz, 2H), 3.99 (q, J = 7.1 Hz, 2H), 3.42 (q, J = 7.1 Hz, 2H), 1.34 (t, J = 7.1 Hz, 3H), 1.15 (t, J = 7.1 Hz, 3H).

^{13}C NMR (75 MHz, $CDCl_3$) δ 195.5, 187.5, 134.1, 133.5, 129.9, 128.8, 48.0, 44.6, 13.7, 11.3.

HRMS (ESI^+) calcd for $C_{12}H_{16}NOS$ $[M + H]^+$ 222.0953. Found 222.0939.

2,2'-(1,4-Phenylene)bis(*N*,*N*-diethyl-2-oxoethanethioamide) (3ab)



Eluent: heptane:ethyl acetate 1:2 to 1:1. Yellow solid. mp 146-148 °C. 201 mg (55%).

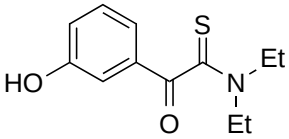
^{1}H NMR (300 MHz, $CDCl_3$) δ 8.07 (s, 4H), 4.06 (q, J = 7.1 Hz, 4H), 3.49 (q, J = 7.1 Hz, 4H), 1.41 (t, J = 7.1 Hz, 6H), 1.25 (t, J = 7.1 Hz, 6H).

^{13}C NMR (75 MHz, $CDCl_3$) δ 194.6, 185.6, 137.7, 130.2, 48.2, 44.8, 13.9, 11.4.

[6] N. Paul, R. Sathishkumar, C. Anuba and S. Muthusubramanian, *RSC Advances* 2013, **3**, 7445.
[7] B. Eftekhari-Sis, S. Vahdati-Khajeh, S. M. ; Amini, Maryam, Z. and Mahnaz, S. *J. Sulfur Chem.* 2013, **34**, 464.

HRMS (ESI$^+$) calcd for $C_{18}H_{25}N_2O_2S_2$ $[M + H]^+$ 365.1357. Found 365.1376.

***N*,*N*-Diethyl-2-(3-hydroxyphenyl)-2-oxoethanethioamide (3ac)**



Eluent: heptane:ethyl acetate 1:2 to 1:1. Orange oil. 150 mg (63%).

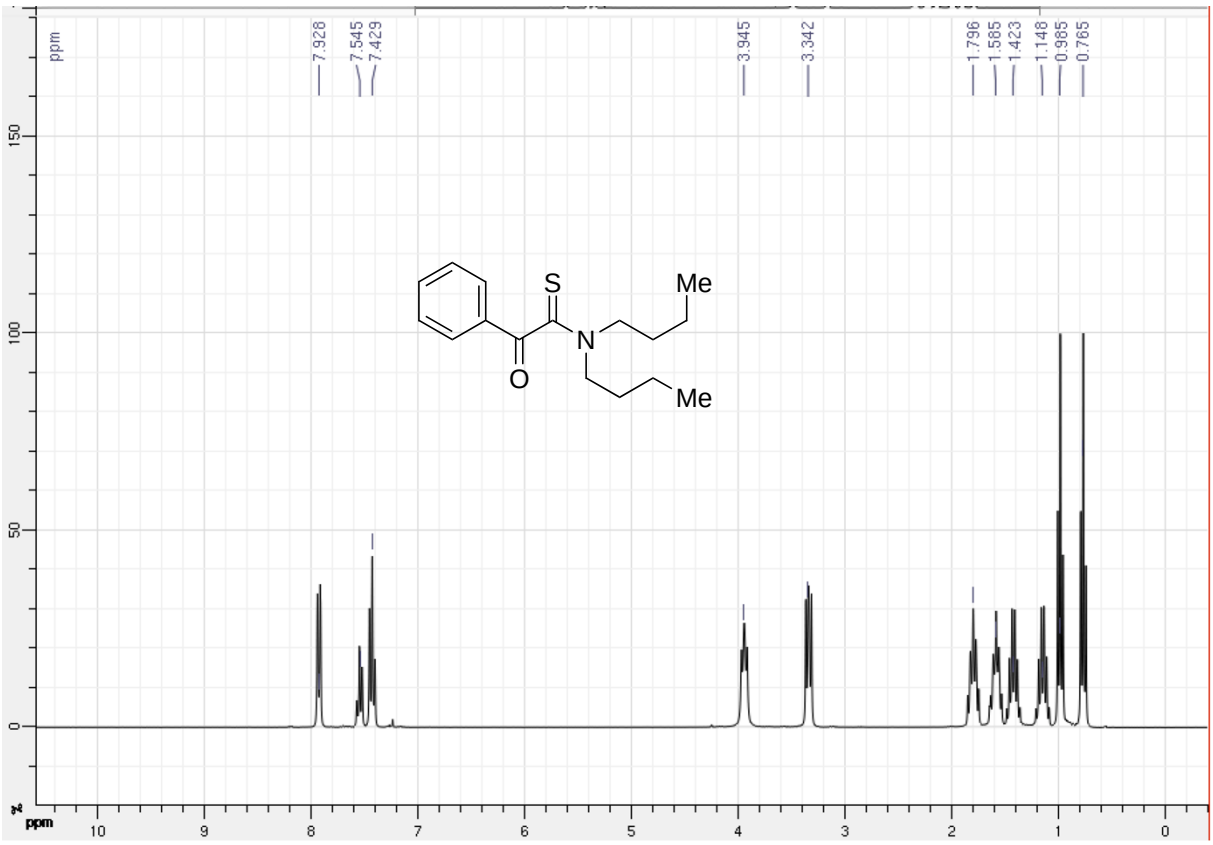
^{1}H NMR (300 MHz, $CDCl_3$) δ 7.51-7.45 (m, 2H), 7.33-7.27 (m, 1H), 7.09-7.05 (m, 1H), 6.56 (broad s, 1H), 4.04 (q, J = 7.1 Hz, 2H), 3.49 (q, J = 7.1 Hz, 2H), 1.41 (t, J = 7.1 Hz, 3H), 1.23 (t, J = 7.1 Hz, 3H).

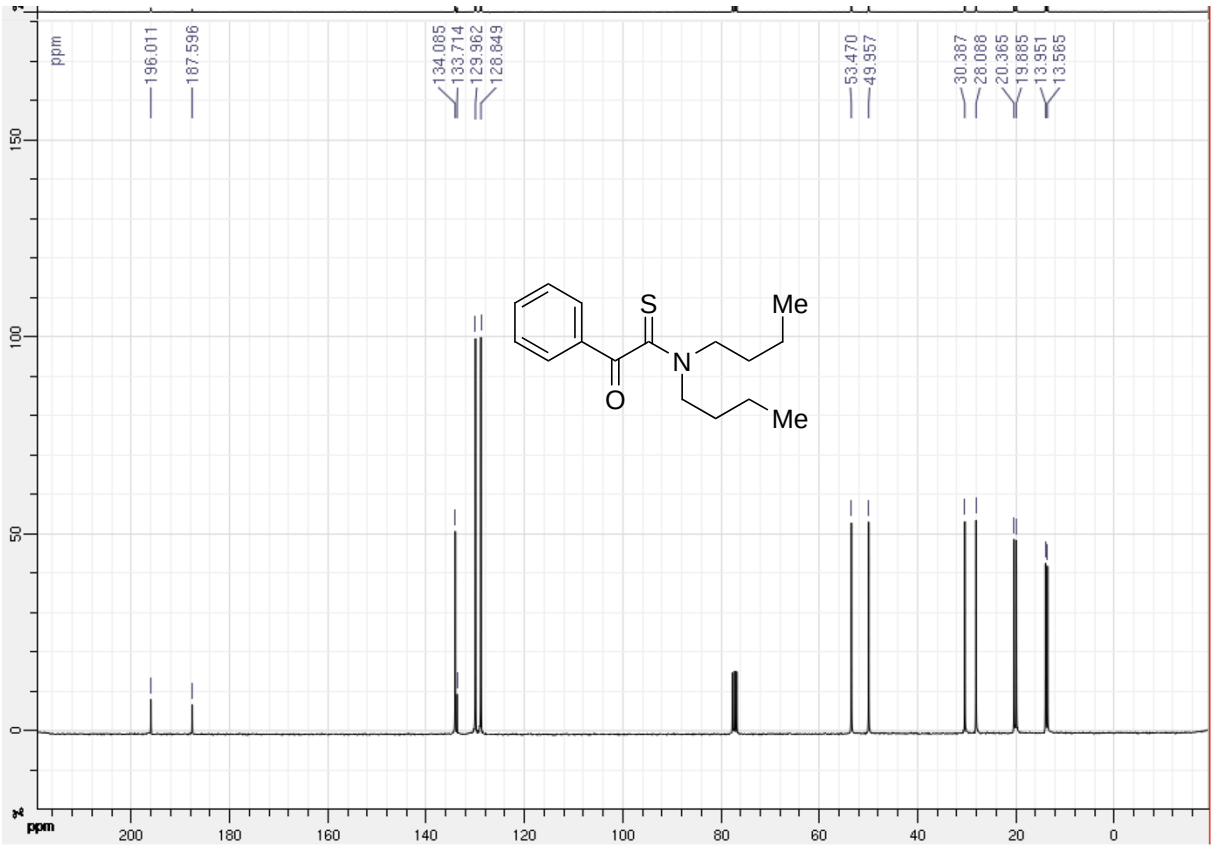
^{13}C NMR (75 MHz, $CDCl_3$) δ 195.4, 187.8, 156.6, 134.7, 130.3, 122.6, 122.1, 116.4, 48.4, 44.9, 13.8, 11.5.

HRMS (ESI$^+$) calcd for $C_{12}H_{16}NO_2S$ $[M + H]^+$ 238.0902. Found 238.0923.

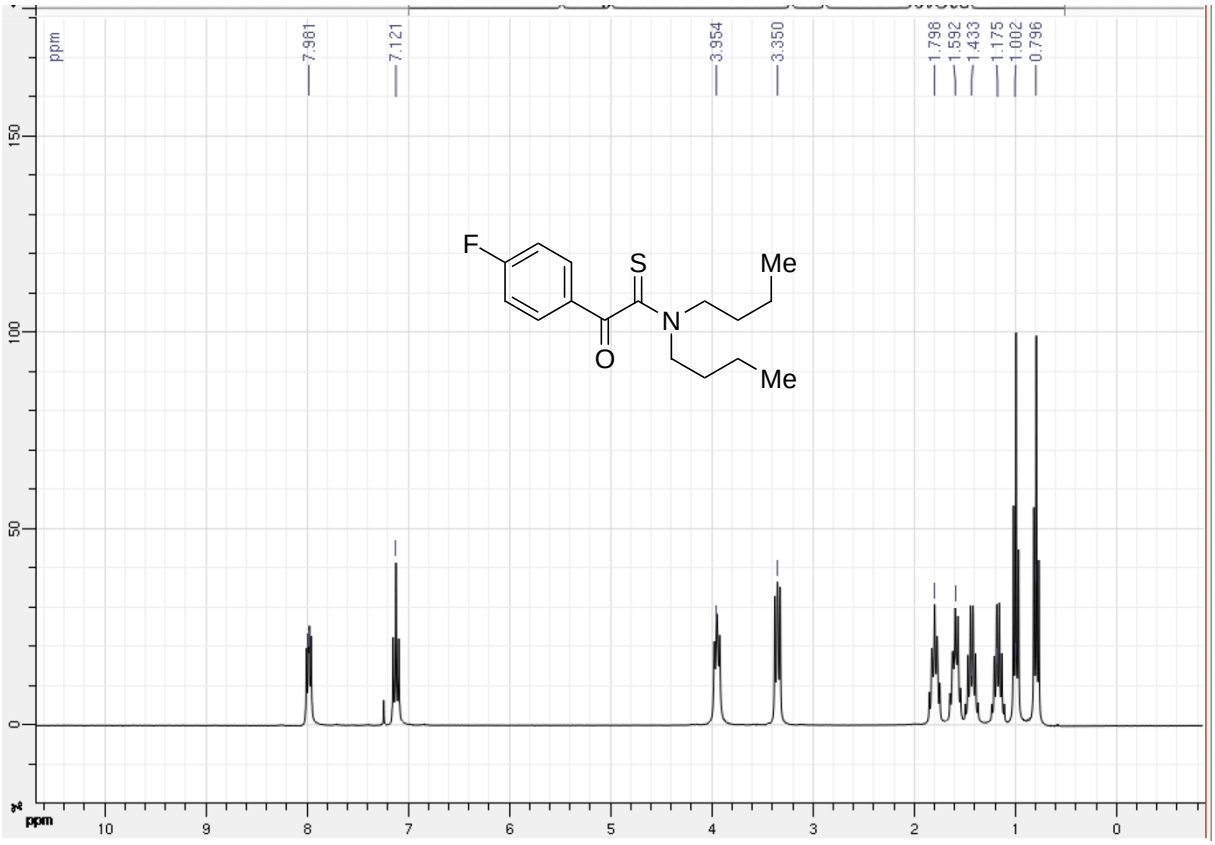
Copies of ^{1}H and ^{13}C NMR

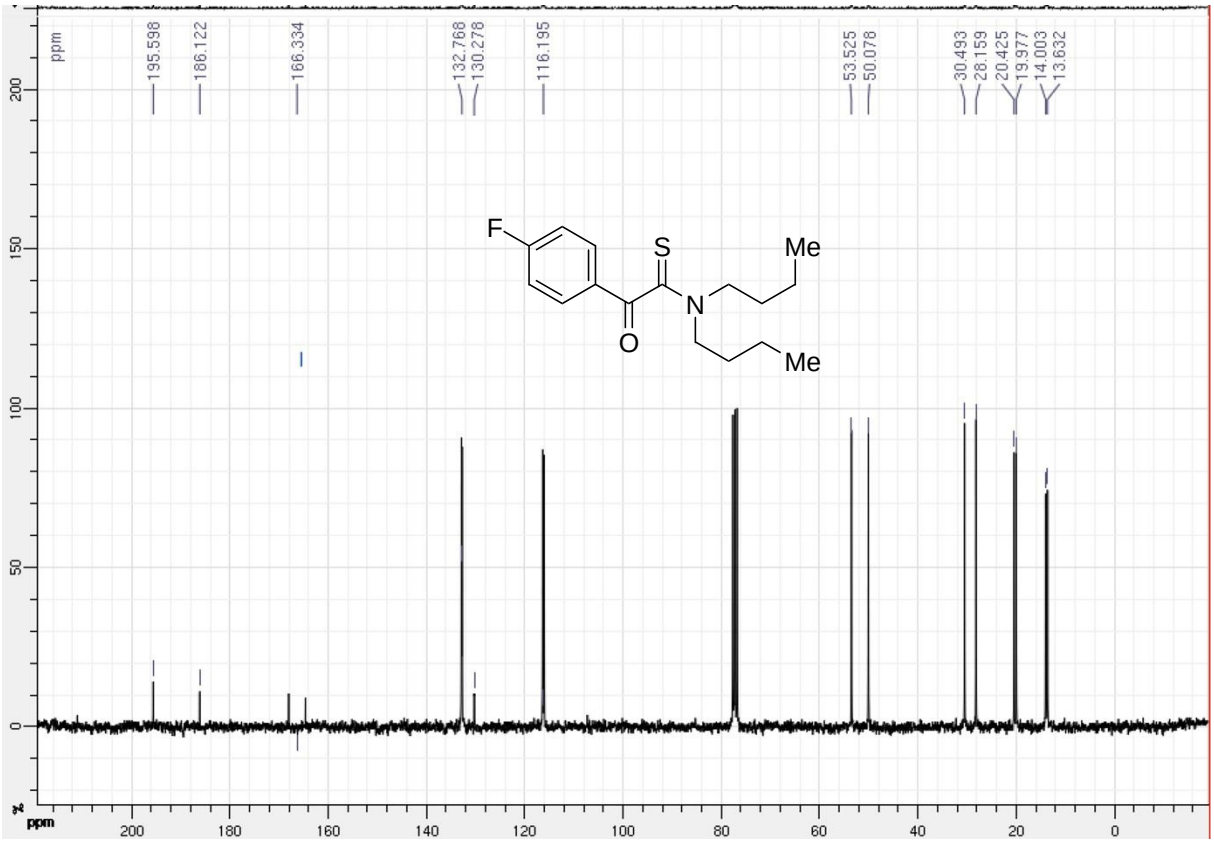
***N*,*N*-Dibutyl-2-phenyl-2-oxoethanethioamide (3a)**

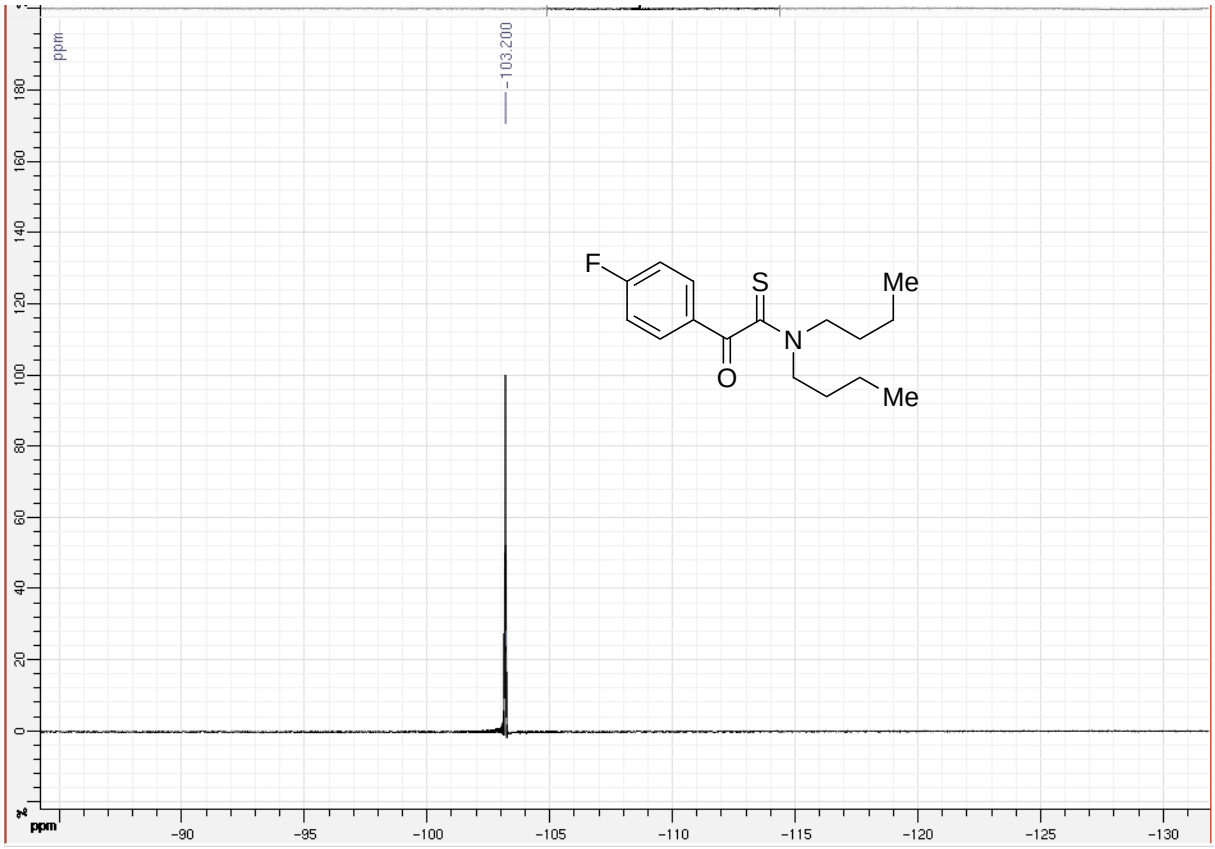




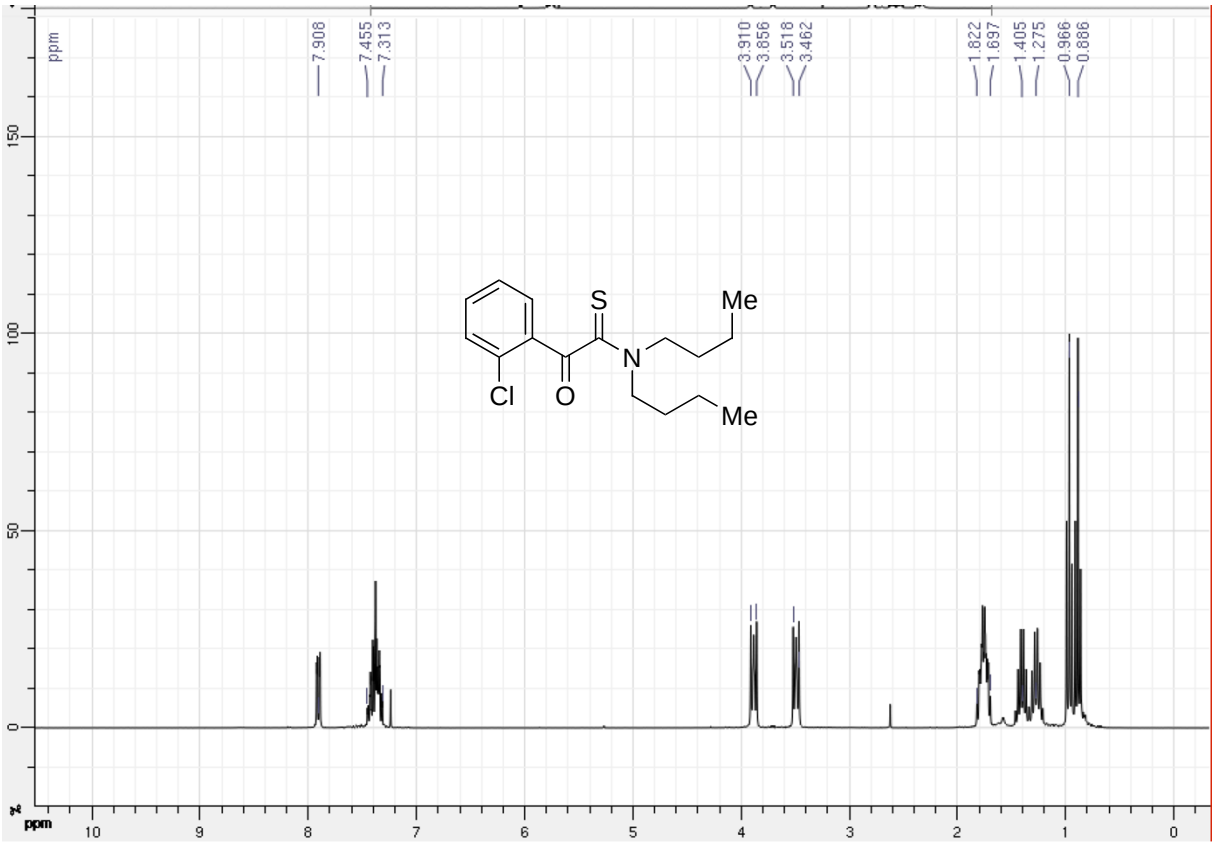
***N*,*N*-Dibutyl-2-(4-fluorophenyl)-2-oxoethanethioamide (3b)**

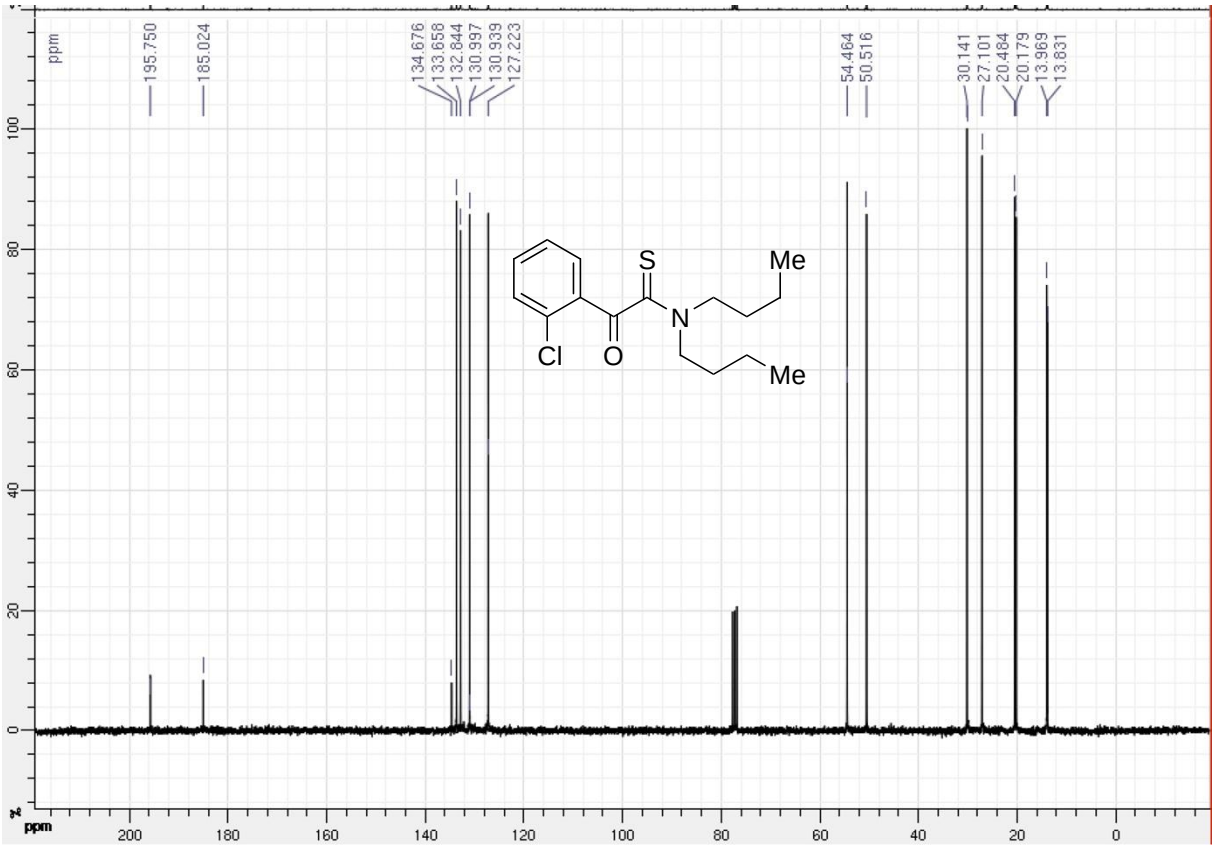




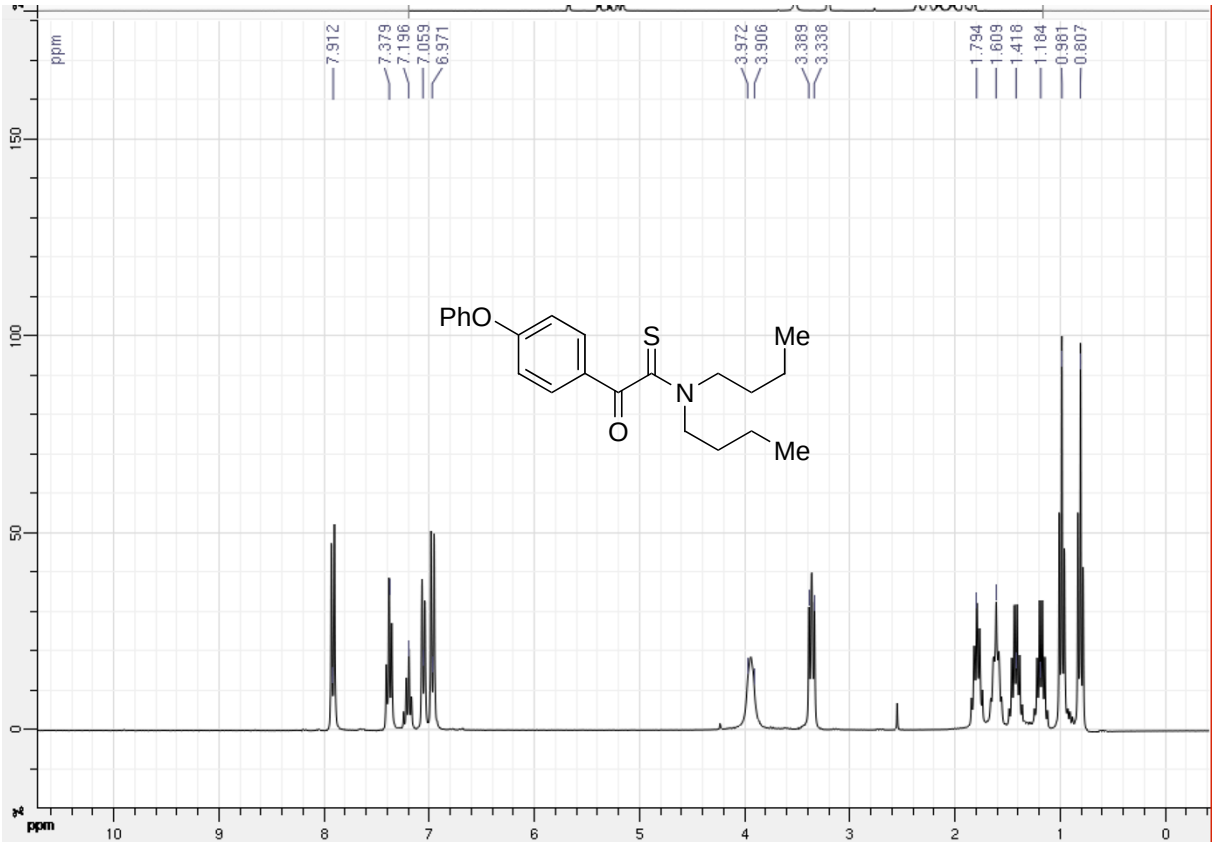

ppm
-103.200
F
S
Me
N
O
Me
ppm
-90
-95
-100
-105
-110
-115
-120
-125
-130

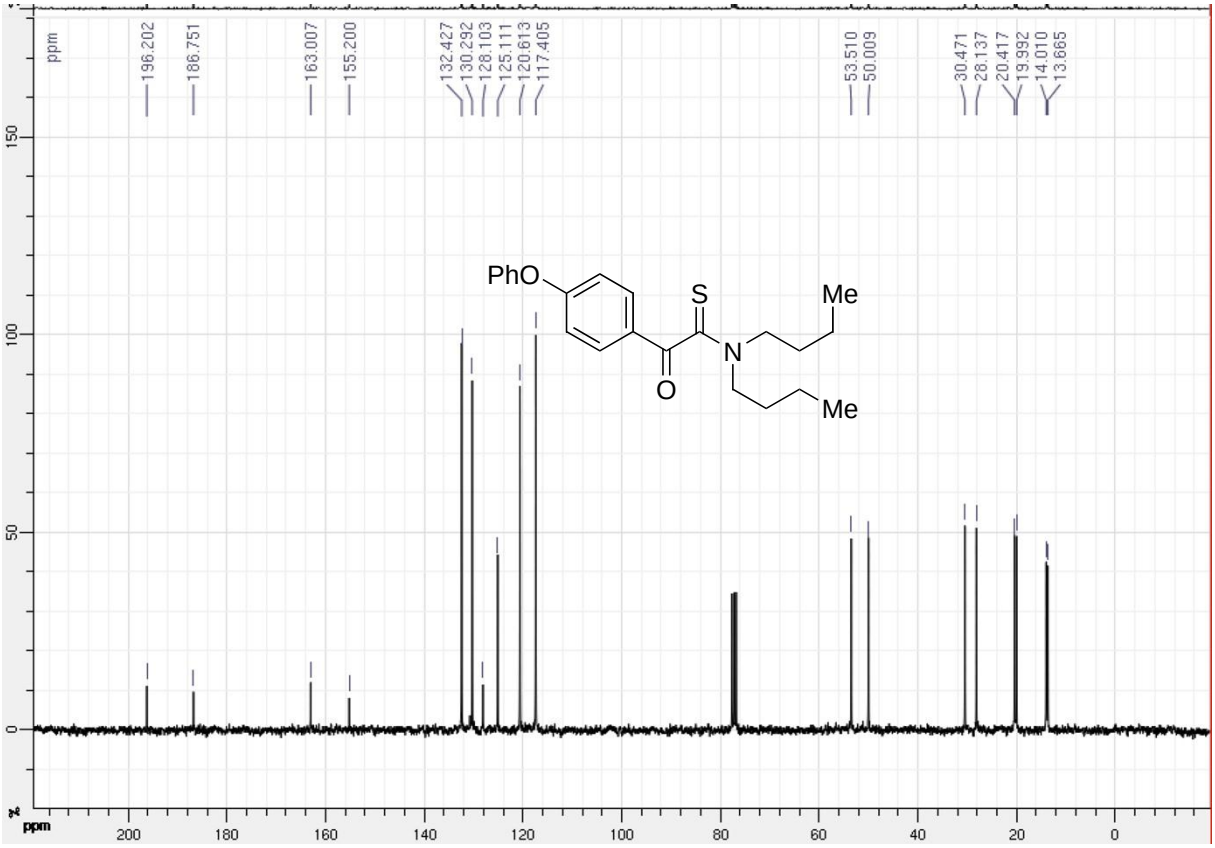
***N*,*N*-Dibutyl-2-(2-chlorophenyl)-2-oxoethanethioamide (3c)**



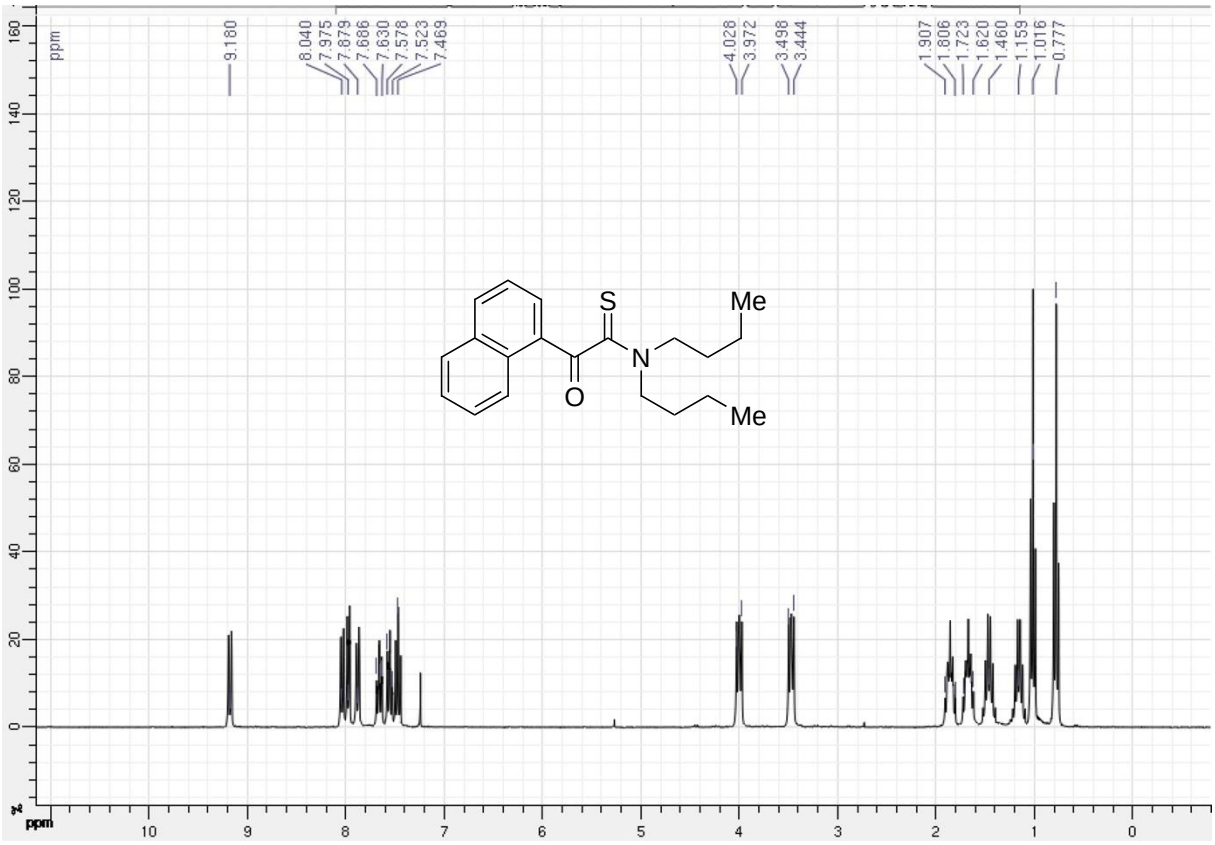


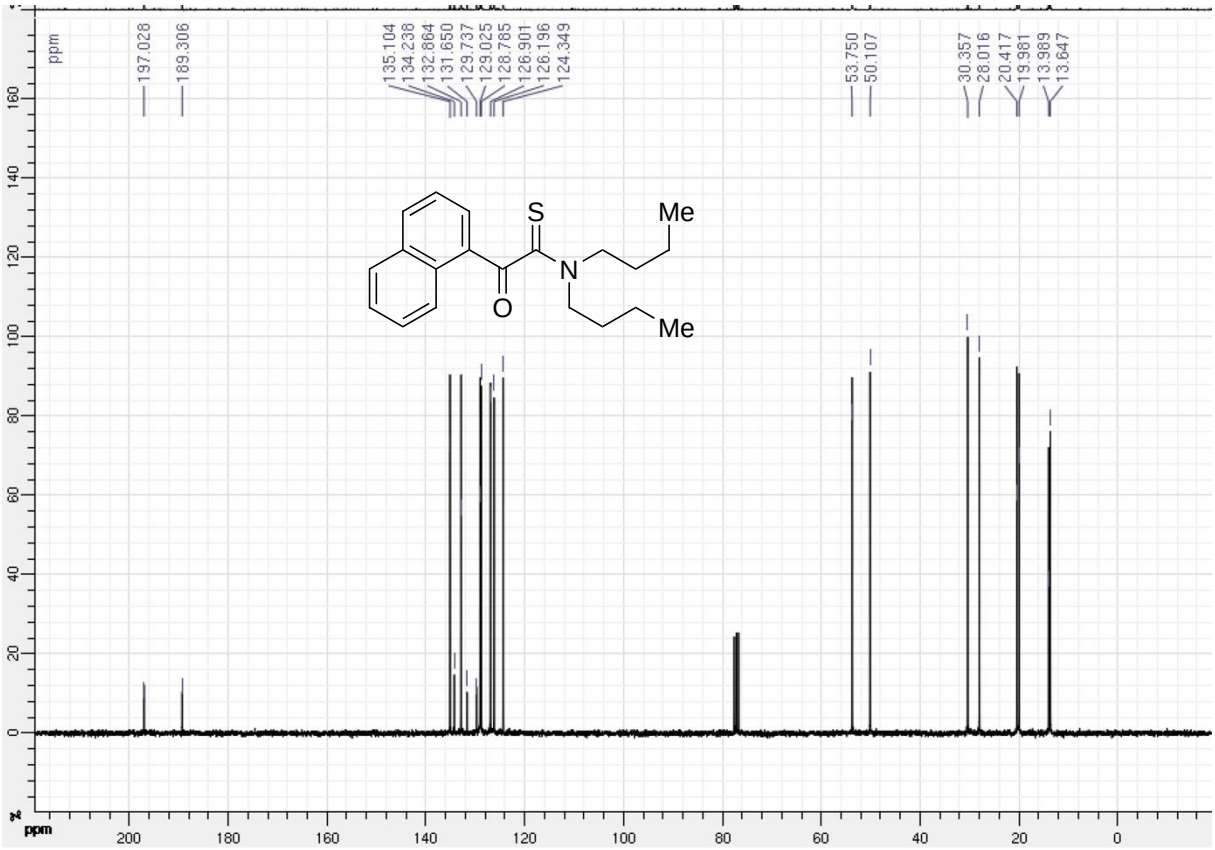
***N*,*N*-Dibutyl-2-oxo-2-(4-phenoxyphenyl)ethanethioamide (3d)**



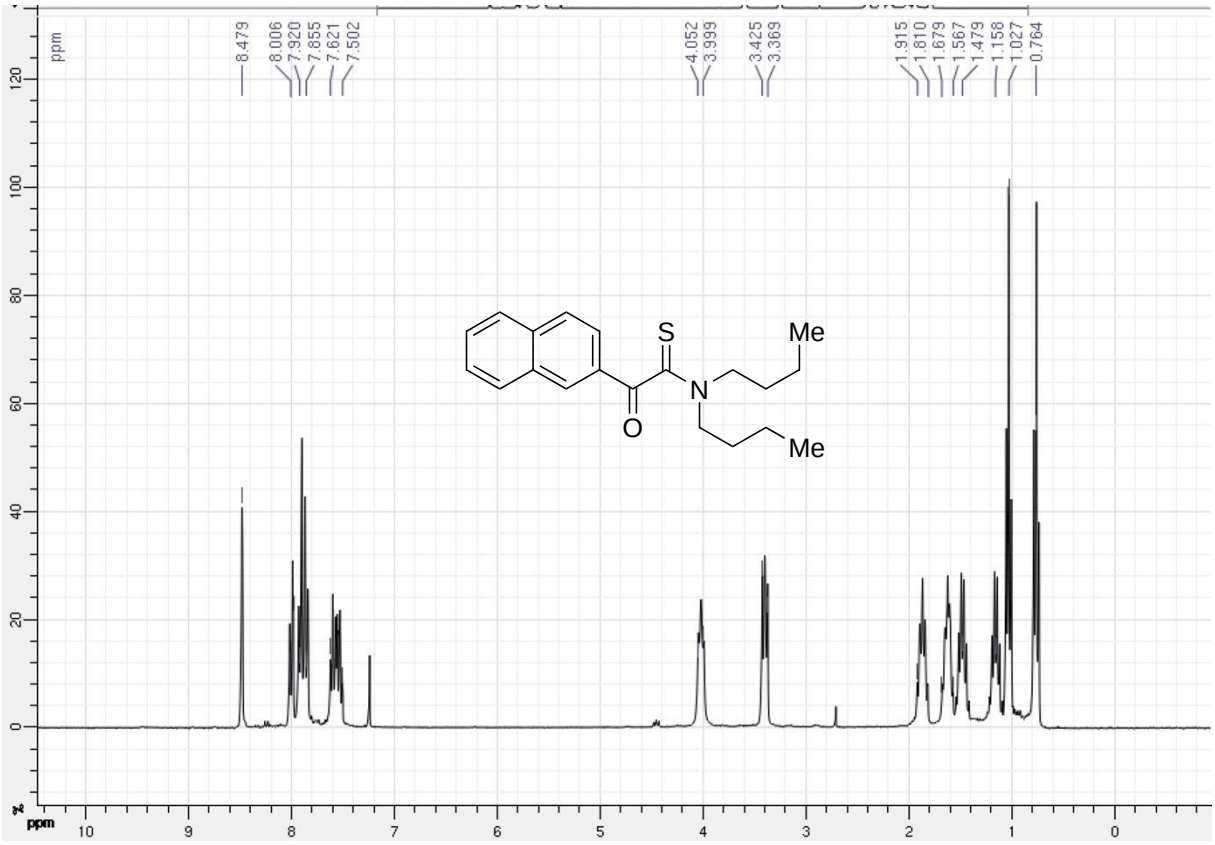


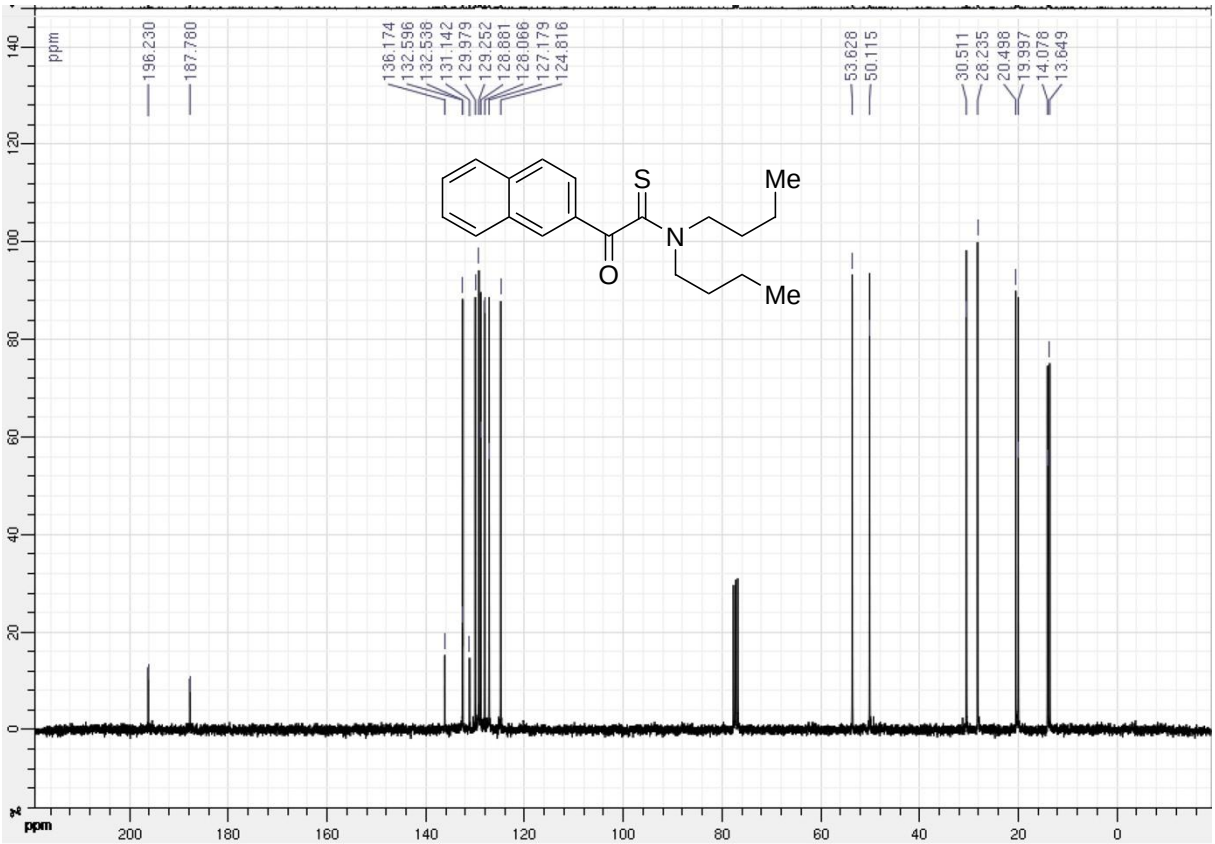
***N*,*N*-Dibutyl-2-(naphthalen-1-yl)-2-oxoethanethioamide (3e)**



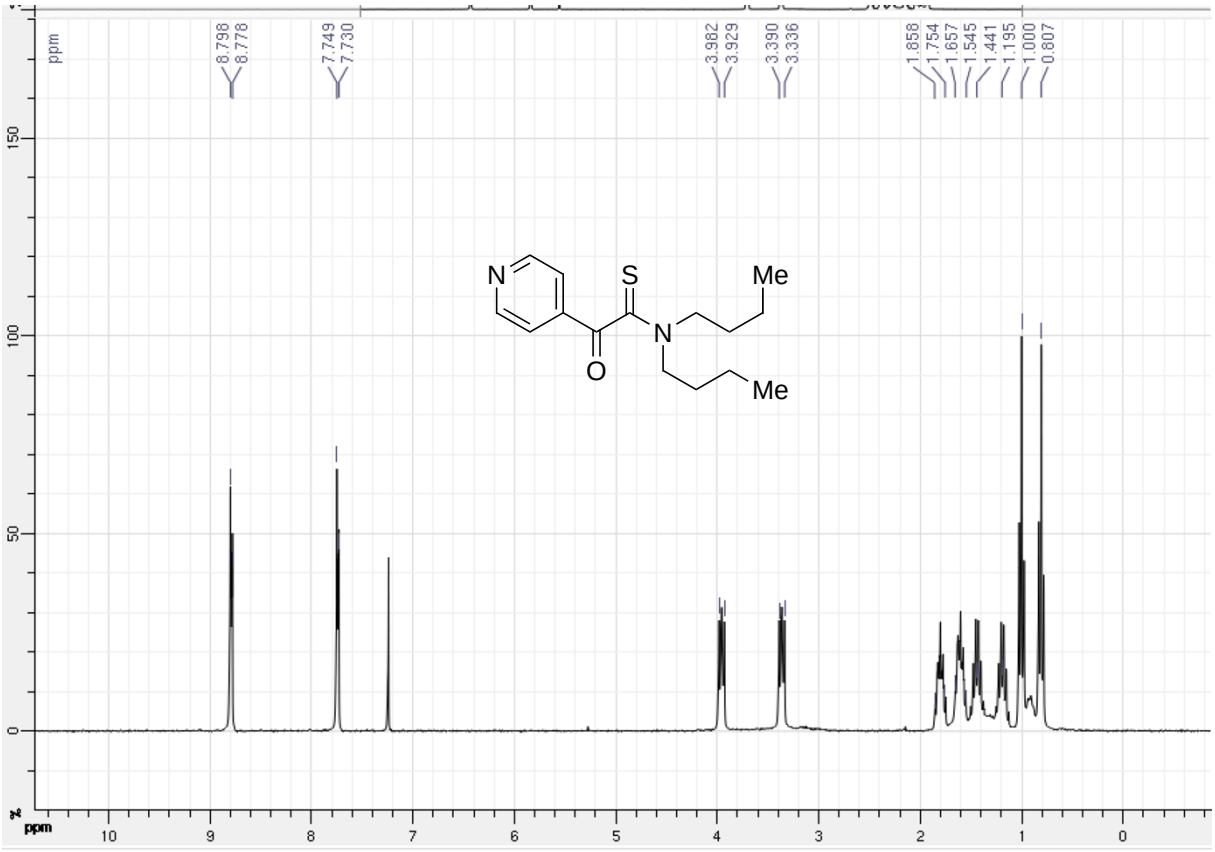


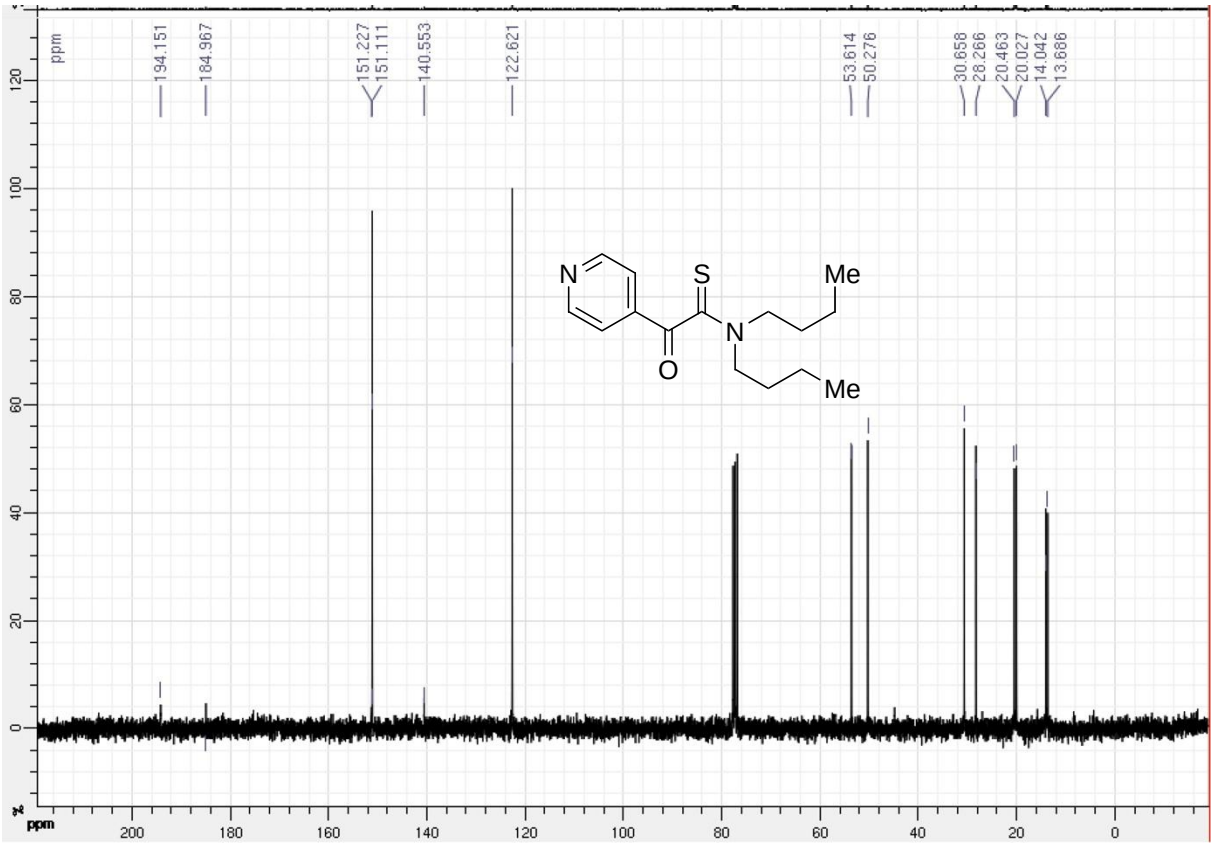
***N*,*N*-Dibutyl-2-(naphthalen-2-yl)-2-oxoethanethioamide (3f)**



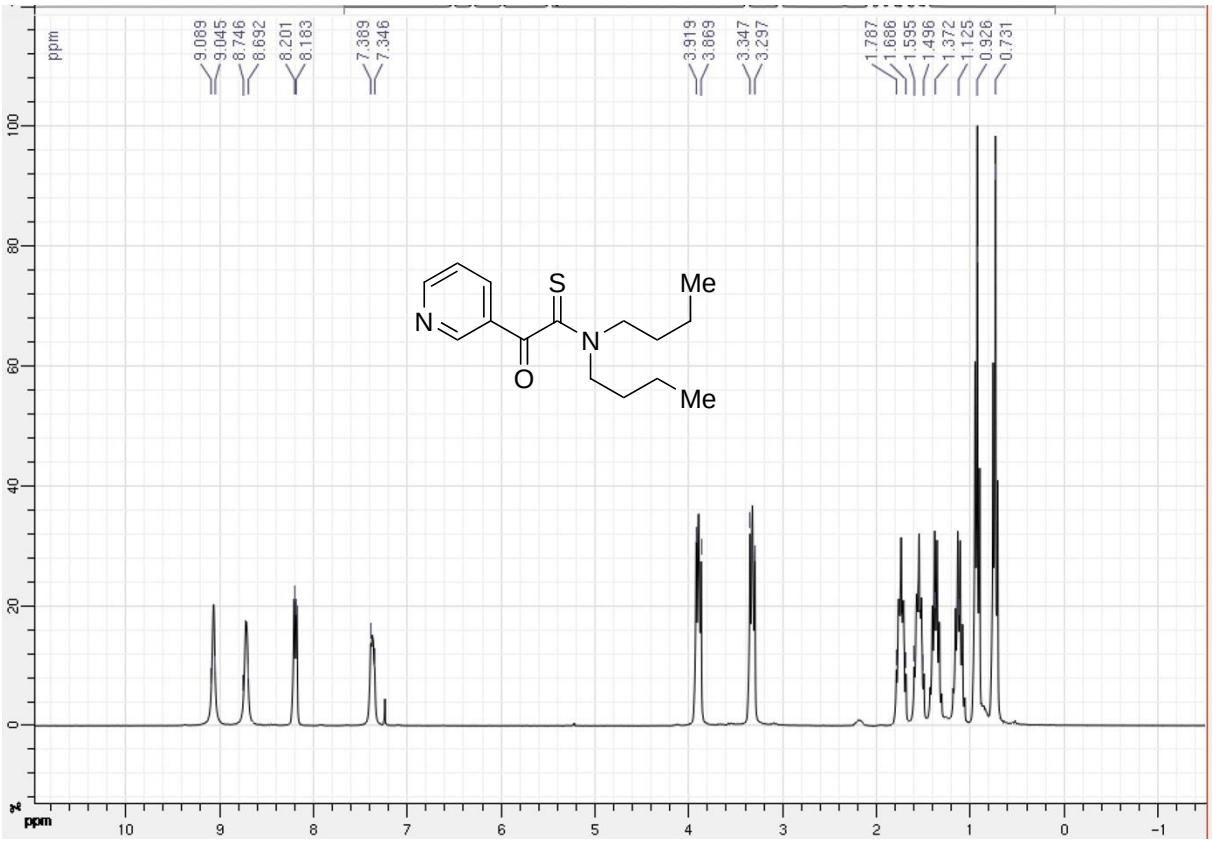


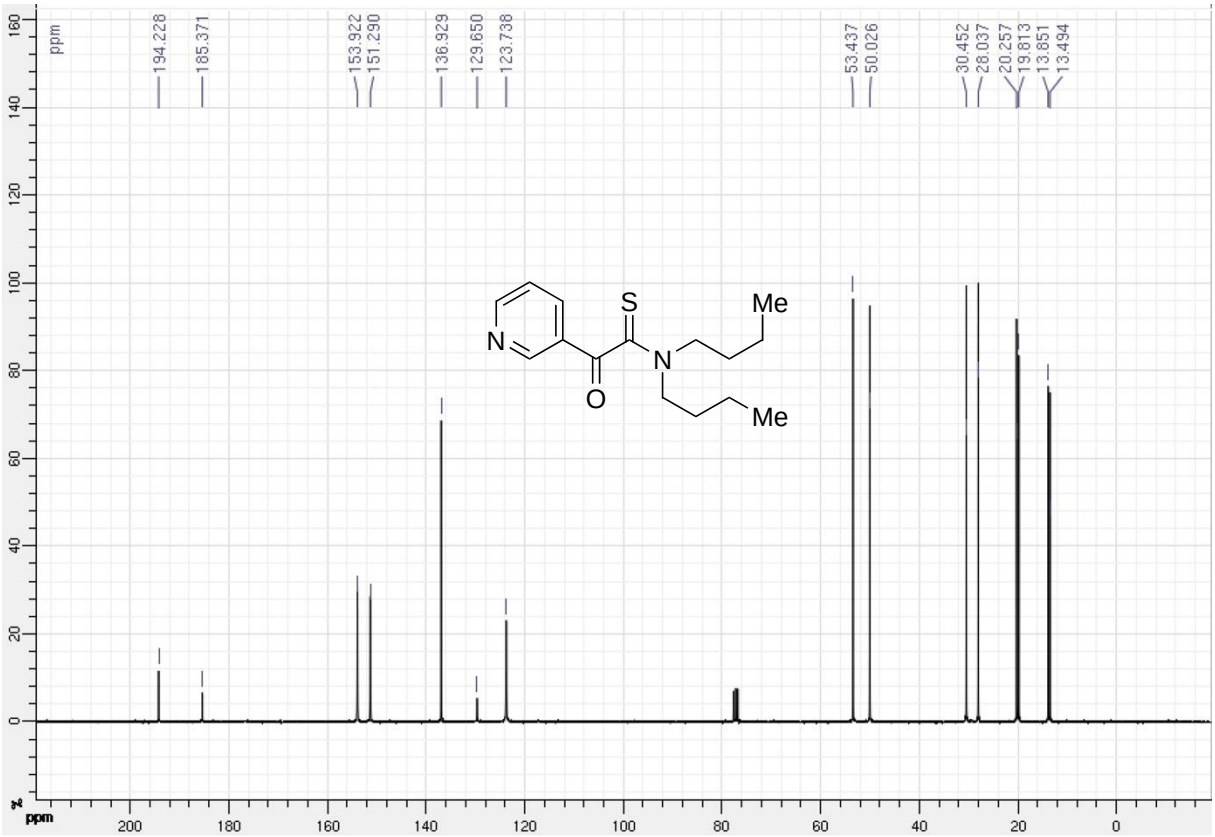
***N*,*N*-Dibutyl-2-oxo-2-(pyridin-4-yl)ethanethioamide (3g)**





***N*,*N*-Dibutyl-2-oxo-2-(pyridin-3-yl)ethanethioamide (3h)**





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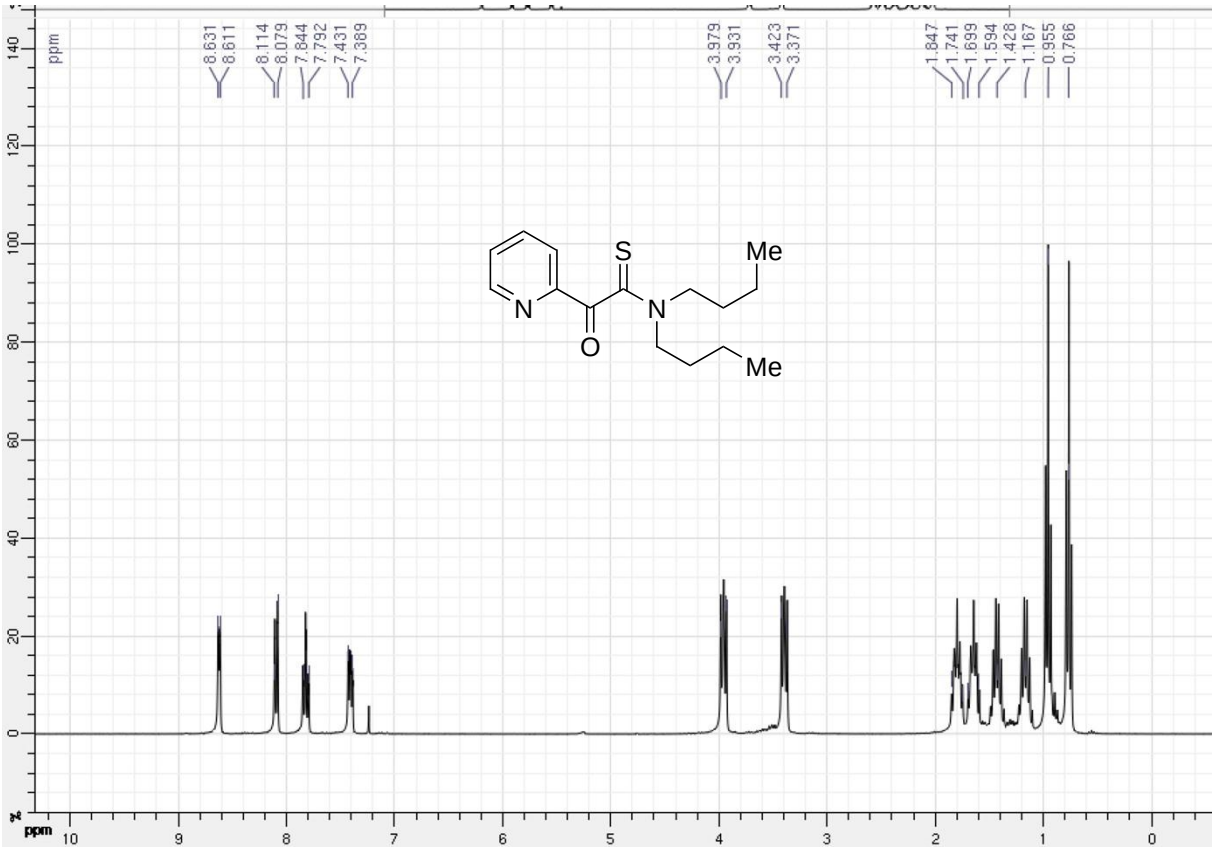

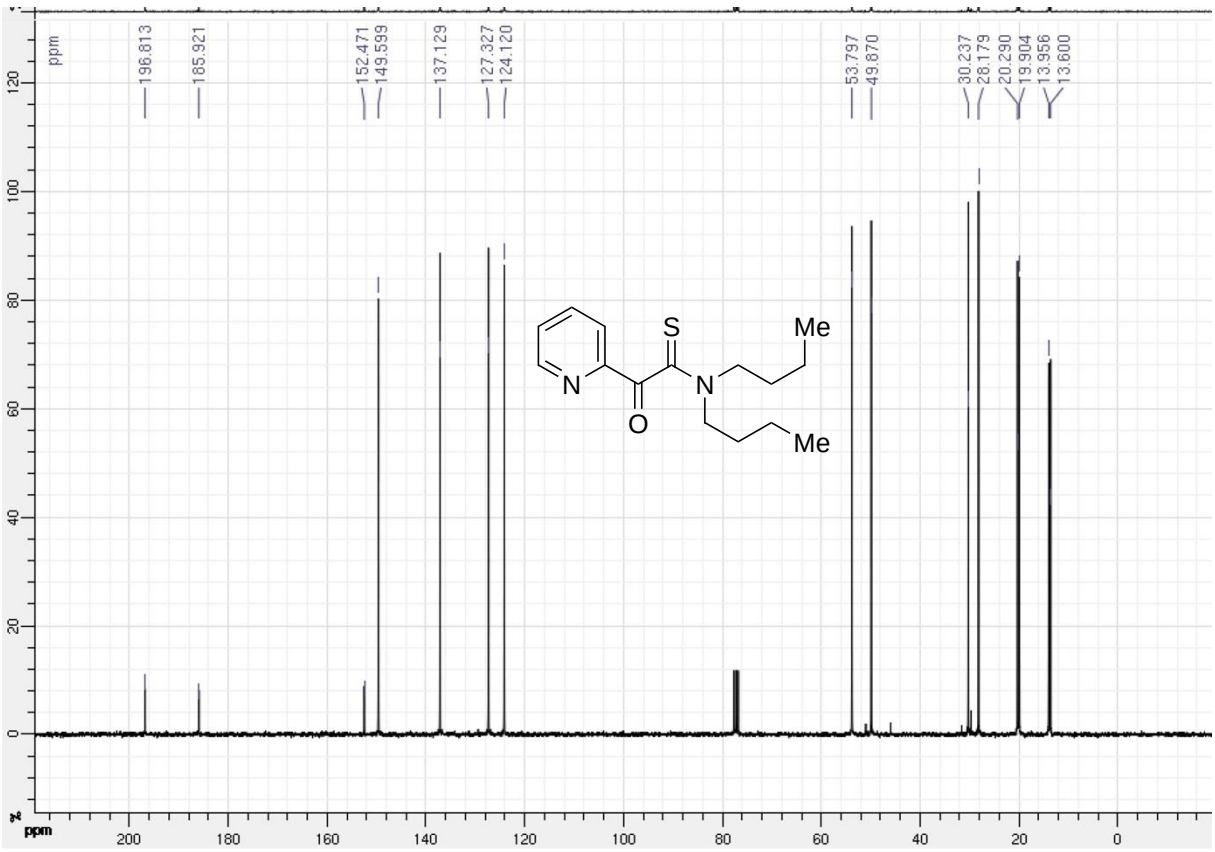

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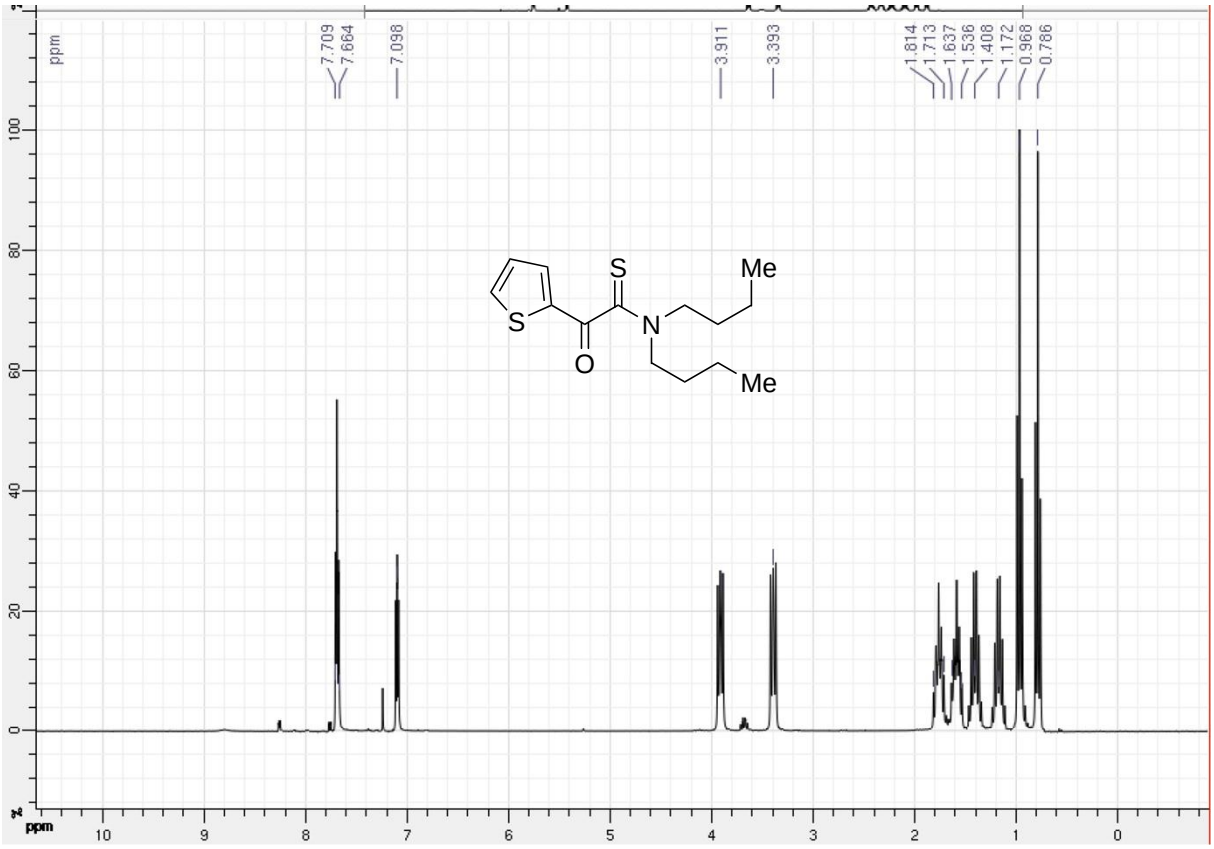

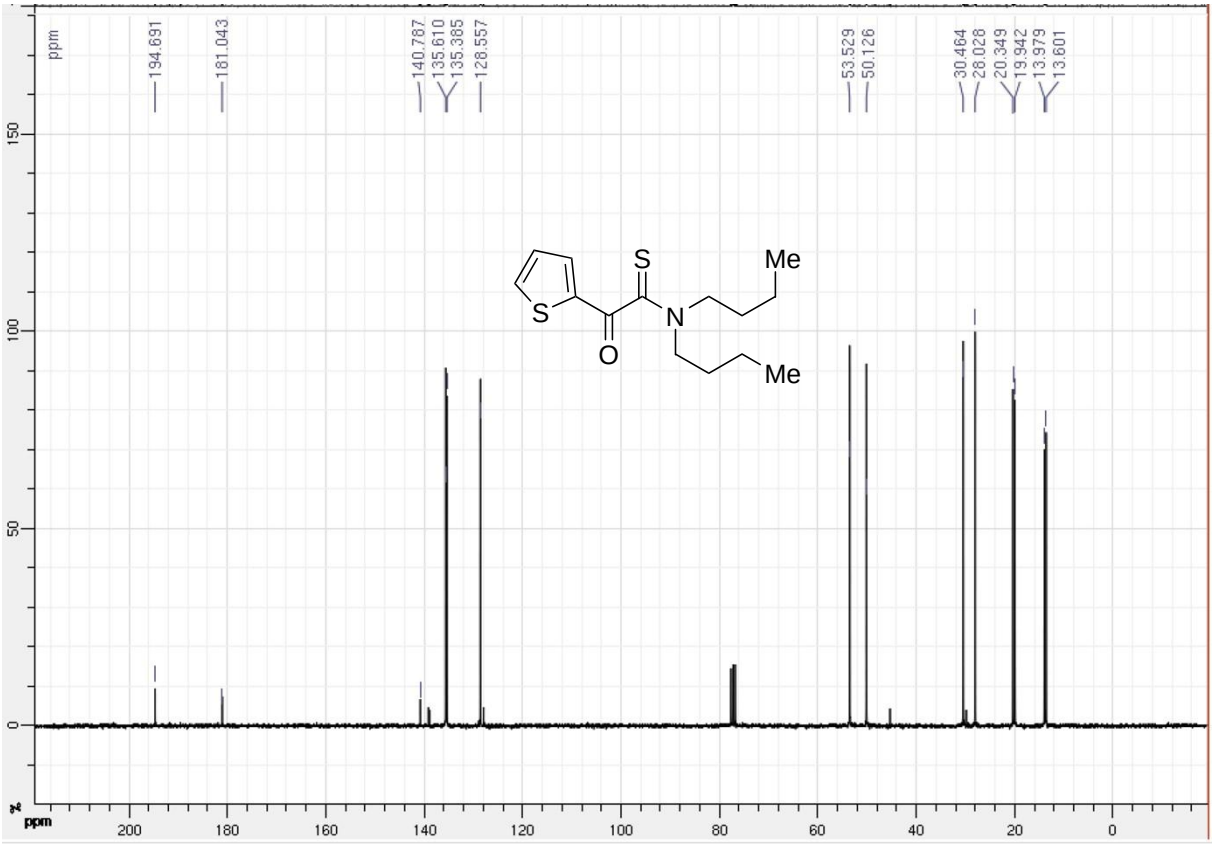

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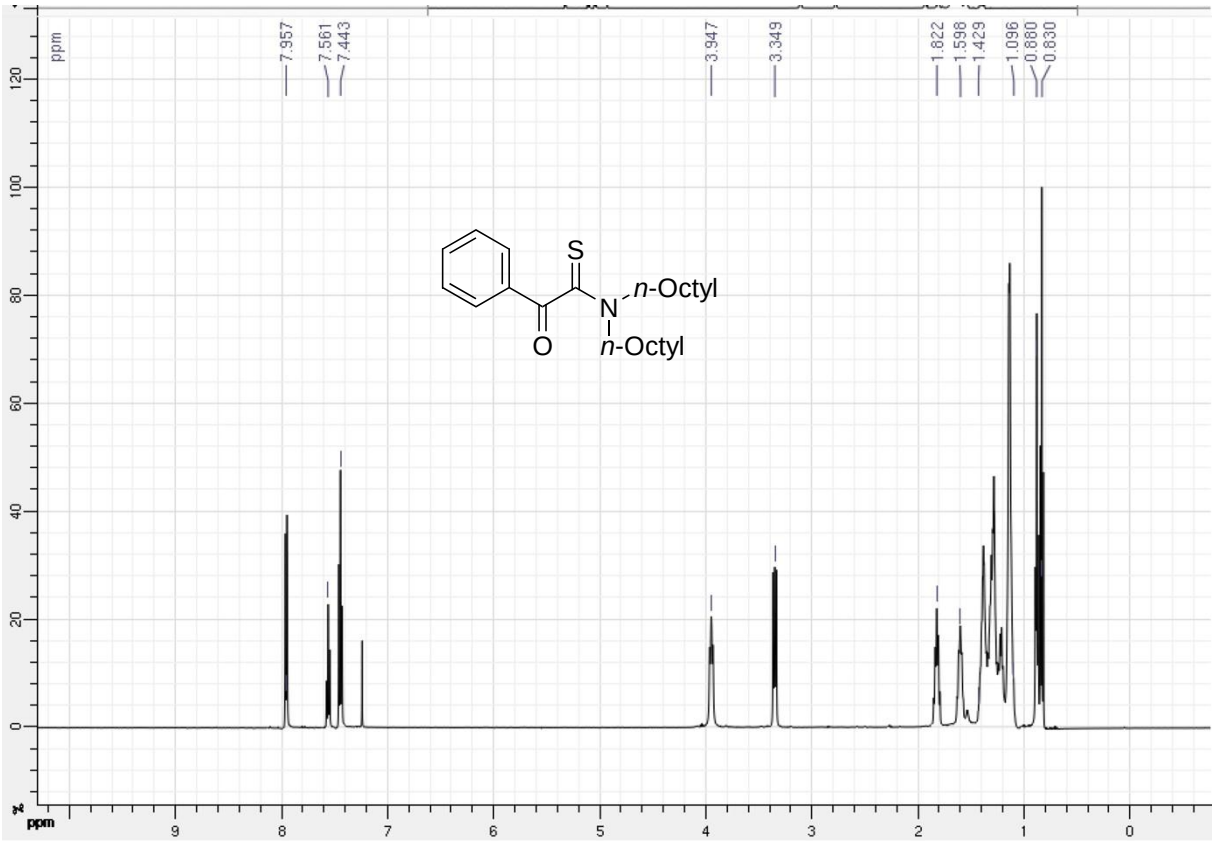

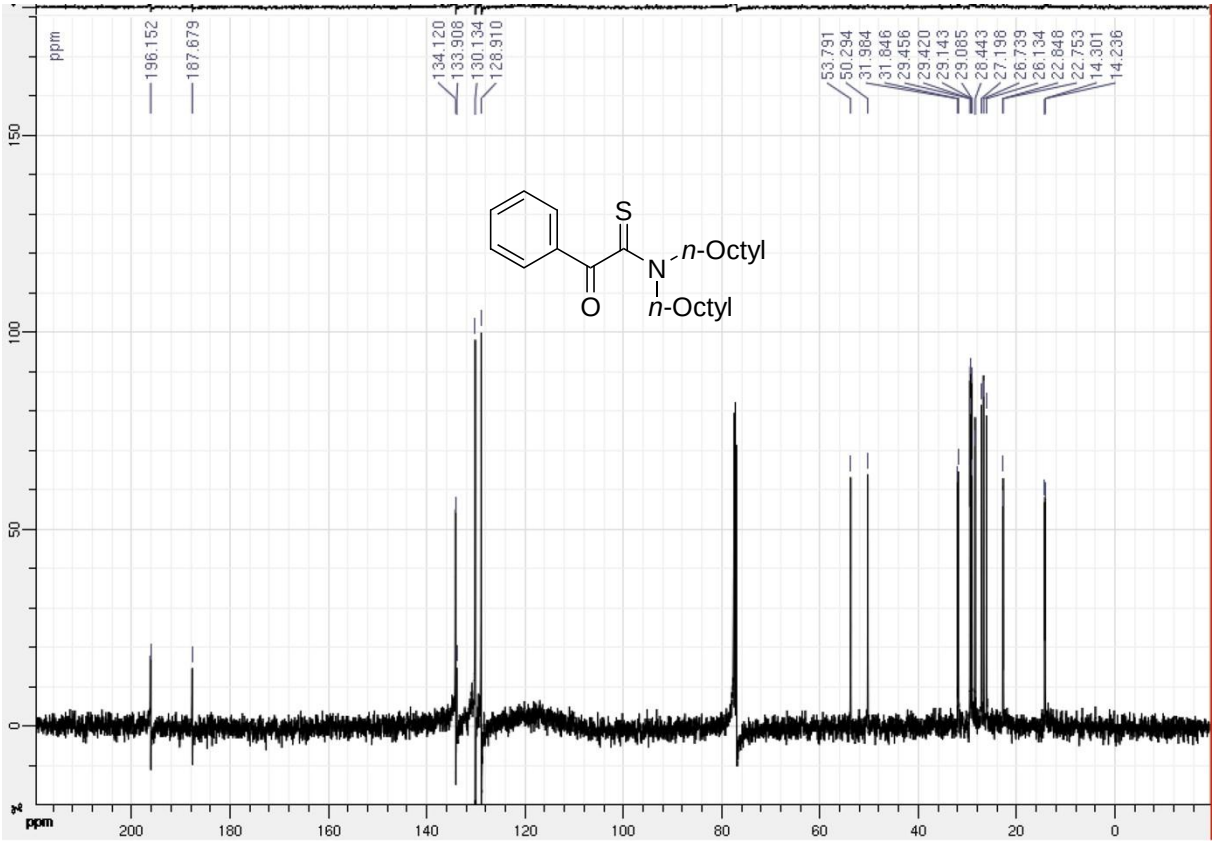

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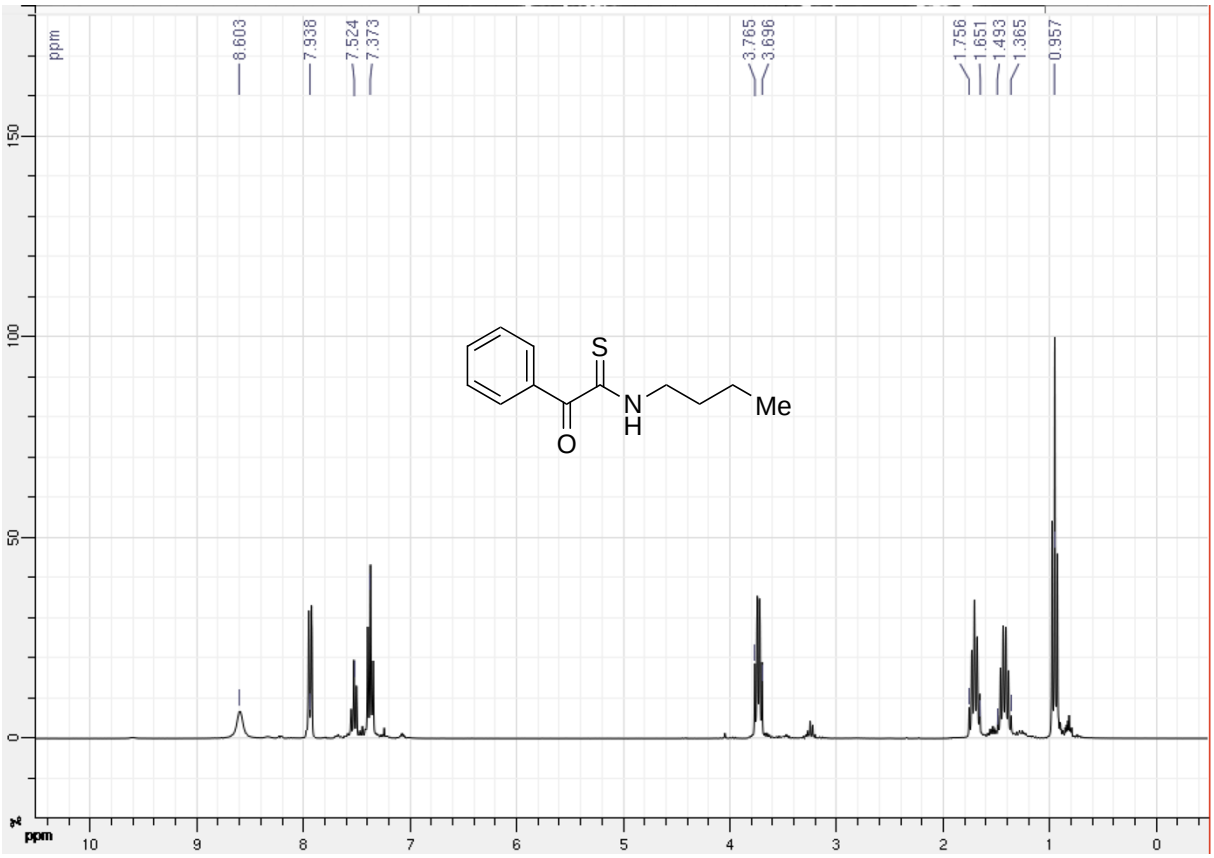

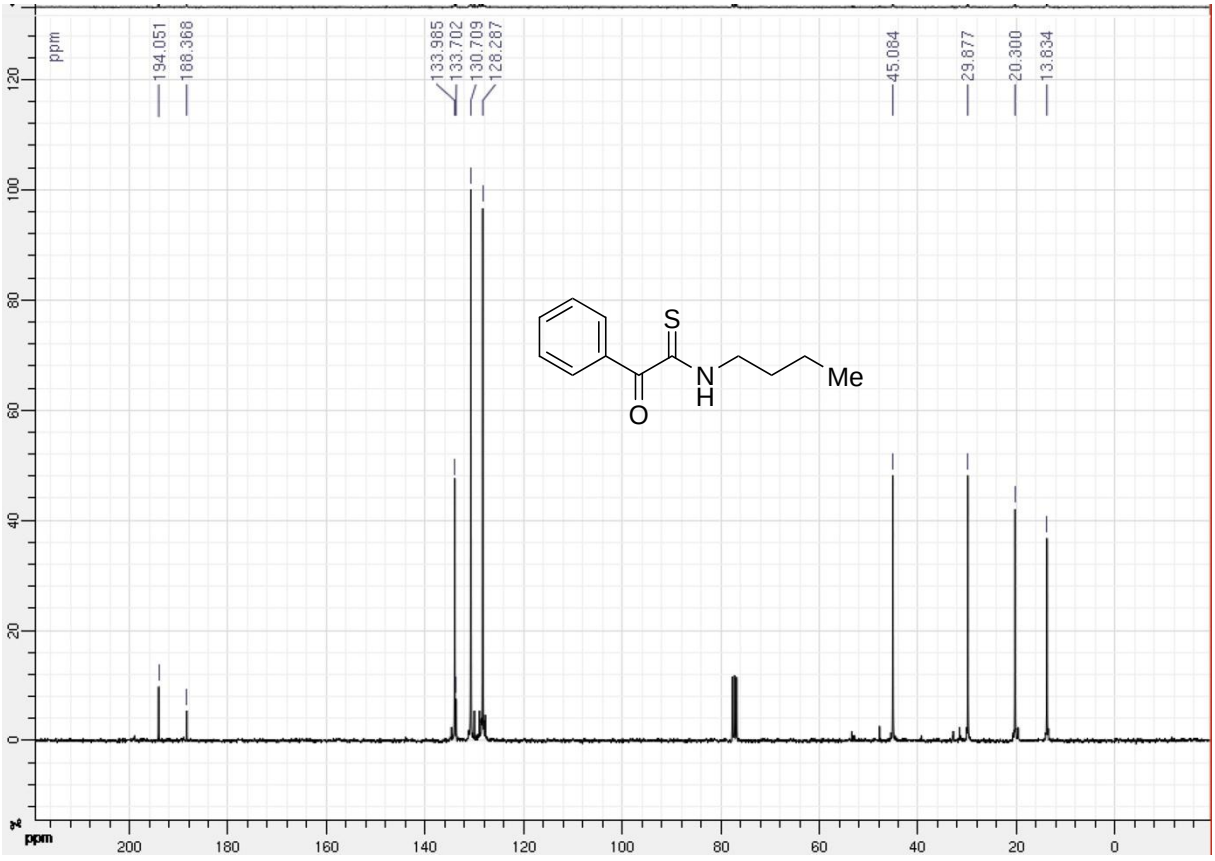

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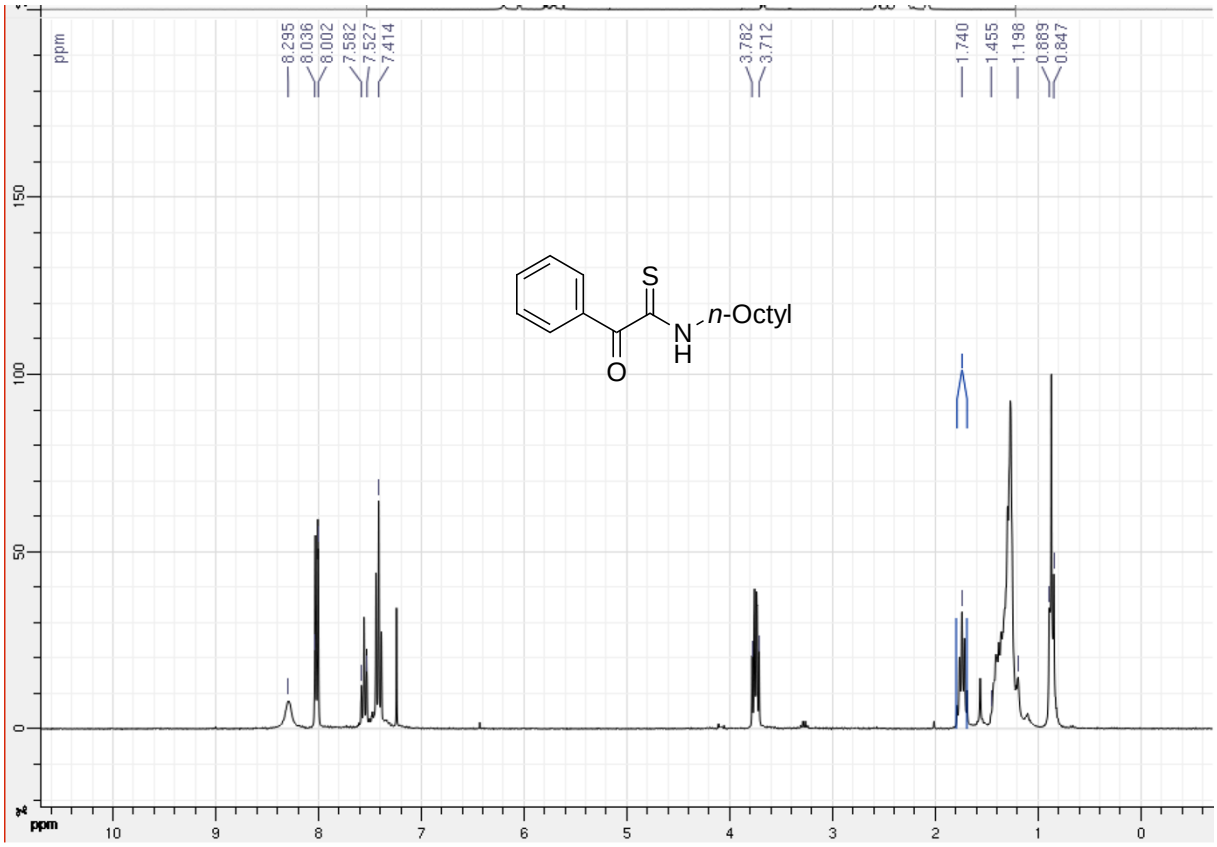
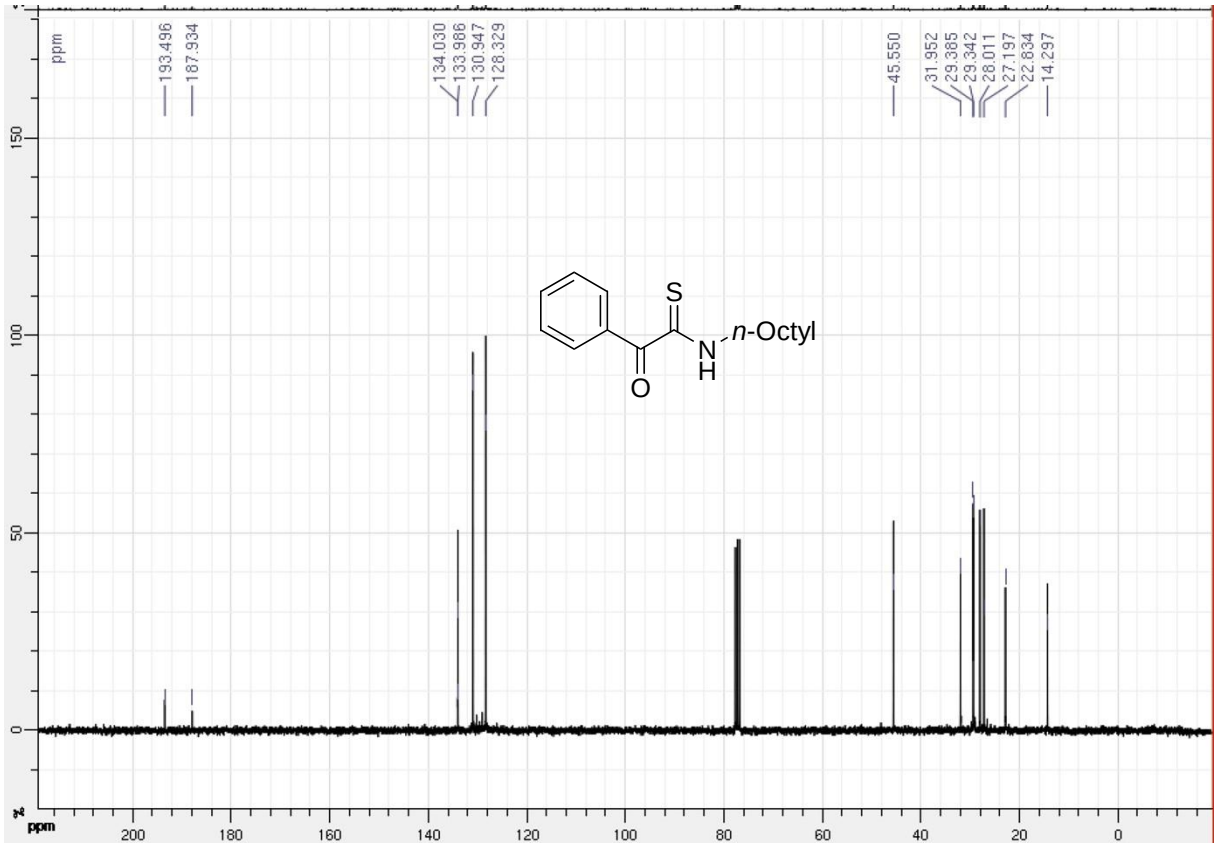
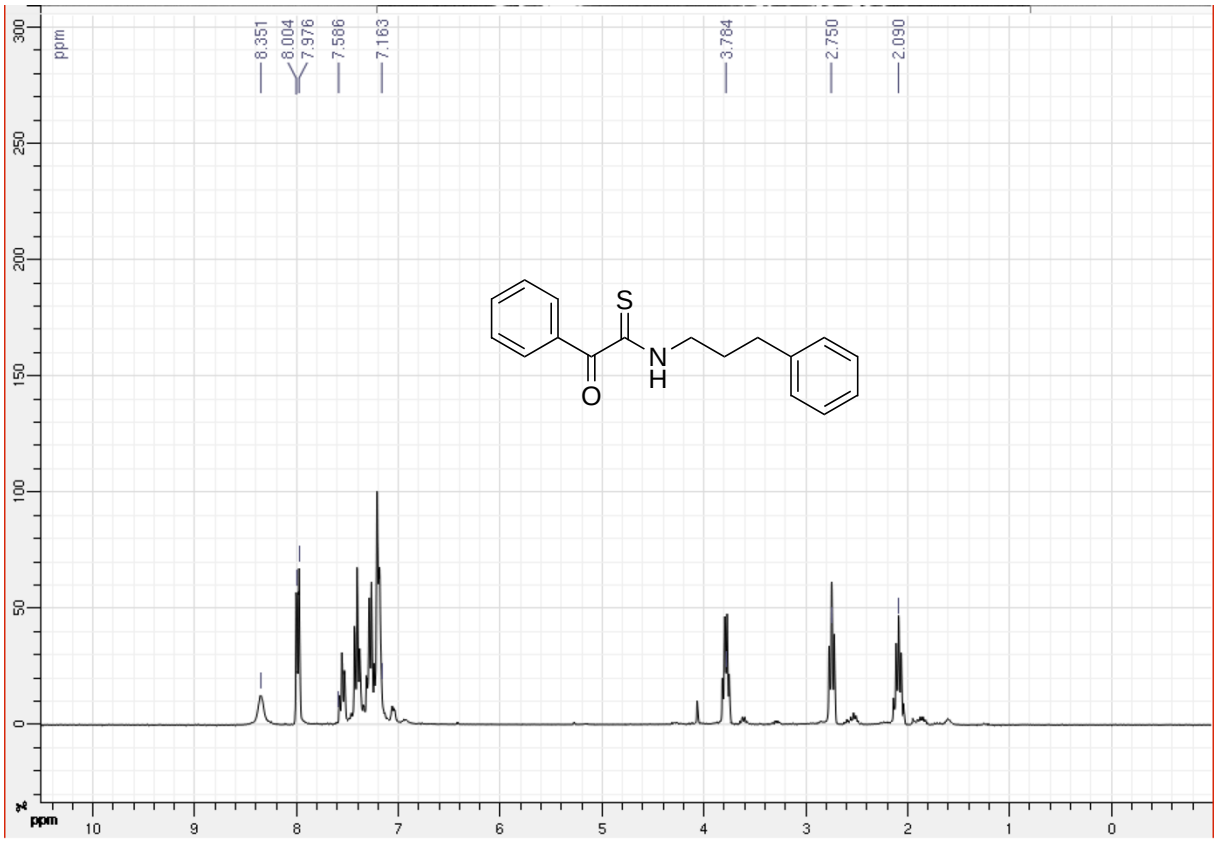
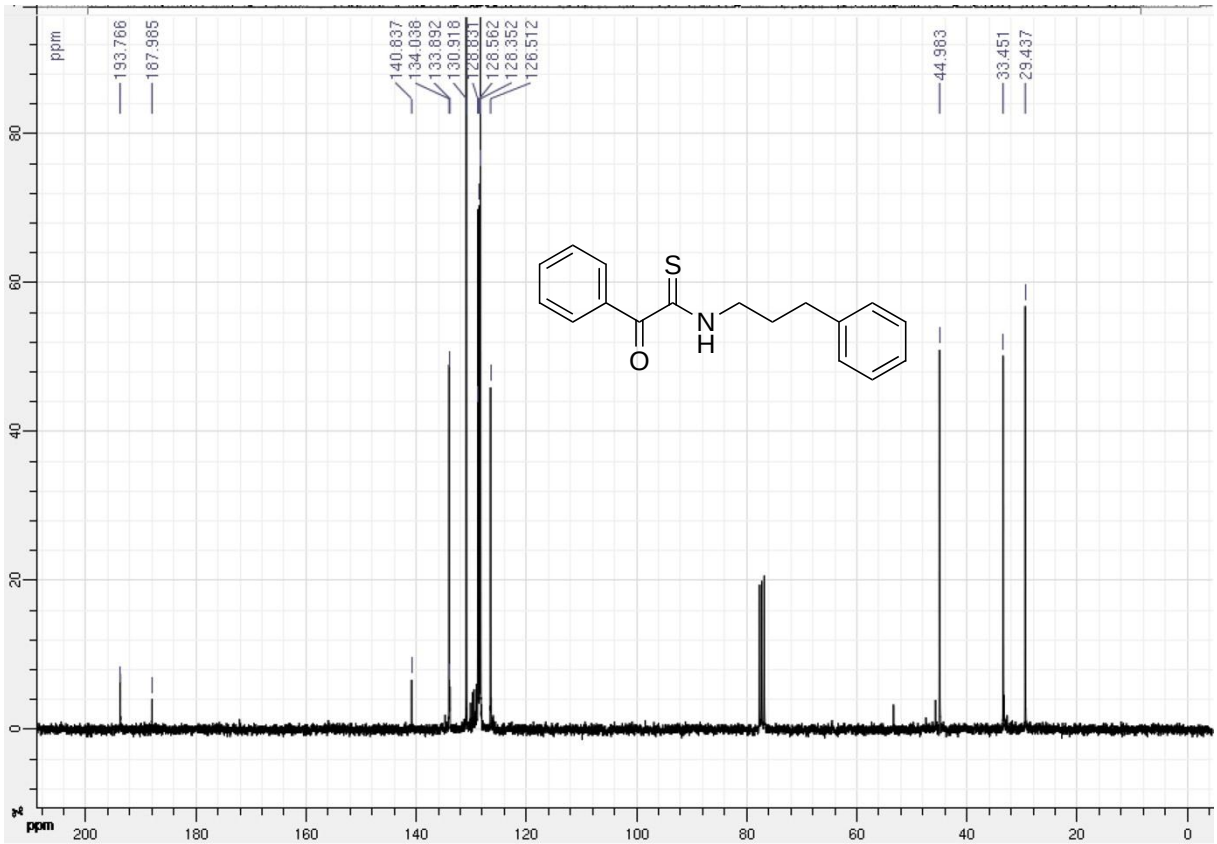


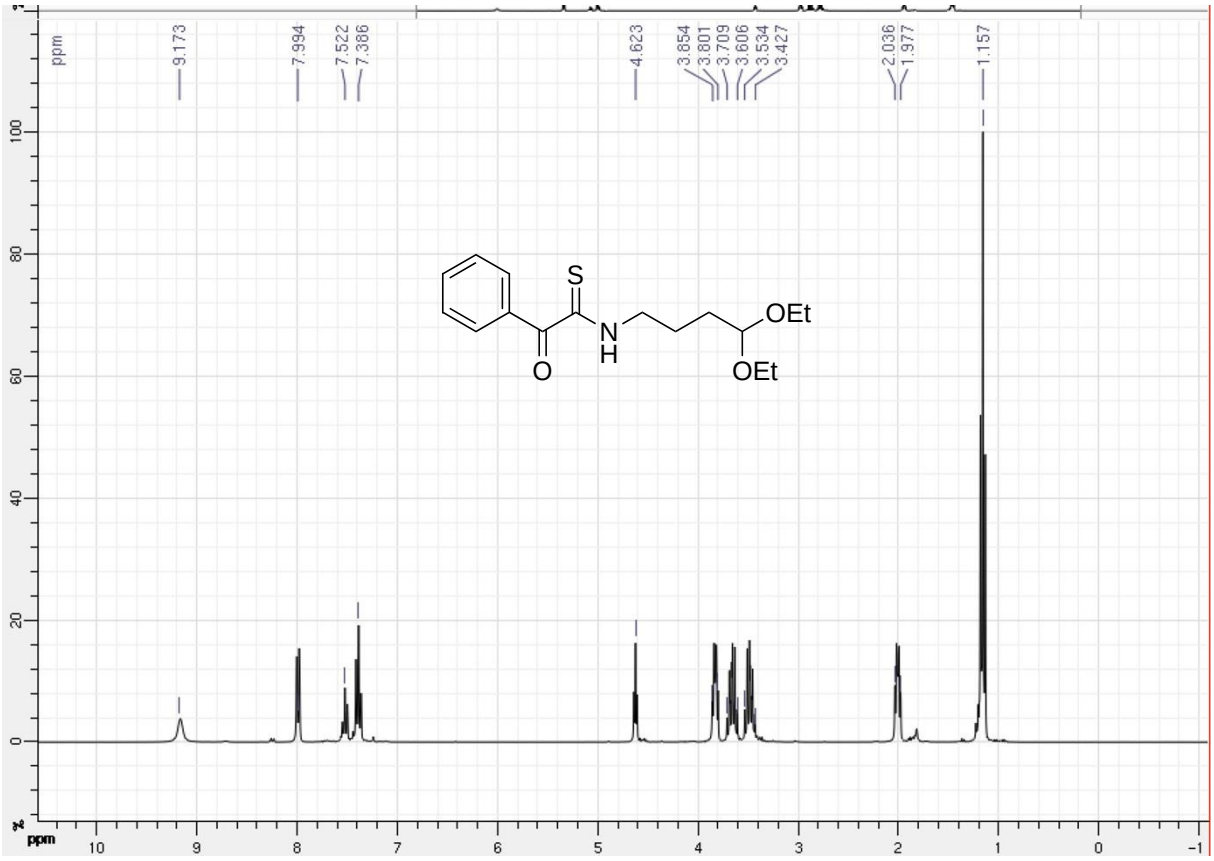


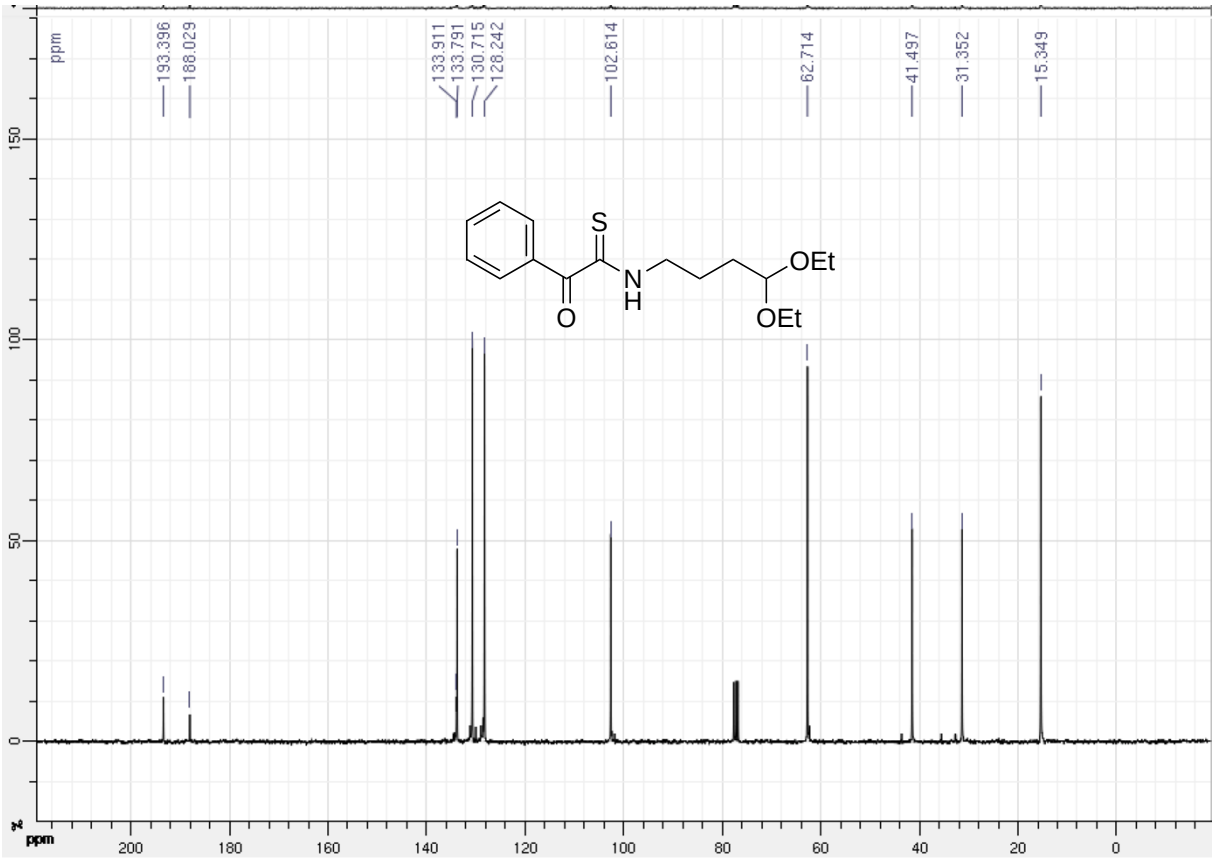
2-Oxo-2-phenyl-*N*-(3-phenylpropyl)ethanethioamide (3n)



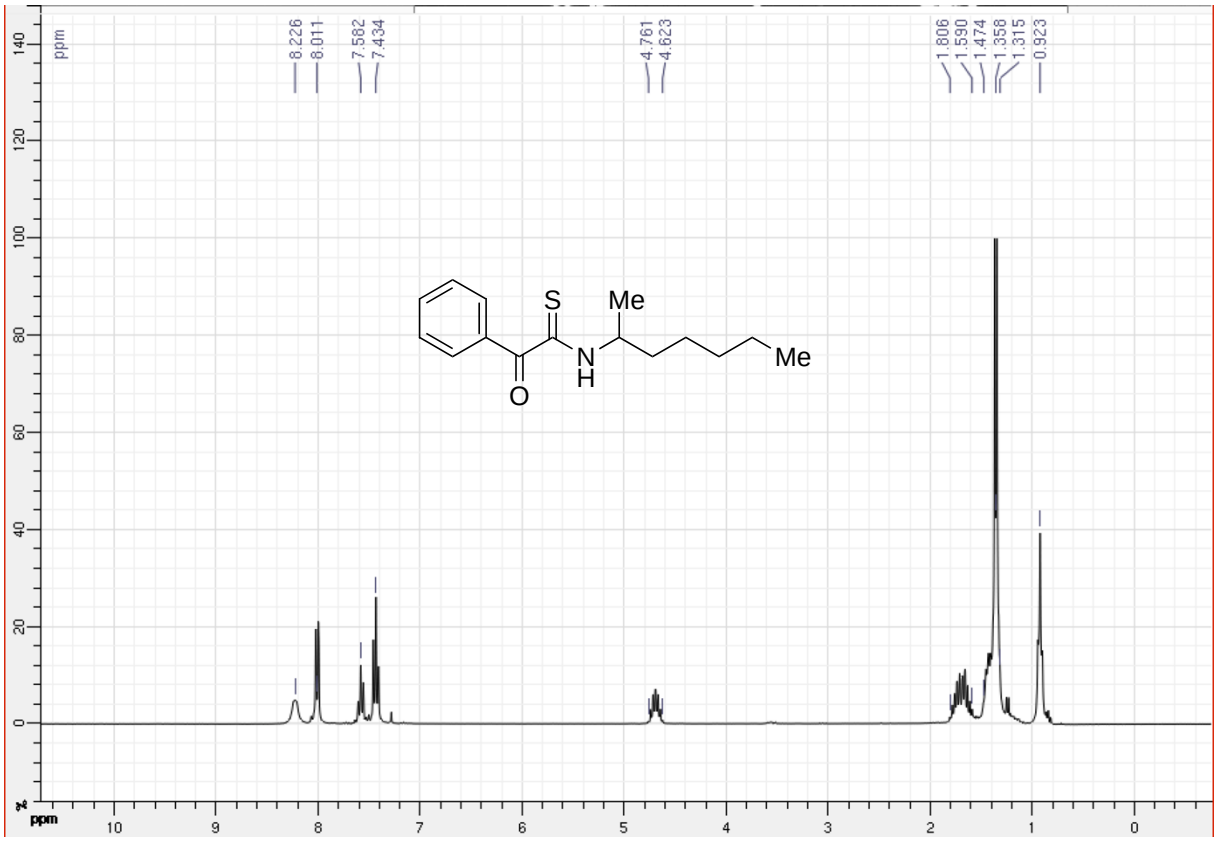


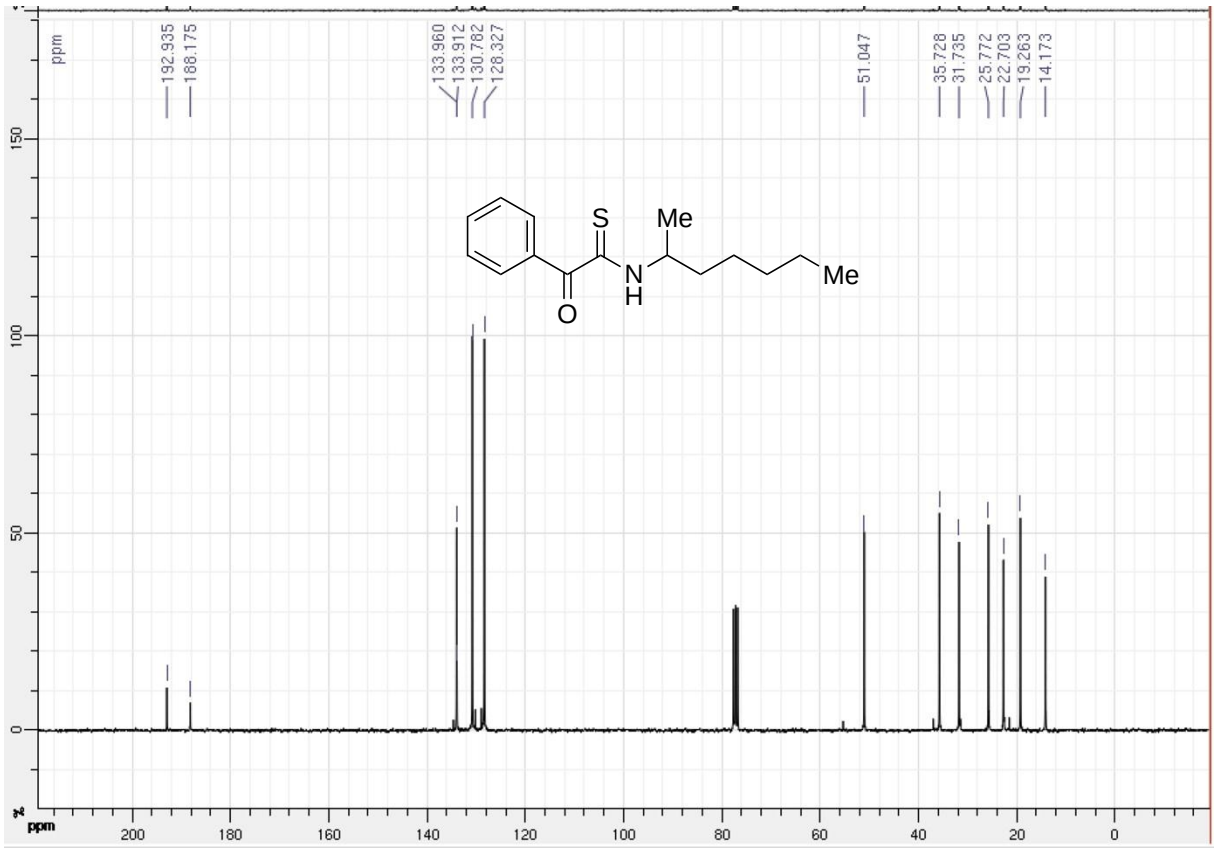
***N*-(4,4-Diethoxybutyl)-2-oxo-2-phenylethanethioamide (3o)**



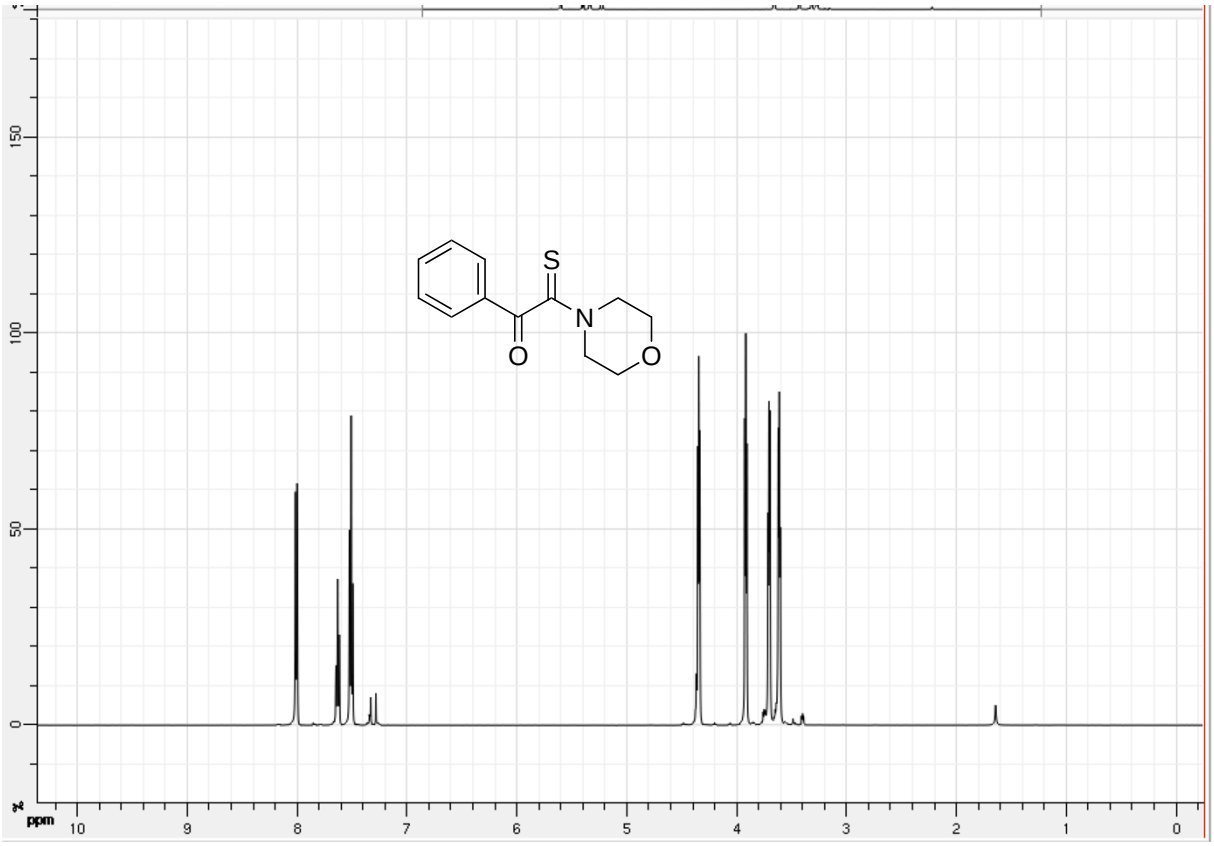


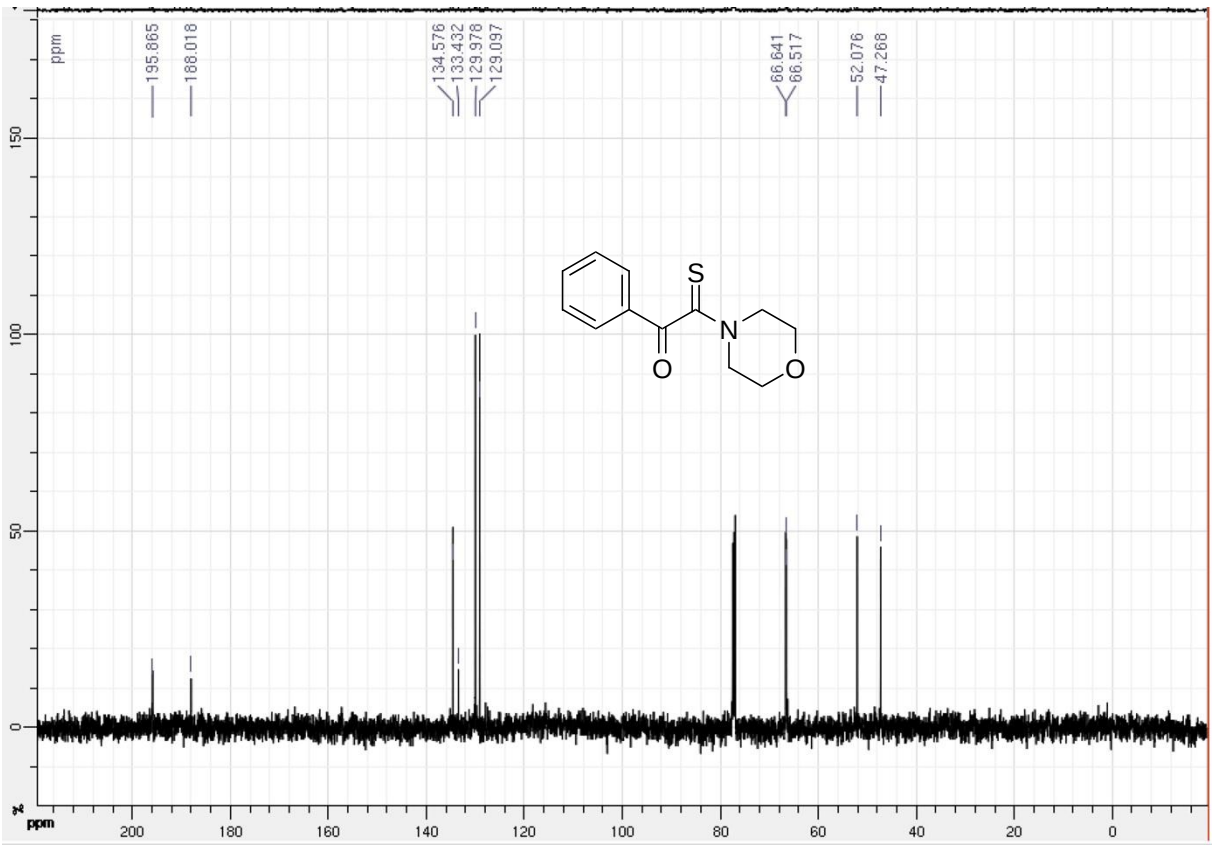
***N*-(Heptan-2-yl)-2-oxo-2-phenylethanethioamide (3p)**



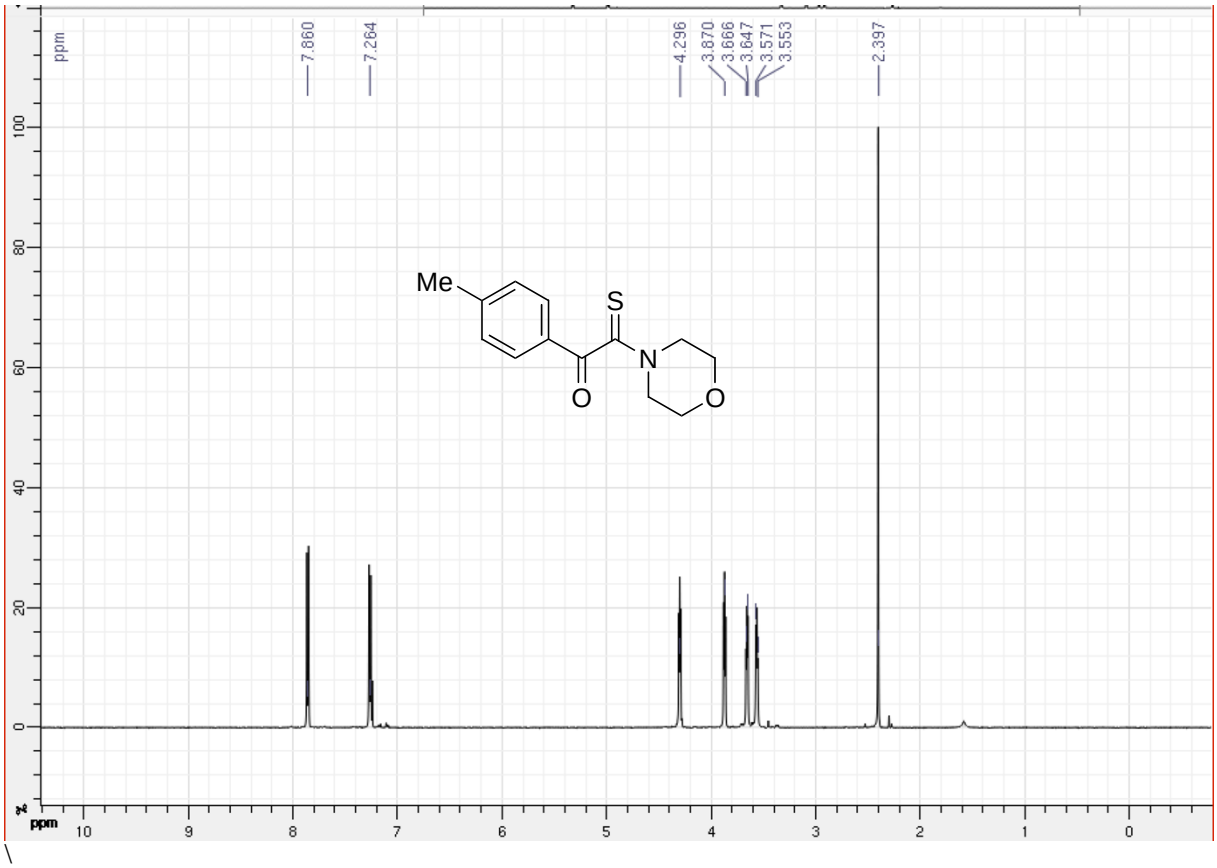


2-Morpholino-1-phenyl-2-thioxoethan-1-one (3q)





2-Morpholino-2-thioxo-1-(*p*-tolyl)ethan-1-one (3r)



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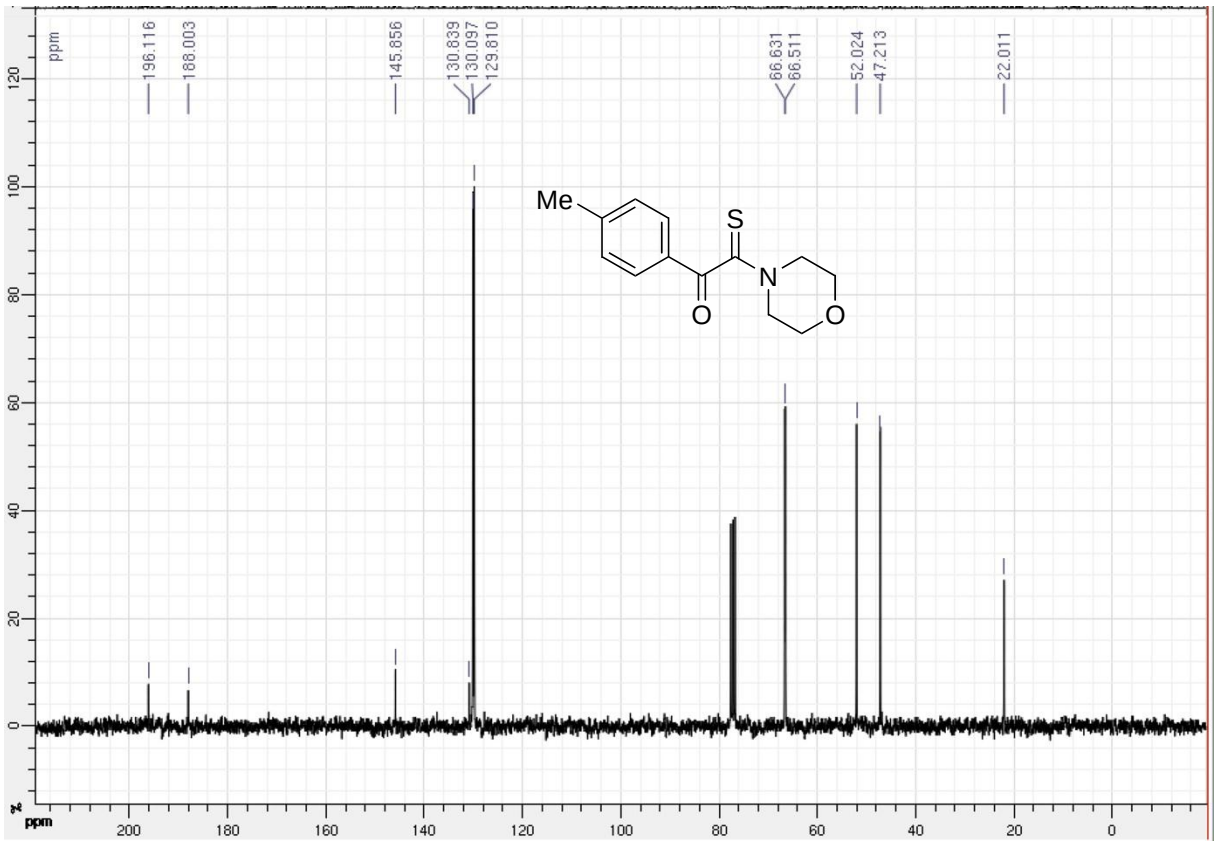
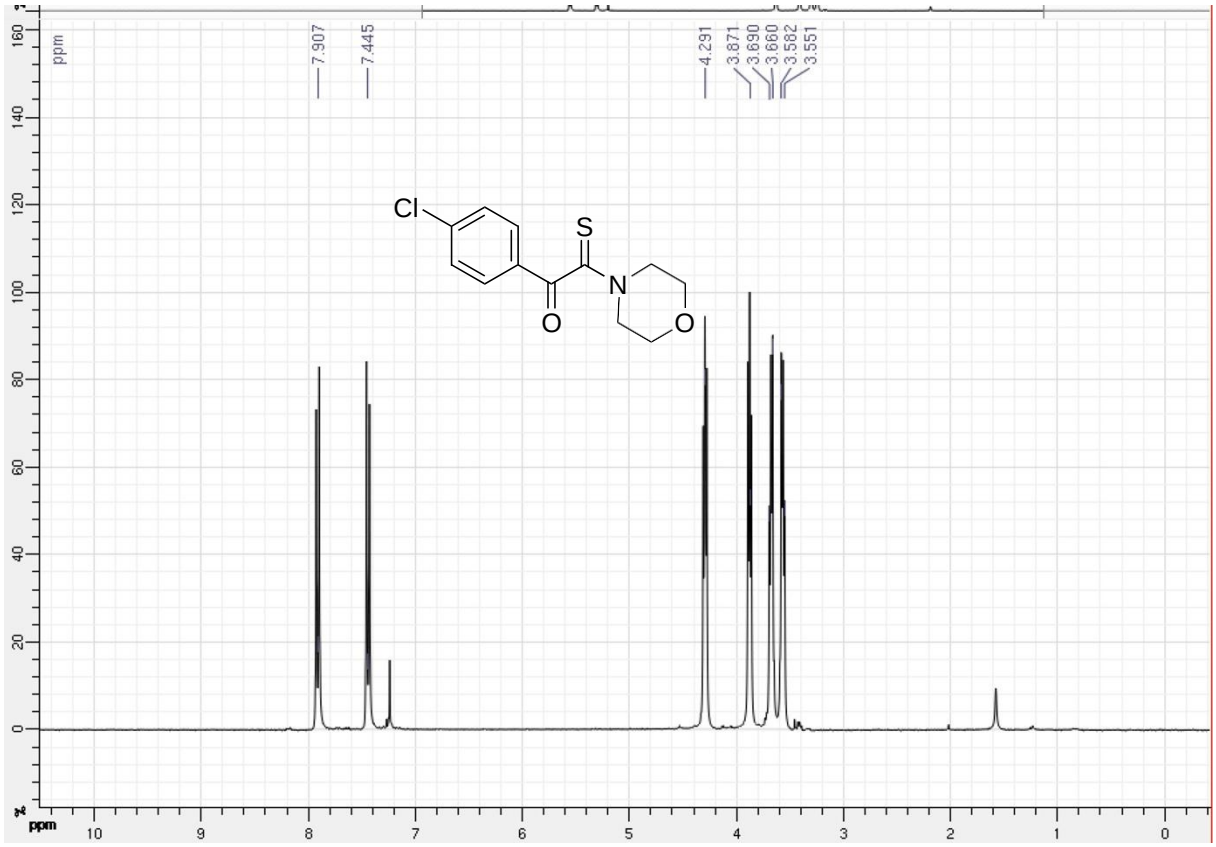
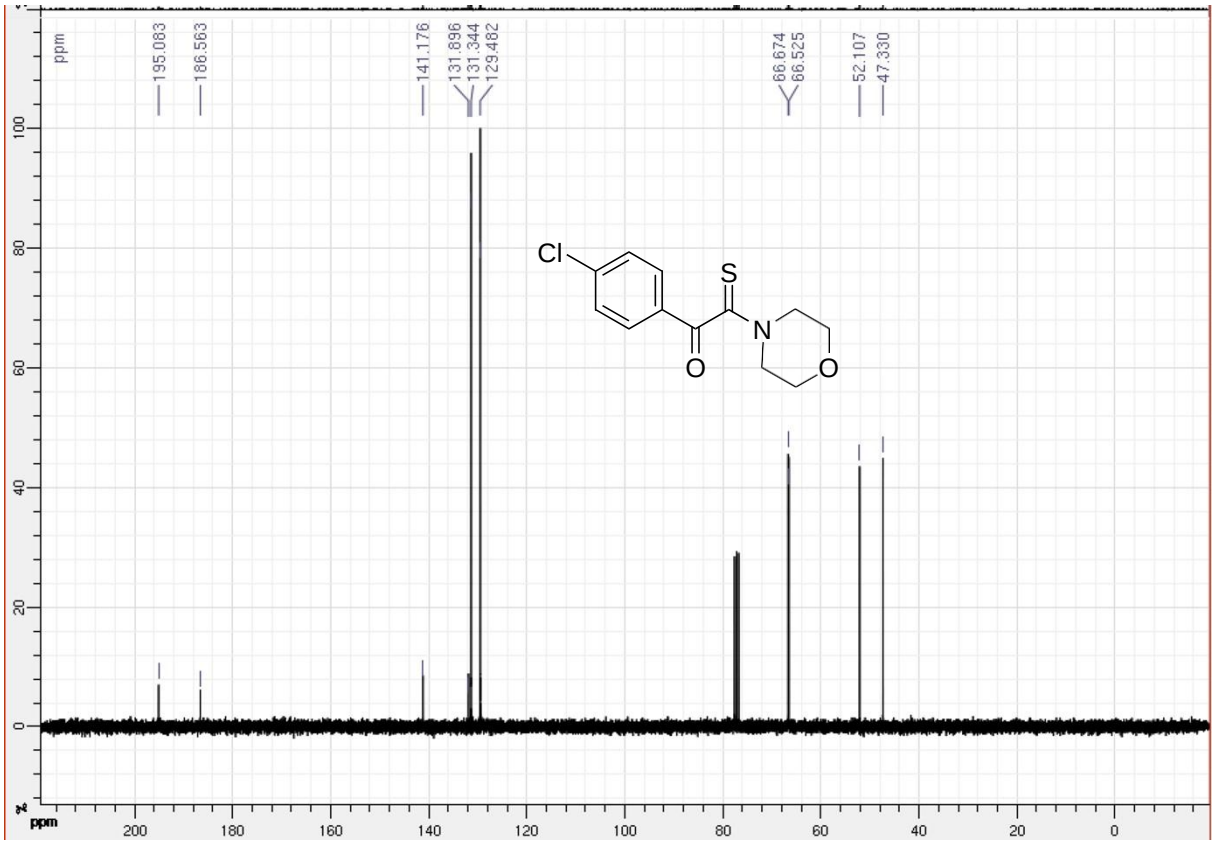
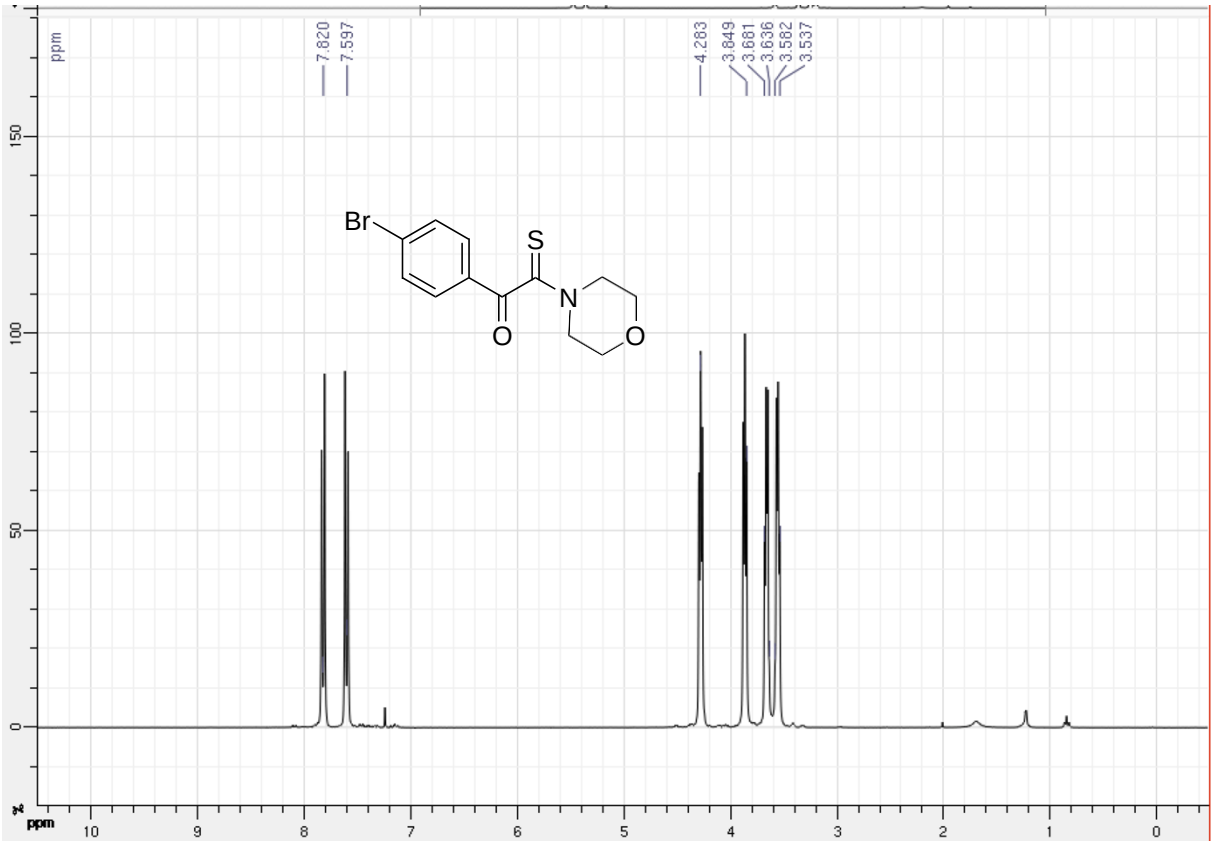


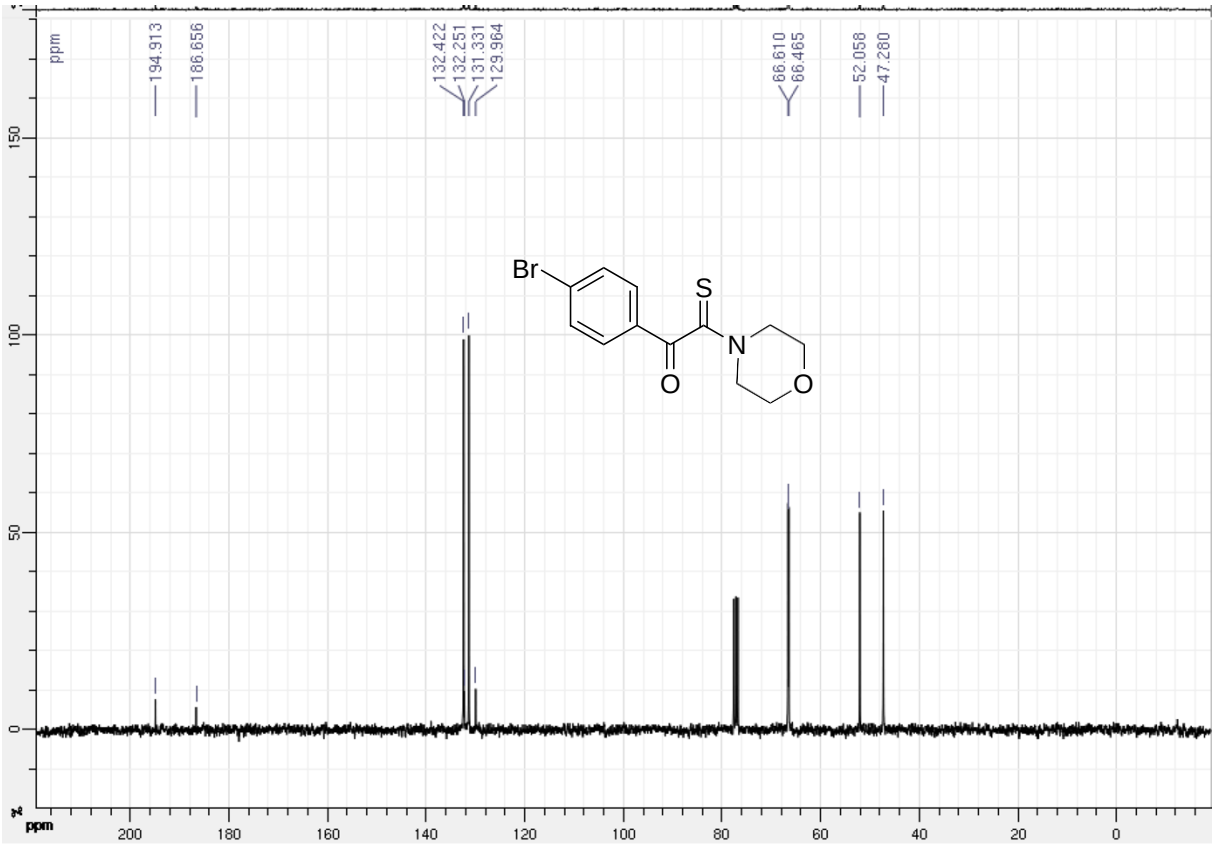
1-(4-Chlorophenyl)-2-morpholino-2-thioxoethan-1-one (3s)



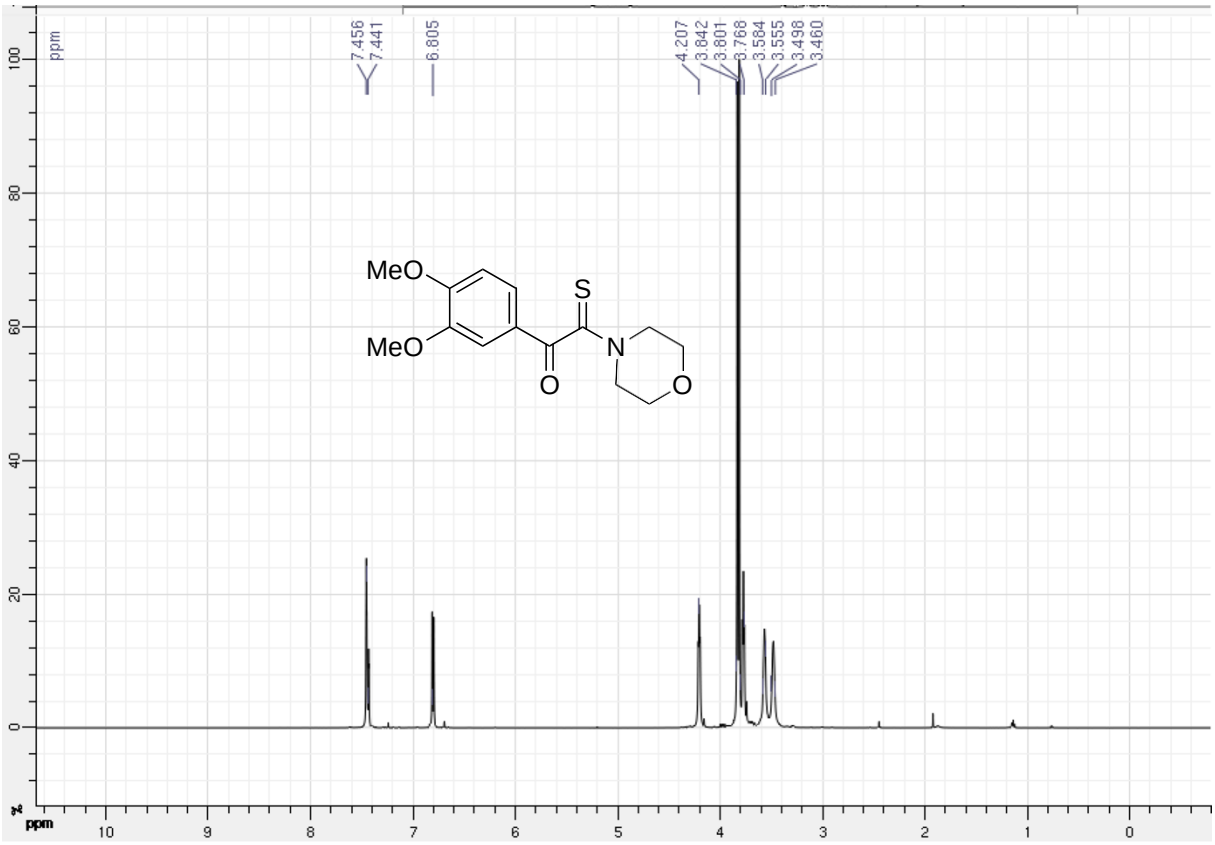


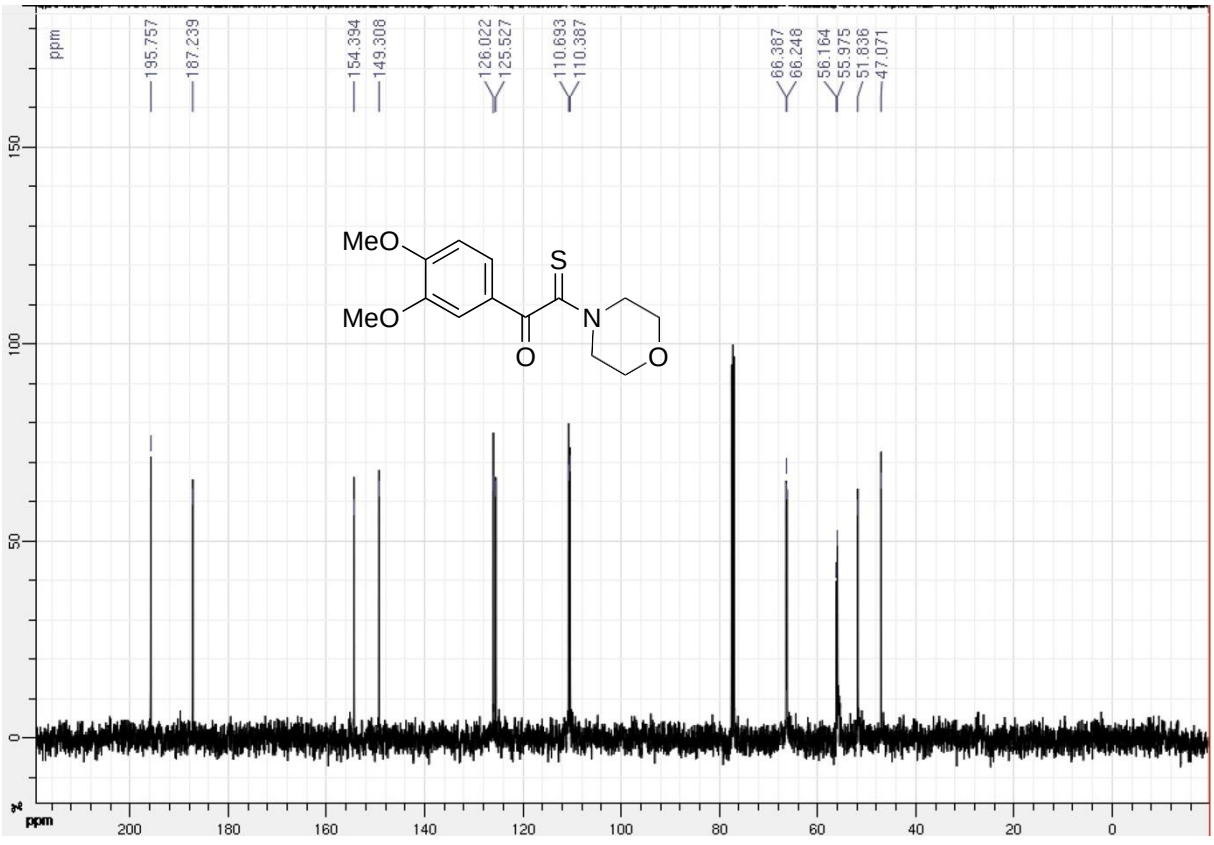
1-(4-Bromophenyl)-2-morpholino-2-thioxoethan-1-one (3t)



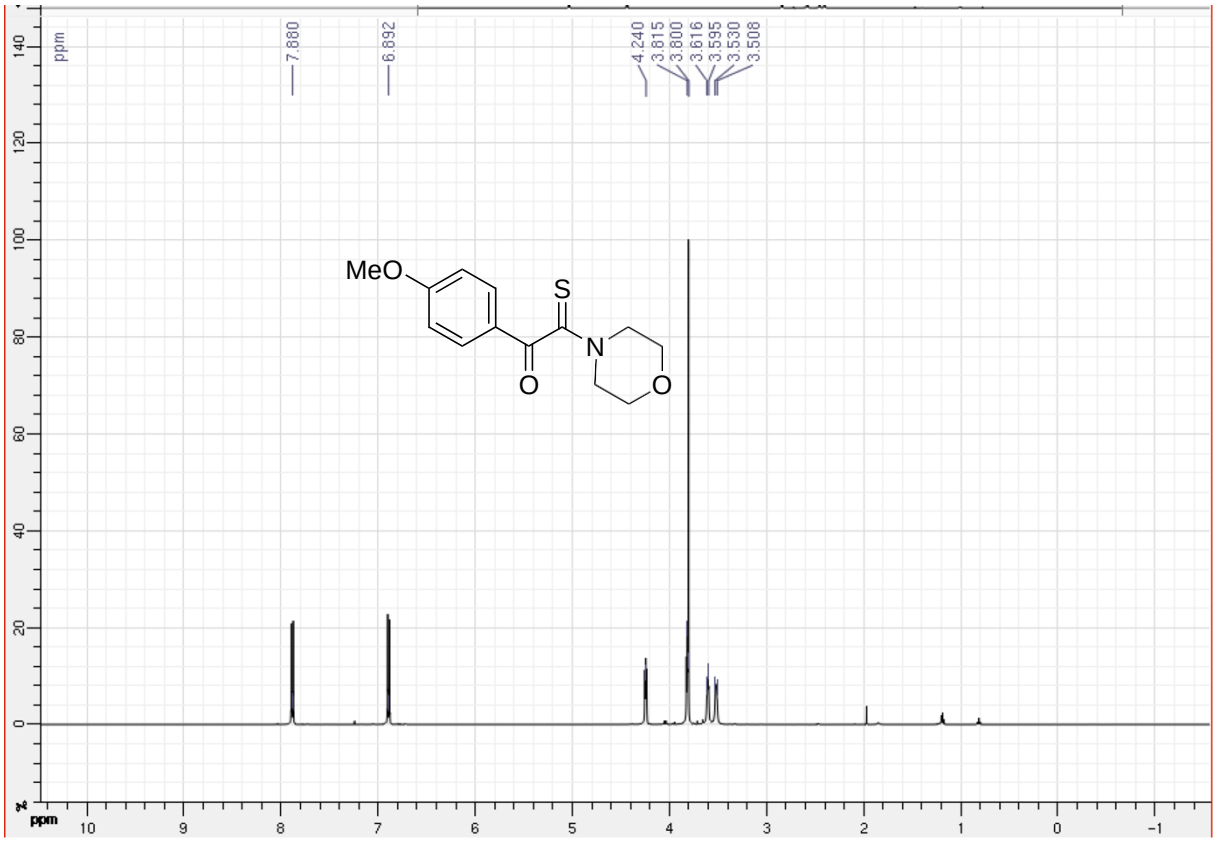


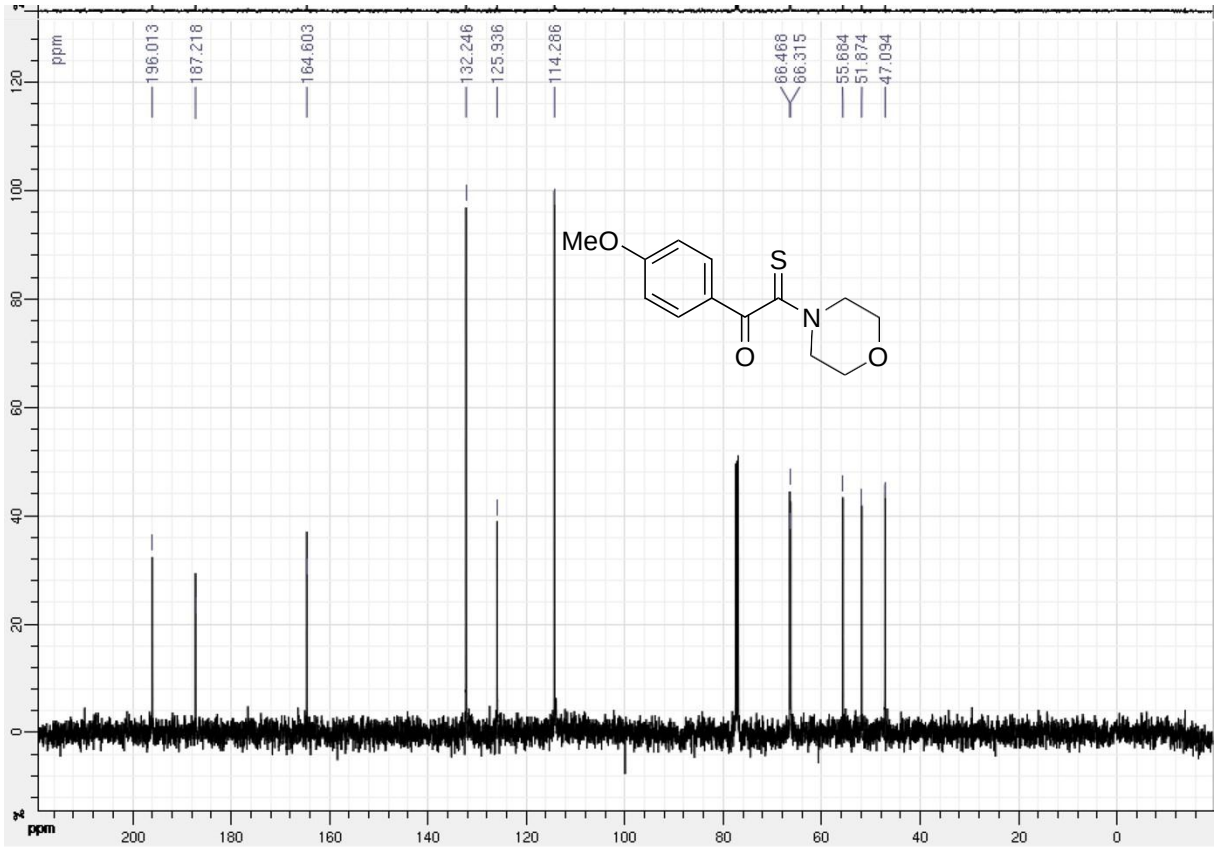
1-(3,4-Dimethoxyphenyl)-2-morpholino-2-thioxoethan-1-one (3u)



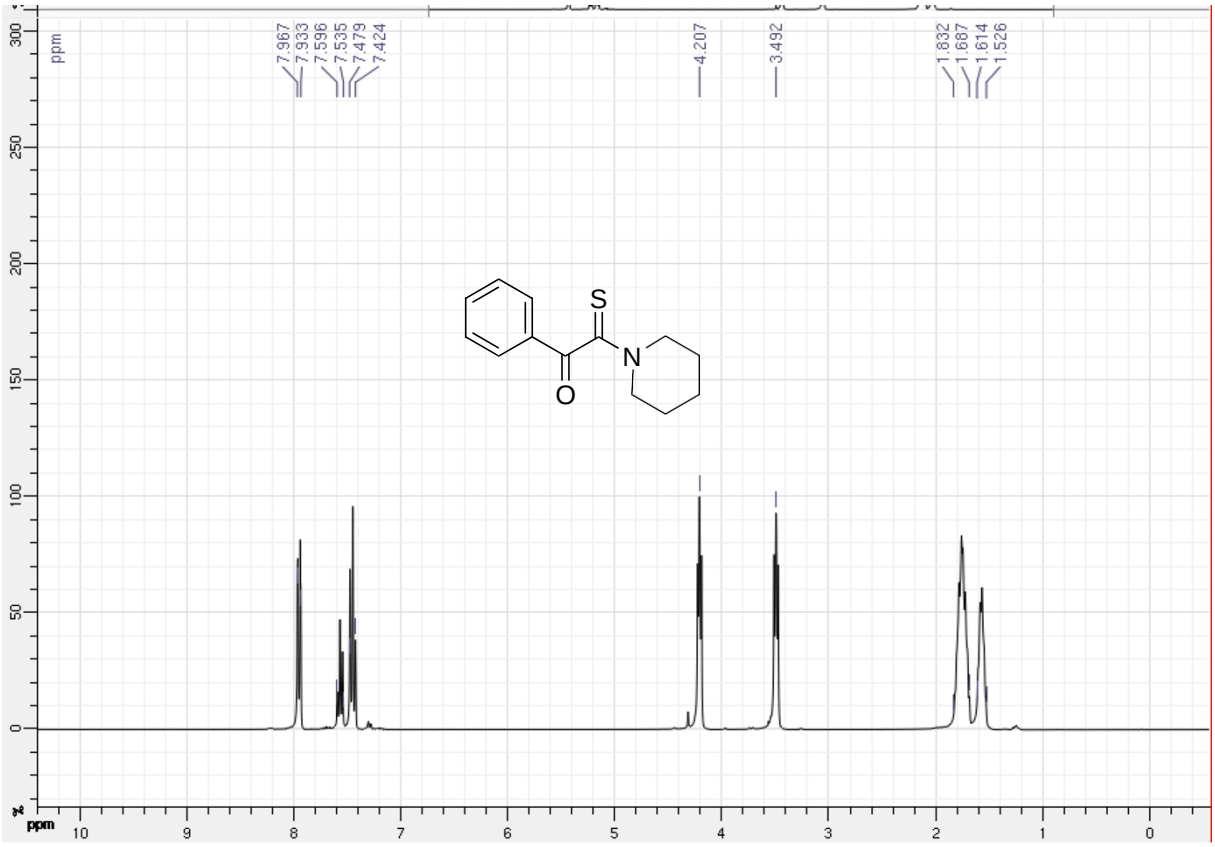


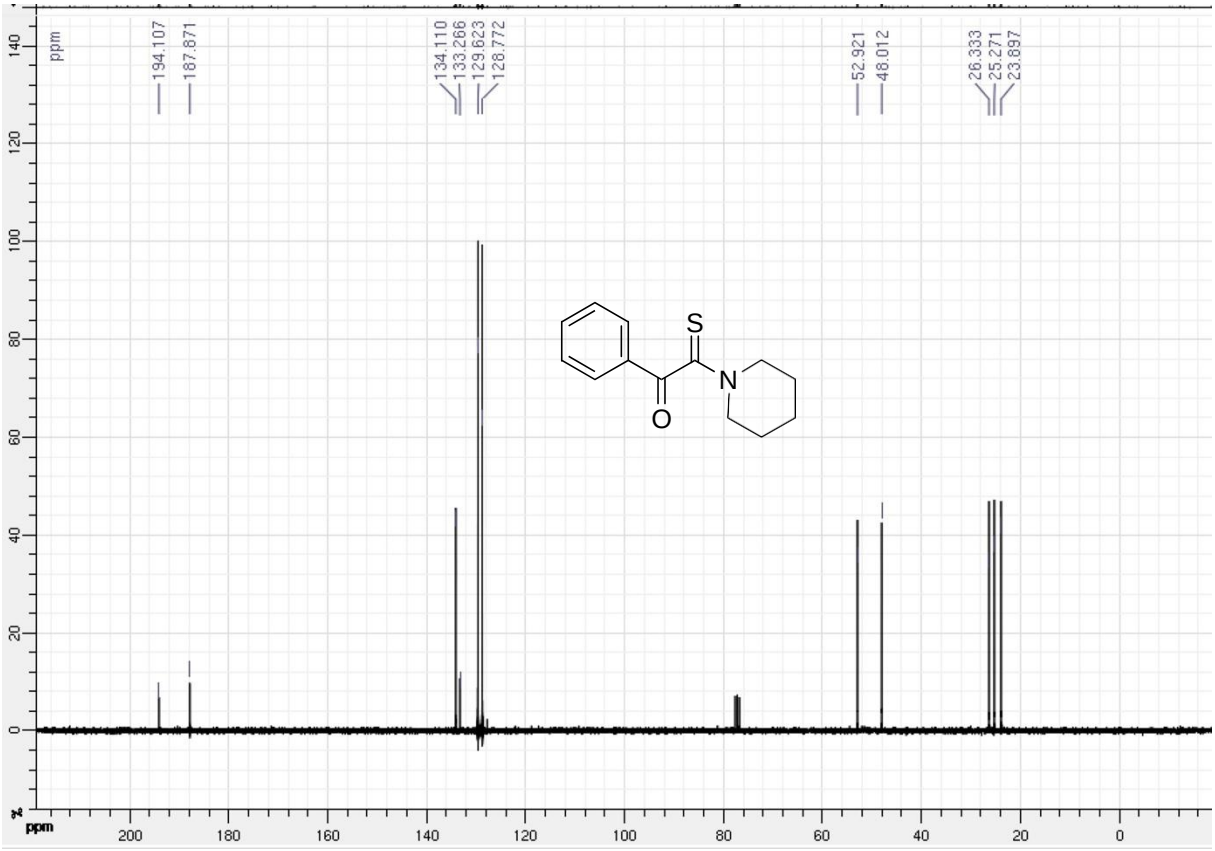
1-(4-Methoxyphenyl)-2-morpholino-2-thioxoethan-1-one (3v)



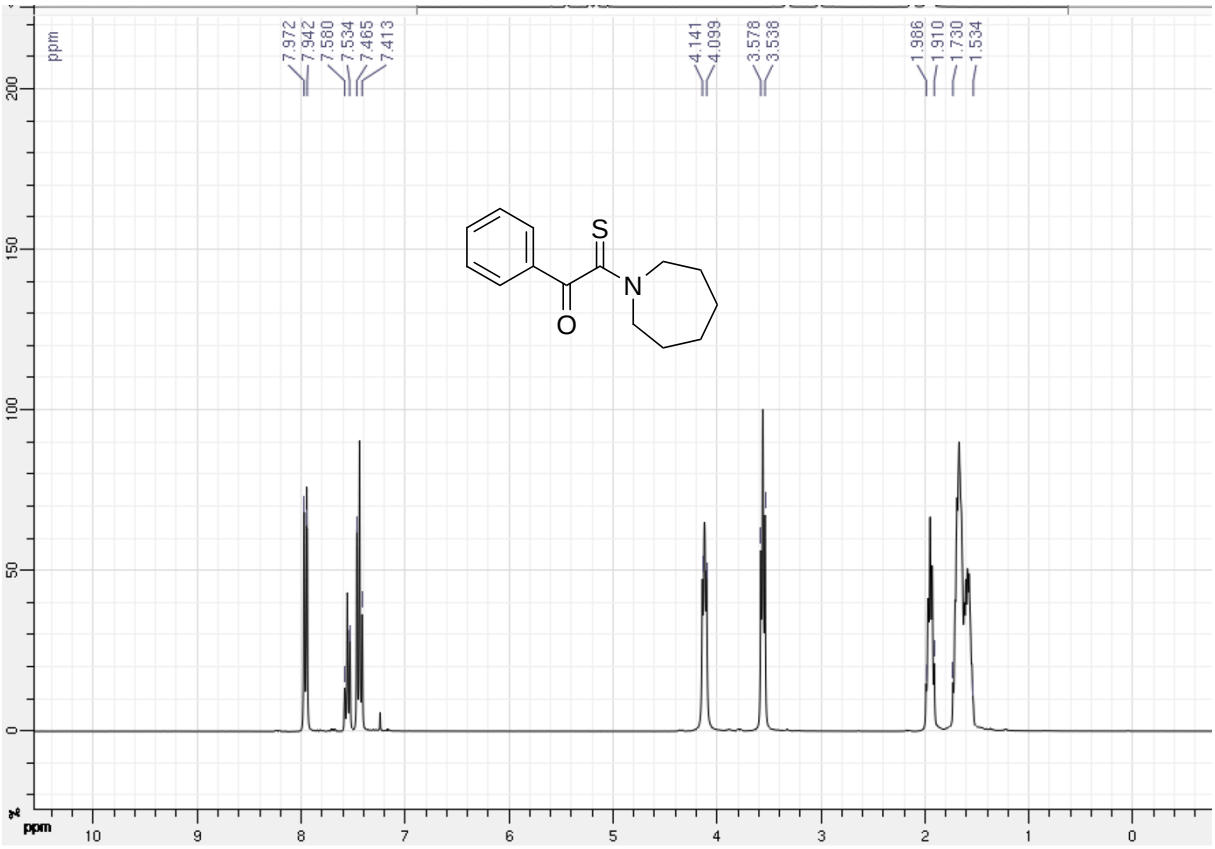


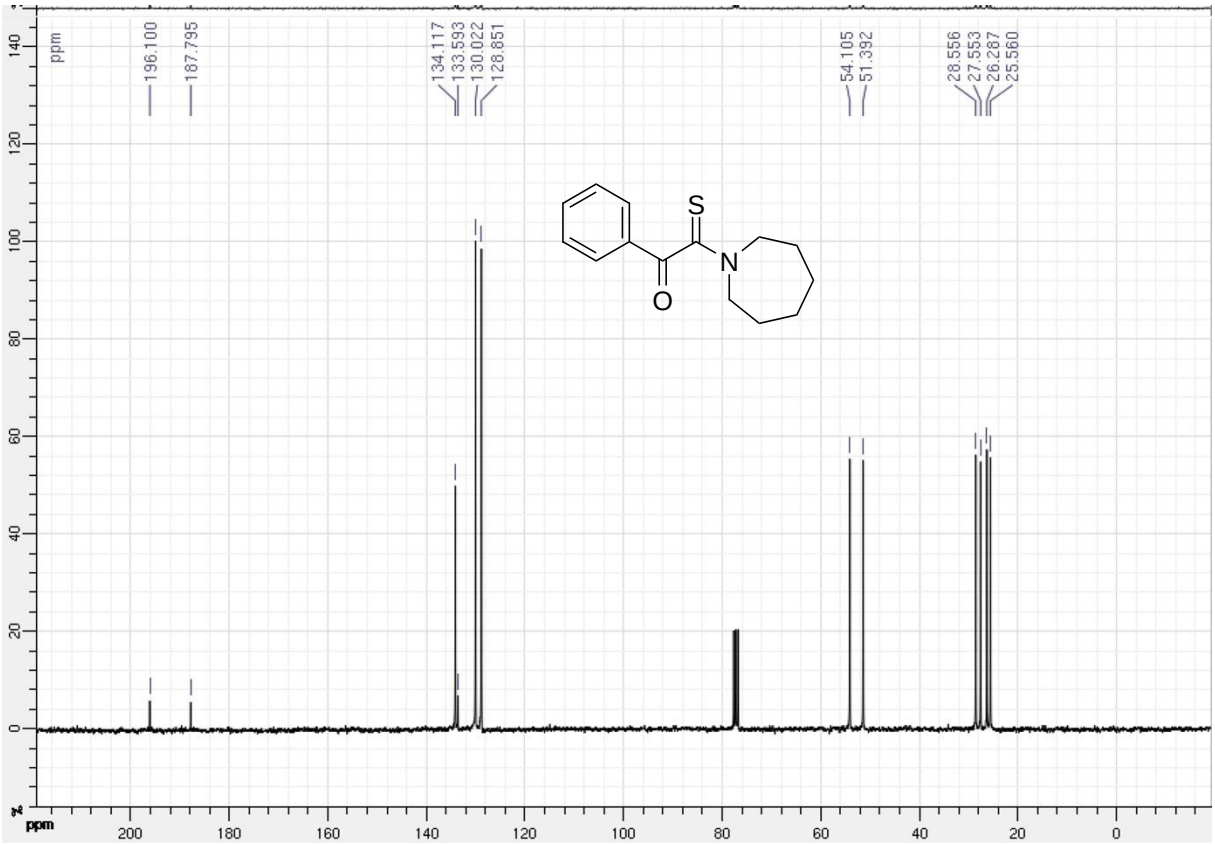
1-Phenyl-2-(piperidin-1-yl)-2-thioxoethan-1-one (3w)



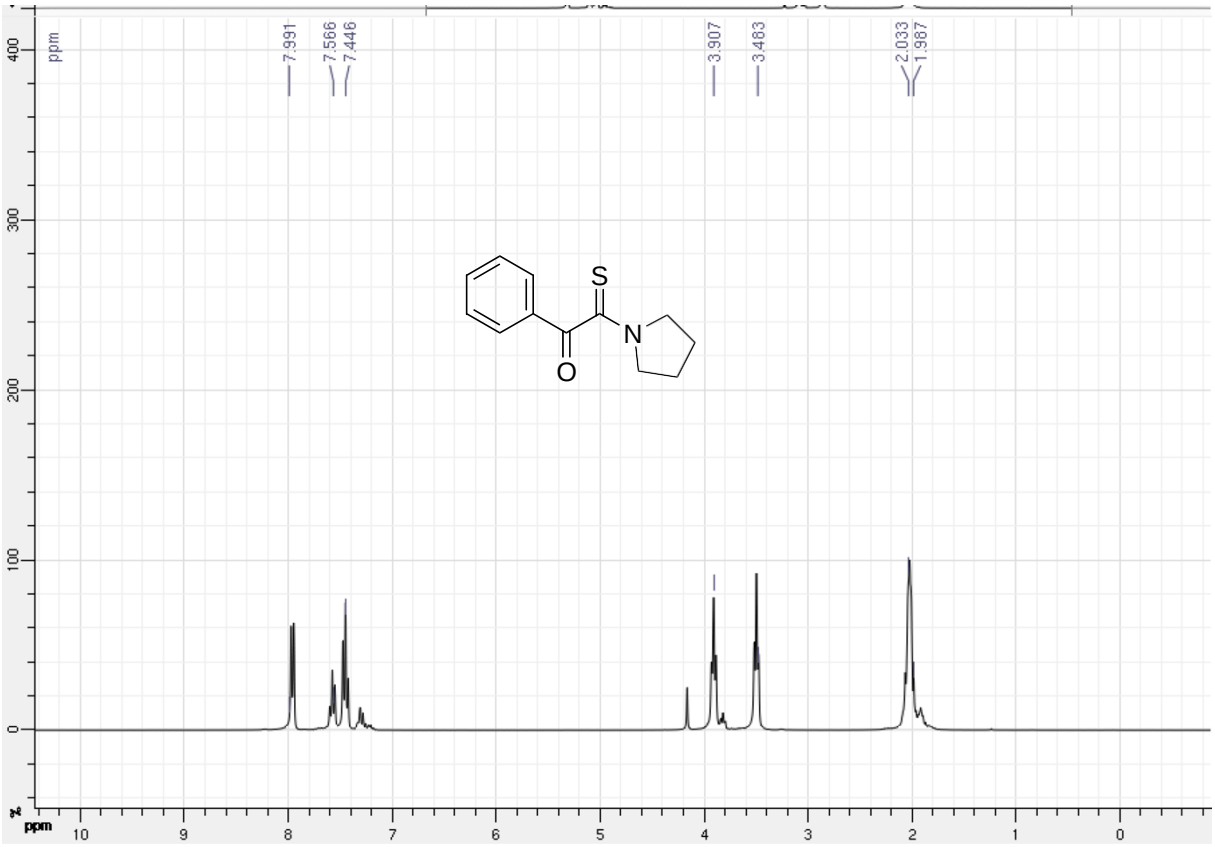


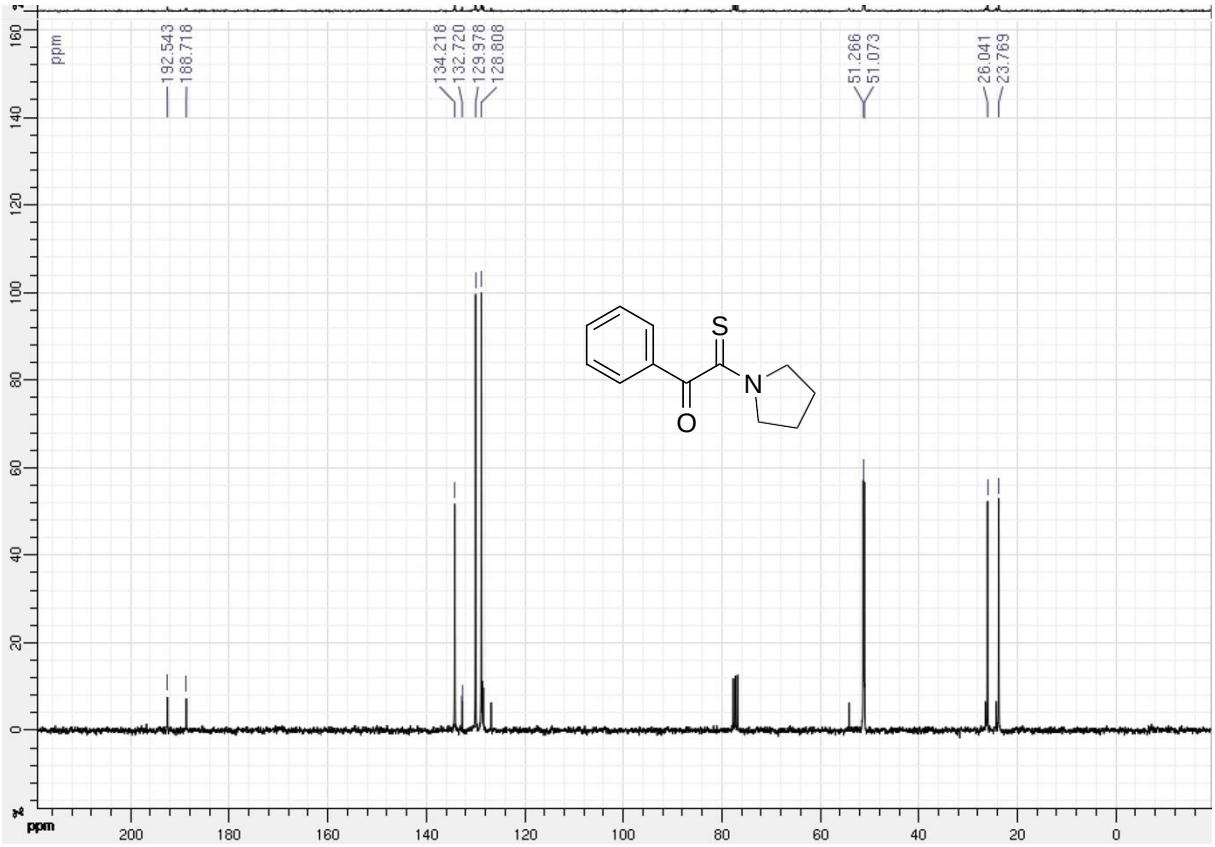
2-(Azepan-1-yl)-1-phenyl-2-thioxoethan-1-one (3x)



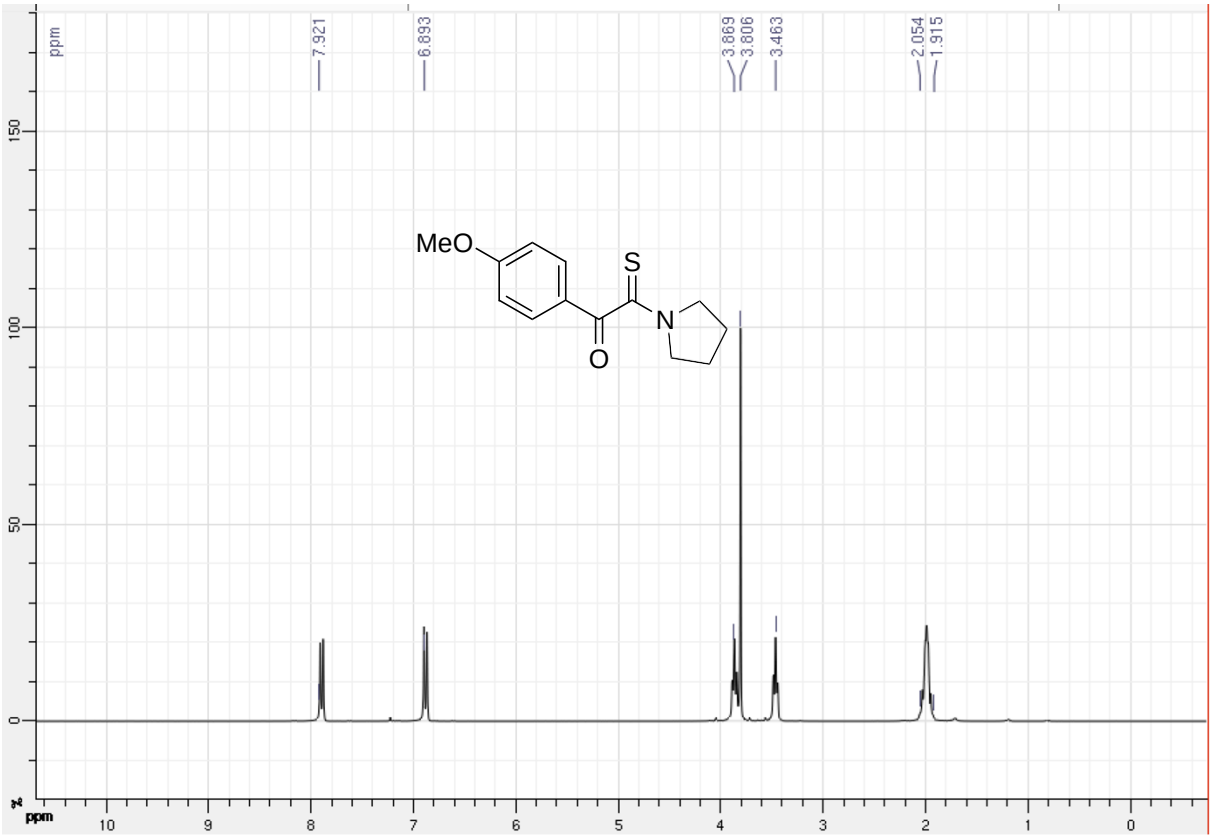


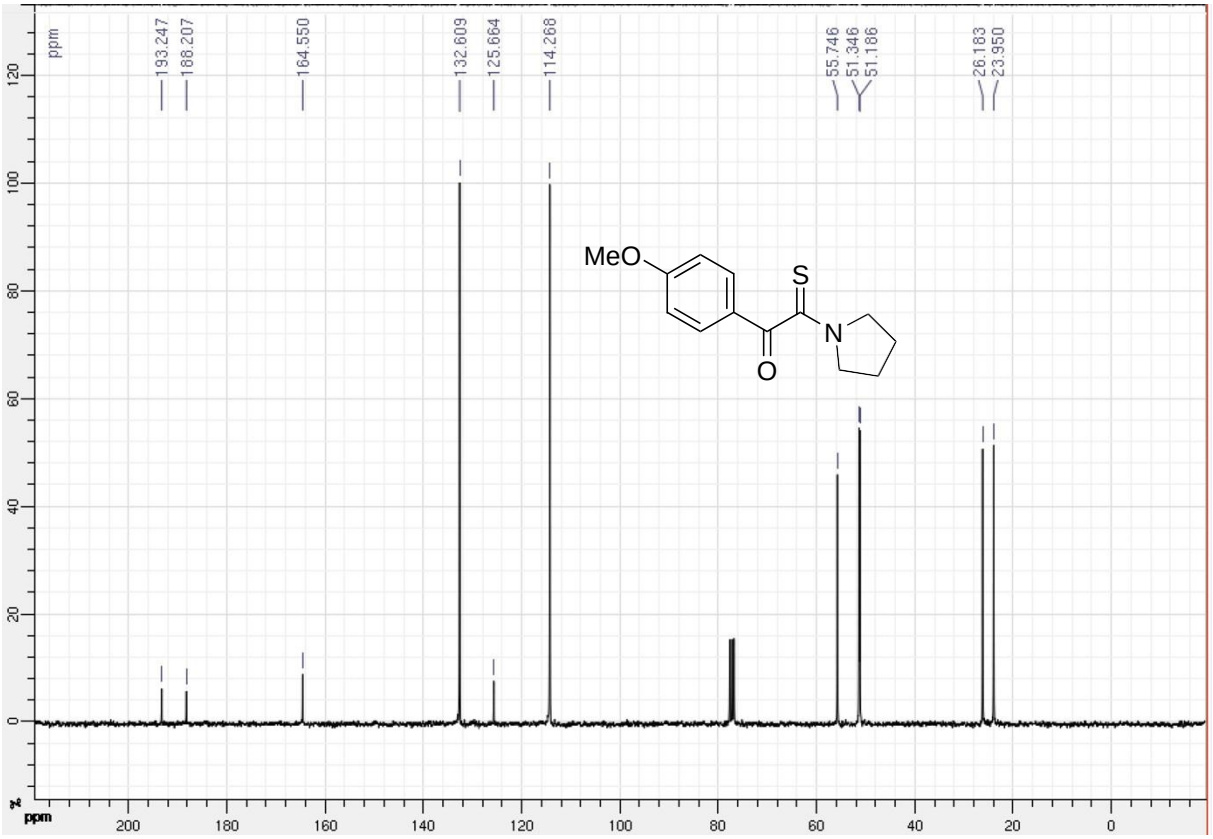
1-Phenyl-2-(pyrrolidin-1-yl)-2-thioxoethan-1-one (3y)



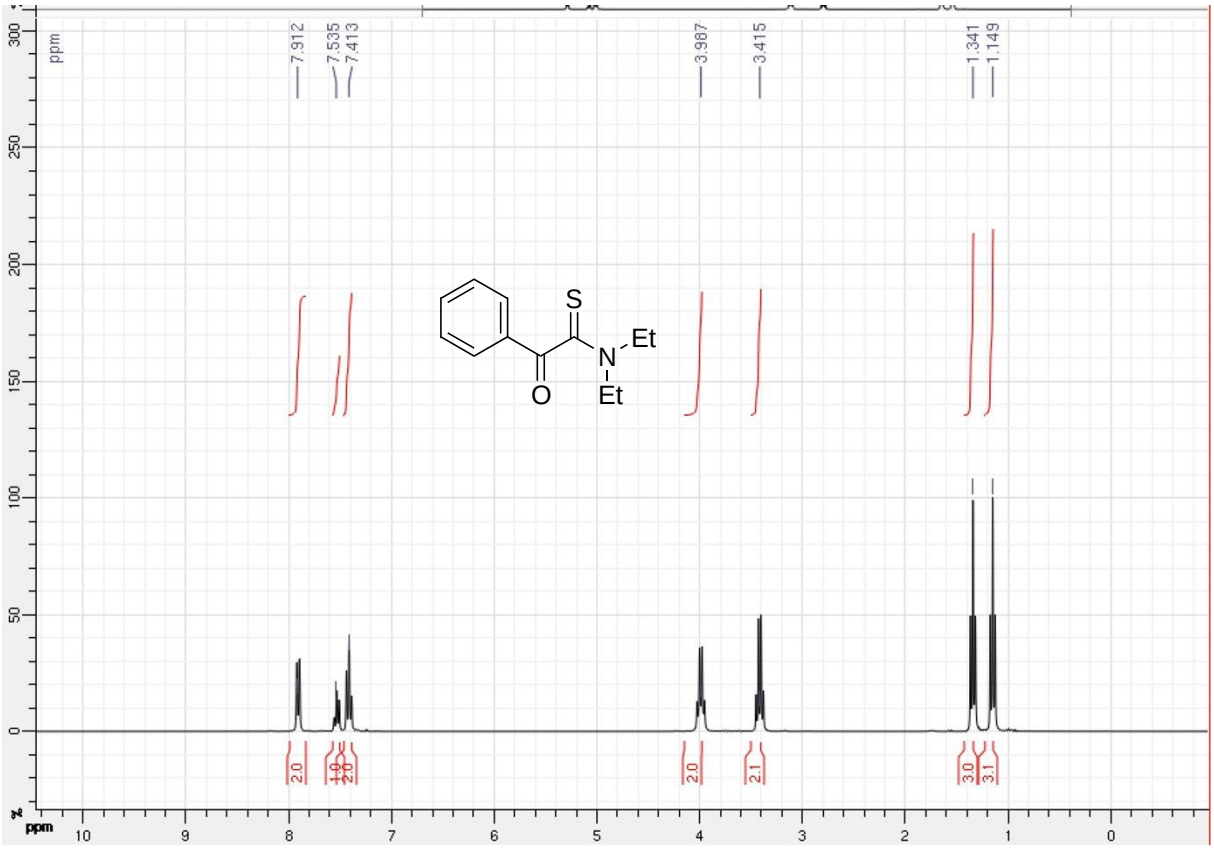


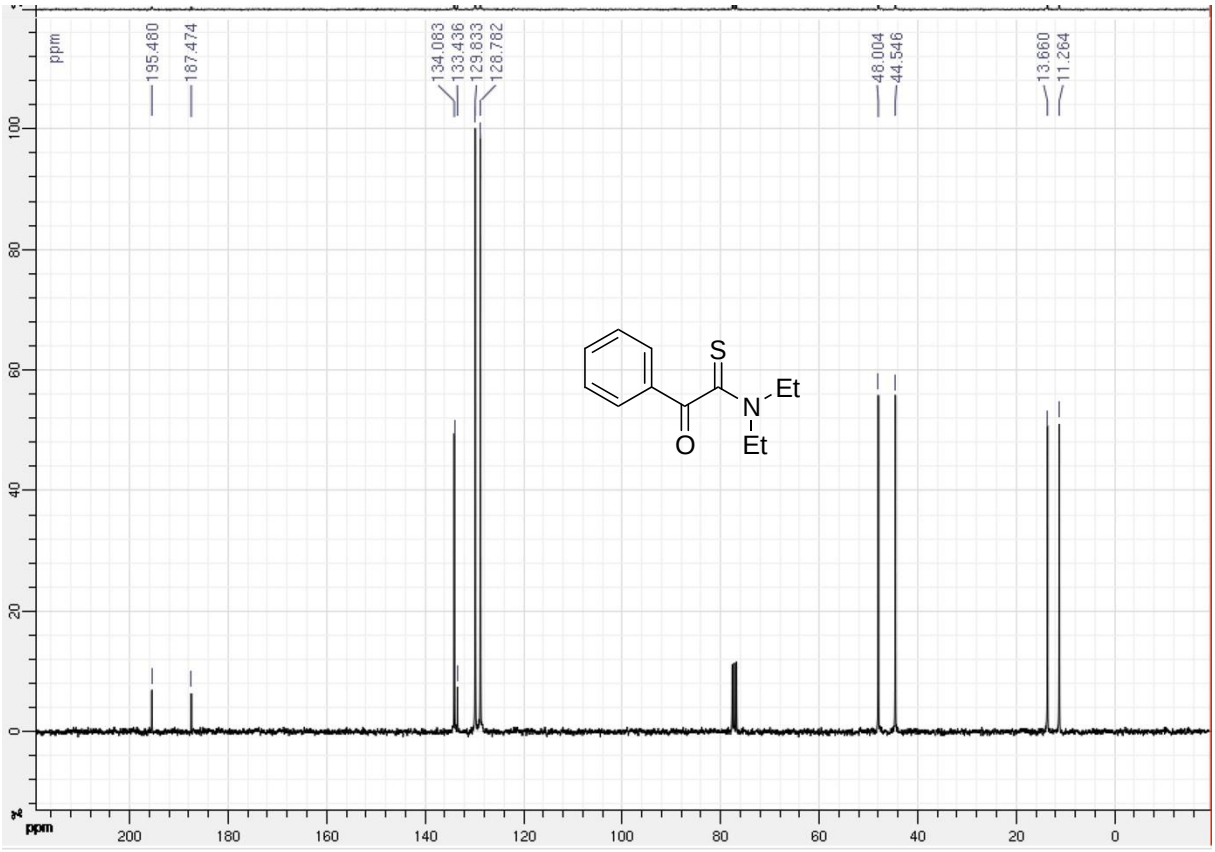
1-(4-Methoxyphenyl)-2-(pyrrolidin-1-yl)-2-thioxoethan-1-one (3z)



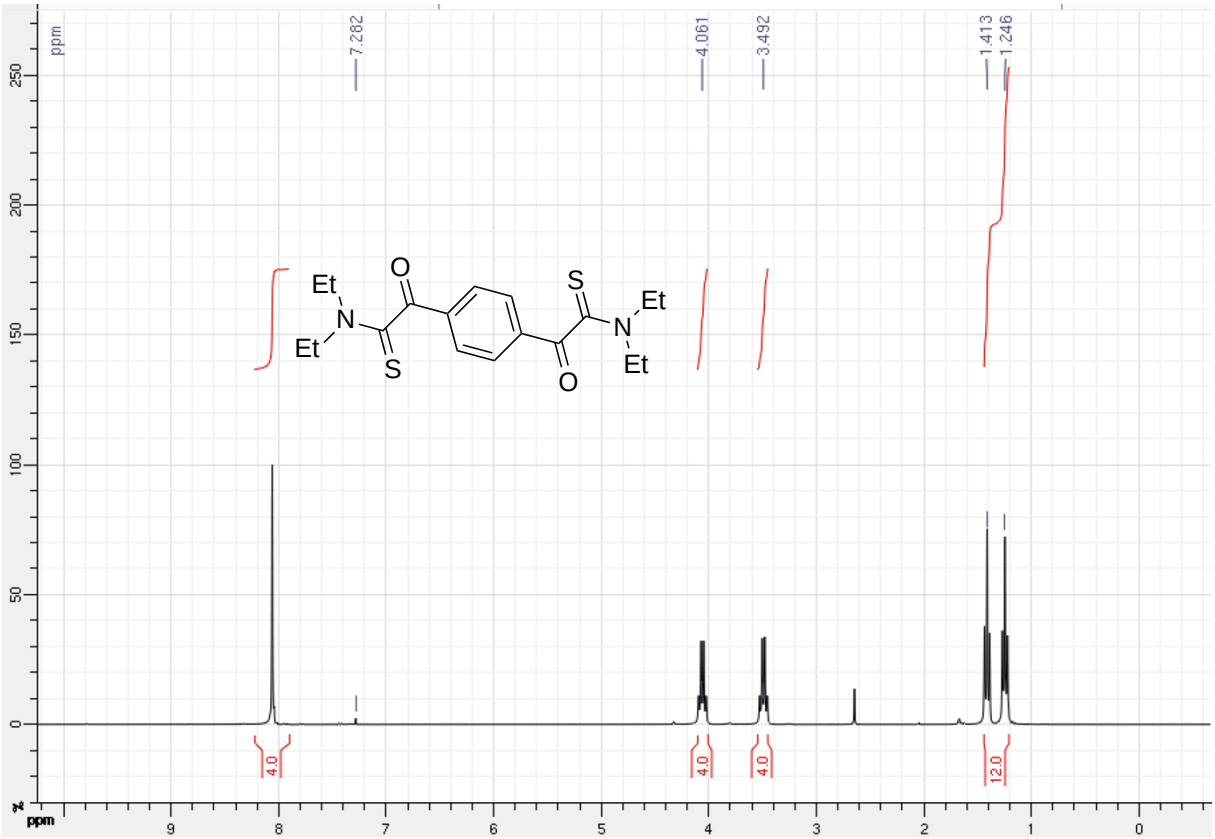


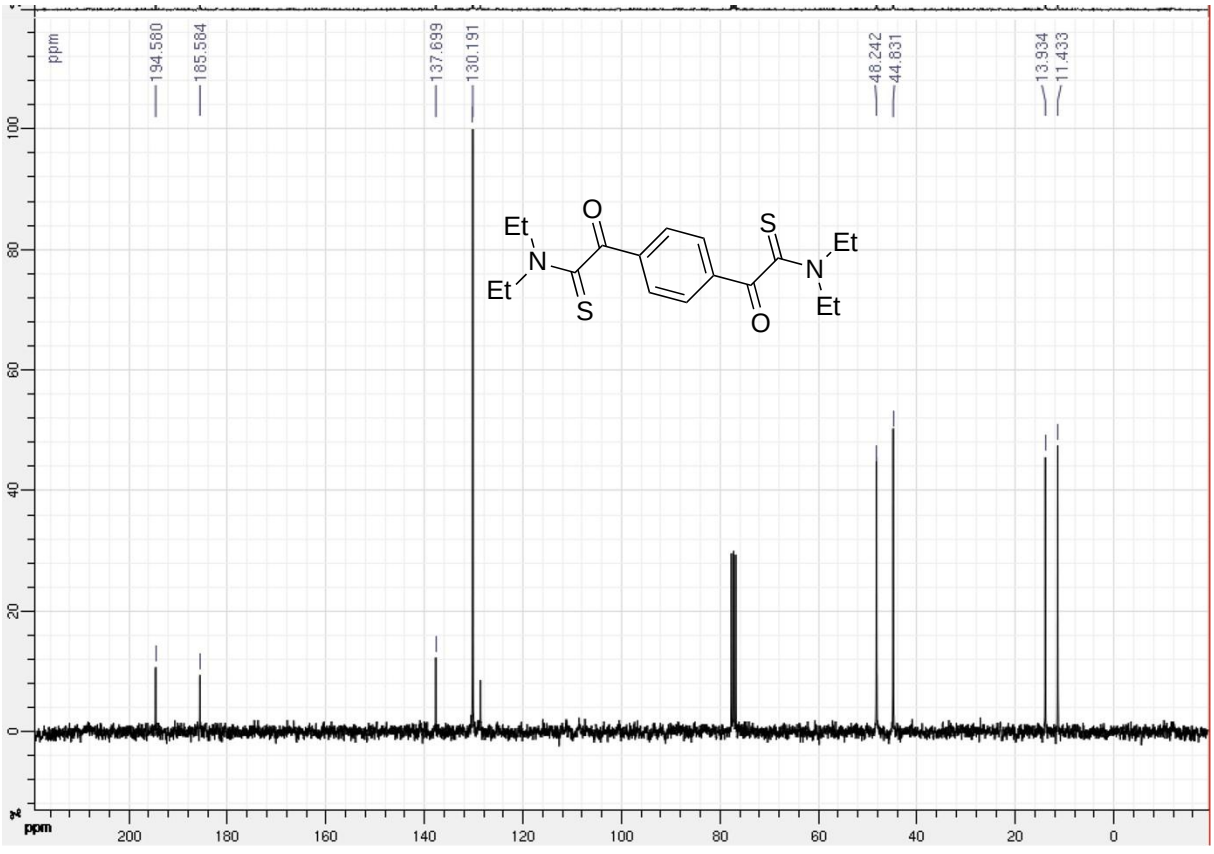
***N*,*N*-Diethyl-2-oxo-2-phenylethanethioamide (3aa)**





2,2'-(1,4-Phenylene)bis(*N*,*N*-diethyl-2-oxoethanethioamide) (3ab)





***N*,*N*-Diethyl-2-(3-hydroxyphenyl)-2-oxoethanethioamide (3ac)**