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Supporting information

for

Metal Free One-Pot Synthesis of α-Ketoamides from Terminal Alkenes

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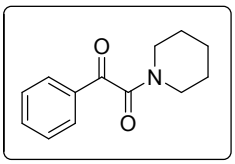
Contents

General considerations

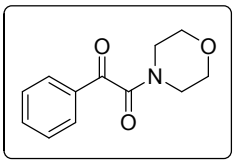
All reactions were carried out in reaction tubes under aerobic atmosphere unless otherwise mentioned. All the solvents were purchased from commercial sources and used without further purification. Wherever necessary, the solvents were dried by standard literature procedures. Reactions were monitored by thin-layer chromatography (TLC) using Merck silica gel 60 F_{254} precoated plates (0.25 mm) and analyzed by UV fluorescence quenching using appropriate mixture of ethyl acetate and hexanes as eluting solvent mixture. Silica gel (particle size 100-200 mesh) purchased from SRL India was used for column chromatography using hexanes and ethyl acetate mixture as eluent. All the chemicals used are purchased from commercially available sources and used without further purification unless otherwise mentioned. IBX was prepared using literature procedure.[1] Reactions were carried out in temperature controlled IKA magnetic stirrers.^{1}H and ^{13}C NMR spectra were recorded on a Bruker 400 or 500 MHz instrument. ^{1}H NMR spectra were reported relative to Me_4Si (δ 0.0 ppm) or residual $CHCl_3$ (δ 7.26 ppm). ^{13}C NMR were reported relative to $CDCl_3$ (δ 77.16 ppm). FTIR spectra were recorded on a Nicolet 6700 spectrometer and were reported in frequency of absorption (cm^{-1}). High resolution mass spectra (HRMS) were recorded on Q-Tof Micro mass spectrometer.

Typical experimental procedure for α-ketoamides from styrenes

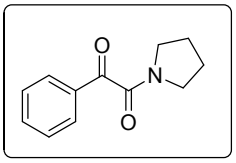
In a clean reaction tube, I_2 (254 mg, 1.0 mmol) and IBX (280 mg, 1.0 mmol) was taken and dissolved in 2.5 mL of DMSO by stirring for 5 min at rt followed by addition of styrene (1a, 0.05 mL, 0.5 mmol). The mixture was transferred to a 80 ^{o}C oil bath and stirred for 3.5 hours. Piperidine (1b, 0.2 mL, 2.0 mmol) was added to the stirring solution slowly and stirred till the reaction was complete. Completion of reaction was monitored using TLC by checking the complete disappearance of the intermediate phenylglyoxal . The reaction was then extracted with ethyl acetate for few times and the combined organic layer was washed with saturated sodium thiosulphate and saturated sodium bicarbonate solutions. It was then dried over anhydrous sodium sulphate, filtered and concentrated under reduced pressure. The crude product was purified using column chromatography (silicagel, petroleum ether:ethyl acetate=85:15) to give the desired tertiary α-ketoamide (2a).



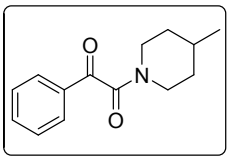
1-Phenyl-2-(piperidin-1-yl)ethane-1,2-dione (2a):[2] yellow solid; mp 94-96 ^{0}C R_f = 0.28 (in 20% ethyl acetate: hexanes); ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.94 (d, *J*=7.2Hz, 2H), 7.62 (t, *J*=7.6Hz, 1H) 7.50 (t, *J*=7.6Hz, 2H), 3.69 (brs, 2H), 3.28 (t, *J*=5.6Hz, 2H) 1.68 (t, *J*=2.8Hz 4H), 1.54 (d, *J*=5.2Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 192.1, 165.6, 134.8, 133.4, 129.7, 129.1, 47.2, 42.3, 26.3, 25.6, 24.5; FTIR: 3418, 2884, 1733, 1638, 1397, 1264, 1048 cm^{-1}; $[M+Na]^+$ calcd. for $C_{13}H_{15}NO_2Na$: 240.0995; found: 240.0998.



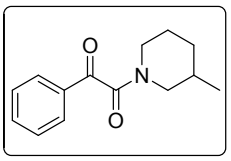
1-Morpholino-2-phenylethane-1,2-dione (2b):[2] yellow oil; R_f = 0.35 (in 30% ethyl acetate: hexanes); ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.99-7.93 (m, 2H), 7.69-7.62 (m, 1H), 7.56-7.49 (m, 2H), 3.79 (brs, 4H), 3.68-3.62 (m, 2H), 3.41-3.35 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 191.3, 165.6, 135.1, 133.2, 129.8, 129.2, 66.9, 66.8, 46.4, 41.8; FTIR: 3436, 2862, 1731, 1665, 1636, 1447, 1106 cm^{-1}; $[M+H]^+$ calcd. for $C_{12}H_{14}NO_3$: 220.0974; found: 220.0973



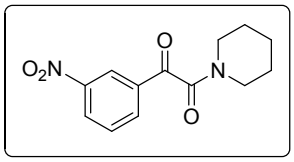
1-Phenyl-2-(pyrrolidin-1-yl)ethane-1,2-dione (2c):[2] Yellow oil; R_f = 0.41 (in 30% ethyl acetate: hexanes); ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.02-7.96 (m, 2H), 7.66-7.59 (m, 1H), 7.54-7.46 (m, 2H), 3.65 (t, *J*=6.4Hz, 2H), 3.42 (t, *J*=6.8Hz, 2H), 2.02-1.88 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 191.7, 165.1, 134.7, 133.0, 130.1, 129.1, 46.8, 45.4, 26.0, 24.2; FTIR: 2967, 2870, 1672, 1651 cm^{-1}; $[M+H]^+$ calcd. for $C_{12}H_{14}NO_2$: 204.1025; found: 204.1021.



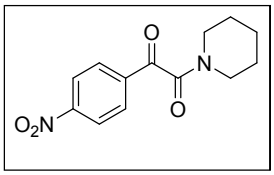
1-(4-Methylpiperidin-1-yl)-2-phenylethane-1,2-dione (2d):[2] yellow oil; R_f = 0.43 (in 20% ethyl acetate : hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97-7.91 (m, 2H), 7.66-7.6 (m, 1H), 7.54-7.47 (m, 2H), 4.7-4.55 (m,1H), 3.6-3.4 (m,1H), 3.1-2.9 (m, 1H), 2.79 (td, J_1=12.8Hz, J_2=2.8Hz, 1H), 2.1-1.5 (m, 3H), 1.40-1.10 (m, 2H), 0.97 (d, *J*=6.8Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 192.0, 165.6, 134.8, 133.4, 129.7, 129.1, 46.5, 41.7, 34.4, 33.7, 31.2, 21.7; FTIR: 2924, 1741, 1641, 1123 cm^{-1}; $[M+Na]^+$ calcd. for $C_{14}H_{17}O_2$ N Na : 254.1152; found: 254.1157.



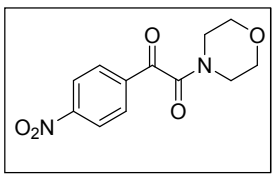
1-(3-Methylpiperidin-1-yl)-2-phenylethane-1,2-dione (2e):[2] yellow oil; R_f = 0.44 (in 20% ethyl acetate: hexane); mixture of cis and trans isomers. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.99-7.92 (m, 4H), 7.67-7.60 (m, 2H), 7.50 (t, *J*=7.6Hz, 4H), 4.6-4.40 (m, 2H), 3.55-3.35 (m, 2H), 3.1-2.95 (m, 1H), 2.85-2.75 (m, 1H), 2.75-2.65 (m, 1H), 2.55-2.45 (m, 1H), 1.95-1.70 (m, 5H), 1.6-1.4 (m, 2H), 1.3-1.1 (m, 3H), 0.99 (d, *J*=6.8Hz, 3H), 0.80 (d, *J*=6.8Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 192.1, 165.6, 134.8, 133.5, 129.8, 129.1, 53.5, 48.6, 46.7, 41.8, 33.1, 33.0, 31,8, 31.2, 25.8, 24.8, 19.1, 18.8; FTIR: 2923, 1601, 1675, 1176 cm^{-1}; $[M+Na]^+$ calcd. for $C_{14}H_{17}O_2$ N Na : 254.1152; found: 254.1156.



1-(3-Nitrophenyl)-2-(piperidin-1-yl)ethane-1,2-dione (2f):[3] yellow oil; R_f = 0.31 (in 30% ethyl acetate: hexanes); ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.79-8.67 (m, 1H); 8.51-8.36 (m, 1H); 8.31-8.2 (m, 1H); 7.71 (t, *J*= 8Hz, 1H); 3.78-3.6 (br, 2H), 3.32 (t, *J*=5.6 Hz, 2H), 1.70 (t, *J*=1.4Hz, 4H), 1.56 (br, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 189.1, 164.1, 148.7, 135.1, 135.0, 130.4, 128.7, 124.3, 47.2, 42.6, 26.5, 25.5, 24.4; FTIR : 3108, 2853, 1681, 1635, 1529, 1445, 1347, 770, 714 cm^{-1}; $[M+H]^+$ calcd. for $C_{13}H_{15}O_4N_2$: 263.1032; found: 263.1020.

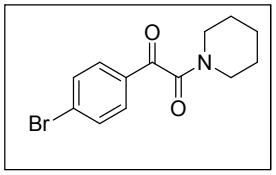


1-(4-Nitrophenyl)-2-(piperidin-1-yl)ethane-1,2-dione (2g):[3] light yellow solid; mp 94–97 °C; R_f = 0.33 (30% EtOAc in hexanes). ^{1}H NMR (400 MHz, CDCl3): δ = 8.38-8.29 (m, 2H), 8.17-8.08 (m, 2H), 3.71 (brs, 2H), 3.35-3.25 (m, 2H), 1.80–1.65 (m, 4H), 1.60–1.50 (brs, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 189.6, 164.2, 151.2, 137.8, 130.8, 124.3, 47.2, 42.6, 26.4, 25.6, 24.4; FTIR : 3102, 2866, 1687, 1638, 1537, 1468, 1346, 12810, 843 cm^{-1}; $[M+H]^+$ calcd. for $C_{13}H_{15}O_4N_2$: 263.1032; found: 263.1021.

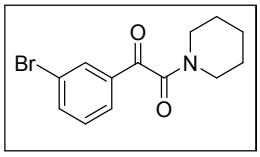


1-morpholino-2-(4-nitrophenyl) ethane-1,2-dione (2h):[3] light yellow solid; mp 137-139 °C ; R_f = 0.33 (30% Ethyl acetate : hexanes). ^{1}H NMR (400 MHz, CDCl3): δ = 8.78 (s, 1H), 8.54-8.45 (m, 1H), 8.30 (d, *J*=8Hz, 1H), 7.74 (t, *J*=8Hz, 1H), 3.82 (brs, 4H), 3.69 (t, *J*=4.8Hz,n2H), 3.47-3.40(m, 2H), ^{13}C NMR (100 MHz, CDCl3): δ 188.3,

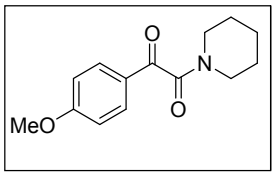
164.0, 148.8, 139.4, 135.2, 130.5, 129.0, 124.7, 66.9, 66.8, 46.5, 42.1, 24.6; FTIR : 3075, 2864, 1682, 1641, 1527, 1455, 1345, 1115, 836 cm^{-1};



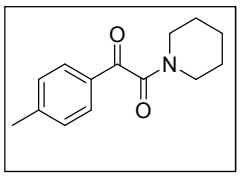
1-(4-Bromophenyl)-2-(piperidin-1-yl)ethane-1,2-dione (2i):[3] white solid; m.p. 88-90, R_f = 0.33 (in 30% ethyl acetate: hexane); ^{1}H NMR (400 MHz, $CDCl_3$): δ= 7.81 (d, *J*= 8.4 Hz, 2H), 7.65 (d, *J*=8.4 Hz, 2H), 3.70-3.69 (t, *J*=4.8 Hz, 2H), 1.69 (br, 4H), 1.55 (br, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 190.9, 165.0, 132.5, 132.3, 131.1, 130.2, 47.2, 42.4, 26.4, 25.6, 24.5; FTIR : 3445, 3072, 2947, 2840, 1668, 1631, 1571, 1109, 842, 753 cm^{-1}; $[M+Na]^+$ calcd. for C_{13} H_{14} O_2 N Br Na : 318.0100; found: 318.0107.



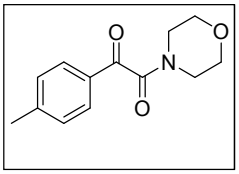
1-(3-Bromophenyl)-2-(piperidin-1-yl)ethane-1,2-dione (2j):[4] yellow liquid; R_f = 0.56 (in 30% Ethyl acetate : hexane); ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.12-8.03 (m, 1 H), 7.84 (d, *J* = 7.6 Hz, 1H), 7.74 (d, *J*=8.0 Hz, 1H), 7.39 (t, *J*=7.6 Hz, 1H), 3.67 (brs, 2 H), 3.32-3.2 (m, 2H), 1.75–1.62 (m, 4H), 1.6–1.5 (m, 2H); ^{13}C NMR (100 MHz, CDCl3): δ 190.4, 164.8, 137.5, 135.2, 132.3, 130.7, 128.3, 123.4, 47.2, 42.4, 26.3, 25.5, 24.4; FTIR : 3069, 2943, 1684, 1634, 1281, 746 cm^{-1}; $[M+Na]^+$ calcd. for C_{13} H_{14} O_2 N Br Na:318.0100; found:318.0104.



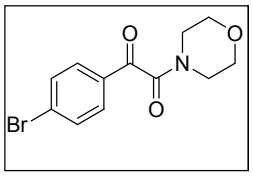
1-(4-Methoxyphenyl)-2-(piperidin-1-yl)ethane-1,2-dione (2k):[5] yellow liquid, R_f = 0.30 (in 30% ethyl acetate: hexanes); ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.89 (d, *J*=7.2Hz, 2H); 6.95 (d, *J*=7.2, 2H); 3.14 (s, 3H); 3.68-3.67 (t, *J*=4Hz, 2H); 3.26 (t, *J*=4.8Hz, 2H); 1.67-1.66 (m, 4H); 1.51 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 190.8, 165.9, 164.9, 132.1, 126.5, 114.4, 55.7, 47.1, 42.1, 26.3, 25.6, 24.5; FTIR: 3071, 2863, 1682, 1641, 1526, 1453, 1346, 1115, 836 cm^{-1} (*m*/*z*): $[M+H]^+$ calcd. for $C_{14}H_{18}NO_3$:248.1287, found: 248.1283.



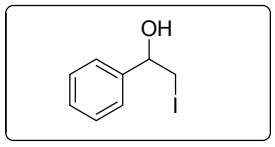
1-(Piperidin-1-yl)-2-(p-tolyl)ethane-1,2-dione (2l):[5] yellow oil; R_f = 0.38 (in 30% ethyl acetate: hexanes); ^{1}H NMR (400 MHz, $CDCl_3$): δ=7.82 (d, *J*=8Hz, 2H), 7.29 (d, *J*=8Hz, 2H), 3.68 (brs, 2H); 3.26 (t, *J*=5.6 Hz, 2H); 2.24 (s, 3H), 1.68-1.67 (m, 4H), 1.53-1.51(m, 2H), ^{13}C NMR (100 MHz, $CDCl_3$): δ 191.9, 165.8, 146, 131, 129.8, 129.8, 47.1, 42.2, 26.3, 25.6, 24.49, 21.98; FTIR : 3038, 2861, 1668, 1641, 1454, 851 cm^{-1}; $[M+Na]^+$ calcd. for $C_{14}H_{17}O_2N$ Na: 254.1152; found: 254.1156.



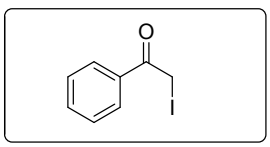
1-Morpholino-2-(*p*-tolyl)ethane-1,2-dione (2m):[5] yellow oil; R_f = 0.18 (in 30% ethyl acetate: hexanes); ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.84 (d, *J*=8Hz, 2H), 7.3 (d, *J*=7.6Hz, 2H), 3.77 (br,2H), 3.64 (t, *J*=5.6 Hz, 2H), 3.39-3.33 (m, 2H), ^{13}C NMR (100 MHz, $CDCl_3$): δ 191.0, 165.8, 146.4, 130.1, 130, 129.78, 66.9, 66.8. 46.4, 41.7, 22.0; FTIR : 3103, 2867, 1686, 1637, 1536, 1468, 1346, 1281, 844 cm^{-1};



1-(4-Bromophenyl)-2-morpholinoethane-1,2-dione (2n):[3] white solid; mp 122-124 ^{o}C; R_f = 0.34 (in 30% ethyl acetate : hexanes);^{1}H NMR (400 MHz, $CDCl_3$) δ 7.84-7.79 (m, 2H), 7.69-7.64 (m, 2H), 3.82-3.74 (m, 4H), 3.67-3.62 (m, 2H), 3.69 (t, *J*=5.2Hz, 2H); ^{13}C NMR (100 MHz, CDCl3): δ 190.0, 165, 132.6, 131.2, 130.6, 66.9, 66.8, 46.4, 41.9; FTIR : 3448, 3073, 2947, 2838, 1671, 1629, 1569, 1109, 842, 756 cm^{-1}; $[M+H]^+$ calcd. for $C_{12}H_{13}NO_3Br$: 298.0079; found: 298.0067.



2-Iodo-1-phenylethanol (1d): Colourless liquid; R_f 0.32 (in 10% Ethyl acetate: hexanes); ^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 7.25-7.37 (m, 5H), 4.81-4.84 (m, 1H), 3.51-3.38 (m, 2H), 2.518 (br, s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): 141.1, 128.7, 128.3, 125.7, 74.06, 15.32. FTIR: 3430, 2867, 1731, 1447, 1102 cm^{-1}; MS(EI) 247.9636 (M^+).



2-Iodo-1-phenylethanone (1e):[6] yellow solid; m.p. 36-38 ^{o}C; R_f 0.66 (in 10% Ethyl acetate: hexanes); ^{1}H NMR ($CDCl_3$, 400 MHz,

ppm): δ 7.86-7.84 (d, *J*=7.2 Hz, 2H), 7.58-754 (t, *J*=7.4, 1H), 7.45-7.42 (m, 2H), 4.81 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): 198.3, 134.2, 133.41, 128.9, 127.6, 30.1; FTIR: 2865, 1716, 1665, 1447, 1112 cm^{-1}; MS(EI) 245.9540(M^+).

References

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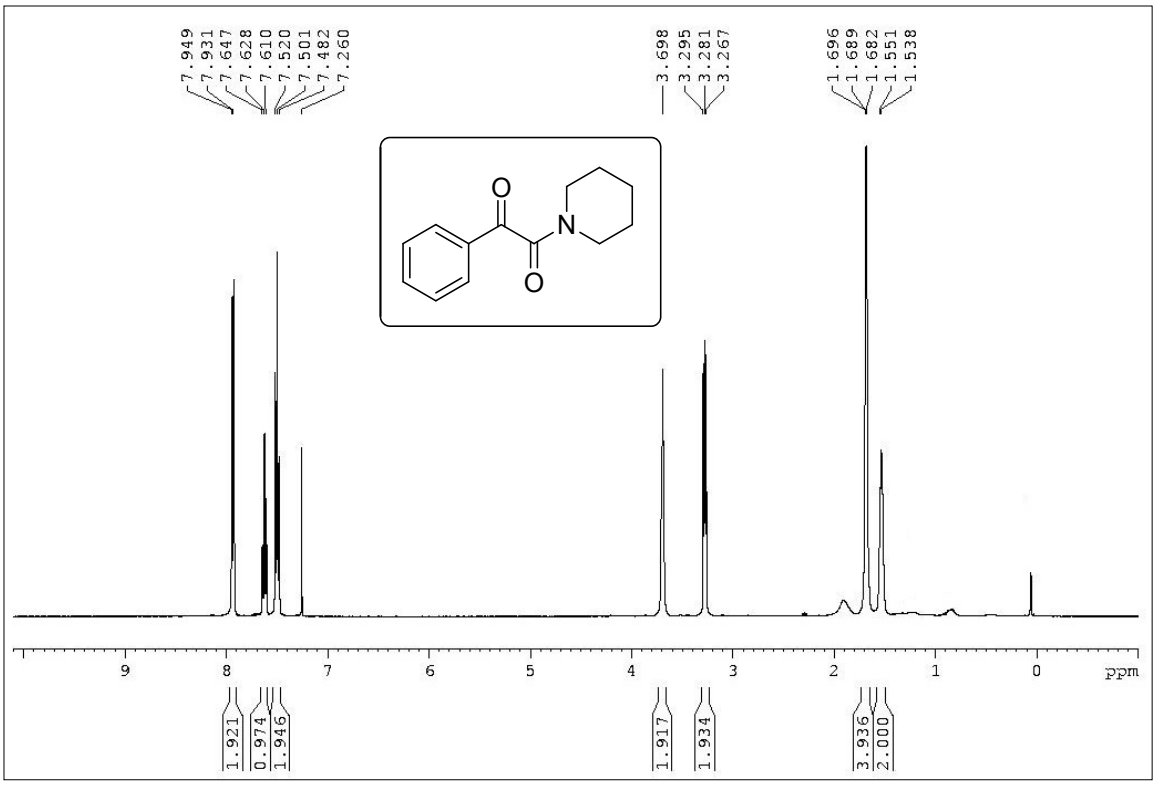


Figure 1:400 MHz ^{1}H NMR spectrum of **2a** in $CDCl_3$

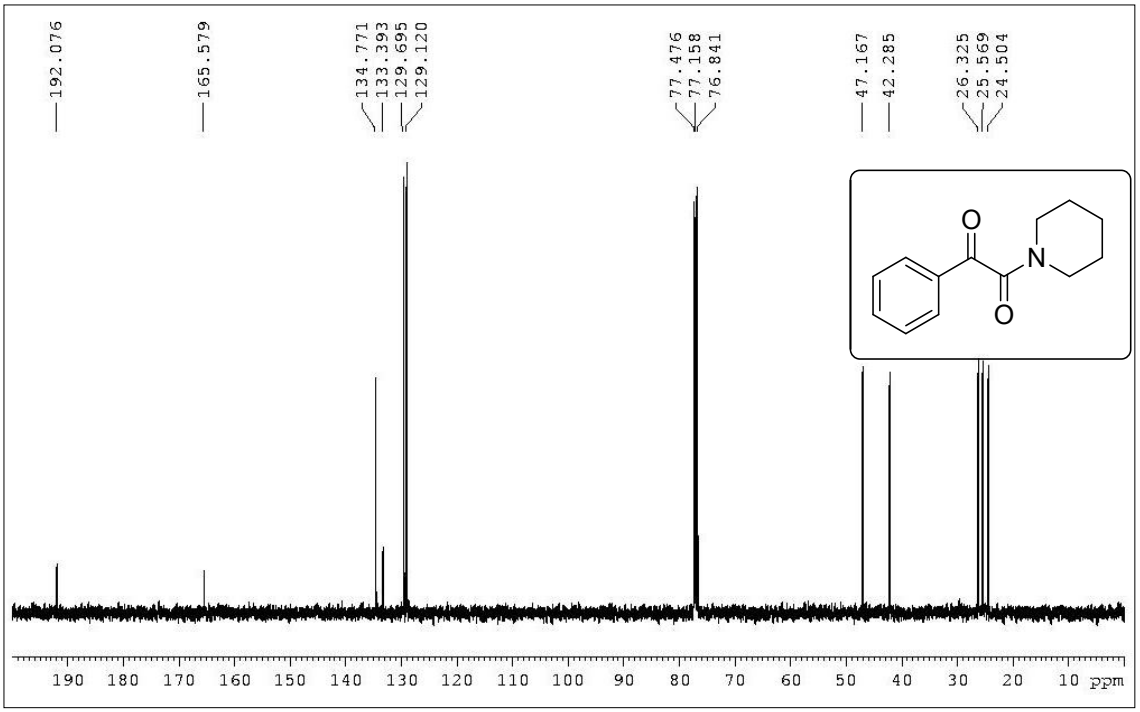


Figure 2:100 MHz ^{13}C NMR spectrum of **2a** in $CDCl_3$

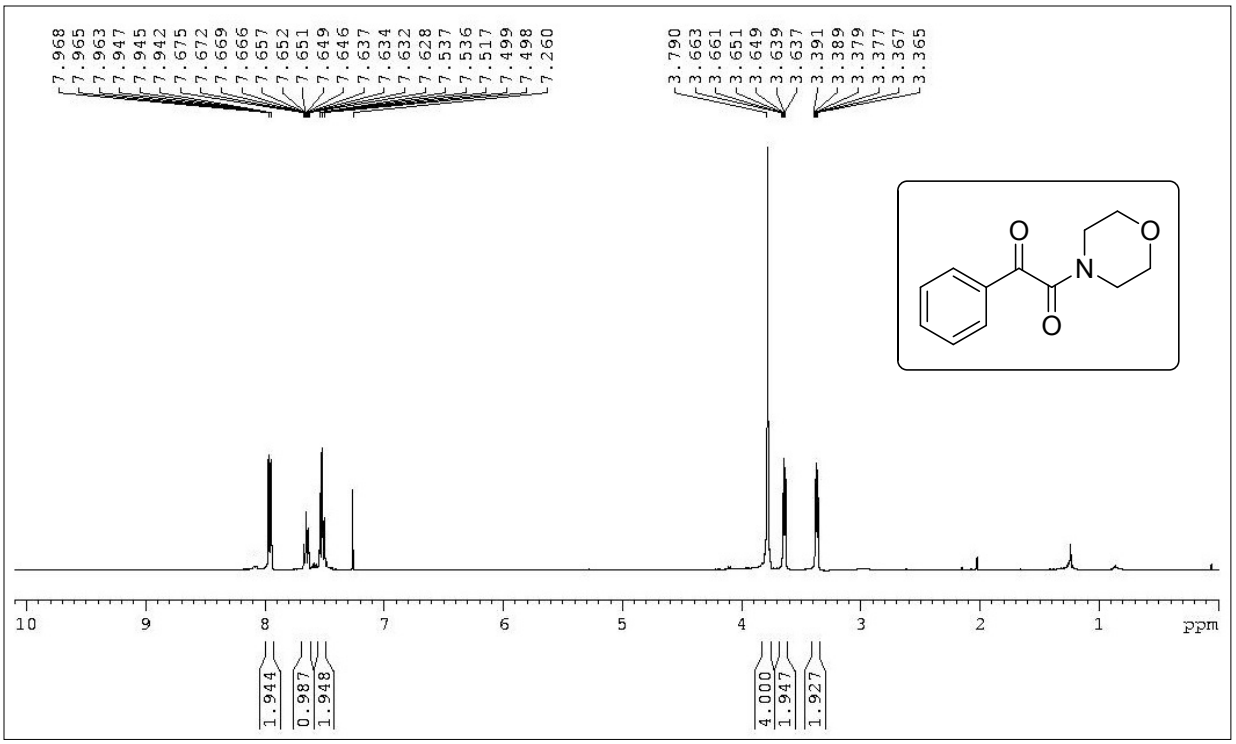


Figure 3:400 MHz ^{1}H NMR spectrum of **2b** in $CDCl_3$

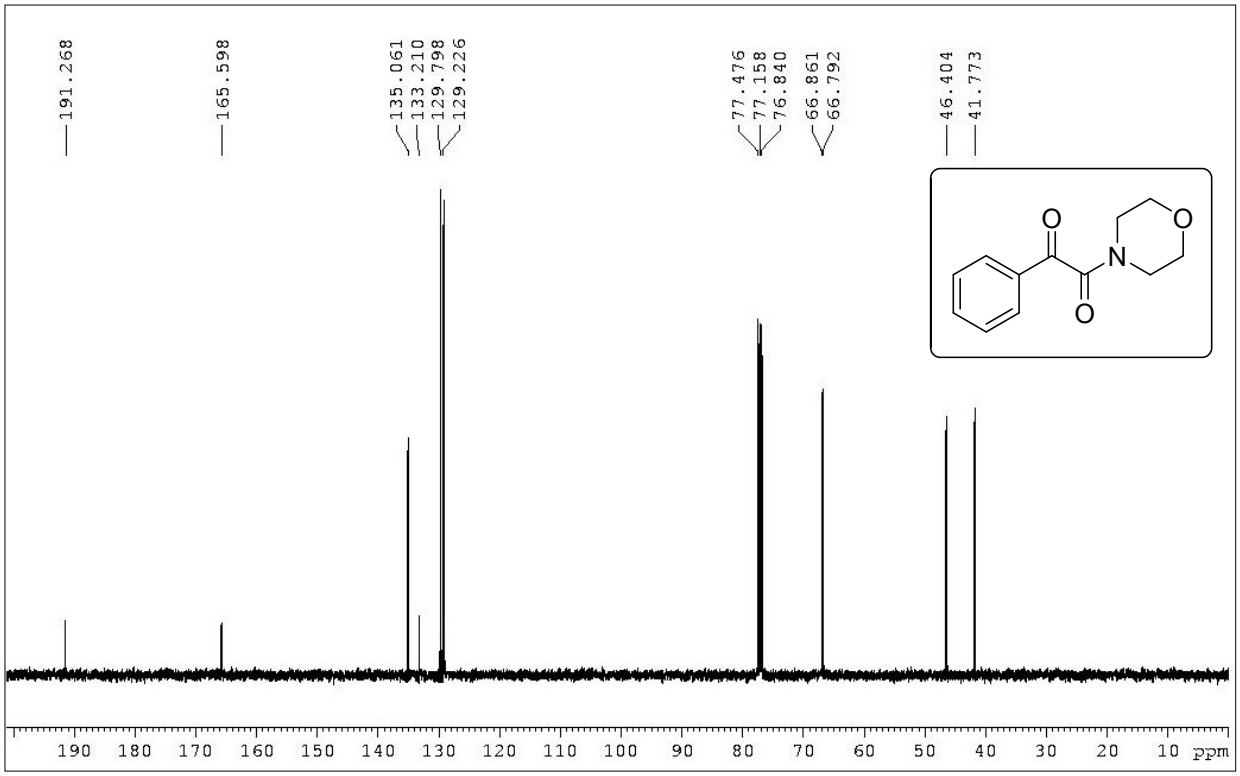


Figure 4:100 MHz ^{13}C NMR spectrum of **2b** in $CDCl_3$

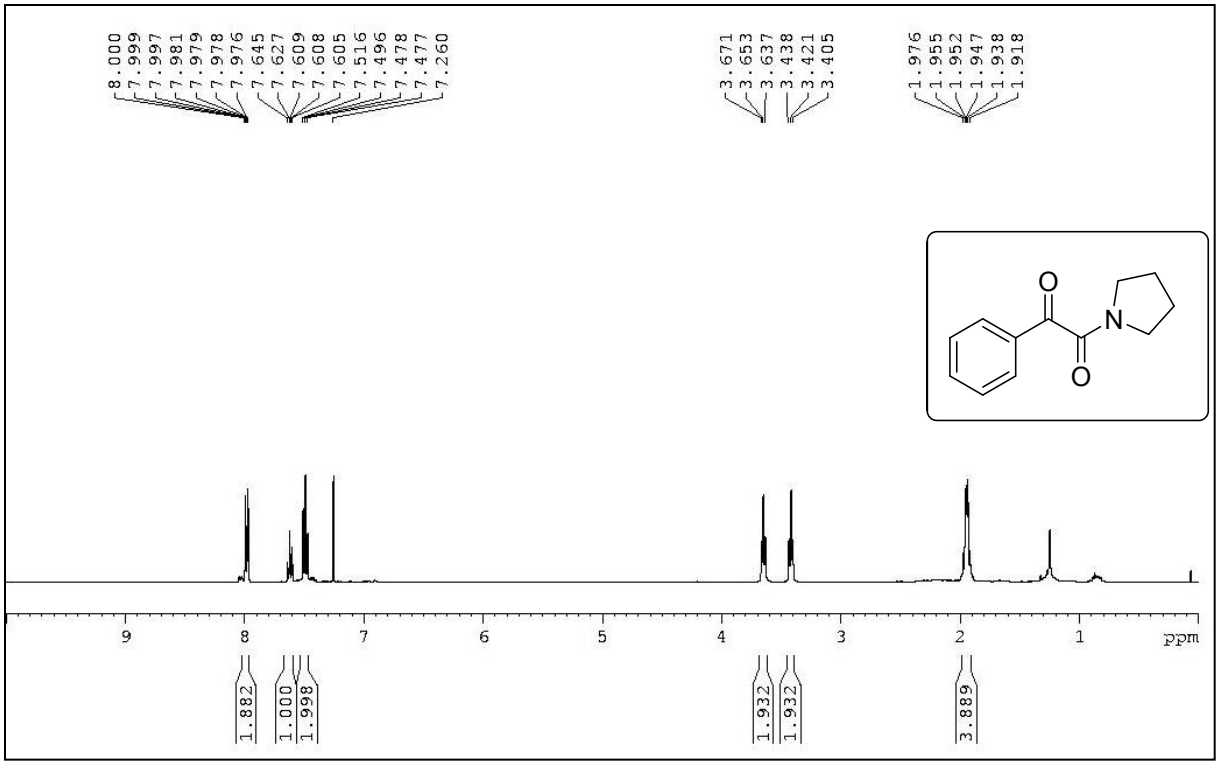


Figure 5:400 MHz ^{1}H NMR spectrum of **2c** in $CDCl_3$

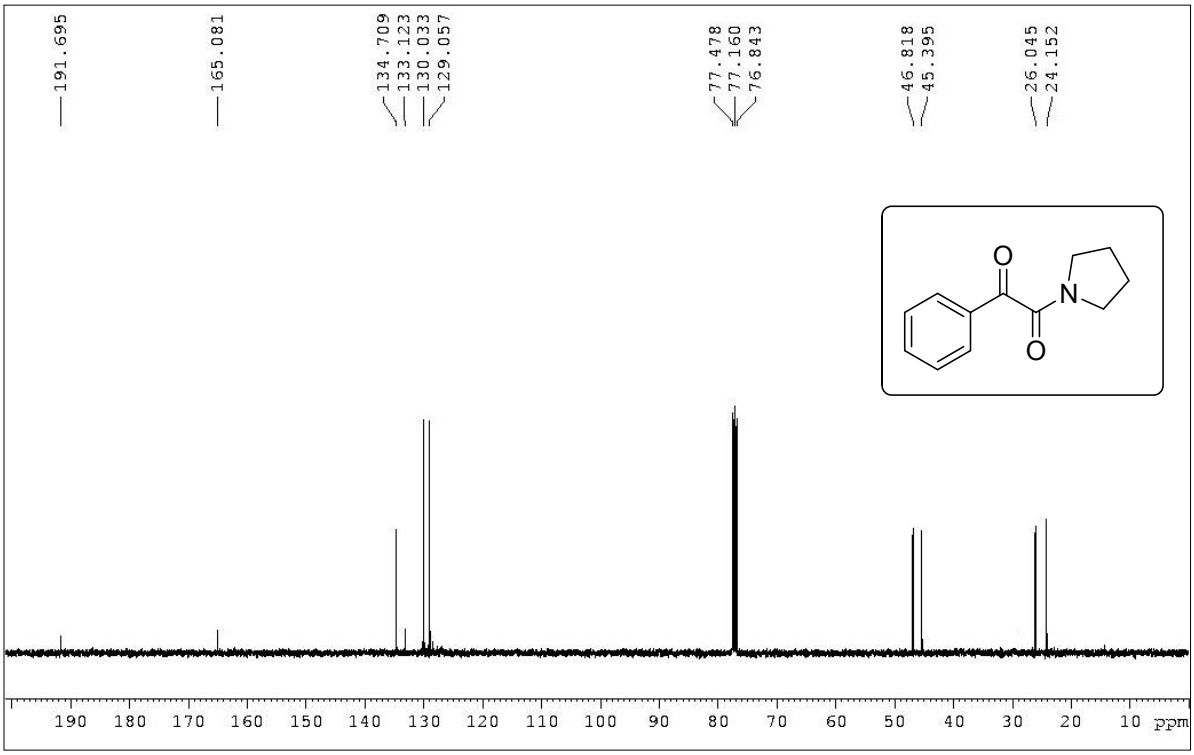


Figure 6:100 MHz ^{13}C NMR spectrum of **2c** in $CDCl_3$

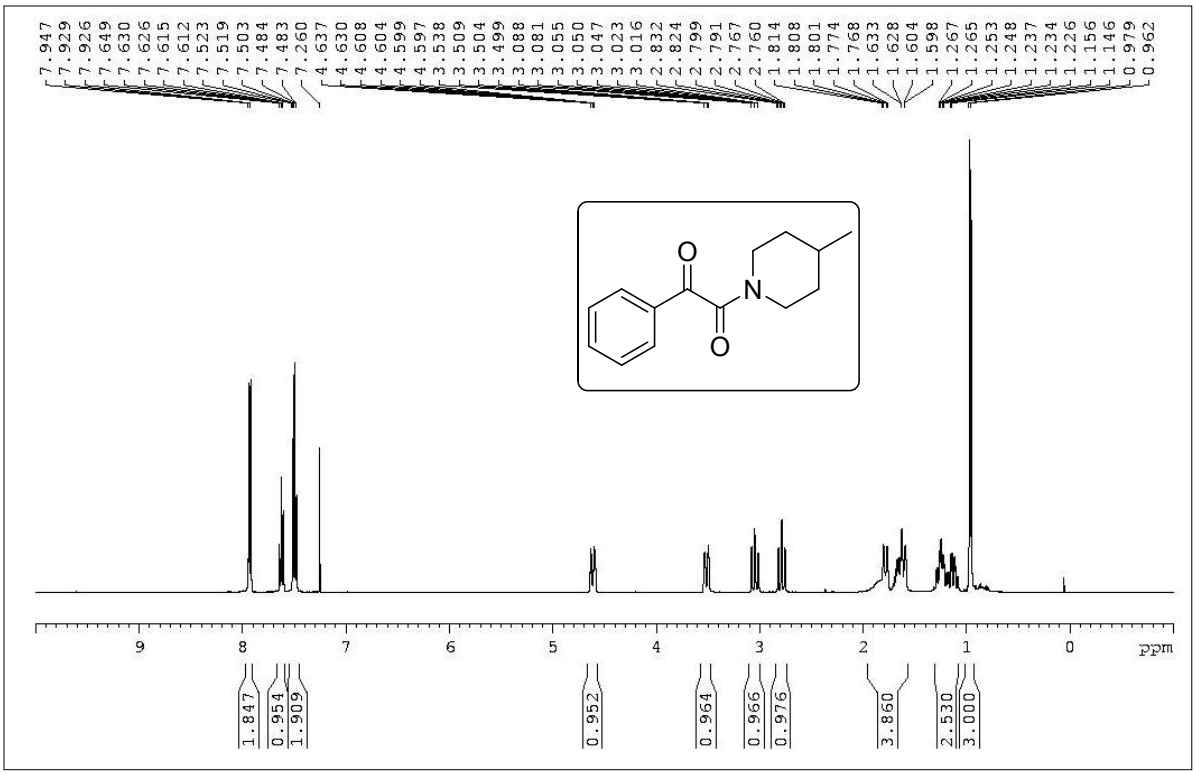


Figure 7:400 MHz ^{1}H NMR spectrum of **2d** in $CDCl_3$

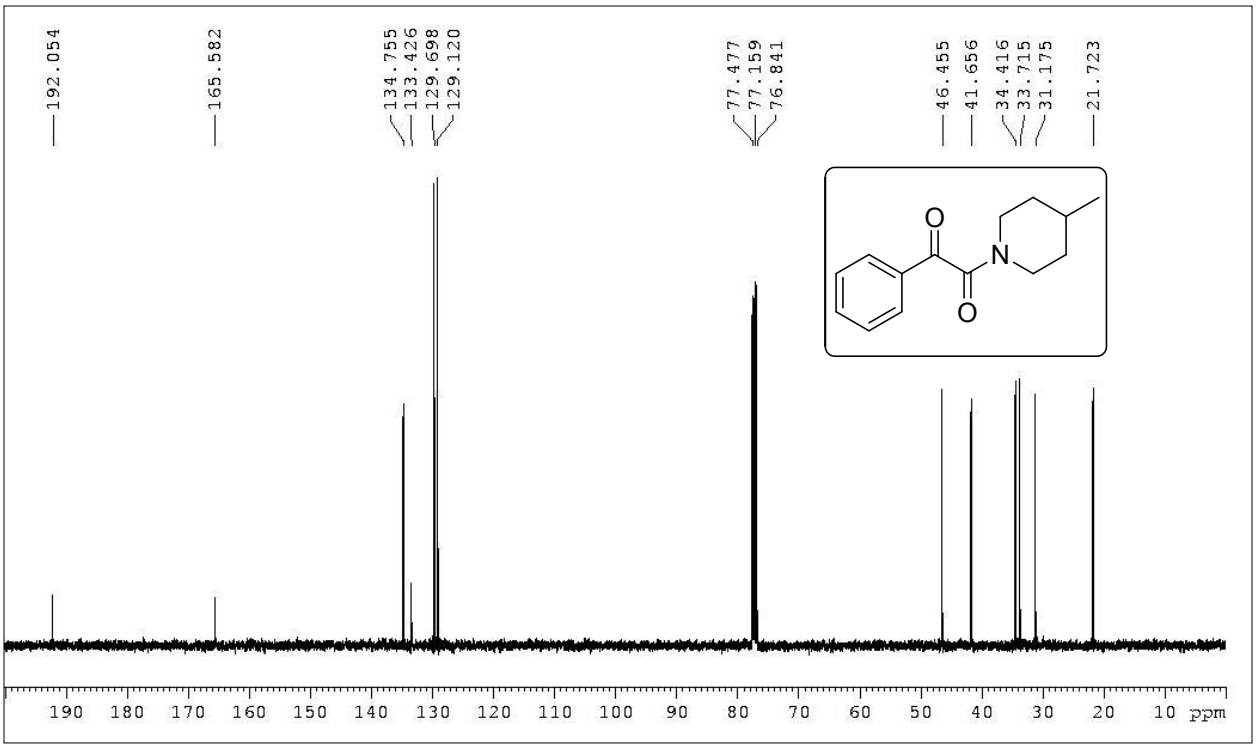


Figure 8:100 MHz ^{13}C NMR spectrum of **2d** in $CDCl_3$

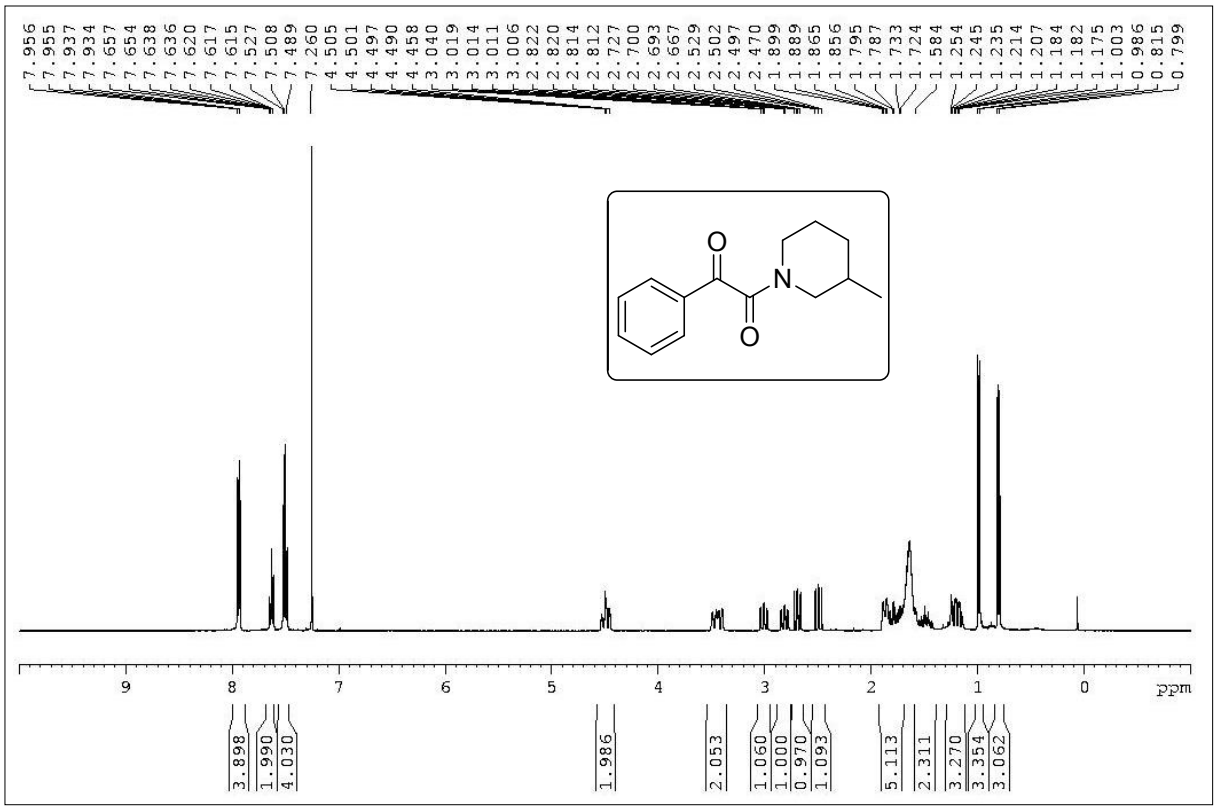


Figure 9:400 MHz ^{1}H NMR spectrum of **2e** in $CDCl_3$

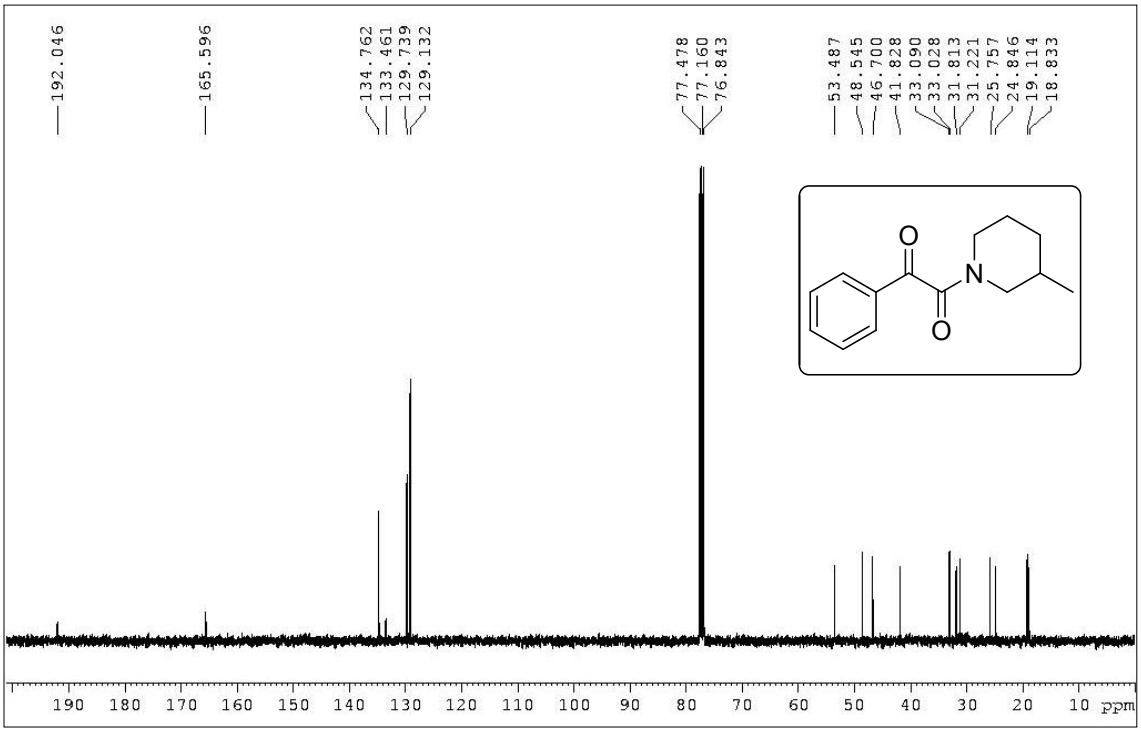


Figure 10:100 MHz ^{13}C NMR spectrum of **2e** in $CDCl_3$

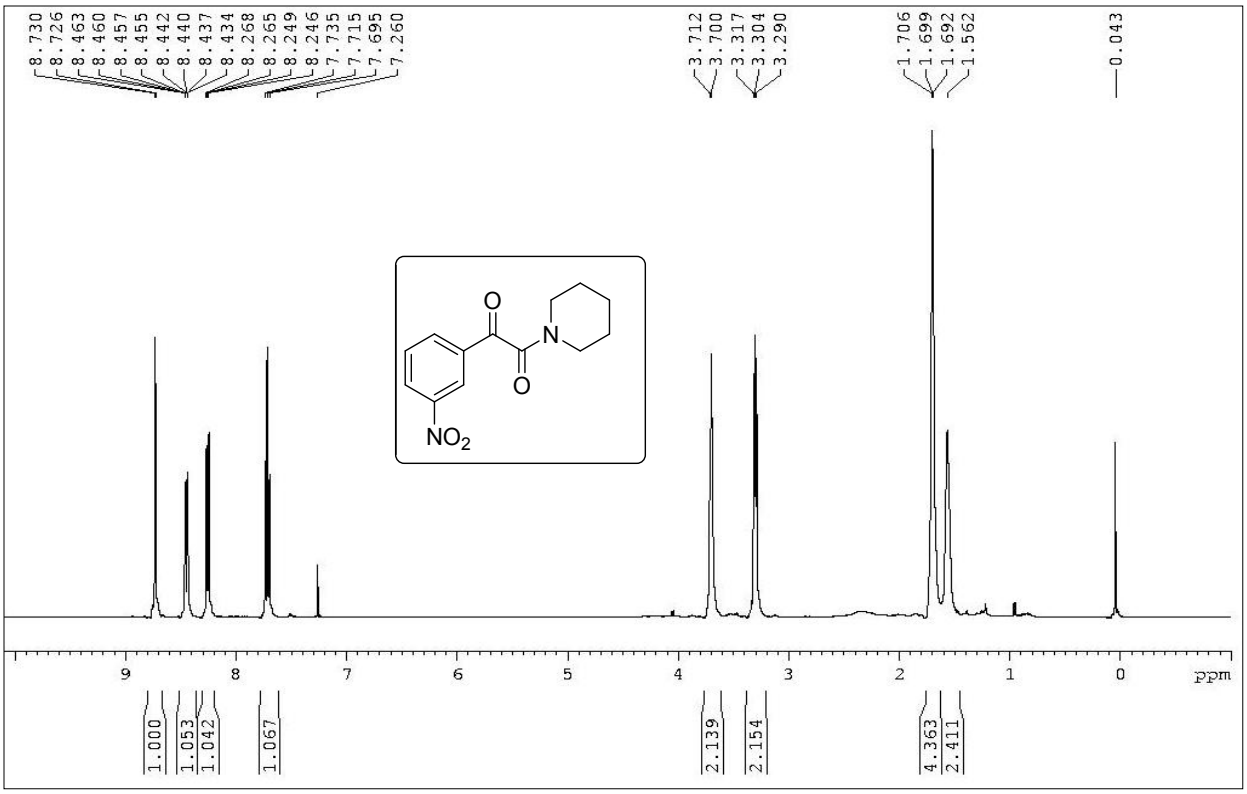


Figure 11:400 MHz ^{1}H NMR spectrum of **2f** in $CDCl_3$

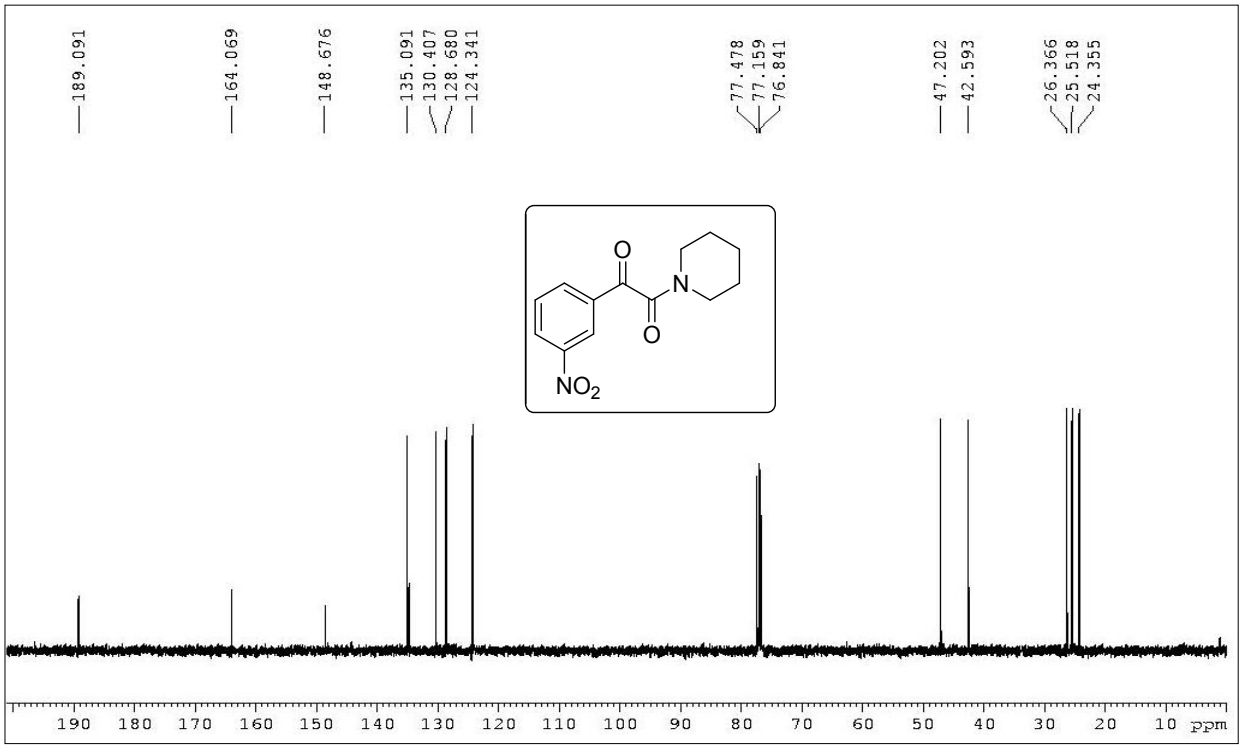


Figure 12:400 MHz ^{13}C NMR spectrum of **2f** in $CDCl_3$

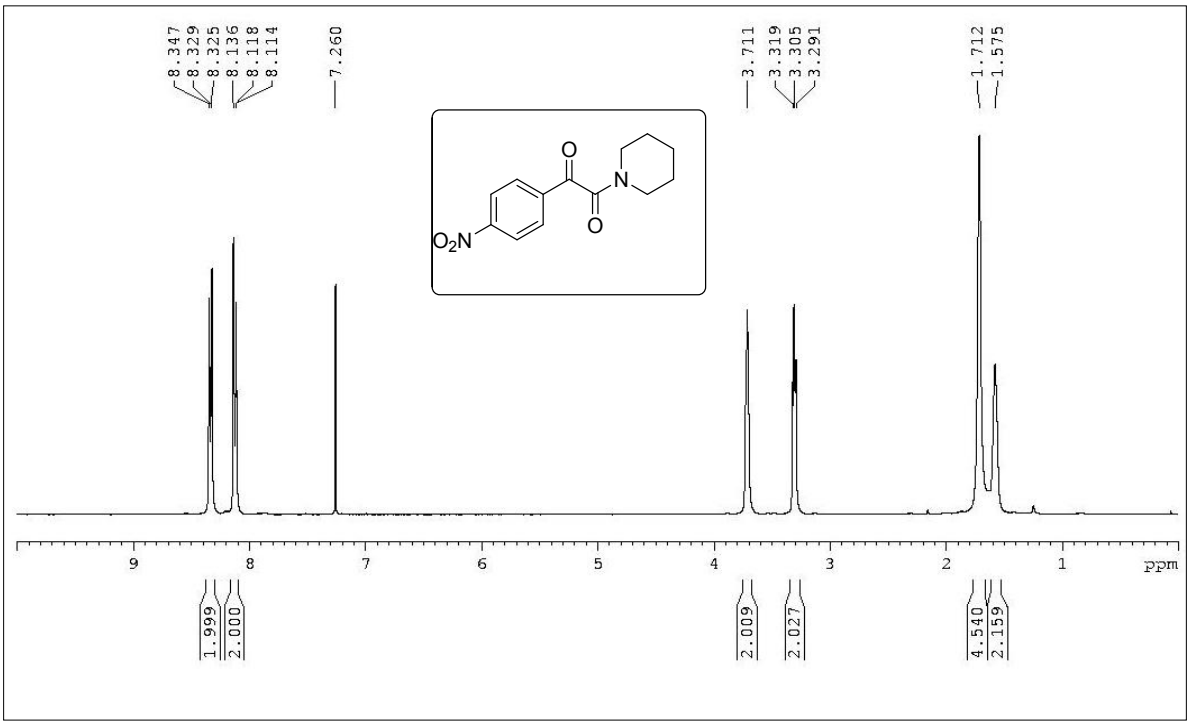


Figure 13:400 MHz ^{1}H NMR spectrum of **2g** in $CDCl_3$

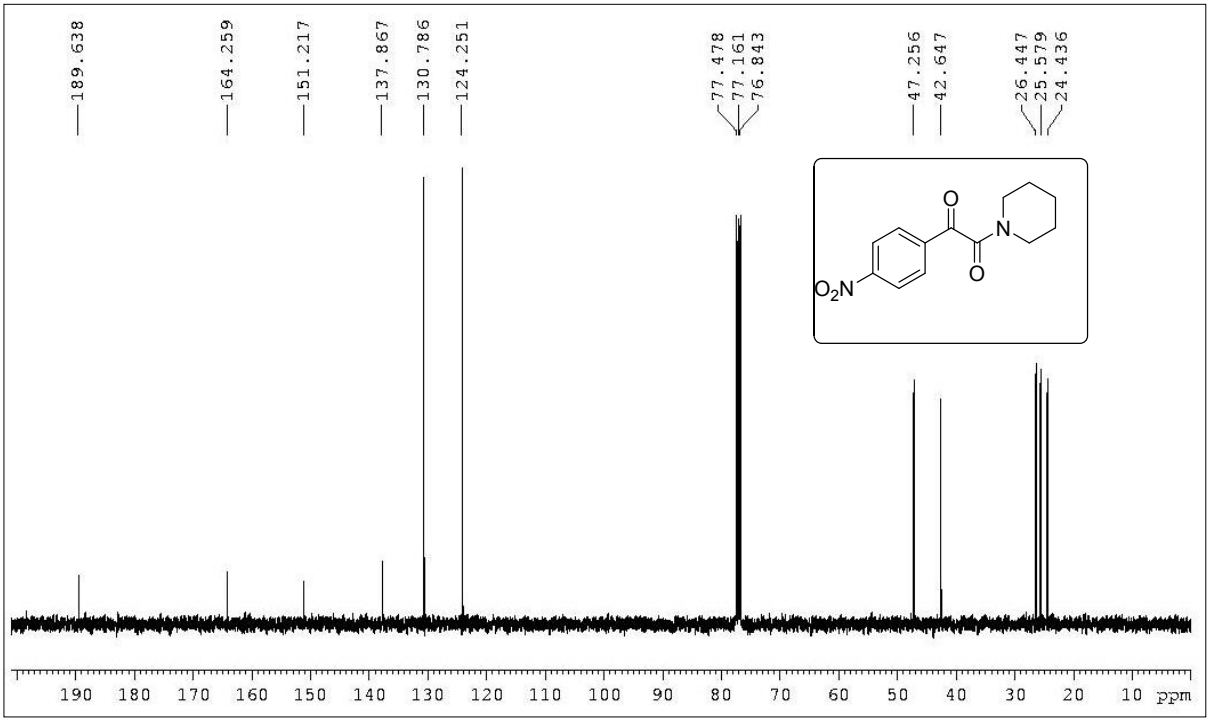


Figure 14:100 MHz ^{13}C NMR spectrum of **2g** in $CDCl_3$

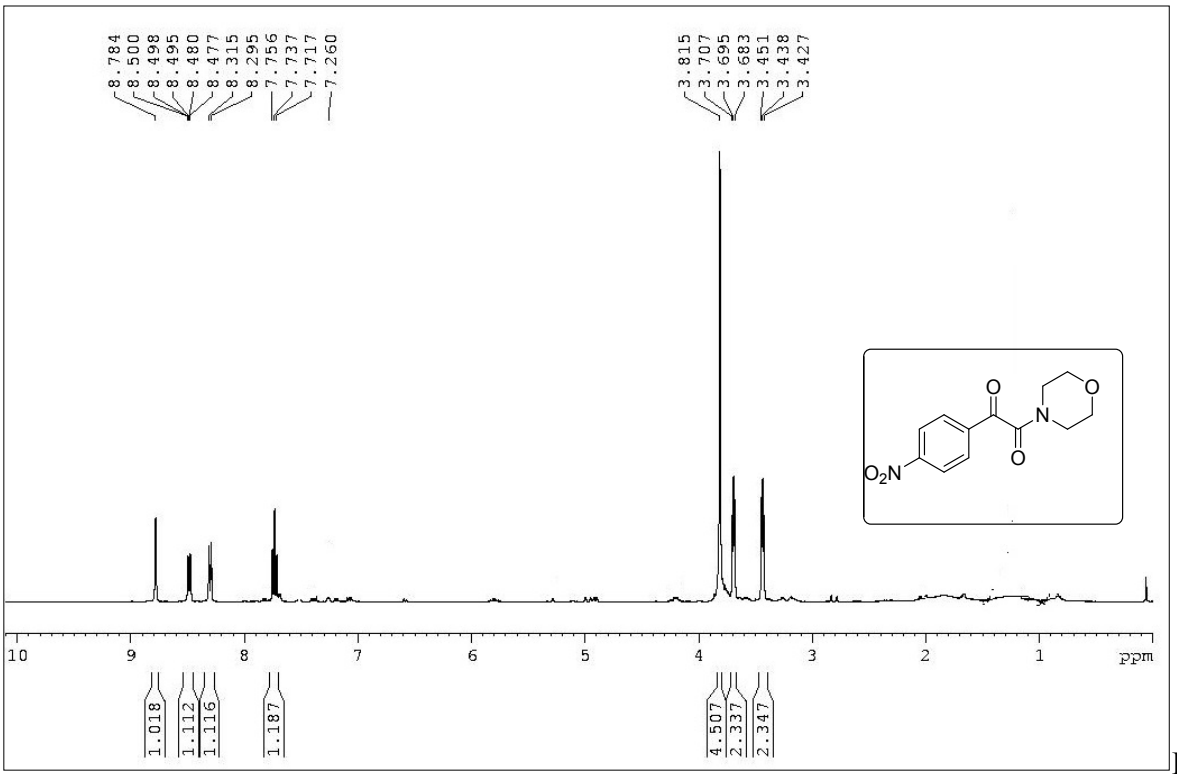


Figure 15:400 MHz ^{1}H NMR spectrum of **2i** in $CDCl_3$

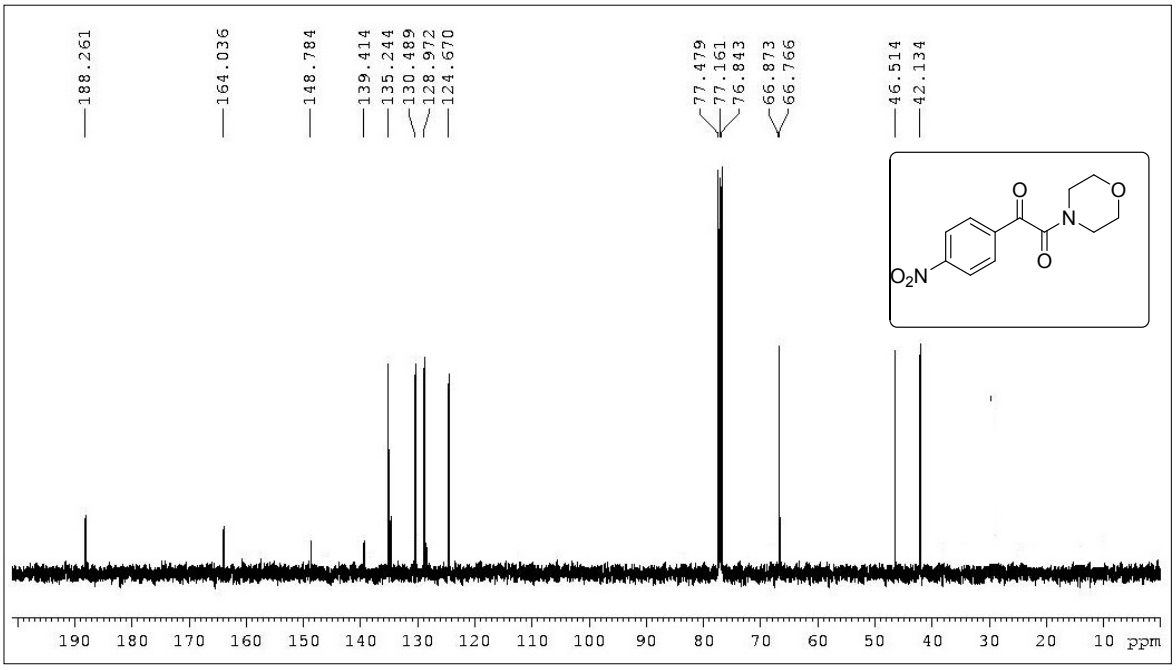


Figure 16:100 MHz ^{1}H NMR spectrum of **2i** in $CDCl_3$

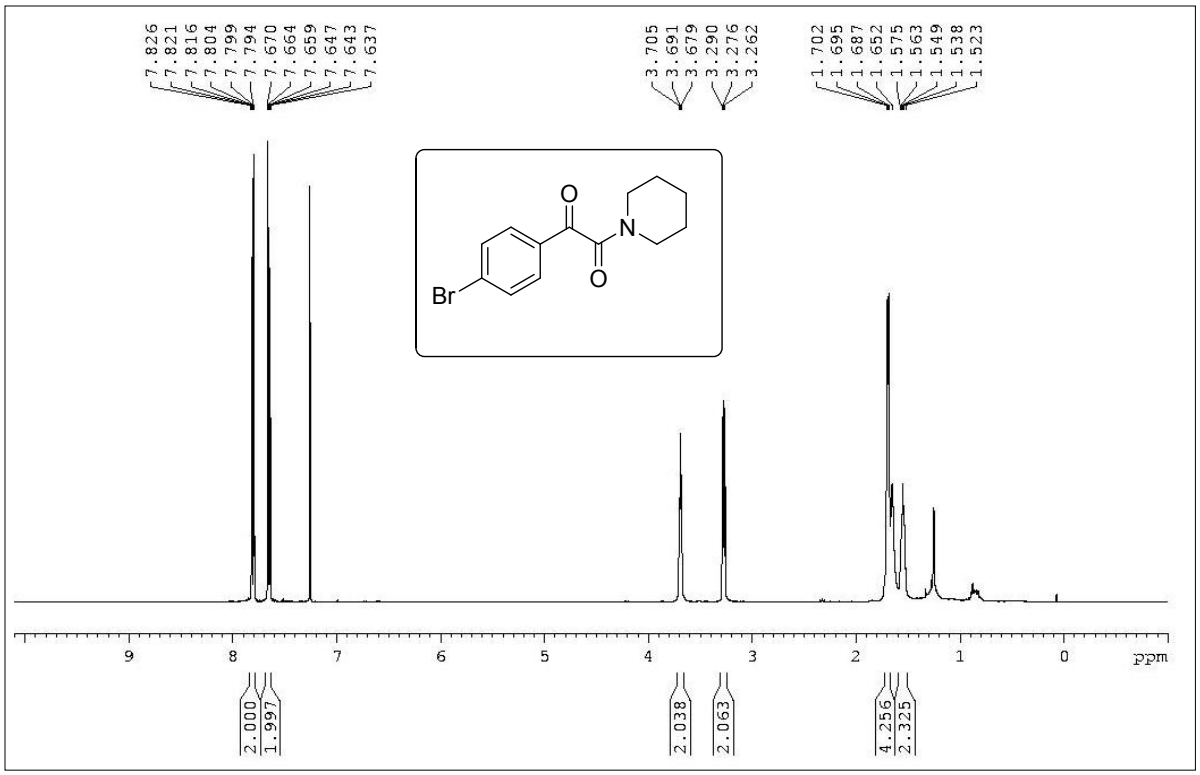


Figure 17:400 MHz ^{1}H NMR spectrum of **2j** in $CDCl_3$

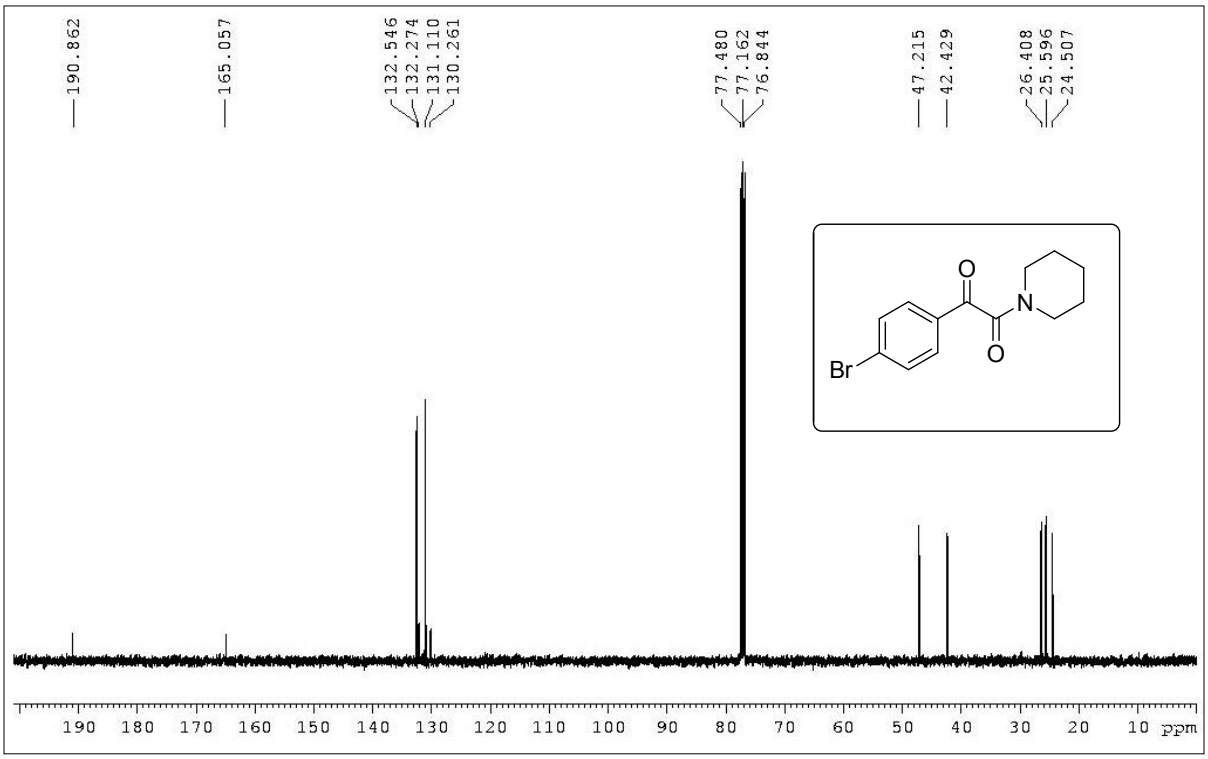


Figure 18:100 MHz ^{1}H NMR spectrum of **2j** in $CDCl_3$

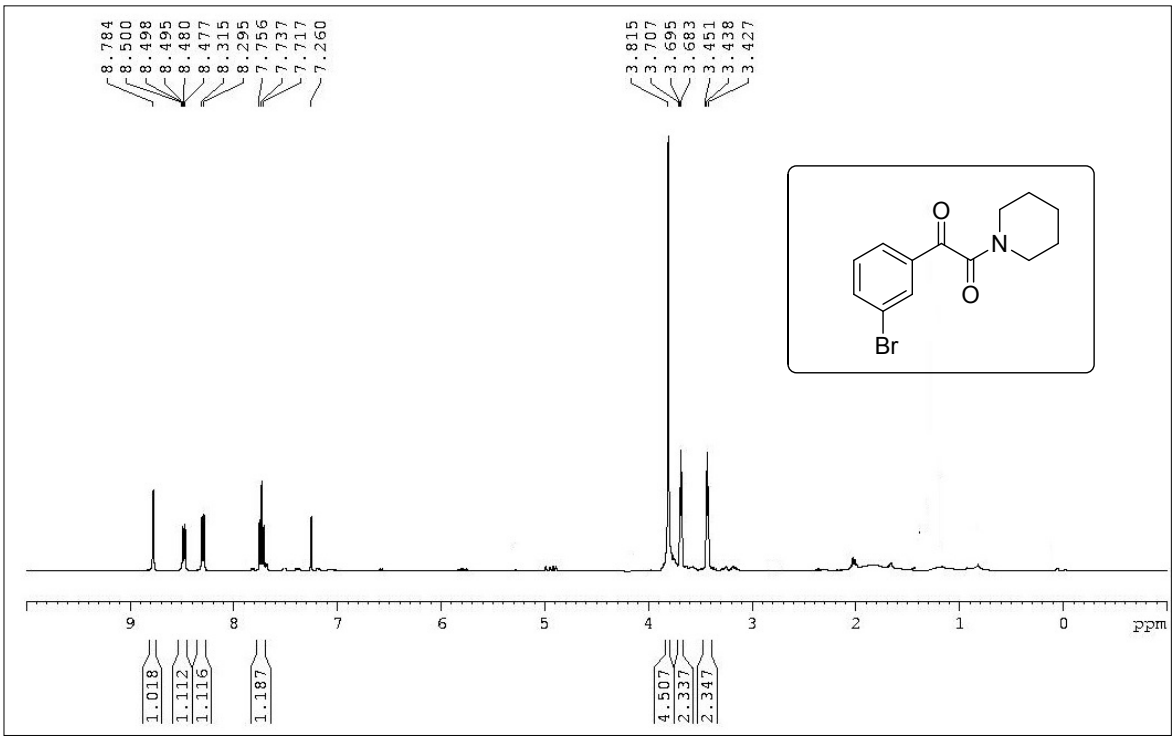
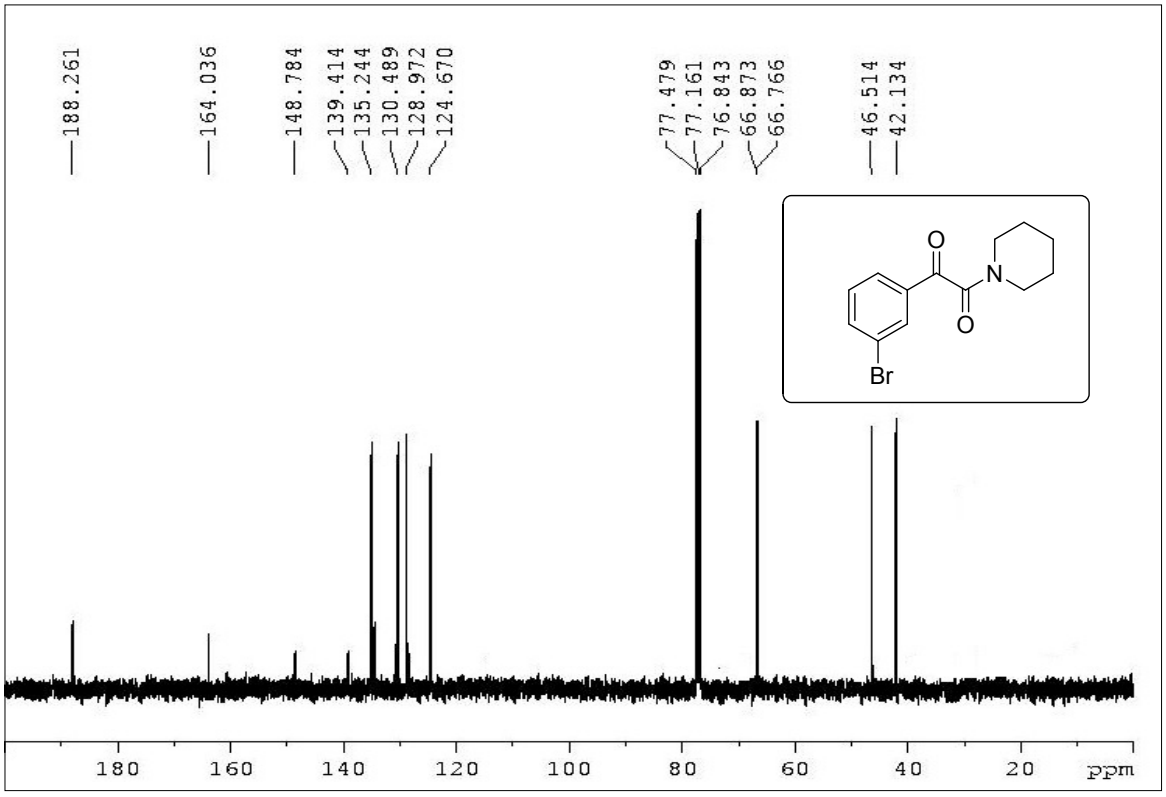


Figure 19:400 MHz ^{1}H NMR spectrum of **2h** in $CDCl_3$



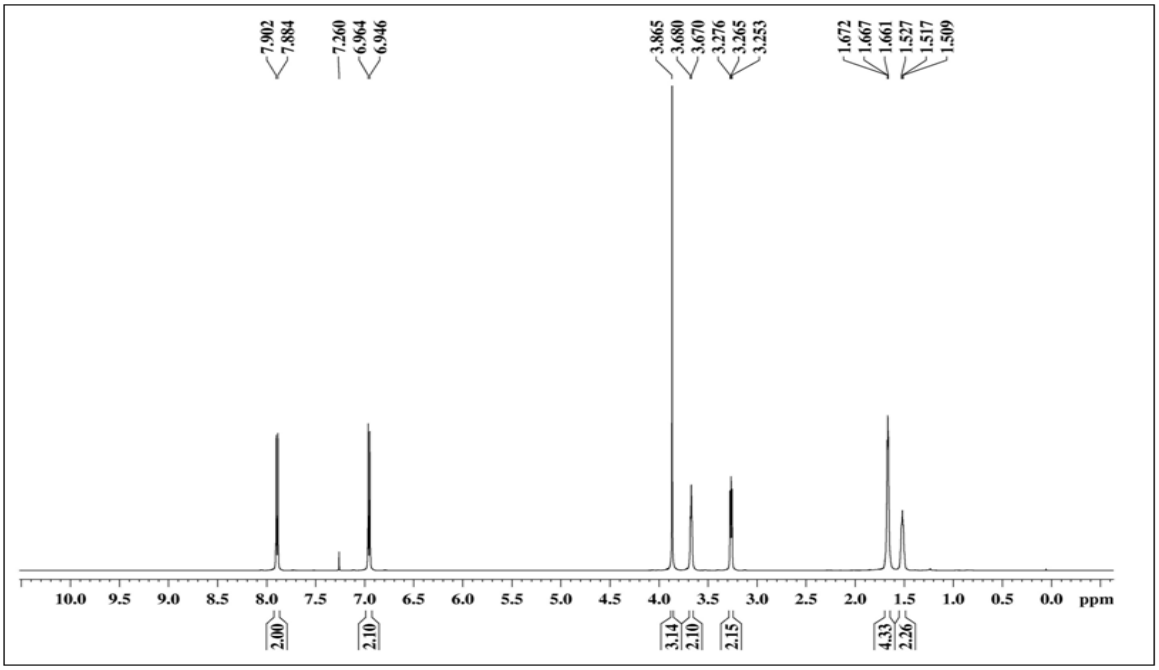
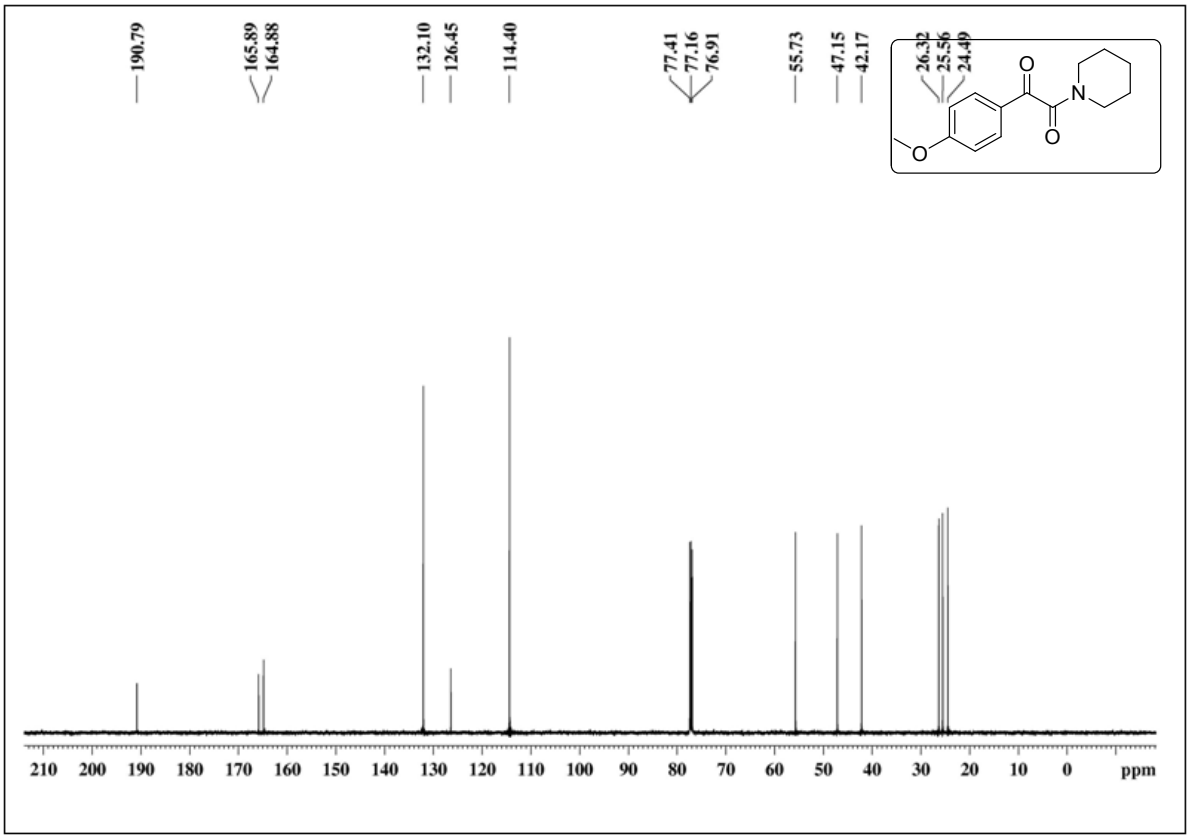


Figure 20:100 MHz ^{1}H NMR spectrum of **2h** in $CDCl_3$

Figure 21:400 MHz ^{1}H NMR spectrum of **2k** in $CDCl_3$

Figure 22:400 MHz ^{13}C NMR spectrum of **2k** in $CDCl_3$



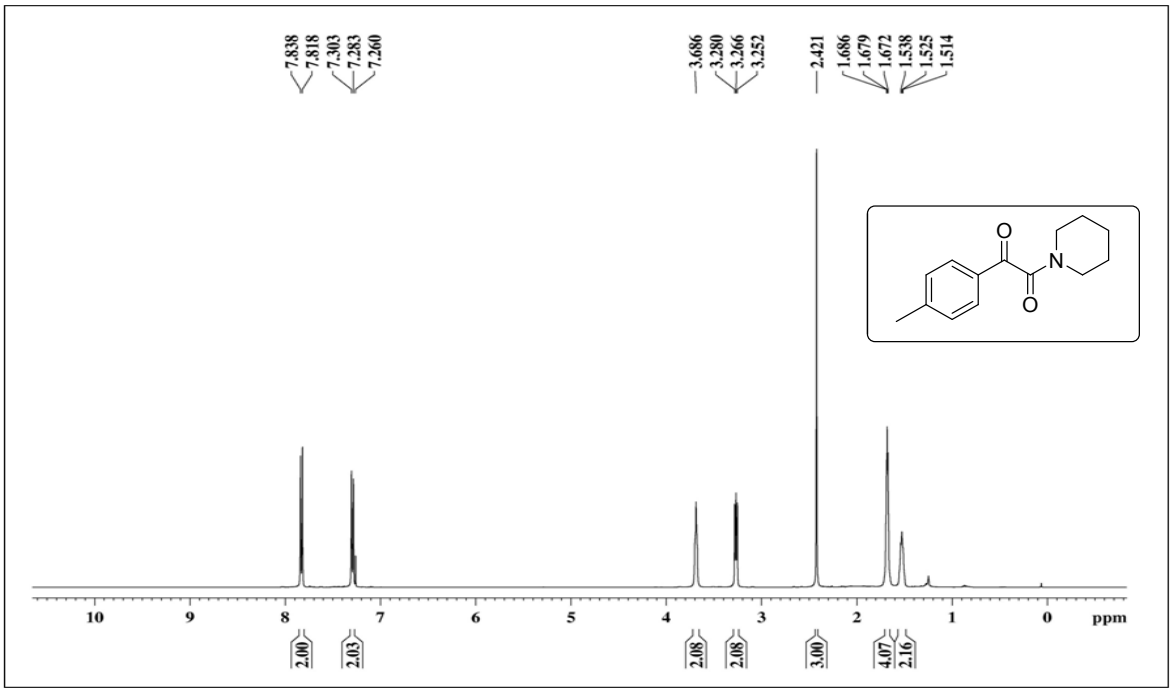


Figure 23:400 MHz ^{1}H NMR spectrum of **2m** in $CDCl_3$

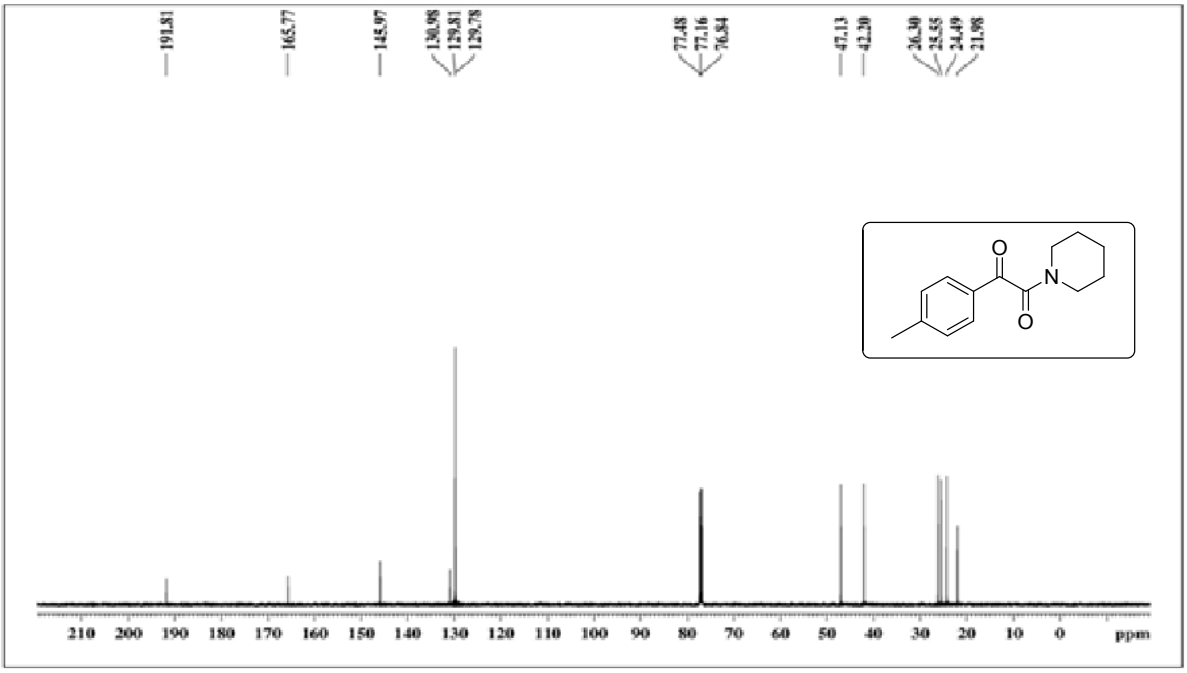


Figure 24:100 MHz ^{13}C NMR spectrum of **2m** in $CDCl_3$

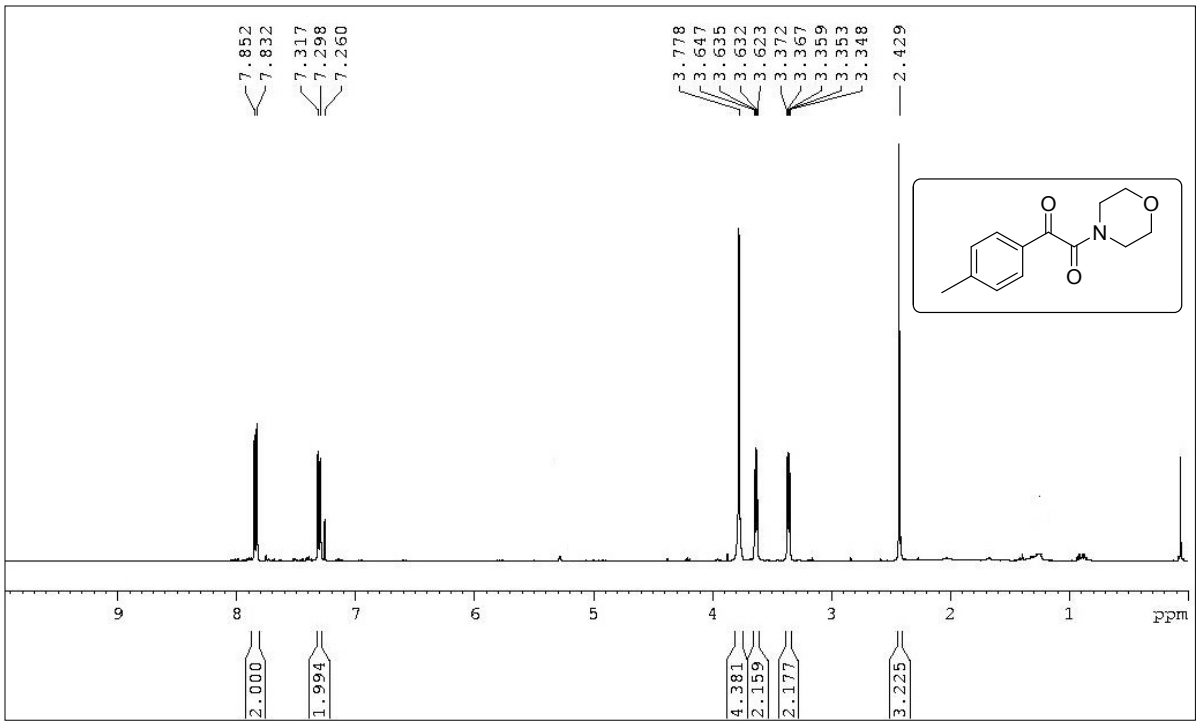


Figure 25:400 MHz ^{1}H NMR spectrum of **2l** in $CDCl_3$

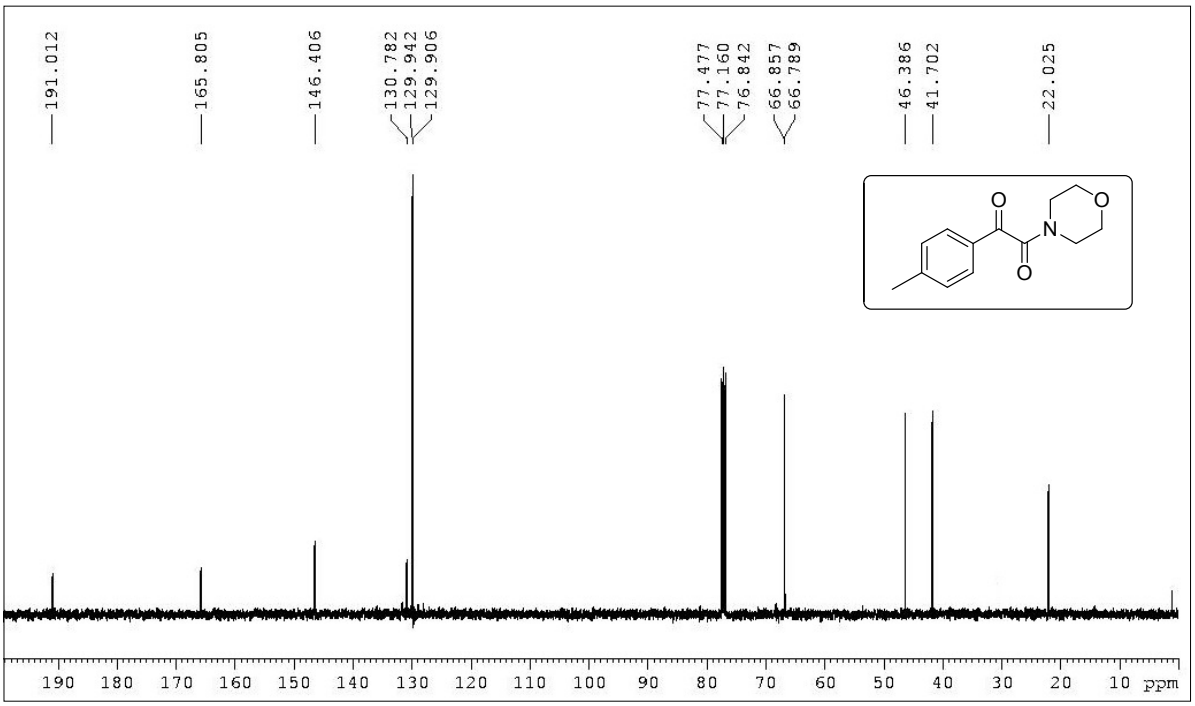


Figure 26:100 MHz ^{1}H NMR spectrum of **2l** in $CDCl_3$

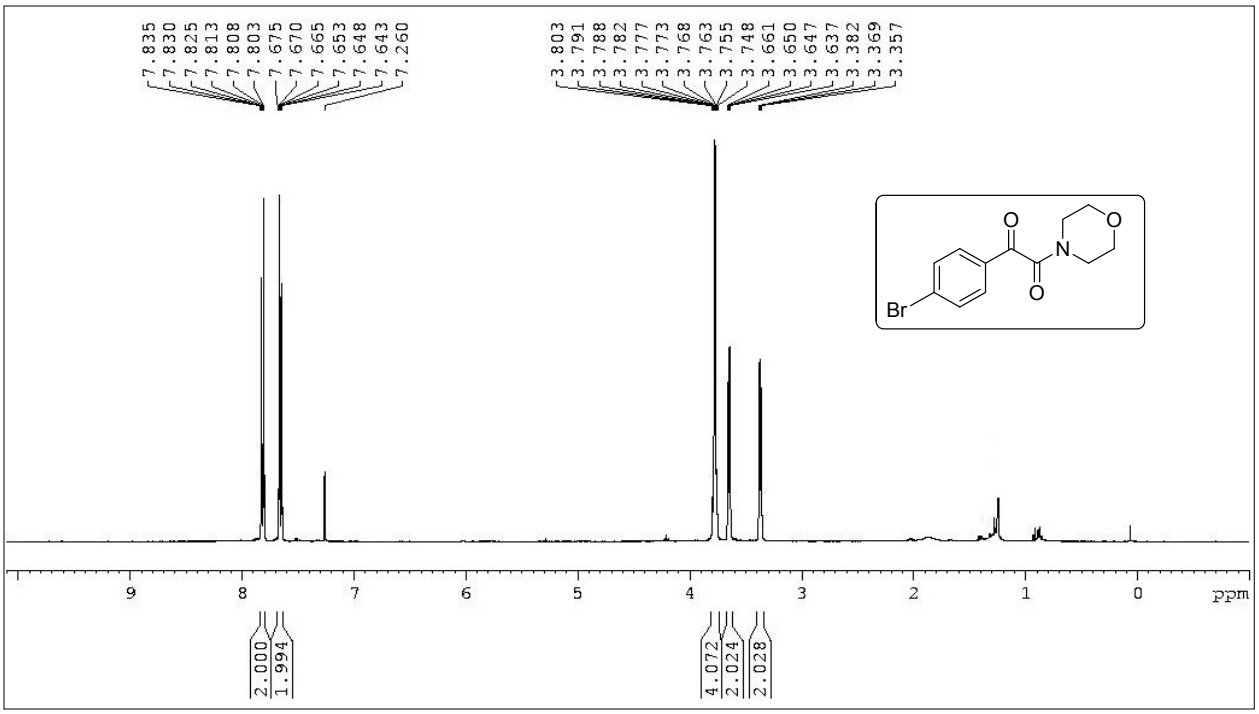


Figure27:400 MHz ^{1}H NMR spectrum of **2n** in $CDCl_3$

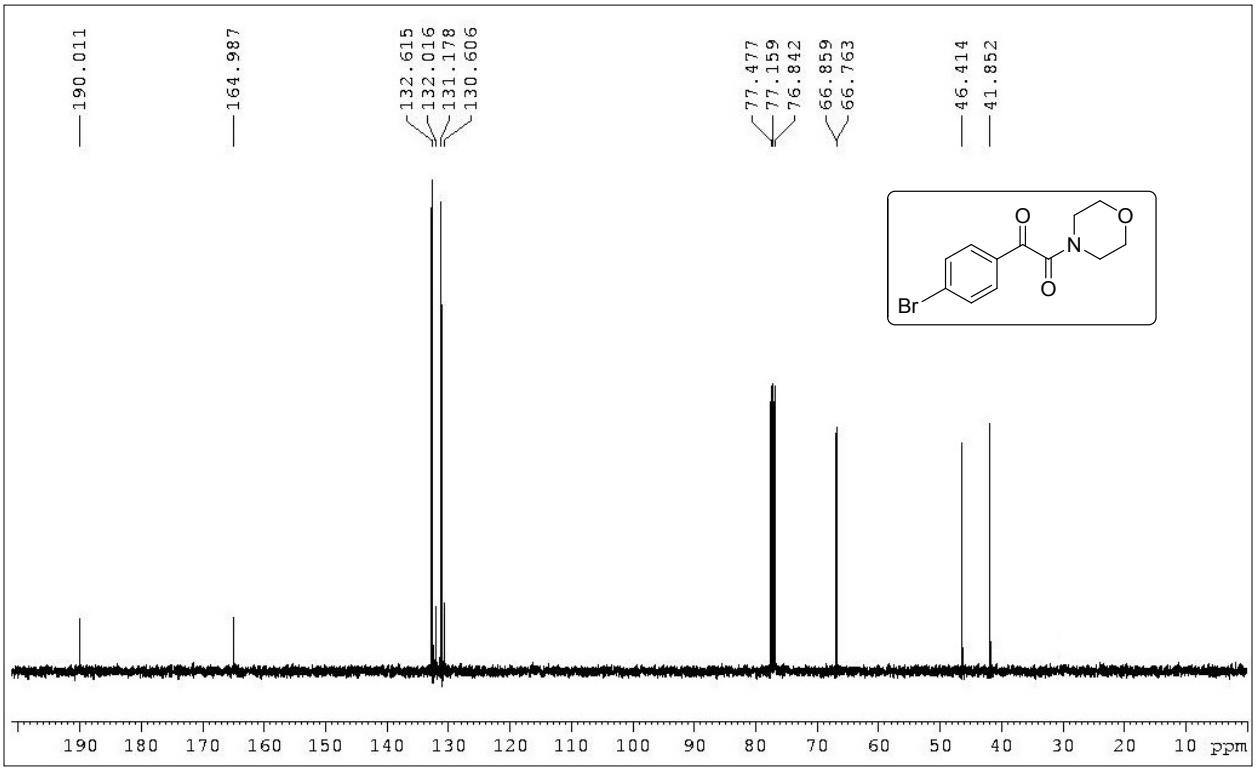


Figure 28:100 MHz ^{13}C NMR spectrum of **2n** in $CDCl_3$

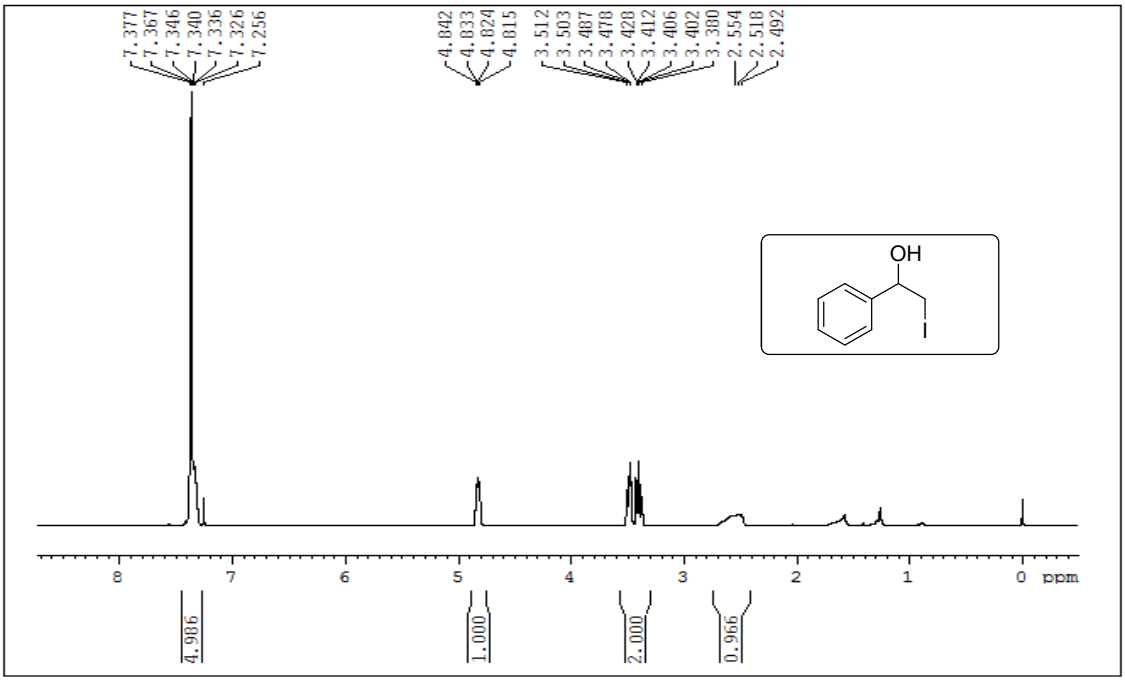


Figure 29: 100 MHz ^{13}C NMR spectrum of **1d** in $CDCl_3$

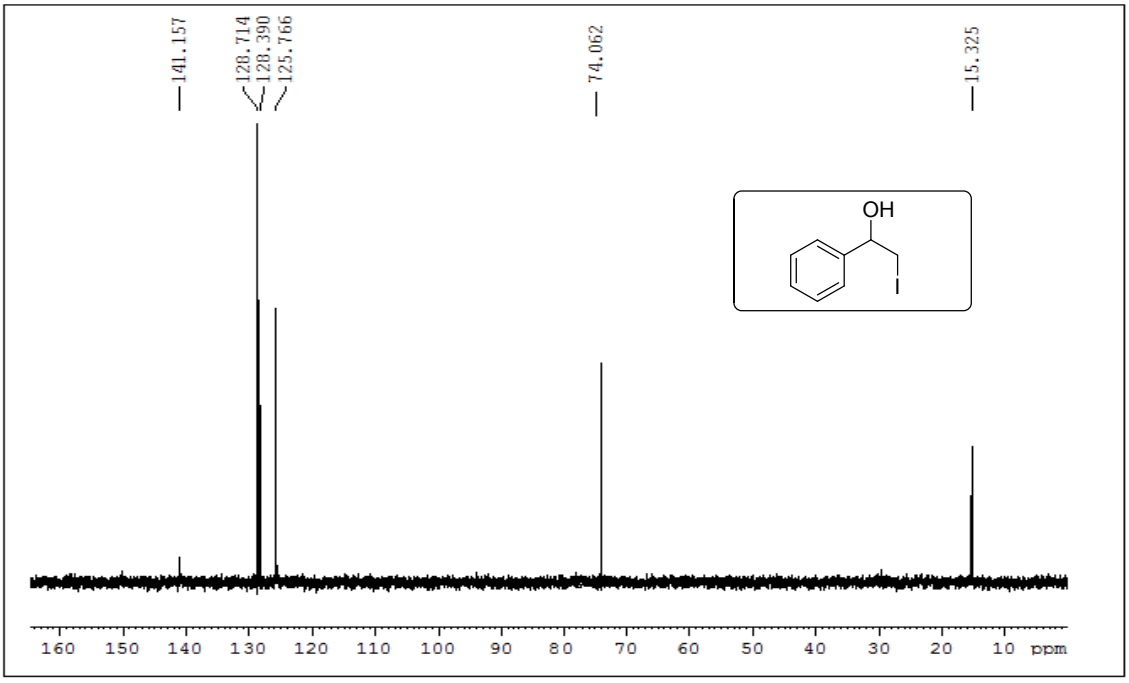


Figure 30: 400 MHz ^{1}H NMR spectrum of **1d** in $CDCl_3$

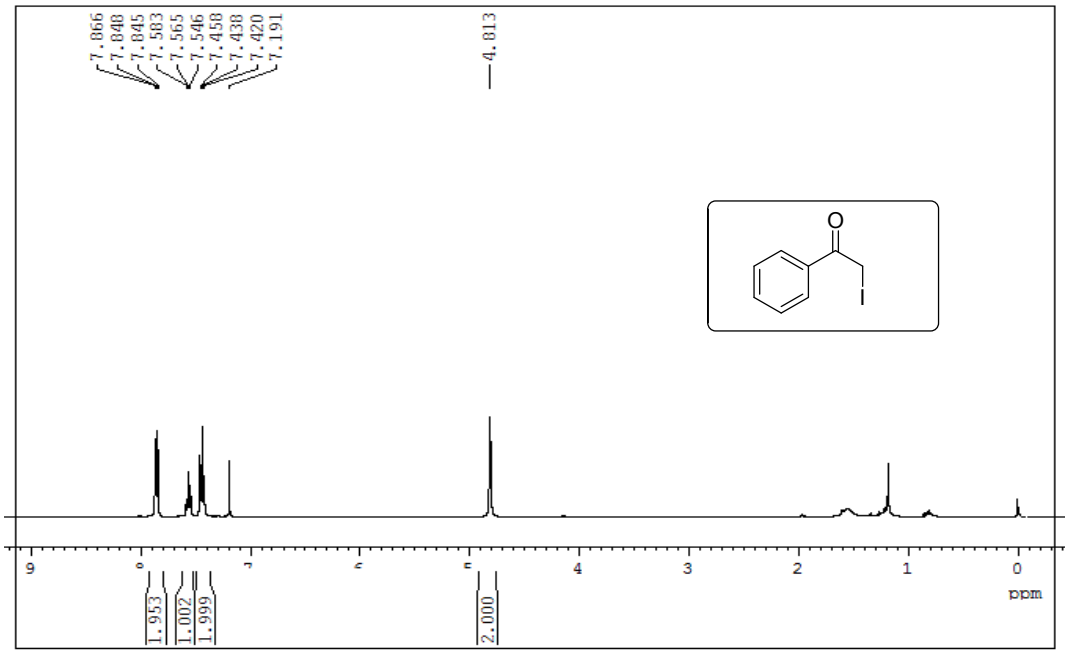


Figure 31: 400 MHz ^{1}H NMR spectrum of **1e** in $CDCl_3$

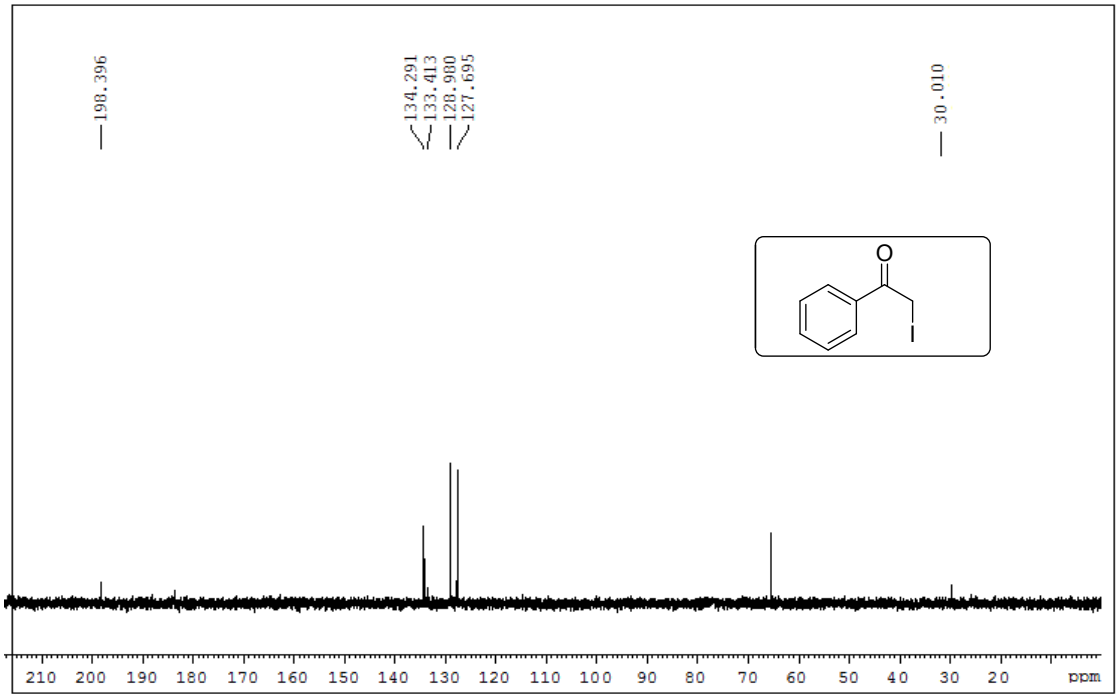


Figure 32: 100 MHz ^{13}C NMR spectrum of **1e** in $CDCl_3$