Electronic Supplementary Material (ESI) for RSC Advances

$InCl_3$ catalyzed domino route to 2*H*-chromene-2-ones via [4 + 2] annulation of 2-hydroxyarylaldehydes with α-oxoketene dithioacetal under solvent-free conditions

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Supporting Information

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General

All starting materials were commercially available and used as received without further purification. α-Oxoketene dithioacetals (**8a-k**) were prepared according to the protocol described in literature.[1] Thin-layer chromatography (TLC) was performed using silica gel 60 F_{254} precoated plates. Infrared (IR) spectra are measured in KBr, and wavelengths (ν) are reported in cm^{-1}. ^{1}H and ^{13}C NMR spectra were recorded on NMR spectrometer operating at 300 and 75 MHz, respectively. Chemical shifts (δ) are given in parts per million (ppm) using the residue solvent peaks as reference relative to TMS. *J* values are given in Hz. Mass spectra (MS) were recorded using Electron spray ionization (ESI) mass spectrometry. The C, H, and N analyses were performed from microanalytical laboratory. The melting points are uncorrected.

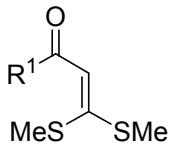
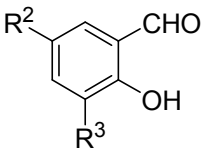
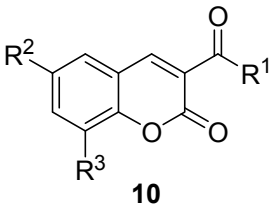
General Procedure for Synthesis of α-Oxoketene dithioacetals[1] (8a-k):

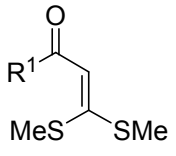
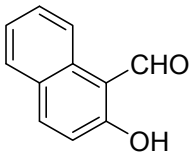
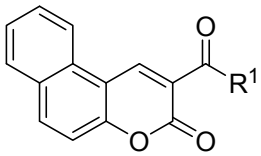
To a stirred suspension of Potassium *tert*-butoxide (4.48 g, 40 mmol) in dry THF (10 mL) at 0 °C, a solution of ketone (10 mmol) and carbon disulfide (0.913 g, 0.73 mL, 12 mmol) in dry THF (10 mL) was added dropwise, and the mixture was vigorously stirred at 0 °C for 90 min. To this suspension, a solution of methyl iodide (1.37 mL, 22 mmol) in dry THF (5 mL) was added dropwise during 10 min at 0 °C, and the reaction mixture was allowed to stir for 3 h. After completion of the reaction (monitored by TLC), the mixture was pored over crushed ice/saturated ammonium chloride solution. Reaction mixture was extracted using ethyl acetate (3 × 25 mL). The combined organic extract was washed with brine (1 × 25 mL), dried, and concentrated under vacuum to obtain the crude product, which was finally purified by silica gel column chromatography using ethyl acetate-*n*-hexane (1:10) as eluent.

General Procedure for the Synthesis of 3-Substituted Coumarins (10 and 12):

A mixture of α-oxoketene dithioacetal **8** (1.0 mmol) and substituted salicylaldehyde **9** (or 2-hydroxy-1-naphthaldehyde **11**) (1.0 mmol) were treated in the presence of $InCl_3$ (10 mol%, 0.1 mmol, 0.022 g) with constant stirring at 65 ^{o}C. The heating was continued for the stipulated period of time (0.5-2.0 h) till the completion of the reaction (monitored by TLC). The reaction mixture was treated with water (20 mL) and extracted with ethyl acetate (2 × 20 mL). The organic layer was washed with brine (1 × 20 mL) and dried over anhyd Na_2SO_4. The solvent was evaporated under vacuum to give the product, which was purified either by recrystallization from ethanol or by column chromatography over silica gel using ethyl acetate-*n*-hexane (1:8) as eluent.

Table 1: Synthesis of 3-substituted-2*H*-chromene-2-ones and benzo[*f*] 2*H*-chromene-2-ones.

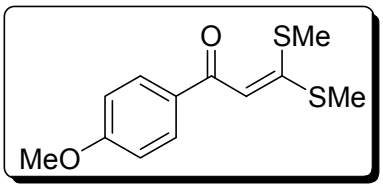
Entry	α-Oxoketene dithioacetals	2-Hydroxy-arylaldehydes	3-Substituted-2*H*-chromene-2-ones	Yield (%)[a]
	 **8**	 **9**	 **10**	
1	**8a**: R^1= 4-$OMeC_6H_4$	**9a**: R^2= H, R^3= H	**10aa**: R^1= 4-$OMeC_6H_4$, R^2= H, R^3= H	94
2	**8a**: R^1= 4-$OMeC_6H_4$	**9b**: R^2= Br, R^3= H	**10ab**: R^1= 4-$OMeC_6H_4$, R^2= Br, R^3= H	92
3	**8a**: R^1= 4-$OMeC_6H_4$	**9c**: R^2= H, R^3= OMe	**10ac**: R^1= 4-$OMeC_6H_4$, R^2= H, R^3= OMe	89
4	**8b**: R^1= 4-ClC_6H_4	**9d**: R^2= NO_2, R^3= H	**10bd**: R^1= 4-ClC_6H_4, R^2= NO_2, R^3= H	85
5	**8b**: R^1= 4-ClC_6H_4	**9e**: R^2= H, R^3= OEt	**10be**: R^1= 4-ClC_6H_4, R^2= H, R^3= OEt	85
6	**8c**: R^1= 4-MeC_6H_4	**9b**: R^2= Br, R^3= H	**10cb**: R^1= 4-MeC_6H_4, R^2= Br, R^3= H	88
7	**8c**: R^1= 4-MeC_6H_4	**9d**: R^2= NO_2, R^3= H	**10cd**: R^1= 4-MeC_6H_4, R^2= NO_2, R^3= H	82
8	**8c**: R^1= 4-MeC_6H_4	**9e**: R^2= H, R^3= OEt	**10ce**: R^1= 4-MeC_6H_4, R^2= H, R^3= OEt	83
9	**8d**: R^1= C_6H_5	**9b**: R^2= Br, R^3= H	**10db**: R^1= C_6H_5, R^2= Br, R^3= H	87
10	**8d**: R^1= C_6H_5	**9e**: R^2= H, R^3= OEt	**10de**: R^1= C_6H_5, R^2= H, R^3= OEt	80
11	**8d**: R^1= C_6H_5	**9f**: R^2= H, R^3= Ph	**10df**: R^1= C_6H_5, R^2= H, R^3= Ph	82
12	**8e**: R^1= 4-BrC_6H_4	**9d**: R^2= NO_2, R^3= H	**10ed**: R^1= 4-BrC_6H_4, R^2= NO_2, R^3= H	80
13	**8e**: R^1= 4-BrC_6H_4	**9f**: R^2= H, R^3= Ph	**10ef**: R^1= 4-BrC_6H_4, R^2= H, R^3= Ph	80
14	**8f**: R^1= 2-ClC_6H_4	**9b**: R^2= Br, R^3= H	**10fb**: R^1= 2-ClC_6H_4, R^2= Br, R^3= H	82
15	**8f**: R^1= 2-ClC_6H_4	**9c**: R^2= H, R^3= OMe	**10fc**: R^1= 2-ClC_6H_4, R^2= H, R^3= OMe	80
16	**8g**: R^1= 4-Biphenyl	**9b**: R^2= Br, R^3= H	**10gb**: R^1= 4-Biphenyl, R^2= Br, R^3= H	81
17	**8g**: R^1= 4-Biphenyl	**9e**: R^2= H, R^3= OEt	**10ge**: R^1= 4-Biphenyl, R^2= H, R^3= OEt	79
18	**8g**: R^1= 4-Biphenyl	**9f**: R^2= H, R^3= Ph	**10gf**: R^1= 4-Biphenyl, R^2= H, R^3= Ph	80
19	**8h**: R^1= 2-Furyl	**9a**: R^2= H, R^3= H	**10ha**: R^1= 2-Furyl, R^2= H, R^3= H	79
20	**8h**: R^1= 2-Furyl	**9b**: R^2= Br, R^3= H	**10hb**: R^1= 2-Furyl, R^2= Br, R^3= H	80
21	**8h**: R^1= 2-Furyl	**9c**: R^2= H, R^3= OMe	**10hc**: R^1= 2-Furyl, R^2= H, R^3= OMe	78
22	**8i**: R^1= 2-Thienyl	**9a**: R^2= H, R^3= H	**10ia**: R^1= 2-Thienyl, R^2= H, R^3= H	79
23	**8i**: R^1= 2-Thienyl	**9b**: R^2= Br, R^3= H	**10ib**: R^1= 2-Thienyl, R^2= Br, R^3= H	80
24	**8i**: R^1= 2-Thienyl	**9f**: R^2= H, R^3= Ph	**10if**: R^1= 2-Thienyl, R^2= H, R^3= Ph	78
25	**8j**: R^1= 2-Ferrocenyl	**9a**: R^2= H, R^3= H	**10ja**: R^1= 2-Ferrocenyl, R^2= H, R^3= H	84
26	**8j**: R^1= 2-Ferrocenyl	**9b**: R^2= Br, R^3= H	**10jb**: R^1= 2-Ferrocenyl, R^2= Br, R^3= H	87
27	**8j**: R^1= 2-Ferrocenyl	**9c**: R^2= H, R^3= OMe	**10jc**: R^1= 2-Ferrocenyl, R^2= H, R^3= OMe	80
28	**8j**: R^1= 2-Ferrocenyl	**9d**: R^2= NO_2, R^3= H	**10jd**: R^1= 2-Ferrocenyl, R^2= NO_2, R^3= H	80
29	**8j**: R^1= 2-Ferrocenyl	**9e**: R^2= H, R^3= OEt	**10je**: R^1= 2-Ferrocenyl, R^2= H, R^3=OEt	82
30	**8k**: R^1= *t*-Butyl	**9b**: R^2= Br, R^3= H	**10kb**: R^1= *t*-Butyl, R^2= Br, R^3= H,	82
31	**8k**: R^1= *t*-Butyl	**9e**: R^2= H, R^3= OEt	**10ke**: R^1= *t*-Butyl, R^2= H, R^3= OEt	80
32	**8k**: R^1= *t*-Butyl	**9f**: R^2= H, R^3= Ph	**10kf**: R^1= *t*-Butyl, R^2= H, R^3= Ph	81

	 **8**	 **11**	 **12**	
33	**8a**: R^1= 4-$OMeC_6H_4$		**12a**: R^1= 4-$OMeC_6H_4$	90
34	**8b**: R^1= 4-ClC_6H_4		**12b**: R^1= 4-ClC_6H_4	87
35	**8c**: R^1= 4-MeC_6H_4		**12c**: R^1= 4-MeC_6H_4	85
36	**8d**: R^1= C_6H_5		**12d**: R^1= C_6H_5	88
37	**8e**: R^1= 4-BrC_6H_4		**12e**: R^1= 4-BrC_6H_4	87
38	**8f**: R^1= 2-ClC_6H_4		**12f**: R^1= 2-ClC_6H_4	82
39	**8g**: R^1= 4-Biphenyl		**12g**: R^1= 4-Biphenyl	88
40	**8h**: R^1= 2-Furyl		**12h**: R^1= 2-Furyl	78
41	**8i**: R^1= 2-Thienyl		**12i**: R^1= 2-Thienyl	79
42	**8j**: R^1= 2-Ferrocenyl		**12j**: R^1= 2-Ferrocenyl	80
43	**8k**: R^1= *t*-Butyl		**12k**: R^1= *t*-Butyl	81

[a]Isolated yields.

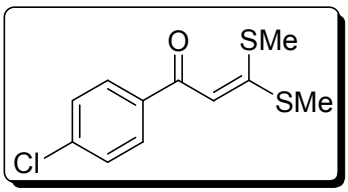
Characterization data of the isolated compounds:

1-(4-Methoxyphenyl)-3,3-[bis(methylthio)]-propenone (8a):



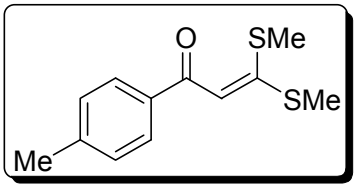
Yellow solid: mp 103-104 °C (Lit.[2a] 97-99 °C). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.91 (d, J = 8.7 Hz, 2H, ArH), 6.92 (d, J = 8.7 Hz, 2H, ArH), 6.74 (s, 1H, CH), 3.86 (s, 3H, OCH_3), 2.55 and 2.52 (2s, 6H, 2 × SCH_3). ^{13}C NMR (75 MHz, $CDCl_3$): δ 184.5, 164.8, 162.4, 132.0, 129.8, 113.5, 109.3, 55.3, 17.2, 15.0. IR (KBr, cm^{-1}): 3057, 2915, 1599, 1473, 1232, 1165, 774. ESI MS (*m/z*): 255 (M^++1); Anal. Calcd for $C_{12}H_{14}O_2S_2$: C, 56.66; H, 5.55. Found: C, 56.81; H, 5.41.

1-(4-Chlorophenyl)-3,3-[bis(methylthio)]-propenone (8b):



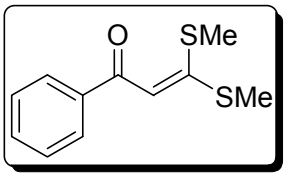
Yellow solid: mp 108-109 °C (Lit.[2b] 109.7 °C). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.85 (d, J = 8.1 Hz, 2H, ArH), 7.40 (d, J = 8.1 Hz, 2H, ArH), 6.70 (s, 1H, CH), 2.56 and 2.53 (2s, 6H, 2 × SCH_3). ^{13}C NMR (75 MHz, $CDCl_3$): δ 184.1, 167.5, 137.8, 137.5, 129.0, 128.6, 108.7, 17.3, 15.0. IR (KBr, cm^{-1}): 3066, 2840, 1610, 1479, 1222, 1166, 769. ESI MS (*m/z*): 259 (M^++1); Anal. Calcd for $C_{11}H_{11}ClOS_2$: C, 51.05; H, 4.28. Found: C, 50.91; H, 4.48.

3,3-[Bis(methylthio)]-1-*p*-tolylpropenone (8c):



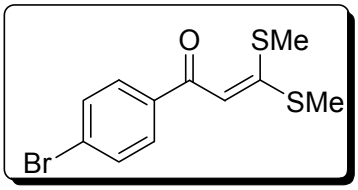
Yellow solid: mp 100-101 °C (Lit.[2a] 104 °C). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.82 (d, J = 7.8 Hz, 2H, ArH), 7.23 (d, J = 7.8 Hz, 2H, ArH), 6.76 (s, 1H, CH), 2.56 and 2.52 (2s, 6H, 2 × SCH_3), 2.39 (s, 3H, $ArCH_3$). ^{13}C NMR (75 MHz, $CDCl_3$): δ 185.3, 165.5, 142.2, 136.6, 129.1, 127.7, 109.4, 21.5, 17.3, 15.0. IR (KBr, cm^{-1}): 3079, 2923, 1607, 1495, 1253, 1171, 780. ESI MS (*m/z*): 239 (M^++1); Anal. Calcd for $C_{12}H_{14}OS_2$: C, 60.46; H, 5.92. Found: C, 60.71; H, 5.71.

3,3-[Bis(methylthio)]-1-phenylpropenone (8d):



Yellow solid: mp 92-93 °C (Lit.[2a] 95 °C). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.91 (d, J = 6.9 Hz, 2H, ArH), 7.50-7.41 (m, 3H, ArH), 6.77 (s, 1H, CH), 2.56 and 2.53 (2s, 6H, 2 × SCH_3). ^{13}C NMR (75 MHz, $CDCl_3$): δ 185.6, 166.3, 139.2, 131.6, 128.4, 127.6, 109.3, 17.3, 15.0. IR (KBr, cm^{-1}): 3043, 2911, 1597, 1478, 1235, 1161, 771. ESI MS (*m/z*): 225 (M^++1); Anal. Calcd for $C_{11}H_{12}OS_2$: C, 58.89; H, 5.39. Found: C, 58.73; H, 5.56.

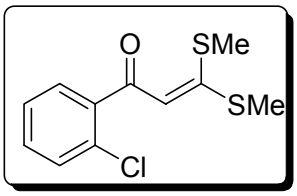
1-(4-Bromophenyl)-3,3-[bis(methylthio)]-propenone (8e):



Yellow solid: mp 106-107 °C (Lit.[2a] 103-104 °C). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.77 (d, J = 8.4 Hz, 2H, ArH), 7.56 (d, J = 8.4 Hz, 2H, ArH), 6.69 (s, 1H, CH), 2.56 and 2.54 (2s, 6H, 2 × SCH_3). ^{13}C NMR (75 MHz, $CDCl_3$): δ 184.2, 167.6, 137.9, 131.5, 129.2, 126.4, 108.5, 17.3, 15.0. IR

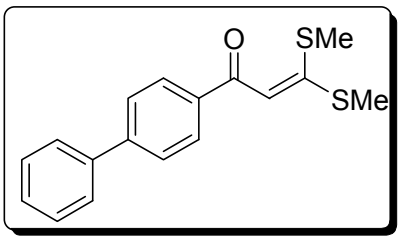
(KBr, cm^{-1}): 3052, 2929, 1591, 1482, 1240, 1155, 789. ESI MS (*m/z*): 303 (M^++1); Anal. Calcd for $C_{11}H_{11}BrOS_2$: C, 43.57; H, 3.66. Found: C, 43.41; H, 3.74.

1-(2-Chlorophenyl)-3,3-[bis(methylthio)]-propenone (8f):



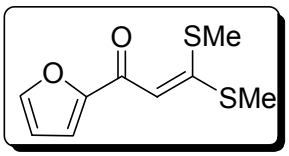
Yellow solid: mp 100-101 °C (Lit.[2c] 113-115 °C). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.54-51 (m, 1H, ArH), 7.39-7.26 (m, 3H, ArH), 6.51 (s, 1H, CH), 2.54 and 2.50 (2s, 6H, 2 × SCH_3). ^{13}C NMR (75 MHz, $CDCl_3$): δ 186.2, 166.6, 140.4, 130.8, 130.2, 130.0, 129.6, 126.7, 112.8, 17.1, 14.9. IR (KBr, cm^{-1}): 3078, 2934, 1601, 1479, 1261, 1171, 781. ESI MS (*m/z*): 259 (M^++1); Anal. Calcd for $C_{11}H_{11}ClOS_2$: C, 51.05; H, 4.28. Found: C, 51.25; H, 4.09.

1-Biphenyl-4-yl-3,3-[bis(methylthio)]-propenone (8g):



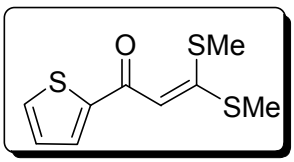
Yellow solid: mp 119-120 °C (Lit.[1a] 112-114 °C). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.99 (d, *J* = 8.1 Hz, 2H, ArH), 7.67-7.61 (m, 4H, ArH), 7.48-7.35 (m, 3H, ArH), 6.81 (s, 1H, CH), 2.58 and 2.54 (2s, 6H, 2 × SCH_3). ^{13}C NMR (75 MHz, $CDCl_3$): δ 185.1, 166.3, 144.3, 140.0, 138.0, 128.8, 128.2, 127.9, 127.2, 127.1, 109.3, 17.3, 15.0. IR (KBr, cm^{-1}): 3049, 2935, 1615, 1451, 1247, 1161, 792. ESI MS (*m/z*): 301 (M^++1); Anal. Calcd for $C_{17}H_{16}OS_2$: C, 67.96; H, 5.37. Found: C, 67.73; H, 5.58.

1-Furan-2-yl-3,3-[bis(methylthio)]-propenone (8h):



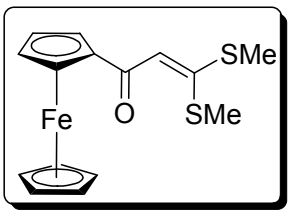
Yellow solid: mp 115-116 °C (Lit.[1c] 115-116 °C). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.51 (s, 1H, ArH), 7.15 (d, *J* = 3.3 Hz, 1H, ArH), 6.71 (s, 1H, CH), 6.51 (s, 1H, ArH), 2.56 and 2.52 (2s, 6H, 2 × SCH_3). ^{13}C NMR (75 MHz, $CDCl_3$): δ 174.5, 166.2, 153.9, 144.7, 115.0, 112.2, 108.6, 17.2, 14.9. IR (KBr, cm^{-1}): 3104, 2914, 1610, 1495, 1460, 1260, 1077, 912, 779. ESI MS (*m/z*): 215 (M^++1); Anal. Calcd for $C_9H_{10}O_2S_2$: C, 50.44; H, 4.70. Found: C, 50.63; H, 4.57.

3,3-Bis(methylthio)-1-thiophen-2-yl-propenone (8i):



Yellow solid: mp 97-98 °C (Lit.[1c] 95.5-97 °C). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.65 (d, *J* = 3.3 Hz, 1H, ArH), 7.54 (d, *J* = 4.5 Hz, 1H, ArH), 7.11-7.08 (m, 1H, ArH), 6.61 (s, 1H, ArH), 2.56 and 2.52 (2s, 6H, 2 × SCH_3). ^{13}C NMR (75 MHz, $CDCl_3$): δ 178.1, 165.8, 146.1, 131.8, 129.4, 127.8, 109.0, 17.2, 15.0. IR (KBr, cm^{-1}): 3110, 2925, 1609, 1500, 1467, 1245, 1064, 902, 775. ESI MS (*m/z*): 231 (M^++1); Anal. Calcd for $C_9H_{10}OS_3$: C, 46.92; H, 4.38. Found: C, 46.81; H, 4.61.

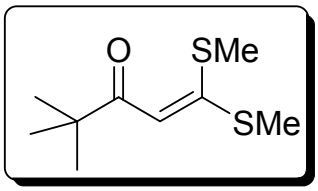
3,3-Bis(methylthio)-1-ferrocen-2-yl-propenone (8j):



Red solid: mp 132-133 °C (Lit.[1a] 112-115 °C). ^{1}H NMR (300 MHz, $CDCl_3$): δ 6.34 (s, 1H, CH), 4.78 (s, 2H, H_{cp}), 4.45 (s, 2H, H_{cp}), 4.18 (s, 5H, H_{cp}), 2.53

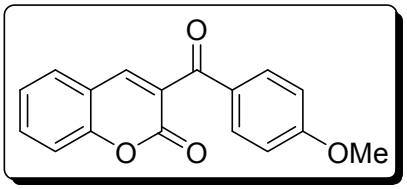
and 2.50 (2s, 6H, 2 × SCH_3). ^{13}C NMR (75 MHz, $CDCl_3$): δ 189.3, 161.5, 111.2, 71.6, 69.8, 69.1, 17.3, 14.9. IR (KBr, cm^{-1}): 3106, 2918, 1608, 1494, 1250, 1100, 765. ESI MS (*m/z*): 333 (M^++1); Anal. Calcd for $C_{15}H_{16}FeOS_2$: C, 54.22; H, 4.85. Found: C, 54.31; H, 4.99.

4,4-Dimethyl-1,1-[bis(methylthio)]-pent-1-en-3-one (8k):



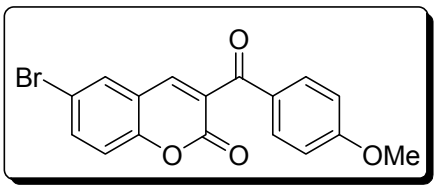
Orange solid: mp 61-62 °C (Lit.[2a] 59-60 °C). ^1H NMR (300 MHz, $CDCl_3$): δ 6.28 (s, 1H, CH), 2.46 (s, 6H, 2 × SCH_3), 1.18 (s, 9H, 3 × CH_3). ^{13}C NMR (75 MHz, $CDCl_3$): δ 200.6, 163.6, 108.6, 42.7, 27.0, 17.0, 14.7. IR (KBr, cm^{-1}): 1742, 1701, 1636, 1475, 1426, 1108. ESI MS (*m/z*): 205 (M^++1); Anal. Calcd for $C_9H_{16}OS_2$: C, 52.90; H, 7.89. Found: C, 53.01; H, 7.99.

3-(4-Methoxybenzoyl)-chromen-2-one (10aa):



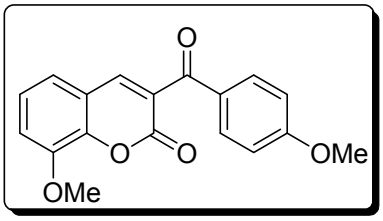
White solid: mp 173-174 °C (Lit.[2d] 174-175 °C). ^1H NMR (300 MHz, $CDCl_3$): δ 8.02 (s, 1H, ArH), 7.88 (d, *J* = 8.7 Hz, 2H, ArH), 7.66-7.57 (m, 2H, ArH), 7.42-7.32 (m, 2H, ArH), 6.95 (d, *J* = 8.7 Hz, 2H, ArH), 3.88 (s, 3H, OCH_3). ^{13}C NMR (75 MHz, $CDCl_3$): δ 189.9, 164.2, 158.5, 154.6, 144.5, 133.3, 132.1, 128.9, 127.5, 124.8, 118.2, 116.8, 113.8, 55.5. IR (KBr, cm^{-1}): 3079, 2923, 1716, 1646, 1603, 1565, 1512, 1255, 1173. ESI MS (*m/z*): 281 (M^++1); Anal. Calcd for $C_{17}H_{12}O_4$: C, 72.85; H, 4.32. Found: C, 72.71; H, 4.41.

6-Bromo-3-(4-methoxybenzoyl)-chromen-2-one (10ab):



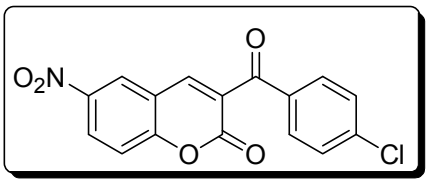
White solid: mp 173-174 °C. ^1H NMR (300 MHz, $CDCl_3$): δ 7.91 (s, 1H, ArH), 7.86 (d, *J* = 8.7 Hz, 2H, ArH), 7.73-7.69 (m, 2H, ArH), 7.31-7.27 (m, 2H, ArH), 6.95 (d, *J* = 9.0 Hz, 2H, ArH), 3.89 (s, 3H, OCH_3). ^{13}C NMR (75 MHz, $CDCl_3$): δ 189.3, 164.4, 153.3, 142.8, 139.9, 132.1, 131.0, 128.7, 119.7, 118.6, 117.4, 114.0, 55.5. IR (KBr, cm^{-1}): 3093, 2929, 1720, 1647, 1601, 1553, 1512, 1255, 1171. ESI MS (*m/z*): 359 (M^++1); Anal. Calcd for $C_{17}H_{11}BrO_4$: C, 56.85; H, 3.09. Found: C, 56.91; H, 3.26.

8-Methoxy-3-(4-methoxybenzoyl)-chromen-2-one (10ac):



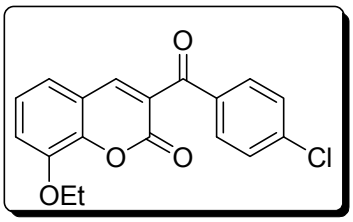
White solid: mp 237-238 °C (Lit.[2e] 233 °C). ^1H NMR (300 MHz, $CDCl_3$): δ 8.00 (s, 1H, ArH), 7.87 (d, *J* = 9.0 Hz, 2H, ArH), 7.29-7.27 (m, 1H, ArH), 7.18-7.14 (m, 2H, ArH), 6.94 (d, *J* = 8.7 Hz, 2H, ArH), 3.99 (s, 3H, OCH_3), 3.88 (s, 3H, OCH_3). ^{13}C NMR (75 MHz, $CDCl_3$): δ 190.0, 164.2, 147.2, 144.8, 132.1, 128.9, 127.8, 124.7, 120.1, 114.9, 113.8, 56.3, 55.5. IR (KBr, cm^{-1}): 2929, 1714, 1648, 1605, 1475, 1249, 1173. ESI MS (*m/z*): 311 (M^++1); Anal. Calcd for $C_{18}H_{14}O_5$: C, 69.67; H, 4.55. Found: C, 69.47; H, 4.73.

3-(4-Chlorobenzoyl)-6-nitro-chromen-2-one (10bd):



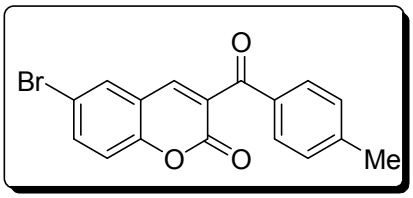
White solid. Mp 242-243 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.55-8.49 (m, 2H, ArH), 8.15 (s, 1H, ArH), 7.84-7.79 (m, 2H, ArH), 7.57-7.47 (m, 3H, ArH); ^{13}C NMR (75 MHz, $CDCl_3$): δ 189.2, 157.9, 144.3, 144.0, 140.9, 133.8, 130.9, 129.1, 128.7, 128.1, 124.8, 118.2, 118.0; IR (KBr, cm^{-1}): 2929, 2859, 1727, 1657, 1617, 1536, 1346, 1246. ESI MS (*m/z*): 330 (M^++1); Anal. Calcd for $C_{16}H_8ClNO_5$: C, 58.29; H, 2.45; N, 4.25. Found: C, 58.41; H, 2.37; N, 4.09.

3-(4-Chlorobenzoyl)-8-ethoxy-chromen-2-one (10be):



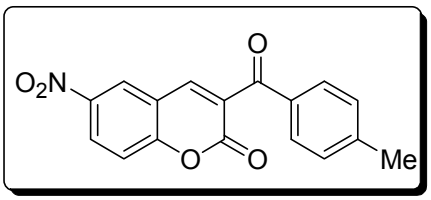
White solid: mp 228-229 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.09 (s, 1H, ArH), 7.81 (d, *J* = 8.4 Hz, 2H, ArH), 7.44 (d, *J* = 8.4 Hz, 2H, ArH), 7.24-7.15 (m, 3H, ArH), 4.21 (q, *J* = 6.9 Hz, 2H, OCH_2), 1.53 (t, *J* = 6.9 Hz, 3H, CH_3). ^{13}C NMR (75 MHz, $CDCl_3$): δ 190.6, 158.1, 146.6, 146.3, 144.7, 140.2, 134.5, 130.9, 128.8, 126.7, 124.9, 120.3, 118.8, 116.5, 65.0, 14.7. IR (KBr, cm^{-1}): 2989, 2929, 1716, 1657, 1603, 1467, 1280, 1244. ESI MS (*m/z*): 329 (M^++1); Anal. Calcd for $C_{18}H_{13}ClO_4$: C, 65.76; H, 3.99. Found: C, 65.97; H, 4.11.

6-Bromo-3-(4-methylbenzoyl)-chromen-2-one (10cb):



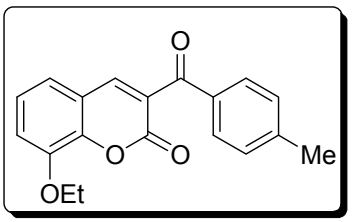
White solid: mp 219-220 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.93 (s, 1H, ArH), 7.77 (d, *J* = 8.1 Hz, 2H, ArH), 7.72-7.70 (m, 2H, ArH), 7.31-7.25 (m, 3H, ArH), 2.43 (s, 3H, $ArCH_3$). ^{13}C NMR (75 MHz, $CDCl_3$): δ 190.6, 157.7, 153.4, 145.2, 143.3, 136.0, 133.2, 131.1, 129.7, 129.3, 128.3, 119.6, 118.6, 117.4, 21.8. IR (KBr, cm^{-1}): 3055, 1722, 1653, 1607, 1478 1287. ESI MS (*m/z*): 343 (M^++1); Anal. Calcd for $C_{17}H_{11}BrO_3$: C, 59.50; H, 3.23. Found: C, 59.42; H, 3.38.

3-(4-methylbenzoyl)-6-nitro-chromen-2-one (10cd):



White solid: mp 192-193 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.52-8.48 (m, 2H, ArH), 8.07 (s, 1H, ArH), 7.78 (d, *J* = 8.1 Hz, 2H, ArH), 7.54 (d, *J* = 8.7 Hz, 1H, ArH), 7.31 (d, *J* = 7.8 Hz, 2H, ArH), 2.45 (s, 3H, $ArCH_3$). ^{13}C NMR (75 MHz, $CDCl_3$): δ 189.8, 157.8, 156.8, 145.6, 144.3, 143.0, 132.9, 129.8, 129.5, 127.8, 124.7, 118.1, 21.8. IR (KBr, cm^{-1}): 3061, 1736, 1658, 1615, 1528, 1346, 1250. ESI MS (*m/z*): 310 (M^++1); Anal. Calcd for $C_{17}H_{11}NO_5$: C, 66.02; H, 3.58; N, 4.53. Found: C, 66.25; H, 3.43; N, 4.86.

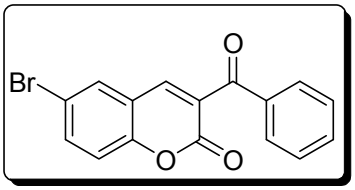
8-Ethoxy-3-(4-methylbenzoyl)-chromen-2-one (10ce):



White solid: mp 130-131 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.02 (s, 1H, ArH), 7.78 (d, *J* = 7.8 Hz, 2H, ArH), 7.27-7.12 (m, 5H, ArH), 4.21 (q, *J*= 6.9 Hz, 2H, OCH_2), 2.42 (s, 3H, $ArCH_3$), 1.52 (t, *J* = 6.9 Hz, 3H, CH_3).

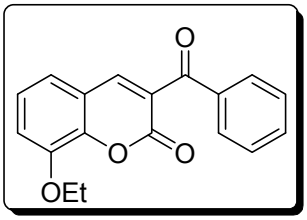
^{13}C NMR (75 MHz, $CDCl_3$): δ 191.2, 158.0, 146.4, 145.2, 144.8, 144.4, 133.5, 129.7, 129.2, 127.3, 124.7, 120.1, 118.8, 116.2, 64.9, 21.7, 14.6. IR (KBr, cm^{-1}): 2988, 2920, 1717, 1657, 1606, 1467, 1279, 1244, 1110. ESI MS (*m/z*): 309 (M^++1); Anal. Calcd for $C_{19}H_{16}O_4$: C, 74.01; H, 5.23. Found: C, 73.92; H, 5.39.

3-Benzoyl-6-bromochromen-2-one (10db):



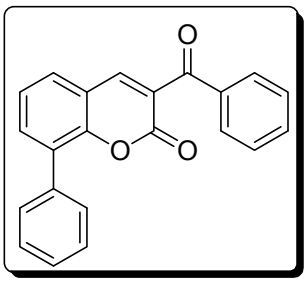
White solid: mp 179-180 °C (Lit.[2e] 177 °C). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.97 (s, 1H, ArH), 7.87 (d, *J* = 7.5 Hz, 2H, ArH), 7.73-7.71 (m, 2H, ArH), 7.63 (t, *J* = 7.2 Hz, 1H, ArH), 7.49 (t, *J* = 7.5 Hz, 2H, ArH), 7.31-7.28 (m, 1H, ArH). ^{13}C NMR (75 MHz, $CDCl_3$): δ 191.0, 157.6, 153.4, 143.7, 136.2, 135.8, 134.0, 131.2, 129.5, 128.6, 128.0, 119.6, 118.6, 117.4. IR (KBr, cm^{-1}): 3064, 1718, 1656, 1617, 1557, 1236, 1181. ESI MS (*m/z*): 329 (M^++1); Anal. Calcd for $C_{16}H_9BrO_3$: C, 58.38; H, 2.76. Found: C, 58.26; H, 2.59.

3-Benzoyl-8-ethoxychromen-2-one (10de):



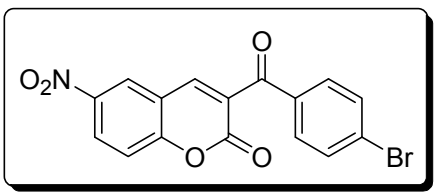
White solid: mp 144-145 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.05 (s, 1H, ArH), 7.88 (d, *J* = 7.5 Hz, 2H, ArH), 7.63-7.58 (m, 1H, ArH), 7.49-7.44 (m, 2H, ArH), 7.28-7.23 (m, 1H, ArH), 7.18-7.13 (m, 2H, ArH), 4.21 (q, *J* = 6.9 Hz, 2H, OCH_2), 1.52 (t, *J* = 6.9 Hz, 3H, CH_3). ^{13}C NMR (75 MHz, $CDCl_3$): δ 191.7, 158.0, 146.5, 145.6, 144.5, 136.1, 133.7, 129.5, 128.5, 127.1, 124.7, 120.2, 118.8, 116.3, 65.0, 14.6. IR (KBr, cm^{-1}): 3061, 2981, 1707, 1659, 1607, 1467, 1279, 1241, 1097. ESI MS (*m/z*): 295 (M^++1); Anal. Calcd for $C_{18}H_{14}O_4$: C, 73.46; H, 4.79. Found: C, 73.59; H, 4.65.

3-Benzoyl-8-phenylchromen-2-one (10df):



White solid: mp 178-179 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.13 (s, 1H, ArH), 7.89 (d, *J* = 8.1 Hz, 2H, ArH), 7.70 (d, *J* = 7.5 Hz, 1H, ArH), 7.64-7.57 (m, 4H, ArH), 7.51-7.39 (m, 6H, ArH). ^{13}C NMR (75 MHz, $CDCl_3$): δ 191.6, 158.0, 151.5, 145.8, 136.1, 135.0, 134.7, 133.8, 130.4, 129.6, 129.4, 128.5, 128.4, 128.2, 126.9, 124.9, 118.6. IR (KBr, cm^{-1}): 3060, 2923, 1716, 1655, 1595, 1452, 1168. ESI MS (*m/z*): 327 (M^++1); Anal. Calcd for $C_{22}H_{14}O_3$: C, 80.97; H, 4.32. Found: C, 80.82; H, 4.45.

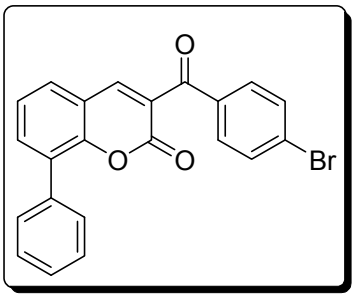
3-(4-Bromobenzoyl)-6-nitrochromen-2-one (10ed):



White solid: mp 267-268 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.54-8.49 (m, 2H, ArH), 8.15 (s, 1H, ArH), 7.73 (d, *J* = 8.4 Hz, 2H, ArH), 7.65 (d, *J* = 8.4 Hz, 2H, ArH), 7.55 (d, *J* = 8.7 Hz, 1H, ArH). ^{13}C NMR (75 MHz, $CDCl_3$): δ 189.5, 158.1, 150.1, 145.2, 144.5, 141.1, 133.2, 130.5, 129.3, 128.3, 127.4, 125.1, 118.6, 117.9. IR (KBr, cm^{-1}): 2960, 1740, 1652,

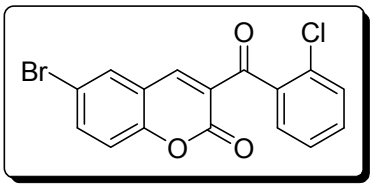
1614, 1532, 1347, 1251, 1157. ESI MS (*m/z*): 374 (M^++1); Anal. Calcd for $C_{16}H_8BrNO_5$: C, 51.36; H, 2.16; N, 3.74. Found: C, 51.21; H, 2.32; N, 3.46.

3-(4-Bromobenzoyl)-8-phenylchromen-2-one (10ef):



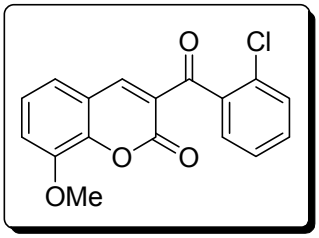
White solid. Mp 192-193 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.18 (s, 1H, ArH), 7.76-7.70 (m, 3H, ArH), 7.63-7.59 (m, 5H, ArH), 7.52-7.40 (m, 4H, ArH); ^{13}C NMR (75 MHz, $CDCl_3$): δ 190.7, 158.0, 151.6, 146.4, 135.0, 134.9, 131.8, 130.9, 130.5, 129.4, 129.0, 128.5, 128.3, 126.4, 125.0, 118.5; IR (KBr, cm^{-1}): 2924, 1721, 1656, 1592, 1456, 1277, 1239, 1172. ESI MS (*m/z*): 405 (M^++1); Anal. Calcd for $C_{22}H_{13}BrO_3$: C, 65.20; H, 3.23. Found: C, 65.37; H, 3.36.

6-Bromo-3-(2-Chlorobenzoyl)-chromen-2-one (10fb):



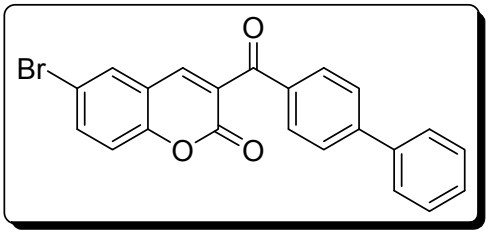
White solid: mp 155-156 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.25 (s, 1H, ArH), 7.79-7.71 (m, 2H, ArH), 7.60-7.57 (m, 1H, ArH), 7.50-7.39 (m, 3H, ArH), 7.29-7.26 (m, 1H, ArH). ^{13}C NMR (75 MHz, $CDCl_3$): δ 190.7, 157.4, 153.9, 145.3, 137.7, 136.8, 132.6, 131.9, 130.1, 129.9, 127.3, 127.2, 119.8, 118.6, 117.4. IR (KBr, cm^{-1}): 3080, 2925, 1738, 1656, 1600, 1546, 1468, 1230, 1154. ESI MS (*m/z*): 363 (M^++1); Anal. Calcd for $C_{16}H_8BrClO_3$: C, 52.85; H, 2.22. Found: C, 52.77; H, 2.11.

3-(2-Chlorobenzoyl)-8-methoxychromen-2-one (10fc):



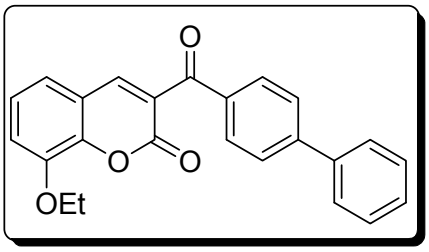
White solid: mp 142-143 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.33 (s, 1H, ArH), 7.57 (d, *J*= 7.5 Hz, 1H, ArH), 7.45-7.36 (m, 3H, ArH), 7.30-7.18 (m, 3H, ArH), 3.98 (s, 3H, OCH_3). ^{13}C NMR (75 MHz, $CDCl_3$): δ 191.1, 157.4, 147.2, 147.0, 144.8, 137.9, 132.3, 131.5, 130.0, 129.8, 127.0, 126.3, 124.7, 120.9, 118.8, 115.8, 56.2. IR (KBr, cm^{-1}): 2935, 1757, 1719, 1674, 1607, 1570, 1472, 1279, 1102. ESI MS (*m/z*): 315 (M^++1); Anal. Calcd for $C_{17}H_{11}ClO_4$: C, 64.88; H, 3.52. Found: C, 64.72; H, 3.38.

3-(Biphenyl-4-carbonyl)-6-bromochromen-2-one (10gb):



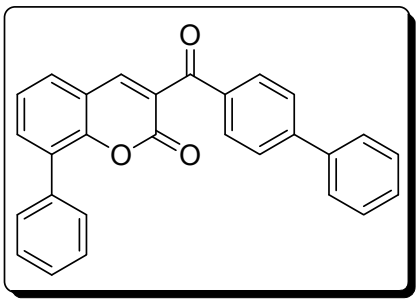
White solid. mp 205-206 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.99-7.93 (m, 3H, ArH), 7.74-7.61 (m, 6H, ArH), 7.47-7.43 (m, 2H, ArH), 7.32-7.25 (m, 2H, ArH); ^{13}C NMR (75 MHz, $CDCl_3$): δ 190.6, 157.8, 153.4, 146.7, 143.6, 139.6, 136.2, 134.5, 131.2, 130.2, 128.9, 128.4, 128.2, 127.3, 119.6, 118.6, 117.5; IR (KBr, cm^{-1}): 3048, 2922, 1724, 1653, 1601, 1555, 1511, 1475, 1235. ESI MS (*m/z*): 405 (M^++1); Anal. Calcd for $C_{22}H_{13}BrO_3$: C, 65.20; H, 3.23. Found: C, 65.08; H, 3.49.

3-(Biphenyl-4-carbonyl)-8-ethoxychromen-2-one (10ge):



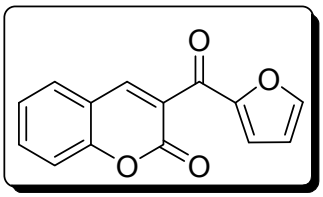
White solid: mp 178-179 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.09 (s, 1H, ArH), 7.96 (d, *J* = 8.4 Hz, 2H, ArH), 7.69-7.61 (m, 4H, ArH), 7.49-7.37 (m, 3H, ArH), 7.29-7.15 (m, 3H, ArH), 4.22 (q, *J* = 7.2 Hz, 2H, OCH_2), 1.55 (t, *J* = 7.2 Hz, 3H, CH_3). ^{13}C NMR (75 MHz, $CDCl_3$): δ 191.2, 158.1, 146.6, 146.5, 145.7, 144.6, 139.7, 134.8, 130.2, 128.9, 128.3, 127.3, 127.2, 124.8, 120.2, 118.9, 116.3, 65.0, 14.7. IR (KBr, cm^{-1}): 2977, 1717, 1658, 1604, 1570, 1466, 1399, 1240, 1182. ESI MS (*m/z*): 371 (M^++1); Anal. Calcd for $C_{24}H_{18}O_4$: C, 77.82; H, 4.90. Found: C, 77.60; H, 4.71.

3-(Biphenyl-4-carbonyl)-8-phenylchromen-2-one (10gf):



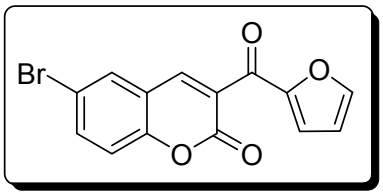
White solid: mp 192-193 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.16 (s, 1H, ArH), 7.97 (d, *J* = 8.4 Hz, 2H, ArH), 7.71-7.59 (m, 8H, ArH), 7.52-7.40 (m, 7H, ArH). ^{13}C NMR (75 MHz, $CDCl_3$): δ 191.1, 158.1, 151.5, 146.5, 145.7, 139.7, 135.0, 134.8, 134.7, 130.4, 130.2, 129.4, 128.9, 128.5, 128.4, 128.3, 128.2, 127.3, 127.2, 127.0, 124.9, 118.6. IR (KBr, cm^{-1}): 3063, 2921, 1717, 1654, 1599, 1455, 1242, 1169. ESI MS (*m/z*): 403 (M^++1); Anal. Calcd for $C_{28}H_{18}O_3$: C, 83.57; H, 4.51. Found: C, 83.41; H, 4.38.

3-(Furan-2-carbonyl)-chromen-2-one (10ha):



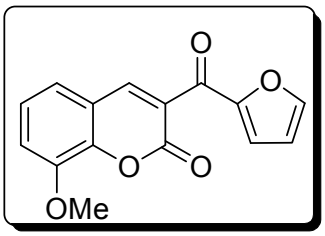
White solid: mp 159-160 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.16 (s, 1H, ArH), 7.67-7.60 (m, 3H, ArH), 7.41-7.32 (m, 3H, ArH), 6.61-6-60 (m, 1H, ArH); ^{13}C NMR (75 MHz, $CDCl_3$): δ 177.9, 158.0, 154.6, 151.6, 147.7, 145.5, 133.7, 129.2, 126.1, 124.9, 120.7, 118.0, 116.8, 112.7. IR (KBr, cm^{-1}): 3109, 2925, 1719, 1648, 1606, 1564, 1457, 1389, 1173. ESI MS (*m/z*): 241 (M^++1); Anal. Calcd for $C_{14}H_8O_4$: C, 70.00; H, 3.36. Found: C, 70.32; H, 3.06.

6-Bromo-3-(furan-2-carbonyl)-chromen-2-one (10hb):



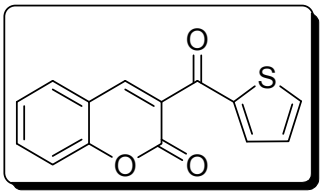
White solid: mp 191-192 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.05 (s, 1H, ArH), 7.74-7.67 (m, 3H, ArH), 7.36 (d, *J* = 3.9 Hz, 1H, ArH), 7.30-7.25 (m, 1H, ArH), 6.62 (dd, *J* = 3.6, 1.2 Hz, 1H, ArH). ^{13}C NMR (75 MHz, $CDCl_3$): δ 177.4, 157.2, 153.4, 151.5, 147.8, 143.8, 136.3, 131.3, 127.1, 120.8, 119.5, 118.6, 117.4, 112.8. IR (KBr, cm^{-1}): 3105, 2932, 1724, 1644, 1604, 1560, 1459, 1359, 1241, 1180. ESI MS (*m/z*): 319 (M^++1); Anal. Calcd for $C_{14}H_7BrO_4$: C, 52.69; H, 2.21. Found: C, 52.44; H, 2.39.

3-(Furan-2-carbonyl)-8-methoxychromen-2-one (10hc):



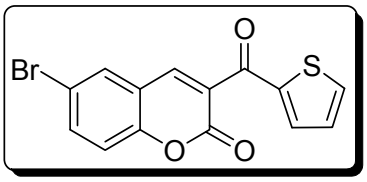
White solid: mp 138-139 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.14 (s, 1H, ArH), 7.66 (s, 1H, ArH), 7.35 (d, *J* = 3.3 Hz, 1H, ArH), 7.30-7.16 (m, 3H, ArH), 6.60-6.59 (m, 1H, ArH), 3.99 (s, 3H, OCH_3). ^{13}C NMR (75 MHz, $CDCl_3$): δ 178.0, 157.5, 151.6, 147.7, 147.1, 145.7, 126.4, 124.8, 120.8, 120.4, 118.6, 115.3, 112.7, 56.3. IR (KBr, cm^{-1}): 2924, 2854, 1720, 1648, 1608, 1465, 1277, 1184. ESI MS (*m/z*): 271 (M^++1); Anal. Calcd for $C_{15}H_{10}O_5$: C, 66.67; H, 3.73. Found: C, 66.51; H, 3.49.

3-(Thiophene-2-carbonyl)-chromen-2-one (10ia):



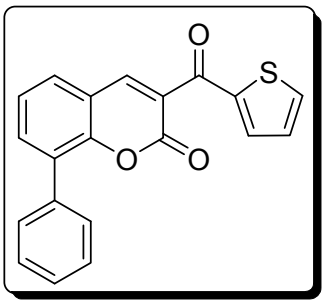
White solid: mp 149-150 °C (Lit.[2d] 148-150 °C). ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.10 (s, 1H, ArH), 7.77-7.72 (m, 2H, ArH), 7.68-7.59 (m, 2H, ArH), 7.42-7.33 (m, 2H, ArH), 7.17-7.14 (m, 1H, ArH). ^{13}C NMR (75 MHz, $CDCl_3$, δ ppm): 182.8, 158.1, 154.5, 144.6, 142.7, 135.6, 135.1, 133.6, 129.1, 128.3, 126.7, 124.9, 117.9, 116.8. IR (KBr, cm^{-1}): 2924, 1718, 1632, 1604, 1563, 1407, 1308, 1241. ESI MS (*m/z*): 257 (M^++1); Anal. Calcd for $C_{14}H_8O_3S$: C, 65.61; H, 3.15. Found: C, 65.87; H, 3.27.

6-Bromo-3-(thiophene-2-carbonyl)-chromen-2-one (10ib):



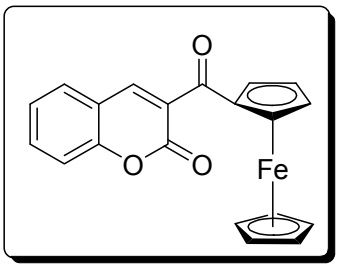
White solid: mp 201-202 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.99 (s, 1H, ArH), 7.79 (d, *J* = 4.8 Hz, 1H, ArH), 7.74-7.70 (m, 3H, ArH), 7.31-7.25 (m, 1H, ArH), 7.18-7.15 (m, 1H, ArH). ^{13}C NMR (75 MHz, $CDCl_3$): δ 182.3, 157.5, 153.3, 143.0, 142.5, 136.3, 136.0, 135.2, 131.2, 128.4, 127.8, 119.4, 118.6, 117.5. IR (KBr, cm^{-1}): 2926, 1721, 1631, 1566, 1410, 1239, 1210, 1160. ESI MS (*m/z*): 335 (M^++1); Anal. Calcd for $C_{14}H_7BrO_3S$: C, 50.17; H, 2.11. Found: C, 50.29; H, 2.23.

8-Phenyl-3-(thiophene-2-carbonyl)-chromen-2-one (10if):



White solid: mp 181-182 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.15 (s, 1H, ArH), 7.76-7.68 (m, 3H, ArH), 7.64-7.57 (m, 3H, ArH), 7.52-7.39 (m, 4H, ArH), 7.16-7.13 (m, 1H, ArH). ^{13}C NMR (75 MHz, $CDCl_3$): δ 182.9, 157.8, 151.4, 145.1, 142.8, 135.6, 135.2, 135.0, 134.8, 130.4, 129.4, 128.5, 128.4, 128.3, 128.2, 126.7, 124.9, 118.4. IR (KBr, cm^{-1}): 2922, 1719, 1632, 1597, 1411, 1242, 1159. ESI MS (*m/z*): 333 (M^++1); Anal. Calcd for $C_{20}H_{12}O_3S$: C, 72.27; H, 3.64. Found: C, 72.39; H, 3.77.

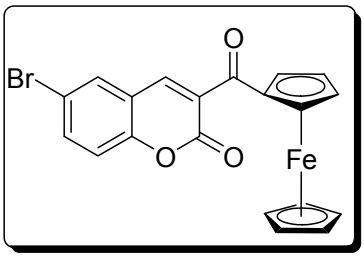
3-(Ferrocene-2-carbonyl)-chromen-2-one (10ja):



Red solid: mp >350 °C (Lit.[1a] >200 °C). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.97 (s, 1H, ArH), 7.65-7.57 (m, 2H, ArH), 7.41-7.32 (m, 2H, ArH), 4.86 (s, 2H, H_{cp}), 4.64 (s, 2H, H_{cp}), 4.29 (s, 5H, H_{cp}). ^{13}C NMR (75 MHz, $CDCl_3$): δ 194.0, 158.0, 154.3, 141.7, 133.1, 128.7, 127.9, 124.8, 118.0,

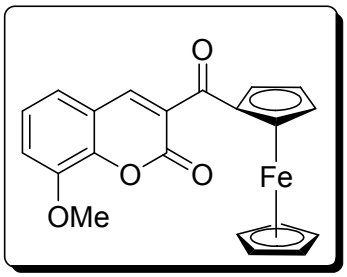
116.8, 73.4, 70.9, 70.4. IR (KBr, cm^{-1}): 3090, 2928, 1727, 1634, 1446, 1370, 1263. ESI MS (*m/z*): 359 (M^++1); Anal. Calcd for $C_{20}H_{14}FeO_3$: C, 67.07; H, 3.94. Found: C, 67.28; H, 3.69.

6-Bromo-3-(Ferrocene-2-carbonyl)-chromen-2-one (10jb):



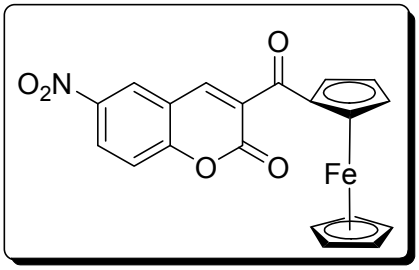
Red solid: mp 181-182 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.86 (s, 1H, ArH), 7.71-7.69 (m, 2H, ArH), 7.30-7.27 (m, 1H, ArH), 4.84 (s, 2H, H_{cp}), 4.66 (s, 2H, H_{cp}), 4.29 (s, 5H, H_{cp}). ^{13}C NMR (75 MHz, $CDCl_3$): δ 193.5, 157.3, 153.1, 140.1, 135.7, 130.9, 128.9, 119.5, 118.5, 117.3, 73.6, 71.6, 70.8. IR (KBr, cm^{-1}): 3088, 2923, 1727, 1641, 1606, 1553, 1451, 1019. ESI MS (*m/z*): 437 (M^++1); Anal. Calcd for $C_{20}H_{13}BrFeO_3$: C, 54.96; H, 3.00. Found: C, 55.12; H, 2.96.

3-(Ferrocene-2-carbonyl)-8-methoxychromen-2-one (10jc):



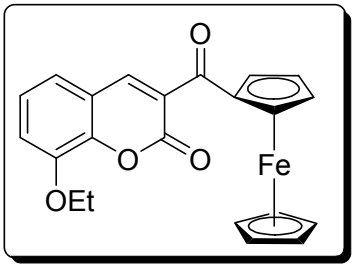
Red solid: mp 178-179 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.94 (s, 1H, ArH), 7.29-7.25 (m, 1H, ArH), 7.17-7.13 (m, 2H, ArH), 4.85 (s, 2H, H_{cp}), 4.63 (s, 2H, H_{cp}), 4.27 (s, 5H, H_{cp}), 4.00 (s, 3H, OCH_3). ^{13}C NMR (75 MHz, $CDCl_3$): δ 194.0, 157.4, 147.1, 144.0, 141.9, 128.2, 124.6, 120.0, 118.6, 114.7, 73.3, 70.9, 70.4, 56.3. IR (KBr, cm^{-1}): 3080, 2925, 1737, 1656, 1608, 1572, 1472, 1360, 1275, 1175. ESI MS (*m/z*): 389 (M^++1); Anal. Calcd for $C_{21}H_{16}FeO_4$: C, 64.97; H, 4.15. Found: C, 64.78; H, 4.39.

3-(Ferrocene-2-carbonyl)-6-nitro-chromen-2-one (10jd):



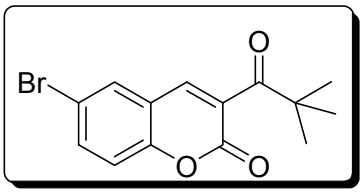
Red solid: mp 222-223 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.51-8.47 (m, 2H, ArH), 7.99 (s, 1H, ArH), 7.53 (d, *J* = 9.0 Hz, 1H, ArH), 4.85 (s, 2H, H_{cp}), 4.70 (s, 2H, H_{cp}), 4.31 (s, 5H, H_{cp}). ^{13}C NMR (75 MHz, $CDCl_3$): δ 192.8, 157.5, 156.4, 144.2, 139.9, 129.9, 127.5, 124.4, 118.2, 118.1, 73.9, 70.8, 70.6. IR (KBr, cm^{-1}): 3052, 2923, 1741, 1632, 1576, 1524, 1343, 1168. ESI MS (*m/z*): 404 (M^++1); Anal. Calcd for $C_{20}H_{13}FeNO_5$: C, 59.58; H, 3.25; N, 3.47. Found: C, 59.87; H, 3.09; N, 3.19.

8-Ethoxy-3-(Ferrocene-2-carbonyl)-chromen-2-one (10je):



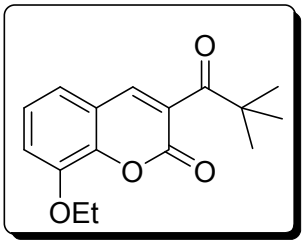
Red solid: mp 145-146 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.94 (s, 1H, ArH), 7.21-7.11 (m, 3H, ArH), 4.86 (s, 2H, H_{cp}), 4.63 (s, 2H, H_{cp}), 4.28 (s, 5H, H_{cp}), 4.23 (q, *J* = 6.9, 2H, OCH_2), 1.53 (t, *J* = 6.9 Hz, 3H, CH_3). ^{13}C NMR (75 MHz, $CDCl_3$): δ 194.1, 157.6, 146.5, 144.2, 142.0, 128.1, 124.6, 119.9, 118.7, 115.9, 73.3, 70.9, 70.4, 65.0, 14.7. IR (KBr, cm^{-1}): 3095, 2925, 1706, 1649, 1612, 1465, 1273, 1173, 1091. ESI MS (*m/z*): 403 (M^++1); Anal. Calcd for $C_{22}H_{18}FeO_4$: C, 65.69; H, 4.51. Found: C, 65.82; H, 4.39.

6-Bromo-3-(2,2-dimethyl-propionyl)-chromen-2-one (10kb):



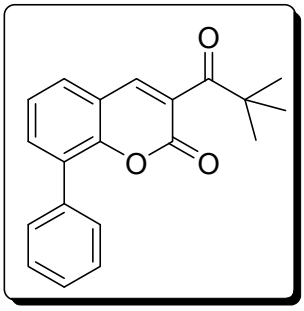
White solid: mp 130-131 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.68-7.65 (m, 2H, ArH), 7.52 (s, 1H, ArH), 7.26 (s, 1H, ArH), 1.30 (s, 9H, 3 × CH_3). ^{13}C NMR (75 MHz, $CDCl_3$): δ 207.3, 157.5, 152.7, 138.9, 135.3, 130.7, 130.6, 119.4, 118.5, 117.4, 45.0, 26.4. IR (KBr, cm^{-1}): 3052, 2952, 1726, 1681, 1554, 1477, 1182. ESI MS: *m/z* = 309 (M^++1); Anal. Calcd for $C_{14}H_{13}BrO_3$: C, 54.39; H, 4.24. Found: C, 54.07; H, 4.47.

3-(2,2-Dimethyl-propionyl)-8-ethoxychromen-2-one (10ke):



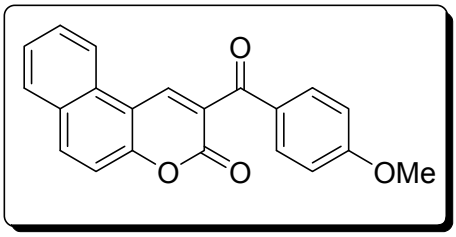
White solid: mp 65-66 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.58 (s, 1H, ArH), 7.24-7.19 (m, 1H, ArH), 7.12-7.05 (m, 2H, ArH), 4.13 (q, *J* = 6.9 Hz, 2H, OCH_2), 1.51 (t, *J* = 6.9 Hz, 3H, CH_3), 1.31 (s, 9H, 3 × CH_3). ^{13}C NMR (75 MHz, $CDCl_3$): δ 208.1, 157.8, 146.4, 143.8, 140.8, 129.8, 124.6, 119.6, 118.6, 115.5, 64.9, 44.9, 26.5, 14.6. IR (KBr, cm^{-1}): 3047, 2967, 1718, 1665, 1559, 1489, 1156. ESI MS: *m/z* = 275 (M^++1); Anal. Calcd for $C_{16}H_{18}O_4$: C, 70.06; H, 6.61. Found: C, 70.35; H, 6.24.

3-(2,2-Dimethyl-propionyl)-8-phenylchromen-2-one (10kf):



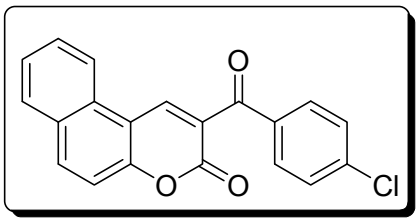
White solid: mp 87-88 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.67 (s, 1H, ArH), 7.64-7.59 (m, 2H, ArH), 7.50-7.35 (m, 6H, ArH), 1.31 (s, 9H, 3 × CH_3). ^{13}C NMR (75 MHz, $CDCl_3$): δ 207.9, 157.8, 150.7, 141.2, 135.1, 133.8, 130.2, 129.6, 129.4, 128.5, 128.1, 127.7, 124.7, 118.3, 45.0, 26.5. IR (KBr, cm^{-1}): 2918, 2850, 1703, 1655, 1458, 1169. ESI MS: *m/z* = 307 (M^++1); Anal. Calcd for $C_{20}H_{18}O_3$: C, 78.41; H, 5.92. Found: C, 78.58; H, 5.79.

3-(4-Methoxybenzoyl)-benzo[*f*]chromen-2-one (12a):



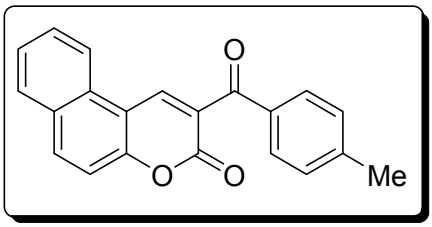
White solid: mp 210-211 °C (Lit.[2e] 210-211 °C). ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.86 (s, 1H, ArH), 8.26 (d, *J* = 8.4 Hz, 1H, ArH), 8.10 (d, *J* = 9.0 Hz, 1H, ArH), 7.96-7.91 (m, 3H, ArH), 7.74-7.69 (m, 1H, ArH), 7.63-7.58 (m, 1H, ArH), 7.52 (d, *J* = 9.0 Hz, 1H, ArH), 6.97 (d, *J* = 8.7 Hz, 2H, ArH), 3.89 (s, 3H, OCH_3). ^{13}C NMR (75 MHz, $CDCl_3$): δ 190.4, 164.1, 158.7, 155.1, 141.1, 135.0, 132.1, 130.3, 129.3, 129.1, 128.8, 126.4, 125.9, 121.5, 116.7, 113.8, 112.7, 55.5. IR (KBr, cm^{-1}): 3056, 1709, 1656, 1604, 1569, 1261, 1175. ESI MS (*m/z*): 331 (M^++1); Anal. Calcd for $C_{21}H_{14}O_4$: C, 76.35; H, 4.27. Found: C, 76.67; H, 3.93.

3-(4-Chlorobenzoyl)-benzo[*f*]chromen-2-one (12b):



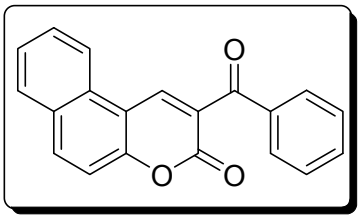
White solid: mp 228-229 °C (Lit.[2f] 230-233 °C). ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.97 (s, 1H, ArH), 8.29 (d, *J* = 8.4 Hz, 1H, ArH), 8.14 (d, *J* = 9.0 Hz, 1H, ArH), 7.96 (d, *J* = 8.1 Hz, 1H, ArH), 7.86 (d, *J* = 8.4 Hz, 2H, ArH), 7.77-7.72 (m, 1H, ArH), 7.65-7.60 (m, 1H, ArH), 7.54-7.46 (m, 3H, ArH). ^{13}C NMR (75 MHz, $CDCl_3$): δ 190.9, 158.5, 155.5, 142.5, 140.1, 135.7, 134.8, 130.9, 130.3, 129.3, 129.2, 129.1, 128.8, 126.6, 124.7, 121.4, 116.7, 112.6. IR (KBr, cm^{-1}): 3060, 2922, 1711, 1660, 1567, 1397, 1262, 1212, 1091. ESI MS (*m/z*): 335 (M^++1); Anal. Calcd for $C_{20}H_{11}ClO_3$: C, 71.76; H, 3.31. Found: C, 71.42; H, 3.52.

3-(4-Methylbenzoyl)-benzo[*f*]chromen-2-one (12c):



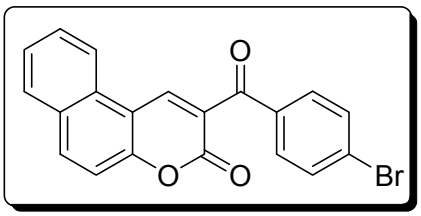
White solid: mp 181-182 °C (Lit.[2f] 190-192). ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.89 (s, 1H, ArH), 8.25 (d, *J* = 8.1 Hz, 1H, ArH), 8.10 (d, *J* = 9.0 Hz, 1H, ArH), 7.94 (d, *J* = 8.1 Hz, 1H, ArH), 7.83 (d, *J* = 8.1 Hz, 2H, ArH), 7.74-7.69 (m, 1H, ArH), 7.63-7.58 (m, 1H, ArH), 7.52 (d, *J* = 9.0 Hz, 1H, ArH), 7.31-7.28 (m, 2H, ArH), 2.44 (s, 3H, $ArCH_3$). ^{13}C NMR (75 MHz, $CDCl_3$): δ 191.6, 158.6, 155.2, 144.8, 141.5, 135.2, 133.8, 130.2, 129.7, 129.3, 129.3, 129.1, 128.9, 126.4, 125.6, 121.5, 116.7, 112.6, 21.8. IR (KBr, cm^{-1}): 2924, 1705, 1652, 1567, 1266. ESI MS (*m/z*): 315 (M^++1); Anal. Calcd for $C_{21}H_{14}O_3$: C, 80.24; H, 4.49. Found: C, 80.57; H, 4.23.

3-Benzoyl benzo[*f*]chromen-2-one (12d):



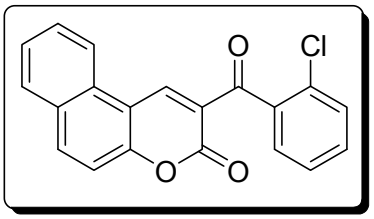
Cream color solid: mp 215-216 °C (Lit.[2f] 208-210 °C). ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.92 (s, 1H, ArH), 8.27 (d, *J* = 8.4 Hz, 1H, ArH), 8.11 (d, *J* = 9.3 Hz, 1H, ArH), 7.97-7.91 (m, 3H, ArH), 7.75-7.70 (m, 1H, ArH), 7.64-7.61 (m, 2H, ArH), 7.59-7.48 (m, 3H, ArH). ^{13}C NMR (75 MHz, $CDCl_3$): δ 192.1, 158.5, 155.4, 141.8, 136.4, 135.4, 133.7, 130.3, 129.5, 129.3, 129.2, 128.9, 128.5, 126.5, 125.3, 121.5, 116.7, 112.6. IR (KBr, cm^{-1}): 3057, 1707, 1656, 1562, 1261, 1211, 1091. ESI MS (*m/z*): 301 (M^++1); Anal. Calcd for $C_{20}H_{12}O_3$: C, 79.99; H, 4.03. Found: C, 79.63; H, 4.21.

3-(4-Bromobenzoyl)-benzo[*f*]chromen-2-one (12e):



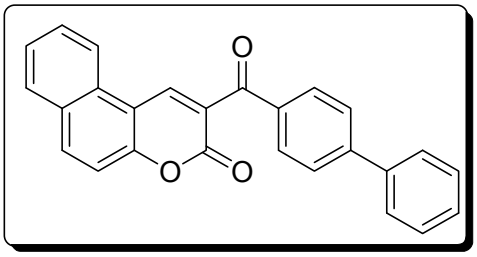
Light yellow solid: mp 252-253 °C (Lit.[2f] 245-248 °C). ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.97 (s, 1H, ArH), 8.29 (d, *J* = 8.4 Hz, 1H, ArH), 8.13 (d, *J* = 9.0 Hz, 1H, ArH), 7.96 (d, *J* = 8.4 Hz, 1H, ArH), 7.79-7.72 (m, 3H, ArH), 7.64 (d, *J* = 8.4 Hz, 3H, ArH), 7.53 (d, *J* = 9.0 Hz, 1H, ArH). ^{13}C NMR (75 MHz, $CDCl_3$): δ 191.1, 158.5, 155.6, 142.5, 135.7, 135.3, 131.8, 130.9, 130.3, 129.3, 129.2, 129.1, 128.9, 126.6, 124.7, 121.5, 116.7, 112.6. IR (KBr, cm^{-1}): 3055, 1710, 1664, 1566, 1462, 1397, 1261, 1215. ESI MS (*m/z*): 379 (M^++1); Anal. Calcd for $C_{20}H_{11}BrO_3$: C, 63.35; H, 2.92. Found: C, 63.51; H, 3.27.

3-(2-Chlorobenzoyl)-benzo[*f*]chromen-2-one (12f):



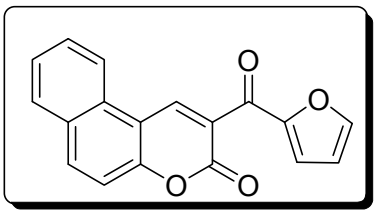
Orange solid: mp 225-226 °C (Lit.[2f] 225-227 °C). ^{1}H NMR (300 MHz, $CDCl_3$): δ 9.23 (s, 1H, ArH), 8.37 (d, *J* = 8.4 Hz, 1H, ArH), 8.12 (d, *J* = 9.0 Hz, 1H, ArH), 7.95 (d, *J* = 7.8 Hz, 1H, ArH), 7.79-7.74 (m, 1H, ArH), 7.65-7.57 (m, 2H, ArH), 7.51-7.42 (m, 4H, ArH). ^{13}C NMR (75 MHz, $CDCl_3$): δ 191.5, 158.3, 156.2, 143.1, 138.5, 136.2, 132.1, 131.4, 130.2, 129.8, 129.75, 129.71, 129.25, 129.20, 127.1, 126.6, 124.2, 121.6, 116.7, 112.9. IR (KBr, cm^{-1}): 3052, 1712, 1657, 1559, 1463, 1431, 1211, 1162. ESI MS (*m/z*): 335 (M^++1); Anal. Calcd for $C_{20}H_{11}ClO_3$: C, 71.76; H, 3.31. Found: C, 71.59; H, 3.63.

3-(Biphenyl-4-carbonyl)-benzo[*f*]chromen-2-one (12g):



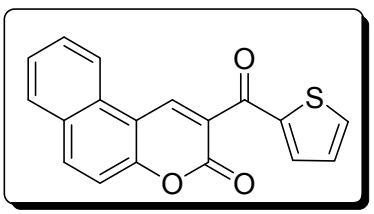
White solid: mp 233-234 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.96 (s, 1H, ArH), 8.29 (d, *J* = 8.1 Hz, 1H, ArH), 8.12 (d, *J* = 9.0 Hz, 1H, ArH), 8.02-7.95 (m, 3H, ArH), 7.76-7.63 (m, 6H, ArH), 7.60-7.38 (m, 4H, ArH). ^{13}C NMR (75 MHz, $CDCl_3$): δ 191.6, 158.6, 155.4, 146.4, 141.8, 139.8, 135.3, 135.1, 130.3, 130.2, 129.4, 129.2, 129.0, 128.9, 128.3, 127.3, 127.2, 126.5, 125.4, 121.5, 116.7, 112.7. IR (KBr, cm^{-1}): 2927, 1716, 1656, 1603, 1565, 1262, 1210. ESI MS (*m/z*): 377 (M^++1); Anal. Calcd for $C_{26}H_{16}O_3$: C, 82.96; H, 4.28. Found: C, 82.63; H, 4.57.

3-(Furan-2-carbonyl)-benzo[*f*]chromen-2-one (12h):



White solid: mp 225-226 °C (Lit.[2f] 227-230 °C). ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.99 (s, 1H, ArH), 8.29 (d, *J* = 8.4 Hz, 1H, ArH), 8.11 (d, *J* = 9.0 Hz, 1H, ArH), 7.95 (d, *J* = 8.4 Hz, 1H, ArH), 7.76-7.64 (m, 2H, ArH), 7.62-7.59 (m, 1H, ArH), 7.52 (d, *J* = 9.0 Hz, 2H, ArH), 7.43 (d, *J* = 2.7 Hz, 1H, ArH), 6.63 (dd, *J* = 3.6, 1.8 Hz, 1H, ArH). ^{13}C NMR (75 MHz, $CDCl_3$): δ 178.2, 158.1, 155.3, 151.8, 147.6, 141.9, 135.5, 130.2, 129.3, 129.2, 129.0, 126.5, 124.5, 121.4, 120.8, 116.6, 112.7, 112.5. IR (KBr, cm^{-1}): 3125, 1712, 1646, 1563, 1457, 1393. ESI MS (*m/z*): 291 (M^++1); Anal. Calcd for $C_{18}H_{10}O_4$: C, 74.48; H, 3.47. Found: C, 74.61; H, 3.22.

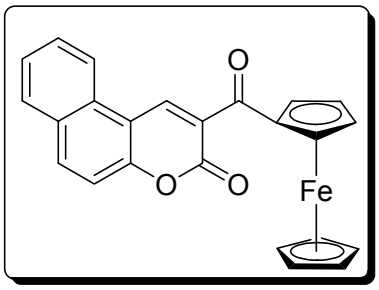
3-(Thiophene-2-carbonyl)-benzo[*f*]chromen-2-one (12i):



White solid: mp 242-243 °C (Lit.[2g] 245 °C). ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.93 (s, 1H, ArH), 8.26 (d, *J* = 8.4 Hz, 1H, ArH), 8.11 (d, *J* = 9.0 Hz, 1H, ArH), 7.95 (d, *J* = 7.8 Hz, 1H, ArH), 7.82-7.70 (m, 3H, ArH), 7.64-7.59 (m, 1H, ArH), 7.53 (d, *J* = 9.0 Hz, 1H, ArH), 7.19-7.17 (m, 1H, ArH). ^{13}C NMR (75 MHz, $CDCl_3$): δ 183.2, 158.3, 155.2, 142.9, 141.2, 135.6, 135.4, 135.1, 130.3, 129.3, 129.2, 129.0, 128.4, 126.5, 125.2, 121.4, 116.7, 112.5; IR (KBr, cm^{-1}): 3097, 2926,

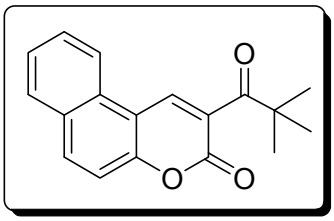
1707, 1631, 1561, 1514, 1407, 1209, 1149. ESI MS (*m/z*): 307 (M^++1); Anal. Calcd for $C_{18}H_{10}O_3S$: C, 70.57; H, 3.29. Found: C, 70.23; H, 3.48.

3-(Ferrocene-2-carbonyl)-benzo[*f*]chromen-2-one (12j):



Red solid: mp 194-195 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.79 (s, 1H, ArH), 8.26 (d, *J* = 8.4 Hz, 1H, ArH), 8.09 (d, *J* = 9.0 Hz, 1H, ArH), 7.96 (d, *J* = 7.8 Hz, 1H, ArH), 7.75-7.70 (m, 1H, ArH), 7.64-7.51 (m, 2H, ArH), 4.93 (s, 2H, H_{cp}), 4.67 (s, 2H, H_{cp}), 4.31 (s, 5H, H_{cp}). ^{13}C NMR (75 MHz, $CDCl_3$): δ 194.3, 154.7, 138.0, 134.7, 130.3, 129.3, 129.2, 128.8, 126.6, 126.4, 121.3, 116.8, 112.4, 73.4, 71.0, 70.5. IR (KBr, cm^{-1}): 3061, 2954, 1718, 1635, 1543, 1461, 1382. ESI MS (*m/z*): 409 (M^++1); Anal. Calcd for $C_{24}H_{16}FeO_3$: C, 70.61; H, 3.95. Found: C, 70.52; H, 4.32.

3-(2,2-Dimethylpropionyl)-benzo[*f*]chromen-2-one (12k):



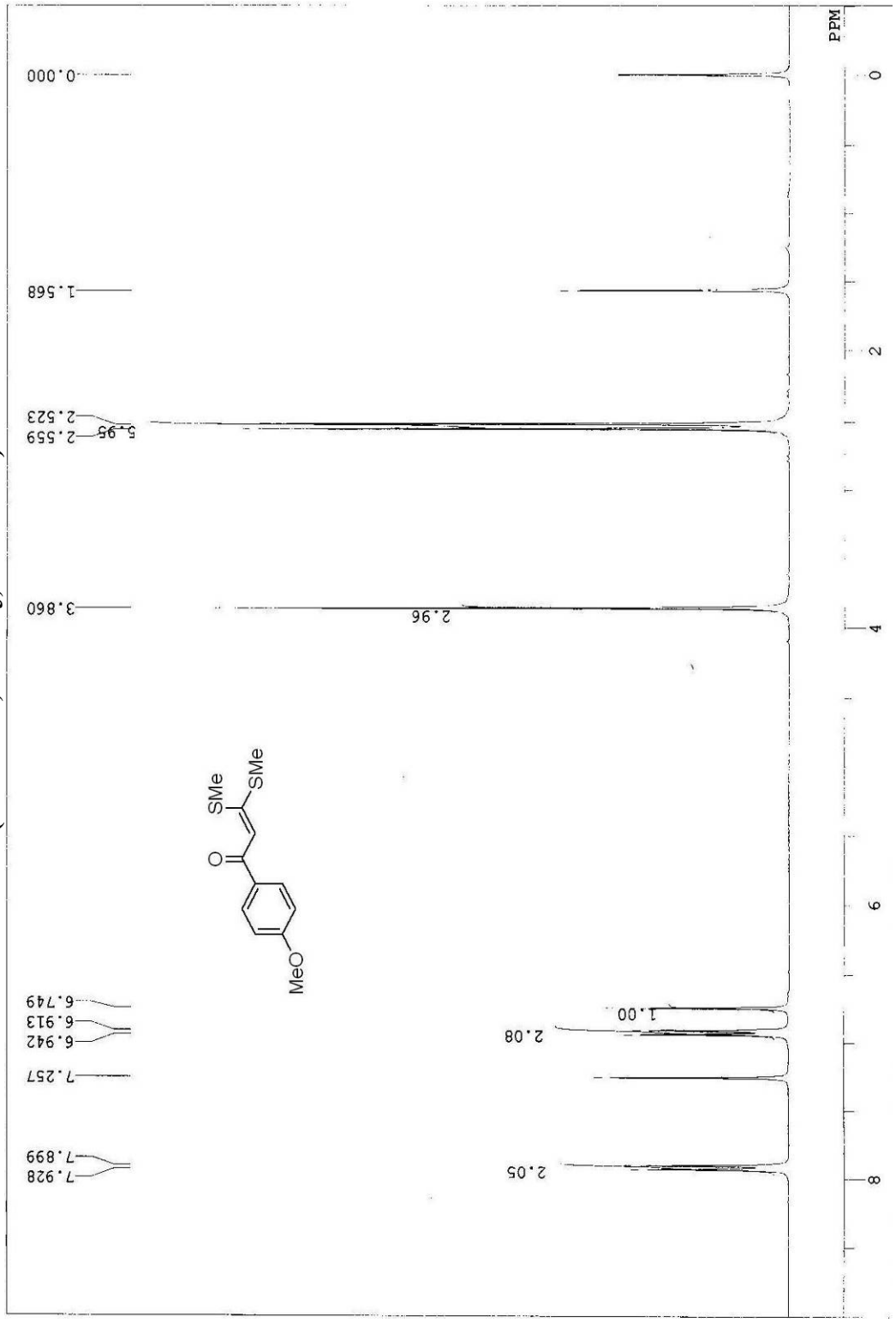
Yellowish solid: mp 133-134 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.46 (s, 1H, ArH), 8.23 (d, *J* = 8.7 Hz, 1H, ArH), 8.05 (d, *J* = 9.0 Hz, 1H, ArH), 7.93 (d, *J* = 8.1 Hz, 1H, ArH), 7.74-7.69 (m, 1H, ArH), 7.62-7.57 (m, 1H, ArH), 7.48 (d, *J* = 9.0 Hz, 1H, ArH), 1.38 (s, 9H, 3 × CH_3). ^{13}C NMR (75 MHz, $CDCl_3$): δ 205.8, 158.2, 154.2, 137.4, 134.2, 130.2, 129.1, 129.0, 128.6, 128.3, 126.3, 121.3, 116.6, 112.2, 44.9, 26.6. IR (KBr, cm^{-1}): 3072, 2973, 1710, 1568, 1460, 1210, 1181. ESI MS (*m/z*): 281 (M^++1); Anal. Calcd for $C_{18}H_{16}O_3$: C, 77.12; H, 5.75. Found: C, 77.43; H, 5.49.

References:

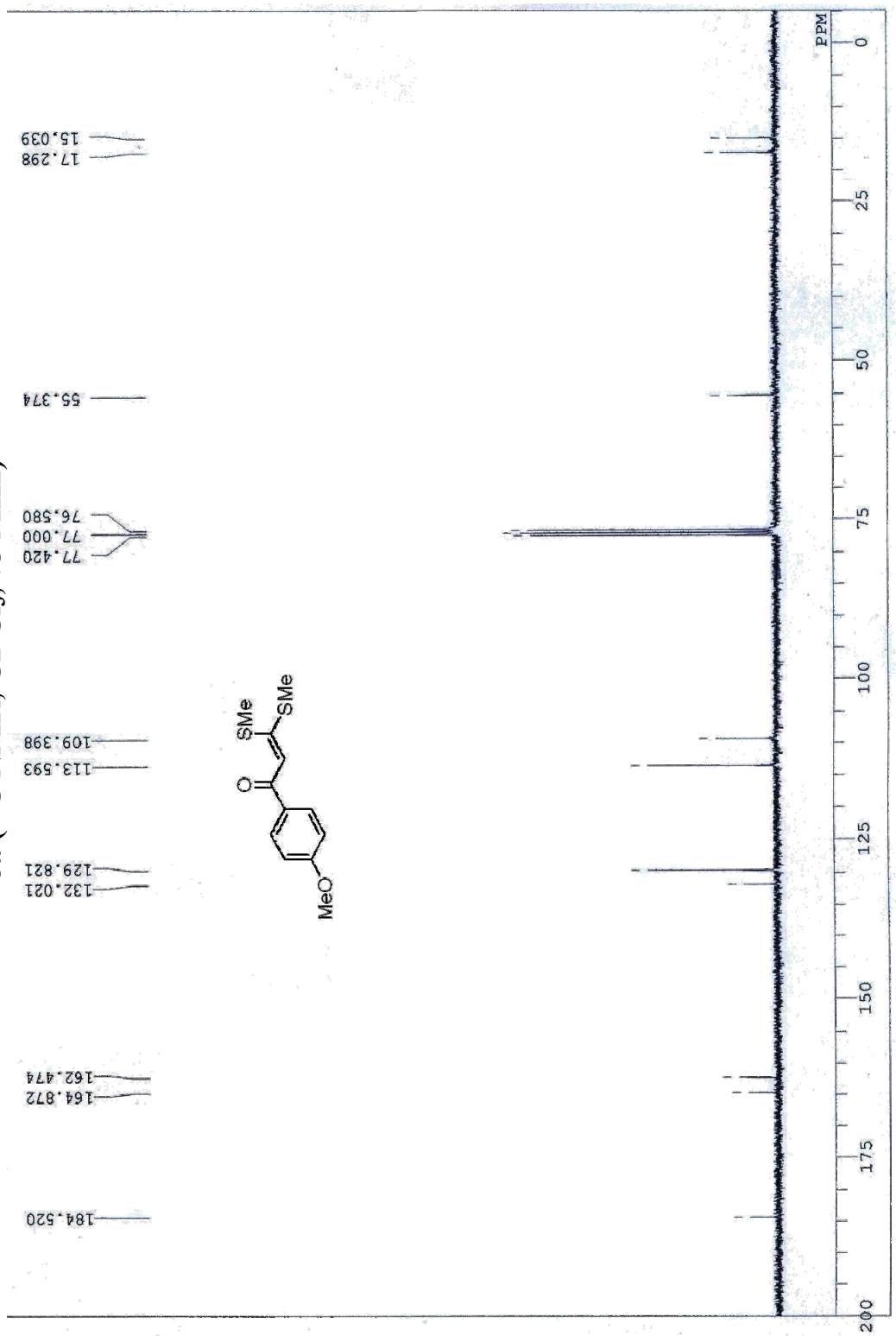
(1) (a) H. S. P. Rao and S. Sivakumar, *J. Org. Chem.*, 2006, **71**, 8715; (b) K. T. Potts and P. A. Winslow, *Synthesis*, 1987, 839; (c) K. T. Potts, M. J. Cipullo, P. Ralli and G. Theodoridis, *J. Org. Chem*. 1982, **47**, 3027; (d) I. Shahak and Y. Sasson, *Tetrahedron Lett*., 1973, **14**, 4207; (e) A. Thuillier and J. Vialle, *Bull. Soc. Chim. France*, 1959, 1398; (f) J. Maignan and J. Vialle, *Bull. Soc. Chim. France*, 1973, 2388.

(2) (a) R. Spitzner, M. Menzel and W. Schroth, *Synthesis*, 1982, 206; (b) S. Kawamura, Y. Sanemitsu, T. Hamada and R. Yoshida, Eur. Pat. Appl. EP 263958 A1, 1988; (c) W. D. Rudorf, A. Schierhorn and M. Augustin, *Tetrahedron*, 1979, **35**, 551; (d) D. P. Specht, P. A. Martic and S. Farid, *Tetrahedron*, 1982, **38**, 1203; (e) Ng. Ph. Buu-Hoi, T. B. Loc and Ng. D. Xuong, *Bull. Soc. Chim. France*, 1958, 361; (f) F. Medda, R. J. M. Russell, M. Higgins, A. R. McCarthy, J. Campbell, A. M. Z. Slawin, D. P. Lane, S. Lain and N. J. Westwood, *J. Med. Chem*., 2009, **52**, 2673; (g) Ng. Ph. Buu-Hoi, G. Saint-Ruf, T. B. Loc and Ng. D. Xuong, *J. Chem. Soc*., 1957, 2593.

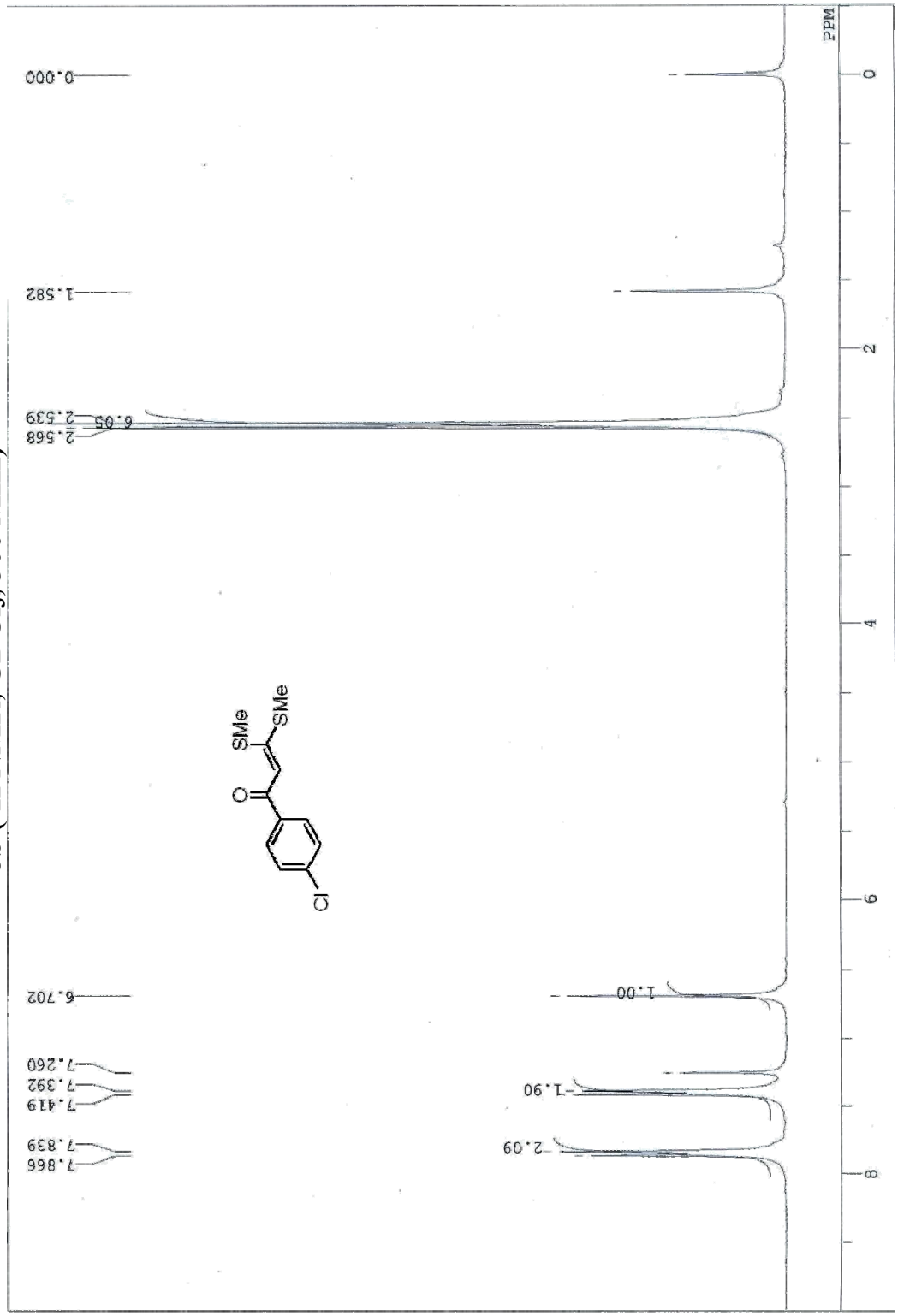
8a (^{1}H NMR, $CDCl_3$, 300 MHz)



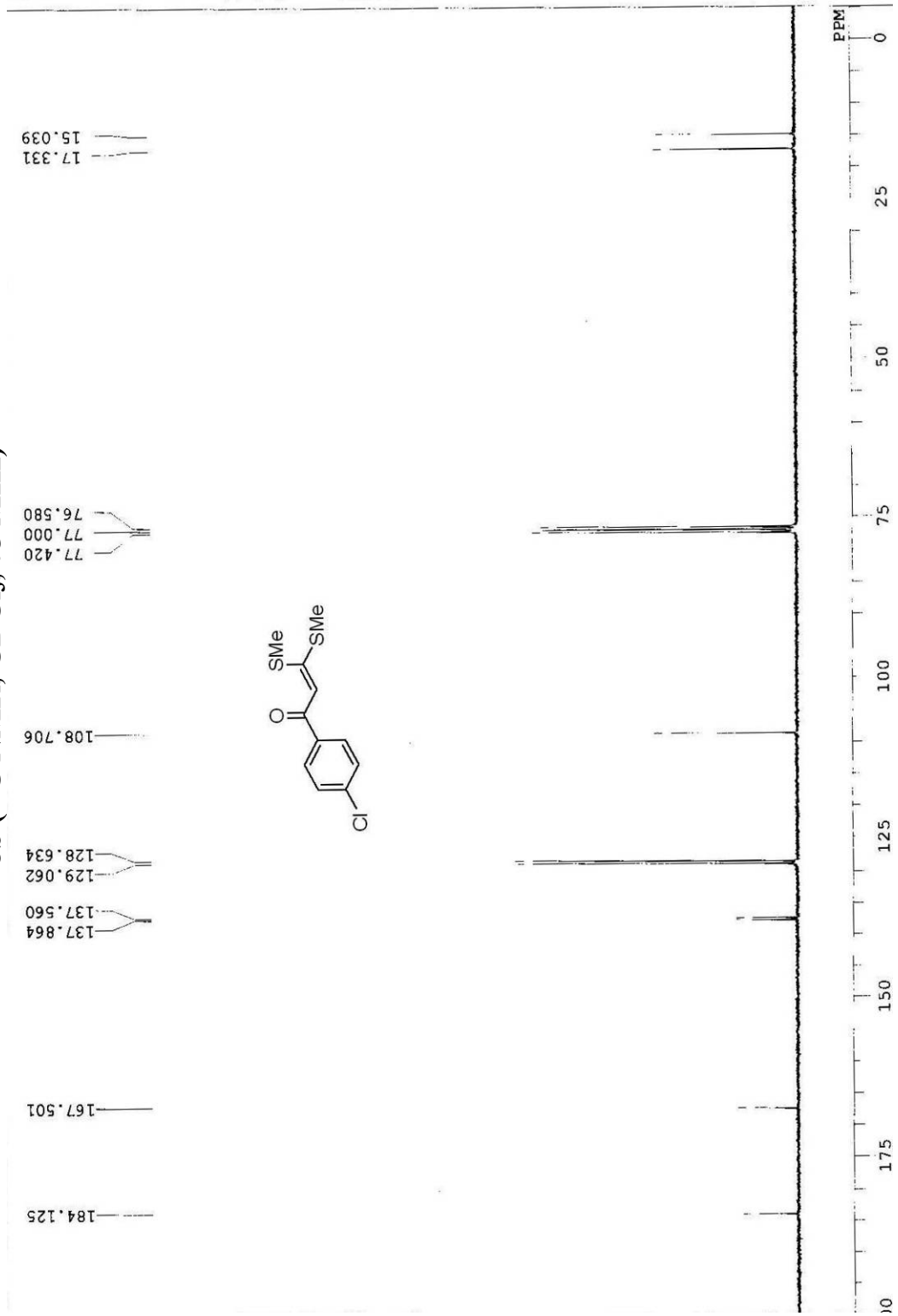
8a (^{13}C NMR, $CDCl_3$, 75 MHz)



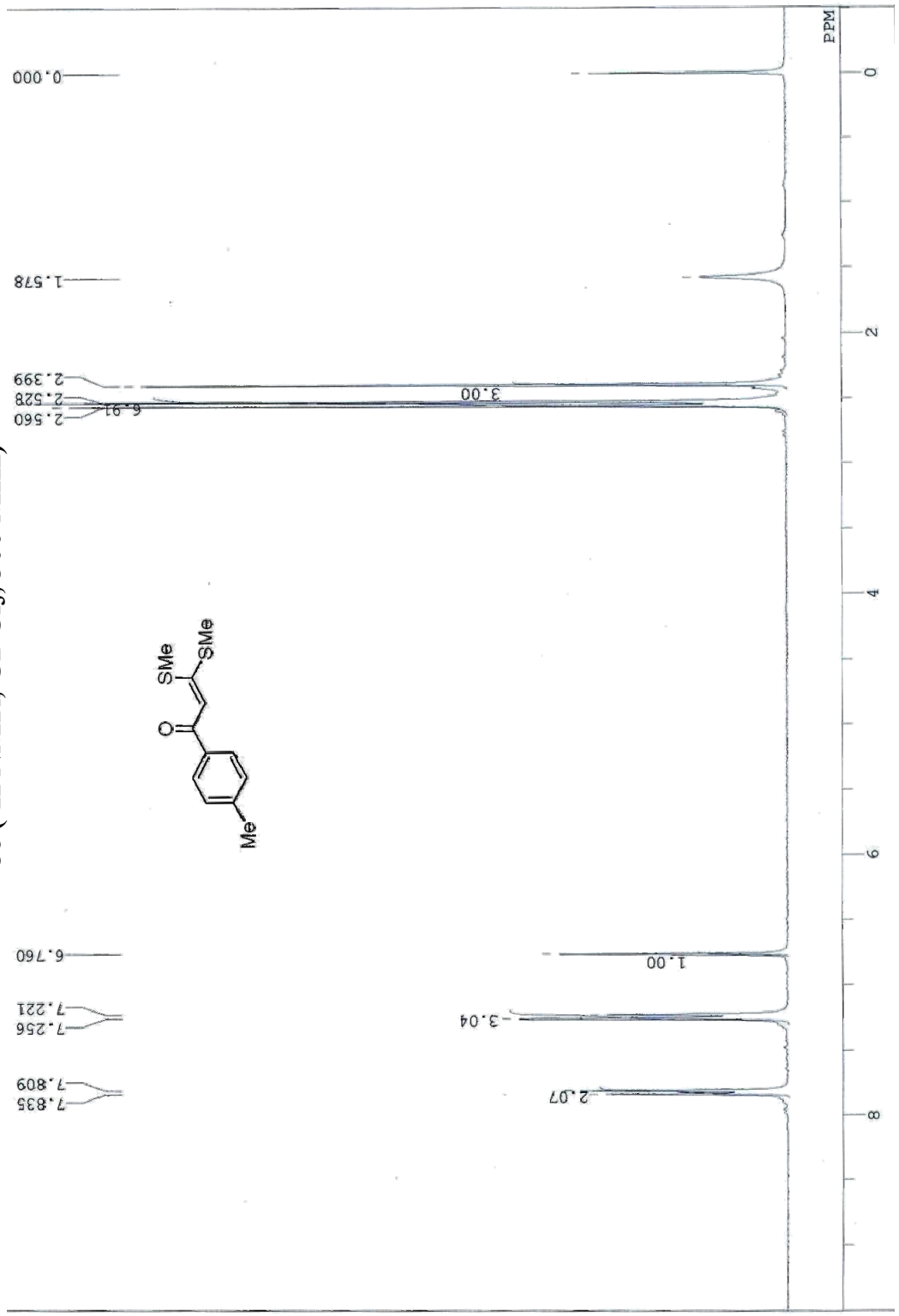
8b (^{1}H NMR, $CDCl_3$, 300 MHz)



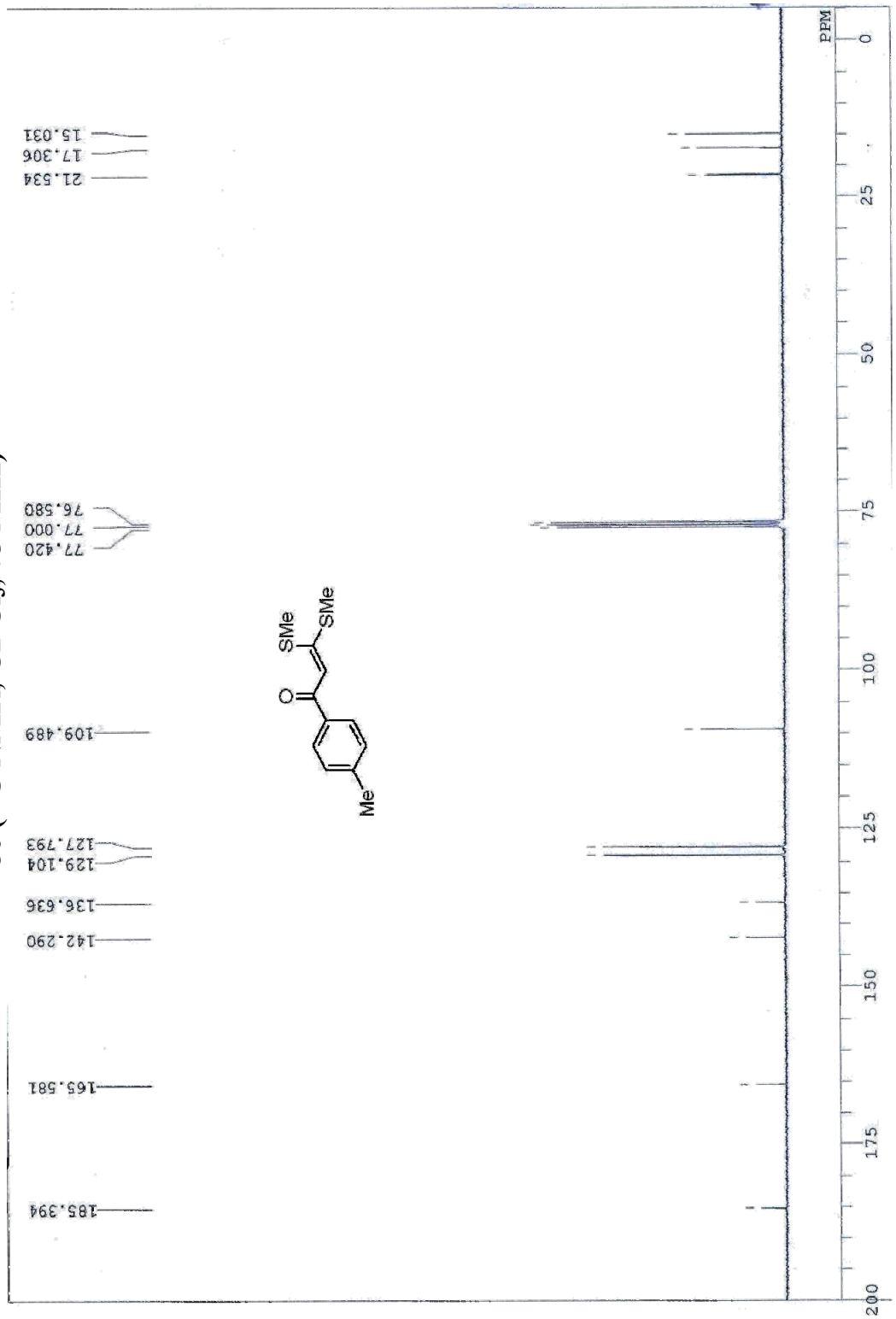
8b (^{13}C NMR, $CDCl_3$, 75 MHz)



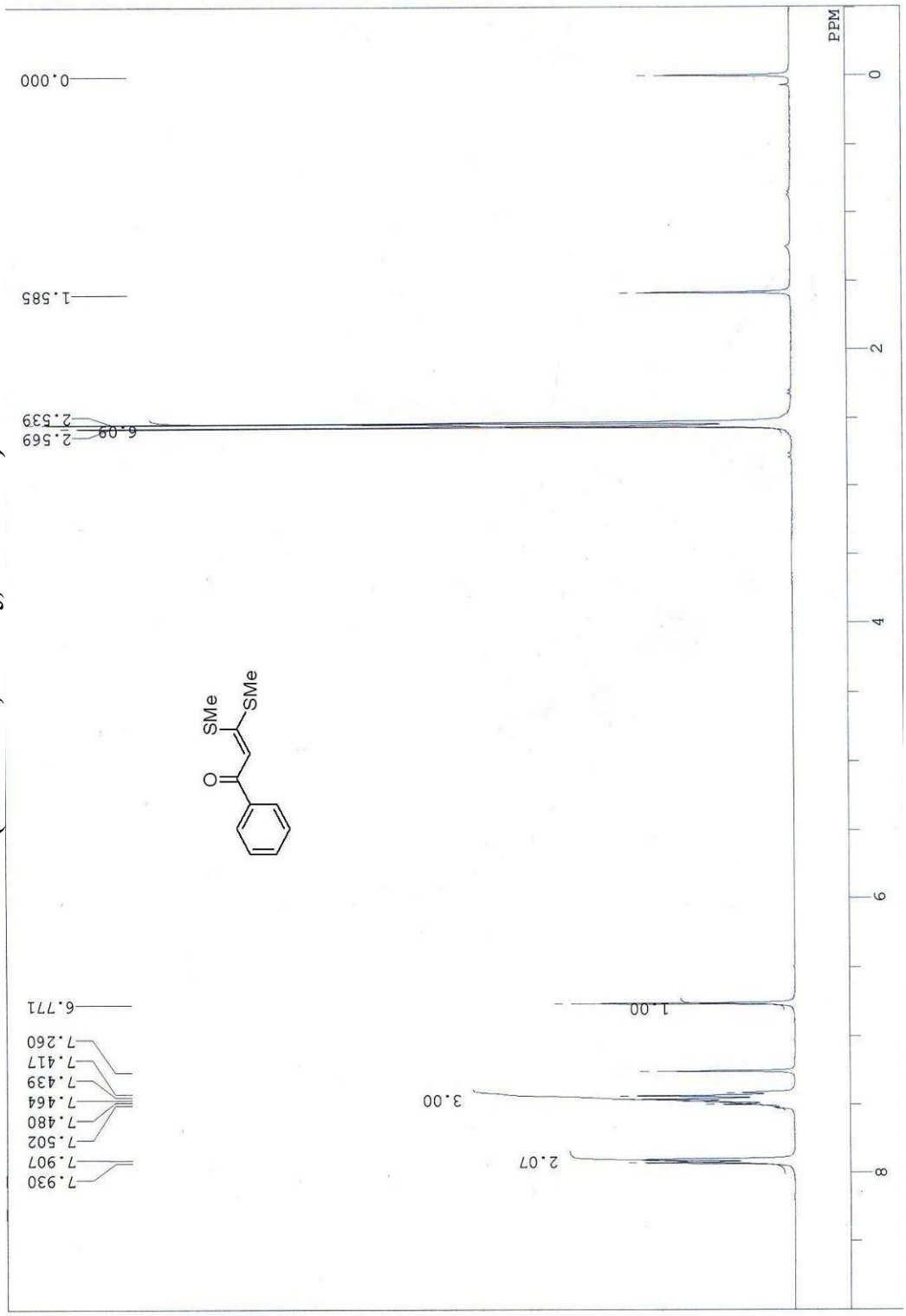
8c (^{1}H NMR, $CDCl_3$, 300 MHz)



8c (^{13}C NMR, $CDCl_3$, 75 MHz)



8d (^{1}H NMR, $CDCl_3$, 300 MHz)



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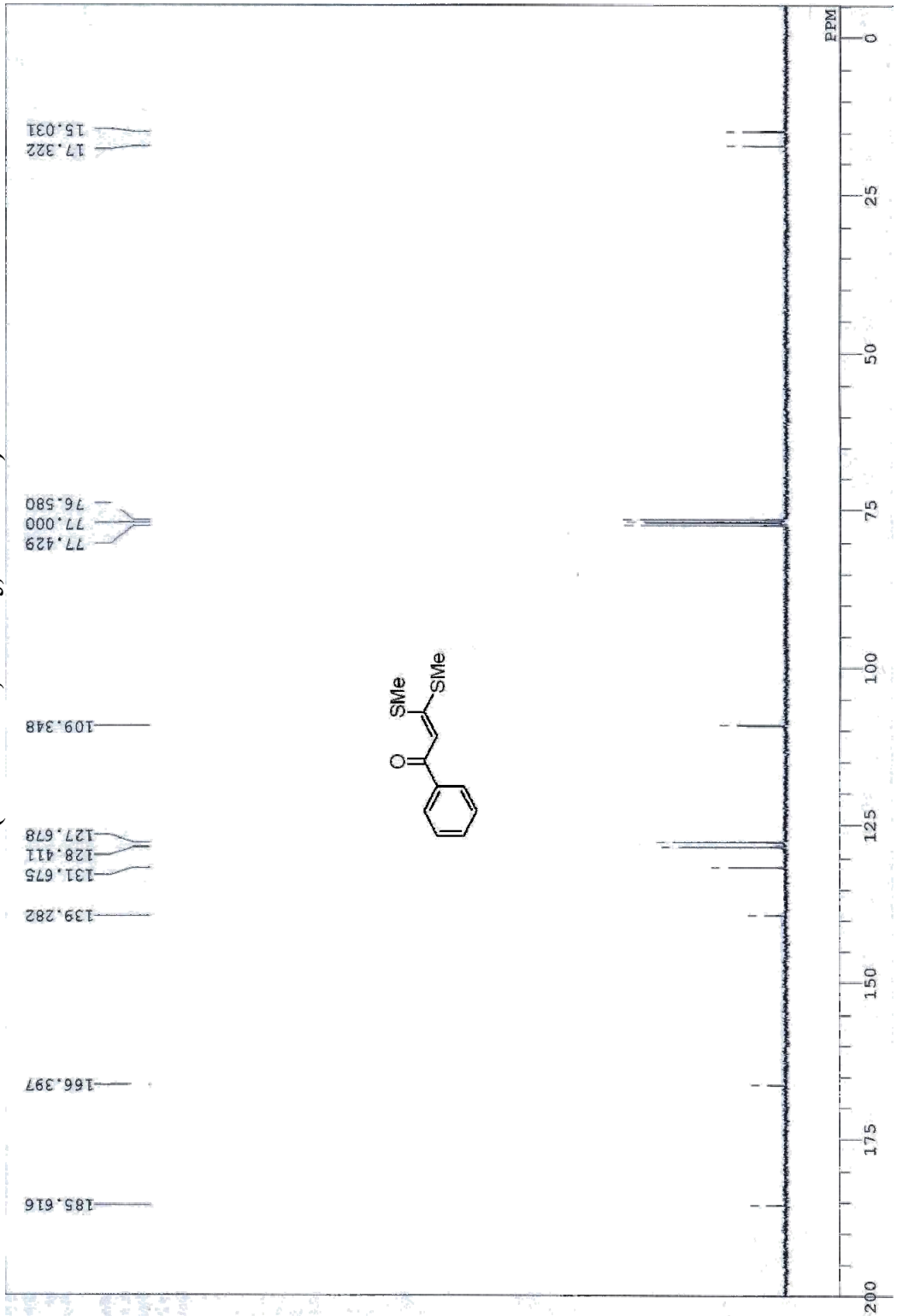
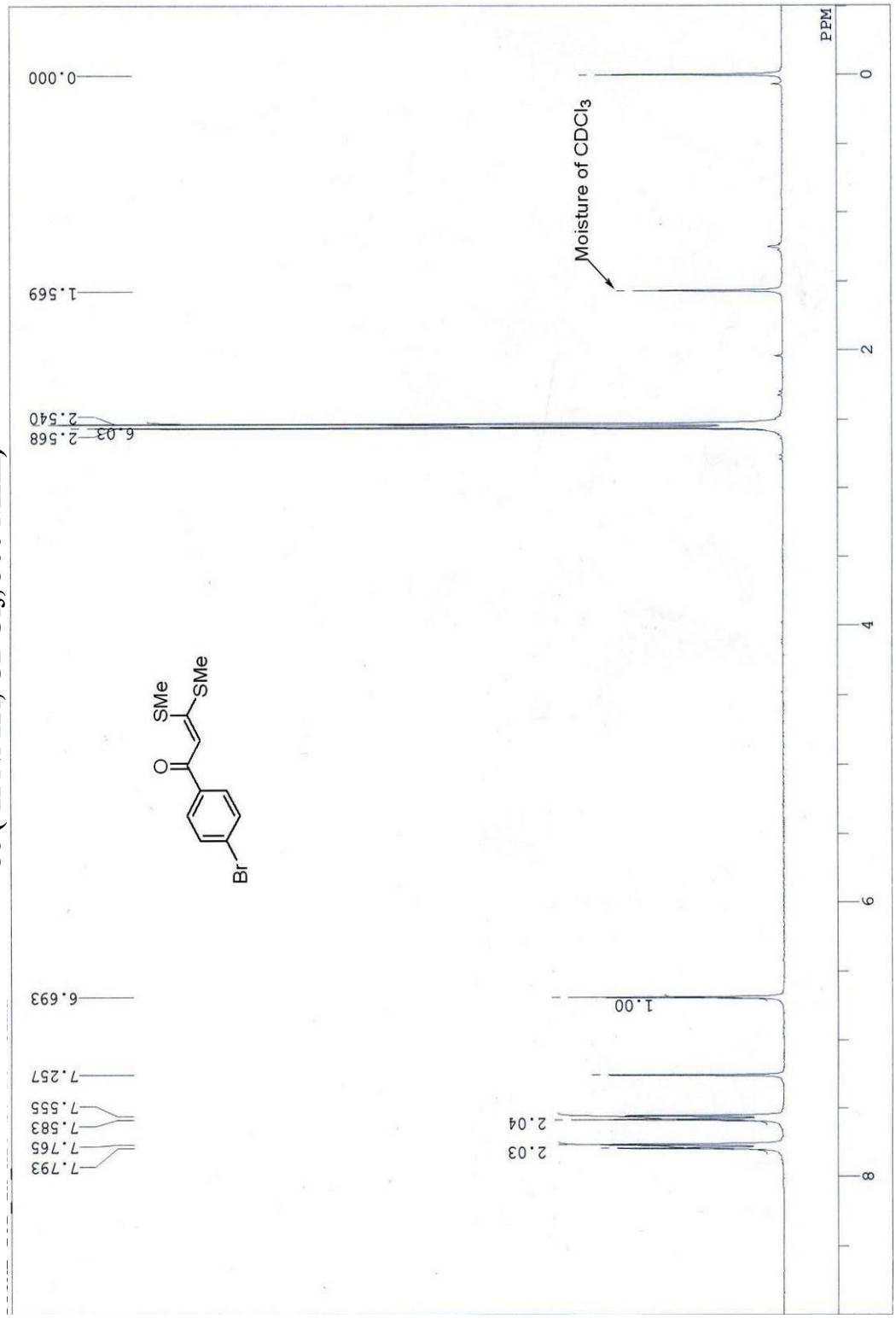
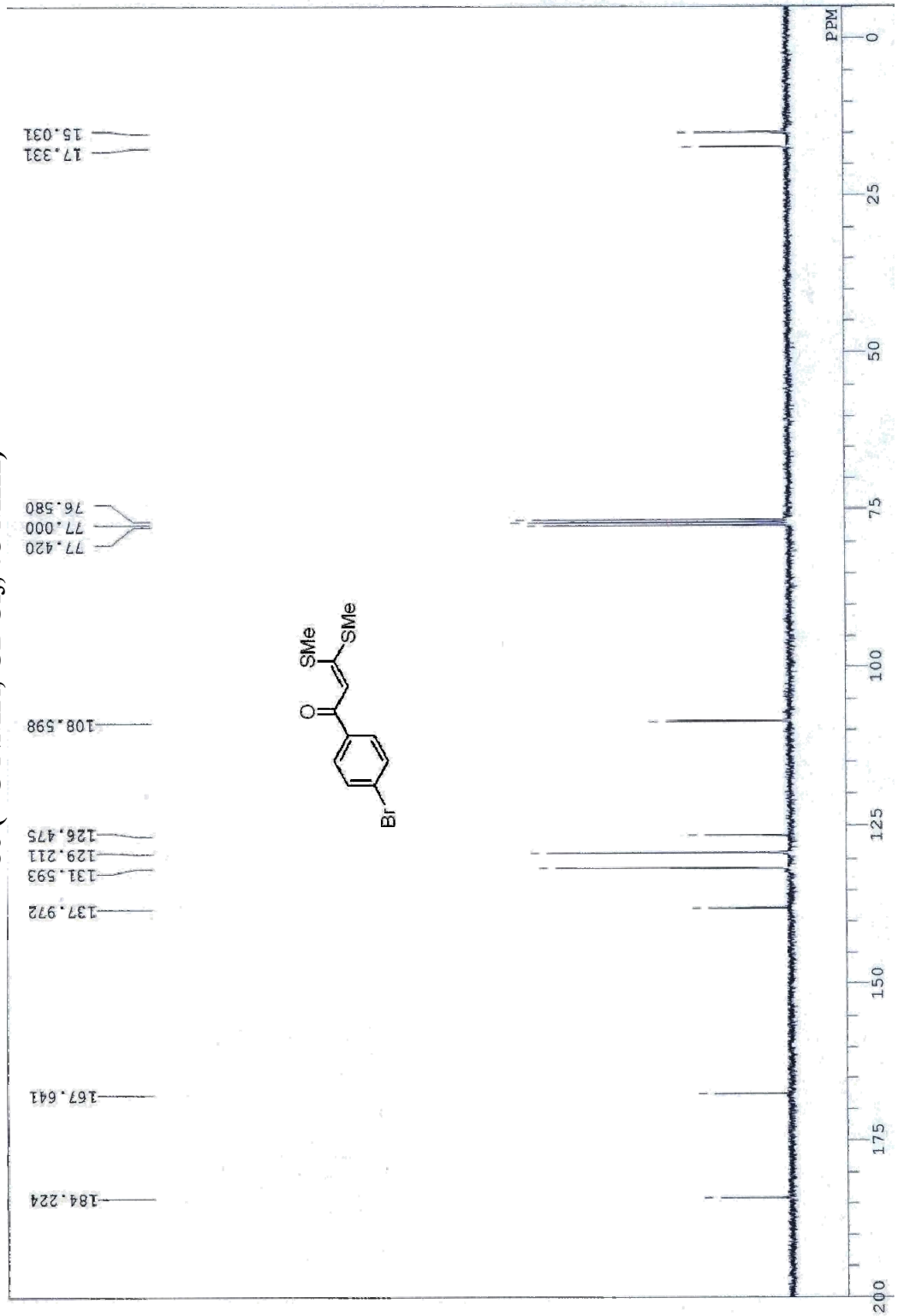


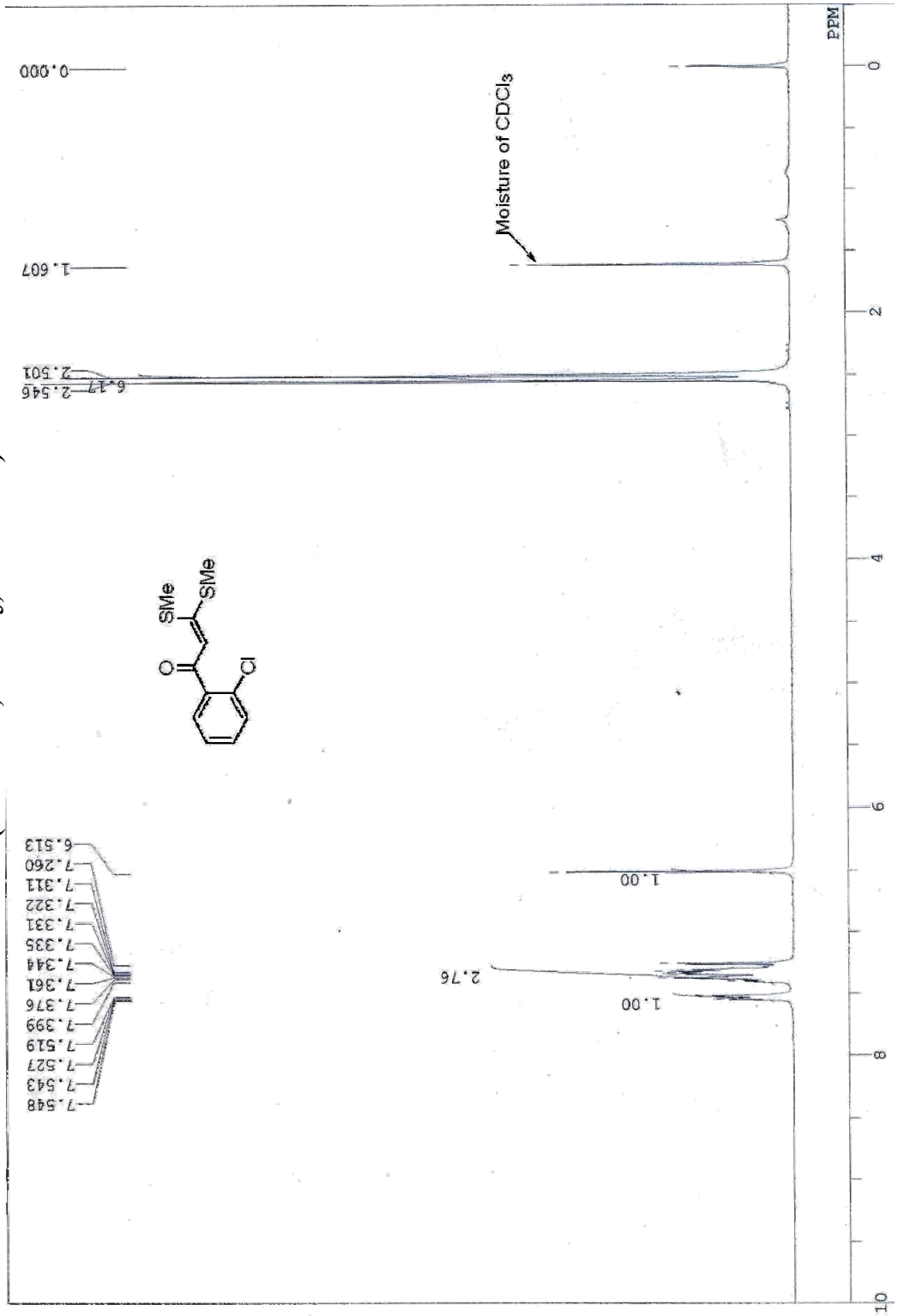
8e (^{1}H NMR, $CDCl_3$, 300 MHz)



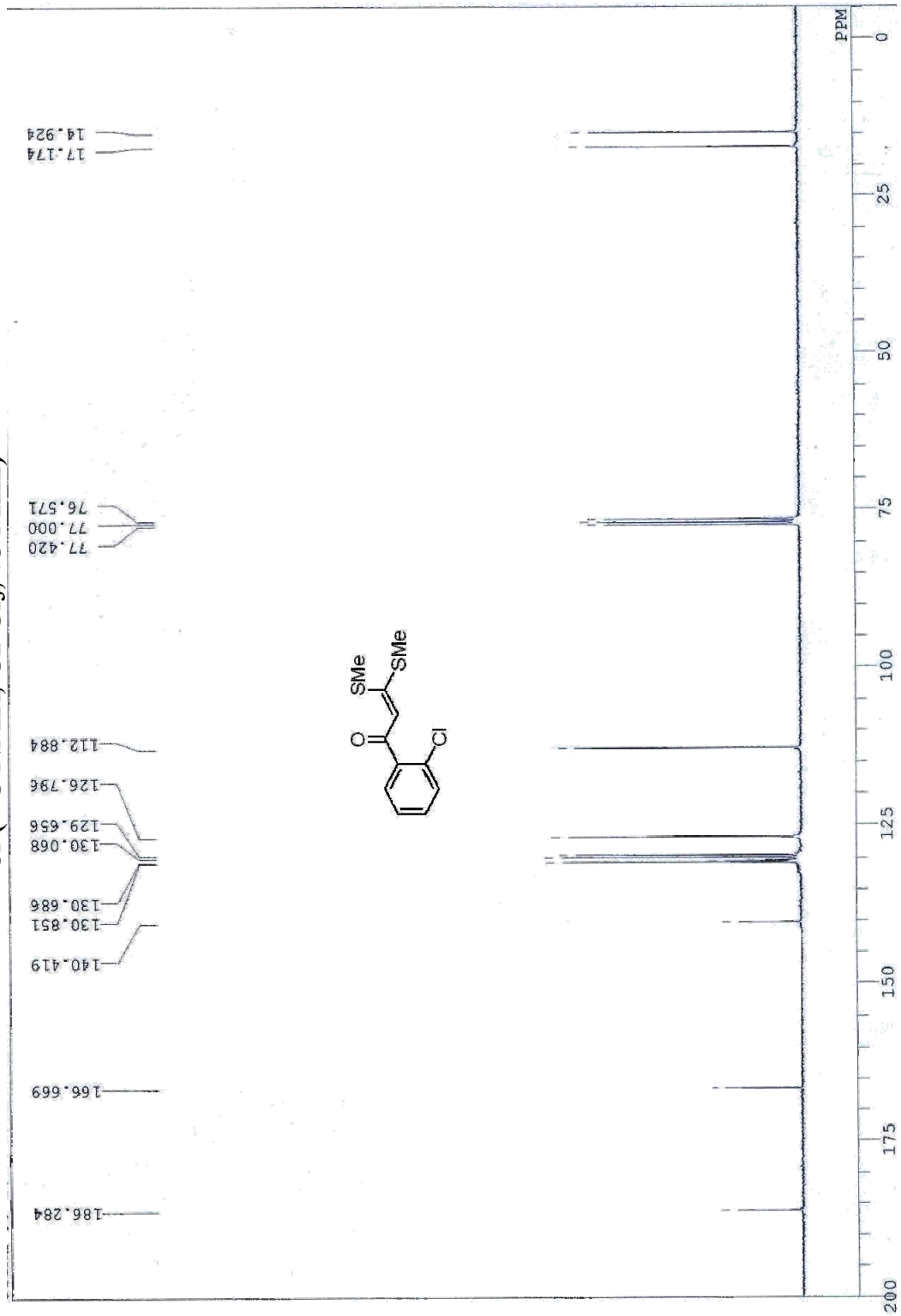
8e (^{13}C NMR, $CDCl_3$, 75 MHz)



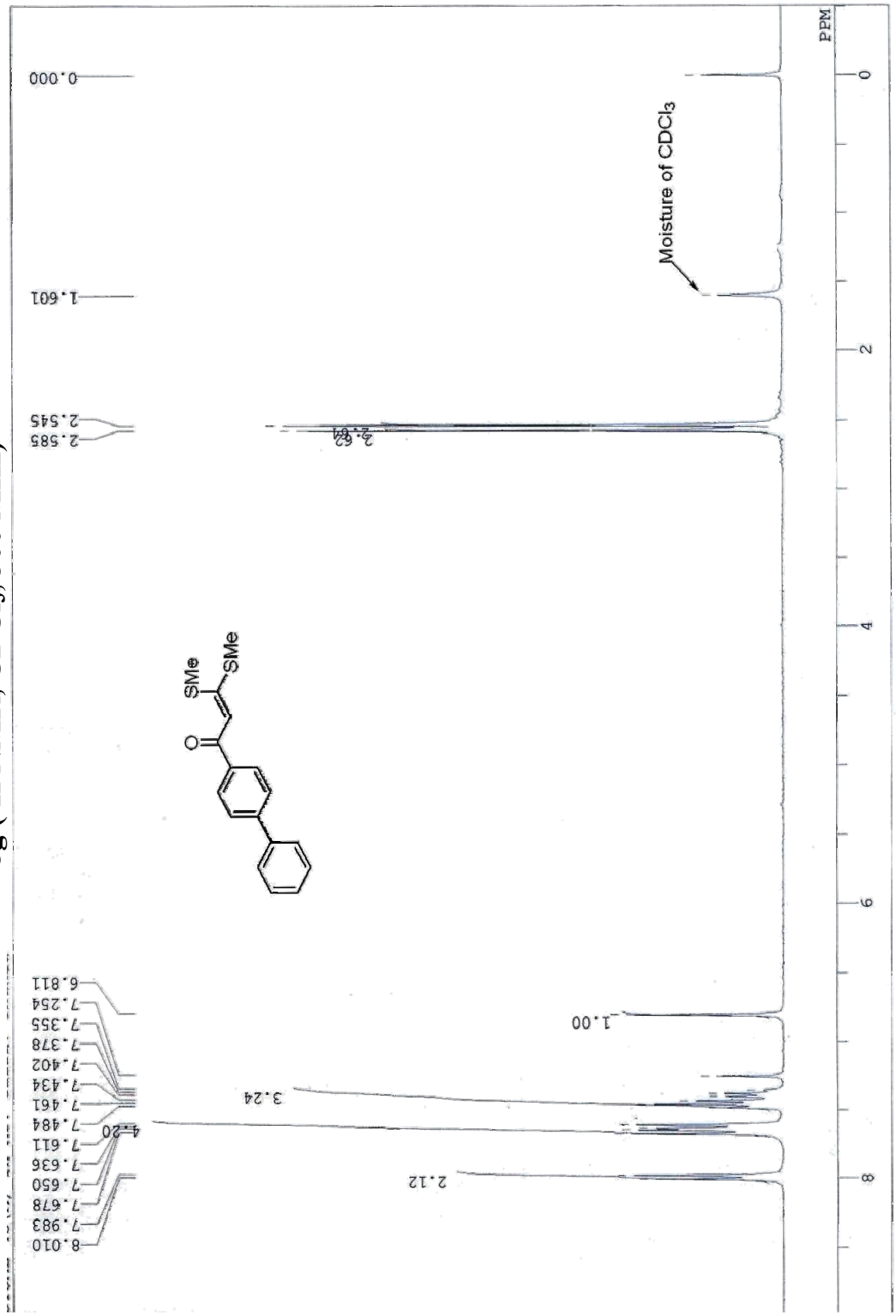
8f (^{1}H NMR, $CDCl_3$, 300 MHz)



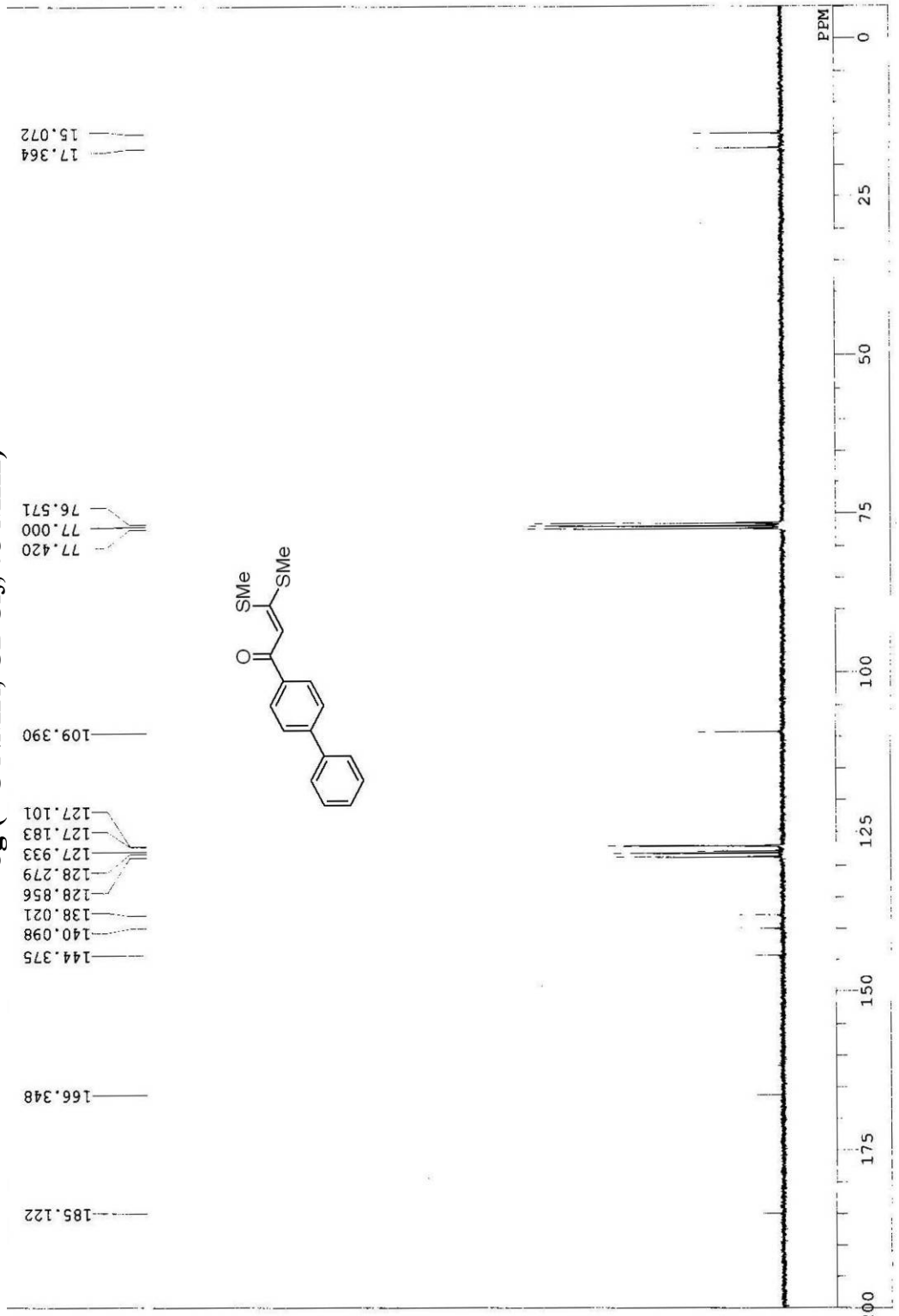
8f (^{13}C NMR, $CDCl_3$, 75 MHz)



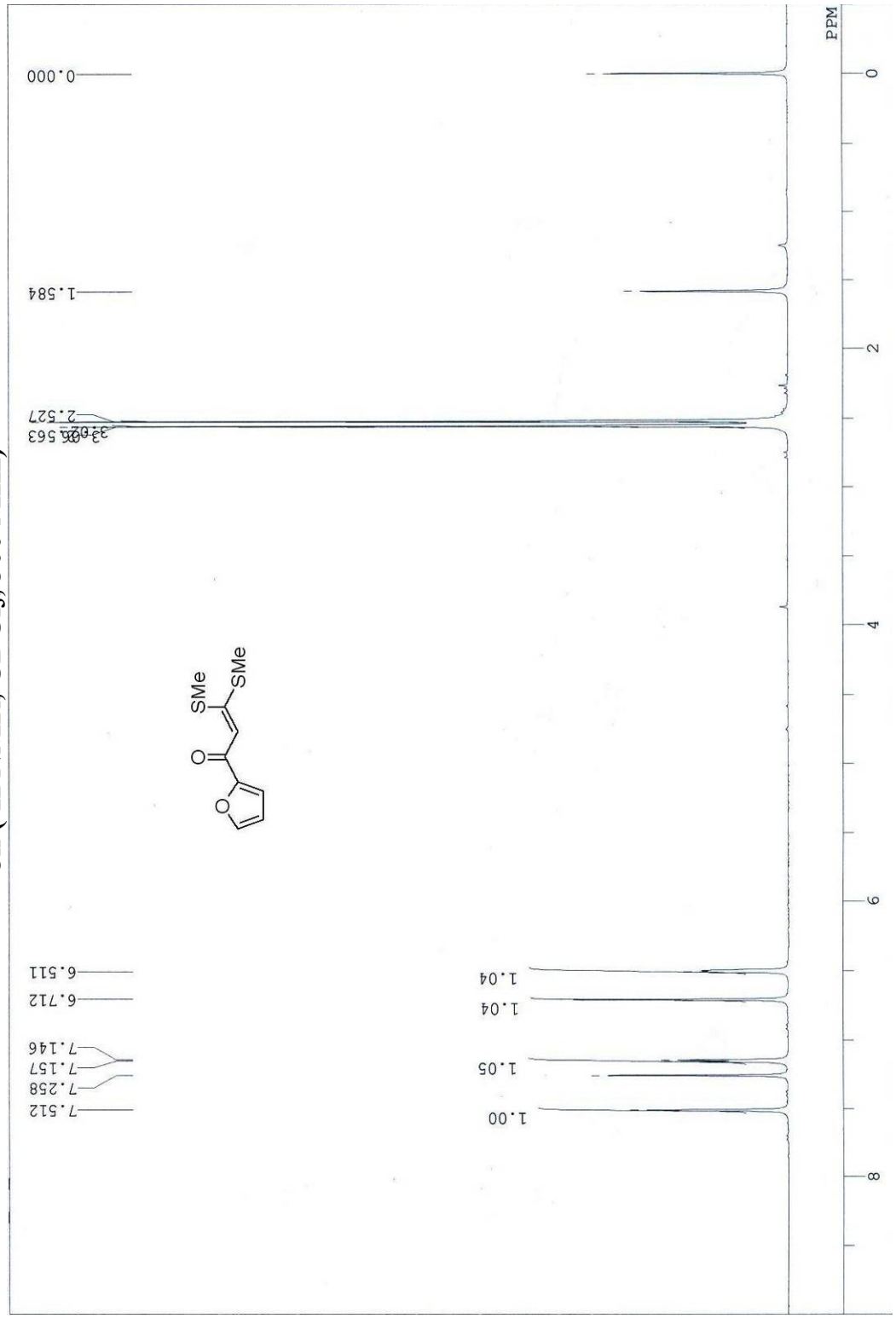
8g (^{1}H NMR, $CDCl_3$, 300 MHz)



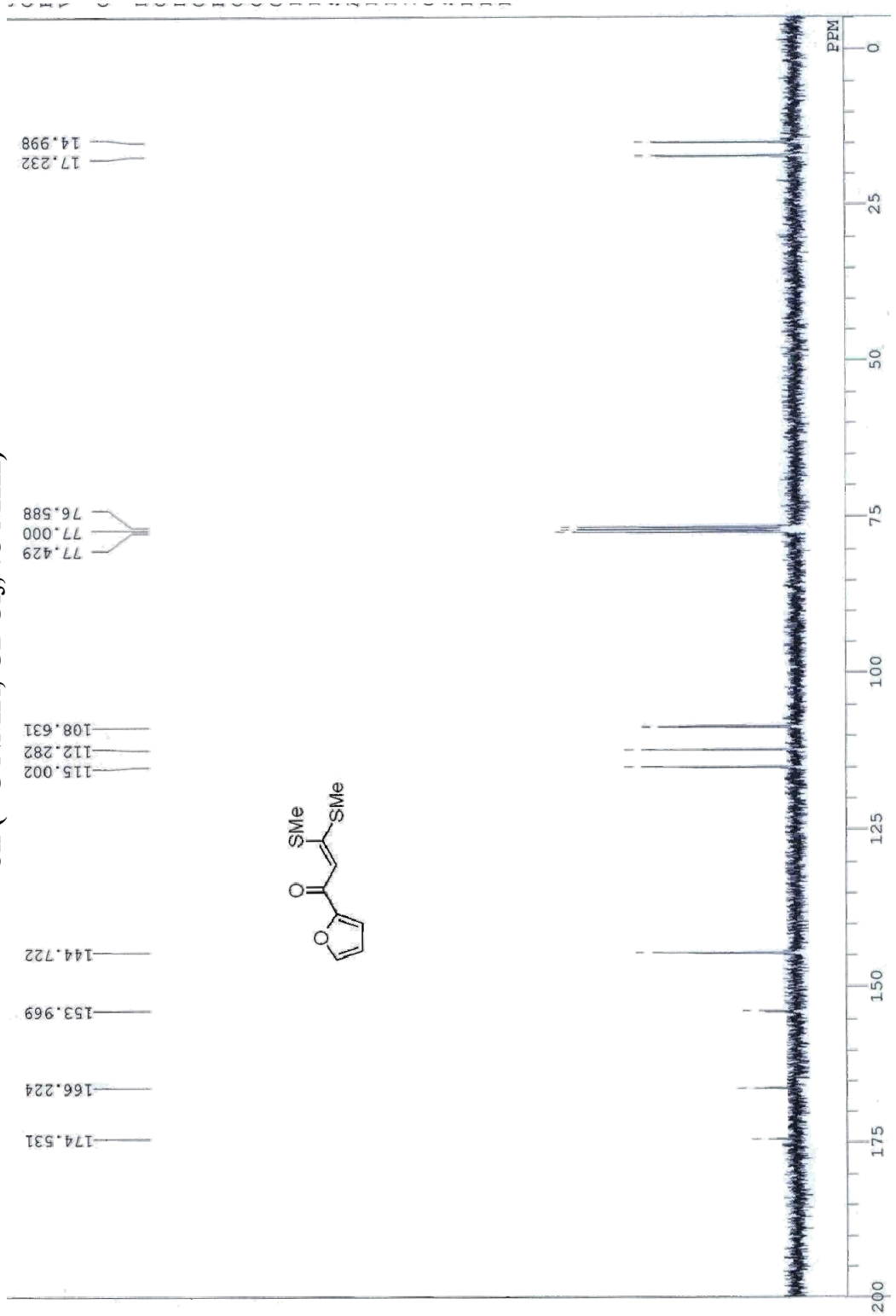
8g (^{13}C NMR, $CDCl_3$, 75 MHz)



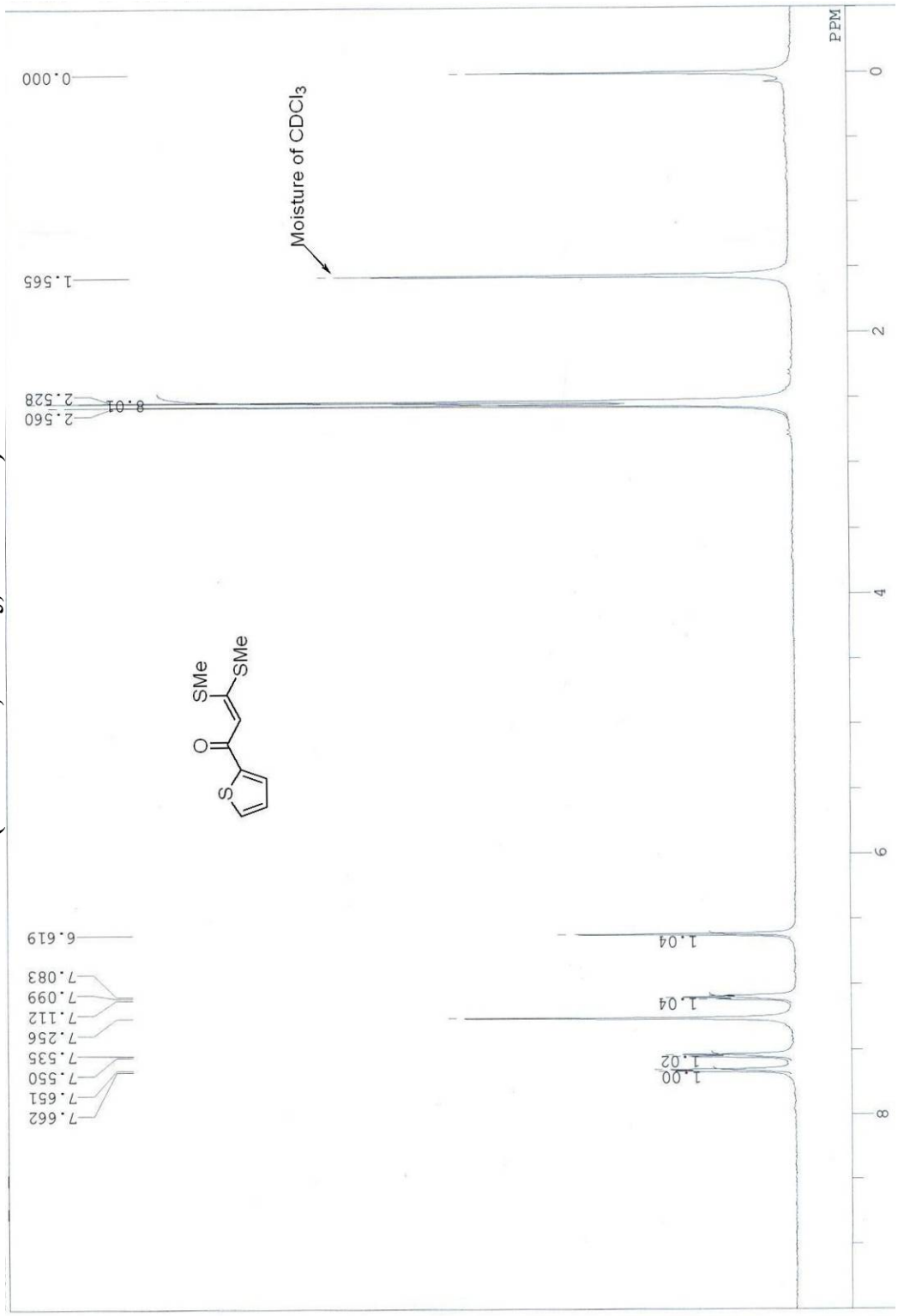
8h (^{1}H NMR, $CDCl_3$, 300 MHz)



8h (^{13}C NMR, $CDCl_3$, 75 MHz)



8i (^{1}H NMR, $CDCl_3$, 300 MHz)



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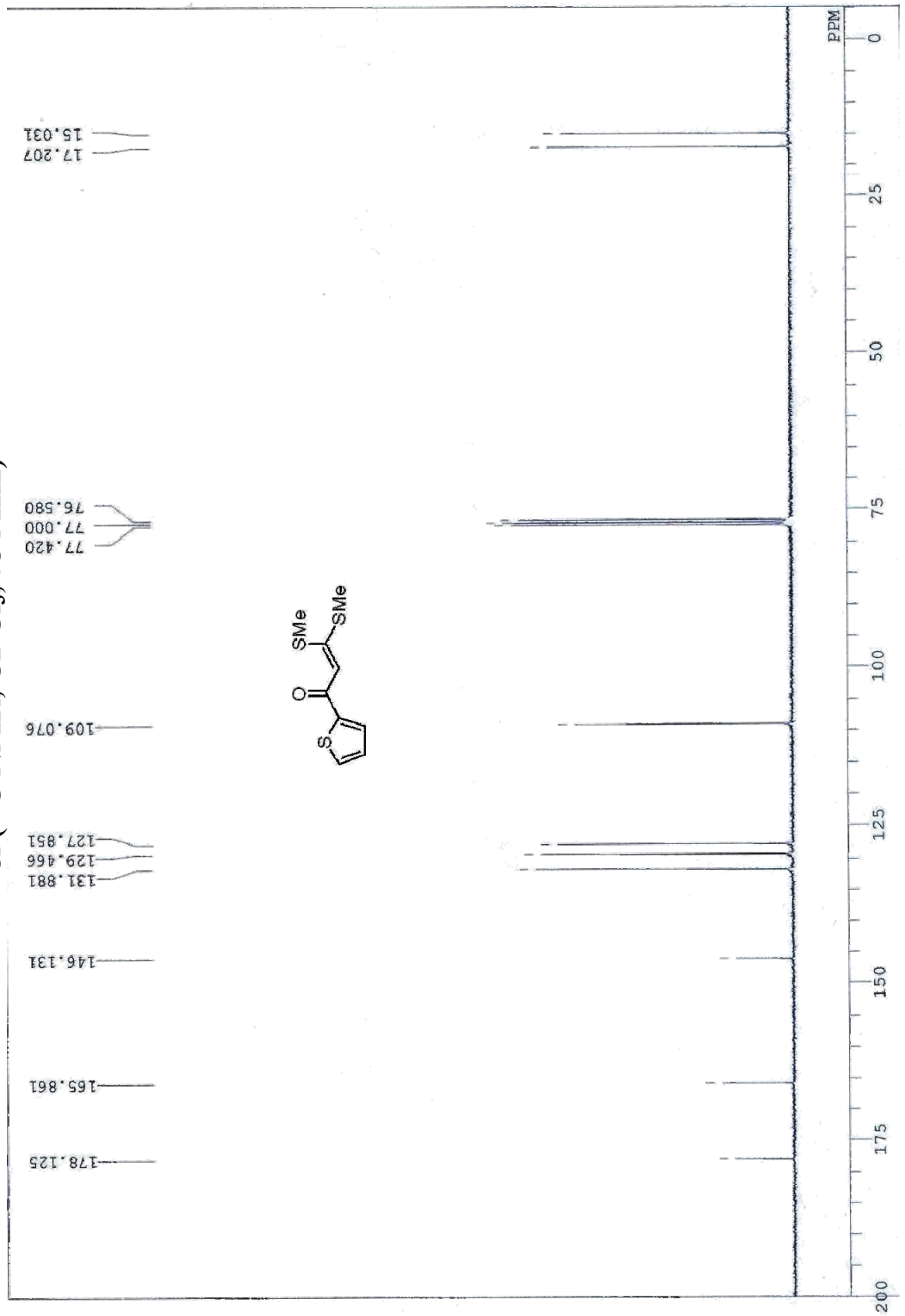
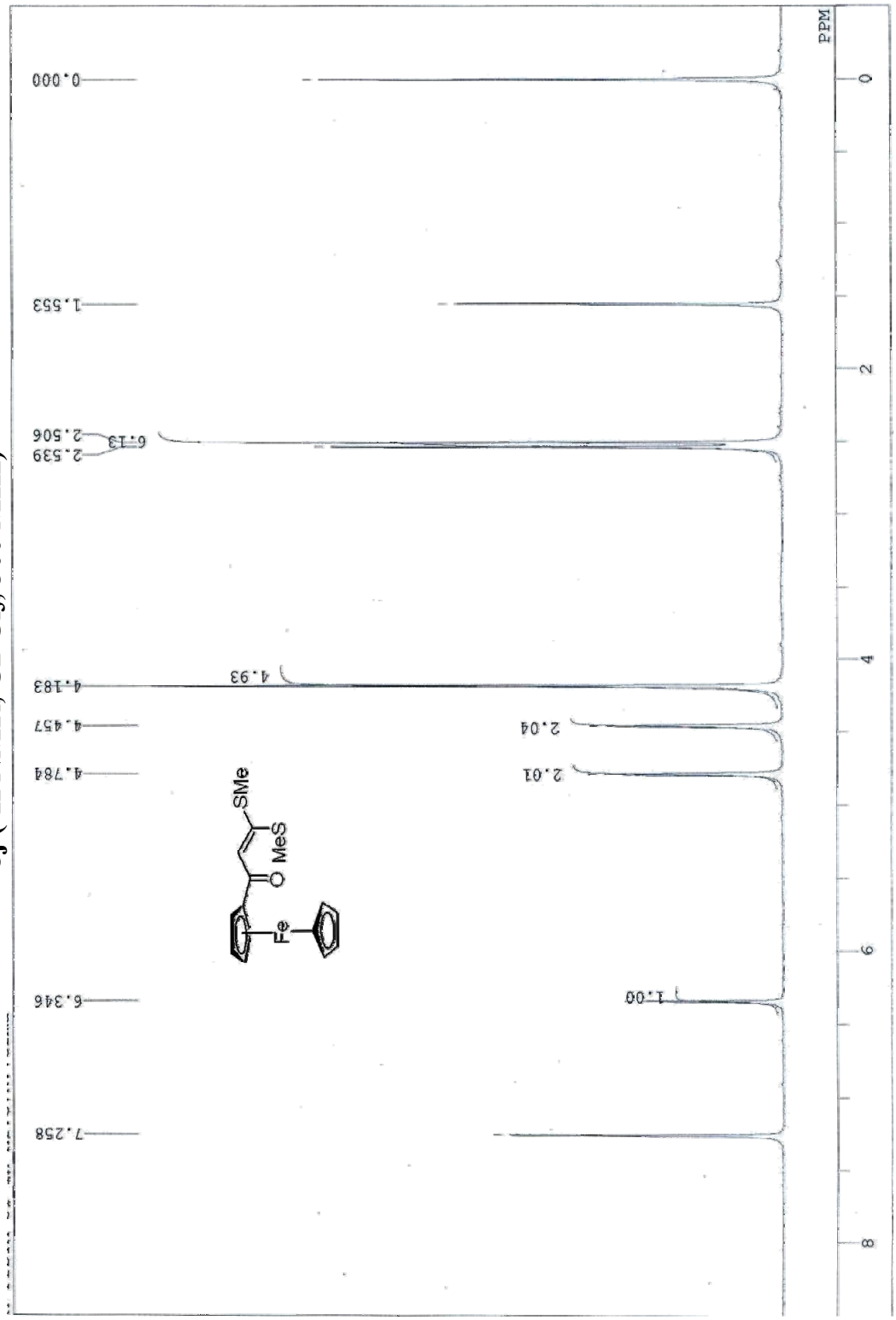
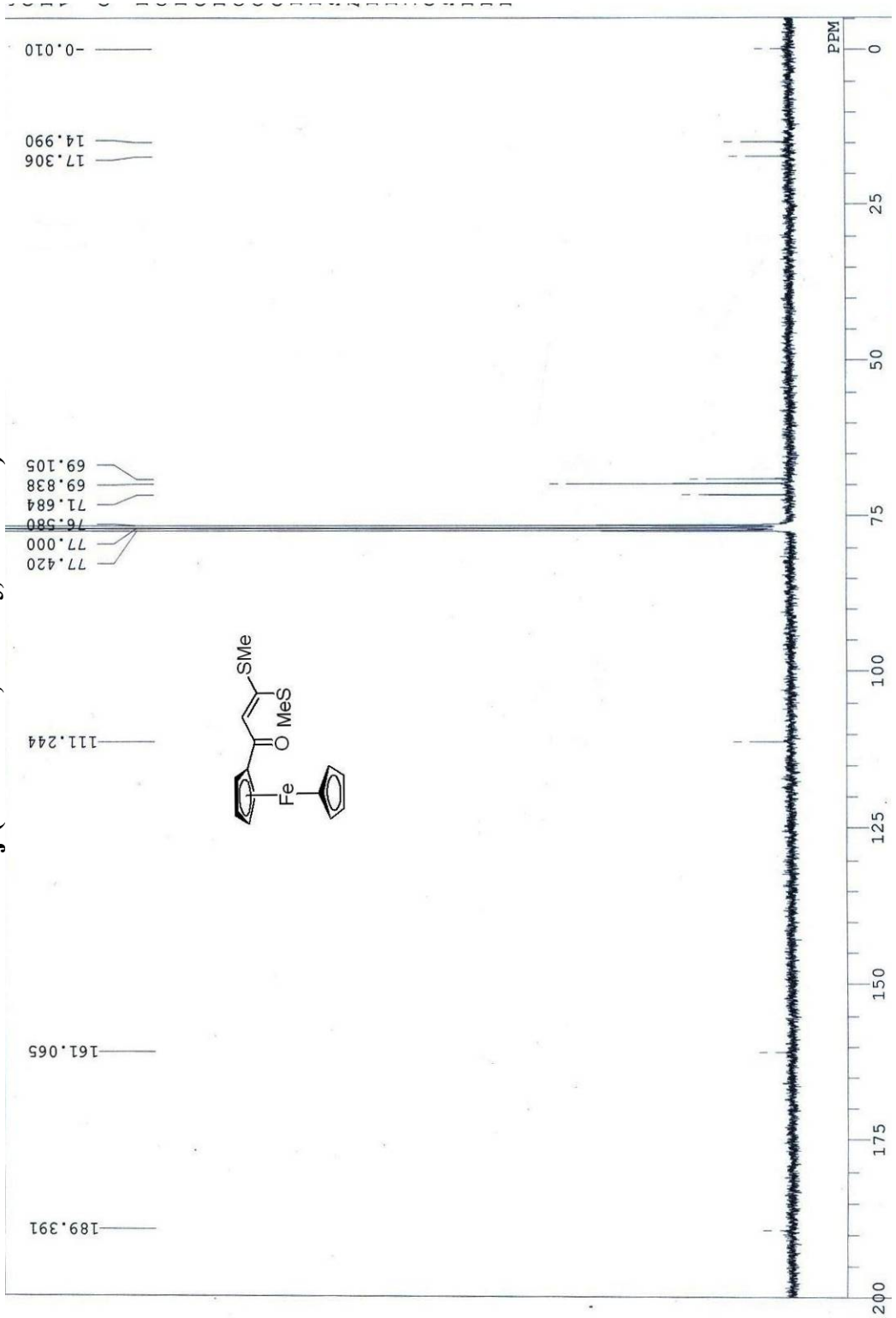


8j (^{1}H NMR, $CDCl_3$, 300 MHz)



8j (^{13}C NMR, $CDCl_3$, 75 MHz)



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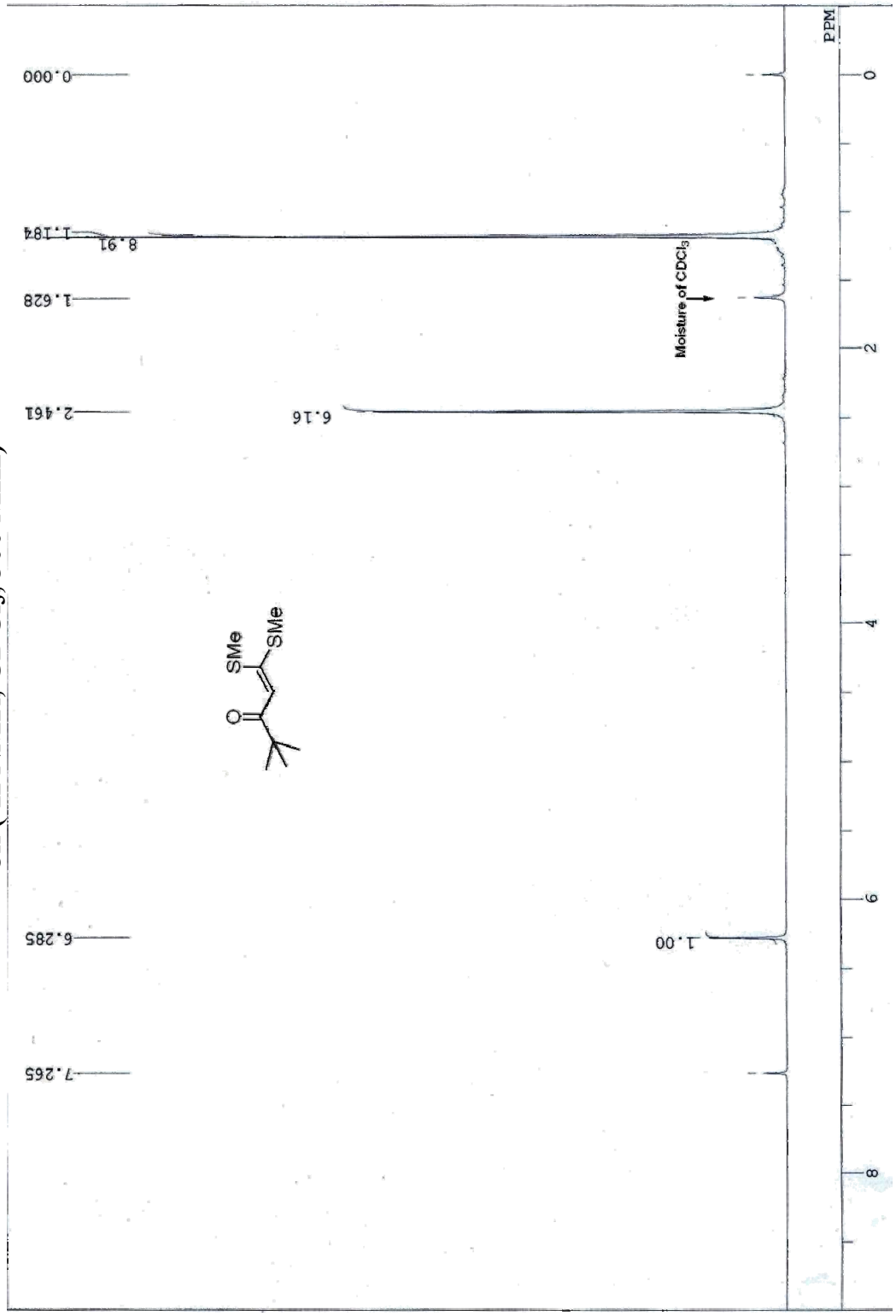

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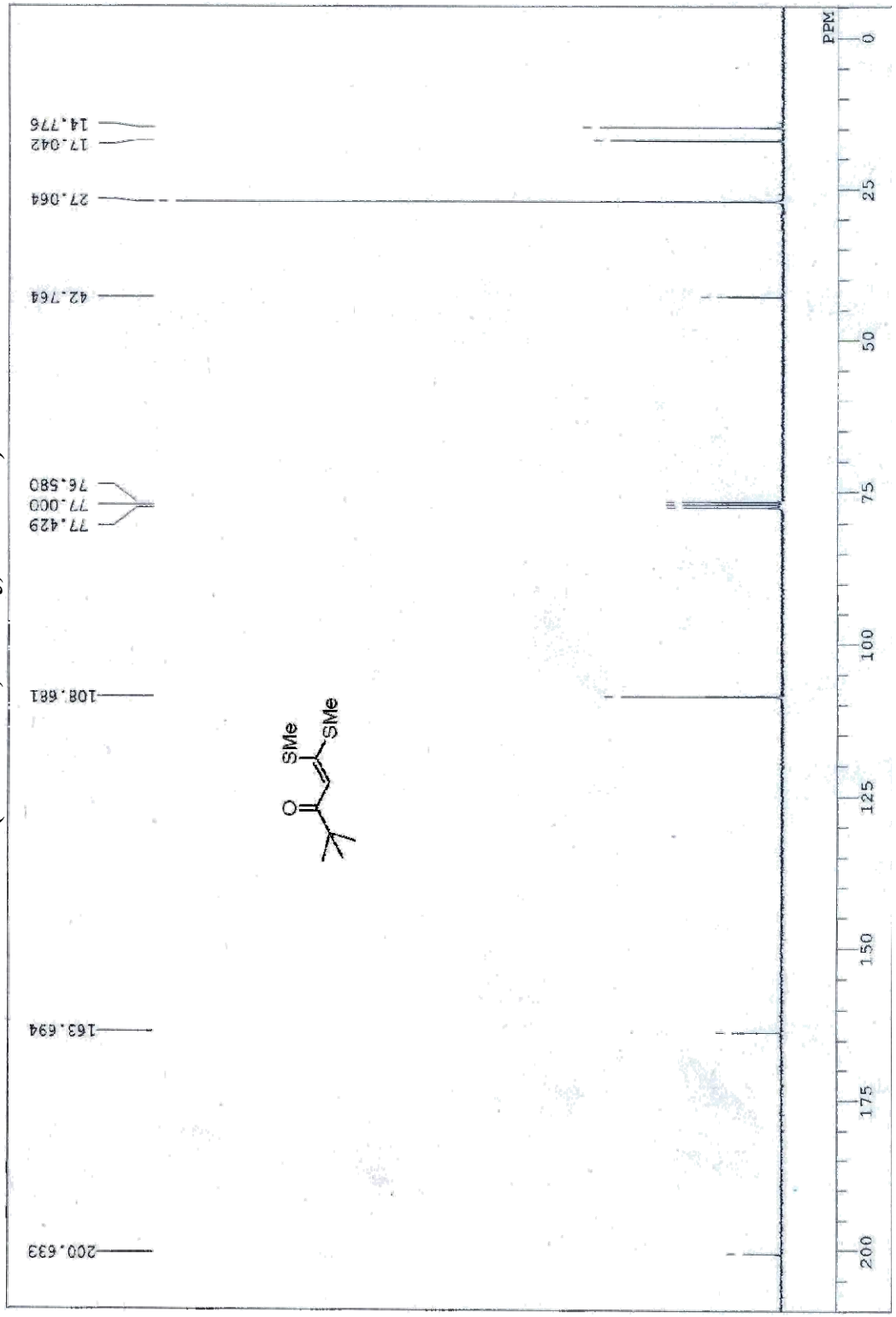
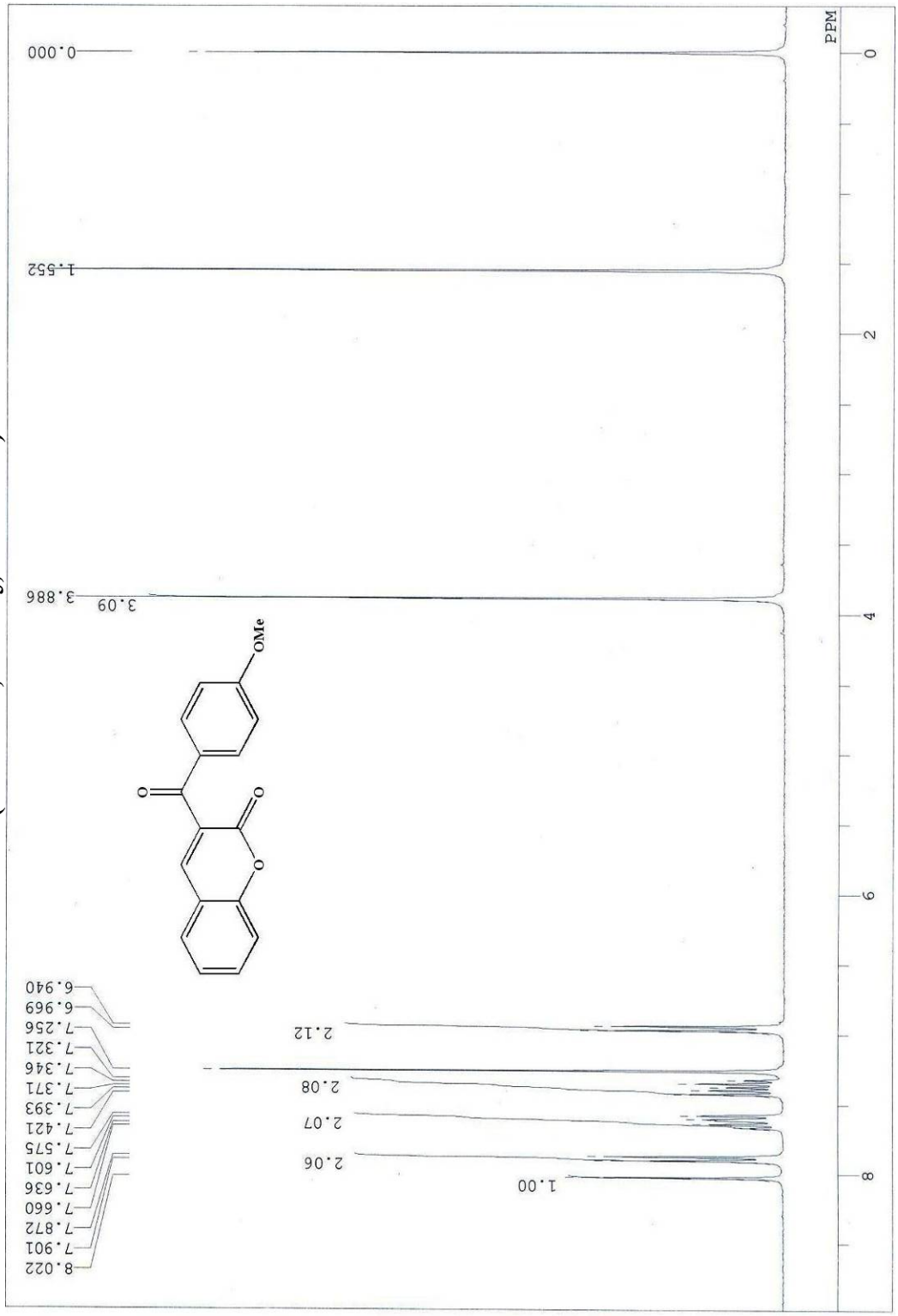


10aa (^{1}H NMR, $CDCl_3$, 300 MHz)



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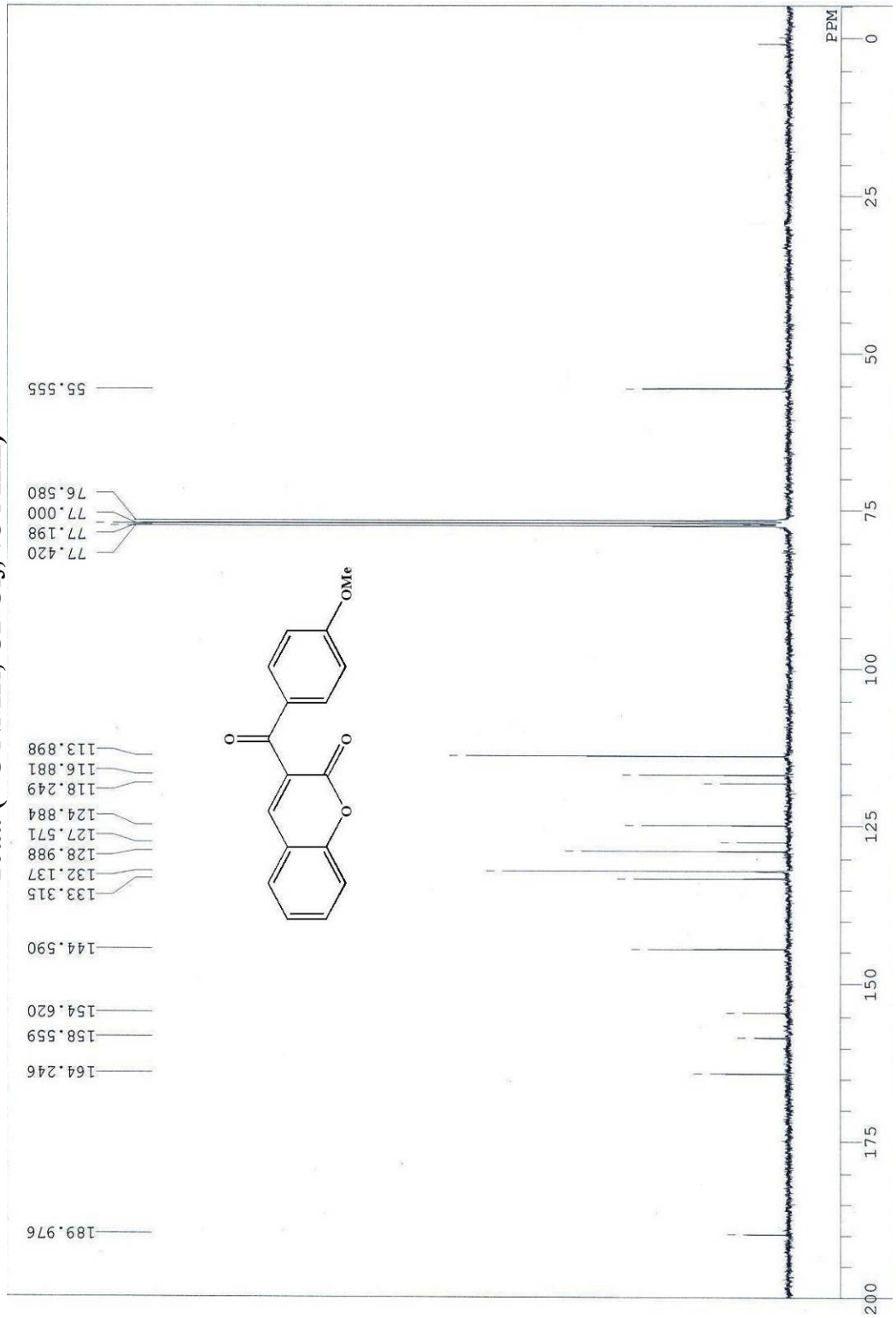

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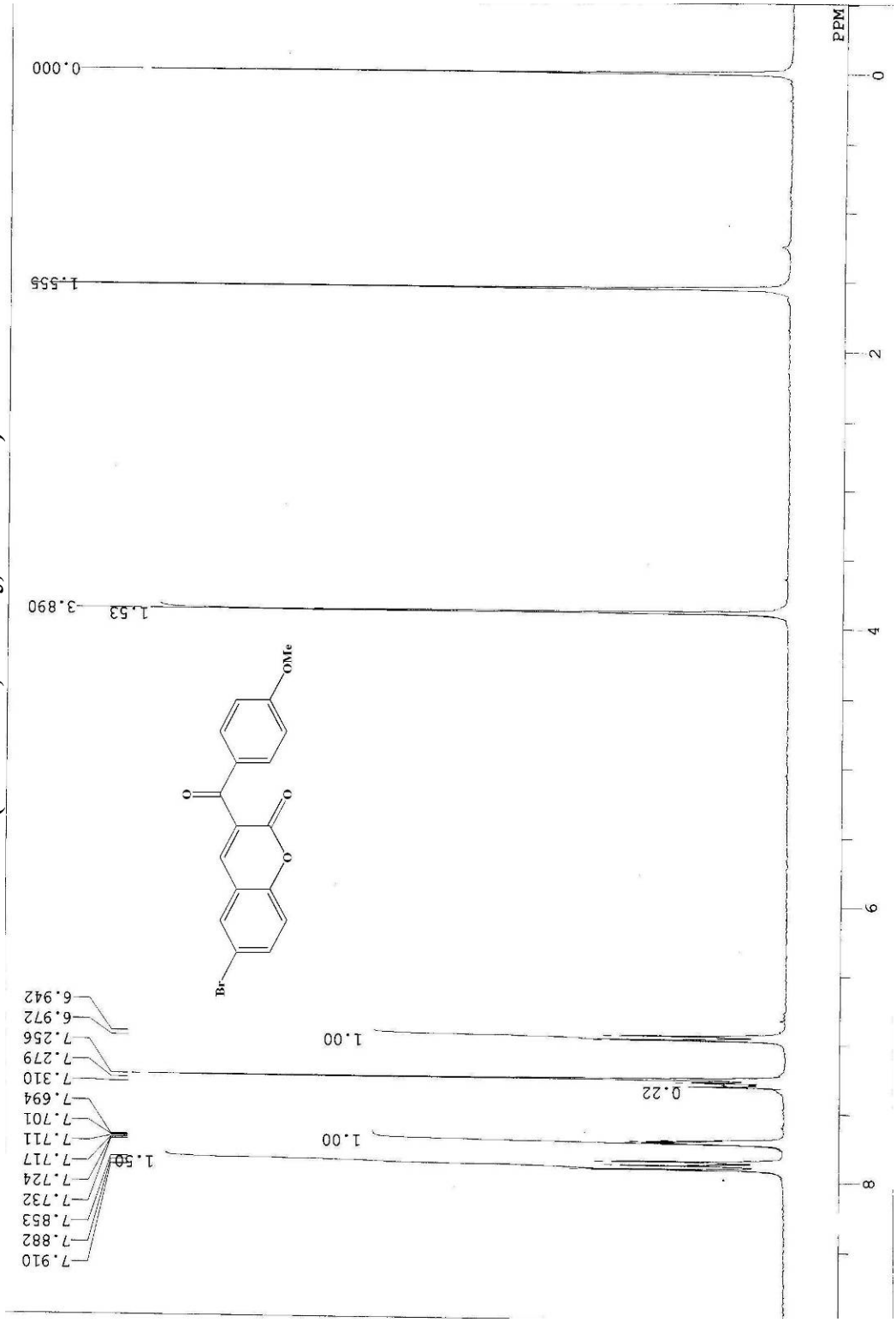
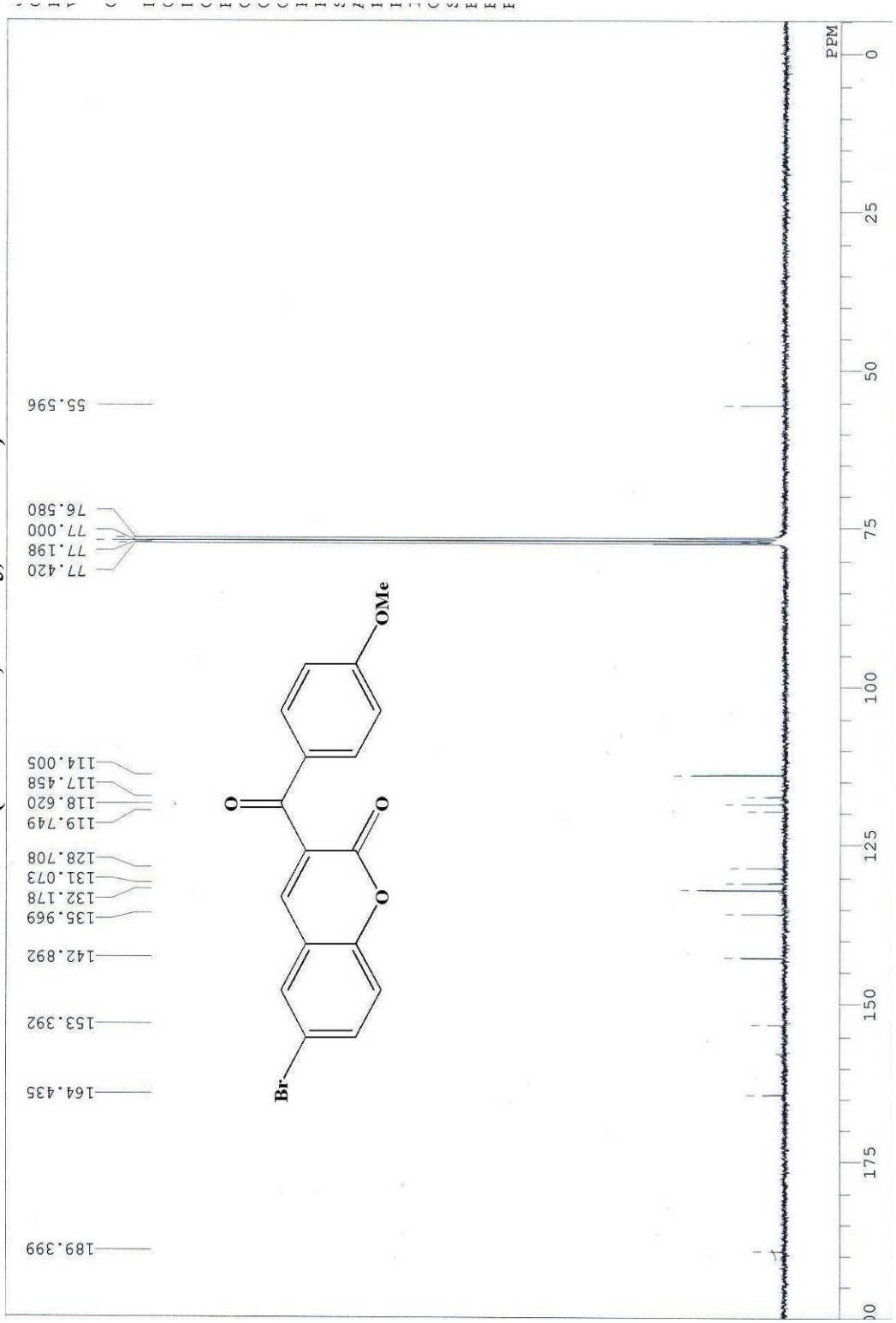


10ab (^{13}C NMR, $CDCl_3$, 75 MHz)



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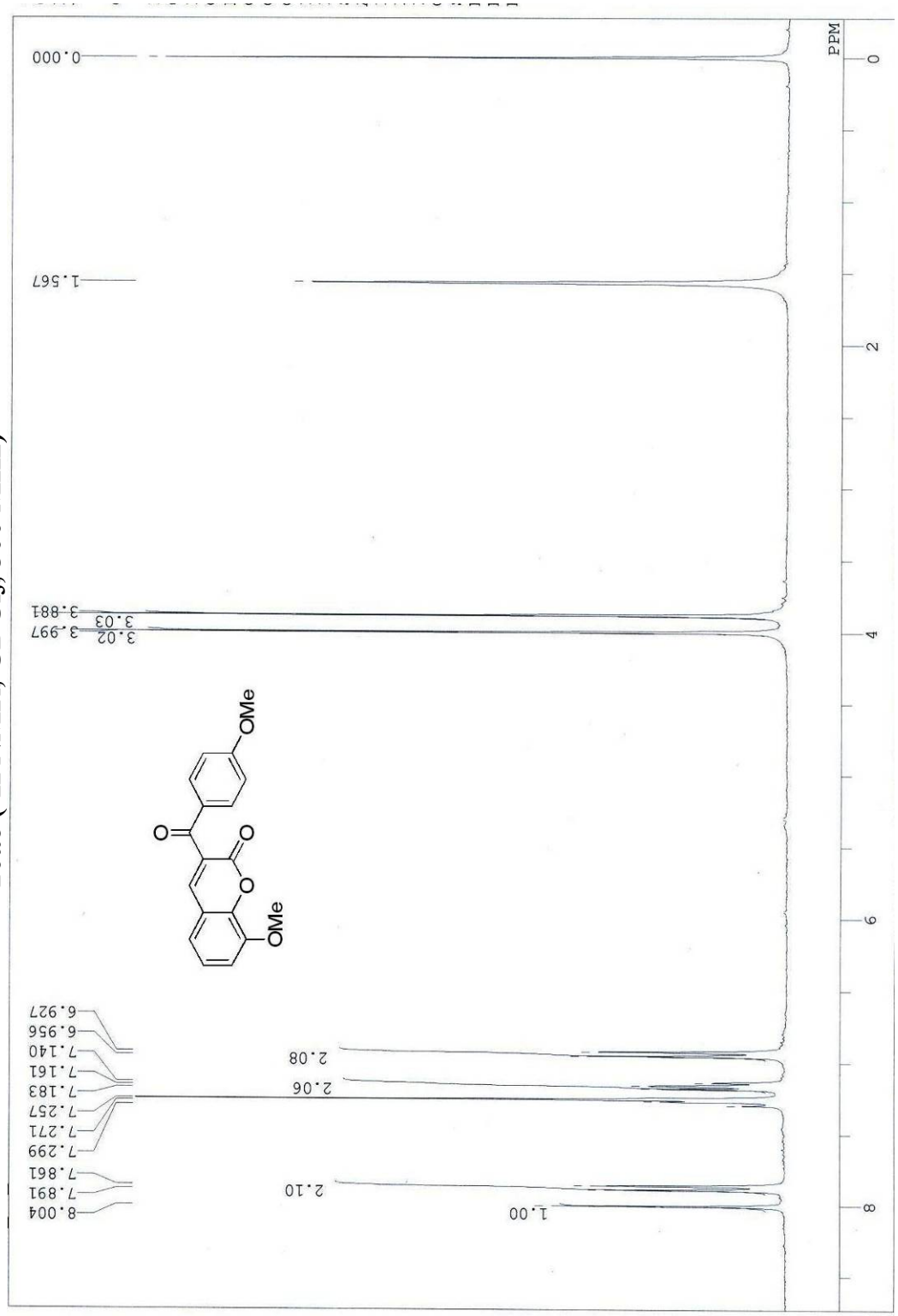
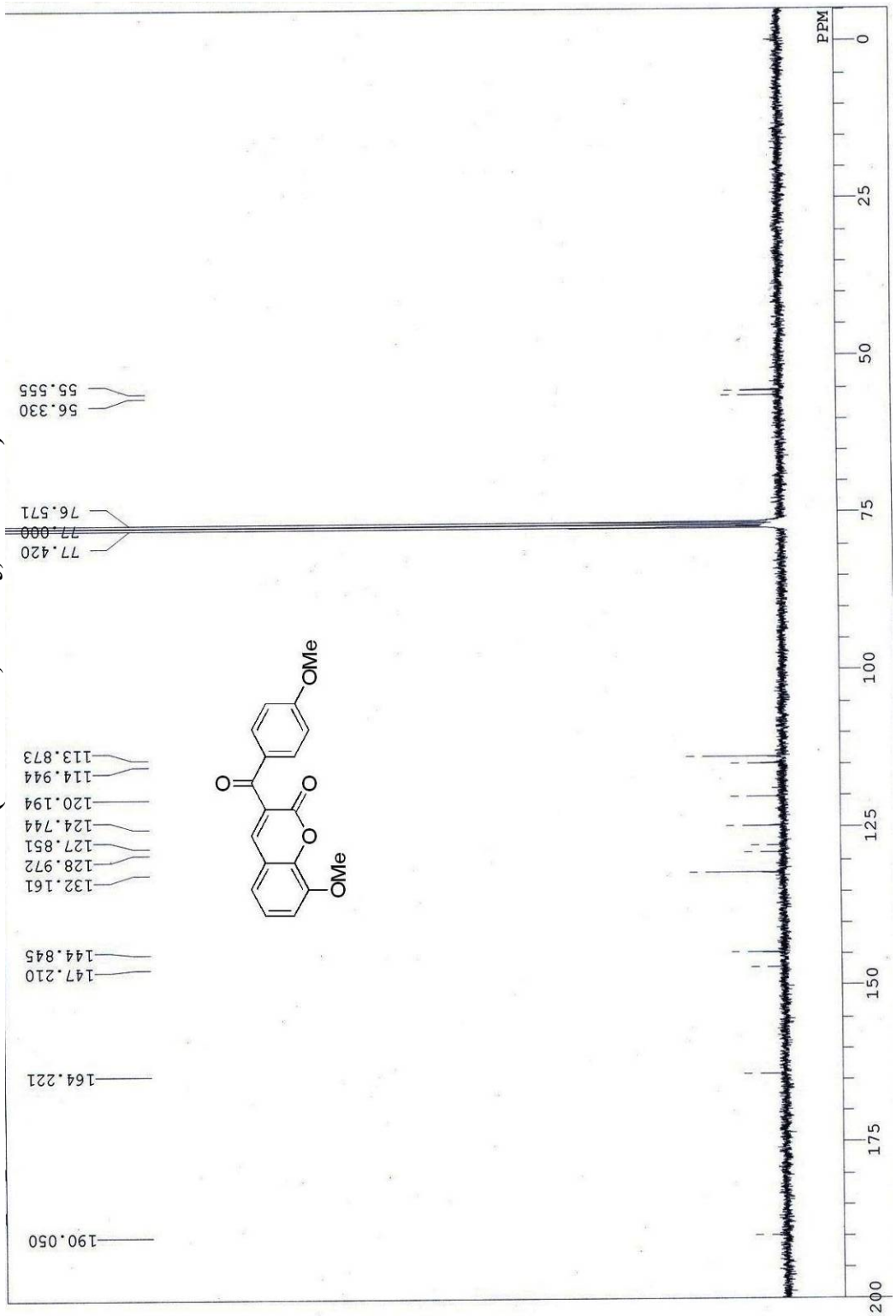


10ac (^{13}C NMR, $CDCl_3$, 75 MHz)



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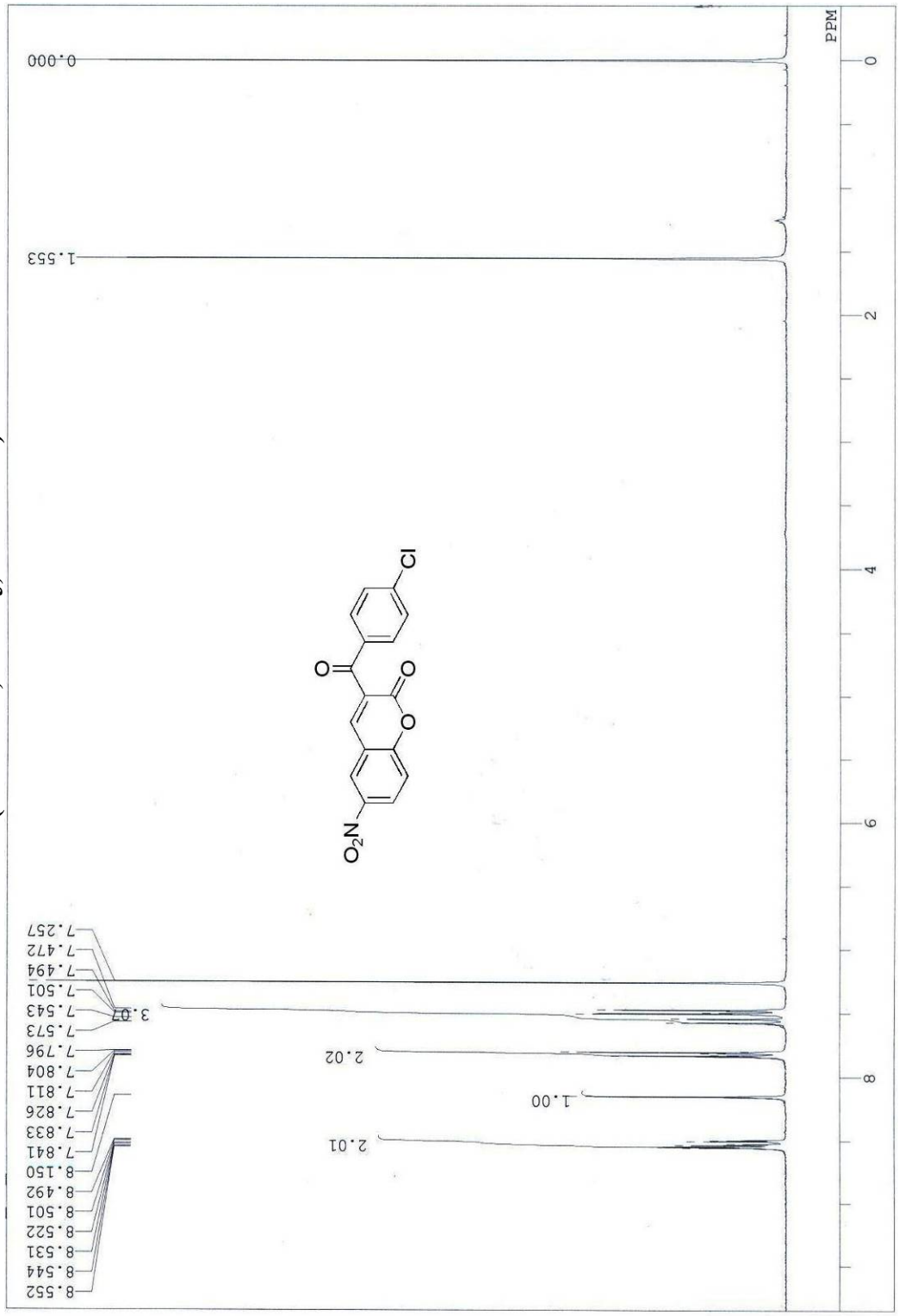
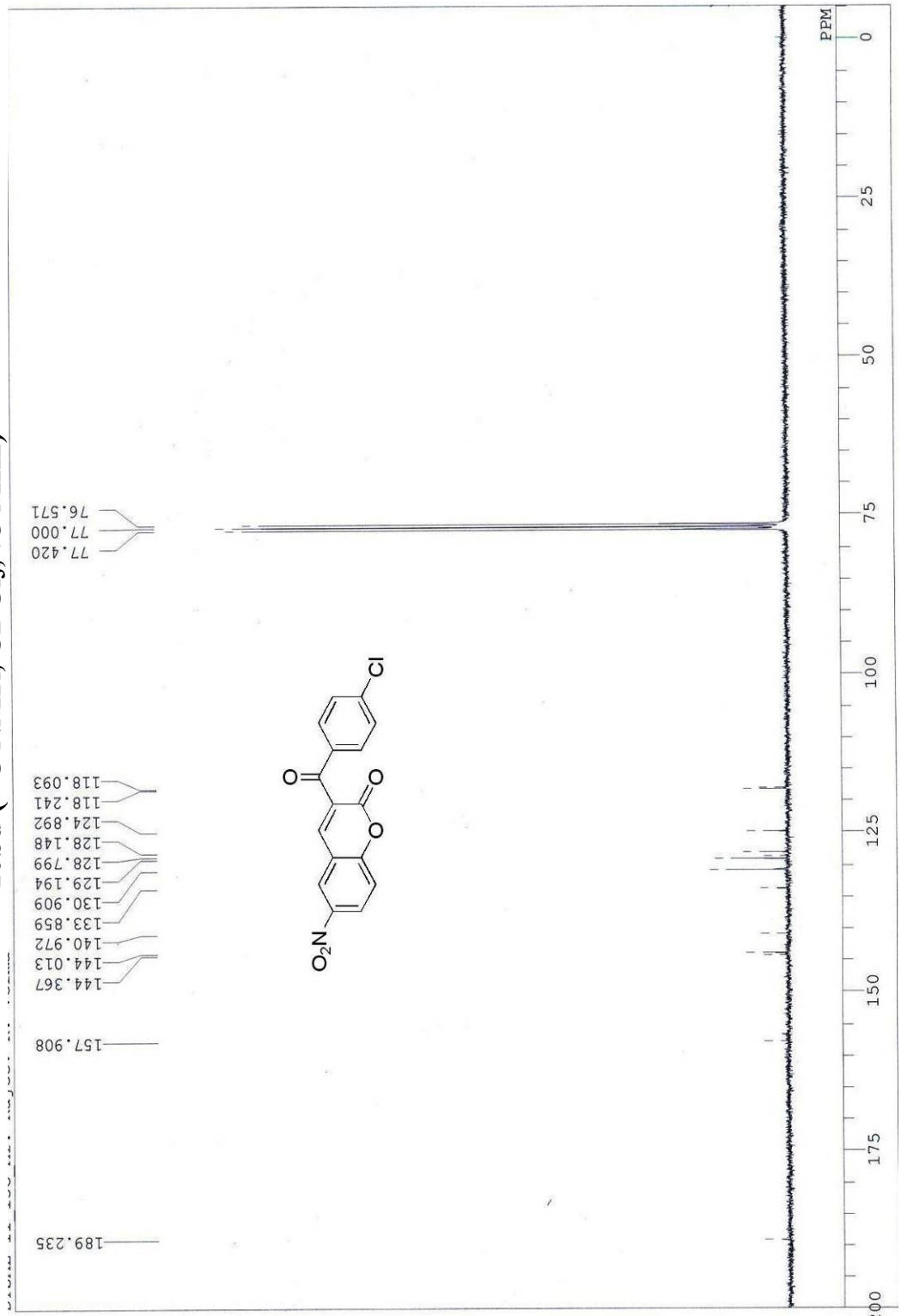
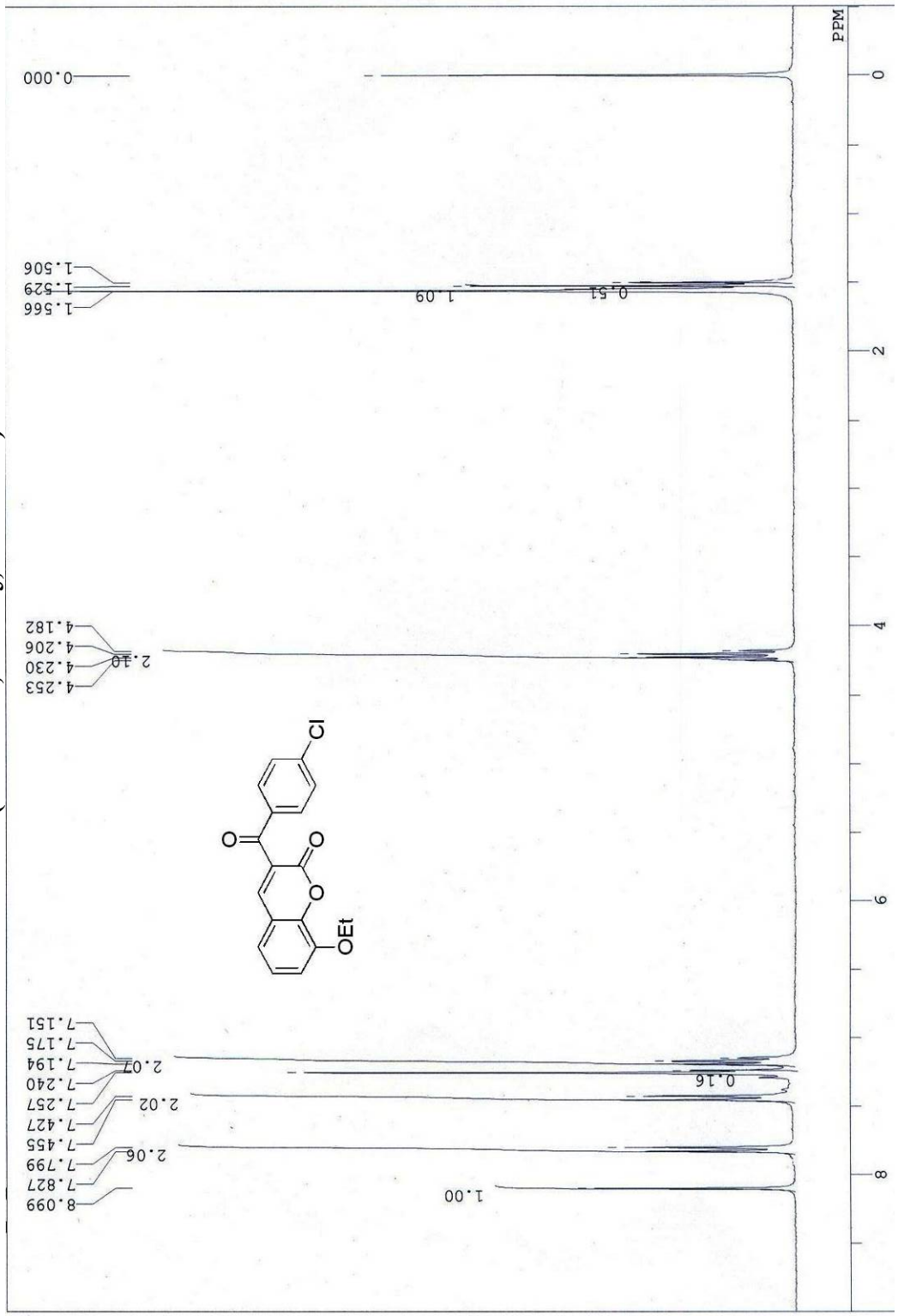


10bd (^{13}C NMR, $CDCl_3$, 75 MHz)



10be (^{1}H NMR, $CDCl_3$, 300 MHz)



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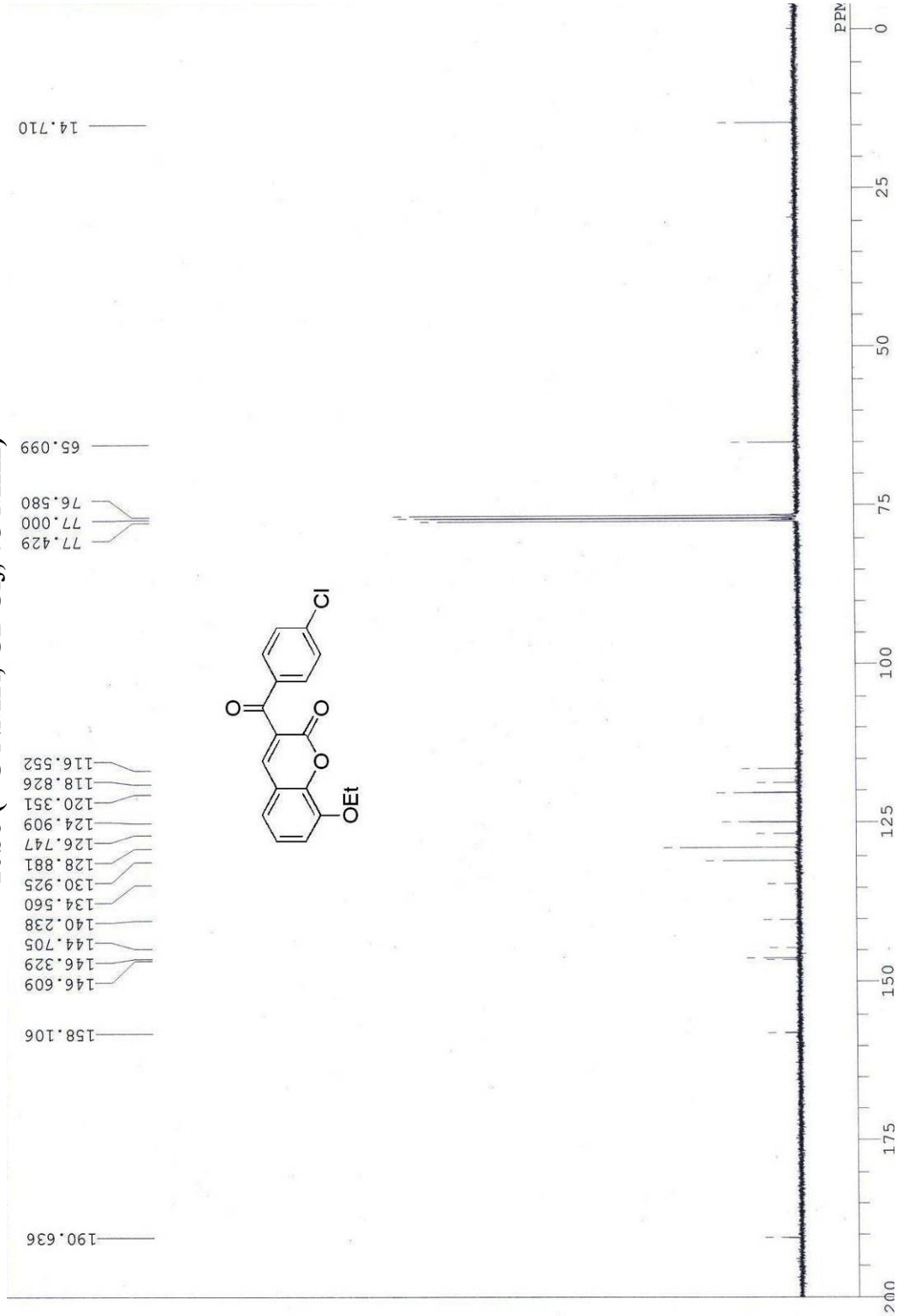

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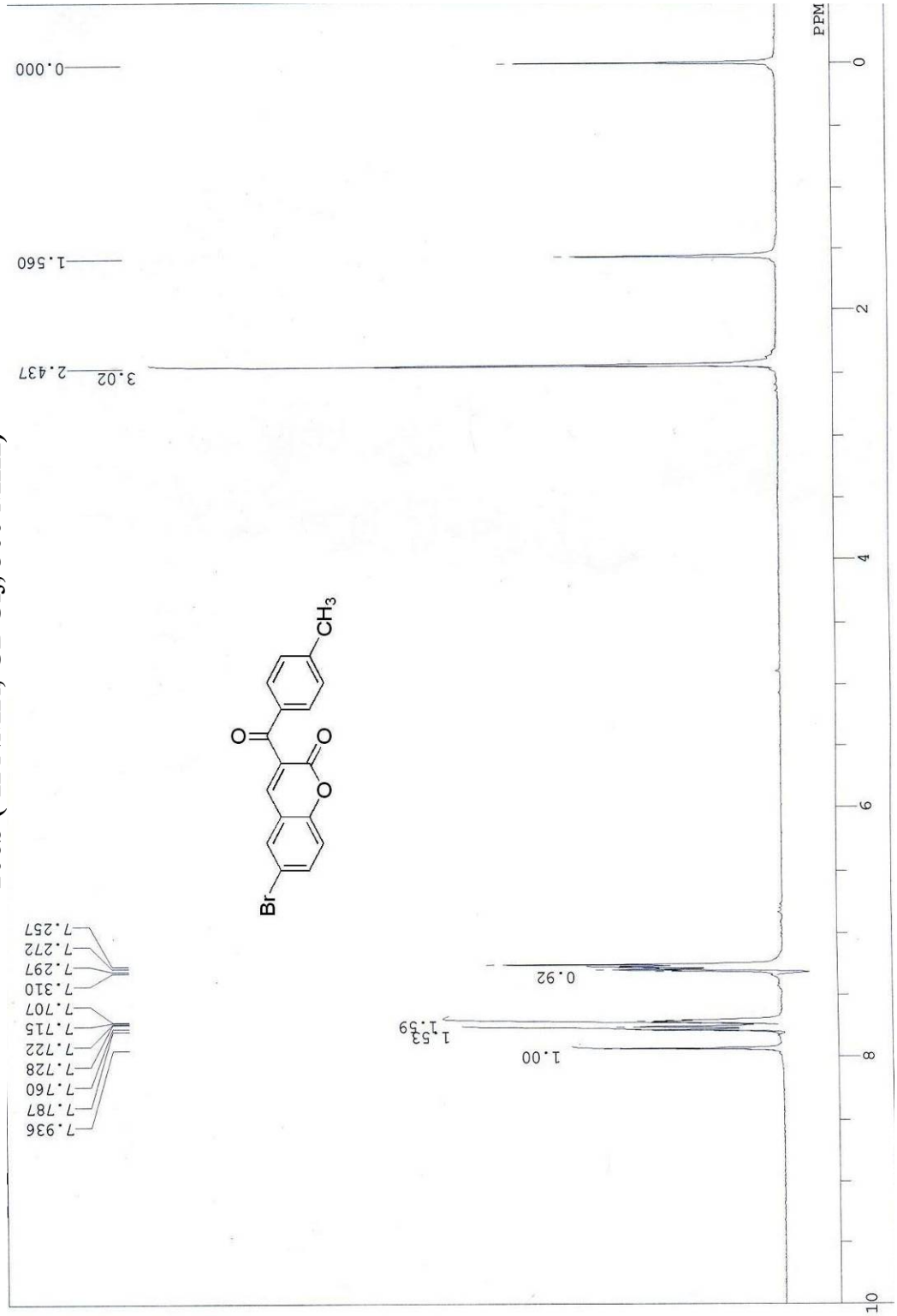

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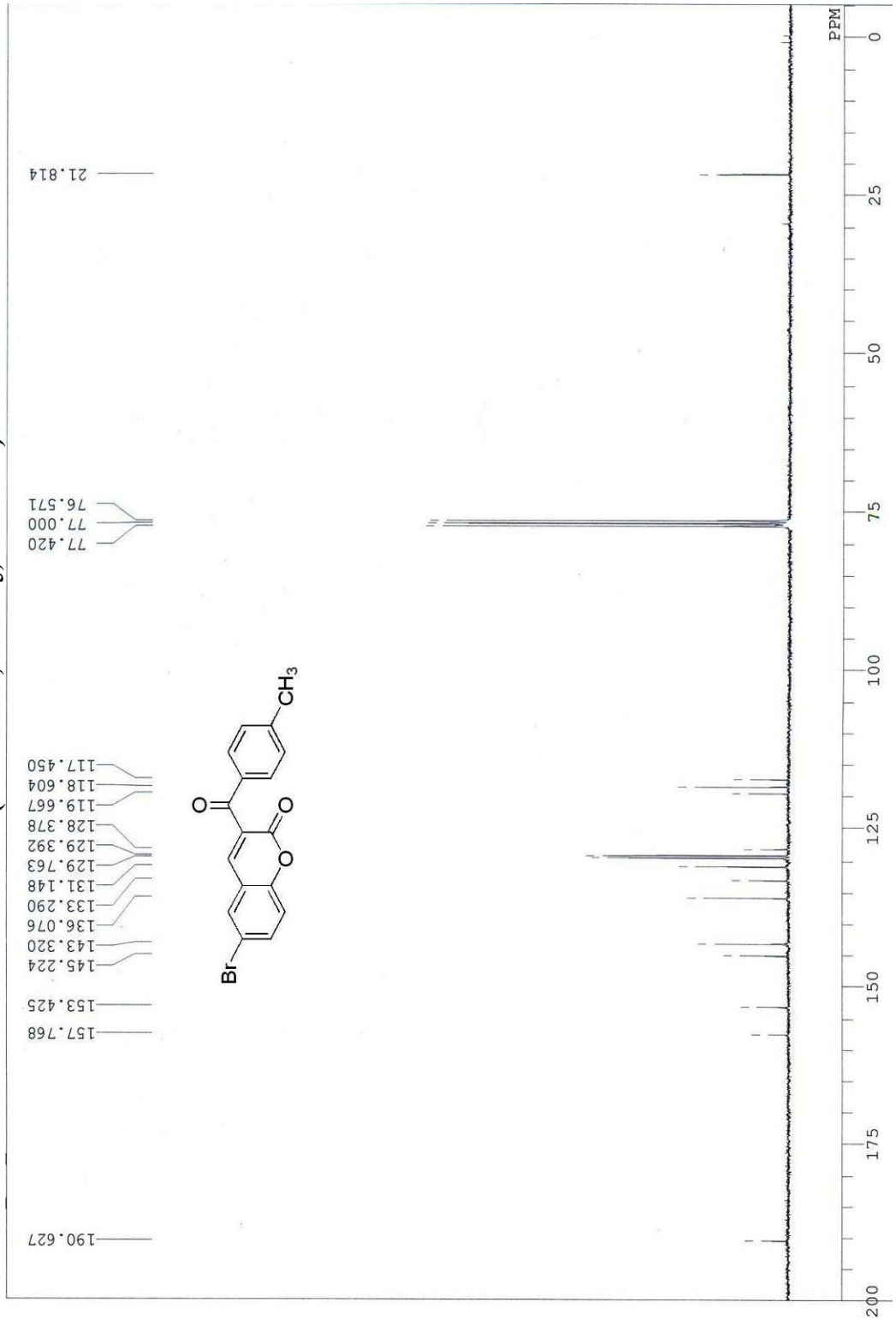

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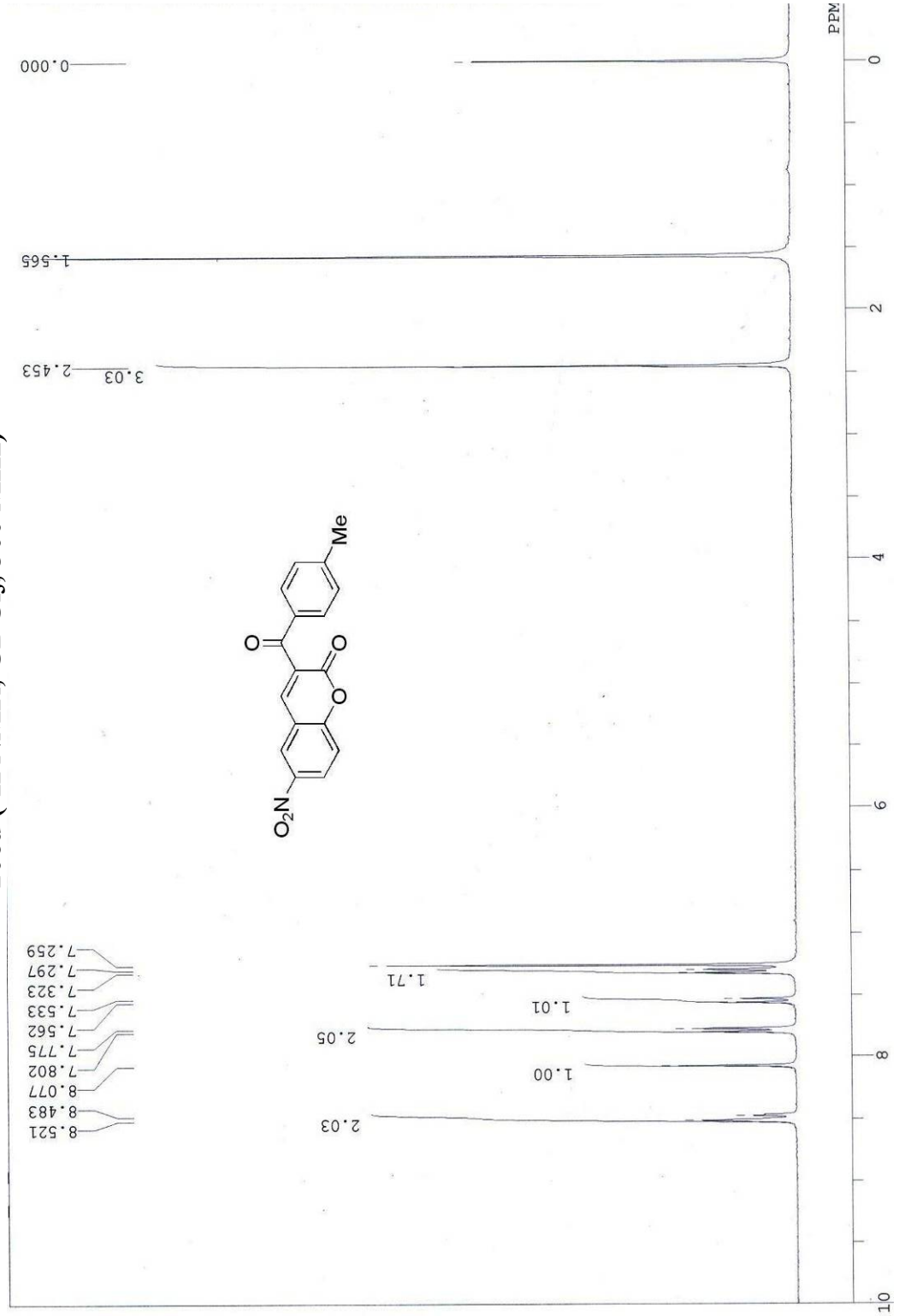

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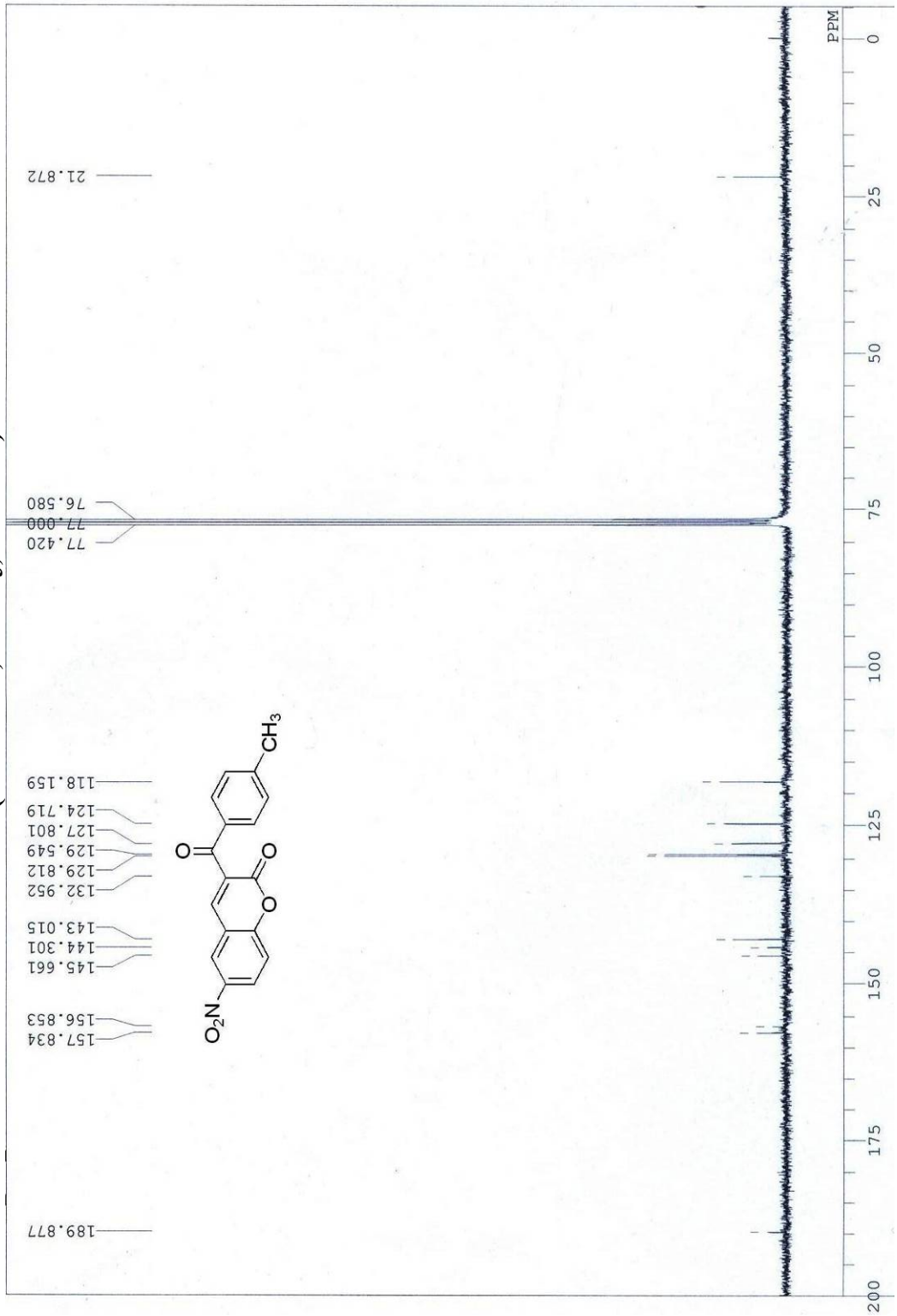

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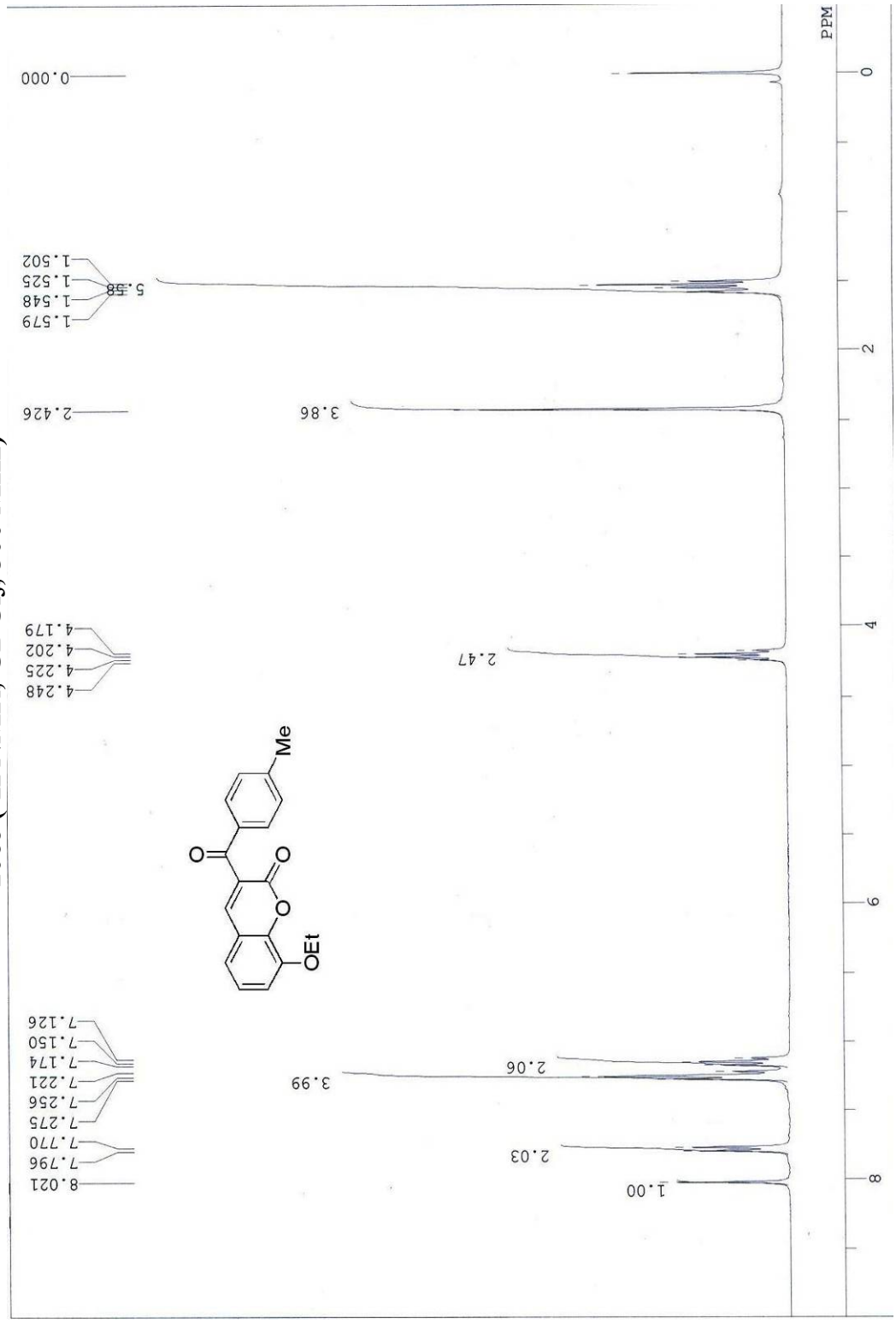

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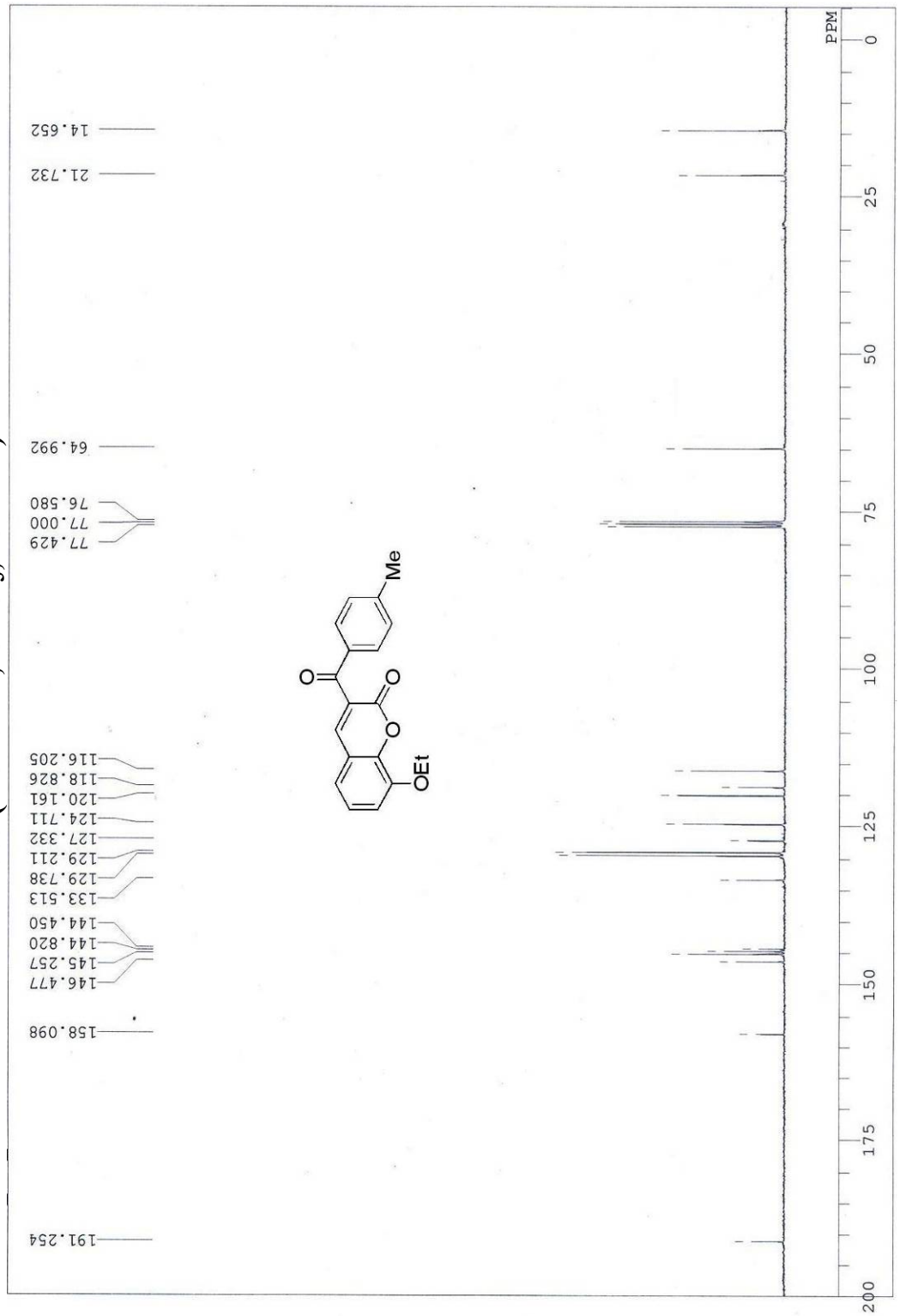

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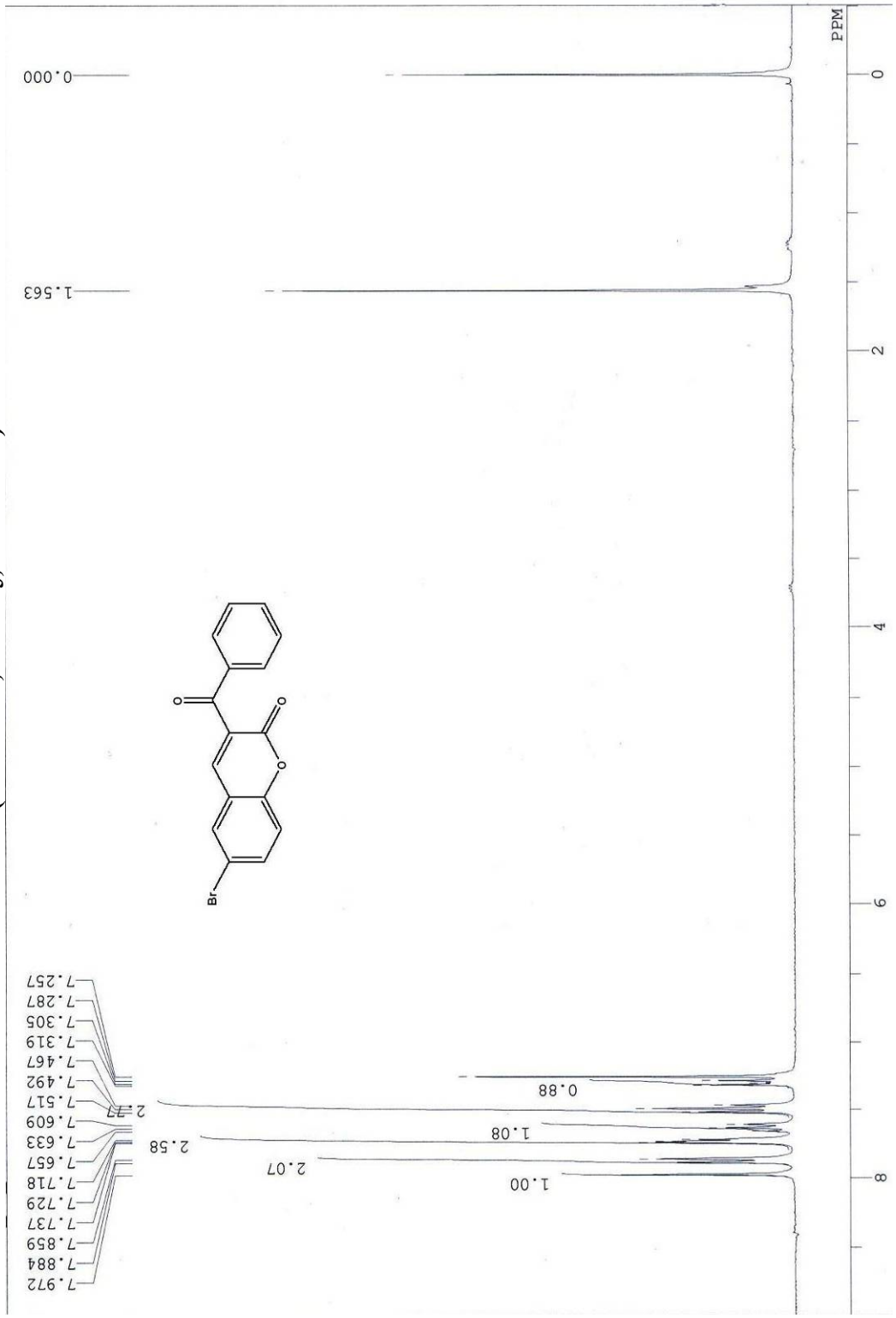

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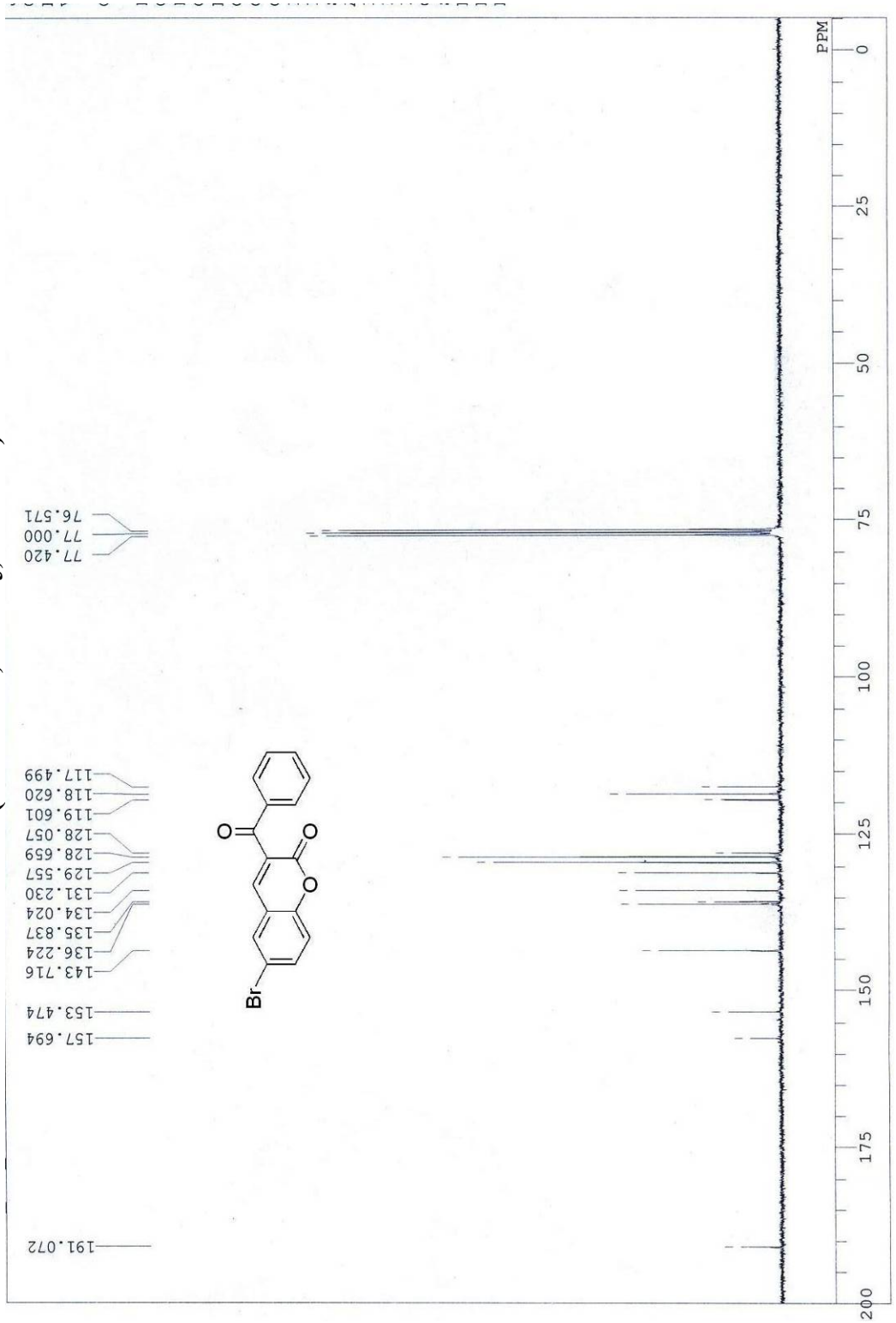

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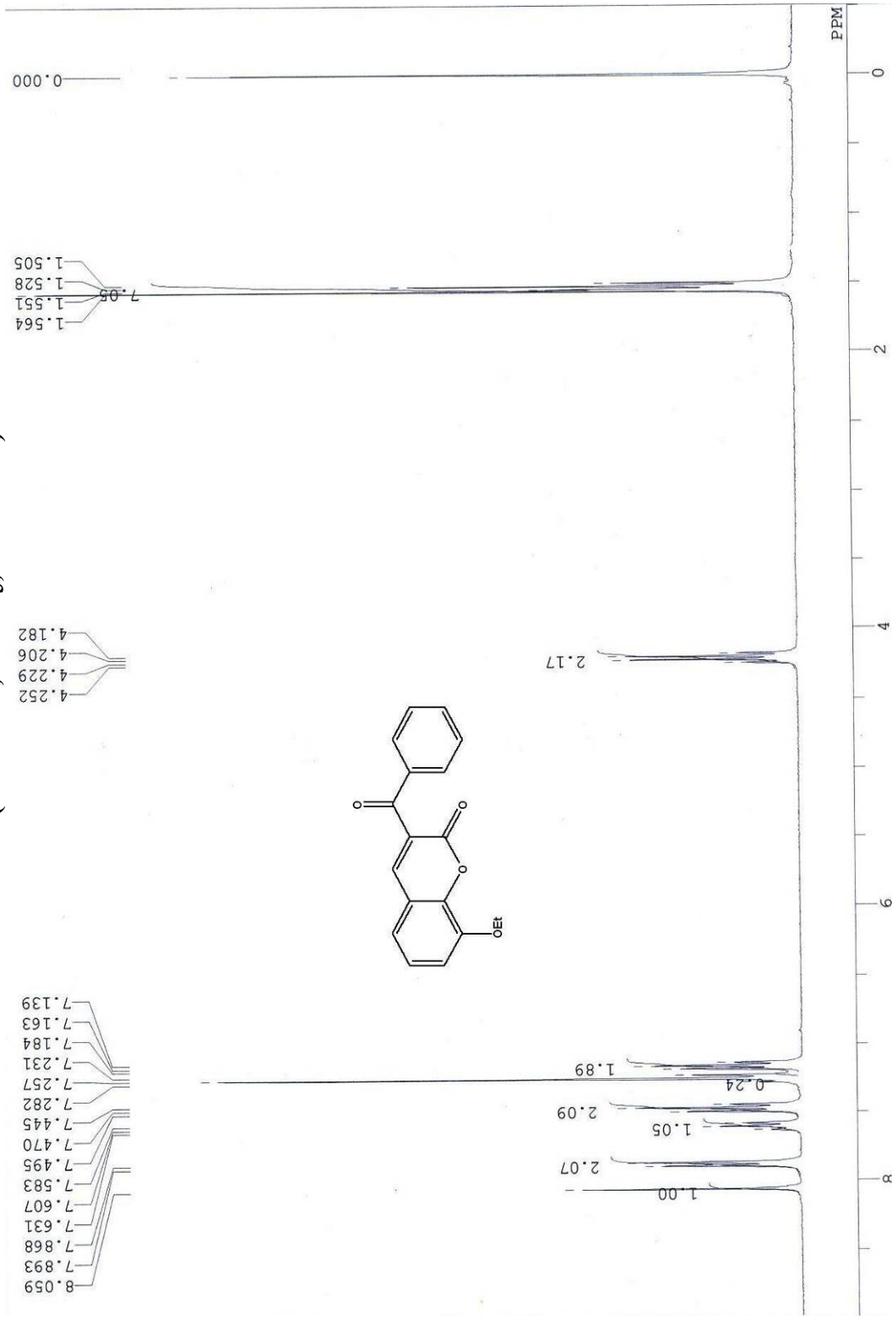

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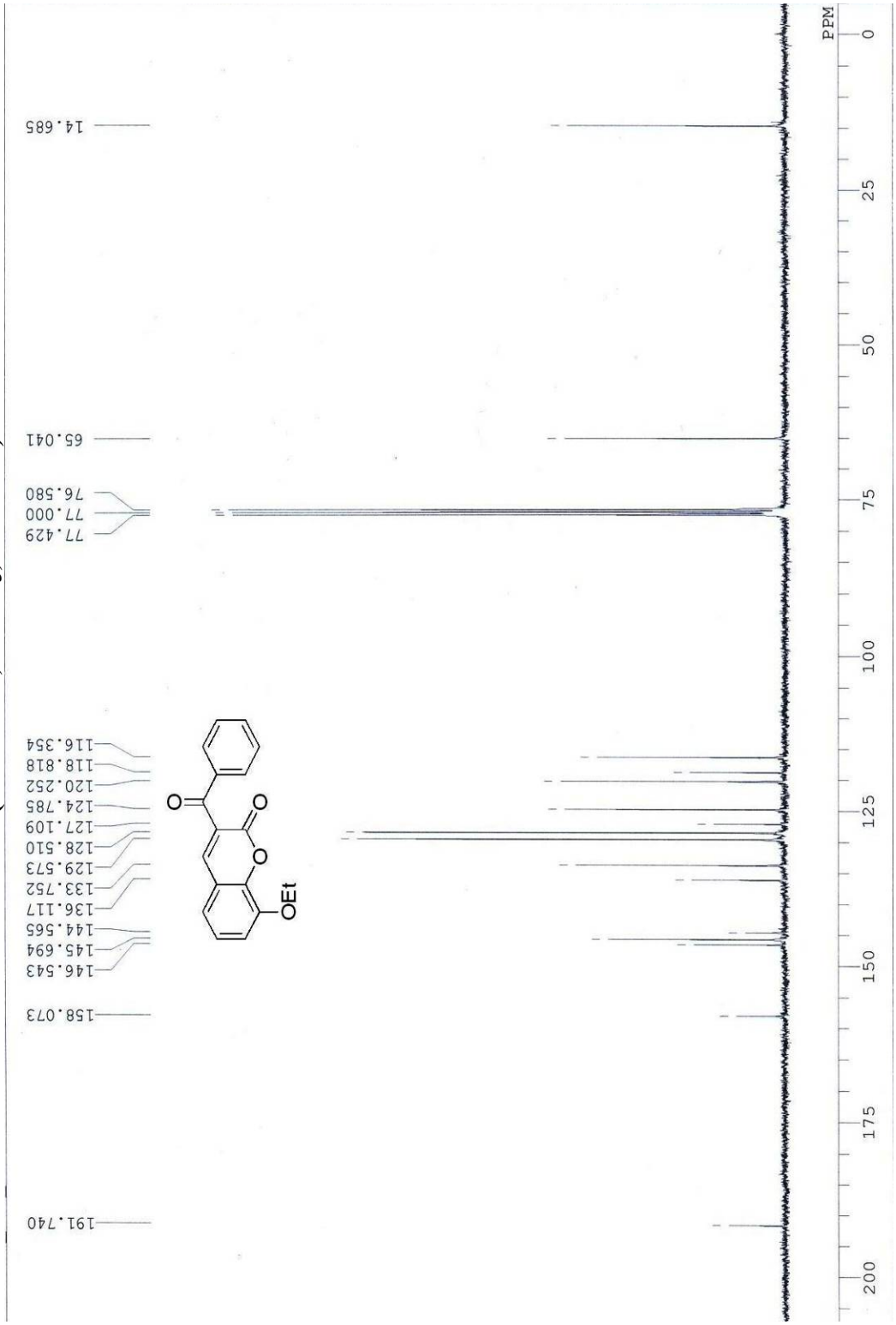

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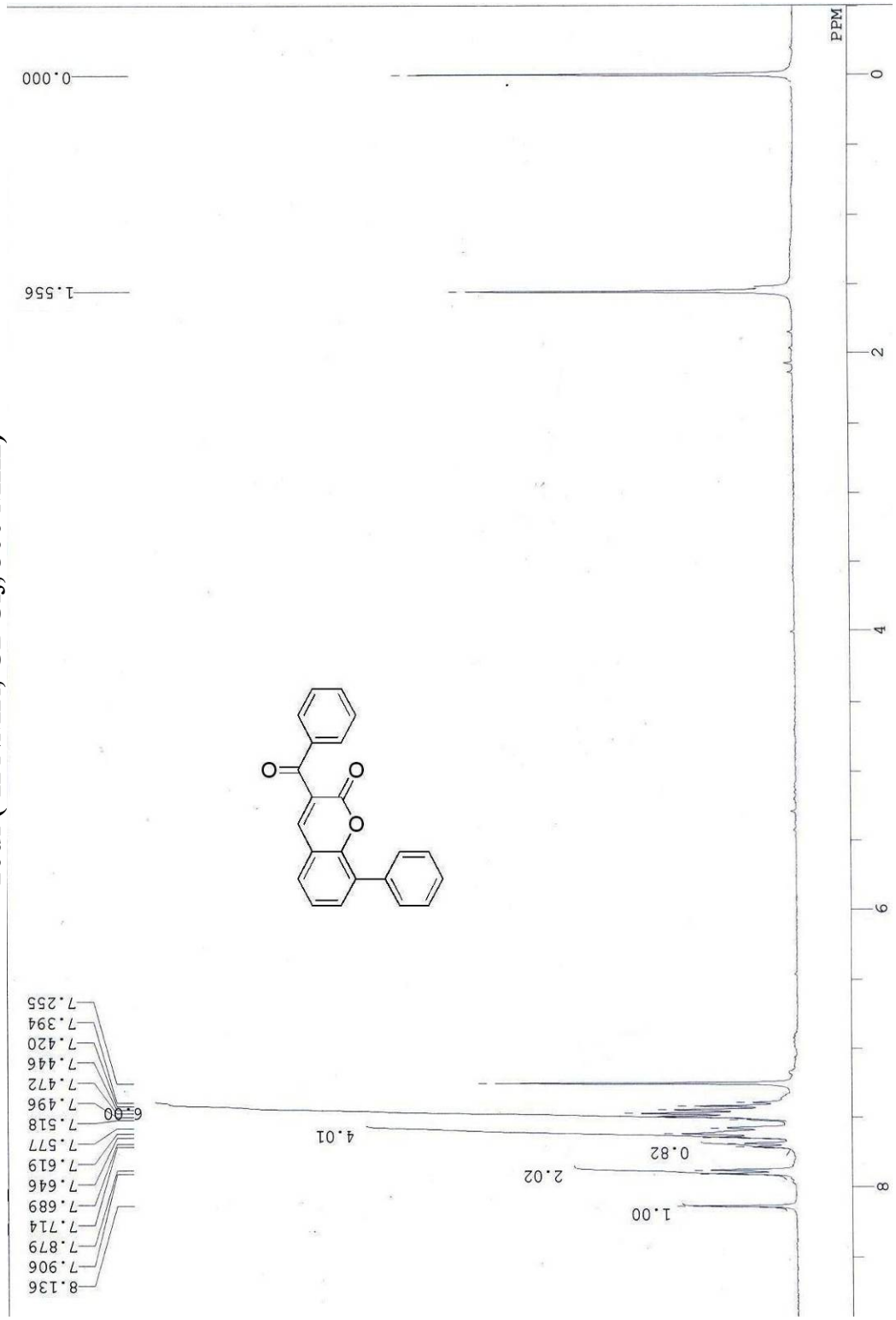

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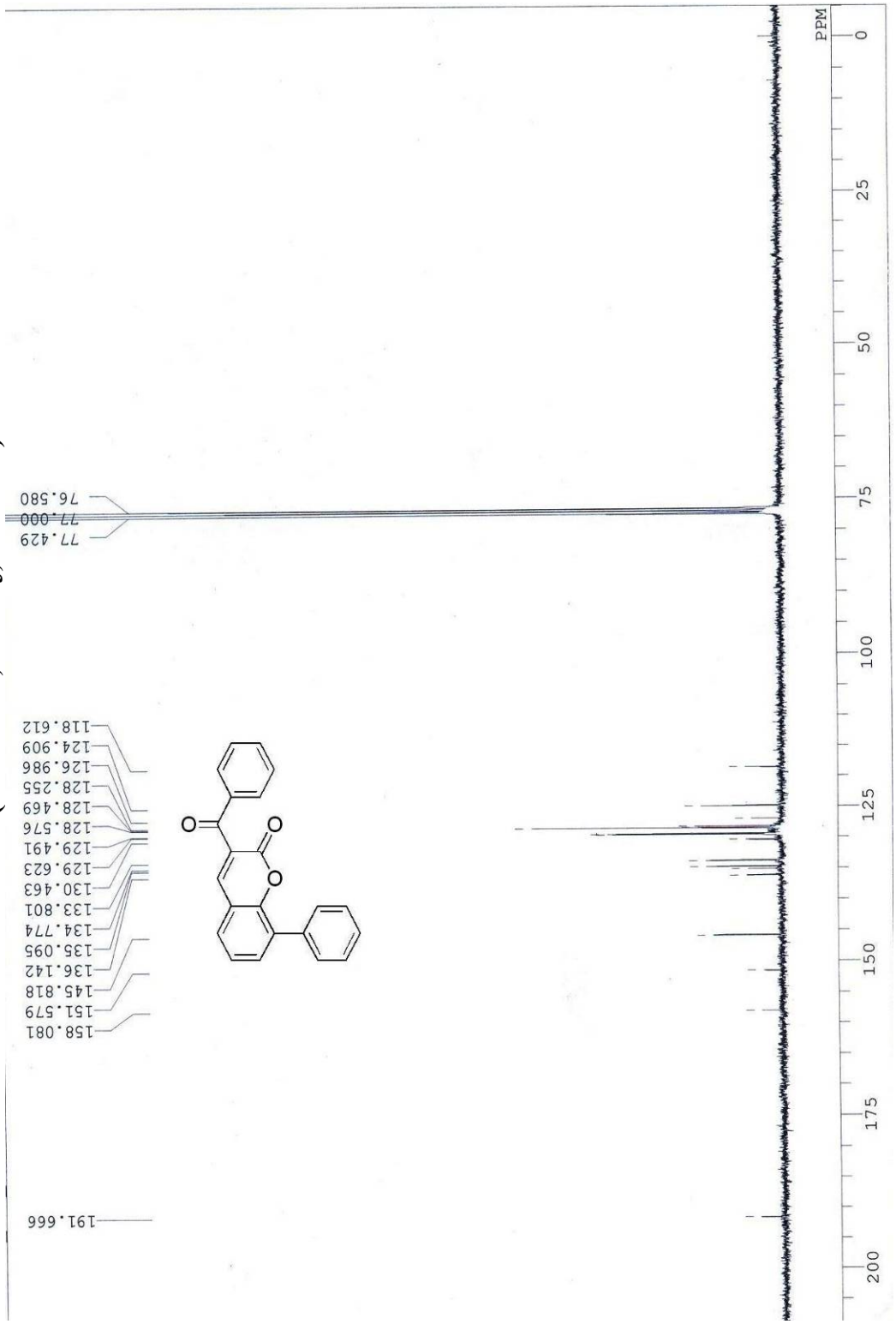

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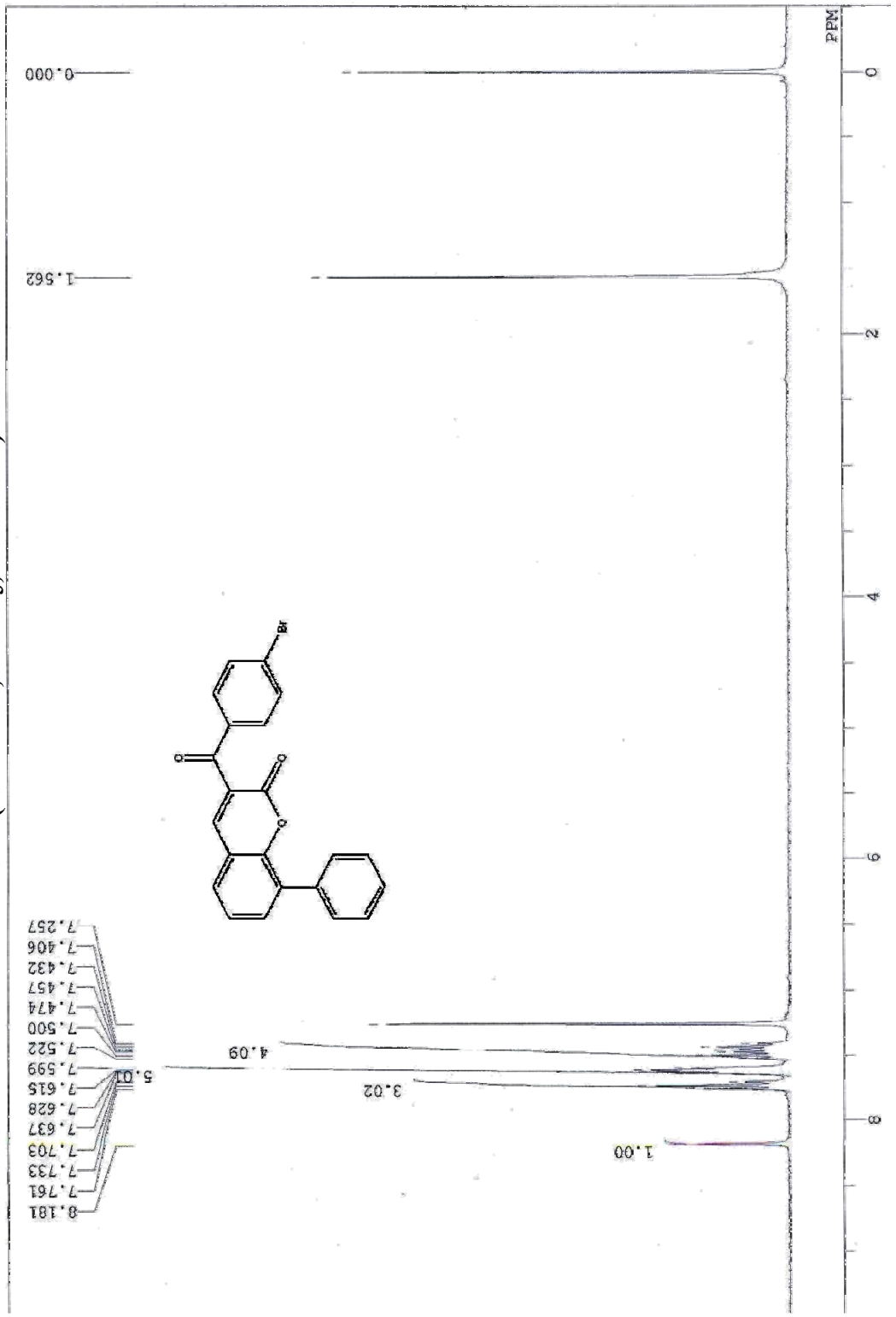

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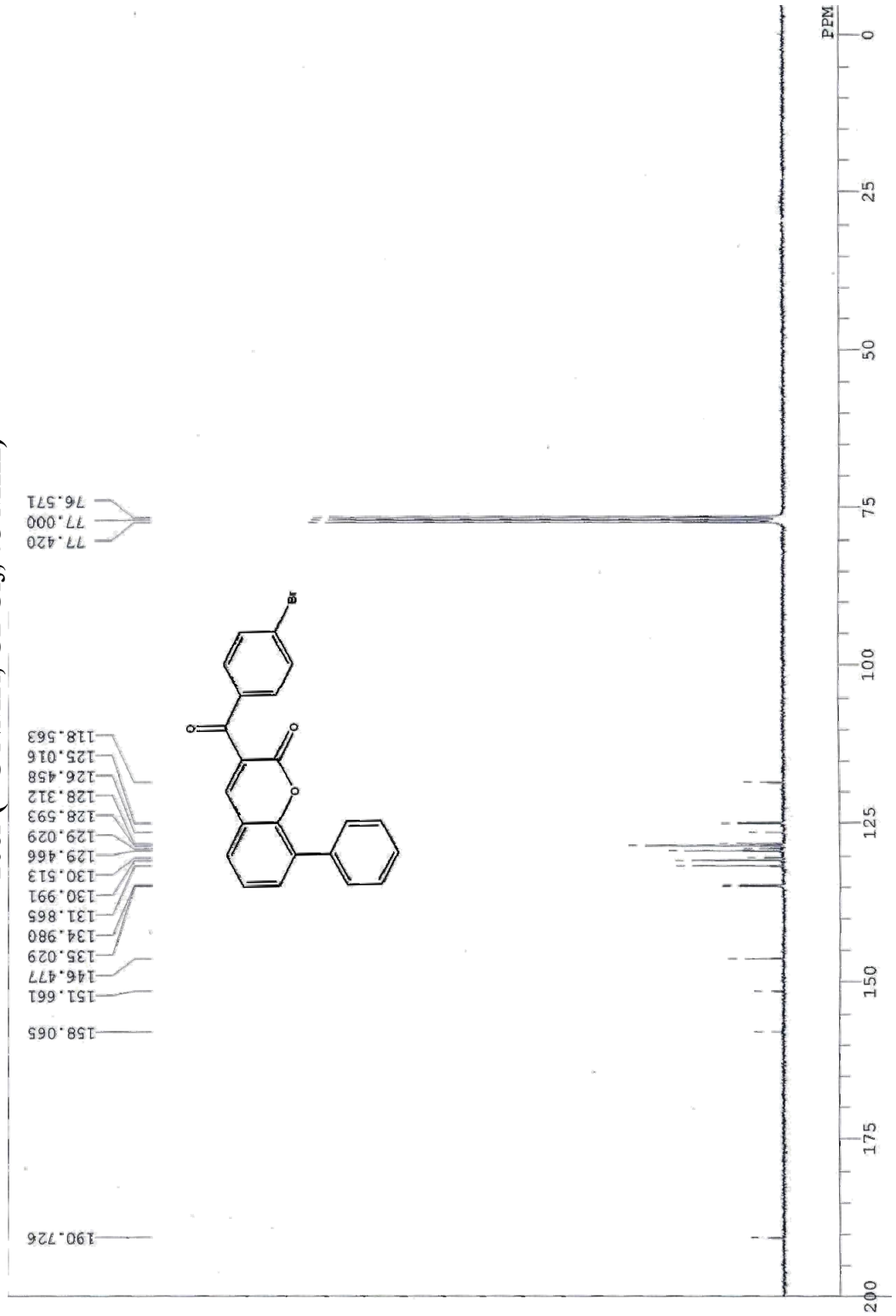

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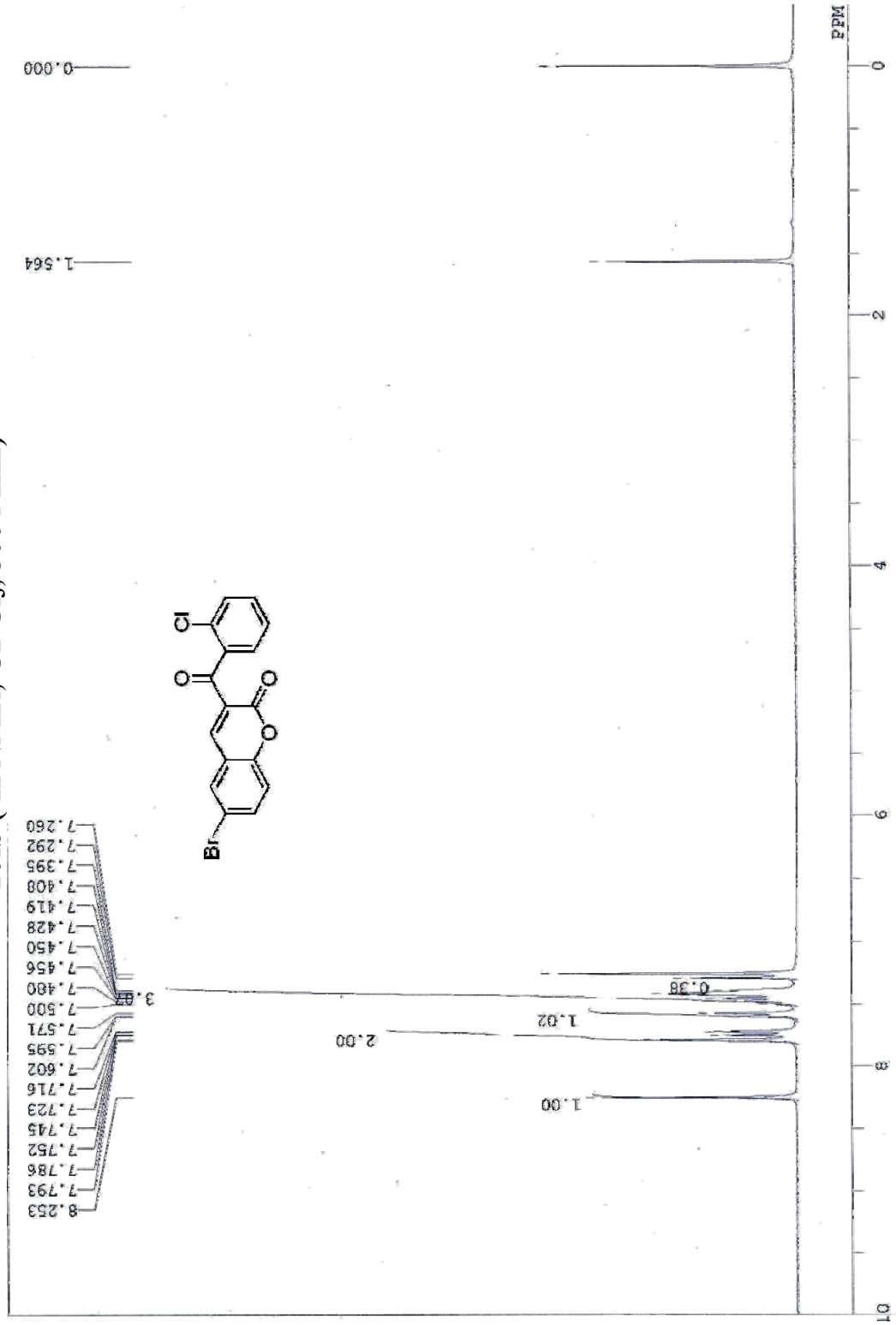

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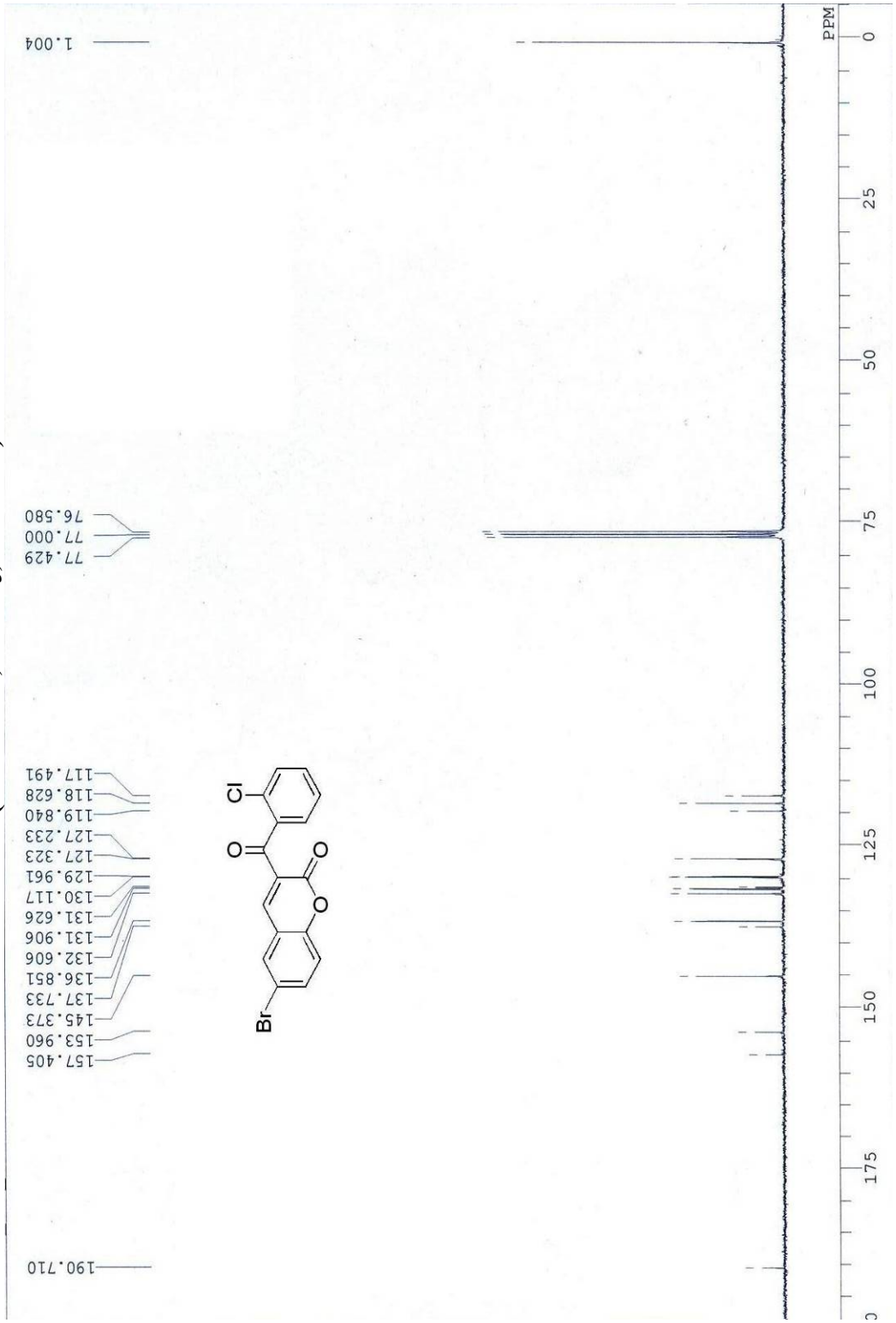

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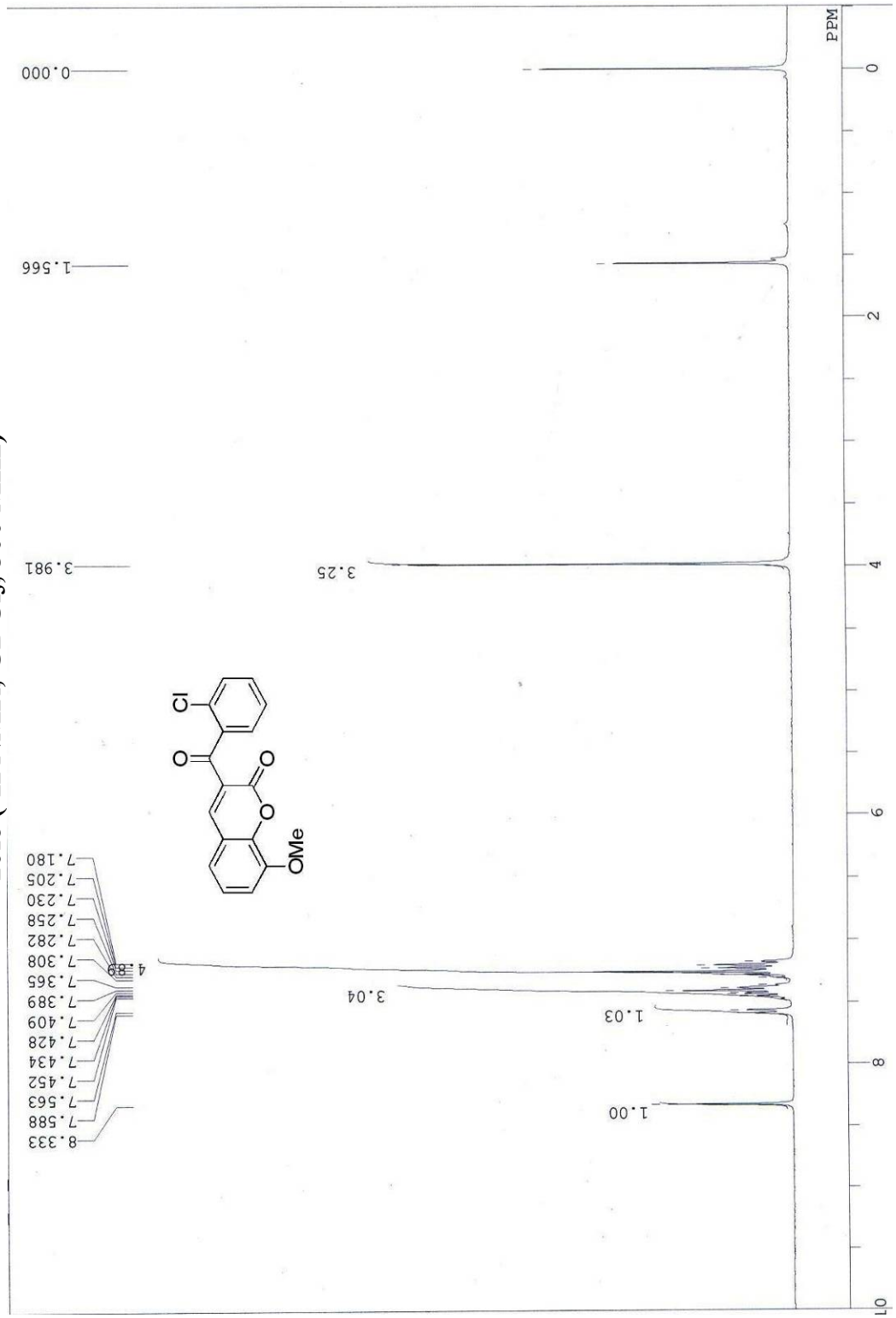

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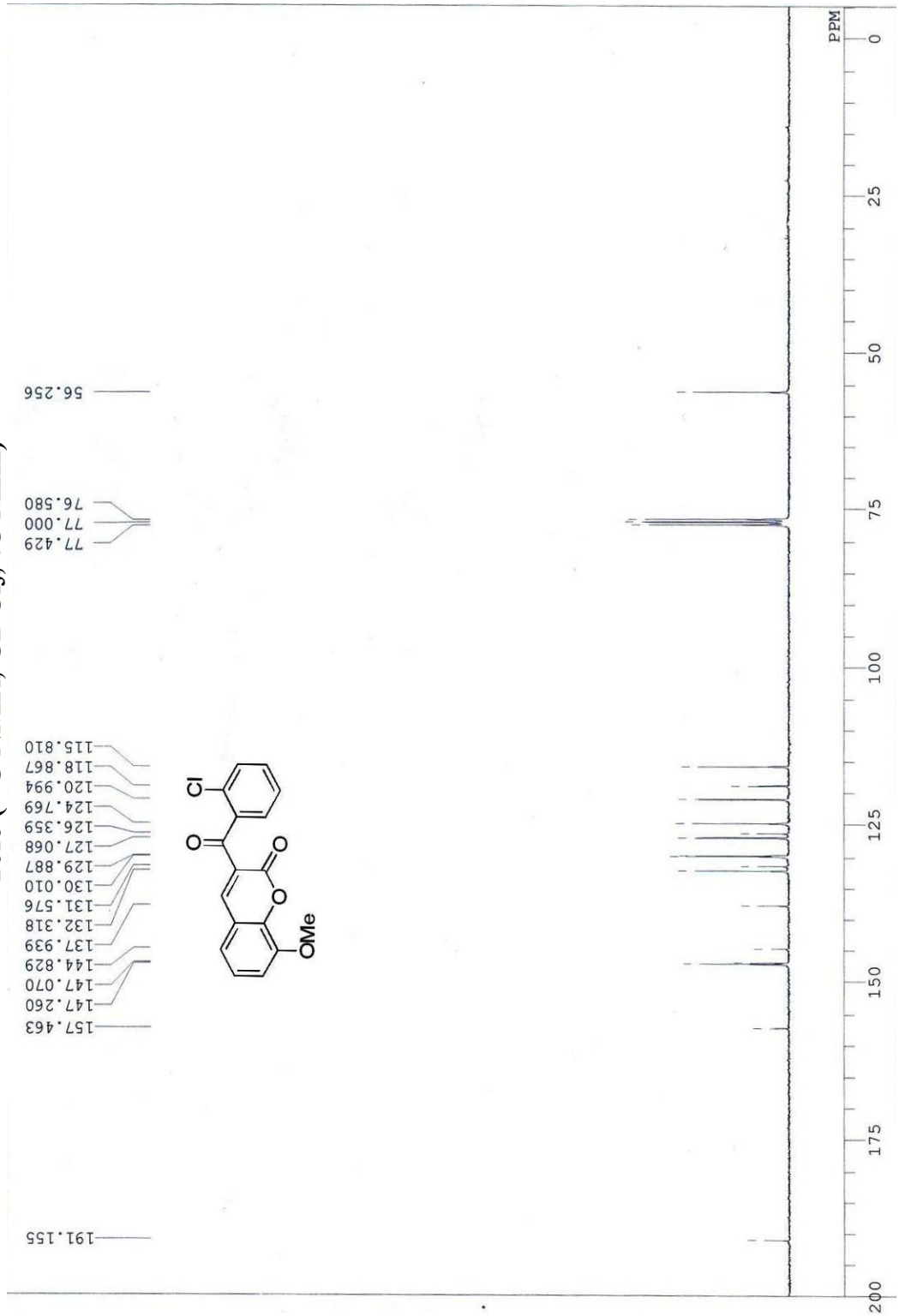
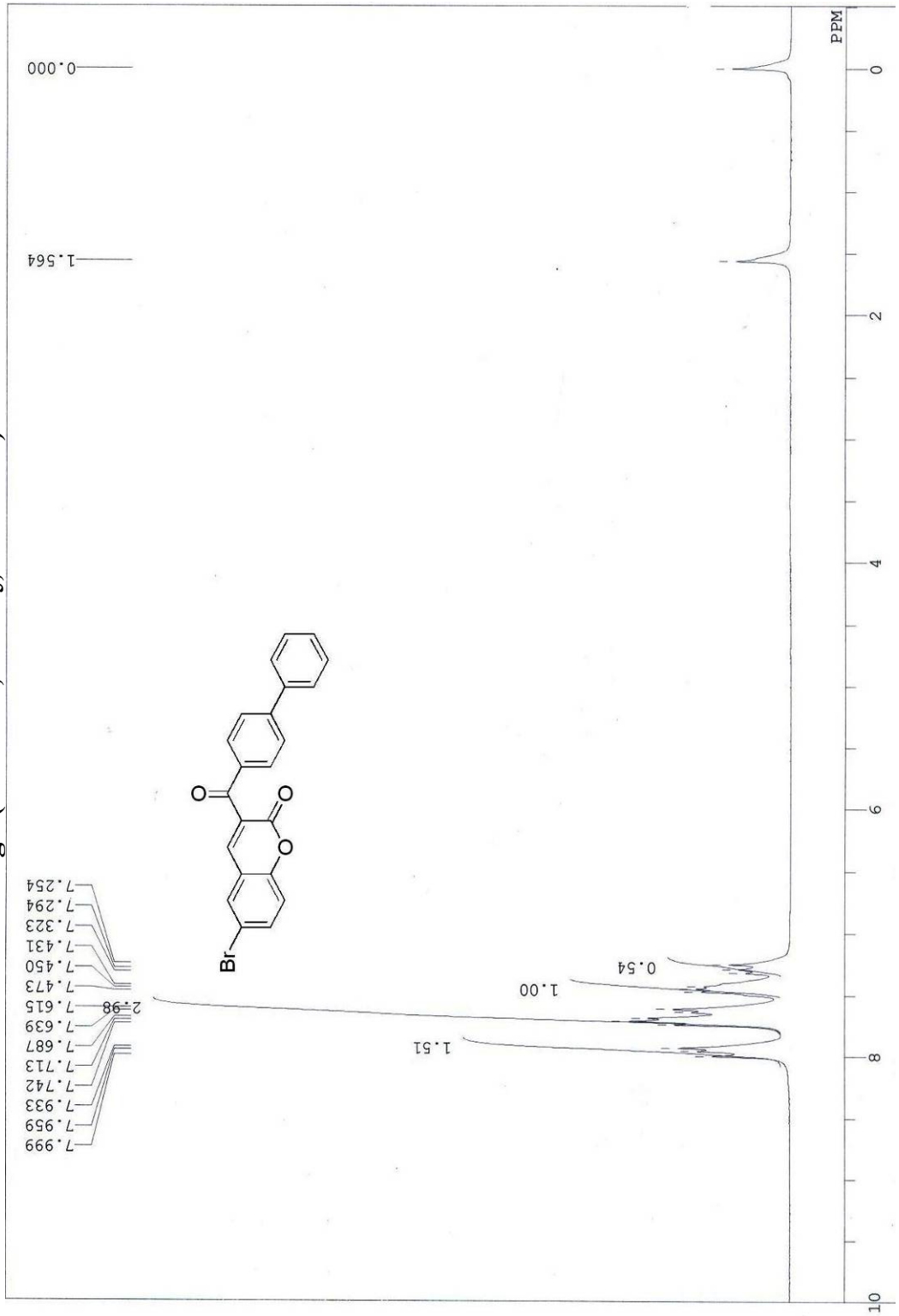
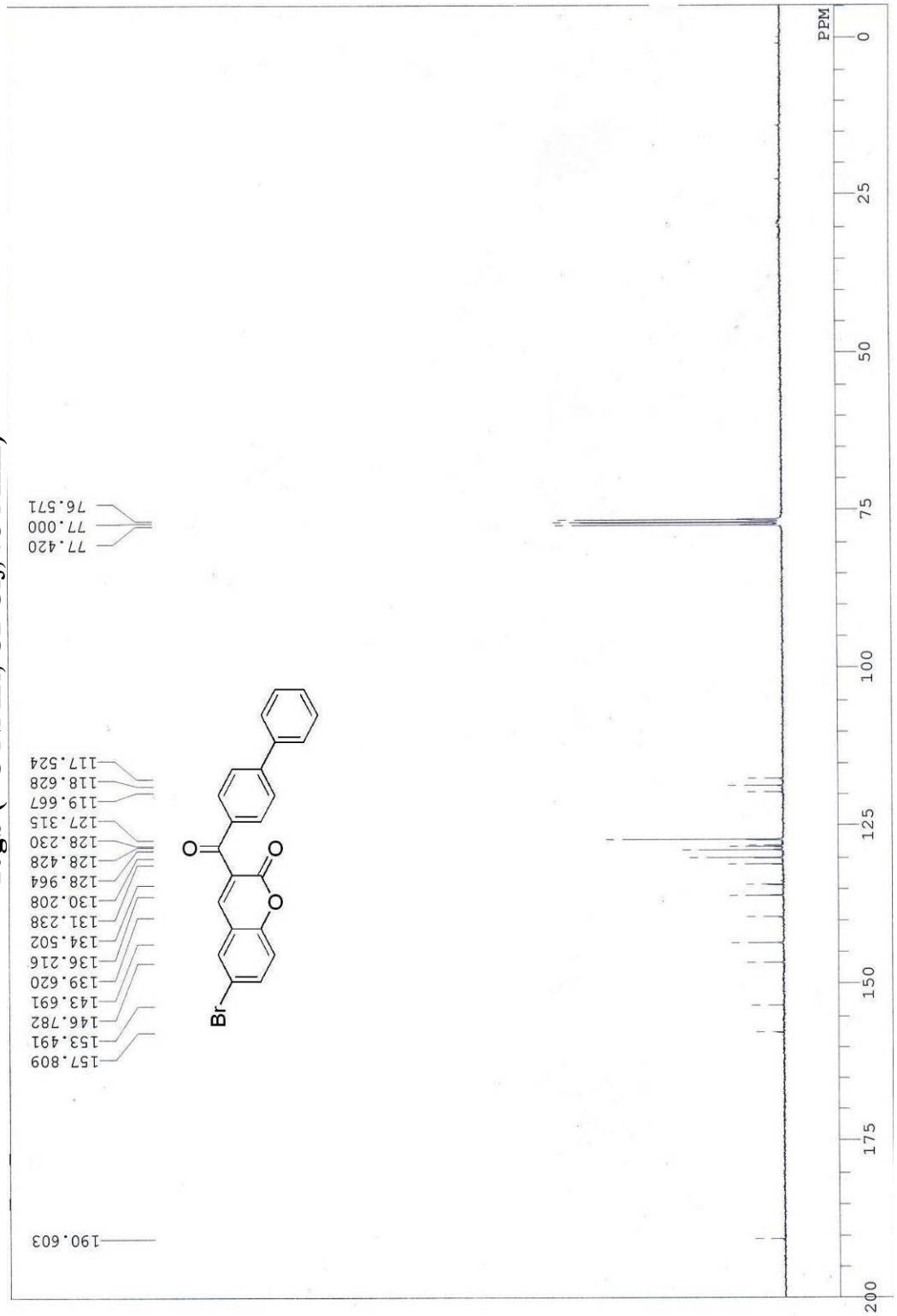


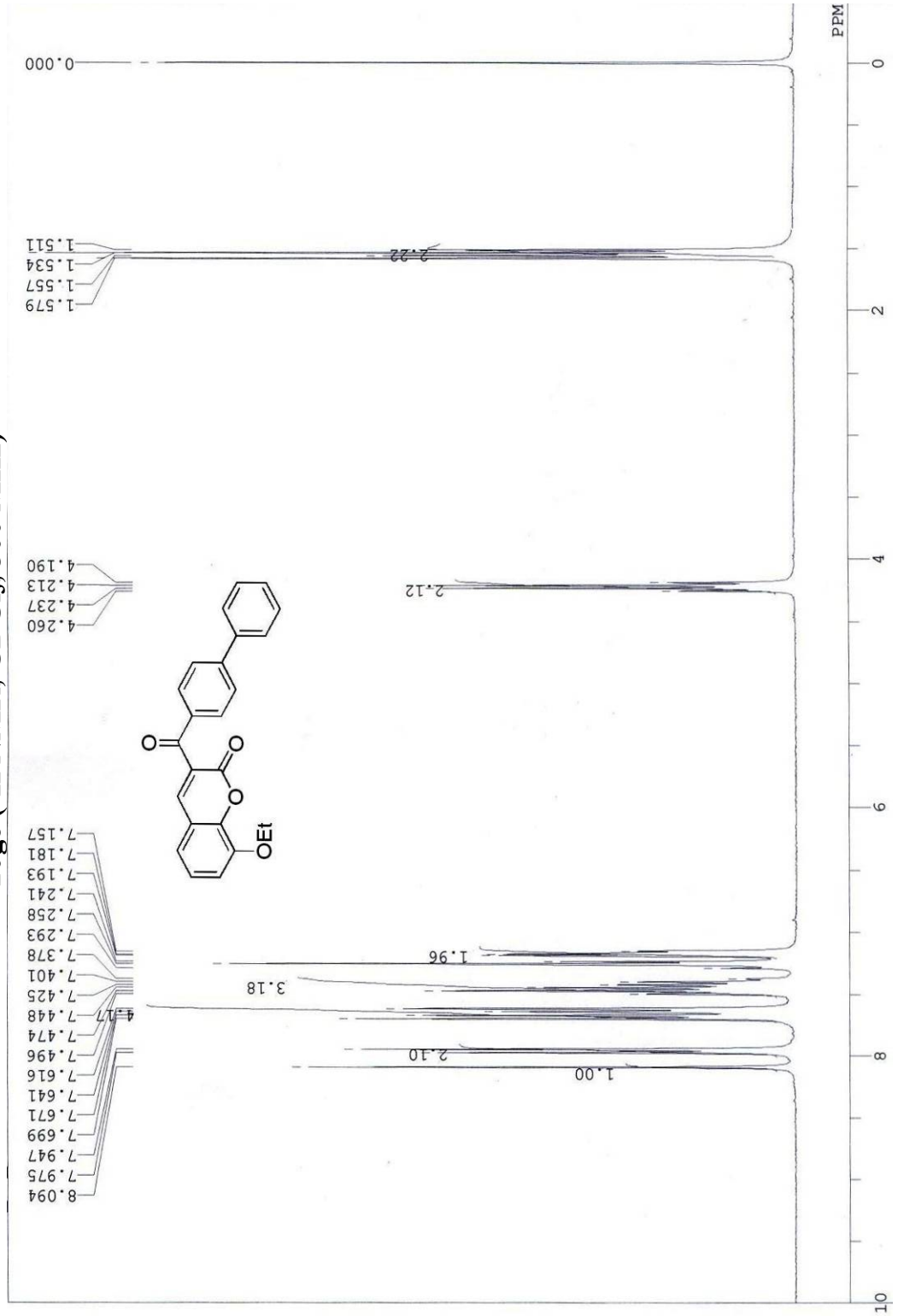
10gb (^{1}H NMR, $CDCl_3$, 300 MHz)



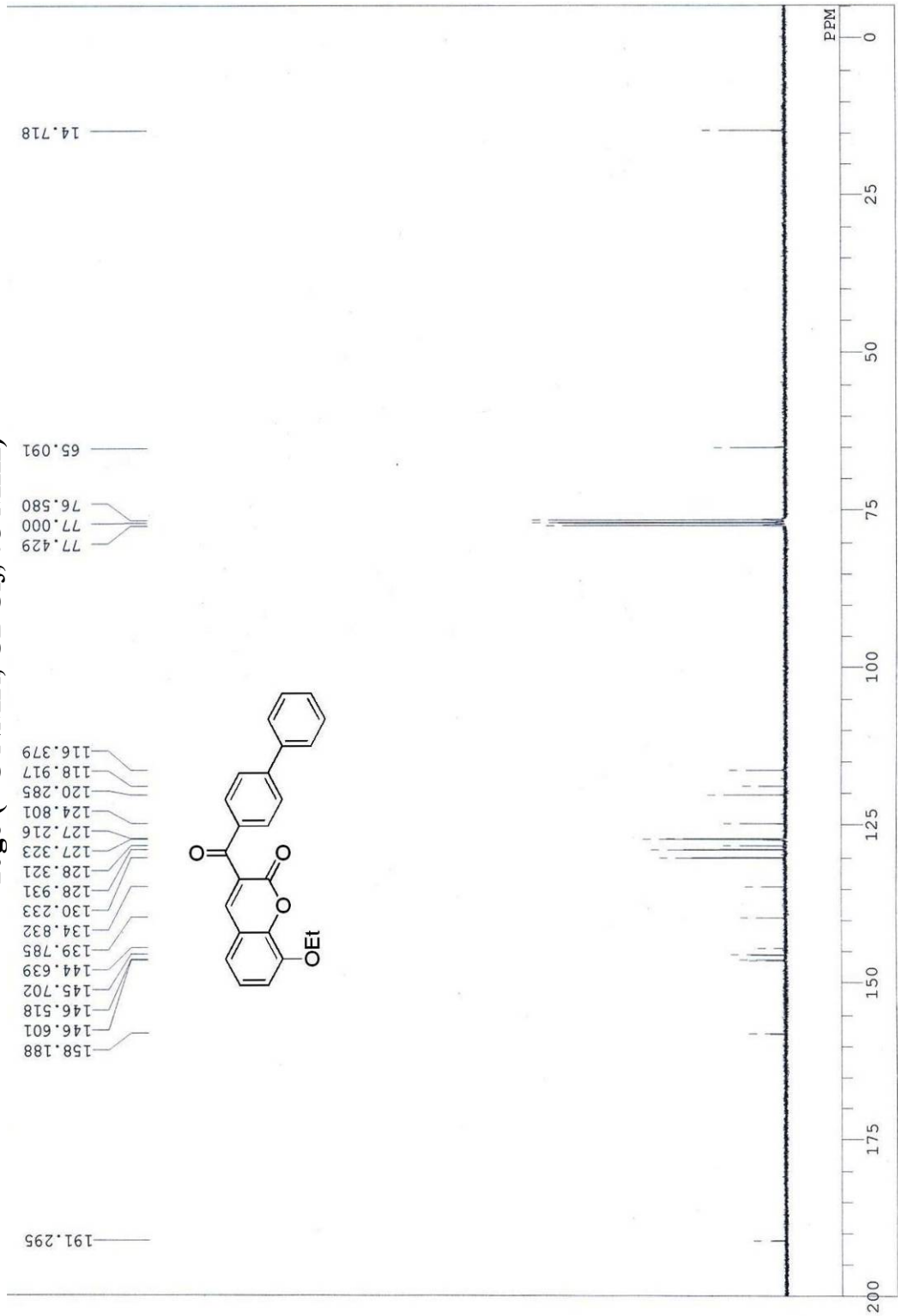
10gb (^{13}C NMR, $CDCl_3$, 75 MHz)



10ge (^{1}H NMR, $CDCl_3$, 300 MHz)



10ge (^{13}C NMR, $CDCl_3$, 75 MHz)



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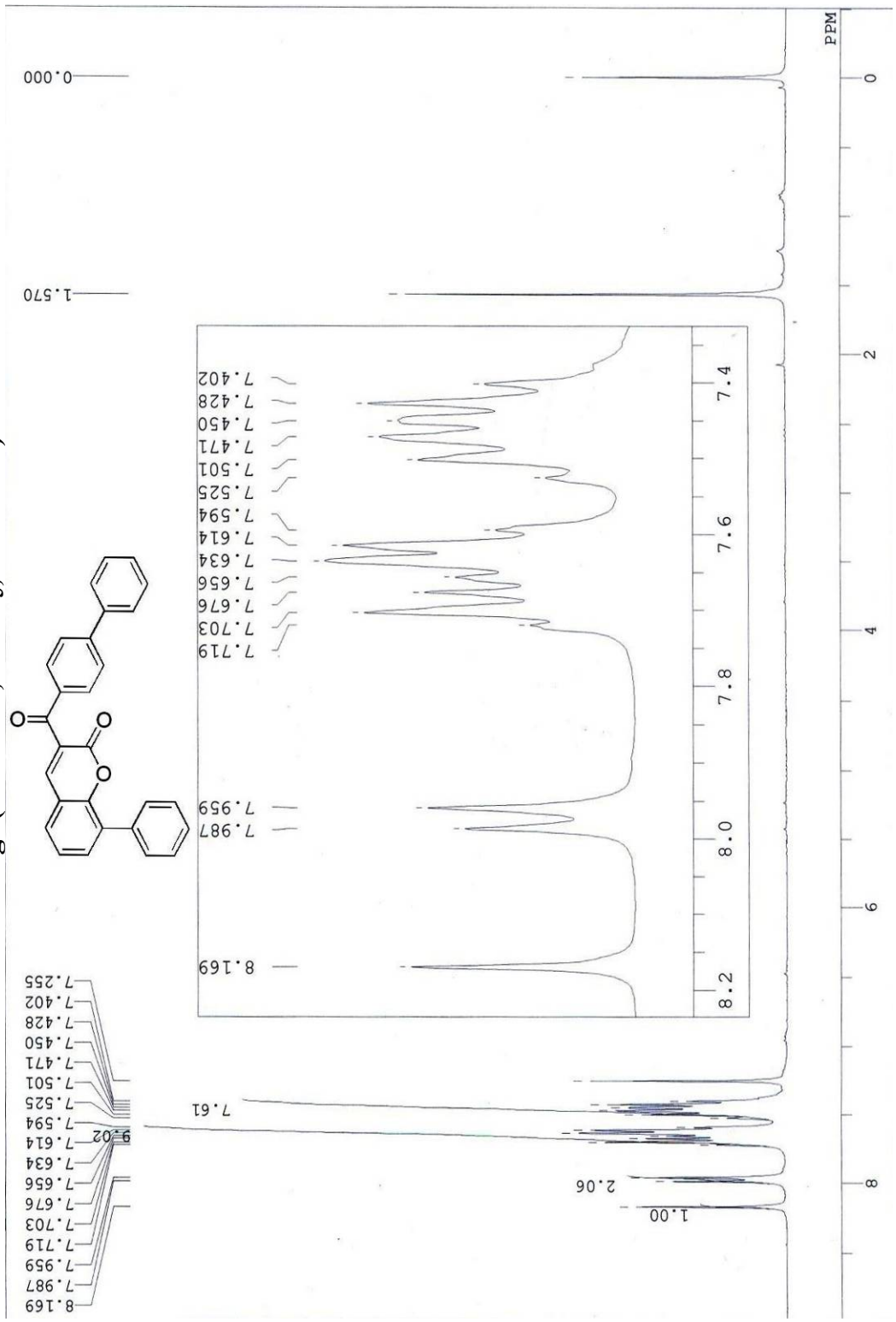

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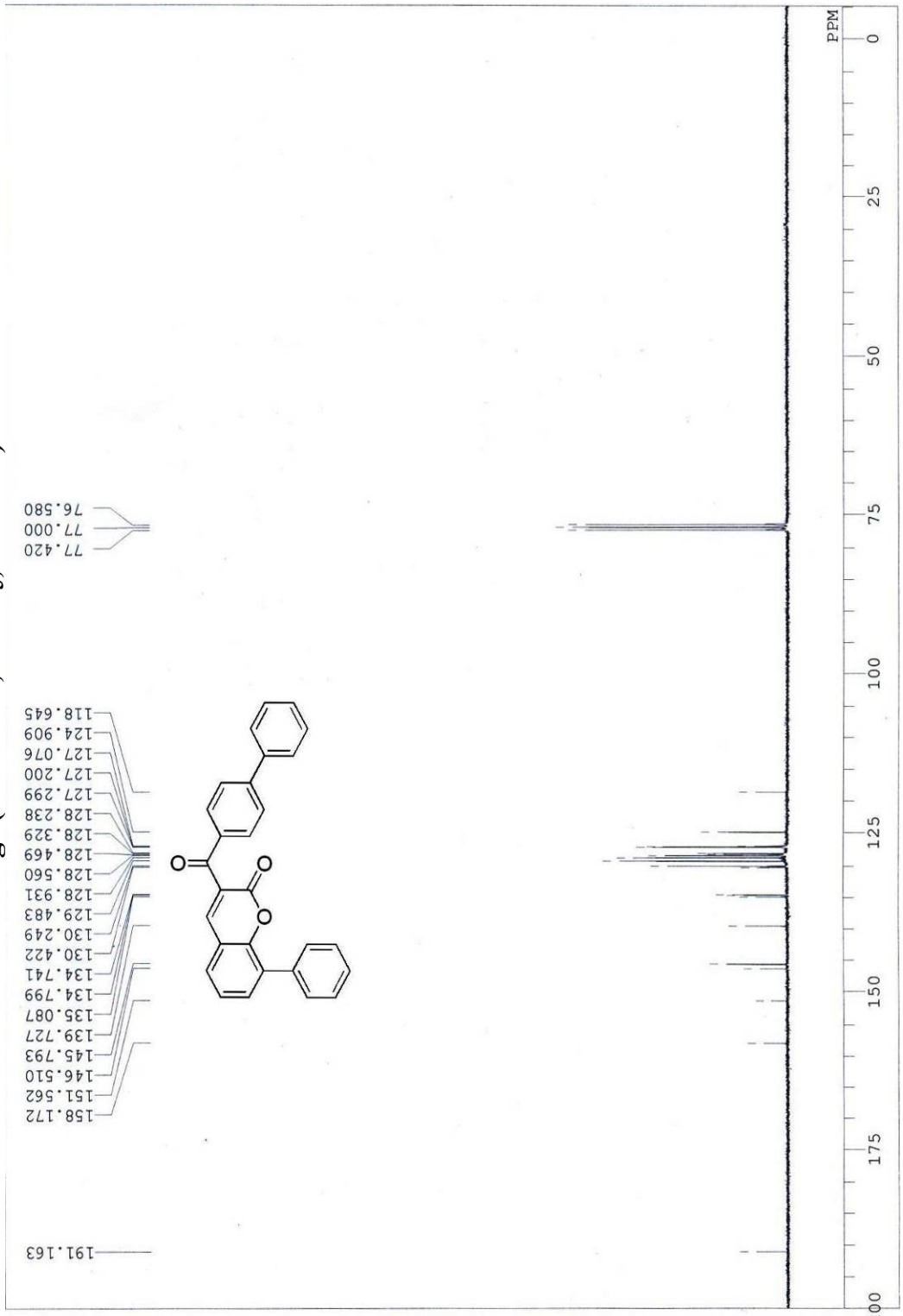
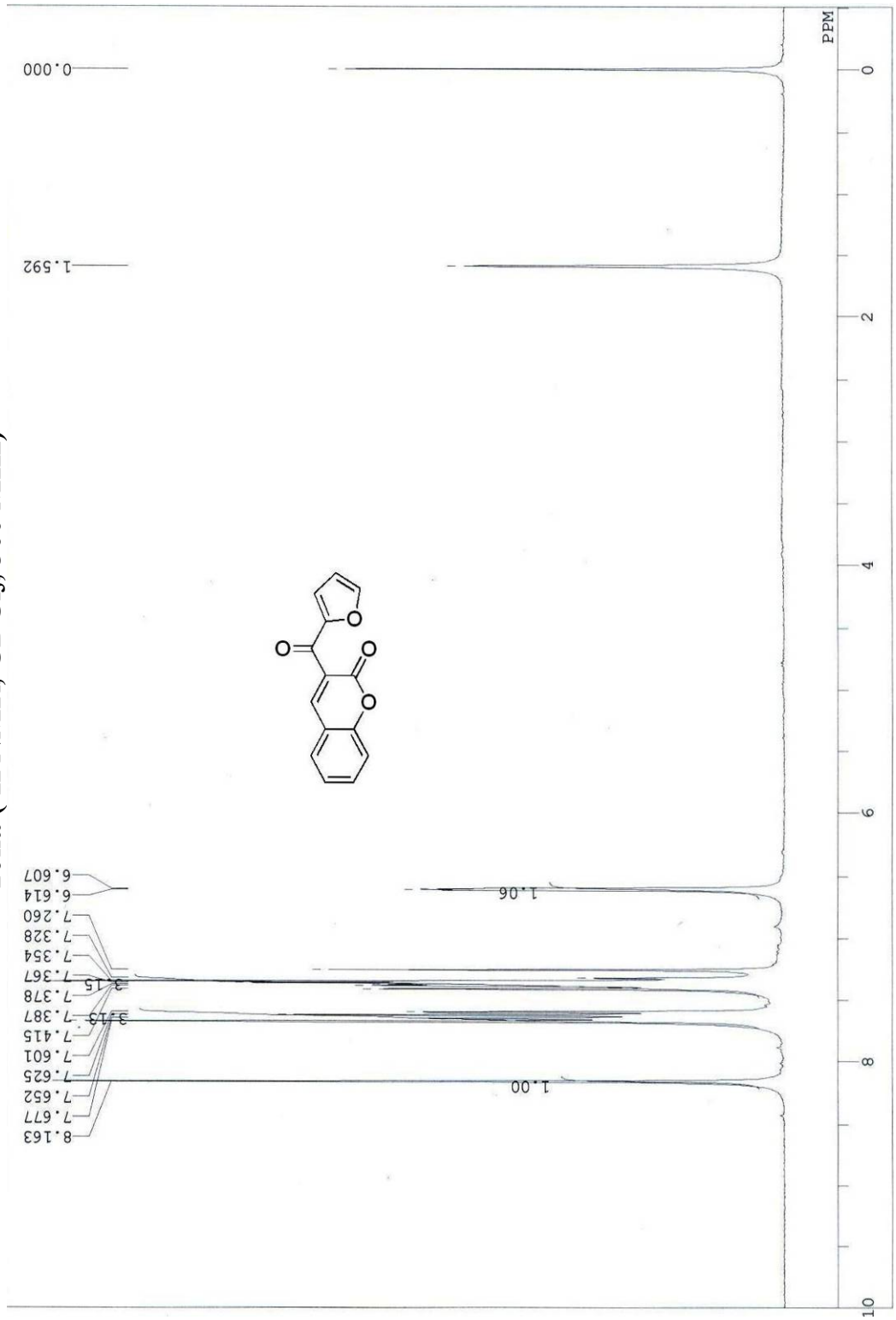
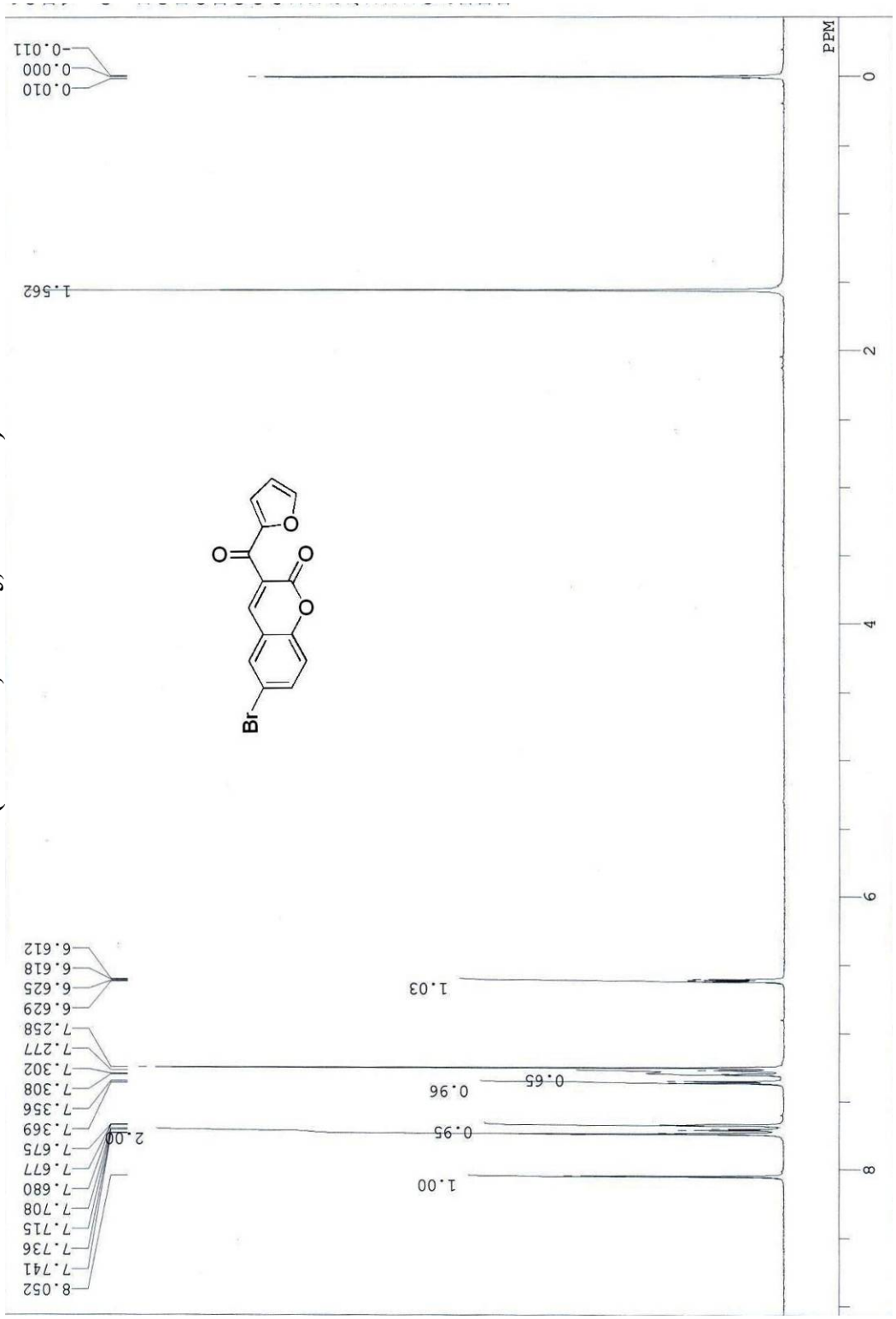


10ha (^{1}H NMR, $CDCl_3$, 300 MHz)

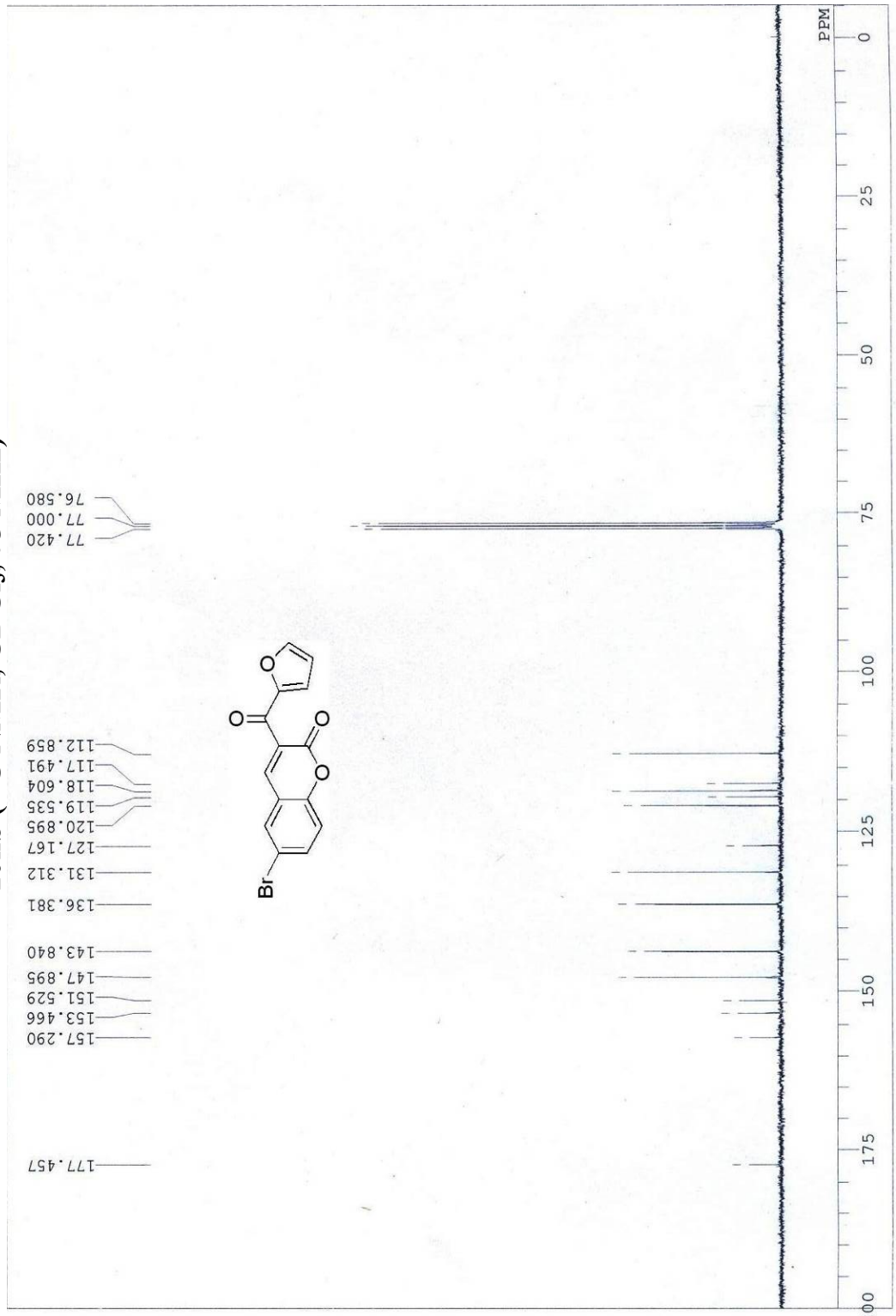


10ha (^{13}C NMR, $CDCl_3$, 75 MHz)

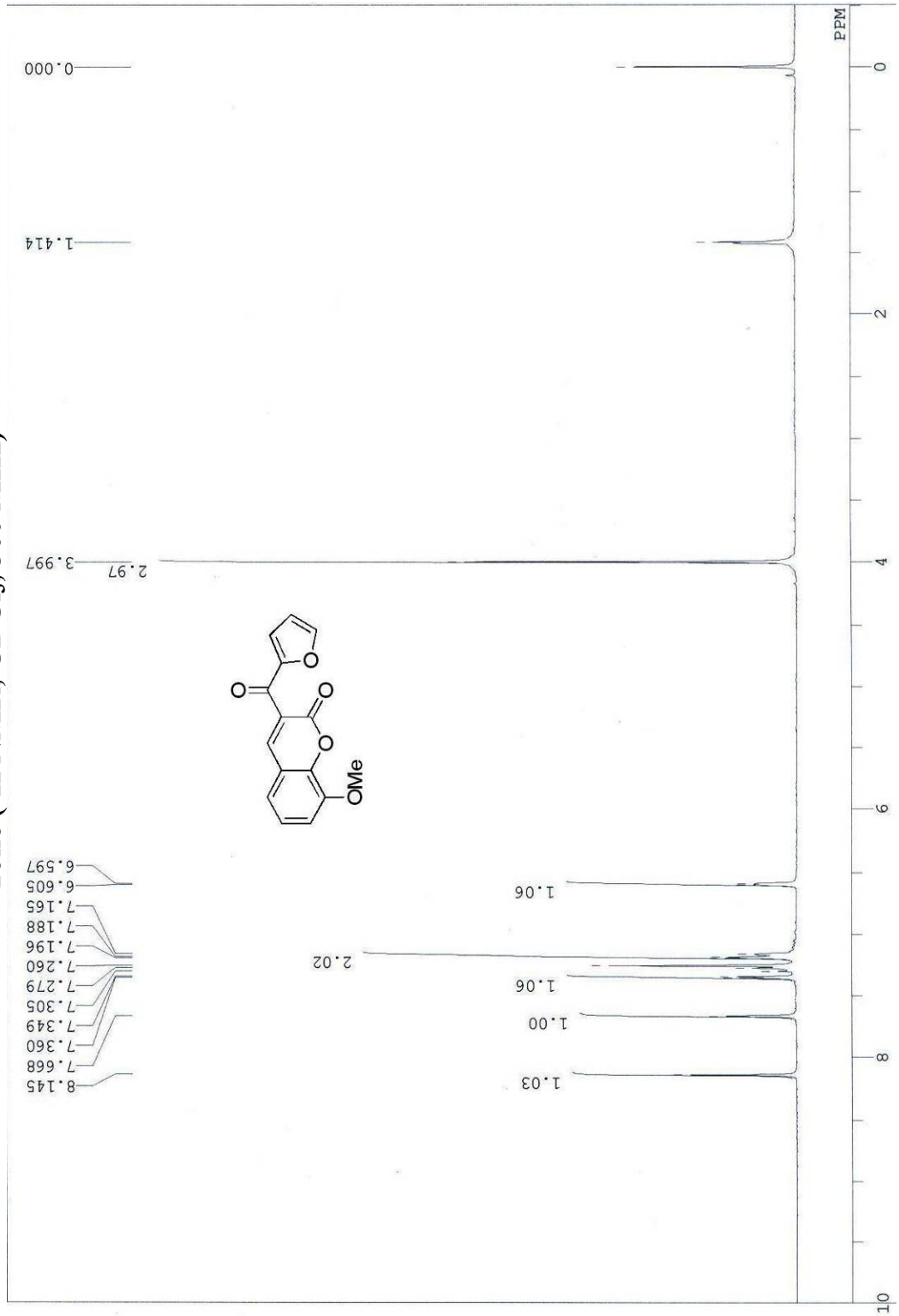
10hb (^{1}H NMR, $CDCl_3$, 300 MHz)



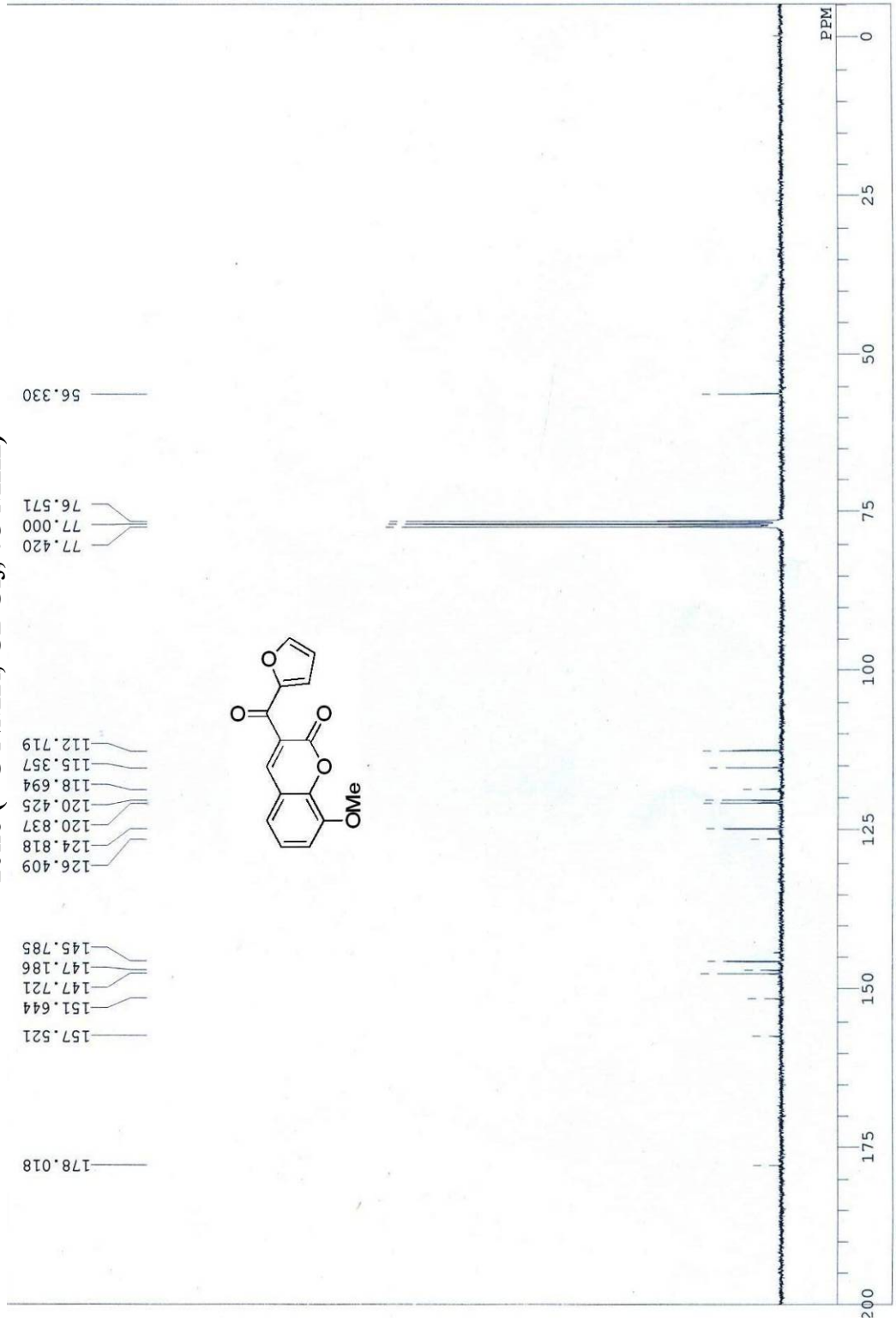
10hb (^{13}C NMR, $CDCl_3$, 75 MHz)



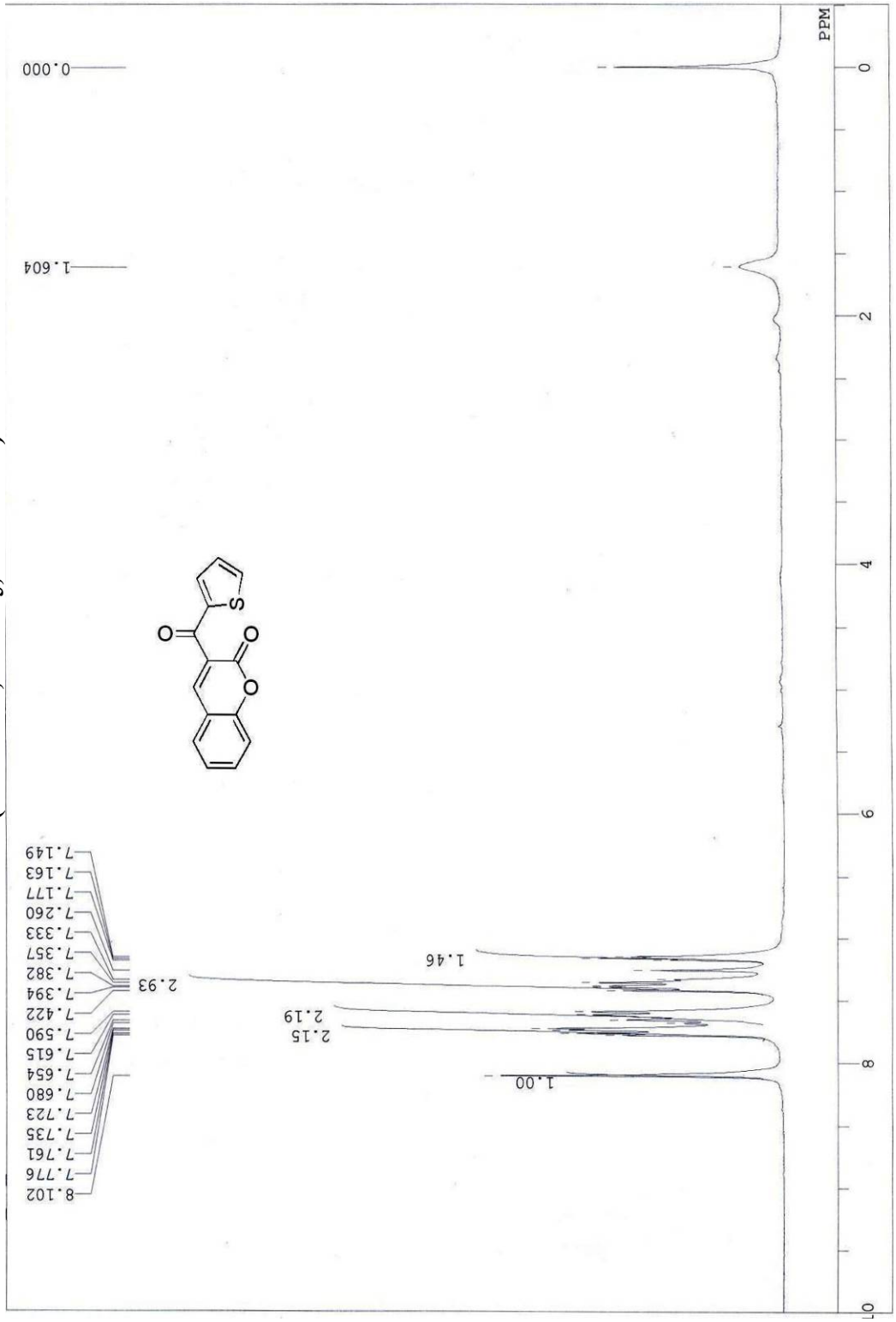
10hc (^{1}H NMR, $CDCl_3$, 300 MHz)



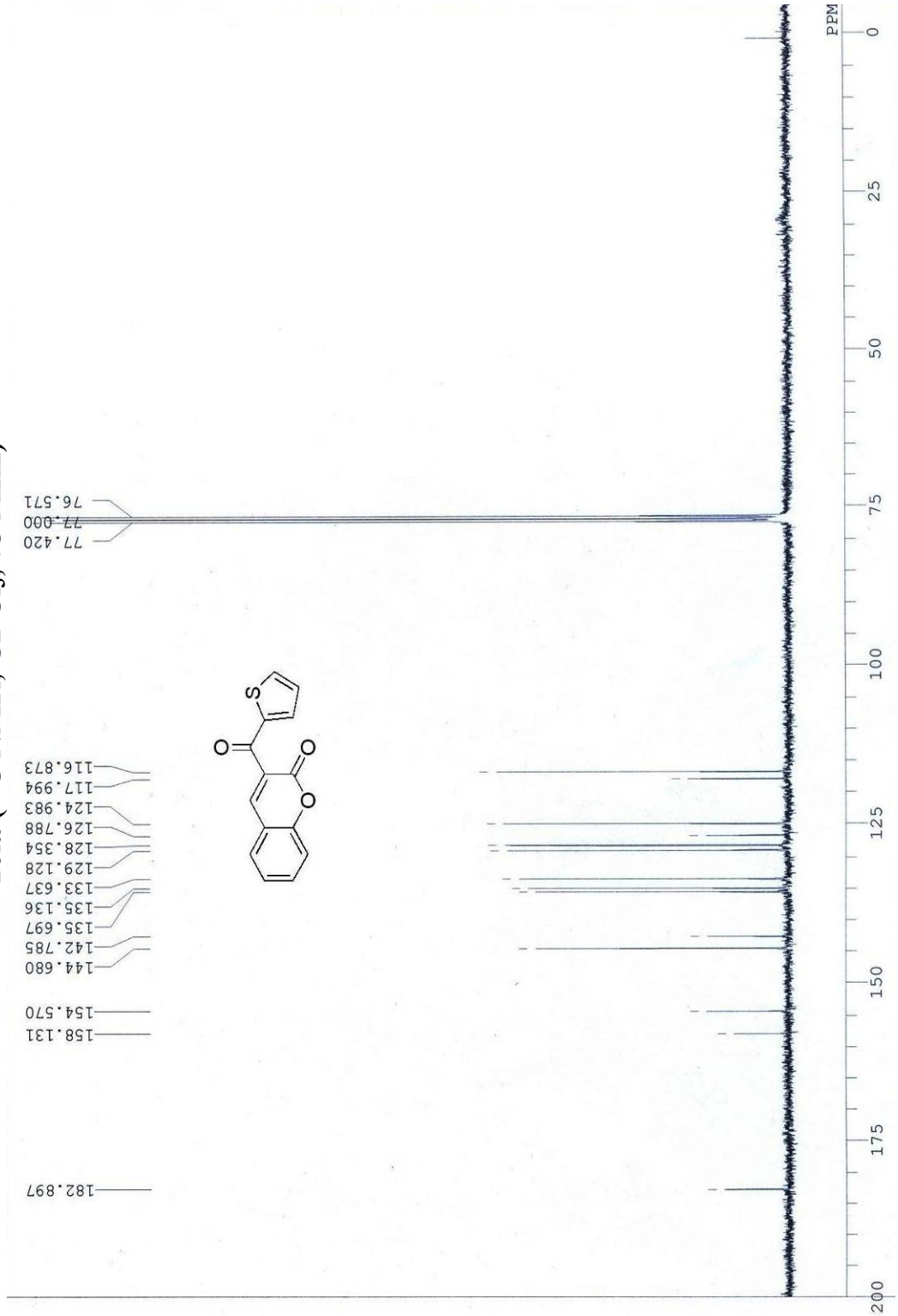
10hc (^{13}C NMR, $CDCl_3$, 75 MHz)



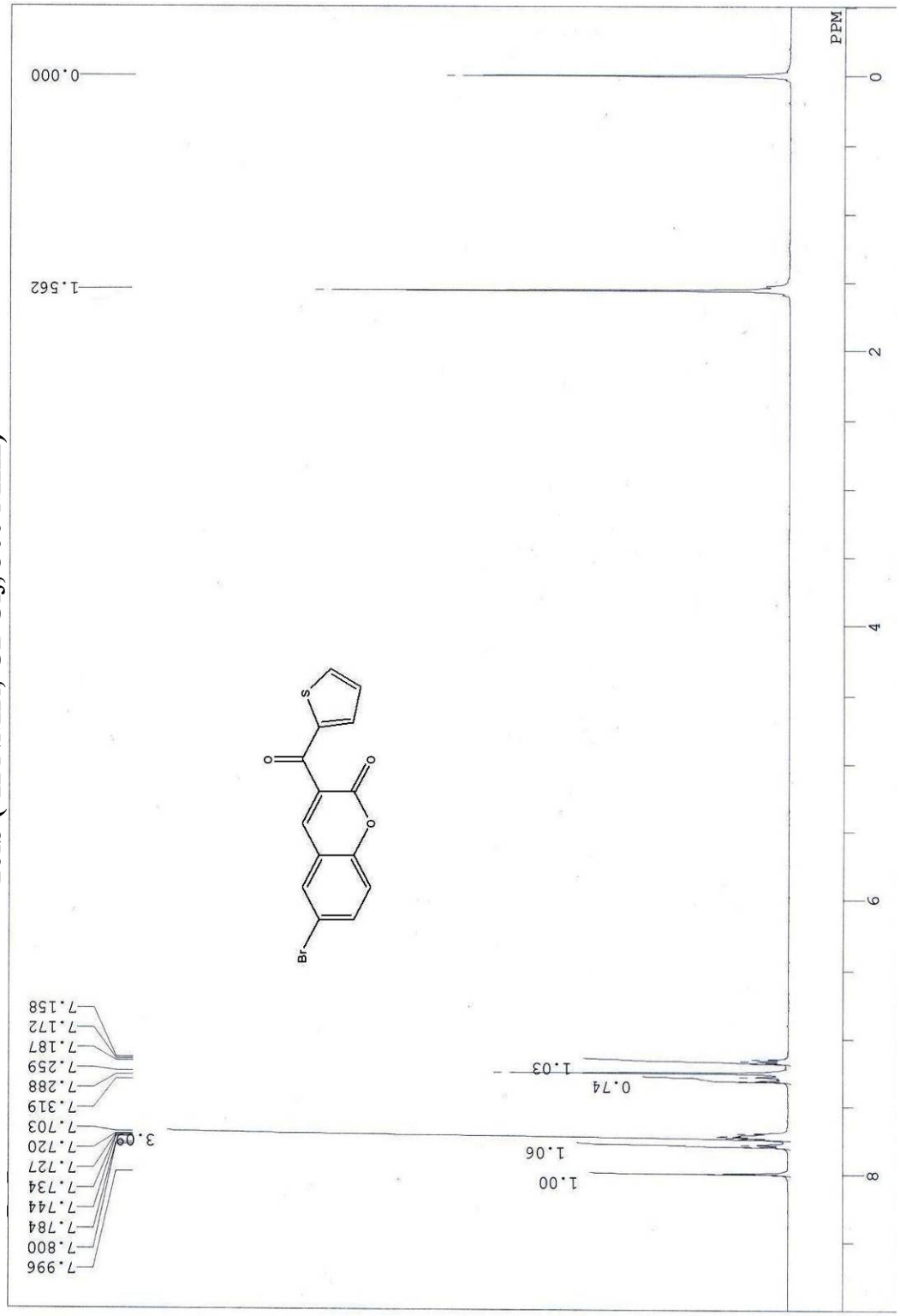
10ia (^{1}H NMR, $CDCl_3$, 300 MHz)



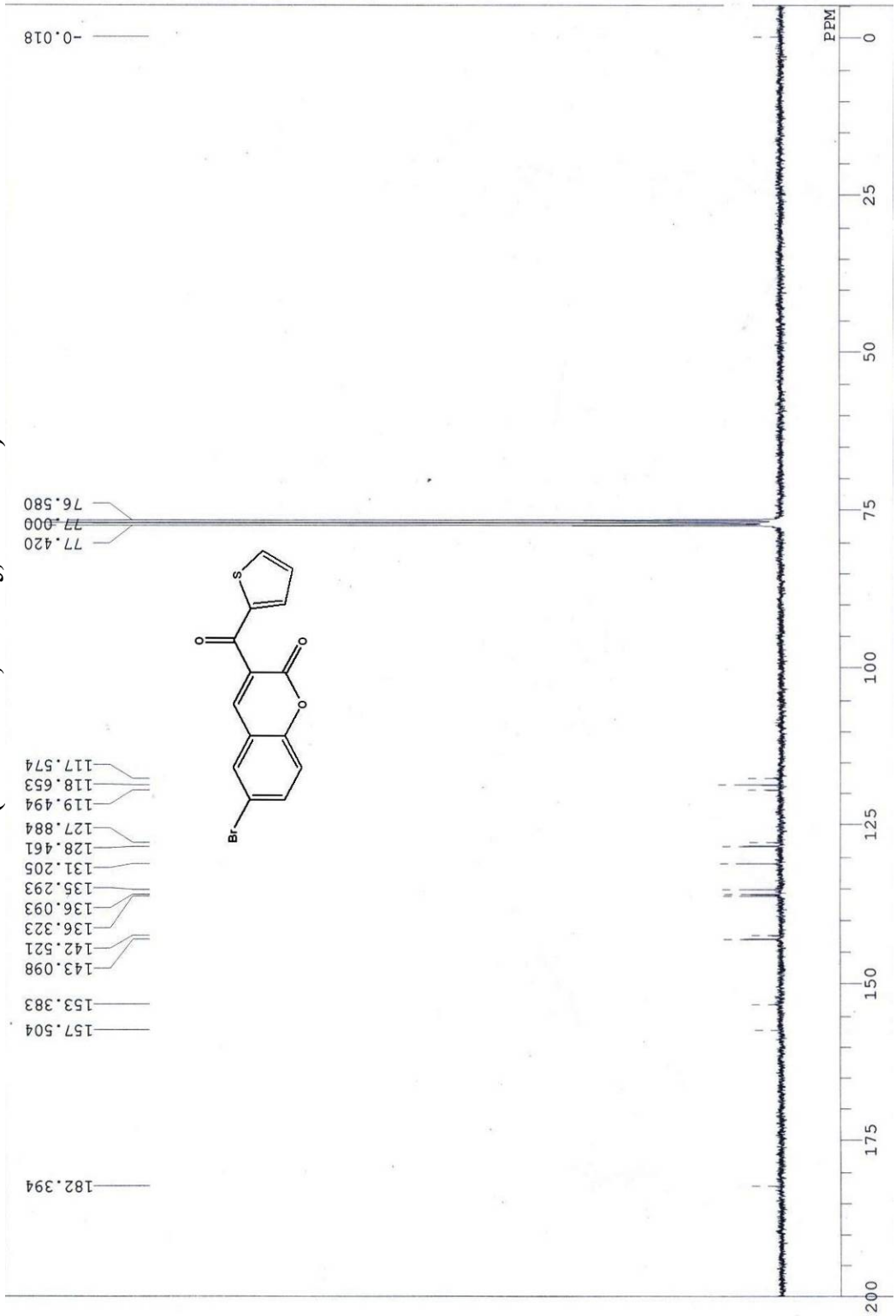
10ia (^{13}C NMR, $CDCl_3$, 75 MHz)



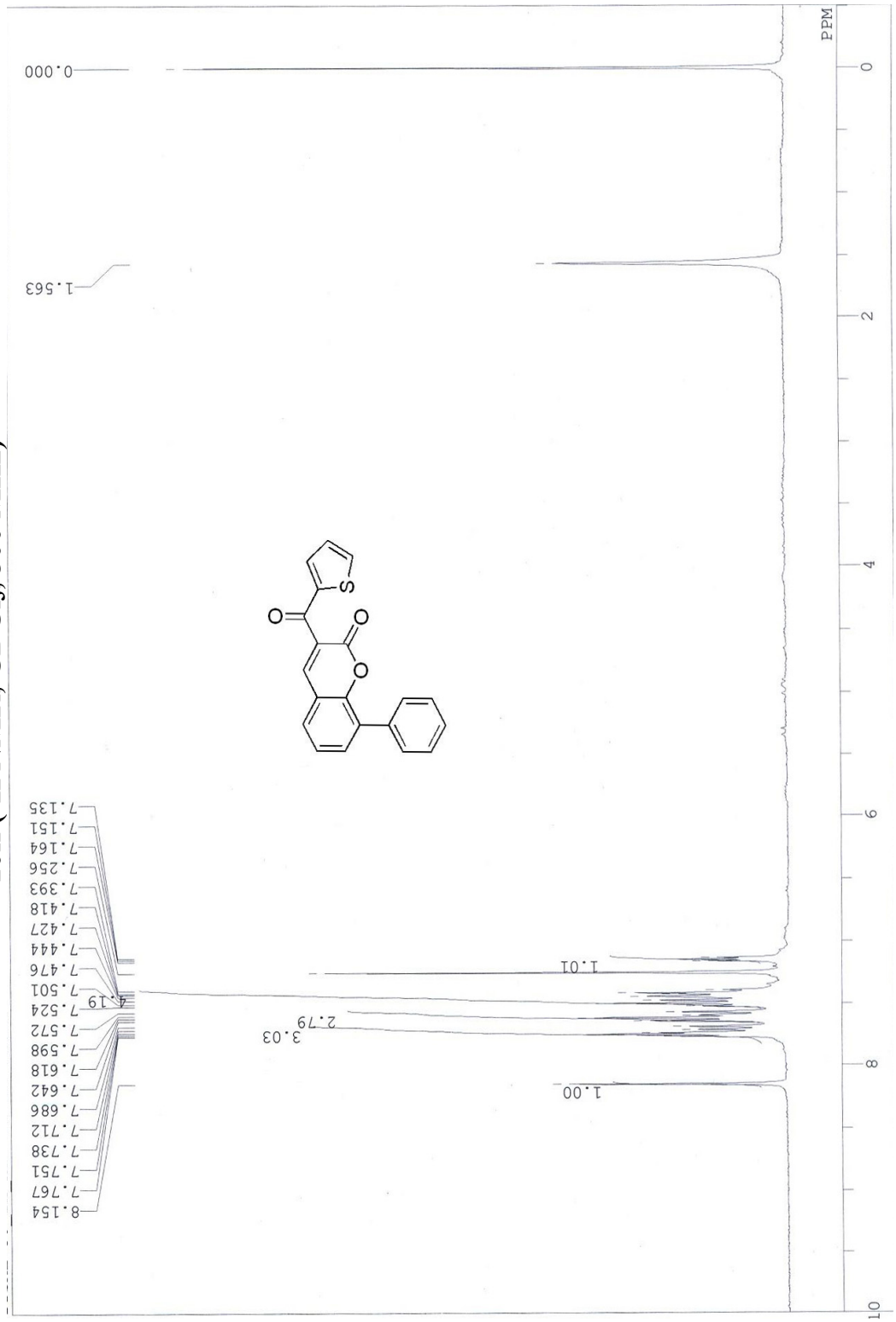
10ib (^{1}H NMR, $CDCl_3$, 300 MHz)



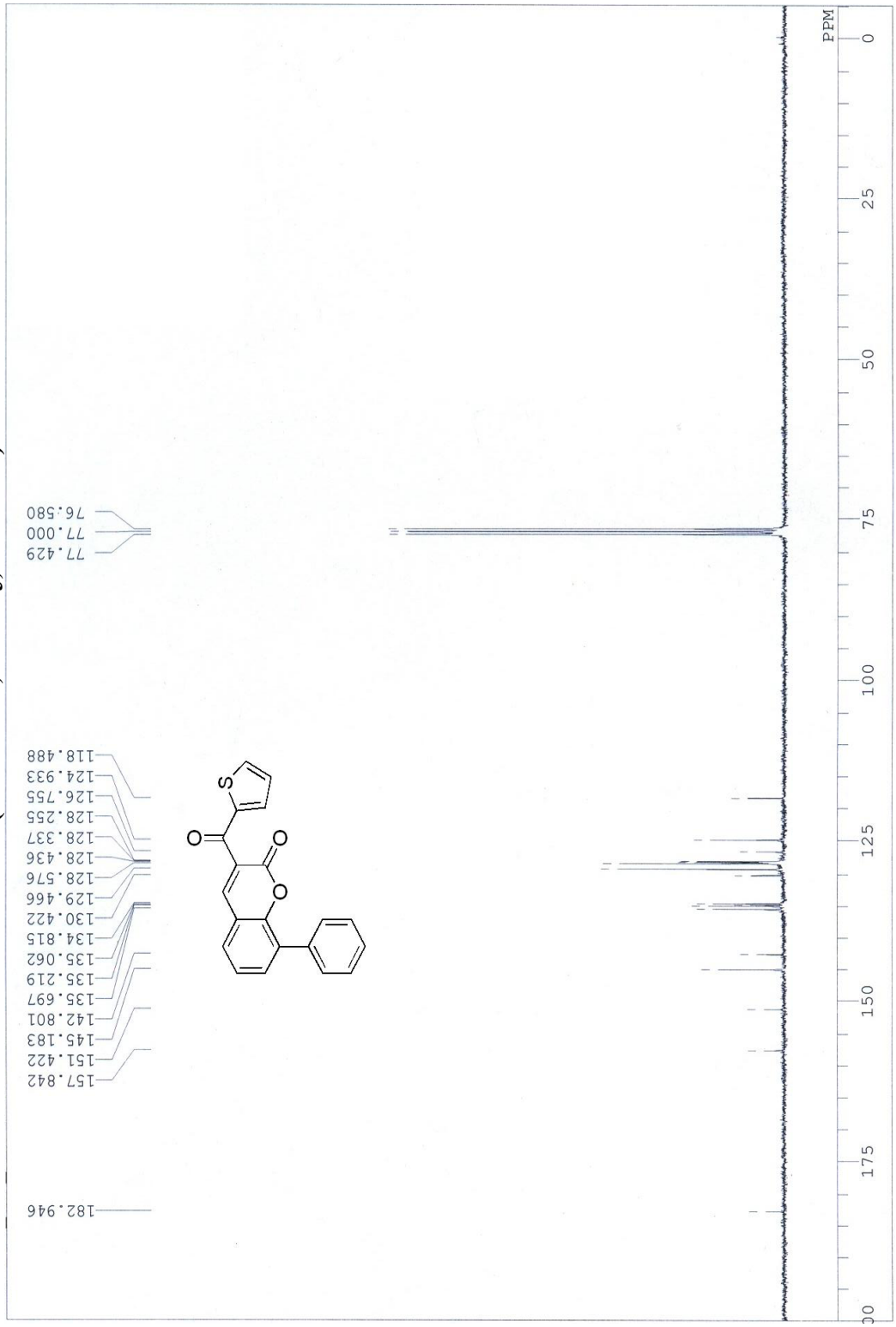
10ib (^{13}C NMR, $CDCl_3$, 75 MHz)



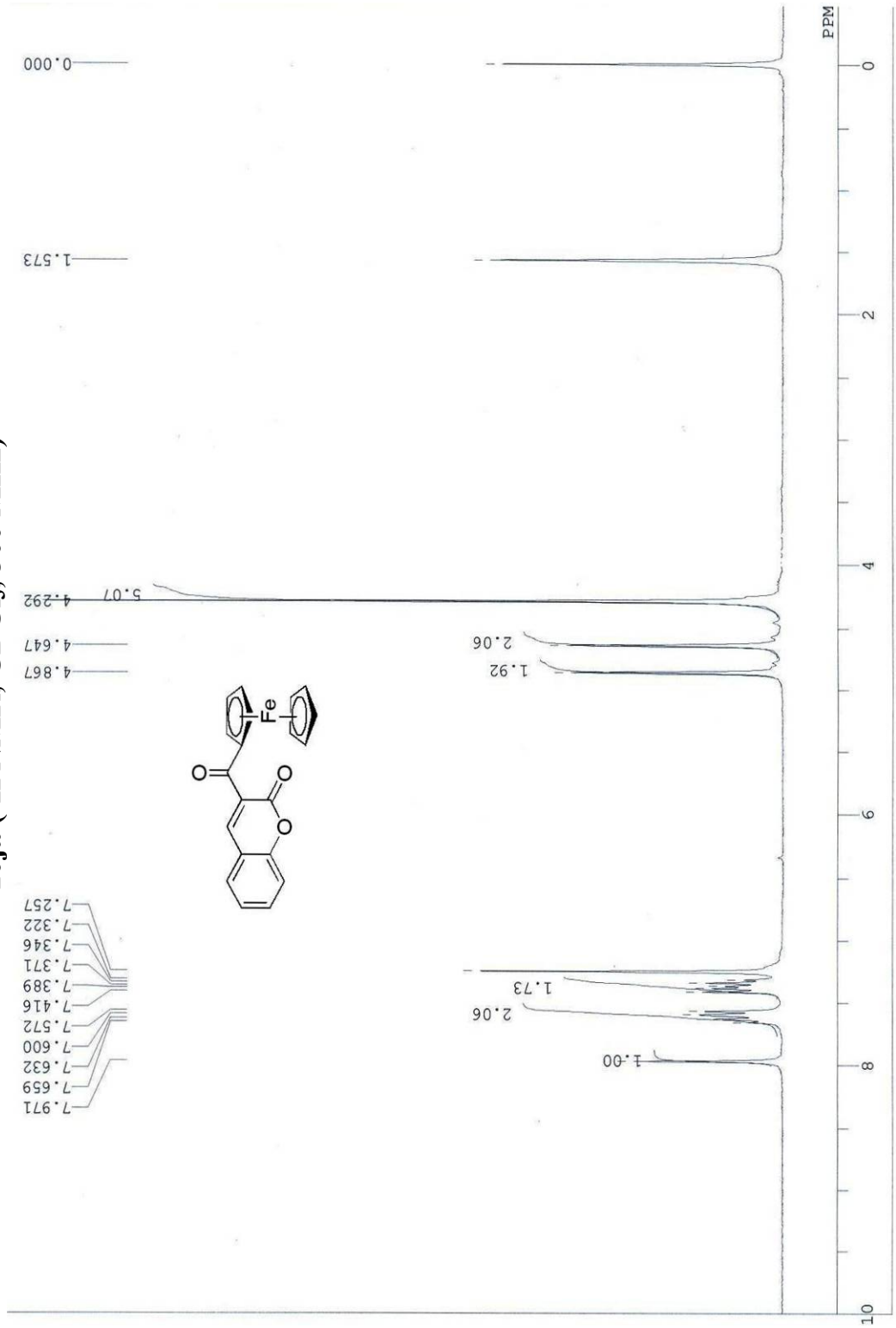
10if (^{1}H NMR, $CDCl_3$, 300 MHz)



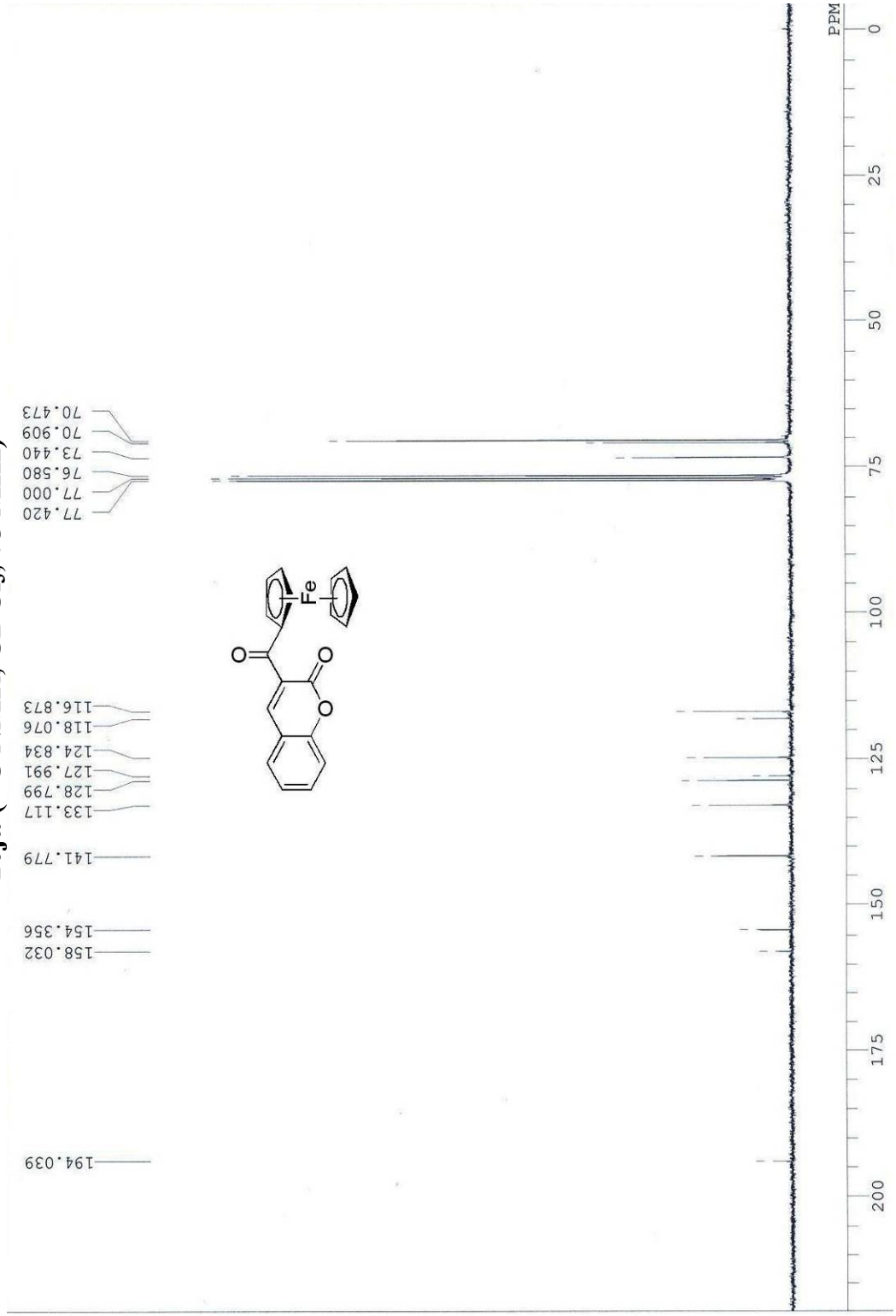
10if (^{13}C NMR, $CDCl_3$, 75 MHz)



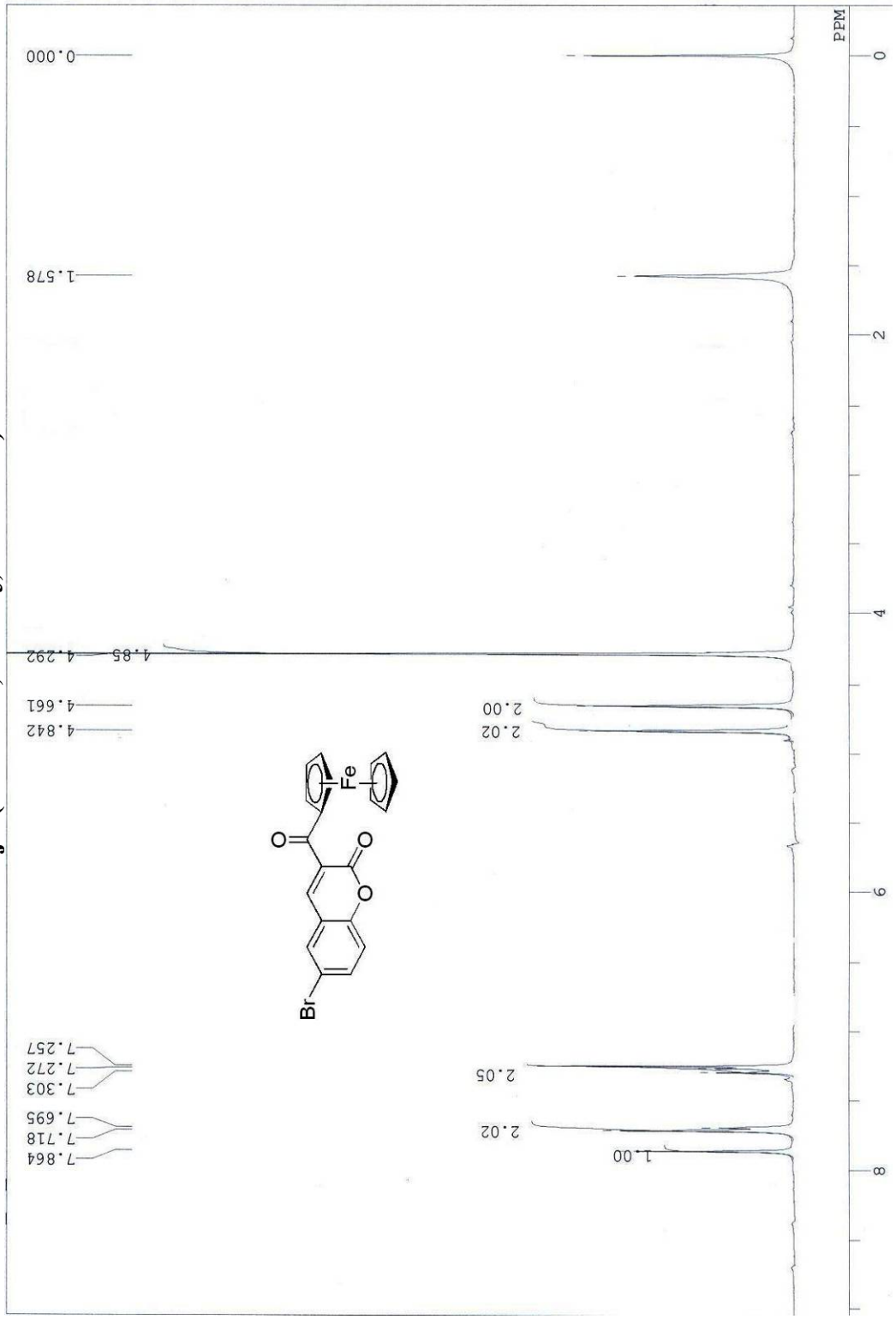
10ja (^{1}H NMR, $CDCl_3$, 300 MHz)



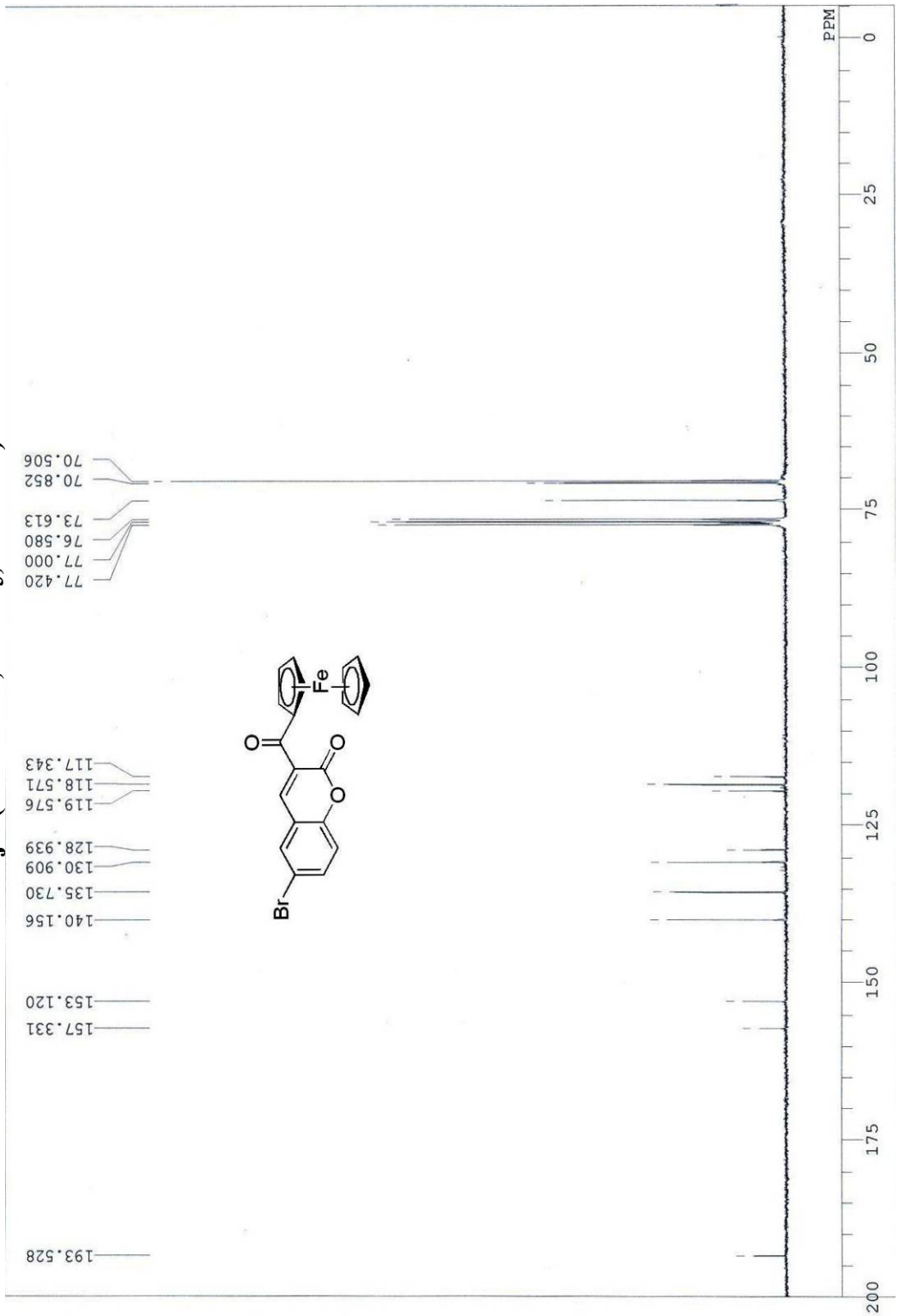
10ja (^{13}C NMR, $CDCl_3$, 75 MHz)



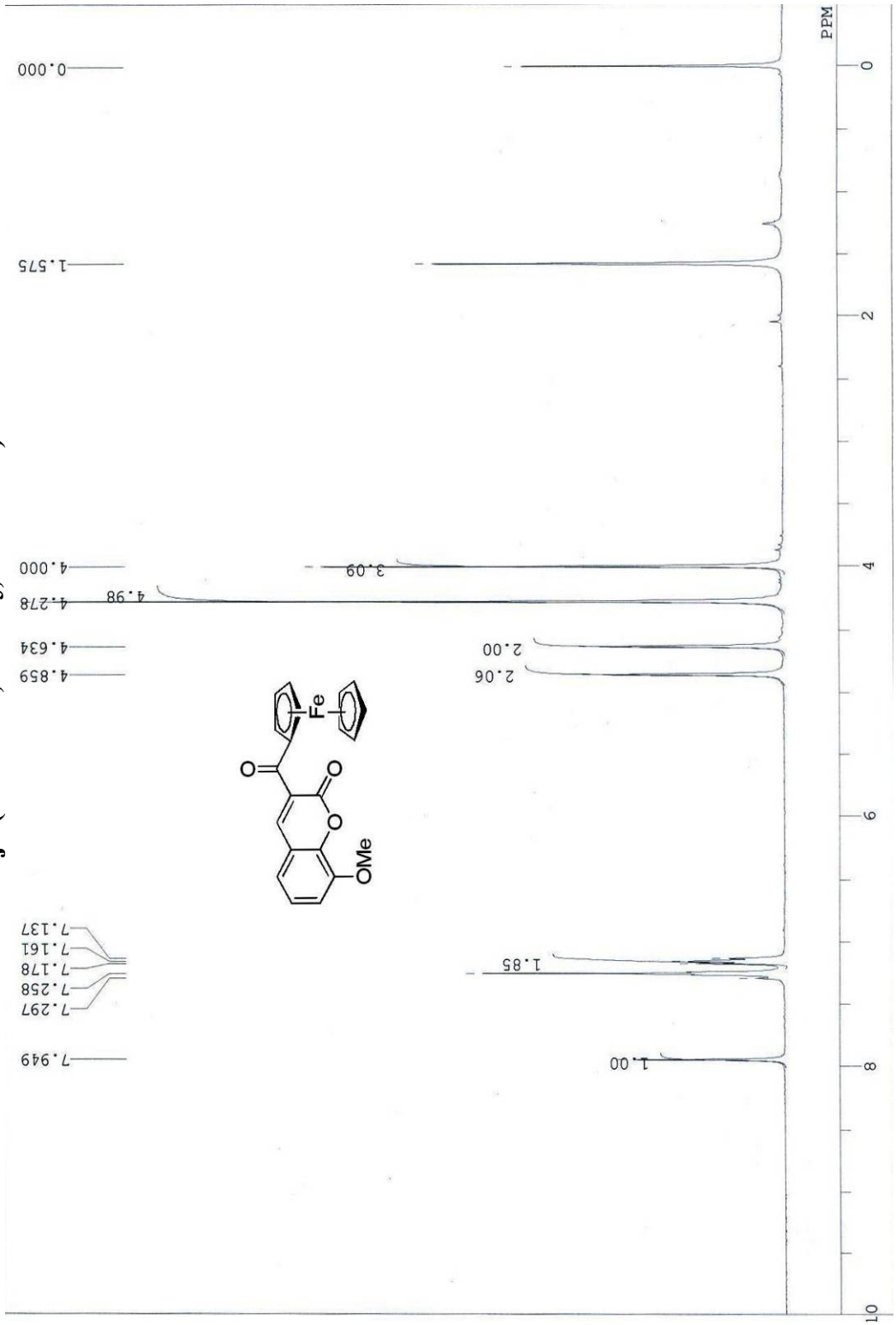
10jb (^{1}H NMR, $CDCl_3$, 300 MHz)



10jb (^{13}C NMR, $CDCl_3$, 75 MHz)



10jc (^{1}H NMR, $CDCl_3$, 300 MHz)



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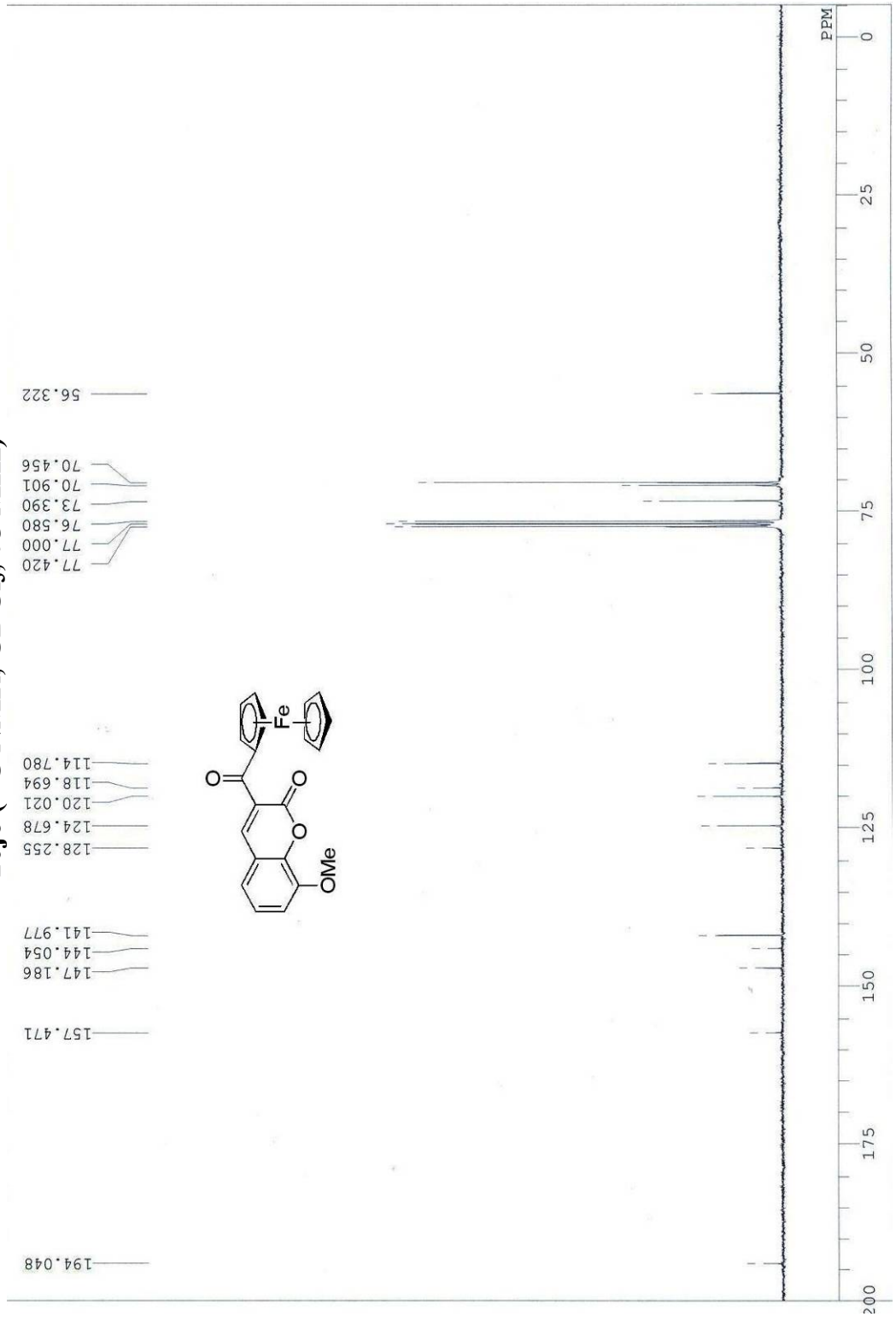

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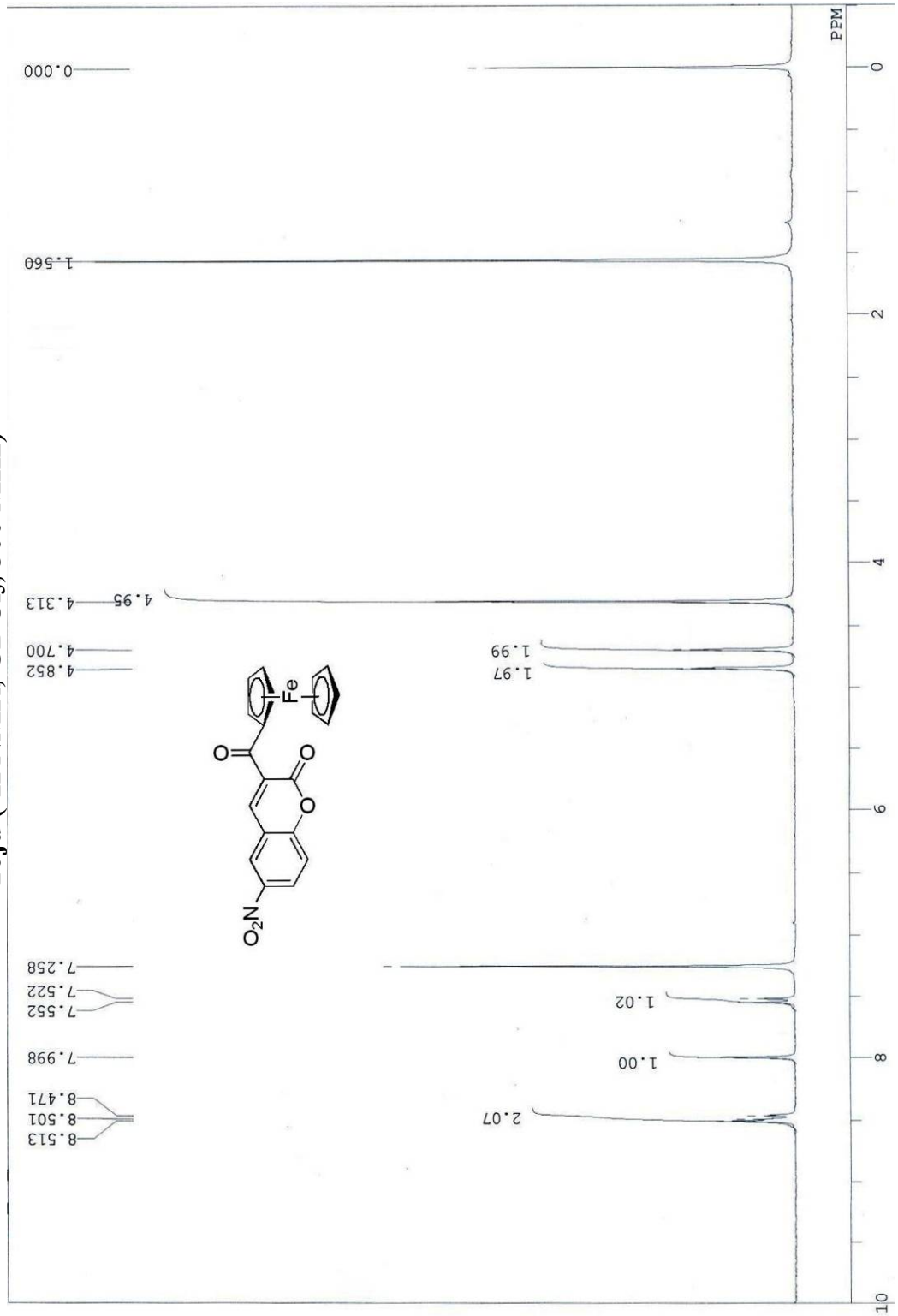
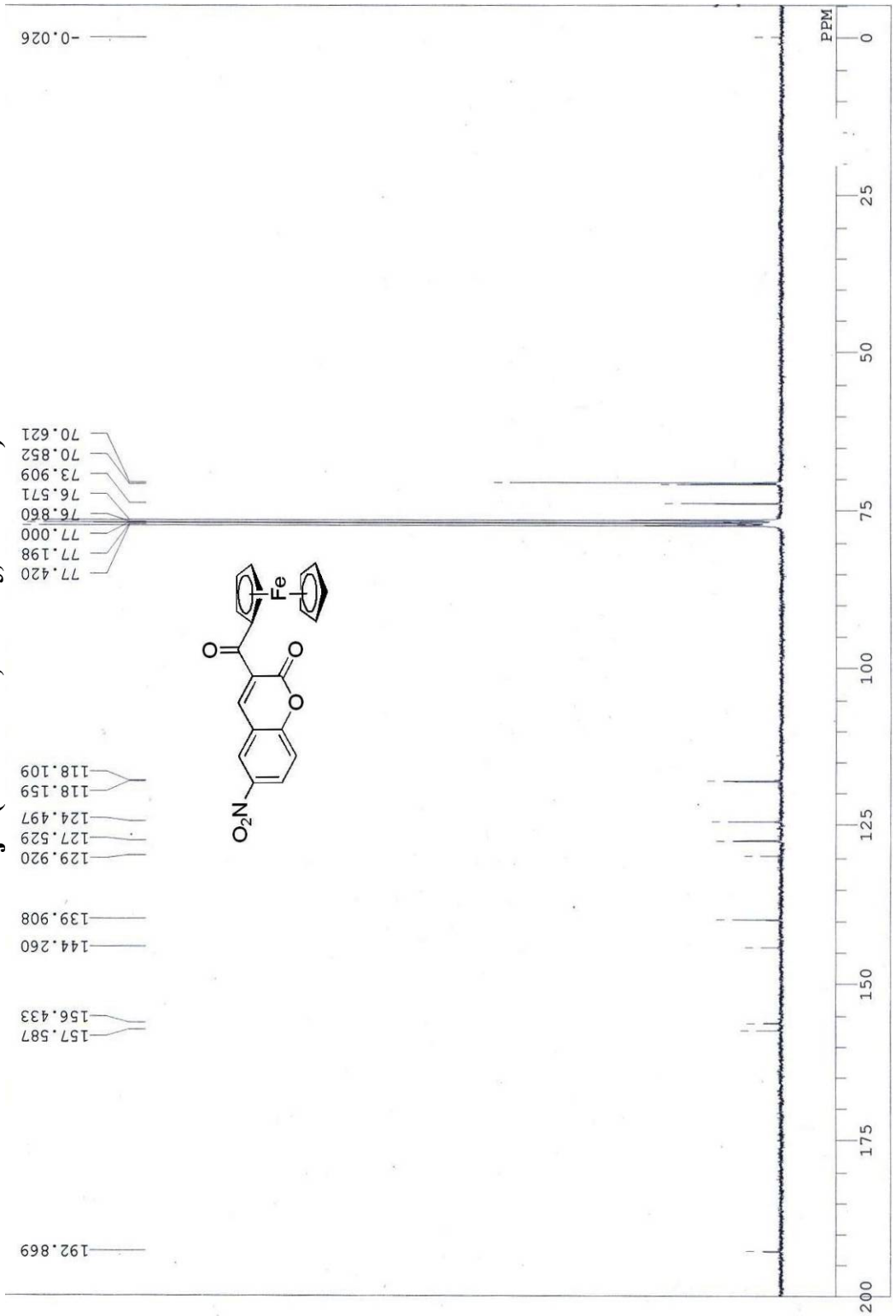
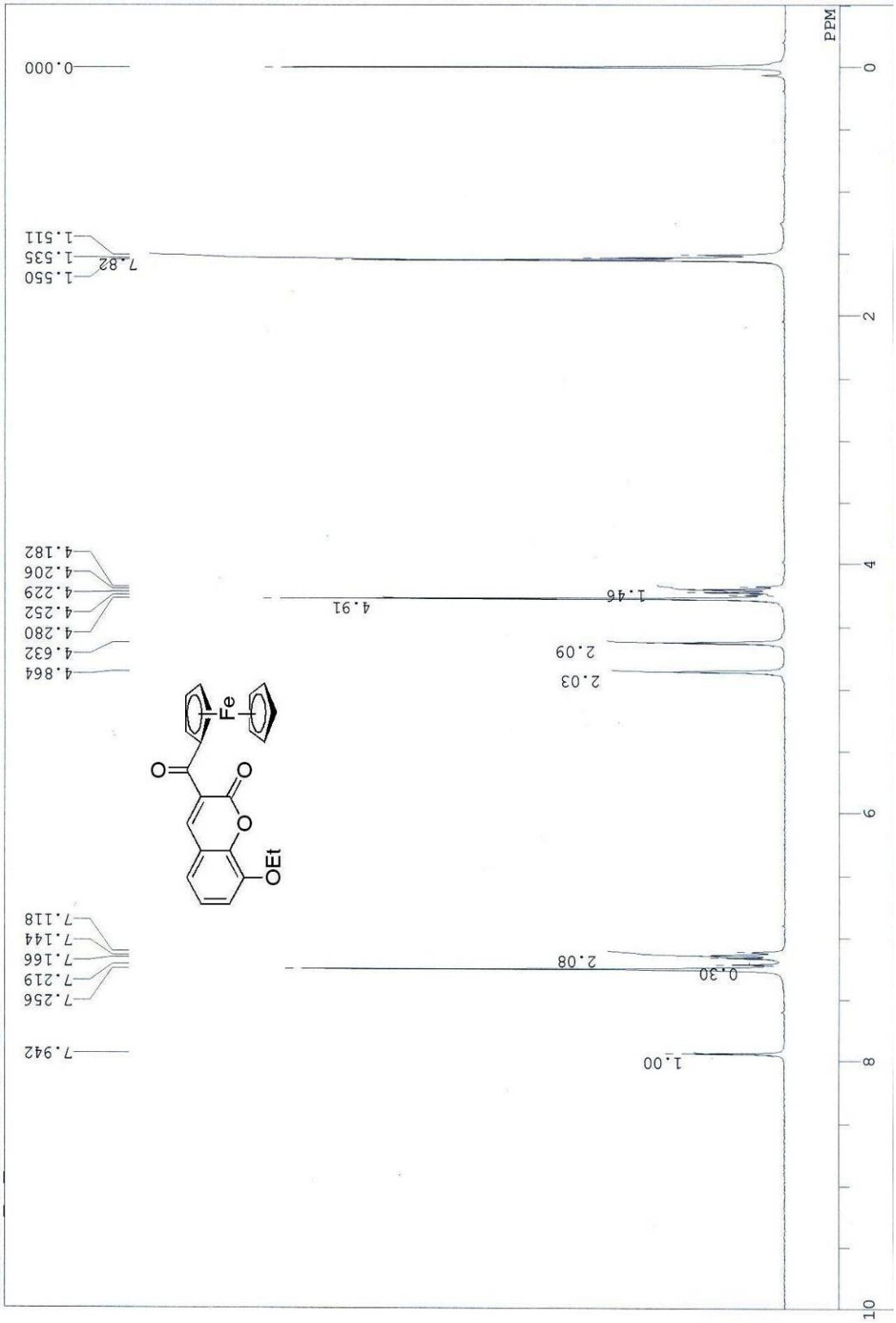


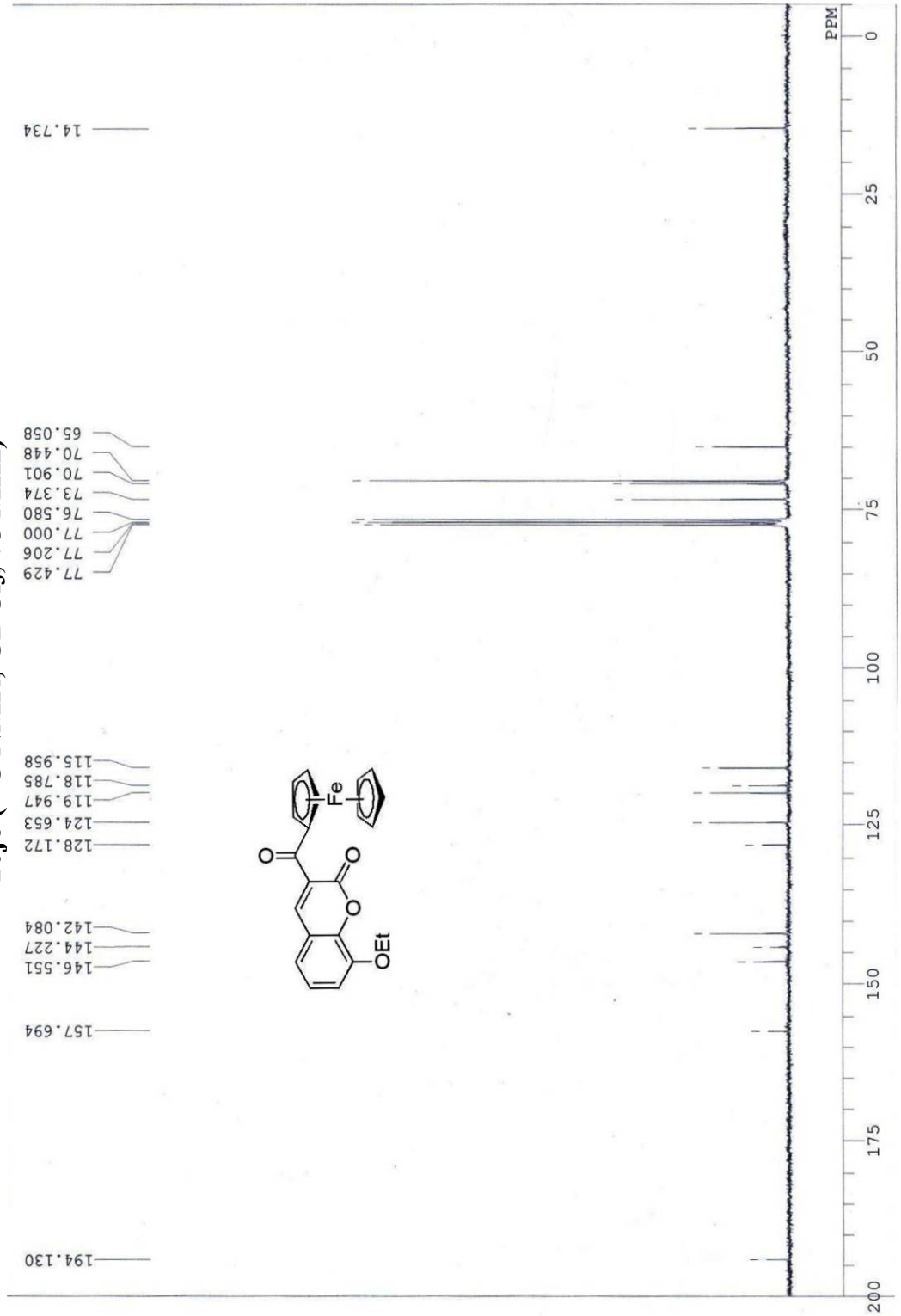
10jd (^{13}C NMR, $CDCl_3$, 75 MHz)



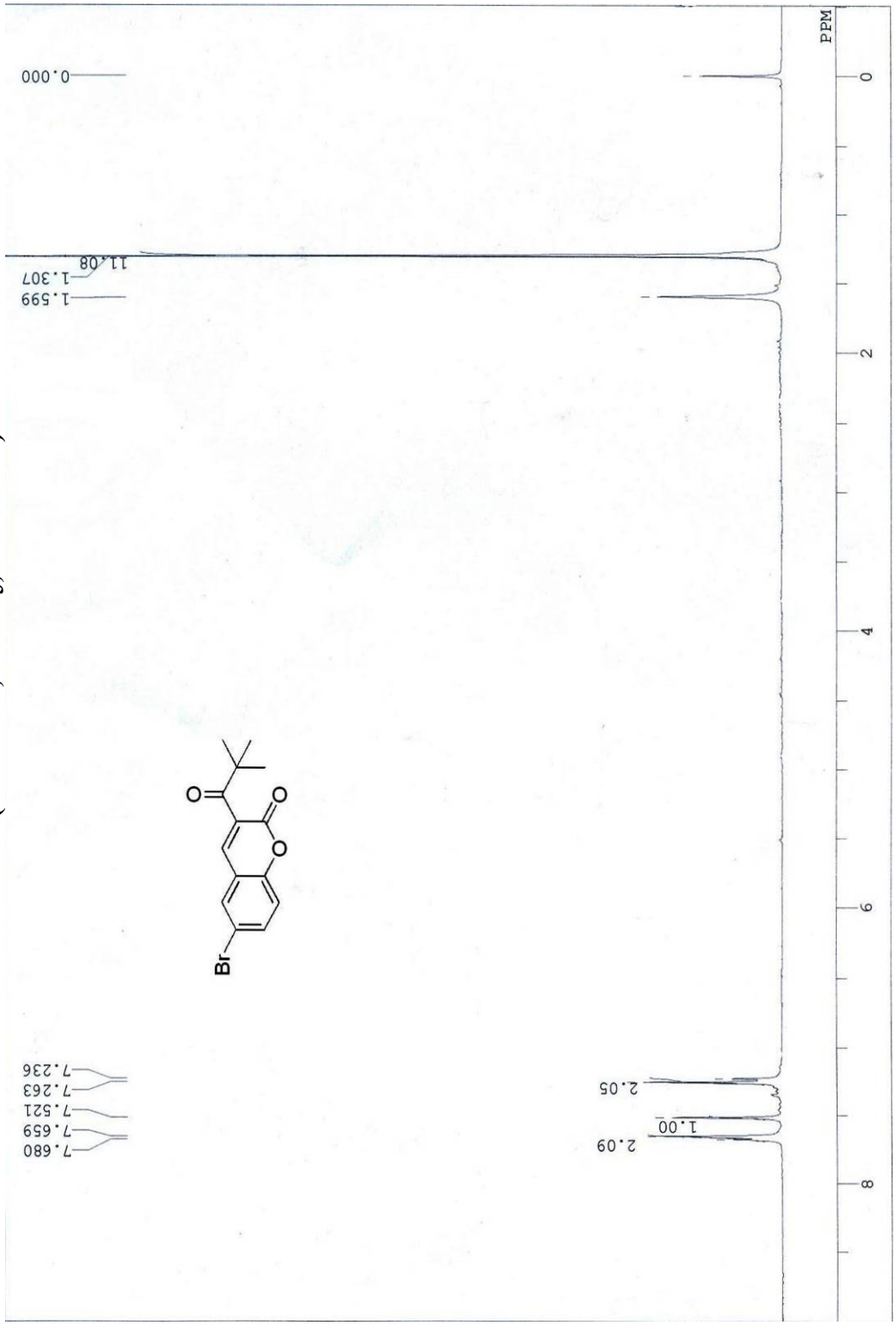
10je (^{1}H NMR, $CDCl_3$, 300 MHz)



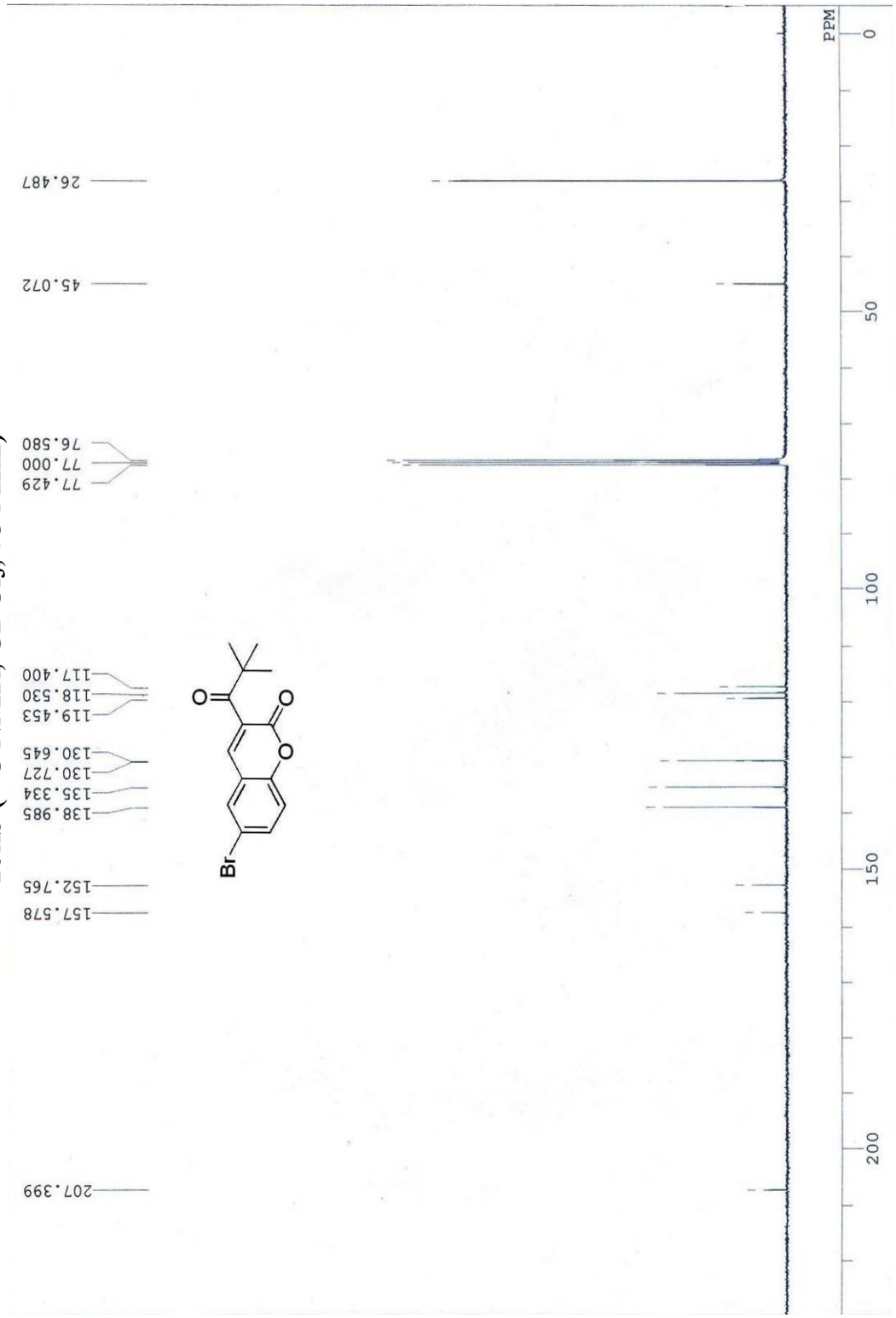
10je (^{13}C NMR, $CDCl_3$, 75 MHz)



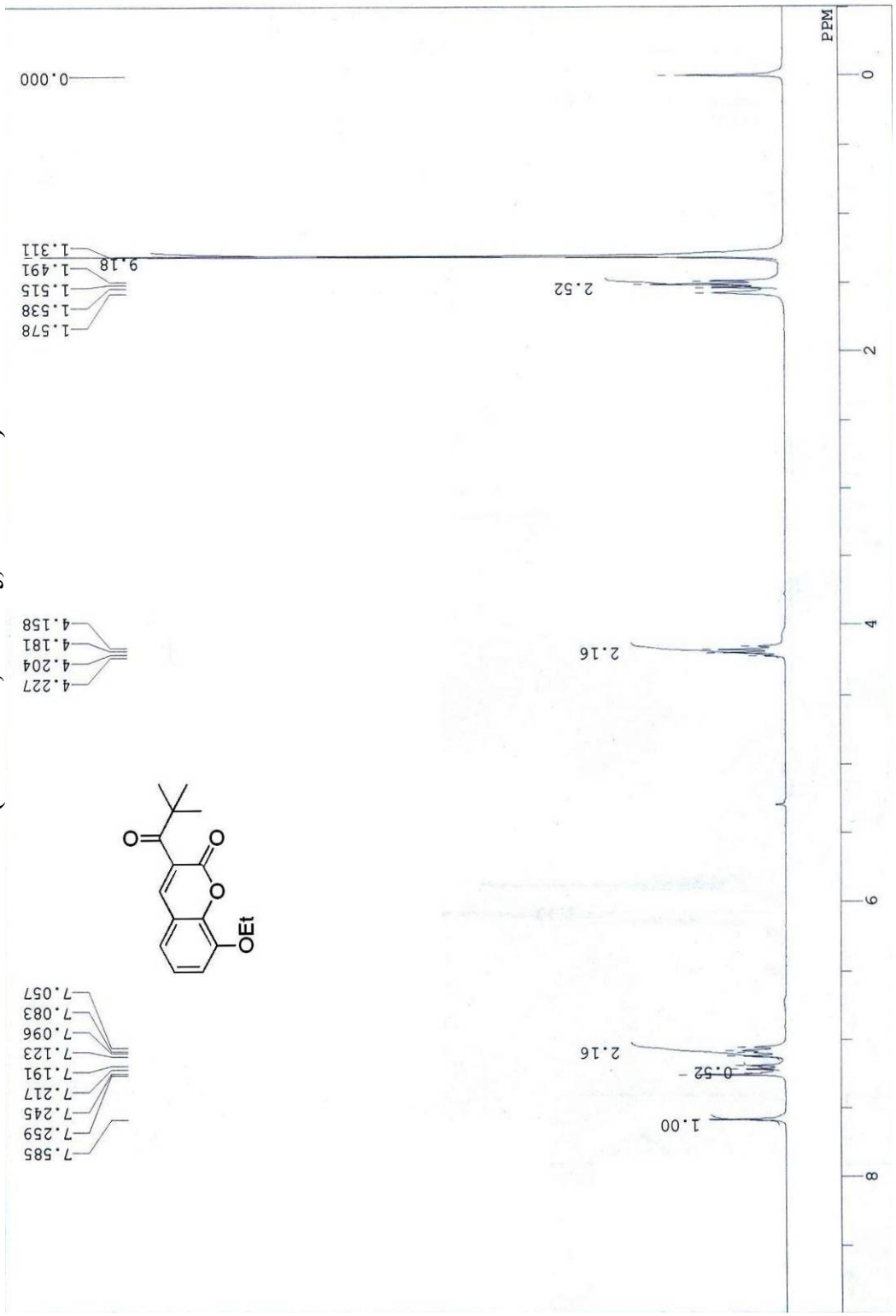
10kb (^{1}H NMR, $CDCl_3$, 300 MHz)



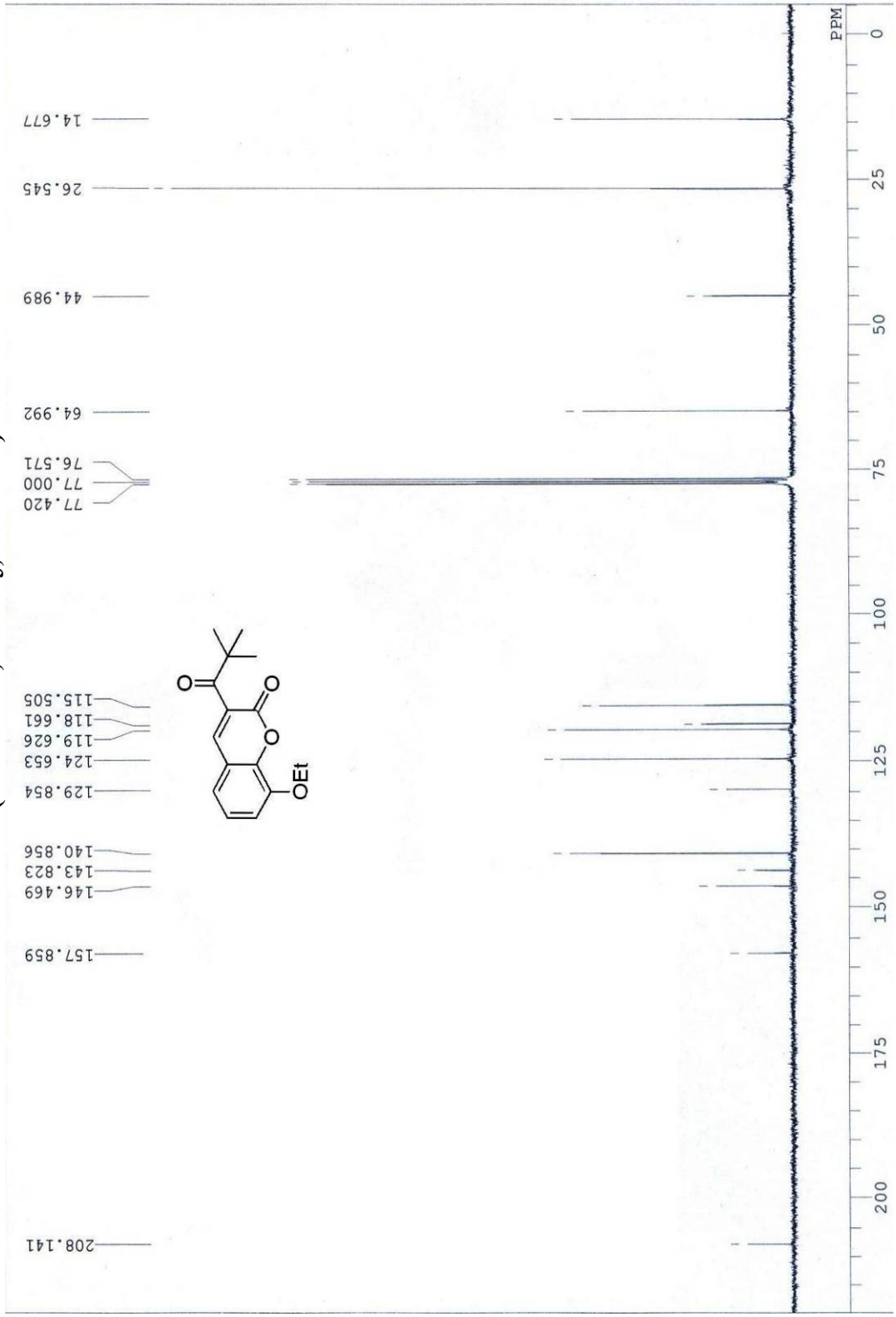
10kb (^{13}C NMR, $CDCl_3$, 75 MHz)



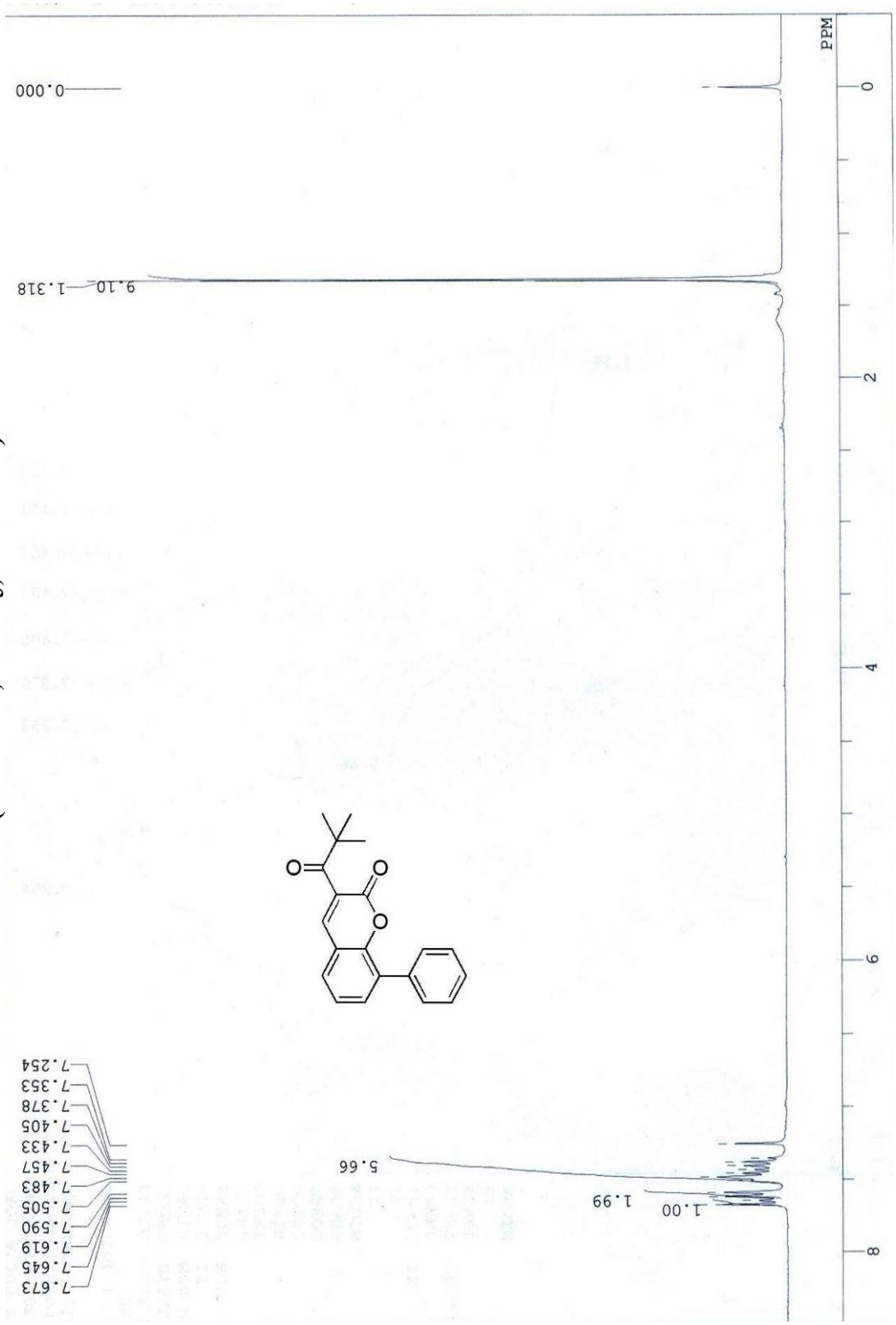
10ke (^{1}H NMR, $CDCl_3$, 300 MHz)



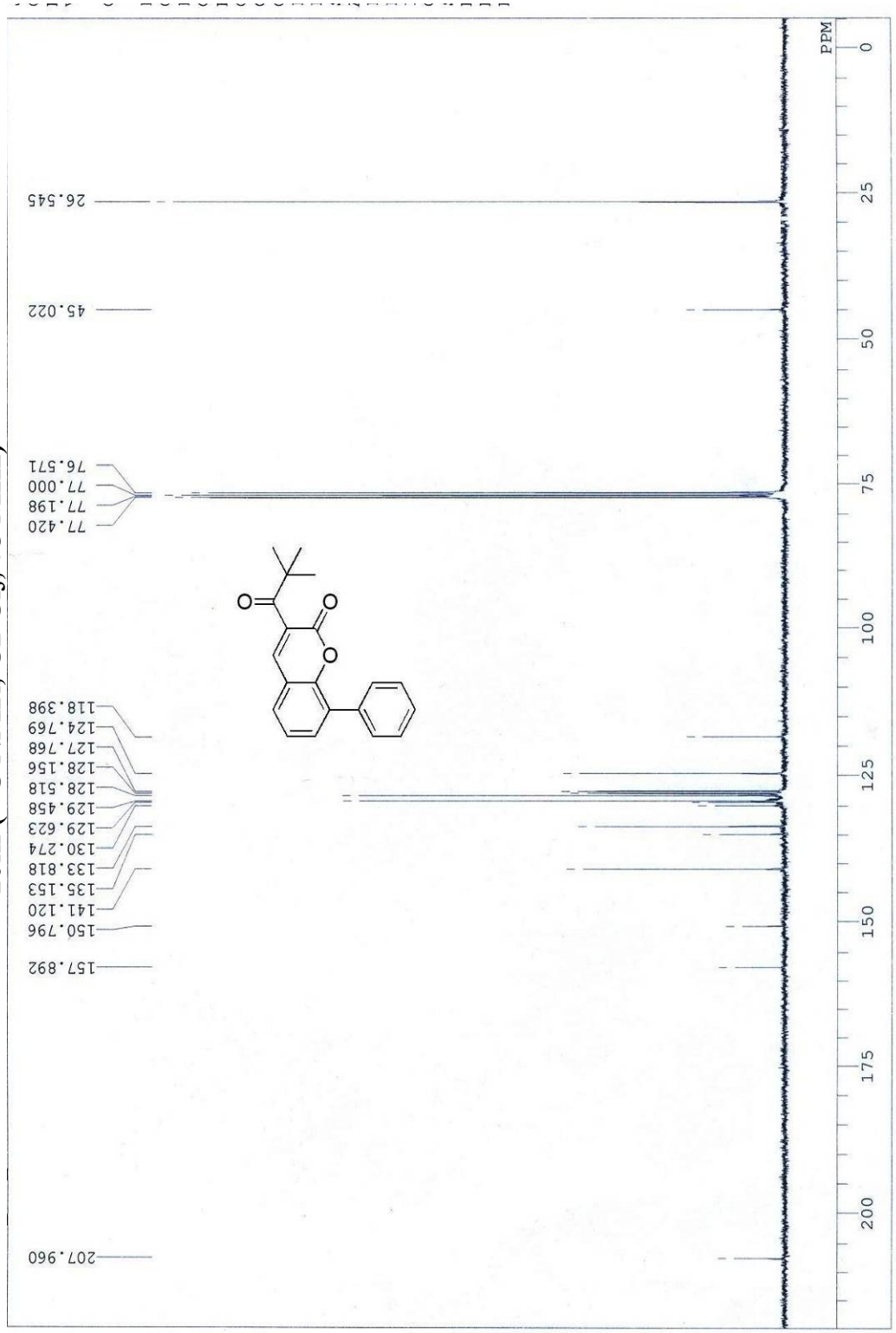
10ke (^{13}C NMR, $CDCl_3$, 75 MHz)



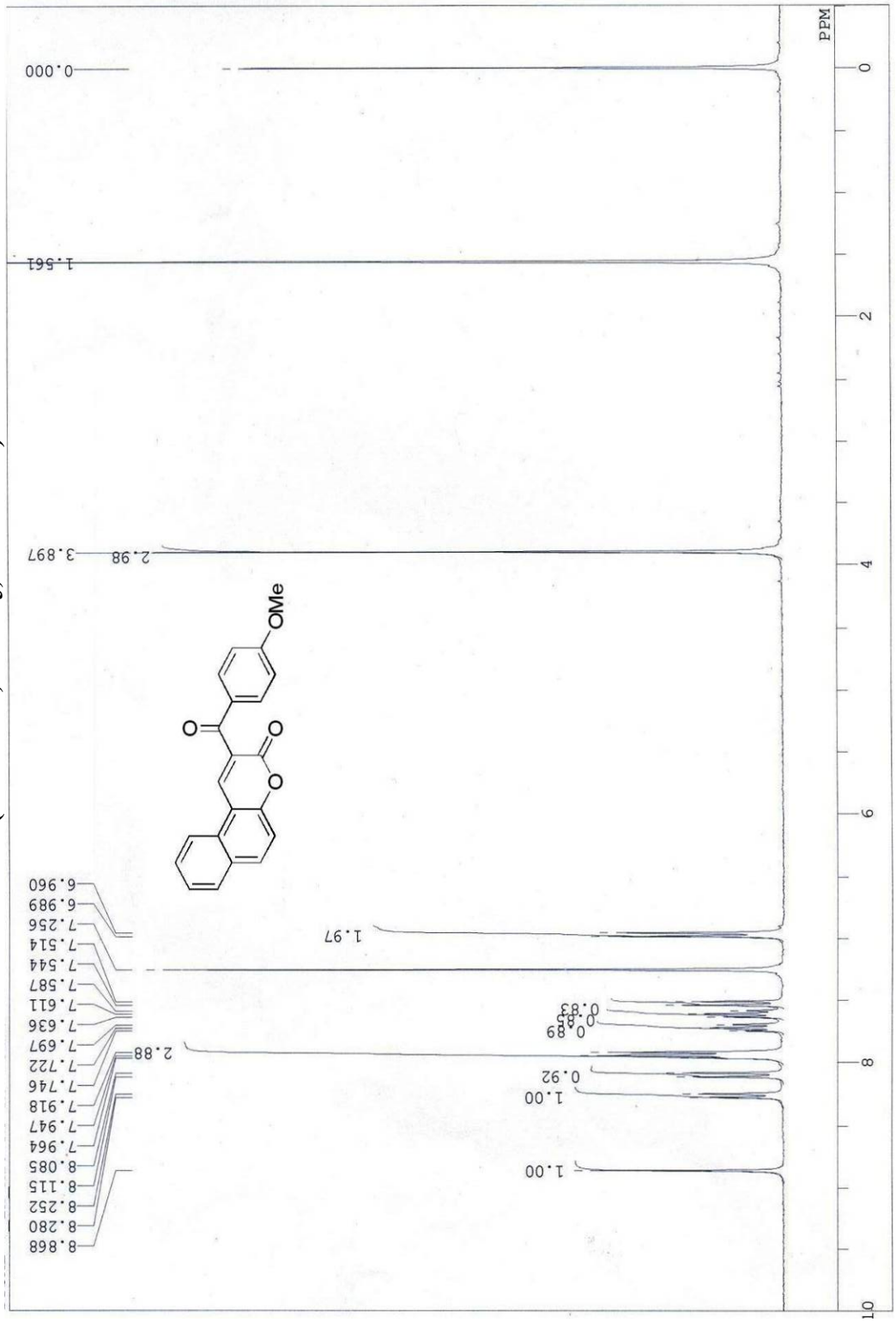
10kf (^{1}H NMR, $CDCl_3$, 300 MHz)



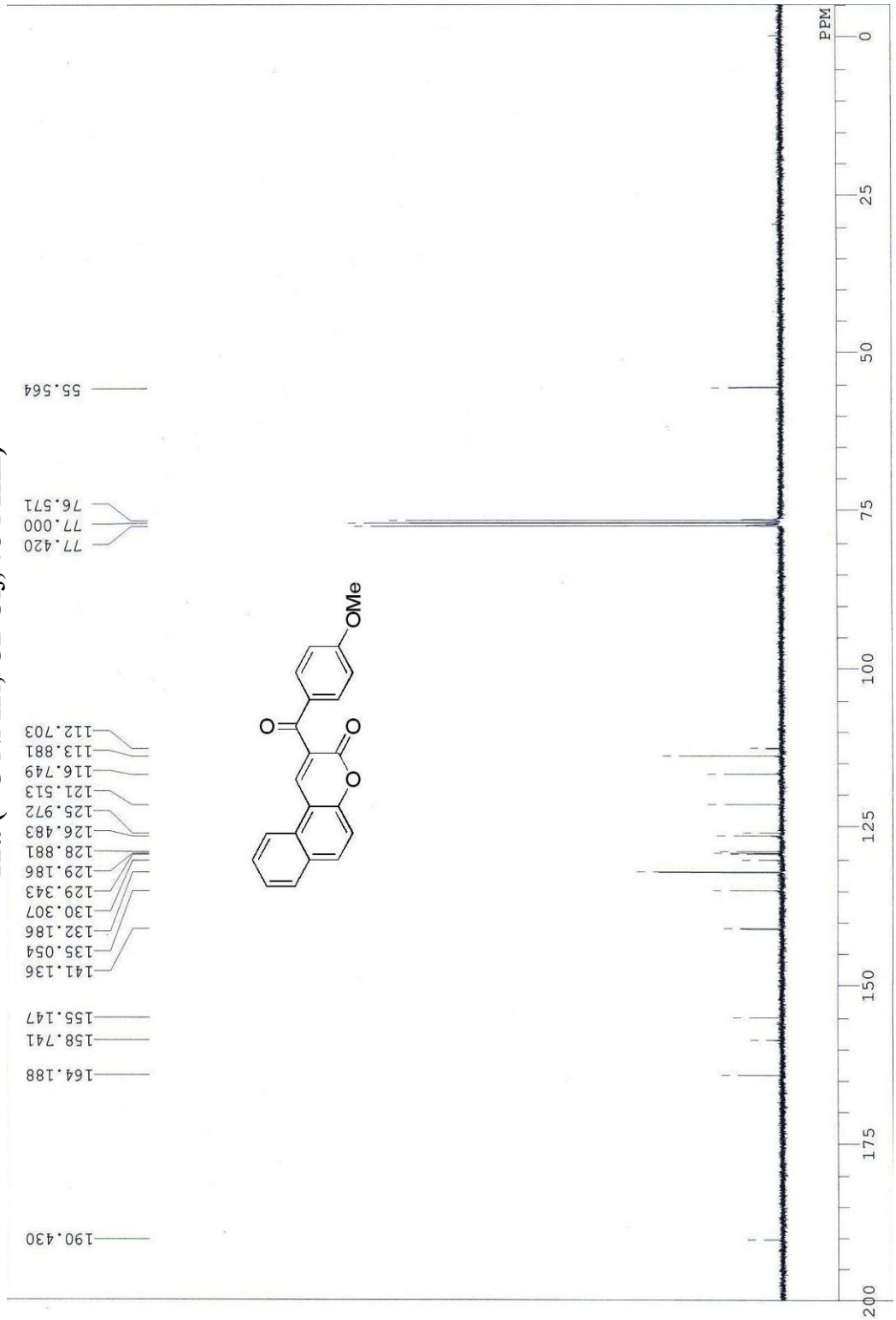
10kf (^{13}C NMR, $CDCl_3$, 75 MHz)



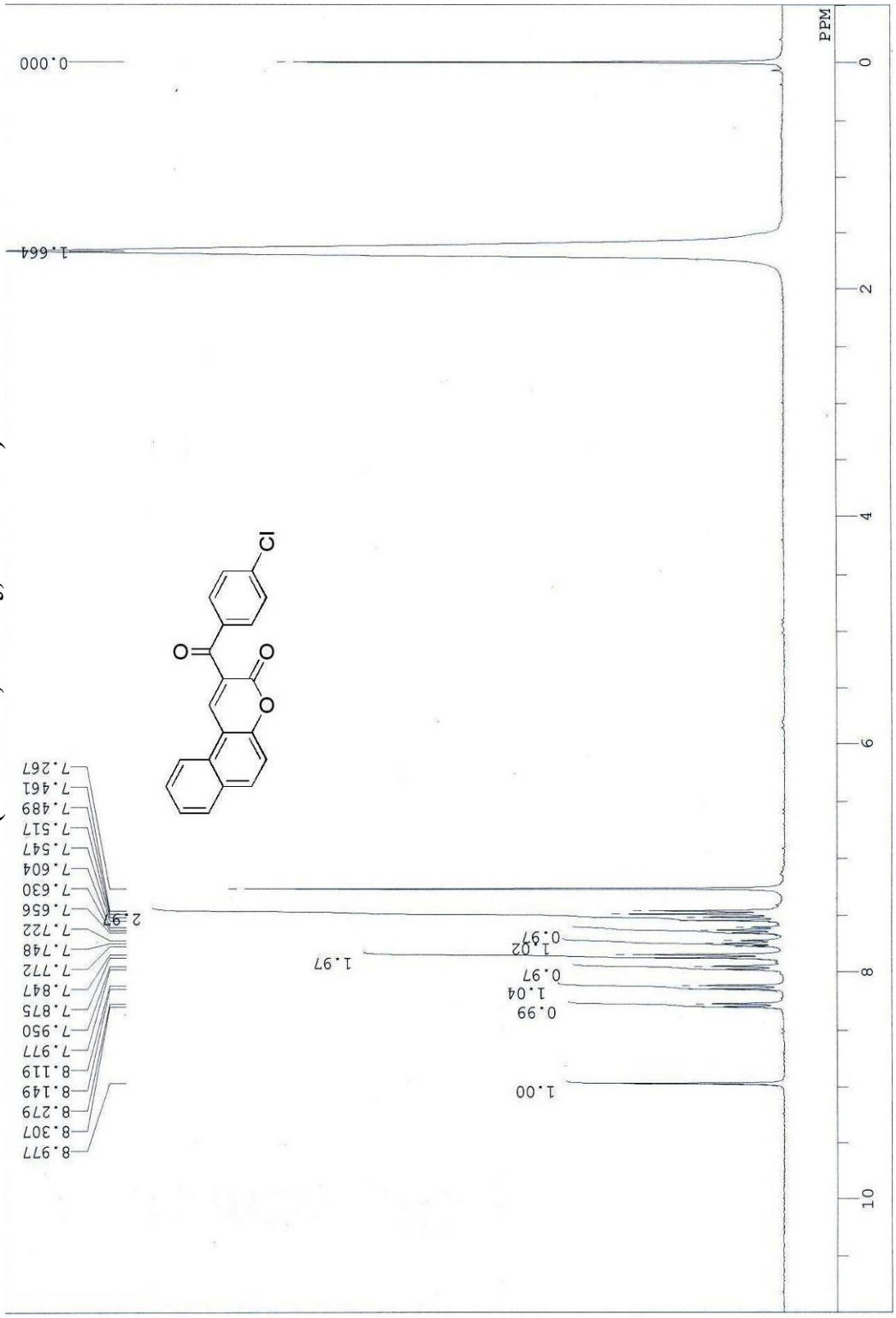
12a (^{1}H NMR, $CDCl_3$, 300 MHz)



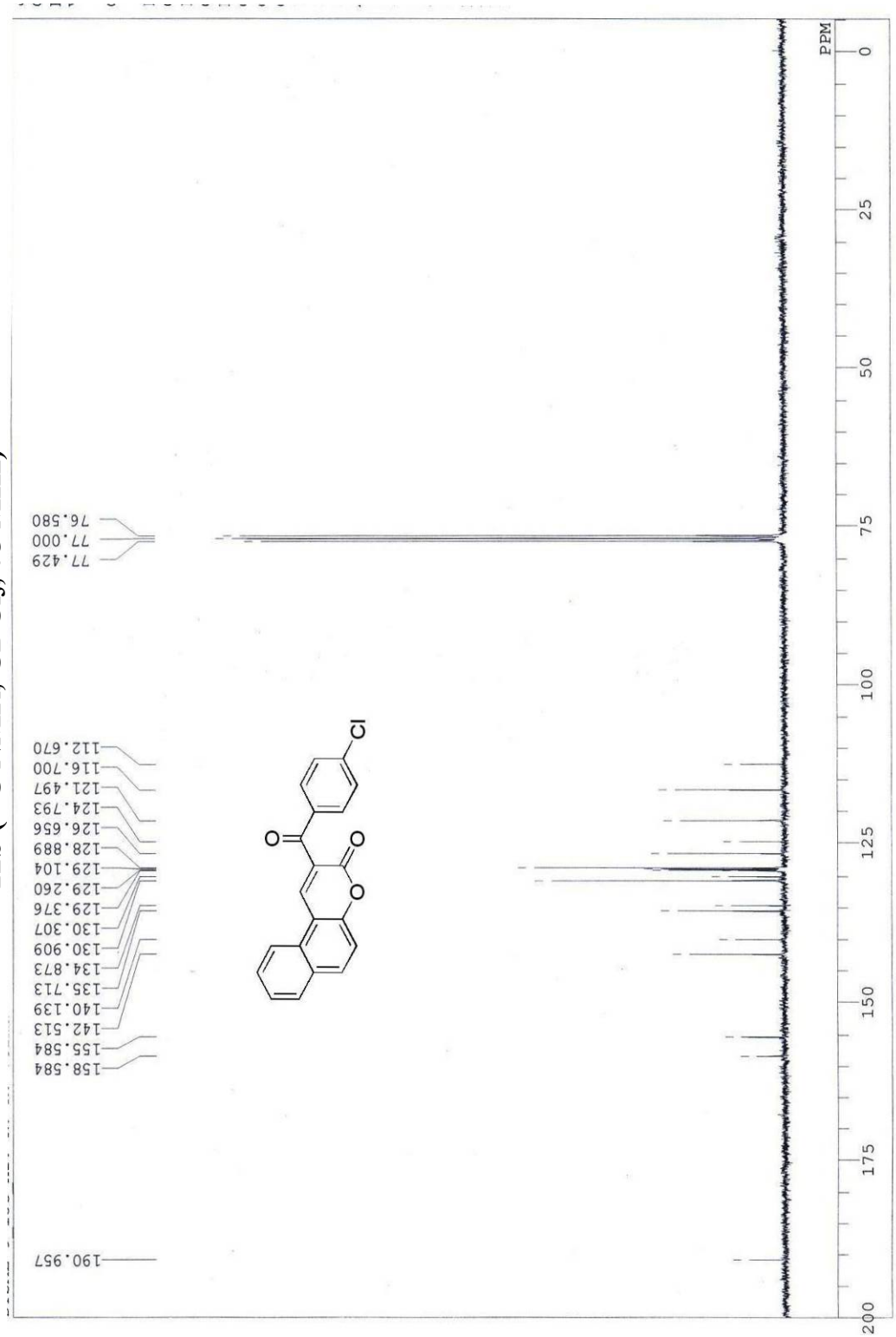
12a (^{13}C NMR, $CDCl_3$, 75 MHz)



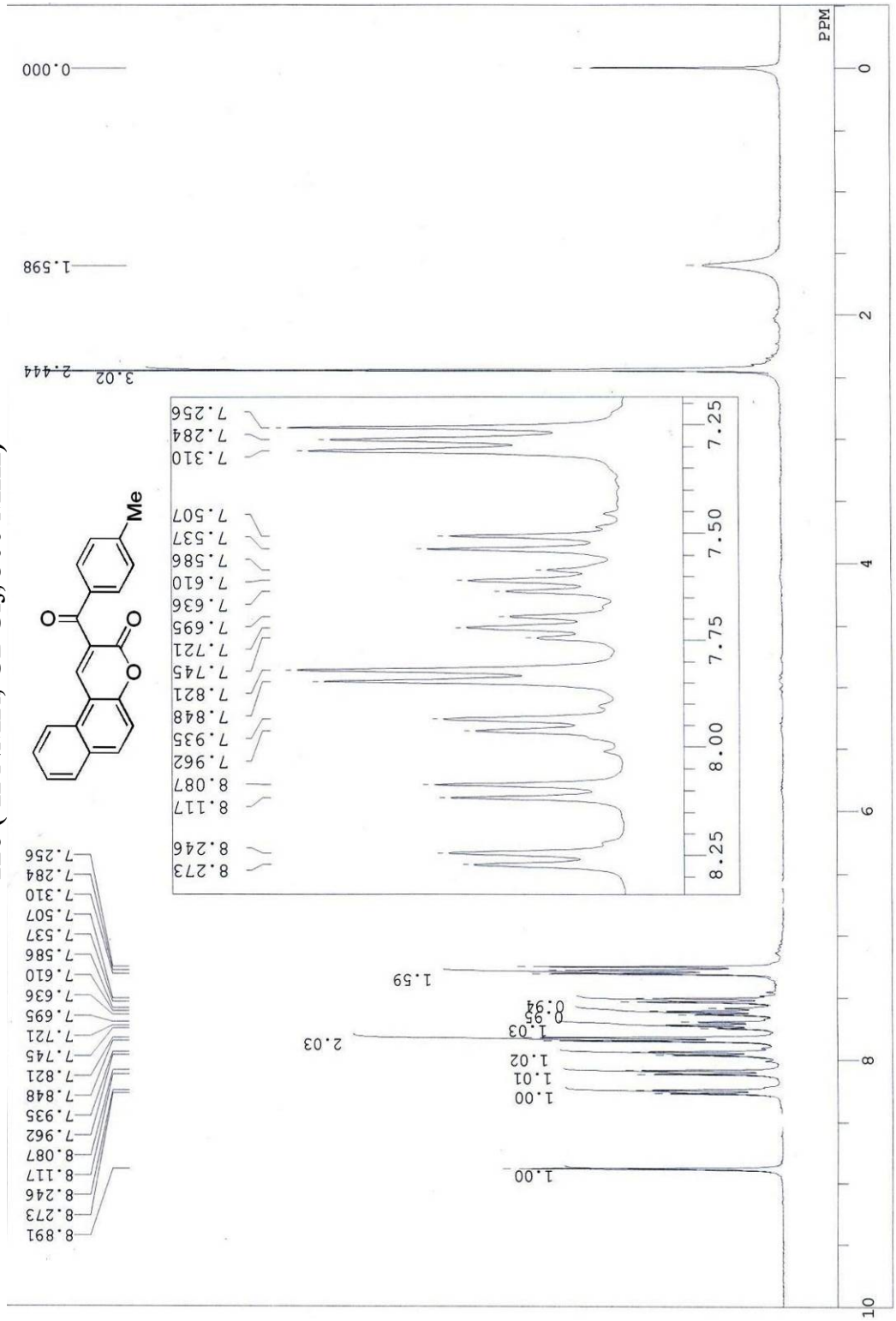
12b (^{1}H NMR, $CDCl_3$, 300 MHz)



12b (^{13}C NMR, $CDCl_3$, 75 MHz)

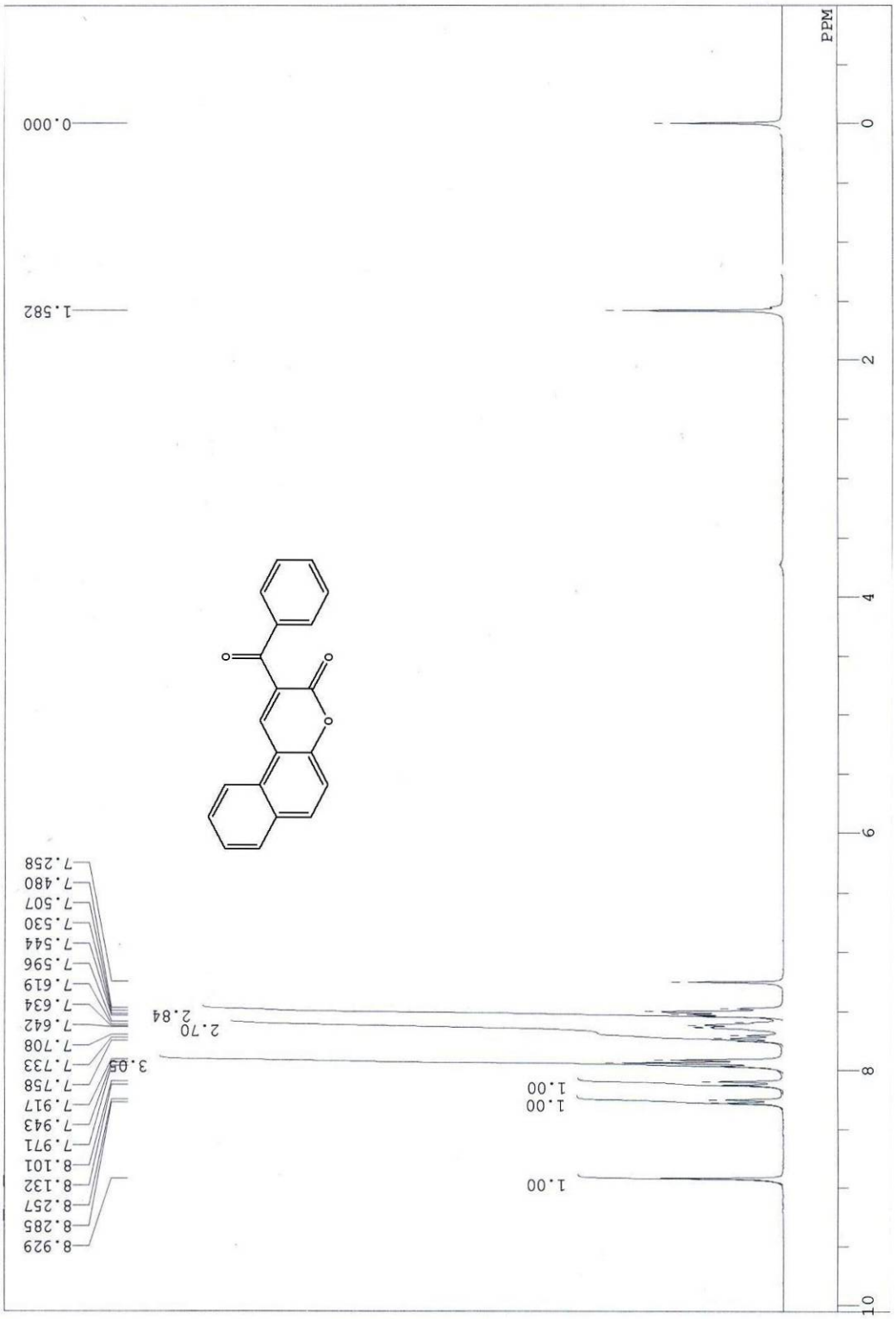


12c (^{1}H NMR, $CDCl_3$, 300 MHz)

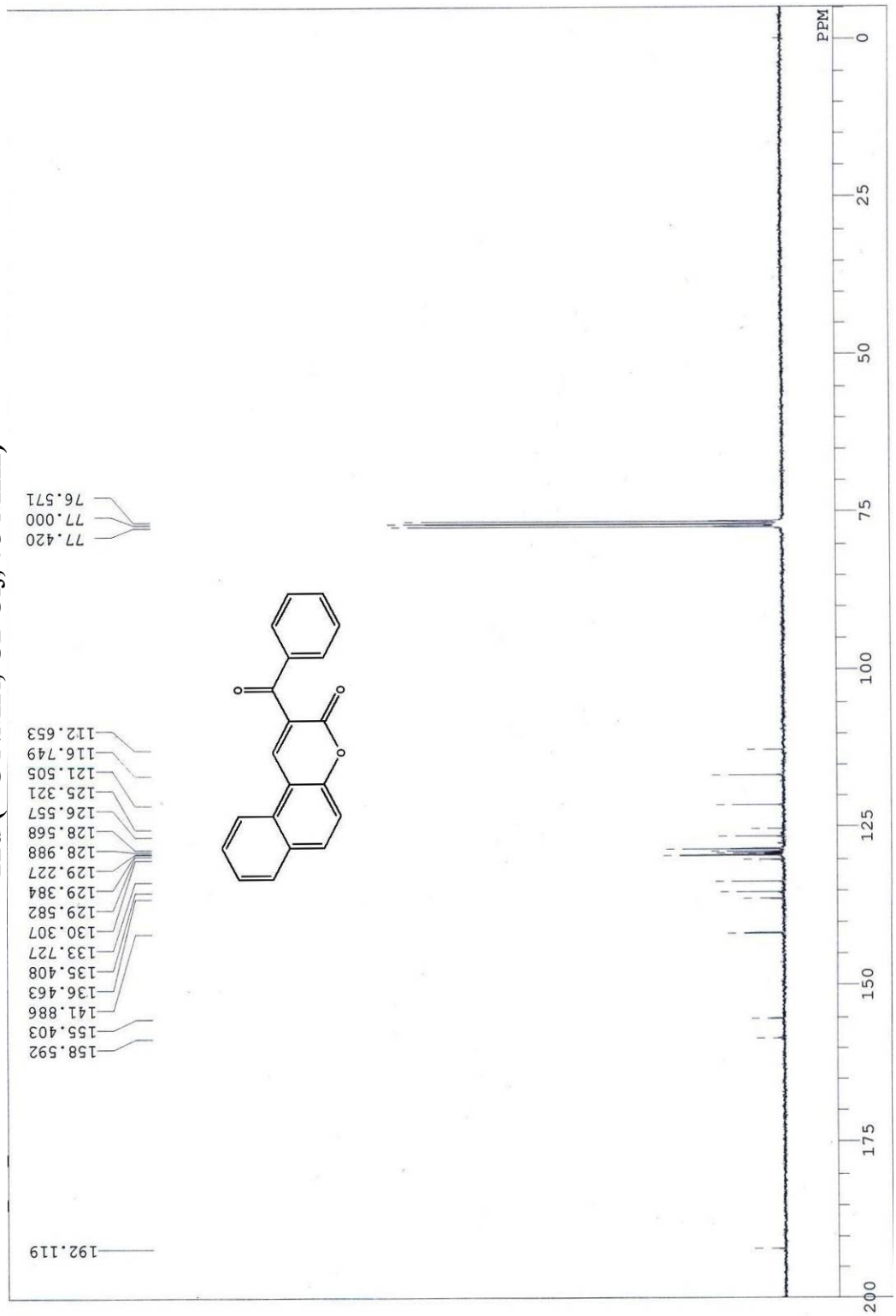


12c (^{13}C NMR, $CDCl_3$, 75 MHz)

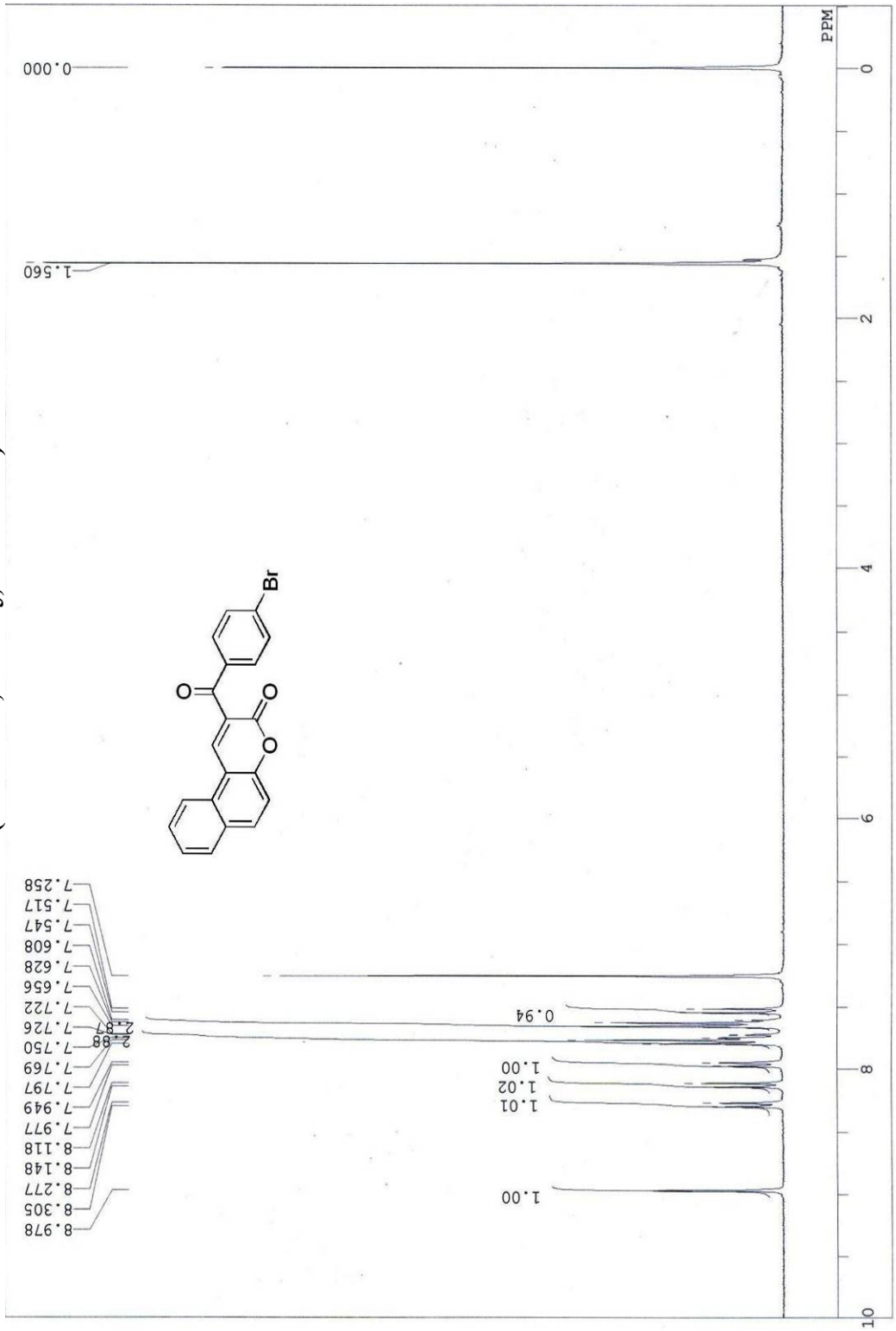
12d (^{1}H NMR, $CDCl_3$, 300 MHz)



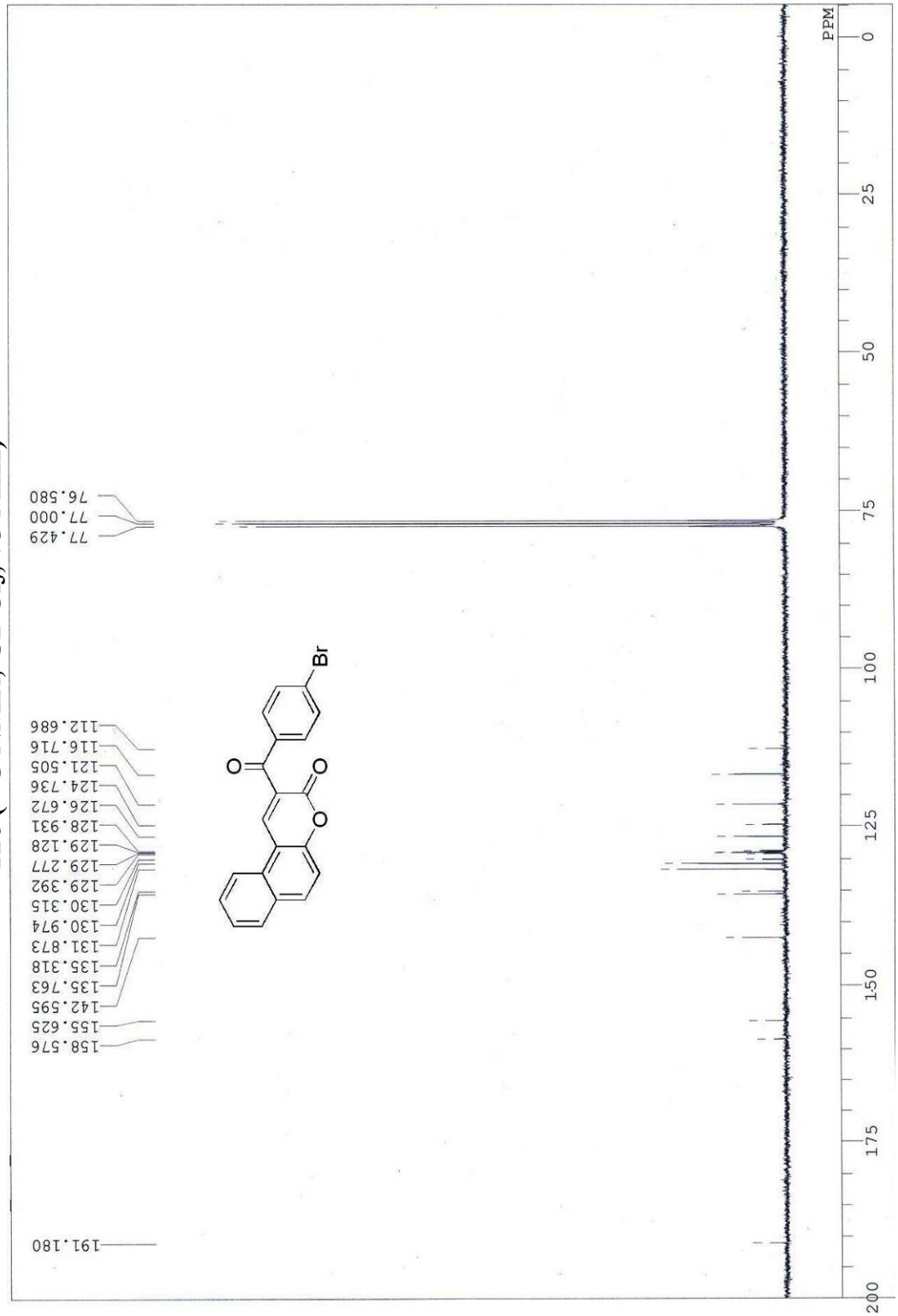
12d (^{13}C NMR, $CDCl_3$, 75 MHz)



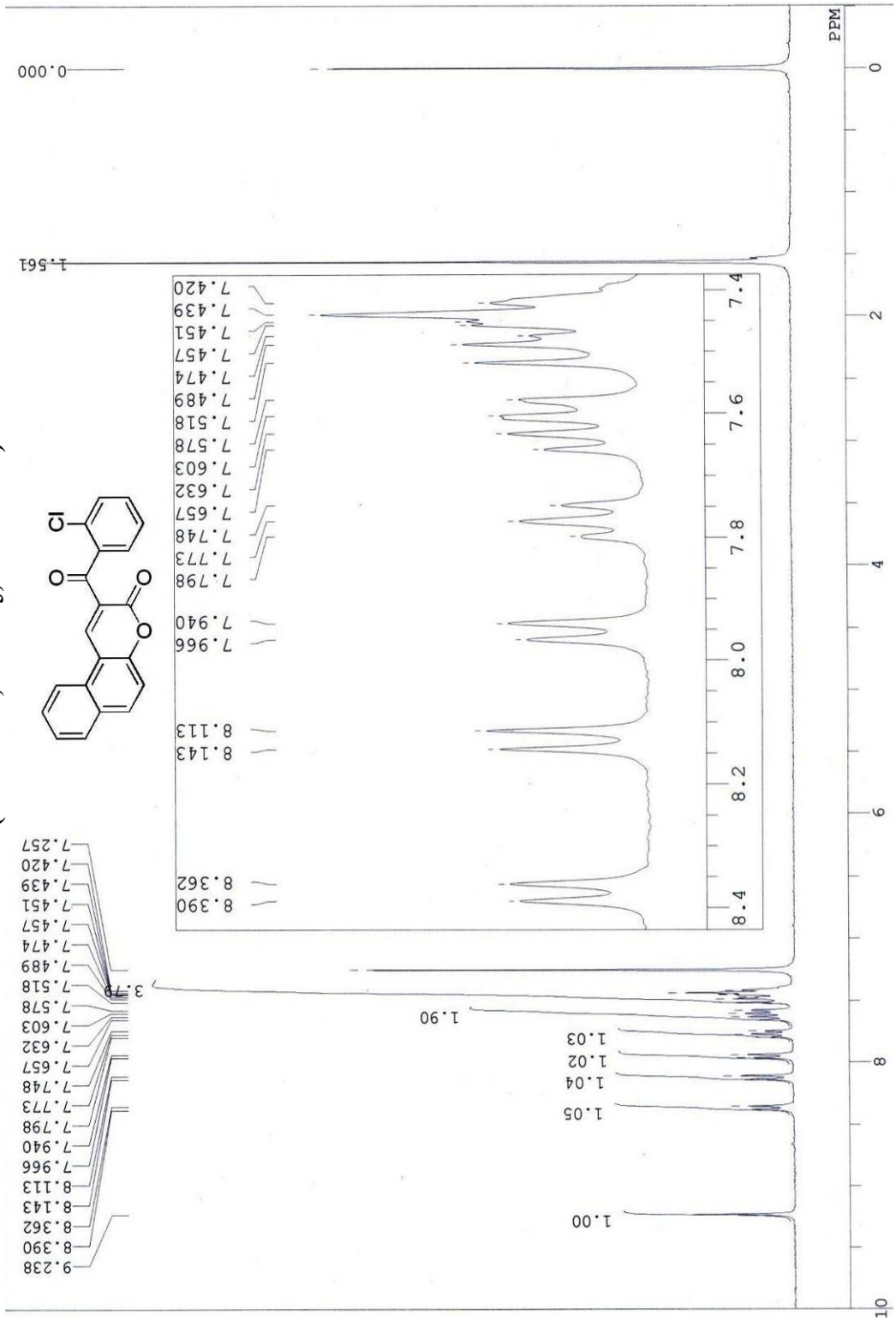
12e (^{1}H NMR, $CDCl_3$, 300 MHz)



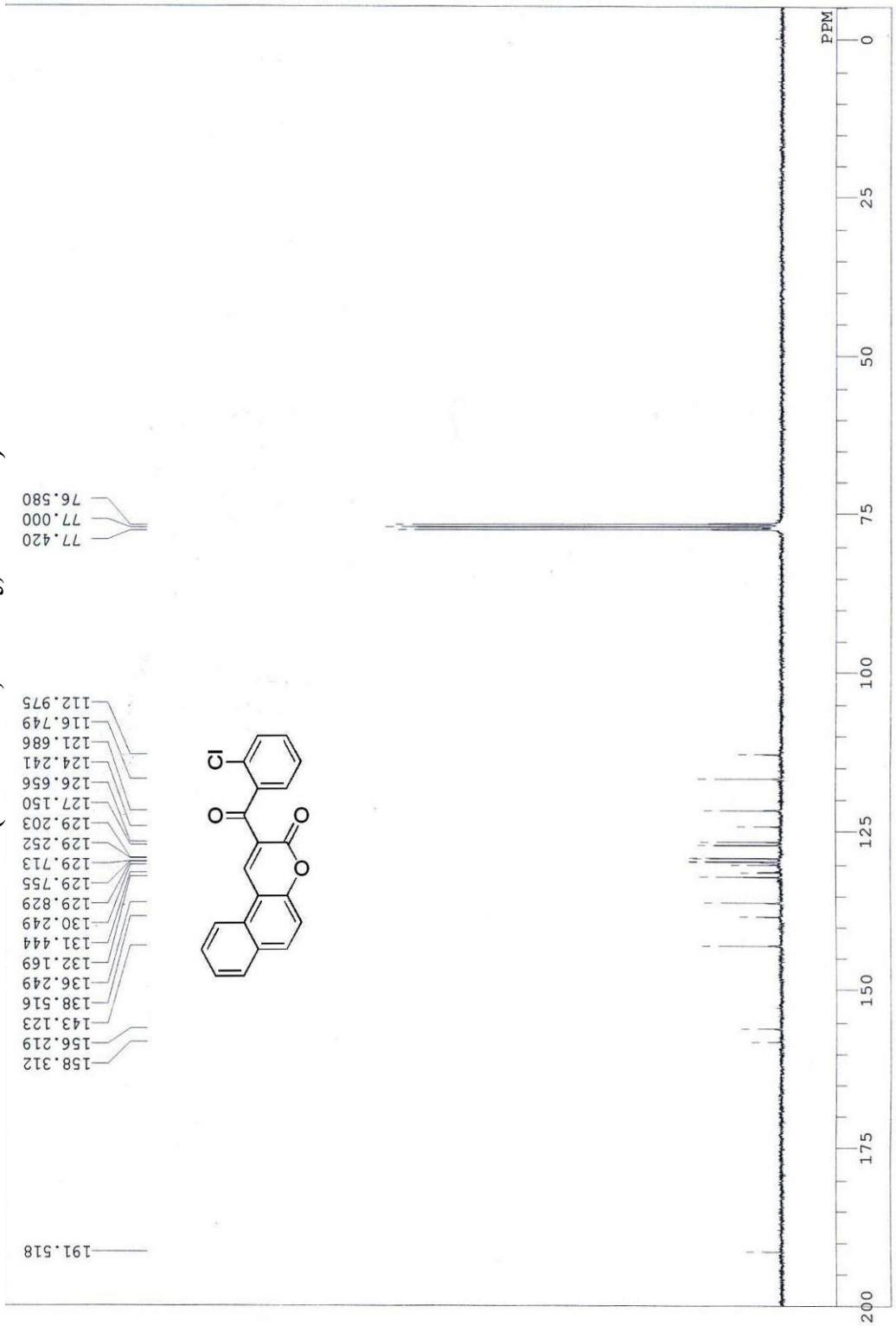
12e (^{13}C NMR, $CDCl_3$, 75 MHz)



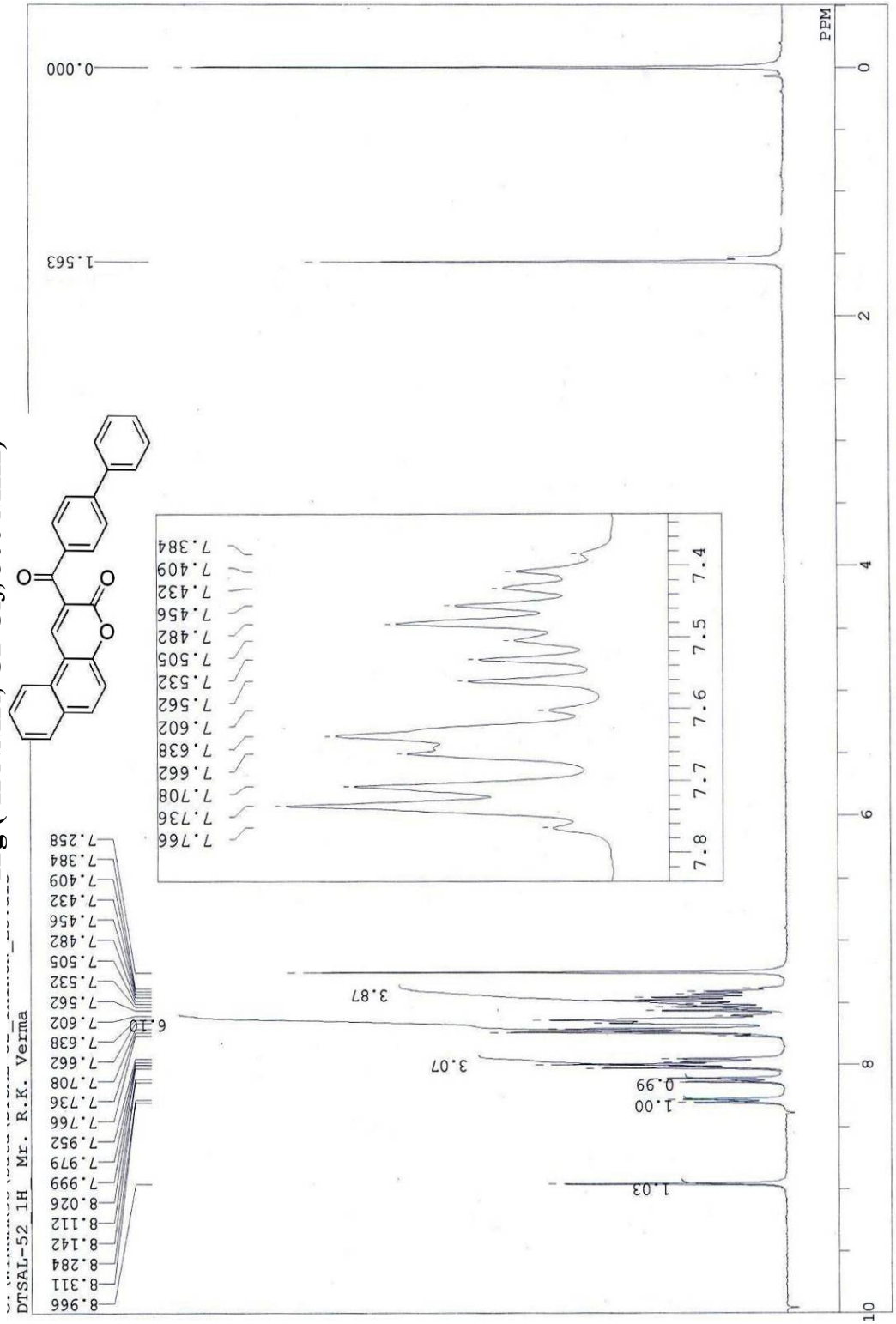
12f (^{1}H NMR, $CDCl_3$, 300 MHz)



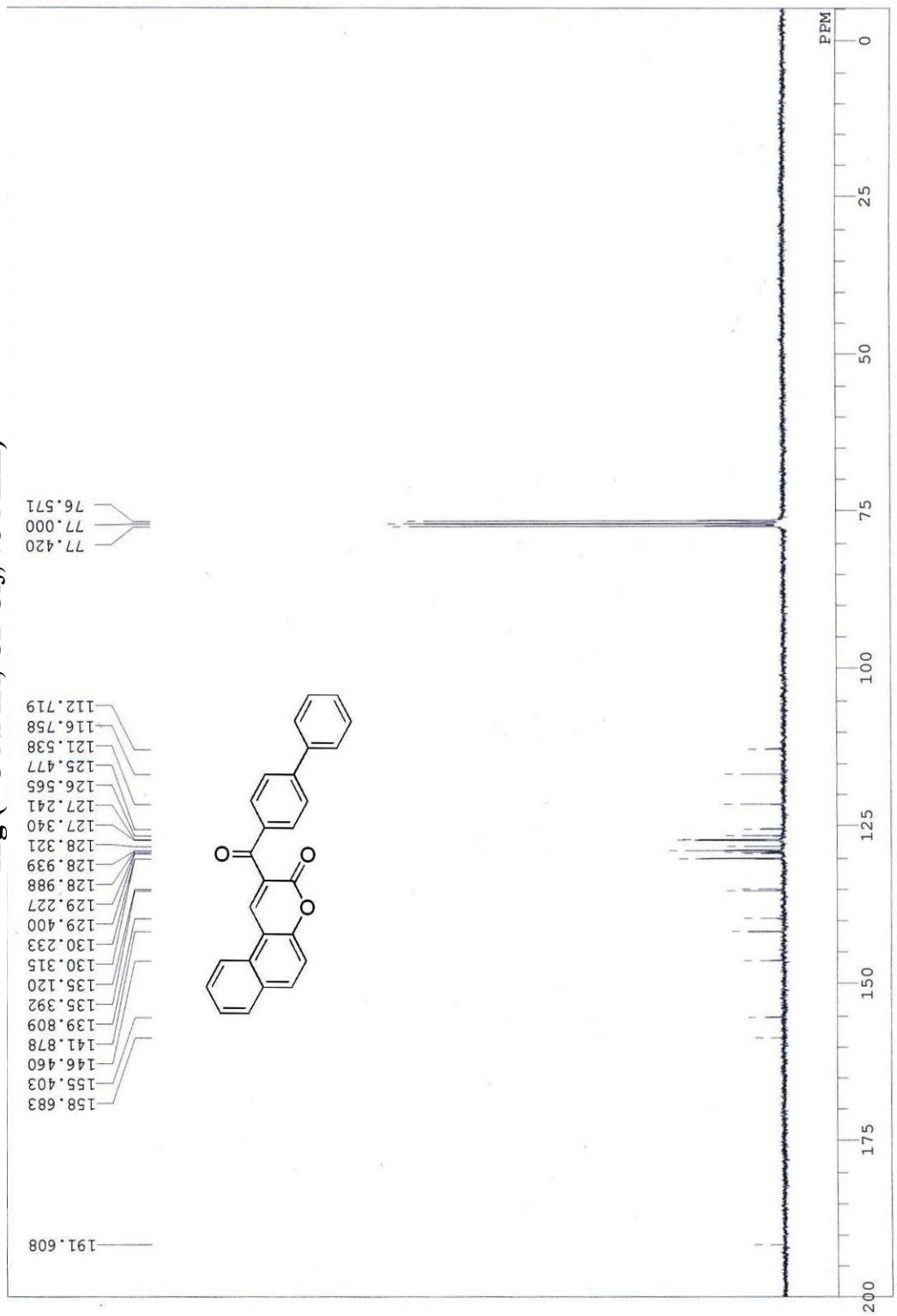
12f (^{13}C NMR, $CDCl_3$, 75 MHz)



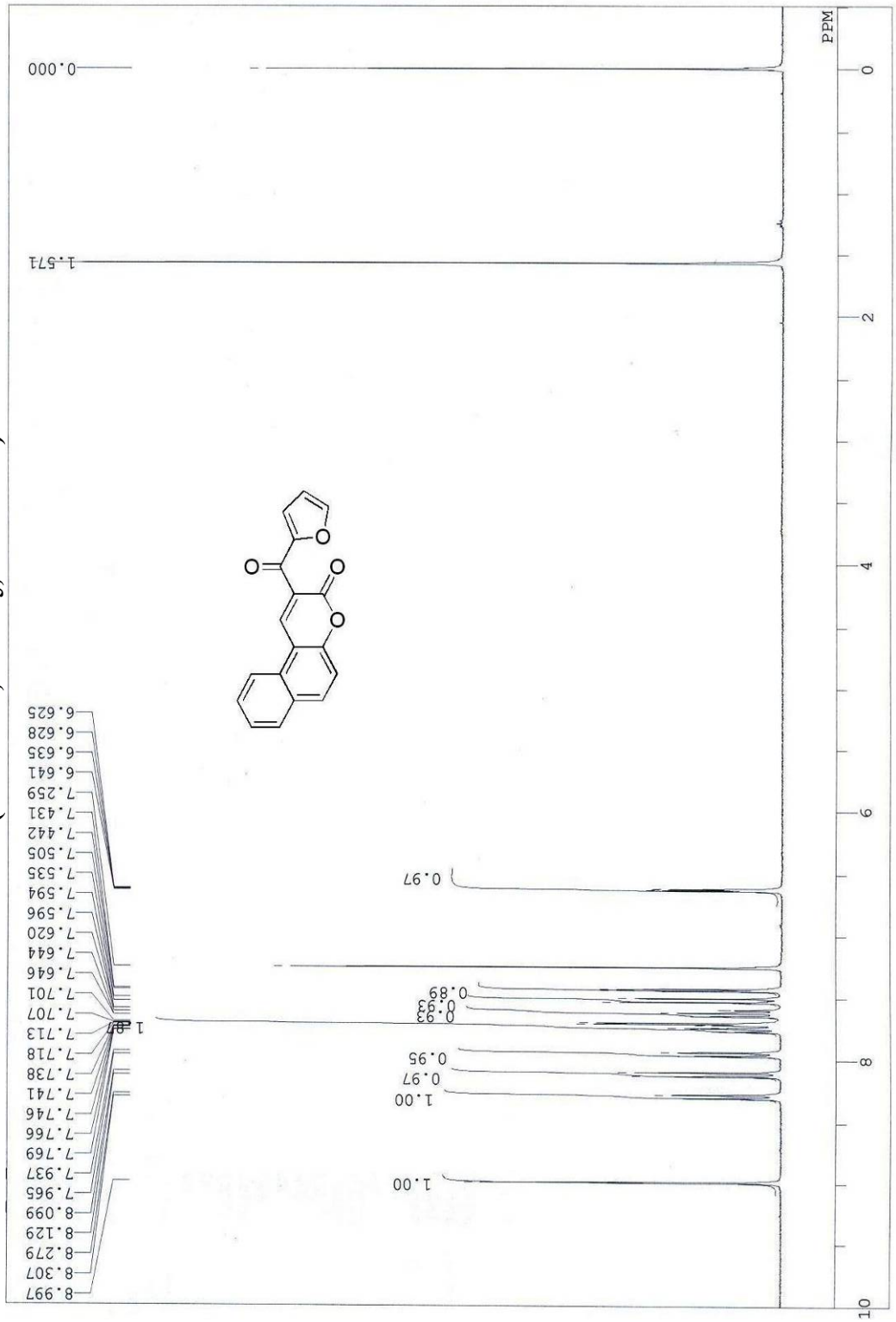
12g (^{1}H NMR, $CDCl_3$, 300 MHz)



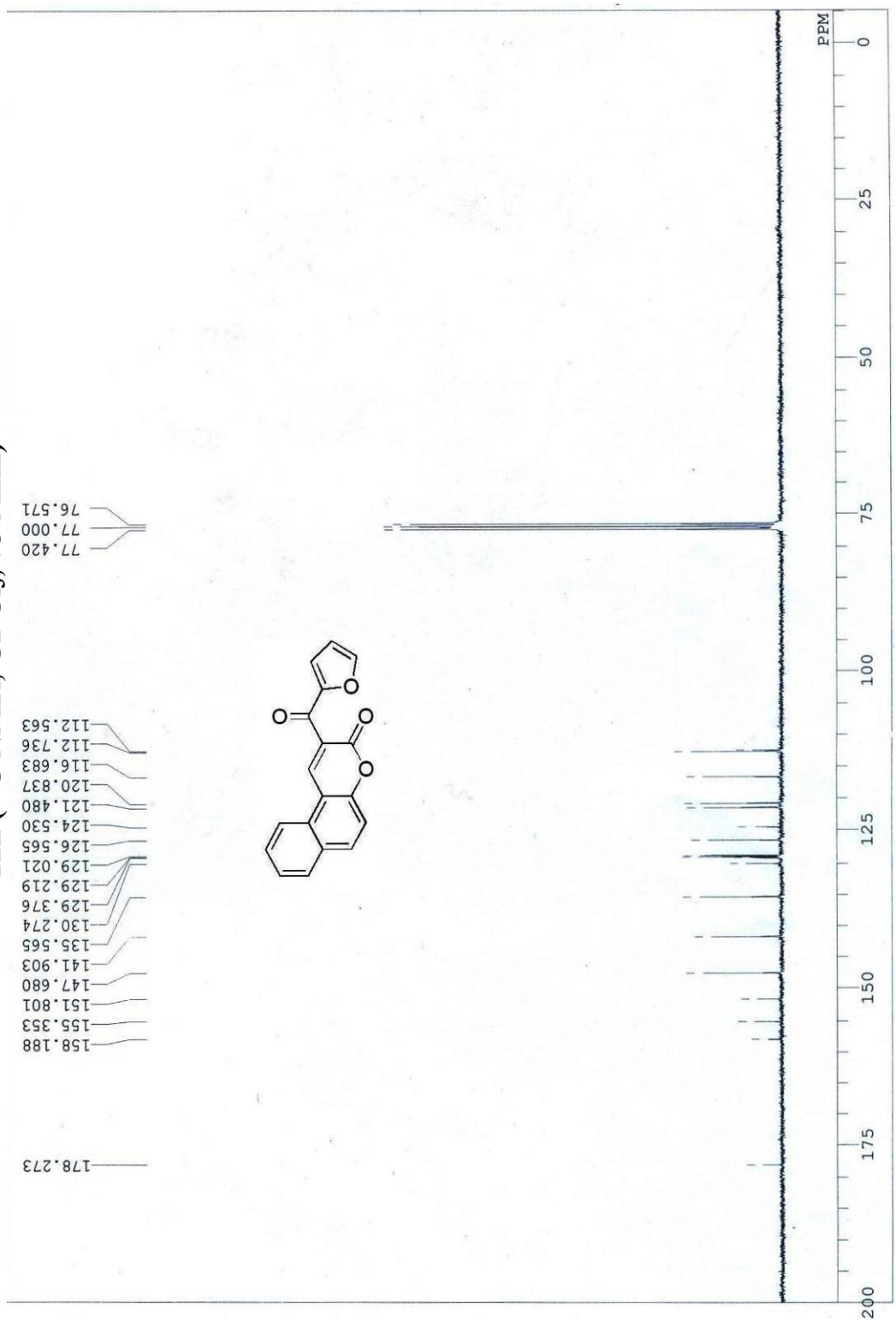
12g (^{13}C NMR, $CDCl_3$, 75 MHz)



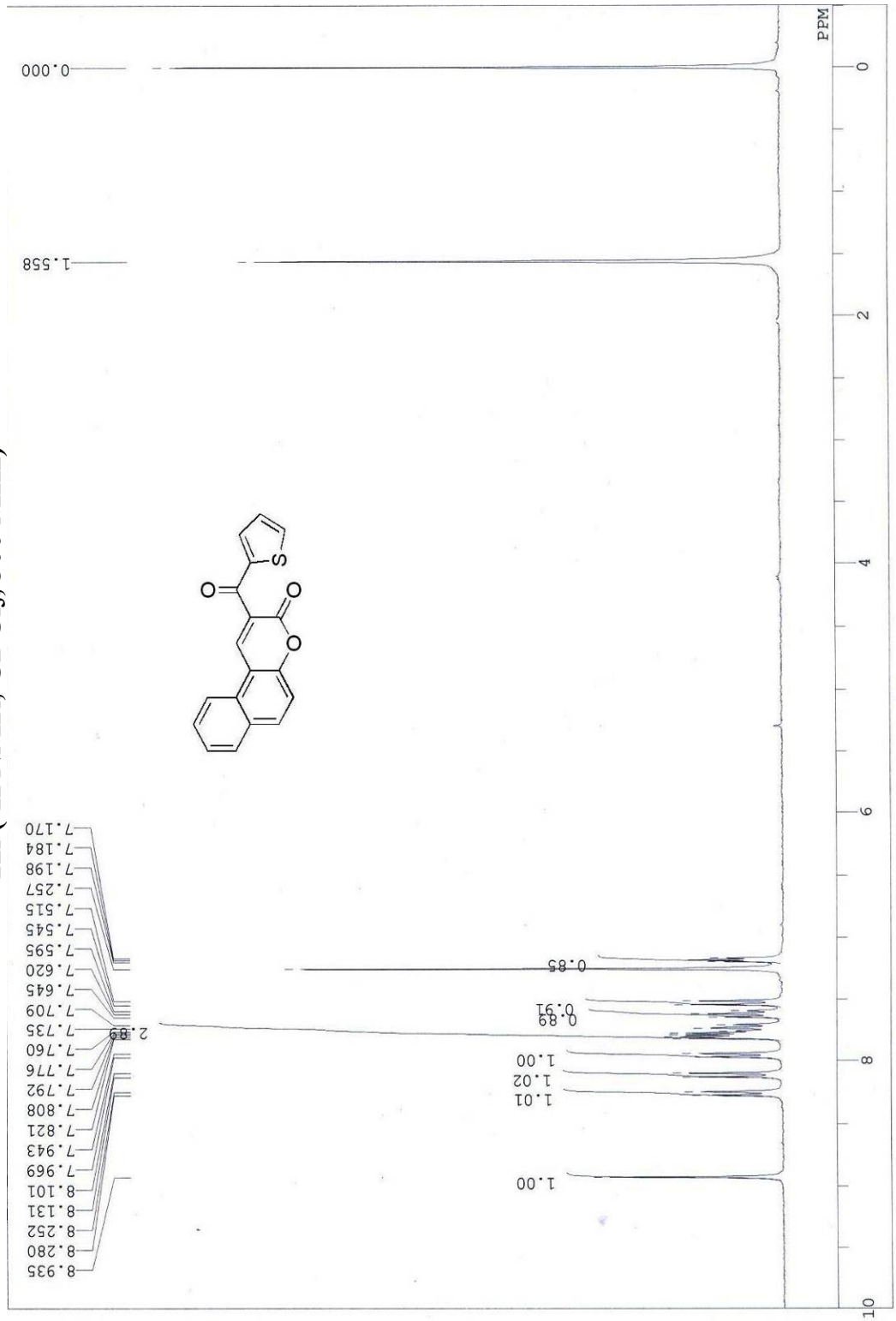
12h (^{1}H NMR, $CDCl_3$, 300 MHz)



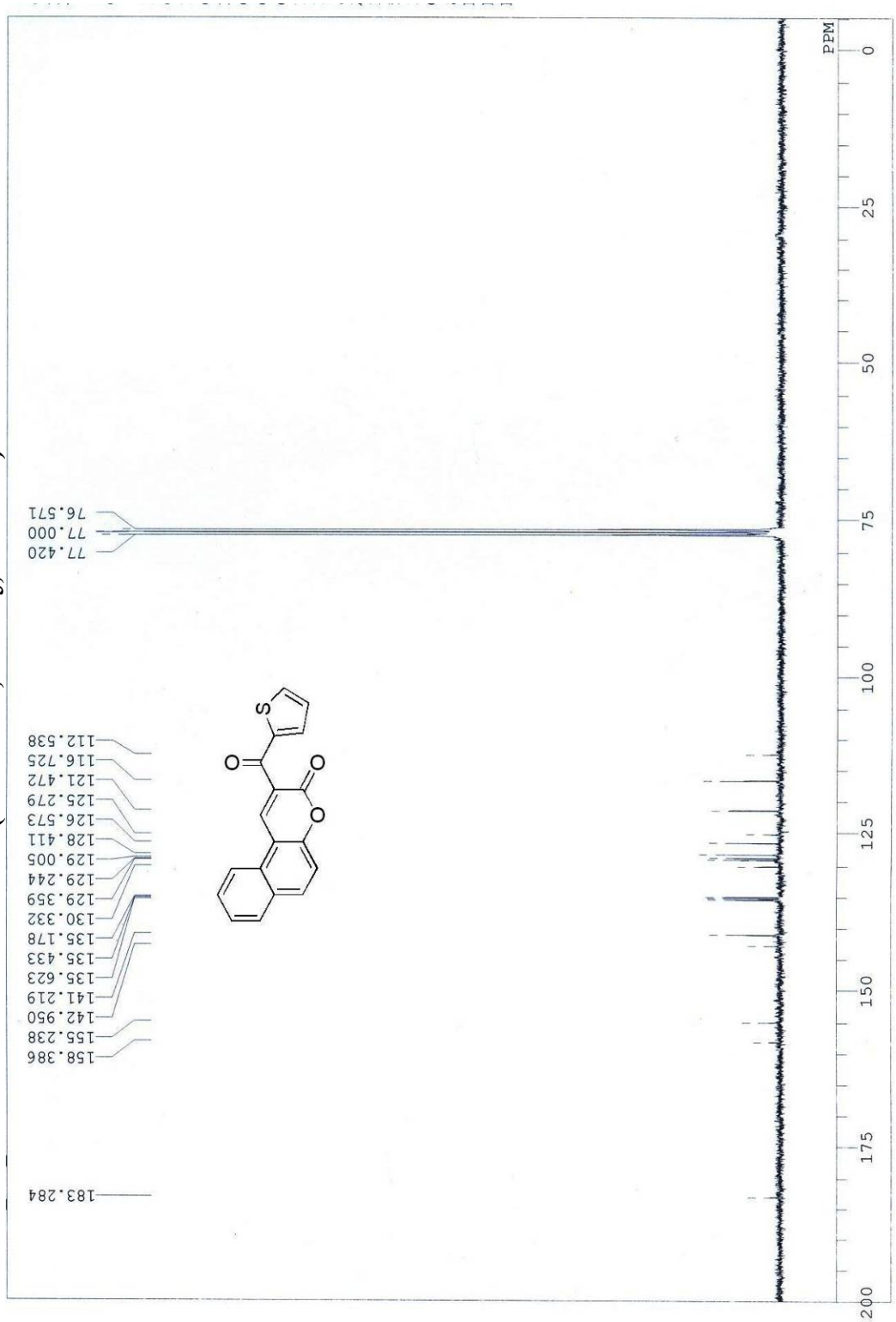
12h (^{13}C NMR, $CDCl_3$, 75 MHz)



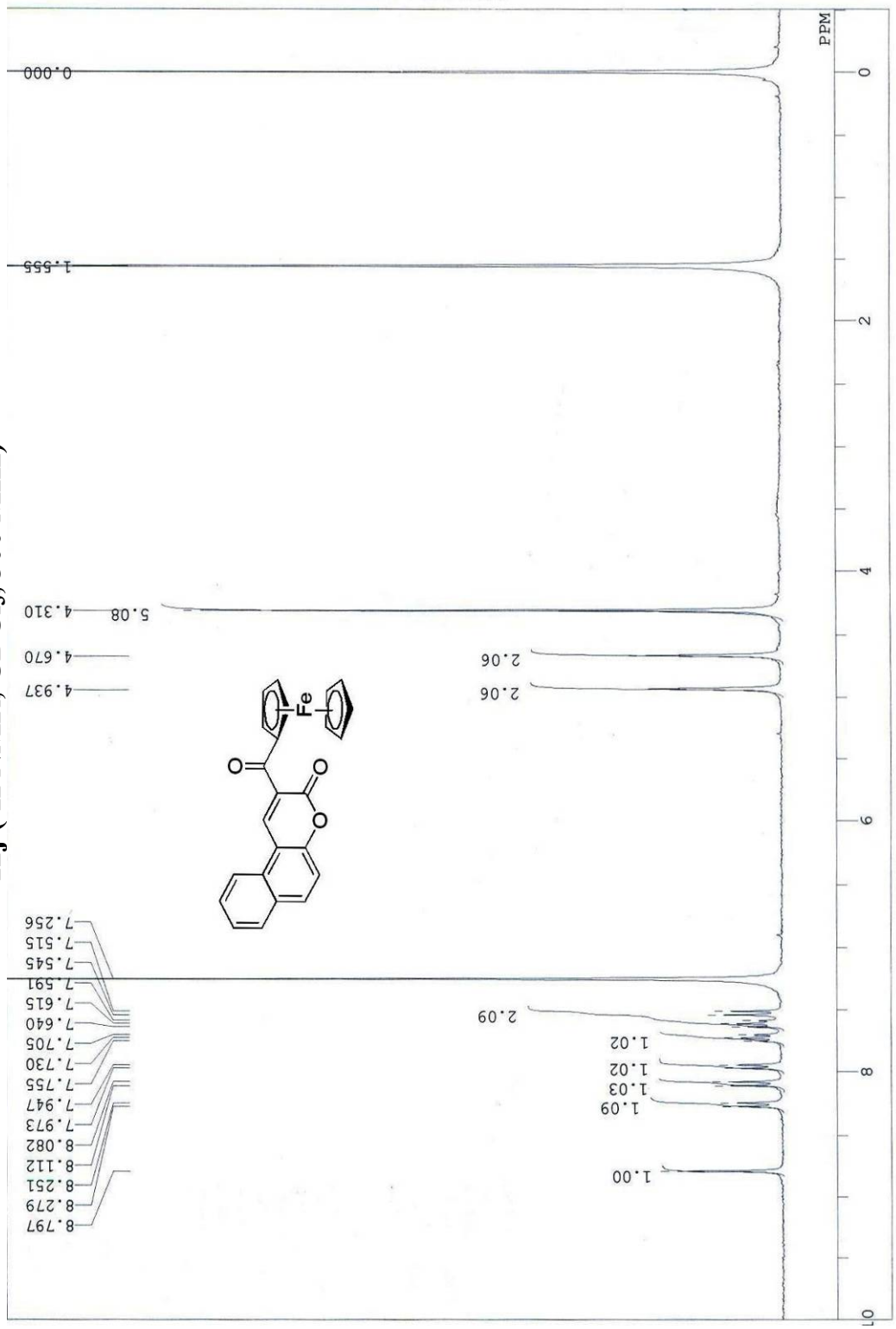
12i (^{1}H NMR, $CDCl_3$, 300 MHz)



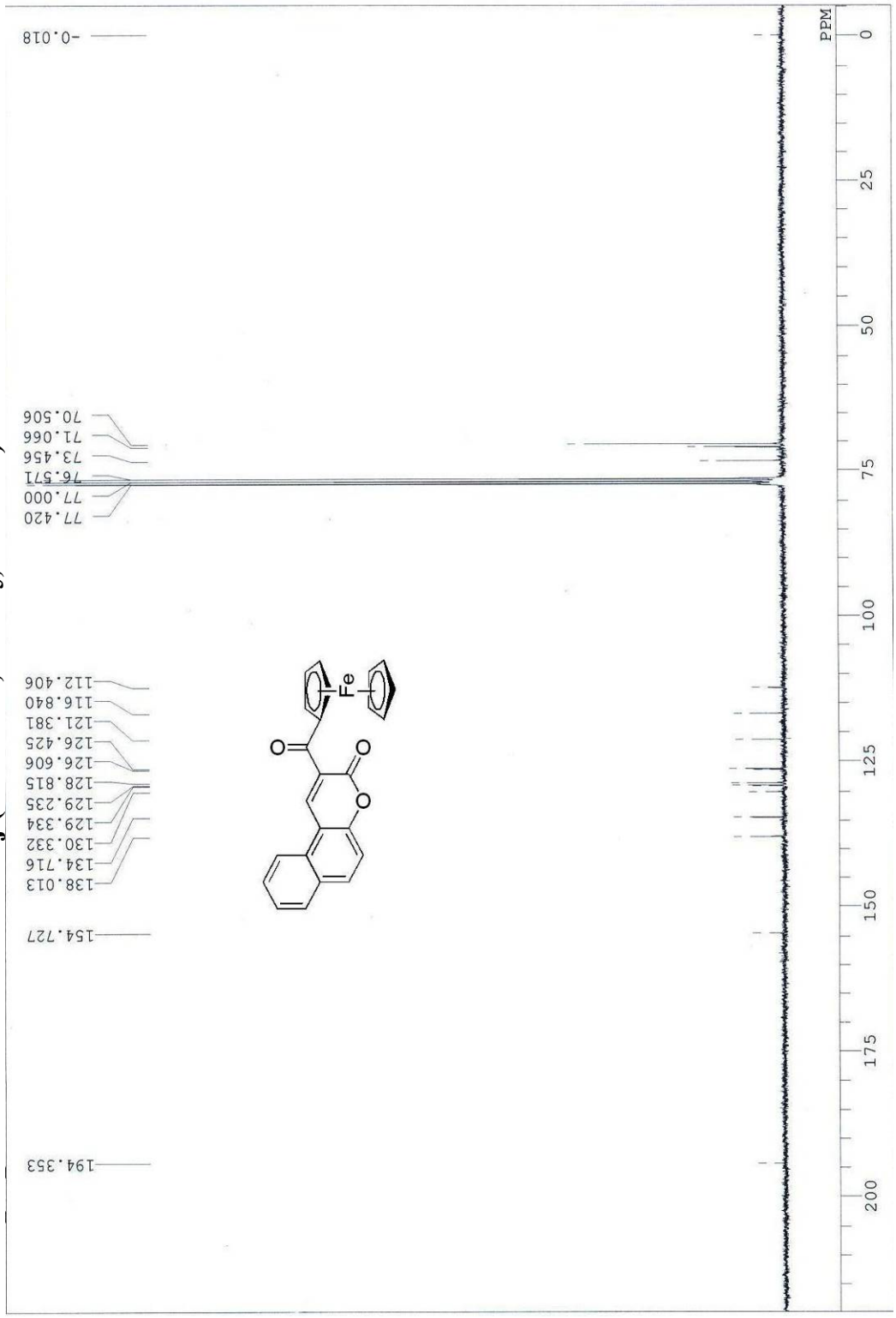
12i (^{13}C NMR, $CDCl_3$, 75 MHz)



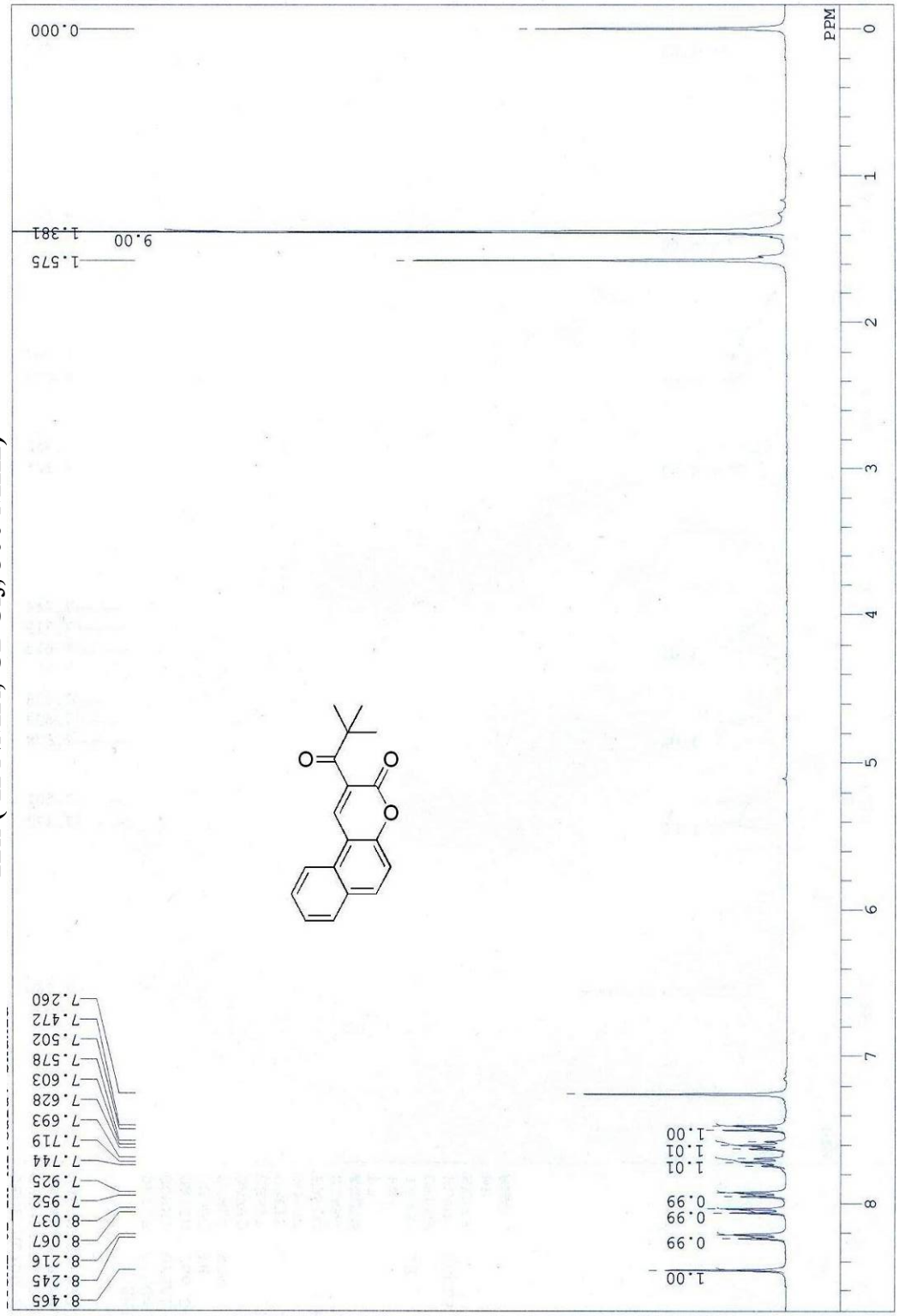
12j (^{1}H NMR, $CDCl_3$, 300 MHz)



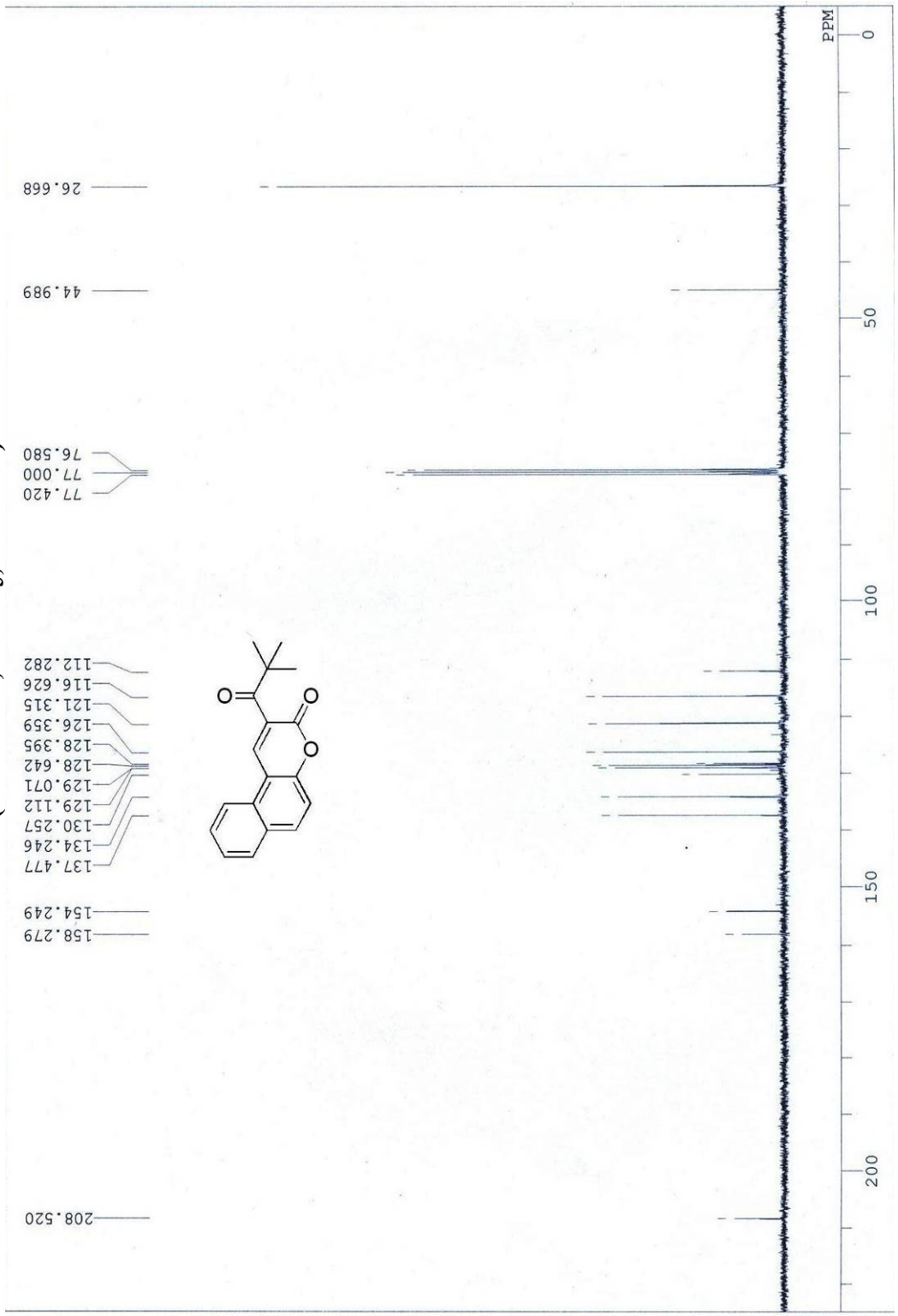
12j (^{13}C NMR, $CDCl_3$, 75 MHz)



12k (^{1}H NMR, $CDCl_3$, 300 MHz)



12k (^{13}C NMR, $CDCl_3$, 75 MHz)



Single Crystal XRD data for compounds 3-(Ferrocene-2-carbonyl)-chromen-2-one (10ja) and 3-(2-Chlorobenzoyl)-benzo[*f*]chromen-2-one (12f):

Crystallographic data for the structures reported in this paper have been deposited with the Cambridge Crystallographic Data Centre as supplementary publication no. **CCDC-805567** and **CCDC-805566**. Copies of the data can be obtained free of charge on application to CCDC, 12 Union Road, Cambridge CB2 1EZ, UK (fax: +44(0)-1223-336033 or e-mail: deposit@ccdc.cam.ac.uk).

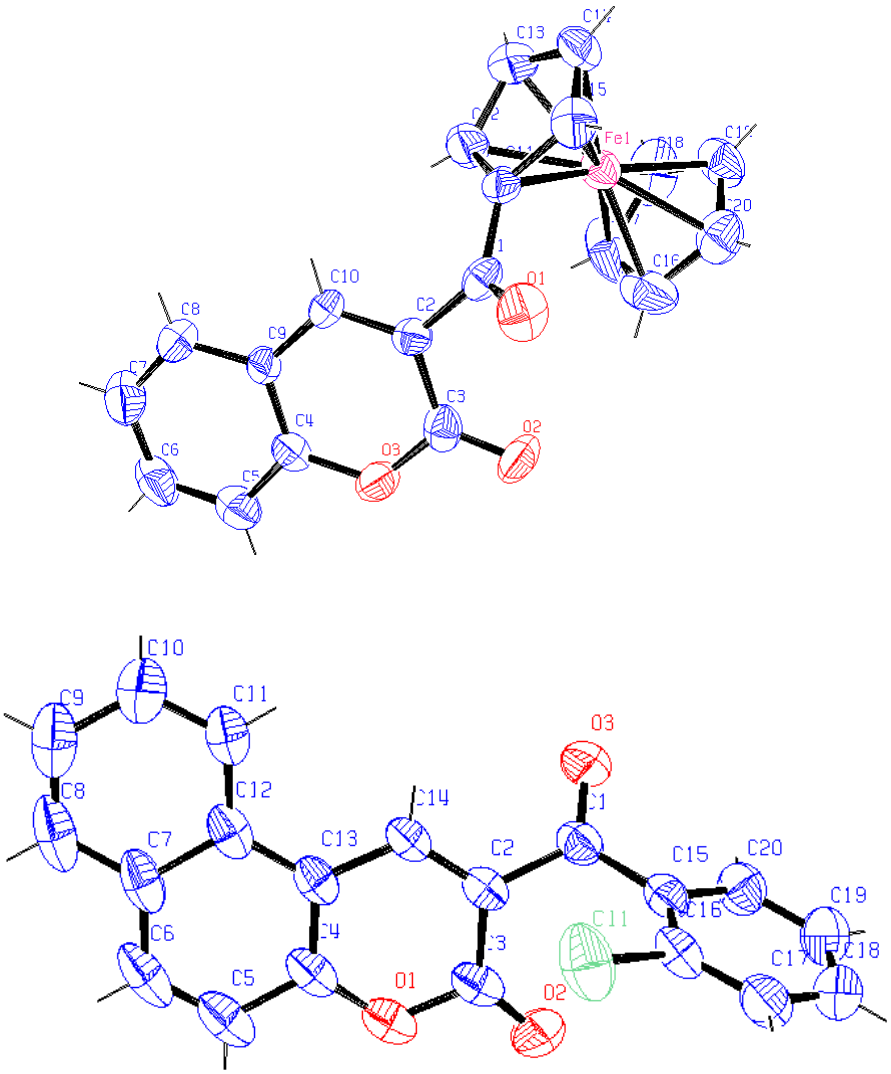
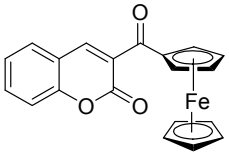
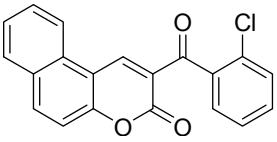


Figure 1: Ortep diagram for 10ja and 12f

Table 2: Basic Crystallographic Parameters for 10ja and 12f:

	Compound 10ja	**Compound 12f**
		
CCDC No.	**CCDC-805567**	**CCDC-805566**
Formula	$C_{20}H_{14}FeO_3$	$C_{20}H_{11}ClO_3$
***M* (g mol^{-1})**	358.16	334.74
Crystal system	Orthorhombic	Triclinic
Space group	P b c a	P -1
***a* (Å)**	12.377(5)	7.3853(5)
***b* (Å)**	10.686(5)	9.6126(7)
***c* (Å)**	23.309(5)	10.8880(7)
α (deg)	90	84.694(6)
β (deg)	90	87.875(5)
γ (deg)	90	84.710(6)
***V* (Å^3)**	3083(2)	766.05(9)
Z	8	2
ρcalc (g cm^{-3})	1.543	1.451
λ (Å)	0.7107	0.7107
F(000)	1472	344.0
***T* (K)**	293	293 K
measured reflections	3548	5538
***R*$_1$**	0.0777	0.0541
ωR_2^a	0.0820	0.1163
R*$_1$ *(all data)	0.2486	0.1038
ωR_2 (all data)	0.1242	0.1453
GOOF	0.915	0.961
μ (mm^{-1})	0.993	0.264