Decarboxylative homocoupling of (hetero)aromatic carboxylic acids

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General Information

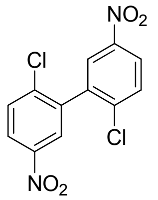
All reactions were carried out under nitrogen atmosphere. Anhydrous DMSO and DMF and all other reagents were purchased from commercial suppliers and used without further purification. Column chromatography was carried out on silica gel, particle size 40-63 μm, using flash techniques. Analytical thin layer chromatography was performed on pre-coated aluminium-backed silica gel F254 plates with visualization under UV light. Melting points were obtained using a hot-stage apparatus and are uncorrected. IR spectra were recorded using a Bruker Tensor 37 FTIR machine and quoted in cm^{-1}. Unless otherwise noted, ^{1}H NMR spectra, recorded at 400 MHz, are referenced to the residual solvent peak at 7.26 ppm ($CDCl_3$) and quoted in ppm to 2 decimal places with coupling constants (*J*) to the nearest 0.1 Hz. Unless otherwise noted, ^{13}C NMR spectra, recorded at 100 MHz, are referenced to the solvent peak at 77.0 ppm ($CDCl_3$) and quoted in ppm to 1 decimal place.

General procedure for the synthesis of dimers.

A suspension of aromatic carboxylic acid (0.5 mmol), Ag_2CO_3 (0.138 g, 0.5 mmol) and $Pd(TFA)_2$ (0.012 g, 0.036 mmol) in 10 mL of DMF:DMSO 95:5 (0.05 M) was stirred at 120 ºC for 16 h in a sealed vessel. After this time, the reaction mixture was cooled down to room temperature and filtered through a plug of silica gel with EtOAc. The fitrate was washed with a saturated solution of $NaHCO_3$ (5 × 20 mL), brine (5 × 20 mL) and the organic layer was evaporated to dryness under reduced pressure. The crude was purified by column chromatography to afford the desired product.

Analytical data for products **2a**, **2b**, and **2c** matched with the previously reported in the literature.

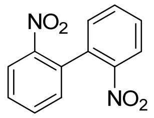
2,2'-Dichloro-5,5'-dinitrobiphenyl (2a)[1]



2a

The reaction was carried out following the general procedure with 2-chloro-5-nitrobenzoic acid (0.101 g, 0.5 mmol) in 5 mL of DMF:DMSO (95:5). The crude product was purified by column chromatography (hexanes:EtOAc 9:1) to afford **2a** as a white solid (0.078 g, 68%) R*f* 0.31 (hexanes:CH_2Cl_2:EtOAc 85:14:1); ^{1}H NMR (400 MHz) δ 8.31 (dd, 2H, *J* = 8.8, 2.7 Hz), 8.22 (d, 2H, *J* = 2.7 Hz), 7.74 (d, 2H, *J* = 8.8 Hz); ^{13}C NMR (101 MHz) δ 146.5 (C), 140.6 (C), 137.4 (C), 130.9 (CH), 126.1 (CH), 125.1 (CH).

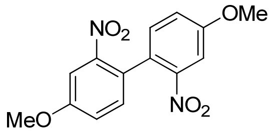
2,2'-Dinitrobiphenyl (2b)[2]



2b

The reaction was carried out following the general procedure with 2-nitrobenzoic acid (0.084 g, 0.5 mmol) at 115 ºC. The crude product was purified by column chromatography (hexanes:EtOAc 9:1) to afford **2b** as a yellow solid (0.057 g, 94%) R*f* 0.23 (hexanes:EtOAc 9:1) ^{1}H NMR (400 MHz) δ 8.23 (d, 2H, *J* = 8.4 Hz), 7.72 – 7.68 (m, 2H), 7.63 – 7.59 (m, 2H), 7.31 (d, 2H, *J* = 7.6 Hz); ^{13}C NMR (101 MHz) δ 147.2 (C), 134.2 (C), 133.4 (CH), 130.9 (CH), 129.1 (CH), 124.9 (CH).

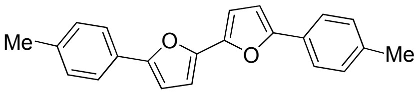
4,4'-Dimethoxy-2,2'-dinitrobiphenyl (2c)[3]



2c

The reaction was carried out following the general procedure with 4-methoxy-2-nitrobenzoic acid (0.099 g, 0.5 mmol) at 115 ºC. The crude product was purified by column chromatography (hexanes:EtOAc 9:1) to afford **2c** as a yellow solid (0.058 g, 76%%); R*f* 0.42 (hexanes:EtOAc 9:1); ^{1}H NMR (400 MHz) δ 7.68 (s, 2H), 7.19 (m, 4H), 3.93 (s, 6H); ^{13}C NMR (101 MHz) δ 159.6 (C), 148.2 (C), 132.2 (CH), 125.7 (C), 119.7(CH), 109.5 (CH), 56.0 (CH_3).

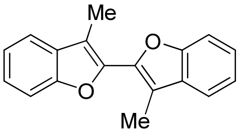
5,5'-Bis-*p*-tolyl-2,2'-bifuran (2d)



2d

The reaction was carried out following the general procedure with 5-*p*-tolylfuran-2-carboxylic acid (0.101 g, 0.5 mmol), Pd(TFA)$_2$ (0.024 g, 0.072 mmol) in 20 mL of DMF:DSMO (95:5) at 125 ºC. The crude product was purified by column chromatography (hexanes) to afford **2d** (0.044 g, 56%); m.p. 176–179 ºC; R$_f$ 0.29 (hexanes) IR: 1505, 1016, 819, 783; ^{1}H NMR (400 MHz) δ 7.63 (d, 4H, *J* = 8.0 Hz), 7.22 (d, 4H, *J* = 8.0 Hz), 6.71 – 6.69 (m, 4H), 2.39 (s, 6H); ^{13}C NMR (101 MHz) δ 153.4 (C), 145.7 (C), 137.3 (C), 129.4 (CH), 127.9 (C), 123.7 (CH), 107.2 (CH), 106.3 (CH), 21.3 (CH_3); HRMS (ESI) calcd. $C_{22}H_{20}O_2$: (M+H)$^+$, 315.1380; found: (M+H)$^+$, 315.1376.

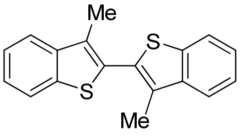
3,3'-Dimethyl-2,2'-bibenzo[*b*]furan (2e)



2e

The reaction was carried out following the general procedure with 3-methylbenzofuran-2-carboxylic acid (0.088 g, 0.5 mmol) at 115 ºC. The crude product was purified by column chromatography (hexanes) to afford **2e** (0.051 g, 78%); m.p. 119–121 ºC; R$_f$ 0.35; IR: 1475, 1329, 1221, 1112, 736; ^{1}H NMR (400 MHz) δ 7.54 (d, 2H, *J* = 8.0 Hz), 7.47 (d, 2H, *J* = 7.9 Hz), 7.32 – 7.22 (m, 4H), 2.56 (s, 6H); ^{13}C NMR (101 MHz) δ 154.5 (C), 144.0 (C), 130.2 (C), 124.8 (CH), 122.7 (CH), 119.5 (CH), 114.3 (C), 111.0 (CH), 8.9 (CH_3); HRMS (ESI) calcd. $C_{18}H_{15}O_2$: (M+H)$^+$, 263.1067; found: (M+H)$^+$, 263.1067.

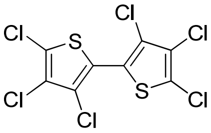
3,3'-Dimethyl-2,2'-bibenzo[*b*]thiophene (2f)



2f

The reaction was carried out following the general procedure with 3-methylbenzothiophene-2-carboxylic acid (0.096, 0.5 mmol) at 130 ºC. The crude product was purified by column chromatography (hexanes) to afford **2f** (0.047, 64%) m.p. 124–126 ºC; R*f* 0.33 (hexanes); IR: 1429, 912, 761, 752; ^{1}H NMR (400 MHz) δ 7.87 (d, 2H, *J* = 8.8 Hz), 7.79 (d, 2H, *J* = 8.2 Hz), 7.49 – 7.40 (m, 4H), 2.42 (s, 6H); ^{13}C NMR (101 MHz) δ 140.4 (C), 140.1 (C), 131.6 (C), 129.9 (C), 124.8 (CH), 124.3 (CH), 122.3 (CH), 122.1 (CH), 12.9 (CH$_3$); HRMS (ESI) calcd. $C_{18}H_{15}S_2$: (M+H)$^+$, 295.0610; found: (M+H)$^+$, 295.0608.

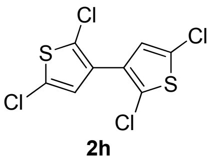
Perchloro-2,2'-bithiophene (2g)



2g

The reaction was carried out following the general procedure with 3,4,5-trichlorothiophene-2-carboxylic acid (0.115 g, 0.5 mmol). The crude product was purified by column chromatography (hexanes) to afford **2g** (0.061 g, 66%); m.p. 182–184 ºC; R*f* 0.8 (hexanes); IR: 1493, 1406, 1315, 1279, 939, 778; ^{13}C NMR (101 MHz, CDCl$_3$ + *d*$_6$-DMSO) δ 126.6 (C), 123.9 (C), 123.8 (C), 123.2 (C); HRMS (ESI) calcd. $C_8HCl_6S_2$: (M+H)$^+$, 370.7645; found: (M+H)$^+$, 370.7644.

2,2',5,5'-Tetrachloro-3,3'-bithiophene (2h)



2h

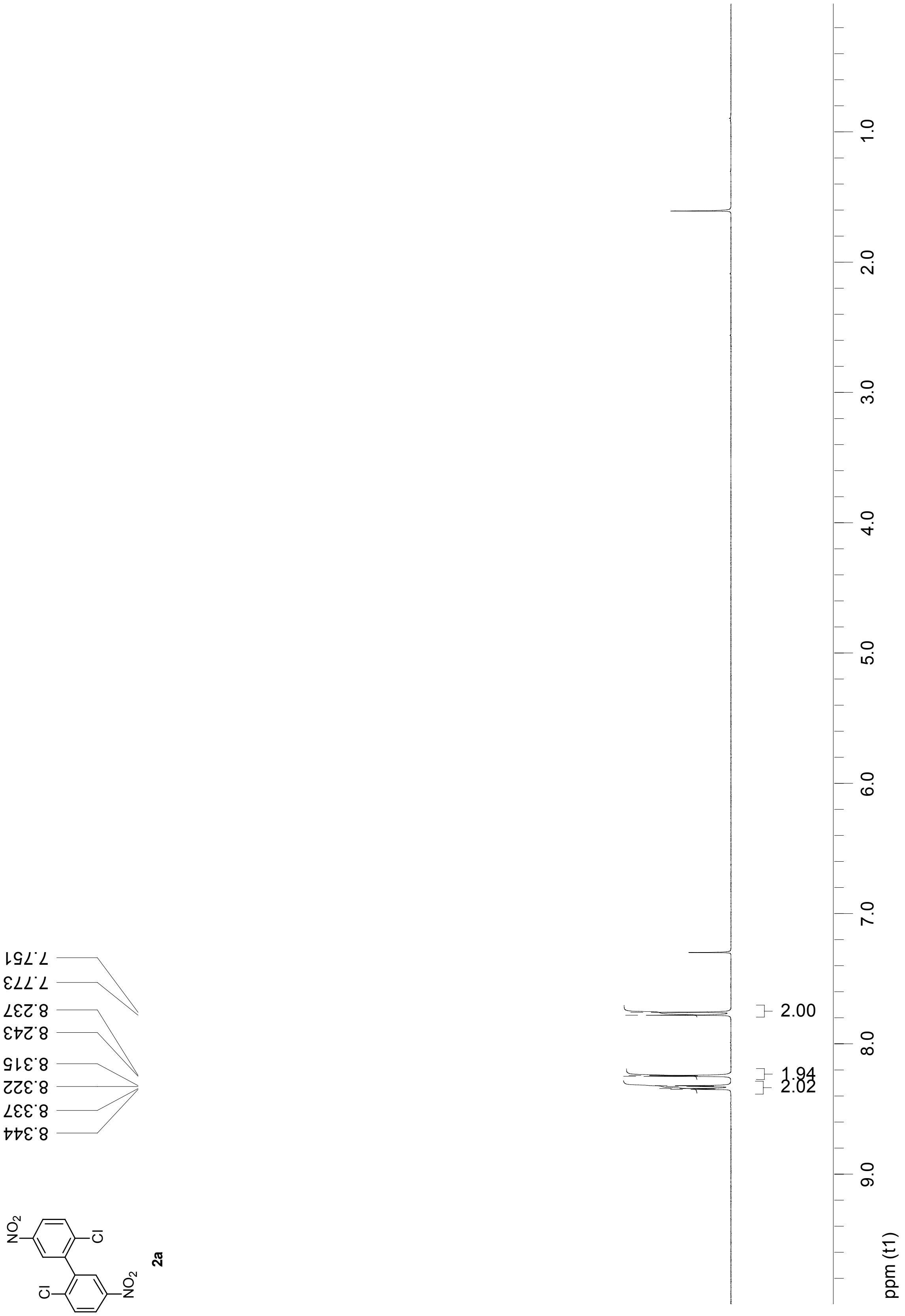
The reaction was carried out following the general procedure with 2,5-dichlorothiophene-2-carboxylic acid (0.099 g, 0.5 mmol) in 20 mL of DMF:DMSO (95:5). The crude product was purified by column chromatography (hexanes) to afford **2h** (0.043 g, 57%); m.p. 106–108 ºC, R*f* 0.84 (hexanes); IR: 1518, 1404, 1057, 1008, 818; ^{1}H NMR (400 MHz) δ 6.94 (s, 2H); ^{13}C NMR (101 MHz) δ 130.6 (C), 127.4 (CH), 127.0 (C), 125.1 (C); HRMS (ESI) calcd. $C_8H_3Cl_3S_2$: $(M+H)^+$, 302.8425; found: $(M+H)^+$, 302.8428.

References:

[1] J. Cornella, P. Lu and I. Larrosa, *Org. Lett.*, 2009, **11**, 5506.

[2] G. Cahiez, C. Chaboche, F. Mahuteau-Betzer and M. Ahr, *Org. Lett.*, 2005, **7**, 1943.

[3] H. R. Bjørsvik, R. Rodríguez and L. Liguori, *J. Org. Chem.*, 2004, **69**, 7720.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8.322
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2.02
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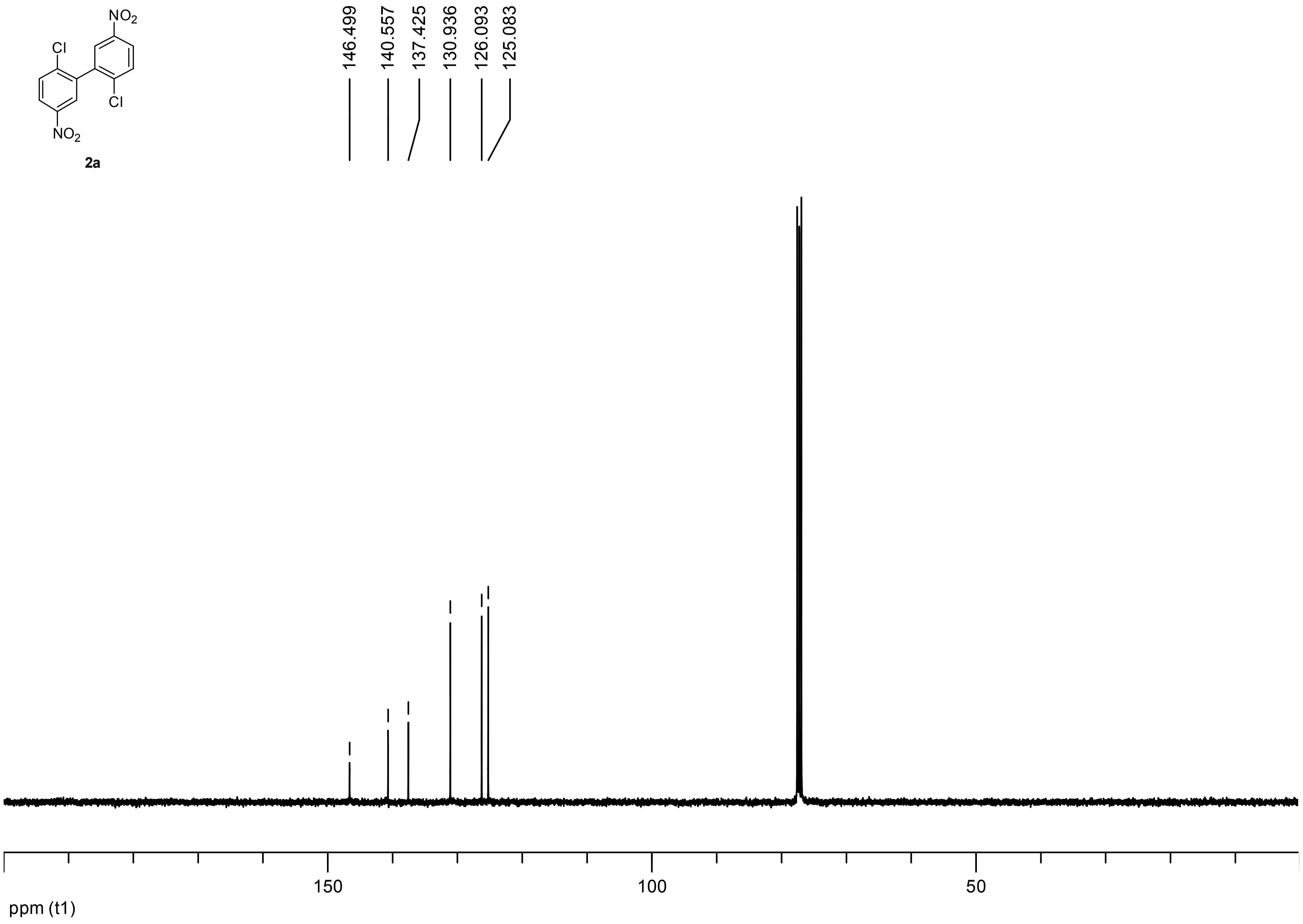
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
ppm (t1)
NO_2
Cl
Cl
NO_2
2a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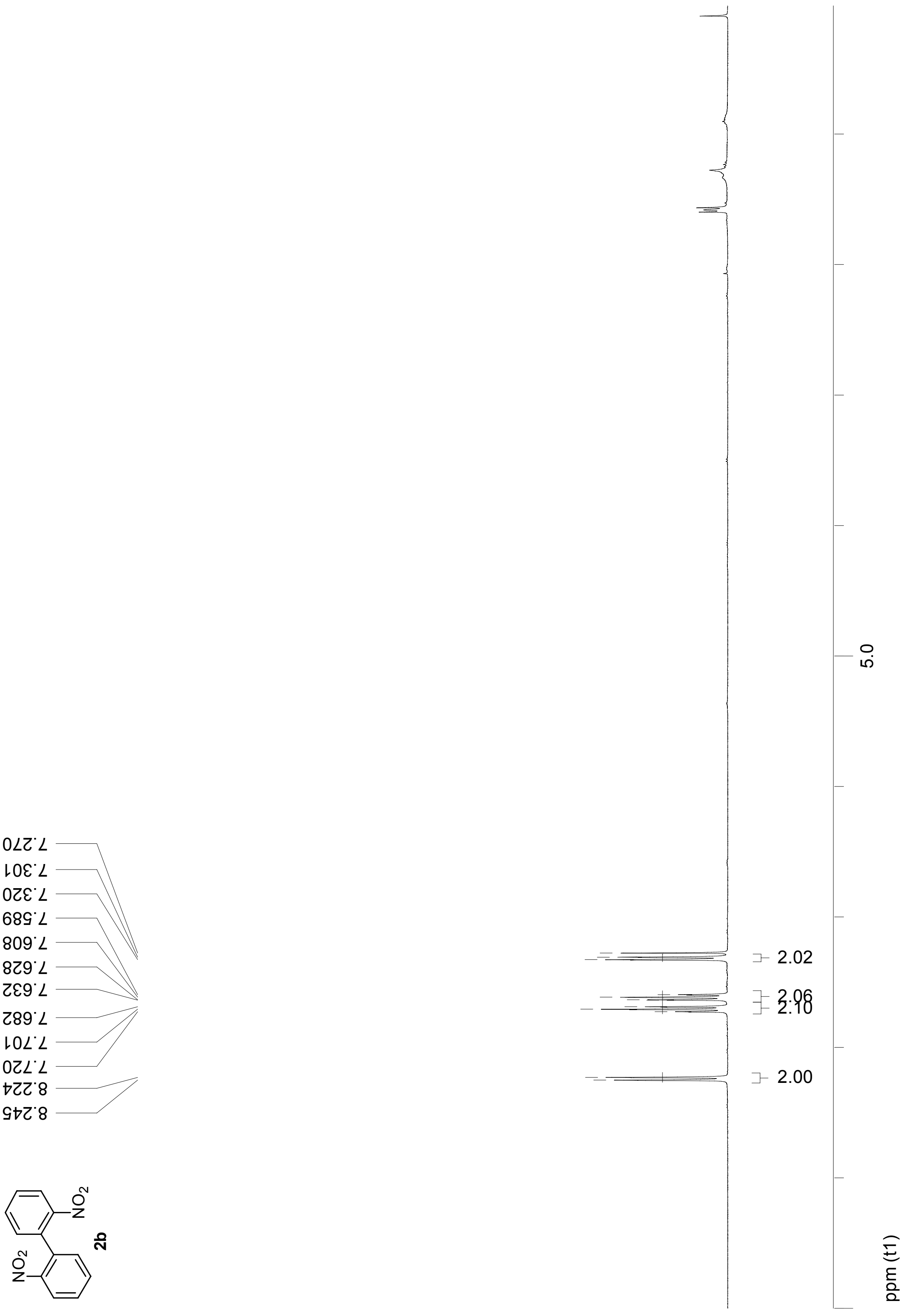
2a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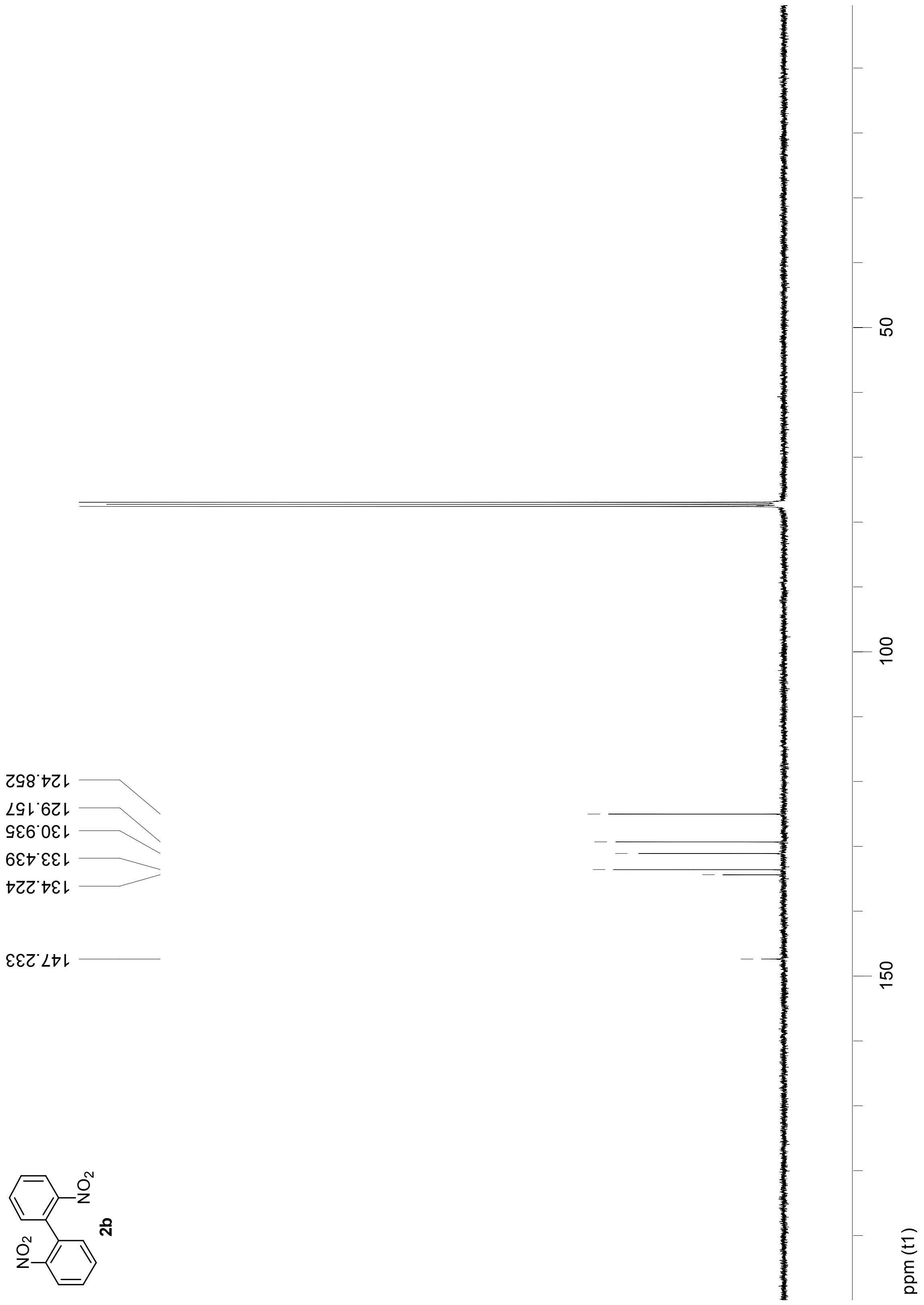
2.06
2.10
2.00
5.0
ppm (t1)
NO_2
NO_2

2b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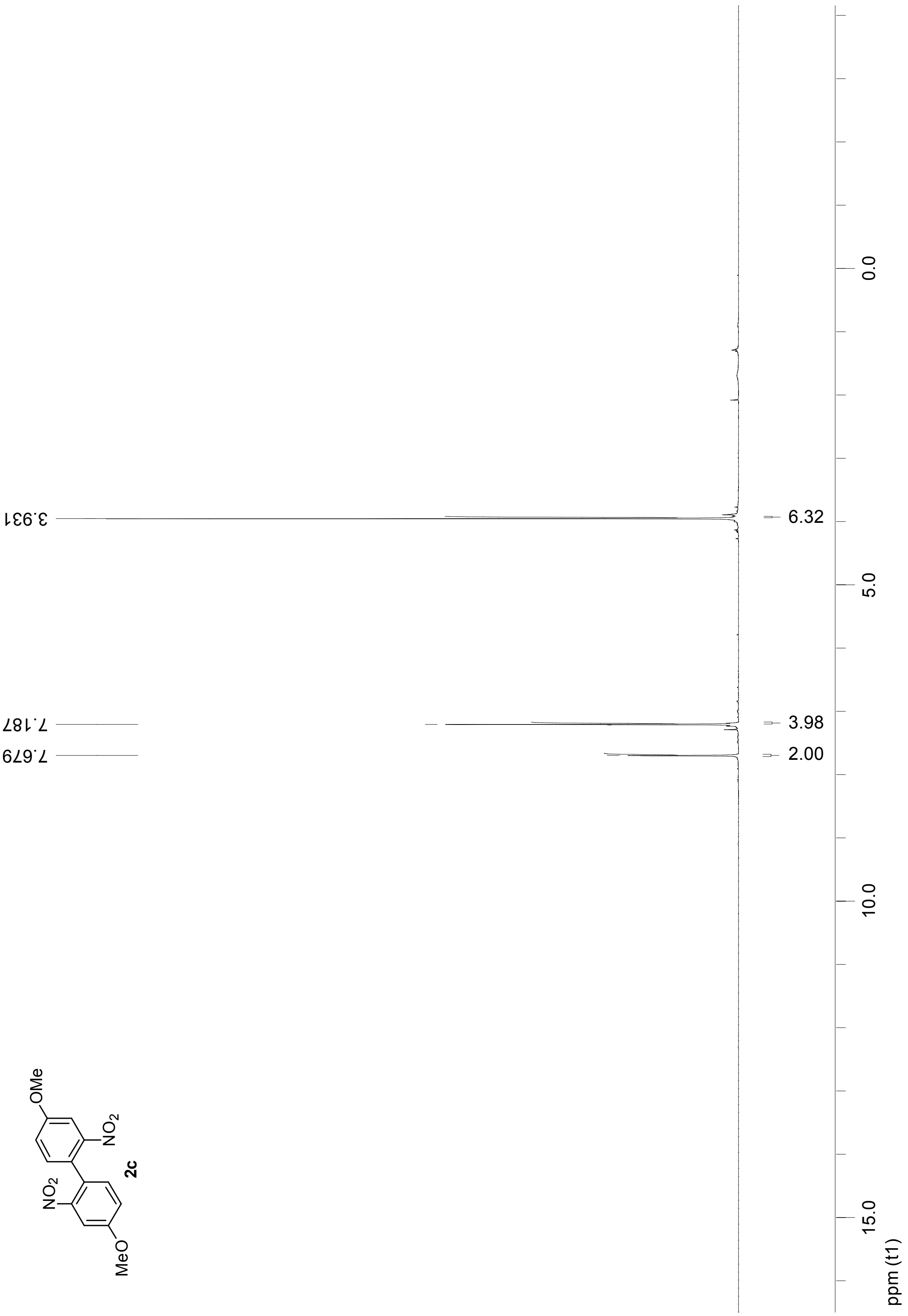
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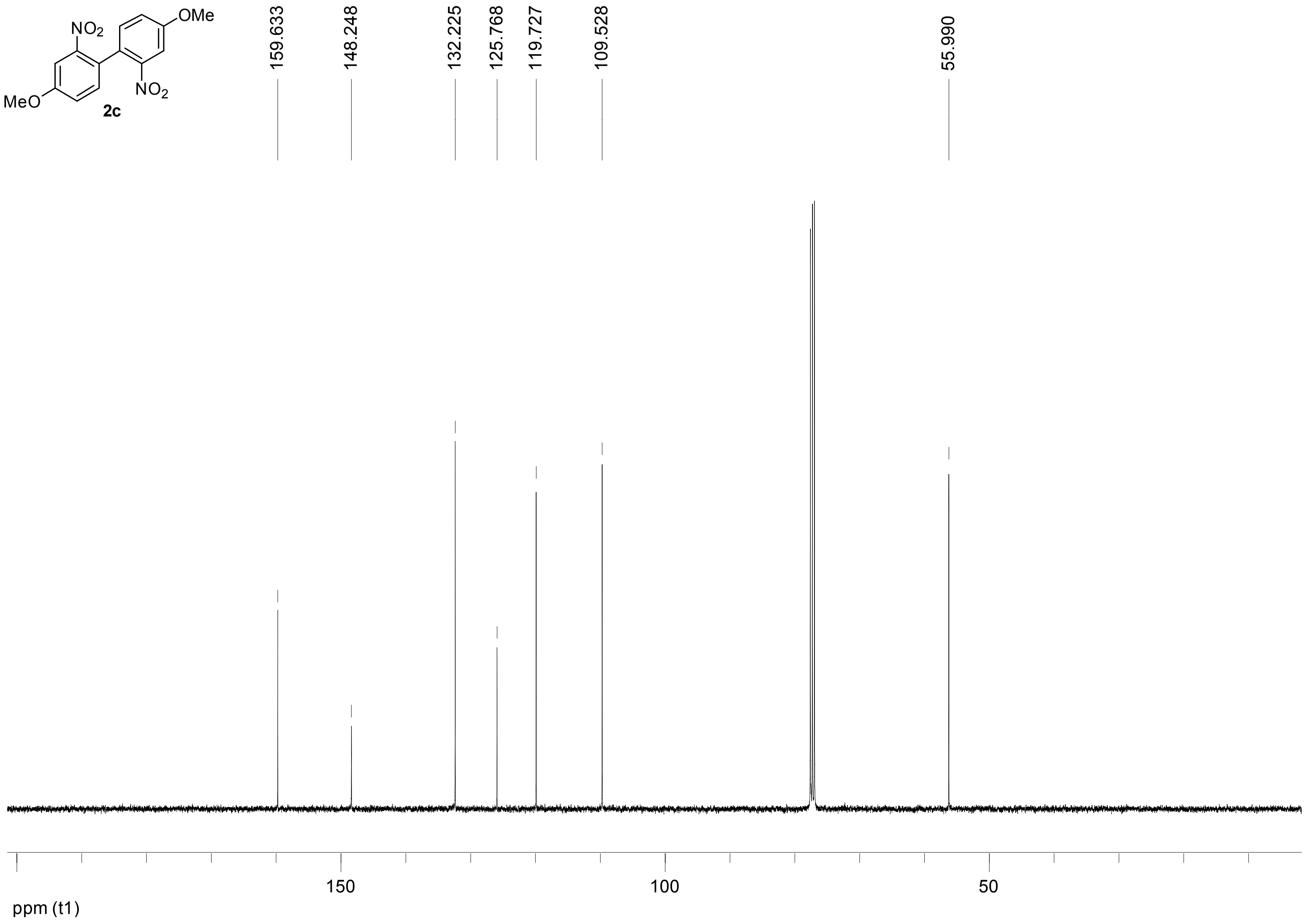
NO_2
NO_2
MeO
2c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MeO
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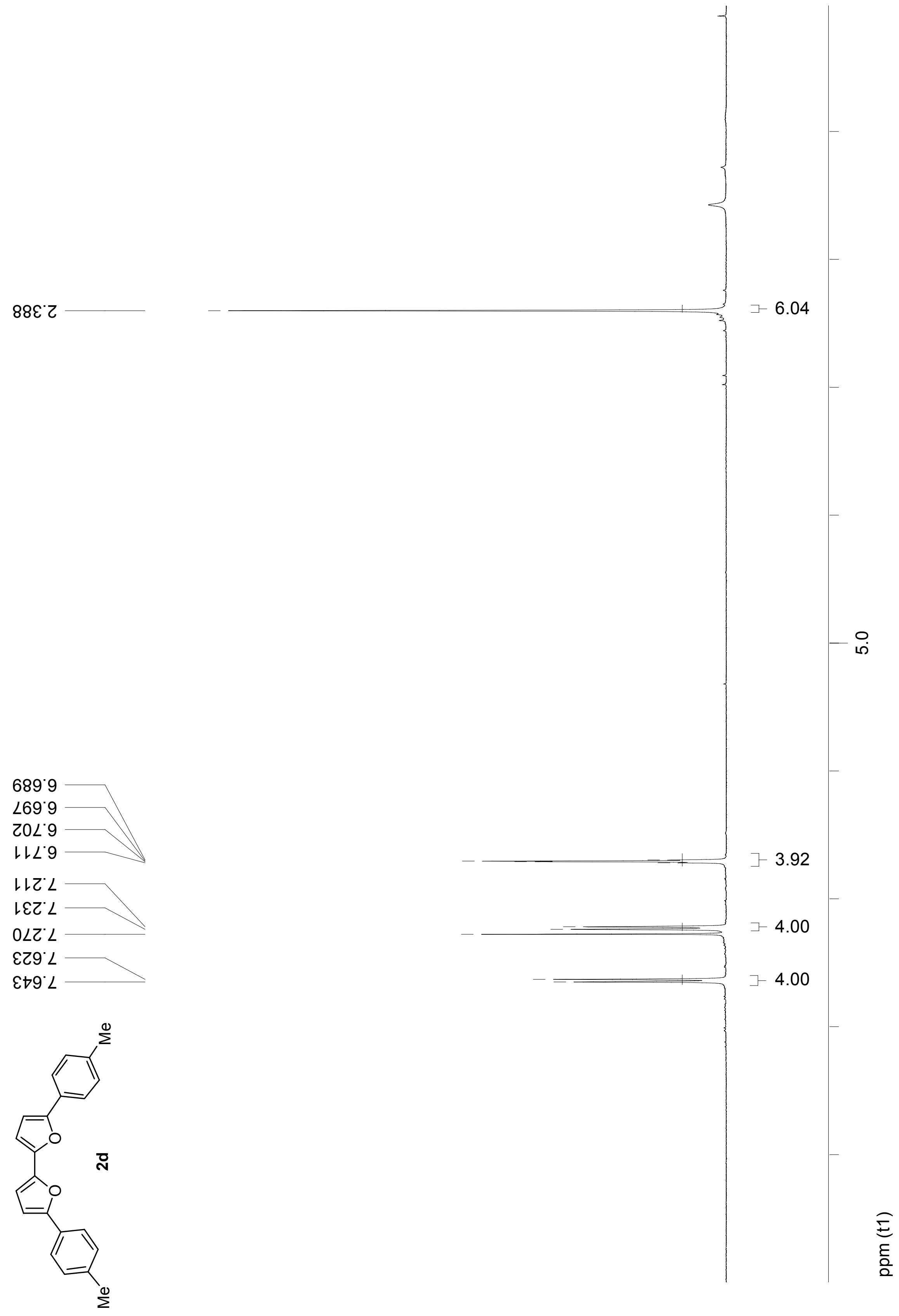
100
50
ppm (t1)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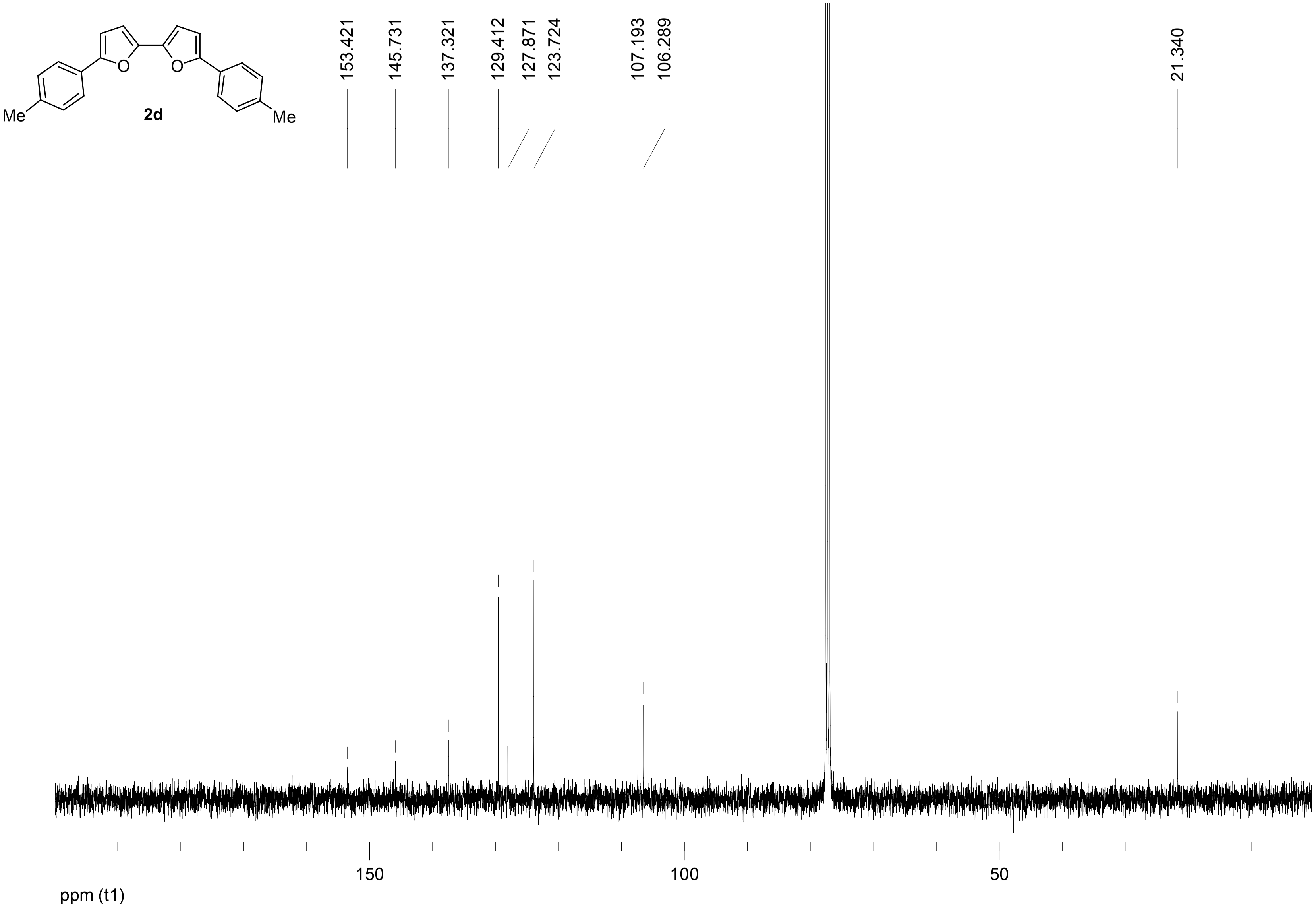
4.00
4.00
5.0
ppm (t1)
Me
Me
O
O

2d


Me
O
O
Me

2d

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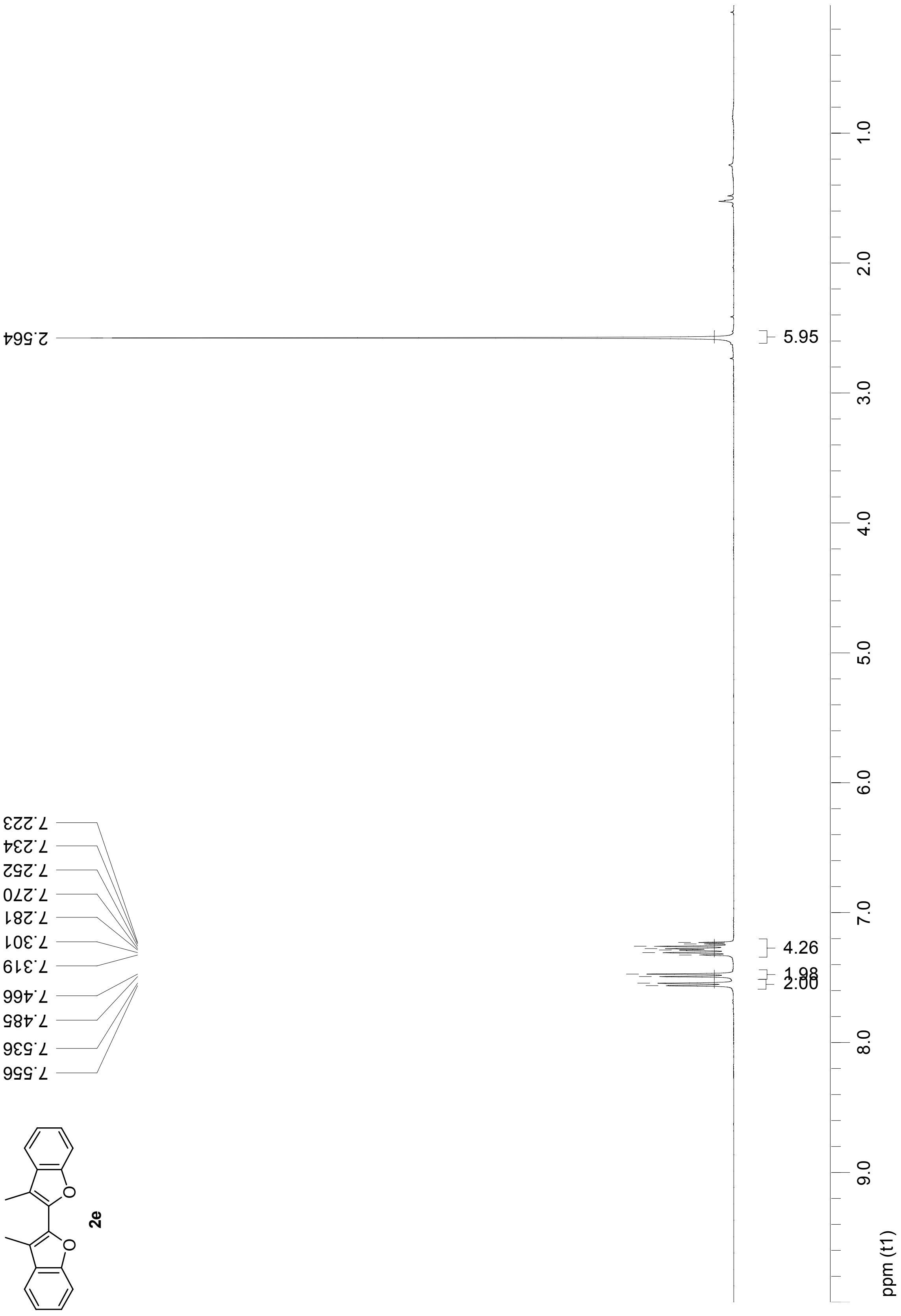
100
50
ppm (t1)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4.26
1.98
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3.0
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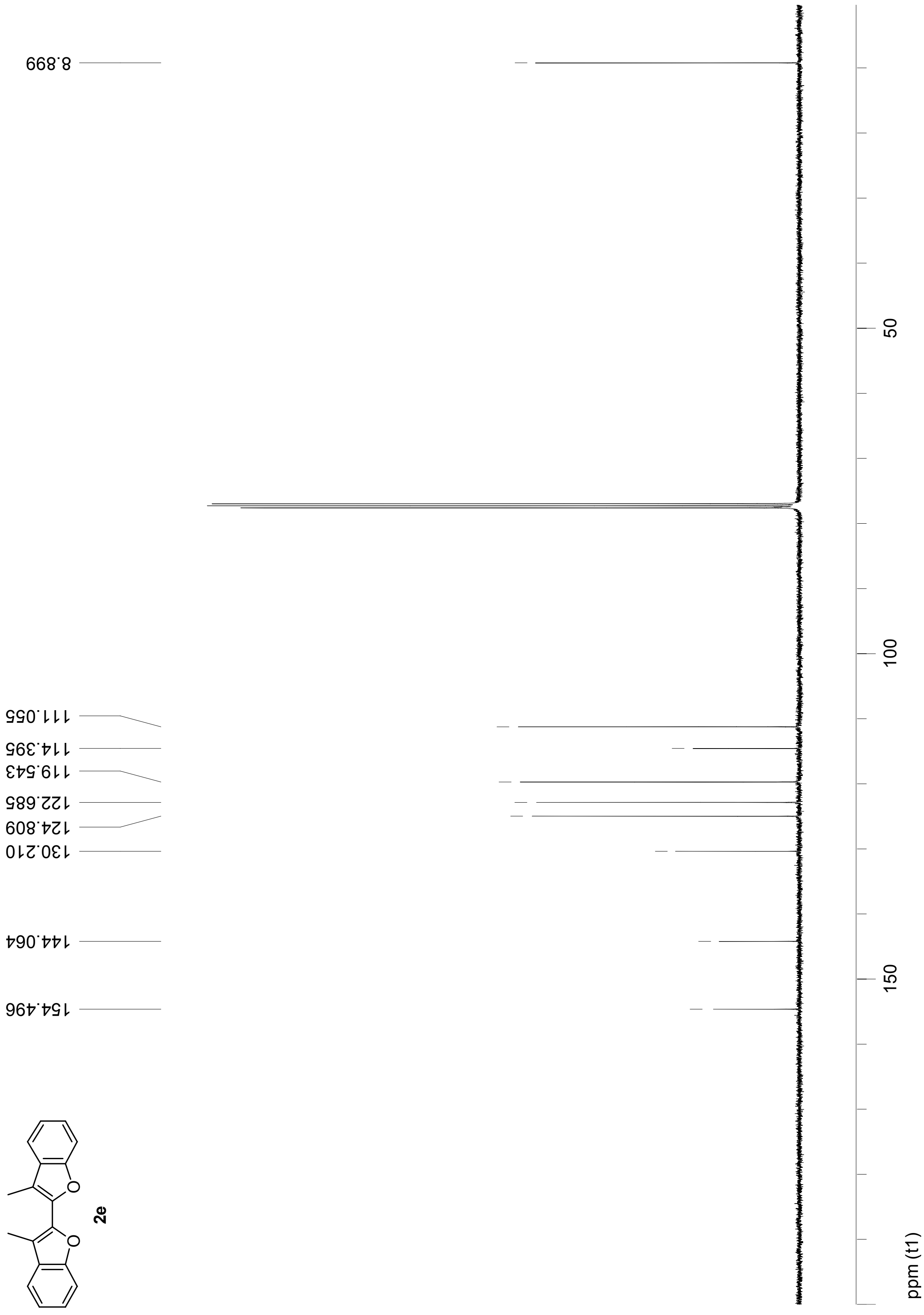
5.0
6.0
7.0
8.0
9.0
ppm (t1)

2e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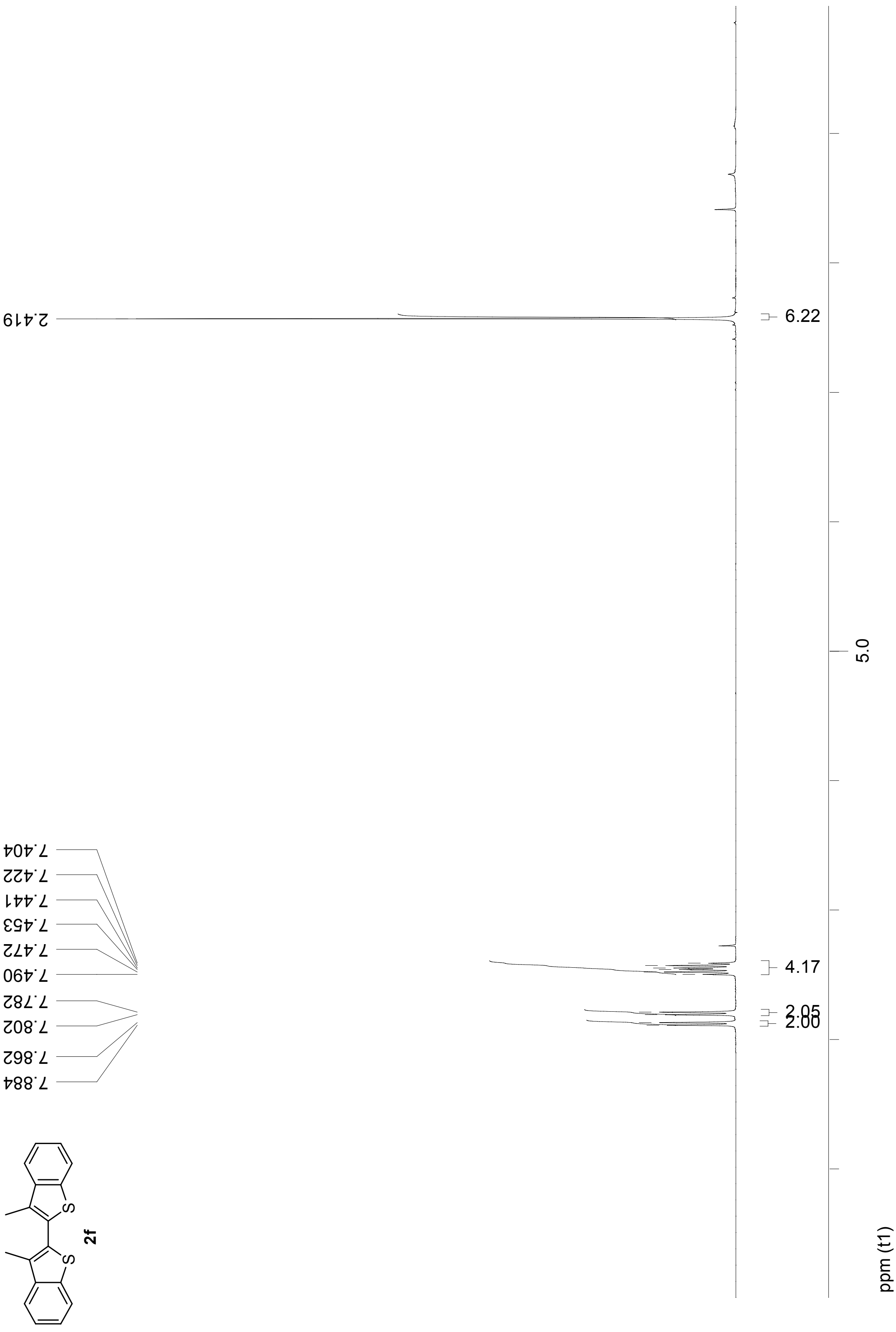
ppm (t1)

2e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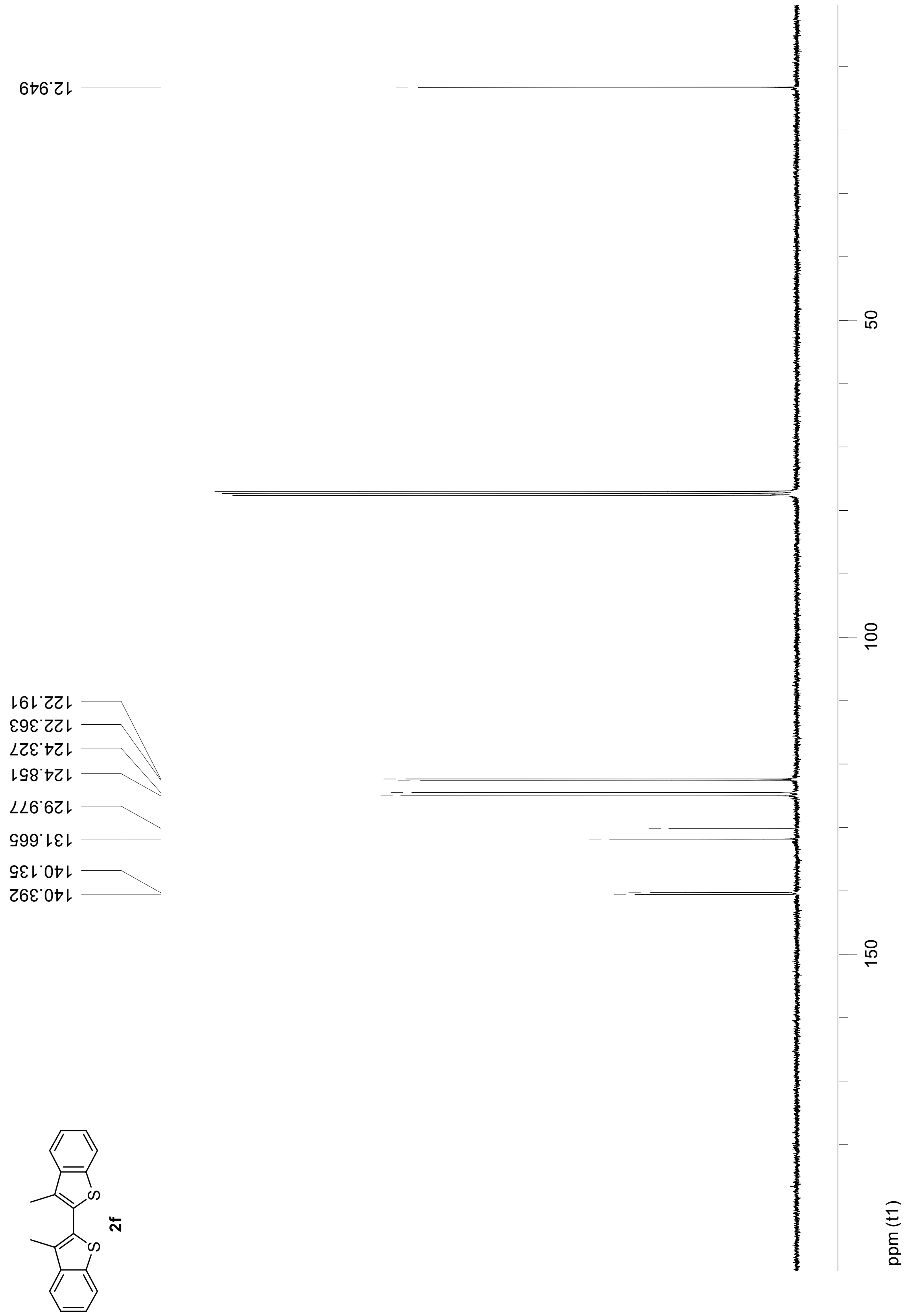
5.0
ppm (t1)
S
S
2f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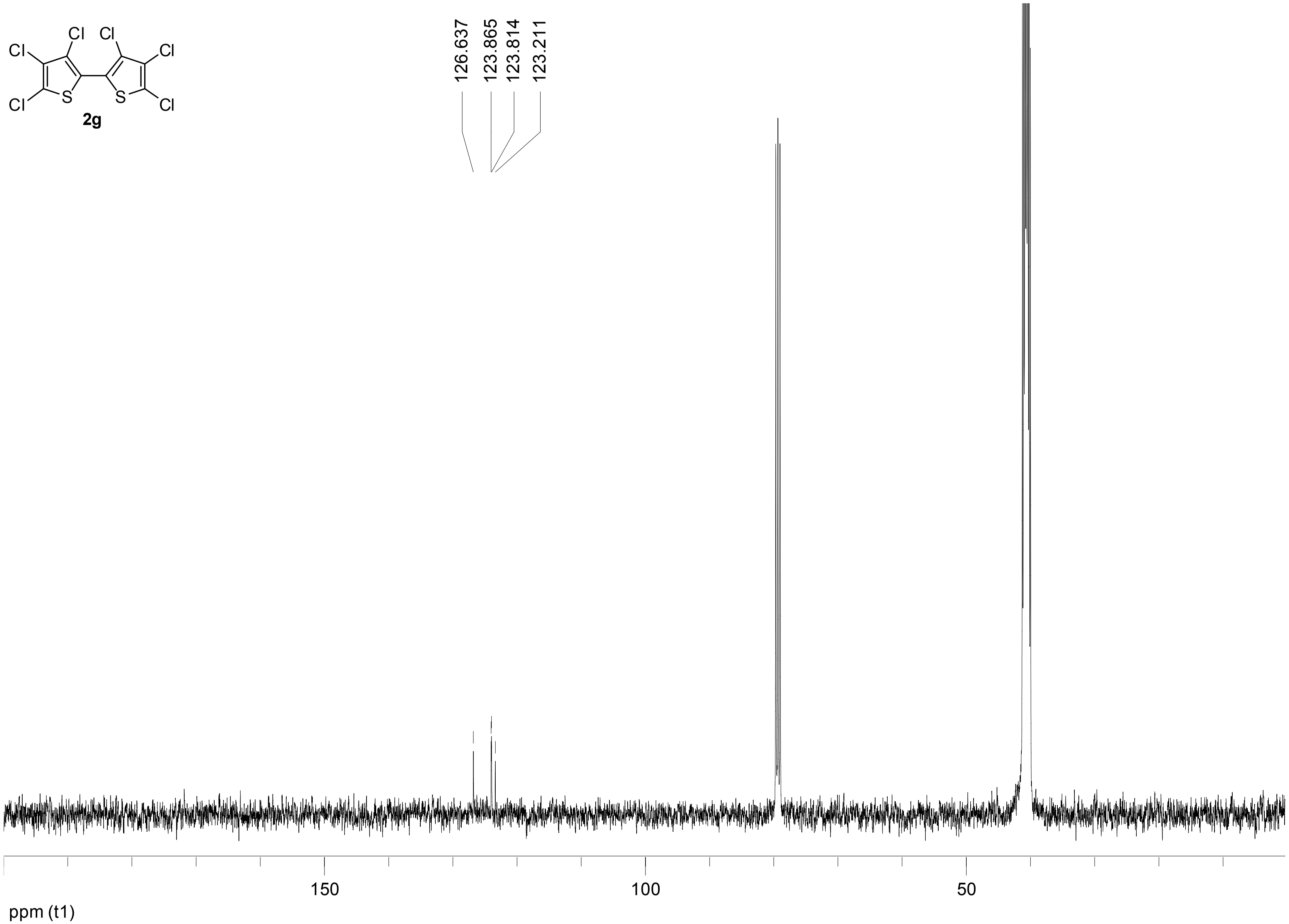
2f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Cl
Cl
S
Cl
Cl
S
Cl
Cl
2g
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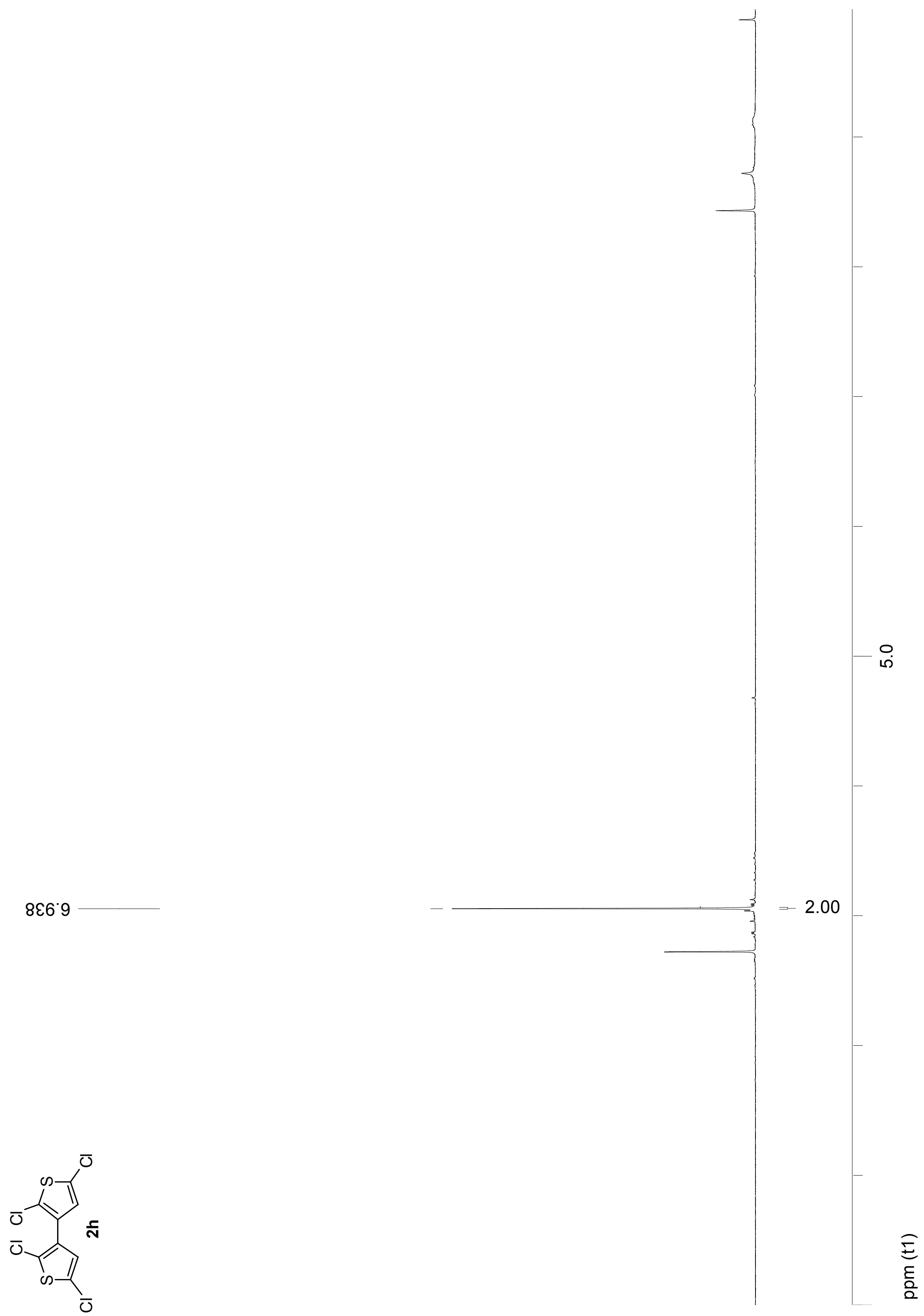
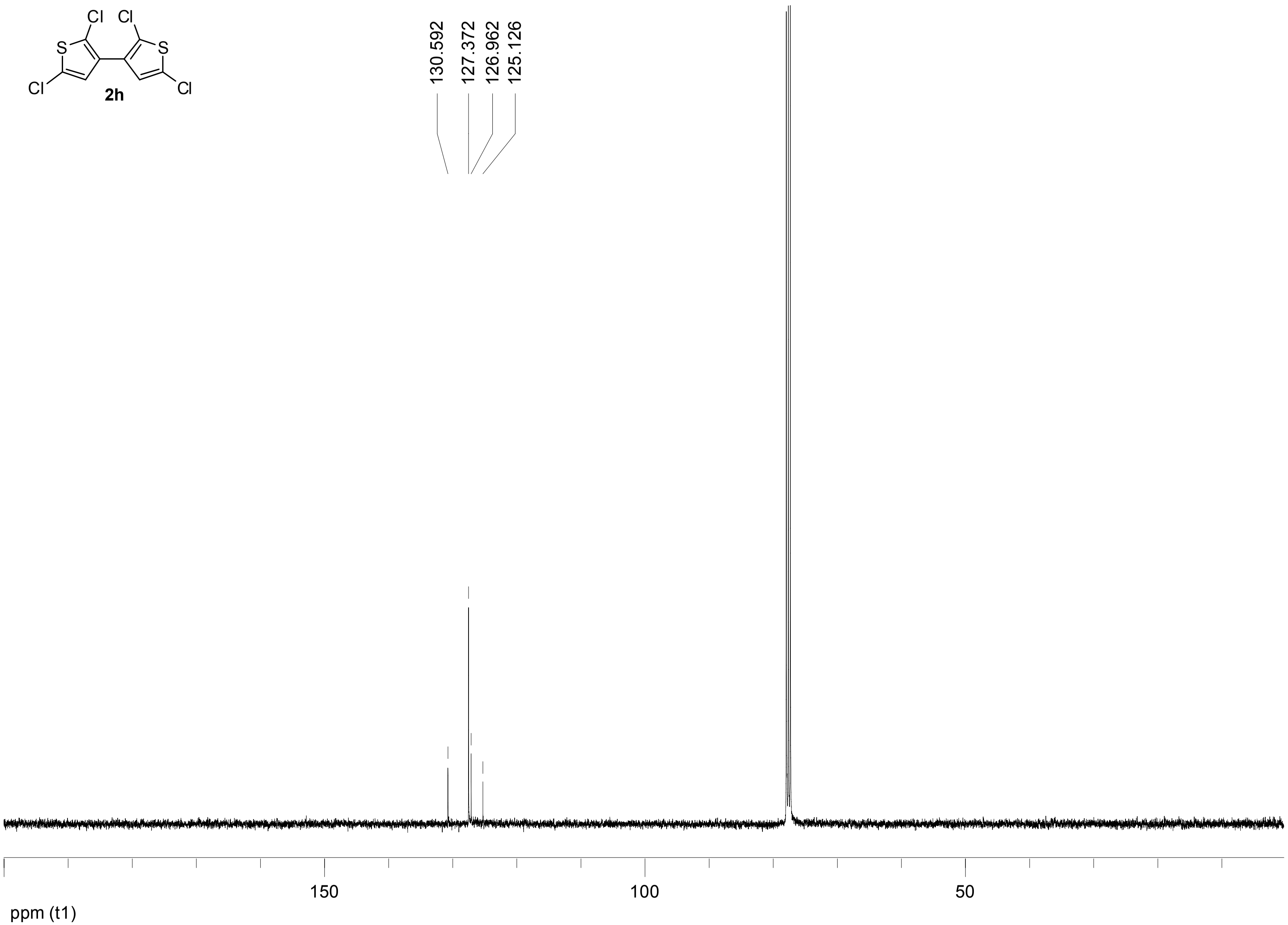
123.211
150
100
50
ppm (t1)



2h


Cl
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S
S
Cl
Cl
2h
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150
100
50
ppm (t1)