Electronic Supplementary Material (ESI) for ChemComm.

Supporting Information

Regioselective Access to CF_3S-substituted Dihydrofurans from Homopropargylic Alcohols with Trifluoromethanesulfenamide

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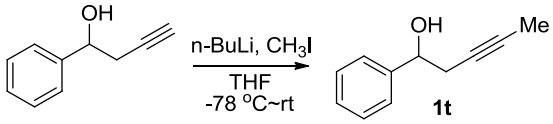
1. General remarks

Column chromatography was carried out on silica gel and analytical TLC was performed with silica gel GF254 plates. NMR spectra were recorded on a Bruker advance Ⅲ 400 spectrometer in $CDCl_3$ at 400 MHz (^{1}H NMR), 100 MHz (^{13}C NMR), 376 MHz (^{19}F NMR). IR spectra were recorded on a FT-IR spectrometer and only major peaks are reported in cm^{-1}. Data collections for crystal structure were performed at room temperature (295 K). Melting points were determined on a microscopic apparatus and were uncorrected. High-resolution mass spectral analysis (HRMS) data were measured on a Bruker Apex II. All products were further characterized by high resolution mass spectra (HRMS). Copies of their ^{1}H NMR, ^{13}C NMR are provided.

Unless otherwise noted, materials obtained from commercial suppliers were used without further purification. Homopropargylic alcohols were prepared according to literature procedures.[1] CH_2Cl_2 was dried and distilled from CaH_2. Room temperature is 27 °C.

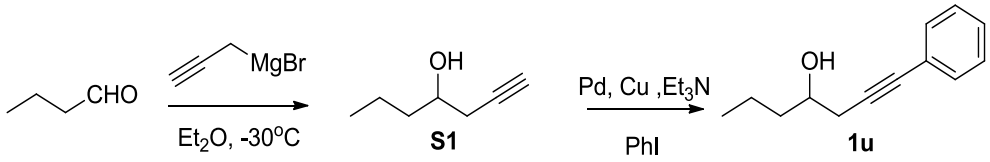
2. General procedure for the synthesis of 1t-1w:

1 1t were prepared in the method[2]:



n-BuLi (2.5 M in hexanes, 6 mL, 15 mmol) was slowly added to a stirred solution of the propargyl alcohol (876 mg, 6 mmol) prepared in dry THF (20 mL) at -78 °C under Ar. After being stirred at -78 °C for 1 h, the reaction mixture was treated with CH_3I (1.12 mL, 18 mmol) and then allowed to warm to rt over night. The reaction mixture was then cooled to -78 °C again, quenched with sat. NH_4Cl (aq) (10 mL), and extracted with Et_2O (3 * 20 mL). The combined organic phases were dried over Na_2SO_4, filtered and concentrated in vacuo. The residue was purified by column chromatography on silica gel to give **1t** as a yellow oil.

2 1u-1y were prepared in the same method[3]:



Under a argon atmosphere, magnesium turnings (0.67 g, 27.5 mmol) and mercury chloride (0.34 g,

1.3 mmol) were mixed in dry diethyl ether (40 mL) in a 250 mL round-bottom flask. To the solution, propargyl bromide (2.0 mL, 25 mmol) was then added dropwise at 60 ^{o}C over about 1 h. The reaction was kept at the same temperature until the yellow solution turned cloudy. This solution was cooled to -30 ^{o}C and a solution of butyraldehyde (6 mmol) in Et_2O (12 ml) was added dropwise. After addition the reaction was moved to room temperature for further 30 min then quenched with sat. NH_4Cl (aq). The aqueous layer was extracted with ether and the extracts were combined with the above organic layer. The combined solution was dried over Na_2SO_4. After evaporation of the solvent the residue was purified by column chromatography (silica gel, appropriate mixture of *n*-hexane/ethyl acetate) to afford **S1**.

To a dried schlenk flask was added **S1** (10.0 mmol), $Pd(PPh_3)_2Cl_2$ (0.2 mmol), CuI (0.4 mmol), iodoarene (11.0 mmol) and freshly distilled Et_3N (50 ml) under argon. The resulting mixture was stirred for 16 h at rt. The reaction mixture was quenched with sat. NH_4Cl (aq) and 50 mL of ethyl acetate were added and the mixture filtered. After removal of solvent using rotary evaporator, the crude compound was purified by column chromatography on silica gel to give **1u**.

3. General experimental procedure

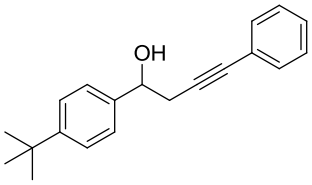
General procedure for synthesis of 4-((trifluoromethyl)thio)-2,3-dihydrofuran from homopropargylic alcohol: homopropargylic alcohol **1a** (44.4 mg, 0.2 mmol), *p*-toluenesulfonic acid (0.6 mmol), $BiCl_3$ (0.2 mmol) were successively added to a solution of trifluoromethanesulfenamide **2** (0.4 mmol) in CH_2Cl_2 (2.0 mL). The reactor was flushed with argon and sealed. The reaction mixture was stirring at 50 ℃ for 5 hour. The reaction mixture was quenched with 2 mL sat. $NaHCO_3$ (aq) and extracted with ethyl acetate (3 * 20 mL). The organic phases were combined and dried over sodium sulfate. The mixture was concentrated in vacuo and then purified by column chromatography on silica gel to afford **3a**.

Dehydrogenation of 2,5-diphenyl-4-((trifluoromethyl)thio)-2,3-dihydrofuran (3a)[4]:

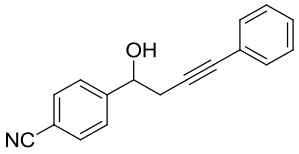
2,3-dichloro-5,6-dicyano-1,4-benzoquinone (DDQ) (59 mg, 0.26 mmol) was added to a solution of **3a** (64.4 mg, 0.2 mmol) in toluene (3 mL). The mixture was refluxed for 5 h and then cooled to r.t. The solution was hydrolyzed and neutralized with aq 5% NaOH solution. The organic phases

were extracted with ethyl acetate (3 * 15 mL) and the combined extracts were dried (Na_2SO_4). After evaporation of the solvent, the residue was purified by column chromatography on silica gel to give **4** (57.4 mg, 90 %) as a white solid.

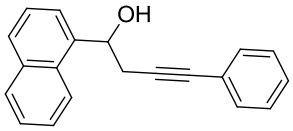
4. Characterization data of 1c, 1f, 1h-1k, 1n, 1s-1y



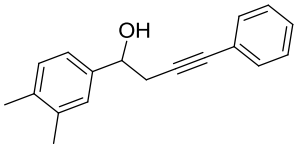
1-(4-(tert-butyl)phenyl)-4-phenylbut-3-yn-1-ol (1c): ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.32 (s, 9H), 2.52 (d, J = 2.0 Hz, 1H), 2.84 (d, J = 6.4 Hz, 2H), 4.89-4.93 (m, 1H), 7.27 (t, J = 3.2 Hz, 3H), 7.34-7.40 (m, 6H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 150.8, 139.7, 131.6, 128.2, 127.9, 125.5, 125.3, 123.3, 86.3, 83.0, 72.4, 34.5, 31.3, 30.4.



1-(4-cyanophenyl)-4-phenylbut-3-yn-1-ol (1f): ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.64 (d, J = 4.0 Hz, 1H), 2.80-2.92 (m, 2H), 4.99-5.03 (m, 1H), 7.28-7.32 (m, 3H), 7.35-7.38 (m, 2H), 7.56 (d, J = 8.0 Hz, 2H), 7.66 (d, J = 8.4 Hz, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 147.8, 132.2, 131.6, 128.3, 128.3, 126.6, 122.8, 118.7, 111.6, 84.6, 83.9, 71.8, 30.5.

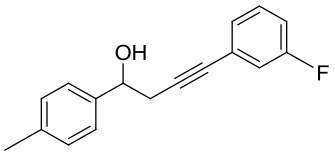


1-(naphthalen-1-yl)-4-phenylbut-3-yn-1-ol (1h): ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.65 (d, J = 3.6 Hz, 1H), 2.94-3.14 (m, 2H), 5.72-5.76 (m, 1H), 7.28-7.30 (m, 3H), 7.37-7.40 (m, 2H), 7.48-7.56 (m, 3H), 7.77 (d, J = 7.2 Hz, 1H), 7.81 (d, J = 8.4 Hz, 1H), 7.88-7.90 (m, 1H), 8.12 (d, J = 8.4 Hz, 1H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 138.0, 133.7, 131.7, 130.2, 129.0, 128.4, 128.2, 128.0, 126.2, 125.6, 125.4, 123.2, 123.0, 122.9, 86.2, 83.5, 69.4, 29.8.

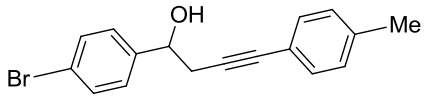


1-(3,4-dimethylphenyl)-4-phenylbut-3-yn-1-ol (1i): ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.26 (d, J =

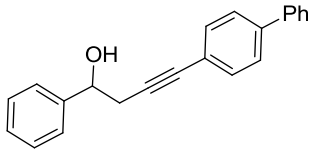
7.6 Hz, 6H), 2.42 (s, 1H), 2.83 (d, *J* = 6.4 Hz, 2H), 4.88 (t, *J* = 6.4 Hz, 1H), 7.11-7.16 (m, 2H), 7.20 (s, 1H), 7.27-7.29 (m, 3H), 7.37-7.40 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 140.2, 136.6, 136.2, 131.6, 129.6, 128.2, 127.9, 127.0, 123.3, 123.2, 86.3, 83.1, 72.5, 30.6, 19.8, 19.4.



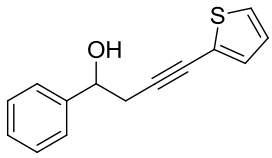
4-(3-fluorophenyl)-1-(p-tolyl)but-3-yn-1-ol (1j): ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.34-2.37 (m, 4H), 2.84 (d, *J* = 6.0 Hz, 2H), 4.90-4.94 (m, 1H), 6.96-7.01 (m, 1H), 7.07 (d, *J* = 9.6 Hz, 1H), 7.15-7.23 (m, 4H), 7.32 (d, *J* = 8.0 Hz, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 162.3 (d, *J* = 245 Hz), 139.7, 137.7, 129.7 (d, *J* = 8.0 Hz), 129.1, 127.5 (d, *J* = 2.0 Hz), 125.7, 125.6 (d, *J* = 92.0 Hz), 118.4 (d, *J* = 22.0 Hz), 115.3 (d, *J* = 21.0 Hz), 87.3, 81.8 (d, *J* = 2.0 Hz), 72.4, 30.4, 21.1; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -113.1 (d, *J* = 3.8 Hz).



1-(4-bromophenyl)-4-(p-tolyl)but-3-yn-1-ol (1k): ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.34 (s, 3H), 2.46 (d, *J* = 3.6 Hz, 1H), 2.76-2.87 (m, 2H), 4.88-4.92 (m, 1H), 7.10 (d, *J* = 7.6 Hz, 2H), 7.26-7.28 (m, 2H), 7.31 (d, *J* = 8.4 Hz, 2H), 7.49 (d, *J* = 8.4 Hz, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 141.7, 138.2, 131.5 (d, *J* = 4.0 Hz), 129.0, 127.5, 121.6, 119.9, 84.5, 83.6, 71.9, 30.6, 21.4.

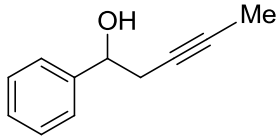


4-([1,1'-biphenyl]-4-yl)-1-phenylbut-3-yn-1-ol (1n): ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.52 (s, 1H), 2.87 (d, *J* = 6.4 Hz, 2H), 4.95 (t, *J* = 6.4 Hz, 1H), 7.29-7.34 (m, 2H), 7.35 -7.40 (m, 3H), 7.42-7.45 (m, 5H), 7.50-7.52 (m, 2H), 7.55-7.57 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 142.7, 140.7, 140.3, 132.0, 128.8, 128.4, 127.9, 127.5, 127.0, 126.9, 125.8, 122.1, 86.7, 83.0, 72.6, 30.6.

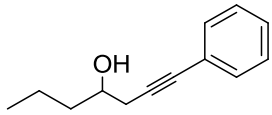


1-phenyl-4-(thiophen-2-yl)but-3-yn-1-ol (1s): ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.63 (s, 1H), 2.83 (d, *J* = 6.4 Hz, 2H), 4.89 (t, *J* = 6.4 Hz, 1H), 6.89-6.92 (m, 1H), 7.11-7.21 (m, 1H), 7.15-7.16 (m,

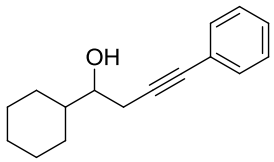
1H), 7.26-7.30 (m, 1H), 7.32-7.36 (m, 2H), 7.38-7.40 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 142.5, 131.5, 128.4, 127.9, 126.7, 126.4, 125.7, 123.3, 90.2, 76.2, 72.4, 30.7.



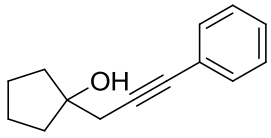
1-phenylpent-3-yn-1-ol (1t): ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.77 (t, J = 2.4 Hz, 3H), 2.51-2.56 (m, 2H), 2.69 (s, 1H), 4.74-4.77 (m, 1H), 7.23-7.28 (m, 1H), 7.30-7.36 (m, 4H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 142.8, 128.2, 127.6, 125.6, 78.5, 75.2, 72.5, 29.8, 3.4.



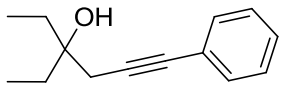
phenylhept-1-yn-4-ol (1u): ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.95 (t, J = 7.2 Hz, 3H), 1.35-1.60 (m, 4H), 2.14 (s, 1H), 2.51-2.67 (m, 2H), 3.84 (t, J = 5.6 Hz, 1H), 7.27-7.29 (m, 3H), 7.40-7.42 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 131.6, 128.2, 127.8, 123.4, 86.2, 82.9, 69.9, 38.5, 28.3, 18.8, 14.0.



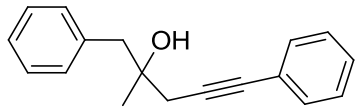
1-cyclohexyl-4-phenylbut-3-yn-1-ol (1v): ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.98-1.11 (m, 2H), 1.12-1.32 (m, 3H), 1.46-1.55 (m, 1H), 1.65-1.78 (m, 4H) 1.91-1.94 (m, 1H), 2.21 (m, 1H), 2.56 (dd, J_1 = 16.8 Hz, J_2 = 7.4 Hz, 1H), 2.66 (dd, J_1 = 16.8 Hz, J_2 = 4.4 Hz, 1H), 3.54-3.58 (m, 1H), 7.25-7.28 (m, 3H), 7.38-7.43 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 131.5, 128.1, 127.7, 123.4, 86.6, 82.7, 74.1, 42.5, 29.0, 28.0, 26.3, 26.1, 25.9, 25.5.



1-(3-phenylprop-2-yn-1-yl)cyclopentanol (1w): ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.67-1.87 (m, 8H), 2.00 (s, 1H), 2.71 (s, 2H), 7.29 (t, J = 3.2 Hz, 3H), 7.40-7.43 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 131.6, 128.2, 127.8, 123.4, 86.8, 82.5, 81.2, 39.2, 32.4, 24.1.

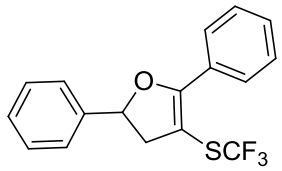


3-ethyl-6-phenylhex-5-yn-3-ol (1x): **^{1}H NMR** (400 MHz, $CDCl_3$) δ 0.93 (t, J = 7.6 Hz, 6H), 1.57-1.72 (m, 4H), 1.80 (s, 1H), 2.57 (s, 2H), 7.27-7.28 (m, 3H), 7.40-7.42 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 131.6, 128.2, 127.8, 123.5, 86.2, 83.2, 74.1, 30.8, 30.2, 7.9.

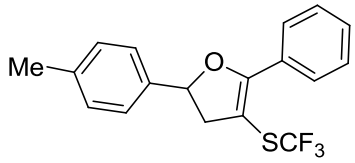


2-methyl-1,5-diphenylpent-4-yn-2-ol (1y): **^{1}H NMR** (400 MHz, $CDCl_3$) δ 1.33 (s, 3H), δ 1.94 (s, 1H), 2.53 (dd, J_1 = 24.0 Hz, J_2 = 16.8 Hz, 2H), 2.94 (q, J_1 = 13.6 Hz, 2H), 7.23-7.34 (m, 8H), 7.43-7.46 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 137.1, 131.6, 130.4, 128.3, 128.2, 127.9, 126.6, 123.4, 86.4, 83.8, 72.4, 46.9, 32.7, 26.7.

5. Characterization data of 3a-3y, 3aa, 4

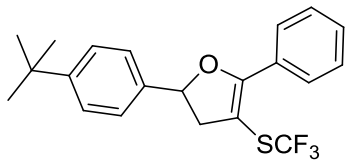


2,5-diphenyl-4-((trifluoromethyl)thio)-2,3-dihydrofuran (3a): Pale yellow oil; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 3.09 (dd, J_1 = 15.2 Hz, J_2 = 8.8 Hz, 1H), 3.54 (dd, J_1 = 15.2 Hz, J_2 = 10.8 Hz, 1H), 5.72 (dd, J_1 = 10.8 Hz, J_2 = 8.8 Hz, 1H), 7.31-7.35 (m, 1H), 7.37-7.43 (m, 7H), 7.91-7.93 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 162.3 (d, J = 1.0 Hz), 141.5, 130.2, 129.7 (q, J = 310.0 Hz), 129.1, 128.8, 128.3, 128.2, 125.7, 90.0 (d, J = 2.0 Hz), 81.9, 45.0; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -42.4; IR (thin film, cm^{-1}) 3361, 3064, 2925, 2371, 1599, 1493, 1448, 1330, 1236, 1124, 919, 770, 694; HRMS (ESI) m/z calcd for $C_{17}H_{13}F_3OS$ $[M+H]^+$: 323.0639, found: 323.0712.

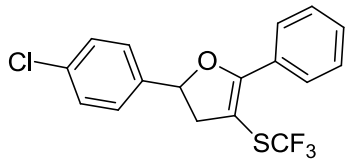


5-phenyl-2-(p-tolyl)-4-((trifluoromethyl)thio)-2,3-dihydrofuran (3b): Pale yellow oil; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 2.36 (s, 3H), 3.08 (dd, J_1 = 15.2 Hz, J_2 = 8.8 Hz, 1H), 3.51 (dd, J_1 = 14.8 Hz, J_2 = 10.8 Hz, 1H), 5.70 (dd, J_1 = 10.4 Hz, J_2 = 8.8 Hz, 1H), 7.20 (d, J= 8.0 Hz, 2H), 7.29 (d, J = 8.4 Hz, 2H), 7.39-7.41 (m, 3H), 7.90-7.92 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 162.3, 138.5, 138.1, 130.1, 129.7 (q, J = 310.0 Hz), 129.4, 129.2, 128.3, 128.1, 125.7, 89.8, 81.9, 44.9, 21.2; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -42.5; IR (thin film, cm^{-1}) 3373, 2925, 2372, 1901, 1768,

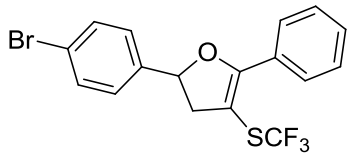
1598, 1492, 1331, 1236, 1123, 917, 816, 770, 692; HRMS (ESI) m/z calcd for $C_{18}H_{15}F_3OS$ $[M+H]^+$: 337.0796, found: 337.0868.



2-(4-(tert-butyl)phenyl)-5-phenyl-4-((trifluoromethyl)thio)-2,3-dihydrofuran (3c): Pale yellow oil; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 1.32 (s, 9H), 3.12 (dd, J_1= 15.2 Hz, J_2= 8.8 Hz, 1H), 3.51 (dd, J_1 = 15.2 Hz, J_2 = 10.8 Hz, 1H), 5.70 (t, J= 9.6 Hz, 1H), 7.34 (d, J = 8.4 Hz, 2H), 7.39-7.43 (m, 5H), 7.90-7.92 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 162.3, 151.4, 138.4, 130.1, 129.7 (q, J = 310.0 Hz), 129.2, 128.3, 128.2, 125.7, 125.6, 89.9 (d, J = 2.0 Hz), 81.9, 44.8, 34.6, 31.3; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -42.4; IR (thin film, cm^{-1}) 3363, 2962, 2373, 1598, 1493, 1331, 1237, 1123, 913, 833, 770, 692; HRMS (ESI) m/z calcd for $C_{21}H_{21}F_3OS$ $[M+H]^+$: 379.1265, found: 379.1338.

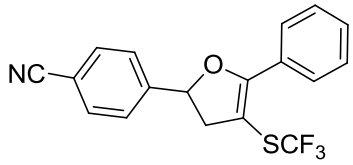


2-(4-chlorophenyl)-5-phenyl-4-((trifluoromethyl)thio)-2,3-dihydrofuran (3d): Pale yellow oil; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 3.03 (dd, J_1 = 15.2 Hz, J_2 = 8.8 Hz, 1H), 3.53 (dd, J_1 = 15.2 Hz, J_2 = 10.8 Hz, 1H), 5.69 (dd, J_1 = 10.8 Hz, J_2 = 8.8 Hz, 1H), 7.31-7.37 (m, 4H), 7.40-7.42 (m, 3H), 7.90-7.92 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 162.1, 140.0, 134.1, 131.9, 130.3, 129.6 (q, J = 310.0 Hz), 129.0, 128.9, 128.2, 127.0, 90.0 (d, J = 2.0 Hz), 81.1, 44.9; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -42.4; IR (thin film, cm^{-1}) 3374, 3061, 2926, 2369, 1899, 1599, 1492, 1446, 1329, 1236, 1124, 1015, 917, 827, 770, 692; HRMS (ESI) m/z calcd for $C_{17}H_{12}ClF_3OS$ $[M+H]^+$: 357.0249, found: 357.0322.

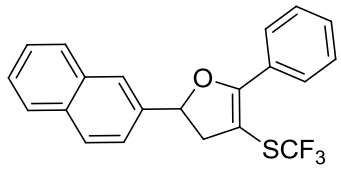


2-(4-bromophenyl)-5-phenyl-4-((trifluoromethyl)thio)-2,3-dihydrofuran (3e): Pale yellow oil; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 3.03 (dd, J_1 = 15.2 Hz, J_2 = 8.4 Hz, 1H), 3.54 (dd, J_1 = 15.2 Hz, J_2 = 10.8 Hz, 1H), 5.68 (dd, J_1 = 10.8 Hz, J_2 = 8.4 Hz, 1H), 7.26 (d, J = 8.4 Hz, 2H), 7.40-7.43 (m,

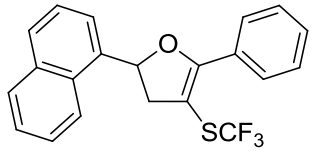
3H), 7.50-7.52 (m, 2H), 7.89-7.92 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 162.1, 140.5, 131.9, 130.3, 129.6 (q, J = 310.0 Hz), 128.9, 128.2, 128.1 127.4, 122.2, 90.0, 81.2, 44.9; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -42.4; IR (thin film, cm^{-1}) 3371, 2925, 2374, 1893, 1597, 1491, 1328, 1237, 1122, 824, 770, 692; HRMS (ESI) m/z calcd for $C_{17}H_{12}BrF_3OS$ $[M+H]^+$: 400.9744, found: 400.9817.



4-(5-phenyl-4-((trifluoromethyl)thio)-2,3-dihydrofuran-2-yl)benzonitrile (3f): Yellow oil; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 3.02 (dd, J_1 = 15.2 Hz, J_2 = 8.4 Hz, 1H), 3.60 (dd, J_1 = 15.2 Hz, J_2 = 10.8 Hz, 1H), 5.78 (dd, J_1 = 10.8 Hz, J_2 = 8.4 Hz, 1H), 7.42-7.45 (m, 3H), 7.49 (d, J = 8.0 Hz, 2H), 7.68 (d, J = 8.4 Hz, 2H), 7.91-7.94 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 162.0 (d, J = 2.0 Hz), 146.7, 132.6, 130.4, 129.5 (q, J = 310.0 Hz), 128.5, 128.3, 128.1, 126.1, 118.5, 112.0, 90.1 (d, J = 2.0 Hz), 80.6, 44.8; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -42.3; IR (thin film, cm^{-1}) 3405, 3062, 2924, 2230, 1920, 1611, 1493, 1327, 1238, 1124, 919, 838, 770, 693; HRMS (ESI) m/z calcd for $C_{18}H_{12}F_3NOS$ $[M+H]^+$: 348.0592, found: 348.0664.

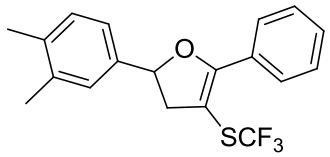


2-(naphthalen-2-yl)-5-phenyl-4-((trifluoromethyl)thio)-2,3-dihydrofuran (3g): White solid. Mp = 86-88 ^{o}C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 3.17 (dd, J_1 = 15.2 Hz, J_2 = 8.8 Hz, 1H), 3.60 (dd, J_1 = 14.8 Hz, J_2 = 10.8 Hz, 1H), 5.76 (t, J = 9.6 Hz, 1H), 7.41-7.51 (m, 6H), 7.83-7.89 (m, 4H), 7.95-7.97 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 162.3, 138.6, 133.2, 133.2, 130.2, 129.7 (q, J = 310.0 Hz), 129.1, 128.9, 128.3, 128.2, 128.1, 127.7, 126.4, 126.3, 124,7, 123.4, 90.1 (d, J = 2.0 Hz), 82.1, 44.9; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -42.4; IR (thin film, cm^{-1}) 3376, 2924, 2371, 1796, 1597, 1384, 1262, 1121, 856, 770, 748, 690; HRMS (ESI) m/z calcd for $C_{21}H_{15}F_3OS$ $[M+H]^+$: 373.0796, found: 373.0868.

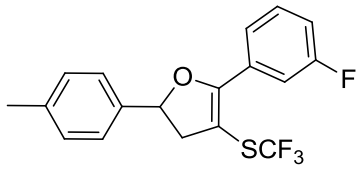


2-(naphthalen-1-yl)-5-phenyl-4-((trifluoromethyl)thio)-2,3-dihydrofuran (3h): Pale yellow oil;

^{1}H NMR (400 MHz, $CDCl_3$) δ 3.14 (dd, J_1 = 15.2 Hz, J_2 = 8.8 Hz, 1H), 3.76 (dd, J_1 = 15.2 Hz, J_2 = 11.2 Hz, 1H), 6.40 (dd, J_1 = 10.8 Hz, J_2 = 9.2 Hz, 1H), 7.44-7.49 (m, 4H), 7.52-7.55 (m, 2H), 7.63 (d, J = 7.2 Hz, 1H), 7.83 (d, J = 8.0 Hz, 1H), 7.88-7.92 (m, 2H), 8.00-8.03 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 159.7, 148.3, 140.7, 135.0, 129.3 (q, J = 310.0 Hz), 129.1, 128.9, 128.6, 125.7, 123.4, 94.2 (d, J = 2.0 Hz), 82.4, 45.0; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -42.3; IR (thin film, cm^{-1}) 3370, 3059, 2926, 2370, 1808, 1598, 1493, 1321, 1236, 1124, 920, 775, 692; HRMS (ESI) m/z calcd for $C_{21}H_{15}F_3OS$ $[M+H]^+$: 373.0796, found: 373.0868.

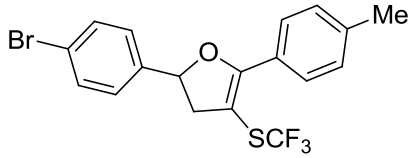


2-(3,4-dimethylphenyl)-5-phenyl-4-((trifluoromethyl)thio)-2,3-dihydrofuran (3i): Pale yellow oil; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 2.27 (d, J = 8.0 Hz, 6H), 3.10 (dd, J_1 = 15.2 Hz, J_2 = 8.8 Hz, 1H), 3.50 (dd, J_1 = 15.2 Hz, J_2 = 10.8 Hz, 1H), 5.67 (dd, J_1 = 9.6 Hz, J_2 = 8.8 Hz, 1H), 7.14-7.17 (m, 3H), 7.39-7.41 (m, 3H), 7.90-7.92 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 162.3, 138.9, 137.1, 136.8, 130.1, 130.0, 129.7 (q, J = 310.0 Hz), 129.2, 128.3, 128.1, 127.1, 123.3, 89.9, 82.1, 44.9, 19.8, 19.5; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -42.5; IR (thin film, cm^{-1}) 3340, 2924, 2369, 1720, 1598, 1447, 1265, 1125, 910, 801, 741, 656; HRMS (ESI) m/z calcd for $C_{19}H_{17}F_3OS$ $[M+H]^+$: 351.0952, found: 351.1025.

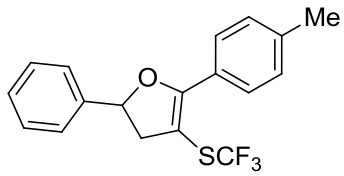


5-(3-fluorophenyl)-2-(p-tolyl)-4-((trifluoromethyl)thio)-2,3-dihydrofuran (3j): Colorless oil; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 2.36 (s, 3H), 3.10 (dd, J_1 = 15.2 Hz, J_2 = 8.8 Hz, 1H), 3.52 (dd, J_1 = 15.2 Hz, J_2 = 10.8 Hz, 1H), 5.70 (dd, J_1 = 10.8 Hz, J_2 = 8.8 Hz, 1H), 7.08-7.13 (m, 1H), 7.20 (d, J = 8.0 Hz, 2H), 7.28 (d, J = 8.0 Hz, 2H), 7.34-7.39 (m, 1H), 7.62-7.65 (m, 1H), 7.73-7.75 (m, 1H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 162.3 (d, J = 244.0 Hz), 160.7, 138.2 (d, J = 12.0 Hz), 131.1 (d, J = 8.0 Hz), 129.8, 129.7, 129.6 (q, J = 310.0 Hz), 129.5, 125.7, 124.0 (d, J = 2.0 Hz), 117.1 (d, J = 21.0 Hz), 115.2 (d, J = 23.0 Hz), 91.2 (d, J = 2.0 Hz), 82.1, 44.9, 21.2; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -42.3, -112.4; IR (thin film, cm^{-1}) 3341, 2926, 2373, 1900, 1583, 1447, 1327, 1252, 1126,

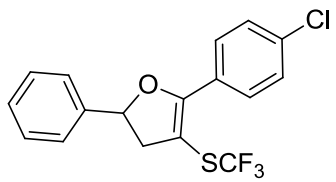
957, 841, 789, 697; HRMS (ESI) m/z calcd for $C_{18}H_{14}F_4OS$ $[M+H]^+$: 355.0701, found: 355.0774.



2-(4-bromophenyl)-5-(p-tolyl)-4-((trifluoromethyl)thio)-2,3-dihydrofuran (3k): Pale yellow oil; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 2.38 (s, 3H), 3.01 (dd, J_1 = 14.8 Hz, J_2 = 8.4 Hz, 1H), 3.52 (dd, J_1 = 14.8 Hz, J_2 = 10.8 Hz, 1H), 5.66 (dd, J_1 = 10.8 Hz, J_2 = 8.4 Hz, 1H), 7.20-7.26 (m, 4H), 7.50 (d, J = 8.4 Hz, 2H), 7.81 (d, J = 8.4 Hz, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 162.3, 140.6, 140.6, 131.9, 129.7 (q, J = 310.0 Hz), 128.9, 128.1, 127.3, 126.0, 122.1, 89.0 (d, J = 2.0 Hz), 81.0, 44.9, 21.5; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -42.5; IR (thin film, cm^{-1}) 3365, 2924, 2370, 1895, 1607, 1490, 1327, 1237, 1123, 915, 822, 661; HRMS (ESI) m/z calcd for $C_{18}H_{14}BrF_3OS$ $[M+H]^+$: 414.9901, found: 414.9974.

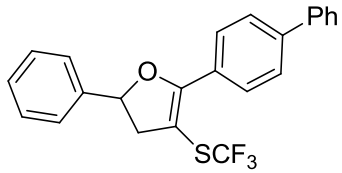


2-phenyl-5-(p-tolyl)-4-((trifluoromethyl)thio)-2,3-dihydrofuran (3l): Pale yellow oil; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 2.37 (s, 3H), 3.07 (dd, J_1 = 14.8 Hz, J_2 = 8.4 Hz, 1H), 3.52 (dd, J_1 = 15.2 Hz, J_2 = 10.8 Hz, 1H), 5.71 (dd, J_1 = 10.8 Hz, J_2 = 8.4 Hz, 1H), 7.20-7.22 (m, 2H), 7.30-7.36 (m, 1H), 7.38-7.39 (m, 4H), 7.83 (d, J = 8.4 Hz, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 162.4, 141.6, 140.4, 129.7 (q, J = 310.0 Hz), 128.9, 128.8, 128.2, 126.3, 125.7, 89.0 (d, J = 1.0 Hz), 81.8, 45.0, 21.4; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -42.5; IR (thin film, cm^{-1}) 3358, 2925, 2372, 1801, 1606, 1509, 1329, 1237, 1123, 919, 822, 756, 698; HRMS (ESI) m/z calcd for $C_{18}H_{15}F_3OS$ $[M+H]^+$: 337.0796, found: 337.0868.

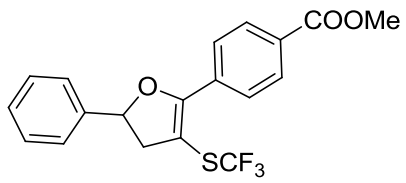


5-(4-chlorophenyl)-2-phenyl-4-((trifluoromethyl)thio)-2,3-dihydrofuran (3m): Pale yellow oil; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 3.09 (dd, J_1 = 15.2 Hz, J_2 = 8.8 Hz, 1H), 3.53 (dd, J_1 = 15.2 Hz, J_2 = 10.8 Hz, 1H), 5.72 (dd, J_1 = 9.6 Hz, J_2 = 9.2 Hz, 1H), 7.33-7.38 (m, 7H), 7.88(d, J = 8.8 Hz, 2H);

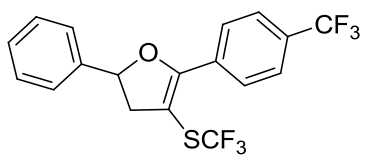
^{13}C NMR (100 MHz, $CDCl_3$) δ 161.1, 141.2, 136.2, 129.6 (q, J = 310.0 Hz), 129.5, 128.8, 128.5, 128.4, 127.5, 125.7, 90.6, 82.0, 45.0; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -42.4; IR (thin film, cm^{-1}) 3368, 2926, 2371, 1907, 1614, 1489, 1328, 1239, 1125, 1014, 919, 834, 755, 698; HRMS (ESI) m/z calcd for $C_{17}H_{12}ClF_3OS$ $[M+H]^+$: 357.0249, found: 357.0322.



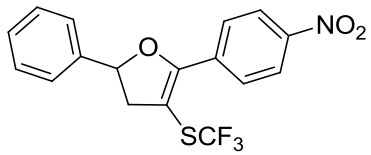
5-([1,1'-biphenyl]-4-yl)-2-phenyl-4-((trifluoromethyl)thio)-2,3-dihydrofuran (3n): White solid. Mp = 80-82 ^{o}C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 3.10 (dd, J_1 = 15.2 Hz, J_2 = 8.8 Hz, 1H), 3.54 (dd, J_1 = 15.2 Hz, J_2 = 10.8 Hz, 1H), 5.73 (dd, J_1 = 9.6 Hz, J_2 = 8.8 Hz, 1H), 7.33-7.45 (m, 8H), 7.59-7.64 (m, 4H), 8.02 (d, J = 8.4 Hz, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 161.9, 142.8, 141.5, 140.2, 129.7 (q, J = 310.0 Hz), 128.9, 128.8, 128.7, 128.3, 127.9, 127.8, 127.1, 126.8, 125.7, 89.9, 81.9, 45.1; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -42.3; IR (thin film, cm^{-1}) 3366, 2925, 2374, 1878, 1604, 1487, 1326, 1241, 1123, 846, 766, 697; HRMS (ESI) m/z calcd for $C_{23}H_{17}F_3OS$ $[M+H]^+$: 399.0952, found: 399.1025.



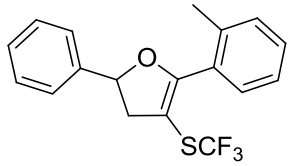
Methyl 4-(5-phenyl-3-((trifluoromethyl)thio)-4,5-dihydrofuran-2-yl)benzoate (3o): Yellow oil; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 3.12 (dd, J_1 = 15.2 Hz, J_2 = 8.8 Hz, 1H), 3.56 (dd, J_1 = 15.6 Hz, J_2 = 10.8 Hz, 1H), 3.92 (s, 3H), 5.75 (dd, J_1 = 10.8 Hz, J_2 = 8.8 Hz, 1H), 7.32-7.37 (m, 1H), 7.39-7.41 (m, 4H), 8.00 (d, J = 8.4 Hz, 2H), 8.08 (d, J = 8.4 Hz, 2H);**^{13}C NMR** (100 MHz, $CDCl_3$) δ 166.4, 161.0, 141.1, 133.2, 131.3, 129.5 (q, J = 310.0 Hz), 129.3, 128.8, 128.4, 128.2, 125.7, 92.3 (q, J = 2.0 Hz), 82.2, 52.2, 45.0; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -42.2; IR (thin film, cm^{-1}) 3428, 2953, 2377, 1940, 1724, 1605, 1437, 1279, 1124, 1018, 862, 776, 700; HRMS (ESI) m/z calcd for $C_{19}H_{15}F_3O_3S$ $[M+H]^+$: 381.0694, found: 381.0767.



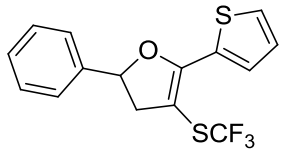
2-phenyl-5-(4-(trifluoromethyl)phenyl)-4-((trifluoromethyl)thio)-2,3-dihydrofuran (3p): Yellow oil; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 3.13 (dd, J_1 = 15.2 Hz, J_2 = 8.8 Hz, 1H), 3.56 (dd, J_1 = 15.2 Hz, J_2 = 10.8 Hz, 1H), 5.76 (dd, J_1 = 10.8 Hz, J_2 = 8.8 Hz, 1H), 7.33-7.43 (m, 5H), 7.66 (d, J = 8.4 Hz, 2H), 8.05 (d, J = 8.0 Hz, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 160.7, 141.1, 132.5, 131.8 (q, J = 32.0 Hz), 129.5 (q, J = 310.0 Hz), 128.9, 128.6, 128.5, 125.7, 125.2 (q, J = 4.0 Hz), 123.8 (q, J = 270.0 Hz), 92.4, 82.3, 45.0; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -42.3, -62.9; IR (thin film, cm^{-1}) 3364, 2926, 2374, 1928, 1611, 1410, 1326, 1169, 1126, 920, 848, 756, 698; HRMS (ESI) m/z calcd for $C_{18}H_{12}F_6OS$ $[M+H]^+$: 391.0513, found: 391.0586.



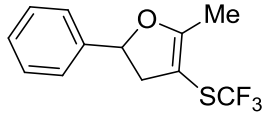
5-(4-nitrophenyl)-2-phenyl-4-((trifluoromethyl)thio)-2,3-dihydrofuran (3q): Yellow oil; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 3.16 (dd, J_1 = 15.6 Hz, J_2 = 8.8 Hz, 1H), 3.59 (dd, J_1 = 15.6 Hz, J_2 = 10.8 Hz, 1H), 5.77 (t, J = 10.0 Hz, 1H), 7.36-7.44 (m, 5H), 8.12 (d, J = 8.8 Hz, 2H), 8.26 (d, J = 8.8 Hz, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 159.6, 148.3, 140.7, 135.0, 129.3 (q, J = 309.0 Hz), 129.1, 128.9, 128.6, 125.7, 123.4, 94.2 (d, J = 2.0 Hz), 82.4, 45.0; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -42.0; IR (thin film, cm^{-1}) 3363, 2926, 2372, 1802, 1590, 1523, 1457, 1328, 1124, 919, 853, 755, 697; HRMS (ESI) m/z calcd for $C_{17}H_{12}F_3NO_3S$ $[M+H]^+$: 368.0490, found: 368.0563.



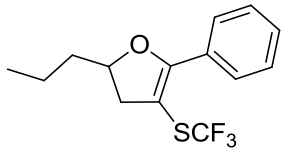
2-phenyl-5-(o-tolyl)-4-((trifluoromethyl)thio)-2,3-dihydrofuran (3r): Pale yellow oil; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 2.34 (s, 3H), 3.15 (dd, J_1 = 14.8 Hz, J_2 = 9.2 Hz, 1H), 3.49 (dd, J_1 = 14.8 Hz, J_2 = 10.8 Hz, 1H), 5.76-5.81 (m, 1H), 7.21-7.24 (m, 2H), 7.30-7.35 (m, 3H), 7.37-7.44 (m, 4H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 165.5, 141.1, 137.5, 130.3, 130.2, 129.9, 129.6 (q, J = 309.0 Hz), 128.9, 128.8, 128.4, 126.0, 125.4, 92.8 (d, J = 2.0 Hz), 83.3, 43.3, 19.7; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -42.7; IR (thin film, cm^{-1}) 3344, 2925, 2372, 1806, 1637, 1458, 1327, 1241, 1125, 919, 755, 698; HRMS (ESI) m/z calcd for $C_{18}H_{15}F_3OS$ $[M+H]^+$: 337.0796, found: 337.0868.



2-phenyl-5-(thiophen-2-yl)-4-((trifluoromethyl)thio)-2,3-dihydrofuran (3s): Pale yellow oil; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 3.05 (dd, J_1 = 15.2 Hz, J_2 = 8.4 Hz, 1H), 3.51 (dd, J_1 = 15.2 Hz, J_2 = 9.6 Hz, 1H), 5.75 (dd, J_1 = 9.6 Hz, J_2 = 8.4 Hz, 1H), 7.07-7.09 (m, 1H), 7.31-7.35 (m, 1H), 7.38-7.39 (m, 4H), 7.44 (d, J = 4.8 Hz, 1H), 7.76 (d, J = 3.6 Hz, 1H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 157.8, 141.3, 130.6, 129.7, 129.5 (q, J = 311.0 Hz), 128.9, 128.8, 128.3, 127.0, 125.6, 88.2, 82.7, 44.7; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -42.4; IR (thin film, cm^{-1}) 3341, 2925, 2373, 1806, 1612, 1425, 1245, 1125, 934, 849, 699; HRMS (ESI) m/z calcd for $C_{15}H_{11}F_3OS_2$ $[M+H]^+$: 329.0203, found: 329.0276.

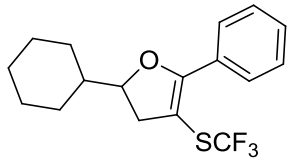


5-methyl-2-phenyl-4-((trifluoromethyl)thio)-2,3-dihydrofuran (3t): Pale yellow oil; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 2.06 (s, 3H), 2.84-2.90 (m, 1H), 3.26-3.33 (m, 1H), 5.60 (dd, J_1 = 10.4 Hz, J_2 = 8.4 Hz, 1H), 7.30-7.33 (m, 3H), 7.36-7.40 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 166.0, 141.4, 129.8 (q, J = 309.0 Hz), 128.8, 128.3, 125.7, 89.3 (d, J = 2.0 Hz), 82.7, 42.8, 12.4; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -43.9; IR (thin film, cm^{-1}) 3343, 3034, 2926, 2371, 1872, 1646, 1495, 1384, 1227, 1113, 966, 757, 698, 607; HRMS (ESI) m/z calcd for $C_{12}H_{11}F_3OS$ $[M+H]^+$: 261.0483, found: 261.0555.

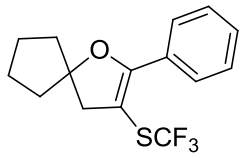


5-phenyl-2-propyl-4-((trifluoromethyl)thio)-2,3-dihydrofuran (3u): Pale yellow oil; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 0.99 (t, J = 7.6 Hz, 3H), 1.44-1.56 (m, 2H), 1.60-1.67 (m, 1H), 1.78-1.85 (m, 1H), 2.71 (dd, J_1 = 14.8 Hz, J_2 = 8.0 Hz, 1H), 3.17 (dd, J_1 = 14.8 Hz, J_2 = 10.0 Hz, 1H), 4.74-4.78 (m, 1H), 7.39 (t, J = 3.6 Hz, 3H), 7.82-7.84 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 162.3, 129.9, 129.8 (q, J = 309.0 Hz), 129.5, 128.2, 128.1, 89.8 (d, J = 3.0 Hz), 81.0, 42.3, 38.1, 18.3, 13.9; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -42.7; IR (thin film, cm^{-1}) 3339, 2961, 2372, 1889, 1598, 1493, 1341, 1236, 1127, 918, 770, 692; HRMS (ESI) m/z calcd for $C_{14}H_{15}F_3OS$ $[M+H]^+$: 289.0796, found:

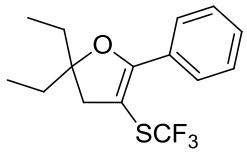
289.0868.



2-cyclohexyl-5-phenyl-4-((trifluoromethyl)thio)-2,3-dihydrofuran (3v): Colorless oil; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 1.04-1.14 (m, 2H), 1.17-1.30 (m, 3H), 1.61-1.65 (m, 1H), 1.67-1.71 (m, 2H), 1.77-1.80 (m, 2H), 1.93-1.96 (m, 1H), 2.82 (dd, J_1= 14.8 Hz, J_2= 8.8 Hz, 1H), 3.06 (dd, J_1= 14.8 Hz, J_2 = 10.4 Hz, 1H), 4.46-4.52 (m, 1H), 7.38-7.40 (m, 3H), 7.83-7.85 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 162.5, 129.9, 129.8 (q, J = 310.0 Hz), 129.5, 128.1, 128.1, 89.8 (d, J = 2.0 Hz), 85.2, 43.1, 39.9, 28.1, 27.9, 26.4, 25.9, 25.7; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -42.6; IR (thin film, cm^{-1}) 3343, 2927,2855, 2364, 1598, 1493, 1448, 1238, 1126, 770, 692; HRMS (ESI) m/z calcd for $C_{17}H_{19}F_3OS$ $[M+H]^+$: 329.1109, found: 329.1181.

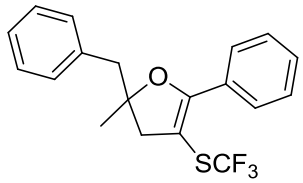


2-phenyl-3-((trifluoromethyl)thio)-1-oxaspiro[4.4]non-2-ene compound with 5-phenyl-2-propyl-4-((trifluoromethyl)thio)-2,3-dihydrofuran (1:1) (3w): Pale yellow oil; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 1.67-1.79 (m, 4H), 1.83-1.92 (m, 2H), 2.11-2.16 (m, 2H), 3.03 (s, 2H), 7.38 (t, J = 3.2 Hz, 3H), 7.80-7.82 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 161.8, 129.8, 129.8 (q, J = 310.0 Hz), 128.2, 128.1, 128.0, 94.9, 89.3 (d, J = 2.0 Hz), 46.9, 39.5, 23.7; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -42.9; IR (thin film, cm^{-1}) 3357, 2960, 2373, 1597, 1492, 1447, 1257, 1125, 767, 692; HRMS (ESI) m/z calcd for $C_{15}H_{15}F_3OS$ $[M+H]^+$: 301.0796, found: 301.0868.

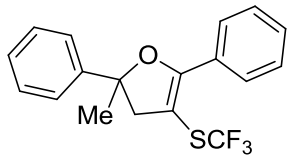


2,2-diethyl-5-phenyl-4-((trifluoromethyl)thio)-2,3-dihydrofuran (3x): Colorless oil; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 0.96 (t, J = 7.6 Hz, 6H), 1.66-1.81 (m, 4H), 2.85 (s, 2H), 7.38-7.39 (m, 3H), 7.81-7.83 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 162.3, 129.8 (q, J = 310.0 Hz), 129.8, 128.2, 128.0, 89.6, 89.1 (d, J = 1.0 Hz), 44.7, 31.8, 7.5; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -42.7; IR (thin film, cm^{-1}) 3309, 2972, 2371, 1598, 1493, 1338, 1254, 1125, 953, 895, 692; HRMS (ESI) m/z

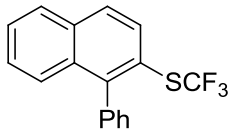
calcd for $C_{15}H_{17}F_3OS$ $[M+H]^+$: 303.0952, found: 303.1015.



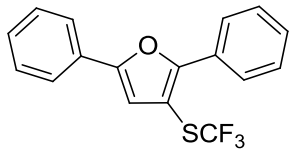
2-benzyl-2-methyl-5-phenyl-4-((trifluoromethyl)thio)-2,3-dihydrofuran (3y): Colorless oil; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 1.46 (s, 3H), 2.77 (m, 1H), 3.01 (s, 2H), 3.05 (m, 1H), 7.23-7.30 (m, *J*, 5H), 7.38-7.39 (m, 3H), 7.79-7.83 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 161.5, 136.4, 130.4, 129.9, 129.7 (q, *J* = 310.0 Hz), 129.6, 128.3, 128.2, 128.1, 126.7, 89.5 (d, *J* = 2.0 Hz), 86.6, 47.4, 46.6, 26.5; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -42.7; IR (thin film, cm^{-1}) 3400, 2927, 2251, 1952, 1887, 1810, 1598, 1493, 1267, 1128, 909, 735, 651; HRMS (ESI) m/z calcd for $C_{19}H_{17}F_3OS$ $[M+H]^+$: 351.0952, found: 351.1022.



2-methyl-2,5-diphenyl-4-((trifluoromethyl)thio)-2,3-dihydrofuran (3z): Yellow oil; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 1.79 (s, 3H), 3.20-3.34 (m, 2H), 7.29 (t, *J* = 7.2 Hz, 1H), 7.36-7.39 (m, 2H), 7.42-7.46 (m, 5H), 7.93-7.96 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 161.4, 146.1, 130.1, 129.7 (q, *J* = 310.0 Hz), 129.5, 128.5, 128.4, 128.3, 127.4, 124.3, 89.4, 87.2, 51.1, 29.2; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -42.6; IR (thin film, cm^{-1}) 3340, 2926, 2374, 1953, 1599, 1493, 1327, 1247, 1125, 918, 852, 762, 696; HRMS (ESI) m/z calcd for $C_{18}H_{15}F_3OS$ $[M+H]^+$: 337.0796, found: 337.0868.



(1-phenylnaphthalen-2-yl)(trifluoromethyl)sulfane (3aa): Yellow oil; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.25-7.27 (m, 2H), 7.39-7.43 (m, 1H), 7.45-7.51 (m, 4H), 7.53-7.57 (m, 1H), 7.82 (d, *J* = 8.8 Hz, 1H), 7.90 (d, *J* = 8.4 Hz, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 146.7, 138.2, 133.9, 133.3, 131.6, 130.3, 129.5 (q, *J* = 307.0 Hz), 128.6, 128.1, 127.9, 127.6, 127.5, 126.8, 121.7; **^{19}F NMR** (376 MHz, $CDCl_3$) δ -41.4; IR (thin film, cm^{-1}) 3370, 3058, 2924, 2367, 1585, 1492, 1443, 1115, 1096, 965, 908, 815, 747, 700; HRMS (ESI) m/z calcd for $C_{17}H_{11}F_3S$ $[M+H]^+$: 305.0534, found: 305.0606.

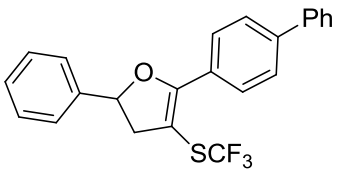


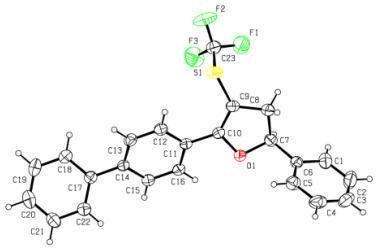
2,5-diphenyl-3-((trifluoromethyl)thio)furan (4): White solid. Mp = 71-72 ^{o}C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 6.84 (s, 1H), 7.30 (t, *J* = 7.6 Hz, 1H), 7.36-7.47 (m, 5H), 7.10 (t, *J* = 7.6 Hz, 2H), 8.05 (t, *J* = 7.2 Hz, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 156.1, 153.1, 129.5, 129.2 (q, *J* = 309.0 Hz), 129.1, 129.0, 128.8, 128.6, 128.3, 126.6, 124.0, 113.0, 103.1 (d, *J* = 3.0 Hz); **^{19}F NMR** (376 MHz, $CDCl_3$) δ -43.0; IR (thin film, cm^{-1}) 3337, 3113, 2925, 2373, 1951, 1739, 1587, 1480, 1136, 1103, 818, 767, 690; HRMS (ESI) m/z calcd for $C_{17}H_{11}F_3OS$ $[M+H]^+$: 321.0483, found: 321.0555.

6. References

1. (a) P. Gao, Y.-W. Shen, R. Fang, X.-H. Hao, Z.-H. Qiu, F. Yang, X.-B. Yan, Q. Wang, X.-J. Gong, X.-Y. Liu and Y.-M. Liang, *Angew. Chem., Int. Ed.*, 2014, **53**, 7629. (b) P. Gao, H.-X. Li, X.-H. Hao, D.-P. Jin, D.-Q. Chen, X.-B. Yan, X.-X. Wu, X.-R. Song, X.-Y. Liu and Y.-M. Liang, *Org. Lett.*, 2014, **16**, 6214.
2. S.-S. Liu, J.-B. Zhao, L. Kaminsky, R. J. Wilson, N. Marino and D. A. Clark, *Org. Lett.*, 2014, **16**, 4456.
3. Y.-Z. Chen, L.-Z. Wu, M.-L. Peng, D. Zhang, L.-P. Zhang and C.-H. Tung, *Tetrahedron*, 2006, **62**, 10688.
4. A. Arrault, F. Touzeau, G. Guillaumet, J.-Y. Mérour, *Synthesis*, 1999, **7**, 1241.

7. Crystallographic data of 3n





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alpha=79.807(13) beta=74.337(16) gamma=82.314(11)

Temperature: 295 K

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Hall group	-P 1	-P 1
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Correction method= MULTI-SCAN

Data completeness= 0.977 Theta(max)= 26.020

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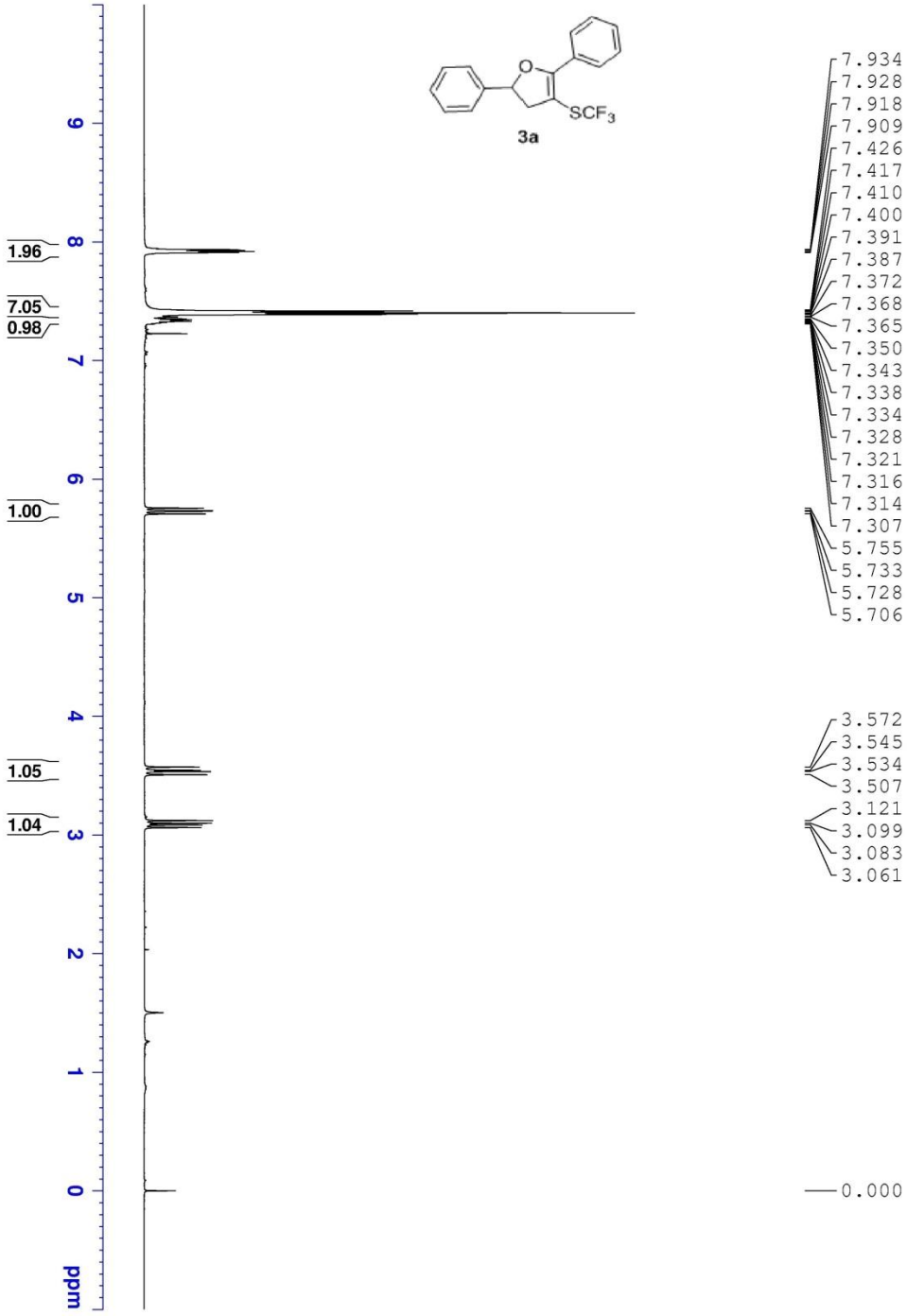
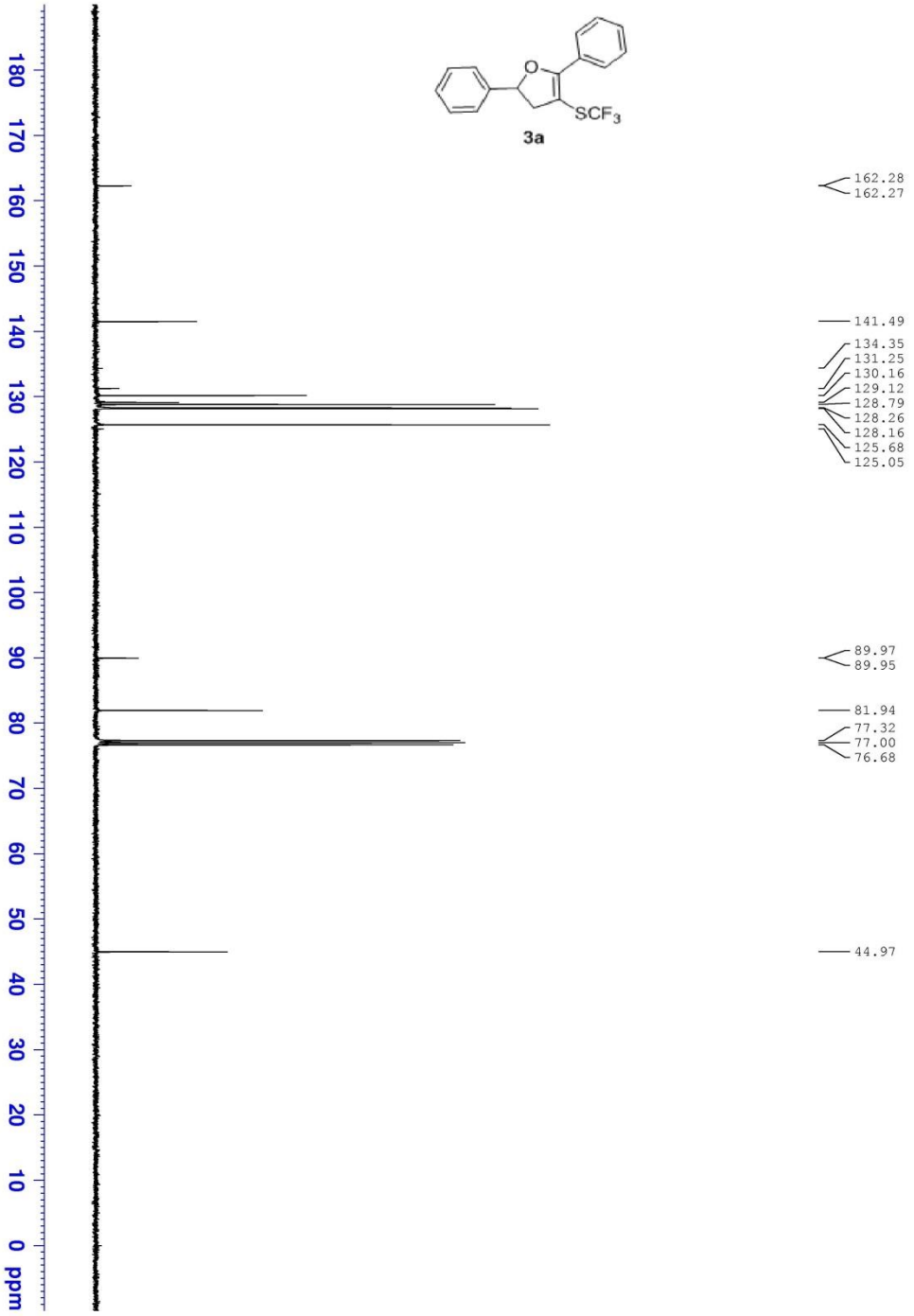
8. ^{1}H NMR, ^{13}C NMR and ^{19}F NMR spectra of 3a-3z, 3aa, 4

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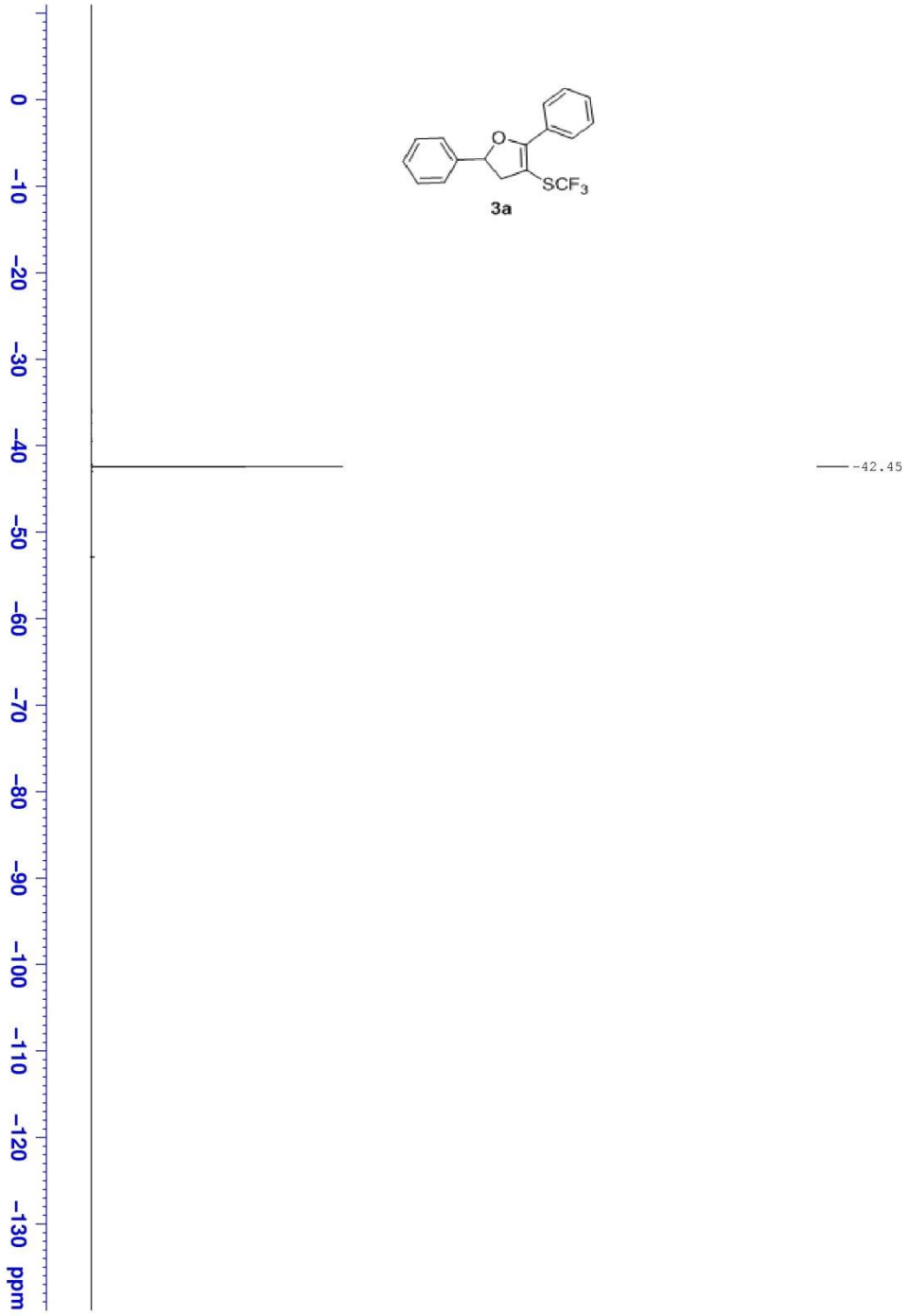
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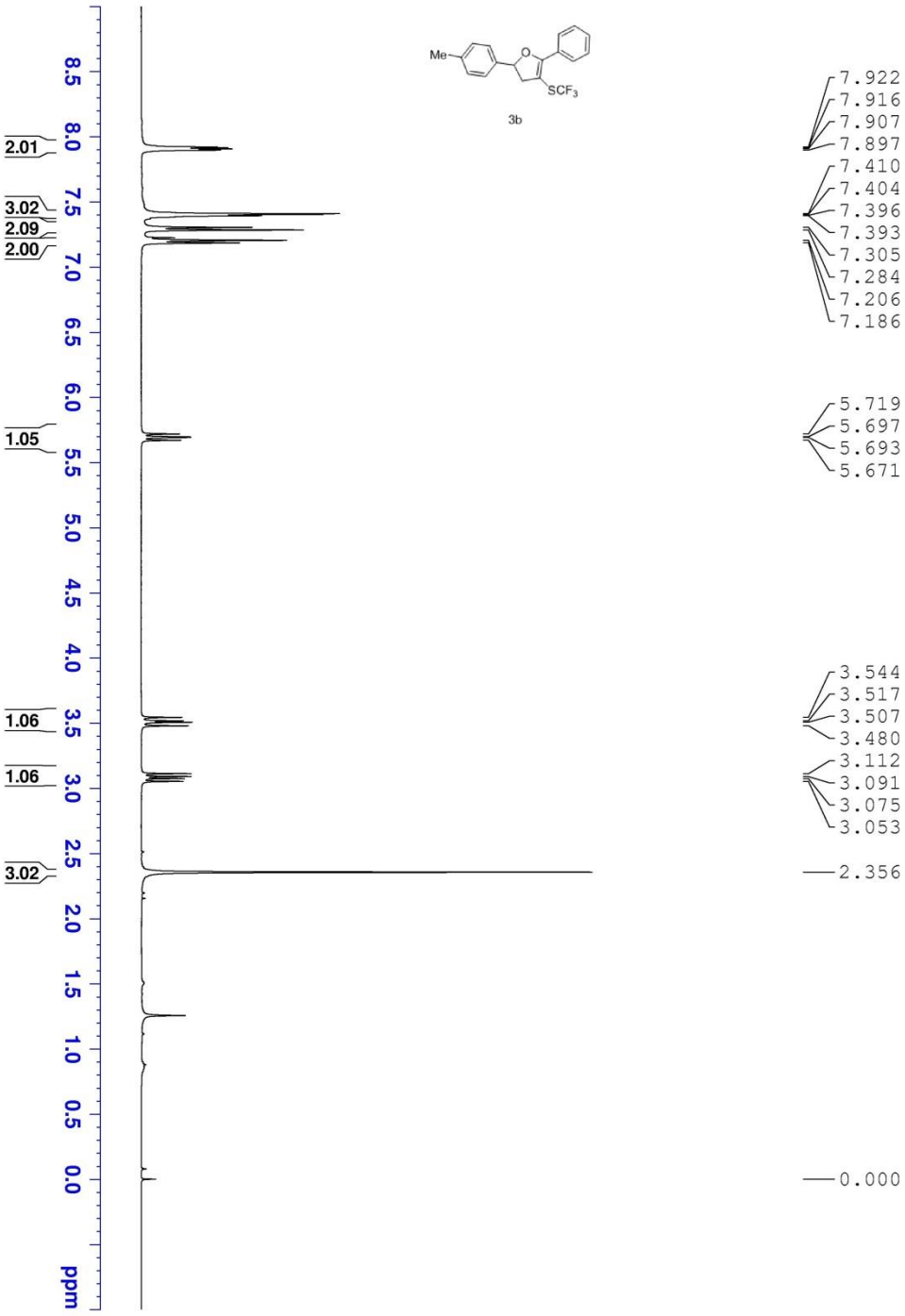
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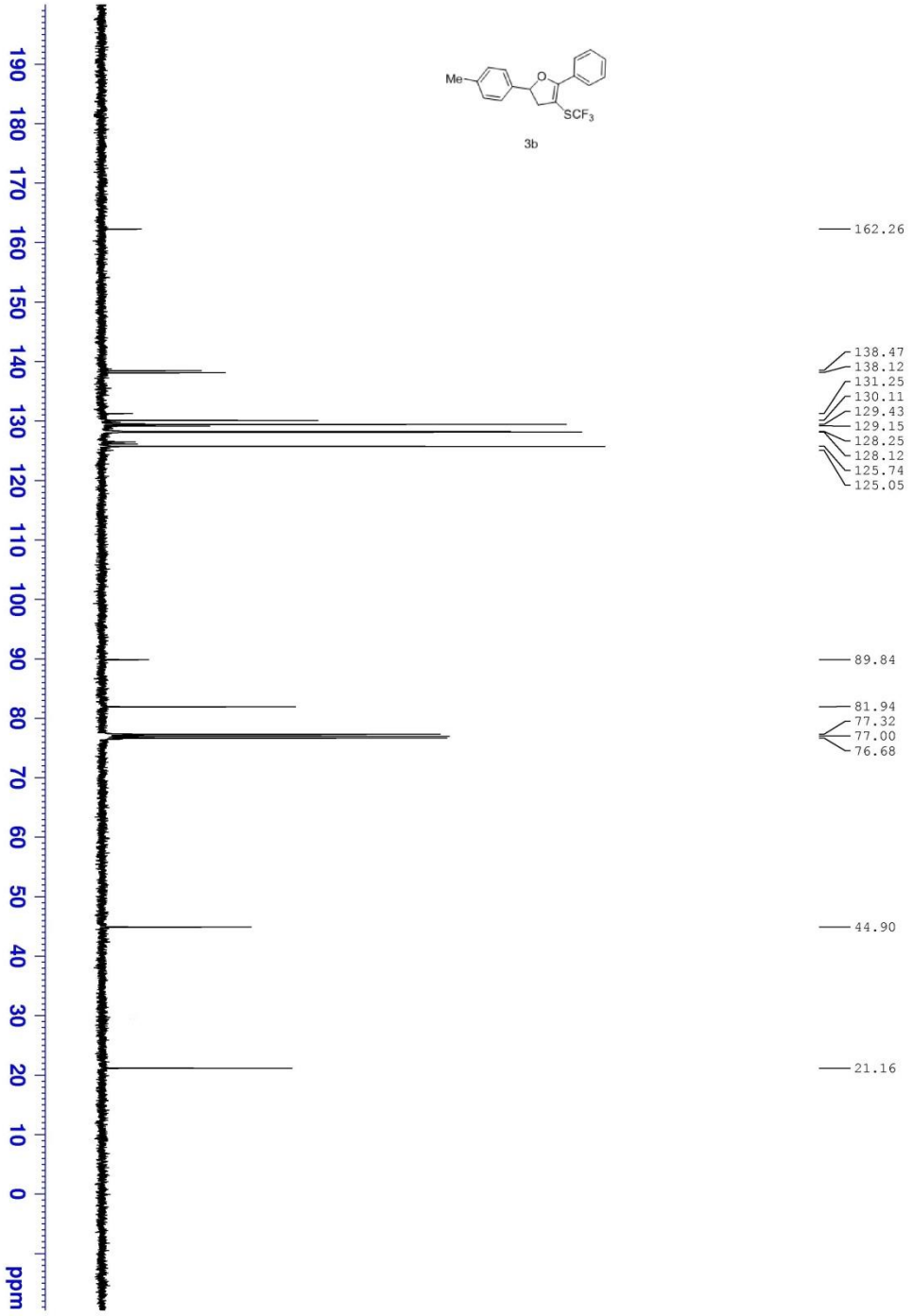
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138.47
138.12
131.25
130.11
129.43
129.15
128.25
128.12
125.74
125.05
89.84
81.94
77.32
77.00
76.68
44.90
21.16
190
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130
120
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80
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20
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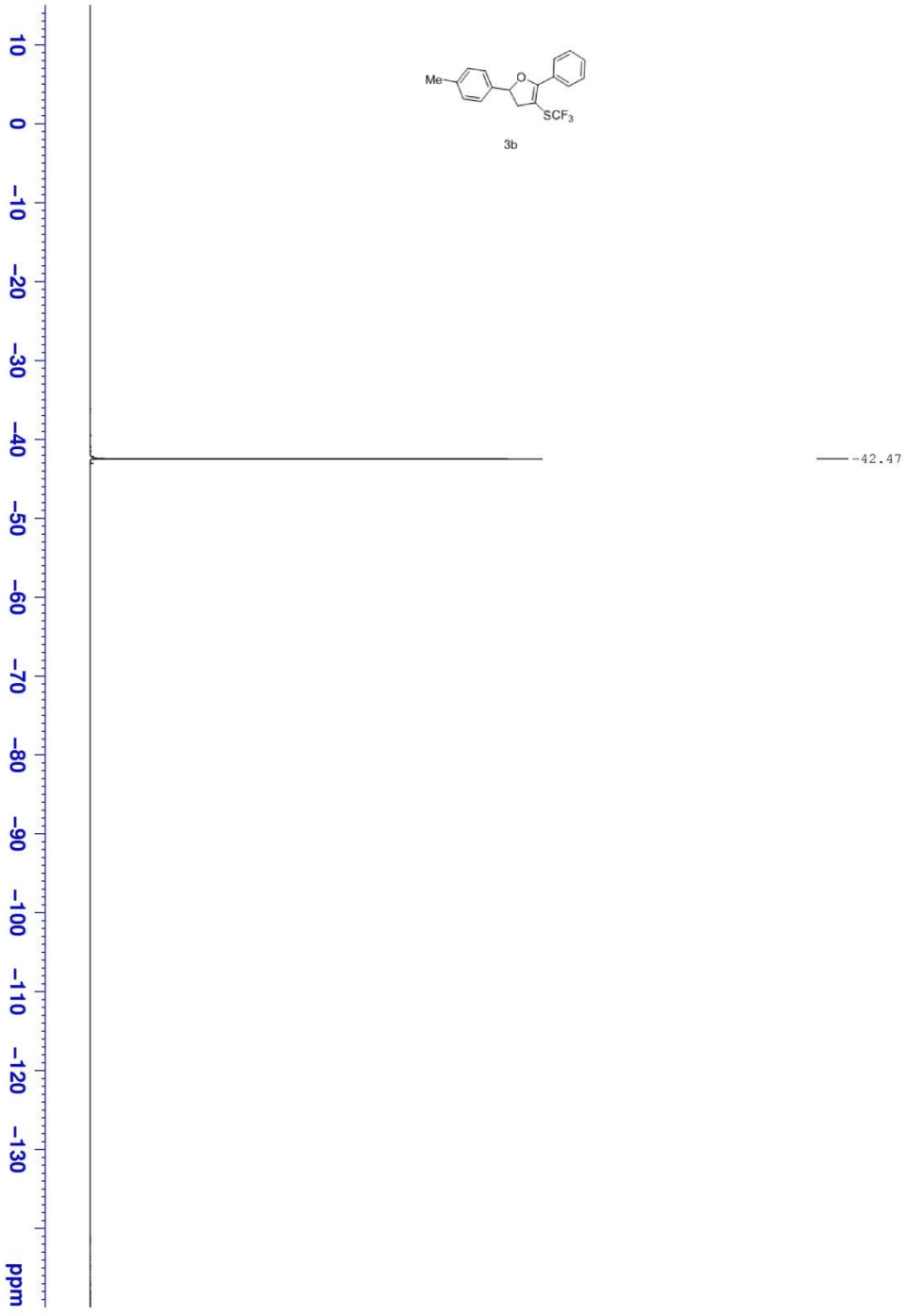
Me
O
SCF3
3b
-42.47
10
0
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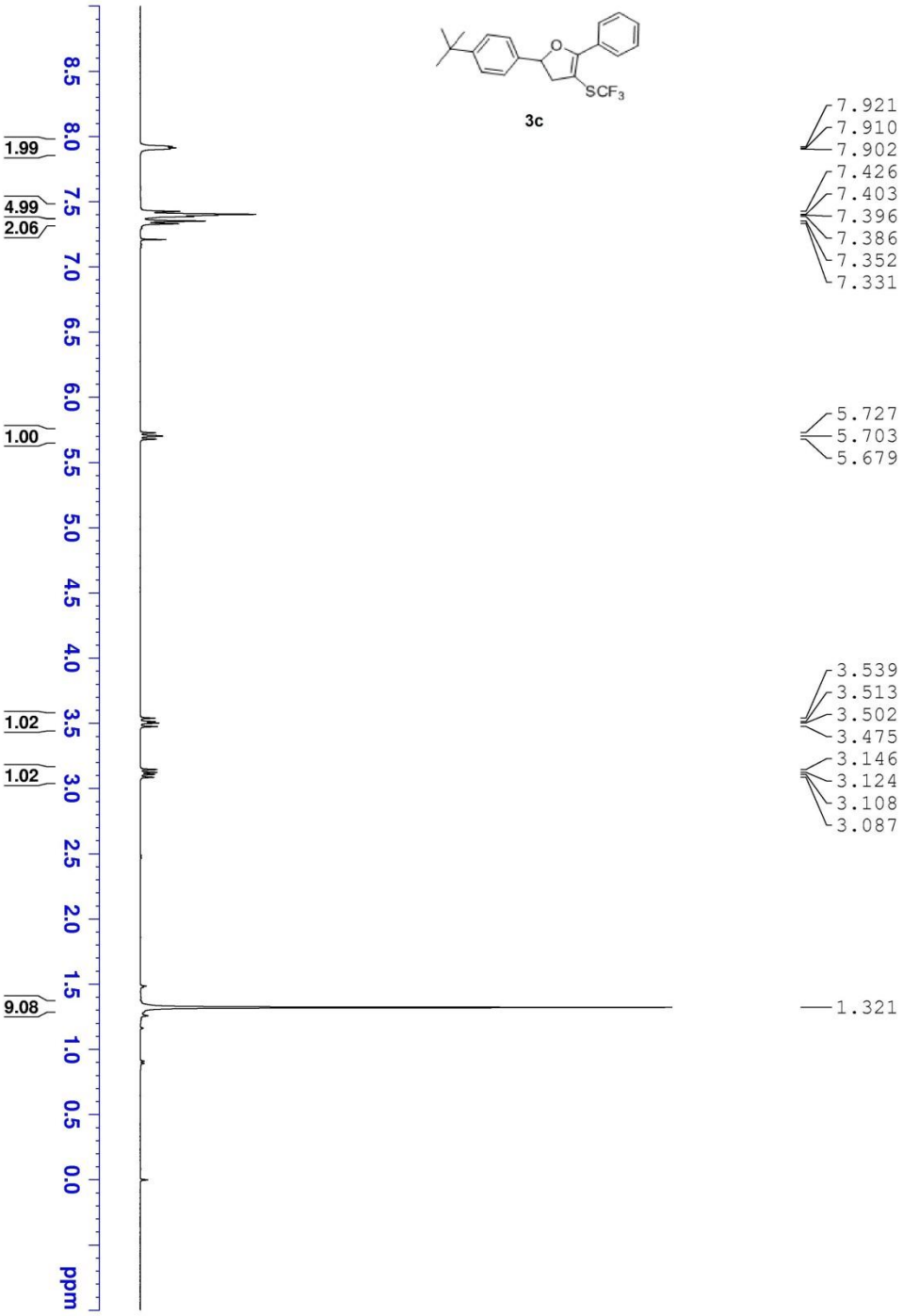
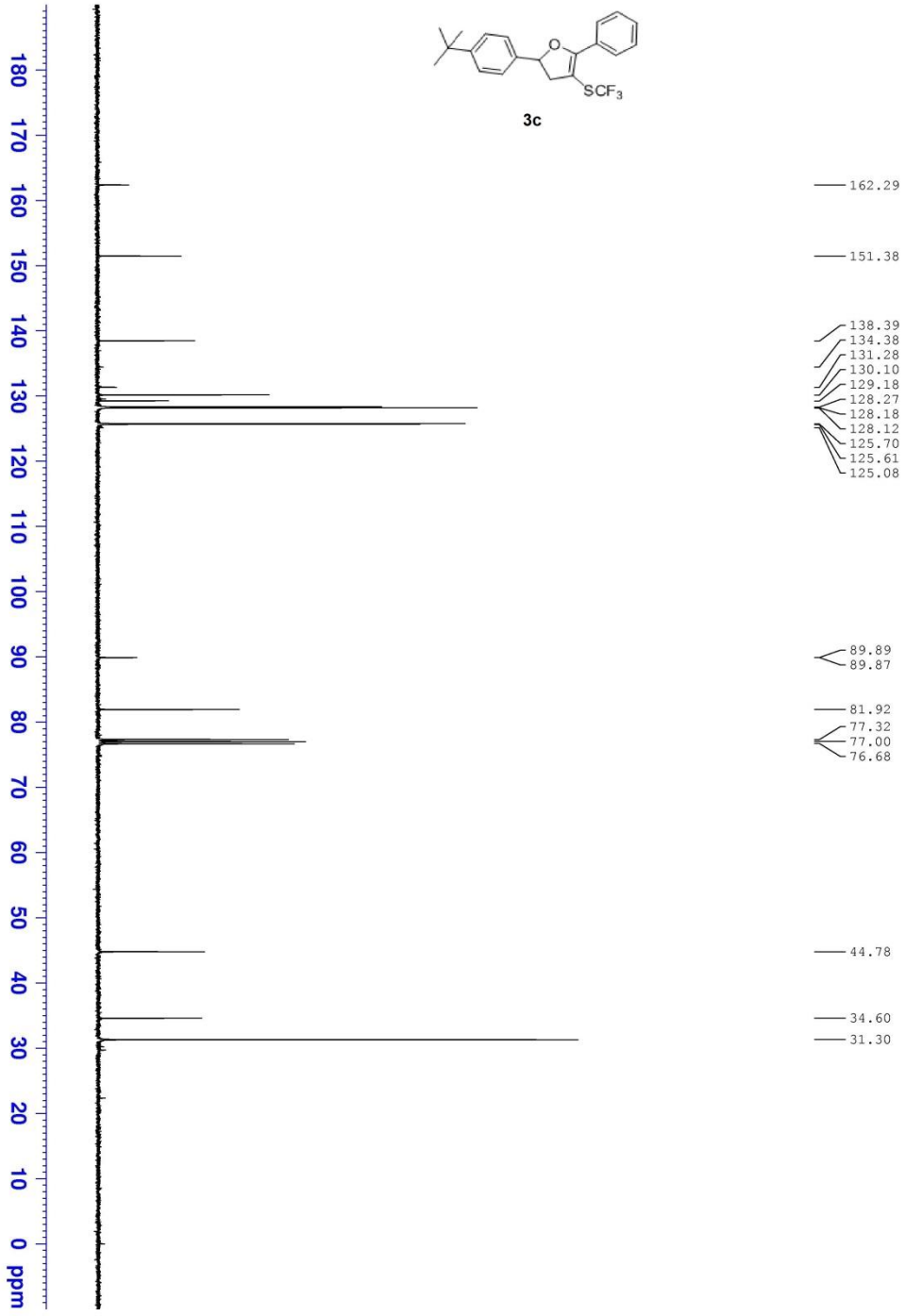
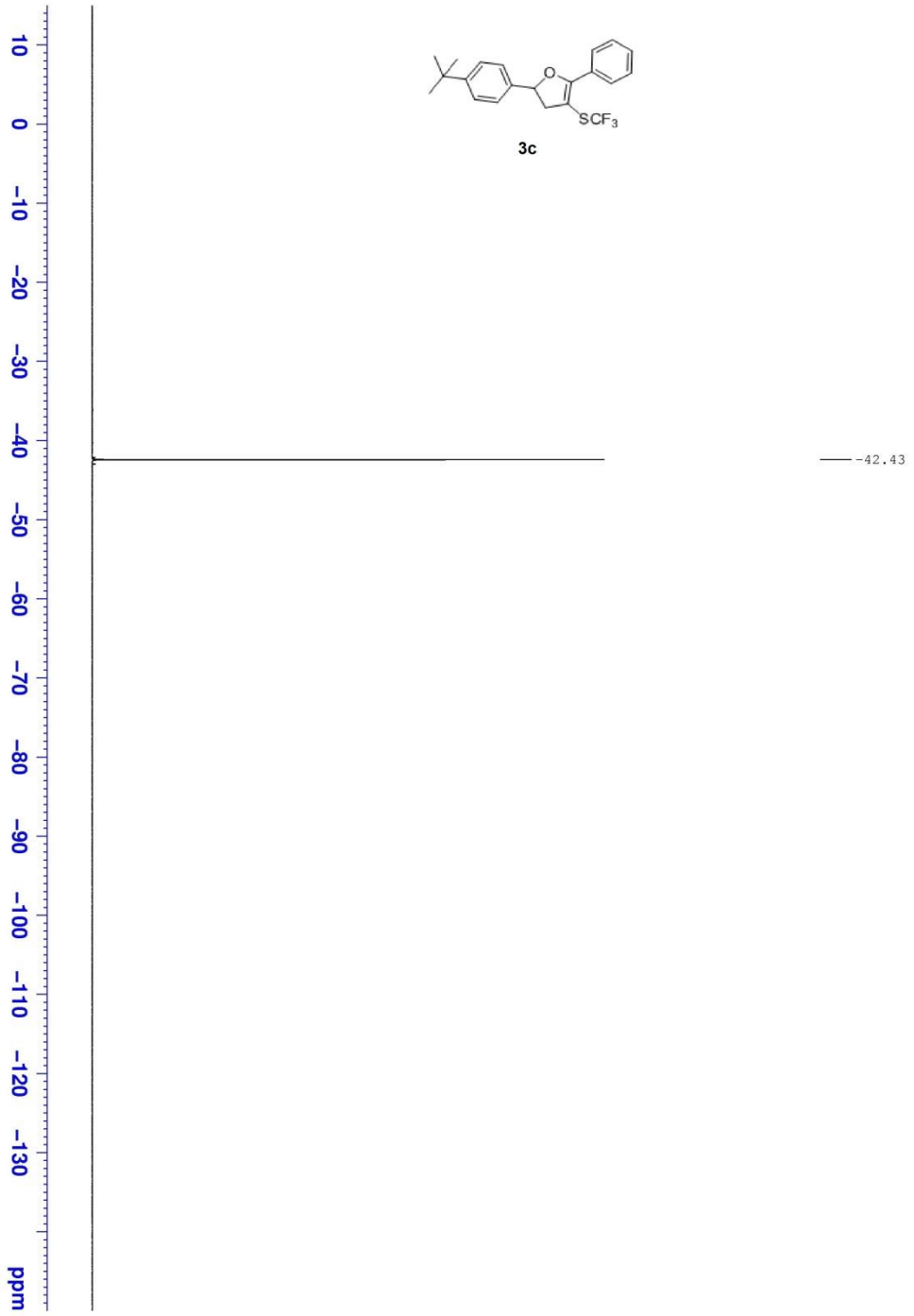
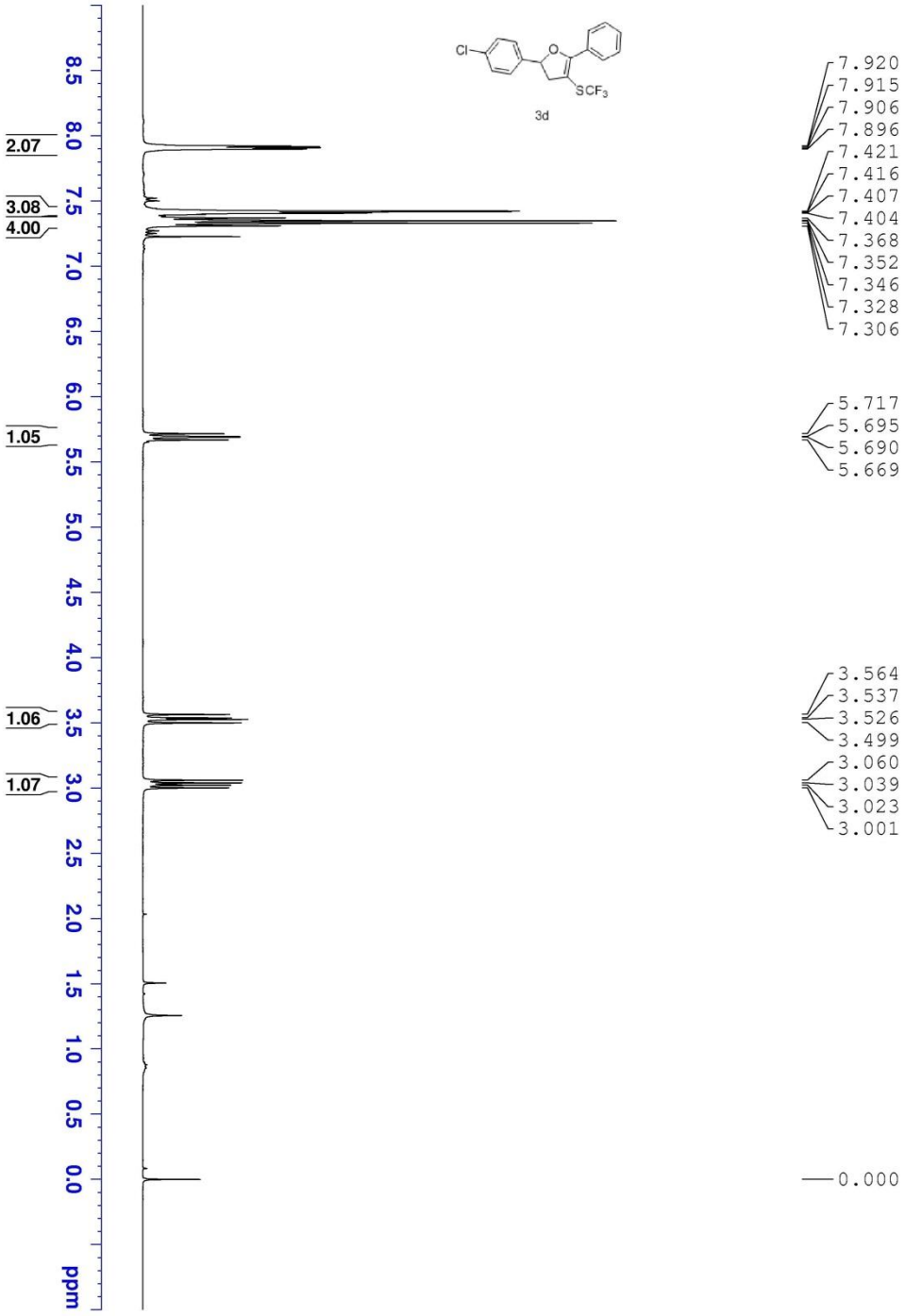
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
ppm


3c
SCF3
7.921
7.910
7.902
7.426
7.403
7.396
7.386
7.352
7.331
5.727
5.703
5.679
3.539
3.513
3.502
3.475
3.146
3.124
3.108
3.087
1.321
1.99
4.99
2.06
1.00
1.02
1.02
9.08
ppm


SCF3
3c
162.29
151.38
138.39
134.38
131.28
130.10
129.18
128.27
128.18
128.12
125.70
125.61
125.08
89.89
89.87
81.92
77.32
77.00
76.68
44.78
34.60
31.30
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm



3c


Cl
O
SCF3
3d
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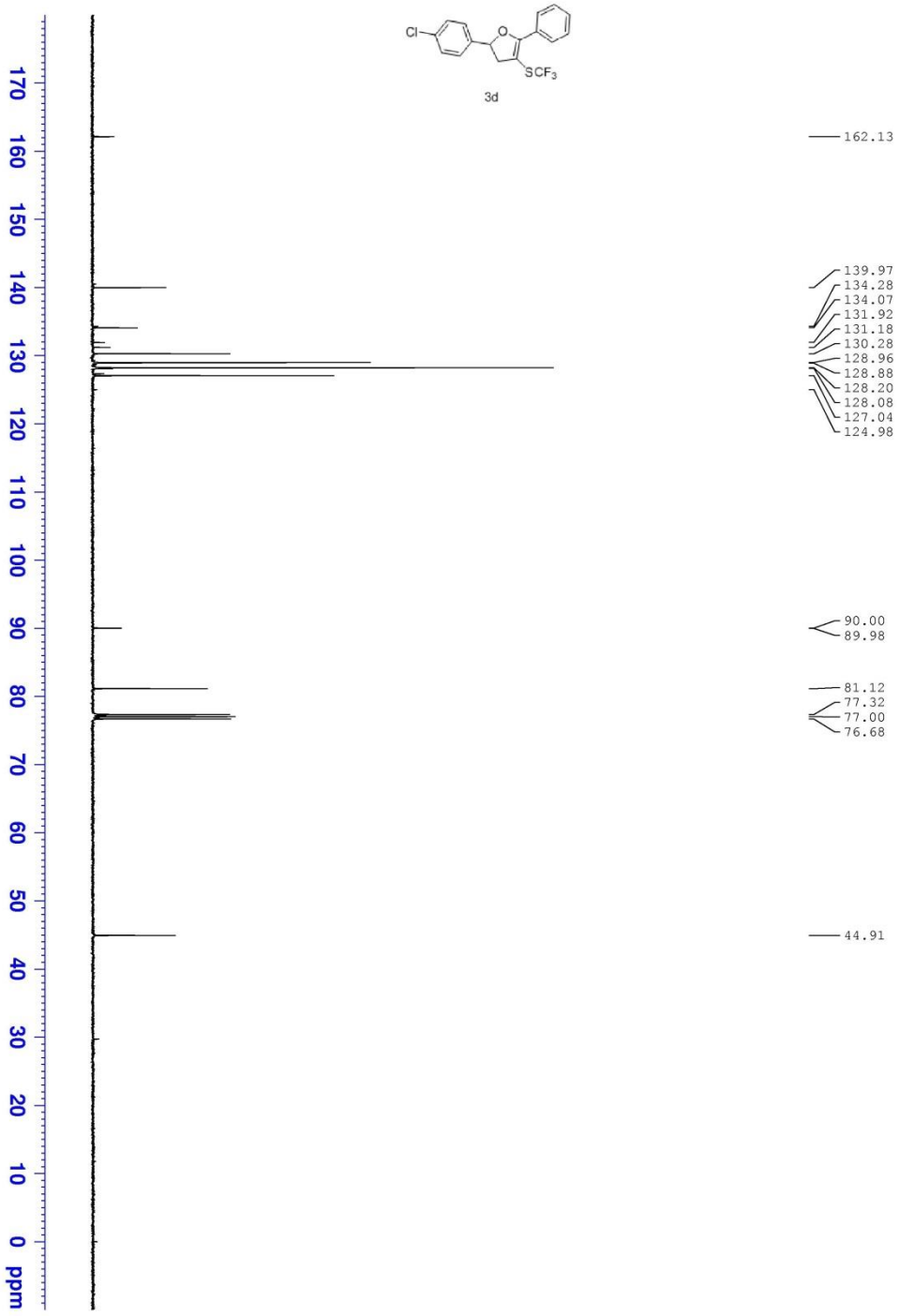
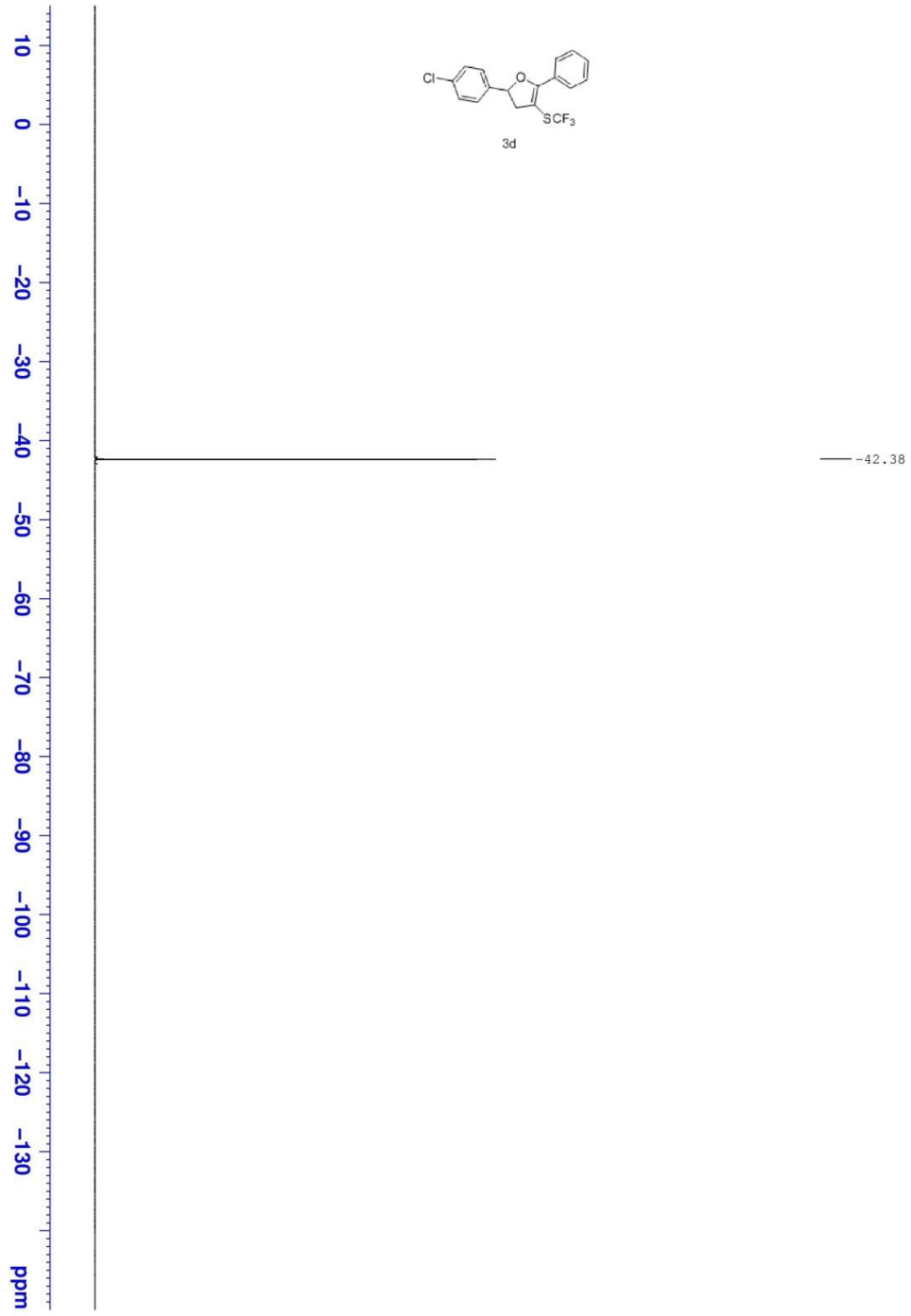
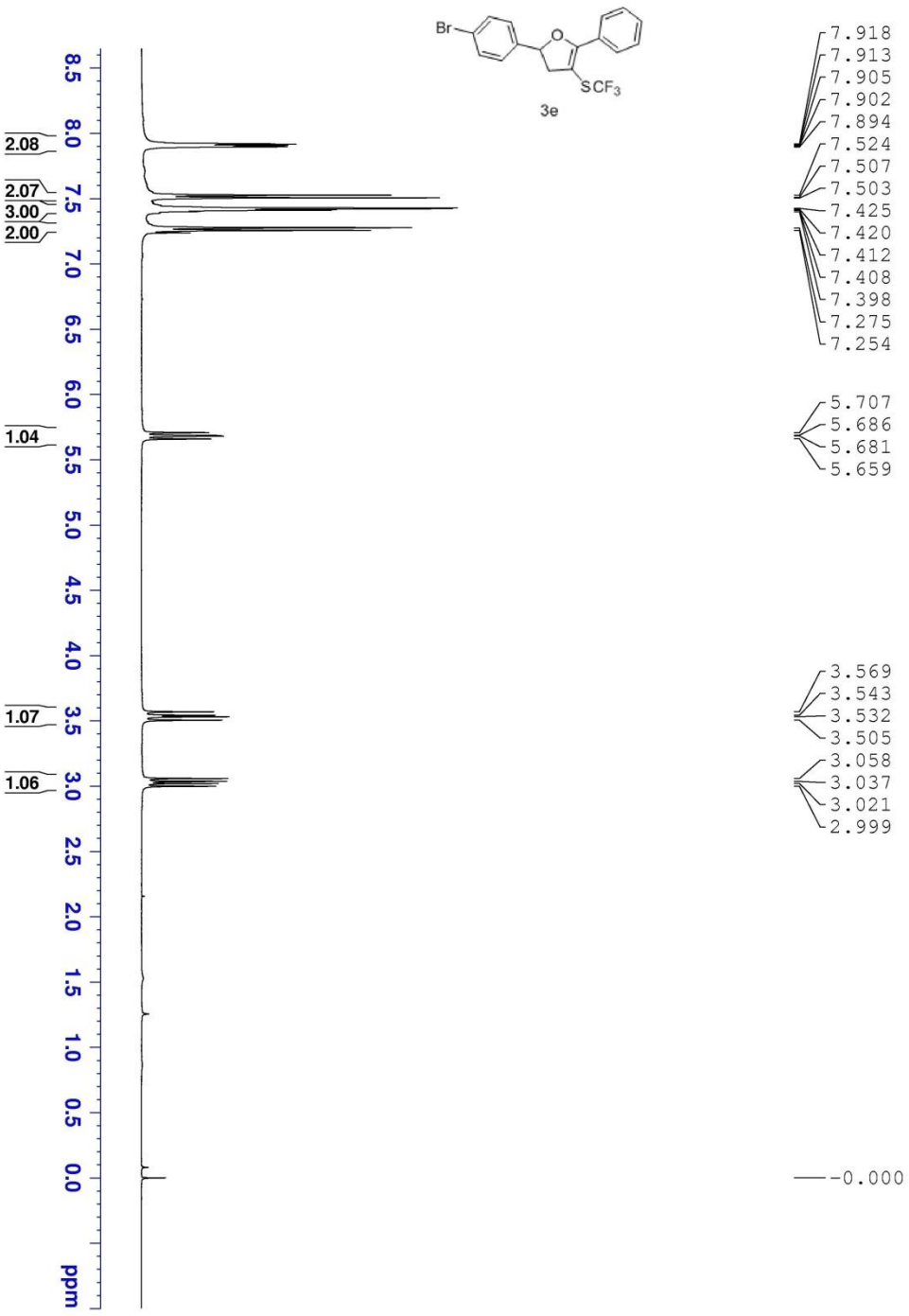
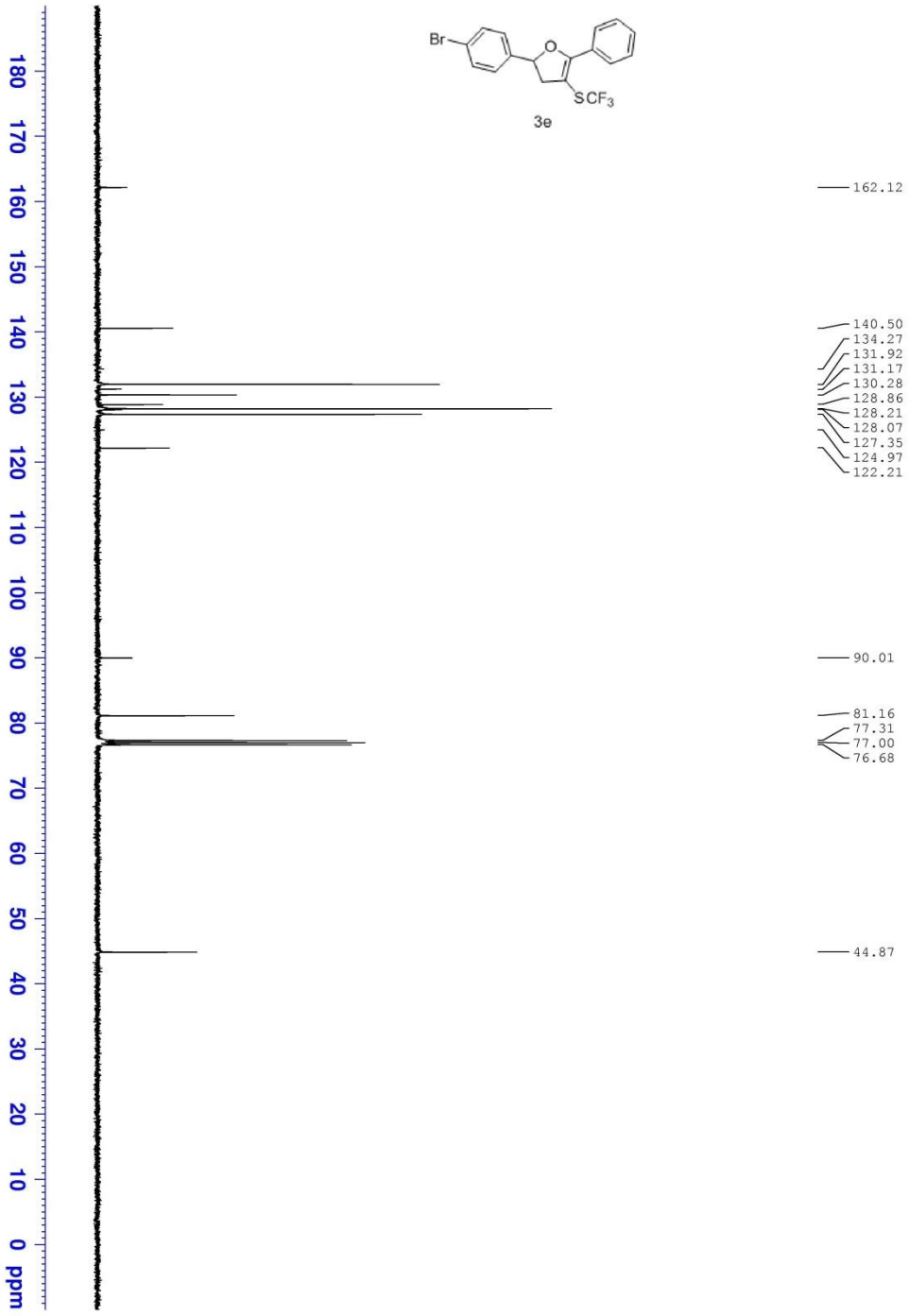
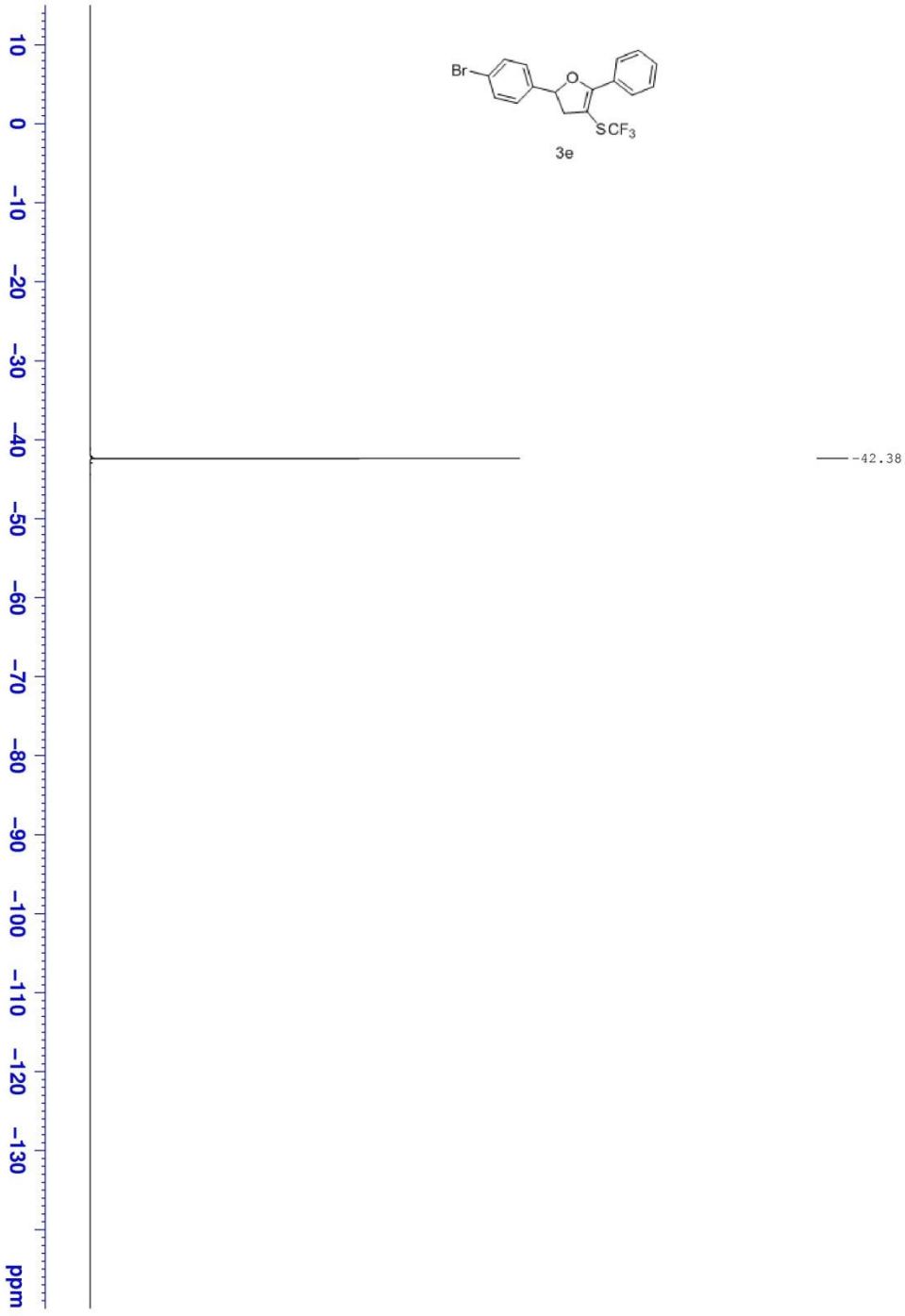
3.08
4.00
1.05
1.06
1.07
7.920
7.915
7.906
7.896
7.421
7.416
7.407
7.404
7.368
7.352
7.346
7.328
7.306
5.717
5.695
5.690
5.669
3.564
3.537
3.526
3.499
3.060
3.039
3.023
3.001
0.000
ppm

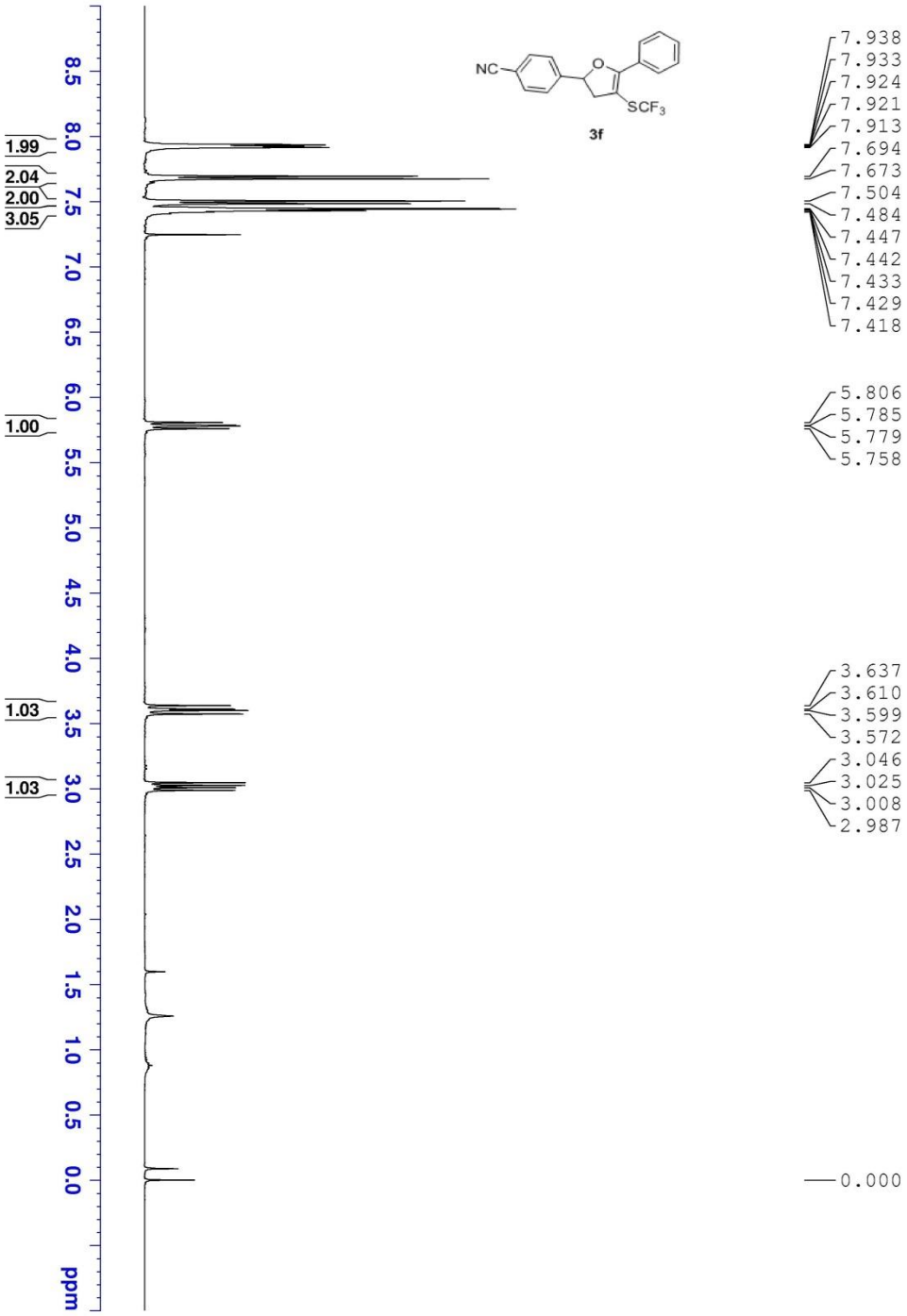

Cl
O
SCF3
3d
162.13
139.97
134.28
134.07
131.92
131.18
130.28
128.96
128.88
128.20
128.08
127.04
124.98
90.00
89.98
81.12
77.32
77.00
76.68
44.91
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

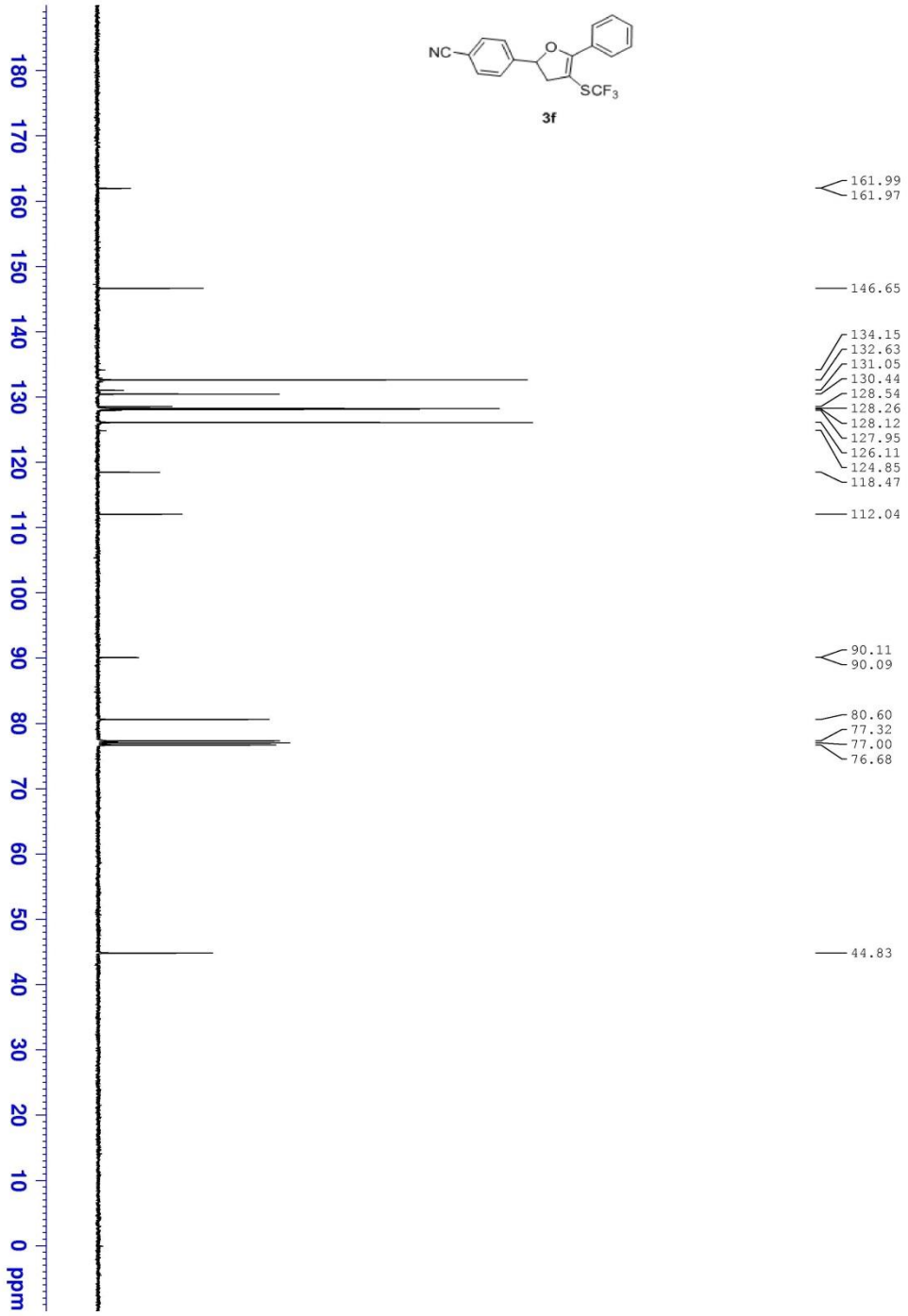

Cl
O
SCF3
3d
-42.38
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
ppm

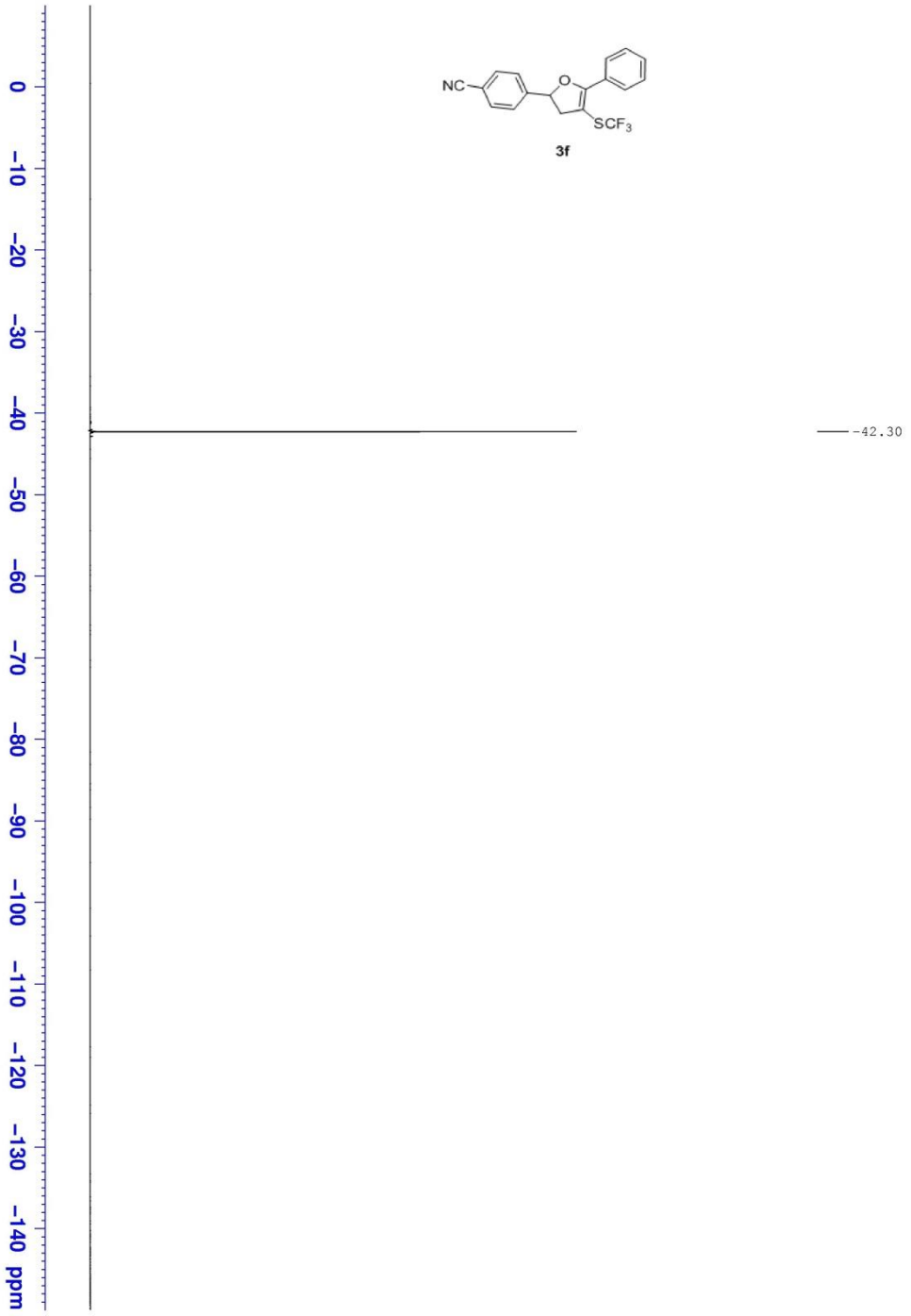

Br
O
SCF3
3e
2.08
2.07
3.00
2.00
1.04
1.07
1.06
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
7.918
7.913
7.905
7.902
7.894
7.524
7.507
7.503
7.425
7.420
7.412
7.408
7.398
7.275
7.254
5.707
5.686
5.681
5.659
3.569
3.543
3.532
3.505
3.058
3.037
3.021
2.999
0.000

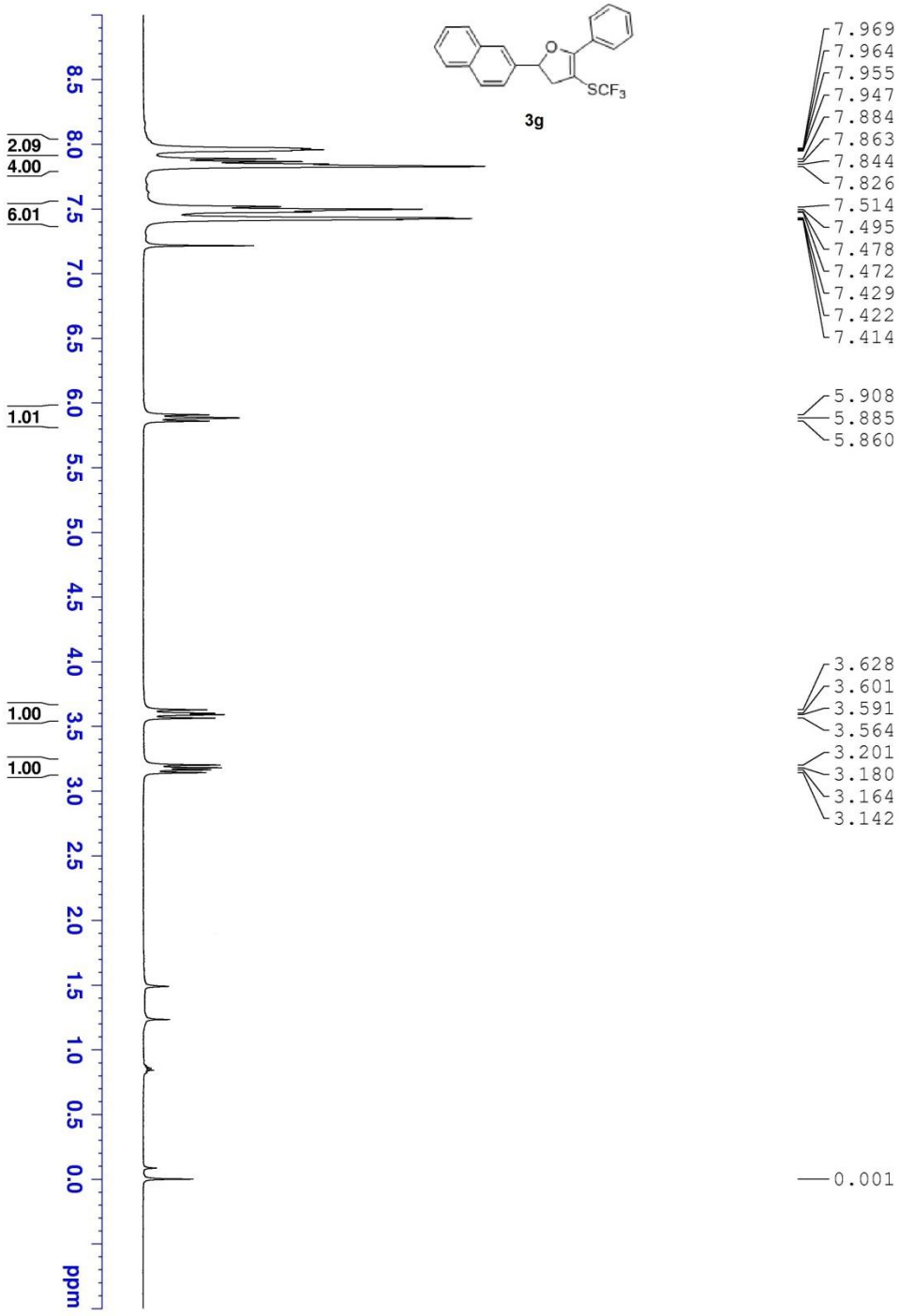

Br
O
SCF3
3e
162.12
140.50
134.27
131.92
131.17
130.28
128.86
128.21
128.07
127.35
124.97
122.21
90.01
81.16
77.31
77.00
76.68
44.87
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0 ppm


Br
O
SCF3
3e
-42.38
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
ppm


NC
O
SCF3
3f
7.938
7.933
7.924
7.921
7.913
7.694
7.673
7.504
7.484
7.447
7.442
7.433
7.429
7.418
5.806
5.785
5.779
5.758
3.637
3.610
3.599
3.572
3.046
3.025
3.008
2.987
0.000
1.99
2.04
2.00
3.05
1.00
1.03
1.03
ppm


NC
O
SCF3
3f
161.99
161.97
146.65
134.15
132.63
131.05
130.44
128.54
128.26
128.12
127.95
126.11
124.85
118.47
112.04
90.11
90.09
80.60
77.32
77.00
76.68
44.83
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm


NC
O
SCF3
3f
-42.30
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
ppm


3g
SCF3
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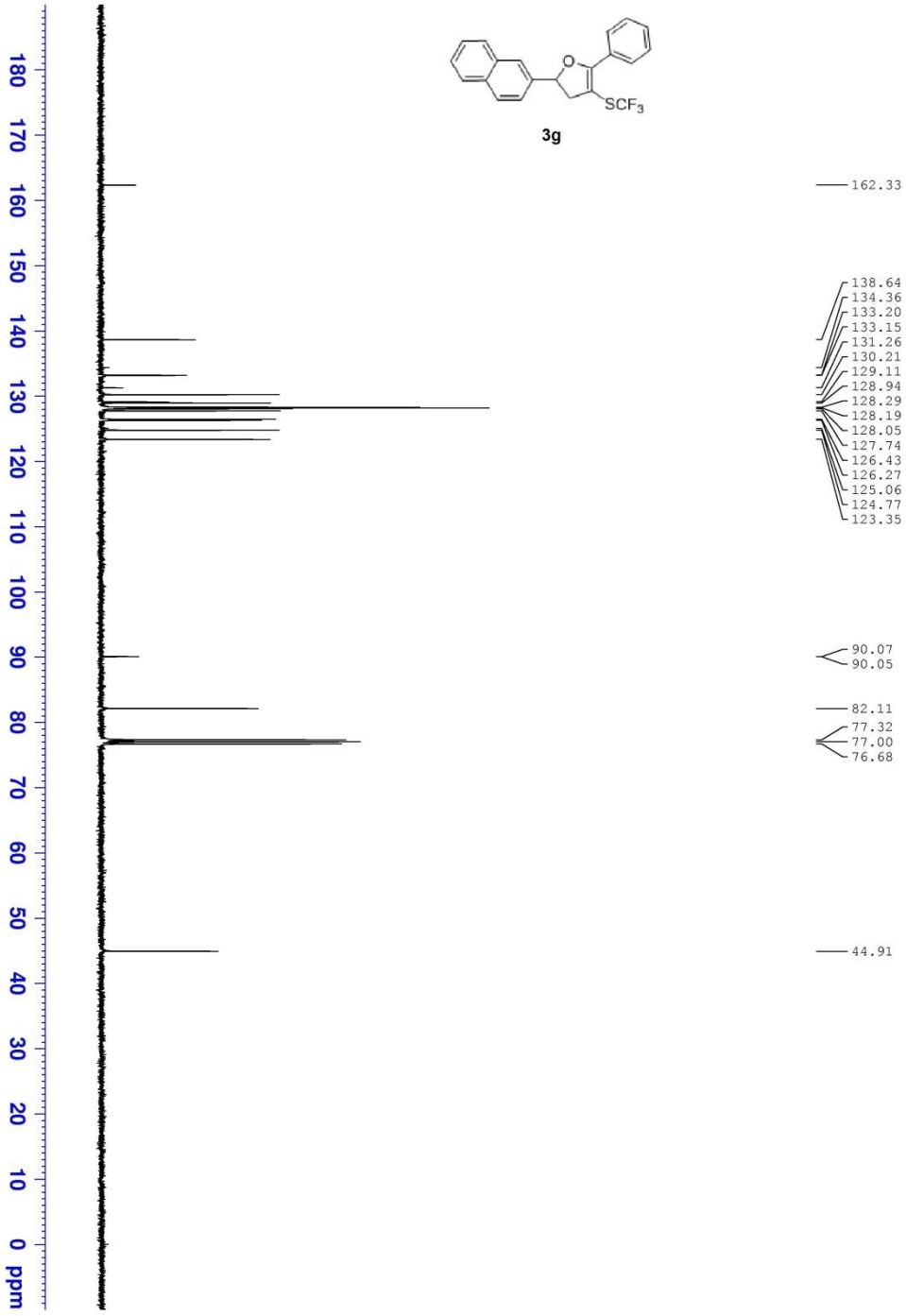
4.00
6.01
1.01
1.00
1.00
7.969
7.964
7.955
7.947
7.884
7.863
7.844
7.826
7.514
7.495
7.478
7.472
7.429
7.422
7.414
5.908
5.885
5.860
3.628
3.601
3.591
3.564
3.201
3.180
3.164
3.142
0.001
ppm


SCF3
3g
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131.26
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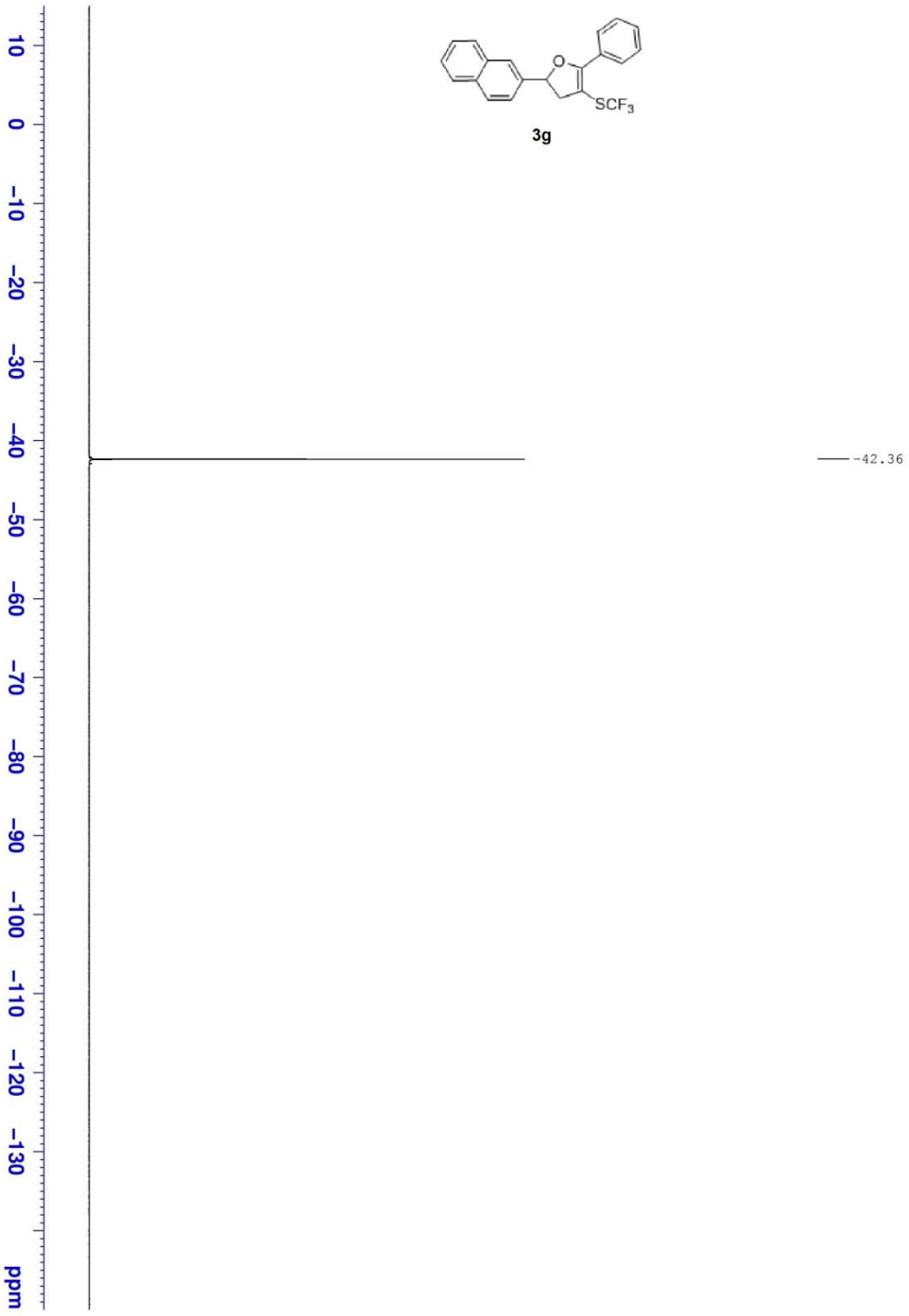
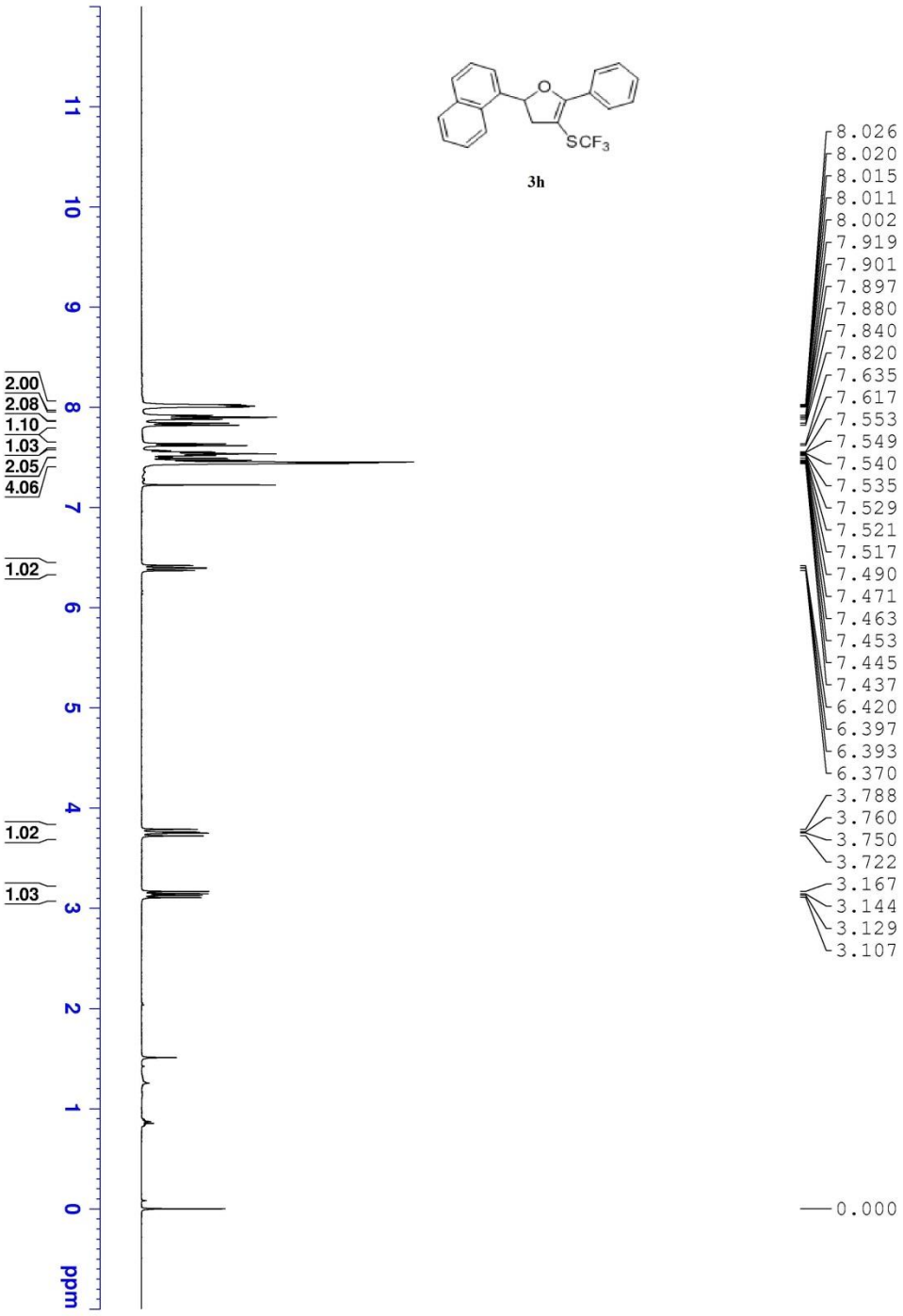
129.11
128.94
128.29
128.19
128.05
127.74
126.43
126.27
125.06
124.77
123.35
90.07
90.05
82.11
77.32
77.00
76.68
44.91
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm



3g


SCF3
3h
2.00
2.08
1.10
1.03
2.05
4.06
1.02
1.02
1.03
ppm
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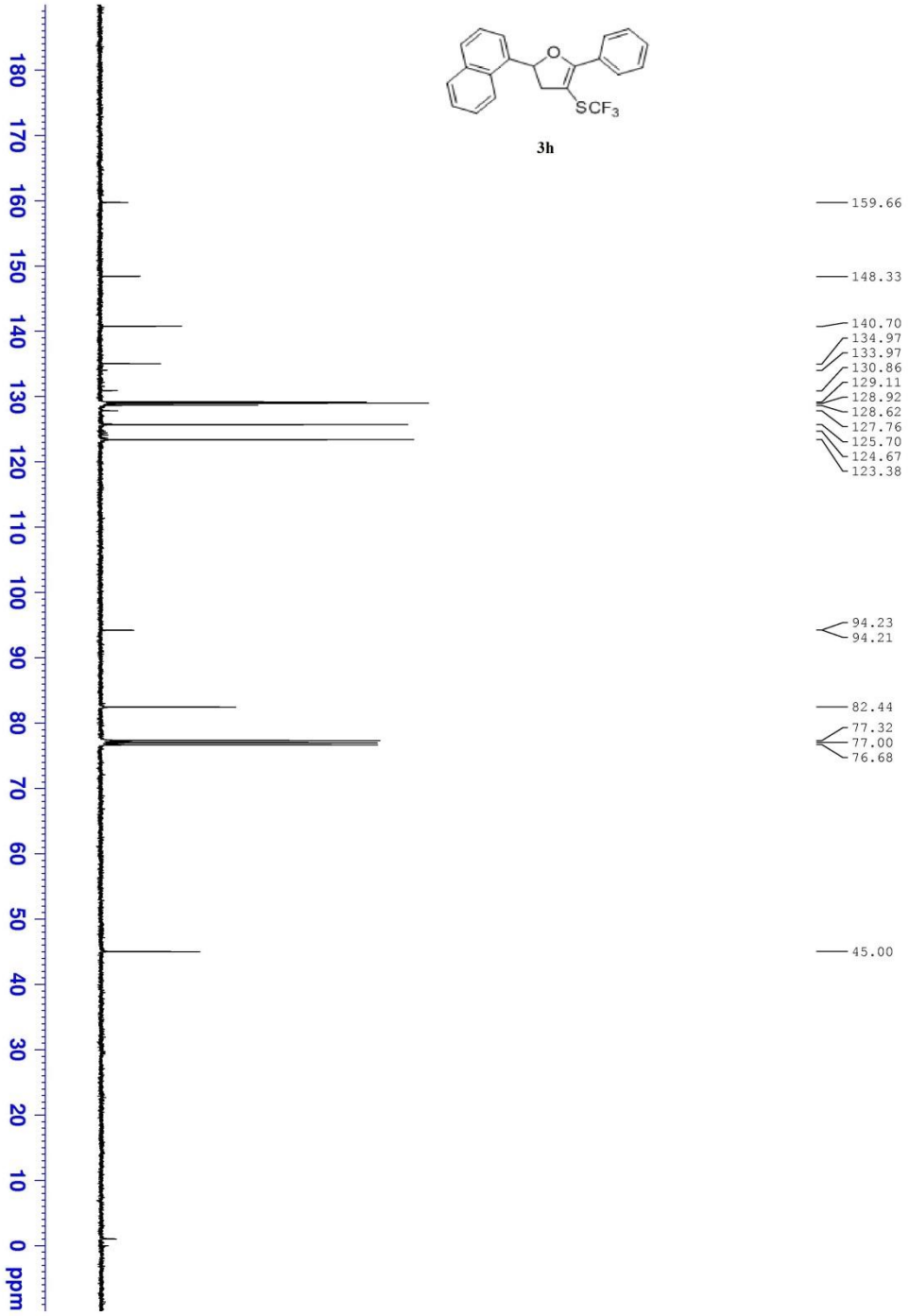
8.020
8.015
8.011
8.002
7.919
7.901
7.897
7.880
7.840
7.820
7.635
7.617
7.553
7.549
7.540
7.535
7.529
7.521
7.517
7.490
7.471
7.463
7.453
7.445
7.437
6.420
6.397
6.393
6.370
3.788
3.760
3.750
3.722
3.167
3.144
3.129
3.107
0.000


SCF3
3h
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148.33
140.70
134.97
133.97
130.86
129.11
128.92
128.62
127.76
125.70
124.67
123.38
94.23
94.21
82.44
77.32
77.00
76.68
45.00
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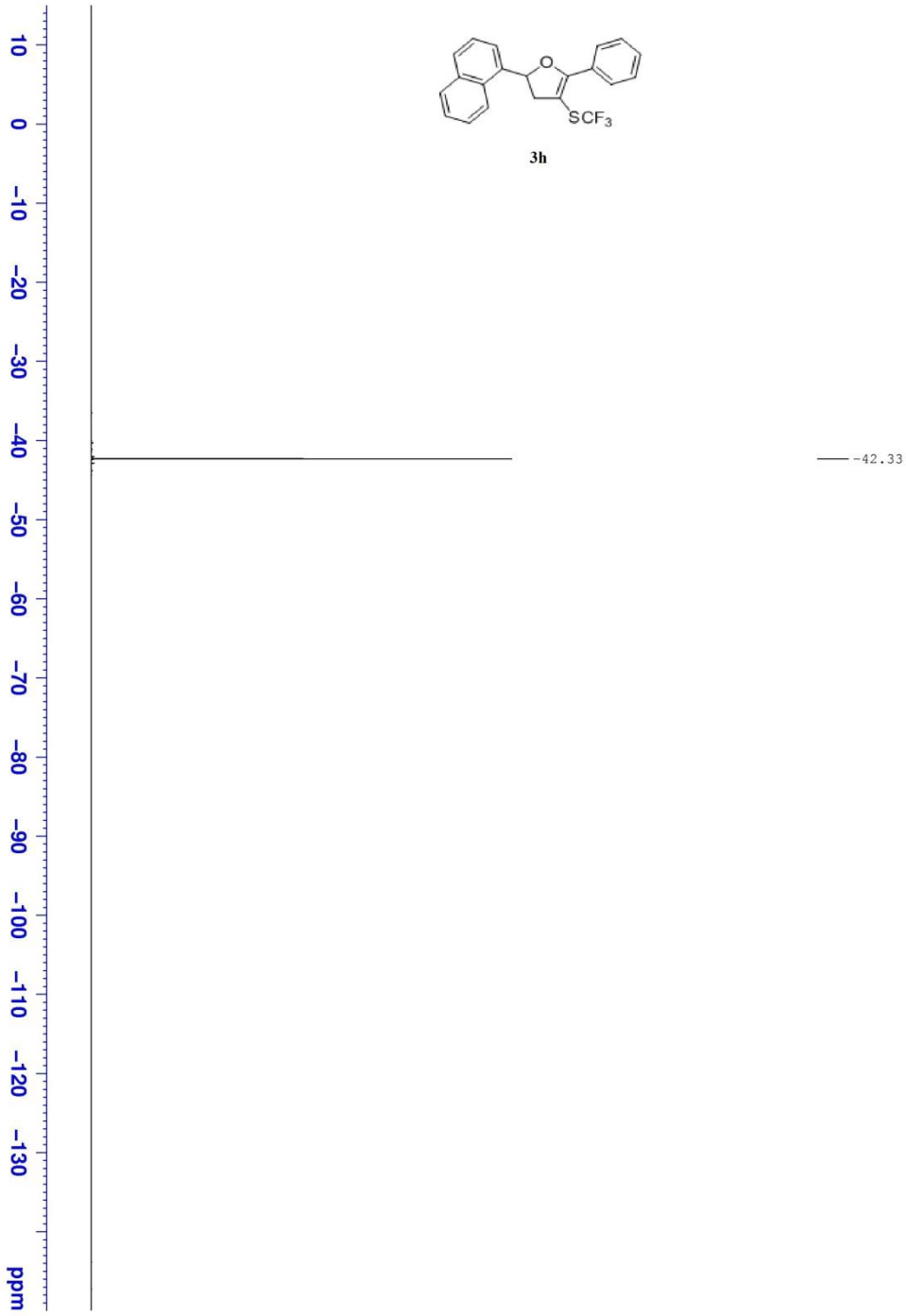
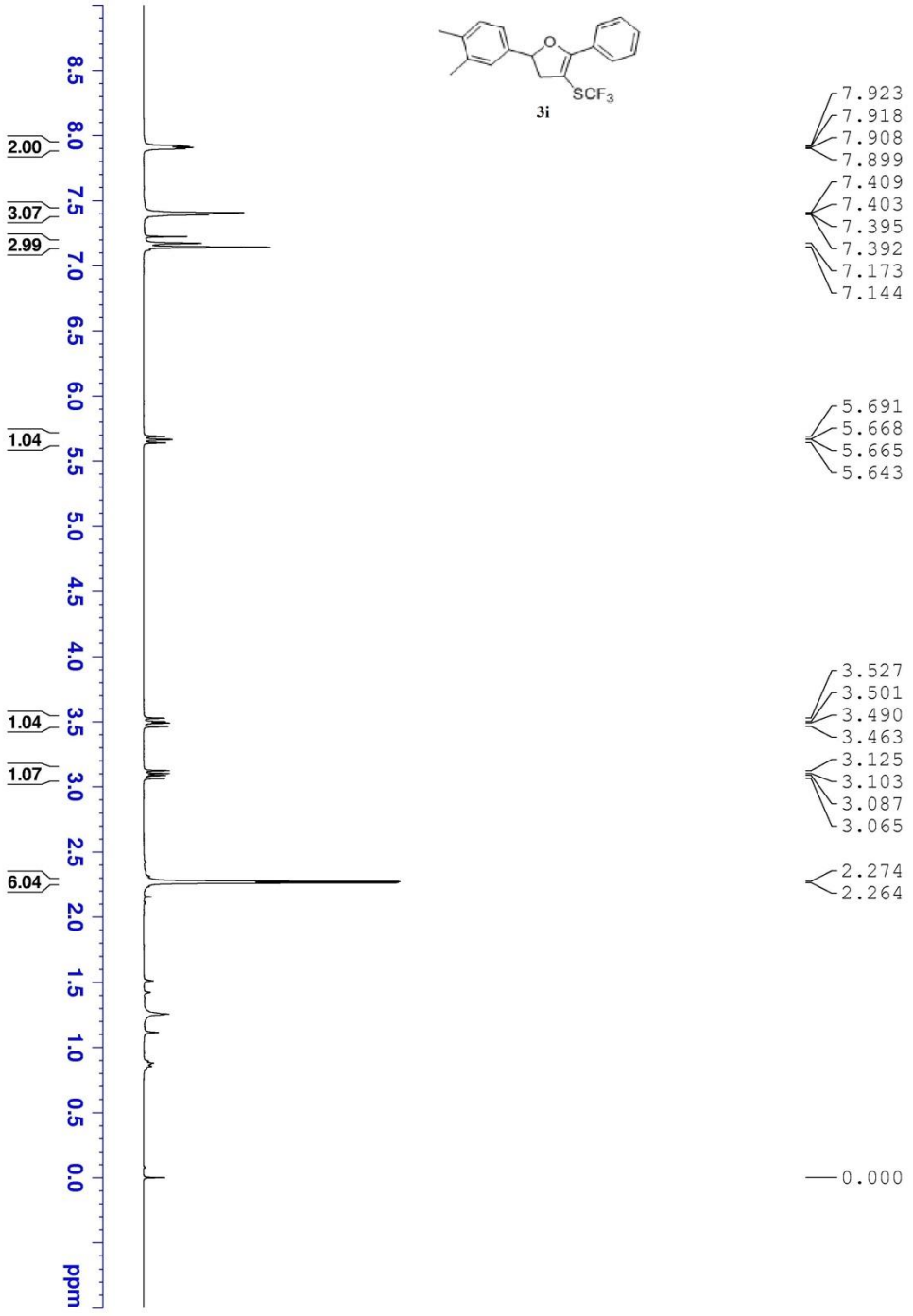
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm



3h


3i
SCF3
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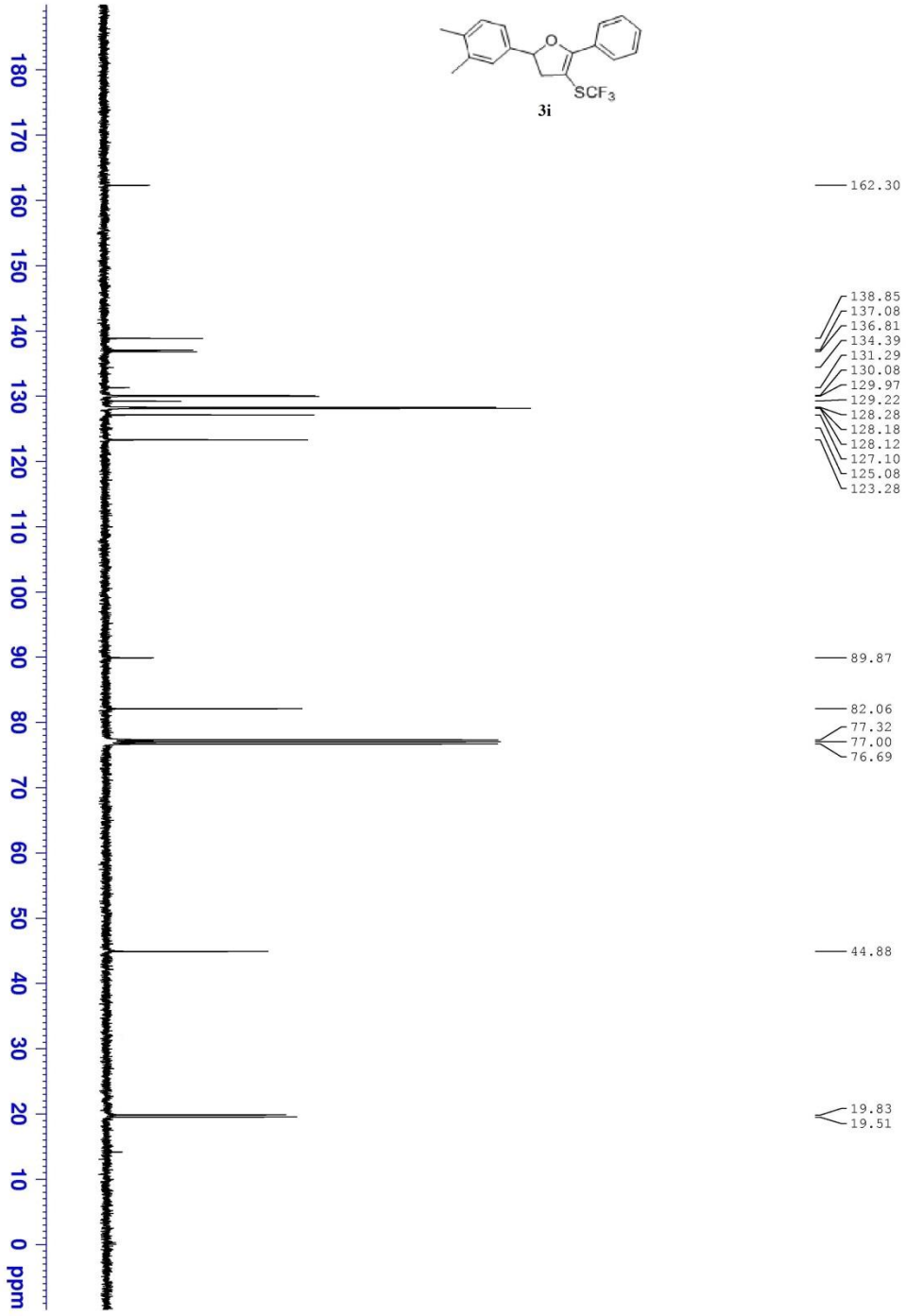
7.899
7.409
7.403
7.395
7.392
7.173
7.144
5.691
5.668
5.665
5.643
3.527
3.501
3.490
3.463
3.125
3.103
3.087
3.065
2.274
2.264
0.000
2.00
3.07
2.99
1.04
1.04
1.07
6.04
ppm


SCF3
3i
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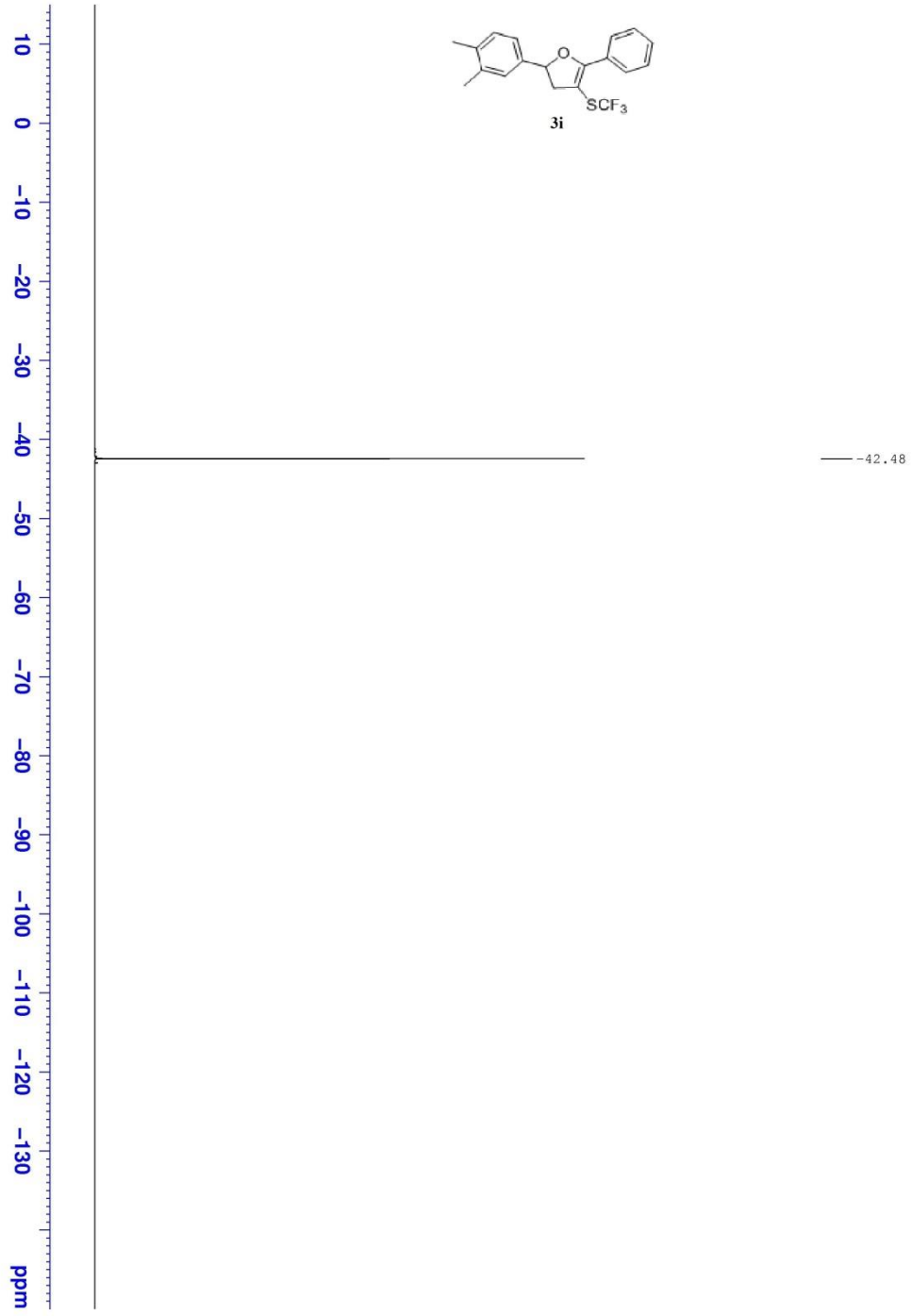
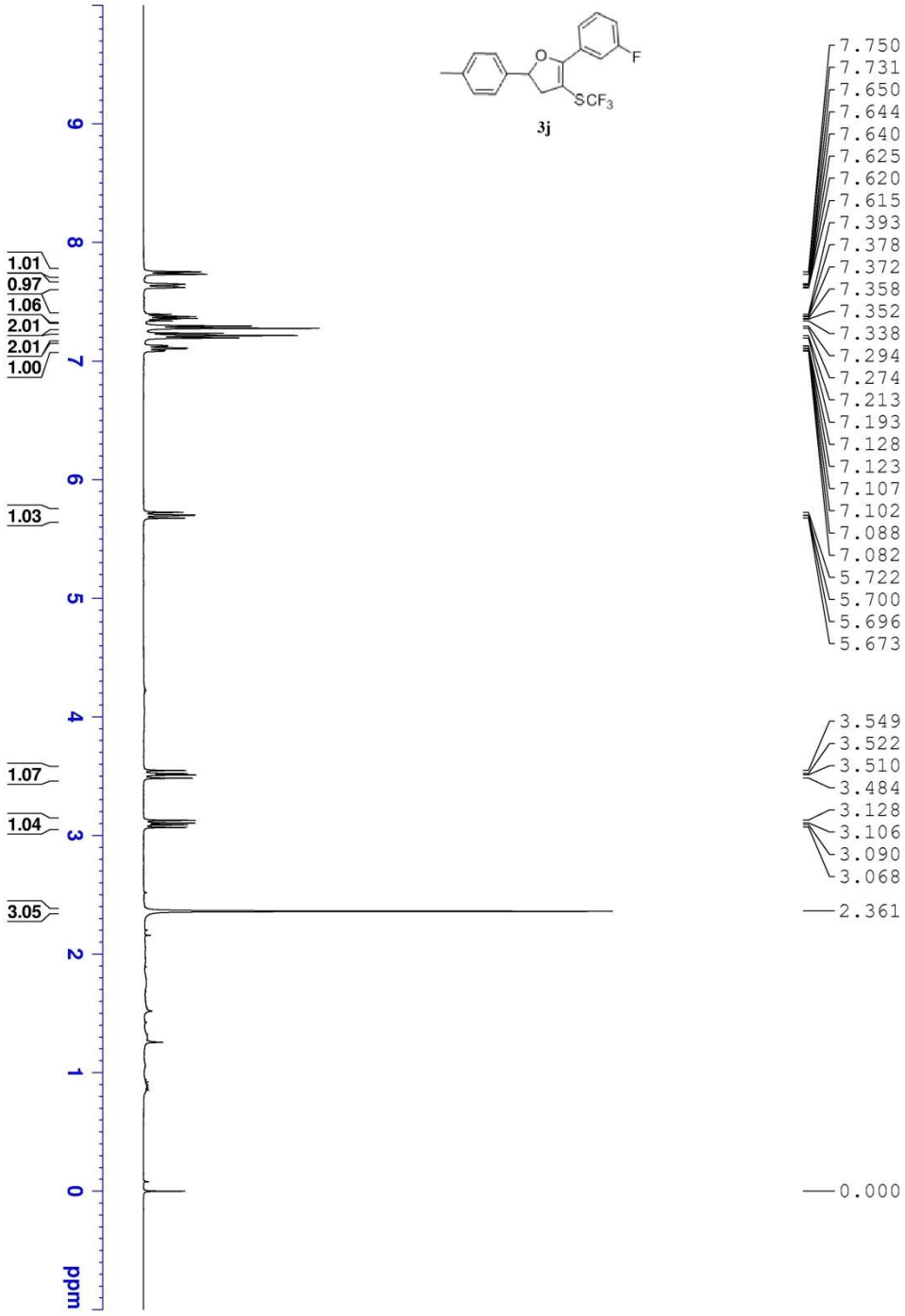
136.81
134.39
131.29
130.08
129.97
129.22
128.28
128.18
128.12
127.10
125.08
123.28
89.87
82.06
77.32
77.00
76.69
44.88
19.83
19.51
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm



3i


3j
1.01
0.97
1.06
2.01
2.01
1.00
1.03
1.07
1.04
3.05
ppm
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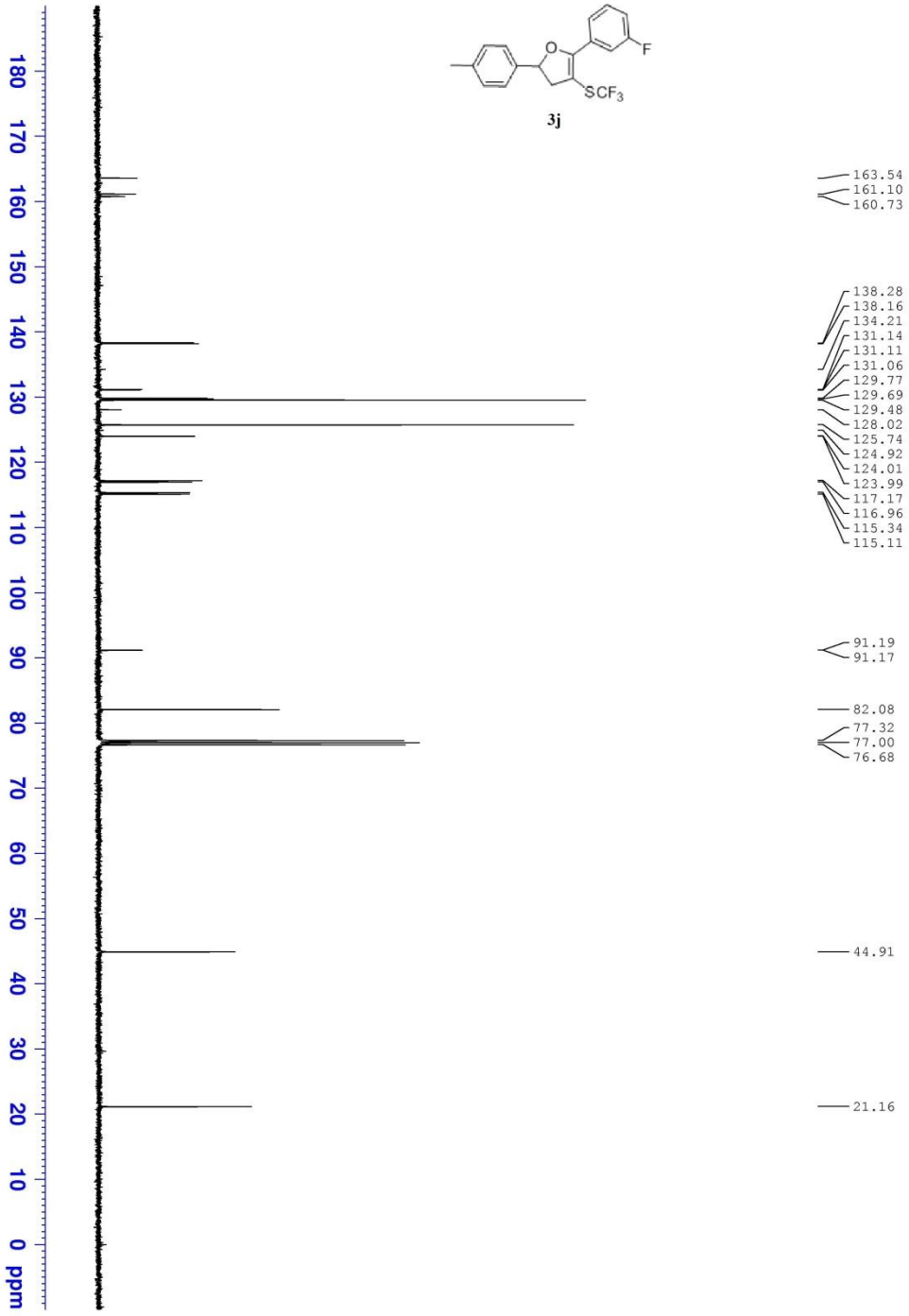
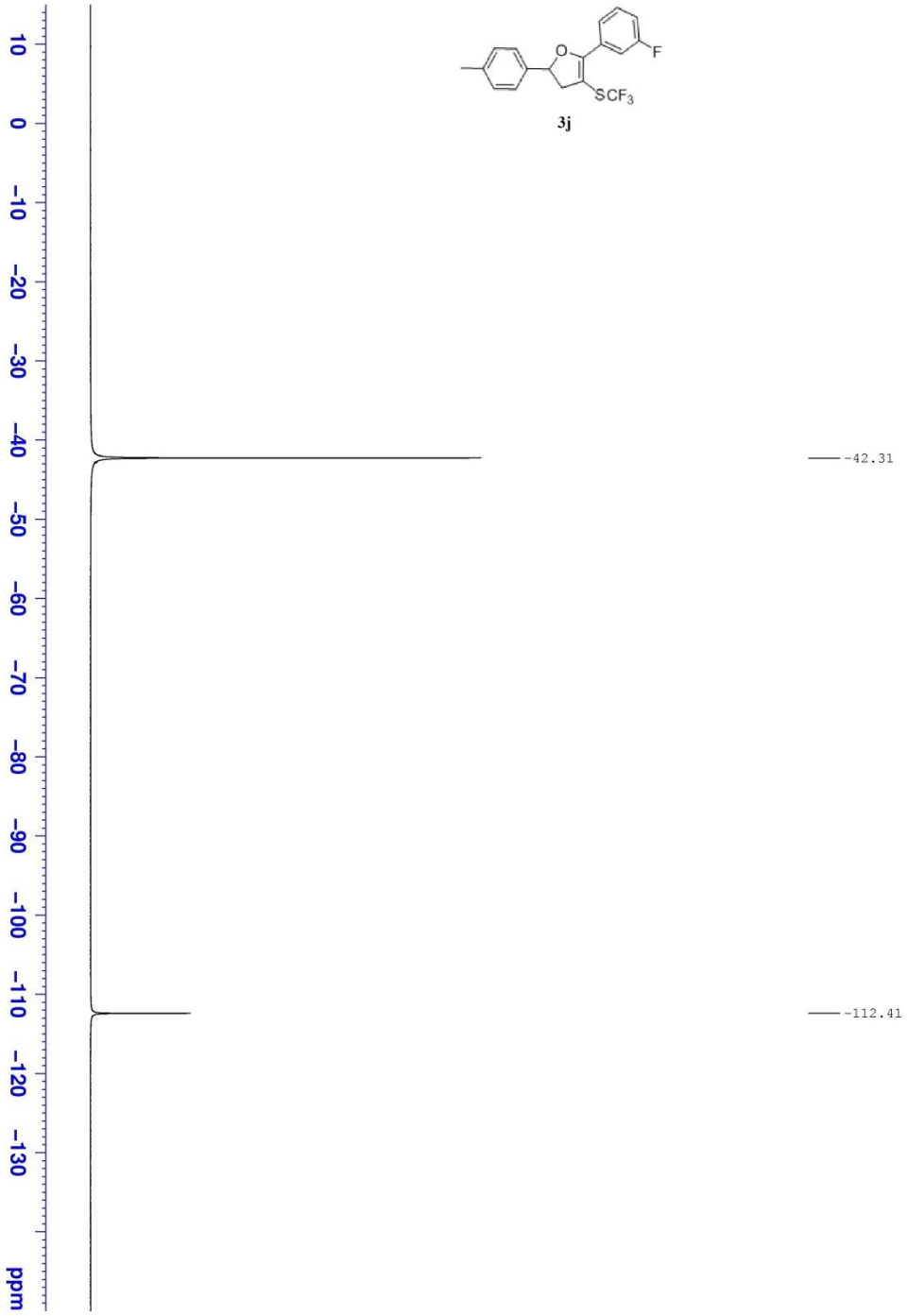
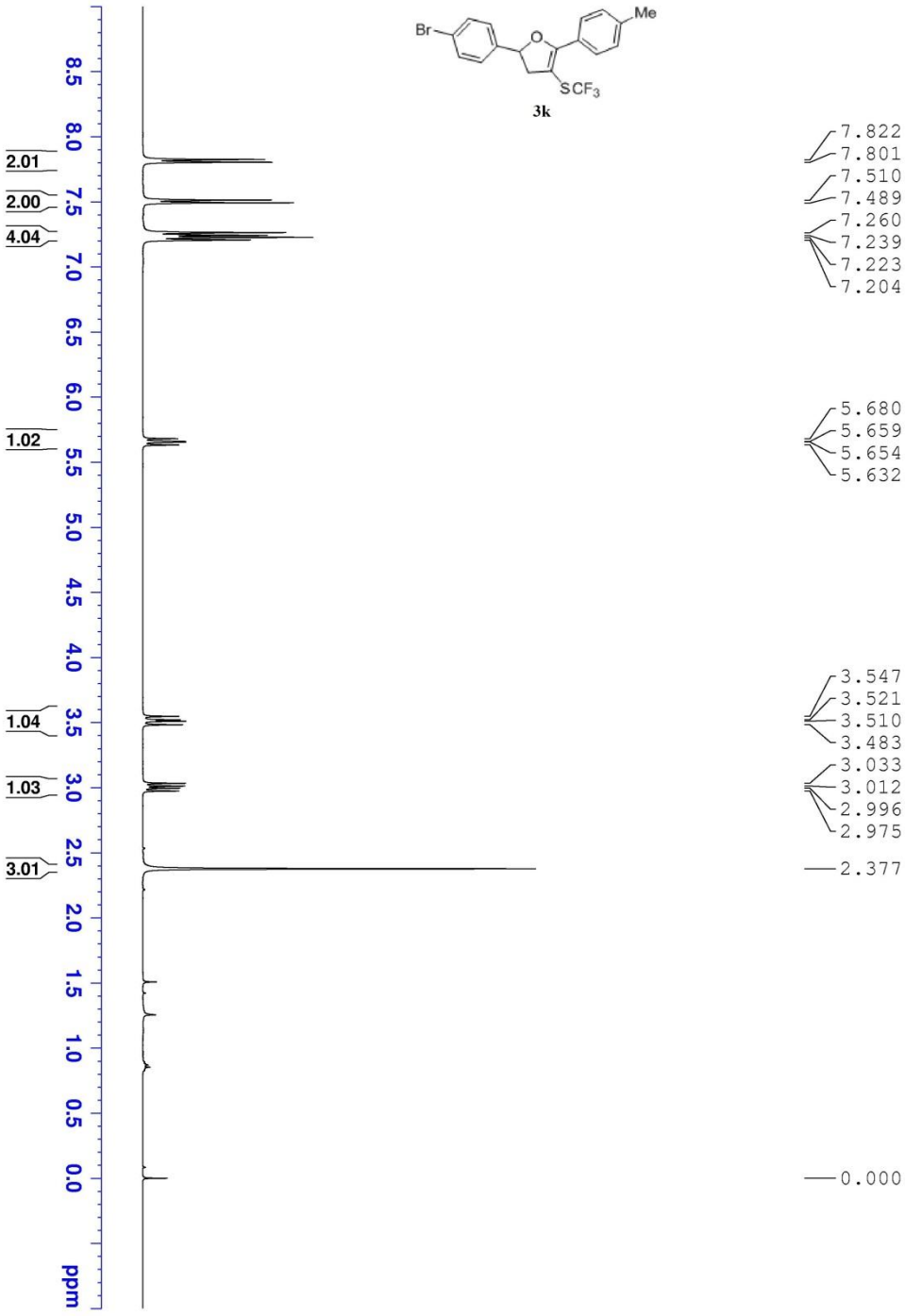
7.731
7.650
7.644
7.640
7.625
7.620
7.615
7.393
7.378
7.372
7.358
7.352
7.338
7.294
7.274
7.213
7.193
7.128
7.123
7.107
7.102
7.088
7.082
5.722
5.700
5.696
5.673
3.549
3.522
3.510
3.484
3.128
3.106
3.090
3.068
2.361
0.000


F
O
SCF3
3j
163.54
161.10
160.73
138.28
138.16
134.21
131.14
131.11
131.06
129.77
129.69
129.48
128.02
125.74
124.92
124.01
123.99
117.17
116.96
115.34
115.11
91.19
91.17
82.08
77.32
77.00
76.68
44.91
21.16
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm


10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
ppm
-42.31
-112.41
O
F
SCF3

3j


Br
O
Me
SCF3
3k
2.01
2.00
4.04
1.02
1.04
1.03
3.01
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
7.822
7.801
7.510
7.489
7.260
7.239
7.223
7.204
5.680
5.659
5.654
5.632
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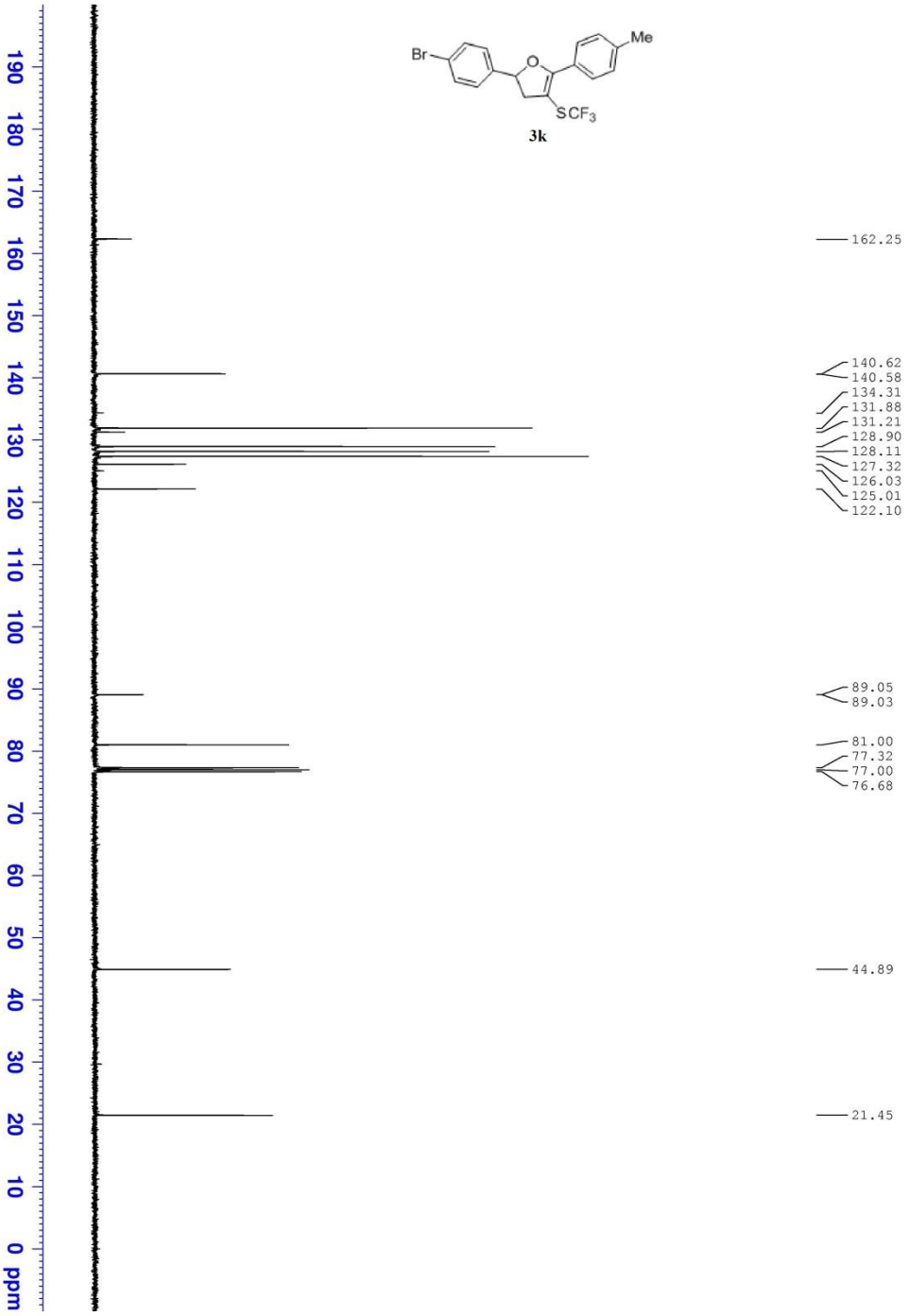
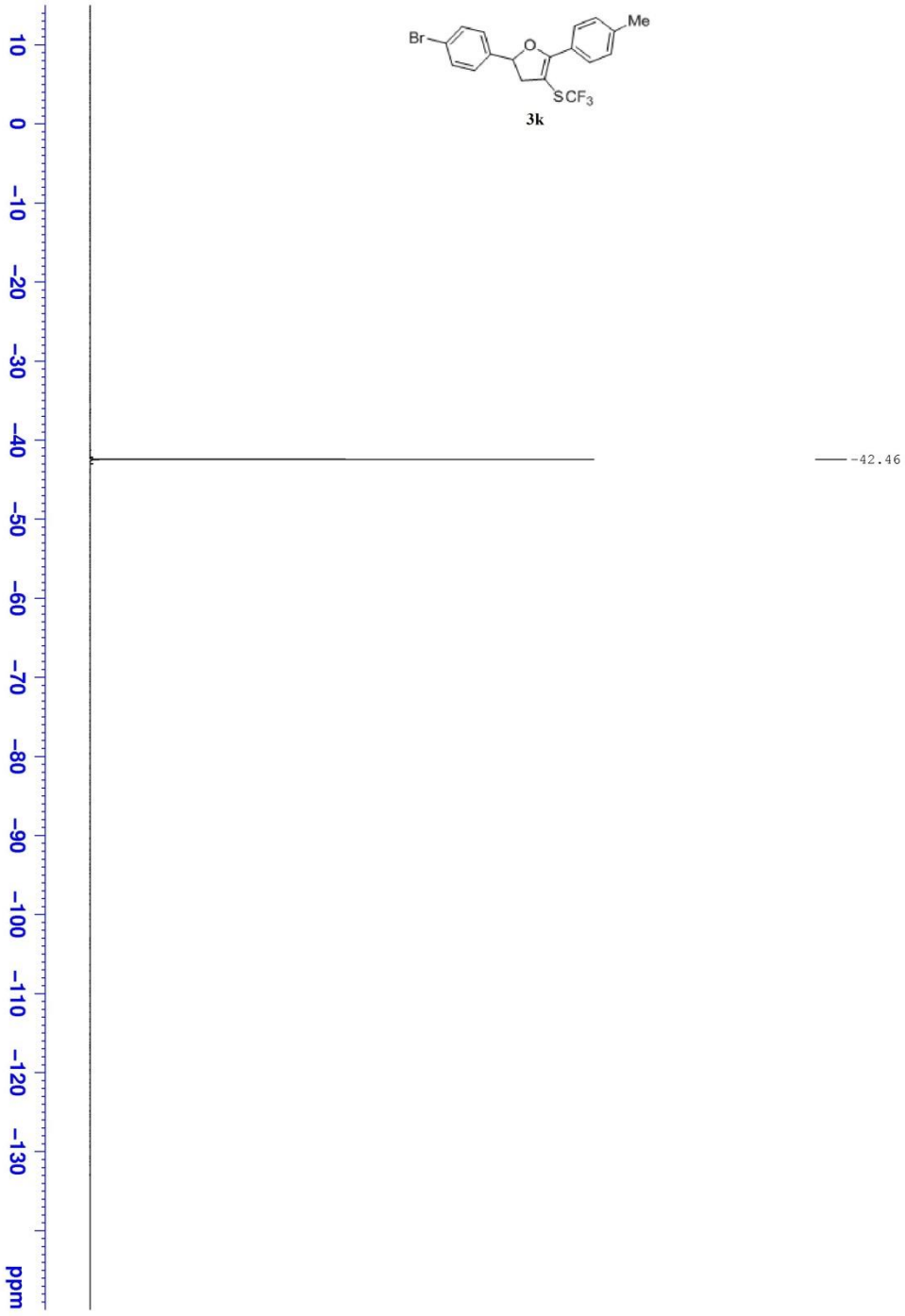
3.012
2.996
2.975
2.377
0.000


Br
O
Me
SCF3
3k
162.25
140.62
140.58
134.31
131.88
131.21
128.90
128.11
127.32
126.03
125.01
122.10
89.05
89.03
81.00
77.32
77.00
76.68
44.89
21.45
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0 ppm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Me
SCF3
3k
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-30
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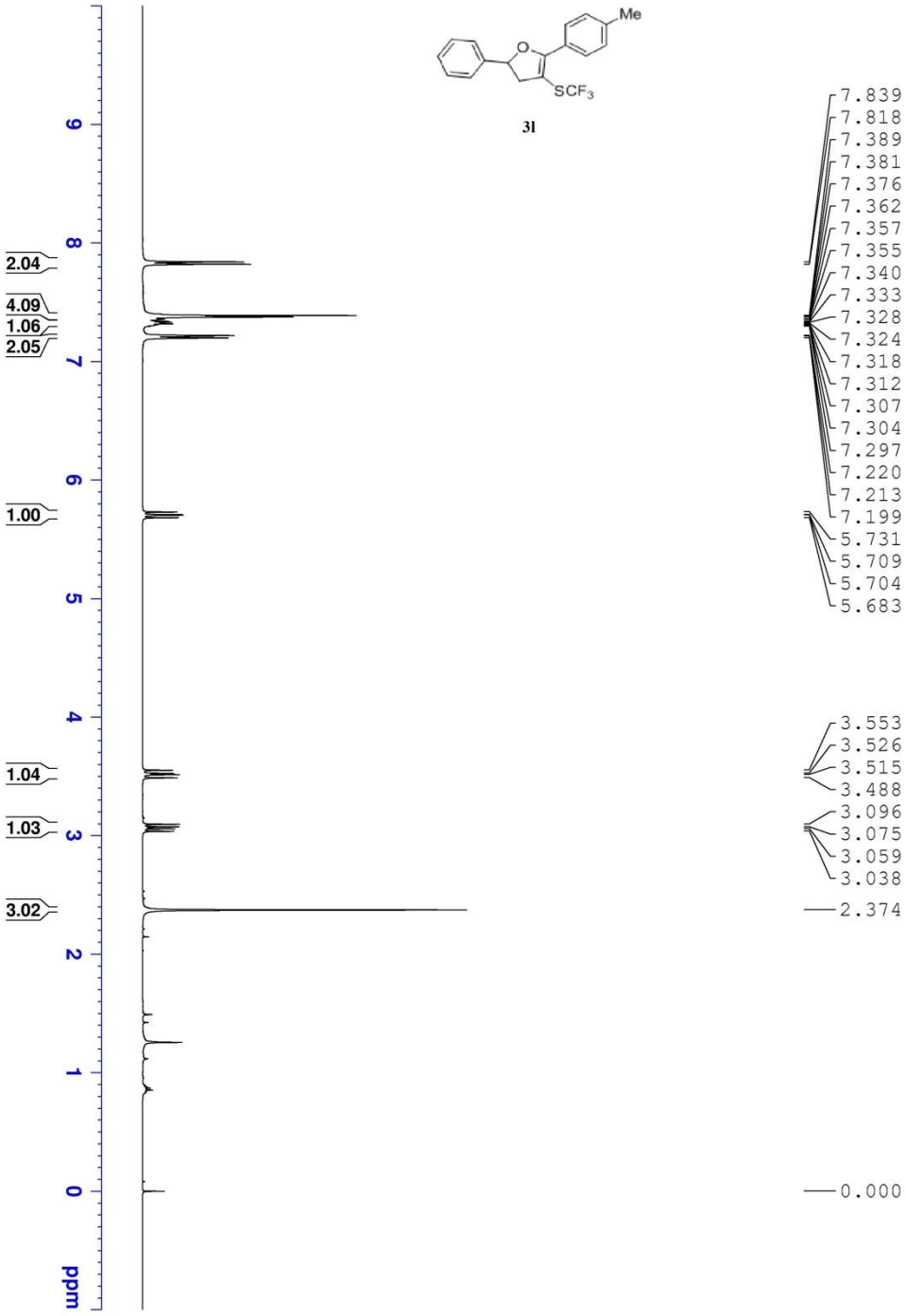
-50
-60
-70
-80
-90
-100
-110
-120
-130
ppm


Me
O
SCF3
3l
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7.381
7.376
7.362
7.357
7.355
7.340
7.333
7.328
7.324
7.318
7.312
7.307
7.304
7.297
7.220
7.213
7.199
5.731
5.709
5.704
5.683
3.553
3.526
3.515
3.488
3.096
3.075
3.059
3.038
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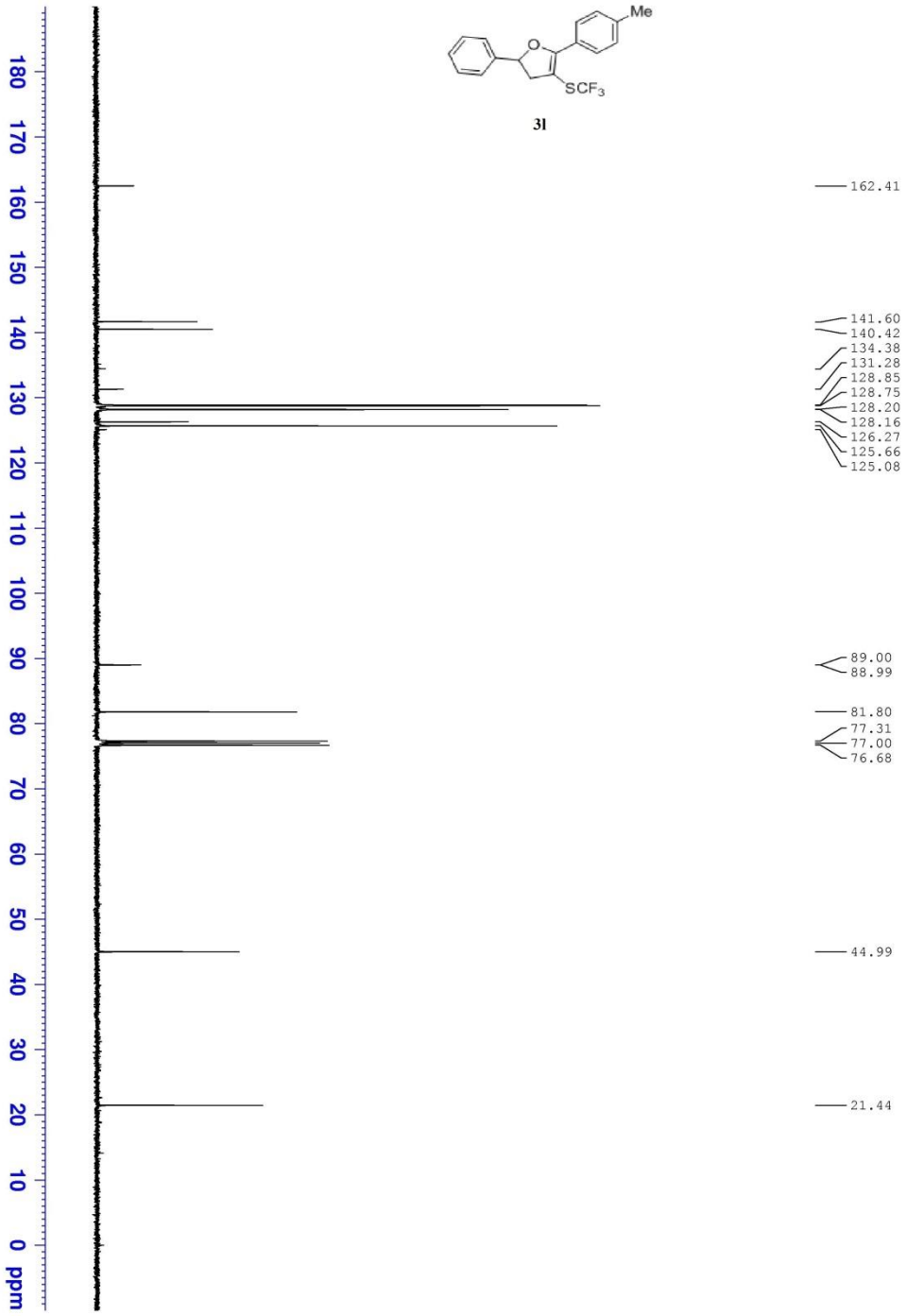
0.000
2.04
4.09
1.06
2.05
1.00
1.04
1.03
3.02
ppm


Me
O
SCF3
3l
162.41
141.60
140.42
134.38
131.28
128.85
128.75
128.20
128.16
126.27
125.66
125.08
89.00
88.99
81.80
77.31
77.00
76.68
44.99
21.44
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140
130
120
110
100
90
80
70
60
50
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20
10
0
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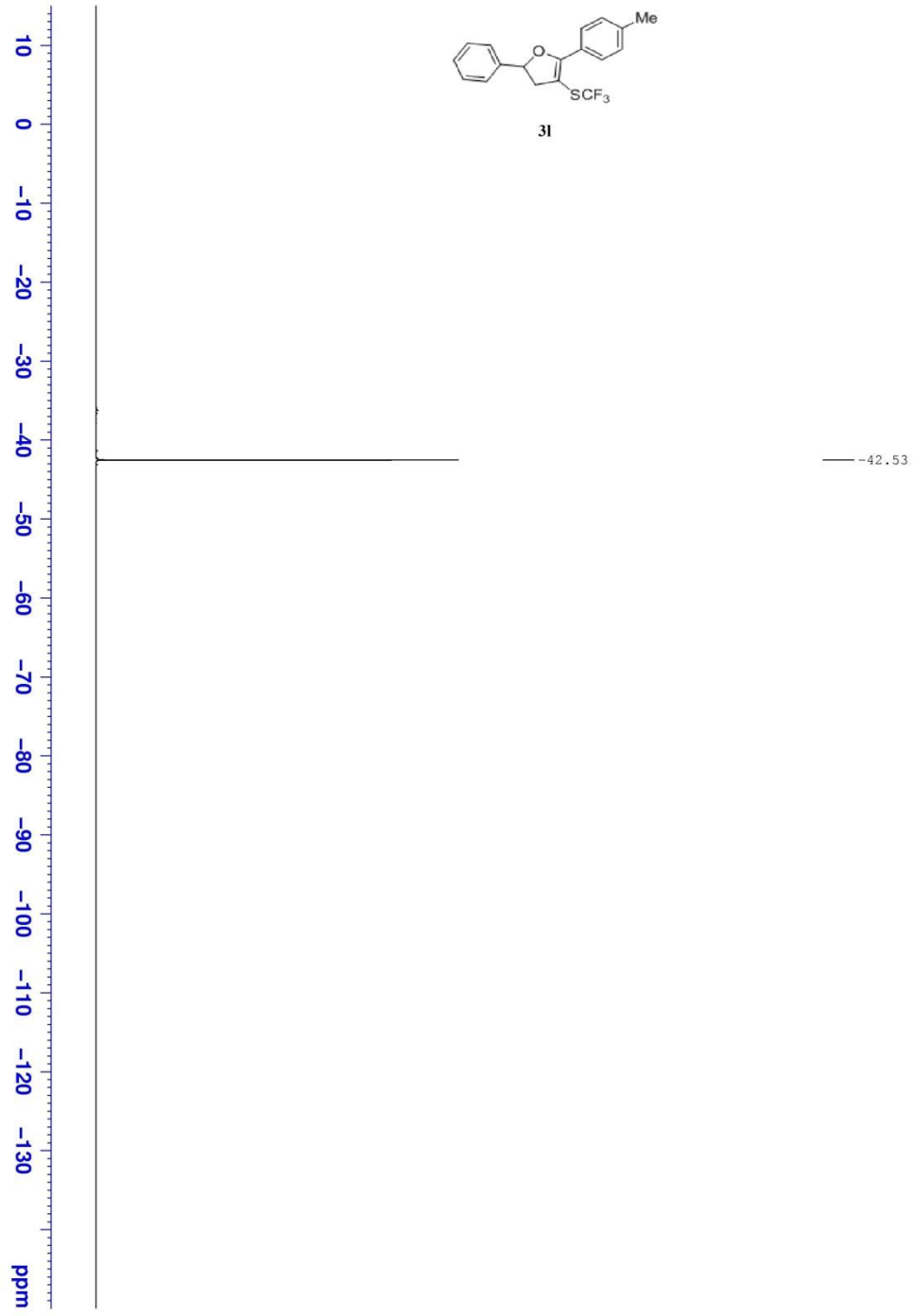
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O
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3l
-42.53
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-30
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-50
-60
-70
-80
-90
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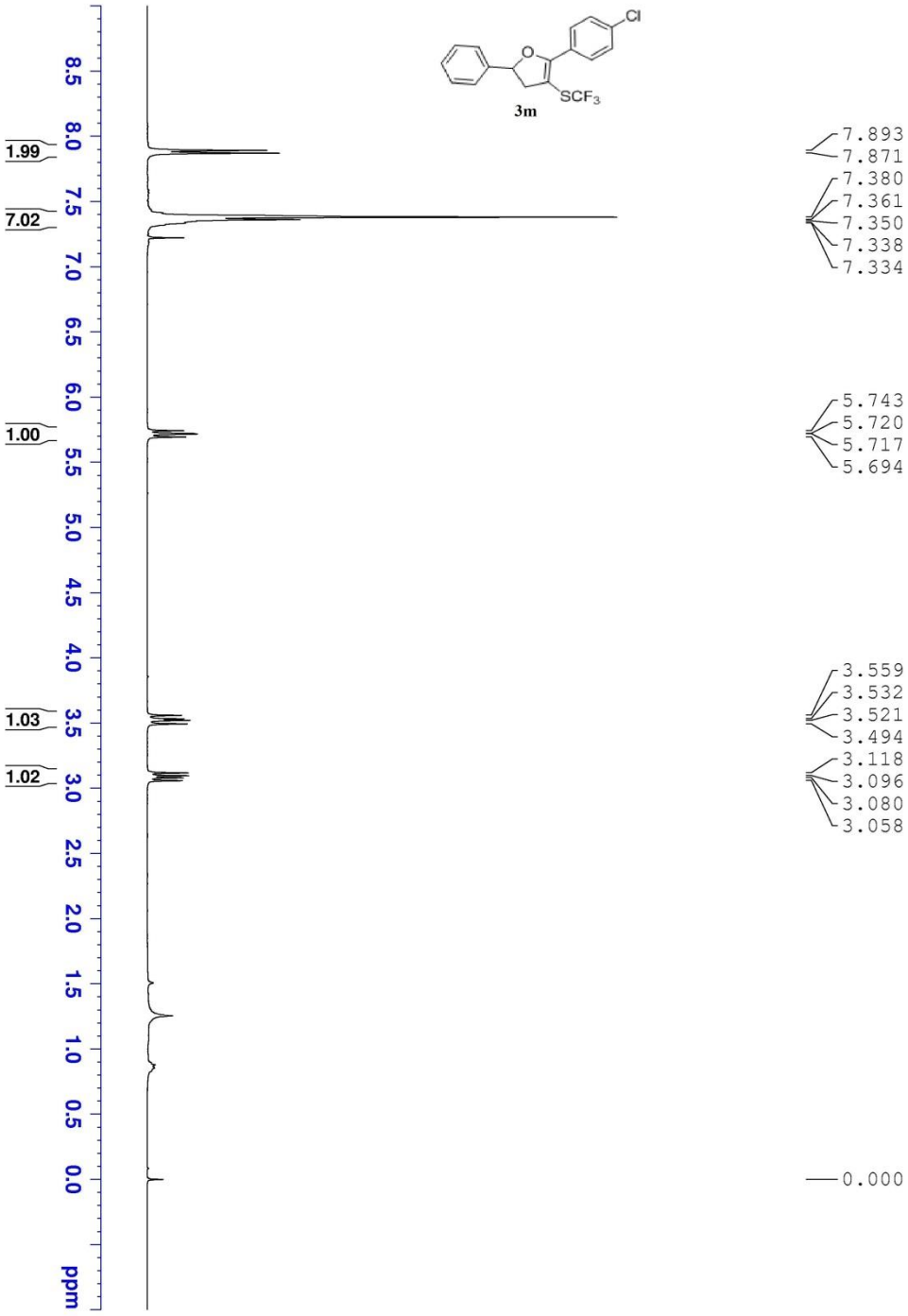
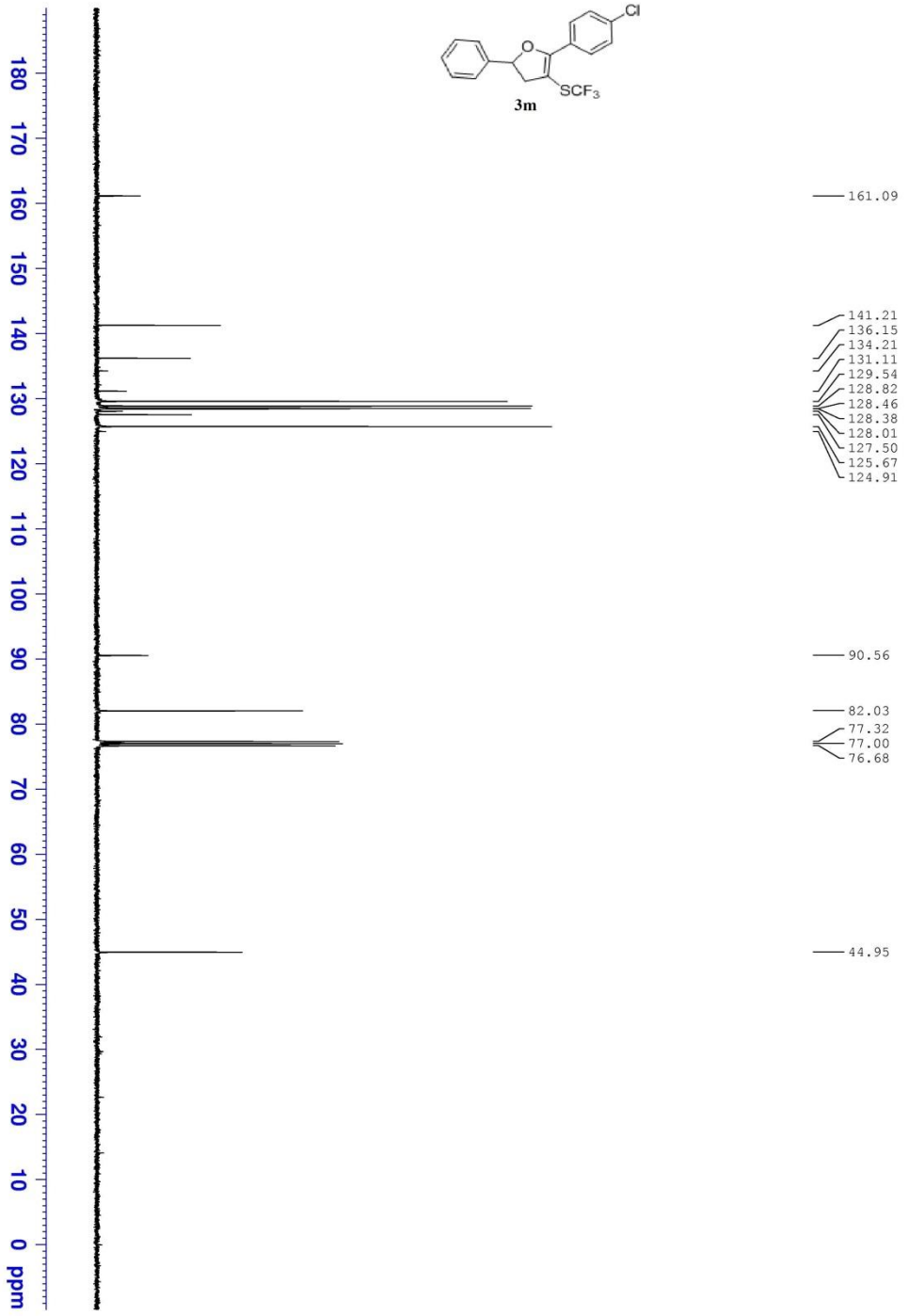
-110
-120
-130
ppm


Cl
O
SCF3
3m
1.99
7.02
1.00
1.03
1.02
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
7.893
7.871
7.380
7.361
7.350
7.338
7.334
5.743
5.720
5.717
5.694
3.559
3.532
3.521
3.494
3.118
3.096
3.080
3.058
0.000


Cl
O
SCF3
3m
161.09
141.21
136.15
134.21
131.11
129.54
128.82
128.46
128.38
128.01
127.50
125.67
124.91
90.56
82.03
77.32
77.00
76.68
44.95
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150
140
130
120
110
100
90
80
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60
50
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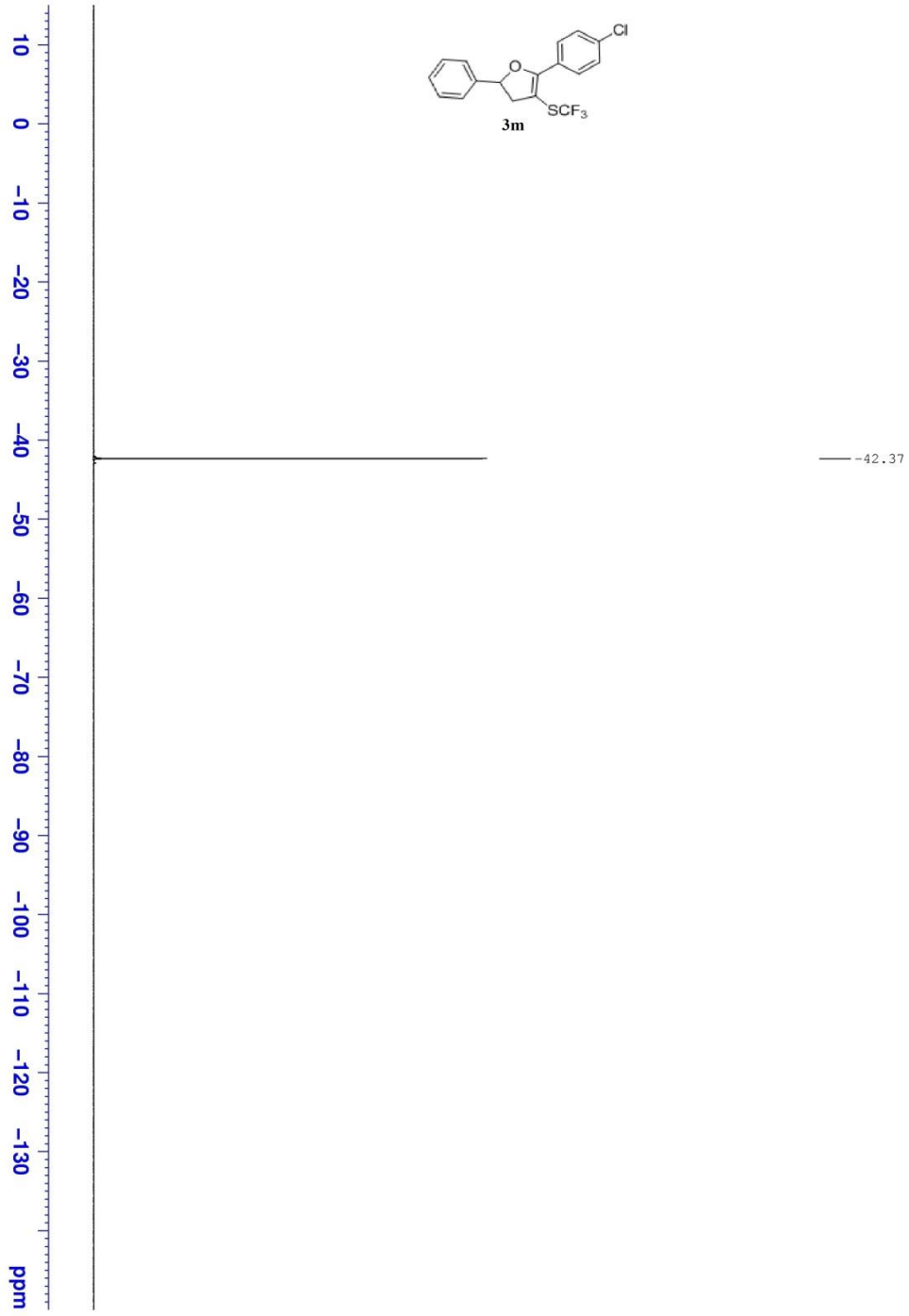
30
20
10
0
ppm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3m
-42.37
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-10
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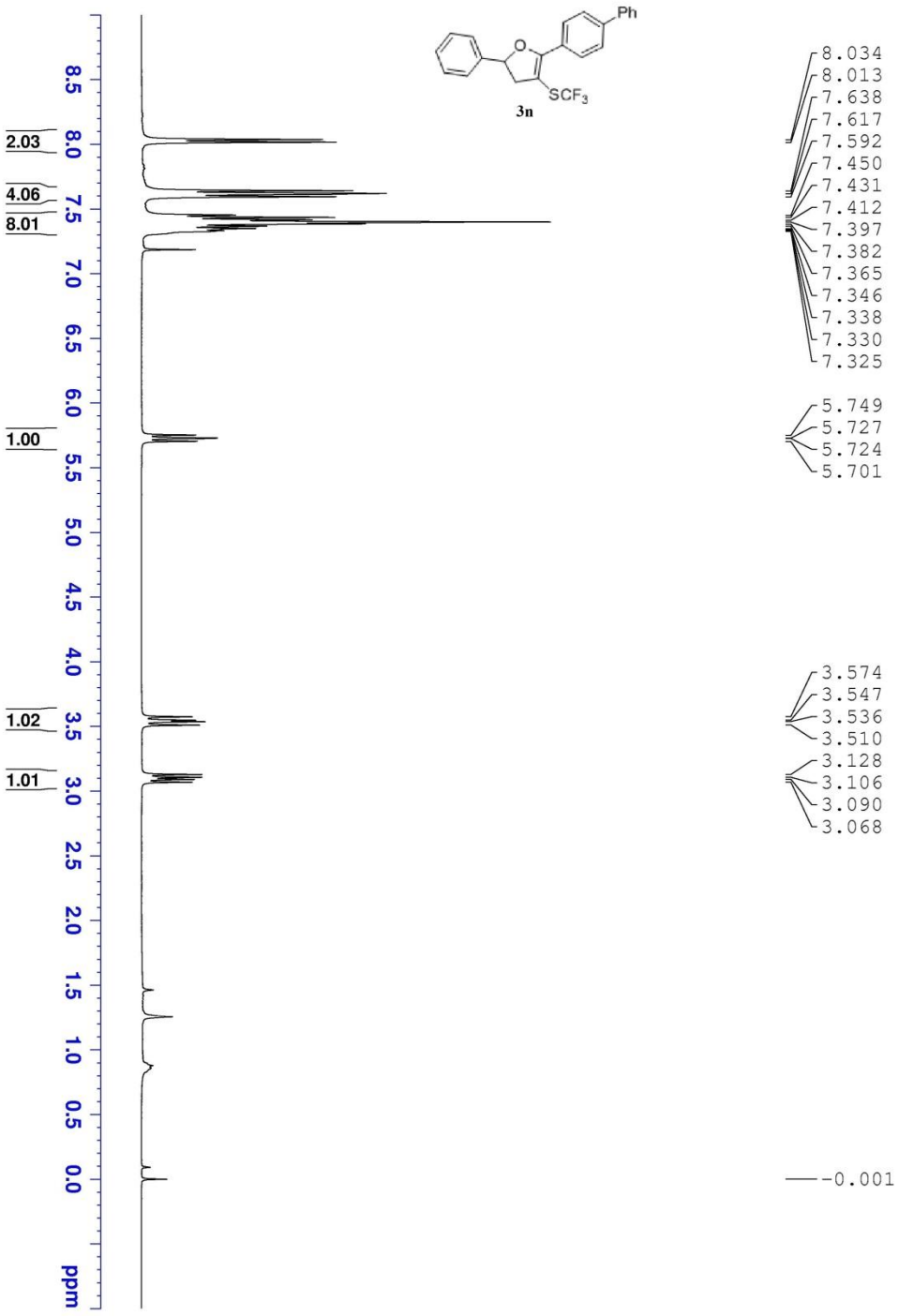
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
ppm


Ph
O
SCF3
3n
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8.013
7.638
7.617
7.592
7.450
7.431
7.412
7.397
7.382
7.365
7.346
7.338
7.330
7.325
5.749
5.727
5.724
5.701
3.574
3.547
3.536
3.510
3.128
3.106
3.090
3.068
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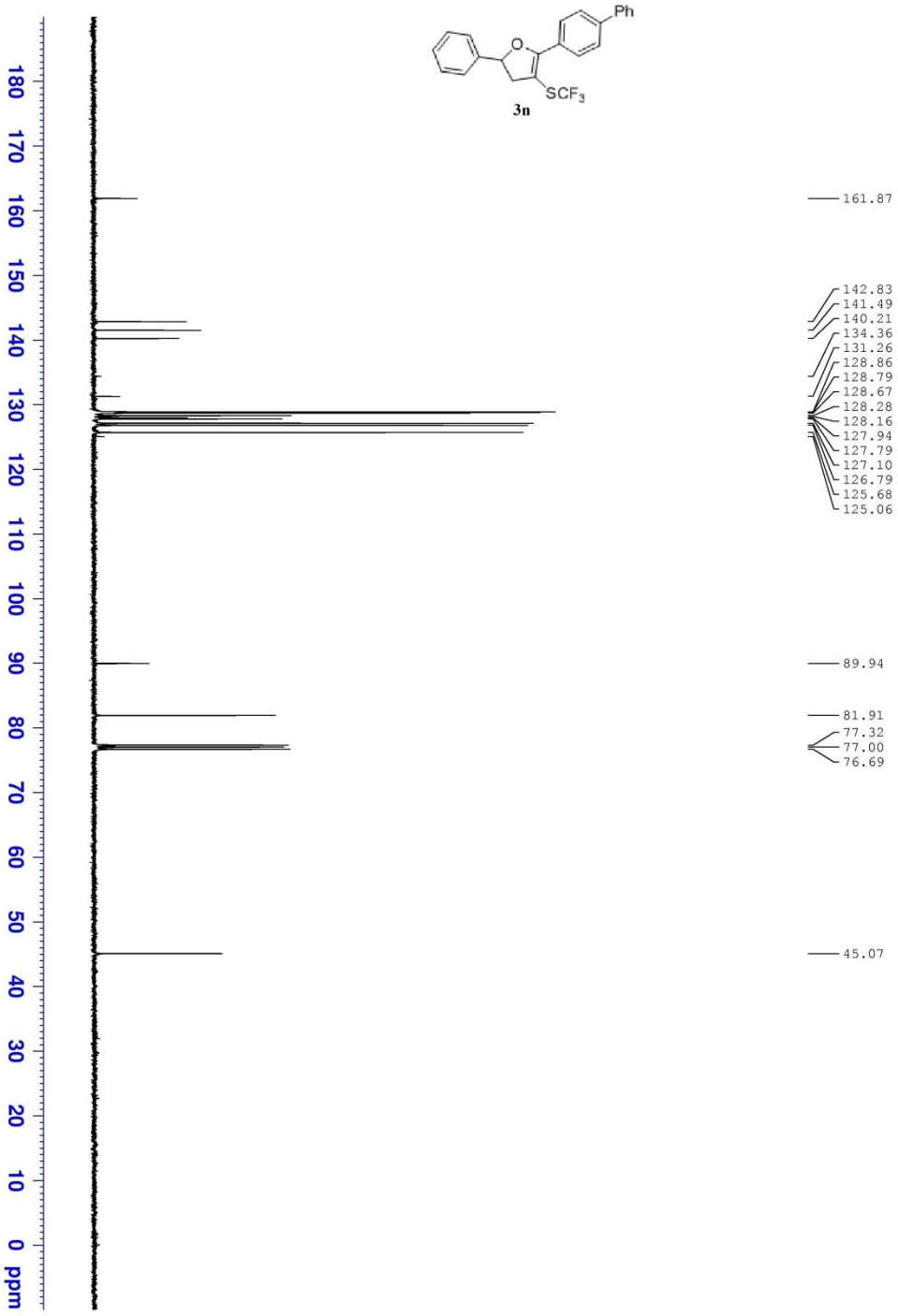
2.03
4.06
8.01
1.00
1.02
1.01
ppm


Ph
O
SCF3
3n
161.87
142.83
141.49
140.21
134.36
131.26
128.86
128.79
128.67
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128.16
127.94
127.79
127.10
126.79
125.68
125.06
89.94
81.91
77.32
77.00
76.69
45.07
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170
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140
130
120
110
100
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80
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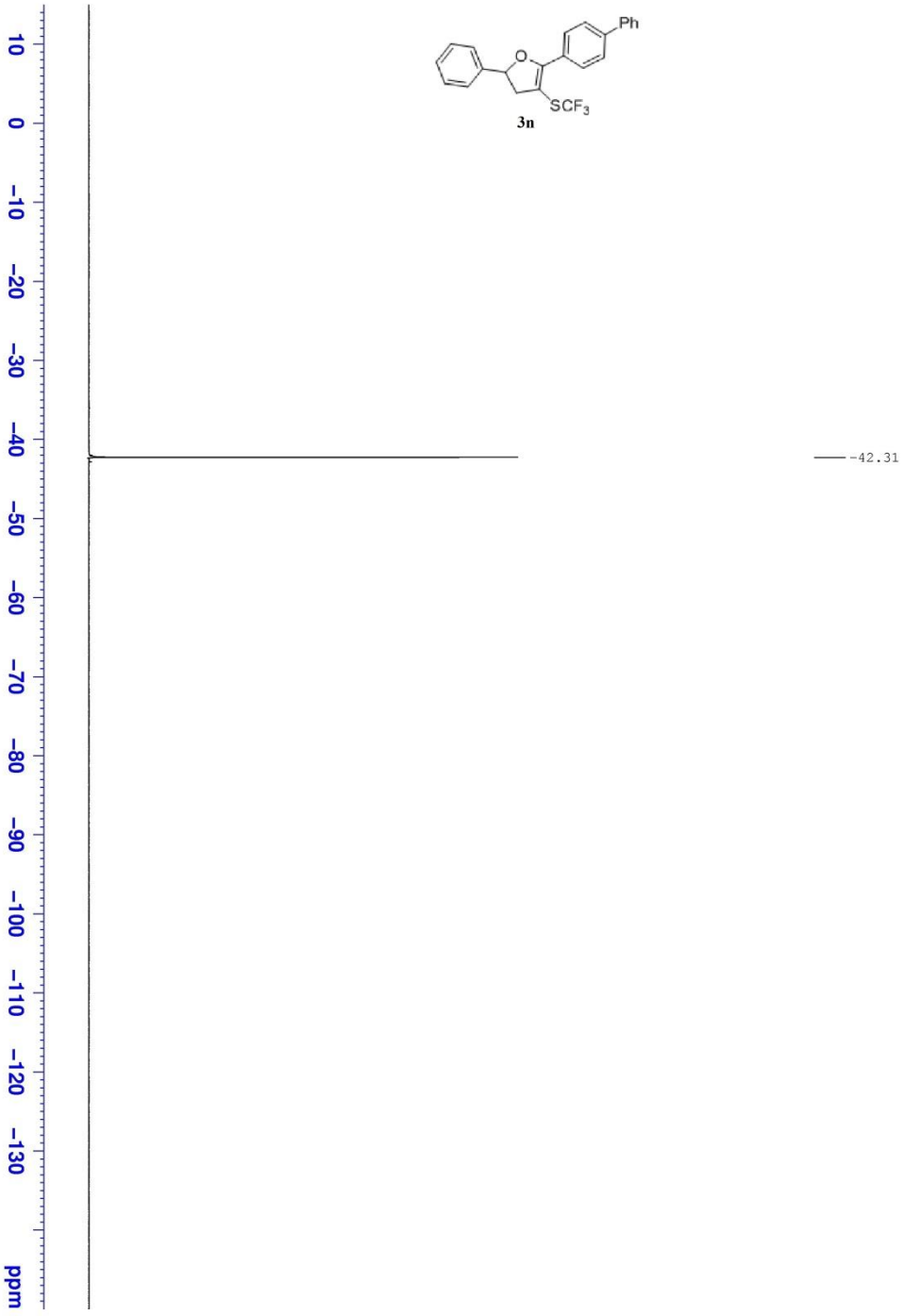
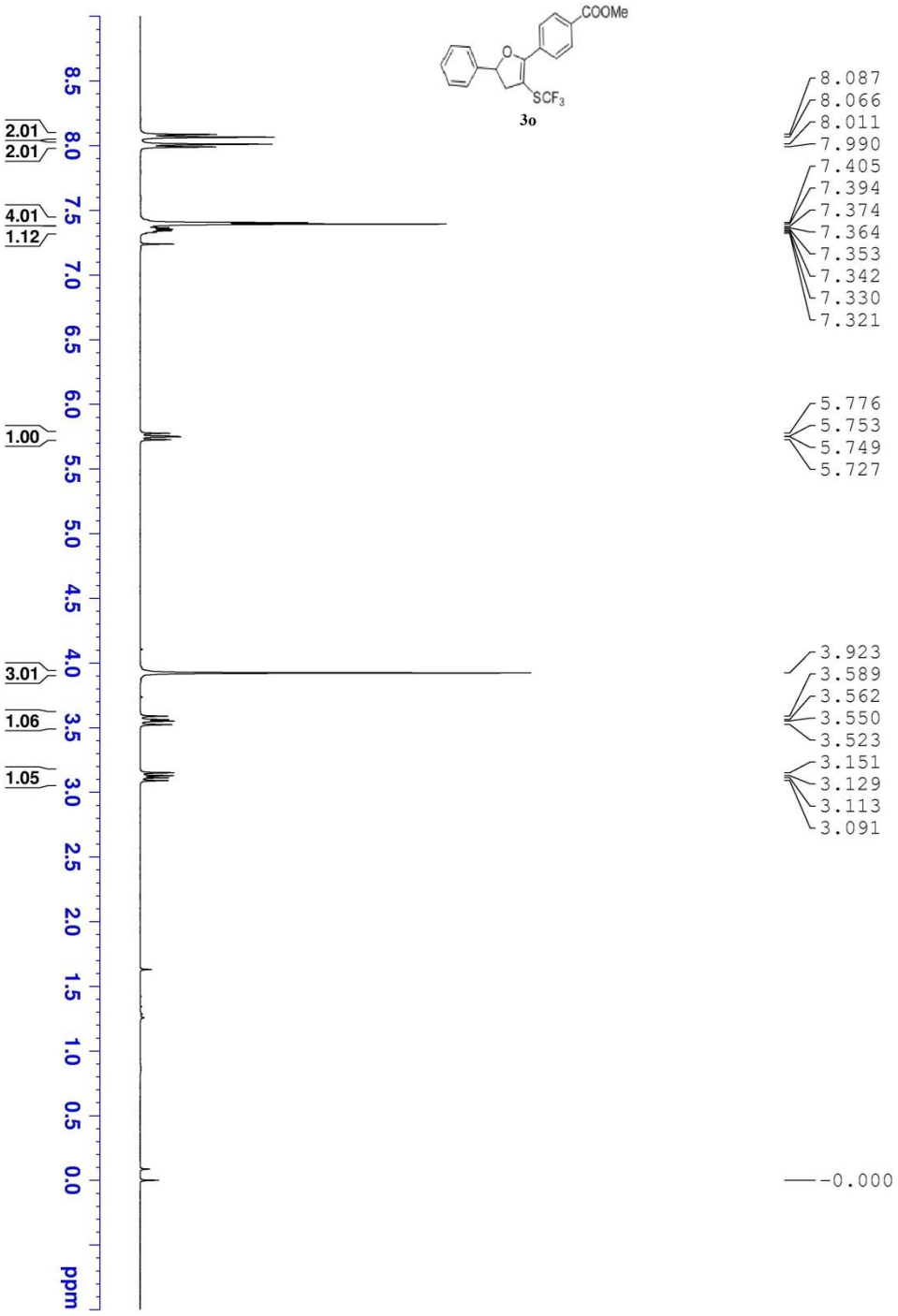
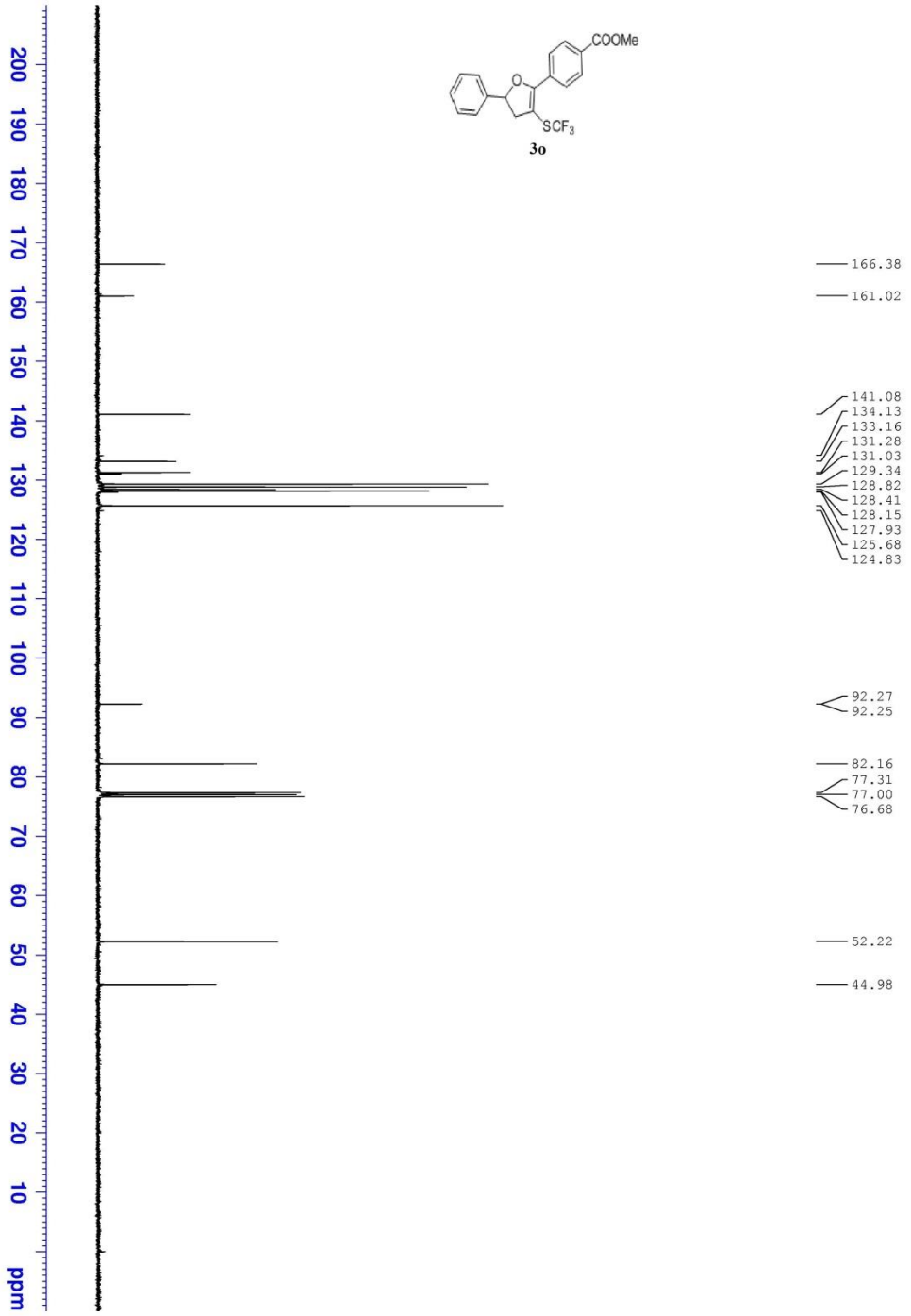
60
50
40
30
20
10
0
ppm


Ph
O
SCF3
3n
-42.31
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
ppm


COOMe
SCF3
3o
8.087
8.066
8.011
7.990
7.405
7.394
7.374
7.364
7.353
7.342
7.330
7.321
5.776
5.753
5.749
5.727
3.923
3.589
3.562
3.550
3.523
3.151
3.129
3.113
3.091
0.000
2.01
2.01
4.01
1.12
1.00
3.01
1.06
1.05
ppm


COOMe
O
SCF3
3o
166.38
161.02
141.08
134.13
133.16
131.28
131.03
129.34
128.82
128.41
128.15
127.93
125.68
124.83
92.27
92.25
82.16
77.31
77.00
76.68
52.22
44.98
200
190
180
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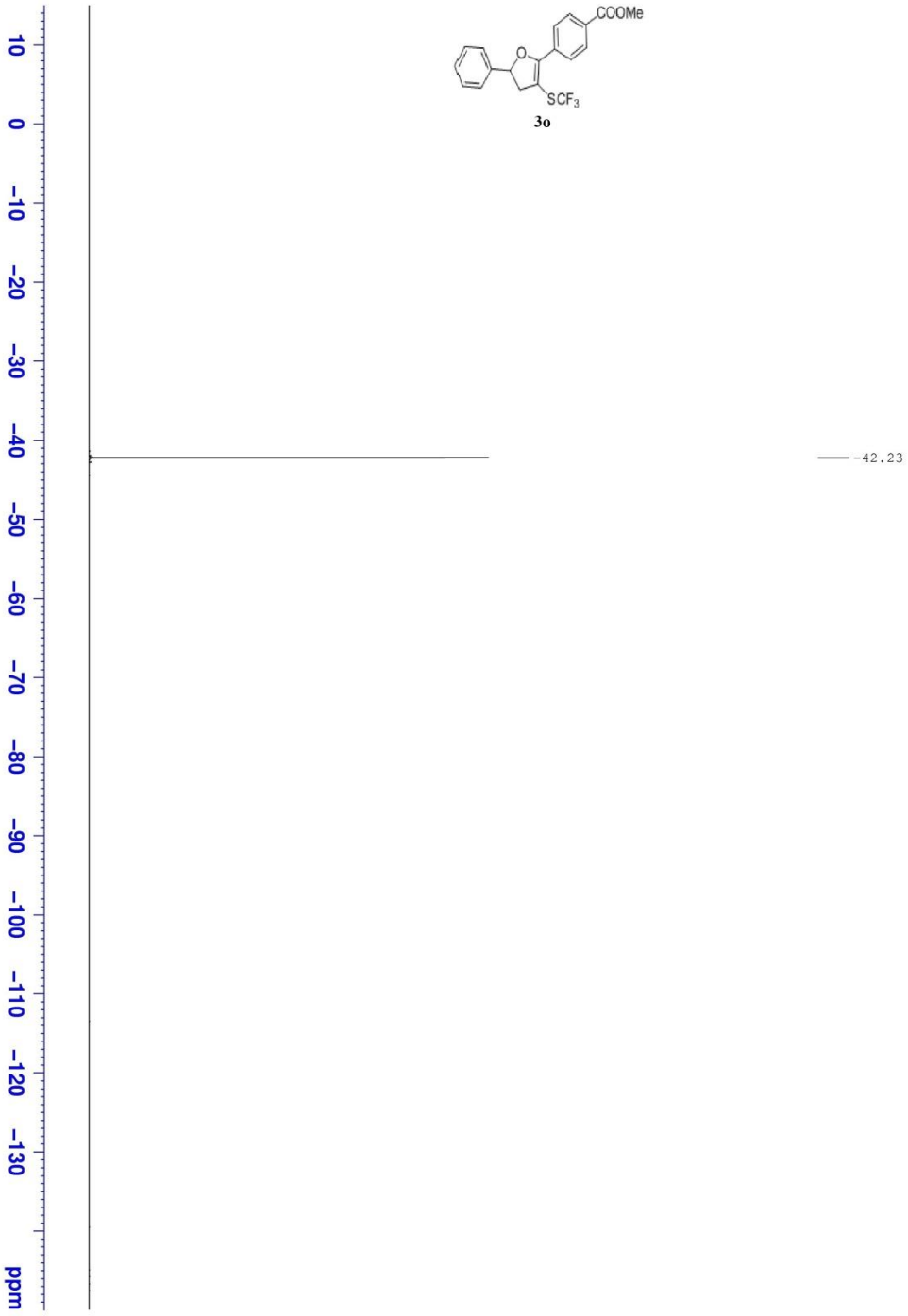
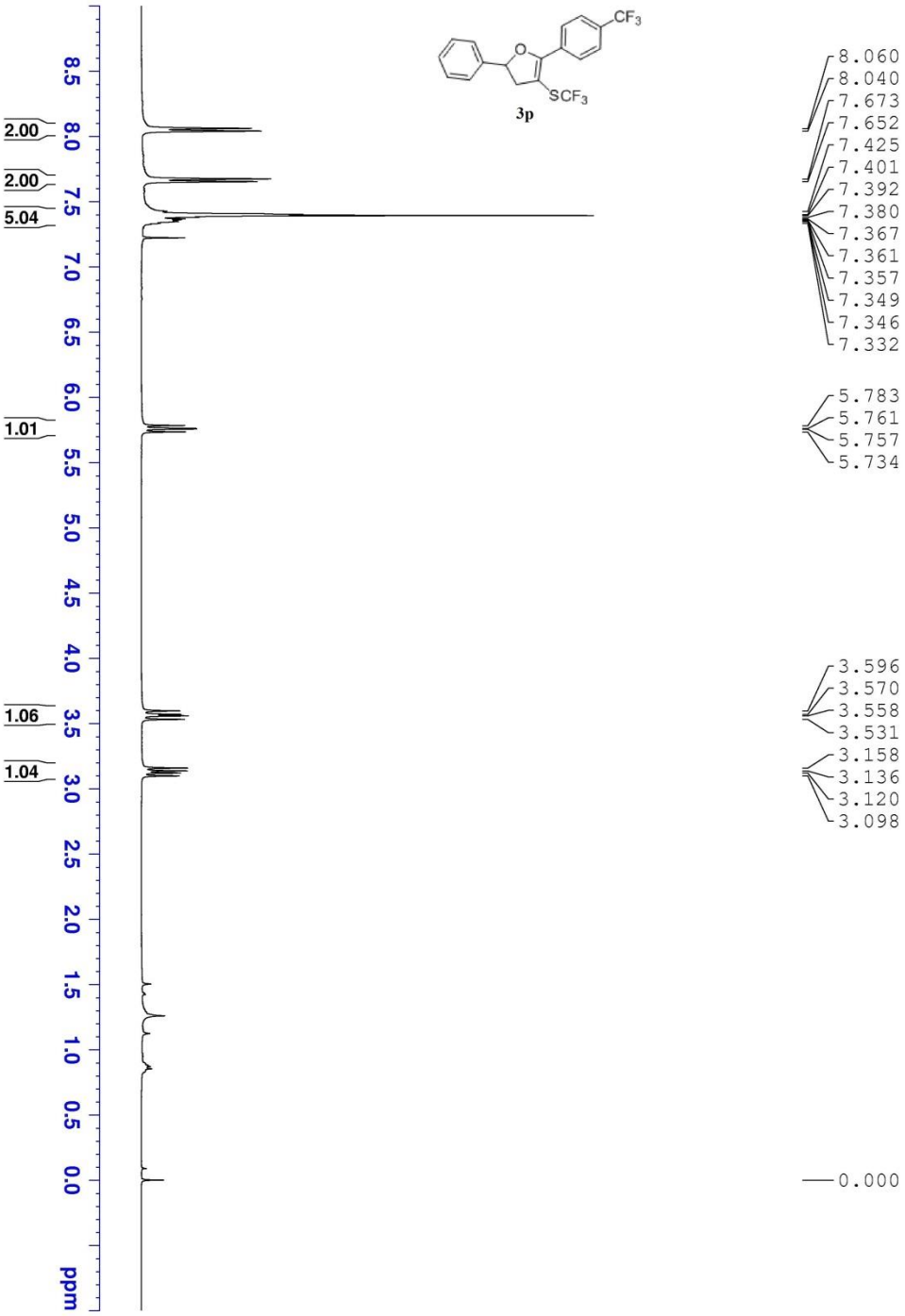
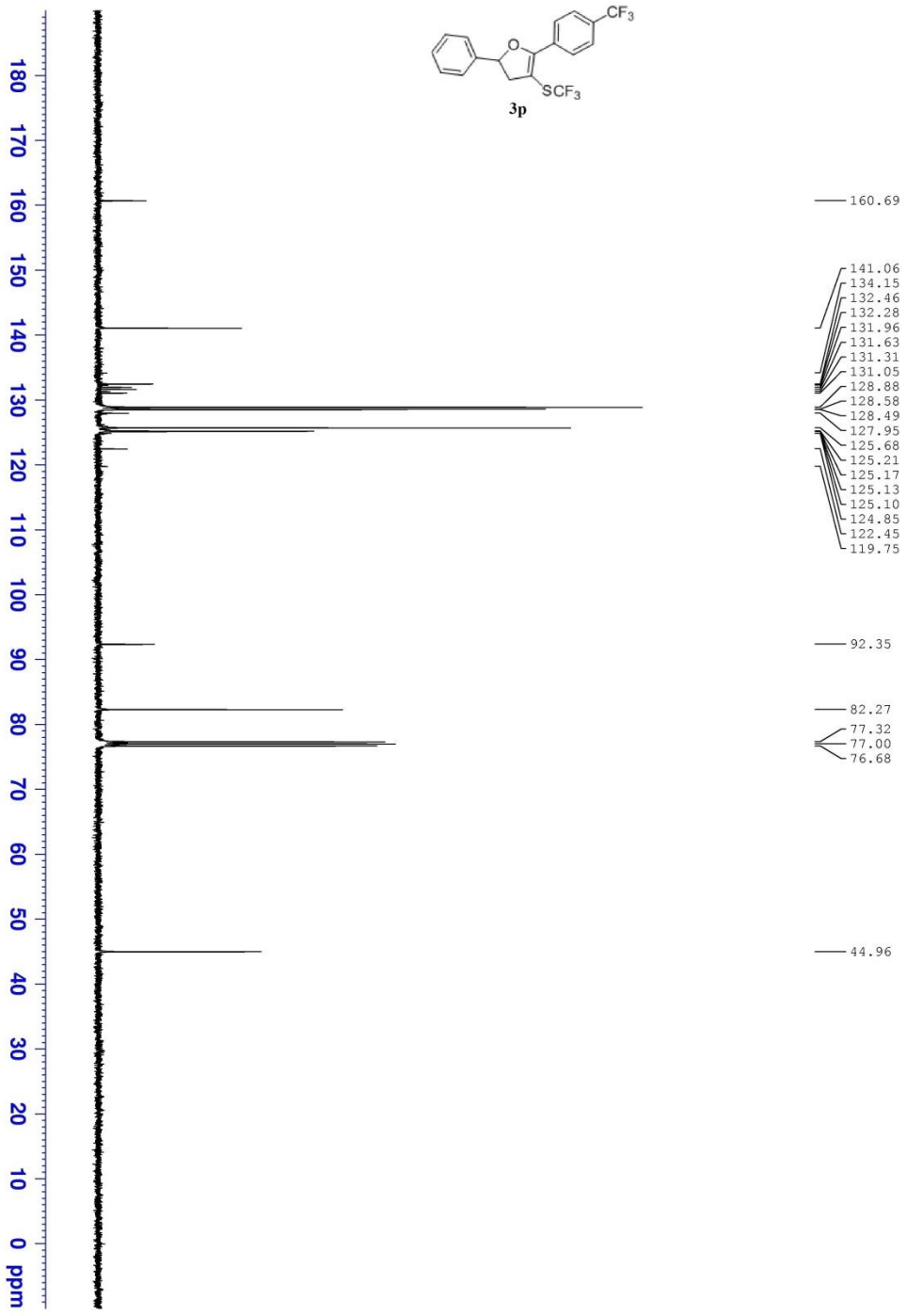
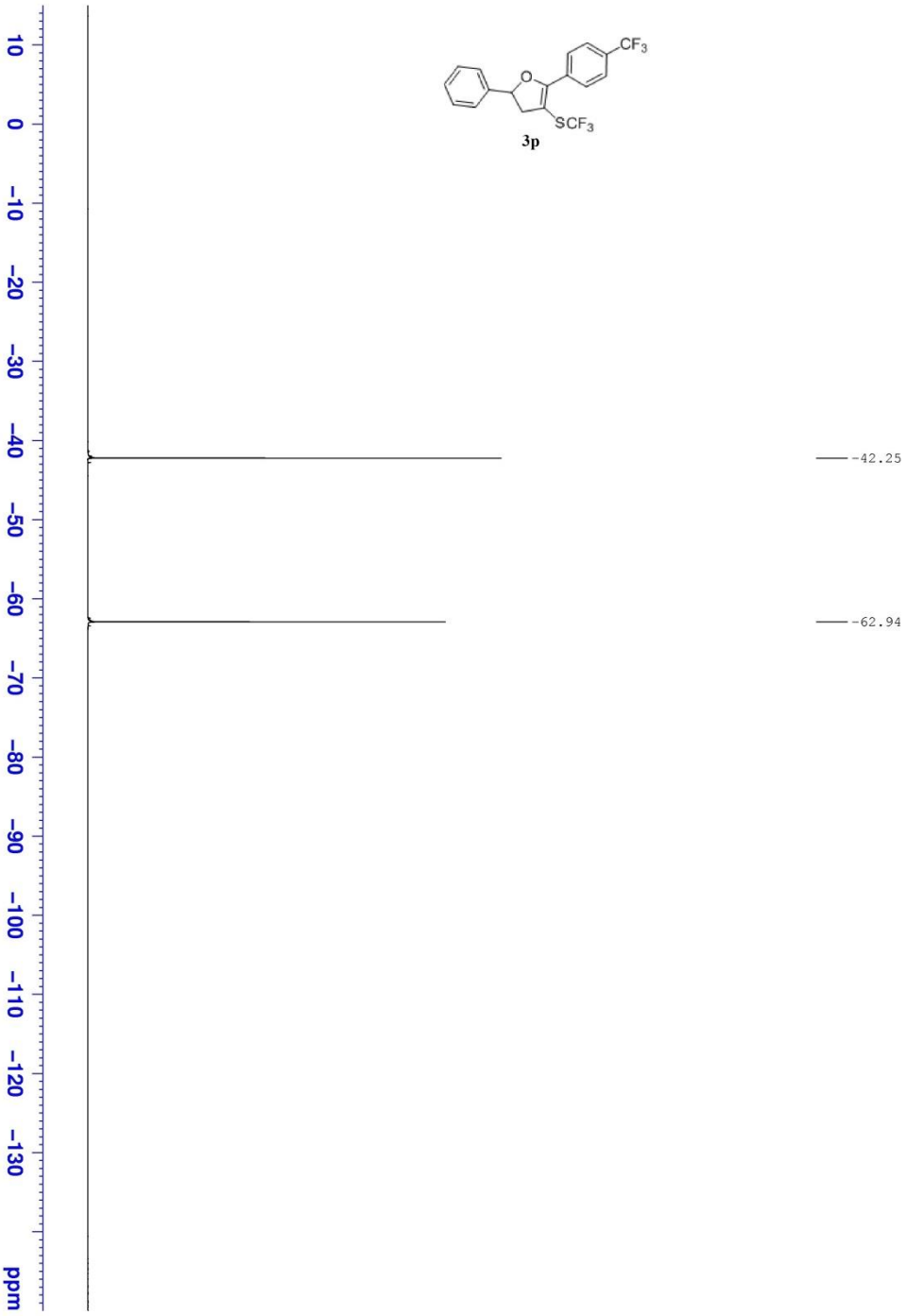
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

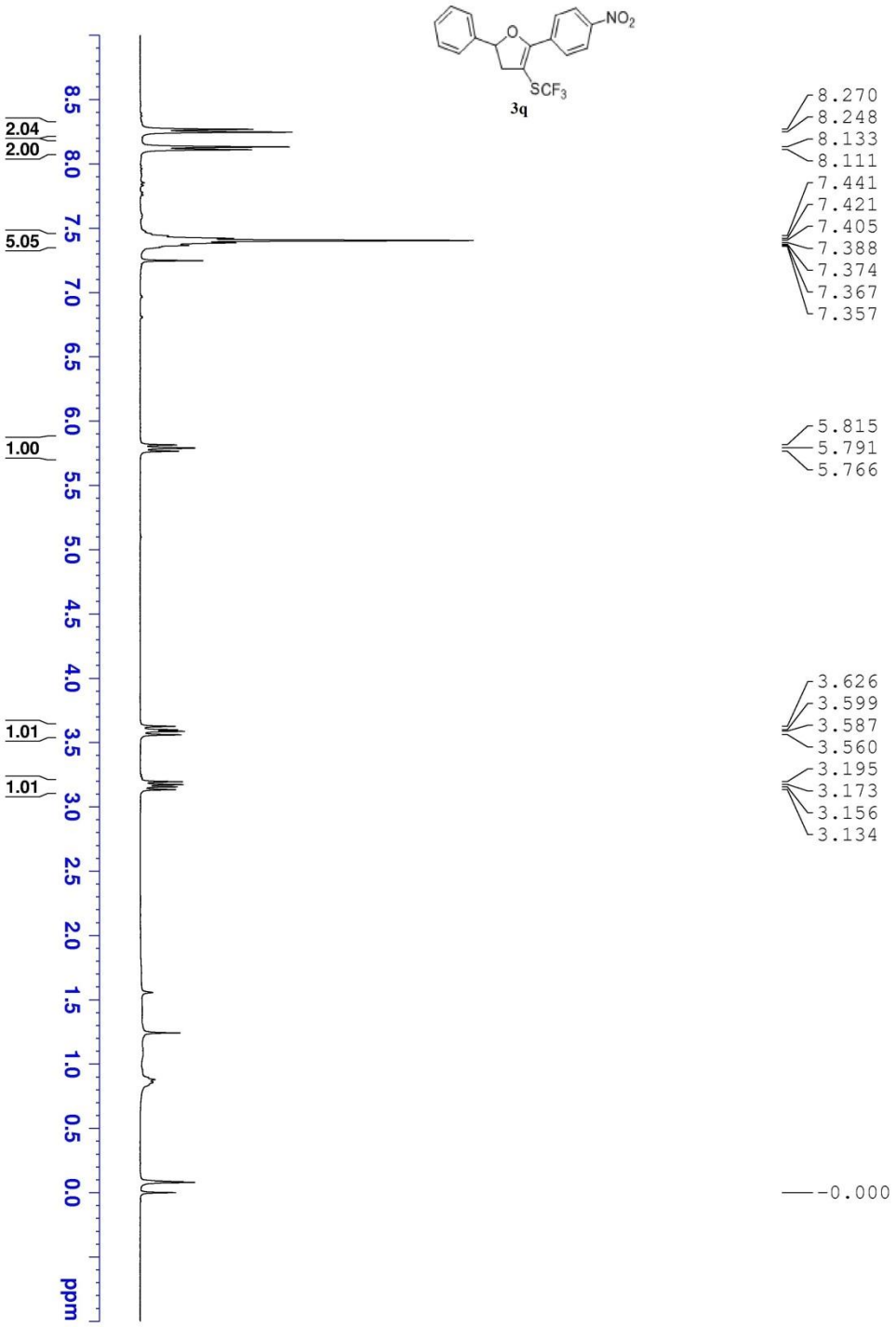

COOMe
O
SCF3
3o
-42.23
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
ppm

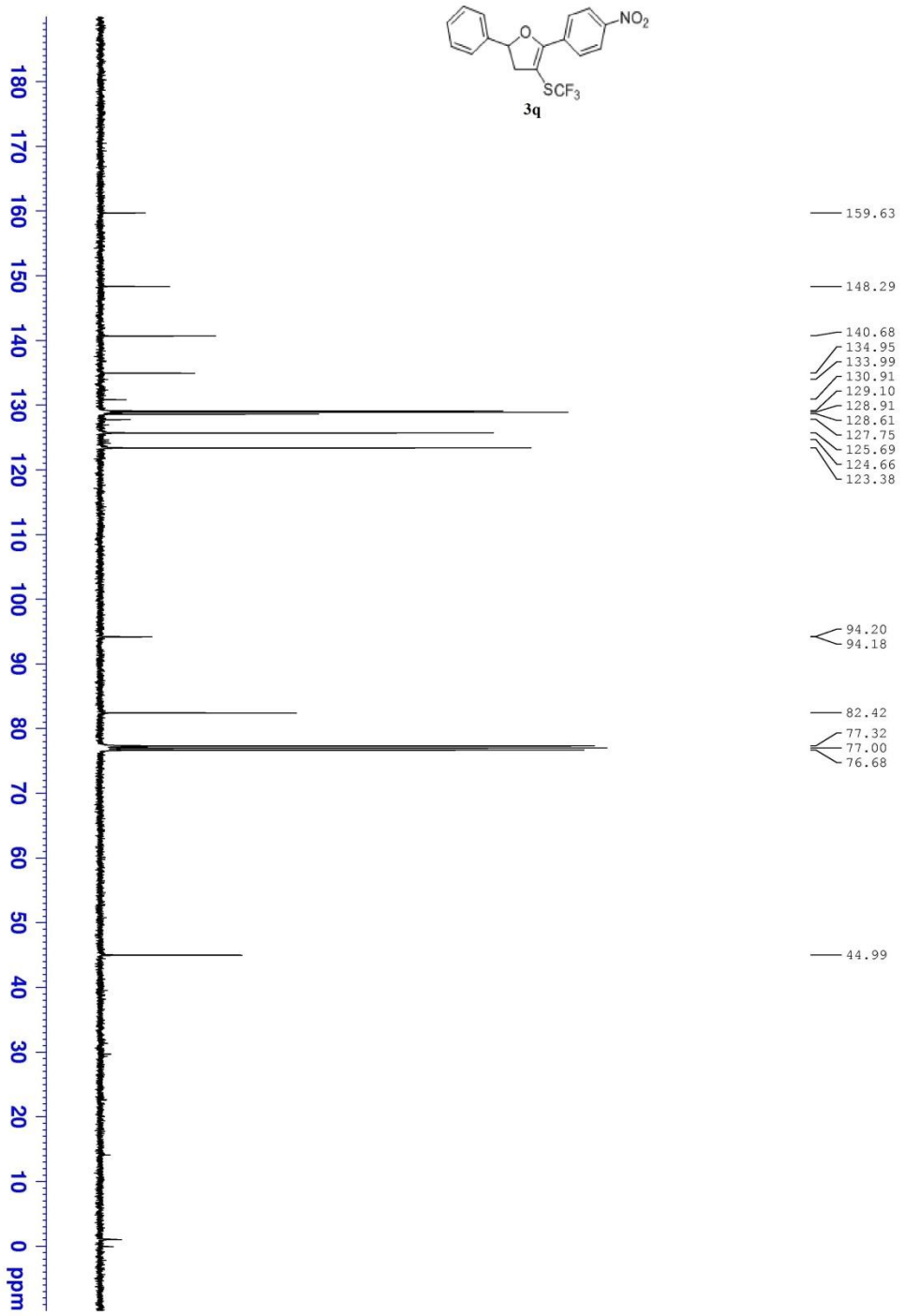

CF3
SCF3
3p
8.060
8.040
7.673
7.652
7.425
7.401
7.392
7.380
7.367
7.361
7.357
7.349
7.346
7.332
5.783
5.761
5.757
5.734
3.596
3.570
3.558
3.531
3.158
3.136
3.120
3.098
0.000
2.00
2.00
5.04
1.01
1.06
1.04
ppm

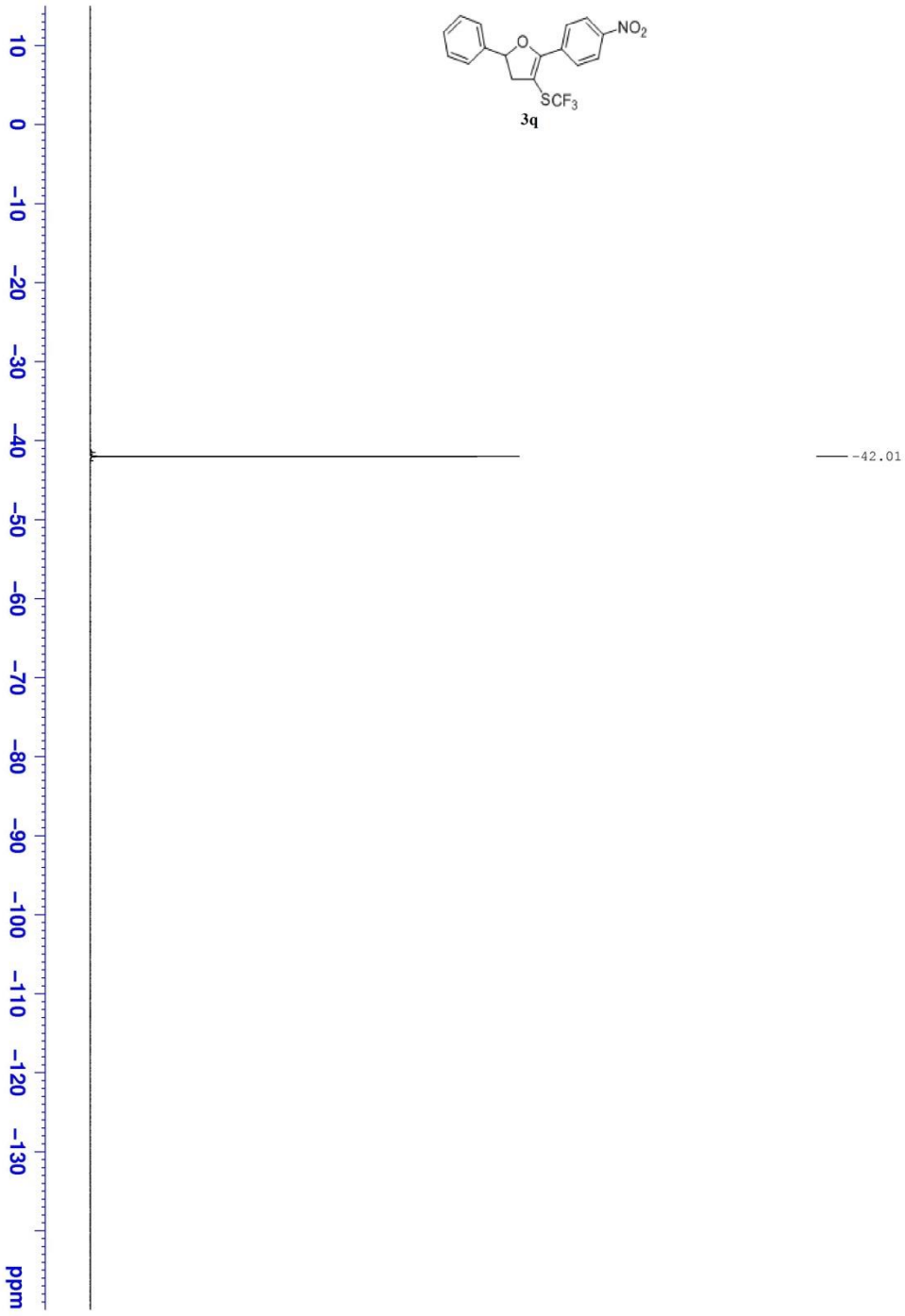

CF3
O
SCF3
3p
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0 ppm
160.69
141.06
134.15
132.46
132.28
131.96
131.63
131.31
131.05
128.88
128.58
128.49
127.95
125.68
125.21
125.17
125.13
125.10
124.85
122.45
119.75
92.35
82.27
77.32
77.00
76.68
44.96


10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
ppm
-42.25
-62.94
CF3
O
SCF3

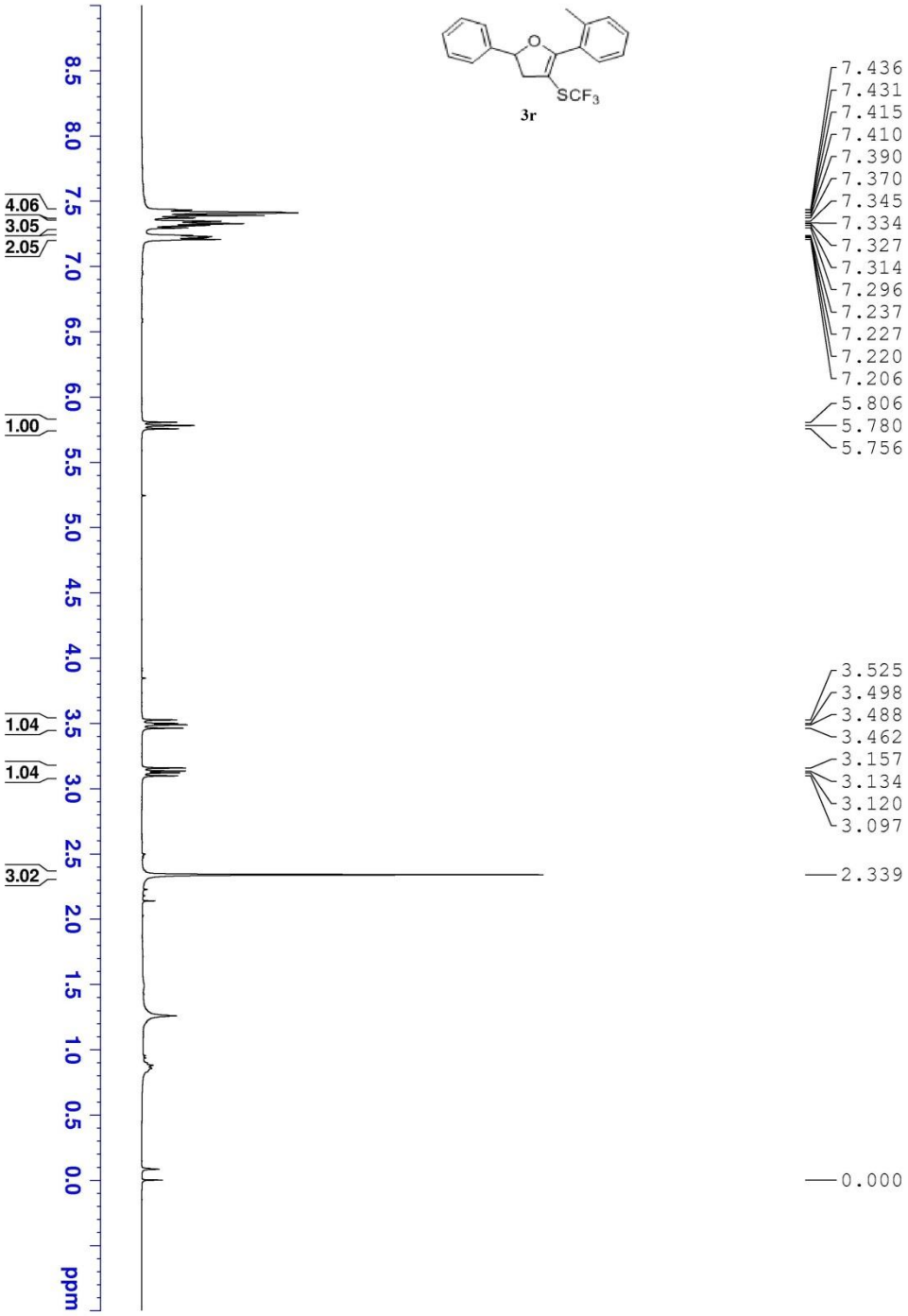
3p

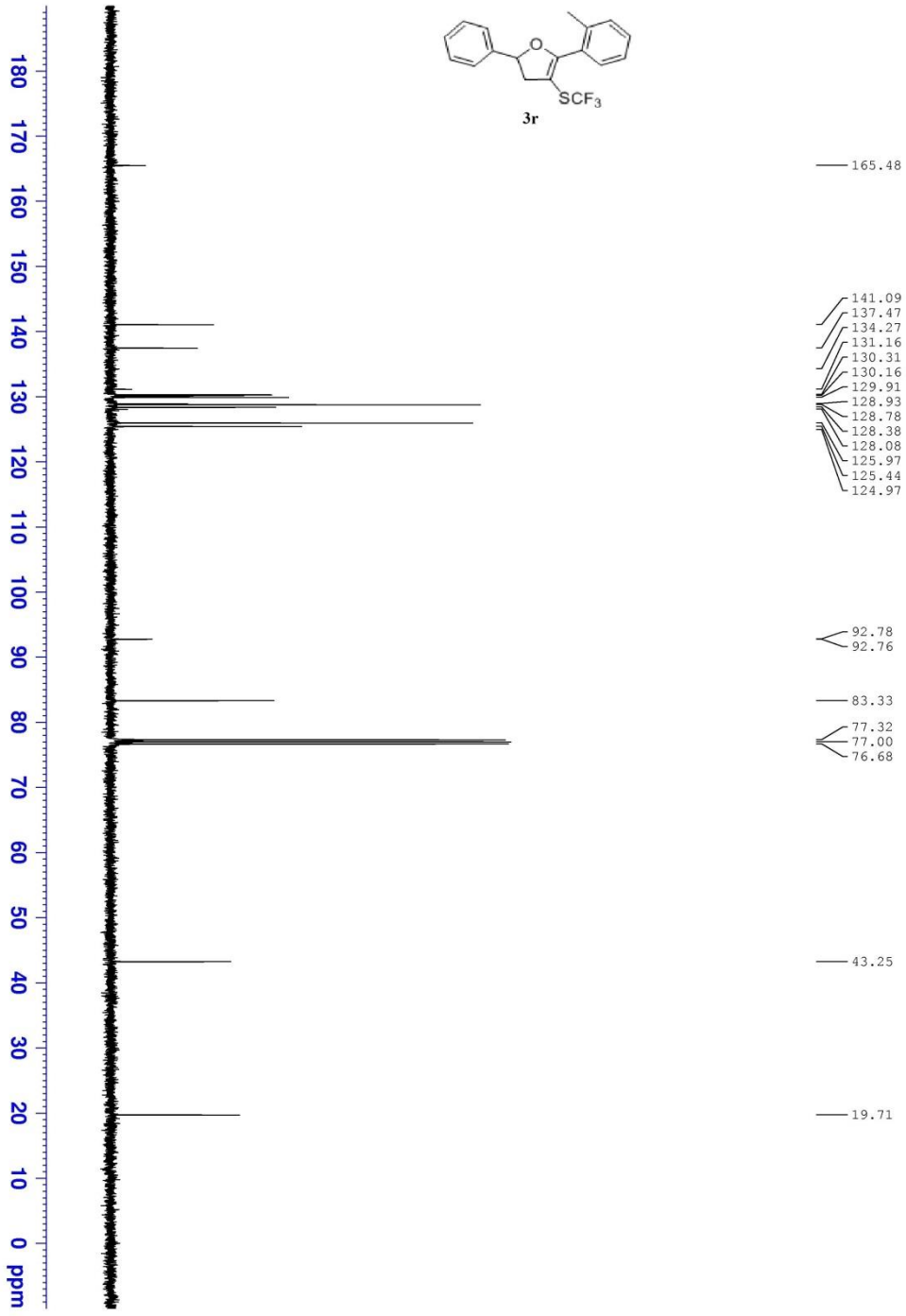

NO2
O
SCF3
3q
8.270
8.248
8.133
8.111
7.441
7.421
7.405
7.388
7.374
7.367
7.357
5.815
5.791
5.766
3.626
3.599
3.587
3.560
3.195
3.173
3.156
3.134
-0.000
2.04
2.00
5.05
1.00
1.01
1.01
ppm


NO2
O
SCF3
3q
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm
159.63
148.29
140.68
134.95
133.99
130.91
129.10
128.91
128.61
127.75
125.69
124.66
123.38
94.20
94.18
82.42
77.32
77.00
76.68
44.99



3q


SCF3
3r
7.436
7.431
7.415
7.410
7.390
7.370
7.345
7.334
7.327
7.314
7.296
7.237
7.227
7.220
7.206
5.806
5.780
5.756
3.525
3.498
3.488
3.462
3.157
3.134
3.120
3.097
2.339
0.000
4.06
3.05
2.05
1.00
1.04
1.04
3.02
ppm


SCF3
3r
165.48
141.09
137.47
134.27
131.16
130.31
130.16
129.91
128.93
128.78
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128.08
125.97
125.44
124.97
92.78
92.76
83.33
77.32
77.00
76.68
43.25
19.71
180
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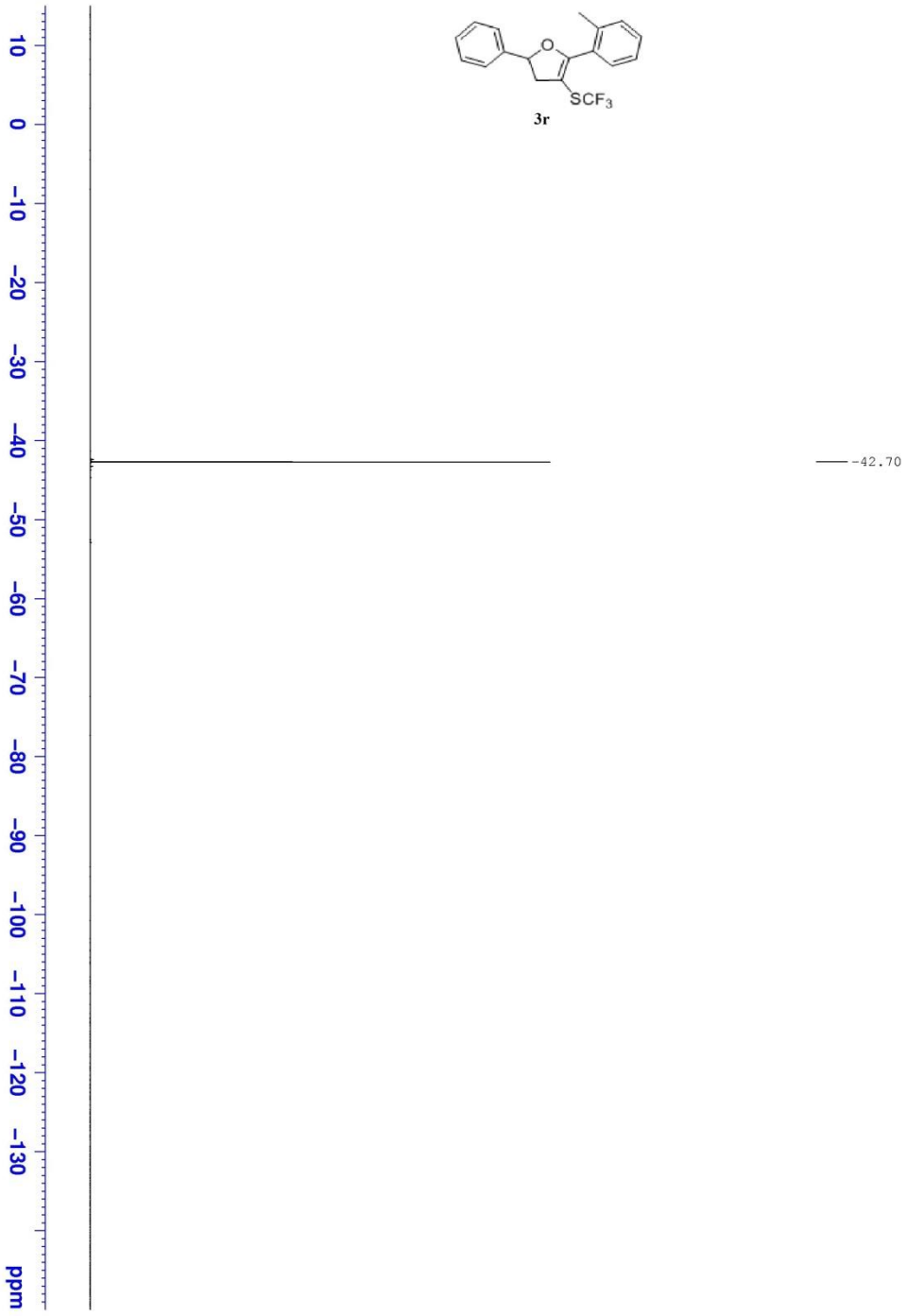
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm


SCF3
3r
-42.70
10
0
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-30
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-50
-60
-70
-80
-90
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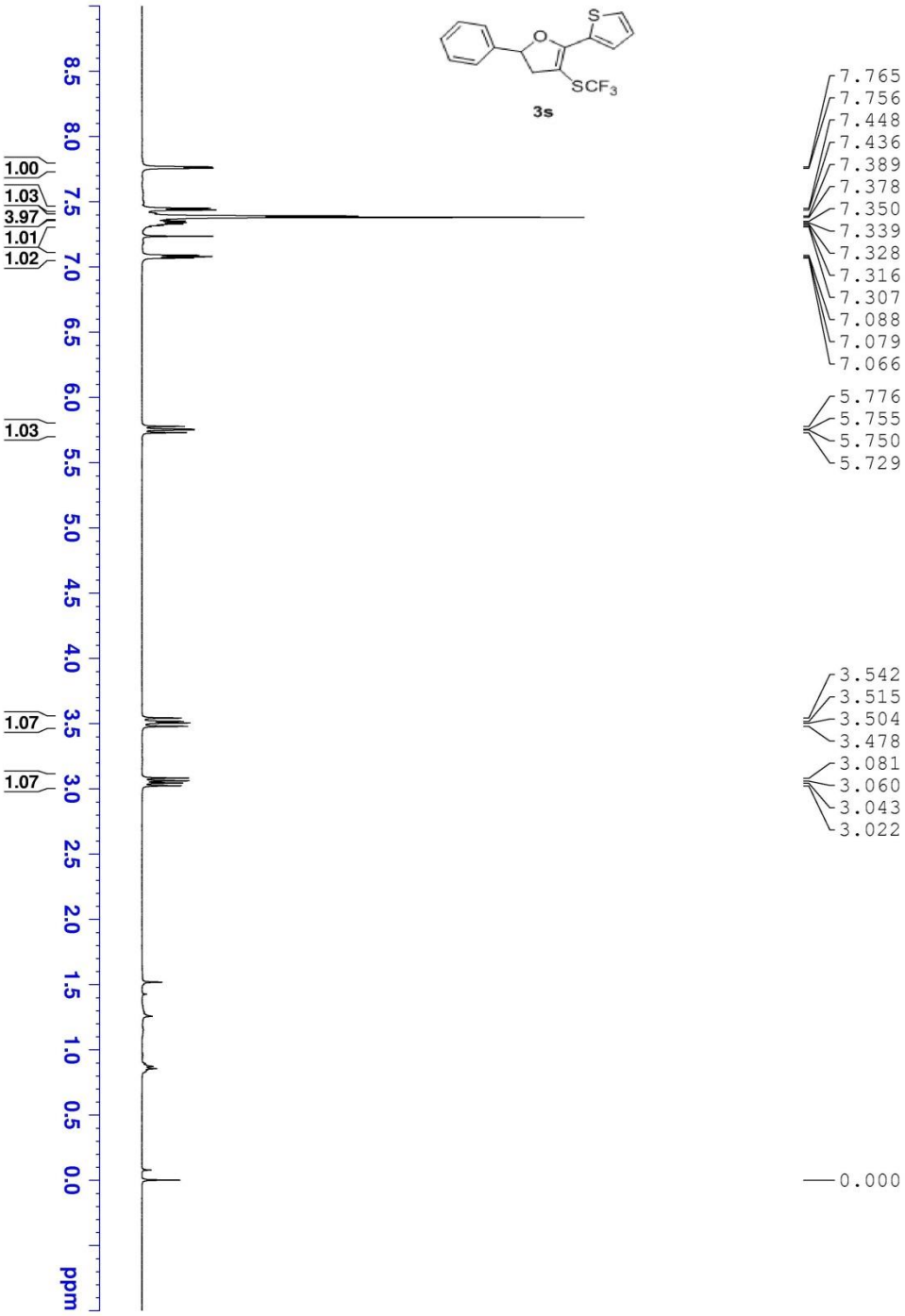
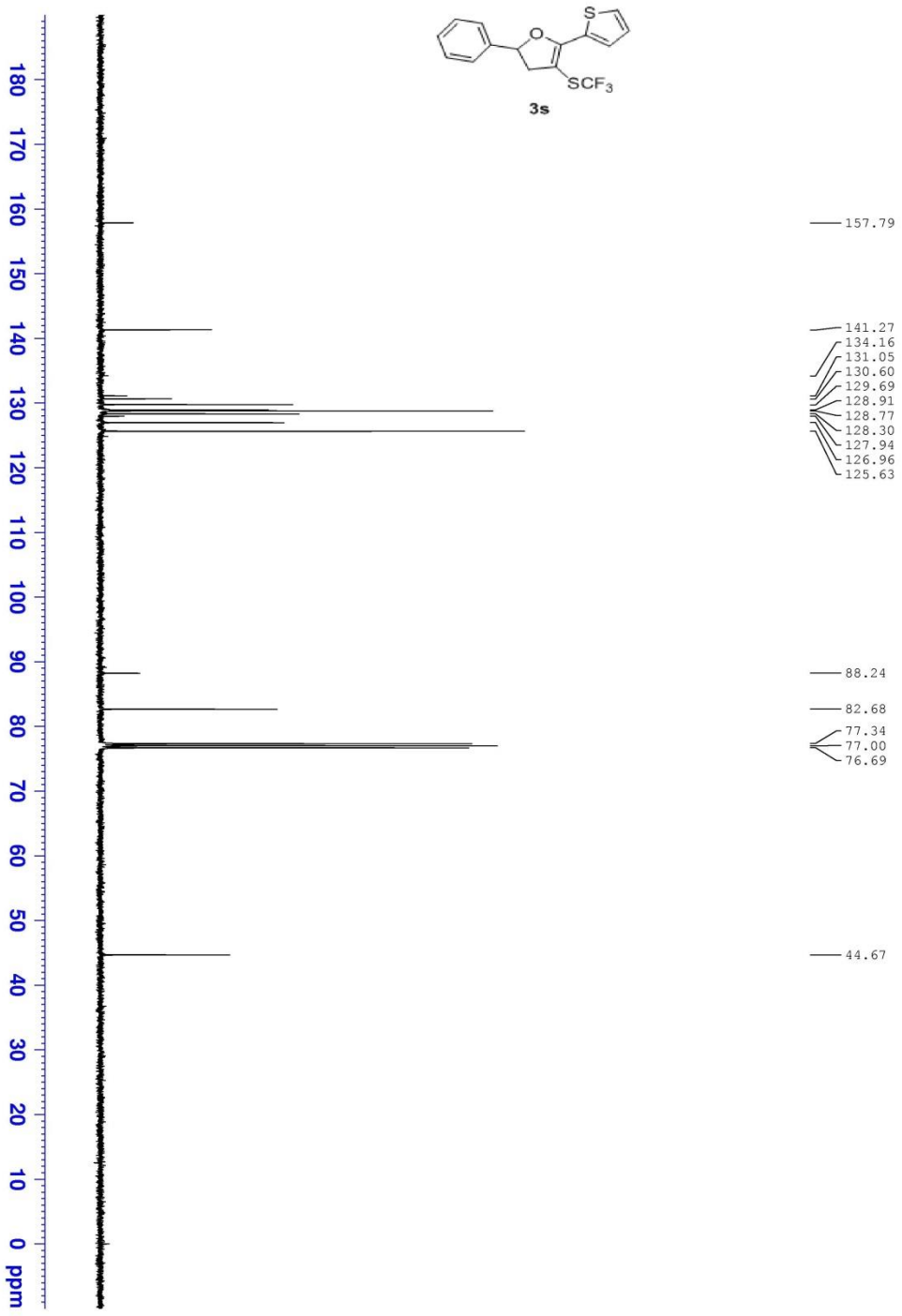
-120
-130
ppm


3s
1.00
1.03
3.97
1.01
1.02
1.03
1.07
1.07
7.765
7.756
7.448
7.436
7.389
7.378
7.350
7.339
7.328
7.316
7.307
7.088
7.079
7.066
5.776
5.755
5.750
5.729
3.542
3.515
3.504
3.478
3.081
3.060
3.043
3.022
0.000
ppm


S
O
SCF3
3s
157.79
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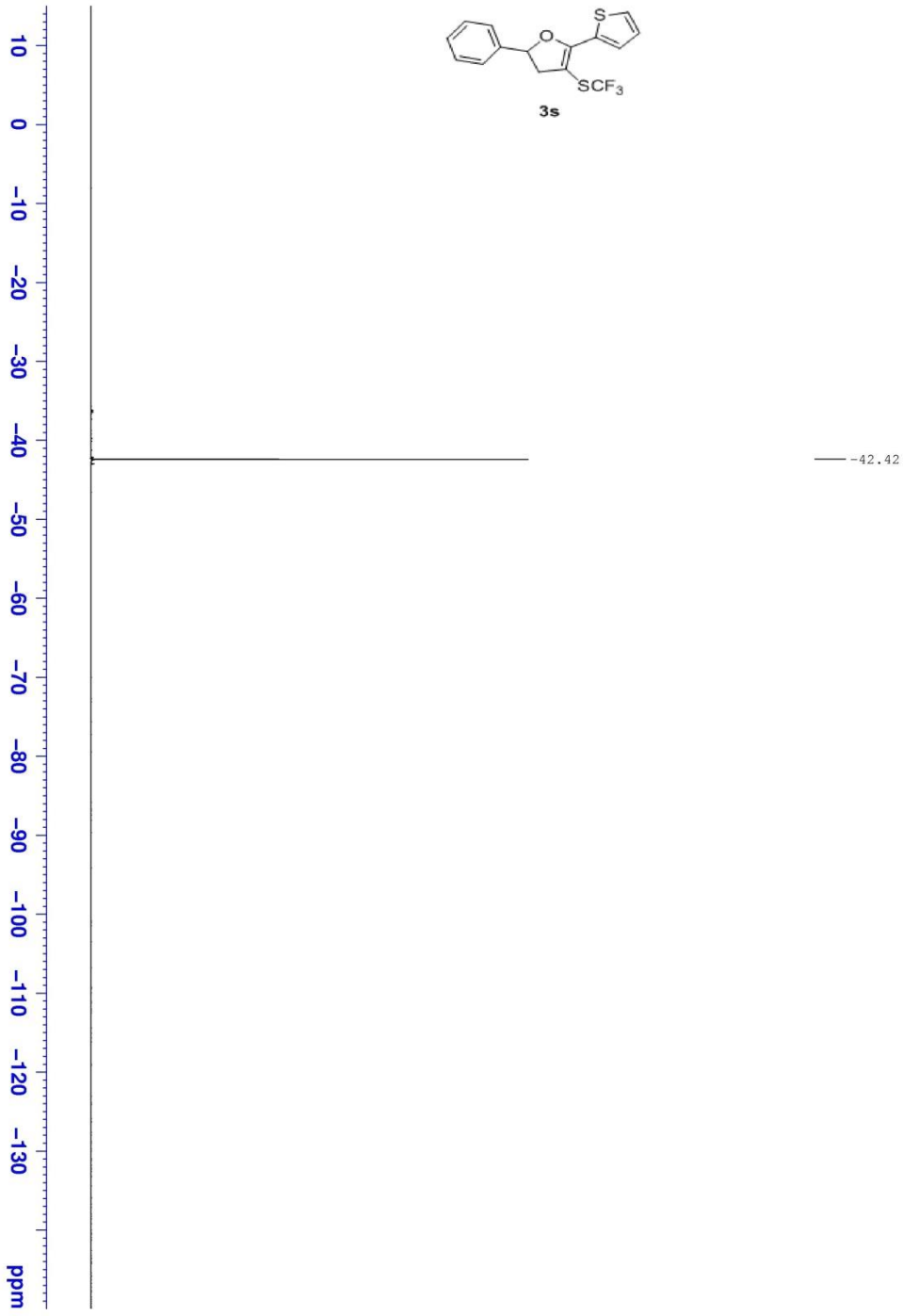
134.16
131.05
130.60
129.69
128.91
128.77
128.30
127.94
126.96
125.63
88.24
82.68
77.34
77.00
76.69
44.67
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0 ppm


S
O
SCF3
3s
-42.42
10
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-20
-30
-40
-50
-60
-70
-80
-90
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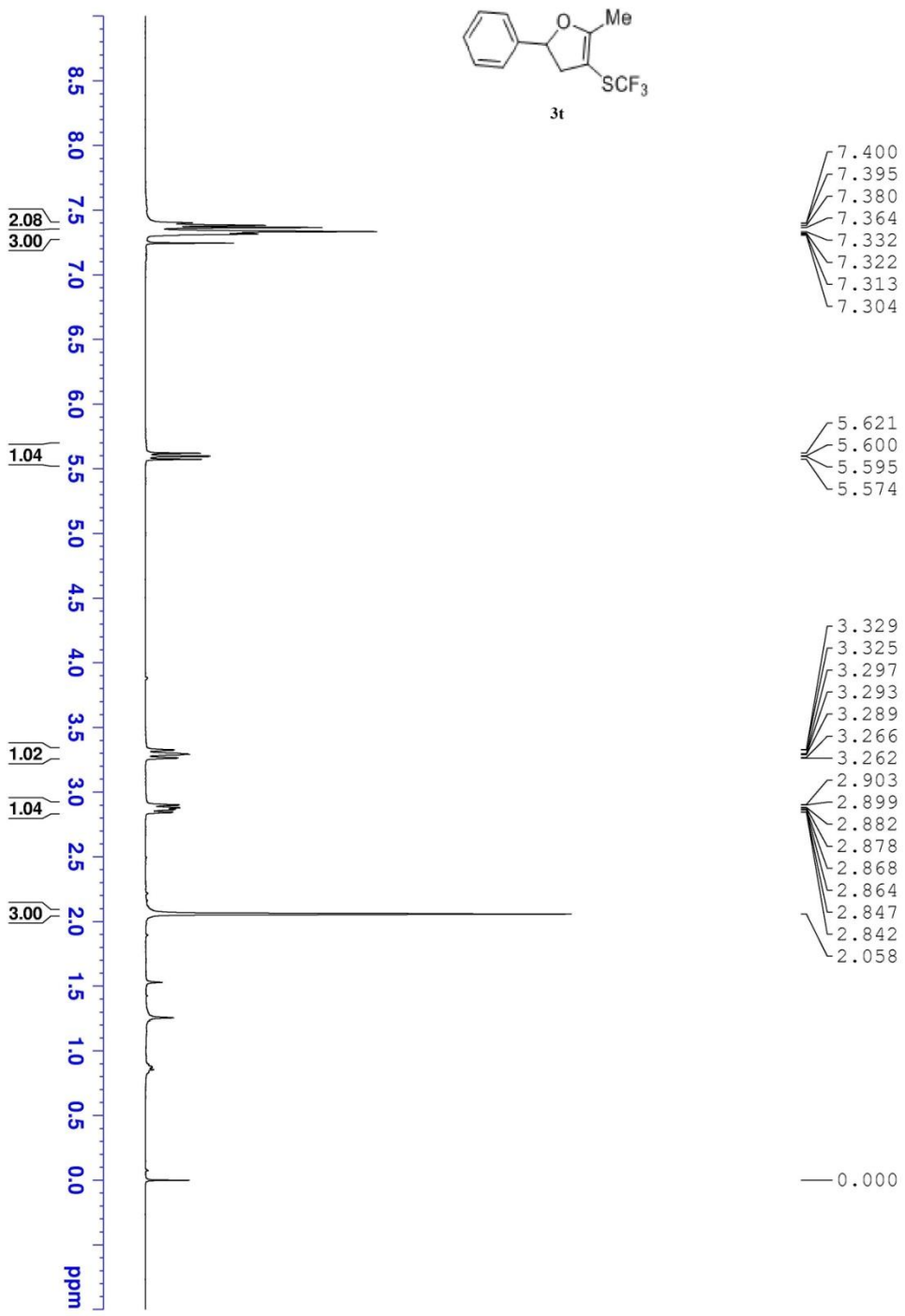
-110
-120
-130
ppm


Me
O
SCF3
3t
7.400
7.395
7.380
7.364
7.332
7.322
7.313
7.304
5.621
5.600
5.595
5.574
3.329
3.325
3.297
3.293
3.289
3.266
3.262
2.903
2.899
2.882
2.878
2.868
2.864
2.847
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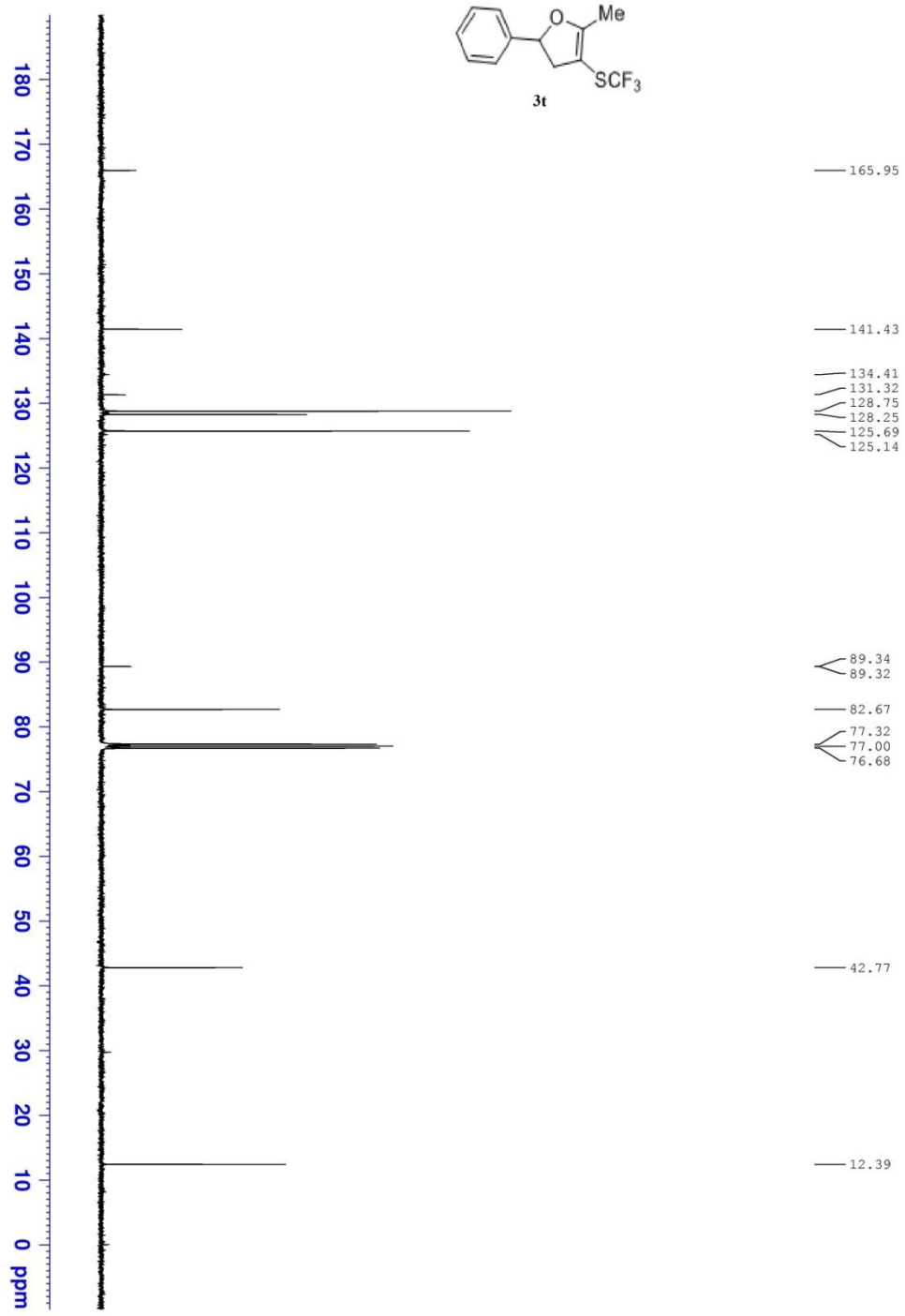
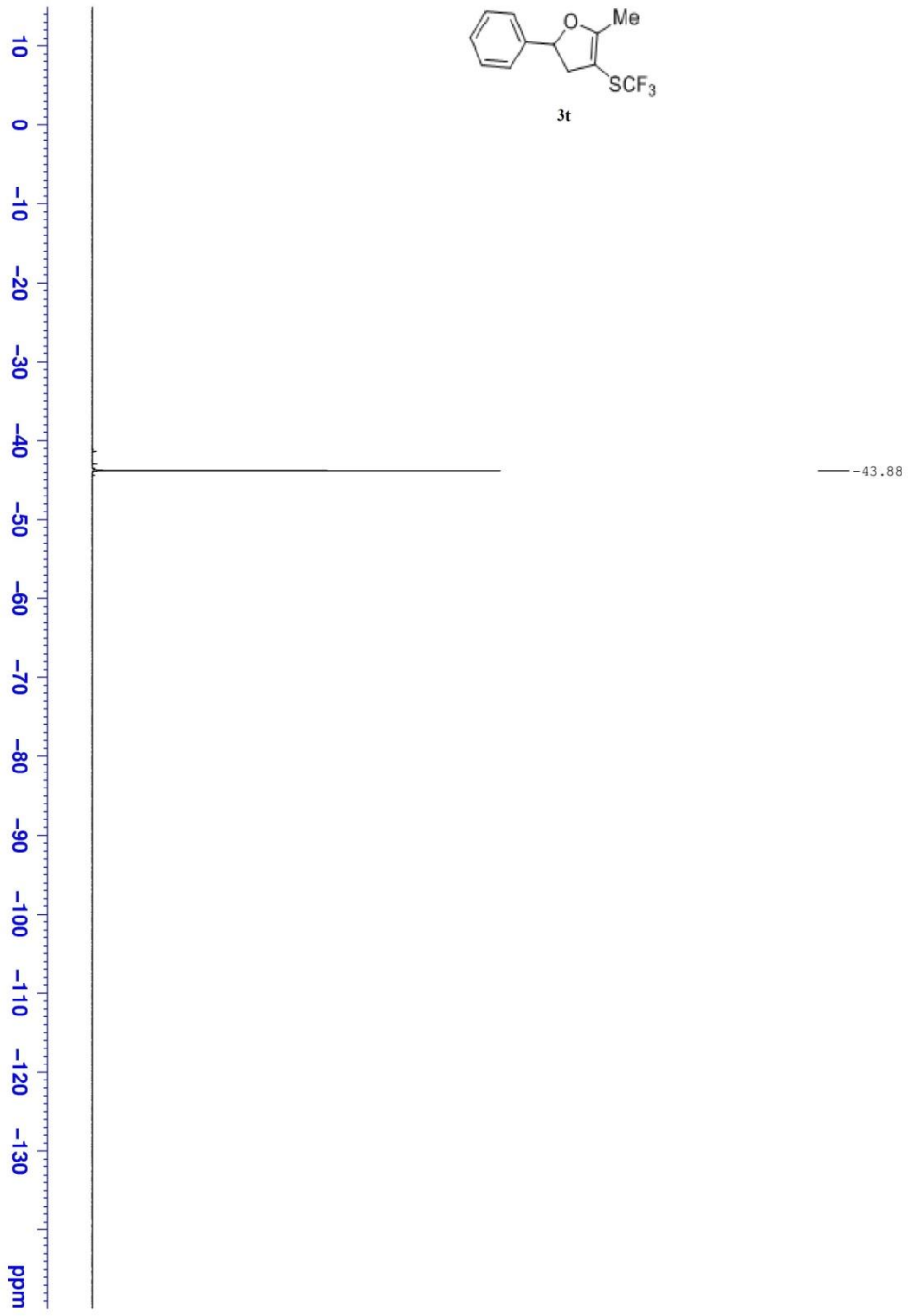
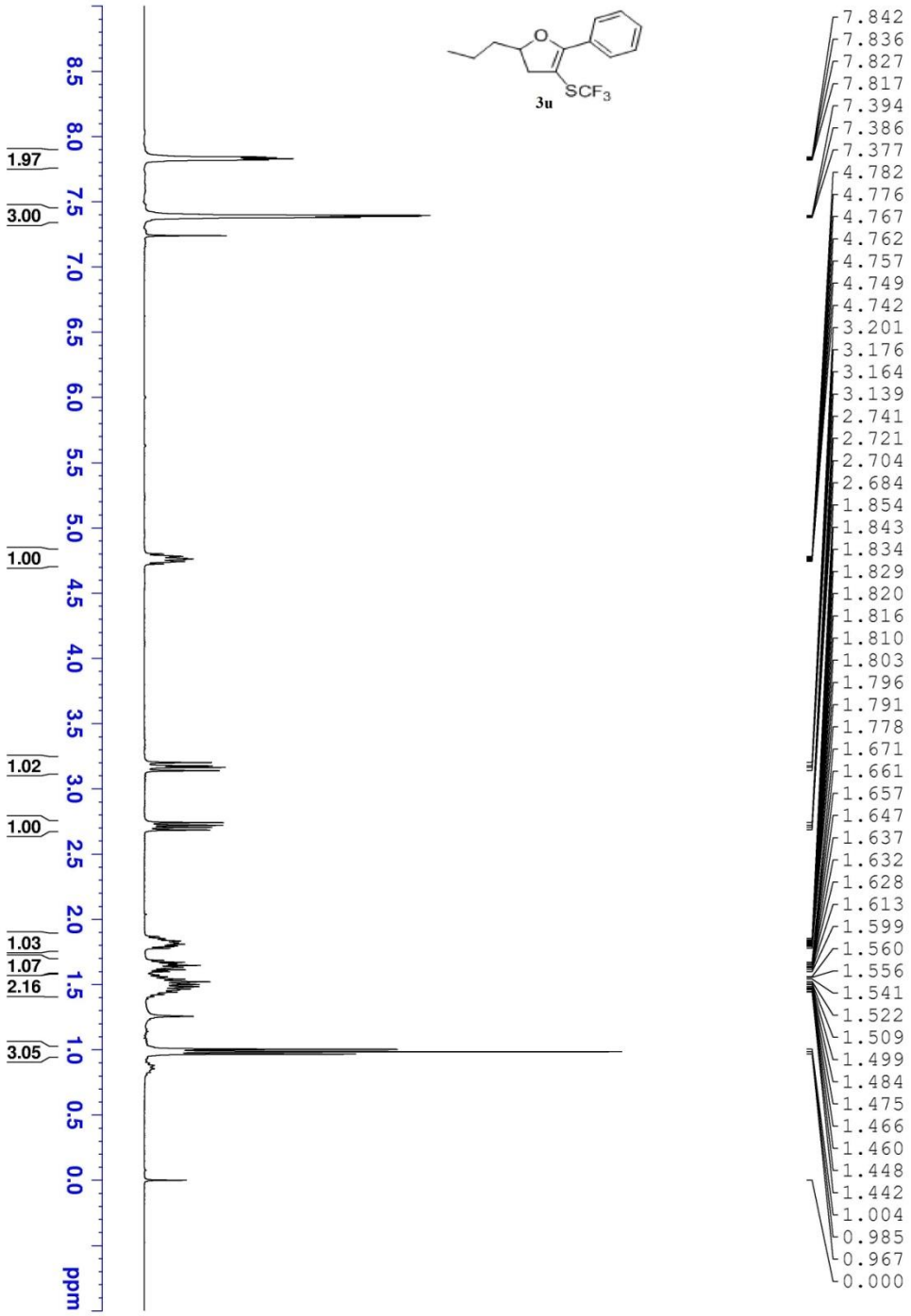
2.058
0.000
2.08
3.00
1.04
1.02
1.04
3.00
ppm

3u


Me
O
SCF3
3t
165.95
141.43
134.41
131.32
128.75
128.25
125.69
125.14
89.34
89.32
82.67
77.32
77.00
76.68
42.77
12.39
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0 ppm


Me
O
SCF3
3t
-43.88
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
ppm


3u
SCF3
1.97
3.00
1.00
1.02
1.00
1.03
1.07
2.16
3.05
ppm
7.842
7.836
7.827
7.817
7.394
7.386
7.377
4.782
4.776
4.767
4.762
4.757
4.749
4.742
3.201
3.176
3.164
3.139
2.741
2.721
2.704
2.684
1.854
1.843
1.834
1.829
1.820
1.816
1.810
1.803
1.796
1.791
1.778
1.671
1.661
1.657
1.647
1.637
1.632
1.628
1.613
1.599
1.560
1.556
1.541
1.522
1.509
1.499
1.484
1.475
1.466
1.460
1.448
1.442
1.004
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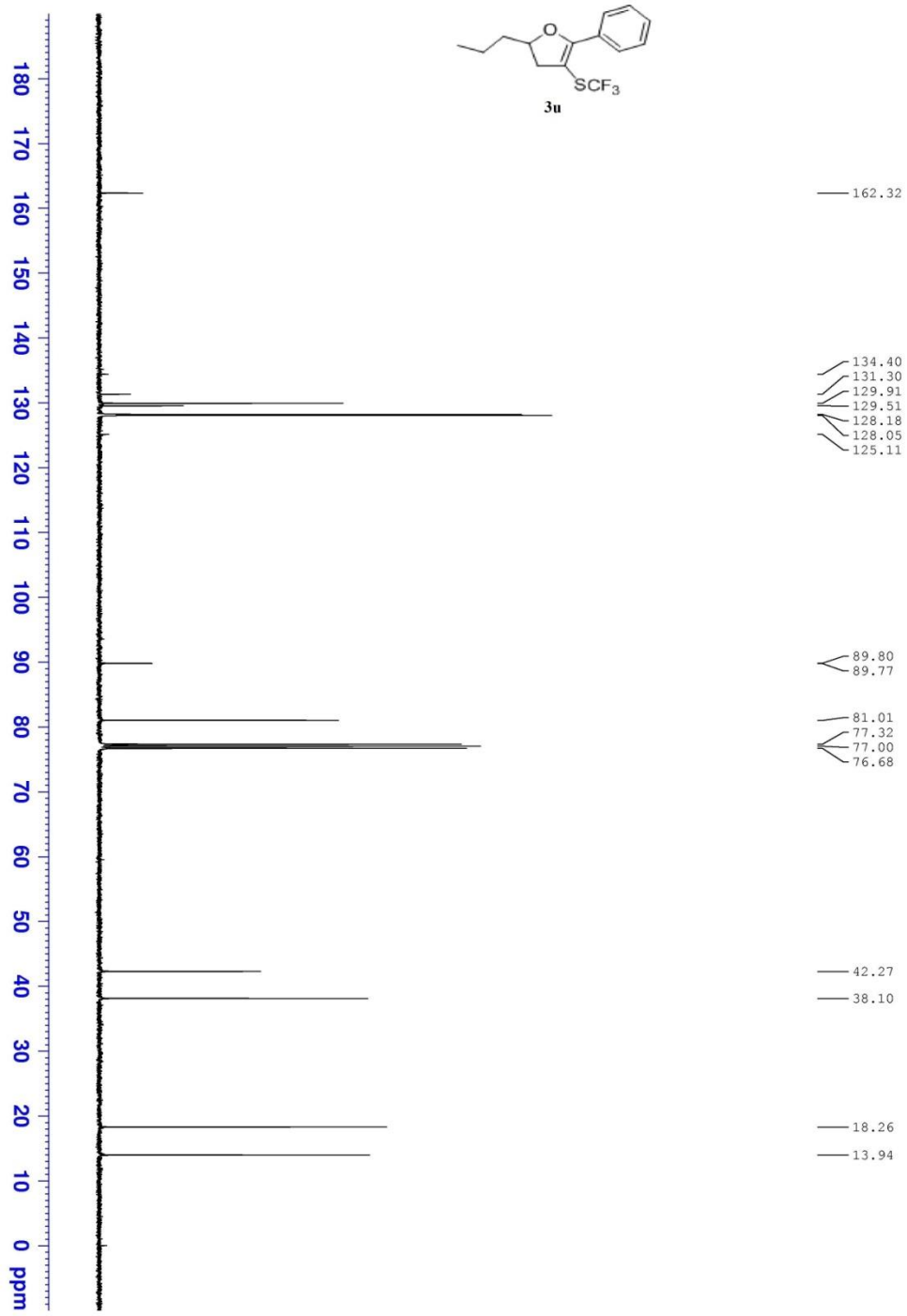
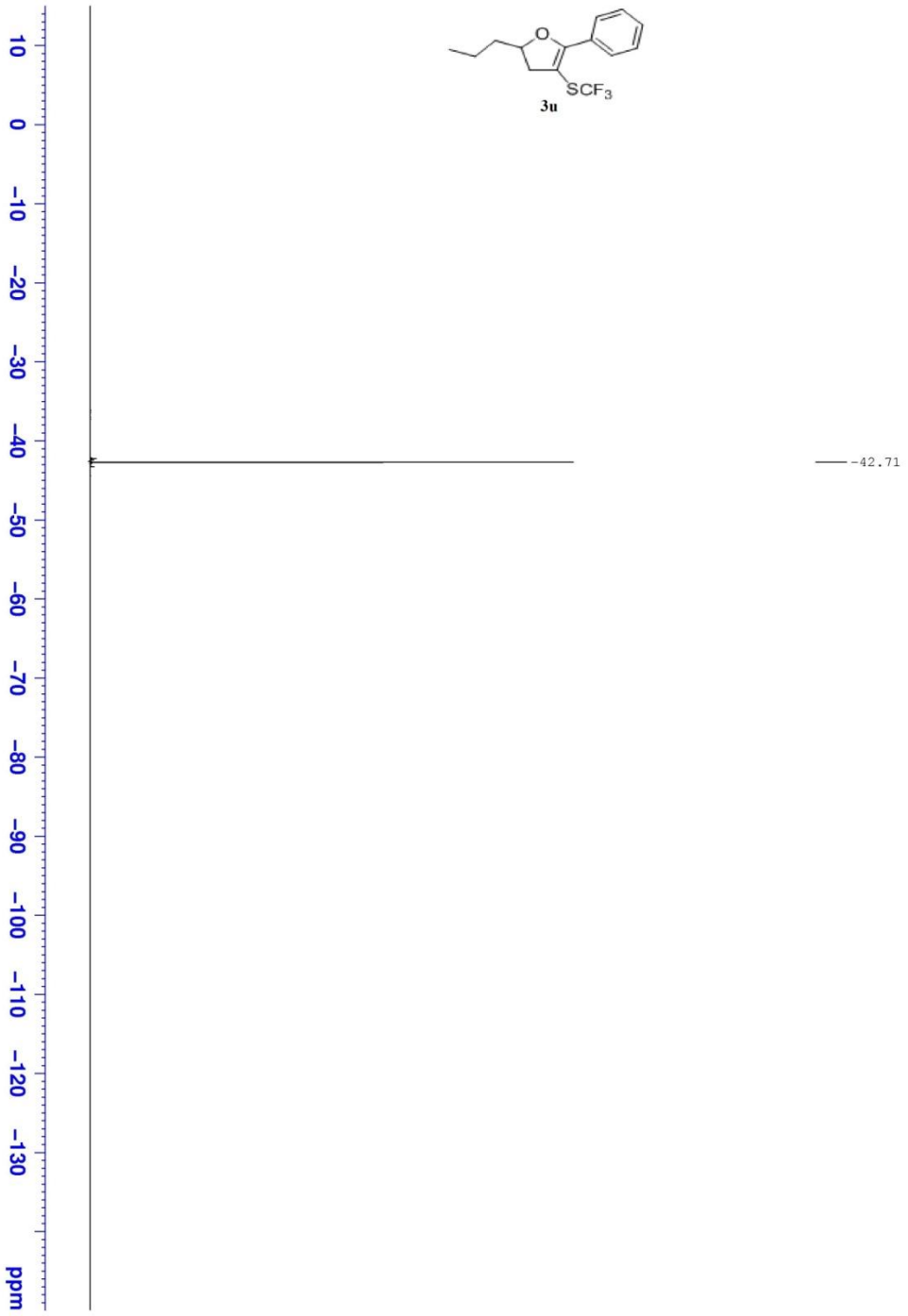
0.967
0.000


O
SCF3
3u
162.32
134.40
131.30
129.91
129.51
128.18
128.05
125.11
89.80
89.77
81.01
77.32
77.00
76.68
42.27
38.10
18.26
13.94
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm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0
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-20
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-50
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-70
-80
-90
-100
-110
-120
-130
ppm
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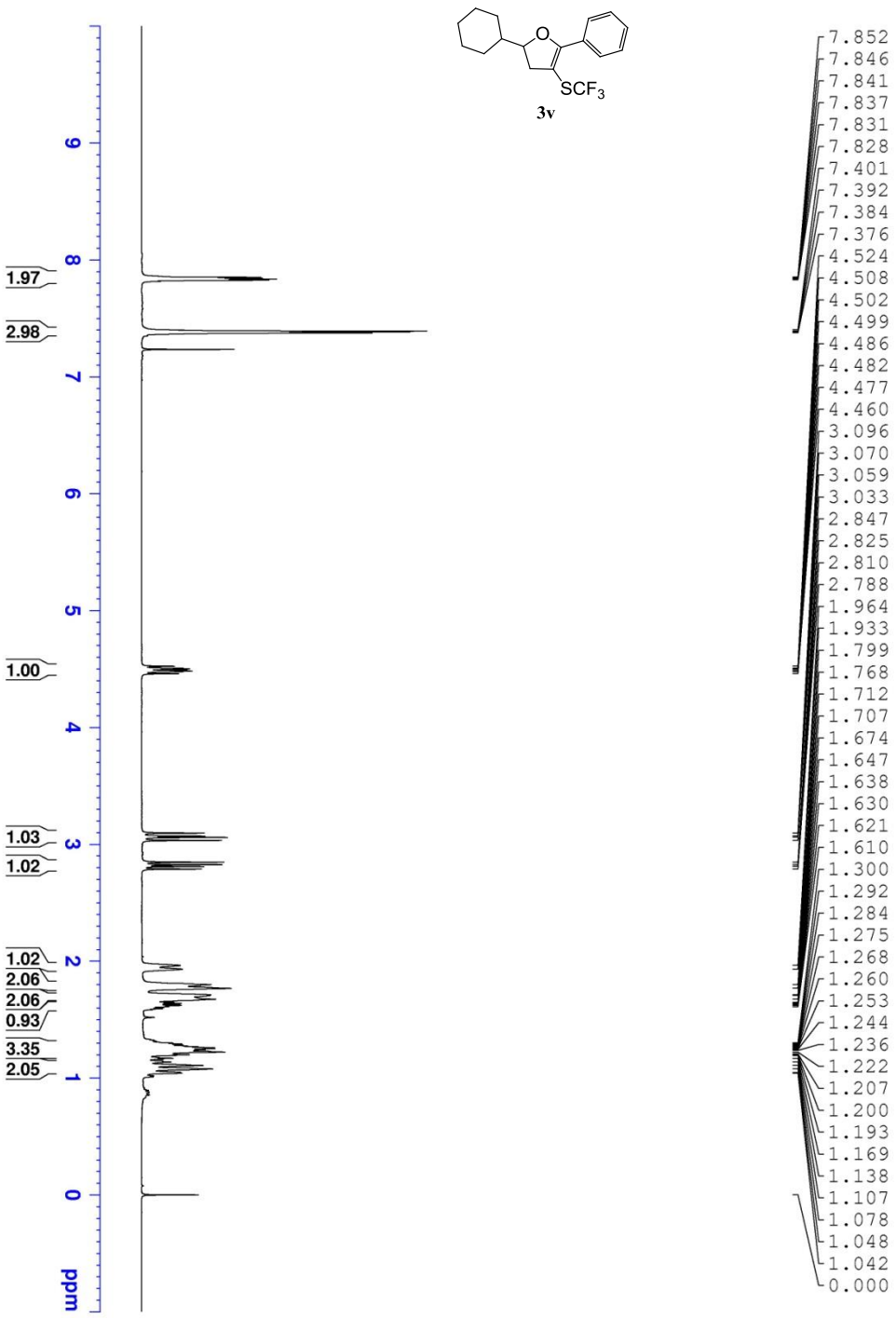
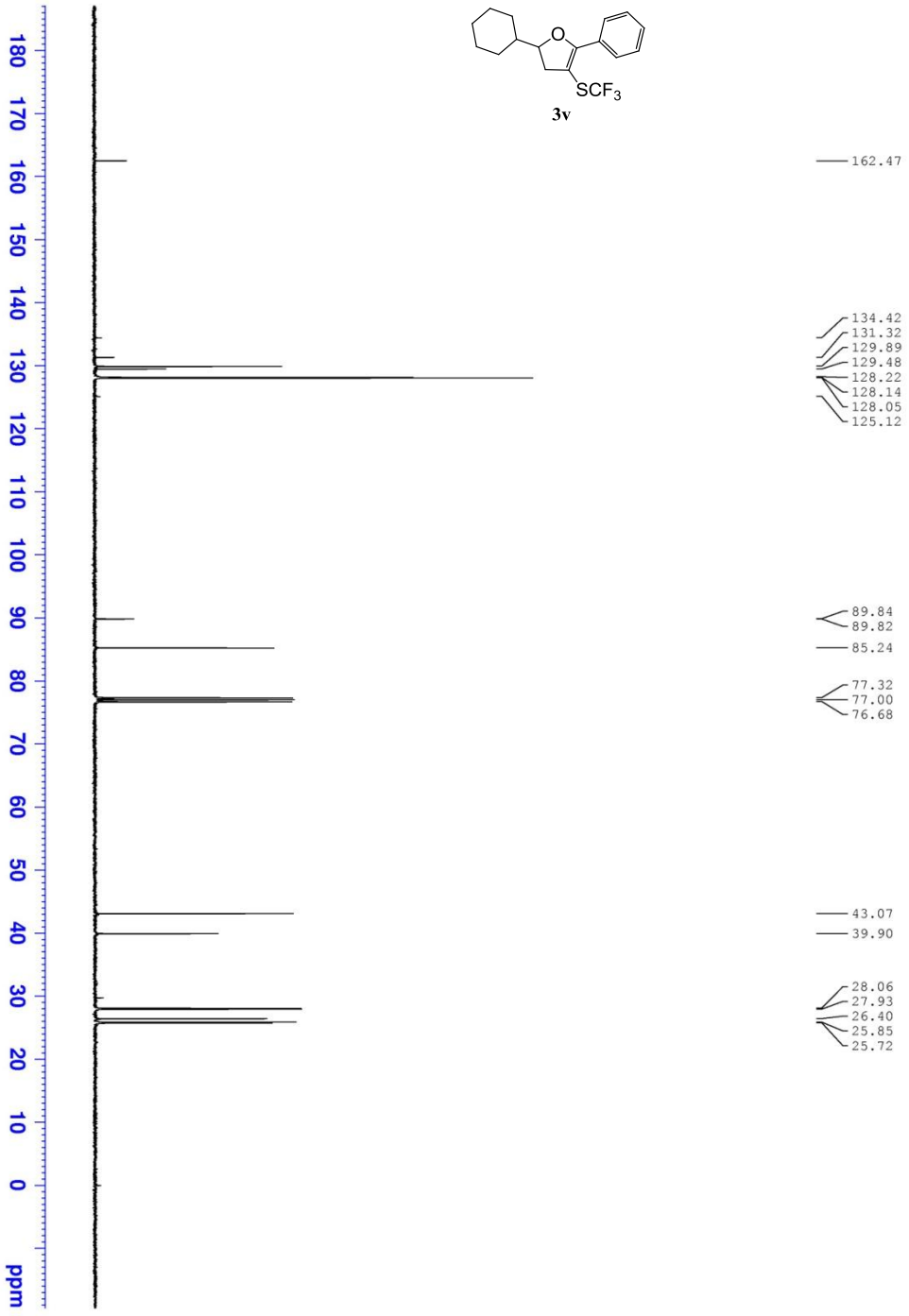
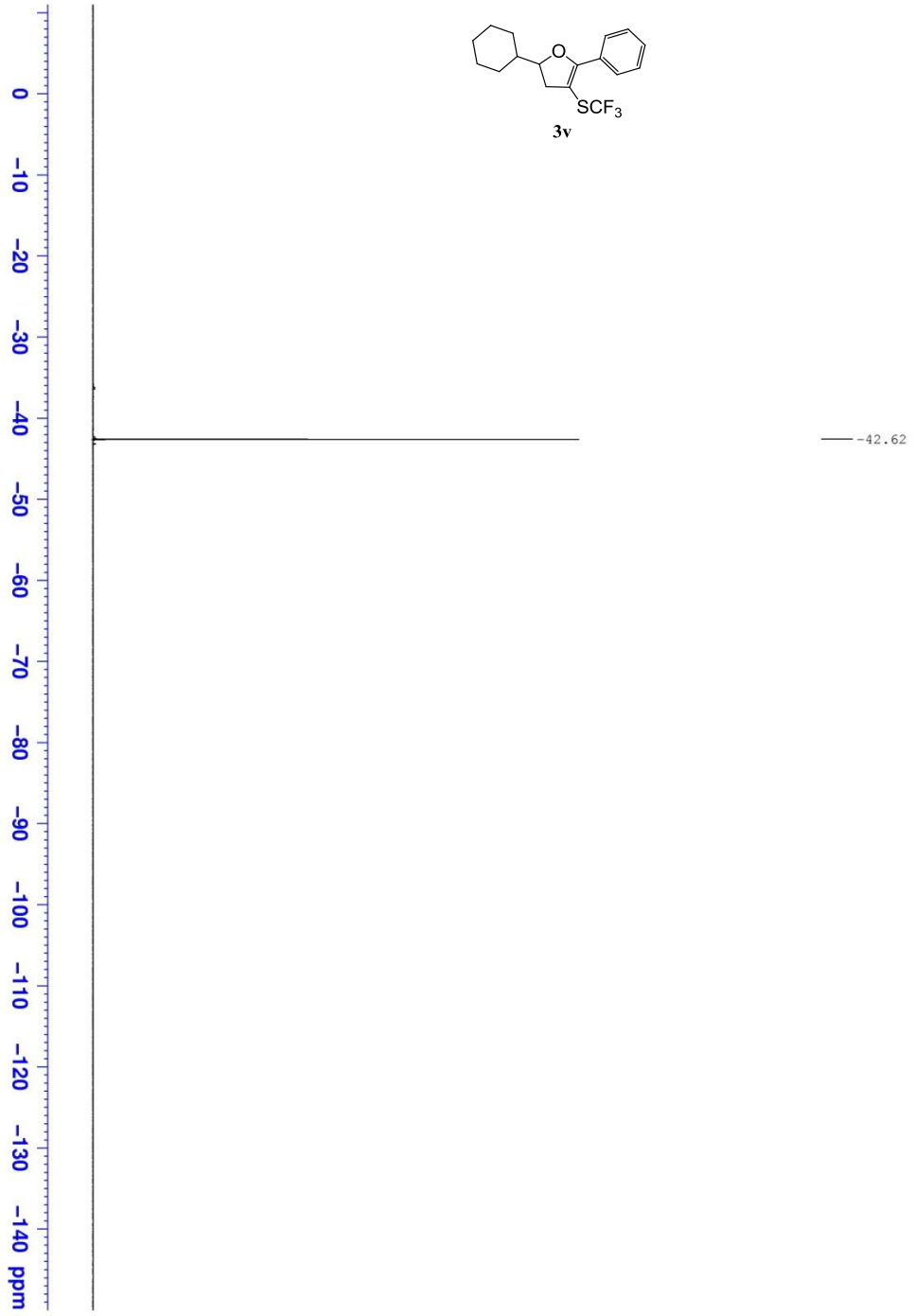
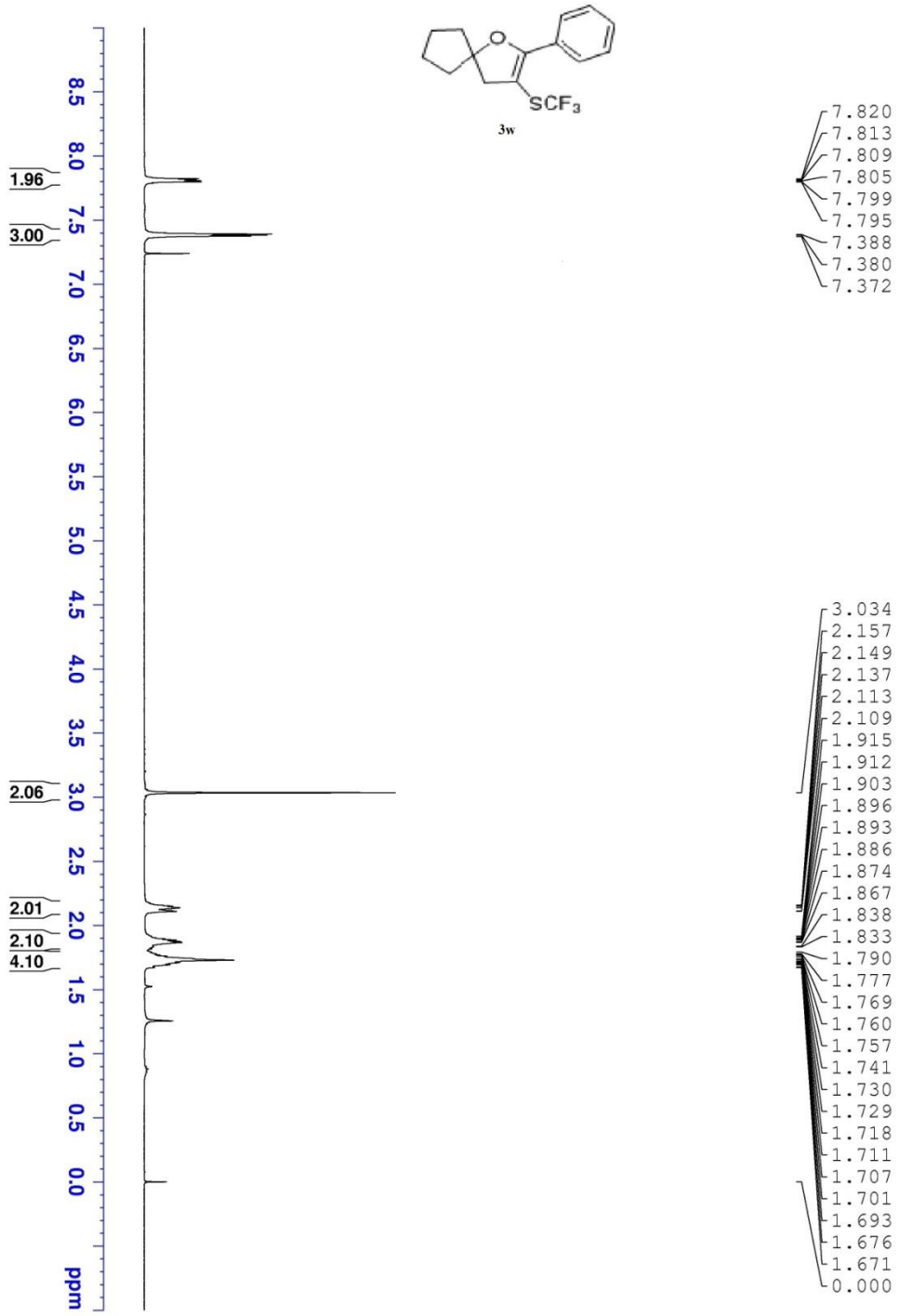
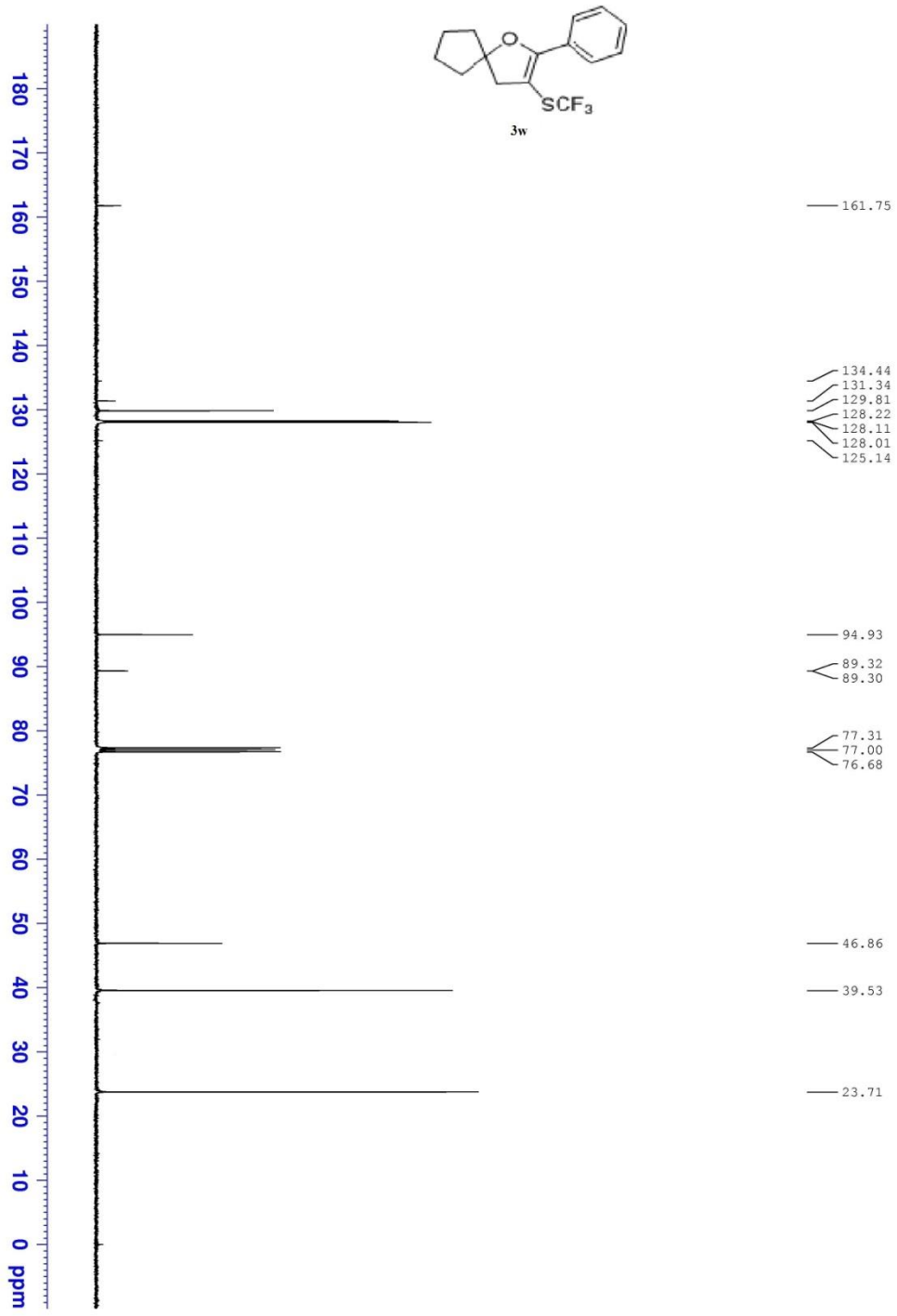
SCF3
3u

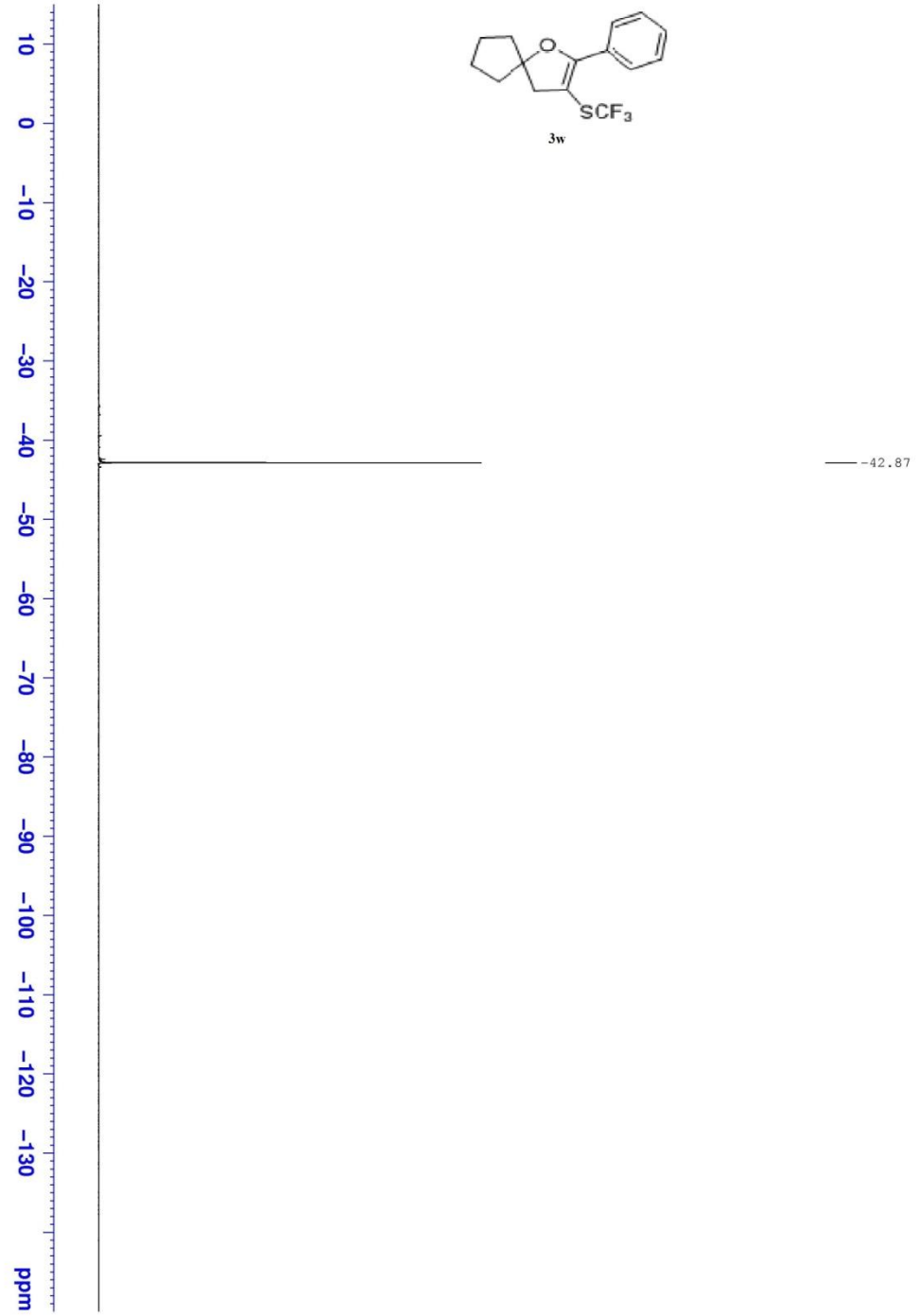

O
SCF3
3v
1.97
2.98
1.00
1.03
1.02
1.02
2.06
2.06
0.93
3.35
2.05
ppm
7.852
7.846
7.841
7.837
7.831
7.828
7.401
7.392
7.384
7.376
4.524
4.508
4.502
4.499
4.486
4.482
4.477
4.460
3.096
3.070
3.059
3.033
2.847
2.825
2.810
2.788
1.964
1.933
1.799
1.768
1.712
1.707
1.674
1.647
1.638
1.630
1.621
1.610
1.300
1.292
1.284
1.275
1.268
1.260
1.253
1.244
1.236
1.222
1.207
1.200
1.193
1.169
1.138
1.107
1.078
1.048
1.042
0.000

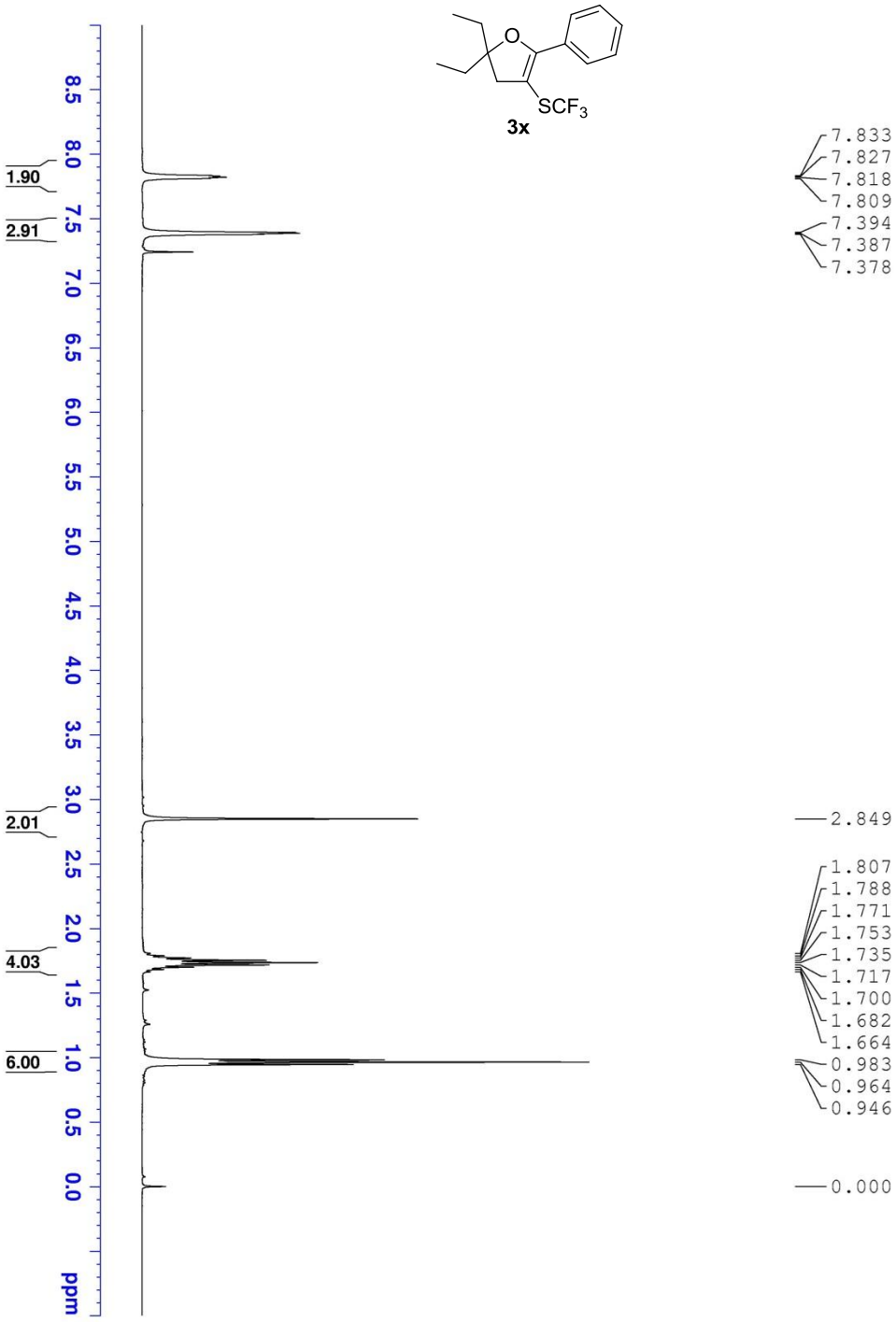

O
SCF3
3v
162.47
134.42
131.32
129.89
129.48
128.22
128.14
128.05
125.12
89.84
89.82
85.24
77.32
77.00
76.68
43.07
39.90
28.06
27.93
26.40
25.85
25.72
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

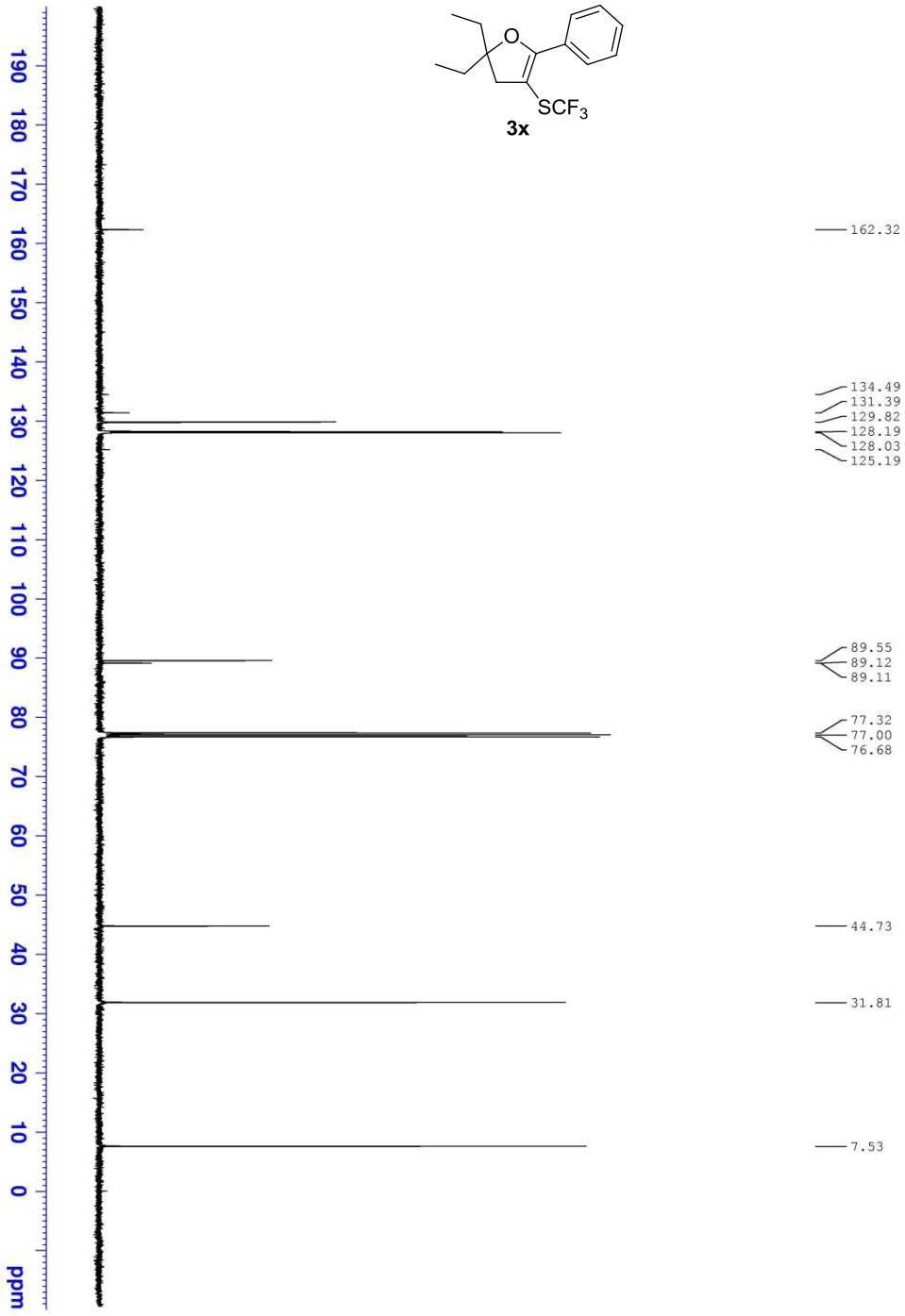

O
SCF3
3v
-42.62
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
ppm


SCF3
3w
7.820
7.813
7.809
7.805
7.799
7.795
7.388
7.380
7.372
3.034
2.157
2.149
2.137
2.113
2.109
1.915
1.912
1.903
1.896
1.893
1.886
1.874
1.867
1.838
1.833
1.790
1.777
1.769
1.760
1.757
1.741
1.730
1.729
1.718
1.711
1.707
1.701
1.693
1.676
1.671
0.000
1.96
3.00
2.06
2.01
2.10
4.10
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
ppm

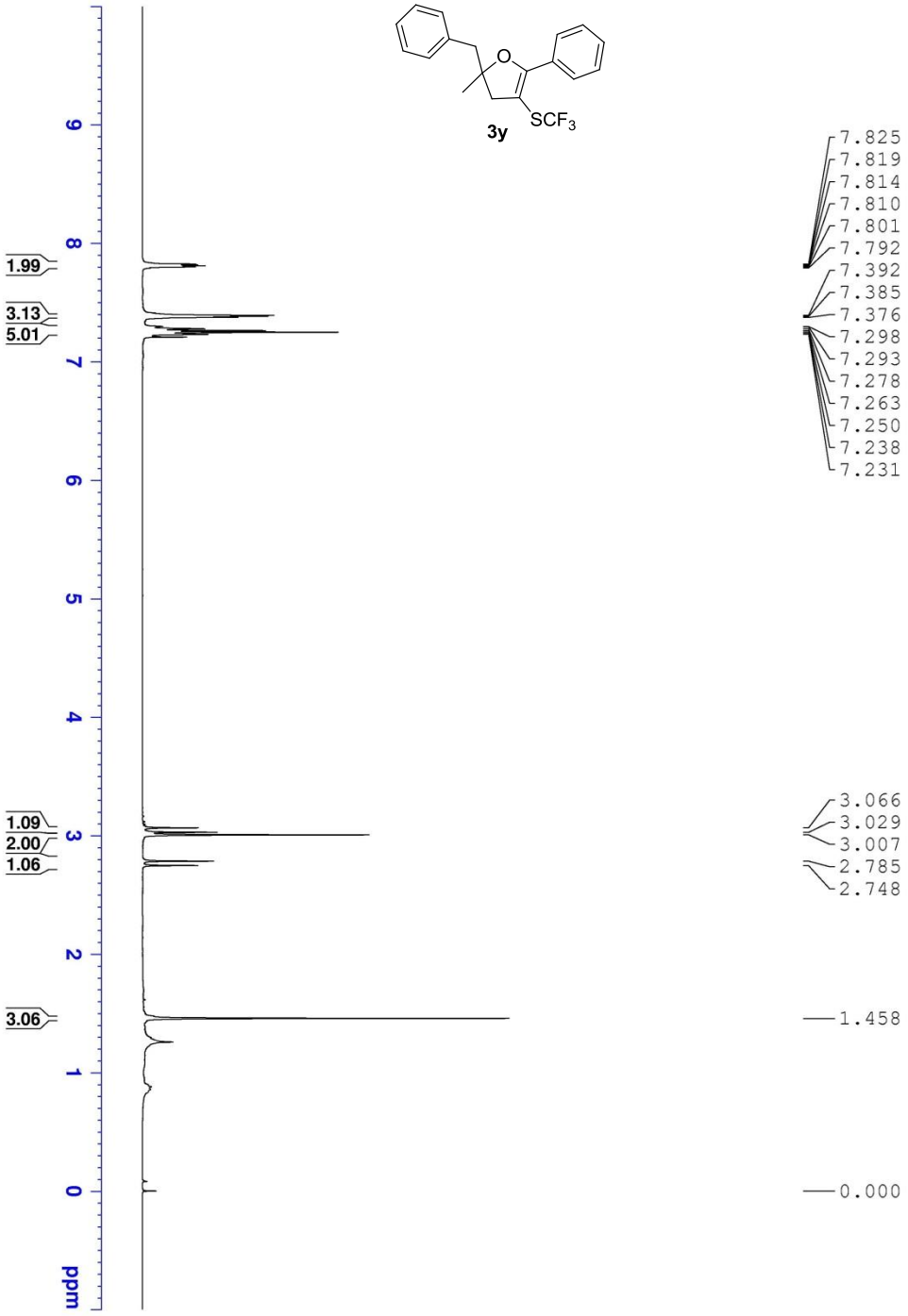

SCF3
3w
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm
161.75
134.44
131.34
129.81
128.22
128.11
128.01
125.14
94.93
89.32
89.30
77.31
77.00
76.68
46.86
39.53
23.71

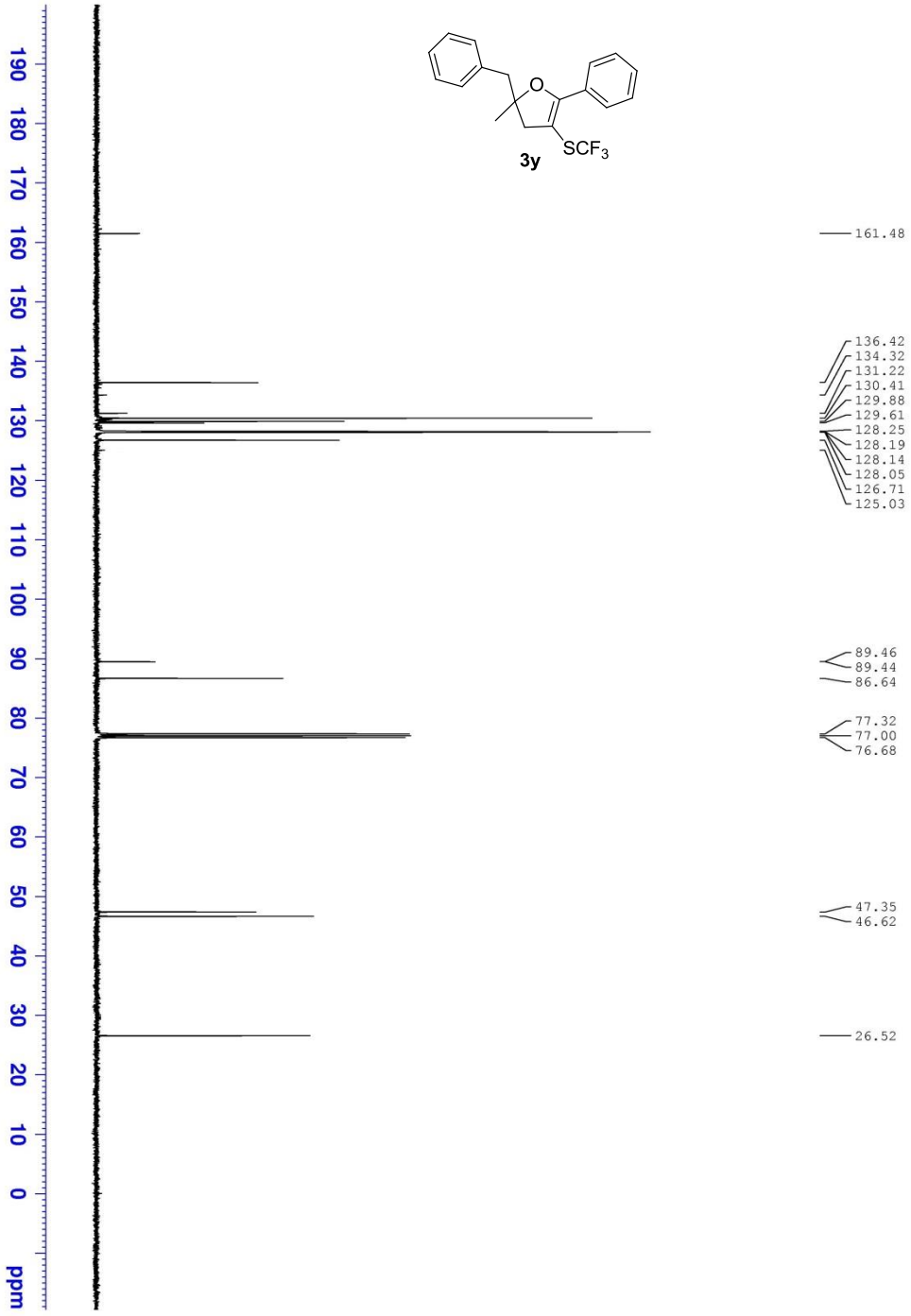

SCF3
3w
-42.87
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
ppm

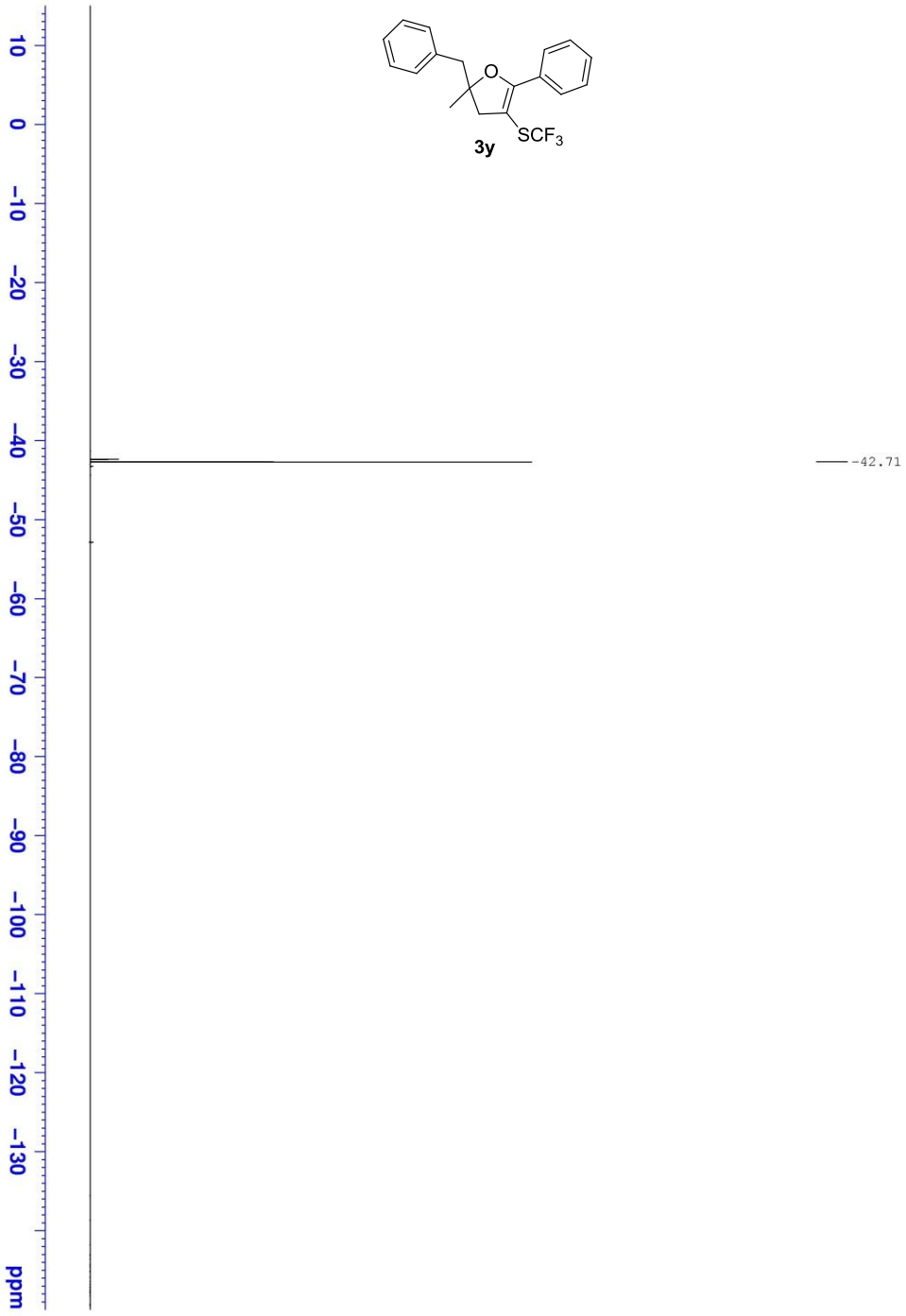

O
SCF3
3x
7.833
7.827
7.818
7.809
7.394
7.387
7.378
2.849
1.807
1.788
1.771
1.753
1.735
1.717
1.700
1.682
1.664
0.983
0.964
0.946
0.000
1.90
2.91
2.01
4.03
6.00
ppm

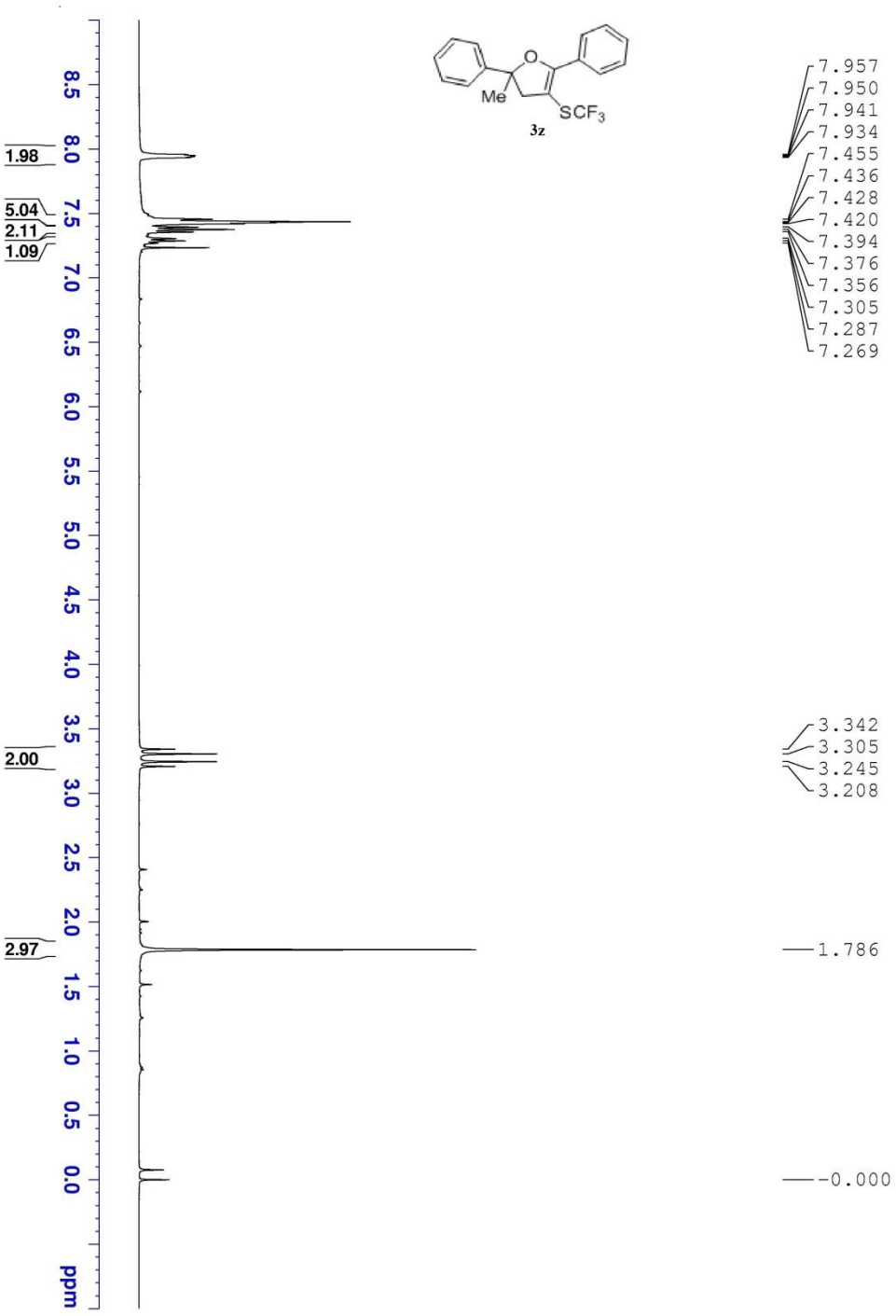

O
SCF3
3x
162.32
134.49
131.39
129.82
128.19
128.03
125.19
89.55
89.12
89.11
77.32
77.00
76.68
44.73
31.81
7.53
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

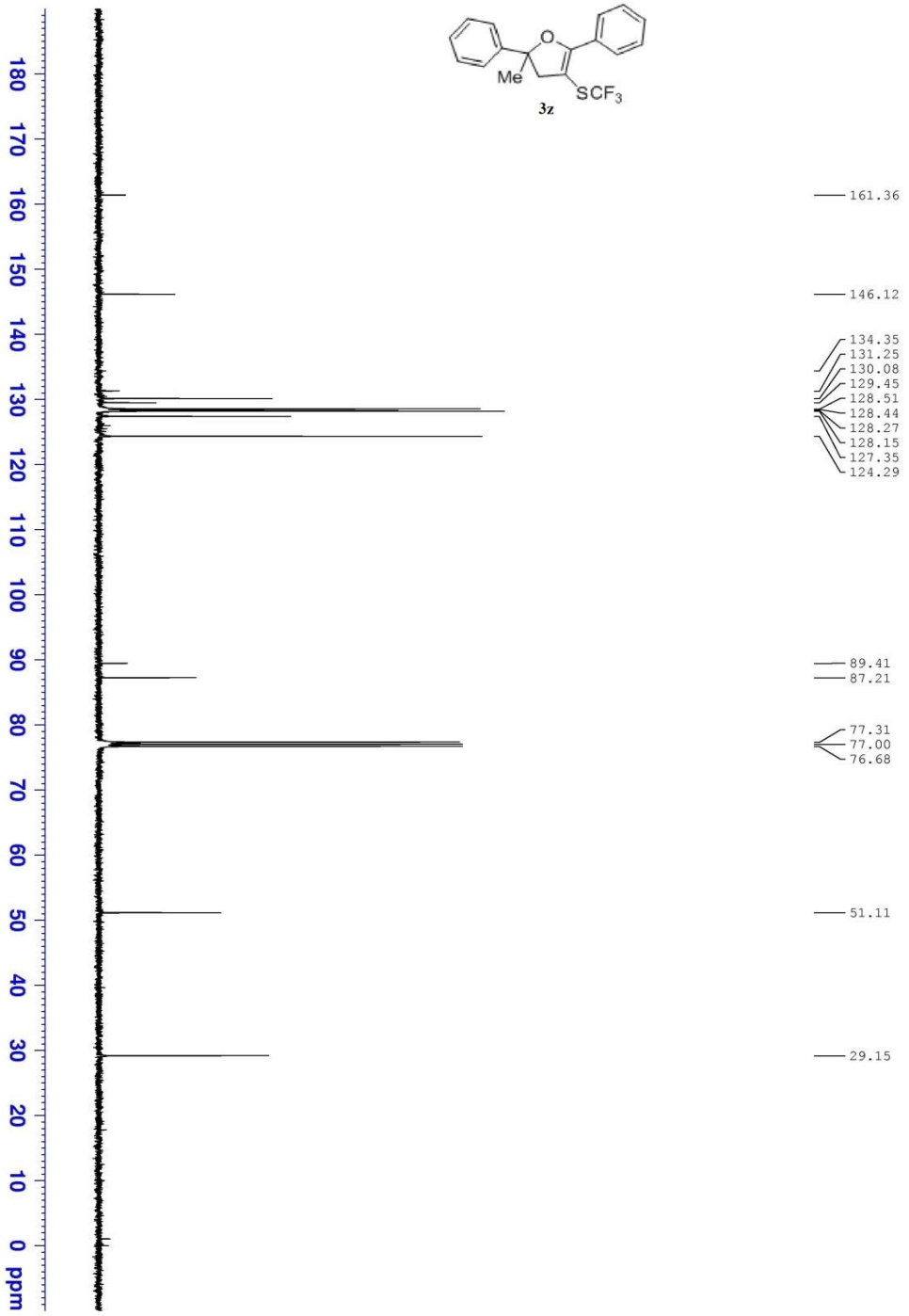

O
SCF3
3x
-42.67
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
ppm

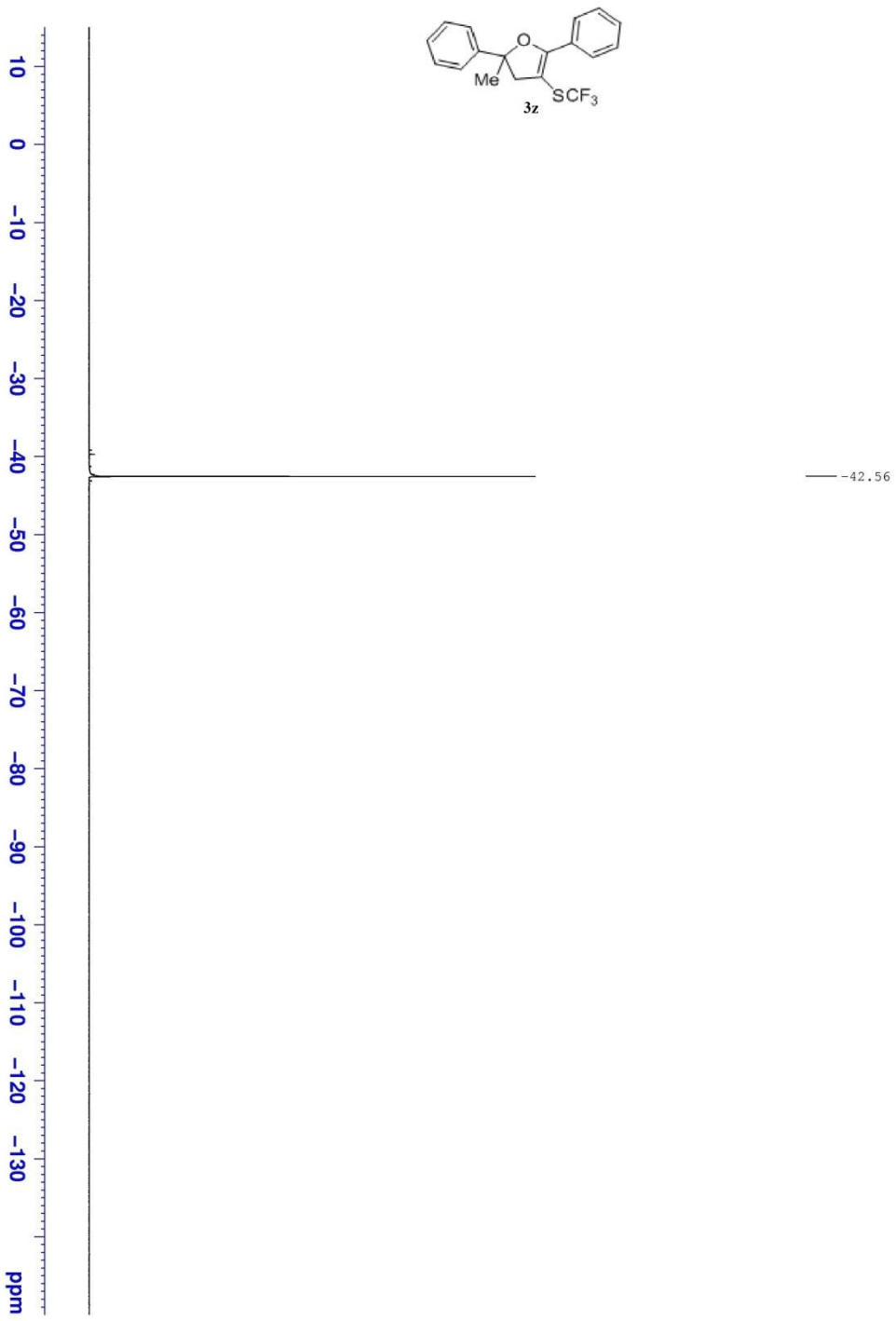

3y
SCF3
7.825
7.819
7.814
7.810
7.801
7.792
7.392
7.385
7.376
7.298
7.293
7.278
7.263
7.250
7.238
7.231
3.066
3.029
3.007
2.785
2.748
1.458
0.000
1.99
3.13
5.01
1.09
2.00
1.06
3.06
ppm

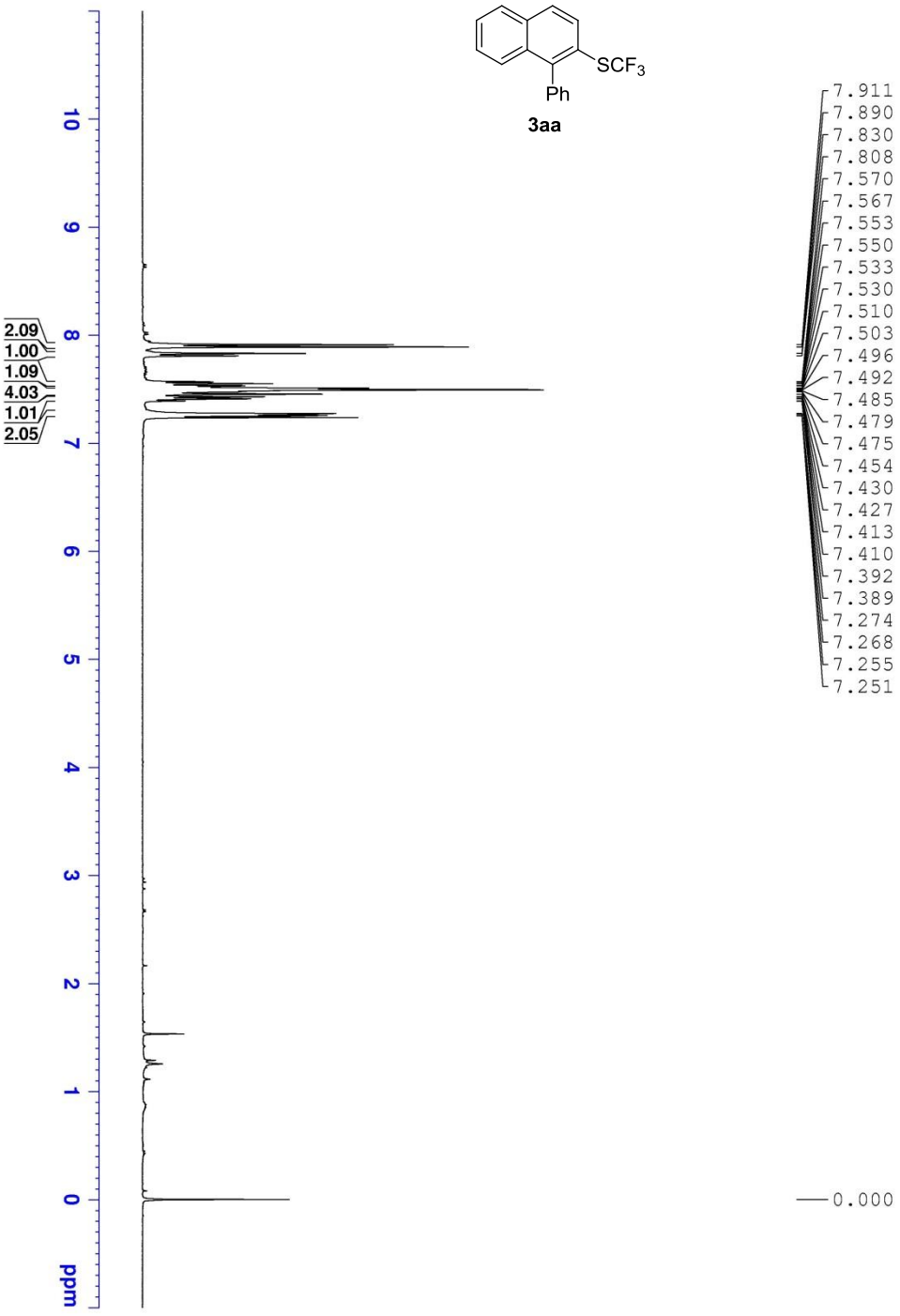

3y
SCF3
O
161.48
136.42
134.32
131.22
130.41
129.88
129.61
128.25
128.19
128.14
128.05
126.71
125.03
89.46
89.44
86.64
77.32
77.00
76.68
47.35
46.62
26.52
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

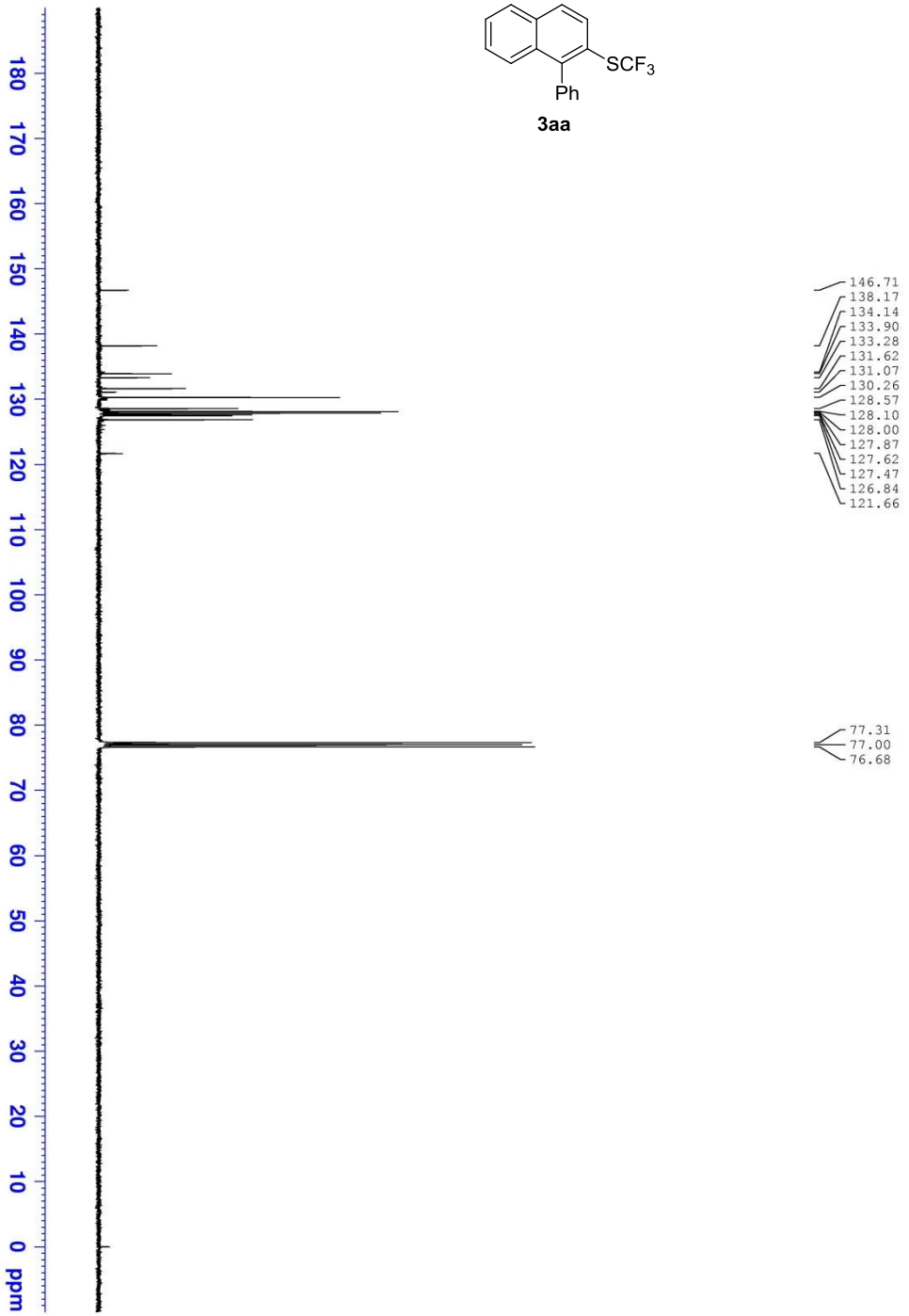

10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
ppm
O
SCF3
3y
-42.71


Me
O
SCF3
3z
7.957
7.950
7.941
7.934
7.455
7.436
7.428
7.420
7.394
7.376
7.356
7.305
7.287
7.269
3.342
3.305
3.245
3.208
1.786
-0.000
1.98
5.04
2.11
1.09
2.00
2.97
ppm


Me
SCF3
3z
161.36
146.12
134.35
131.25
130.08
129.45
128.51
128.44
128.27
128.15
127.35
124.29
89.41
87.21
77.31
77.00
76.68
51.11
29.15
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm


Me
SCF3
3z
-42.56
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
ppm


SCF3
Ph
3aa
7.911
7.890
7.830
7.808
7.570
7.567
7.553
7.550
7.533
7.530
7.510
7.503
7.496
7.492
7.485
7.479
7.475
7.454
7.430
7.427
7.413
7.410
7.392
7.389
7.274
7.268
7.255
7.251
0.000
2.09
1.00
1.09
4.03
1.01
2.05
10
9
8
7
6
5
4
3
2
1
0
ppm


SCF3
Ph
3aa
146.71
138.17
134.14
133.90
133.28
131.62
131.07
130.26
128.57
128.10
128.00
127.87
127.62
127.47
126.84
121.66
77.31
77.00
76.68
180
170
160
150
140
130
120
110
100
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60
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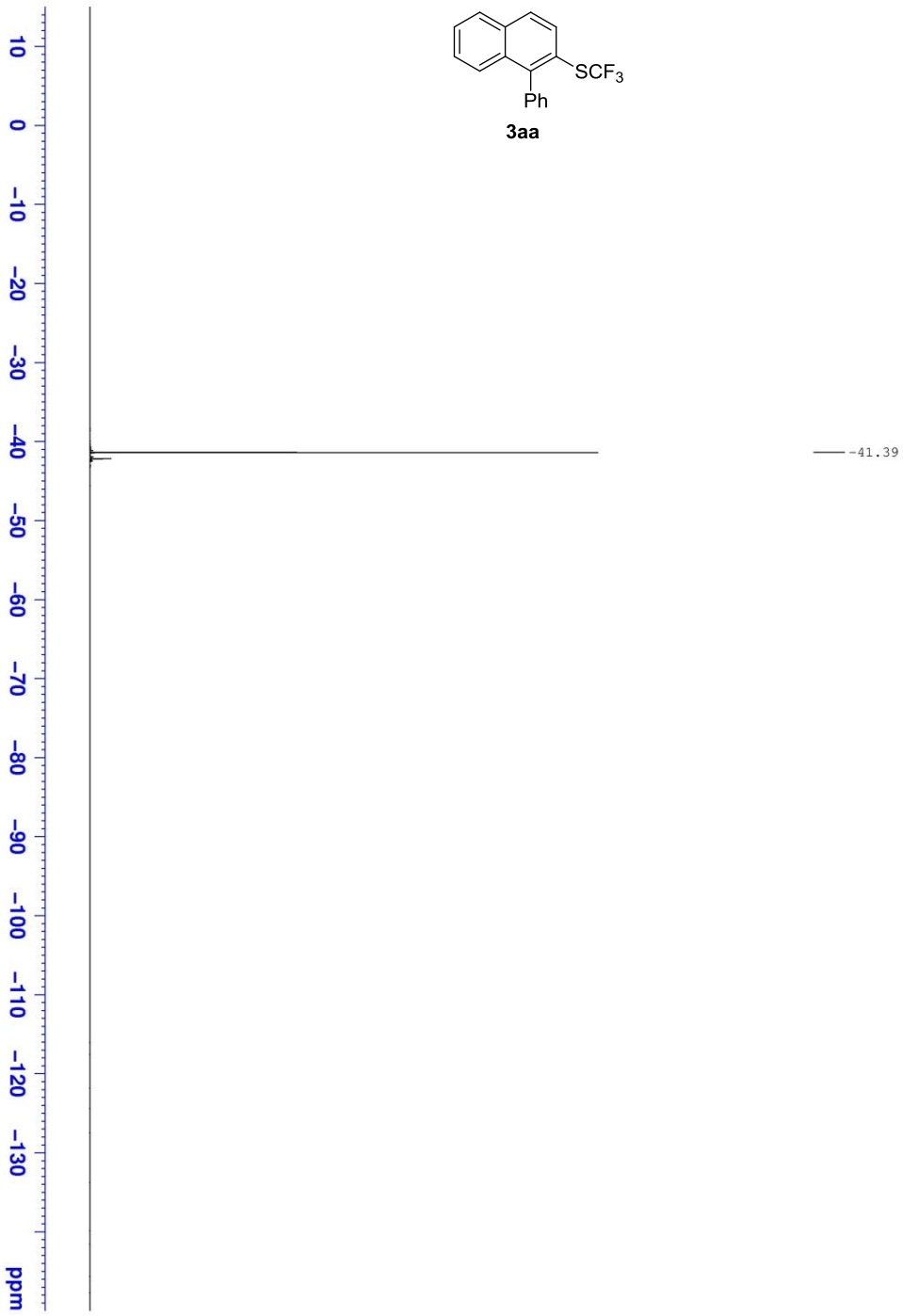
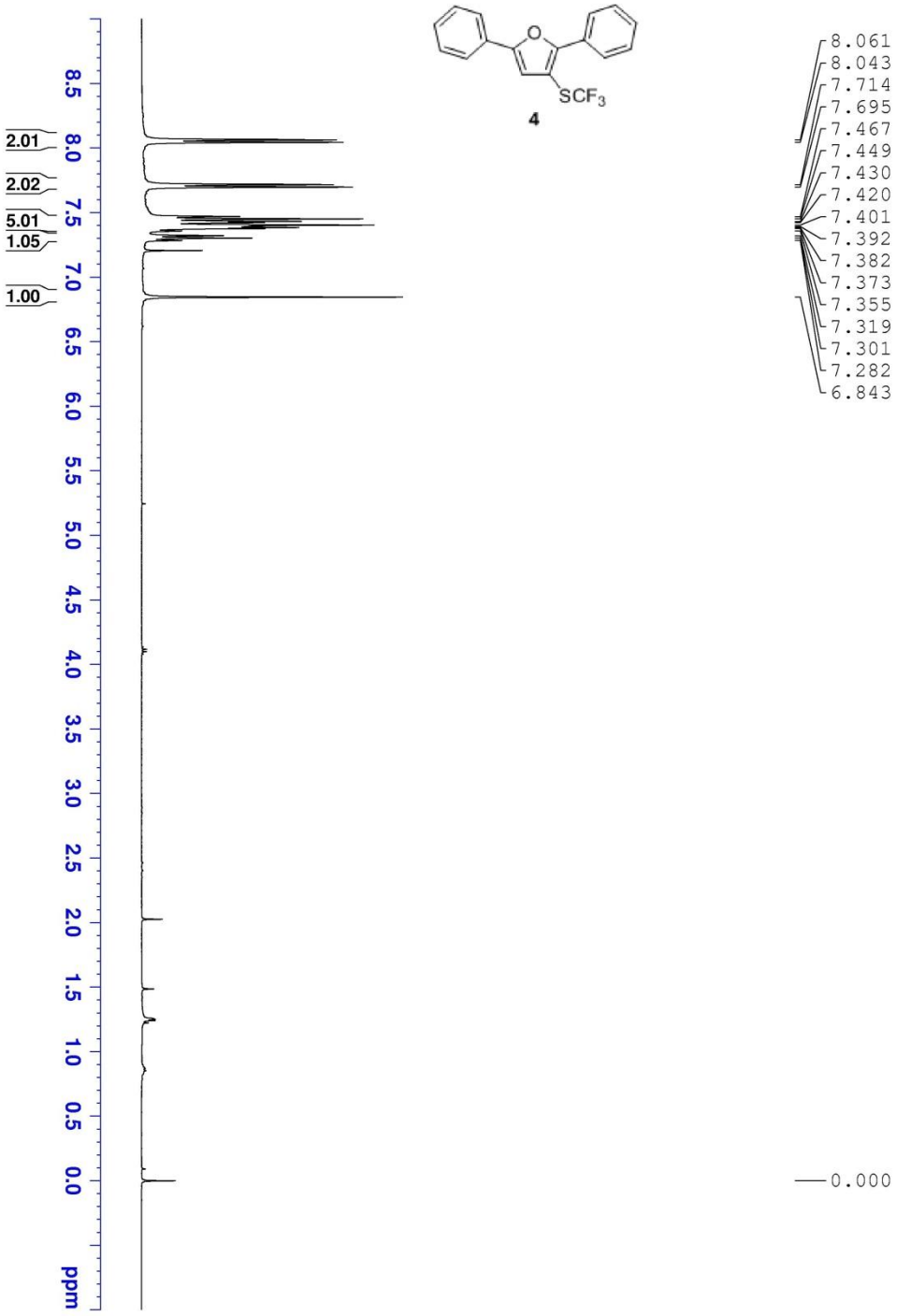
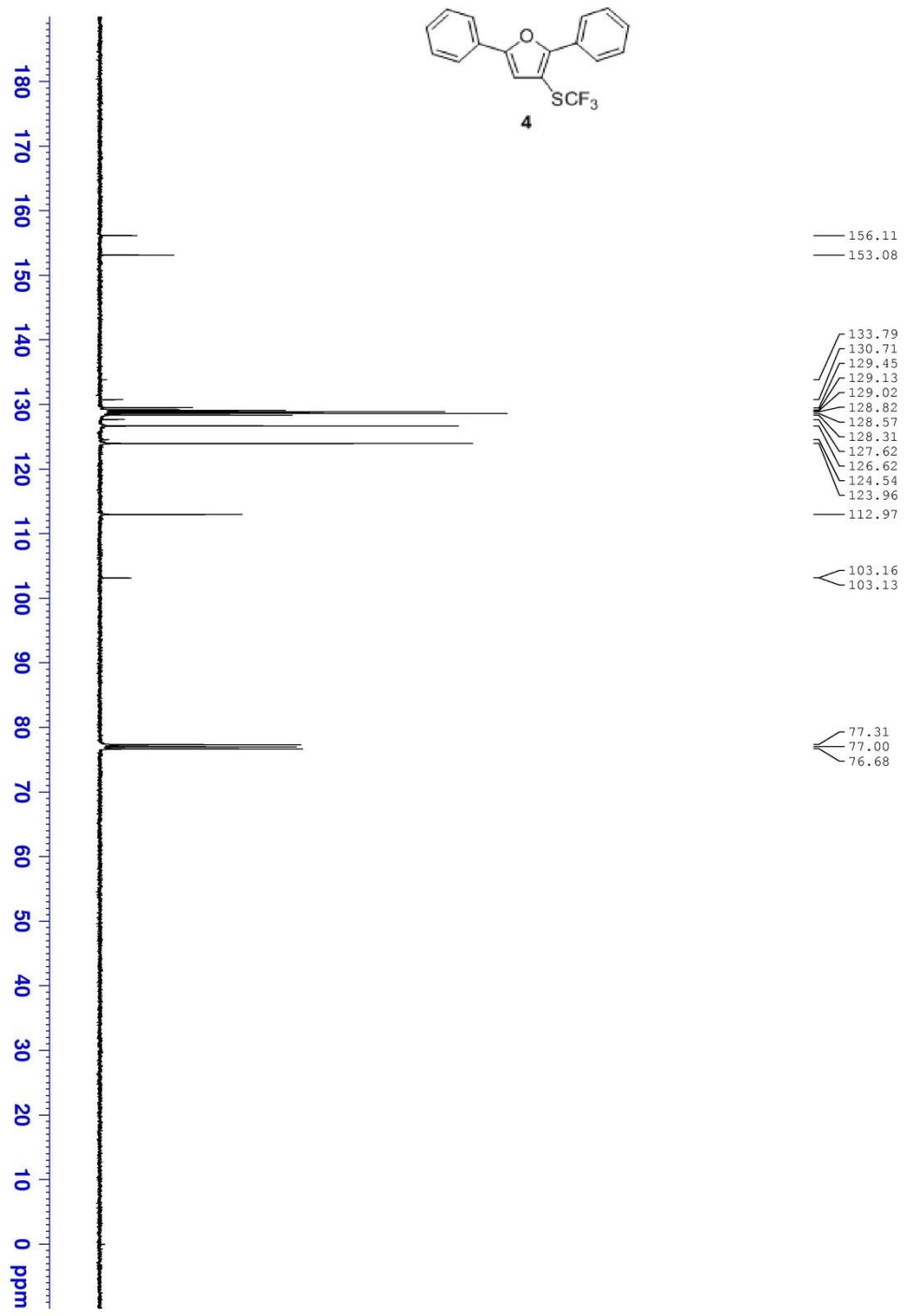
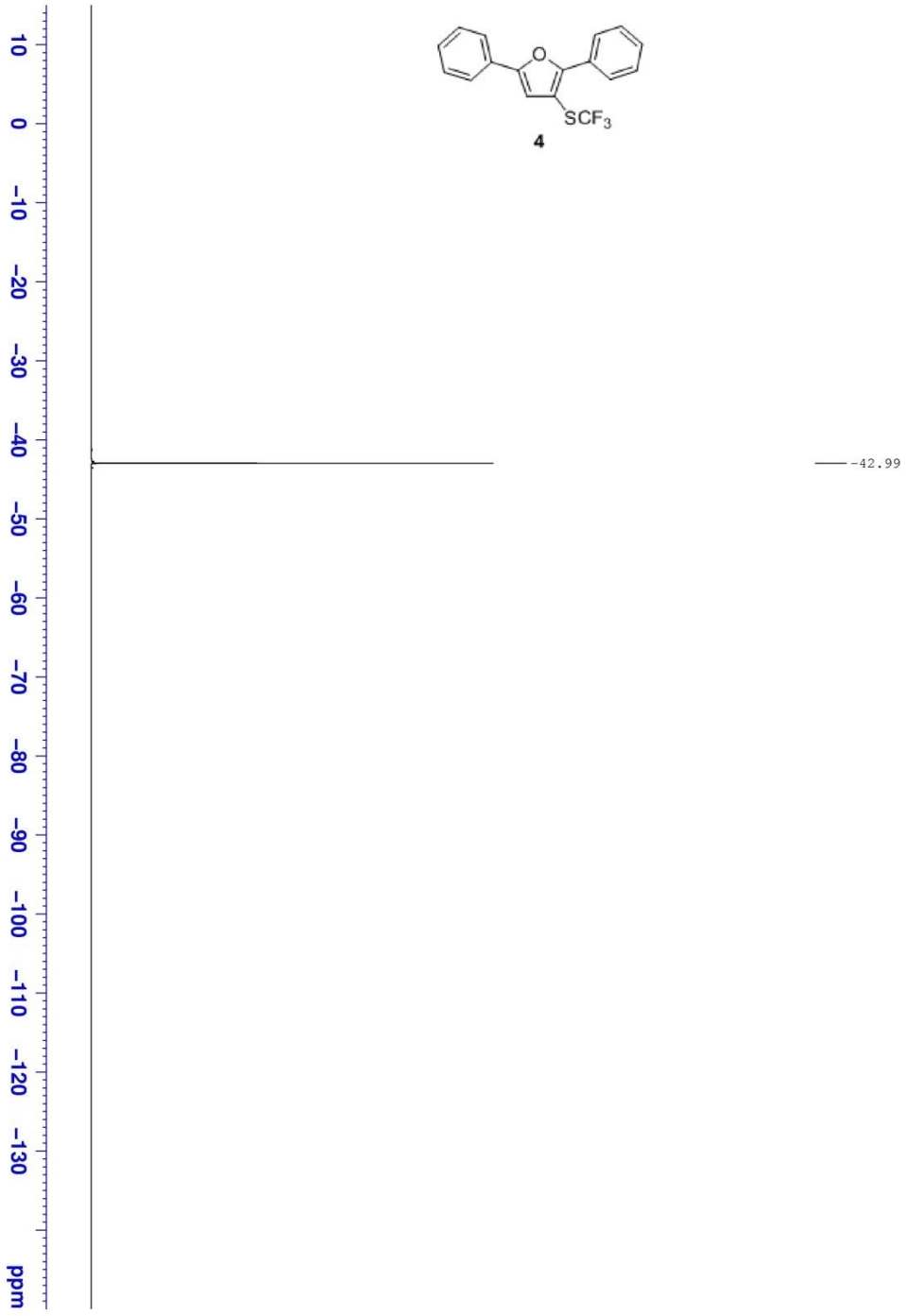
20
10
0
ppm



3aa


SCF3
4
2.01
2.02
5.01
1.05
1.00
8.061
8.043
7.714
7.695
7.467
7.449
7.430
7.420
7.401
7.392
7.382
7.373
7.355
7.319
7.301
7.282
6.843
0.000
ppm


SCF3
4
156.11
153.08
133.79
130.71
129.45
129.13
129.02
128.82
128.57
128.31
127.62
126.62
124.54
123.96
112.97
103.16
103.13
77.31
77.00
76.68
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm


10
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-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
ppm
-42.99
SCF3
4