Ni-Catalyzed Regioselective β,δ-Diarylation of Unactivated Olefins in Ketimines via Ligand-Enabled Contraction of Transient Nickellacycles: Rapid Access to Remotely Diarylated Ketones

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1. General Information

All the reactions were set up inside a nitrogen-filled glovebox and all the chemicals were handled under nitrogen atmosphere unless stated otherwise. All the glassware including the 4-dram and 1-dram borosilicate (Kimble-Chase) vials, and pressure vessels were properly dried in an oven before use. Bulk solvents were obtained from EMD and anhydrous solvents (DMF, DMA, DMSO, NMP, dioxane, toluene, MeCN) were obtained from Sigma-Aldrich, and were used directly without further purification. Deuterated solvents were purchased from Sigma-Aldrich. $NiBr_2$ was purchased from Alfa-Aesar. Aryl halides were purchased from Acros, Sigma-Aldrich, Oakwood, TCI-America, Matrix and Alfa-Aesar. ^1H, ^{13}C, ^{19}F and ^{31}P NMR spectra were recorded on a Bruker instrument (500 or 300, 75 or 126, 282 and 121.5 MHz respectively) and internally referenced to the residual solvent signals of $CDCl_3$ for ^1H and ^{13}C NMR, ^{19}F NMR and ^{31}P NMR at 7.26 ppm, 77.16 ppm, −164.9 ppm and 0 respectively. The chemical shifts of NMR and the coupling constants (J) for ^1H, ^{13}C, ^{19}F NMR and ^{31}P NMR are reported in δ parts per millions (ppm) and in Hertz, respectively. The following conventions are used for multiplicities: s, singlet; d, doublet; t, triplet; q, quartet; m, multiplet; dd, doublet of doublet. High resolution mass of new compounds were recorded at the Mass Spectrometry, Department of Chemistry and Chemical Biology, University of New Mexico (UNM) and University of Texas at Austin. All NMR spectra were collected at Department of Chemistry and Chemical Biology, University of New Mexico (UNM). X-ray diffraction was performed on Bruker Kappa APEX II CCD diffractometer at the Department of Chemistry and Chemical Biology, UNM. Infrared (IR) spectra were recorded on Bruker Alpha-P ATR-IR at UNM and ν_{max} is reported in cm^{-1}.

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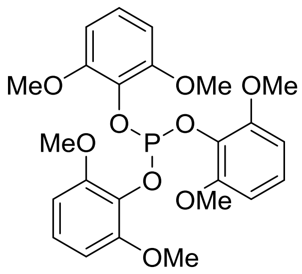
2. Experimental Section

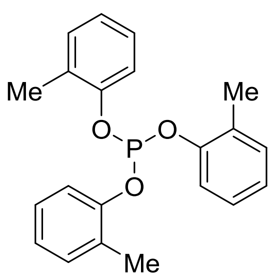
2.1 Ligand Preparation

Tris(2,6-dimethylphenyl) phosphite (**10**),[1] tris(4-methoxyphenyl) phosphite (**8**),[2] tris(4-(trifluoromethyl)phenyl) phosphite (**13**)[3] and tri(1H-pyrrol-1-yl)phosphane (**14**)[4] were prepared following the literature procedure.



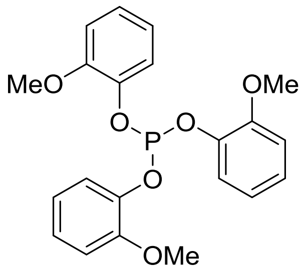
Tris(2,6-dimethoxyphenyl) phosphite (12): To a well stirred solution of 2,6 dimethoxyphenol (16.0 mmol) in THF (100 ml) under nitrogen at 0 °C, Et_3N (20.0 mmol) was added dropwise freshly distilled PCl_3 (5.0 mmol). The reaction mixture was stirred for 16h at room temperature. After the reaction was complete, the reaction mixture was filtered through fret funnel and the filtrate obtained was concentrated on rotavapor. The crude reaction mixture obtained was then purified by flash chromatography on a silica-gel column to obtain white solid (71% yield).

^{1}H NMR (300 MHz, $CDCl_3$): δ 3.62 (s, 18H), 6.54 (d, *J*=9.0 Hz, 6H), 6.92 (t, *J*=7.5 Hz, 3H) ;**^{13}C NMR (75 MHz, $CDCl_3$):** δ 56.4, 105.8, 122.8, 132.6, 152.3; **^{31}P NMR (121.5 MHz, $CDCl_3$)** δ 146.6.



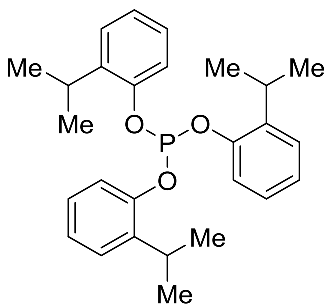
Tris(2-methoxyphenyl) phosphite (6): Prepared following the same procedure as for the synthesis of tris(2,6-dimethoxyphenyl) phosphite (colorless liquid, 81% yield).

^{1}H NMR (300 MHz, $CDCl_3$): δ 2.27 (s, 9H), 7.08 (t, *J*=6.0 Hz, 3H), 7.18 (t, *J*=7.5 Hz, 3H), (d, *J*=9.0 Hz, 6H) ;**^{13}C NMR (75 MHz, $CDCl_3$):** 16.7, 120.4, 124.2, 126.9, 130.0, 131.4, 150.4; **^{31}P NMR (121.5 MHz, $CDCl_3$)** δ 131.3



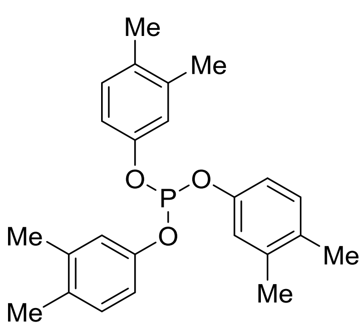
Tris(2-methoxyphenyl) phosphite (7): Prepared following the same procedure as for the synthesis of tris(2,6-dimethoxyphenyl) phosphite. (colorless liquid, 84% yield).

^{1}H NMR (300 MHz, $CDCl_3$): δ 3.73 (s, 9H), 6.86- 6.93 (m, 6H), 7.07 (t, *J*=7.5 Hz, 3H), 7.25 (d, *J*=9.0 Hz, 3H) ;**^{13}C NMR (75 MHz, $CDCl_3$):** δ 56.0, 112.6, 120.9, 122.6, 122.7, 124.5, 141.7, 151.2; **^{31}P NMR (121.5 MHz, $CDCl_3$)** δ 134.9.



Tris(2-isopropylphenyl) phosphite (9): Prepared following the same procedure as for the synthesis of tris(2,6-dimethoxyphenyl) phosphite (colorless liquid, 76% yield).

^{1}H NMR (300 MHz, $CDCl_3$): δ 1.17 (d, *J*=6.0 Hz, 18H), 3.26-3.35 (m, 3H), 7.11-7.16 (m, 6H), 7.21-7.24 (m, 3H), 7.29-7.32 (m, 3H) ;**^{13}C NMR (75 MHz, $CDCl_3$):** δ 23.1, 27.0, 120.3, 120.5, 124.4, 126.6, 126.9, 140.2, 149.3; **^{31}P NMR (121.5 MHz, $CDCl_3$)** δ 131.5.

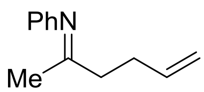


Tris(3,4-dimethylphenyl) phosphite (11): Prepared following procedure reported in literature.[5]

^{1}H NMR (300 MHz, $CDCl_3$): δ 2.23 (s, 9H), 2.25 (s, 9H), 6.89-6.96 (m, 6H), 7.08 (d, *J*=9.0 Hz, 3H) ;**^{13}C NMR (75 MHz, $CDCl_3$):** δ 19.2, 20.0, 118.0, 118.1, 122.0, 122.1, 130.6, 132.3, 138.1, 149.7, 149.7; **^{31}P NMR (121.5 MHz, $CDCl_3$)** δ 129.2.

2.2 General Procedure for the Preparation of Ketimine

To a mixture of ketone (1.0 equiv) and aniline (2.0 equiv) in anhydrous toluene under nitrogen, molecular sieves 4 Å (1.0 gm/mmol) was added and heated at 80-120 °C for 24-36h. After the reaction was complete, the reaction mixture was filtered through a filter paper. Solvent was removed from the filtrate using rotavapor. The residue obtained was then purified by distillation or flash chromatography on a silica-gel column (deactivated by 10% TEA in hexanes).

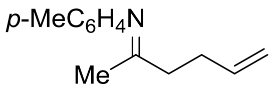


Hex-5-en-2-one was prepared following literature procedure.[6] N-Phenylhex-5-en-2-imine was then prepared following the general procedure using hex-5-en-2-one and aniline at 80 °C for 24h. The crude was purified by flash chromatography on a silica-gel column (deactivated by 10% TEA in hexanes) using hexanes as an eluent to get a yellow liquid (72% yield).

^{1}H NMR (300 MHz, $CDCl_3$): δ 1.78 (s, 0.80×3H), 2.17 (s, 0.20×3H), 2.23-2.24 (m, 0.20×4H), 2.43-2.55 (m, 0.80×4H), 4.94-5.14 (m, 2H), 5.61-5.70 (m, 0.20×1H), 5.85-5.99 (m, 0.80×1H), 6.69 (d, *J*=9.0 Hz, 2H), 7.03 (t, *J*=9.0 Hz, 1H), 7.28 (t, *J*=7.5 Hz, 2H) ; **^{13}C NMR (75 MHz, $CDCl_3$):** δ 19.8, 26.1, 30.4, 31.0, 33.4, 40.7, 115.2, 115.6, 119.5, 123.1, 128.9, 136.9, 137.7, 151.0, 151.6, 171.1, 171.7 ; **IR (neat):** 3004, 2926, 1715, 1323, 1110, 1016.

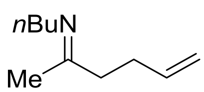
N-(4-Fluorophenyl) hex-5-en-2-imine was prepared following the general procedure using hex-5-en-2-one and 4-fluoroaniline at 80 °C for 24h. The crude was purified by flash chromatography on a silica-gel column (deactivated by 10% TEA in hexanes) using hexanes as an eluent to get a yellow liquid (75% yield).

^{1}H NMR (300 MHz, CDCl$_3$): δ 1.77 (s, 0.80×3H), 2.15 (s, 0.20×3H), 2.21-2.22 (m, 0.20×4H), 2.41-2.52 (m, 0.80×4H), 4.94-5.12 (m, 2H), 5.58-5.70 (m, 0.20×1H), 5.83-5.96 (m, 0.80×1H), 6.60-6.65 (m, 2H), 6.94-6.99 (m, 2H); **^{13}C NMR (75 MHz, CDCl$_3$):** δ 19.8, 26.1, 30.4, 30.9, 33.3, 40.7, 115.2, 115.5, 115.8, 120.7, 120.8, 120.9, 136.7, 137.6, 147.6, 159.3 (d, *J*=239.3 Hz), 172.1, 172.7; **^{19}F NMR (282 MHz, CDCl$_3$)** δ -121.6 ; **IR (neat):** 2968, 1658, 1593, 1484, 1363.



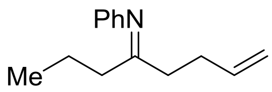
N-(*p*-Tolyl)hex-5-en-2-imine was prepared following the general procedure using hex-5-en-2-one and *p*-toluidine at 80 °C for 24h. The crude was purified by flash chromatography on a silica-gel column (deactivated by 10% TEA in hexanes) using hexanes as an eluent to get a yellow liquid (64% yield).

^{1}H NMR (300 MHz, CDCl$_3$): δ 1.78 (s, 0.80×3H), 2.15 (s, 0.20×3H), 2.23-2.31 (m, 0.20×4H), 2.31 (s, 3H), 2.43-2.52 (m, 0.80×4H), 4.94-5.13 (m, 2H), 5.57-5.72 (m, 0.20×1H), 5.85-5.98 (m, 0.80×1H), 6.59 (d, *J*=9.0 Hz, 2H), 7.09 (d, *J*=9.0 Hz, 2H); **^{13}C NMR (75 MHz, CDCl$_3$):** δ 19.7, 20.9, 26.1, 30.5, 31.0, 33.2, 40.8, 115.1, 115.2, 119.4, 119.5, 129.5, 132.3, 136.9, 137.8, 148.4, 149.0, 171.1, 171.7 ; **IR (neat):** 3026, 1654, 1593, 1495, 1483.



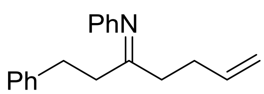
N-Butylhex-5-en-2-imine was prepared following the general procedure using hex-5-en-2-one and *n*-butylamine at 80 °C for 24h. The crude was purified by flash chromatography on a silica-gel column (deactivated by 10% TEA in hexanes) using hexanes as an eluent to get a yellow liquid (61% yield).

^{1}H NMR (300 MHz, CDCl$_3$): δ 0.90 (t, *J*=6.0 Hz, 3H), 1.27-1.39 (m, 2H), 1.51-1.62 (m, 2H), 1.78 (s, 0.80×3H), 1.97 (s, 0.20×3H), 2.20-2.34 (m, 4H), 3.20 (t, *J*=7.5 Hz, 2H), 4.90-5.06 (m, 2H), 5.74-5.87 (m, 1H) ; **^{13}C NMR (75 MHz, CDCl$_3$):** δ 14.1, 17.2, 20.8, 27.1, 30.5, 31.0, 31.5, 33.1, 33.4, 42.0, 50.1, 51.2, 114.8, 115.4, 137.3, 138.1, 168.8, 169.3 ; **IR (neat):** 2956, 2928, 1661, 1640, 1434, 1364.



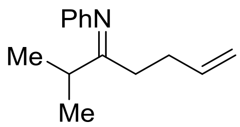
Oct-7-en-4-one was prepared following a procedure described in the literature.[7] N-Phenyloct-7-en-4-imine was then prepared using the general procedure using oct-7-en-4-one and aniline at 120 °C for 24h. The crude was purified by distillation under vacuum at 90 °C (0.3 torr) in which impurities were distilled out. The remaining light reddish liquid was the desired imine. (74% yield).

^{1}H NMR (300 MHz, $CDCl_3$): δ 0.81 (t, *J*=9.0 Hz, 0.6×3H), 1.01 (t, *J*= 9.0 Hz, 0.4×3H), 1.44-1.52 (m, 0.6×2H), 2.10 (t, *J*= 9.0 Hz, 0.6×2H), 2.17-2.22 (m, 0.4×4H), 2.39 (t, *J*= 9.0 Hz, 0.40×2H), 2.43-2.51 (m, 0.60×4H), 4.91-5.13 (m, 2H), 5.57-5.71 (m, 0.40×1H), 5.85-5.99 (m, 0.60×1H), 6.63-6.68 (m, 2H), 7.00 (t, *J*=7.5 Hz, 1H), 7.26 (t, *J*=7.5 Hz, 2H) ; **^{13}C NMR (75 MHz, $CDCl_3$):** δ 14.0, 14.3, 19.8, 20.4, 30.5, 31.1, 32.4, 35.4, 37.5, 40.7, 115.0, 115.5, 119.5, 122.8, 122.9, 128.9, 137.1, 138.1, 151.5, 174.3 ; **IR (neat):** 2960, 1654, 1593, 1447, 1166.



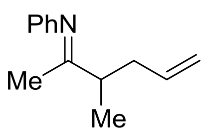
1-Phenylhept-6-en-3-one was prepared following a literature procedure.[8] N,1-Diphenylhept-6-en-3-imine was then prepared following the general procedure using 1-phenylhept-6-en-3-one and aniline at 120 °C for 36h. The crude was purified by distillation under vacuum at 120 °C (0.3 torr) in which impurities were distilled out. The remaining light reddish liquid was the desired imine (68% yield).

^{1}H NMR (300 MHz, $CDCl_3$): δ 2.19-2.28 (m, 2H), 2.45-2.56 (m, 2H), 2.57-2.61 (m, 0.50×2H), 2.74-2.80 (m, 2H), 3.04-3.09 (m, 0.50×2H), 4.94-5.19 (m, 2H), 5.59-5.72 (m, 0.50×1H), 5.90-6.04 (m, 0.50×1H), 6.61 (d, *J*=9.0 Hz, 0.50×2H), 6.70 (d, *J*=9.0 Hz, 0.50×2H), 7.01-7.08 (m, 2H), 7.20-7.37 (m, 6H) ; **^{13}C NMR (75 MHz, $CDCl_3$):** δ 30.4, 30.9, 32.4, 32.9, 33.1, 35.3, 37.9, 40.0, 115.2, 115.6, 119.3, 119.3, 122.9, 126.0, 126.3, 128.2, 128.4, 128.5, 128.6, 128.6, 128.9, 128.9, 136.9, 137.9, 140.6, 141.9, 151.2, 173.1 ; **IR (neat):** 3026, 1654, 1593, 1483, 1452, 1070.



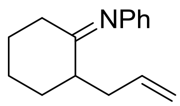
2-Methylhept-6-en-3-one was prepared following a literature procedure.[9] 2-Methyl-N-phenylhept-6-en-3-imine was then prepared following general procedure using 2-methylhept-6-en-3-one and aniline at 80 °C for 24h. The crude was purified by flash chromatography on a silica-gel column (deactivated by 10% TEA in hexanes) using hexanes as an eluent to get a yellow liquid (74% yield).

^{1}H NMR (300 MHz, $CDCl_3$): δ 1.01 (d, *J*=9.0 Hz, 0.40×6H), 1.21 (d, *J*=9.0 Hz, 0.60×6H), 2.10-2.18 (m, 0.60×2H), 2.22-2.29 (m, 0.40×2H), 2.62-2.81 (m, 1H), 4.88-5.13 (m, 2H), 5.55-5.69 (m, 0.60×1H), 5.87-5.98 (m, 0.40×1H), 6.63-6.67 (m, 2H), 6.99 (t, *J*=7.5 Hz, 1H), 7.26 (t, *J*=6.0 Hz, 2H) ; **^{13}C NMR (75 MHz, $CDCl_3$):** δ 20.1, 20.5, 30.5, 31.2, 31.3, 31.6, 32.0, 36.1, 114.8, 115.3, 119.1, 119.2, 122.6, 122.7, 128.8, 128.9, 137.2, 138.5, 151.5, 177.6, 178.5 ; **IR (neat):** 2965, 1653, 1576, 1465, 1203.



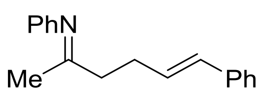
3-Methylhex-5-en-2-one was prepared following a literature procedure.[10] 3-Methyl-N-phenylhex-5-en-2-imine was then prepared following the general procedure using 3-methylhex-5-en-2-one and aniline at 80 °C for 24h. The crude was purified by flash chromatography on a silica-gel column (deactivated by 10% TEA in hexanes) using hexanes as an eluent to get a yellow liquid (63% yield).

^{1}H NMR (300 MHz, $CDCl_3$): δ 1.05 (d, *J*=6.0 Hz, 0.15×3H), 1.21 (d, *J*=6.0 Hz, 0.85×3H), 1.74 (s, 0.85×3H), 2.08 (s, 0.15×3H), 2.19-2.29 (m, 1H), 2.42-2.52 (m, 1H), 2.55-2.64 (m, 1H), 4.99-5.14 (m, 2H), 5.51-5.65 (m, 0.15×1H), 5.80-5.94 (m, 0.85×1H), 6.68 (d, *J*=9.0 Hz, 2H), 7.03 (t, *J*=7.5 Hz, 1H), 7.29 (t, *J*=7.5 Hz, 2H) ; **^{13}C NMR (75 MHz, $CDCl_3$):** δ 17.6, 17.8, 18.3, 21.1, 37.3, 38.8, 38.8, 44.3, 116.3, 116.7, 119.4, 122.8, 123.0, 128.9, 135.8, 136.6, 151.7, 175.0, 175.2 ; **IR (neat):** 2968, 1658, 1593, 1484, 1363.



2-Allylcyclohexan-1-one was prepared following a literature procedure.[11] 2-Allyl-N-phenylcyclohexan-1-imine was then prepared following the general procedure using 2-allylcyclohexan-1-one and aniline at 120 °C for 24h. The crude was purified by distillation under vacuum at 100 °C (.3 torr) in which impurities were distilled out. The remaining yellow liquid was the desired imine (71% yield).

^{1}H NMR (300 MHz, $CDCl_3$): δ 1.47- 2.76 (m, 11H), 4.97-5.12 (m, 2H), 5.43-5.57 (m, 0.15×1H), 5.85-5.99 (m, 0.85×1H), 6.59-6.75 (m, 2H), 7.03 (t, *J*=7.5 Hz, 0.85× 1H), 7.17 (t, *J*=7.5 Hz, 0.85×1H), 7.29 (t, *J*=7.5 Hz, 2H) ; **^{13}C NMR (75 MHz, $CDCl_3$):** δ 20.2, 24.5, 28.4, 30.9, 31.0, 33.5, 35.6, 35.8, 38.9, 40.4, 46.9, 115.9, 116.7, 119.7, 119.7, 122.9, 122.9, 128.9, 135.8, 137.5, 151.4, 176.1, 177.5 ; **IR (neat):** 2968, 1658, 1593, 1484, 1363.



(E)-6-Phenylhex-5-en-2-one was prepared following a literature procedure.[12] (5E)-N,6-Diphenylhex-5-en-2-imine was then prepared following the general procedure using (E)-6-phenylhex-5-en-2-one and aniline at 80 °C for 24h. The crude was purified by distillation under vacuum at 100 °C (.3 torr) in which impurities were distilled out. The remaining yellow liquid was the desired imine (66% yield).

^{1}H NMR (300 MHz, $CDCl_3$): δ 1.82 (s, 0.80×3H), 2.22 (s, 0.20×3H), 2.33-2.43 (m, 0.20×4H), 2.59-2.65 (m, 0.80×4H), 6.00-6.06 (m, 0.20×1H), 6.29-6.38 (m, 0.80×1H), 6.50 (d, *J*=18.0 Hz, 1H), 6.71 (d, *J*=9.0 Hz, 2H), 7.05 (t, *J*=7.5 Hz, 1H), 7.20- 7.40 (m, 7H) ; **^{13}C NMR (75 MHz, $CDCl_3$):** δ 20.0, 26.2, 29.7, 30.3, 33.8, 41.1, 119.6, 123.1, 126.1, 127.1, 127.3, 128.6, 129.0, 129.7, 130.7, 130.9, 137.7, 151.6, 171.0.

2.3 General Procedure for the preparation of organozinc reagents (Knochel's Method)[13]

Under nitrogen, anhydrous LiCl (1.0 equiv) and zinc powder (1.5 equiv) were transferred to a Schlenk flask and dried under high vacuum at 150°C to 170°C for 2 h. The mixture was cooled to room temperature and then taken to a glovebox. Anhydrous THF (1ml/mmol) was added and stirred at room temperature. The reaction mixture was stirred for 5 min after the zinc was activated by adding 5 mol% of 1,2 dibromoethane and 3 mol% of TMSCl to the zinc/THF suspension. To this stirred solution was added corresponding aryl iodides (neat) dropwise and the reaction mixture was refluxed for 24h. The final concentration of the arylzinc reagent was determined by titration with molecular iodine in THF.[14]

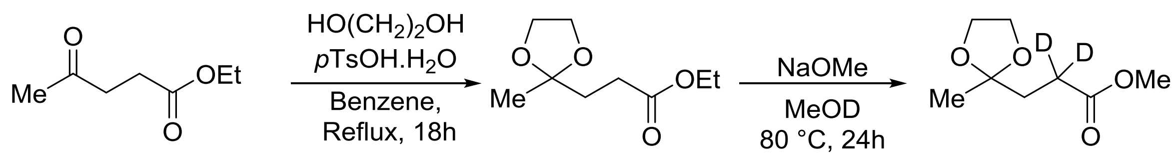
2.4 General procedure for screening reaction conditions

In a glovebox, 4-(trifluoromethyl) phenyl)zinc iodide solution in THF (0.12 mmol) was taken in a 1-dram vial and the solvent was removed under vacuum. To the residue, $NiBr_2$ (1.1 mg, 0.005 mmol, 5 mol%), triphenyl phosphite (1.6 mg, 0.005 mmol, 5 mol%), 4-iodotoluene (32.7 mg, 0.15 mmol) and N-phenylhex-5-en-2-imine (17.6 mg, 0.10 mmol) were added. The mixture was then dissolved in 0.5 ml of MeCN. The vial was capped tightly and placed in a hotplate preheated to 60 °C with vigorous stirring. After 2h, the reaction mixture was cooled to room temperature. 1 mL of 6N HCl was added and shaken for about 2 minutes to hydrolyze the imines to ketones. The reaction mixture was then extracted with EtOAc (1 mL × 3), 50 μL of pyrene (0.010 mmol, 0.20 M stock solution) as an internal standard was added and the solvent was removed in a rotary evaporator. The residue was dissolved in $CDCl_3$ and NMR spectrum was acquired. The yield was determined by integrating a product peak at 3.25 ppm against the pyrene peak at 8.06 ppm.

2.5 General procedure for Tables 2 and 3

In a glovebox, stock solution of arylzinc in THF (0.60 mmol) was taken in a 15 mL sealed tube and the solvent was removed under vacuum. To the residue of arylzinc, $NiBr_2$ (5.5 mg, 0.025 mmol, 5.0 mol%), triphenyl phosphite (7.8 mg, 0.025 mmol, 5.0 mol %), aryl iodides (0.75 mmol) and ketimine (0.5 mmol) were added. The mixture was then dissolved in MeCN (2.5 mL). The sealed tube was capped tightly, and placed in an oil-bath preheated to 60 °C with vigorous stirring. After 2-14h, the reaction mixture was cooled to room temperature, 5 mL of 6N HCl was added and shaken for about 2 minutes to hydrolyze the imines to ketones. The reaction mixture was then extracted with EtOAc (3 mL × 4) and the combined ethyl acetate fraction was dried over Na_2SO_4 and solvent was removed in a rotary evaporator. The product was purified by silica gel column chromatography using diethyl ether/hexanes as eluent.

Preparation of deuterated imine

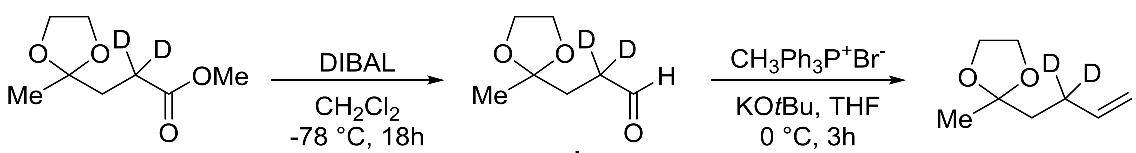


a b c

Ethyl 3-(2-methyl-1,3-dioxolan-2-yl) propanoate **b** was prepared following a literature procedure.[15]

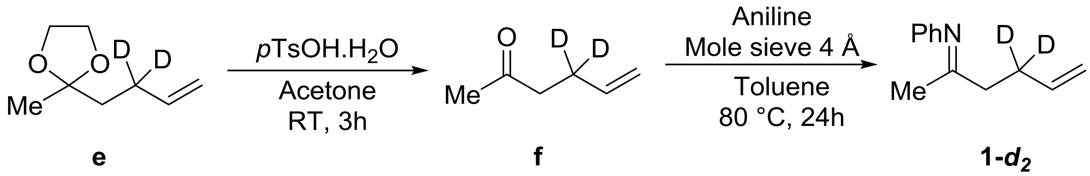
Deuterium labelling performed according to a literature procedure.[16] Sodium methoxide (324 mg, 6.0 mmol) was added to a MeOD (16 ml) solution of **b** (752.8 mg, 4.0 mmol) under nitrogen and the mixture was refluxed at 80 °C for 24 h. After the reaction was complete, reaction mixture was cooled to room temperature and D_2O (8 ml) was added. The mixture was then extracted with dichloromethane. Organic layer was dried over Na_2SO_4 and concentrated in vacuum to get (methyl 3-(2-methyl-1,3-dioxolan-2-yl) propanoate-2,2-d_2 as a colorless liquid (61 % yield).

^{1}H NMR (300 MHz, $CDCl_3$): 1.31 (s, 3H), 2.01 (s, 2H), 3.66 (s, 3H), 3.92-3.94 (m, 4H). **^{13}C NMR (75 MHz, $CDCl_3$):** δ 24.1, 28.7, 34.0, 51.7, 64.9, 109.3, 174.2.



c d e

3-(2-Methyl-1,3-dioxolan-2-yl) propanal-2,2-d_2 **d** was prepared from (methyl 3-(2-methyl-1,3-dioxolan-2-yl) propanoate-2,2-d_2 following literature procedure.[15] The crude product obtained was used without further purification in the next step. To a well stirred solution of $CH_3Ph_3P^+Br^-$ (785.8 mg, 2.2 mmol) and KO*t*Bu (224 mg, 2.0 mmol) in THF (5 ml), **d** was added dropwise at 0 °C. After 3h the reaction mixture was filtered through a short pad of silica and the filtrate was concentrated carefully in rotavapor. The crude mixture was then partially purified by flash column chromatography using hexanes. The olefin **e** obtained as a colorless liquid was used in the next step without further purification.[16]



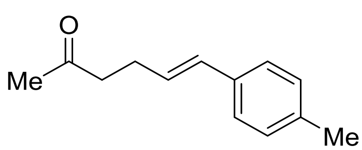
To a well- stirred solution of *p*TsOH.H_2O (14.2 mg, 5 mol%) in acetone (2 ml), 2-(but-3-en-1-yl-2,2-d_2)-2-methyl-1,3-dioxolane **e** was added at room temperature and the reaction mixture was left stirring for 4 h. The reaction mixture was then distilled to get hex-5-en-2-one-4,4-d_2 (**f**) [17] as a colorless liquid (65% yield).

^{1}H NMR (300 MHz, $CDCl_3$): 2.15 (s, 3H), 2.52 (s, 2H), 4.94-5.04 (m, 2H), 5.74-5.82 (m,1H).

N-phenylhex-5-en-2-imine-4,4-d_2 **1-*d₂*** was prepared following the general procedure for the preparation of imine using aniline and hex-5-en-2-one-4,4-d_2 at 80 °C for 24h. Then the reaction mixture was cooled to room temperature and filtered through a filter paper. Filtrate was concentrated in vacuum and the residue was purified by flash chromatography on a silica-gel column (deactivated by 10% TEA in hexanes) using hexanes as an eluent to get a yellow liquid with 86% deuterium incorporated in the imine.

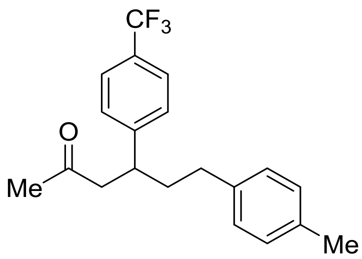
^{1}H NMR (300 MHz, $CDCl_3$): 1.78 (s, 0.80×3H), 2.17 (s, 0.20×3H), 2.23 (m, 0.20×2H), 2.50 (s, 0.80×2H), 4.94-5.14 (m, 2H), 5.61-5.69 (m, 0.20×1H), 5.90-5.96 (m, 0.80×1H), 6.69 (d, *J*=9.0 Hz, 2H), 7.03 (t, *J*=7.5 Hz, 1H), 7.28 (t, *J*=9.0 Hz, 2H).

2.6 Characterization data for new compounds



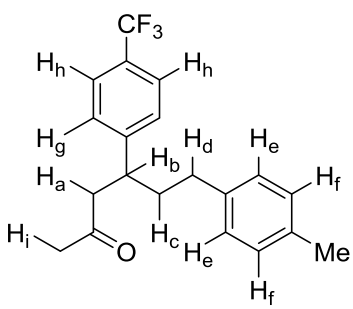
6-(p-Tolyl)hex-5-en-2-one ***(2)*****:** The title compound **2** was obtained as a colorless oil (69.6 mg, 74% yield) in 2h after purification by silica gel column chromatography (Hex : Et_2O = 20:1).

^{1}H NMR (300 MHz, $CDCl_3$): δ 2.17 (s, 3H), 2.32 (s, 3H), 2.48 (t, *J*=6.0 Hz, 2H), 2.61 (t, *J*=7.5 Hz, 2H), 6.09-6.19 (m, 1H), 6.38 (d, , *J*=15.0 Hz, 1H), 7.10 (d, *J*=9.0 Hz, 2H), 7.23 (d, *J*=9.0 Hz, 2H) ; **^{13}C NMR (75 MHz, $CDCl_3$):** δ 21.3, 27.3, 30.2, 43.4, 126.0, 127.9, 129.3, 130.7, 134.8, 137.0, 208.2 ; **IR (neat):** 2920, 1713, 1512, 1360, 1159 ; **HRMS (ESI):** Calcd for $C_{13}H_{17}O$ $(M+H)^+$ 189.1279, found 189.1272.

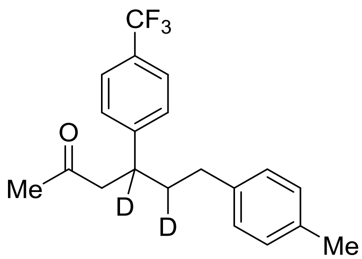


6-(p-Tolyl)-4-(4-(trifluoromethyl)phenyl)hexan-2-one ***(5)***: The title compound **5** was obtained as a yellow oil (117 mg, 70% yield) in 2h after purification by silica gel column chromatography (Hex : Ether = 10:1).

^{1}H NMR (300 MHz, $CDCl_3$): δ 1.82-2.01 (m, 2H), 2.03 (s, 3H), 2.32 (s, 3H), 2.41 (t, *J*=7.5 Hz, 2H), 2.77 (d, *J*=6.0 Hz, 2H), 3.22-3.32 (m, 1H), 6.99 (d, *J*=9.0 Hz, 2H), 7.09 (d, *J*=9.0 Hz, 2H), 7.34 (d, *J*=9.0 Hz, 2H), 7.59 (d, *J*=9.0 Hz, 2H); **^{13}C NMR (126 MHz, $CDCl_3$):** δ 21.1, 30.7, 33.2, 38.0, 40.6, 50.6, 124.4 (q, J_{CF}= 272.2 Hz), 125.6 (q, J_{CF}= 3.8 Hz), 128.1, 128.3, 128.9 (q, J_{CF}= 32.8 Hz), 129.2, 135.5, 138.5, 148.5, 207.0; **^{19}F NMR (282 MHz, $CDCl_3$)** δ -62.6; **IR (neat):** 3004, 2926, 1715, 1323, 1110, 1016; **HRMS (ESI):** Calcd for $C_{20}H_{21}F_3NaO$ $(M+Na)^+$ 357.1442, found 357.1432.

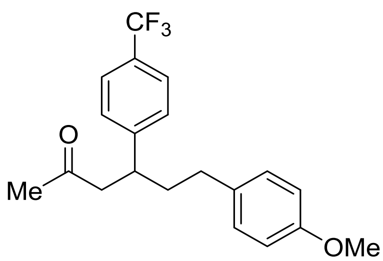


H_b NOE Correlations	H_g NOE Correlations
H_a 3.5 %	H_h 3.8 %
H_c 2.6 %	H_b 1.5 %
H_d 1.9 %	H_a 0.9 %
H_g 3.2 %	H_c 1.2 %



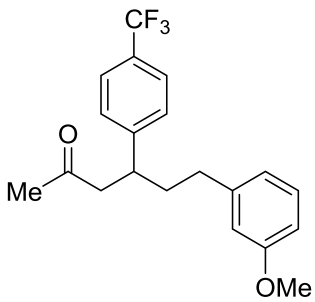
6-(p-Tolyl)-4-(4-(trifluoromethyl)phenyl)hexan-2-one-4,5-d_2 ***(5-d_2)*****:** The title compound **5-*d_2*** was obtained as a yellow oil (45.6 mg, 68% yield) in 2h after purification by silica gel column chromatography (Hex : Et_2O = 20:1).

^{1}H NMR (300 MHz, $CDCl_3$): δ 1.93-1.95 (m, 1H), 2.03 (s, 3H), 2.30 (s, 3H), 2.39 (d, *J*=9.0 Hz 2H), 2.75 (s, 2H), 6.97 (d, *J*=6.0 Hz, 2H), 7.07 (d, *J*=6.0 Hz, 2H), 7.32 (d, *J*=6.0 Hz, 2H), 7.57 (d, *J*=6.0 Hz, 2H).



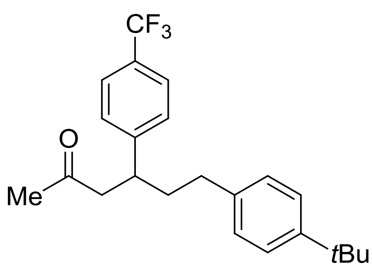
6-(4-Methoxyphenyl)-4-(4-(trifluoromethyl)phenyl)hexan-2-one ***(27)*****:** The title compound **27** was obtained as a yellow oil (120.9 mg, 69% yield) in 2h after purification by silica gel column chromatography (Hex : Ether = 10:1).

^{1}H NMR (500 MHz, $CDCl_3$): δ 1.83-1.91 (m, 1H), 1.94-2.01 (m, 1H), 2.03 (s, 3H), 2.39 (t, *J*=7.5 Hz, 2H), 2.76 (d, *J*=5.0 Hz, 2H), 3.22-3.28 (m, 1H), 3.78 (s, 3H), 6.81 (d, *J*=10.0 Hz, 2H), 7.0 (d, *J*=10.0 Hz, 2H), 7.33 (d, *J*=5.0 Hz, 2H), 7.58 (d, *J*=5.0 Hz, 2H) ; **^{13}C NMR (126 MHz, $CDCl_3$):** δ 30.7, 32.7, 38.1, 40.5, 50.6, 55.3, 113.9, 124.4 (q, J_{CF}= 272.2 Hz), 125.6 (q, J_{CF}= 3.8 Hz), 128.1, 128.9 (q, J_{CF}= 31.5 Hz), 129.3, 133.6, 148.5, 158.0, 207.0 ; **^{19}F NMR (282 MHz, $CDCl_3$)** δ -62.4 ; **IR (neat):** 2934, 1715, 1616, 1322, 1244, 1111 ; **HRMS (ESI):** Calcd for $C_{20}H_{21}F_3NaO_2$ $(M+Na)^+$ 373.1391, found 373.1380.



6-(3-Methoxyphenyl)-4-(4-(trifluoromethyl)phenyl)hexan-2-one **(28)**: The title compound **28** was obtained as a yellow oil (136.6 mg, 78% yield) in 2h after purification by silica gel column chromatography (Hex : Ether = 10:1).

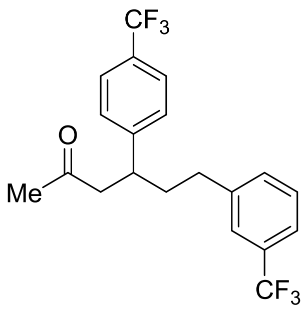
^{1}H NMR (300 MHz, CDCl$_3$): δ 1.85-2.01 (m, 2H), 2.03 (s, 3H), 2.42 (t, *J*=7.5 Hz, 2H), 2.77 (d, *J*=9.0 Hz, 2H), 3.24-3.31 (m, 1H), 3.78 (s, 3H), 6.63-6.74 (m, 3H), 7.18 (d, *J*=7.5 Hz, 1H), 7.33 (d, *J*=9.0 Hz, 2H), 7.58 (d, *J*=9.0 Hz, 2H) ; **^{13}C NMR (75 MHz, CDCl$_3$):** δ 30.7, 33.7, 37.7, 40.5, 50.6, 55.2, 111.3, 114.3, 120.8, 124.4 (q, J_{CF}= 270.0 Hz), 125.7 (q, J_{CF}= 3.8 Hz), 128.1, 128.9 (q, J_{CF}= 32.3 Hz), 129.5, 143.2, 148.4, 159.8, 206.9 ; **^{19}F NMR (282 MHz, CDCl$_3$)** δ -60.5 ; **IR (neat):** 3004, 2926, 1715, 1323, 1110, 1016; **HRMS (ESI):** Calcd for $C_{20}H_{21}F_3NaO_2$ $(M+Na)^+$ 373.1391, found 373.1380.



6-(4-(tert-Butyl)phenyl)-4-(4-(trifluoromethyl)phenyl)hexan-2-one ***(29)*****:** The title compound **29** was obtained as a yellow oil (86.6 mg, 46% yield) in 2h after purification by silica gel column chromatography (Hex : Ether = 20:1).

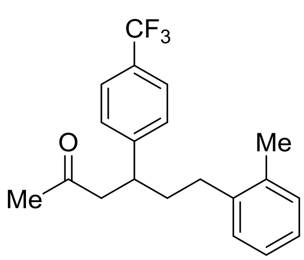
^{1}H NMR (300 MHz, CDCl$_3$): δ 1.29 (s, 9H), 1.87-2.07 (m, 2H), 2.02 (s, 3H), 2.38-2.44 (m, 2H), 2.76 (d, *J*=6.0 Hz, 2H), 3.22-3.32 (m, 1H), 7.02 (d, *J*=9.0 Hz, 2H), 7.28 (d, *J*=9.0 Hz, 2H), 7.33 (d, *J*=9.0 Hz, 2H), 7.57 (d, *J*=9.0 Hz, 2H) ; **^{13}C NMR (126 MHz, CDCl$_3$):** δ 30.7, 31.5, 33.1, 34.5, 37.9, 40.7, 50.7, 124.3 (q, J_{CF}= 252.0 Hz), 125.4, 125.6 (q, J_{CF}= 3.8 Hz), 128.0, 128.1, 128.9

(q, J_{CF}= 31.5 Hz),138.5, 148.5, 148.9, 207.0 ; **^{19}F NMR (282 MHz, CDCl$_3$)** δ -61.2; **IR (neat):** 2962, 1716, 1618, 1323, 1161, 1117 ; **HRMS (ESI):** Calcd for $C_{23}H_{27}F_3NaO$ $(M+Na)^+$ 399.1912, found 399.1904.



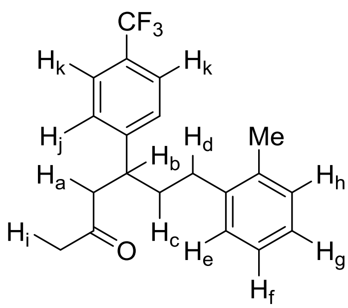
6-(3-(Trifluoromethyl)phenyl)-4-(4-(trifluoromethyl)phenyl)hexan-2-one ***(30)*****:** The title compound **30** was obtained as a yellow oil (102.9 mg, 53% yield) in 2h after purification by silica gel column chromatography (Hex : Ether = 20:1).

^{1}H NMR (300 MHz, CDCl$_3$): δ 1.83-2.03 (m, 2H), 2.04 (s, 3H), 2.46-2.53 (m, 2H), 2.78 (d, J=6.0 Hz, 2H), 3.21-3.30 (m, 1H), 7.26 (d, J=6.0 Hz, 1H), 7.32 (d, J=6.0 Hz, 3H), 7.37 (d, J=6.0 Hz, 1H), 7.43 (d, J=6.0 Hz, 1H), 7.58 (d, J=6.0 Hz, 2H) ; **^{13}C NMR (75 MHz, CDCl$_3$):** δ 30.6, 33.5, 37.4, 40.5, 50.6, 123.0 (q, J_{CF}= 3.8 Hz), 124.3 (q, J_{CF}= 270.0 Hz), 125.1 (q, J_{CF}= 3.8 Hz), 125.8 (q, J_{CF}= 3.8 Hz), 128.1, 128.9, 129.1 (q, J_{CF}= 30.8 Hz), 130.8 (q, J_{CF}= 31.5 Hz), 131.9, 142.5, 148.1, 206.7 ; **^{19}F NMR (282 MHz, CDCl$_3$)** δ -62.7, -62.8 ; **IR (neat):** 2928, 1716, 1618, 1322, 1110 ; **HRMS (ESI):** Calcd for $C_{20}H_{18}F_6NaO$ $(M+Na)^+$ 411.1160, found 411.1147.

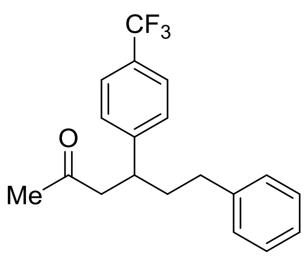


6-(o-Tolyl)-4-(4-(trifluoromethyl)phenyl)hexan-2-one ***(31)*****:** The title compound **31** was obtained as a colorless oil (75.2 mg, 45% yield) in 2h after purification by silica gel column chromatography (Hex : Ether = 10:1).

^{1}H NMR (300 MHz, CDCl$_3$): δ 1.79-2.01 (m, 2H), 2.05 (s, 3H), 2.16 (s, 3H), 2.31-2.53 (m, 2H), 2.79 (d, *J*=9.0 Hz, 2H), 3.27-3.37 (m, 1H), 7.02-7.04 (m, 1H), 7.08-7.14 (m, 3H), 7.36 (d, *J*=6.0 Hz, 2H), 7.59 (d, *J*=6.0 Hz, 2H); **^{13}C NMR (126 MHz, CDCl$_3$):** δ 19.2, 30.8, 31.3, 36.8, 41.0, 50.6, 124.4 (q, J_{CF}= 272.2 Hz), 125.7 (q, J_{CF}= 3.8 Hz), 126.1, 126.2, 128.1, 128.8, 129.0 (q, J_{CF}= 31.5 Hz), 130.4, 135.8, 139.9, 148.5, 206.9 ; **^{19}F NMR (282 MHz, CDCl$_3$)** δ -61.0 ; **IR (neat):** 3016, 1716, 1322, 1113, 1067, 1016 ; **HRMS (ESI):** Calcd for $C_{20}H_{21}F_3NaO$ $(M+Na)^+$ 357.1442, found 357.1431.

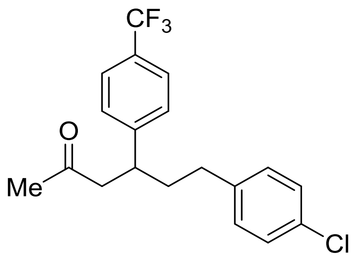


H_b NOE Correlations	H_j NOE Correlations
H_a 3.0 %	H_k 2.9 %
H_d 1.7 %	H_b 1.6 %
H_c 2.2 %	H_a 0.9 %
H_j 2.9 %	H_c 1.3 %



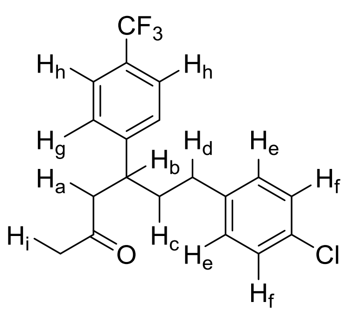
6-Phenyl-4-(4-(trifluoromethyl)phenyl)hexan-2-one ***(32)*****:** The title compound **32** was obtained as a colorless oil (96.1 mg, 60% yield) in 2h after purification by silica gel column chromatography (Hex : Ether = 20:1).

^{1}H NMR (300 MHz, CDCl$_3$): δ 1.85-2.07 (m, 2H), 2.03 (s, 3H), 2.44 (t, *J*=9.0 Hz, 2H), 2.77 (d, *J*=6.0 Hz, 2H), 3.22-3.31 (m, 1H), 7.09 (d, *J*=9.0 Hz, 2H), 7.14-7.20 (m, 1H), 7.26 (t, *J*=7.5 Hz, 2H), 7.33 (d, *J*=6.0 Hz, 2H), 7.58 (d, *J*=6.0 Hz, 2H), ; **^{13}C NMR (126 MHz, CDCl$_3$):** δ 30.7, 33.6, 37.9, 40.6, 50.6, 124.4 (q, J_{CF}= 272.2 Hz), 125.7 (q, J_{CF}= 3.8 Hz), 126.1, 128.1, 128.4, 128.5, 128.9 (q, J_{CF}= 32.8 Hz), 141.6, 148.5, 206.9 ; **^{19}F NMR (282 MHz, $CDCl_3$)** δ -62.6 ; **IR (neat):** 2927, 1715, 1322, 1160, 1109, 1067 ; **HRMS (ESI):** Calcd for $C_{19}H_{19}F_3NaO$ $(M+Na)^+$ 343.1286, found 343.1276.



6-(4-Chlorophenyl)-4-(4-(trifluoromethyl)phenyl)hexan-2-one ***(33)*****:** The title compound **33** was obtained as a yellow oil (124.2 mg, 70% yield) in 2h after purification by silica gel column chromatography (Hex : Ether = 10:1).

^{1}H NMR (300 MHz, $CDCl_3$): δ 1.81-2.02 (m, 2H), 2.04 (s, 3H), 2.40 (t, J=7.5 Hz, 2H), 2.76 (d, J=6.0 Hz, 2H), 3.19-3.28 (m, 1H), 7.00 (d, J=6.0 Hz, 2H), 7.22 (d, J=9.0 Hz, 2H), 7.31 (d, J=9.0 Hz, 2H), 7.58 (d, J=9.0 Hz, 2H) ; **^{13}C NMR (126 MHz, $CDCl_3$):** δ 30.7, 33.0, 37.6, 40.4, 50.6, 124.3 (q, J_{CF}= 272.2 Hz), 125.7 (q, J_{CF}= 3.8 Hz), 128.1, 128.6,, 129.1(q, J_{CF}= 32.8 Hz), 129.8, 131.8, 140.0, 148.2, 206.8 ; **^{19}F NMR (282 MHz, $CDCl_3$)** δ -62.5 ; **IR (neat):** 2928, 1715, 1322, 1160, 1110, 1068 ; **HRMS (ESI):** Calcd for $C_{19}H_{18}ClF_3NaO$ $(M+Na)^+$ 377.0896, found 377.0882.



H_e NOE correlations	H_g NOE correlations	H_a NOE correlations
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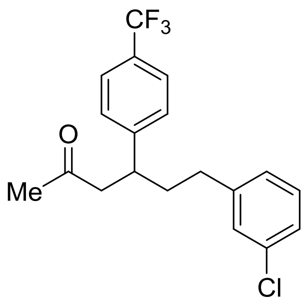
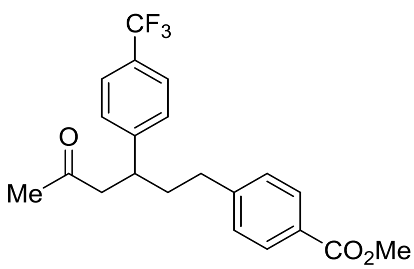
H_d 0.93 %	H_b 1.7 %	H_d 0.4 %
H_c 0.64 %	H_a 1.0 %	H_c 1.4 %
	H_d 0.5 %	H_i 0.9 %
	H_c 1.5 %	H_g 1.2 %



6-(3-Chlorophenyl)-4-(4-(trifluoromethyl)phenyl)hexan-2-one ***(34)*****:** The title compound **34** was obtained as a yellow oil (106.2 mg, 60% yield) in 2h after purification by silica gel column chromatography (Hex : Et_2O = 10:1).

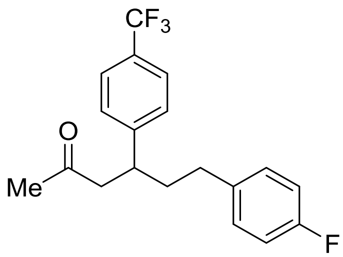
^{1}H NMR (300 MHz, $CDCl_3$): δ 1.80-2.01 (m, 2H), 2.04 (s, 3H), 2.37-2.46 (m, 2H), 2.77 (d, *J*=6.0 Hz, 2H), 3.20-3.30 (m, 1H), 6.95 (d, *J*=6.0 Hz, 1H), 7.06 (s, 1H), 7.13 - 7.20 (m, 2H), 7.32 (d, *J*=9.0 Hz, 2H), 7.58 (d, *J*=9.0 Hz, 2H) ; **^{13}C NMR (75 MHz, $CDCl_3$):** δ 30.7, 33.4, 37.5, 40.5, 50.6, 124.3(q, J_{CF}= 270.0 Hz), 125.7 (q, J_{CF}= 4.5 Hz), 126.3, 126.6, 128.1, 128.5, 128.9, 129.1(q, J_{CF}= 32.3 Hz), 134.3, 143.7, 148.2, 206.7 ; **^{19}F NMR (282 MHz, $CDCl_3$)** δ -60.9 ; **IR (neat):** 2928, 1771, 1322, 1160, 1110, 1068 ; **HRMS (ESI):** Calcd for $C_{19}H_{18}ClF_3NaO$ $(M+Na)^+$ 377.0896, found 377.0884.



Methyl 4-(5-oxo-3-(4-(trifluoromethyl)phenyl)hexyl)benzoate ***(35)*****:** The title compound **35** was obtained as a yellow oil (113.5 mg, 60% yield) in 2h after purification by silica gel column chromatography (Hex : Et_2O = 5:1).

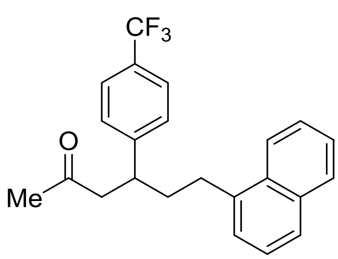
^{1}H NMR (300 MHz, $CDCl_3$): δ 1.85-2.08 (m, 2H), 2.03 (s, 3H), 2.48 (t, *J*=9.0 Hz, 2H), 2.77 (d, *J*=9.0 Hz, 2H), 3.20-3.28 (m, 1H), 3.89 (s, 3H), 7.14 (d, *J*=9.0 Hz, 2H), 7.32 (d, *J*=9.0 Hz, 2H), 7.58 (d, *J*=9.0 Hz, 2H), 7.93 (d, *J*=9.0 Hz, 2H) ; **^{13}C NMR (126 MHz, $CDCl_3$):** δ 30.7, 33.7, 37.3, 40.5, 50.6, 52.1, 124.3 (q, J_{CF}= 272.2 Hz), 125.7 (q, J_{CF}= 3.8 Hz), 128.1, 128.5, 129.1 (q, J_{CF}=

32.8 Hz), 129.9, 147.1, 148.2, 167.2, 206.7 ; **^{19}F NMR (282 MHz, CDCl$_3$)** δ -61.2 ; **IR (neat):** 2920, 1713, 1512, 1409, 1159 ; **HRMS (ESI):** Calcd for $C_{21}H_{22}F_3O_3$ $(M+H)^+$ 379.1521, found 379.1515.



6-(4-Fluorophenyl)-4-(4-(trifluoromethyl)phenyl)hexan-2-one ***(36)*****:** The title compound **36** was obtained as a yellow oil (93.0 mg, 55% yield) in 2h after purification by silica gel column chromatography (Hex : Ether = 20:1).

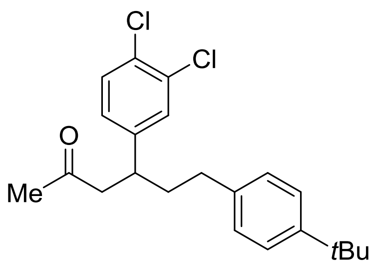
^{1}H NMR (300 MHz, CDCl$_3$): δ 1.84-2.02 (m, 2H), 2.03 (s, 3H), 2.41 (t, *J*= 7.5 Hz, 2H), 2.77 (d, *J*=9.0 Hz, 2H), 3.19-3.28 (m, 1H), 6.90-6.96 (m, 2H), 6.99 - 7.05 (m, 2H), 7.32 (d, *J*=9.0 Hz, 2H), 7.58 (d, *J*=9.0 Hz, 2H) ; **^{13}C NMR (126 MHz, CDCl$_3$):** δ 30.7, 32.8, 37.9, 40.4, 50.6, 115.2 (d, J_{CF}= 21.4 Hz), 124.3(q, J_{CF}= 272.2 Hz), 125.7 (q, J_{CF}= 3.8 Hz), 128.1, 129.3 (q, J_{CF}= 31.5 Hz),129.7 (d, J_{CF}= 7.6 Hz), 137.2 (d, J_{CF}= 2.5 Hz 148.3, 161.4 (d, J_{CF}= 243.2 Hz), 206.9 ; **^{19}F NMR (282 MHz, CDCl$_3$)** δ -116.3, -61.2 ; **IR (neat):** 2928, 1715, 1652, 1508, 1322, 1110 ; **HRMS (ESI):** Calcd for $C_{19}H_{18}F_4NaO$ $(M+Na)^+$ 361.1191 found 361.1197.



6-(Naphthalen-1-yl)-4-(4-(trifluoromethyl)phenyl)hexan-2-one ***(37)*****:** The title compound **37** was obtained as a yellow oil (75.9 mg, 41% yield) in 2h after purification by silica gel column chromatography (Hex : Ether = 20:1).

^{1}H NMR (300 MHz, CDCl$_3$): δ 1.96-2.19 (m, 2H), 2.03 (s, 3H), 2.80 (d, *J*=9.0 Hz, 2H), 2.85-2.98 (m, 2H), 3.35-3.45 (m, 1H), 7.22 (d, *J*=6.0 Hz, 1H), 7.36 (d, *J*=9.0 Hz, 1H), 7.41 (d, *J*=6.0

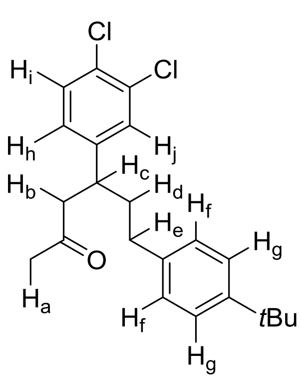
Hz, 2H), 7.47 (dd, J=3.0 Hz, 6.0 Hz, 2H), 7.63 ((d, J=9.0 Hz, 2H), 7.71 (d, J=9.0 Hz, 1H), 7.78 (dd, J=3.0 Hz, 6.0 Hz, 1H), 7.85 (dd, J=3.0 Hz, 6.0 Hz, 1H) ; **^{13}C NMR (126 MHz, CDCl$_3$):** δ 30.7, 31.0, 37.4, 41.1, 50.6, 123.6, 124.4 (q, J_{CF}= 270.9 Hz), 125.6, 125.6, 125.7(q, J_{CF}= 3.8 Hz), 126.0, 126.0, 126.9, 128.2, 128.9 (q, J_{CF}= 28.9 Hz), 129.0, 131.7, 134.0, 137.9, 148.5, 206.9 ; **^{19}F NMR (282 MHz, CDCl$_3$)** δ -62.6 ; **IR (neat):** 3046, 2935, 1714, 1261, 1066, 1015; **HRMS (ESI):** Calcd for $C_{23}H_{21}F_3NaO$ (M+Na)$^+$ 393.1442, found 393.1436.



6-(4-(tert-Butyl)phenyl)-4-(3,4-dichlorophenyl)hexan-2-one ***(38)*****:** The title compound **38** was obtained as a colorless oil (98.1 mg, 52% yield) in 4h after purification by silica gel column chromatography (Hex : Et_2O = 10:1).

^{1}H NMR (300 MHz, CDCl$_3$): δ 1.30 (s, 9H), 1.78-2.00 (m, 2H), 2.03 (s, 3H), 2.41 (t, J=9.0 Hz, 2H), 2.72 (d, J=6.0 Hz, 2H), 3.11-3.21 (m, 1H), 7.00-7.06 (m, 3H), 7.28 (d, J=6.0 Hz, 3H), 7.37 (d, J=9.0 Hz, 1H) ; **^{13}C NMR (75 MHz, CDCl$_3$):** δ 30.8, 31.5, 33.1, 34.5, 37.8, 40.1, 50.6, 125.4, 127.4, 128.1, 129.7, 130.6, 132.7, 138.4, 144.8, 148.9, 206.8 ; **IR (neat):** 2960, 1716, 1470, 1361, 1109, 1029 ; **HRMS (ESI):** Calcd for $C_{22}H_{26}Cl_2NaO$ (M+Na)$^+$ 399.1258, found 399.1258.

H_c NOE correlations



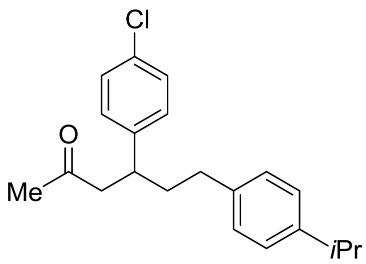
H_b 2.1 %

H_e 0.9 %

H_d 1.5 %

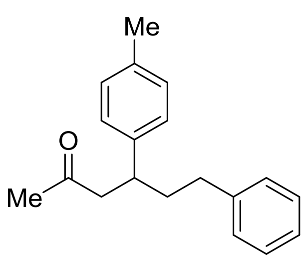
H_j 1.3 %

H_h 1.5 %



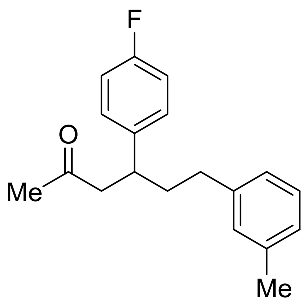
4-(4-Chlorophenyl)-6-(4-isopropylphenyl)hexan-2-one ***(39)*****:** The title compound **39** was obtained as a yellow oil (83.6 mg, 51% yield) in 4h after purification by silica gel column chromatography (Hex : Et_2O = 10:1).

^{1}H NMR (300 MHz, $CDCl_3$): δ 1.23 (d, *J*=6.0 Hz, 6H), 1.79-1.97 (m, 2H), 2.00 (s, 3H), 2.40 (t, *J*=7.5 Hz, 2H), 2.72 (d, *J*=9.0 Hz, 2H), 2.82-2.91 (m, 1H), 3.11-3.21 (m, 1H), 7.01(d, *J*=9.0 Hz, 2H), 7.13 (d, *J*=9.0 Hz, 4H), 7.29 (d, *J*=9.0 Hz, 2H) ; **^{13}C NMR (75 MHz, $CDCl_3$):** δ 24.2, 30.8, 33.2, 33.8, 38.1, 40.4, 50.9, 126.5, 128.3, 128.8, 129.1, 132.2, 139.1, 142.8, 146.6, 207.4 ; **IR (neat):** 2958, 1714, 1491, 1359, 1061, 1013 ; **HRMS (ESI):** Calcd for $C_{21}H_{25}ClNaO$ $(M+Na)^+$ 351.1492, found 351.1473.



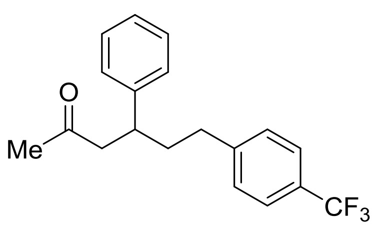
6-Phenyl-4-(p-tolyl) hexan-2-one ***(40)*****:** The title compound **40** was obtained as a yellow oil (55.9 mg, 42% yield) in 2h after purification by silica gel column chromatography (Hex: Et_2O = 10:1).

^{1}H NMR (300 MHz, $CDCl_3$): δ 1.81-1.97 (m, 2H), 2.00 (s, 3H), 2.35 (s, 3H), 2.46 (t, *J*=9.0 Hz, 2H), 2.73 (d, *J*=9.0 Hz, 2H), 3.09-3.19 (m, 1H), 7.10-7.17 (m, 7H), 7.24-7.29 (m, 2H) ; **^{13}C NMR (75 MHz, $CDCl_3$):** δ 21.2, 30.7, 33.8, 38.2, 40.7, 51.2, 125.9, 127.6, 128.4, 128.5, 129.4, 136.1, 141.0, 142.2, 207.9 ; **IR (neat):** 2928, 1771, 1652, 1540, 1507 ; **HRMS (ESI):** Calcd for $C_{19}H_{23}O$ $(M+H)^+$ 267.1749, found 267.1726.



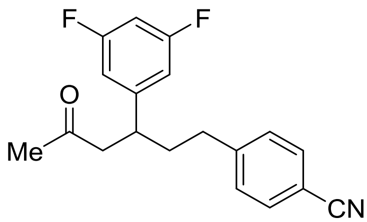
4-(4-Fluorophenyl)-6-(m-tolyl)hexan-2-one ***(41)*****:** The title compound **41** was obtained as a yellow oil (86.7 mg, 61% yield) in 4h after purification by silica gel column chromatography (Hex : Et_2O = 20:1).

^{1}H NMR (300 MHz, $CDCl_3$): δ 1.79-1.97 (m, 2H), 2.01 (s, 3H), 2.31 (s, 3H), 2.40 (t, *J*=9.0 Hz, 2H), 2.72 (d, *J*=6.0 Hz, 2H), 3.12-3.22 (m, 1H), 6.89 (d, *J*=9.0 Hz, 2H), 6.98-7.04 (m, 3H), 7.12-7.20 (m, 3H) ; **^{13}C NMR (75 MHz, $CDCl_3$):** δ 21.5, 30.8, 33.6, 38.3, 40.3, 51.1, 115.5 (d, J_{CF}= 20.3 Hz), 125.4, 126.7, 129.1, 129.2 (d, J_{CF}= 6.0 Hz), 138.0, 139.9, 141.9, 161.6 (d, J_{CF}= 243.0 Hz), 207.6 ; **^{19}F NMR (282 MHz, $CDCl_3$)** δ -115.1 ; **IR (neat):** 2922, 1715, 1604, 1508, 1221, 1158 ; **HRMS (ESI):** Calcd for $C_{19}H_{21}FNaO$ $(M+Na)^+$ 307.1474, found 307.1461.



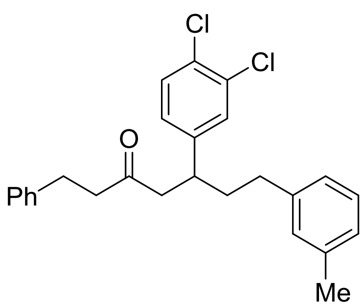
4-Phenyl-6-(4-(trifluoromethyl)phenyl)hexan-2-one ***(42)*****:** The title compound **42** was obtained as a yellow oil (81.7 mg, 51% yield) in 4h after purification by silica gel column chromatography (Hex : Et_2O = 20:1).

^{1}H NMR (300 MHz, $CDCl_3$): δ 1.84-2.07 (m, 2H), 2.01 (s, 3H), 2.50 (t, *J*=7.5 Hz, 2H), 2.68-2.82 (m, , 2H), 3.12-3.21 (m, 1H), 7.18-7.26 (m, 5H), 7.30-7.36 (m, 2H), 7.50 (d, *J*=9.0 Hz, 2H) ; **^{13}C NMR (126 MHz, $CDCl_3$):** δ 30.8, 33.6, 37.7, 40.9, 51.0, 124.5 (q, J_{CF}= 272.2 Hz), 125.3 (q, J_{CF}= 3.8 Hz), 126.8, 127.7, 128.3 (q, J_{CF}= 31.5 Hz), 128.8, 128.8, 143.8, 146.2, 207.6; **^{19}F NMR (282 MHz, $CDCl_3$)** δ -62.3;**IR (neat):** 2928, 1714, 1617, 1322, 1108 ; **HRMS (ESI):** Calcd for $C_{19}H_{19}F_3NaO$ $(M+Na)^+$ 343.1286, found 343.1275.



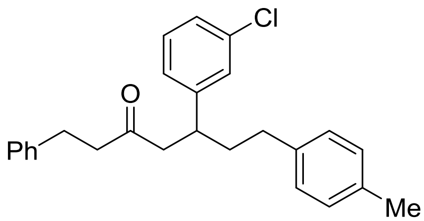
4-(3-(3,5-Difluorophenyl)-5-oxohexyl)benzonitrile ***(43)*****:** The title compound **43** was obtained as a yellow oil (75.2 mg, 48% yield) in 4h after purification by silica gel column chromatography (Hex: DCM = 3:2).

^{1}H NMR (300 MHz, $CDCl_3$): δ 1.74-1.87 (m, 1H), 1.93- 2.04 (m, 1H), 2.07 (s, 3H), 2.50 (t, *J*=9.0 Hz, 2H), 2.73 (d, *J*=6.0 Hz, 2H), 3.12-3.21 (m, 1H), 6.65-6.74 (m, 3H), 7.19 (d, *J*=6.0 Hz, 2H), 7.55 (d, *J*=6.0 Hz, 2H) ; **^{13}C NMR (75 MHz, $CDCl_3$):** δ 30.7, 33.8, 36.9, 40.3, 50.3, 102.4 (t, J_{CF}= 25.1 Hz), 110.1, 110.5 (dd, J_{CF}= 7.5, 16.5 Hz), 119.1, 129.2, 132.3, 147.1, 148.0 (t, J_{CF}= 8.3 Hz), 163.3 (dd, J_{CF}= 13.1, 247.5 Hz), 206.3 ; ; **^{19}F NMR (282 MHz, $CDCl_3$)** δ -107.9 ; **IR (neat):** 2929, 1714, 1594, 1416, 1115 ; **HRMS (ESI):** Calcd for $C_{19}H_{18}F_2NO$ $(M+H)^+$ 314.1356, found 314.1361.



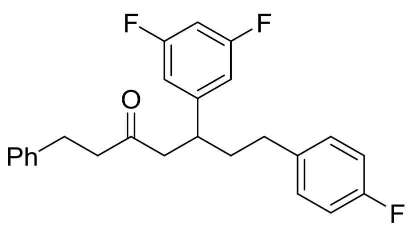
5-(3,4-Dichlorophenyl)-1-phenyl-7-(m-tolyl)heptan-3-one ***(44)*****:** The title compound **44** was obtained as a yellow oil (137.8 mg, 65% yield) in 6h after purification by silica gel column chromatography (Hex : Et_2O = 10:1).

^{1}H NMR (300 MHz, $CDCl_3$): δ 1.73-1.98 (m, 2H), 2.32 (s, 3H), 2.39 (t, *J*=7.5 Hz, 2H), 2.49-2.63 (m, 2H), 2.67 (d, *J*=6.0 Hz, 2H), 2.81 (t, *J*=7.5 Hz, 2H), 3.11-3.21 (m, 1H), 6.89 (s, 1H), 7.01 (t, *J*=9.0 Hz, 2H), 7.09 (d, *J*=6.0 Hz, 2H), 7.13-7.20 (m, 3H), 7.23-7.28 (m, 3H), 7.37 (d, *J*=9.0 Hz, 1H) ; **^{13}C NMR (75 MHz, $CDCl_3$):** δ 21.5, 29.7, 33.6, 37.8, 40.0, 45.0, 50.0, 125.4, 126.3, 126.8, 127.3, 128.4, 128.4, 128.6, 129.2, 129.7, 130.5, 130.6, 132.6, 138.0, 140.9, 141.4, 144.7, 208.0 ; **IR (neat):** 2924, 1712, 1468, 1363, 1092 ; **HRMS (ESI):** Calcd for $C_{26}H_{26}Cl_2ONa$ $(M+Na)^+$ 447.1258, found 447.1252.



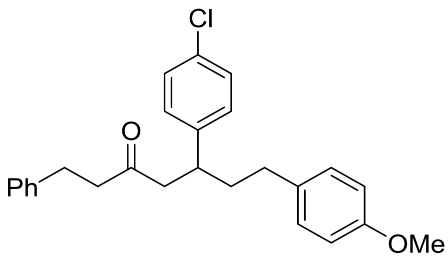
5-(3-Chlorophenyl)-1-phenyl-7-(p-tolyl)heptan-3-one ***(45)*****:** The title compound **45** was obtained as a yellow oil (158.0 mg, 81% yield) in 6h after purification by silica gel column chromatography (Hex : Et_2O = 10:1).

^{1}H NMR (300 MHz, $CDCl_3$): δ 1.79-2.01 (m, 2H), 2.35 (s, 3H), 2.43 (t, *J*=7.5 Hz, 2H), 2.50-2.67 (m, 2H), 2.71 (d, *J*=6.0 Hz, 2H), 2.81-2.86 (m, 2H), 3.16-3.25 (m, 1H), 7.01 (d, *J*=6.0 Hz, 2H), 7.09-7.14 (m, 5H), 7.21-7.31 (m, 6H) ; **^{13}C NMR (75 MHz, $CDCl_3$):** δ 21.1, 29.6, 33.2, 37.9, 40.5, 45.0, 50.1, 126.1, 126.2, 126.8, 127.7, 128.3, 128.4, 128.6, 129.1, 129.9, 134.5, 135.4, 138.6, 141.0, 146.5, 208.2 ; **IR (neat):** 2922, 1712, 1453, 1080, 1030 ; **HRMS (ESI):** Calcd for $C_{26}H_{28}ClO$ $(M+H)^+$ 391.1829, found 391.1830.



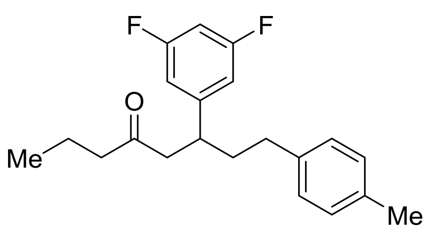
5-(3,5-Difluorophenyl)-7-(4-fluorophenyl)-1-phenylheptan-3-one ***(46)*****:** The title compound **46** was obtained as a yellow oil (120.8 mg, 61% yield) in 6h after purification by silica gel column chromatography (Hex: Et_2O = 20:1).

^{1}H NMR (300 MHz, $CDCl_3$): δ 1.74-1.99 (m, 2H), 2.43 (t, *J*=7.5 Hz, 2H), 2.55-2.75 (m, 4H), 2.86 (t, *J*=7.5 Hz, 2H), 3.16-3.25 (m, 1H), 6.67-6.77 (m, 3H), 6.95-7.08 (m, 4H), 7.14 (d, *J*=9.0 Hz 2H), 7.18-7.32 (m, 3H) ; **^{13}C NMR (75 MHz, $CDCl_3$):** δ 29.7, 32.8, 37.7, 40.4, 45.0, 49.8, 102.2 (t, J_{CF}= 25.1 Hz), 110.5 (dd, J_{CF}= 7.5, 16.5 Hz), 115.3 (d, J_{CF}= 21.0 Hz), 126.3, 128.5 (d, J_{CF}= 18.8 Hz), 129.7 (d, J_{CF}= 8.3 Hz), 137.1 (d, J_{CF}= 3.0 Hz), 140.8, 148.4 (t, J_{CF}= 8.3 Hz), 159.8, 163.2 (dd, J_{CF}= 12.8, 247.5 Hz), 163.0, 207.8 ; ; **^{19}F NMR (282 MHz, $CDCl_3$)** δ -116.0, 108.2; **IR (neat):** 2928, 1714, 1594, 1508, 1115 ; **HRMS (ESI):** Calcd for $C_{25}H_{24}F_3O$ $(M+H)^+$ 397.1779, found 397.1785



5-(4-Chlorophenyl)-7-(4-methoxyphenyl)-1-phenylheptan-3-one ***(47)*****:** The title compound **47** was obtained as a yellow oil (126.2 mg, 62% yield) in 6h after purification by silica gel column chromatography (Hex: Et_2O = 10:1).

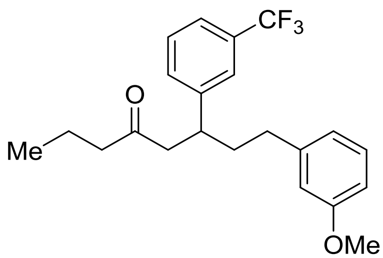
^{1}H NMR (300 MHz, $CDCl_3$): δ 1.76-1.97 (m, 2H), 2.37 (t, *J*=9.0 Hz, 2H), 2.48-2.63 (m, 2H), 2.68 (d, *J*=9.0 Hz, 2H), 2.79 (t, *J*=9.0 Hz, 2H), 3.11-3.20 (m, 1H), 3.79 (s, 3H), 6.81 (d, *J*=6.0 Hz, 2H), 7.00 (d, *J*=9.0 Hz, 2H), 7.07-7.12 (m, 4H), 7.18-7.29 (m, 5H) ; **^{13}C NMR (75 MHz, $CDCl_3$):** δ 29.6, 32.7, 38.1, 40.2, 45.1, 50.3, 55.4, 113.9, 126.2, 128.4, 128.6, 128.8, 129.1, 129.3, 132.2, 133.8, 141.0, 142.7, 157.9, 208.5 ; **IR (neat):** 2930, 1734, 1511, 1242, 1034 ; **HRMS (ESI):** Calcd for $C_{26}H_{27}ClNaO_2$ $(M+Na)^+$ 429.1597, found 429.1590.



6-(3,5-Difluorophenyl)-8-(p-tolyl) octan-4-one ***(48)*****:** The title compound **48** was obtained as a yellow oil (125.6 mg, 76% yield) in 6h after purification by silica gel column chromatography (Hex: Et_2O = 10:1).

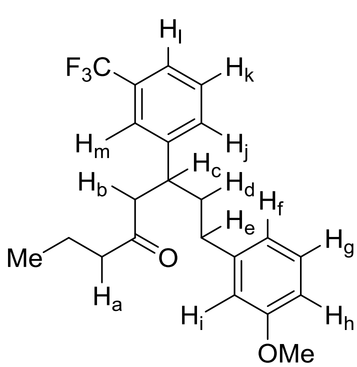
^{1}H NMR (300 MHz, $CDCl_3$): δ 0.84 (t, *J*=7.5 Hz, 3H), 1.46-1.58 (m, 2H), 1.77-1.99 (m, 2H), 2.16- 2.27 (m, 2H), 2.31 (s, 3H), 2.42 (t, *J*=7.5 Hz, 2H), 2.68 (d, *J*=6.0 Hz, 2H), 3.16-3.25 (m, 1H), 6.62-6.78 (m, 3H), 6.99 (d, *J*=9.0 Hz, 2H), 7.08 (d, *J*=6.0 Hz, 2H) ; **^{13}C NMR (75 MHz,**

$CDCl_3$): δ 13.7, 17.2, 21.1, 33.2, 37.9, 40.6, 45.5, 49.6, 102.0 (t, J_{CF}= 25.5 Hz), 110.6 (dd, J_{CF}= 7.5, 16.5 Hz), 128.3, 129.2, 135.6, 138.5, 148.7 (t, J_{CF}= 7.9 Hz), 163.2 (dd, J_{CF}= 13.1, 246.0 Hz), 209.0 ; **^{19}F NMR (282 MHz, $CDCl_3$)** δ -108.4 **IR (neat):** 2931, 1712, 1622, 1594, 1115 ; **HRMS (ESI):** Calcd for $C_{21}H_{25}F_2O$ $(M+H)^+$ 331.1873, found 331.1869.

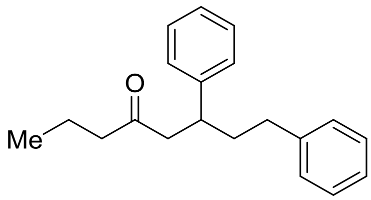


8-(3-Methoxyphenyl)-6-(3-(trifluoromethyl)phenyl)octan-4-one ***(49)*****:** The title compound **49** was obtained as a yellow oil (140.0 mg, 74% yield) in 6h after purification by silica gel column chromatography (Hex : Et_2O = 10:1).

^{1}H NMR (300 MHz, $CDCl_3$): δ 0.81(t, J=7.5 Hz, 3H), 1.44-1.53 (m, 2H), 1.85-2.07 (m, 2H), 2.14-2.34 (m, 2H), 2.42 (t, J=7.5 Hz, 2H), 2.71 (d, J=6.0 Hz, 2H), 3.24-3.33 (m, 1H), 3.78 (s, 3H), 6.62-6.74 (m, 3H), 7.18 (t, J=7.5 Hz, 1H), 7.40-7.50 (m, 4H) ; **^{13}C NMR (75 MHz, $CDCl_3$):** δ 13.7, 17.2, 33.7, 37.7, 40.6, 45.5, 49.8, 55.2, 111.4, 114.2, 120.8, 123.5(q, J_{CF}= 3.8 Hz), 124.3 (q, J_{CF}= 3.8 Hz), 124.4 (q, J_{CF}= 269.3 Hz), 129.1, 129.5, 130.8 (q, J_{CF}= 31.5 Hz), 131.4, 143.3, 145.4, 159.8, 209.2, ; **^{19}F NMR (282 MHz, $CDCl_3$)** δ -61.0 ; **IR (neat):** 2935, 1712, 1325, 1120, 1043 ; **HRMS (ESI):** Calcd for $C_{22}H_{26}F_3O_2$ $(M+H)^+$ 379.1885, found 379.1887

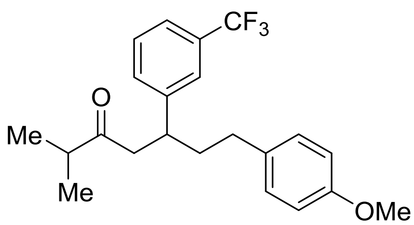


H_b NOE correlations	H_e NOE correlations
H_c 1.4 %	H_c 1.3 %
H_e 0.5 %	H_b 0.6 %
H_a 1.4 %	H_d 1.8 %
H_d 2.0 %	H_i 1.0 %
	H_f 1.0 %



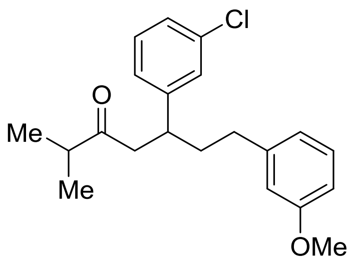
6, 8-Diphenyloctan-4-one ***(50)*****:** The title compound **50** was obtained as a yellow oil (72.8 mg, 52% yield) in 6h after purification by silica gel column chromatography (Hex: DCM = 4:1).

^{1}H NMR (300 MHz, $CDCl_3$): δ 0.81 (t, *J*=7.5 Hz, 3H), 1.49 (q, *J*=6.0 Hz, 2H), 1.89-2.00 (m, 2H), 2.18-2.27 (m, 2H), 2.46 (t, *J*=9.0 Hz, 2H), 2.64-2.78 (m, 2H), 3.16-3.25 (m, 1H), 7.10 (d, *J*=6.0 Hz, 2H), 7.17-7.35 (m, 8H) ; **^{13}C NMR (75 MHz, $CDCl_3$):** δ 13.8, 17.1, 33.8, 38.1, 41.1, 45.6, 50.3, 125.9, 126.6, 127.8, 128.4, 128.5, 128.7, 142.2, 144.3, 210.0 ; **IR (neat):** 2930, 1710, 1453, 1369, 1123; **HRMS (ESI):** Calcd for $C_{20}H_{25}O$ $(M+H)^+$ 281.1905, found 281.1907.



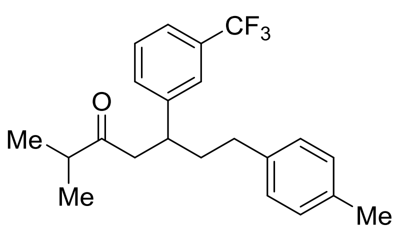
2-Methyl-7-(p-tolyl)-6-(3-(trifluoromethyl)phenyl)heptan-3-one ***(51)*****:** The title compound **51** was obtained as a yellow oil (112.2 mg, 62% yield) in 2h after purification by silica gel column chromatography (Hex : Et_2O = 20:1).

^{1}H NMR (300 MHz, $CDCl_3$): δ 0.93 (d, *J*=6.0 Hz, 3H), 1.01 (d, *J*=6.0 Hz, 3H) 1.81-2.03 (m, 2H), 2.36-2.49 (m, 3H), 2.77 (d, *J*=6.0 Hz, 2H), 3.24-3.33 (m, 1H), 3.78 (s, 3H), 6.81 (d, *J*=9.0 Hz, 2H), 7.00 (d, *J*=9.0 Hz, 2H),7.39-7.49 (m, 4H) ; **^{13}C NMR (75 MHz, $CDCl_3$):** δ 17.8, 18.0, 32.8, 37.9, 40.3, 41.3, 47.5, 55.2, 113.9, 122.5, 123.4 (q, J_{CF}= 3.8 Hz), 124.3 (q, J_{CF}= 270.0 Hz), 124.3 (q, J_{CF}= 3.8 Hz), 126.1, 129.0, 129.3, 130.9 (q, J_{CF}= 31.5 Hz), 131.5, 133.7, 145.7, 157.9, 212.7 ; **^{19}F NMR (282 MHz, $CDCl_3$)** δ -61.0 ; **IR (neat):** 2934, 1709, 1511, 1325, 1120 ; **HRMS (ESI):** Calcd for $C_{22}H_{25}F_3NaO_2$ $(M+Na)^+$ 401.1704, found 401.1691.



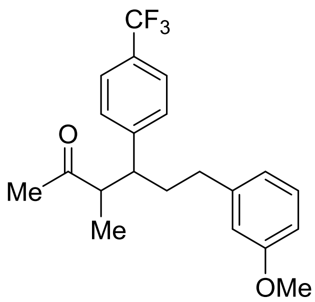
*5-(3-Chlorophenyl)-7-(3-methoxyphenyl)-2-methylheptan-3-one **(52)***: The title compound **52** was obtained as a colorless oil (108.4 mg, 63% yield) in 2h after purification by silica gel column chromatography (Hex: Et_2O = 20:1).

^{1}H NMR (300 MHz, $CDCl_3$): δ 0.94 (d, *J*=6.0 Hz, 3H), 1.02(d, *J*=9.0 Hz, 3H) 1.78-2.02 (m, 2H), 2.39-2.48 (m, 3H), 2.74 (dd, *J*=3.0 Hz, 6.0 Hz, 2H), 3.16-3.25 (m, 1H), 3.78 (s, 3H), 6.63-6.73 (m, 3H), 7.08-7.27 (m, 5H) ; **^{13}C NMR (75 MHz, $CDCl_3$):** δ 17.9, 18.0, 33.8, 37.6, 40.4, 41.5, 47.6, 55.2, 111.3, 114.2, 120.8, 126.2, 126.7, 127.8, 129.4, 129.9, 134.4, 143.5, 146.7, 159.7, 212.8 ; **IR (neat):** 2934, 1708, 1595, 1456, 1259, 1043 ; **HRMS (ESI):** Calcd for $C_{21}H_{26}ClO_2$ $(M+H)^+$ 345.1621, found 345.1631.



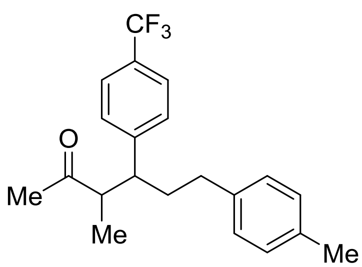
*2-Methyl-7-(p-tolyl)-5-(3-(trifluoromethyl)phenyl)heptan-3-one **(53)***: The title compound **53** was obtained as a yellow oil (99.6 mg, 55% yield) in 2h after purification by silica gel column chromatography (Hex : Et_2O = 10:1).

^{1}H NMR (300 MHz, $CDCl_3$): δ 0.96 (d, *J*=6.0 Hz, 3H), 1.05 (d, *J*=6.0 Hz, 3H), 1.89-2.09 (m, 2H), 2.34 (s, 3H), 2.42-2.52 (m, 3H), 2.81 (d, *J*=6.0 Hz, 2H), 3.29-3.39 (m, 1H), 7.01 (d, *J*=6.0 Hz, 2H), 7.11 (d, *J*=9.0 Hz, 2H), 7.43-7.51 (m, 4H) ; **^{13}C NMR (75 MHz, $CDCl_3$):** δ 17.8, 18.0, 21.0, 33.3, 37.9, 40.4, 41.3, 47.6, 123.4 (q, J_{CF}= 3.8 Hz), 124.3 (q, J_{CF}= 270.0 Hz), 124.3 (q, J_{CF}= 3.8 Hz), 128.3, 129.0, , 129.2, 130.8 (q, J_{CF}= 32.3 Hz) , 131.5, 135.4, 138.6, 145.7, 212.6 ; **^{19}F NMR (282 MHz, $CDCl_3$)** δ -61.0 ; **IR (neat):** 2970, 1710, 1325, 1121, 1072 ; **HRMS (ESI):** Calcd for $C_{22}H_{25}F_3NaO$ $(M+Na)^+$ 385.1755, found 385.1747.



6-(3-Methoxyphenyl)-3-methyl-4-(4-(trifluoromethyl)phenyl)hexan-2-one ***(54)*****:** The title compound **54** was obtained as a yellow oil (81.9 mg, 45% yield) in 14h after purification by silica gel column chromatography (Hex : Et_2O = 20:1).

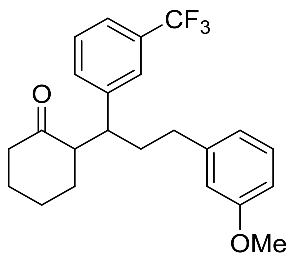
^{1}H NMR (300 MHz, $CDCl_3$): δ 0.80 (d, *J*=6.0 Hz, 0.5×3H), 1.16 (d, *J*=6.0 Hz, 0.5×3H), 1.85 (s, 0.5×3H), 1.86-1.94 (m, 0.5×2H), 2.04-2.09 (m, 0.5×2H), 2.16 (s, 0.5×3H), 2.28-2.35 (m, 2H), 2.74-2.98 (m, 2H), 3.77 (s, 3H), 6.57-6.66 (m, 2H), 6.69-6.74 (m, 1H), 7.12-7.23 (m, 2H), 7.30 (t, *J*=7.5 Hz, 1H), 7.52-7.62 (m, 2H) ; **^{13}C NMR (75 MHz, $CDCl_3$):** δ 14.4, 15.9, 29.3, 29.6, 33.3, 33.4, 33.8, 36.1, 47.3, 47.9, 53.0, 53.1, 55.2, 111.2, 111.3, 114.2, 114.3, 114.8, 120.8, 123.3 (q, J_{CF}= 274.5 Hz), 124.3 (q, J_{CF}= 270.0 Hz), 125.6 (q, J_{CF}= 3.8 Hz), 128.3, 128.7, 128.9, 129.1 (q, J_{CF}= 35.2 Hz), 129.4, 129.5, 143.2, 143.3, 146.5, 147.3, 159.8, 211.5, 212.1; **^{19}F NMR (282 MHz, $CDCl_3$)** δ -60.9, -60.9 ;**IR (neat):** 2935, 1711, 1325, 1115, 1066 ; **HRMS (ESI):** Calcd for $C_{21}H_{24}F_3O_2$ $(M+H)^+$ 365.1728, found 365.1723.



3-Methyl-6-(p-tolyl)-4-(4-(trifluoromethyl) phenyl)hexan-2-one ***(55):*** The title compound **55** was obtained as a yellow oil (88.8 mg, 51% yield) in 14h after purification by silica gel column chromatography (Hex : Et_2O = 20:1).

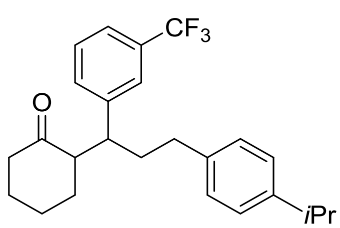
^{1}H NMR (300 MHz, $CDCl_3$): δ 0.80 (d, *J*=6.0 Hz, 0.55×3H), 1.16 (d, *J*=6.0 Hz, 0.45×3H), 1.85 (s, 0.55×3H), 1.86-1.93 (m, 0.55×2H), 2.04-2.14 (m, 0.45×2H), 2.16 (s, 0.45×3H), 2.27-2.37 (m, 5H), 2.74-2.99 (m, 2H), 6.94 (t, *J*=7.5 Hz, 2H), 7.05-7.09 (m, 2H),7.30 (t, *J*=6.0 Hz, 2H)

7.60 (t, J=7.5 Hz, 2H) ; **^{13}C NMR (126 MHz, CDCl$_3$):** δ 14.4, 15.9, 21.1, 29.3, 29.6, 32.9, 33.2, 33.6, 36.4, 47.3, 47.9, 53.0, 53.1, 124.3 (q, J_{CF}= 272.2 Hz), 124.3 (q, J_{CF}= 272.2 Hz), 125.6 (q, J_{CF}= 3.8 Hz),, 128.3, 128.7, 128.9 (q, J_{CF}= 25.2 Hz),, 129.2, 129.2, 135.5, 135.6, 138.4, 138.6, 146.5, 147.4, 211.6, 212.2 ; **^{19}F NMR (282 MHz, CDCl$_3$)** δ -62.6, -62.6 ;**IR (neat):** 2926, 1712, 1323, 1161, 1116 ; **HRMS (ESI):** Calcd for $C_{21}H_{23}F_3NaO$ (M+Na)$^+$ 371.1599, found 371.1589.



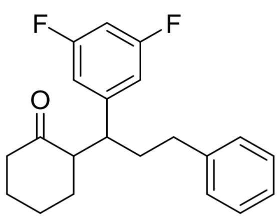
2-(3-(3-Methoxyphenyl)-1-(3-(trifluoromethyl)phenyl)propyl)cyclohexan-1-one ***(56)*:** The title compound **56** was obtained as a colorless oil (123.0 mg, 63% yield) in 14h after purification by silica gel column chromatography (Hex : Et_2O = 10:1).

^{1}H NMR (300 MHz, CDCl$_3$): δ 1.13-2.17 (m, 9H), 2.32-2.40 (m, 3H), 2.48-2.62 (m, 1H), 3.08-3.16 (m, 0.55×1H), 3.30-3.37 (m, 0.45×1H), 3.77 (s, 0.55×3H), 3.78 (s, 0.45×3H), 6.60-6.73 (m, 3H), 7.13-7.20 (m, 1H), 7.34-7.52 (m, 4H), ; **^{13}C NMR (126 MHz, CDCl$_3$):** δ 24.5, 25.0, 27.8, 28.7, 29.3, 32.3, 32.6, 33.8, 34.0, 36.1, 42.5, 43.5, 44.4, 55.2, 56.6, 56.8, 111.3, 111.5, 114.0, 114.2, 120.8, 120.9, 123.3 (q, J_{CF}=3.8 Hz), 123.5 (q, J_{CF}=3.8 Hz), , 124.3 (q, J_{CF}=272.2 Hz), 125.3 (q, J_{CF}=3.8 Hz), 125.4 (q, J_{CF}=3.8 Hz), 128.9, 129.1, 129.4, 129.4, 130.8 (q, J_{CF}=31.5 Hz), 130.9 (q, J_{CF}=31.5 Hz), 132.2, 132.2, 143.4, 143.7, 143.7, 144.8, 159.7, 211.3, 212.8 ; **^{19}F NMR (282 MHz, CDCl$_3$)** δ -62.7, -62.; **IR (neat):** 2936, 1706, 1325, 1260, 1119 ; **HRMS (ESI):** Calcd for $C_{23}H_{25}F_3NaO_2$ (M+Na)$^+$ 413.1704, found 413.1687.



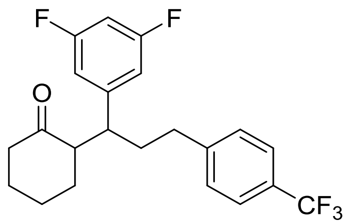
2-(3-(4-Isopropylphenyl)-1-(3-(trifluoromethyl) phenyl)propyl)cyclohexan-1-one ***(57)*****:** The title compound **57** was obtained as a yellow oil (112.7 mg, 56% yield) in 14h after purification by silica gel column chromatography (Hex : Et_2O = 10:1).

^{1}H NMR (300 MHz, $CDCl_3$): δ 1.23-1.26 (m, 6H), 1.54-2.18 (m, 9H), 2.35-2.42 (m, 3H), 2.52-2.64 (m, 1H), 2.84-2.93 (m, 1H), 3.13-3.21 (m, 0.45×1H), 3.33-3.40 (m, 0.55×1H), 7.02 (t, J=10.5 Hz, 2H), 7.13 (t, J=6.0 Hz, 2H) 7.38-7.53 (m, 4H) ; **^{13}C NMR (75 MHz, $CDCl_3$):** δ 24.2, 24.4, 25.0, 27.8, 28.6, 29.3, 29.8, 32.5, 33.4, 33.6, 33.8, 36.3, 42.5, 43.6, 44.6, 56.6, 56.8, 122.6, 123.2 (q, J_{CF}= 3.8 Hz), 123.4 (q, J_{CF}= 3.8 Hz), 124.4 (q, J_{CF}= 270.7 Hz), 124.4 (q, J_{CF}= 271.5 Hz), 125.3 (q, J_{CF}= 3.8 Hz), 125.4 (q, J_{CF}= 3.8 Hz), 126.4, 126.5, 126.6, 128.3, 128.4, 128.9, 129.0, 130.5, 130.7 (q, J_{CF}= 31.5 Hz), 130.8 (q, J_{CF}= 32.3 Hz), 130.9, 132.2, 132.3, 139.1, 139.4, 143.7, 144.9, 146.5, 211.3, 212.8 ; **^{19}F NMR (282 MHz, $CDCl_3$)** δ -61.0, -61.0 ; **IR (neat):** 2957, 1707, 1324, 1120, 1072 ; **HRMS (ESI):** Calcd for $C_{25}H_{29}F_3NaO$ $(M+Na)^+$ 425.2068, found 425.2065.



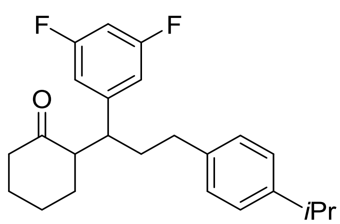
2-(1-(3,5-Difluorophenyl)-3-phenylpropyl) cyclohexan-1-one ***(58)*****:** The title compound **58** was obtained as a yellow oil (101.8 mg, 62% yield) in 14h after purification by silica gel column chromatography (Hex: Et_2O = 20:1).

^{1}H NMR (300 MHz, $CDCl_3$): δ 1.16-2.12 (m, 9H), 2.30-2.55 (m, 4H), 3.01-3.09 (m, 0.5×1H), 3.21-3.29 (m, 0.5×1H), 6.63-6.81 (m, 3H), 7.10 (t, J= 9.0 Hz, 2H), 7.16-7.29 (m, 3H) ; **^{13}C NMR (75 MHz, $CDCl_3$):** δ 24.6, 25.0, 27.8, 28.7, 29.5, 32.5, 32.7, 33.8, 33.9, 36.2, 42.5, 43.6, 44.6, 56.5, 56.6, 101.9 (t, J_{CF}=25.5 Hz), 102.1 (t, J_{CF}= 25.5 Hz), 111.3 (d, J_{CF}= 8.3 Hz), 111.5, 111.6 (d, J_{CF}= 8.3 Hz), 126.0, 128.4, 141.8 (d, J_{CF}=19.5 Hz), 147.0 (t, J_{CF}= 8.3 Hz), 148.2 (t, J_{CF}= 8.3 Hz), 163.2 (dd, J_{CF}= 7.5, 240.0 Hz), 163.3 (dd, J_{CF}= 8.3, 240.0 Hz), 211.1, 212.5 ; **^{19}F NMR (282 MHz, $CDCl_3$)** δ -108.8, -108.5; **IR (neat):** 2935, 1735, 1622, 1593, 1449 ; **HRMS (ESI):** Calcd for $C_{21}H_{22}F_2NaO$ $(M+Na)^+$ 351.1536, found 351.1524.



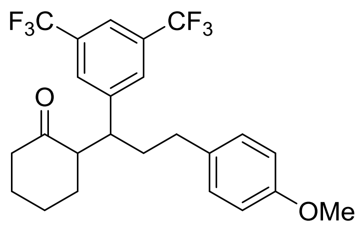
2-(1-(3,5-Difluorophenyl)-3-(4-(trifluoromethyl) phenyl)propyl)cyclohexan-1-one ***(59)*****:** The title compound **59** was obtained as a colorless oil (114.9 mg, 58% yield) in 14h after purification by silica gel column chromatography (Hex : Et_2O = 20:1).

^{1}H NMR (300 MHz, CDCl$_3$): δ 1.12-2.18 (m, 9H), 2.32-2.52 (m, 4H), 2.96-3.04 (m, 0.60×1H), 3.21-3.28 (m, 0.40×1H), 6.67-6.77 (m, 3H), 7.20 (t, *J*= 6.0 Hz, 2H), 7.48-7.52 (m, 2H) ; **^{13}C NMR (75 MHz, CDCl$_3$):** δ 24.9, 25.1, 27.8, 28.8, 29.3, 31.9, 33.0, 33.7, 33.9, 35.9, 42.5, 42.8, 43.5, 44.7, 56.4, 56.5 , 102.1 (t, J_{CF}=25.1 Hz), 102.3 (t, J_{CF}=25.1 Hz), 111.3 (d, J_{CF}= 24.0 Hz), 124.5 (q, J_{CF}= 269.3 Hz), 122.7, 125.4 (t, J_{CF}=3.8 Hz), 128.3 (q, J_{CF}= 30.8 Hz), 128.8, 145.8, 146.0, 146.8 (t, J_{CF}=8.3 Hz), 147.8 163.2 (dd, J_{CF}= 12.0, 240.0 Hz), 211.0, 212.5 ; **^{19}F NMR (282 MHz, CDCl$_3$)** δ -108.5, -108.2, -60.8 ; **IR (neat):** 2936, 1707, 1594, 1322, 1112 ; **HRMS (ESI):** Calcd for $C_{22}H_{21}F_5NaO$ $(M+Na)^+$ 419.1410, found 419.1404.



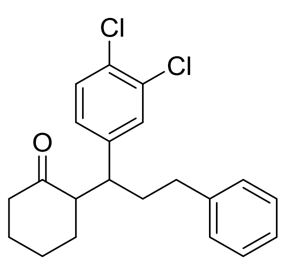
2-(1-(3,5-Difluorophenyl)-3-(4-isopropylphenyl)propyl)cyclohexan-1-one ***(60)*****:** The title compound **60** was obtained as a colorless oil (80.0 mg, 43% yield) in 14h after purification by silica gel column chromatography (Hex : Et_2O = 10:1).

^{1}H NMR (300 MHz, CDCl$_3$): δ 1.24 (d, *J*=6.0 Hz, 6H), 1.54-2.12 (m, 9H), 2.36-2.54 (m, 4H), 2.85-2.90 (m, 1H), 3.04-3.12 (m, 0.58×1H), 3.23-3.30 (m, 0.42×1H), 6.64-6.80 (m, 3H), 7.01-7.15 (m, 4H) ; **^{13}C NMR (75 MHz, CDCl$_3$):** δ 24.2, 24.6, 25.0, 27.8, 28.7, 29.5, 32.6, 33.4, 33.5, 33.8, 36.3, 42.5, 43.7, 44.7, 56.5, 56.6, 101.8 (t, J_{CF}= 25.5 Hz), 102.0 (t, J_{CF}= 25.5 Hz), 111.3 (d, J_{CF}= 9.0 Hz), 111.4, 111.6 (d, J_{CF}= 9.0 Hz), 126.4, 126.5, 128.3, 146.5, 146.5, 147.1 (t, J_{CF}= 8.3 Hz), 148.3 (t, J_{CF}= 8.3 Hz), 161 (d, J_{CF}= 3.0 Hz), 140.8, 148.4 (t, J_{CF}= 8.3 Hz), 163.1 (dd, J_{CF}= 7.9, 247.5 Hz), 163.3 (dd, J_{CF}= 7.5, 247.5 Hz), 211.1, 212.5 ; **^{19}F NMR (282 MHz, $CDCl_3$)** δ -108.8, -108.5 ; **IR (neat):** 2956, 1707, 1622, 1593, 1448 ; **HRMS (ESI):** Calcd for $C_{24}H_{28}F_2NaO$ $(M+Na)^+$ 393.2006, found 393.2009.



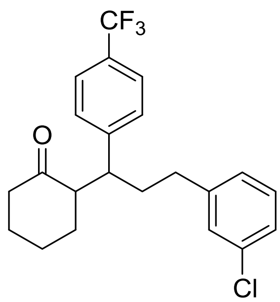
2-(1-(3,5-Bis(trifluoromethyl)phenyl)-3-(4-methoxyphenyl)propyl)cyclohexan-1-one ***(61)*****:** The title compound **61** was obtained as a yellow oil (142.0 mg, 62% yield) in 14h after purification by silica gel column chromatography (Hex : Et_2O = 10:1).

^{1}H NMR (300 MHz, $CDCl_3$): δ 1.07-2.17 (m, 9H), 2.32-2.37 (m, 3H), 2.51-2.64 (m, 1H), 3.18-3.27 (m, 0.5×1H), 3.30-3.37 (m, 0.5×1H), 3.77 (s, 3H), 6.77-6.81 (m, 2H), 6.93-6.98 (m, 2H), 7.60 (s, 1H), 7.66 (s, 1H), 7.73 (s, 0.5×1H), 7.75 (s, 0.5×1H) ; **^{13}C NMR (75 MHz, $CDCl_3$):** δ 24.8, 25.2, 27.8, 28.5, 29.8, 32.4, 32.6, 32.8, 32.9, 36.0, 42.6, 43.7, 44.2, 55.4, 56.1, 56.5, 113.9, 114.0, 120.4 (q, J_{CF}=3.5 Hz), 120.6 (q, J_{CF}=3.8 Hz), 123.5 (q, J_{CF}=270.8 Hz), 123.6 (q, J_{CF}=270.8 Hz),129.0, 129.1, 129.4, 131.6 (q, J_{CF}=33.0 Hz), 131.7 (q, J_{CF}=32.3 Hz), 133.1, 133.4, 145.5, 146.8, 158.0, 210.8, 211.9 ; **^{19}F NMR (282 MHz, $CDCl_3$)** δ -61.2 ; **IR (neat):** 2928, 1771, 1652, 1540, 1507 ; **HRMS (ESI):** Calcd for $C_{24}H_{24}F_6NaO_2$ $(M+Na)^+$ 481.1578, found 481.1580.



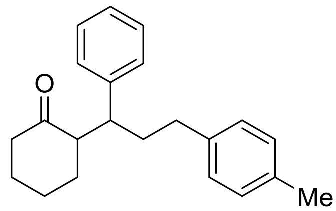
2-(3-(3-Methoxyphenyl)-1-(3-(trifluoromethyl)phenyl)propyl)cyclohexan-1-one ***(62)*****:** The title compound **62** was obtained as a yellow oil (74.1 mg, 41% yield) in 14h after purification by silica gel column chromatography (Hex : Et_2O = 10:1).

^{1}H NMR (300 MHz, $CDCl_3$): δ 1.11-2.15 (m, 9H), 2.30-2.56 (m, 4H), 2.99-3.07 (m, 0.43×1H), 3.17-3.24 (m, 0.57×1H), 7.00-7.11 (m, 2H), 7.14-7.20 (m, 1H), 7.23-7.35 (m, 3H), 7.37-7.55 (m, 2H) ; **^{13}C NMR (75 MHz, $CDCl_3$):** δ 24.5, 25.0, 27.8, 28.6, 29.5, 32.5, 33.8, 36.1, 42.5, 43.1, 43.9, 56.4, 56.6, 126.0, 127.0, 128.2, 128.2, 128.4, 128.9, 130.2, 130.3, 130.4, 130.5, 130.6, 132.4, 132.6, 141.7, 141.9, 143.1, 144.3, 211.2, 212.5 ; **IR (neat):** 2936, 1705, 1470, 1129, 1029 ; **HRMS (ESI):** Calcd for $C_{21}H_{22}Cl_2NaO$ $(M+Na)^+$ 383.0945, found 383.0930.



2-(3-(3-Chlorophenyl)-1-(4-(trifluoromethyl) phenyl)propyl)cyclohexan-1-one ***(63)*****:** The title compound **63** was obtained as a yellow oil (120.4 mg, 61% yield) in 14h after purification by silica gel column chromatography (Hex : Et_2O = 10:1).

^{1}H NMR (300 MHz, $CDCl_3$): δ 1.12-2.02 (m, 9H), 2.30-2.44 (m, 3H), 2.49-2.62 (m, 1H), 3.06-3.14 (m, 0.60×1H), 3.28-3.35 (m, 0.40×1H), 6.95 (t, *J*= 7.5 Hz, 1H), 7.04-7.20 (m, 3H), 7.28 (d, *J*= 9.0 Hz, 0.60×2H), 7.34 (d, *J*= 6.0 Hz, 0.40×2H), 7.56-7.60 (m, 2H) ; **^{13}C NMR (75 MHz, $CDCl_3$):** δ 24.7, 25.0, 27.8, 28.7, 29.4, 32.1, 32.8, 33.6, 33.7, 36.0, 42.5, 42.6, 43.6, 44.6, 56.5, 56.7, 124.4 (q, J_{CF}=270.0 Hz), 125.6 (q, J_{CF}=3.8 Hz), 126.2, 126.7, 128.6, 128.9,129.0 (q, J_{CF}=31.5 Hz), 129.1, 129.7, 134.1, 143.9, 144.1, 146.7, 147.8, 211.3, 212.7 ; **^{19}F NMR (282 MHz, $CDCl_3$)** δ -60.8, -60.8 ; **IR (neat)**: 2935, 1734, 1323, 1112, 1066 ; **HRMS (ESI):** Calcd for $C_{22}H_{22}ClF_3NaO$ $(M+Na)^+$ 417.1209, found 417.1201.

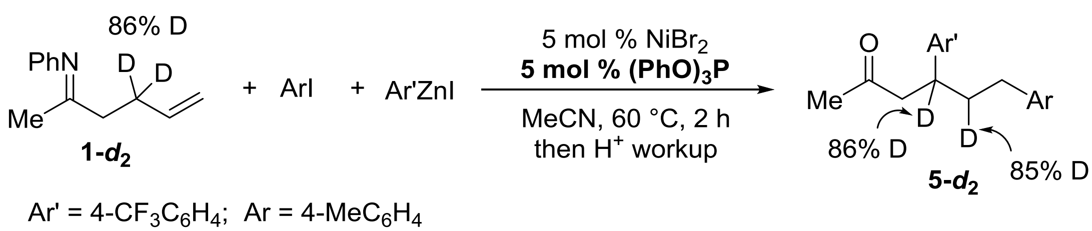


2-(1-Phenyl-3-(p-tolyl) propyl)cyclohexan-1-one ***(64)*****:** The title compound **64** was obtained as a colorless oil (67.4 mg, 44% yield) in 14h after purification by silica gel column chromatography (Hex : Et_2O = 10:1).

^{1}H NMR (300 MHz, $CDCl_3$): δ 1.21-2.13 (m, 9H), 2.27-2.46 (m, 6H), 2.52-2.62 (m, 1H), 3.01-3.09 (m, 0.57×1H), 3.29-3.36 (m, 0.43×1H), 6.98-7.11 (m, 3H), 7.15-7.38 (m, 6H) ; **^{13}C NMR (75 MHz, $CDCl_3$):** δ 21.1, 24.0, 24.7, 27.7, 28.8, 28.9, 32.5, 32.7, 33.3, 33.7, 36.6, 42.2, 42.3, 43.4, 44.6, 56.9, 57.0, 125.7, 126.3, 126.5, 128.3, 128.4, 128.6, 128.7, 129.0, 129.0, 135.1, 135.1, 139.2, 139.5, 142.5, 143.6, 211.8, 213.7 ; **IR (neat):** 2929, 1733, 1705, 1493, 1126; **HRMS (ESI):** Calcd for $C_{22}H_{26}NaO$ $(M+Na)^+$ 329.1881, found 329.1872.

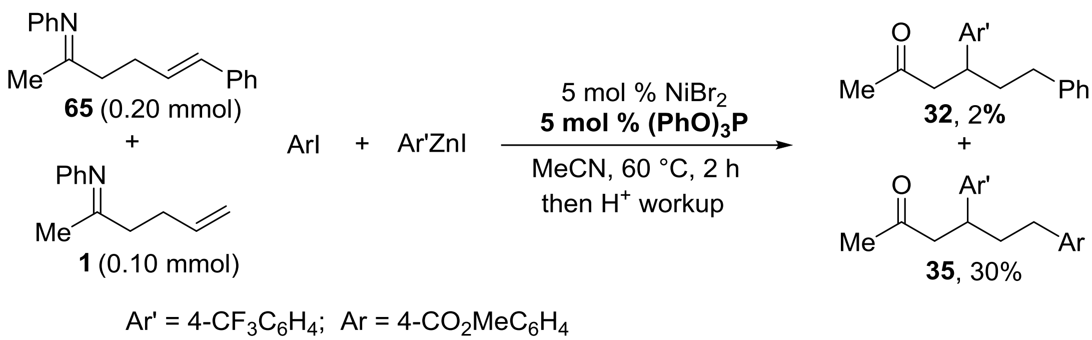
2.7 Mechanistic investigation

Deuterium labelling experiment



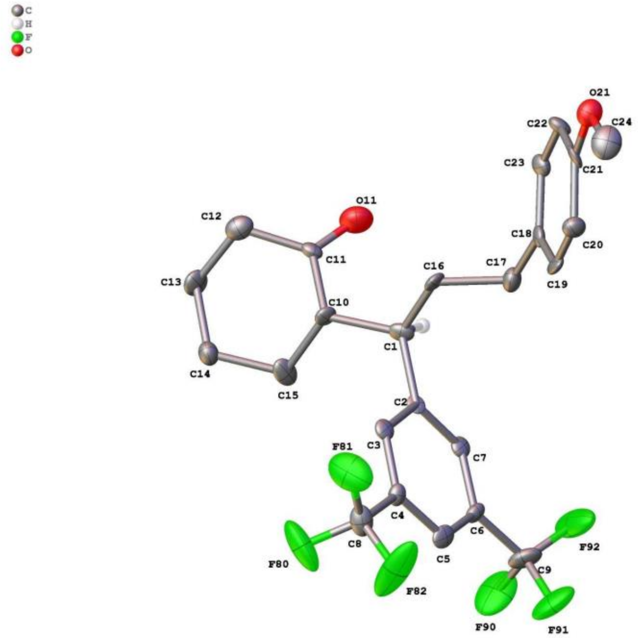
In a glovebox, stock solution of (4-(trifluoromethyl) phenyl)zinc iodide in THF (0.24 mmol) was taken in a 15 mL sealed tube and the solvent was removed under vacuum. To the residue of aryl zinc iodide, $NiBr_2$ (2.3 mg, 0.01mmol), triphenyl phosphite (3.1 mg, 0.01mmol), 4-iodotoluene (0.3 mmol) and N-phenylhex-5-en-2-imine-4,4-d_2 (0.2 mmol) was added. The mixture was then dissolved in MeCN (1.0 mL). The sealed tube was capped tightly, and placed in an oil-bath preheated to 60 °C with vigorous stirring. After 2h, the reaction mixture was cooled to room temperature, 2 mL of 6N HCl was added and shaken for about 2 minutes to hydrolyze the imines to ketones. The reaction mixture was then extracted with EtOAc (3 mL × 4) and the combined ethyl acetate fraction was dried over Na_2SO_4 and the solvent was removed in a rotavapor. The crude was purified by silica gel column chromatography using diethyl ether/hexane (1:10) as an eluent to get the desired product as a colorless liquid (68% yield). The ^{1}H NMR of the 1,3-diarylated product shows the quantitative migration of one deuterium atom to the γ- position of the carbonyl group.

Cross-Over experiment



In a glovebox, stock solution of (4-(trifluoromethyl) phenyl)zinc iodide in THF (0.12 mmol) was taken in an oven dried 4-dram vial and THF was removed under vacuum. To this residue, $NiBr_2$ (1.2 mg, 0.05 mmol), $(PhO)_3P$ (1.6 mg, 0.05 mmol), Methyl 4-iodobenzoate (0.15 mmol), N,6-diphenylhex-5-en-2-imine (0.2 mmol), N-phenylhex-5-en-2-imine (0.1 mmol) were added. 0.5 ml of MeCN was transferred to the vial and was tightly capped, taken outside the glovebox and placed in a hotplate preheated at 60 °C with well stirring. After reaction was complete, reaction mixture was cooled to room temperature and 50 µl of internal standard (0.2 M stock solution of pyrene in dioxane), 2 ml of ethyl acetate and 1ml of 6N HCl were added. The mixture was well shaken for 2 minutes. Then, 1 ml of the organic layer was taken and filtered through the short pad of silica to get a clear solution which was analyzed in the GC. The product peaks were compared to the retention time of the pure compound. The analysis of the GC peaks of products with pyrene (internal standard) shows the formation of 2% of product **32** and 30% of product **35** in the reaction.

3. X-ray Crystallographic Data for Compound 61



A colorless plate-like specimen of $C_{24}H_{23}F_6O_2$, approximate dimensions 0.228 mm x 0.157 mm x 0.112 mm, was used for the X-ray crystallographic analysis. The X-ray intensity data were measured on a Bruker APEX II Ultra system equipped with a Double Bounce Multilayer Mirrors monochromator and a MoKα Micro Focus Rotating Anode (λ = 0.71073 Å).

The frames were integrated with the Bruker SAINT software package using a narrow-frame algorithm. The integration of the data using a orthorhombic unit cell yielded a total of 10554 reflections to a maximum θ angle of 25.34° (0.83 Å resolution), of which 3994 were independent (average redundancy 2.642, completeness = 99.9%, R_{int} = 15.80%, R_{sig} = 27.01%) and 1802 (45.12%) were greater than $2\sigma(F^2)$. The final cell constants of a = 9.5667(13) Å, b = 9.7395(11) Å, c = 23.460(3) Å, volume = 2185.9(5) $Å^3$, are based upon the refinement of the XYZ-centroids of 519 reflections above 20 σ(I) with 4.528° < 2θ < 50.688°. Data were corrected for absorption effects using the Multi-Scan method (SADABS). The ratio of minimum to maximum apparent transmission was 0.806. The final anisotropic full-matrix least-squares refinement on F^2 with 284 variables converged at R1 = 8.92%, for the observed data and wR2 = 17.51% for all data. The goodness-of-fit was 0.977. The largest peak in the final difference electron density synthesis was 0.595 e-/$Å^3$ and the largest hole was -0.304 e-/$Å^3$ with an RMS deviation of 0.072 e-/$Å^3$. On the basis of the final model, the calculated density was 1.390 g/cm^3 and F(000), 948 e-.

Table 1 Crystal data and structure refinement for compound 61.

Identification code	jsOp212121_a
Empirical formula	$C_{24}H_{23}F_6O_2$
Formula weight	457.42
Temperature/K	99.51
Crystal system	orthorhombic
Space group	$P2_12_12_1$
a/Å	9.5667(13)
b/Å	9.7395(11)
c/Å	23.460(3)
α/°	90
β/°	90
γ/°	90
Volume/Å^3	2185.9(5)
Z	4
ρ_{calc}g/cm^3	1.390
μ/mm^{-1}	0.122
F(000)	948.0
Crystal size/mm^3	0.228 × 0.157 × 0.112
Radiation	MoKα (λ = 0.71073)
2Θ range for data collection/°	4.528 to 50.688
Index ranges	$-11 \leq h \leq 11$, $-9 \leq k \leq 11$, $-28 \leq l \leq 17$
Reflections collected	10554

Independent reflections	3994 [R_{int} = 0.1580, R_{sigma} = 0.2701]
Data/restraints/parameters	3994/0/284
Goodness-of-fit on F^2	0.977
Final R indexes [I>=2σ (I)]	R_1 = 0.0892, wR_2 = 0.1357
Final R indexes [all data]	R_1 = 0.2225, wR_2 = 0.1751
Largest diff. peak/hole / e Å^{-3}	0.59/-0.30
Flack parameter	-1.4(10)

Table 2 Fractional Atomic Coordinates (×10^4) and Equivalent Isotropic Displacement Parameters (Å^2×10^3) for jsOp212121_a. U_{eq} is defined as 1/3 of of the trace of the orthogonalised U_{IJ} tensor.

Atom	***x***	***y***	***z***	**U(eq)**
F80	9891(7)	1671(7)	6187(3)	66(2)
F81	10099(6)	2724(6)	5411(3)	57(2)
F82	9041(7)	820(7)	5440(4)	93(3)
F90	3768(7)	1409(7)	6531(3)	66(2)
F91	4132(6)	677(6)	5694(3)	54(2)
F92	2991(6)	2507(6)	5818(4)	75(3)
O11	6465(8)	8980(6)	6587(3)	45(2)
O21	7880(6)	8957(6)	3025(3)	28.8(17)
C1	6628(10)	6349(7)	6116(4)	19(2)
C2	6601(10)	4804(8)	6038(3)	12(2)
C3	7845(10)	4102(8)	5918(3)	16.4(15)
C4	7875(9)	2698(9)	5835(4)	16(2)
C5	6637(10)	1948(9)	5862(4)	20(2)

C6	5400(9)	2615(8)	5979(4)	16(2)
C7	5393(9)	4040(8)	6075(4)	16.4(15)
C8	9213(11)	1980(10)	5723(4)	28(3)
C9	4062(11)	1804(9)	6009(5)	33(3)
C10	7720(9)	6845(8)	6541(4)	18(2)
C11	7518(10)	8322(8)	6710(4)	16(2)
C12	8664(10)	8908(9)	7064(4)	27(3)
C13	8760(10)	8090(8)	7621(4)	27(3)
C14	8873(10)	6545(8)	7506(4)	25(2)
C15	7690(10)	6024(9)	7114(4)	27(3)
C16	6887(9)	7029(8)	5540(4)	19(2)
C17	5688(10)	6922(9)	5116(4)	27(2)
C18	6157(9)	7443(9)	4533(4)	18(2)
C19	6709(9)	6550(9)	4134(4)	26(3)
C20	7271(9)	6988(9)	3621(4)	23(2)
C21	7306(9)	8384(9)	3506(4)	19(2)
C22	6741(9)	9300(8)	3892(4)	19(2)
C23	6197(9)	8827(8)	4399(4)	21(2)
C24	8453(11)	8047(10)	2612(4)	37(3)

Table 3 Anisotropic Displacement Parameters (Å^2×10^3) for jsOp212121_a. The Anisotropic displacement factor exponent takes the form: -2π^2[h^{2}a*^{2}U$_{11}$+2hka*b*U$_{12}$+…].

Atom	U_{11}	U_{22}	U_{33}	U_{23}	U_{13}	U_{12}
F80	50(4)	111(5)	37(4)	15(4)	-5(4)	45(4)

F81	36(4)	70(4)	66(5)	16(4)	27(4)	17(4)
F82	33(4)	74(5)	173(9)	-93(5)	-7(5)	13(4)
F90	53(5)	90(5)	54(5)	-3(4)	27(4)	-40(4)
F91	39(4)	37(4)	87(6)	-22(4)	20(4)	-22(3)
F92	25(4)	34(4)	165(8)	12(4)	-21(5)	-8(3)
O11	54(6)	26(4)	55(5)	-4(4)	-7(4)	3(4)
O21	30(5)	30(4)	26(4)	-5(3)	0(4)	-1(3)
C1	21(6)	13(5)	23(6)	1(4)	5(5)	7(4)
C2	14(6)	18(5)	4(5)	4(4)	4(4)	-1(4)
C3	22(4)	21(3)	6(3)	2(3)	0(3)	-1(3)
C4	15(6)	20(5)	12(5)	-4(4)	0(5)	0(4)
C5	30(6)	22(5)	7(5)	-6(4)	1(5)	-4(5)
C6	21(6)	16(5)	11(5)	-4(4)	0(4)	-6(5)
C7	22(4)	21(3)	6(3)	2(3)	0(3)	-1(3)
C8	25(7)	36(7)	23(6)	-10(5)	-2(5)	10(5)
C9	39(8)	13(5)	46(8)	-8(6)	7(6)	-3(5)
C10	26(6)	11(5)	17(5)	-7(4)	-2(5)	0(4)
C11	21(6)	13(5)	13(5)	4(4)	1(5)	3(5)
C12	27(7)	23(5)	31(7)	-5(5)	5(5)	0(5)
C13	38(7)	22(5)	21(6)	-12(5)	-6(5)	1(5)
C14	26(6)	24(6)	23(6)	0(4)	-8(5)	2(5)
C15	42(7)	24(5)	15(6)	-10(4)	-6(5)	12(5)
C16	25(6)	11(5)	21(6)	-6(4)	-5(5)	-6(4)
C17	26(7)	24(5)	29(6)	-4(5)	-12(5)	-1(5)

C18	12(6)	23(5)	21(6)	3(5)	-10(5)	-2(5)
C19	18(6)	14(5)	47(8)	3(5)	-19(5)	-7(4)
C20	29(7)	16(5)	23(6)	-3(5)	-3(5)	1(4)
C21	20(6)	22(5)	17(6)	4(5)	-11(5)	8(5)
C22	27(6)	15(5)	16(6)	5(4)	-3(5)	6(5)
C23	15(6)	22(6)	26(6)	3(5)	-6(5)	3(4)
C24	34(7)	50(7)	29(7)	-4(6)	8(6)	-2(6)

Table 4 Bond Lengths for jsOp212121_a.

Atom	Atom	Length/Å	Atom	Atom	Length/Å
F80	C8	1.302(11)	C5	C6	1.377(11)
F81	C8	1.335(11)	C6	C7	1.406(11)
F82	C8	1.321(11)	C6	C9	1.506(12)
F90	C9	1.313(12)	C10	C11	1.504(11)
F91	C9	1.326(10)	C10	C15	1.564(12)
F92	C9	1.310(11)	C11	C12	1.488(12)
O11	C11	1.229(10)	C12	C13	1.533(12)
O21	C21	1.373(10)	C13	C14	1.533(11)
O21	C24	1.423(10)	C14	C15	1.544(12)
C1	C2	1.517(10)	C16	C17	1.520(12)
C1	C10	1.522(12)	C17	C18	1.527(12)
C1	C16	1.527(12)	C18	C19	1.383(12)
C2	C3	1.401(12)	C18	C23	1.384(11)
C2	C7	1.377(11)	C19	C20	1.384(12)

C3	C4	1.381(11)	C20	C21	1.386(11)
C4	C5	1.393(11)	C21	C22	1.382(11)
C4	C8	1.482(12)	C22	C23	1.377(12)

Table 5 Bond Angles for jsOp212121_a.

Atom	Atom	Atom	Angle/°	Atom	Atom	Atom	Angle/°
C21	O21	C24	117.4(7)	F92	C9	F90	107.7(9)
C2	C1	C10	114.0(7)	F92	C9	F91	106.3(9)
C2	C1	C16	109.0(7)	F92	C9	C6	112.0(8)
C10	C1	C16	109.3(7)	C1	C10	C15	112.8(7)
C3	C2	C1	119.7(8)	C11	C10	C1	112.9(7)
C7	C2	C1	122.8(8)	C11	C10	C15	105.1(7)
C7	C2	C3	117.5(7)	O11	C11	C10	122.8(9)
C4	C3	C2	122.0(9)	O11	C11	C12	122.3(8)
C3	C4	C5	119.6(9)	C12	C11	C10	114.8(8)
C3	C4	C8	120.7(9)	C11	C12	C13	108.7(8)
C5	C4	C8	119.7(8)	C14	C13	C12	111.4(7)
C6	C5	C4	119.5(8)	C13	C14	C15	112.1(8)
C5	C6	C7	120.1(9)	C14	C15	C10	109.3(8)
C5	C6	C9	119.5(8)	C17	C16	C1	115.2(8)
C7	C6	C9	120.4(8)	C16	C17	C18	109.9(7)
C2	C7	C6	121.3(9)	C19	C18	C17	120.7(8)
F80	C8	F81	105.5(9)	C19	C18	C23	116.5(9)
F80	C8	F82	106.5(8)	C23	C18	C17	122.4(9)

F80	C8	C4	113.1(8)	C18	C19	C20	122.9(8)
F81	C8	C4	112.9(8)	C19	C20	C21	118.8(9)
F82	C8	F81	105.5(9)	O21	C21	C20	124.7(8)
F82	C8	C4	112.6(9)	O21	C21	C22	115.6(8)
F90	C9	F91	106.8(8)	C22	C21	C20	119.7(9)
F90	C9	C6	112.3(9)	C23	C22	C21	119.8(8)
F91	C9	C6	111.4(8)	C22	C23	C18	122.2(9)

Table 6 Hydrogen Atom Coordinates (Å×10^4) and Isotropic Displacement Parameters (Å^2×10^3) for jsOp212121_a.

Atom	***x***	***y***	***z***	**U(eq)**
H1	5687.35	6645.6	6256.15	23
H3	8692.29	4606.11	5892.89	20
H5	6644.81	984.53	5799.22	24
H7	4538.8	4484.78	6167.36	20
H12A	8468.79	9885.69	7147.56	32
H12B	9560.97	8852.41	6854.57	32
H13A	9589.23	8397.45	7838.47	32
H13B	7920.28	8272.95	7855.05	32
H14A	8834.53	6043.79	7872.46	30
H14B	9786.65	6346.58	7325.61	30
H15A	6775.23	6150.32	7303.55	32
H15B	7818.57	5032.79	7036.2	32
H16A	7093.56	8012.85	5603.99	23

H16B	7727.93	6608.83	5366.24	23
H17A	4885.77	7473.9	5252.68	32
H17B	5382.24	5954.05	5084.94	32
H19	6701.06	5594.45	4214.43	31
H20	7627.46	6344.37	3353.92	27
H22	6728.99	10254.22	3808.29	23
H23	5836.6	9471.42	4664.63	25
H24A	8927.58	8579.8	2314.79	56
H24B	7700.71	7504.24	2439.88	56
H24C	9125.57	7431.51	2795.99	56

4. References

(1) Burton, S. D.; Swamy, K. C. K.; Holmes, J. M.; Day, R. O.; Holmes, R. R. *J. Am. Chem. Soc.* **1990**, *112*, 6104.

(2) Scotson, J. L.; Andrews, B. I.; Laws, A. P.; Page, M. I. *Org. Biomol. Chem.* **2016**, *14*, 10840.

(3) Sawamura, Y.; Nakatsuji, H.; Sakakura, A.; Ishihara, K. *Chem. Sci.* **2013**, *4*, 4181.

(4) Jackstell, R.; Klein, H.; Beller, M.; Wiese, K.-D.; Röttger, D. *Eur. J. Org. Chem.* **2001**, *2001*, 3871.

(5) Pietrusewicz, E.; Sieñczyk, M.; Oleksys, J. *J. Enzyme Inhib. Med. Chem.* **2009**, *24*, 1229.

(6) Storcken, R. P. M.; Panella, L.; van Delft, F. L.; Kaptein, B.; Broxterman, Q. B.; Schoemaker, H. E.; Rutjes, F. P. J. T. *Adv. Synth. Catal.* **2007**, *349*, 161.

(7) Šmit, B. M.; Pavlović, R. Z. *Tetrahedron* **2015**, *71*, 1101.

(8) Davies, J.; Booth, S. G.; Essafi, S.; Dryfe, R. A. W.; Leonori, D. *Angew. Chem. Int. Ed.* **2015**, *54*, 14017.

(9) Zabawa, T. P.; Chemler, S. R. *Org. Lett.* **2007**, *9*, 2035.

(10) White, D. R.; Wolfe, J. P. *Chem. Eur. J.* **2017**, *23*, 5419.

(11) Portela-Cubillo, F.; Lymer, J.; Scanlan, E. M.; Scott, J. S.; Walton, J. C. *Tetrahedron* **2008**, *64*, 11908.

(12) Ondet, P.; Lempenauer, L.; Dunach, E.; Lemiere, G. *Org. Chem. Front.* **2016**, *3*, 999.

(13) Krasovskiy, A.; Malakhov, V.; Gavryushin, A.; Knochel, P. *Angew. Chem. Int. Ed.* **2006**, *45*, 6040.

(14) Krasovskiy, A.; Knochel, P. *Synthesis* **2006**, *2006*, 0890.

(15) Ogura, T.; Usuki, T. *Tetrahedron* **2013**, *69*, 2807.

(16) Matsumori, N.; Yasuda, T.; Okazaki, H.; Suzuki, T.; Yamaguchi, T.; Tsuchikawa, H.; Doi, M.; Oishi, T.; Murata, M. *Biochem.* **2012**, *51*, 8363.

(17) Pan, S.; Jang, S.-Y.; Wang, D.; Liew, S. S.; Li, Z.; Lee, J.-S.; Yao, S. Q. *Angew. Chem. Int. Ed.* **2017**, *56*, 11816.

5. NMR Spectra

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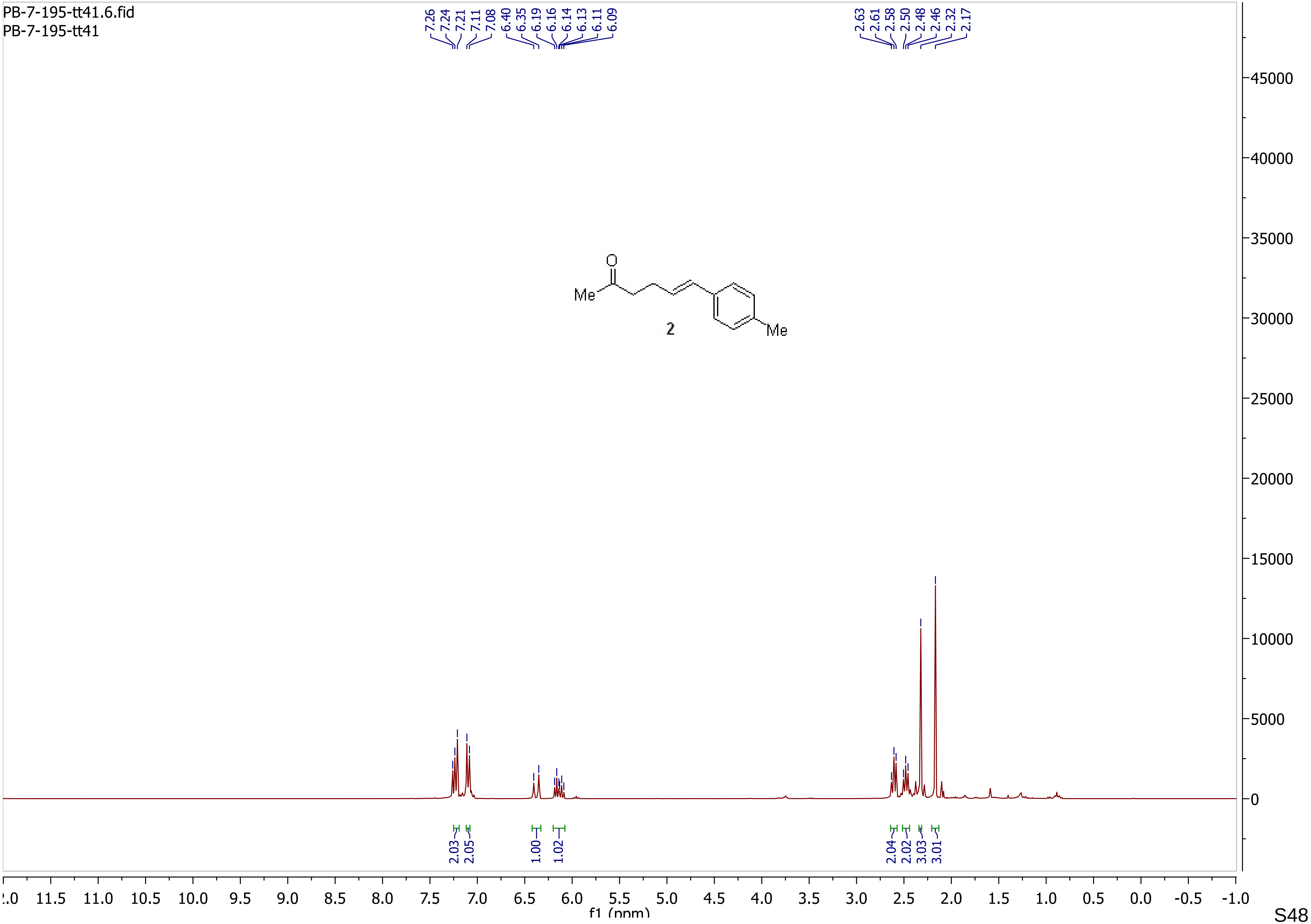

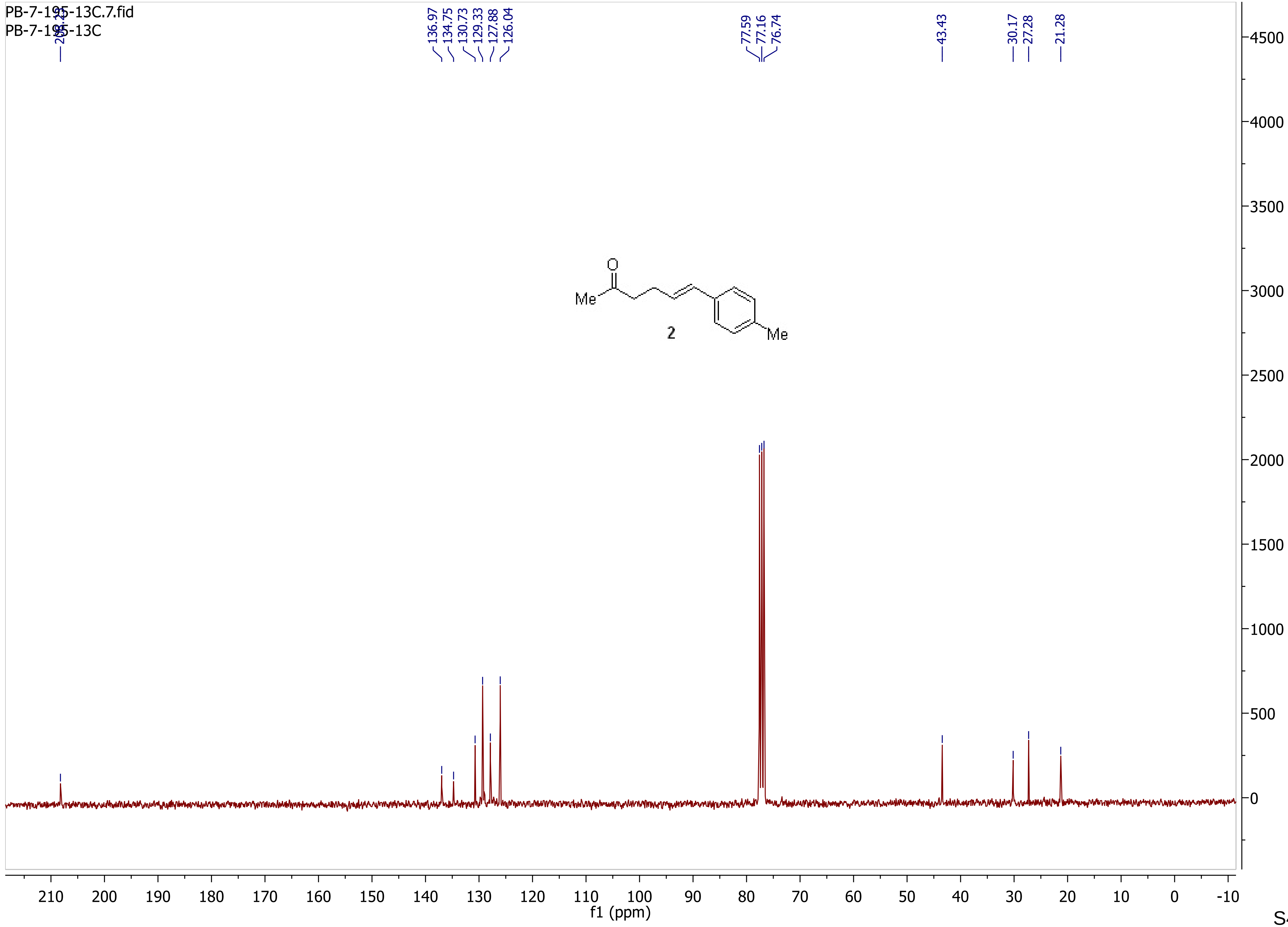
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76.74
43.43
30.17
27.28
21.28
O
Me
Me
2
4500
4000
3500
3000
2500
2000
1500
1000
500
0
210
200
190
180
170
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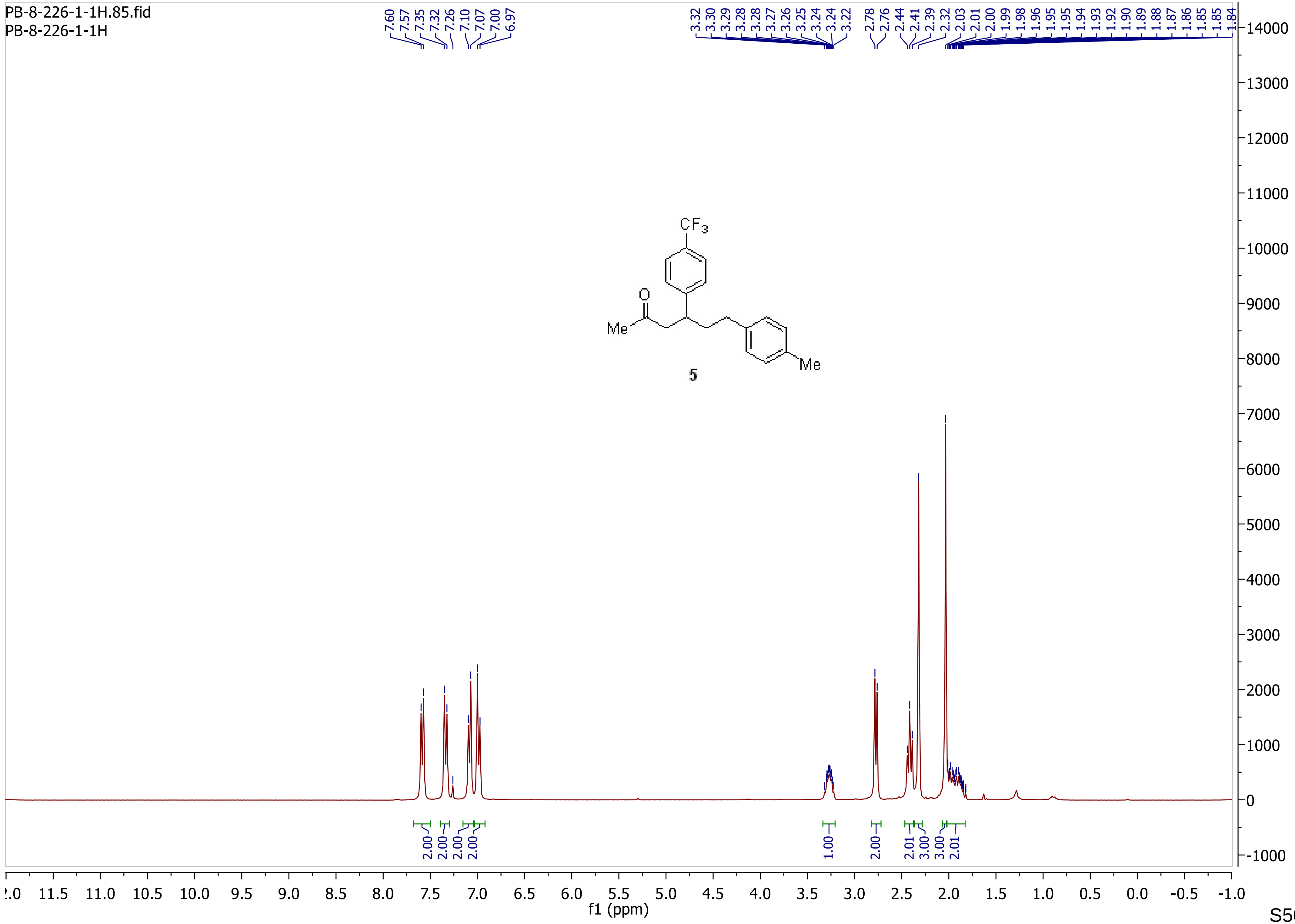
f1 (ppm)



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3.29
3.28
3.28
3.27
3.26
3.25
3.24
3.24
3.22
2.78
2.76
2.44
2.41
2.39
2.32
2.03
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1.96
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1.95
1.94
1.93
1.92
1.90
1.89
1.88
1.87
1.86
1.85
1.85
1.84
CF3
O
Me
Me
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2.00
1.00
2.00
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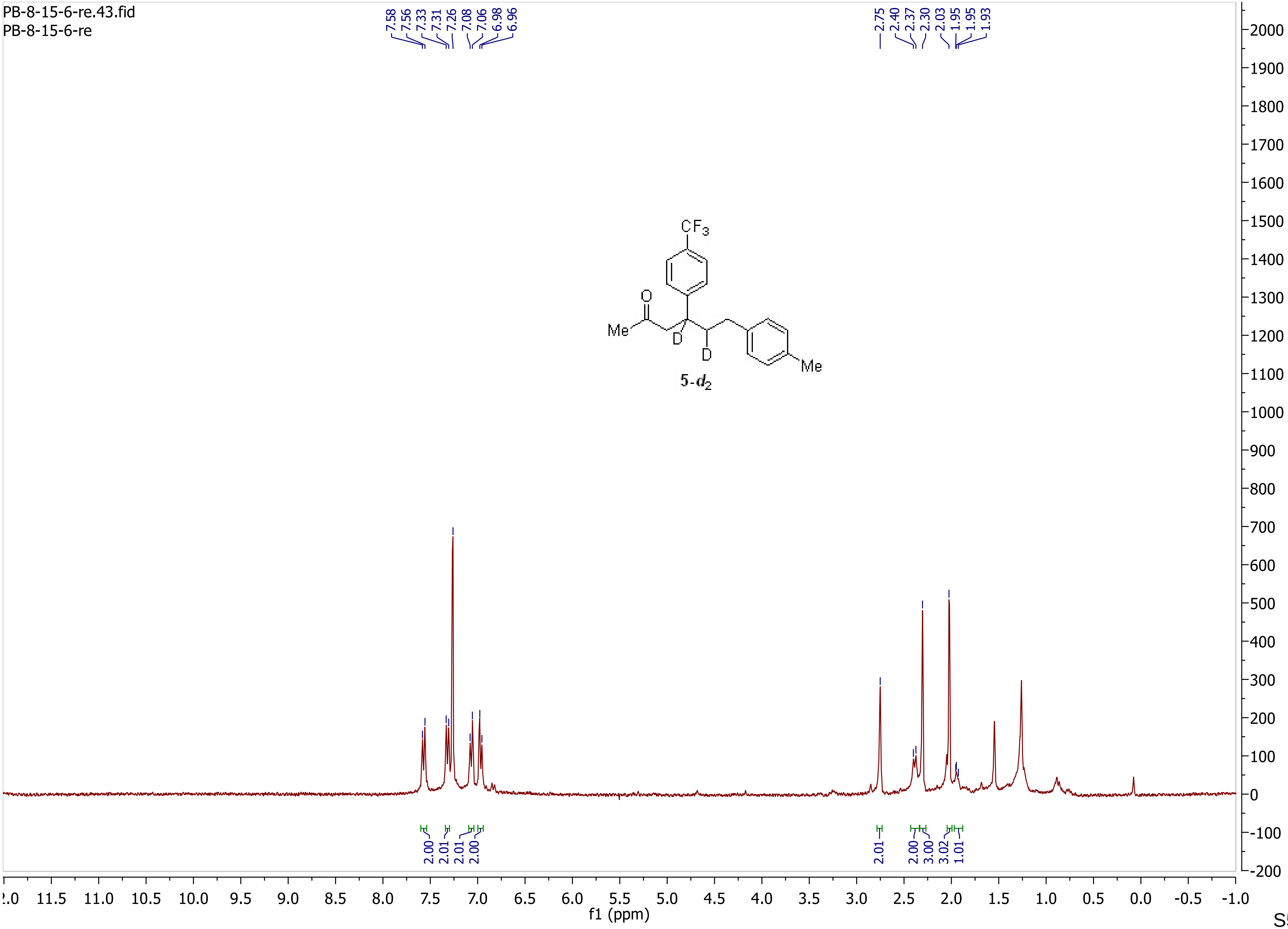
3.00
3.00
2.01
f1 (ppm)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D
D
Me
5-d2
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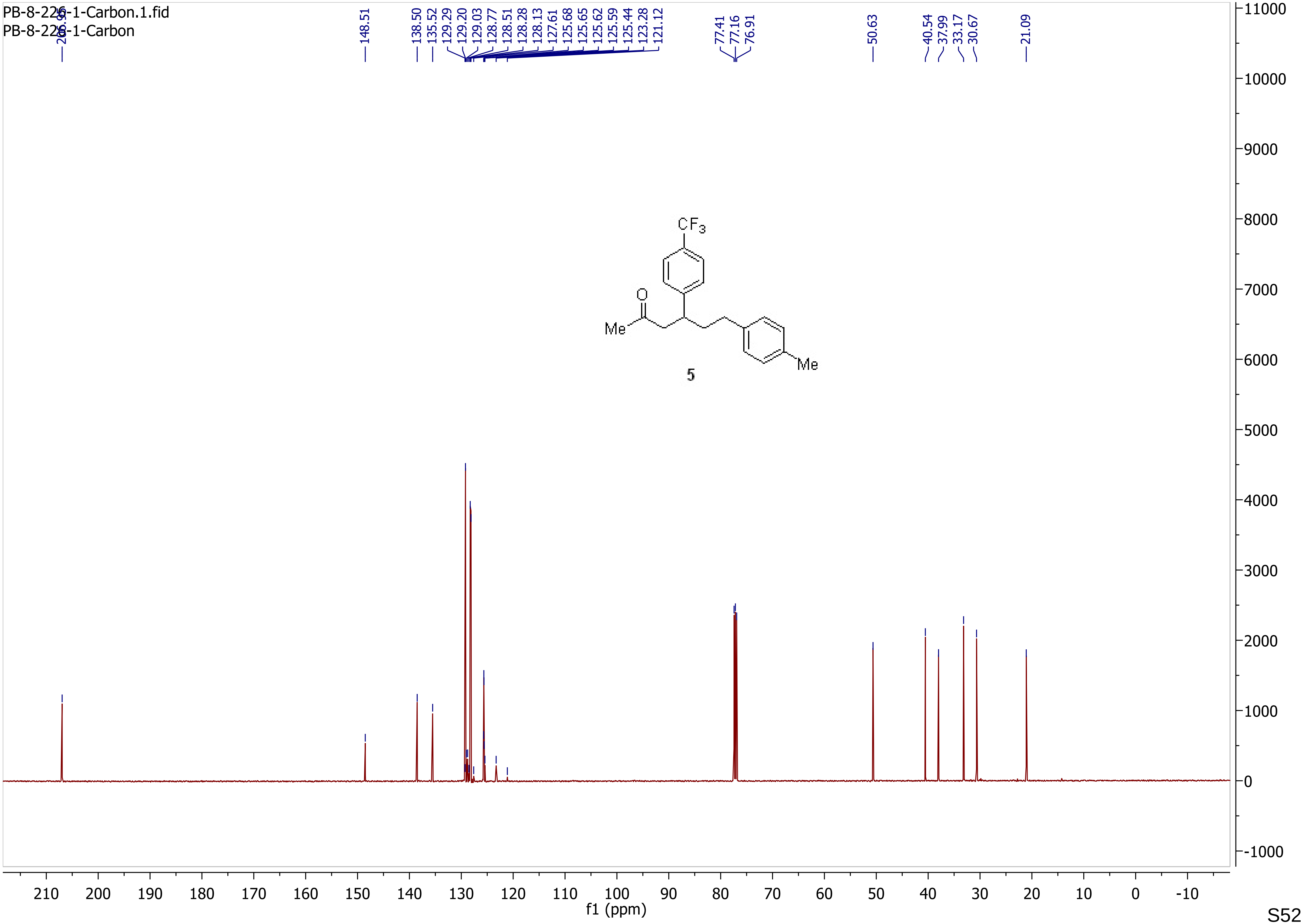
2.01 2.00 3.00 3.02 1.01
f1 (ppm)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127.61
125.68
125.65
125.62
125.59
125.44
123.28
121.12
77.41
77.16
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37.99
33.17
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CF3
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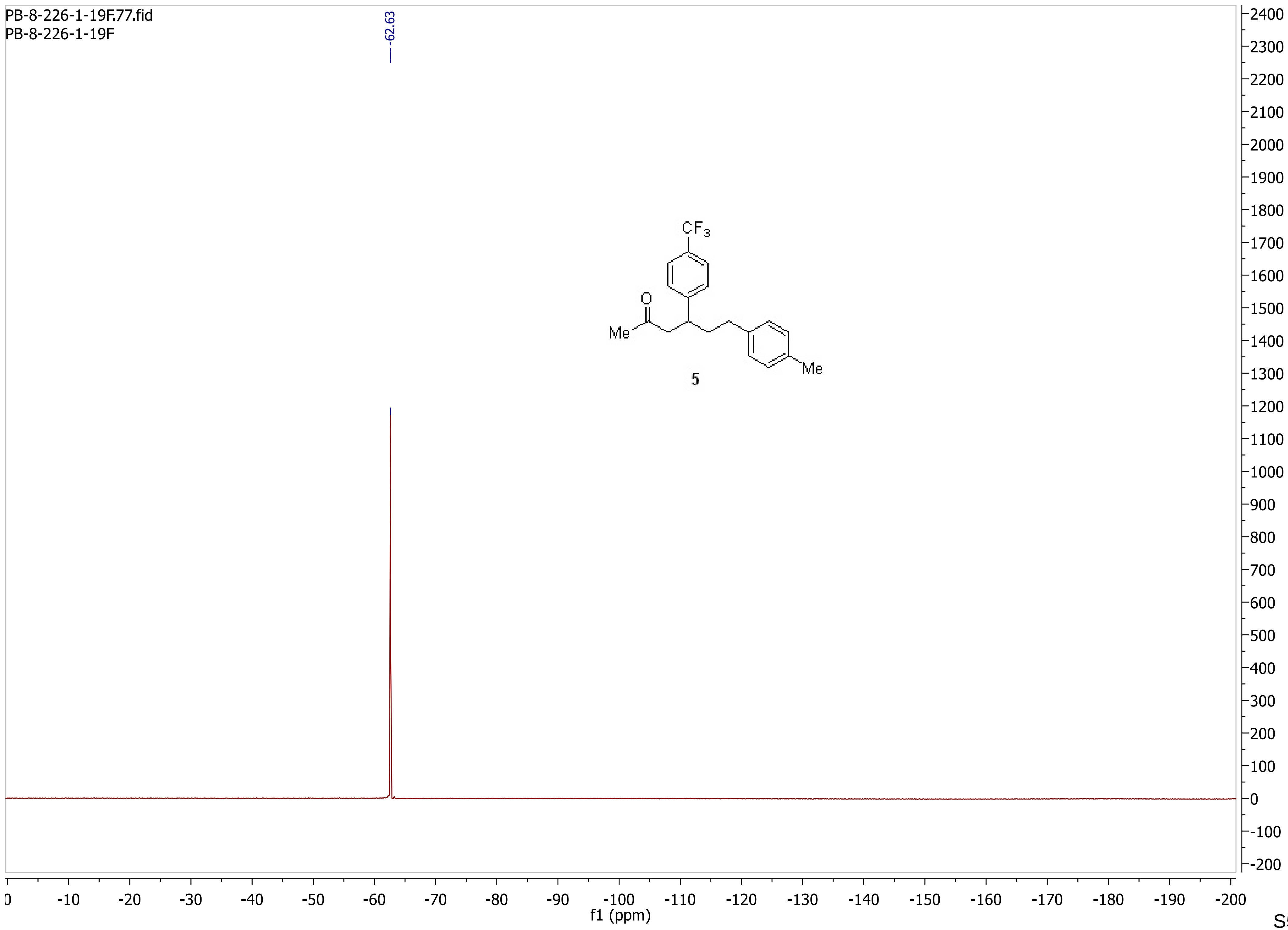
Me
Me
5
f1 (ppm)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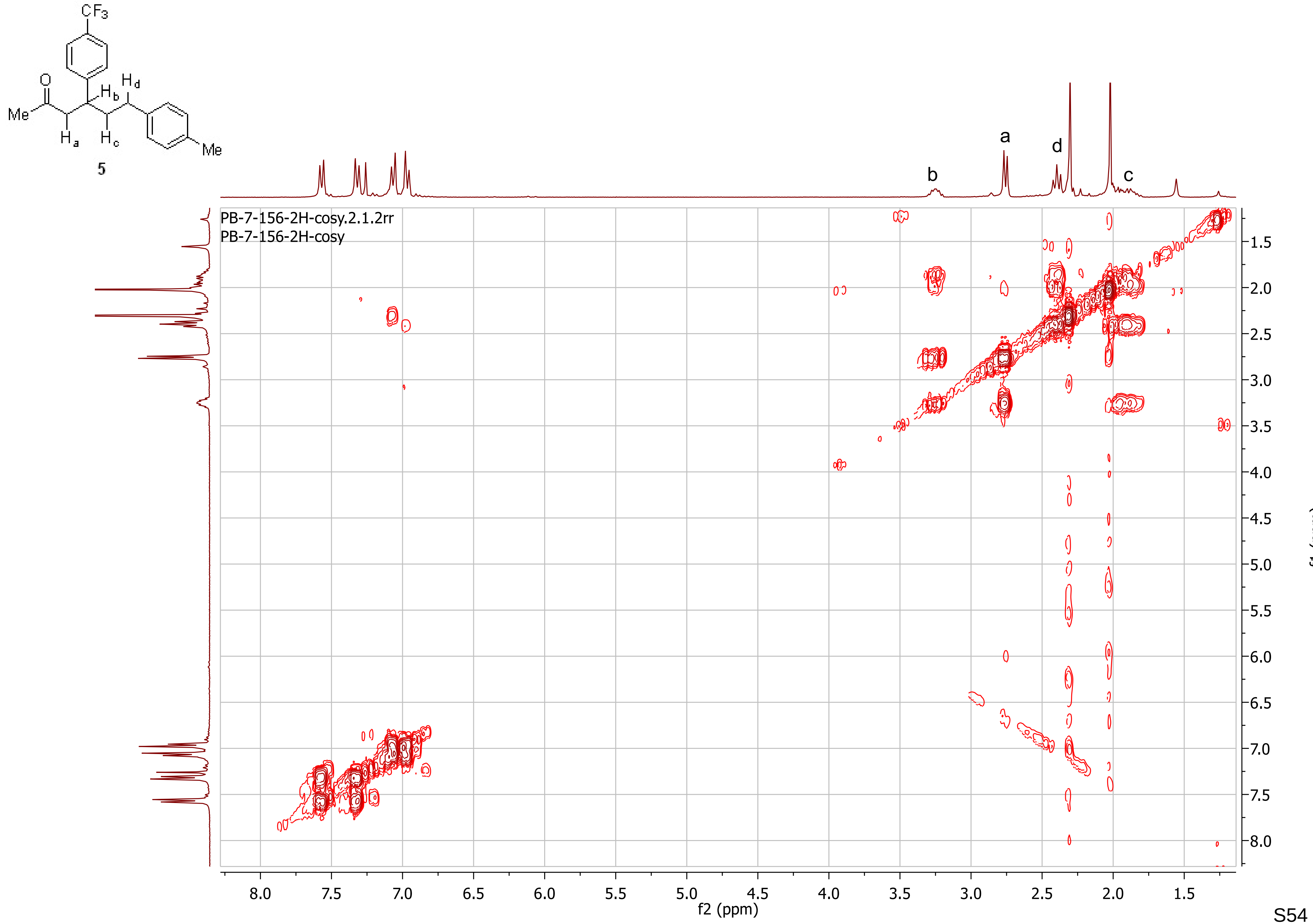
f1 (ppm)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f1 (ppm)

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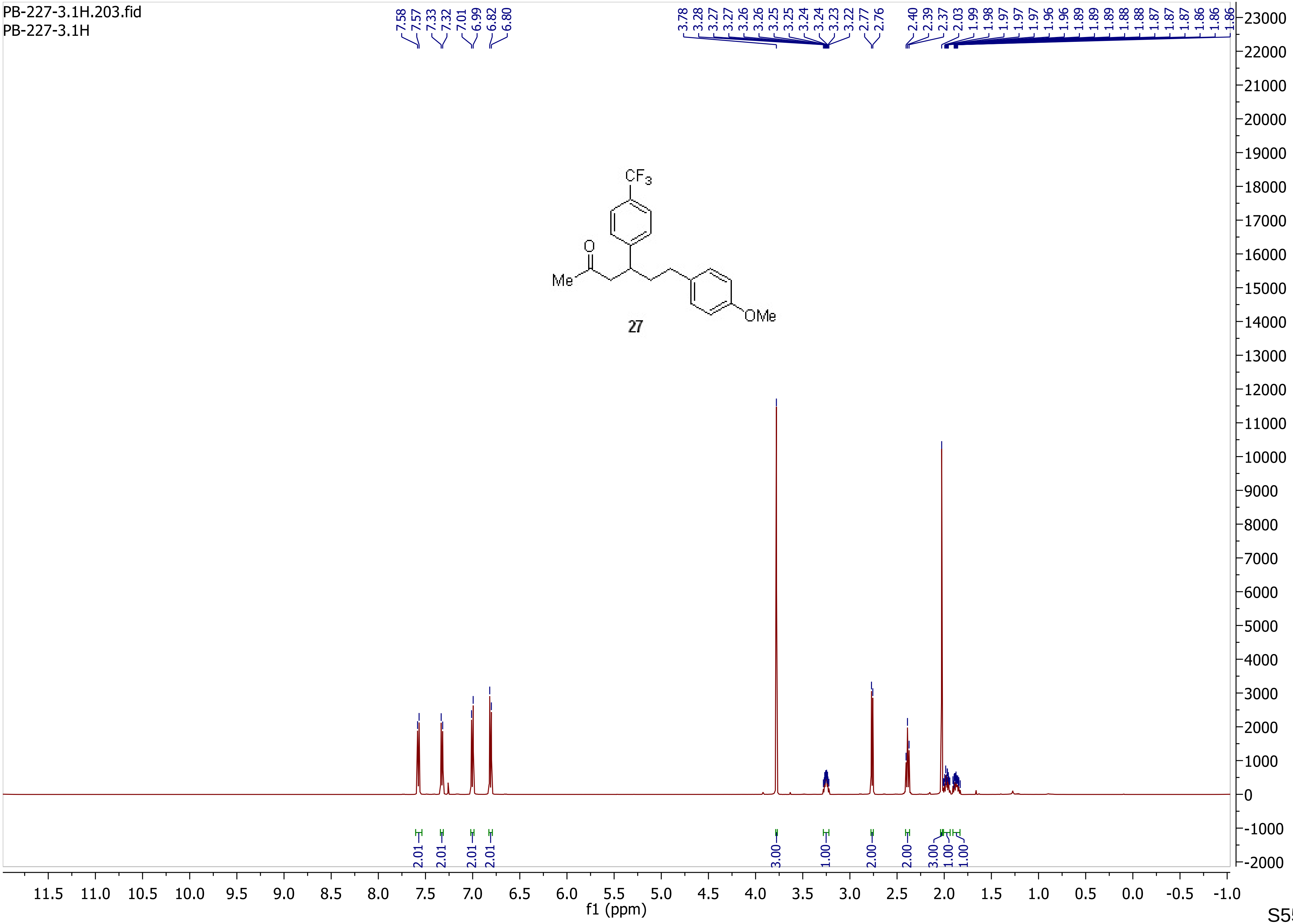

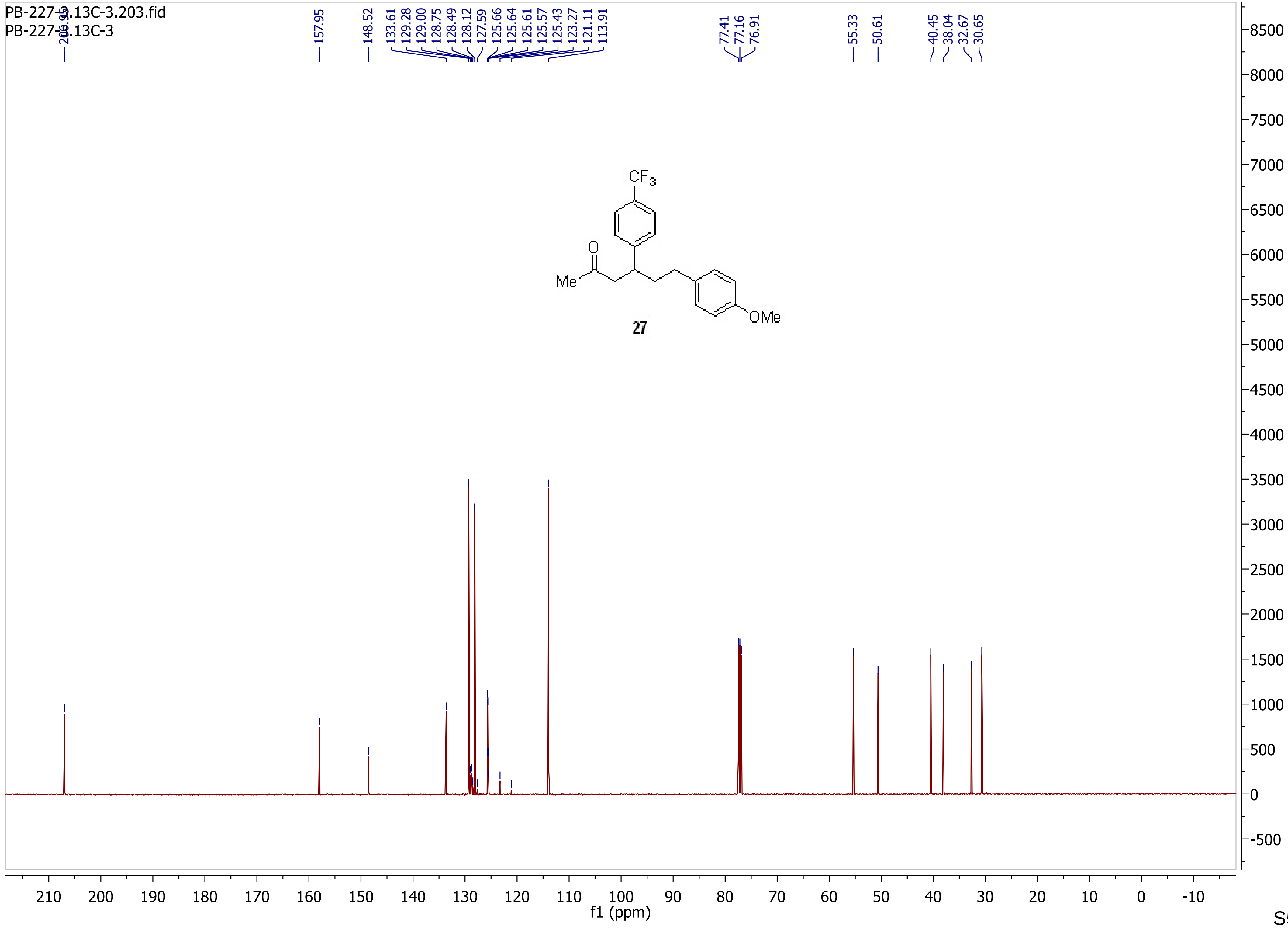

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121.11
113.91
77.41
77.16
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CF3
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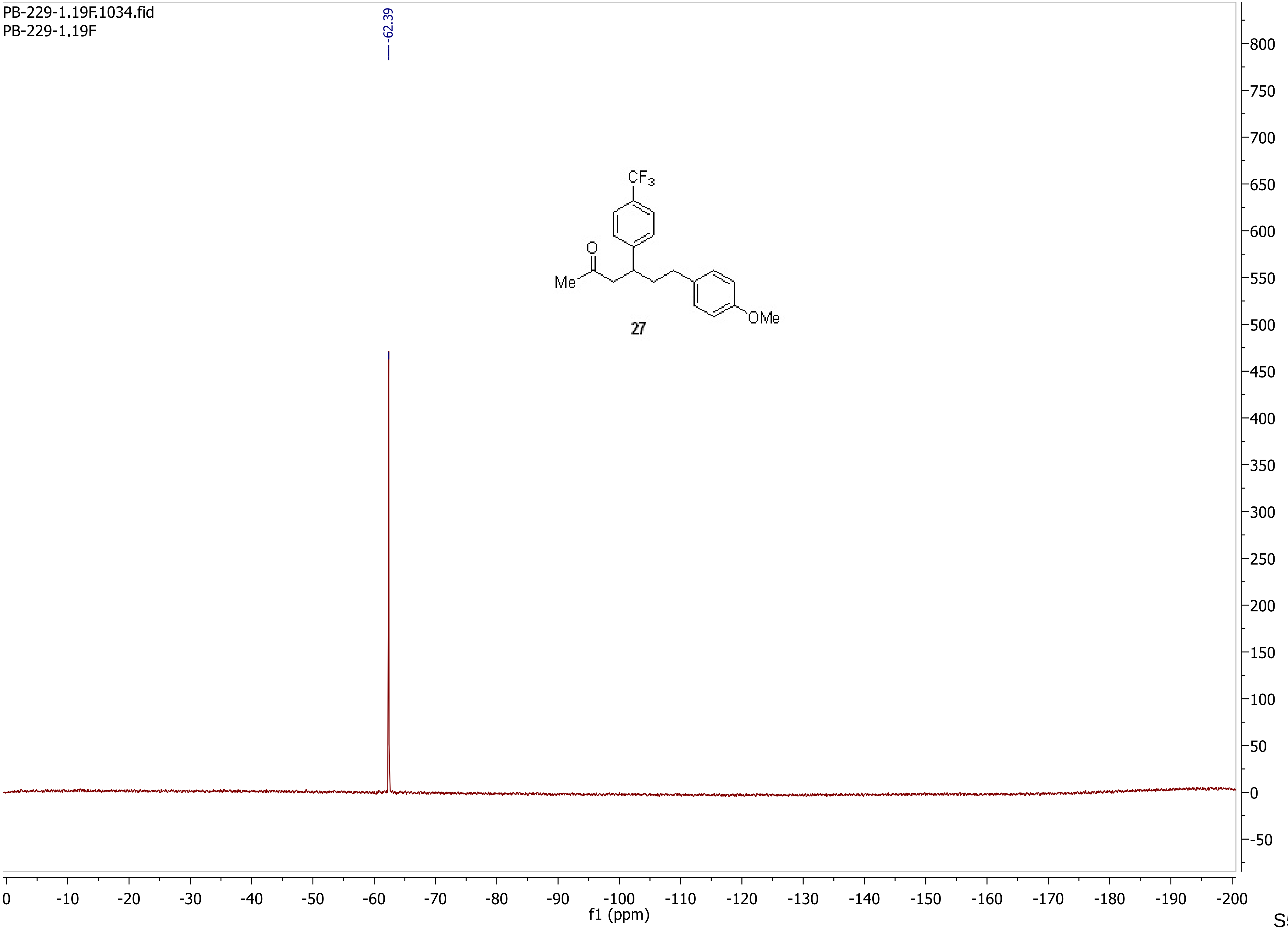
Me
OMe
27
f1 (ppm)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Me
OMe
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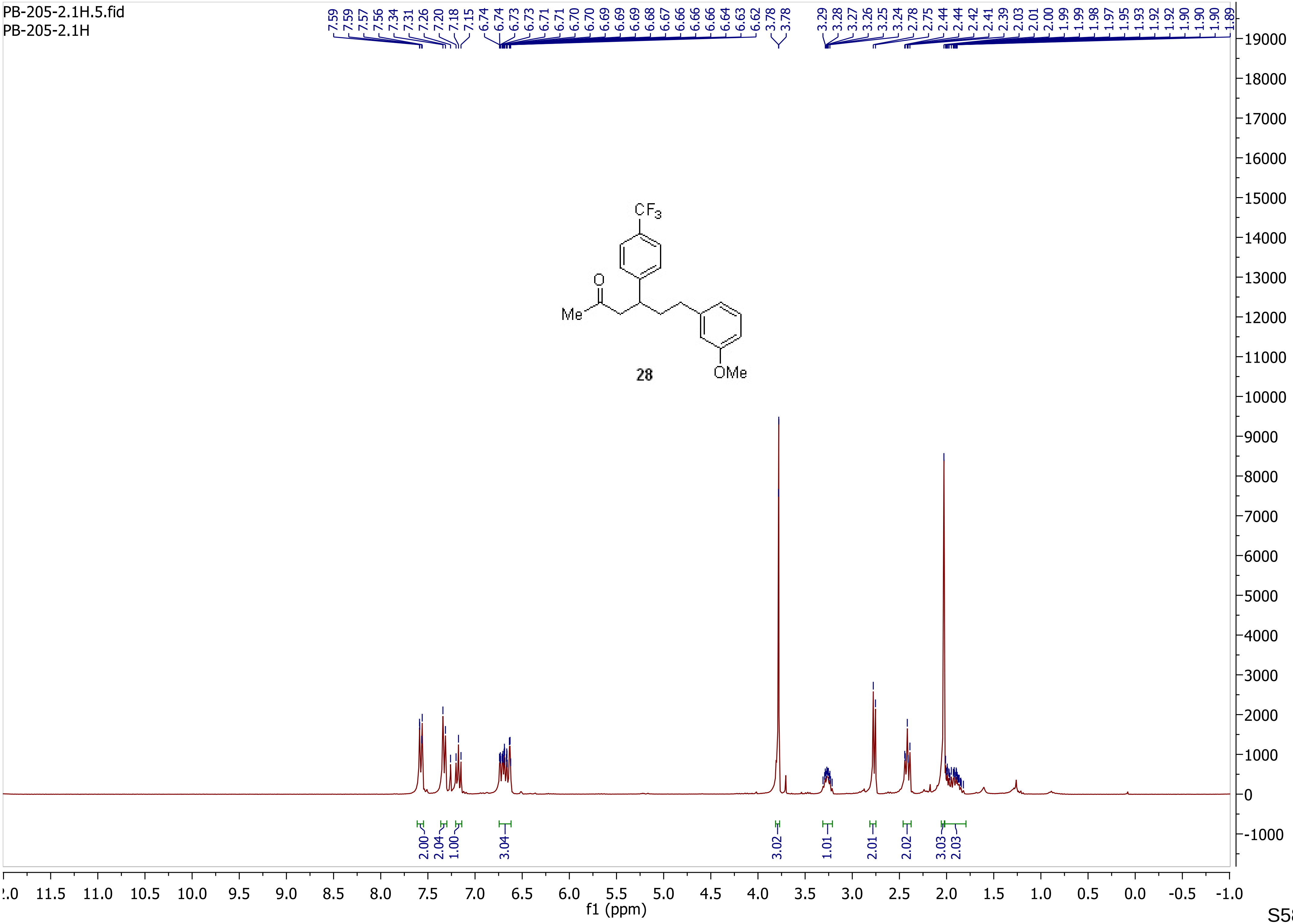
f1 (ppm)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O
Me
OMe
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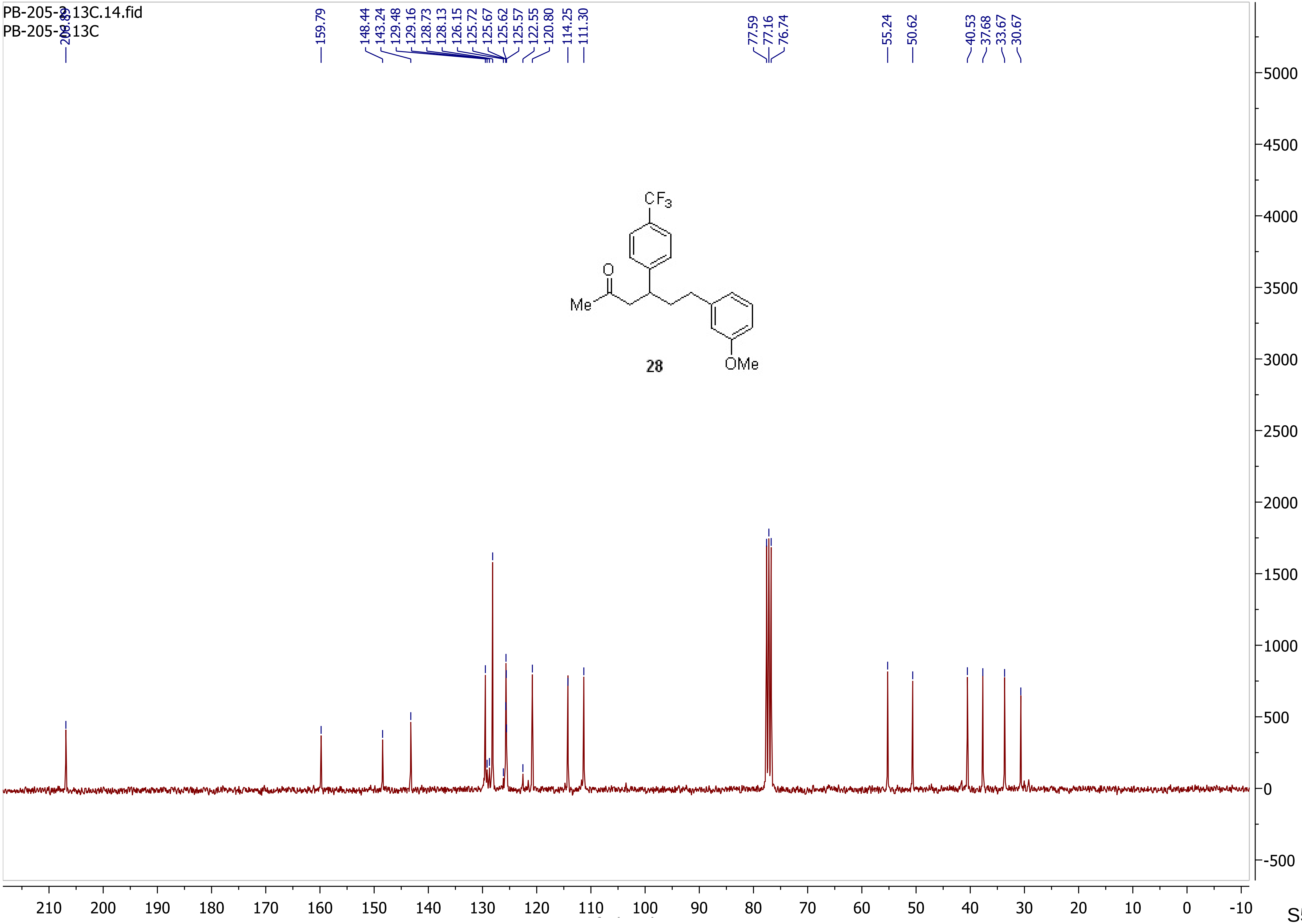
2.01
2.02
3.03
2.03
f1 (ppm)



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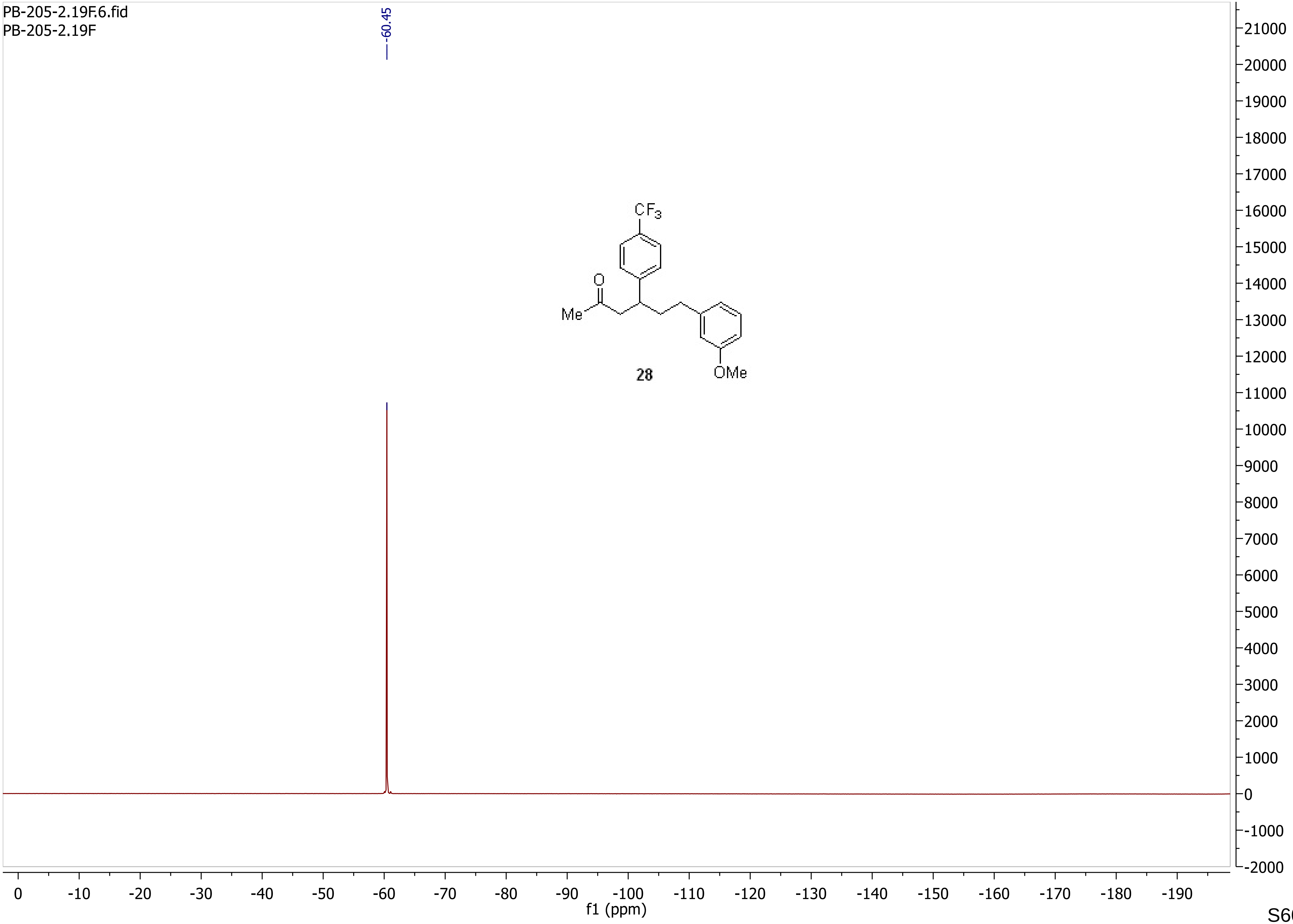
CF3
O
Me
OMe
28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12000
11000
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9000
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7000
6000
5000
4000
3000
2000
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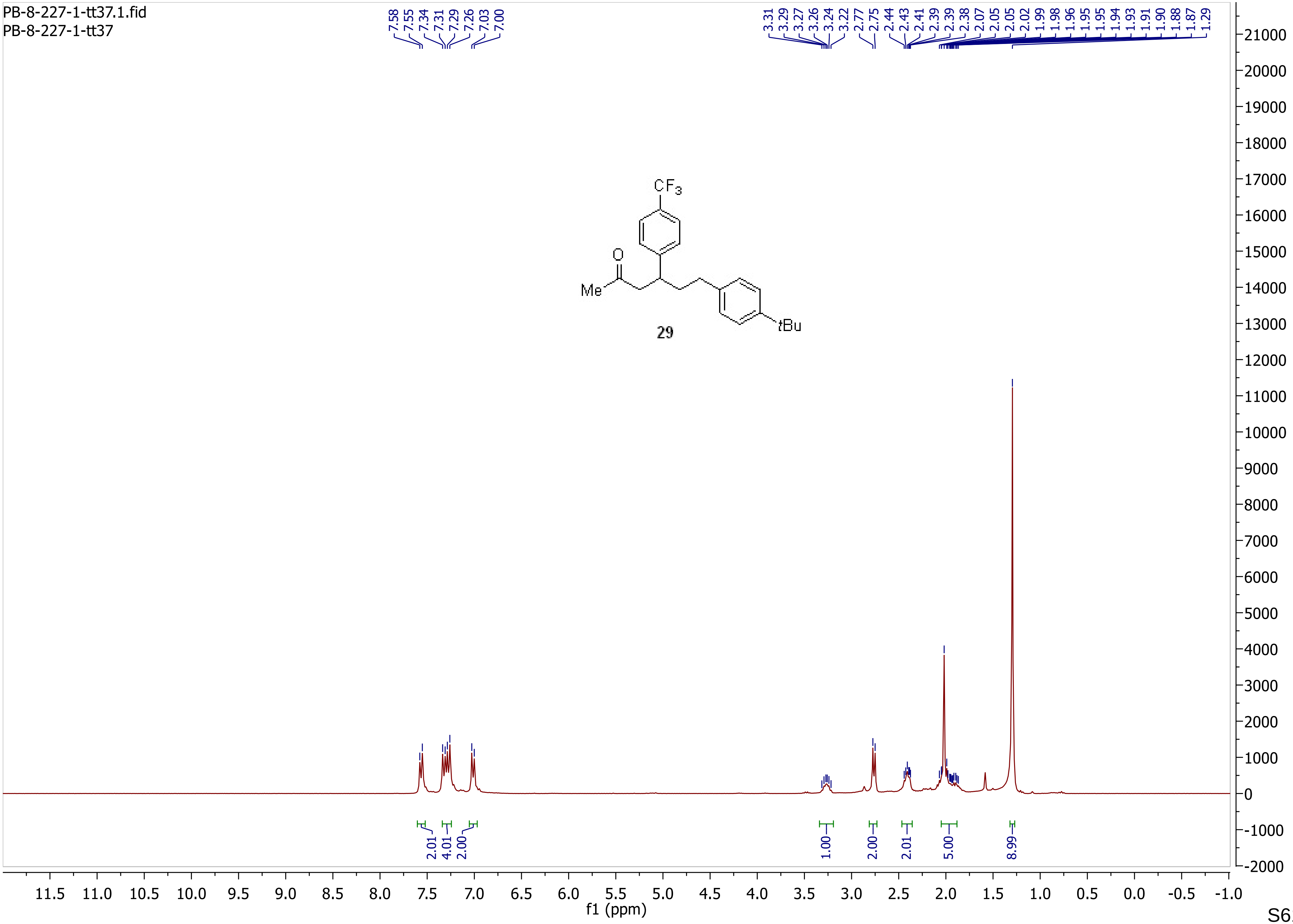
f1 (ppm)



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CF3
O
Me
tBu
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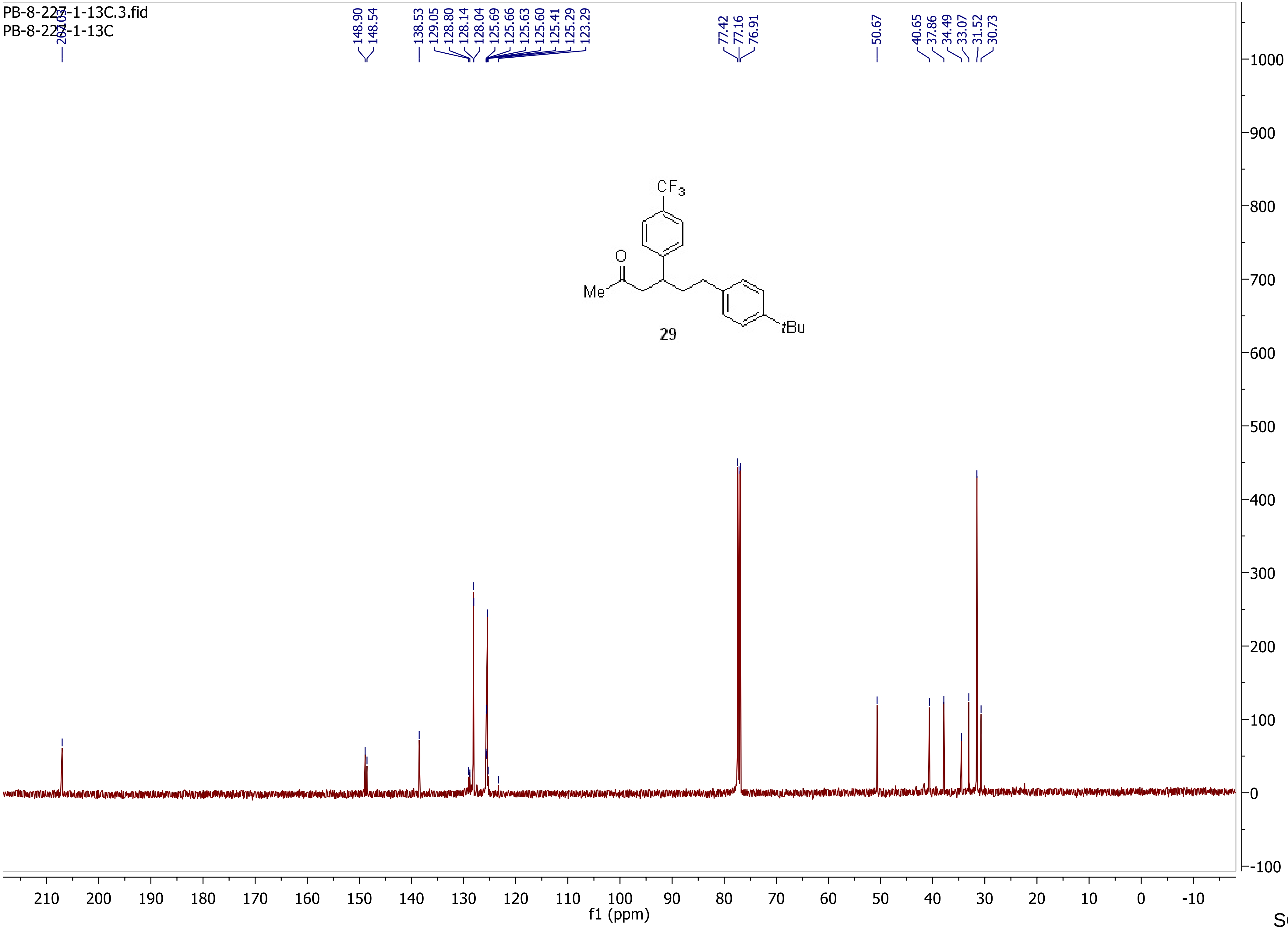
f1 (ppm)



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125.41
125.29
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77.42
77.16
76.91
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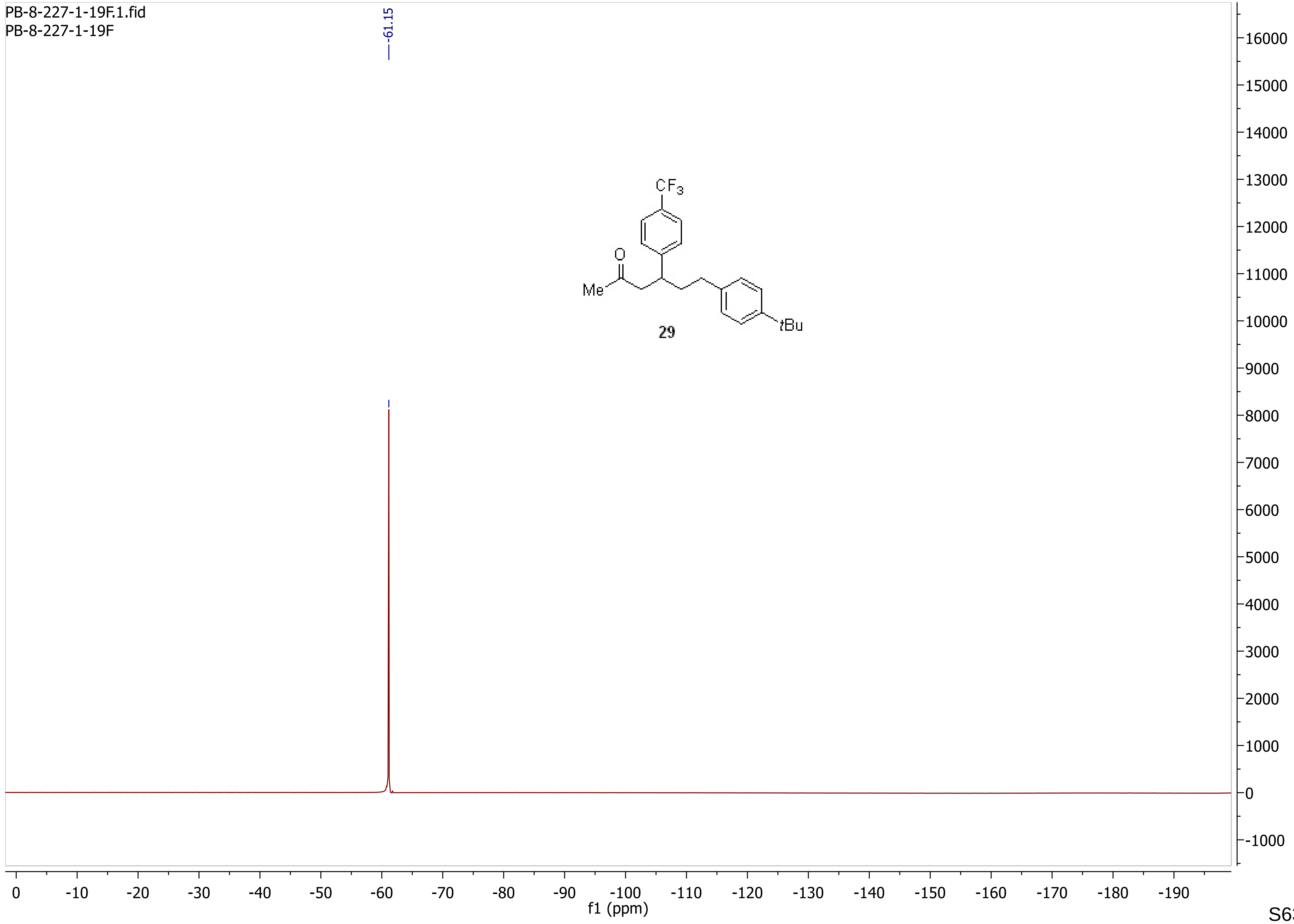
33.07
31.52
30.73
CF3
O
Me
tBu
29
f1 (ppm)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13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
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-10
-20
-30
-40
-50
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-120
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-140
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-160
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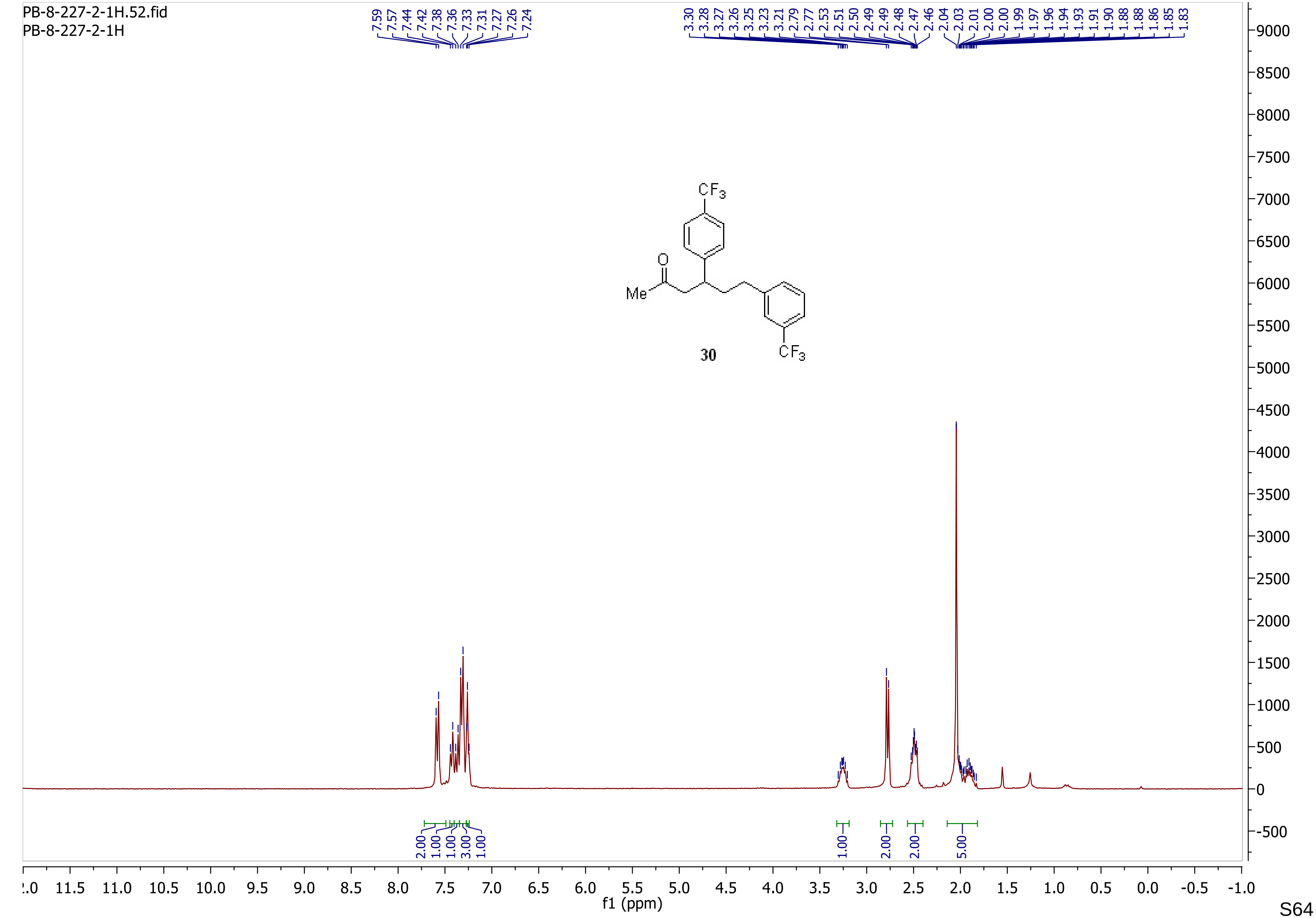
-180
-190
f1 (ppm)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Me
CF3
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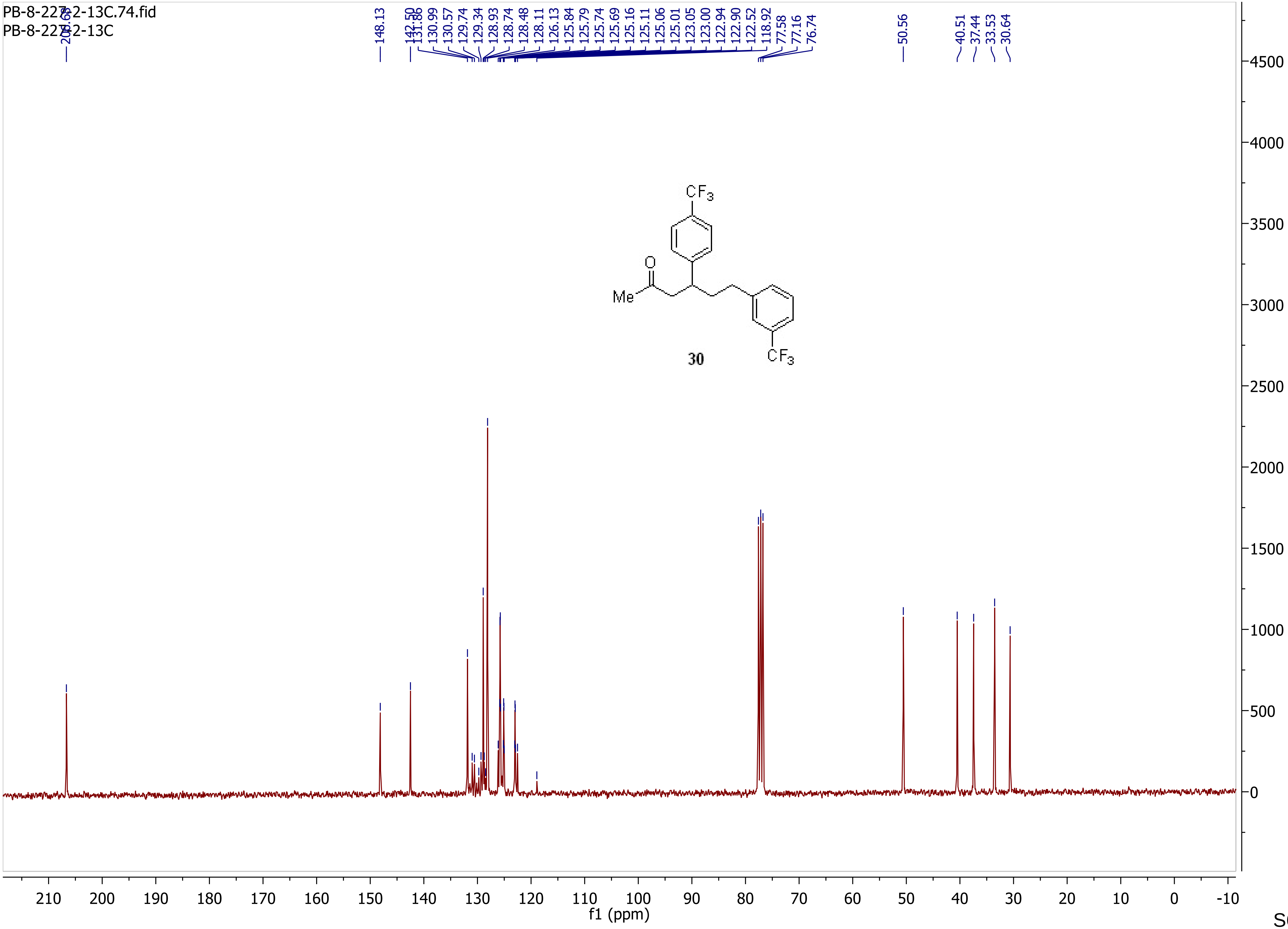
1.00 2.00 2.00 5.00
f1 (ppm)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125.79
125.74
125.69
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125.11
125.06
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122.90
122.52
118.92
77.58
77.16
76.74
50.56
40.51
37.44
33.53
30.64
CF3
O
Me
30
CF3
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3000
2500
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1000
500
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200
190
180
170
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40
30
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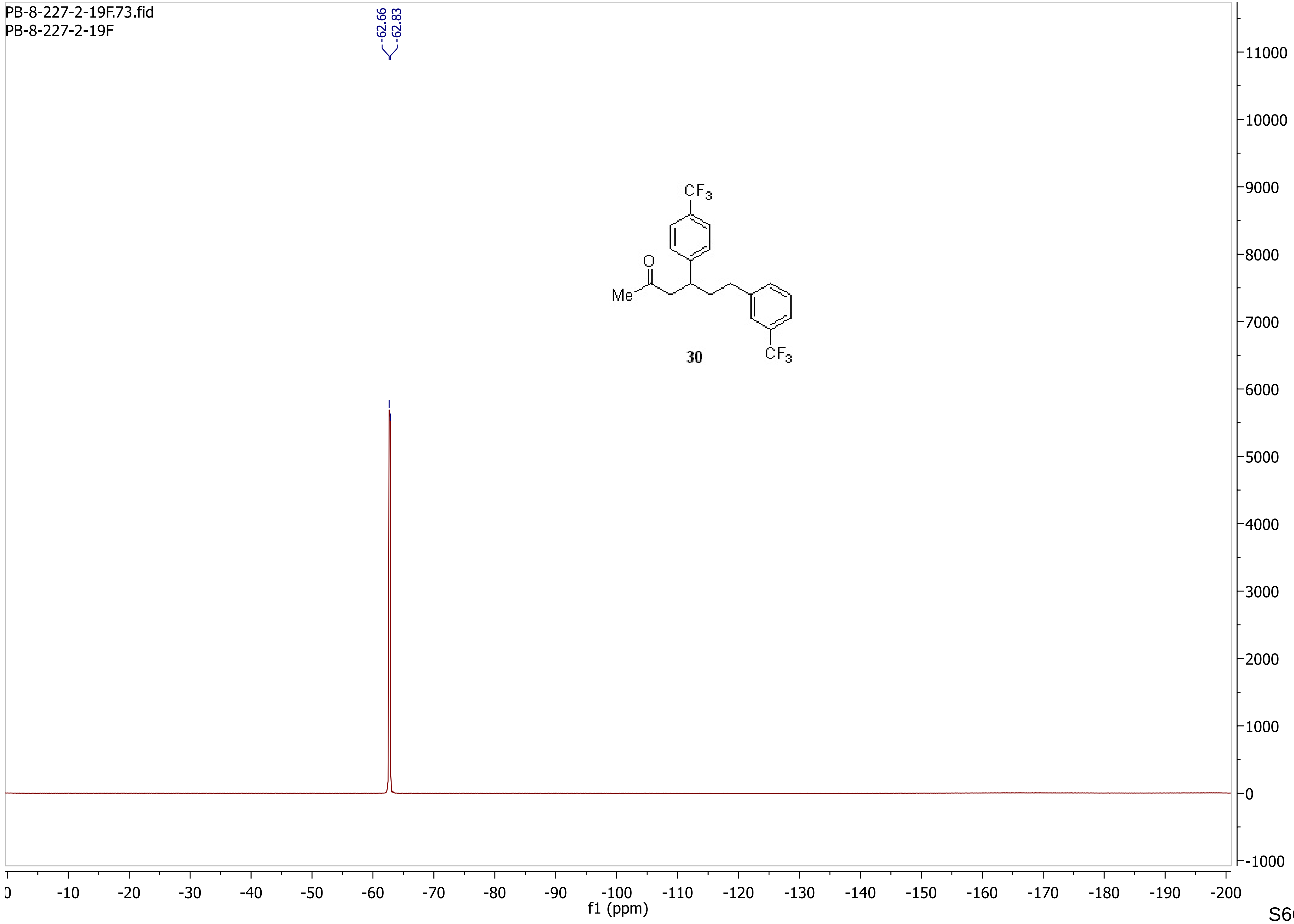
f1 (ppm)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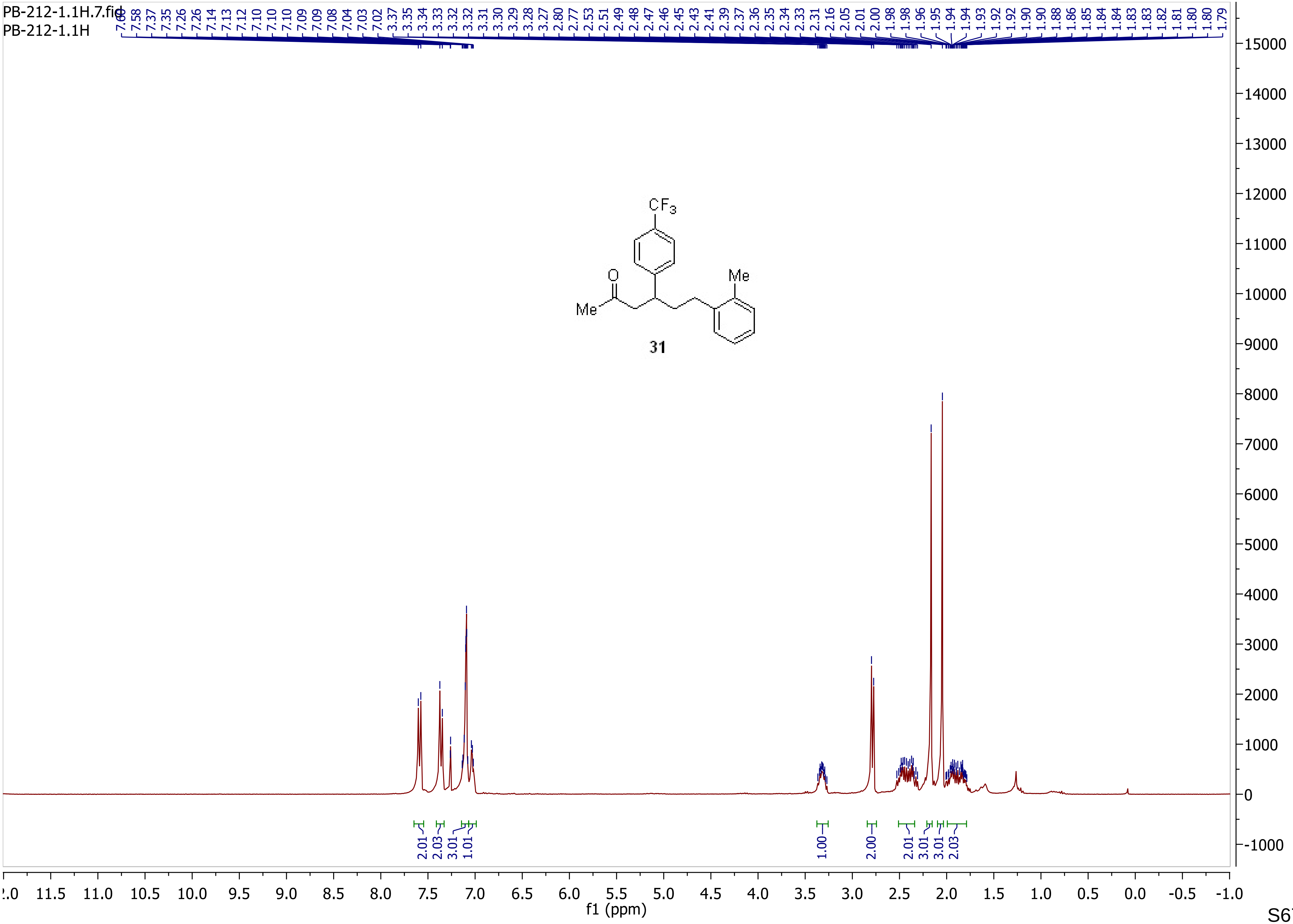
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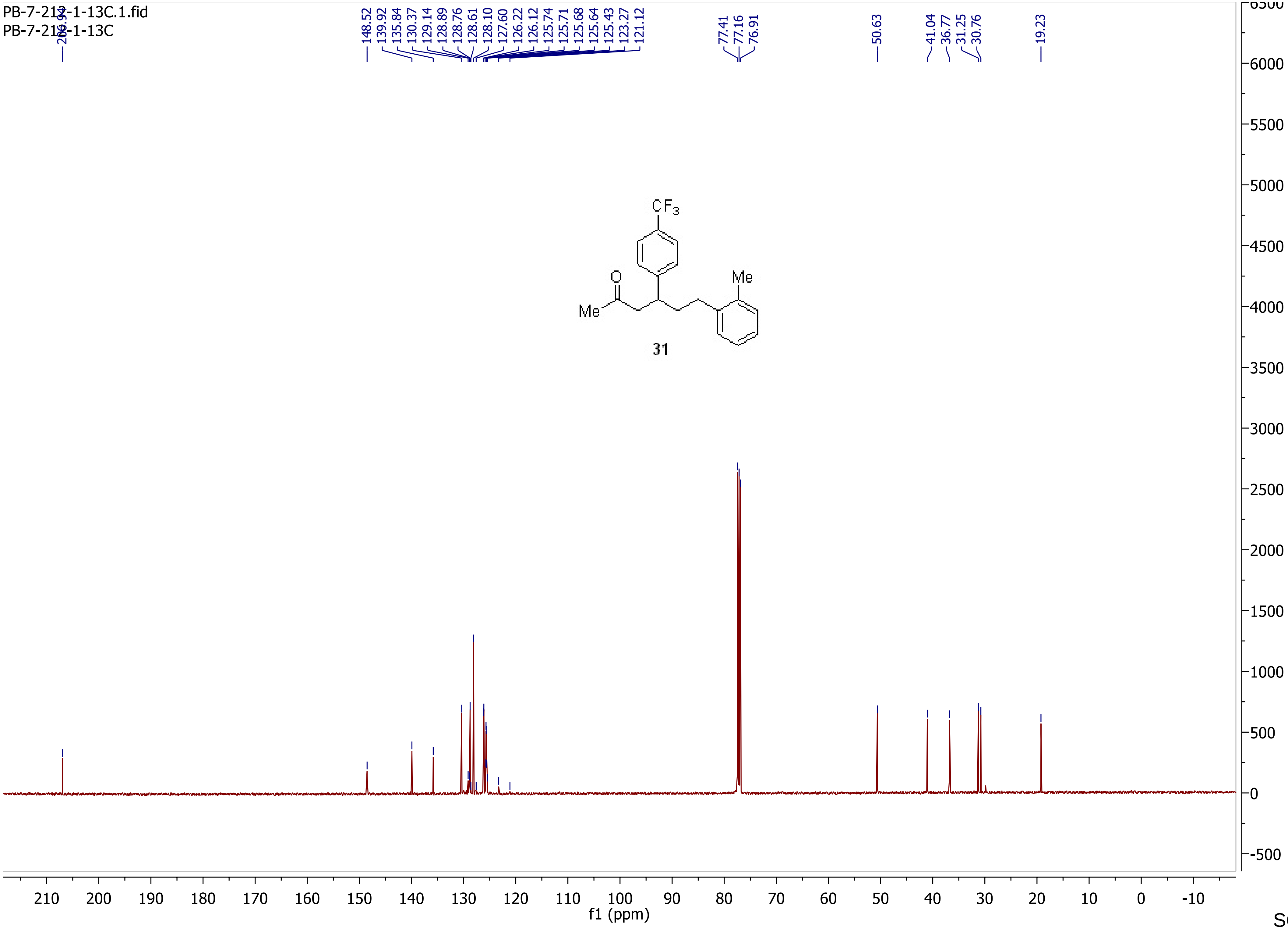
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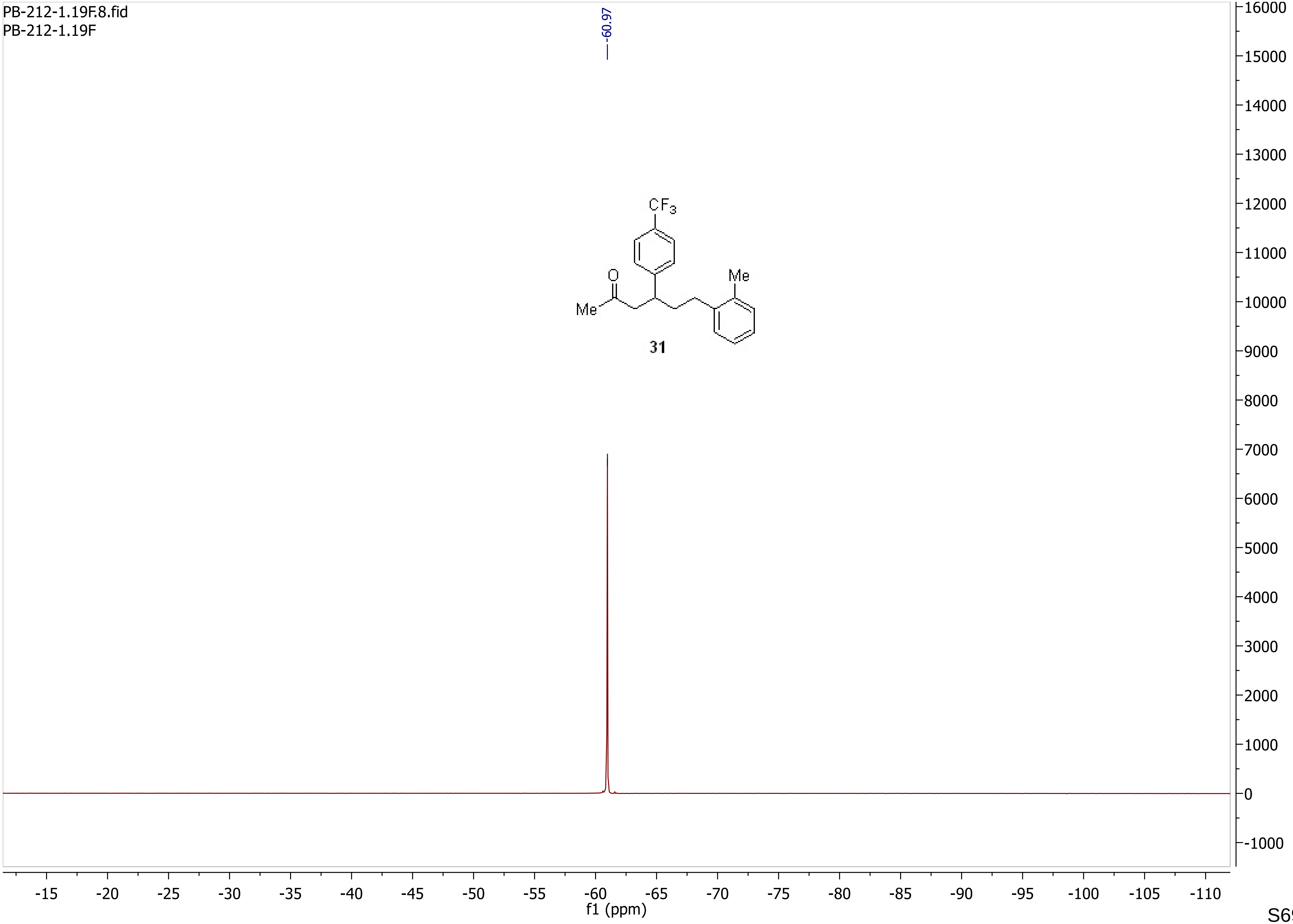
Me
Me
31
f1 (ppm)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Me
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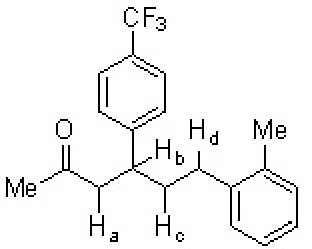
f1 (ppm)



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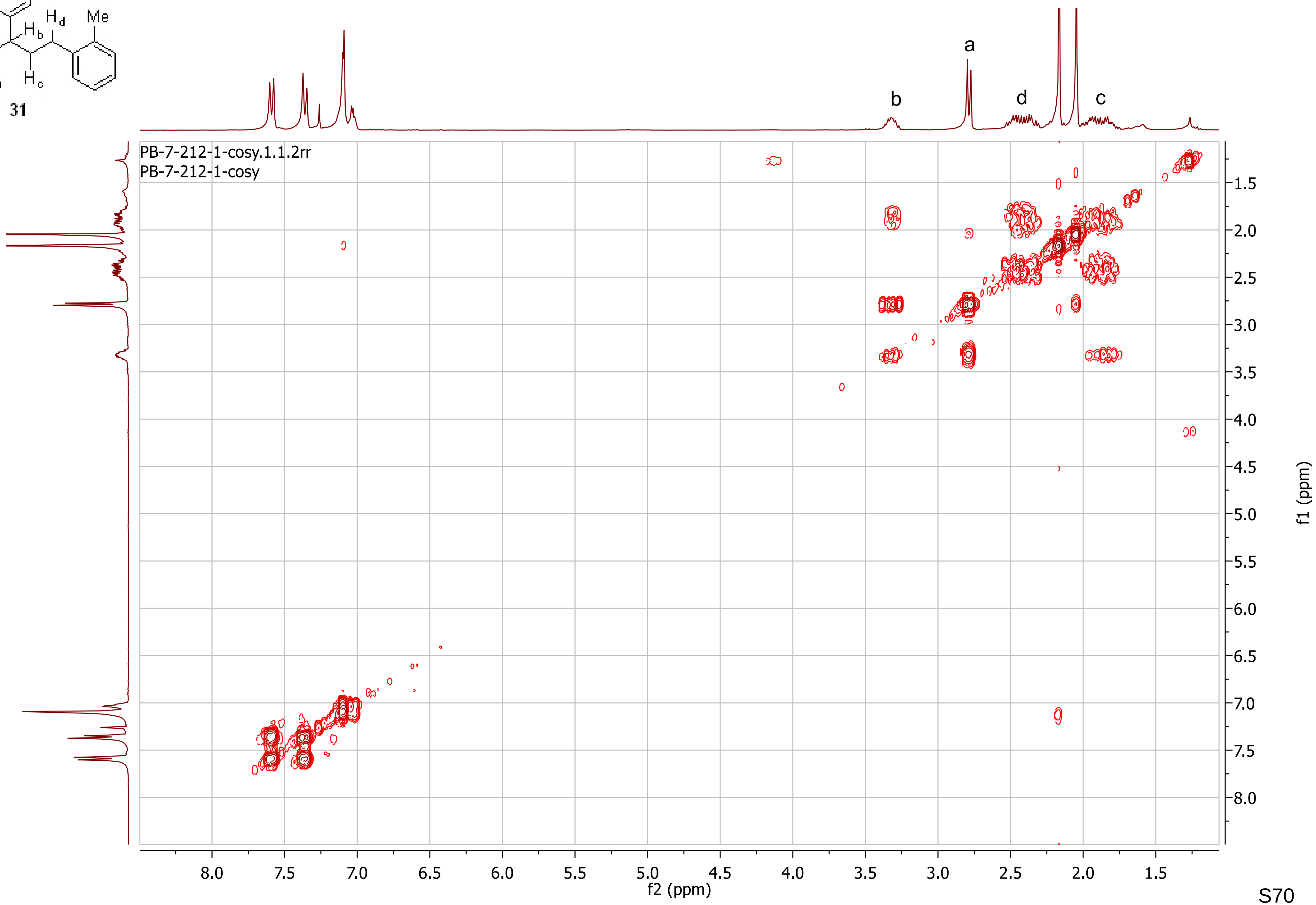

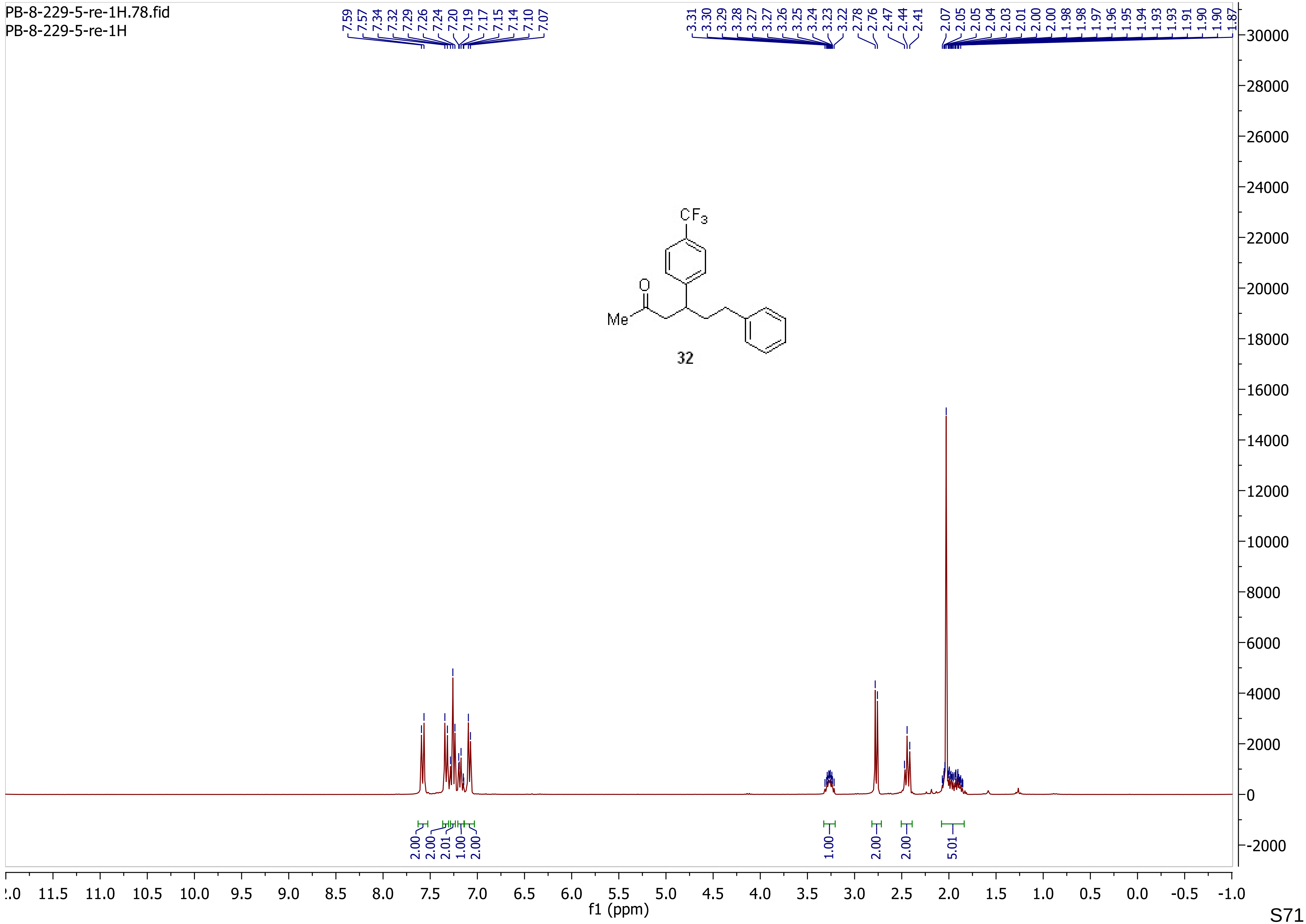
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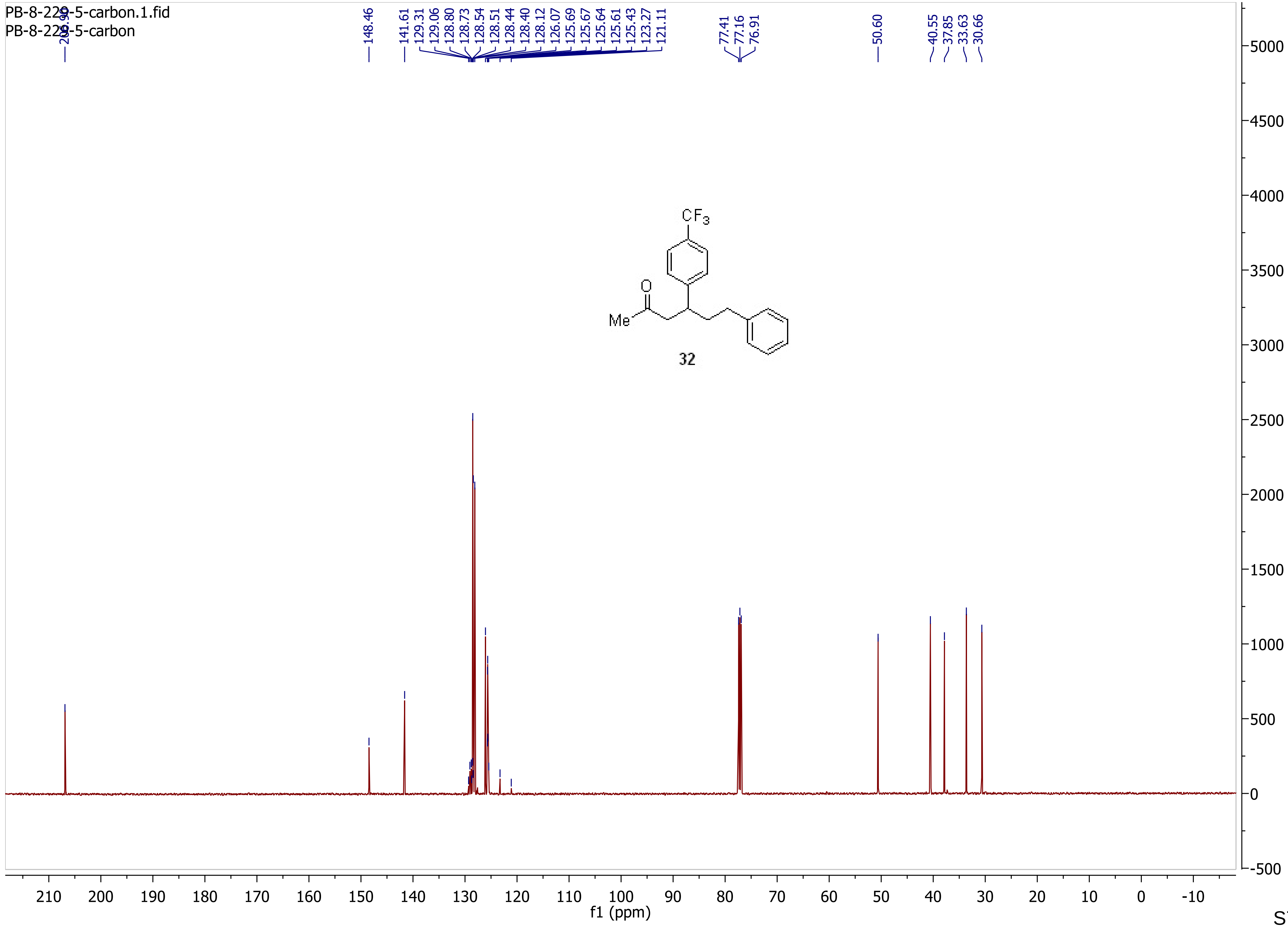
Me
32
f1 (ppm)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128.44
128.40
128.12
126.07
125.69
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125.64
125.61
125.43
123.27
121.11
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77.16
76.91
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40.55
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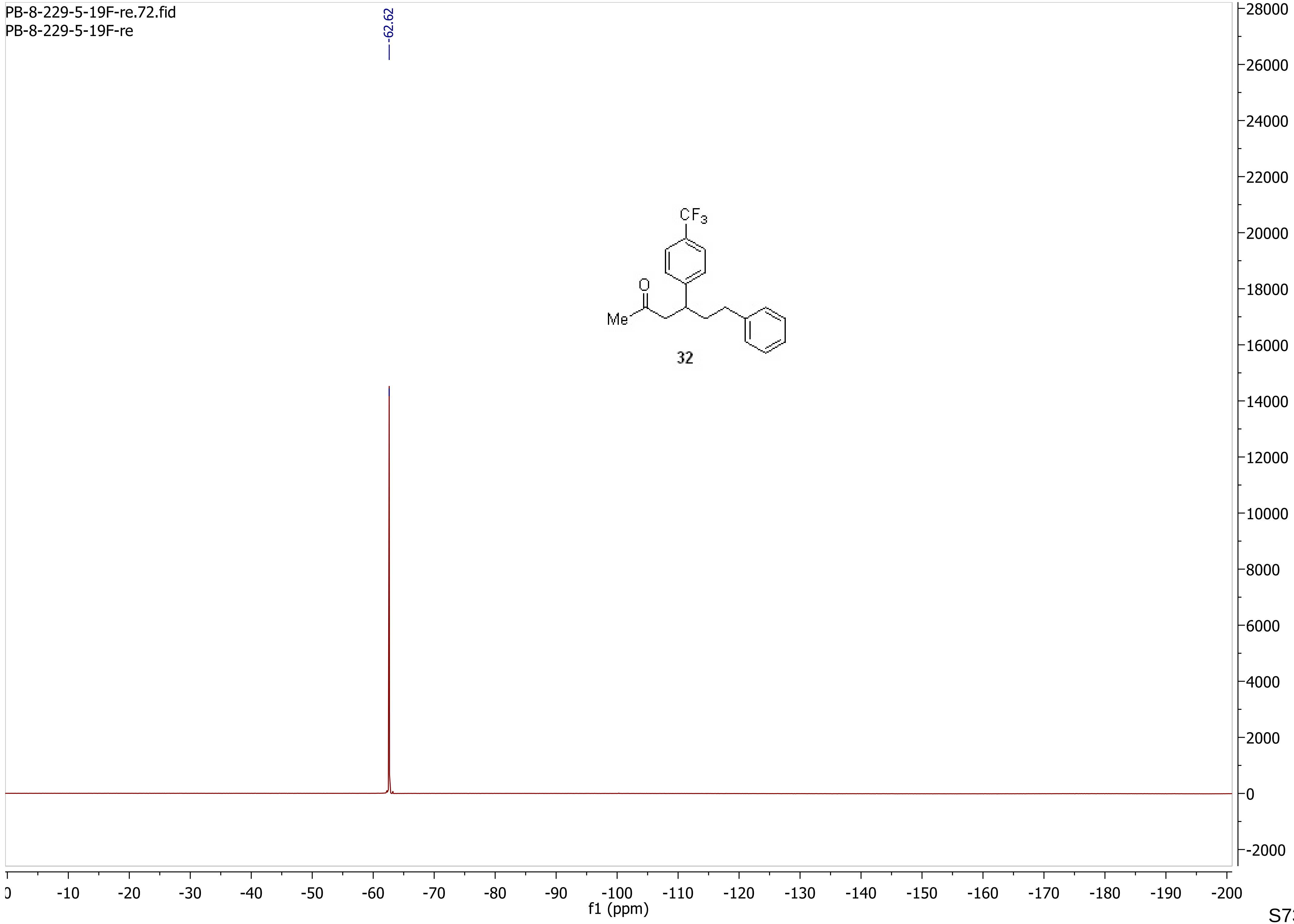
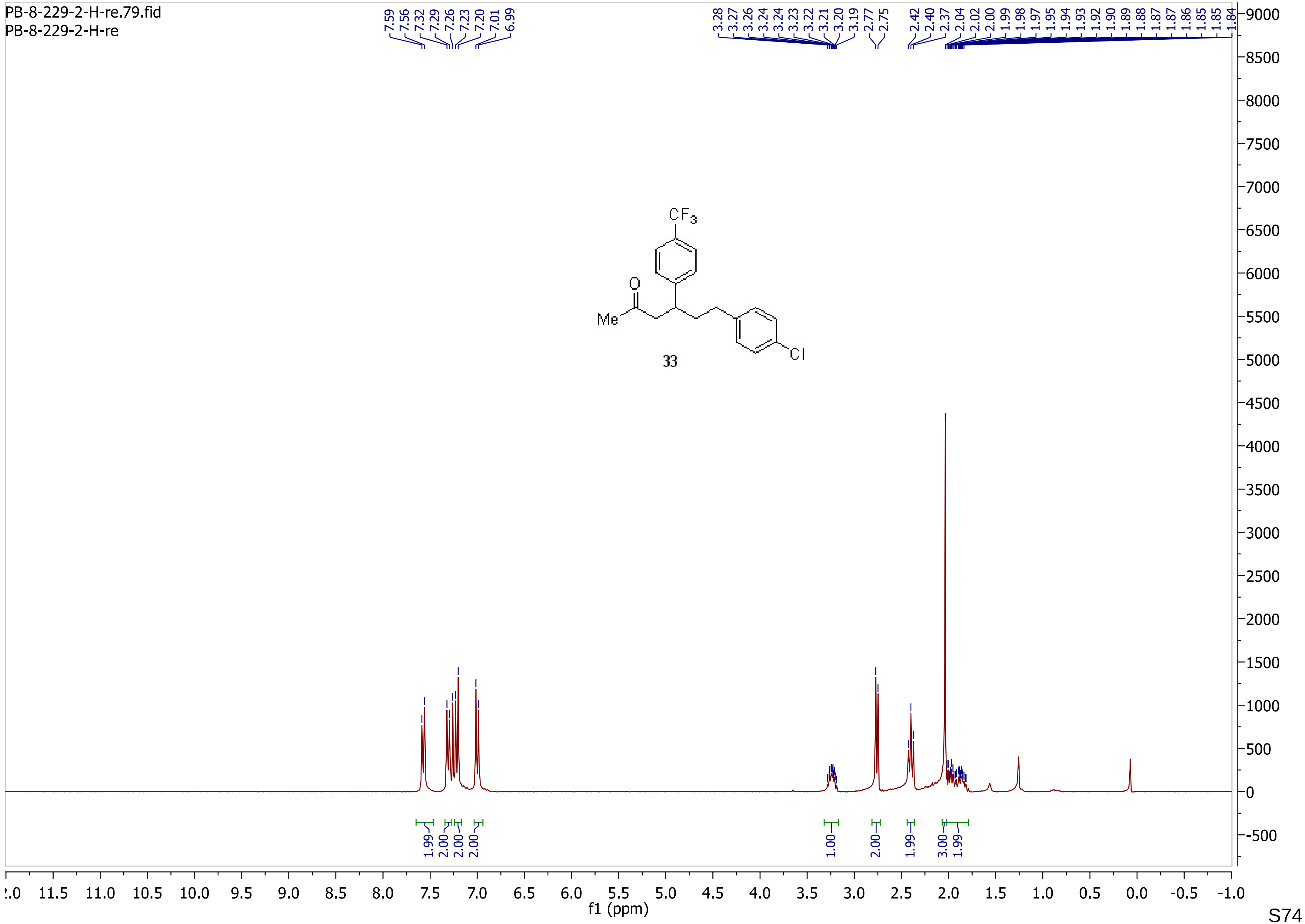
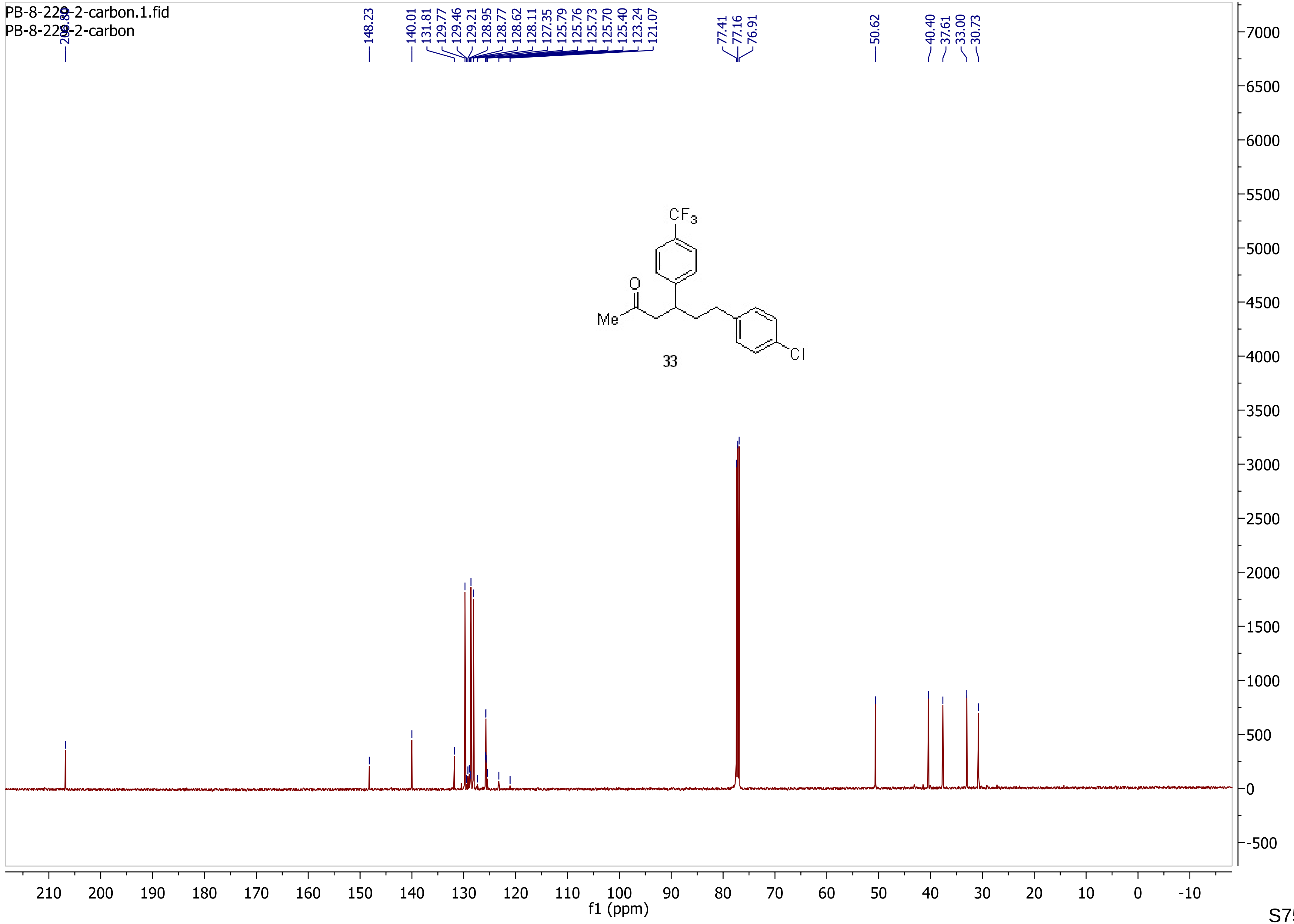
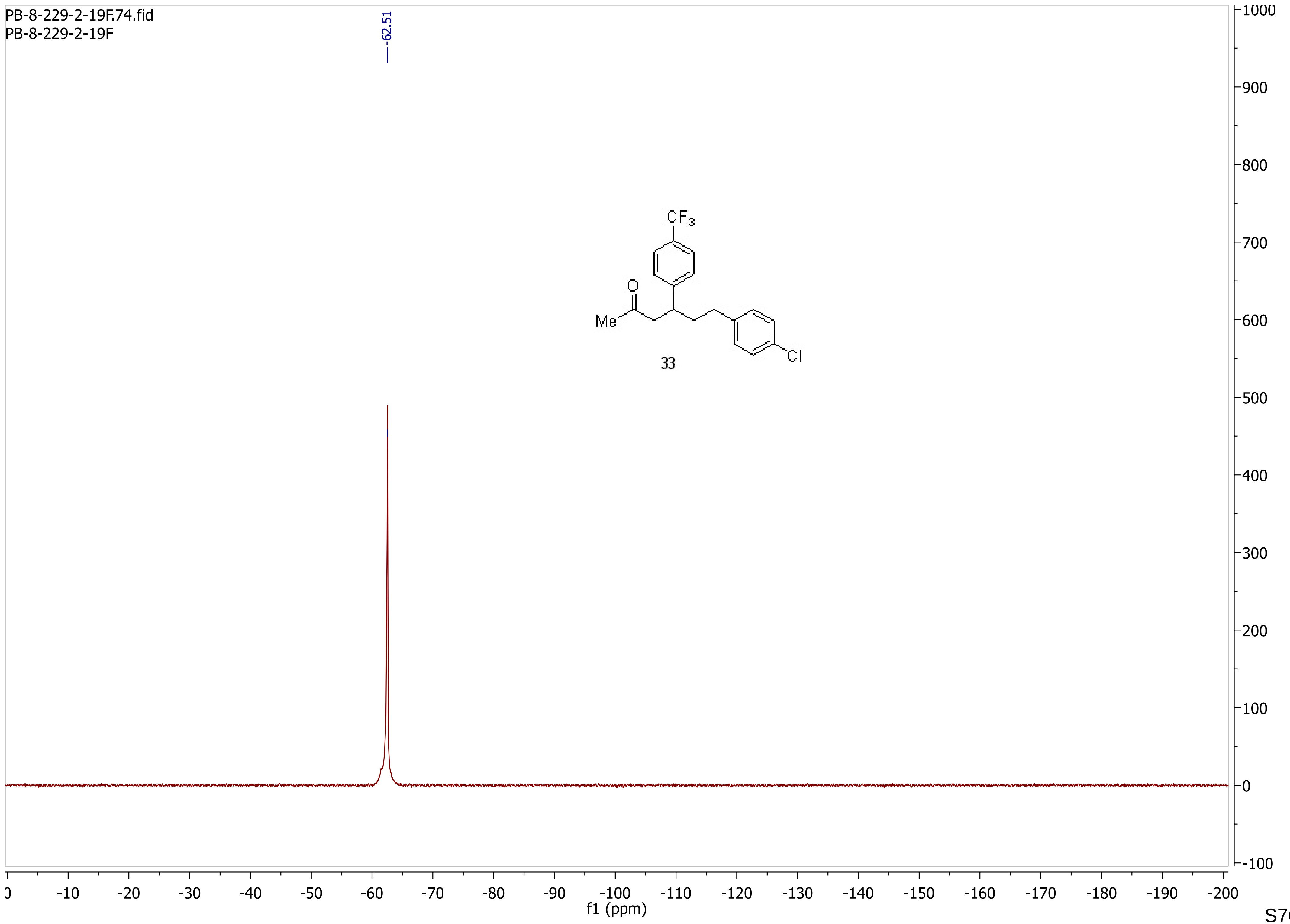
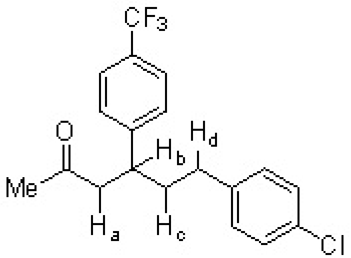
33.63
30.66
CF_3
O
Me
32
f1 (ppm)


PB-8-229-5-19F-re.72.fid
PB-8-229-5-19F-re
-62.62
CF3
O
Me
32
f1 (ppm)

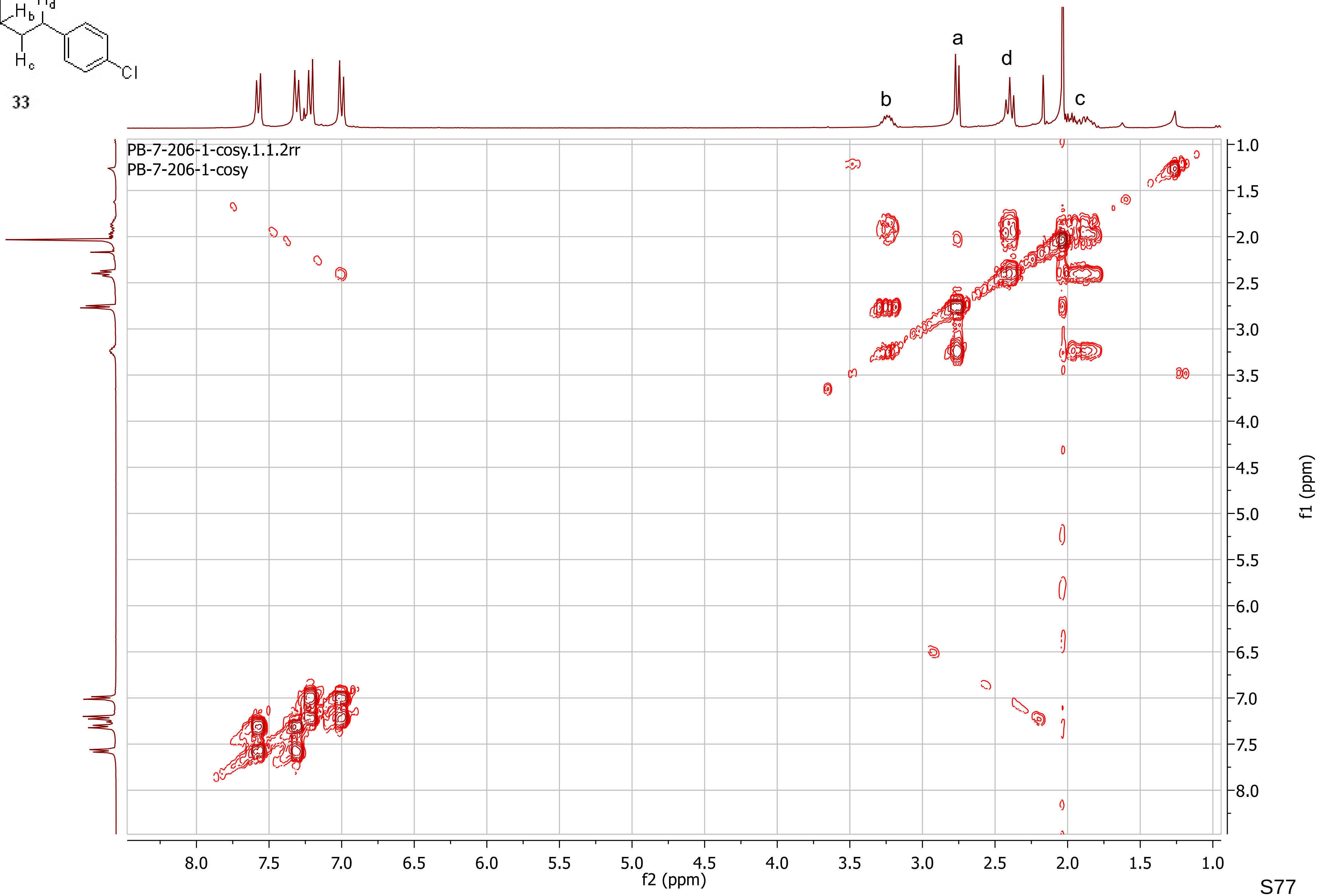

PB-8-229-2-H-re.79.fid
PB-8-229-2-H-re
7.59 7.56 7.32 7.29 7.26 7.23 7.20 7.01 6.99
3.28 3.27 3.26 3.24 3.24 3.23 3.22 3.21 3.20 3.19 2.77 2.75
2.42 2.40 2.37 2.04 2.02 2.00 1.99 1.98 1.97 1.95 1.94 1.93 1.92 1.90 1.89 1.88 1.87 1.87 1.86 1.85 1.85 1.84
CF3
O
Me
Cl
33
1.99 2.00 2.00 2.00
1.00 2.00 1.99 3.00 1.99
f1 (ppm)

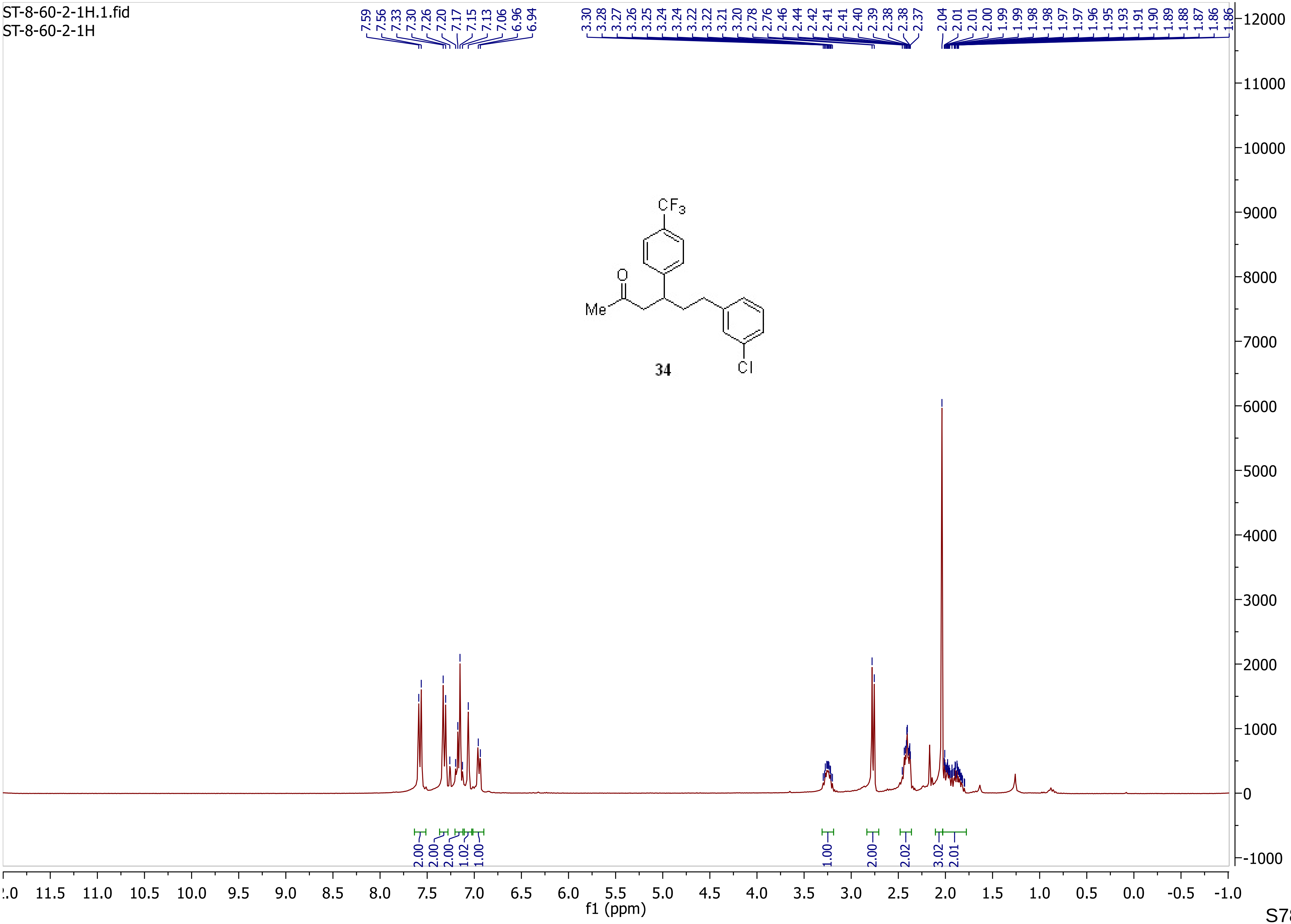

PB-8-229-2-carbon.1.fid
PB-8-229-2-carbon
148.23
140.01
131.81
129.77
129.46
129.21
128.95
128.77
128.62
128.11
127.35
125.79
125.76
125.73
125.70
125.40
123.24
121.07
77.41
77.16
76.91
50.62
40.40
37.61
33.00
30.73
CF3
O
Me
Cl
33
f1 (ppm)

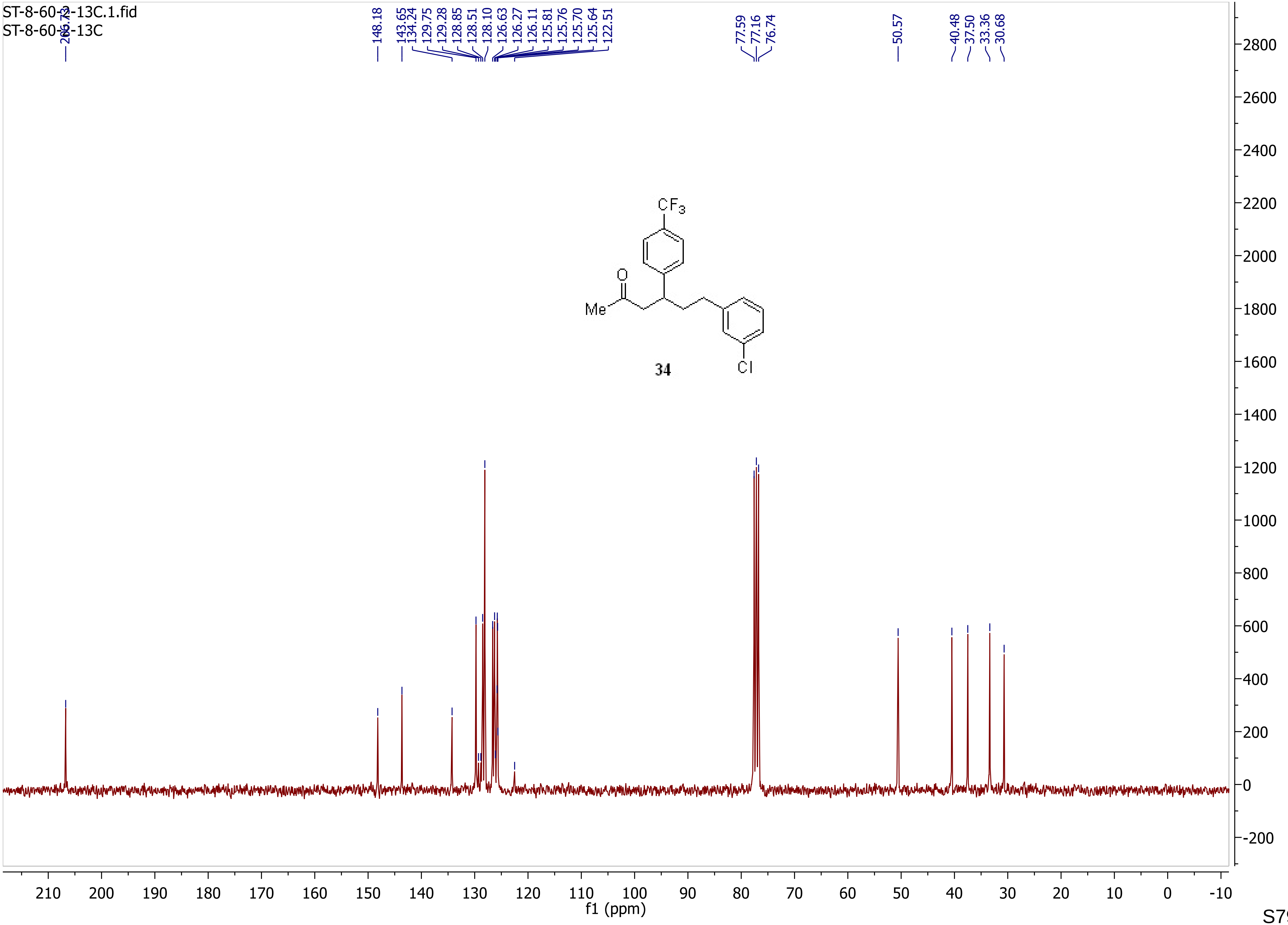

PB-8-229-2-19F.74.fid
PB-8-229-2-19F
-62.51
CF3
O
Me
Cl
33
f1 (ppm)


CF3
O
Me
Hb
Hd
Ha
Hc
Cl

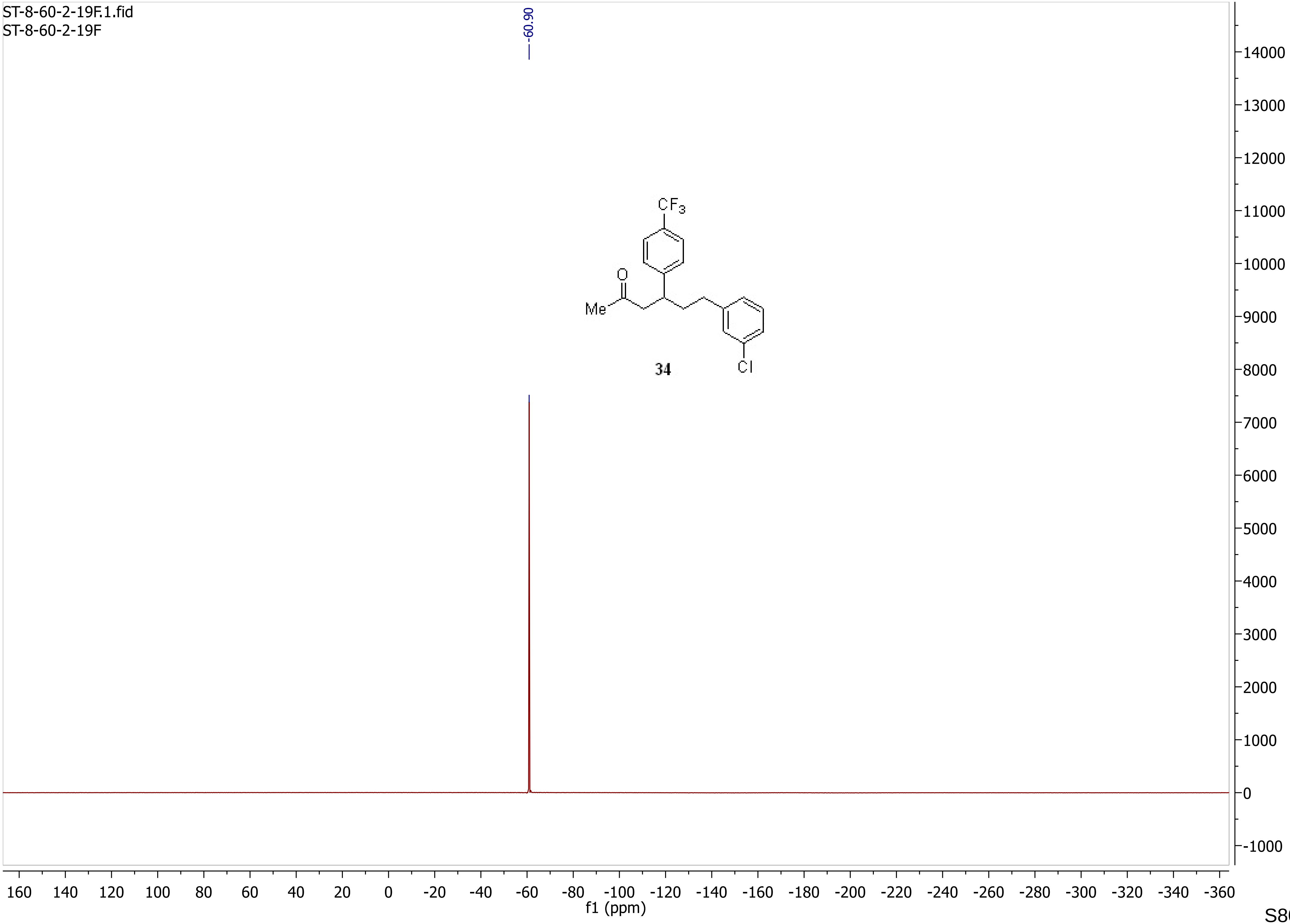
33


a
d
b
c
PB-7-206-1-cosy.1.1.2rr
PB-7-206-1-cosy
f2 (ppm)
f1 (ppm)

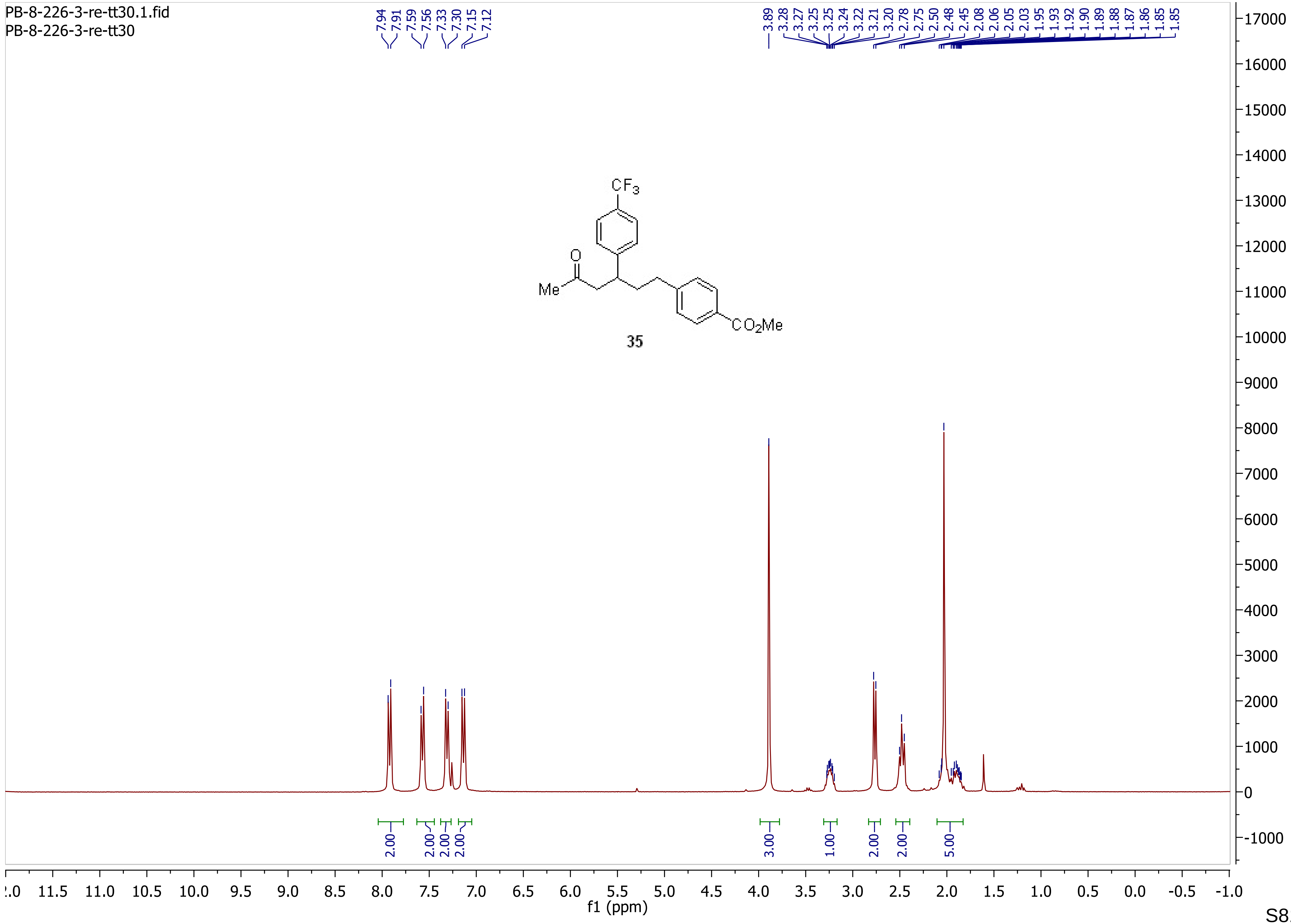

ST-8-60-2-1H.1.fid
ST-8-60-2-1H
7.59 7.56 7.33 7.30 7.26 7.20 7.17 7.15 7.13 7.06 6.96 6.94
3.30 3.28 3.27 3.26 3.25 3.24 3.24 3.22 3.22 3.21 3.20 2.78 2.76 2.46 2.44 2.42 2.41 2.41 2.40 2.39 2.38 2.38 2.37
2.04 2.01 2.01 2.00 1.99 1.99 1.98 1.98 1.97 1.97 1.96 1.95 1.93 1.91 1.90 1.89 1.88 1.87 1.86 1.86
CF3
O
Me
Cl
34
2.00 2.00 2.00 1.02 1.00 1.00 2.00 2.02 3.02 2.01
f1 (ppm)

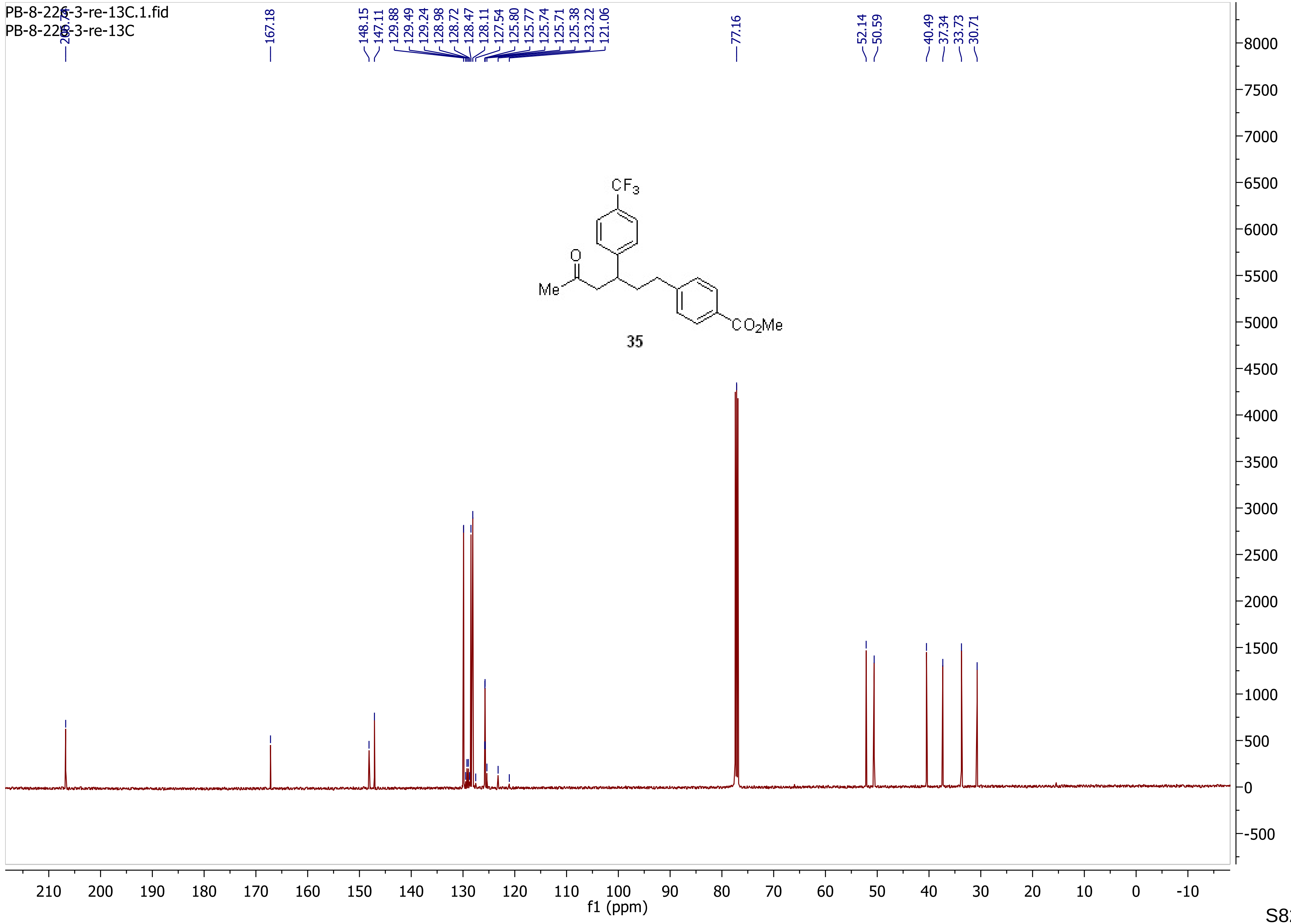

ST-8-60-2-13C.1.fid
ST-8-60-2-13C
206.72
148.18
143.65
134.24
129.75
129.28
128.85
128.51
128.10
126.63
126.27
126.11
125.81
125.76
125.70
125.64
122.51
77.59
77.16
76.74
50.57
40.48
37.50
33.36
30.68
CF3
O
Me
Cl
34
f1 (ppm)

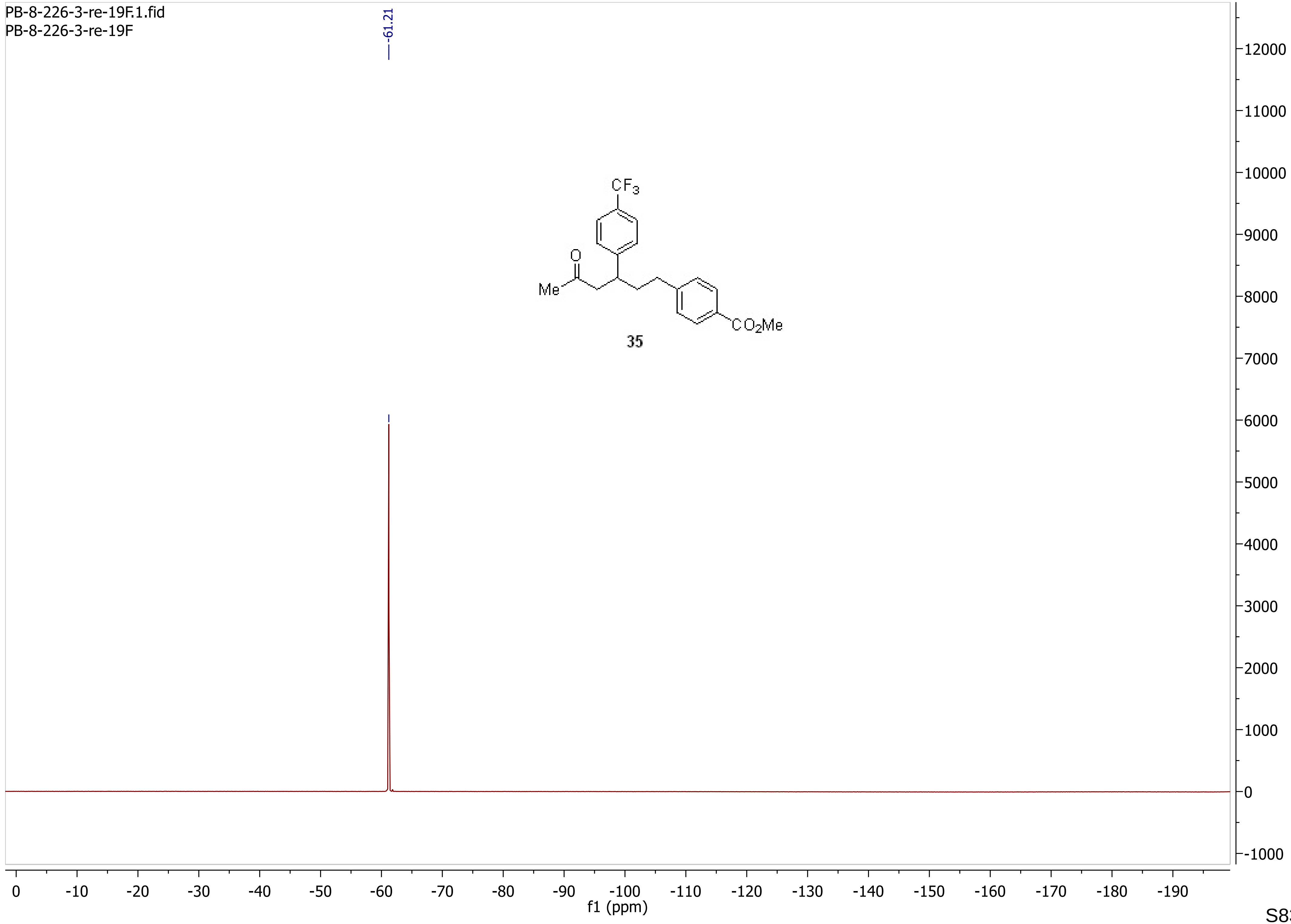
ST-8-60-2-19F.1.fid
ST-8-60-2-19F

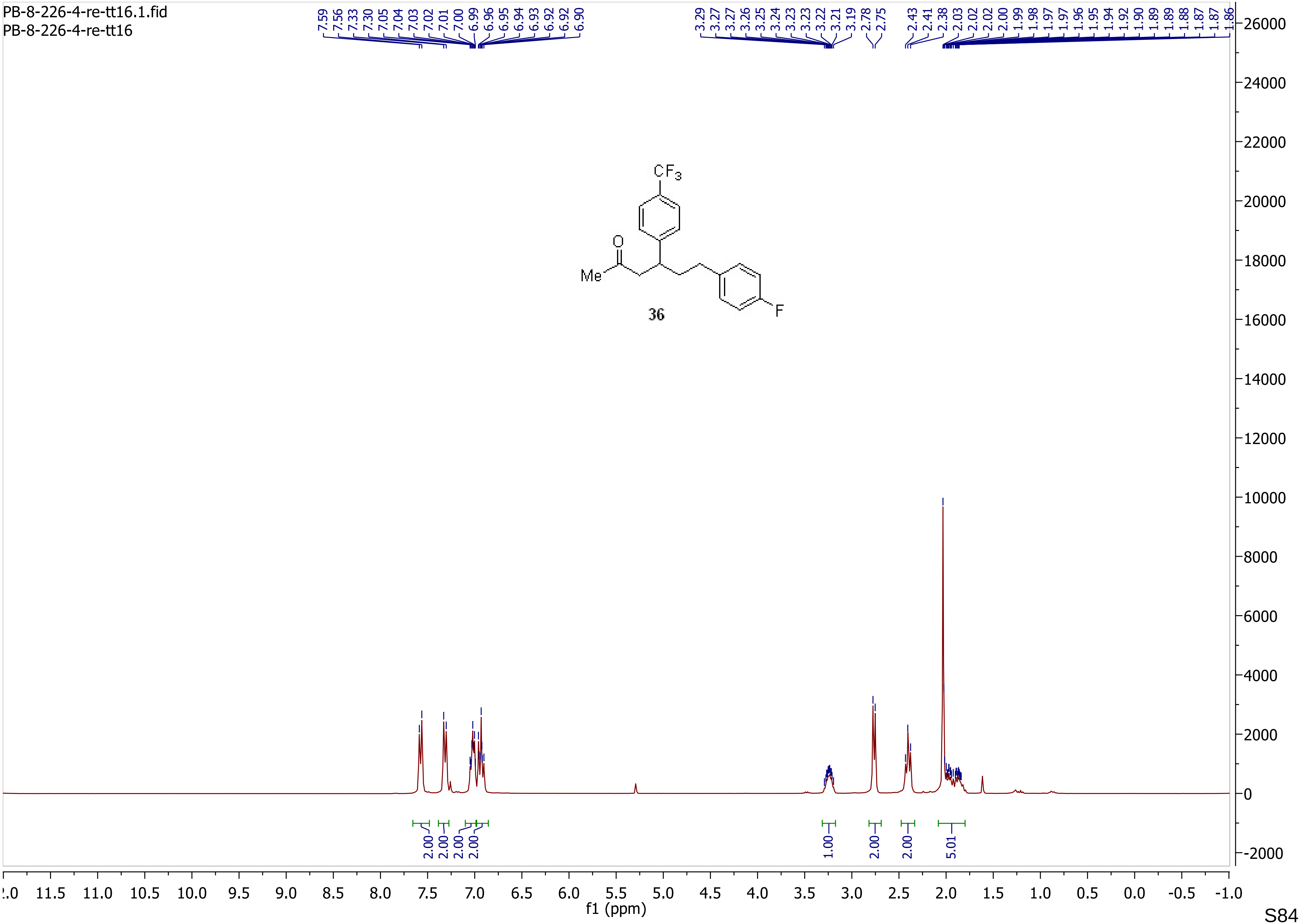


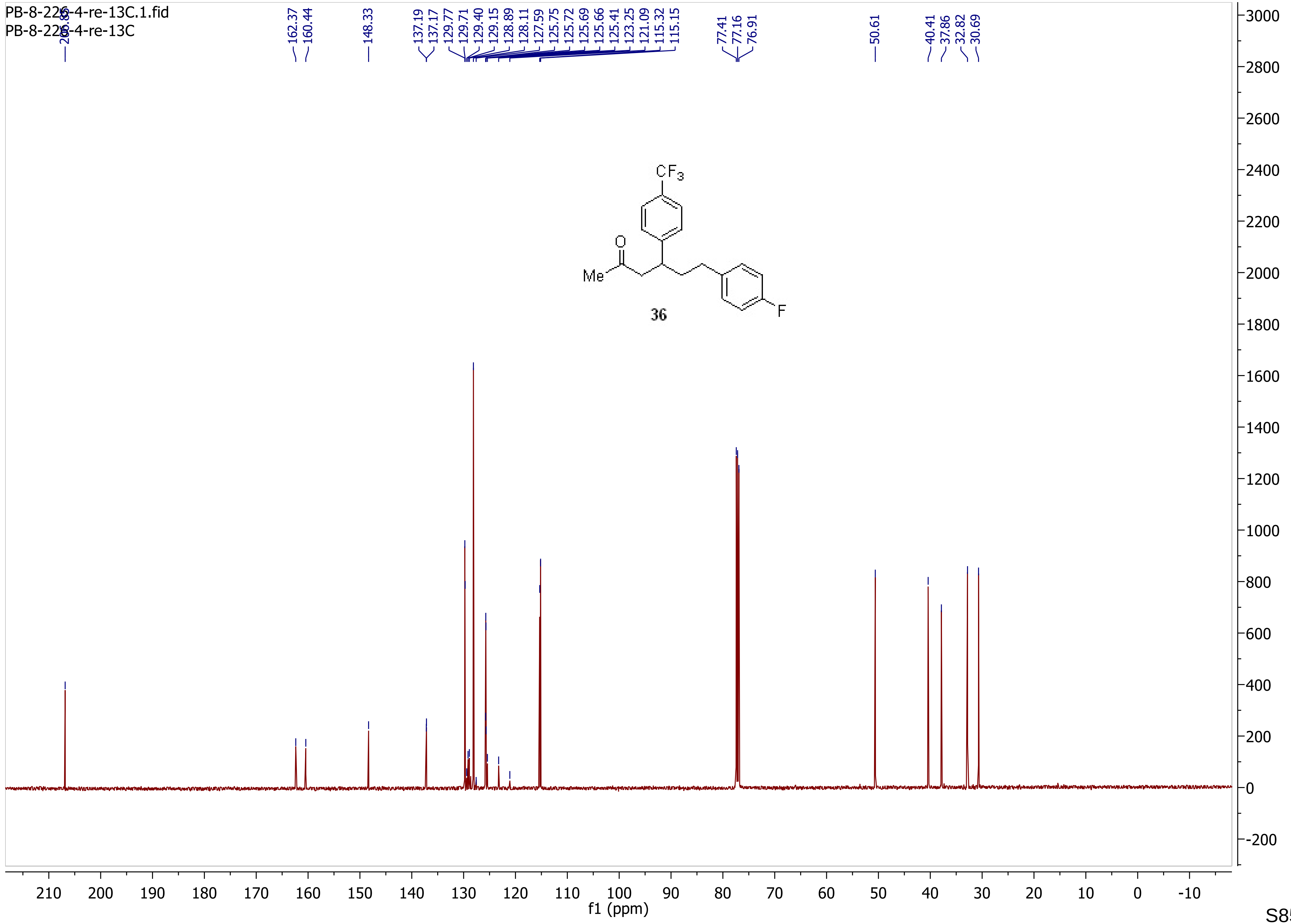
34


PB-8-226-3-re-tt30.1.fid
PB-8-226-3-re-tt30
7.94
7.91
7.59
7.56
7.33
7.30
7.15
7.12
3.89
3.28
3.27
3.25
3.25
3.24
3.22
3.21
3.20
2.78
2.75
2.50
2.48
2.45
2.08
2.06
2.05
2.03
1.95
1.93
1.92
1.90
1.89
1.88
1.87
1.86
1.85
1.85
CF3
O
Me
CO2Me
35
2.00
2.00
2.00
2.00
3.00
1.00
2.00
2.00
5.00
f1 (ppm)

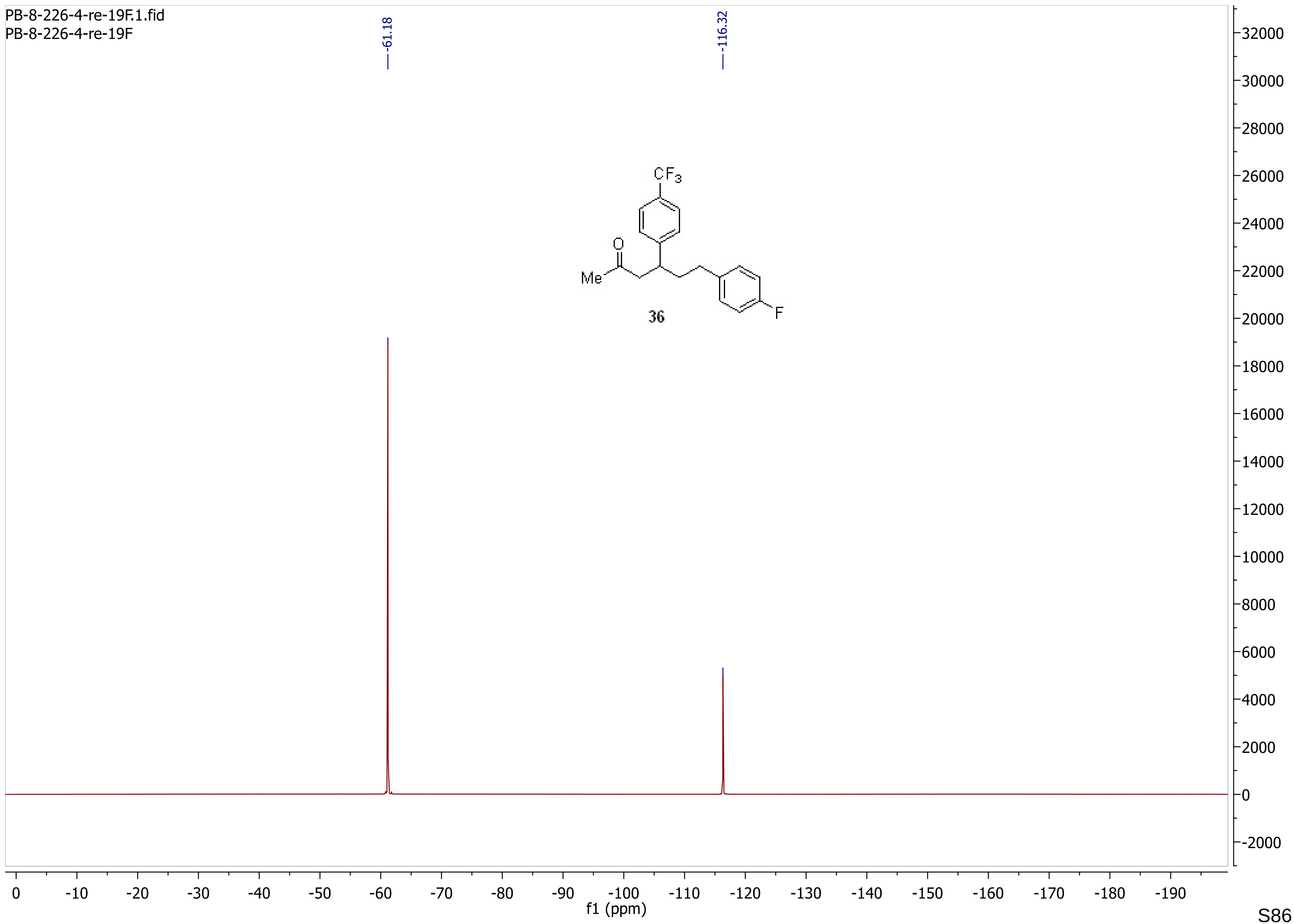

PB-8-226-3-re-13C.1.fid
PB-8-226-3-re-13C
167.18
148.15
147.11
129.88
129.49
129.24
128.98
128.72
128.47
128.11
127.54
125.80
125.77
125.74
125.71
125.38
123.22
121.06
77.16
52.14
50.59
40.49
37.34
33.73
30.71
CF3
O
Me
CO2Me
35
f1 (ppm)

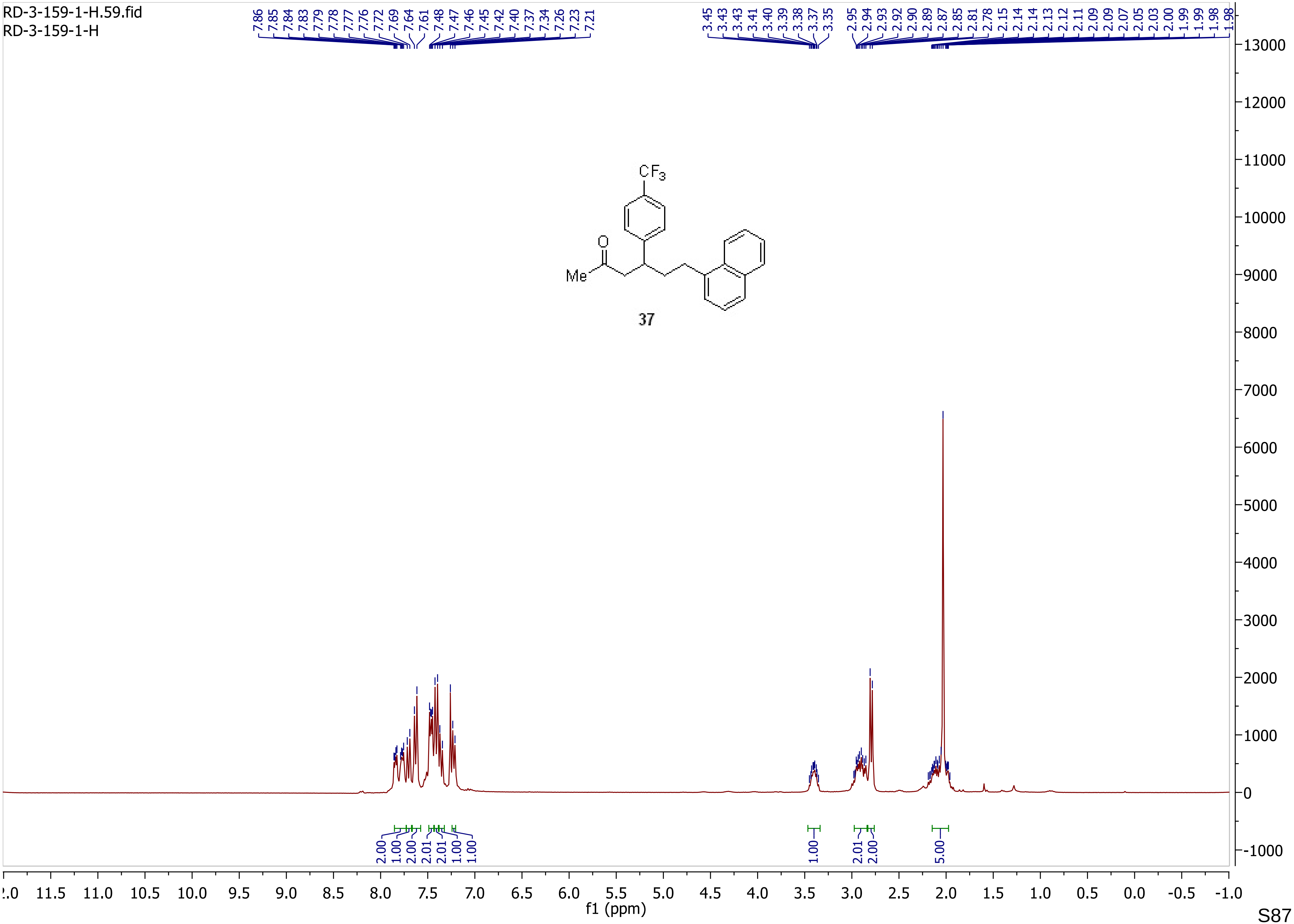

PB-8-226-3-re-19F.1.fid
PB-8-226-3-re-19F
-61.21
CF3
O
Me
CO2Me
35
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
f1 (ppm)
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000

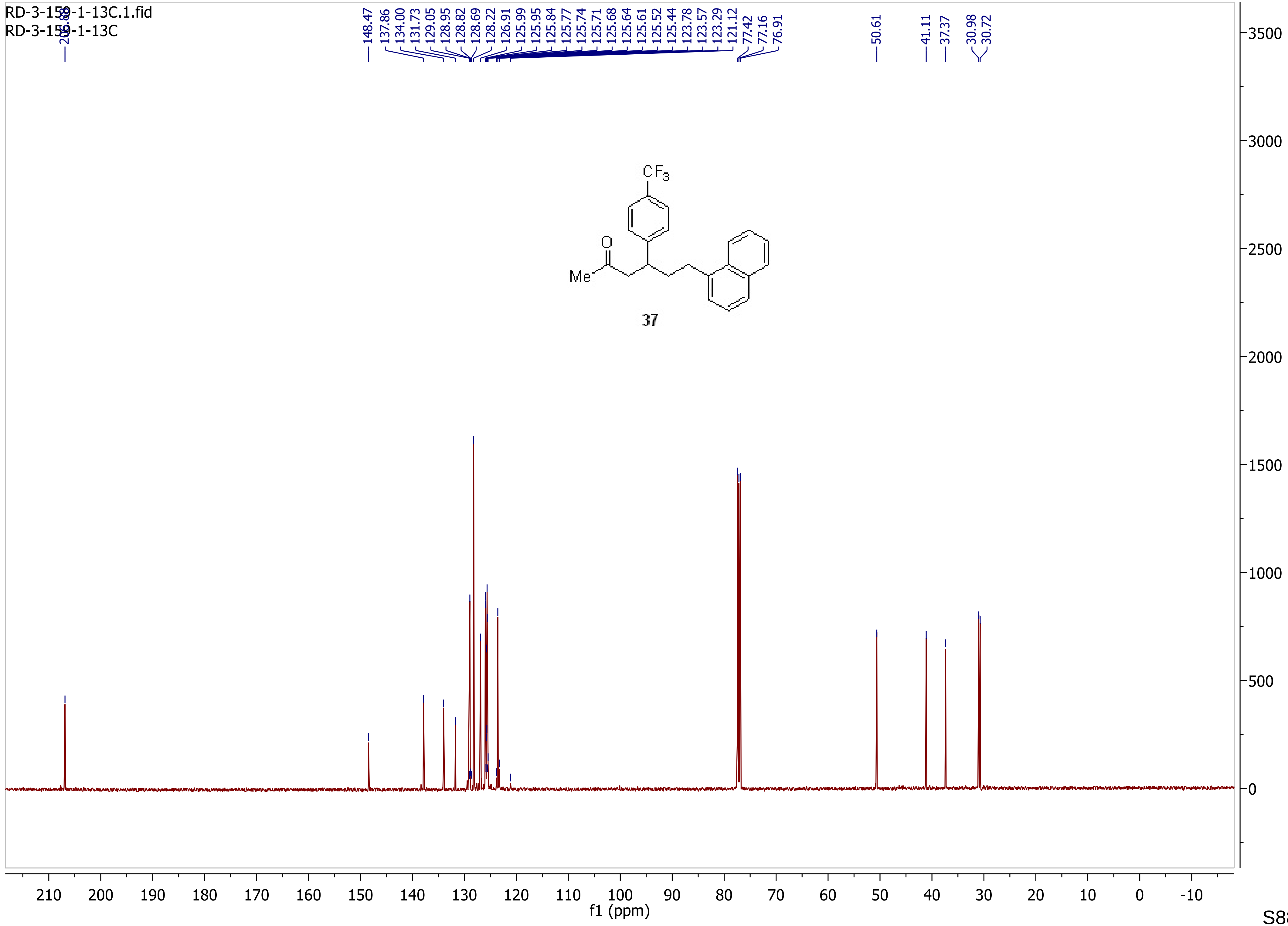

PB-8-226-4-re-tt16.1.fid
PB-8-226-4-re-tt16
CF3
O
Me
F
36
f1 (ppm)



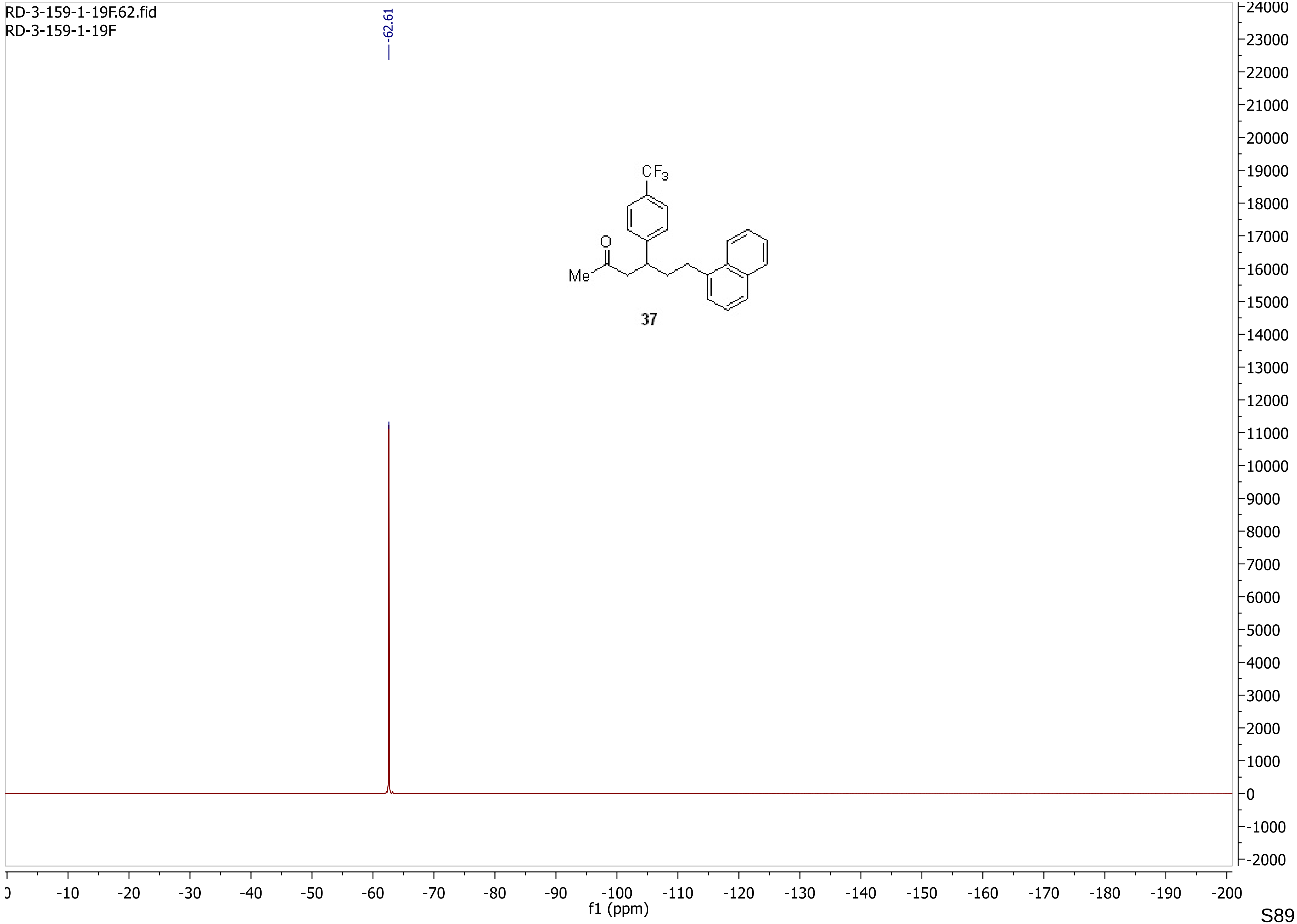
PB-8-226-4-re-13C.1.fid
PB-8-226-4-re-13C
162.37
160.44
148.33
137.19
137.17
129.77
129.71
129.40
129.15
128.89
128.11
127.59
125.75
125.72
125.69
125.66
125.41
123.25
121.09
115.32
115.15
77.41
77.16
76.91
50.61
40.41
37.86
32.82
30.69
CF3
O
Me
F
36
f1 (ppm)


PB-8-226-4-re-19F.1.fid
PB-8-226-4-re-19F
-61.18
-116.32
CF3
O
Me
F
36
f1 (ppm)

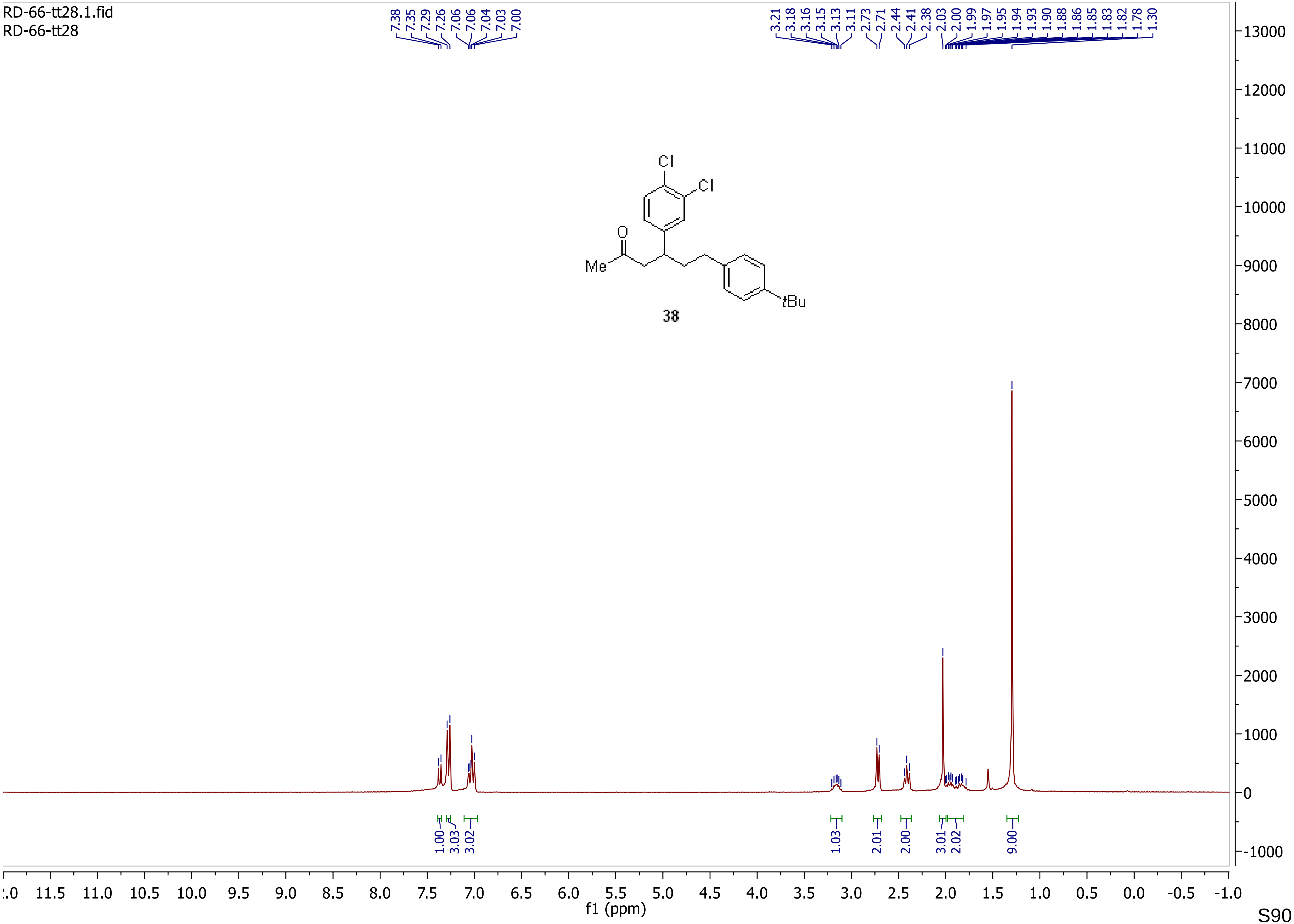

RD-3-159-1-H.59.fid
RD-3-159-1-H
7.86 7.85 7.84 7.83 7.79 7.78 7.77 7.76 7.72 7.69 7.64 7.61 7.48 7.47 7.46 7.45 7.42 7.40 7.37 7.34 7.26 7.23 7.21
3.45 3.43 3.43 3.41 3.40 3.39 3.38 3.37 3.35
2.95 2.94 2.93 2.92 2.90 2.89 2.87 2.85 2.81 2.78 2.15 2.14 2.14 2.13 2.12 2.11 2.09 2.09 2.07 2.05 2.03 2.00 1.99 1.99 1.98 1.98
CF3
O
Me
37
2.00 1.00 2.00 2.01 2.01 1.00 1.00
1.00
2.01 2.00
5.00
f1 (ppm)

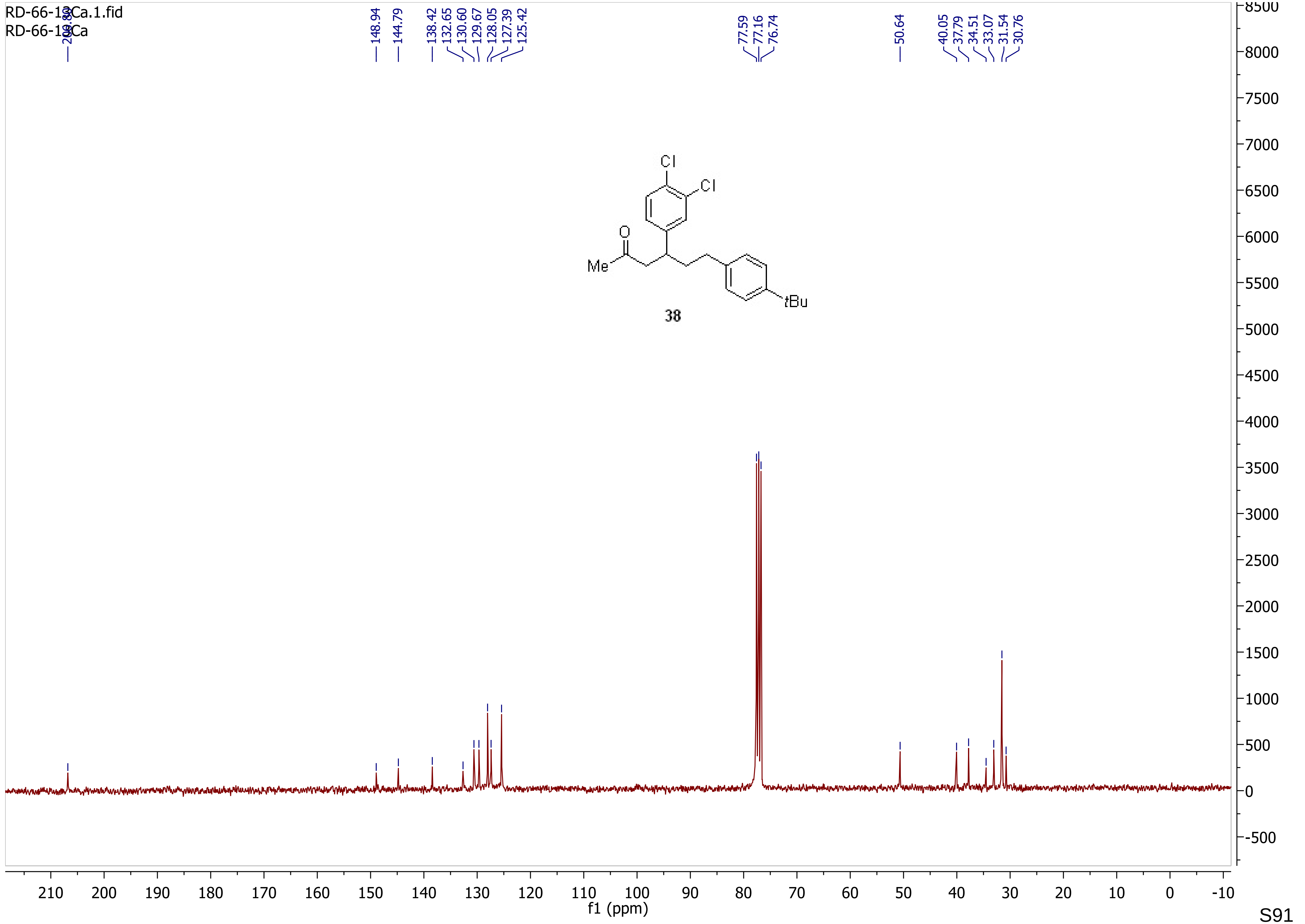


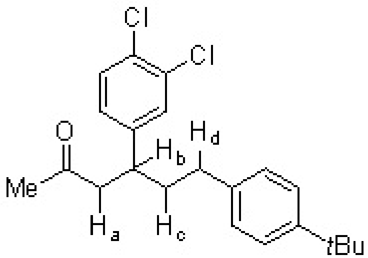
RD-3-159-1-13C.1.fid
RD-3-159-1-13C
148.47
137.86
134.00
131.73
129.05
128.95
128.82
128.69
128.22
126.91
125.99
125.95
125.84
125.77
125.74
125.71
125.68
125.64
125.61
125.52
125.44
123.78
123.57
123.29
121.12
77.42
77.16
76.91
50.61
41.11
37.37
30.98
30.72
CF3
O
Me
37
f1 (ppm)



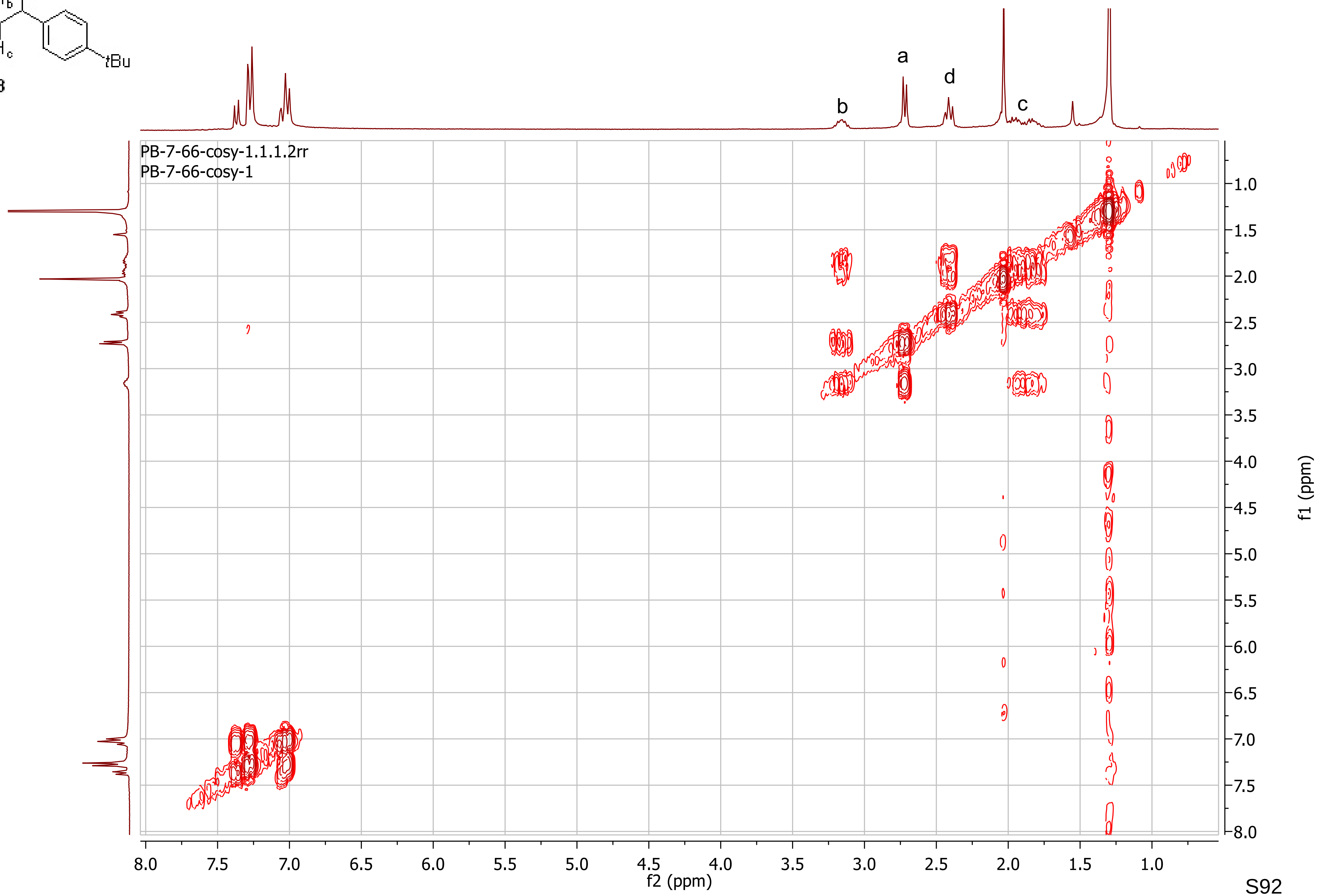
37

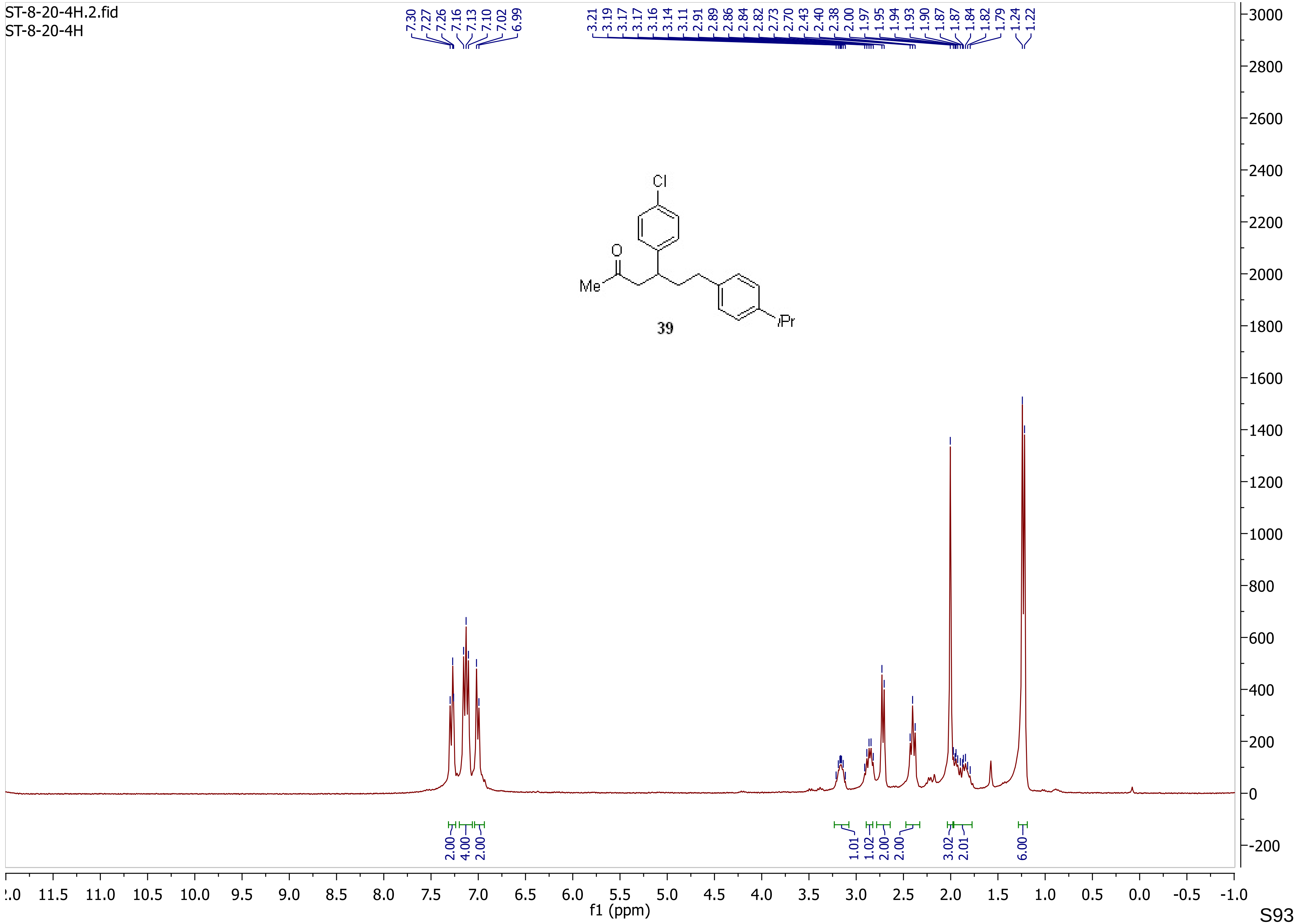

RD-66-tt28.1.fid
RD-66-tt28
7.38 7.35 7.29 7.26 7.06 7.06 7.04 7.03 7.00
3.21 3.18 3.16 3.15 3.13 3.11 2.73 2.71 2.44 2.41 2.38 2.03 2.00 1.99 1.97 1.95 1.94 1.93 1.90 1.88 1.86 1.85 1.83 1.82 1.78 1.30
Cl
Cl
O
Me
tBu
38
1.00 3.03 3.02 1.03 2.01 2.00 3.01 2.02 9.00
f1 (ppm)

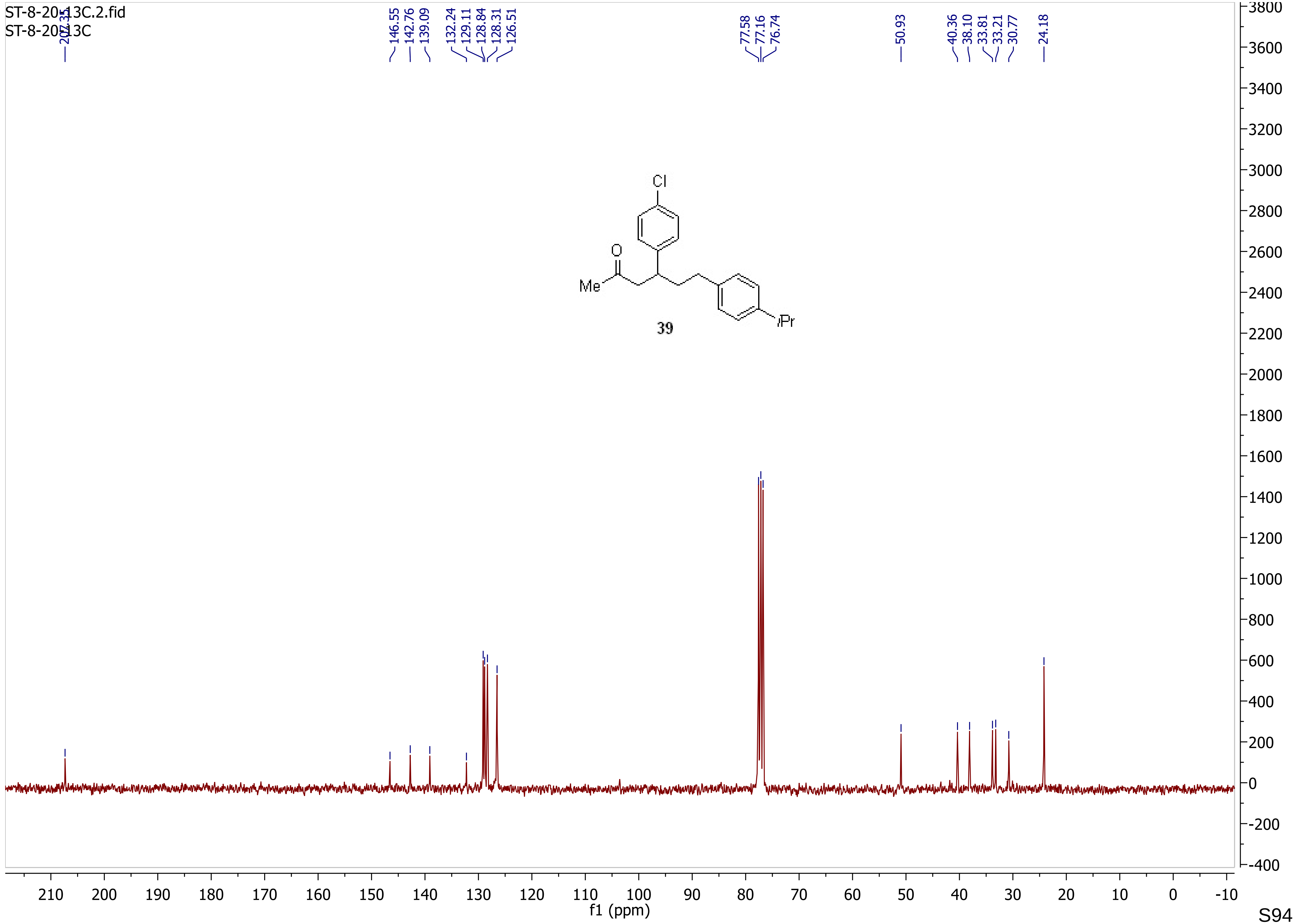

RD-66-13Ca.1.fid
RD-66-13Ca
206.80
148.94
144.79
138.42
132.65
130.60
129.67
128.05
127.39
125.42
77.59
77.16
76.74
50.64
40.05
37.79
34.51
33.07
31.54
30.76
Cl
Cl
O
Me
tBu
38
8500
8000
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-500
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

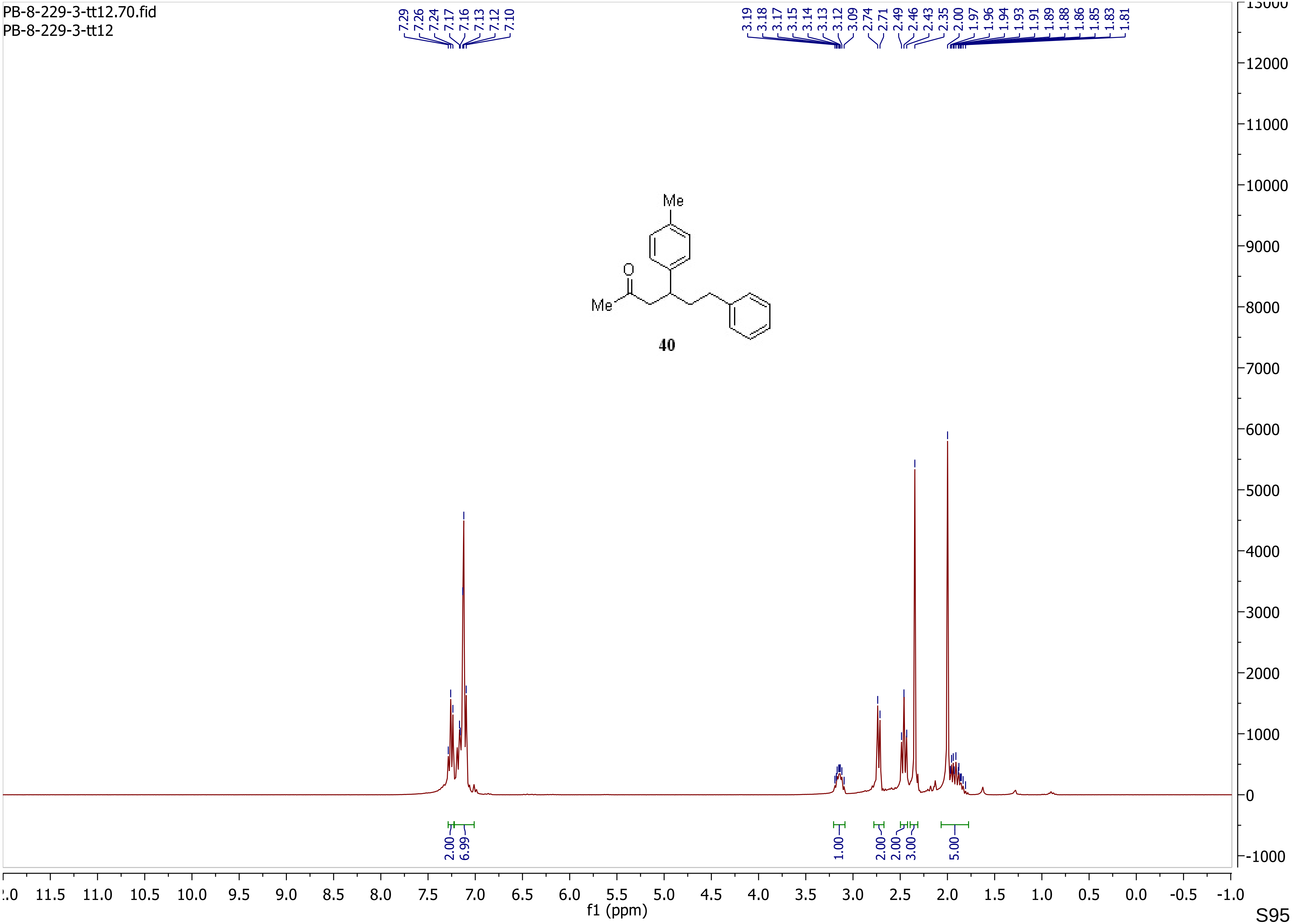

Cl
Cl
O
Me
H
b
H
d
H
a
H
c
tBu

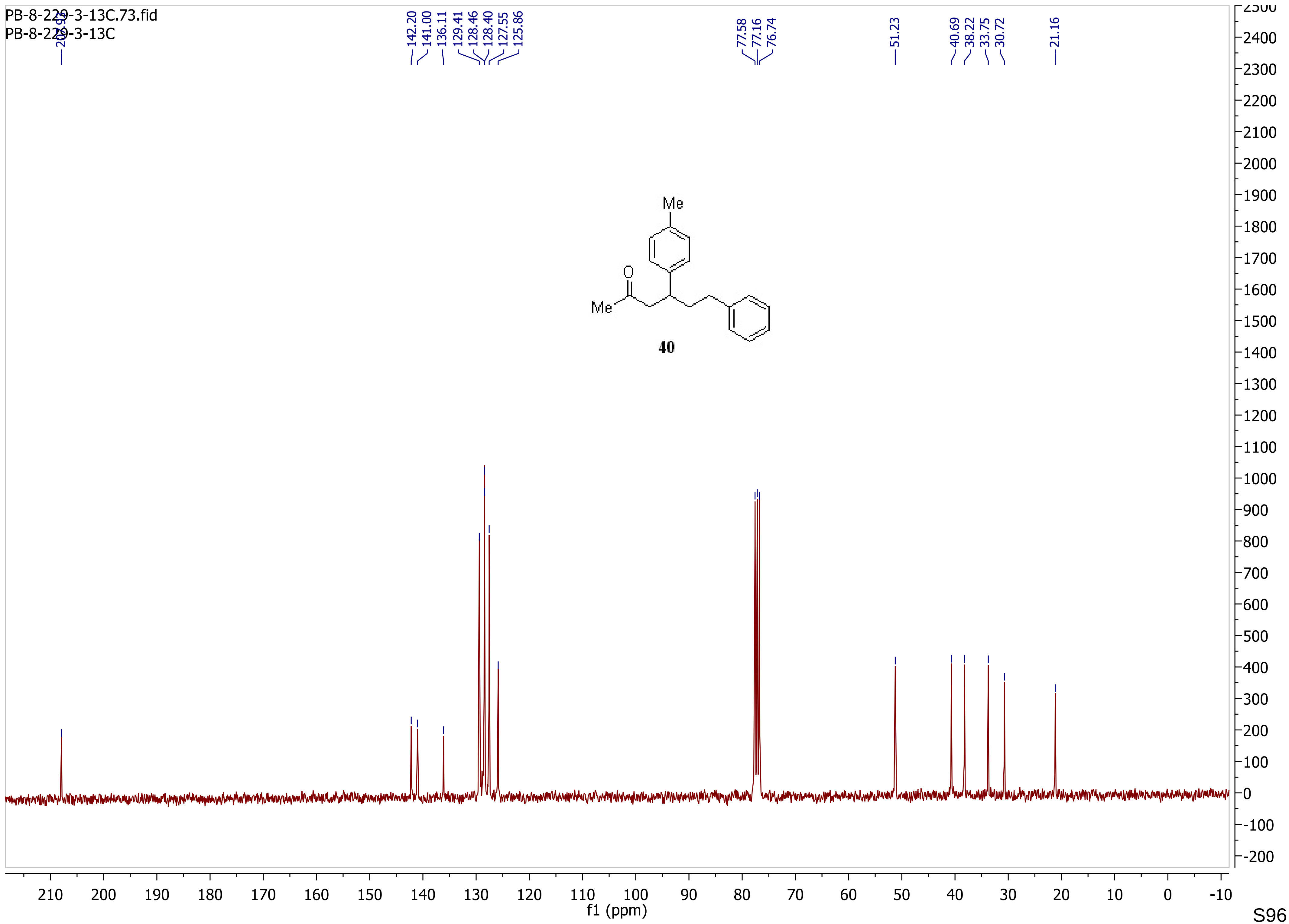
38


b
a
d
c
PB-7-66-cosy-1.1.1.2rr
PB-7-66-cosy-1
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
f2 (ppm)
f1 (ppm)

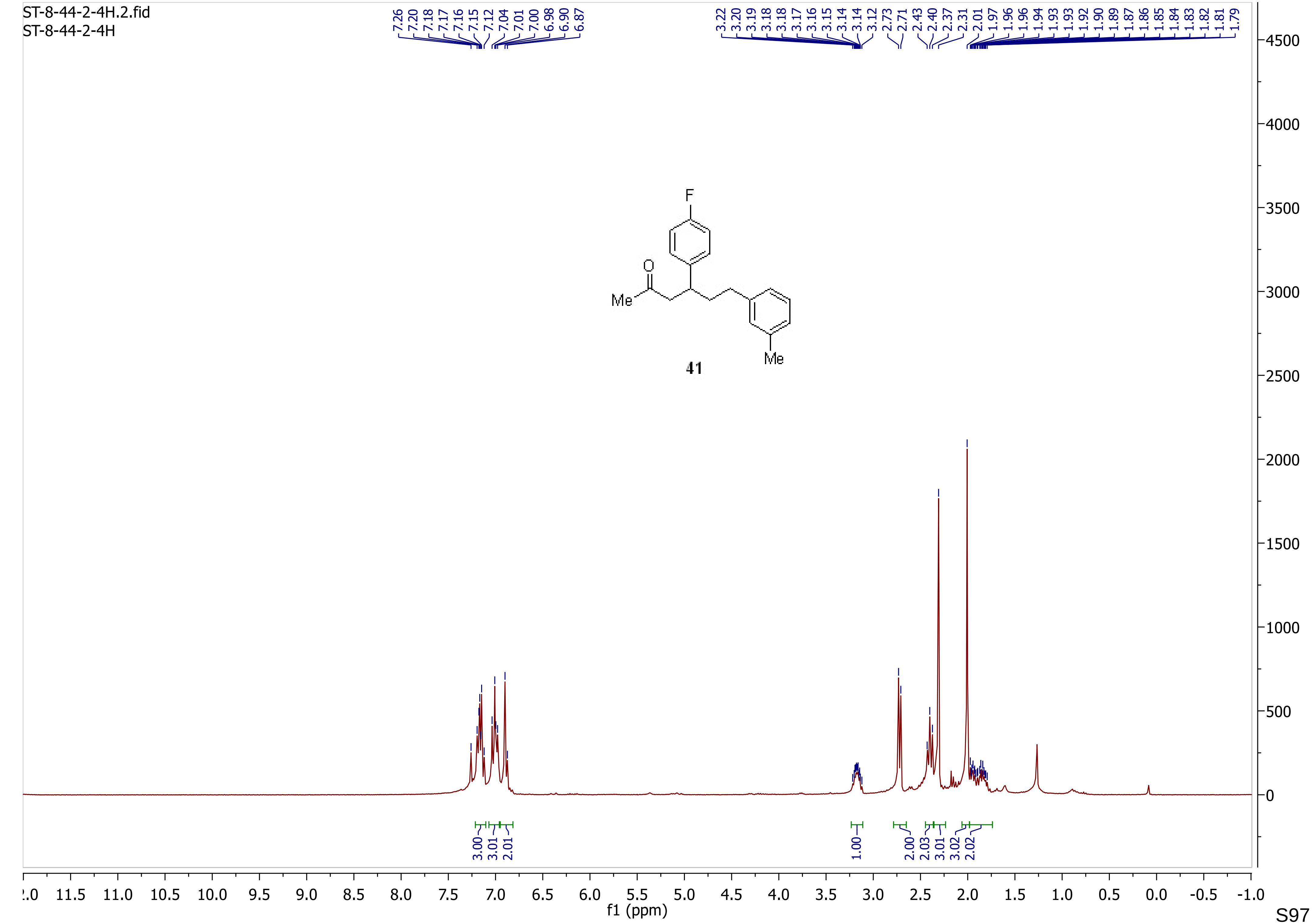

ST-8-20-4H.2.fid
ST-8-20-4H
7.30
7.27
7.26
7.16
7.13
7.10
7.02
6.99
3.21
3.19
3.17
3.17
3.16
3.14
3.11
2.91
2.89
2.86
2.84
2.82
2.73
2.70
2.43
2.40
2.38
2.00
1.97
1.95
1.94
1.93
1.90
1.87
1.87
1.84
1.82
1.79
1.24
1.22
Cl
O
Me
iPr
39
2.00
4.00
2.00
1.01
1.02
2.00
2.00
3.02
2.01
6.00
f1 (ppm)

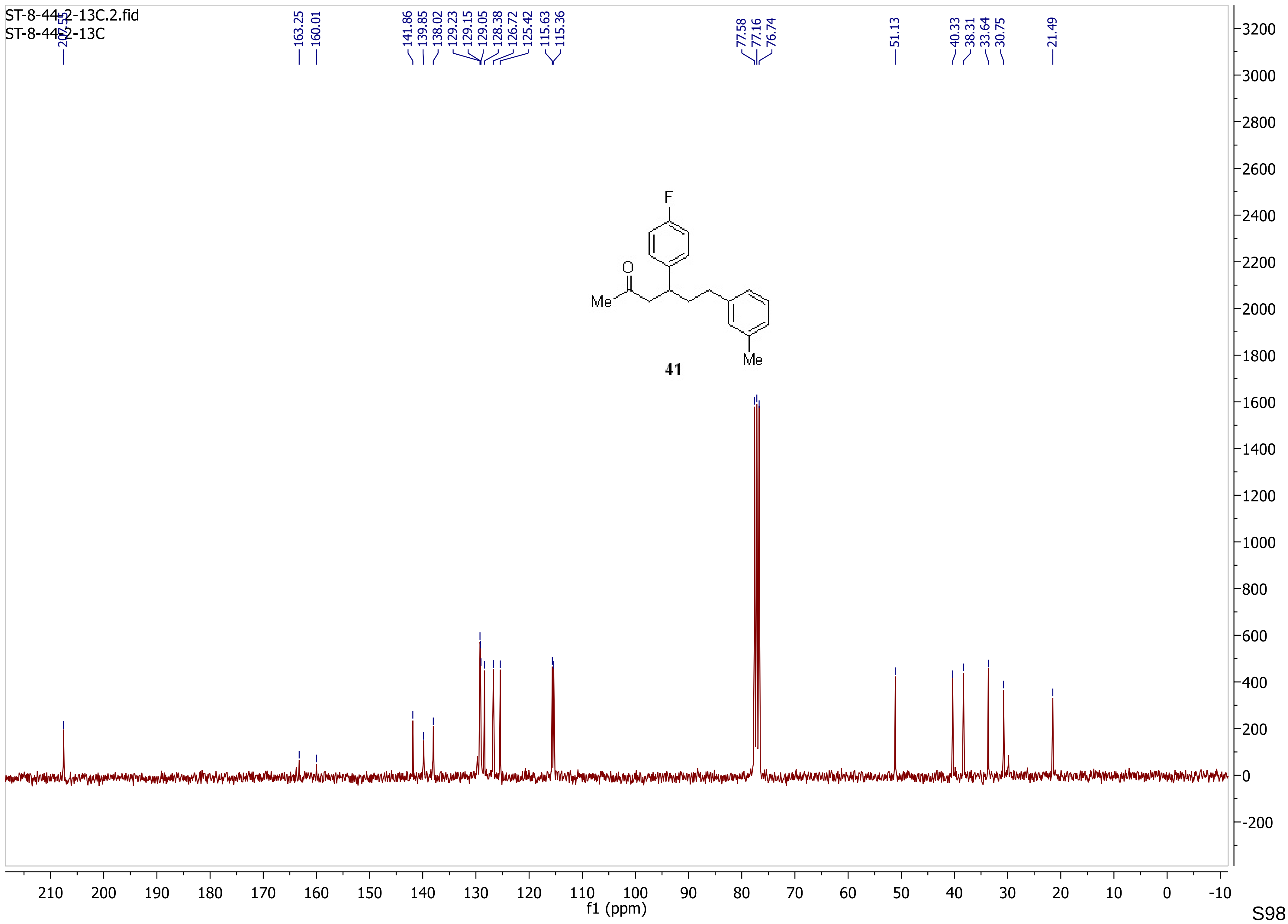

ST-8-20-13C.2.fid
ST-8-20-13C
207.35
146.55
142.76
139.09
132.24
129.11
128.84
128.31
126.51
77.58
77.16
76.74
50.93
40.36
38.10
33.81
33.21
30.77
24.18
Cl
O
Me
iPr
39
f1 (ppm)

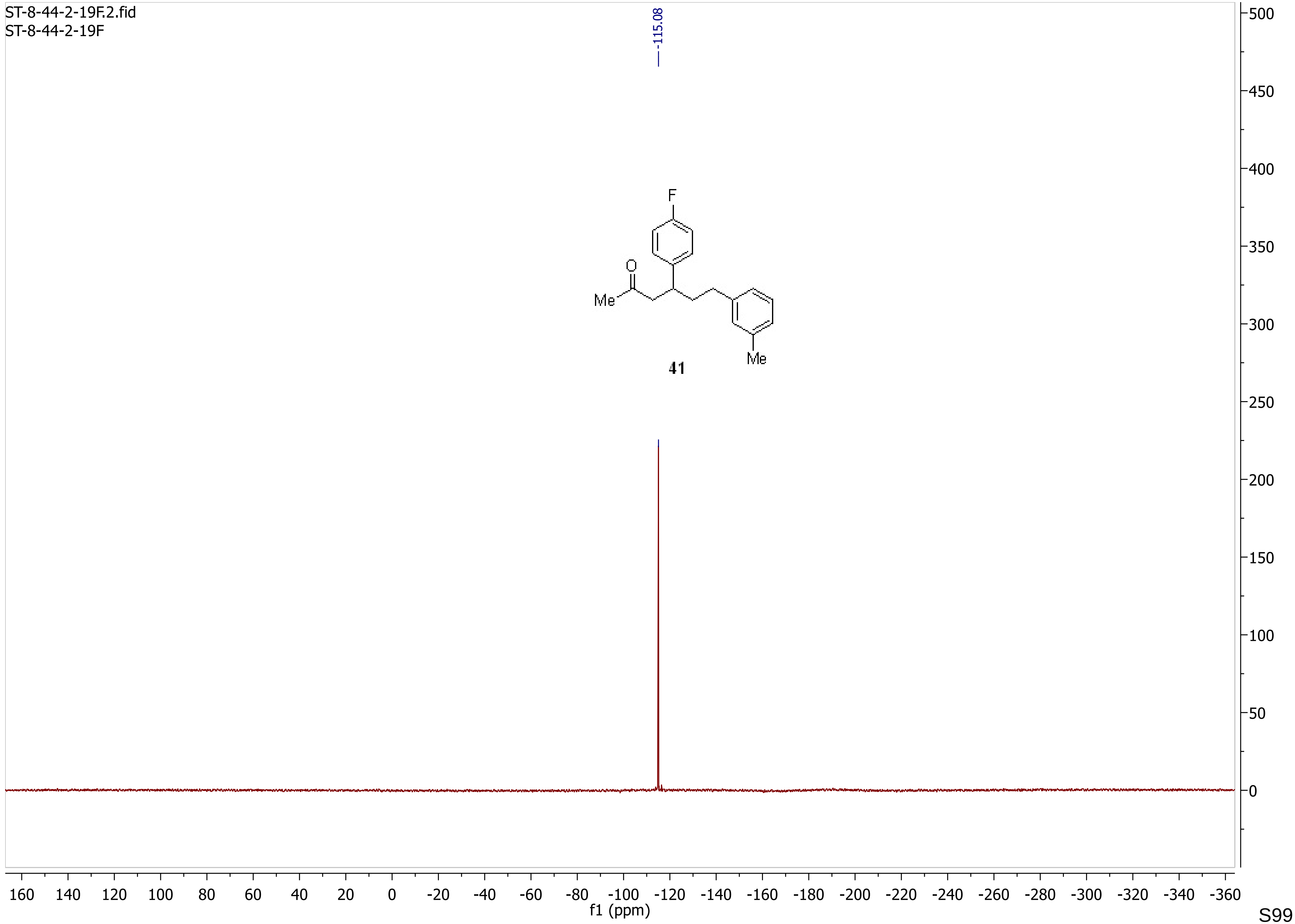

PB-8-229-3-tt12.70.fid
PB-8-229-3-tt12
7.29 7.26 7.24 7.17 7.16 7.13 7.12 7.10
3.19 3.18 3.17 3.15 3.14 3.13 3.12 3.09 2.74 2.71 2.49 2.46 2.43 2.35 2.00 1.97 1.96 1.94 1.93 1.91 1.89 1.88 1.86 1.85 1.83 1.81
Me
O
Me
40
2.00 6.99 1.00 2.00 2.00 3.00 5.00
f1 (ppm)

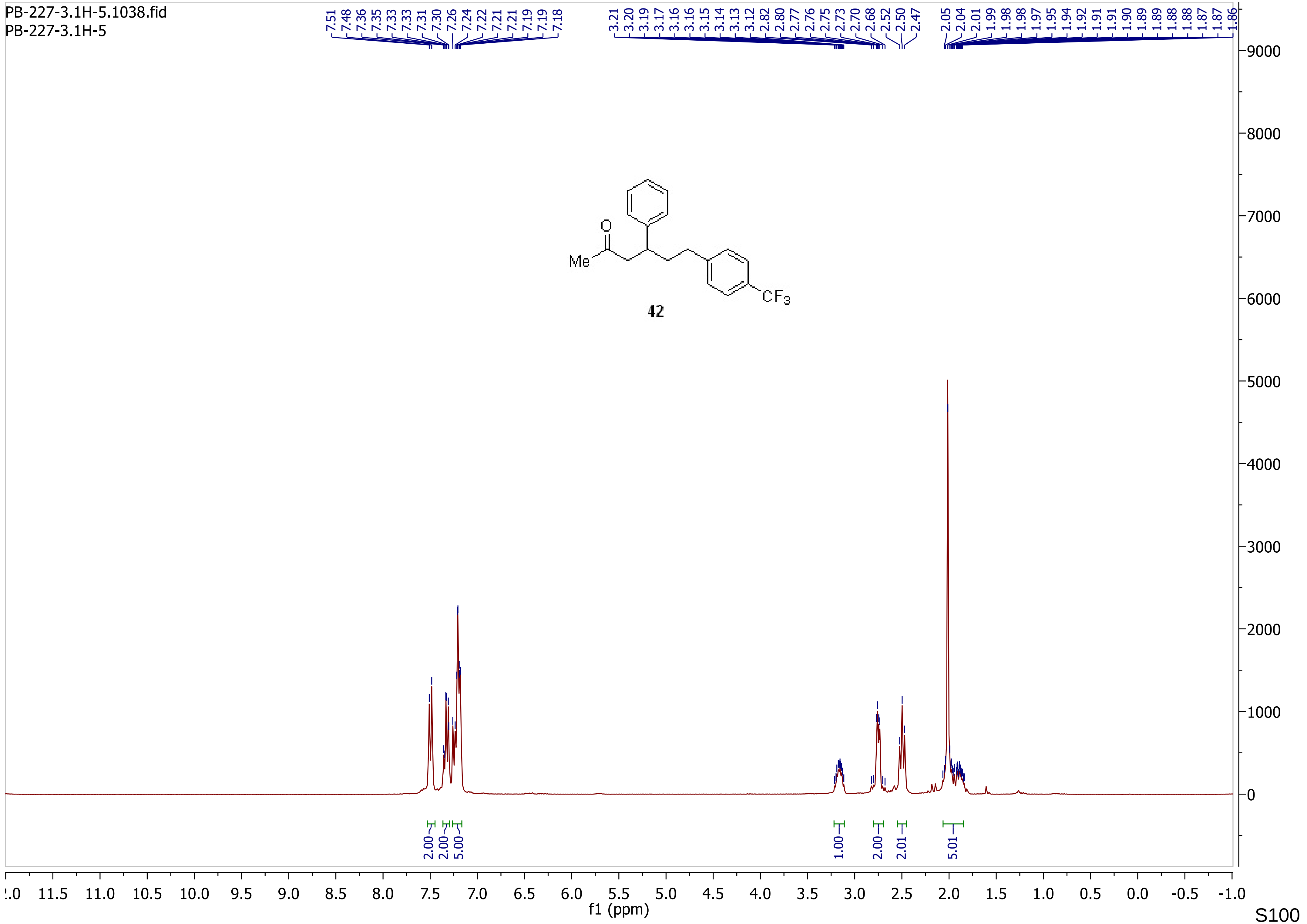


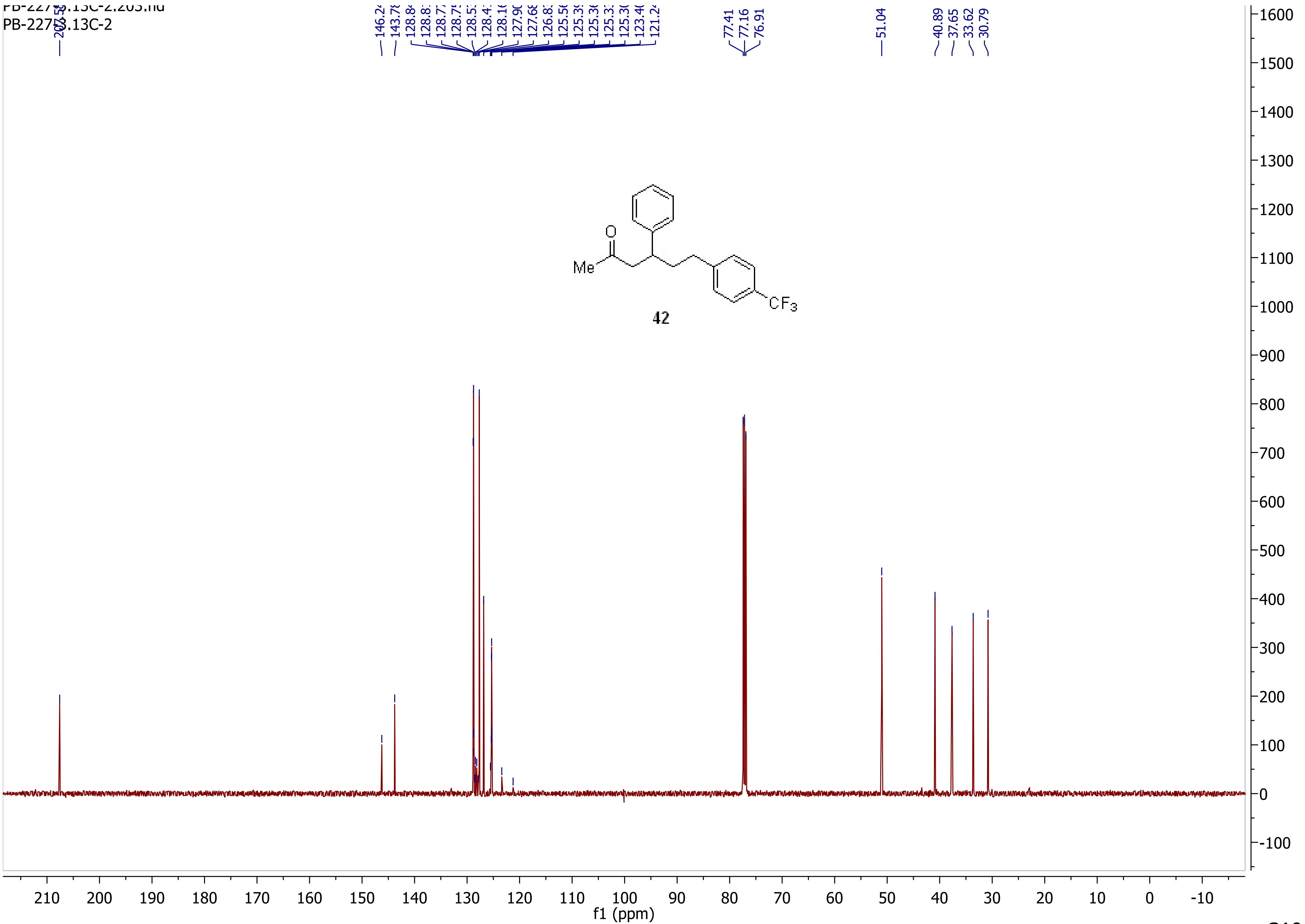
PB-8-229-3-13C.73.fid
PB-8-229-3-13C
142.20
141.00
136.11
129.41
128.46
128.40
127.55
125.86
77.58
77.16
76.74
51.23
40.69
38.22
33.75
30.72
21.16
Me
O
Me
40
f1 (ppm)

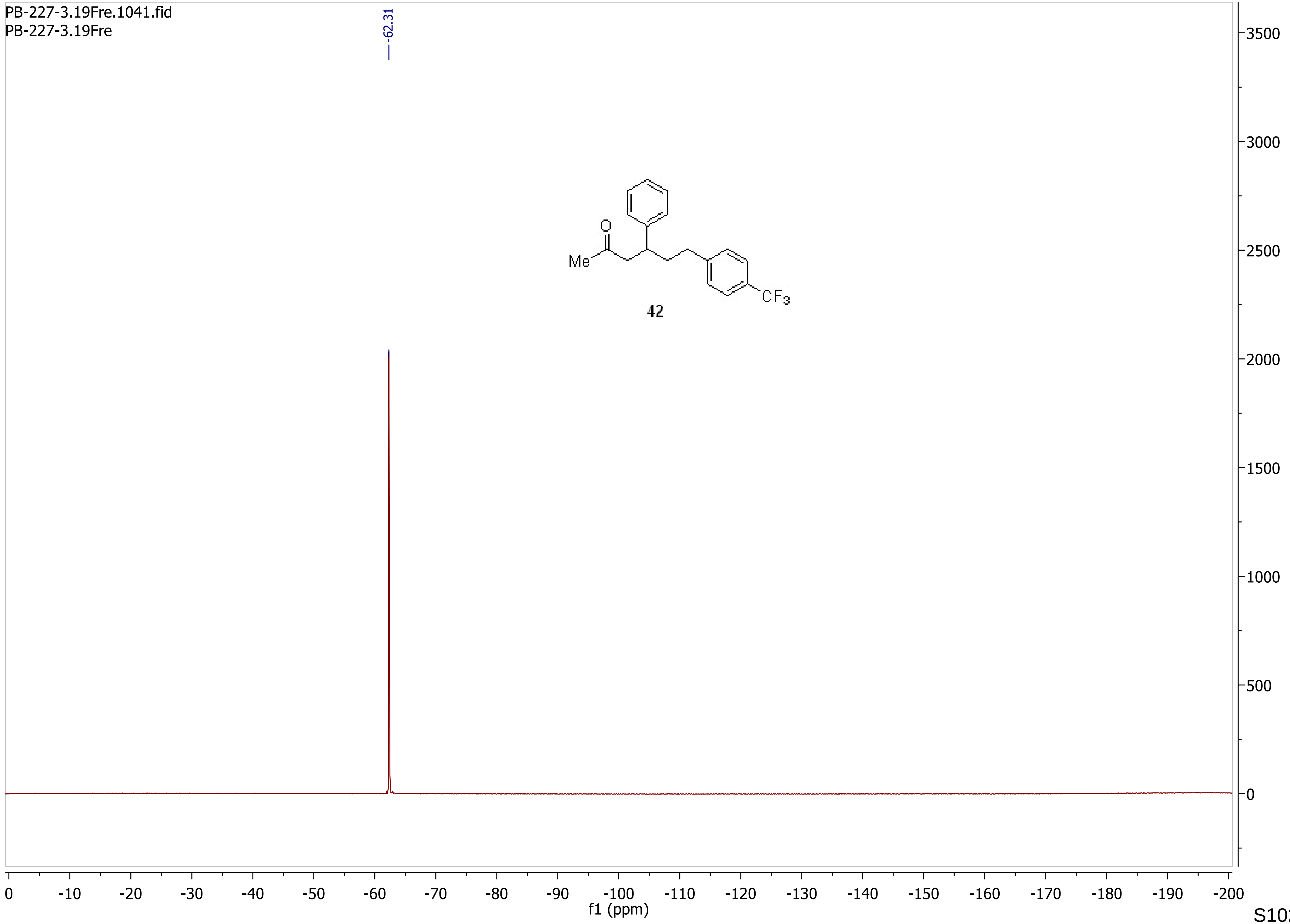

ST-8-44-2-4H.2.fid
ST-8-44-2-4H
7.26 7.20 7.18 7.17 7.16 7.15 7.12 7.04 7.01 7.00 6.98 6.90 6.87
3.22 3.20 3.19 3.18 3.18 3.17 3.16 3.15 3.14 3.14 3.12 2.73 2.71 2.43 2.40 2.37 2.31 2.01 1.97 1.96 1.96 1.94 1.93 1.93 1.92 1.90 1.89 1.87 1.86 1.85 1.84 1.83 1.82 1.81 1.79
F
O
Me
Me
41
3.00 3.01 2.01 1.00 2.00 2.03 3.01 3.02 2.02
f1 (ppm)

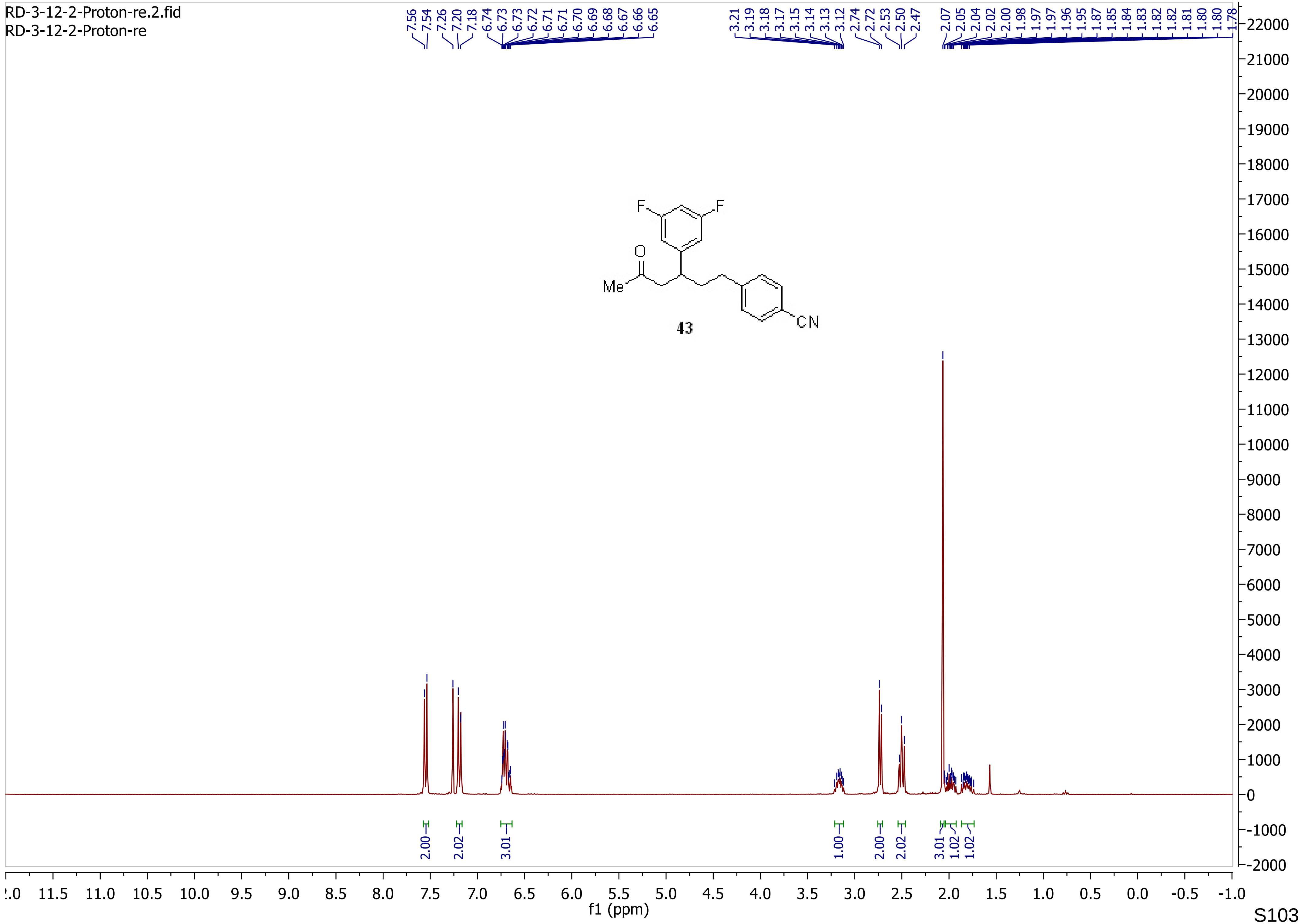

ST-8-44-2-13C.2.fid
ST-8-442-13C
207.53
163.25
160.01
141.86
139.85
138.02
129.23
129.15
129.05
128.38
126.72
125.42
115.63
115.36
77.58
77.16
76.74
51.13
40.33
38.31
33.64
30.75
21.49
F
O
Me
Me
41
f1 (ppm)

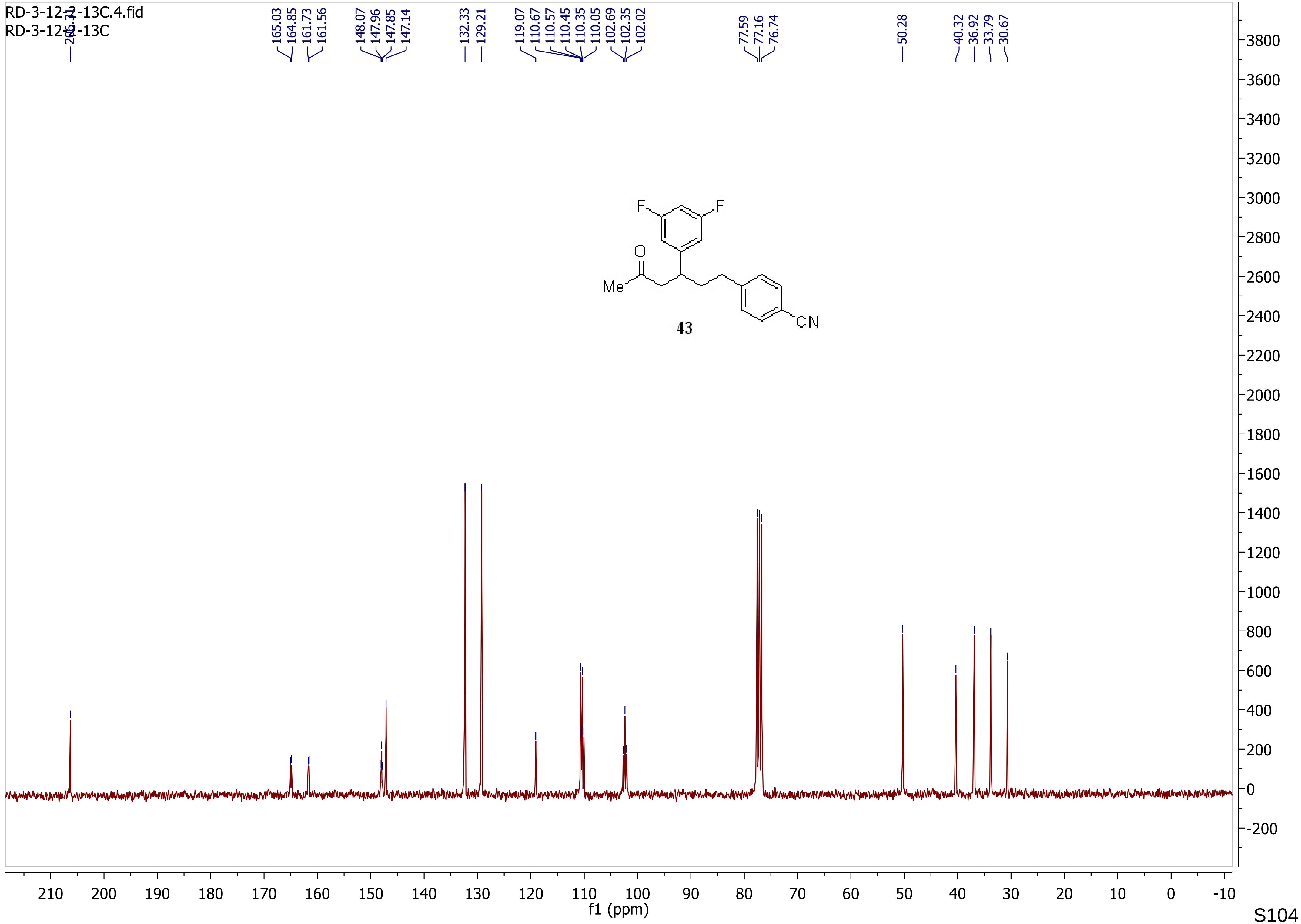

ST-8-44-2-19F.2.fid
ST-8-44-2-19F
-115.08
F
O
Me
Me
41
160 140 120 100 80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240 -260 -280 -300 -320 -340 -360
f1 (ppm)
500 450 400 350 300 250 200 150 100 50 0


PB-227-3.1H-5.1038.fid
PB-227-3.1H-5
7.51 7.48 7.36 7.35 7.33 7.33 7.31 7.30 7.26 7.24 7.22 7.21 7.21 7.19 7.19 7.18
3.21 3.20 3.19 3.17 3.16 3.16 3.15 3.14 3.13 3.12 2.82 2.80 2.77 2.76 2.75 2.73 2.70 2.68 2.52 2.50 2.47
2.05 2.04 2.01 1.99 1.98 1.98 1.97 1.95 1.94 1.92 1.91 1.91 1.90 1.89 1.89 1.88 1.88 1.87 1.87 1.86
O
Me
CF3
42
2.00 2.00 5.00 1.00 2.00 2.01 5.01
f1 (ppm)

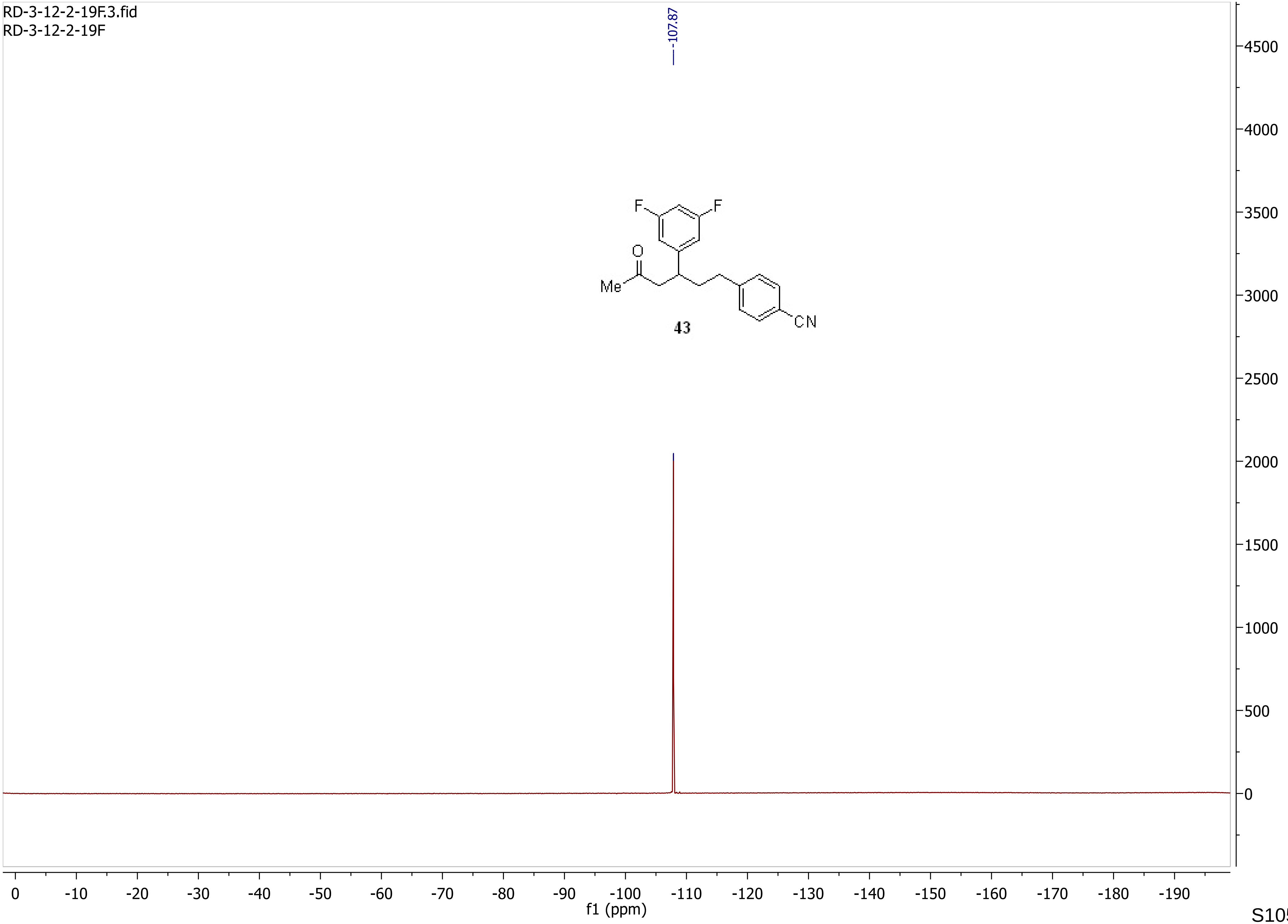

PB-2273.13C-2
207.59
146.24
143.78
128.84
128.81
128.77
128.75
128.53
128.41
128.16
127.90
127.68
126.83
125.56
125.39
125.36
125.33
125.30
123.40
121.24
77.41
77.16
76.91
51.04
40.89
37.65
33.62
30.79
O
Me
CF3
42
f1 (ppm)

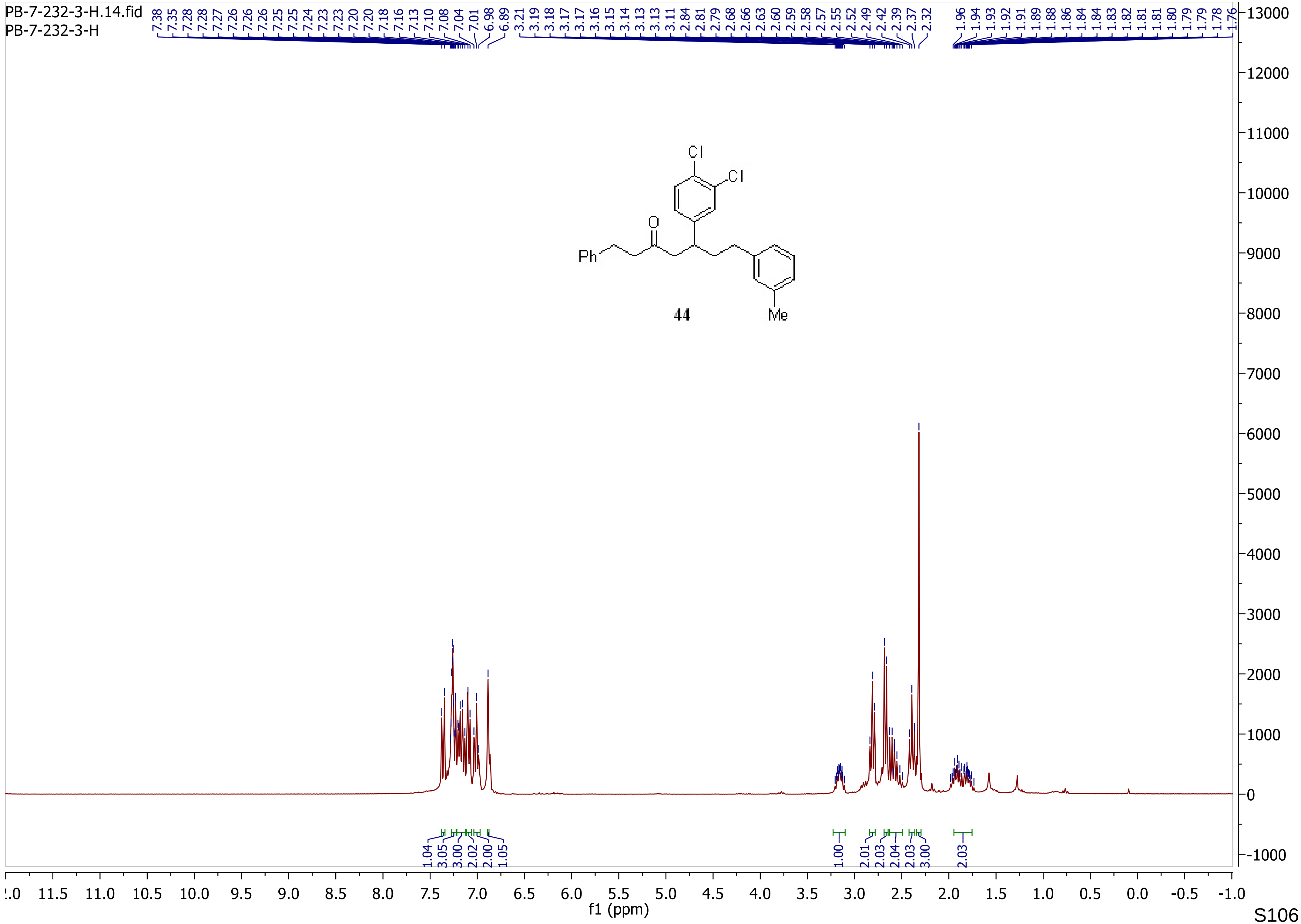

PB-227-3.19Fre.1041.fid
PB-227-3.19Fre
-62.31
O
Me
CF3
42
f1 (ppm)

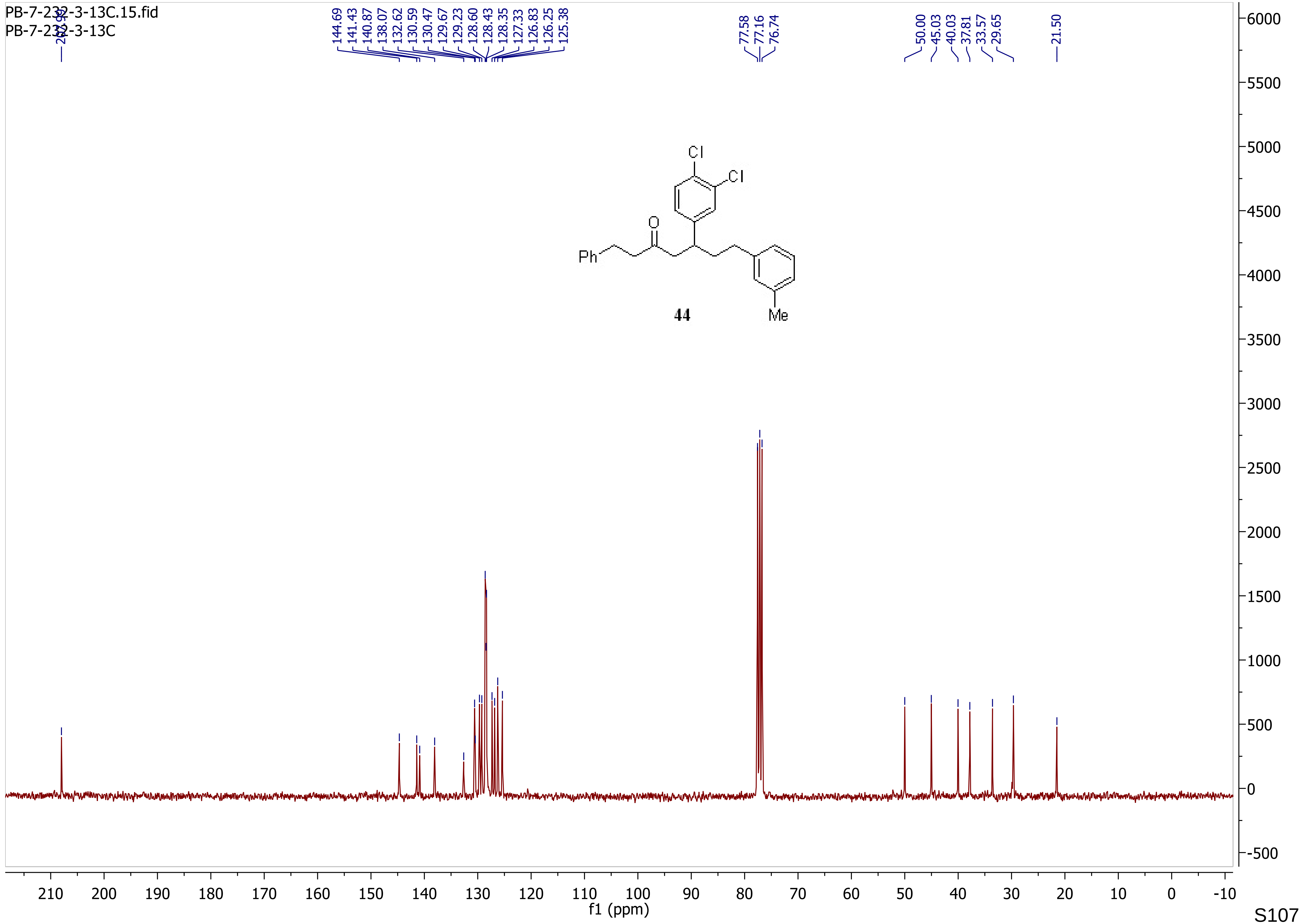

RD-3-12-2-Proton-re.2.fid
RD-3-12-2-Proton-re
7.56 7.54 7.26 7.20 7.18 6.74 6.73 6.73 6.72 6.71 6.71 6.70 6.69 6.68 6.67 6.66 6.65
3.21 3.19 3.18 3.17 3.15 3.14 3.13 3.12 2.74 2.72 2.53 2.50 2.47
2.07 2.05 2.04 2.02 2.00 1.98 1.97 1.97 1.96 1.95 1.87 1.85 1.84 1.83 1.82 1.82 1.81 1.80 1.80 1.78
F
F
O
Me
CN
43
2.00 2.02 3.01 1.00 2.00 2.02 3.01 1.02 1.02
f1 (ppm)

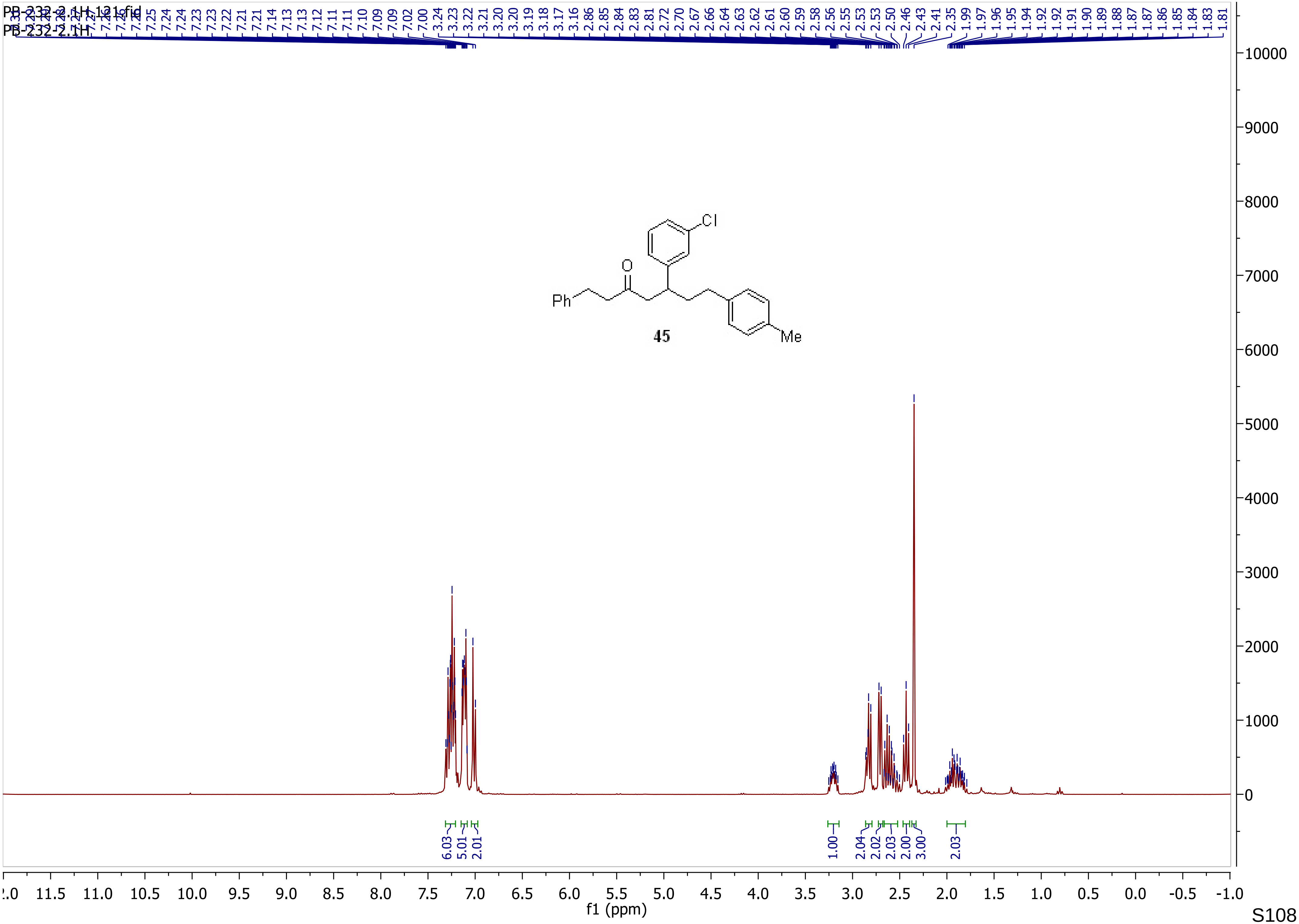

RD-3-12-2-13C.4.fid
RD-3-12-2-13C
165.03
164.85
161.73
161.56
148.07
147.96
147.85
147.14
132.33
129.21
119.07
110.67
110.57
110.45
110.35
110.05
102.69
102.35
102.02
77.59
77.16
76.74
50.28
40.32
36.92
33.79
30.67
F
F
O
Me
CN
43
f1 (ppm)

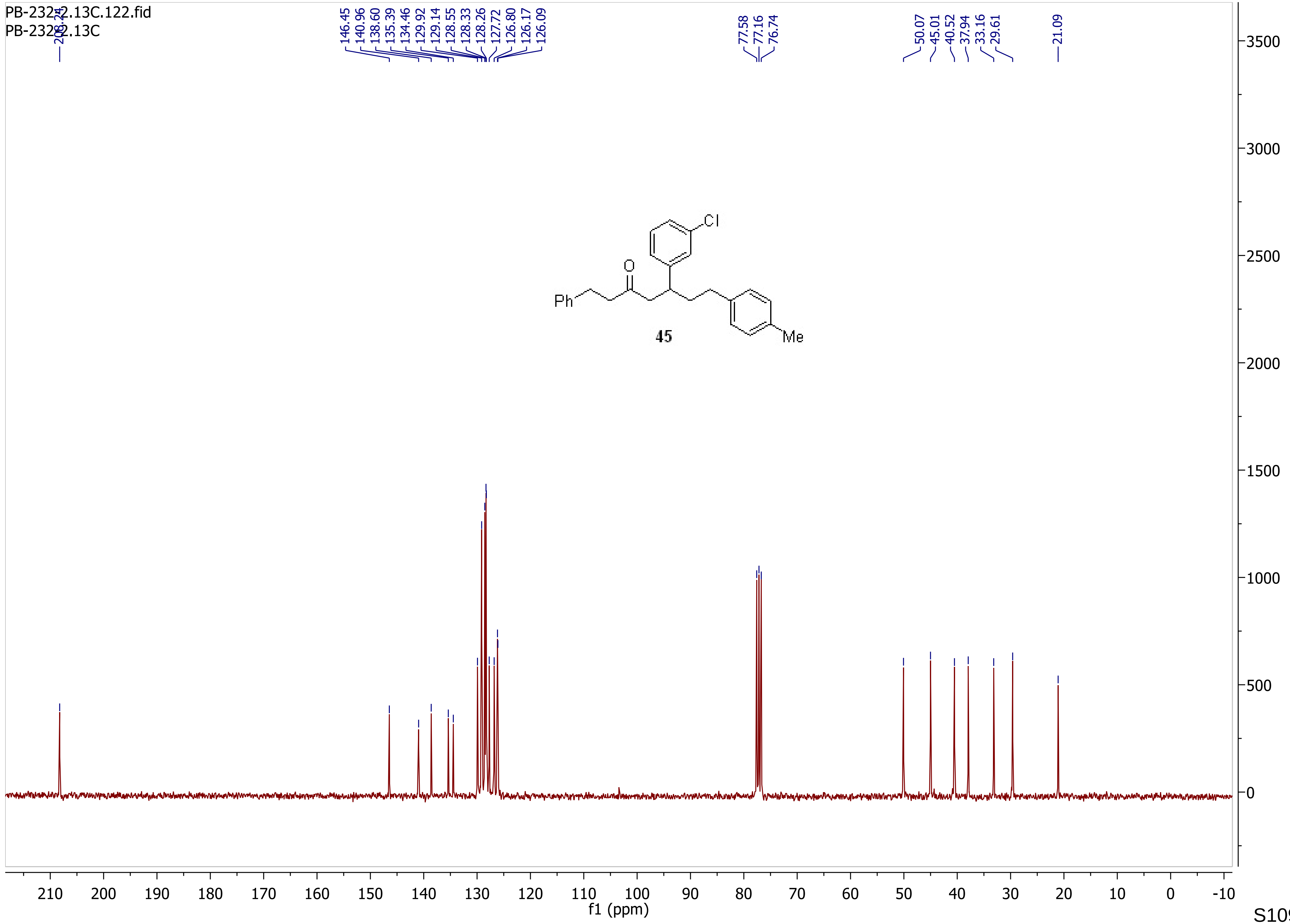
RD-3-12-2-19F.3.fid
RD-3-12-2-19F

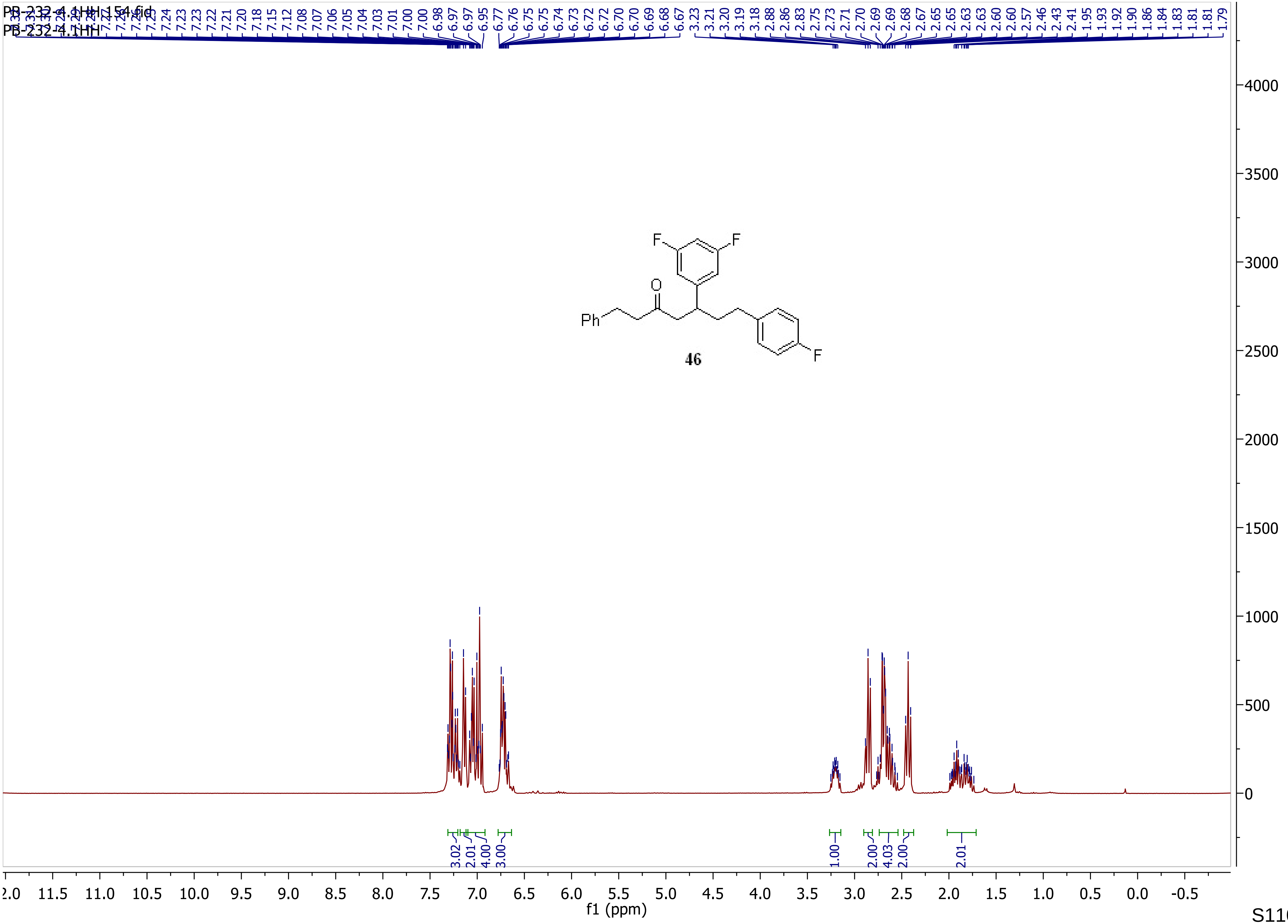


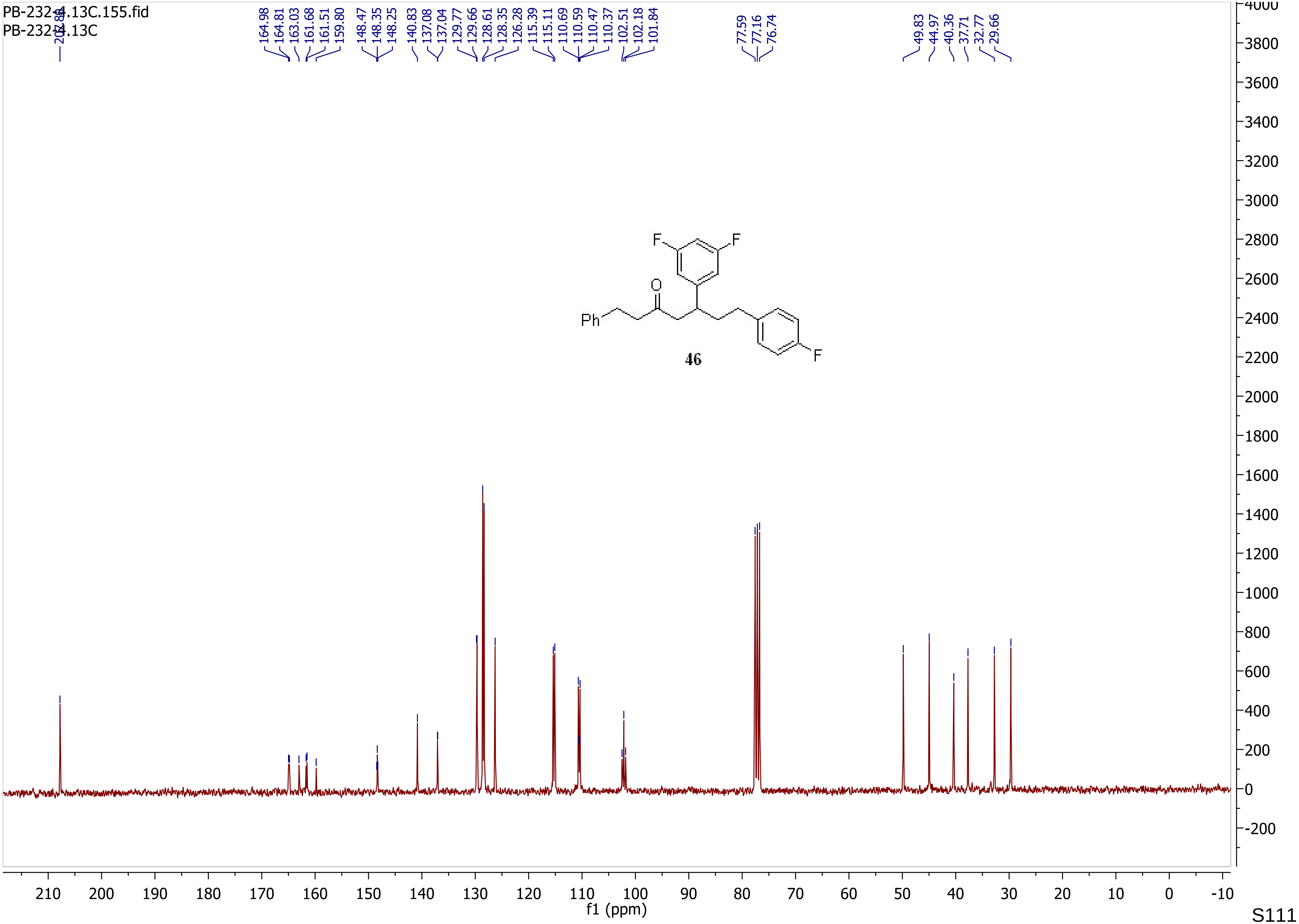

PB-7-232-3-H.14.fid
PB-7-232-3-H
7.38 7.35 7.28 7.28 7.27 7.26 7.26 7.26 7.25 7.25 7.24 7.23 7.23 7.20 7.20 7.18 7.16 7.13 7.10 7.08 7.04 7.01 6.98 6.89
3.21 3.19 3.18 3.17 3.17 3.16 3.15 3.14 3.13 3.13 3.11 2.84 2.81 2.79 2.68 2.66 2.63 2.60 2.59 2.58 2.57 2.55 2.52 2.49 2.42 2.39 2.37 2.32
1.96 1.94 1.93 1.92 1.91 1.89 1.88 1.86 1.84 1.84 1.83 1.82 1.81 1.81 1.80 1.79 1.79 1.78 1.76
Cl
Cl
O
Ph
Me
44
1.04 3.05 3.00 2.02 2.00 1.05
1.00 2.01 2.03 2.04 2.03 3.00
2.03
f1 (ppm)


PB-7-232-3-13C.15.fid
PB-7-232-3-13C
144.69
141.43
140.87
138.07
132.62
130.59
130.47
129.67
129.23
128.60
128.43
128.35
127.33
126.83
126.25
125.38
77.58
77.16
76.74
50.00
45.03
40.03
37.81
33.57
29.65
21.50
Cl
Cl
O
Ph
Me
44
f1 (ppm)

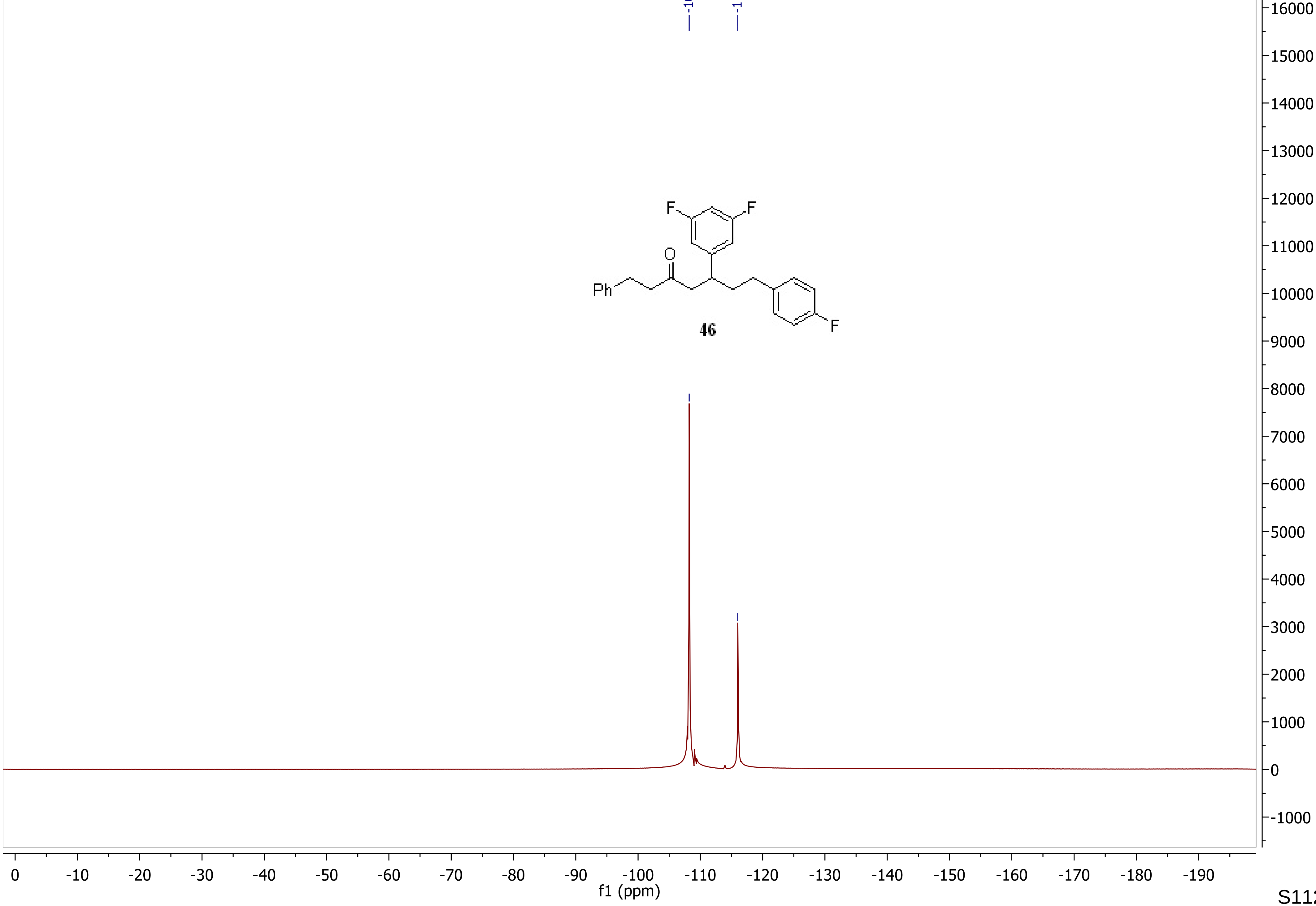

PB-232-2.1H.1.fid
PB-232-2.1H
Ph
O
Cl
Me
45
f1 (ppm)


PB-232-2.13C.122.fid
PB-232-2.13C
208.24
146.45
140.96
138.60
135.39
134.46
129.92
129.14
128.55
128.33
128.26
127.72
126.80
126.17
126.09
77.58
77.16
76.74
50.07
45.01
40.52
37.94
33.16
29.61
21.09
Cl
O
Ph
Me
45
3500
3000
2500
2000
1500
1000
500
0
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

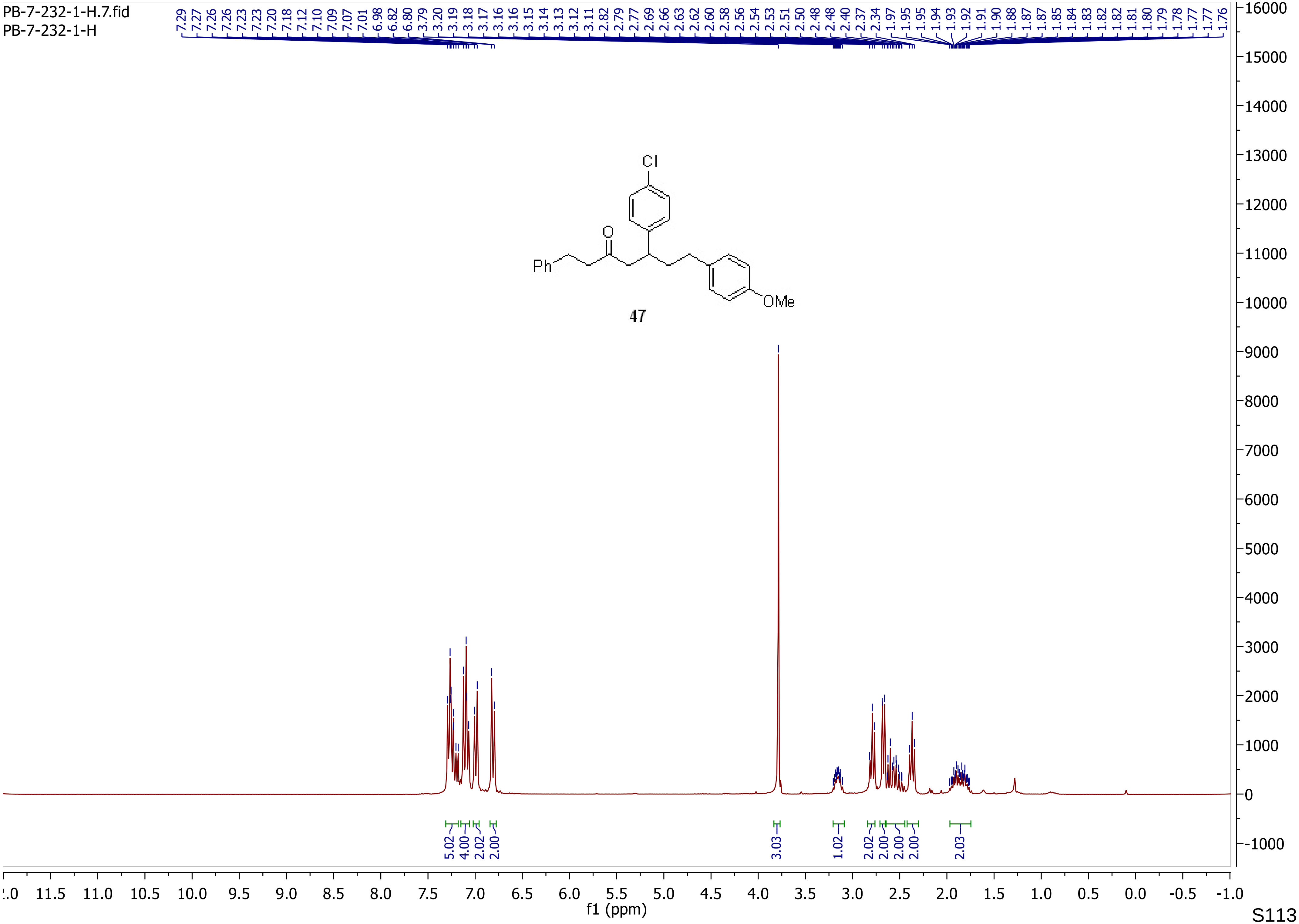


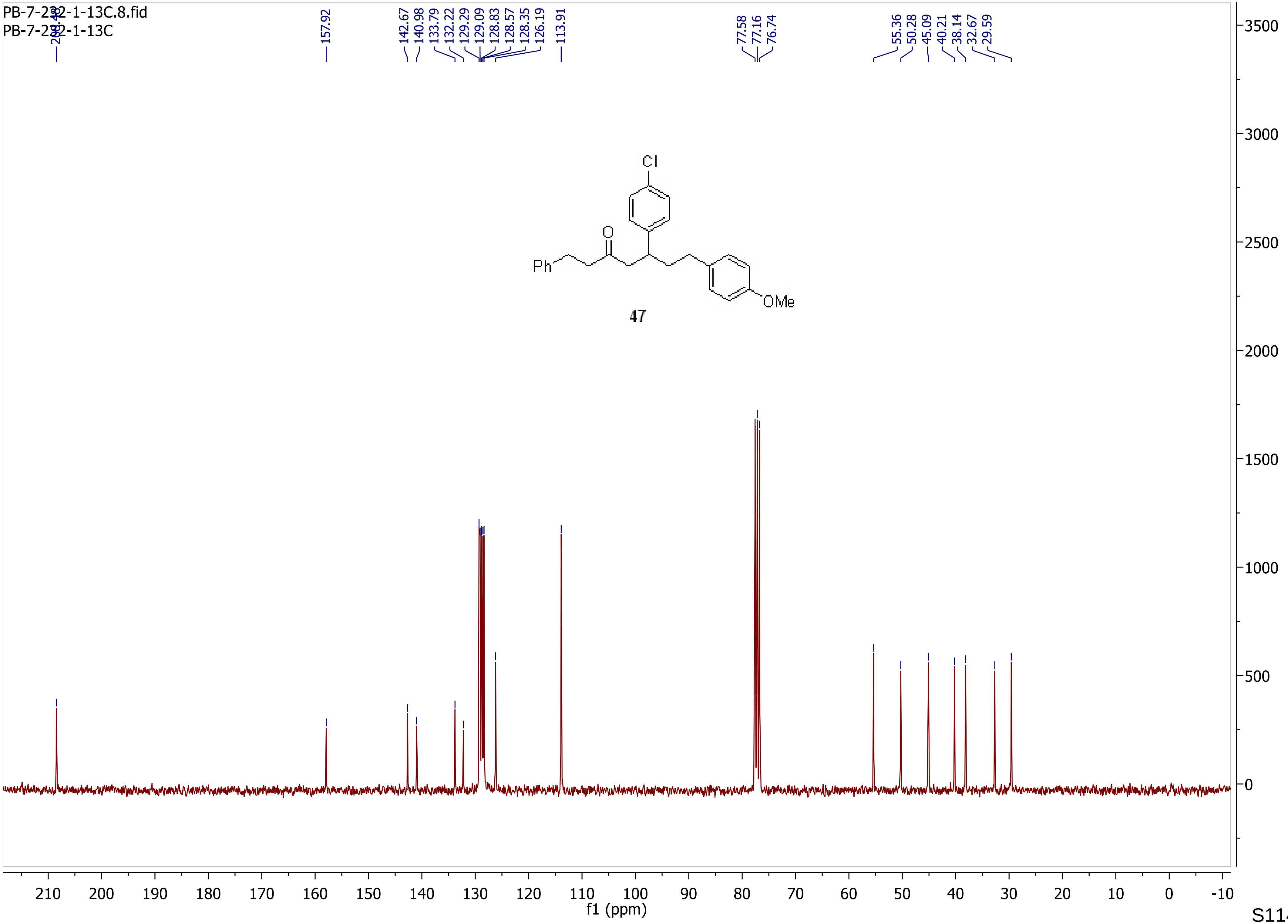

PB-232-4.13C.155.fid
PB-232-4.13C
164.98
164.81
163.03
161.68
161.51
159.80
148.47
148.35
148.25
140.83
137.08
137.04
129.77
129.66
128.61
128.35
126.28
115.39
115.11
110.69
110.59
110.47
110.37
102.51
102.18
101.84
77.59
77.16
76.74
49.83
44.97
40.36
37.71
32.77
29.66
F
F
O
Ph
F
46
f1 (ppm)

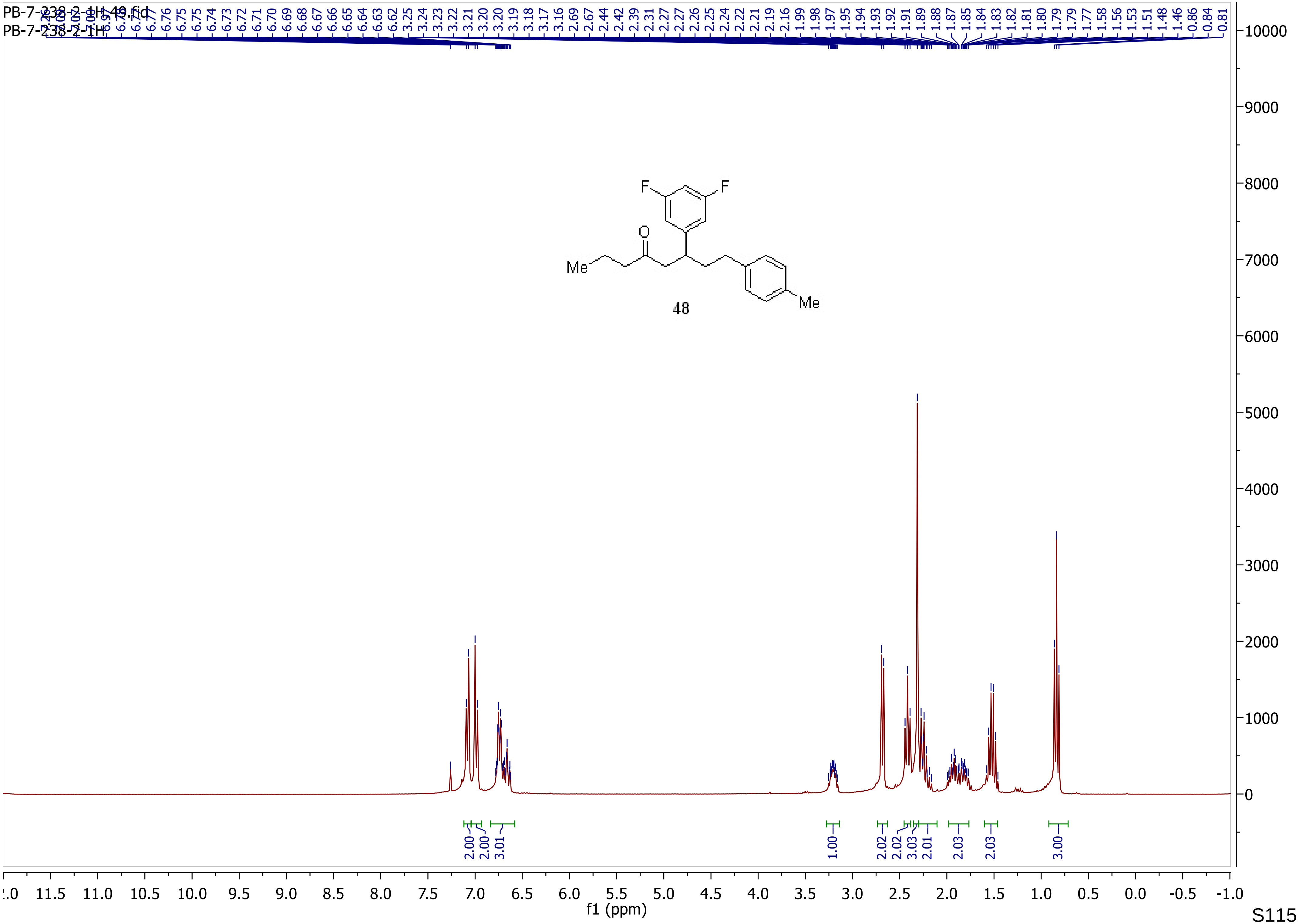
PB-232-4.19F..150.fid
PB-232-4.19F.

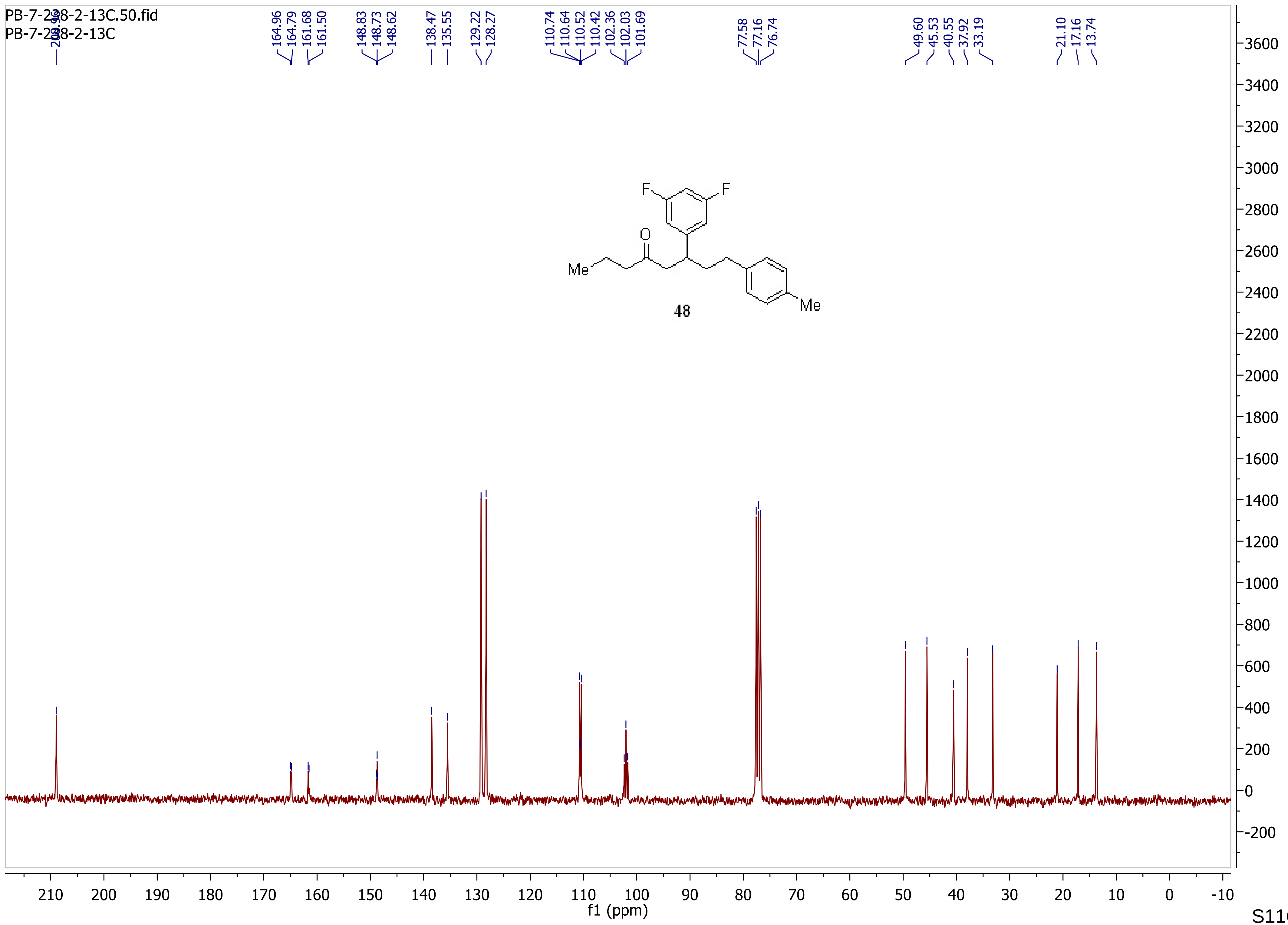


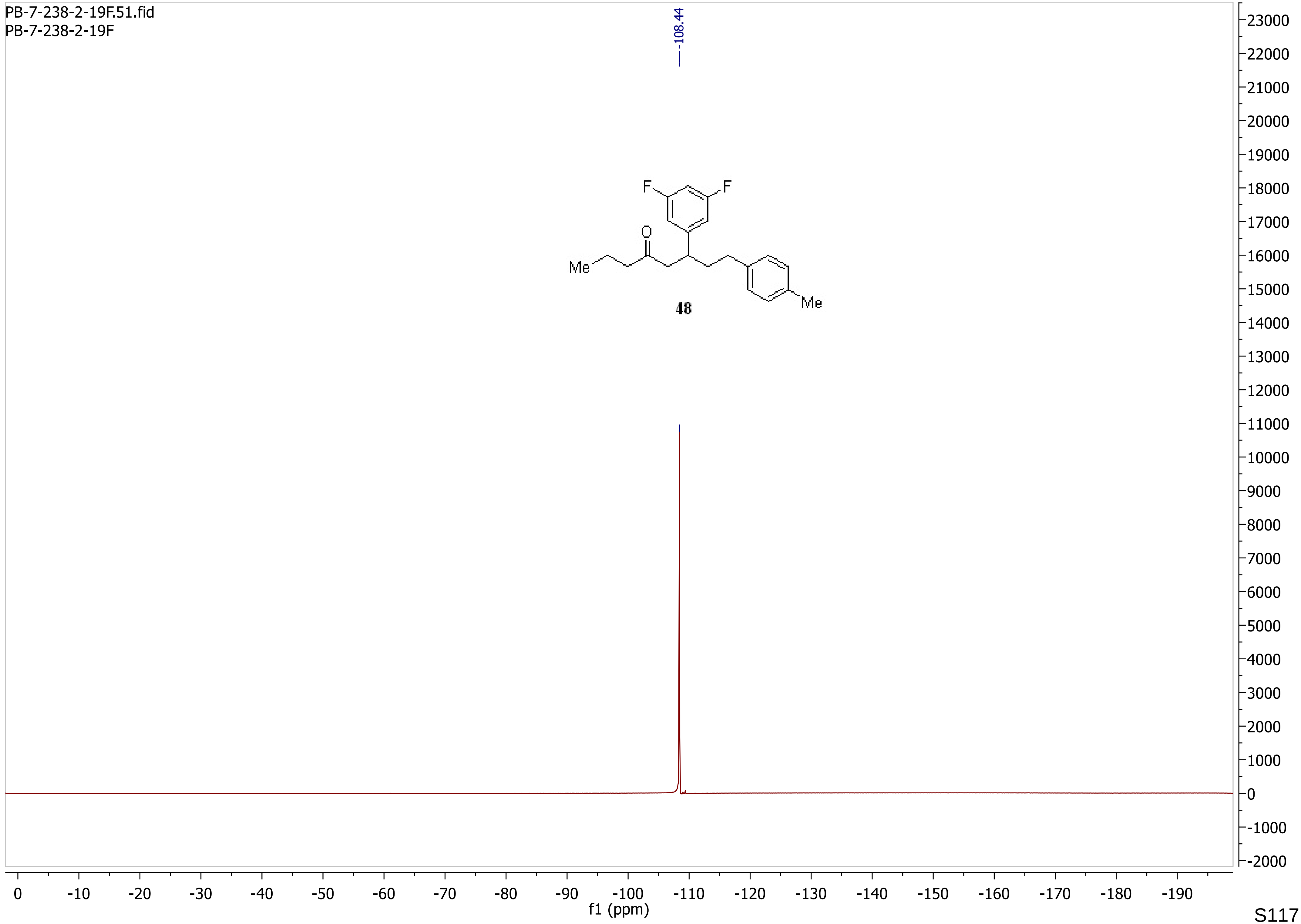
PB-7-232-1-H.7.fid
PB-7-232-1-H

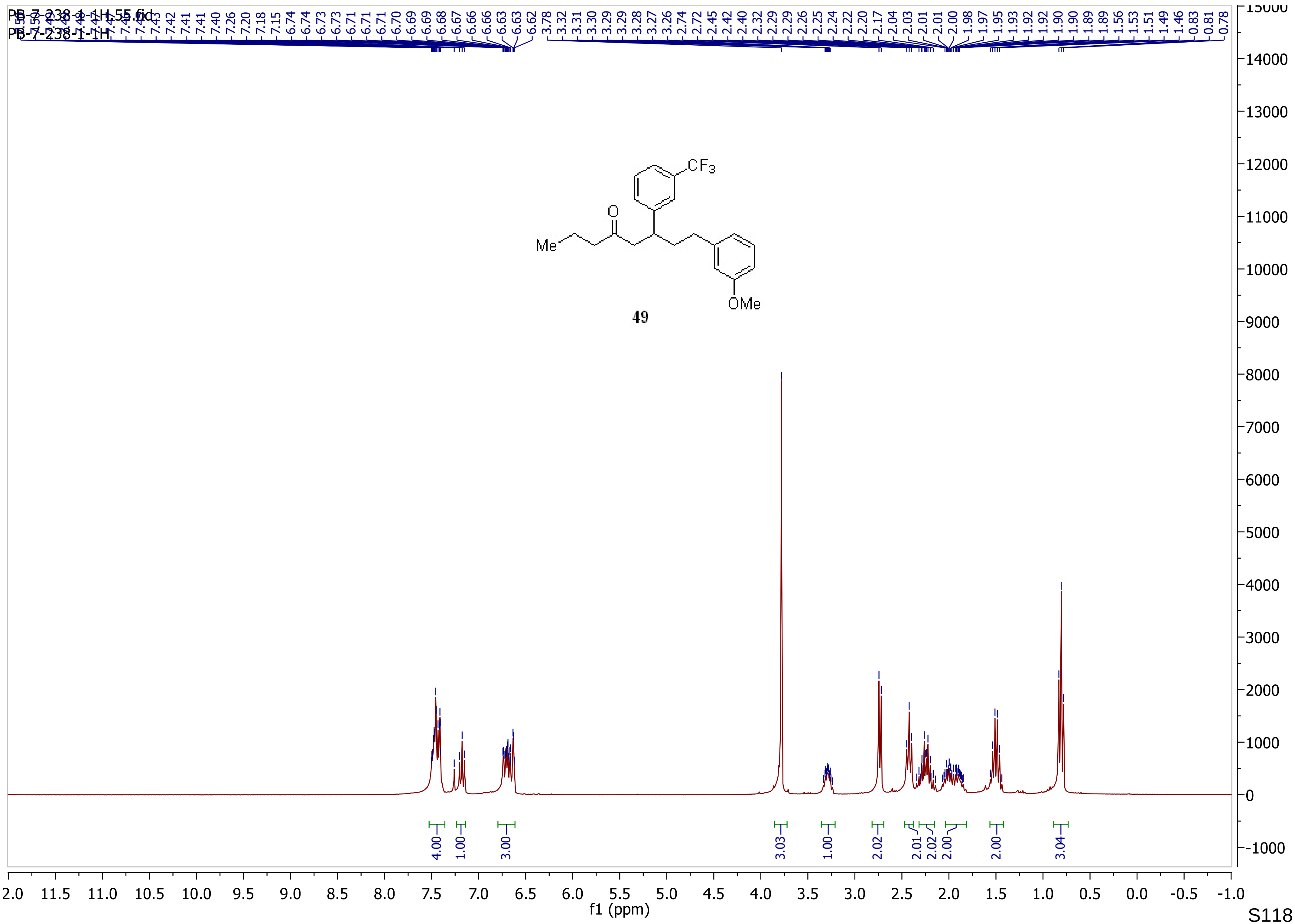



PB-7-232-1-13C.8.fid
PB-7-232-1-13C
208.48
157.92
142.67
140.98
133.79
132.22
129.29
129.09
128.83
128.57
128.35
126.19
113.91
77.58
77.16
76.74
55.36
50.28
45.09
40.21
38.14
32.67
29.59
Cl
O
Ph
OMe
47
3500
3000
2500
2000
1500
1000
500
0
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

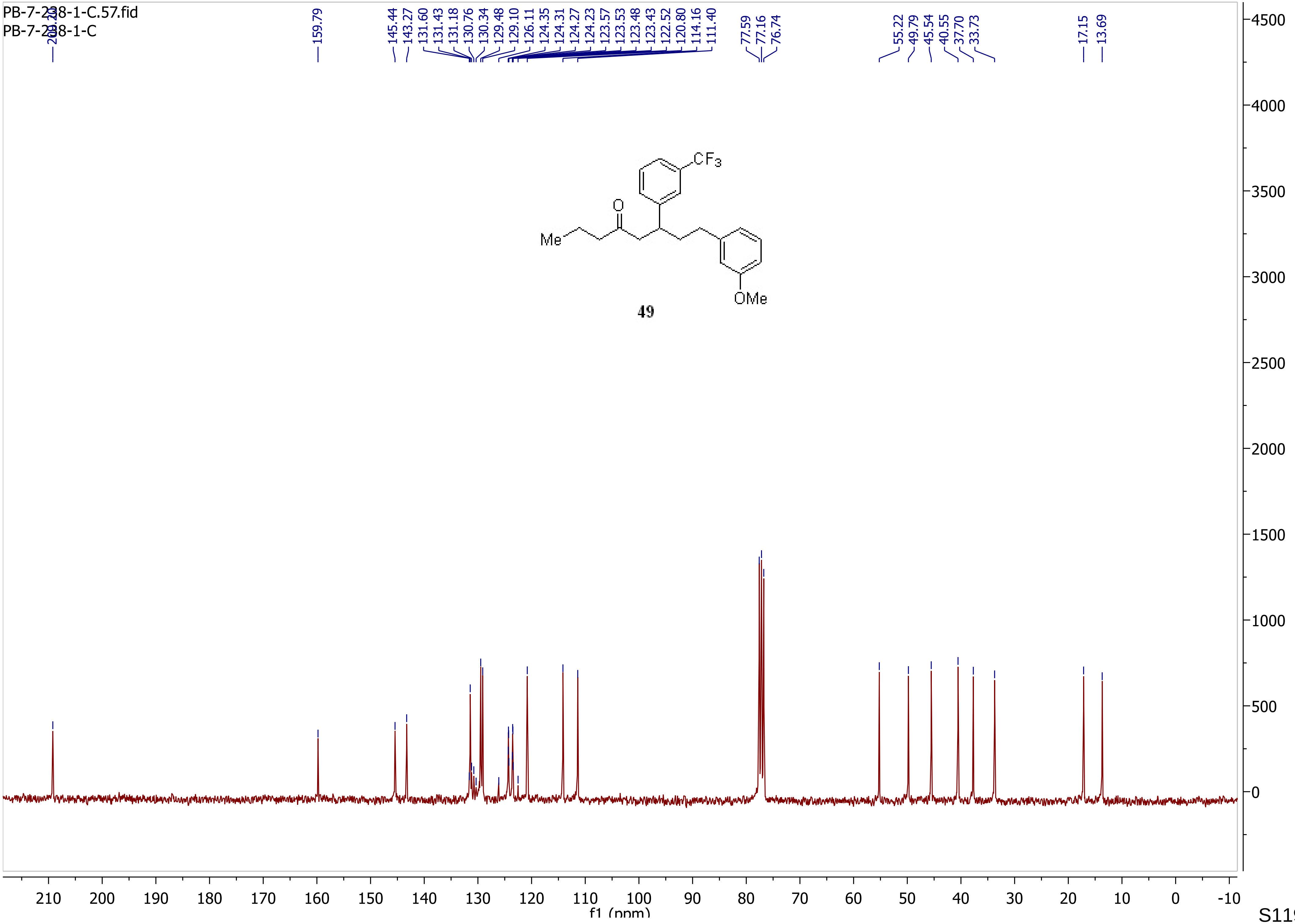

PB-7-238-2-1H.49.fid
PB-7-238-2-1H
6.76 6.75 6.75 6.74 6.73 6.72 6.71 6.70 6.69 6.68 6.67 6.66 6.65 6.64 6.63 6.62 3.25 3.24 3.23 3.22 3.21 3.20 3.20 3.19 3.18 3.17 3.16 2.69 2.67 2.44 2.42 2.39 2.31 2.27 2.27 2.26 2.25 2.24 2.22 2.21 2.19 2.16 1.99 1.98 1.97 1.95 1.94 1.93 1.92 1.91 1.89 1.88 1.87 1.85 1.84 1.83 1.82 1.81 1.80 1.79 1.79 1.77 1.58 1.56 1.53 1.51 1.48 1.46 0.86 0.84 0.81
F
F
O
Me
Me
48
2.00 2.00 3.01 1.00 2.02 2.02 3.03 2.01 2.03 2.03 3.00
f1 (ppm)

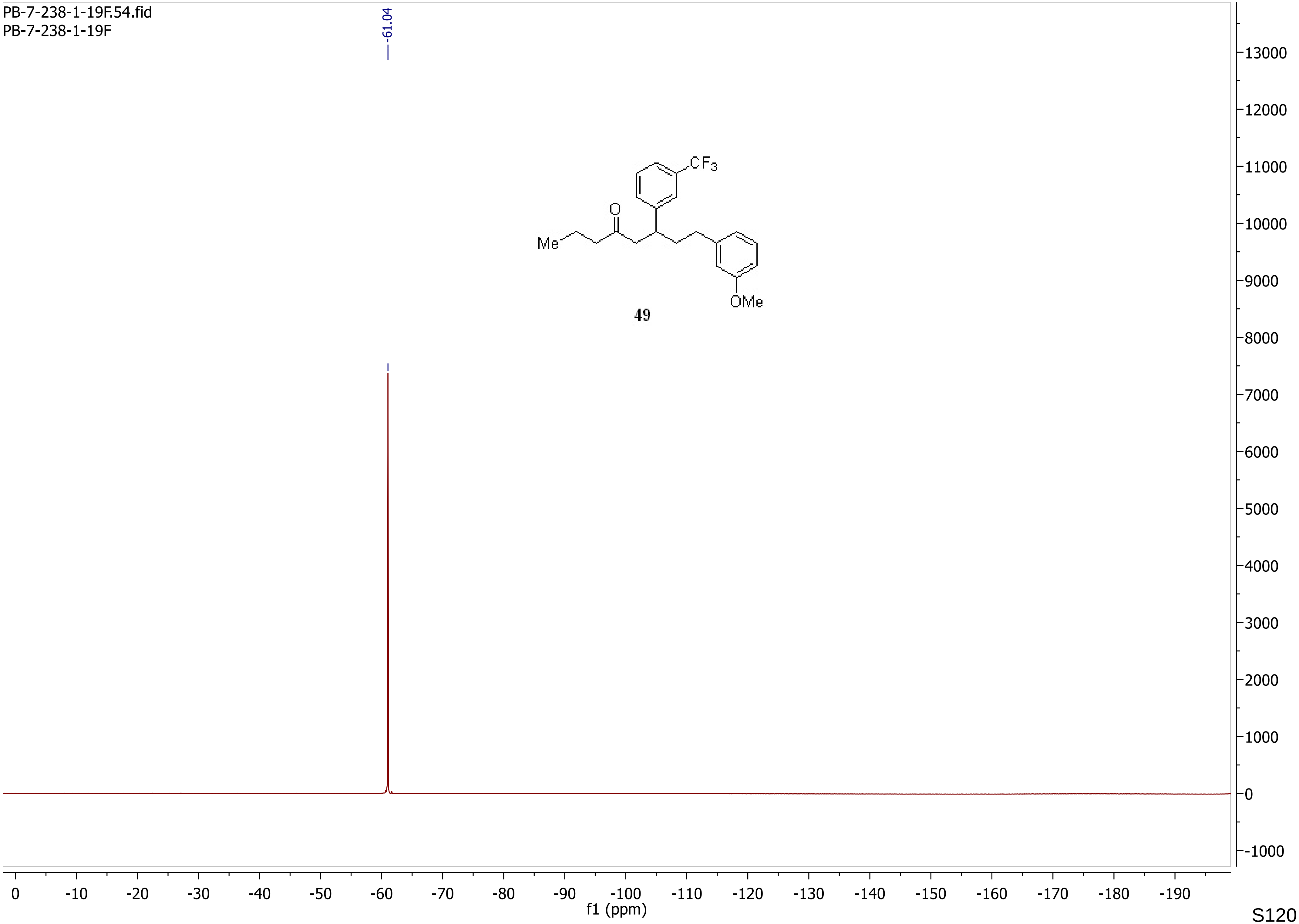

PB-7-238-2-13C.50.fid
PB-7-238-2-13C
208.98
164.96
164.79
161.68
161.50
148.83
148.73
148.62
138.47
135.55
129.22
128.27
110.74
110.64
110.52
110.42
102.36
102.03
101.69
77.58
77.16
76.74
49.60
45.53
40.55
37.92
33.19
21.10
17.16
13.74
F
F
O
Me
Me
48
f1 (ppm)

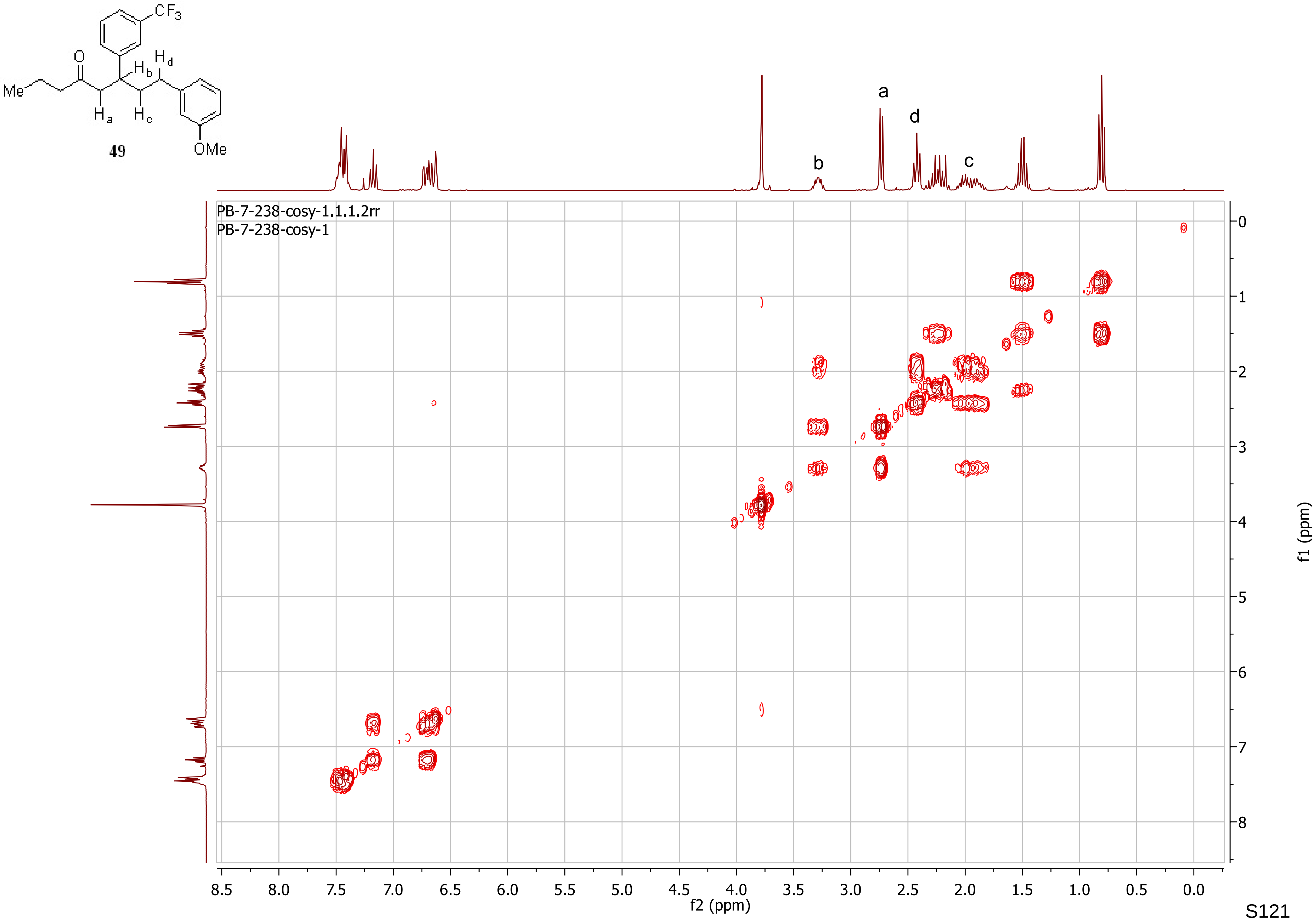

PB-7-238-2-19F.51.fid
PB-7-238-2-19F
-108.44
F
F
O
Me
Me
48
23000
22000
21000
20000
19000
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
f1 (ppm)

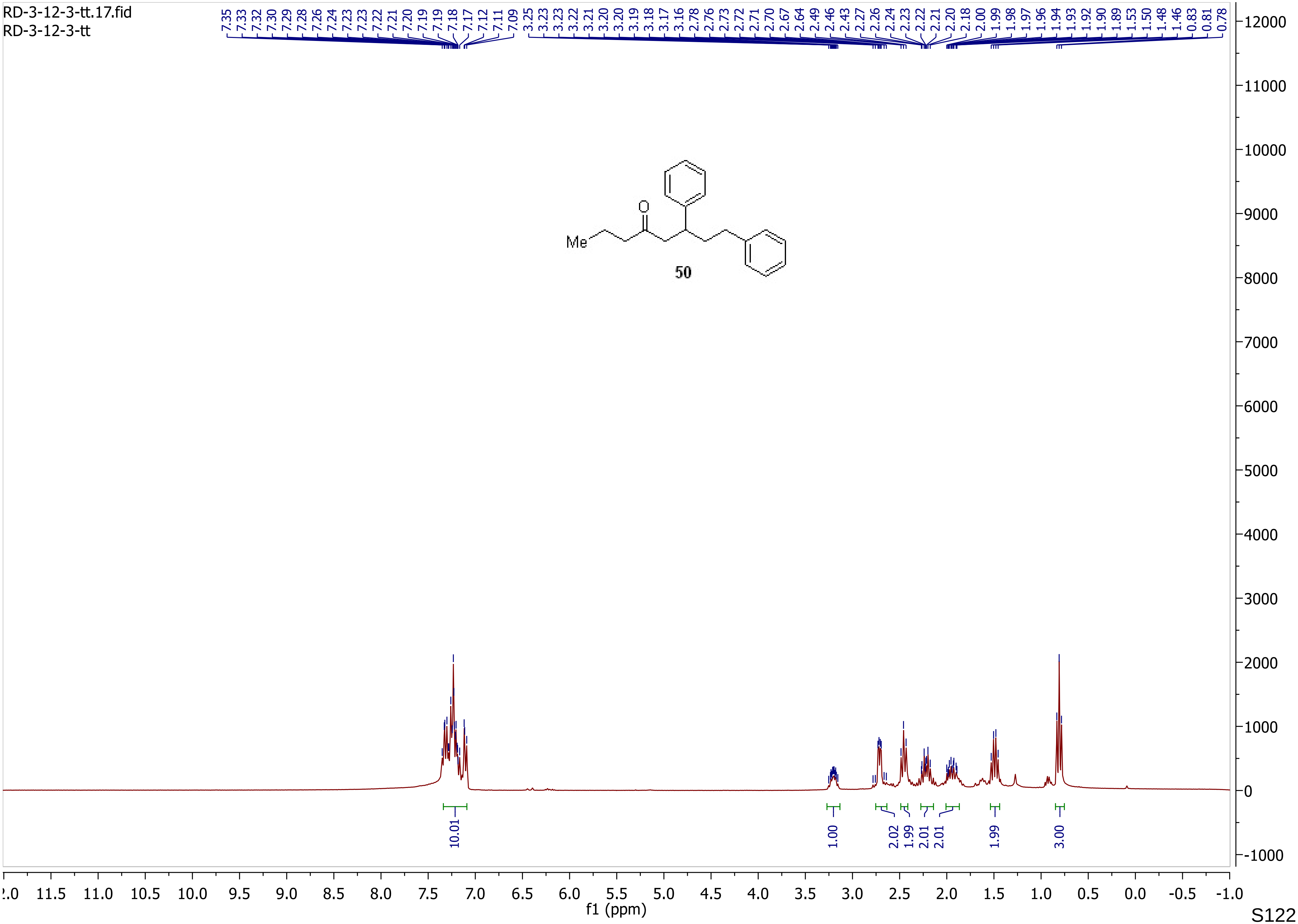


PB-7-238-1-1H.55.fid
PB-7-238-1-1H
Me
O
CF3
OMe
49
4.00
1.00
3.00
3.03
1.00
2.02
2.01
2.02
2.00
2.00
3.04
f1 (ppm)

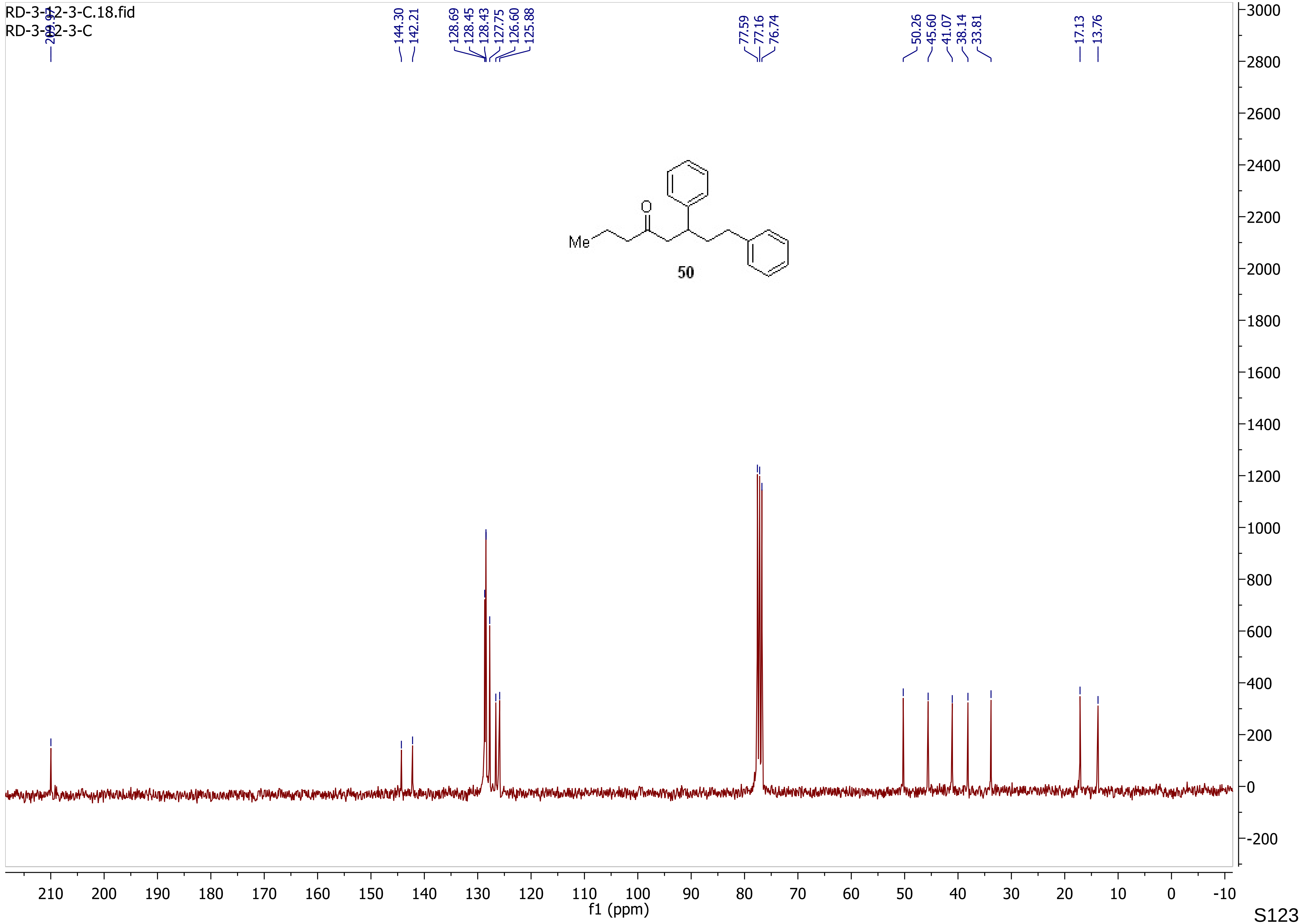

PB-7-238-1-C.57.fid
PB-7-238-1-C
209.20
159.79
145.44
143.27
131.60
131.43
131.18
130.76
130.34
129.48
129.10
126.11
124.35
124.31
124.27
124.23
123.57
123.53
123.48
123.43
122.52
120.80
114.16
111.40
77.59
77.16
76.74
55.22
49.79
45.54
40.55
37.70
33.73
17.15
13.69
CF3
O
Me
OMe
49
4500
4000
3500
3000
2500
2000
1500
1000
500
0
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

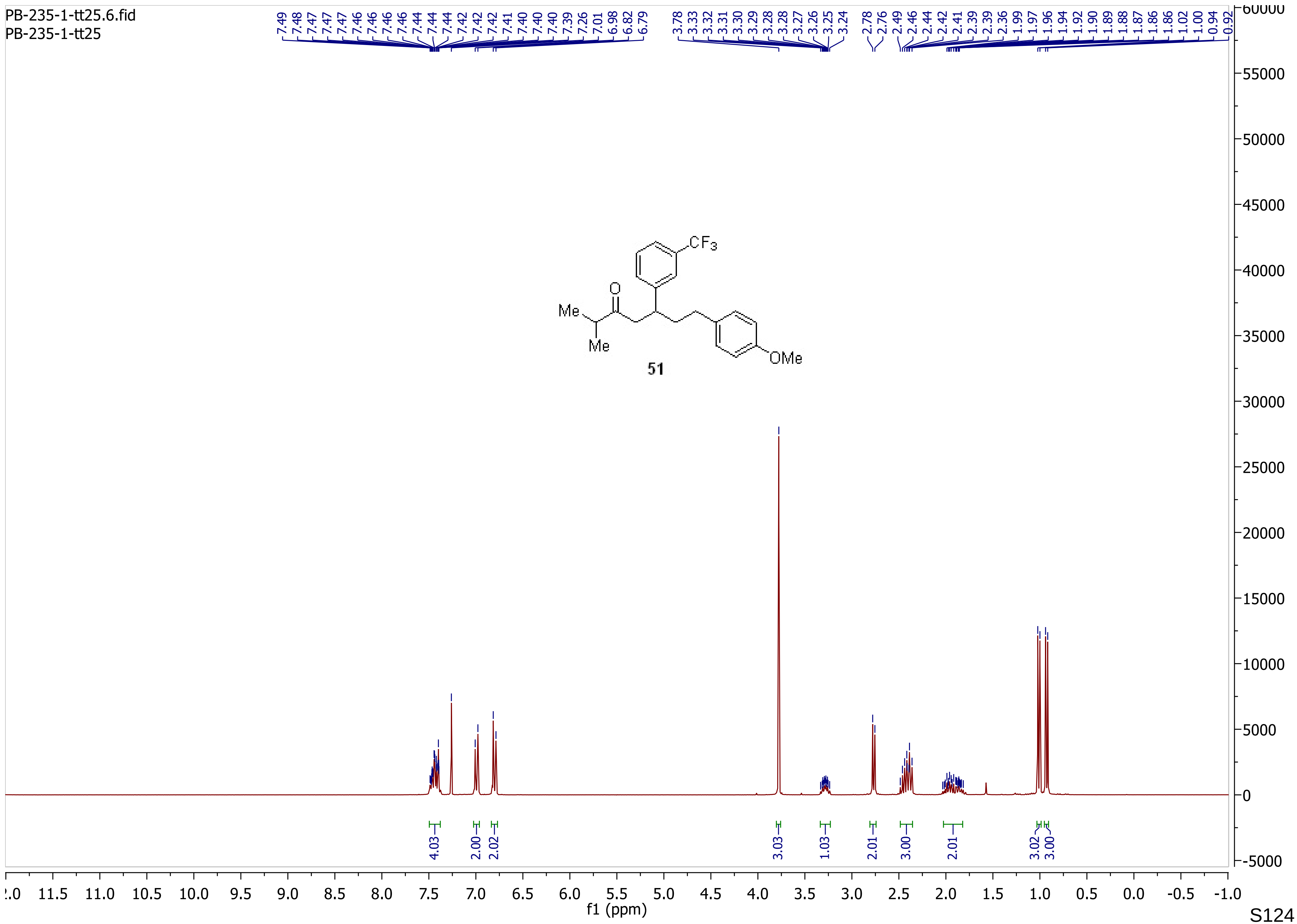

PB-7-238-1-19F.54.fid
PB-7-238-1-19F
-61.04
CF3
O
Me
OMe
49
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190
f1 (ppm)

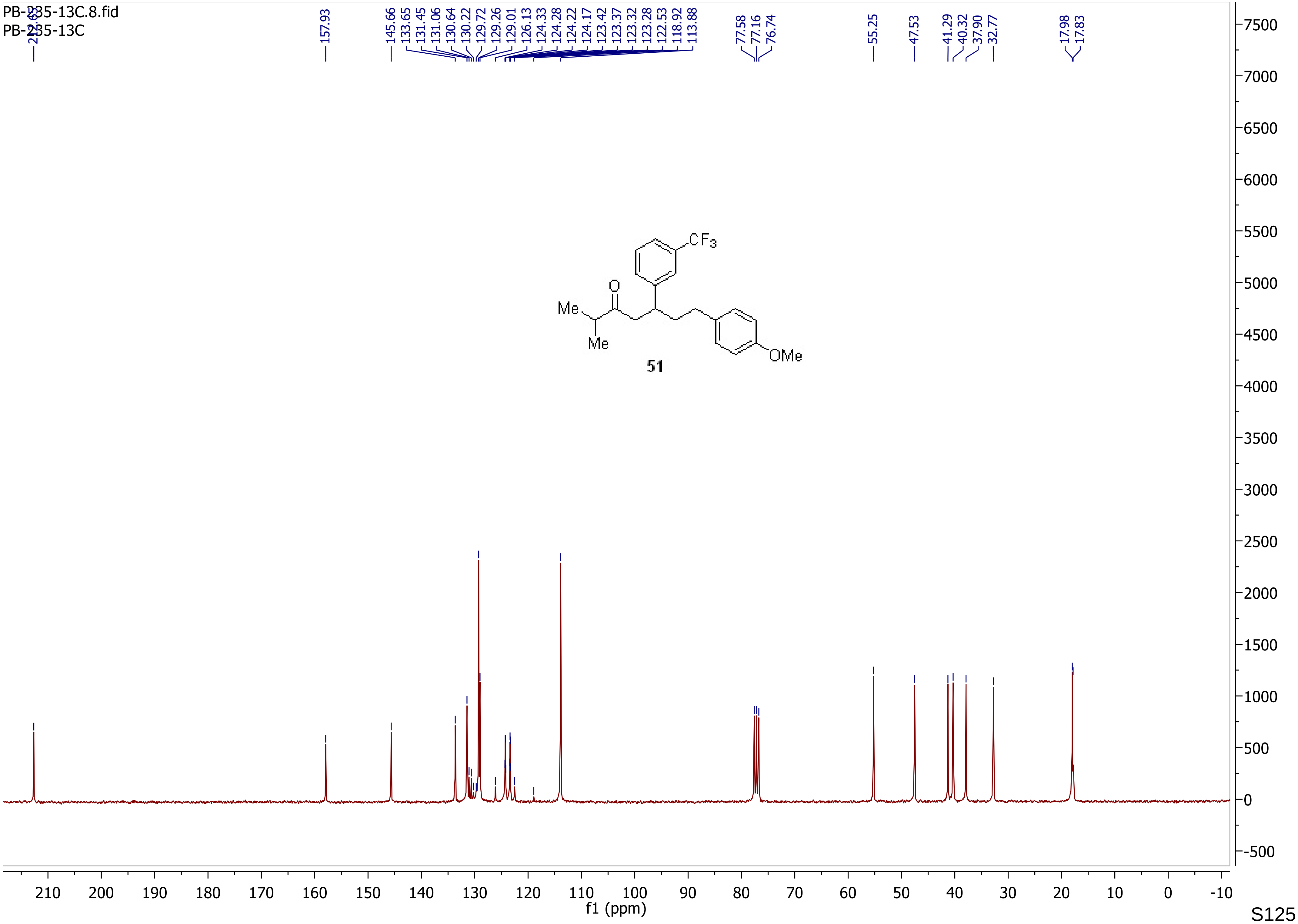

CF3
O
Me
Hb
Hd
Ha
Hc
OMe
49
a
d
b
c
PB-7-238-cosy-1.1.1.2rr
PB-7-238-cosy-1
f1 (ppm)
f2 (ppm)

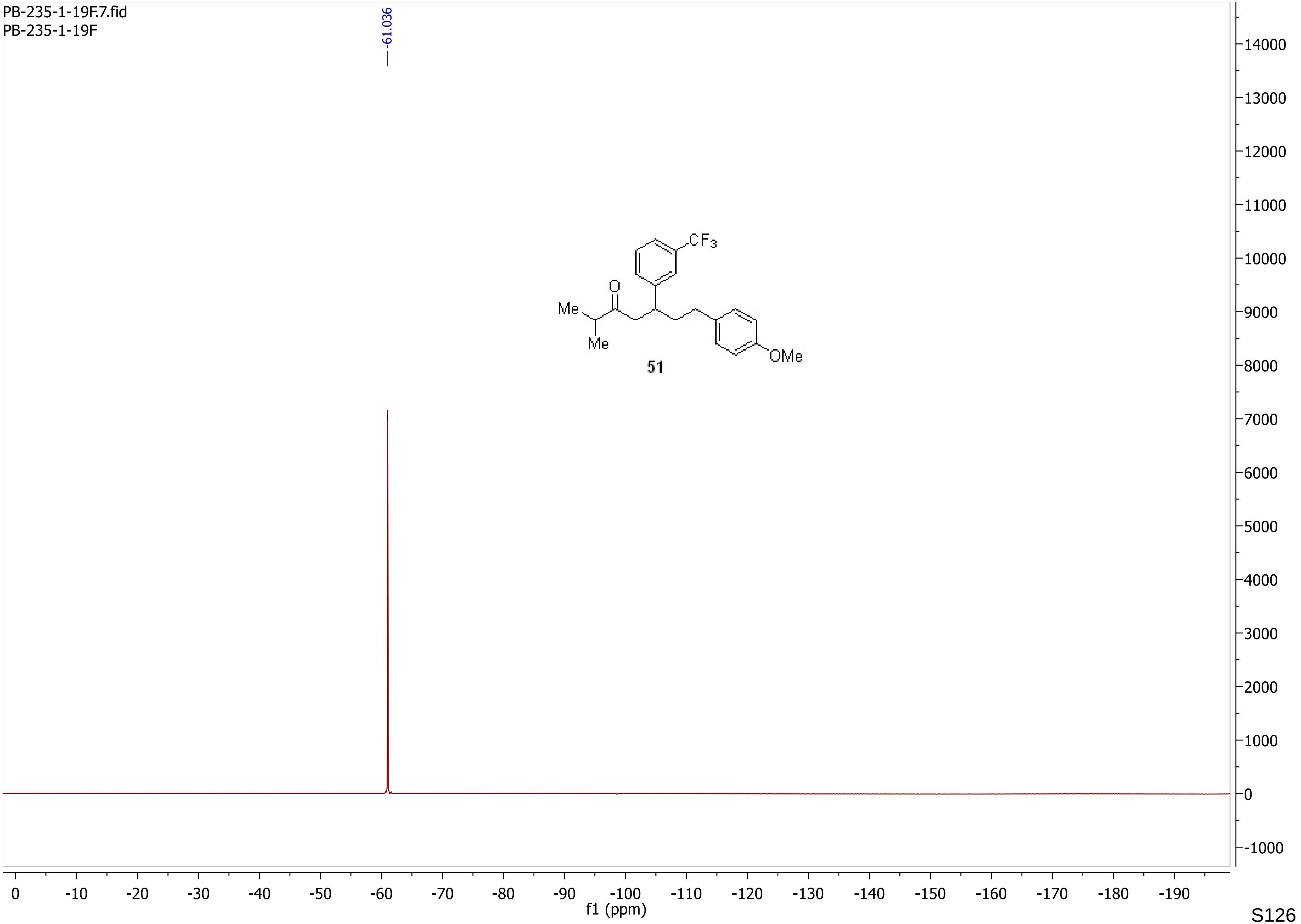


RD-3-12-3-tt.17.fid
RD-3-12-3-tt
7.35 7.33 7.32 7.30 7.29 7.28 7.26 7.24 7.23 7.23 7.22 7.21 7.20 7.19 7.18 7.17 7.12 7.11 7.09
3.25 3.23 3.23 3.22 3.21 3.20 3.20 3.19 3.18 3.17 3.16 2.78 2.76 2.73 2.72 2.71 2.70 2.67 2.64 2.49 2.46 2.43 2.27 2.26 2.24 2.23 2.22 2.21 2.20 2.18 2.00 1.99 1.98 1.97 1.96 1.94 1.93 1.92 1.90 1.89 1.53 1.50 1.48 1.46 0.83 0.81 0.78
Me
O
50
10.01
1.00
2.02
1.99
2.01
2.01
1.99
3.00
f1 (ppm)

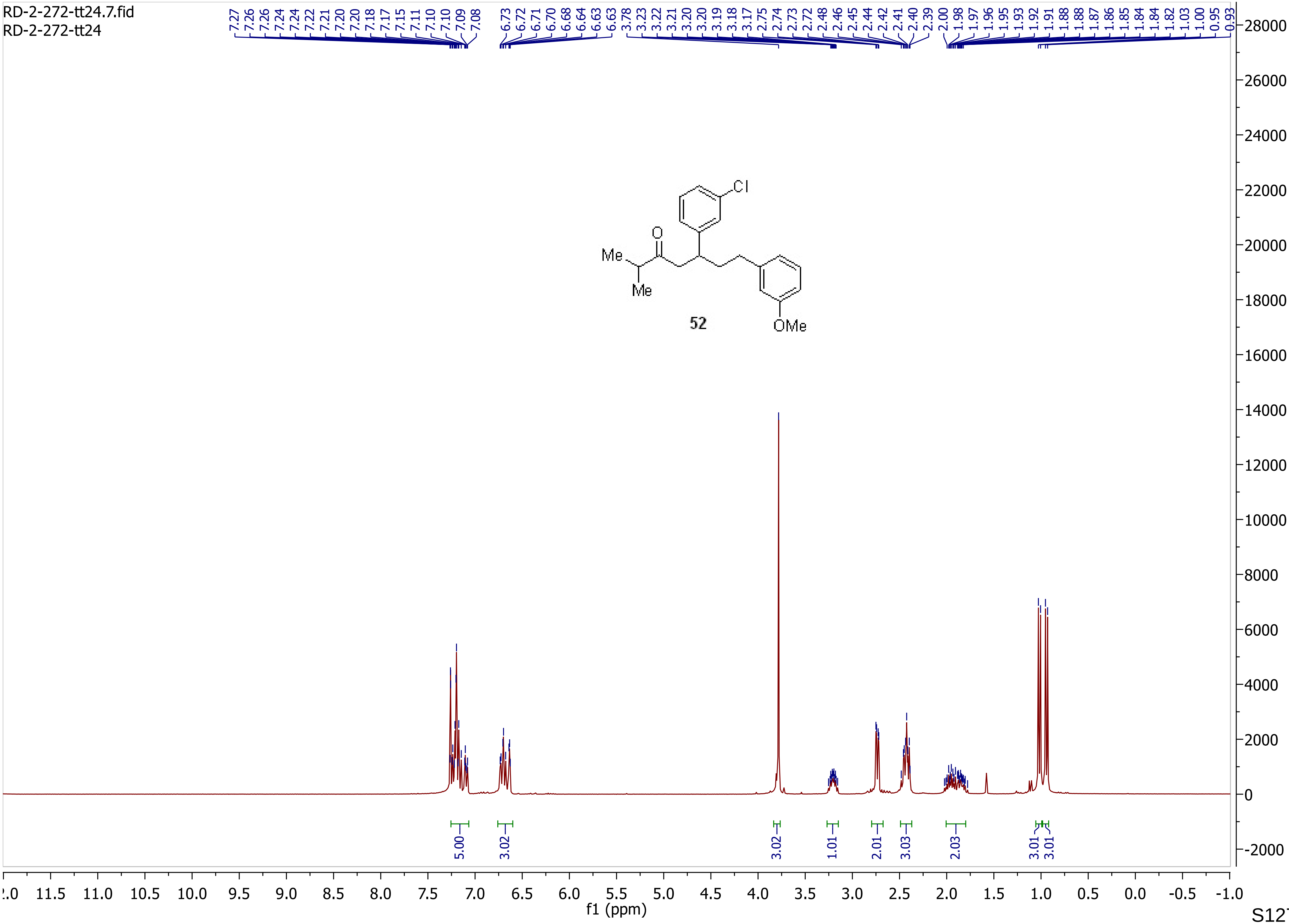

RD-3-12-3-C.18.fid
RD-3-12-3-C
144.30
142.21
128.69
128.45
128.43
127.75
126.60
125.88
77.59
77.16
76.74
50.26
45.60
41.07
38.14
33.81
17.13
13.76
O
Me
50
f1 (ppm)


PB-235-1-tt25.6.fid
PB-235-1-tt25
7.49 7.48 7.47 7.47 7.47 7.46 7.46 7.46 7.46 7.44 7.44 7.44 7.42 7.42 7.42 7.41 7.40 7.40 7.40 7.39 7.26 7.01 6.98 6.82 6.79
3.78 3.33 3.32 3.31 3.30 3.29 3.28 3.28 3.27 3.26 3.25 3.24
2.78 2.76 2.49 2.46 2.44 2.42 2.41 2.39 2.39 2.36 1.99 1.97 1.96 1.94 1.92 1.90 1.89 1.88 1.87 1.86 1.86 1.02 1.00 0.94 0.92
CF3
O
Me
Me
OMe
51
4.03 2.00 2.02 3.03 1.03 2.01 3.00 2.01 3.02 3.00
f1 (ppm)

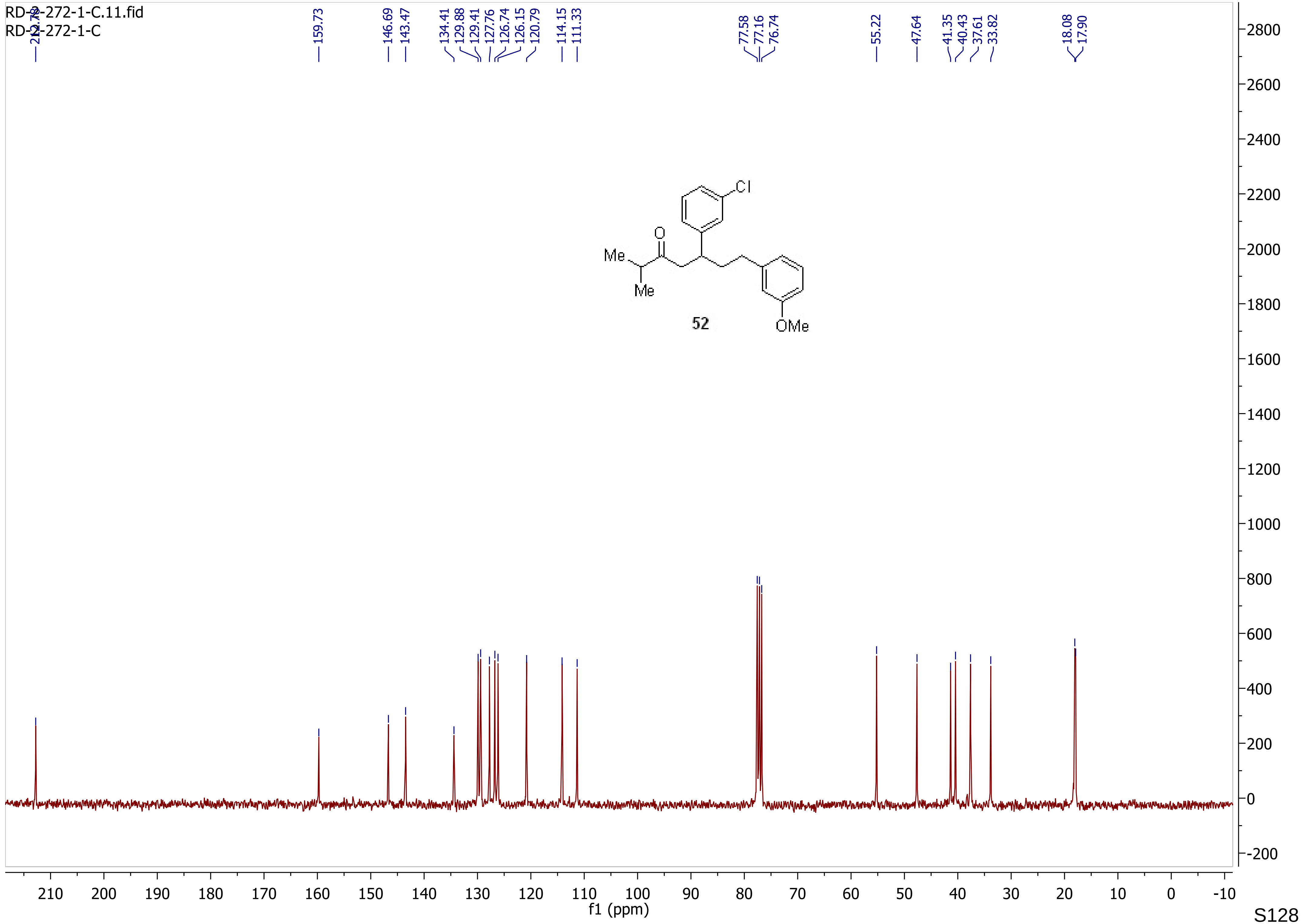

PB-235-13C.8.fid
PB-235-13C
157.93
145.66
133.65
131.45
131.06
130.64
130.22
129.72
129.26
129.01
126.13
124.33
124.28
124.22
124.17
123.42
123.37
123.32
123.28
122.53
118.92
113.88
77.58
77.16
76.74
55.25
47.53
41.29
40.32
37.90
32.77
17.98
17.83
CF3
O
Me
Me
OMe
51
f1 (ppm)

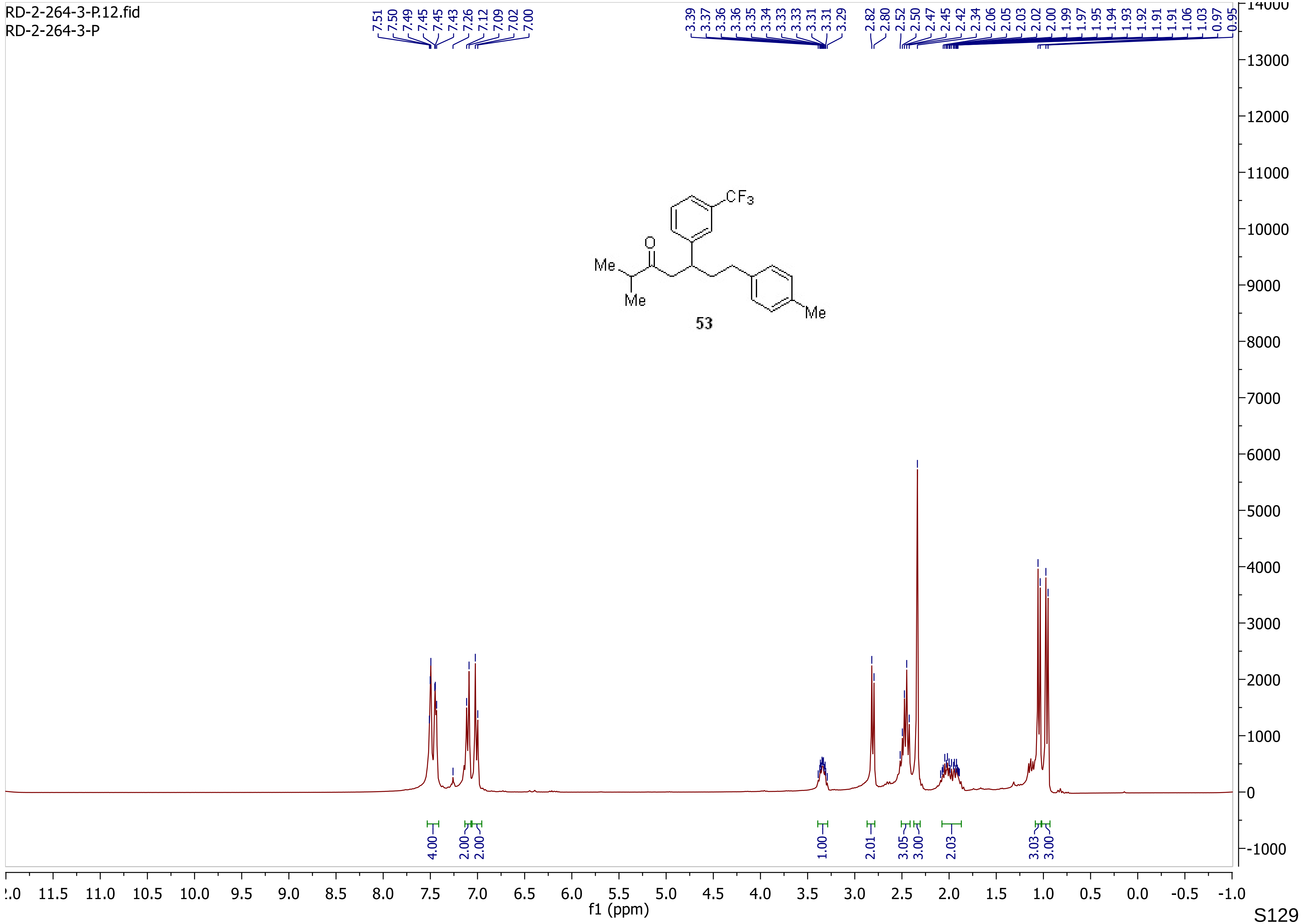

PB-235-1-19F.7.fid
PB-235-1-19F
-61.036
CF3
O
Me
Me
OMe
51
f1 (ppm)

RD-2-272-tt24.7.fid
RD-2-272-tt24

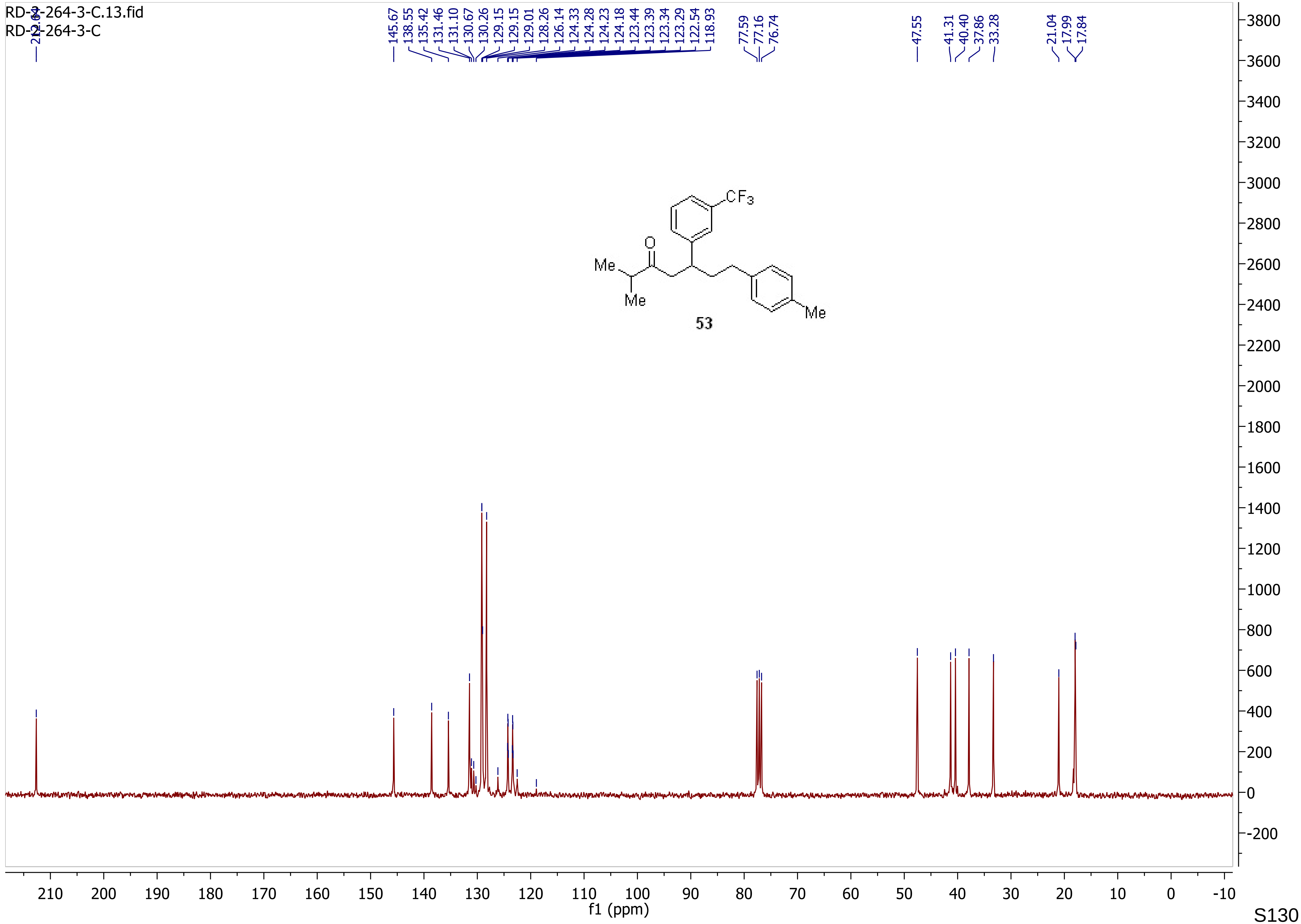


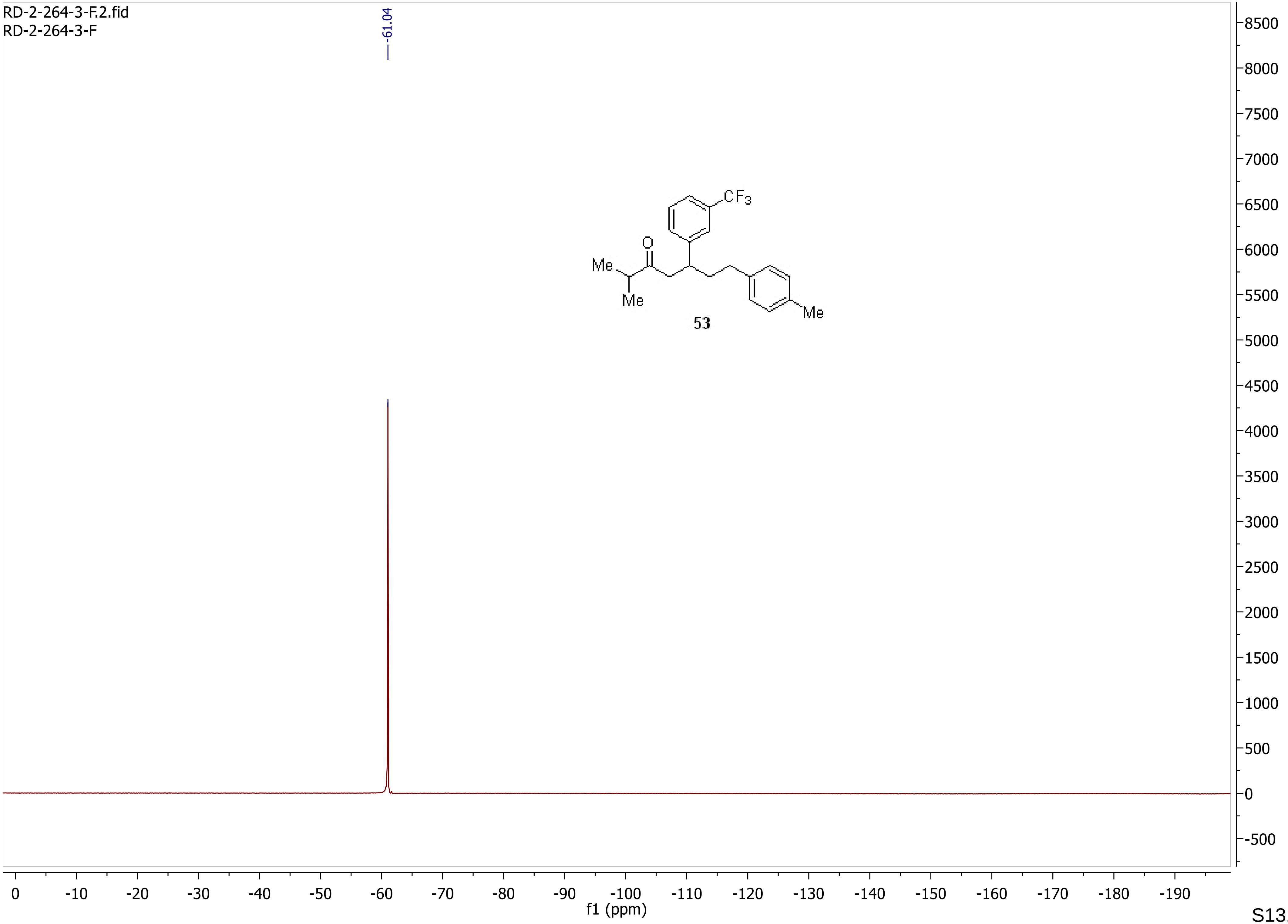
52

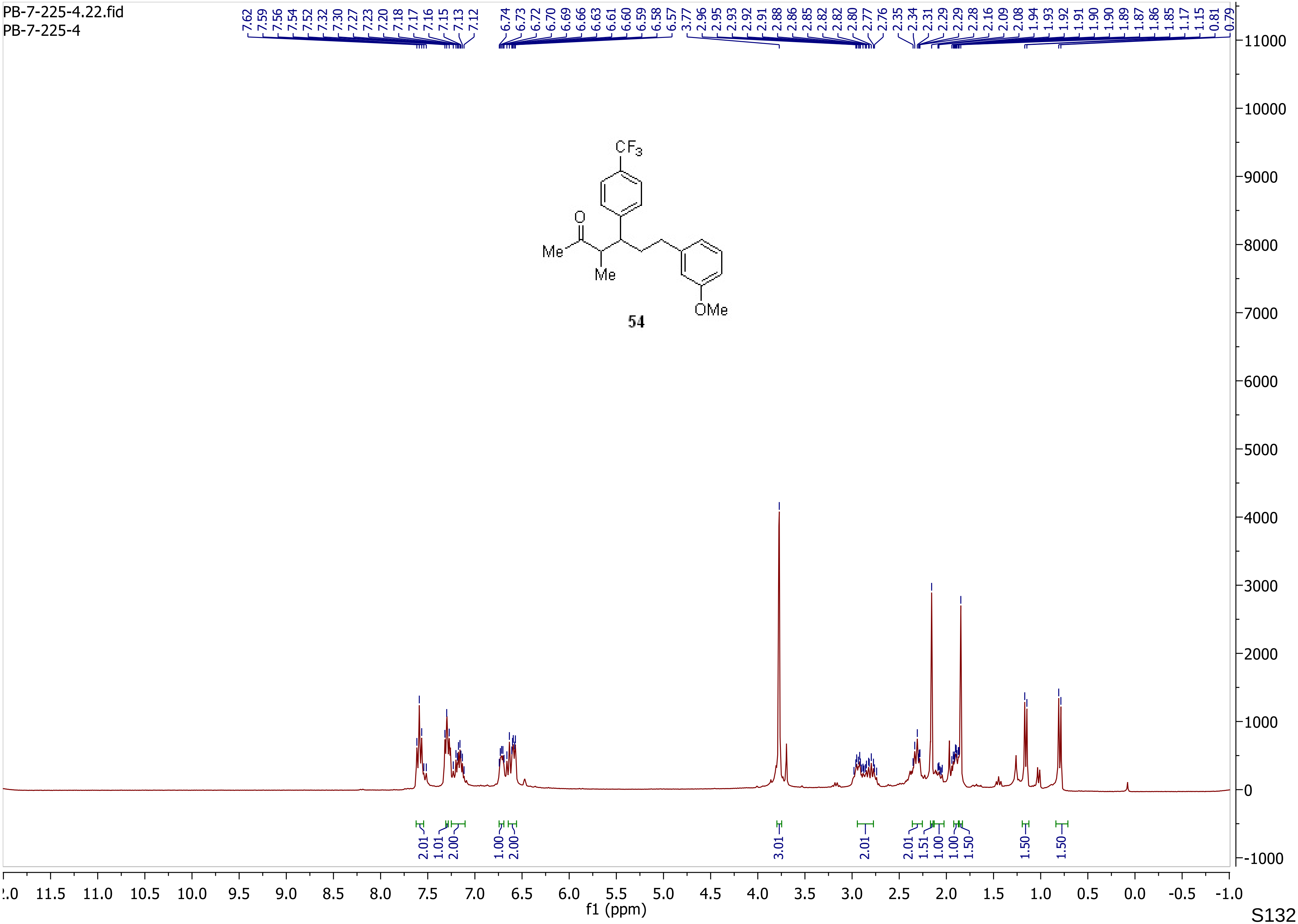

RD-2-272-1-C.11.fid
RD-2-272-1-C
212.78
159.73
146.69
143.47
134.41
129.88
129.41
127.76
126.74
126.15
120.79
114.15
111.33
77.58
77.16
76.74
55.22
47.64
41.35
40.43
37.61
33.82
18.08
17.90
Cl
O
Me
Me
OMe
52
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
-200
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

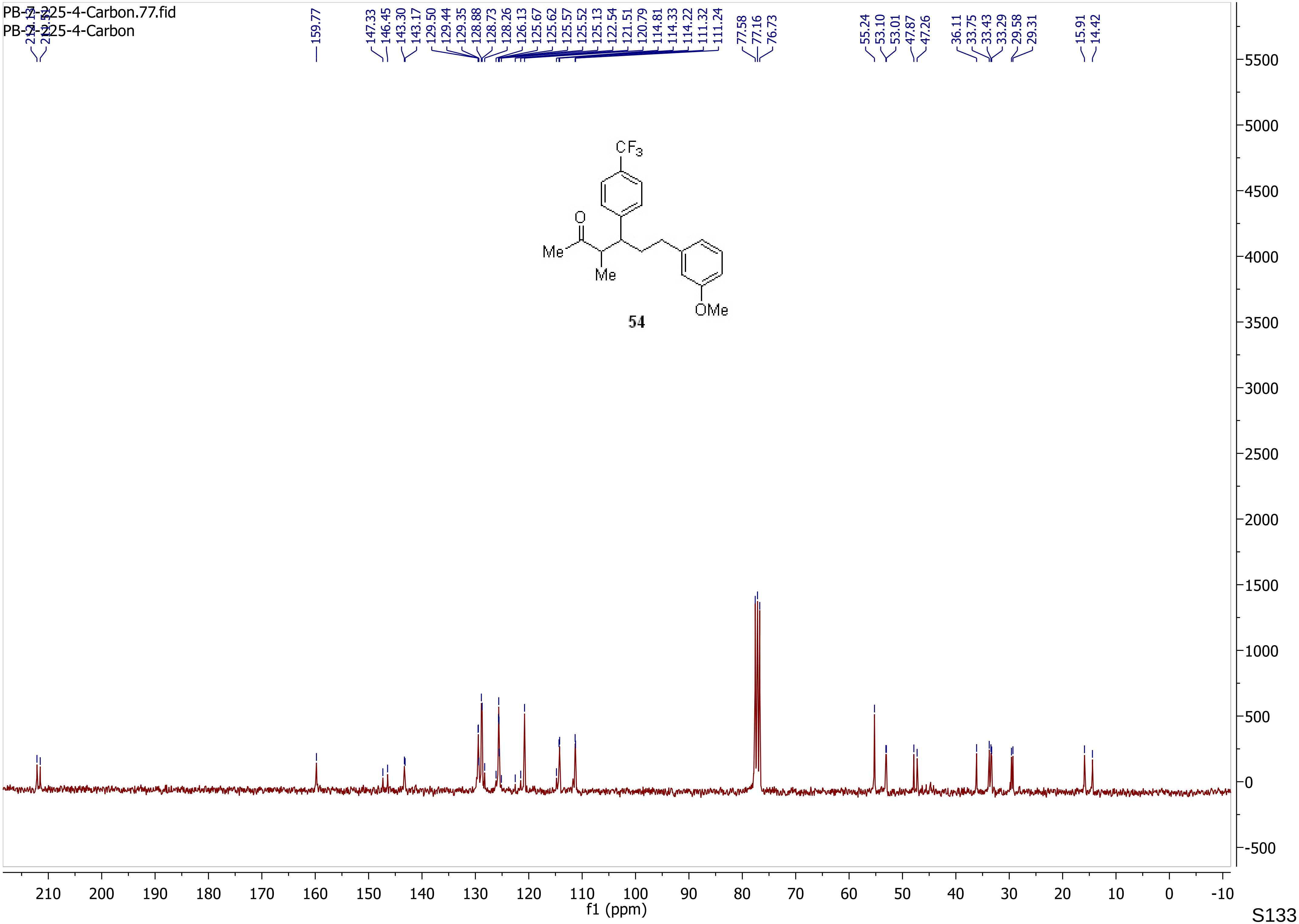

RD-2-264-3-P.12.fid
RD-2-264-3-P
7.51
7.50
7.49
7.45
7.45
7.43
7.26
7.12
7.09
7.02
7.00
3.39
3.37
3.36
3.36
3.35
3.34
3.33
3.33
3.31
3.31
3.29
2.82
2.80
2.52
2.50
2.47
2.45
2.42
2.34
2.06
2.05
2.03
2.02
2.00
1.99
1.97
1.95
1.94
1.93
1.92
1.91
1.91
1.06
1.03
0.97
0.95
CF3
O
Me
Me
Me
4.00
2.00
2.00
1.00
2.01
3.05
3.00
2.03
3.03
3.00
f1 (ppm)

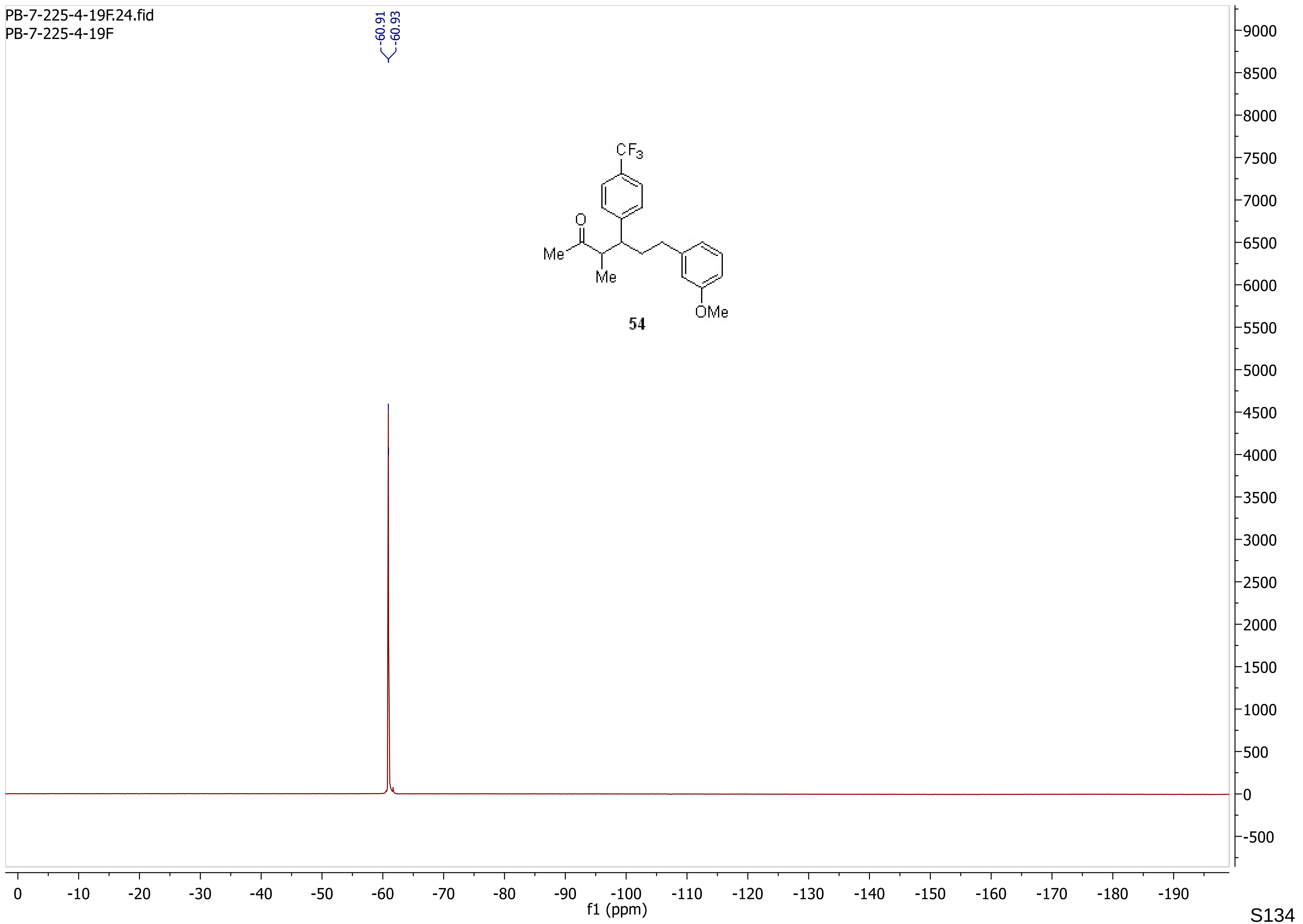
53


RD-2-264-3-C.13.fid
RD-2-264-3-C
145.67
138.55
135.42
131.46
131.10
130.67
130.26
129.15
129.15
129.01
128.26
126.14
124.33
124.28
124.23
124.18
123.44
123.39
123.34
123.29
122.54
118.93
77.59
77.16
76.74
47.55
41.31
40.40
37.86
33.28
21.04
17.99
17.84
CF3
O
Me
Me
Me
53
f1 (ppm)

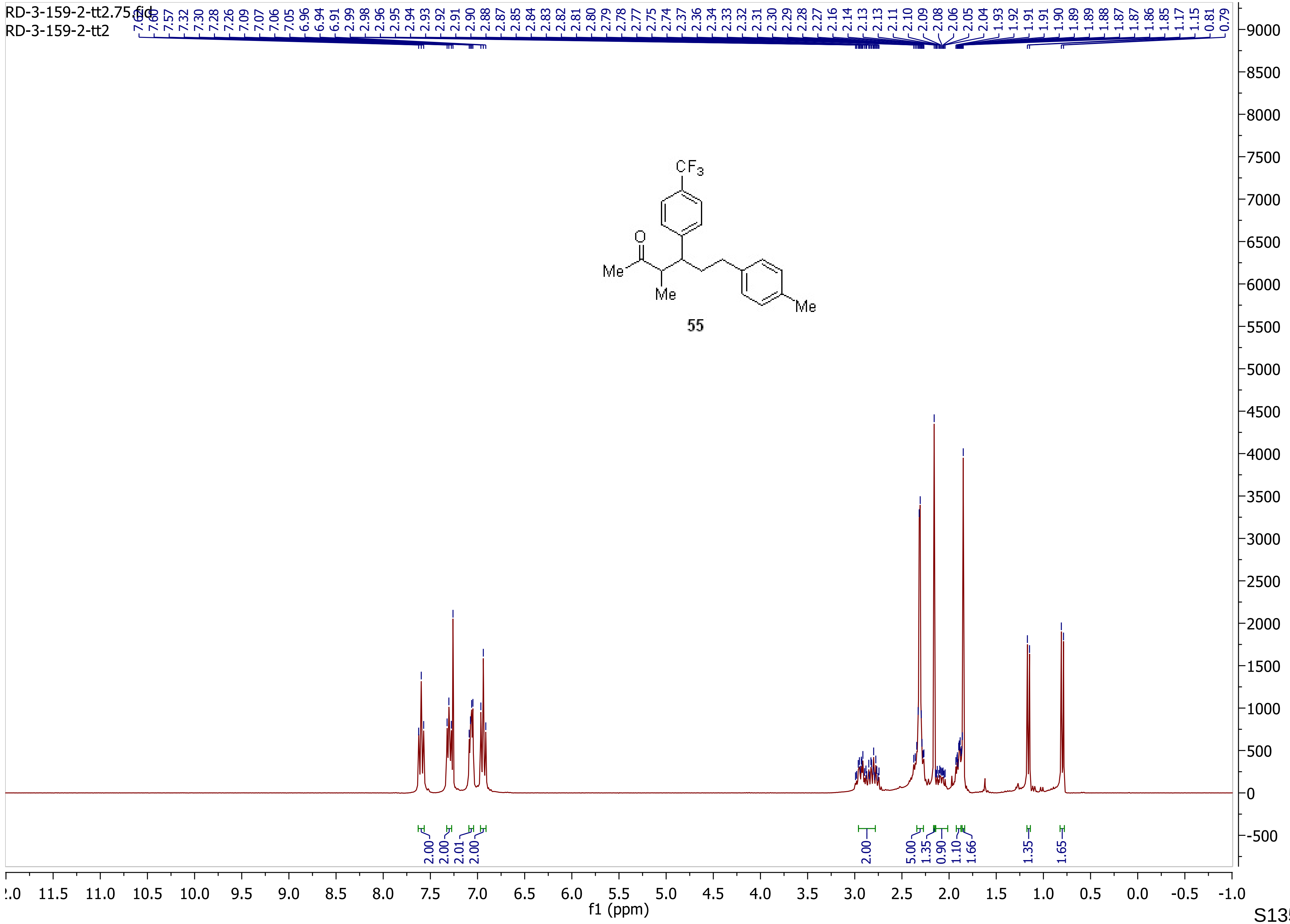

RD-2-264-3-F.2.fid
RD-2-264-3-F
-61.04
CF3
O
Me
Me
Me
53
f1 (ppm)

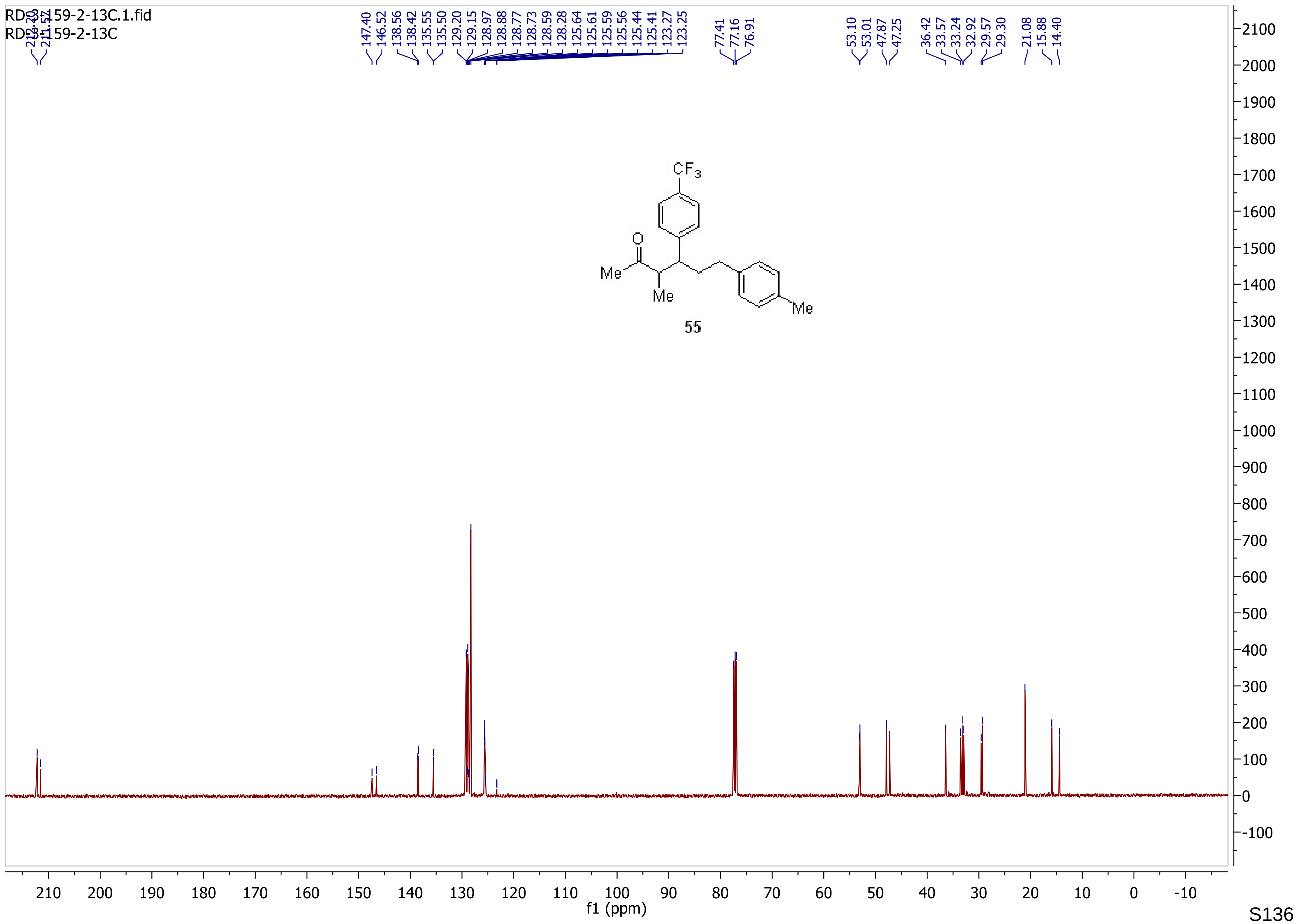

PB-7-225-4.22.fid
PB-7-225-4
CF3
O
Me
Me
OMe
54
f1 (ppm)

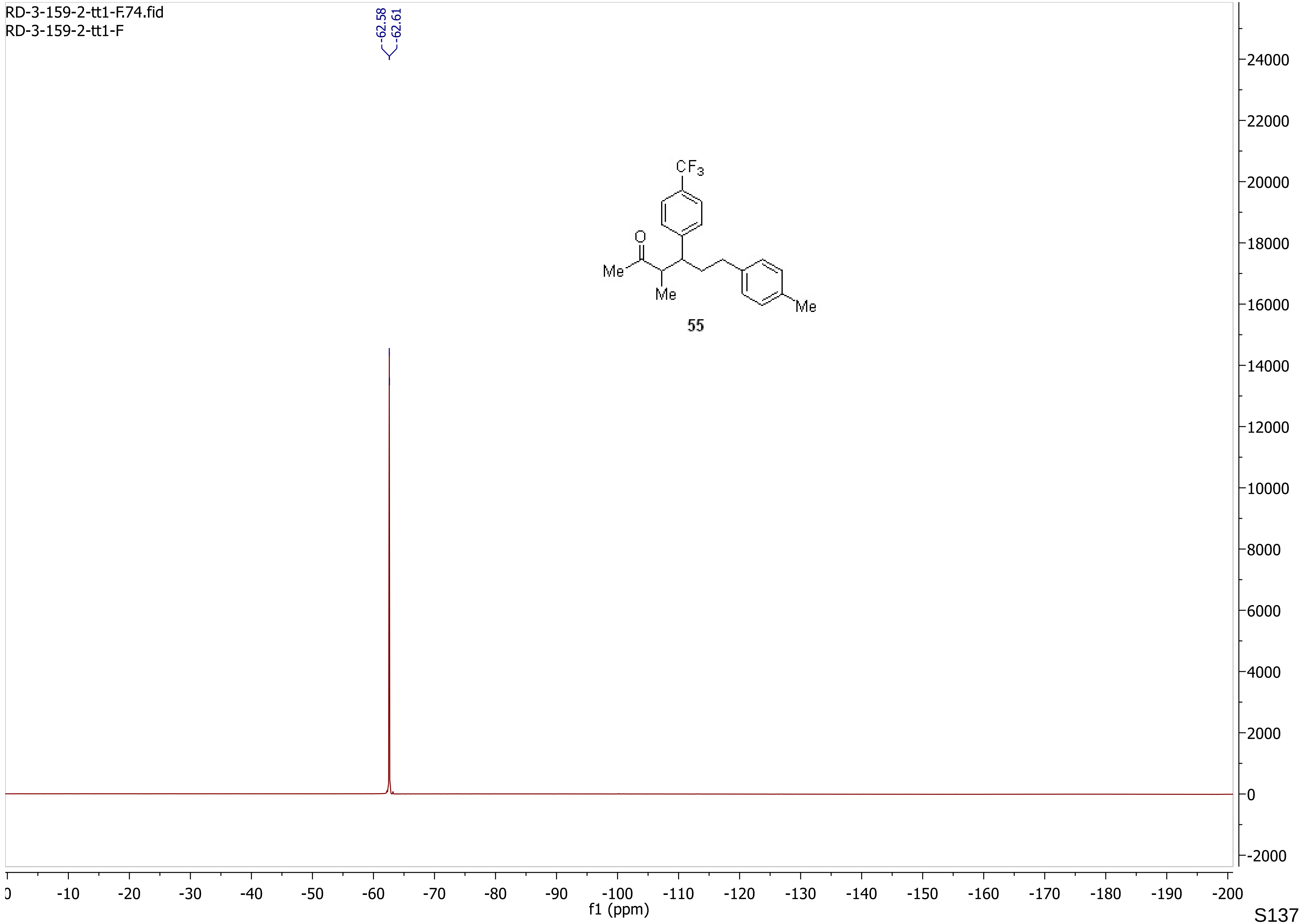

PB-7-225-4-Carbon.77.fid
PB-7-225-4-Carbon
159.77
147.33
146.45
143.30
143.17
129.50
129.44
129.35
128.88
128.73
128.26
126.13
125.67
125.62
125.57
125.52
125.13
122.54
121.51
120.79
114.81
114.33
114.22
111.32
111.24
77.58
77.16
76.73
55.24
53.10
53.01
47.87
47.26
36.11
33.75
33.43
33.29
29.58
29.31
15.91
14.42
CF3
O
Me
Me
OMe
54
f1 (ppm)

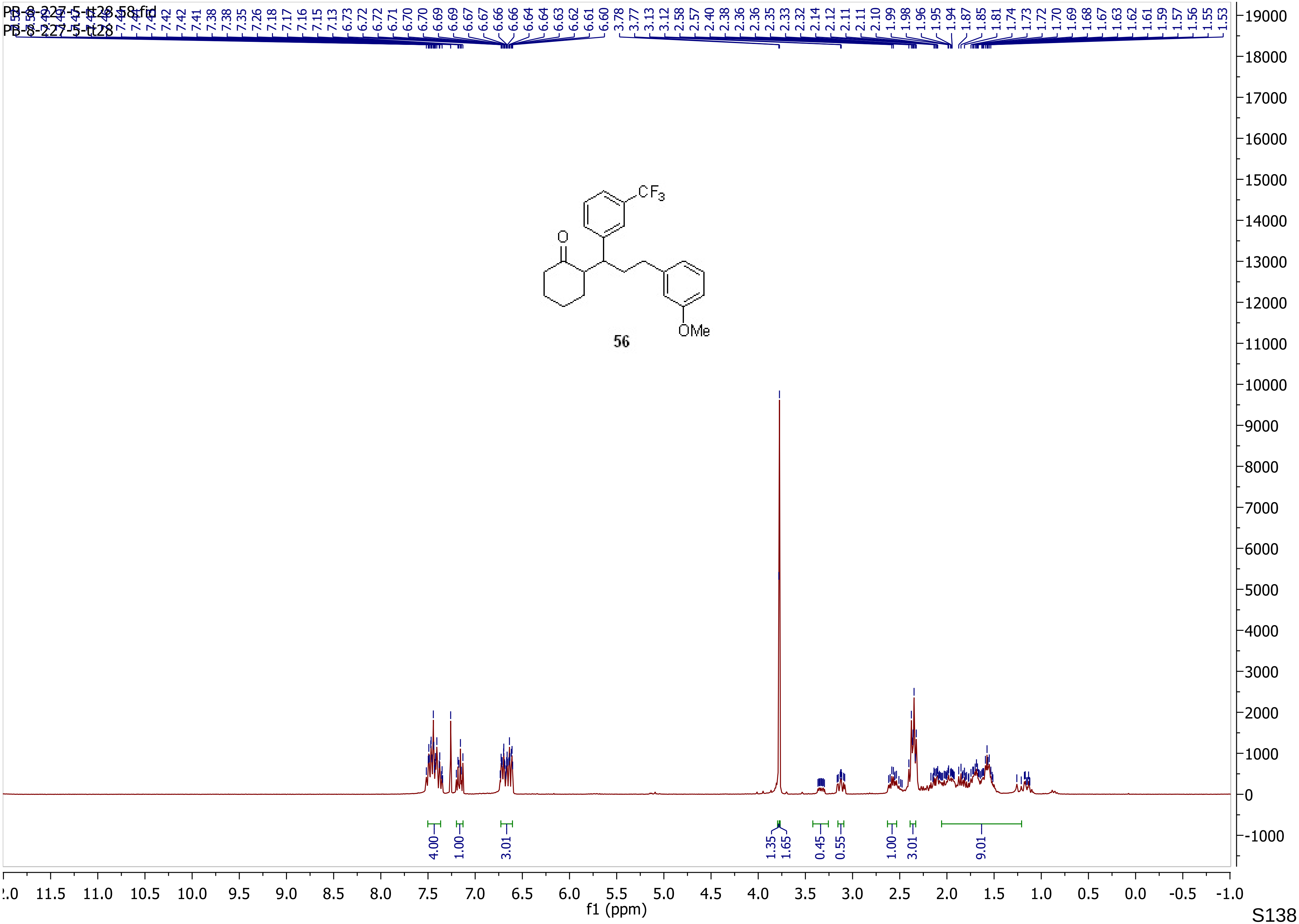


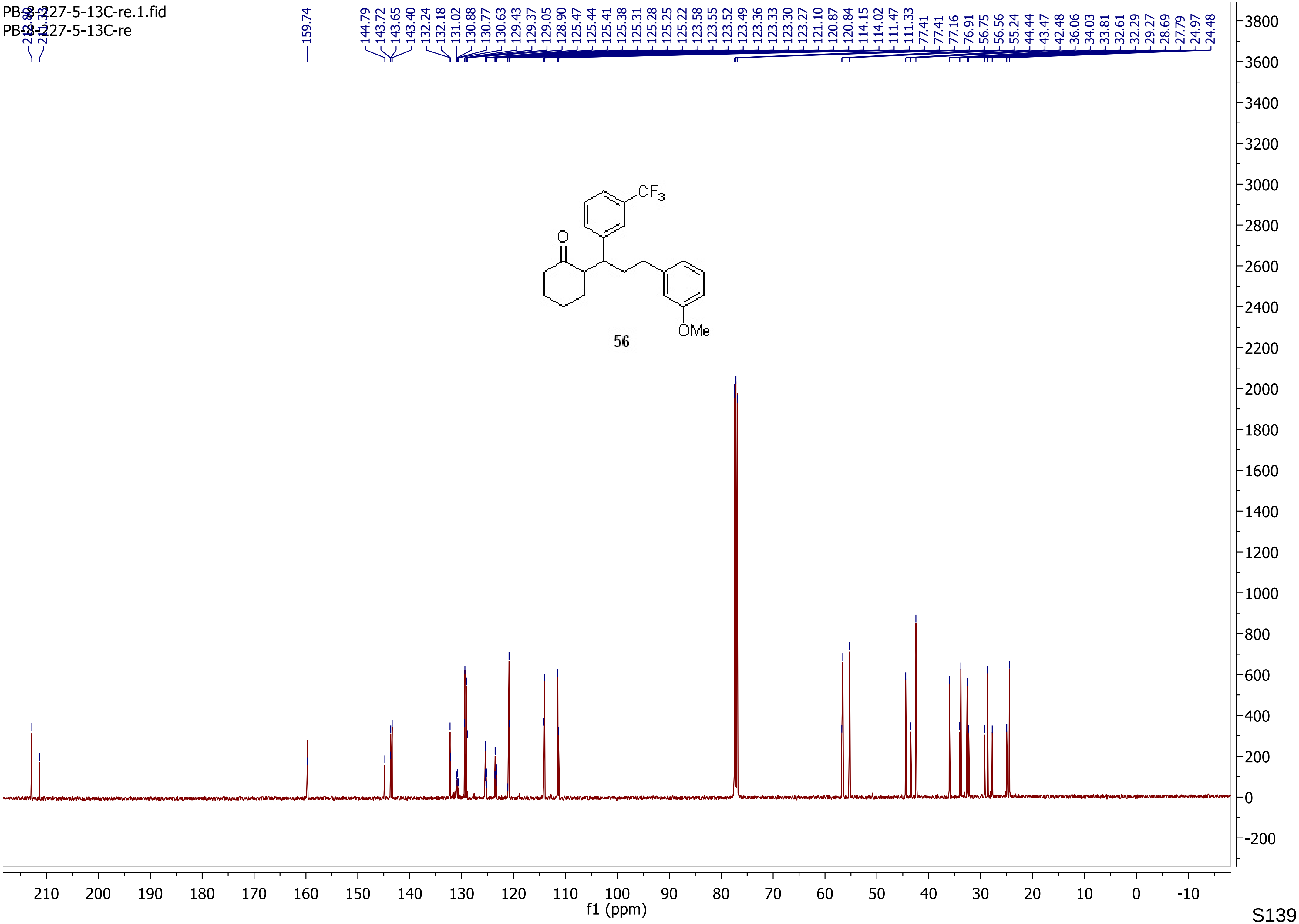
PB-7-225-4-19F.24.fid
PB-7-225-4-19F
-60.91
-60.93
CF3
O
Me
Me
OMe
54
f1 (ppm)

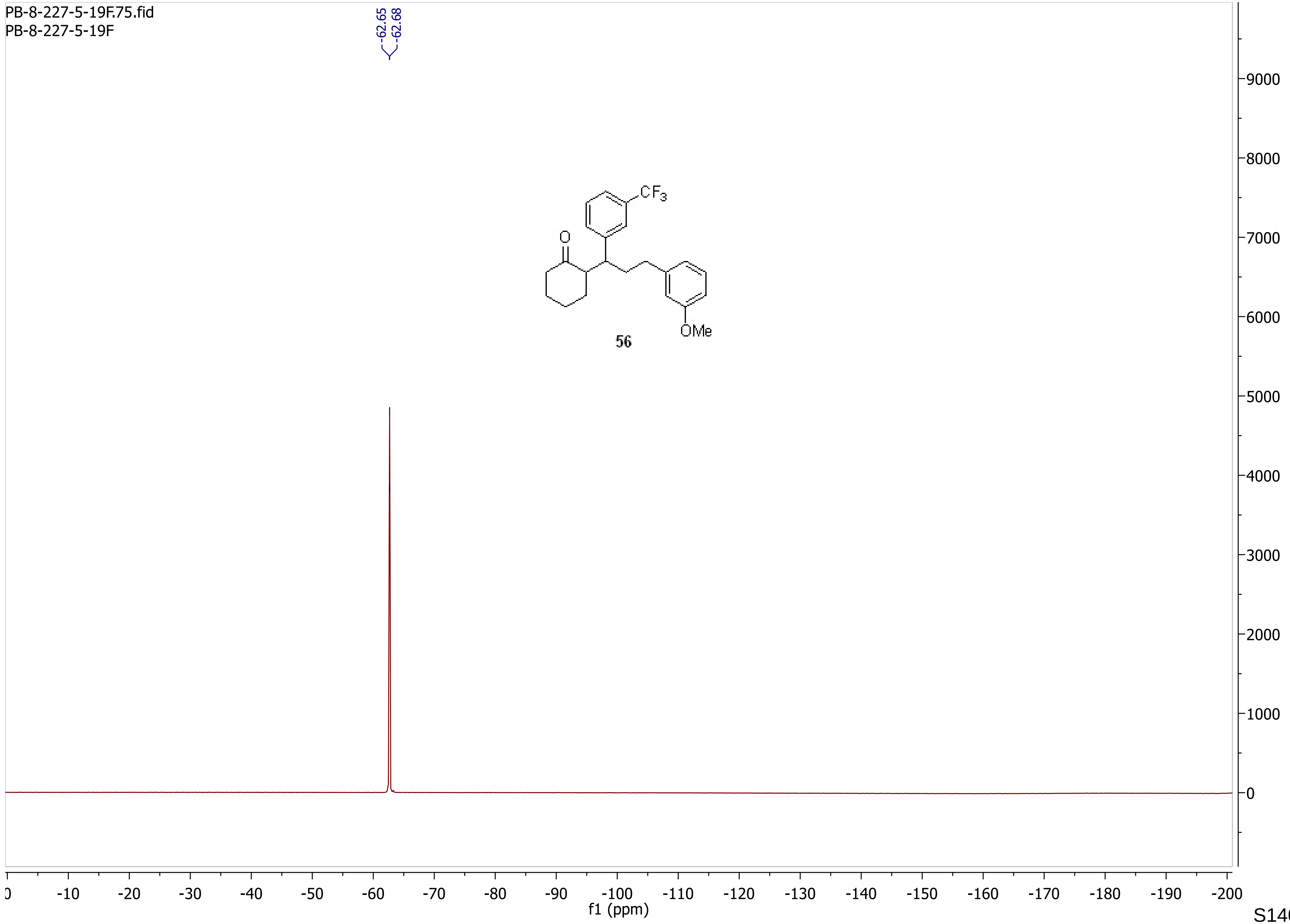

RD-3-159-2-tt2.75.fid
RD-3-159-2-tt2
7.60 7.57 7.32 7.30 7.28 7.26 7.09 7.07 7.06 7.05 6.96 6.94 6.91 2.99 2.98 2.96 2.95 2.94 2.93 2.92 2.91 2.90 2.88 2.87 2.85 2.84 2.83 2.82 2.81 2.80 2.79 2.78 2.77 2.75 2.74 2.37 2.36 2.34 2.33 2.32 2.31 2.30 2.29 2.28 2.27 2.16 2.14 2.13 2.13 2.11 2.10 2.09 2.08 2.06 2.05 2.04 1.93 1.92 1.91 1.91 1.90 1.89 1.89 1.88 1.87 1.87 1.86 1.85 1.17 1.15 0.81 0.79
CF3
O
Me
Me
Me
55
2.00 2.00 2.01 2.00 2.00 5.00 1.35 0.90 1.10 1.66 1.35 1.65
f1 (ppm)

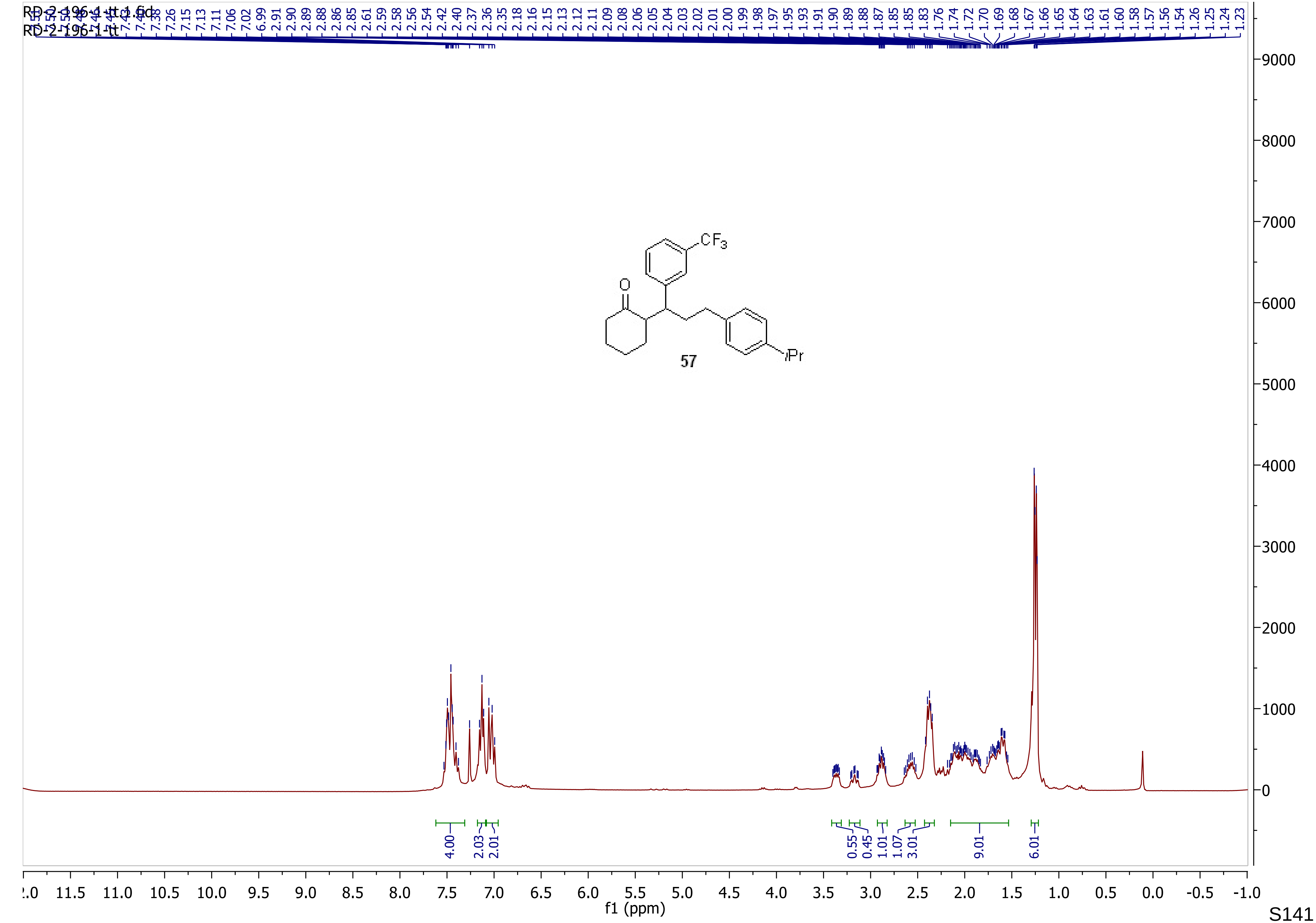

RD-3-159-2-13C.1.fid
RD-3-159-2-13C
212.20
211.57
147.40
146.52
138.56
138.42
135.55
135.50
129.20
129.15
128.97
128.88
128.77
128.73
128.59
128.28
125.64
125.61
125.59
125.56
125.44
125.41
123.27
123.25
77.41
77.16
76.91
53.10
53.01
47.87
47.25
36.42
33.57
33.24
32.92
29.57
29.30
21.08
15.88
14.40
CF3
O
Me
Me
Me
55
f1 (ppm)


RD-3-159-2-tt1-F.74.fid
RD-3-159-2-tt1-F
-62.58
-62.61
CF3
O
Me
Me
Me
55
f1 (ppm)

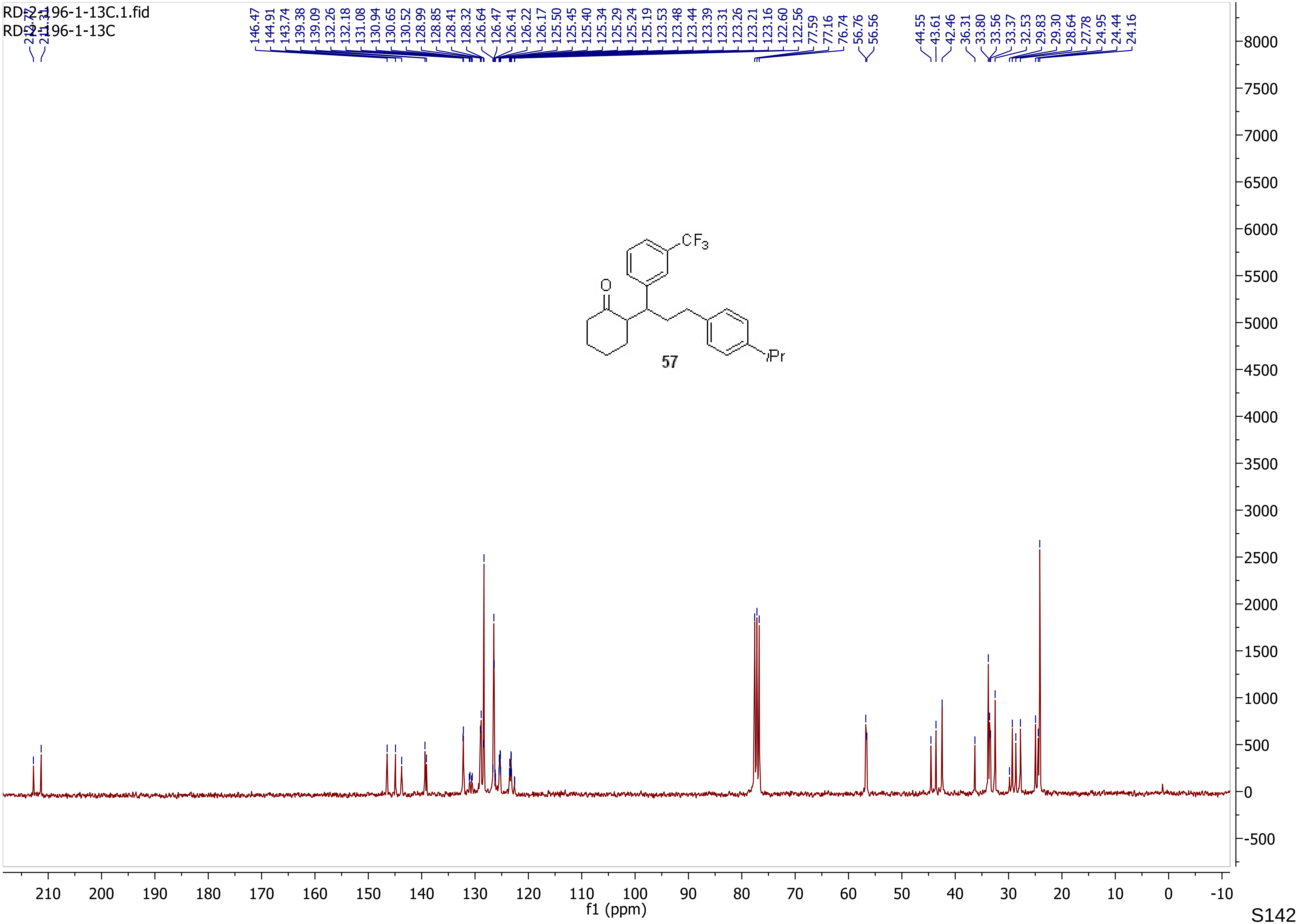

PB-8-227-5-tt28.58.fid
PB-8-227-5-tt28
CF3
O
OMe
56
4.00
1.00
3.01
1.35
1.65
0.45
0.55
1.00
3.01
9.01
f1 (ppm)

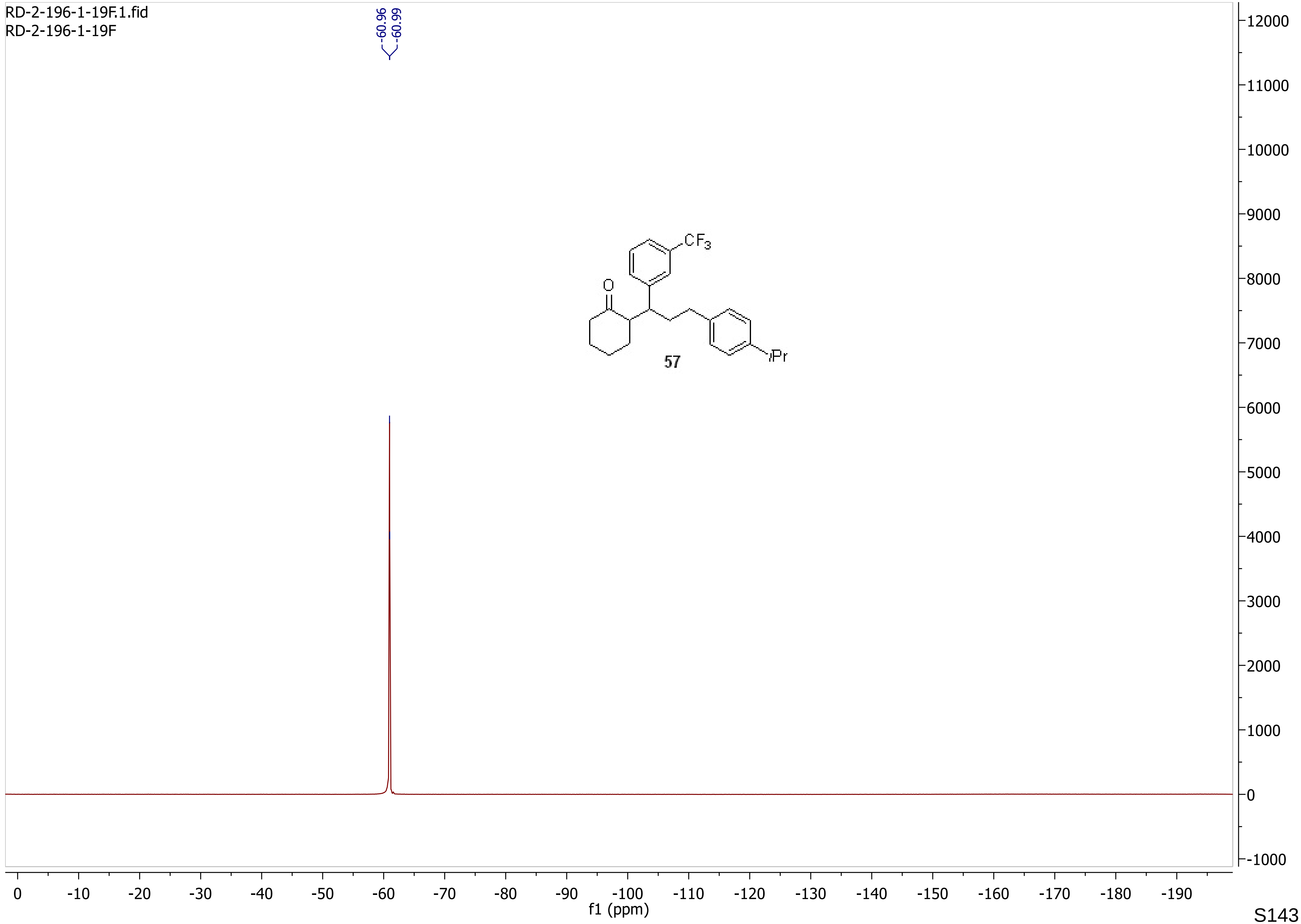

PB-8-227-5-13C-re.1.fid
PB-8-227-5-13C-re
159.74
144.79
143.72
143.65
143.40
132.24
132.18
131.02
130.88
130.77
130.63
129.43
129.37
129.05
128.90
125.47
125.44
125.41
125.38
125.31
125.28
125.25
125.22
123.58
123.55
123.52
123.49
123.36
123.33
123.30
123.27
121.10
120.87
120.84
114.15
114.02
111.47
111.33
77.41
77.41
77.16
76.91
56.75
56.56
55.24
44.44
43.47
42.48
36.06
34.03
33.81
32.61
32.29
29.27
28.69
27.79
24.97
24.48
CF3
O
OMe
56
f1 (ppm)

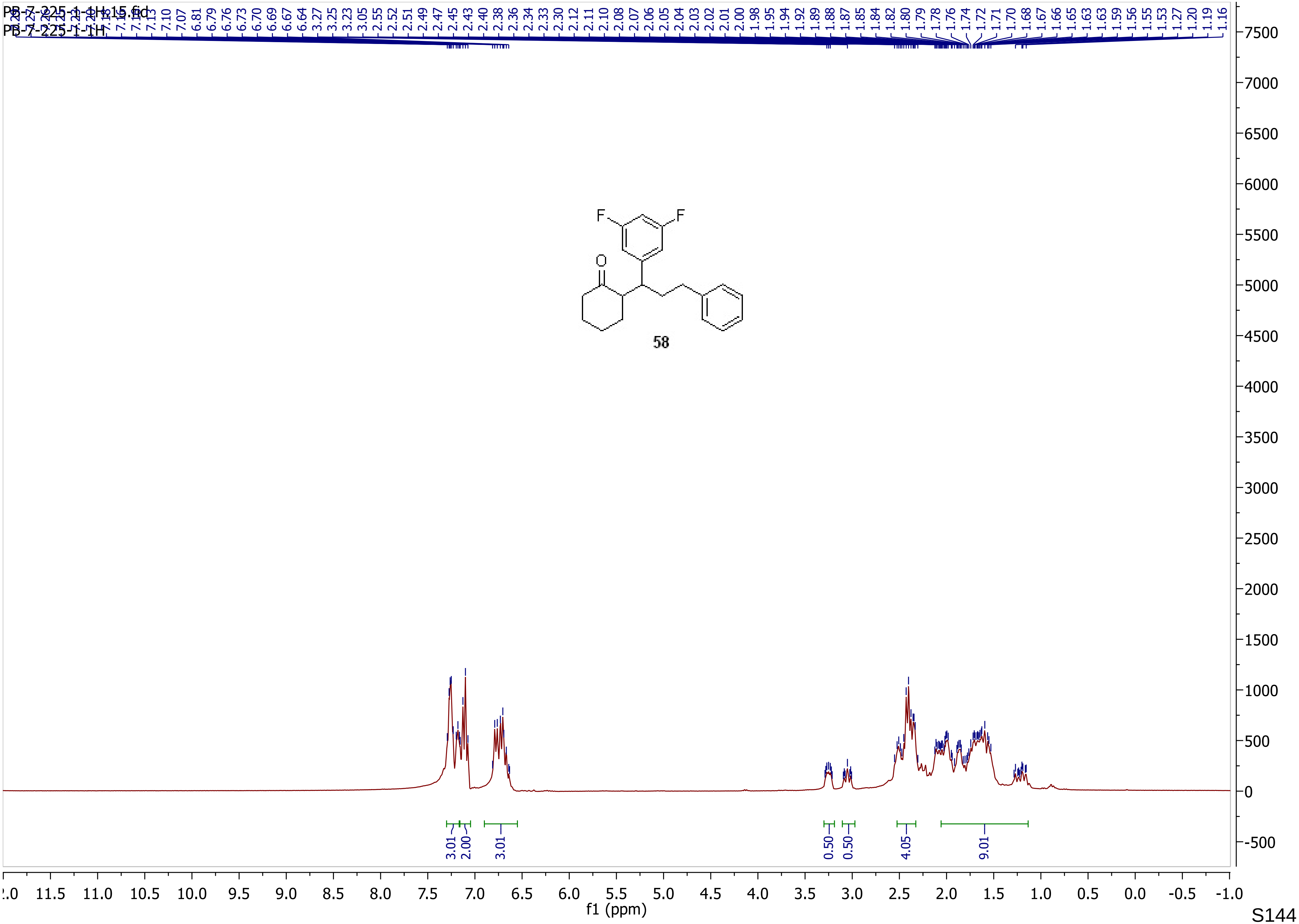

PB-8-227-5-19F.75.fid
PB-8-227-5-19F
-62.65
-62.68
CF3
O
OMe
56
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
f1 (ppm)

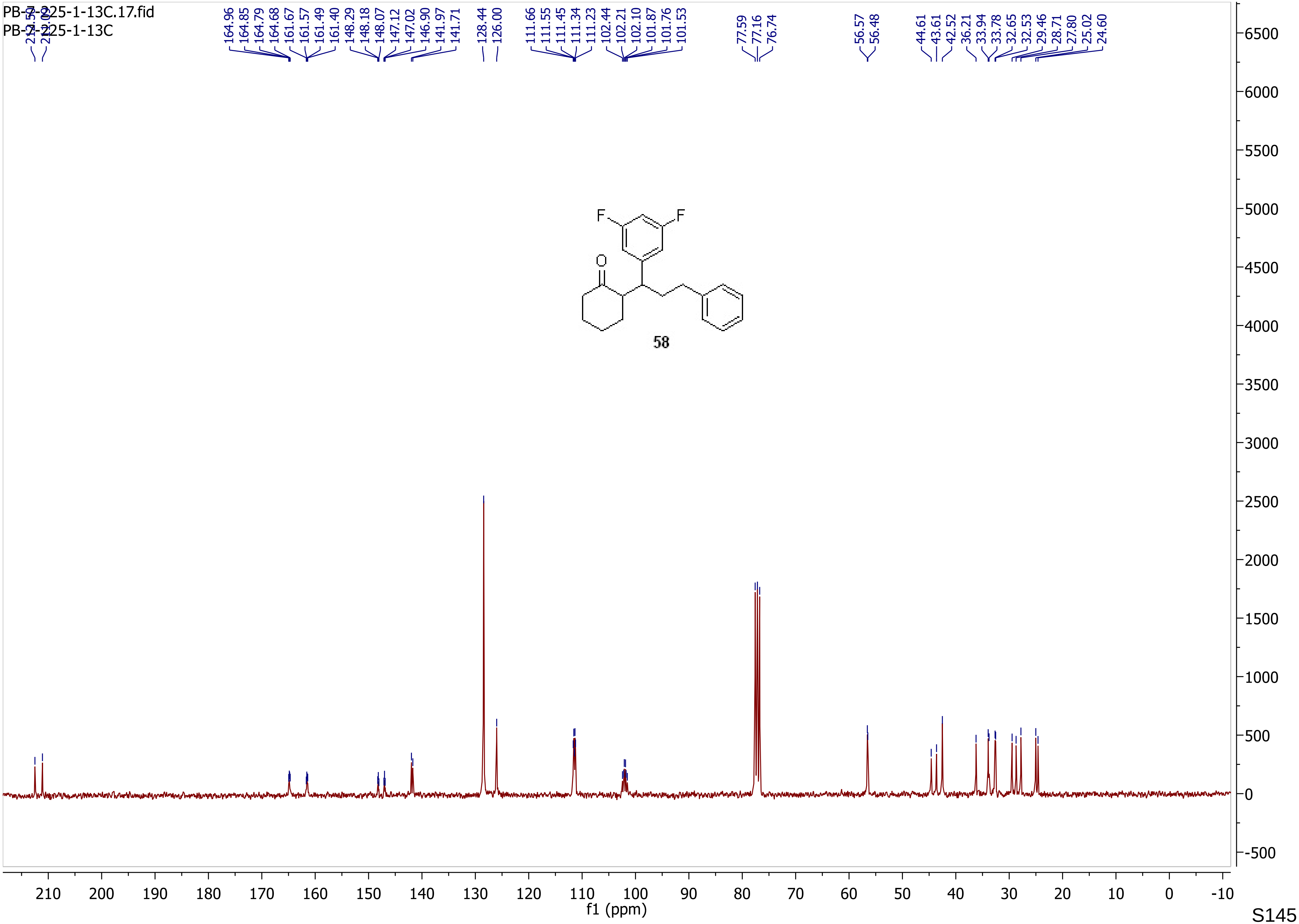


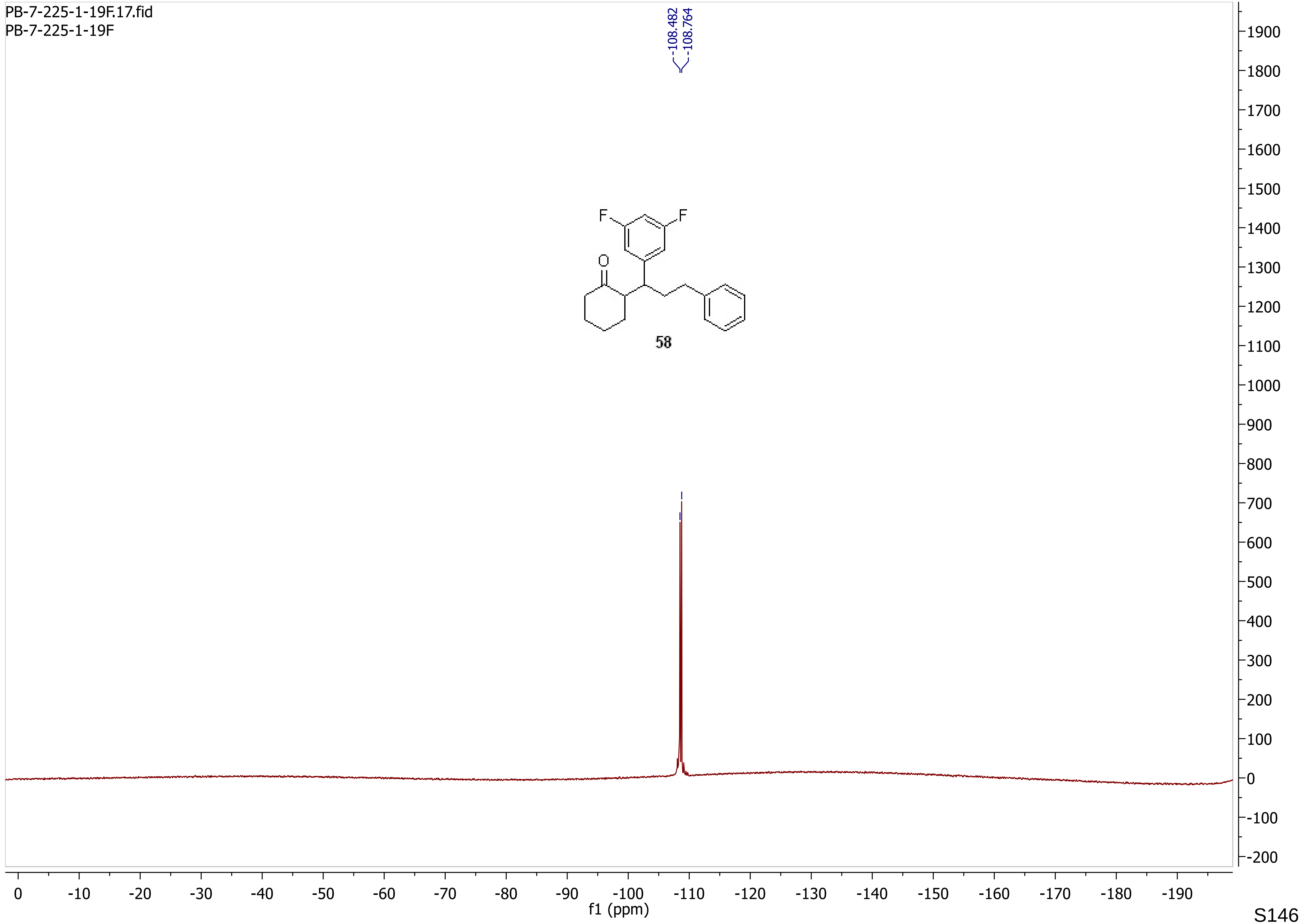
RD-2-196-1-tt.1.fid
RD-2-196-1-tt
7.38
7.26
7.15
7.13
7.11
7.06
7.02
6.99
2.91
2.90
2.89
2.88
2.86
2.85
2.61
2.59
2.58
2.56
2.54
2.42
2.40
2.37
2.36
2.35
2.18
2.16
2.15
2.13
2.12
2.11
2.09
2.08
2.06
2.05
2.04
2.03
2.02
2.01
2.00
1.99
1.98
1.97
1.95
1.93
1.91
1.90
1.89
1.88
1.87
1.85
1.85
1.83
1.76
1.74
1.72
1.70
1.69
1.68
1.67
1.66
1.65
1.64
1.63
1.61
1.60
1.58
1.57
1.56
1.54
1.26
1.25
1.24
1.23
CF3
O
iPr
57
4.00
2.03
2.01
0.55
0.45
1.01
1.07
3.01
9.01
6.01
f1 (ppm)

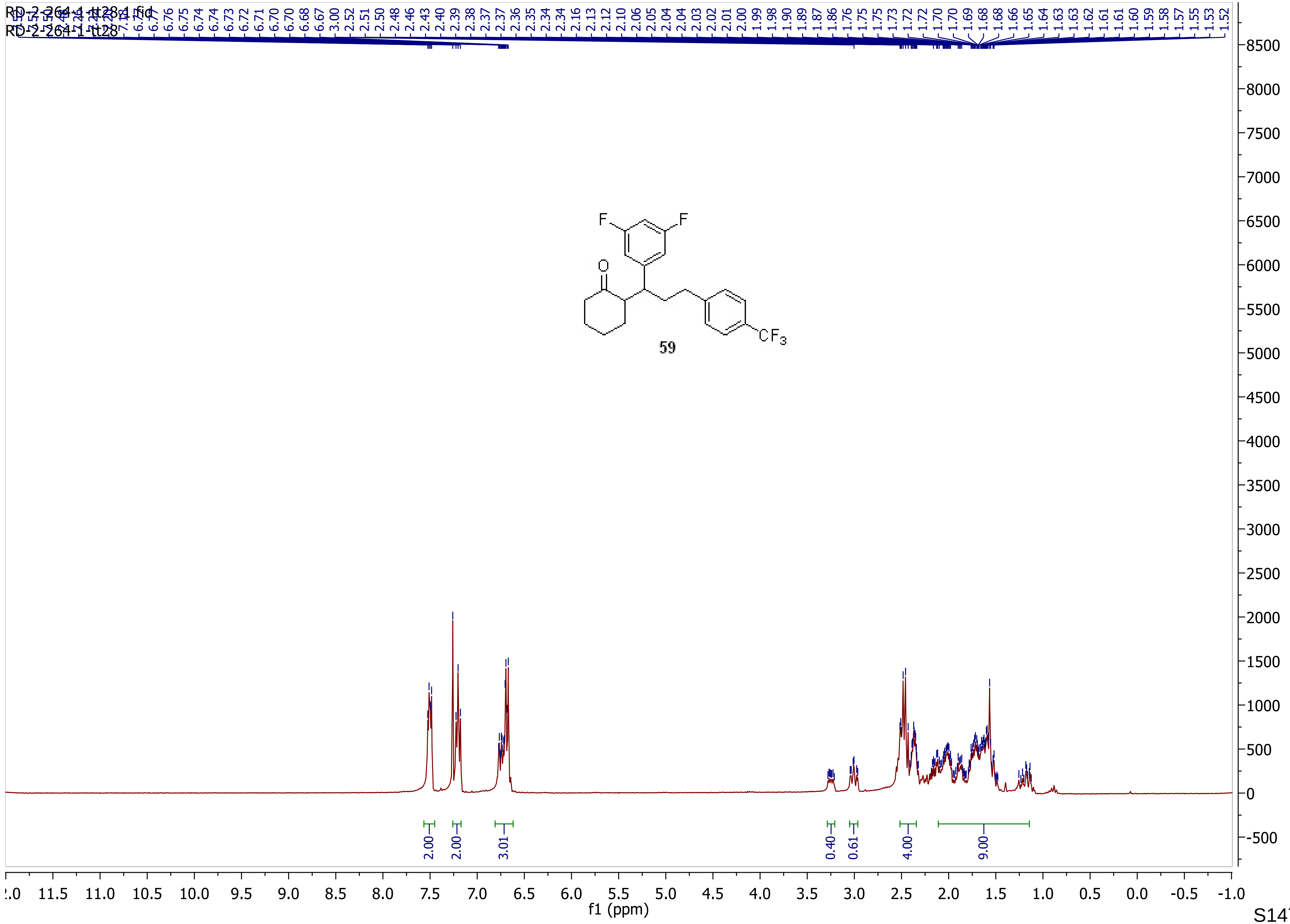

RD-2-196-1-13C.1.fid
RD-2-196-1-13C
146.47
144.91
143.74
139.38
139.09
132.26
132.18
131.08
130.94
130.65
130.52
128.99
128.85
128.41
128.32
126.64
126.47
126.41
126.22
126.17
125.50
125.45
125.40
125.34
125.29
125.24
125.19
123.53
123.48
123.44
123.39
123.31
123.26
123.21
123.16
122.60
122.56
77.59
77.16
76.74
56.76
56.56
44.55
43.61
42.46
36.31
33.80
33.56
33.37
32.53
29.83
29.30
28.64
27.78
24.95
24.44
24.16
O
CF_3
*i*Pr
57
f1 (ppm)


RD-2-196-1-19F.1.fid
RD-2-196-1-19F
-60.96
-60.99
CF3
O
57
iPr
f1 (ppm)

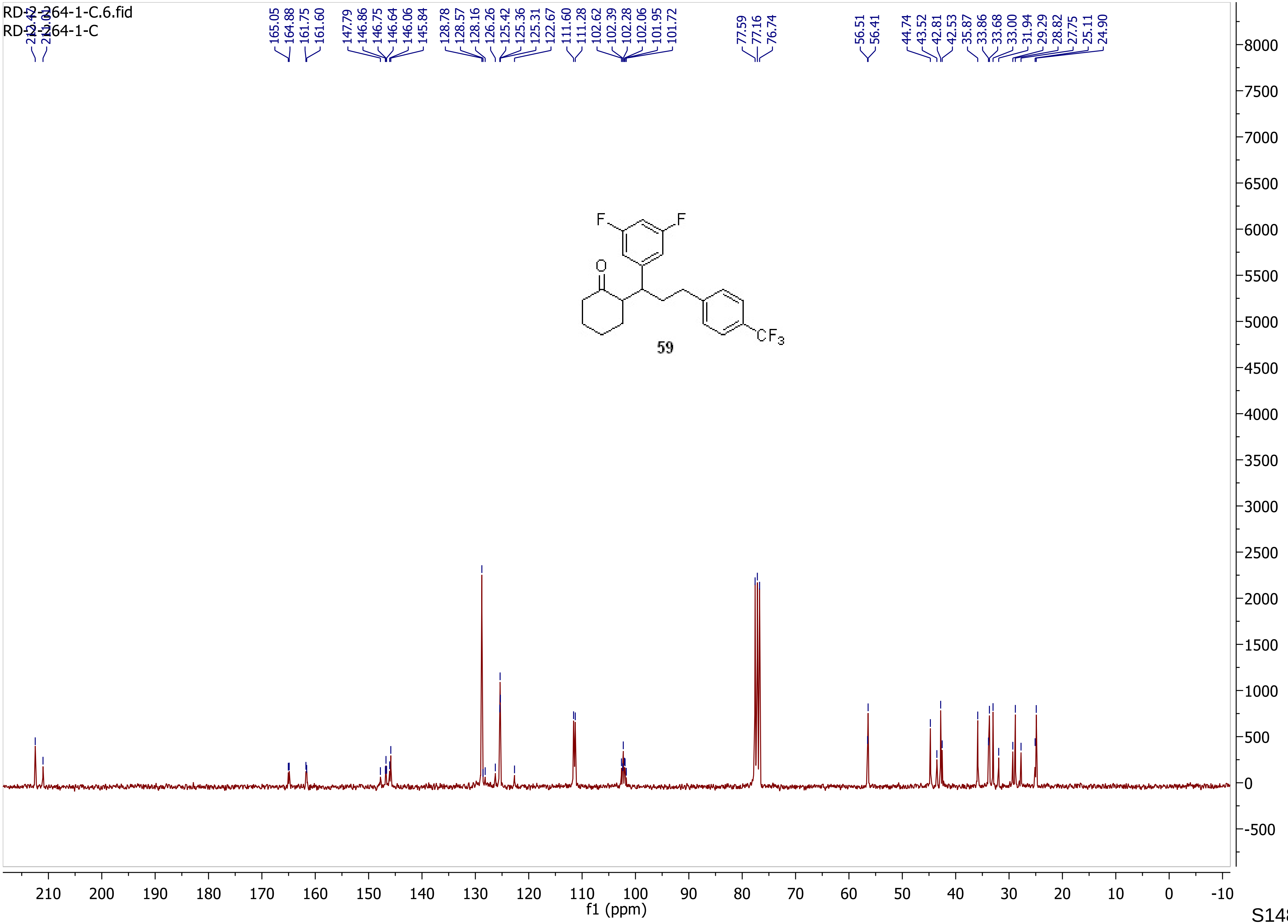

PB-7-225-1-1H
7.10
7.07
6.81
6.79
6.76
6.73
6.70
6.69
6.67
6.64
3.27
3.25
3.23
3.05
2.55
2.52
2.51
2.49
2.47
2.45
2.43
2.40
2.38
2.36
2.34
2.33
2.30
2.12
2.11
2.10
2.08
2.07
2.06
2.05
2.04
2.03
2.02
2.01
2.00
1.98
1.95
1.94
1.92
1.89
1.88
1.87
1.85
1.84
1.82
1.80
1.79
1.78
1.76
1.74
1.72
1.71
1.70
1.68
1.67
1.66
1.65
1.63
1.63
1.59
1.56
1.55
1.53
1.27
1.20
1.19
1.16
F
F
O
58
3.01
2.00
3.01
0.50
0.50
4.05
9.01
f1 (ppm)

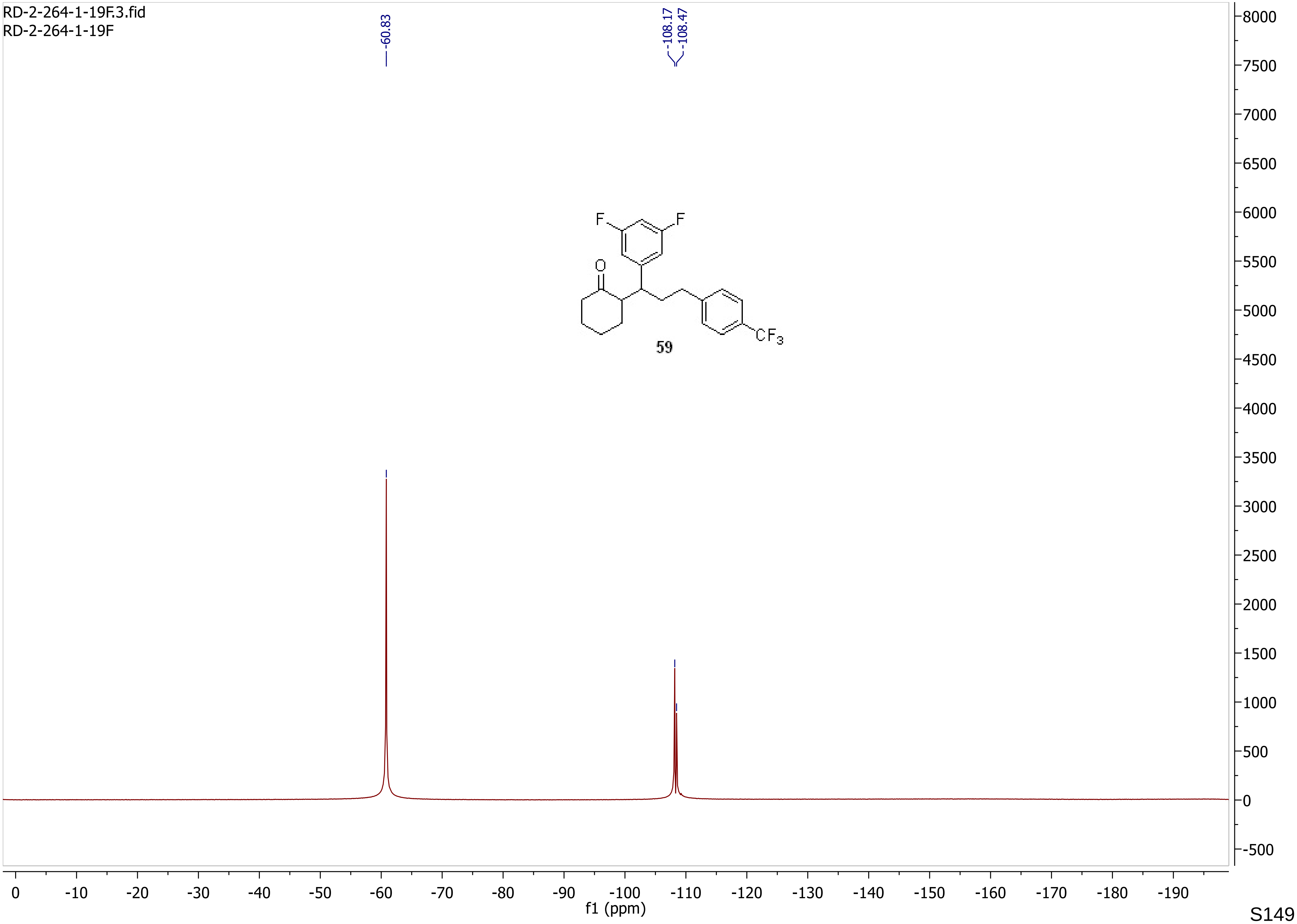

PB-7-225-1-13C.17.fid
PB-7-225-1-13C
164.96
164.85
164.79
164.68
161.67
161.57
161.49
161.40
148.29
148.18
148.07
147.12
147.02
146.90
141.97
141.71
128.44
126.00
111.66
111.55
111.45
111.34
111.23
102.44
102.21
102.10
101.87
101.76
101.53
77.59
77.16
76.74
56.57
56.48
44.61
43.61
42.52
36.21
33.94
33.78
32.65
32.53
29.46
28.71
27.80
25.02
24.60
F
F
O
58
f1 (ppm)

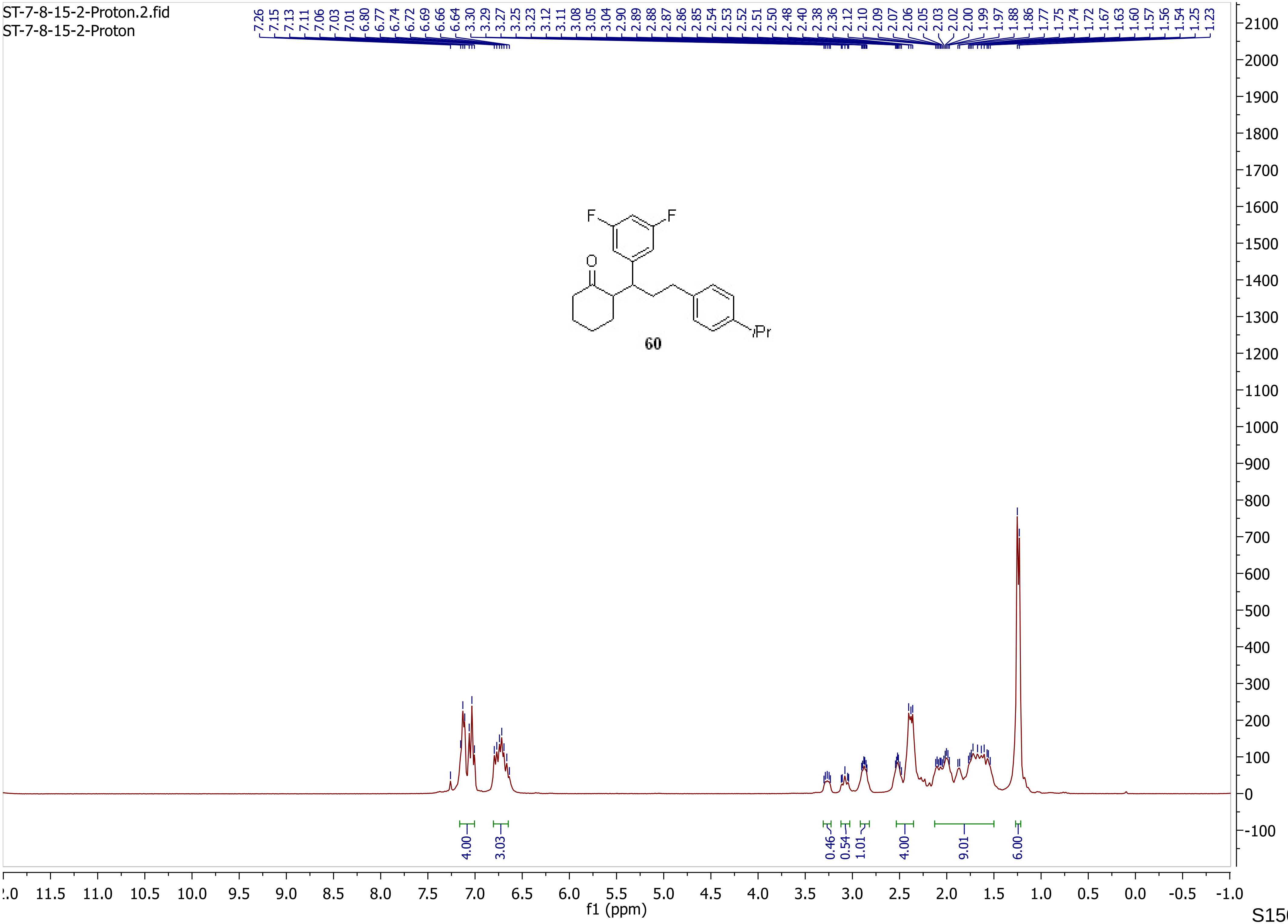

PB-7-225-1-19F.17.fid
PB-7-225-1-19F
-108.482
-108.764
F
F
O
58
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
-100
-200
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
f1 (ppm)

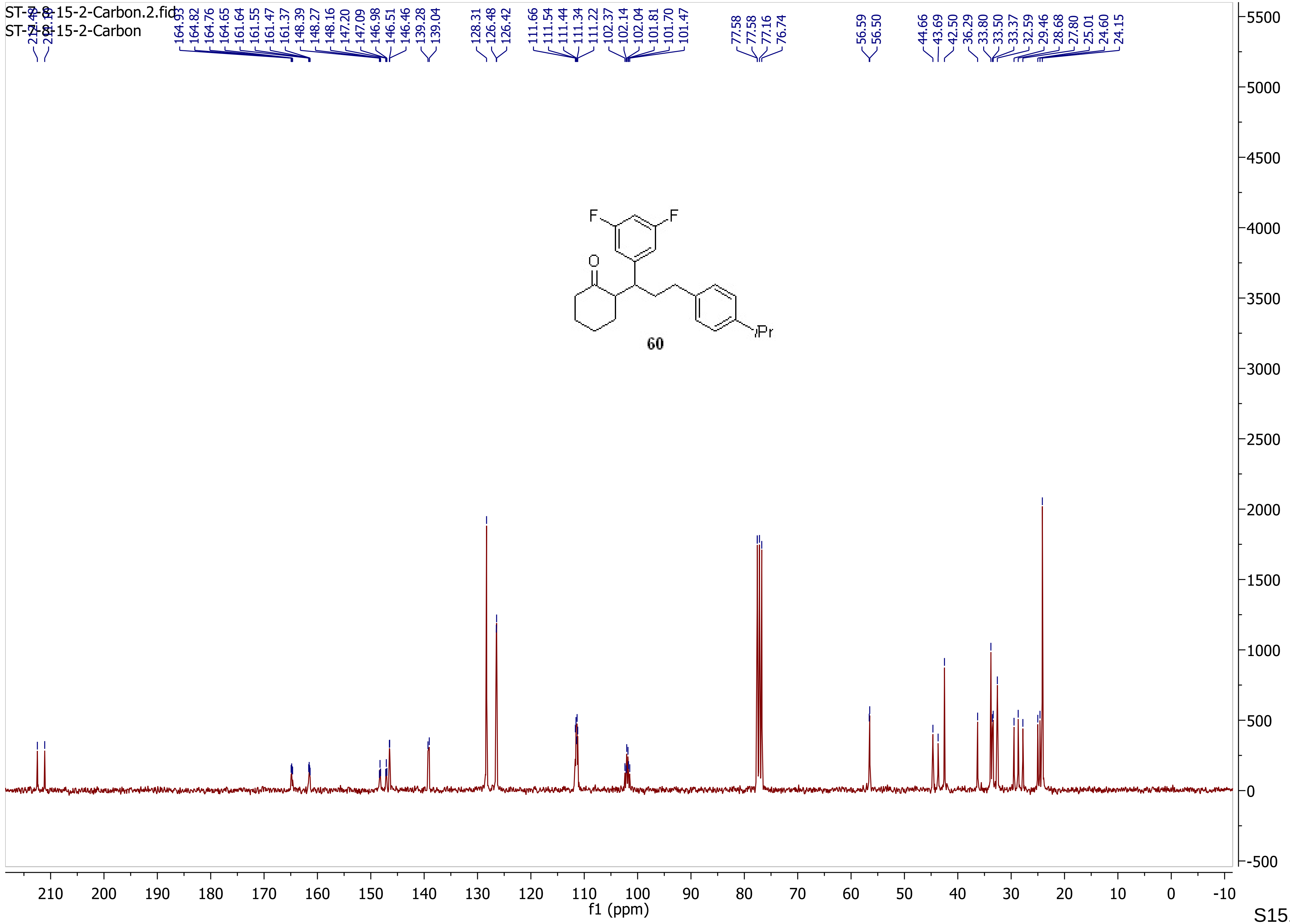


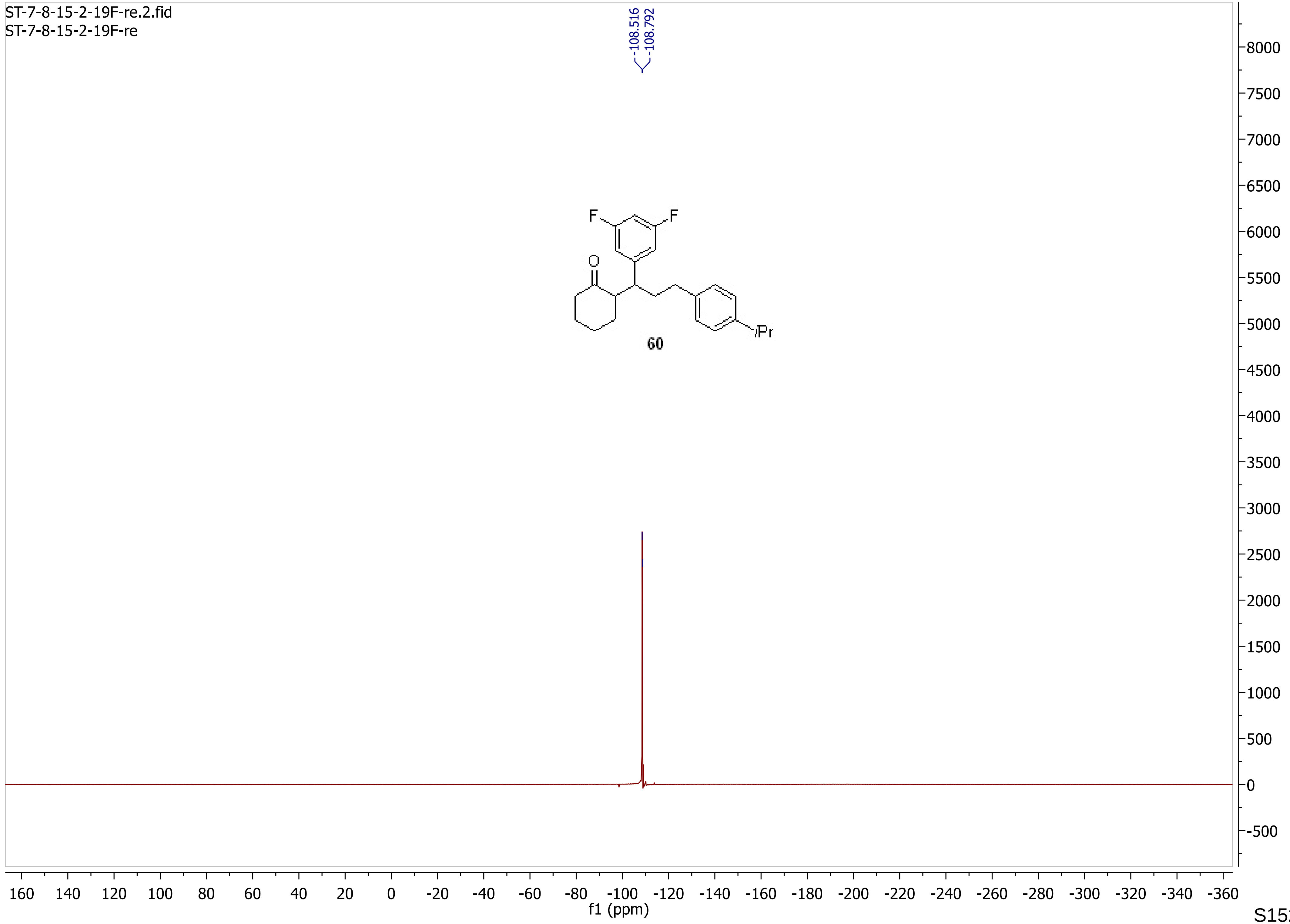
RD-2-264-1-tt28.1.fid
RD-2-264-1-tt28
6.76 6.75 6.74 6.74 6.73 6.72 6.71 6.70 6.70 6.68 6.67 3.00 2.52 2.51 2.50 2.48 2.46 2.43 2.40 2.39 2.38 2.37 2.37 2.36 2.35 2.34 2.34 2.16 2.13 2.12 2.10 2.06 2.05 2.04 2.04 2.03 2.02 2.01 2.00 1.99 1.98 1.90 1.89 1.87 1.86 1.76 1.75 1.75 1.73 1.72 1.72 1.70 1.70 1.69 1.68 1.68 1.66 1.65 1.64 1.63 1.63 1.62 1.61 1.61 1.60 1.59 1.58 1.57 1.55 1.53 1.52
F
F
O
CF3
59
2.00
2.00
3.01
0.40
0.61
4.00
9.00
f1 (ppm)

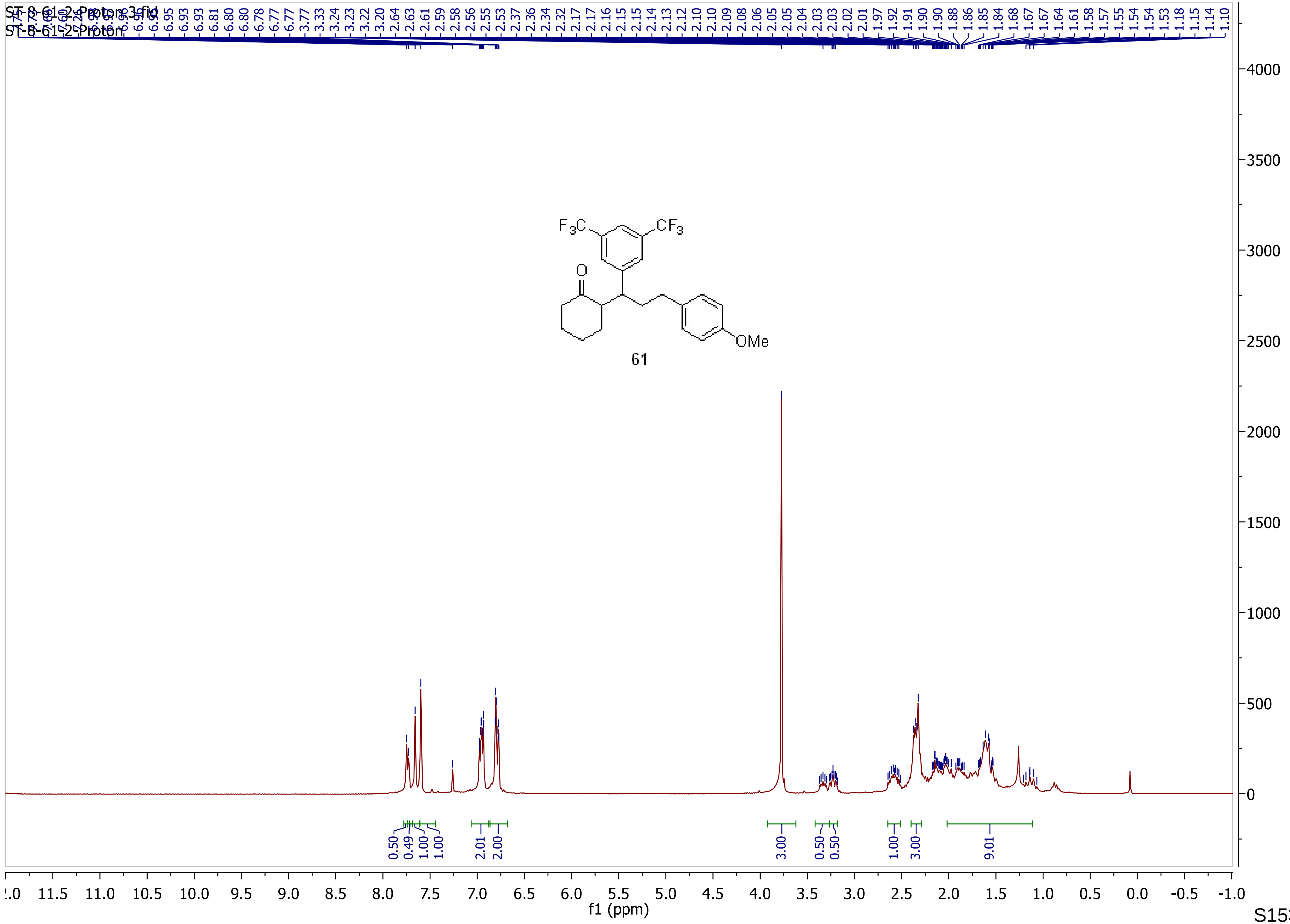

RD-2-264-1-C.6.fid
RD-2-264-1-C
165.05
164.88
161.75
161.60
147.79
146.86
146.75
146.64
146.06
145.84
128.78
128.57
128.16
126.26
125.42
125.36
125.31
122.67
111.60
111.28
102.62
102.39
102.28
102.06
101.95
101.72
77.59
77.16
76.74
56.51
56.41
44.74
43.52
42.81
42.53
35.87
33.86
33.68
33.00
31.94
29.29
28.82
27.75
25.11
24.90
F
F
O
CF_3
59
f1 (ppm)

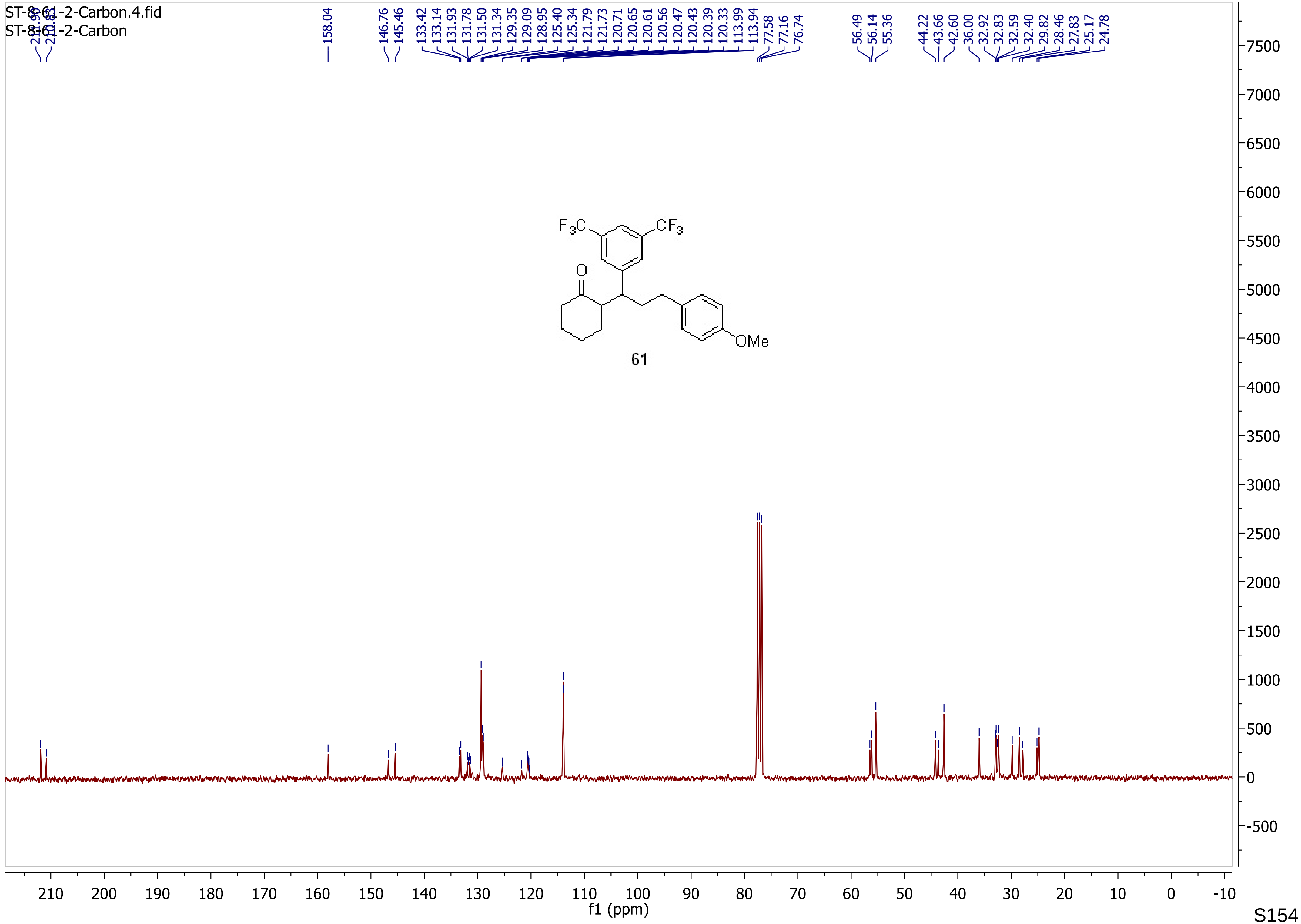

RD-2-264-1-19F.3.fid
RD-2-264-1-19F
-60.83
-108.17
-108.47
F
F
O
CF3
59
8000
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-500
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
f1 (ppm)

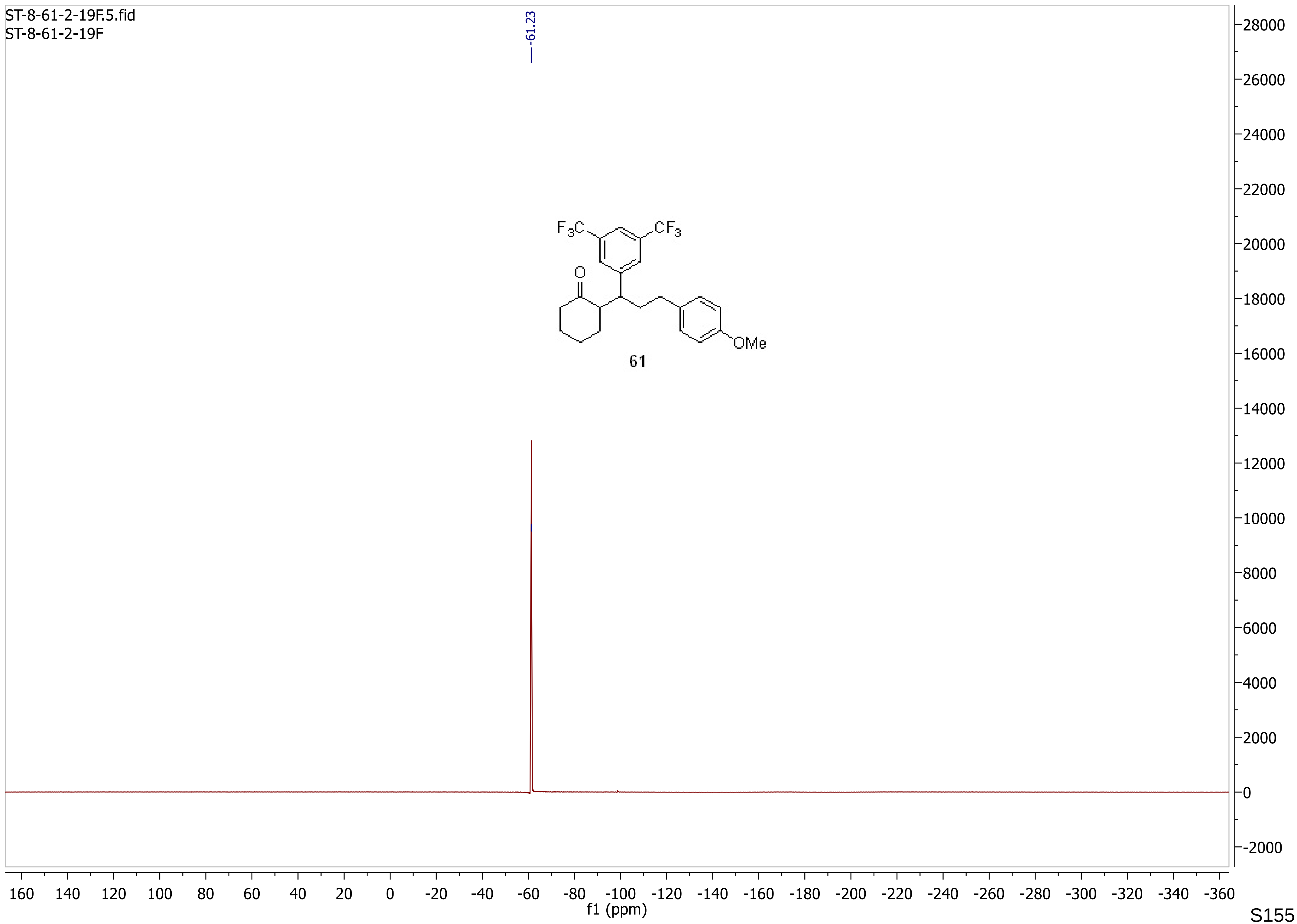

ST-7-8-15-2-Proton.2.fid
ST-7-8-15-2-Proton
7.26 7.15 7.13 7.11 7.06 7.03 7.01 6.80 6.77 6.74 6.72 6.69 6.66 6.64 3.30 3.29 3.27 3.25 3.23 3.12 3.11 3.08 3.05 3.04 2.90 2.89 2.88 2.87 2.86 2.85 2.54 2.53 2.52 2.51 2.50 2.48 2.40 2.38 2.36 2.12 2.10 2.09 2.07 2.06 2.05 2.03 2.02 2.00 1.99 1.97 1.88 1.86 1.77 1.75 1.74 1.72 1.67 1.63 1.60 1.57 1.56 1.54 1.25 1.23
F
F
O
iPr
60
4.00
3.03
0.46
0.54
1.01
4.00
9.01
6.00
f1 (ppm)


ST-7-8-15-2-Carbon.2.fid
ST-7-8-15-2-Carbon
164.93
164.82
164.76
164.65
161.64
161.55
161.47
161.37
148.39
148.27
148.16
147.20
147.09
146.98
146.51
146.46
139.28
139.04
128.31
126.48
126.42
111.66
111.54
111.44
111.34
111.22
102.37
102.14
102.04
101.81
101.70
101.47
77.58
77.58
77.16
76.74
56.59
56.50
44.66
43.69
42.50
36.29
33.80
33.50
33.37
32.59
29.46
28.68
27.80
25.01
24.60
24.15
F
F
O
iPr
60
f1 (ppm)

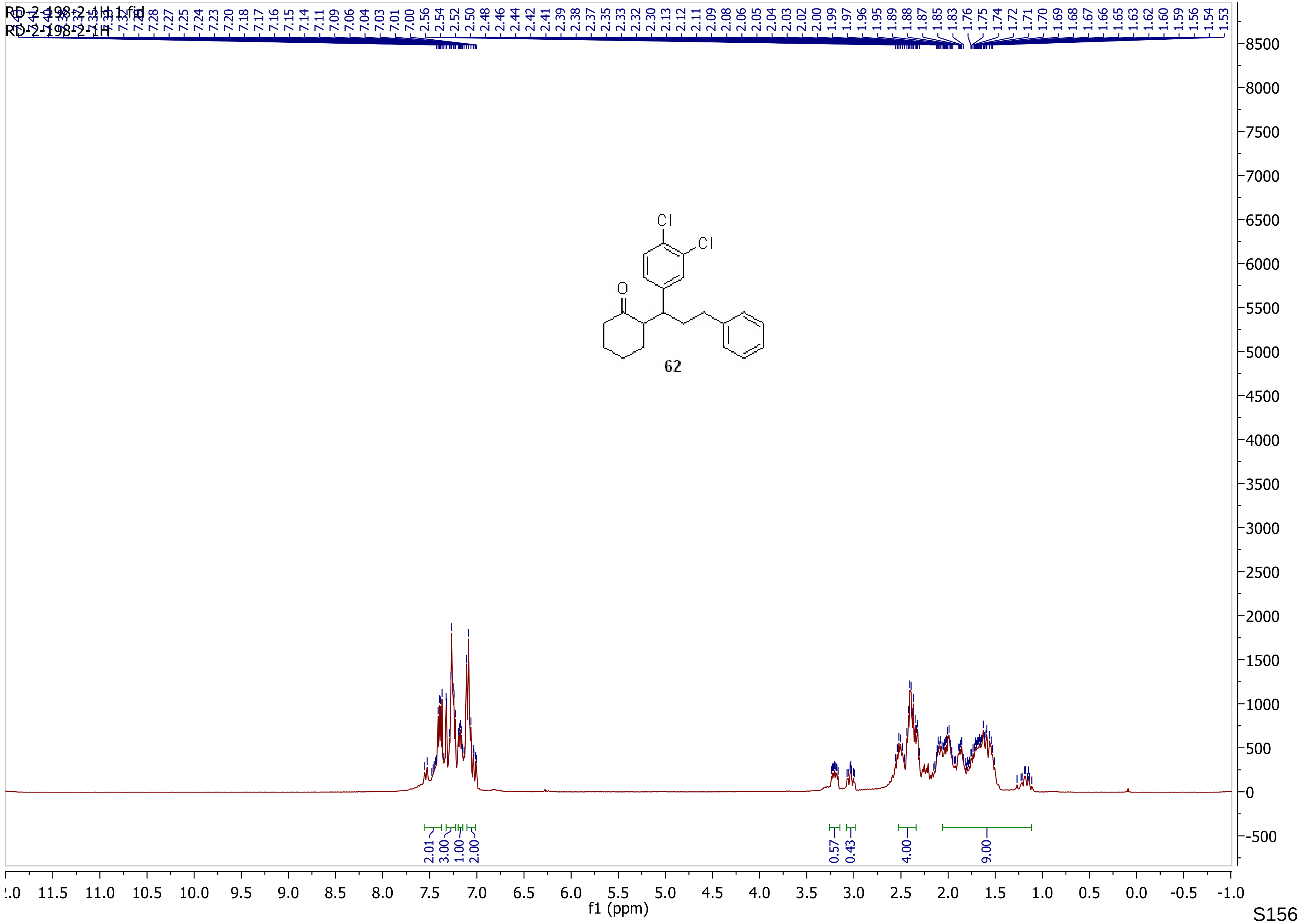

ST-7-8-15-2-19F-re.2.fid
ST-7-8-15-2-19F-re
-108.516
-108.792
F
F
O
iPr
60
f1 (ppm)


ST-8-61-2-Proton.3.fid
ST-8-61-2-Proton
F3C
CF3
O
OMe
61
0.50
0.49
1.00
1.00
2.01
2.00
3.00
0.50
0.50
1.00
3.00
9.01
f1 (ppm)

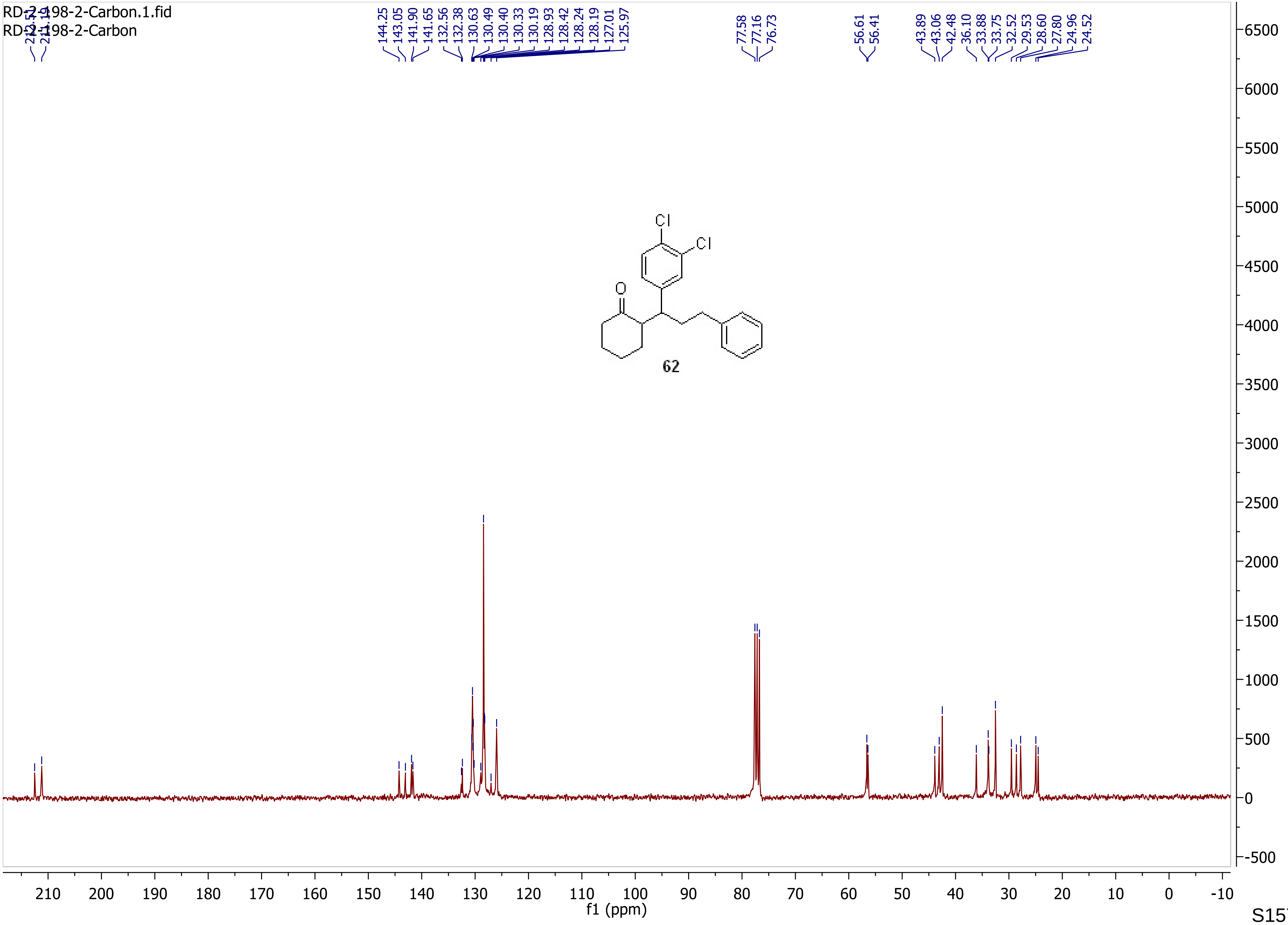

ST-8-61-2-Carbon.4.fid
ST-8-61-2-Carbon
211.90
210.83
158.04
146.76
145.46
133.42
133.14
131.93
131.78
131.50
131.34
129.35
129.09
128.95
125.40
125.34
121.79
121.73
120.71
120.65
120.61
120.56
120.47
120.43
120.39
120.33
113.99
113.94
77.58
77.16
76.74
56.49
56.14
55.36
44.22
43.66
42.60
36.00
32.92
32.83
32.59
32.40
29.82
28.46
27.83
25.17
24.78
F_3C
CF_3
O
OMe
61
f1 (ppm)

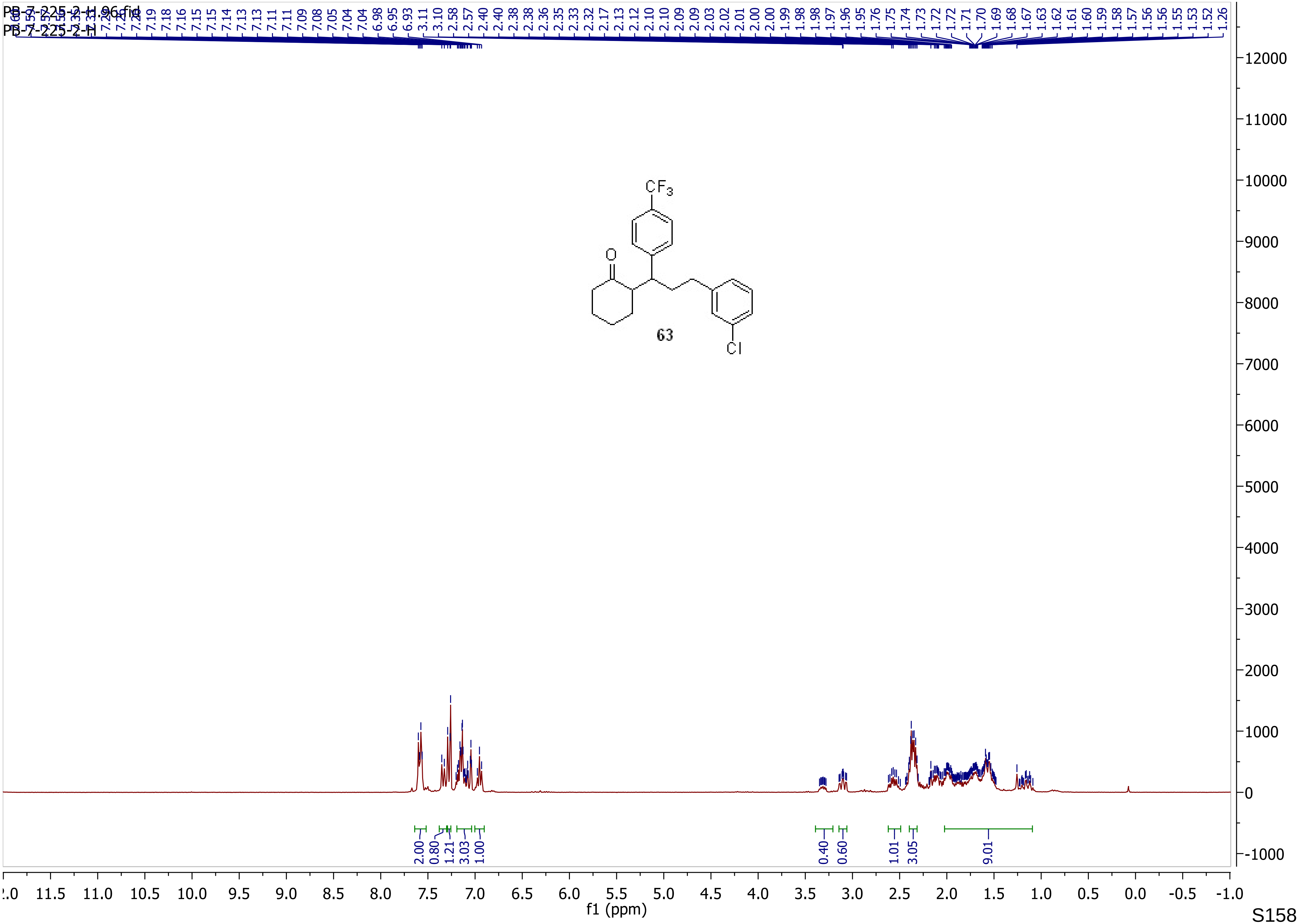


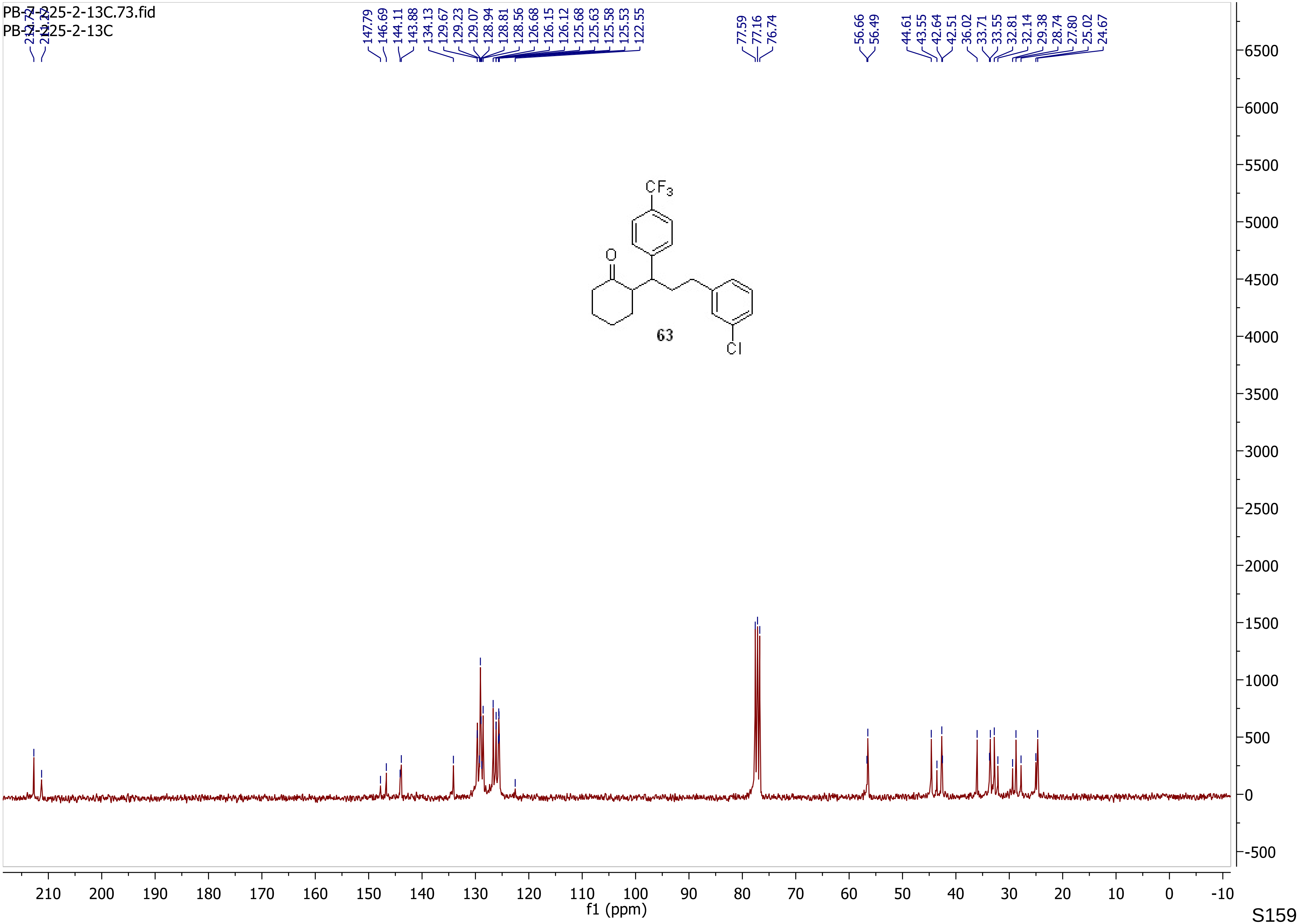
61

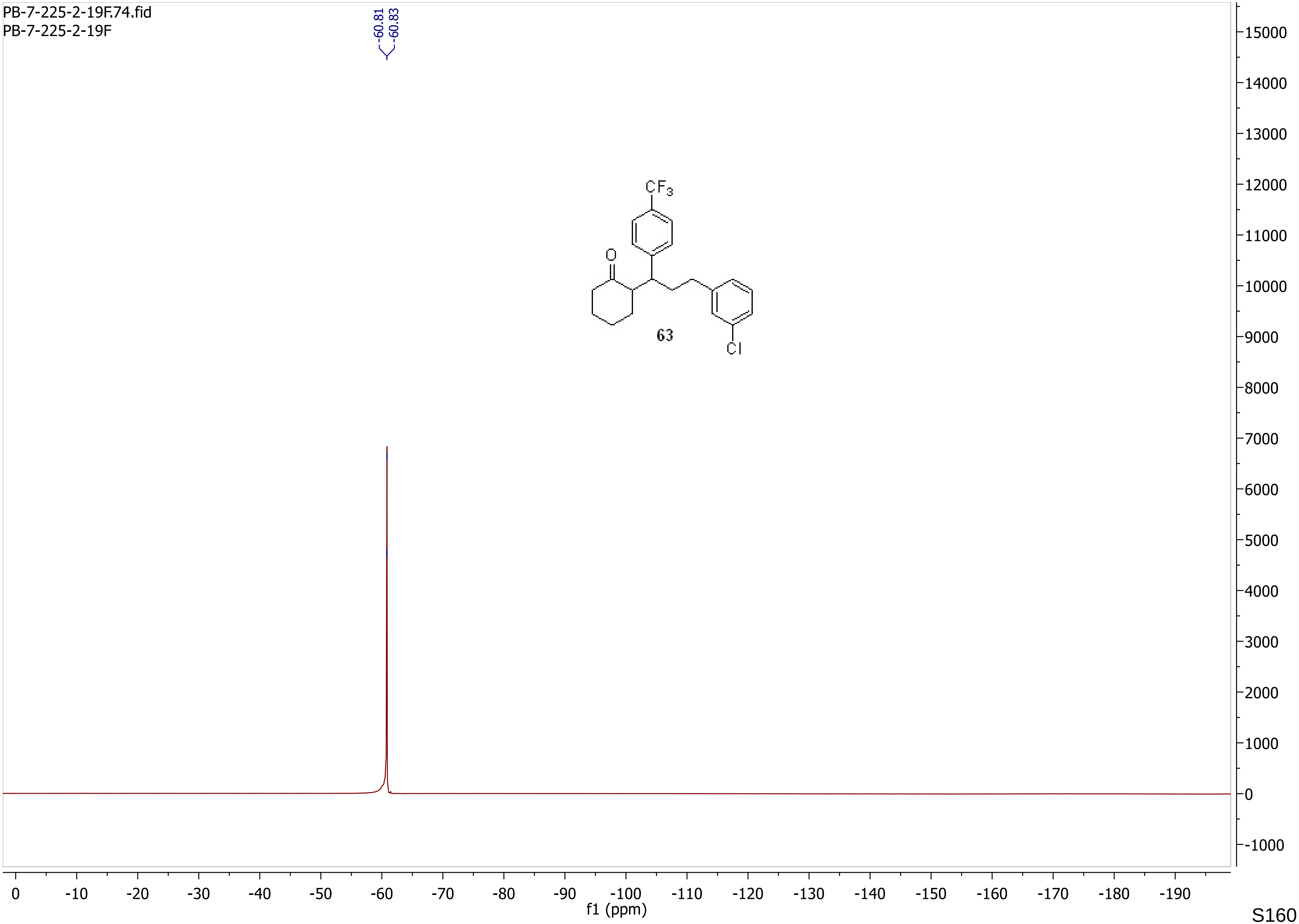


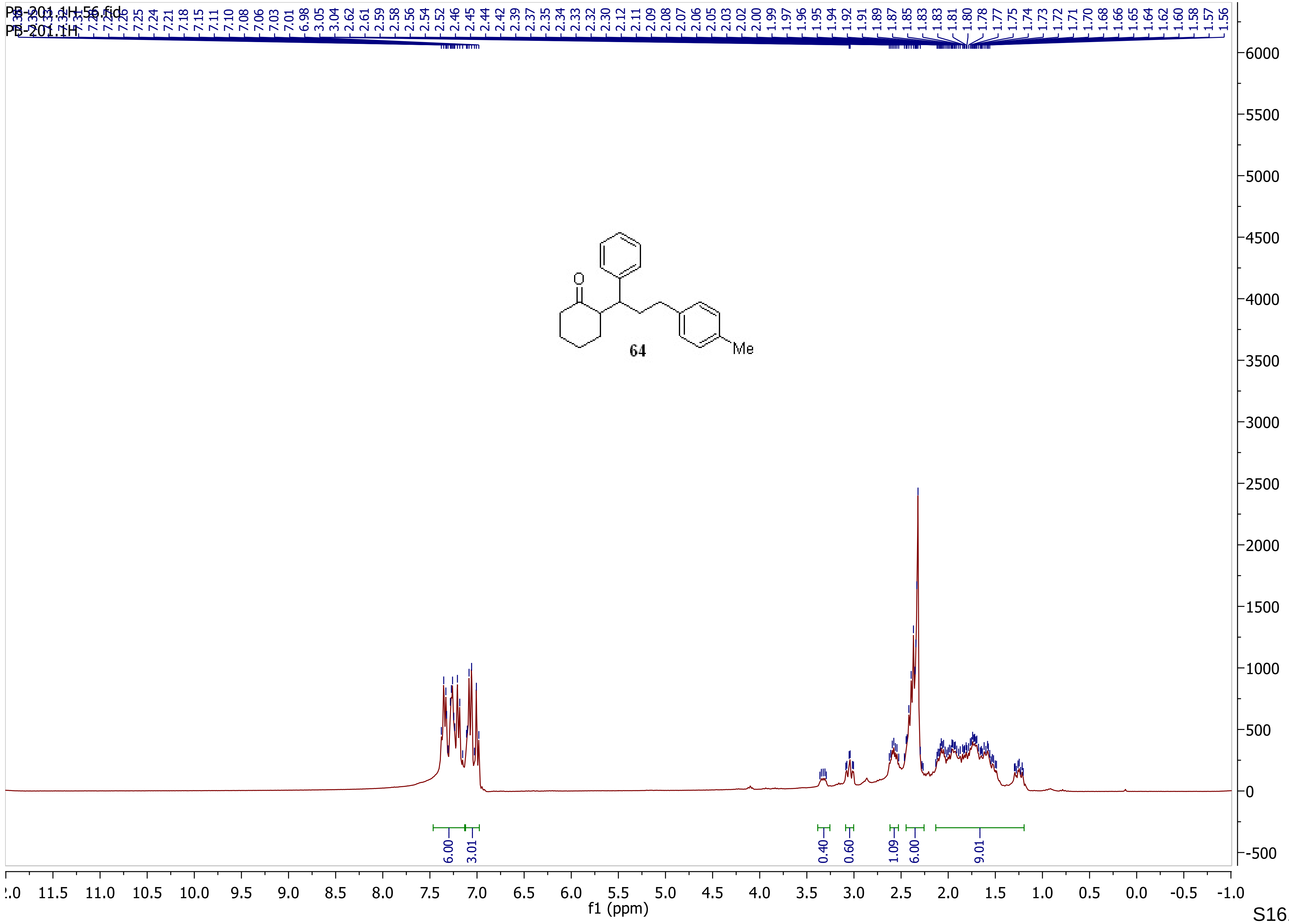
RD-2-198-2-1H.1.fid
RD-2-198-2-1H
62
f1 (ppm)

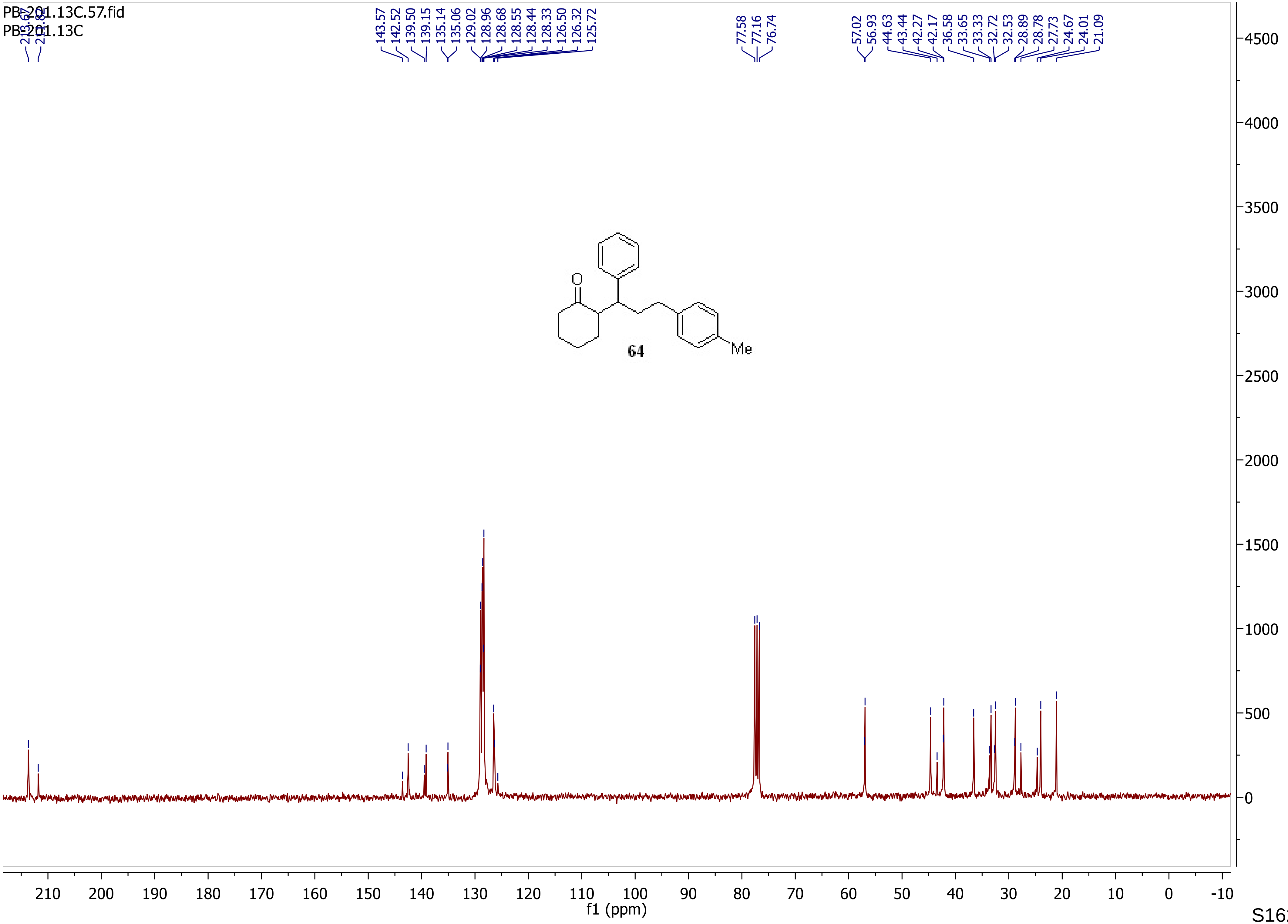

RD-2-198-2-Carbon.1.fid
RD-2-198-2-Carbon
144.25
143.05
141.90
141.65
132.56
132.38
130.63
130.49
130.40
130.33
130.19
128.93
128.42
128.24
128.19
127.01
125.97
77.58
77.16
76.73
56.61
56.41
43.89
43.06
42.48
36.10
33.88
33.75
32.52
29.53
28.60
27.80
24.96
24.52
Cl
Cl
O
62
f1 (ppm)


PB-7-225-2-H.96.fid
PB-7-225-2-H
CF3
O
Cl
63
f1 (ppm)
2.00
0.80
1.21
3.03
1.00
0.40
0.60
1.01
3.05
9.01


PB-7-225-2-13C.73.fid
PB-7-225-2-13C
147.79
146.69
144.11
143.88
134.13
129.67
129.23
129.07
128.94
128.81
128.56
126.68
126.15
126.12
125.68
125.63
125.58
125.53
122.55
77.59
77.16
76.74
56.66
56.49
44.61
43.55
42.64
42.51
36.02
33.71
33.55
32.81
32.14
29.38
28.74
27.80
25.02
24.67
CF3
O
63
Cl
f1 (ppm)


PB-7-225-2-19F.74.fid
PB-7-225-2-19F
-60.81
-60.83
CF_3
O
63
Cl
f1 (ppm)
0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190
15000 14000 13000 12000 11000 10000 9000 8000 7000 6000 5000 4000 3000 2000 1000 0 -1000


PB-201.1H-56.fid
PB-201.1H
64
Me
f1 (ppm)


PB-201.13C.57.fid
PB-201.13C
143.57
142.52
139.50
139.15
135.14
135.06
129.02
128.96
128.68
128.55
128.44
128.33
126.50
126.32
125.72
77.58
77.16
76.74
57.02
56.93
44.63
43.44
42.27
42.17
36.58
33.65
33.33
32.72
32.53
28.89
28.78
27.73
24.67
24.01
21.09
O
Me
64
f1 (ppm)