Electroreductive Carboxylation of Benzylphosphine Salts with CO_2 through the Cleavage of the C(sp^3)-P Bond

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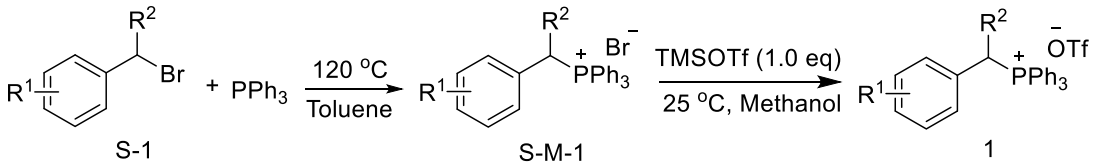
Supporting Information

1. General Information

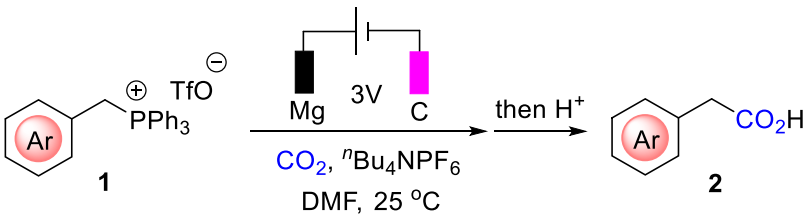
All the electrochemical reactions were performed in an oven-dried undivided electrochemical cell unless otherwise noted. The amount of electricity consumed per mole of reactant is measured by an ampere hour meter. THF was distilled from sodium/benzophenone. Anhydrous DMF, DMA, NMP and DMSO were purchased from Adamas-beta and used without further purification. All commercial reagents were purchased from Acros Organics, Sigma-Aldrich, Alfa Aesar, Adamas-beta, Bidepharm, and Energy Chemical of the highest purity grade. ^{1}H NMR and ^{13}C NMR spectra were recorded respectively at 400 MHz and 100 MHz on a Bruker AVANCE 400 and chemical shifts are reported in δ (ppm) referenced to residual undeuterated solvent signal for ^{1}H NMR (7.26 ppm for $CDCl_3$ or 2.54 ppm for DMSO-d_6), ^{13}C NMR (77.16 ppm for $CDCl_3$ or 40.45 ppm for DMSO-d_6). HRMS was conducted on a Thermo Scientific LTQ Orbitrap XL apparatus using an electrospray (ESI) or MALDI ionization source. The following abbreviations were used to designate chemical shift multiplicities: s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet. All the electrochemical reactions were performed with an HY3005B DC (30 V) power supply purchased from Zhejiang Huayi Electronic Industry Co., Ltd. Carbon rod and graphite felt (GF) was purchased from Beijing Jinglong special carbon technology Co., Ltd. Platinum electrode, Al electrode, and Zn electrode are all purchased from Shanghai yueci Electronic Technology Co., Ltd. Magnesium plate (The purity is 99.95%) was purchased from Xintong Weiye Metal Material Sales Co., Ltd.

2. General procedure for the synthesis of 1.



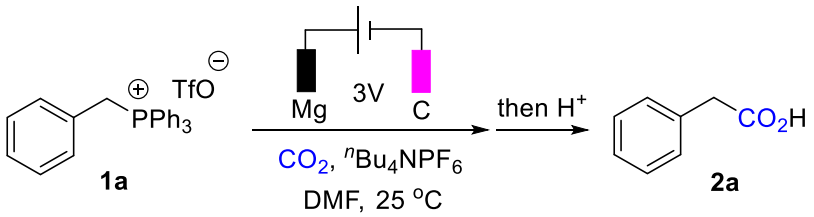
To a solution of substituted benzyl bromide **S-1** (3.4 g, 20.0 mmol) in toluene (20 mL) was added triphenylphosphine (5.2 g, 20.0 mmol). The solution was refluxed for 16 h to form a White suspension. After filtration at room temperature, the White powder was washed with cyclohexane and dried under vaccuo to give the pure phosphonium bromide salt **S-M-1**[1]. To a solution of phosphonium bromide salt **S-M-1** (2.2 g, 5.0 mmol) in methanol (10 mL) was added trimethylsilyl trifluoromethanesulfonate (TMSOTf, 0.9 mL, 5.0 mmol). The solution was stirred for 4 hours, and concentrated under reduced pressure. Dissolve the crude product in a small amount of acetone and add ether for recrystallization to give the corresponding phosphinium trifluoromethanesulfonate salt **1**.

3. General procedure for the synthesis of aryl acetic acids 2.



The electrolysis was conducted in an undivided cell equipped with a Mg anode (15 mm x 10 mm x 2 mm) and a C cathode (φ = 6 mm) with a distance of about 1.0 cm between the two electrodes, and the depth of each electrode immersed in the reaction mixture is about 10 mm. To a 15 mL oven-dried undivided electrochemical cell were added benzyl triphenyl phosphonium salt **1** (0.2 mmol), $^{n}Bu_4NPF_6$ (193.7 mg, 0.5 mmol) and followed by the addition of solvent DMF (5 mL, 0.1 M) in the glove box. Then, seal the tube and remove it from the glove box. After bubbling CO_2 gas into the mixture for 10 min, the electrolysis was carried out with constant voltage electrolysis (cell voltage = 5 V) at 25 °C for 7 h under a CO_2 balloon. The resulting mixture is transferred to a separator funnel for preparing the reaction solution at the beginning. The cell was washed with ethyl acetate (2 mL x 2) twice. The combined organic solution was acidified (pH < 2) by the addition of 1 M HCl and extracted with ethyl acetate (5 x 3 mL). The combined organic layers were washed with water, brine, dried over anhydrous Na_2SO_4, filtered, and concentrated in vacuo. The residue was purified by flash chromatography (PE/EA) to afford aryl acetic acids **2**.

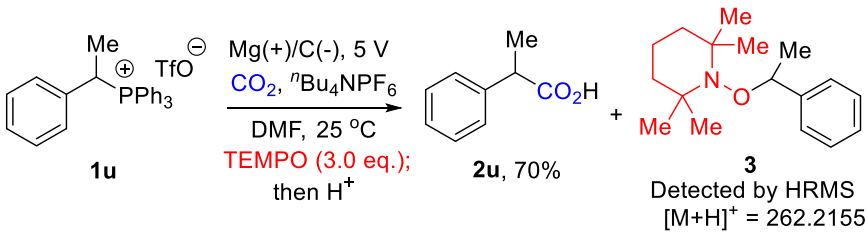
4. Experiment details for gram-scale synthesis of product



The electrolysis was conducted in an undivided cell equipped with a Mg anode (50 mm x 30 mm x 2 mm) and a C cathode (φ = 6 mm) with a distance of about 5.0 cm between the two electrodes, and the depth of each electrode immersed in the reaction mixture is about 20 mm. To a 250 mL oven-dried undivided electrochemical cell were added benzyltriphenylphosphonium trifluoromethanesulfonate **1a** (2.1 g, 4.0 mmol), $^{n}Bu_4NPF_6$ (3.9 g, 10.0 mmol) and followed by the addition of solvent DMF (100 mL, 0.1 M) in the glove box. Then, seal the tube and remove it from the glove box. After bubbling CO_2 gas into the mixture for 10 min, the electrolysis was carried out with constant voltage electrolysis (cell voltage = 5 V) at 25 °C for 7 h under a CO_2 balloon. The resulting mixture is transferred to a separator funnel for preparing the reaction solution at the beginning. The cell was washed with ethyl acetate (5 mL x 2) twice. The combined organic solution was acidified (pH < 2) by addition of 1 M HCl and extracted with ethyl acetate (30 x 3 mL). The combined organic layers were washed with water, brine, dried over anhydrous Na_2SO_4, filtered and concentrated in vacuo. The residue was purified by flash chromatography (PE/EA) to afford aryl acetic acids **2a**.

5. Procedure of controlled experiments.

5.1 Radical trapping experiment with TEMPO.



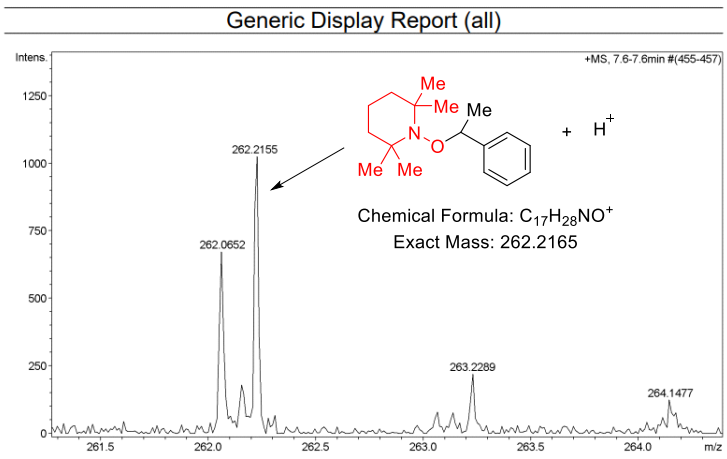
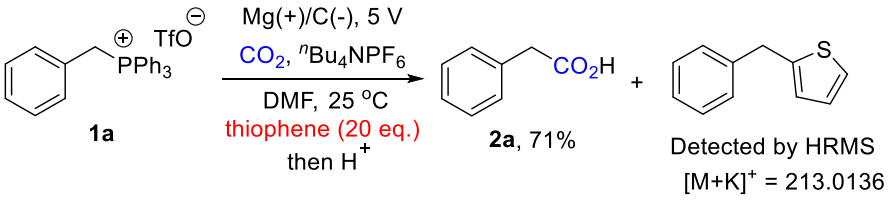
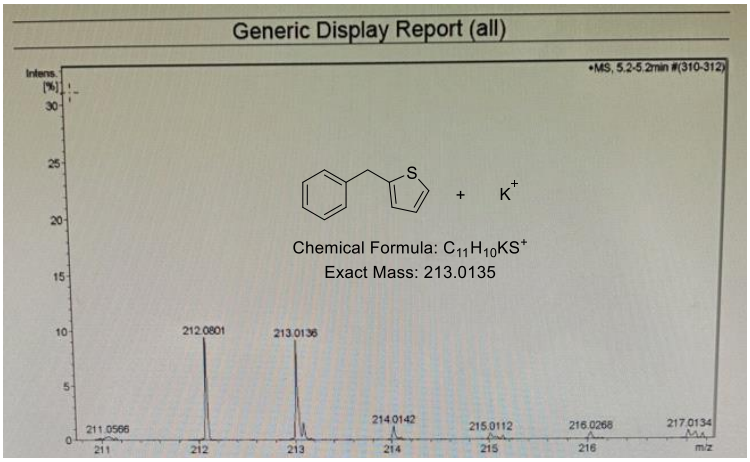


Figure S1 The HRMS spectra of compound **3**.

The electrolysis was conducted in an undivided cell equipped with a Mg anode (15 mm x 10 mm x 2 mm) and a C cathode (φ = 6 mm) with a distance of about 1.0 cm between the two electrodes, and the depth of each electrode immersed in the reaction mixture is about 10 mm. To a 15 mL oven-dried undivided electrochemical cell were added triphenyl(1-phenylethyl)phosphonium trifluoromethanesulfonate **1u** (0.2 mmol), $^{n}Bu_4NPF_6$ (193.7 mg, 0.5 mmol), TEMPO (3.0 equiv.), and followed by the addition of solvent DMF (5 mL, 0.1 M) in the glove box. Then, seal the tube and remove it from the glove box. After bubbling CO_2 ga s into the mixture for 10 min, the electrolysis was carried out with constant voltage electrolysis (cell voltage = 5V) at 25 °C for 7 h under a CO_2 balloon. The resulting mixture is transferred to a separator funnel for preparing the reaction solution at the beginning. The cell was washed with ethyl acetate (2 mL x 2) twice. The combined organic solution was acidified (pH < 2) by addition of 1 M HCl and extracted with ethyl acetate (5 x 3 mL). The combined organic layers were washed with water, brine, dried over anhydrous Na_2SO_4, filtered and concentrated in vacuo to achieve the crude residue. The crude yield was 70% which was determined by ^{1}H NMR analysis using 1,3,5-trimethoxybenzene as internal standard. Also, the crude residue was tested with HRMS. The adduct of TEMPO with benzyl radical was detected by HRMS (ESI): HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{17}H_{28}NO^+$ 262.2165; Found = 262.2155.

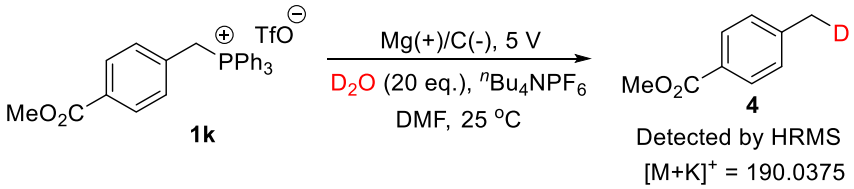
5.2 Radical trapping experiment with thiophene.





The radical trapping experimental procedure with thiophene (4.0 mmol, 20 eq.) as the radical scavenger was the same as **procedure 5.1**. The crude yield was 71%.

5.3 Deuteration experiment.



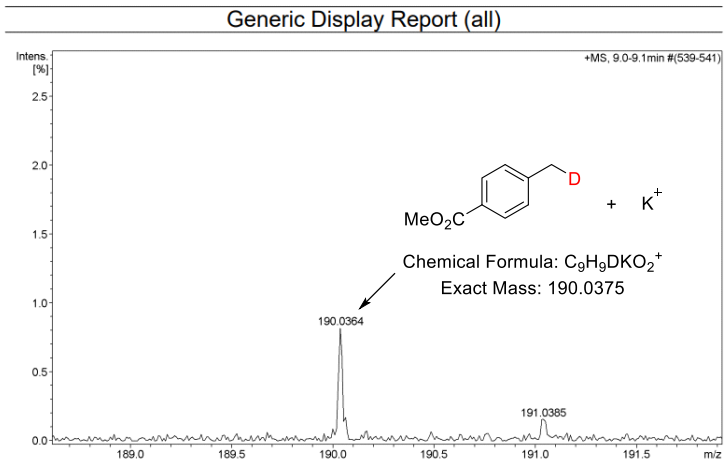


Figure S2 The HRMS spectra of compound **4**.

The electrolysis was conducted in an undivided cell equipped with a Mg anode (15 mm x 10 mm x 2 mm) and a C cathode (φ = 6 mm) with a distance of about 1.0 cm between the two electrodes, and the depth of each electrode immersed in the reaction mixture is about 10 mm. To a 15 mL oven-dried undivided electrochemical cell were added (4-(methoxycarbonyl)benzyl)triphenylphosphonium trifluoromethanesulfonate

1k (0.2 mmol), $^{n}Bu_4NPF_6$ (193.7 mg, 0.5 mmol), D_2O (4.0 mmol, 20.0 eq.), and followed by the addition of solvent DMF (5 mL, 0.1 M) in the glove box. Then, seal the tube and remove it from the glove box. The electrolysis was carried out with constant voltage electrolysis (cell voltage = 5 V) at 25 ºC for 7 h under argon atmosphere. Then, the resulting mixture is transferred to a separator funnel for preparing the reaction solution at the beginning. The cell was washed with ethyl acetate (2 mL x 2) twice. The combined organic solution was extracted with ethyl acetate (5 x 3 mL). The combined organic layers were washed with water, brine, dried over anhydrous Na_2SO_4, filtered and concentrated in vacuo to achieve the crude residue. The crude residue was tested with HRMS. The deuterated product was detected by HRMS (ESI): HRMS (ESI) m/z: $[M+K]^+$ Calcd for $C_9H_9DKO_2$ 190.0375; Found 190.0364.

6. Cyclic voltammetry experiments.

Electrochemical studies were carried out with a CHI600D electrochemical workstation. All cyclic voltammograms were measured at 25 ºC using an Ag/Ag^+ reference electrode, a platinum (Pt) wire counter electrode and a glassy carbon working electrode (3mm-diameter, disc-electrode). The measurements were carried out at a scan rate of 100 mV s^{-1} in DMF/ $^{n}Bu_4NPF_6$ (0.1 M). All data are measured in Ar atmosphere.

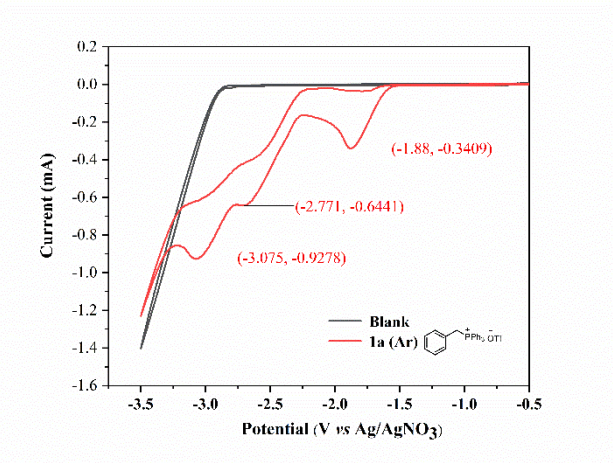


Figure S3. Cyclic voltammetry of Blank: (none); **1a** (40 mM);

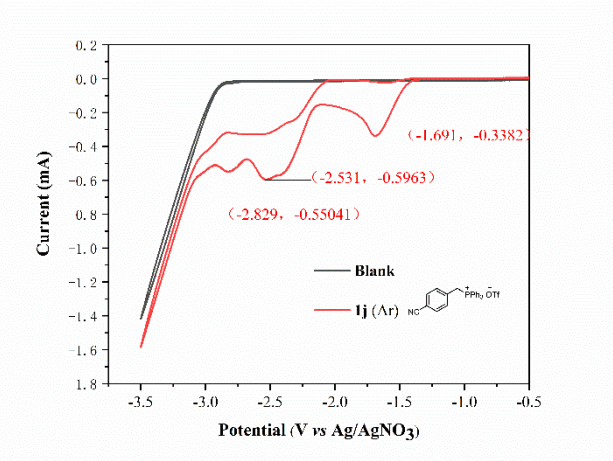


Figure S4. Cyclic voltammetry of Blank: (none); **1j** (40 mM);

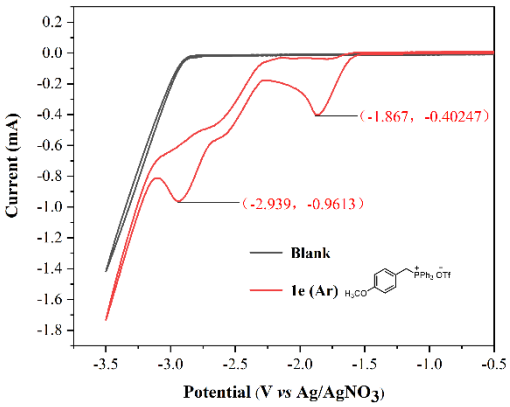


Figure S5. Cyclic voltammetry of Blank: (none); **1e** (40 mM);

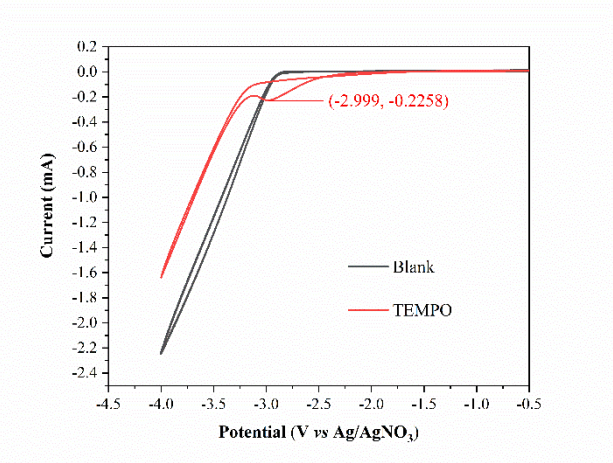
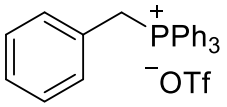


Figure S6. Cyclic voltammetry of Blank: (none); Tempo (20 mM);

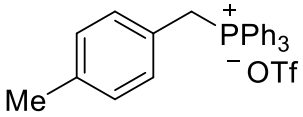
7. Characterization data for compounds 1 and 2.

benzyltriphenylphosphonium trifluoromethanesulfonate (1a).



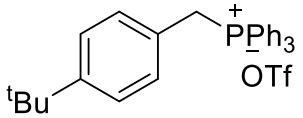
White powder. ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.92 – 7.89 (m, 3H), 7.77 – 7.72 (m, 6H), 7.69 – 7.64 (m, 6H), 7.32 – 7.28 (m, 1H), 7.25 – 7.21(m, 2H), 6.98 – 6.96 (m, 2H), 5.14 (d, J = 15.6 Hz, 2H) ppm. ^{13}C NMR (100 MHz, DMSO-d_6) δ 135.1 (d, J = 2.8 Hz), 134.0 (d, J = 9.9 Hz), 130.8 (d, J = 5.7 Hz), 130.1 (d, J = 12.3 Hz), 128.8 (d, J = 2.9 Hz), 128.3 (d, J = 3.6 Hz), 127.8 (d, J = 8.6 Hz), 120.7 (q, J = 320.6 Hz) 117.8 (d, J = 85 Hz), 28.2 (d, J = 46.6 Hz) ppm. ^{31}P NMR (162 MHz, DMSO-d_6) δ 23.1 ppm. ^{19}F NMR (376 MHz, DMSO-d_6) δ -77.7 ppm. HRMS (ESI) m/z: $[M\text{-}OTf]^+$ Calcd for $C_{25}H_{22}P$ 353.1454; Found 353.1450.

methylbenzyl)triphenylphosphonium trifluoromethanesulfonate (1b).



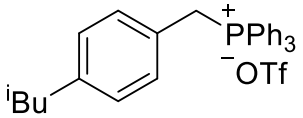
^{1}H NMR (400 MHz, DMSO-d_6) δ 7.92 – 7.89 (m, 3H), 7.77 – 7.72 (m, 6H), 7.69 – 7.63 (m, 6H), 7.04 (d, J = 7.6 Hz, 2H), 6.86 – 6.84 (m, 2H), 5.08 (d, J = 15.6 Hz, 2H), 2.23 (d, J = 2.0 Hz, 3H) ppm. ^{13}C NMR (100 MHz, DMSO-d_6) δ 137.8 (d, J = 4.0 Hz), 135.0 (d, J = 2.7 Hz), 134.0 (d, J = 9.8 Hz),130.7 (d, J = 4.6 Hz), 130.0 (d, J = 12.3 Hz), 129.3 (d, J = 4.0 Hz), 124.5 (d, J = 8.6 Hz), 120.7 (q, 320.5 Hz), 117.8 (d, J = 84.8 Hz), 27.9 (d, J = 46.3 Hz) ppm. ^{31}P NMR (162 MHz, DMSO-d_6) δ 22.6 ppm. ^{19}F NMR (376 MHz, DMSO-d_6) δ -77.7 ppm. HRMS (ESI) m/z: [M-OTf]$^+$ Calcd for $C_{26}H_{24}P$ 367.1610; Found 367.1606.

(4-(tert-butyl)benzyl)triphenylphosphonium trifluoromethanesulfonate (1c).



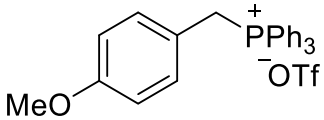
^{1}H NMR (400 MHz, DMSO-d_6) δ 7.93 – 7.89 (m, 3H), 7.76 – 7.72 (m, 6H), 7.67 – 7.62 (m, 6H), 7.25 (d, J = 8.4 Hz, 2H), 6.91 – 6.88 (m, 2H), 5.09 (d, J = 15.6 Hz, 2H), 1.22 (s, 9H) ppm. ^{13}C NMR (100 MHz, DMSO-d_6) δ 151.6 (d, J = 4.1 Hz), 135.6 (d, J = 2.8 Hz), 134.4 (d, J = 9.7 Hz), 130.9 (d, J = 5.6 Hz), 130.6 (d, J = 12.3 Hz), 126.0 (d, J = 3.1 Hz), 125.2 (d, J = 8.6 Hz), 121.2 (q, J = 320.5 Hz), 118.4 (d, J = 84.9 Hz), 34.8, 31.4, 28.2 (d, J = 46.6 Hz) ppm. ^{31}P NMR (162 MHz, DMSO-d_6) δ 23.03 ppm. ^{19}F NMR (376 MHz, DMSO-d_6) δ -77.69 ppm. HRMS (ESI) m/z: [M-OTf]$^+$ Calcd for $C_{29}H_{30}P$ 409.2080; Found 409.2078.

(4-isobutylbenzyl)triphenylphosphonium trifluoromethanesulfonate (1d).



^{1}H NMR (400 MHz, DMSO-d_6) δ 7.93 – 7.89 (m, 3H), 7.76 – 7.71 (m, 6H), 7.67 – 7.62 (m, 6H), 7.02 (d, J = 7.6 Hz, 2H), 6.88 – 6.86 (m, 2H), 5.09 (d, J = 15.2 Hz, 2H), 2.39 (d, J = 6.8 Hz, 2H), 1.80 – 1.74 (m, 1H), 0.82 (d, J = 6.4 Hz, 6H) ppm. ^{13}C NMR (100 MHz, DMSO-d_6) δ 142.4 (d, J = 4.1 Hz), 136.0 (d, J = 2.6 Hz), 134.9 (d, J = 9.7 Hz), 131.5 (d, J = 5.5 Hz), 131.0 (d, J = 12.4 Hz), 130.3 (d, J = 3.1 Hz), 125.9 (d, J = 8.4 Hz), 121.6 (q, J = 320.3 Hz), 118.8 (d, J = 84.8 Hz), 44.9, 30.4, 28.7 (d, J = 46.2 Hz), 22.9 ppm. ^{31}P NMR (162 MHz, DMSO-d_6) δ 23.0 ppm. ^{19}F NMR (376 MHz, DMSO-d_6) δ -77.7 ppm. HRMS (ESI) m/z: [M-OTf]$^+$ Calcd for $C_{29}H_{30}P$ 409.2080; Found 409.2078.

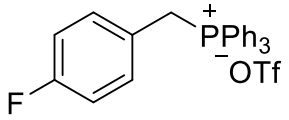
(4-methoxybenzyl)triphenylphosphonium trifluoromethanesulfonate (1e).



^{1}H NMR (400 MHz, DMSO-d_6) δ 7.92 – 7.88 (m, 3H), 7.77 – 7.72 (m, 6H), 7.68 – 7.63

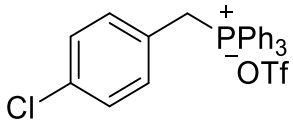
(m, 6H), 6.90 – 6.87 (m, 2H), 6.79 (d, *J* = 8.8 Hz, 2H), 5.05 (d, *J* = 14.8 Hz, 2H), 3.69 (s, 3H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 159.3 (d, *J* = 3.6 Hz), 135.2 (d, *J* = 2.7 Hz), 134.1 (d, *J* = 9.8 Hz), 132.1 (d, *J* = 5.5 Hz), 130.2 (d, *J* = 12.3 Hz), 120.8 (q, *J* = 320.5 Hz), 119.1 (d, *J* = 2.9 Hz), 118.0 (d, *J* = 84.8 Hz), 114.4 (d, *J* = 2.9 Hz), 55.2, 27.6 (d, *J* = 46.4 Hz). ^{31}P NMR (162 MHz, DMSO-d_6) δ 22.3 ppm. ^{19}F NMR (376 MHz, DMSO-d_6) δ -77.7 ppm. HRMS (ESI) m/z: $[M\text{-}OTf]^+$ Calcd for $C_{26}H_{24}OP$ 383.1559; Found 383.1559.

(4-fluorobenzyl)triphenylphosphonium trifluoromethanesulfonate (1f).



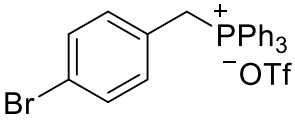
^{1}H NMR (400 MHz, DMSO-d_6) δ 7.93 – 7.90 (m, 3H), 7.78 – 7.74 (m, 6H), 7.70 – 7.65 (m, 6H), 7.12 –7.08 (m, 2H), 7.03 – 6.97 (m, 2H), 5.14 (d, *J* = 15.6 Hz, 2H) ppm. ^{13}C NMR (100 MHz, DMSO-d_6) δ 161.9 (d, *J* = 248.4 Hz), 135.1 (d, *J* = 2.8 Hz), 134.0 (d, *J* = 9.7 Hz), 132.8 (dd, *J* = 8.3, 5.5 Hz), 130.1 (d, *J* = 12.3 Hz), 124.0 (dd, *J* = 8.6, 2.9 Hz), 120.7 (q, 320.2 Hz), 117.6 (d, *J* = 85.1 Hz), 115.8 (d, *J* = 21.6, 3.0 Hz), 27.6, 27.1 ppm. ^{31}P NMR (162 MHz, DMSO-d_6) δ 23.1 ppm. ^{19}F NMR (376 MHz, DMSO-d_6) δ -77.7, -113.1 ppm. HRMS (ESI) m/z: $[M\text{-}OTf]^+$ Calcd for $C_{25}H_{21}FP$ 371.1359; Found 371.1356.

(4-chlorobenzyl)triphenylphosphonium trifluoromethanesulfonate (1g).



^{1}H NMR (400 MHz, DMSO-d_6) δ 7.93 –7.90 (m, 3H), 7.77 – 7.68 (m, 12H), 7.32 (d, *J* = 8.0 Hz, 2H), 7.00 (d, *J* = 6.8 Hz, 2H), 5.18 (d, *J* = 16.0 Hz, 2H) ppm. ^{13}C NMR (100 MHz, DMSO-d_6) δ 135.2 (d, *J* = 2.7 Hz), 134.0 (d, *J* = 9.8 Hz), 133.3 (d, *J* = 4.5 Hz), 132.5 (d, *J* = 5.6 Hz), 130.1 (d, *J* = 12.4 Hz), 128.8 (d, *J* = 3.0 Hz), 126.9 (d, *J* = 8.6 Hz), 120.7 (q, *J* = 320.4 Hz), 117.5 (d, *J* = 85.0 Hz), 27.5 (d, *J* = 47.0 Hz) ppm. ^{31}P NMR (162 MHz, DMSO-d_6) δ 23.0 ppm. ^{19}F NMR (376 MHz, DMSO-d_6) δ -77.7 ppm. HRMS (ESI) m/z: $[M\text{-}OTf]^+$ Calcd for $C_{25}H_{21}ClP$ 387.1064; Found 387.1062.

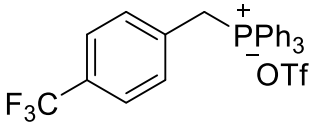
(4-bromobenzyl)triphenylphosphonium trifluoromethanesulfonate (1h).



^{1}H NMR (400 MHz, DMSO-d_6) δ 7.92 –7.90 (m,3H), 7.76 – 7.70 (m, 12H), 7.46 (d, *J* = 6.4 Hz, 2H), 6.91 (d, *J* = 6.4 Hz, 2H), 5.17 (d, *J* = 16.0 Hz, 2H) ppm. ^{13}C NMR (100 MHz, DMSO-d_6) δ 135.2 (d, *J* = 2.7 Hz), 134.0 (d, *J* = 9.7 Hz), 132.87 (d, *J* = 5.4 Hz), 131.7 (d, *J* = 2.9 Hz), 130.1 (d, *J* = 12.3 Hz), 127.5 (d, *J* = 8.6 Hz), 121.8 (d, *J* = 4.7 Hz), 117.6 (d, *J* = 85.0 Hz), 27.5 (d, *J* = 46.6 Hz) ppm. ^{31}P NMR (162 MHz, DMSO-d_6) δ 22.9 ppm. ^{19}F NMR (376 MHz, DMSO-d_6) δ -77.7 ppm. HRMS (ESI) m/z: [M-

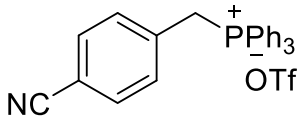
OTf]$^+$ Calcd for $C_{25}H_{21}BrP$ 431.0559; Found 431.0559.

triphenyl(4-(trifluoromethyl)benzyl)phosphonium trifluoromethanesu- lfonate (1i).



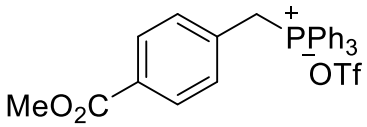
^{1}H NMR (400 MHz, DMSO-d_6) δ 7.92 – 7.91 (m, 3H), 7.76 – 7.63 (m, 14H), 7.20 – 7.18 (m, 2H), 5.29 (d, J = 16.0 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 135.3 (d, J = 3.0 Hz), 134.1 (d, J = 9.6 Hz), 131.7 (d, J = 5.3 Hz), 131.6 (d, J = 7.9 Hz), 130.7 (d, J = 3.8 Hz), 130.3 (d, J = 12.5 Hz), 125.6 (q, J = 3.6 Hz), 123.7 (q, J = 270.2 Hz), 120.8 (q, J = 318.7 Hz), 117.0 (d, J = 85.8 Hz), 29.6 (d, J = 48.0 Hz) ppm. ^{31}P NMR (162 MHz, DMSO-d_6) δ 23.5 ppm. ^{19}F NMR (376 MHz, DMSO-d_6) δ -61.1, -77.8 ppm. HRMS (ESI) m/z: [M-OTf]$^+$ Calcd for $C_{26}H_{21}F_3P$ 421.1327; Found 421.1326.

(4-methylbenzyl)triphenylphosphonium trifluoromethanesulfonate (1j).



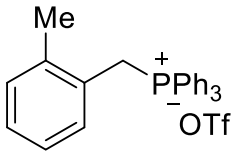
^{1}H NMR (400 MHz, DMSO-d_6) δ 7.94 – 7.90 (m, 3H), 7.79 – 7.66 (m, 14H), 7.16 – 7.14 (m, 2H), 5.28 (d, J = 15.6 Hz, 2H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 135.3 (d, J = 2.9 Hz), 134.0 (d, J = 9.8 Hz), 132.6 (d, J = 4.2 Hz), 131.7 (d, J = 4.5 Hz), 130.2 (d, J = 12.5 Hz), 120.7 (d, J = 320.5 Hz), 118.2 (d, J = 7.8 Hz), 117.3 (d, J = 85.3 Hz), 111.3 (d, J = 4.1 Hz), 28.2 (d, J = 46.8 Hz) ppm. ^{31}P NMR (162 MHz, DMSO-d_6) δ 23.5 ppm. ^{19}F NMR (376 MHz, DMSO-d_6) δ -77.7 ppm. HRMS (ESI) m/z: [M-OTf]$^+$ Calcd for $C_{26}H_{21}NP$ 378.1406; Found 378.1402.

(4-(methoxycarbonyl)benzyl)triphenylphosphonium trifluoromethanesulfonate (1k).



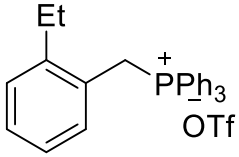
^{1}H NMR (400 MHz, DMSO-d_6) δ 7.95 – 7.91(m, 3H), 7.83 – 7.67 (m, 14H), 7.13 (d, J = 6.4 Hz, 2H), 5.27 (d, J = 16.0 Hz, 2H), 3.82 (s, 3H) ppm. ^{13}C NMR (100 MHz, DMSO-d_6) δ 1T65.6 (d, J = 1.0 Hz), 135.2 (d, J = 2.6 Hz), 134.0 (d, J = 9.9 Hz), 133.6 (d, J = 8.5 Hz), 131.2 (d, J = 5.4 Hz), 130.2 (d, J = 12.5 Hz), 129.4 (d, J = 2.5 Hz), 120.8 (q, J = 320.2 Hz), 117.4 (d, J = 85.3 Hz), 52.2, 28.2 (d, J = 46.6 Hz) ppm. ^{31}P NMR (162 MHz, DMSO-d_6) δ 23.3 ppm. ^{19}F NMR (376 MHz, DMSO-d_6) δ -77.7 ppm. HRMS (ESI) m/z: [M-OTf]$^+$ Calcd for $C_{27}H_{24}O_2P$ 411.1508; Found 411.1509.

(2-methylbenzyl)triphenylphosphonium trifluoromethanesulfonate (1l)



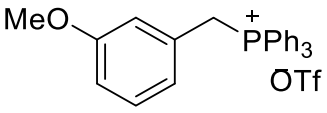
^{1}H NMR (400 MHz, DMSO-d_6) δ 7.94 – 7.90 (m, 3H), 7.76 – 7.71 (m, 6H), 7.64 – 7.59 (m, 6H), 7.25 – 7.21(m, 1H), 7.11 (d, J = 7.6 Hz, 1H), 7.06 –7.03 (m, 1H), 6.94 (d, J = 8.4 Hz, 1H), 5.00 (d, J = 14.8 Hz, 2H), 1.64 (s, 3H) ppm. ^{13}C NMR (100 MHz, DMSO-d_6) δ 138.8 (d, J = 5.9 Hz), 135.4 (d, J = 2.8 Hz), 134.1 (d, J = 9.8 Hz), 131.1 (d, J = 3 Hz), 130.9 (d, J = 5.0 Hz), 130.3 (d, J = 12.3 Hz), 128.8 (d, J = 3.7 Hz), 126.4 (d, J = 3.1 Hz), 126.1 (d, J = 8.5 Hz), 120.8 (q, J = 318.6 Hz), 117.6 (d, J = 84.6 Hz), 26.1 (d, J = 47.0 Hz), 18.9 ppm. ^{31}P NMR (162 MHz, DMSO-d_6) δ 22.3 ppm. ^{19}F NMR (376 MHz, DMSO-d_6) δ -77.7 ppm. HRMS (ESI) m/z: [M-OTf]$^+$ Calcd for $C_{26}H_{24}P$ 367.1610; Found 367.1606.

(2-ethylbenzyl)triphenylphosphonium trifluoromethanesulfonate (1m).



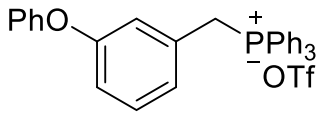
^{1}H NMR (400 MHz, DMSO-d_6) δ 7.94 – 7.90 (m, 3H), 7.76 – 7.71 (m, 6H), 7.63 – 7.58 (m, 6H), 7.31 – 7.28 (m, 1H), 7.18 (d, J = 7.6 Hz, 1H), 7.06 – 7.02 (m, 1H), 6.92 (d, J = 8.0 Hz, 1H), 4.99 (d, J = 15.2 Hz, 2H), 1.95 (q, J = 7.6 Hz, 2H), 0.84 (t, J = 7.6 Hz, 3H) ppm. ^{13}C NMR (100 MHz, DMSO-d_6) δ 144.2 (d, J = 6.2 Hz), 135.3 (d, J = 2.8 Hz), 134.1 (d, J = 9.7 Hz), 131.0 (d, J = 4.8 Hz), 130.2 (d, J = 12.3 Hz), 129.0 (d, J = 3.8 Hz), 128.9 (d, J = 2.9 Hz), 126.2 (d, J = 3.4 Hz), 125.3 (d, J = 8.6 Hz), 120.7 (q, J = 320.2 Hz), 117.6 (d, J = 84.8 Hz), 25.6 (d, J = 46.8 Hz), 24.4, 14.3 ppm. ^{31}P NMR (162 MHz, DMSO-d_6) δ 22.5 ppm. ^{19}F NMR (376 MHz, DMSO-d_6) δ -77.8 ppm. HRMS (ESI) m/z: [M-OTf]$^+$ Calcd for $C_{27}H_{26}P$ 381.1767; Found 381.1766.

(3-methoxybenzyl)triphenylphosphonium trifluoromethanesulfonate (1n)



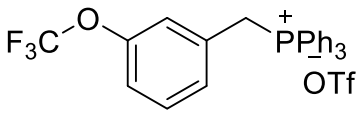
^{1}H NMR (400 MHz, DMSO-d_6) δ 7.93 – 7.90 (m, 3H), 7.78 – 7.73 (m, 6H), 7.71 – 7.66 (m, 6H), 7.19 –7.15 (m, 1H), 6.87 (d, J = 8.0 Hz, 1H), 6.61 (d, J = 7.6 Hz, 1H), 6.48 (d, J = 1.6 Hz, 1H), 5.10 (d, J = 15.6 Hz, 2H), 3.50 (s, 3H) ppm. ^{13}C NMR (100 MHz, DMSO-d_6) δ 159.3 (d, J = 3.4 Hz), 135.2 (d, J = 2.7 Hz), 134.1 (d, J = 9.7 Hz), 130.2 (d, J = 12.3 Hz),130.0 (d, J = 3.0 Hz), 129.3 (d, J = 8.5 Hz), 123.1 (d, J = 5.7 Hz), 117.9 (d, J = 85.2 Hz), 120.8 (q, J = 320.3 Hz), 116.3 (d, J = 5.4 Hz), 114.4 (d, J = 3.6 Hz), 55.0, 28.4 (d, J = 46.8 Hz) ppm. ^{31}P NMR (162 MHz, DMSO-d_6) δ 23.1 ppm. ^{19}F NMR (376 MHz, DMSO-d_6) δ -77.7 ppm. HRMS (ESI) m/z: [M-OTf]$^+$ Calcd for $C_{26}H_{24}OP$ 383.1559; Found 383.1559.

(3-phenoxybenzyl)triphenylphosphonium trifluoromethanesulfonate (1o).



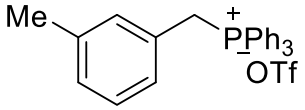
^{1}H NMR (400 MHz, DMSO-d_6) δ 7.94 – 7.90 (m, 3H), 7.75 – 7.65 (m, 12H), 7.36 – 7.32 (m, 2H), 7.29 – 7.25 (m, 1H), 7.17 – 7.13(m, 1H), 7.00 (d, J = 8.0 Hz, 1H), 6.83 – 6.77 (m, 3H), 6.58 (s, 1H), 5.20 (d, J = 16.0 Hz, 2H) ppm. ^{13}C NMR (100 MHz, DMSO-d_6) δ 156.9 (d, J = 3.3 Hz), 155.7, 135.1 (d, J = 2.7 Hz), 134.0 (d, J = 9.7 Hz), 130.4 (d, J = 3.2 Hz), 130.11 (d, J = 12.3 Hz), 130.08, 129.9 (d, J = 8.7 Hz), 125.5 (d, J = 5.5 Hz), 123.8, 120.2 (d, J = 5.6 Hz), 118.8, 118.6 (d, J = 3.5 Hz), 117.6 (d, J = 85.2 Hz), 28.0 (d, J = 46.6 Hz) ppm. ^{31}P NMR (162 MHz, DMSO-d_6) δ 23.3 ppm. ^{19}F NMR (376 MHz, DMSO-d_6) δ -77.7 ppm. HRMS (ESI) m/z: $[M\text{-}OTf]^+$ Calcd for $C_{31}H_{26}OP$ 445.1716 Found 445.1717.

triphenyl(3-(trifluoromethoxy)benzyl)phosphonium trifluoromethanesulfonate (1p).



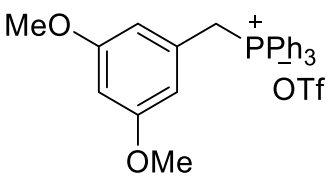
^{1}H NMR (400 MHz, DMSO-d_6) δ 7.94 –7.90 (m, 3H), 7.78 – 7.66 (m, 12H), 7.42 – 7.38 (m, 1H), 7.31 (d, J = 8.4 Hz, 1H), 7.06 (d, J = 7.6 Hz, 1H), 6.94 (s, 1H), 5.28 (d, J = 15.6 Hz, 2H) ppm. ^{13}C NMR (100 MHz, DMSO-d_6) δ 149.1, 136.1 (d, J = 2.8 Hz), 134.9 (d, J = 10.0 Hz), 131.7 (q, J = 3.2 Hz), 131.6, 131.0 (d, J = 12.4 Hz), 130.7 (d, J = 5.3 Hz), 124.1 (d, J = 5.4 Hz), 121.9 (d, J = 3.2 Hz), 120.7 (q, J = 255.4 Hz), 118.3 (d, J = 85.3 Hz), 28.7 (d, J = 47.1 Hz) ppm. ^{31}P NMR (162 MHz, DMSO-d_6) δ 23.5 ppm. ^{19}F NMR (376 MHz, DMSO-d_6) δ -56.8, -77.8 ppm. HRMS (ESI) m/z: $[M\text{-}OTf]^+$ Calcd for $C_{26}H_{21}F_3OP$ 437.1277; Found 437.1277.

methylbenzyl)triphenylphosphonium trifluoromethanesulfonate (1q).



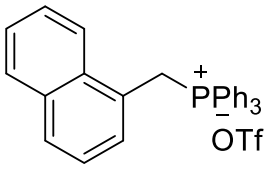
^{1}H NMR (400 MHz, DMSO-d_6) δ 7.93 – 7.90 (m, 3H), 7.78 – 7.73 (m, 6H), 7.69 – 7.64 (m, 6H), 7.13 (d, J = 6.0 Hz, 2H), 6.81 (d, J = 6.4 Hz, 1H), 6.65 (s, 1H), 5.08 (d, J = 15.6 Hz, 2H), 2.09 (s, 3H) ppm. ^{13}C NMR (100 MHz, DMSO-d_6) δ 138.8 (d, J = 3.2 Hz), 136.0 (d, J = 2.7 Hz), 134.9 (d, J = 9.9 Hz), 132.5 (d, J = 5.5 Hz), 131.0 (d, J = 12.4 Hz), 129.8 (d, J = 3.8 Hz), 129.6 (d, J = 3.0 Hz), 128.8 (d, J = 5.6 Hz), 128.5 (d, J = 8.5 Hz), 121.6 (d, J = 320.5 Hz), 118.7 (d, J = 8.5 Hz), 28.1 (d, J = 46.4 Hz), 20.7 ppm. ^{31}P NMR (162 MHz, DMSO-d_6) δ 23.0 ppm. ^{19}F NMR (376 MHz, DMSO-d_6) δ -77.7 ppm. HRMS (ESI) m/z: $[M\text{-}OTf]^+$ Calcd for $C_{26}H_{24}P$ 367.1610; Found 367.1606.

(3,5-dimethoxybenzyl)triphenylphosphonium trifluoromethanesulfonate (1r).



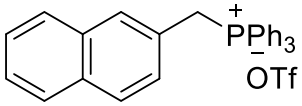
^{1}H NMR (400 MHz, DMSO-d_6) δ 7.93 – 7.89 (m, 3H), 7.78 – 7.73 (m, 6H), 7.69 – 7.65 (m, 6H), 6.42 (s, 1H), 6.12 (s, 2H), 5.02 (d, J = 15.6 Hz, 2H), 3.50 (s, 9H) ppm. ^{13}C NMR (100 MHz, DMSO-d_6) δ 160.5 (d, J = 3.1 Hz), 135.2 (d, J = 2.7 Hz), 134.1 (d, J = 9.7 Hz), 130.2 (d, J = 12.3 Hz), 129.9 (d, J = 8.4 Hz), 120.8 (q, J = 320.4 Hz), 117.8 (d, J = 85.2 Hz), 109.0 (d, J = 5.4 Hz), 100.3 (d, J = 3.3 Hz), 55.2, 28.6 (d, J = 46.1 Hz) ppm. ^{31}P NMR (162 MHz, DMSO-d_6) δ 23.0 ppm. ^{19}F NMR (376 MHz, DMSO-d_6) δ -77.8 ppm. HRMS (ESI) m/z: $[M\text{-}OTf]^+$ Calcd for $C_{27}H_{26}O_2P$ 413.1665 Found 413.1664.

(naphthalen-1-ylmethyl)triphenylphosphonium trifluoromethanesulfonate (1s).



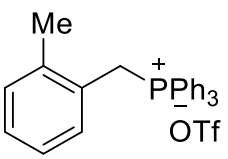
^{1}H NMR (400 MHz, DMSO-d_6) δ 7.91 – 7.81 (m, 5H), 7.69 – 7.60 (m, 13H), 7.41 – 7.34 (m, 2H), 7.31 – 7.29 (m, 1H), 7.13 – 7.09 (m, 1H), 5.58 (d, J = 15.6 Hz, 2H) ppm. ^{13}C NMR (100 MHz, DMSO-d_6) δ 135.0 (d, J = 2.8 Hz), 134.0 (d, J = 9.9 Hz), 133.2 (d, J = 2.7 Hz), 132.0 (d, J = 4.6 Hz), 129.9 (d, J = 12.4 Hz), 129.7 (d, J = 6.8 Hz), 129.2 (d, J = 4.2 Hz), 128.4, 125.9, 125.1 (d, J = 3.9 Hz), 123.9 (d, J = 9.0 Hz), 123.7, 120.6 (d, J = 320.4 Hz), 117.6 (d, J = 84.6 Hz), 25.2 (d, J = 47.3 Hz) ppm. ^{31}P NMR (162 MHz, DMSO-d_6) δ 22.8 ppm. ^{19}F NMR (376 MHz, DMSO-d_6) δ -77.7 ppm. HRMS (ESI) m/z: $[M\text{-}OTf]^+$ Calcd for $C_{29}H_{24}P$ 403.1610 Found 403.1610.

(naphthalen-2-ylmethyl)triphenylphosphonium trifluoromethanesulfonate (1t).



^{1}H NMR (400 MHz, DMSO-d_6) δ 7.93 – 7.86 (m, 4H), 7.79 – 7.68 (m, 13H), 7.62 – 7.59 (m, 1H), 7.53 – 7.47 (m, 3H), 7.06 (d, J = 8.4 Hz, 1H), 5.32 (d, J = 15.6 Hz, 2H) ppm. ^{13}C NMR (100 MHz, DMSO-d_6) δ 135.1 (d, J = 2.8 Hz), 134.0 (d, J = 9.9 Hz), 132.5 (d, J = 3.1 Hz), 132.2 (d, J = 2.6 Hz), 130.3 (d, J = 7.3 Hz), 130.1 (d, J = 12.3 Hz), 128.3 (d, J = 2.3 Hz), 128.0 (d, J = 4.2 Hz), 127.6, 127.4, 126.8 (d, J = 8.9 Hz), 125.4 (d, J = 9.0 Hz), 120.8 (q, J = 320.3 Hz), 117.8 (d, J = 85.1 Hz), 28.4 (d, J = 46.4 Hz) ppm. ^{31}P NMR (162 MHz, DMSO-d_6) δ 22.9 ppm. ^{19}F NMR (376 MHz, DMSO-d_6) δ -77.7 ppm. HRMS (ESI) m/z: $[M\text{-}OTf]^+$ Calcd for $C_{29}H_{24}P$ 403.1610 Found 403.1610.

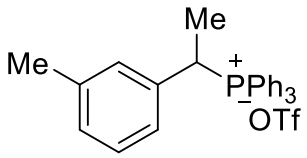
triphenyl(1-phenylethyl)phosphonium trifluoromethanesulfonate (1u).



^{1}H NMR (400 MHz, DMSO-d_6) δ 7.93 – 7.89 (m, 3H), 7.70 – 7.72 (m, 6H), 7.71 – 7.64

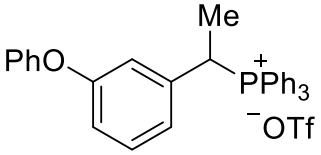
(m, 6H), 7.35 –7.34 (m, 1H), 7.28 (t, *J* = 7.6 Hz, 2H), 6.96 –6.94 (m, 2H), 5.65 –5.56 (m, 1H), 1.74 (dd, *J* = 18.8, 7.2 Hz, 3H).^{13}C NMR (100 MHz, DMSO-d_6) δ 135.2 (d, *J* = 2.7 Hz), 134.3 (d, *J* = 9.1 Hz), 133.7 (d, *J* = 5.2 Hz), 130.3 (d, *J* = 12.0 Hz), 129.7 (d, *J* = 5.8 Hz), 129.05, 128.98 (d, *J* = 2.1 Hz), 120.6 (q, *J* = 320.6 Hz), 117.2 (d, *J* = 82.1 Hz), 34.2 (d, *J* = 43.6 Hz), 16.8 ppm. ^{31}P NMR (162 MHz, DMSO-d_6) δ 26.3 ppm. ^{19}F NMR (376 MHz, DMSO-d_6) δ -77.7 ppm. $[M\text{-}OTf]^+$ Calcd for $C_{26}H_{24}P$ 367.1610; Found 367.1606.

triphenyl(1-(m-tolyl)ethyl)phosphonium trifluoromethanesulfonate (1v).



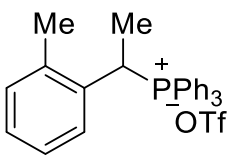
^{1}H NMR (400 MHz, DMSO-d_6) δ 7.95 –7.91 (m, 3H), 7.79 – 7.68 (m, 12H), 7.22 – 7.18 (m, 2H), 6.87 (d, *J* = 6.8 Hz, 1H), 6.58 (s, 1H), 5.61 – 5.52 (m, 1H), 2.12 (s, 3H), 1.73 (dd, *J* = 18.8, 7.2 Hz, 3H) ppm. ^{13}C NMR (100 MHz, DMSO-d_6) δ 138.1 (d, *J* = 2.4 Hz), 135.0 (d, *J* = 2.8 Hz), 134.3 (d, *J* = 9.1 Hz), 134.0 (d, *J* = 9.8 Hz), 133.3 (d, *J* = 5.2 Hz), 130.3 (d, *J* = 5.6 Hz),130.1 (d, *J* = 12 Hz), 129.4 (d, *J* = 3.1 Hz), 128.7 (d, *J* = 2.1 Hz), 126.8 (d, *J* = 5.9 Hz), 120.8 (d, *J* = 320.5 Hz), 117.1 (d, 82.0 Hz), 34.1 (d, *J* = 43.4 Hz), 20.8, 16.6 ppm. ^{31}P NMR (162 MHz, DMSO-d_6) δ 26.3 ppm. ^{19}F NMR (376 MHz, DMSO-d_6) δ -77.7 ppm. $[M\text{-}OTf]^+$ Calcd for $C_{27}H_{26}P$ 381.1767; Found 381.1765.

(1-(3-phenoxyphenyl)ethyl)triphenylphosphonium trifluoromethanesulfonate (1w).



^{1}H NMR (400 MHz, DMSO-d_6) δ 7.94 – 7.90 (m, 3H), 7.77 – 7.72 (m, 6H), 7.70 – 7.65 (m, 6H), 7.41 – 7.30 (m, 3H), 7.20 – 7.16 (m, 1H), 7.05 (d, *J* = 8.0 Hz, 1H), 6.89 (d, *J* = 7.6 Hz, 2H), 6.70 (d, *J* = 7.6 Hz, 1H), 6.58 (d, *J* = 1.6 Hz, 1H), 5.62 – 5.52 (m, 1H), 1.71 (dd, *J* = 18.8, 7.2 Hz, 3H) ppm. ^{13}C NMR (100 MHz, DMSO-d_6) δ 157.1 (d, *J* = 2.4 Hz), 155.7, 135.7 (d, *J* = 5.1 Hz), 135.1 (d, *J* = 2.7 Hz), 134.2 (d, *J* = 9.2 Hz), 130.7 (d, *J* = 2.0 Hz), 130.3, 130.2 (d, *J* = 1.0 Hz), 124.2 (d, *J* = 5.6 Hz), 124.0, 119.25 (d, *J* = 5.9 Hz), 119.15 (d, *J* = 2.9 Hz), 119.0, 116.9 (d, *J* = 82.3 Hz), 34.20 (d, *J* = 44.3 Hz), 16.8 ppm. ^{31}P NMR (162 MHz, DMSO-d_6) δ 26.2 ppm. ^{19}F NMR (376 MHz, DMSO-d_6) δ -77.7 ppm. $[M\text{-}OTf]^+$ Calcd for $C_{32}H_{28}OP$ 459.1872; Found 459.1872.

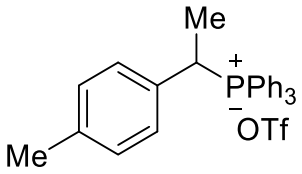
triphenyl(1-(o-tolyl)ethyl)phosphonium trifluoromethanesulfonate (1x)



^{1}H NMR (400 MHz, DMSO-d_6) δ 7.97 – 7.94(m, 3H), 7.77 – 7.72 (m, 6H), 7.52 – 7.47

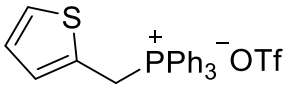
(m, 6H), 7.33 –7.30 (m, 1H), 7.20 (d, *J* = 7.6 Hz, 1H), 7.13–7.09 (m, 1H), 6.65 (d, *J* = 8.0 Hz, 1H), 5.16 – 5.07 (m, 1H), 1.89 – 1.81 (m, 6H) ppm. ^{13}C NMR (100 MHz, DMSO-d_6) δ 138.4 (d, *J* = 7.3 Hz), 135.5 (d, *J* = 2.7 Hz), 134.5 (d, *J* = 9.1 Hz), 131.9 (d, *J* = 5.2 Hz), 131.3, 130.4 (d, *J* = 11.9 Hz), 129.2 (d, *J* = 2.9 Hz), 128.2 (d, *J* = 4.5 Hz), 126.8 (d, *J* = 2.7 Hz), 120.9 (q, *J* = 320.3 Hz), 116.7 (d, *J* = 81.9 Hz), 32.6 (d, *J* = 44.6 Hz), 19.1, 17.4 ppm. ^{31}P NMR (162 MHz, DMSO-d_6) δ 24.9 ppm. ^{19}F NMR (376 MHz, DMSO-d_6) δ -77.7 ppm. $[M\text{-}OTf]^+$ Calcd for $C_{27}H_{26}P$ 381.1767; Found 381.1765.

triphenyl(1-(p-tolyl)ethyl)phosphonium trifluoromethanesulfonate (1y).



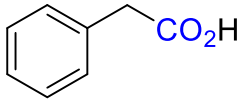
^{1}H NMR (400 MHz, DMSO-d_6) δ 7.92 –7.89 (m,3H), 7.78 – 7.66 (m, 12H), 7.08 (d, *J* = 8.0 Hz, 2H), 6.84 – 6.82(m, 2H), 5.56 –5.52 (m, 1H), 2.26 (d, *J* = 1.6 Hz, 3H), 1.70 (dd, *J* = 18.8, 7.2, Hz, 3H).^{13}C NMR (100 MHz, DMSO-d_6) δ 139.0 (d, *J* = 3.3 Hz), 135.5 (d, *J* = 2.7 Hz), 134.7 (d, *J* = 9.2 Hz), 130.9 (d, *J* = 5.3 Hz), 130.7 (d, *J* = 12.0 Hz), 130.1 (d, *J* = 5.7 Hz), 129.9 (d, *J* = 2.3 Hz), 121.2 (q, *J* = 320.2 Hz) 117.7 (d, *J* = 82.1 Hz),34.3(d, *J* = 43.4 Hz) , 21.1, 17.3 ppm . ^{31}P NMR (162 MHz, DMSO-d_6) δ 26.0 ppm. ^{19}F NMR (376 MHz, DMSO-d_6) δ -77.7ppm. $[M\text{-}OTf]^+$ Calcd for $C_{27}H_{26}P$ 381.1767; Found 381.1765.

triphenyl(thiophen-2-ylmethyl)phosphonium trifluoromethanesulfonate (1a')



^{1}H NMR (400 MHz, DMSO-d_6) δ 7.87 –7.84 (m, 3H), 7.72 – 7.68 (m, 6H), 7.65 – 7.60(m, 7.6 Hz, 6H), 7.46 – 7.44 (m, 1H), 7.11 (s, 1H), 6.52 (d, *J* = 5.2, Hz, 1H), 5.20 (d, *J* = 15.2 Hz, 2H) ppm. ^{13}C NMR (100 MHz, DMSO-d_6) δ 135.0 (d, *J* = 2.8 Hz), 133.8 (d, *J* = 9.7 Hz), 130.1 (d, *J* = 12.3 Hz), 128.7 (d, *J* = 3.3 Hz), 127.4 (d, *J* = 1.2 Hz), 126.9, 126.8, 118.0 (d, *J* = 85.0 Hz), 23.5 (d, *J* = 48.3 Hz) ppm.^{19}F NMR (377 MHz, DMSO-d_6) δ -77.72 (s). ^{31}P NMR (162 MHz, DMSO) δ 21.79 ppm. ^{19}F NMR (376 MHz, DMSO-d_6) δ -77.72 ppm.

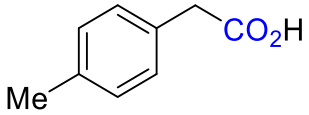
2-phenylacetic acid (2a)[2].



White solid (22.3 mg, 82% yield). Conformed the documental reports. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.38 – 7.29 (m, 5H), 3.66 (s, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ

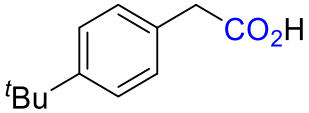
178.1, 133.4, 129.5, 128.8, 127.5, 41.2 ppm.

2-(*p*-tolyl)acetic acid (2b)[3].



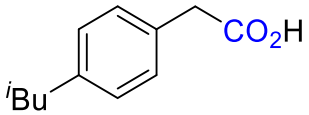
White solid (20.3 mg, 68% yield). Conformed the documental reports. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.18 (d, J = 7.6 Hz, 2H), 7.16 (d, J = 8.4 Hz, 2H), 3.62 (s, 2H), 2.34 (s, 3H), 0.09 (s, 3H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 178.4, 137.2, 130.3, 129.5, 129.37, 40.8, 21.2, 1.2 ppm.

2-(4-(*tert*-butyl)phenyl)acetic acid (2c)[2].



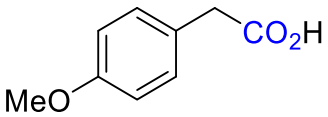
Colorless oil (19.0 mg, 50% yield). Conformed the documental reports. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37 (d, J = 7.6 Hz, 2H), 7.23 (d, J = 8.0 Hz, 2H), 3.63 (s, 2H), 1.32 (s, 9H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 178.1, 150.4, 130.4, 129.2, 125.8, 40.7, 34.6, 31.5 ppm.

2-(4-isobutylphenyl)acetic acid (2d)[8].



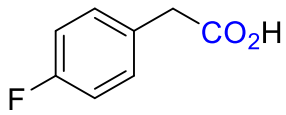
White solid (30.9 mg, 75% yield). Conformed the documental reports.^{1}H NMR (400 MHz, $CDCl_3$) δ 7.20 (d, J = 8.0 Hz, 2H), 7.12 (d, J = 8.0 Hz, 2H), 3.62 (s, 2H), 2.46 (d, J = 7.2 Hz, 2H), 1.93 – 1.81 (m, 1H), 0.91 (d, J = 6.8 Hz, 6H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 178.2, 141.0, 130.6, 129.5, 129.2, 45.2, 40.8, 30.3, 22.5 ppm.

2-(4-methoxyphenyl)acetic acid (2e)[2].



White solid (24.6 mg, 74% yield). Conformed the documental reports. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.21 (d, J = 8.8 Hz, 2H), 6.88 (d, J = 8.4 Hz, 2H), 3.80 (s, 3H), 3.59 (s, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 178.4, 159.0, 130.5, 125.5, 114.2, 55.4, 40.3 ppm.

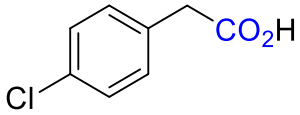
2-(4-fluorophenyl)acetic acid (2f)[2].



White solid (21.4 mg, 69% yield). Conformed the documental reports. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.25 (dd, J = 7.6, 4.6 Hz, 2H), 7.02 (t, J = 8.6 Hz, 2H), 3.63 (s, 2H)

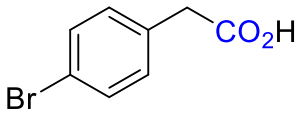
ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 177.4, 162.3 (d, J = 244.5Hz), 131.1 (d, J = 8 Hz), 129.1 (d, J = 3.4 Hz), 115.7 (d, J = 21.3 Hz), 40.2 ppm. ^{19}F NMR (376 MHz, $CDCl_3$) δ -120.0 ppm.

2-(4-chlorophenyl)acetic acid (2g)[4].



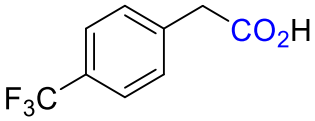
White solid (15.0 mg, 44% yield). Conformed the documental reports. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.31 (d, J = 8.4 Hz, 2H), 7.21 (d, J = 8.4 Hz, 2H), 3.62 (s, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 177.6, 133.6, 131.8, 130.9, 129.0, 40.4 ppm.

2-(4-bromophenyl)acetic acid (2h)[2].



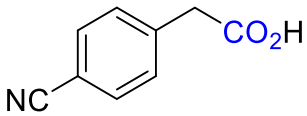
White solid (13.6 mg, 51% yield). Conformed the documental reports. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.46 (d, J = 8.4 Hz, 2H), 7.16 (d, J = 8.4 Hz, 2H), 3.60(s, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 177.3, 132.3, 131.9, 131.2, 121.6, 40.5 ppm.

2-(4-(trifluoromethyl)phenyl)acetic acid (2i)[3].



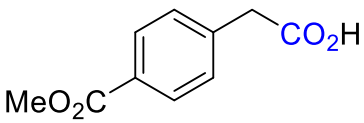
White solid (28.7 mg, 70% yield). Conformed the documental reports. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60 (d, J = 7.2 Hz, 2H), 7.41 (d, J = 7.2 Hz, 2H), 3.72 (s, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 177.82, 137.65, 130.3 (q, J = 32.4 Hz), 126.1 (q, J = 3.7 Hz), 124.6 (q, J = 270.4 Hz), 41.33 ppm.

2-(4-cyanophenyl)acetic acid (2j)[3].



White solid (22.7 mg, 71% yield). Conformed the documental reports. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.64 (d, J = 8.4 Hz, 2H), 7.41 (d, J = 8.0 Hz, 2H), 3.72 (s, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 174.9, 138.6, 132.6, 130.4, 118.7, 111.7, 40.9 ppm.

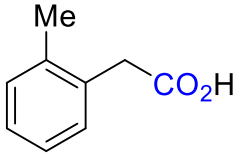
2-(4-(methoxycarbonyl)phenyl)acetic acid (2k)[5].



White solid (25.3 mg, 65% yield). Conformed the documental reports. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.00 (d, J = 8.4 Hz, 2H), 7.36 (d, J = 8.0 Hz, 2H), 3.91 (s, 3H), 3.71

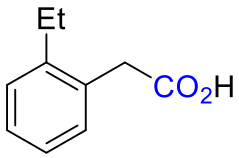
(s, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.5, 167.0, 138.5, 130.1, 129.6, 129.5, 52.3, 41.0 ppm.

2-(*o*-tolyl)acetic acid (2l)[2].



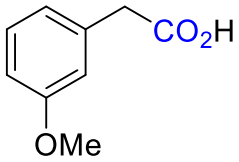
White solid (18.2 mg, 61% yield). Conformed the documental reports. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.24 – 7.16 (m, 4H), 3.68 (s, 2H), 2.34 (s, 3H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 178.0, 137.1, 132.1, 130.6, 130.4, 127.8, 126.3, 39.0, 19.7 ppm.

2-(2-ethylphenyl)acetic acid (2m)[7].



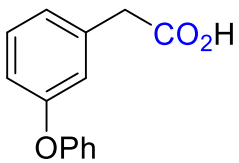
White solid (16.7 mg, 51% yield). Conformed the documental reports. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.26 – 7.14 (m, 4H), 3.68 (s, 2H), 2.66 (q, J = 7.6 Hz, 2H), 1.21 (t, J = 7.6 Hz, 3H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 178.0, 142.8, 131.4, 130.7, 128.8, 128.0, 126.2, 38.37, 25.9, 14.9 ppm.

2-(3-methoxyphenyl)acetic acid (2n)[3].



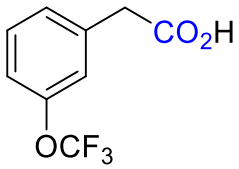
White solid (17.6 mg, 53% yield). Conformed the documental reports. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.30 – 7.28 (m, 1H), 6.91 – 6.85 (m, 3H), 3.83 (s, 3H), 3.66 (s, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 177.4, 159.9, 134.8, 129.8, 121.9, 115.2, 113.0, 55.4, 41.2 ppm.

2-(3-phenoxyphenyl)acetic acid (2o)[3].



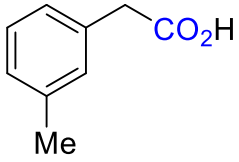
White solid (42.6 mg, 88% yield). Conformed the documental reports. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37 – 7.28 (m, 3H), 7.12 (t, J = 7.4 Hz, 1H), 7.03 (d, J = 8.0 Hz, 3H), 6.97 – 6.92 (m, 2H), 3.64 (s, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 177.7, 157.6, 157.0, 135.2, 130.0, 129.9, 124.3, 123.6, 119.9, 119.2, 117.7, 41.0 ppm.

2-(3-(trifluoromethoxy)phenyl)acetic acid (2p).



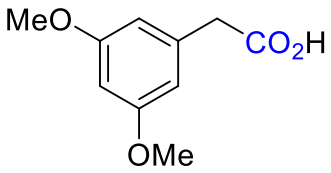
White solid (35.7 mg, 81% yield). Conformed the documental reports. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.46 (t, *J* = 7.6 Hz, 1H), 7.36 – 7.31 (m, 1H), 7.26 – 7.24 (m, 2H), 3.77 (s, 2H).^{13}C NMR (100 MHz, $CDCl_3$) δ 177.40, 149.5, 135.4, 130.1, 128.0, 122.2, 120.6 (q, *J*= 255.6 Hz), 120.0, 40.74 ppm. HRMS (ESI) m/z: $[M-H]^-$ Calcd for $C_9H_6F_3O_3^-$ 219.0275; Found 219.0270.

2-(m-tolyl)acetic acid (2q)[2].



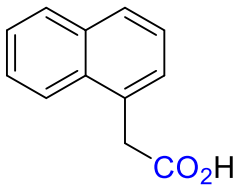
White solid (25.2 mg, 84% yield). Conformed the documental reports. ^{1}H NMR (400 MHz, $CDCl_3$) *δ* 7.24 – 7.21 (m, 1H), 7.10 – 7.08 (m, 3H), 3.61 (s, 2H), 2.34 (s, 3H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) *δ* 177.4, 138.5, 133.3, 130.3, 128.7, 128.3, 126.5, 41.1, 21.5 ppm.

2-(3, 5-dimethoxyphenyl)acetic acid (2r)[4].



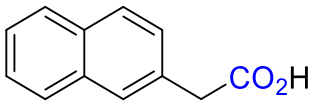
White solid (25.9 mg, 66% yield). Conformed the documental reports. ^{1}H NMR (400 MHz, $CDCl_3$) *δ* 6.44 (d, *J* = 2.4 Hz, 2H), 6.39 (t, *J* = 2.2 Hz, 1H), 3.78 (s, 6H), 3.58 (s, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) *δ* 177.3, 161.1, 135.4, 107.6, 99.6, 55.5, 41.4 ppm.

2-(naphthalen-1-yl)acetic acid (2s).[9]



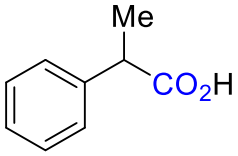
White solid (23.5 mg, 63% yield). Conformed the documental reports. ^{1}H NMR (400 MHz, $CDCl_3$) *δ* 7.96 (d, *J* = 8.0 Hz, 1H), 7.87 (d, *J* = 7.6 Hz, 1H), 7.82 (d, *J* = 8.0 Hz, 1H), 7.56 – 7.48 (m, 2H), 7.46 – 7.40 (m, 2H), 4.09 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) *δ* 177.8, 133.9, 132.1, 129.9, 128.9, 128.5, 128.4, 126.7, 126.0, 125.6, 123.8, 38.9 ppm.

2-(naphthalen-2-yl)acetic acid (2t)[2].



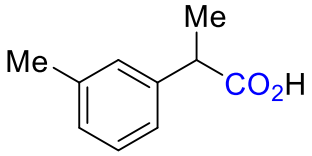
White solid (19.7 mg, 53% yield). Conformed the documental reports.[1]H NMR (400 MHz, $CDCl_3$) δ 7.81 (t, J = 8.0 Hz, 3H), 7.74 (s, 1H), 7.49 – 7.44 (m, 2H), 7.41 (dd, J = 8.4, 1.6 Hz, 1H), 3.82 (s, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 177.3, 133.6, 132.7, 130.9, 128.5, 128.3, 127.8, 127.8, 127.4, 126.4, 126.1, 41.3 ppm.

2-phenylpropanoic acid (2u)[2].



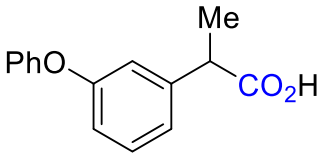
Colorless oil (24.5 mg, 82% yield). Conformed the documental reports. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.34 (d, J = 4.0 Hz, 4H), 7.30 – 7.27 (m, 1H), 3.76 (q, J = 7.2 Hz, 1H), 1.53 (d, J = 7.2 Hz, 3H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 180.9, 139.9, 128.8, 127.8, 127.5, 45.5, 18.2 ppm.

2-(*m*-tolyl)propanoic acid (2v)[5].



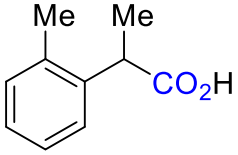
Colorless oil (15.7 mg, 48% yield). Conformed the documental reports. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.23 (t, J = 7.6 Hz, 1H), 7.14 – 7.08 (m, 3H), 3.71 (q, J = 7.2 Hz, 1H), 2.36 (s, 3H), 1.51 (d, J = 7.2 Hz, 3H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 180.8, 139.9, 138.5, 128.7, 128.5, 128.3, 124.8, 45.4, 21.6, 18.2 ppm.

2-(3-phenoxyphenyl)propanoic acid (2w)[3].



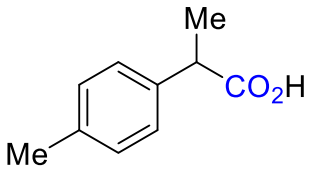
White solid (40.6 mg, 83% yield). Conformed the documental reports. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.31 – 7.27 (m, 2H), 7.24 – 7.21 (m, 1H), 7.08 – 7.01 (m, 2H), 6.99 – 6.96 (m, 3H), 6.86 – 6.84 (m, 1H), 3.68 (q, J = 7.2 Hz, 1H), 1.46 (d, J = 7.2 Hz, 3H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 180.3, 157.6, 157.1, 141.8, 130.0, 129.9, 123.5, 122.5, 119.1, 118.4, 117.6, 45.3, 18.2 ppm.

2-(*o*-tolyl)propanoic acid (2x)[5].



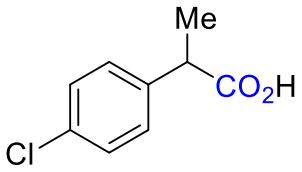
White solid (24.3 mg, 74% yield). Conformed the documental reports. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.30 (d, J = 6.8 Hz, 1H), 7.23 – 7.17 (m, 3H), 3.99 (q, J = 7.2 Hz, 1H), 2.39 (s, 3H), 1.50 (d, J = 6.8 Hz, 3H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 180.9, 138.5, 136.1, 130.7, 127.3, 126.7, 126.6, 41.2, 19.8, 17.7 ppm.

2-(*p*-tolyl)propanoic acid (2y)[2].



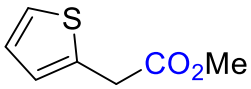
Colorless oil (17.3 mg, 53% yield). Conformed the documental reports. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.22 (d, J = 8.0 Hz, 2H), 7.15 (d, J = 8.0 Hz, 2H), 3.71 (q, J = 7.2 Hz, 1H), 2.33 (s, 3H), 1.50 (d, J = 7.2 Hz, 3H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 181.0, 137.2, 136.9, 129.5, 127.6, 45.0, 21.2, 18.2 ppm.

2-(4-chlorophenyl)propanoic acid (2z)[6].



White solid (22.9 mg, 62% yield). Conformed the documental reports. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.31 (d, J = 8.8 Hz, 2H), 7.26 (d, J = 8.8 Hz, 2H), 3.72 (q, J = 7.2 Hz, 1H), 1.50 (d, J = 7.2 Hz, 3H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 180.3, 138.3, 133.5, 129.2, 129.0, 44.9, 18.2 ppm.

methyl 2-(thiophen-2-yl)acetate. (2a')[10]



Brown oily liquid (11.0 mg, 35% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.29 (dd, J = 4.8, 2.8Hz, 1H), 7.15 – 7.14 (d, J = 1.8 Hz, 1H), 7.04 (d, J = 4.8 Hz, 1H), 3.71 (s, 3H), 3.67 (s, 2H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.7, 133.7, 128.6, 125.9, 123.0, 52.2, 35.8 ppm.

8. References.

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Org. Chem. **2021**, *86*, 16162-16170.
[5] Z. Huang, Y. Cheng, X. Chen, H.-F. Wang, C.-X. Du, Y. Li, *Chem. Commun.* **2018**, *54*, 3967-3970.
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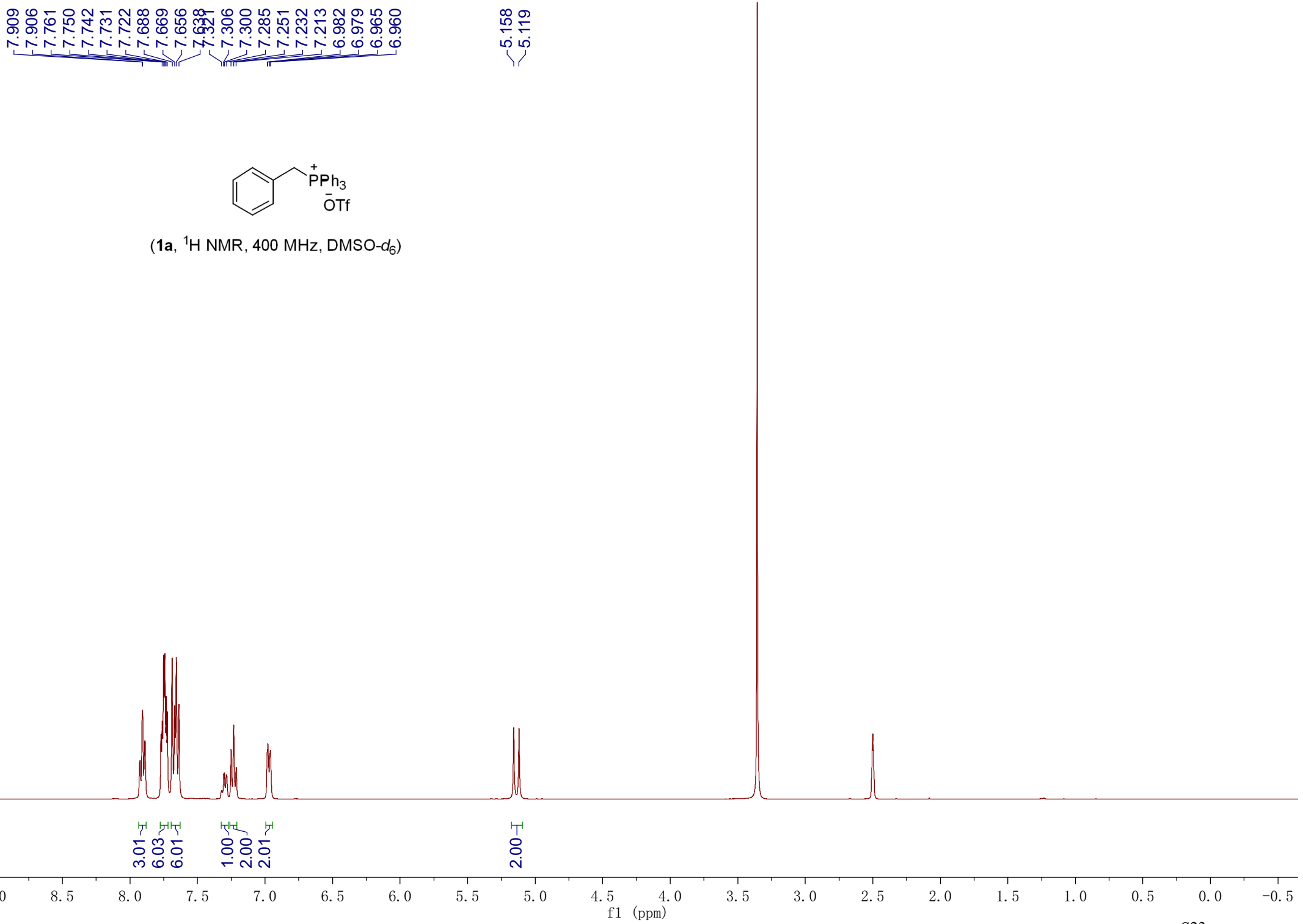
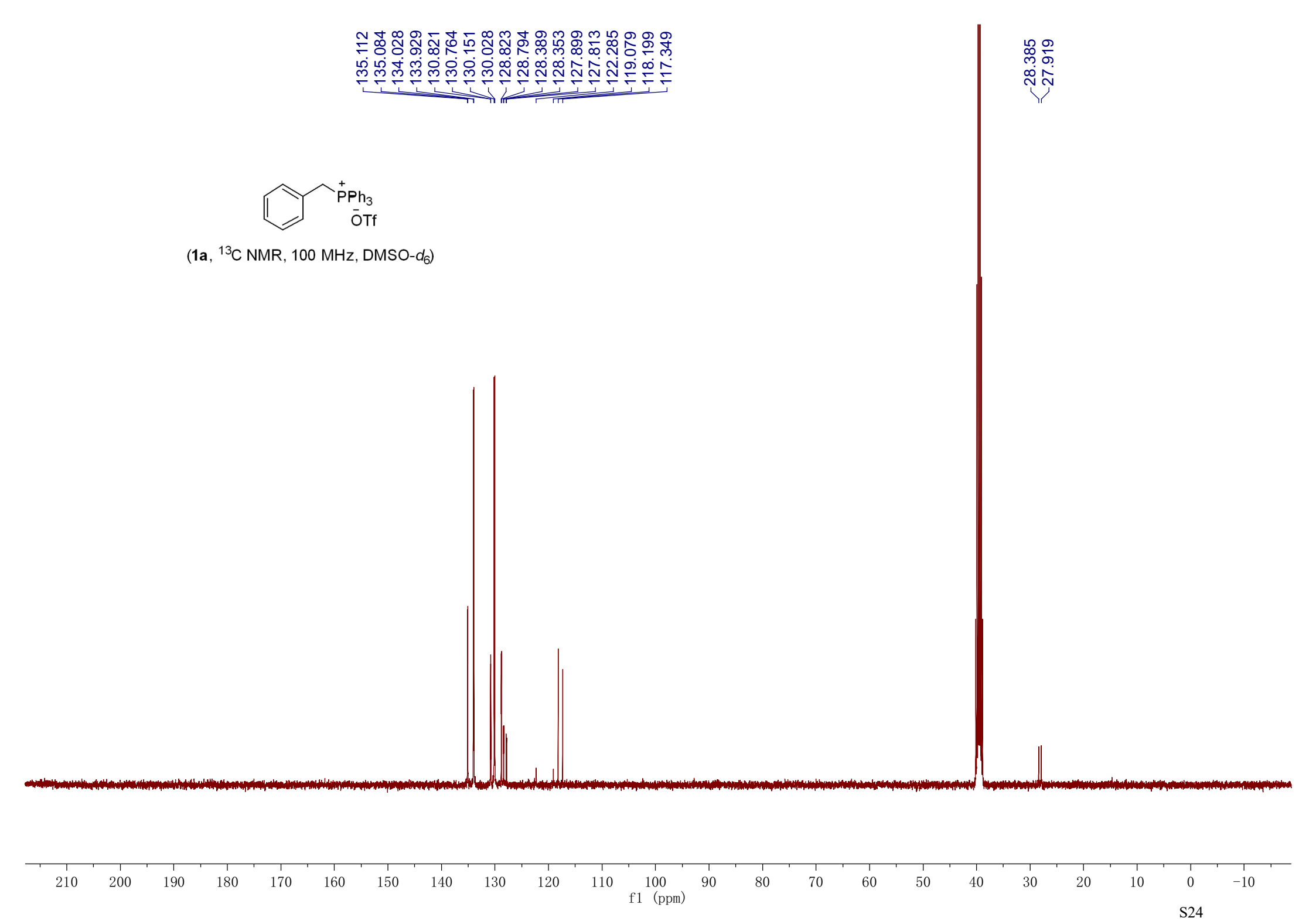
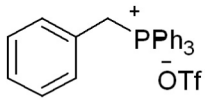
9. NMR Spectra of Coupled Products

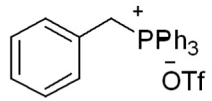


(**1a**, ^{1}H NMR, 400 MHz, DMSO-d_6)

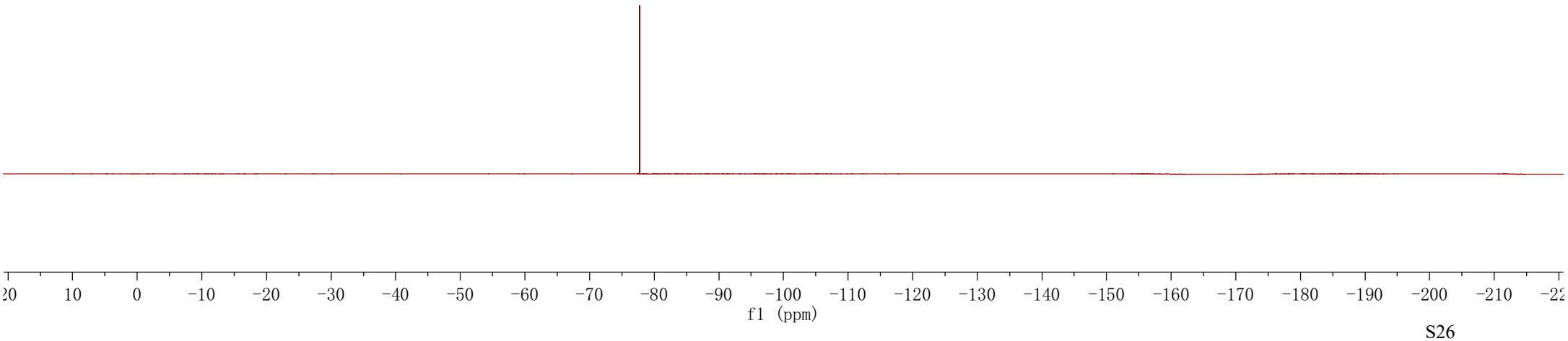

135.112
135.084
134.028
133.929
130.821
130.764
130.151
130.028
128.823
128.794
128.389
128.353
127.899
127.813
122.285
119.079
118.199
117.349
28.385
27.919
PPh3
OTf
(1a, 13C NMR, 100 MHz, DMSO-d6)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

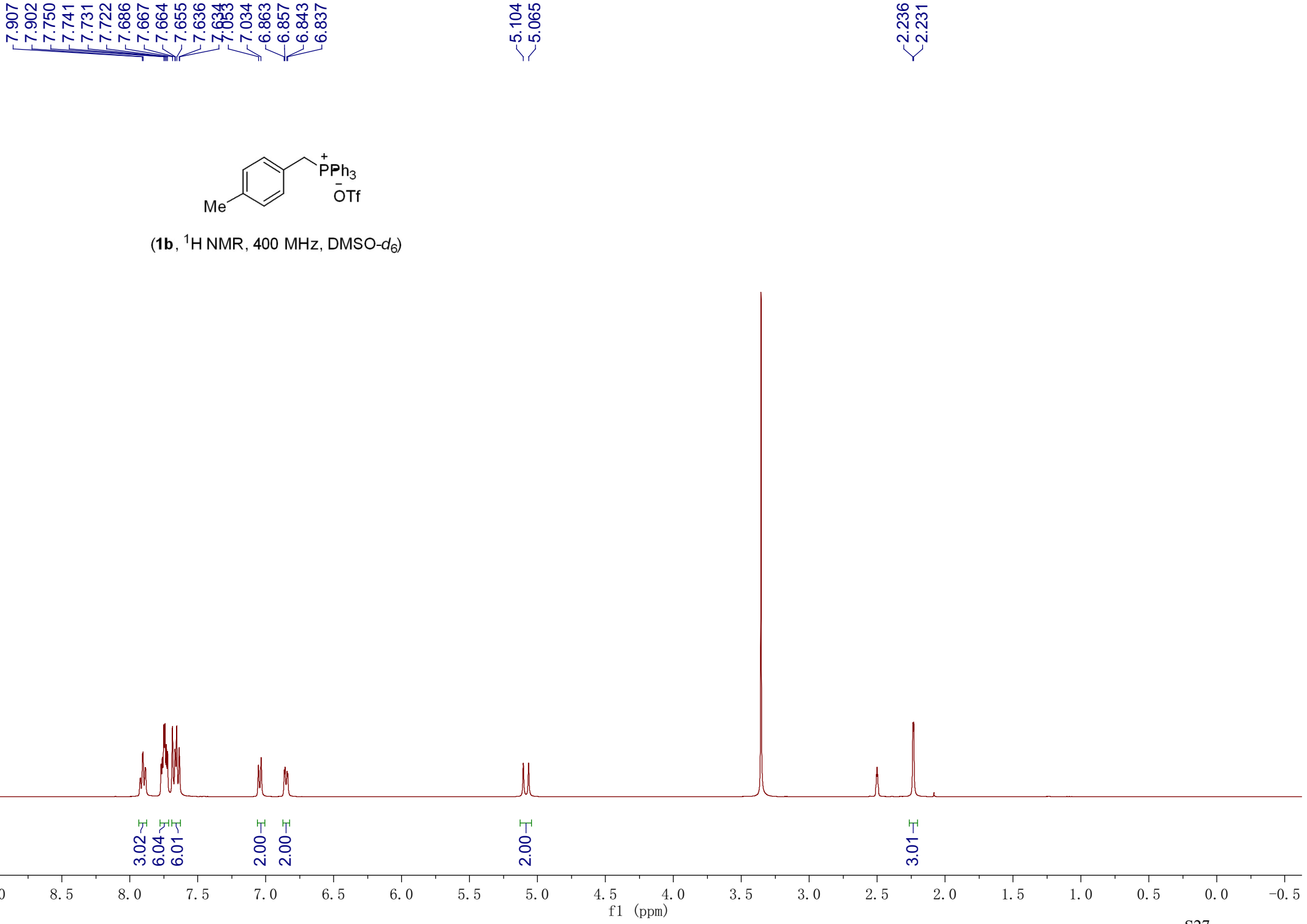


(**1a**, ^{31}P NMR, 162 MHz, DMSO-d_6)

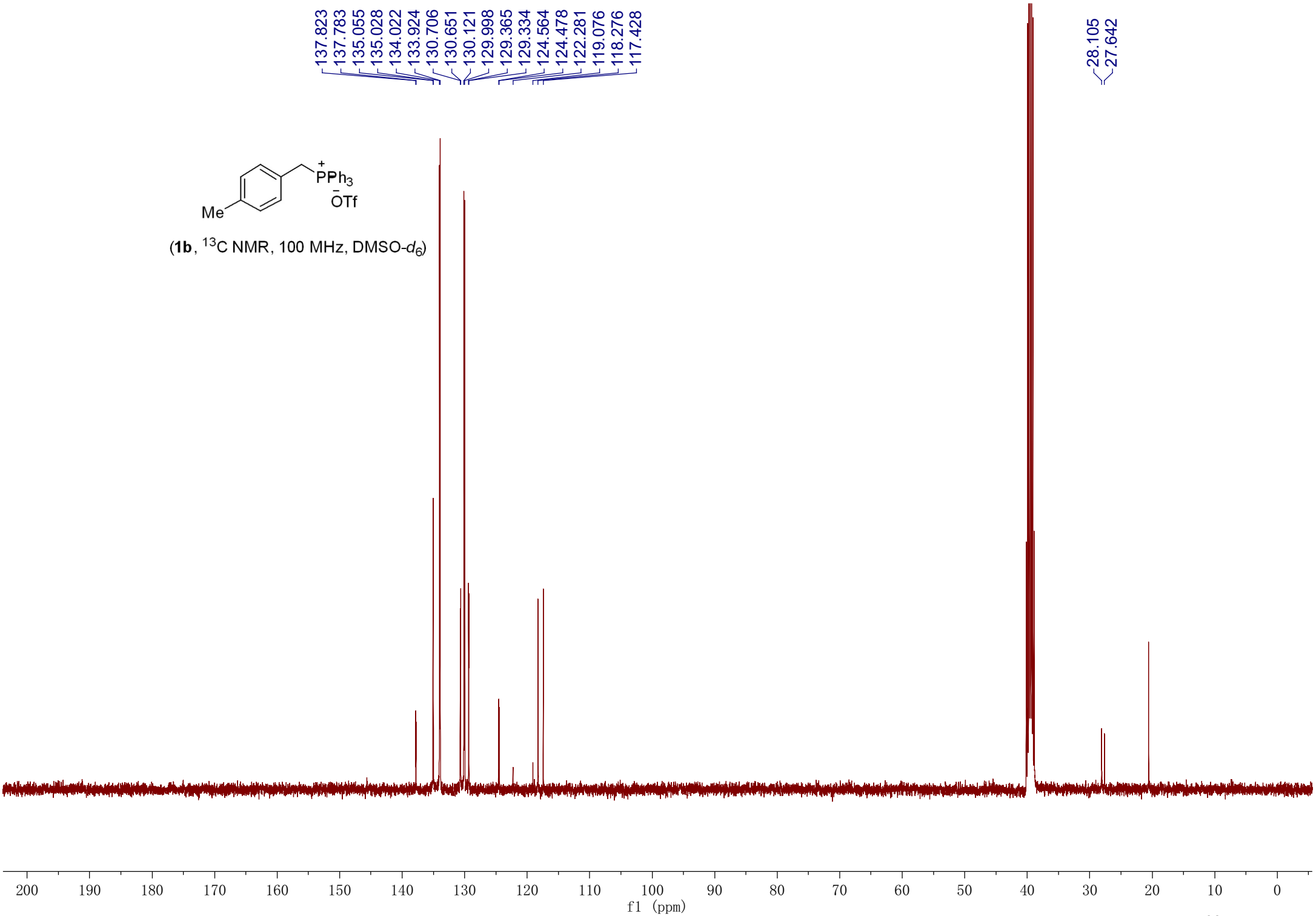


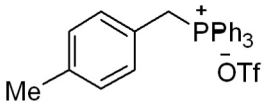
(**1a**, ^{19}F NMR, 376 MHz, DMSO-d_6)



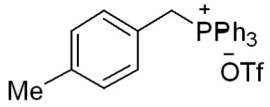


(**1b**, ^{1}H NMR, 400 MHz, DMSO-d_6)

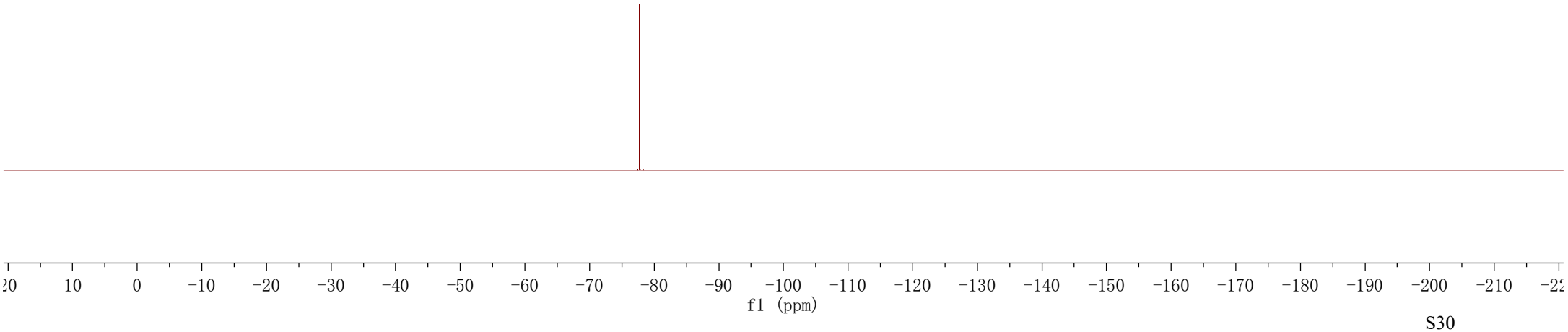

137.823
137.783
135.055
135.028
134.022
133.924
130.706
130.651
130.121
129.998
129.365
129.334
124.564
124.478
122.281
119.076
118.276
117.428
28.105
27.642
PPh3
OTf
Me
(1b, 13C NMR, 100 MHz, DMSO-d6)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

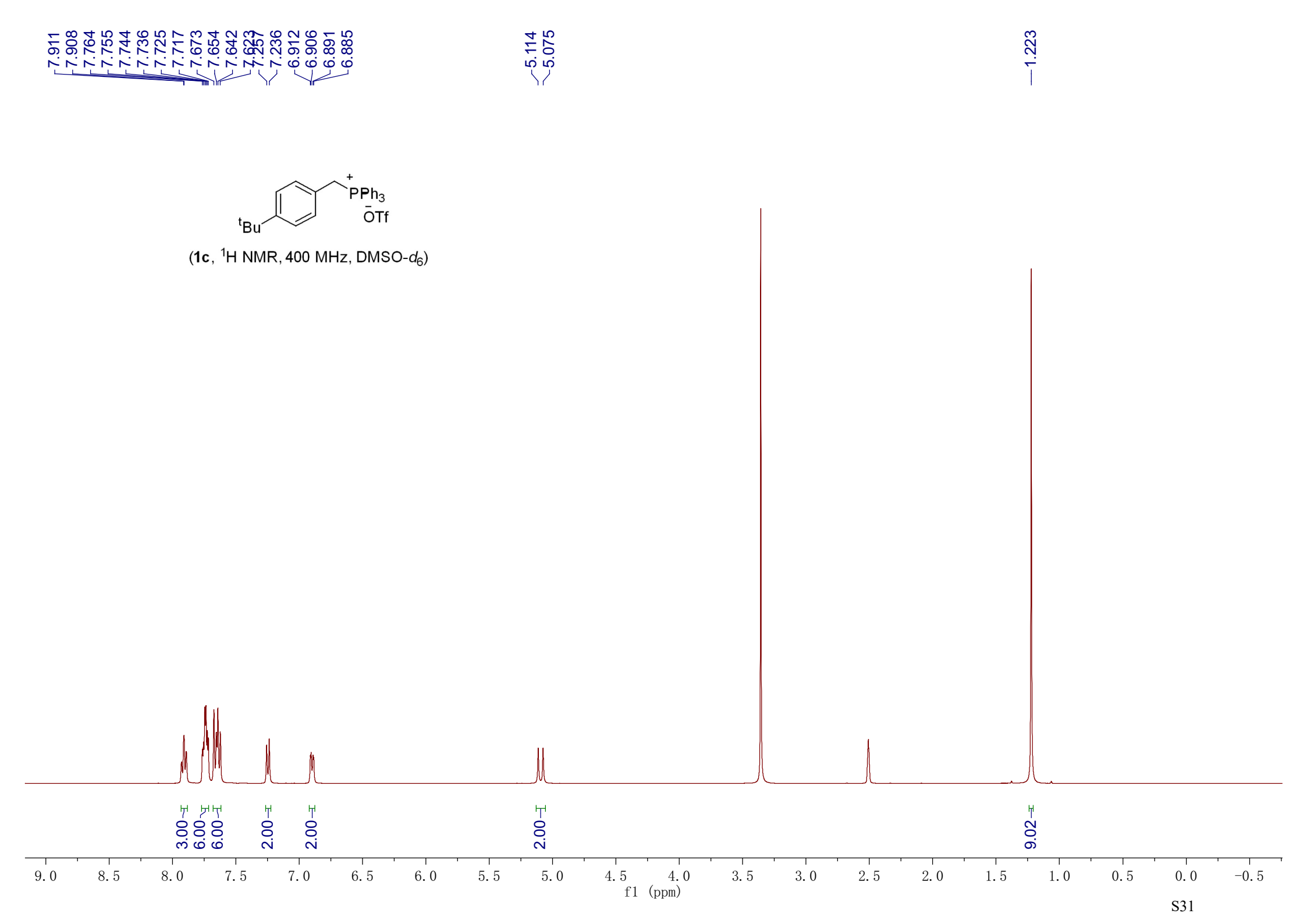


(**1b**, ^{31}P NMR 162 MHz, DMSO-d_6)

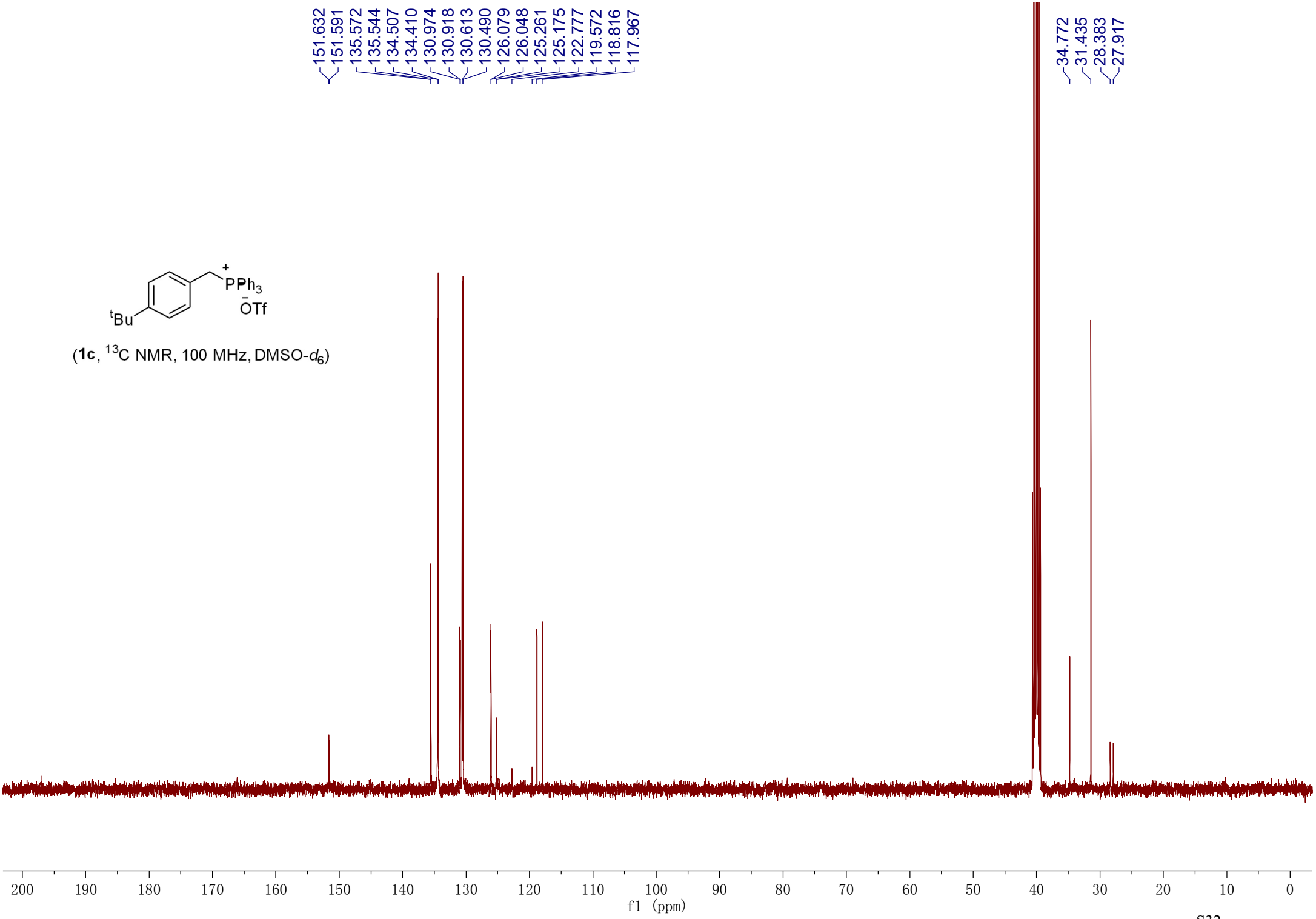


(**1b**, ^{19}F NMR, 376 MHz, DMSO-d_6)

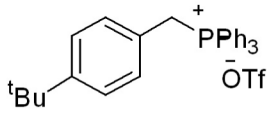




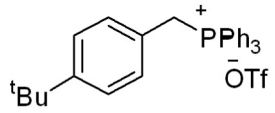
(**1c**, ^{1}H NMR, 400 MHz, DMSO-d_6)



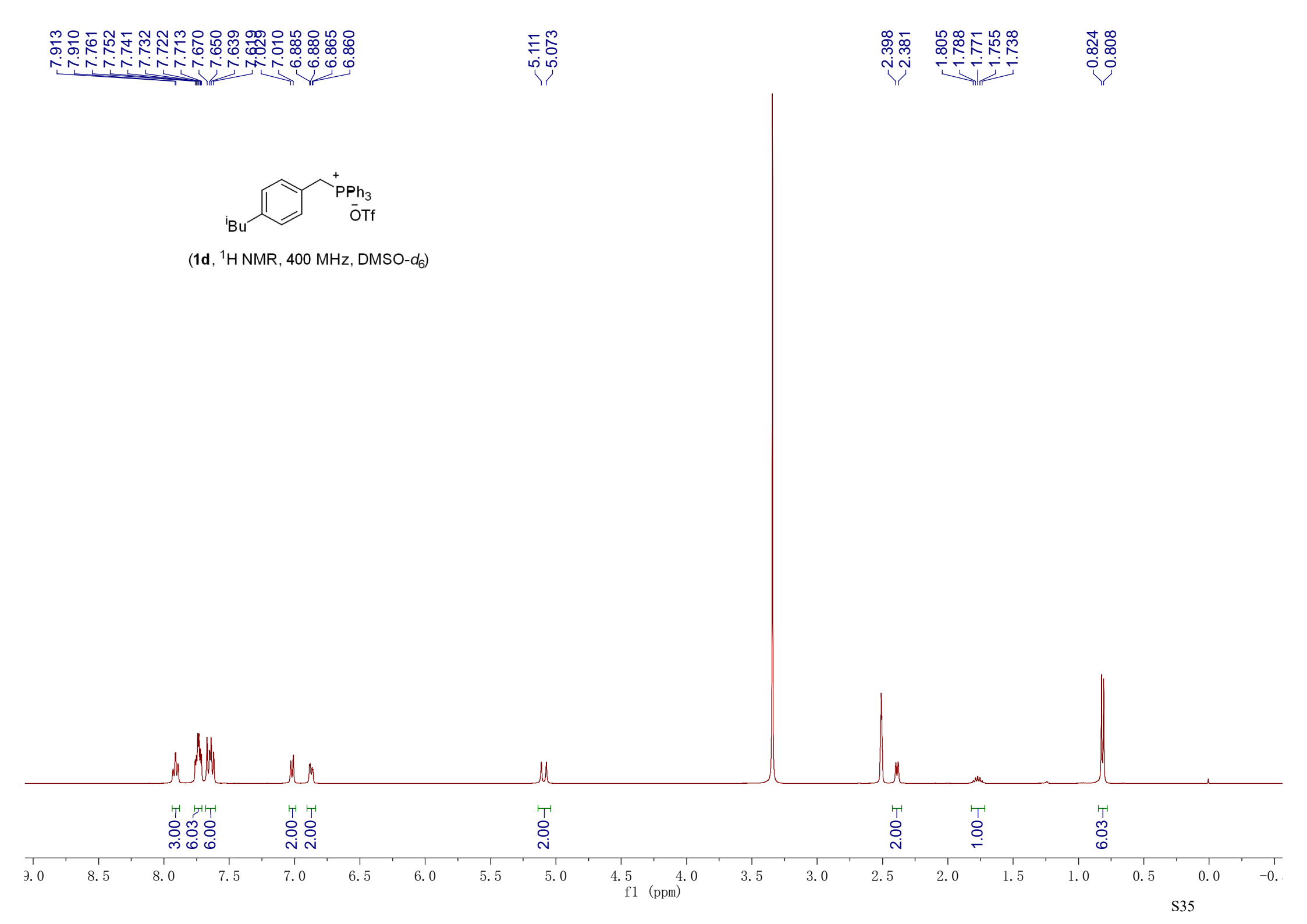
(**1c**, ^{13}C NMR, 100 MHz, DMSO-d_6)



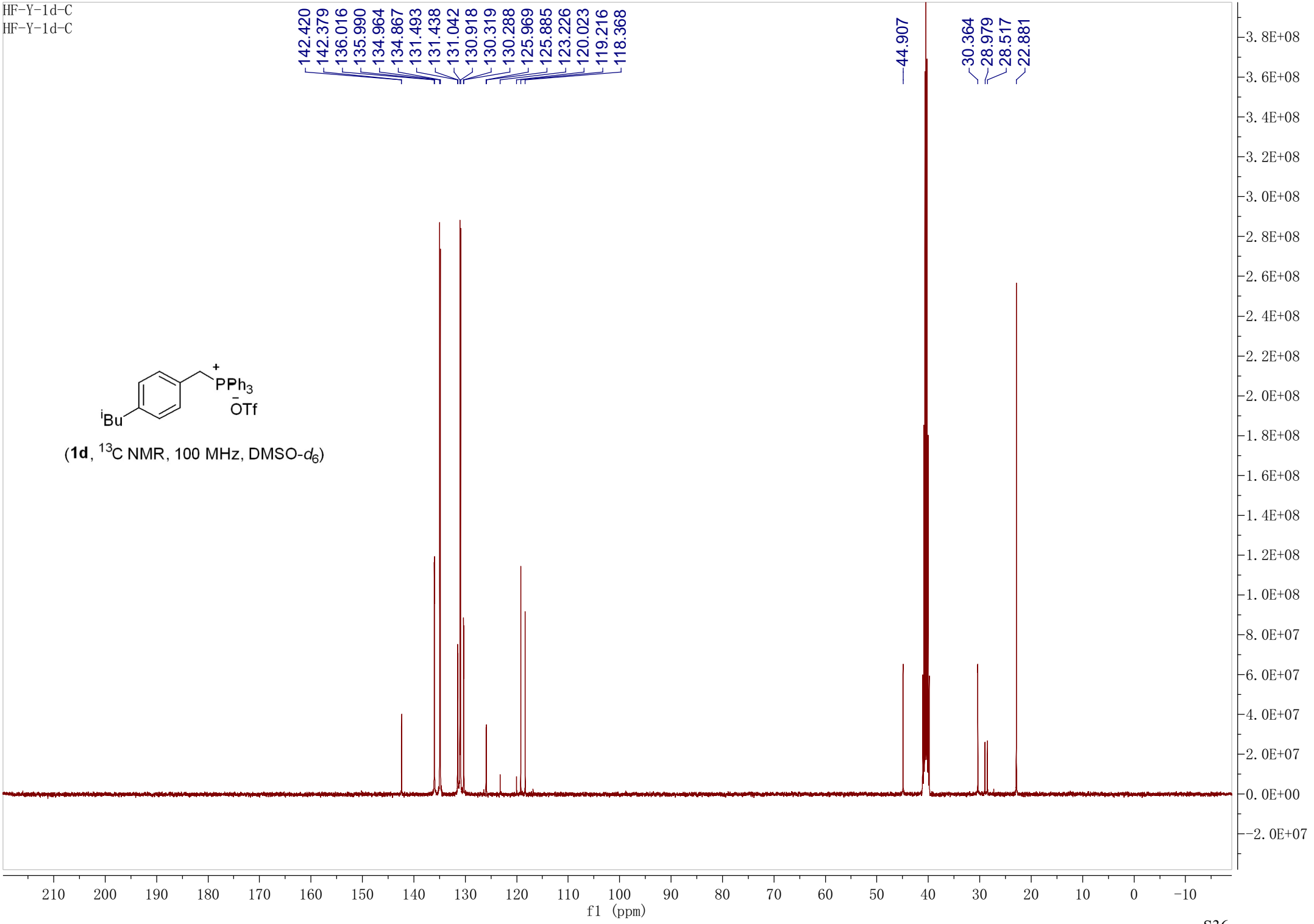
(**1c**, ^{31}P NMR, 162 MHz, DMSO-d_6)

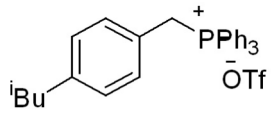


(**1c**, ^{19}F NMR, 376 MHz, DMSO-d_6)

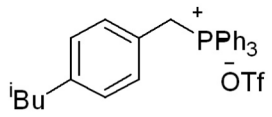


(**1d**, ^{1}H NMR, 400 MHz, DMSO-d_6)

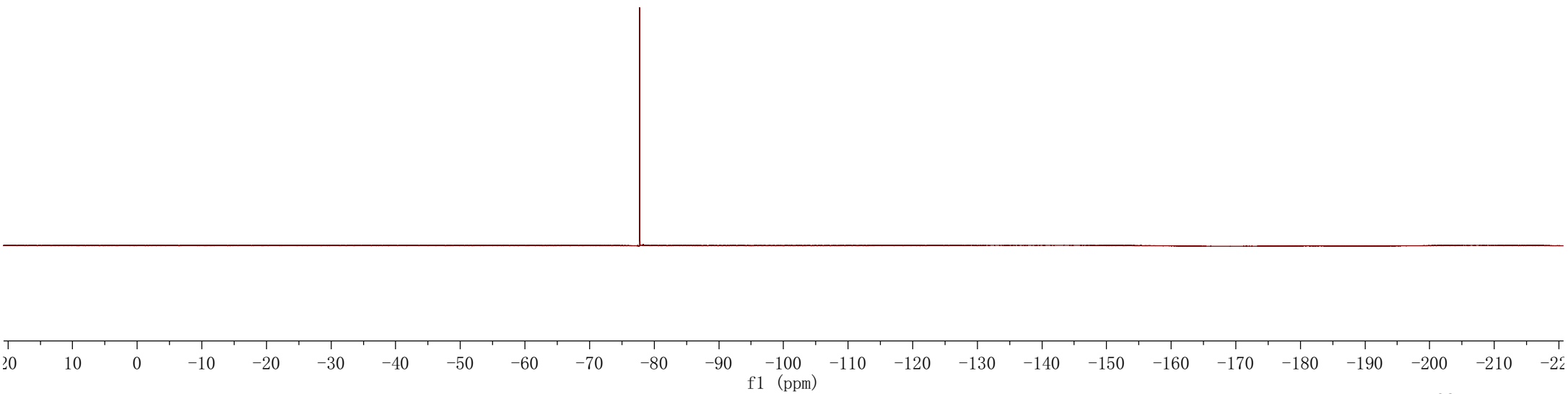

HF-Y-1d-C
HF-Y-1d-C
142.420
142.379
136.016
135.990
134.964
134.867
131.493
131.438
131.042
130.918
130.319
130.288
125.969
125.885
123.226
120.023
119.216
118.368
44.907
30.364
28.979
28.517
22.881
PPh3
OTf
iBu
(1d, 13C NMR, 100 MHz, DMSO-d6)
f1 (ppm)

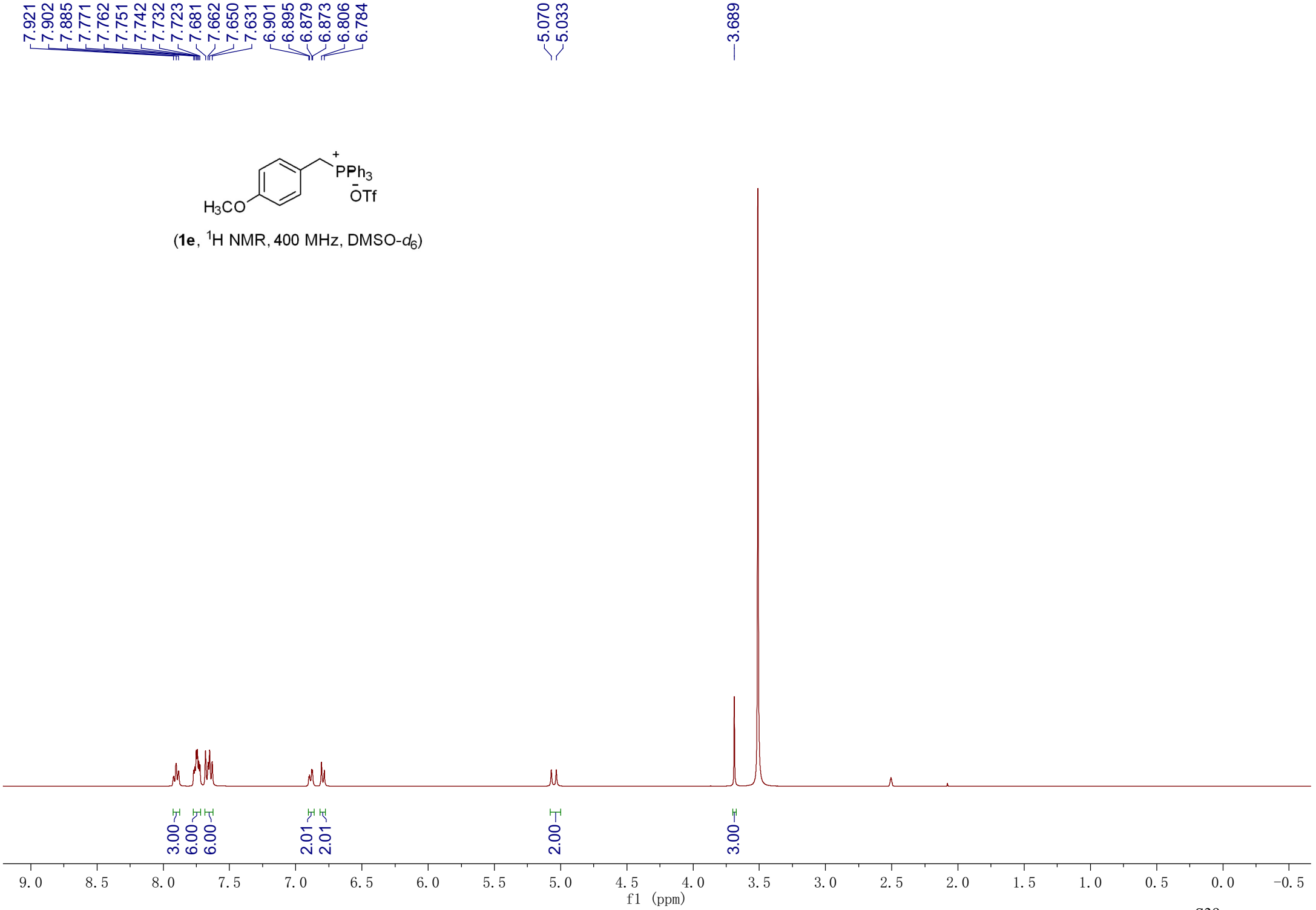


(**1d**, ^{31}P NMR, 162 MHz, DMSO-d_6)

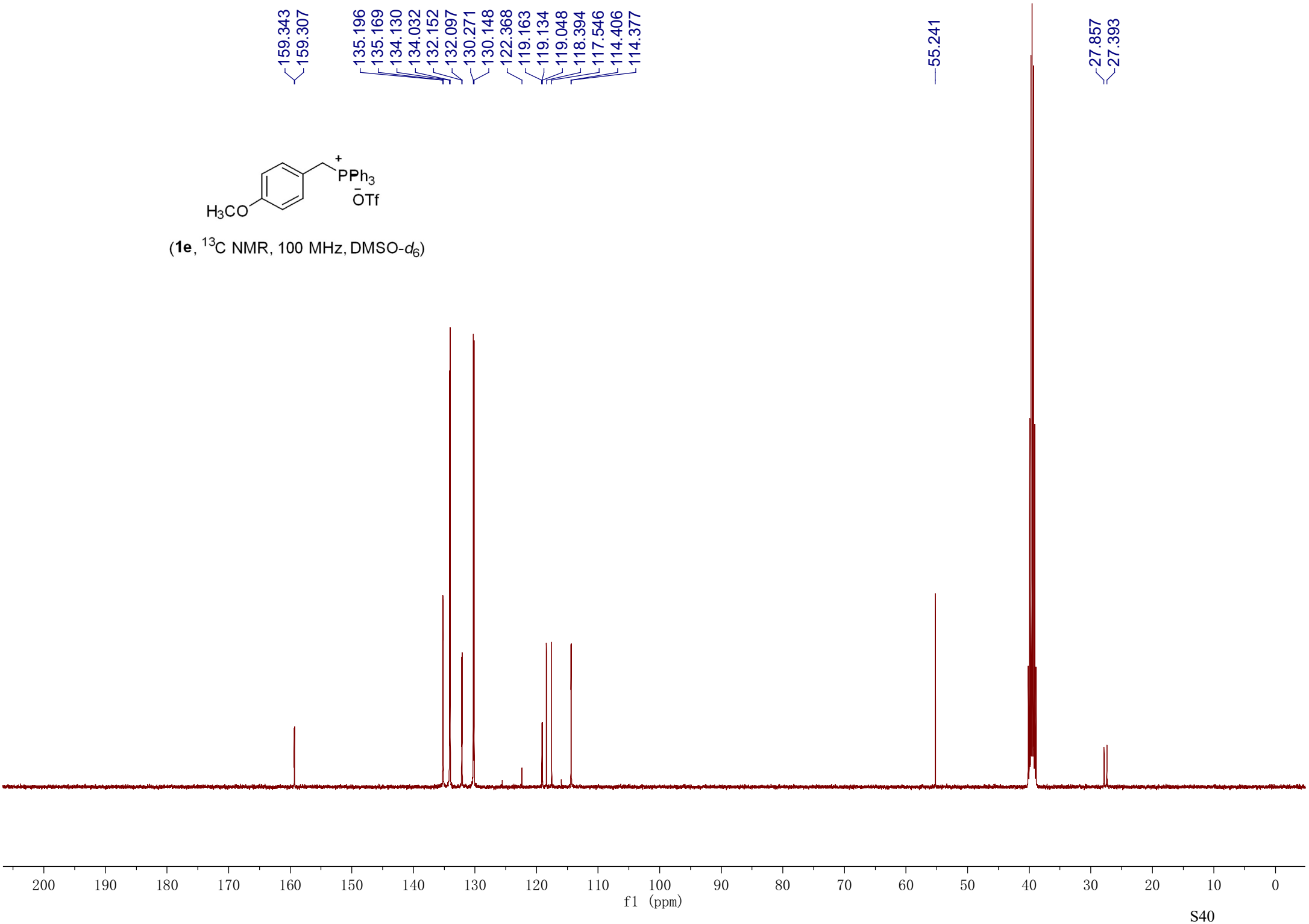


(**1d**, ^{19}F NMR, 376 MHz, DMSO-d_6)

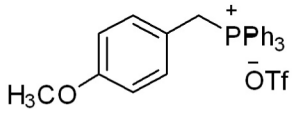




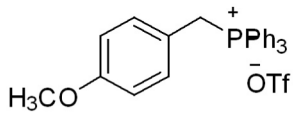
(**1e**, ^{1}H NMR, 400 MHz, DMSO-d_6)



(**1e**, ^{13}C NMR, 100 MHz, DMSO-d_6)

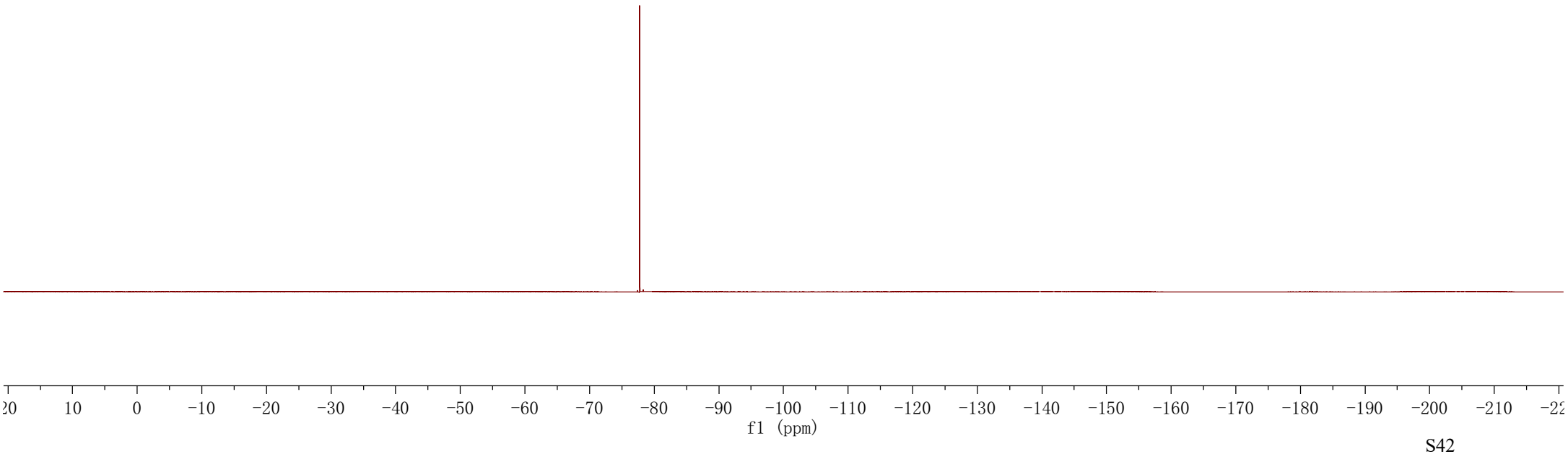


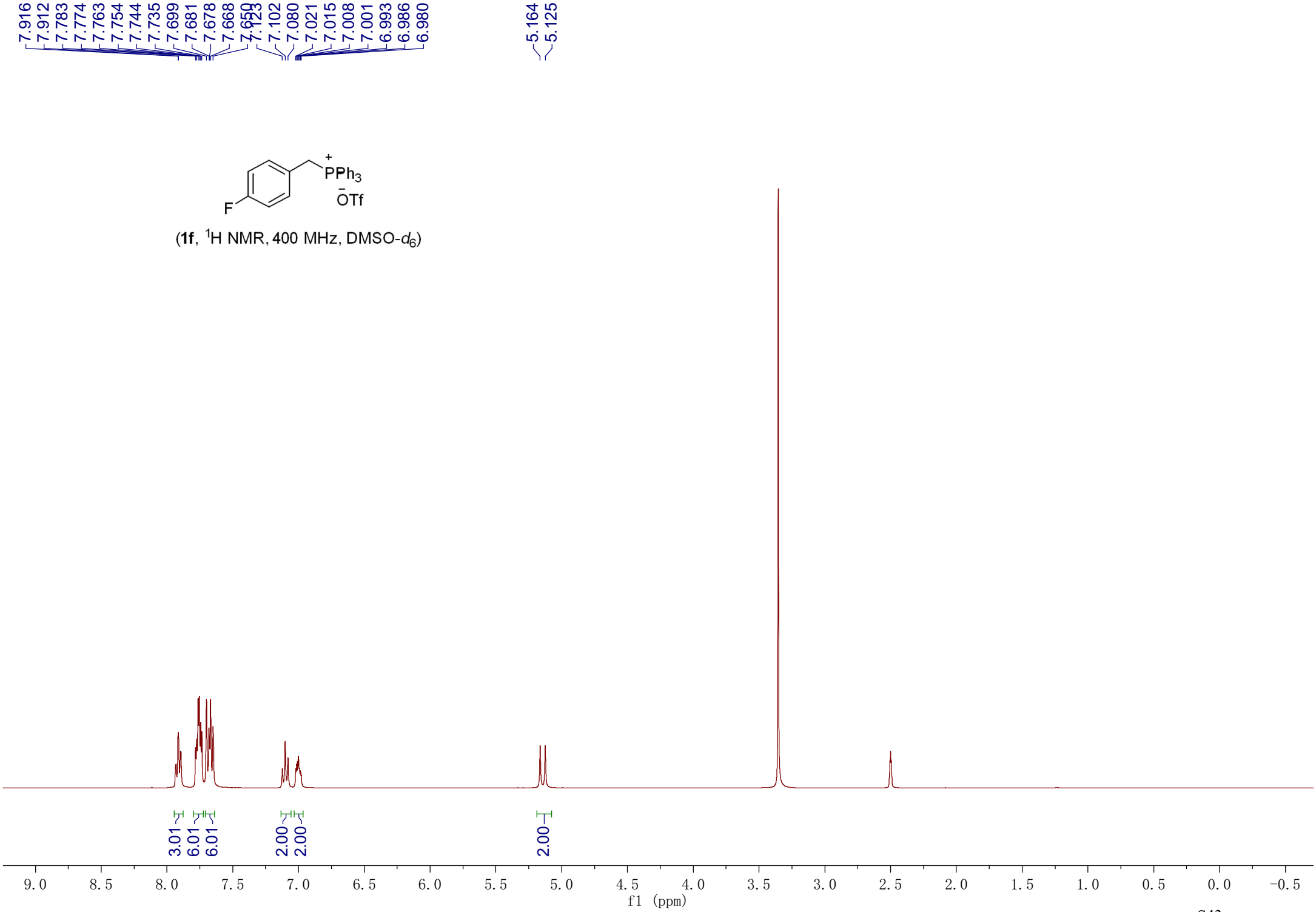
(**1e**, ^{31}P NMR, 162 MHz, DMSO-d_6)



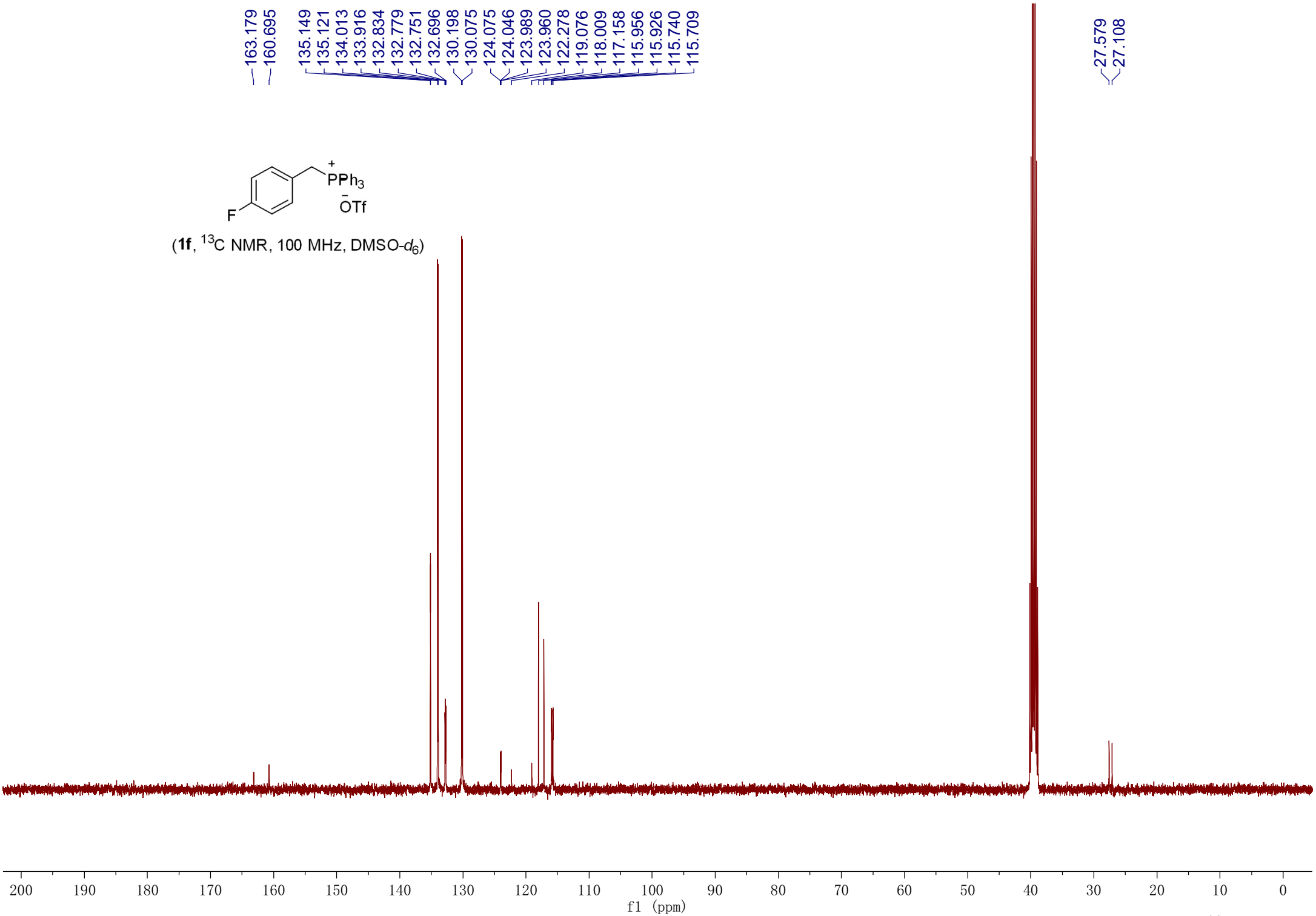
(**1e**, ^{19}F NMR, 376 MHz, DMSO-d_6)

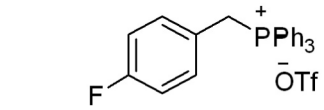
-77.741



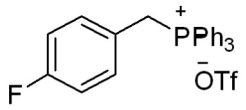


(**1f**, ^{1}H NMR, 400 MHz, DMSO-d_6)

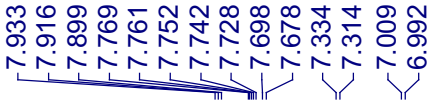

163.179
160.695
135.149
135.121
134.013
133.916
132.834
132.779
132.751
132.696
130.198
130.075
124.075
124.046
123.989
123.960
122.278
119.076
118.009
117.158
115.956
115.926
115.740
115.709
27.579
27.108
PPh3
OTf
F
(1f, 13C NMR, 100 MHz, DMSO-d6)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

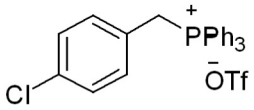


(**1f**, ^{31}P NMR, 162 MHz, DMSO-d_6)

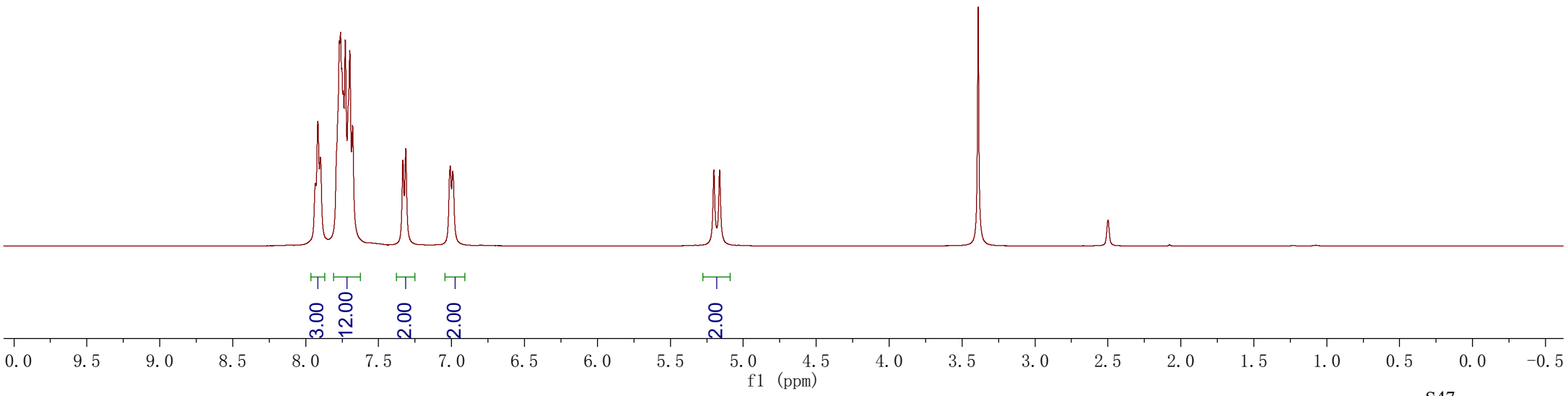


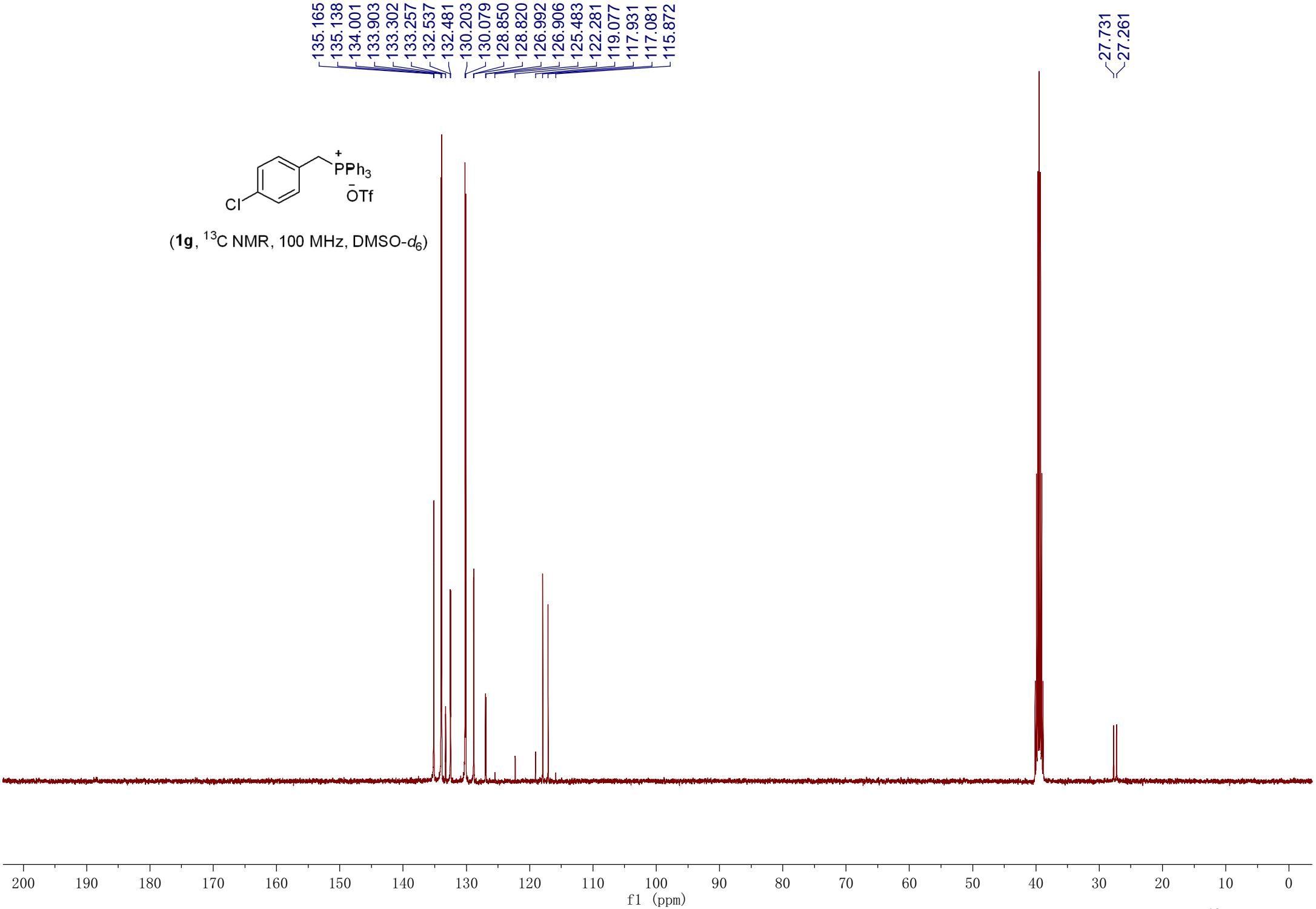
(**1f**, ^{19}F NMR, 376 MHz, DMSO-d_6)

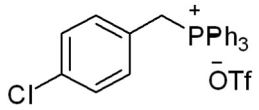




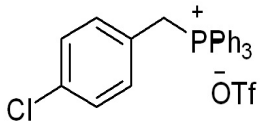
(**1g**, ^{1}H NMR, 400 MHz, DMSO-d_6)



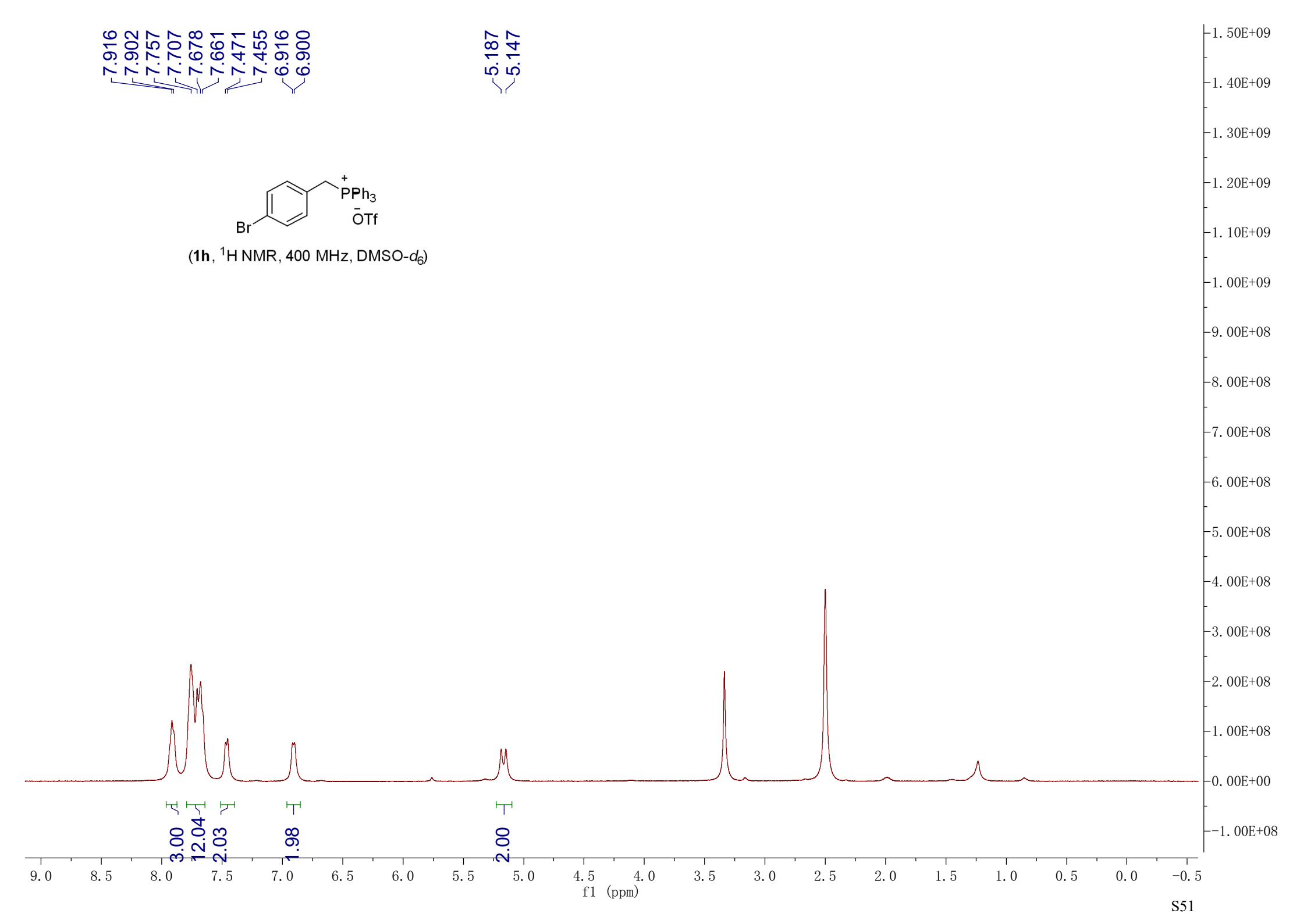

135.165
135.138
134.001
133.903
133.302
133.257
132.537
132.481
130.203
130.079
128.850
128.820
126.992
126.906
125.483
122.281
119.077
117.931
117.081
115.872
27.731
27.261
PPh3
OTf
Cl
(1g, 13C NMR, 100 MHz, DMSO-d6)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

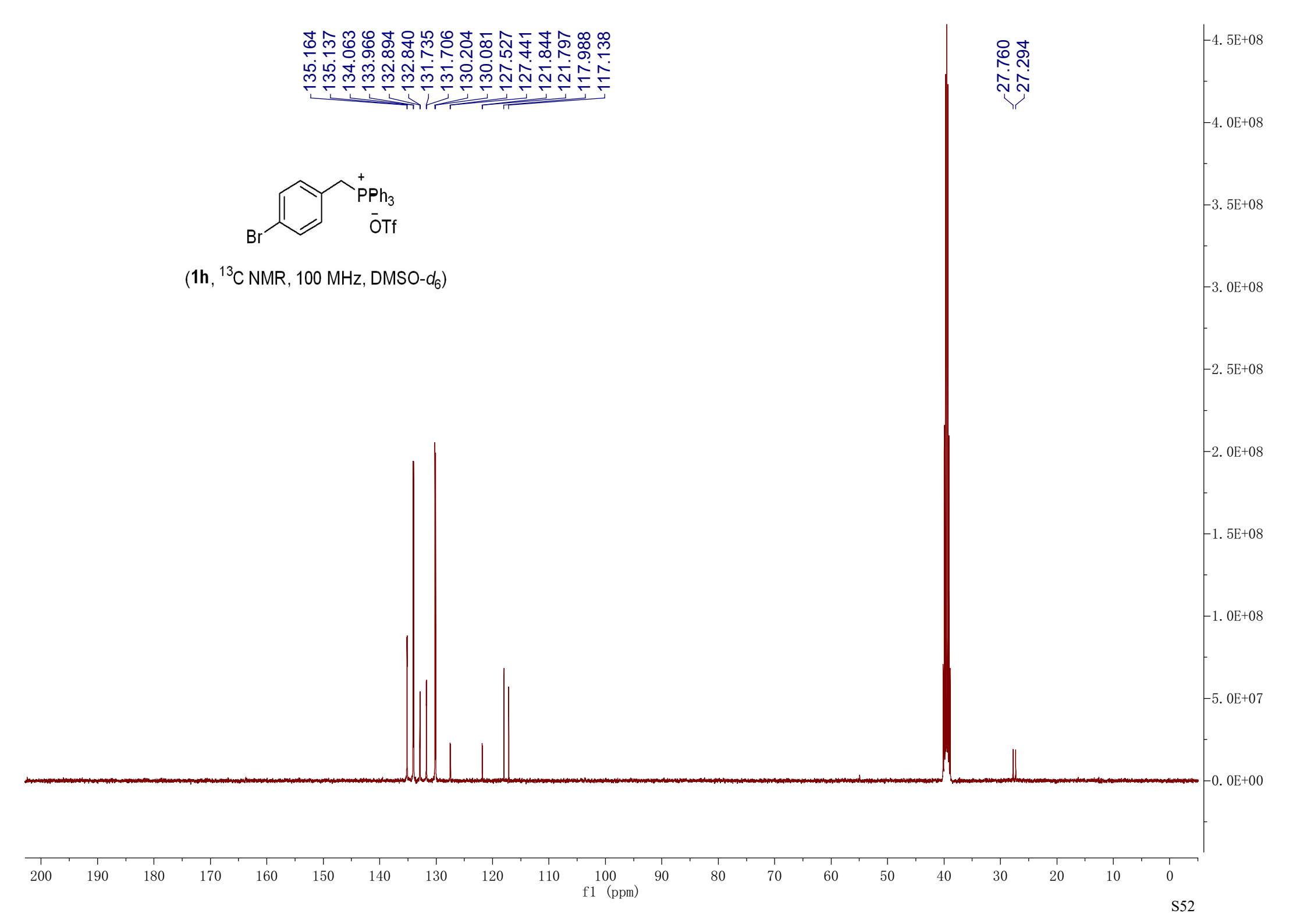


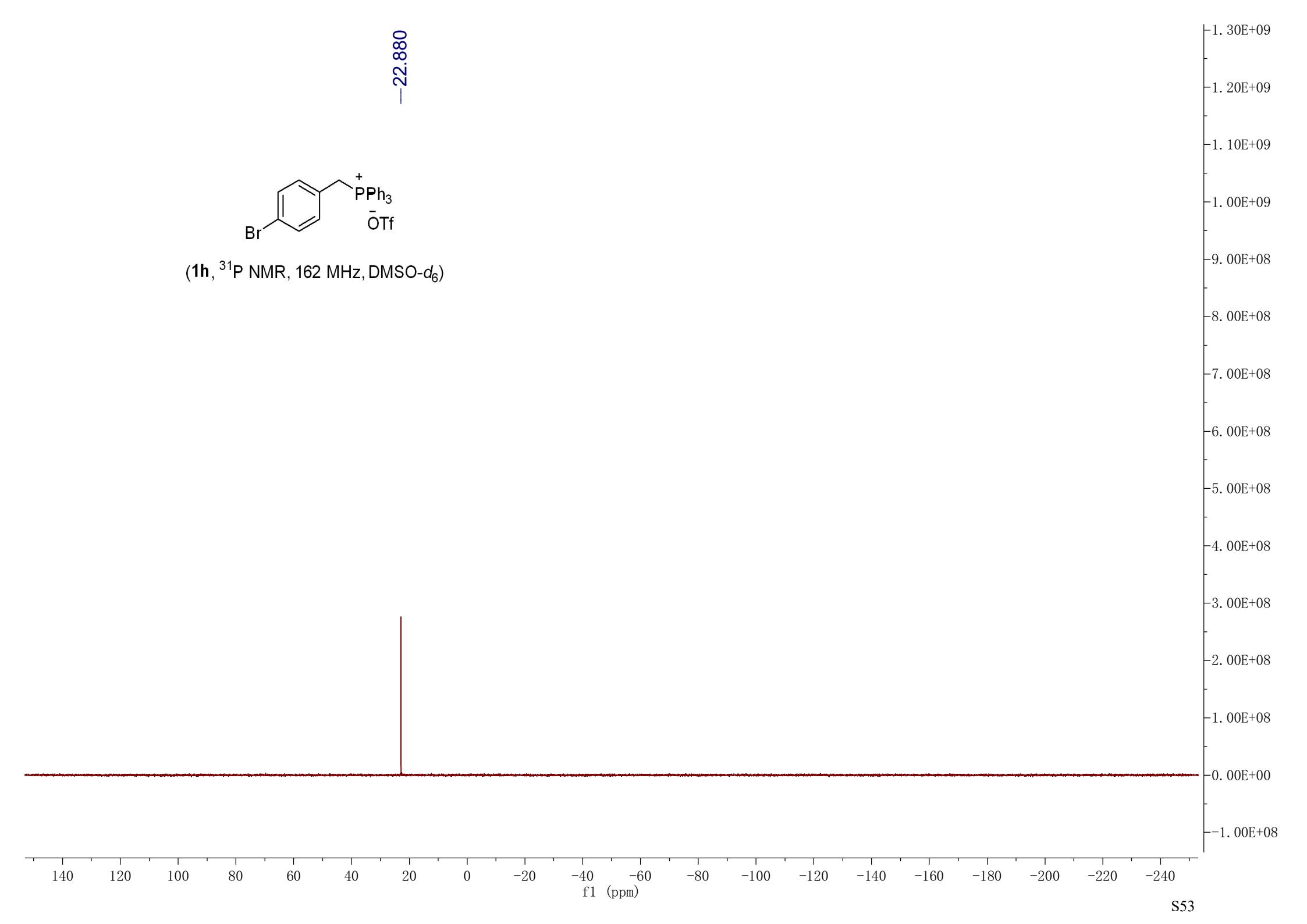
(**1g**, ^{31}P NMR, 162 MHz, DMSO-d_6)

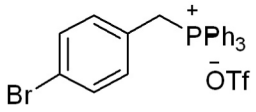


(**1g**, ^{19}F NMR, 376 MHz, DMSO-d_6)

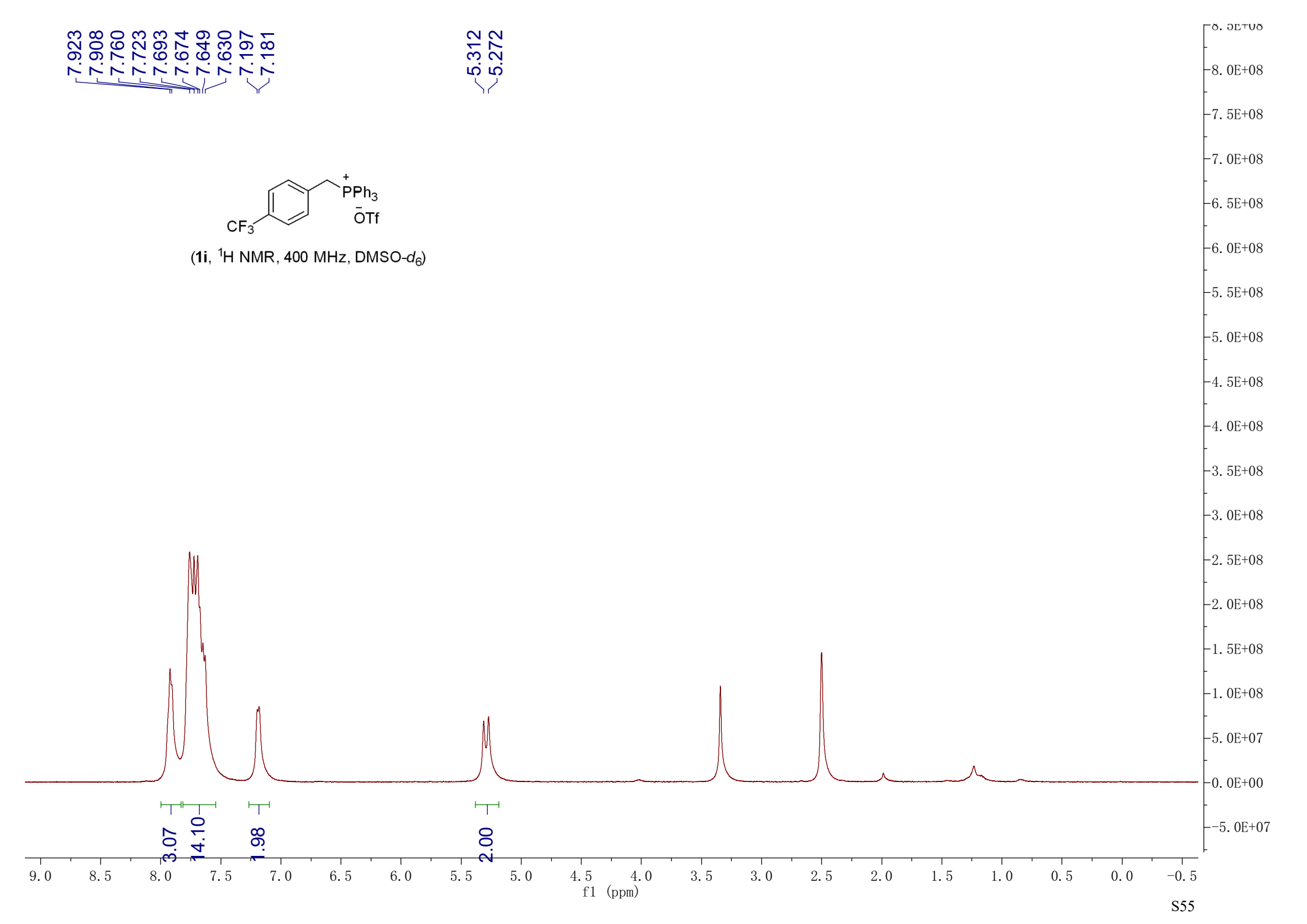

7.916
7.902
7.757
7.707
7.678
7.661
7.471
7.455
6.916
6.900
5.187
5.147
PPh3
OTf
Br
(1h, 1H NMR, 400 MHz, DMSO-d6)
3.00
12.04
2.03
1.98
2.00
f1 (ppm)


135.164
135.137
134.063
133.966
132.894
132.840
131.735
131.706
130.204
130.081
127.527
127.441
121.844
121.797
117.988
117.138
27.760
27.294
PPh3
OTf
Br
(1h, 13C NMR, 100 MHz, DMSO-d6)
4.5E+08
4.0E+08
3.5E+08
3.0E+08
2.5E+08
2.0E+08
1.5E+08
1.0E+08
5.0E+07
0.0E+00
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

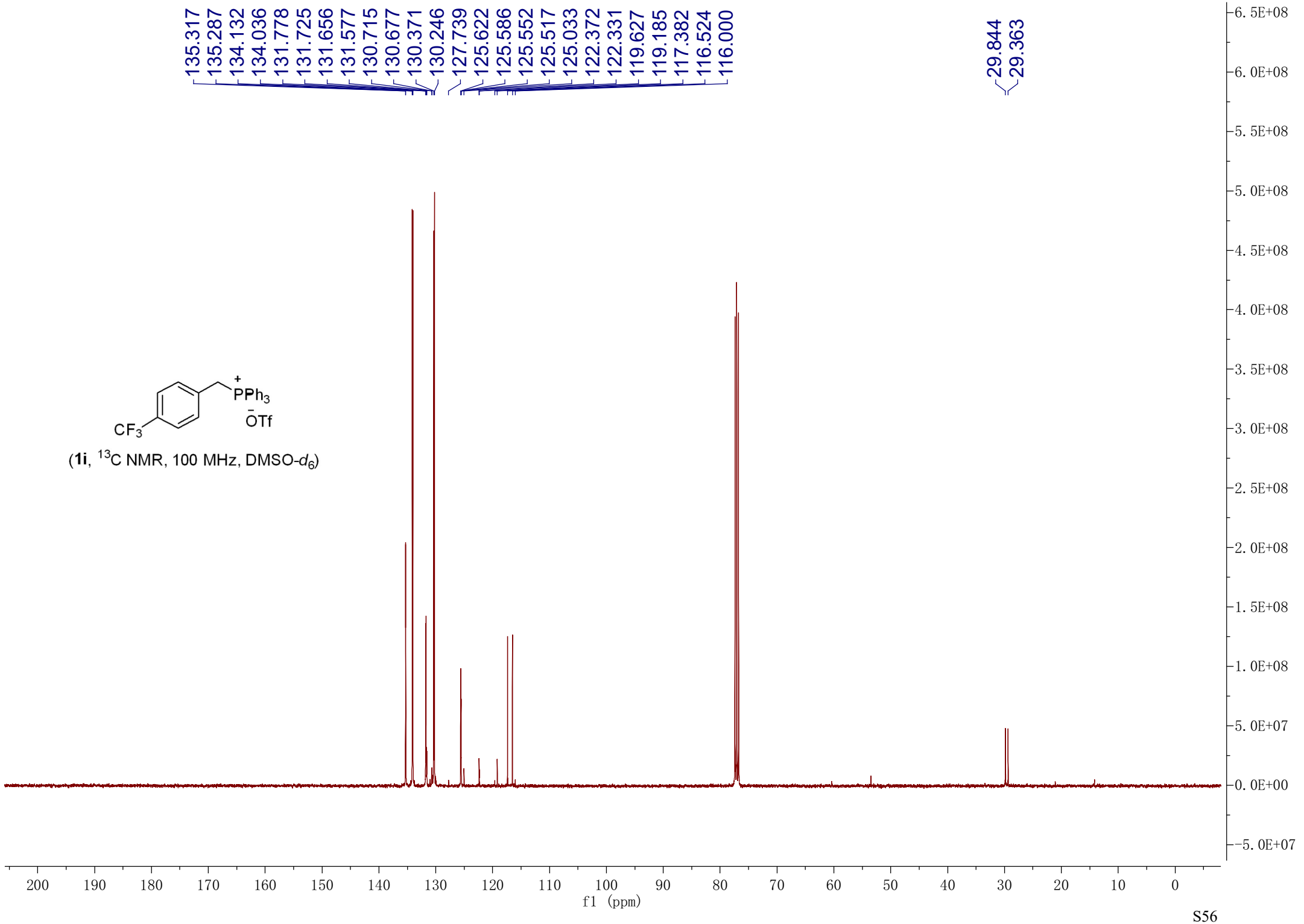

22.880
Br
PPh3
OTf
(1h, 31P NMR, 162 MHz, DMSO-d6)
1.30E+09
1.20E+09
1.10E+09
1.00E+09
9.00E+08
8.00E+08
7.00E+08
6.00E+08
5.00E+08
4.00E+08
3.00E+08
2.00E+08
1.00E+08
0.00E+00
-1.00E+08
140 120 100 80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240
f1 (ppm)



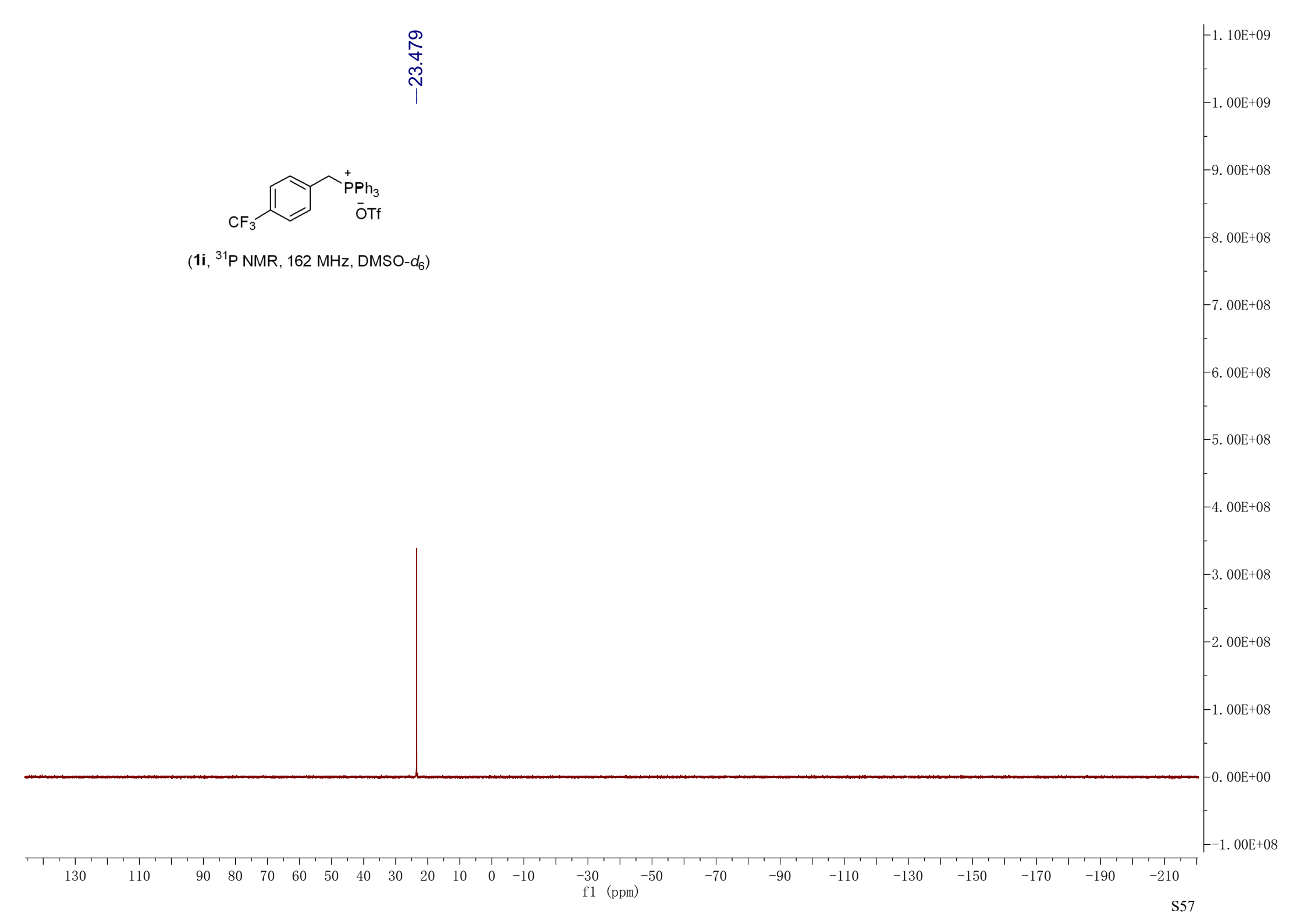
(**1h**, ^{19}F NMR, 376 MHz, DMSO-d_6)

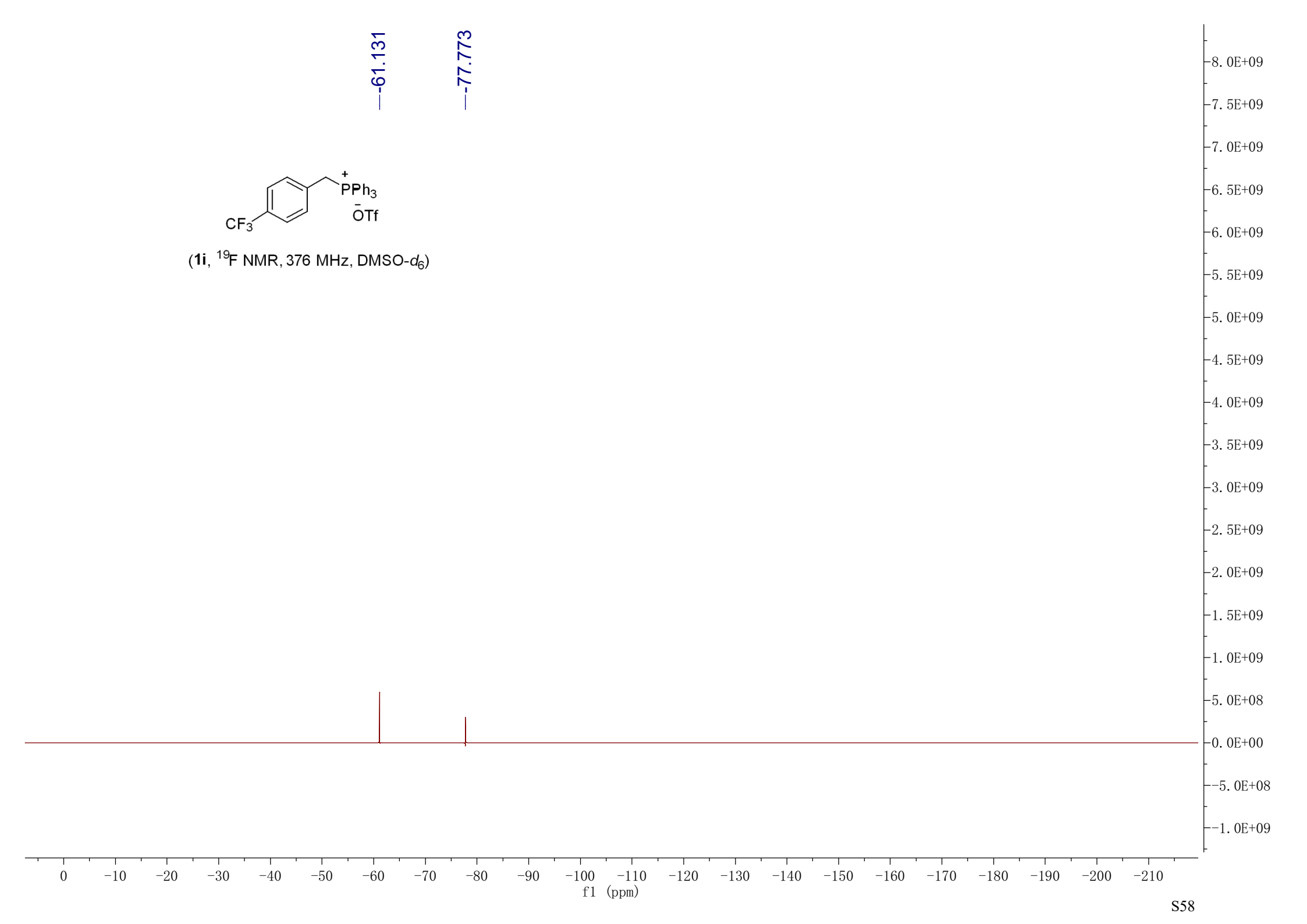


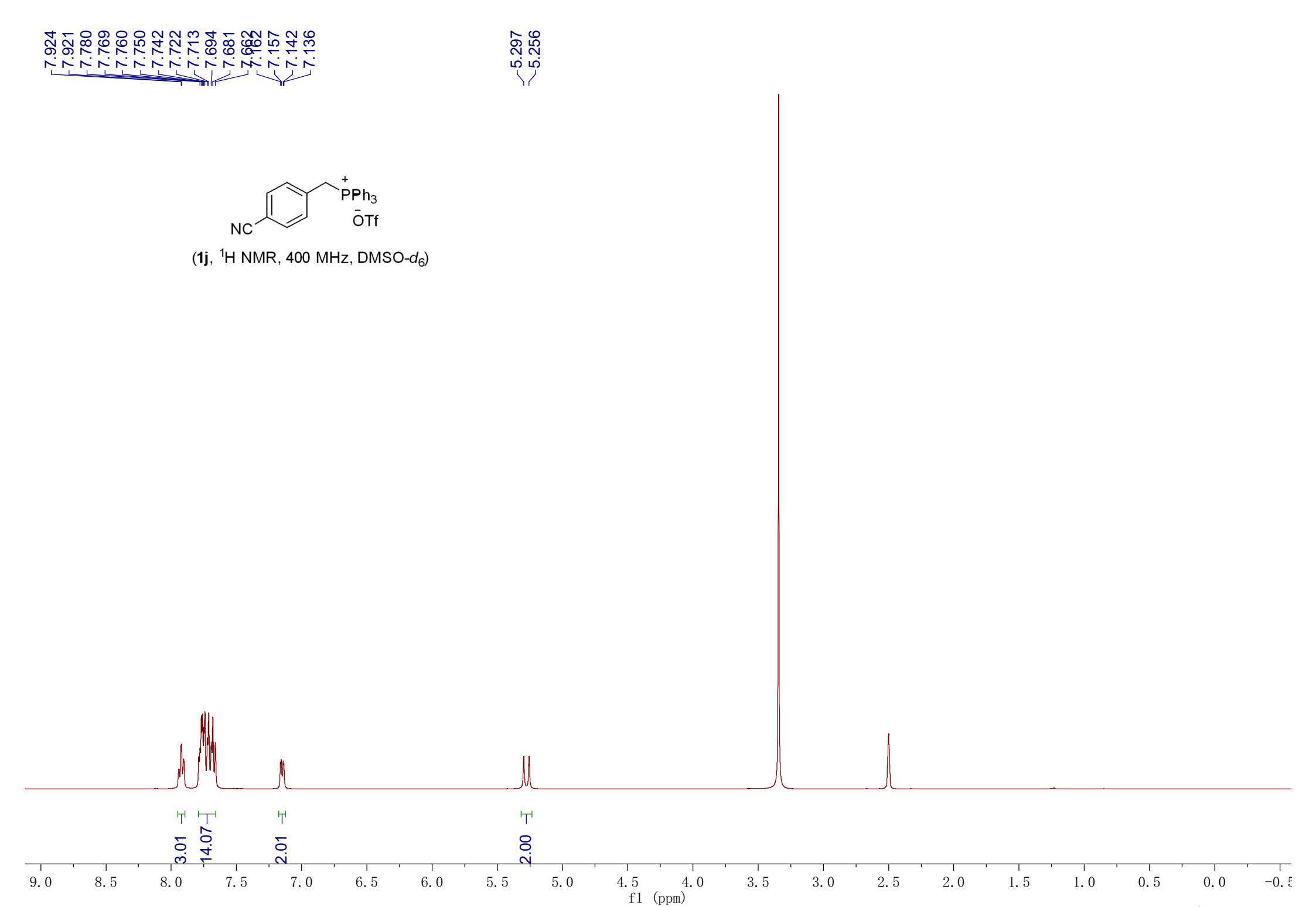
(**1i**, ^{1}H NMR, 400 MHz, DMSO-d_6)



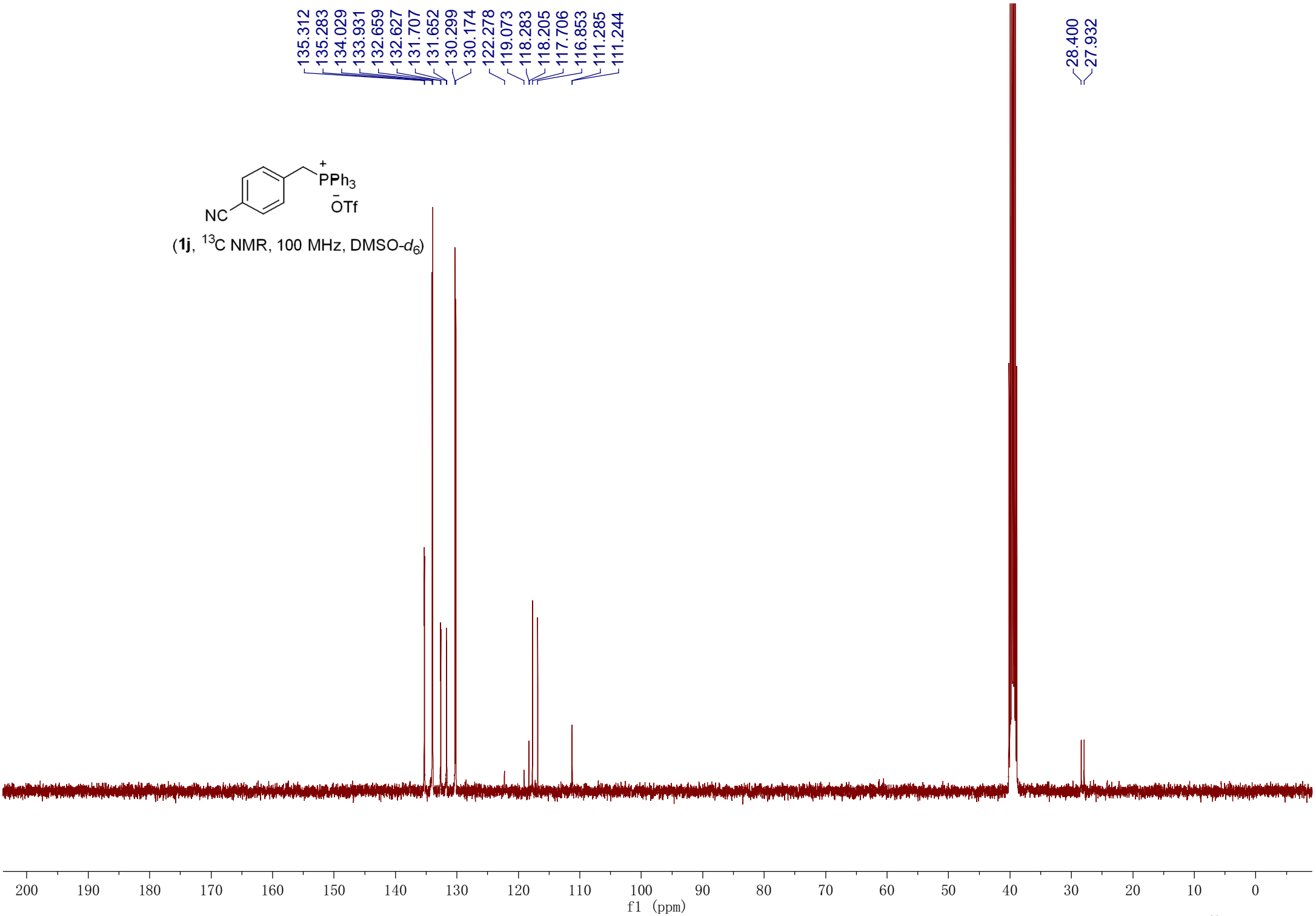
(**1i**, ^{13}C NMR, 100 MHz, DMSO-d_6)

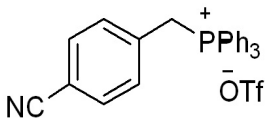

23.479
PPh3
OTf
CF3
(1i, 31P NMR, 162 MHz, DMSO-d6)
1.10E+09
1.00E+09
9.00E+08
8.00E+08
7.00E+08
6.00E+08
5.00E+08
4.00E+08
3.00E+08
2.00E+08
1.00E+08
0.00E+00
-1.00E+08
130 110 90 80 70 60 50 40 30 20 10 0 -10 -30 -50 -70 -90 -110 -130 -150 -170 -190 -210
f1 (ppm)


-61.131
-77.773
PPh3
OTf
CF3
(1i, 19F NMR, 376 MHz, DMSO-d6)
8.0E+09
7.5E+09
7.0E+09
6.5E+09
6.0E+09
5.5E+09
5.0E+09
4.5E+09
4.0E+09
3.5E+09
3.0E+09
2.5E+09
2.0E+09
1.5E+09
1.0E+09
5.0E+08
0.0E+00
-5.0E+08
-1.0E+09
0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)

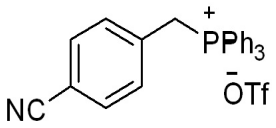


(**1j**, ^{1}H NMR, 400 MHz, DMSO-d_6)


135.312
135.283
134.029
133.931
132.659
132.627
131.707
131.652
130.299
130.174
122.278
119.073
118.283
118.205
117.706
116.853
111.285
111.244
28.400
27.932
NC
PPh3
OTf
(1j, 13C NMR, 100 MHz, DMSO-d6)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)



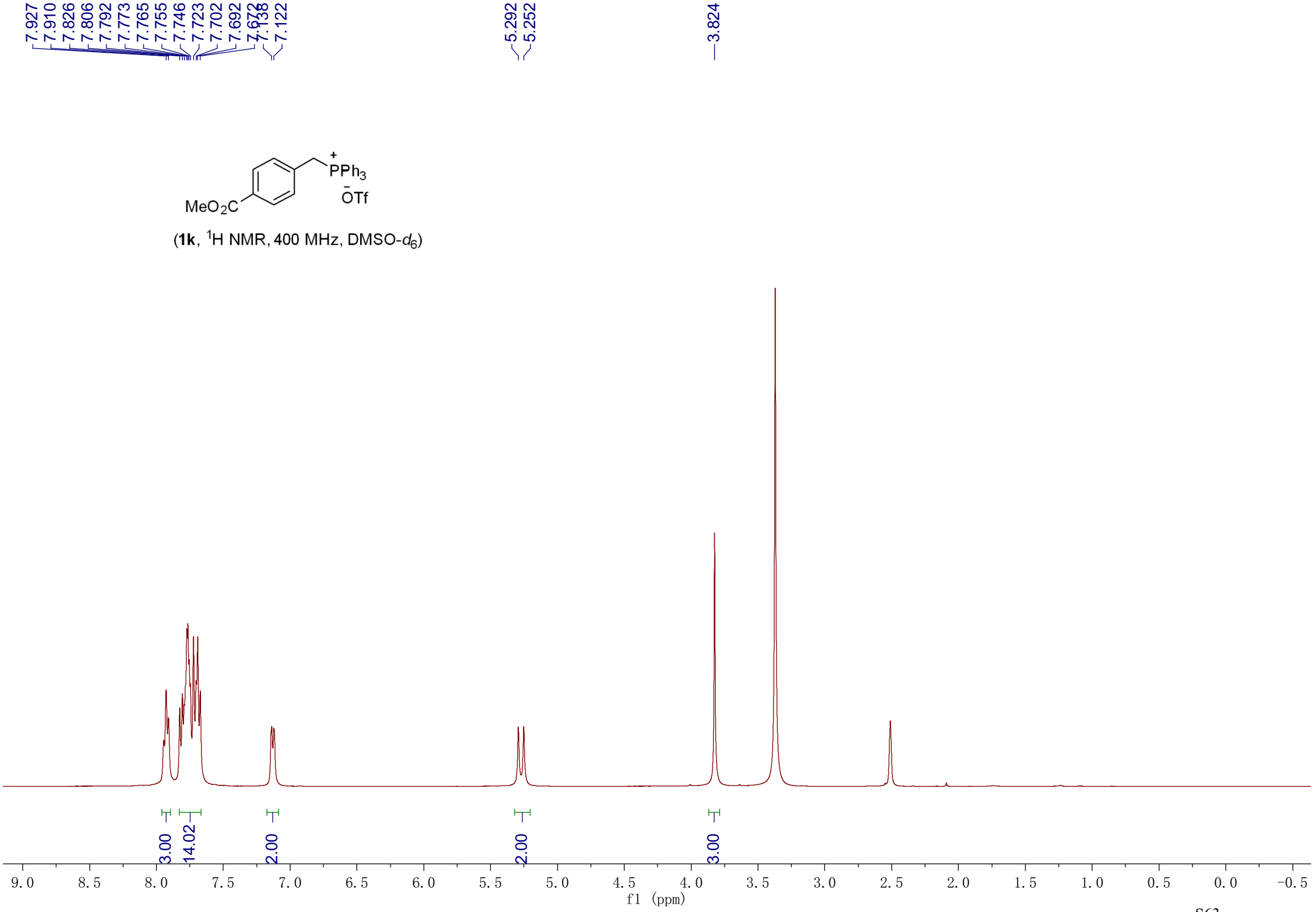
(**1j**, ^{31}P NMR, 162 MHz, DMSO-d_6)



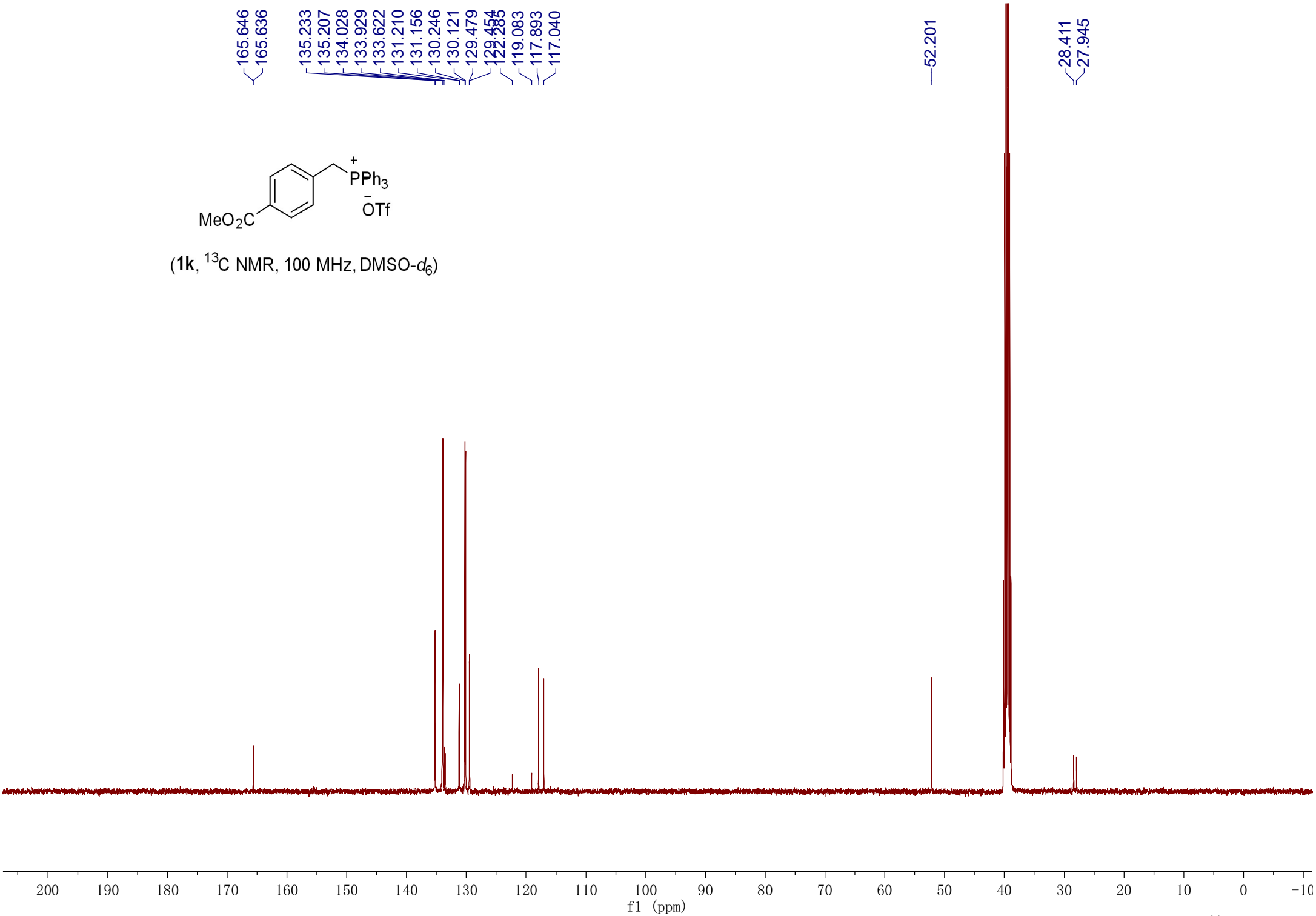
(**1j**, ^{19}F NMR, 376 MHz, DMSO-d_6)

-77.736

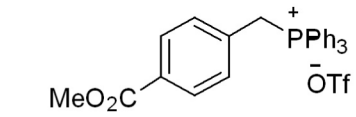
f1 (ppm)



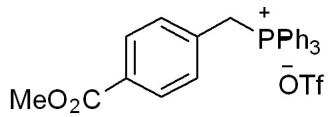
(**1k**, ^{1}H NMR, 400 MHz, DMSO-d_6)



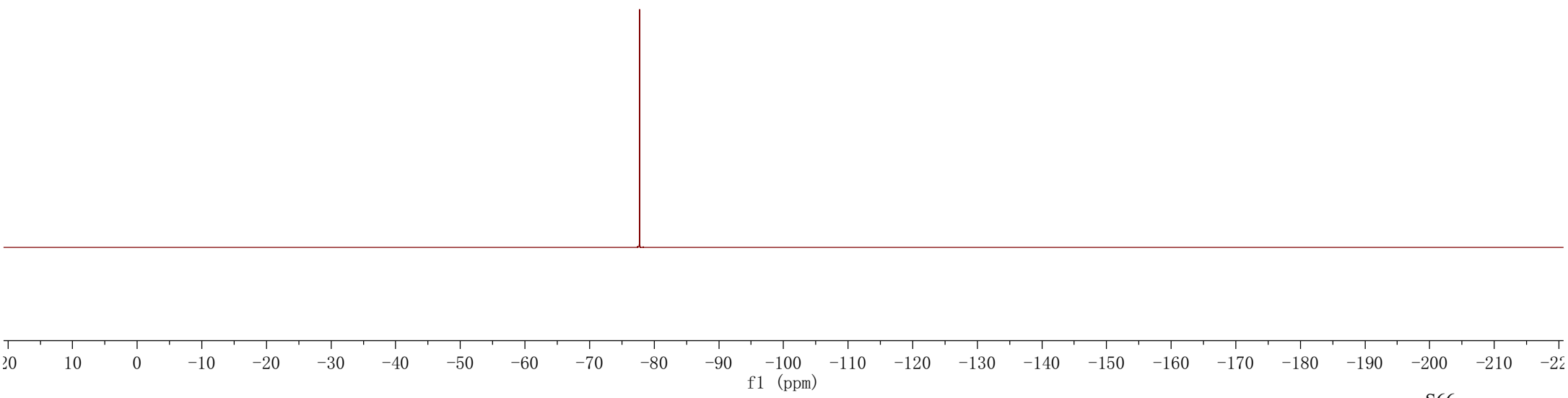
(**1k**, ^{13}C NMR, 100 MHz, DMSO-d_6)

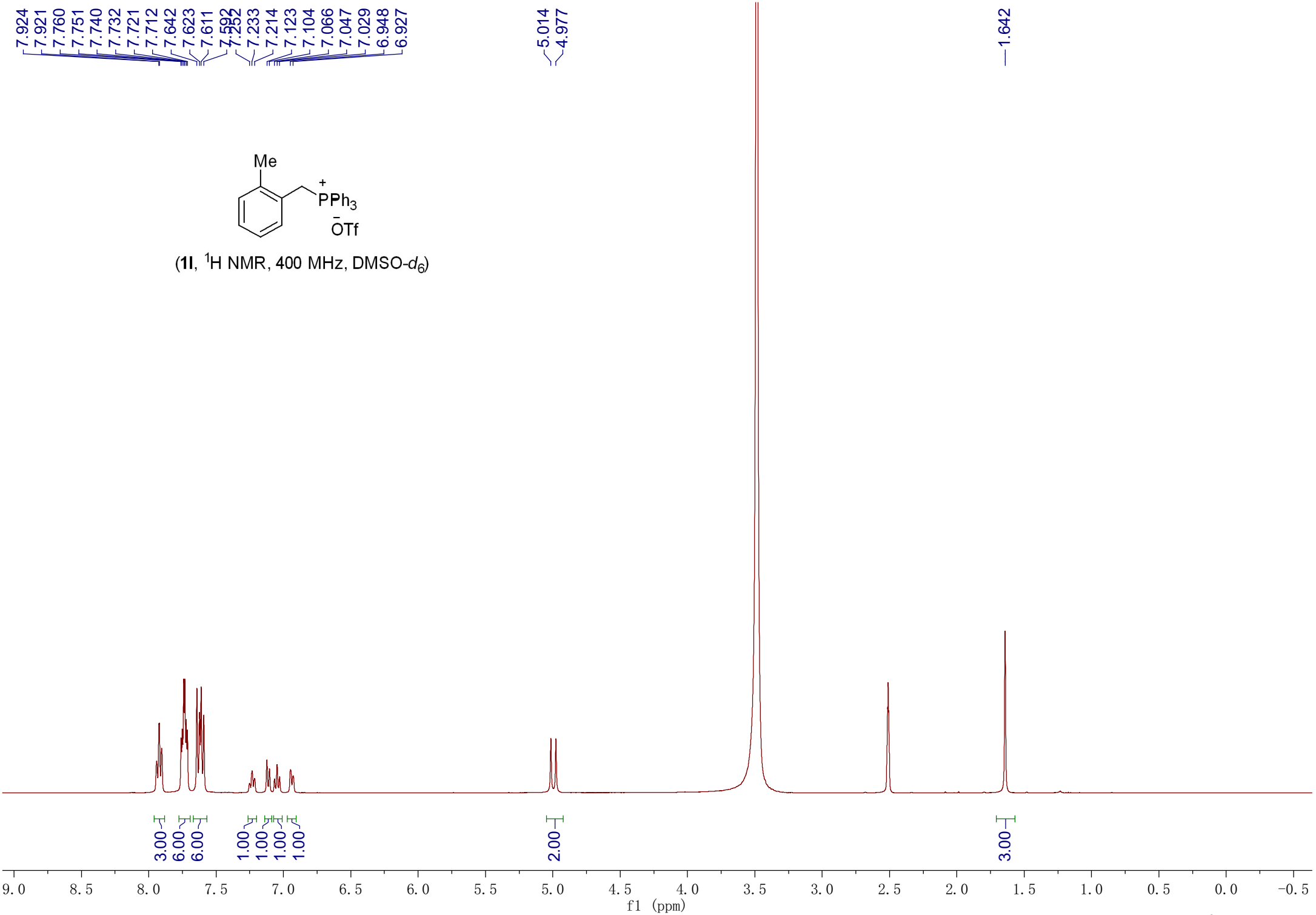


(**1k**, ^{31}P NMR, 162 MHz, DMSO-d_6)

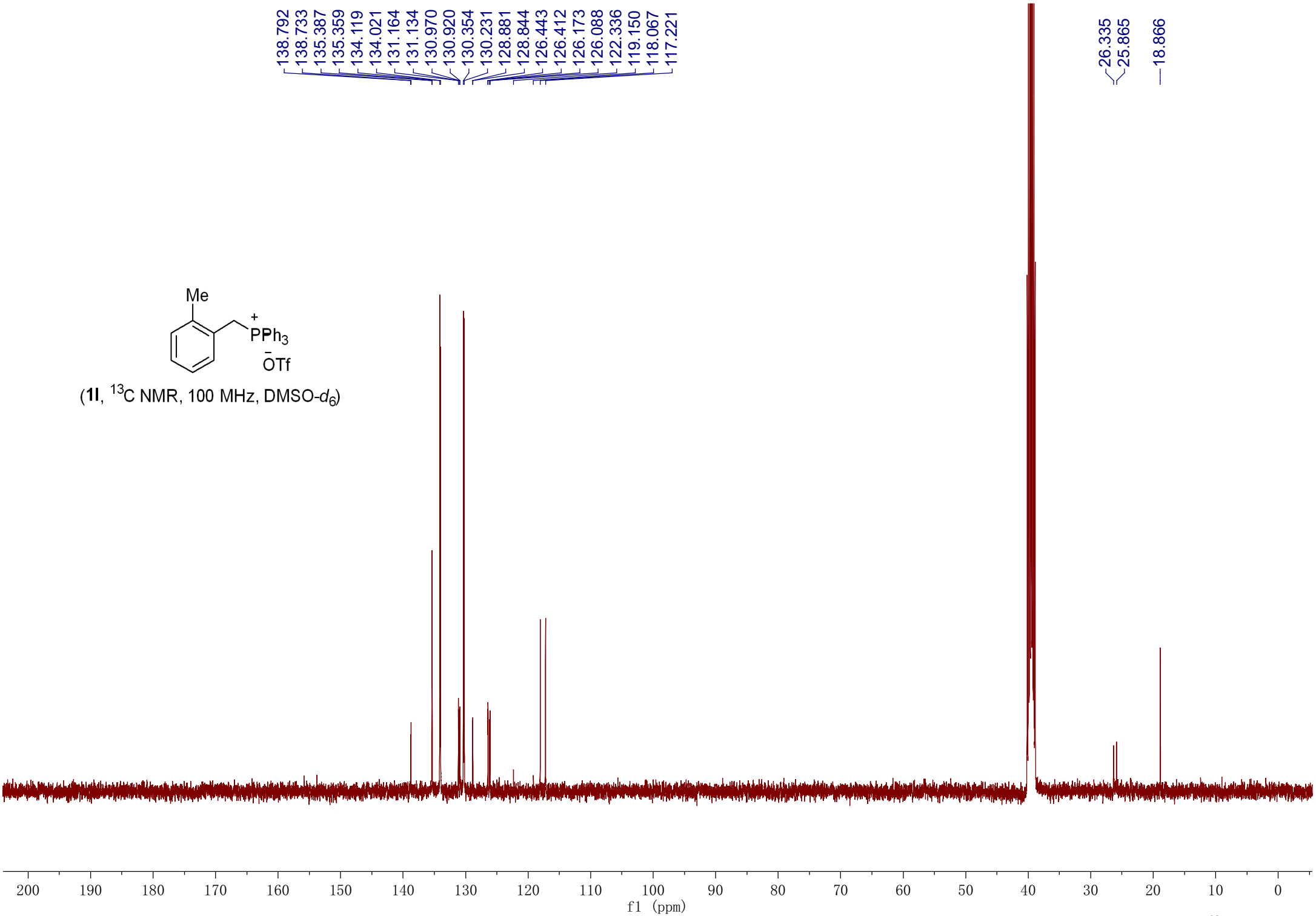


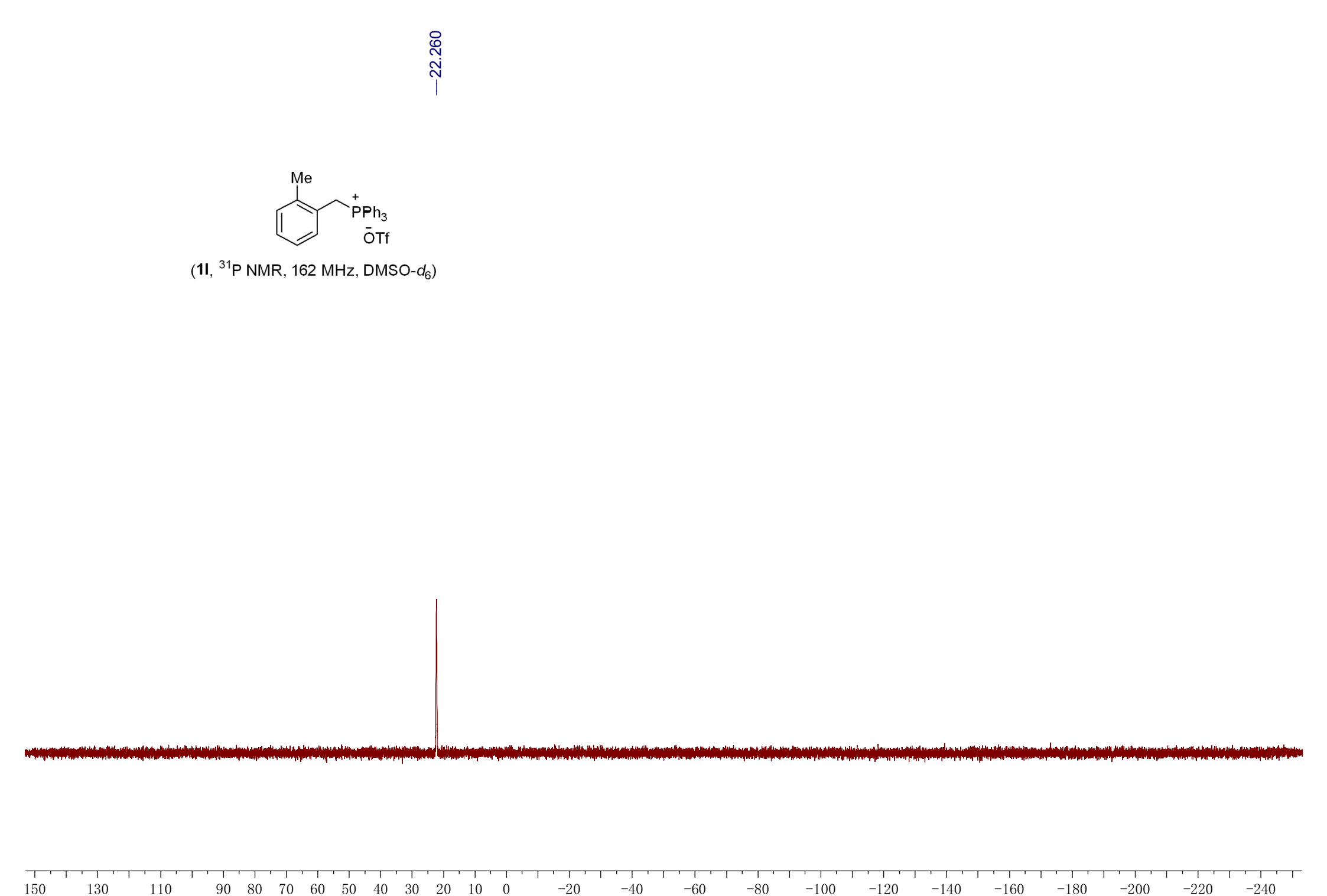
(**1k**, ^{19}F NMR, 376 MHz, DMSO-d_6)



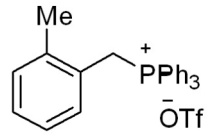


(**1l**, ^{1}H NMR, 400 MHz, DMSO-d_6)


138.792
138.733
135.387
135.359
134.119
134.021
131.164
131.134
130.970
130.920
130.354
130.231
128.881
128.844
126.443
126.412
126.173
126.088
122.336
119.150
118.067
117.221
26.335
25.865
18.866
Me
PPh3
OTf
(1l, 13C NMR, 100 MHz, DMSO-d6)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)



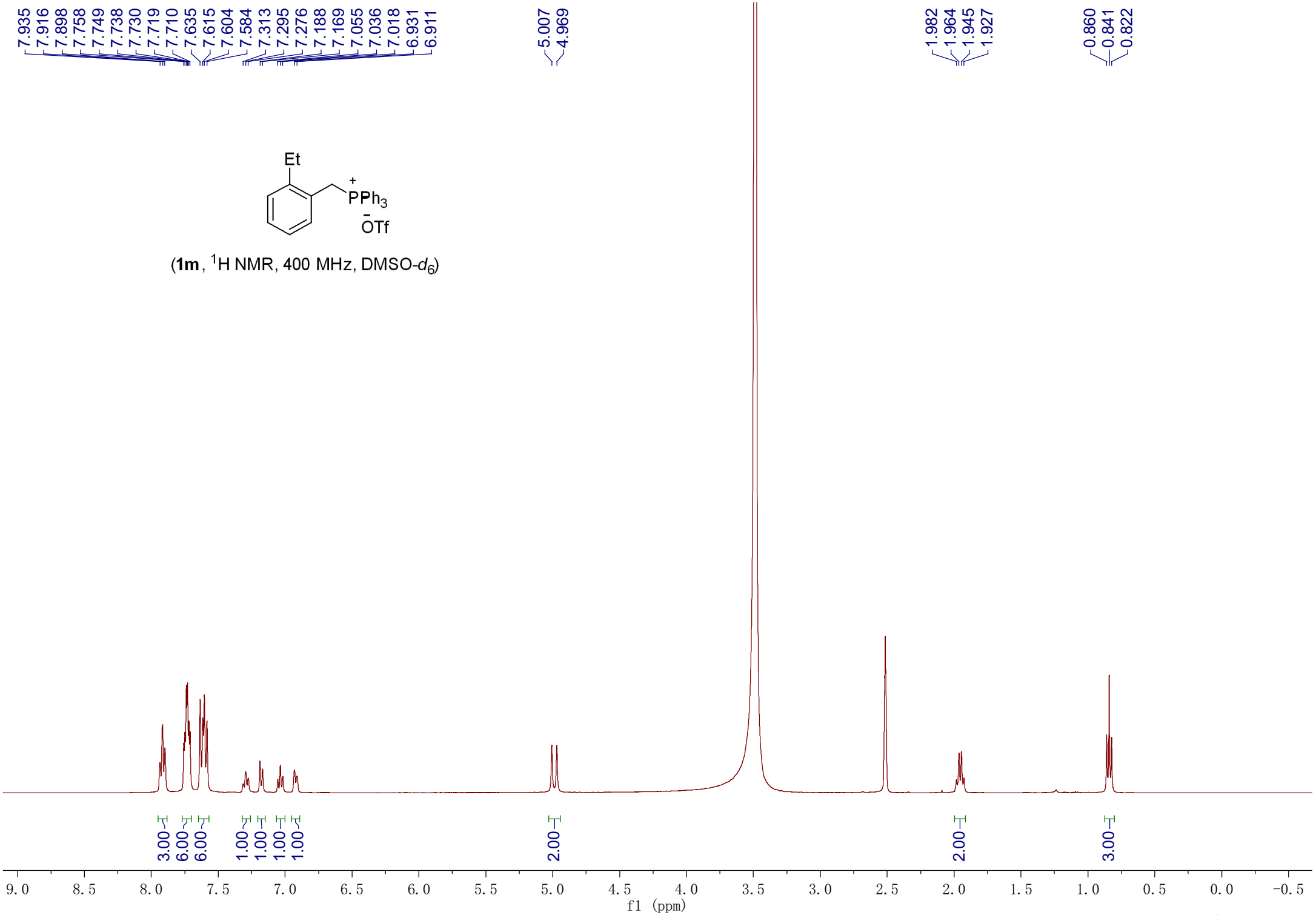
(**1l**, ^{31}P NMR, 162 MHz, DMSO-d_6)



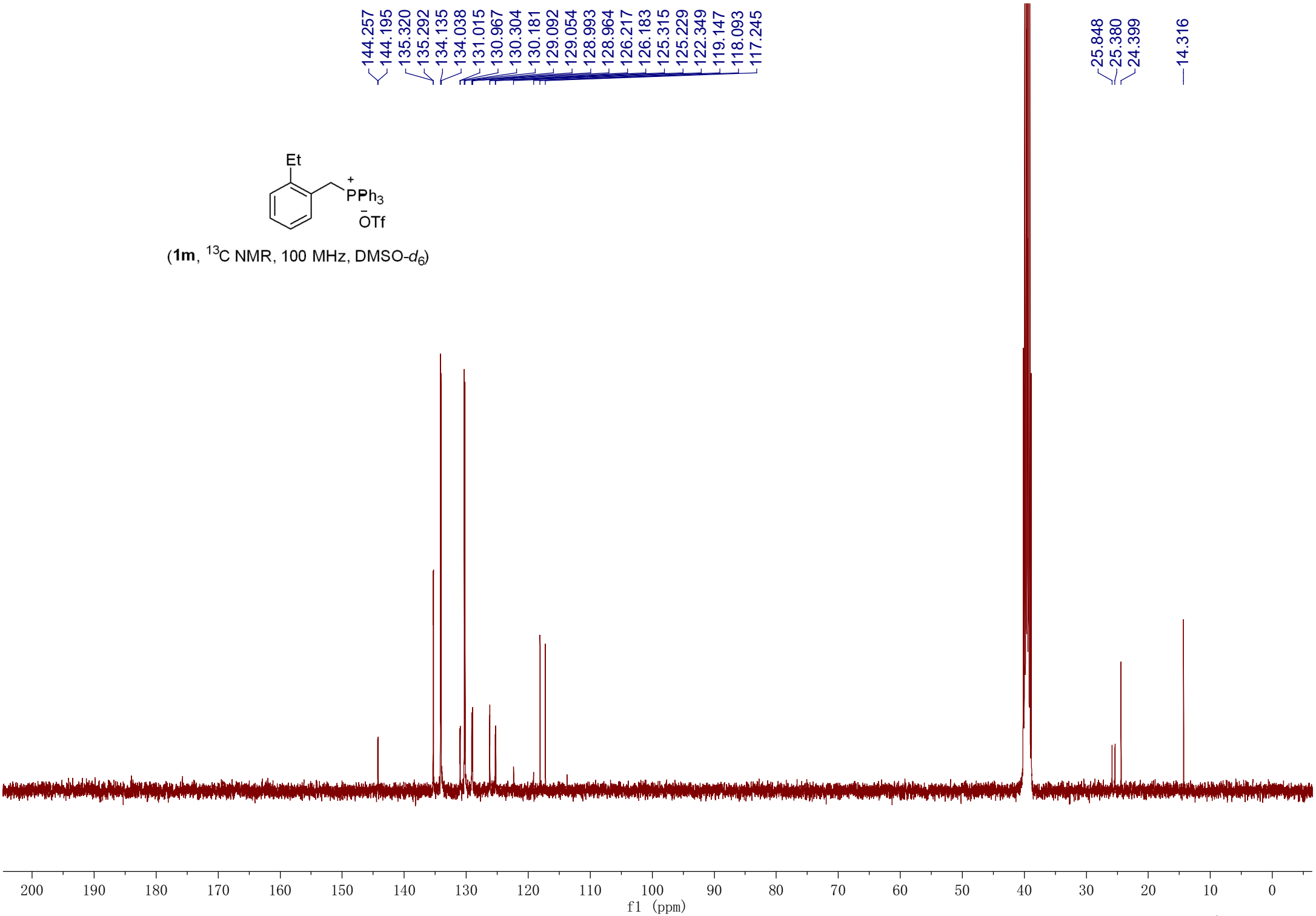
(**1l**, ^{19}F NMR, 376 MHz, DMSO-d_6)

-77.754

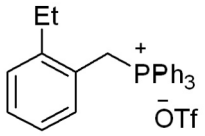
f1 (ppm)



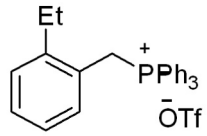
(**1m**, ^{1}H NMR, 400 MHz, DMSO-d_6)



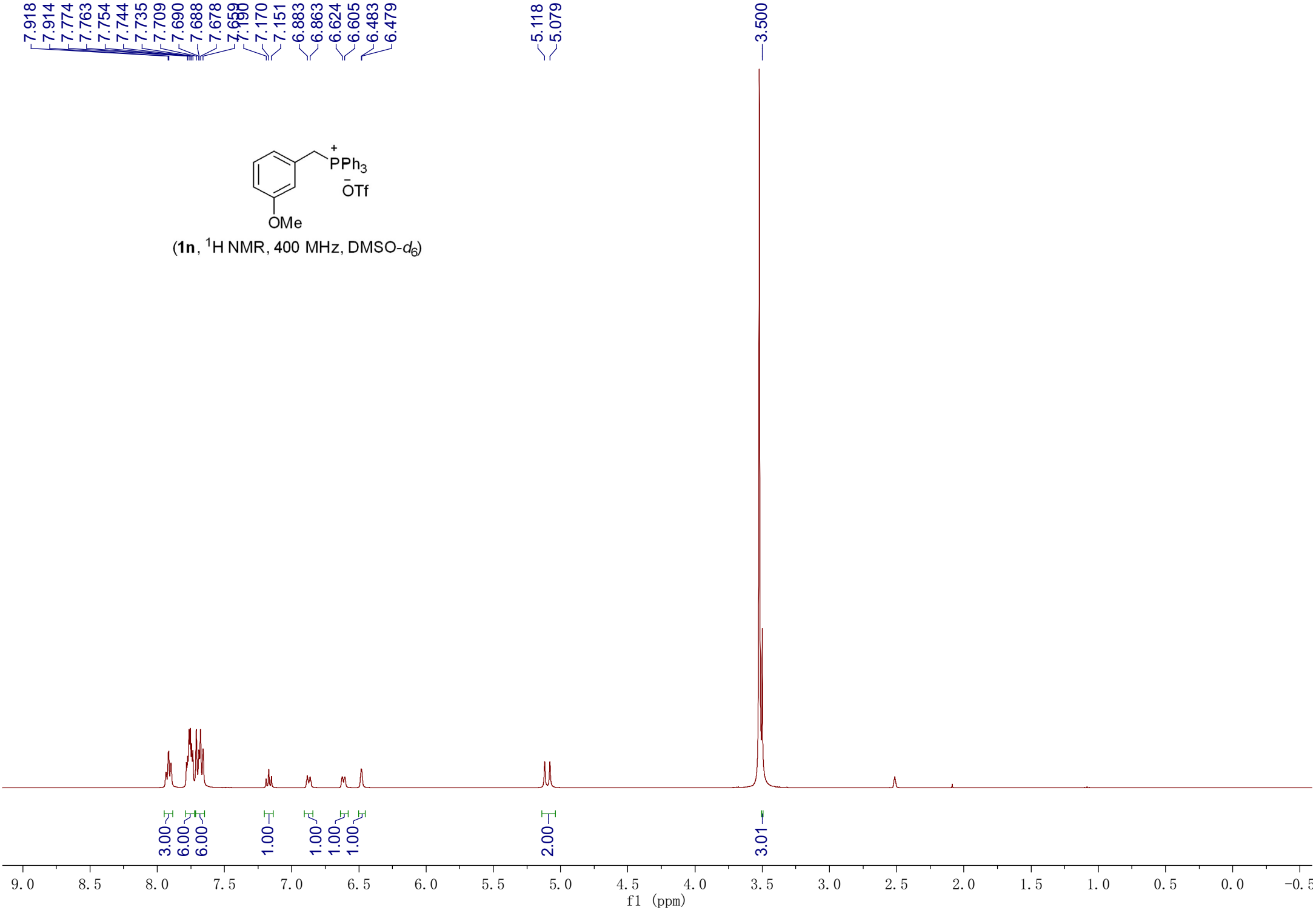
(**1m**, ^{13}C NMR, 100 MHz, DMSO-d_6)



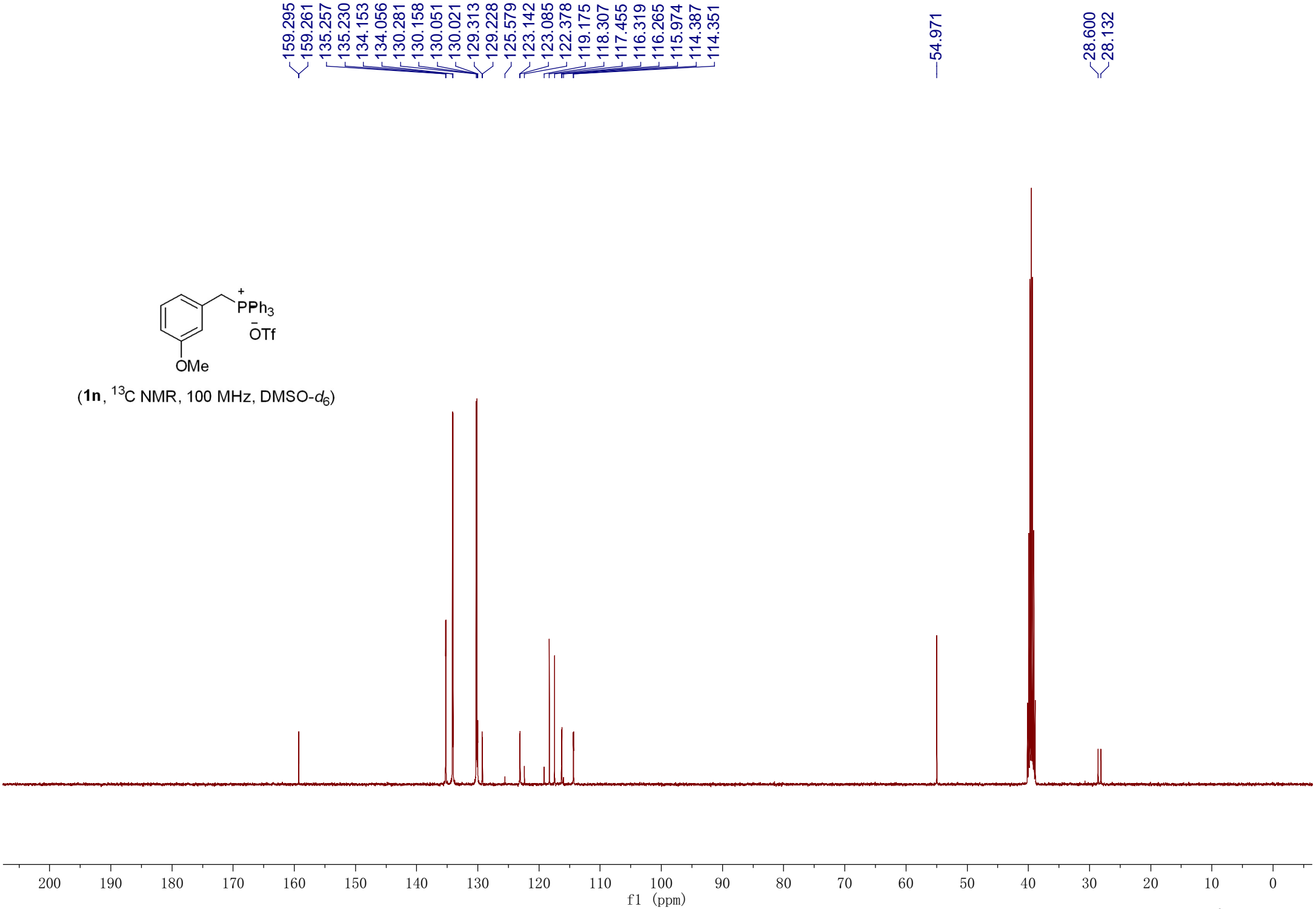
(**1m**, ^{31}P NMR, 162 MHz, DMSO-d_6)

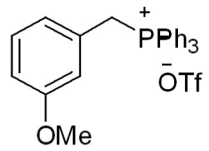


(**1m**, ^{19}F NMR, 376 MHz, DMSO-d_6)

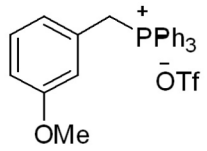


(**1n**, ^{1}H NMR, 400 MHz, DMSO-d_6)


159.295
159.261
135.257
135.230
134.153
134.056
130.281
130.158
130.051
130.021
129.313
129.228
125.579
123.142
123.085
122.378
119.175
118.307
117.455
116.319
116.265
115.974
114.387
114.351
54.971
28.600
28.132
PPh3
OTf
OMe
(1n, 13C NMR, 100 MHz, DMSO-d6)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)



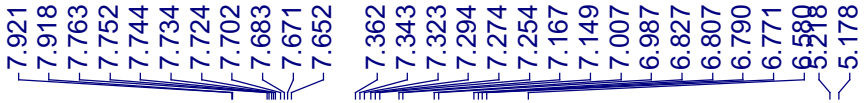
(**1n**, ^{31}P NMR, 162 MHz, DMSO-d_6)

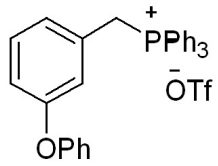


(**1n**, ^{19}F NMR, 376 MHz, DMSO-d_6)

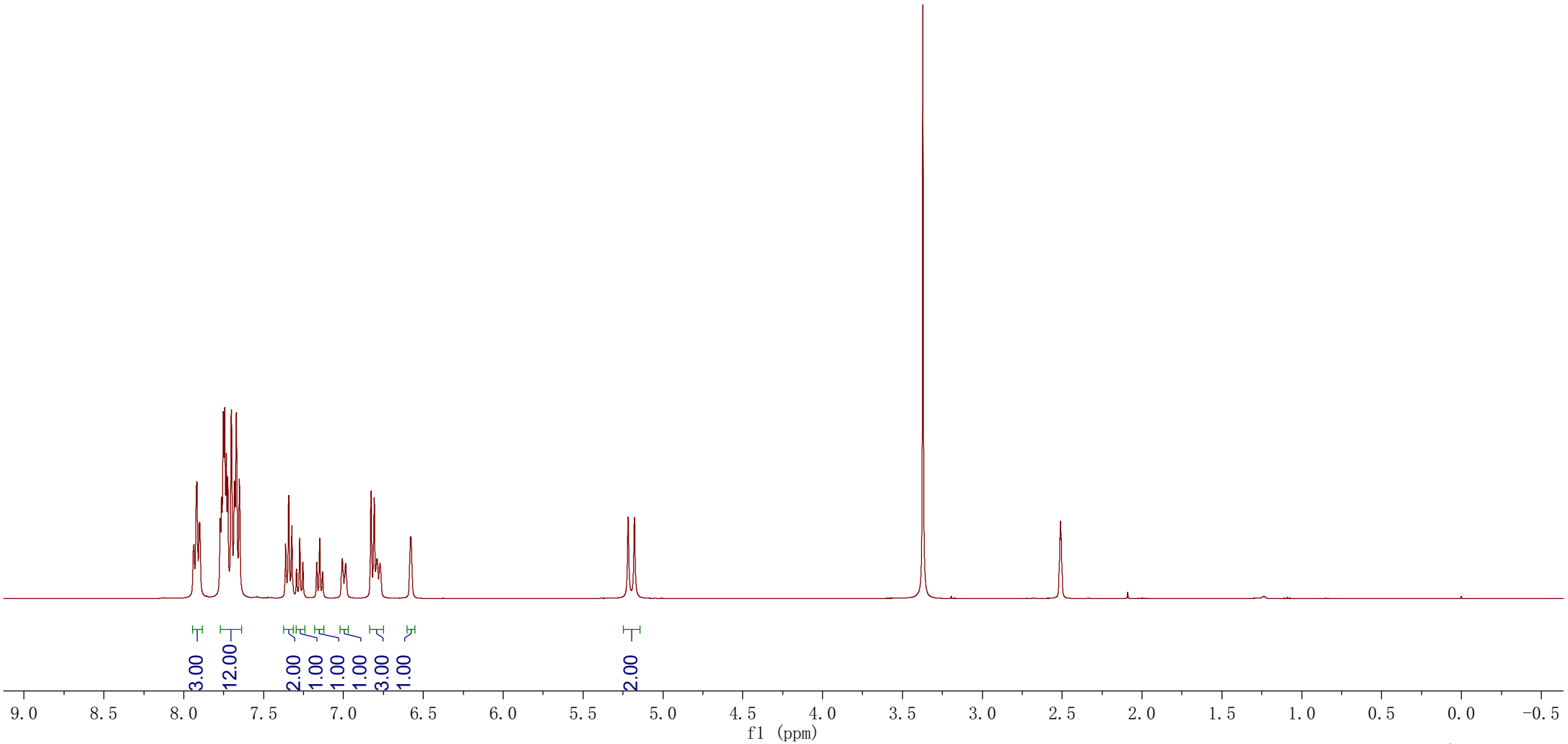
-77.729

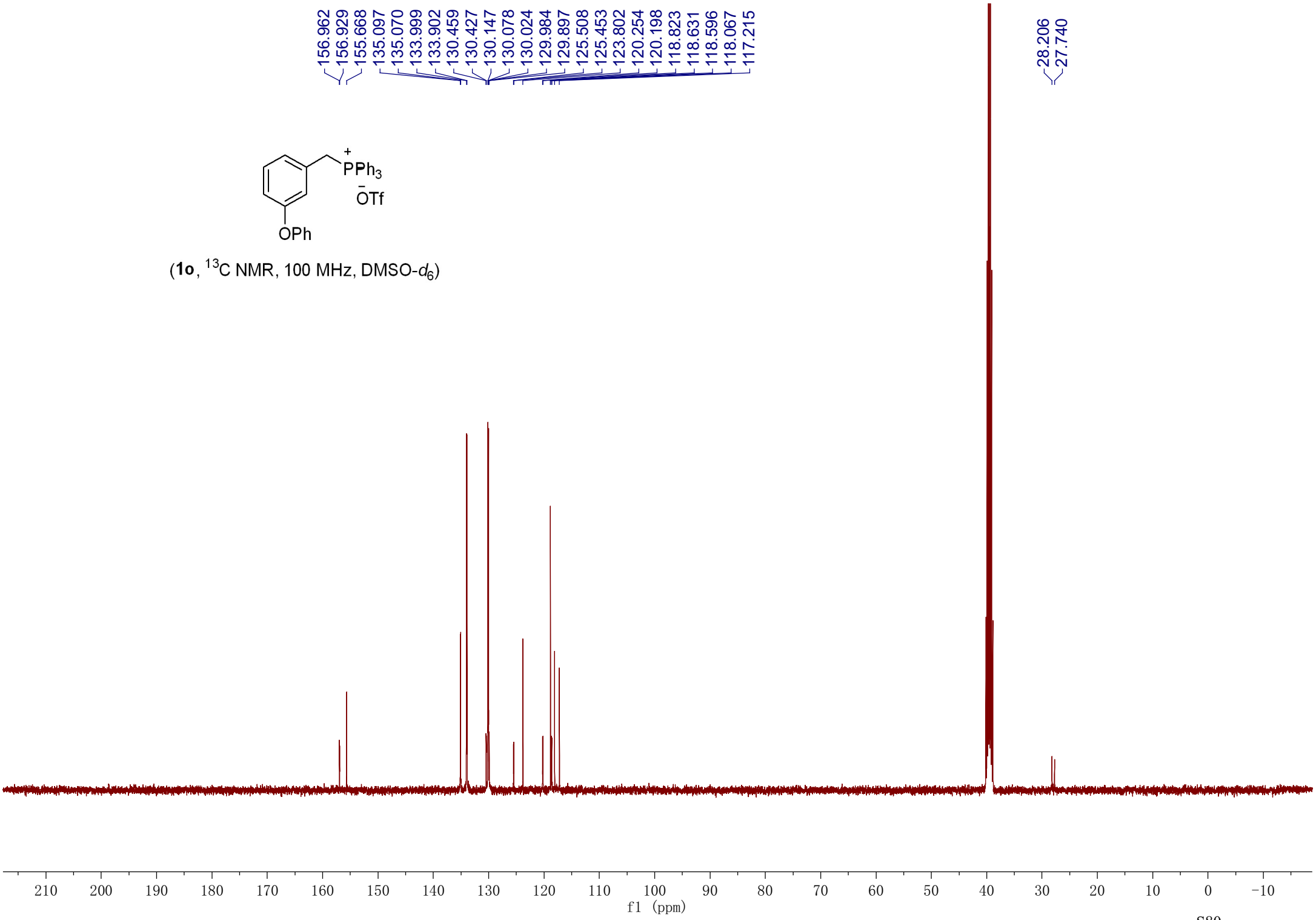
f1 (ppm)



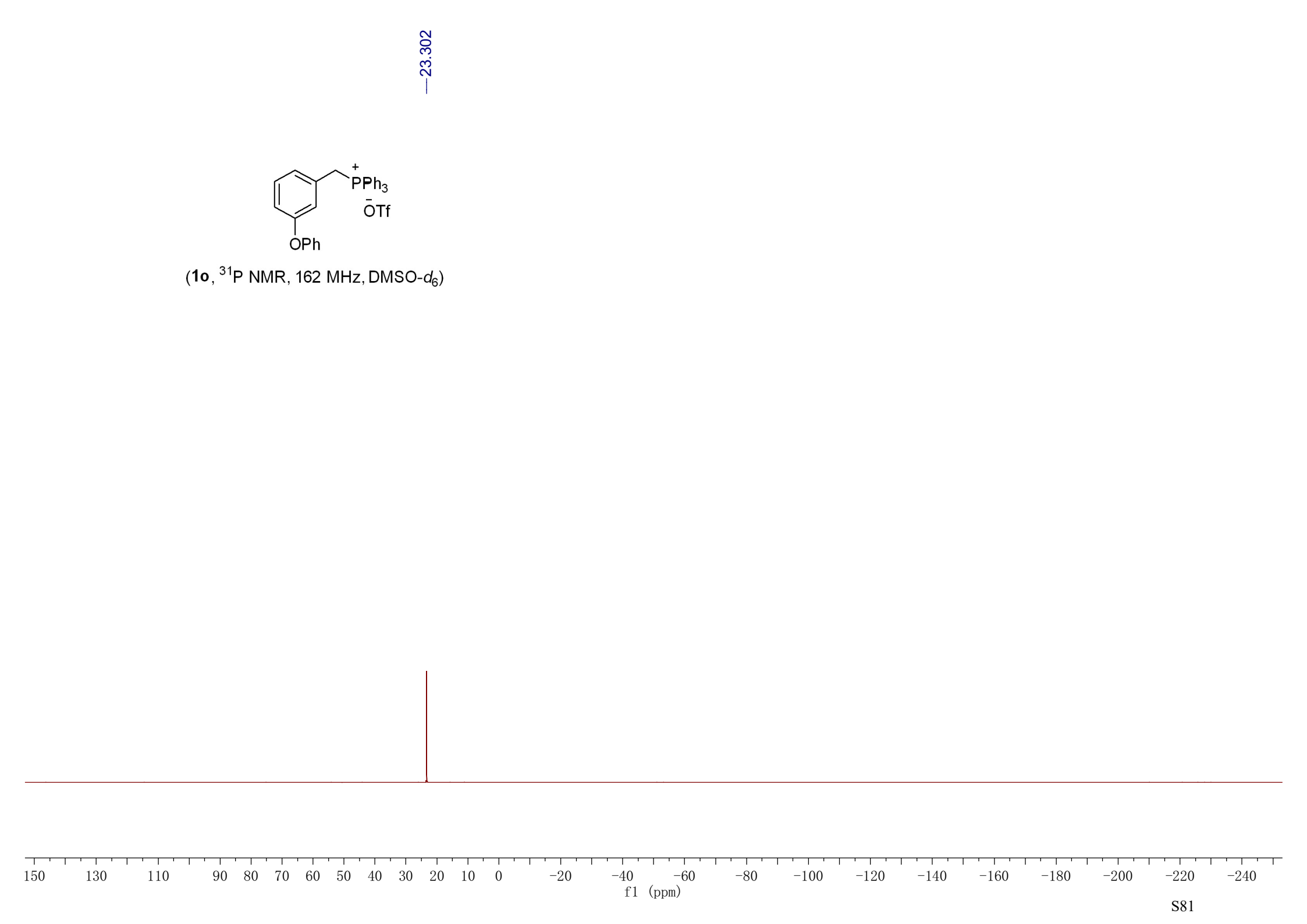


(**1o**, ^{1}H NMR, 400 MHz, DMSO-d_6)

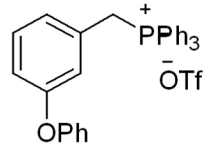




(**1o**, ^{13}C NMR, 100 MHz, DMSO-d_6)

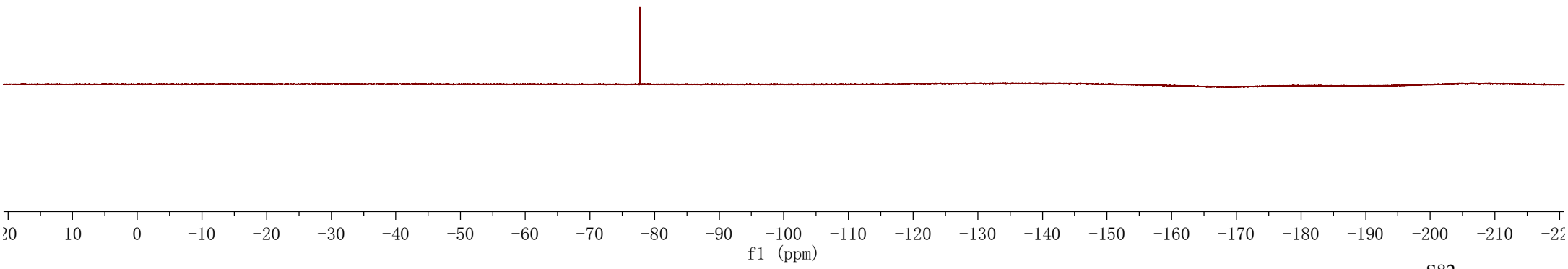


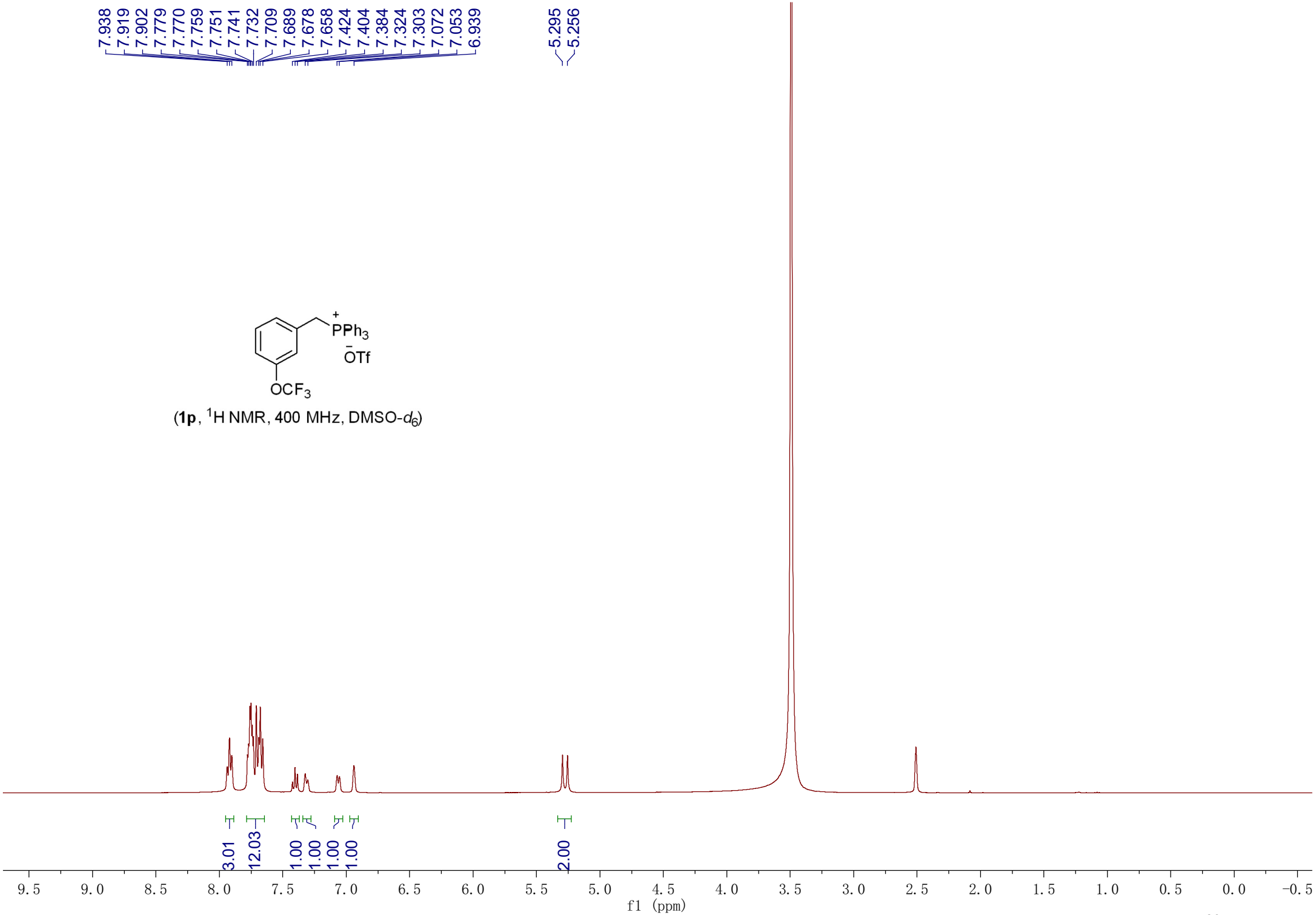
(**1o**, ^{31}P NMR, 162 MHz, DMSO-d_6)



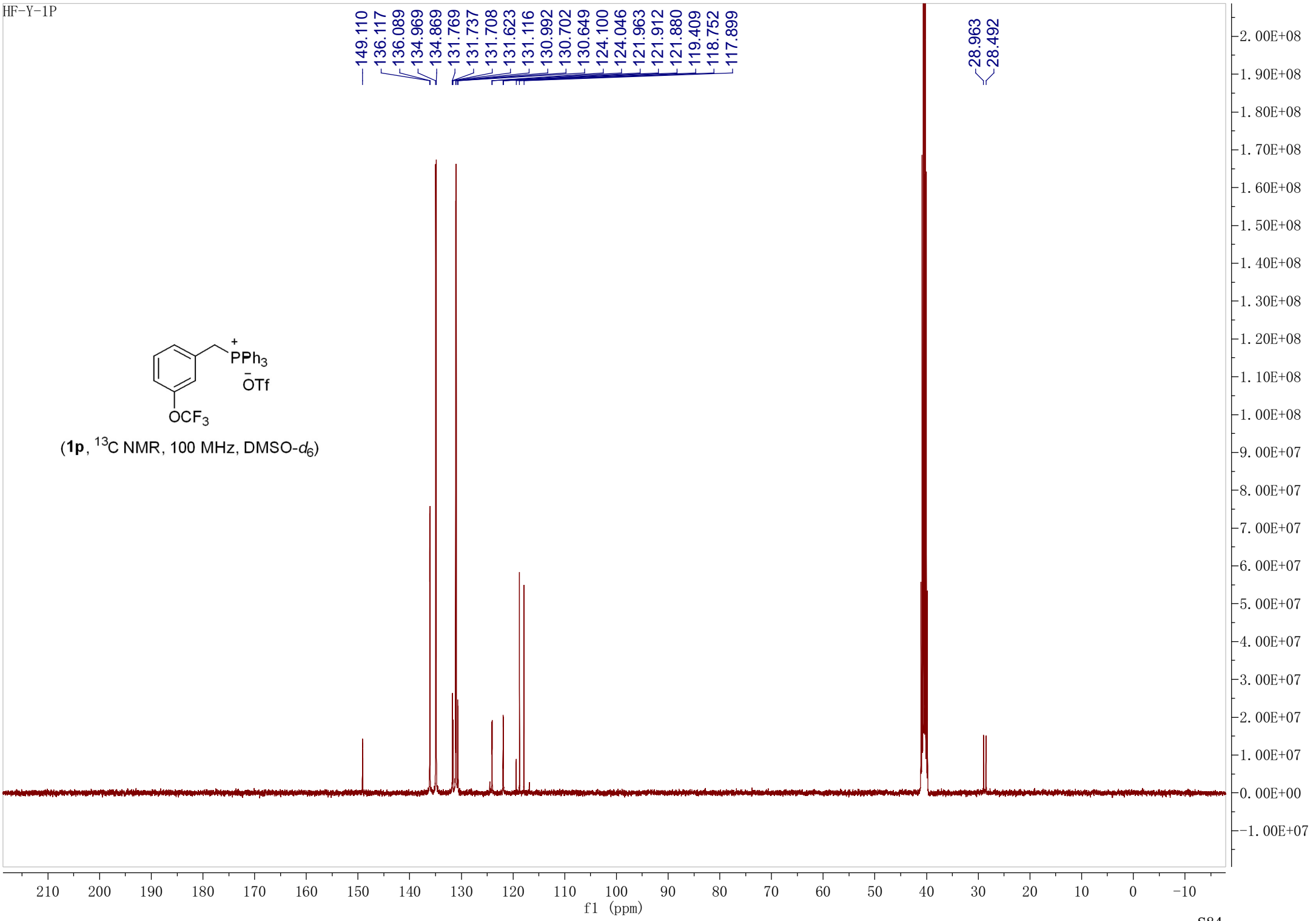
(**1o**, ^{19}F NMR, 376 MHz, DMSO-d_6)

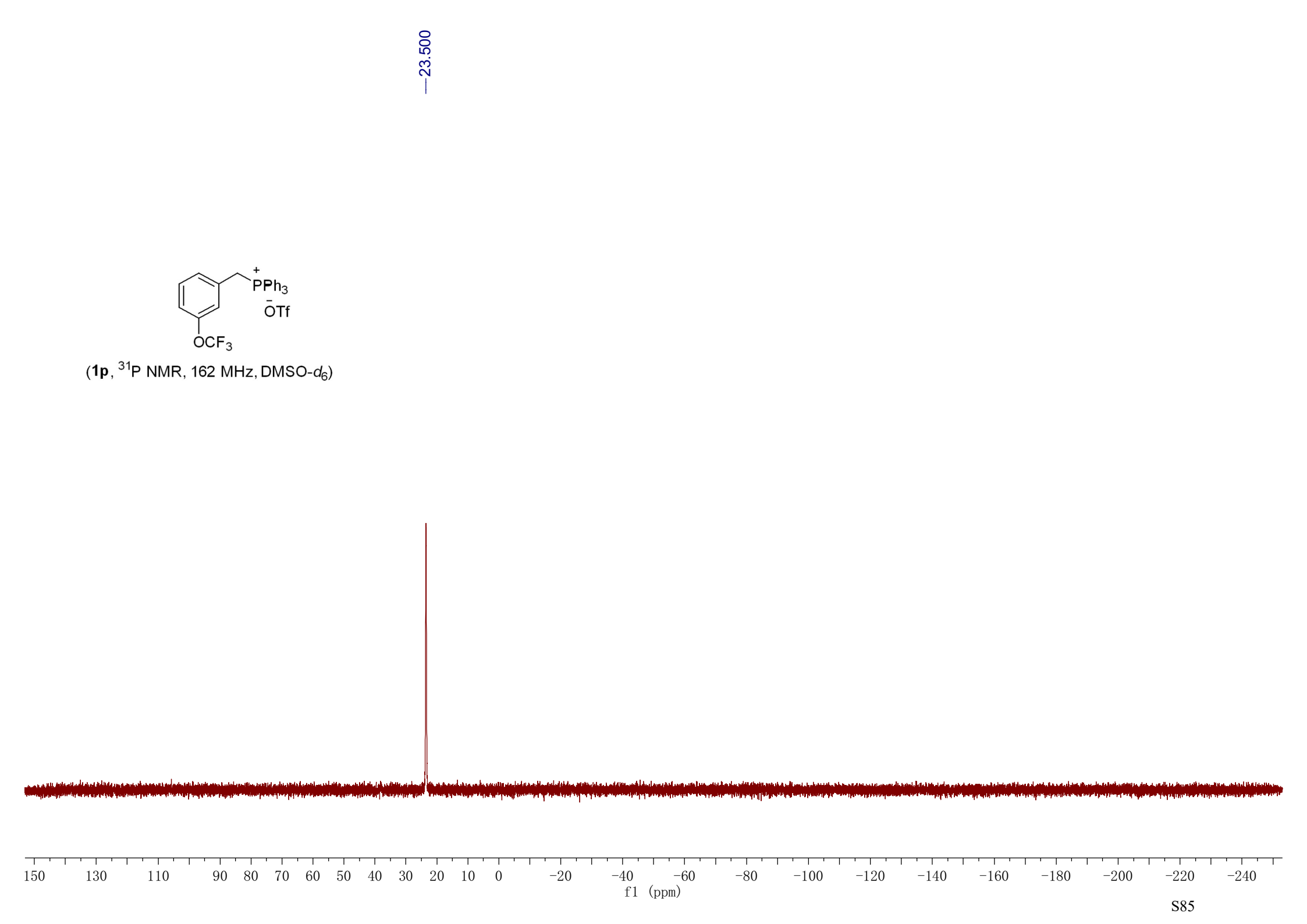
-77.717



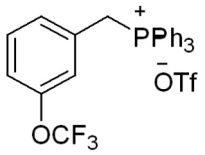


(**1p**, ^{1}H NMR, 400 MHz, DMSO-d_6)

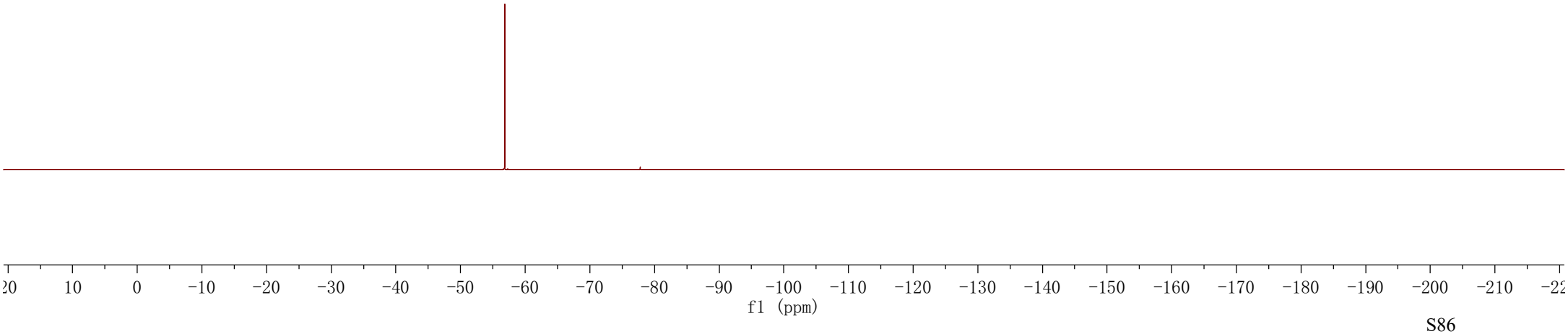

HF-Y-1P
149.110
136.117
136.089
134.969
134.869
131.769
131.737
131.708
131.623
131.116
130.992
130.702
130.649
124.100
124.046
121.963
121.912
121.880
119.409
118.752
117.899
28.963
28.492
PPh3
OTf
OCF3
(1p, 13C NMR, 100 MHz, DMSO-d6)
f1 (ppm)

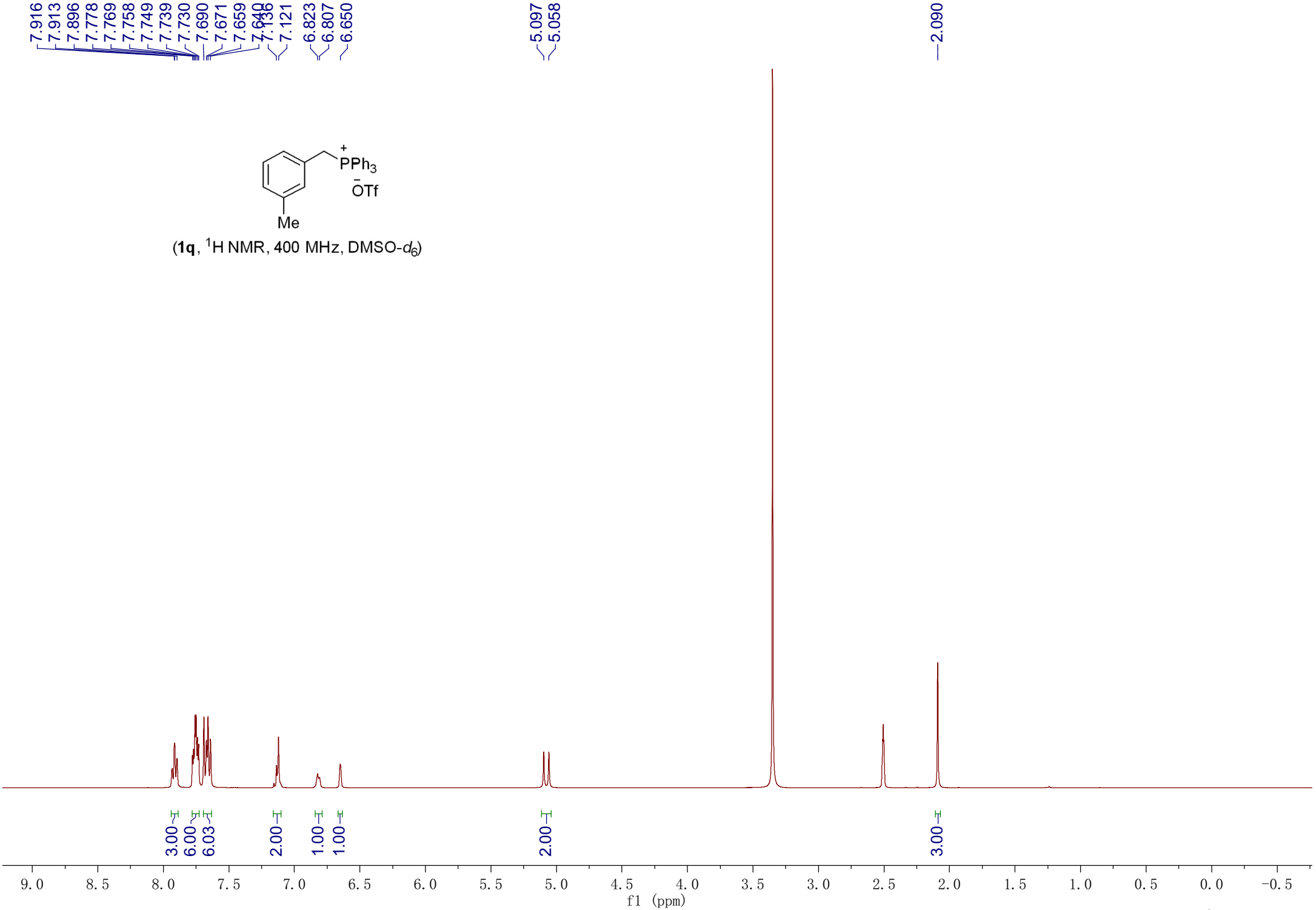


(**1p**, ^{31}P NMR, 162 MHz, DMSO-d_6)

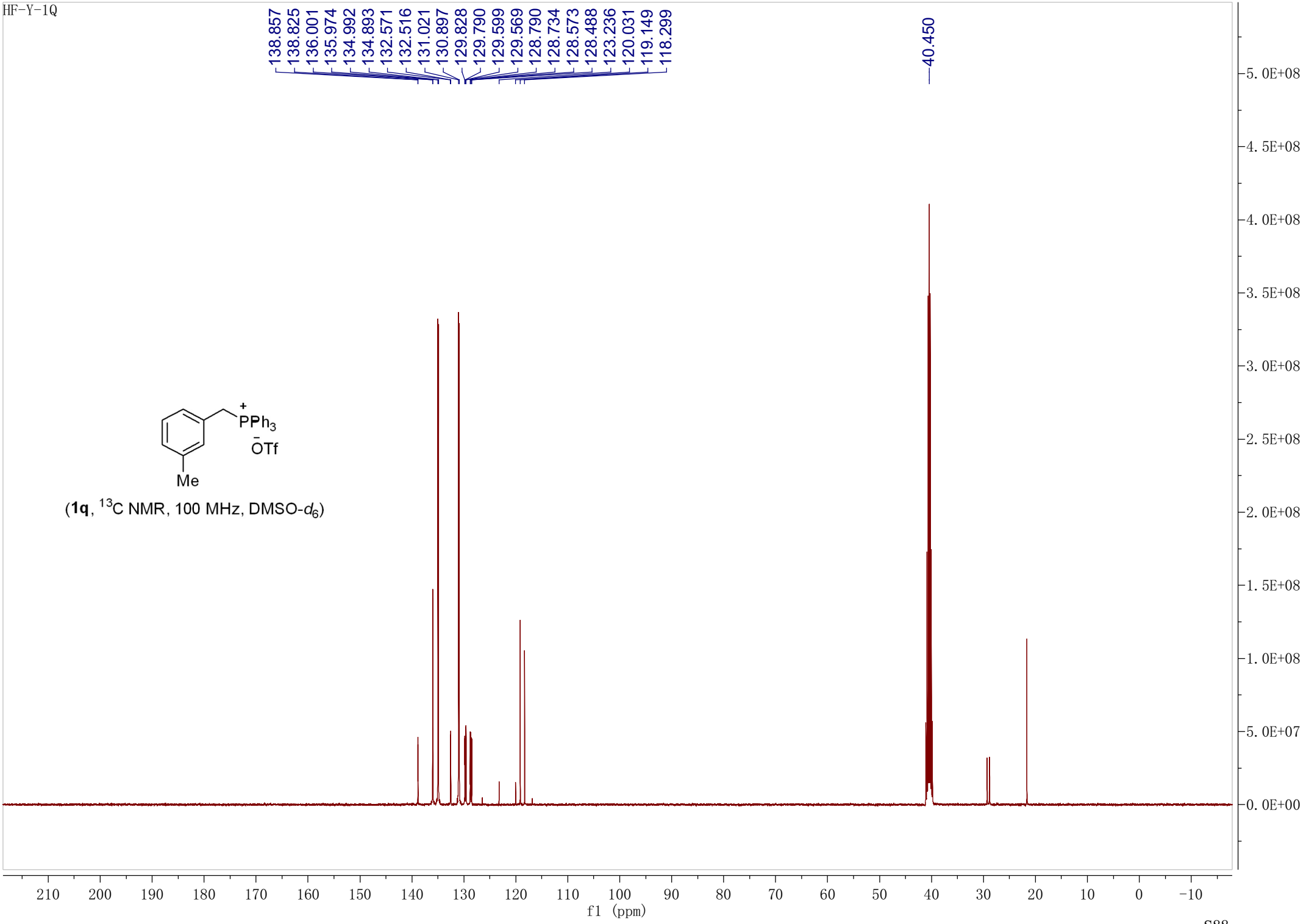


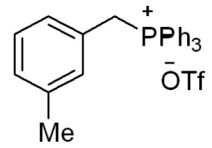
(**1p**, ^{19}F NMR, 376 MHz, DMSO-d_6)



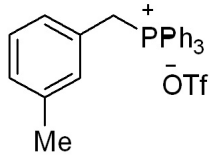


(**1q**, ^{1}H NMR, 400 MHz, DMSO-d_6)

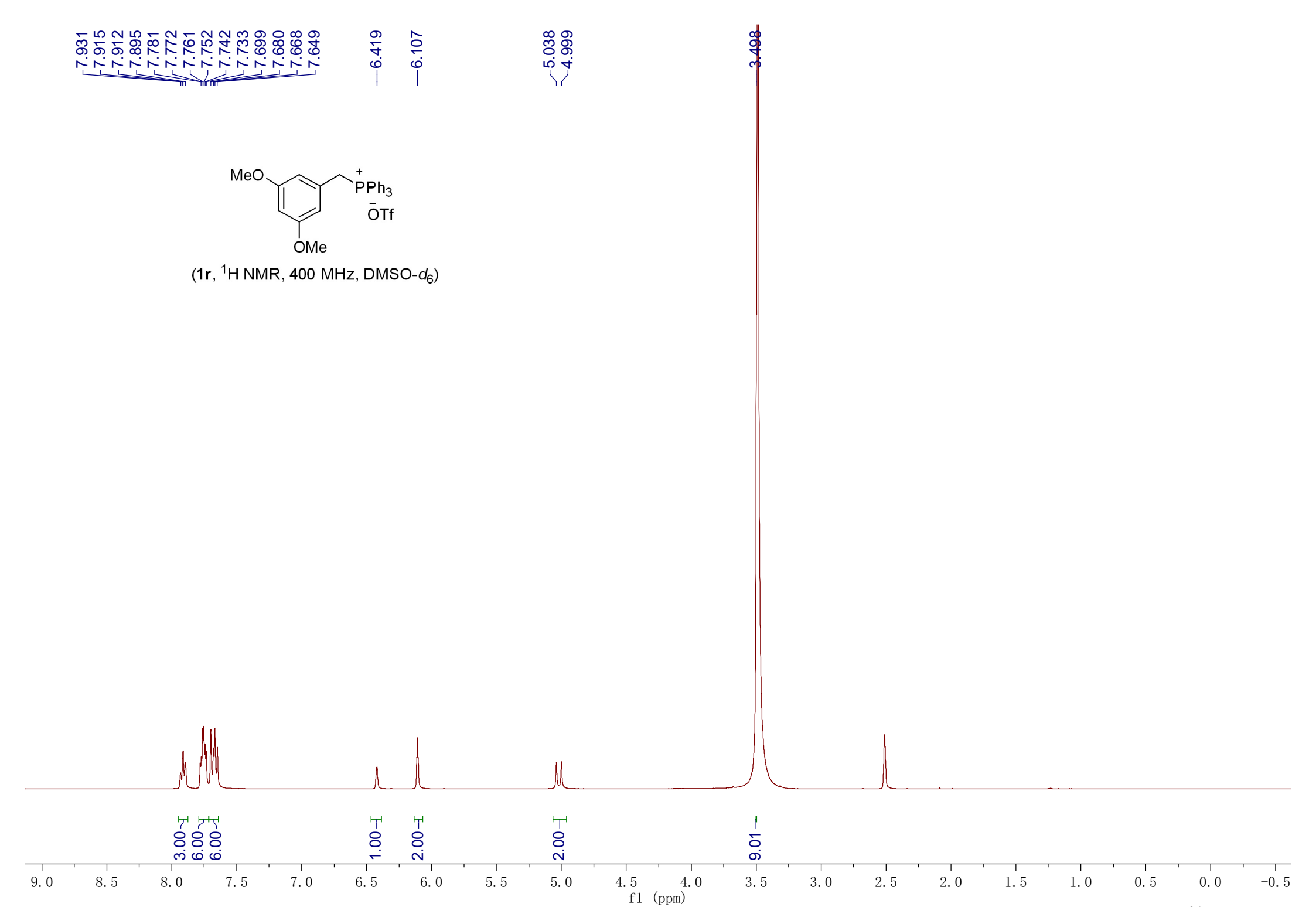

HF-Y-1Q
138.857
138.825
136.001
135.974
134.992
134.893
132.571
132.516
131.021
130.897
129.828
129.790
129.599
129.569
128.790
128.734
128.573
128.488
123.236
120.031
119.149
118.299
40.450
PPh3
OTf
Me
(1q, 13C NMR, 100 MHz, DMSO-d6)
5.0E+08
4.5E+08
4.0E+08
3.5E+08
3.0E+08
2.5E+08
2.0E+08
1.5E+08
1.0E+08
5.0E+07
0.0E+00
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)



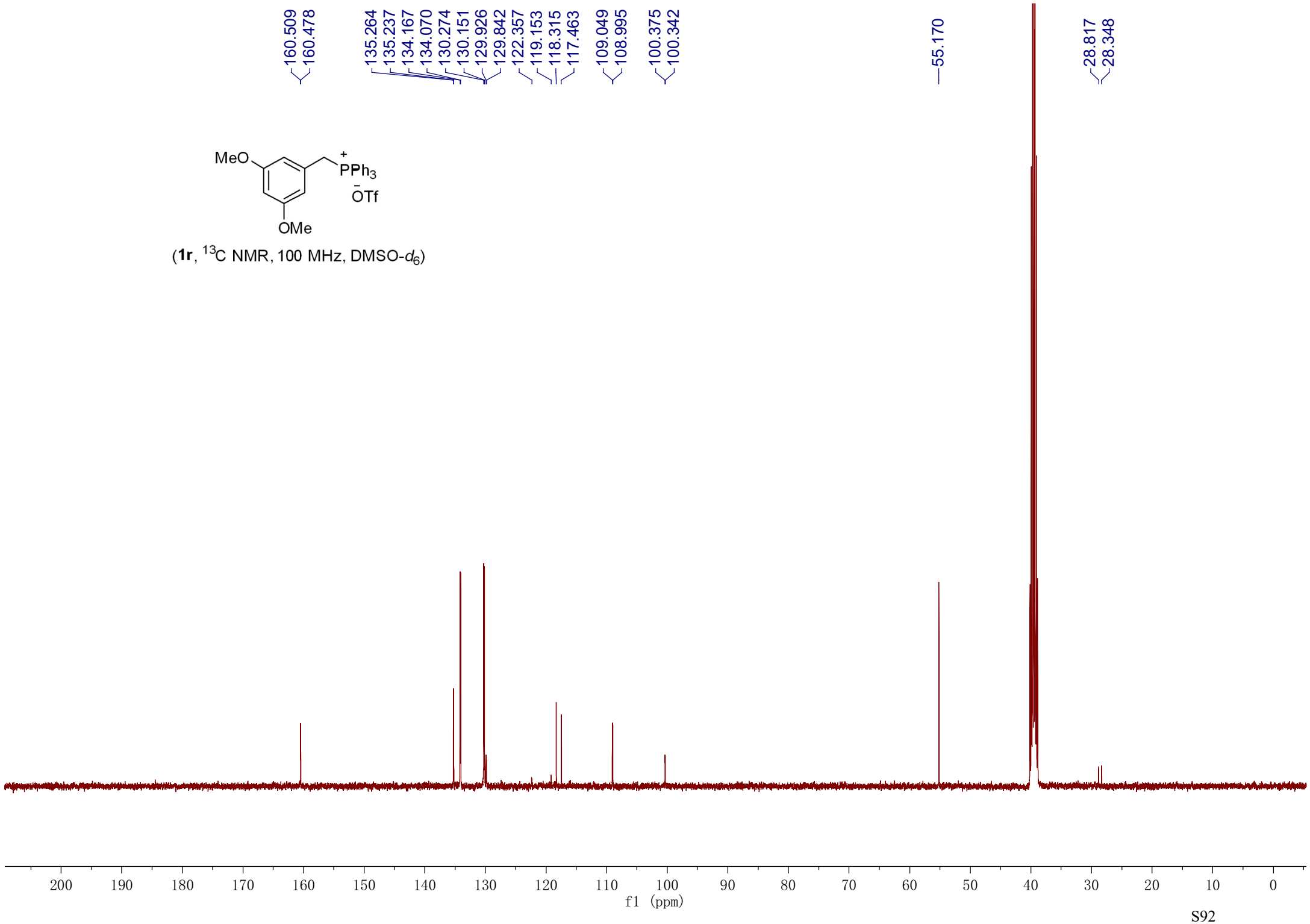
(**1q**, ^{31}P NMR, 162 MHz, DMSO-d_6)



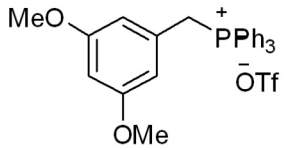
(**1q**, ^{19}F NMR, 376 MHz, DMSO-d_6)



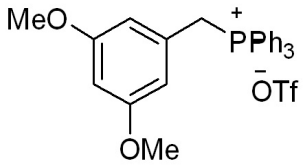
(**1r**, ^{1}H NMR, 400 MHz, DMSO-d_6)



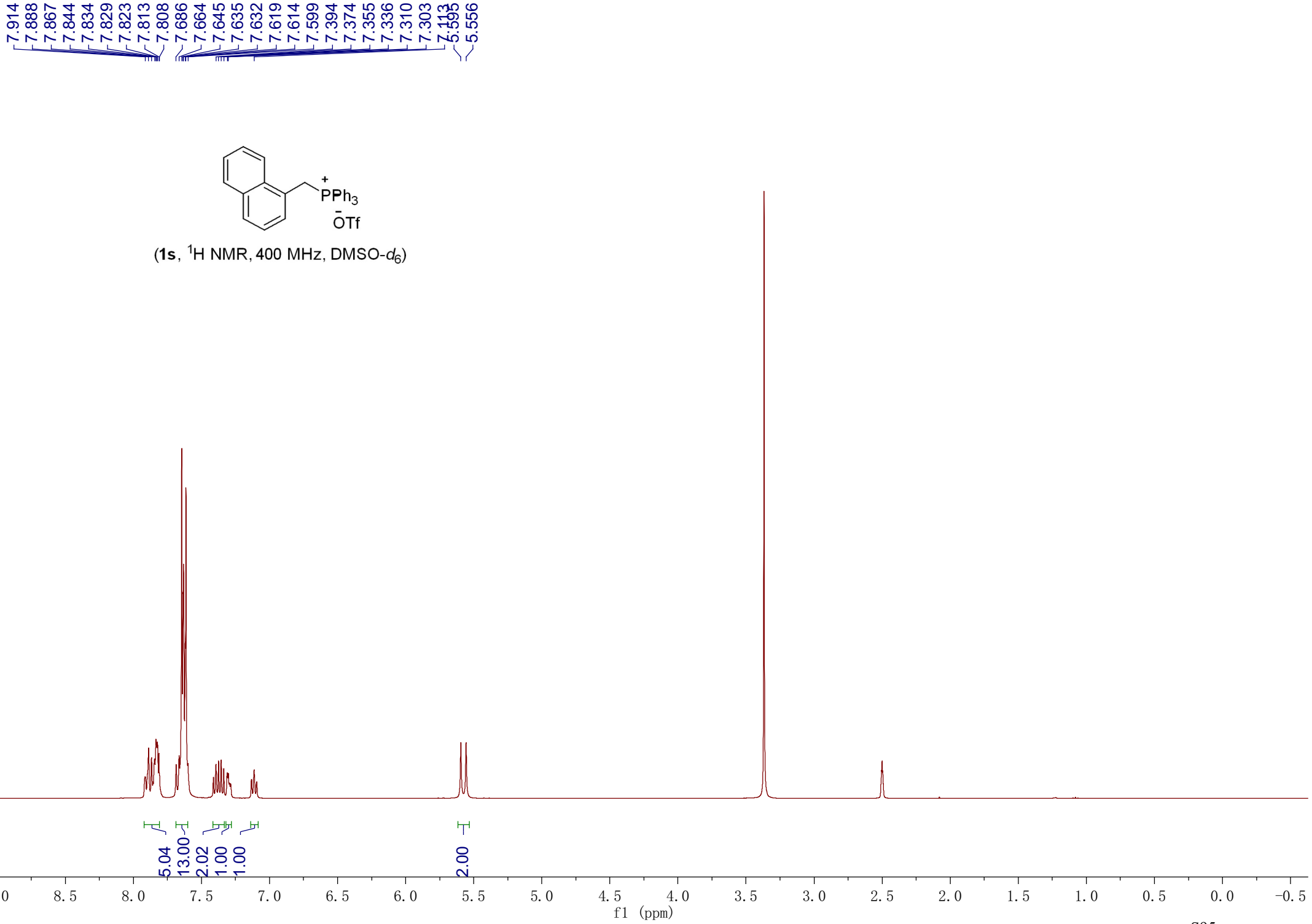
(**1r**, ^{13}C NMR, 100 MHz, DMSO-d_6)



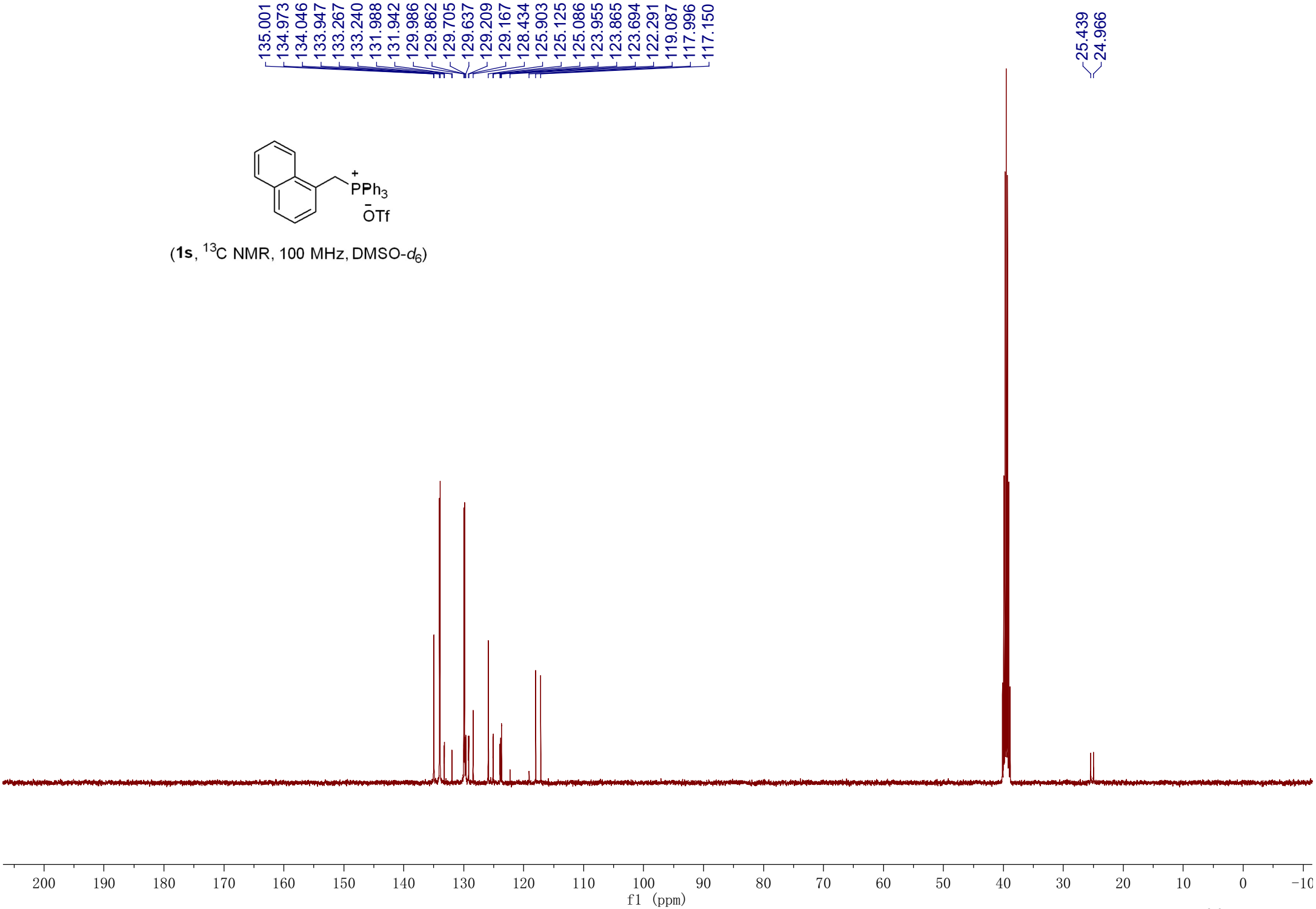
(**1r**, ^{31}P NMR, 162 MHz, DMSO-d_6)



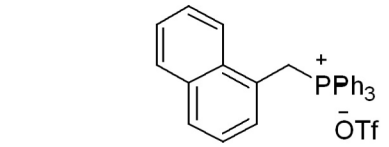
(**1r**, ^{19}F NMR, 376 MHz, DMSO-d_6)



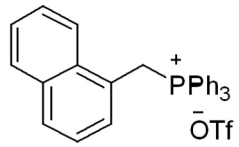
(**1s**, ^{1}H NMR, 400 MHz, DMSO-d_6)



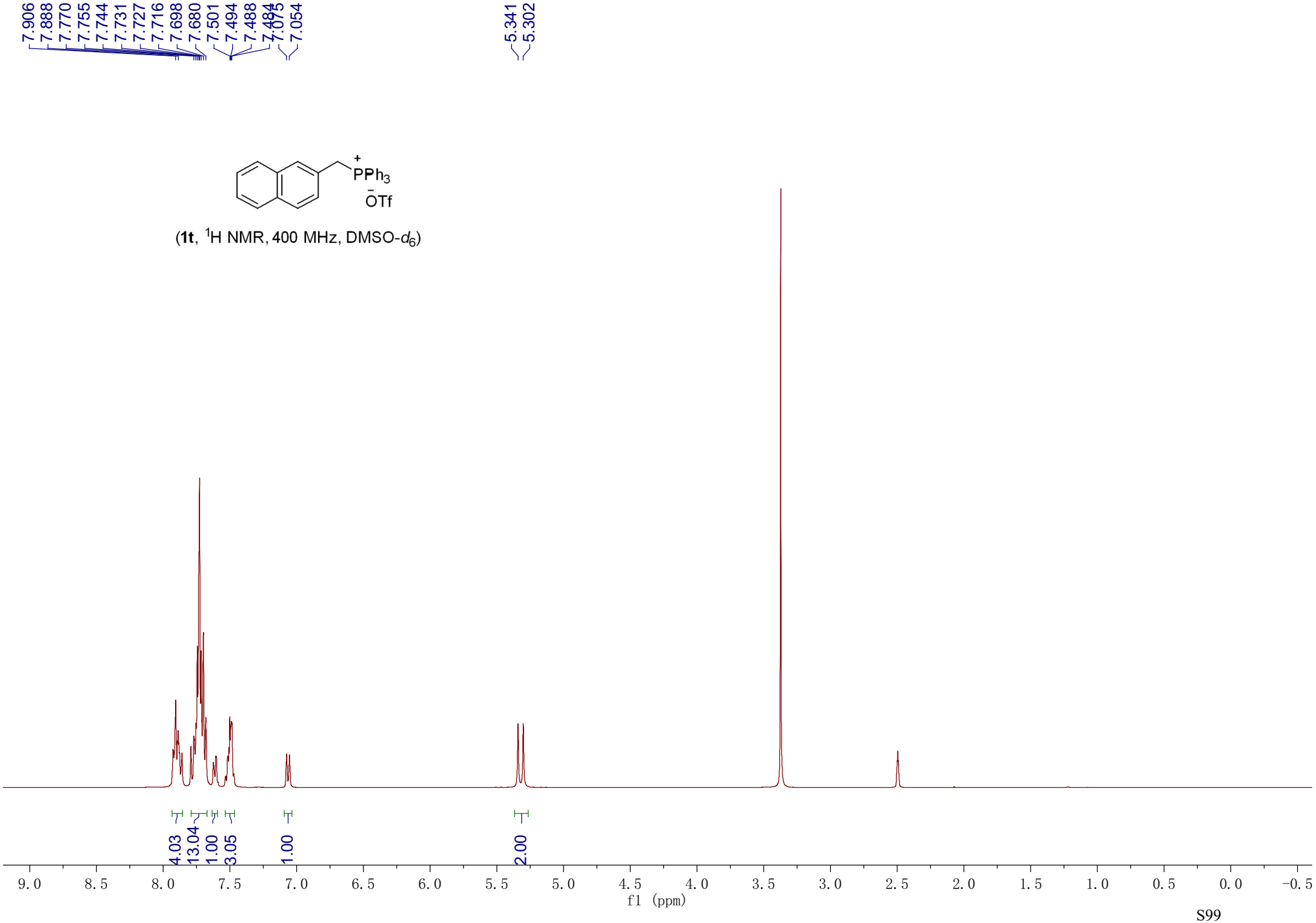
(**1s**, ^{13}C NMR, 100 MHz, DMSO-d_6)



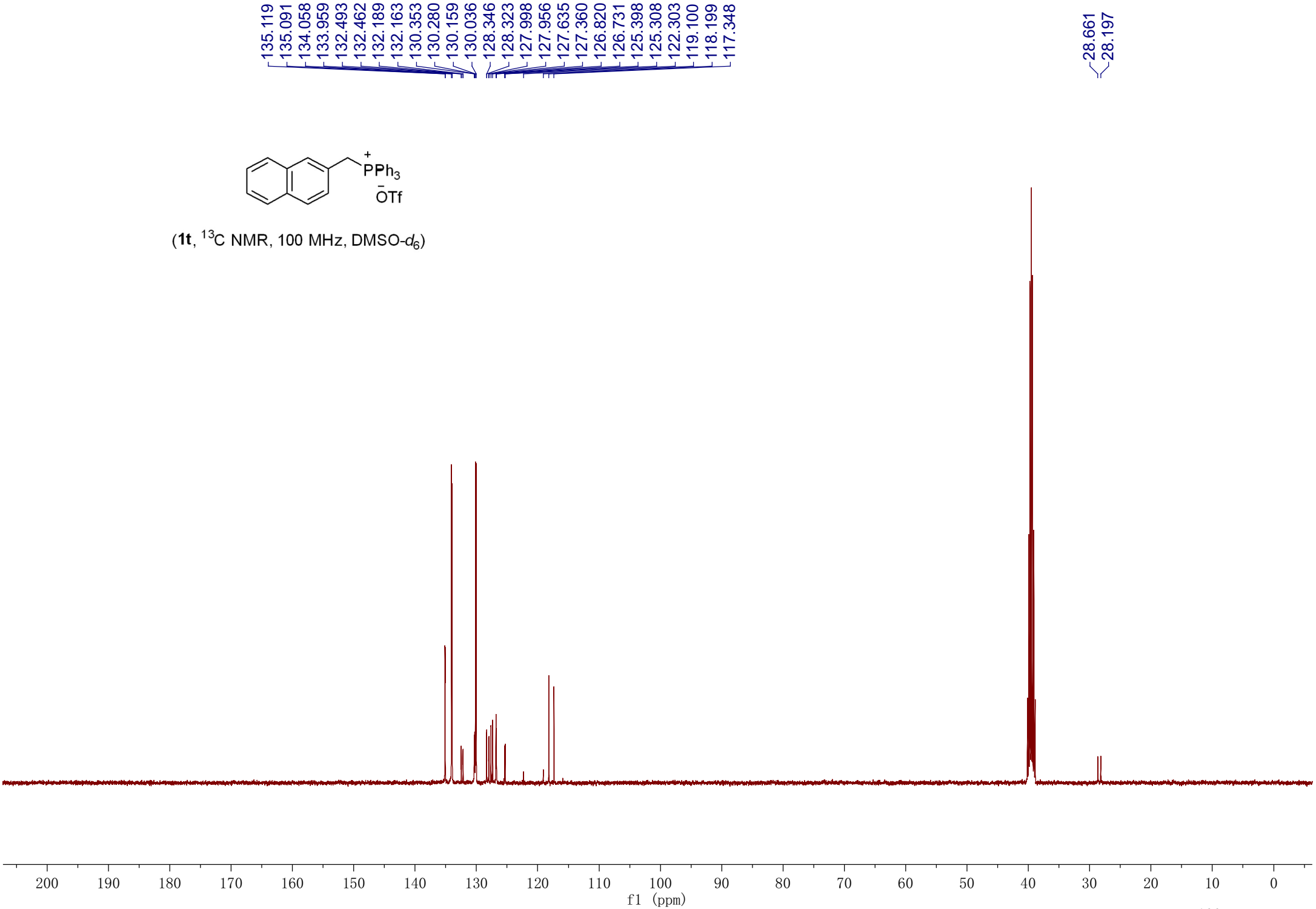
(**1s**, ^{31}P NMR, 162 MHz, DMSO-d_6)



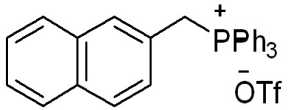
(**1s**, ^{19}F NMR, 376 MHz, DMSO-d_6)



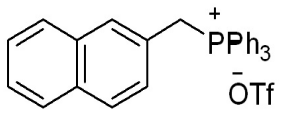
(**1t**, ^{1}H NMR, 400 MHz, DMSO-d_6)



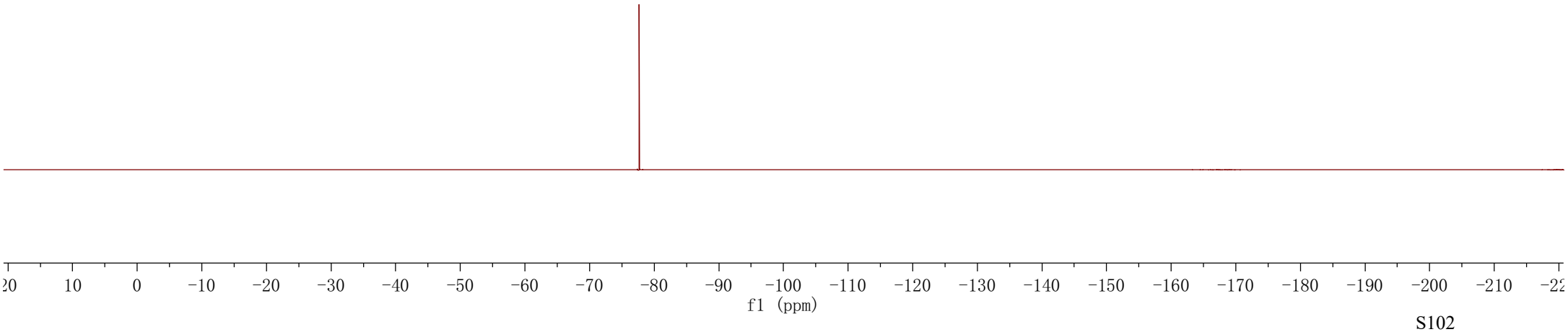
(**1t**, ^{13}C NMR, 100 MHz, DMSO-d_6)

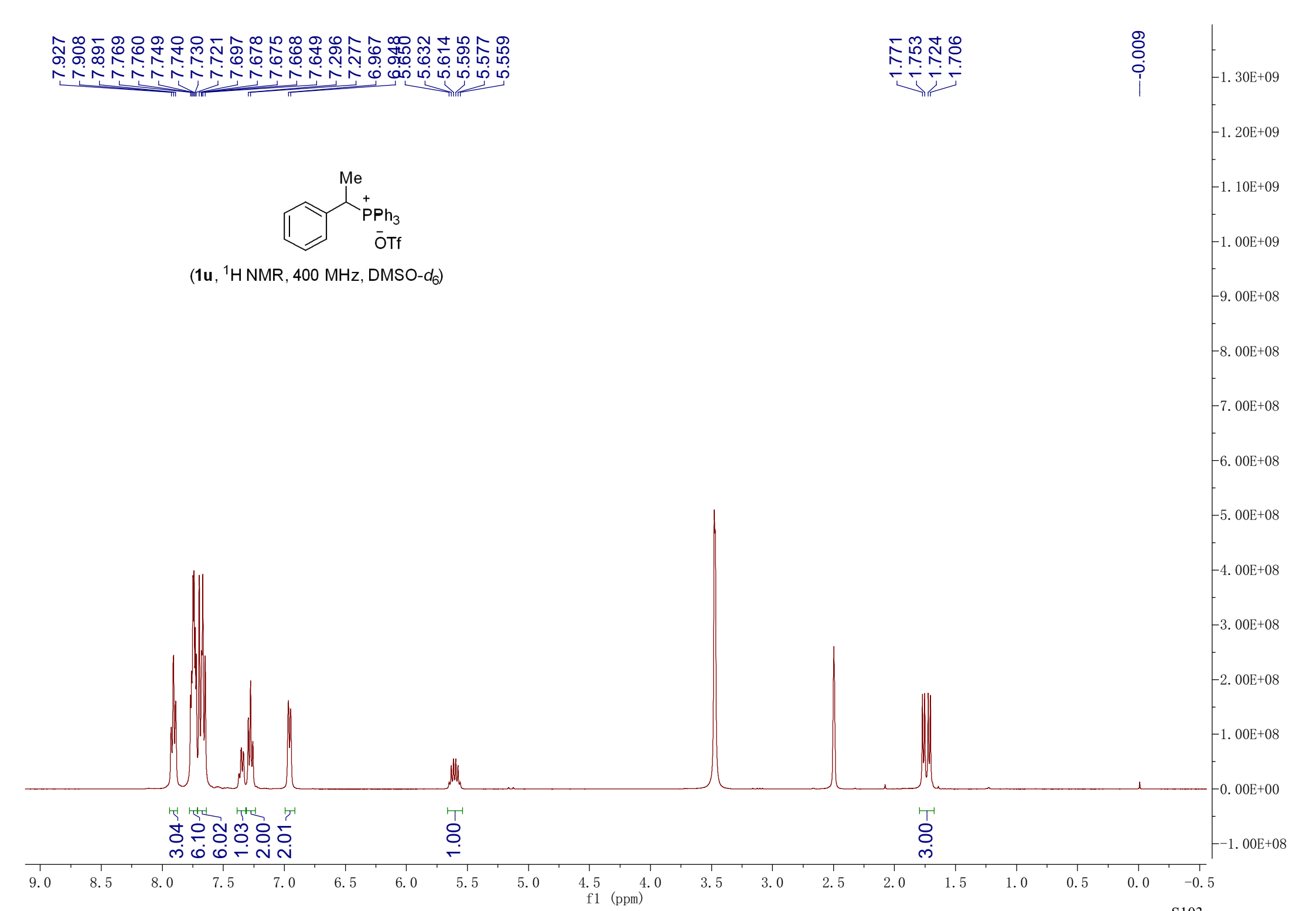


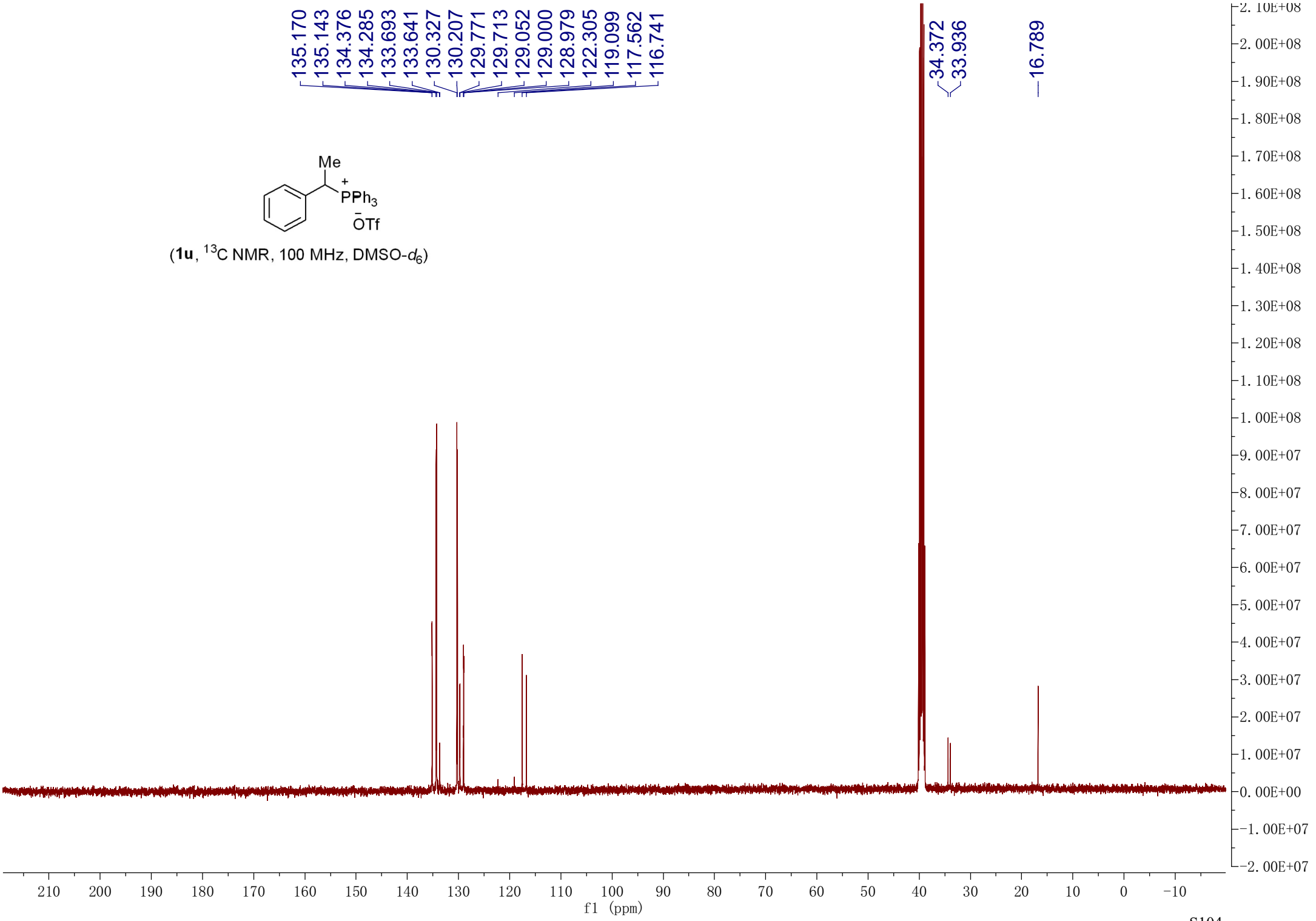
(**1t**, ^{31}P NMR, 162 MHz, DMSO-d_6)



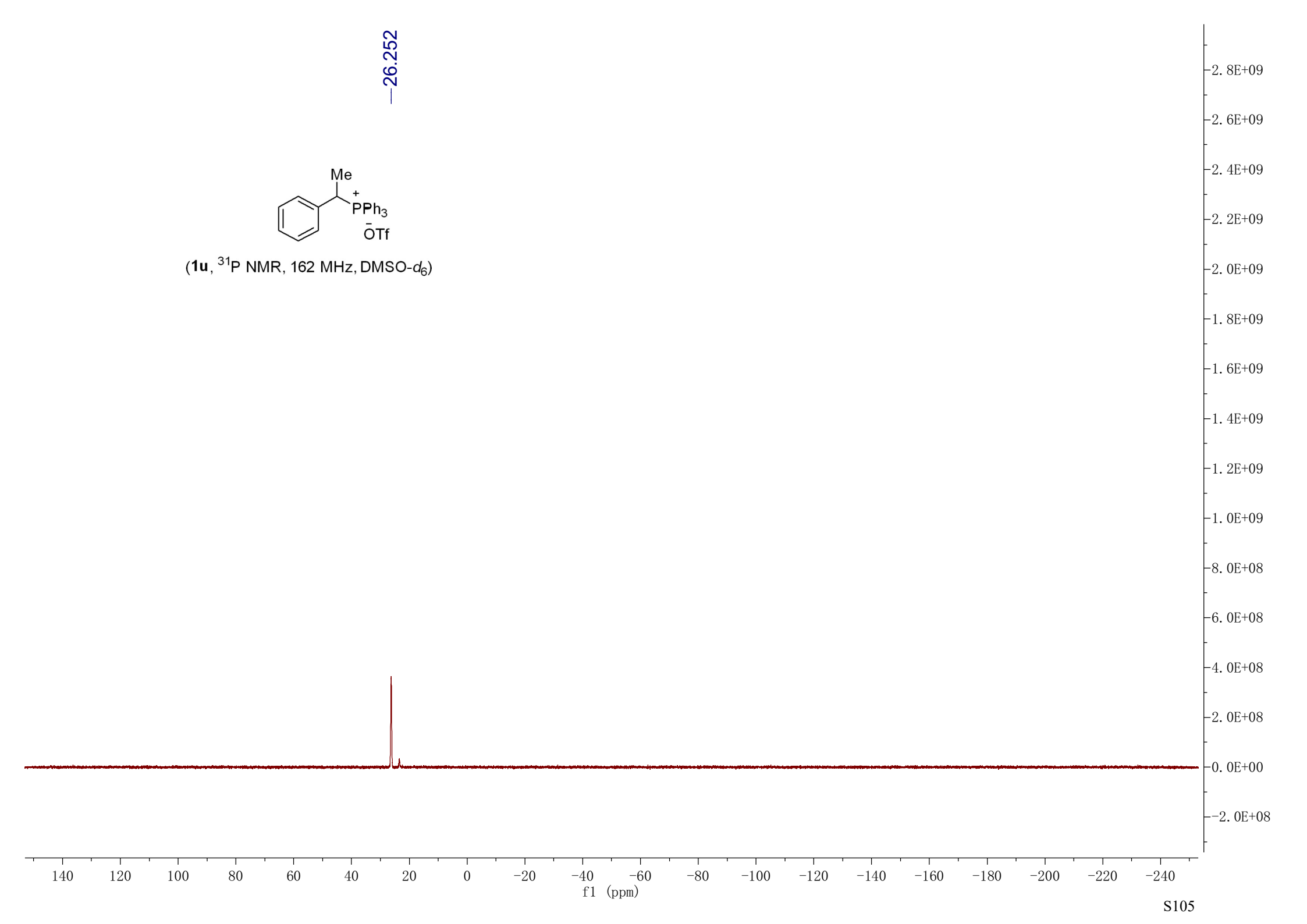
(**1t**, ^{19}F NMR, 376 MHz, DMSO-d_6)

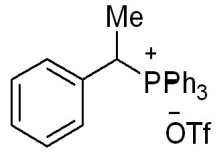



7.927
7.908
7.891
7.769
7.760
7.749
7.740
7.730
7.721
7.697
7.678
7.675
7.668
7.649
7.296
7.277
6.967
6.948
5.650
5.632
5.614
5.595
5.577
5.559
1.771
1.753
1.724
1.706
-0.009
Me
PPh3
OTf
(1u, 1H NMR, 400 MHz, DMSO-d6)
3.04
6.10
6.02
1.03
2.00
2.01
1.00
3.00
f1 (ppm)

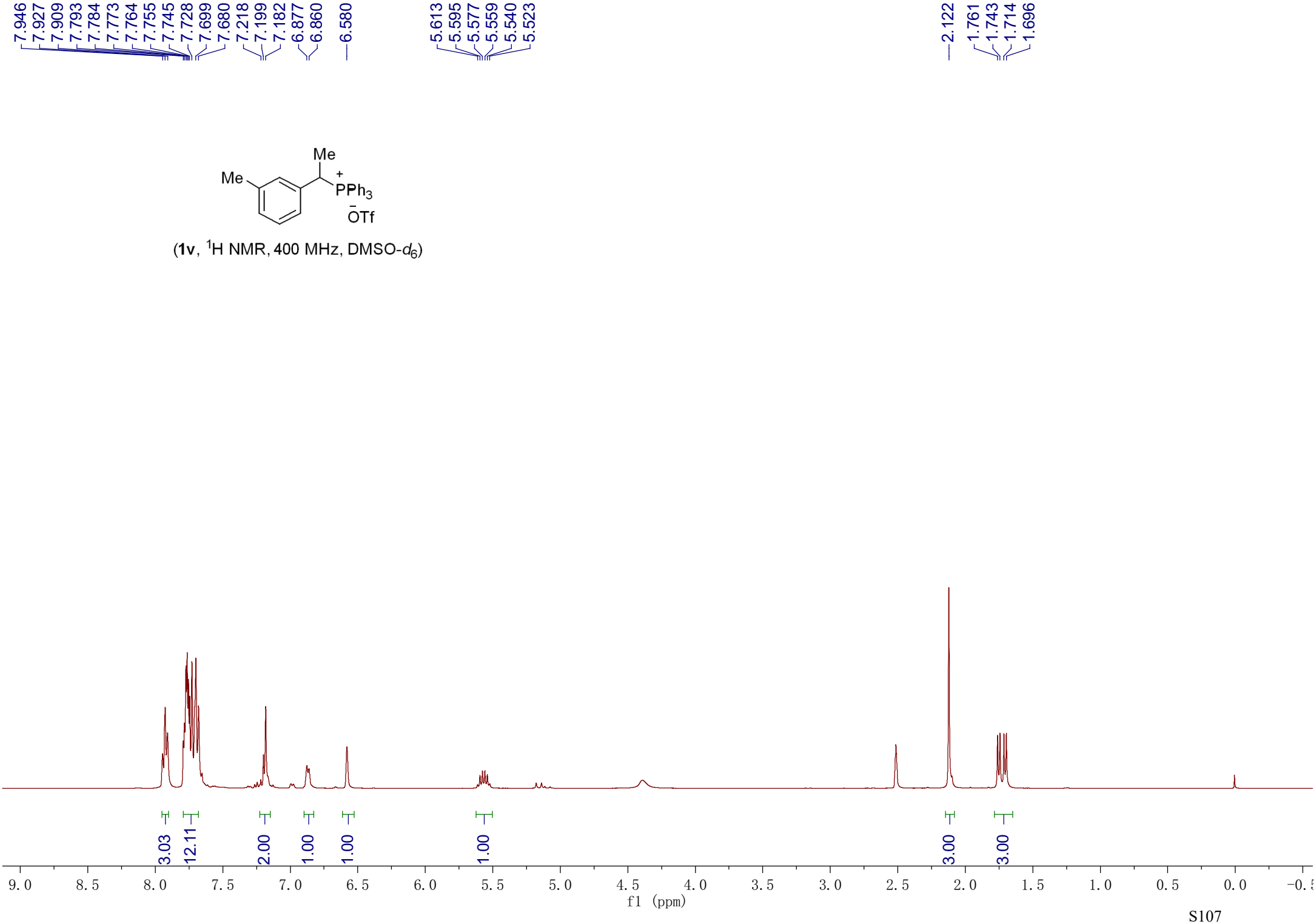


(**1u**, ^{13}C NMR, 100 MHz, DMSO-d_6)

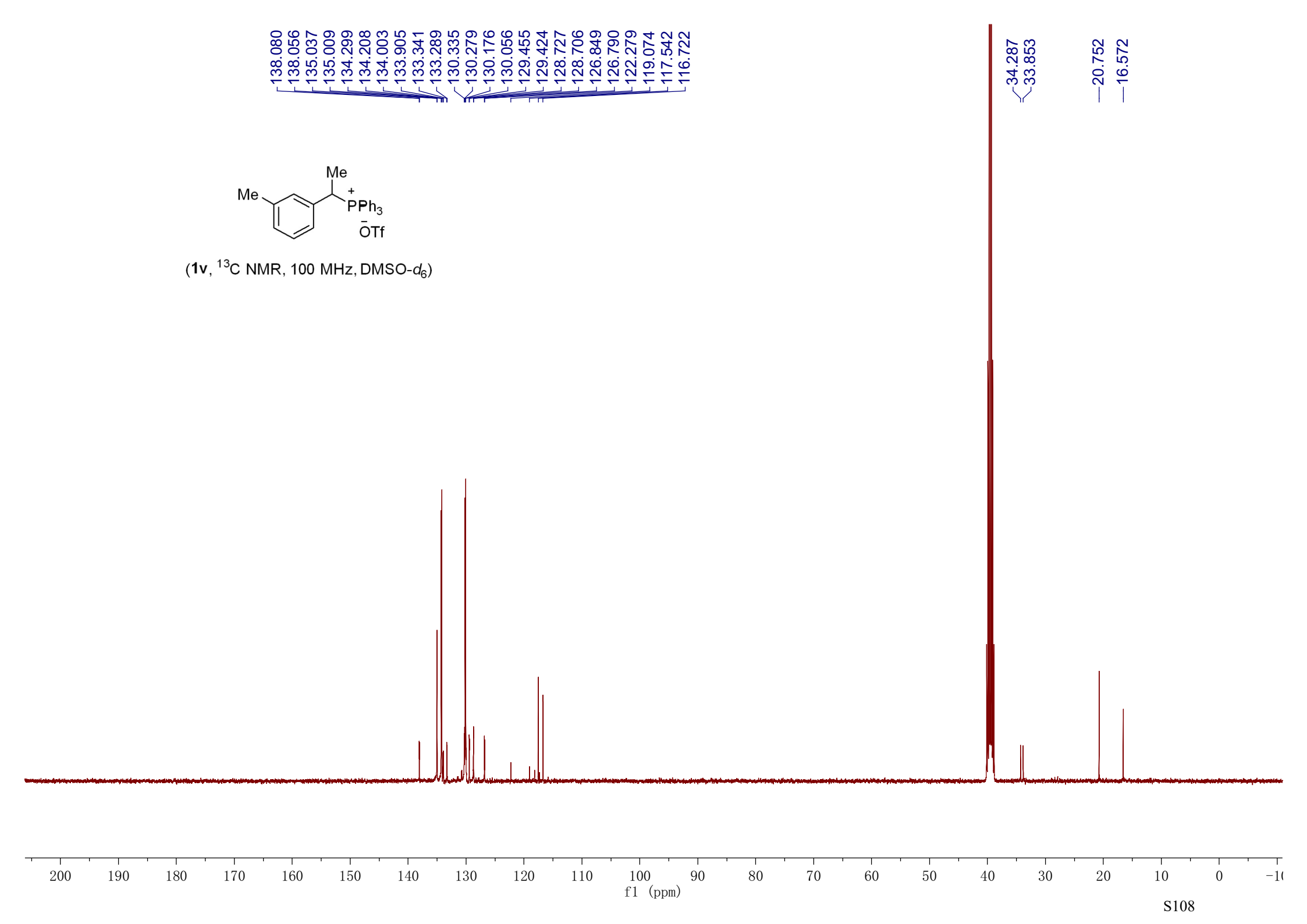

26.252
Me
PPh3
OTf
(1u, 31P NMR, 162 MHz, DMSO-d6)
2.8E+09
2.6E+09
2.4E+09
2.2E+09
2.0E+09
1.8E+09
1.6E+09
1.4E+09
1.2E+09
1.0E+09
8.0E+08
6.0E+08
4.0E+08
2.0E+08
0.0E+00
-2.0E+08
140 120 100 80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240
f1 (ppm)



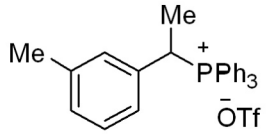
(**1u**, ^{19}F NMR, 376 MHz, DMSO-d_6)



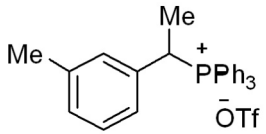
(**1v**, ^{1}H NMR, 400 MHz, DMSO-d_6)



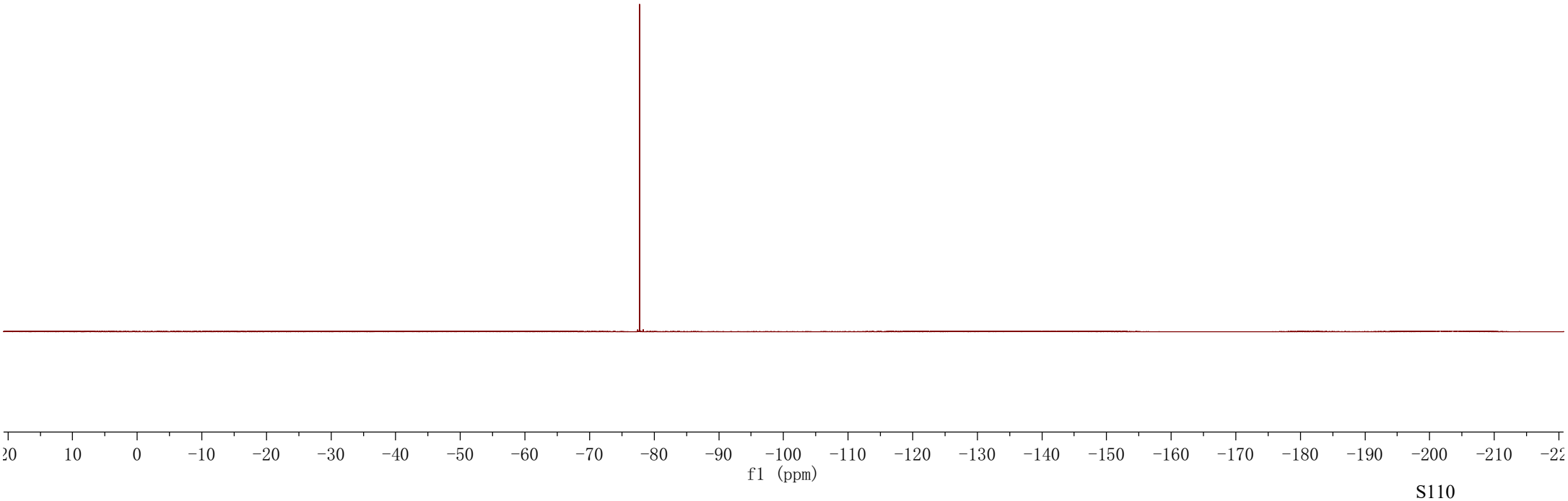
(**1v**, ^{13}C NMR, 100 MHz, DMSO-d_6)

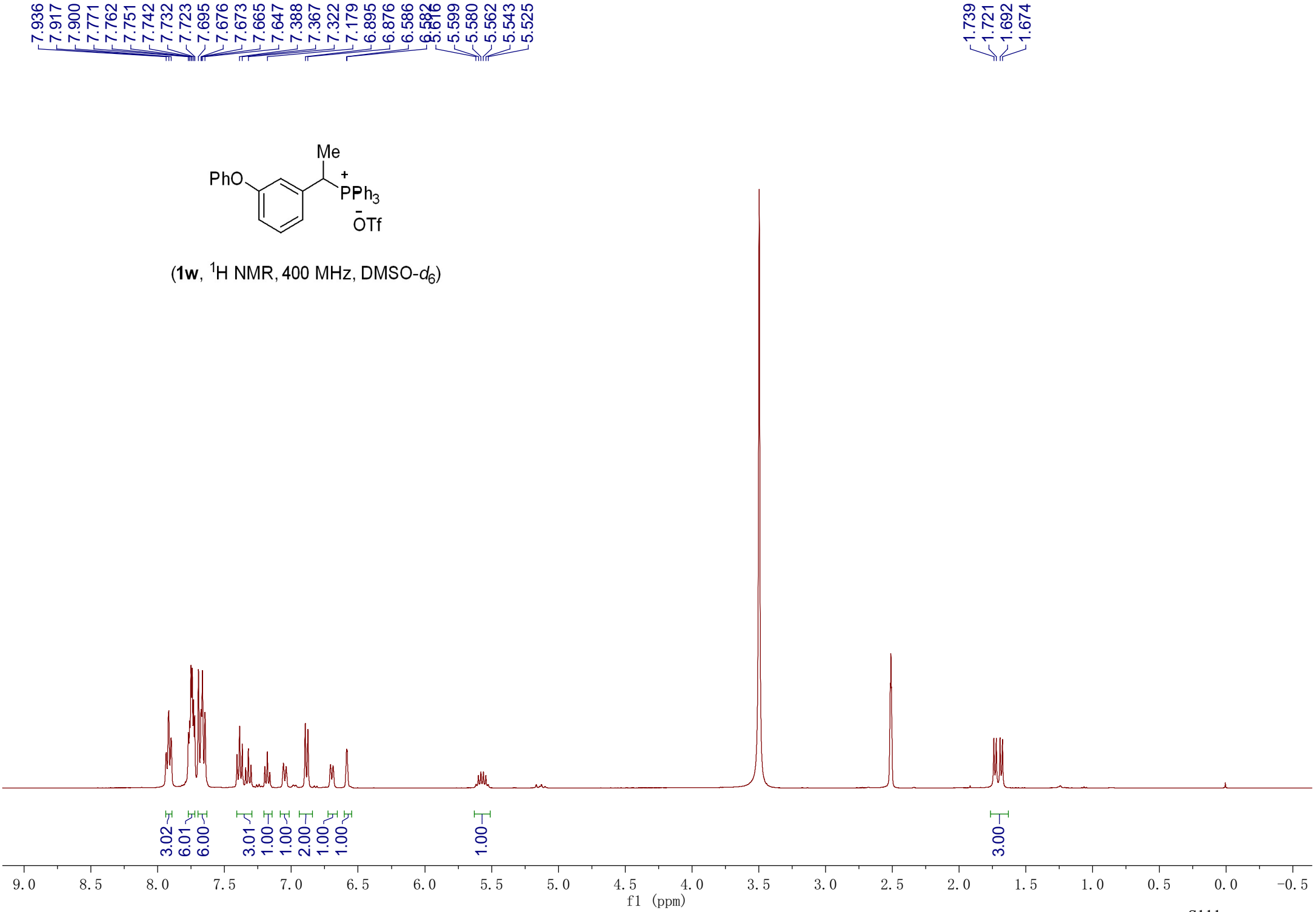


(**1v**, ^{31}P NMR, 162 MHz, DMSO-d_6)

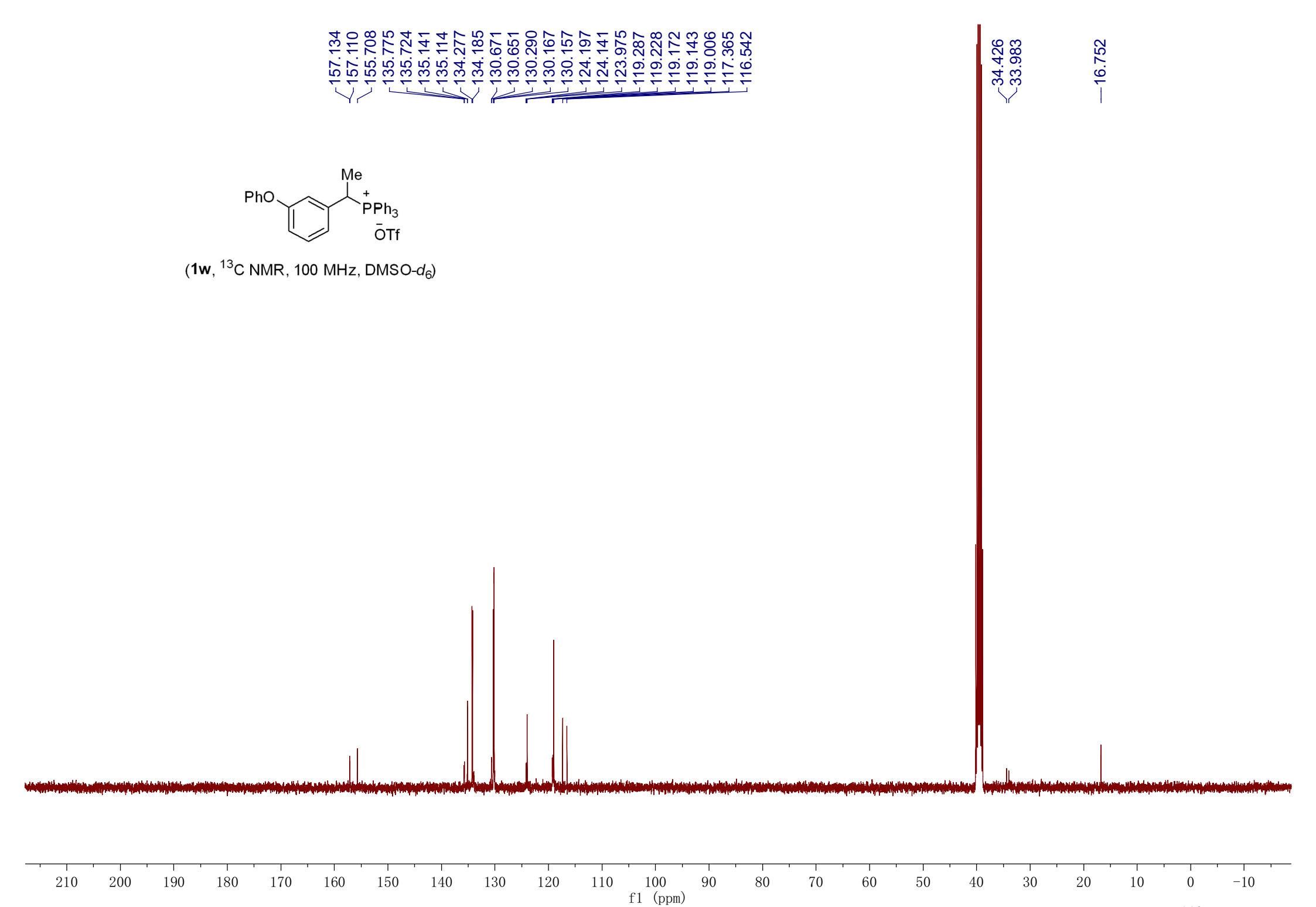


(**1v**, ^{19}F NMR, 376 MHz, DMSO-d_6)

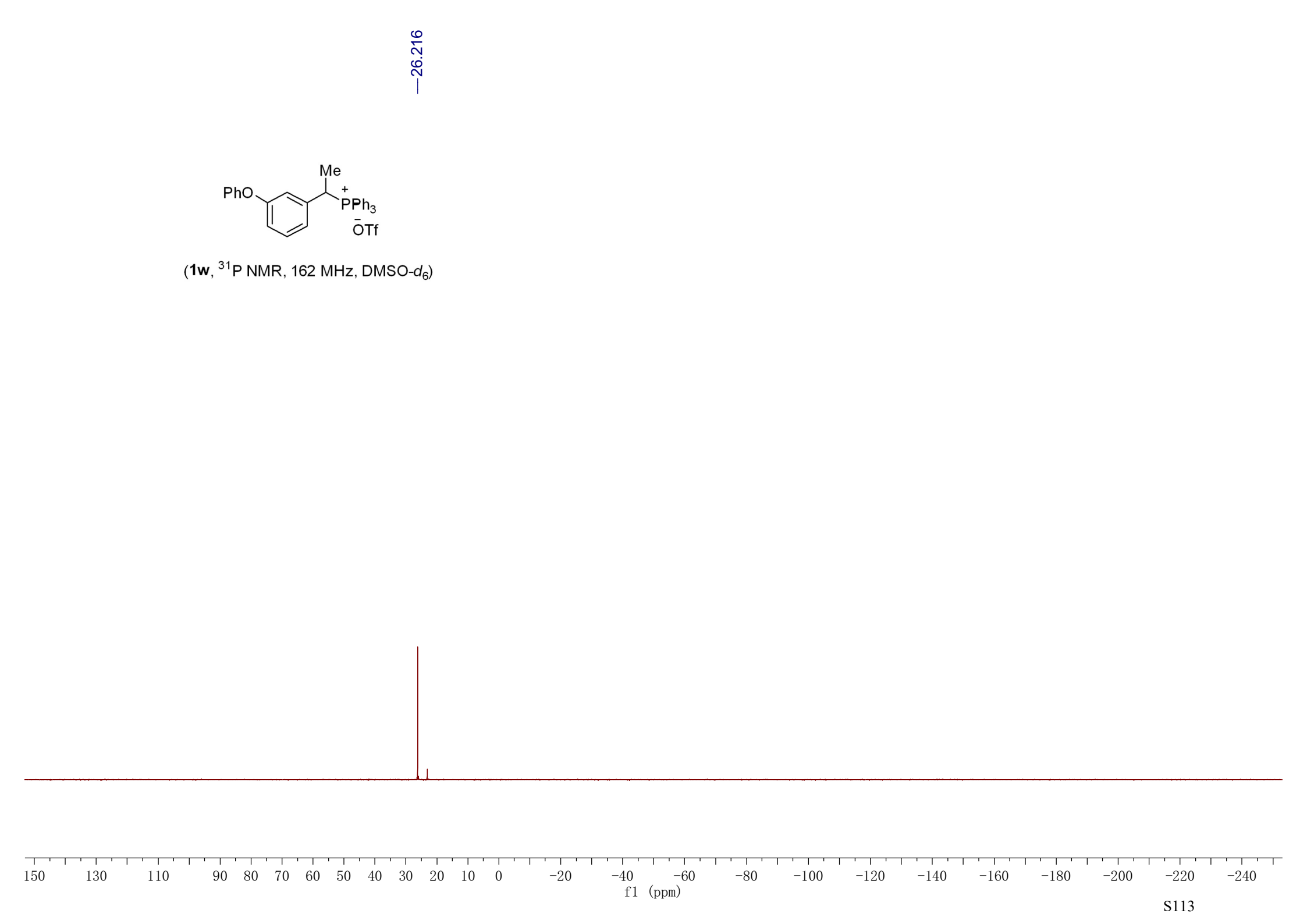




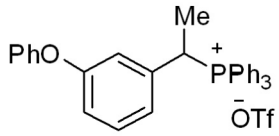
(**1w**, ^{1}H NMR, 400 MHz, DMSO-d_6)



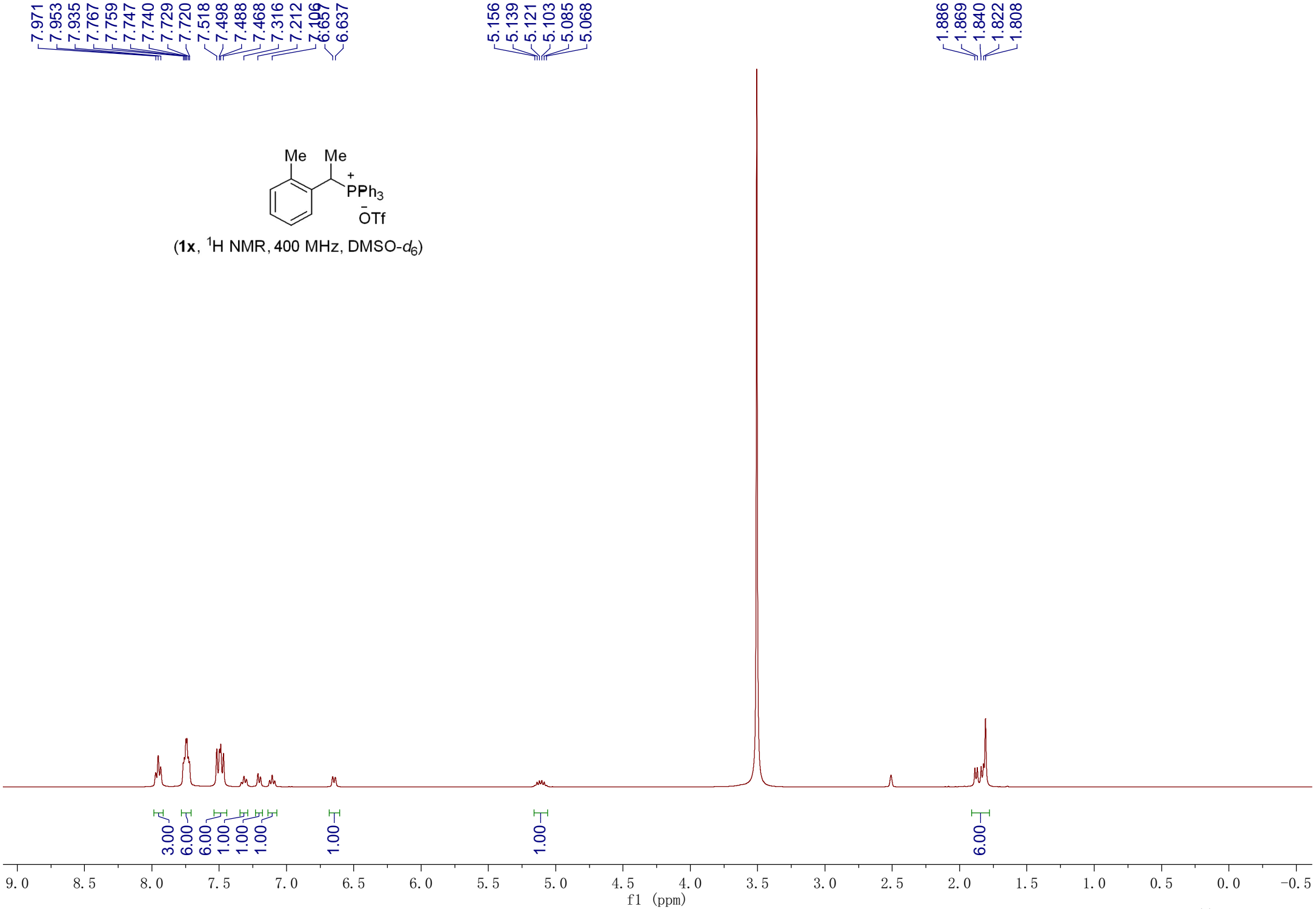
(**1w**, ^{13}C NMR, 100 MHz, DMSO-d_6)

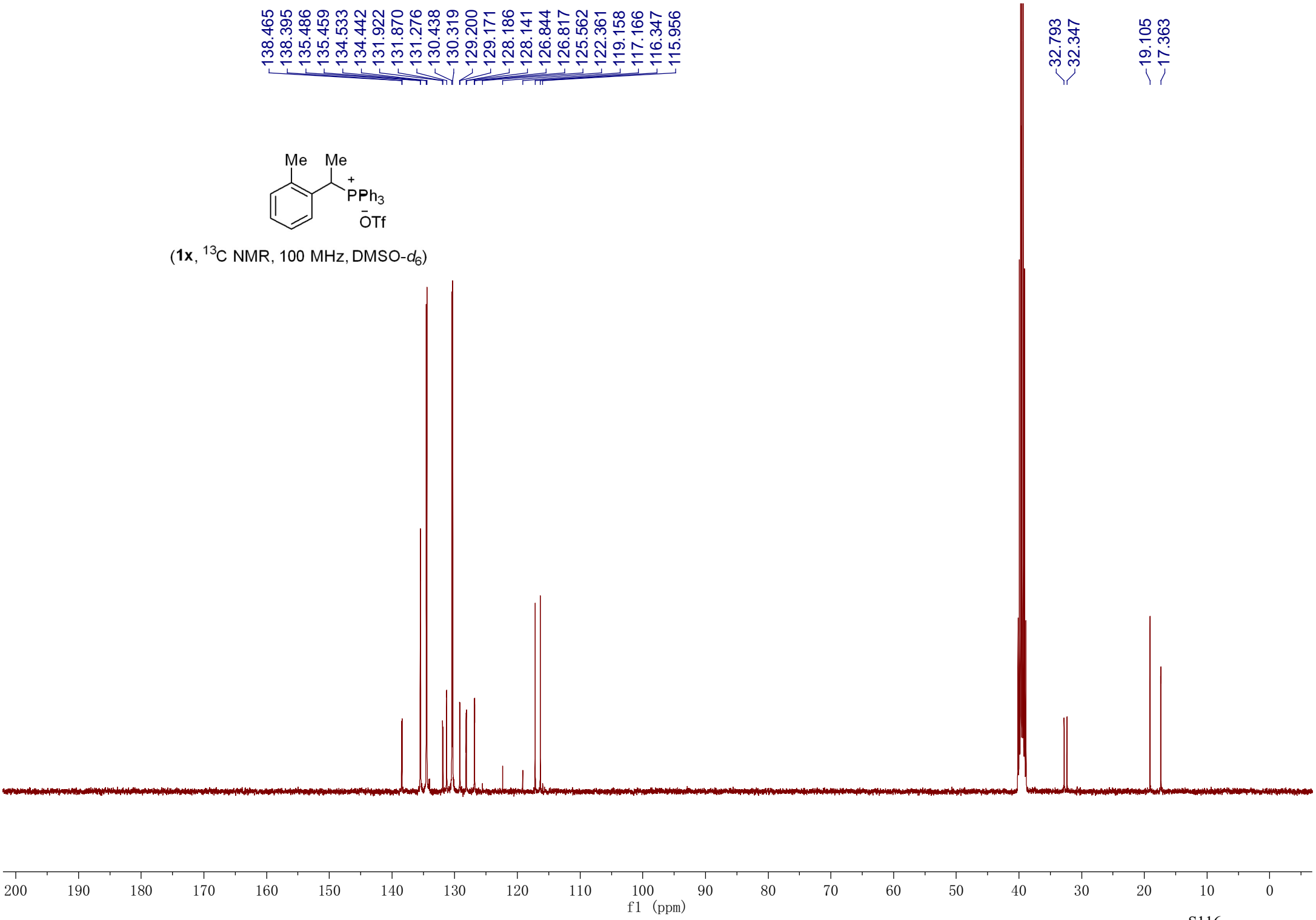


(**1w**, ^{31}P NMR, 162 MHz, DMSO-d_6)

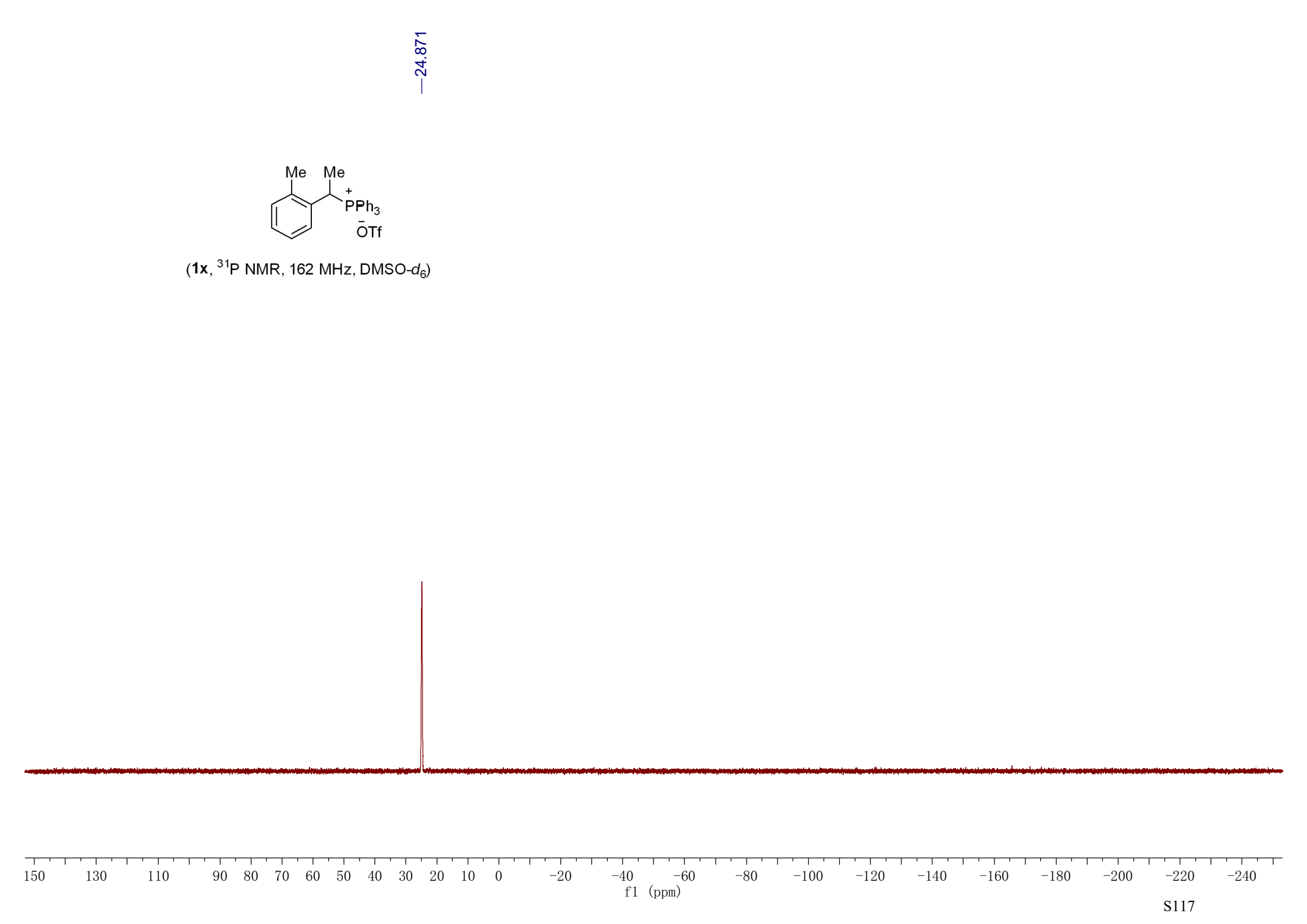


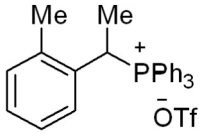
(**1w**, ^{19}F NMR, 376 MHz, DMSO-d_6)


7.971
7.953
7.935
7.767
7.759
7.747
7.740
7.729
7.720
7.518
7.498
7.488
7.468
7.316
7.212
7.196
6.657
6.637
5.156
5.139
5.121
5.103
5.085
5.068
1.886
1.869
1.840
1.822
1.808
Me
Me
PPh3
OTf
(1x, 1H NMR, 400 MHz, DMSO-d6)
3.00
6.00
6.00
1.00
1.00
1.00
1.00
1.00
6.00
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

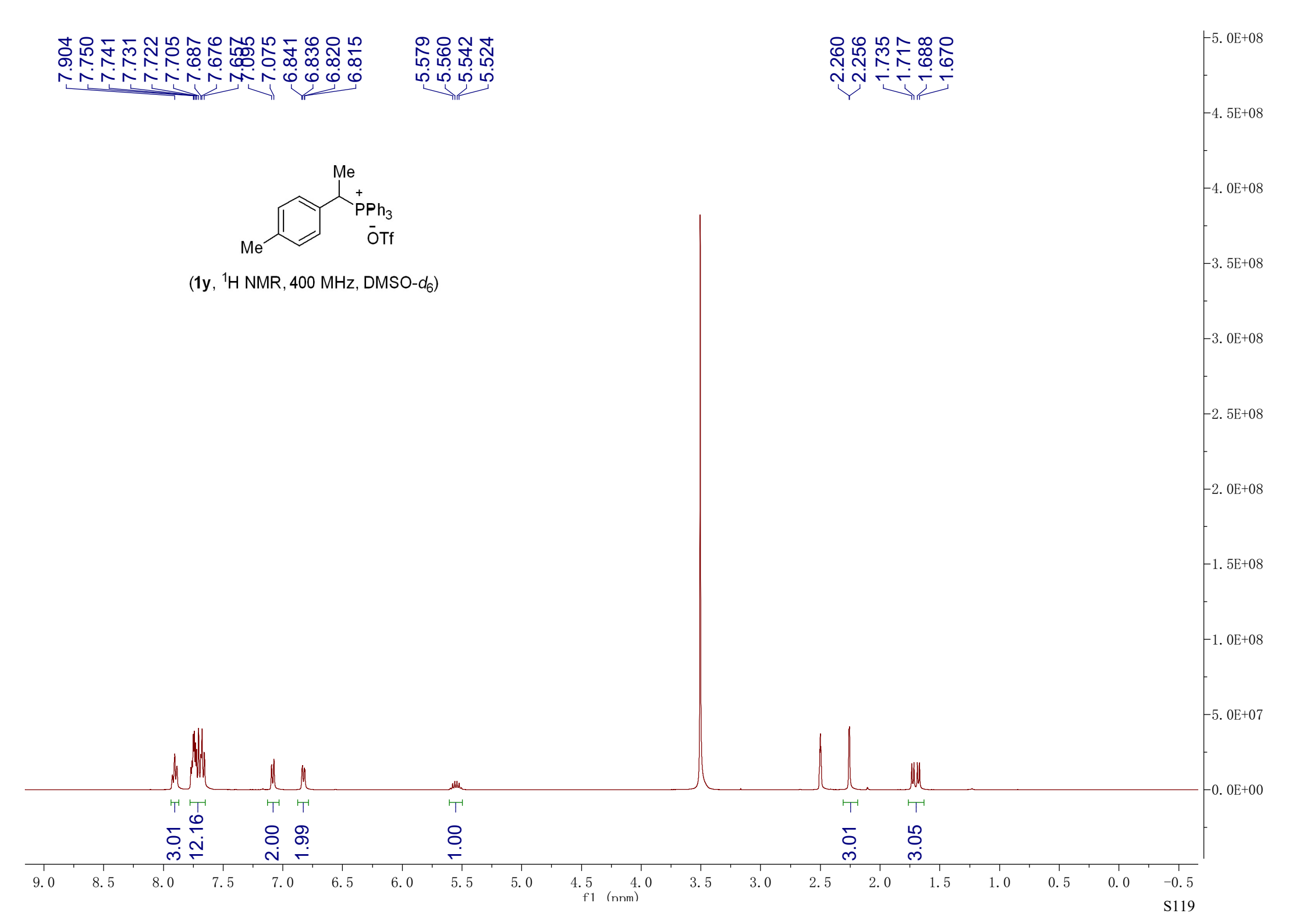


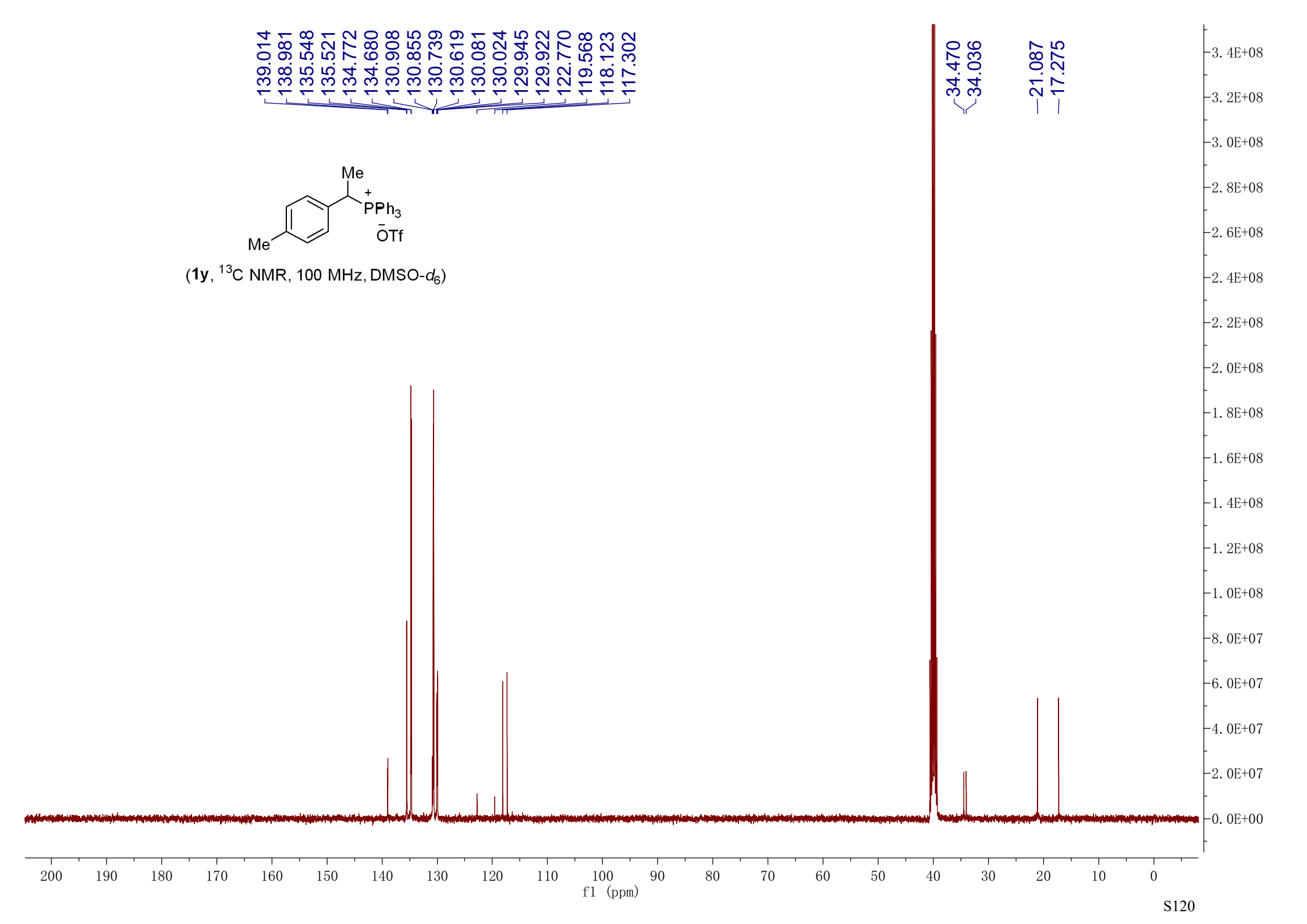
(**1x**, ^{13}C NMR, 100 MHz, DMSO-d_6)

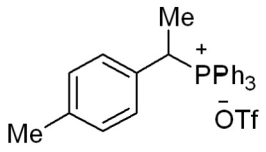

24.871
Me
Me
PPh3
OTf
(1x, 31P NMR, 162 MHz, DMSO-d6)
150
130
110
90
80
70
60
50
40
30
20
10
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
f1 (ppm)



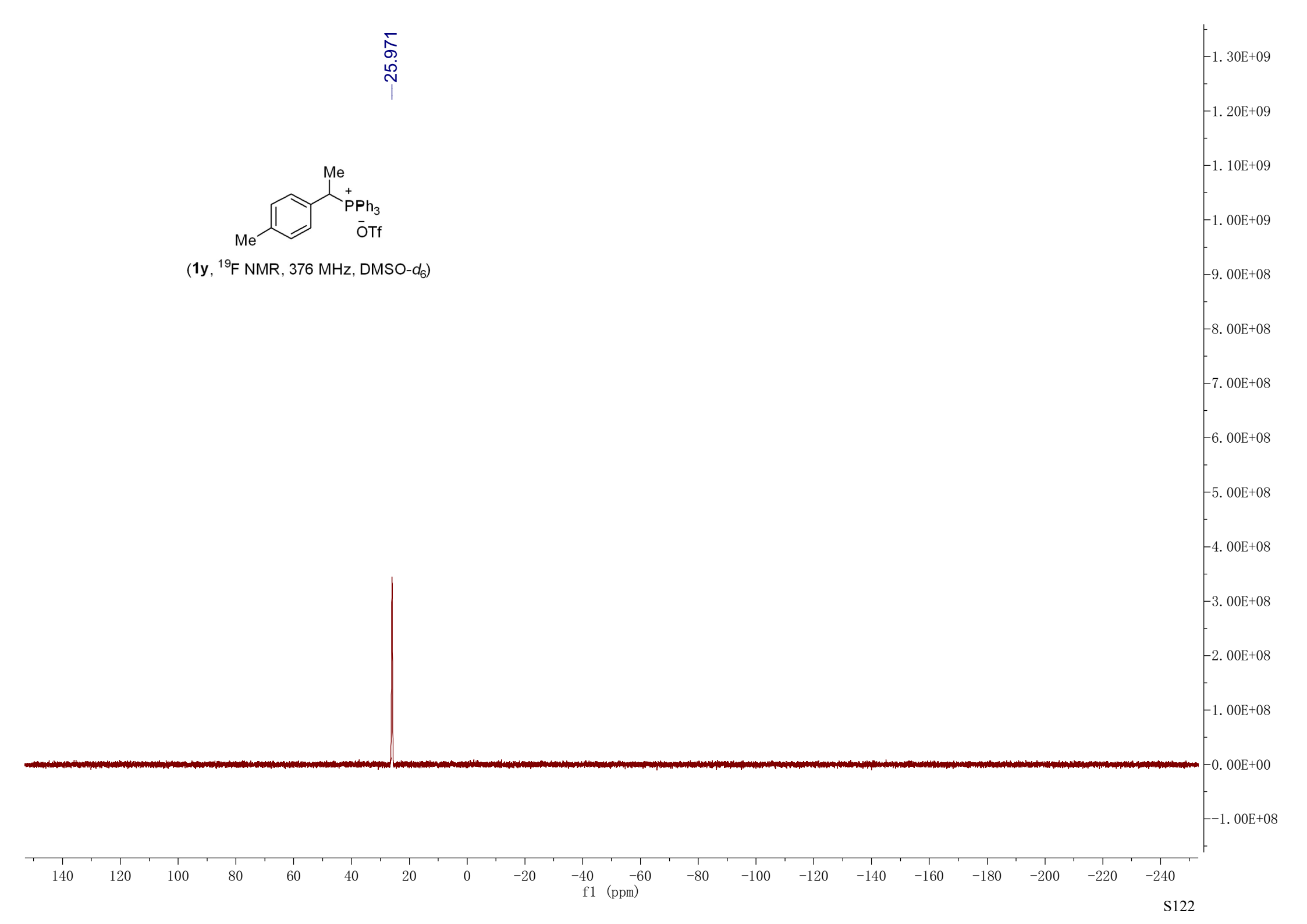
(**1x**, ^{19}F NMR, 376 MHz, DMSO-d_6)

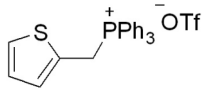

7.904
7.750
7.741
7.731
7.722
7.705
7.687
7.676
7.657
7.095
7.075
6.841
6.836
6.820
6.815
5.579
5.560
5.542
5.524
2.260
2.256
1.735
1.717
1.688
1.670
Me
PPh3
OTf
Me
(1y, 1H NMR, 400 MHz, DMSO-d6)
3.01
12.16
2.00
1.99
1.00
3.01
3.05
f1 (ppm)


139.014
138.981
135.548
135.521
134.772
134.680
130.908
130.855
130.739
130.619
130.081
130.024
129.945
129.922
122.770
119.568
118.123
117.302
34.470
34.036
21.087
17.275
Me
PPh3
OTf
Me
(1y, 13C NMR, 100 MHz, DMSO-d6)
f1 (ppm)

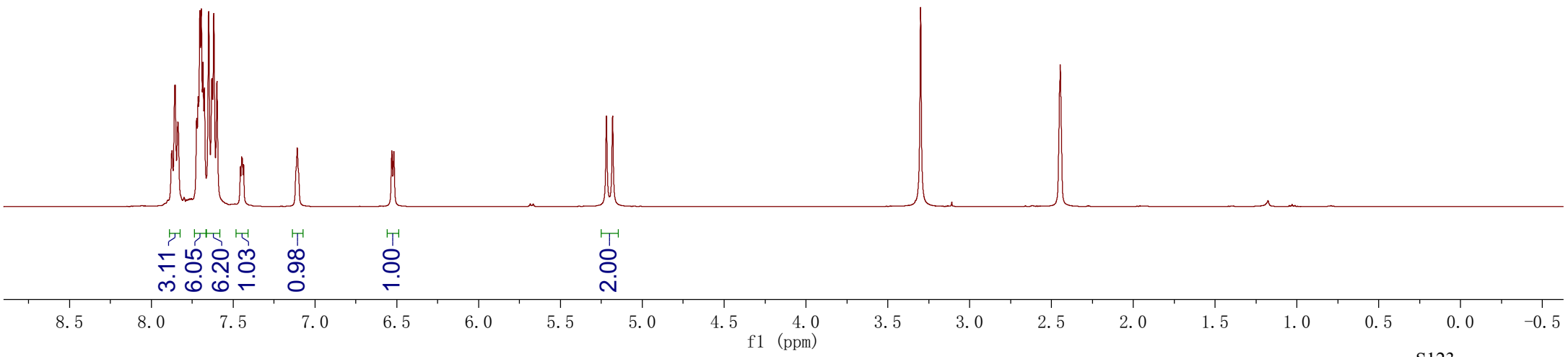


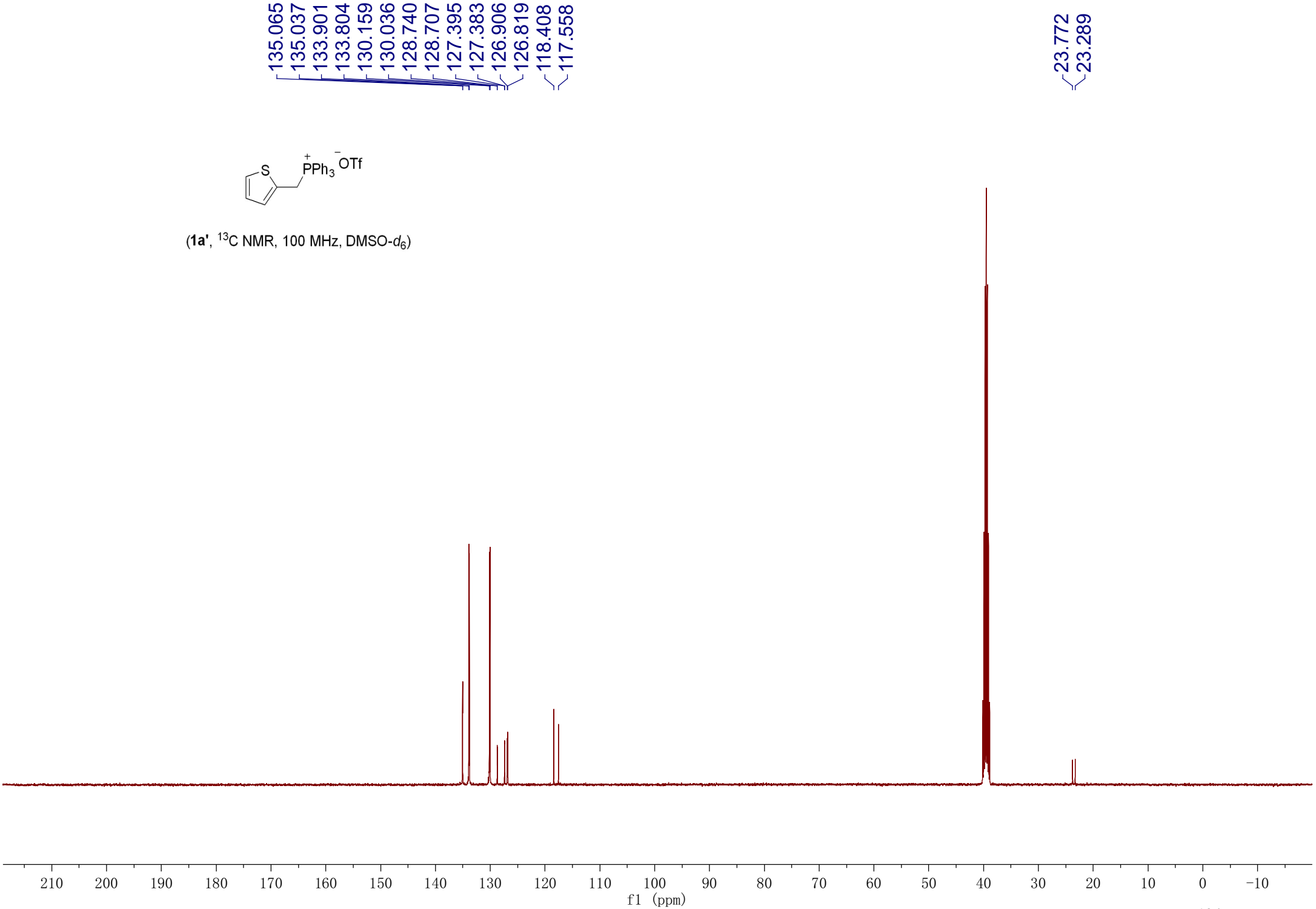
(**1y**, ^{31}P NMR, 162 MHz, DMSO-d_6)

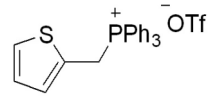

—25.971
Me
PPh3
OTf
Me
(1y, 19F NMR, 376 MHz, DMSO-d6)
1.30E+09
1.20E+09
1.10E+09
1.00E+09
9.00E+08
8.00E+08
7.00E+08
6.00E+08
5.00E+08
4.00E+08
3.00E+08
2.00E+08
1.00E+08
0.00E+00
-1.00E+08
140 120 100 80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240
f1 (ppm)



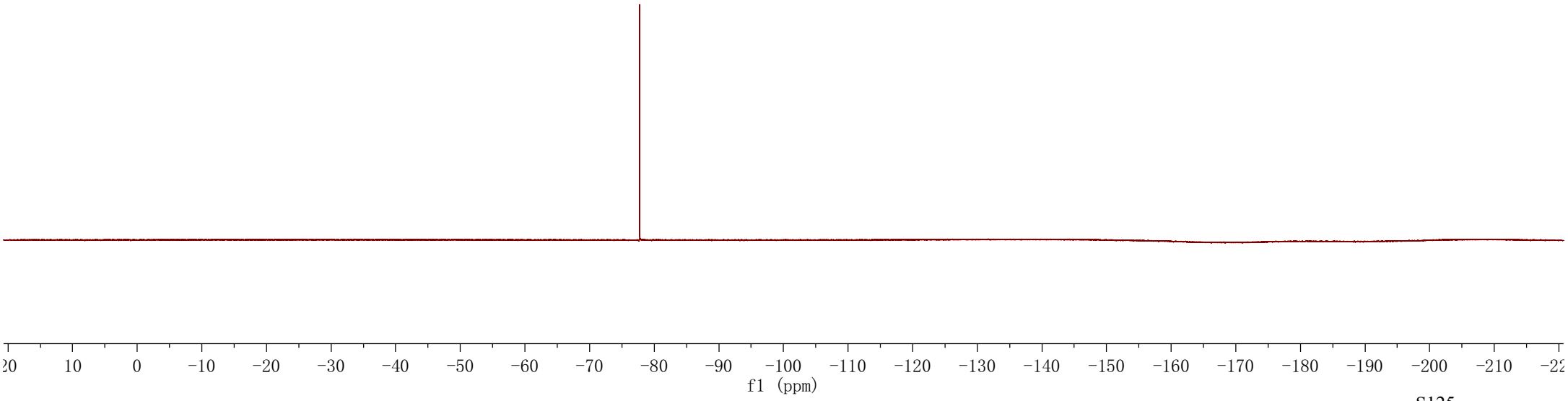
(**1a'**, ^{1}H NMR, 400 MHz, DMSO-d_6)

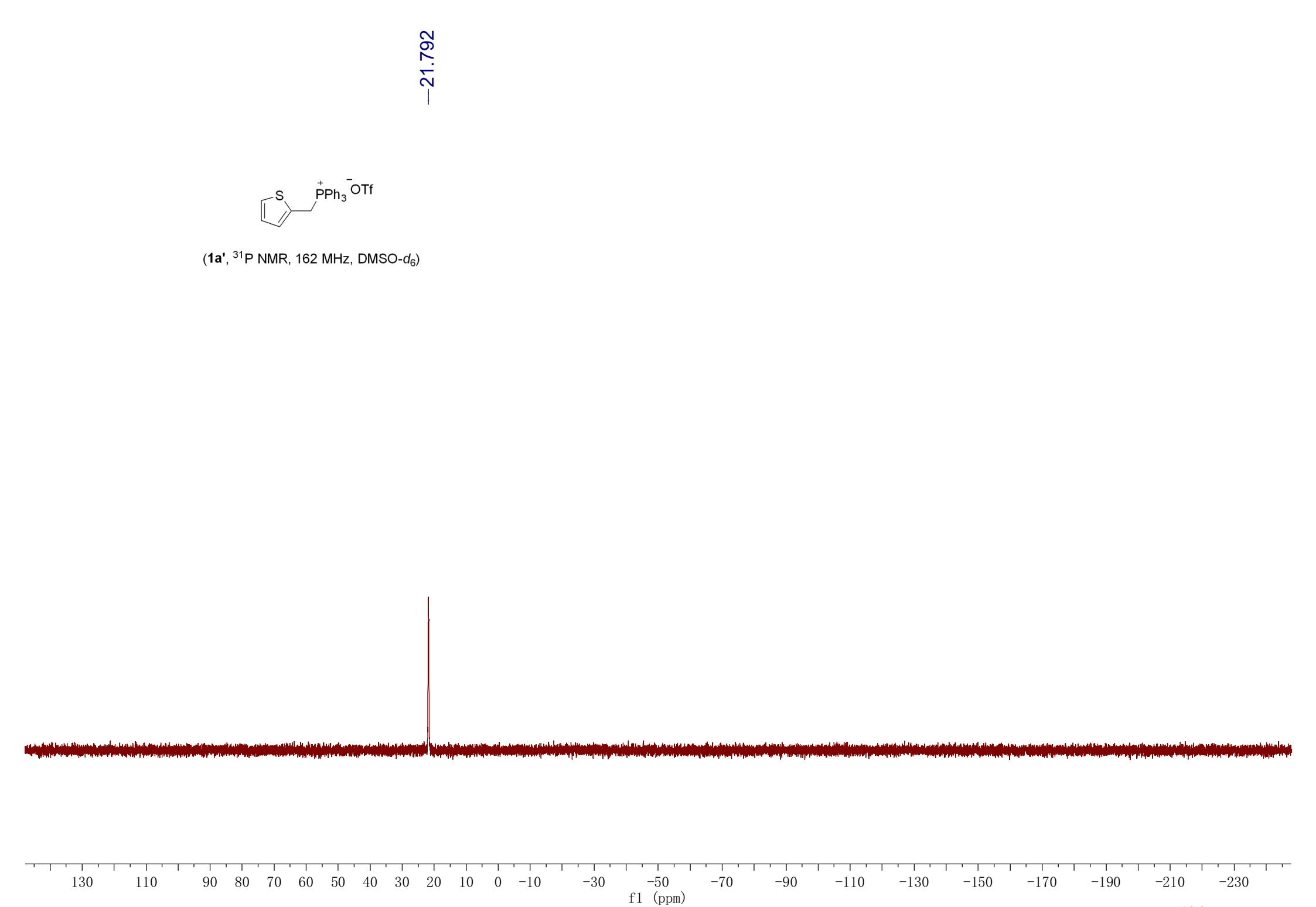



135.065
135.037
133.901
133.804
130.159
130.036
128.740
128.707
127.395
127.383
126.906
126.819
118.408
117.558
23.772
23.289
S
PPh3
OTf
(1a', 13C NMR, 100 MHz, DMSO-d6)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

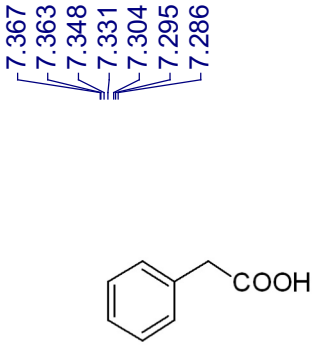


(**1a'**, ^{19}F NMR, 376 MHz, DMSO-d_6)

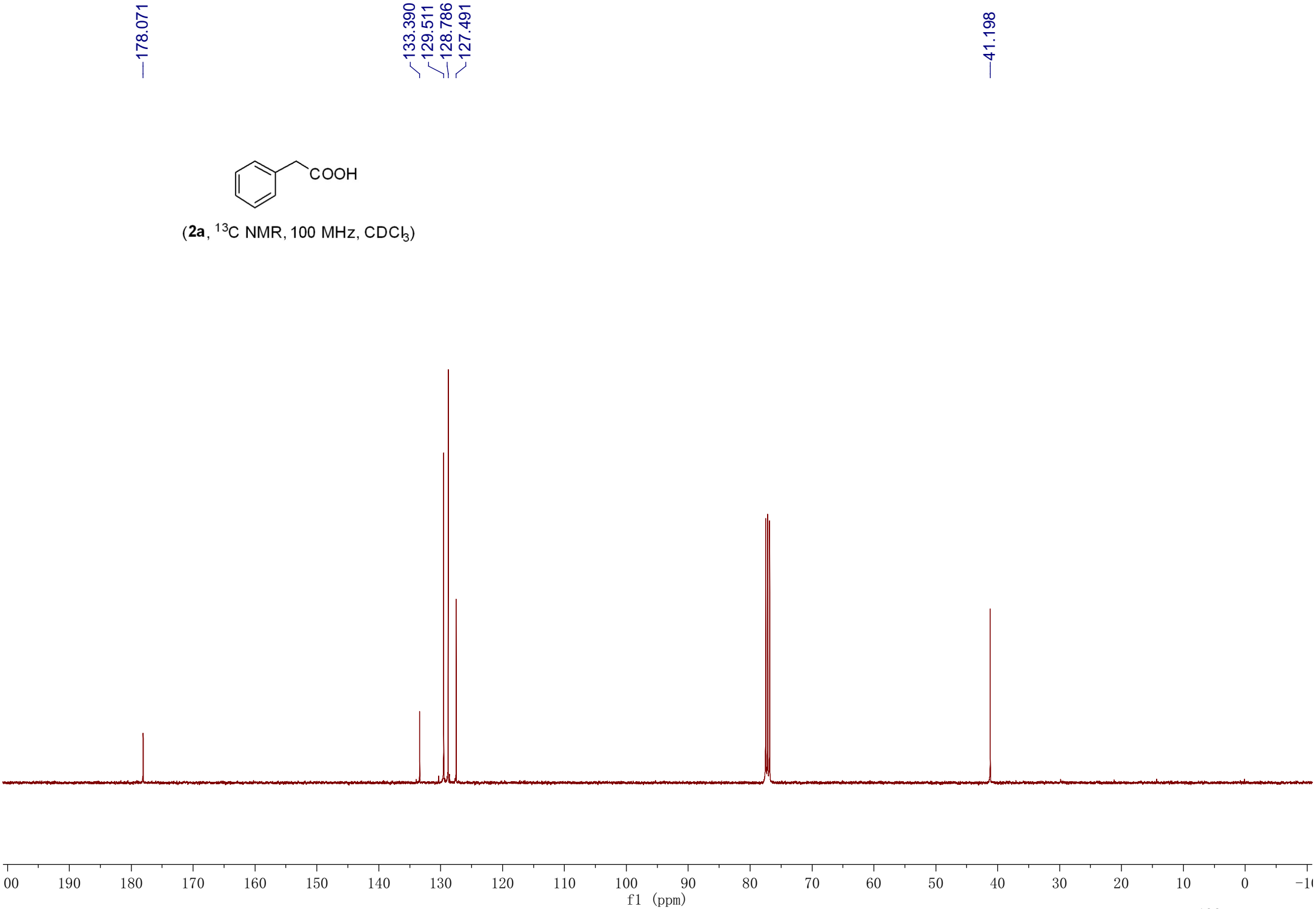




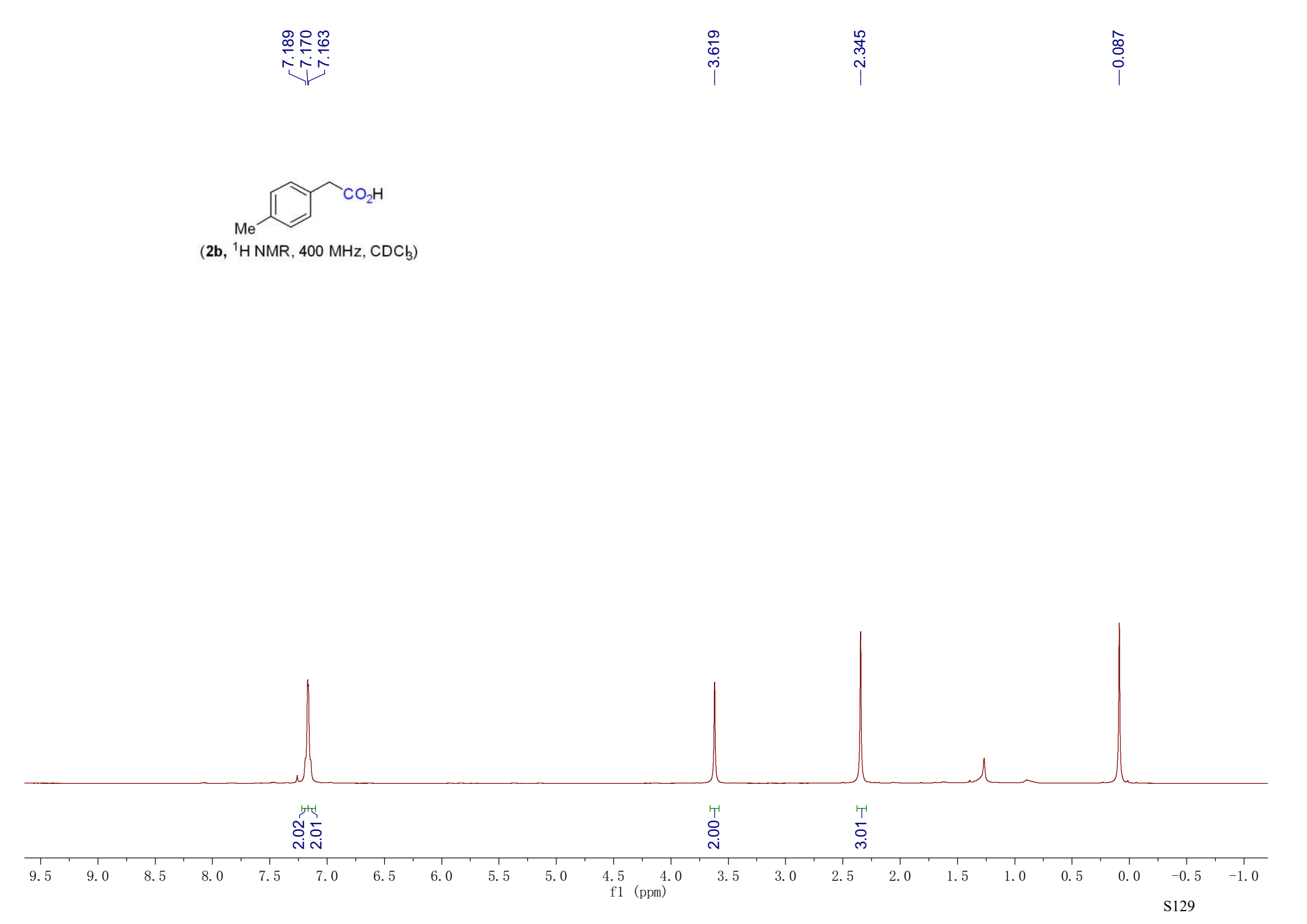
(**1a'**, ^{31}P NMR, 162 MHz, DMSO-d_6)



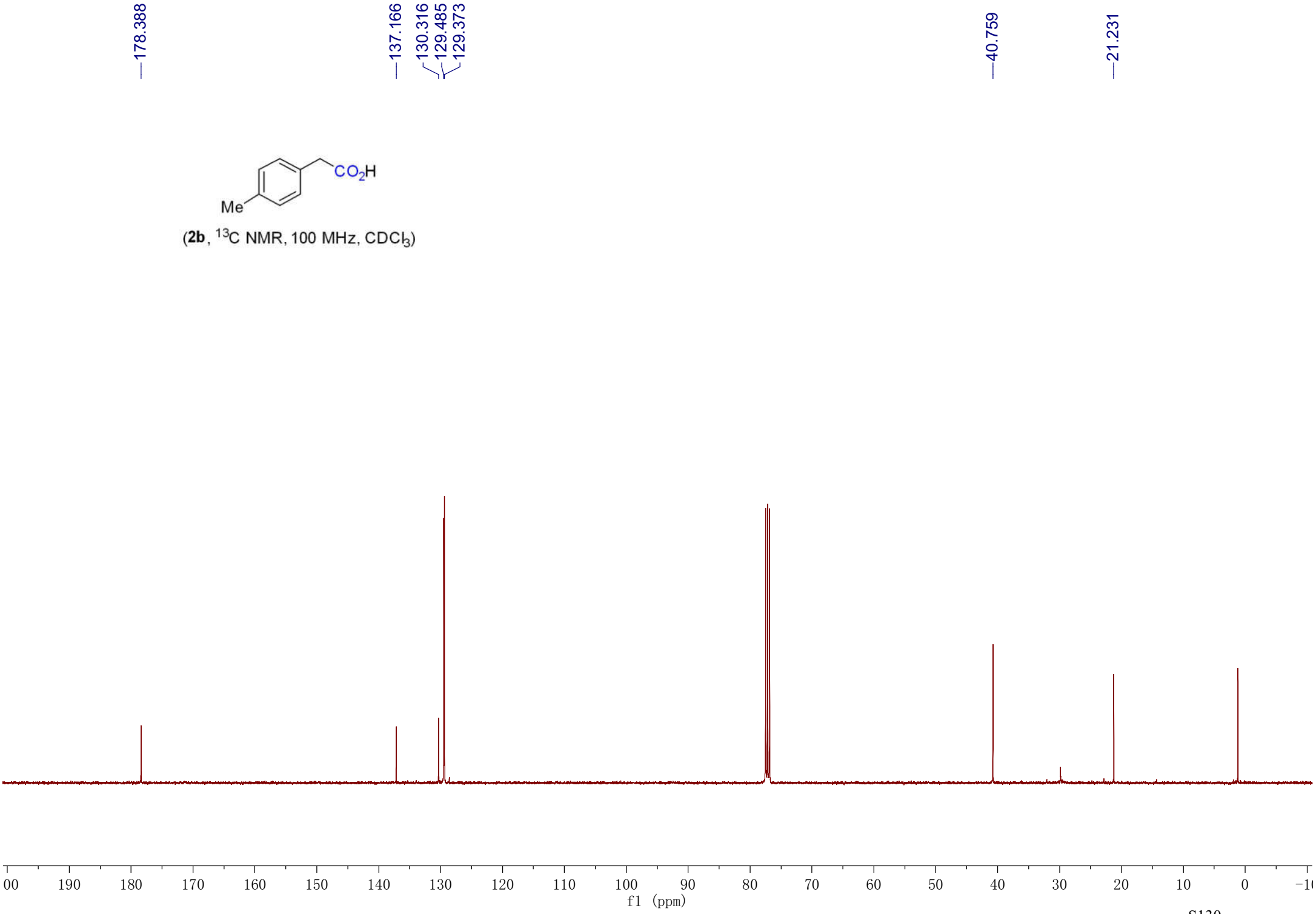
(**2a**, ^{1}H NMR, 400 MHz, $CDCl_3$)



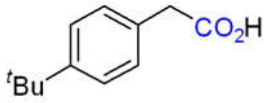
(**2a**, ^{13}C NMR, 100 MHz, $CDCl_3$)



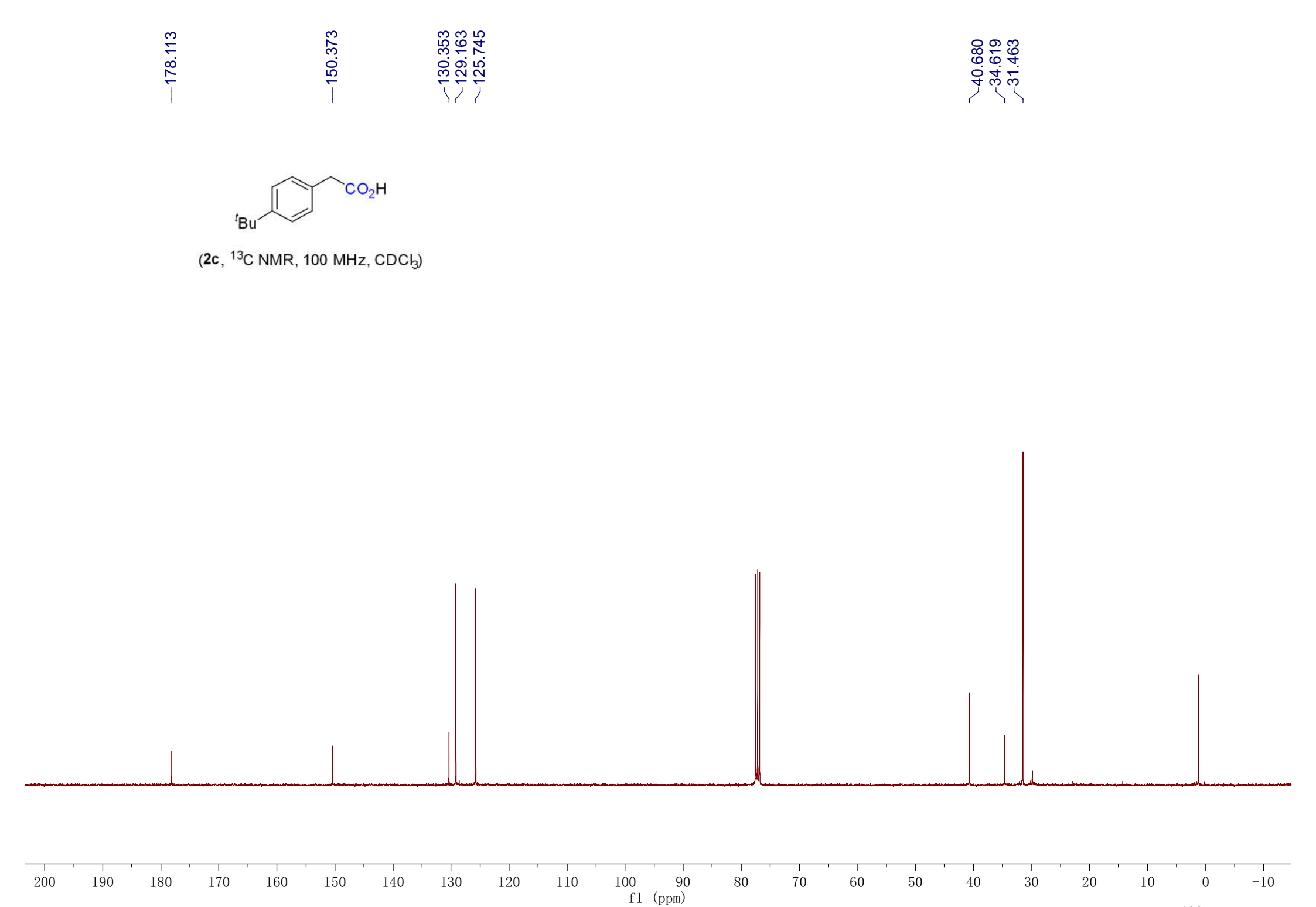
(**2b,** ^{1}H NMR, 400 MHz, $CDCl_3$)



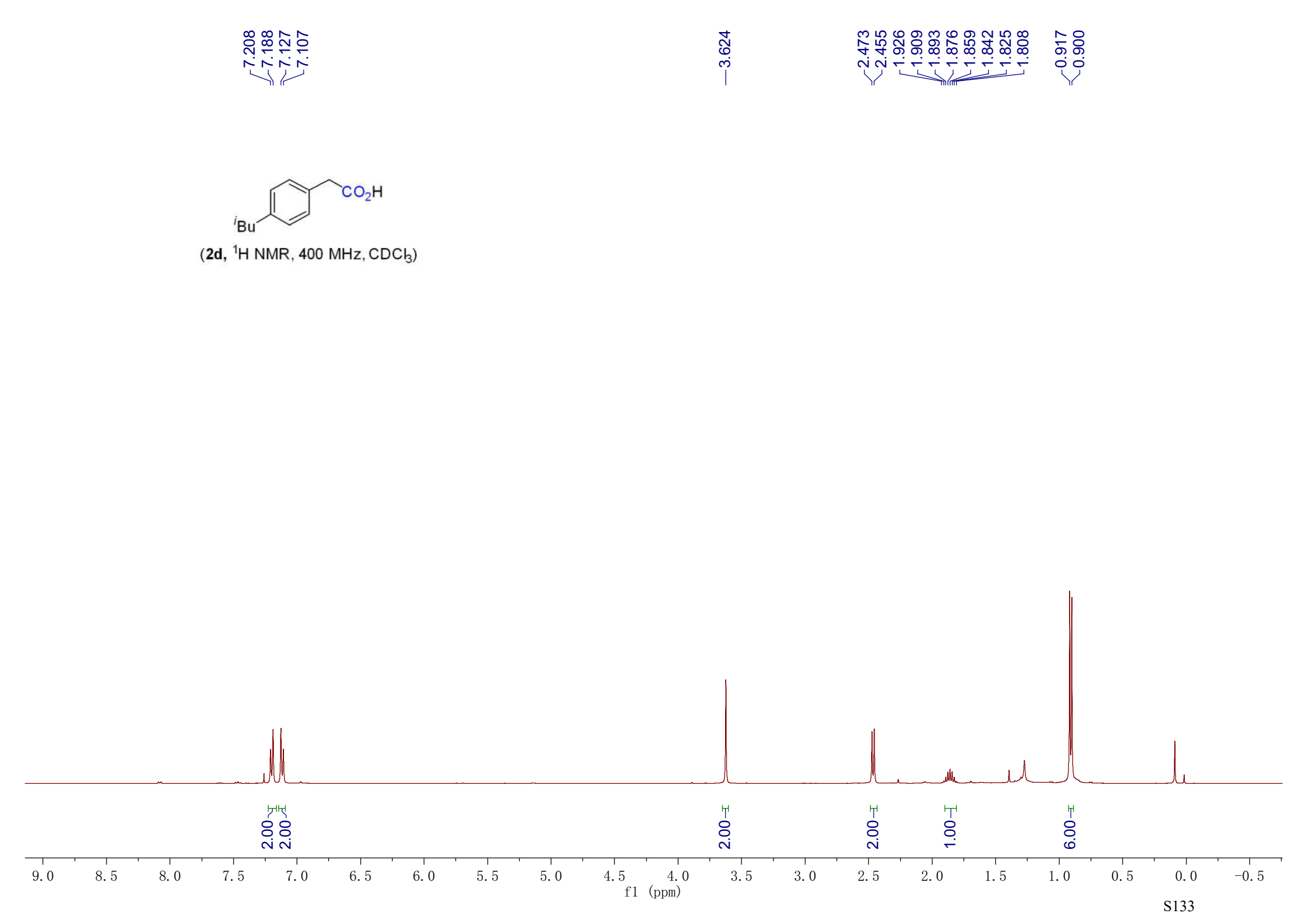
(**2b**, ^{13}C NMR, 100 MHz, $CDCl_3$)



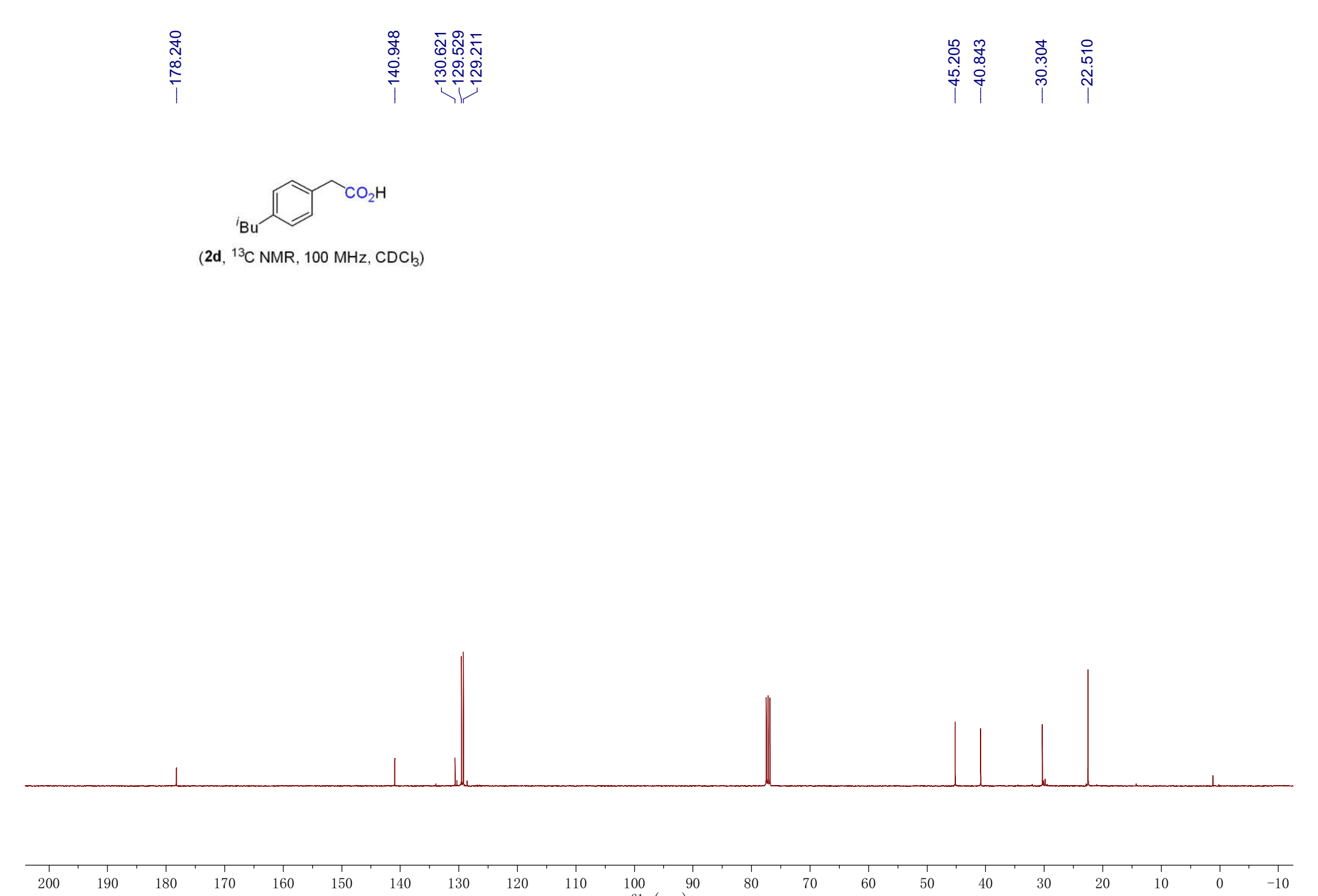
(**2c**, ^{1}H NMR, 400 MHz, $CDCl_3$)



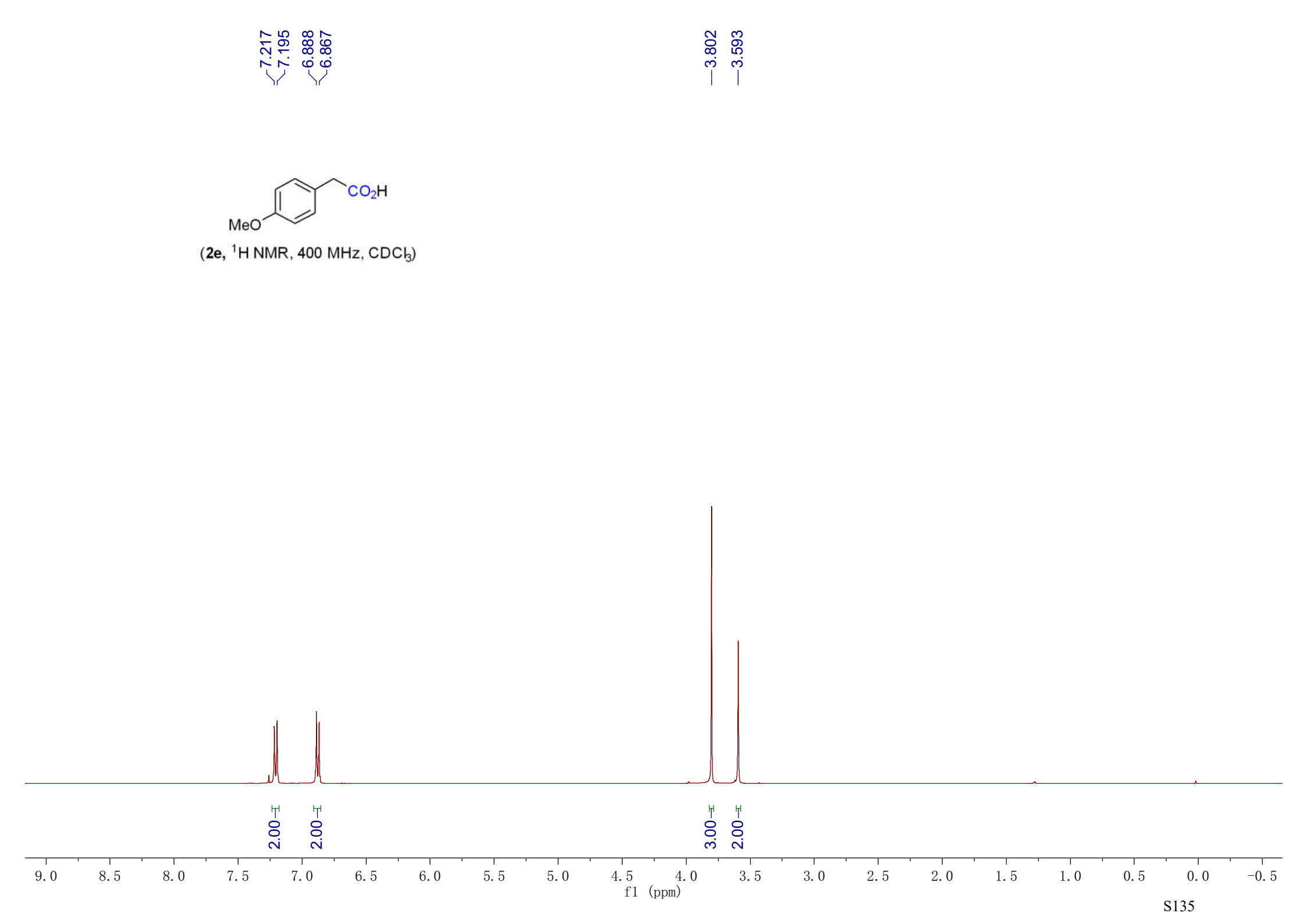
(**2c**, ^{13}C NMR, 100 MHz, $CDCl_3$)



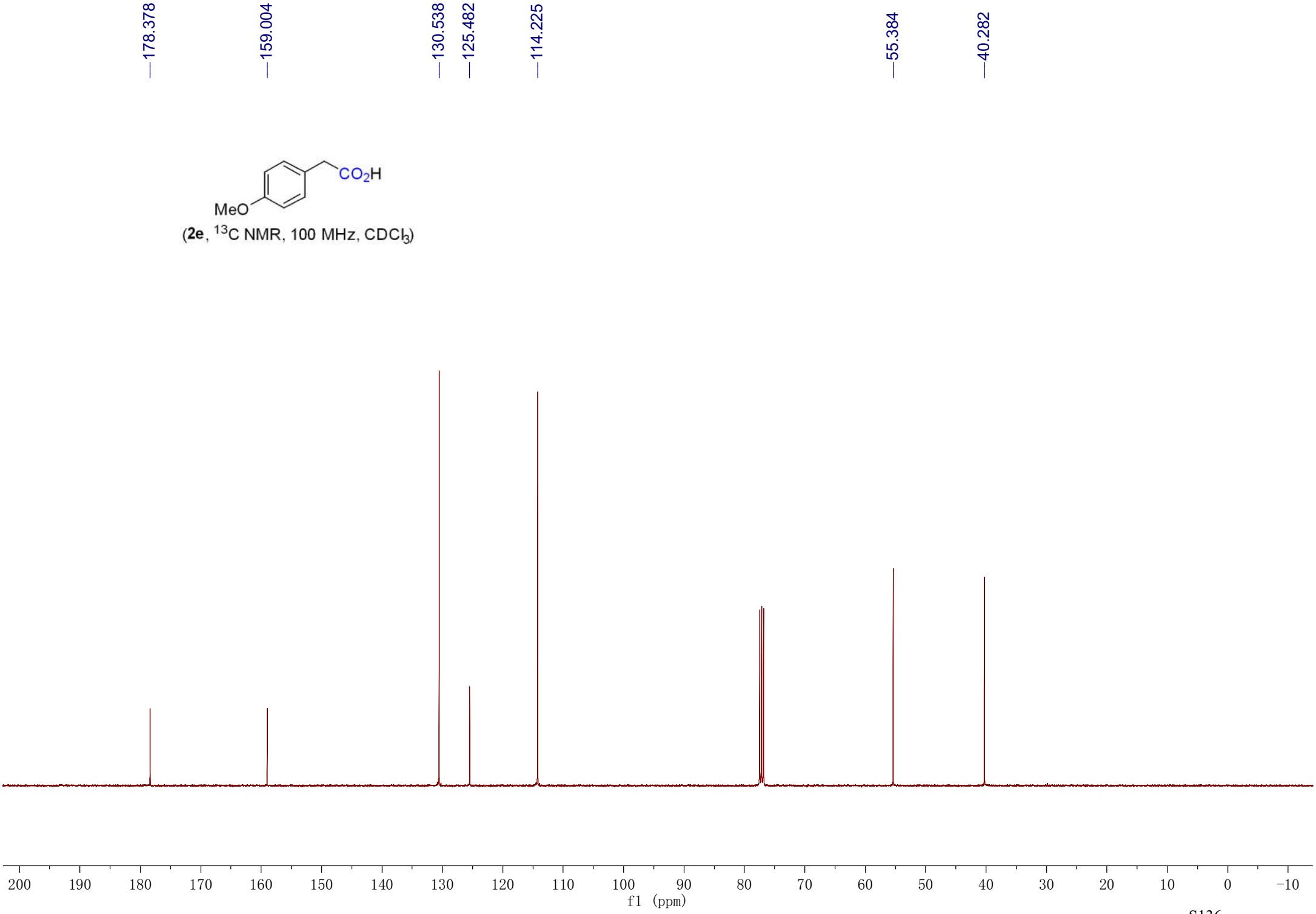
(**2d,** ^{1}H NMR, 400 MHz, $CDCl_3$)

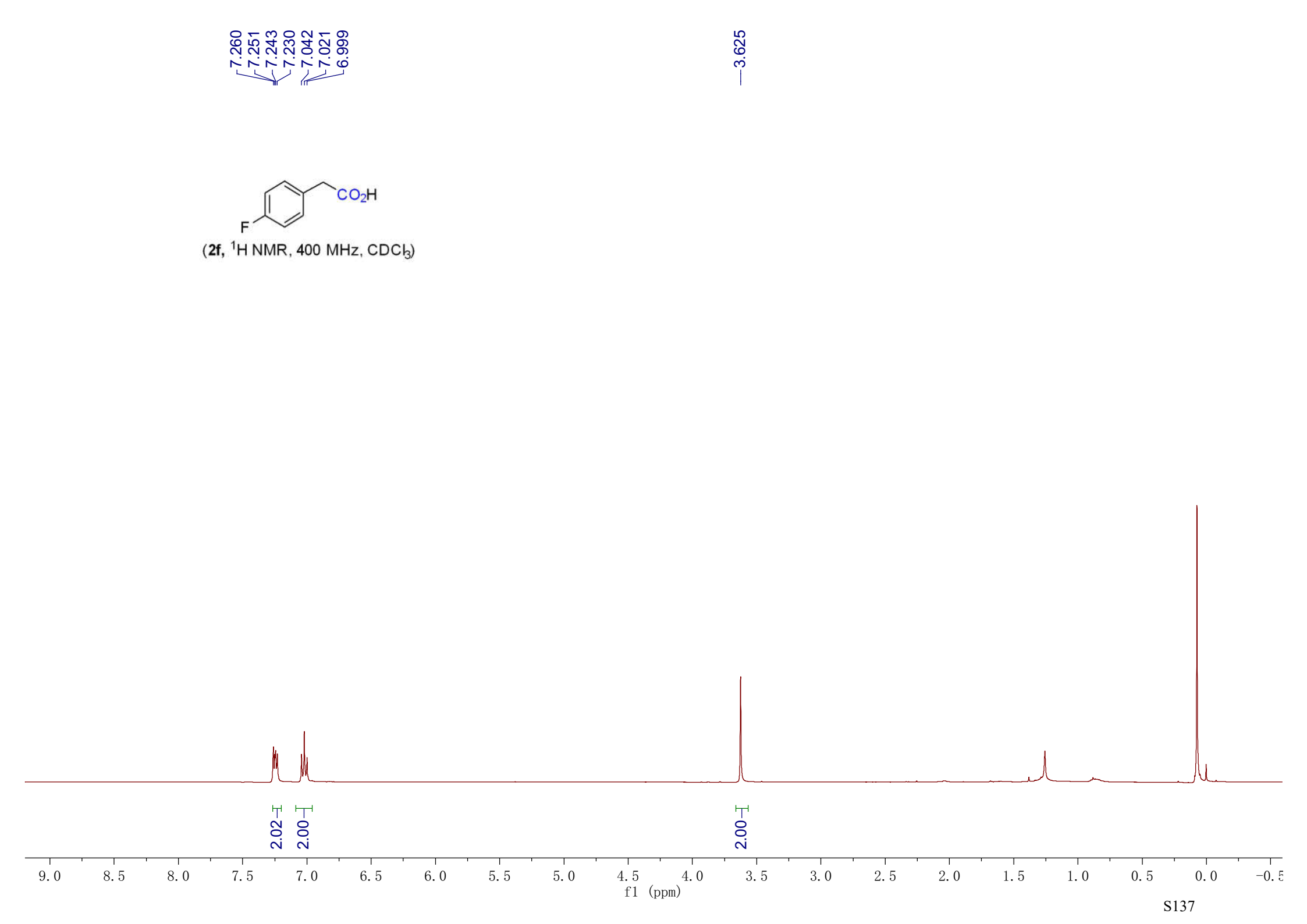


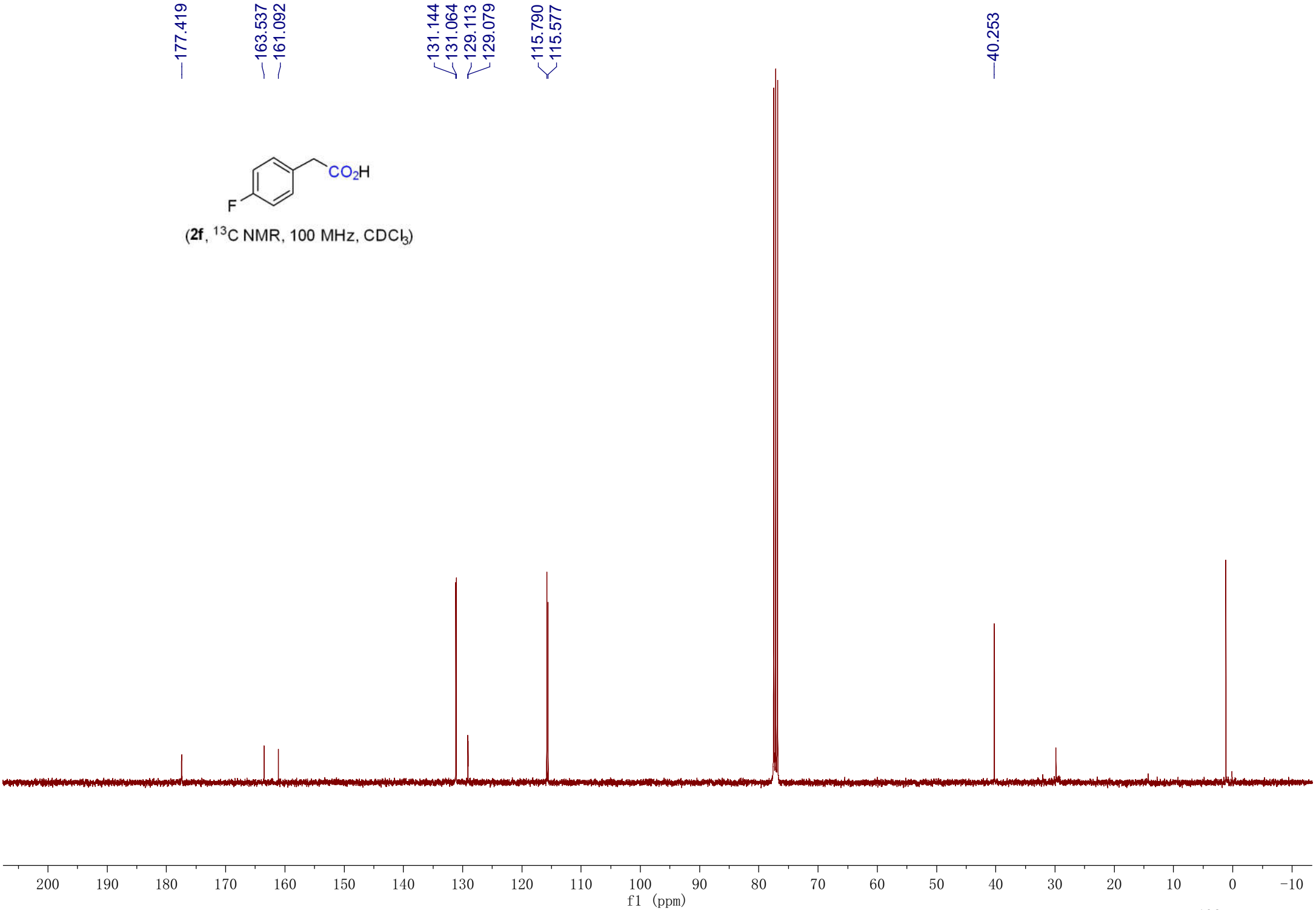
(**2d**, ^{13}C NMR, 100 MHz, $CDCl_3$)

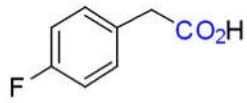


(**2e,** ^{1}H NMR, 400 MHz, $CDCl_3$)

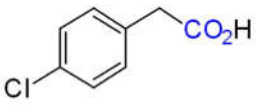

178.378
159.004
130.538
125.482
114.225
55.384
40.282
CO2H
MeO
(2e, 13C NMR, 100 MHz, CDCl3)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)


7.260
7.251
7.243
7.230
7.042
7.021
6.999
3.625
CO2H
F
(2f, 1H NMR, 400 MHz, CDCl3)
2.02
2.00
2.00
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

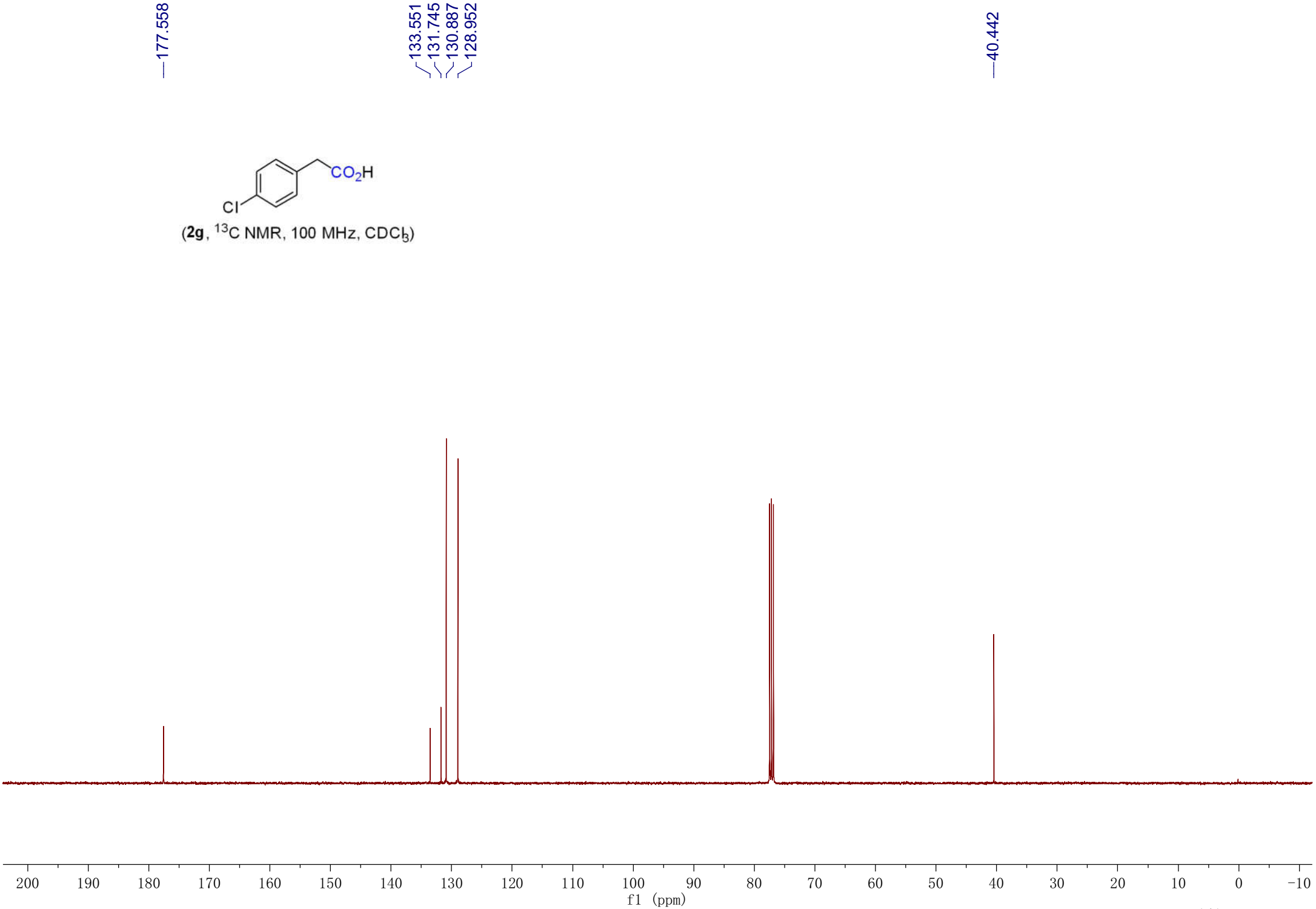

177.419
163.537
161.092
131.144
131.064
129.113
129.079
115.790
115.577
40.253
CO2H
F
(2f, 13C NMR, 100 MHz, CDCl3)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)



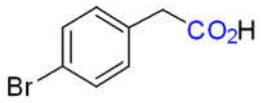
(**2f**, ^{19}F NMR, 376 MHz, $CDCl_3$)



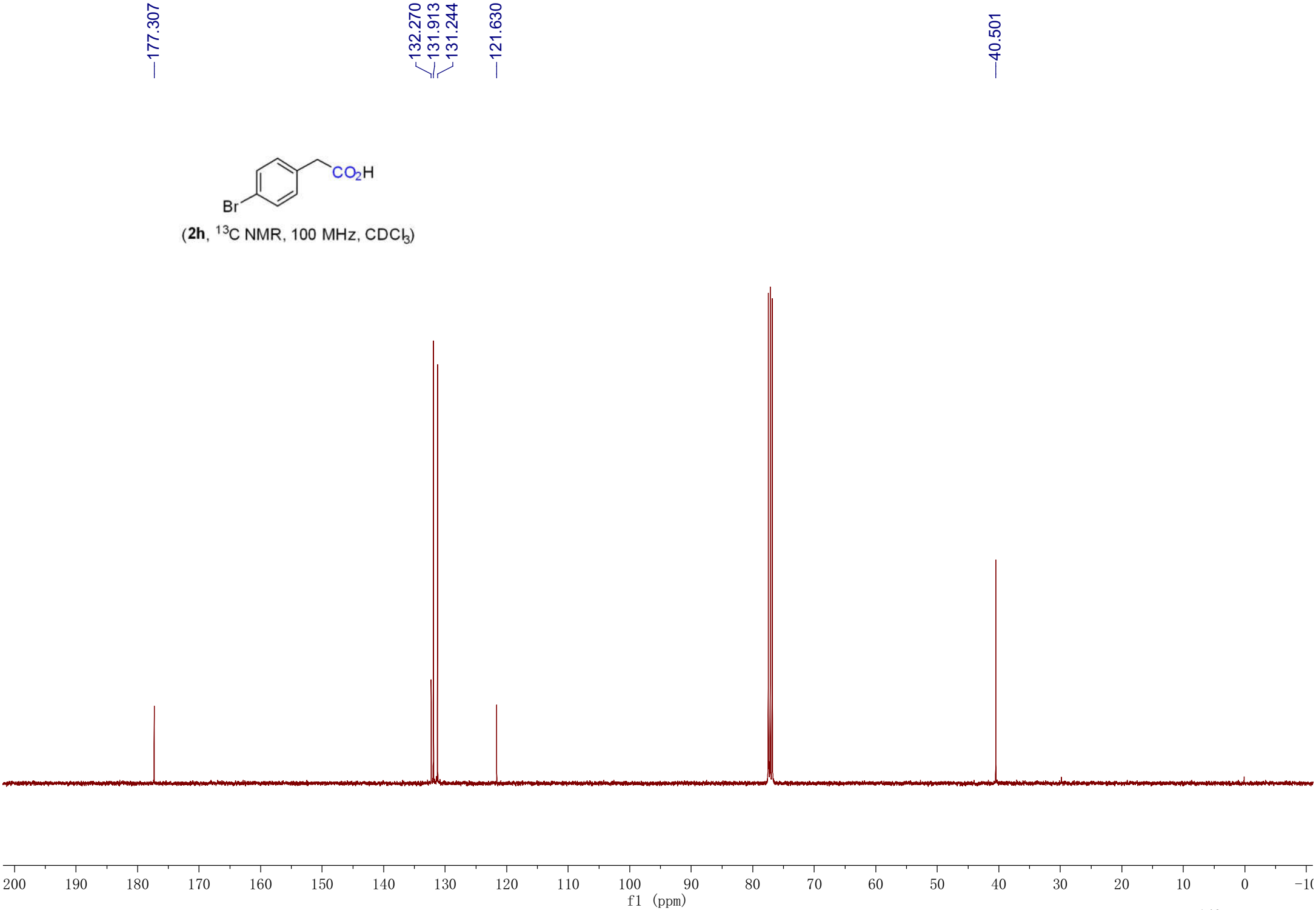
(**2g,** ^{1}H NMR, 400 MHz, $CDCl_3$)

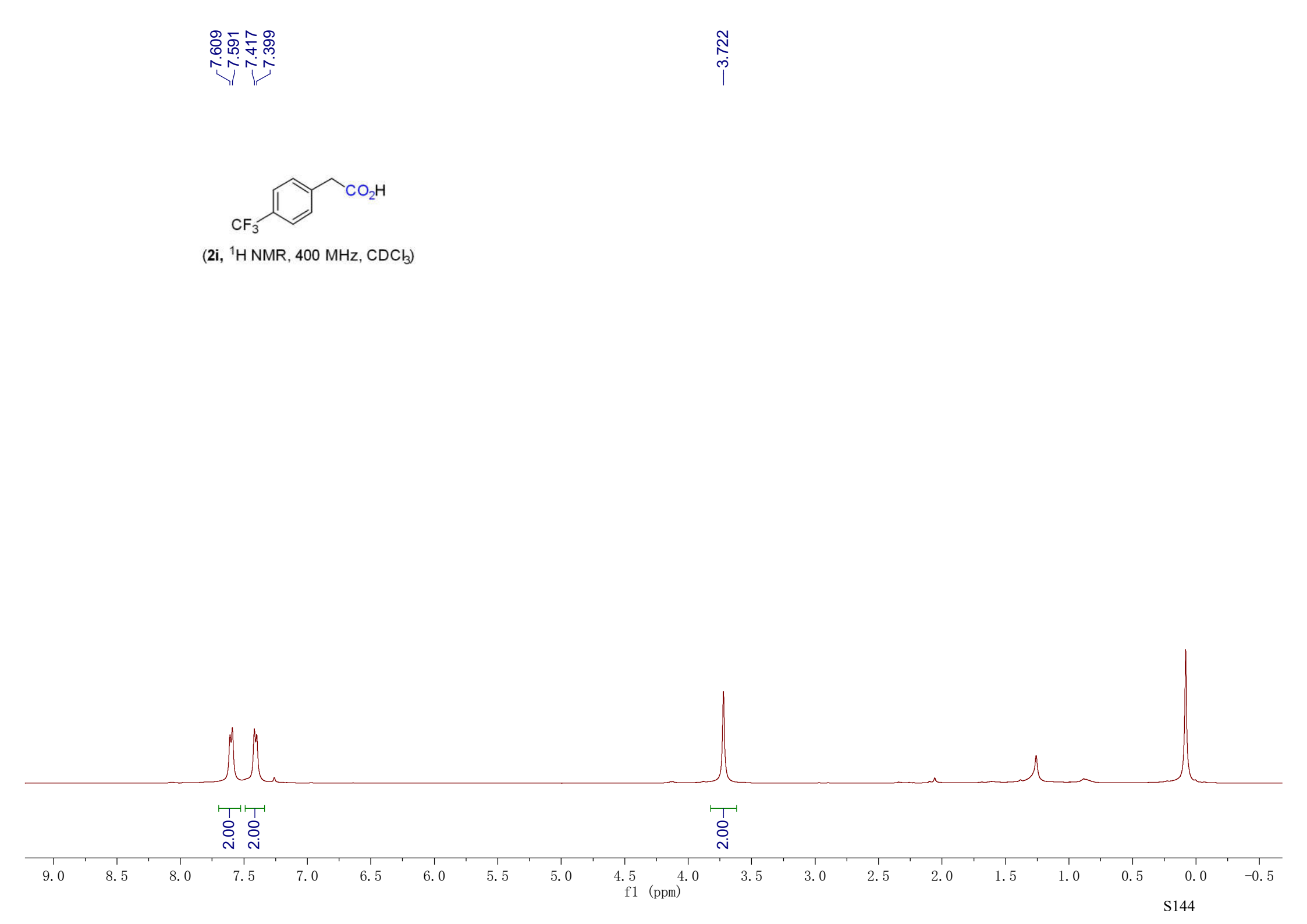


(**2g**, ^{13}C NMR, 100 MHz, $CDCl_3$)

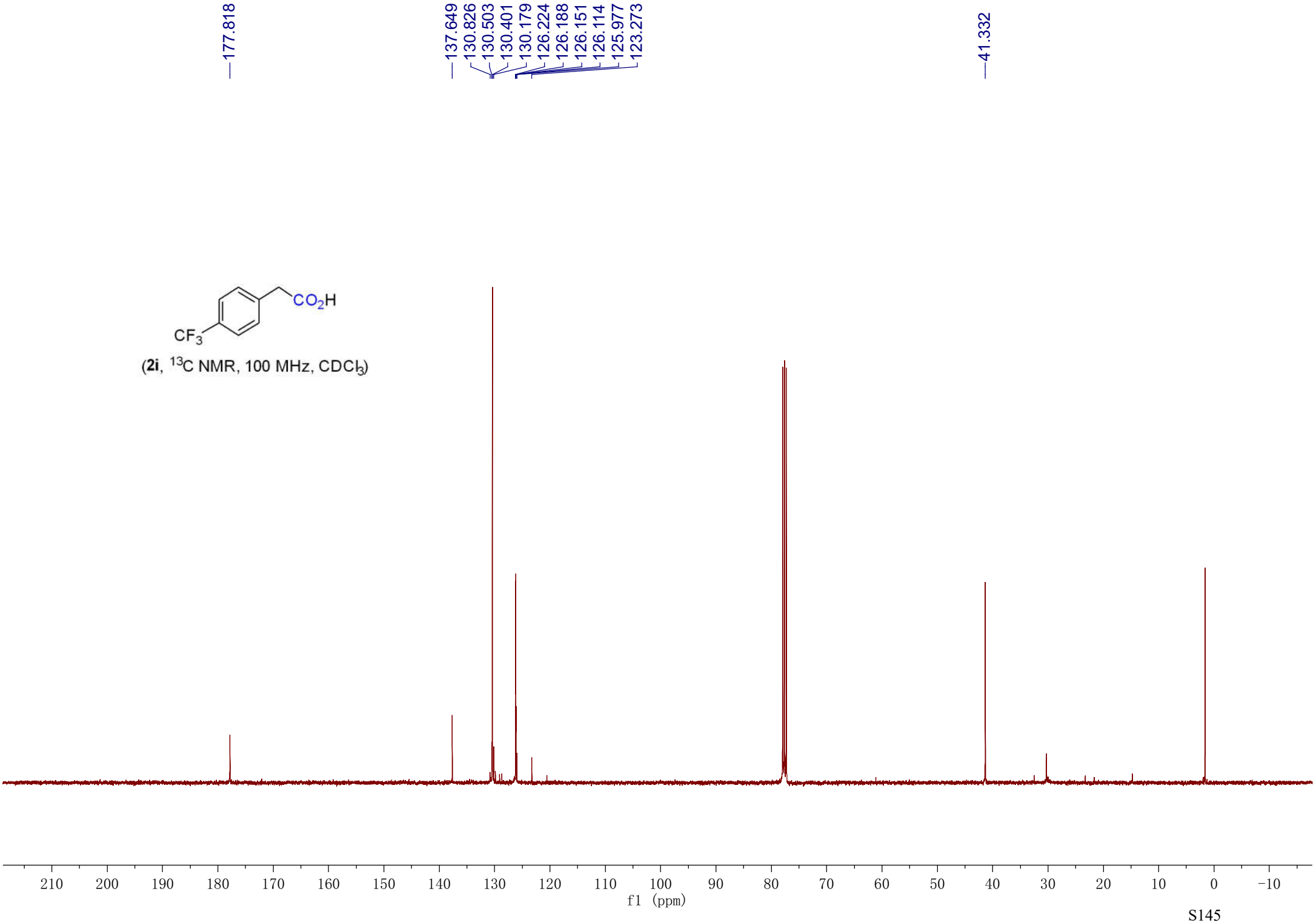


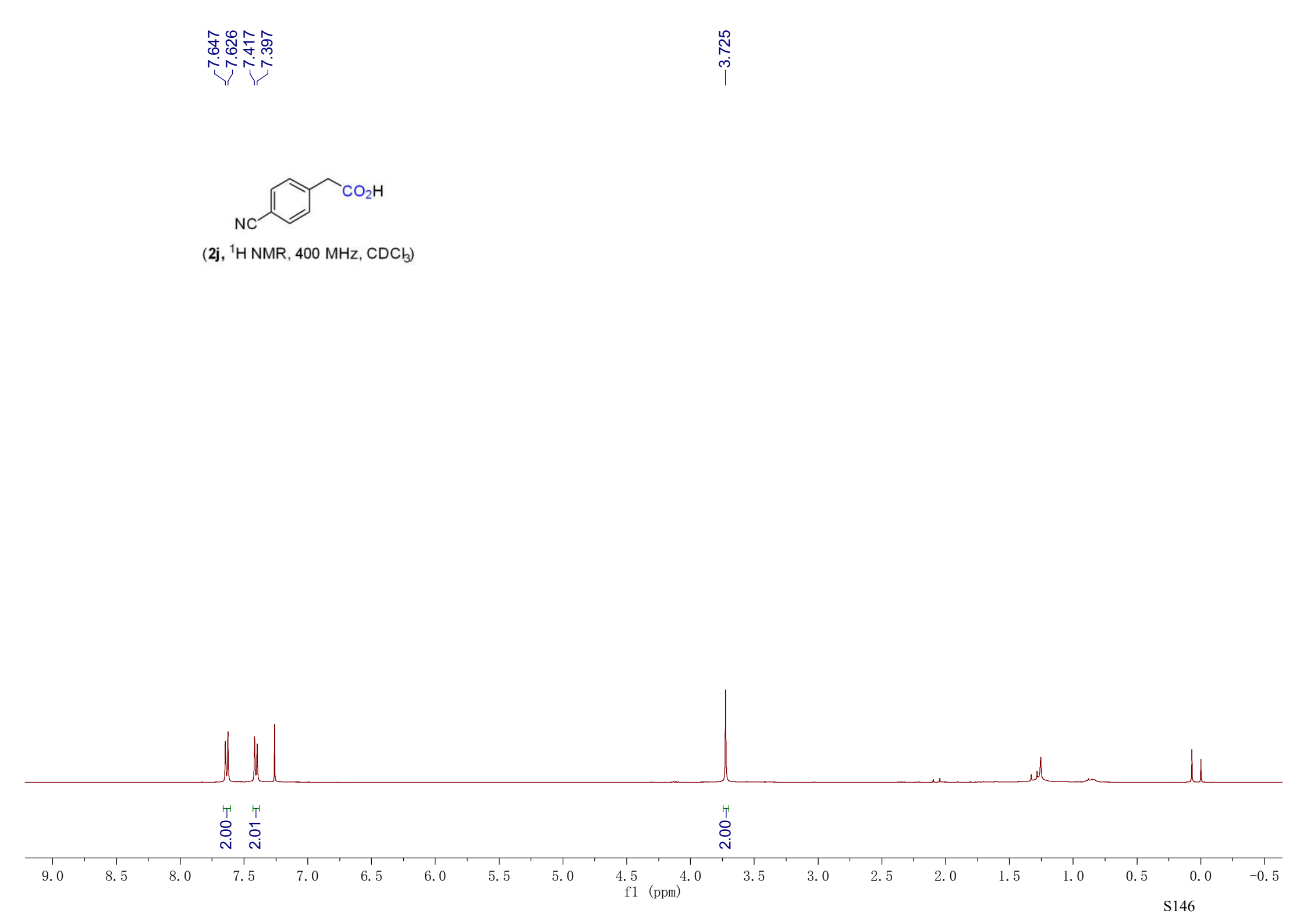
(**2h,** ^{1}H NMR, 400 MHz, $CDCl_3$)


177.307
132.270
131.913
131.244
121.630
40.501
CO2H
Br
(2h, 13C NMR, 100 MHz, CDCl3)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

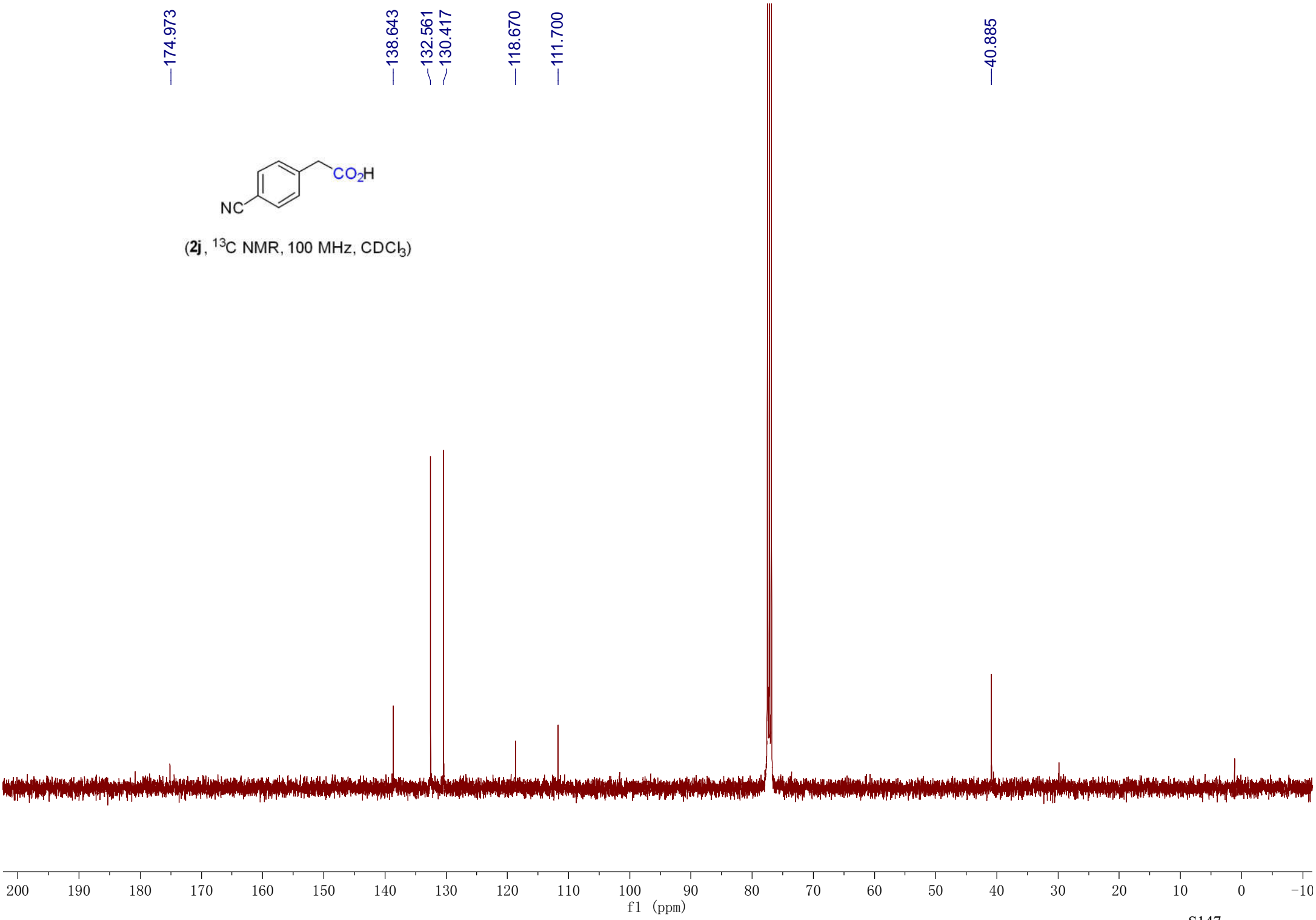


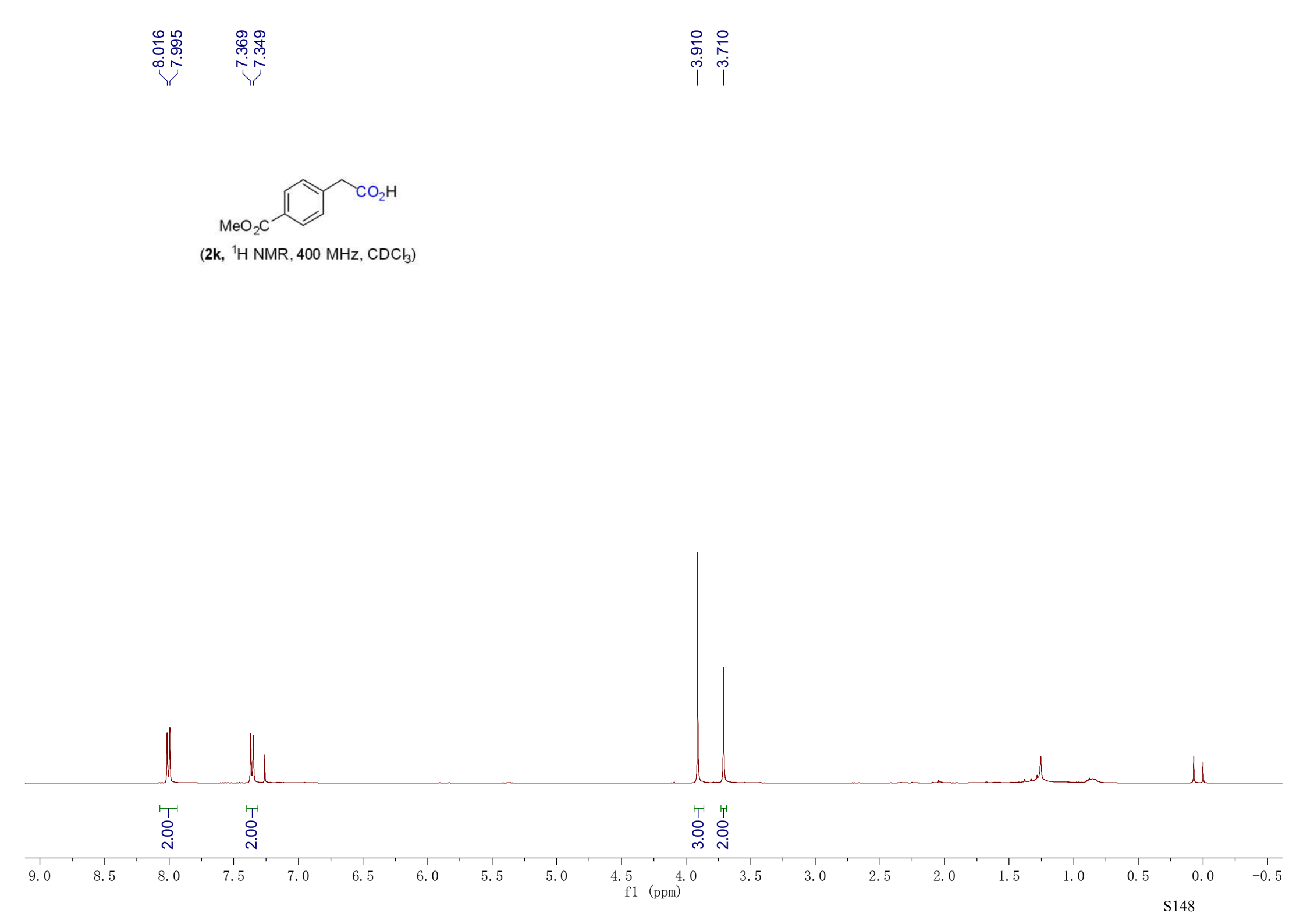
(**2i,** ^{1}H NMR, 400 MHz, $CDCl_3$)

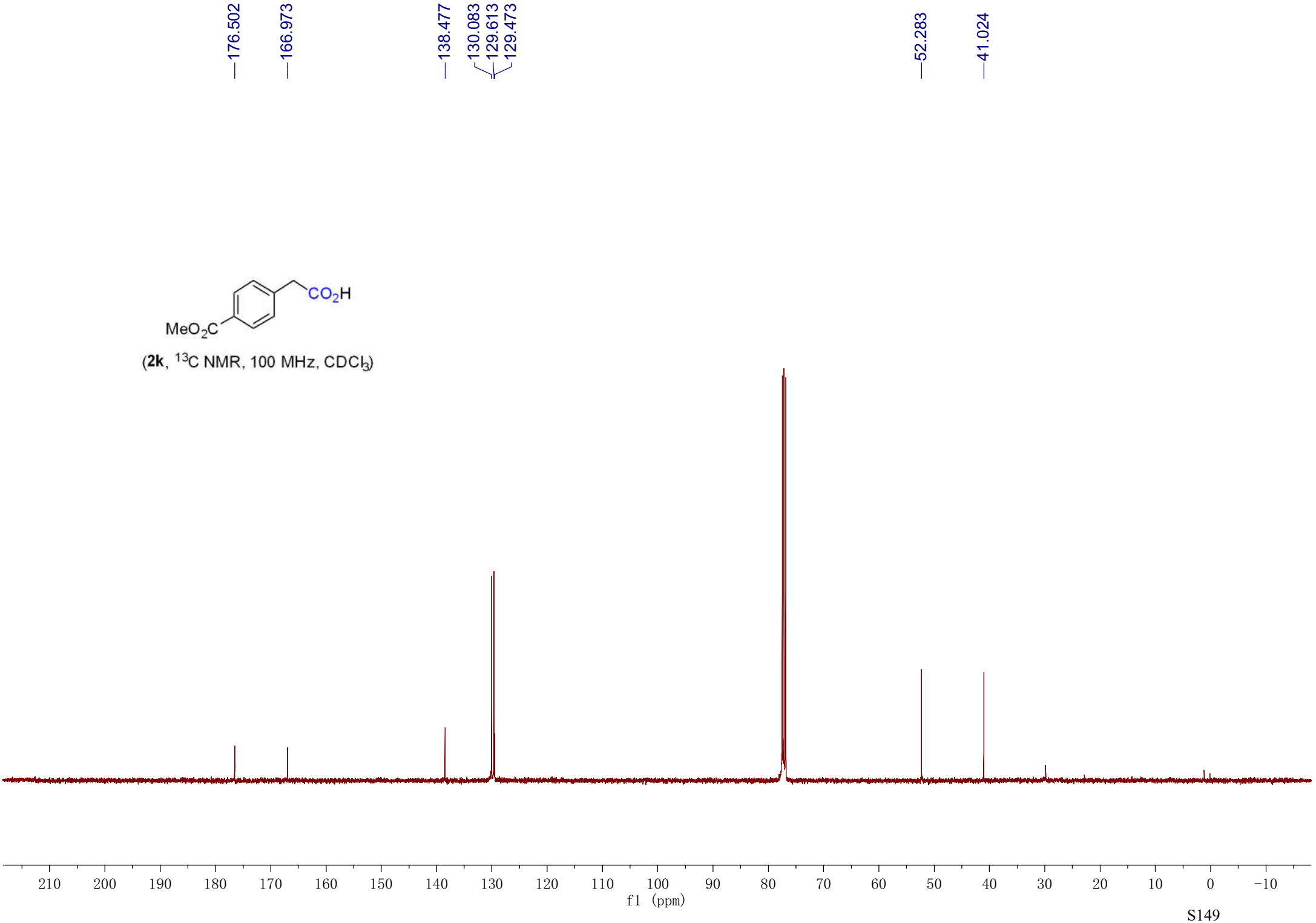

177.818
137.649
130.826
130.503
130.401
130.179
126.224
126.188
126.151
126.114
125.977
123.273
41.332
CO2H
CF3
(2i, 13C NMR, 100 MHz, CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

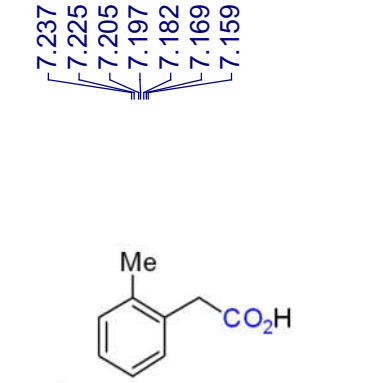


(**2j**, ^{1}H NMR, 400 MHz, $CDCl_3$)

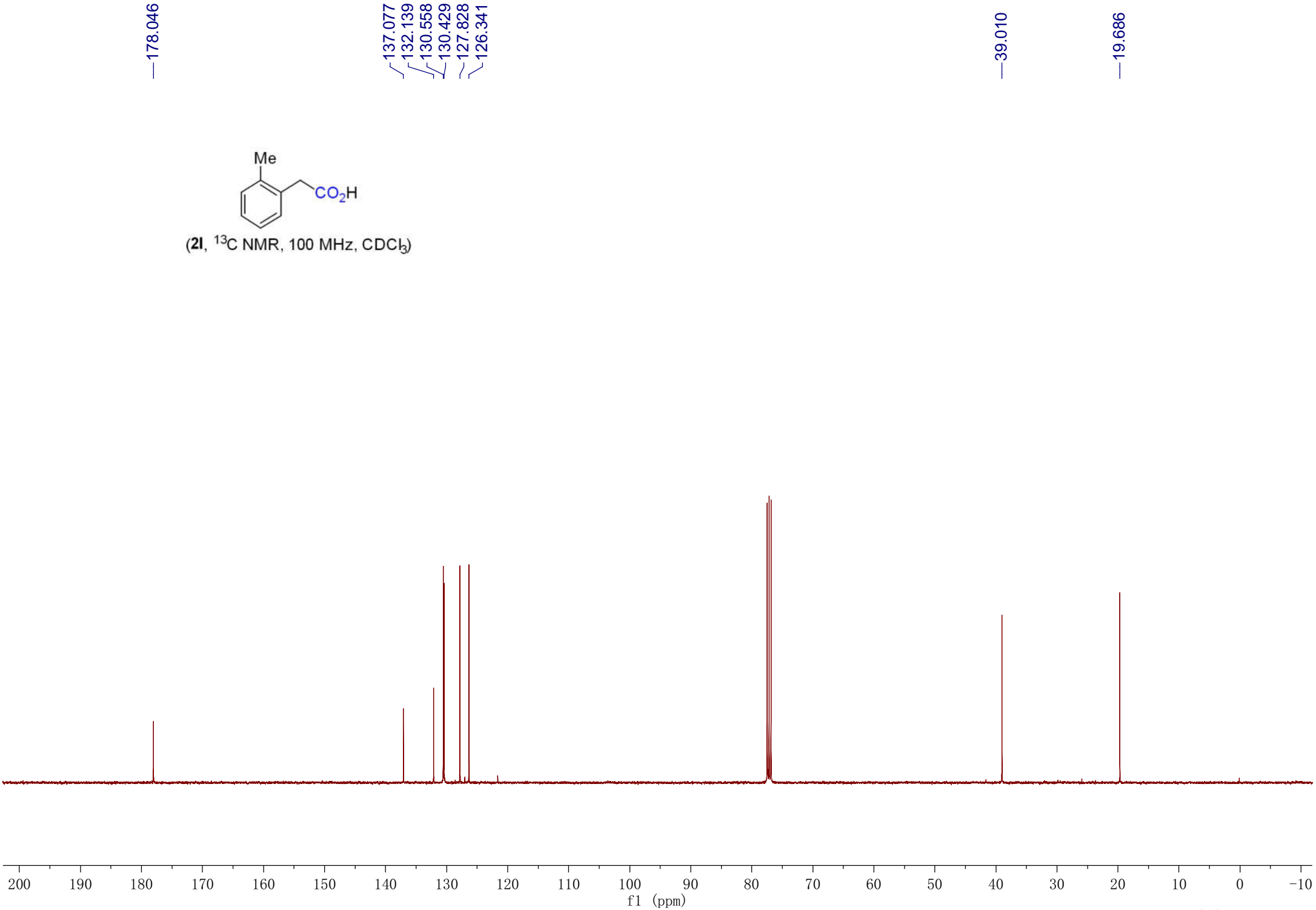

174.973
138.643
132.561
130.417
118.670
111.700
40.885
CO2H
NC
(2j, 13C NMR, 100 MHz, CDCl3)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)


8.016
7.995
7.369
7.349
3.910
3.710
CO2H
MeO2C
(2k, 1H NMR, 400 MHz, CDCl3)
2.00
2.00
3.00
2.00
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

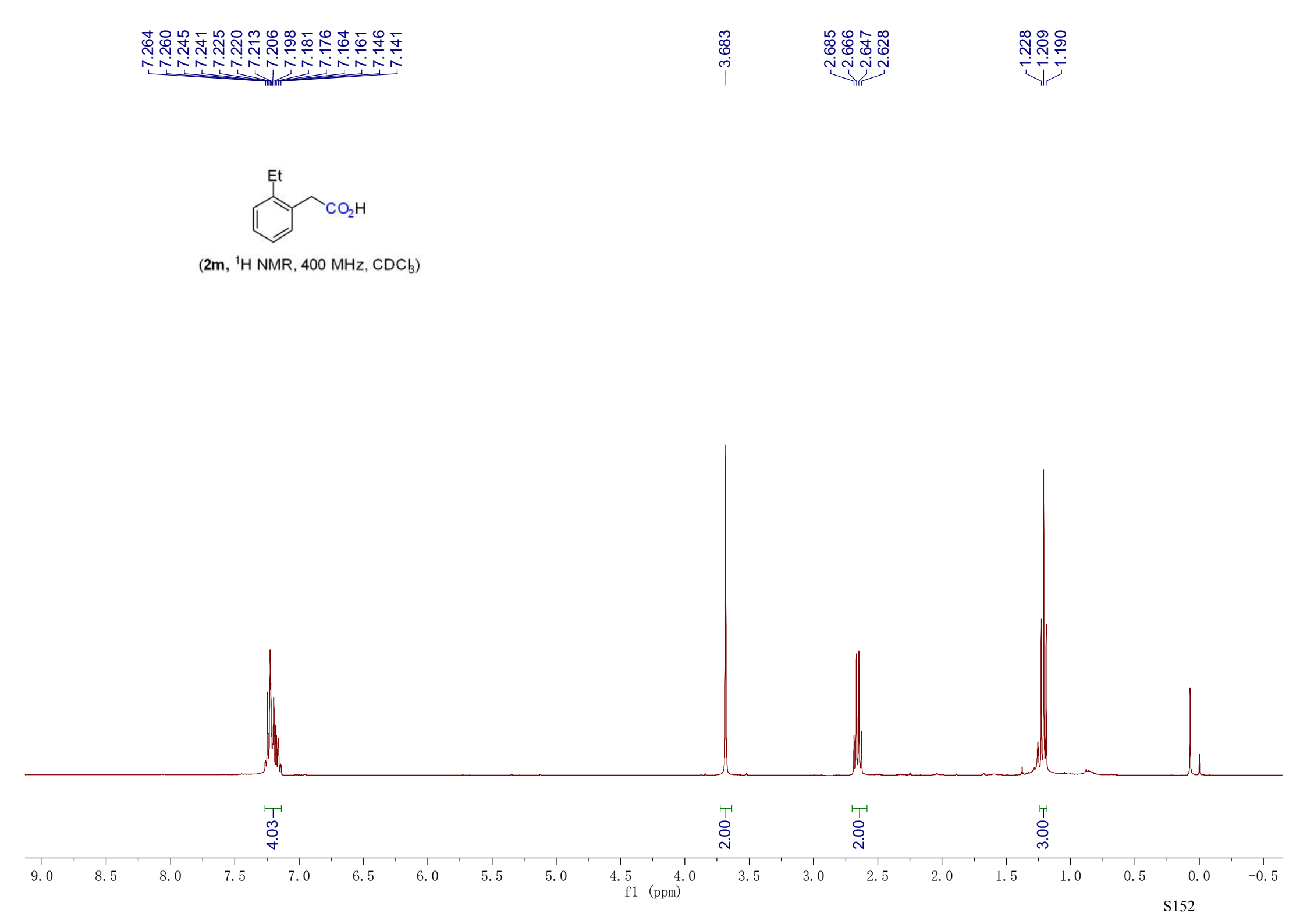

176.502
166.973
138.477
130.083
129.613
129.473
52.283
41.024
CO2H
MeO2C
(2k, 13C NMR, 100 MHz, CDCl3)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)



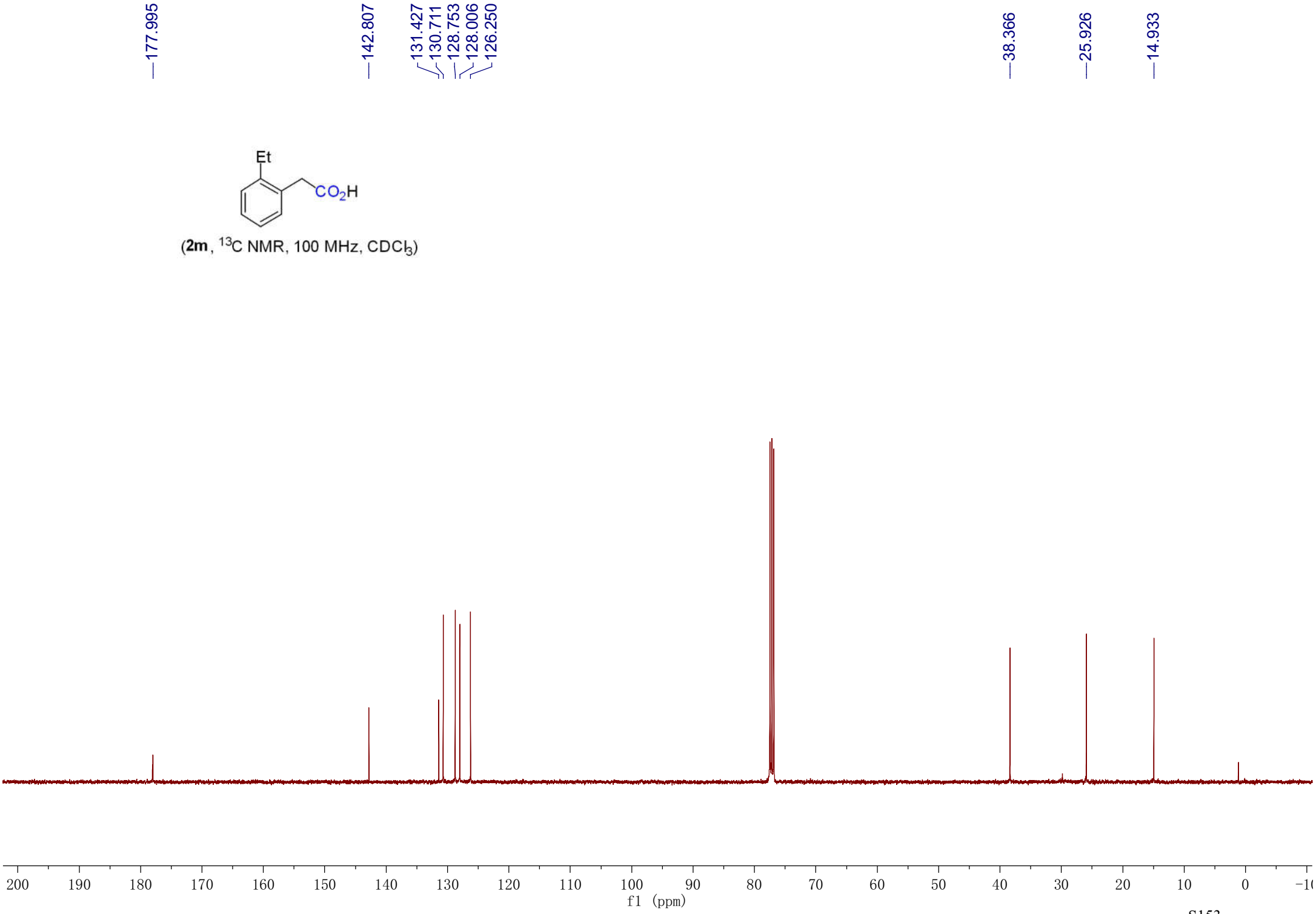
(**2l**, ^{1}H NMR, 400 MHz, $CDCl_3$)



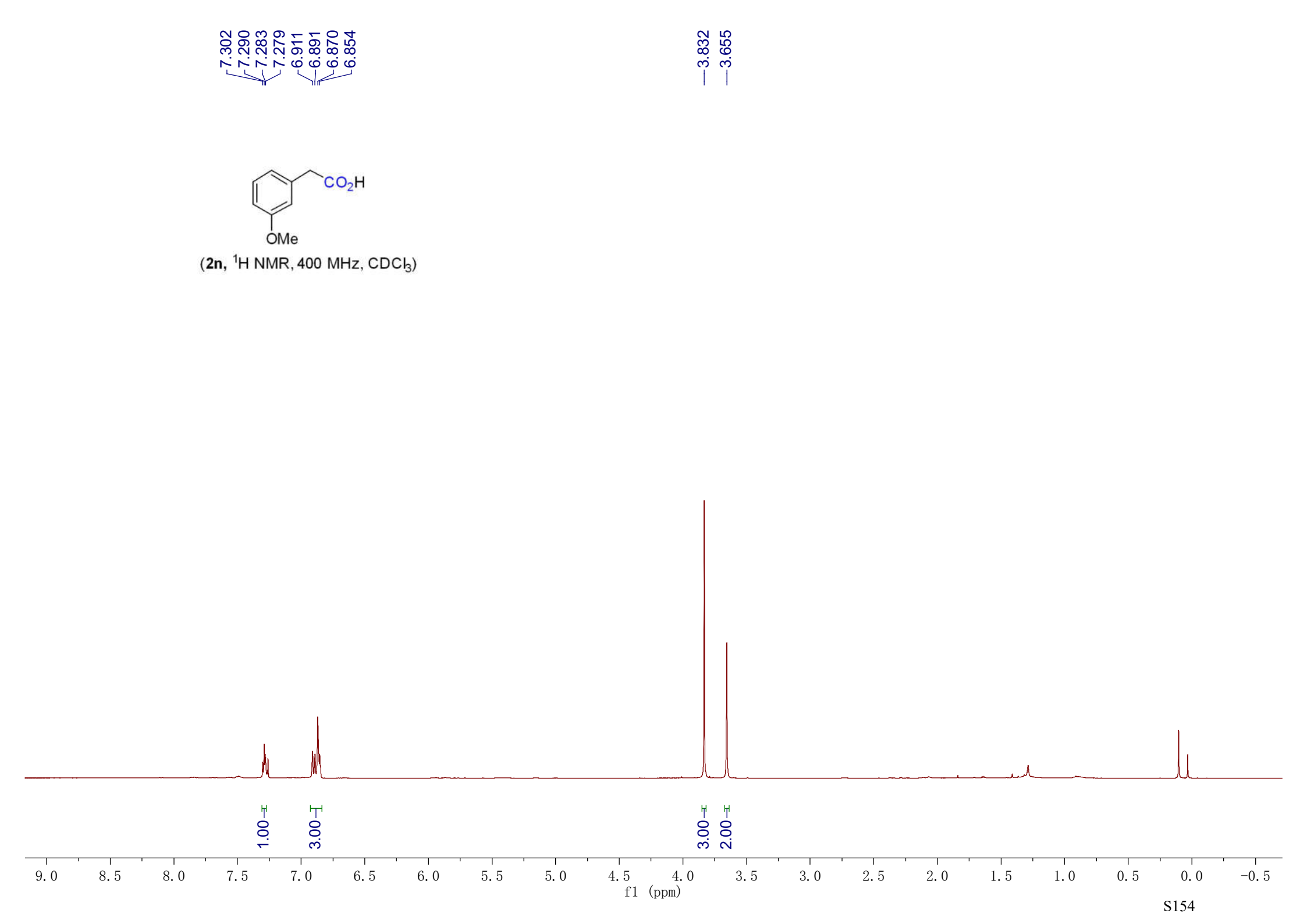
(**2l**, ^{13}C NMR, 100 MHz, $CDCl_3$)



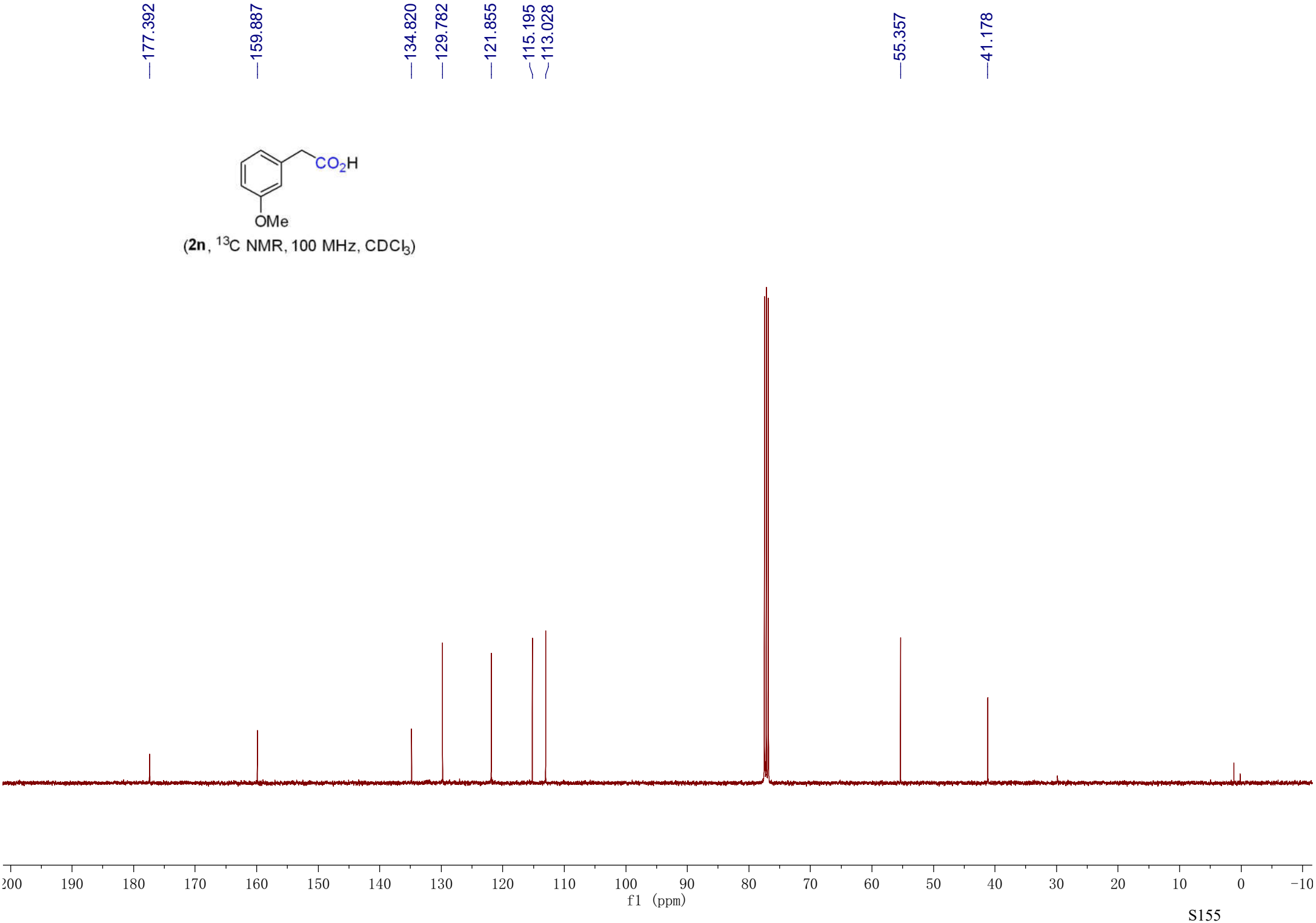
(**2m**, ^{1}H NMR, 400 MHz, $CDCl_3$)

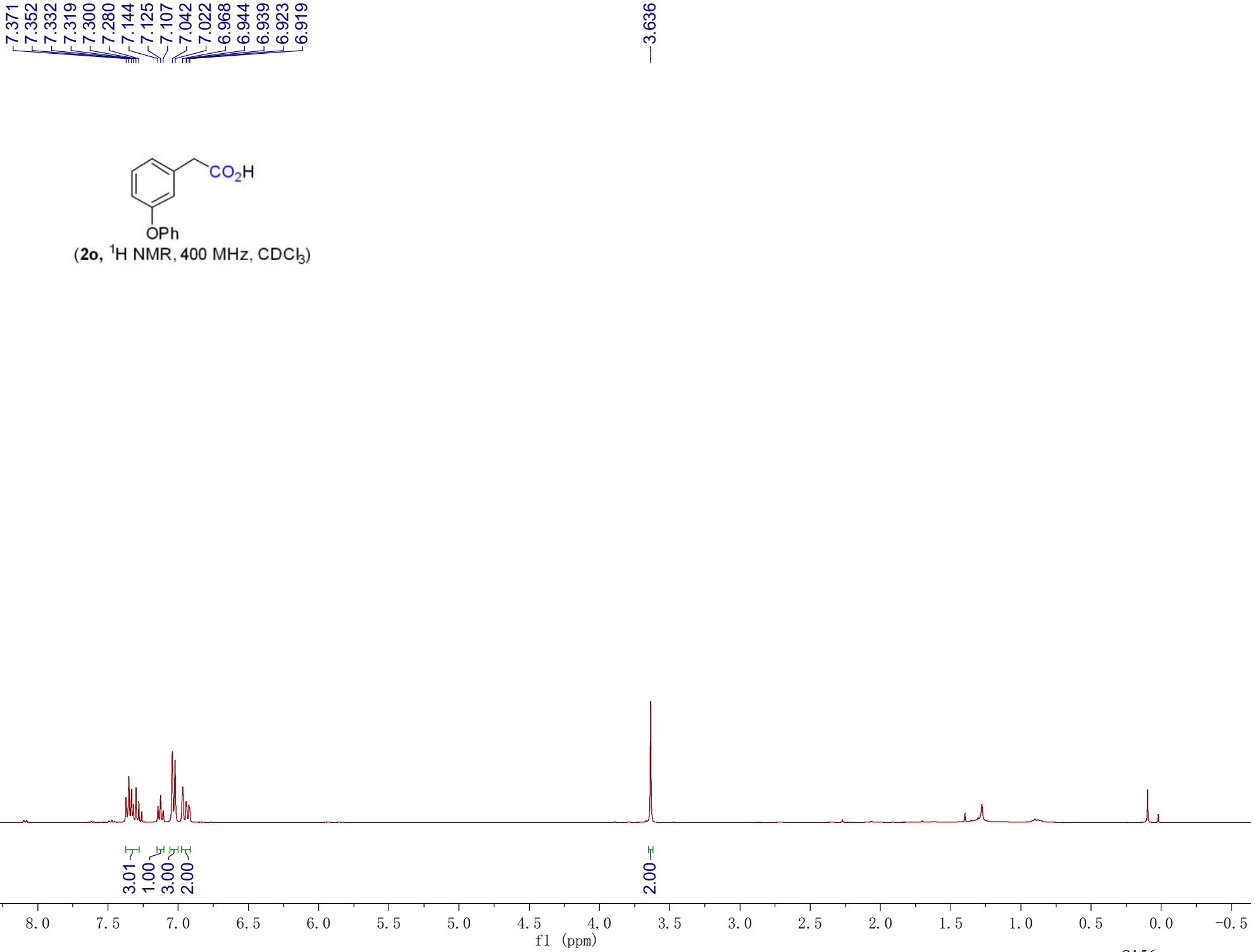


(**2m**, ^{13}C NMR, 100 MHz, $CDCl_3$)

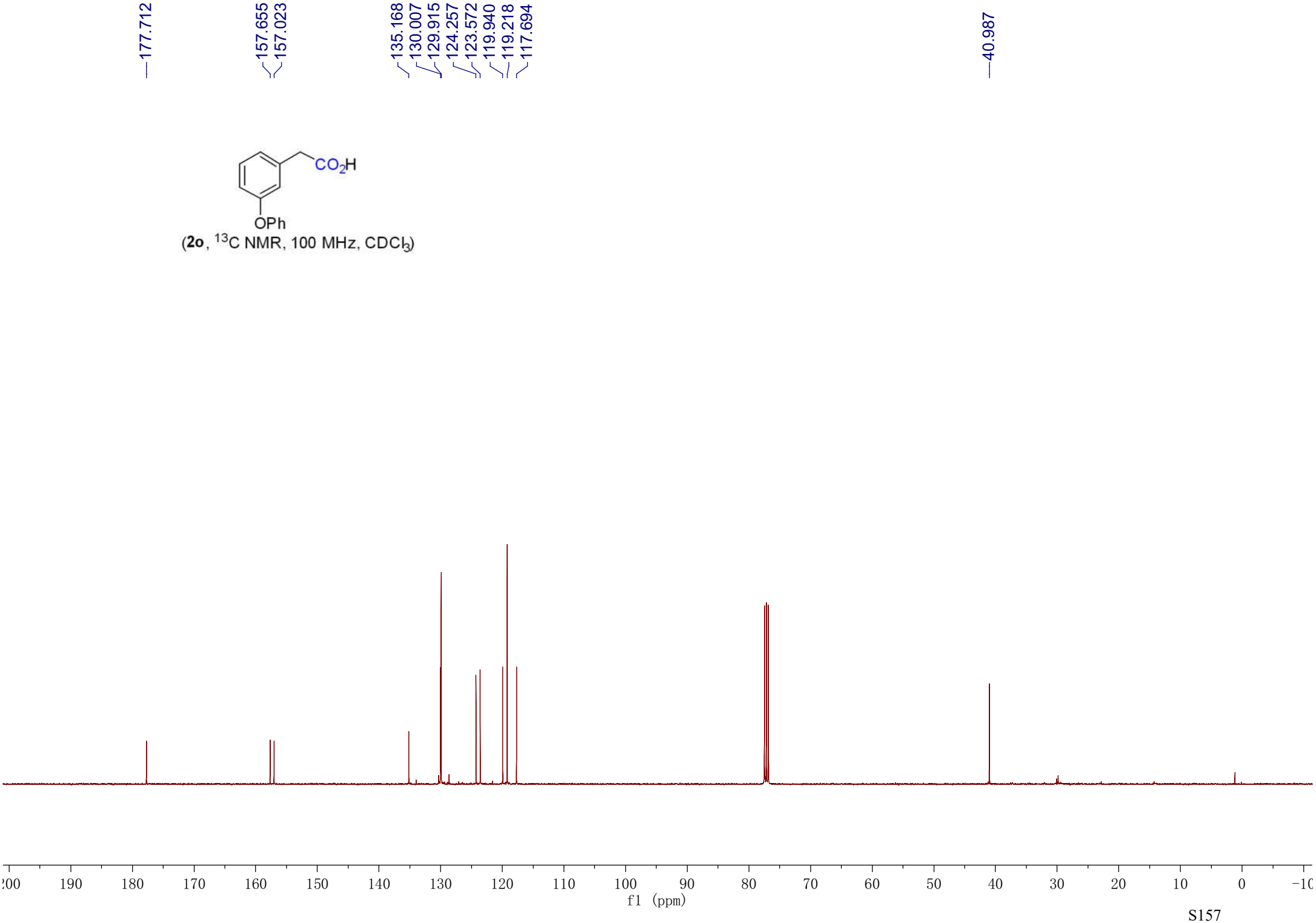


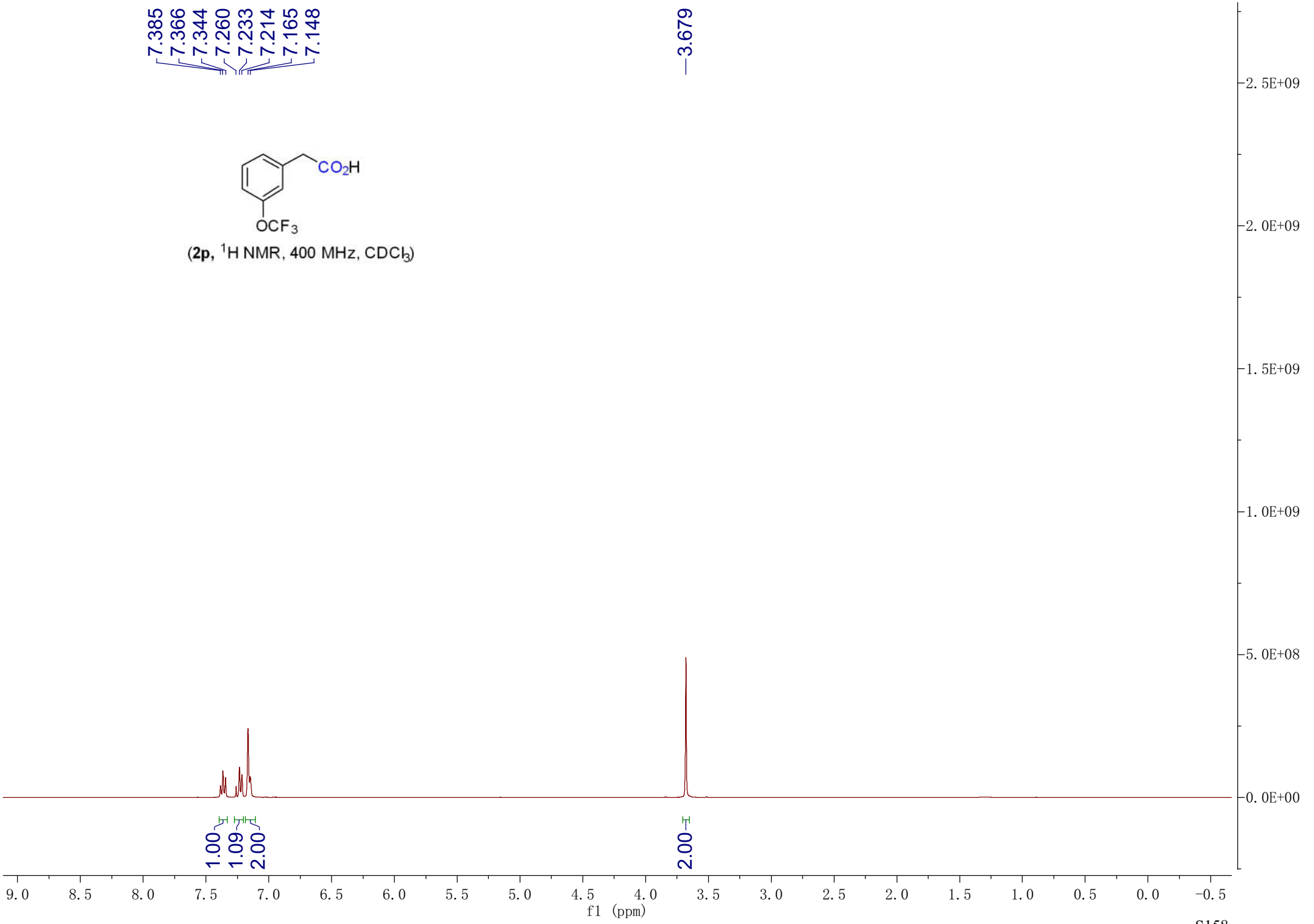
(**2n,** ^{1}H NMR, 400 MHz, $CDCl_3$)

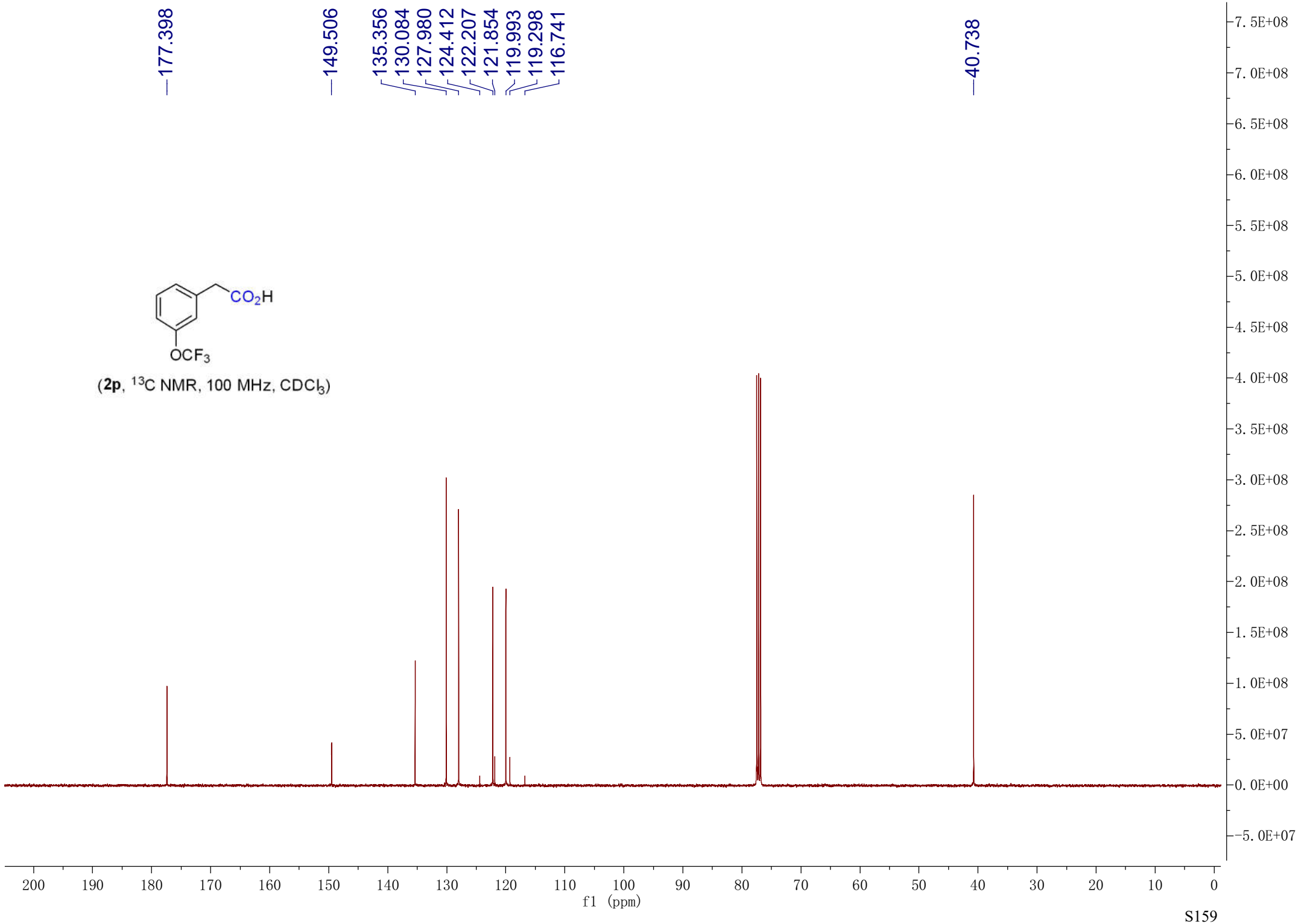

177.392
159.887
134.820
129.782
121.855
115.195
113.028
55.357
41.178
CO2H
OMe
(2n, 13C NMR, 100 MHz, CDCl3)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

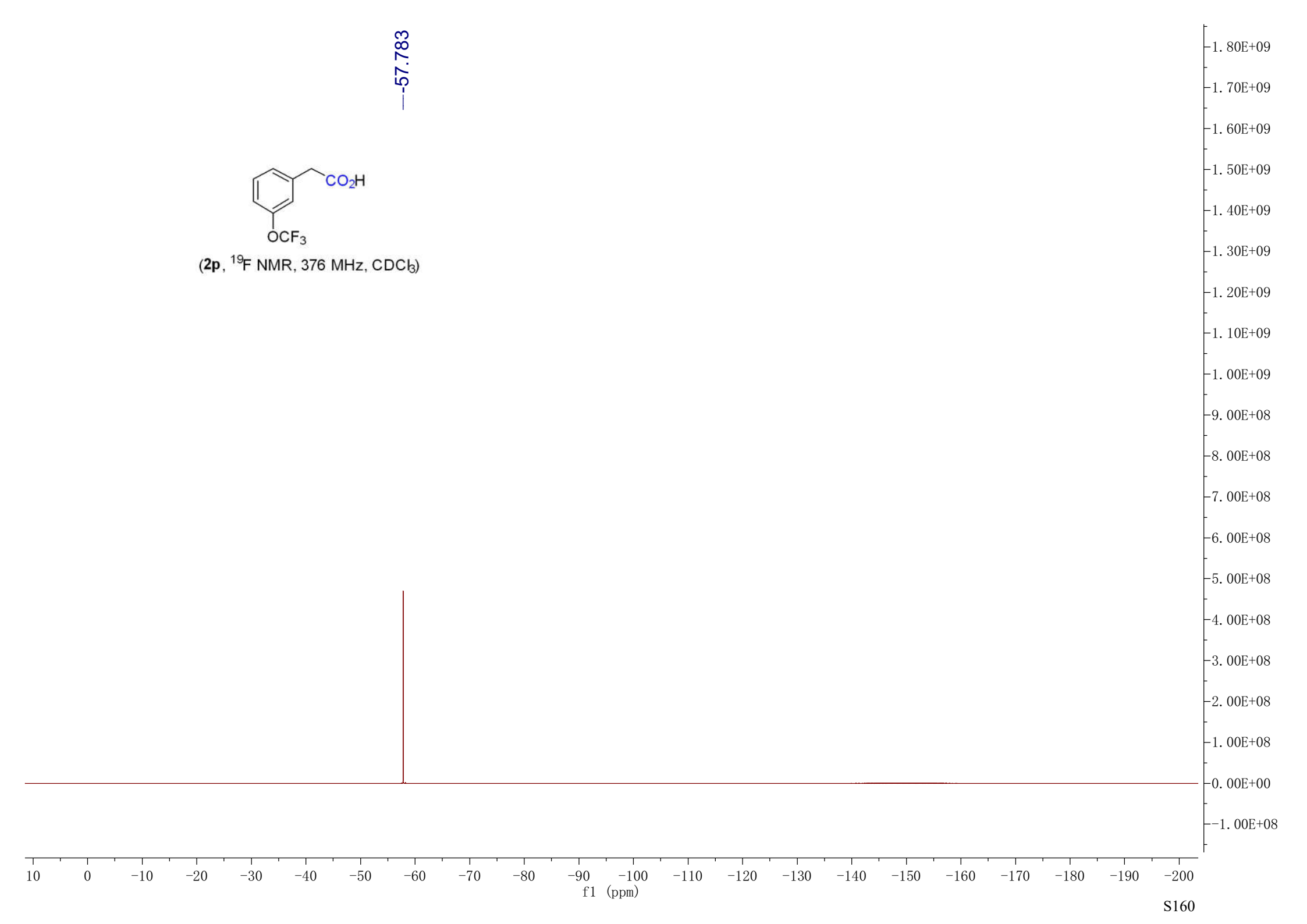


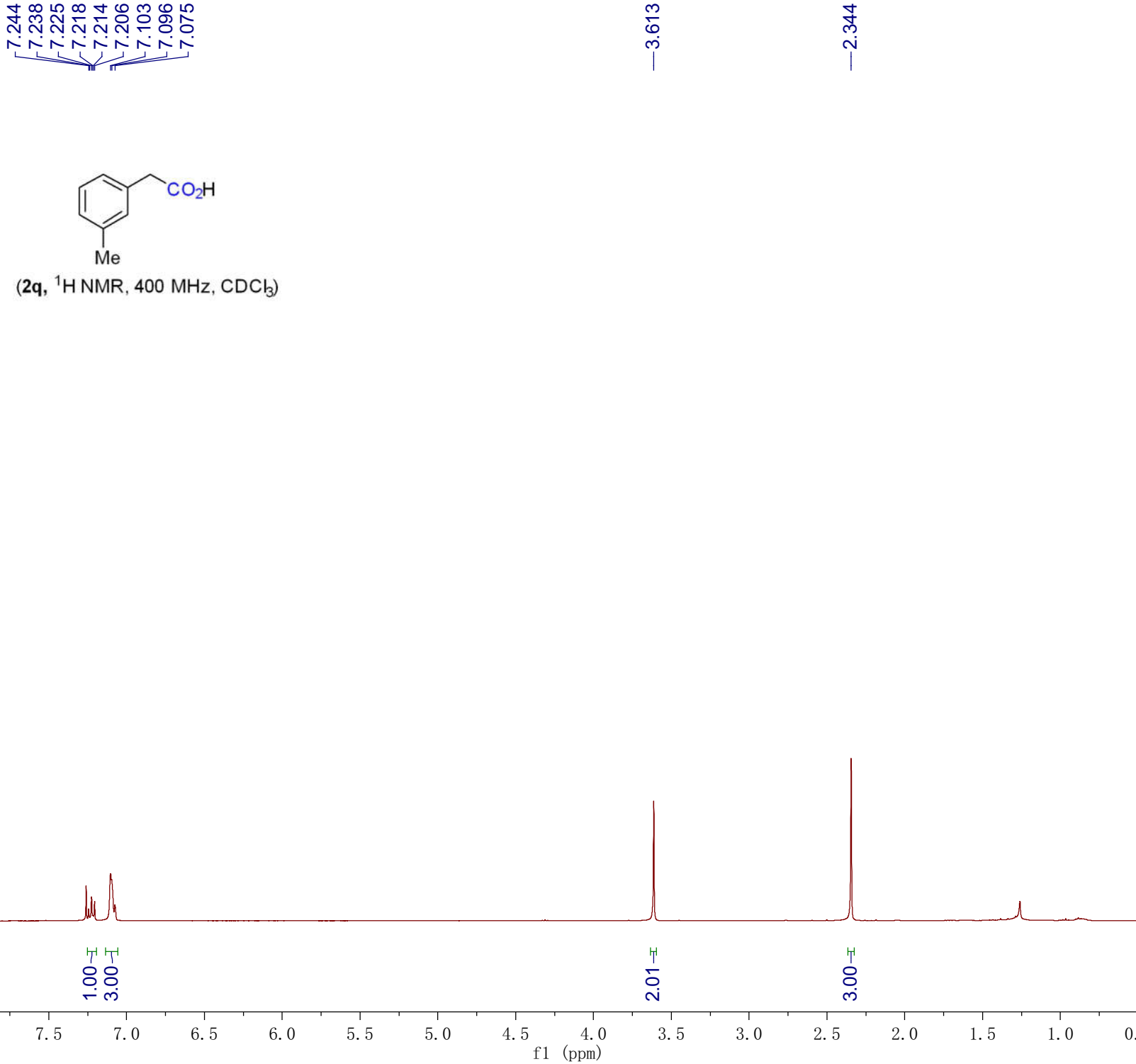
(**2o**, ^{1}H NMR, 400 MHz, $CDCl_3$)


177.712
157.655
157.023
135.168
130.007
129.915
124.257
123.572
119.940
119.218
117.694
40.987
CO2H
OPh
(2o, 13C NMR, 100 MHz, CDCl3)
f1 (ppm)

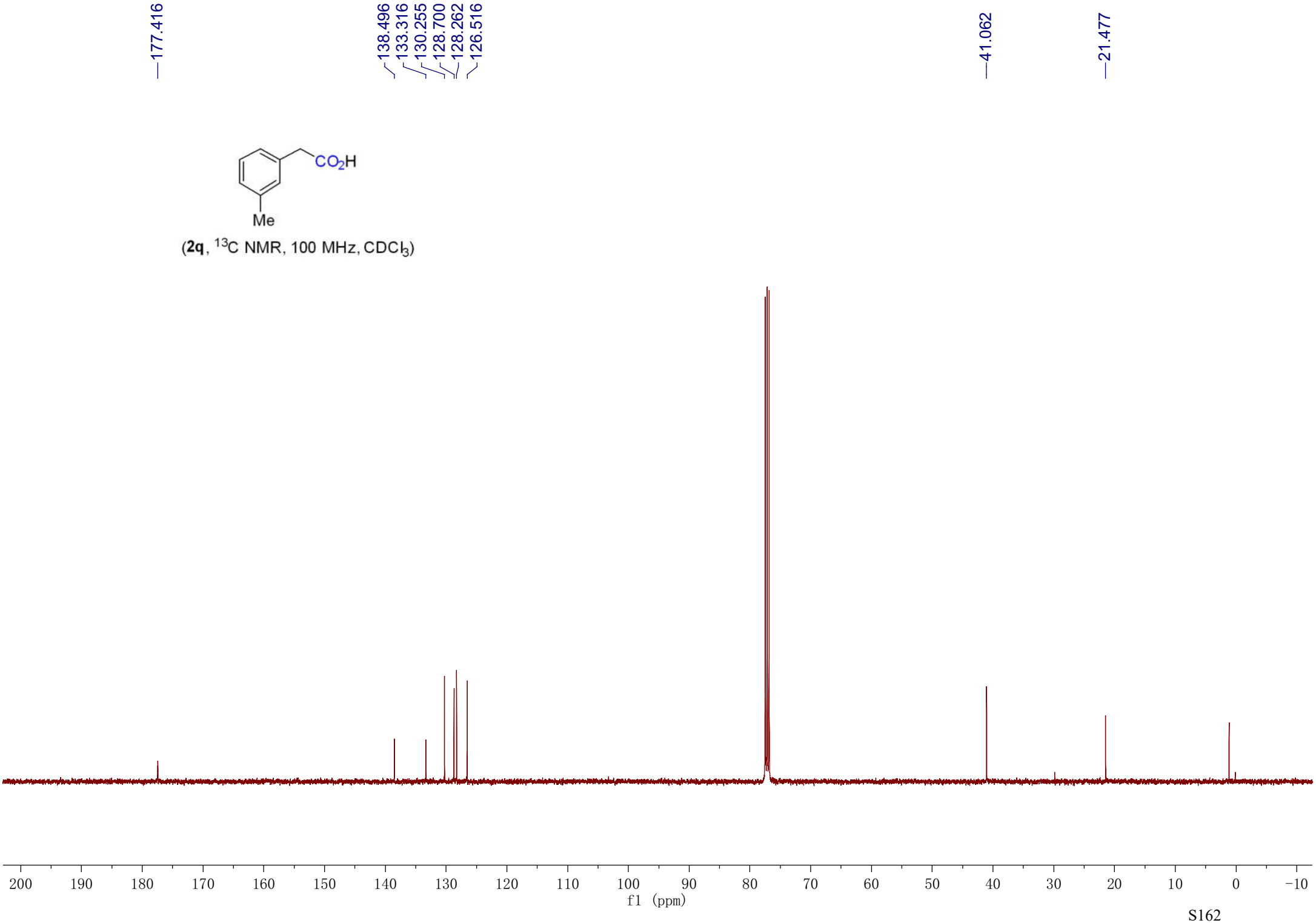

7.385
7.366
7.344
7.260
7.233
7.214
7.165
7.148
3.679
CO2H
OCF3
(2p, 1H NMR, 400 MHz, CDCl3)
2.5E+09
2.0E+09
1.5E+09
1.0E+09
5.0E+08
0.0E+00
1.00
1.09
2.00
2.00
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)


177.398
149.506
135.356
130.084
127.980
124.412
122.207
121.854
119.993
119.298
116.741
40.738
CO2H
OCF3
(2p, 13C NMR, 100 MHz, CDCl3)
7.5E+08
7.0E+08
6.5E+08
6.0E+08
5.5E+08
5.0E+08
4.5E+08
4.0E+08
3.5E+08
3.0E+08
2.5E+08
2.0E+08
1.5E+08
1.0E+08
5.0E+07
0.0E+00
-5.0E+07
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

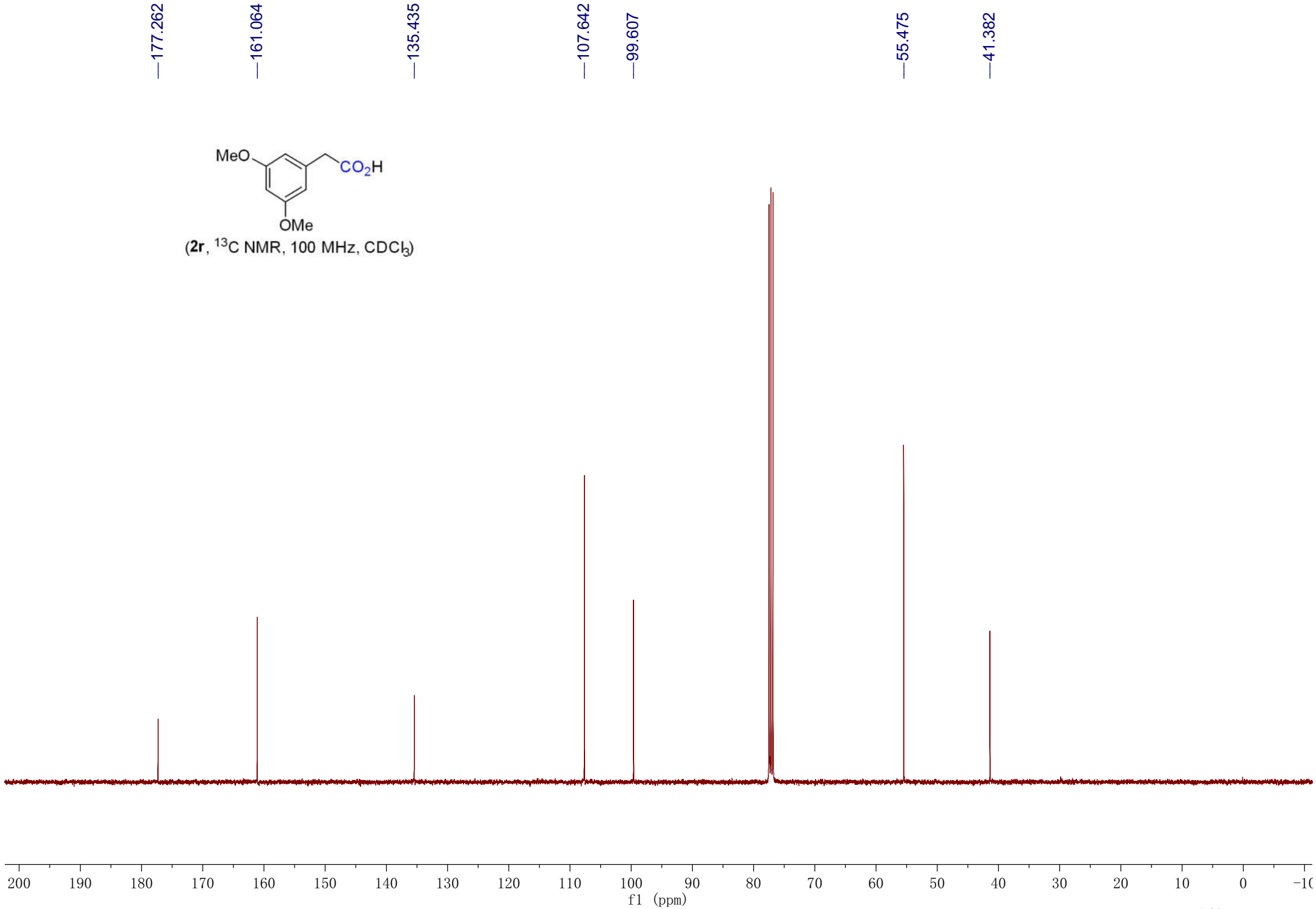

-57.783
CO2H
OCF3
(2p, 19F NMR, 376 MHz, CDCl3)
1.80E+09
1.70E+09
1.60E+09
1.50E+09
1.40E+09
1.30E+09
1.20E+09
1.10E+09
1.00E+09
9.00E+08
8.00E+08
7.00E+08
6.00E+08
5.00E+08
4.00E+08
3.00E+08
2.00E+08
1.00E+08
0.00E+00
-1.00E+08
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200
f1 (ppm)

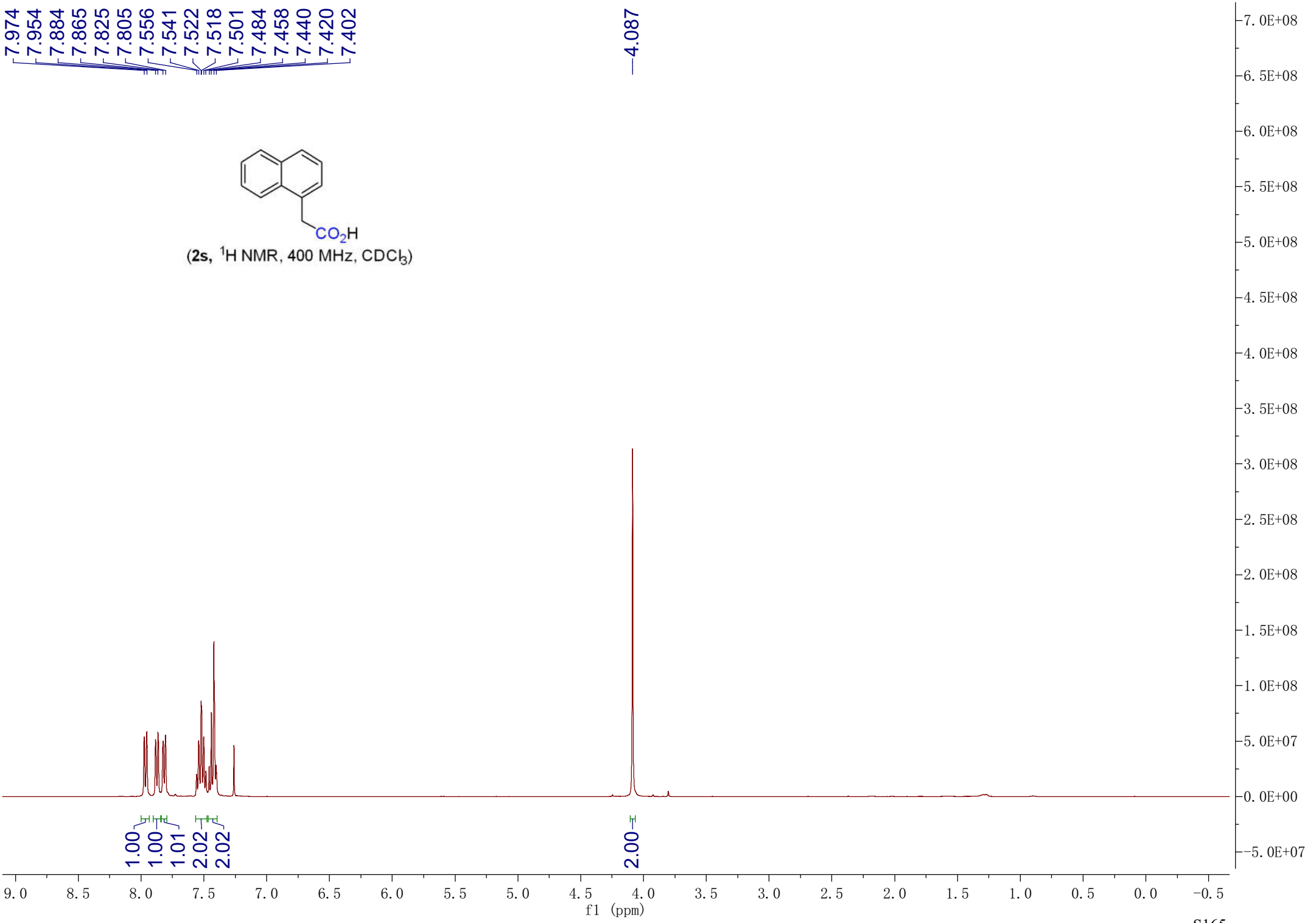


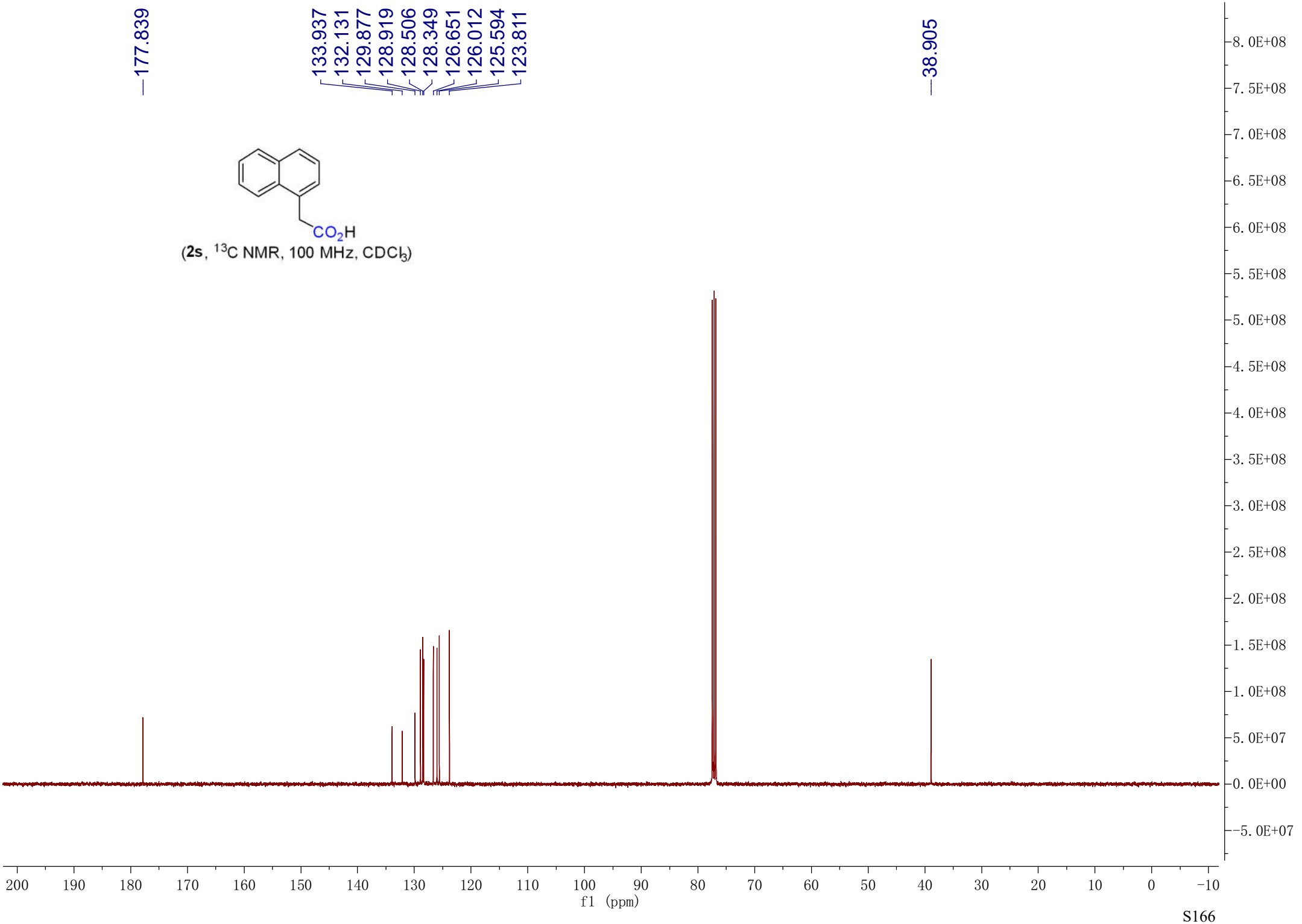
(**2q**, ^{1}H NMR, 400 MHz, $CDCl_3$)

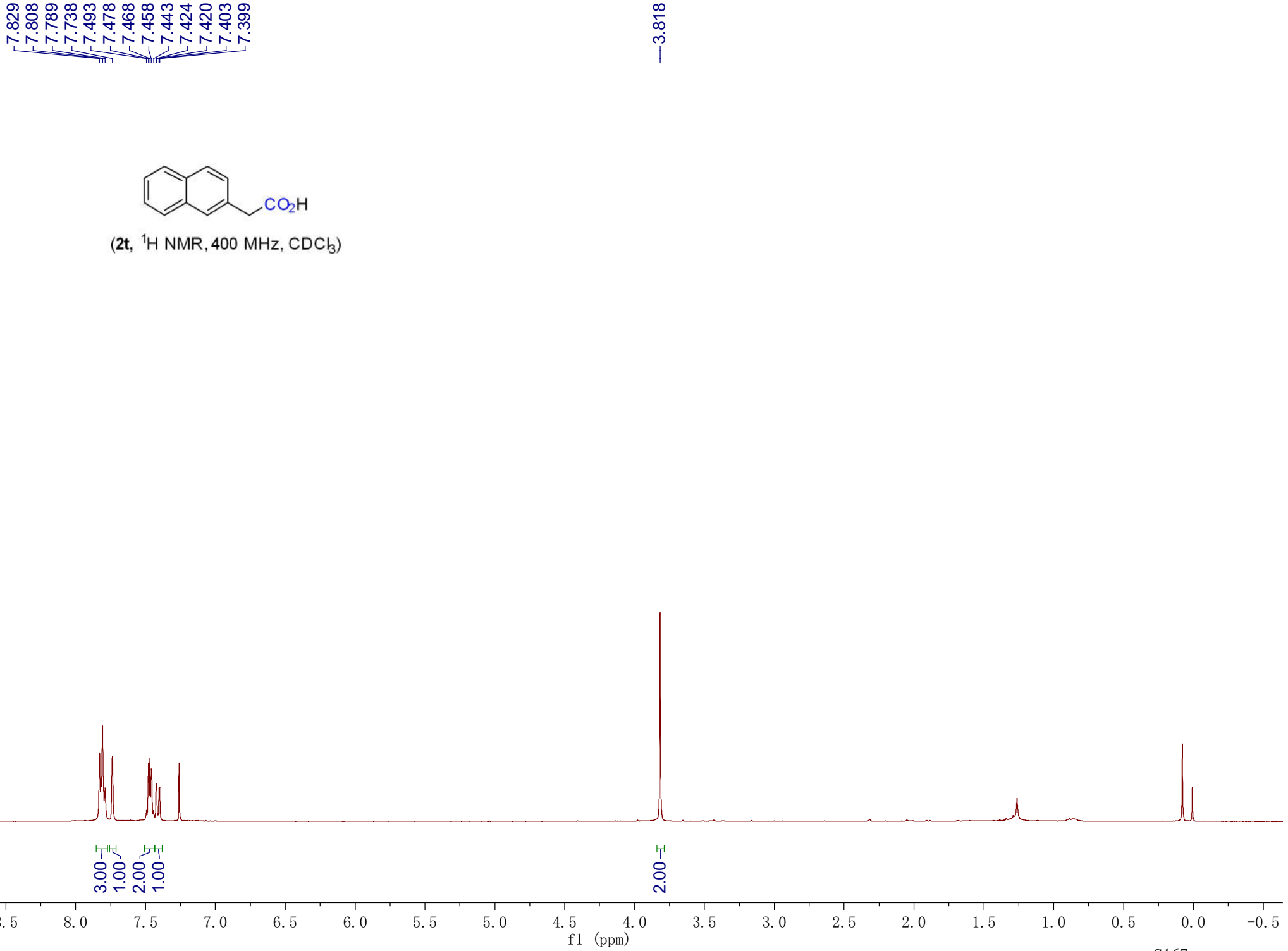

177.416
138.496
133.316
130.255
128.700
128.262
126.516
41.062
21.477
CO2H
Me
(2q, 13C NMR, 100 MHz, CDCl3)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

(**2r,** ^{1}H NMR, 400 MHz, $CDCl_3$)

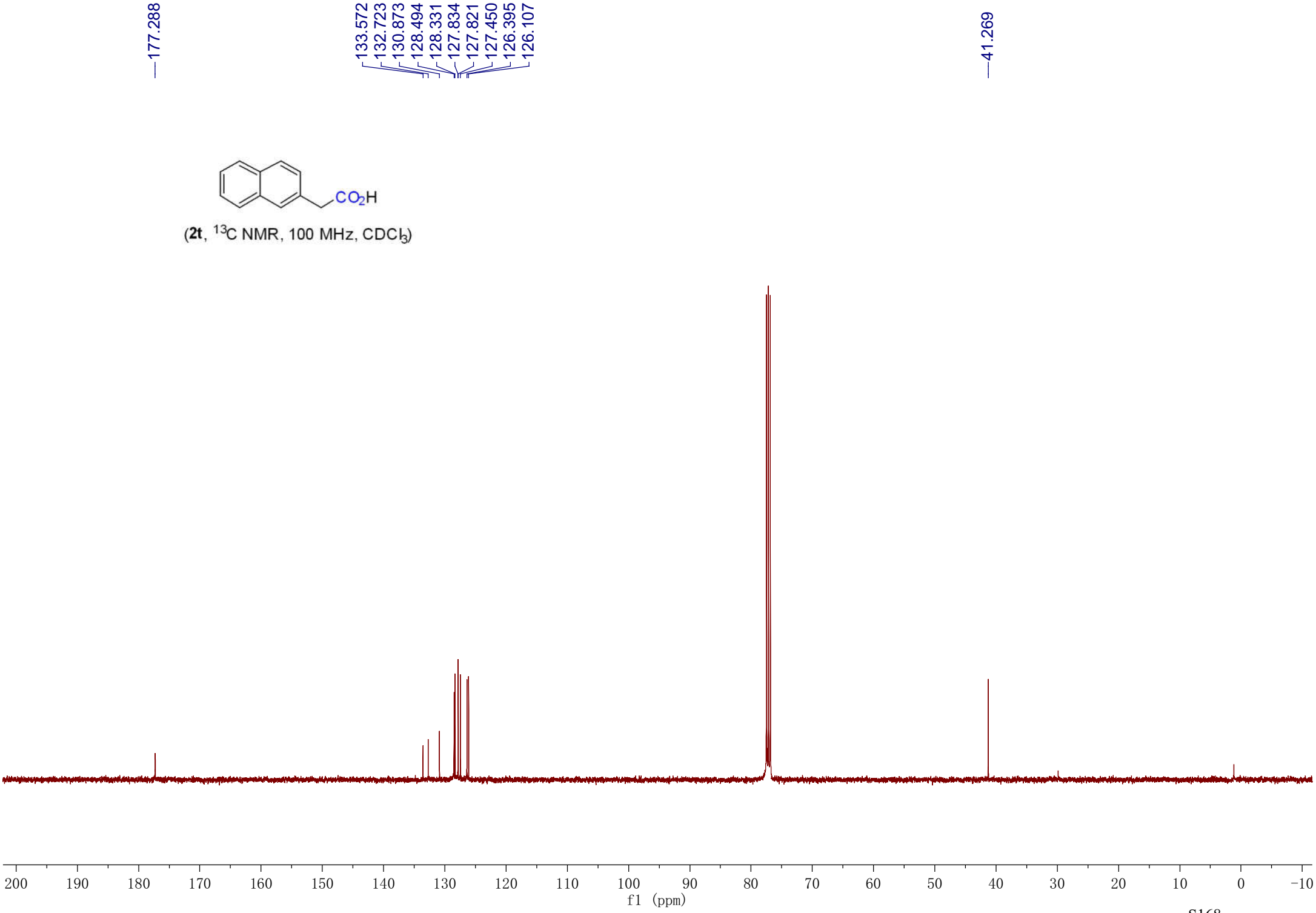

177.262
161.064
135.435
107.642
99.607
55.475
41.382
MeO
CO2H
OMe
(2r, 13C NMR, 100 MHz, CDCl3)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

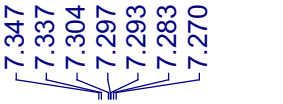

7.974
7.954
7.884
7.865
7.825
7.805
7.556
7.541
7.522
7.518
7.501
7.484
7.458
7.440
7.420
7.402
4.087
CO2H
(2s, 1H NMR, 400 MHz, CDCl3)
1.00
1.00
1.01
2.02
2.02
2.00
f1 (ppm)

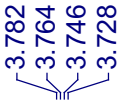

177.839
133.937
132.131
129.877
128.919
128.506
128.349
126.651
126.012
125.594
123.811
38.905
CO2H
(2s, 13C NMR, 100 MHz, CDCl3)
8.0E+08
7.5E+08
7.0E+08
6.5E+08
6.0E+08
5.5E+08
5.0E+08
4.5E+08
4.0E+08
3.5E+08
3.0E+08
2.5E+08
2.0E+08
1.5E+08
1.0E+08
5.0E+07
0.0E+00
-5.0E+07
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

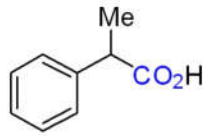


(**2t,** ^{1}H NMR, 400 MHz, $CDCl_3$)

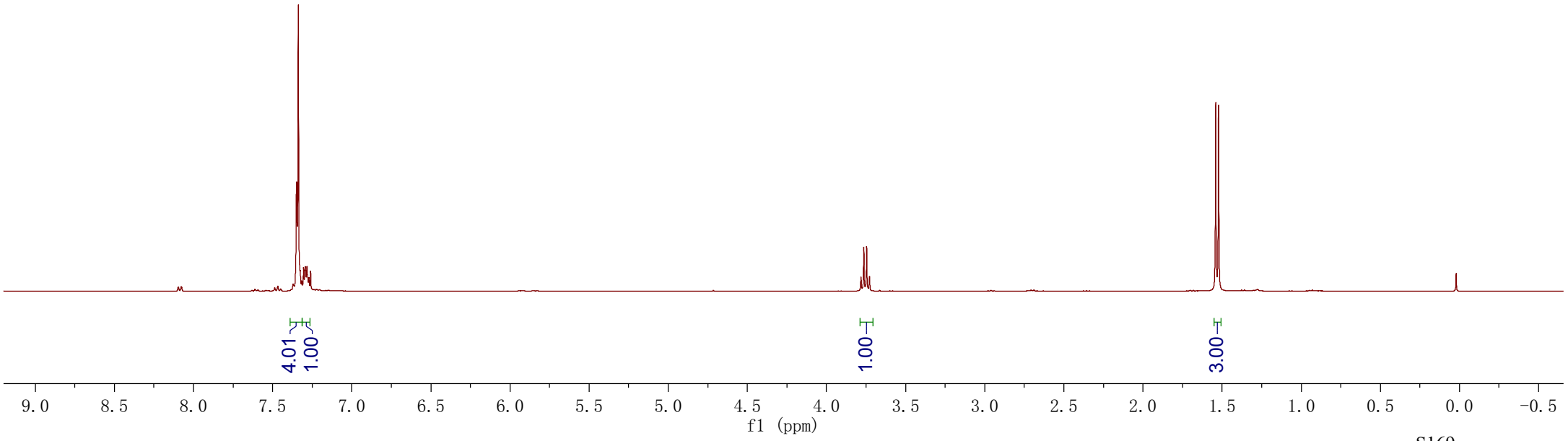

177.288
133.572
132.723
130.873
128.494
128.331
127.834
127.821
127.450
126.395
126.107
41.269
CO2H
(2t, 13C NMR, 100 MHz, CDCl3)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

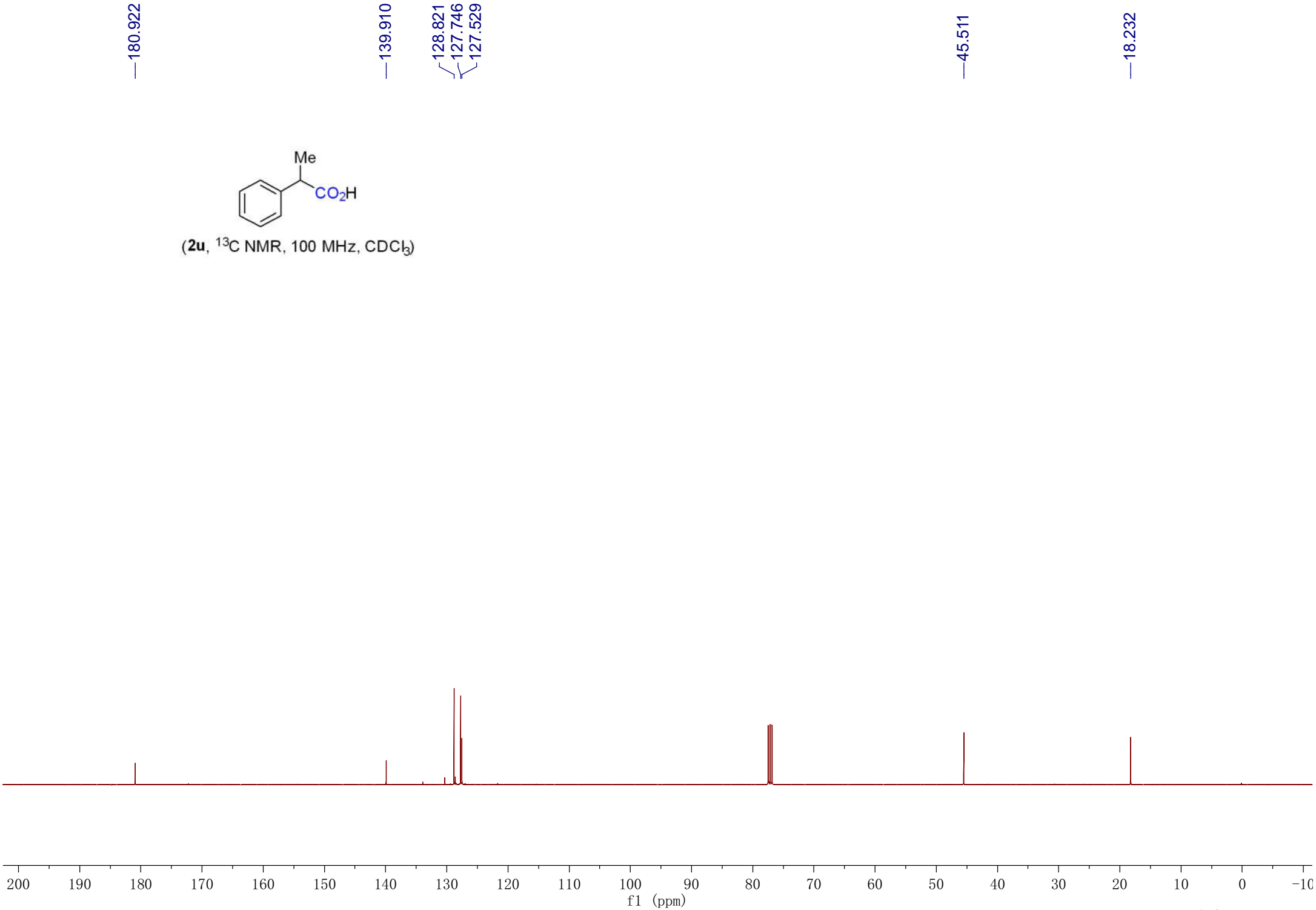




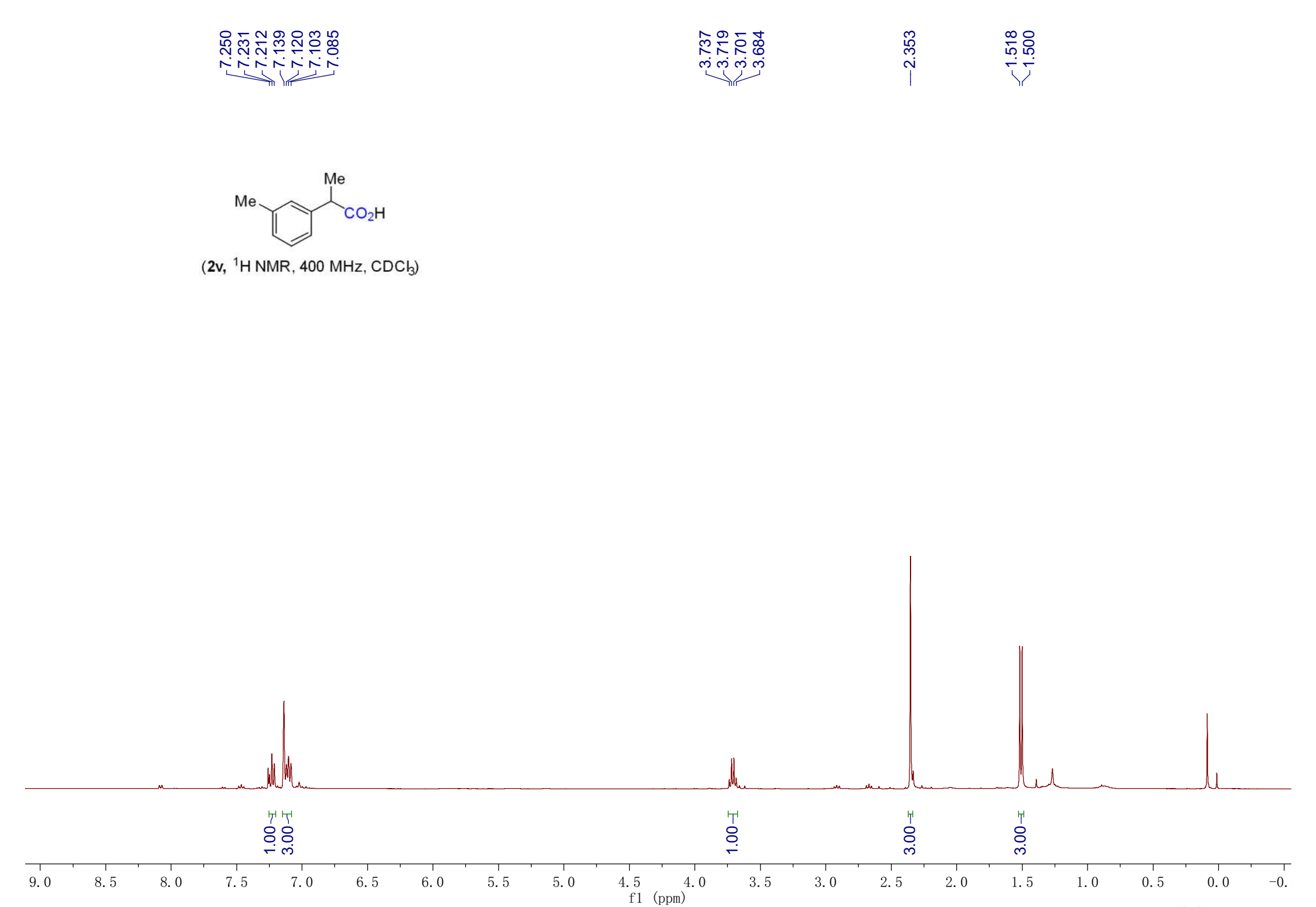


(**2u,** ^{1}H NMR, 400 MHz, $CDCl_3$)

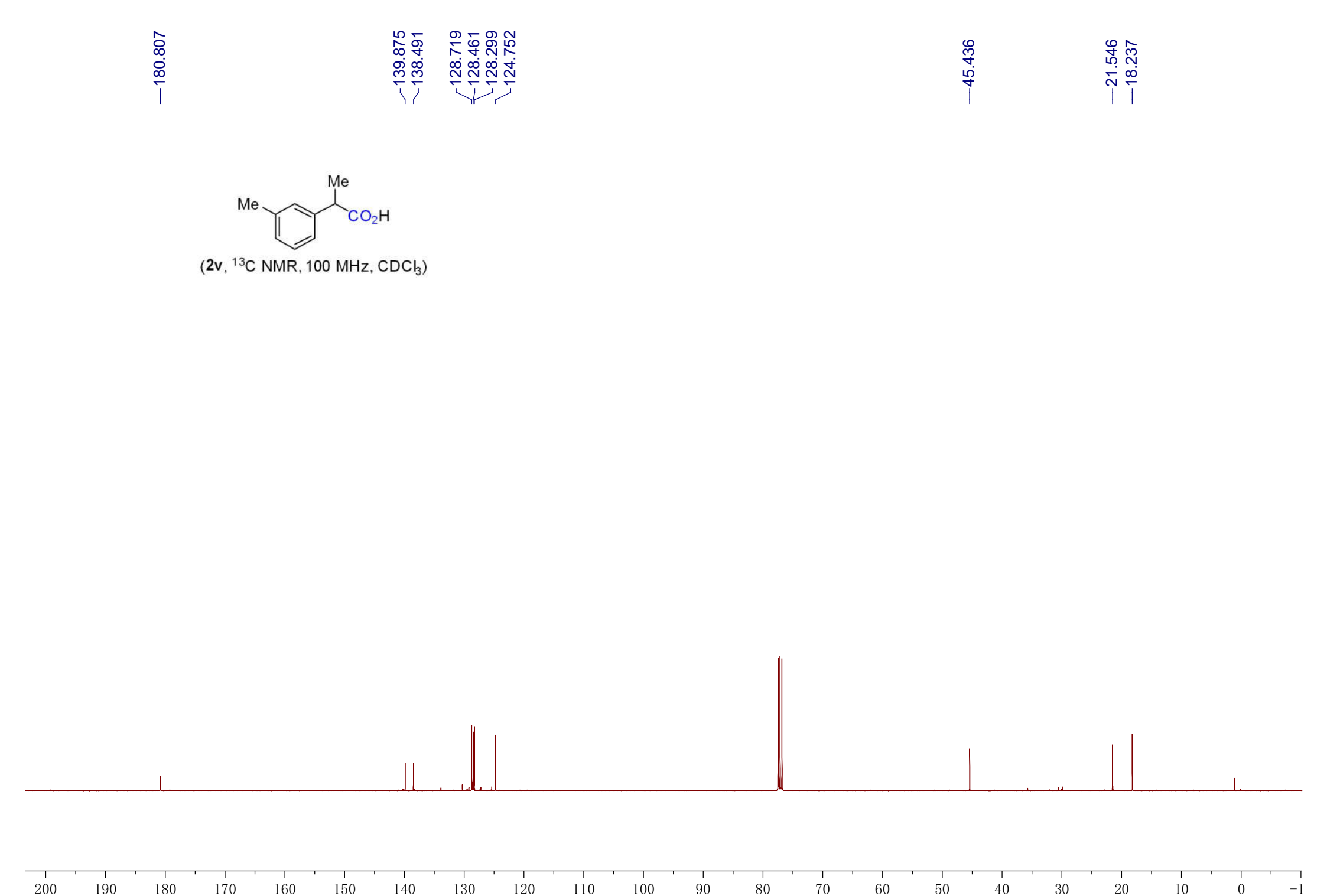


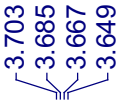


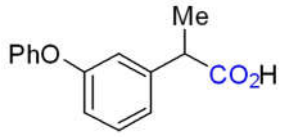
(**2u**, ^{13}C NMR, 100 MHz, $CDCl_3$)



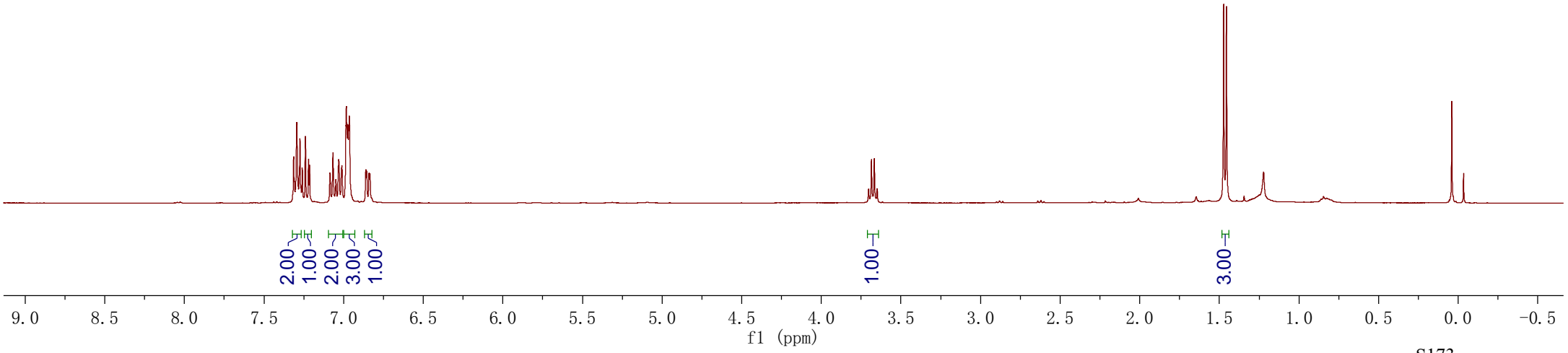
(**2v,** ^{1}H NMR, 400 MHz, $CDCl_3$)

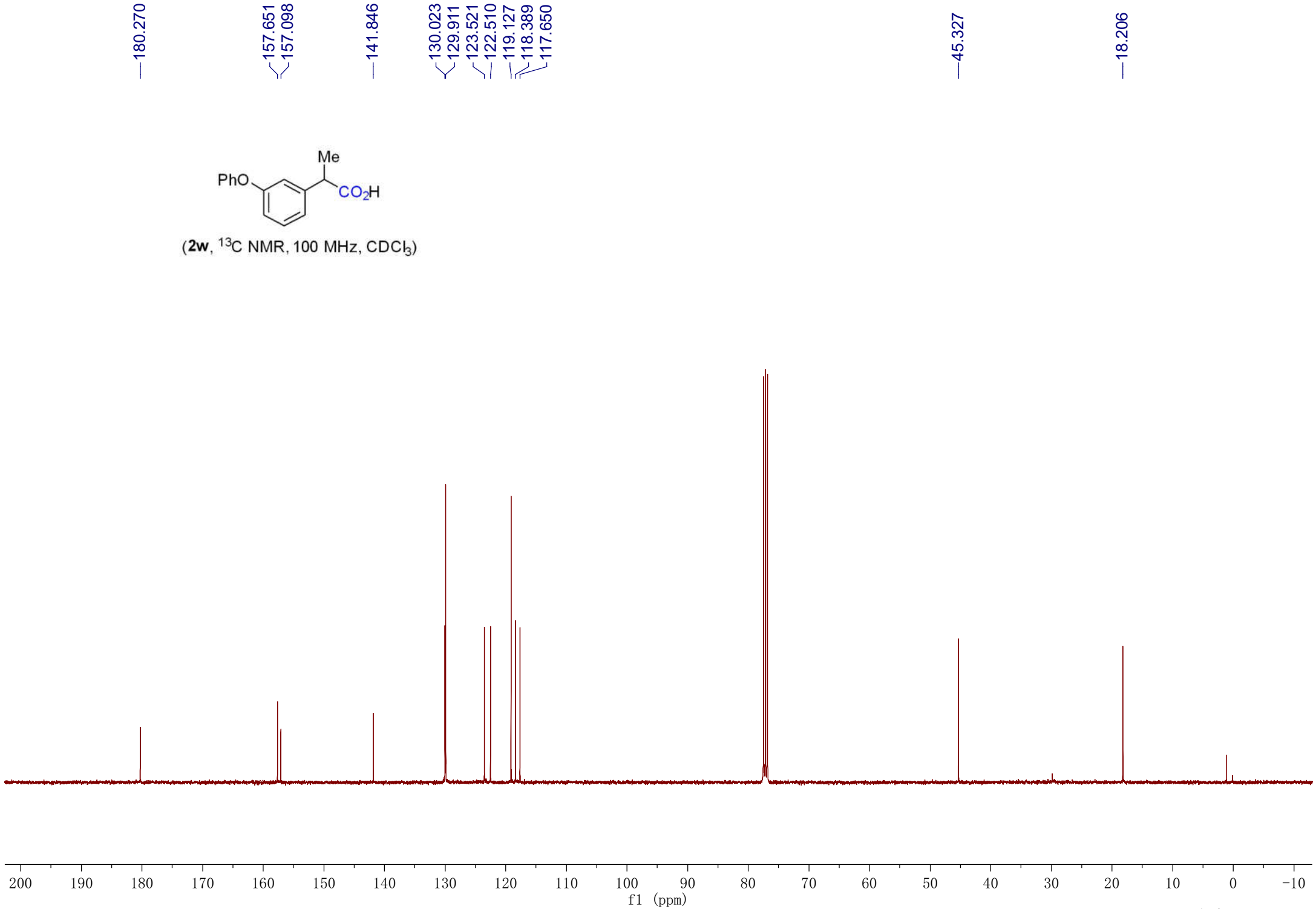

180.807
139.875
138.491
128.719
128.461
128.299
124.752
45.436
21.546
18.237
Me
Me
CO2H
(2v, 13C NMR, 100 MHz, CDCl3)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−1
f1 (ppm)

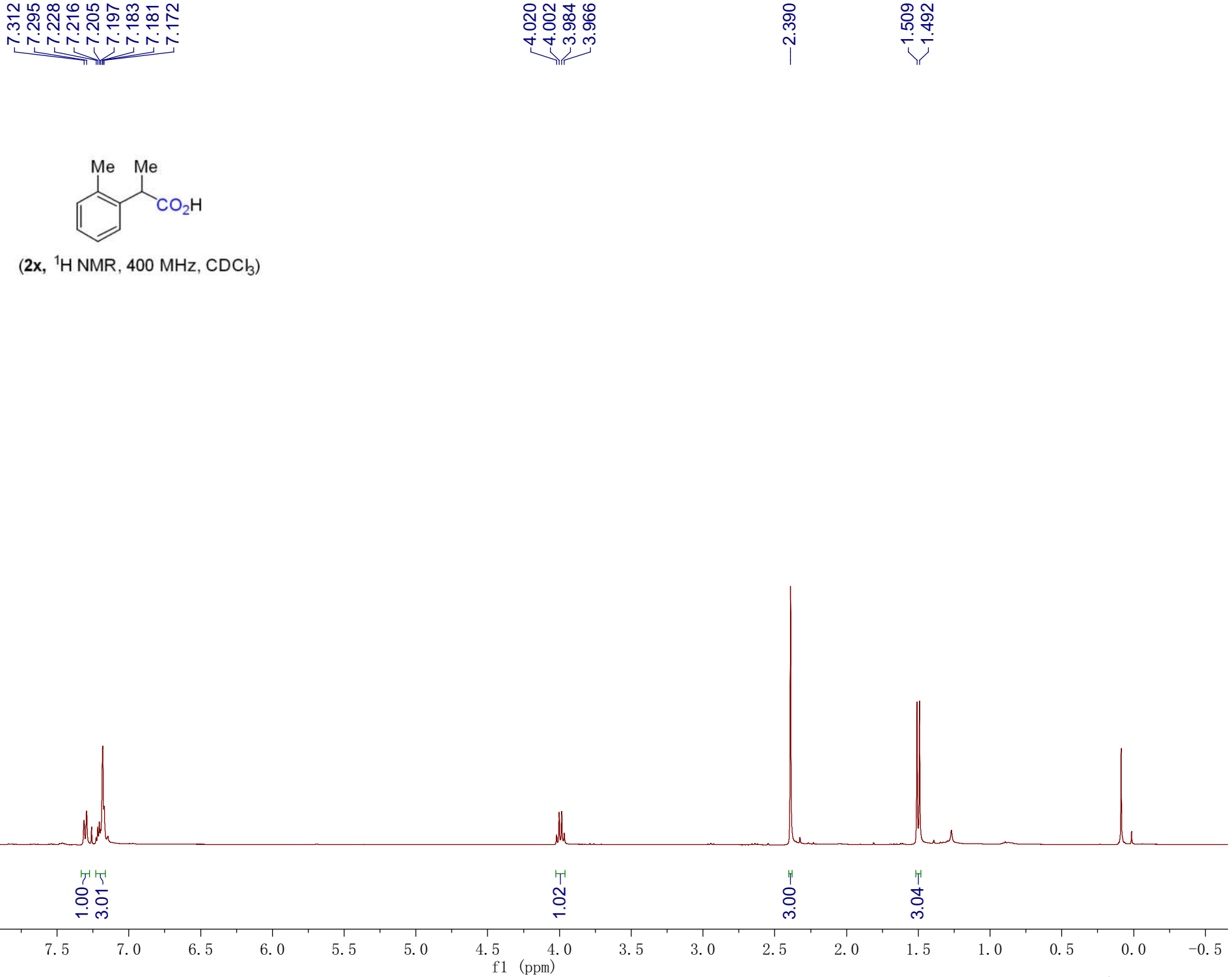




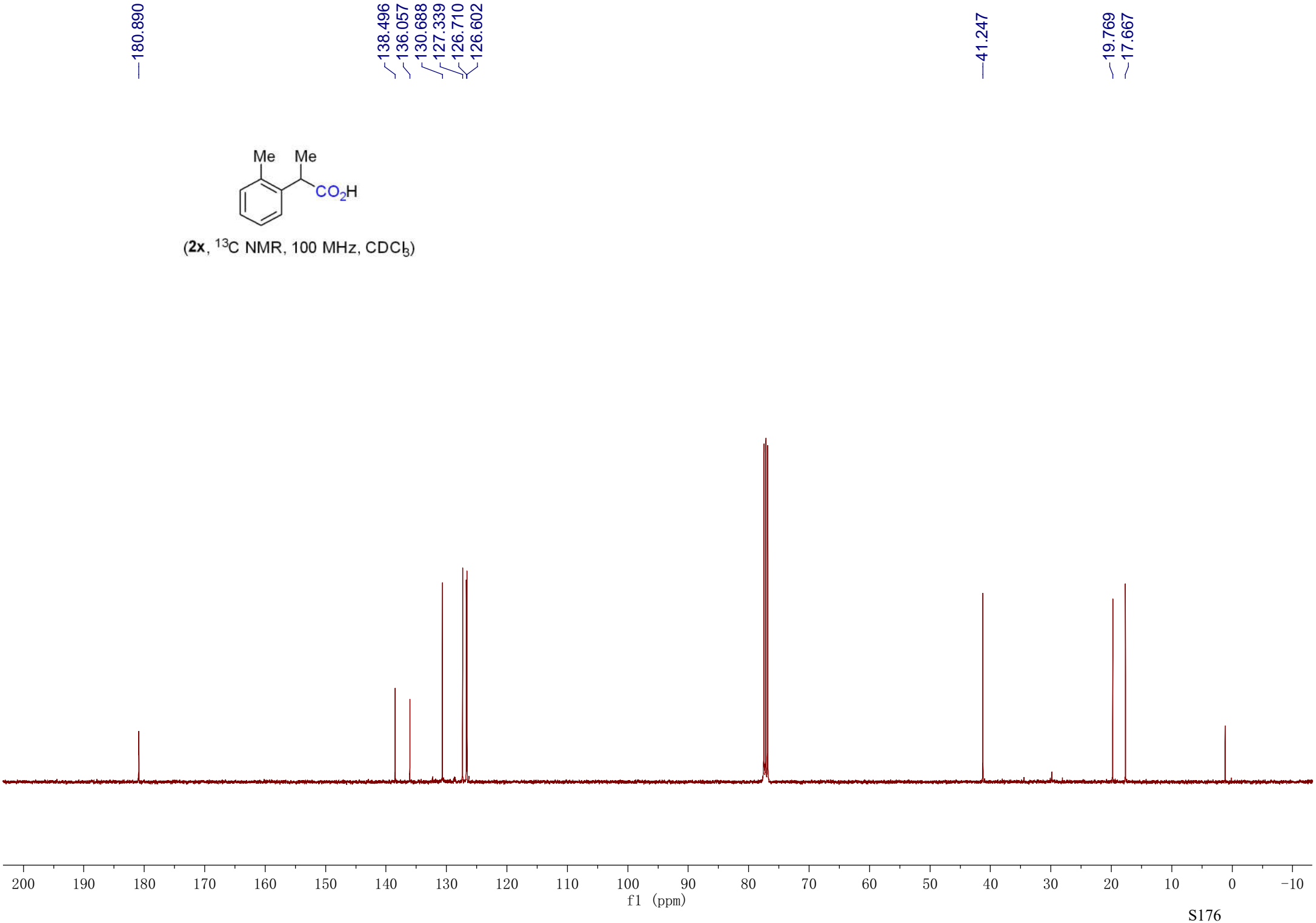
(**2w,** ^{1}H NMR, 400 MHz, $CDCl_3$)



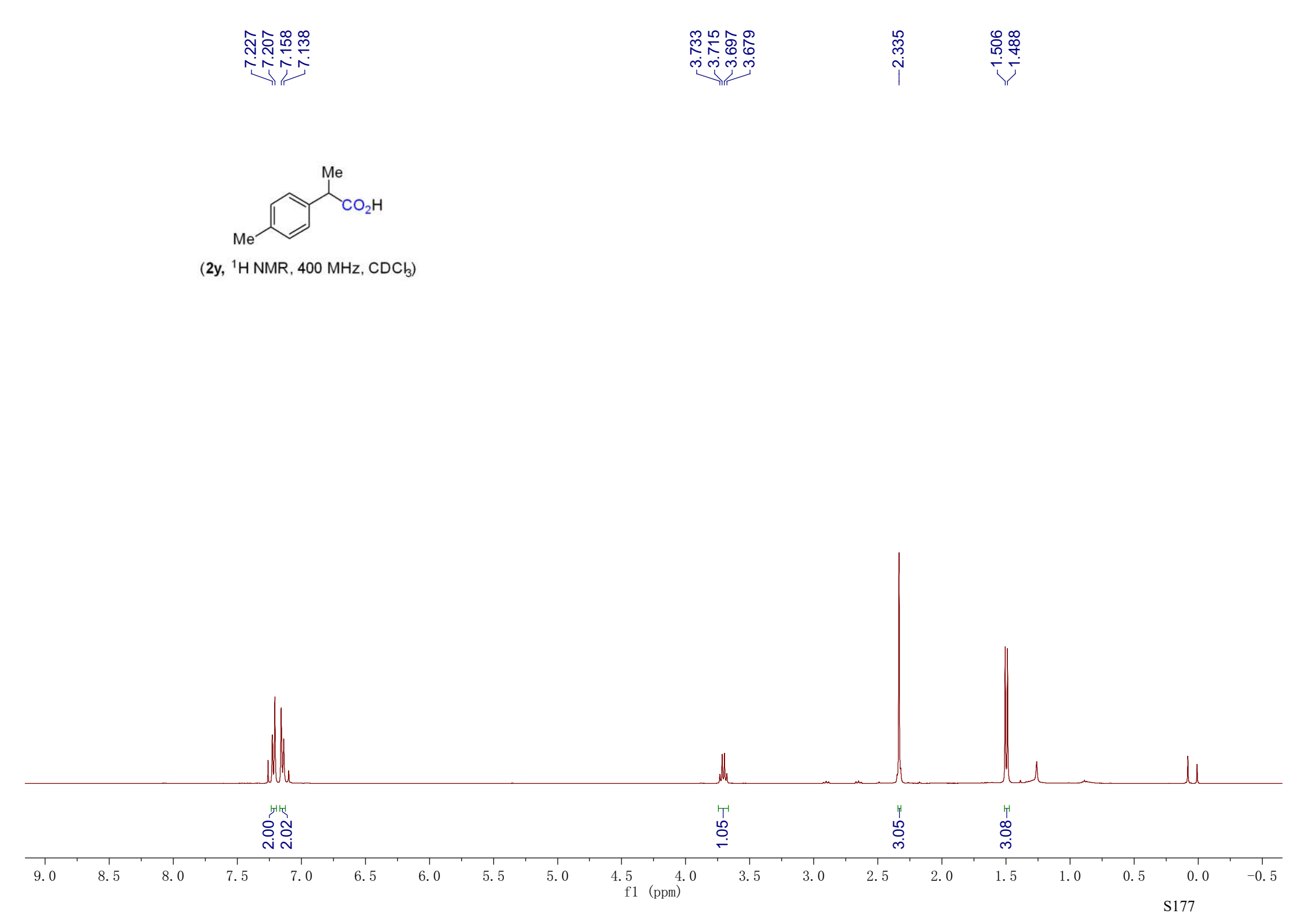

180.270
157.651
157.098
141.846
130.023
129.911
123.521
122.510
119.127
118.389
117.650
45.327
18.206
Me
PhO
CO2H
(2w, 13C NMR, 100 MHz, CDCl3)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)



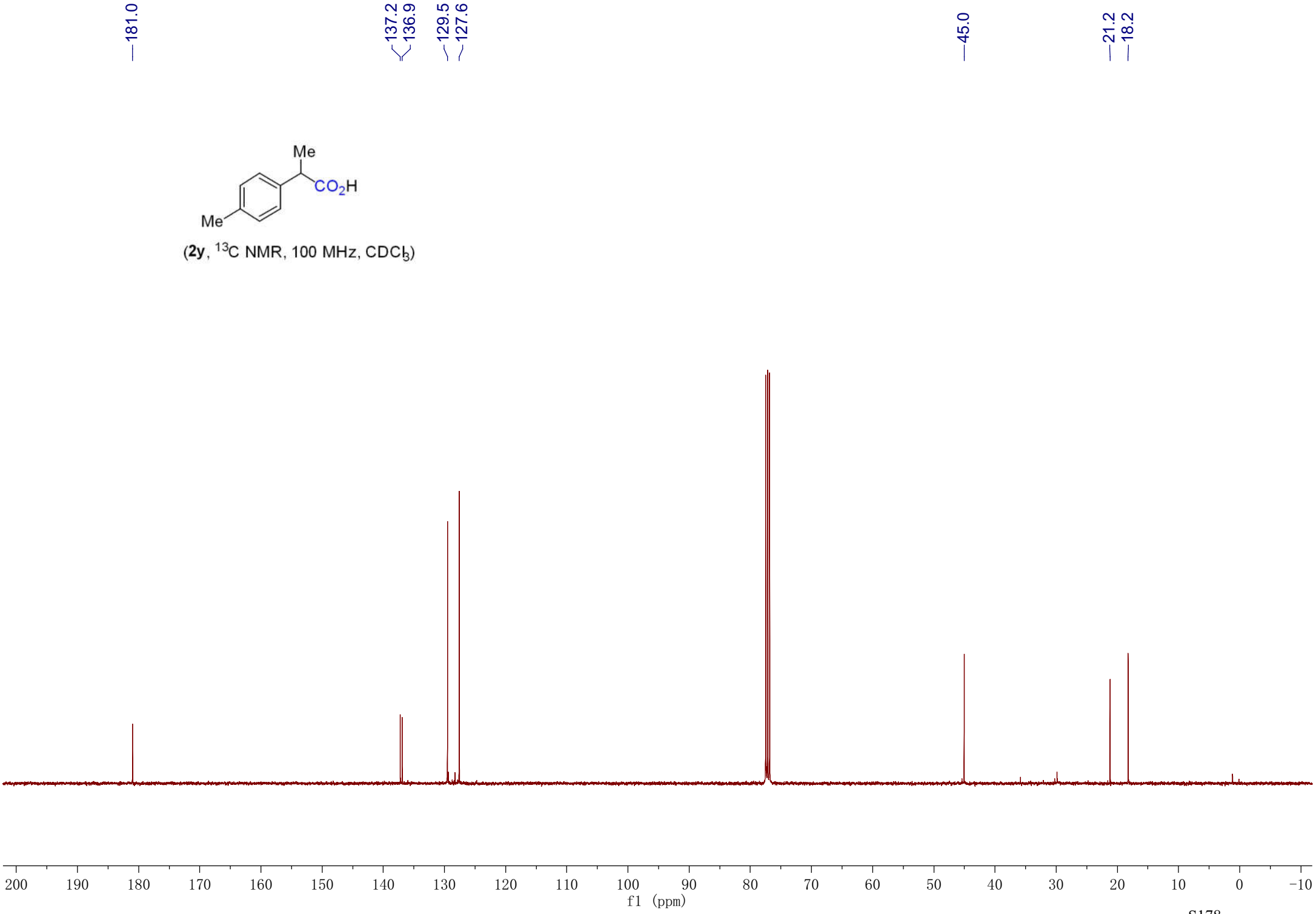
(**2x,** ^{1}H NMR, 400 MHz, $CDCl_3$)

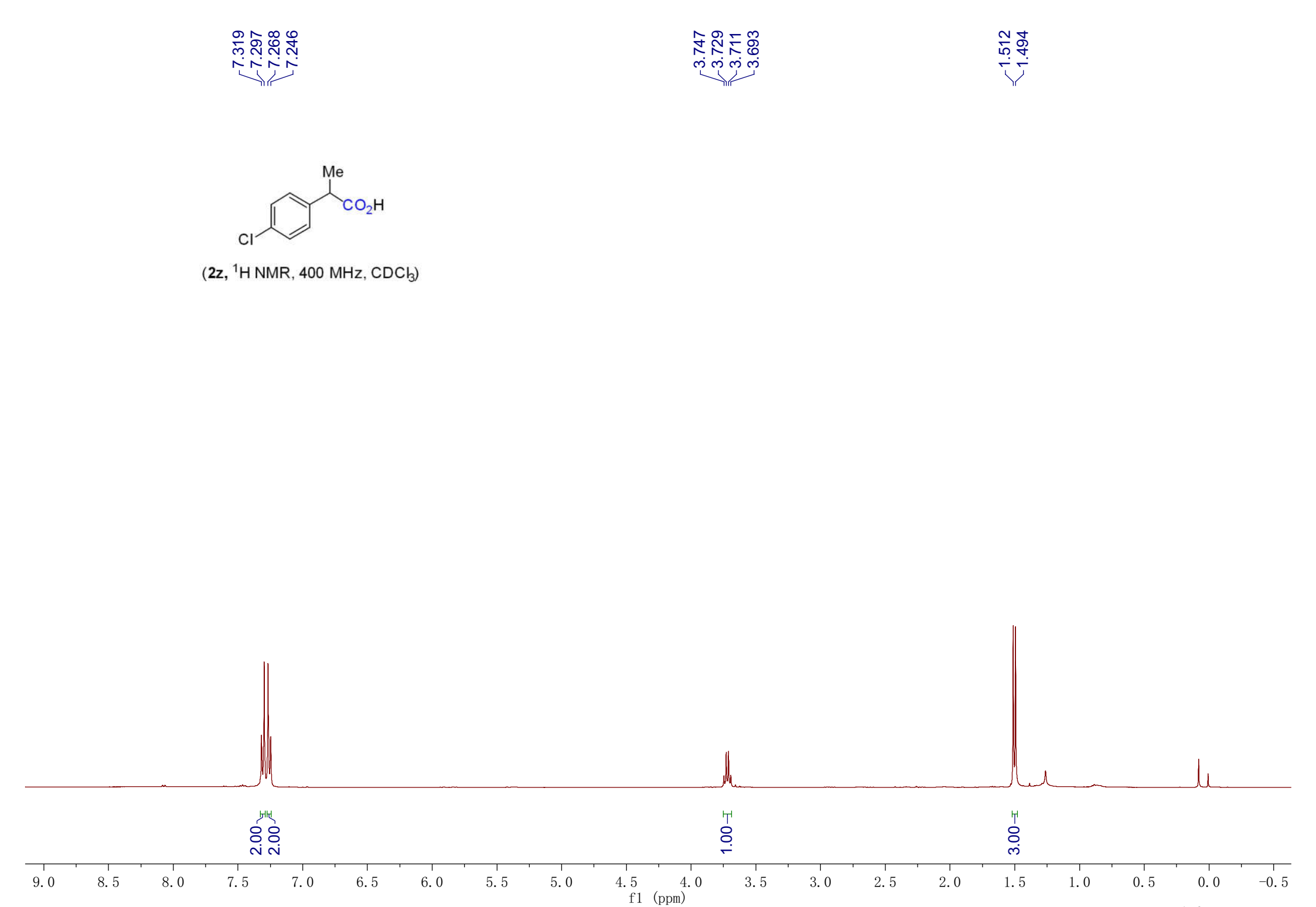


(**2x**, ^{13}C NMR, 100 MHz, $CDCl_3$)

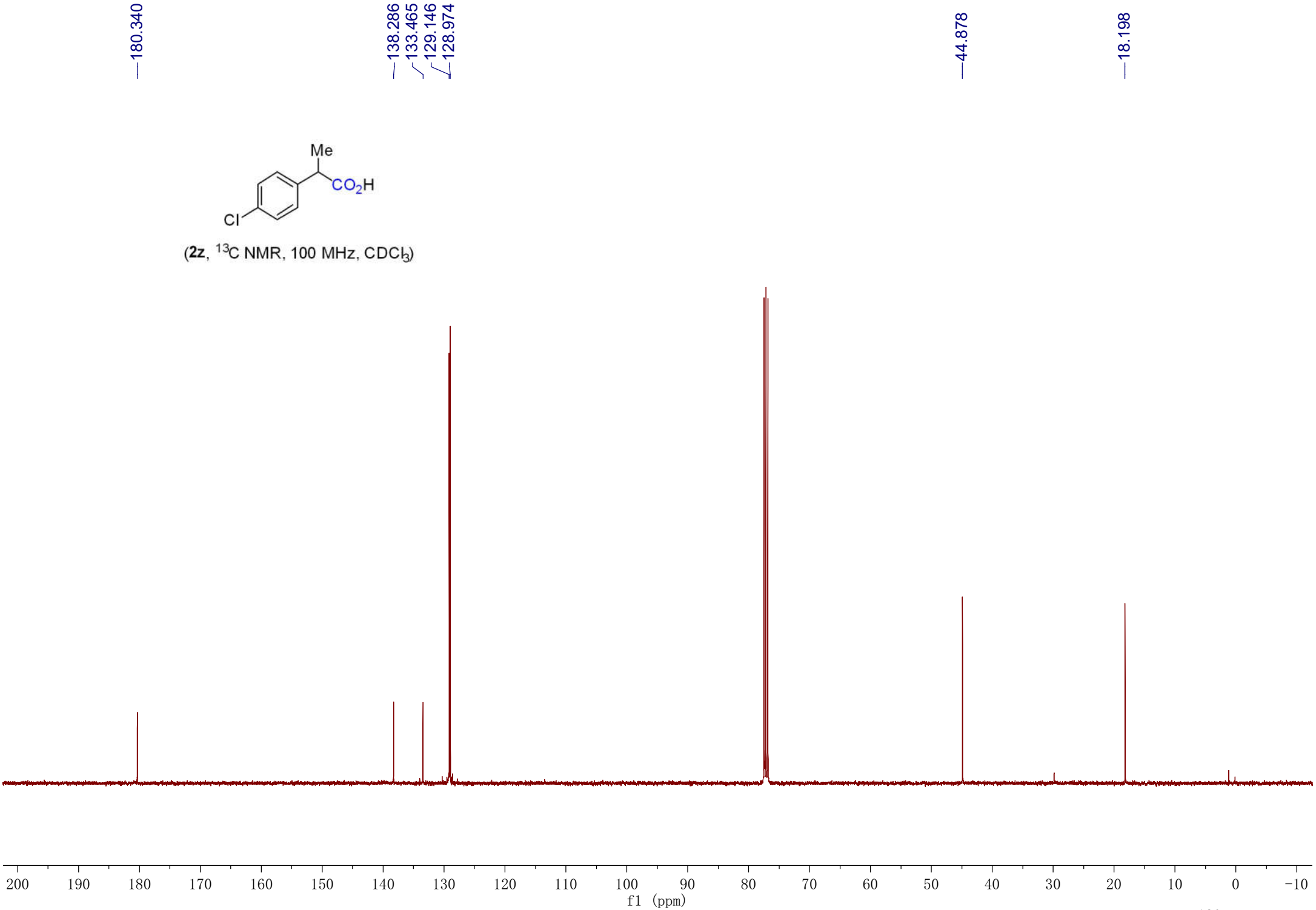


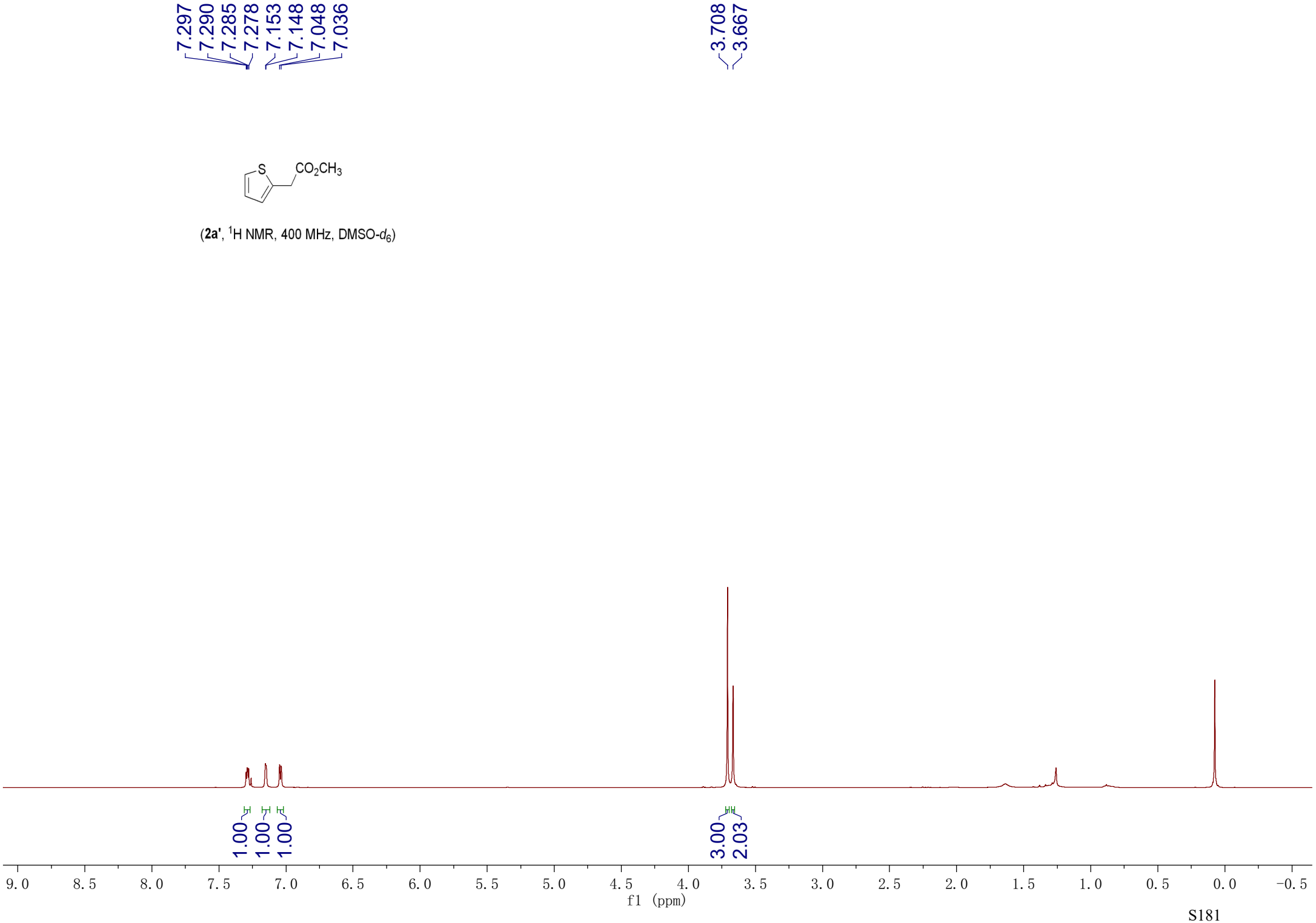
(**2y**, ^{1}H NMR, 400 MHz, $CDCl_3$)


181.0
137.2
136.9
129.5
127.6
45.0
21.2
18.2
Me
CO2H
Me
(2y, 13C NMR, 100 MHz, CDCl3)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

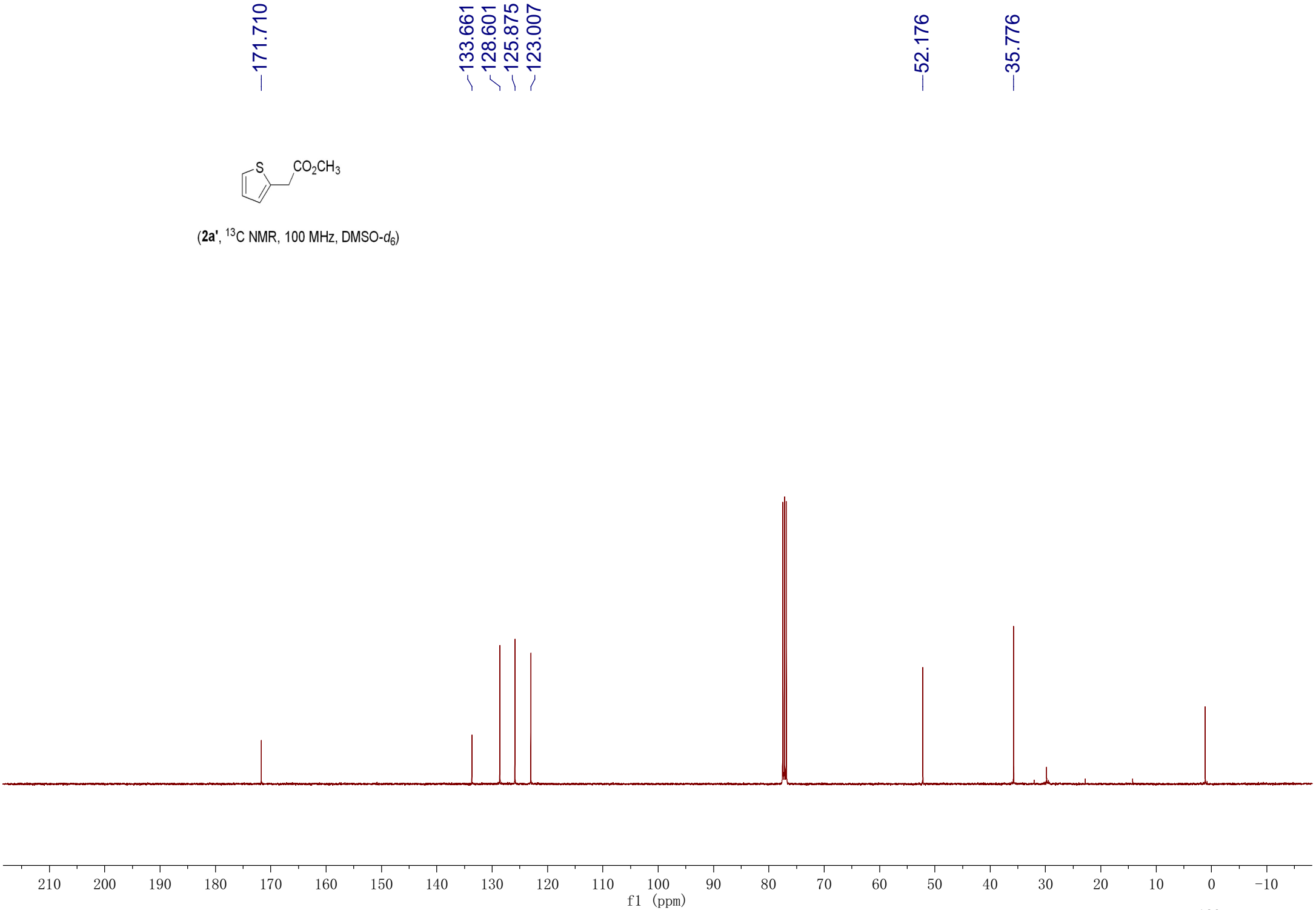


(**2z,** ^{1}H NMR, 400 MHz, $CDCl_3$)


180.340
138.286
133.465
129.146
128.974
44.878
18.198
Me
CO2H
Cl
(2z, 13C NMR, 100 MHz, CDCl3)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)



(**2a'**, ^{1}H NMR, 400 MHz, DMSO-d_6)



(**2a'**, ^{13}C NMR, 100 MHz, DMSO-d_6)