Electronic Supplementary Material (ESI) for ChemComm.

Supporting Information

Organoboron/Iodide-Catalyzed Photoredox N-Functionalization of NH-Sulfoximines/Sulfonimidamides

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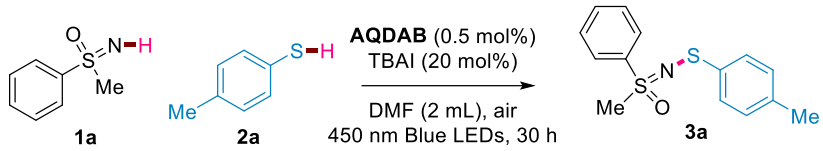
1. General considerations

General. Unless otherwise noted, all reactions were carried out under an air atmosphere. Analytical thin-λayer chromatography (TLC) was performed on glass plates coated with 0.25 mm 230–400 mesh silica gel containing a fluorescent indicator. Visualization was accomplished by exposure to a UV lamp. All the products in this article are compatible with standard silica gel chromatography. Column chromatography was performed on silica gel (200–300 mesh) using standard methods.

Structural analysis. NMR spectra were measured on a Bruker Ascend 400 spectrometer and chemical shifts (δ) are reported in parts per million (ppm). ^{1}H NMR spectra were recorded at 400 MHz in NMR solvents and referenced internally to corresponding solvent resonance, and ^{13}C NMR spectra were recorded at 101 MHz and referenced to corresponding solvent resonance. Coupling constants are reported in Hz with multiplicities denoted as s (singlet), d (doublet), t (triplet), q (quartet), m (multiplet) and br (broad). Infrared spectra were collected on a Thermo Fisher Nicolet 6700 FT-IR spectrometer using ATR (Attenuated Total Reflectance) method. Absorption maxima (ν max) are reported in wavenumbers (cm^{-1}). High resolution mass spectra (HRMS) were acquired on Thermo Scientific LTQ Orbitrap XL with an APCI source.

Materials. Commercial reagents and solvent were purchased from Adamas, J&K, Energy, Sigma-Aldrich, Alfa Aesar, Acros Organics, TCI and used as received unless otherwise stated.

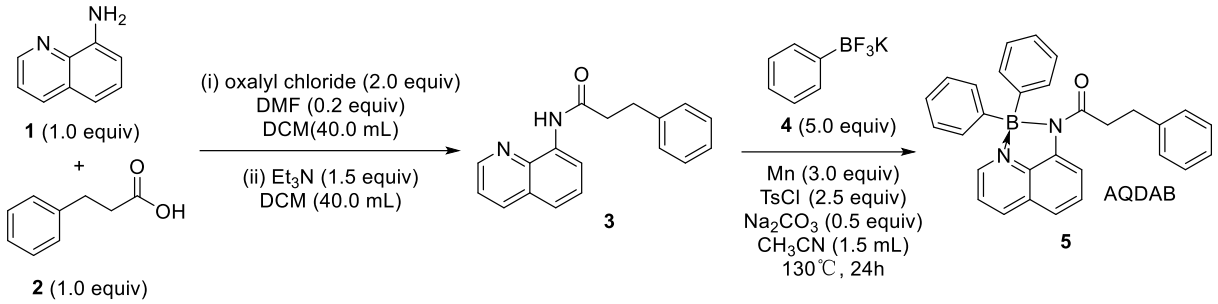
2. Optimizing the selection of photocatalysts for the synthesis of N-sulfenylated products



Entey	Photocatalyst used instead of AQDAB	Yield (%)
1	**0.5 mol% AQDAB**	**92**
	2 mol% Rose Bengal	Trace
	2 mol% Eosin Y	Trace
	2 mol% TXO	66
	2 mol% $[Ir(dF(CF_3)ppy)_2(dtbbpy)](PF_6)$	64
	2 mol% $[Ru(bpy)_3]Cl_2$	Trace
	2 mol% 4CzIPN	53
	2 mol% Rhodamine B	23
	2 mol% CdS	31

Scheme S1. Optimizing the selection of photocatalysts for the synthesis of N-sulfenylated products.

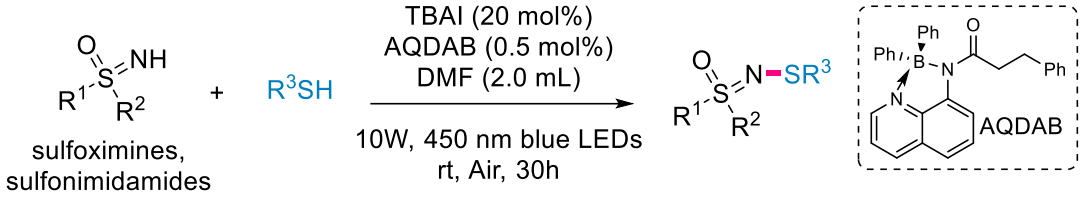
3. The synthesis of the photocatalyst used



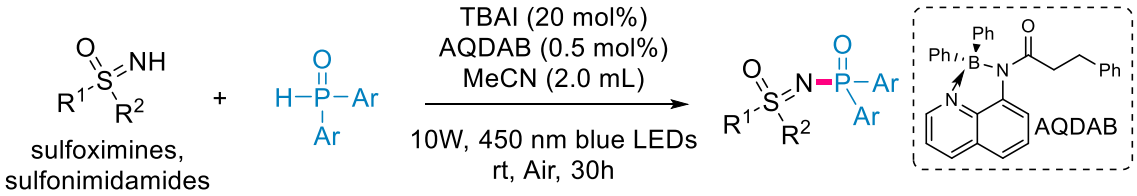
A mixture of hydrocinnamic acid **2** (3.0 g, 20 mmol), oxalyl chloride (5.1 g, 40 mmol, 2.0 equiv), DMF (0.3 mL, 4 mmol, 0.2 equiv) in anhydrous DCM (40.0 mL) was stirred at room temperature overnight. The reaction mixture was then concentrated in vacuo to give the crude hydrocinnamoyl chloride. A mixture of hydrocinnamoyl chloride, 8-aminoquinoline **1** (2.9 g, 20 mmol, 1.0 equiv), and triethylamine (4.2 mL, 30 mmol, 1.5 equiv) in anhydrous DCM (40 mL) was stirred at room temperature overnight. The reaction mixture was then washed with water and brine, dried over anhydrous Na_2SO_4 and concentrated in vacuo. The resulting residue was purified by silica gel flash chromatography to give 4.1 g of the 3-phenyl-N-(quinolin-8-yl)propanamide **3** in 75% yield.

A flame-dried 25 mL reaction tube was placed with a stirring bar. Then, 3-phenyl-N-(quinolin-8-yl)propanamide **3** (41.4 mg, 0.15 mmol, 1.0 equiv), phenyl trifluoroborate **4** (138 mg, 0.75 mmol, 5.0 equiv), Mn (24.7 mg, 0.45 mmol, 3.0 equiv), 4-toluenesulfonyl chloride (71.5 mg, 0.375 mmol, 2.5 equiv), Na_2CO_3 (7.9 mg, 0.075 mmol, 0.5 equiv) and CH_3CN (1.5 mL) were added. The resulting mixture was stirred at 130 ℃ for 24 hours. Then, the reaction mixture was filtered, concentrated and purified by column chromatography (silica gel) to give 62.7 mg of the target product **AQDAB** in 95% yield.

4. General procedure for the N-functionalization of sulfoximines and sulfonimidamides



General Procedure A: sulfoximines or sulfonimidamides (0.20 mmol, 1.0 equiv), thiol (0.40 mmol, 2.0 equiv), TBAI (0.04 mmol, 20 mol%), AQDAB (0.001 mmol, 0.5 mol%), and DMF (2.0 mL) were added to a dried 25 mL reaction tube. The reaction tube was placed on a photocatalytic parallel reactor with a 450 nm blue. LEDs light source (10 W) at the bottom (**Figure S1**). Then the reaction mixture was irradiated with the 450 nm blue LEDs (at approximately 0.3 cm away from the light source). After stirring for 30 hours at 25 ℃, the reaction mixture was added 10 mL H_2O and then extracted with ethyl acetate (3 × 10 mL). The combined organic phase was dried over Na_2SO_4, and concentrated under vacuum to afford the crude product, which was purified by column chromatography on silica gel using PE/EA (3: 1) as eluent to give the target products.



General Procedure B: sulfoximines or sulfonimidamides (0.20 mmol, 1.0 equiv), diphenylphosphine oxide (0.40 mmol, 2.0 equiv), TBAI (0.04 mmol, 20 mol%), AQDAB (0.001 mmol, 0.5 mol%), and MeCN (2.0 mL) were added to a dried 25 mL reaction tube. The reaction tube was placed on a photocatalytic parallel reactor with a 450 nm blue. LEDs light source (10 W) at the bottom (**Figure S1**). Then the reaction mixture was irradiated with the 450 nm blue LEDs (at approximately 0.3 cm away from the light source). After stirring for 30 hours at 25 ℃, the reaction mixture was added 10 mL H_2O and then extracted with ethyl acetate (3 × 10 mL). The combined organic phase was dried over Na_2SO_4, and concentrated under vacuum to afford the crude product, which was purified by column chromatography on silica gel using PE/EA (3: 1) as eluent to give the target products.

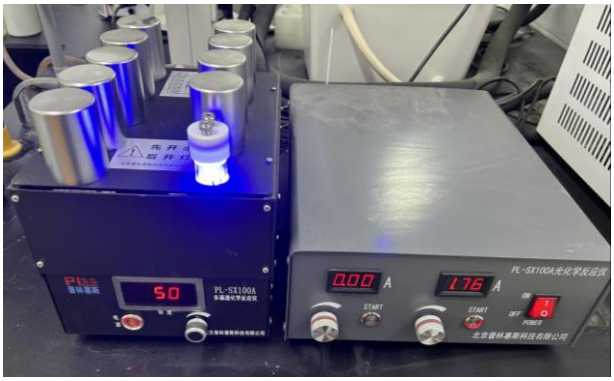
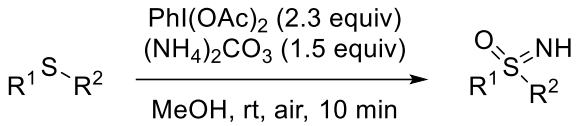


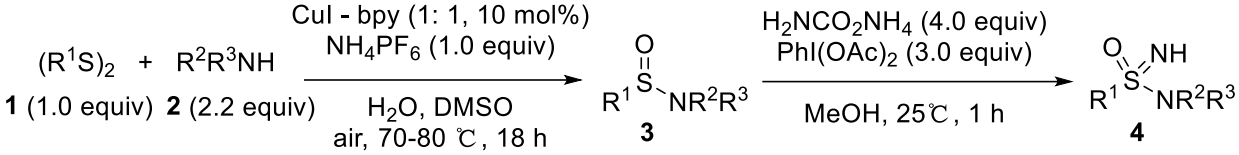
Figure S1. Picture of the reactor

5. General Procedure for the Synthesis of NH-Sulfoximines [1]



General Procedure for the Synthesis of NH-Sulfoximines. In a dried 50 mL pear-shaped flask equipped with a stirring bar, sulfide (1.0 mmol), $PhI(OAc)_2$ (2.3 mmol, 2.3 equiv), and $(NH_4)_2CO_3$ (1.5 mmol, 1.5 equiv) were added. Then, MeOH (10.0 mL) was added, and the reaction mixture was stirred at 25 °C for 10 min. The reaction was then quenched by the addition of saturated sodium bicarbonate (10.0 mL). The aqueous phase was extracted with ethyl acetate (10 mL × 3). The combined organic phase was dried over anhydrous $MgSO_4$, filtered, and concentrated. The resulting residual was purified by flash silica gel column chromatography using a mixture of PE and EA as the eluent to afford the NH-sulfoximines.

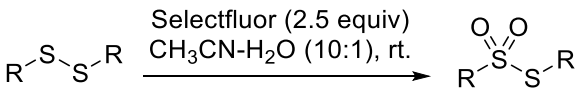
6. General Procedure for the Synthesis of NH- Sulfonimidamides [2,3]



To a mixture of disulfides **1** (1.0 mmol), diethylamine **2** (2.2 mmol, 2.2 equiv), and NH_4PF_6 (1.0 mmol, 1.0 equiv), in DMSO (0.6 mL) and H_2O (0.15 mL) were added CuI (0.1 mmol, 10 mmol%) and bpy (0.1 mmol, 10 mmol%), and the mixture was stirred at 80 °C for 18 h in the presence of air provided by a balloon. After the residue was dissolved in Et_2O, the solution was washed with H_2O and saturated sodium chloride and dried with anhydrous magnesium sulfate. The resulting residual was purified by flash silica gel column chromatography using a mixture of diethyl ether and hexane as the eluent to afford the Sulfinamides **3**.

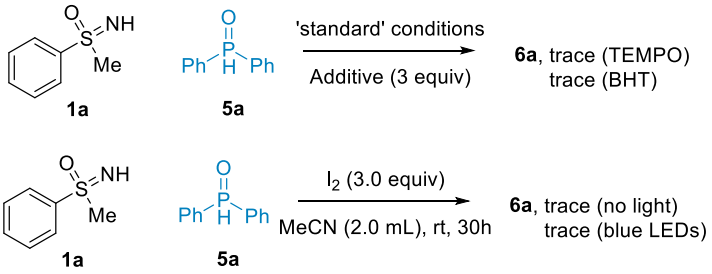
To the sulfinamide **3** (1.0 mmol) were added $PhI(OAc)_2$ (3.0 mmol, 3.0 equiv), $H_2NCO_2NH_4$ (4.0 mmol, 4.0 equiv) and finally MeOH (2.0 mL, 0.5 M). The mixture was stirred in an open flask at 25℃ for 1 h. The reaction was then quenched by the addition of saturated sodium bicarbonate (10.0 mL). The aqueous phase was extracted with ethyl acetate (10 mL × 3). The combined organic phase was dried over anhydrous $MgSO_4$, filtered, and concentrated. The resulting residual was purified by flash silica gel column chromatography using a mixture of PE and EA as the eluent to afford the NH-sulfonimidamides **4**.

7. General Procedure for the Synthesis of Thiosulfonate [4]



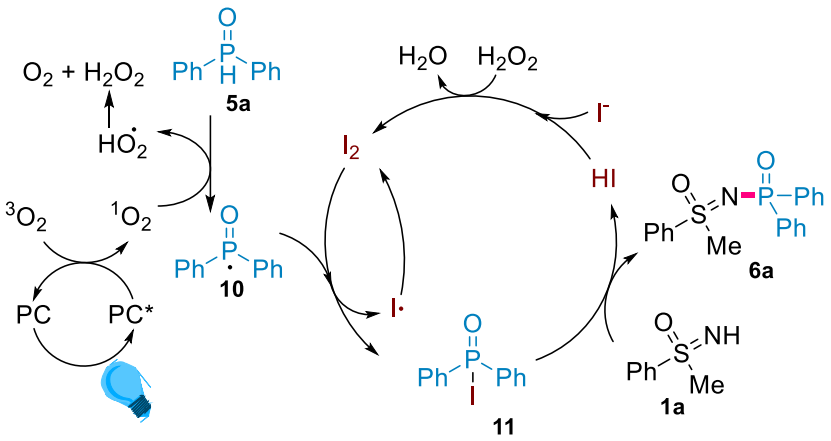
To a mixture of p-tolyl disulfide (1.0 mmol, 1.0 equiv), in acetonitrile (2.0 ml) and water (0.2 mL) were added Selectfluor (2.5 mmol, 2.5 equiv), and the mixture was stirred at room temperature for 20 min. The reaction was monitored by thin layer chromatography (TLC). After the disulfide disappeared from the TLC, water (5 mL) was added and the resulting mixture was extracted with ethyl acetate (15 mL × 3). The extract was washed with brine, dried over anhydrous magnesium sulfate, and evaporated. Chromatography on silica gel gave thiosulfonate as colorless crystals.

8. A possible mechanism of N-phosphonylation of NH-sulfoximines



Scheme S2. Mechanistic studies for N-phosphonylation of NH-sulfoximines.

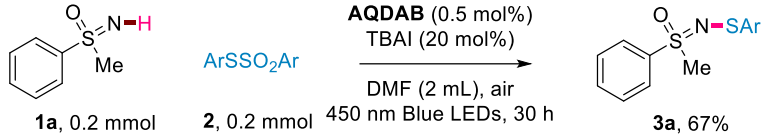
To further investigate the reaction mechanism for N-phosphonylation of NH-sulfoximines, a series of control experiments were conducted (**Scheme S2**). When a radical scavenger (TEMPO, BHT) was introduced into the reaction mixture, a significant suppression of the reaction process was observed. This indicates that radical species might be involved in the reaction mechanism. To confirm the role of iodine in the reaction, we attempted to carry out the reaction between diphenylphosphine oxide **5a** and sulfoximine **1a** using stoichiometric iodine. However, the desired compound could not be generated.



Scheme S3. A proposed mechanism for the N-phosphonylation of NH-sulfoximines.

A possible reaction mechanism has been proposed (**Scheme S3**). Initially, the photocatalyst PC was excited by visible light. The excited state PC* was then quenched by triplet oxygen to generate singlet oxygen $^1O_2$. Subsequently, the hydrogen atom transfer (HAT) of the diphenylphosphine oxide **5a** by singlet oxygen $^1O_2$ produced the P-centered radical **10** and hydroperoxide radical species. The disproportionation of the hydroperoxide radical would generate O_2 and H_2O_2. At the same time, iodides were oxidized to I_2 in the presence of H_2O_2. P-centered radical **10** reacted with I_2 to generate active electrophilic species **11**. Subsequently, intermediate **11** and sulfoxide imine **1a** undergo nucleophilic substitution to obtain the final product **6a**.

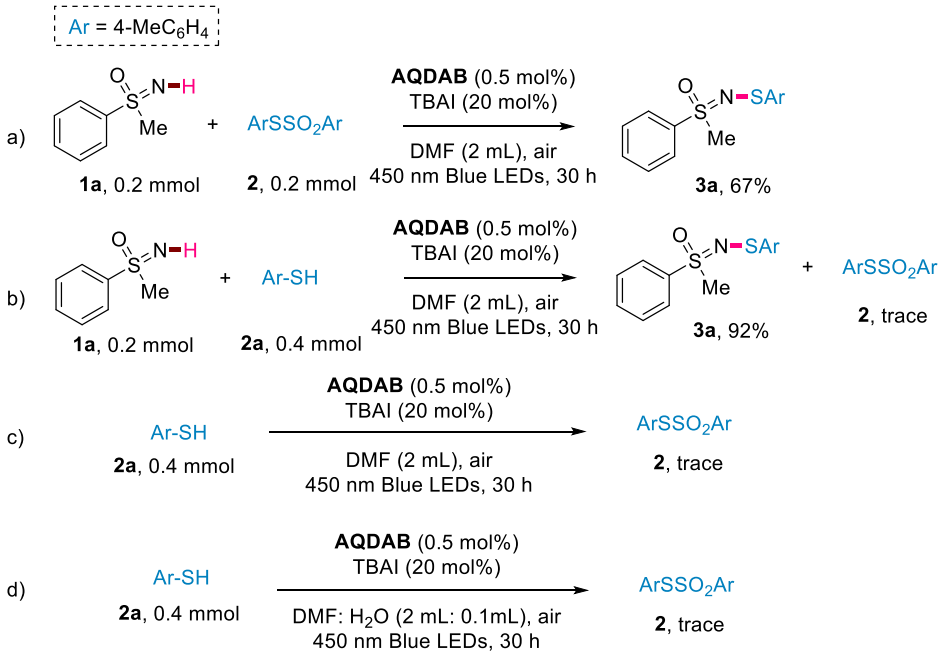
9. Mechanism Study on N-sulfenylation of NH-sulfoximines using thiosulfonate



Entry	Deviation from 'standard' conditions	Yield (%)
1	**None**	**67%**
2	Without AQDAB	N.R.
3	Without TBAI	N.R.
4	Without light	N.R.

Scheme S4. Control Experiment for N-sulfenylation of NH-sulfoximines using thiosulfonate.

When thiosulfonate was used instead of thiol, the reaction proceeded smoothly and achieved a yield of 67%. In the absence of photocatalyst, iodine source or blue LEDs, no desired product was obtained (**Scheme S4** entries 2-4), indicating their essential role in N-sulfenylation during this transformation.

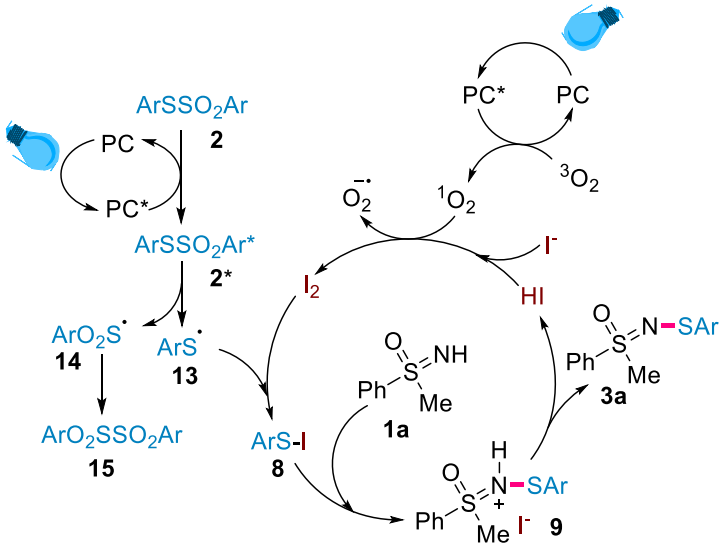


Scheme S5. Mechanistic studies for N-sulfenylation of NH-sulfoximines using thiosulfonate.

In order to further investigate the mechanism of thiosulfonate conversion in this reaction, we conducted control experiments (**Scheme S5**). Firstly, we substituted thiol with thiosulfonate under standard conditions and achieved a 67% yield of the desired product (Scheme S5a). However, we did not observe the formation of thiosulfonate in the reaction using thiol and sulfoximines (Scheme S5b). Similarly, when the reaction involved only thiol, we were unable to detect the formation of the oxidized product, thiosulfonate (Scheme S5cd). Based on these results, we propose a possible mechanism for this transformation.

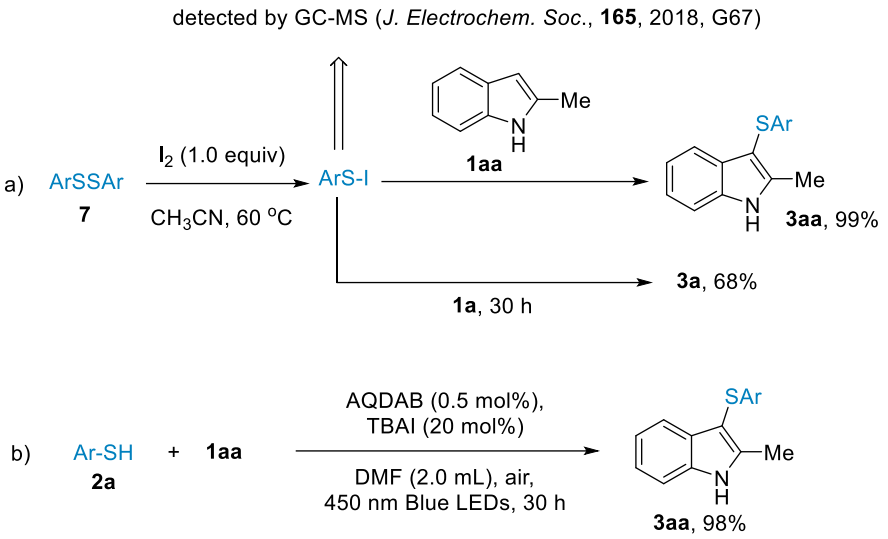
A possible reaction mechanism has been proposed (**Scheme S6**). Initially, the photocatalyst PC was excited by visible light. The excited state PC* was then quenched by triplet oxygen to generate singlet oxygen $^1O_2$. Subsequently, singlet oxygen $^1O_2$ oxidizes I^- to I_2 via a process of single electron transfer

(SET), resulting in the formation of the superoxide radical anion, $O_2^{\cdot-}$. In addition, PC was activated to excited state under the irradiation of blue LEDs and underwent energy transfer to thiosulfonate **2**. This process resulted in an excited **2***. The excited **2*** underwent homolytic cleavage to give thiol radicals **13** and sulfonyl radicals **14**. Thiol radicals **13** reacted with I_2 to generate active electrophilic species ArS-I **8**. Then,1a functioned as the nucleophile to attack ArS-I **8**, affording **9**, which underwent deprotonation to generate the desired product **3a**.



Scheme S6. A proposed mechanism for the N-sulfenylation of NH-sulfoximines using thiosulfonate.

10. Trapping experiment of ArS-I

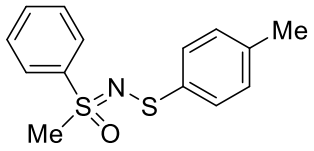


Scheme S7. Trapping experiment of ArS-I

In order to further confirm the existence of ArS-I intermediates, we designed and conducted several trapping experiments. According to the literature[6-8] by Chen group (*J. Electrochem. Soc.*, **165**, 2018, G67), ArS-I could be generated *in situ* from ArSSAr and I_2, which was detected by GC-MS analysis, when they explored the mechanism of sulfenylation of 2-methylindole **1aa** (Scheme S7a). Using the same method, to the mixture of **7** and I_2 at 60℃, 2-methylindole **1aa** and sulfoximine **1a** were added separately. 2-Methylindole was then sulfenylated to afford **3aa** in 99% yield, in line with the result reported by Chen group. In the meanwhile, **3a** was isolated in 68% yield. This implied these two reactions might involve the same ArS-I intermediate during the reaction process. Furthermore, **3aa** could also be successfully generated in 98% yield under the AQDAB/TBAI-catalyzed system (Scheme S7b). This also provided an indirect evidence for the involvement of ArS-I in the photoinduced transformation.

11. Characterization data of products

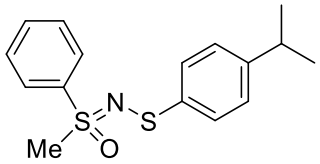
(3a) methyl(phenyl)((p-tolylthio)imino)-λ⁶-sulfanone (CAS: 2247600-31-1)[9]



methyl(phenyl)((*p*-tolylthio)imino)-λ⁶-sulfanone
Chemical Formula: $C_{14}H_{15}NOS_2$
Exact Mass: 277.0595
Molecular Weight: 277.4000

Following the General Procedure A with sulfoximine (31.0 mg, 0.2 mmol) and 4-toluenethiol (49.7 mg, 0.4 mmol), **3a** was obtained as a colorless oil (51.1 mg, 92%).
This target product was purified by column chromatography on silica gel (PE/EA = 3:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94 (d, J = 7.6 Hz, 2H), 7.64 (d, J = 7.2 Hz, 1H), 7.56 (t, J = 7.6 Hz, 2H), 7.31 (d, J = 8.0 Hz, 2H), 7.08 (d, J = 8.0 Hz, 2H), 3.25 (s, 3H), 2.29 (s, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 138.8, 138.2, 135.2, 133.6, 129.4, 129.3, 128.4, 125.0, 43.7, 21.0.

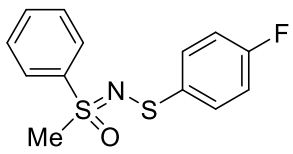
(3b) (((4-isopropylphenyl)thio)imino)(methyl)(phenyl)-λ⁶-sulfanone



(((4-isopropylphenyl)thio)imino)(methyl)(phenyl)-λ⁶-sulfanone
Chemical Formula: $C_{16}H_{19}NOS_2$
Exact Mass: 305.0908
Molecular Weight: 305.4540

Following the General Procedure A with sulfoximine (31.0 mg, 0.2 mmol) and 4-isopropylbenzenethiol (60.9 mg, 0.4 mmol), **3b** was obtained as a colorless oil (47.0 mg, 78%).
This target product was purified by column chromatography on silica gel (PE/EA = 3:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.93 (d, J = 8.0 Hz, 2H), 7.62 (d, J = 6.4 Hz, 1H), 7.54 (t, J = 6.8 Hz, 2H), 7.33 (d, J = 7.2 Hz, 2H), 7.12 (d, J = 7.6 Hz, 2H), 3.24 (s, 3H), 2.89 – 2.80 (m, 1H), 1.22 (s, 3H), 1.20 (s, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 146.4, 138.9, 138.6, 133.6, 129.5, 128.5, 126.7, 125.0, 43.8, 33.7, 24.0, 24.0.
IR (cm^{-1}): 3060, 3018, 2961, 2926, 2870, 1595, 1493, 1447, 1406, 1213, 1092, 982, 822, 743, 687, 525
HRMS (APCI) m/z calcd for $C_{16}H_{20}NOS_2^+$ $(M+H)^+$ 306.0981, found 306.0980.

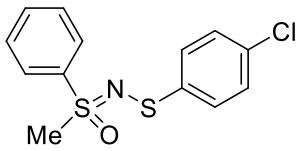
(3c) (((4-fluorophenyl)thio)imino)(methyl)(phenyl)-λ⁶-sulfanone (CAS: 2247600-33-3)[10]



(((4-fluorophenyl)thio)imino)(methyl)(phenyl)-λ⁶-sulfanone
Chemical Formula: $C_{13}H_{12}FNOS_2$
Exact Mass: 281.0344
Molecular Weight: 281.3634

Following the General Procedure A with sulfoximine (31.0 mg, 0.2 mmol) and 4-fluorobenzenethiol (50.5 mg, 0.4 mmol), **3c** was obtained as a colorless oil (50.6 mg, 90%).
This target product was purified by column chromatography on silica gel (PE/EA = 3:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92 (d, J = 8.0 Hz, 2H), 7.65 (t, J = 7.2 Hz, 1H), 7.57 (t, J = 8.0 Hz, 2H), 7.43 – 7.34 (m, 2H), 6.96 (t, J = 8.8 Hz, 2H), 3.26 (s, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 161.3 (d, J = 244.4 Hz), 138.6, 136.9 (d, J = 3.0 Hz), 133.8, 129.6, 128.4, 127.0 (d, J = 7.9 Hz), 115.6 (d, J = 22.1 Hz), 43.9.
^{19}F NMR (376 MHz, $CDCl_3$) δ -117.31.

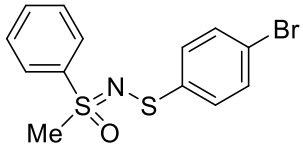
(3d) (((4-chlorophenyl)thio)imino)(methyl)(phenyl)-λ⁶-sulfanone (CAS: 2247600-32-2)[10]



(((4-chlorophenyl)thio)imino)(methyl)(phenyl)-λ^6-sulfanone
Chemical Formula: $C_{13}H_{12}ClNOS_2$
Exact Mass: 297.0049
Molecular Weight: 297.8150

Following the General Procedure A with sulfoximine (31.0 mg, 0.2 mmol) and 4-chlorobenzenethiol (57.8 mg, 0.4 mmol), **3d** was obtained as a colorless oil (53.4 mg, 90%). This target product was purified by column chromatography on silica gel (PE/EA = 3:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92 (d, J = 7.6 Hz, 2H), 7.66 (t, J = 7.2 Hz, 1H), 7.57 (t, J = 7.6 Hz, 2H), 7.31 (d, J = 8.4 Hz, 2H), 7.21 (d, J = 8.4 Hz, 2H), 3.27 (s, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 141.0, 138.5, 133.9, 130.6, 129.6, 128.5, 128.4, 125.1, 43.8.

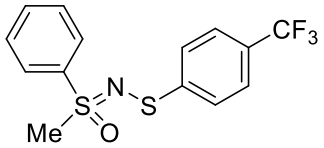
(3e) (((4-bromophenyl)thio)imino)(methyl)(phenyl)-λ⁶-sulfanone (CAS: 2762998-29-6)[9]



(((4-bromophenyl)thio)imino)(methyl)(phenyl)-λ^6-sulfanone
Chemical Formula: $C_{13}H_{12}BrNOS_2$
Exact Mass: 340.9544
Molecular Weight: 342.2690

Following the General Procedure A with sulfoximine (31.0 mg, 0.2 mmol) and 4-bromobenzenethiol (74.8 mg, 0.4 mmol), **3e** was obtained as a colorless oil (65.6 mg, 96%). This target product was purified by column chromatography on silica gel (PE/EA = 3:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92 (d, J = 7.2 Hz, 2H), 7.66 (t, J = 7.6 Hz, 1H), 7.57 (t, J = 8.0 Hz, 2H), 7.31 (d, J = 8.4 Hz, 2H), 7.21 (d, J = 8.4 Hz, 2H), 3.27 (s, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 141.8, 138.5, 133.9, 131.4, 129.6, 128.4, 125.3, 118.4, 43.9.

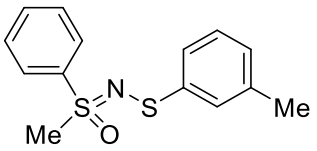
(3f) methyl(phenyl)(((4-(trifluoromethyl)phenyl)thio)imino)-λ⁶-sulfanone (CAS: 2762998-27-4)[9]



methyl(phenyl)(((4-(trifluoromethyl)phenyl)thio)imino)-λ^6-sulfanone
Chemical Formula: $C_{14}H_{12}F_3NOS_2$
Exact Mass: 331.0312
Molecular Weight: 331.3712

Following the General Procedure A with sulfoximine (31.0 mg, 0.2 mmol) and 4-(trifluoromethyl)benzenethiol (71.3 mg, 0.4 mmol), **3f** was obtained as a colorless oil (55.6 mg, 84%). This target product was purified by column chromatography on silica gel (PE/EA = 3:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94 (d, J = 8.0 Hz, 2H), 7.68 (t, J = 7.6 Hz, 1H), 7.60 (t, J = 7.6 Hz, 2H), 7.47 (q, J = 8.8 Hz, 4H), 3.31 (s, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 148.1, 138.3, 134.0, 129.7, 128.4, 126.6 (q, J = 32.4 Hz), 125.3 (q, J = 3.8 Hz), 124.4 (q, J = 271.3 Hz), 122.5, 44.0.
^{19}F NMR (376 MHz, $CDCl_3$) δ -62.10.

(3g) methyl(phenyl)((m-tolylthio)imino)-λ⁶-sulfanone (CAS: 2247600-37-7)[10]

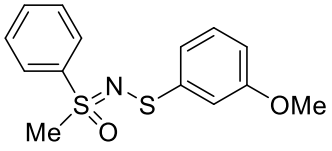


methyl(phenyl)((*m*-tolylthio)imino)-λ^6-sulfanone
Chemical Formula: $C_{14}H_{15}NOS_2$
Exact Mass: 277.0595
Molecular Weight: 277.4000

Following the General Procedure A with sulfoximine (31.0 mg, 0.2 mmol) and 3-methylbenzenethiol (49.7 mg, 0.4 mmol), **3g** was obtained as a colorless oil (46.7 mg, 84%). This target product was purified by column chromatography on silica gel (PE/EA = 3:1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94 (d, J = 7.6 Hz, 2H), 7.64 (t, J = 7.6 Hz, 1H), 7.56 (t, J = 7.6 Hz, 2H), 7.23 – 7.11 (m, 3H), 6.89 (d, J = 7.2 Hz, 1H), 3.26 (s, 3H), 2.30 (s, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 141.9, 138.8, 138.2, 133.7, 129.5, 128.4, 128.4, 126.1, 124.4, 121.1, 43.8, 21.5.

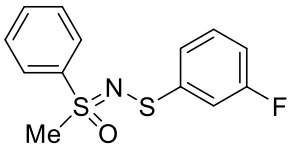
(3h) (((3-methoxyphenyl)thio)imino)(methyl)(phenyl)-λ^6-sulfanone



(((3-methoxyphenyl)thio)imino)(methyl)(phenyl)-λ^6-sulfanone
Chemical Formula: $C_{14}H_{15}NO_2S_2$
Exact Mass: 293.0544
Molecular Weight: 293.3990

Following the General Procedure A with sulfoximine (31.0 mg, 0.2 mmol) and 3-methoxybenzenethiol (56.1 mg, 0.4 mmol), **3h** was obtained as a colorless oil (43.4 mg, 74%).
This target product was purified by column chromatography on silica gel (PE/EA = 3:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.95 (d, J = 8.0 Hz, 2H), 7.68 – 7.62 (m, 1H), 7.61 – 7.53 (m, 2H), 7.22 – 7.13 (m, 1H), 7.00 (s, 1H), 6.94 (d, J = 8.0 Hz, 1H), 6.63 (d, J = 8.0 Hz, 1H), 3.78 (s, 3H), 3.27 (s, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 159.9, 143.8, 138.7, 133.8, 129.5, 129.4, 128.4, 115.9, 111.1, 108.9, 55.2, 43.7.
IR (cm^{-1}): 3298, 3063, 3005, 2928, 2835, 1576, 1474, 1281, 1217, 1092, 984, 858, 744, 685, 525.
HRMS (APCI) m/z calcd for $C_{14}H_{16}NO_2S_2^+$ $(M+H)^+$ 294.0617, found 294.0611.

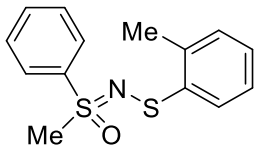
(3i) (((3-fluorophenyl)thio)imino)(methyl)(phenyl)-λ^6-sulfanone



(((3-fluorophenyl)thio)imino)(methyl)(phenyl)-λ^6-sulfanone
Chemical Formula: $C_{13}H_{12}FNOS_2$
Exact Mass: 281.0344
Molecular Weight: 281.3634

Following the General Procedure A with sulfoximine (31.0 mg, 0.2 mmol) and 3-fluorobenzenethiol (51.3 mg, 0.4 mmol), **3i** was obtained as a colorless oil (47.3 mg, 84%).
This target product was purified by column chromatography on silica gel (PE/EA = 3:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.95 (d, J = 8.4 Hz, 2H), 7.67 (t, J = 6.4 Hz, 1H), 7.59 (t, J = 7.2 Hz, 2H), 7.21 – 7.12 (m, 2H), 7.08 (d, J = 8.0 Hz, 1H), 6.76 – 6.67 (m, 1H), 3.30 (s, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 163.1 (d, J = 247.1 Hz), 145.3 (d, J = 7.5 Hz), 138.5, 133.9, 129.7 (d, J = 8.5 Hz), 129.6, 128.4, 118.6 (d, J = 2.8 Hz), 111.7 (d, J = 21.6 Hz), 110.3 (d, J = 24.6 Hz), 43.9.
^{19}F NMR (376 MHz, $CDCl_3$) δ -112.66.
IR (cm^{-1}): 3065, 3017, 2926, 1597, 1470, 1207, 1092, 983, 879, 777, 743, 679, 525.
HRMS (APCI) m/z calcd for $C_{13}H_{13}FNOS_2^+$ $(M+H)^+$ 282.0417, found 282.0413.

(3j) methyl(phenyl)((o-tolylthio)imino)-λ^6-sulfanone (CAS: 2247600-34-4)[10]

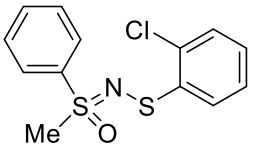


methyl(phenyl)((*o*-tolylthio)imino)-λ^6-sulfanone
Chemical Formula: $C_{14}H_{15}NOS_2$
Exact Mass: 277.0595
Molecular Weight: 277.4000

Following the General Procedure A with sulfoximine (31.0 mg, 0.2 mmol) and 2-methylbenzenethiol (49.7 mg, 0.4 mmol), **3j** was obtained as a colorless oil (37.2 mg, 67%).
This target product was purified by column chromatography on silica gel (PE/EA = 3:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.96 (d, J = 7.6 Hz, 2H), 7.64 (t, J = 8.0 Hz, 2H), 7.56 (t, J = 8.0 Hz, 2H), 7.23 –

7.16 (m, 1H), 7.04 – 6.91 (m, 2H), 3.27 (s, 3H), 2.15 (s, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 140.8, 138.9, 133.7, 132.2, 129.5, 129.5, 128.4, 126.3, 124.5, 123.3, 43.8, 18.8.

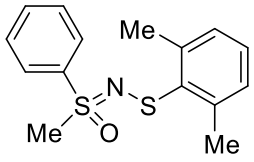
(3k) (((2-chlorophenyl)thio)imino)(methyl)(phenyl)-λ^6-sulfanone (CAS: 2762998-28-5)[9]



(((2-chlorophenyl)thio)imino)(methyl)(phenyl)-λ^6-sulfanone
Chemical Formula: $C_{13}H_{12}ClNOS_2$
Exact Mass: 297.0049
Molecular Weight: 297.8150

Following the General Procedure A with sulfoximine (31.0 mg, 0.2 mmol) and 2-chlorobenzenethiol (57.8 mg, 0.4 mmol), **3k** was obtained as a colorless oil (44.4 mg, 75%). This target product was purified by column chromatography on silica gel (PE/EA = 3:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.96 (d, J = 8.6 Hz, 2H), 7.68 (dd, J = 16.3, 7.7 Hz, 2H), 7.59 (t, J = 7.6 Hz, 2H), 7.26 (t, J = 7.6 Hz, 1H), 7.18 (d, J = 7.9 Hz, 1H), 7.00 (t, J = 7.6 Hz, 1H), 3.31 (s, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 141.4, 138.6, 133.9, 129.7, 128.7, 128.4, 127.0, 126.9, 125.2, 124.1, 44.0.

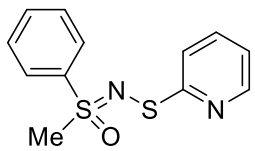
(3l) (((2,6-dimethylphenyl)thio)imino)(methyl)(phenyl)-λ^6-sulfanone



(((2,6-dimethylphenyl)thio)imino)(methyl)(phenyl)-λ^6-sulfanone
Chemical Formula: $C_{15}H_{17}NOS_2$
Exact Mass: 291.0752
Molecular Weight: 291.4270

Following the General Procedure A with sulfoximine (31.0 mg, 0.2 mmol) and 2,6-dimethylbenzenethiol (55.3 mg, 0.4 mmol), **3l** was obtained as a colorless oil (37.3 mg, 64%).
This target product was purified by column chromatography on silica gel (PE/EA = 3:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.69 (d, J = 7.6 Hz, 2H), 7.54 (t, J = 7.6 Hz, 1H), 7.39 (t, J = 8.0 Hz, 2H), 7.06 – 7.00 (m, 1H), 6.94 (d, J = 7.6 Hz, 2H), 3.09 (s, 3H), 2.43 (s, 6H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 141.8, 139.1, 137.6, 133.2, 129.1, 128.7, 128.6, 127.8, 44.2, 21.6.
IR (cm^{-1}): 3057, 3011, 2928, 1580, 1447, 1202, 1090, 989, 771, 746, 689, 523.
HRMS (APCI) m/z calcd for $C_{15}H_{18}NOS_2^+$ $(M+H)^+$ 292.0824, found 292.0816.

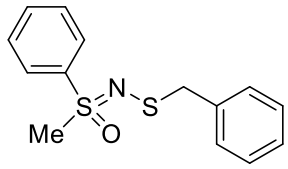
(3m) methyl(phenyl)((pyridin-2-ylthio)imino)- λ^6-sulfanone (CAS: 2762998-30-9)[9]



methyl(phenyl)((pyridin-2-ylthio)imino)-λ^6-sulfanone
Chemical Formula: $C_{12}H_{12}N_2OS_2$
Exact Mass: 264.0391
Molecular Weight: 264.3610

Following the General Procedure A with sulfoximine (31.0 mg, 0.2 mmol) and 2-pyridinethione (44.5 mg, 0.4 mmol), **3m** was obtained as a colorless oil (33.8 mg, 64%).
This target product was purified by column chromatography on silica gel (PE/EA = 3:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.39 – 8.31 (m, 1H), 8.04 – 7.94 (m, 2H), 7.70 – 7.56 (m, 5H), 6.98 – 6.89 (m, 1H), 3.35 (s, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 165.8, 148.6, 138.4, 136.6, 133.9, 129.6, 128.5, 119.1, 117.9, 43.8.

(3n) ((benzylthio)imino)(methyl)(phenyl)- λ⁶-sulfanone (CAS: 2762998-33-2)[9]



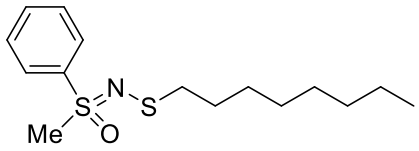
((benzylthio)imino)(methyl)(phenyl)-λ⁶-sulfanone
Chemical Formula: $C_{14}H_{15}NOS_2$
Exact Mass: 277.0595
Molecular Weight: 277.4000

Following the General Procedure A with sulfoximine (31.0 mg, 0.2 mmol) and benzyl mercaptan (49.7 mg, 0.4 mmol), **3n** was obtained as a colorless oil (22.7 mg, 41%). This target product was purified by column chromatography on silica gel (PE/EA = 3:1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92 – 7.85 (m, 2H), 7.67 – 7.61 (m, 1H), 7.59 – 7.53 (m, 2H), 7.37 – 7.32 (m, 2H), 7.31 – 7.25 (m, 2H), 7.24 – 7.19 (m, 1H), 4.16 – 4.02 (m, 2H), 3.09 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 139.2, 136.8, 133.5, 129.5, 129.4, 128.5, 128.4, 127.1, 45.9, 43.4.

(3o) methyl((octylthio)imino)(phenyl)- λ⁶-sulfanone



methyl((octylthio)imino)(phenyl)-λ⁶-sulfanone
Chemical Formula: $C_{15}H_{25}NOS_2$
Exact Mass: 299.1378
Molecular Weight: 299.4910

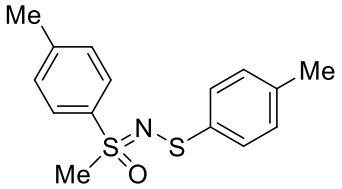
Following the General Procedure A with sulfoximine (31.0 mg, 0.2 mmol) and 1-mercaptooctane (58.5 mg, 0.4 mmol), **3o** was obtained as a colorless oil (18.5 mg, 31%).

This target product was purified by column chromatography on silica gel (PE/EA = 3:1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.99 – 7.85 (m, 2H), 7.68 – 7.62 (m, 1H), 7.62 – 7.54 (m, 2H), 3.19 (s, 3H), 2.91 – 2.72 (m, 2H), 1.68 (t, J = 7.6 Hz, 2H), 1.41 – 1.34 (m, 2H), 1.31 – 1.23 (m, 8H), 0.89 – 0.85 (m, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 139.3, 133.4, 129.4, 128.5, 43.9, 41.1, 31.8, 29.2, 29.2, 28.8, 27.8, 22.7, 14.1.

(3p) methyl(p-tolyl)((p-tolylthio)imino)-λ⁶-sulfanone



methyl(*p*-tolyl)((*p*-tolylthio)imino)-λ⁶-sulfanone
Chemical Formula: $C_{15}H_{17}NOS_2$
Exact Mass: 291.0752
Molecular Weight: 291.4270

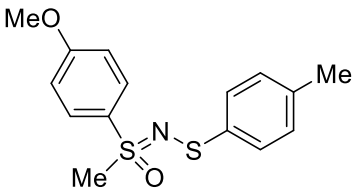
Following the General Procedure A with imino(methyl)(p-tolyl)-λ⁶-sulfanone (33.8 mg, 0.2 mmol) and 4-toluenethiol (49.7 mg, 0.4 mmol), **3p** was obtained as a colorless oil (50.7 mg, 87%).

This target product was purified by column chromatography on silica gel (PE/EA = 3:1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.81 (d, J = 8.0 Hz, 2H), 7.35 (d, J = 8.4 Hz, 2H), 7.31 (d, J = 8.0 Hz, 2H), 7.07 (d, J = 8.0 Hz, 2H), 3.22 (s, 3H), 2.44 (s, 3H), 2.29 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.7, 138.5, 135.7, 135.1, 130.2, 129.3, 128.5, 124.8, 43.9, 21.6, 21.0.
IR (cm^{-1}): 3306, 3020, 2922, 1917, 1597, 1489, 1448, 1398, 1315, 1204, 1090, 980, 806, 752, 528.
HRMS (APCI) m/z calcd for $C_{15}H_{17}NOS_2Na^+$ $(M+Na)^+$ 314.0644, found 314.0635.

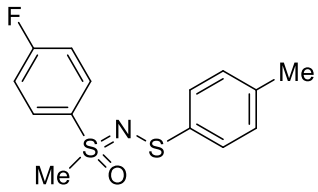
(3q) (4-methoxyphenyl)(methyl)((p-tolylthio)imino)-λ⁶-sulfanone



(4-methoxyphenyl)(methyl)((*p*-tolylthio)imino)-λ^6-sulfanone
Chemical Formula: $C_{15}H_{17}NO_2S_2$
Exact Mass: 307.0701
Molecular Weight: 307.4260

Following the General Procedure A with imino(4-methoxyphenyl)(methyl)-λ^6-sulfanone (37.0 mg, 0.2 mmol) and 4-toluenethiol (49.7 mg, 0.4 mmol), **3q** was obtained as a colorless oil (48.3 mg, 79%).
This target product was purified by column chromatography on silica gel (PE/EA = 3:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.85 (d, J = 6.8 Hz, 2H), 7.31 (d, J = 6.4 Hz, 2H), 7.07 (d, J = 7.2 Hz, 2H), 7.05 – 6.96 (m, 2H), 3.87 (s, 3H), 3.23 (s, 3H), 2.29 (s, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 163.7, 138.5, 135.0, 130.5, 129.7, 129.2, 124.7, 114.6, 55.7, 44.0, 20.9.
IR (cm^{-1}): 3308, 3013, 2924, 2575, 1900, 1593, 1491, 1406, 1310, 1258, 1094, 831, 764, 704, 522.
HRMS (APCI) m/z calcd for $C_{15}H_{17}NO_2S_2Na^+$ $(M+Na)^+$ 330.0593, found 330.0582.

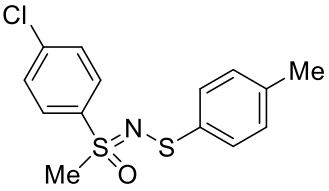
(3r) (4-fluorophenyl)(methyl)((p-tolylthio)imino)-λ^6-sulfanone



(4-fluorophenyl)(methyl)((*p*-tolylthio)imino)-λ^6-sulfanone
Chemical Formula: $C_{14}H_{14}FNOS_2$
Exact Mass: 295.0501
Molecular Weight: 295.3904

Following the General Procedure A with (4-fluorophenyl)(imino)(methyl)-λ^6-sulfanone (34.6 mg, 0.2 mmol) and 4-toluenethiol (49.7 mg, 0.4 mmol), **3r** was obtained as a colorless oil (53.9 mg, 91%).
This target product was purified by column chromatography on silica gel (PE/EA = 3:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97 – 7.89 (m, 2H), 7.29 (d, J = 8.0 Hz, 2H), 7.22 (t, J = 8.8 Hz, 2H), 7.08 (d, J = 7.6 Hz, 2H), 3.25 (s, 3H), 2.29 (s, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 165.8 (d, J = 256.4 Hz), 138.0, 135.5, 134.6 (d, J = 3.1 Hz), 131.3 (d, J = 9.6 Hz), 129.4, 125.2, 116.8 (d, J = 22.7 Hz), 43.9, 21.0.
^{19}F NMR (376 MHz, $CDCl_3$) δ -103.77.
IR (cm^{-1}): 3099, 3057, 3018, 2928, 1587, 1489, 1402, 1207, 1094, 991, 962, 847, 800, 714, 532, 482.
HRMS (APCI) m/z calcd for $C_{14}H_{15}FNOS_2^+$ $(M+H)^+$ 296.0574, found 296.0568.

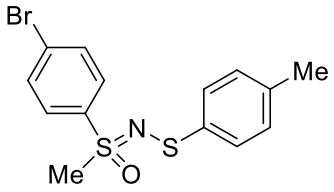
(3s) (4-chlorophenyl)(methyl)((p-tolylthio)imino)-λ^6-sulfanone



(4-chlorophenyl)(methyl)((*p*-tolylthio)imino)-λ^6-sulfanone
Chemical Formula: $C_{14}H_{14}ClNOS_2$
Exact Mass: 311.0205
Molecular Weight: 311.8420

Following the General Procedure A with (4-chlorophenyl)(imino)(methyl)-λ^6-sulfanone (37.9 mg, 0.2 mmol) and 4-toluenethiol (49.7 mg, 0.4 mmol), **3s** was obtained as a colorless oil (53.7 mg, 86%).
This target product was purified by column chromatography on silica gel (PE/EA = 3:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.85 (d, J = 8.8 Hz, 2H), 7.52 (d, J = 8.8 Hz, 2H), 7.29 (d, J = 8.0 Hz, 2H), 7.08 (d, J = 8.0 Hz, 2H), 3.24 (s, 3H), 2.29 (s, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 140.5, 137.9, 137.3, 135.6, 130.0, 129.8, 129.4, 125.3, 43.8, 21.0.
IR (cm^{-1}): 3076, 3017, 2920, 1572, 1489, 1396, 1215, 1086, 945, 802, 775, 525.
HRMS (APCI) m/z calcd for $C_{14}H_{15}ClNOS_2^+$ $(M+H)^+$ 312.0278, found 312.0283.

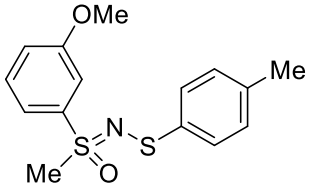
(3t) (4-bromophenyl)(methyl)((p-tolylthio)imino)-λ⁶-sulfanone



(4-bromophenyl)(methyl)((*p*-tolylthio)imino)-λ⁶-sulfanone
Chemical Formula: $C_{14}H_{14}BrNOS_2$
Exact Mass: 354.9700
Molecular Weight: 356.2960

Following the General Procedure A with (4-bromophenyl)(imino)(methyl)-λ⁶-sulfanone (46.8 mg, 0.2 mmol) and 4-toluenethiol (49.7 mg, 0.4 mmol), **3t** was obtained as a colorless oil (64.2 mg, 90%).
This target product was purified by column chromatography on silica gel (PE/EA = 3:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, J = 8.8 Hz, 2H), 7.68 (d, J = 8.8 Hz, 2H), 7.28 (d, J = 8.0 Hz, 2H), 7.08 (d, J = 8.0 Hz, 2H), 3.24 (s, 3H), 2.29 (s, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 137.9, 135.6, 132.8, 130.1, 129.4, 129.0, 125.3, 43.8, 21.1.
IR (cm^{-1}): 3298, 3082, 3015, 2922, 2864, 1570, 1489, 1387, 1209, 1090, 982, 804, 766, 519.
HRMS (APCI) m/z calcd for $C_{14}H_{15}BrNOS_2^+$ $(M+H)^+$ 355.9773, found 355.9766.

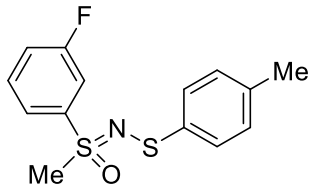
(3u) (3-methoxyphenyl)(methyl)((p-tolylthio)imino)-λ⁶-sulfanone



(3-methoxyphenyl)(methyl)((*p*-tolylthio)imino)-λ⁶-sulfanone
Chemical Formula: $C_{15}H_{17}NO_2S_2$
Exact Mass: 307.0701
Molecular Weight: 307.4260

Following the General Procedure A with imino(3-methoxyphenyl)(methyl)-λ⁶-sulfanone (37.0 mg, 0.2 mmol) and 4-toluenethiol (49.7 mg, 0.4 mmol), **3u** was obtained as a colorless oil (51.1 mg, 83%).
This target product was purified by column chromatography on silica gel (PE/EA = 3:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.52 – 7.44 (m, 2H), 7.40 (s, 1H), 7.31 (d, J = 6.8 Hz, 2H), 7.15 (d, J = 8.0 Hz, 1H), 7.07 (d, J = 7.2 Hz, 2H), 3.82 (s, 3H), 3.24 (s, 3H), 2.29 (s, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 160.1, 139.9, 138.2, 135.2, 130.4, 129.2, 125.0, 120.5, 120.2, 112.7, 55.6, 43.8, 20.9.
IR (cm^{-1}): 3437, 3308, 3013, 2922, 1894, 1597, 1483, 1321, 1086, 852, 710, 530.
HRMS (APCI) m/z calcd for $C_{15}H_{17}NO_2S_2Na^+$ $(M+Na)^+$ 330.0593, found 330.0582.

(3v) (3-fluorophenyl)(methyl)((p-tolylthio)imino)-λ⁶-sulfanone

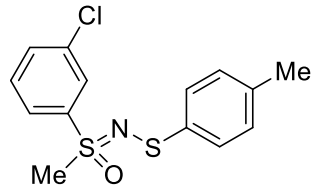


(3-fluorophenyl)(methyl)((*p*-tolylthio)imino)-λ⁶-sulfanone
Chemical Formula: $C_{14}H_{14}FNOS_2$
Exact Mass: 295.0501
Molecular Weight: 295.3904

Following the General Procedure A with (3-fluorophenyl)(imino)(methyl)-λ⁶-sulfanone (34.6 mg, 0.2 mmol) and 4-toluenethiol (49.7 mg, 0.4 mmol), **3v** was obtained as a colorless oil (49.7 mg, 84%).
This target product was purified by column chromatography on silica gel (PE/EA = 3:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72 (d, J = 8.0 Hz, 1H), 7.64 (d, J = 7.6 Hz, 1H), 7.58 – 7.50 (m, 1H), 7.37 – 7.33 (m, 1H), 7.30 (d, J = 8.4 Hz, 2H), 7.09 (d, J = 8.0 Hz, 2H), 3.26 (s, 3H), 2.30 (s, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 162.7 (d, J = 252.8 Hz), 141.1 (d, J = 6.5 Hz), 137.8, 135.7, 131.2 (d, J = 7.6 Hz), 129.4, 125.4, 124.2 (d, J = 3.4 Hz), 116.0 (d, J = 24.5 Hz), 43.8, 21.0.
^{19}F NMR (376 MHz, $CDCl_3$) δ -108.83.
IR (cm^{-1}): 3298, 3072, 3018, 2924, 1593, 1477, 1431, 1223, 1082, 991, 878, 804, 766, 677, 527.

HRMS (APCI) m/z calcd for $C^{14}H^{15}FNOS_2^+$ $(M+H)^+$ 296.0574, found 296.0566.

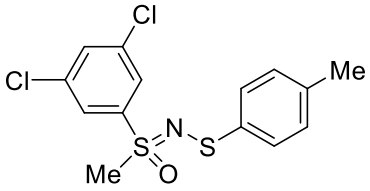
(3w) (3-chlorophenyl)(methyl)((p-tolylthio)imino)-λ⁶-sulfanone



(3-chlorophenyl)(methyl)((*p*-tolylthio)imino)-λ⁶-sulfanone
Chemical Formula: $C_{14}H_{14}ClNOS_2$
Exact Mass: 311.0205
Molecular Weight: 311.8420

Following the General Procedure A with (3-chlorophenyl)(imino)(methyl)-λ⁶-sulfanone (37.9 mg, 0.2 mmol) and 4-toluenethiol (49.7 mg, 0.4 mmol), **3w** was obtained as a colorless oil (51.1 mg, 82%).
This target product was purified by column chromatography on silica gel (PE/EA = 3:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92 – 7.87 (m, 1H), 7.80 (d, J = 7.6 Hz, 1H), 7.60 (d, J = 6.8 Hz, 1H), 7.49 (t, J = 8.0 Hz, 1H), 7.29 (d, J = 8.4 Hz, 2H), 7.08 (d, J = 8.0 Hz, 2H), 3.25 (s, 3H), 2.29 (s, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 140.7, 137.7, 135.7, 135.7, 133.8, 130.7, 129.4, 128.6, 126.6, 125.6, 43.8, 21.1.
IR (cm^{-1}): 3298, 3065, 3017, 2922, 2864, 1701, 1576, 1489, 1466, 1406, 1317, 1217, 1119, 986, 783, 675, 517.
HRMS (APCI) m/z calcd for $C_{14}H_{15}ClNOS_2^+$ $(M+H)^+$ 312.0278, found 312.0270.

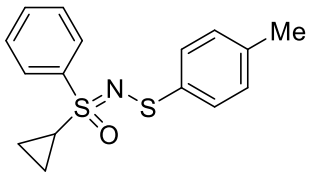
(3x) (3,5-dichlorophenyl)(methyl)((p-tolylthio)imino)-λ⁶-sulfanone



(3,5-dichlorophenyl)(methyl)((*p*-tolylthio)imino)-λ⁶-sulfanone
Chemical Formula: $C_{14}H_{13}Cl_2NOS_2$
Exact Mass: 344.9816
Molecular Weight: 346.2840

Following the General Procedure A with (3,5-dichlorophenyl)(imino)(methyl)-λ⁶-sulfanone (44.8 mg, 0.2 mmol) and 4-toluenethiol (49.7 mg, 0.4 mmol), **3x** was obtained as a colorless oil (53.4 mg, 77%).
This target product was purified by column chromatography on silica gel (PE/EA = 3:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 – 7.72 (m, 2H), 7.58 (s, 1H), 7.28 (d, J = 8.0 Hz, 2H), 7.08 (d, J = 8.0 Hz, 2H), 3.25 (s, 3H), 2.30 (s, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 142.0, 137.1, 136.4, 136.2, 133.6, 129.4, 127.0, 126.2, 43.8, 21.1.
IR (cm^{-1}): 3300, 3074, 3018, 2922, 1568, 1491, 1416, 1217, 1142, 1096, 1003, 868, 802, 702, 665, 513.
HRMS (APCI) m/z calcd for $C_{14}H_{14}Cl_2NOS_2^+$ $(M+H)^+$ 345.9888, found 345.9889.

(3y) cyclopropyl(phenyl)((p-tolylthio)imino)-λ⁶-sulfanone

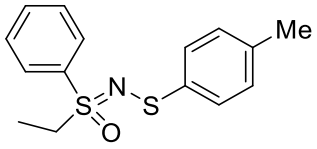


cyclopropyl(phenyl)((*p*-tolylthio)imino)-λ⁶-sulfanone
Chemical Formula: $C_{16}H_{17}NOS_2$
Exact Mass: 303.0752
Molecular Weight: 303.4380

Following the General Procedure A with cyclopropyl(imino)(phenyl)-λ⁶-sulfanone (36.3 mg, 0.2 mmol) and 4-toluenethiol (49.7 mg, 0.4 mmol), **3y** was obtained as a colorless oil (47.8 mg, 79%).
This target product was purified by column chromatography on silica gel (PE/EA = 3:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.88 (d, J = 8.0 Hz, 2H), 7.61 (d, J = 8.0 Hz, 1H), 7.54 (t, J = 7.2 Hz, 2H), 7.28 (d, J = 6.8 Hz, 2H), 7.06 (d, J = 7.6 Hz, 2H), 2.71 – 2.59 (m, 1H), 2.28 (s, 3H), 1.70 – 1.60 (m, 1H), 1.23 – 1.09 (m, 2H), 0.97 – 0.85 (m, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 139.2, 138.8, 135.0, 1333, 129.3, 129.2, 128.5, 124.8, 33.0, 21.0, 7.0, 5.6.
IR (cm^{-1}): 3057, 30315, 2920, 1489, 1445, 1215, 1186, 1094, 982, 885, 806, 735, 689, 533.
HRMS (APCI) m/z calcd for $C_{16}H_{18}NOS_2^+$ $(M+H)^+$ 304.0824, found 304.0819.

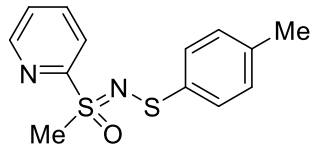
(3z) ethyl(phenyl)((p-tolylthio)imino)-λ^6-sulfanone



ethyl(phenyl)((*p*-tolylthio)imino)-λ^6-sulfanone
Chemical Formula: $C_{15}H_{17}NOS_2$
Exact Mass: 291.0752
Molecular Weight: 291.4270

Following the General Procedure A with ethyl(imino)(phenyl)-λ^6-sulfanone (33.8 mg, 0.2 mmol) and 4-toluenethiol (49.7 mg, 0.4 mmol), **3z** was obtained as a colorless oil (48.4 mg, 83%). This target product was purified by column chromatography on silica gel (PE/EA = 3:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.88 (d, J = 7.2 Hz, 2H), 7.64 (t, J = 7.6 Hz, 1H), 7.55 (t, J = 8.0 Hz, 2H), 7.31 (d, J = 8.0 Hz, 2H), 7.07 (d, J = 8.0 Hz, 2H), 3.52 – 3.40 (m, 1H), 3.39 – 3.27 (m, 1H), 2.28 (s, 3H), 1.27 (t, J = 7.6 Hz, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 138.7, 136.8, 135.1, 133.6, 129.4, 129.3, 128.6, 124.9, 50.2, 21.0, 7.8.
IR (cm^{-1}): 3059, 2976, 2937, 2872, 1491, 1447, 1204, 1094, 970, 804, 731, 689, 544.
HRMS (APCI) m/z calcd for $C_{15}H_{17}NOS_2Na^+$ $(M+Na)^+$ 314.0644, found 314.0635.

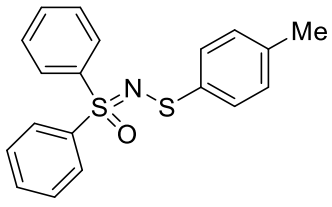
(3za) methyl(pyridin-2-yl)((p-tolylthio)imino)-λ^6-sulfanone



methyl(pyridin-2-yl)((*p*-tolylthio)imino)-λ^6-sulfanone
Chemical Formula: $C_{13}H_{14}N_2OS_2$
Exact Mass: 278.0548
Molecular Weight: 278.3880

Following the General Procedure A with imino(methyl)(pyridin-2-yl)-λ^6-sulfanone (31.2 mg, 0.2 mmol) and 4-toluenethiol (49.7 mg, 0.4 mmol), **3za** was obtained as a colorless oil (34.3 mg, 62%). This target product was purified by column chromatography on silica gel (PE/EA = 3:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.67 (d, J = 4.4 Hz, 1H), 8.15 (d, J = 7.6 Hz, 1H), 7.90 (t, J = 7.6 Hz, 1H), 7.51 – 7.43 (m, 1H), 7.20 (d, J = 8.0 Hz, 2H), 7.02 (d, J = 8.0 Hz, 2H), 3.45 (s, 3H), 2.26 (s, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 156.9, 150.1, 138.0, 137.8, 135.0, 129.2, 127.1, 124.5, 123.7, 39.5, 21.0.
IR (cm^{-1}): 3294, 3015, 2924, 2866, 1578, 1489, 1425, 1312, 1213, 1084, 989, 804, 758, 689, 615, 523.
HRMS (APCI) m/z calcd for $C_{13}H_{14}N_2OS_2Na^+$ $(M+Na)^+$ 301.0440, found 301.0430.

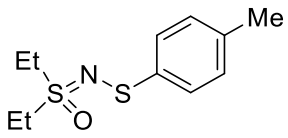
(3zb) diphenyl((p-tolylthio)imino)-λ^6-sulfanone (CAS: 91378-34-6)[11]



diphenyl((*p*-tolylthio)imino)-λ^6-sulfanone
Chemical Formula: $C_{19}H_{17}NOS_2$
Exact Mass: 339.0752
Molecular Weight: 339.4710

Following the General Procedure A with iminodiphenyl-λ^6-sulfanone (43.5 mg, 0.2 mmol) and 4-toluenethiol (49.7 mg, 0.4 mmol), **3zb** was obtained as a colorless oil (52.7 mg, 78%). This target product was purified by column chromatography on silica gel (PE/EA = 3:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.00 (d, J = 7.6 Hz, 4H), 7.53 (d, J = 7.2 Hz, 2H), 7.48 (t, J = 7.6 Hz, 4H), 7.35 (d, J = 8.0 Hz, 2H), 7.06 (d, J = 8.0 Hz, 2H), 2.28 (s, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 140.1, 138.3, 135.2, 133.2, 129.3, 129.3, 128.5, 125.2, 21.1.

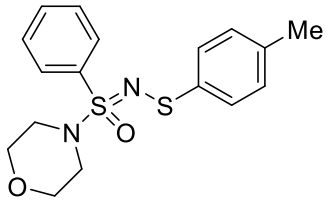
(3zc) diethyl((p-tolylthio)imino)-λ⁶-sulfanone



diethyl((*p*-tolylthio)imino)-λ^6-sulfanone
Chemical Formula: $C_{11}H_{17}NOS_2$
Exact Mass: 243.0752
Molecular Weight: 243.3830

Following the General Procedure A with diethyl(imino)-λ^6-sulfanone (24.2 mg, 0.2 mmol) and 4-toluenethiol (49.7 mg, 0.4 mmol), **3zc** was obtained as a colorless oil (36.5 mg, 75%).
This target product was purified by column chromatography on silica gel (PE/EA = 3:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.32 – 7.24 (m, 2H), 7.09 (d, J = 8.0 Hz, 2H), 3.36 – 3.09 (m, 4H), 2.29 (s, 3H), 1.40 (t, J = 7.2 Hz, 6H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 141.0, 138.5, 133.9, 130.6, 129.6, 128.5, 128.4, 125.1, 43.8.
IR (cm^{-1}): 3275, 2974, 2937, 1491, 1454, 1408, 1248, 1198, 1013, 806, 714, 490.
HRMS (APCI) m/z calcd for $C_{11}H_{17}NOS_2Na^+$ $(M+Na)^+$ 266.0644, found 266.0637.

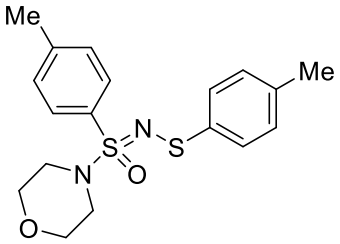
(3zd) N-(morpholino(oxo)(phenyl)-λ⁶-sulfaneylidene)-S-(p-tolyl)thiohydroxylamine



N-(morpholino(oxo)(phenyl)-λ^6-sulfaneylidene)-*S*-(*p*-tolyl)thiohydroxylamine
Chemical Formula: $C_{17}H_{20}N_2O_2S_2$
Exact Mass: 348.0966
Molecular Weight: 348.4790

Following the General Procedure A with 4-(phenylsulfonimidoyl)morpholine (45.2 mg, 0.2 mmol) and 4-toluenethiol (49.7 mg, 0.4 mmol), **3zd** was obtained as a colorless oil (55.4 mg, 80%).
This target product was purified by column chromatography on silica gel (PE/EA = 3:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.90 (d, J = 7.2 Hz, 2H), 7.65 – 7.58 (m, 1H), 7.57 – 7.50 (m, 2H), 7.37 (d, J = 8.0 Hz, 1H), 7.15 – 7.02 (m, 3H), 3.73 – 3.63 (m, 4H), 3.06 – 2.94 (m, 4H), 2.29 (s, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 137.7, 135.4, 134.7, 133.1, 129.4, 129.1, 128.1, 125.4, 66.1, 46.7, 21.1.
IR (cm^{-1}): 2963, 2916, 2854, 1489, 1445, 1242, 1111, 993, 926, 806, 739, 690, 577, 523.
HRMS (APCI) m/z calcd for $C_{17}H_{21}N_2O_2S_2^+$ $(M+H)^+$ 349.1039, found 349.1031.

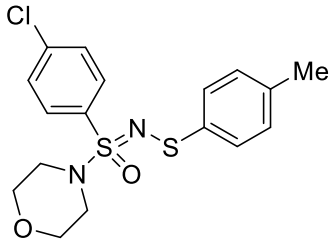
(3ze) N-(morpholino(oxo)(phenyl)-λ⁶-sulfaneylidene)-S-(p-tolyl)thiohydroxylamine



N-(morpholino(oxo)(*p*-tolyl)-λ^6-sulfaneylidene)-*S*-(*p*-tolyl)thiohydroxylamine
Chemical Formula: $C_{18}H_{22}N_2O_2S_2$
Exact Mass: 362.1123
Molecular Weight: 362.5060

Following the General Procedure A with 4-(4-methylphenylsulfonimidoyl)morpholine (48.1 mg, 0.2 mmol) and 4-toluenethiol (49.7 mg, 0.4 mmol), **3ze** was obtained as a colorless oil (59.4 mg, 82%).
This target product was purified by column chromatography on silica gel (PE/EA = 3:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, J = 7.6 Hz, 2H), 7.35 (t, J = 8.8 Hz, 4H), 7.13 – 7.03 (m, 2H), 3.74 – 3.63 (m, 4H), 3.07 – 2.91 (m, 4H), 2.44 (s, 3H), 2.29 (s, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 144.0, 137.8, 135.3, 131.5, 129.7, 129.3, 128.2, 125.3, 66.1, 46.7, 21.6, 21.0.
IR (cm^{-1}): 2966, 2918, 2856, 1491, 1452, 1240, 1113, 989, 935, 810, 737, 521.
HRMS (APCI) m/z calcd for $C_{18}H_{22}N_2O_2S_2^+$ $(M+H)^+$ 363.1195, found 363.1187.

(3zf) N-((4-chlorophenyl)(morpholino)(oxo)-λ⁶-sulfaneylidene)-S-(p-tolyl)thiohydroxylamine



N-((4-chlorophenyl)(morpholino)(oxo)-λ^6-sulfaneylidene)-*S*-(*p*-tolyl)thiohydroxylamine
Chemical Formula: $C_{17}H_{19}ClN_2O_2S_2$
Exact Mass: 382.0576
Molecular Weight: 382.9210

Following the General Procedure A with 4-(4-chlorophenylsulfonimidoyl)morpholine (52.1 mg, 0.2 mmol) and 4-toluenethiol (49.7 mg, 0.4 mmol), **3zf** was obtained as a colorless oil (53.3 mg, 70%).

This target product was purified by column chromatography on silica gel (PE/EA = 3:1).

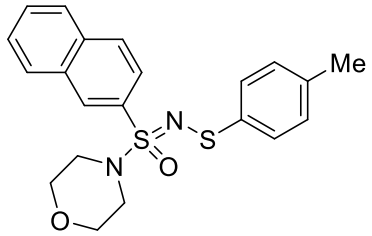
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83 (d, J = 8.8 Hz, 2H), 7.51 (d, J = 8.8 Hz, 2H), 7.35 (d, J = 8.4 Hz, 2H), 7.09 (d, J = 8.0 Hz, 2H), 3.74 – 3.67 (m, 4H), 3.07 – 2.93 (m, 4H), 2.29 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 139.8, 137.3, 135.7, 133., 129.5, 129.4, 129.4, 125.4, 66.1, 46.7, 21.1.

IR (cm^{-1}): 2968, 2918, 2858, 1568, 1493, 1452, 1393, 1244, 1113, 1084, 989, 937, 810, 768, 717, 530.

HRMS (APCI) m/z calcd for $C_{17}H_{20}ClN_2O_2S_2^+$ $(M+H)^+$ 383.0649, found 383.0640.

(3zg) N-(morpholino(naphthalen-2-yl)(oxo)-λ^6-sulfaneylidene)-S-(p-tolyl)thiohydroxylamine



N-(morpholino(naphthalen-2-yl)(oxo)-λ^6-sulfaneylidene)-*S*-(*p*-tolyl)thiohydroxylamine
Chemical Formula: $C_{21}H_{22}N_2O_2S_2$
Exact Mass: 398.1123
Molecular Weight: 398.5390

Following the General Procedure A with 4-(naphthalene-2-sulfonimidoyl)morpholine (55.3 mg, 0.2 mmol) and 4-toluenethiol (49.7 mg, 0.4 mmol), **3zg** was obtained as a colorless oil (59.7 mg, 75%).

This target product was purified by column chromatography on silica gel (PE/EA = 3:1).

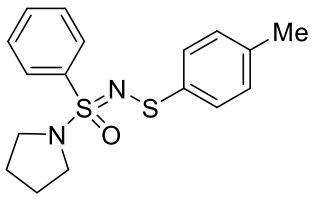
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.53 – 8.45 (m, 1H), 7.98 (d, J = 8.4 Hz, 2H), 7.92 (d, J = 8.0 Hz, 1H), 7.88 (d, J = 8.4 Hz, 1H), 7.70 – 7.57 (m, 2H), 7.40 (d, J = 8.0 Hz, 2H), 7.14 – 7.07 (m, 2H), 3.75 – 3.64 (m, 4H), 3.16 – 3.00 (m, 4H), 2.29 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 137.7, 135.5, 135.0, 132.2, 131.8, 129.6, 129.4, 129.4, 129.2, 129.1, 128.0, 127.7, 125.5, 123.3, 66.2, 46.8, 21.1.

IR (cm^{-1}): 2966, 2916, 2856, 1489, 1452, 1248, 1113, 1074, 1007, 932, 804, 731, 636, 480.

HRMS (APCI) m/z calcd for $C_{21}H_{22}N_2O_2S_2^+$ $(M+H)^+$ 399.1195, found 399.1188.

(3zh) N-(oxo(phenyl)(pyrrolidin-1-yl)-λ^6-sulfaneylidene)-S-(p-tolyl)thiohydroxylamine



N-(oxo(phenyl)(pyrrolidin-1-yl)-λ^6-sulfaneylidene)-*S*-(*p*-tolyl)thiohydroxylamine
Chemical Formula: $C_{17}H_{20}N_2OS_2$
Exact Mass: 332.1017
Molecular Weight: 332.4800

Following the General Procedure A with 1-(phenylsulfonimidoyl)pyrrolidine (42.1 mg, 0.2 mmol) and 4-toluenethiol (49.7 mg, 0.4 mmol), **3zh** was obtained as a colorless oil (47.3 mg, 71%).

This target product was purified by column chromatography on silica gel (PE/EA = 3:1).

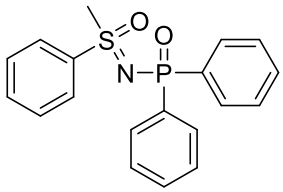
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97 (d, J = 8.0 Hz, 2H), 7.58 (d, J = 7.2 Hz, 1H), 7.56 – 7.49 (m, 2H), 7.35 (d, J = 8.0 Hz, 1H), 7.14 – 7.10 (m, 1H), 7.09 – 7.00 (m, 2H), 3.33 – 3.18 (m, 4H), 2.28 (s, 3H), 1.81 – 1.69 (m, 4H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 138.3, 136.5, 134.9, 132.7, 129.3, 129.0, 128.0, 124.8, 48.6, 25.4, 21.0.

IR (cm^{-1}): 3061, 2974, 2874, 1489, 1445, 1240, 1099, 1013, 804, 748, 690, 581.

HRMS (APCI) m/z calcd for $C_{17}H_{21}N_2OS_2^+$ $(M+H)^+$ 333.1090, found 333.1082.

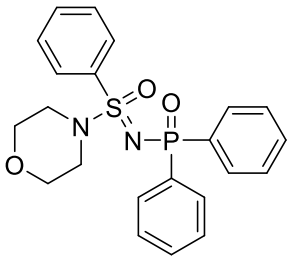
(6a) N-(methyl(oxo)(phenyl)-λ⁶-sulfaneylidene)-P,P-diphenylphosphinic amide (CAS: 2384177-23-3)[12]



N-(methyl(oxo)(phenyl)-λ^6-sulfaneylidene)-*P*,*P*-diphenylphosphinic amide
Chemical Formula: $C_{19}H_{18}NO_2PS$
Exact Mass: 355.0796
Molecular Weight: 355.3918

Following the General Procedure B with sulfoximine (31.0 mg, 0.2 mmol) and diphenylphosphine oxide (80.9 mg, 0.4 mmol), **6a** was obtained as a yellow oil (57.5 mg, 81%). This target product was purified by column chromatography on silica gel (PE/EA = 1:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.03 (d, J = 8.0 Hz, 2H), 7.98 – 7.84 (m, 4H), 7.66 – 7.60 (m, 1H), 7.58 – 7.51 (m, 2H), 7.49 – 7.32 (m, 6H), 3.40 (s, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 141.3, 141.2, 136.9, 136.6, 135.6, 135.2, 133.6, 131.3, 131.21, 131.16, 131.1, 131.0, 129.4, 128.3, 128.2, 127.2, 48.02, 48.00.
^{31}P NMR (162 MHz, $CDCl_3$) δ 18.21.

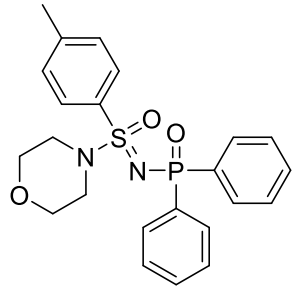
(6b) N-(morpholino(oxo)(phenyl)-λ⁶-sulfaneylidene)-P,P-diphenylphosphinic amide



N-(morpholino(oxo)(phenyl)-λ^6-sulfaneylidene)-*P*,*P*-diphenylphosphinic amide
Chemical Formula: $C_{22}H_{23}N_2O_3PS$
Exact Mass: 426.1167
Molecular Weight: 426.4708

Following the General Procedure B with 4-(phenylsulfonimidoyl)morpholine (45.2 mg, 0.2 mmol) and diphenylphosphine oxide (80.9 mg, 0.4 mmol), **6b** was obtained as a yellow oil (67.7 mg, 76%). This target product was purified by column chromatography on silica gel (PE/EA = 1:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97 – 7.80 (m, 6H), 7.64 – 7.58 (m, 1H), 7.54 (t, J = 7.6 Hz, 2H), 7.48 – 7.33 (m, 6H), 3.67 – 3.55 (m, 4H), 3.19 – 3.06 (m, 2H), 2.98 – 2.82 (m, 2H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 136.2, 135.8, 135.7, 134.8, 134.8, 133.2, 131.5, 131.4, 131.3, 131.2, 129.1, 128.3, 128.2, 128.1, 128.0, 127.7, 66.0, 46.6.
^{31}P NMR (162 MHz, $CDCl_3$) δ 14.48.
IR (cm^{-1}): 3058, 2966, 2858, 1645, 1439, 1288, 1259, 1171, 1111, 937, 737, 694, 598, 542.
HRMS (APCI) m/z calcd for $C_{22}H_{24}N_2O_3PS$ $(M+H)^+$ 427.1240, found 427.1235.

(6c) N-(morpholino(oxo)(p-tolyl)-λ⁶-sulfaneylidene)-P,P-diphenylphosphinic amide

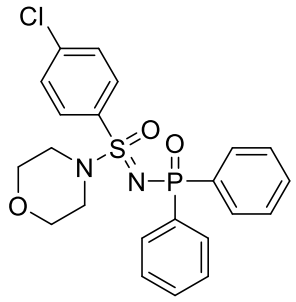


N-(morpholino(oxo)(*p*-tolyl)-λ^6-sulfaneylidene)-*P*,*P*-diphenylphosphinic amide
Chemical Formula: $C_{23}H_{25}N_2O_3PS$
Exact Mass: 440.13
Molecular Weight: 440.50

Following the General Procedure B with 4-(4-methylphenylsulfonimidoyl)morpholine (48.0 mg, 0.2 mmol) and diphenylphosphine oxide (80.9 mg, 0.4 mmol), **6c** was obtained as a yellow oil (63.4 mg, 72%).
This target product was purified by column chromatography on silica gel (PE/EA = 1:1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.96 – 7.82 (m, 4H), 7.74 (d, J = 7.6 Hz, 2H), 7.48 – 7.29 (m, 8H), 3.65 – 3.53 (m, 4H), 3.18 – 3.03 (m, 2H), 2.94 – 2.80 (m, 2H), 2.42 (s, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 144.1, 136.2, 136.1, 134.8, 132.7, 132.7, 131.5, 131.4, 131.3, 131.2, 129.8, 128.3, 128.1, 128.1, 128.0, 127.8, 66.0, 46.5, 21.5.
^{31}P NMR (162 MHz, $CDCl_3$) δ 14.42.
IR (cm^{-1}): 3057, 2966, 2922, 2585, 1593, 1439, 1292, 1169, 1111, 937, 725, 696, 526.
HRMS (APCI) m/z calcd for $C_{23}H_{26}N_2O_3PS$ $(M+H)^+$ 441.1396, found 441.1391.

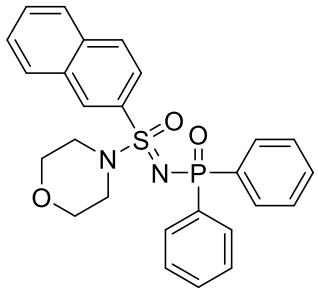
(6d) N-((4-chlorophenyl)(morpholino)(oxo)-λ^6-sulfaneylidene)-P,P-diphenylphosphinic amide



N-((4-chlorophenyl)(morpholino)(oxo)-λ^6-sulfaneylidene)-*P*,*P*-diphenylphosphinic amide
Chemical Formula: $C_{22}H_{22}ClN_2O_3PS$
Exact Mass: 460.0777
Molecular Weight: 460.9128

Following the General Procedure B with 4-(4-chlorophenylsulfonimidoyl)morpholine (52.0 mg, 0.2 mmol) and diphenylphosphine oxide (80.9 mg, 0.4 mmol), **6d** was obtained as a yellow oil (60.7 mg, 66%).
This target product was purified by column chromatography on silica gel (PE/EA = 1:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94 – 7.84 (m, 4H), 7.81 – 7.75 (m, 2H), 7.51 – 7.47 (m, 2H), 7.46 – 7.33 (m, 6H), 3.67 – 3.54 (m, 4H), 3.16 – 3.05 (m, 2H), 2.95 – 2.86 (m, 2H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 139.9, 135.8, 134.4, 134.3, 131.5, 131.4, 131.4, 131.3, 131.2, 129.4, 129.2, 128.3, 128.2, 128.1, 127.7, 127.6, 66.0, 46.5.
^{31}P NMR (162 MHz, $CDCl_3$) δ 14.71.
IR (cm^{-1}): 3429, 3057, 2966, 2918, 2858, 1577, 1436, 1288, 1178, 1109, 930, 723, 696, 527.
HRMS (APCI) m/z calcd for $C_{22}H_{23}ClN_2O_3PS$ $(M+H)^+$ 461.0850, found 461.0843.

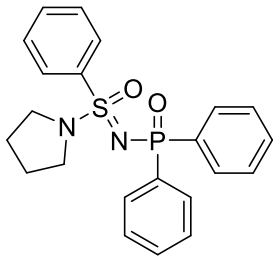
(6e) N-(morpholino(naphthalen-2-yl)(oxo)-λ^6-sulfaneylidene)-P,P-diphenylphosphinic amide



N-(morpholino(naphthalen-2-yl)(oxo)-λ^6-sulfaneylidene)-*P*,*P*-diphenylphosphinic amide
Chemical Formula: $C_{26}H_{25}N_2O_3PS$
Exact Mass: 476.1323
Molecular Weight: 476.5308

Following the General Procedure B with 4-(naphthalene-2-sulfonimidoyl)morpholine (55.2 mg, 0.2 mmol) and diphenylphosphine oxide (80.9 mg, 0.4 mmol), **6e** was obtained as a yellow oil (61.9 mg, 65%).
This target product was purified by column chromatography on silica gel (PE/EA = 1:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.43 (s, 1H), 8.00 – 7.82 (m, 8H), 7.68 – 7.56 (m, 2H), 7.49 – 7.33 (m, 6H), 3.68 – 3.54 (m, 4H), 3.26 – 3.13 (m, 2H), 3.03 – 2.92 (m, 2H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 136.1, 135.0, 134.8, 134.7, 133.0, 132.9, 132.1, 131.6, 131.5, 131.3, 131.2, 129.4, 129.4, 129.2, 129.2, 128.3, 128.2, 128.0, 128.0, 127.7, 122.8, 66.1, 46.6.
^{31}P NMR (162 MHz, $CDCl_3$) δ 14.56.
IR (cm^{-1}): 3057, 2964, 2858, 2220, 1715, 1589, 1439, 1292, 1174, 1113, 1074, 935, 723, 696, 636, 538.
HRMS (APCI) m/z calcd for $C_{26}H_{26}N_2O_3PS$ $(M+H)^+$ 477.1396, found 477.1391.

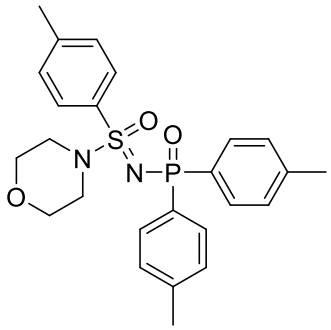
(6f) N-(oxo(phenyl)(pyrrolidin-1-yl)-λ^6-sulfaneylidene)-P,P-diphenylphosphinic amide



N-(oxo(phenyl)(pyrrolidin-1-yl)-λ^6-sulfaneylidene)-*P*,*P*-diphenylphosphinic amide
Chemical Formula: $C_{22}H_{23}N_2O_2PS$
Exact Mass: 410.1218
Molecular Weight: 410.4718

Following the General Procedure B with 1-(phenylsulfonimidoyl)pyrrolidine (42.0 mg, 0.2 mmol) and diphenylphosphine oxide (80.9 mg, 0.4 mmol), **6f** was obtained as a yellow oil (50.8 mg, 62%).
This target product was purified by column chromatography on silica gel (PE/EA = 1:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.98 – 7.82 (m, 6H), 7.59 – 7.53 (m, 1H), 7.49 (t, J = 7.6 Hz, 2H), 7.45 – 7.31 (m, 6H), 3.38 – 3.26 (m, 2H), 3.24 – 3.11 (m, 2H), 1.68 (s, 4H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 138.1, 138.0, 136.5, 135.2, 135.1, 132.7, 131.4, 131.3, 131.3, 131.2, 131.1, 129.0, 128.2, 128.1, 128.0, 127.4, 48.5, 25.2.
^{31}P NMR (162 MHz, $CDCl_3$) δ 14.19.
IR (cm^{-1}): 3057, 2976, 2876, 2216, 1717, 1591, 1483, 1439, 1271, 1165, 997, 914, 721, 690, 517.
HRMS (APCI) m/z calcd for $C_{22}H_{24}N_2O_2PS$ $(M+H)^+$ 411.1291, found 411.1285.

(6g) N-(morpholino(oxo)(p-tolyl)-λ^6-sulfaneylidene)-P,P-di-p-tolylphosphinic amide



N-(morpholino(oxo)(*p*-tolyl)-λ^6-sulfaneylidene)-*P*,*P*-di-*p*-tolylphosphinic amide
Chemical Formula: $C_{25}H_{29}N_2O_3PS$
Exact Mass: 468.1637
Molecular Weight: 468.5518

Following the General Procedure B with 4-(4-methylphenylsulfonimidoyl)morpholine (48.0 mg, 0.2 mmol) and di-p-tolylphosphine oxide (92.0 mg, 0.4 mmol), **6g** was obtained as a yellow oil (65.5 mg, 70%). This target product was purified by column chromatography on silica gel (PE/EA = 1:1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.81 – 7.71 (m, 6H), 7.32 (d, J = 8.0 Hz, 2H), 7.22 – 7.15 (m, 4H), 3.69 – 3.57 (m, 4H), 3.18 – 3.07 (m, 2H), 2.94 – 2.83 (m, 2H), 2.43 (s, 3H), 2.34 (d, J = 2.8 Hz, 6H).

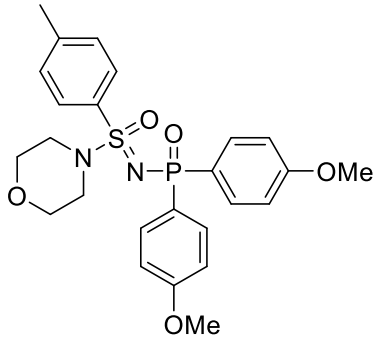
^{13}C NMR (101 MHz, $CDCl_3$) δ 144.0, 141.4, 133.4, 133.3, 132.9, 132.9, 132.0, 131.5, 131.4, 131.3, 131.2, 129.7, 129.0, 128.8, 128.7, 127.8, 66.1, 46.6, 21.6, 21.5.

^{31}P NMR (162 MHz, $CDCl_3$) δ 14.93.

IR (cm^{-1}): 3022, 2966, 2920, 2860, 1601, 1452, 1288, 1259, 1169, 1111, 937, 810, 727, 663, 530.

HRMS (APCI) m/z calcd for $C_{25}H_{30}N_2O_3PS$ $(M+H)^+$ 469.1709, found 469.1700.

(6h) P,P-bis(4-methoxyphenyl)-N-(morpholino(oxo)(p-tolyl)-λ⁶-sulfaneylidene)phosphinic amide



P,*P*-bis(4-methoxyphenyl)-*N*-(morpholino(oxo)(*p*-tolyl)-λ^6-sulfaneylidene)phosphinic amide
Chemical Formula: $C_{25}H_{29}N_2O_5PS$
Exact Mass: 500.15
Molecular Weight: 500.55

Following the General Procedure B with 4-(4-methylphenylsulfonimidoyl)morpholine (48.0 mg, 0.2 mmol) and bis(4-methoxyphenyl)phosphine oxide (104.8 mg, 0.4 mmol), **6h** was obtained as a yellow oil (70.0 mg, 70%).

This target product was purified by column chromatography on silica gel (PE/EA = 1:1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.88 – 7.71 (m, 6H), 7.32 (d, J = 7.6 Hz, 2H), 6.90 (t, J = 8.8 Hz, 4H), 3.80 (d, J = 4.4 Hz, 6H), 3.70 – 3.56 (m, 4H), 3.19 – 3.07 (m, 2H), 2.98 – 2.84 (m, 2H), 2.43 (s, 3H).

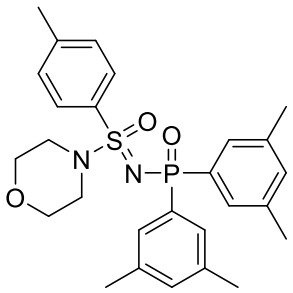
^{13}C NMR (101 MHz, $CDCl_3$) δ 161.9, 144.0, 133.3, 133.2, 133.0, 132.9, 132.8, 129.7, 128.3, 128.2, 127.8, 126.8, 113.7, 113.6, 113.4, 66.1, 55.2, 55.2, 46.6, 21.5.

^{31}P NMR (162 MHz, $CDCl_3$) δ 14.59.

IR (cm^{-1}): 2964, 2916, 2858, 1597, 1500, 1452, 1283, 1254, 1165, 1123, 1026, 937, 802, 723, 667, 530.

HRMS (APCI) m/z calcd for $C_{25}H_{30}N_2O_5PS$ $(M+H)^+$ 501.1608, found 501.1603.

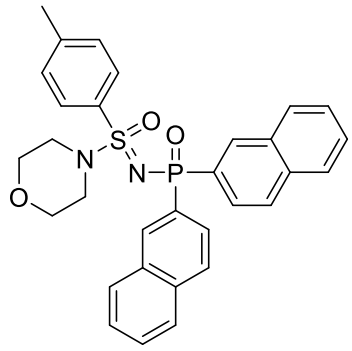
(6i) P,P-bis(3,5-dimethylphenyl)-N-(morpholino(oxo)(p-tolyl)-λ⁶-sulfaneylidene)phosphinic amide



P,*P*-bis(3,5-dimethylphenyl)-*N*-(morpholino(oxo)(*p*-tolyl)-λ^6-sulfaneylidene)phosphinic amide
Chemical Formula: $C_{27}H_{33}N_2O_3PS$
Exact Mass: 496.19
Molecular Weight: 496.61

Following the General Procedure B with 4-(4-methylphenylsulfonimidoyl)morpholine (48.0 mg, 0.2 mmol) and bis(3,5-dimethylphenyl)phosphine oxide (103.2 mg, 0.4 mmol), **6i** was obtained as a yellow oil (67.5 mg, 68%).
This target product was purified by column chromatography on silica gel (PE/EA = 1:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.74 (d, J = 7.2 Hz, 2H), 7.49 (t, J = 14.4 Hz, 4H), 7.32 (d, J = 7.6 Hz, 2H), 7.05 (d, J = 8.0 Hz, 2H), 3.70 – 3.55 (m, 4H), 3.15 – 3.04 (m, 2H), 2.95 – 2.86 (m, 2H), 2.43 (s, 4H), 2.30 (d, J = 7.6 Hz, 12H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 144.0, 137.8, 137.6, 137.6, 137.4, 132.97, 132.95, 132.90, 132.88, 129.7, 129.1, 129.0, 128.9, 128.78, 127.8, 66.1, 46.5, 21.5, 21.3, 21.3.
^{31}P NMR (162 MHz, $CDCl_3$) δ 15.49.
IR (cm^{-1}): 2964, 2918, 2856, 2214, 1599, 1452, 1277, 1169, 1113, 937, 852, 725, 692, 588, 528.
HRMS (APCI) m/z calcd for $C_{27}H_{34}N_2O_3PS$ $(M+H)^+$ 497.2022, found 497.2015.

(6j) N-(morpholino(oxo)(p-tolyl)-λ^6-sulfaneylidene)-P,P-di(naphthalen-2-yl)phosphinic amide

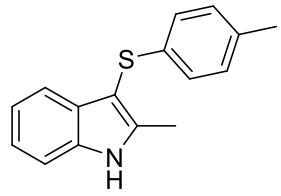


N-(morpholino(oxo)(*p*-tolyl)-λ^6-sulfaneylidene)-*P*,*P*-di(naphthalen-2-yl)phosphinic amide
Chemical Formula: $C_{31}H_{29}N_2O_3PS$
Exact Mass: 540.16
Molecular Weight: 540.62

Following the General Procedure B with 4-(4-methylphenylsulfonimidoyl)morpholine (48.0 mg, 0.2 mmol) and di(naphthalen-2-yl)phosphine oxide (120.8 mg, 0.4 mmol), **6j** was obtained as a yellow oil (75.6 mg, 70%).
This target product was purified by column chromatography on silica gel (PE/EA = 1:1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.59 (d, J = 14.4 Hz, 1H), 8.51 (d, J = 14.4 Hz, 1H), 7.94 – 7.87 (m, 4H), 7.87 – 7.74 (m, 6H), 7.55 – 7.46 (m, 4H), 7.31 (d, J = 7.6 Hz, 2H), 3.69 – 3.54 (m, 4H), 3.22 – 3.12 (m, 2H), 2.98 – 2.87 (m, 2H), 2.41 (s, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 144.2, 134.6, 134.5, 132.8, 132.6, 132.4, 129.8, 129.0, 128.1, 128.0, 127.9, 127.8, 127.7, 127.7, 127.1, 127.0, 126.8, 126.7, 126.5, 66.1, 46.6, 21.5.
^{31}P NMR (162 MHz, $CDCl_3$) δ 14.20.
IR (cm^{-1}): 3057, 2964, 2918, 2858, 2220, 1593, 1501, 1452, 1275, 1165, 1111, 1088, 933, 858, 818, 725, 662, 528.
HRMS (APCI) m/z calcd for $C_{31}H_{30}N_2O_3PS$ $(M+H)^+$ 541.1709, found 541.1703.

(3aa) 2-methyl-3-(p-tolylthio)-1H-indole (CAS: 955125-54-9)[13]



2-methyl-3-(*p*-tolylthio)-1*H*-indole
Chemical Formula: $C_{16}H_{15}NS$
Exact Mass: 253.0925
Molecular Weight: 253.3630

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.18 (s, 1H), 7.54 (d, J = 7.6 Hz, 1H), 7.32 (d, J = 8.0 Hz, 1H), 7.22 – 7.15 (m, 1H), 7.14 – 7.08 m, 1H), 6.95 (s, 4H), 2.50 (s, 3H), 2.24 (s, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 140.9, 135.7, 135.4, 134.3, 130.4, 129.5, 125.78, 122.2, 120.7, 119.4, 110.6, 99.9, 20.9, 12.2.

12. References

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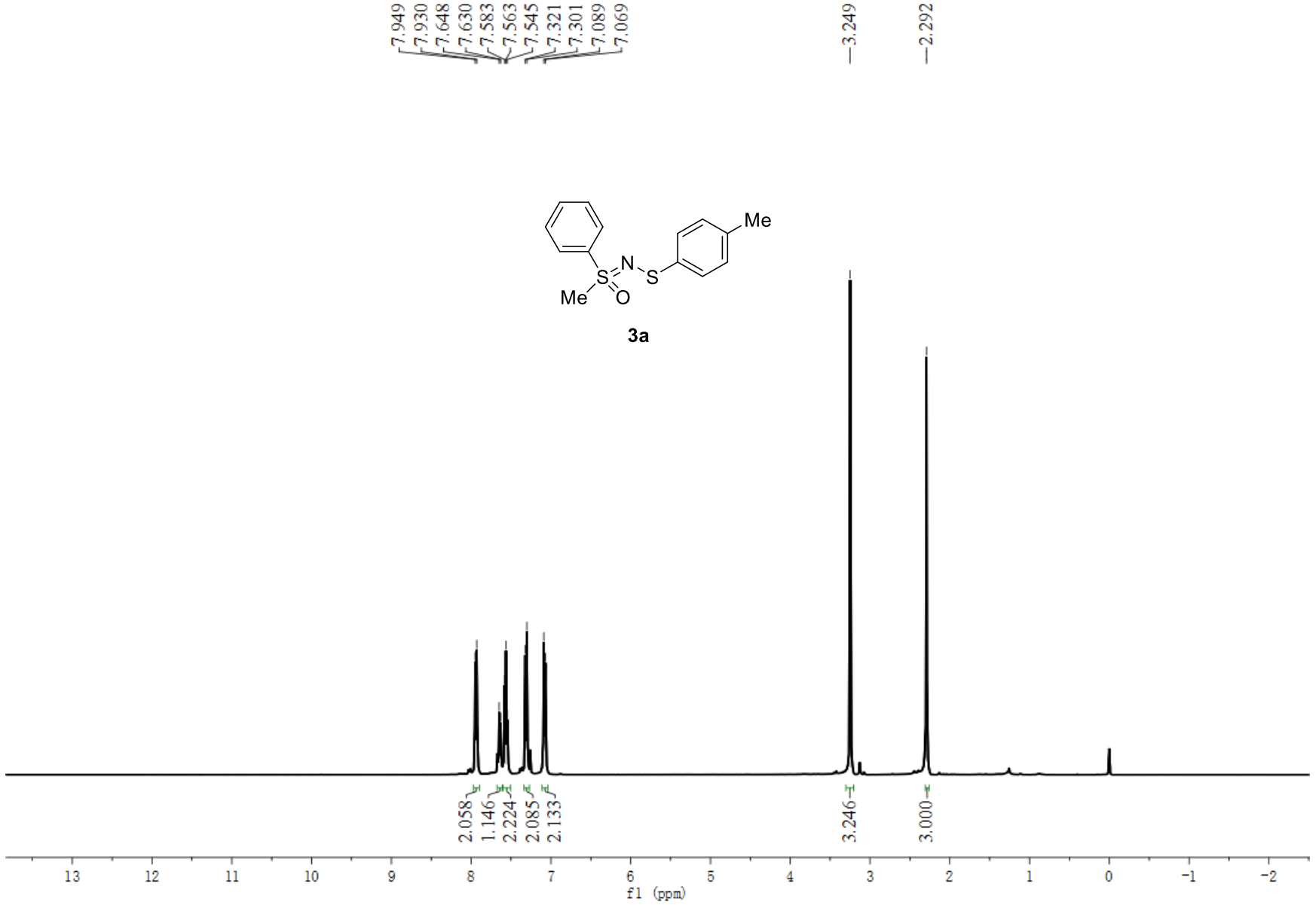
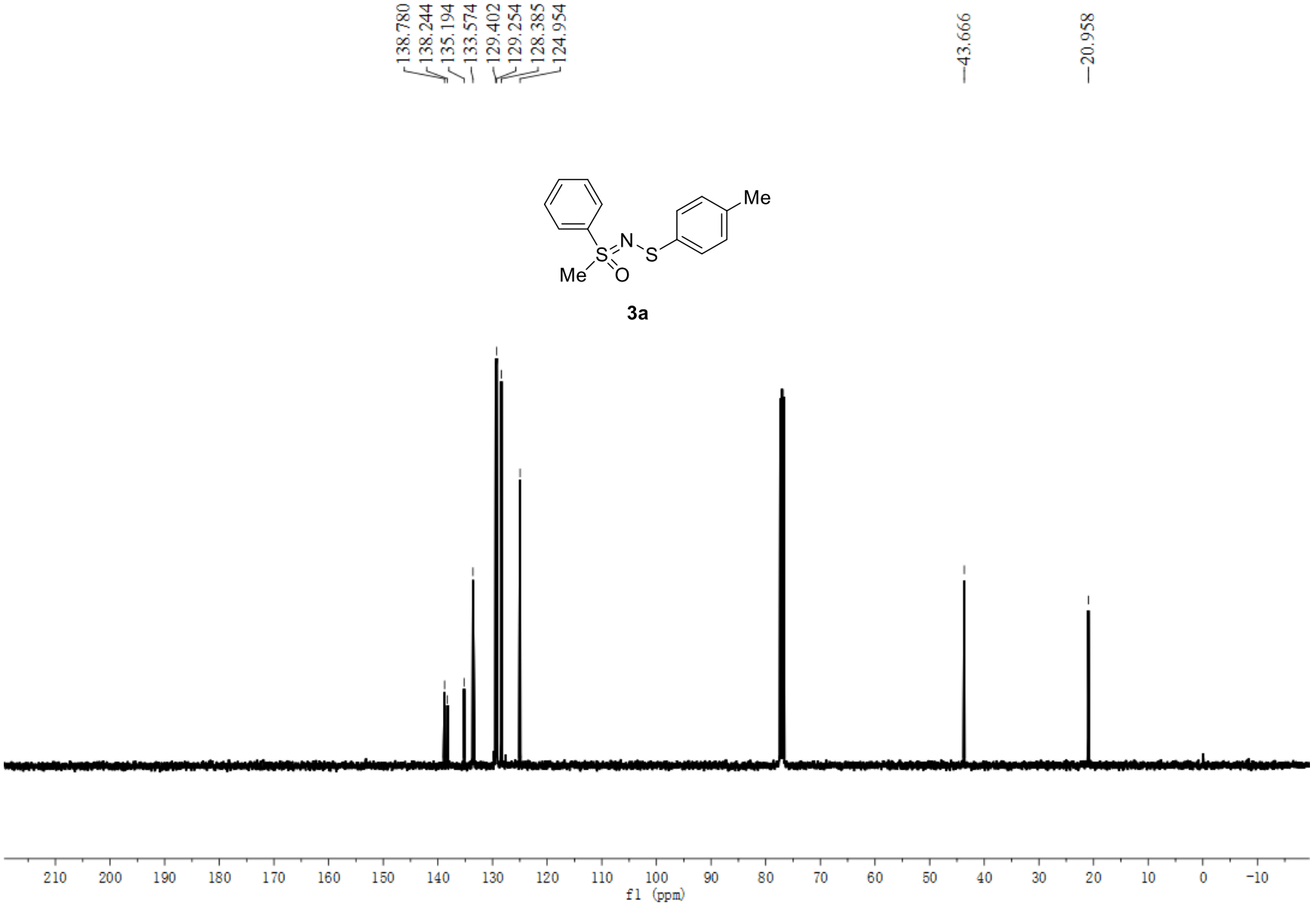
13. Copies of NMR spectra

^{1}H NMR spectra of compound **3a** (400 MHz, $CDCl_3$)

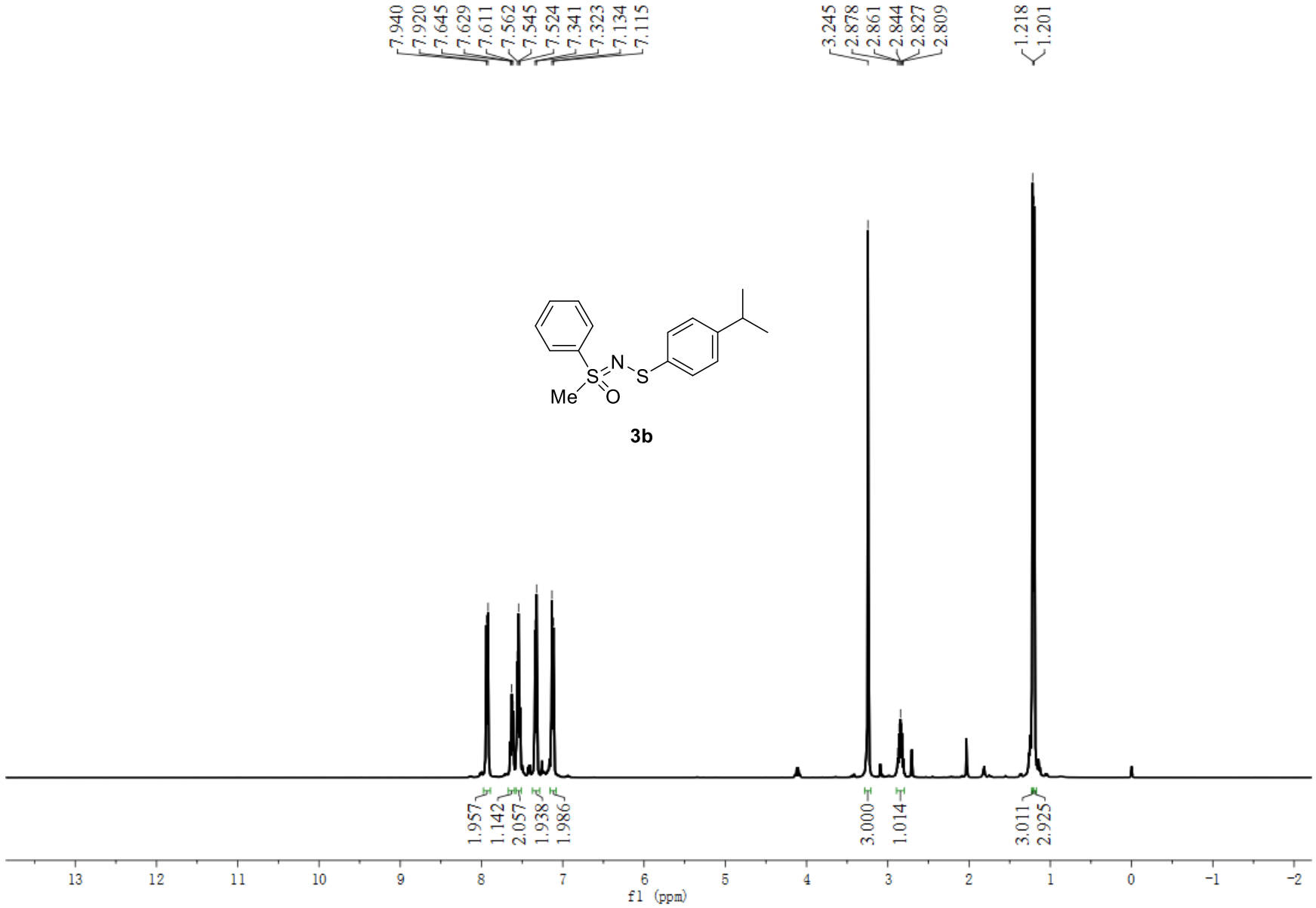


^{13}C NMR spectra of compound **3a** (101 MHz, $CDCl_3$)

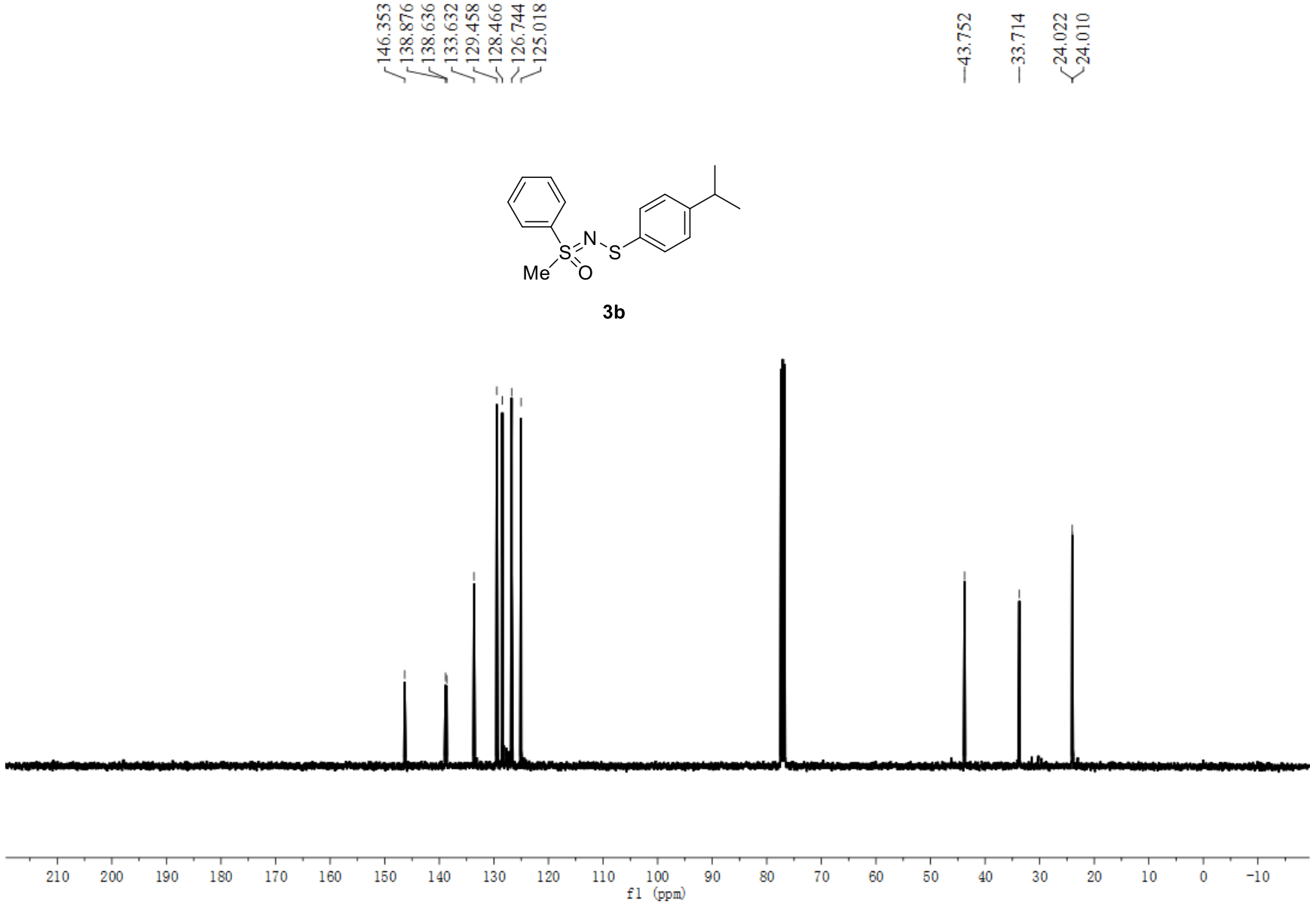


3a

^{1}H NMR spectra of compound **3b** (400 MHz, $CDCl_3$)

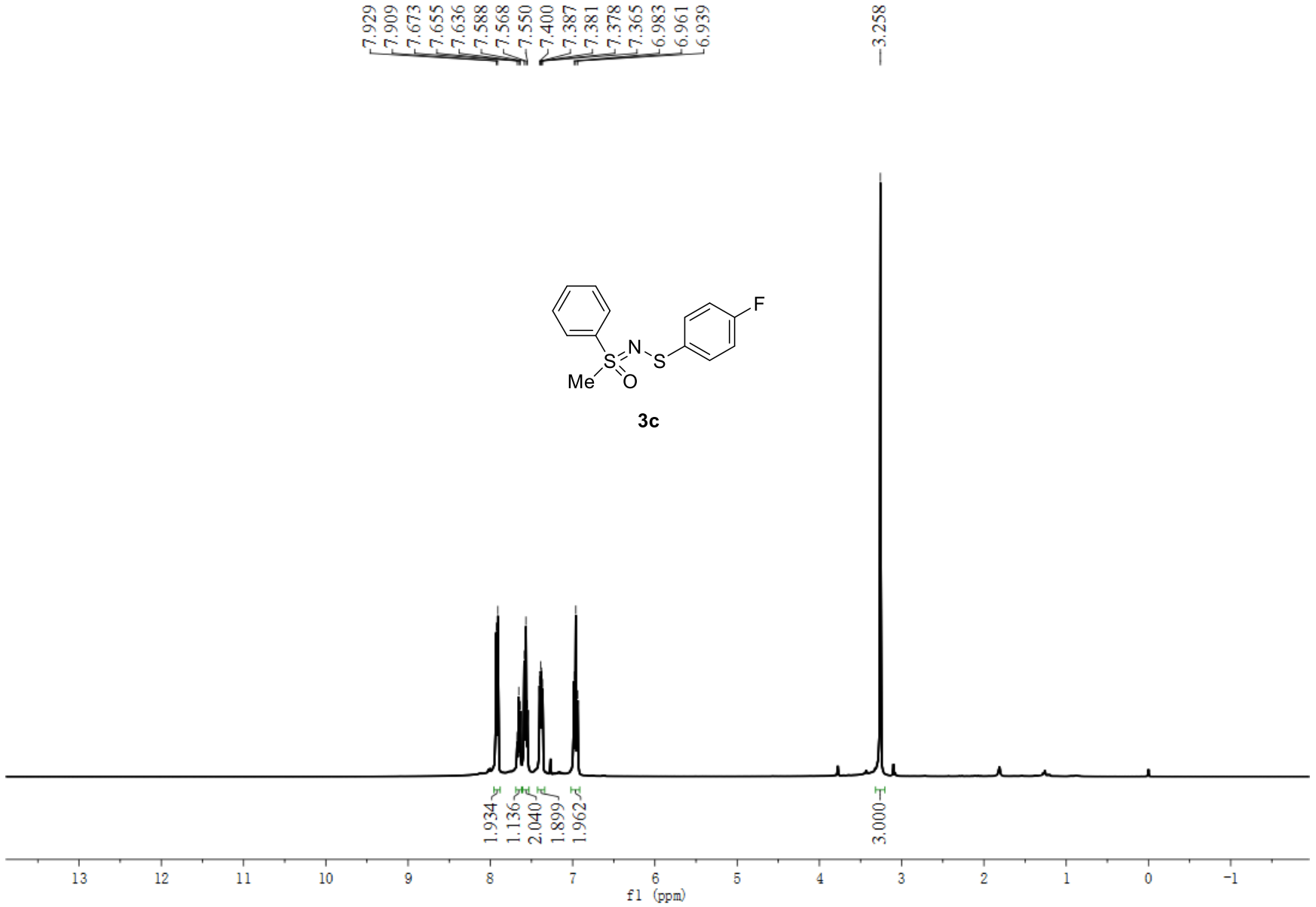


$^{13}C\{^{1}H\}$ spectra of compound **3b** (101 MHz, $CDCl_3$)

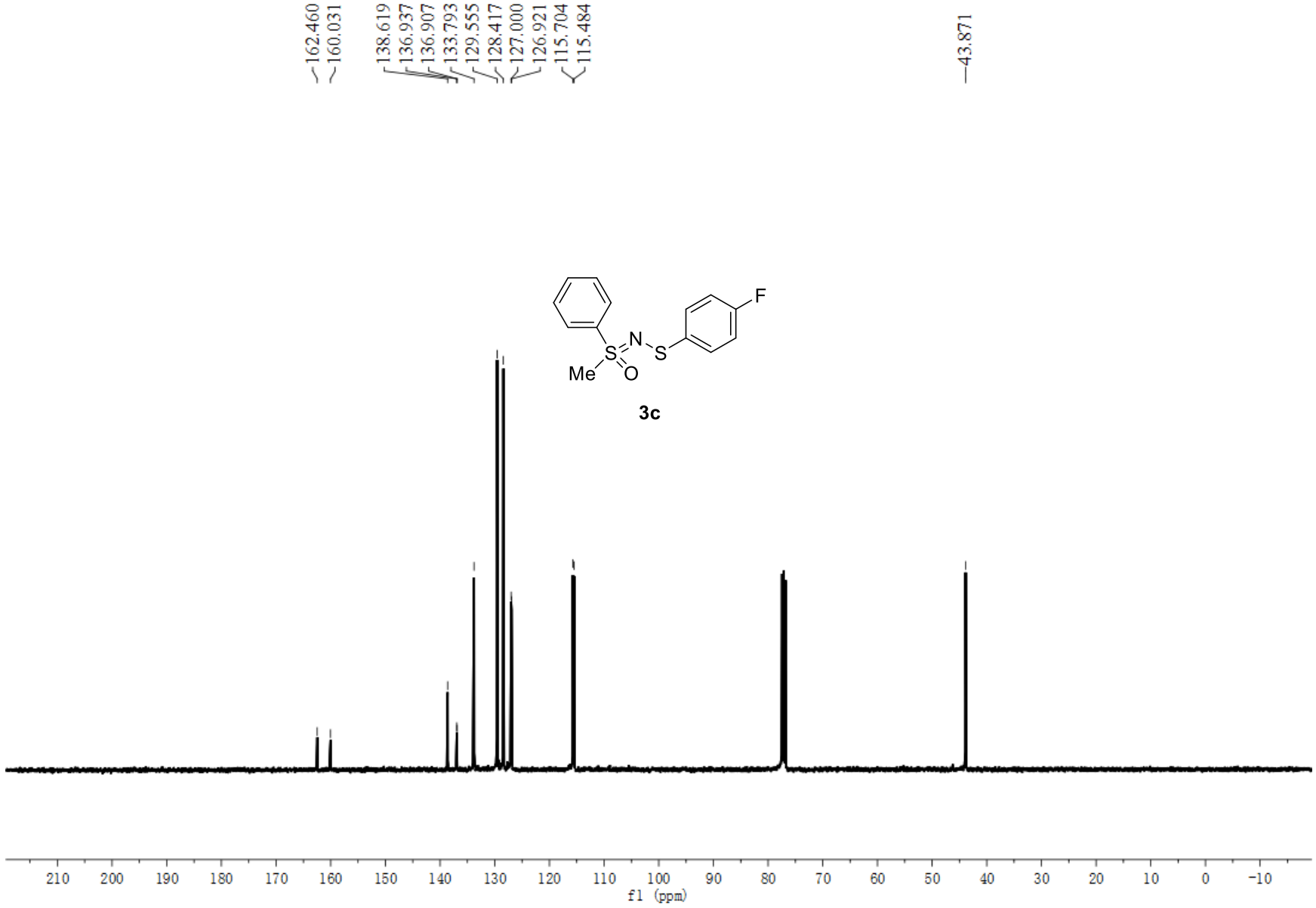


3b

^{1}H NMR spectra of compound **3c** (400 MHz, $CDCl_3$)

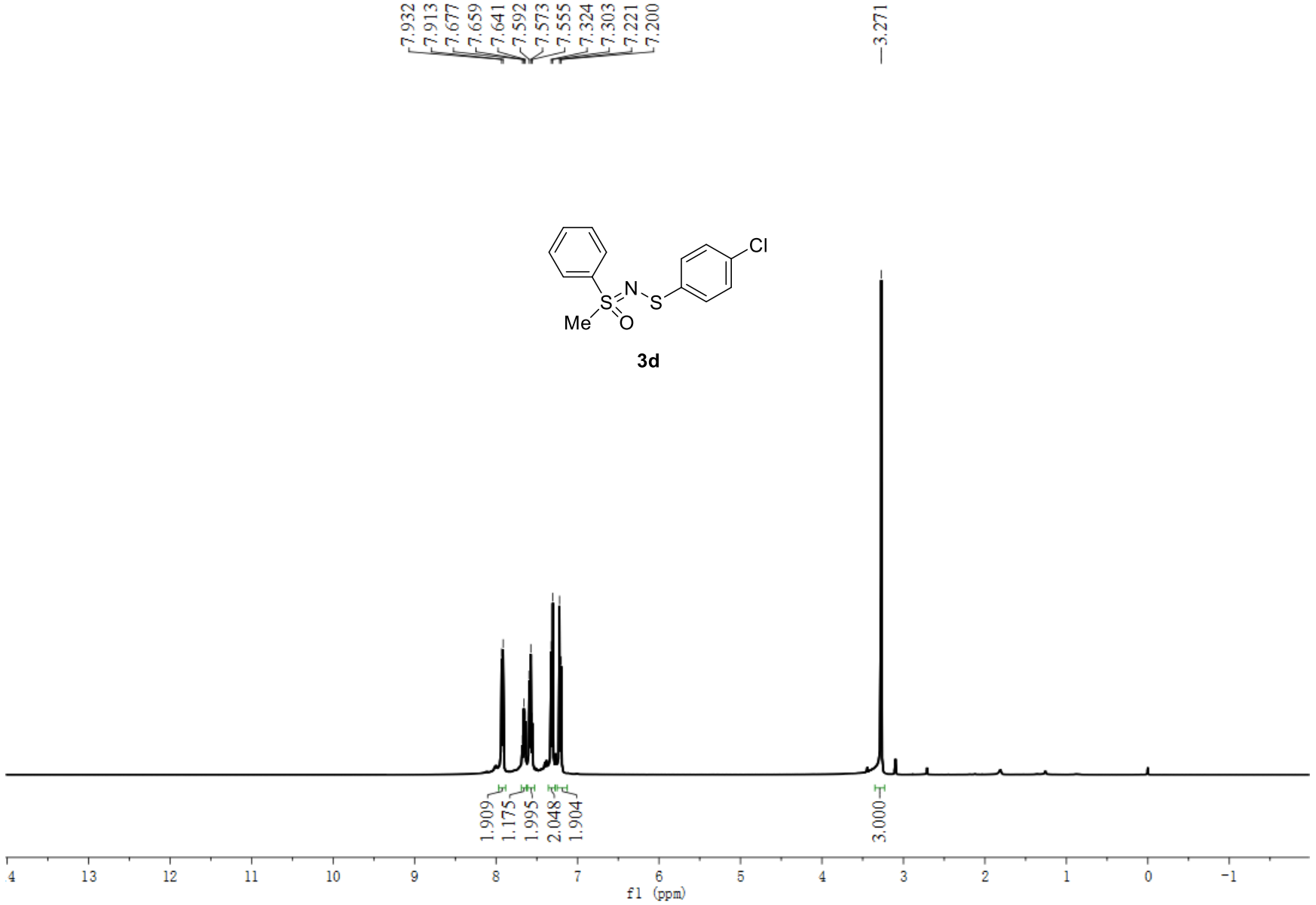


^{13}C NMR spectra of compound **3c** (101 MHz, $CDCl_3$)

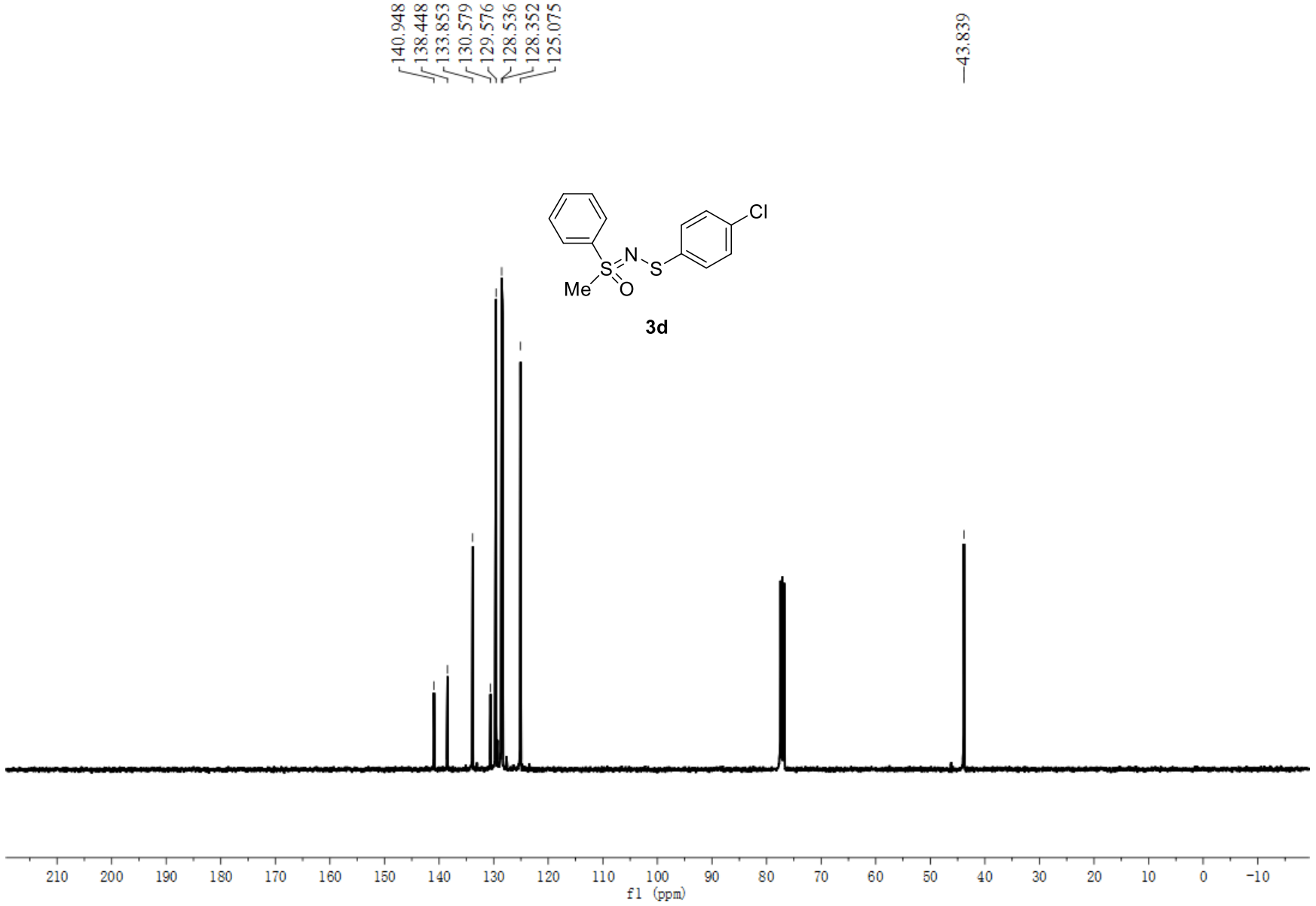


^{19}F NMR spectra of compound **3c** (376 MHz, $CDCl_3$)

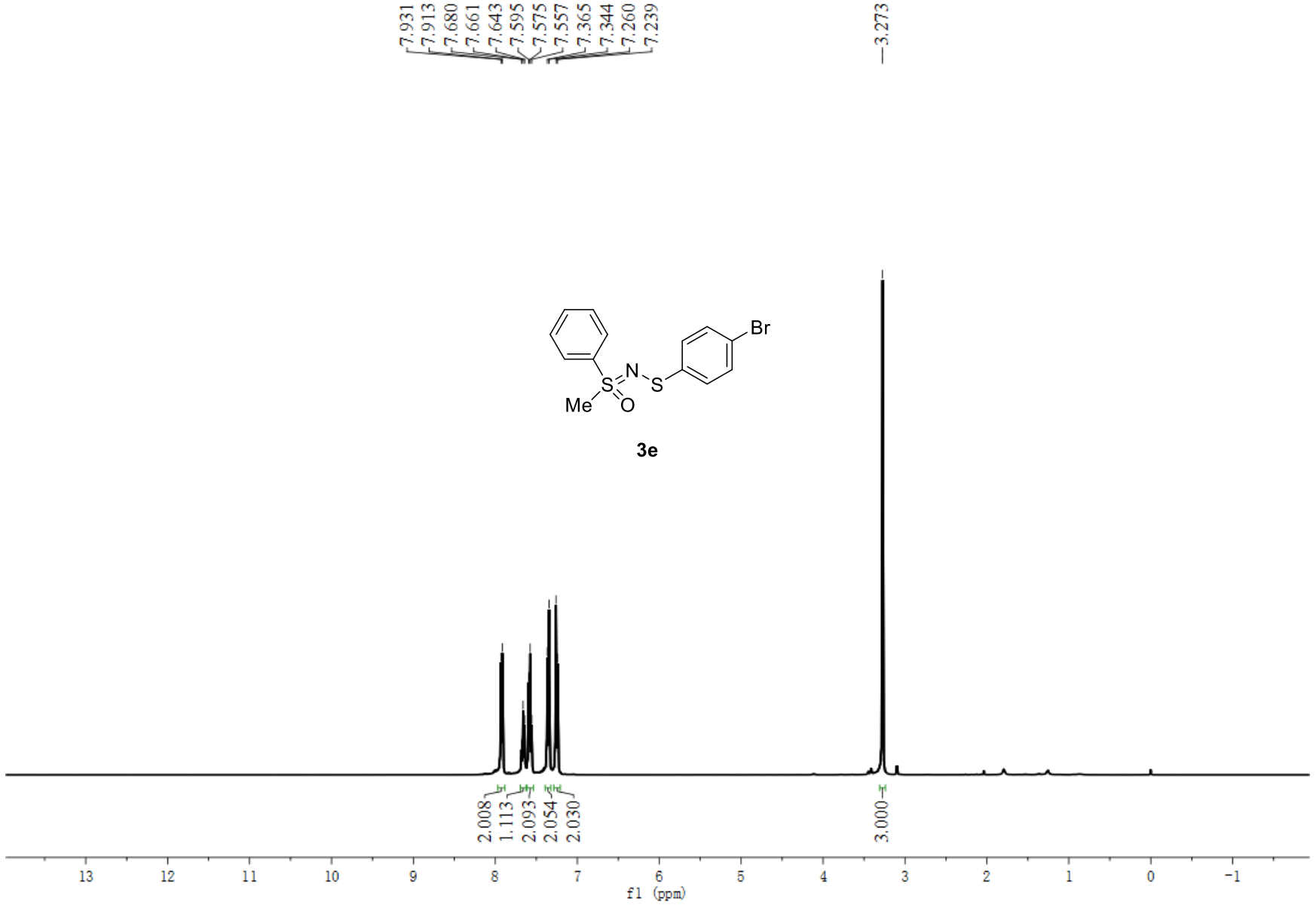
^{1}H NMR spectra of compound **3d** (400 MHz, $CDCl_3$)



^{13}C NMR spectra of compound **3d** (400 MHz, $CDCl_3$)

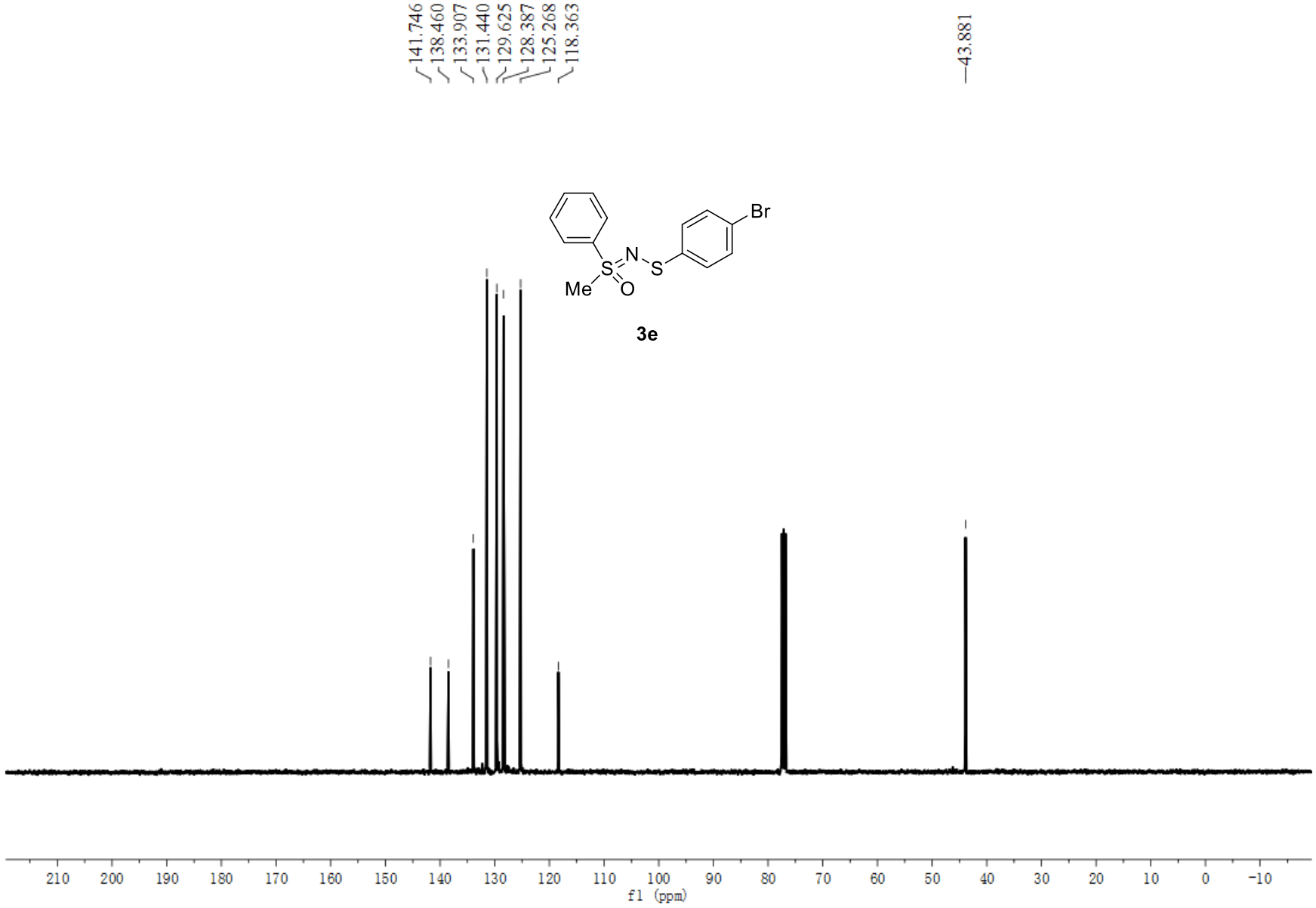


^{1}H NMR spectra of compound **3e** (400 MHz, $CDCl_3$)

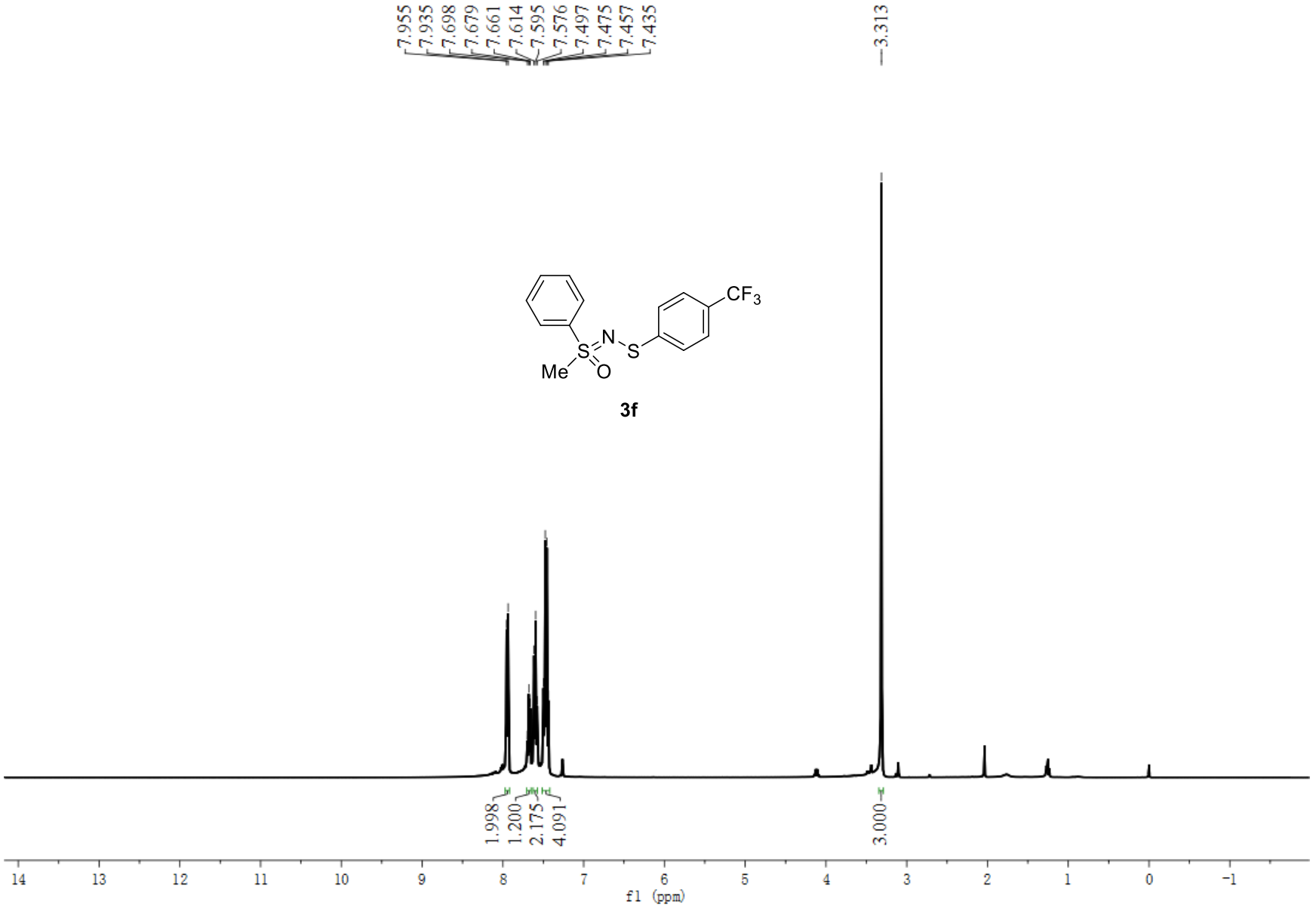


3e

^{13}C NMR spectra of compound **3e** (101 MHz, $CDCl_3$)

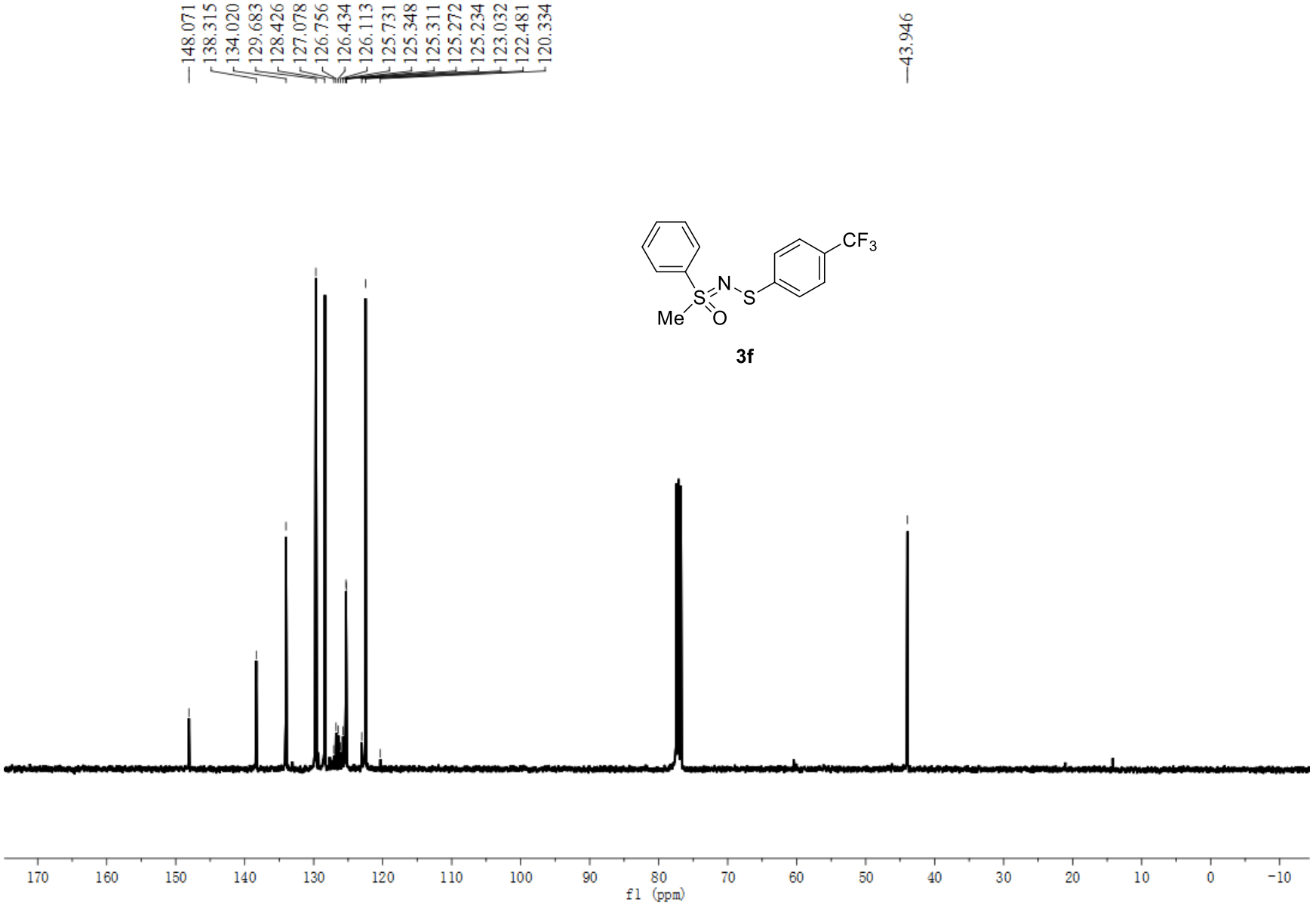


^{1}H NMR spectra of compound **3f** (400 MHz, $CDCl_3$)

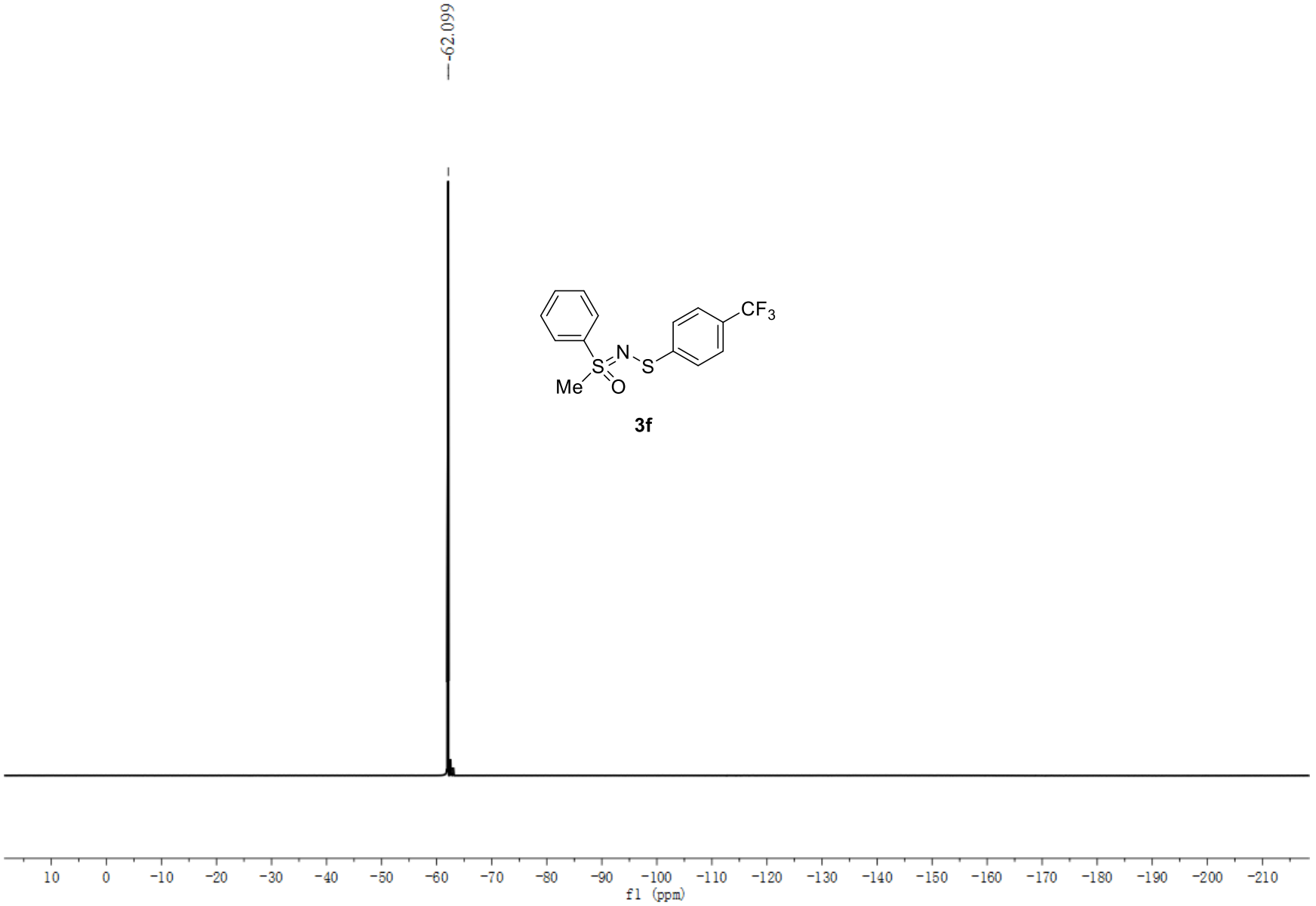


3f

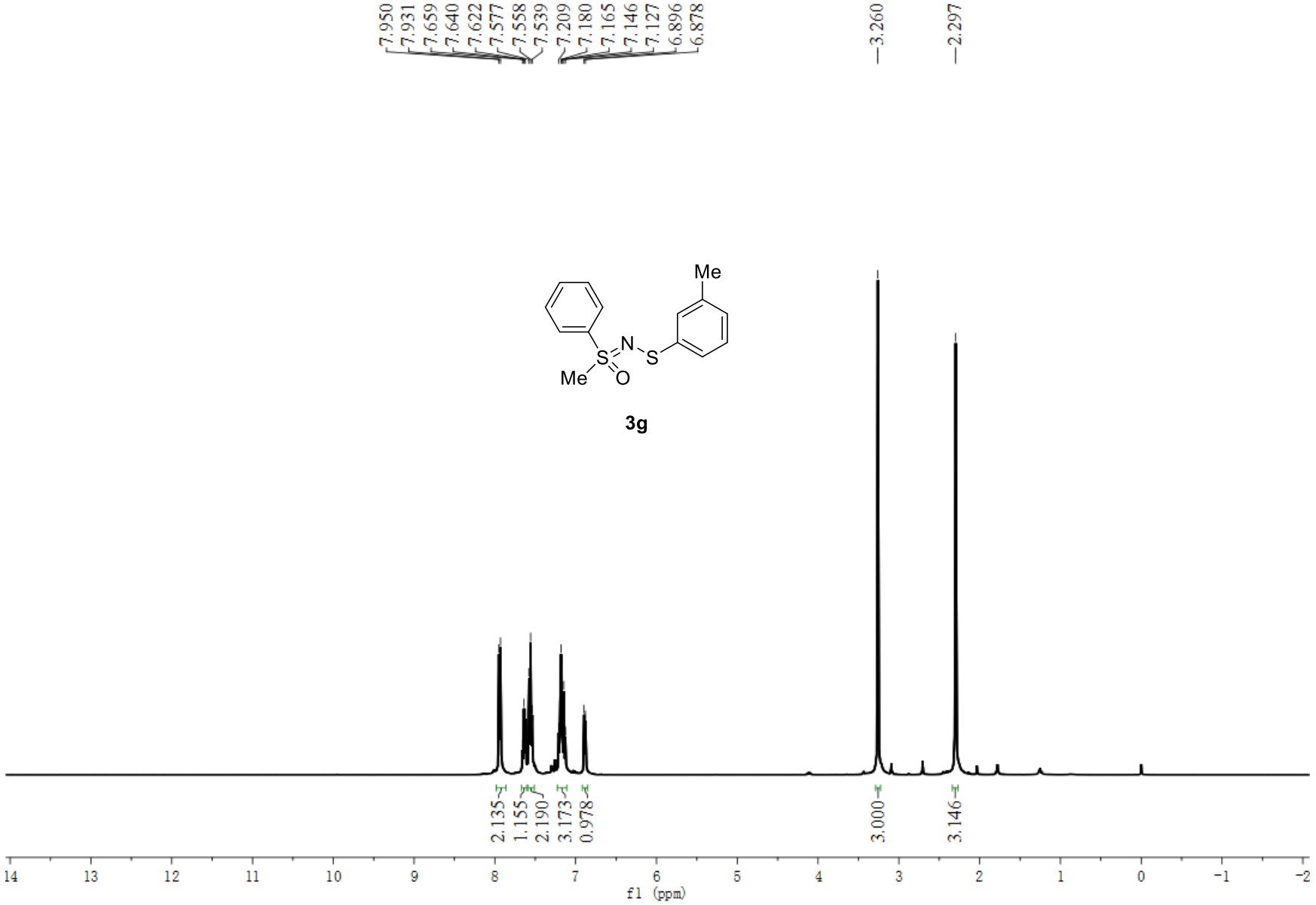
^{13}C NMR spectra of compound **3f** (101 MHz, $CDCl_3$)



^{19}F NMR spectra of compound **3f** (376 MHz, $CDCl_3$)

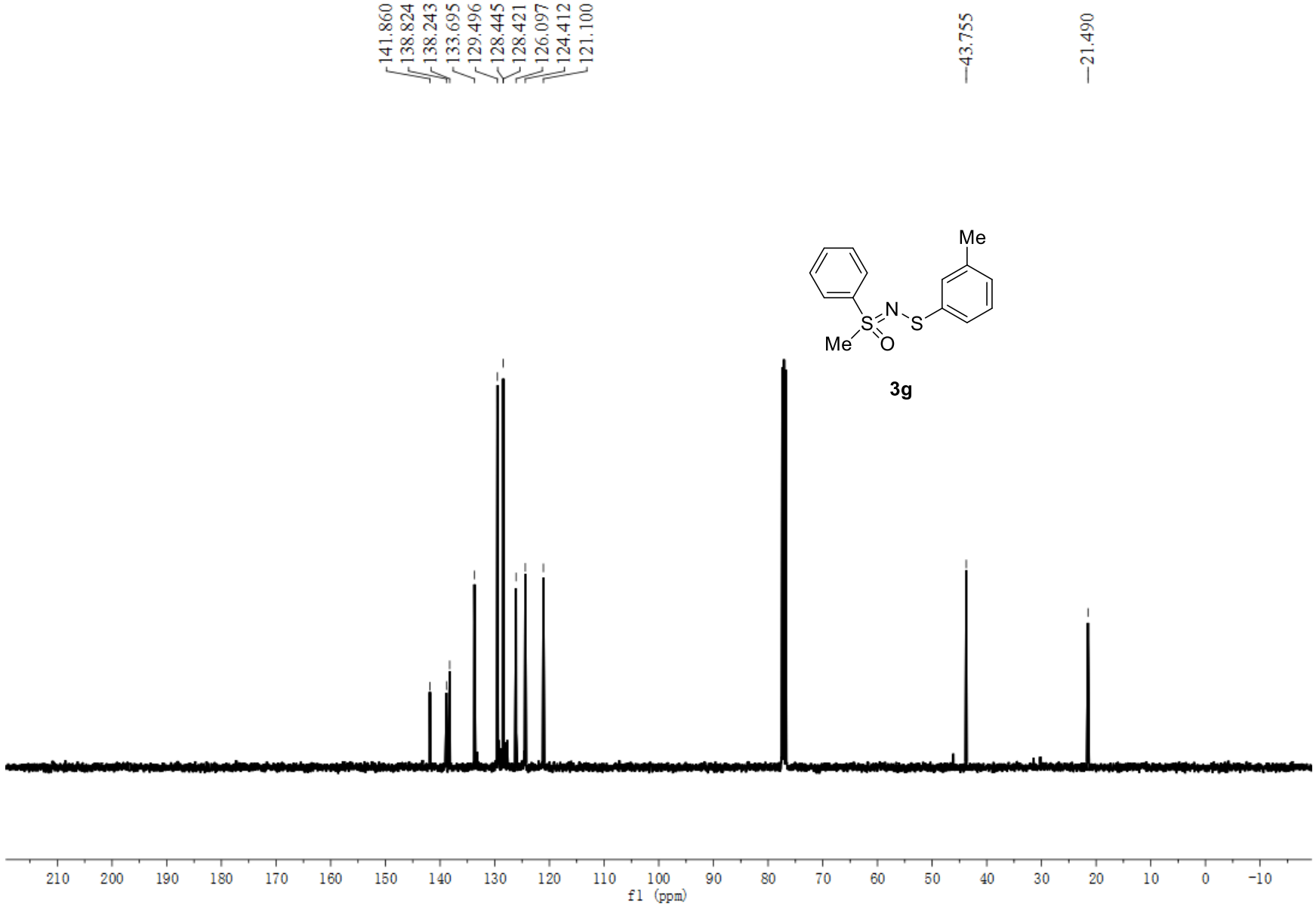


^{1}H NMR spectra of compound **3g** (400 MHz, $CDCl_3$)

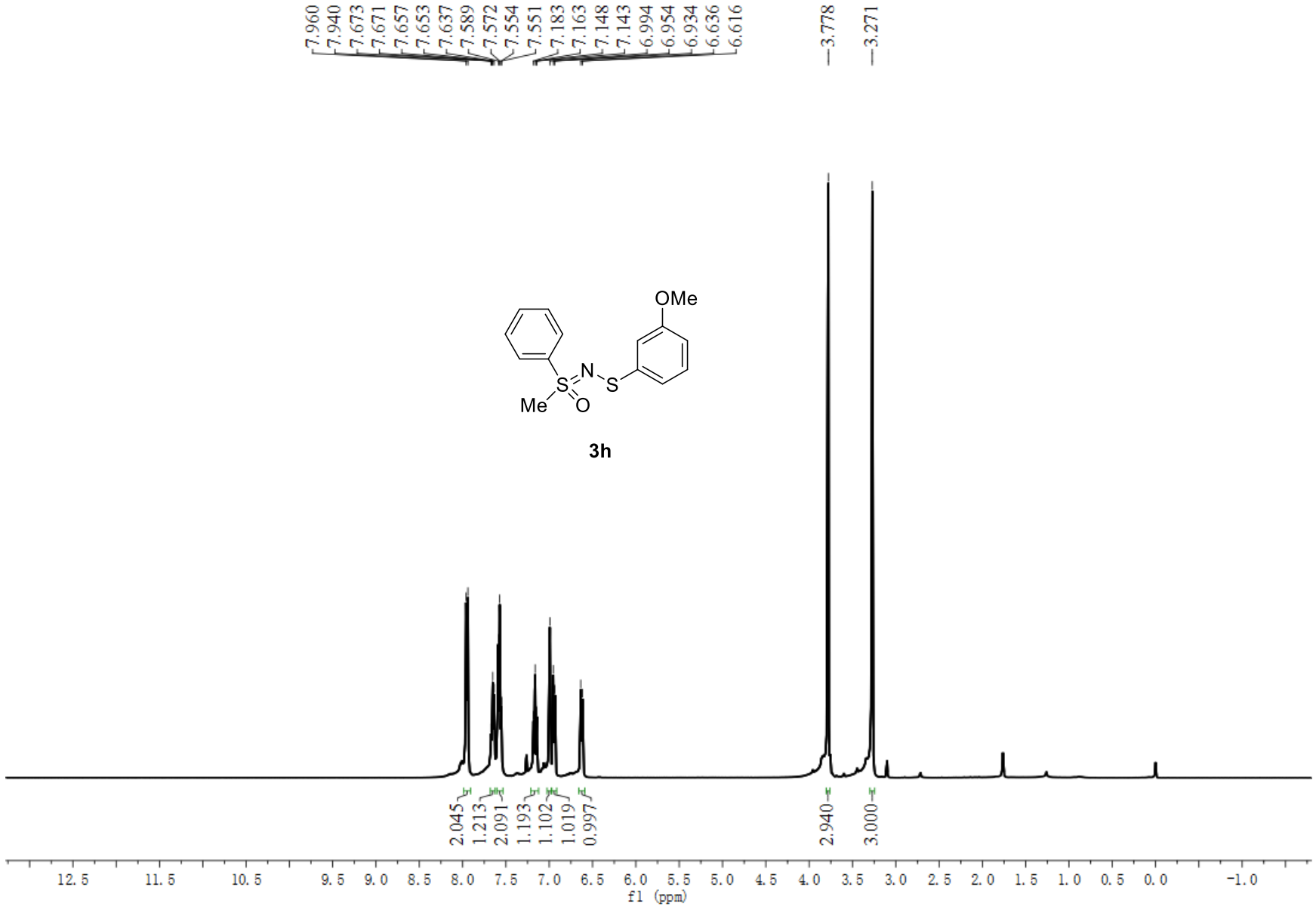


3g

^{13}C NMR spectra of compound **3g** (101 MHz, $CDCl_3$)

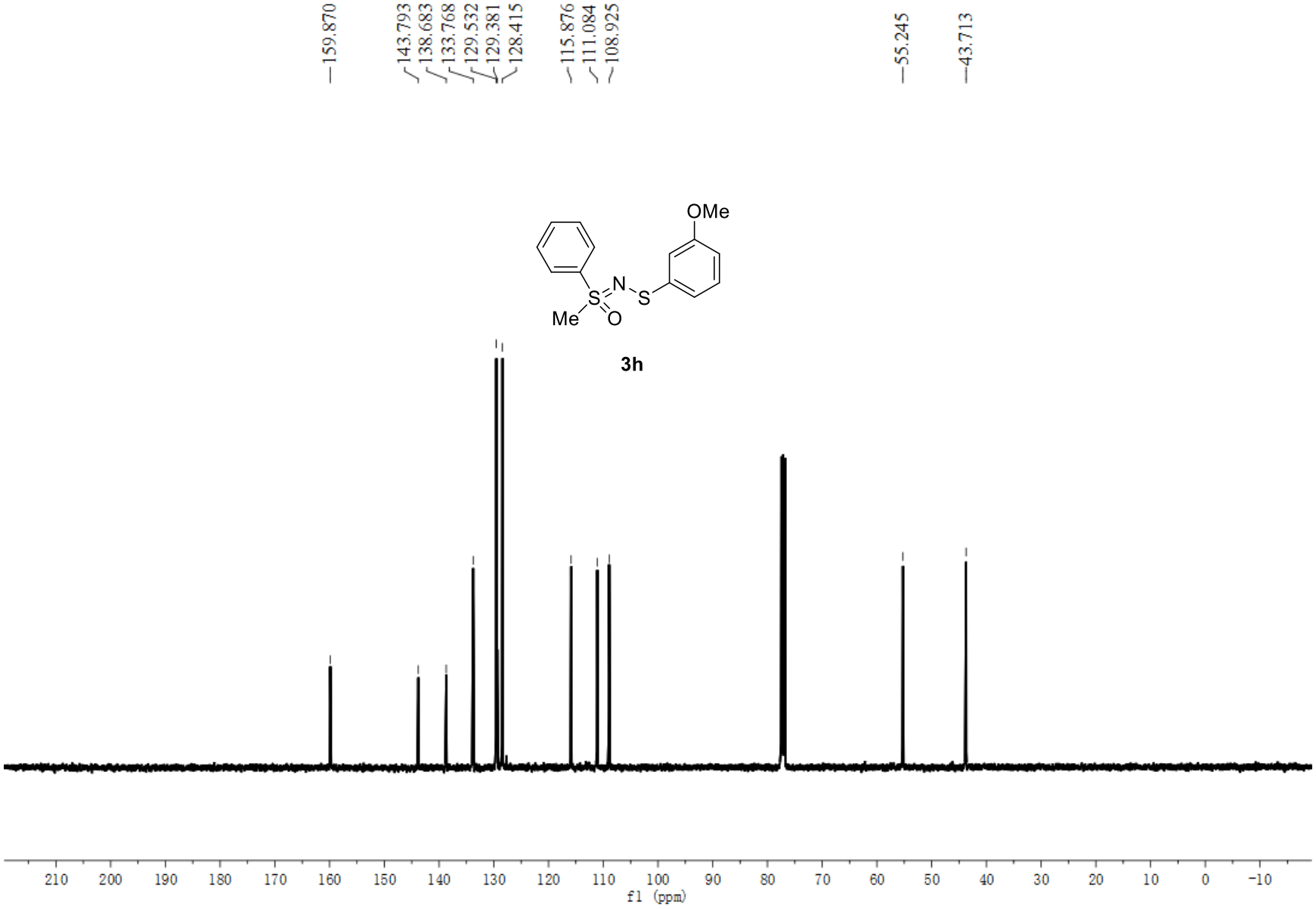


^{1}H NMR spectra of compound **3h** (400 MHz, $CDCl_3$)

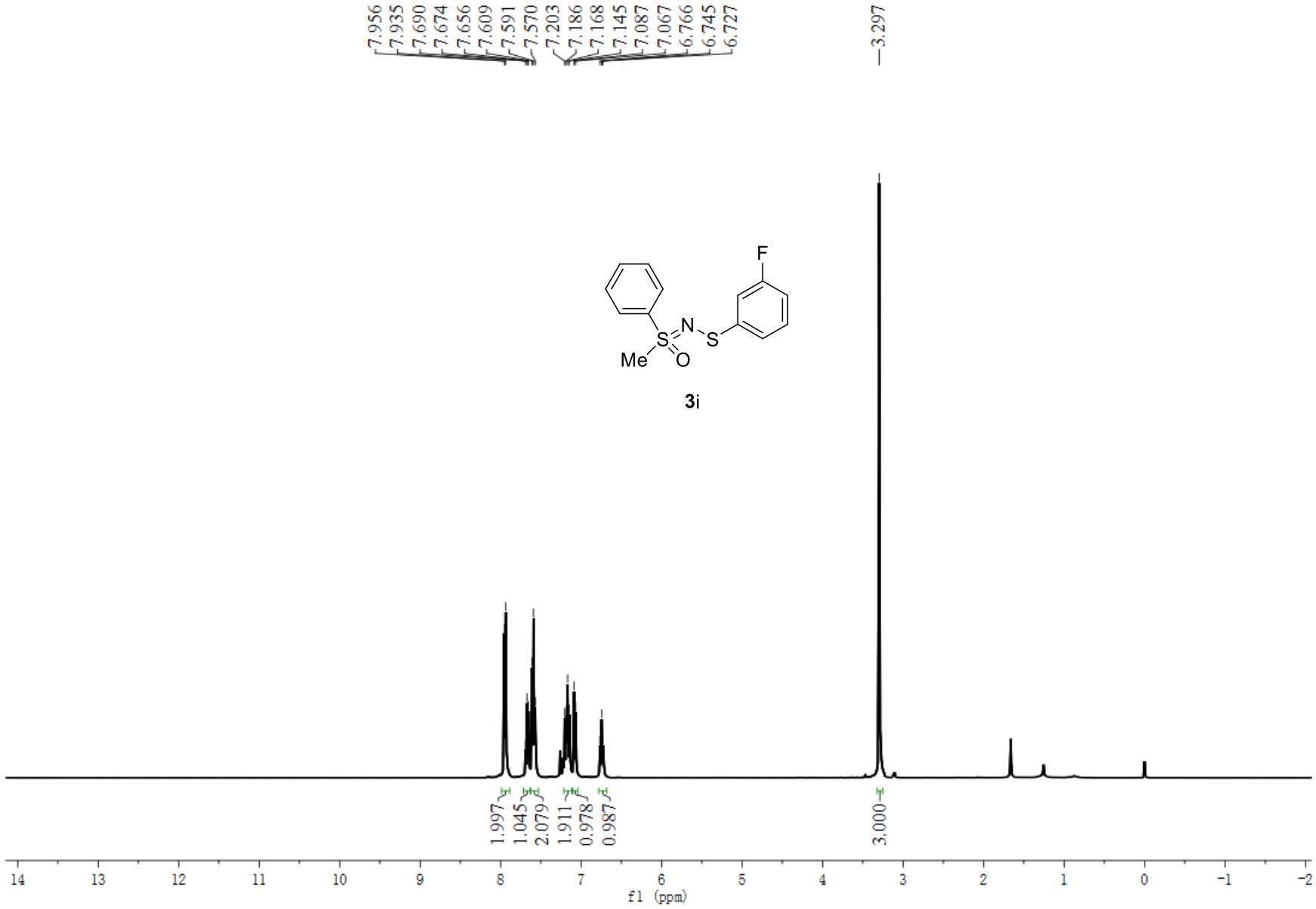


3h

^{13}C NMR spectra of compound **3h** (101 MHz, $CDCl_3$)

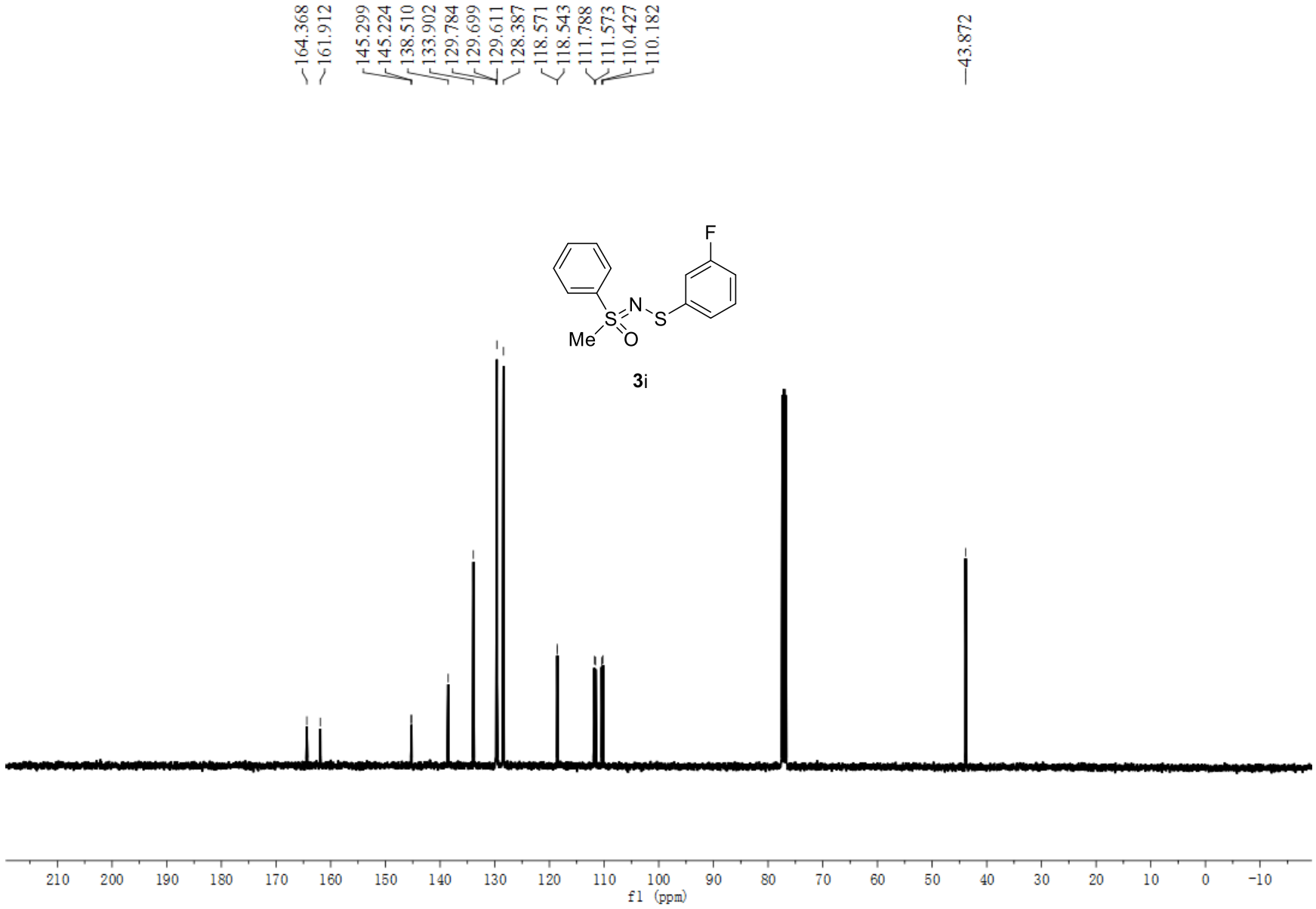


^{1}H NMR spectra of compound **3i** (400 MHz, $CDCl_3$)

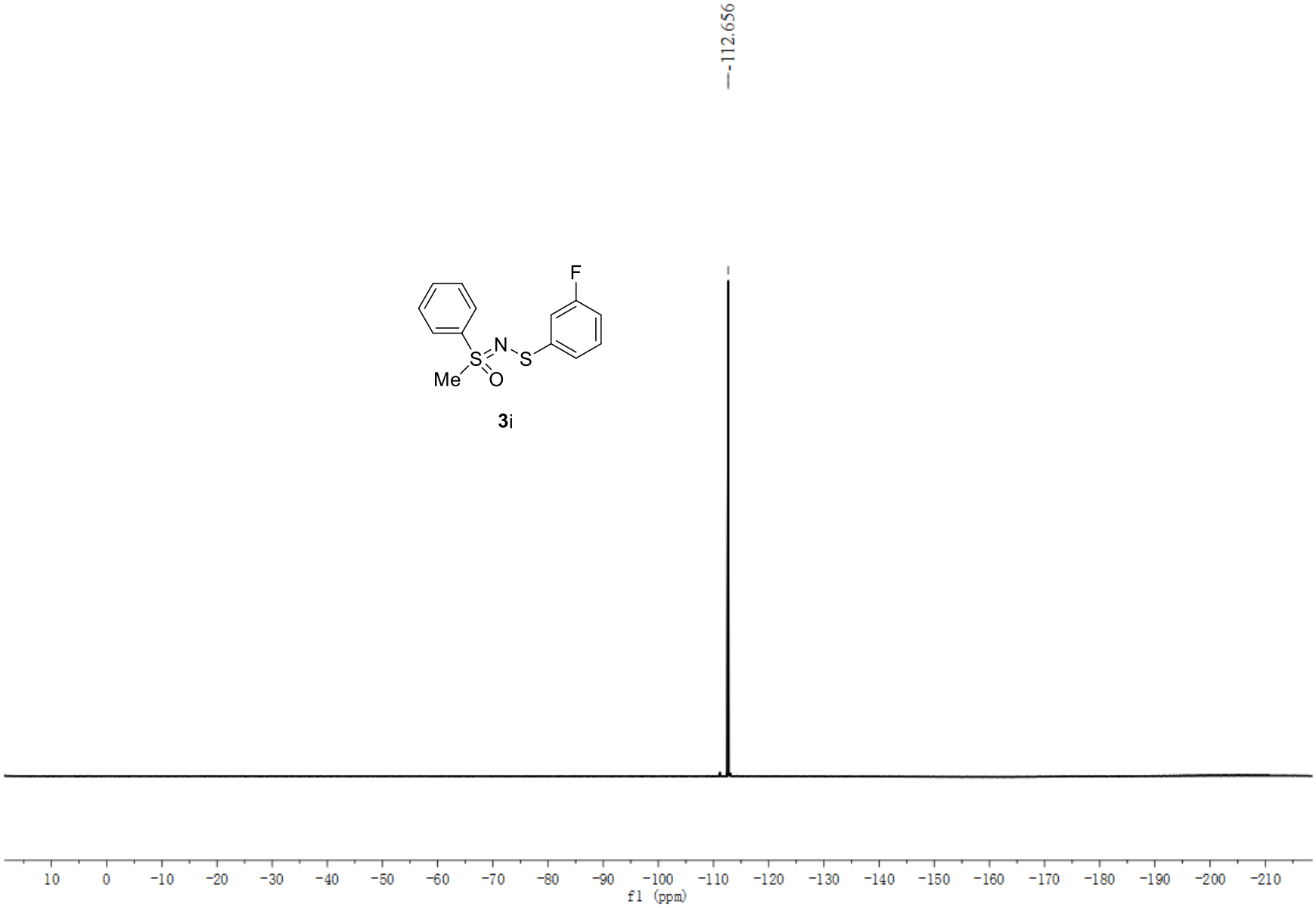


3i

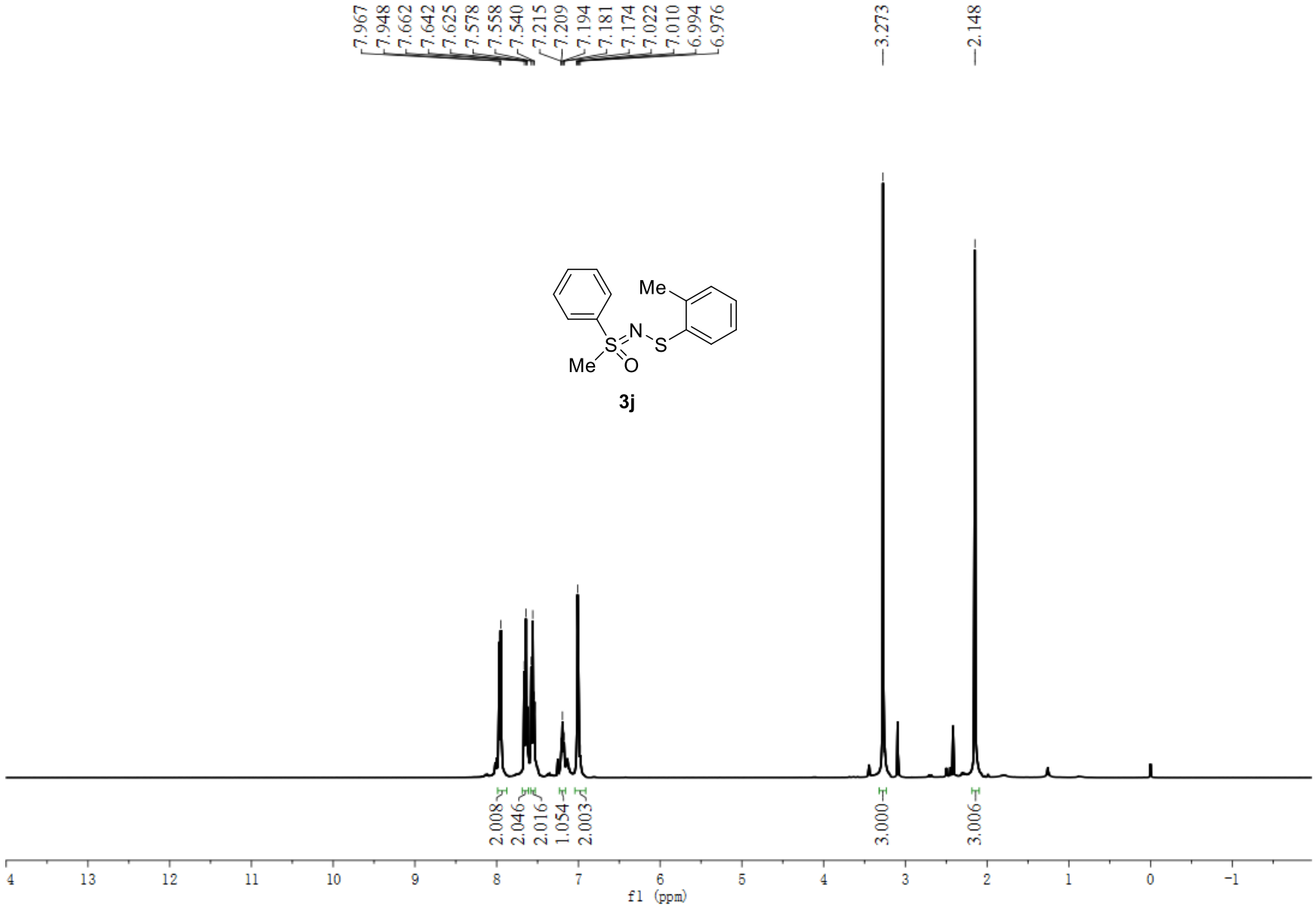
^{13}C NMR spectra of compound **3i** (101 MHz, $CDCl_3$)



^{19}F NMR spectra of compound **3i** (376 MHz, $CDCl_3$)

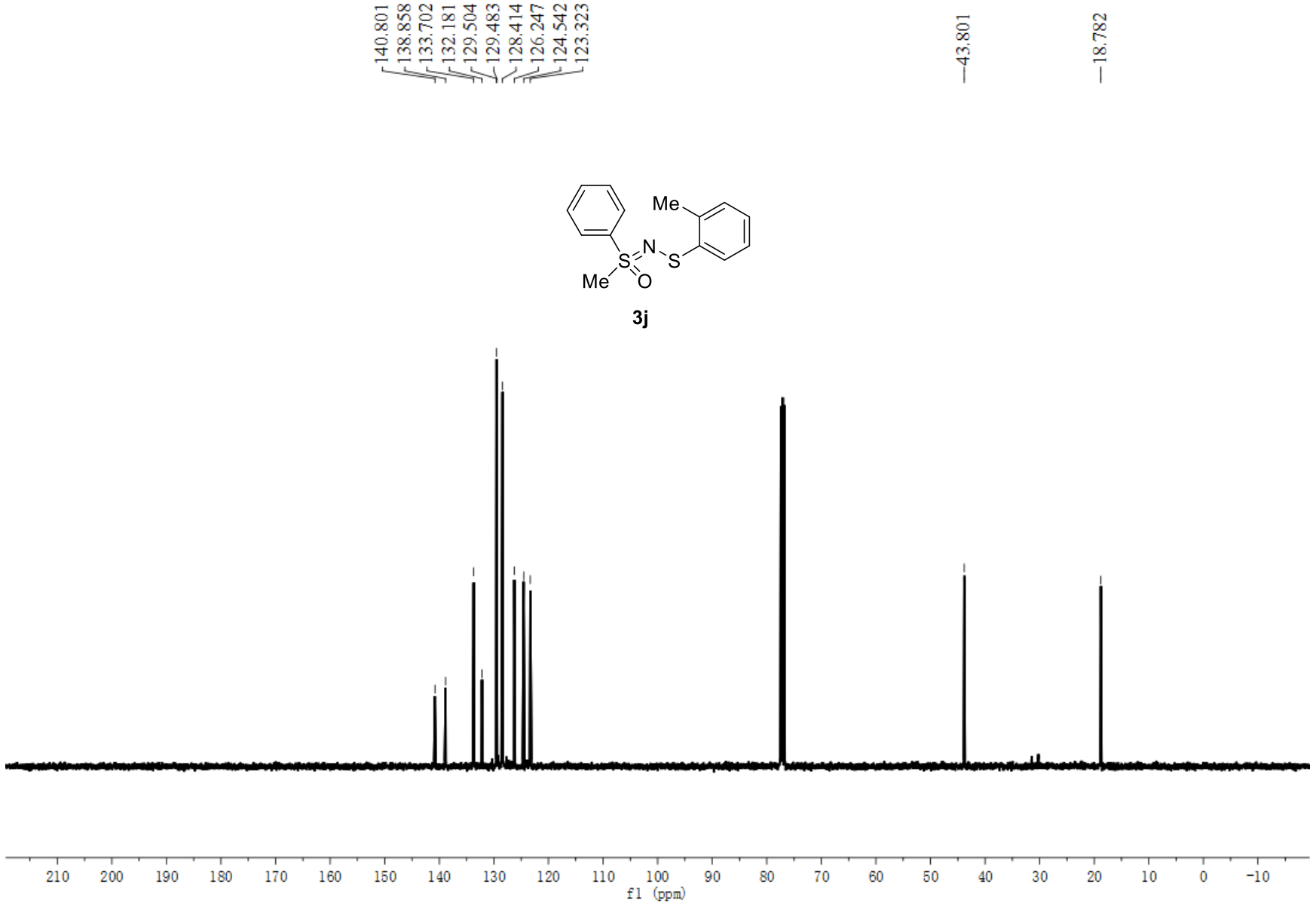


^{1}H NMR spectra of compound **3j** (400 MHz, $CDCl_3$)



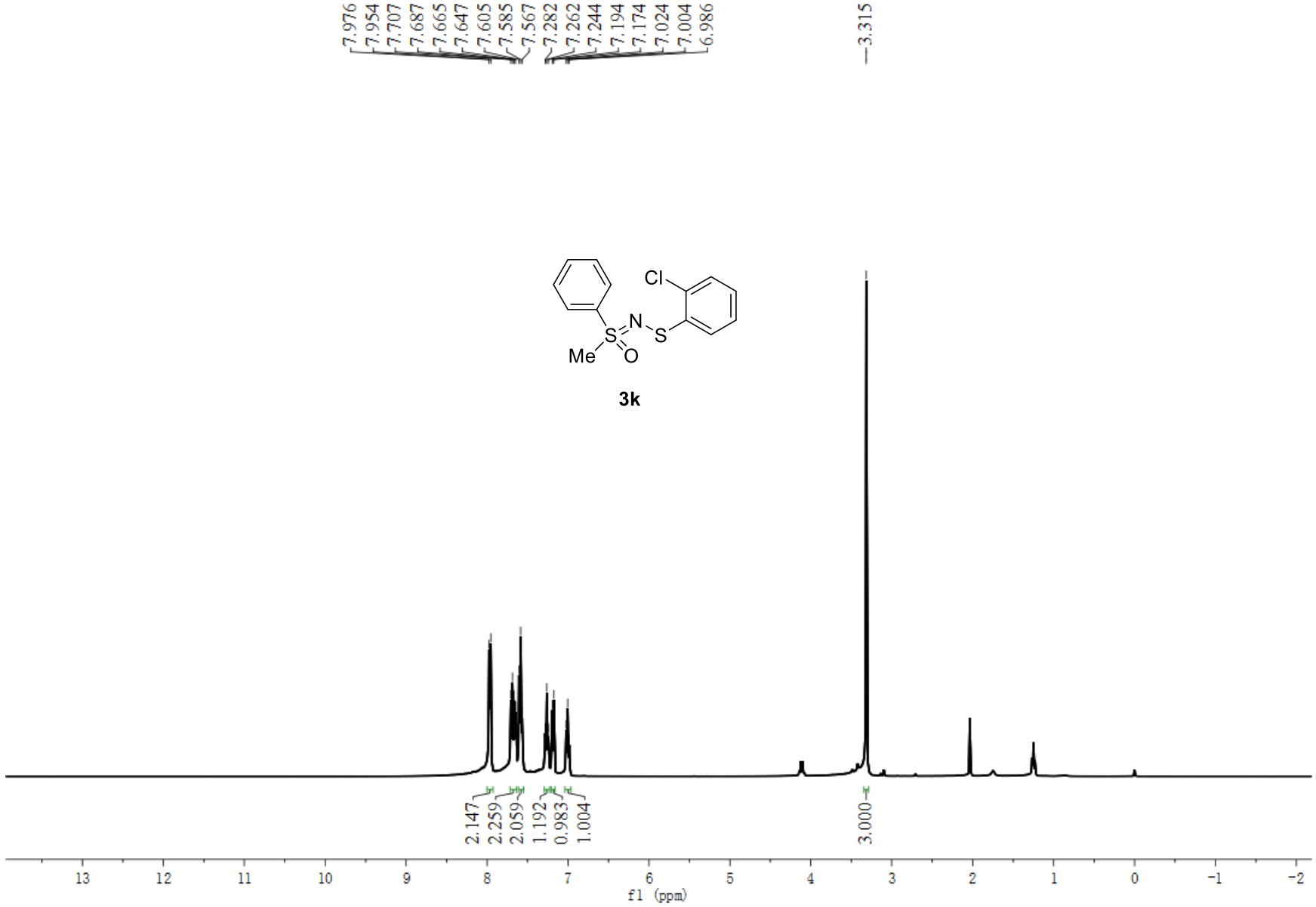
3j

^{13}C NMR spectra of compound **3j** (101 MHz, $CDCl_3$)



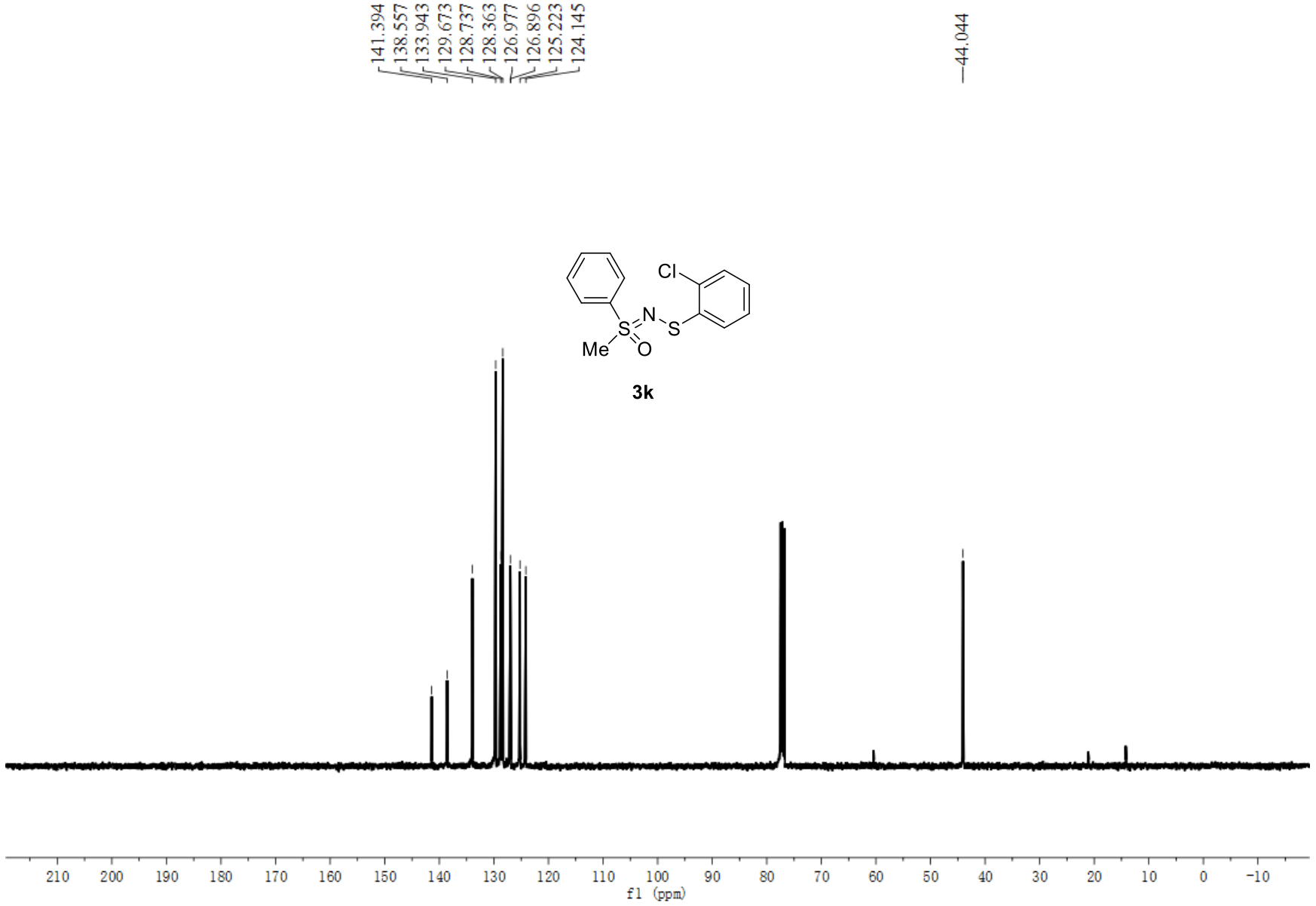
3j

^{1}H NMR spectra of compound **3k** (400 MHz, $CDCl_3$)

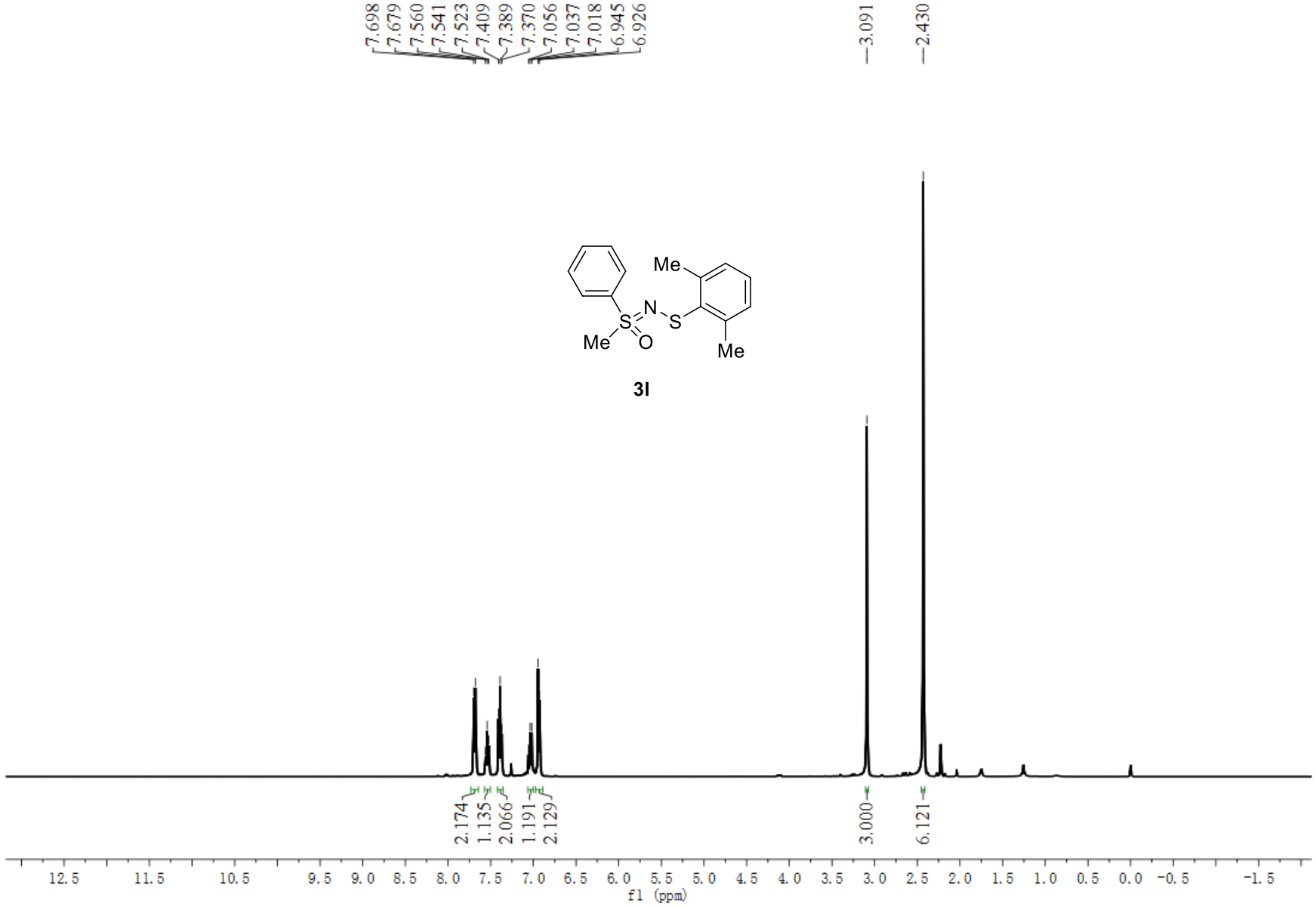


3k

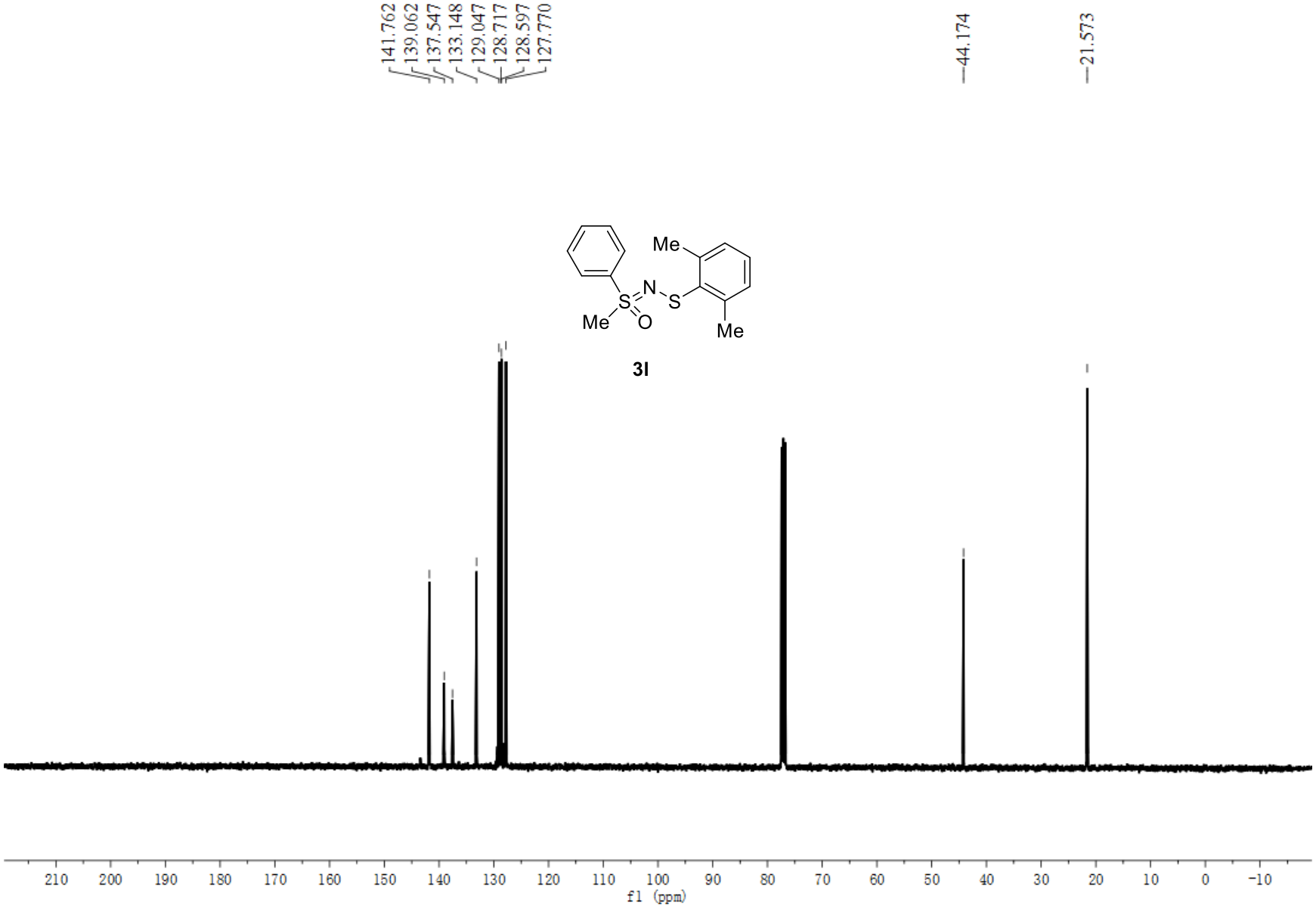
^{13}C NMR spectra of compound **3k** (101 MHz, $CDCl_3$)



^{1}H NMR spectra of compound **3l** (400 MHz, $CDCl_3$)

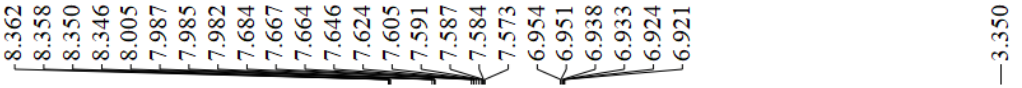


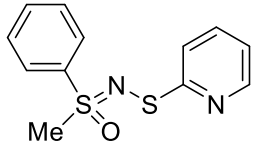
^{13}C NMR spectra of compound **3l** (101 MHz, $CDCl_3$)



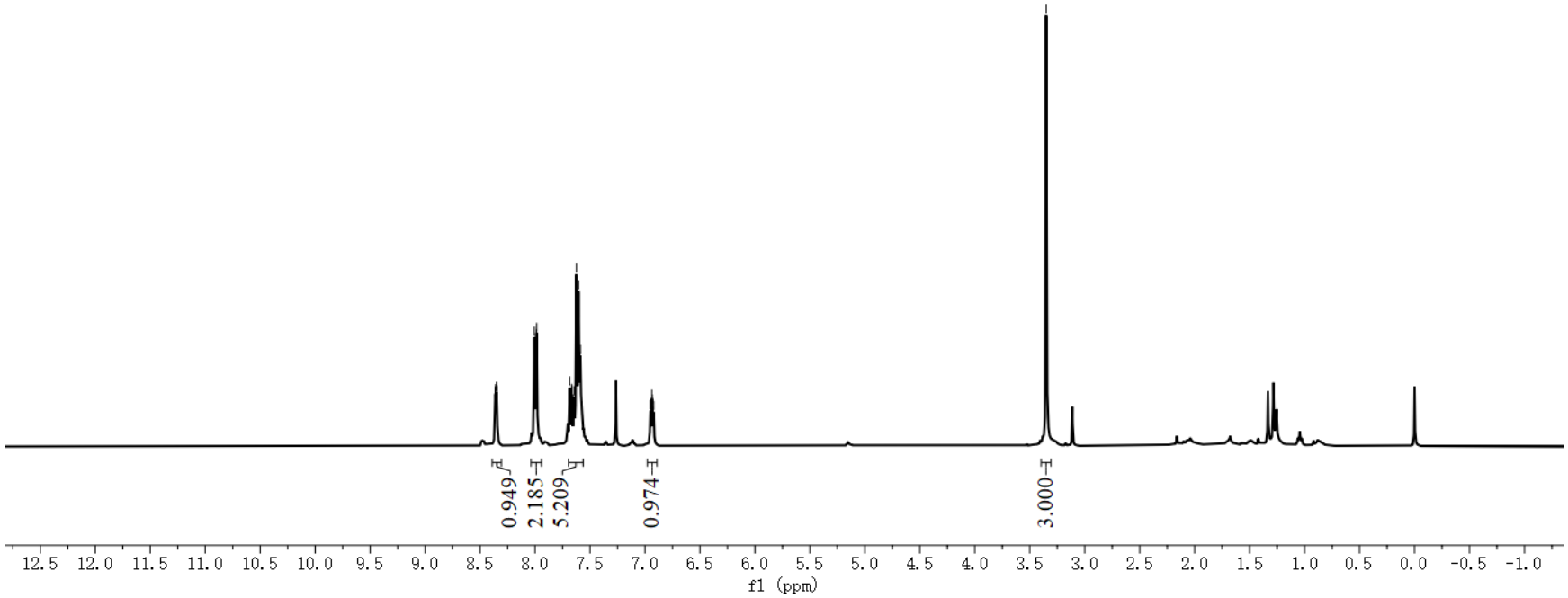
3l

^{1}H NMR spectra of compound **3m** (400 MHz, $CDCl_3$)

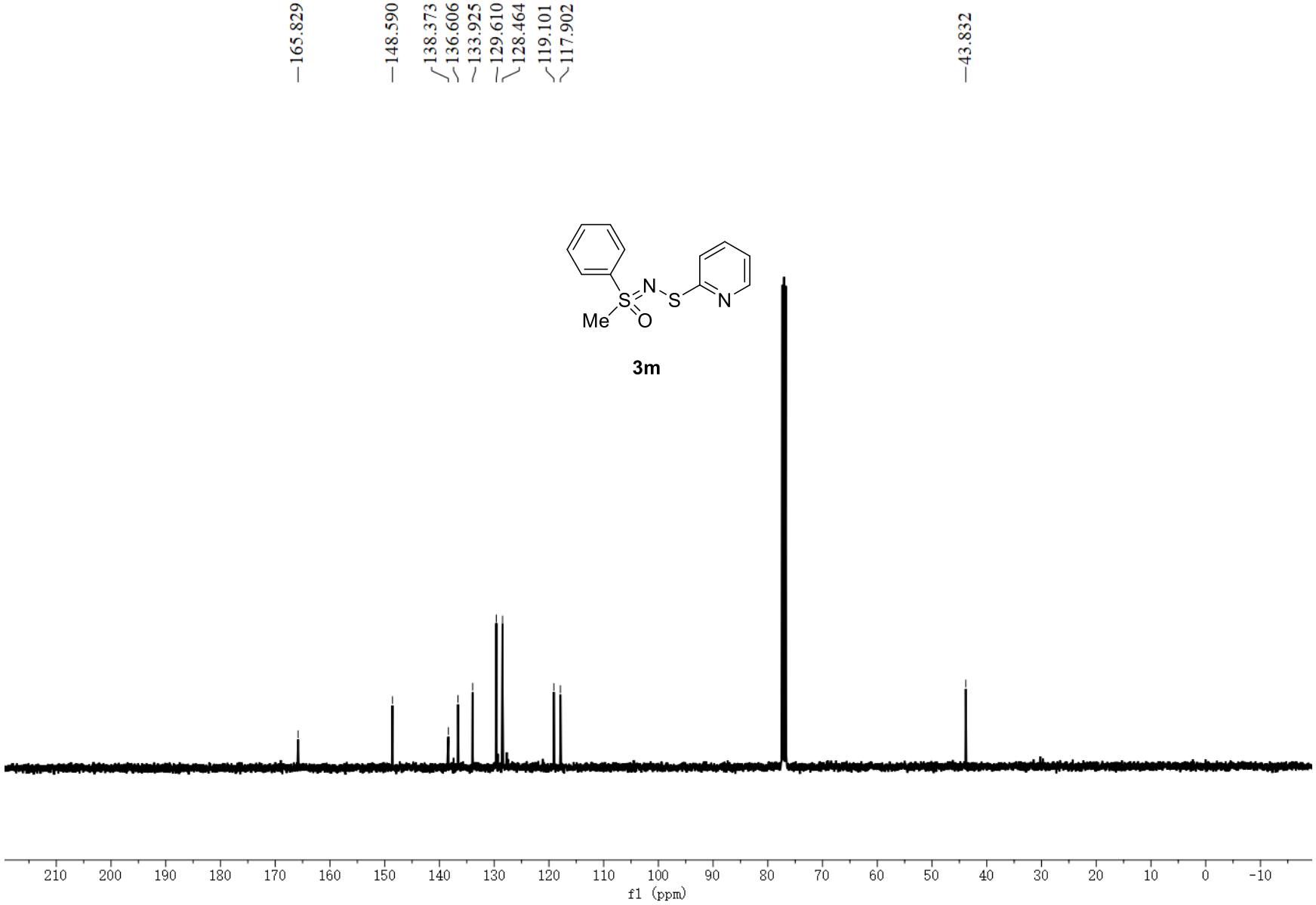




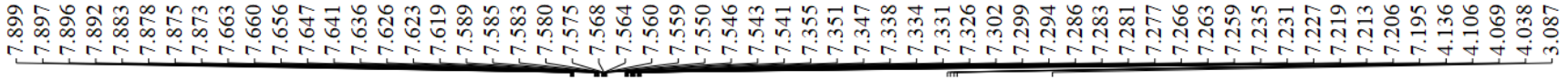
3m

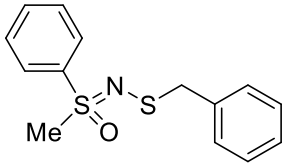


^{13}C NMR spectra of compound **3m** (101 MHz, $CDCl_3$)

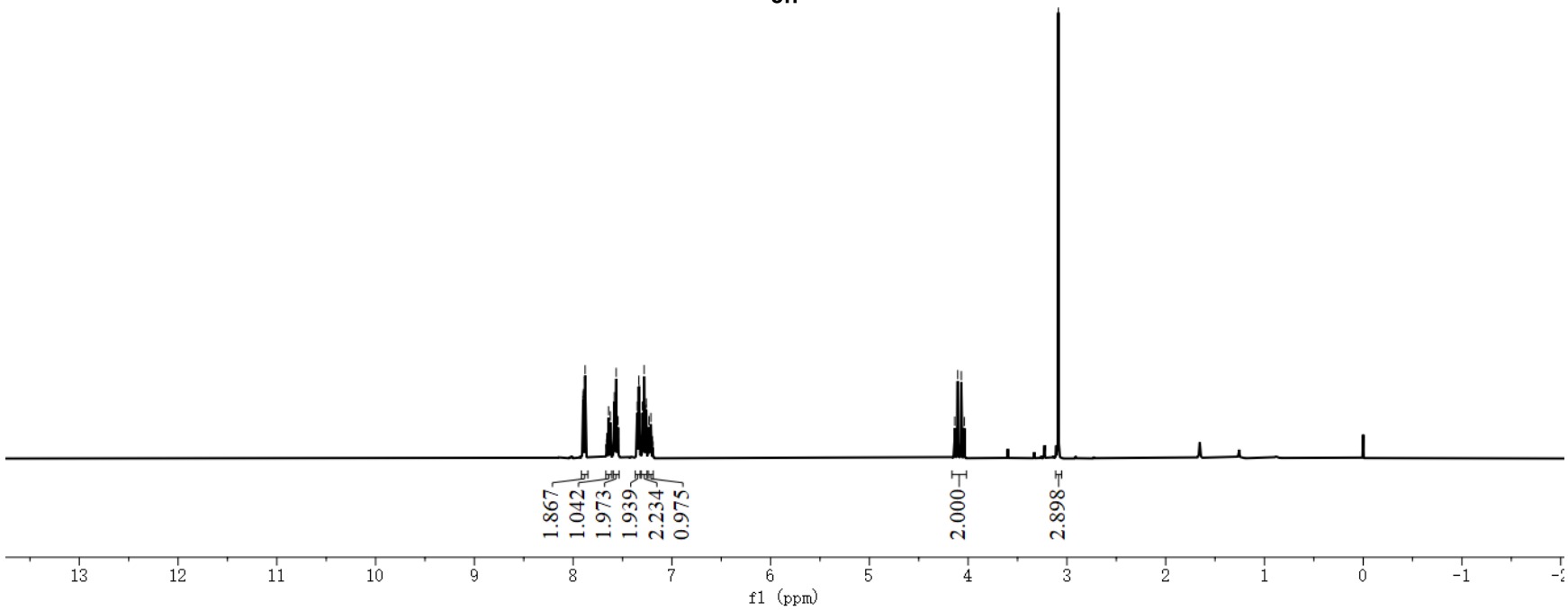


^{1}H NMR spectra of compound **3n** (400 MHz, $CDCl_3$)

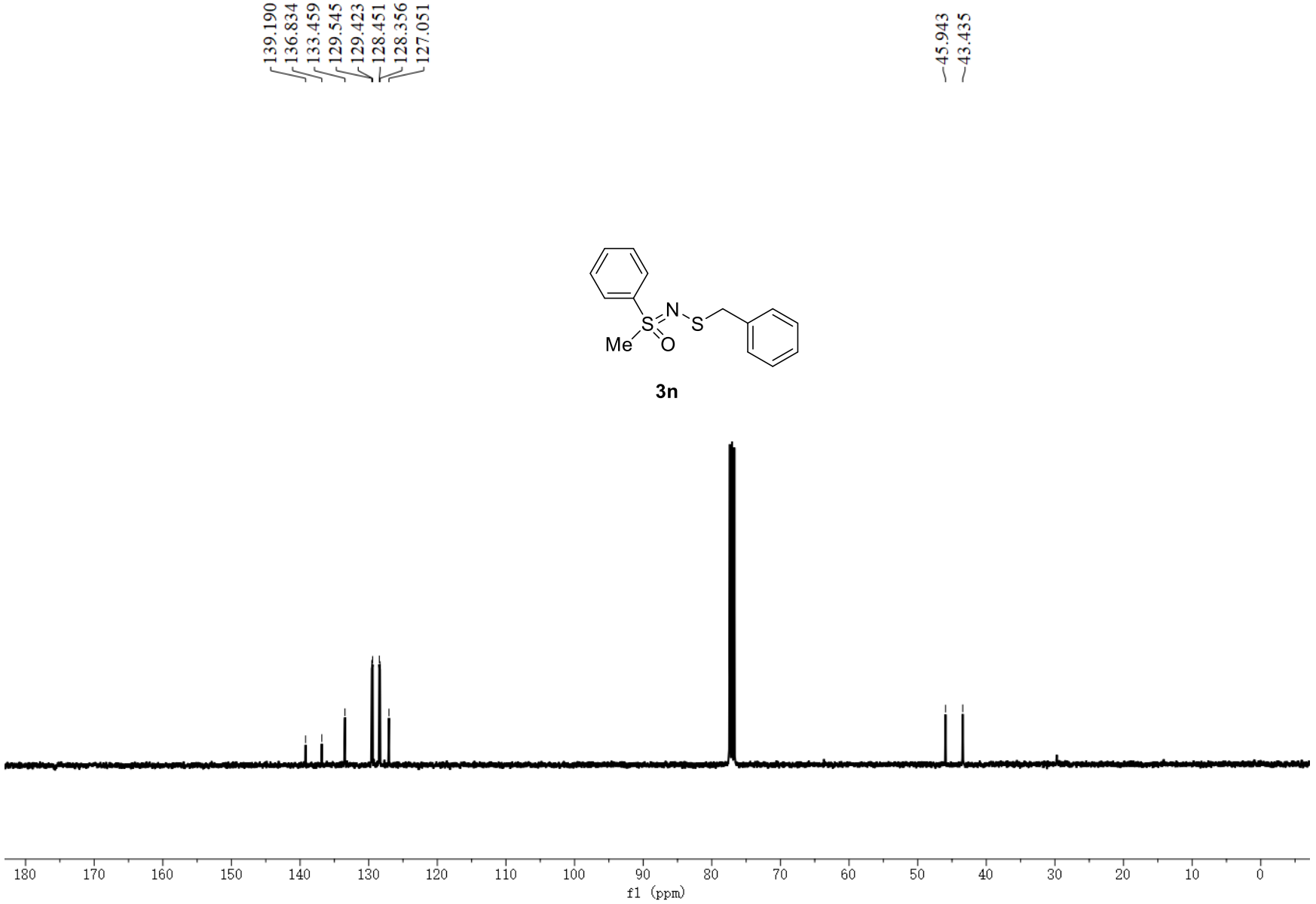




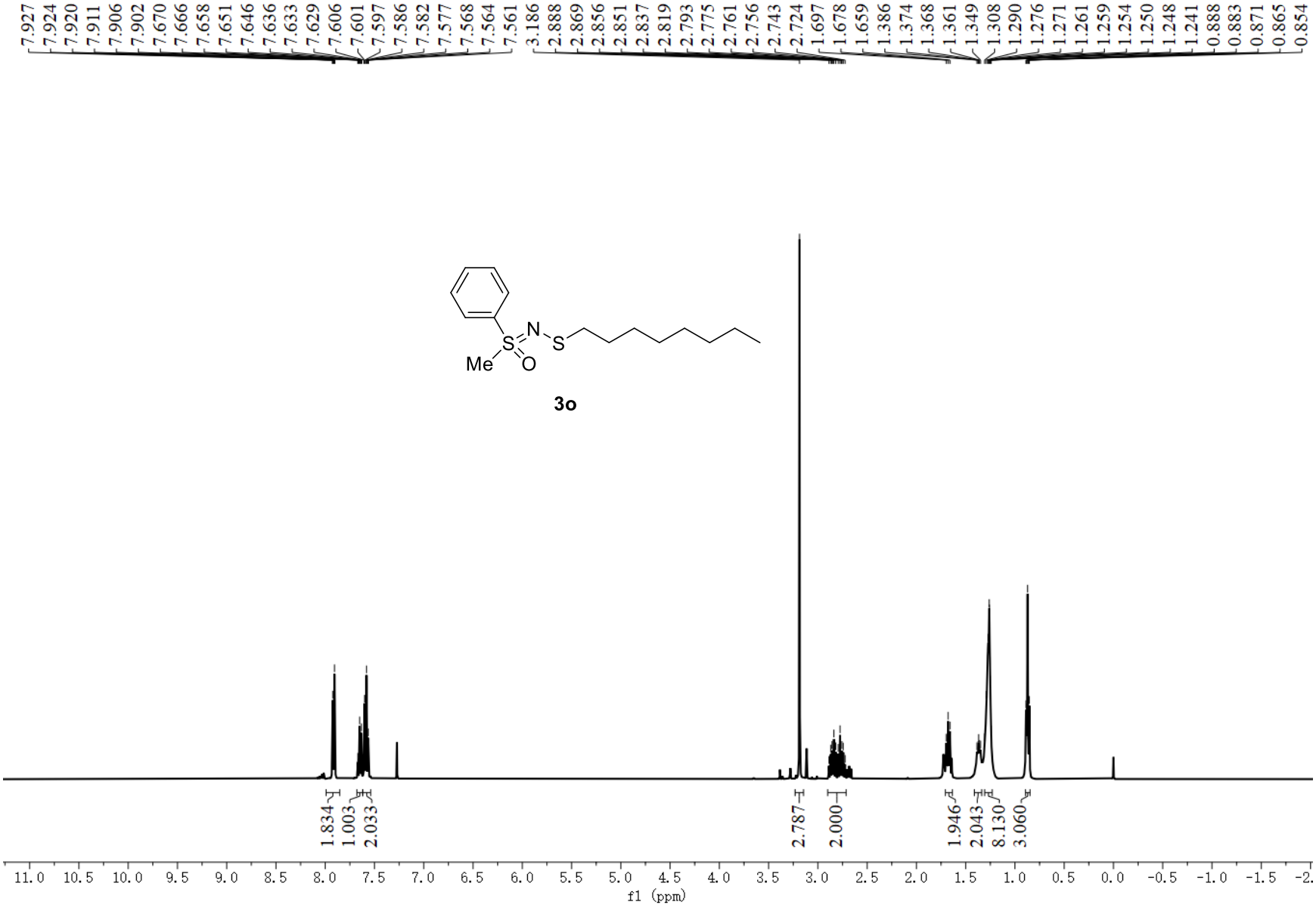
3n



^{13}C NMR spectra of compound **3n** (101 MHz, $CDCl_3$)

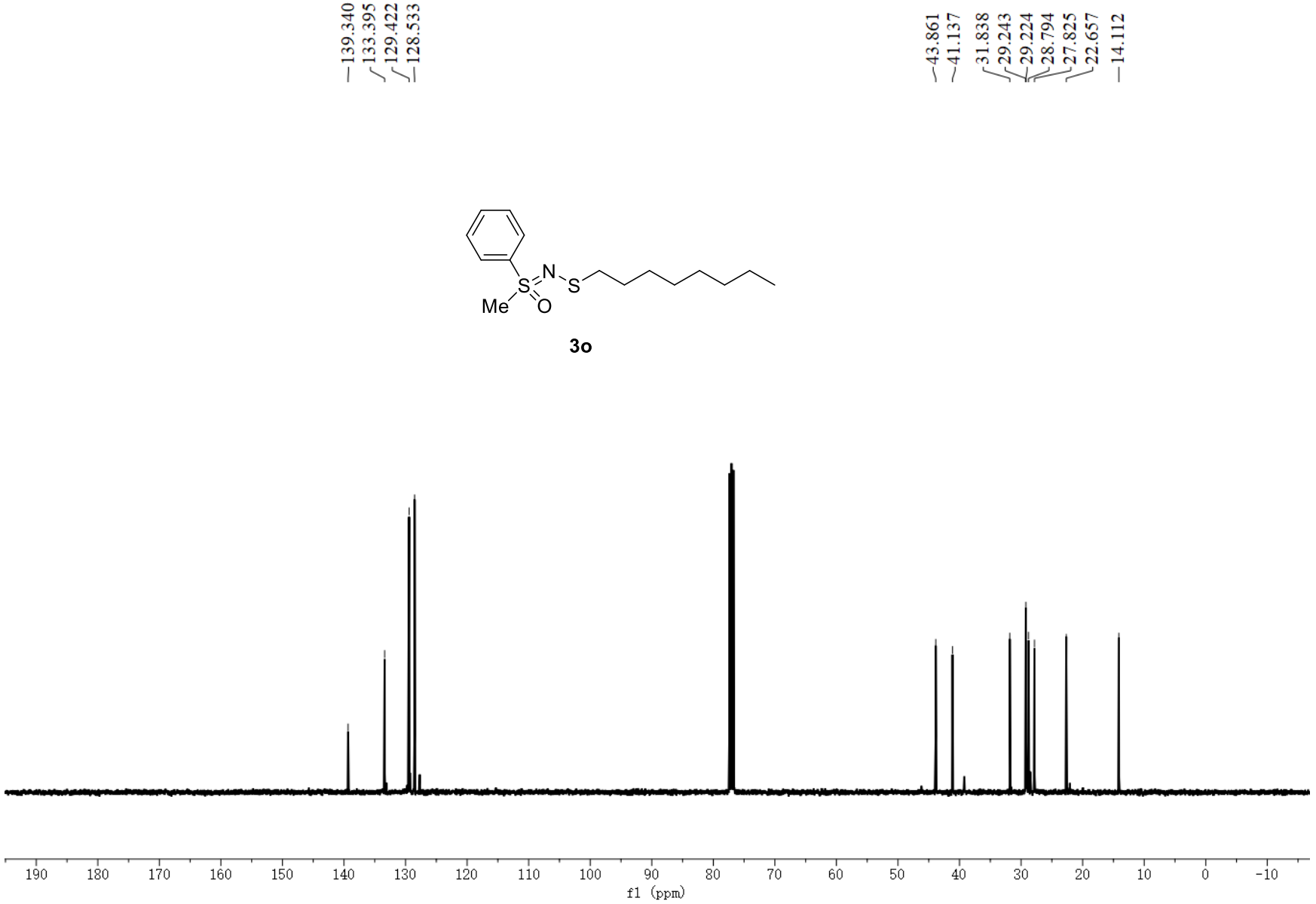


^{1}H NMR spectra of compound **3o** (400 MHz, $CDCl_3$)



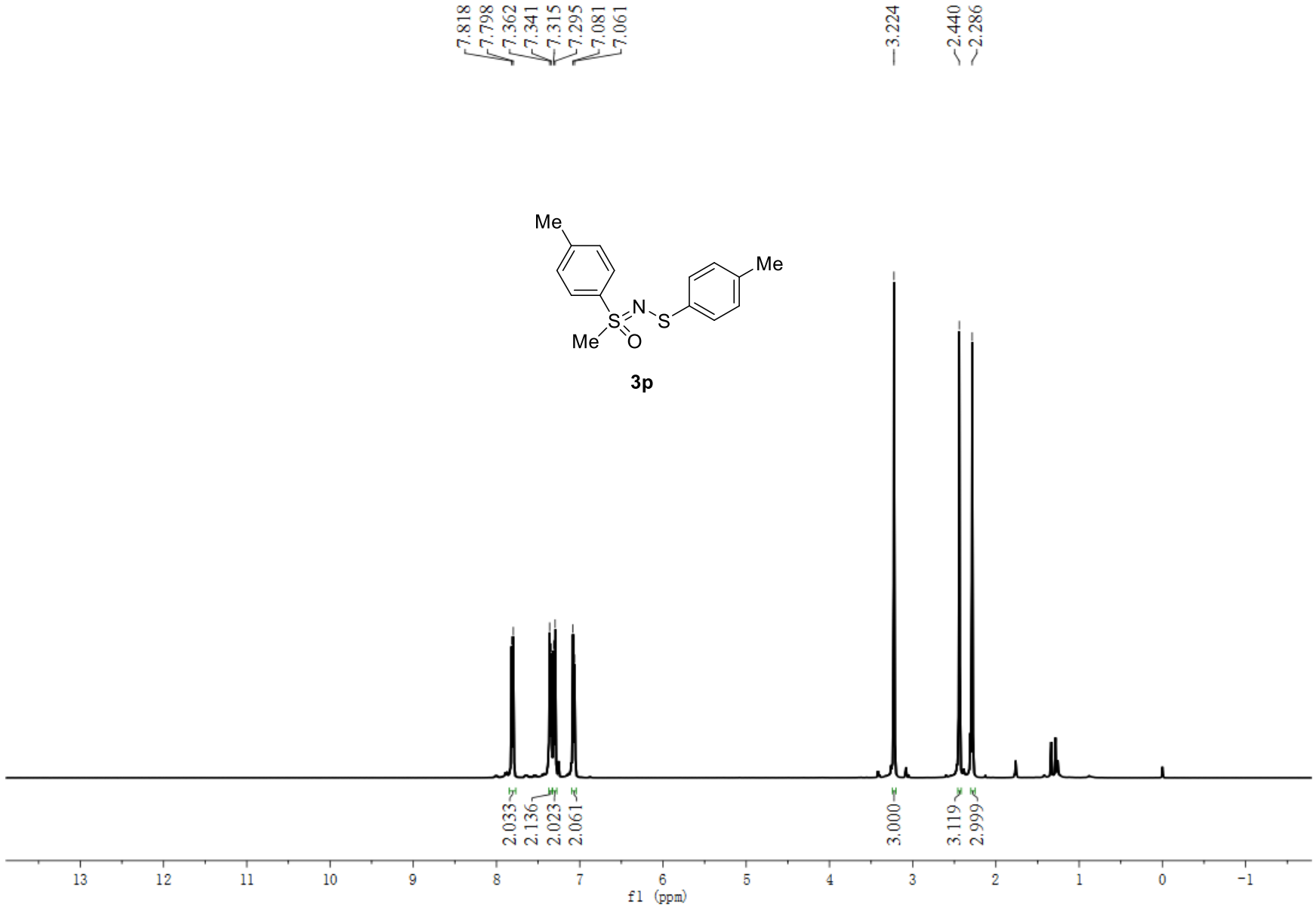
^{13}C

NMR spectra of compound **3o** (101 MHz, $CDCl_3$)



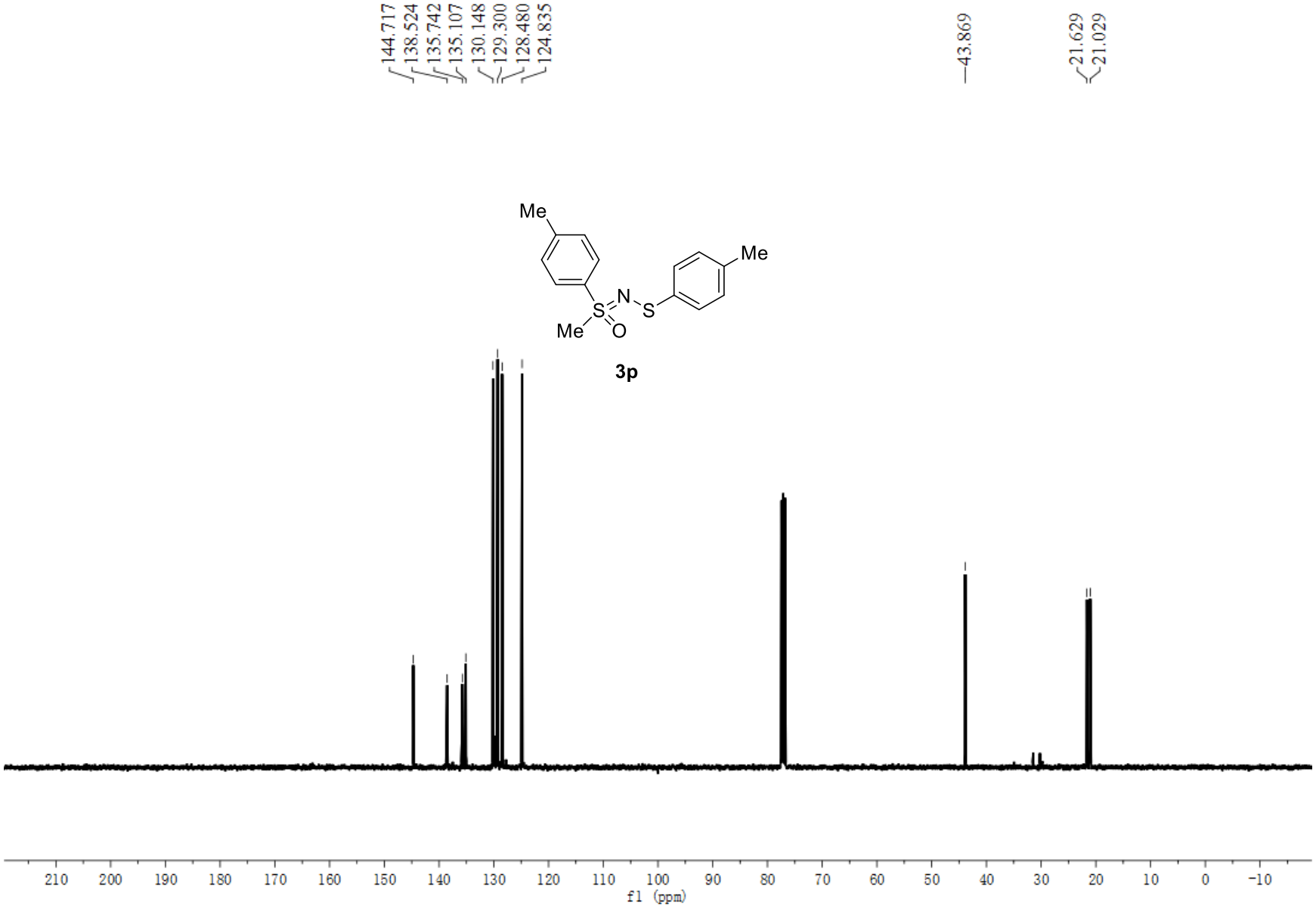
3o

^{1}H NMR spectra of compound **3p** (400 MHz, $CDCl_3$)

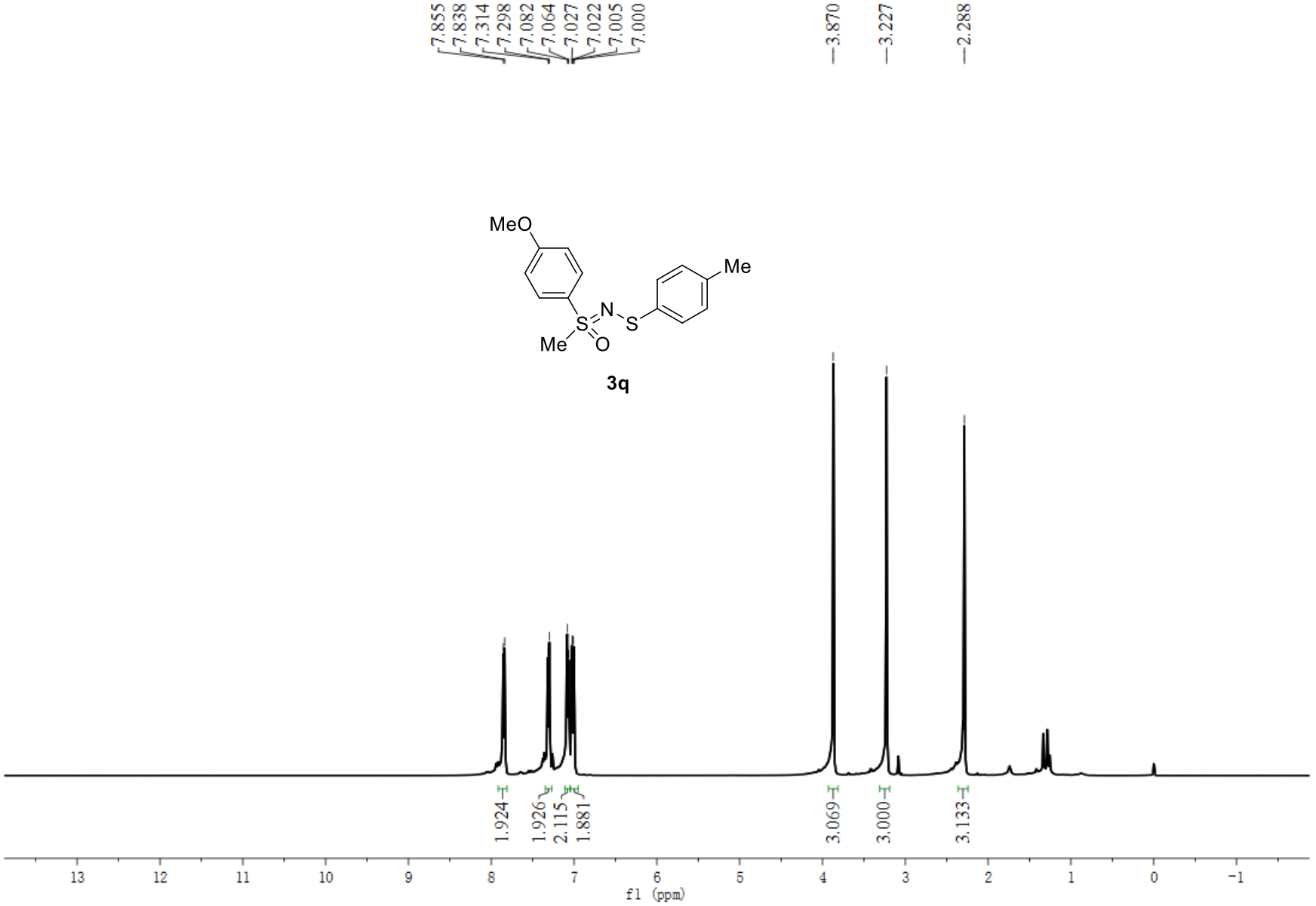


3p

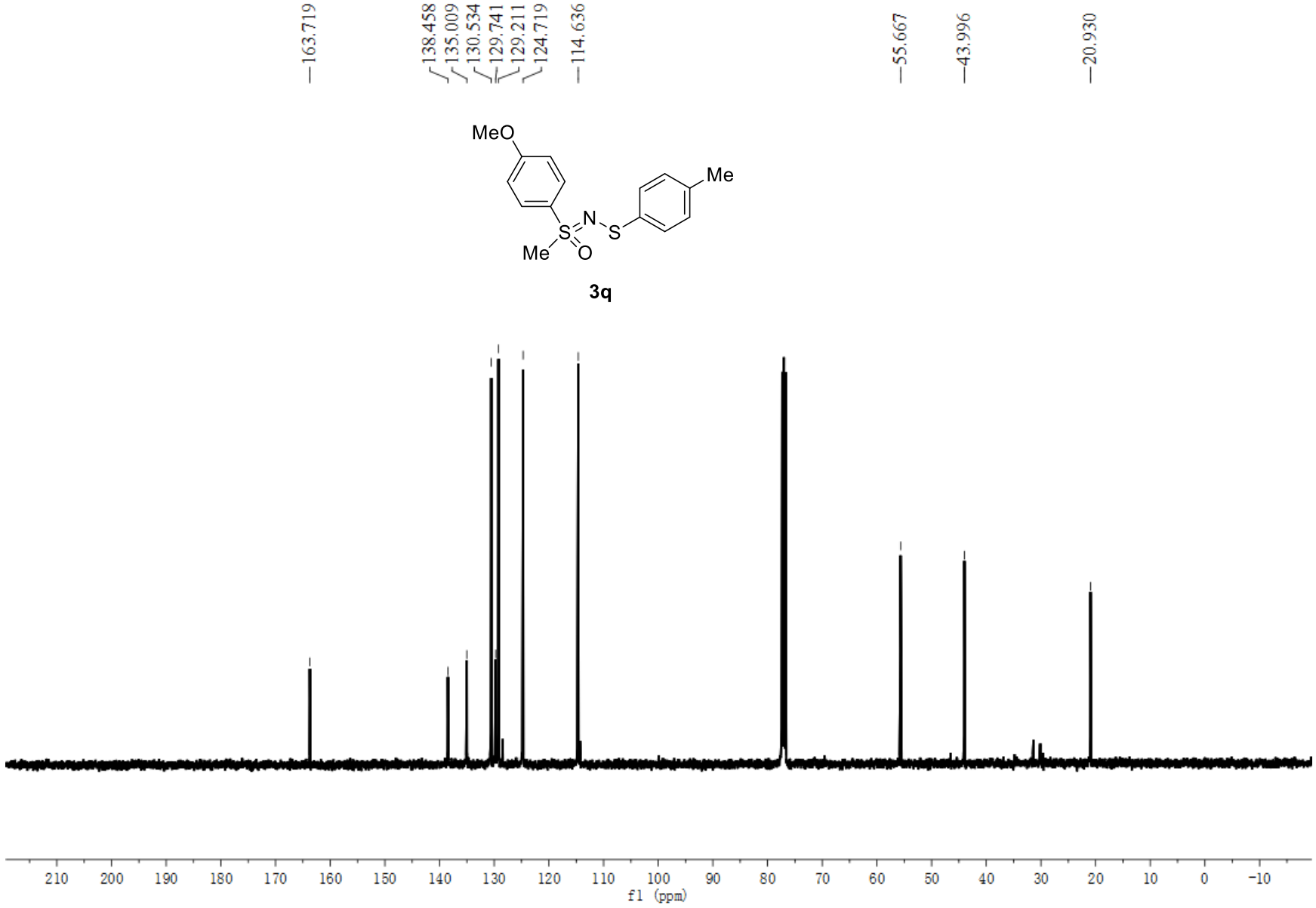
^{13}C NMR spectra of compound **3p** (101 MHz, $CDCl_3$)



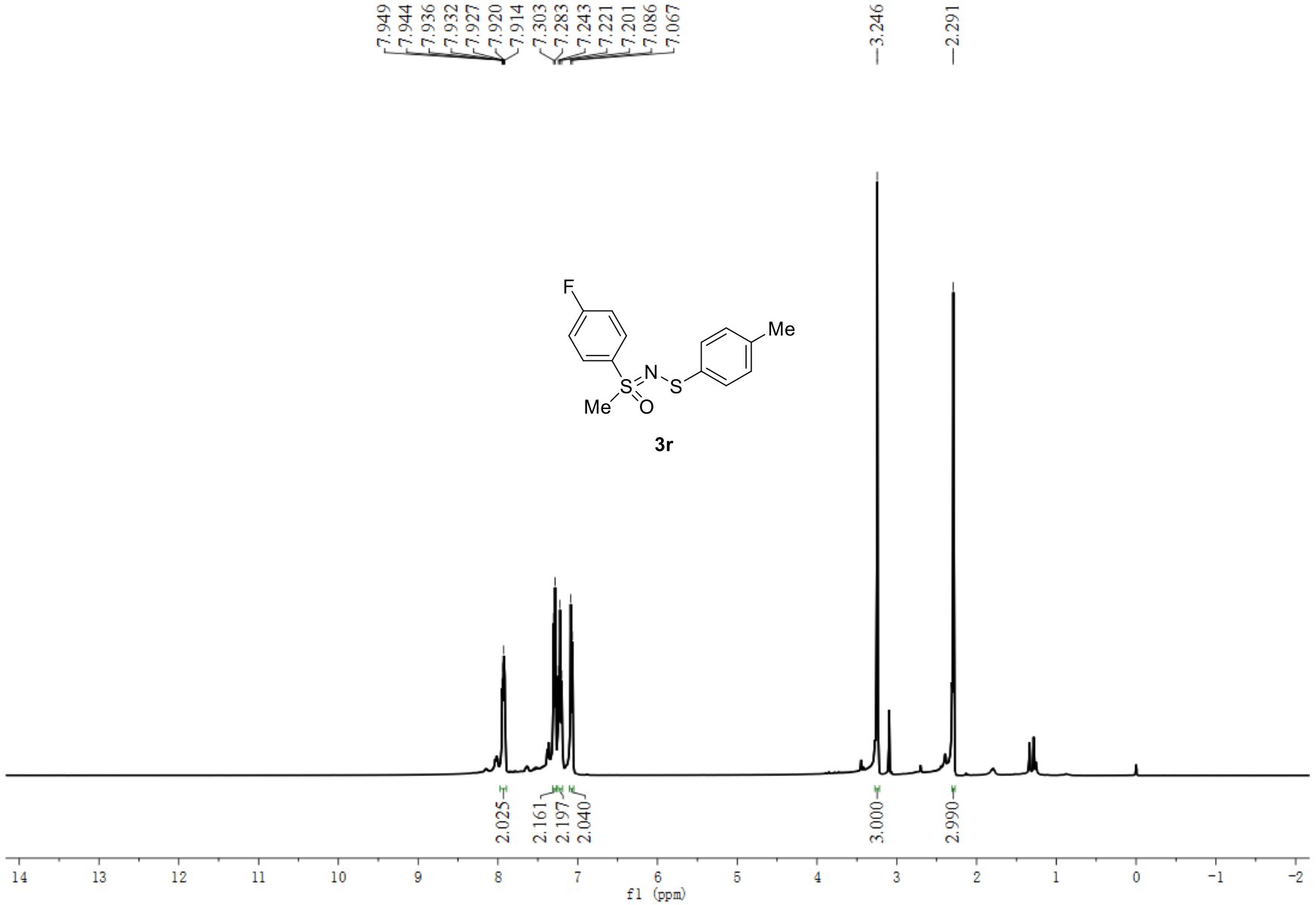
^{1}H NMR spectra of compound **3q** (400 MHz, $CDCl_3$)



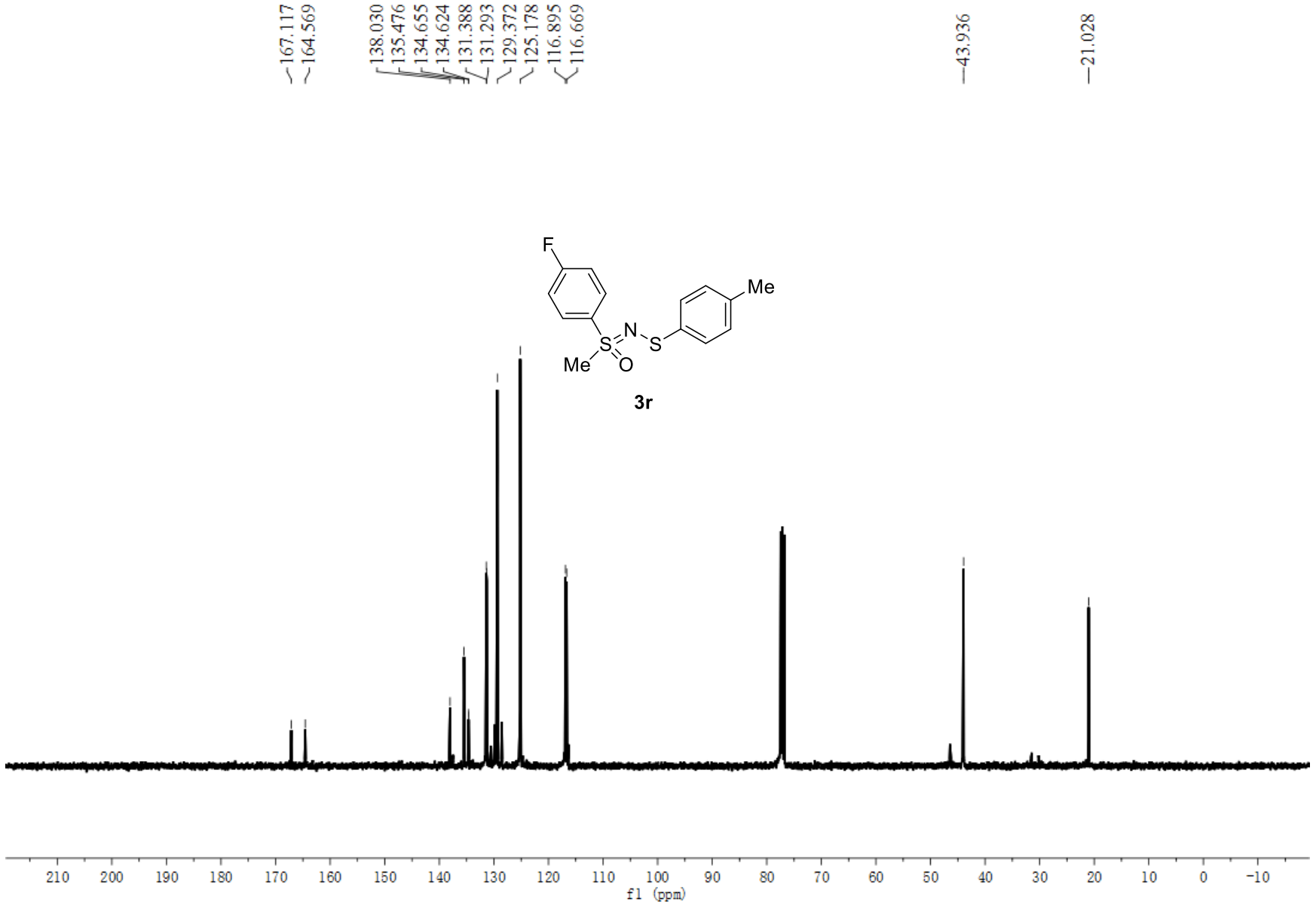
^{13}C NMR spectra of compound **3q** (101 MHz, $CDCl_3$)



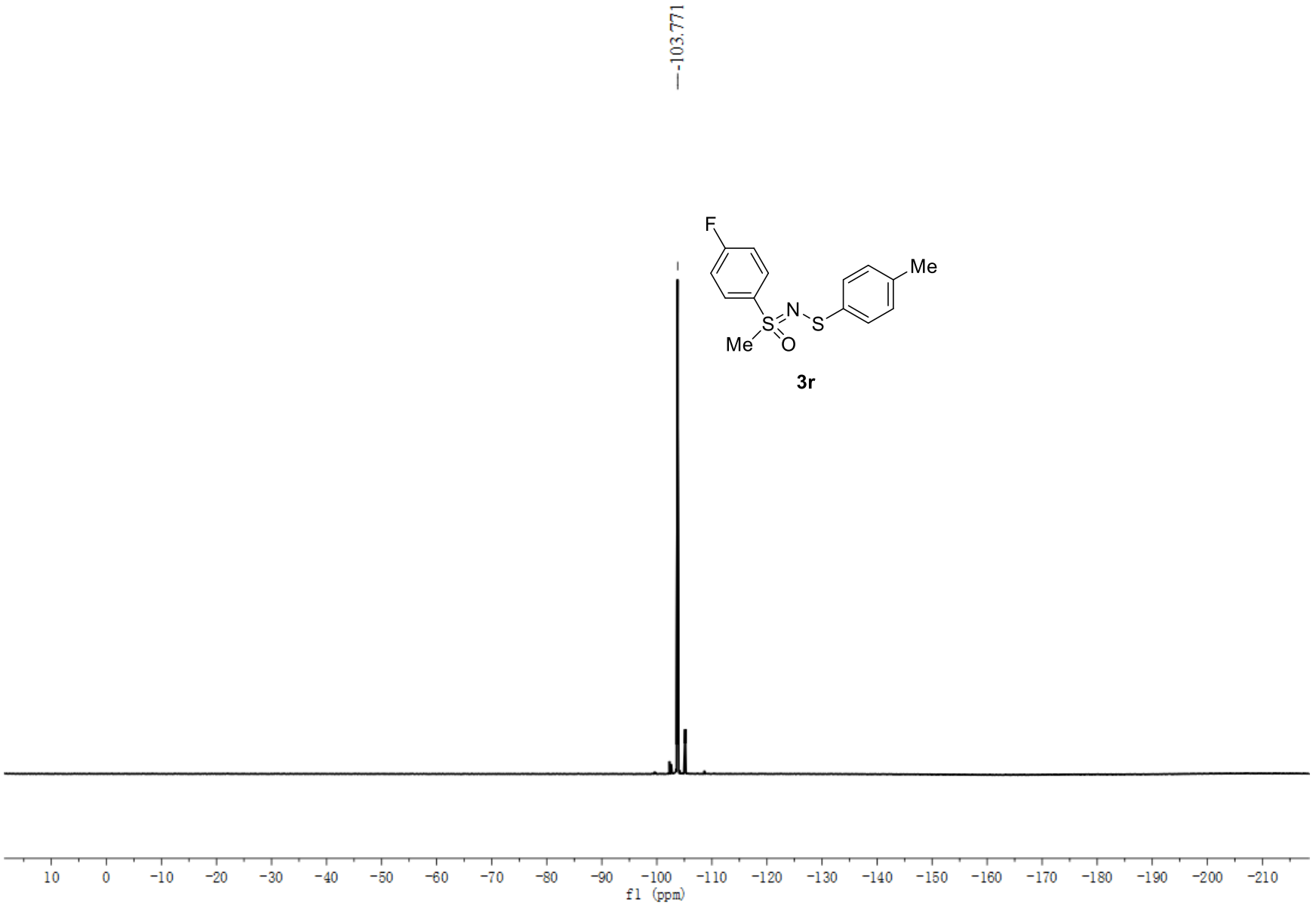
^{1}H NMR spectra of compound **3r** (400 MHz, $CDCl_3$)



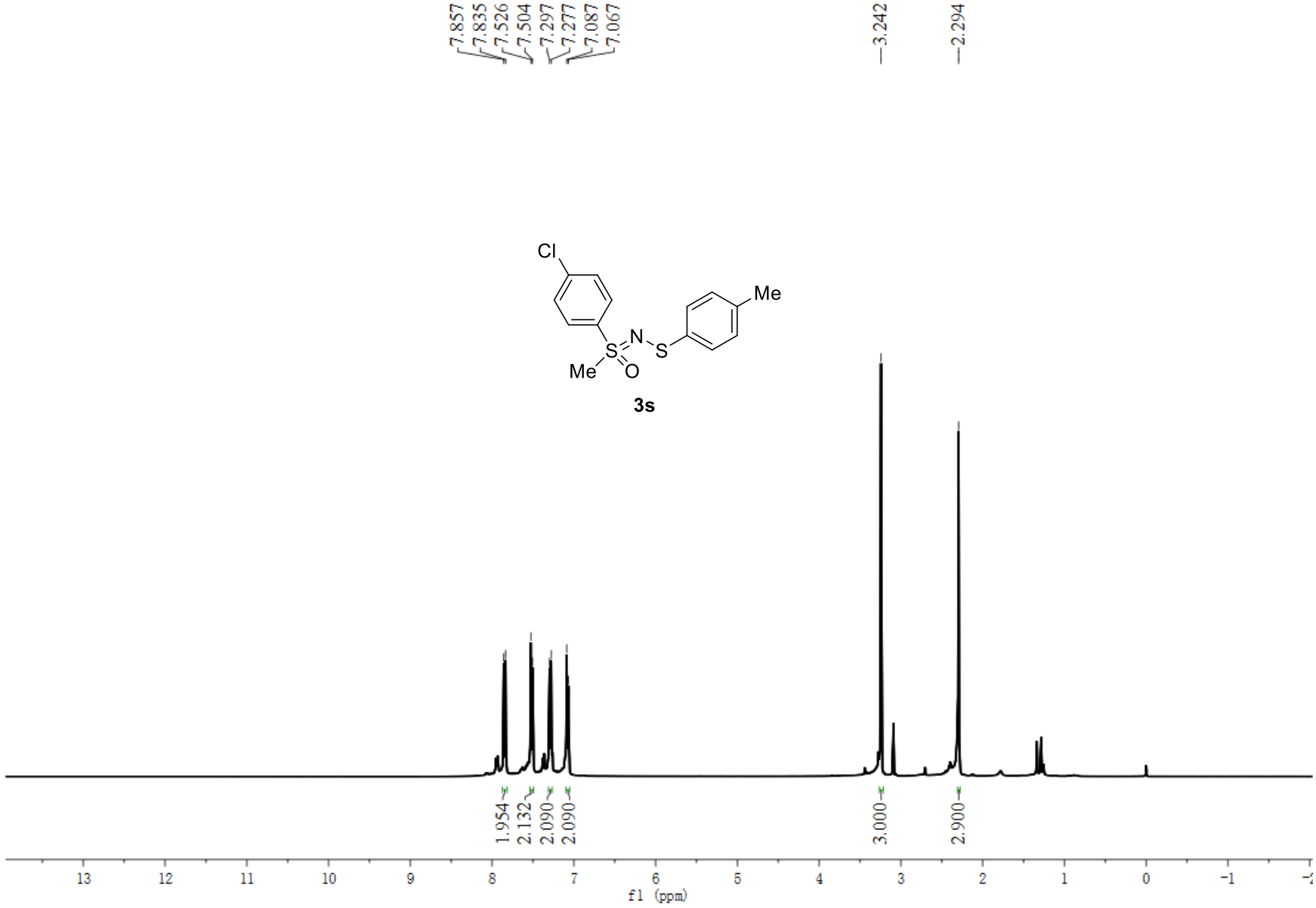
^{13}C NMR spectra of compound **3r** (101 MHz, $CDCl_3$)



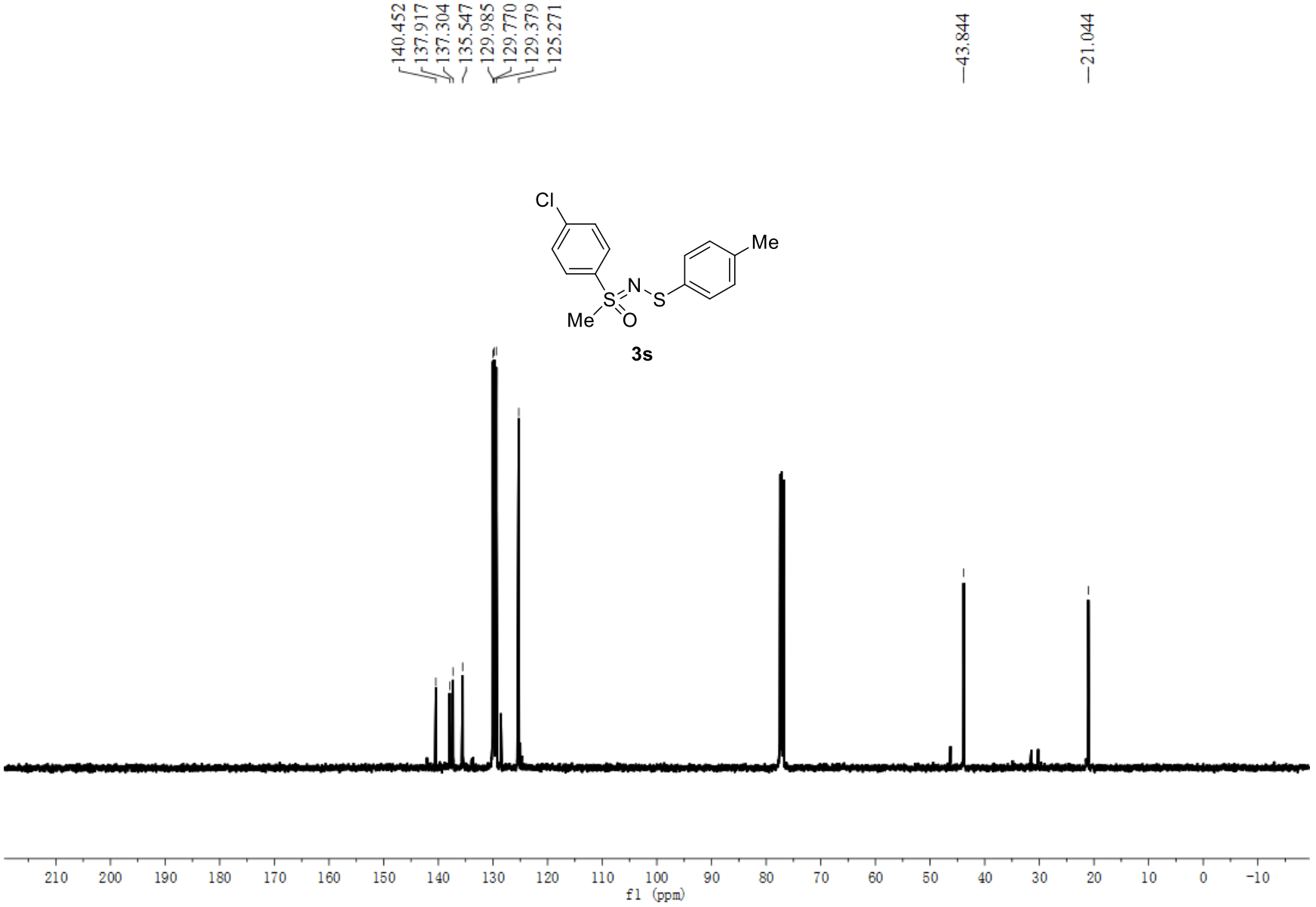
^{19}F NMR spectra of compound **3r** (376 MHz, $CDCl_3$)



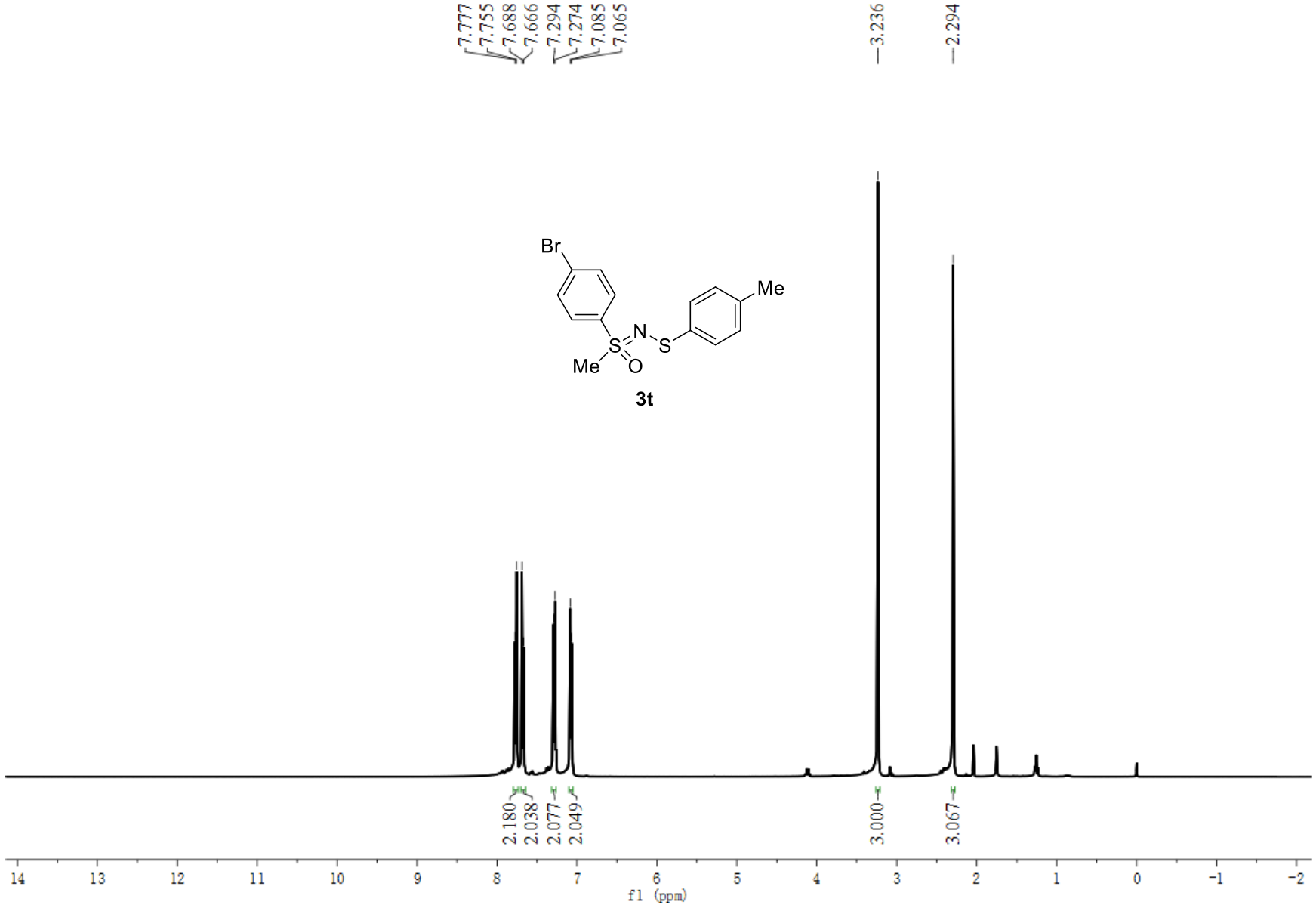
^{1}H NMR spectra of compound **3s** (400 MHz, $CDCl_3$)



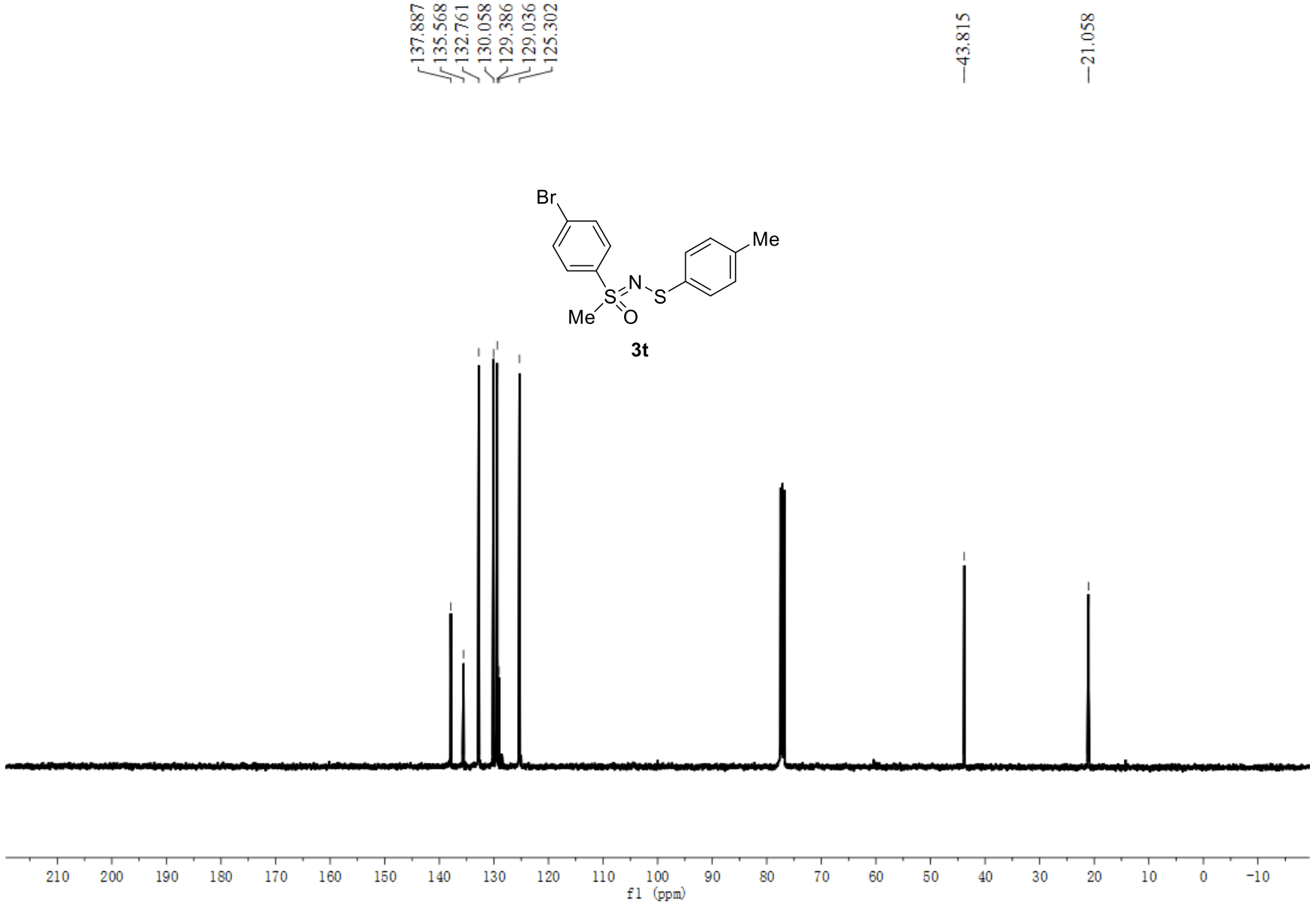
^{13}C NMR spectra of compound **3s** (101 MHz, $CDCl_3$)



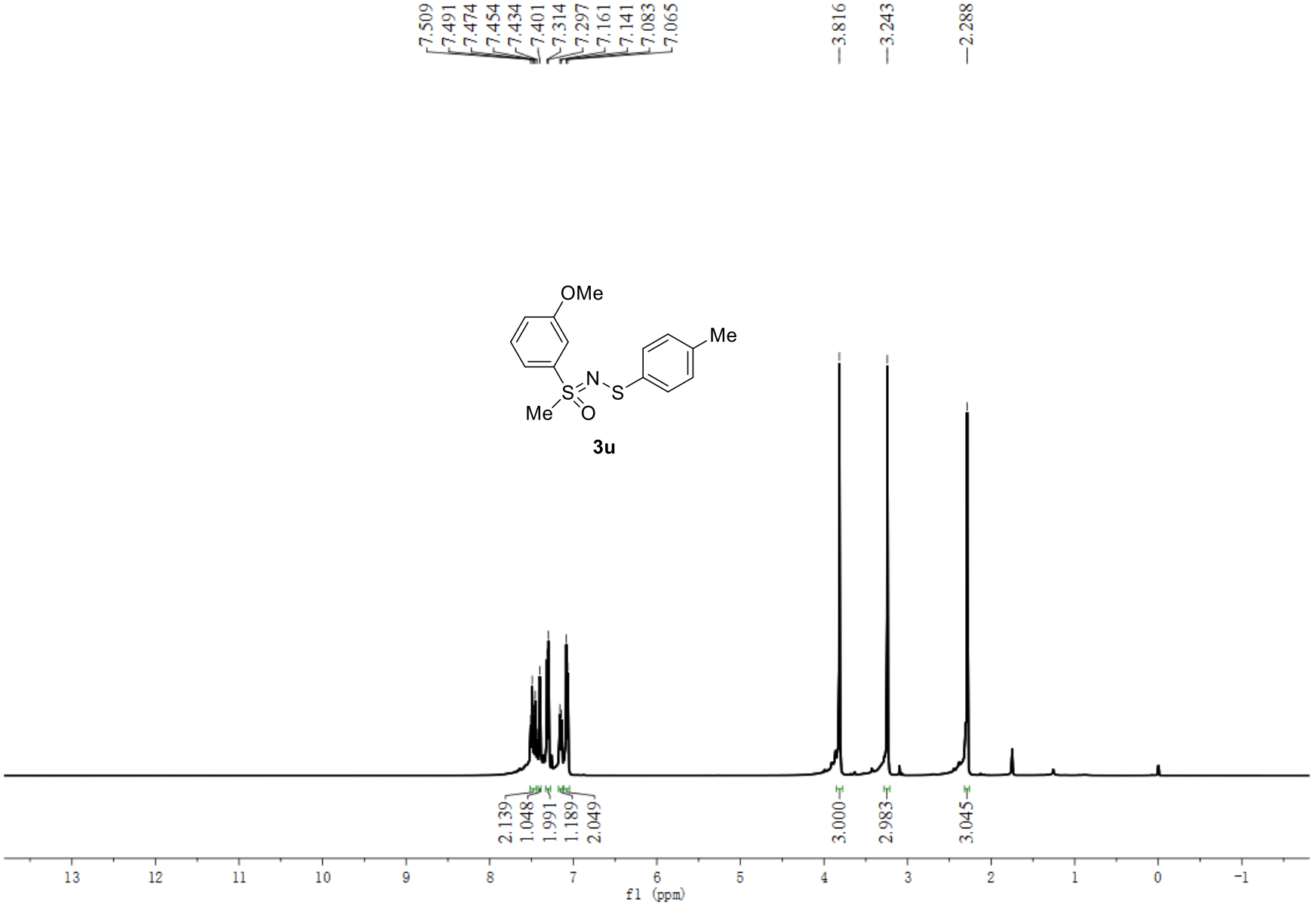
^{1}H NMR spectra of compound **3t** (400 MHz, $CDCl_3$)



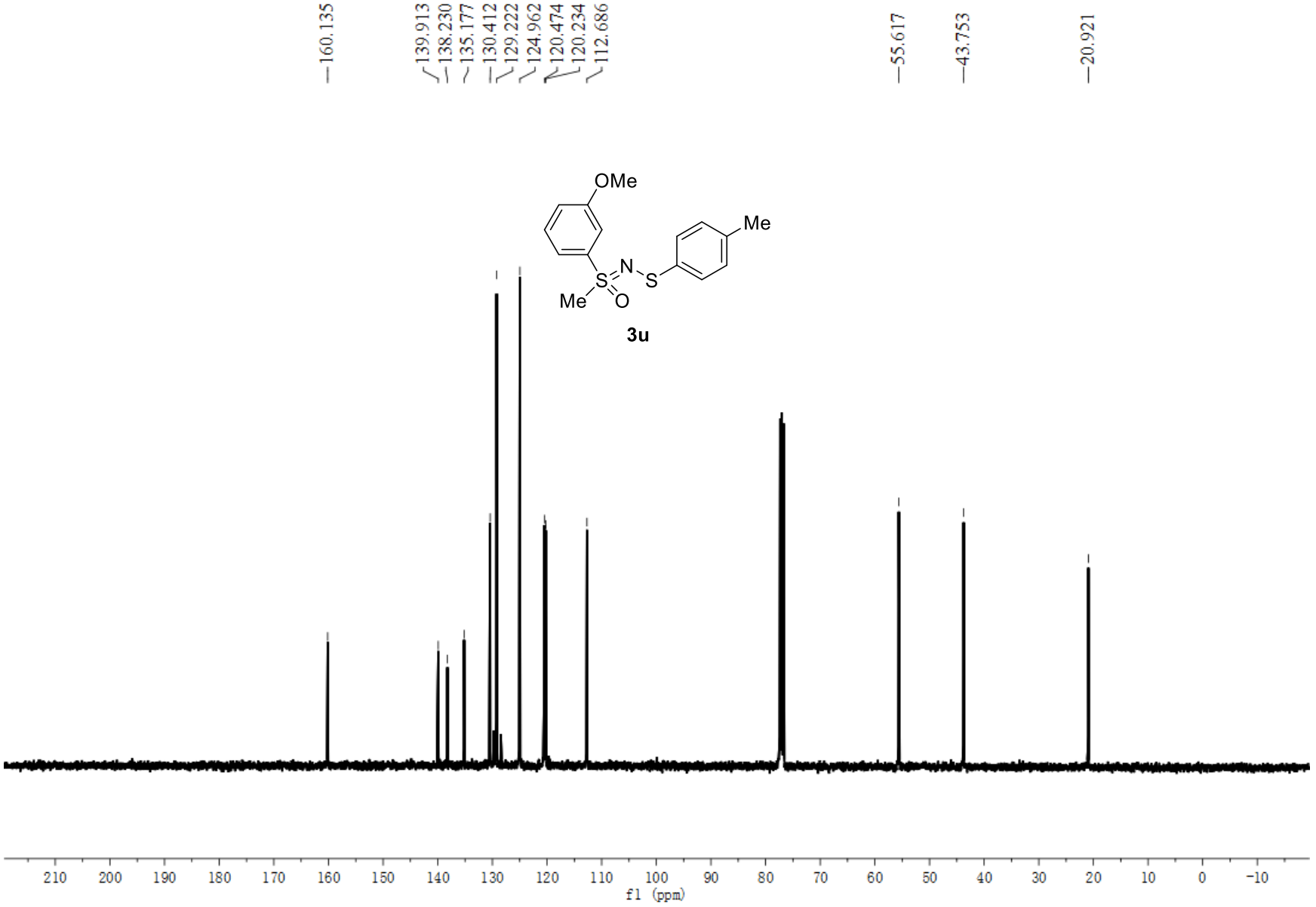
^{13}C NMR spectra of compound **3t** (101 MHz, $CDCl_3$)



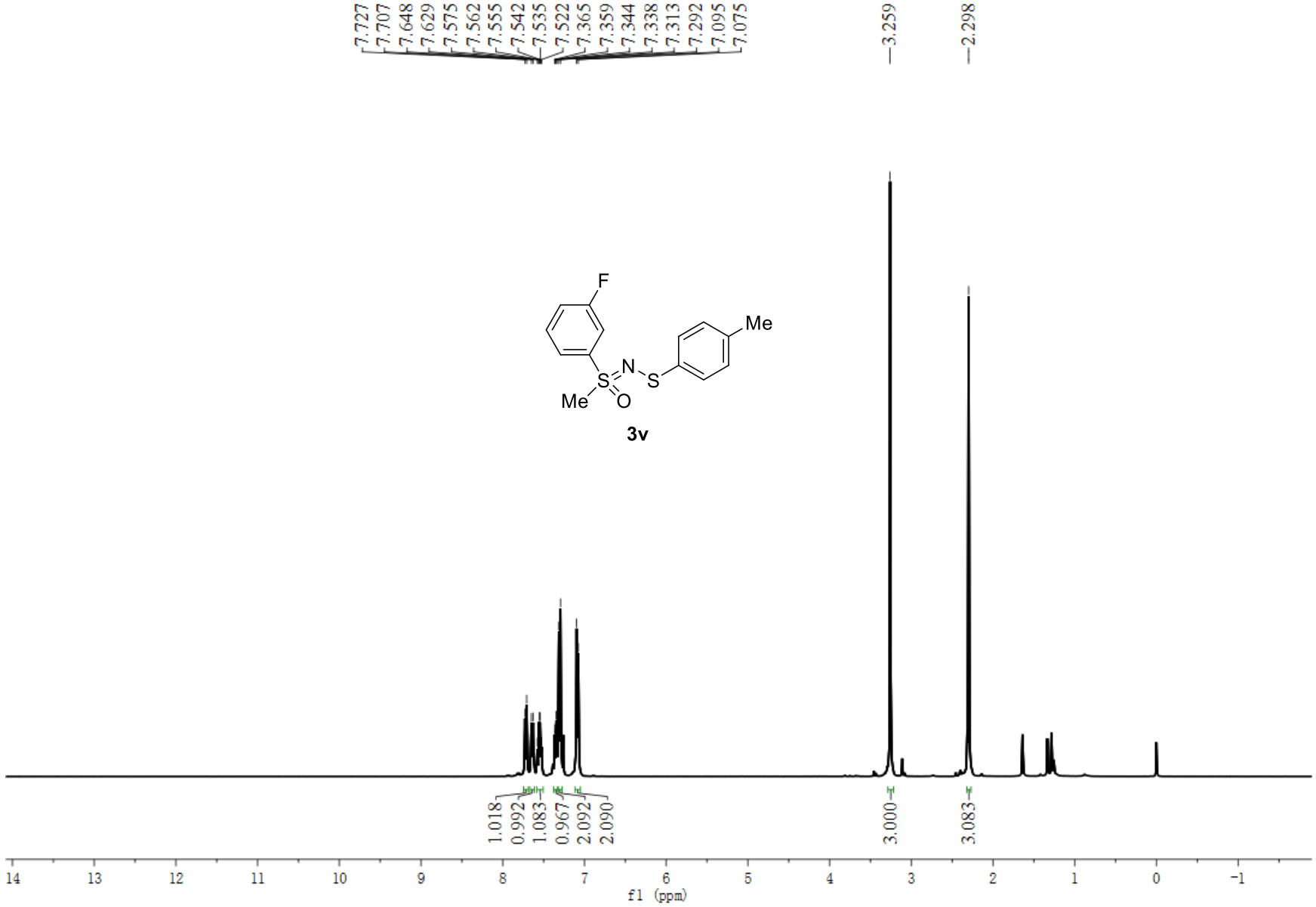
^{1}H NMR spectra of compound **3u** (400 MHz, $CDCl_3$)



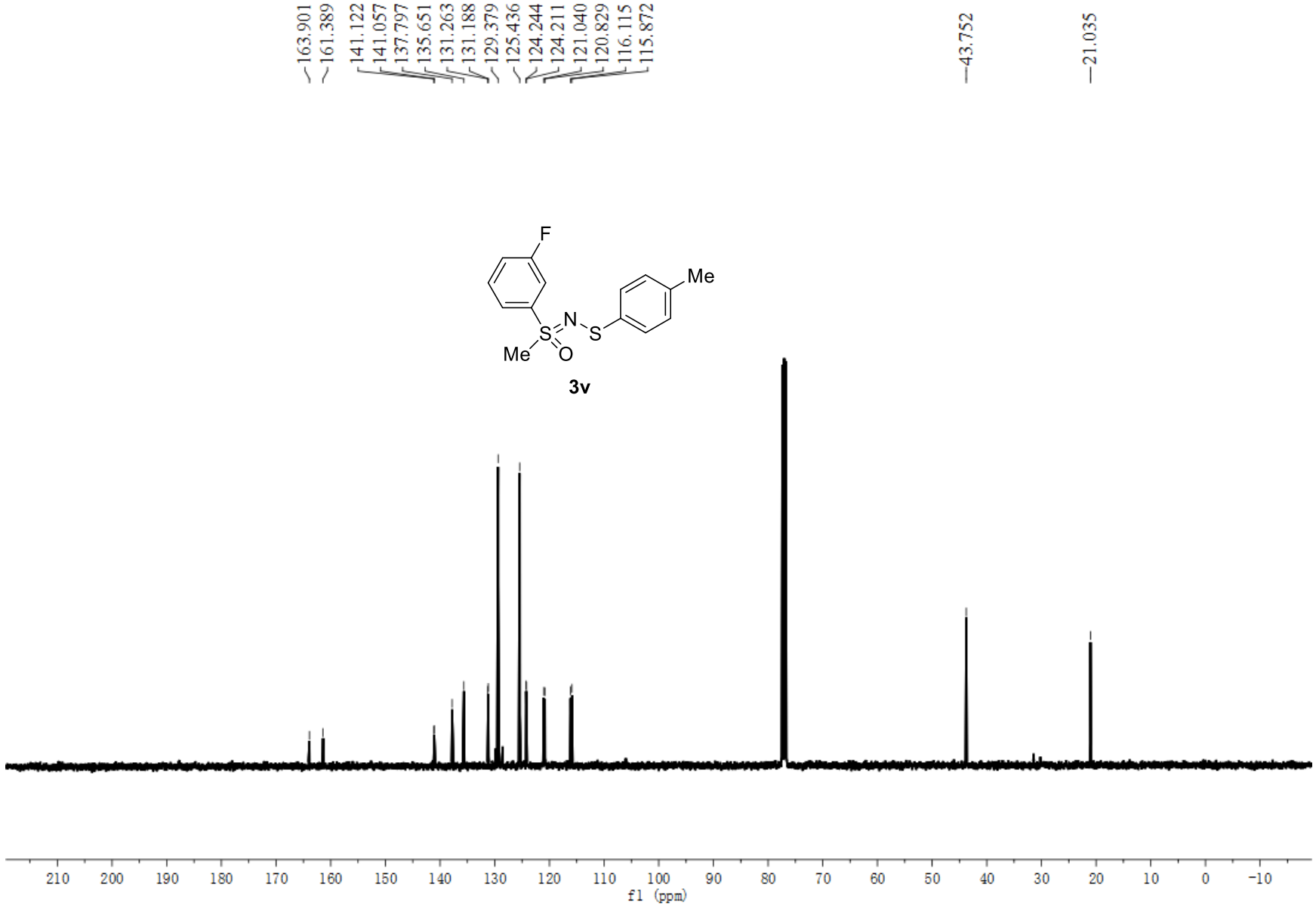
^{13}C NMR spectra of compound **3u** (101 MHz, $CDCl_3$)



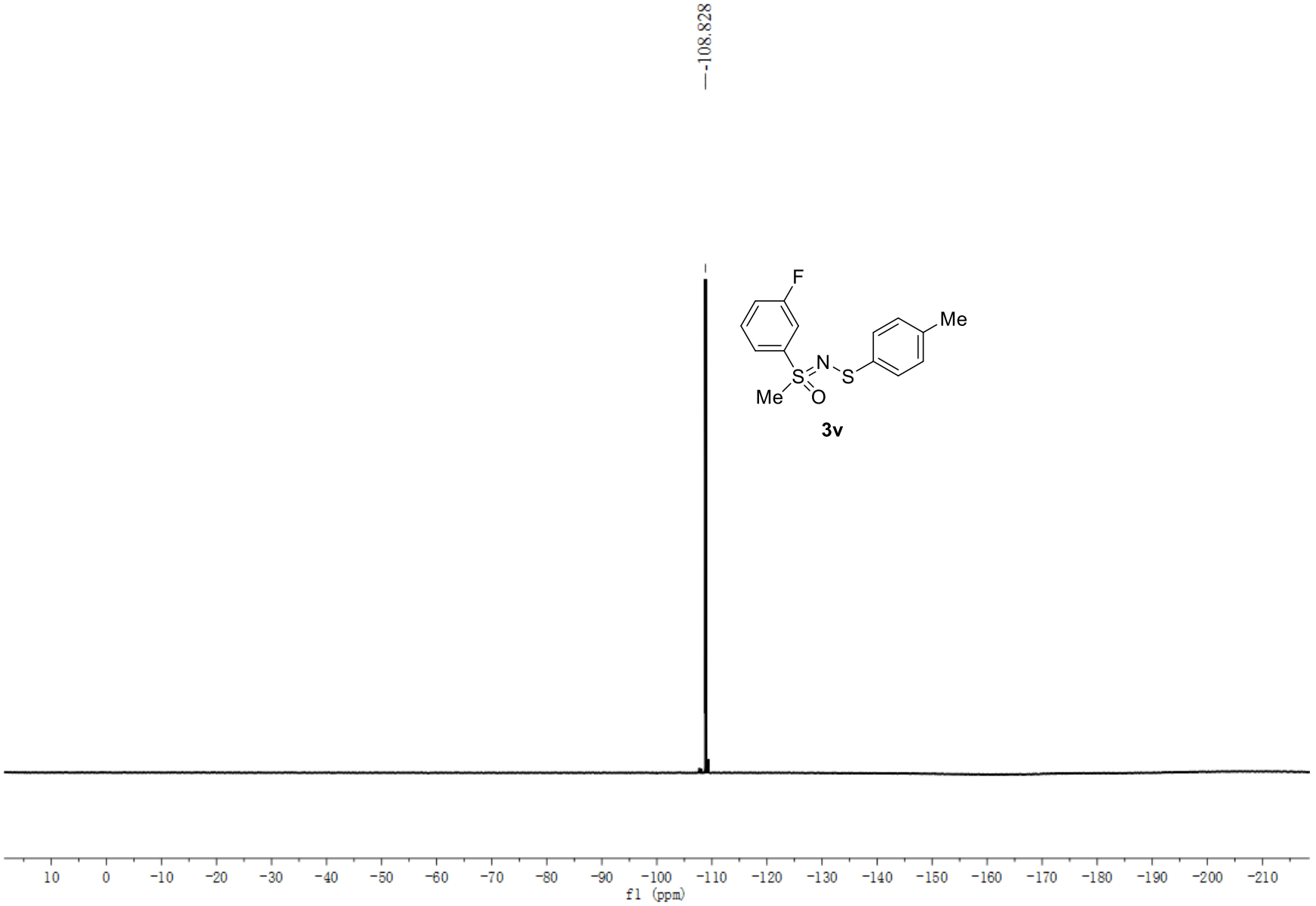
^{1}H NMR spectra of compound **3v** (400 MHz, $CDCl_3$)



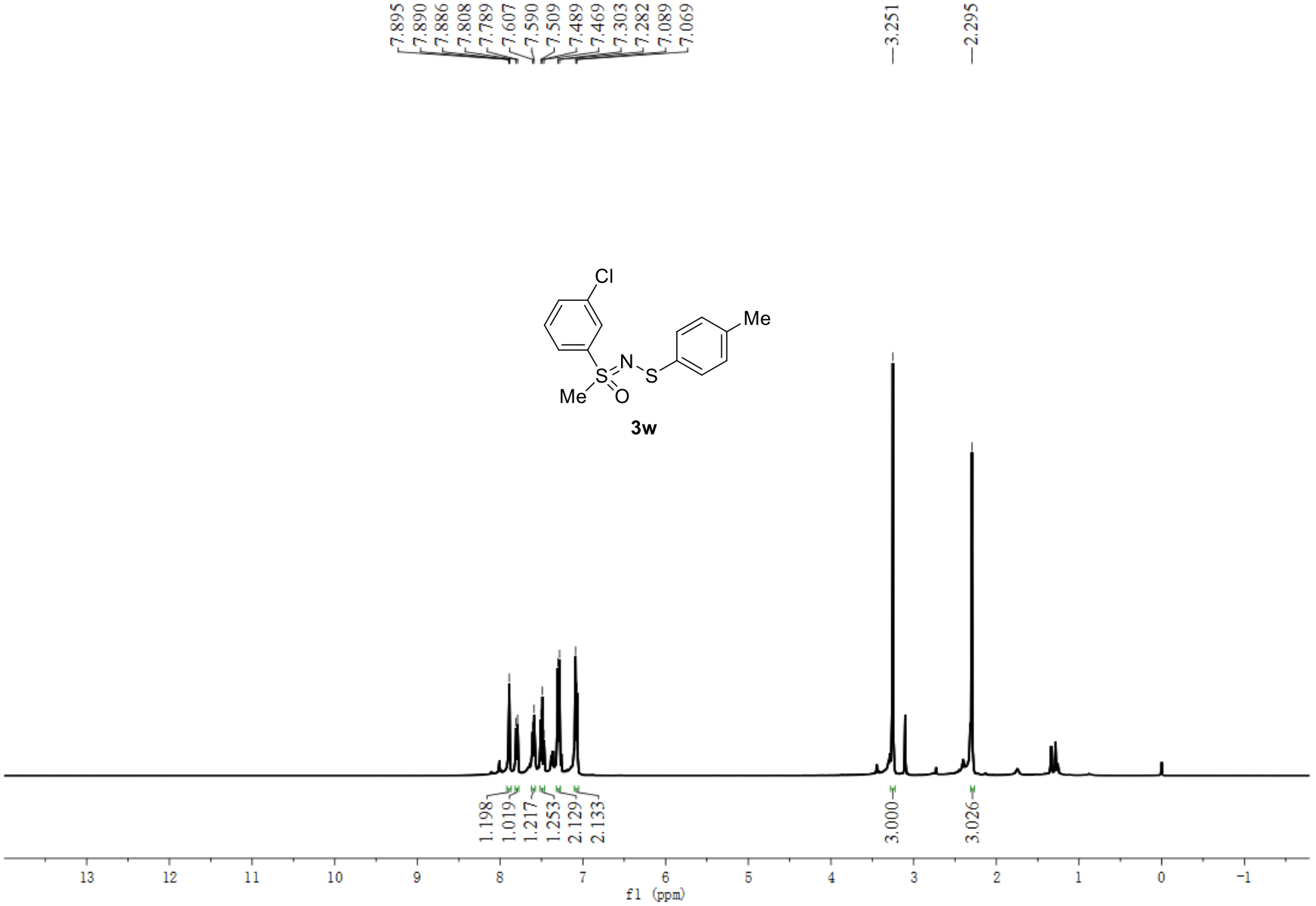
^{13}C NMR spectra of compound **3v** (101 MHz, $CDCl_3$)



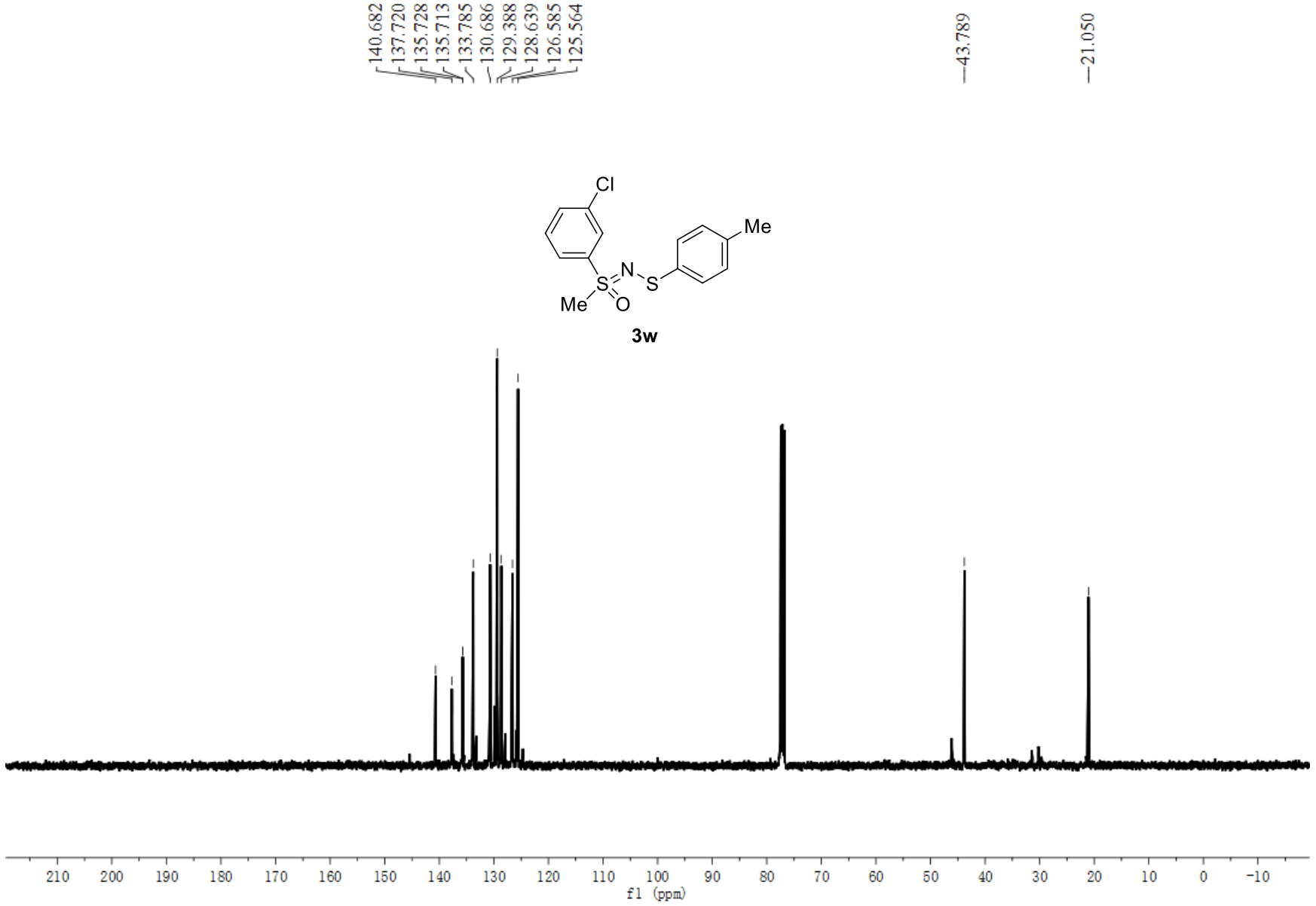
^{19}F NMR spectra of compound **3v** (376 MHz, $CDCl_3$)



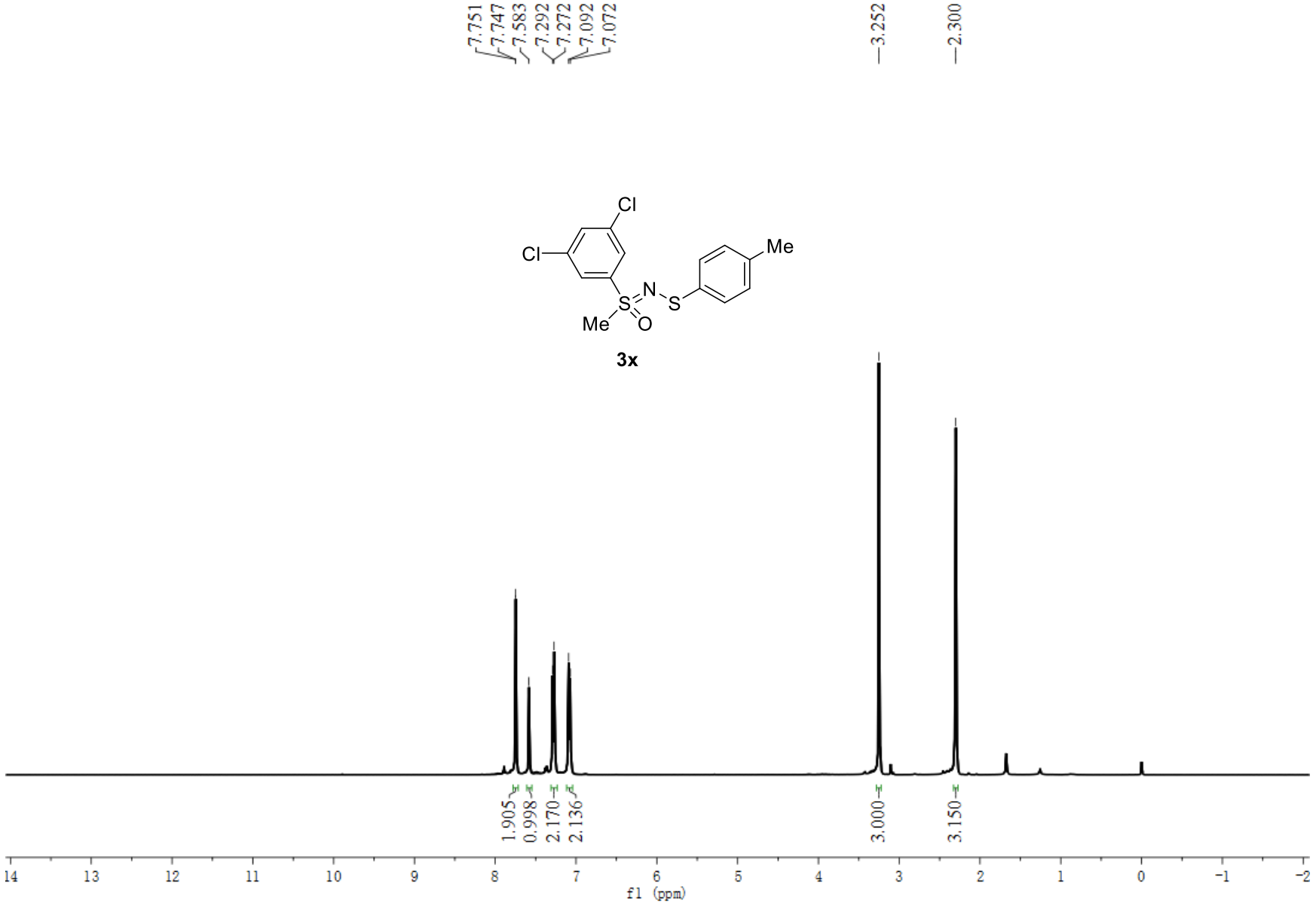
^{1}H NMR spectra of compound **3w** (400 MHz, $CDCl_3$)



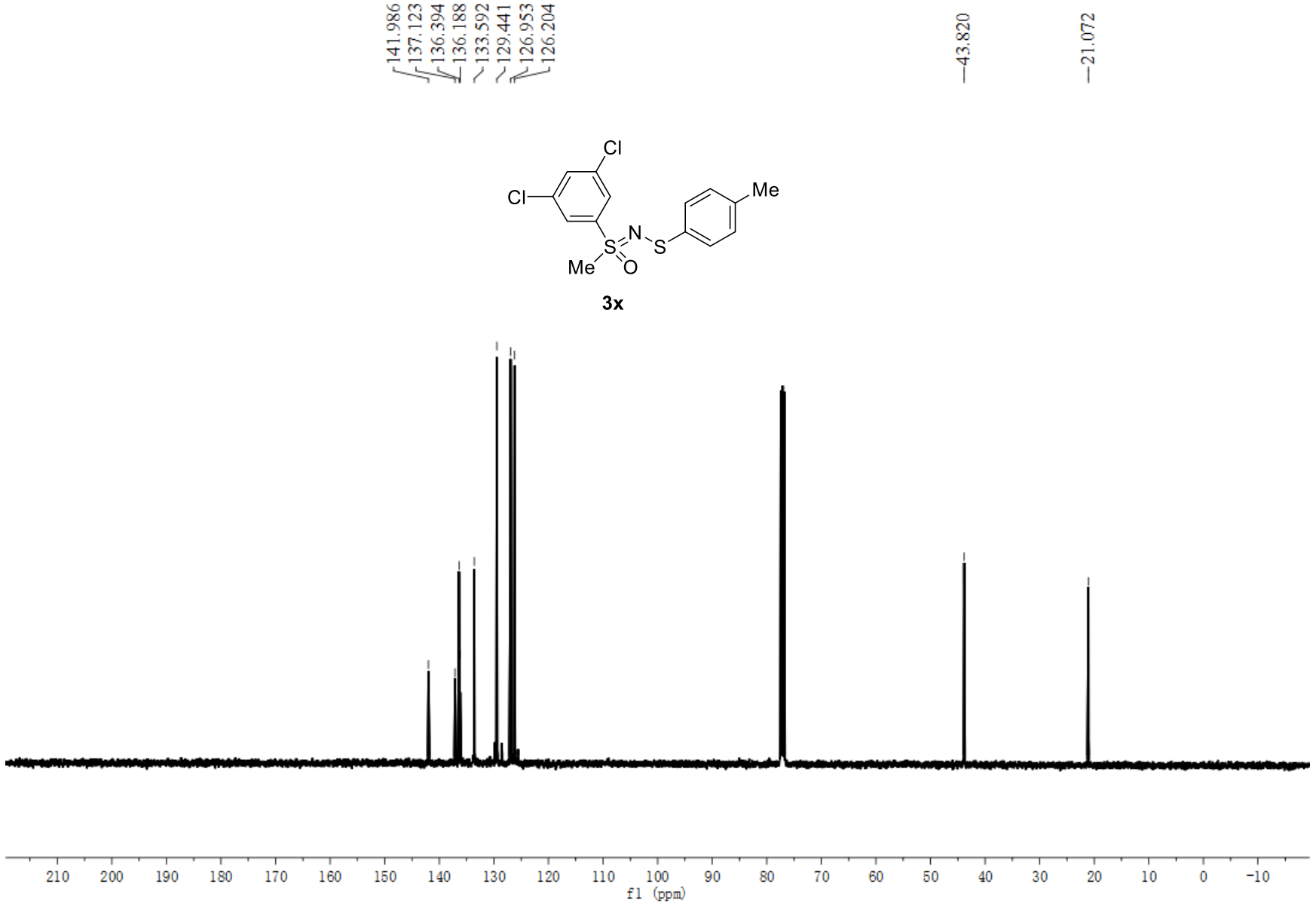
^{13}C NMR spectra of compound **3w** (101 MHz, $CDCl_3$)



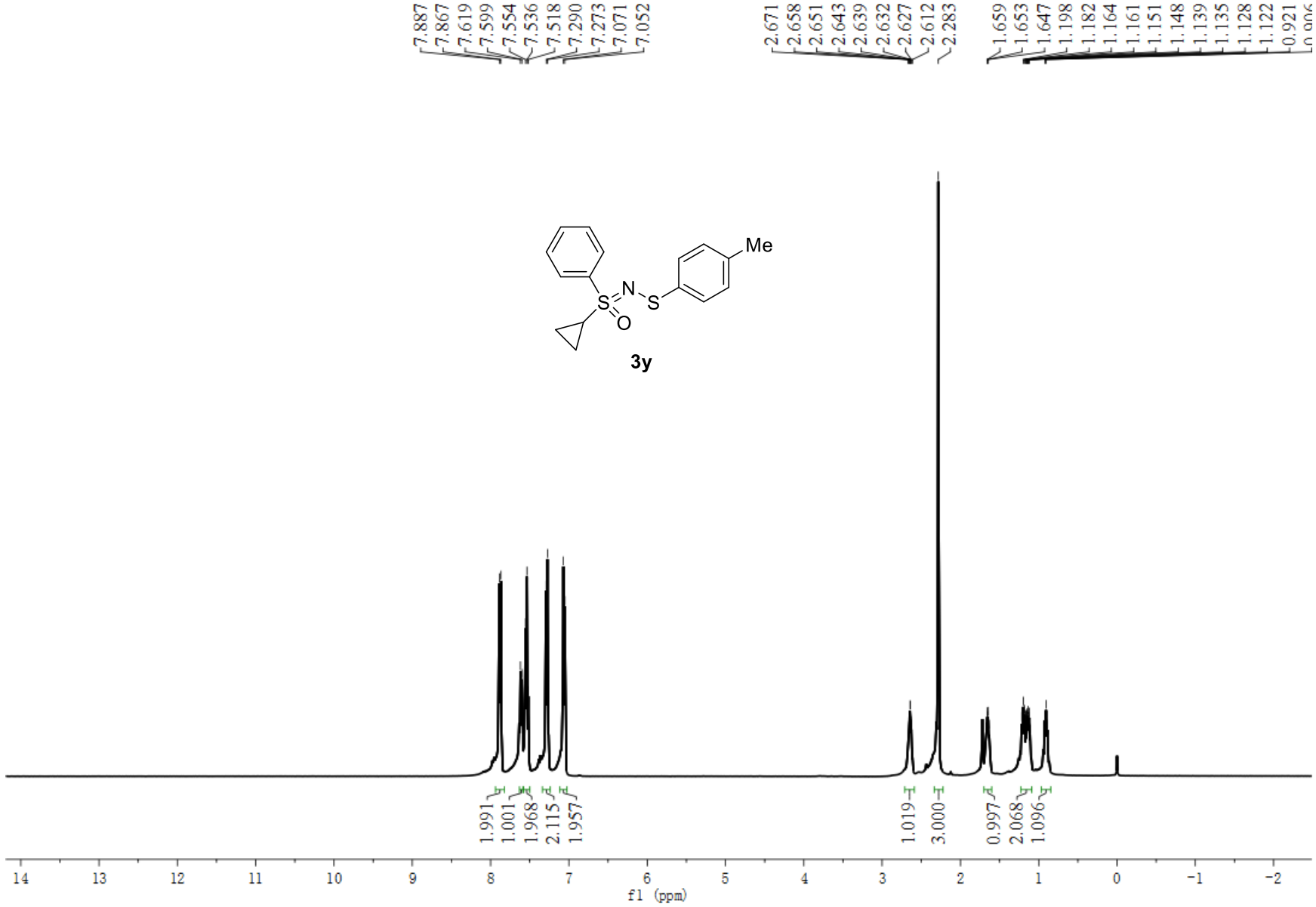
^{1}H NMR spectra of compound **3x** (400 MHz, $CDCl_3$)



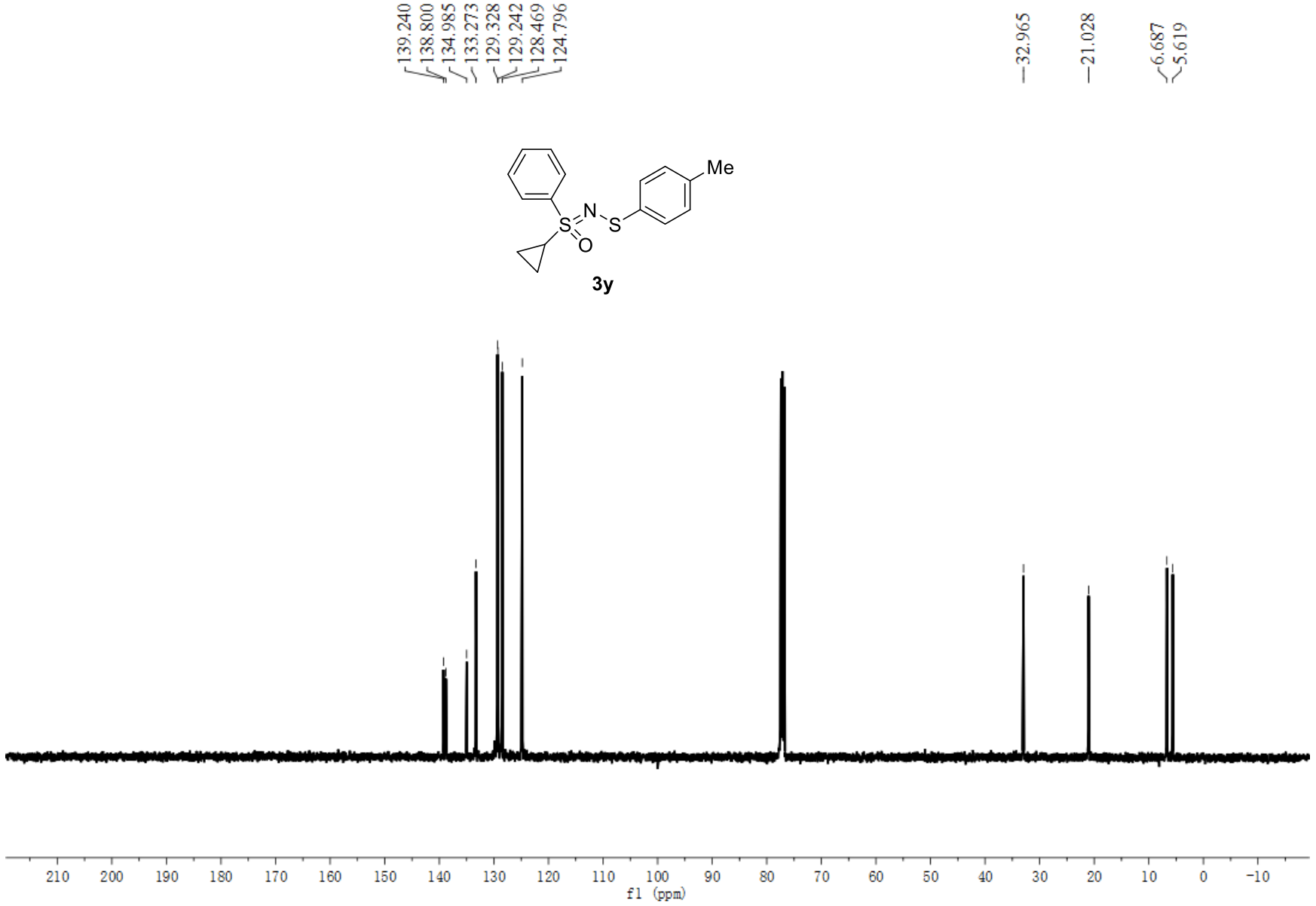
^{13}C NMR spectra of compound **3x** (101 MHz, $CDCl_3$)



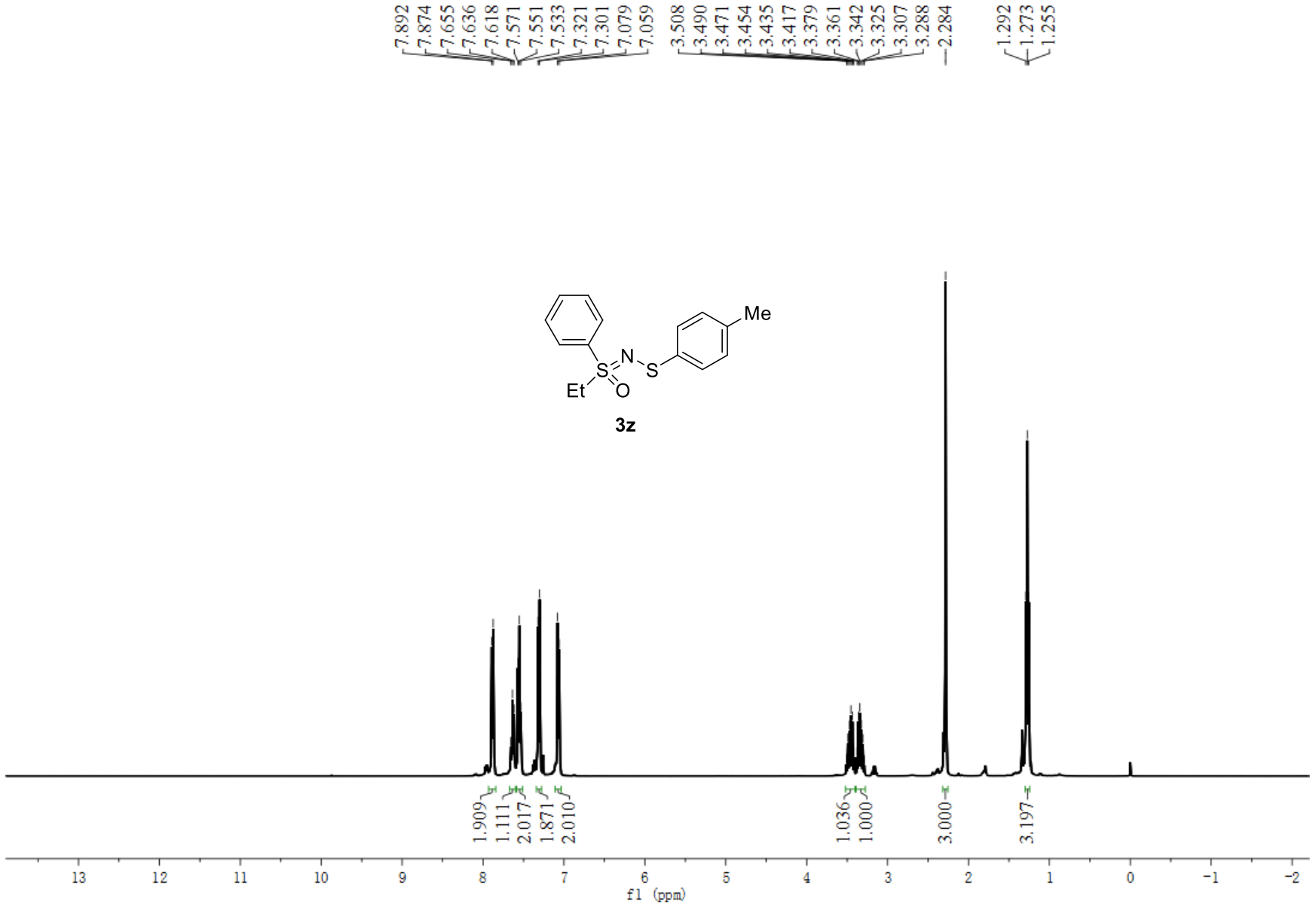
^{1}H NMR spectra of compound **3y** (400 MHz, $CDCl_3$)



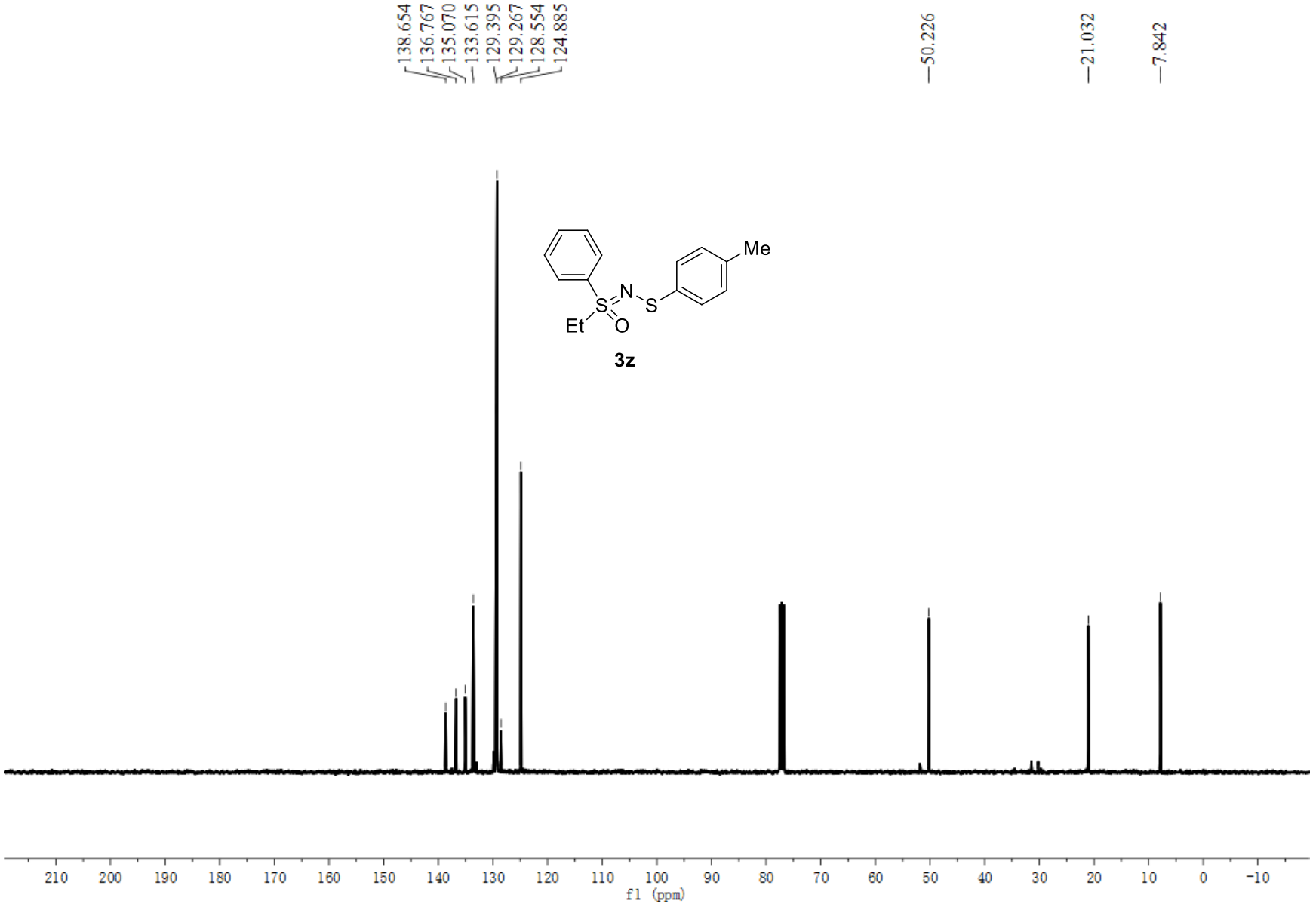
^{13}C NMR spectra of compound **3y** (101 MHz, $CDCl_3$)



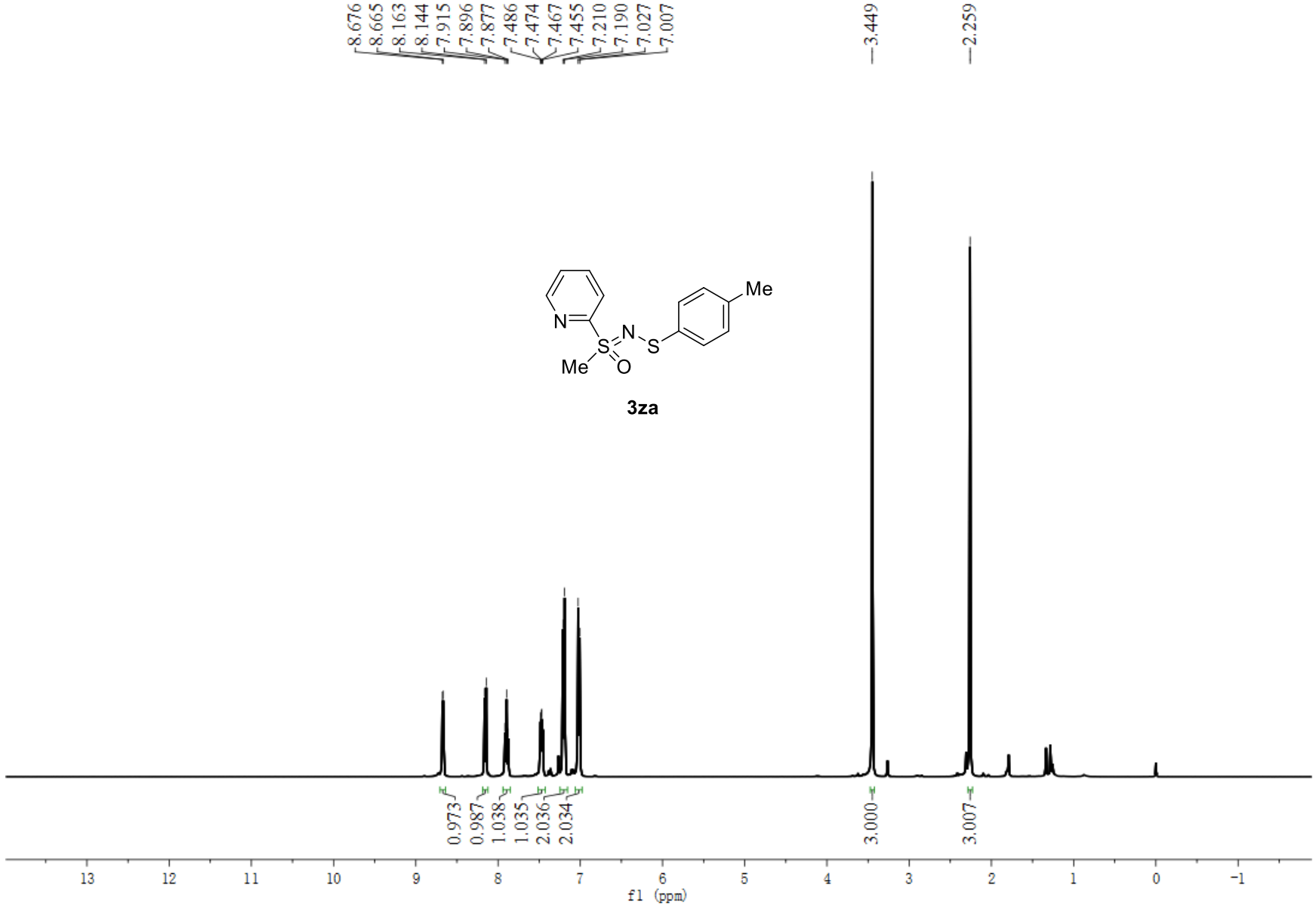
^{1}H NMR spectra of compound **3z** (400 MHz, $CDCl_3$)



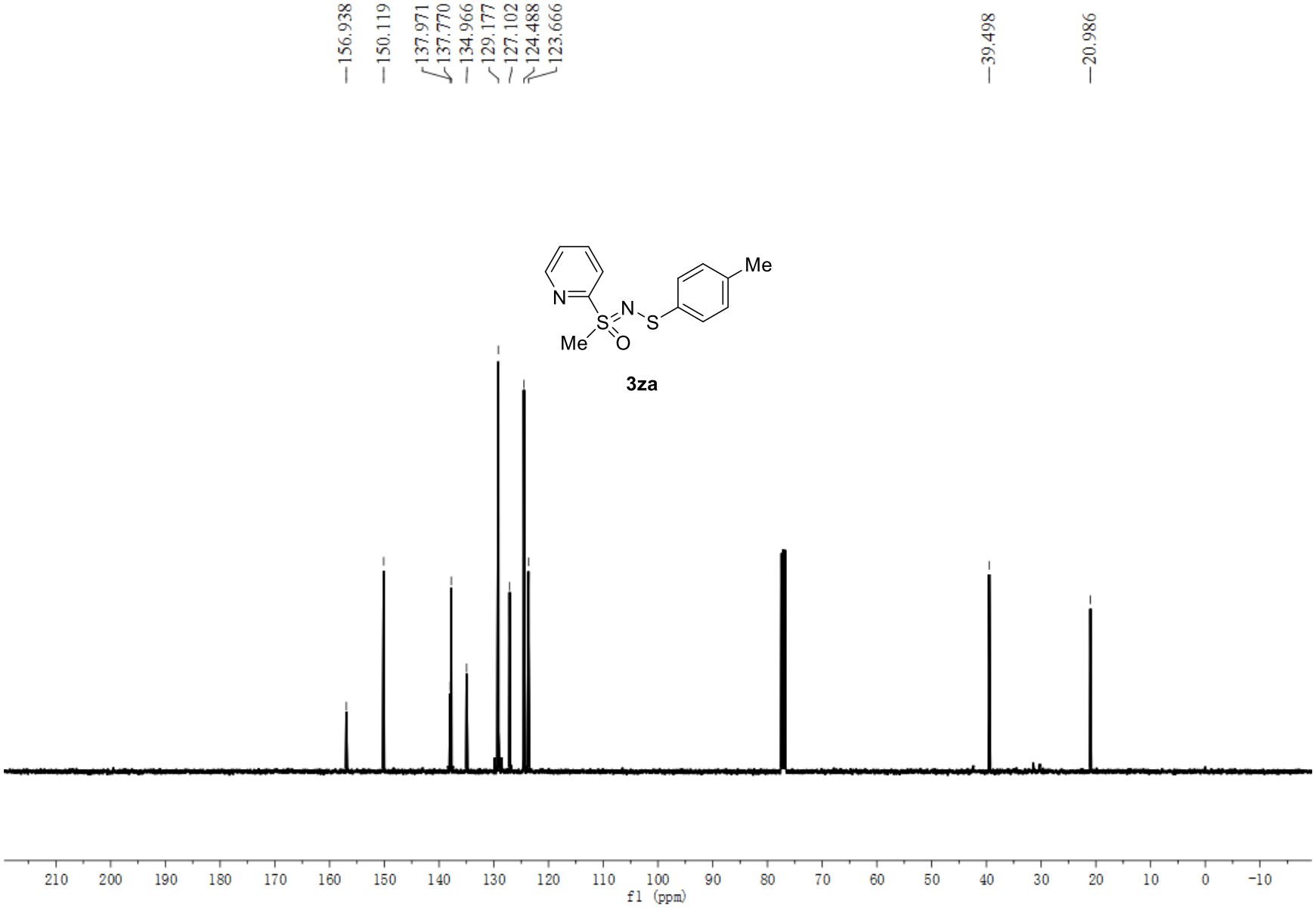
^{13}C NMR spectra of compound **3z** (101 MHz, $CDCl_3$)



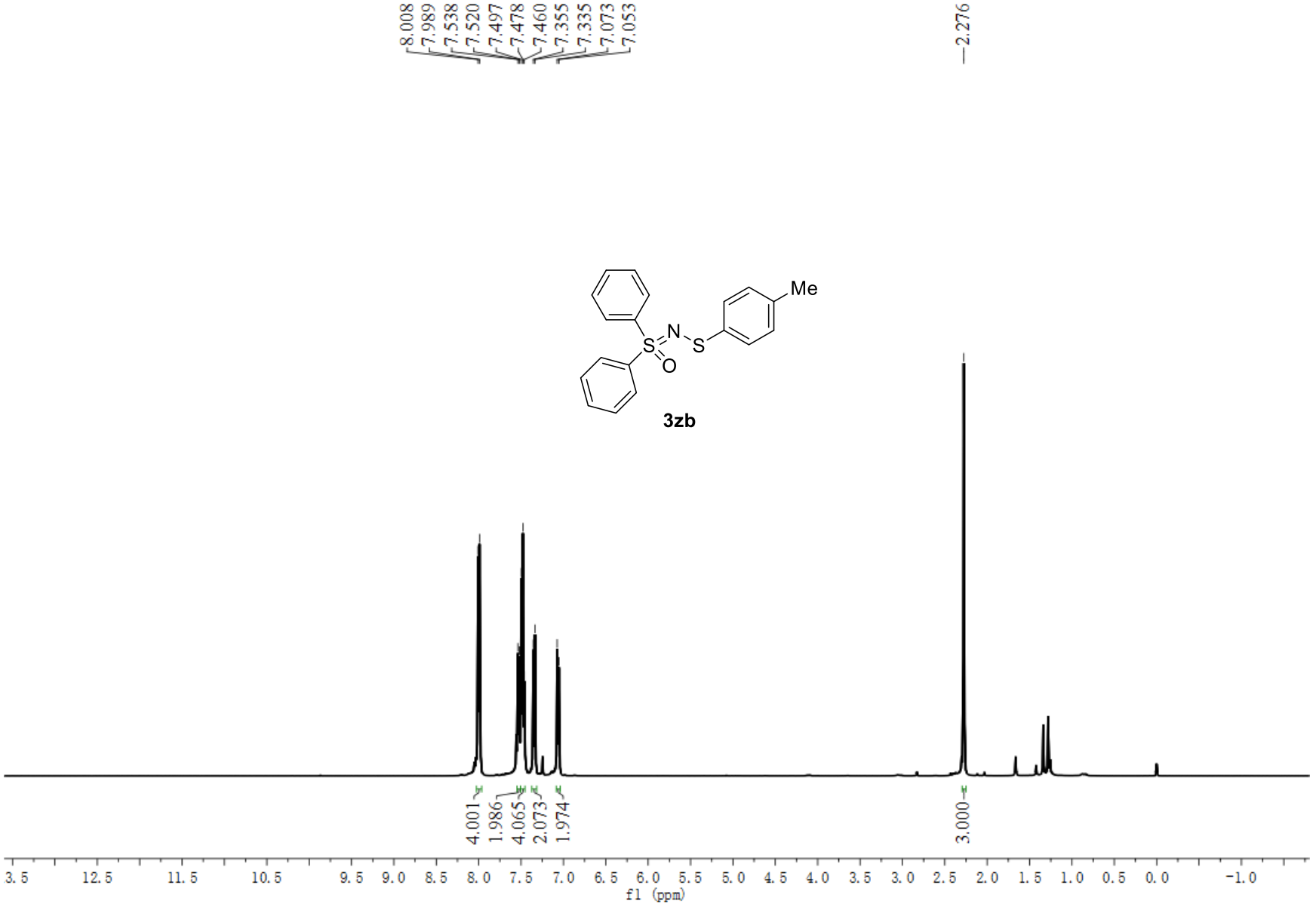
^{1}H NMR spectra of compound **3za** (400 MHz, $CDCl_3$)



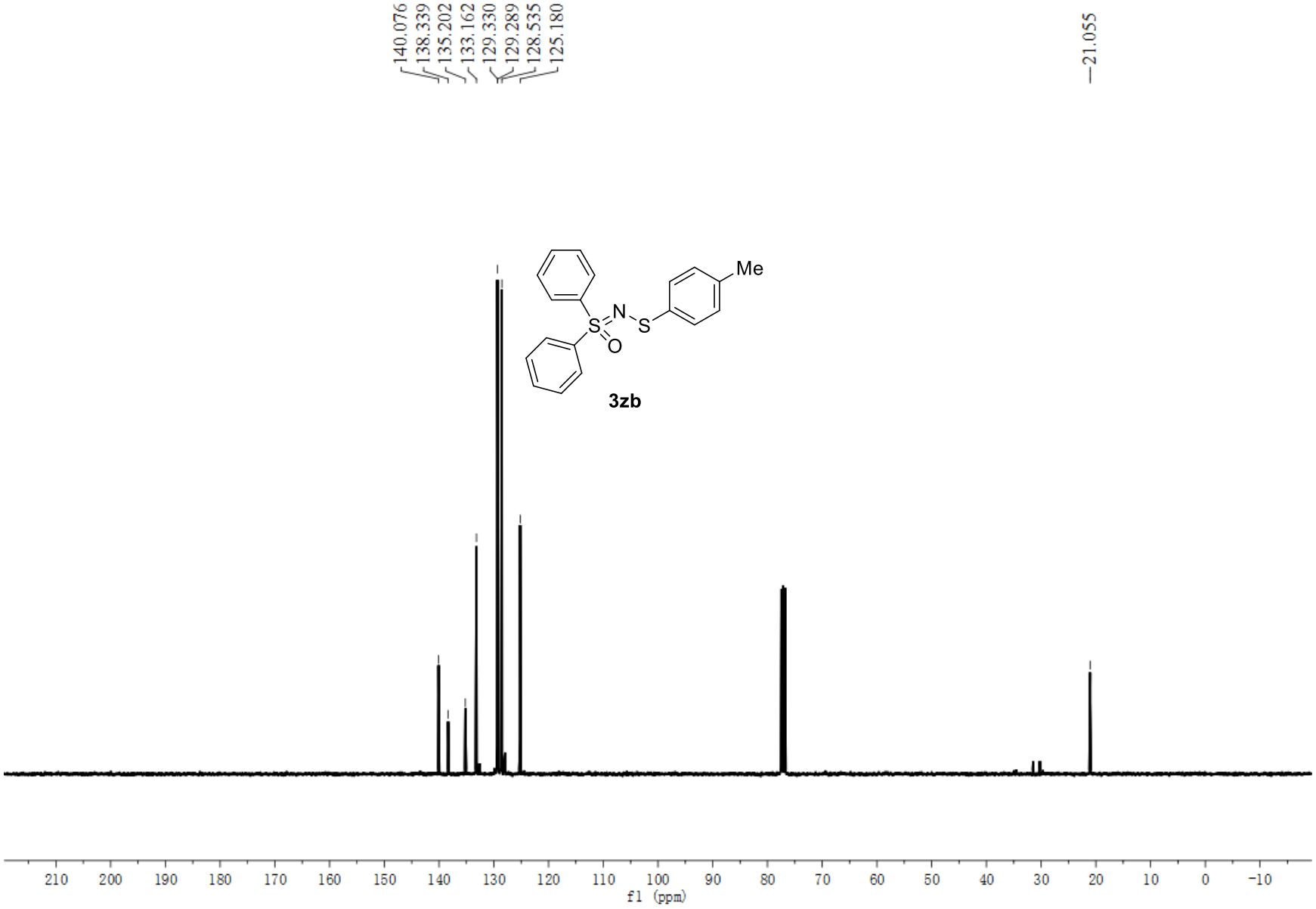
^{13}C NMR spectra of compound **3za** (101 MHz, $CDCl_3$)



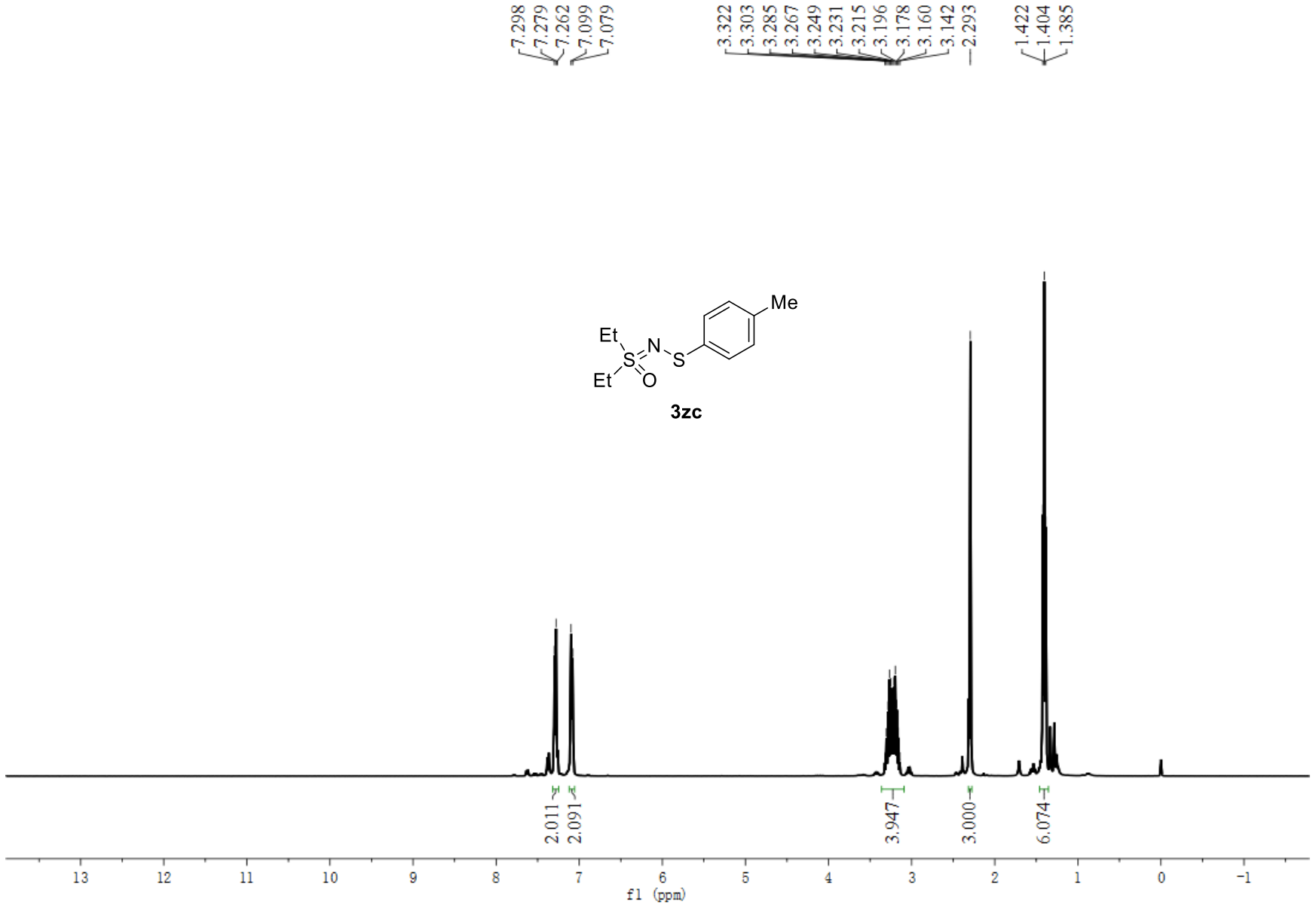
^{1}H NMR spectra of compound **3zb** (400 MHz, $CDCl_3$)



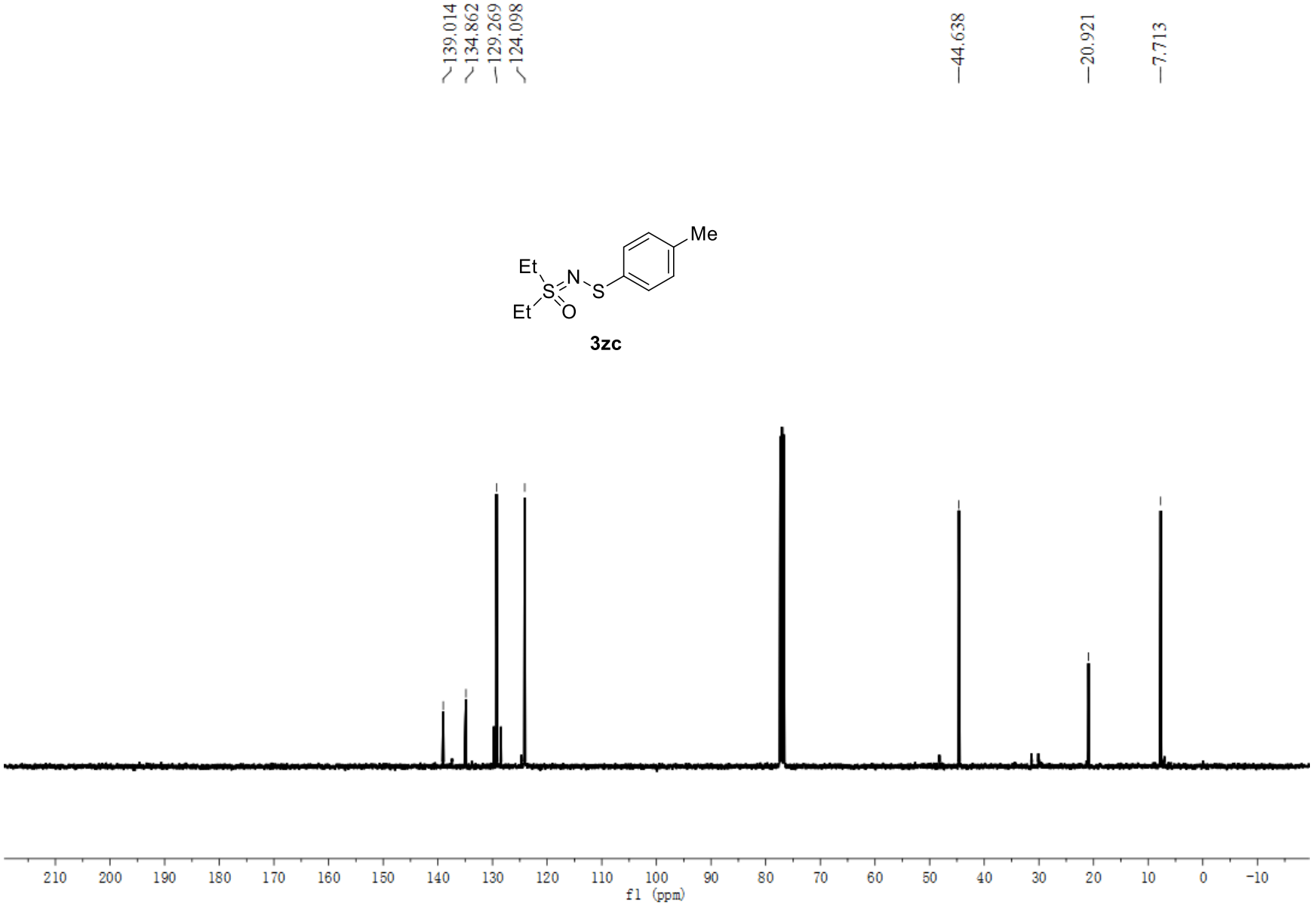
^{13}C NMR spectra of compound **3zb** (101 MHz, $CDCl_3$)



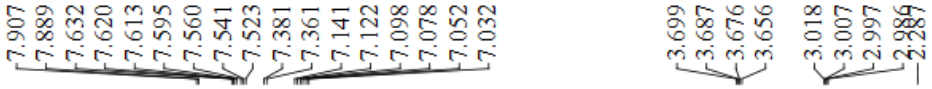
^{1}H NMR spectra of compound **3zc** (400 MHz, $CDCl_3$)

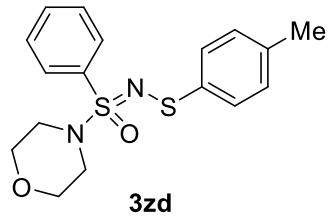


^{13}C NMR spectra of compound **3zc** (101 MHz, $CDCl_3$)



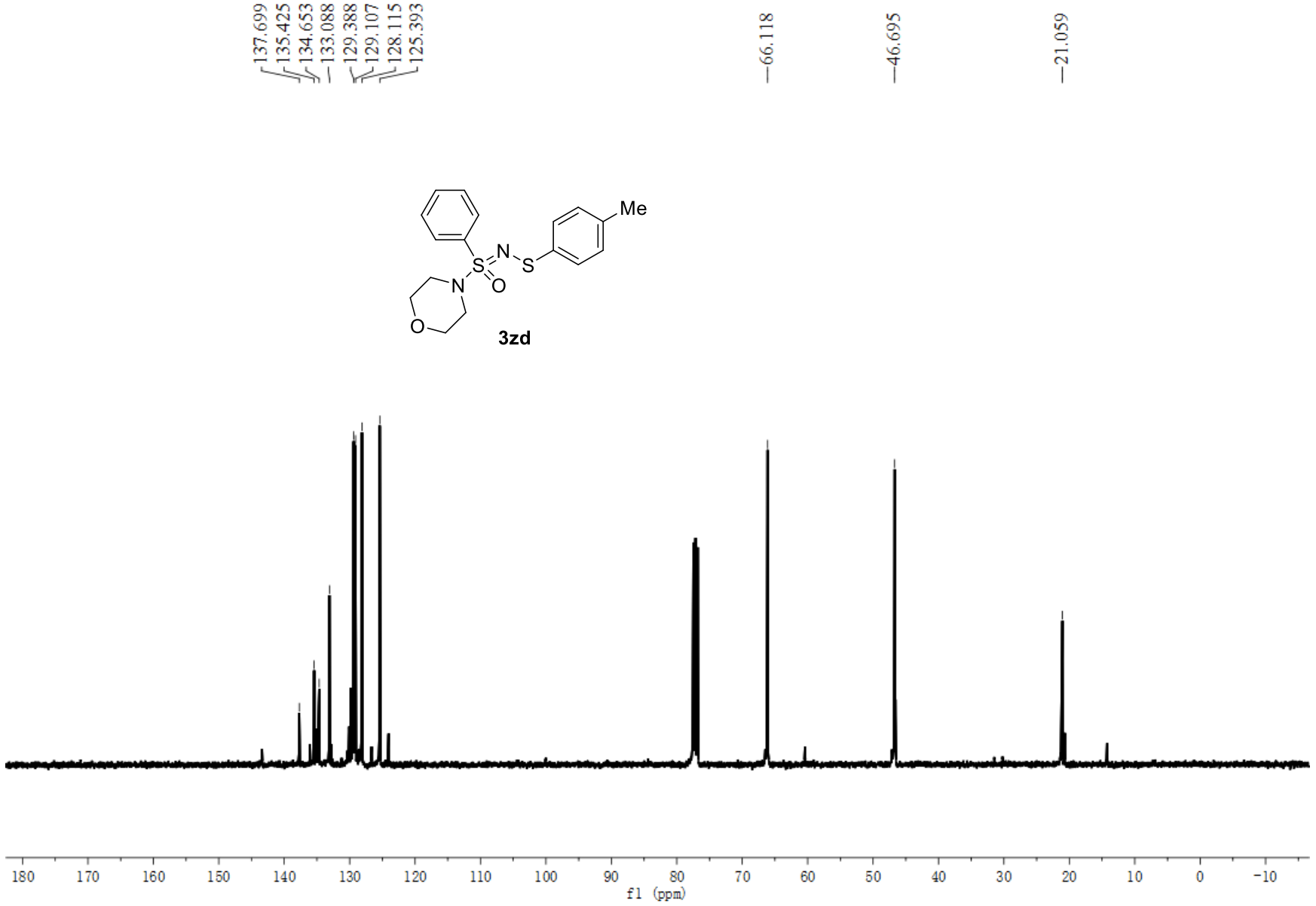
^{1}H NMR spectra of compound **3zd** (400 MHz, $CDCl_3$)



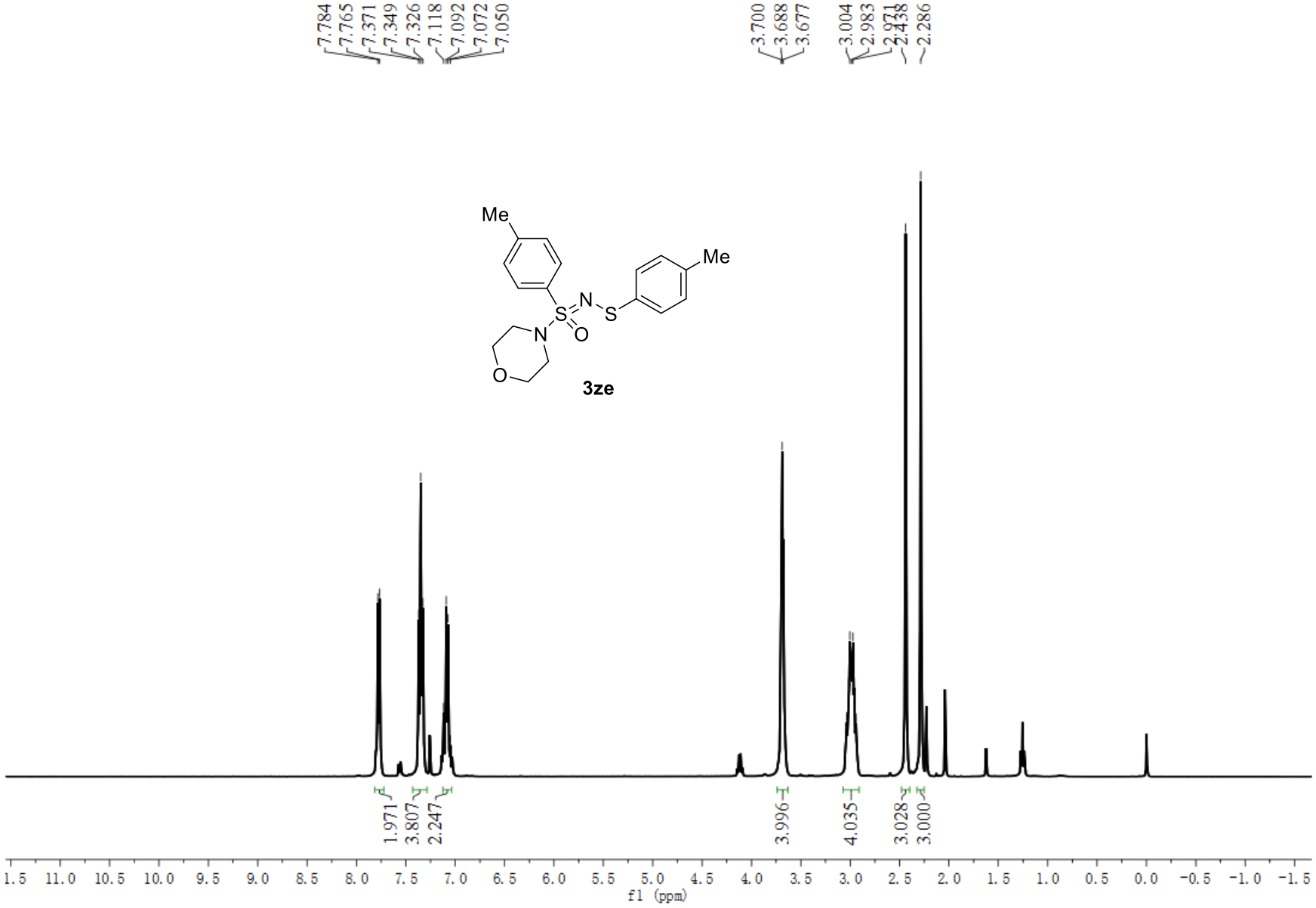


3zd

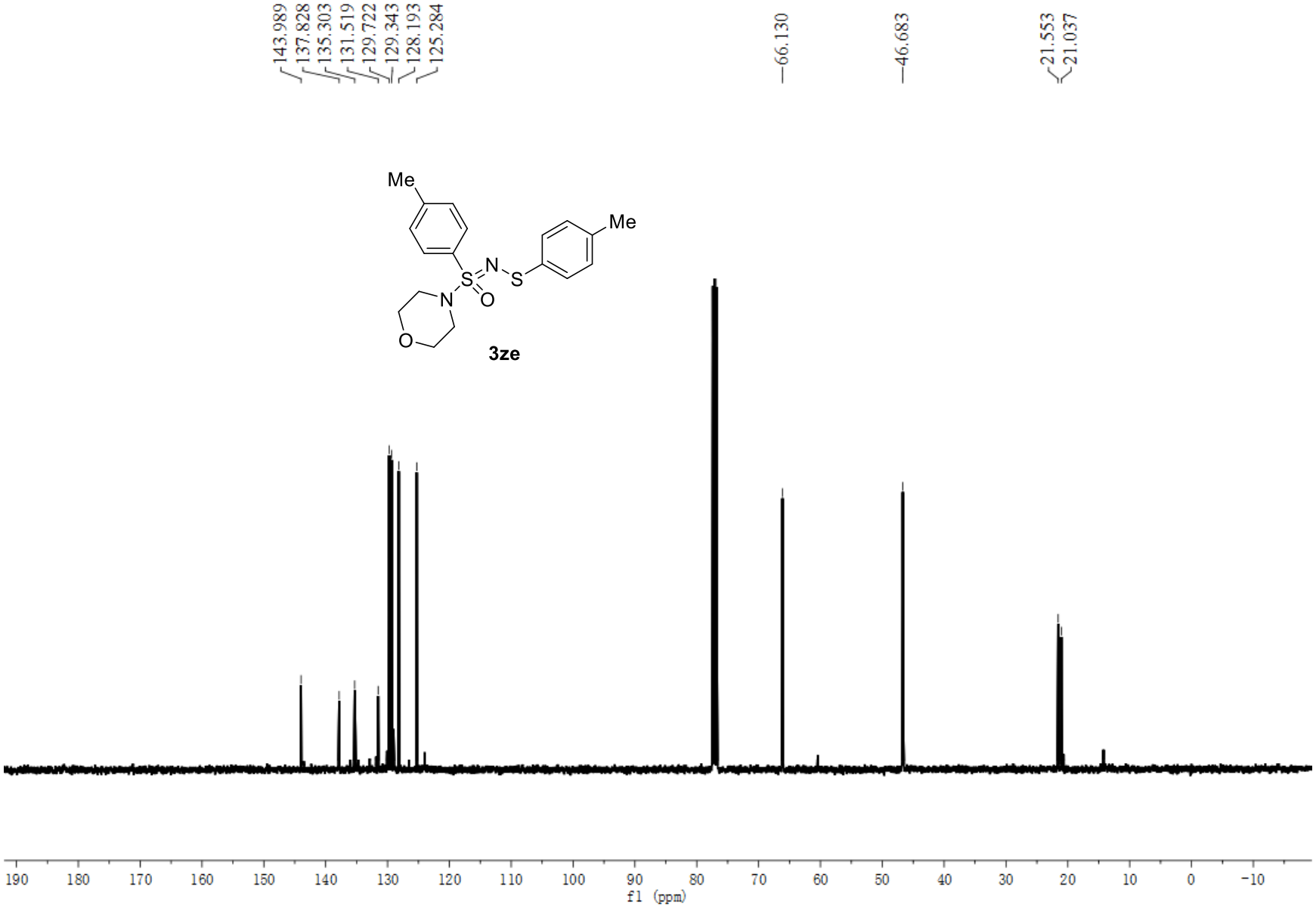
$^{13}C\{^{1}H\}$NMR spectra of compound **3zd** (101 MHz, $CDCl_3$)



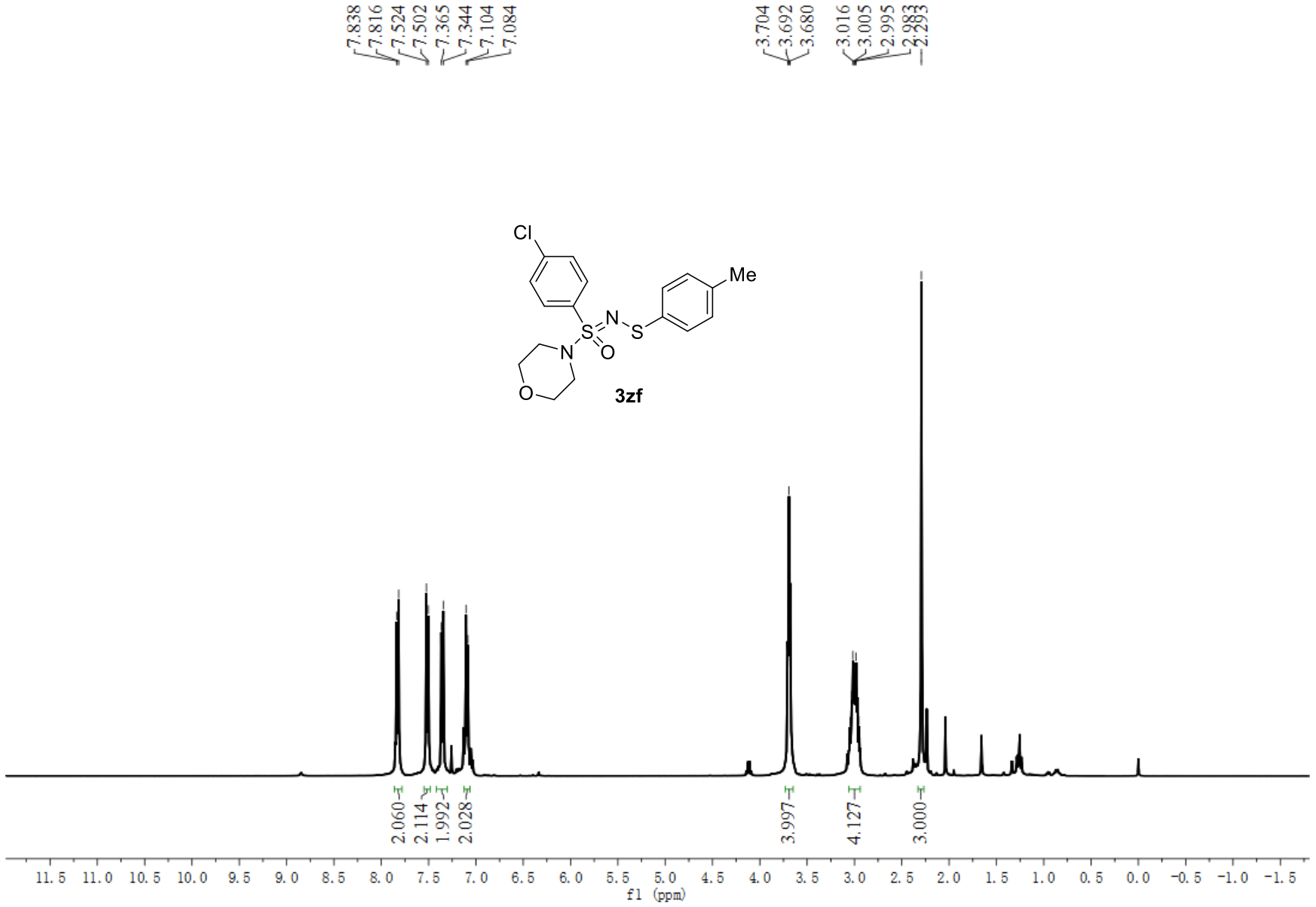
^{1}H NMR spectra of compound **3ze** (400 MHz, $CDCl_3$)



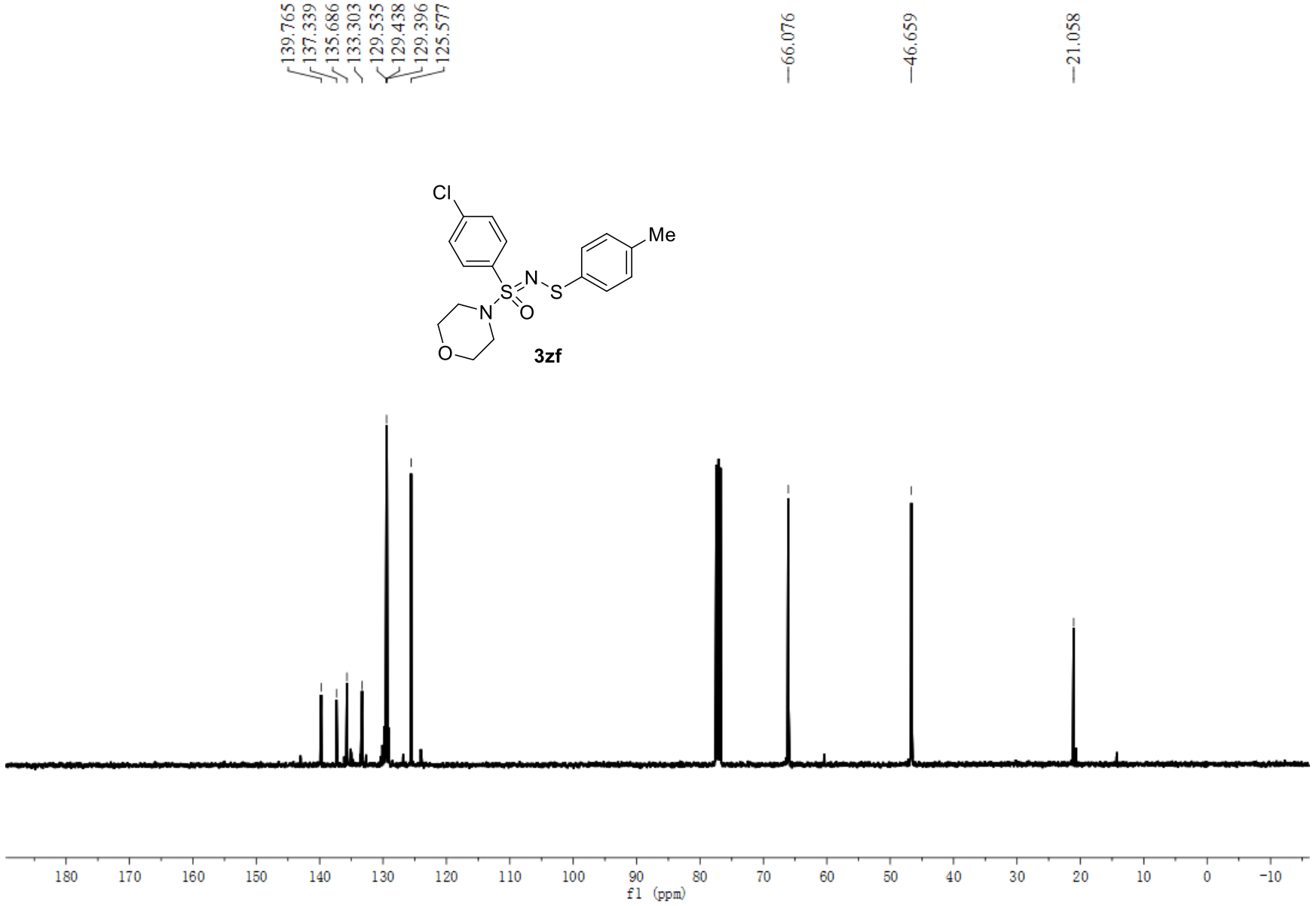
^{13}C NMR spectra of compound **3ze** (101 MHz, $CDCl_3$)



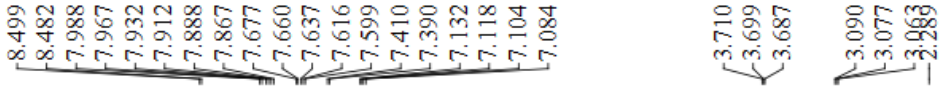
^{1}H NMR spectra of compound **3zf** (400 MHz, $CDCl_3$)

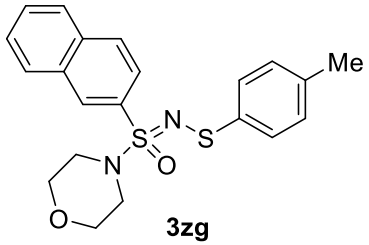


^{13}C NMR spectra of compound **3zf** (101 MHz, $CDCl_3$)

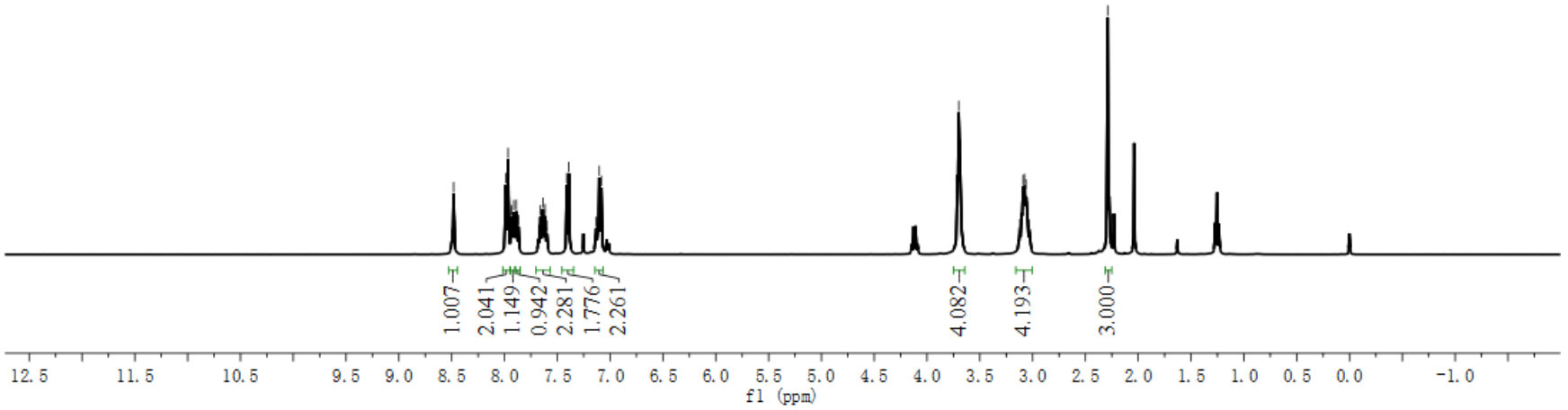


^{1}H NMR spectra of compound **3zg** (400 MHz, $CDCl_3$)

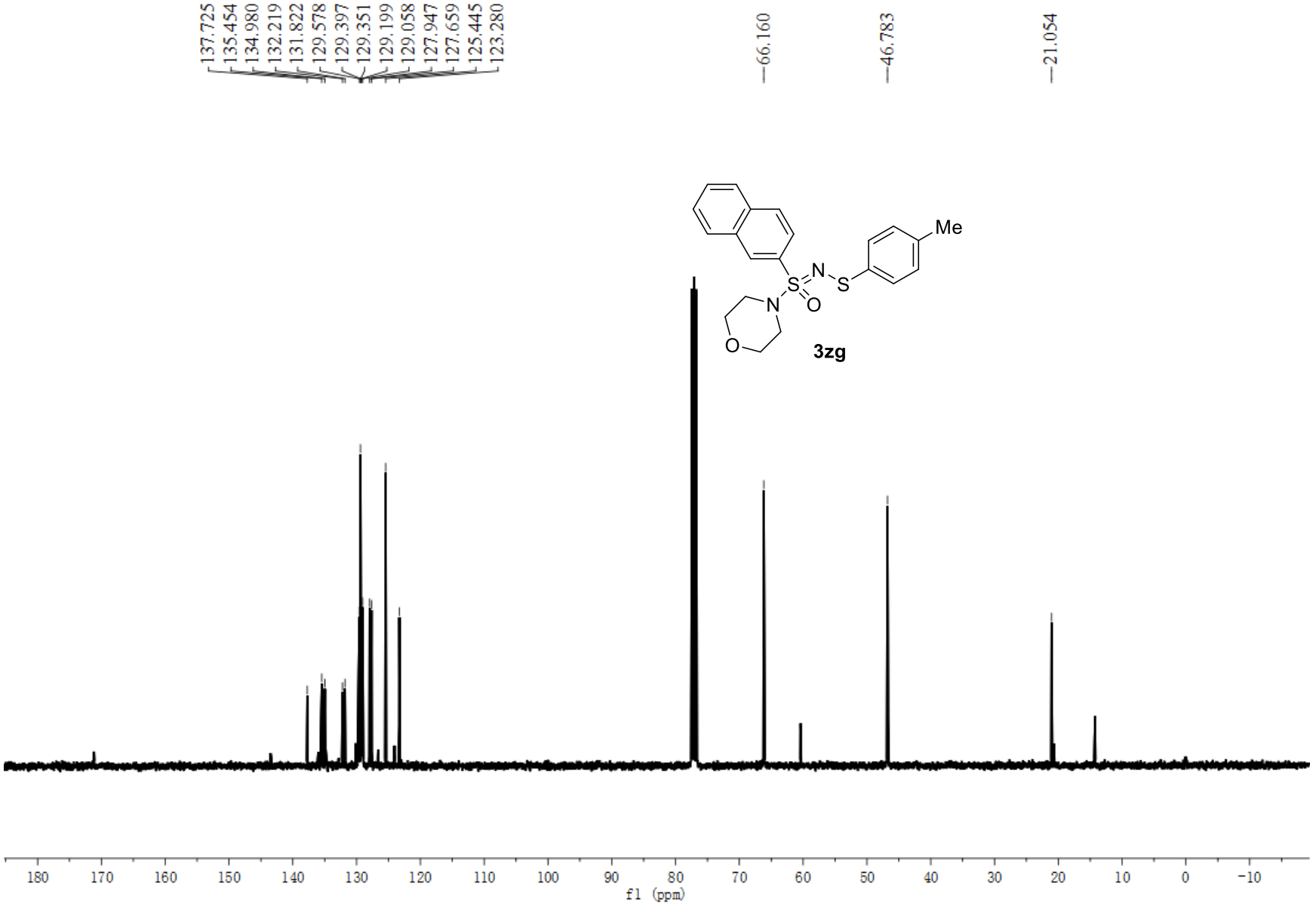




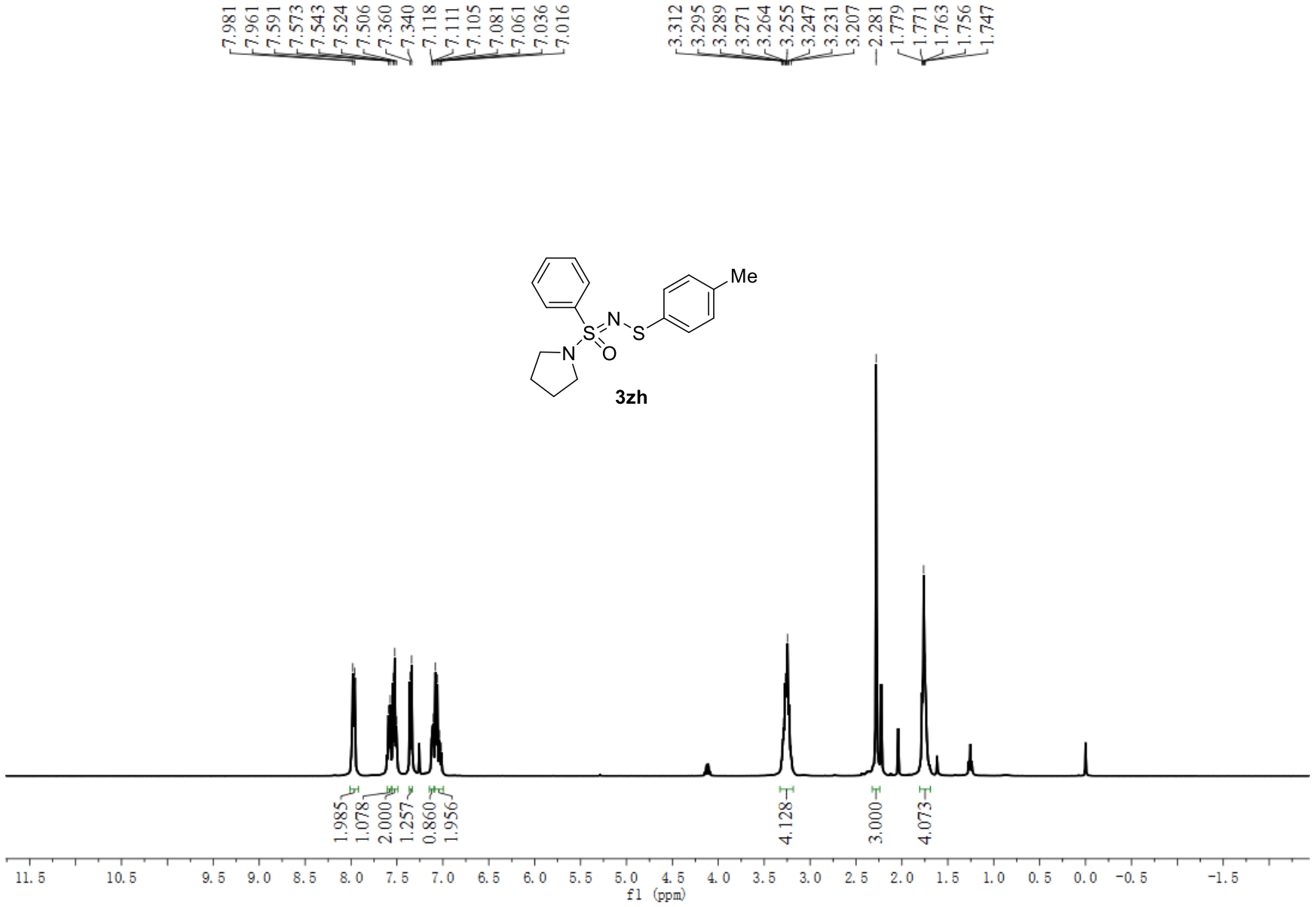
3zg



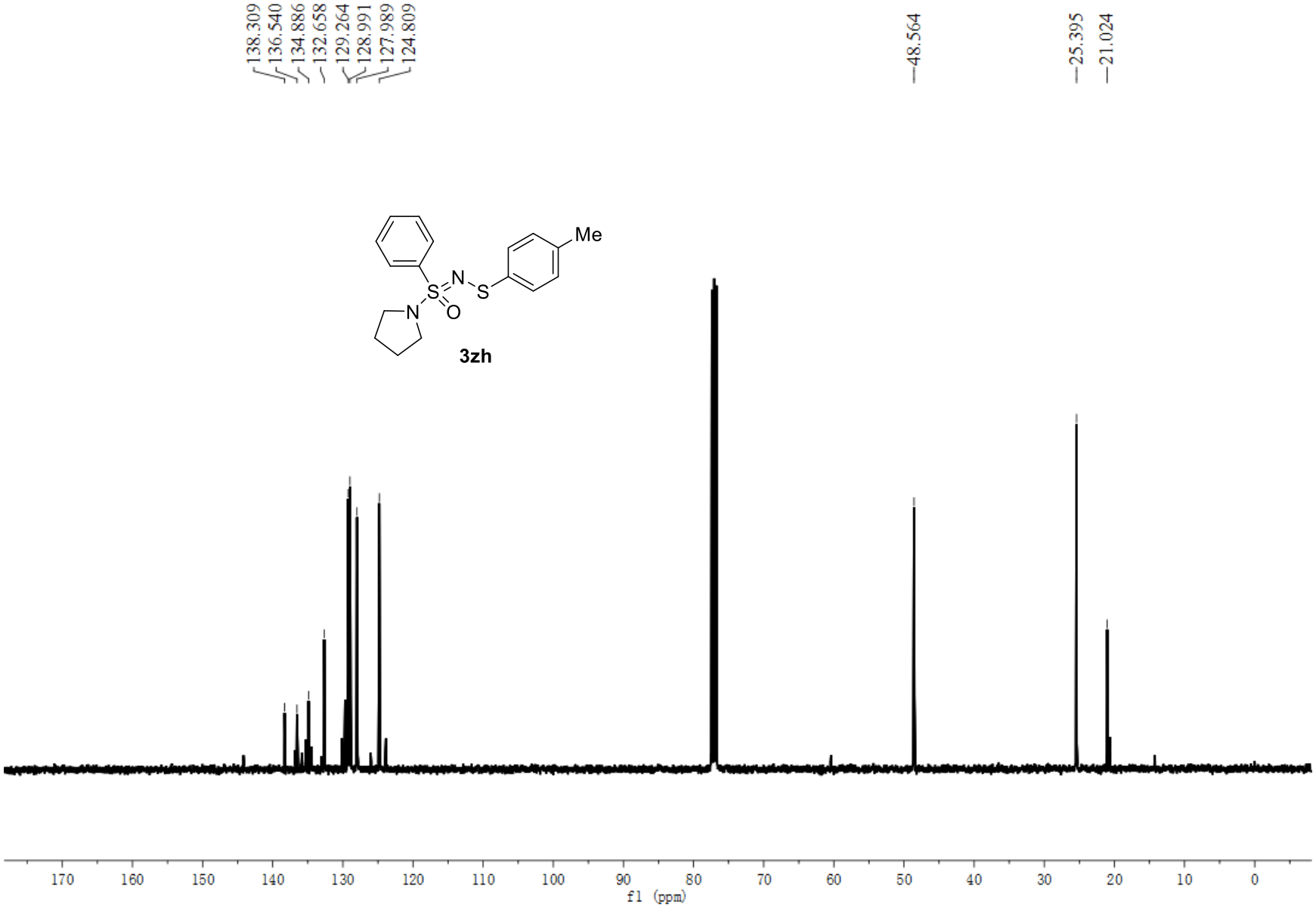
^{13}C NMR spectra of compound **3zg** (101 MHz, $CDCl_3$)



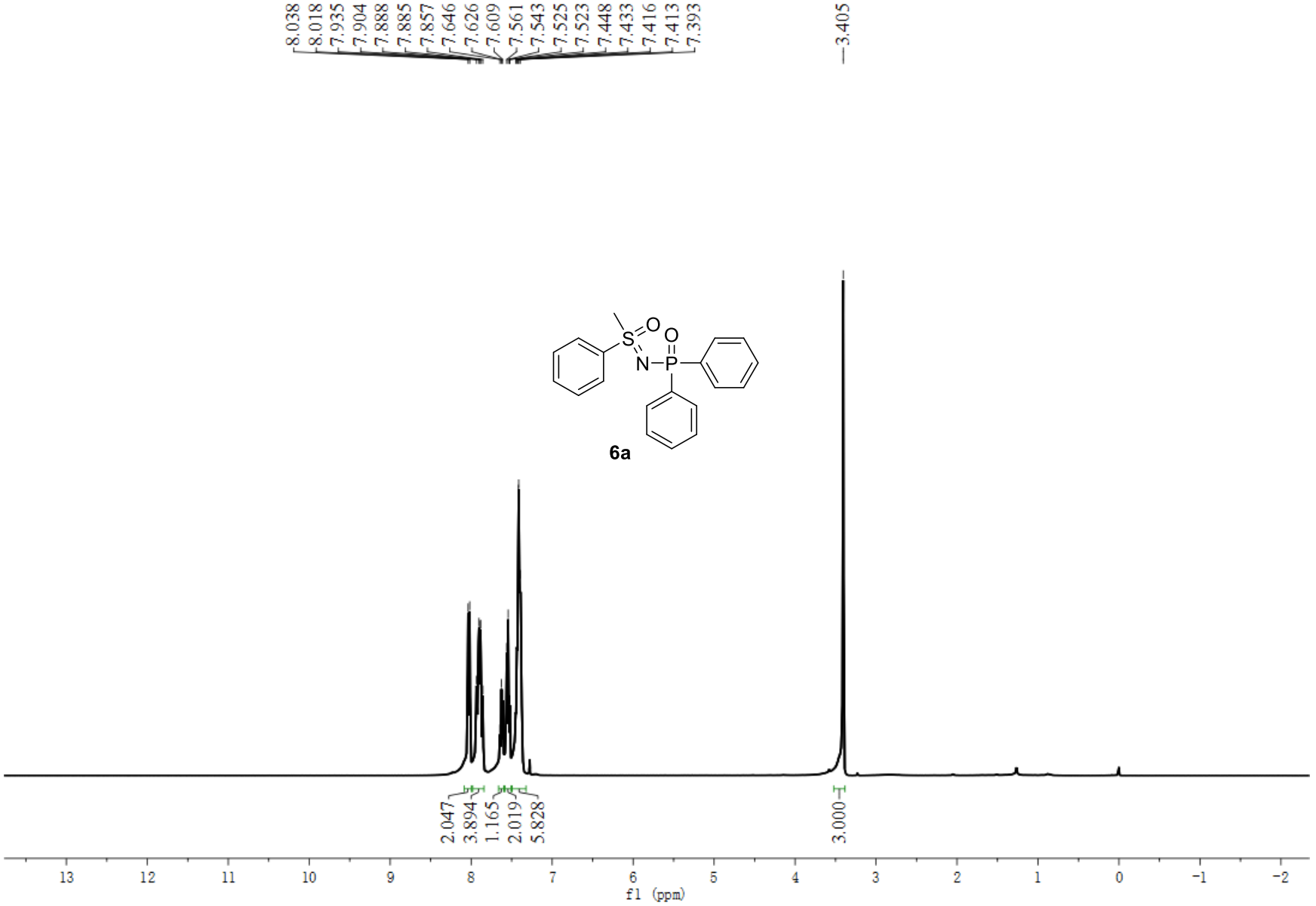
^{1}H NMR spectra of compound **3zh** (400 MHz, $CDCl_3$)



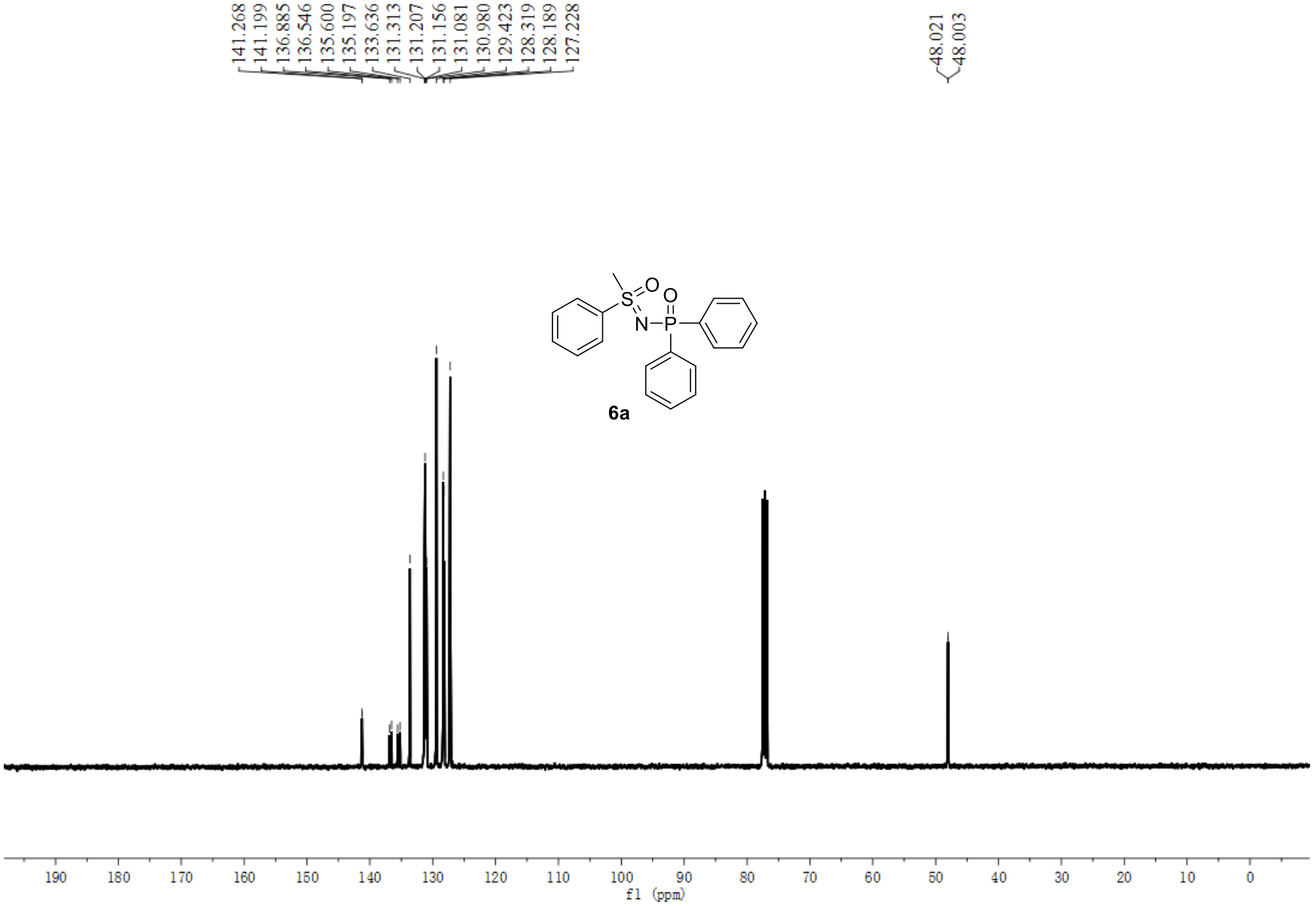
^{13}C NMR spectra of compound **3zh** (101 MHz, $CDCl_3$)



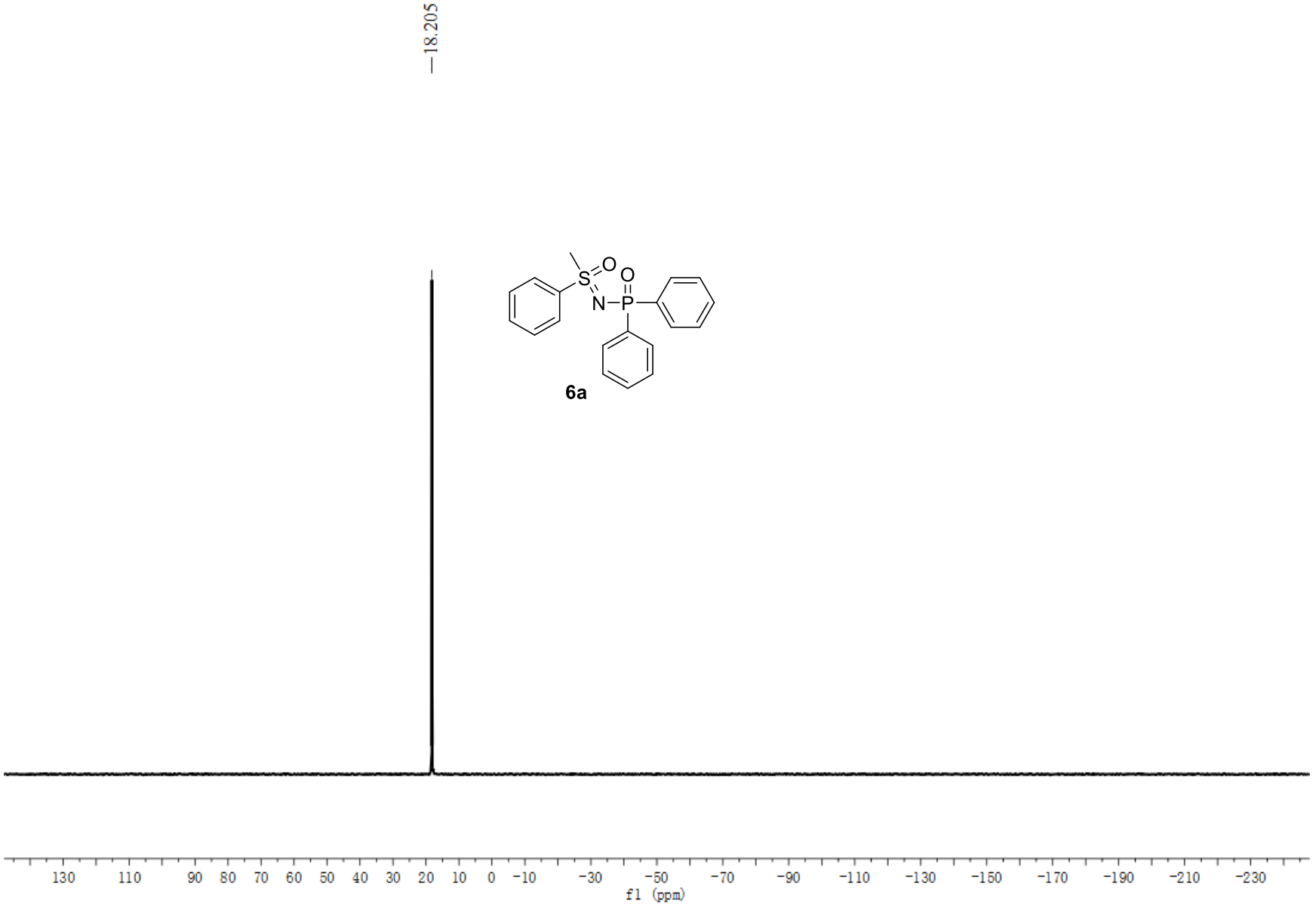
^{1}H NMR spectra of compound **6a** (400 MHz, $CDCl_3$)



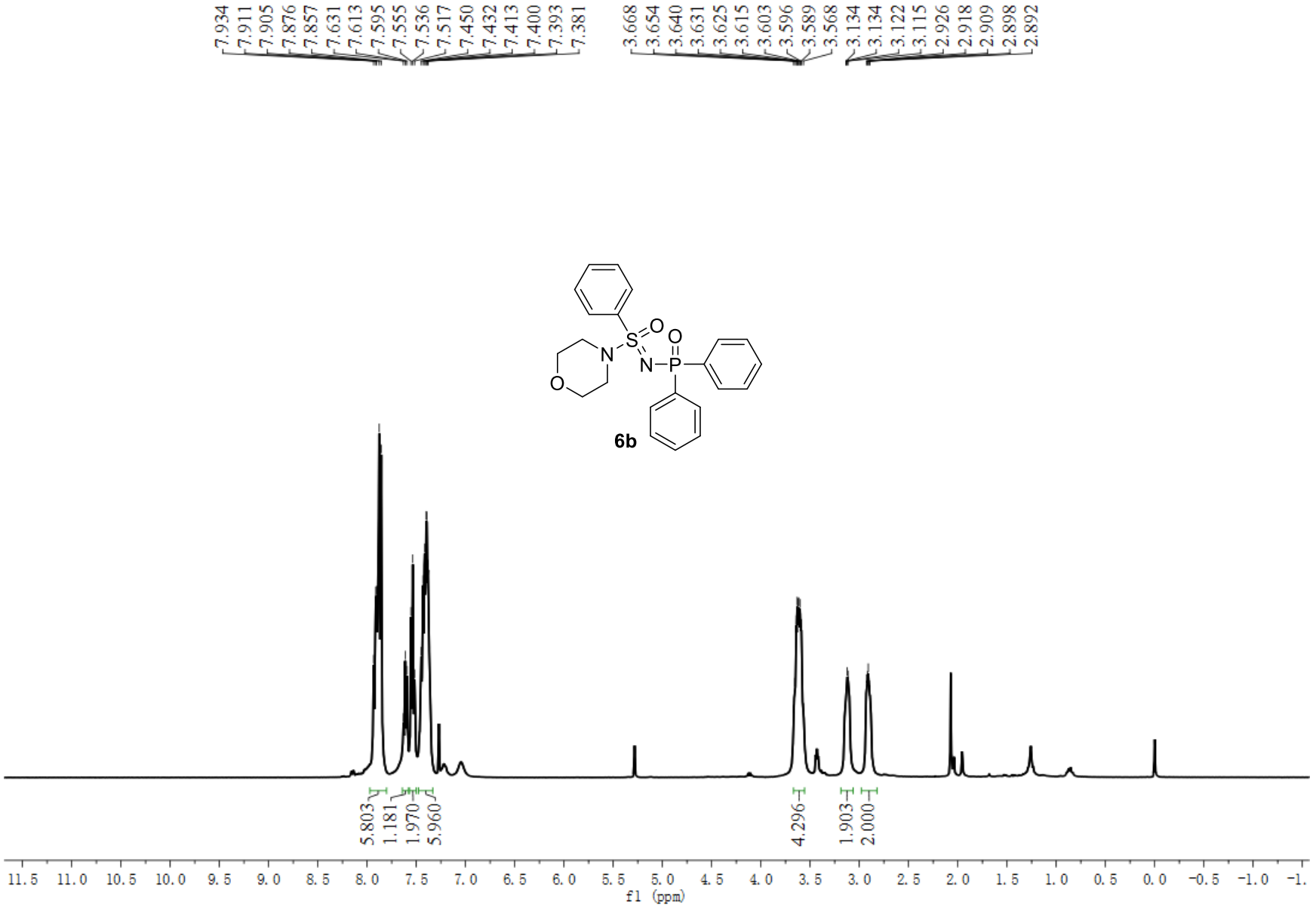
^{13}C NMR spectra of compound **6a** (101 MHz, $CDCl_3$)



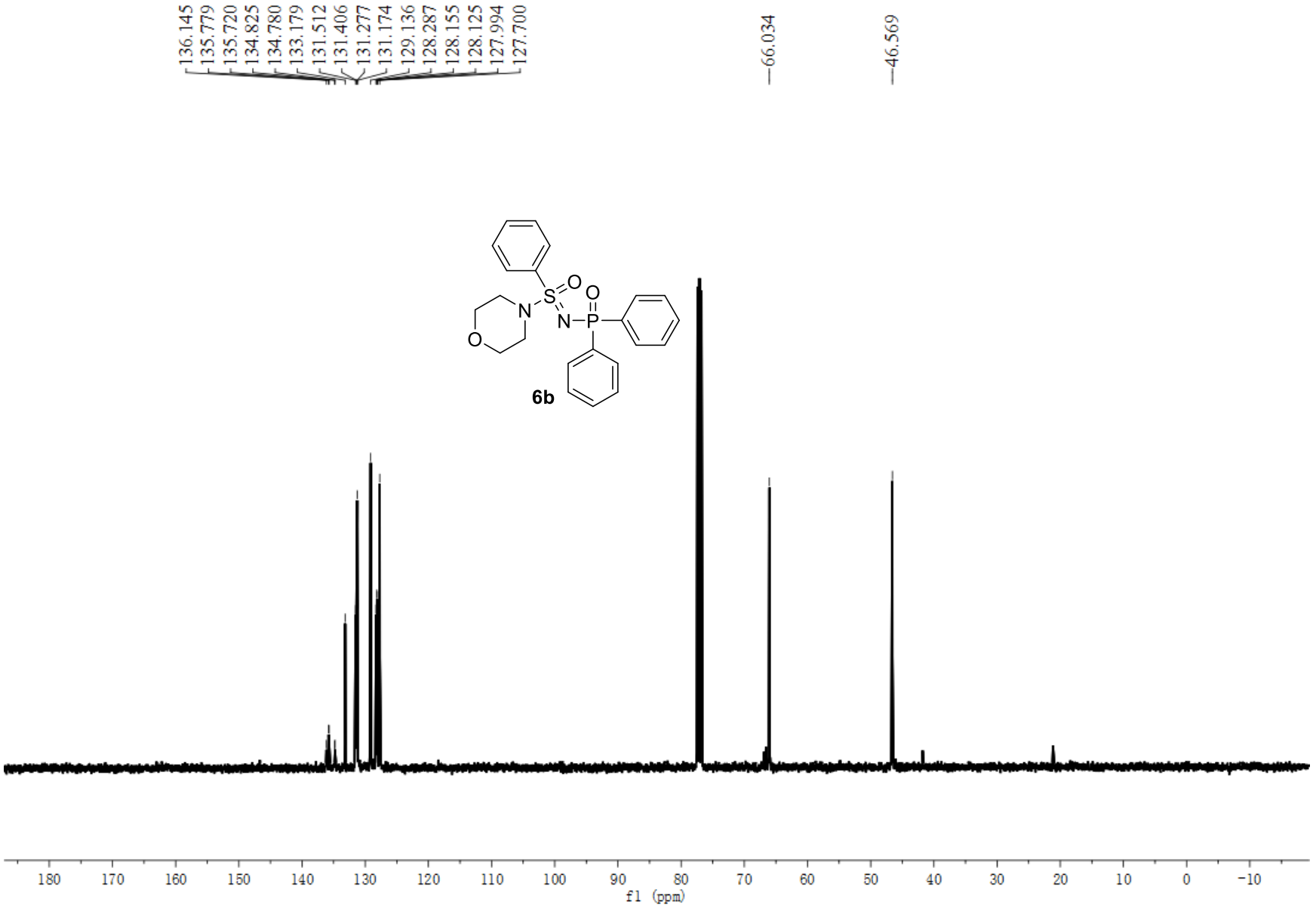
^{31}P NMR spectra of compound **6a** (162 MHz, $CDCl_3$)



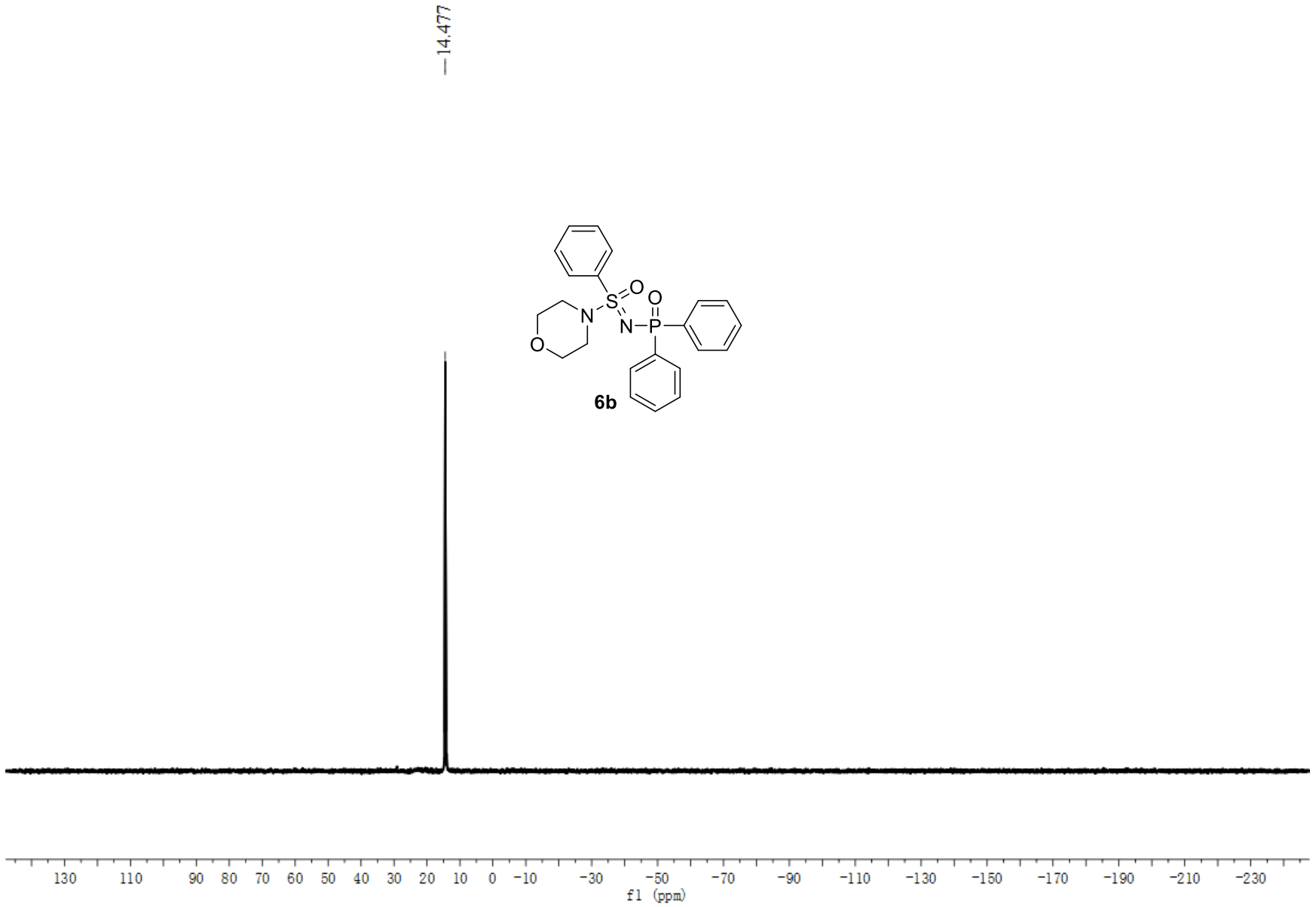
^{1}H NMR spectra of compound **6b** (400 MHz, $CDCl_3$)



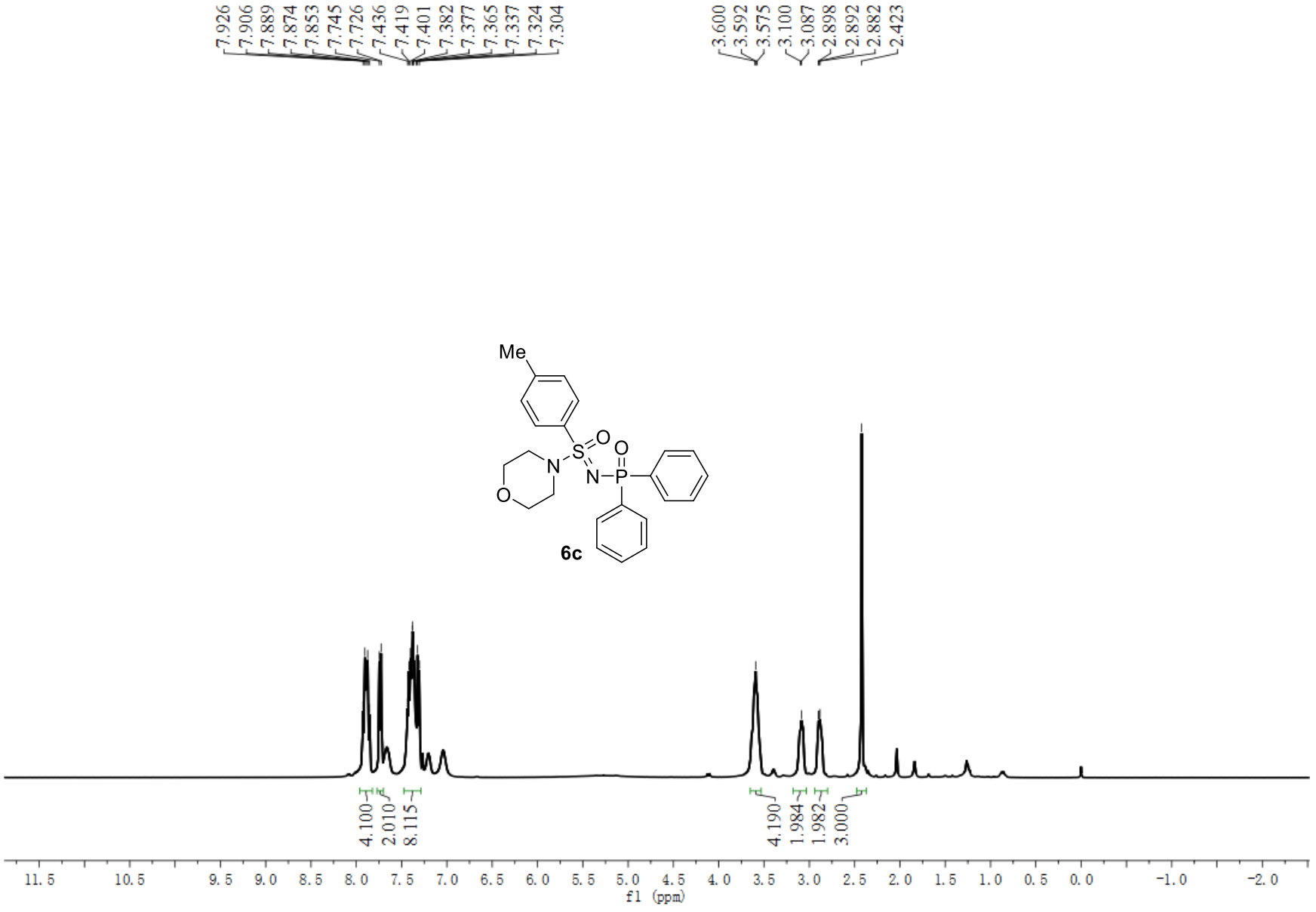
^{13}C NMR spectra of compound **6b** (101 MHz, $CDCl_3$)



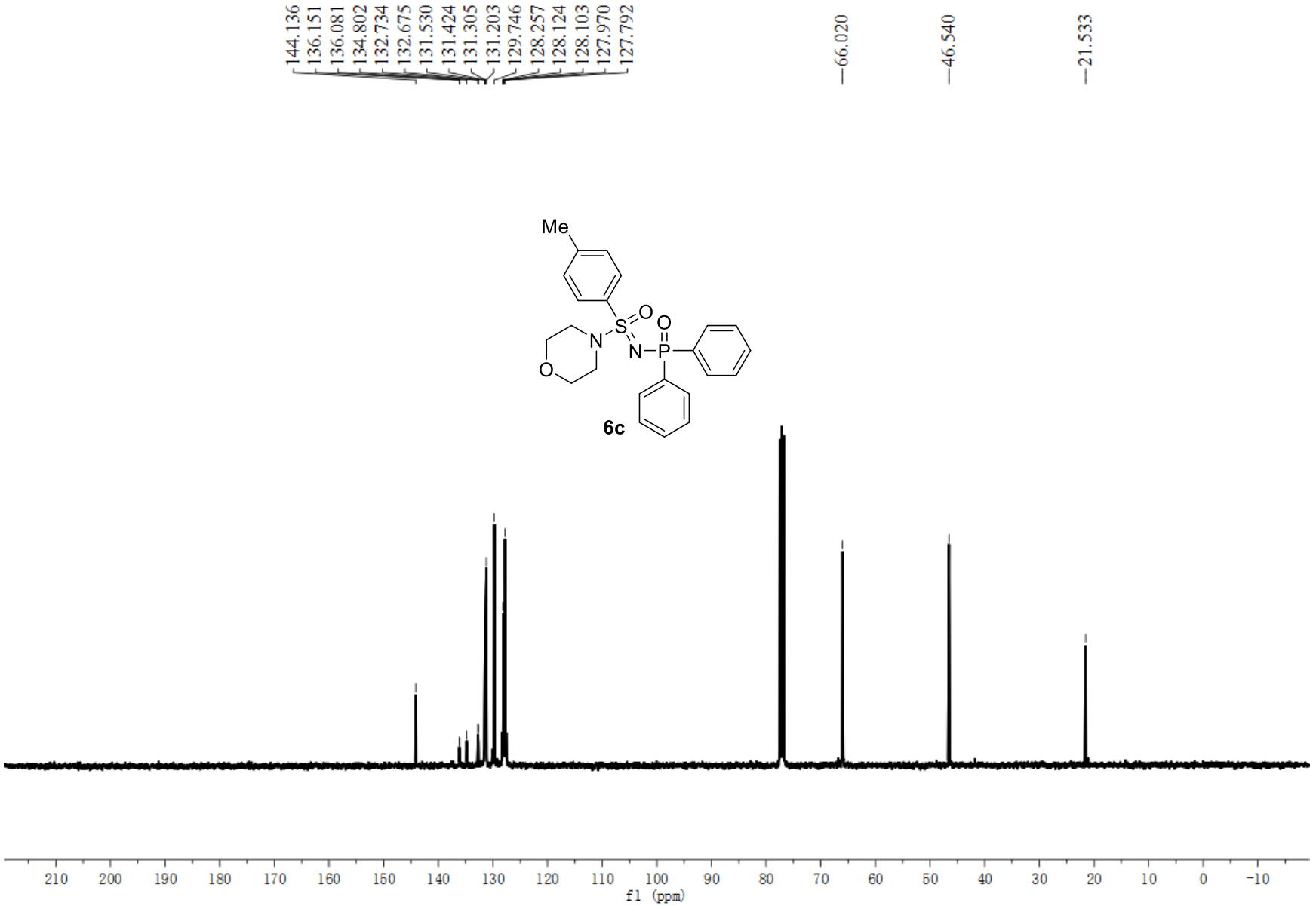
^{31}P NMR spectra of compound **6b** (162 MHz, $CDCl_3$)



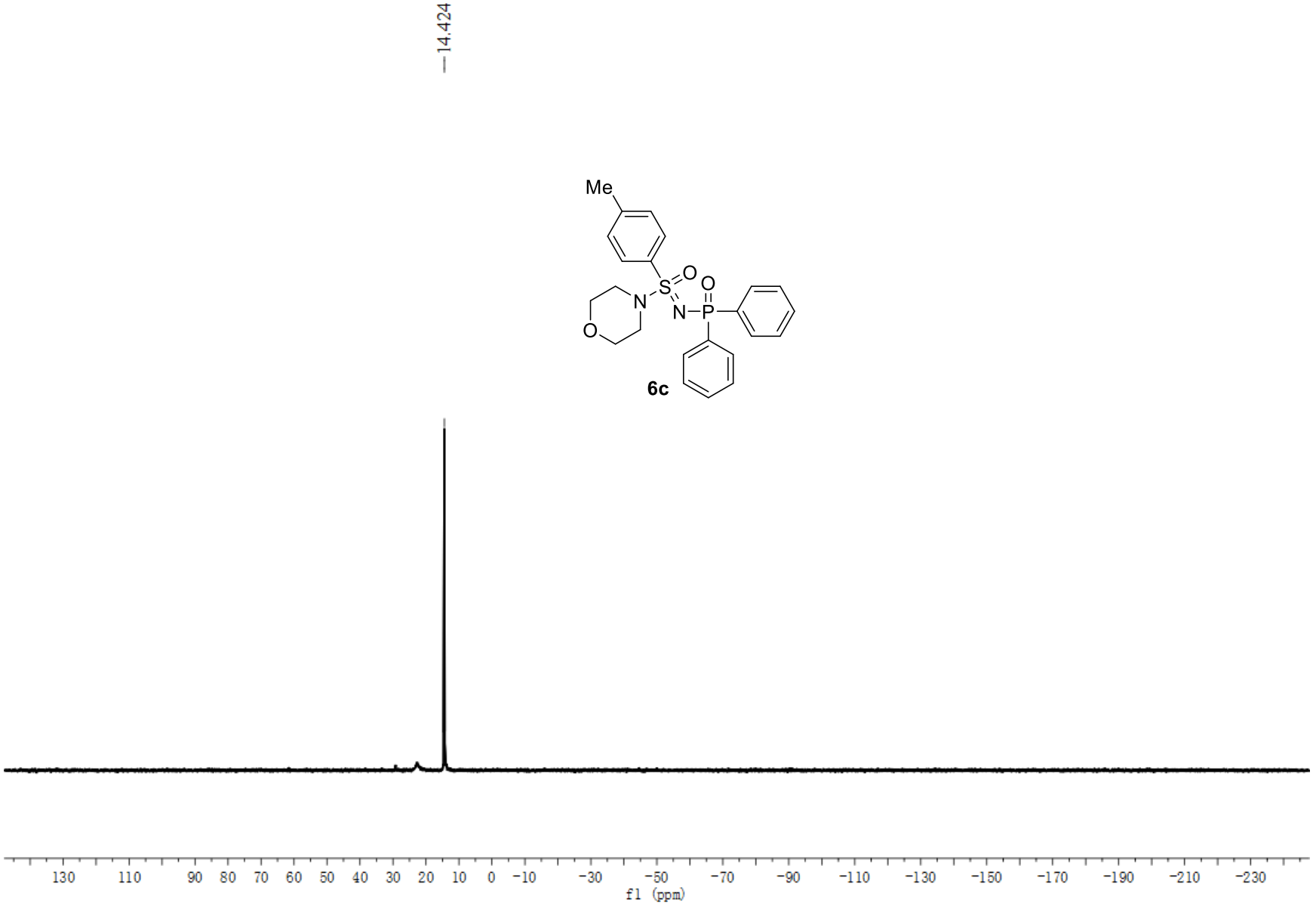
^{1}H NMR spectra of compound **6c** (400 MHz, $CDCl_3$)



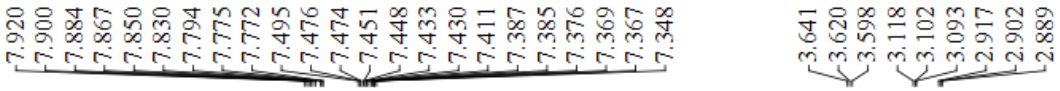
^{13}C NMR spectra of compound **6c** (101 MHz, $CDCl_3$)

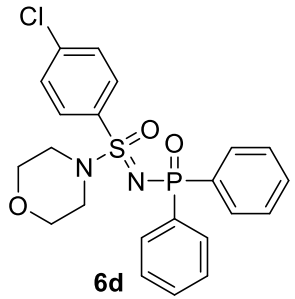


^{31}P NMR spectra of compound **6c** (162 MHz, $CDCl_3$)

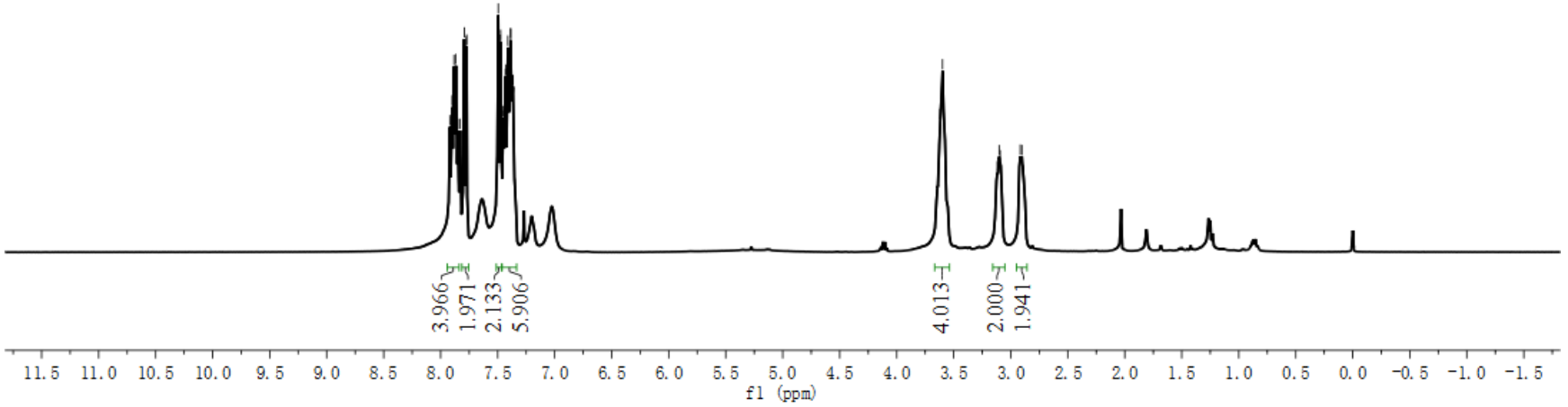


^{1}H NMR spectra of compound **6d** (400 MHz, $CDCl_3$)

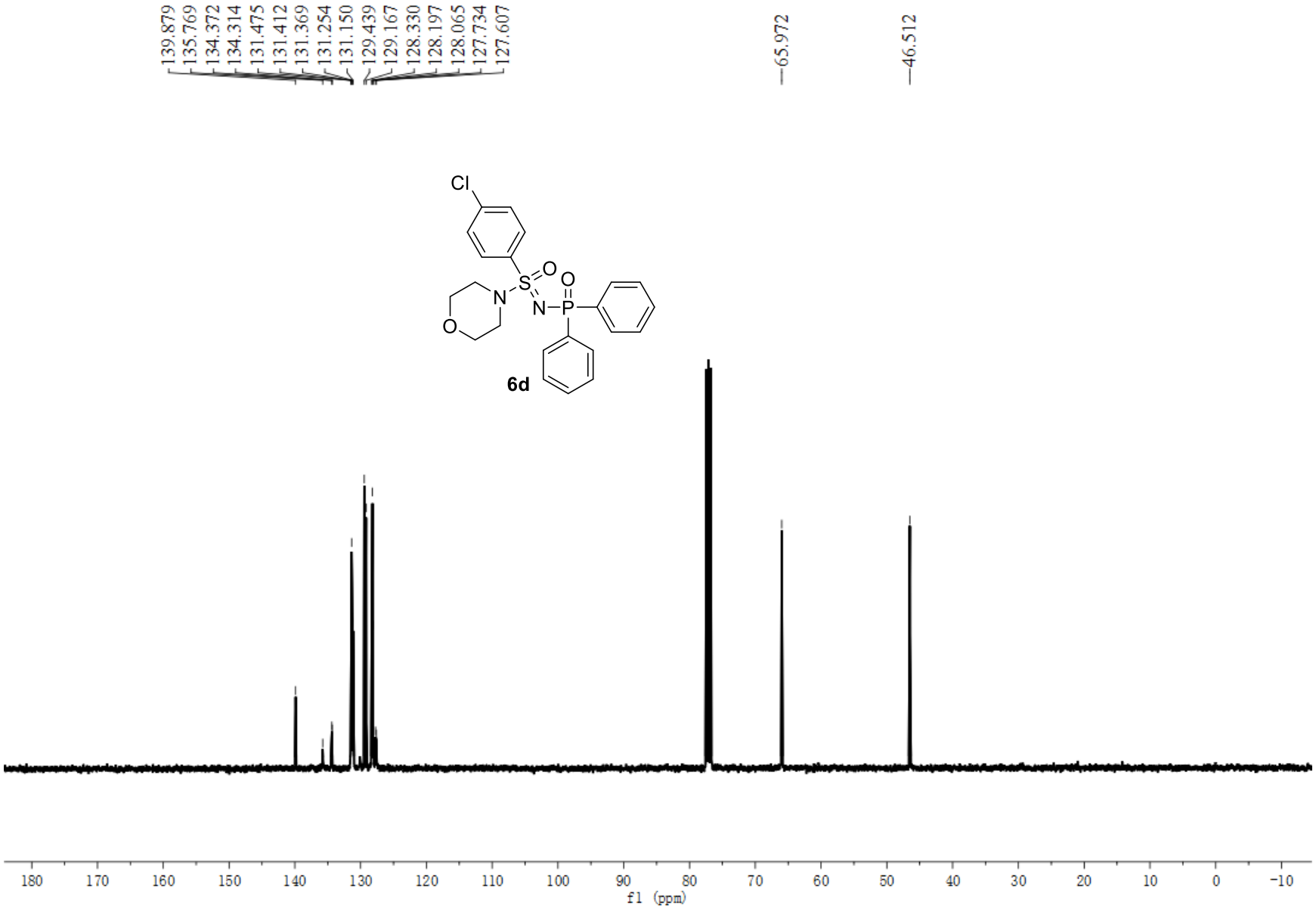




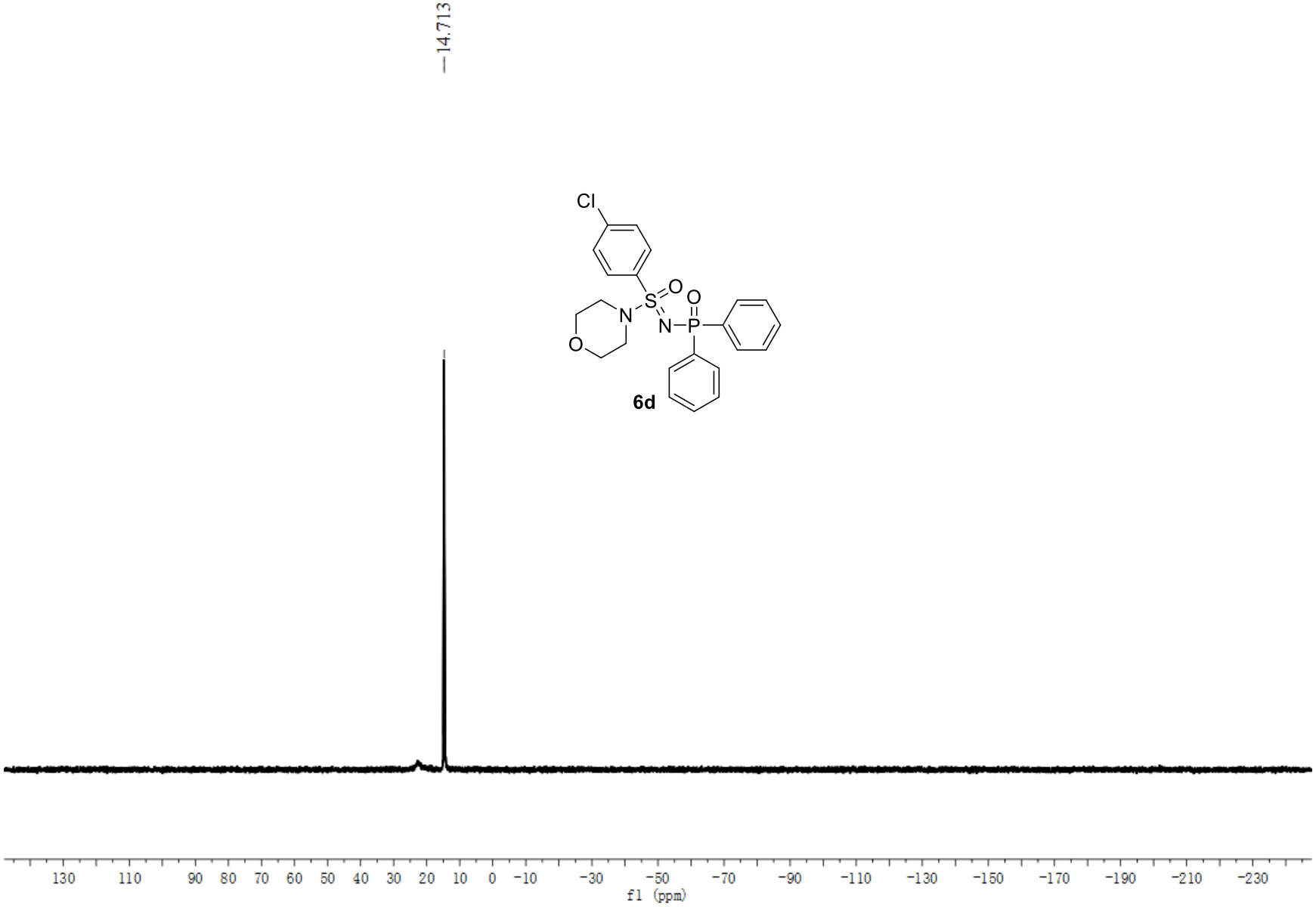
6d



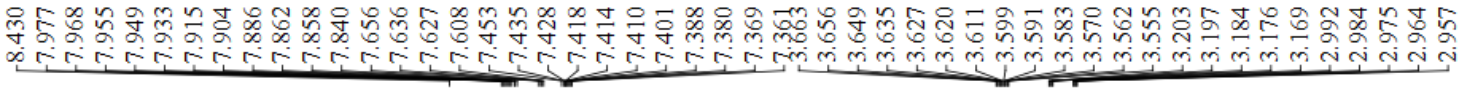
^{13}C NMR spectra of compound **6d** (101 MHz, $CDCl_3$)

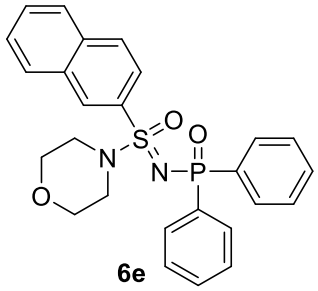


^{31}P NMR spectra of compound **6d** (162 MHz, $CDCl_3$)

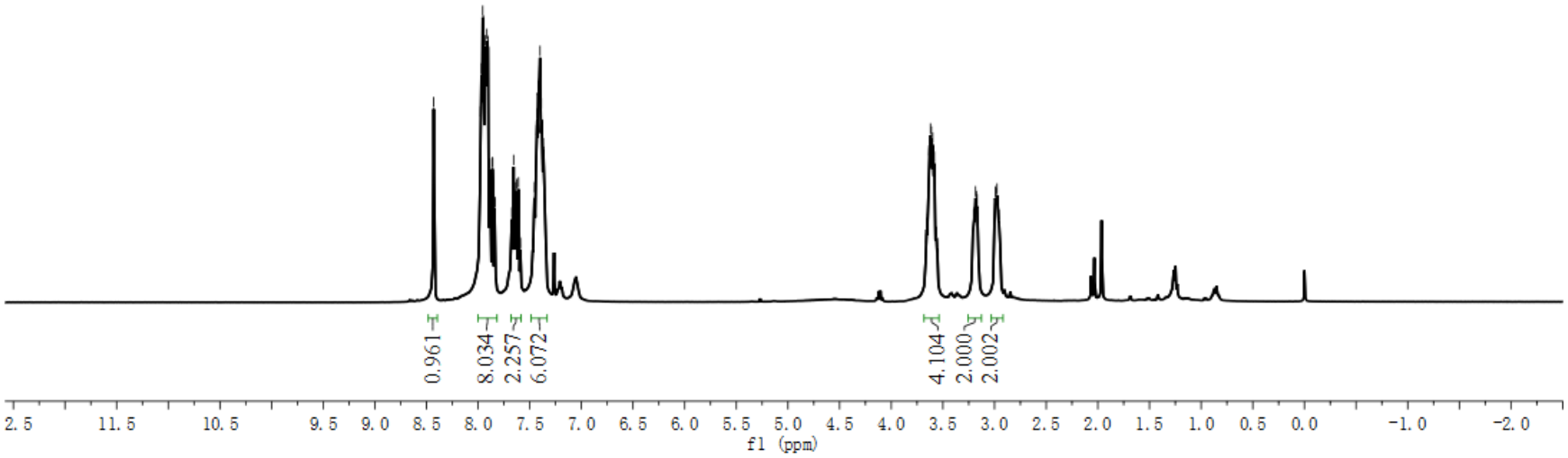


^{1}H NMR spectra of compound **6e** (400 MHz, $CDCl_3$)

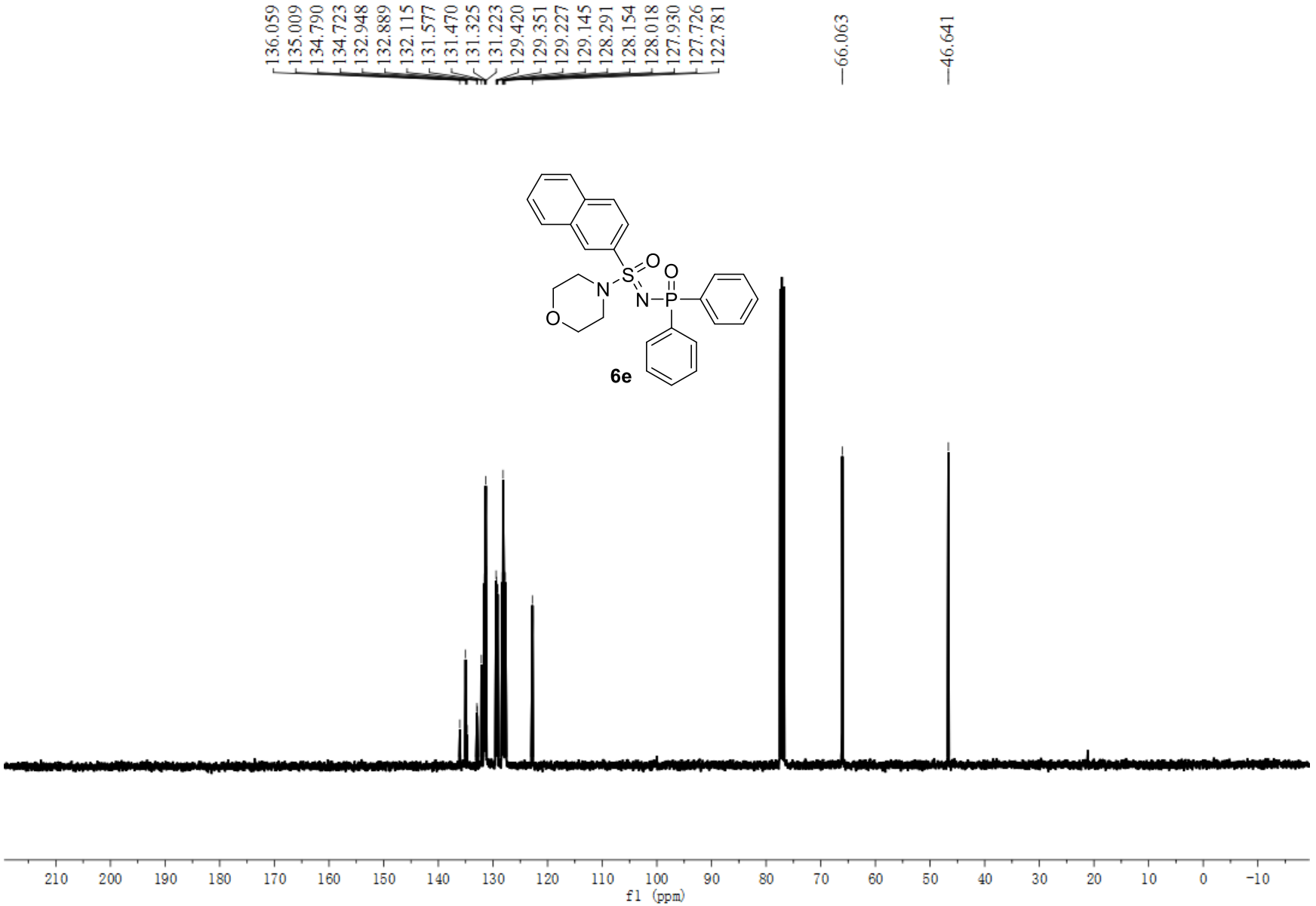




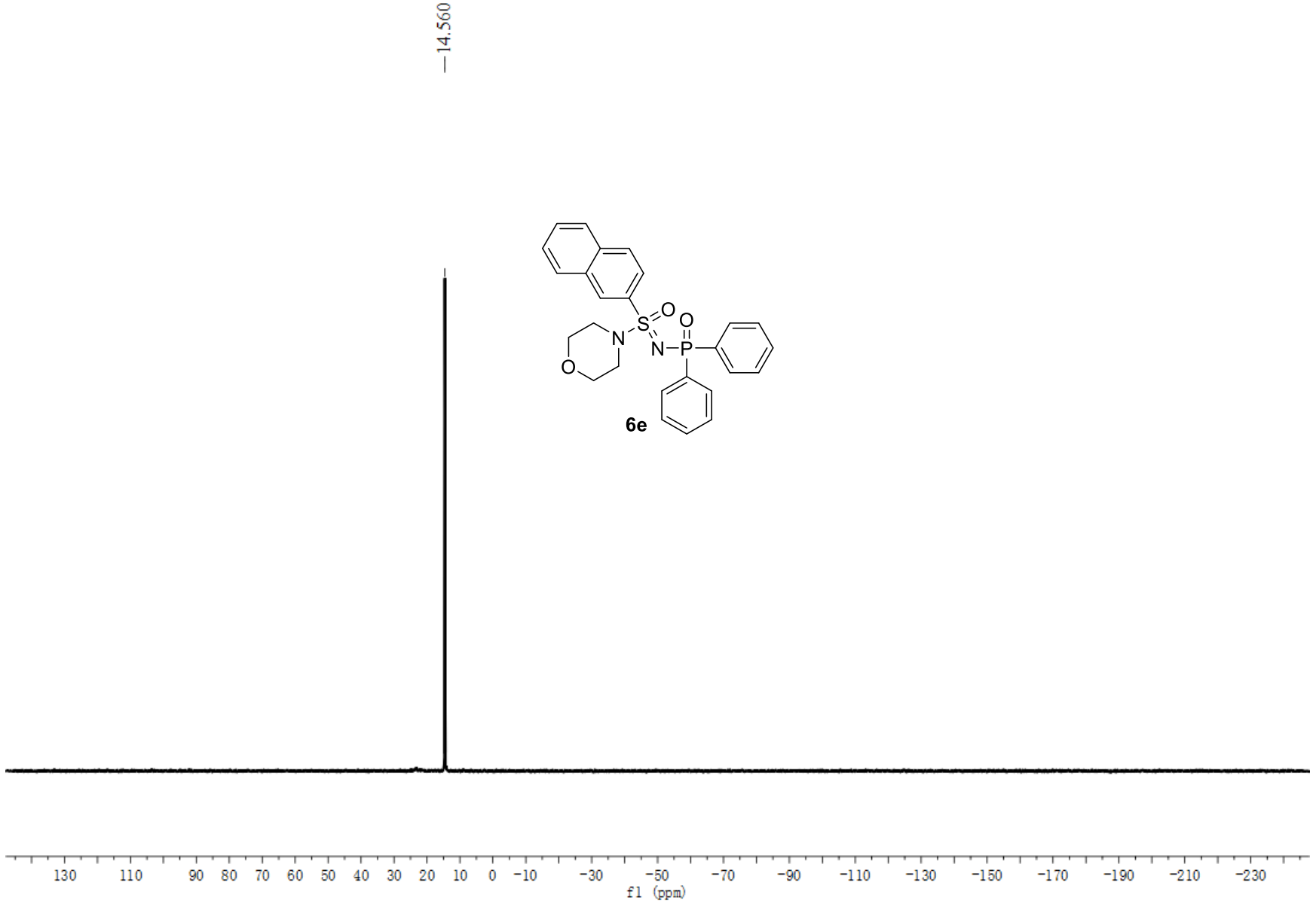
6e



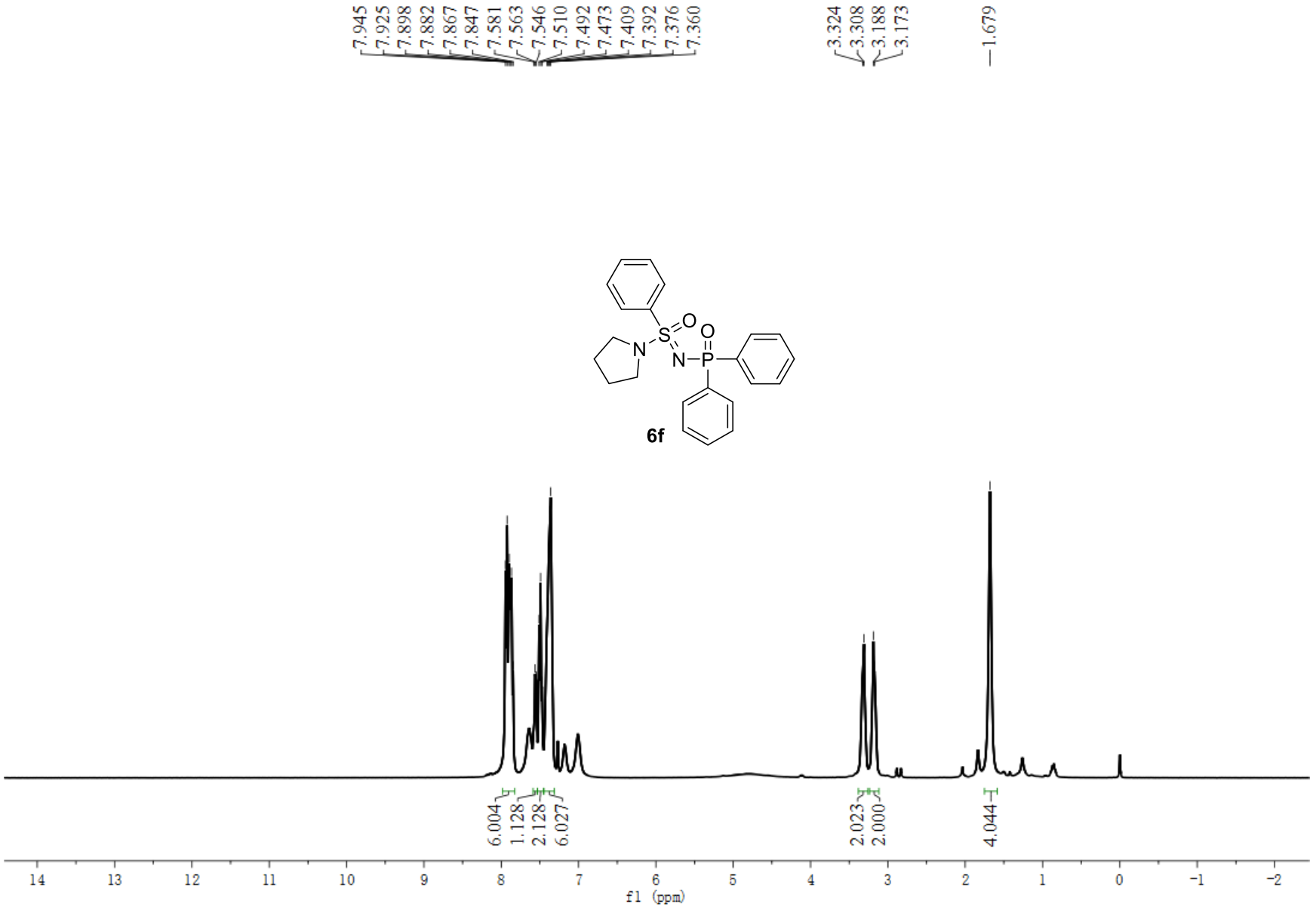
^{13}C NMR spectra of compound **6e** (101 MHz, $CDCl_3$)



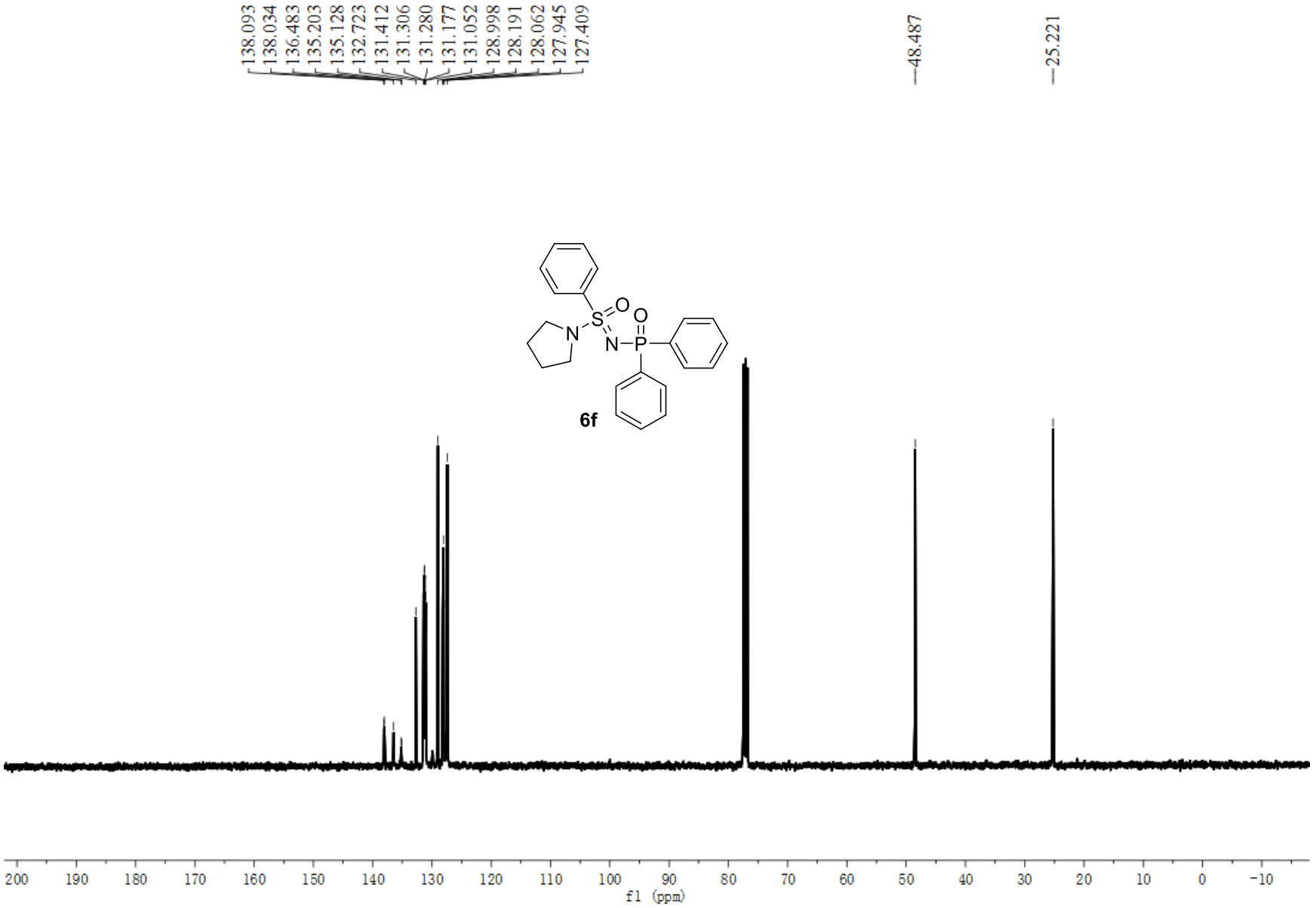
^{31}P NMR spectra of compound **6e** (162 MHz, $CDCl_3$)



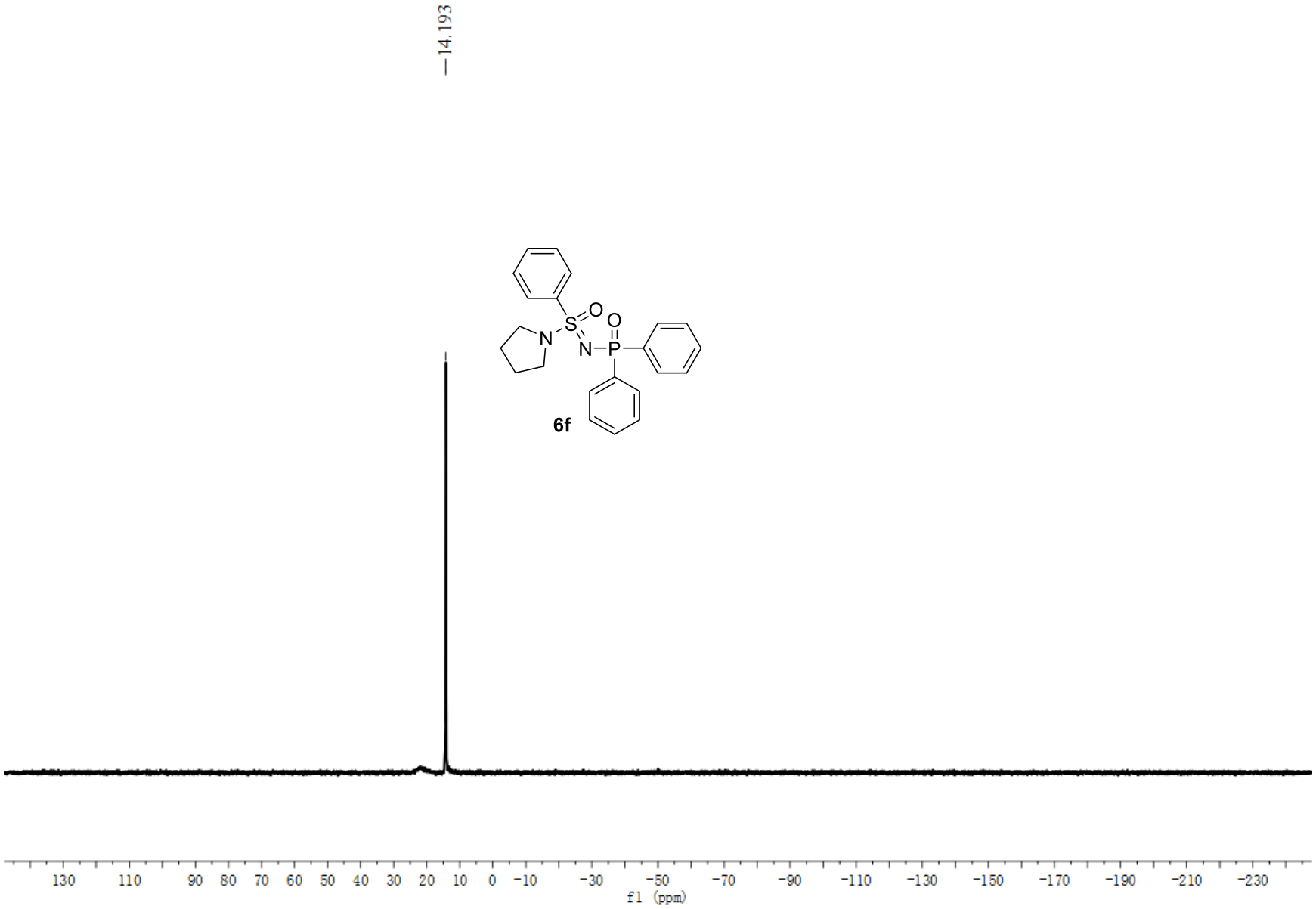
^{1}H NMR spectra of compound **6f** (400 MHz, $CDCl_3$)



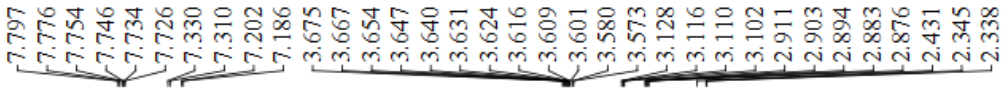
^{13}C NMR spectra of compound **6f** (101 MHz, $CDCl_3$)

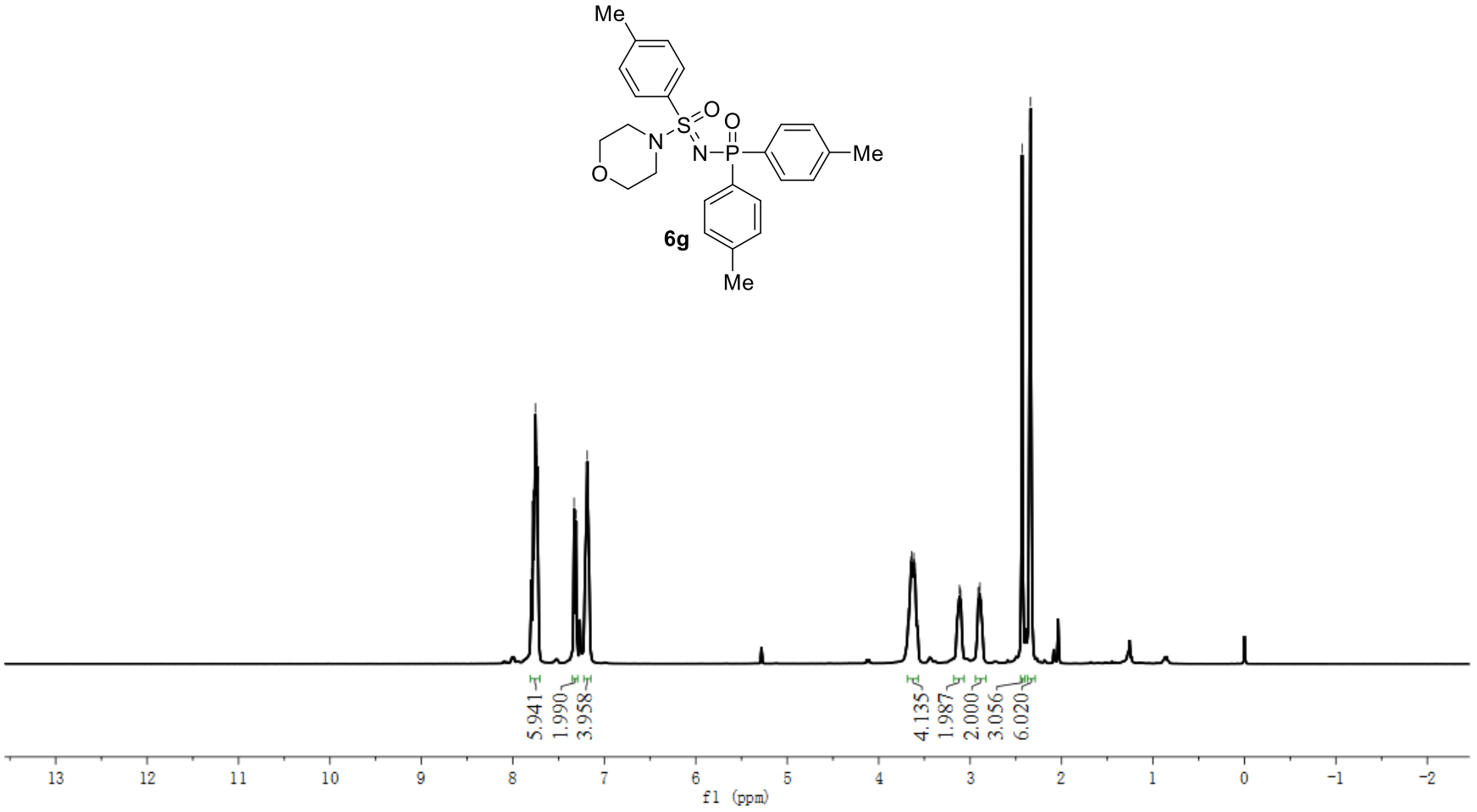


^{31}P NMR spectra of compound **6f** (162 MHz, $CDCl_3$)

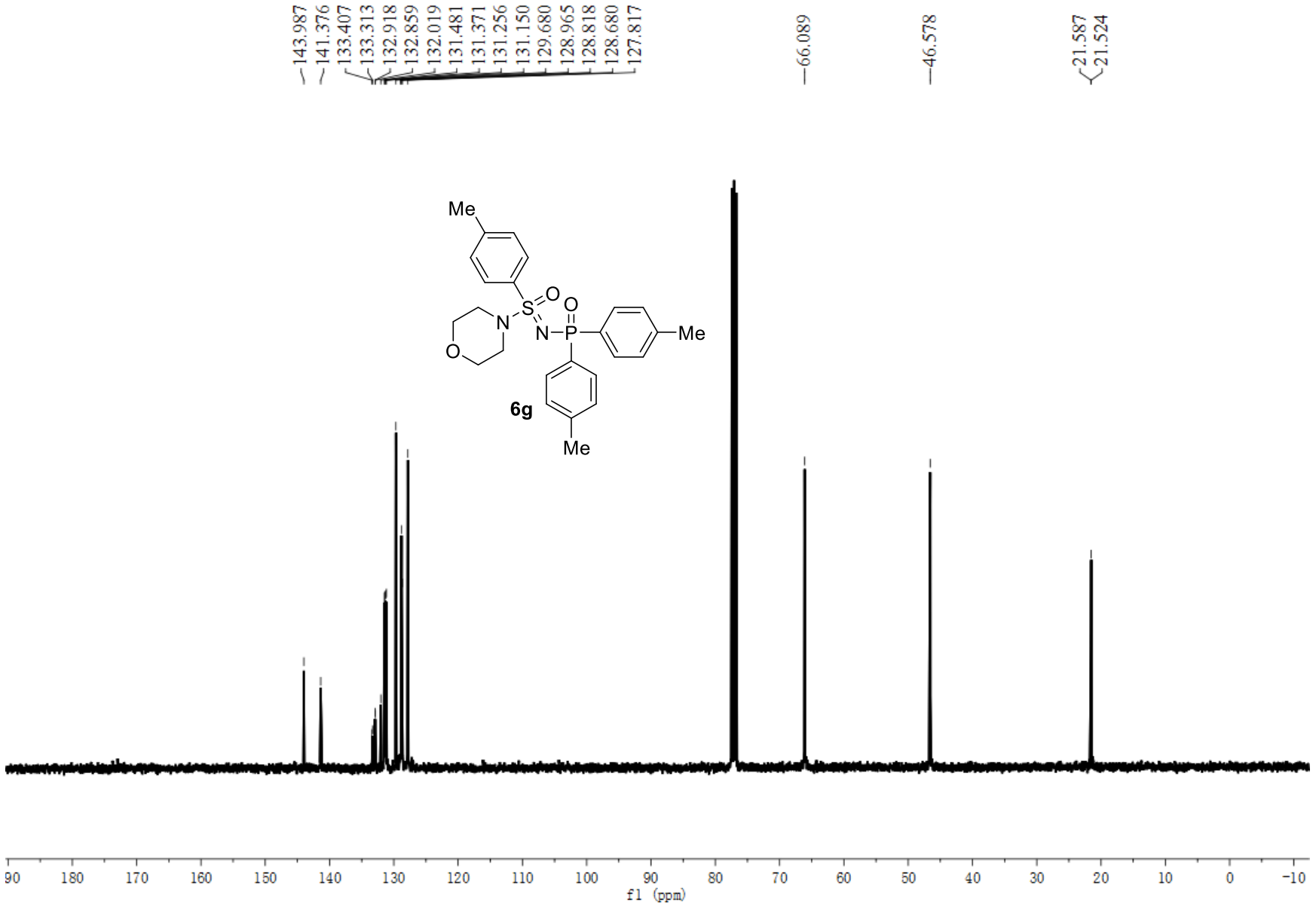


^{1}H NMR spectra of compound **6g** (400 MHz, $CDCl_3$)

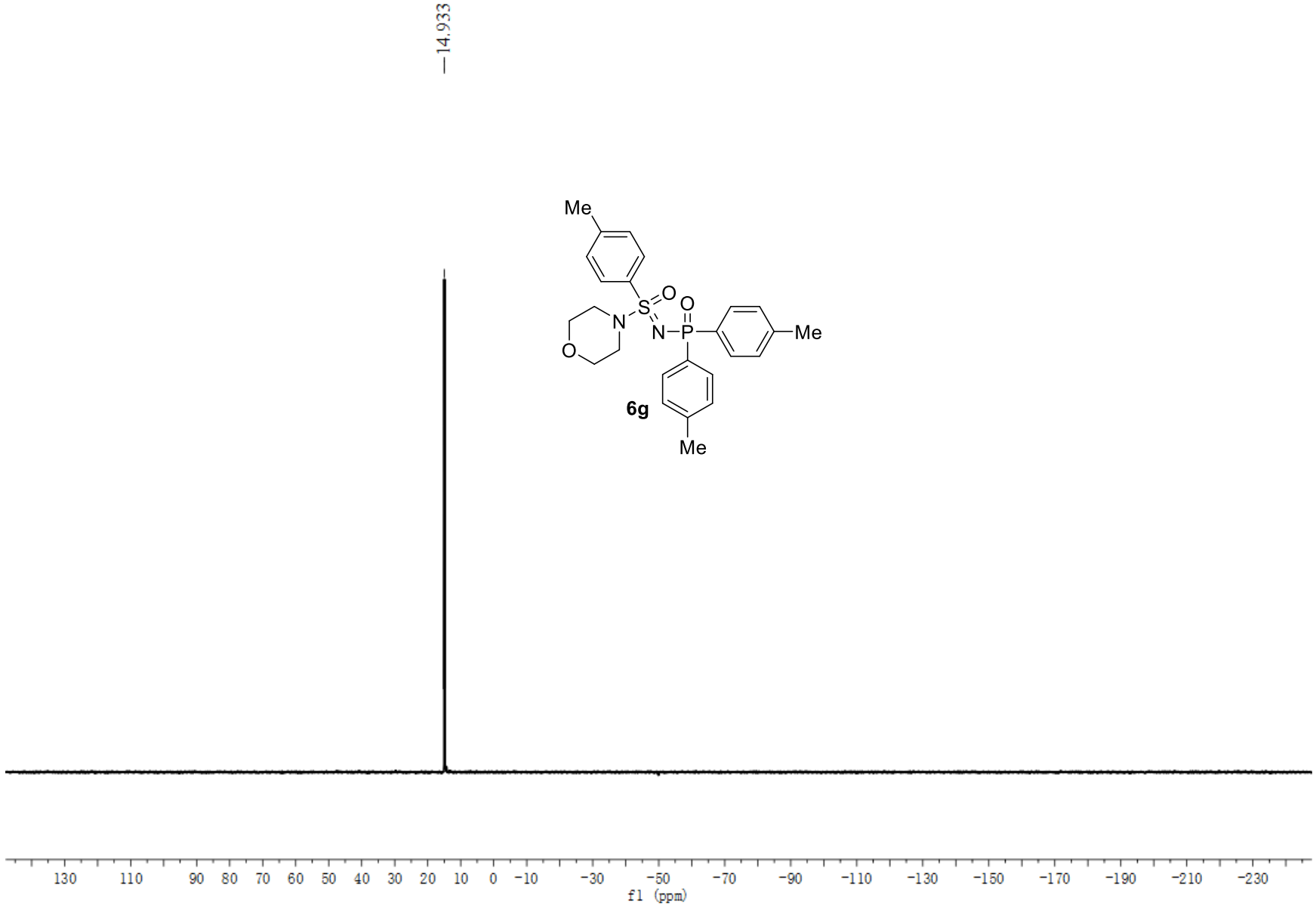




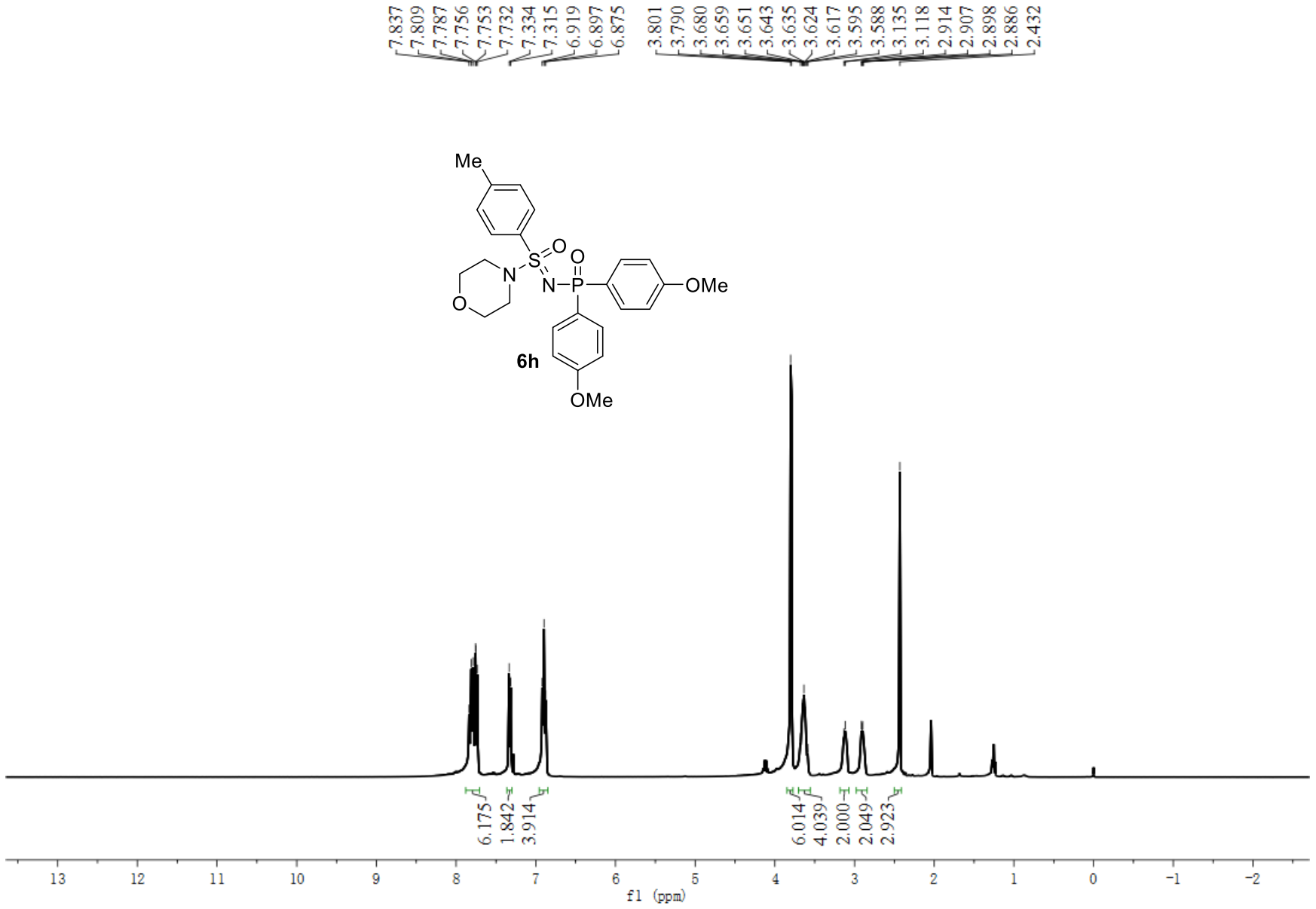
^{13}C NMR spectra of compound **6g** (101 MHz, $CDCl_3$)



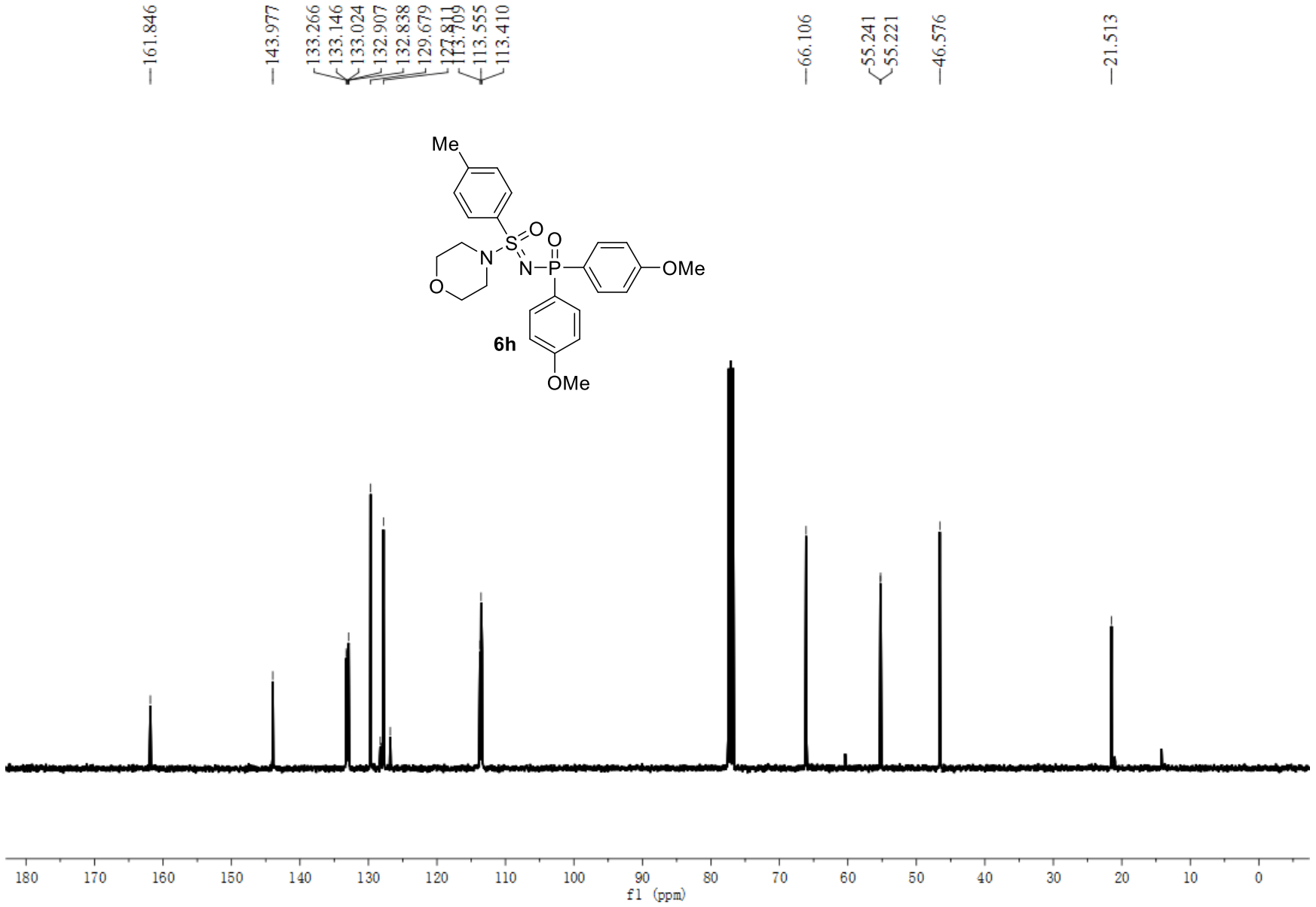
^{31}P NMR spectra of compound **6g** (162 MHz, $CDCl_3$)



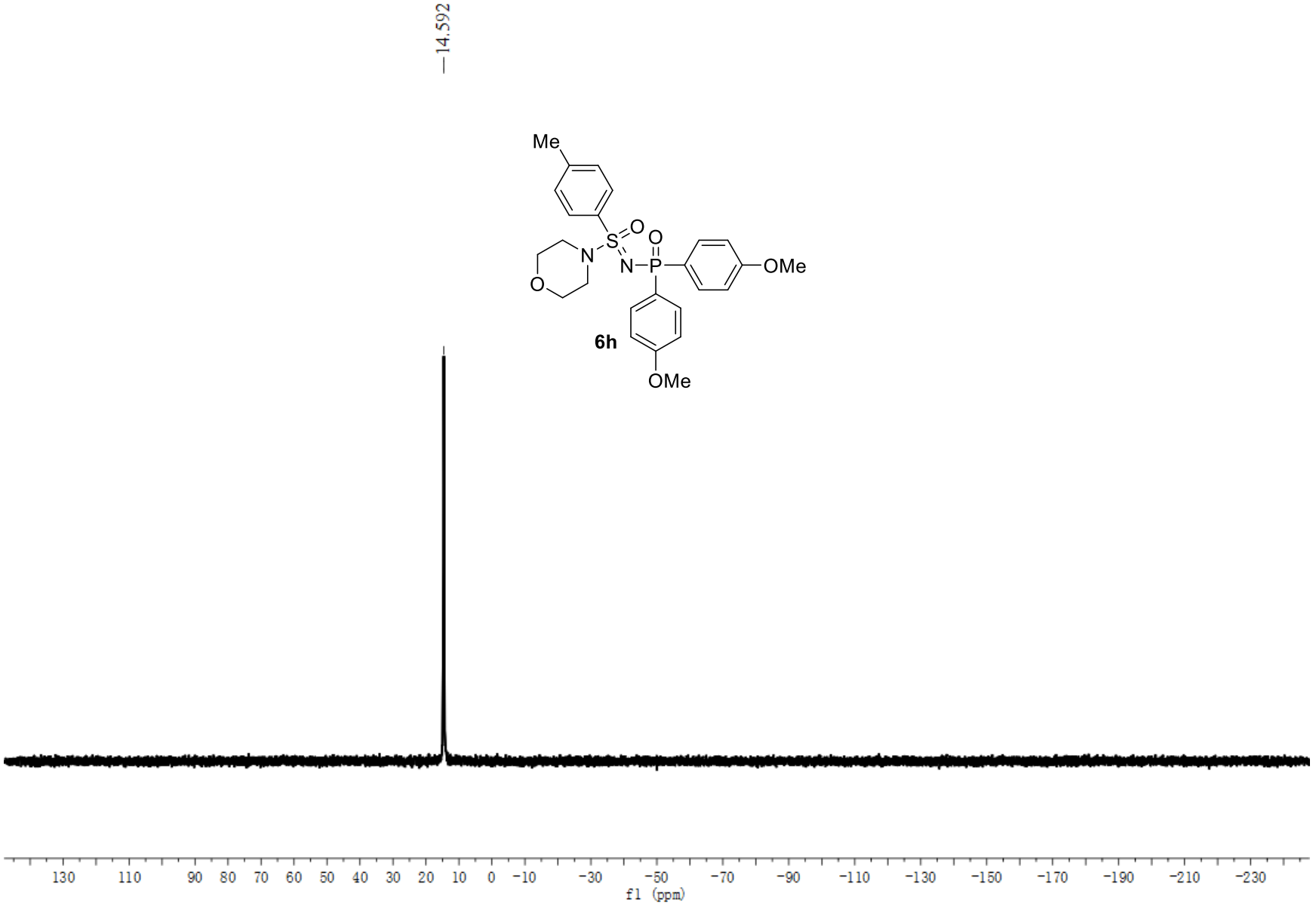
^{1}H NMR spectra of compound **6h** (400 MHz, $CDCl_3$)



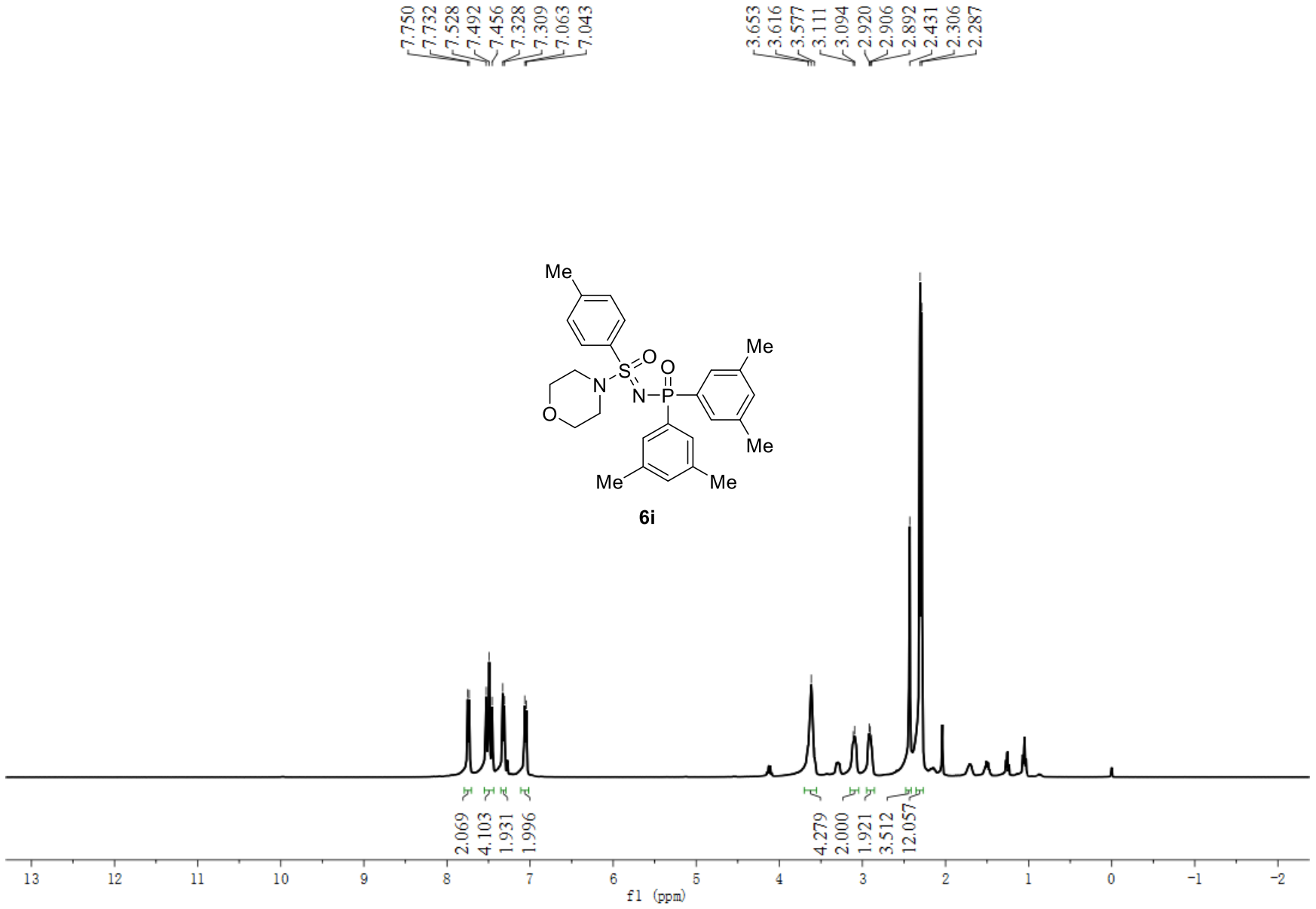
^{13}C NMR spectra of compound **6h** (101 MHz, $CDCl_3$)



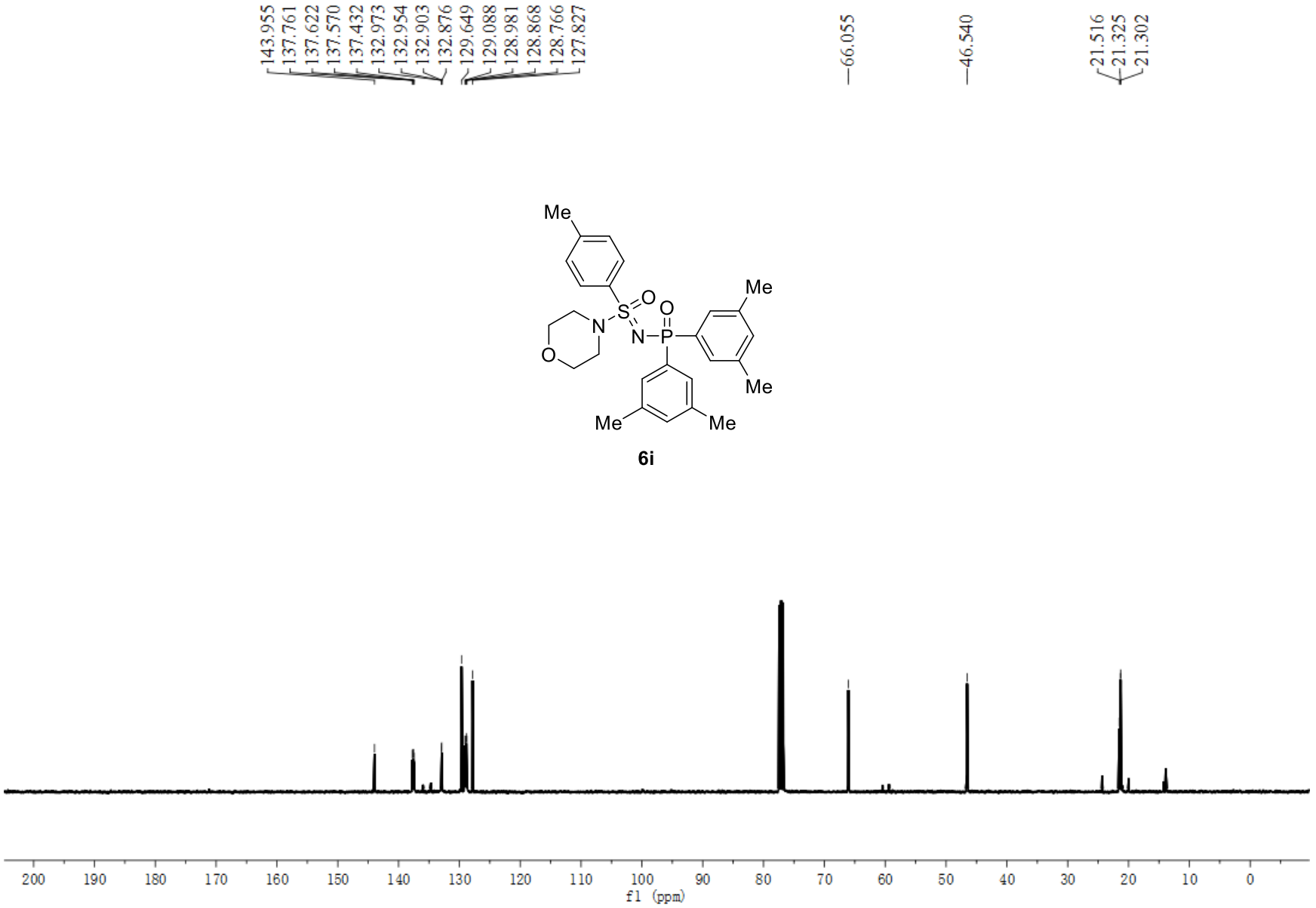
^{31}P NMR spectra of compound **6h** (162 MHz, $CDCl_3$)



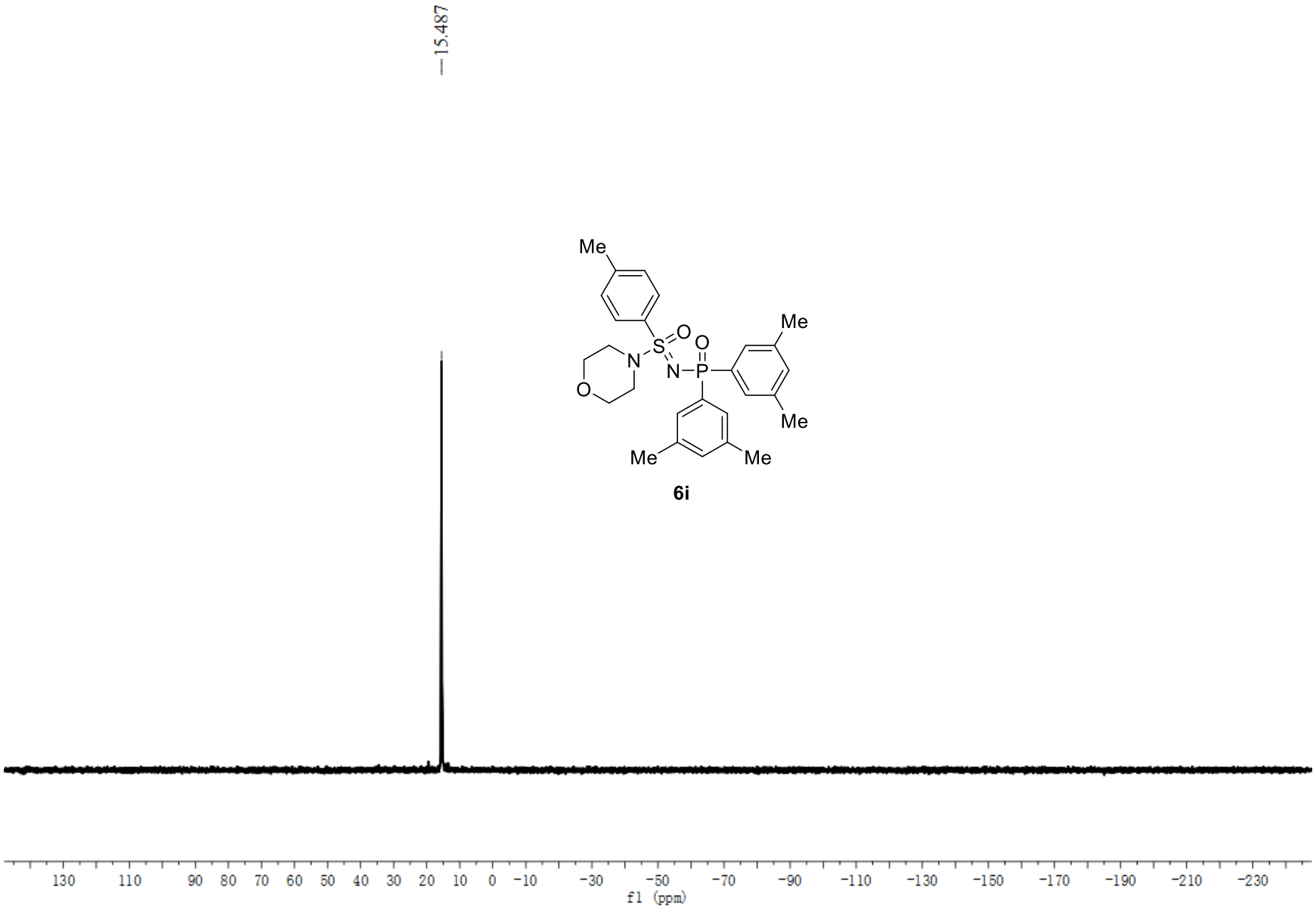
^{1}H NMR spectra of compound **6i** (400 MHz, $CDCl_3$)



^{13}C NMR spectra of compound **6i** (101 MHz, $CDCl_3$)

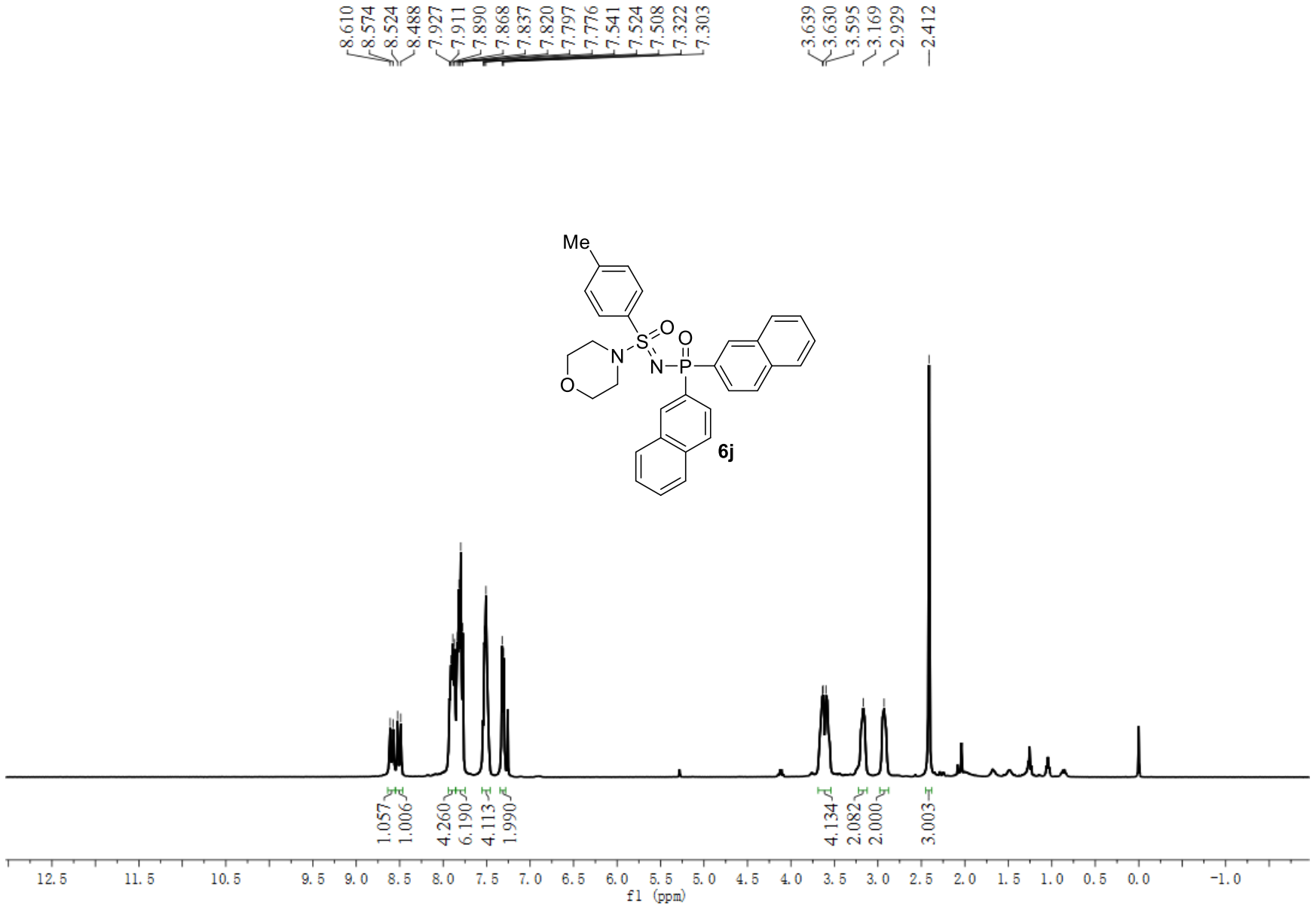


^{31}P NMR spectra of compound **6i** (162 MHz, $CDCl_3$)

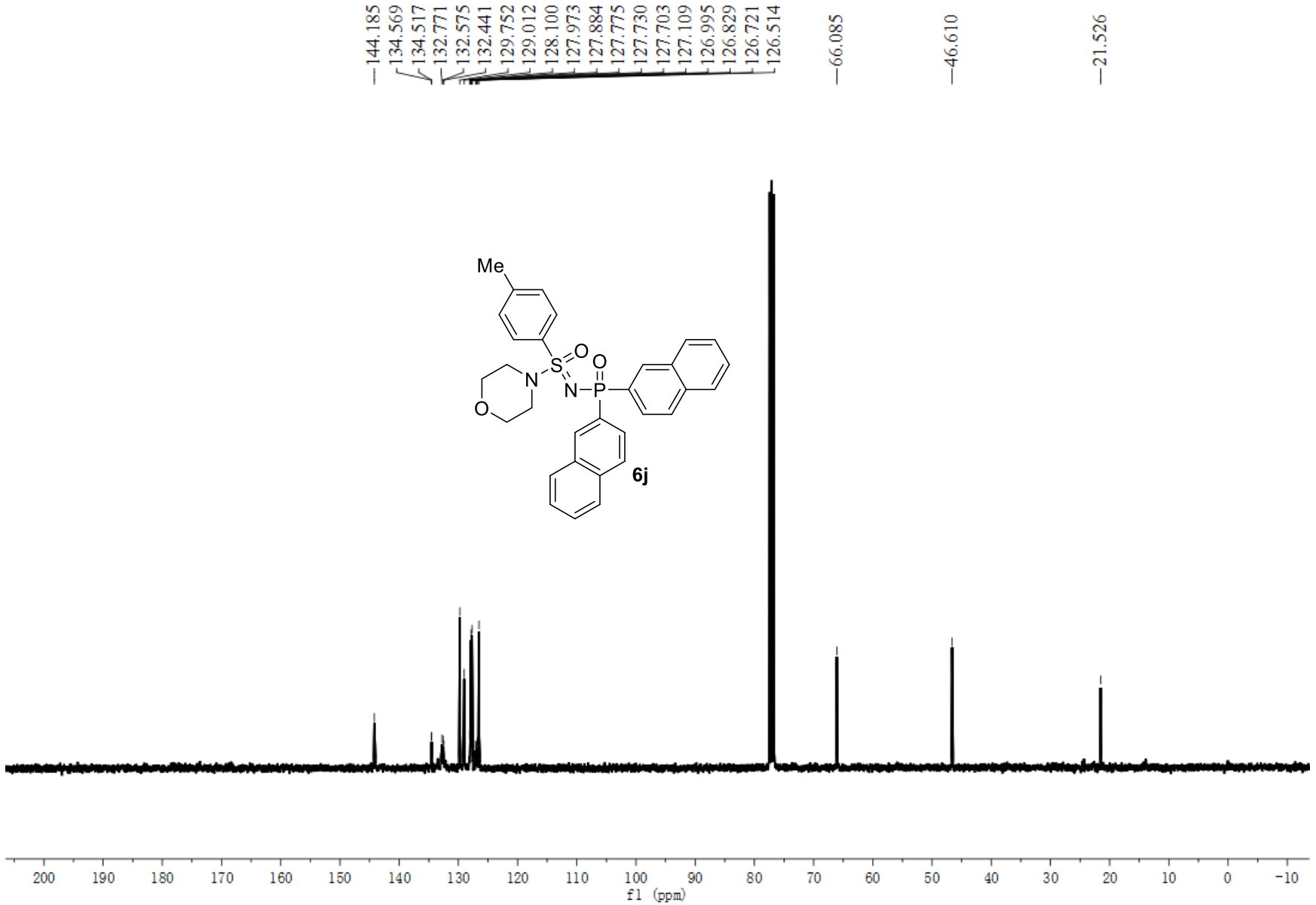


6i

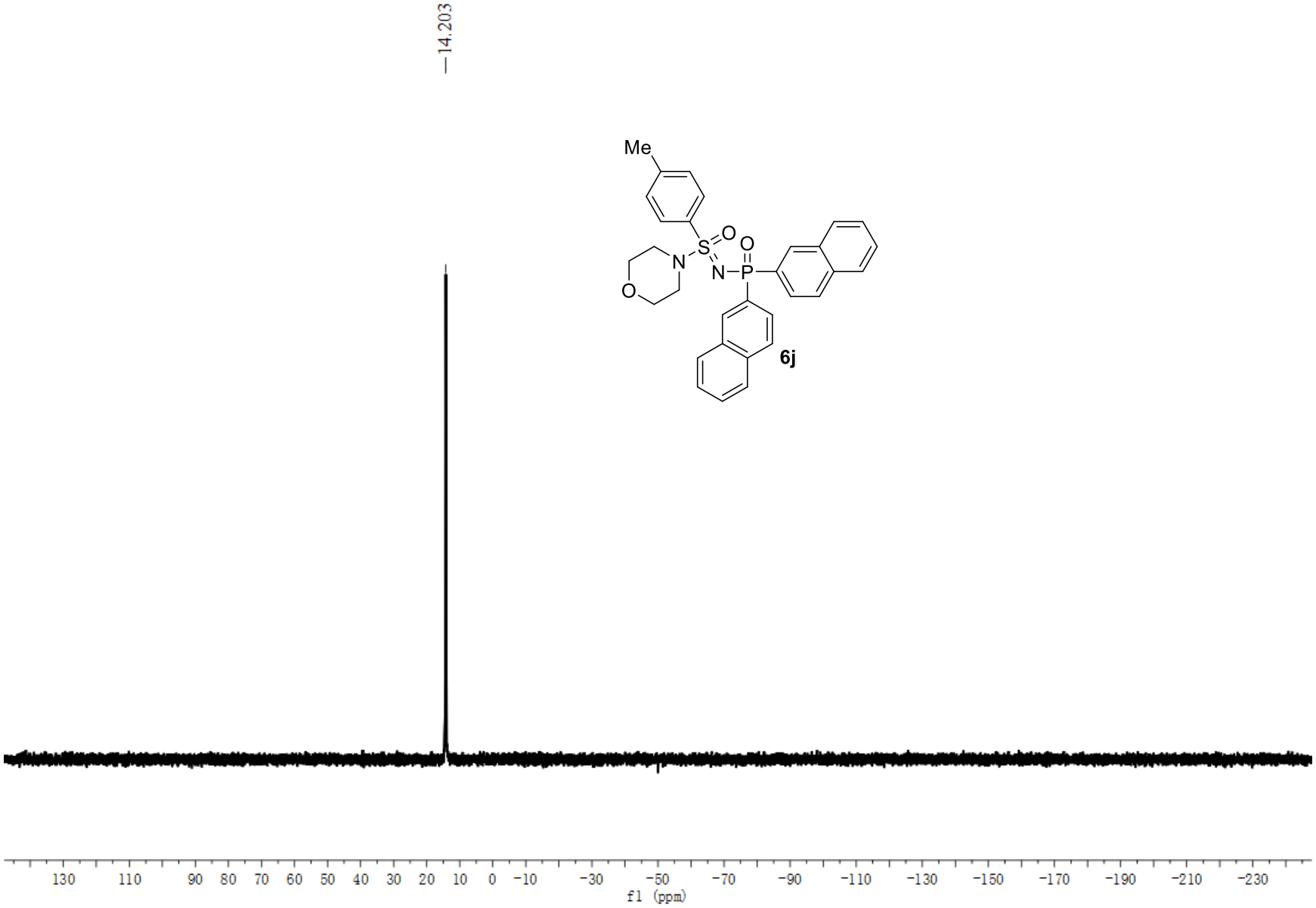
^{1}H NMR spectra of compound **6j** (400 MHz, $CDCl_3$)



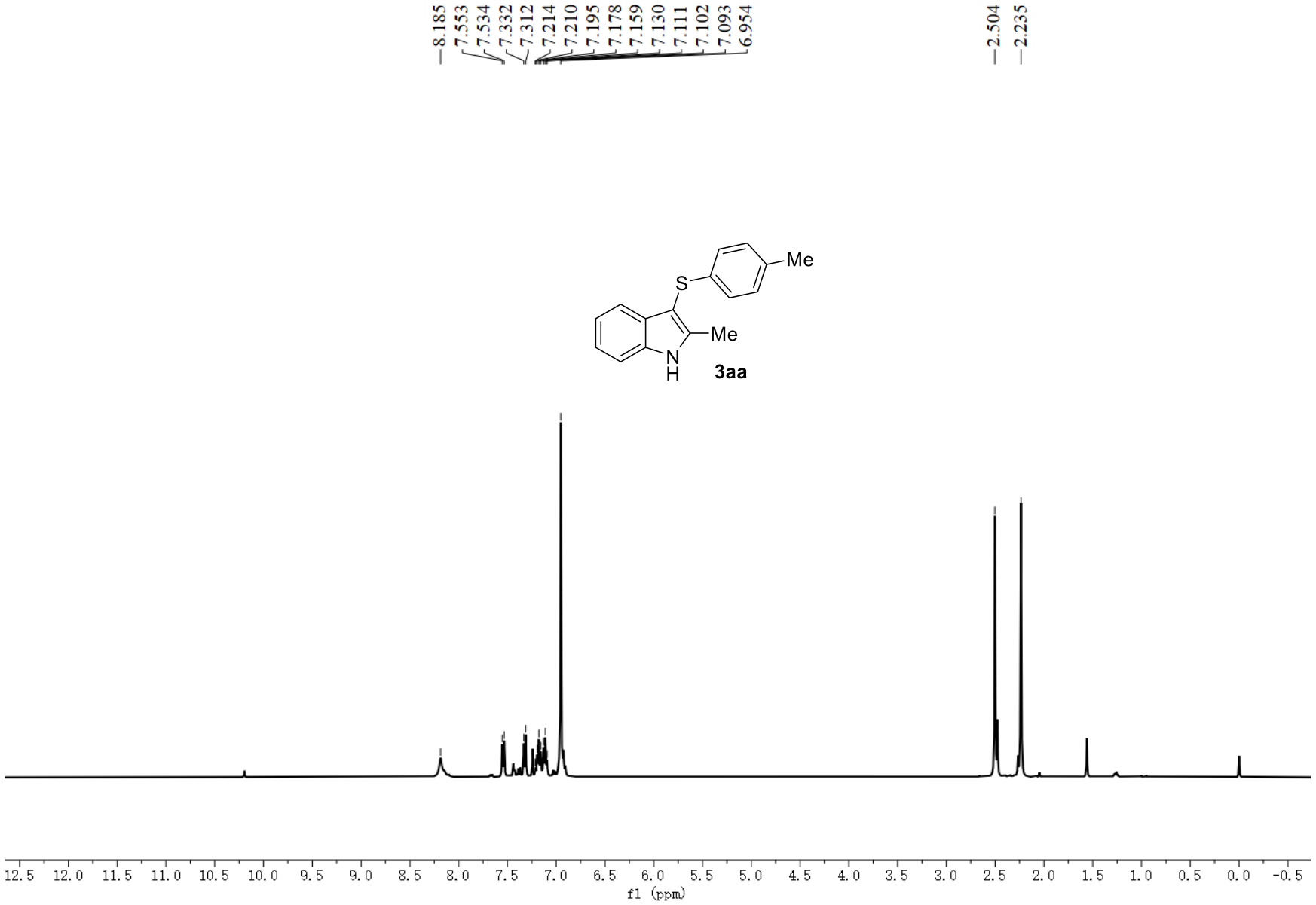
^{13}C NMR spectra of compound **6j** (101 MHz, $CDCl_3$)



^{31}P NMR spectra of compound **6j** (162 MHz, $CDCl_3$)



^{1}H NMR spectra of compound **3aa** (400 MHz, $CDCl_3$)



^{13}C NMR spectra of compound **3aa** (101 MHz, $CDCl_3$)