Light Induced [2+2] Cycloadditions for Construction of Cyclobutane-Fused Pyridinyl Sulfonyl Fluorides

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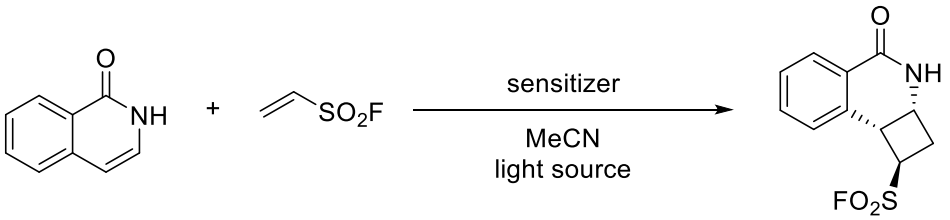
1. General Information

All reactions sensitive to air or moisture were carried out in flame-dried glassware under argon. Reagents used in the reactions were all purchased from commercial sources and used without further purification. The solvents used were purified by distillation over the drying agents indicated in parentheses and were transferred under argon: DCE (CaH_2), THF (Na-benzophenone), DMF (CaH_2), MeCN (CaH_2), 1,4-dioxane (Na-benzophenone), toluene (CaH_2). Unless otherwise specified, NMR spectra were recorded in $CDCl_3$ or DMSO-d_6 on a 500 MHz (for ^1H), 471 MHz (for ^{19}F), 126 MHz (for ^{13}C) spectrometer. All chemical shifts were reported in ppm relative to TMS (^1H NMR, 0 ppm) as internal standards. The HPLC experiments were carried out on a Waters e2695 instrument (column: J&K, RP-C18, 5 μm, 4.6 × 150 mm), and the yields of the products were determined by using the corresponding pure compounds as the external standards. Melting points of the products were measured on a micro melting point apparatus (SGW X-4) and uncorrected. HRMS experiments were performed on a TOF-Q ESI or CI/EI instrument. The coupling constants were reported in Hertz (Hz). The following abbreviations were used to explain the multiplicities: s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet.

Photochemical experiments were performed in pyrex tubes. Prior to irradiation, the reaction mixture was degassed by purging with argon.

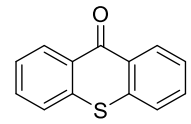
2. Screening the optimized reaction conditions

Table 1 Screening the sensitizer and the Light source[a]

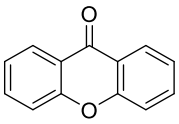


1a **2** **3a**

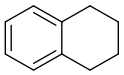
Entry	Sensitizer	Solvent	Light source	Yield (**3a**, %)[b]
1	Thioxanthen-9-One	MeCN	White LED	ND[c]
2	Thioxanthen-9-One	MeCN	Blue LED	ND
3	Thioxanthen-9-One	MeCN	Purple LED	ND
4	Thioxanthen-9-One	MeCN	365nm UV lamp	43
5	Xanthone	MeCN	365nm UV lamp	14
6	THN	MeCN	365nm UV lamp	Trace
7	**Benzophenone**	**MeCN**	**365nm UV lamp**	**53**
8	Eosin Y	MeCN	365nm UV lamp	ND
9	-	MeCN	365nm UV lamp	ND



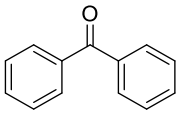
Thioxanthen-9-One



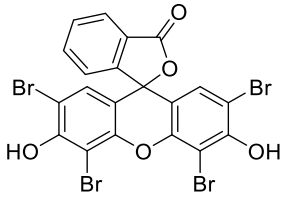
Xanthone



THN



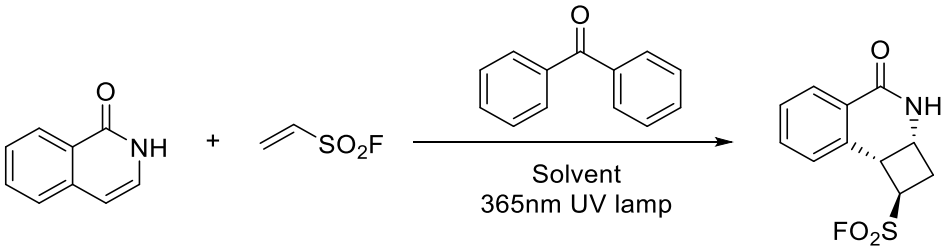
Benzophenone



Eosin Y

[a] Reaction conditions: isoquinolin-1(2*H*)-one **1a** (0.10 mmol, 1.00 eq.) and sensitizer (0.05 mmol, 0.50 eq.) and ESF **2** (1.00 mmol, 10.00 eq.) were dissolved in anhydrous MeCN (2.00 mL), and the mixture was irradiated with different light sources under argon atmosphere for 24 h. [b] The yield was determined by HPLC using **3a** as the external standard (t_R = 5.279 min, λ_{max} = 209.9 nm, water/acetonitrile = 60 : 40 (v / v)). [c] ND = Not Detected.

Table 2 Screening the Solvent[a]

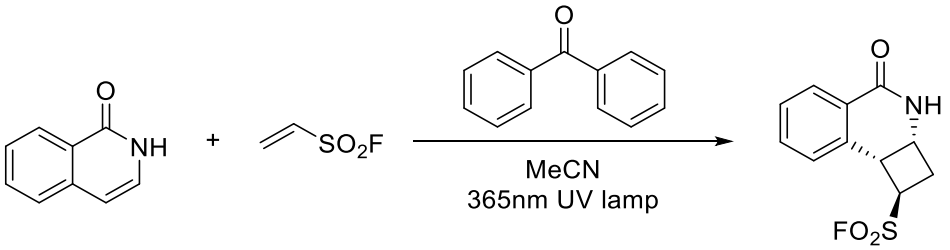


1a **2** **3a**

Entry	Sensitizer	Light source	Solvent	Yield (**3a**, %)[b]
1	Benzophenone	365nm UV lamp	DCE	50
2	Benzophenone	365nm UV lamp	THF	7
3	Benzophenone	365nm UV lamp	DMF	25
4	**Benzophenone**	**365nm UV lamp**	**MeCN**	**53**
5	Benzophenone	365nm UV lamp	1,4-dioxane	45
6	Benzophenone	365nm UV lamp	Toluene	52

[a] Reaction conditions: isoquinolin-1(2*H*)-one **1a** (0.10 mmol, 1.00 eq.) and benzophenone (0.05 mmol, 0.50 eq.) and ESF **2** (1.00 mmol, 10.00 eq.) were dissolved in anhydrous MeCN (2.00 mL), and the mixture was irradiated with 365nm UV lamp under argon atmosphere for 24 h. [b] The yield was determined by HPLC using **3a** as the external standard (t_R = 5.279 min, λ_{max} = 209.9 nm, water/acetonitrile = 60 : 40 (v / v)).

Table 3 Screening the Loading of Concentration[a]

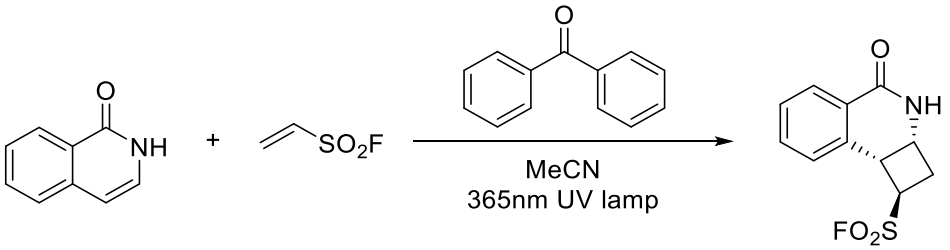


1a **2** **3a**

Entry	Sensitizer	Solvent	Light source	Yield (**3a**, %)[b]
1	Benzophenone	MeCN (1 mL)	365nm UV lamp	38
2	Benzophenone	MeCN (2 mL)	365nm UV lamp	53
3	Benzophenone	MeCN (3 mL)	365nm UV lamp	59
4	Benzophenone	MeCN (4 mL)	365nm UV lamp	67
5	**Benzophenone**	**MeCN (5 mL)**	**365nm UV lamp**	**72**
6	Benzophenone	MeCN (6 mL)	365nm UV lamp	69
7	Benzophenone	MeCN (7 mL)	365nm UV lamp	62
8	Benzophenone	MeCN (8 mL)	365nm UV lamp	68
9	Benzophenone	MeCN (9 mL)	365nm UV lamp	67
10	Benzophenone	MeCN (10 mL)	365nm UV lamp	66

[a] Reaction conditions: isoquinolin-1(2*H*)-one **1a** (0.10 mmol, 1.00 eq.) and benzophenone (0.05 mmol, 0.50 eq.) and ESF **2** (1.00 mmol, 10.00 eq.) were dissolved in anhydrous MeCN, and the mixture was irradiated with 365 nm UV lamp under argon atmosphere for 24 h. [b] The yield was determined by HPLC using **3a** as the external standard (t_R = 5.279 min, λ_{max} = 209.9 nm, water/acetonitrile = 60 : 40 (v / v)).

Table 4 Screening the Loading of ESF[a]

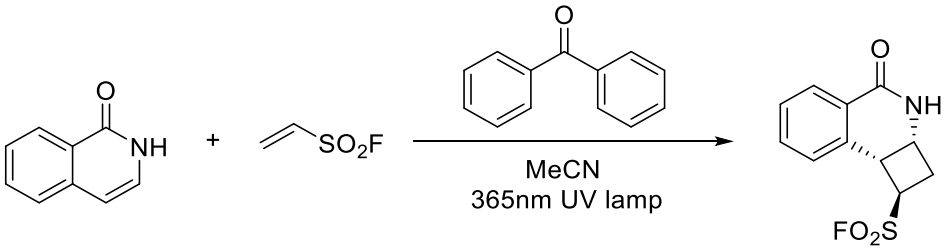


1a **2** **3a**

Entry	Loading of ESF	Sensitizer	Solvent	Yield (**3a**, %)[b]
1	10 eq.	Benzophenone	MeCN	62
2	9 eq.	Benzophenone	MeCN	62
3	8 eq.	Benzophenone	MeCN	63
4	7 eq.	Benzophenone	MeCN	66
5	6 eq.	Benzophenone	MeCN	71
6	**5 eq.**	**Benzophenone**	**MeCN**	**84**
7	4 eq.	Benzophenone	MeCN	66
8	3 eq.	Benzophenone	MeCN	65
9	2 eq.	Benzophenone	MeCN	54

[a] Reaction conditions: isoquinolin-1(2*H*)-one **1a** (0.10 mmol, 1.00 eq.) and benzophenone (0.05 mmol, 0.50 eq.) and ESF **2** were dissolved in anhydrous MeCN (5.00 mL), and the mixture was irradiated with 365 nm UV lamp under argon atmosphere for 24 h. [b] The yield was determined by HPLC using **3a** as the external standard (t_R = 5.279 min, λ_{max} = 209.9 nm, water/acetonitrile = 60 : 40 (v / v)).

Table 5 Screening the Loading of Sensitizer [a]

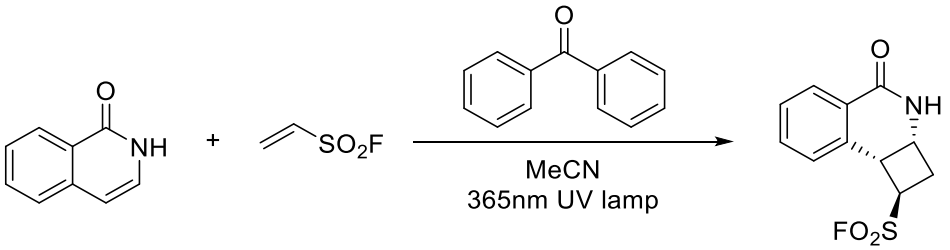


1a **2** **3a**

Entry	Sensitizer	Solvent	Yield (**3a**, %)[b]
1	Benzophenone (1.0 eq.)	MeCN	68
2	Benzophenone (0.7 eq.)	MeCN	70
3	**Benzophenone (0.5 eq.)**	**MeCN**	**84**
4	Benzophenone (0.3 eq.)	MeCN	59

[a] Reaction conditions: isoquinolin-1(2*H*)-one **1a** (0.10 mmol, 1.00 eq.) and benzophenone and ESF **2** (0.50 mmol, 5.00 eq.) were dissolved in anhydrous MeCN (5.00 mL), and the mixture was irradiated with 365 UV lamp under argon atmosphere for 24 h. [b] The yield was determined by HPLC using **3a** as the external standard (t_R = 5.279 min, λ_{max} = 209.9 nm, water/acetonitrile = 60 : 40 (v / v)).

Table 6 Screening the Time[a]



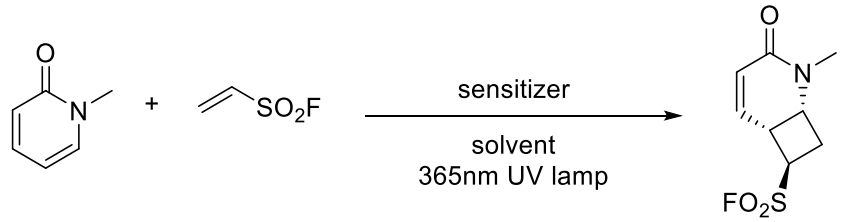
1a **2** **3a**

Entry	Time	Sensitizer	Solvent	Yield (**3a**, %)[b]
1	6h	Benzophenone	MeCN	62
2	12h	Benzophenone	MeCN	65
3	**24h**	**Benzophenone**	**MeCN**	**84**
4	36h	Benzophenone	MeCN	69
5	48h	Benzophenone	MeCN	68

[a] Reaction conditions: isoquinolin-1(2*H*)-one **1a** (0.10 mmol, 1.00 eq.) and benzophenone (0.05 mmol, 0.50 eq.) and ESF **2** (0.50 mmol, 5.00 eq.) were dissolved in anhydrous MeCN (5.00 mL), and the mixture was irradiated with 365 UV lamp under argon atmosphere. [b] The yield was determined by HPLC using **3a** as the external standard (t_R = 5.279 min, λ_{max} = 209.9 nm, water/acetonitrile = 60 : 40 (v /

v)).

Table 7 Screening the optimized reaction conditions of 4a and 2

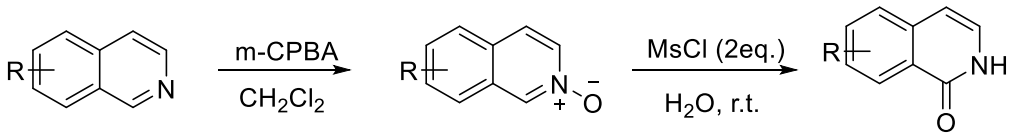


4a **2** **5a**

Entry	Sensitizer	Solvent	Light source	Yield (**5a**, %)[b]
1	**Thioxanthen-9-One**	**MeCN**	**365nm UV lamp**	**99**
2	Xanthone	MeCN	365nm UV lamp	18
3	Benzophenone	MeCN	365nm UV lamp	49
4	Benzophenone	DCE	365nm UV lamp	66

[a]Reaction conditions: 1-methylpyridin-2(1*H*)-one **4a** (0.10 mmol, 1.00 eq.), sensitizer (0.05 mmol, 0.50 eq.) and ESF **2** (1.00 mmol, 10.00 eq.) were dissolved in anhydrous MeCN (5.00 mL), and the mixture was irradiated with 365 nm UV lamp under argon atmosphere for 24 h. [b]The yield was determined by HPLC using **5a** as the external standard (t_R = 3.465 min, λmax = 209.9 nm, water/acetonitrile = 60 : 40 (v / v)). [c]Isolated yield.

3. General Procedure for the synthesis of different isoquinolones[1]



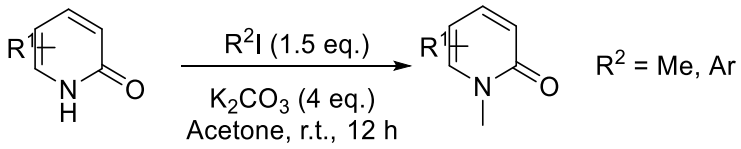
Step 1: To a solution of the corresponding quinolines substrate (2.00 mmol) in CH_2Cl_2 (15.00 mL) m-chloroperbenzoic acid (m-CPBA, 3.00 mmol, 1.50 equiv.) was added at 0 ^oC. The reaction mixture was allowed to stir at room temperature for 24 h. Next, saturated aq. $NaHCO_3$ solution (50.00 mL) was added to the reaction mixture. Then it was extracted with CH_2Cl_2 and the organic extracts were dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The crude product was purified by column chromatography on silica gel to obtain the pure quinoline *N*-oxides.

Step 2: In a vail were consecutively placed isoquinoline *N*-oxide (2 mmol), H_2O (20

mL) and MsCl (4 mmol), then the contents were shaken at room temperature. The progress of the reaction was monitored by TLC. Upon completion, the crude product was purified by column chromatography on silica gel.

All the homemade starting materials are identical to those reported regarding the ^{1}H and ^{13}C NMR and melting points (if applicable).[2-8]

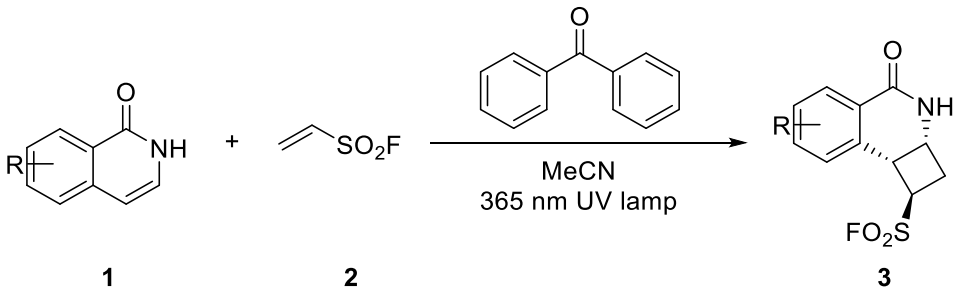
4. General Procedure for the synthesis of different *N*-substituted pyridones [9]



Substituted pyridin-2(1*H*)-ones (5.00 mmol) were taken in 50.00 mL acetone in a round bottom flask. Then anhydrous potassium carbonate K_2CO_3 (20.00 mmol) and MeI (7.50 mmol) were added to it. The reaction mixture was allowed to stir at room temperature for 12 h. Reaction was monitored by TLC. After full consumption of the starting materials, acetone was removed in vacuum and the residue was dissolved in water. After that, it was extracted with ethyl acetate for 3 times (100 mL×3). The organic layer was dried over anhydrous sodium sulfate and concentrated in vacuum. The product was purified by flash silica gel column chromatography.

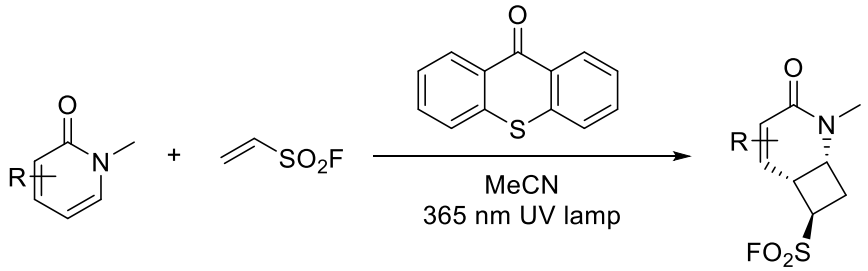
All the homemade starting materials are identical to those reported regarding the ^{1}H and ^{13}C NMR and melting points (if applicable).[10-17]

5. Procedure for the synthesis of 3a-3l



Isoquinolones (0.20 mmol, 1.00 eq.) and benzophenone (0.10 mmol, 0.50 eq.) were dissolved in dry acetonitrile (10.00 mL). After degassing the solution, ESF (1.00 mmol, 5.00 eq.) was added and the mixture was irradiated at 365 nm UV lamp under argon atmosphere for 24 h at ambient temperature. After removing the solvent, purification was achieved by flash column chromatography (silica, pentane/ethyl acetate 1:1).

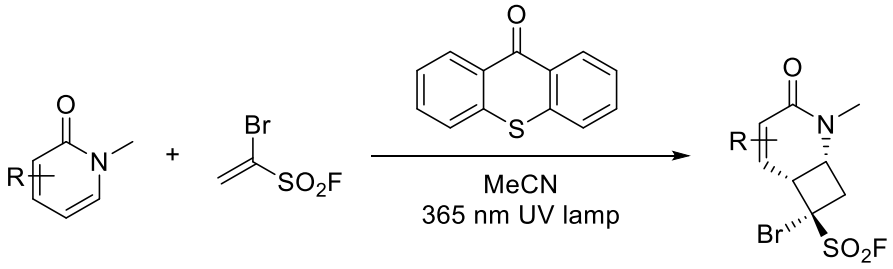
6. Procedure for the synthesis of 5a-5k



4 **2** **5**

1-methylpyridin-2(1*H*)-ones (0.20 mmol, 1.00 eq.) and thioxanthen-9-one (0.10 mmol, 0.50 eq.) were dissolved in dry acetonitrile (10.00 mL). After degassing the solution, ESF (1.00 mmol, 5.00 eq.) was added and the mixture was irradiated with 365 nm UV lamp under argon atmosphere for 24 h at ambient temperature. After removing the solvent, purification was achieved by flash column chromatography (silica, pentane/ethyl acetate 1:1).

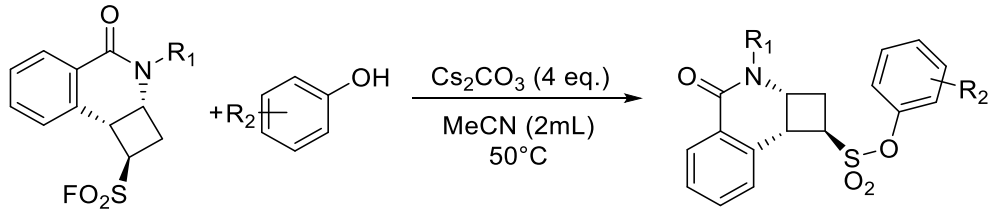
7. Procedure for the synthesis of 7a-7j



4 **6** **7**

1-methylpyridin-2(1H)-ones (0.20 mmol, 1.00 eq.) and thioxanthen-9-one (0.10 mmol, 0.50 eq.) were dissolved in dry acetonitrile (10.00 mL). After degassing the solution, 1-Bromoethene-1-sulfonyl fluoride (Br-ESF) (1.00 mmol, 5.00 eq.) was added and the mixture was irradiated with 365 nm UV lamp under argon atmosphere for 24 h at ambient temperature. After removing the solvent, purification was achieved by flash column chromatography (silica, pentane/ethyl acetate 1:1).

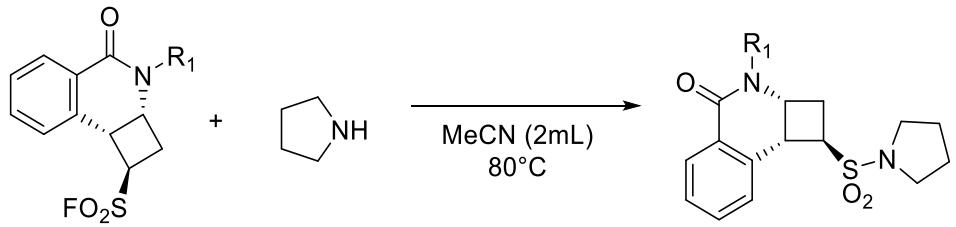
8. Procedure for the synthesis of 9aa-9ac



3 8 9

Product **3** (0.20 mmol, 1.00 eq.), phenol **8** (0.22 mmol, 1.10 eq.) and Cs_2CO_3 (0.8 mmol, 4.00 eq.) were added in acetonitrile (2.00 mL). Then the mixture was stirred for 24 h at 50°C. After removing the solvent, purification was achieved by flash column chromatography (silica, pentane/ethyl acetate 1:1).

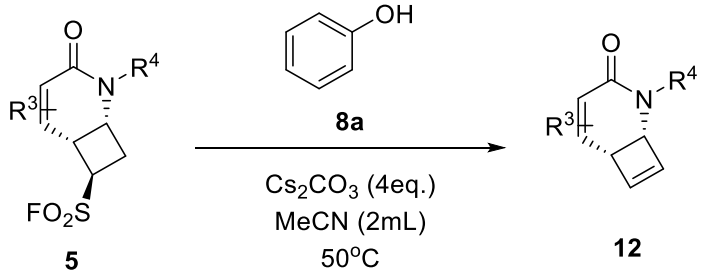
9. Procedure for the synthesis of 11aa, 11ka



3 10 11

Product **3** (0.20 mmol, 1.00 eq.) and tetrahydropyrrole **10** (0.40 mmol, 2.00 eq.) were added in acetonitrile (2.00 mL). Then the mixture was stirred for 24 h at 50°C. After removing the solvent, purification was achieved by flash column chromatography (silica, pentane/ethyl acetate 1:1).

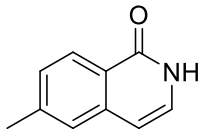
10. Procedure for the synthesis of 12a-12j



5 12

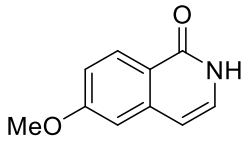
Product **5** (0.20 mmol, 1.00 eq.) phenol **8a** (0.22 mmol, 1.10 eq.) and Cs_2CO_3 (0.80 mmol, 4.00 eq.) were added in acetonitrile (2.00 mL). Then the mixture was stirred for 24 h at 50°C. After removing the solvent, purification was achieved by flash column chromatography (silica, pentane/ethyl acetate 1:1).

11. Characterization of substrates



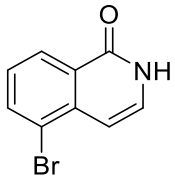
1b

6-methylisoquinolin-1(2H)-one (1b). [4] Yellow solid. ^{1}H NMR (500 MHz, DMSO-d$_6$) δ 11.11 (s, 1H), 8.06 (d, J = 8.1 Hz, 1H), 7.42 (s, 1H), 7.30 (dd, J = 8.3 Hz, J = 1.1 Hz, 1H), 7.13-7.11 (m, 1H), 6.46 (d, J = 7.1 Hz, 1H), 2.42 (s, 3H).



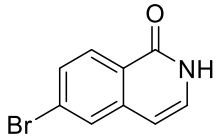
1c

6-methoxyisoquinolin-1(2H)-one (1c). [2] White solid. ^{1}H NMR (500 MHz, DMSO-d$_6$) δ 11.05 (s, 1H), 8.08 (d, J = 8.8 Hz, 1H), 7.13 (d, J = 6.9 Hz, 1H), 7.10 (d, J = 2.4 Hz, 1H), 7.04 (dd, J = 8.9 Hz, J = 2.4 Hz, 1H), 6.47 (d, J = 7.0 Hz, 1H), 3.85 (s, 3H).



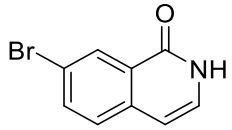
1d

5-bromoisoquinolin-1(2H)-one (1d). [3] Light yellow solid. ^{1}H NMR (500 MHz, DMSO-d$_6$) δ 11.51 (s, 1H), 8.20 (d, J = 8.0 Hz, 1H), 7.99 (dd, J = 7.8 Hz, J = 1.0 Hz, 1H), 7.39 (t, J = 8.0 Hz, 1H), 7.32 (q, J = 3.0 Hz, 1H), 6.66 (d, J = 7.4 Hz, 1H).



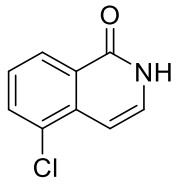
1e

6-bromoisoquinolin-1(2H)-one (1e). [2] Light yellow solid. ^{1}H NMR (500 MHz, DMSO-d$_6$) δ 11.36 (s, 1H), 8.08 (d, J = 8.6 Hz, 1H), 7.94 (d, J = 1.8 Hz, 1H), 7.61 (dd, J = 8.5 Hz, J = 1.8 Hz, 1H), 7.22 (t, J = 6.2 Hz, 1H), 6.53 (d, J = 7.1 Hz, 1H).



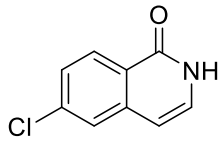
1f

7-bromoisoquinolin-1(2H)-one (1f). [8] Yellow solid. ^{1}H NMR (500 MHz, DMSO-d_6) δ 11.42 (s, 1H), 8.26 (d, J = 2.1 Hz, 1H), 7.84 (dd, J = 8.4 Hz, J = 2.1 Hz, 1H), 7.64 (d, J = 8.4 Hz, 1H), 7.22 (t, J = 6.4 Hz, 1H), 6.57 (d, J = 7.2 Hz, 1H).



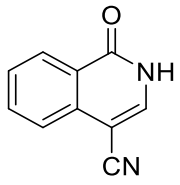
1g

5-chloroisoquinolin-1(2H)-one (1g). [6] Yellow solid. ^{1}H NMR (500 MHz, DMSO-d_6) δ 11.52 (s, 1H), 8.17 (d, J = 7.9 Hz, 1H), 7.84 (dd, J = 7.8 Hz, J = 1.1 Hz, 1H), 7.46 (t, J = 7.9 Hz, 1H), 7.33-7.30 (m, 1H), 6.69 (d, J = 7.3 Hz, 1H).



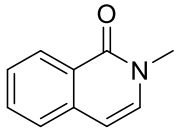
1h

6-chloroisoquinolin-1(2H)-one (1h). [5] Yellow solid. ^{1}H NMR (500 MHz, DMSO-d_6) δ 11.35 (s, 1H), 8.16 (d, J = 8.5 Hz, 1H), 7.77 (d, J = 1.8 Hz, 1H), 7.48 (dd, J = 8.5 Hz, J = 2.0 Hz, 1H), 7.23 (t, J = 8.5 Hz, 1H), 6.53 (d, J = 7.2 Hz, 1H).



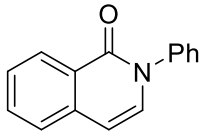
1i

1-oxo-1,2-dihydroisoquinoline-4-carbonitrile (1i). [7] Yellow solid. ^{1}H NMR (500 MHz, DMSO-d_6) δ 12.16 (s, 1H), 8.24 (d, J = 7.8 Hz, 1H), 8.18 (d, J = 3.8 Hz, 1H), 7.90-7.87 (m, 1H), 7.71 (d, J = 8.0 Hz, 1H), 7.65-7.62 (m, 1H).



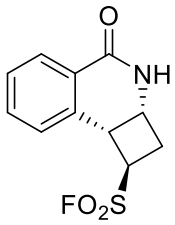
1j

2-methylisoquinolin-1(2H)-one (1j). [12] Pink solid. ^{1}H NMR (500 MHz, DMSO-d$_6$) δ 8.22 (d, J = 8.1 Hz, 1H), 7.69-7.66 (m, 1H), 7.63 (d, J = 7.5 Hz, 1H), 7.50-7.47 (m, 1H), 7.44 (d, J = 7.3 Hz, 1H), 6.59 (d, J = 7.3 Hz, 1H), 3.50 (s, 1H).



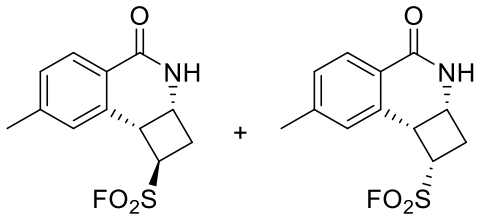
1k

2-phenylisoquinolin-1(2H)-one (1k). [8] White solid. ^{1}H NMR (500 MHz, DMSO-d$_6$) δ 8.27 (d, J = 8.0 Hz, 1H), 7.76-7.71 (m, 2H), 7.57-7.52 (m, 3H), 7.47-7.43 (m, 4H), 6.72 (d, J = 7.3 Hz, 1H).



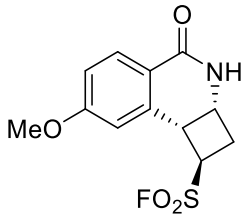
3a

4-oxo-1,2,2a,3,4,8b-hexahydrocyclobuta[c]isoquinoline-1-sulfonyl fluoride (3a). White solid (42.84 mg, isolated yield 84%). ^{1}H NMR (500 MHz, DMSO-d$_6$) δ 8.19 (s, 1H), 8.00 (dd, J = 7.8 Hz, J = 0.8 Hz, 1H), 7.57 (td, J = 7.5 Hz, J = 1.2 Hz, 1H), 7.47-7.44 (m, 1H), 7.21 (d, J = 7.6 Hz, 1H), 5.18-5.13 (m, 1H), 4.37-4.36 (m, 2H), 2.88-2.82 (m, 1H), 2.53-2.52 (m, 1H). ^{19}F NMR (471 MHz, DMSO-d$_6$) δ 46.3 (s, 1F). ^{13}C NMR (126 MHz, DMSO-d$_6$) δ 161.8, 135.1, 132.6, 128.2, 127.6, 127.5, 127.0, 58.3 (d, J = 13.6 Hz), 45.4, 36.9, 32.3. Mp 173-175 °C. HRMS ESI (m/z): $[M+H]^+$ calcd for $C_{11}H_{11}FNO_3S$: 256.0438, found: 256.0442.



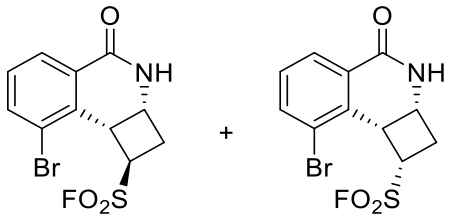
3b **3b'**

7-methyl-4-oxo-1,2,2a,3,4,8b-hexahydrocyclobuta[c]isoquinoline-1-sulfonyl fluoride (3b). A mixture of white solid (30.13 mg, isolated yield 56%). Anti-isomer (**3b**) and syn-isomer (**3b'**) were obtained in about 10:1 ratio. (1) **3b**: ^{1}H NMR (500 MHz, DMSO-d$_6$) δ 8.09 (s, 1H), 7.87 (d, J = 7.9 Hz, 1H), 7.26 (d, J = 7.7 Hz, 1H), 7.01 (s, 1H), 5.09-5.04 (m, 1H), 4.35-4.34 (m, 1H), 4.32-4.29 (m, 1H), 2.86-2.81 (m, 1H), 2.55-2.52 (m, 1H), 2.34 (s, 3H). ^{19}F NMR (471 MHz, DMSO-d$_6$) δ 46.3 (s, 1F). ^{13}C NMR (126 MHz, DMSO-d$_6$) δ 162.1, 142.9, 135.2, 129.1, 127.9, 127.8, 124.5, 58.5 (d, J = 13.6 Hz), 45.5, 37.1, 32.4, 21.1. (2) **3b'**: ^{1}H NMR (500 MHz, DMSO-d$_6$) δ 8.11 (d, J = 4.3 Hz, 0.1H), 7.81 (d, J = 7.9 Hz, 0.1H), 7.15 (d, J = 8.1 Hz, 0.1H), 7.01 (s, 0.1H), 4.97-4.92 (m, 0.1H), 4.89-4.85 (m, 0.1H), 4.04-3.98 (m, 0.1H), 3.17-3.11 (m, 0.1H), 2.39-2.37 (m, 0.1H), 2.32 (s, 0.3H). ^{19}F NMR (471 MHz, DMSO-d$_6$) δ 56.3 (s). ^{13}C NMR (126 MHz, DMSO-d$_6$) δ 162.9, 147.2, 139.8, 129.2, 127.9, 127.3, 123.7, 58.9 (d, J = 10.0 Hz), 48.9, 31.3, 30.7, 21.2. Mp 190-192 °C. HRMS ESI (m/z): [M+H]$^+$ calcd for $C_{12}H_{13}FNO_3S$: 270.0595, found: 270.0592.



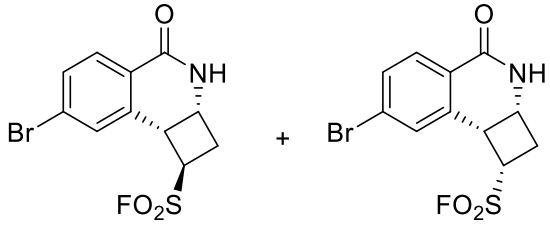
3c

7-methoxy-4-oxo-1,2,2a,3,4,8b-hexahydrocyclobuta[c]isoquinoline-1-sulfonyl fluoride (3c). White solid (48.45 mg, isolated yield 85%). ^{1}H NMR (500 MHz, DMSO-d$_6$) δ 7.99 (s, 1H), 7.93 (d, J = 8.6 Hz, 1H), 7.00 (dd, J = 8.7 Hz, J = 2.4 Hz, 1H), 6.69 (d, J = 2.4 Hz, 1H), 5.13-5.08 (m, 1H), 4.34-4.31 (m, 2H), 3.81 (s, 3H), 2.86-2.80 (m, 1H), 2.54-2.52 (m, 1H). ^{19}F NMR (471 MHz, DMSO-d$_6$) δ 46.3 (s, 1F). ^{13}C NMR (126 MHz, DMSO-d$_6$) δ 162.3, 161.9, 137.1, 129.8, 119.8, 114.0, 112.2, 58.3 (d, J = 14.5 Hz), 55.5, 45.5, 37.2, 32.4. Mp 205-207 °C. HRMS ESI (m/z): [M+H]$^+$ calcd for $C_{12}H_{13}FNO_4S$: 286.0544, found: 286.0543.



3d **3d'**

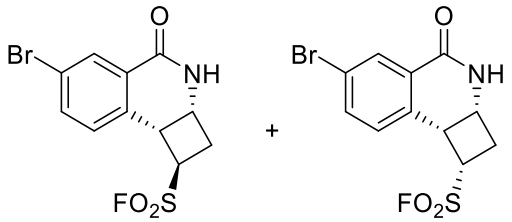
8-bromo-4-oxo-1,2,2a,3,4,8b-hexahydrocyclobuta[c]isoquinoline-1-sulfonyl fluoride (3d). A mixture of white solid (47.29 mg, isolated yield 71%). Anti-isomer (**3d**) and syn-isomer (**3d'**) were obtained in about 10:1 ratio. (1) **3d**: ^{1}H NMR (500 MHz, DMSO-d$_6$) δ 8.40 (s, 1H), 8.05 (dd, J = 7.7 Hz, J = 0.9 Hz, 1H), 7.86 (dd, J = 7.9 Hz, J = 1.2 Hz, 1H), 7.43 (t, J = 7.9 Hz, 1H), 5.14 (q, J = 7.5 Hz, 1H), 4.48 (t, J = 7.7 Hz, 1H), 4.40-4.39 (m, 1H), 2.86-2.81 (m, 1H), 2.56-2.51 (m, 1H). ^{19}F NMR (471 MHz, DMSO-d$_6$) δ 48.7 (s, 1F). ^{13}C NMR (126 MHz, DMSO-d$_6$) δ 161.1, 136.5, 134.3, 130.1, 130.0, 127.4, 122.8, 58.0 (d, J = 14.5 Hz), 45.5, 38.3, 32.6. (2) **3d'**: ^{1}H NMR (500 MHz, DMSO-d$_6$) δ 8.47 (d, J = 3.9 Hz, 0.1H), 7.99 (dd, J = 7.6 Hz, J = 0.9 Hz, 0.1H), 7.81 (dd, J = 7.9 Hz, J = 1.1 Hz, 0.1H), 7.34 (t, J = 7.8 Hz, 0.1H), 5.00-4.93 (m, 0.2H), 4.10-4.05 (m, 0.1H), 3.26-3.22 (m, 0.1H), 2.37-2.33 (m, 0.1H). ^{19}F NMR (471 MHz, DMSO-d$_6$) δ 56.4 (s). ^{13}C NMR (126 MHz, DMSO-d$_6$) δ 161.8, 138.5, 136.2, 128.8, 126.7, 122.1, 58.6 (d, J = 9.1 Hz), 47.5, 32.9, 29.5. Mp 168-170 °C. HRMS ESI (m/z): $[M+H]^+$ calcd for $C_{11}H_{10}BrFNO_3S$: 333.9543, found: 333.9548.



3e **3e'**

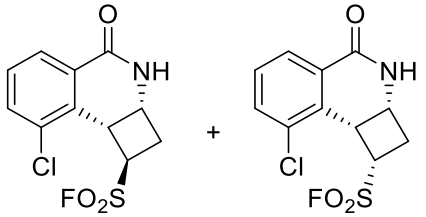
7-bromo-4-oxo-1,2,2a,3,4,8b-hexahydrocyclobuta[c]isoquinoline-1-sulfonyl fluoride (3e). A mixture of white solid (35.30 mg, isolated yield 53%). Anti-isomer (**3e**) and syn-isomer (**3e'**) were obtained in about 20:1 ratio. (1) **3e**: ^{1}H NMR (500 MHz, DMSO-d$_6$) δ 8.29 (s, 1H), 7.91 (d, J = 8.4 Hz, 1H), 7.66 (dd, J = 8.4 Hz, J = 2.0 Hz, 1H), 7.40 (d, J = 1.8 Hz, 1H), 5.27-5.21 (m, 1H), 4.41 (t, J = 8.2 Hz, 1H), 4.38-4.35 (m, 1H), 2.88-2.83 (m, 1H), 2.53-2.52 (m, 1H). ^{19}F NMR (471 MHz, DMSO-d$_6$) δ 46.2 (s, 1F). ^{13}C NMR (126 MHz, DMSO-d$_6$) δ 161.1, 137.3, 131.3,

130.2, 129.8, 126.3, 126.0, 58.0 (d, J = 13.7 Hz), 45.5, 36.3, 32.4. (2) **3e'**: ^{1}H NMR (500 MHz, DMSO-d_6) δ 8.36 (d, J = 5.1 Hz, 0.05H), 7.84 (d, J = 8.4 Hz, 0.05H), 7.56-7.51 (m, 0.1H), 5.32 (t, J = 4.7 Hz, 0.1H), 3.17 (d, J = 5.2 Hz, 0.05H), 2.64-2.63 (m, 0.1H). ^{19}F NMR (471 MHz, DMSO-d_6) δ 56.4 (s). ^{13}C NMR (126 MHz, DMSO-d_6) δ 161.4, 139.7, 130.6, 129.2, 129.1, 126.4, 124.9, 59.0 (d, J = 9.1 Hz), 48.5, 31.3, 30.4. Mp 203-205 °C. HRMS ESI (m/z): $[M+H]^+$ calcd for $C_{11}H_{10}BrFNO_3S$: 333.9543, found: 333.9547.



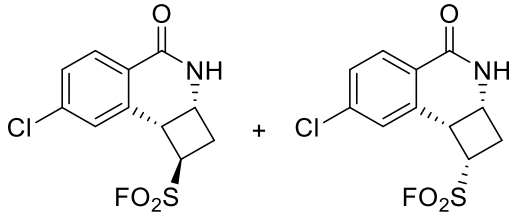
3f **3f'**

6-bromo-4-oxo-1,2,2a,3,4,8b-hexahydrocyclobuta[c]isoquinoline-1-sulfonyl fluoride (3f). A mixture of white solid (55.28 mg, isolated yield 83%). Anti-isomer (**3f**) and syn-isomer (**3f'**) were obtained in about 10:1 ratio. (1) **3f**: ^{1}H NMR (500 MHz, DMSO-d_6) δ 8.34 (s, 1H), 8.07 (d, J = 2.1 Hz, 1H), 7.78 (dd, J = 8.2 Hz, J = 2.3 Hz, 1H), 7.19 (d, J = 8.2 Hz, 1H), 5.20-5.15 (m, 1H), 4.39-4.35 (m, 2H), 2.89-2.83 (m, 1H), 2.56-2.53 (m, 1H). ^{19}F NMR (471 MHz, DMSO-d_6) δ 46.4 (s, 1F). ^{13}C NMR (126 MHz, DMSO-d_6) δ 160.6, 135.3, 134.3, 130.1, 130.0, 129.1, 121.4, 58.0 (d, J = 14.6 Hz), 45.4, 36.3, 32.3. (2) **3f'**: ^{1}H NMR (500 MHz, DMSO-d_6) δ 8.43 (d, J = 3.6 Hz, 0.1H), 8.01 (d, J = 2.2 Hz, 0.1H), 7.73 (dd, J = 8.0 Hz, J = 2.1 Hz, 0.1H), 7.23 (d, J = 8.2 Hz, 0.1H), 4.98-4.90 (m, 0.2H), 4.12-4.08 (m, 0.1H), 3.60-3.54 (m, 0.1H), 2.38-2.33 (m, 0.1H). ^{19}F NMR (471 MHz, DMSO-d_6) δ 56.3 (s). ^{13}C NMR (126 MHz, DMSO-d_6) δ 161.5, 139.1, 129.7, 129.4, 128.4, 120.0, 59.1 (d, J = 8.1 Hz), 48.7, 48.3, 31.2, 30.2. Mp 243-245 °C. HRMS ESI (m/z): $[M+H]^+$ calcd for $C_{11}H_{10}BrFNO_3S$: 333.9543, found: 333.9547.



3g **3g'**

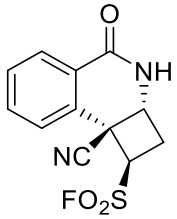
6-bromo-4-oxo-1,2,2a,3,4,8b-hexahydrocyclobuta[c]isoquinoline-1-sulfonyl fluoride (3g). A mixture of white solid (40.46 mg, isolated yield 70%). Anti-isomer (**3g**) and syn-isomer (**3g'**) were obtained in about 20:1 ratio. (1) **3g**: ^{1}H NMR (500 MHz, DMSO-d_6) δ 8.40 (s, 1H), 8.01 (dd, J = 7.6 Hz, J = 0.7 Hz, 1H), 7.72 (dd, J = 8.0 Hz, J = 1.1 Hz, 1H), 7.51 (t, J = 7.9 Hz, 1H), 5.12 (q, J = 6.9 Hz, 1H), 4.52 (t, J = 7.8 Hz, 1H), 4.41-4.40 (m, 1H), 2.87-2.82 (m, 1H), 2.60-2.55 (m, 1H). ^{19}F NMR (471 MHz, DMSO-d_6) δ 48.1 (s, 1F). ^{13}C NMR (126 MHz, DMSO-d_6) δ 160.9, 133.0, 132.7, 132.3, 129.7, 129.6, 126.7, 57.7 (d, J = 14.5 Hz), 45.2, 36.0, 32.7. (2) **3g'**: ^{1}H NMR (500 MHz, DMSO-d_6) δ 8.48 (d, J = 3.8 Hz, 0.05H), 7.94 (d, J = 7.8 Hz, 0.05H), 7.67 (dd, J = 7.9 Hz, J = 1.1 Hz, 0.05H), 7.42 (t, J = 7.9 Hz, 0.05H), 5.00-4.94 (m, 0.1H), 4.16-4.10 (m, 0.05H), 3.26-3.21 (m, 0.05H), 2.64-2.63 (m, 0.05H). ^{19}F NMR (471 MHz, DMSO-d_6) δ 56.4 (s). ^{13}C NMR (126 MHz, DMSO-d_6) δ 160.9, 133.0, 132.7, 132.3, 129.7, 129.6, 126.7, 57.7 (d, J = 14.5 Hz), 45.2, 36.0, 32.7. Mp 153-155 °C. HRMS ESI (m/z): $[M+H]^+$ calcd for $C_{11}H_{10}ClFNO_3S$: 290.0048, found: 290.00451.



3h **3h'**

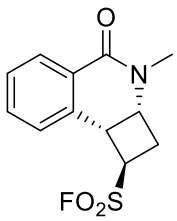
7-chloro-4-oxo-1,2,2a,3,4,8b-hexahydrocyclobuta[c]isoquinoline-1-sulfonyl fluoride (3h). A mixture of white solid (38.15 mg, isolated yield 66%). Anti-isomer (**3h**) and syn-isomer (**3h'**) were obtained in about 20:1 ratio. (1) **3h**: ^{1}H NMR (500 MHz, DMSO-d_6) δ 8.28 (s, 1H), 7.99 (d, J = 8.4 Hz, 1H), 7.52 (dd, J = 8.2 Hz, J = 2.0 Hz, 1H), 7.26 (d, J = 2.0 Hz, 1H), 5.26-5.21 (m, 1H), 4.43-4.40 (m, 1H), 4.38-4.35 (m, 1H), 2.88-2.83 (m, 1H), 2.55-2.52 (m, 1H). ^{19}F NMR (471 MHz, DMSO-d_6) δ 46.2 (s, 1F). ^{13}C NMR (126 MHz, DMSO-d_6) δ 161.1, 137.2, 137.0, 129.7, 128.4, 127.3,

126.0, 58.0 (d, J = 14.5 Hz), 45.5, 36.4, 32.4. (2) **3h'**: ^{1}H NMR (500 MHz, DMSO-d_6) δ 8.35 (d, J = 3.9 Hz, 0.05H), 7.92 (d, J = 8.4 Hz, 0.05H), 7.41-7.37 (m, 0.1H), 5.32 (t, J = 4.8 Hz, 0.05H), 4.97-4.88 (m, 0.1H), 2.64-2.63 (m, 0.05H), 2.37-2.36 (m, 0.05H). ^{19}F NMR (471 MHz, DMSO-d_6) δ 56.4 (s). ^{13}C NMR (126 MHz, DMSO-d_6) δ 161.3, 139.5, 137.3, 130.6, 129.1, 126.5, 125.3, 60.0 (d, J = 37.2 Hz), 48.5, 31.4, 30.3. Mp 213-215 °C. HRMS ESI (m/z): $[M+H]^+$ calcd for $C_{11}H_{10}ClFNO_3S$: 290.0048, found: 290.00450.



3i

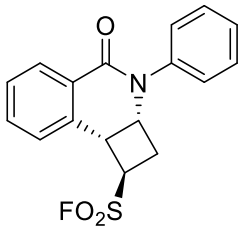
8b-cyano-4-oxo-1,2,2a,3,4,8b-hexahydrocyclobuta[c]isoquinoline-1-sulfonyl fluoride (3i). Yellow solid (18.48 mg, isolated yield 33%). ^{1}H NMR (500 MHz, DMSO-d_6) δ 8.69 (d, J = 4.4 Hz, 1H), 8.12-8.10 (m, 1H), 7.82 (td, J = 7.7 Hz, J = 1.1 Hz, 1H), 7.67 (t, J = 7.4 Hz, 1H), 7.59 (d, J = 7.6 Hz, 1H), 5.42 (dd, J = 9.4 Hz, J = 4.0 Hz, 1H), 4.78-4.74 (m, 1H), 3.02-2.97 (m, 1H), 2.91-2.85 (m, 1H). ^{19}F NMR (471 MHz, DMSO-d_6) δ 51.8 (s, 1F). ^{13}C NMR (126 MHz, DMSO-d_6) δ 160.5, 134.1, 131.7, 130.4, 128.4, 128.3, 126.7, 116.8, 60.2 (d, J = 15.4 Hz), 49.5, 38.6, 32.2. Mp 149-151 °C. HRMS ESI (m/z): $[M+H]^+$ calcd for $C_{12}H_{10}FN_2O_3S$: 281.0391, found: 281.0393.



3j

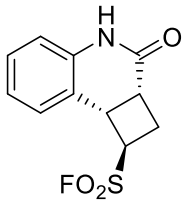
3-methyl-4-oxo-1,2,2a,3,4,8b-hexahydrocyclobuta[c]isoquinoline-1-sulfonyl fluoride (3j). Yellow solid (25.82 mg, isolated yield 48%). ^{1}H NMR (500 MHz, DMSO-d_6) δ 8.02-8.01 (m, 1H), 7.57 (td, J = 7.4 Hz, J = 1.2 Hz, 1H), 7.45 (td, J = 7.6 Hz, J = 0.8 Hz, 1H), 7.19 (d, J = 7.4 Hz, 1H), 5.11-5.06 (m, 1H), 4.51-4.48 (m, 1H), 4.46-4.44 (m, 1H), 2.94 (s, 3H), 2.91-2.85 (m, 1H), 2.80-2.75 (m, 1H). ^{19}F NMR (471

MHz, DMSO-d_6) δ 46.1 (s, 1F). ^{13}C NMR (126 MHz, DMSO-d_6) δ 160.8, 134.4, 132.4, 128.2, 127.8, 127.3, 126.9, 57.8 (d, J = 13.6 Hz), 51.5, 37.0, 31.2, 30.2. Mp 108-110 °C. HRMS ESI (m/z): $[M+H]^+$ calcd for $C_{12}H_{13}FNO_3S$: 270.0595, found: 270.0594.



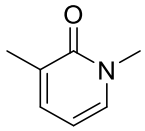
3k

4-oxo-3-phenyl-1,2,2a,3,4,8b-hexahydrocyclobuta[c]isoquinoline-1-sulfonyl fluoride (3k). Yellow solid (52.96 mg, isolated yield 80%). ^{1}H NMR (500 MHz, DMSO-d_6) δ 8.08 (d, J = 7.6 Hz, 1H), 7.67-7.64 (m,1H), 7.51 (t, J = 7.6 Hz, 1H), 7.49-7.46 (m, 2H), 7.43-7.40 (m, 2H), 7.35 (t, J = 7.4 Hz, 1H), 7.30 (d, J = 7.4 Hz, 1H), 5.32 (q, J = 7.4 Hz, 1H), 4.90-4.88 (m, 1H), 4.59 (t, J = 8.0 Hz, 1H), 2.82-2.77 (m, 1H), 2.65-2.60 (m, 1H). ^{19}F NMR (471 MHz, DMSO-d_6) δ 46.7 (s, 1F). ^{13}C NMR (126 MHz, DMSO-d_6) δ 161.0, 140.3, 134.6, 133.0, 129.2, 128.4, 128.3, 127.6, 127.5, 127.2, 127.2, 57.8 (d, J = 14.5 Hz), 52.6, 39.0, 37.7, 30.4. Mp 170-172 °C. HRMS ESI (m/z): $[M+H]^+$ calcd for $C_{17}H_{15}FNO_3S$: 332.0751, found: 332.0749.



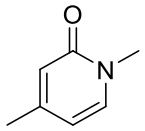
3l

3-oxo-1,2,2a,3,4,8b-hexahydrocyclobuta[c]quinoline-1-sulfonyl fluoride (3l). Light yellow solid (30.82 mg, isolated yield 60%). ^{1}H NMR (500 MHz, DMSO-d_6) δ 10.37 (s, 1H), 7.24-7.21 (m, 1H), 7.06 (d, J = 7.4 Hz, 1H), 6.98-6.92 (m, 2H), 5.14-5.08 (m, 1H), 4.31 (t, J = 9.3 Hz, 1H), 3.42 (t, J = 10.3 Hz, 1H), 3.01-2.95 (m, 1H), 2.67-2.63 (m, 1H). ^{19}F NMR (471 MHz, DMSO-d_6) δ 45.7 (s, 1F). ^{13}C NMR (126 MHz, DMSO-d_6) δ 169.0, 138.2, 129.0, 127.9, 122.6, 118.9, 115.7, 57.6 (d, J = 12.7 Hz), 39.8, 33.2, 27.7. Mp 189-191 °C. HRMS ESI (m/z): $[M+H]^+$ calcd for $C_{11}H_{11}FNO_3S$: 256.0438, found: 256.0441.



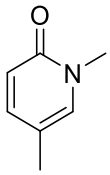
4b

1,3-dimethylpyridin-2(1H)-one (4b). [12] Yellow oil. ^{1}H NMR (500 MHz, DMSO-d$_6$) δ 7.52 (dd, J = 6.8 Hz, J = 1.4 Hz, 1H), 7.27 (dd, J = 6.7 Hz, J = 0.8 Hz, 1H), 6.10 (t, J = 6.7 Hz, 1H), 3.42 (s, 3H), 1.98 (s, 3H).



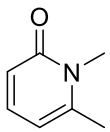
4c

1,4-dimethylpyridin-2(1H)-one (4c). [12] Light yellow solid. ^{1}H NMR (500 MHz, DMSO-d$_6$) δ 7.53 (d, J = 6.9 Hz, 1H), 6.17 (s, 1H), 6.03 (dd, J = 6.8 Hz, J = 1.8 Hz, 1H), 3.36 (s, 3H), 2.09 (s, 3H).



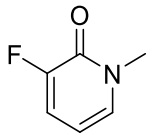
4d

1,5-dimethylpyridin-2(1H)-one (4d). [12] Yellow oil. ^{1}H NMR (500 MHz, DMSO-d$_6$) δ 7.45 (s, 1H), 7.26 (dd, J = 9.2 Hz, J = 2.6 Hz, 1H), 6.30 (d, J = 9.3 Hz, 1H), 3.36 (s, 3H), 1.99 (s, 3H).



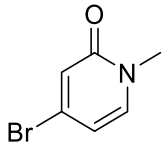
4e

1,6-dimethylpyridin-2(1H)-one (4e). [13] Yellow oil. ^{1}H NMR (500 MHz, DMSO-d$_6$) δ 7.26 (dd, J = 9.2 Hz, J = 6.9 Hz, 1H), 6.24 (d, J = 9.0 Hz, 1H), 6.10 (d, J = 6.8 Hz, 1H), 3.44 (s, 3H), 2.32 (s, 3H).



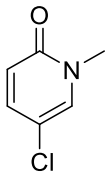
4f

3-fluoro-1-methylpyridin-2(1H)-one (4f). [11] Yellow solid. ^{1}H NMR (500 MHz, DMSO-d$_6$) δ 7.55-7.54 (m, 1H), 7.38-7.34 (m, 1H), 6.18-6.15 (m, 1H), 3.49 (s, 3H).



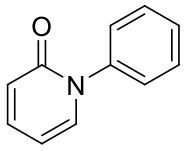
4g

4-bromo-1-methylpyridin-2(1H)-one (4g). [10] Yellow solid. ^{1}H NMR (500 MHz, DMSO-d$_6$) δ 7.67 (d, J = 7.4 Hz, 1H), 6.68 (d, J = 2.3 Hz, 1H), 6.43 (dd, J = 7.2 Hz, J = 2.1 Hz, 1H), 3.38 (s, 3H).



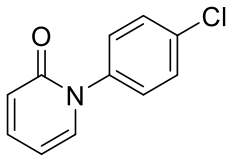
4h

5-chloro-1-methylpyridin-2(1H)-one (4h). [14] White solid. ^{1}H NMR (500 MHz, DMSO-d$_6$) δ 7.95 (d, J = 2.9 Hz, 1H), 7.45 (dd, J = 9.8 Hz, J = 3.0 Hz, 1H), 6.40 (d, J = 9.6 Hz, 1H), 3.40 (s, 3H).



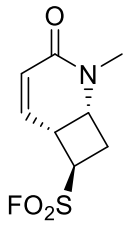
4i

1-phenylpyridin-2(1H)-one (4i). [17] White solid. ^{1}H NMR (500 MHz, DMSO-d$_6$) δ 7.62 (dd, J = 6.9 Hz, J = 1.8 Hz, 1H), 7.53-7.49 (m, 3H), 7.45-7.43 (m, 1H), 7.41-7.39 (m, 2H), 6.49 (d, J = 9.3 Hz, 1H), 6.31 (td, J = 6.7 Hz, J = 1.2 Hz, 1H).



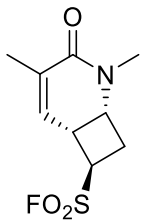
4j

1-(4-chlorophenyl)pyridin-2(1H)-one (4j). [17] White solid. ^{1}H NMR (500 MHz, DMSO-d_6) δ 7.64 (dd, J = 6.9 Hz, J = 1.7 Hz, 1H), 7.58-7.55 (m, 2H), 7.53-7.49 (m, 1H), 7.46-7.44 (m, 2H), 6.49 (d, J = 9.2 Hz, 1H), 6.32 (td, J = 6.8 Hz, J = 1.3 Hz, 1H).



5a

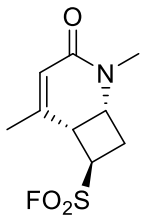
2-methyl-3-oxo-2-azabicyclo[4.2.0]oct-4-ene-7-sulfonyl fluoride (5a). White solid (43.36 mg, isolated yield 99%). ^{1}H NMR (500 MHz, DMSO-d_6) δ 6.51 (dd, J = 10.0 Hz, J = 4.3 Hz, 1H), 5.86 (dd, J = 9.8 Hz, J = 1.5 Hz, 1H), 4.81-4.79 (m, 1H), 4.34 (q, J = 7.5 Hz, 1H), 3.89-3.85 (m, 1H), 2.86 (t, J = 7.3 Hz, 2H), 2.77 (s, 3H). ^{19}F NMR (471 MHz, DMSO-d_6) δ 45.6 (s, 1F). ^{13}C NMR (126 MHz, DMSO-d_6) δ 160.7, 135.9, 124.7, 55.8 (d, J = 14.5 Hz), 51.0, 36.6, 31.4, 31.0. Mp 88-90 °C. HRMS ESI (m/z): $[M+H]^+$ calcd for $C_8H_{11}FNO_3S$: 220.0438, found: 220.0435.



5b

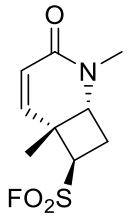
2,4-dimethyl-3-oxo-2-azabicyclo[4.2.0]oct-4-ene-7-sulfonyl fluoride (5b). Yellow oil (42.87 mg, isolated yield 92%). ^{1}H NMR (500 MHz, DMSO-d_6) δ 6.27 (dd, J = 4.4 Hz, J = 1.4 Hz, 1H), 4.80-4.77 (m, 1H), 4.34-4.29 (m, 1H), 3.81-3.79 (m, 1H), 2.85-2.81 (m, 2H), 2.77 (s, 3H), 1.80 (t, J = 1.5 Hz, 3H). ^{19}F NMR (471 MHz, DMSO-d_6) δ 45.5 (s, 1F). ^{13}C NMR (126 MHz, DMSO-d_6) δ 162.1, 130.6, 130.1, 56.3 (d, J = 13.7 Hz), 51.4, 36.2, 31.4, 31.3, 17.5. HRMS ESI (m/z): $[M+H]^+$ calcd for

$C_9H_{13}FNO_3S$: 234.0595, found: 234.0594.



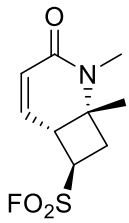
5c

2,5-dimethyl-3-oxo-2-azabicyclo[4.2.0]oct-4-ene-7-sulfonyl fluoride (5c). Light yellow solid (23.77 mg, isolated yield 51%). ^{1}H NMR (500 MHz, DMSO-d$_6$) δ 5.67 (s, 1H), 4.95-4.90 (m, 1H), 4.36-4.31 (m, 1H), 3.81-3.78 (m, 1H), 2.87-2.81 (m, 1H), 2.78-2.75 (m, 1H), 2.74 (s, 3H), 1.83 (s, 3H). ^{19}F NMR (471 MHz, DMSO-d$_6$) δ 44.5 (s, 1F). ^{13}C NMR (126 MHz, DMSO-d$_6$) δ 161.2, 145.6, 121.5, 55.4 (d, J = 14.5 Hz), 50.8, 40.0, 30.8, 30.4, 19.0. Mp 126-128 °C. HRMS ESI (m/z): $[M+H]^+$ calcd for $C_9H_{13}FNO_3S$: 234.0595, found: 234.0592.



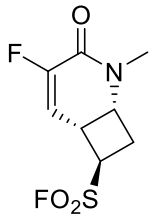
5d

2,6-dimethyl-3-oxo-2-azabicyclo[4.2.0]oct-4-ene-7-sulfonyl fluoride (5d). Yellow oil (44.74 mg, isolated yield 96%). ^{1}H NMR (500 MHz, DMSO-d$_6$) δ 6.48 (dd, J = 9.8 Hz, J = 1.3 Hz, 1H), 5.84 (d, J = 9.7 Hz, 1H), 4.67 (dd, J = 9.8 Hz, J = 3.5 Hz, 1H), 4.01 (t, J = 8.2 Hz, 1H), 2.81 (s, 3H), 2.80-2.77 (m, 1H), 2.73-2.66 (m, 1H), 1.41 (d, J = 1.0 Hz, 3H). ^{19}F NMR (471 MHz, DMSO-d$_6$) δ 55.3 (s, 1F). ^{13}C NMR (126 MHz, DMSO-d$_6$) δ 160.7, 141.9, 123.0, 58.6 (d, J = 12.7 Hz), 57.6, 44.1, 32.0, 29.6, 21.2. HRMS ESI (m/z): $[M+H]^+$ calcd for $C_9H_{13}FNO_3S$: 234.0595, found: 234.0593.



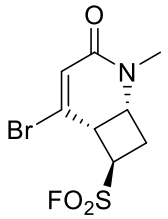
5e

1,2-dimethyl-3-oxo-2-azabicyclo[4.2.0]oct-4-ene-7-sulfonyl fluoride (5e). Light yellow solid (46.13 mg, isolated yield 99%). ^{1}H NMR (500 MHz, DMSO-d_6) δ 6.45 (dd, J = 9.8 Hz, J = 5.8 Hz, 1H), 5.85 (d, J = 9.7 Hz, 1H), 5.00-4.95 (m, 1H), 3.53 (dd, J = 9.0 Hz, J = 5.8 Hz, 1H), 2.89 (dd, J = 12.6 Hz, J = 9.0 Hz, 1H), 2.75 (s, 3H), 2.46 (dd, J = 12.6 Hz, J = 9.0 Hz, 1H), 1.42 (s, 3H). ^{19}F NMR (471 MHz, DMSO-d_6) δ 46.2 (s, 1F). ^{13}C NMR (126 MHz, DMSO-d_6) δ 161.3, 133.7, 125.4, 57.4, 54.7 (d, J = 14.6 Hz), 40.8, 34.8, 27.2, 25.5. Mp 119-121 °C. HRMS ESI (m/z): $[M+H]^+$ calcd for $C_9H_{13}FNO_3S$: 234.0595, found: 234.0592..



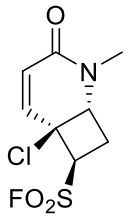
5f

4-fluoro-2-methyl-3-oxo-2-azabicyclo[4.2.0]oct-4-ene-7-sulfonyl fluoride (5f). Yellow solid (20.38 mg, isolated yield 43%). ^{1}H NMR (500 MHz, DMSO-d_6) δ 6.20 (dd, J = 11.2 Hz, J = 4.9 Hz, 1H), 4.93-4.92 (m, 1H), 4.35 (q, J = 7.7 Hz, 1H), 4.00-3.97 (m, 1H), 3.00-2.96 (m, 1H), 2.88-2.83 (m, 1H), 2.80 (s, 3H). ^{19}F NMR (471 MHz, DMSO-d_6) δ 45.9 (s, 1F), -125.3 (m, 1F). ^{13}C NMR (126 MHz, DMSO-d_6) δ 156.1 (d, J = 31.8 Hz), 148.5 (d, J = 251.6 Hz), 110.7 (d, J = 18.2 Hz), 56.3 (dd, J = 14.5 Hz, J = 3.6 Hz), 51.0, 35.0 (d, J = 8.2 Hz), 31.3 (d, J = 1.8 Hz), 31.1. Mp 102-104 °C. HRMS ESI (m/z): $[M+H]^+$ calcd for $C_8H_{10}F_2NO_3S$: 238.0344, found: 238.0342.



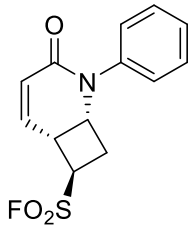
5g

5-bromo-2-methyl-3-oxo-2-azabicyclo[4.2.0]oct-4-ene-7-sulfonyl fluoride (5g). Light yellow solid (26.14 mg, isolated yield 44%). ^{1}H NMR (500 MHz, DMSO-d$_6$) δ 6.37 (d, J = 1.1 Hz, 1H), 5.00-4.98 (m, 1H), 4.39 (dd, J = 17.2 Hz, J = 7.4 Hz, 1H), 4.23 (dd, J = 10.1 Hz, J = 5.4 Hz, 1H), 2.89-2.85 (m, 2H), 2.76 (s, 3H). ^{19}F NMR (471 MHz, DMSO-d$_6$) δ 46.2 (s, 1F). ^{13}C NMR (126 MHz, DMSO-d$_6$) δ 159.1, 133.1, 126.8, 56.2 (d, J = 16.3 Hz), 51.4, 44.0, 30.7, 30.6. Mp 132-134 °C. HRMS ESI (m/z): [M+H]$^+$ calcd for $C_8H_{10}BrFNO_3S$: 297.9543, found: 297.9547.



5h

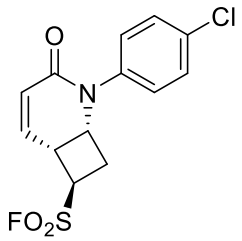
6-chloro-2-methyl-3-oxo-2-azabicyclo[4.2.0]oct-4-ene-7-sulfonyl fluoride (5h). Yellow oil (17.71 mg, isolated yield 35%). ^{1}H NMR (500 MHz, DMSO-d$_6$) δ 6.71 (dd, J = 9.8 Hz, J = 2.0 Hz, 1H), 6.10 (d, J = 9.8 Hz, 1H), 5.26-5.23 (m, 1H), 4.69-4.65 (m, 1H), 3.07-3.01 (m, 1H), 2.91 (s, 3H), 2.71-2.65 (m, 1H). ^{19}F NMR (471 MHz, DMSO-d$_6$) δ 55.7 (s, 1F). ^{13}C NMR (126 MHz, DMSO-d$_6$) δ 159.8, 136.1, 125.5, 61.2, 60.6 (d, J = 15.4 Hz), 58.7, 32.5, 29.2. HRMS ESI (m/z): [M+H]$^+$ calcd for $C_8H_{10}ClFNO_3S$: 254.0048, found: 254.0050.



5i

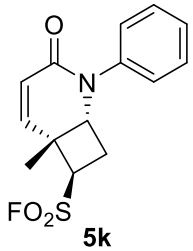
3-oxo-2-phenyl-2-azabicyclo[4.2.0]oct-4-ene-7-sulfonyl fluoride (5i). Yellow solid (44.40 mg, isolated yield 79%). ^{1}H NMR (500 MHz, DMSO-d$_6$) δ 7.42-7.39 (m, 2H),

7.29-7.26 (m, 3H), 6.72 (dd, J = 9.9 Hz, J = 4.0 Hz, 1H), 6.04 (dd, J = 9.9 Hz, J = 1.7 Hz, 1H), 4.89-4.87 (m, 1H), 4.67 (q, J = 8.1 Hz, 1H), 4.03-4.01 (m, 1H), 3.15-3.08 (m, 1H), 2.96-2.90 (m, 1H). ^{19}F NMR (471 MHz, DMSO-d_6) δ 46.3 (s, 1F). ^{13}C NMR (126 MHz, DMSO-d_6) δ 160.5, 140.8, 137.1, 129.0, 126.6, 126.1, 125.1, 55.7 (d, J = 14.6 Hz), 52.5, 38.0, 32.4. Mp 89-91 °C. HRMS ESI (m/z): $[M+H]^+$ calcd for $C_{13}H_{13}FNO_3S$: 282.0595, found: 282.0594.



5j

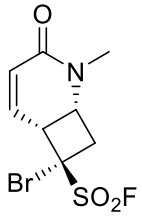
2-(4-chlorophenyl)-3-oxo-2-azabicyclo[4.2.0]oct-4-ene-7-sulfonyl fluoride (5j). Light yellow solid (40.95 mg, isolated yield 65%). ^{1}H NMR (500 MHz, DMSO-d_6) δ 7.46-7.44 (m, 2H), 7.34-7.31 (m, 2H), 6.73 (dd, J = 9.9 Hz, J = 4.0 Hz, 1H), 6.04 (dd, J = 9.9 Hz, J = 1.7 Hz, 1H), 4.89-4.88 (m, 1H), 4.68 (q, J = 8.1 Hz, 1H), 4.03-4.01 (m, 1H), 3.13-3.07 (m, 1H), 2.97-2.92 (m, 1H). ^{19}F NMR (471 MHz, DMSO-d_6) δ 46.3 (s, 1F). ^{13}C NMR (126 MHz, DMSO-d_6) δ 160.6, 139.6, 137.4, 130.8, 128.9, 127.9, 124.9, 55.7 (d, J = 15.6 Hz), 52.3, 37.9, 32.2. Mp 130-132 °C. HRMS ESI (m/z): $[M+H]^+$ calcd for $C_{13}H_{12}ClFNO_3S$: 316.0205, found: 316.0208.



5k

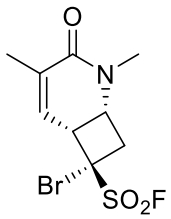
6-methyl-3-oxo-2-phenyl-2-azabicyclo[4.2.0]oct-4-ene-7-sulfonyl fluoride (5k). Light yellow solid (28.32 mg, isolated yield 48%). ^{1}H NMR (500 MHz, DMSO-d_6) δ 7.40 (t, J = 7.7 Hz, 2H), 7.29-7.27 (m, 3H), 6.68 (dd, J = 10.0 Hz, J = 1.4 Hz, 1H), 6.02 (d, J = 9.9 Hz, 1H), 4.77 (dd, J = 9.7 Hz, J = 2.4 Hz, 1H), 4.32 (t, J = 8.6 Hz, 1H), 3.11-3.04 (m, 1H), 2.96-2.91 (m, 1H), 1.49 (s,3H). ^{19}F NMR (471 MHz, DMSO-d_6) δ 55.7 (s, 1F). ^{13}C NMR (126 MHz, DMSO-d_6) δ 160.3, 142.8, 141.3, 129.0, 126.5, 125.7, 123.5, 59.1, 58.7 (d, J = 11.8 Hz), 45.3, 30.7, 20.8. Mp

154-156 °C. HRMS ESI (m/z): $[M+H]^+$ calcd for C14H15FNO3S: 296.0751, found: 296.0753.



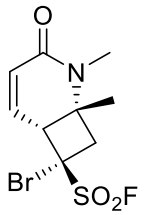
7a

7-bromo-2-methyl-3-oxo-2-azabicyclo[4.2.0]oct-4-ene-7-sulfonyl fluoride (7a). Brown solid (48.71 mg, isolated yield 82%). ^{1}H NMR (500 MHz, DMSO-d_6) δ 6.40 (dd, J = 9.9 Hz, J = 4.4 Hz, 1H), 6.05 (dd, J = 9.9 Hz, J = 1.8 Hz, 1H), 4.46-4.43 (m, 1H), 4.42-4.39 (m, 1H), 3.70-3.65 (m, 1H), 3.27 (dd, J = 15.1 Hz, J = 6.7 Hz, 1H), 2.77 (s, 3H). ^{19}F NMR (471 MHz, DMSO-d_6) δ 34.4 (s, 1F). ^{13}C NMR (126 MHz, DMSO-d_6) δ 159.8, 135.2, 126.0, 67.9 (d, J = 17.3 Hz), 50.1, 44.6, 43.0, 31.0. Mp 109-111 °C. HRMS ESI (m/z): $[M+H]^+$ calcd for $C_8H_{10}BrFNO_3S$: 297.9543, found: 297.9546.



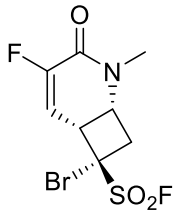
7b

7-bromo-2,4-dimethyl-3-oxo-2-azabicyclo[4.2.0]oct-4-ene-7-sulfonyl fluoride (7b). Yellow solid (47.89 mg, isolated yield 77%). ^{1}H NMR (500 MHz, DMSO-d_6) δ 6.16-6.15 (m, 1H), 4.39-4.37 (m, 2H), 3.67-3.62 (m, 1H), 3.28-3.23 (m, 1H), 2.77 (s, 3H), 1.88 (s, 3H). ^{19}F NMR (471 MHz, DMSO-d_6) δ 34.4 (s, 1F). ^{13}C NMR (126 MHz, DMSO-d_6) δ 161.3, 132.4, 129.4, 68.9 (d, J = 17.3 Hz), 50.5, 44.4, 42.6, 31.5, 17.6. Mp 111-113 °C. HRMS ESI (m/z): $[M+H]^+$ calcd for $C_9H_{12}BrFNO_3S$: 311.9700, found: 311.9703.



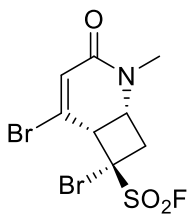
7e

7-bromo-1,2-dimethyl-3-oxo-2-azabicyclo[4.2.0]oct-4-ene-7-sulfonyl fluoride (7e). Yellow solid (34.83 mg, isolated yield 56%). ^{1}H NMR (500 MHz, DMSO-d_6) δ 6.27 (dd, J = 9.8 Hz, J = 6.1 Hz, 1H), 6.13 (d, J = 9.9 Hz, 1H),4.24 (d, J = 6.1 Hz, 1H), 3.33 (d, J = 0.8 Hz , 1H), 3.20 (d, J = 14.9 Hz, 1H), 2.74 (s, 3H), 1.44 (s, 3H). ^{19}F NMR (471 MHz, DMSO-d_6) δ 34.3 (s, 1F). ^{13}C NMR (126 MHz, DMSO-d_6) δ 160.6, 131.9, 128.3, 67.6 (d, J = 17.3 Hz), 56.6, 46.1, 46.0, 26.9, 25.8. Mp 122-124 °C. HRMS ESI (m/z): $[M+H]^+$ calcd for $C_9H_{12}BrFNO_3S$: 311.9700, found: 311.9703.



7f

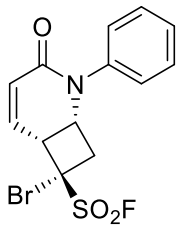
7-bromo-4-fluoro-2-methyl-3-oxo-2-azabicyclo[4.2.0]oct-4-ene-7-sulfonyl fluoride (7f). Yellow solid (18.93 mg, isolated yield 30%). ^{1}H NMR (500 MHz, DMSO-d_6) δ 6.16 (dd, J = 11.0 Hz, J = 5.0 Hz, 1H), 4.58-4.55 (m, 1H), 4.44-4.39 (m, 1H), 3.68-3.93 (m, 1H), 3.47 (dd, J = 15.1 Hz, J = 6.7 Hz, 1H), 2.80 (s, 3H). ^{19}F NMR (471 MHz, DMSO-d_6) δ 34.8 (s, 1F), -122.1 (m, 1F). ^{13}C NMR (126 MHz, DMSO-d_6) δ 155.3 (d, J = 31.7 Hz), 149.1 (d, J = 253.5 Hz), 110.5 (d, J = 19.9 Hz), 68.8 (dd, J = 17.2 Hz, J = 4.5 Hz), 50.0, 48.3, 42.2 (d, J = 8.2 Hz), 31.3. Mp 110-112 °C. HRMS ESI (m/z): $[M+H]^+$ calcd for $C_8H_9BrF_2NO_3S$: 315.9449, found: 315.9451.



7g

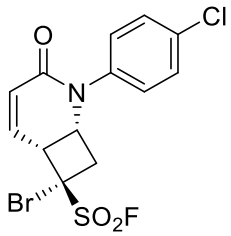
5,7-dibromo-2-methyl-3-oxo-2-azabicyclo[4.2.0]oct-4-ene-7-sulfonyl fluoride (7g).

Yellow solid (19.51 mg, isolated yield 26%). ^{1}H NMR (500 MHz, DMSO-d_6) δ 6.62 (s, 1H), 4.85 (d, J = 9.6 Hz, 1H), 4.44-4.40 (m, 1H), 3.70-3.65 (m, 1H), 3.17 (dd, J = 15.4 Hz, J = 4.0 Hz, 1H), 2.75 (s, 3H). ^{19}F NMR (471 MHz, DMSO-d_6) δ 34.8 (s, 1F). ^{13}C NMR (126 MHz, DMSO-d_6) δ 158.8, 130.1, 129.4, 67.8 (d, J = 18.1 Hz), 51.2, 48.2, 42.3, 29.8. Mp 106-107 °C. HRMS ESI (m/z): $[M+H]^+$ calcd for $C_8H_9Br_2FNO_3S$: 375.8648, found: 375.8650.



7i

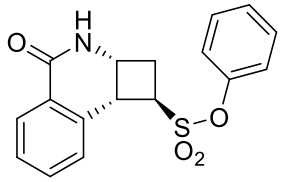
7-bromo-3-oxo-2-phenyl-2-azabicyclo[4.2.0]oct-4-ene-7-sulfonyl fluoride (7i). White solid (50.29 mg, isolated yield 70%). ^{1}H NMR (500 MHz, DMSO-d_6) δ 7.42-7.39 (m, 2H), 7.31-7.27 (m, 3H), 6.61 (dd, J = 9.9 Hz, J = 4.3 Hz, 1H), 6.22 (dd, J = 9.9 Hz, J = 1.8 Hz, 1H), 4.68 (q, J = 7.8 Hz, 1H), 4.58-4.56 (m, 1H), 3.75-3.70 (m, 1H), 3.59 (dd, J = 14.6 Hz, J = 7.4 Hz, 1H). ^{19}F NMR (471 MHz, DMSO-d_6) δ 35.2 (s, 1F). ^{13}C NMR (126 MHz, DMSO-d_6) δ 159.8, 140.4, 136.4, 129.1, 126.9, 126.4, 126.3, 67.7 (d, J = 18.2 Hz), 51.7, 45.1, 44.2. Mp 103-105 °C. HRMS ESI (m/z): $[M+H]^+$ calcd for C13H12BrFNO3S: 359.9700, found: 359.9703.



7j

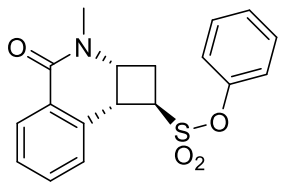
7-bromo-2-(4-chlorophenyl)-3-oxo-2-azabicyclo[4.2.0]oct-4-ene-7-sulfonyl fluoride (7j). White solid (58.95 mg, isolated yield 75%). ^{1}H NMR (500 MHz, DMSO-d_6) δ 7.47-7.45 (m, 2H), 7.34-7.32 (m, 2H), 6.62 (dd, J = 10.1 Hz, J = 4.3 Hz, 1H), 6.22 (dd, J = 10.0 Hz, J = 2.0 Hz, 1H), 4.69 (q, J = 7.6 Hz, 1H), 4.58-4.55 (m, 1H), 3.75-3.70 (m, 1H), 3.61 (dd, J = 35.2 Hz, J = 7.5 Hz, 1H). ^{19}F NMR (471 MHz,

DMSO-d_6) δ 35.2 (s, 1F). ^{13}C NMR (126 MHz, DMSO-d_6) δ 159.8, 139.2, 136.7, 131.2, 129.0, 128.2, 126.1, 67.6 (d, J = 18.2 Hz), 51.6, 44.9, 44.2. Mp 129-131 °C. HRMS ESI (m/z): $[M+H]^+$ calcd for $C_{13}H_{11}BrClFNO_3S$: 393.9310, found: 393.9313.



9aa

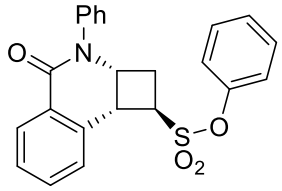
phenyl 4-oxo-1,2,2a,3,4,8b-hexahydrocyclobuta[c]isoquinoline-1-sulfonate (9aa). White solid (54.63 mg, isolated yield 83%). ^{1}H NMR (500 MHz, DMSO-d_6) δ 8.15 (s, 1H), 7.99 (dd, J = 7.8 Hz, J = 0.9 Hz, 1H), 7.54 (td, J = 7.4 Hz, J = 1.3 Hz, 1H), 7.47-7.43 (m, 3H), 7.38-7.35 (m, 1H), 7.29-7.27 (m, 2H), 7.21 (d, J = 7.7 Hz, 1H), 4.64 (q, J = 7.6 Hz, 1H), 4.36-4.29 (m, 2H), 2.73-2.67 (m, 1H), 2.45-2.41 (m, 1H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 161.9, 148.7, 135.8, 132.6, 130.2, 128.0, 127.7, 127.5, 127.0, 122.3, 58.8, 45.4, 36.7, 32.8. Mp 157-158 °C. HRMS ESI (m/z): $[M+H]^+$ calcd for $C_{17}H_{16}NO_4S$: 330.0795, found: 330.0793.



9ja

phenyl

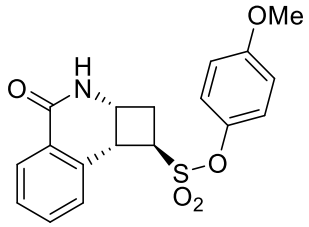
3-methyl-4-oxo-1,2,2a,3,4,8b-hexahydrocyclobuta[c]isoquinoline-1-sulfonate (9ja). White solid (50.15 mg, isolated yield 73%). ^{1}H NMR (500 MHz, DMSO-d_6) δ 8.01 (dd, J = 7.8 Hz, J = 1.1 Hz, 1H), 7.53 (td, J = 7.5 Hz, J = 1.4 Hz, 1H), 7.47-7.41 (m, 3H), 7.38-7.35 (m, 1H), 7.29-7.27 (m, 2H), 7.18 (d, J = 7.4 Hz, 1H), 4.61-4.56 (m, 1H), 4.45-4.39 (m, 2H), 2.93 (s, 3H), 2.78-2.67 (m, 2H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 160.9, 148.7, 135.1, 132.4, 130.2, 128.0, 127.8, 127.5, 127.4, 126.9, 122.2, 58.3, 51.6, 36.8, 31.3, 30.5. Mp 104-106 °C. HRMS ESI (m/z): $[M+H]^+$ calcd for $C_{18}H_{18}NO_4S$: 344.0951, found: 344.0959.



9ka

phenyl

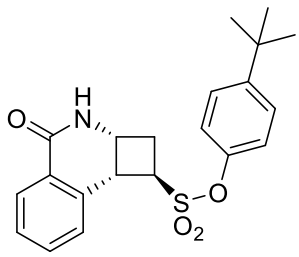
4-oxo-3-phenyl-1,2,2a,3,4,8b-hexahydrocyclobuta[c]isoquinoline-1-sulfonate (9ka). White solid (58.32 mg, isolated yield 72%). ^{1}H NMR (500 MHz, DMSO-d$_6$) δ 8.07 (d, J = 7.5 Hz, 1H), 7.63-7.60 (m, 1H), 7.50-7.40 (m, 7H), 7.37-7.32 (m, 2H), 7.28 (dd, J = 7.3 Hz, J = 0.9 Hz, 3H), 4.88-4.84 (m, 2H), 4.53 (t, J = 8.0 Hz, 1H), 2.68-2.63 (m, 1H), 2.59-2.54 (m, 1H). ^{13}C NMR (126 MHz, DMSO-d$_6$) δ 161.1, 148.6, 140.5, 135.4, 132.9, 130.2, 129.1, 128.2, 128.2, 127.8, 127.5, 127.2, 127.1, 122.3, 58.2, 52.7, 37.6, 30.9. Mp 152-153 °C. HRMS ESI (m/z): $[M+H]^+$ calcd for $C_{23}H_{20}NO_4S$: 406.1108, found: 406.1112.



9ab

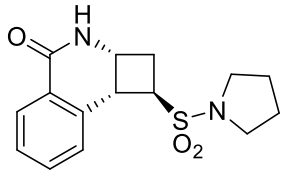
4-methoxyphenyl

4-oxo-1,2,2a,3,4,8b-hexahydrocyclobuta[c]isoquinoline-1-sulfonate (9ab). White solid (37.51 mg, isolated yield 52%). ^{1}H NMR (500 MHz, DMSO-d$_6$) δ 8.14 (s, 1H), 7.99 (d, J = 6.9 Hz, 1H), 7.54 (td, J = 7.5 Hz, J = 1.4 Hz, 1H), 7.43 (td, J = 7.8 Hz, J = 0.8 Hz, 1H), 7.20-7.19 (m, 3H), 6.97-6.95 (m, 2H), 4.58 (q, J = 7.8 Hz, 1H), 4.35-4.31 (m, 1H), 4.30-4.27 (m, 1H), 3.75 (s, 3H), 2.70-2.65 (m, 1H), 2.43-2.39 (m, 1H). ^{13}C NMR (126 MHz, DMSO-d$_6$) δ 161.9, 158.0, 141.9, 135.9, 132.5, 128.0, 127.7, 127.5, 127.0, 123.3, 114.9, 58.5, 55.6, 45.4, 36.7, 32.8. Mp 146-147 °C. HRMS ESI (m/z): $[M+H]^+$ calcd for $C_{18}H_{18}NO_5S$: 360.0900, found: 360.0901.



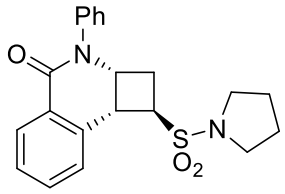
9ac

4-(tert-butyl)phenyl 4-oxo-1,2,2a,3,4,8b-hexahydrocyclobuta[c]isoquinoline-1-sulfonate (9ac). White solid (55.01 mg, isolated yield 71%). ^{1}H NMR (500 MHz, DMSO-d$_6$) δ 8.16 (s, 1H), 8.00 (d, J = 7.6 Hz, 1H), 7.54 (td, J = 7.4 Hz, J = 1.2 Hz, 1H), 7.45-7.42 (m, 3H), 7.20 (d, J = 6.6 Hz, 1H), 7.18-7.16 (m, 2H), 4.59 (q, J = 7.8 Hz, 1H), 4.37-4.33 (m, 1H), 4.32-4.29 (m, 1H), 2.73-2.69 (m, 1H), 2.47-2.43 (m, 1H), 1.26 (s, 9H). ^{13}C NMR (126 MHz, DMSO-d$_6$) δ 161.9, 150.0, 146.4, 135.8, 132.5, 128.0, 127.7, 127.5, 127.0, 126.9, 121.7, 58.6, 45.4, 36.7, 34.4, 32.7, 31.1. Mp 168-170 °C. HRMS ESI (m/z): [M+H]$^+$ calcd for $C_{21}H_{24}NO_4S$: 386.1421, found: 386.1418.



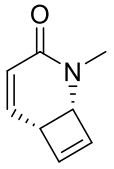
11aa

1-(pyrrolidin-1-ylsulfonyl)-1,2a,3,8b-tetrahydrocyclobuta[c]isoquinolin-4(2H)-one (11aa). White solid (41.80 mg, isolated yield 68%). ^{1}H NMR (500 MHz, DMSO-d$_6$) δ 8.11 (s, 1H), 7.96 (d, J = 7.4 Hz, 1H), 7.53 (td, J = 7.4 Hz, J = 1.2 Hz, 1H), 7.40 (t, J = 7.6 Hz, 1H), 7.18 (d, J = 7.7 Hz, 1H), 4.27-4.26 (m, 1H), 4.24-4.21 (m, 1H), 4.08 (t, J = 7.8 Hz, 1H), 3.27-3.23 (m, 2H), 3.20-3.17 (m, 2H), 2.70-2.65 (m, 1H), 2.36-2.31 (m, 1H), 1.80-1.78 (m, 4H). ^{13}C NMR (126 MHz, DMSO-d$_6$) δ 162.1, 136.9, 132.4, 127.8, 127.6, 127.3, 127.0, 57.7, 47.6, 45.7, 36.7, 33.0, 25.3. Mp 191-192 °C. HRMS ESI (m/z): [M+H]$^+$ calcd for $C_{15}H_{19}N_2O_3S$: 307.1111, found: 307.1108.



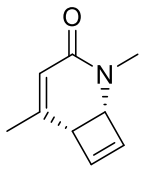
11ka

3-phenyl-1-(pyrrolidin-1-ylsulfonyl)-1,2a,3,8b-tetrahydrocyclobuta[c]isoquinolin -4(2H)-one (11ka). White solid (19.51 mg, isolated yield 48%). ^{1}H NMR (500 MHz, DMSO-d_6) δ 8.05 (d, J = 7.6 Hz, 1H), 7.62 (t, J = 7.2 Hz, 1H), 7.46 (t, J = 7.7 Hz, 3H), 7.40 (d, J = 7.5 Hz, 2H), 7.33 (t, J = 7.2 Hz, 1H), 7.27 (d, J = 7.7 Hz, 1H), 4.83-4.79 (m, 1H), 4.42 (q, J = 7.4 Hz , 1H), 4.31 (t, J = 7.7 Hz, 1H), 3.28-3.20 (m, 4H), 2.65-2.59 (m, 1H), 2.48-2.46 (m, 1H), 1.80 (s, 4H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 161.2, 140.7, 136.6, 132.8, 129.1, 128.0, 127.8, 127.7, 127.4, 127.1, 127.0, 57.0, 53.0, 47.7, 37.5, 31.3, 25.3. Mp 188-190 °C. HRMS ESI (m/z): $[M+H]^+$ calcd for $C_{21}H_{23}N_2O_3S$: 383.1424, found: 383.1420.



12a

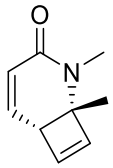
2-methyl-2-azabicyclo[4.2.0]octa-4,7-dien-3-one (12a). Yellow oil (23.61 mg, isolated yield 87%). ^{1}H NMR (500 MHz, DMSO-d_6) δ 7.75 (d, J = 2.4 Hz, 1H), 7.72 (dd, J = 9.4 Hz, J = 2.6 Hz, 1H), 6.45 (dd, J = 17.5 Hz, J = 10.9 Hz, 1H), 6.40 (d, J = 9.4 Hz, 1H), 5.54 (d, J = 17.6 Hz, 1H), 5.06 (d, J = 11.1 Hz, 1H), 3.41 (s, 3H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 161.5, 138.5, 136.4, 131.9, 119.4, 115.9, 111.0, 36.8. HRMS ESI (m/z): $[M+H]^+$ calcd for $C_8H_{10}NO$: 136.0757, found: 136.0755.



12c

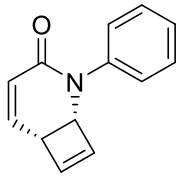
2,5-dimethyl-2-azabicyclo[4.2.0]octa-4,7-dien-3-one (12c). Yellow oil (12.05 mg, isolated yield 40%). ^{1}H NMR (500 MHz, DMSO-d_6) δ 7.84 (s, 1H), 6.57 (dd, J = 17.6 Hz, J = 11.2 Hz, 1H), 6.22 (s, 1H), 5.49 (dd, J = 17.4 Hz, J = 1.2 Hz, 1H), 5.12 (dd, J

= 10.9 Hz, *J* = 1.0 Hz, 1H), 3.41 (s, 3H), 2.14 (s, 3H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 161.2, 149.2, 135.9, 130.9, 117.7, 116.7, 113.4, 36.4, 19.3. HRMS ESI (m/z): $[M+H]^+$ calcd for $C_9H_{12}NO$: 150.0913, found: 150.0910.



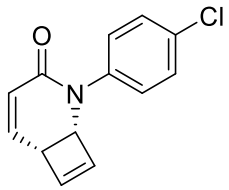
12e

1,2-dimethyl-2-azabicyclo[4.2.0]octa-4,7-dien-3-one (12e). Yellow solid (19.51 mg, isolated yield 26%). ^{1}H NMR (500 MHz, DMSO-d_6) δ 7.64 (d, *J* = 9.4 Hz, 1H), 6.80 (dd, *J* = 17.2 Hz, *J* = 11.0 Hz, 1H), 6.32 (d, *J* = 9.5 Hz, 1H), 5.49 (d, *J* = 17.3 Hz, 1H), 5.13 (d, *J* = 10.9 Hz, 1H), 3.46 (s, 3H), 2.38 (s, 3H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 161.9, 145.0, 136.6, 132.0, 116.3, 114.1, 112.7, 31.0, 15.9. Mp 74-76 °C. HRMS ESI (m/z): $[M+H]^+$ calcd for $C_9H_{12}NO$: 150.0913, found: 150.0911.



12i

2-phenyl-2-azabicyclo[4.2.0]octa-4,7-dien-3-one (12i). White solid (31.30 mg, isolated yield 79%). ^{1}H NMR (500 MHz, DMSO-d_6) δ 7.87 (dd, *J* = 9.6 Hz, *J* = 2.6 Hz, 1H), 7.73 (d, *J* = 2.3 Hz, 1H), 7.52 (t, *J* = 7.6 Hz, 1H), 7.47-7.44 (m, 1H), 7.43-7.42 (m, 2H), 6.57-6.52 (m, 2H), 5.62 (d, *J* = 17.5 Hz, 1H), 5.12 (d, *J* = 11.0 Hz, 1H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 160.8, 140.7, 137.7, 136.9, 131.8, 129.1, 128.3, 126.8, 120.8, 116.4, 111.6. Mp 113-114 °C. HRMS ESI (m/z): $[M+H]^+$ calcd for $C_{13}H_{12}NO$: 198.0913, found: 198.0909.



12j

2-(4-chlorophenyl)-2-azabicyclo[4.2.0]octa-4,7-dien-3-one (12j). White solid (43.62 mg, isolated yield 94%). ^{1}H NMR (500 MHz, DMSO-d_6) δ 7.87 (dd, J = 9.6 Hz, J = 2.4 Hz, 1H), 7.73 (d, J = 2.4 Hz, 1H), 7.58 (d, J = 8.6 Hz, 2H), 7.48 (d, J = 8.7 Hz, 2H), 6.56-6.50 (m, 2H), 5.62 (d, J = 17.5 Hz, 1H), 5.13 (d, J = 11.0 Hz, 1H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 160.7, 139.4, 137.4, 137.3, 132.9, 131.7, 129.1, 128.9, 120.8, 116.6, 111.9. Mp 197-199 °C. HRMS ESI (m/z): $[M+H]^+$ calcd for $C_{13}H_{11}ClNO$: 232.0524, found: 232.0520.

12. Reference

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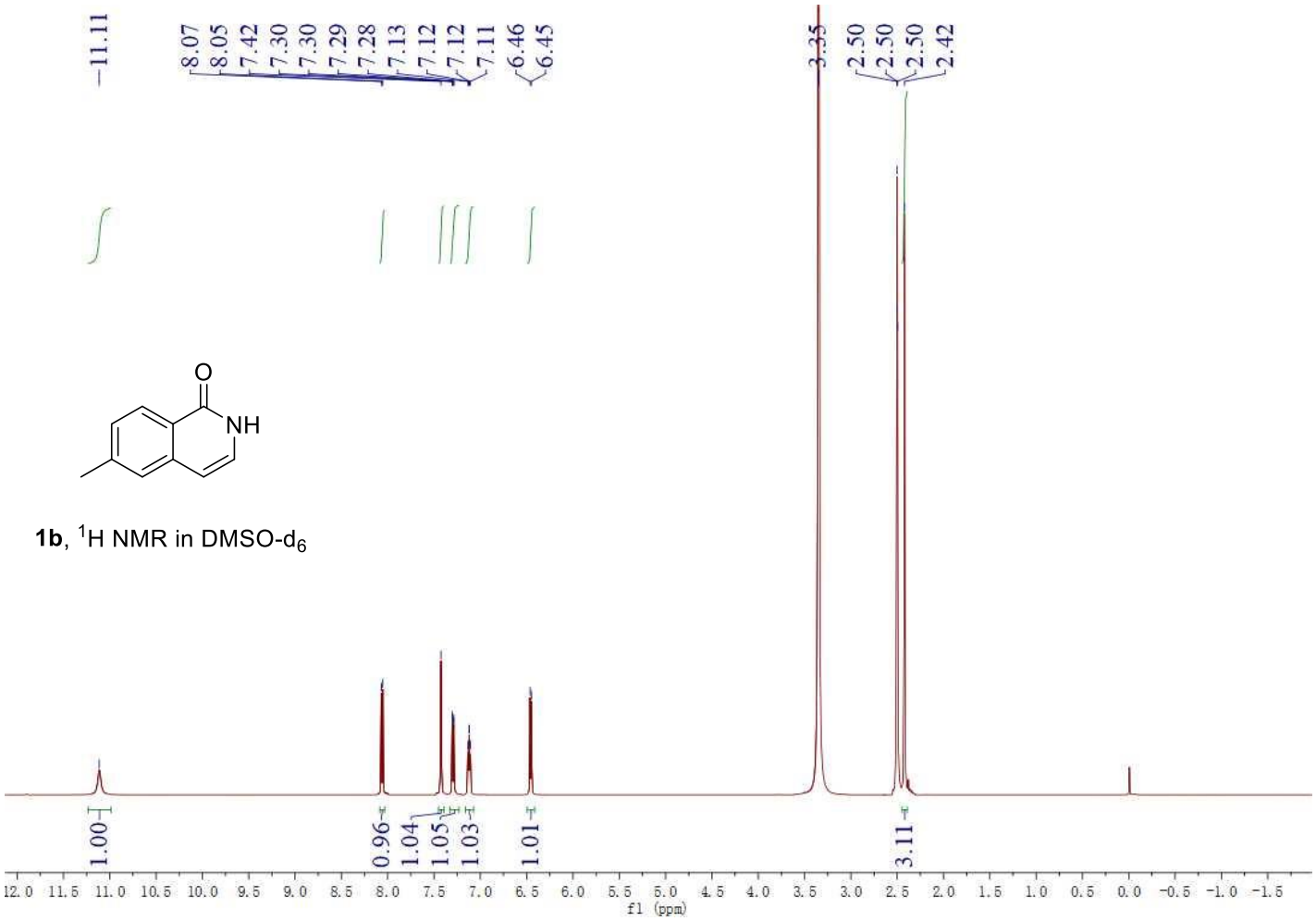
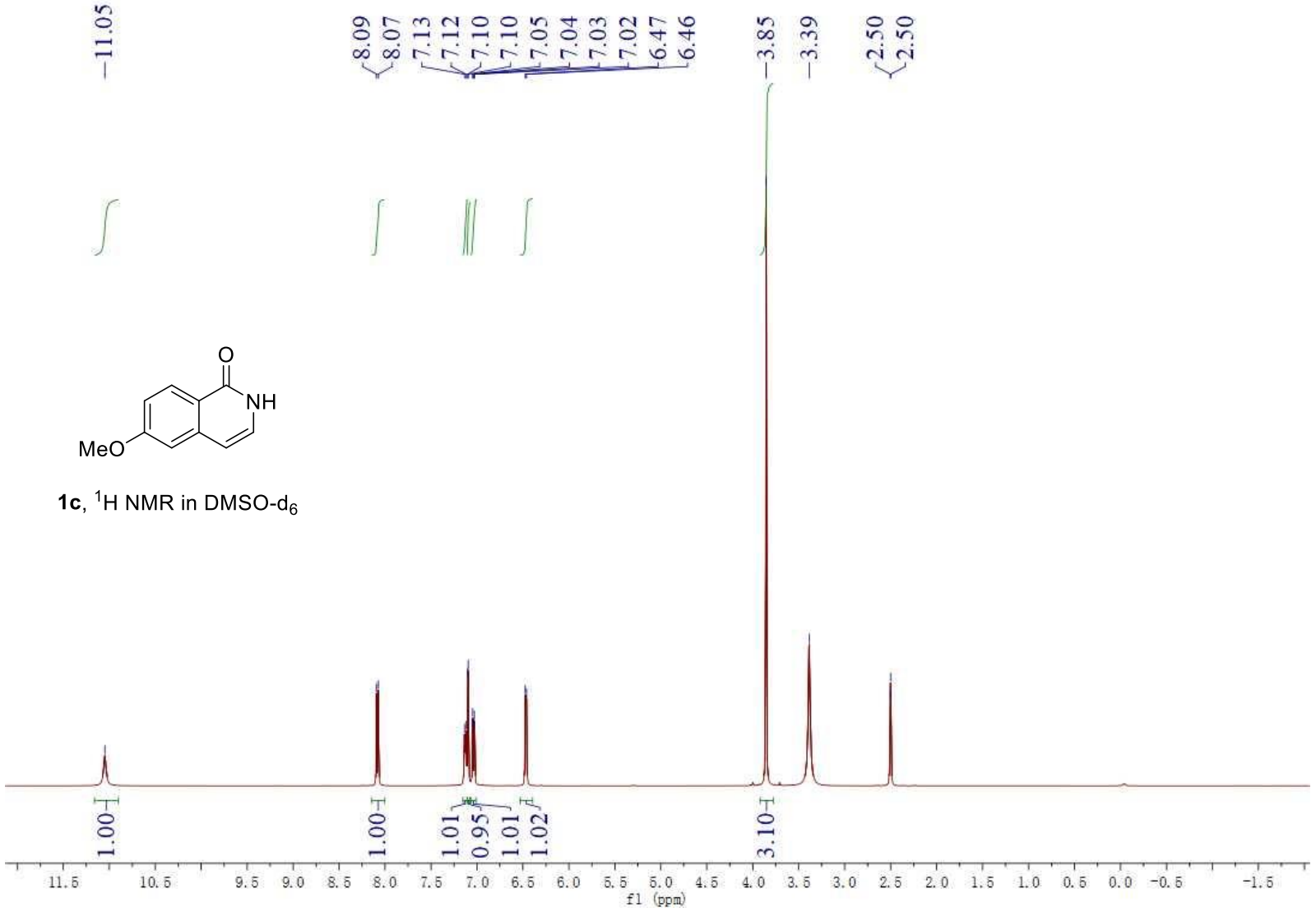
13. ^{1}H, ^{19}F, ^{13}C NMR spectra



1b, ^{1}H NMR in DMSO-d_6



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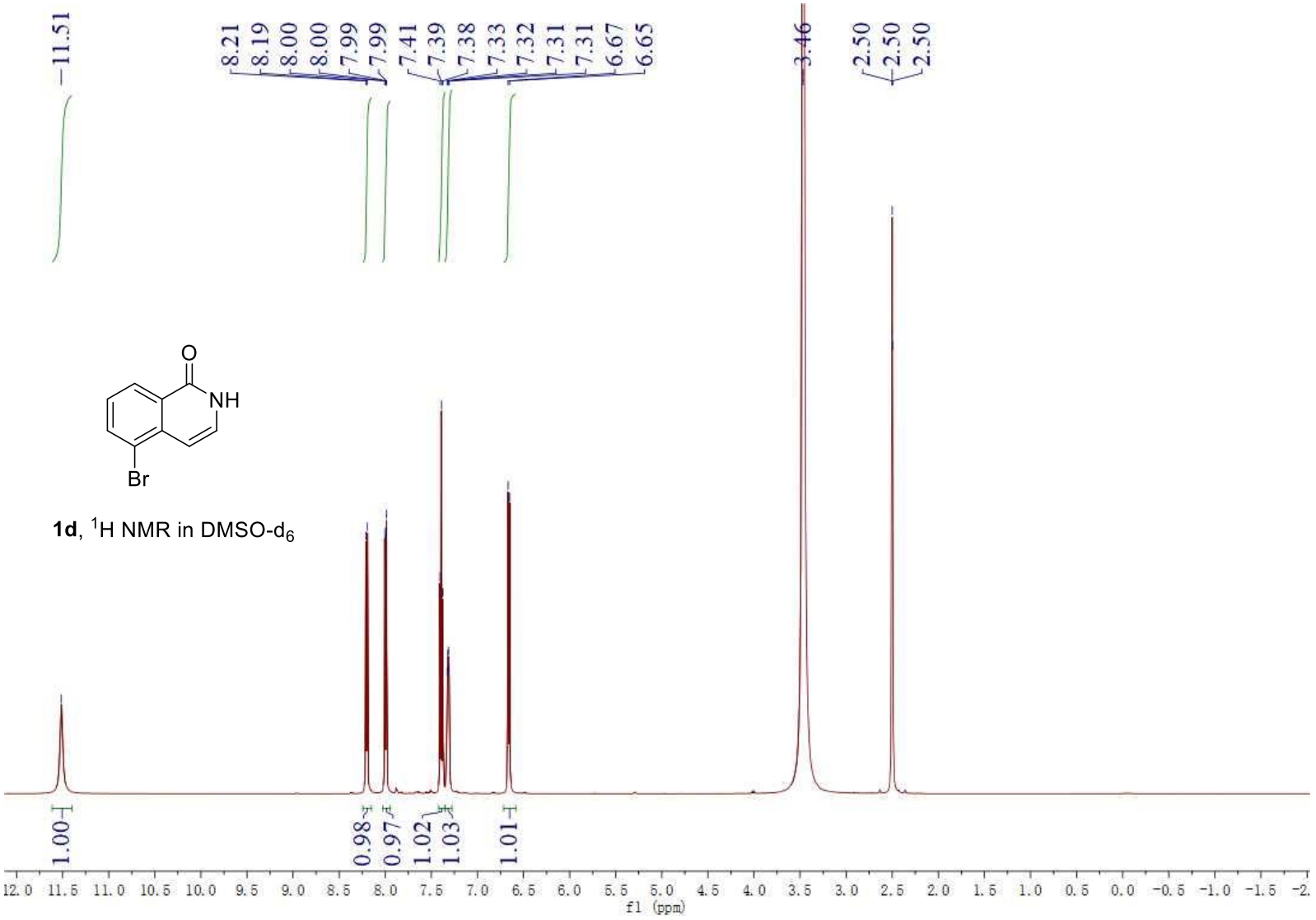

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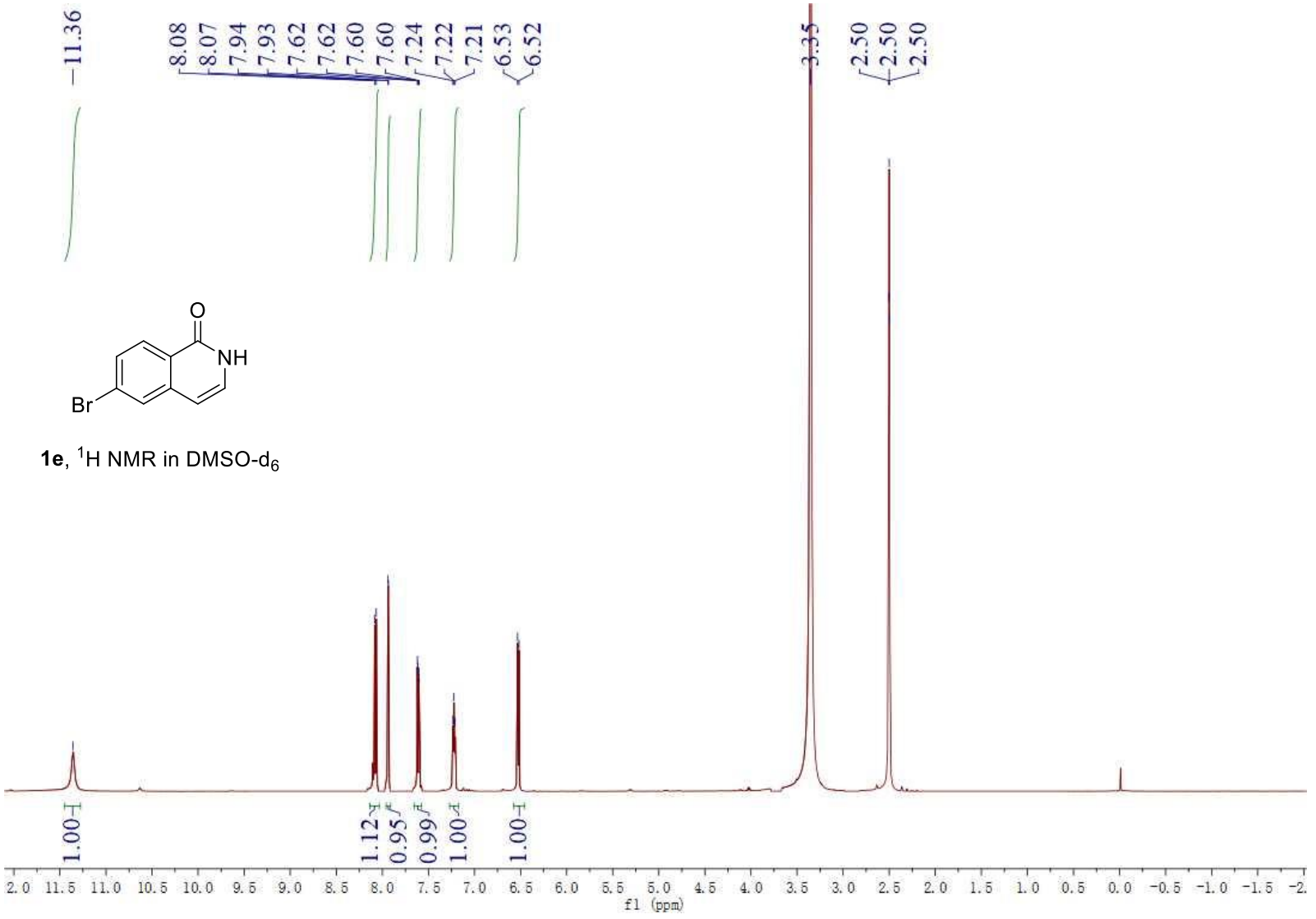

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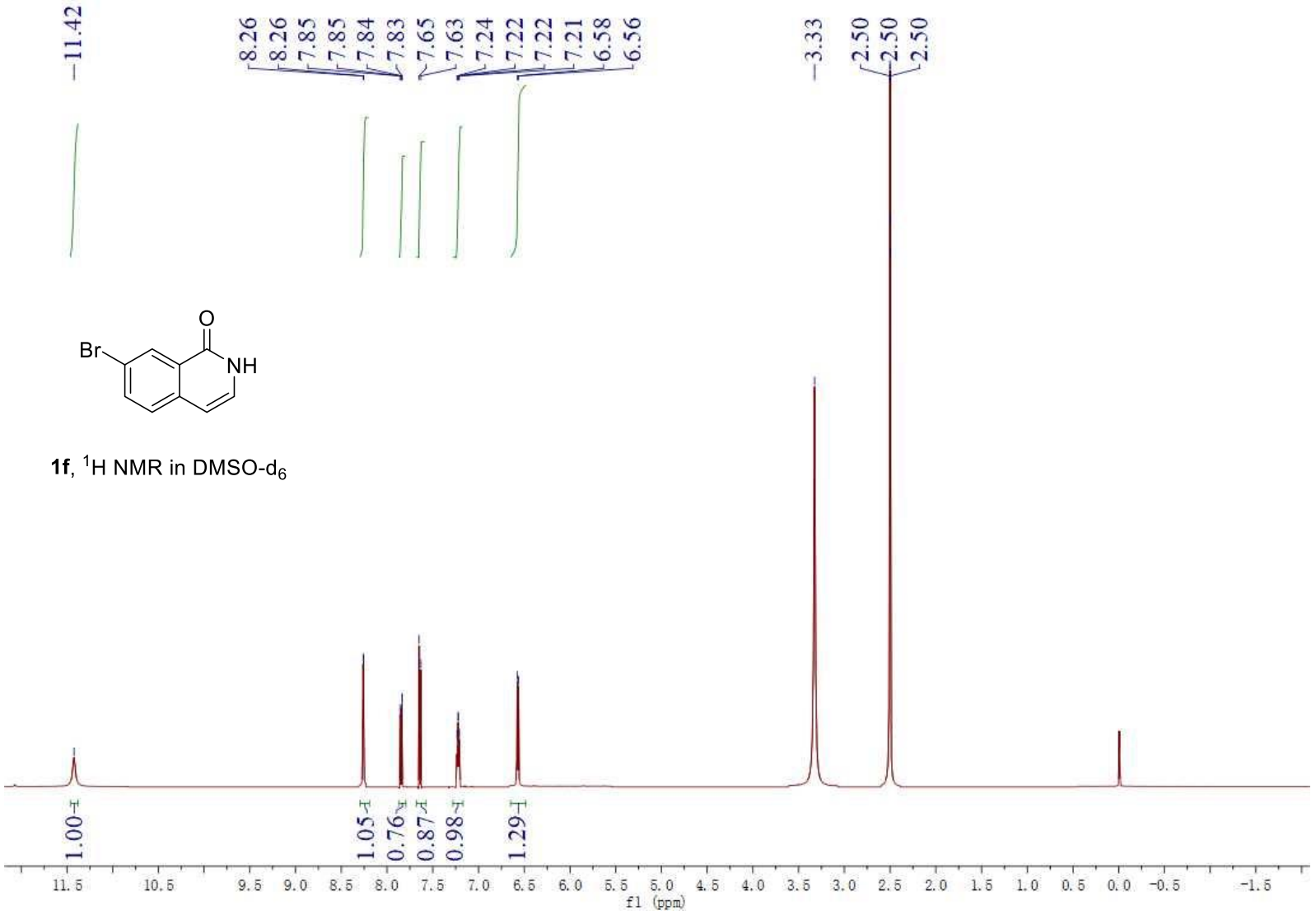
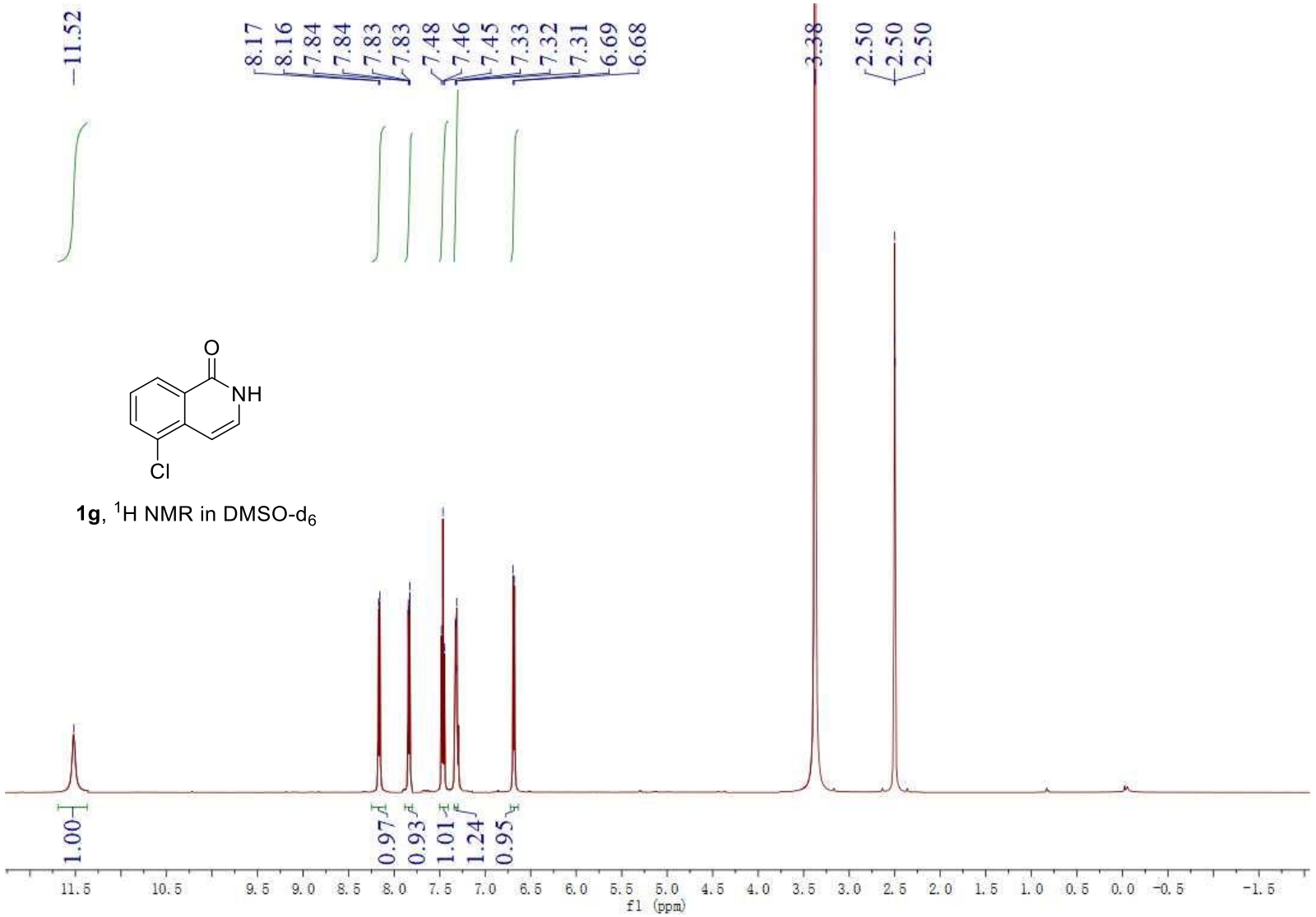
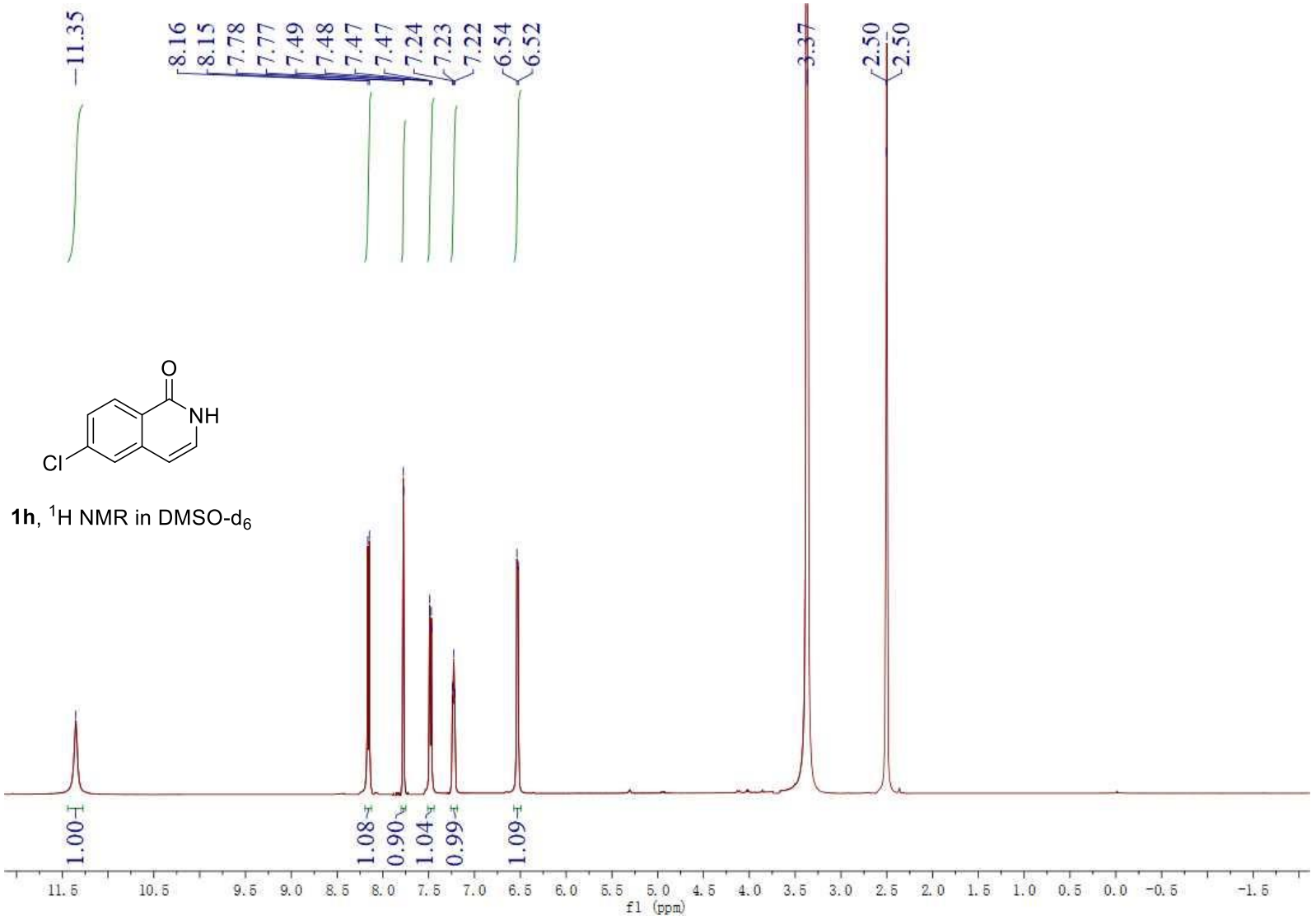


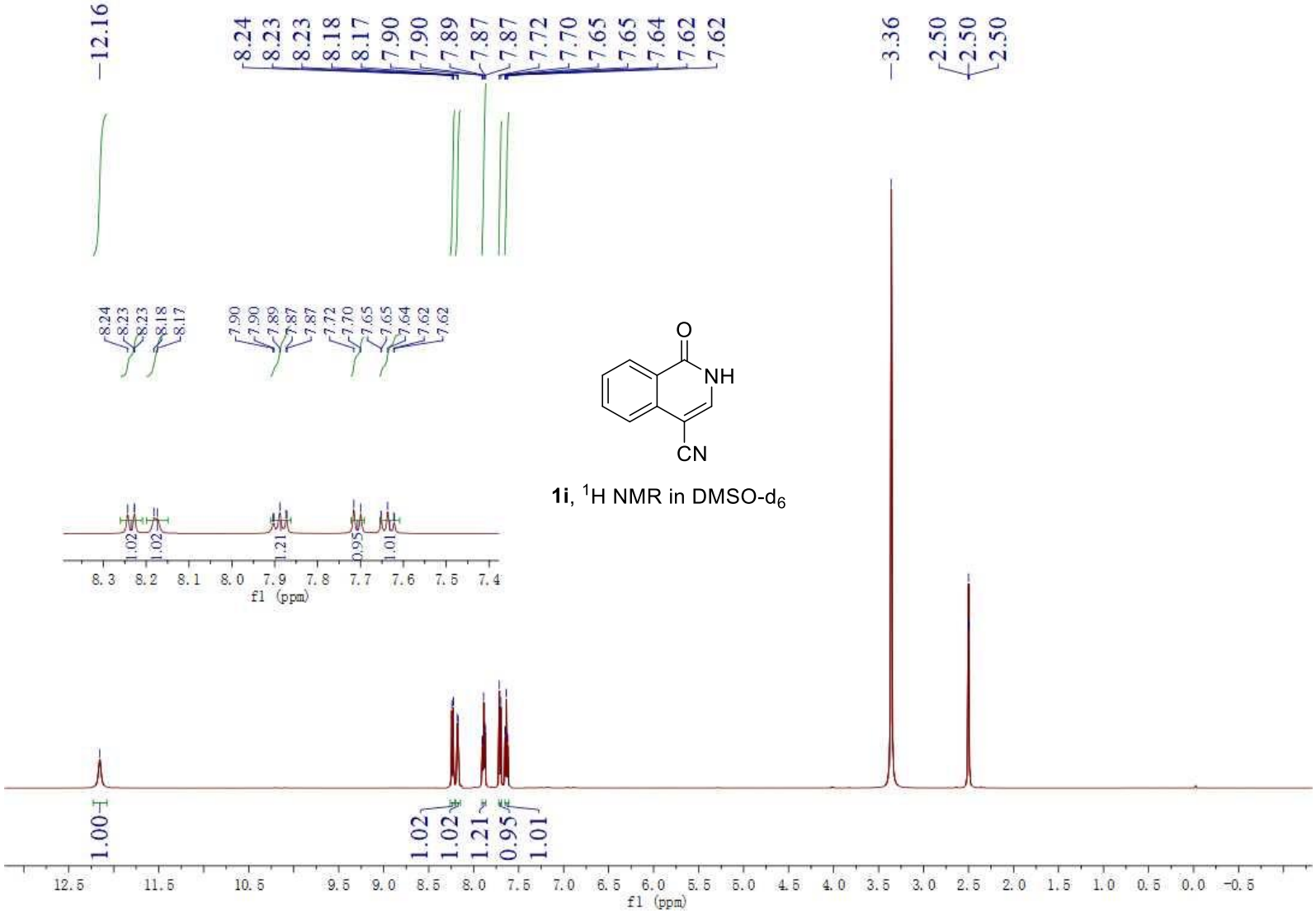
1f, ^{1}H NMR in DMSO-d_6



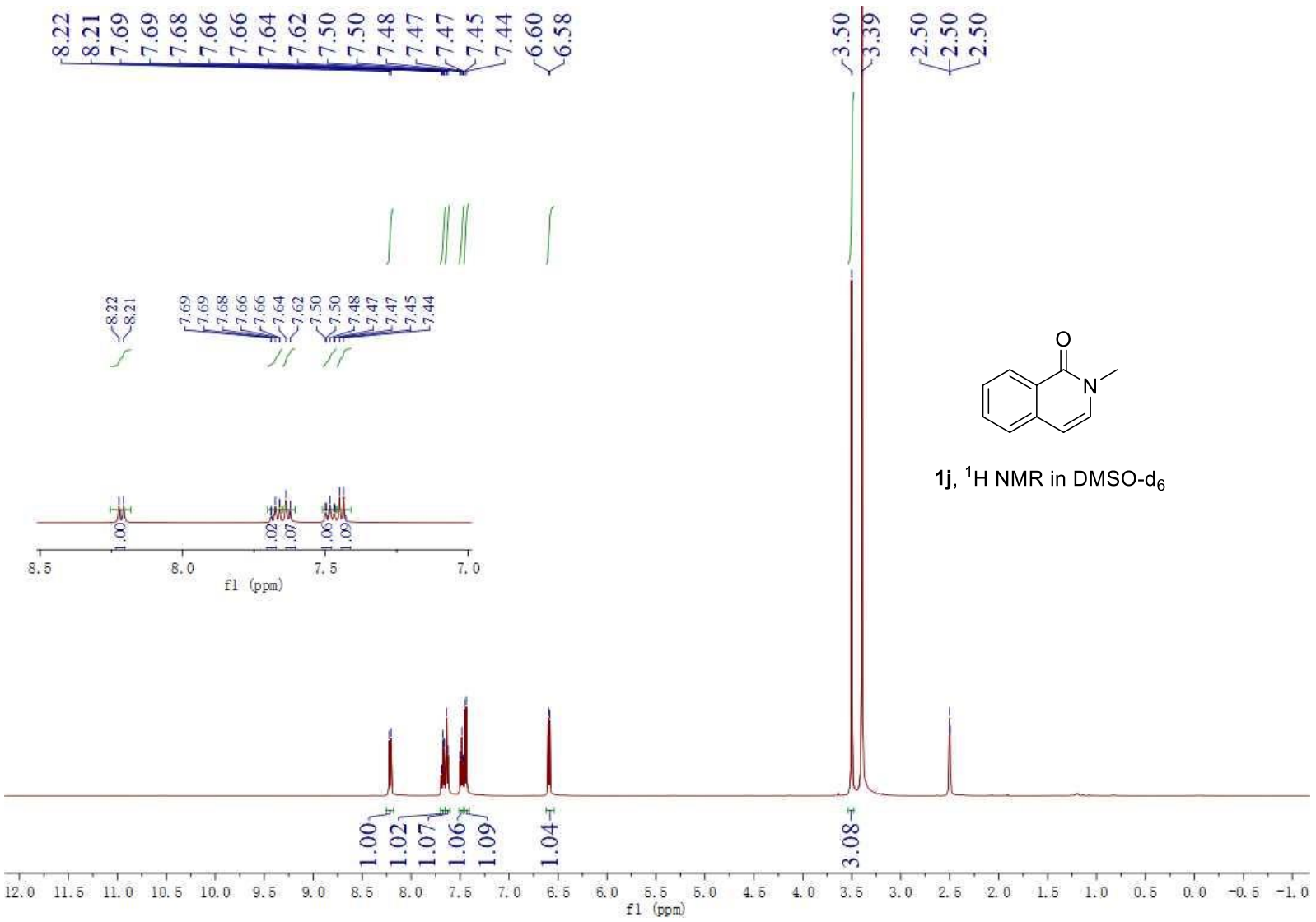
1g, ^{1}H NMR in DMSO-d_6



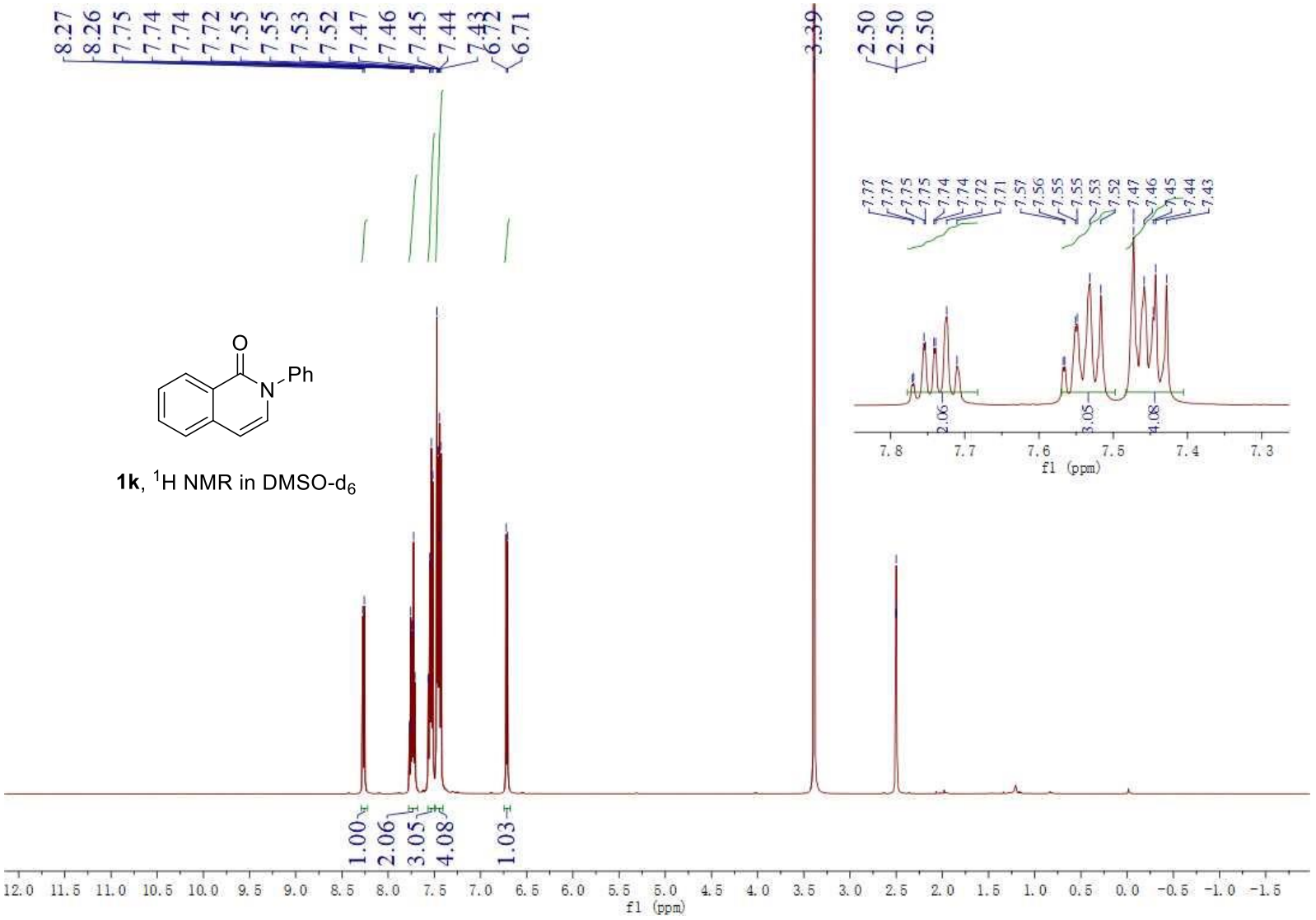
1h, ^{1}H NMR in DMSO-d_6



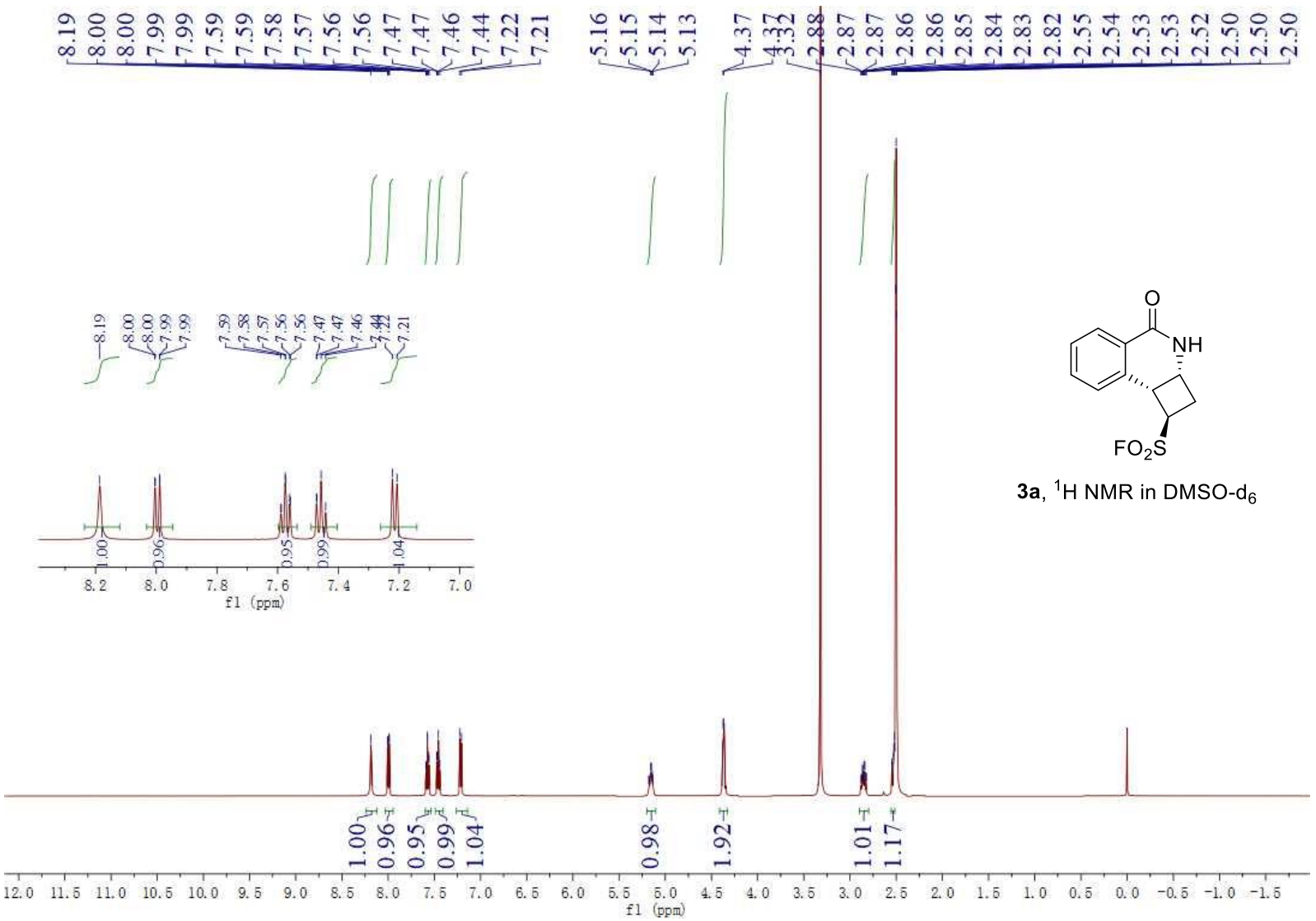
1i, ^{1}H NMR in DMSO-d_6



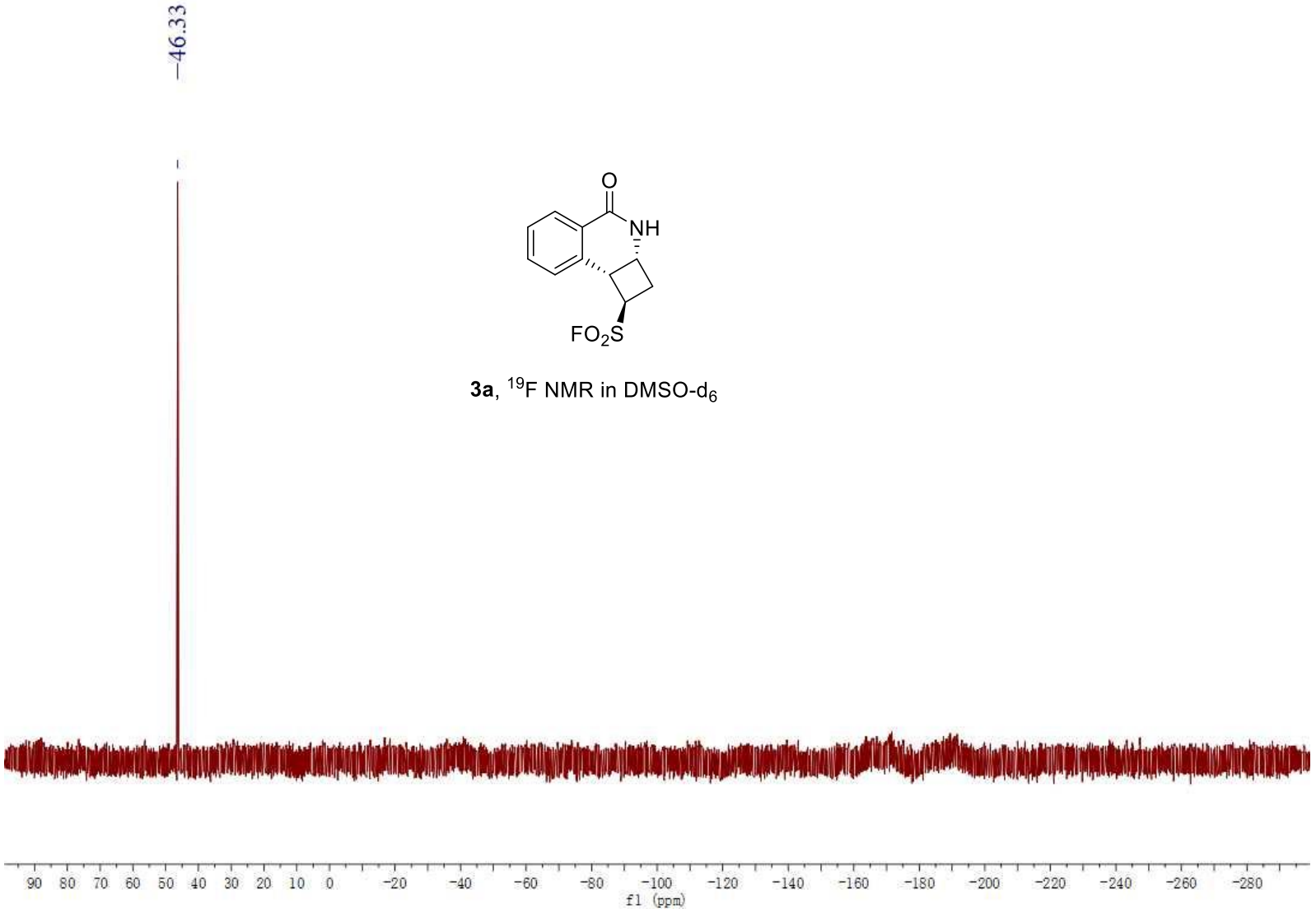
1j, ^{1}H NMR in DMSO-d_6



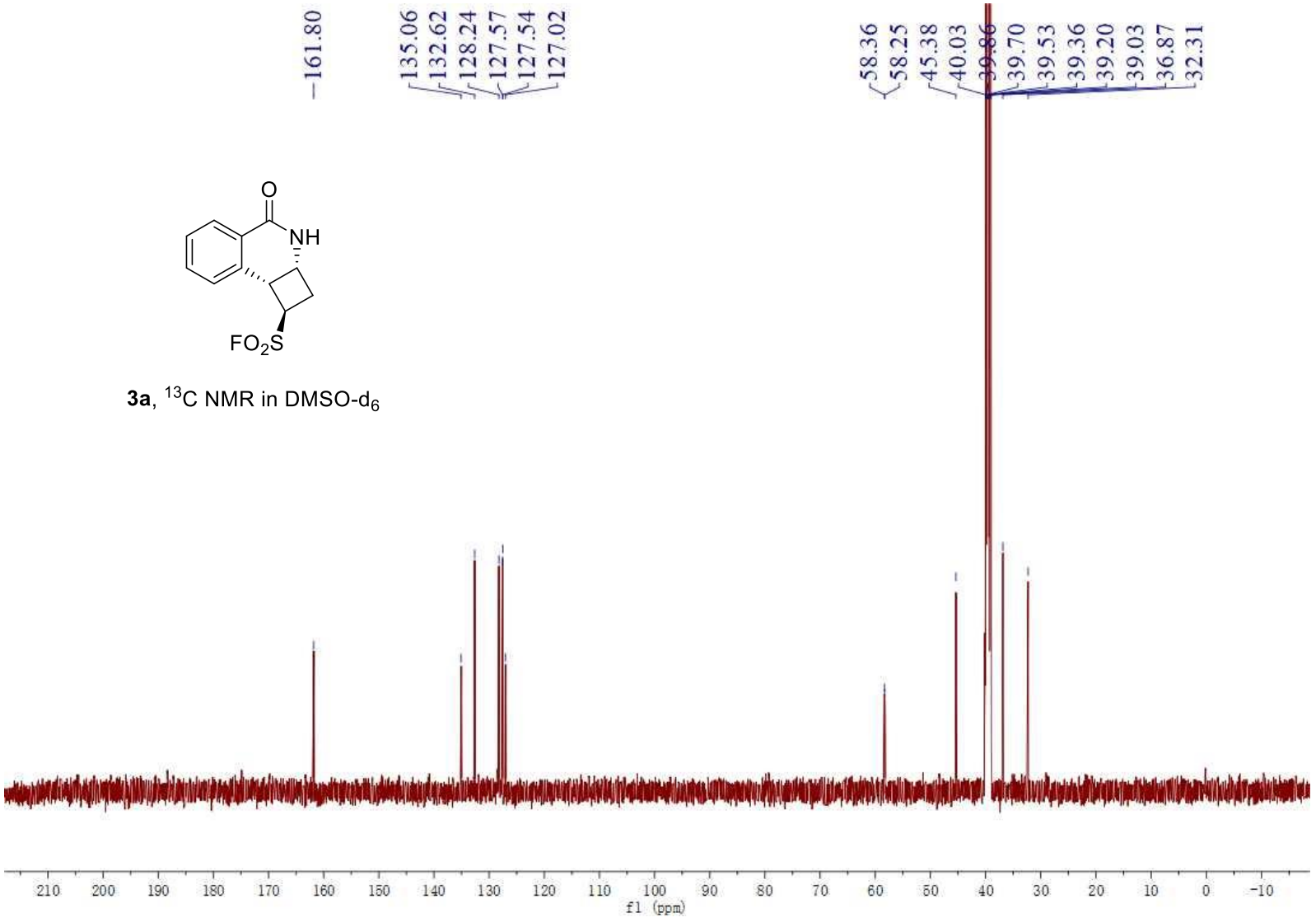
1k, ^{1}H NMR in DMSO-d_6



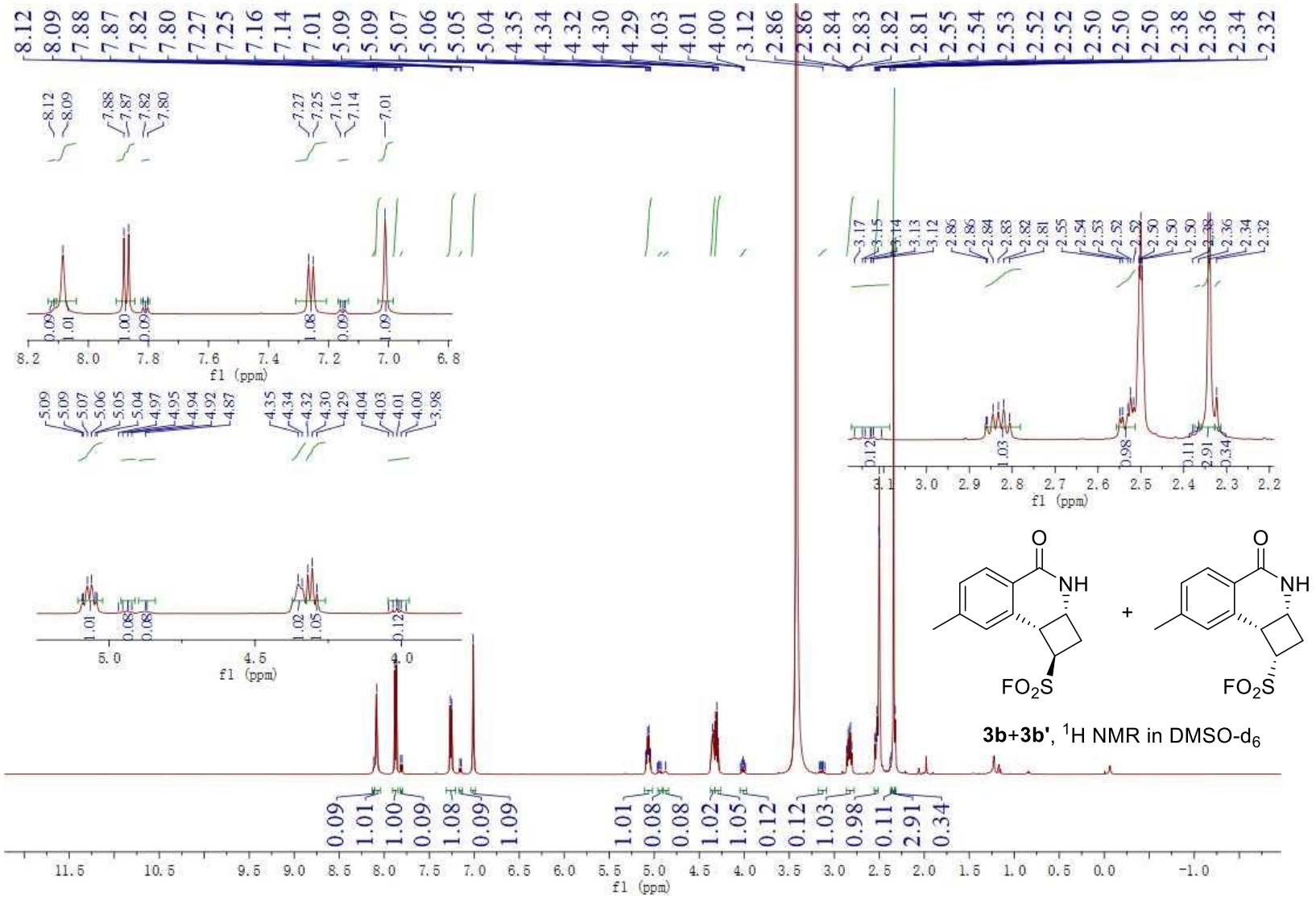
3a, ^{1}H NMR in DMSO-d_6



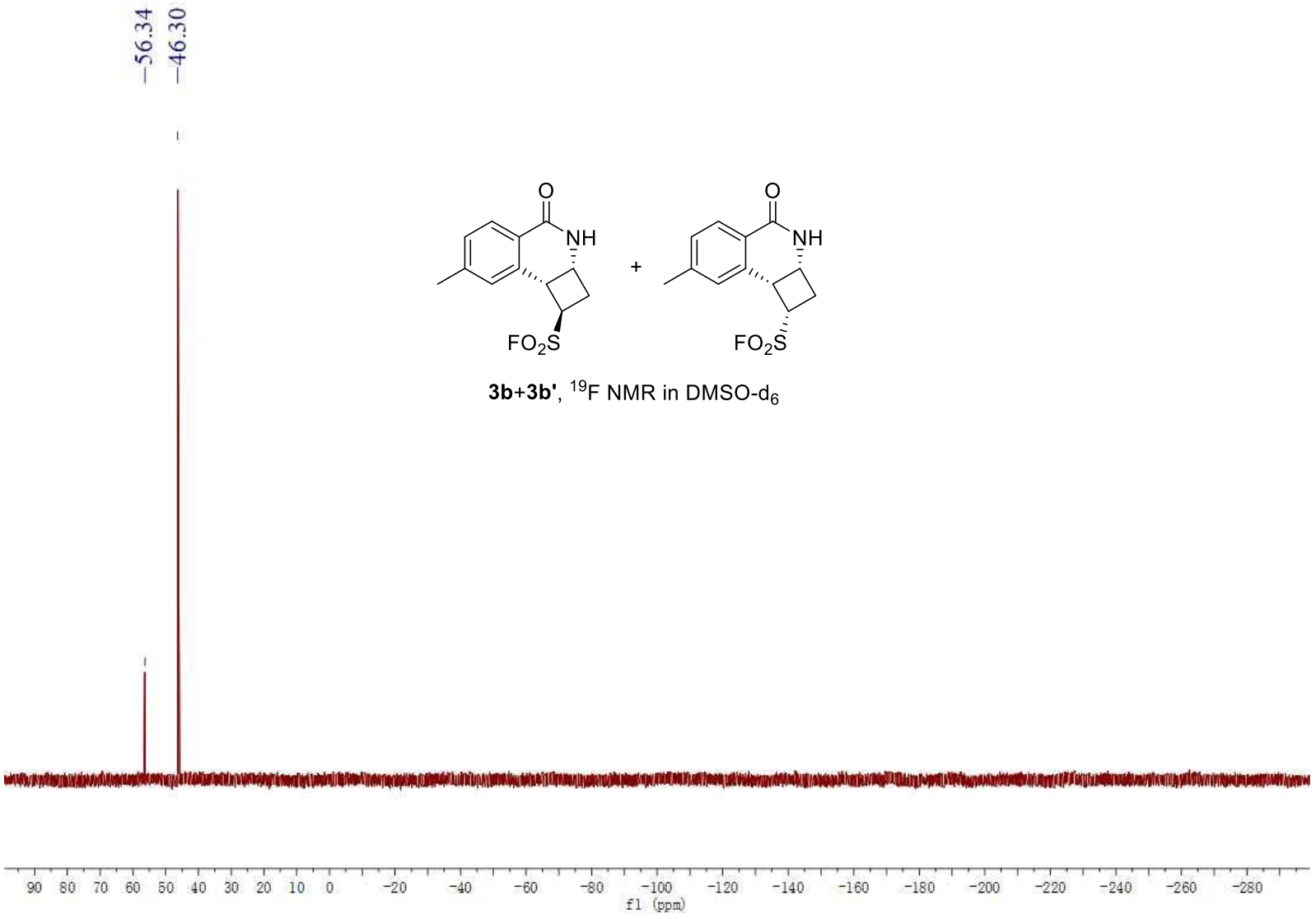
3a, ^{19}F NMR in DMSO-d_6



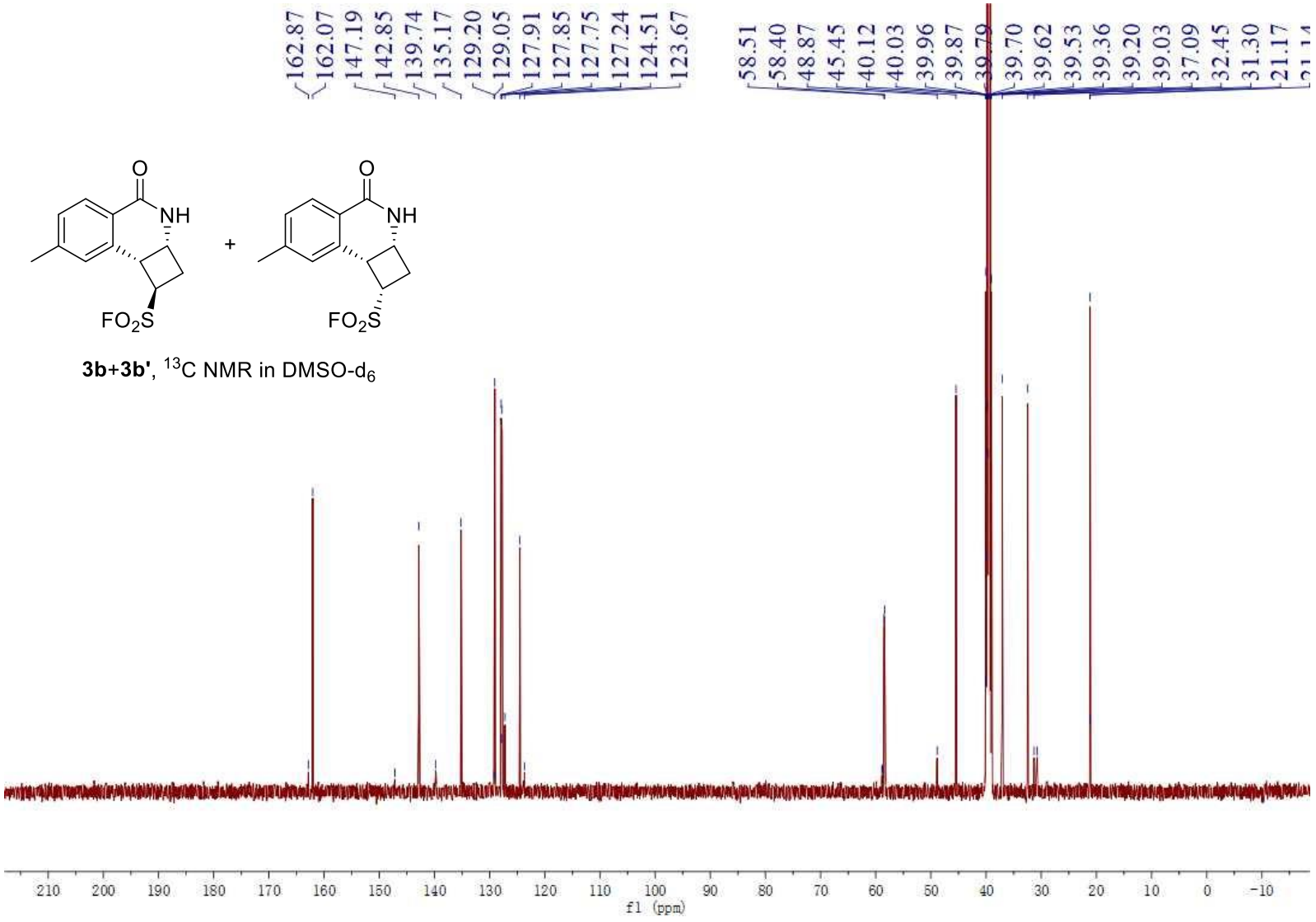
3a, ^{13}C NMR in DMSO-d_6

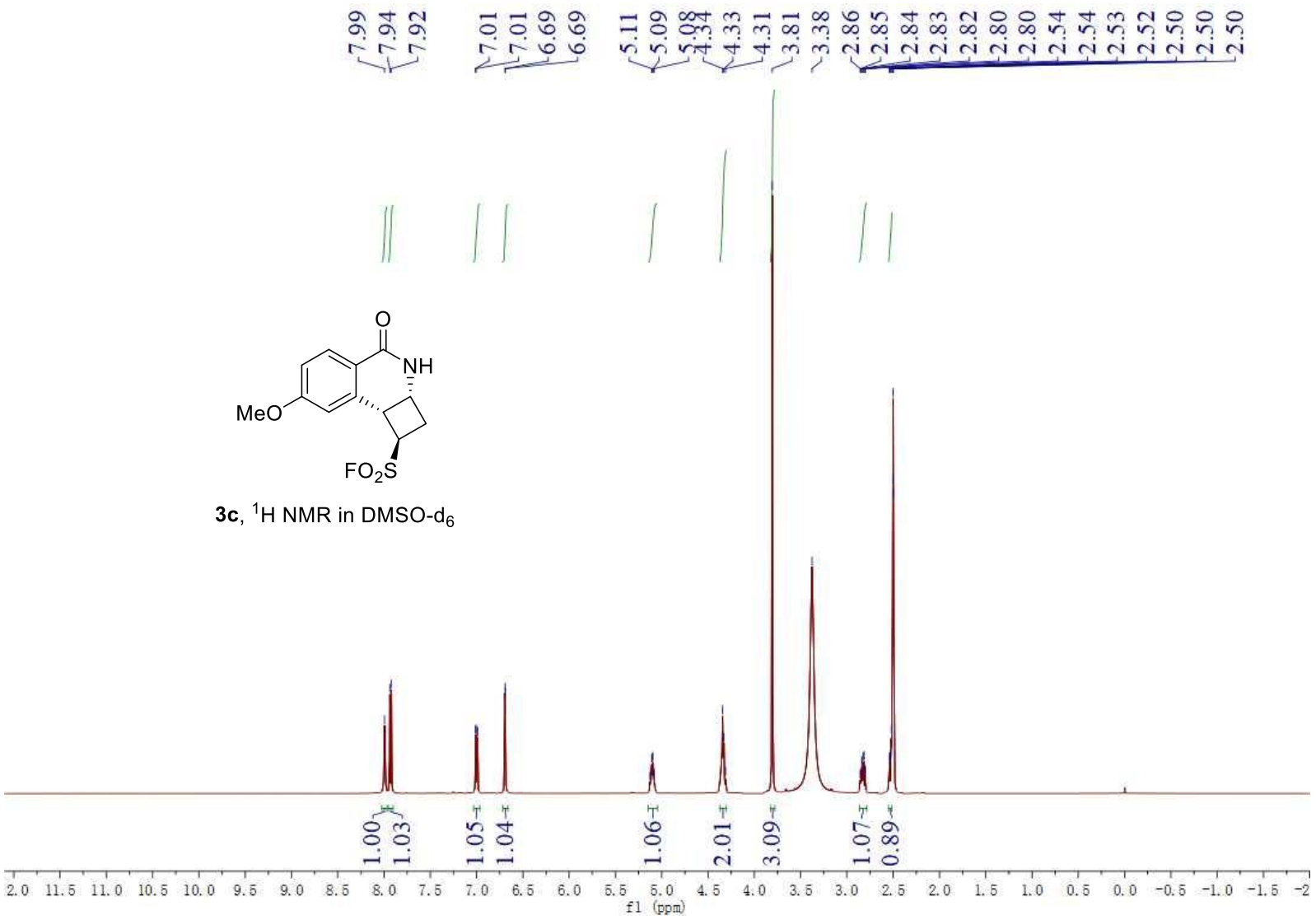


3b+3b', ^{1}H NMR in DMSO-d_6

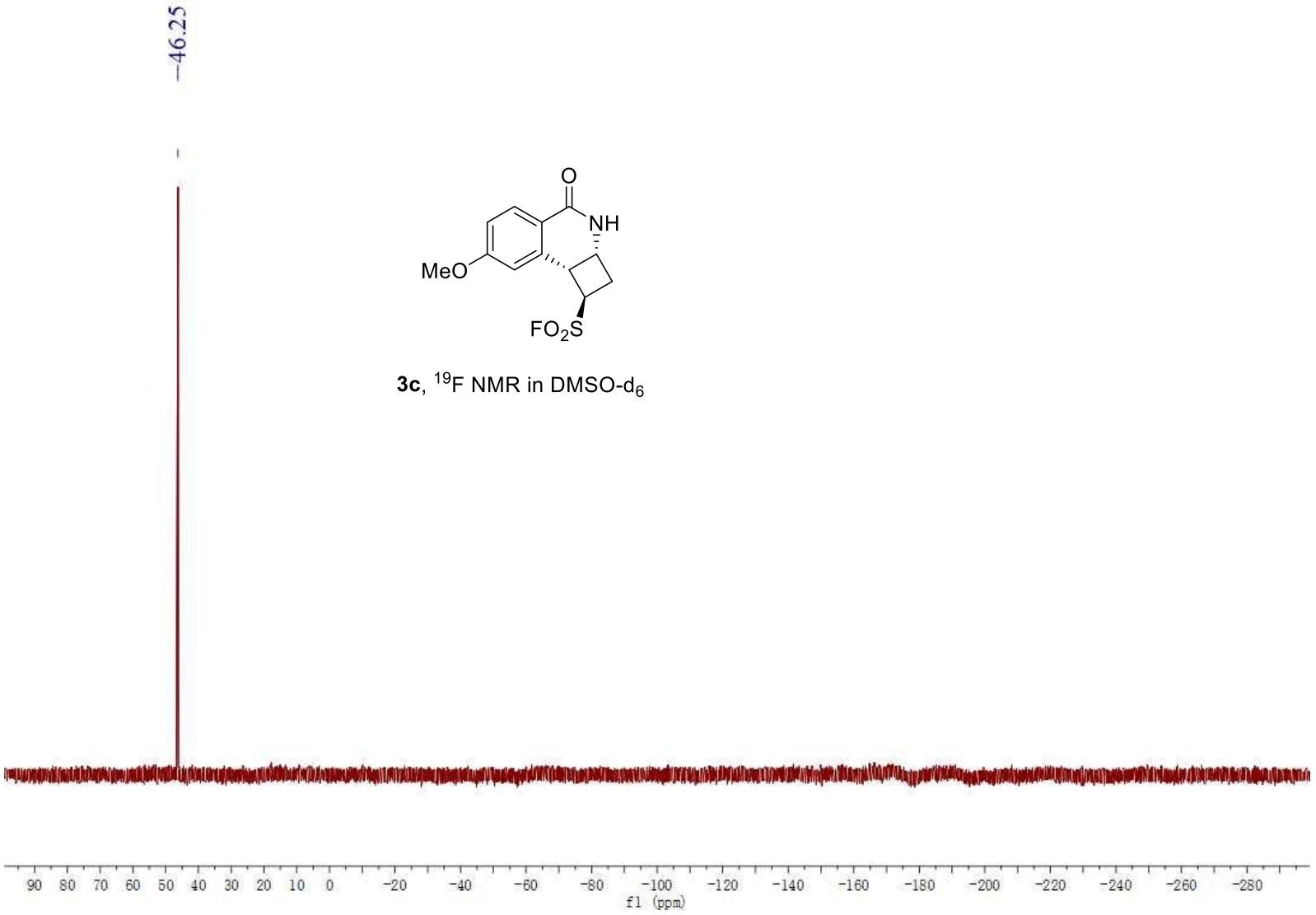


3b+**3b'**, ^{19}F NMR in DMSO-d_6


162.87
162.07
147.19
142.85
139.74
135.17
129.20
129.05
127.91
127.85
127.75
127.24
124.51
123.67
58.51
58.40
48.87
45.45
40.12
40.03
39.96
39.87
39.79
39.70
39.62
39.53
39.36
39.20
39.03
37.09
32.45
31.30
21.17
O
NH
FO2S
+
O
NH
FO2S
3b+3b', 13C NMR in DMSO-d6
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)



3c, ^{1}H NMR in DMSO-d_6



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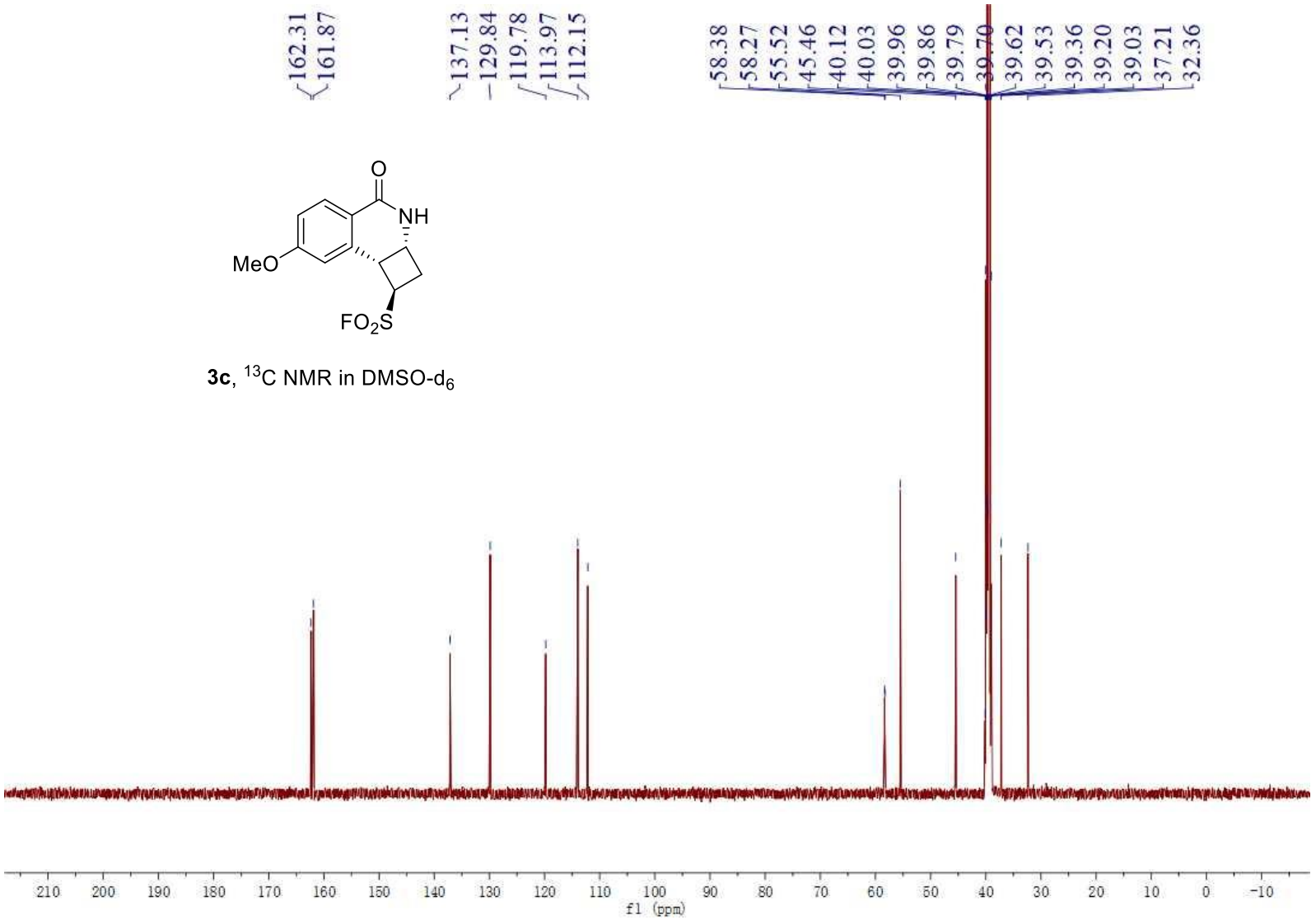
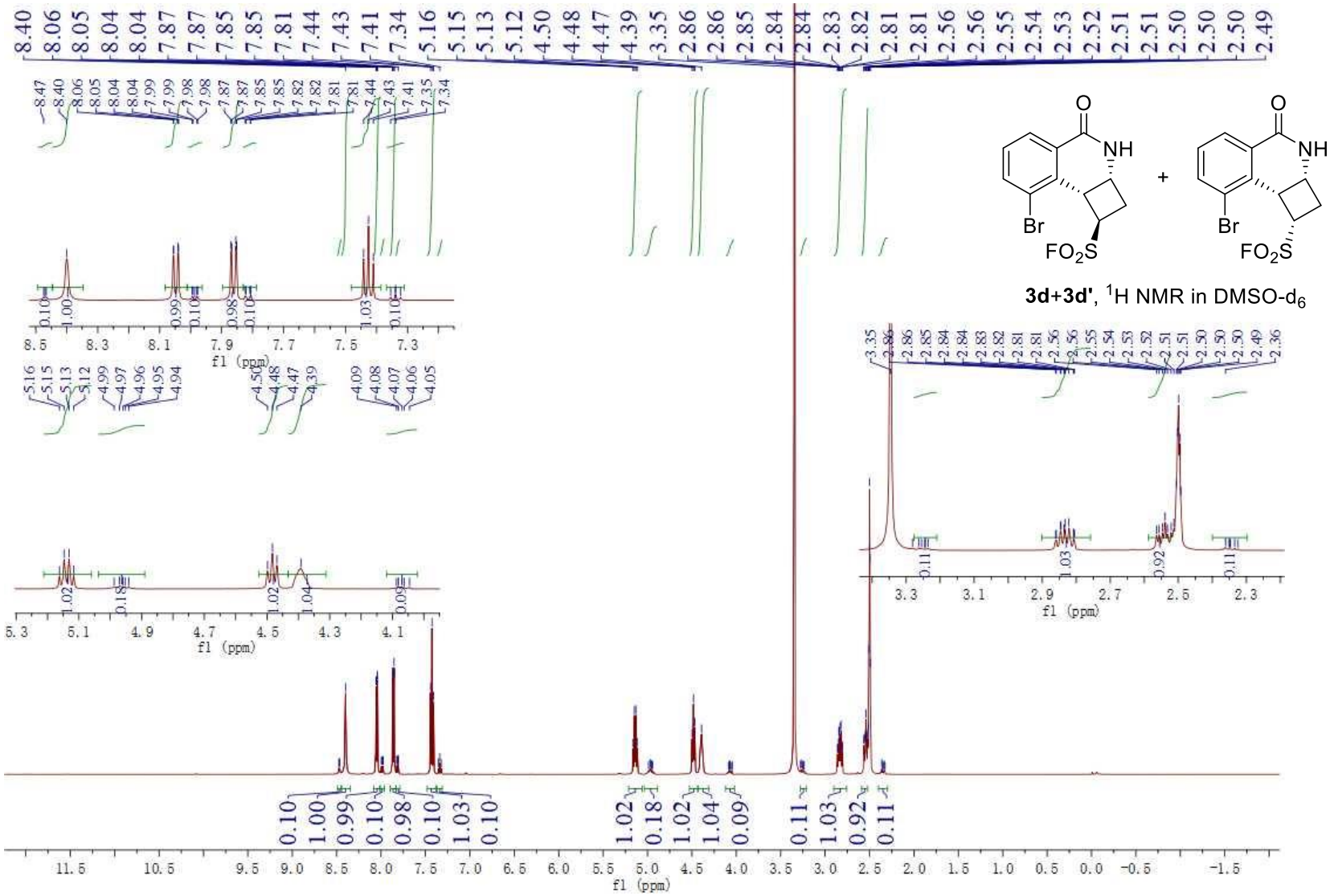
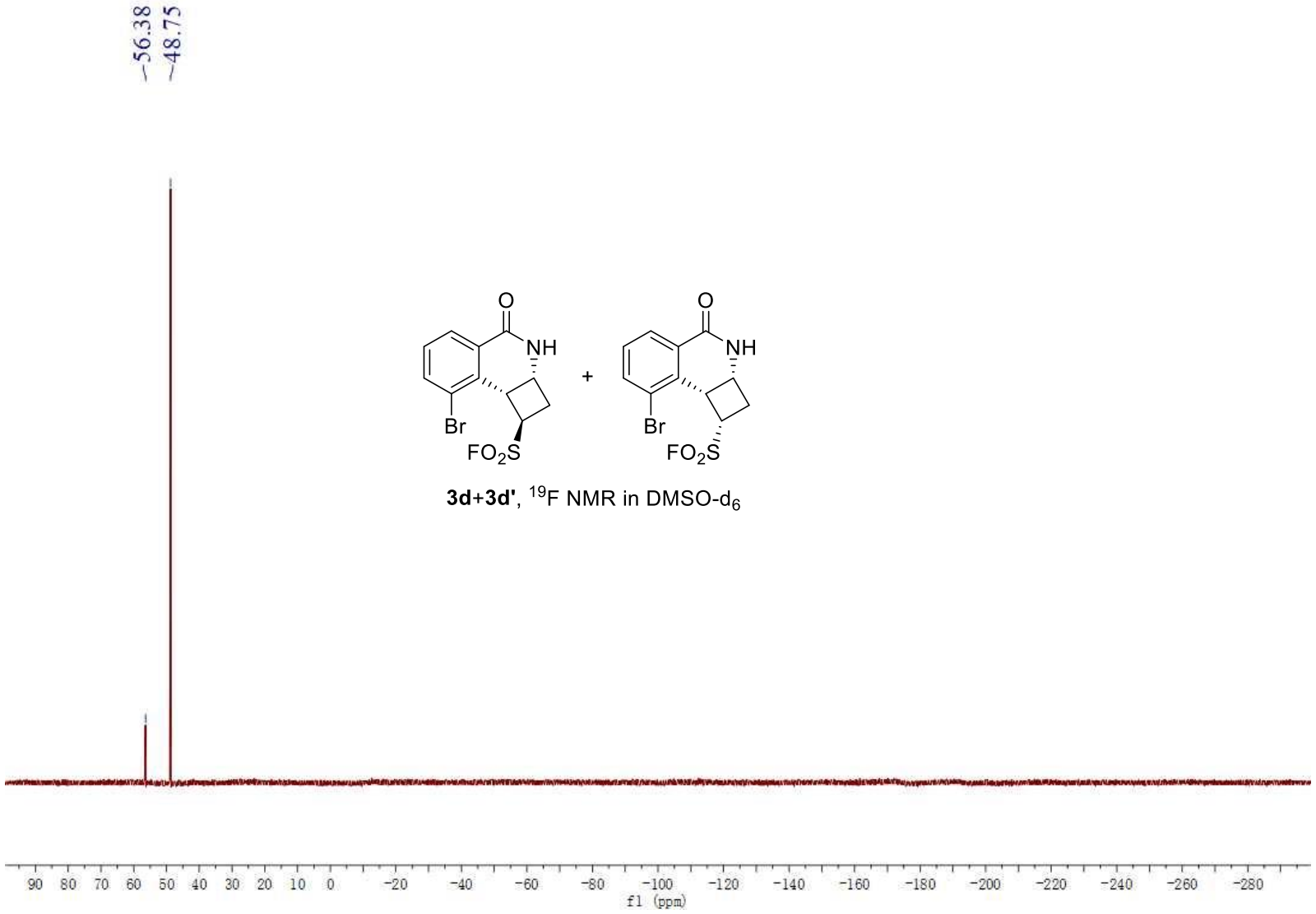
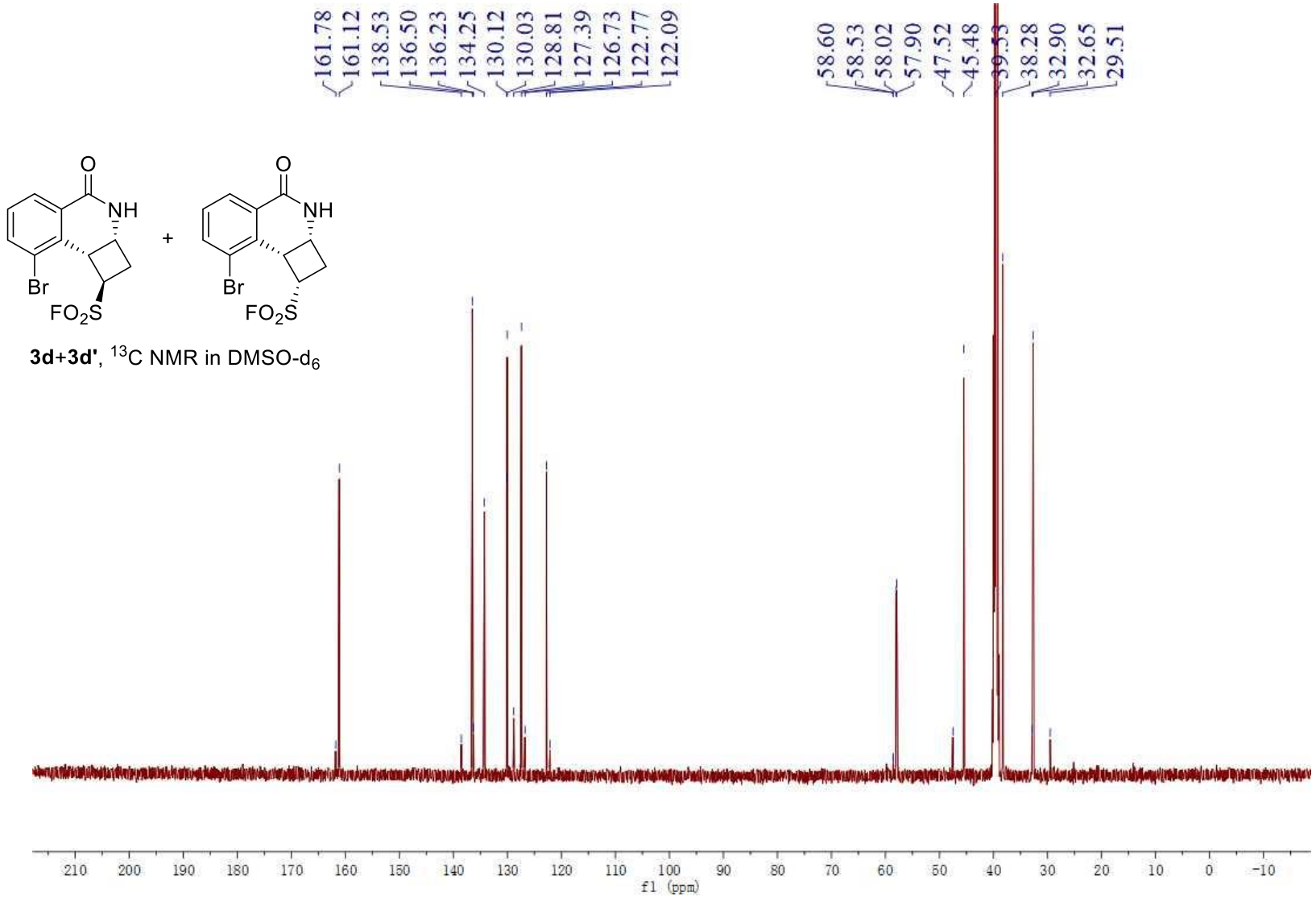


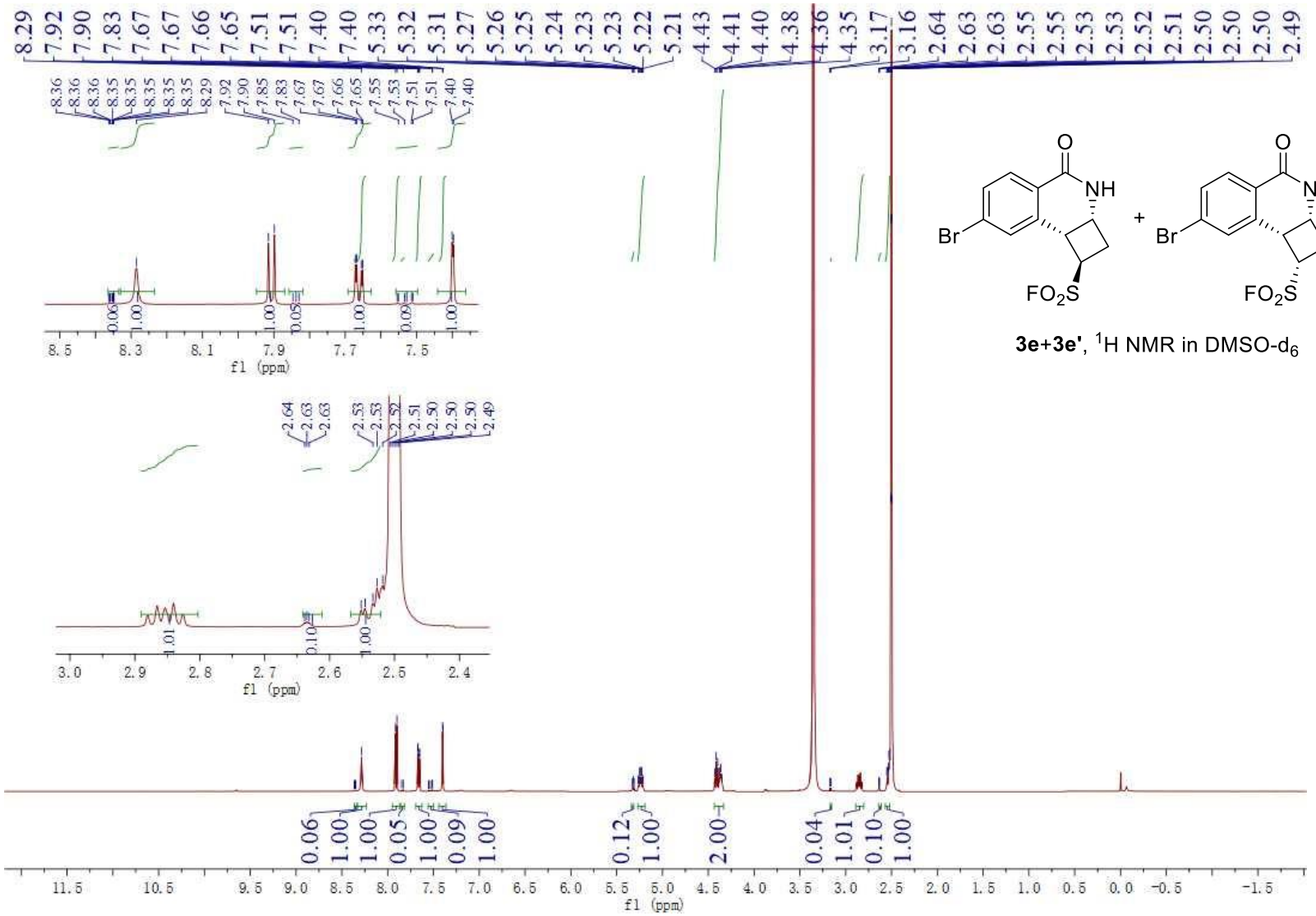
3c, ^{13}C NMR in DMSO-d_6

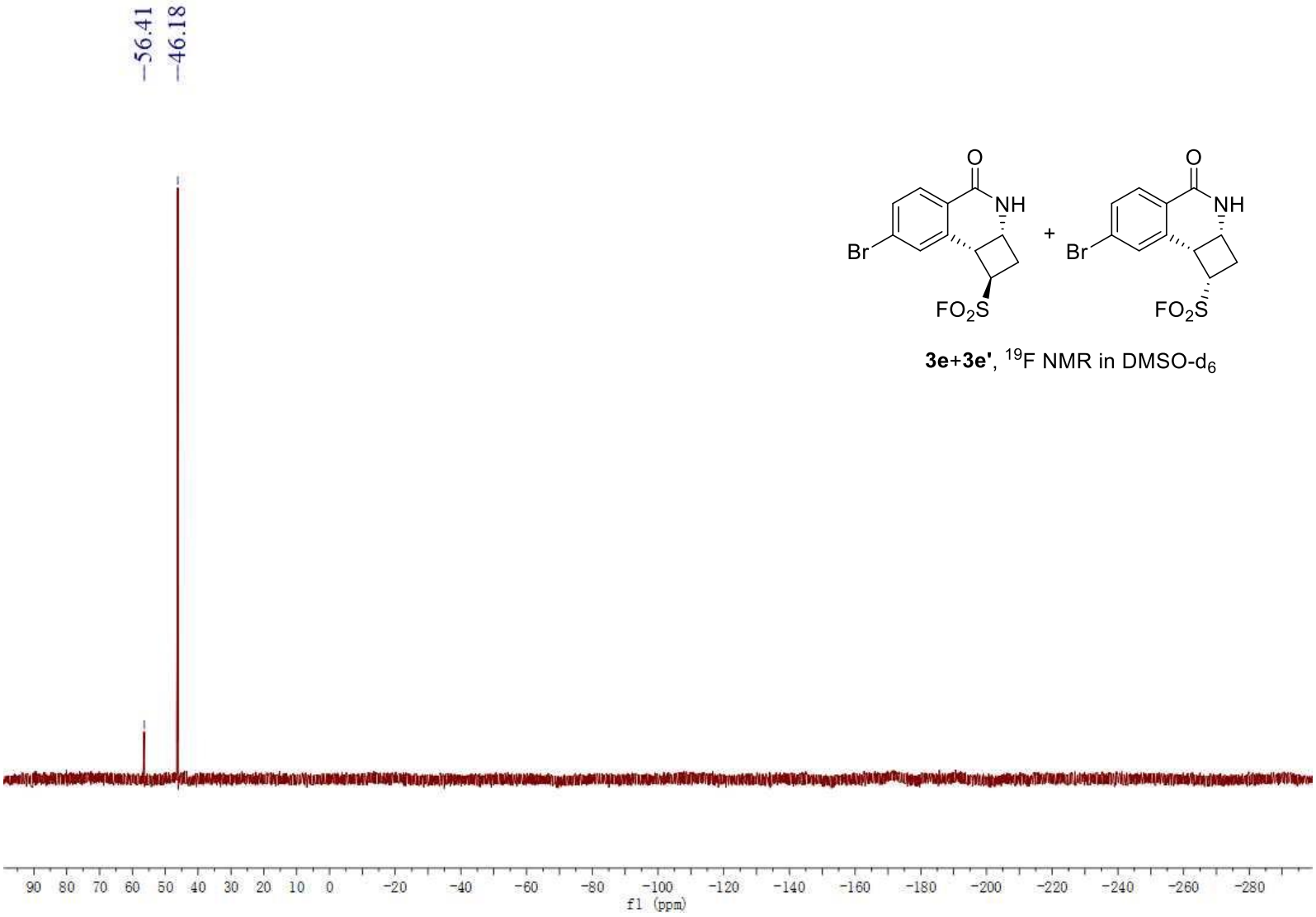

O
NH
Br
FO2S
+
O
NH
Br
FO2S
3d+3d', 1H NMR in DMSO-d6
f1 (ppm)



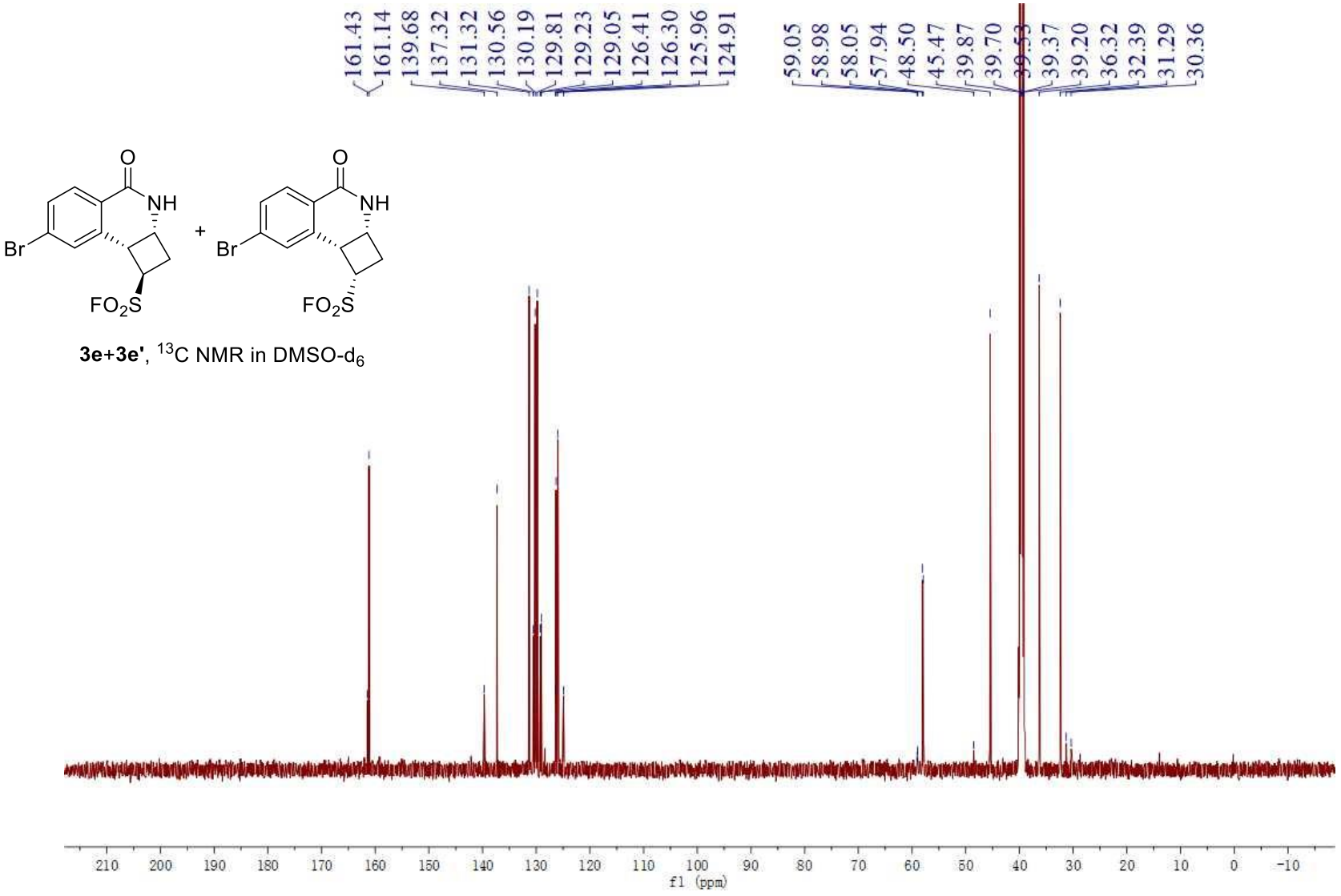
3d+**3d'**, ^{19}F NMR in DMSO-d_6


161.78
161.12
138.53
136.50
136.23
134.25
130.12
130.03
128.81
127.39
126.73
122.77
122.09
58.60
58.53
58.02
57.90
47.52
45.48
39.53
38.28
32.90
32.65
29.51
O
NH
Br
FO2S
+
O
NH
Br
FO2S
3d+3d', 13C NMR in DMSO-d6
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

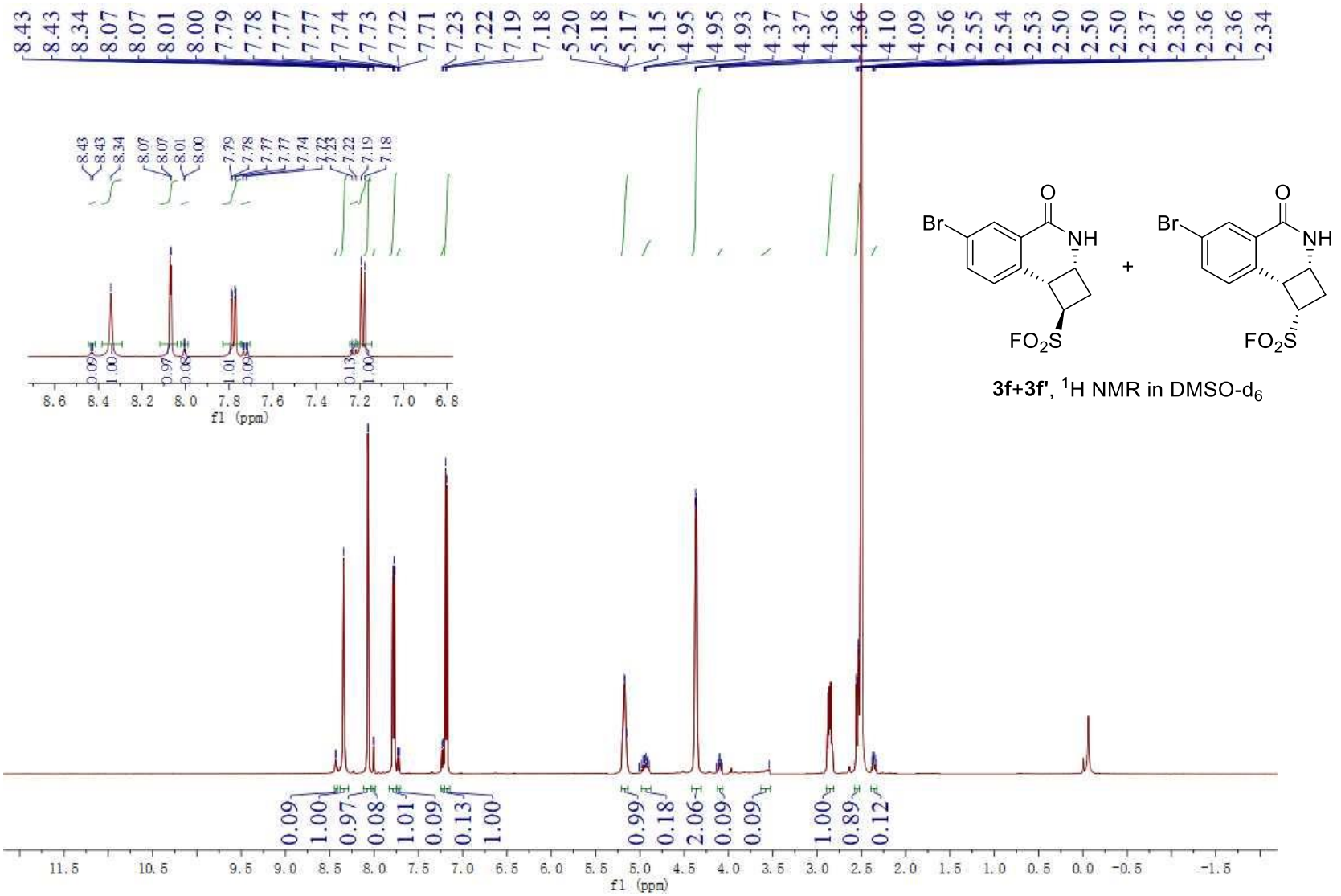

O
NH
Br
FO2S
+
3e+3e', 1H NMR in DMSO-d6
f1 (ppm)

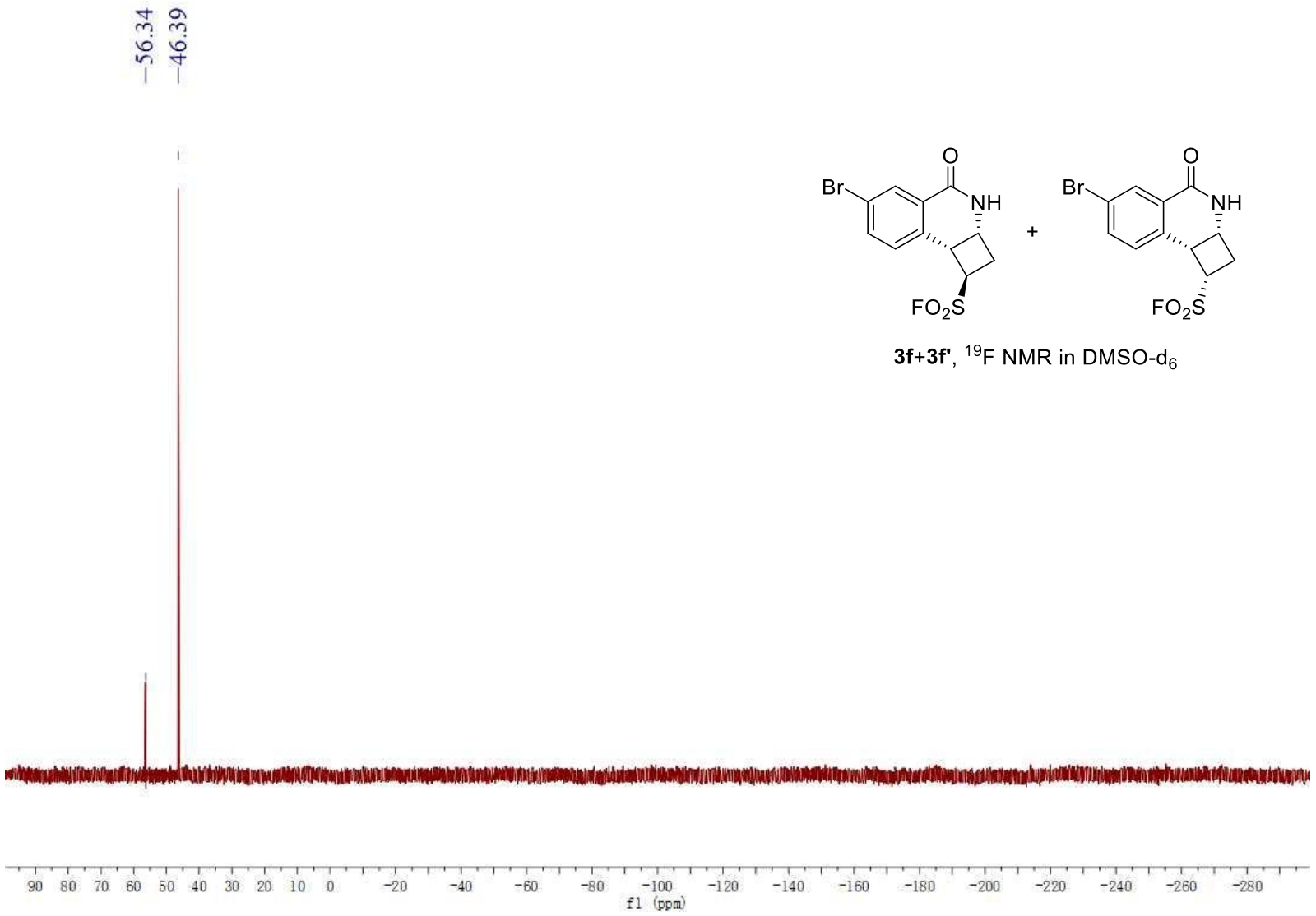


3e+**3e'**, ^{19}F NMR in DMSO-d_6

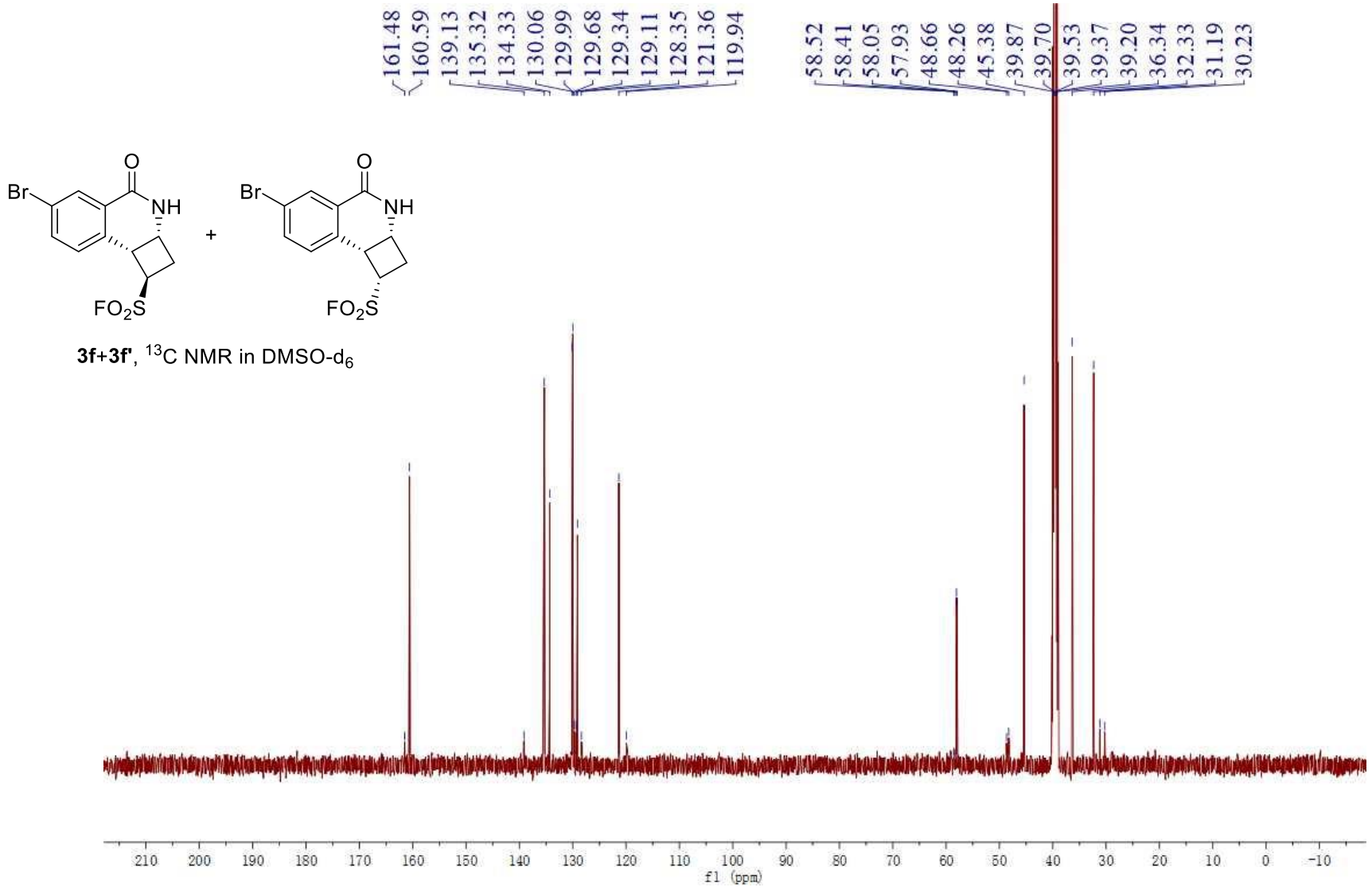


3e+**3e'**, ^{13}C NMR in DMSO-d_6

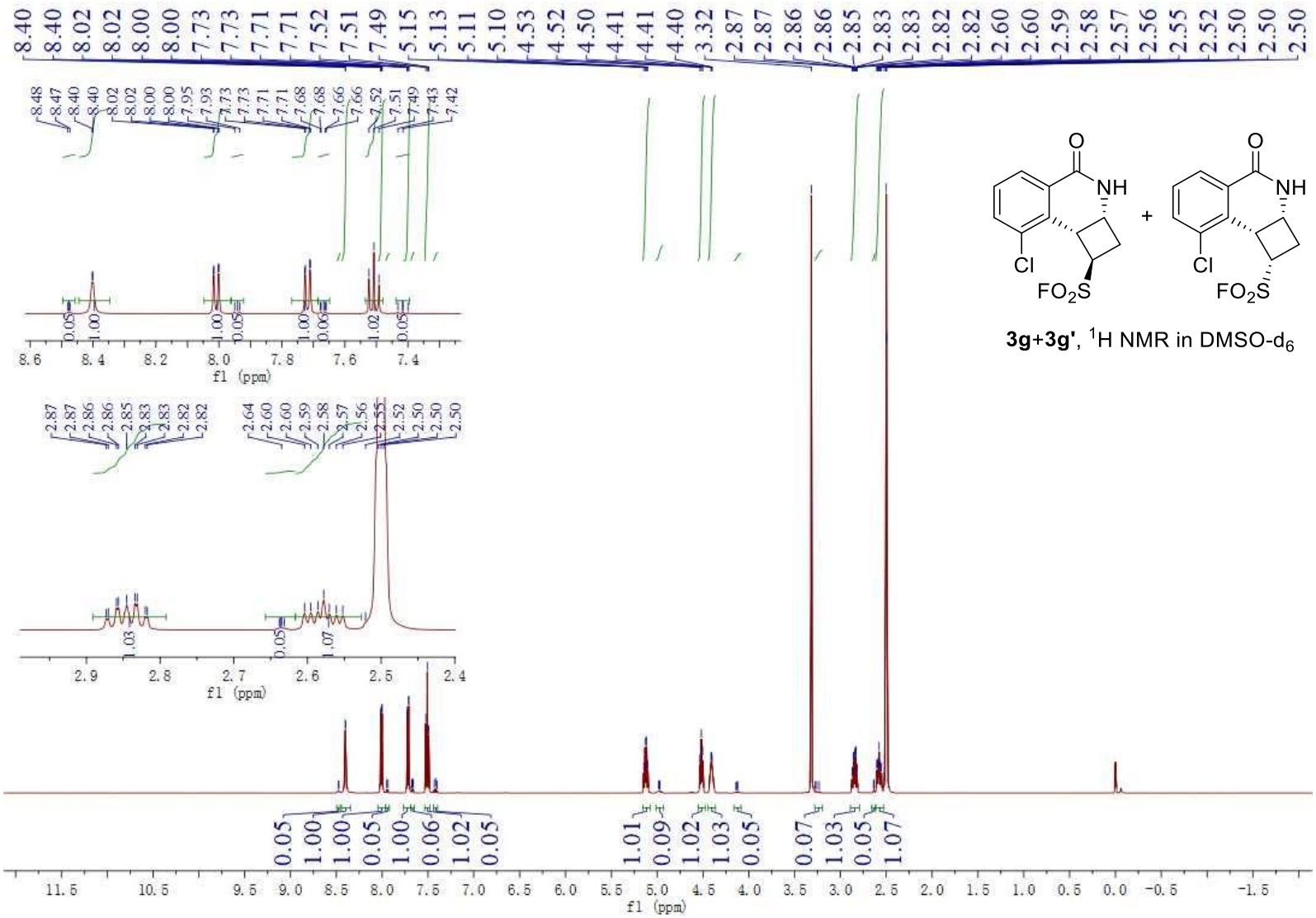

8.43 8.43 8.34 8.07 8.07 8.01 8.00 7.79 7.78 7.77 7.77 7.74 7.73 7.72 7.71 7.23 7.22 7.19 7.18 5.20 5.18 5.17 5.15 4.95 4.95 4.93 4.37 4.37 4.36 4.36 4.10 4.09 2.56 2.55 2.54 2.53 2.50 2.50 2.50 2.37 2.36 2.36 2.36 2.34
0.09 1.00 0.97 0.08 1.01 0.09 0.13 1.00 0.99 0.18 2.06 0.09 0.09 1.00 0.89 0.12
f1 (ppm)
Br
NH
O
FO2S
+
3f+3f', 1H NMR in DMSO-d6

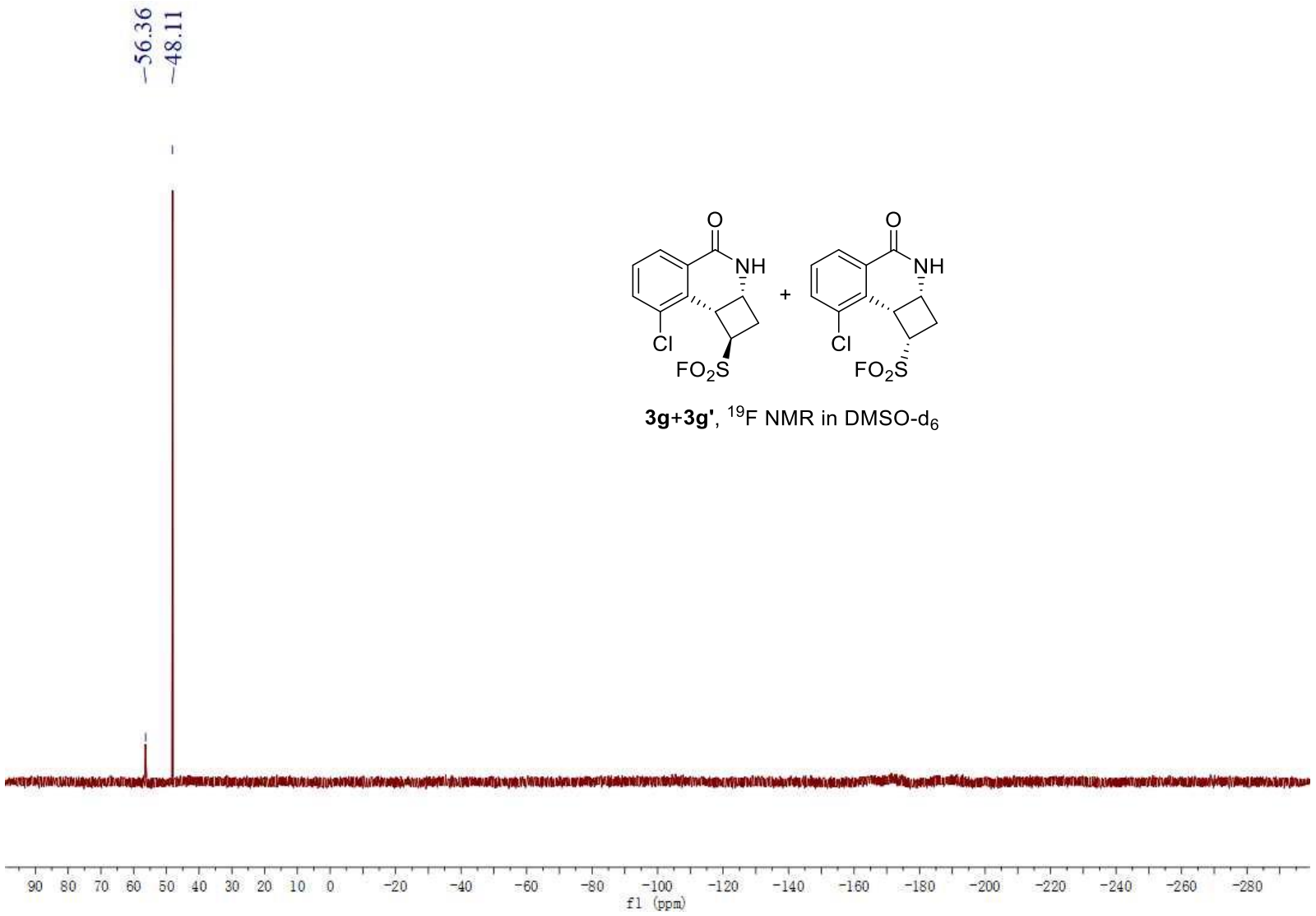


3f+**3f'**, ^{19}F NMR in DMSO-d_6

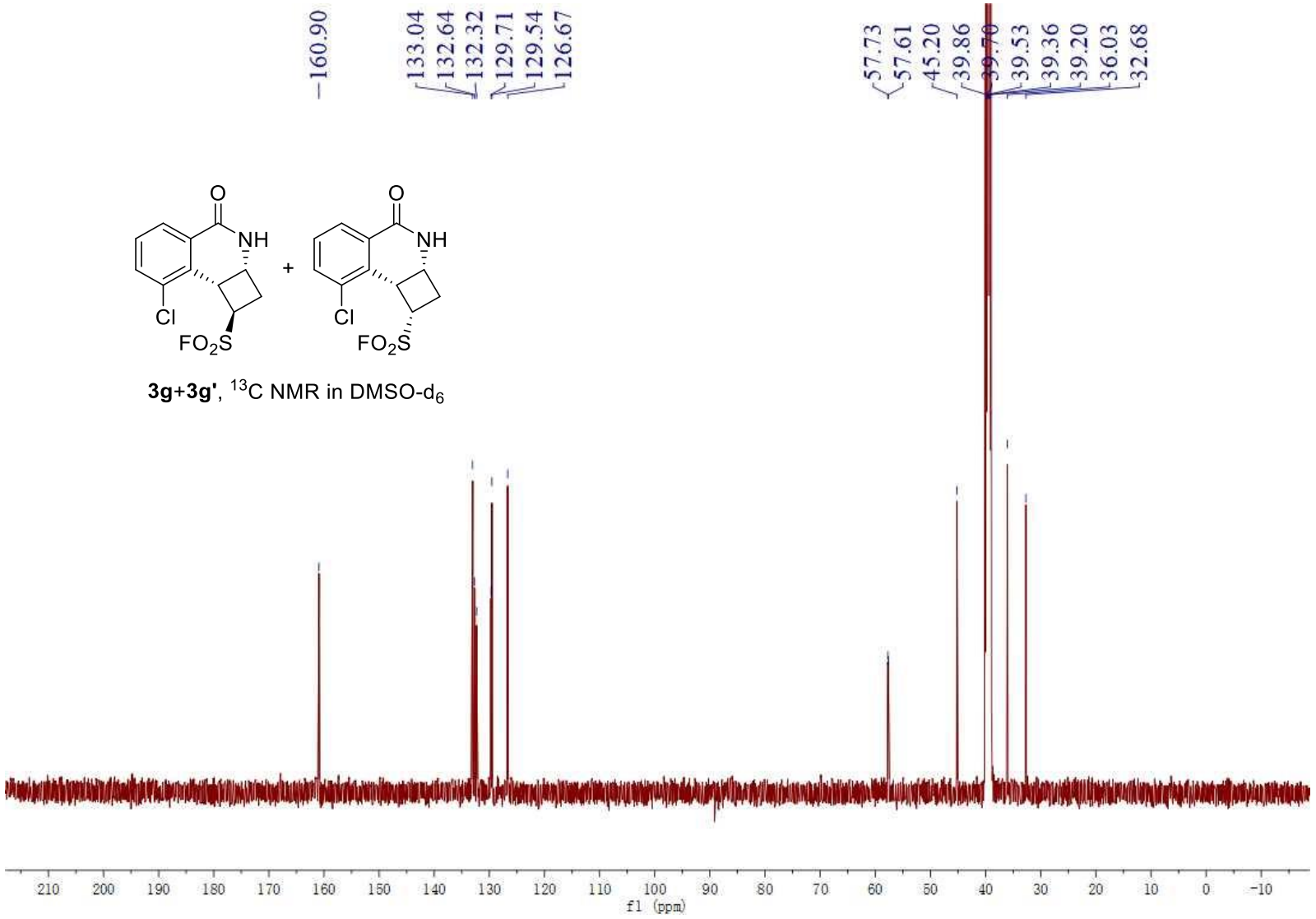


3f+**3f'**, ^{13}C NMR in DMSO-d_6

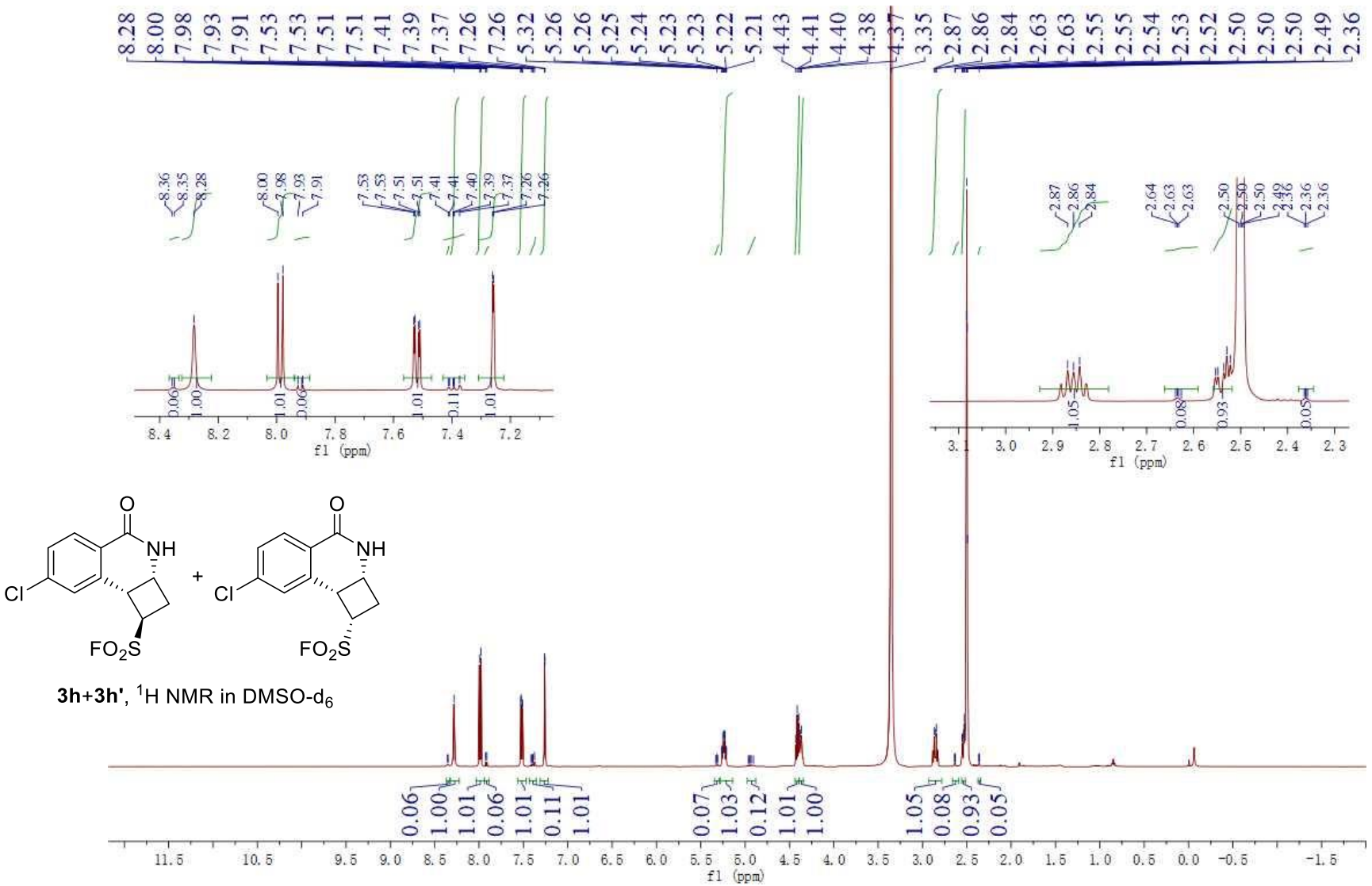

O
NH
Cl
FO_2S
+
3g+3g', ^{1}H NMR in DMSO-d_6
f1 (ppm)



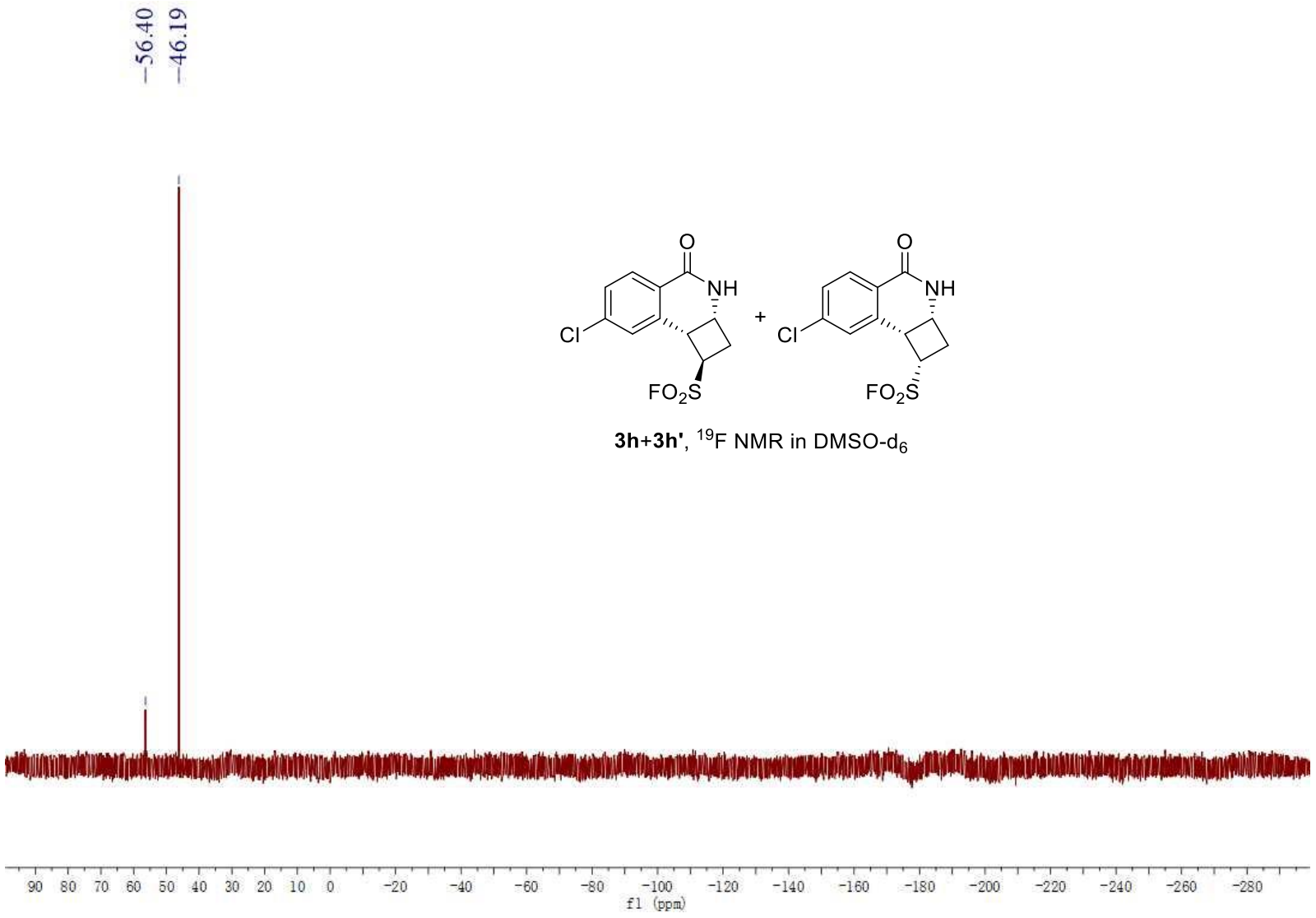
3g+**3g'**, ^{19}F NMR in DMSO-d_6



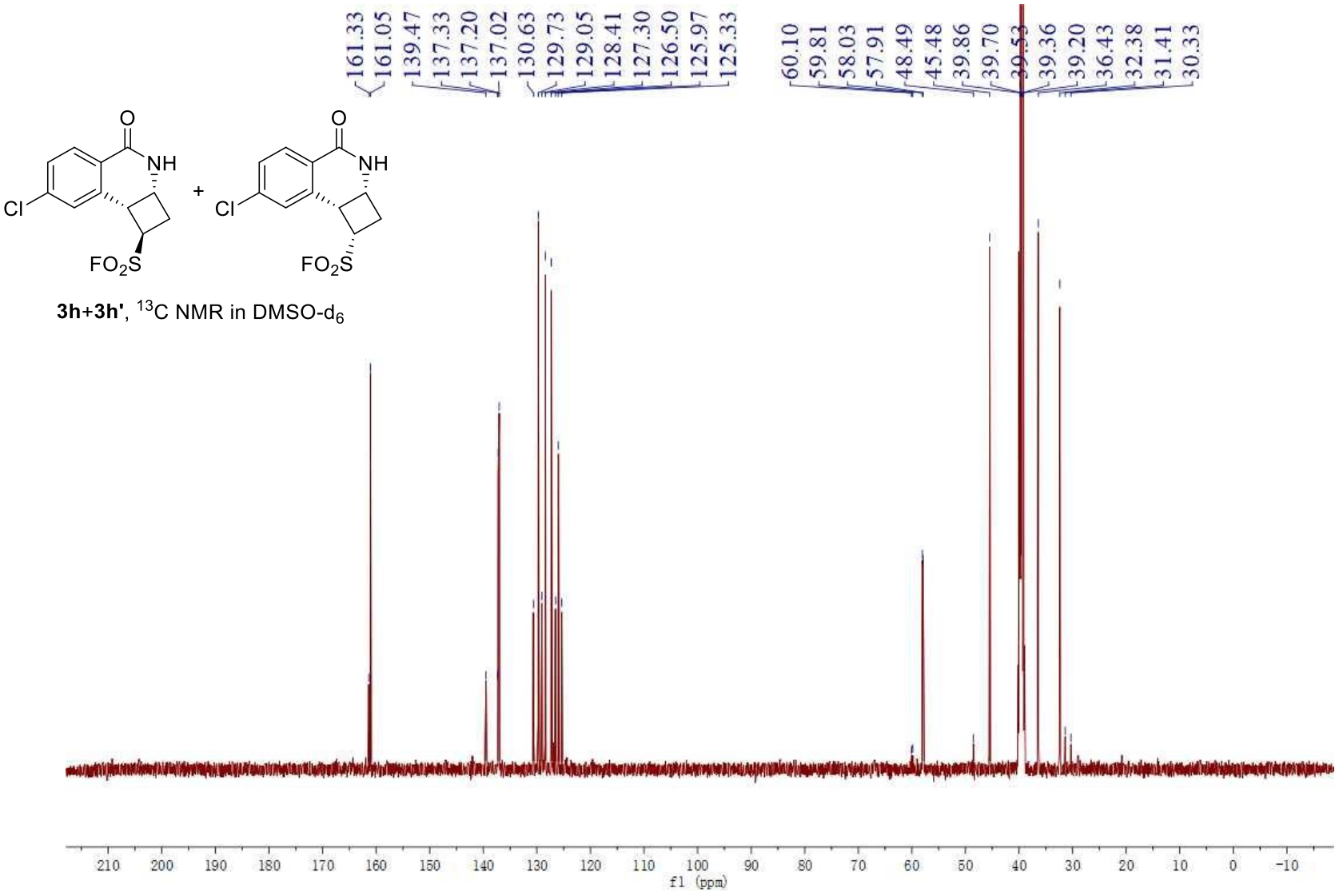
3g+**3g'**, ^{13}C NMR in DMSO-d_6



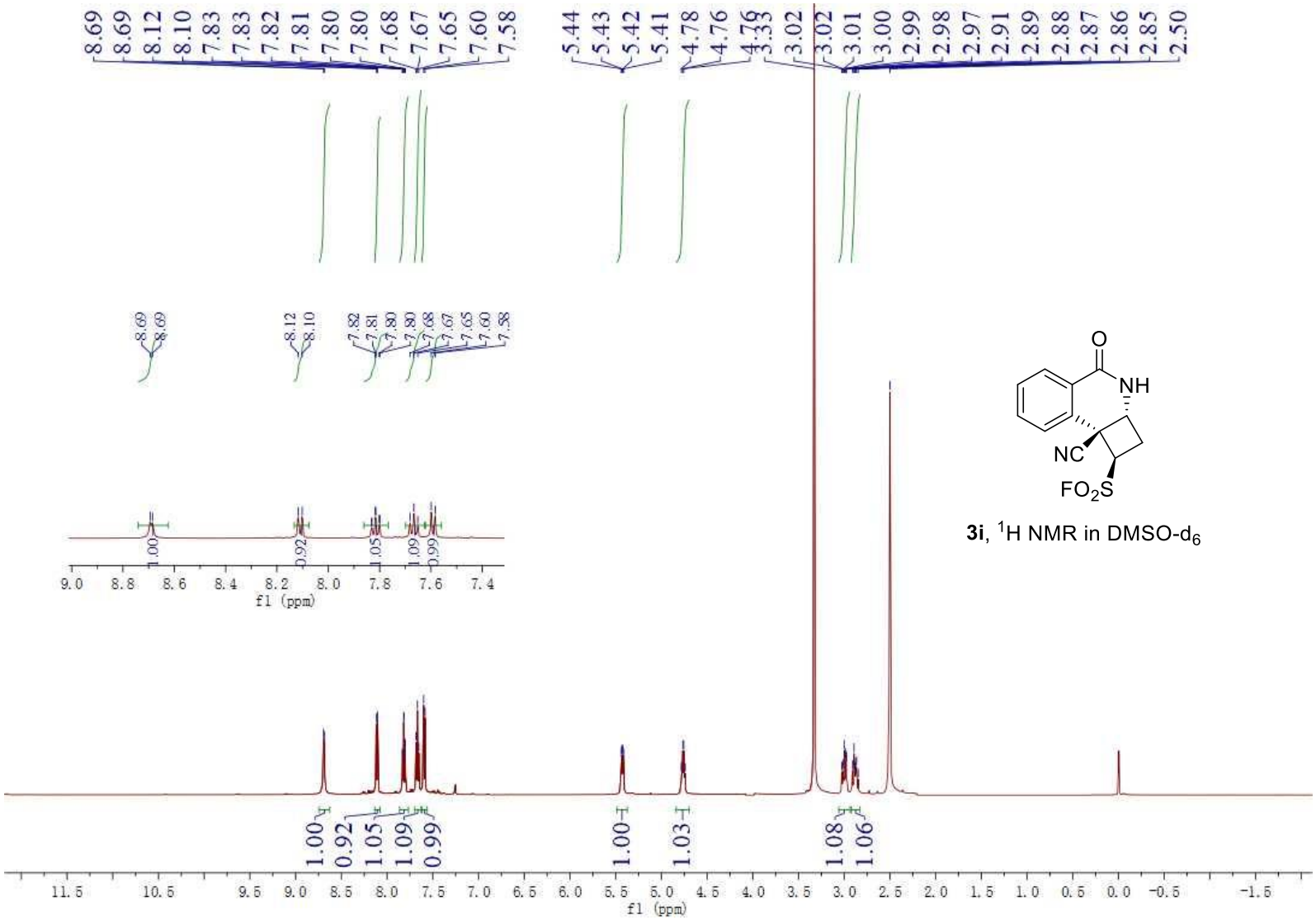
3h+3h', ^{1}H NMR in DMSO-d_6



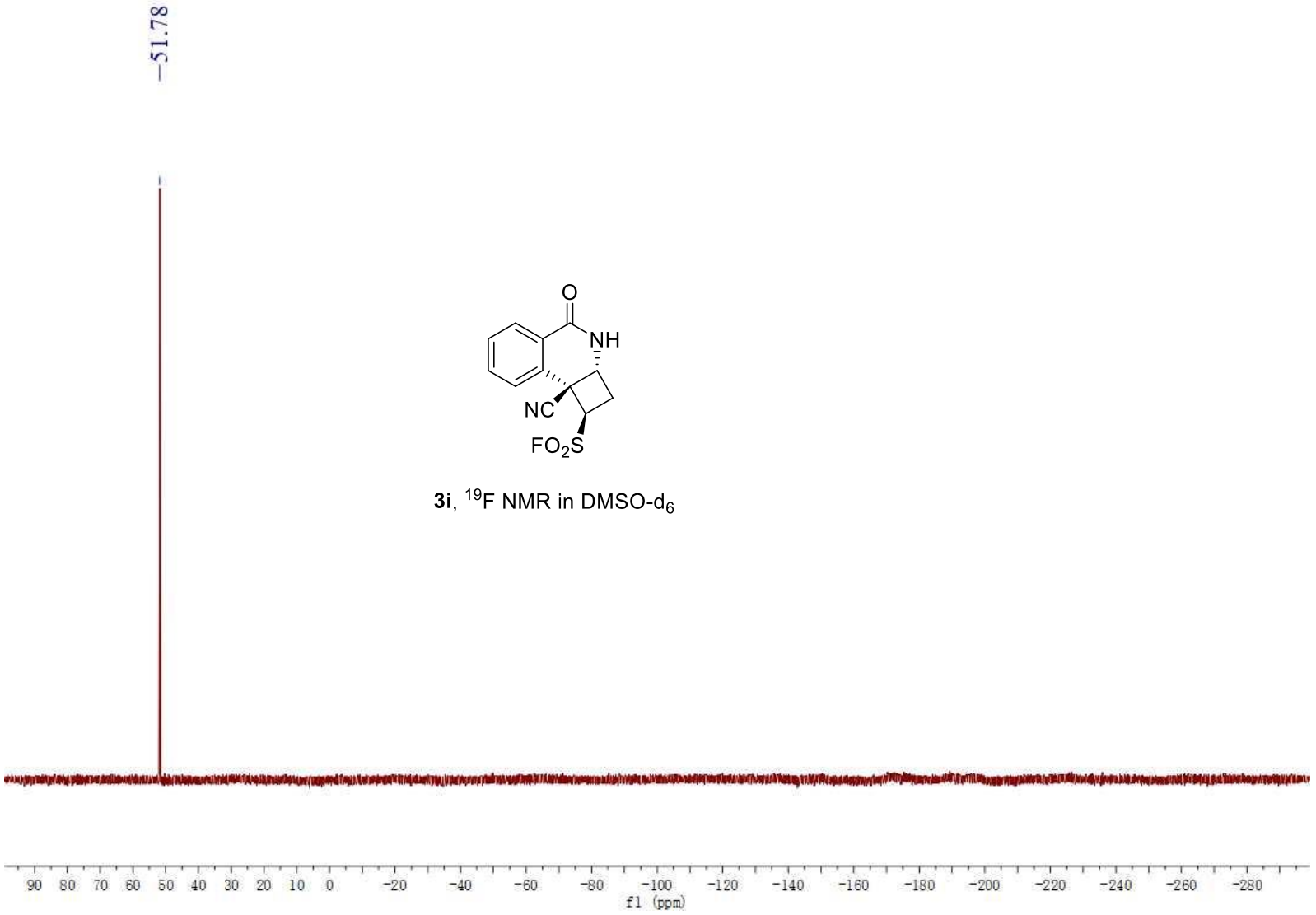
3h+3h', ^{19}F NMR in DMSO-d_6



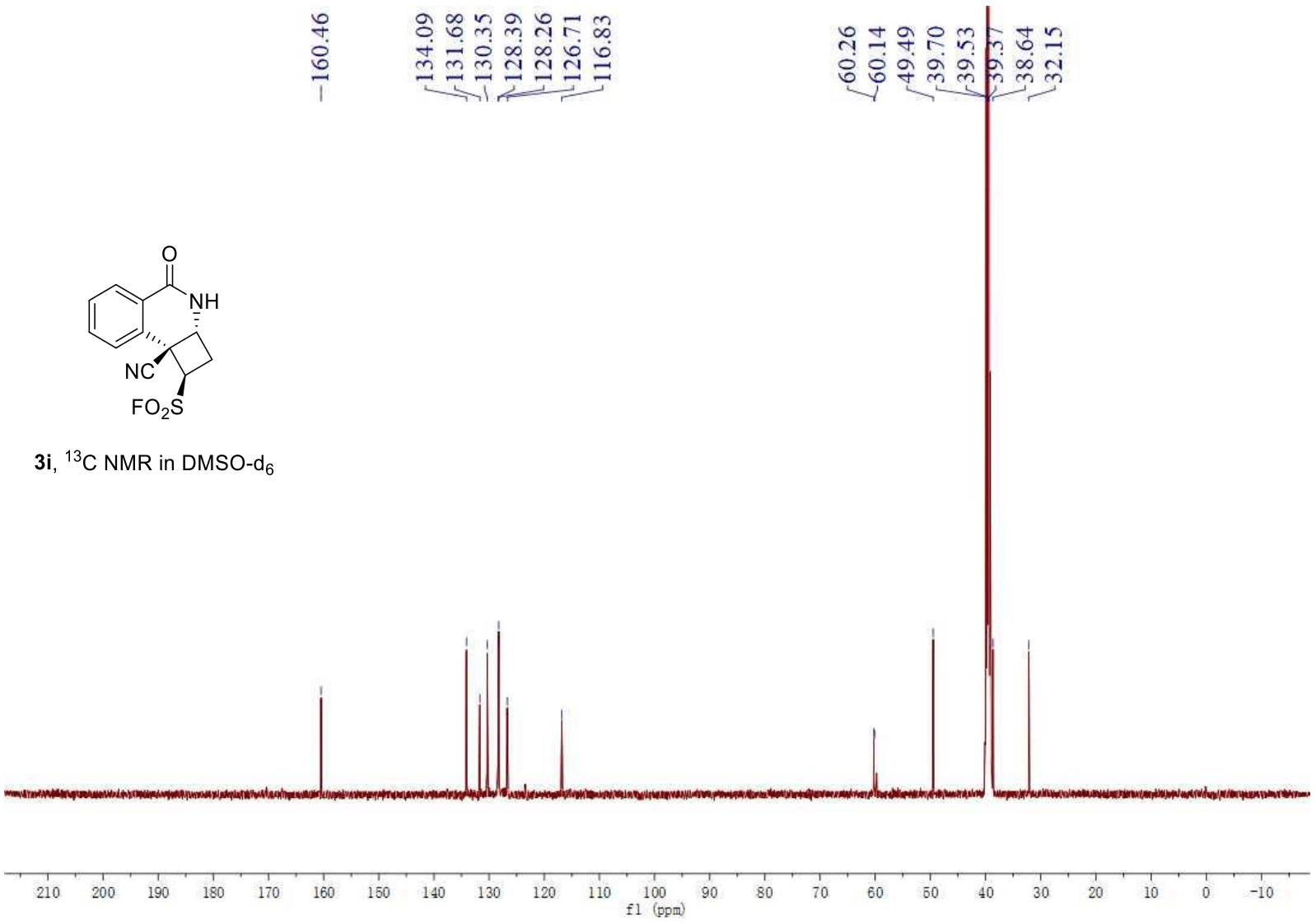
3h+3h', ^{13}C NMR in DMSO-d_6



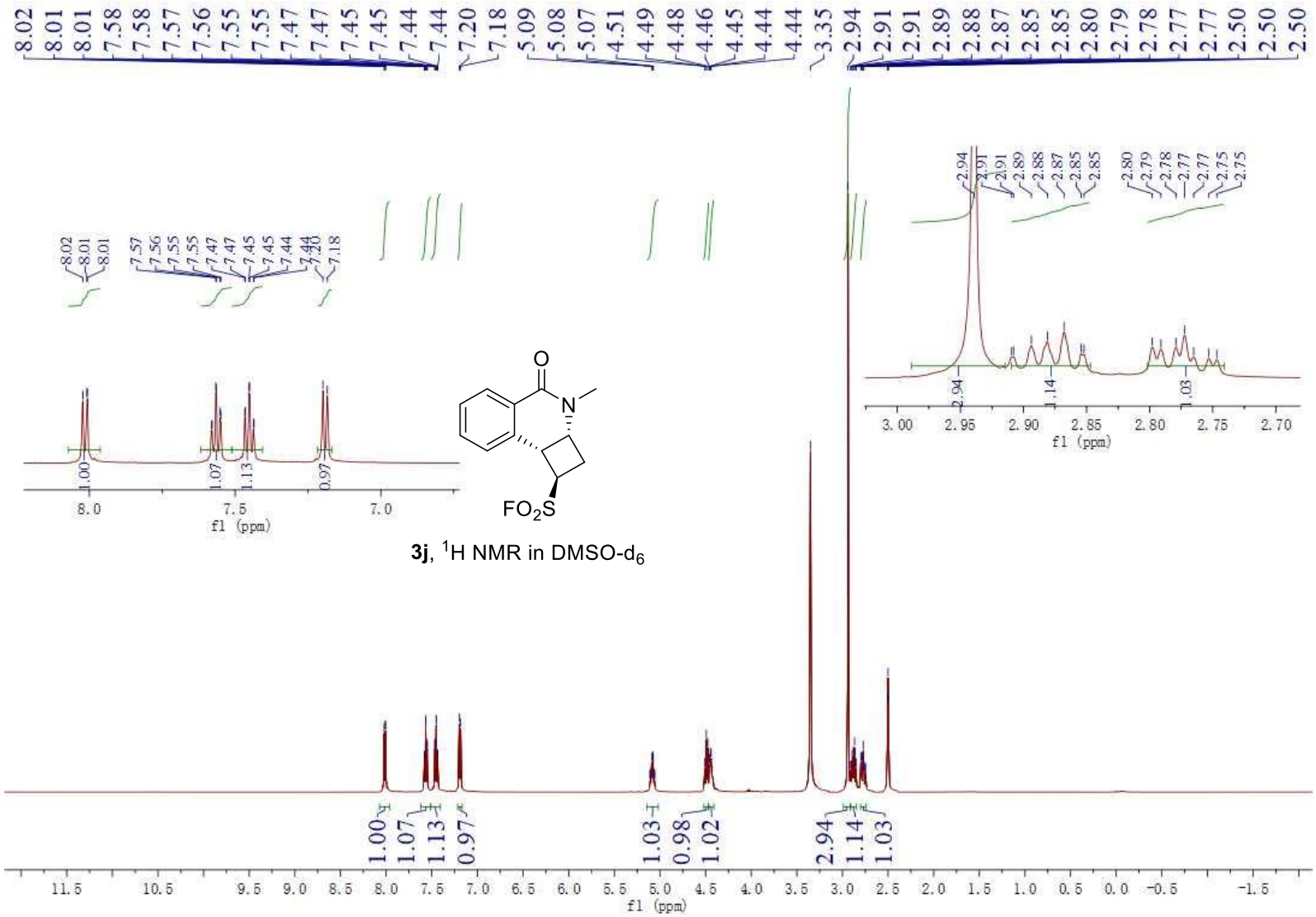
3i, ^{1}H NMR in DMSO-d_6



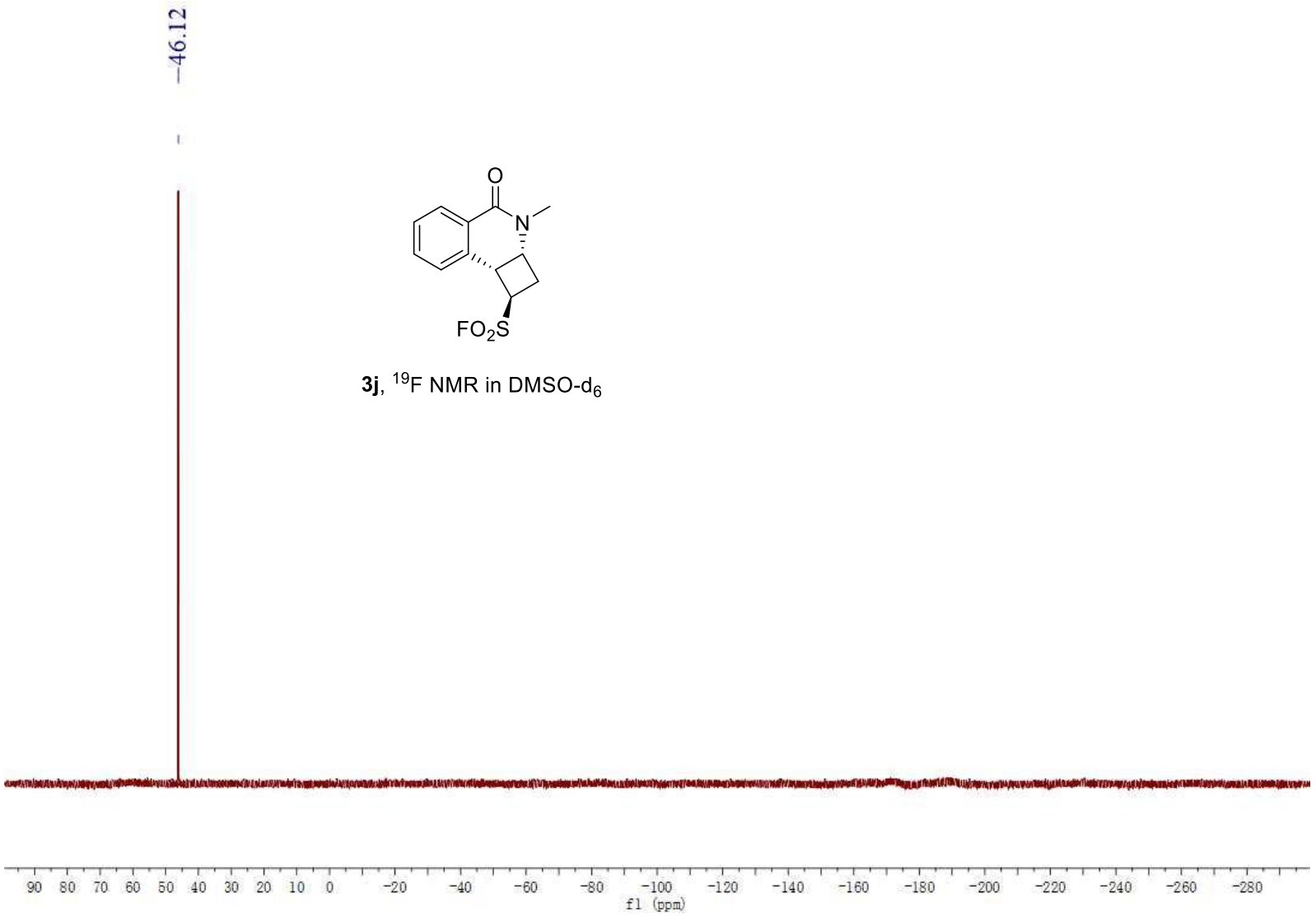
3i, ^{19}F NMR in DMSO-d_6



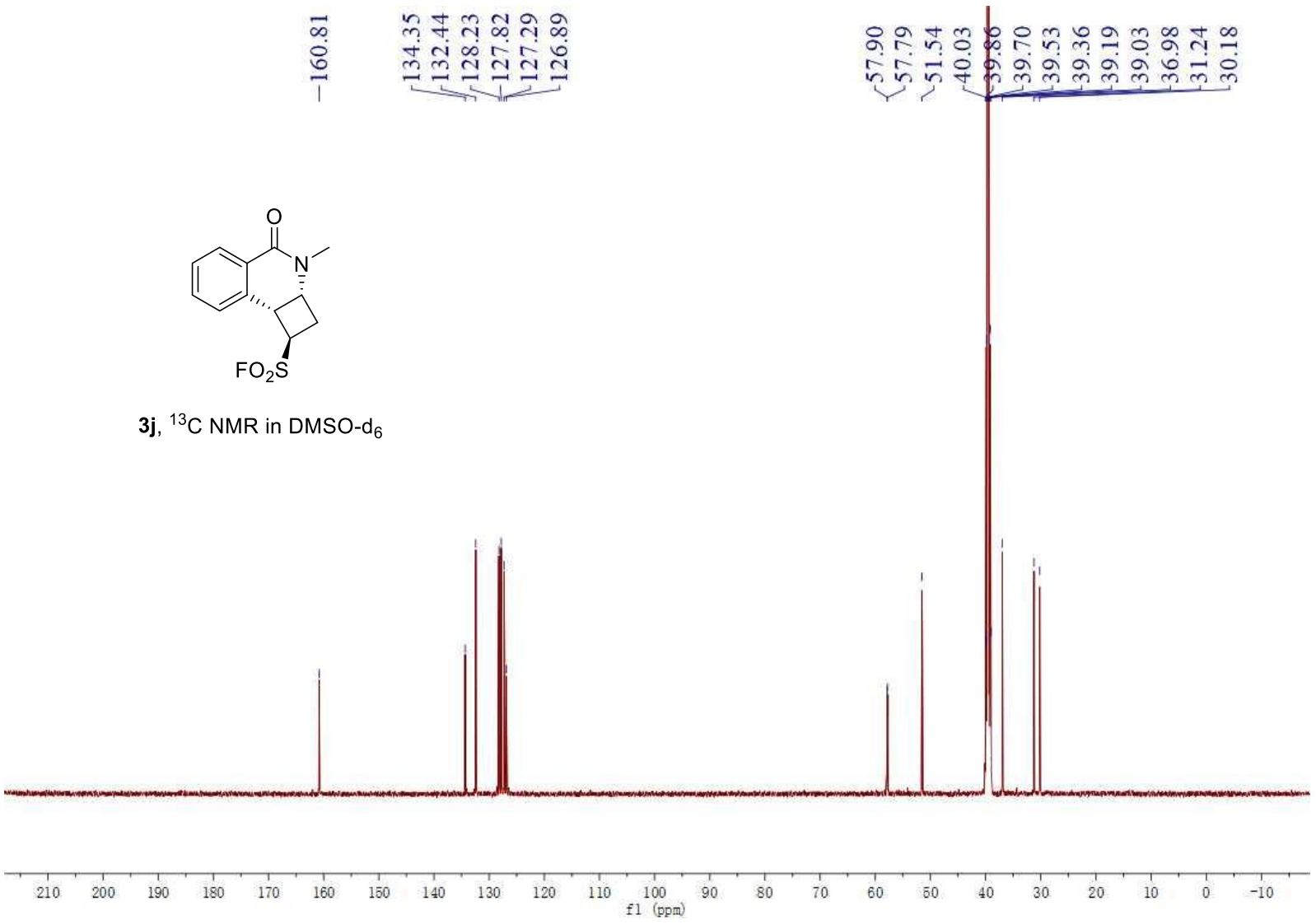
3i, ^{13}C NMR in DMSO-d_6



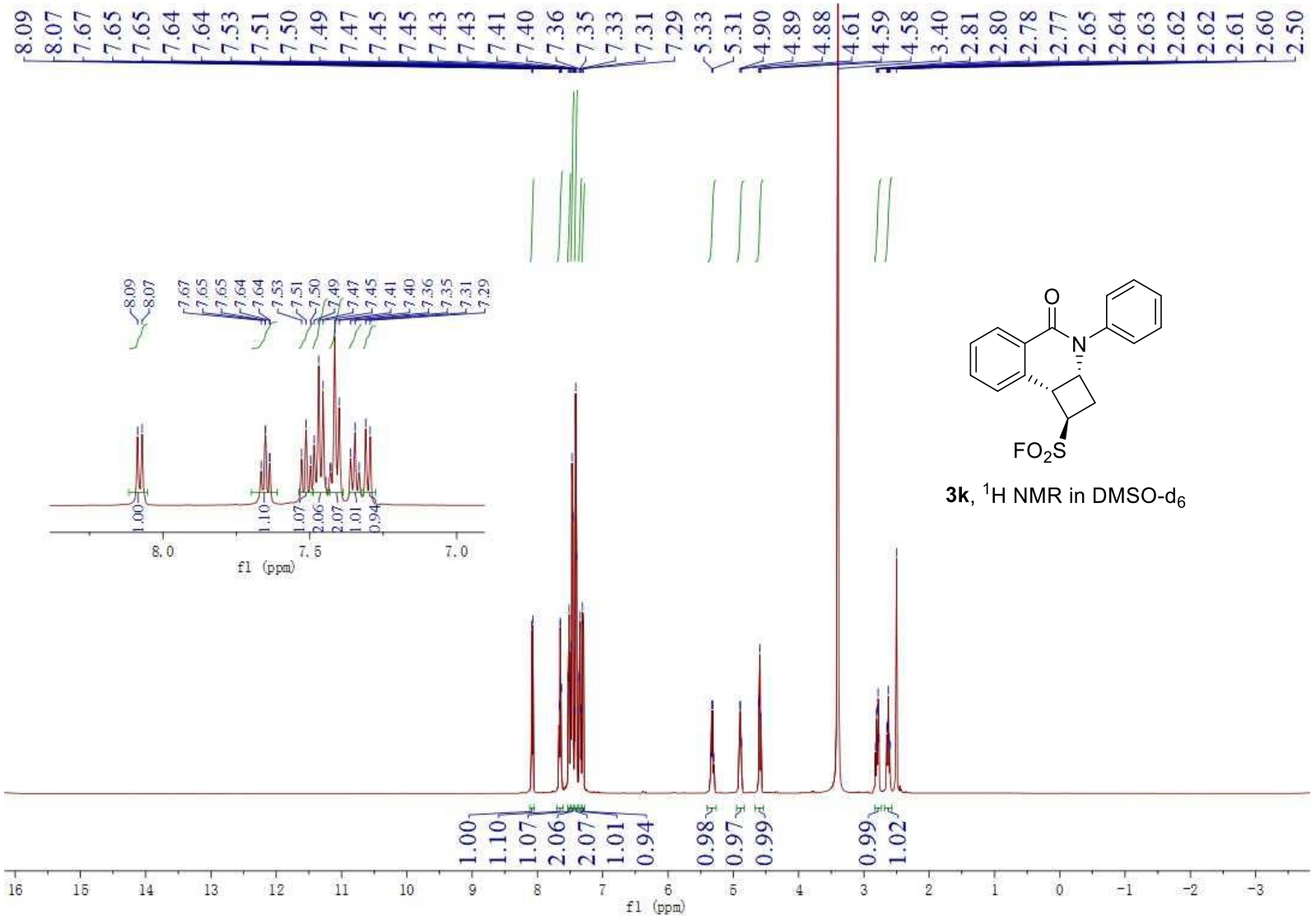
3j, ^{1}H NMR in DMSO-d_6



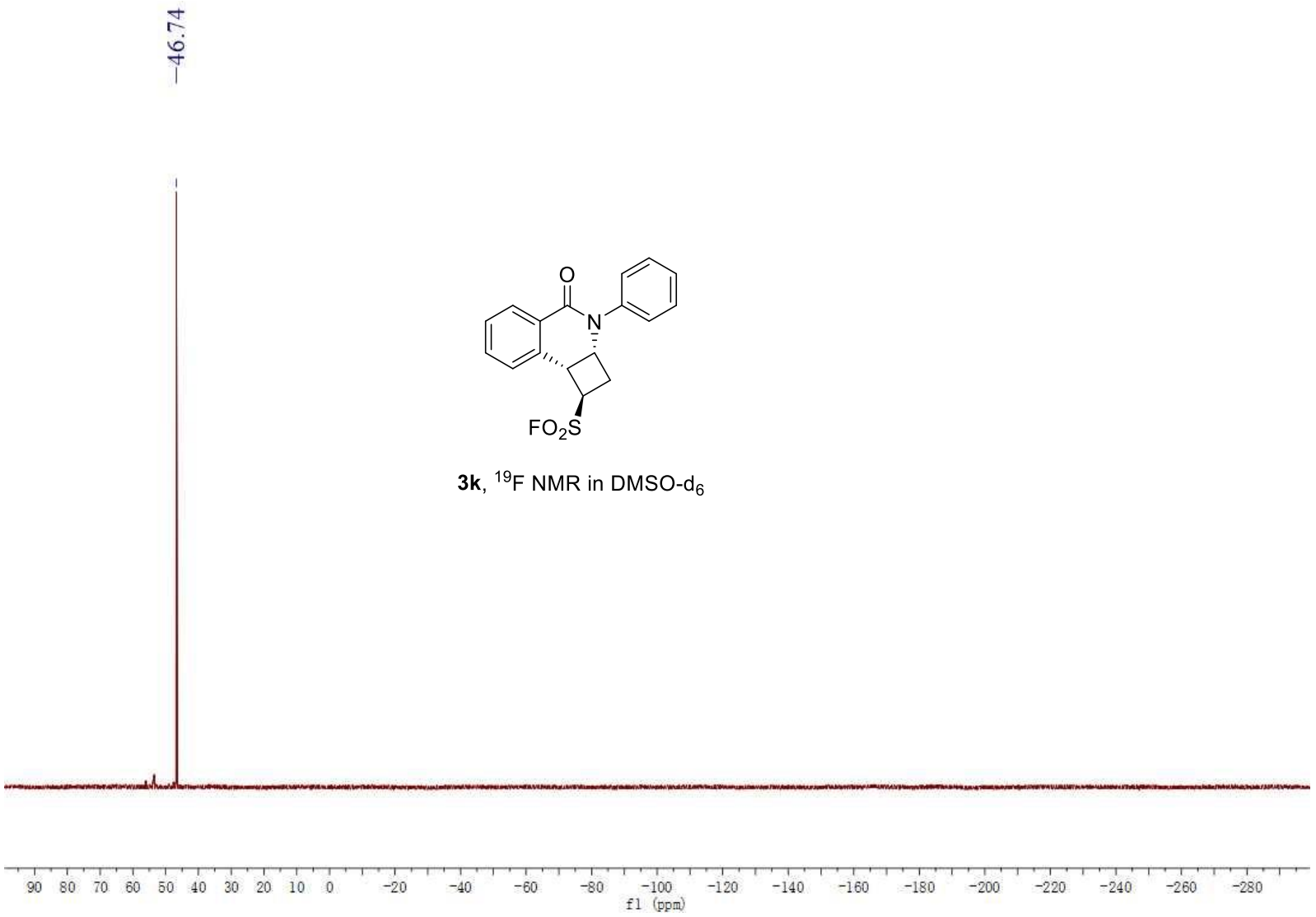
3j, ^{19}F NMR in DMSO-d_6



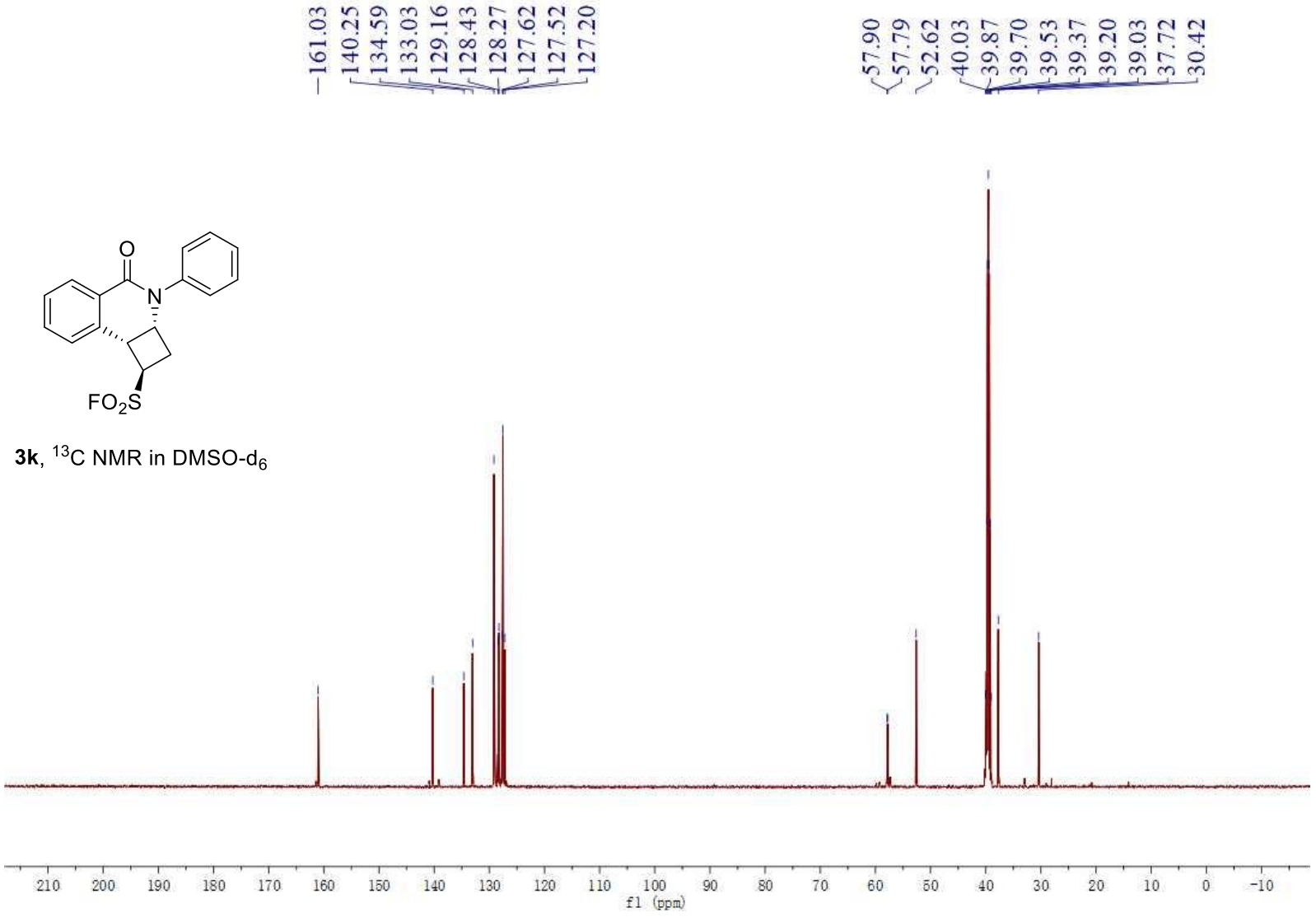
3j, ^{13}C NMR in DMSO-d_6



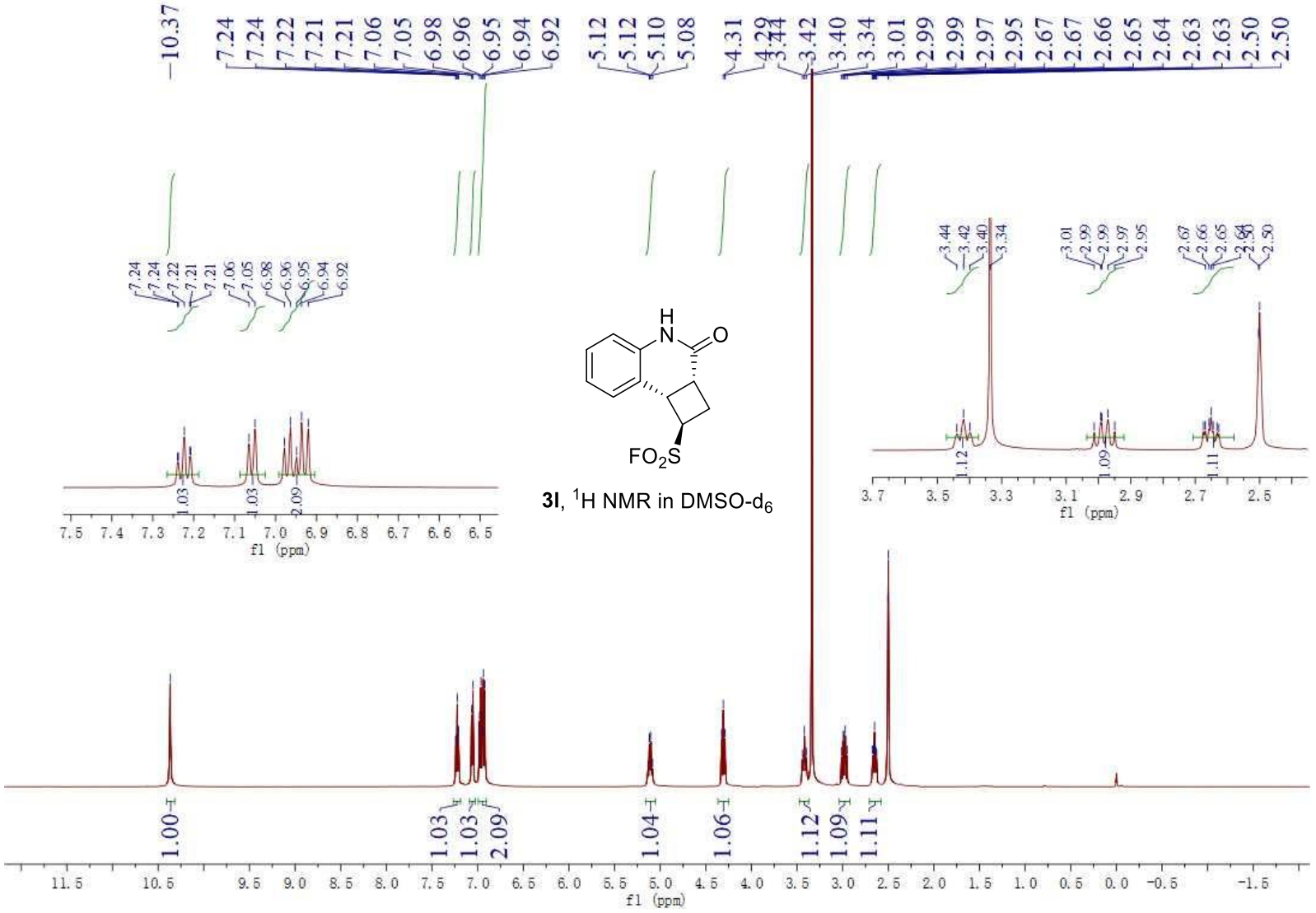
3k, ^{1}H NMR in DMSO-d_6



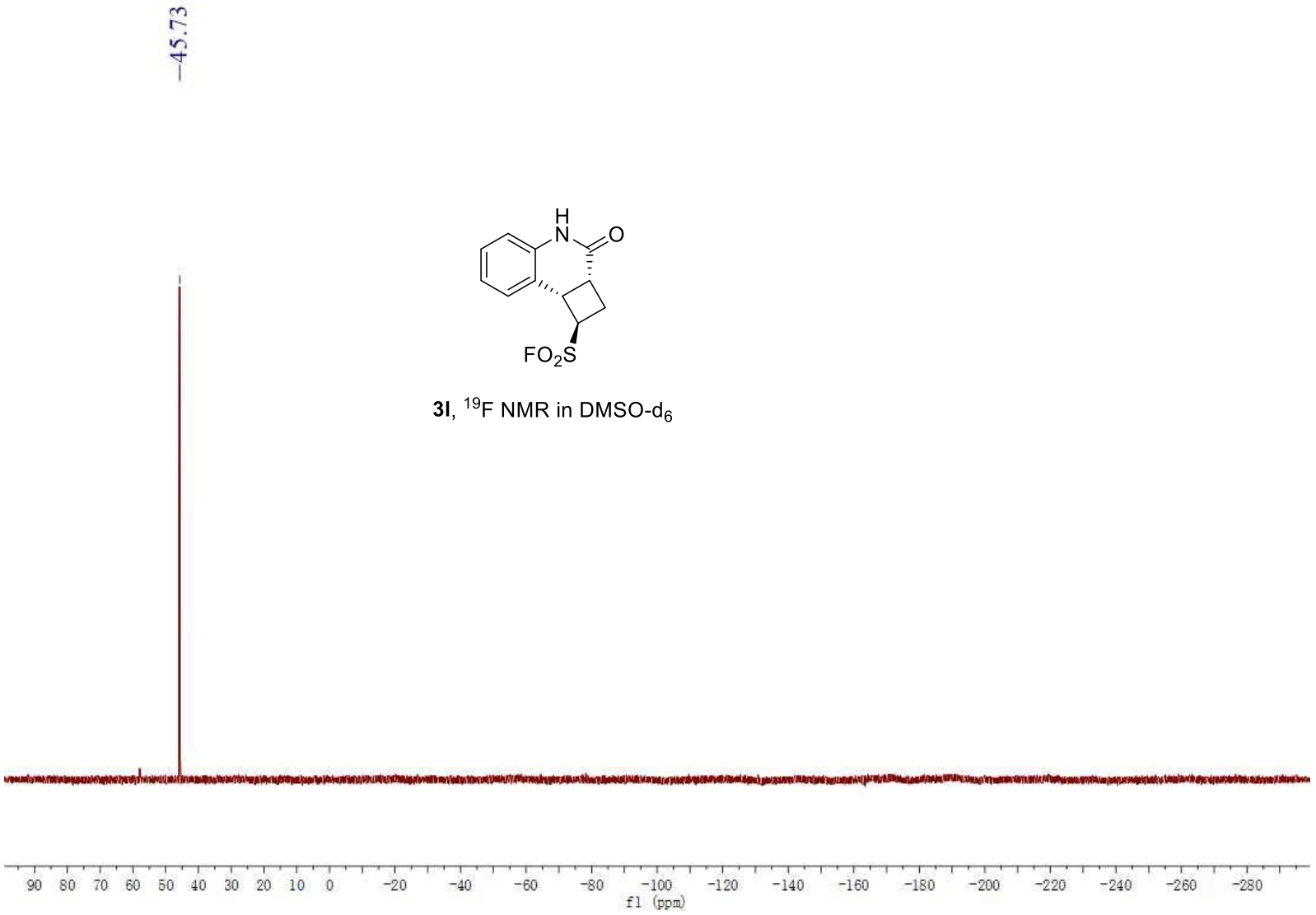
3k, ^{19}F NMR in DMSO-d_6



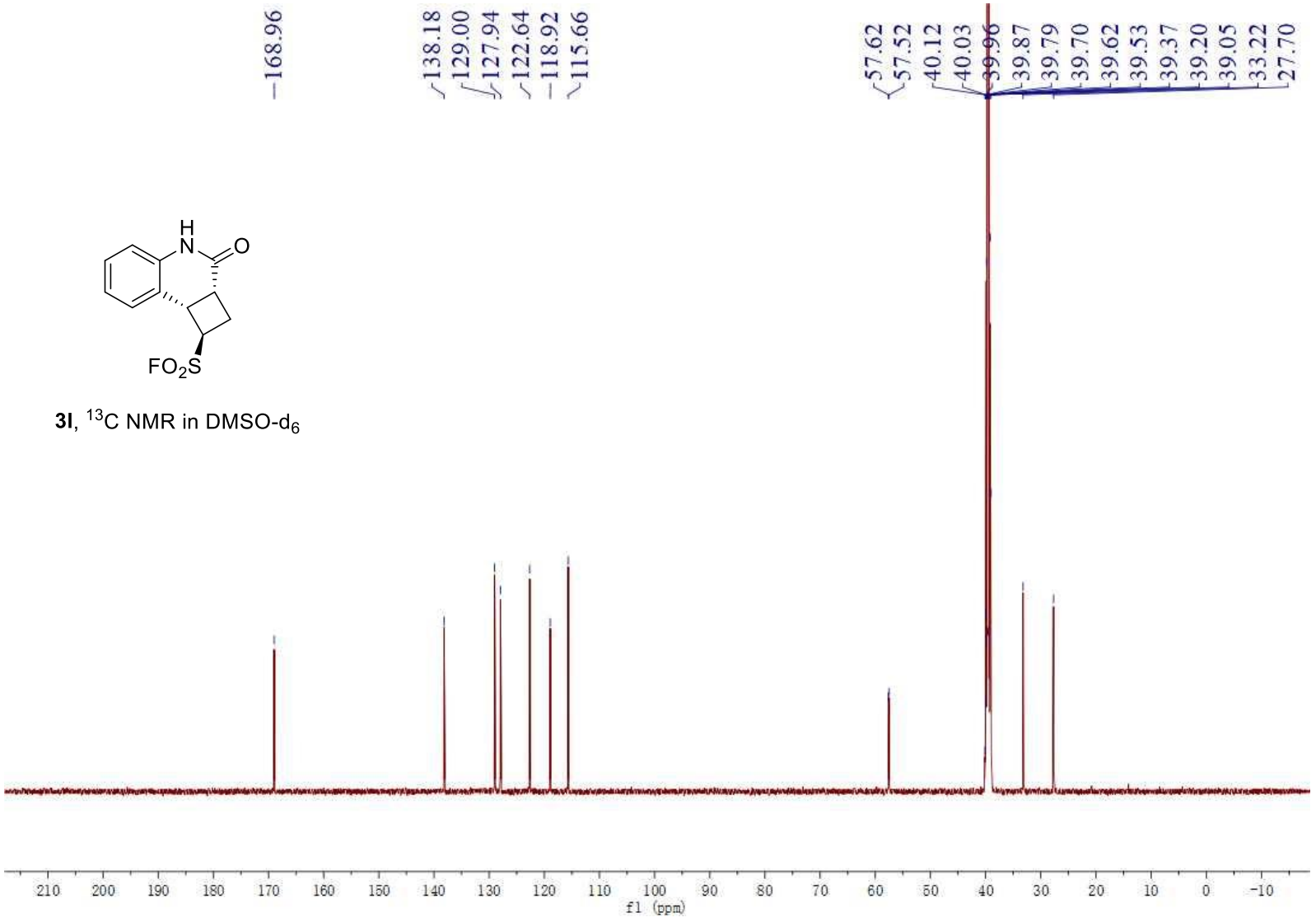
3k, ^{13}C NMR in DMSO-d_6



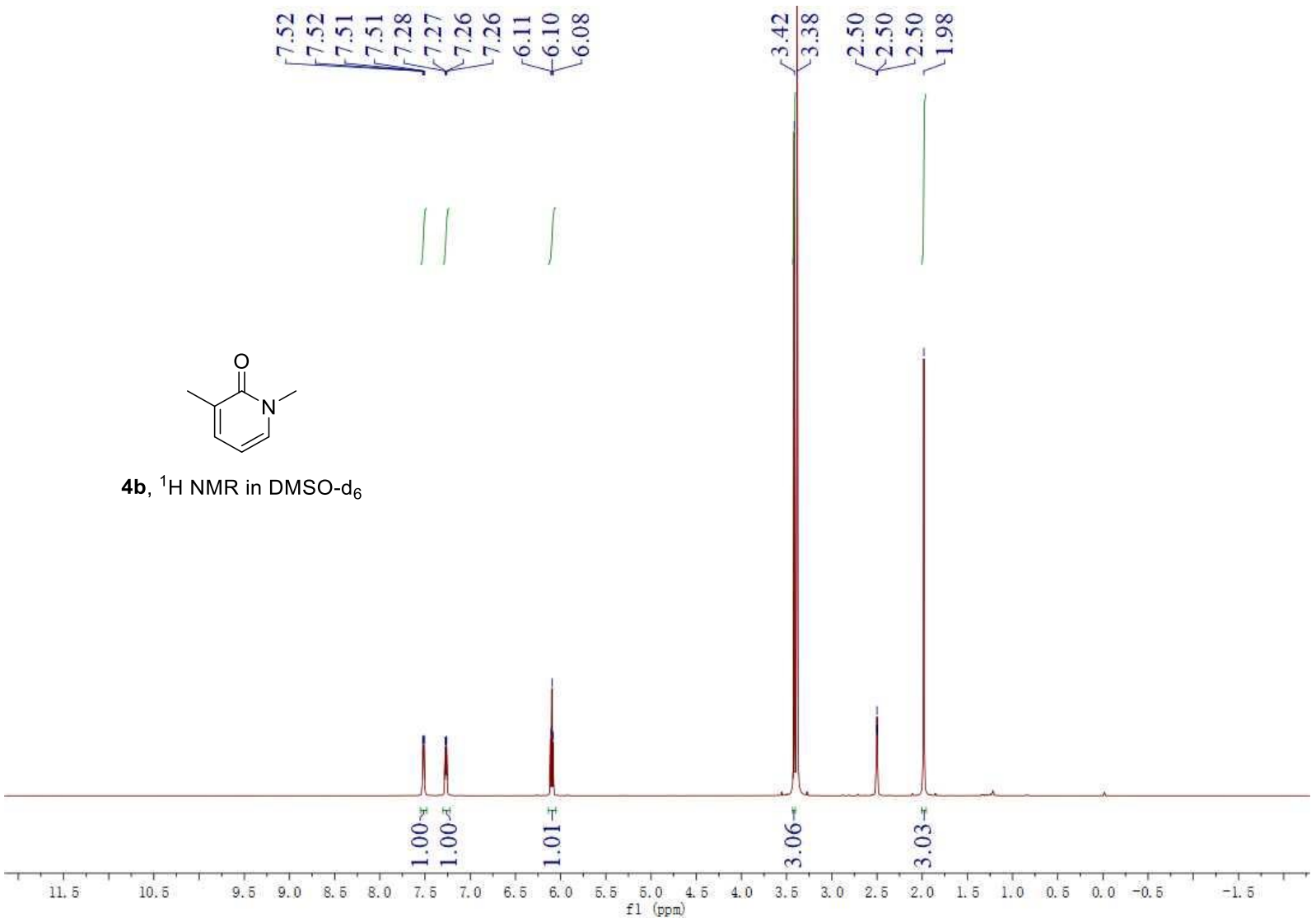
3l, ^{1}H NMR in DMSO-d_6



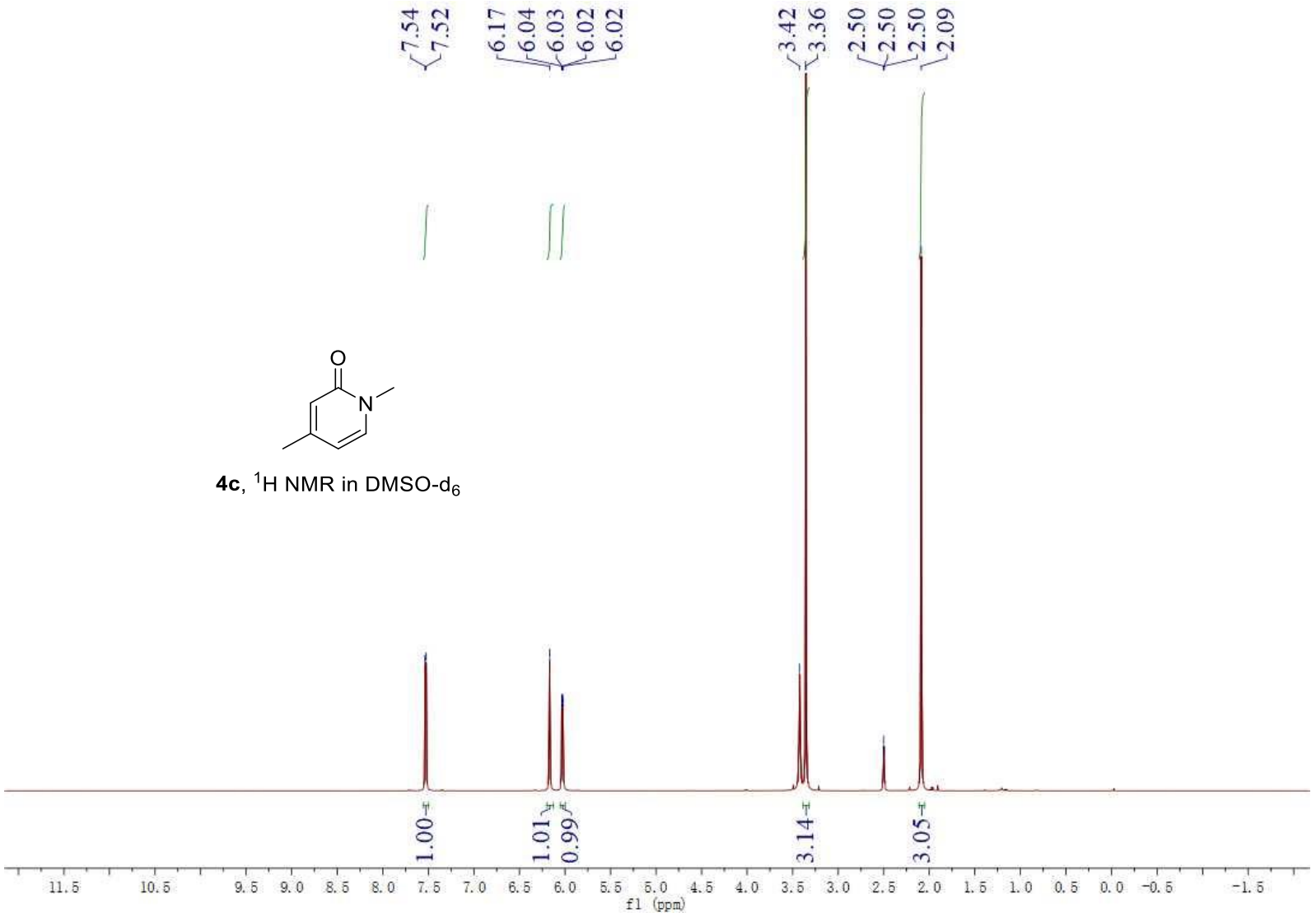
3l, ^{19}F NMR in DMSO-d_6



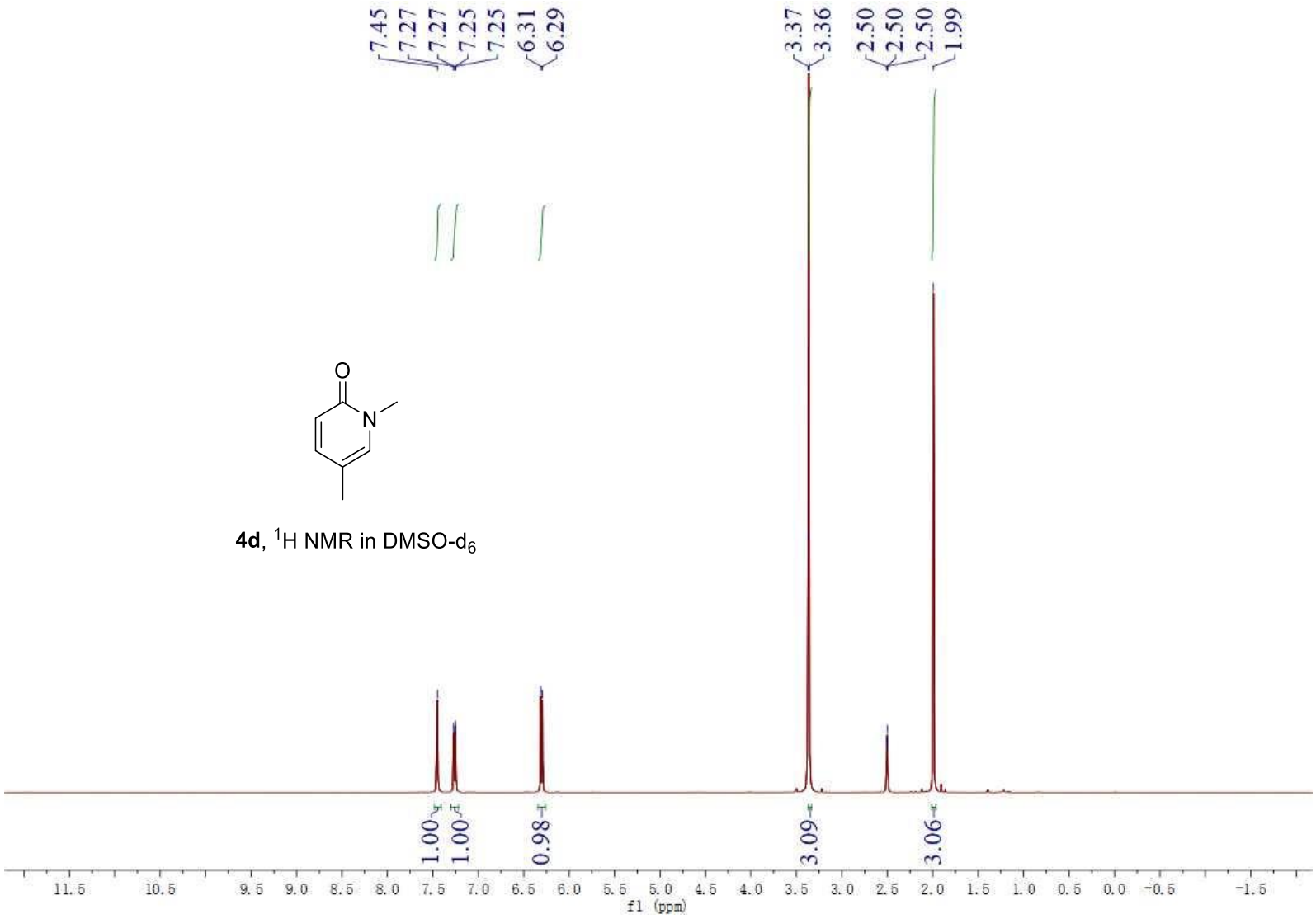
3l, ^{13}C NMR in DMSO-d_6



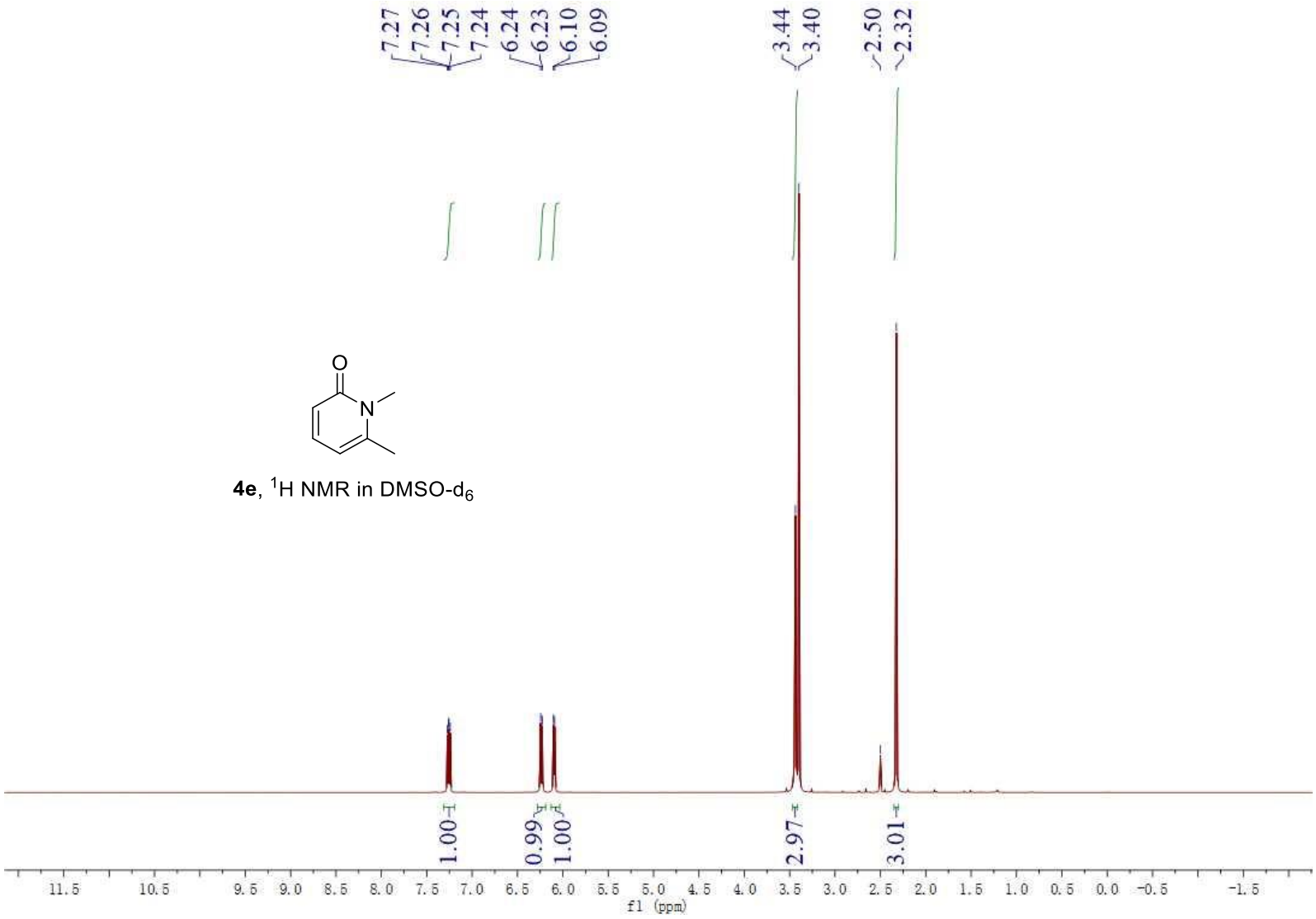
4b, ^{1}H NMR in DMSO-d_6



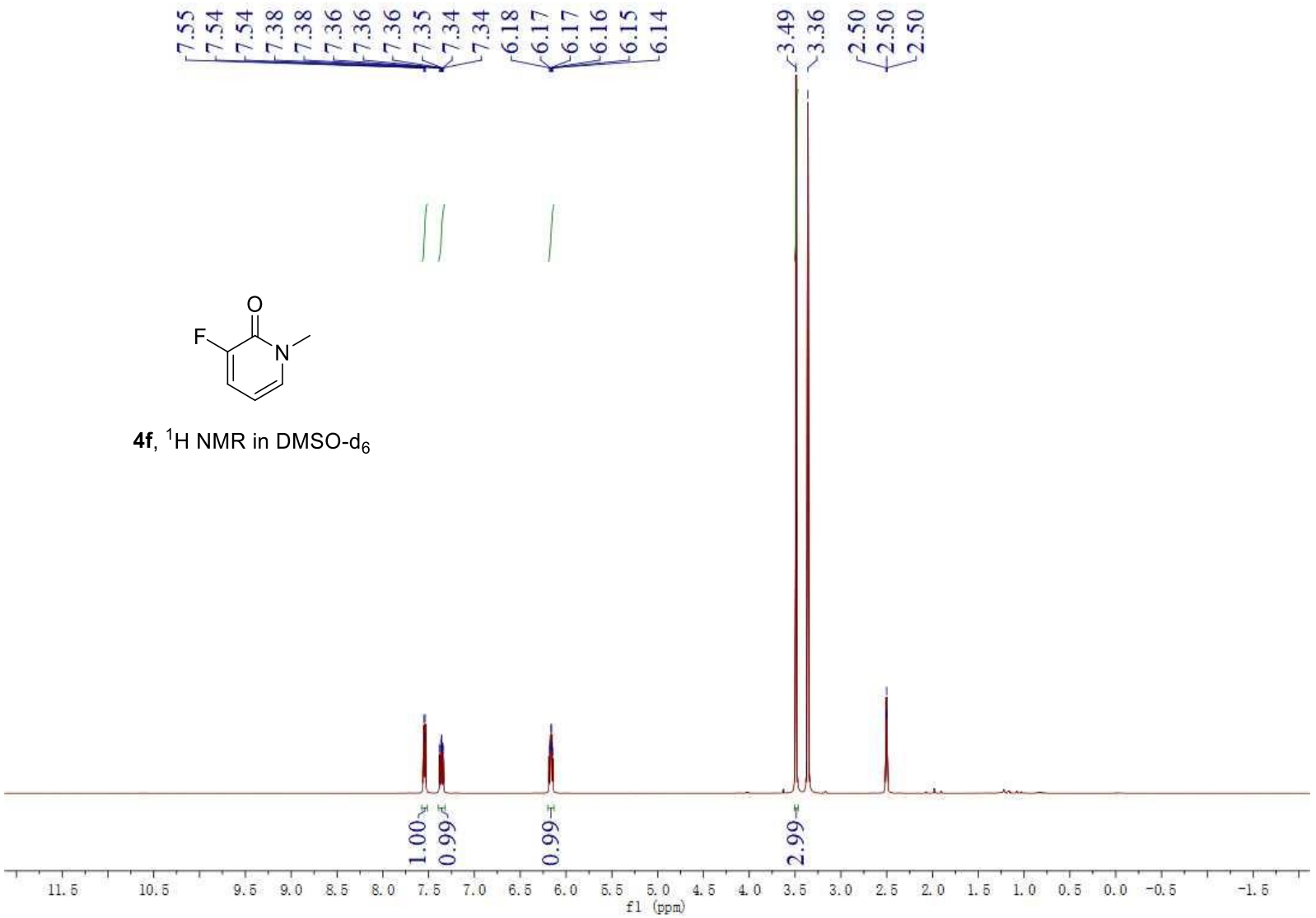
4c, ^{1}H NMR in DMSO-d_6



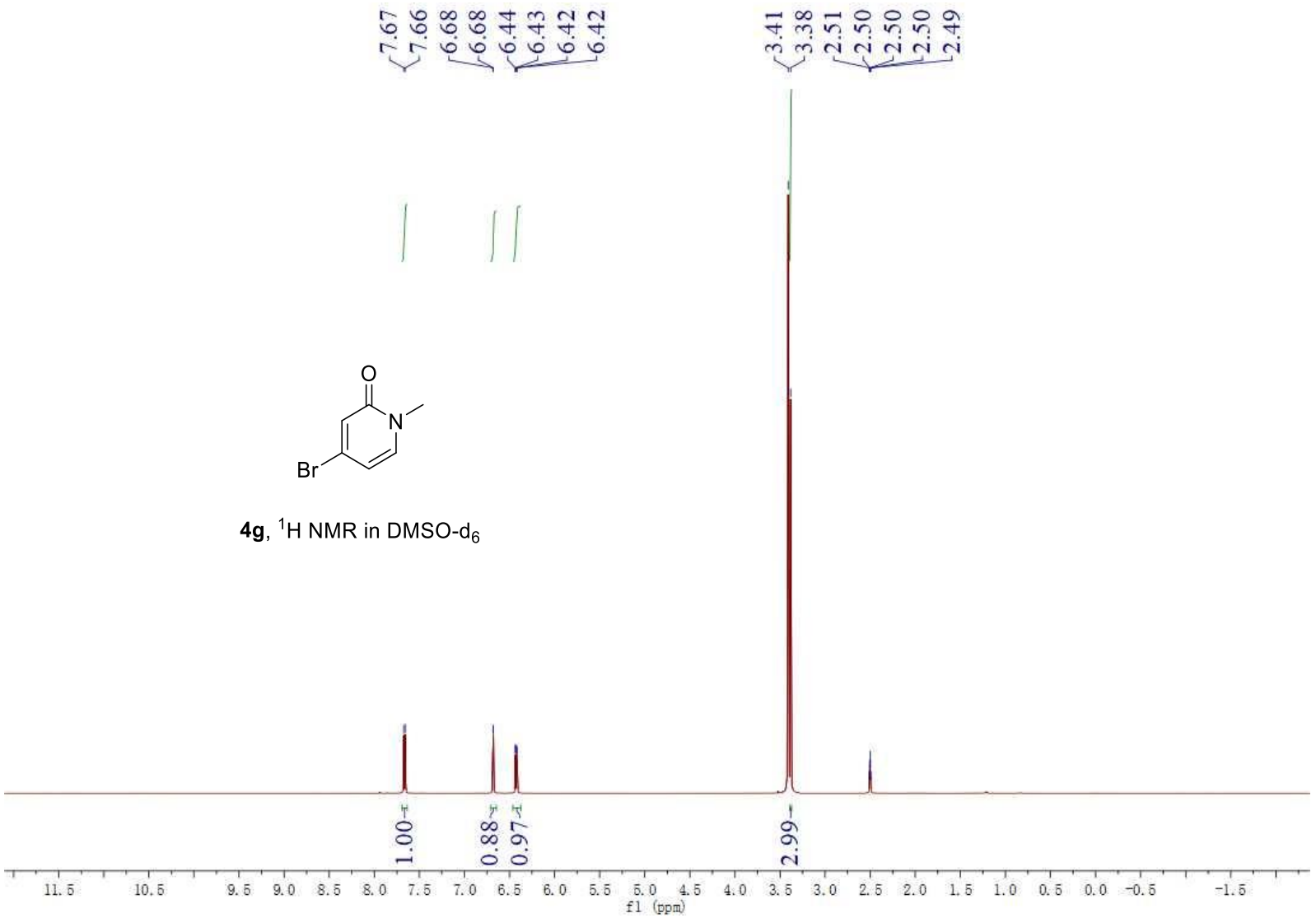
4d, ^{1}H NMR in DMSO-d_6



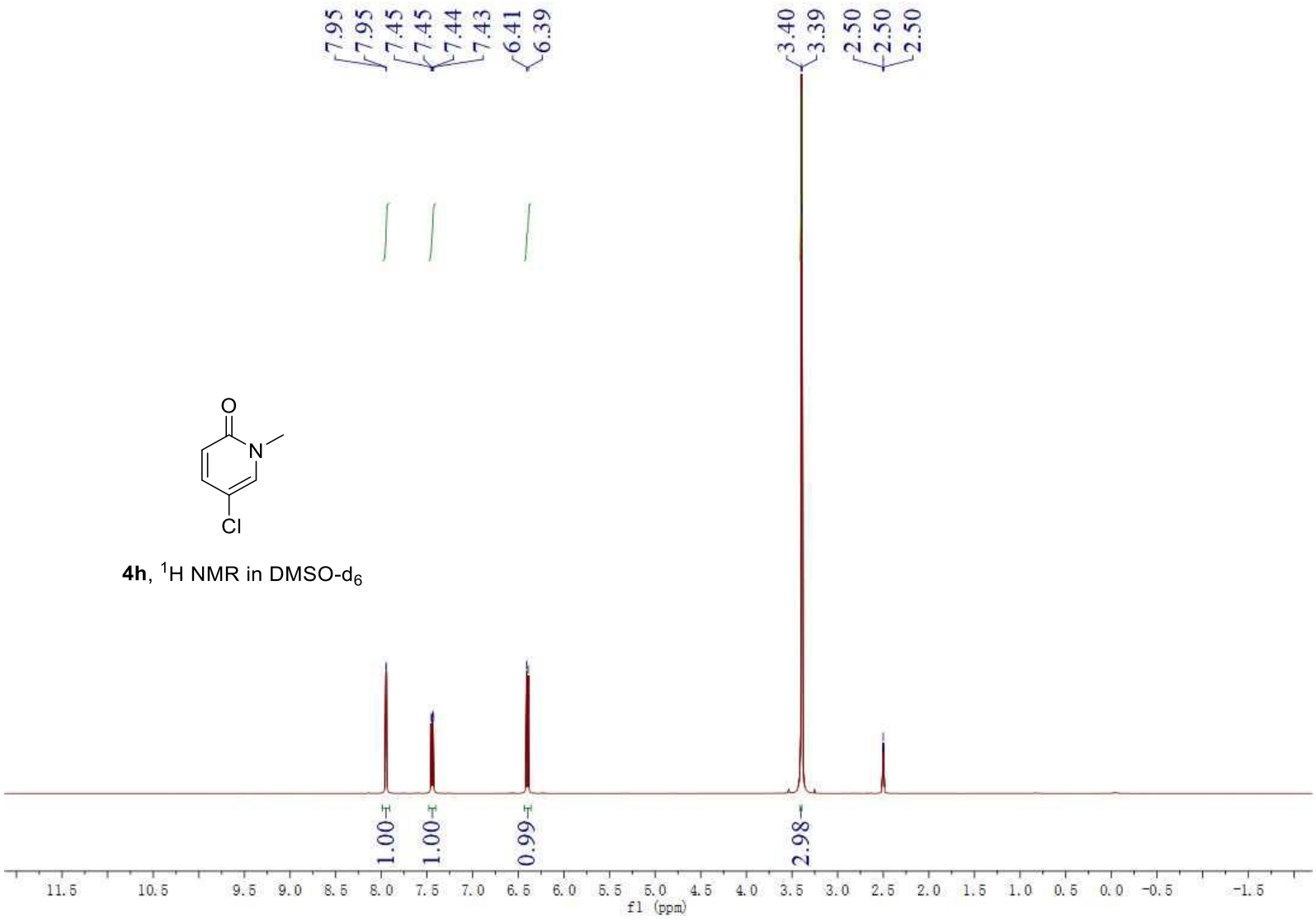
4e, ^{1}H NMR in DMSO-d_6



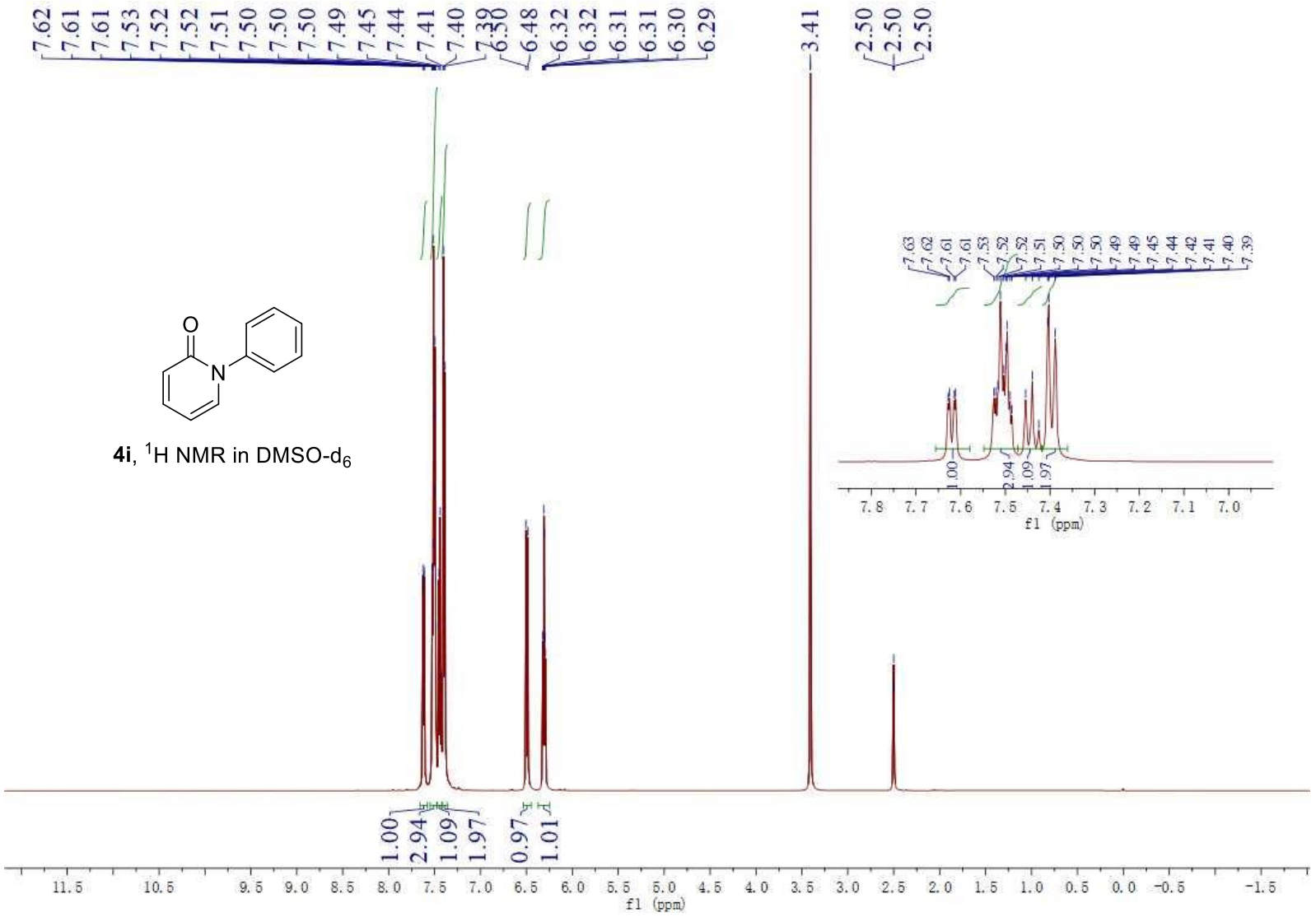
4f, ^{1}H NMR in DMSO-d_6



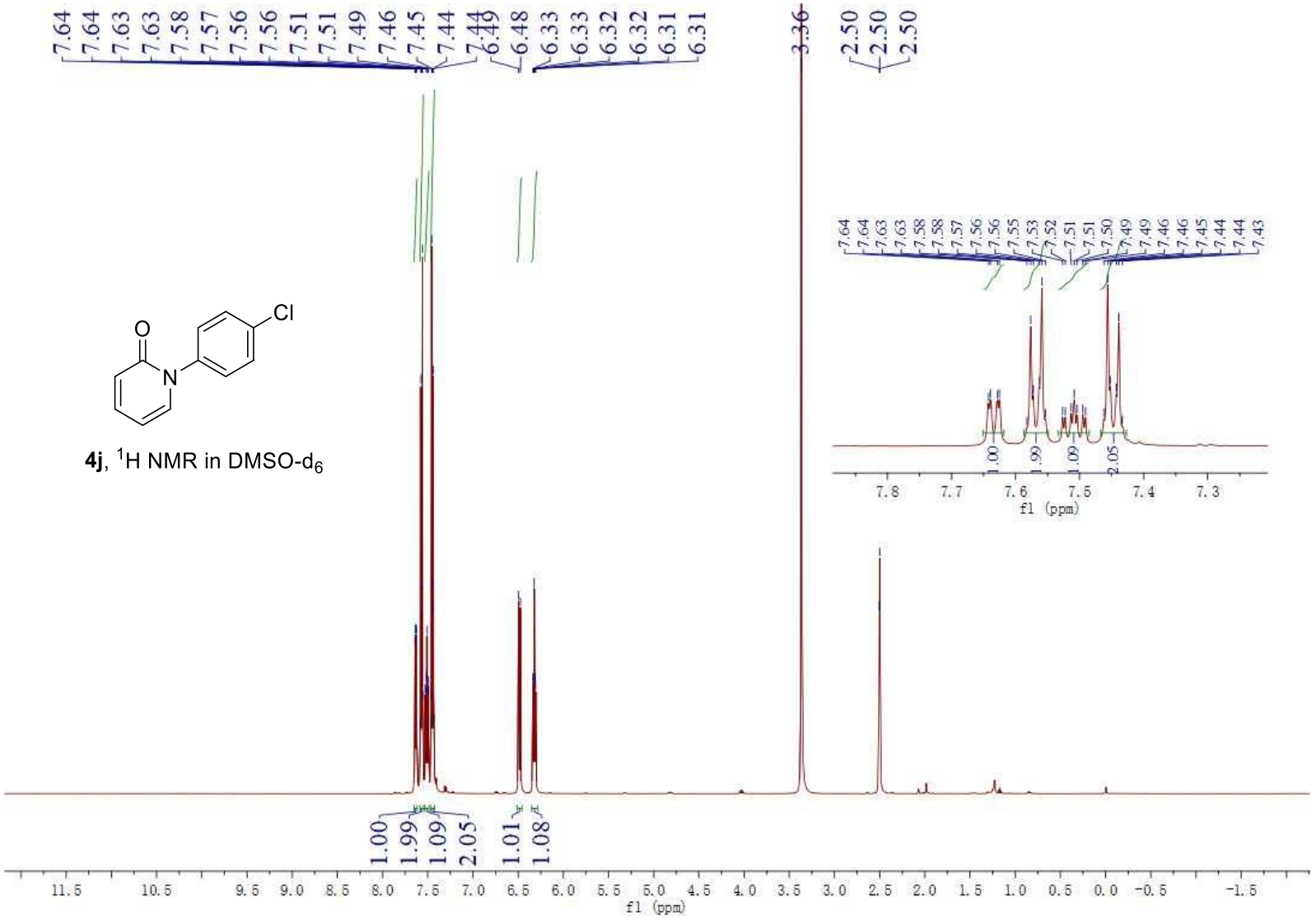
4g, ^{1}H NMR in DMSO-d_6



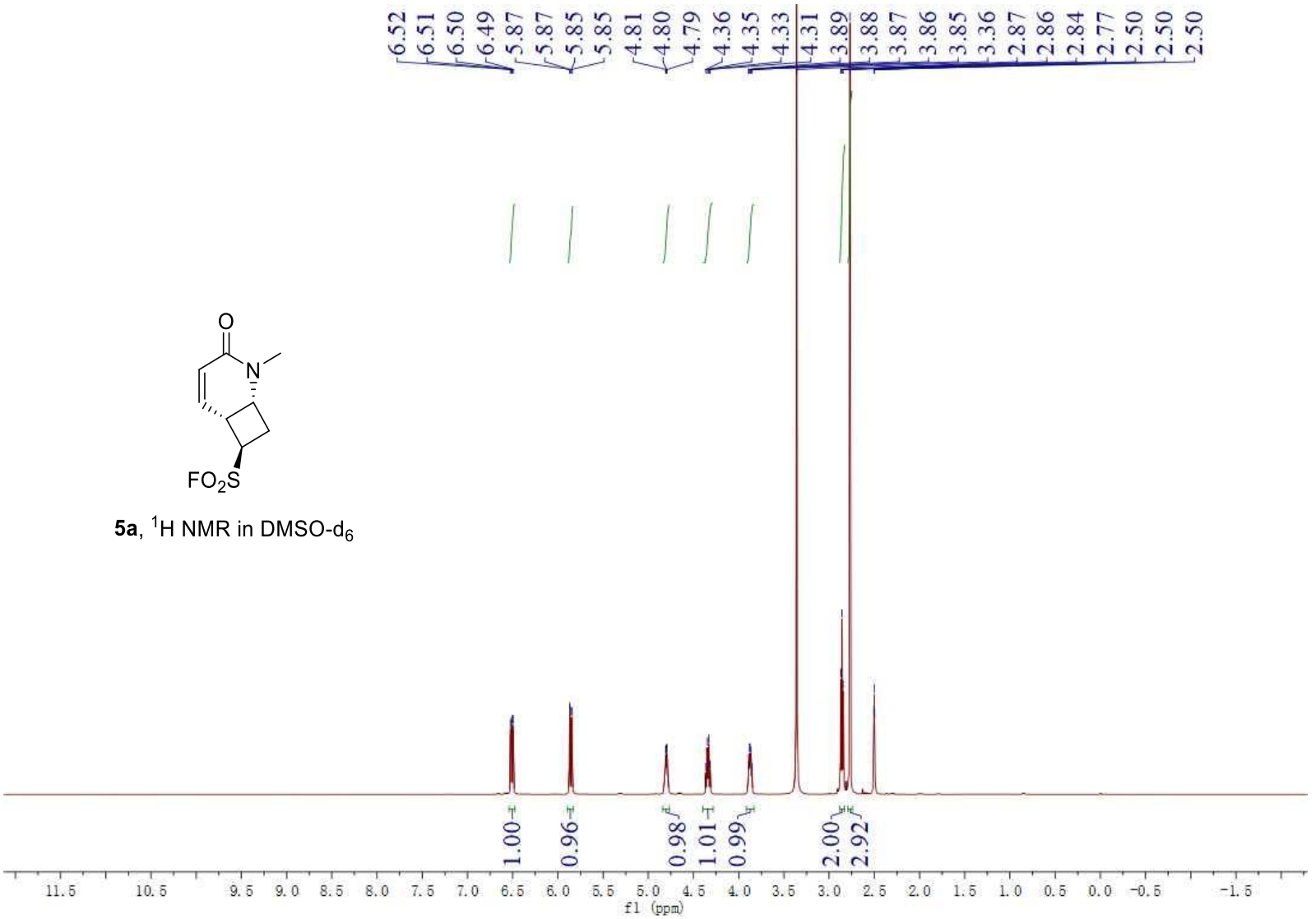
4h, ^{1}H NMR in DMSO-d_6



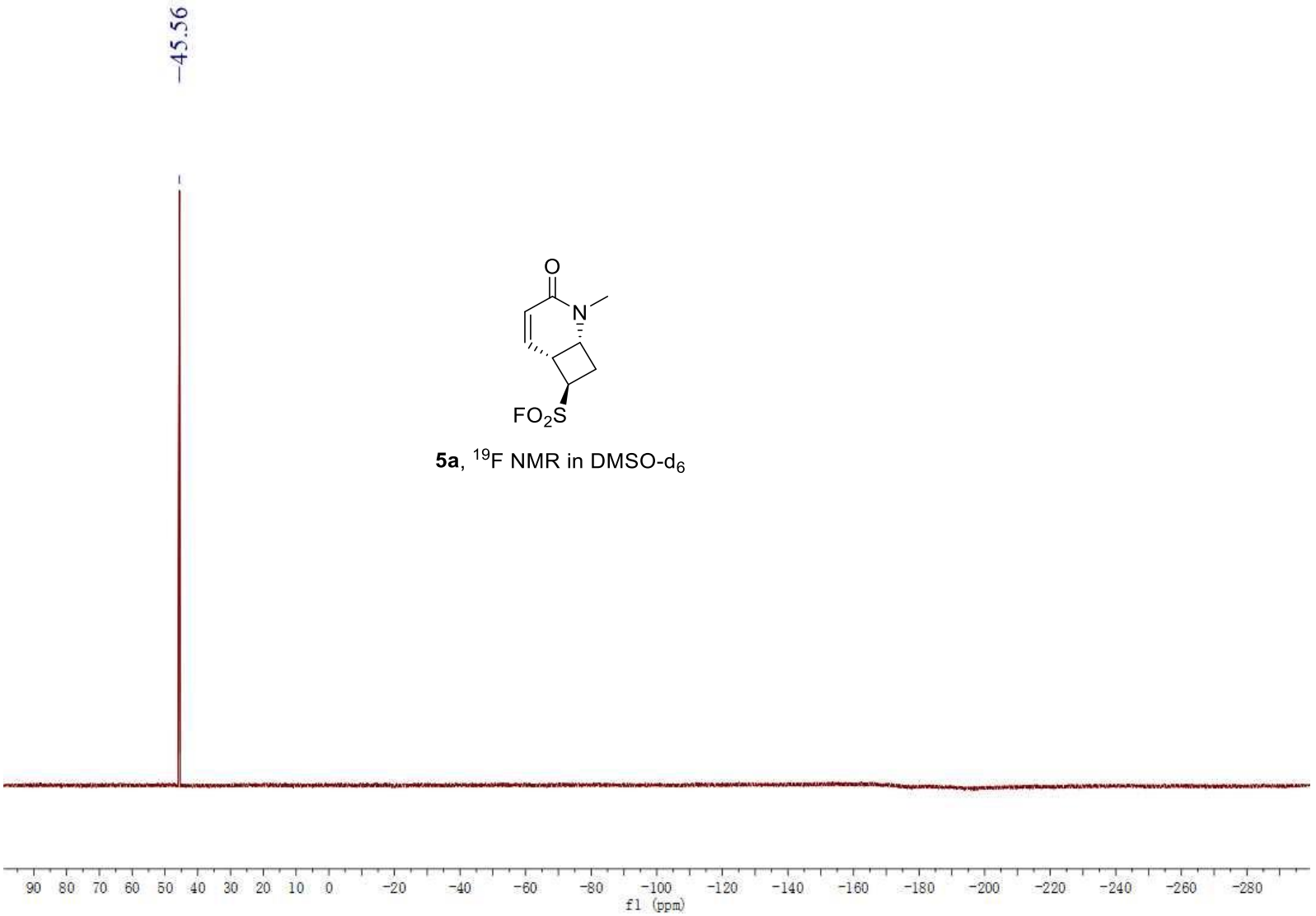
4i, ^{1}H NMR in DMSO-d_6



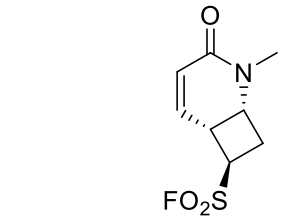
4j, ^{1}H NMR in DMSO-d_6



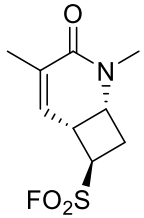
5a, ^{1}H NMR in DMSO-d_6



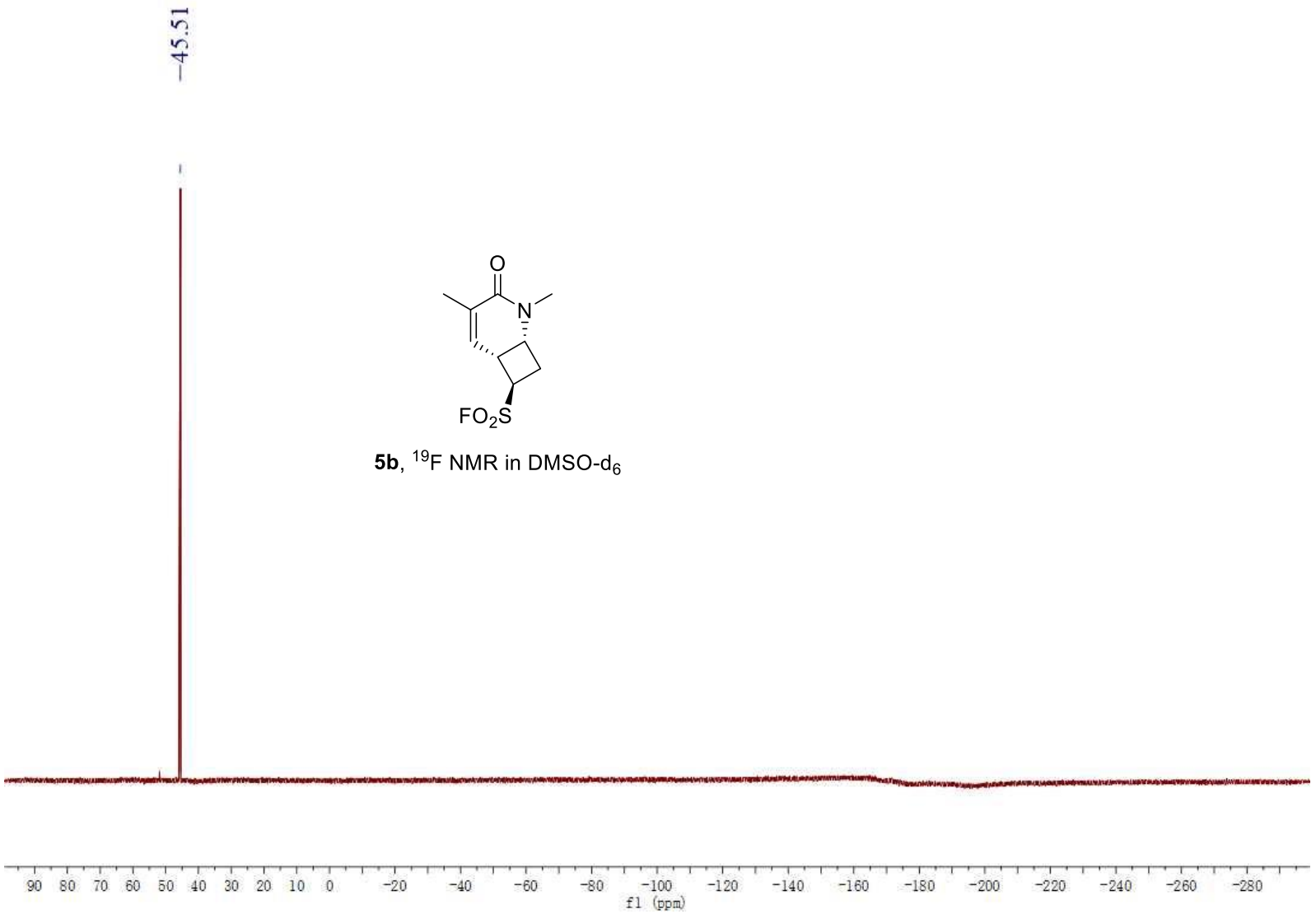
5a, ^{19}F NMR in DMSO-d_6



5a, ^{13}C NMR in DMSO-d_6



5b, ^{1}H NMR in DMSO-d_6



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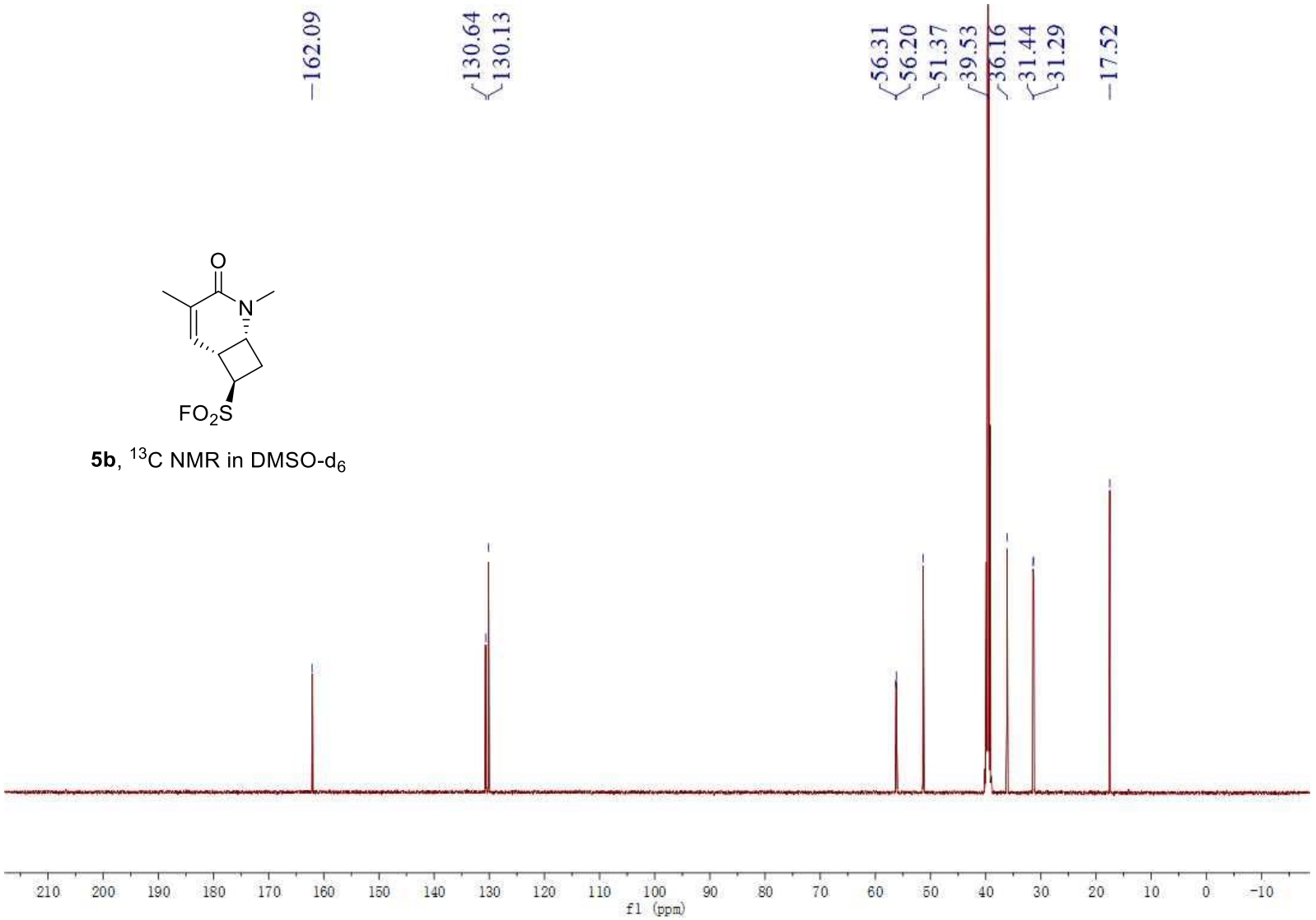

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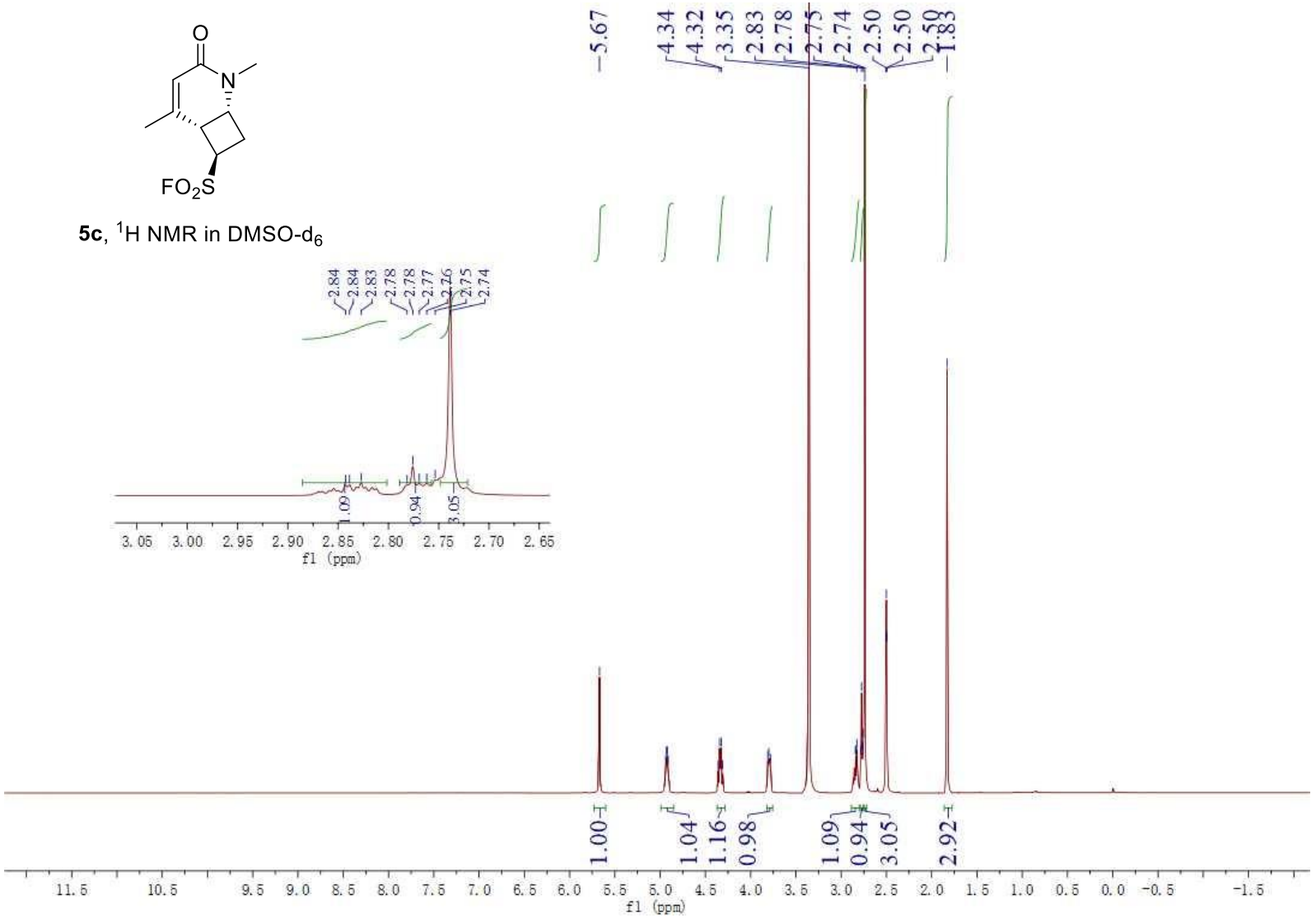

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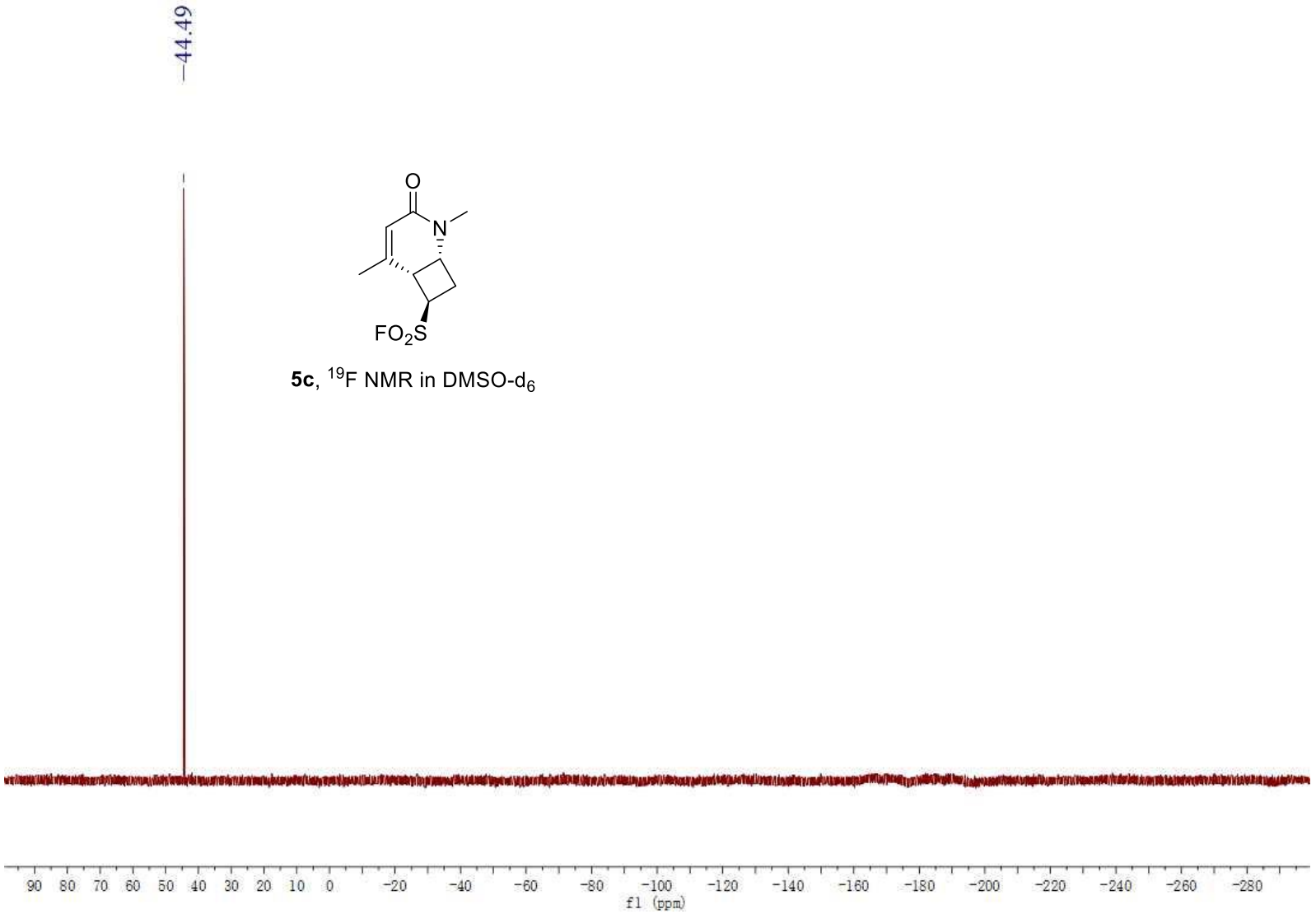

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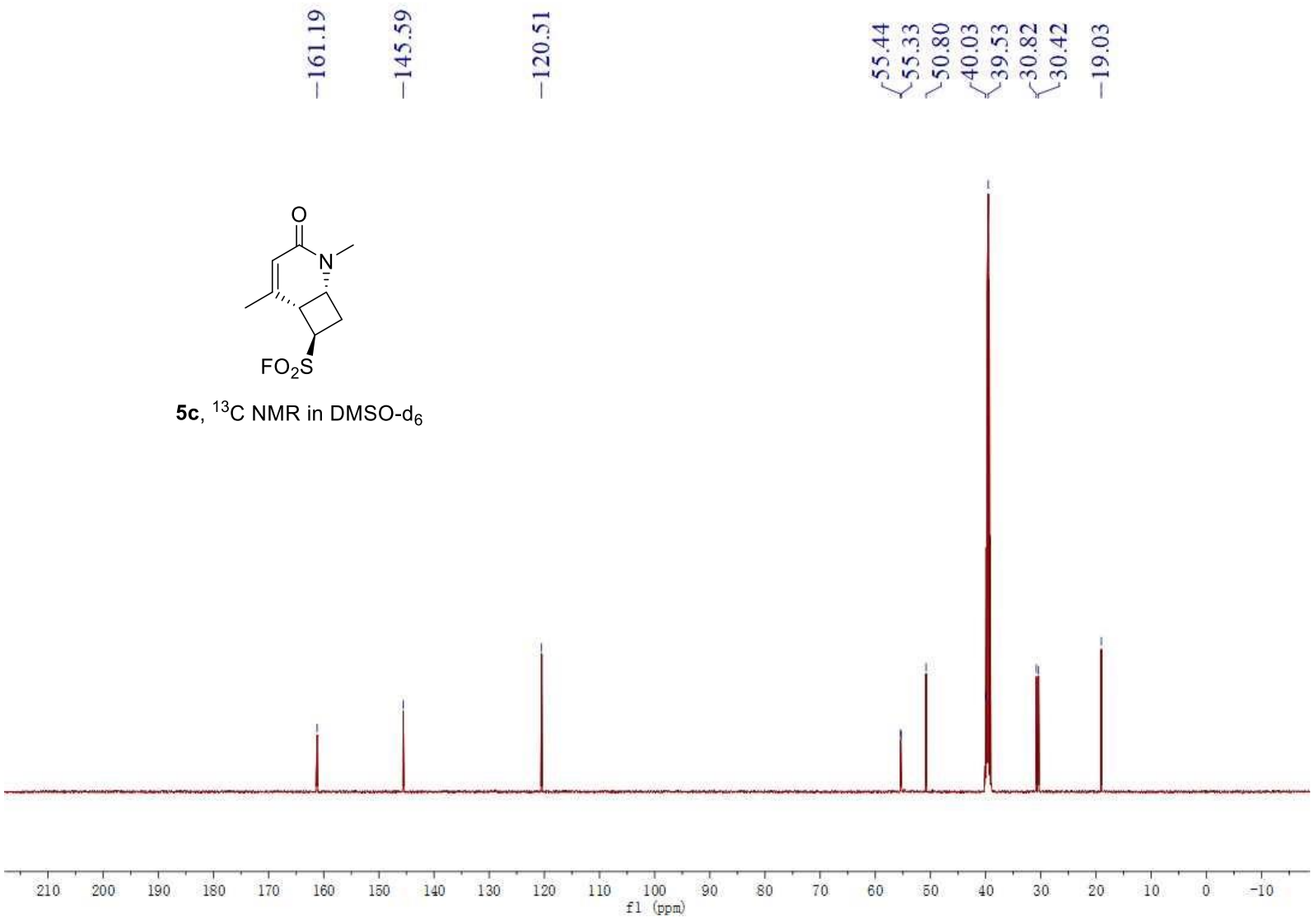

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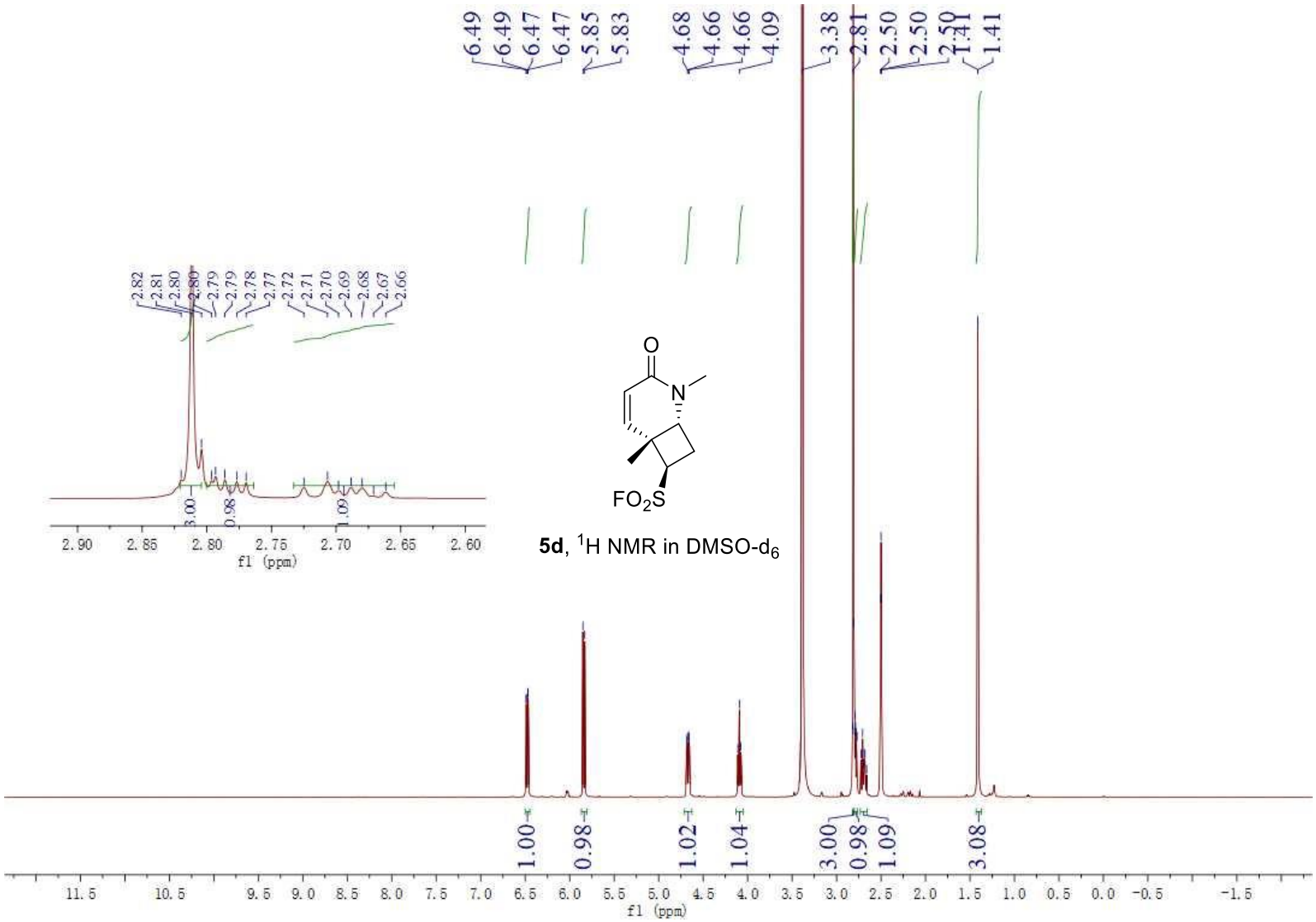

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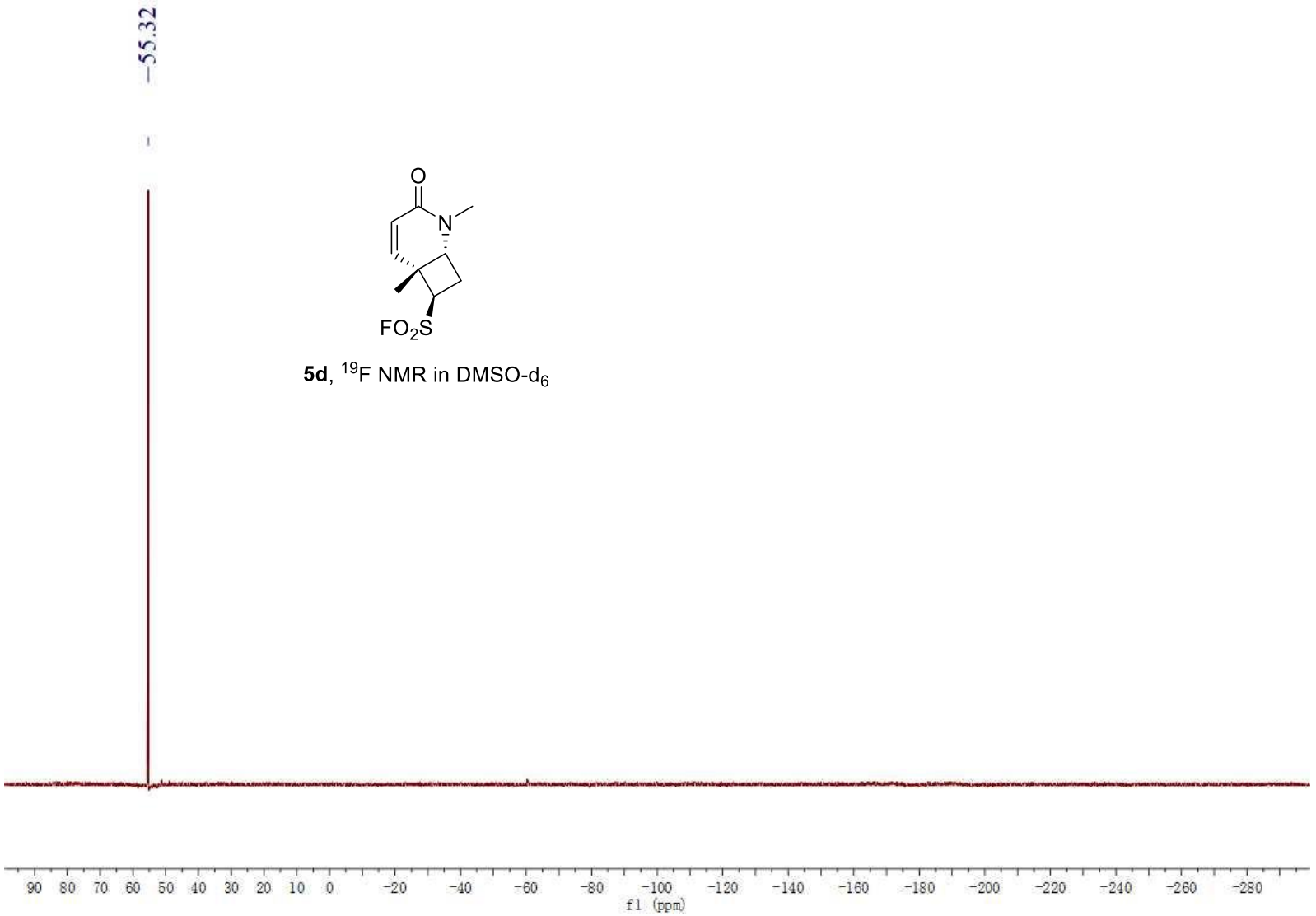

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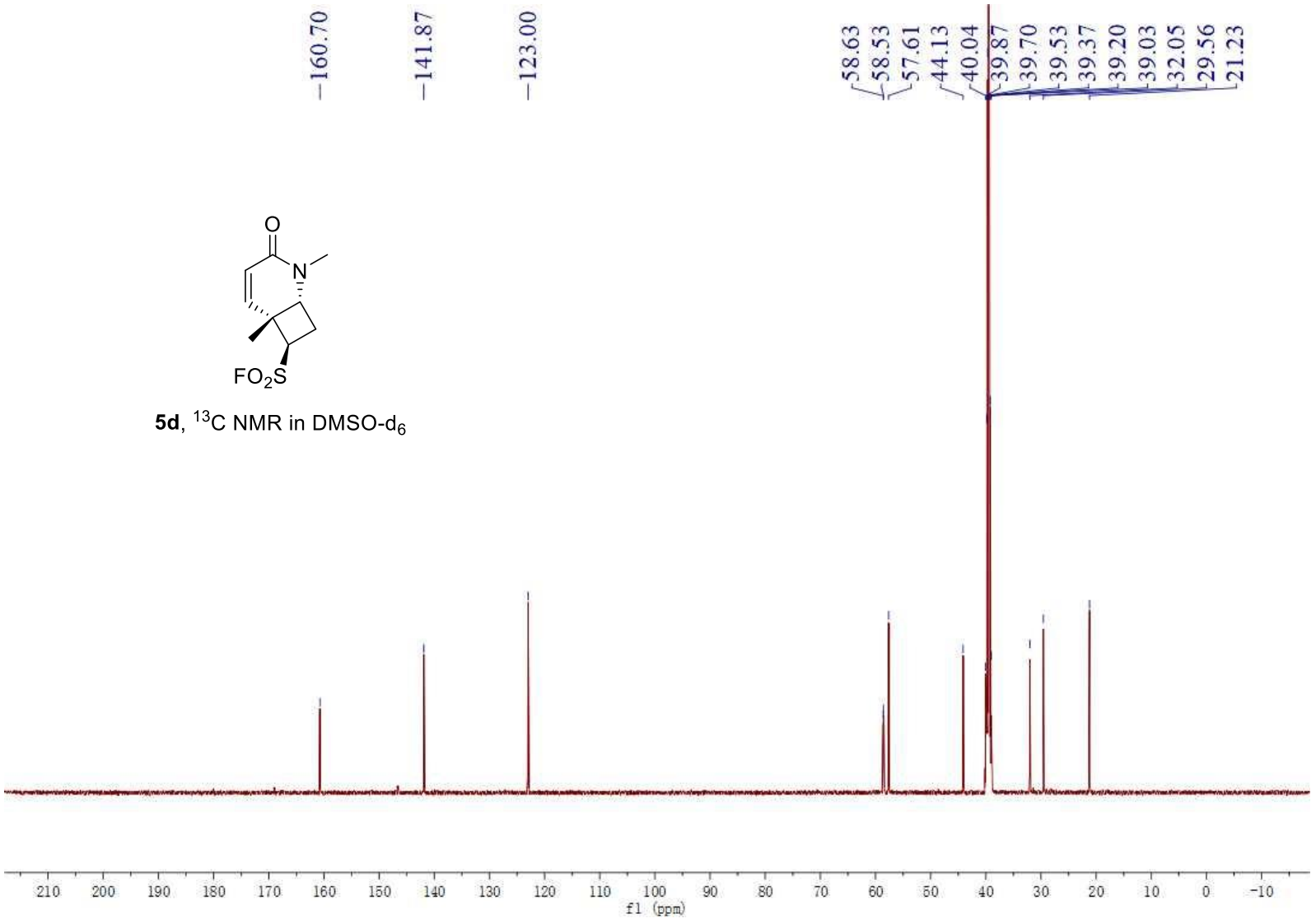

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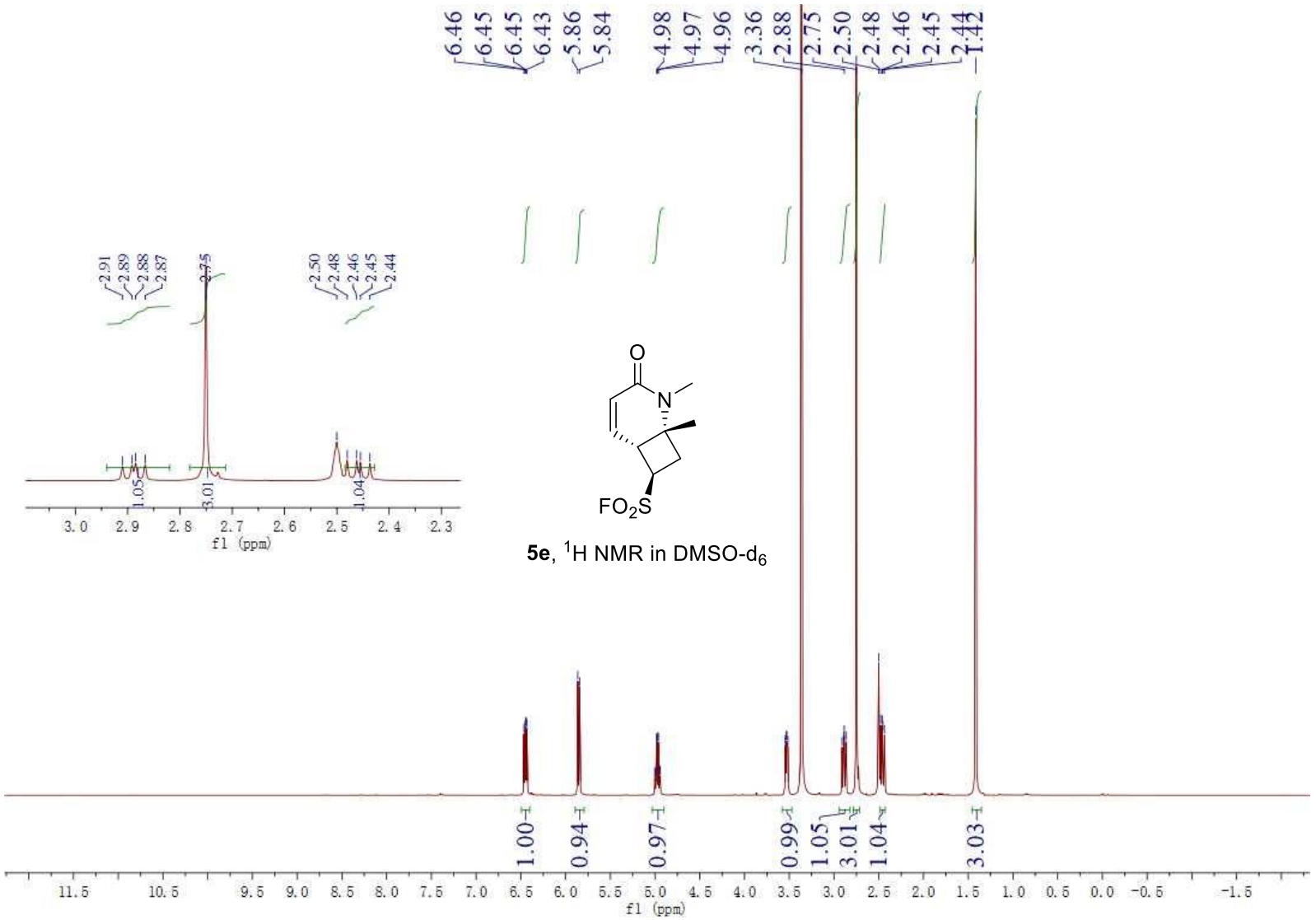
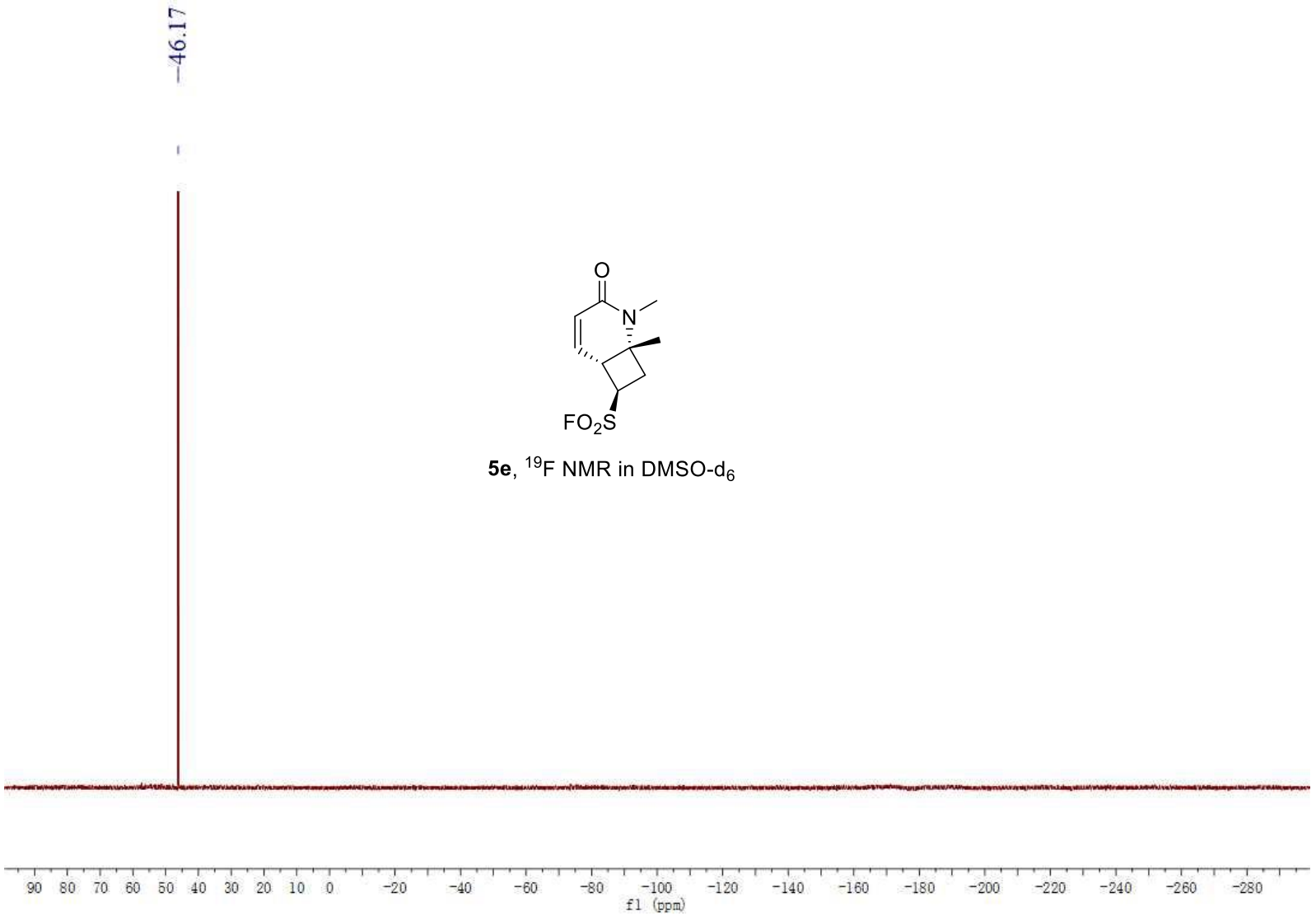


5e, ^{1}H NMR in DMSO-d_6



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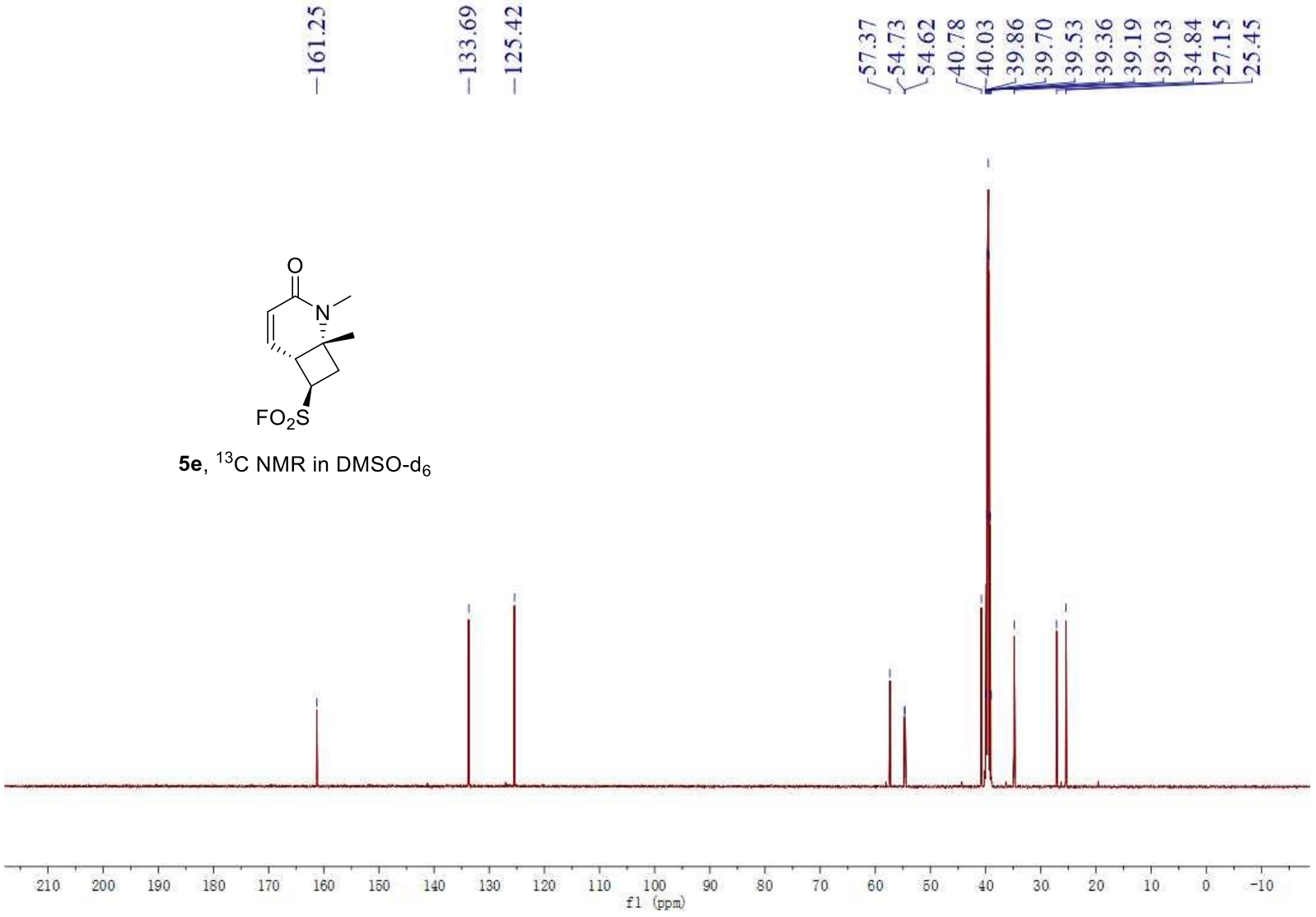
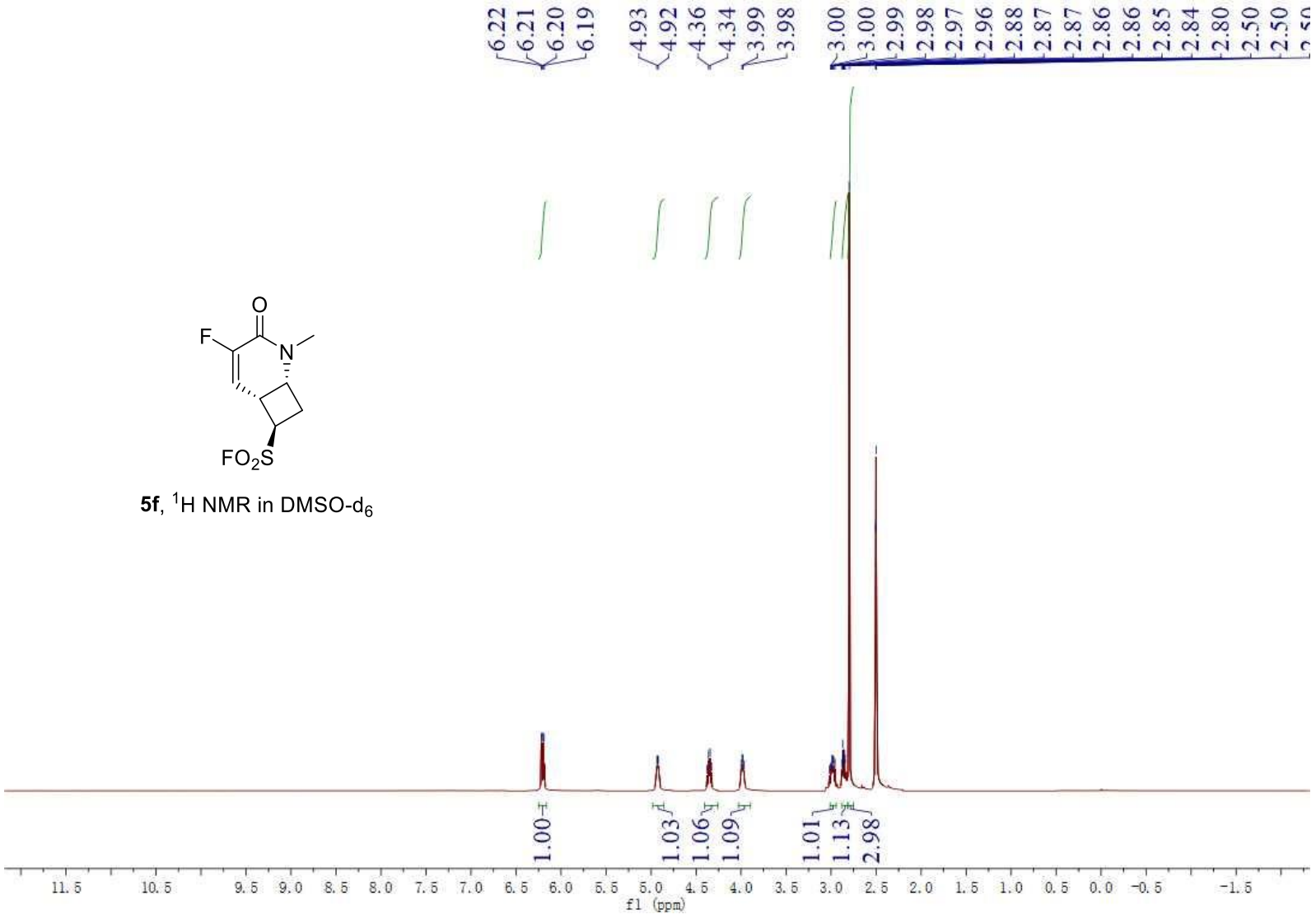
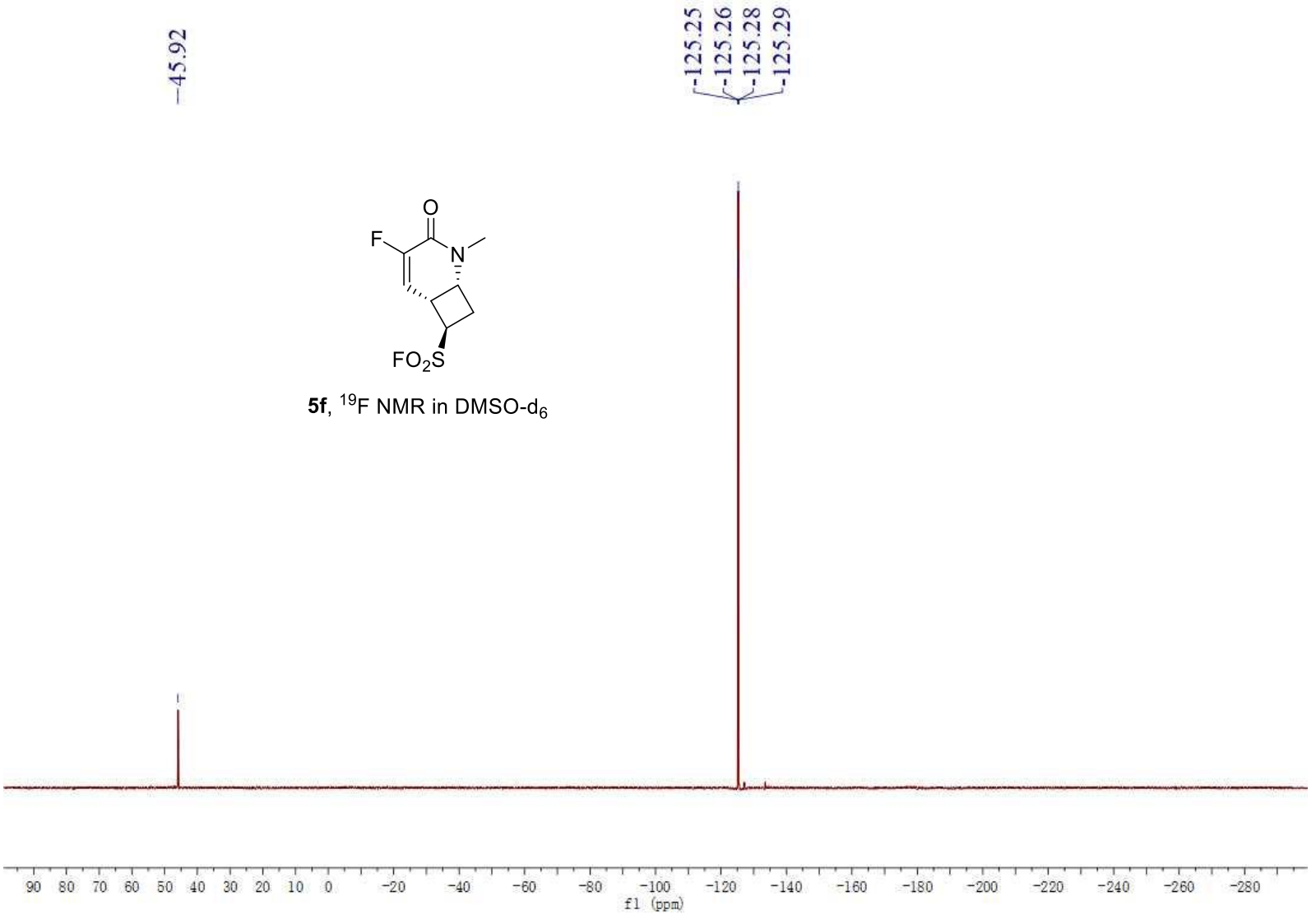


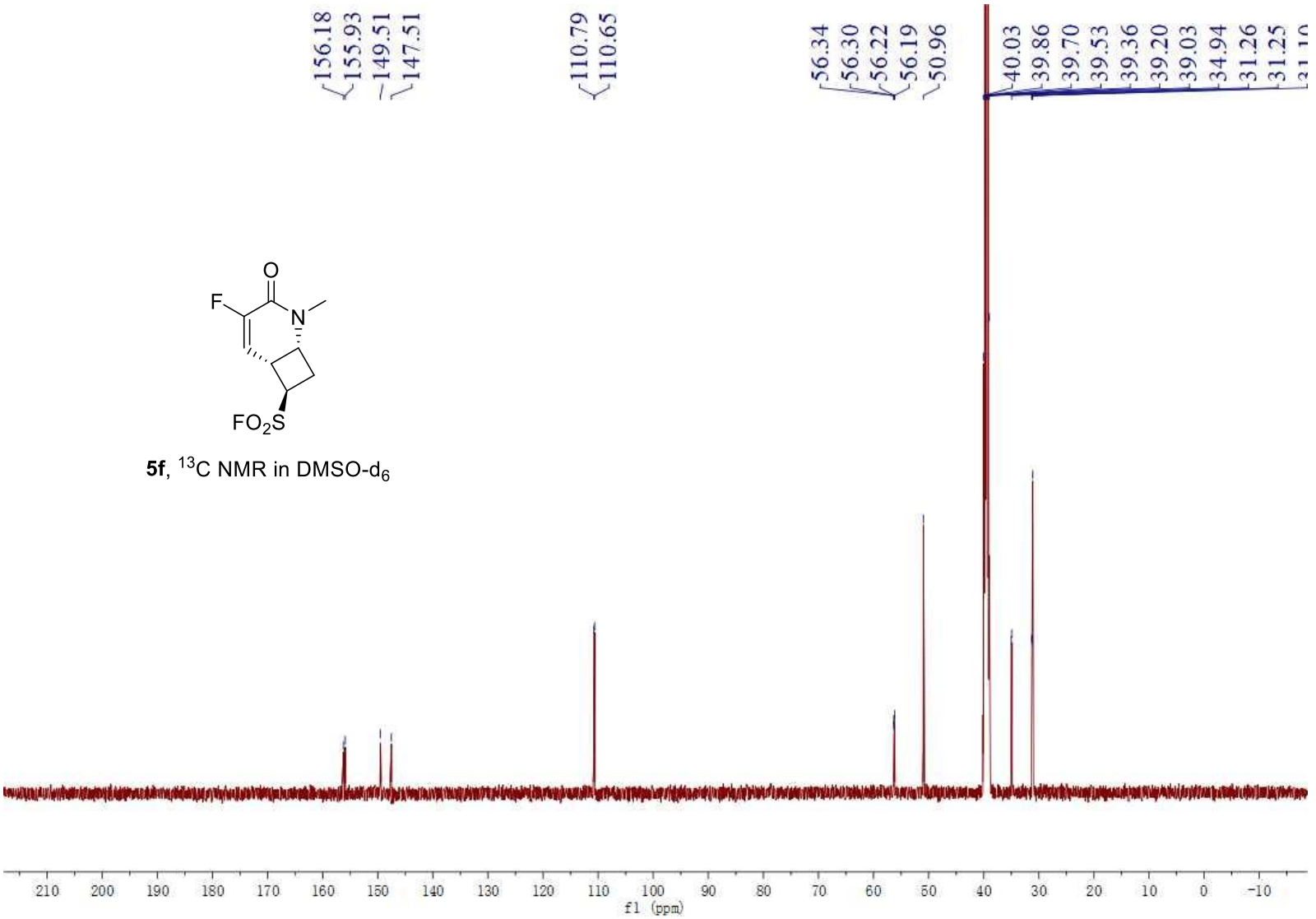
5e, ^{13}C NMR in DMSO-d_6



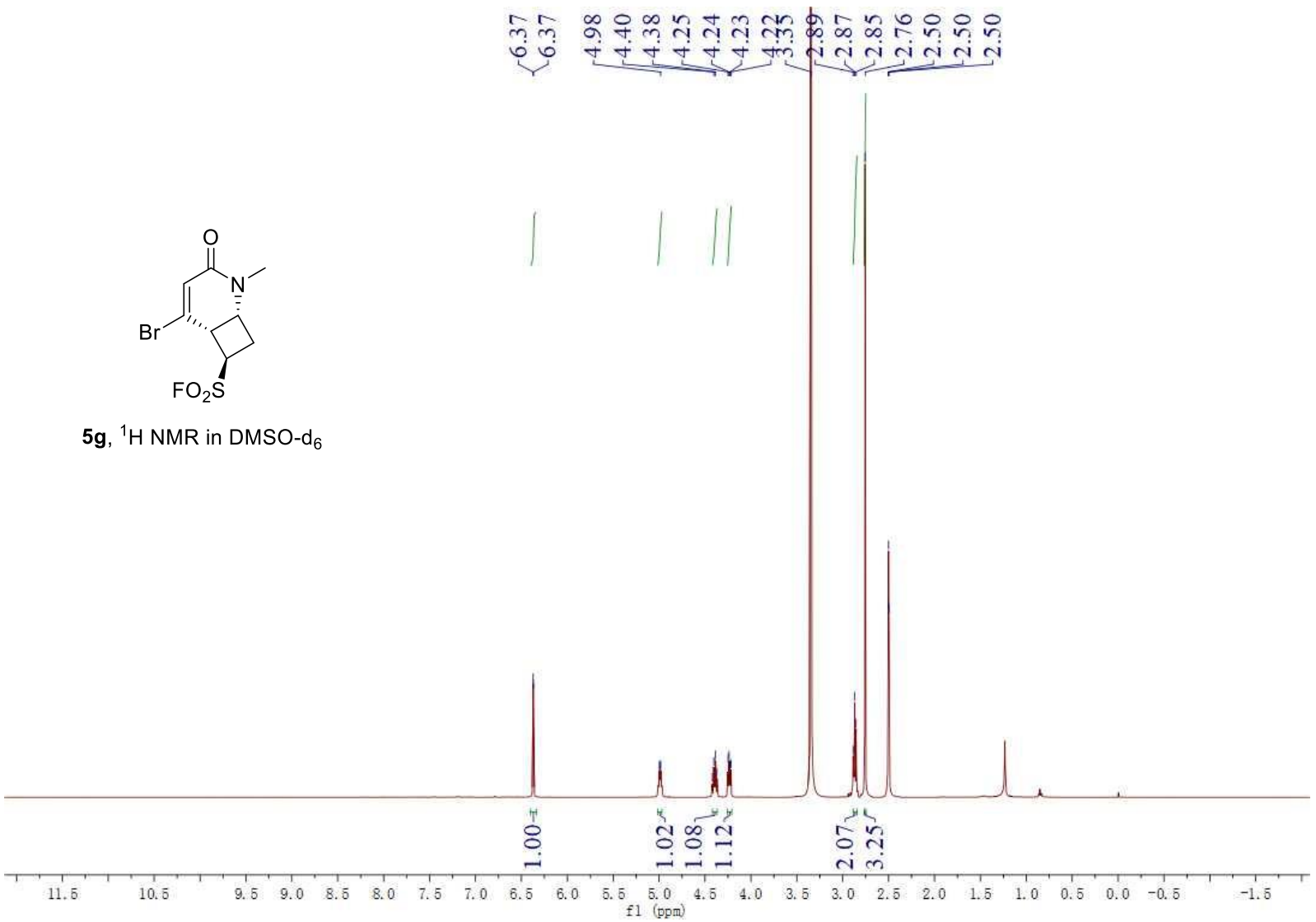
5f, ^{1}H NMR in DMSO-d_6



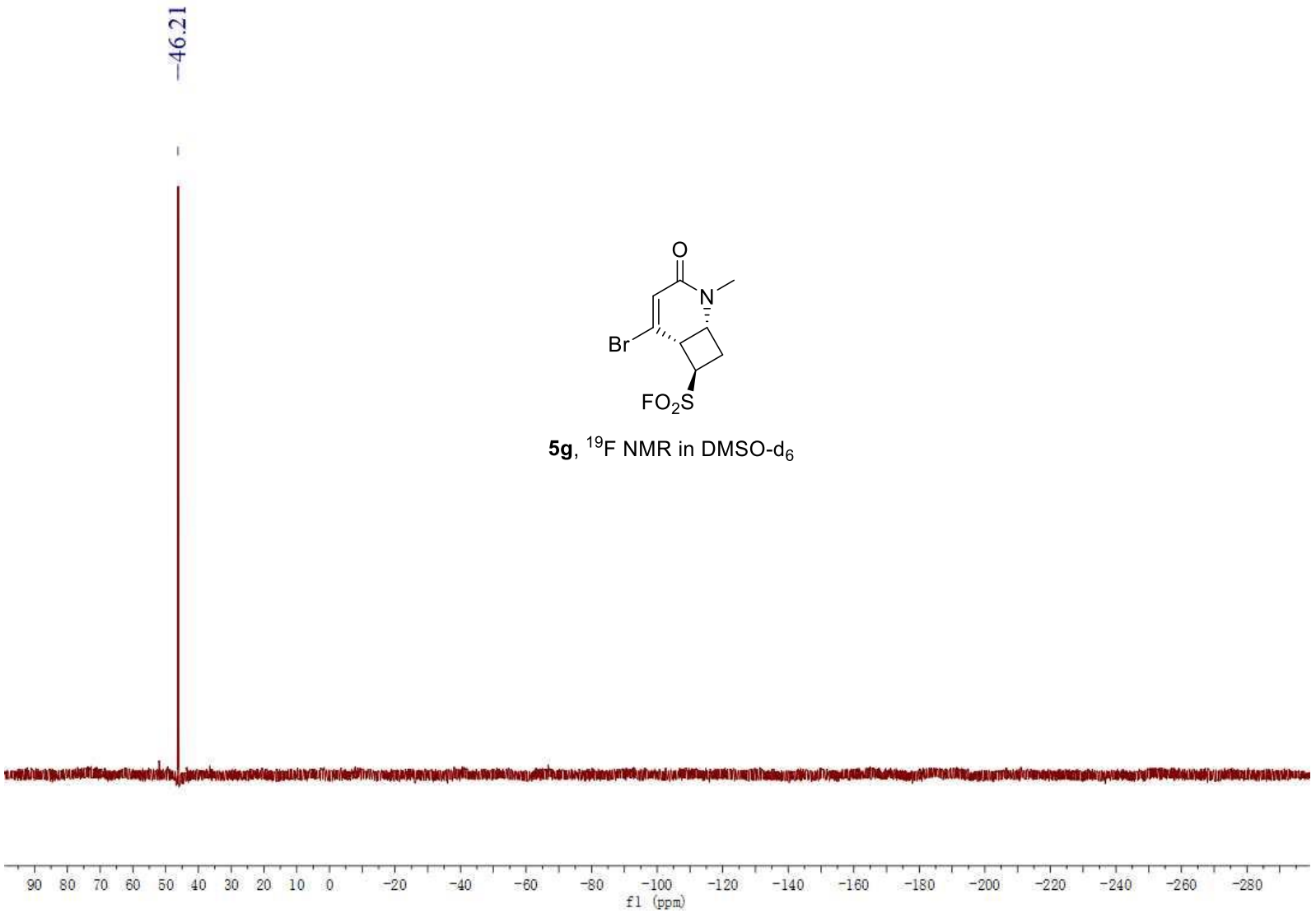
5f, ^{19}F NMR in DMSO-d_6



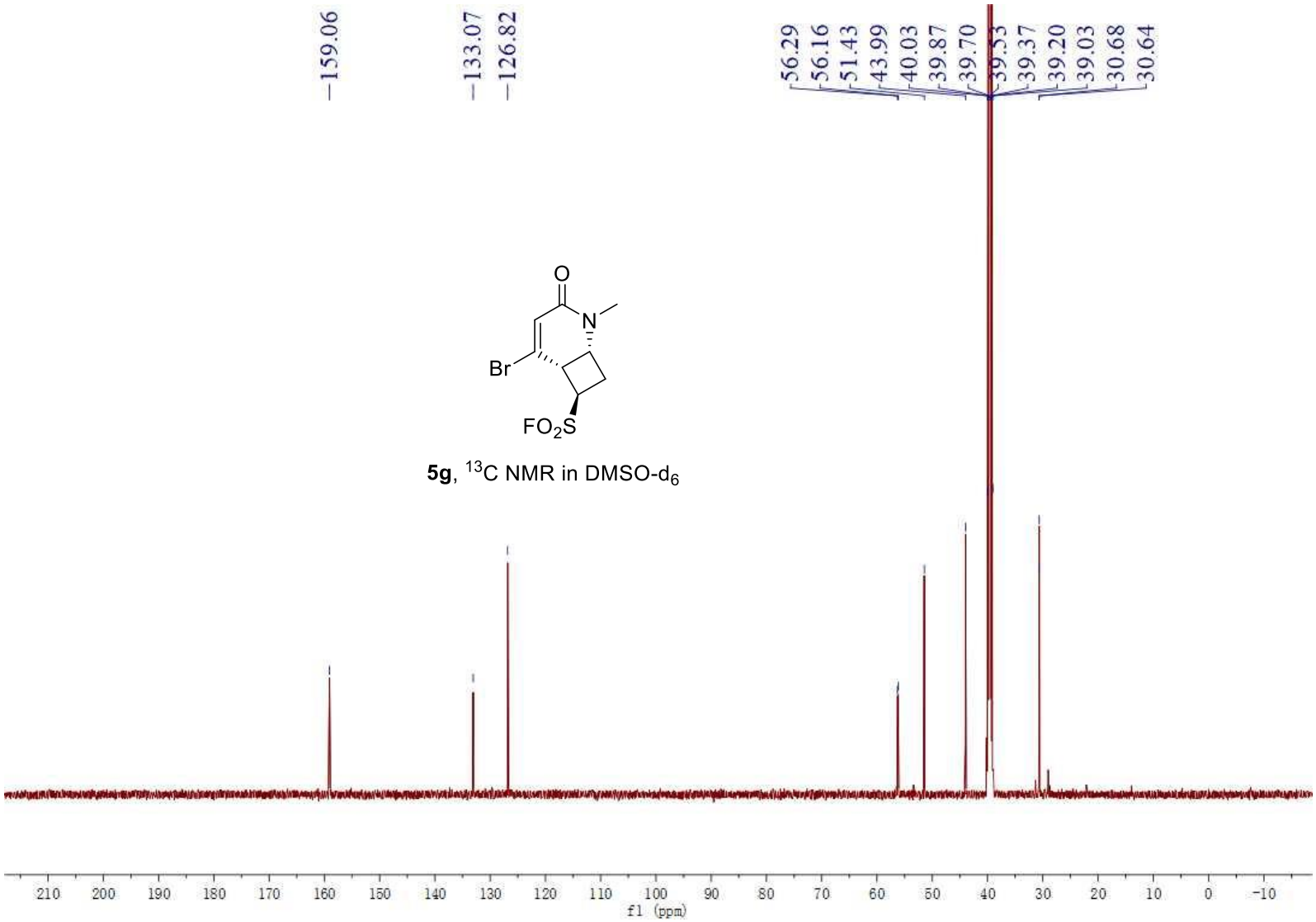
5f, ^{13}C NMR in DMSO-d_6



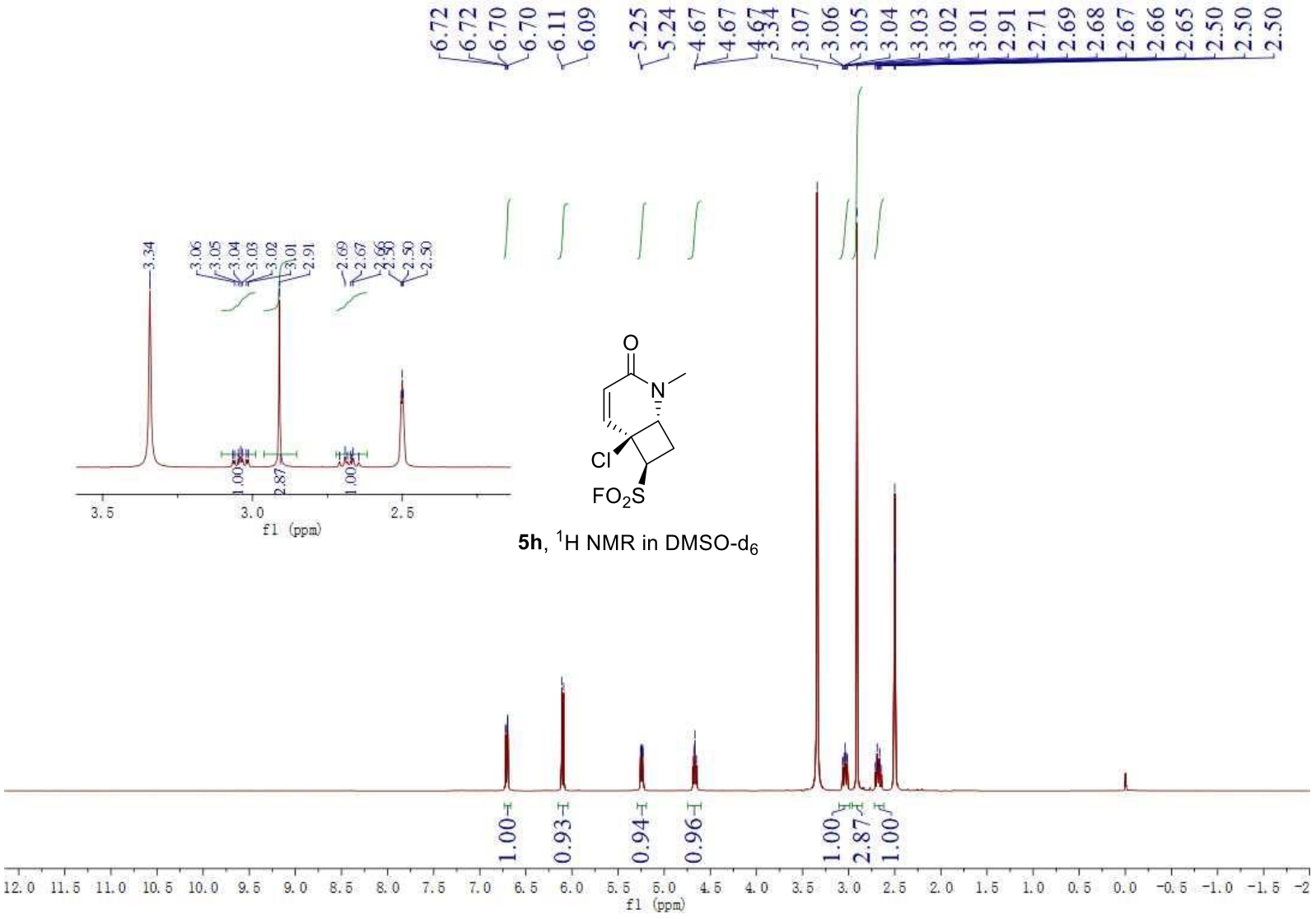
5g, ^{1}H NMR in DMSO-d_6



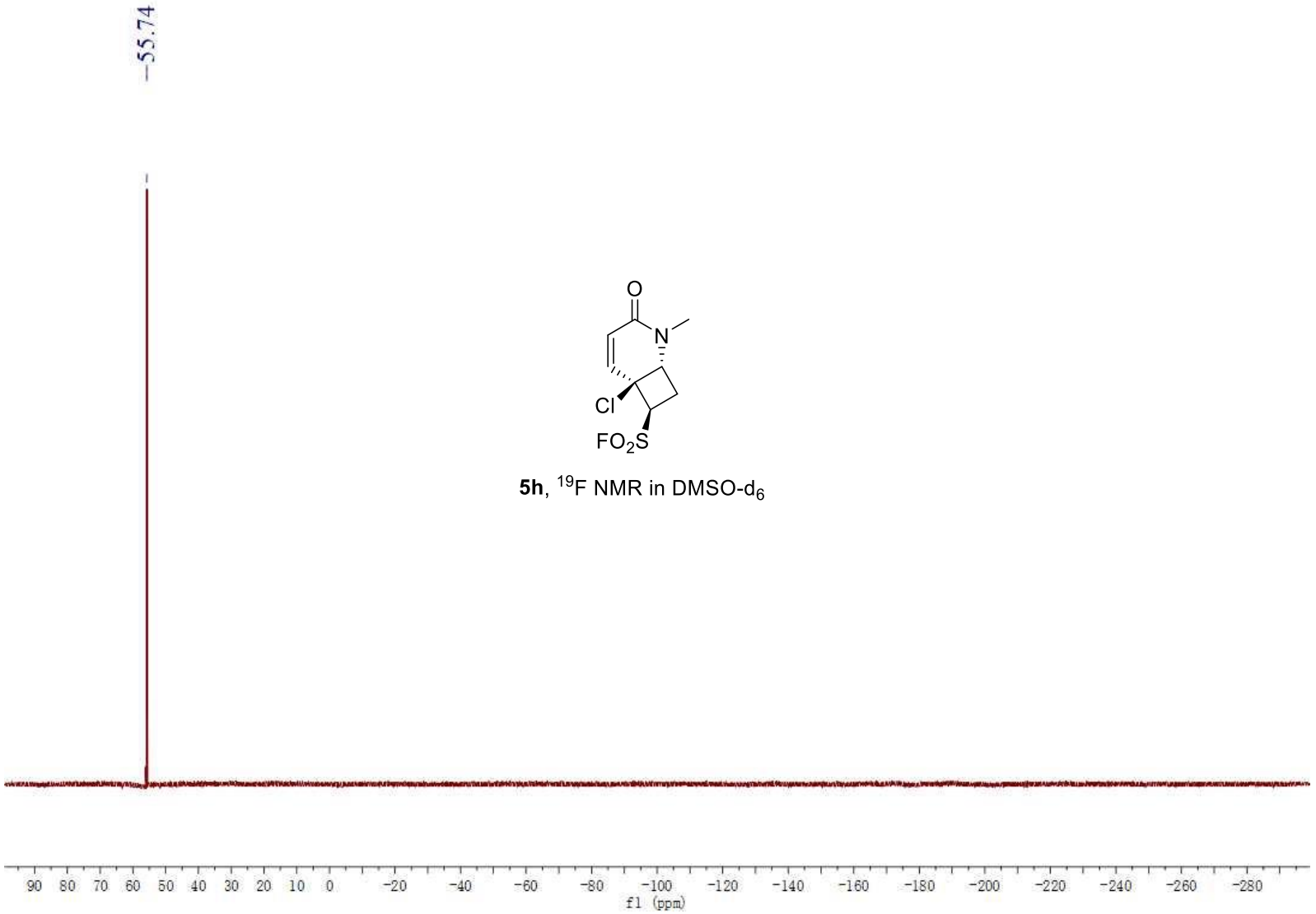
5g, ^{19}F NMR in DMSO-d_6



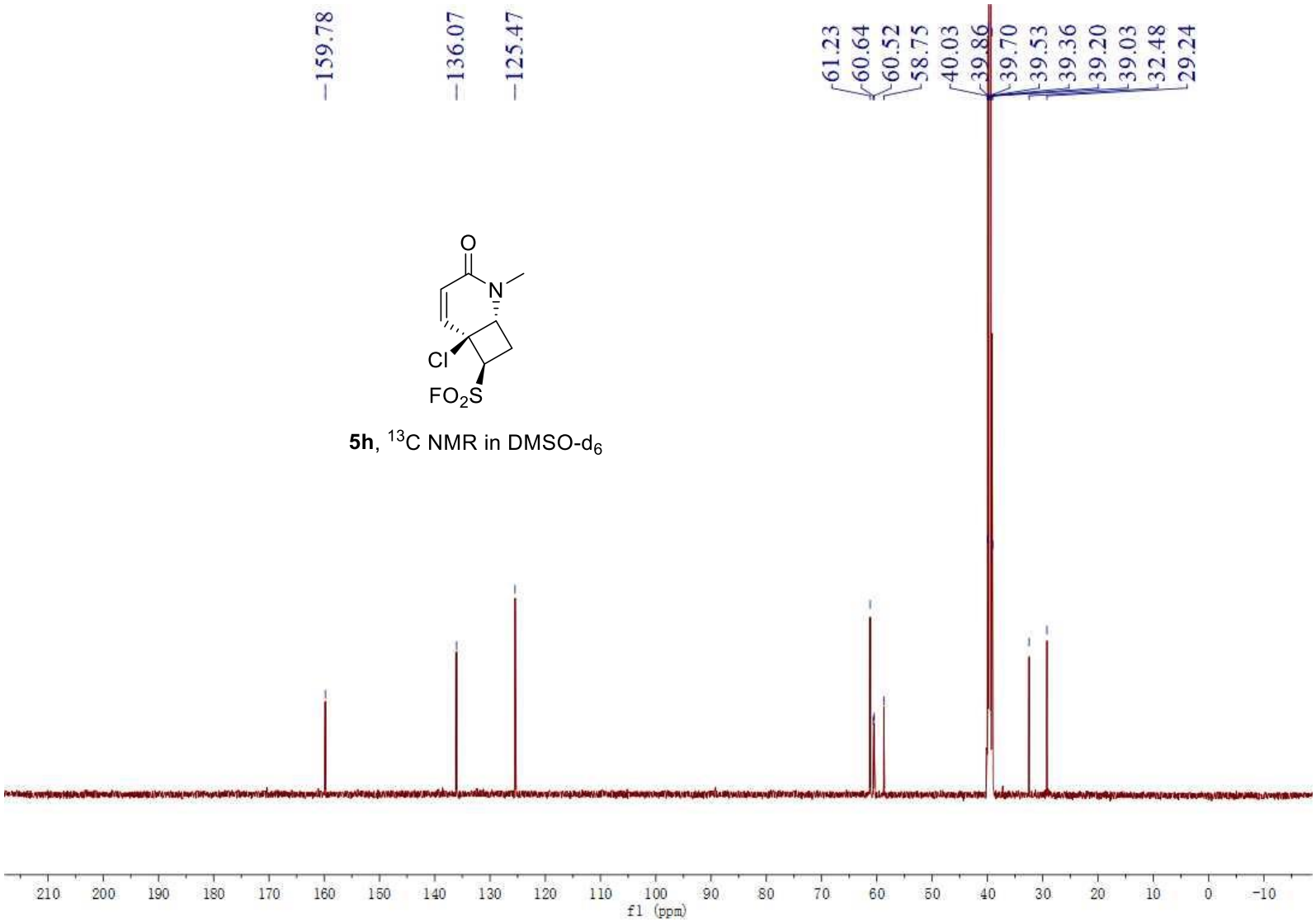
5g, ^{13}C NMR in DMSO-d_6



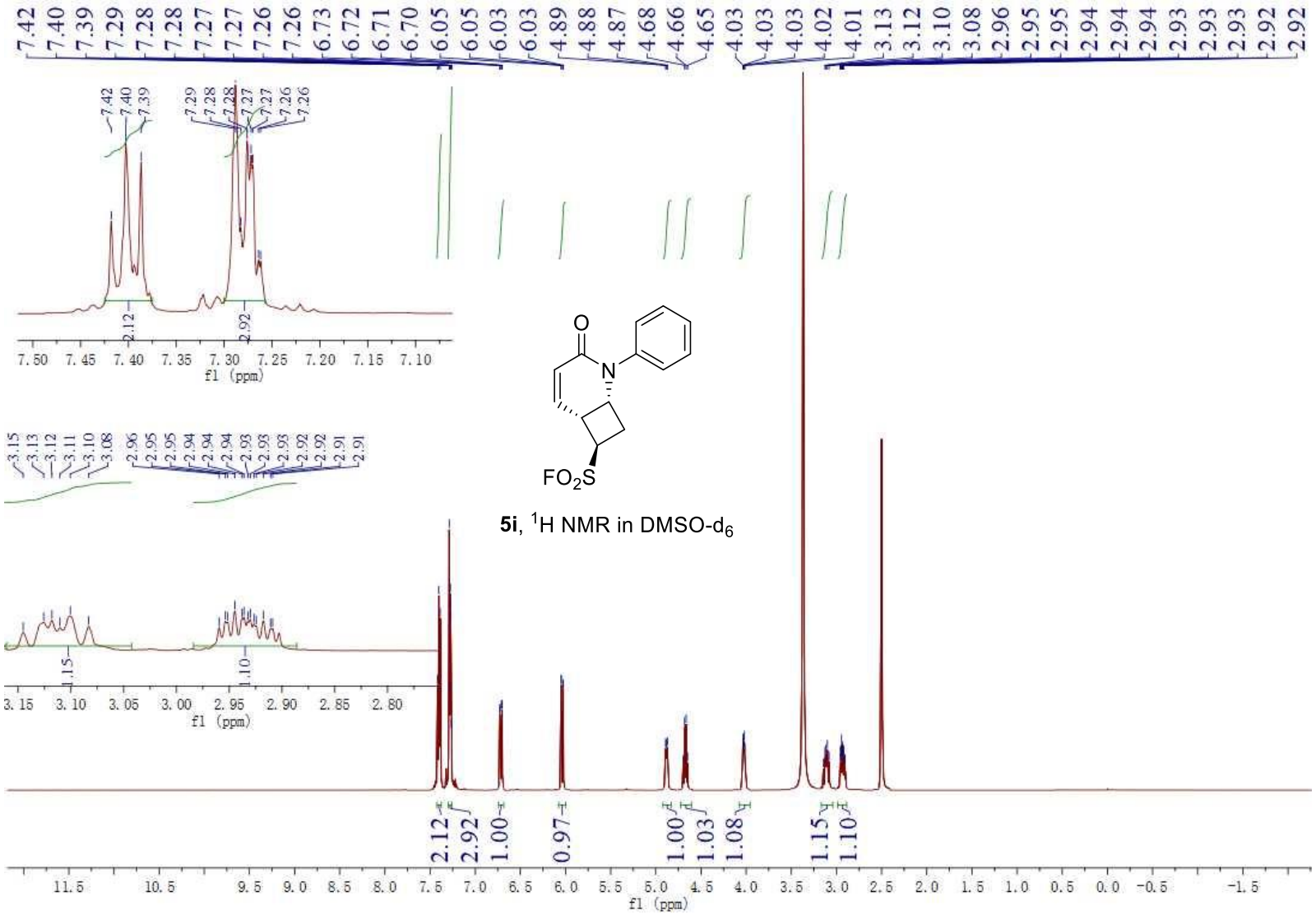
5h, ^{1}H NMR in DMSO-d_6



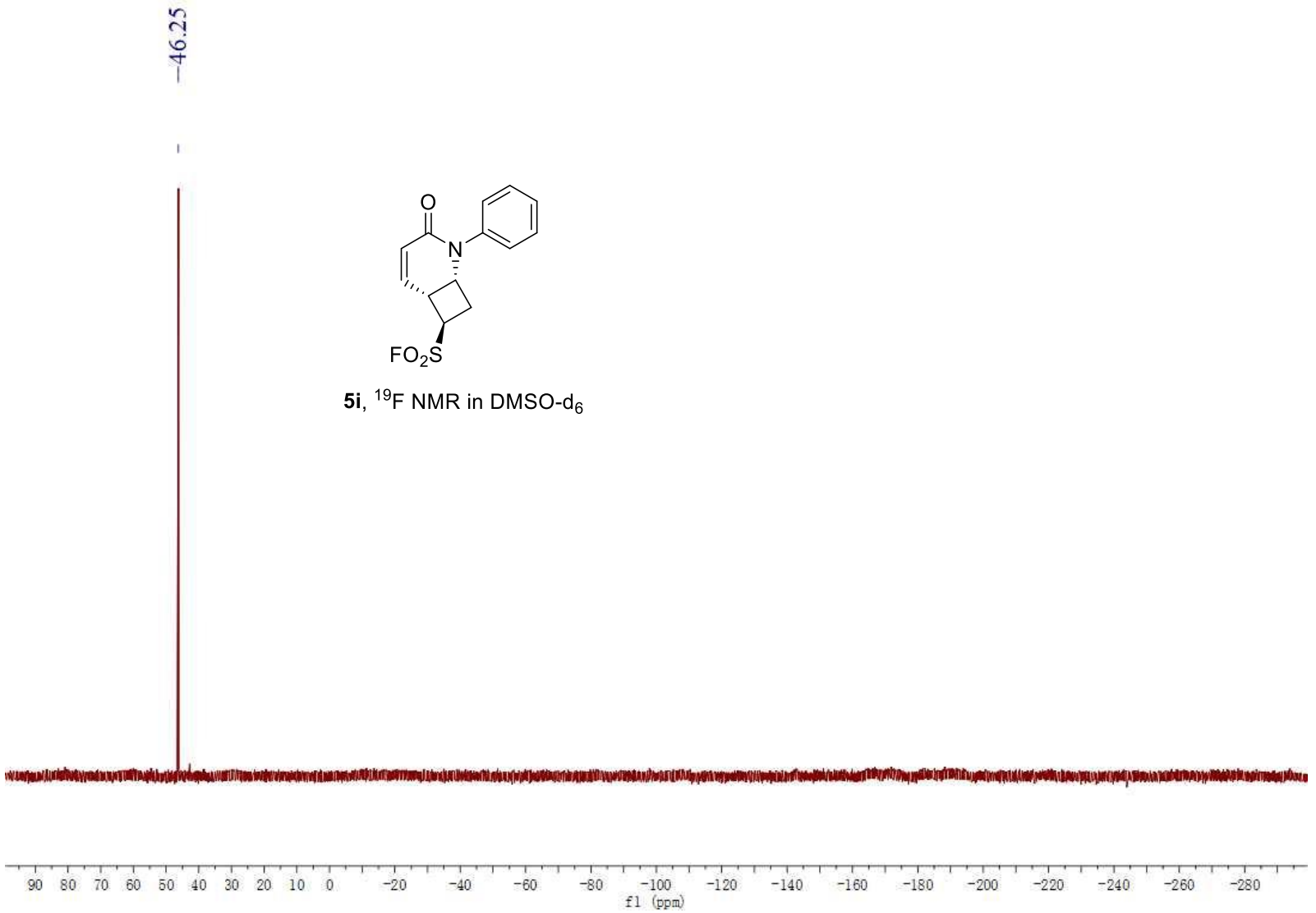
5h, ^{19}F NMR in DMSO-d_6



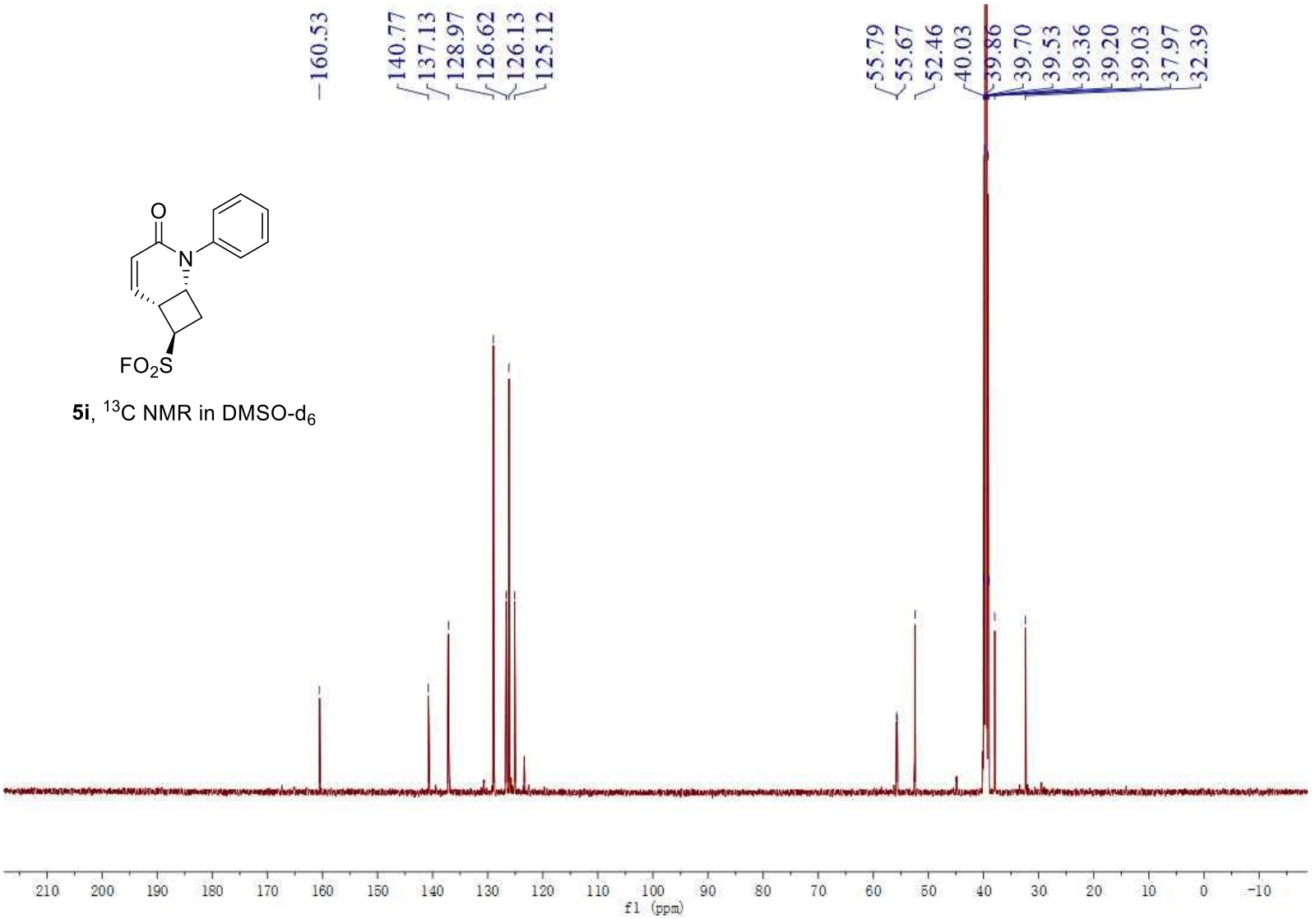
5h, ^{13}C NMR in DMSO-d_6



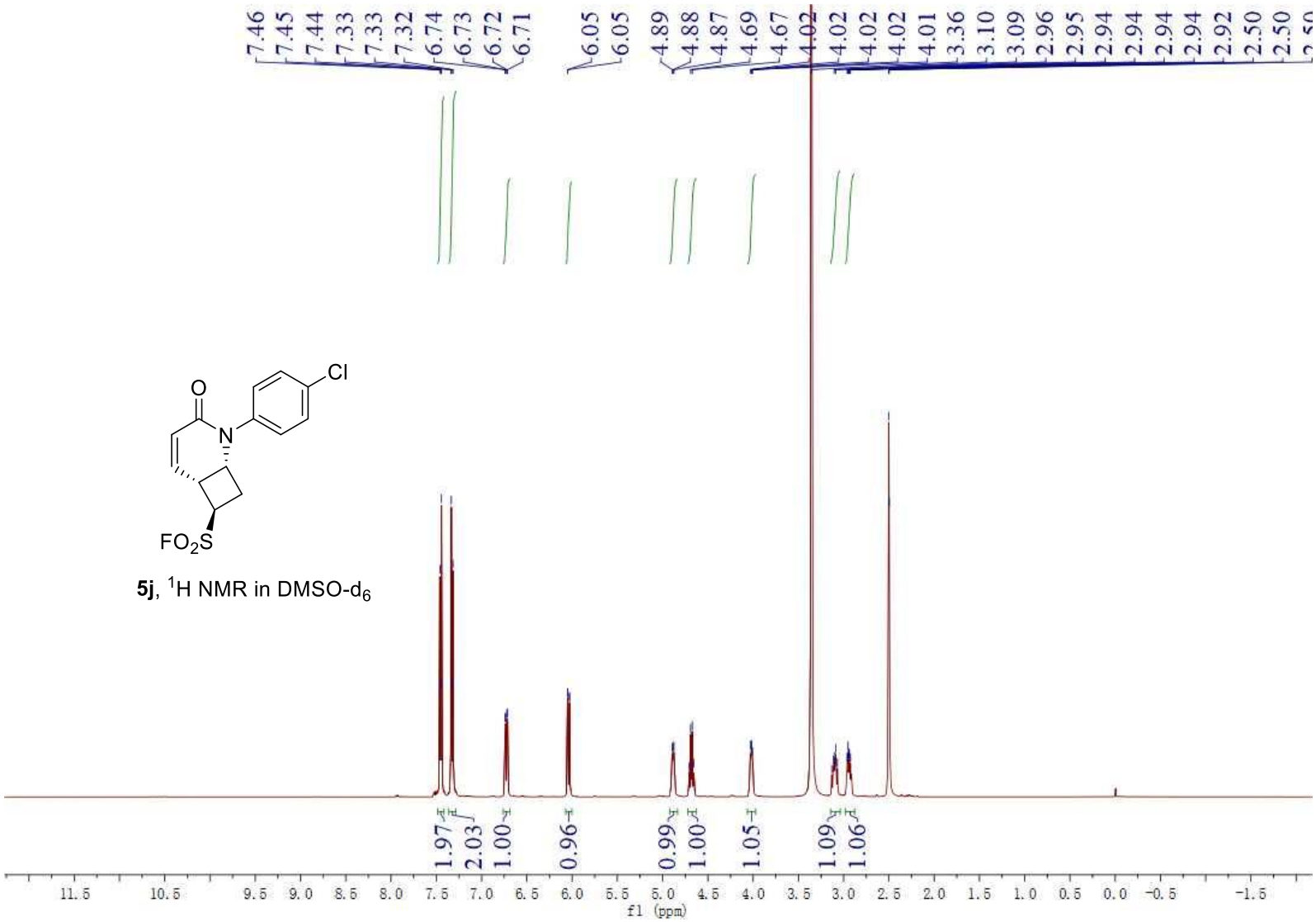
5i, ^{1}H NMR in DMSO-d$_6$



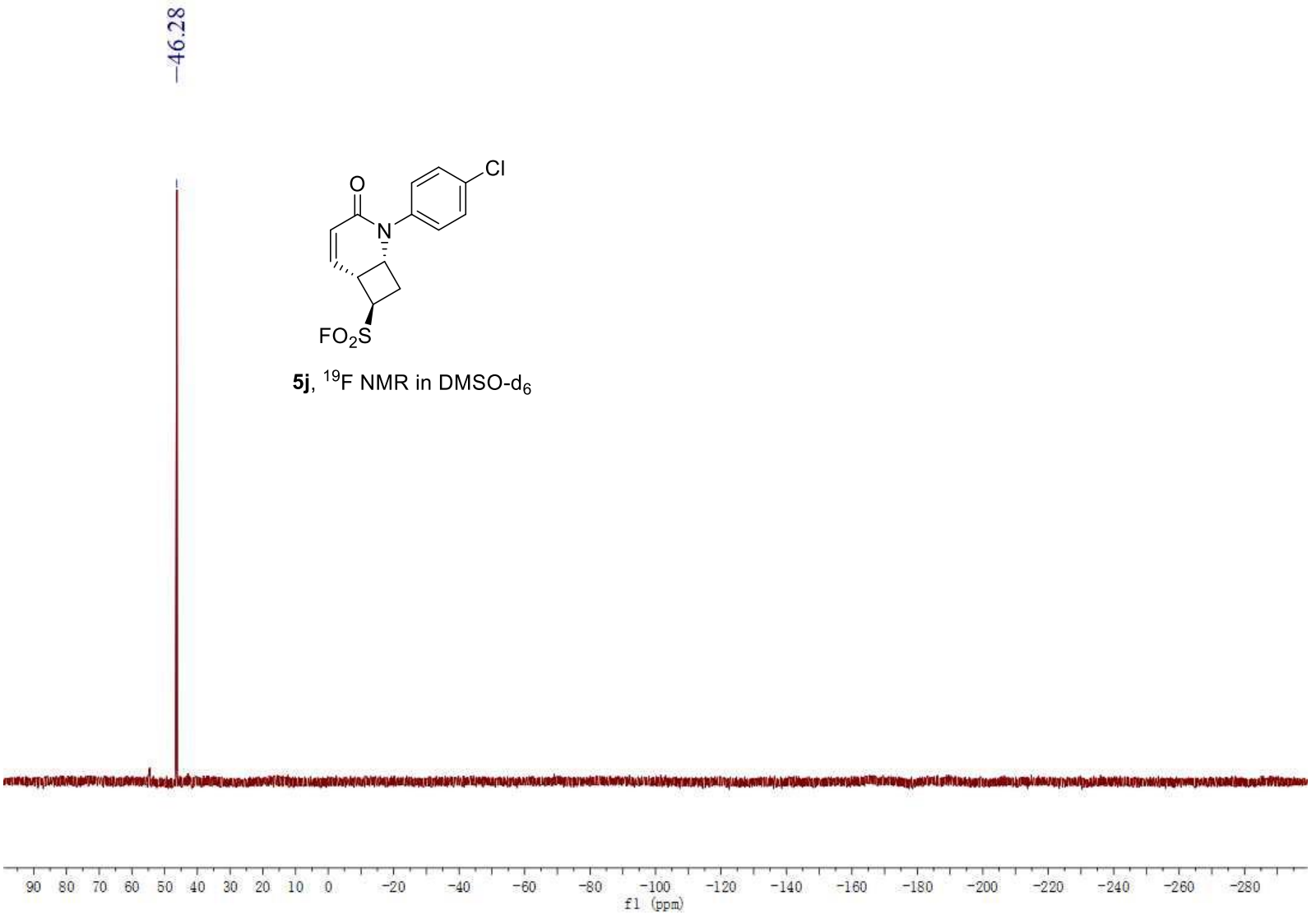
5i, ^{19}F NMR in DMSO-d_6



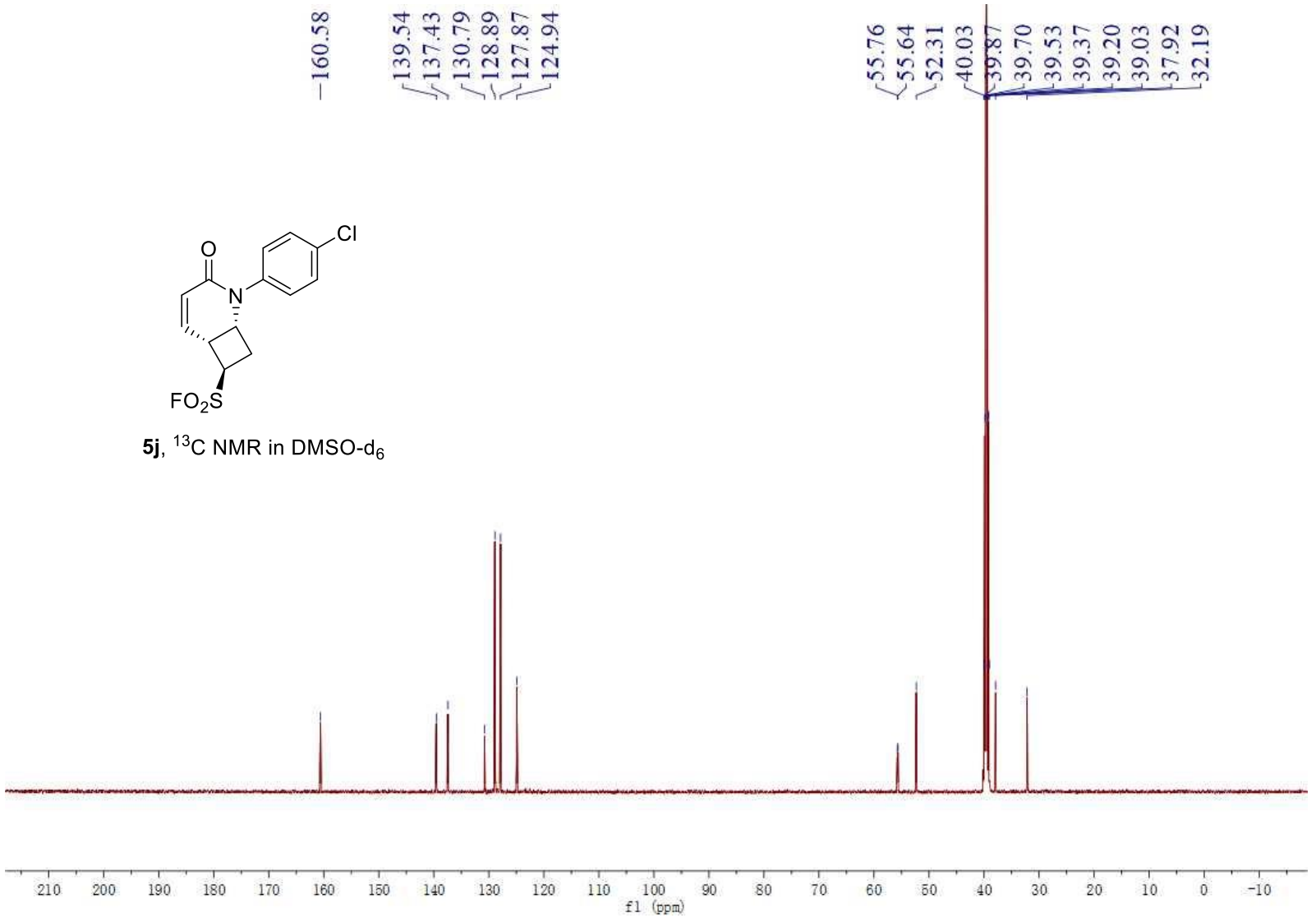
5i, ^{13}C NMR in DMSO-d_6



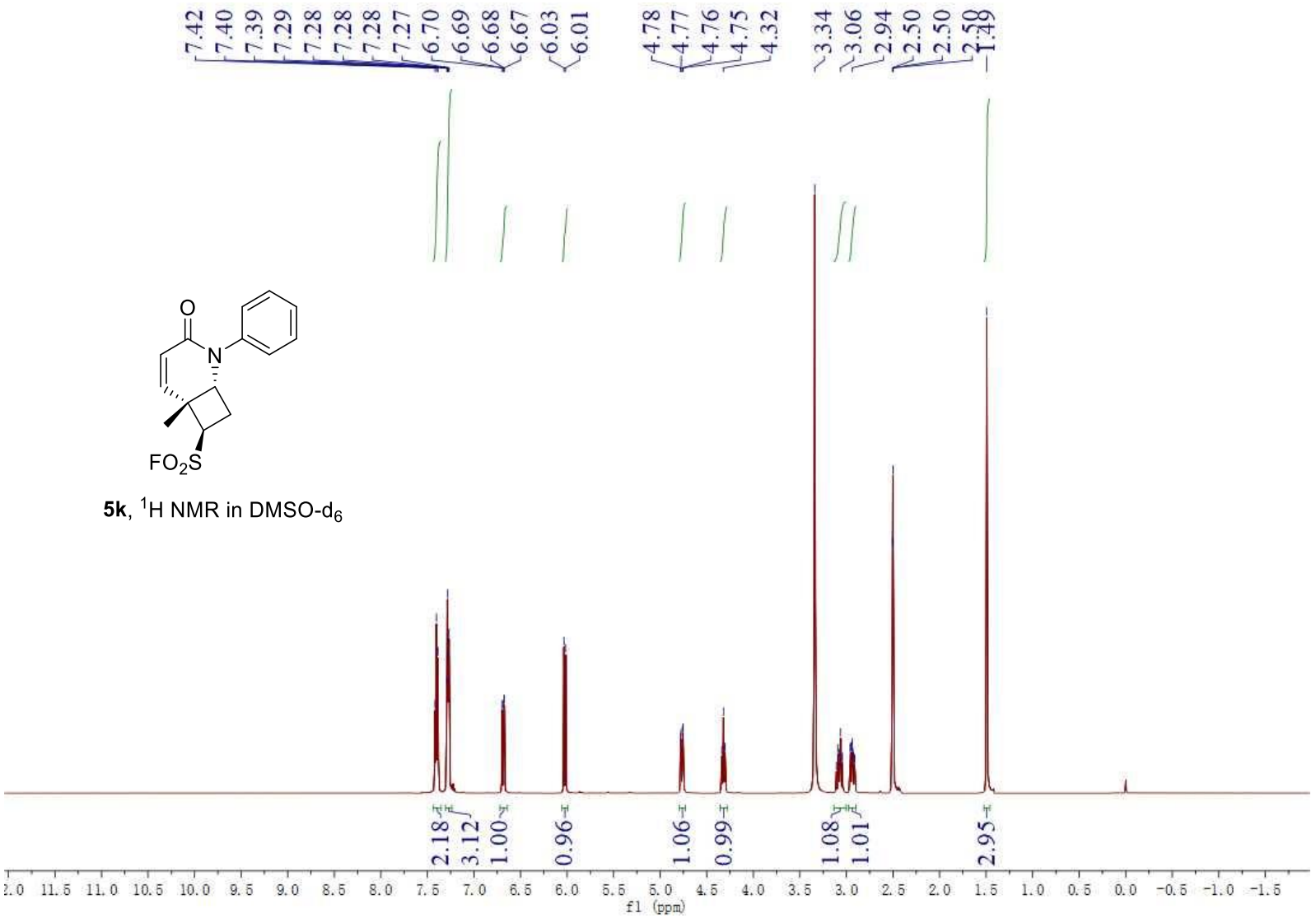
5j, ^{1}H NMR in DMSO-d_6



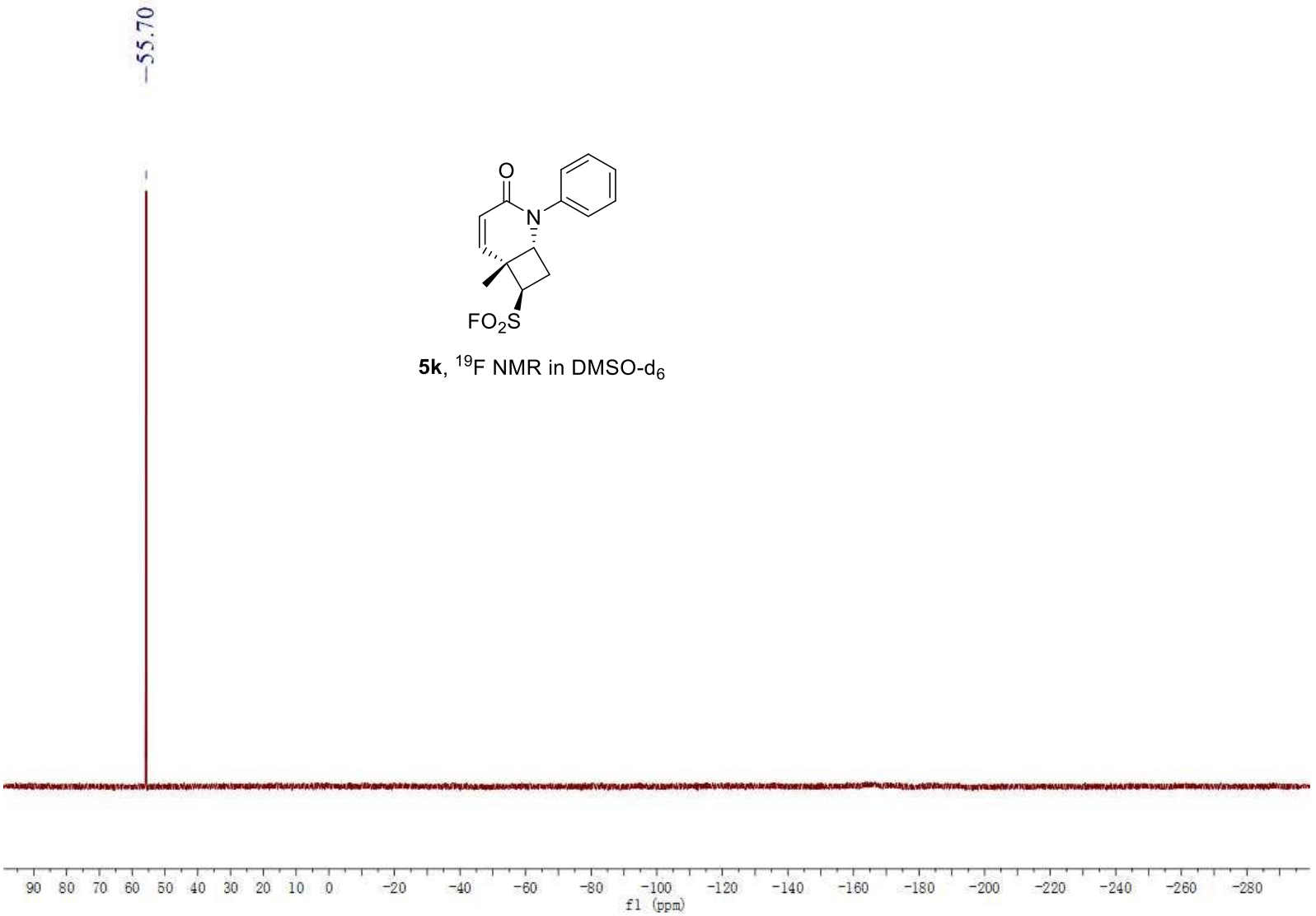
5j, ^{19}F NMR in DMSO-d_6



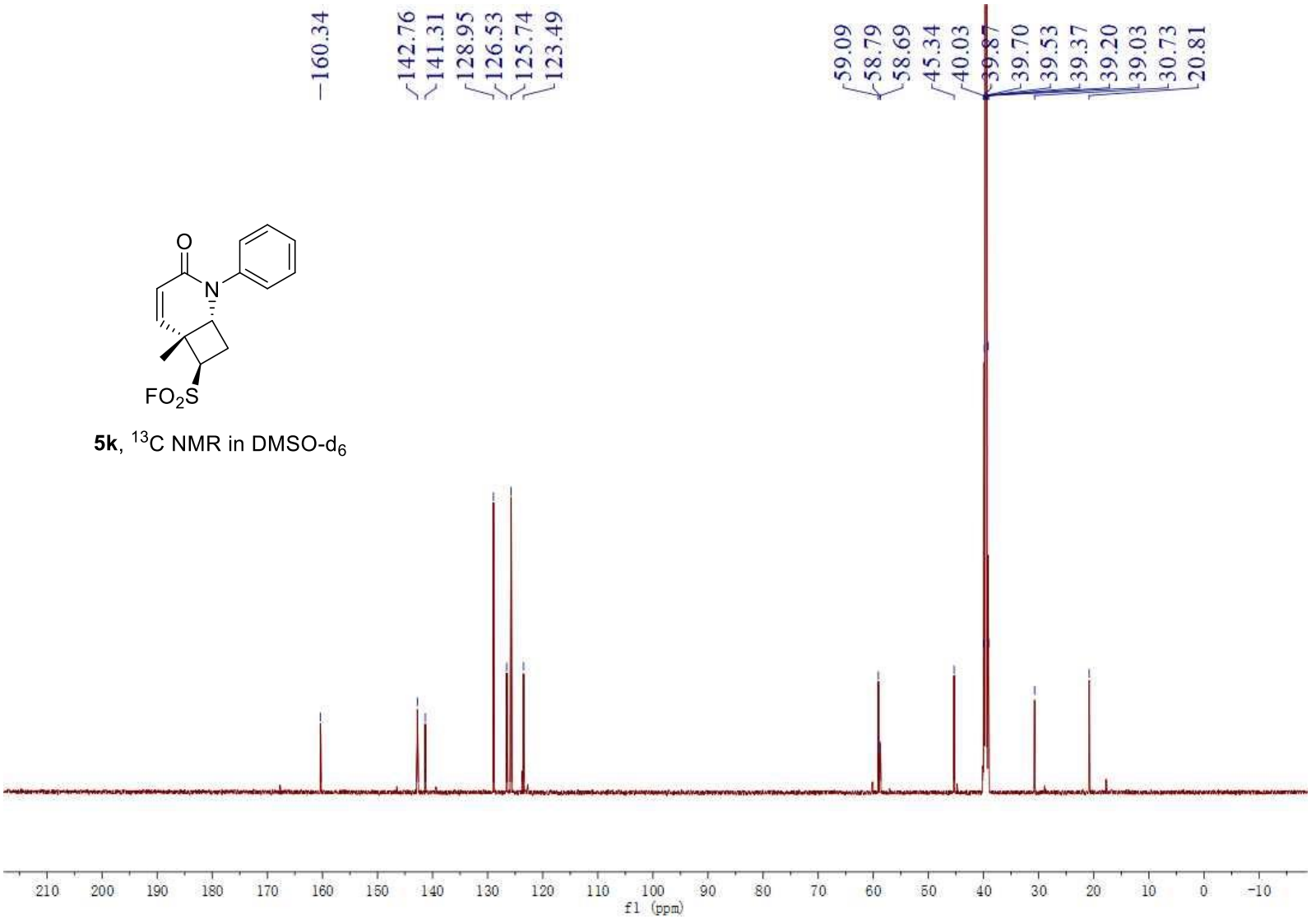
5j, ^{13}C NMR in DMSO-d_6



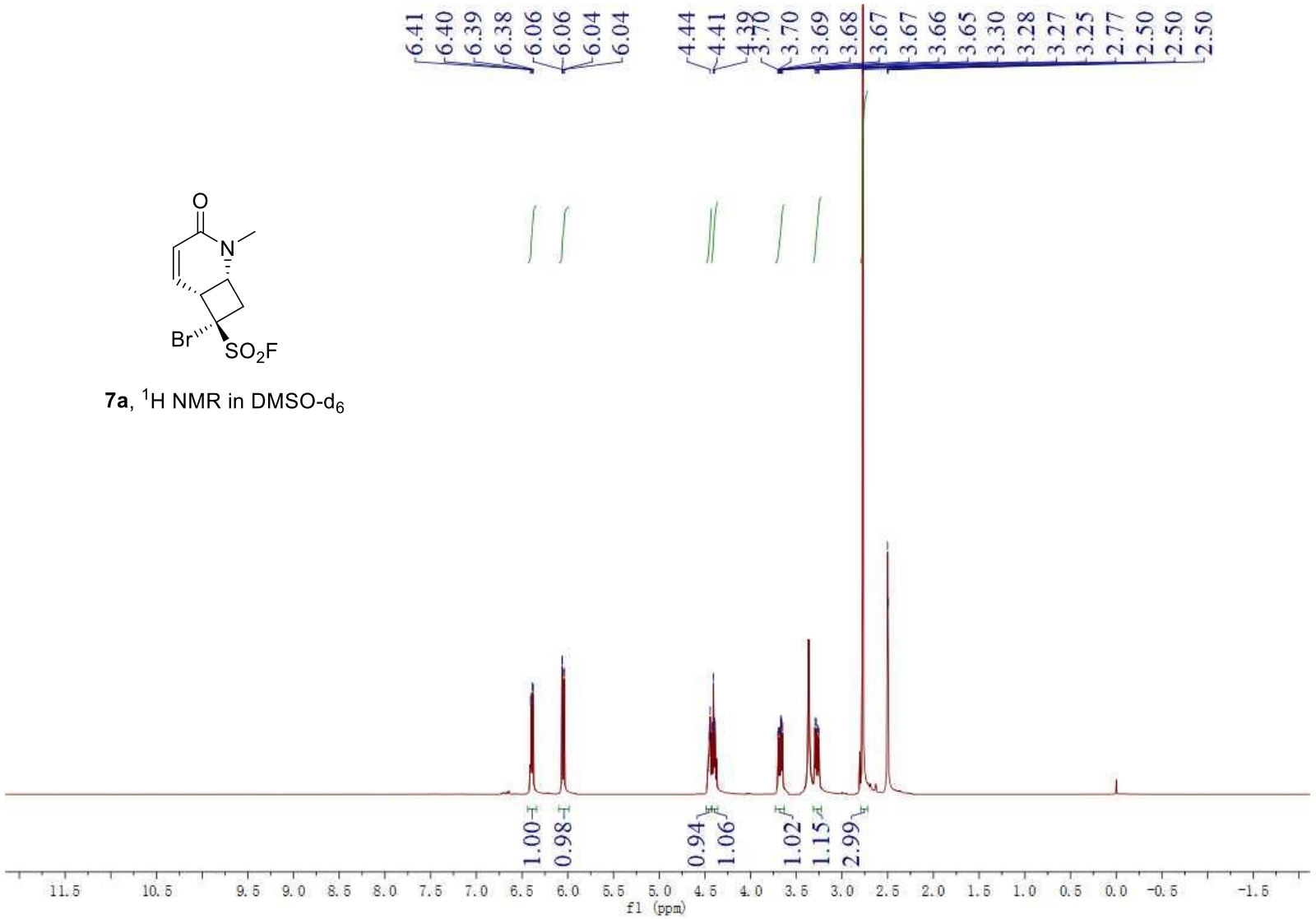
5k, ^{1}H NMR in DMSO-d_6



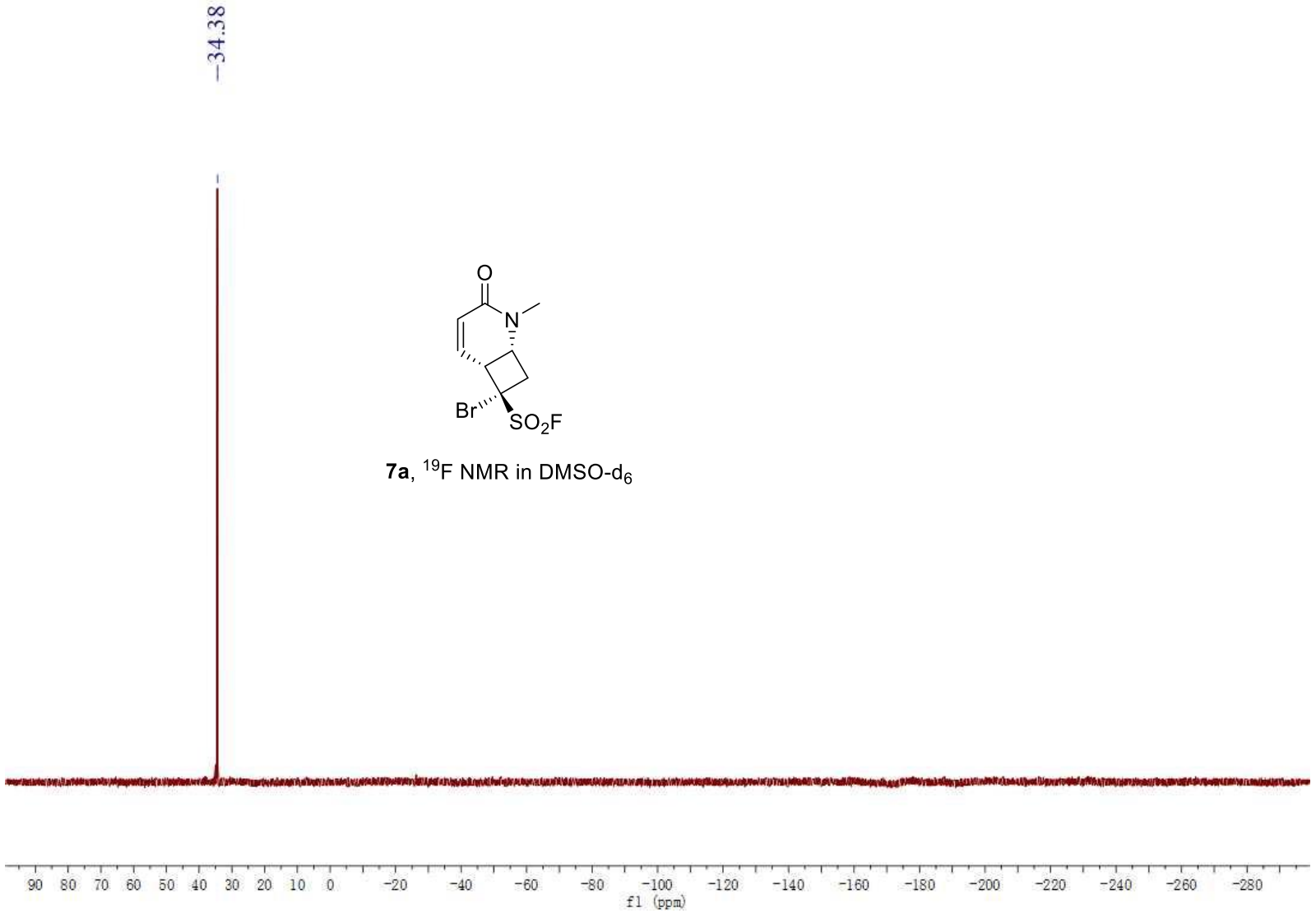
5k, ^{19}F NMR in DMSO-d_6



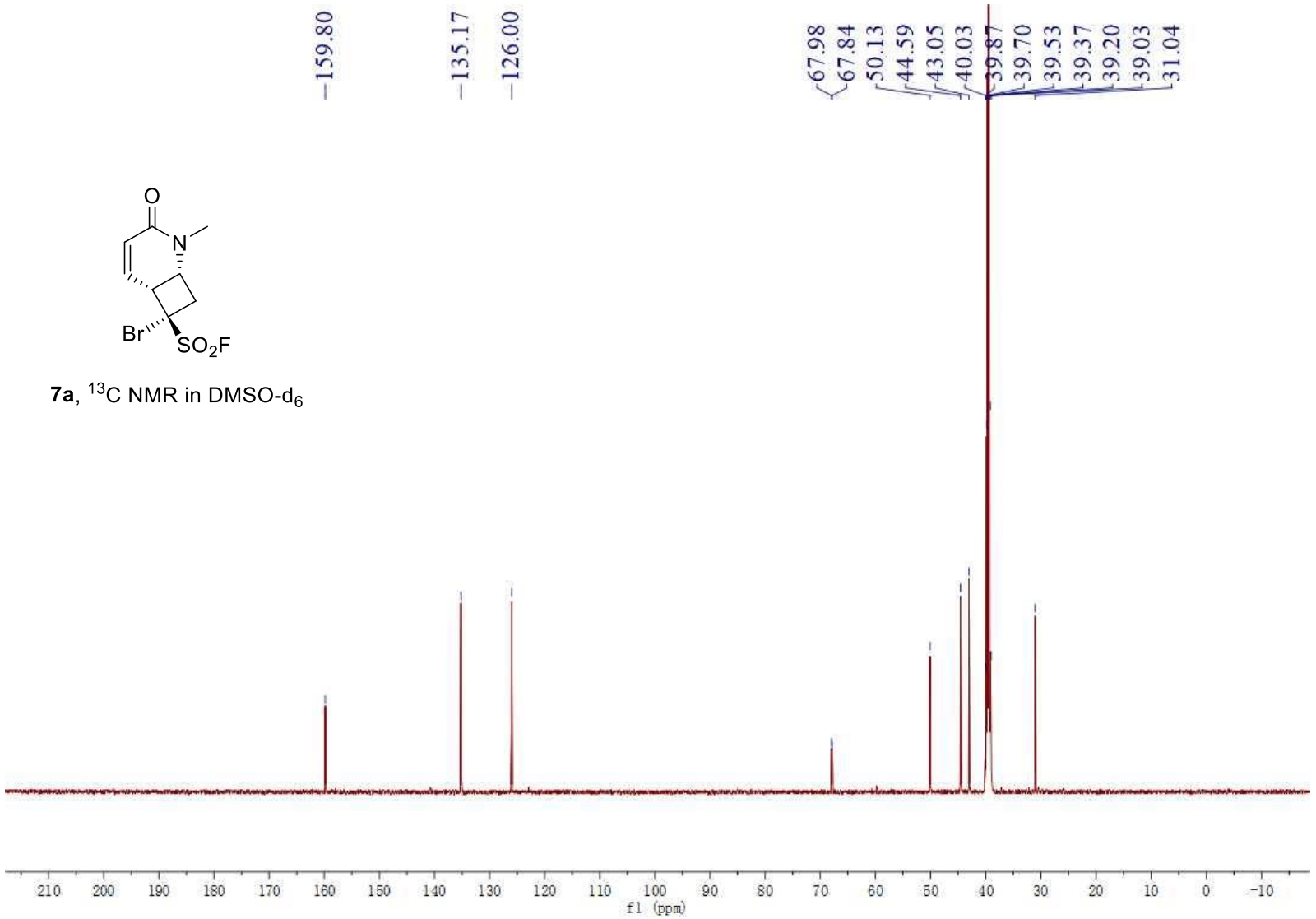
5k, ^{13}C NMR in DMSO-d_6



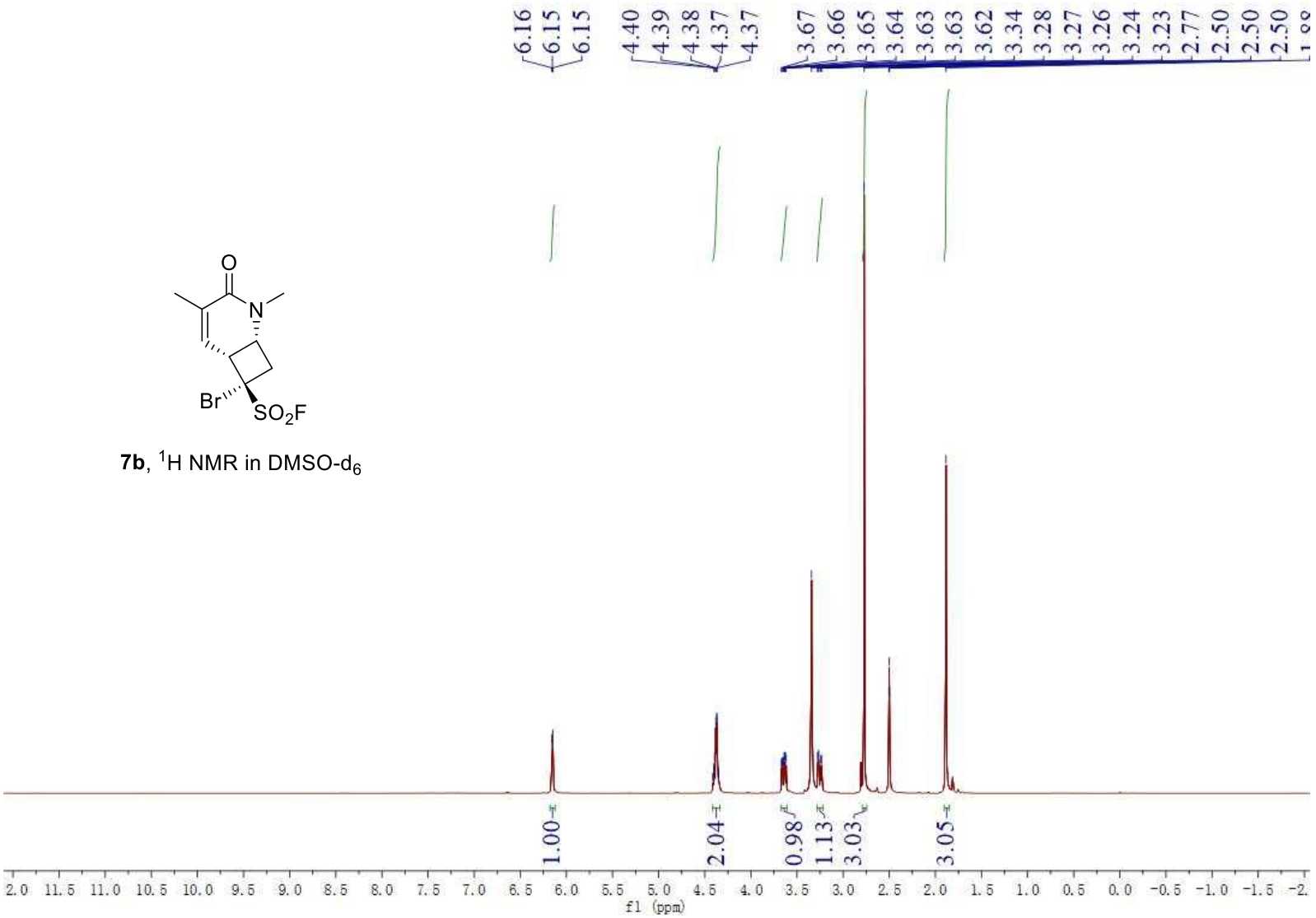
7a, ^{1}H NMR in DMSO-d_6



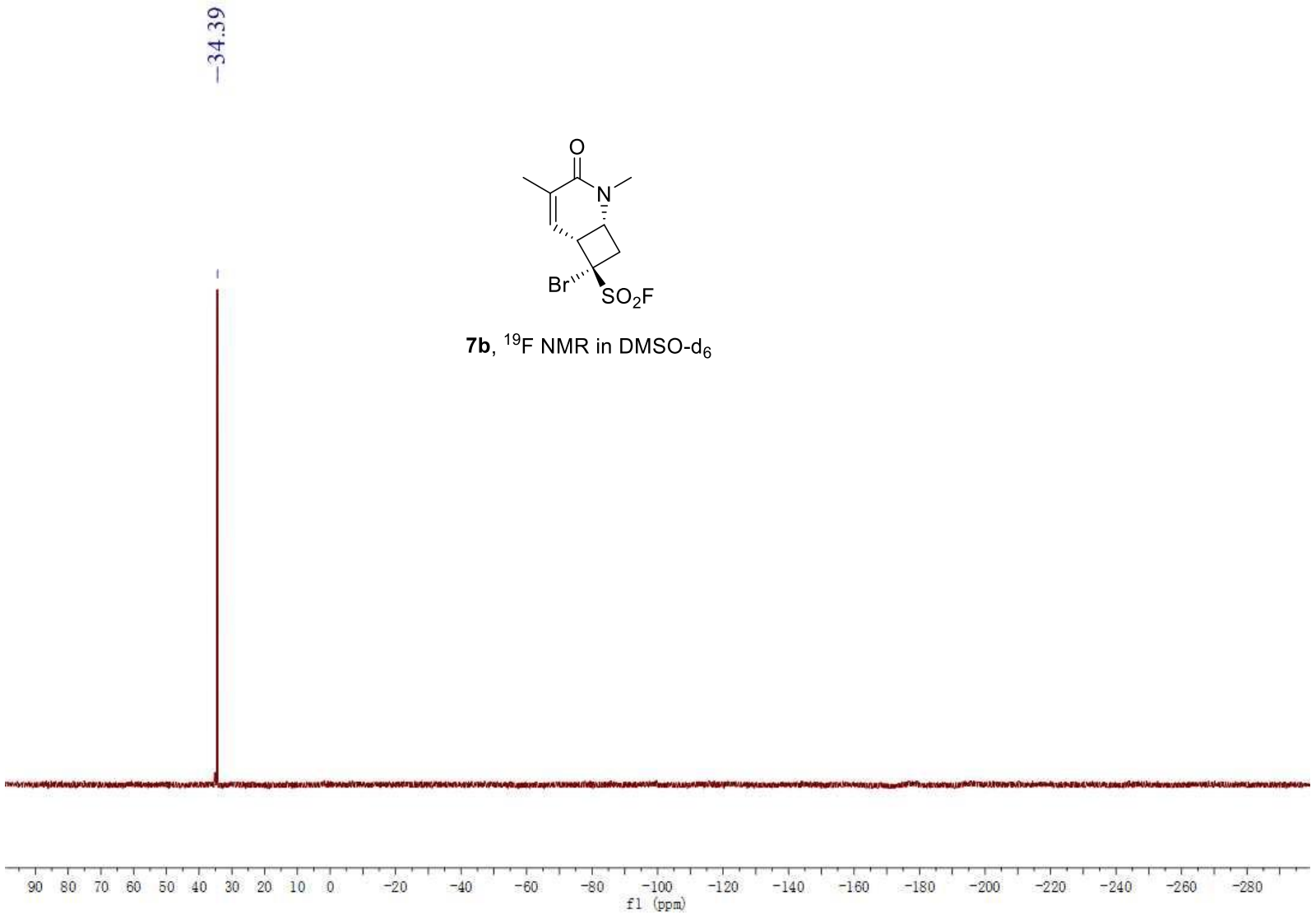
7a, ^{19}F NMR in DMSO-d_6



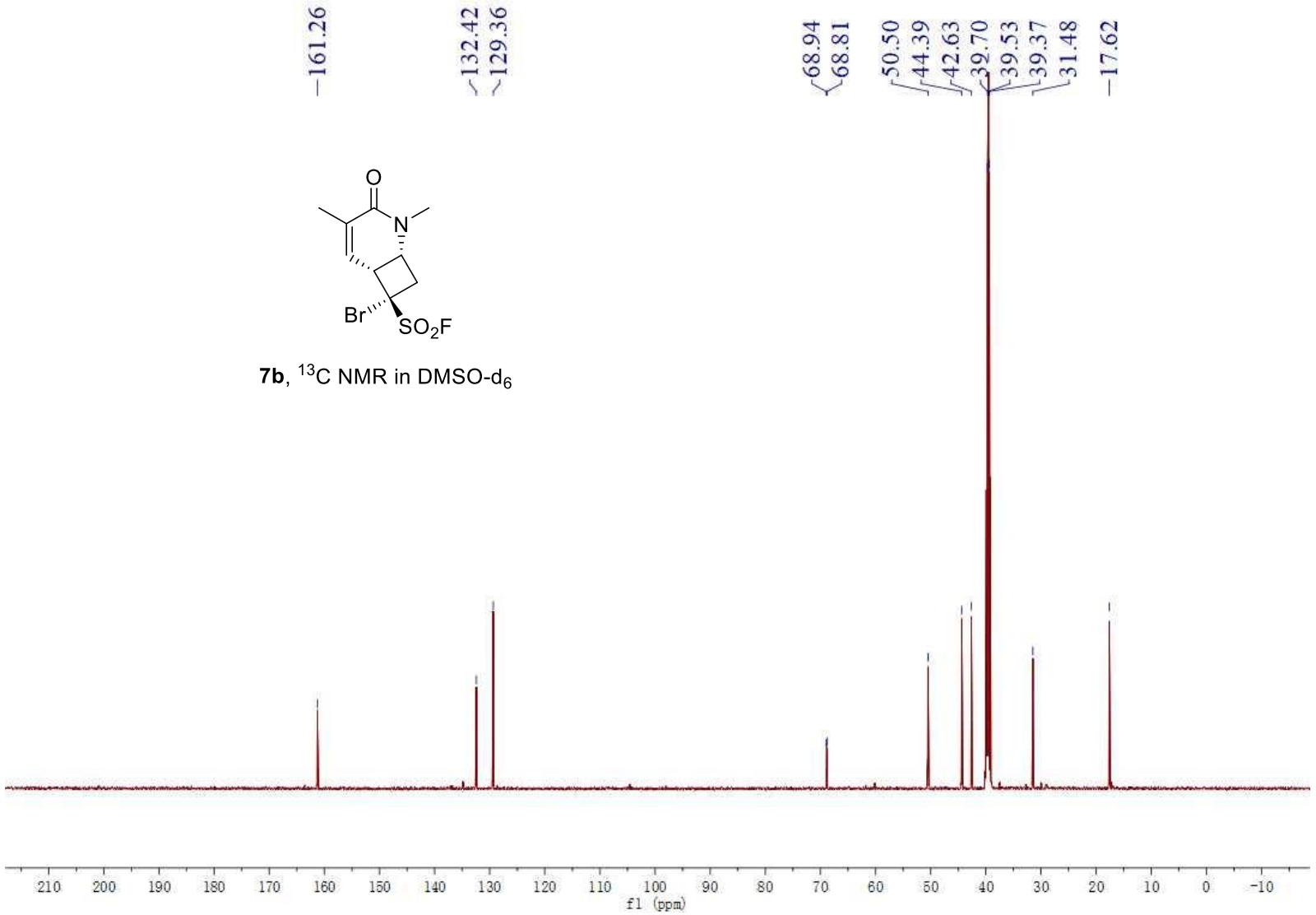
7a, ^{13}C NMR in DMSO-d_6



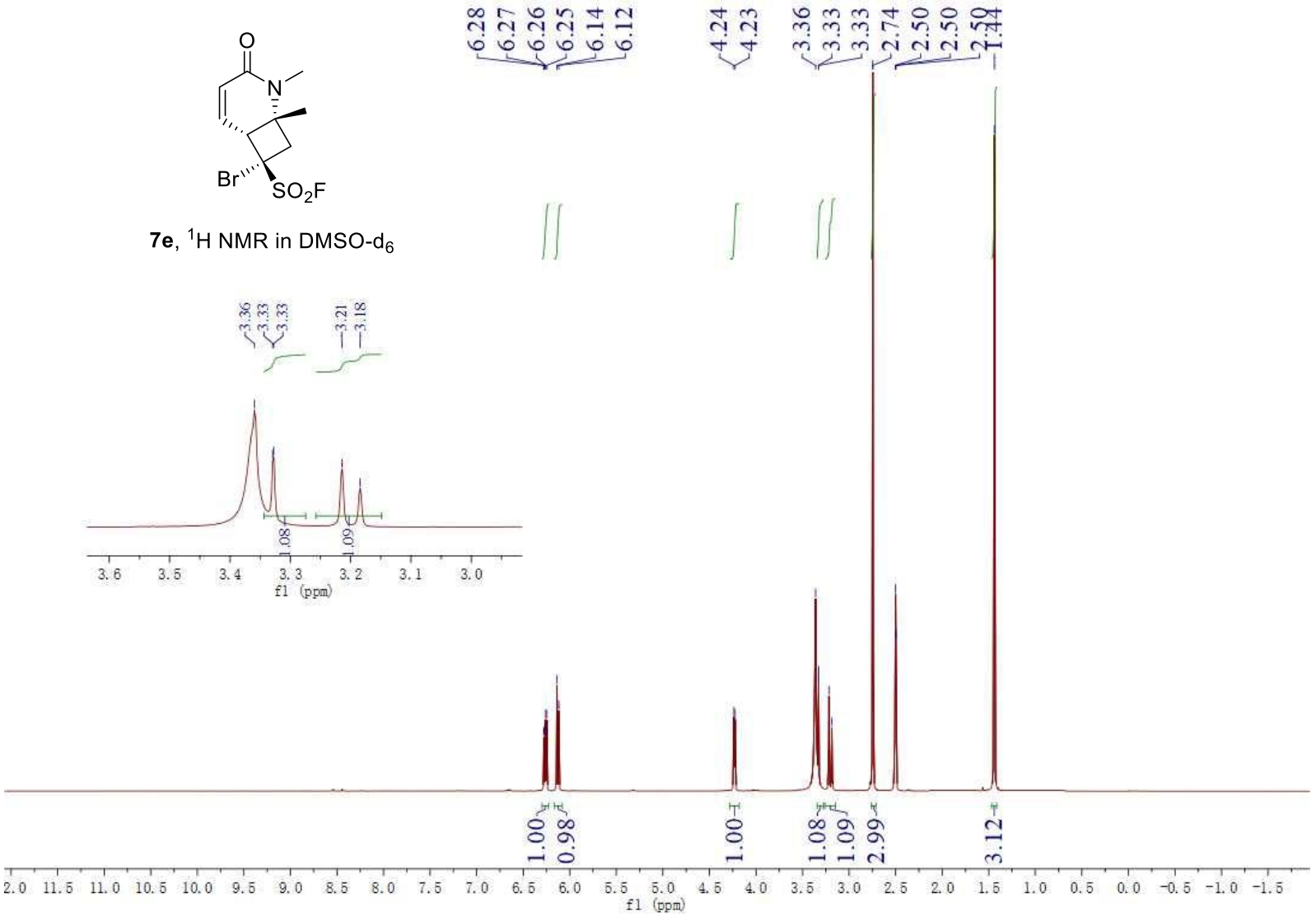
7b, ^{1}H NMR in DMSO-d_6

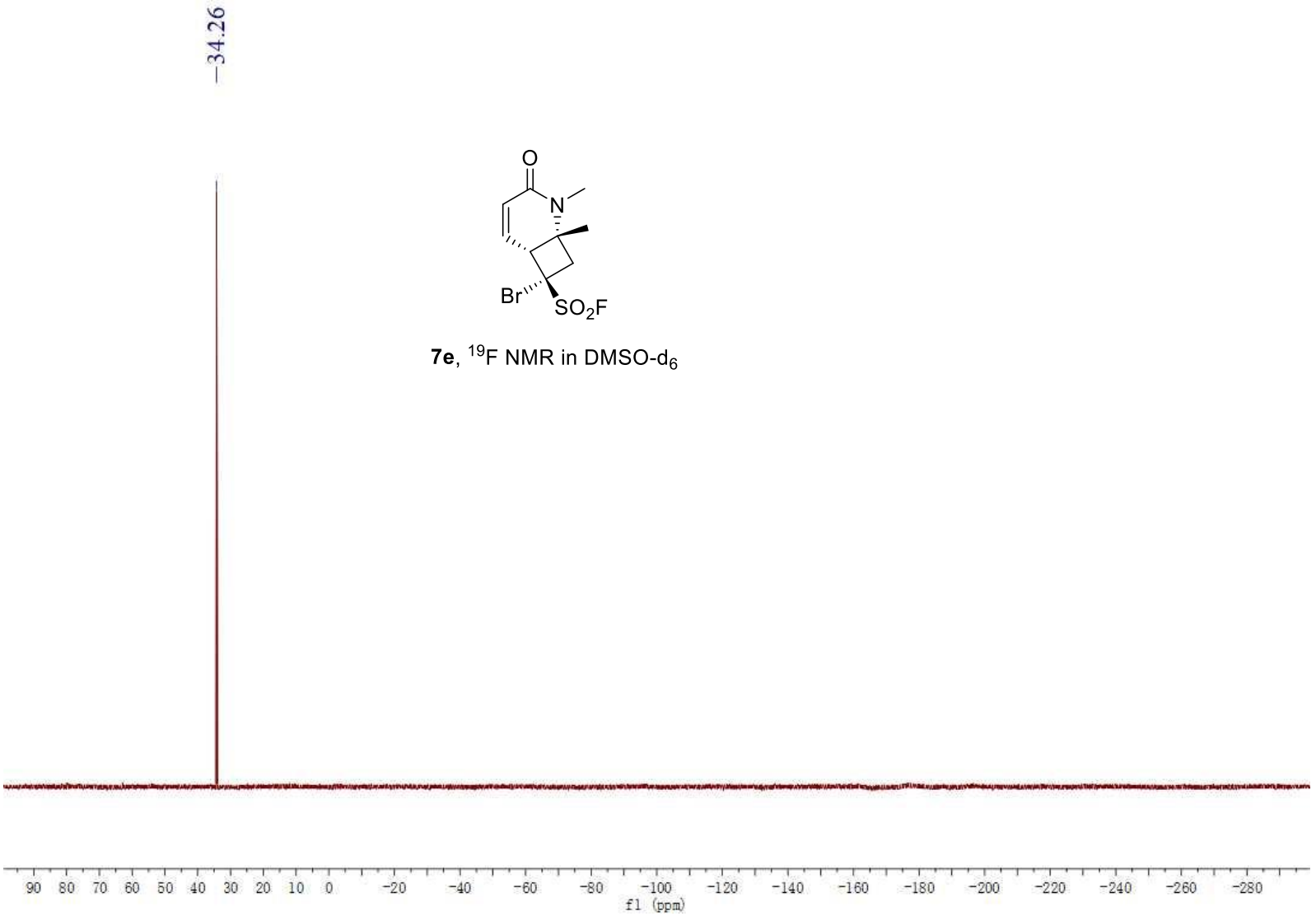


7b, ^{19}F NMR in DMSO-d_6

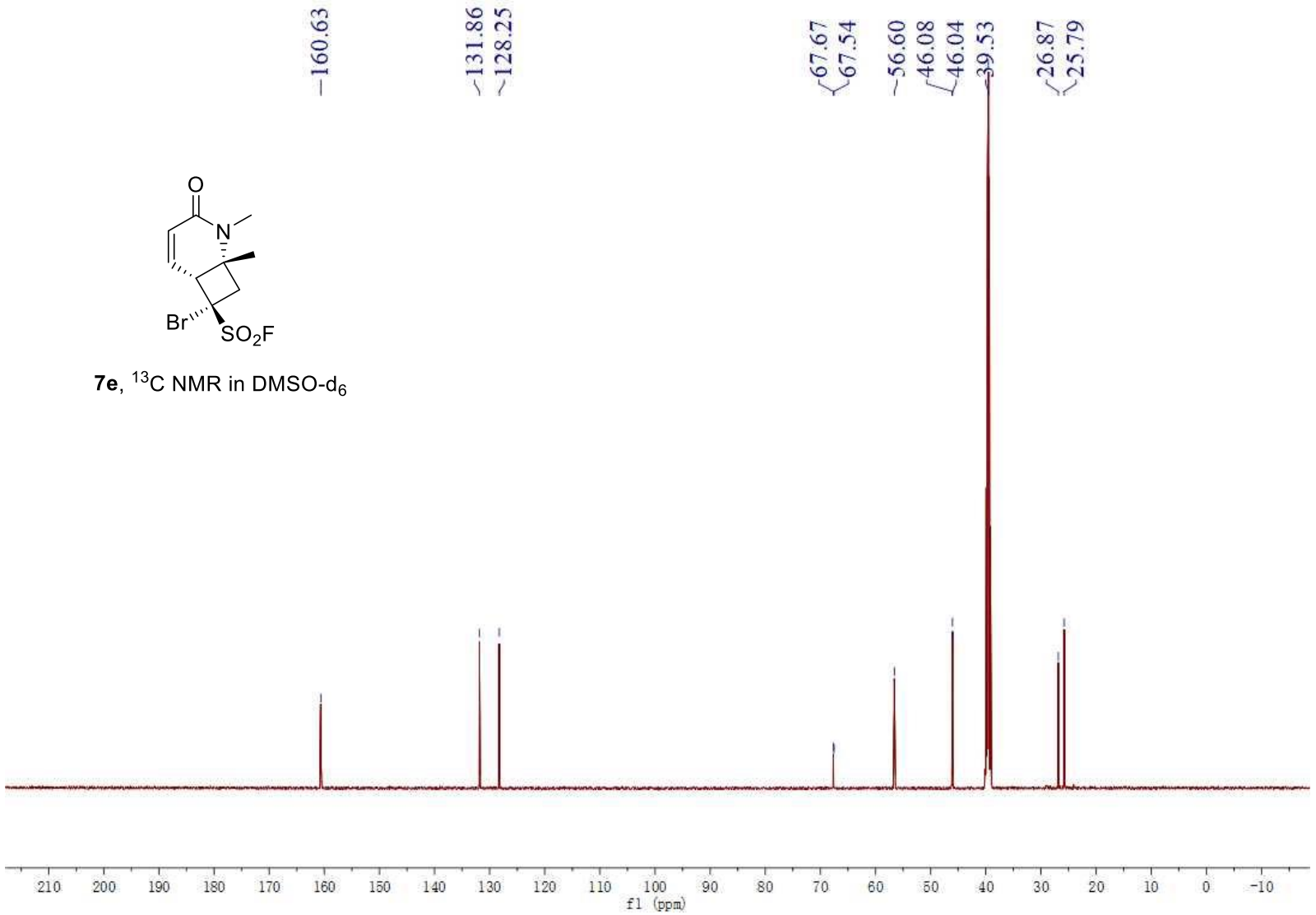


7b, ^{13}C NMR in DMSO-d_6

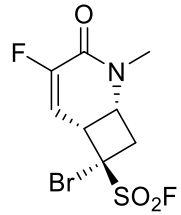

O
N
Br
SO2F
7e, 1H NMR in DMSO-d6
6.28
6.27
6.26
6.25
6.14
6.12
4.24
4.23
3.36
3.33
3.33
2.74
2.50
2.50
2.50
1.44
3.36
3.33
3.33
3.21
3.18
1.08
1.09
3.6 3.5 3.4 3.3 3.2 3.1 3.0
f1 (ppm)
1.00
0.98
1.00
1.08
1.09
2.99
3.12
2.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5
f1 (ppm)



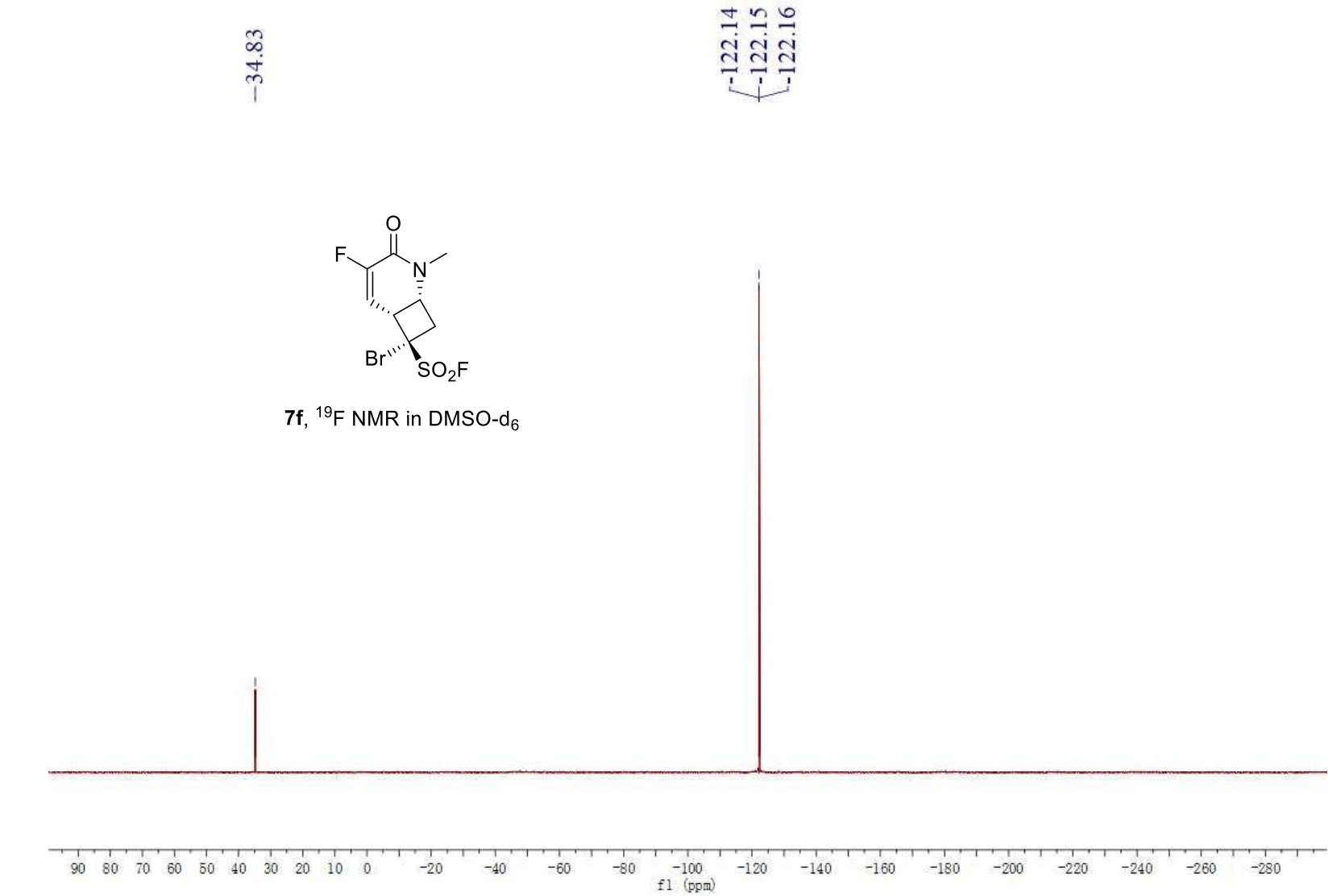
7e, ^{19}F NMR in DMSO-d_6



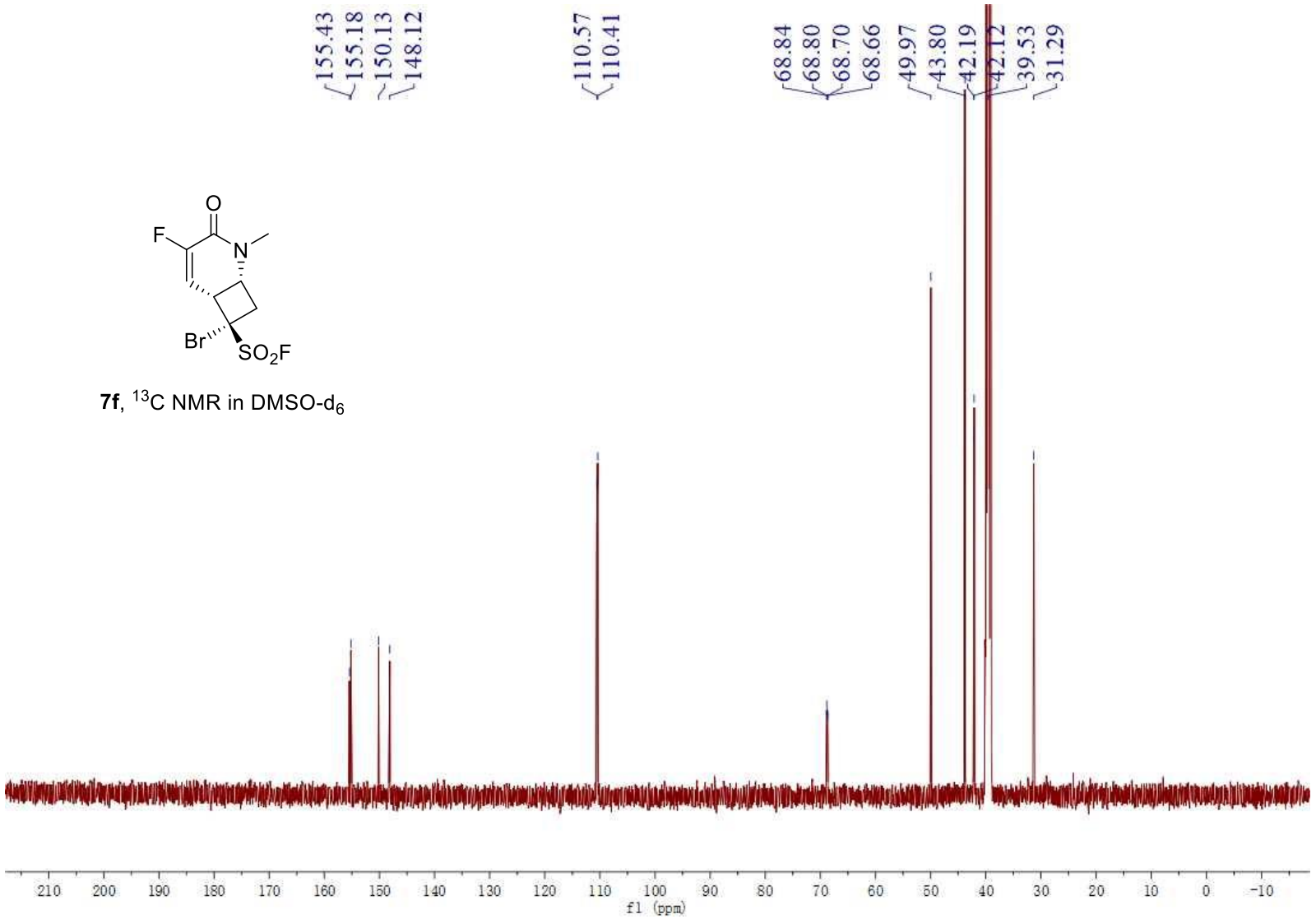
7e, ^{13}C NMR in DMSO-d_6



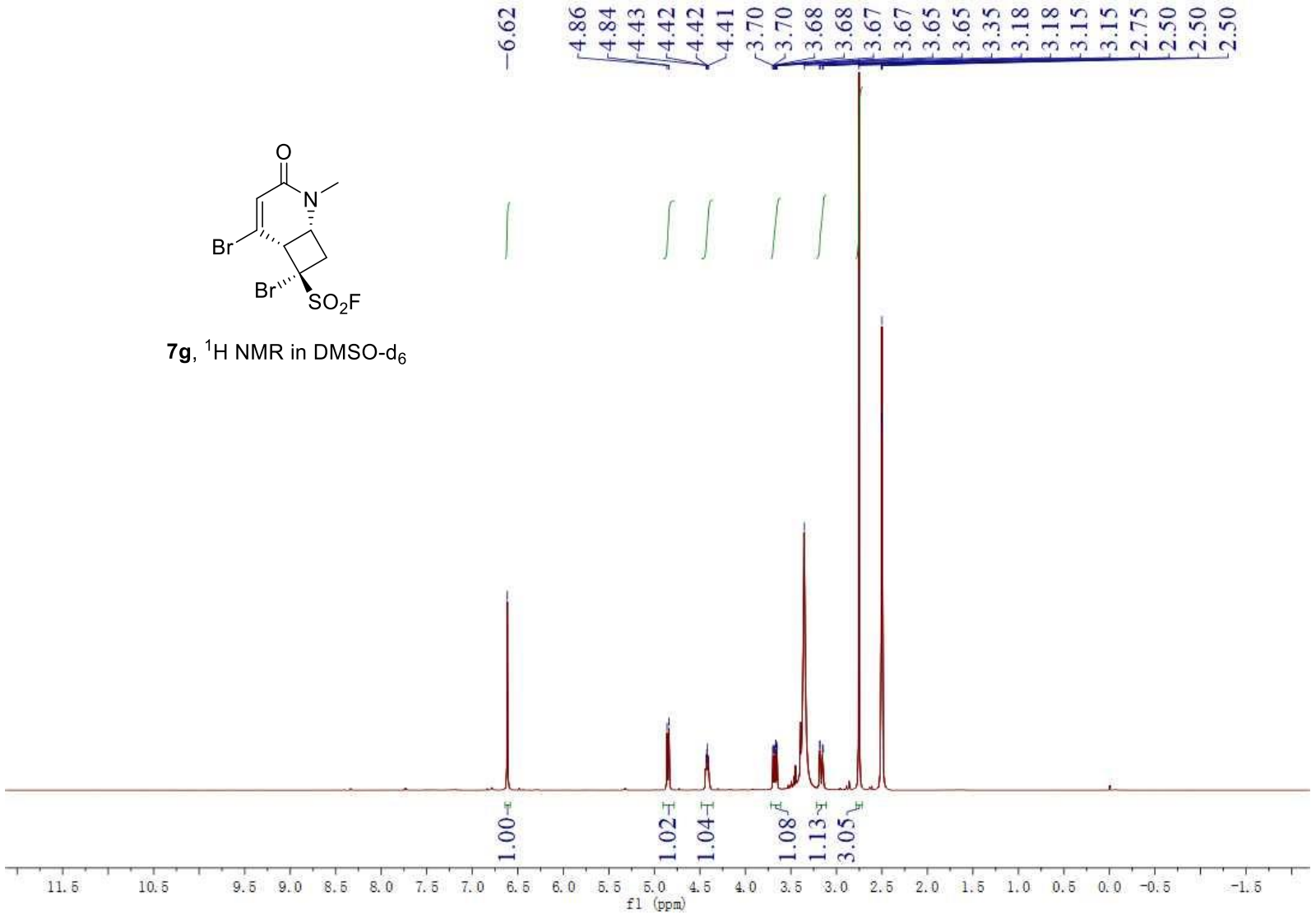
7f, ^{1}H NMR in DMSO-d_6



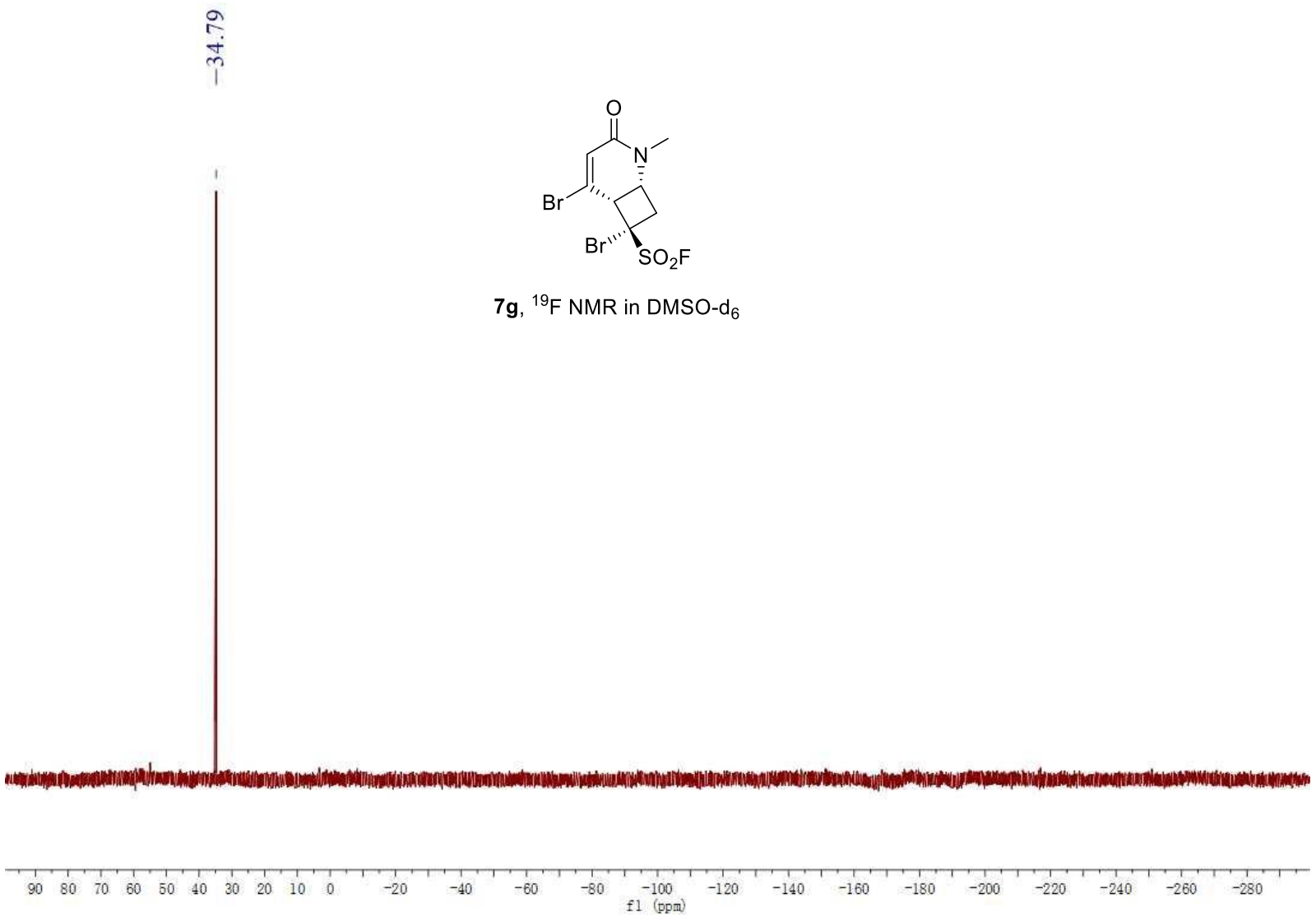
7f, ^{19}F NMR in DMSO-d_6



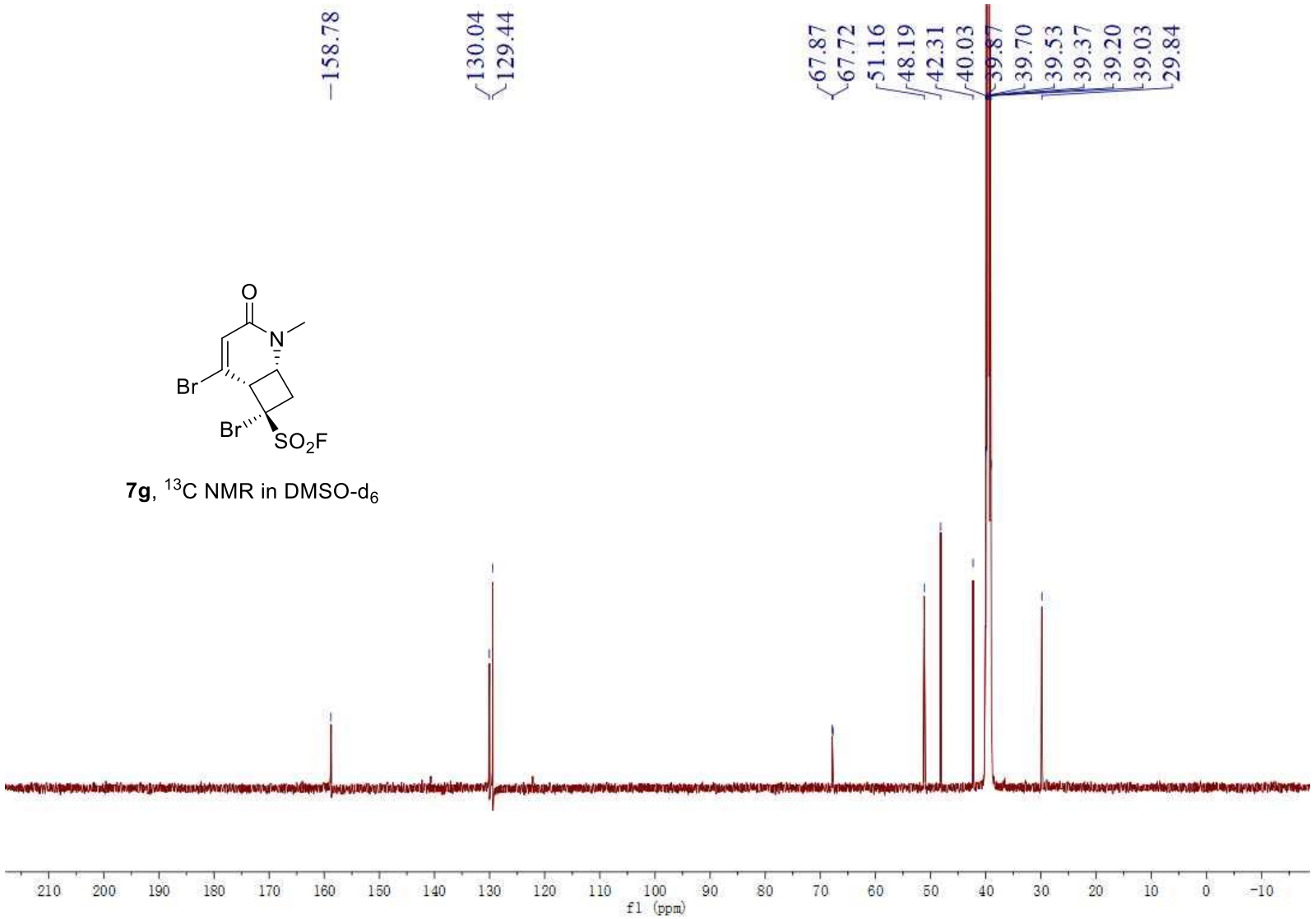
7f, ^{13}C NMR in DMSO-d_6



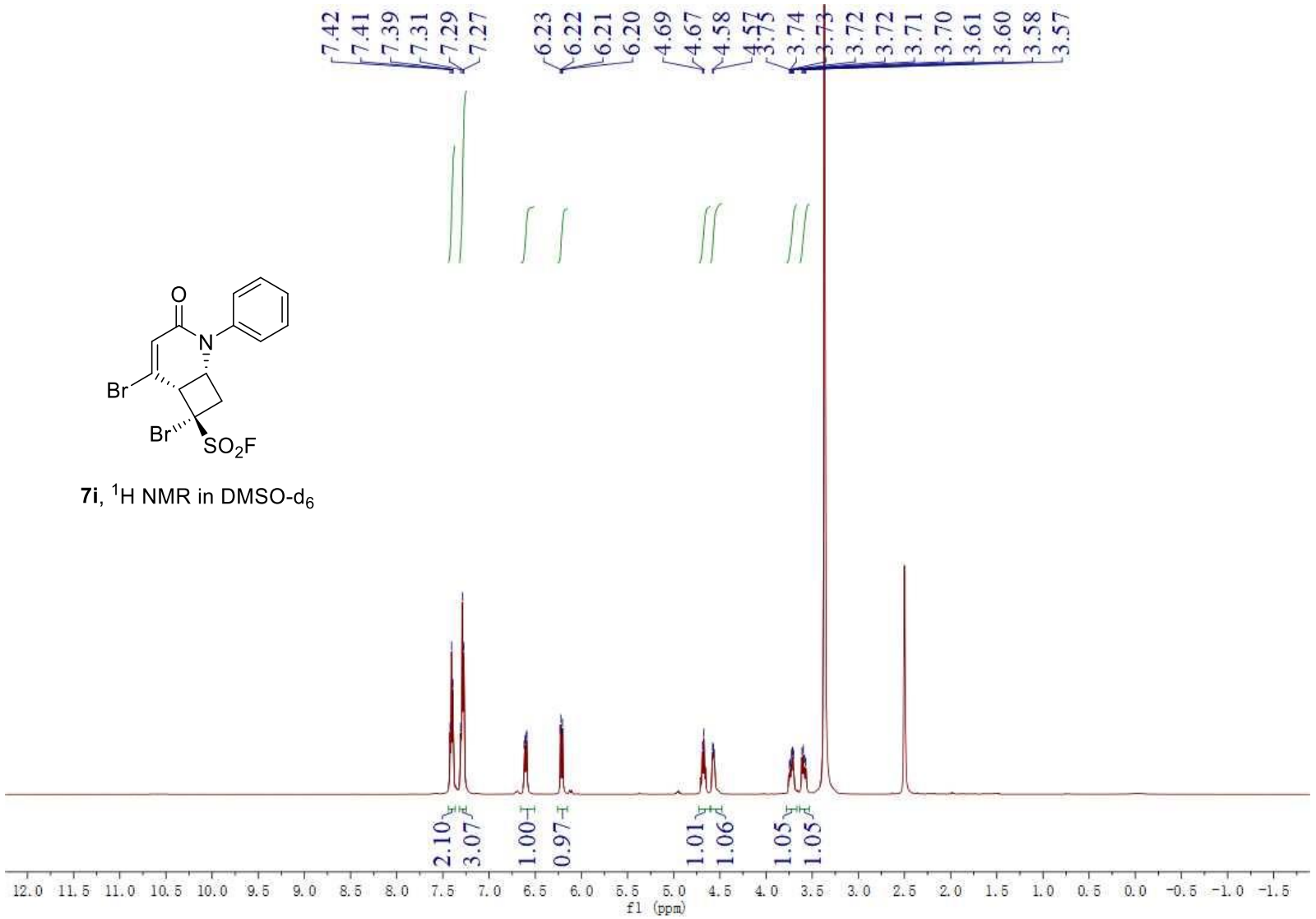
7g, ^{1}H NMR in DMSO-d_6



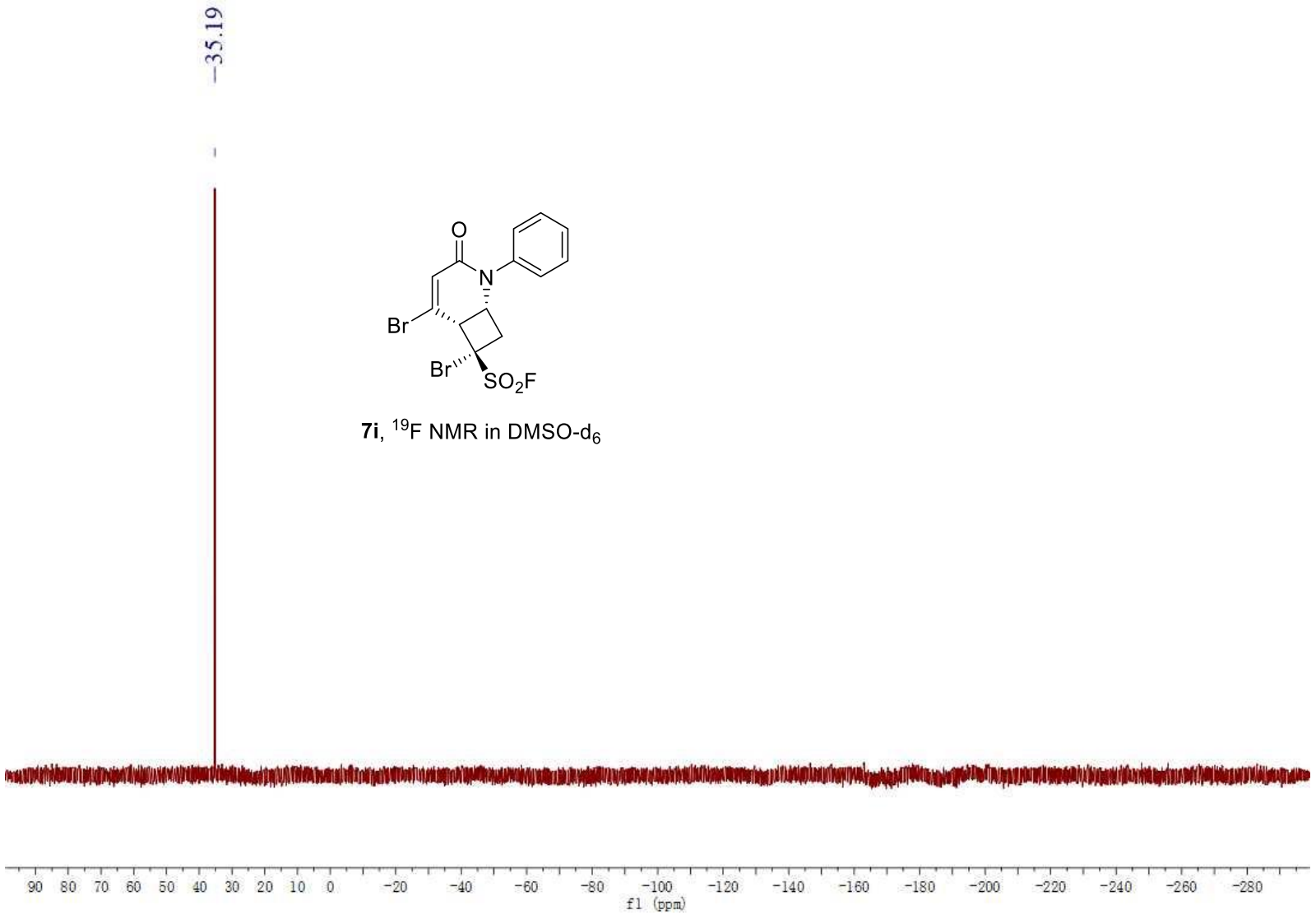
7g, ^{19}F NMR in DMSO-d_6



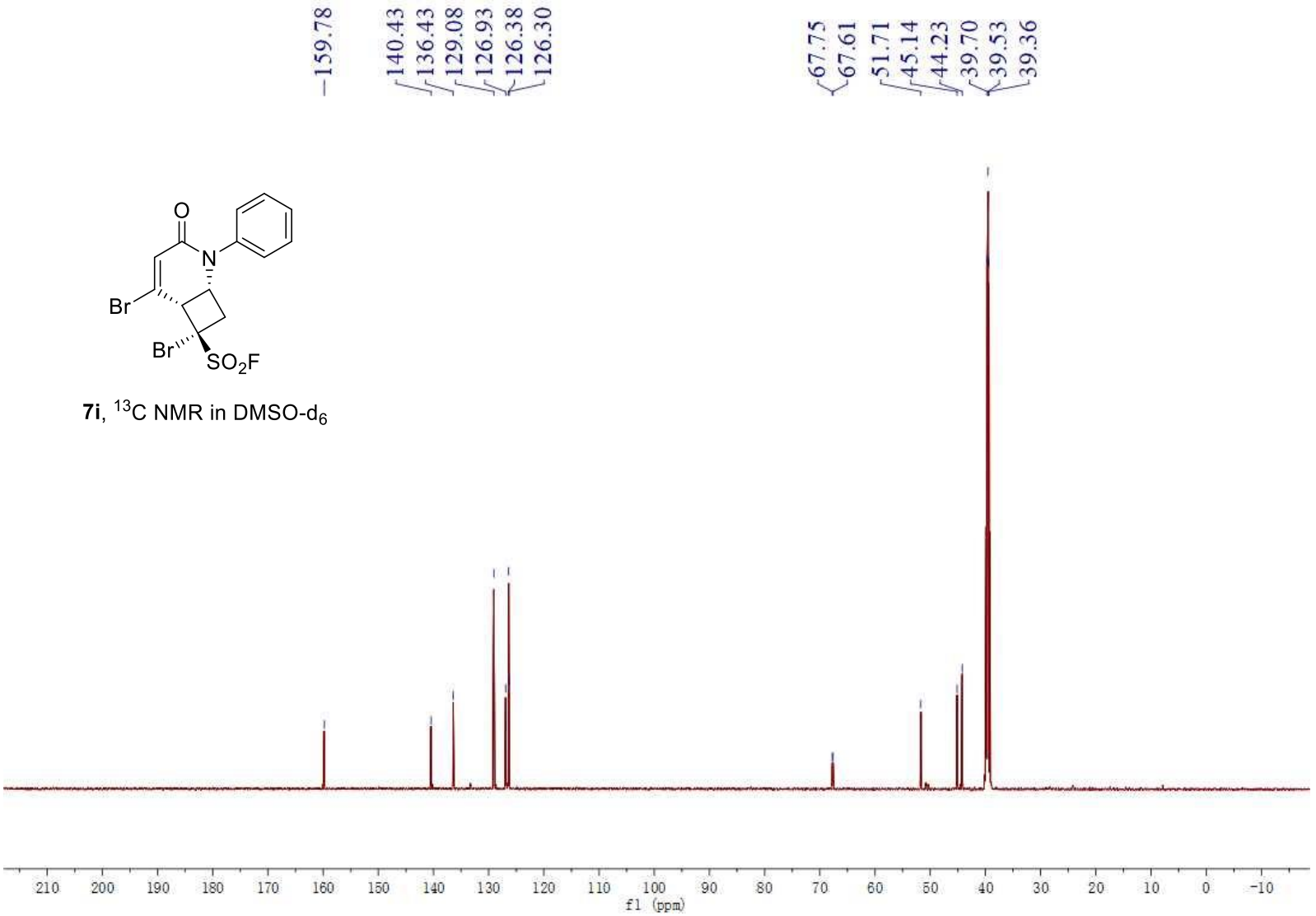
7g, ^{13}C NMR in DMSO-d_6



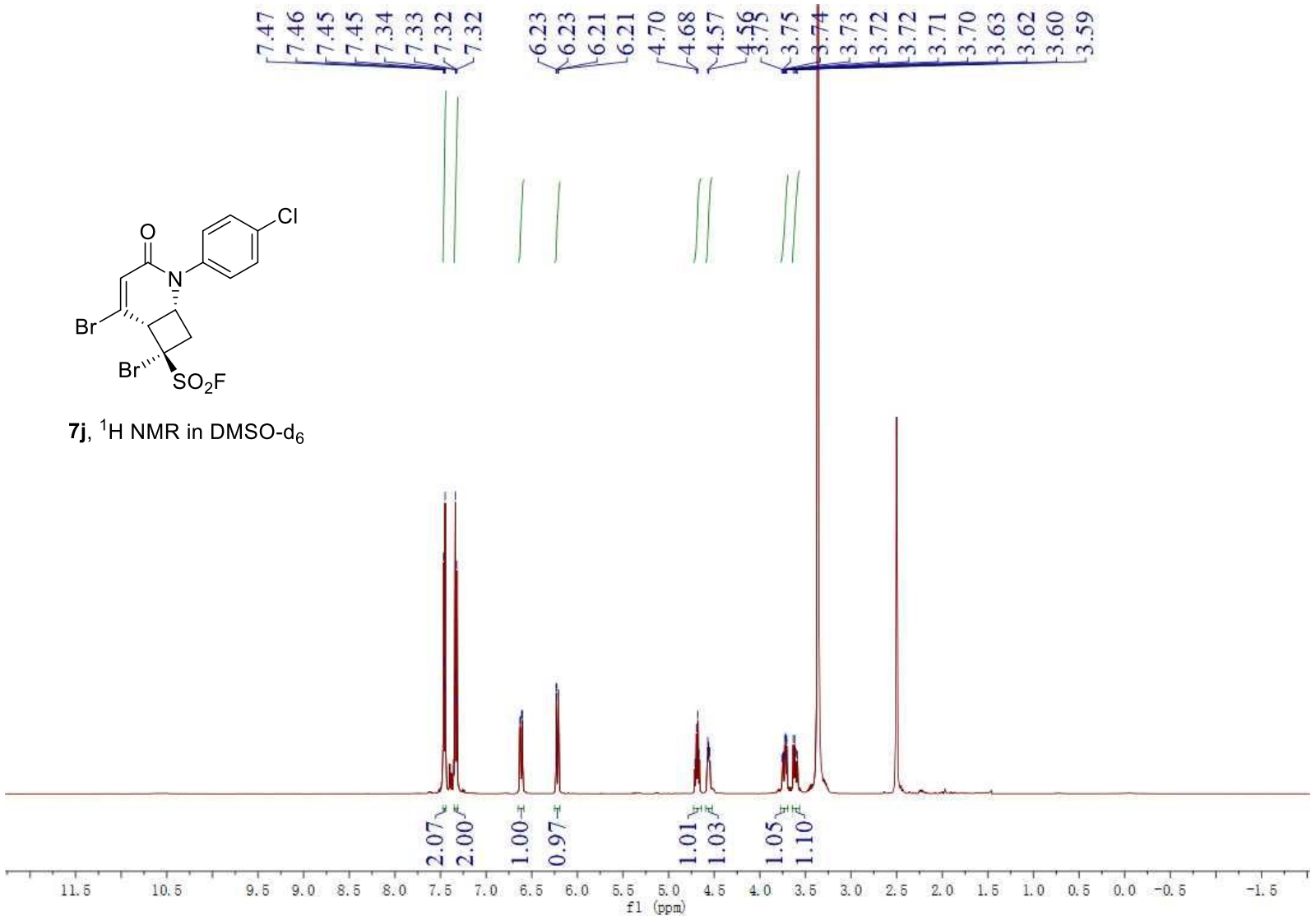
7i, ^{1}H NMR in DMSO-d_6



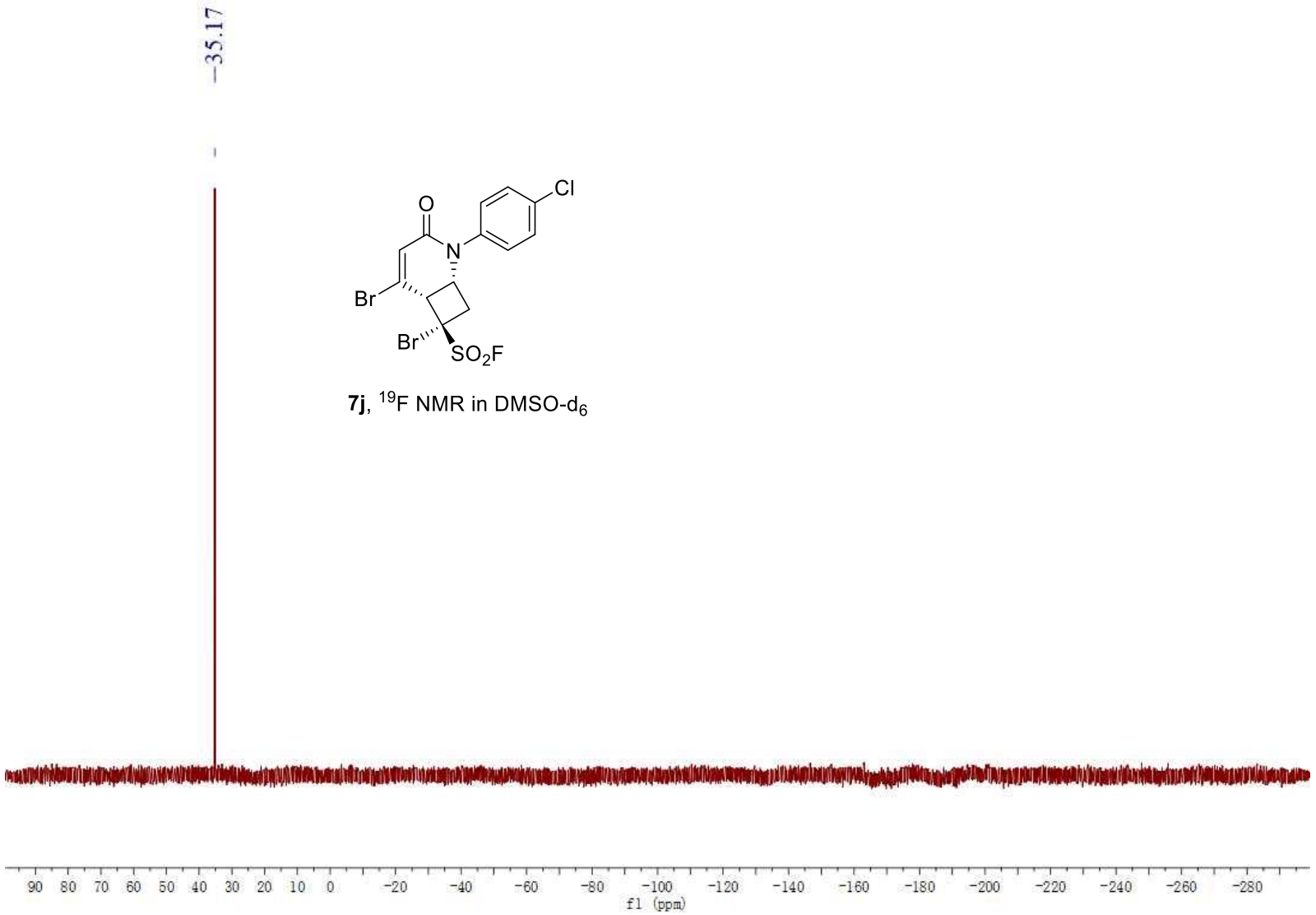
7i, ^{19}F NMR in DMSO-d_6



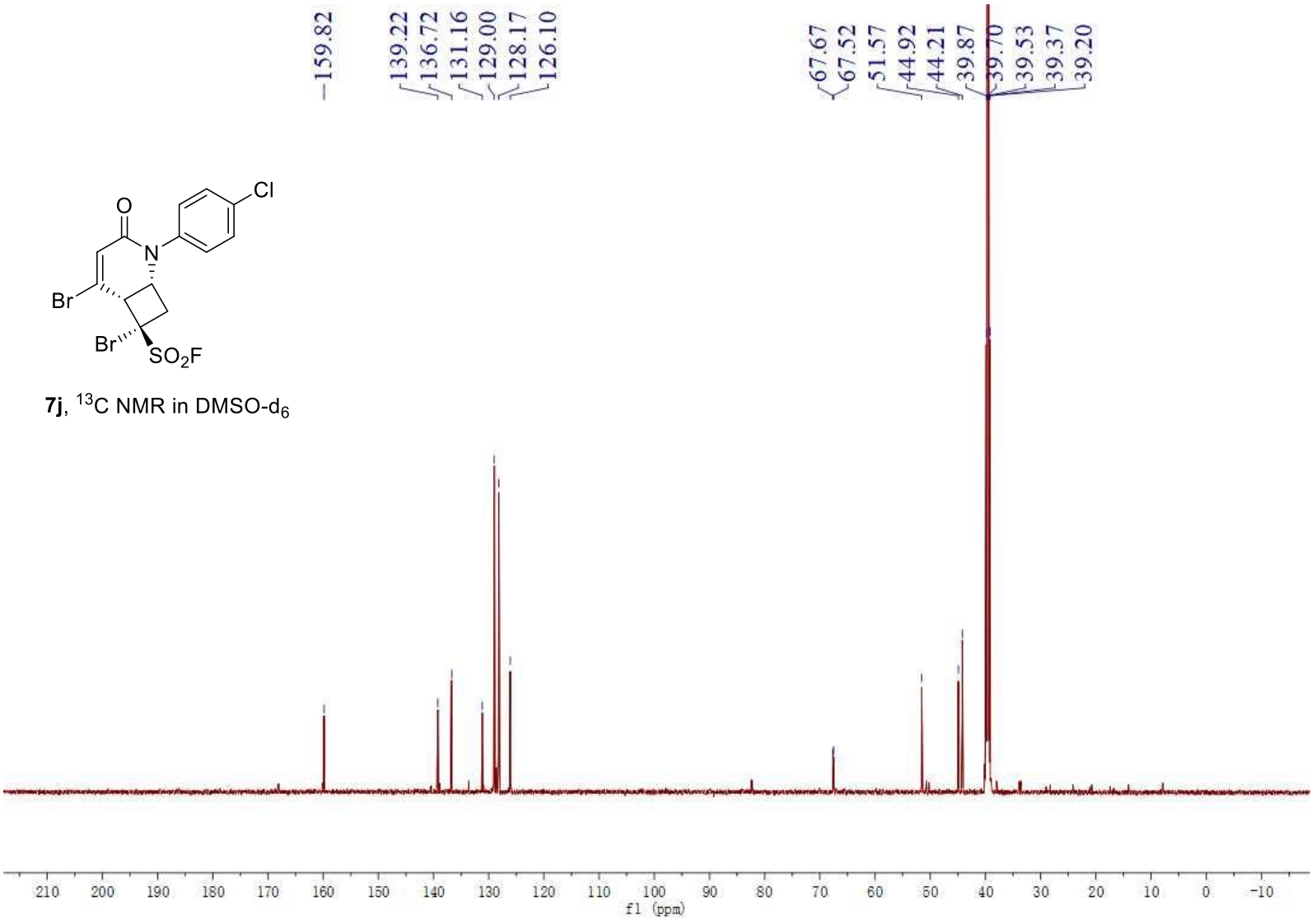
7i, ^{13}C NMR in DMSO-d_6



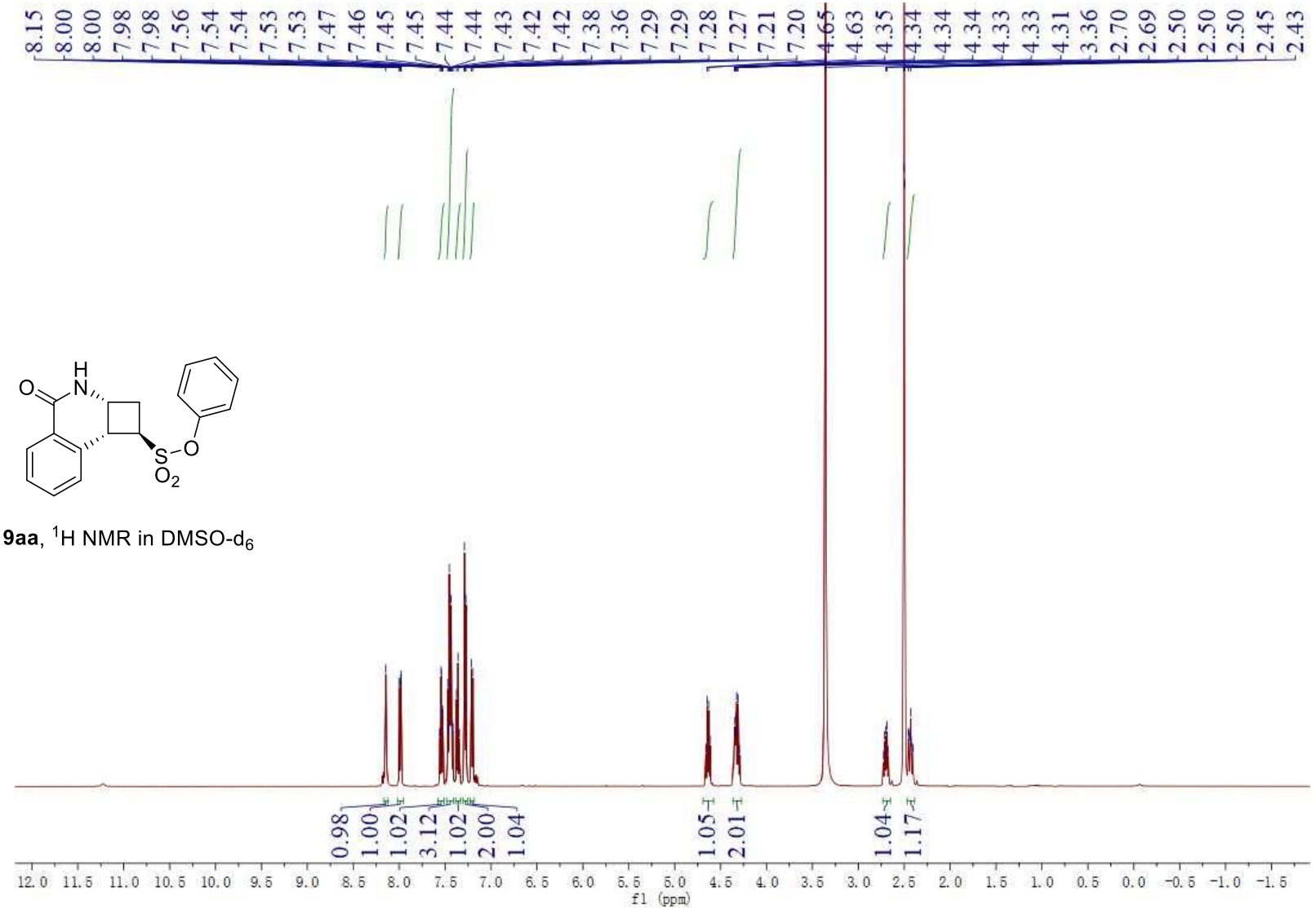
7j, ^{1}H NMR in DMSO-d_6



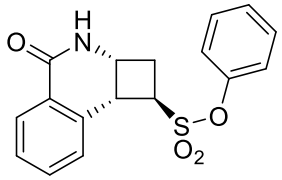
7j, ^{19}F NMR in DMSO-d_6



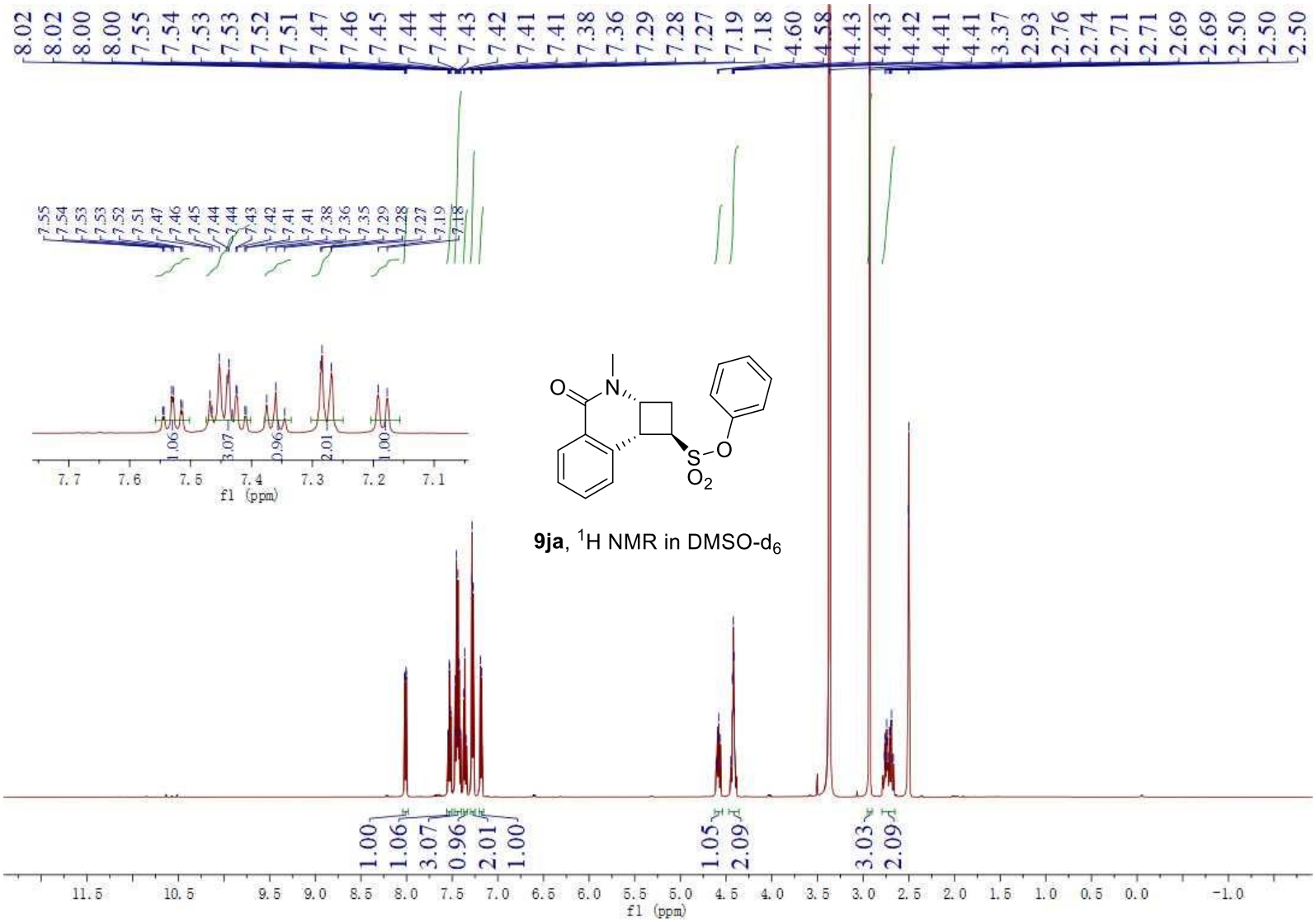
7j, ^{13}C NMR in DMSO-d_6



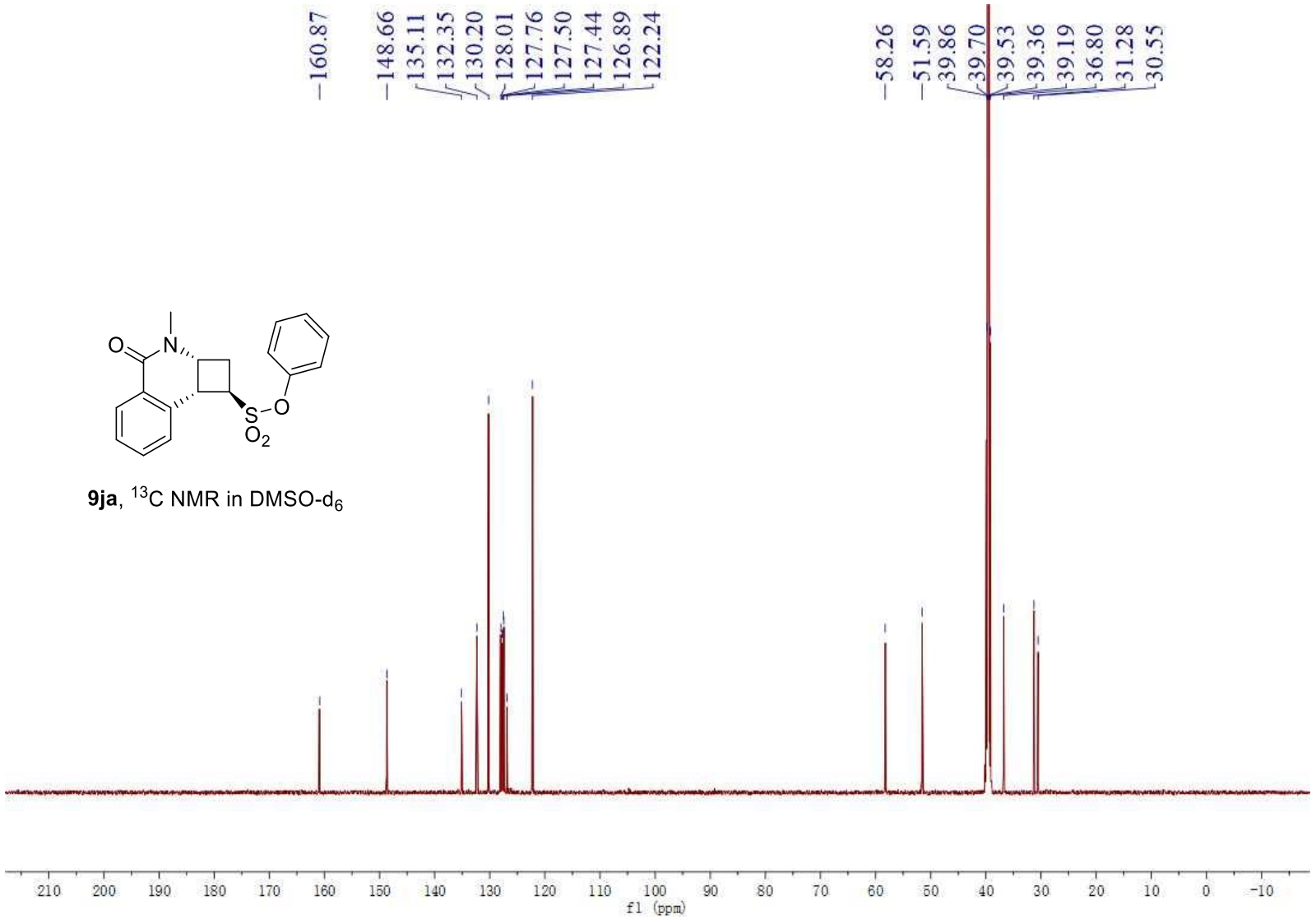
9aa, ^{1}H NMR in DMSO-d_6



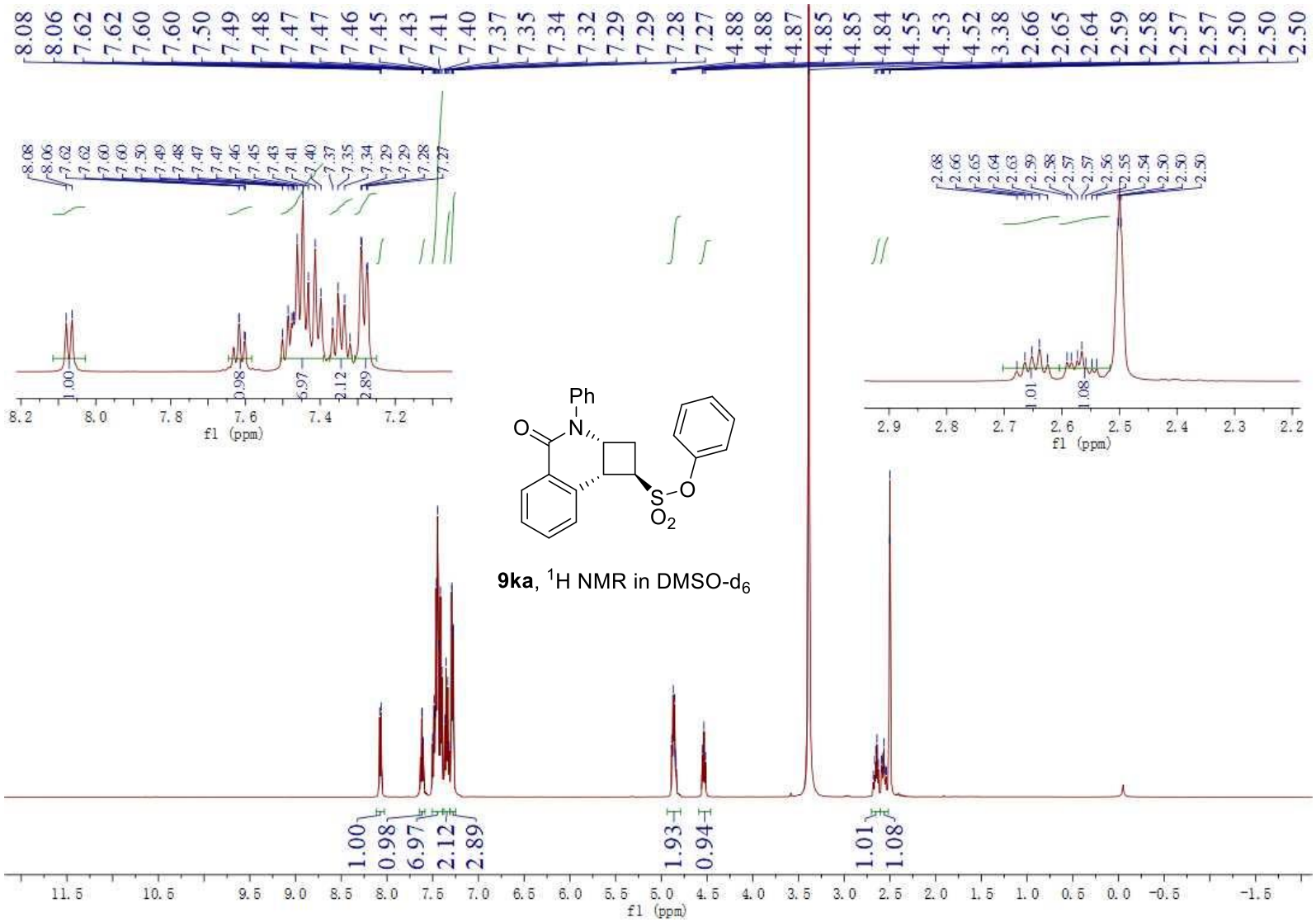
9aa, ^{13}C NMR in DMSO-d_6

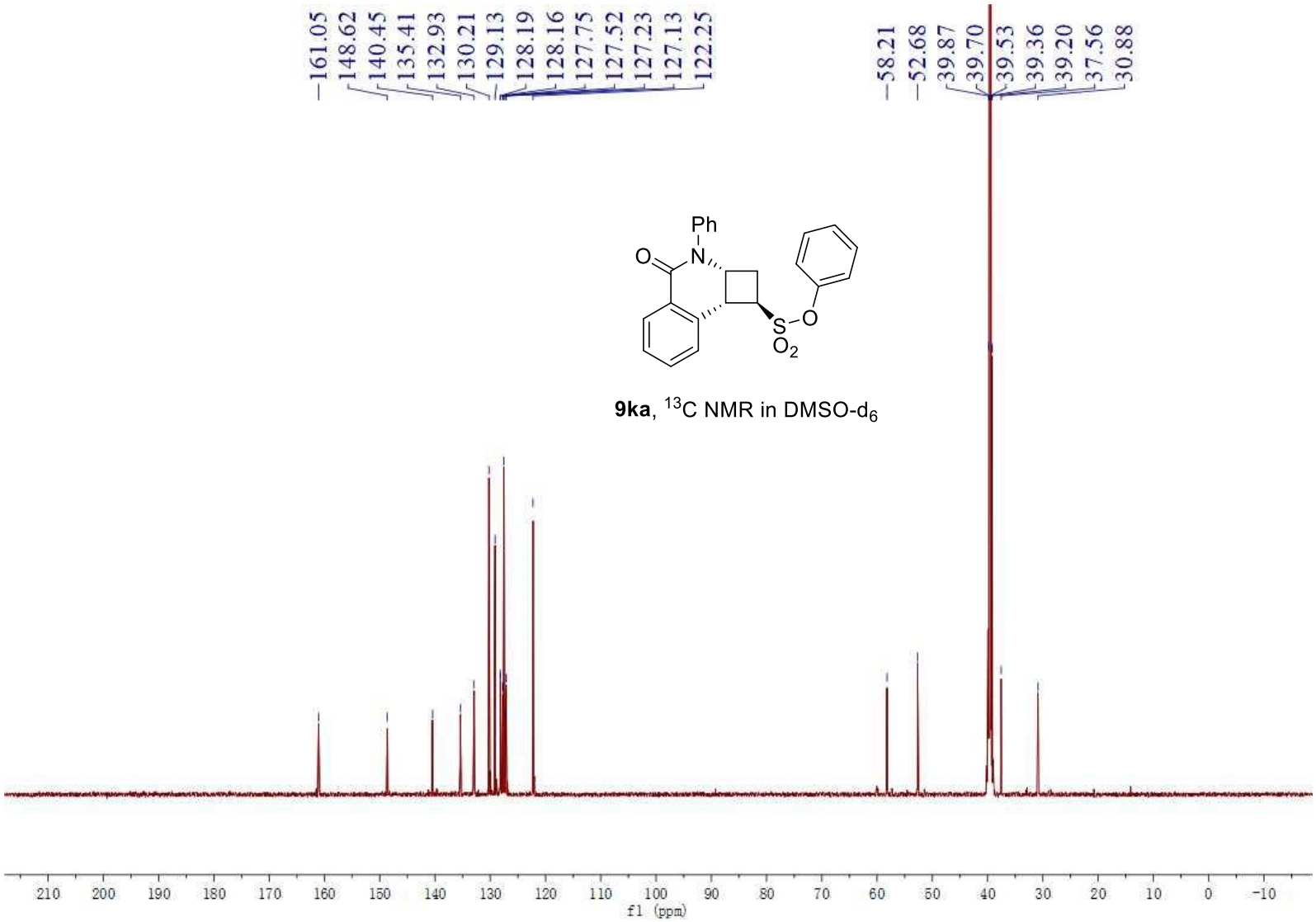


9ja, ^{1}H NMR in DMSO-d_6

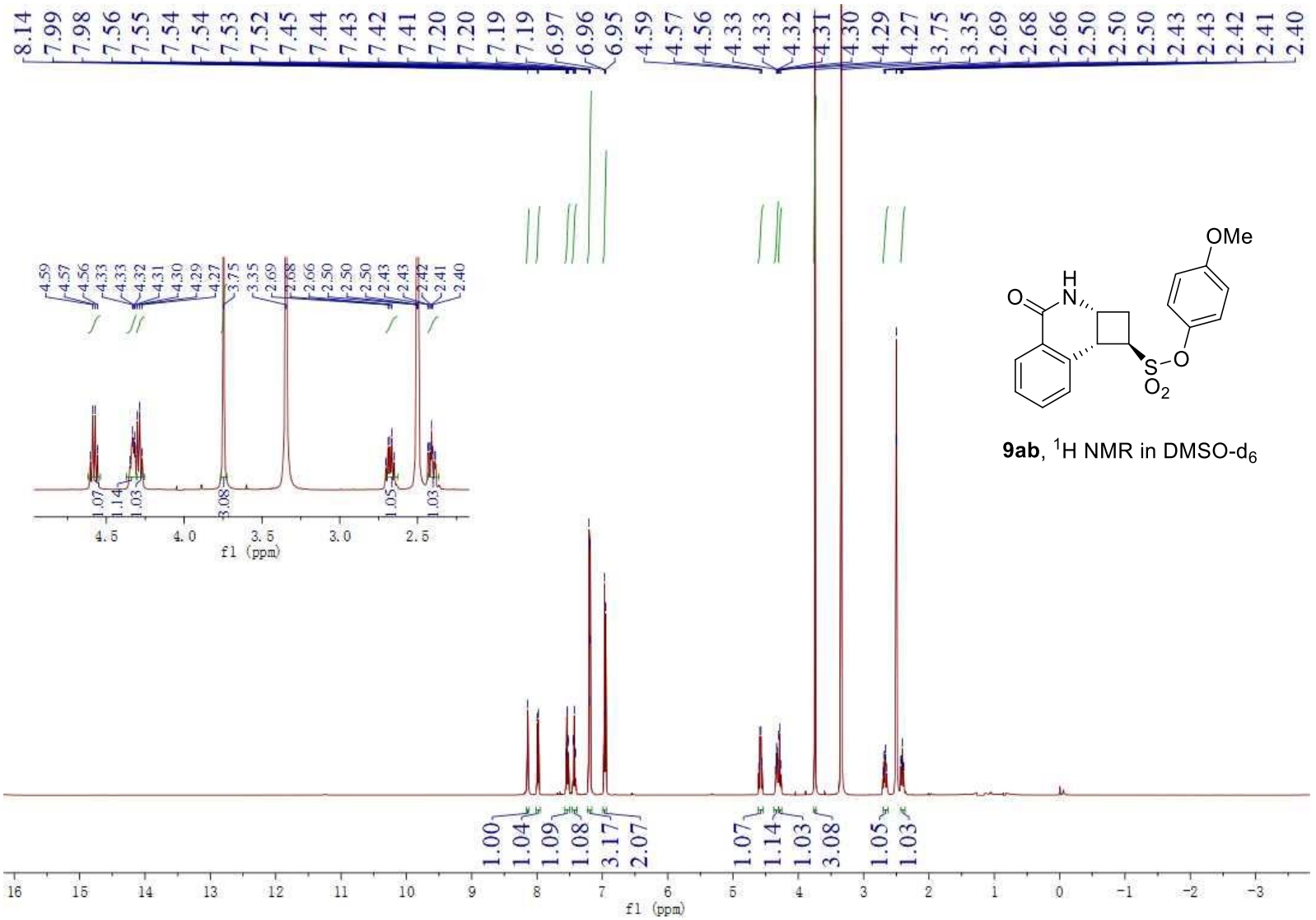


9ja, ^{13}C NMR in DMSO-d_6

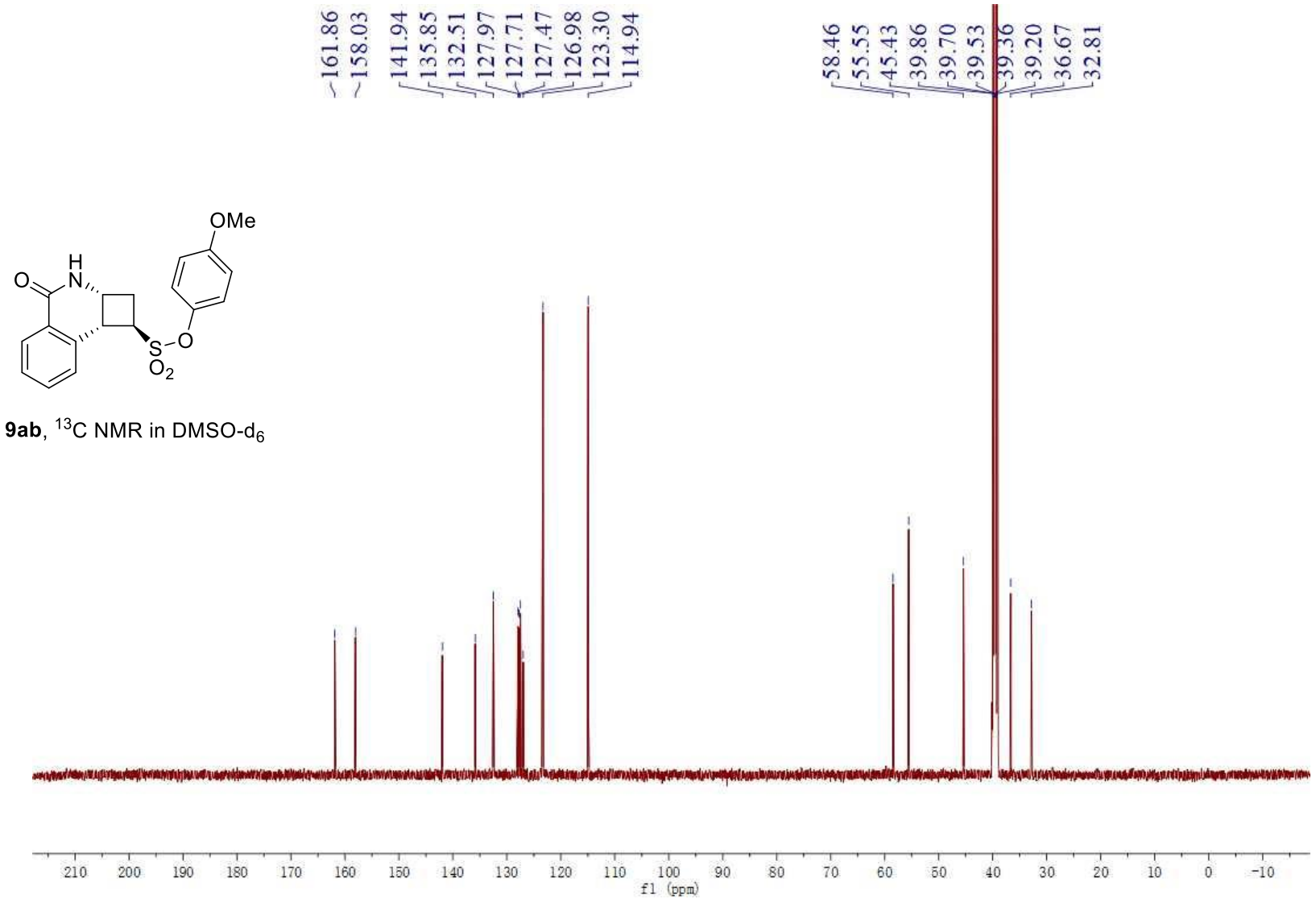

Ph
O
N
S
O
O2
9ka, 1H NMR in DMSO-d6
f1 (ppm)



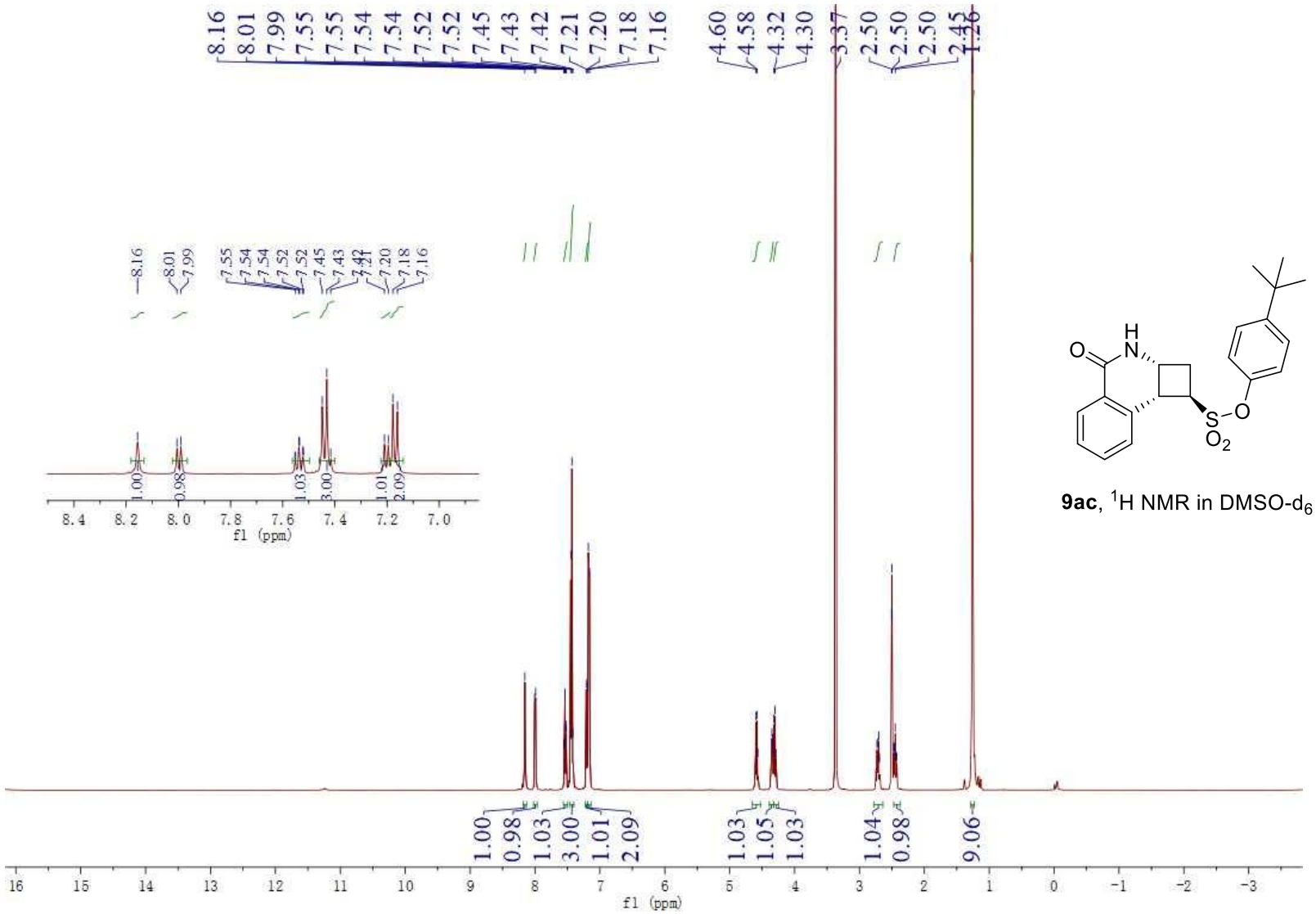
9ka, ^{13}C NMR in DMSO-d_6



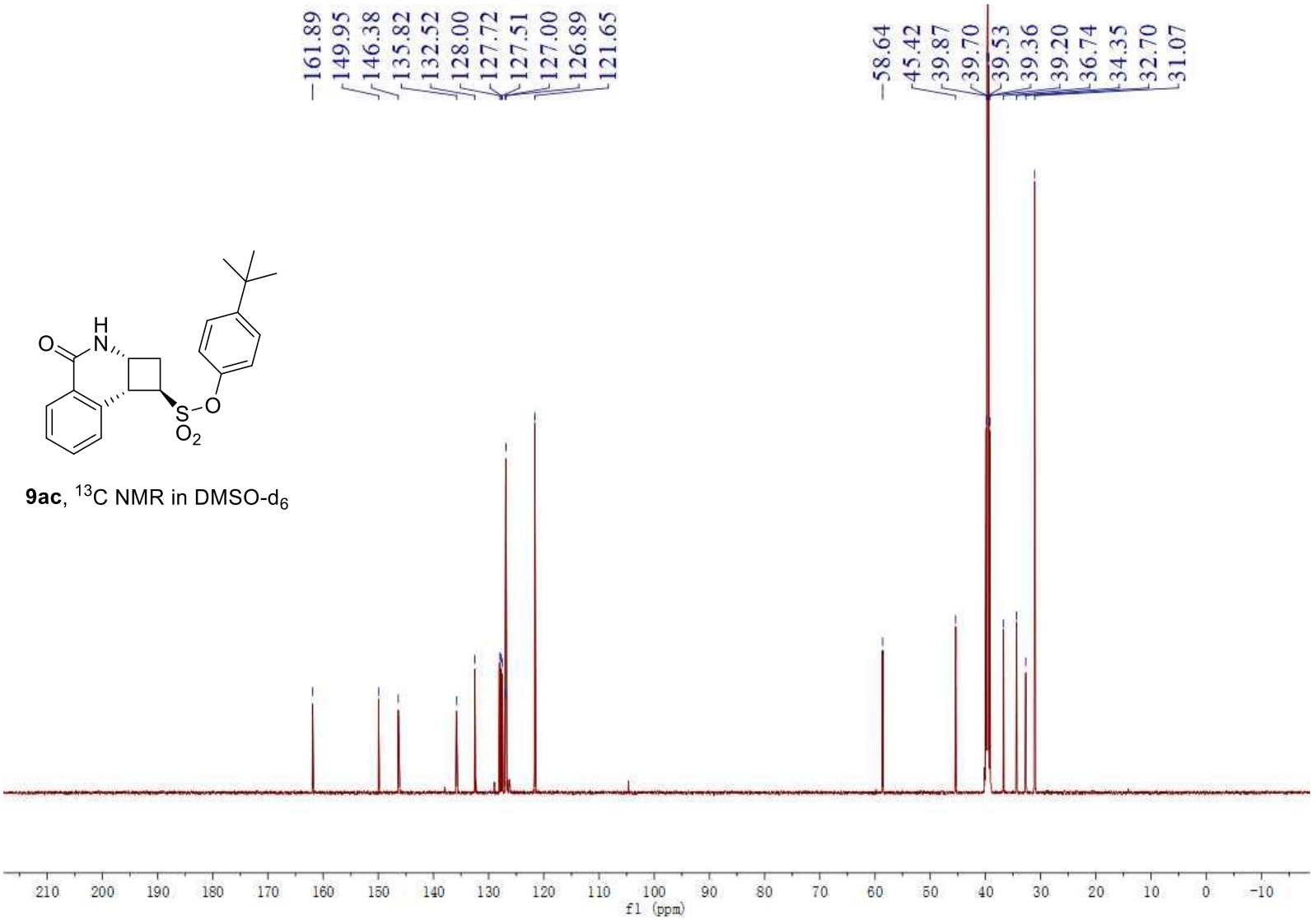
9ab, ^{1}H NMR in DMSO-d_6



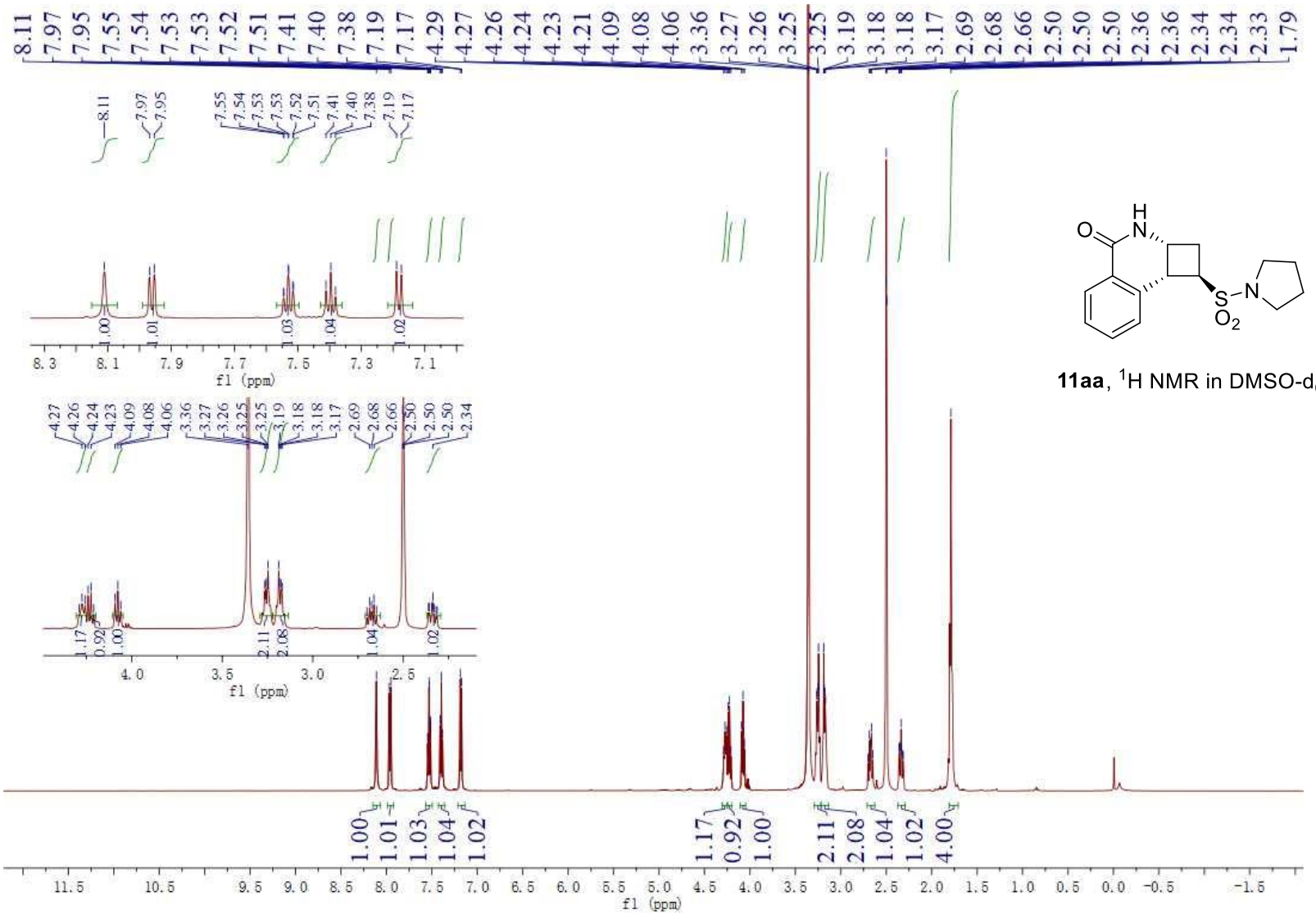
9ab, ^{13}C NMR in DMSO-d_6



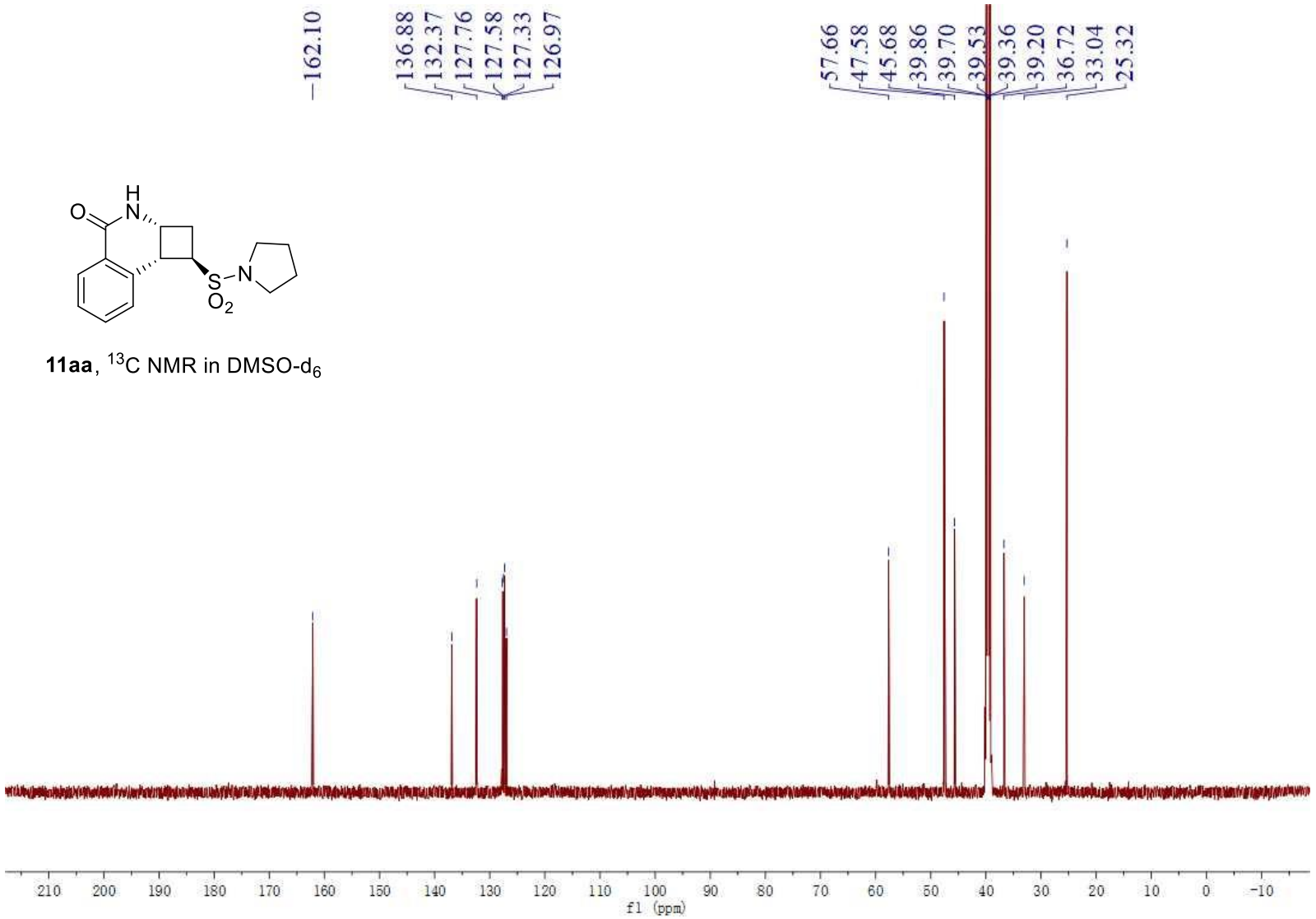
9ac, ^{1}H NMR in DMSO-d_6



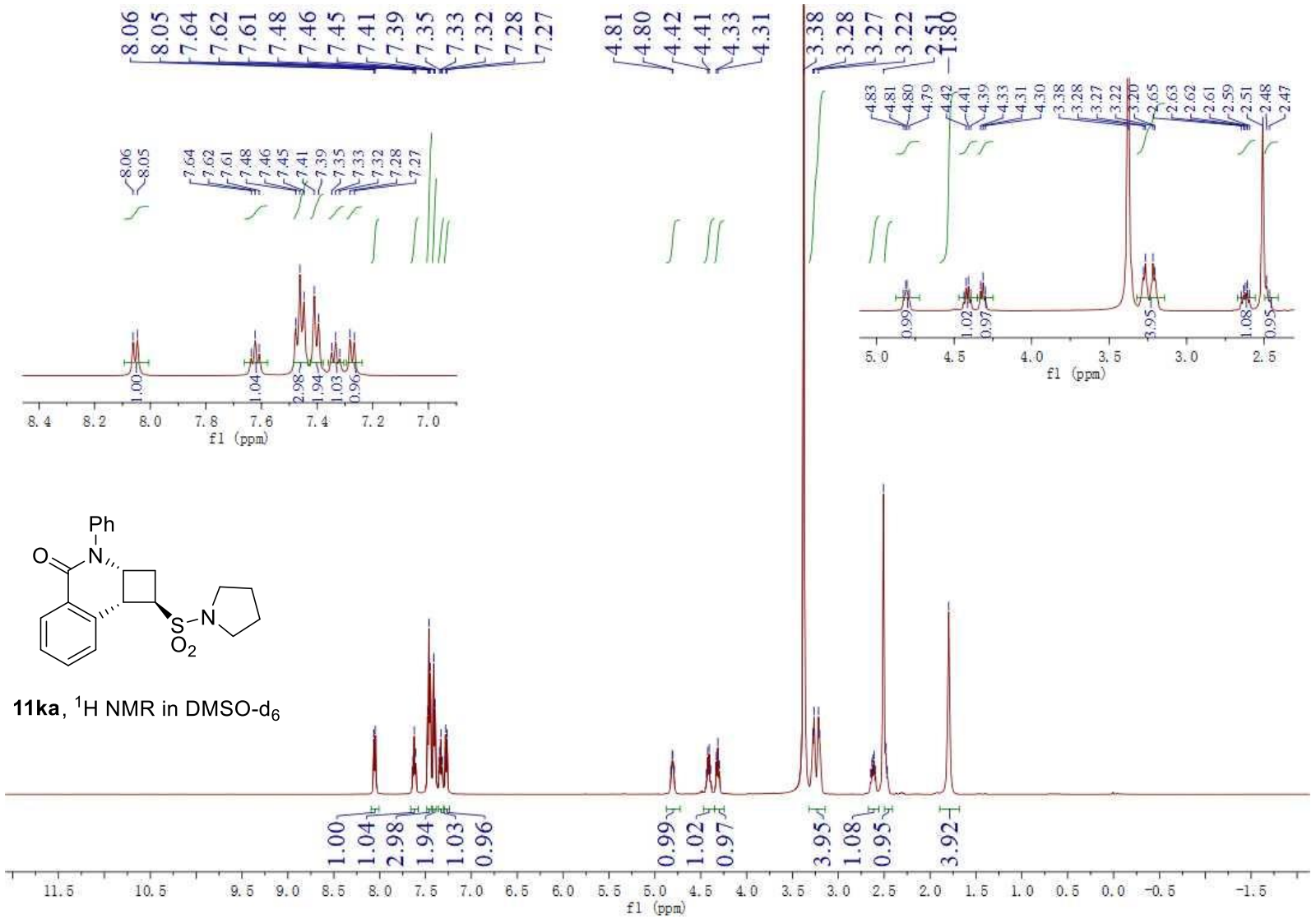
9ac, ^{13}C NMR in DMSO-d_6

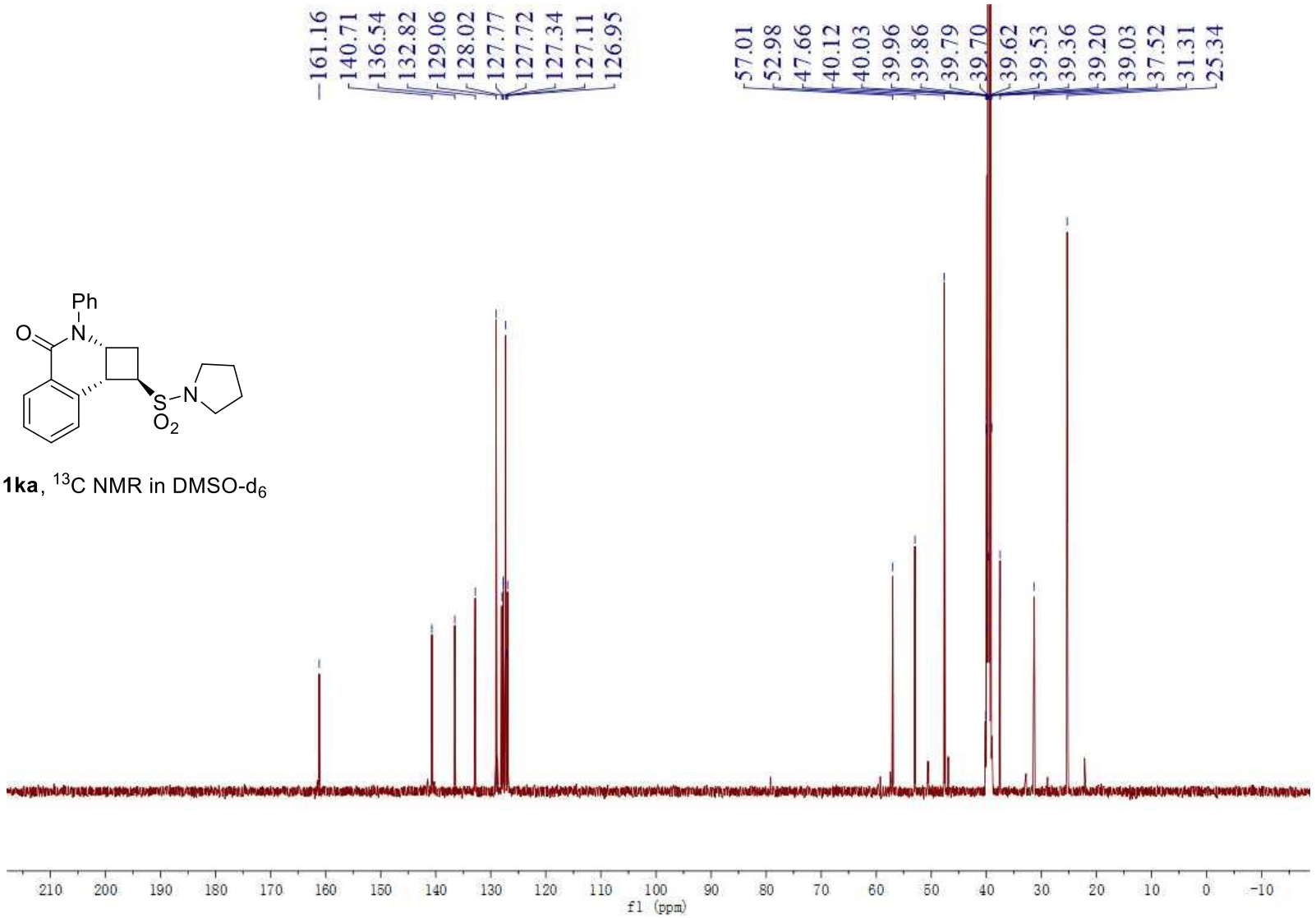


11aa, ^{1}H NMR in DMSO-d_6

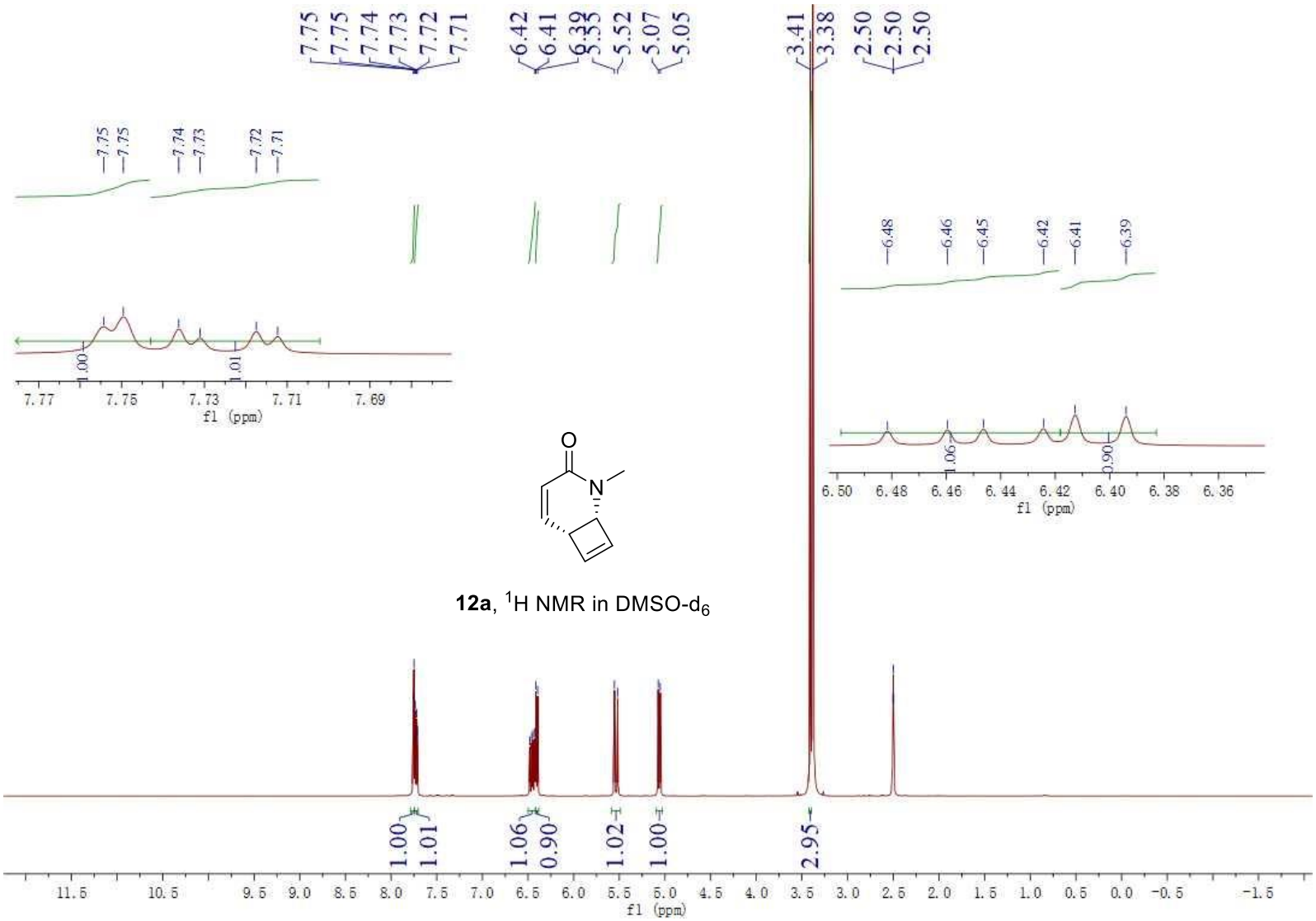


11aa, ^{13}C NMR in DMSO-d_6

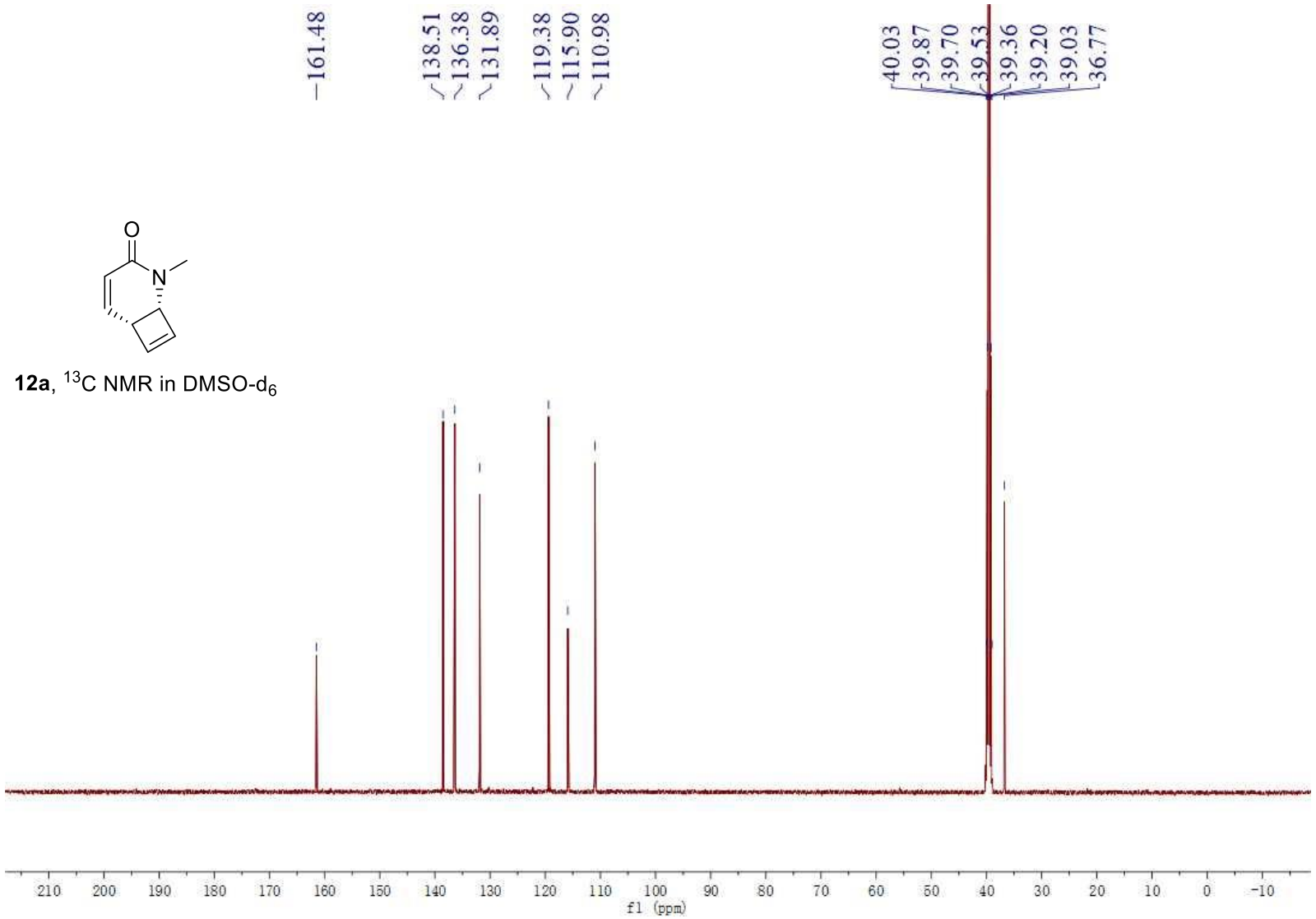

Ph
O
N
S
N
O2
11ka, 1H NMR in DMSO-d6
f1 (ppm)



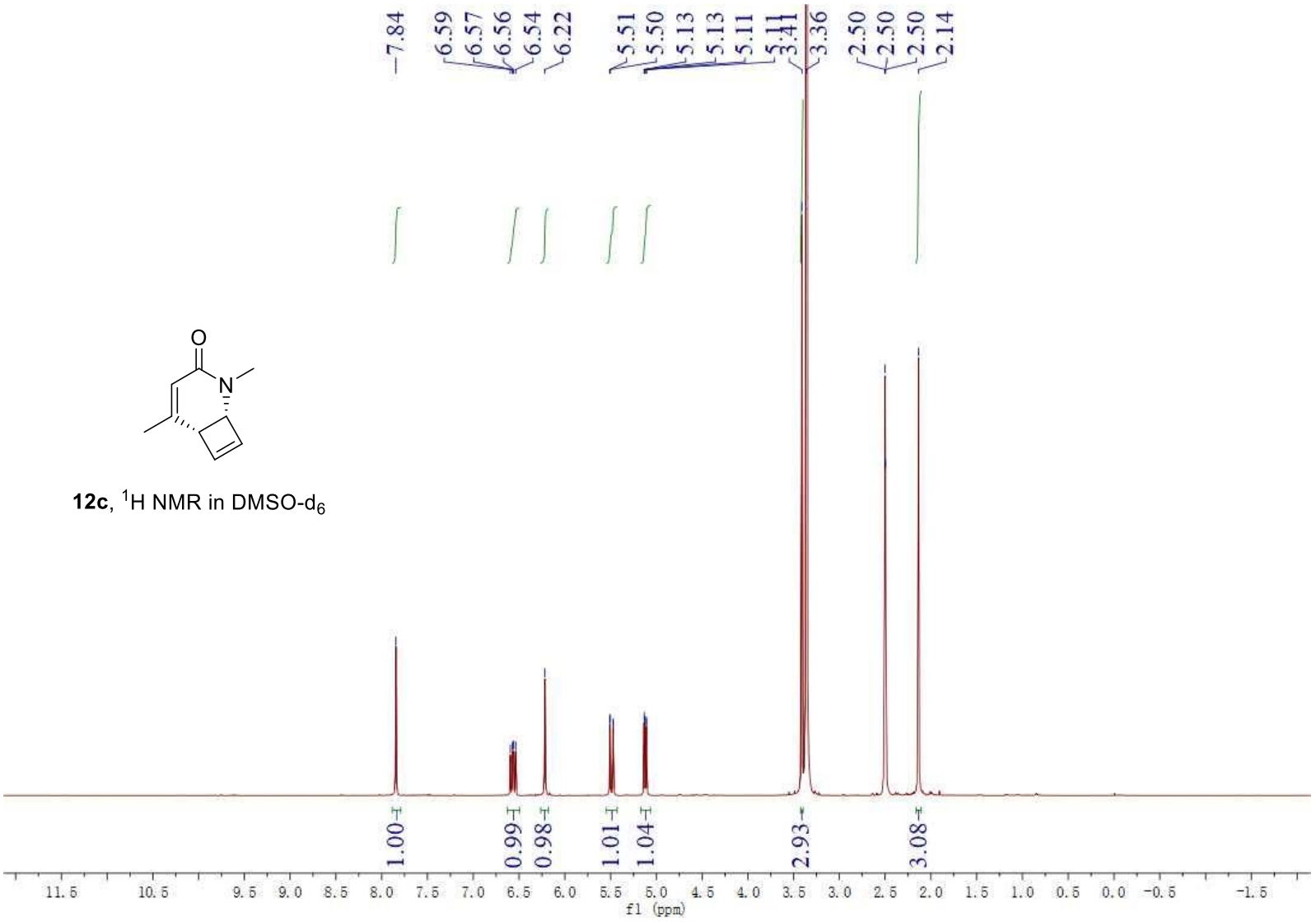
11ka, ^{13}C NMR in DMSO-d_6



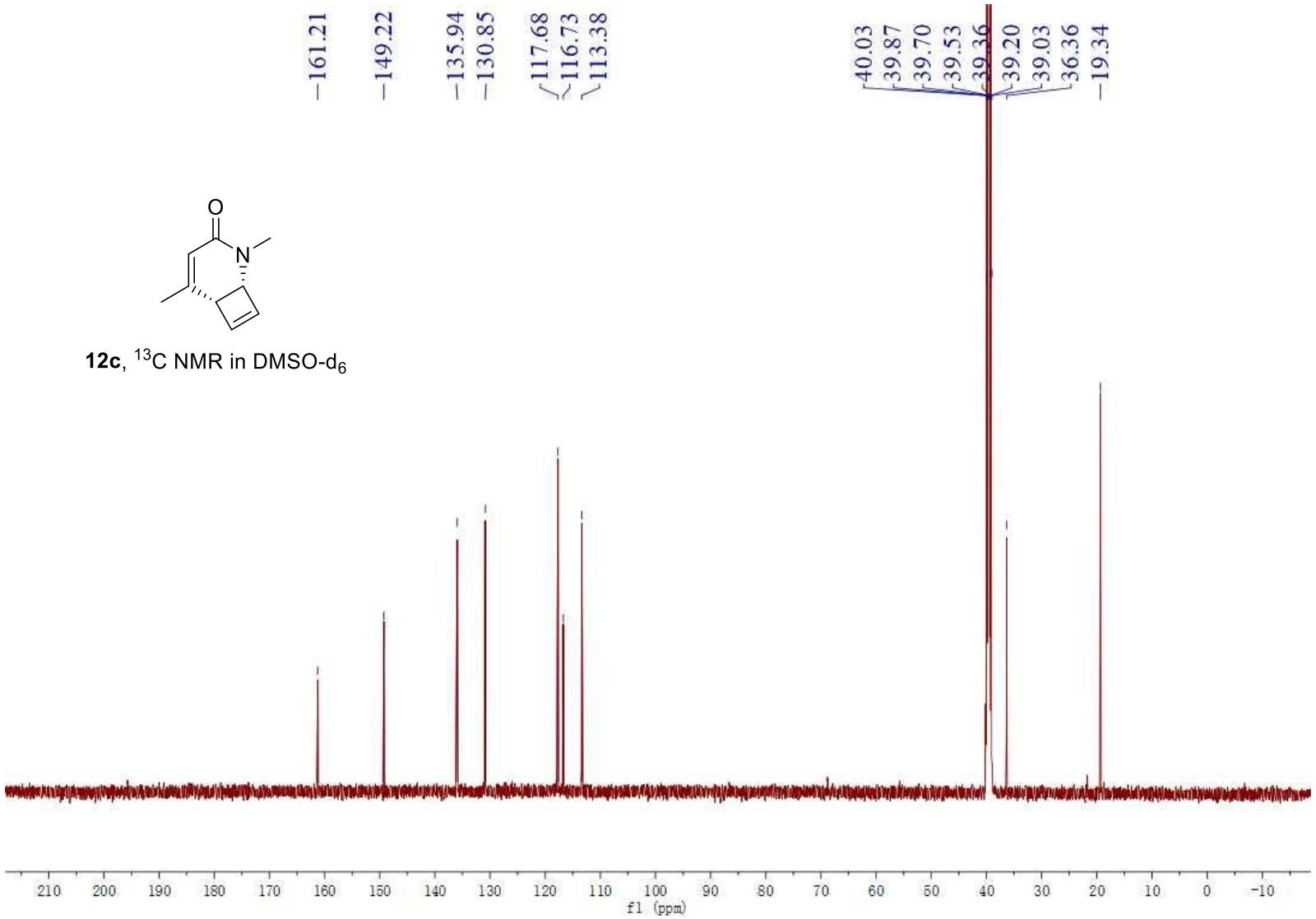
12a, ^{1}H NMR in DMSO-d_6



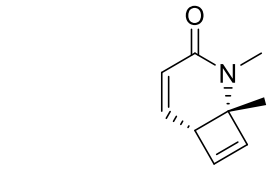
12a, ^{13}C NMR in DMSO-d_6



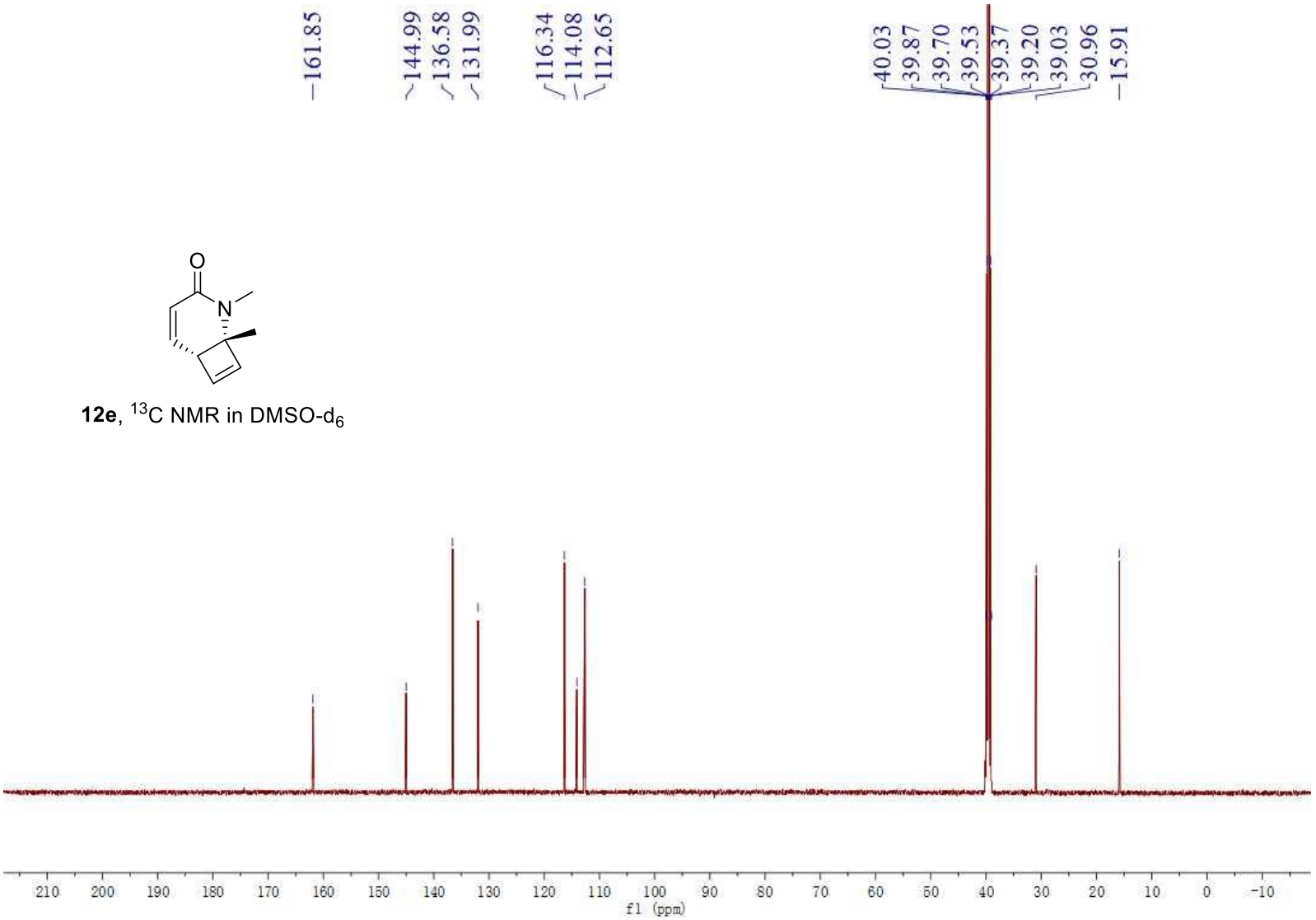
12c, ^{1}H NMR in DMSO-d_6



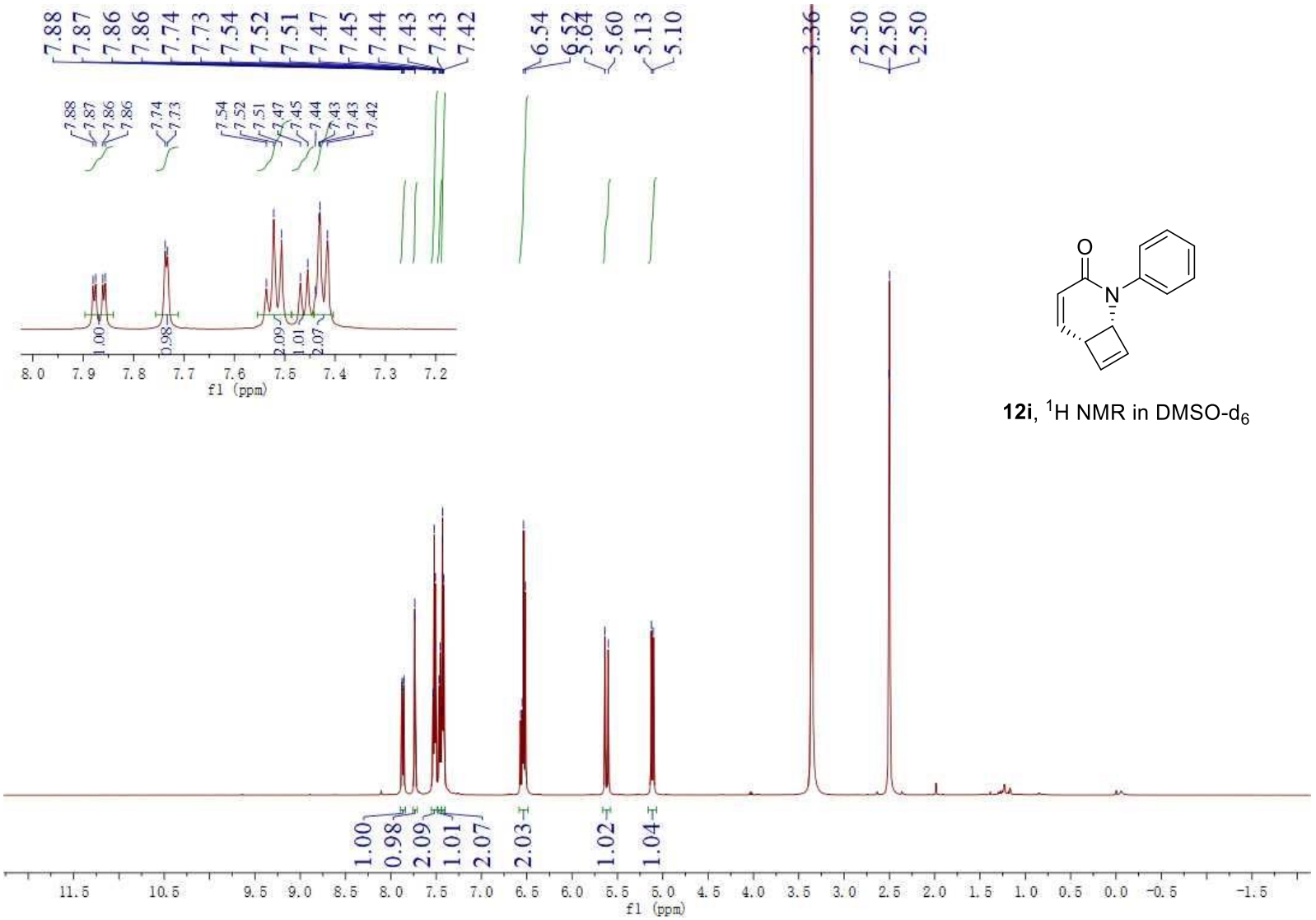
12c, ^{13}C NMR in DMSO-d_6



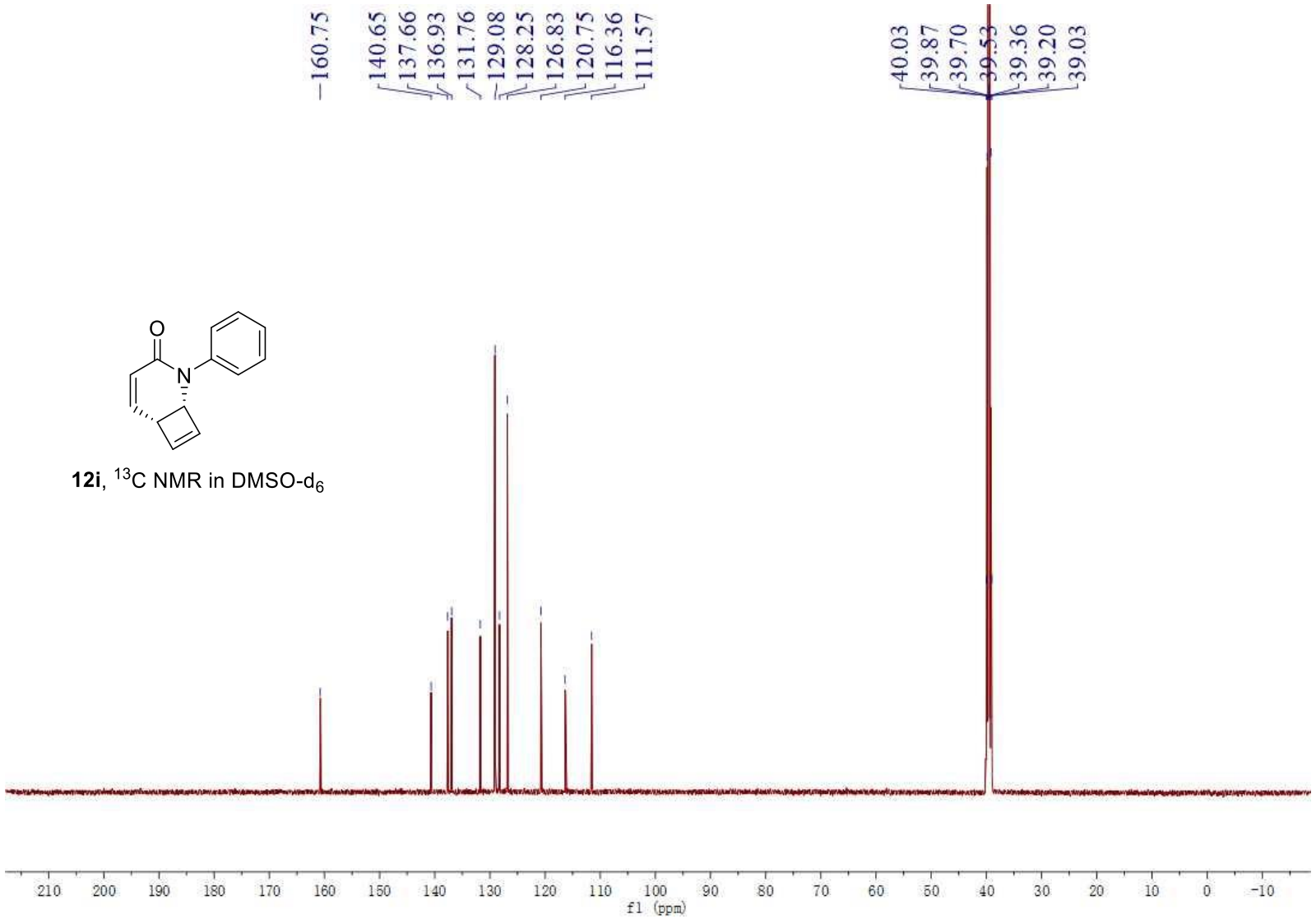
12e, ^{1}H NMR in DMSO-d_6



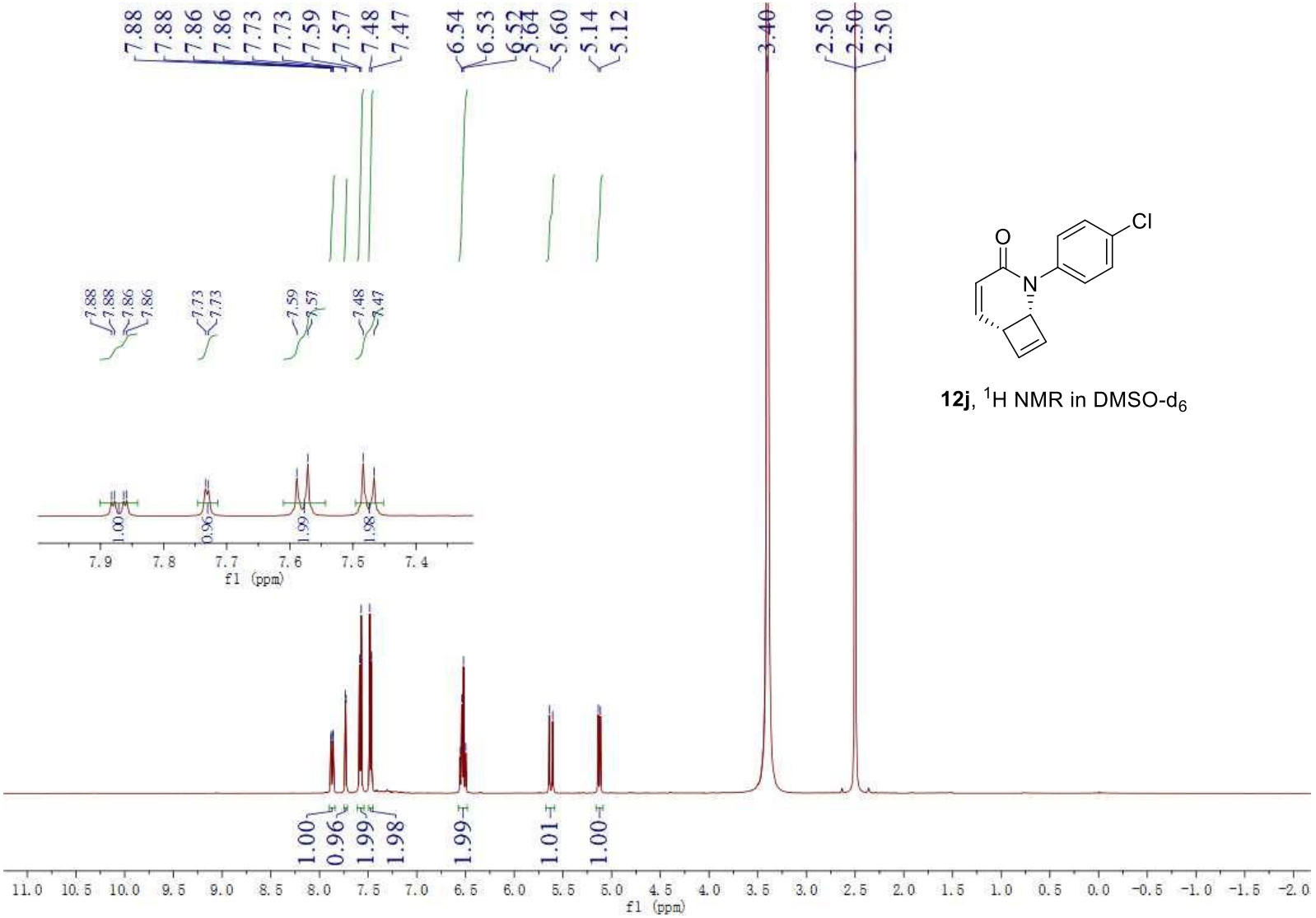
12e, ^{13}C NMR in DMSO-d_6



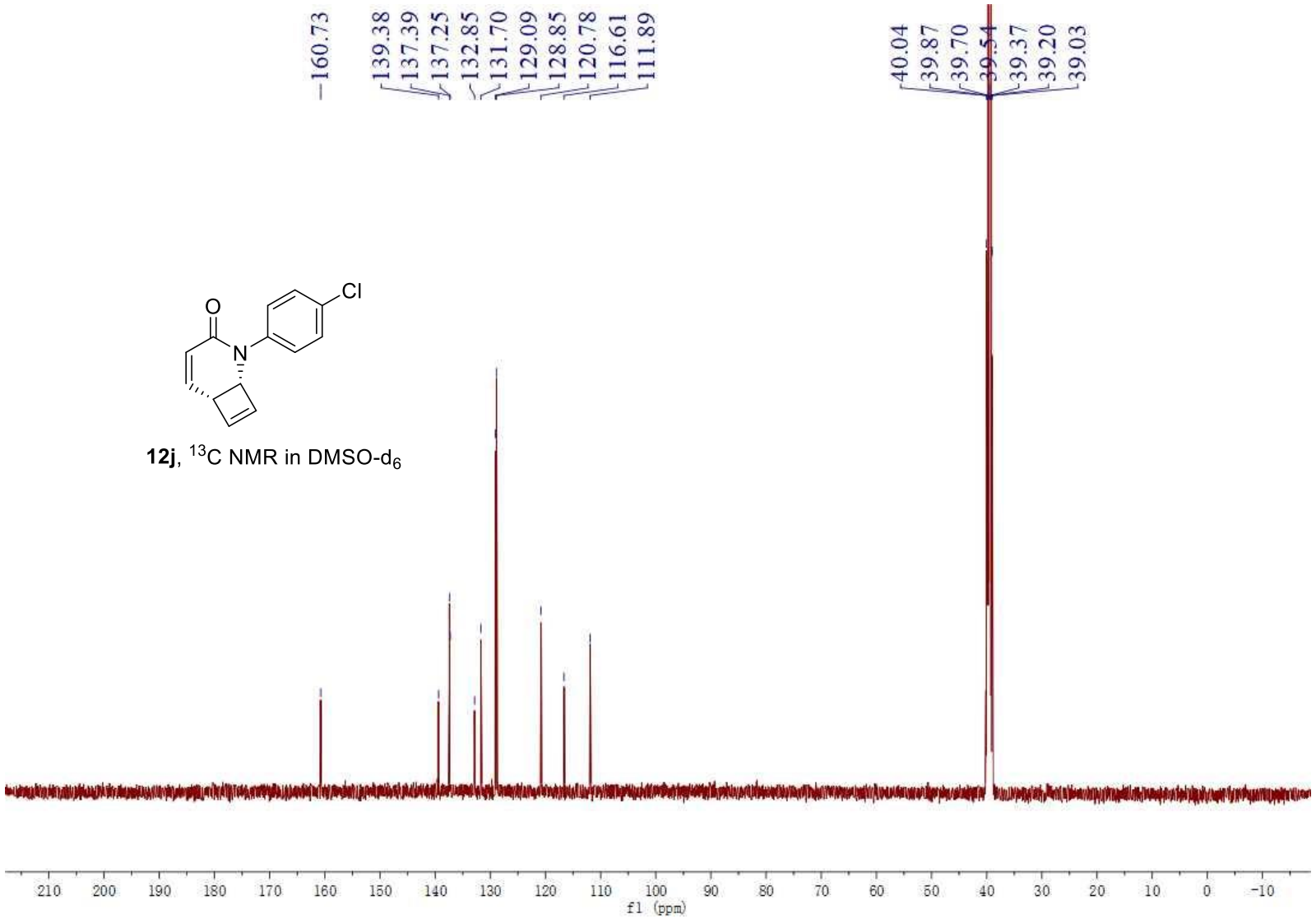
12i, ^{1}H NMR in DMSO-d_6



12i, ^{13}C NMR in DMSO-d_6



12j, ^{1}H NMR in DMSO-d_6



12j, ^{13}C NMR in DMSO-d_6

14. X-ray crystallographic data of 5a

Table 8. Crystal data and structure refinement for 190909f.

Identification code	190909f
Empirical formula	C8 H12 F N O4 S
Formula weight	237.25
Temperature	298(2) K
Wavelength	0.71073 A
Crystal system, space group	Triclinic, P-1
Unit cell dimensions	a = 6.9928(5) A alpha = 79.6510(10) deg. b = 7.7011(6) A beta = 81.793(2) deg. c = 10.3093(9) A gamma = 80.0050(10) deg.
Volume	534.28(7) A^3
Z, Calculated density	2, 1.475 Mg/m^3
Absorption coefficient	0.312 mm^-1
F(000)	248
Crystal size	0.48 x 0.40 x 0.36 mm
Theta range for data collection	2.72 to 25.02 deg.
Limiting indices	-8<=h<=7, -7<=k<=9, -12<=l<=8
Reflections collected / unique	2675 / 1849 [R(int) = 0.0197]
Completeness to theta = 25.02	98.1 %
Absorption correction	Semi-empirical from equivalents
Max. and min. transmission	0.8961 and 0.8648

Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	1849 / 0 / 136
Goodness-of-fit on F^2	1.067
Final R indices [I>2sigma(I)]	R1 = 0.0402, wR2 = 0.1065
R indices (all data)	R1 = 0.0492, wR2 = 0.1132
Largest diff. peak and hole	0.254 and -0.290 e.A^-3

Table 9. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters (A^2 x 10^3) for 190909f.
U(eq) is defined as one third of the trace of the orthogonalized Uij tensor.

	x	y	z	U(eq)
F(1)	7129(3)	568(3)	332(2)	94(1)
N(1)	590(3)	4696(2)	2794(2)	40(1)
O(1)	-2202(2)	4403(2)	4182(2)	53(1)
O(2)	8158(3)	726(3)	2416(2)	66(1)
O(3)	7016(3)	3427(2)	965(2)	63(1)
O(4)	5485(3)	2835(2)	6467(2)	66(1)
S(1)	6836(1)	1598(1)	1458(1)	52(1)
C(1)	-449(3)	3851(3)	3837(2)	39(1)
C(2)	566(3)	2236(3)	4617(2)	43(1)
C(3)	2460(3)	1661(3)	4399(2)	45(1)
C(4)	3743(3)	2574(3)	3305(2)	38(1)
C(5)	2583(3)	3964(3)	2316(2)	38(1)
C(6)	2848(3)	2596(3)	1353(2)	46(1)
C(7)	4427(3)	1419(3)	2169(2)	41(1)
C(8)	-317(4)	6313(3)	1995(3)	61(1)

Table 10. Bond lengths [A] and angles [deg] for 190909f.

F(1)-S(1)	1.4917(19)
N(1)-C(1)	1.341(3)
N(1)-C(5)	1.461(3)
N(1)-C(8)	1.462(3)
O(1)-C(1)	1.248(3)
O(2)-S(1)	1.4451(19)
O(3)-S(1)	1.4297(18)
O(4)-H(4C)	0.8500
O(4)-H(4D)	0.8500
S(1)-C(7)	1.757(2)
C(1)-C(2)	1.481(3)
C(2)-C(3)	1.322(3)
C(2)-H(2)	0.9300
C(3)-C(4)	1.489(3)
C(3)-H(3)	0.9300
C(4)-C(5)	1.544(3)
C(4)-C(7)	1.568(3)
C(4)-H(4)	0.9800
C(5)-C(6)	1.544(3)
C(5)-H(5)	0.9800
C(6)-C(7)	1.547(3)
C(6)-H(6A)	0.9700
C(6)-H(6B)	0.9700
C(7)-H(7)	0.9800
C(8)-H(8A)	0.9600
C(8)-H(8B)	0.9600
C(8)-H(8C)	0.9600
C(1)-N(1)-C(5)	122.35(18)
C(1)-N(1)-C(8)	120.51(19)
C(5)-N(1)-C(8)	116.83(18)
H(4C)-O(4)-H(4D)	108.0
O(3)-S(1)-O(2)	114.53(12)
O(3)-S(1)-F(1)	109.86(13)
O(2)-S(1)-F(1)	109.00(13)
O(3)-S(1)-C(7)	110.03(11)
O(2)-S(1)-C(7)	108.84(11)
F(1)-S(1)-C(7)	104.05(11)
O(1)-C(1)-N(1)	122.4(2)

O(1)-C(1)-C(2)	119.8(2)
N(1)-C(1)-C(2)	117.81(19)
C(3)-C(2)-C(1)	123.6(2)
C(3)-C(2)-H(2)	118.2
C(1)-C(2)-H(2)	118.2
C(2)-C(3)-C(4)	122.0(2)
C(2)-C(3)-H(3)	119.0
C(4)-C(3)-H(3)	119.0
C(3)-C(4)-C(5)	112.97(18)
C(3)-C(4)-C(7)	111.36(17)
C(5)-C(4)-C(7)	88.32(15)
C(3)-C(4)-H(4)	113.9
C(5)-C(4)-H(4)	113.9
C(7)-C(4)-H(4)	113.9
N(1)-C(5)-C(4)	117.18(17)
N(1)-C(5)-C(6)	117.73(18)
C(4)-C(5)-C(6)	90.17(16)
N(1)-C(5)-H(5)	110.1
C(4)-C(5)-H(5)	110.1
C(6)-C(5)-H(5)	110.1
C(5)-C(6)-C(7)	89.07(16)
C(5)-C(6)-H(6A)	113.8
C(7)-C(6)-H(6A)	113.8
C(5)-C(6)-H(6B)	113.8
C(7)-C(6)-H(6B)	113.8
H(6A)-C(6)-H(6B)	111.0
C(6)-C(7)-C(4)	89.21(16)
C(6)-C(7)-S(1)	114.04(16)
C(4)-C(7)-S(1)	112.42(14)
C(6)-C(7)-H(7)	113.0
C(4)-C(7)-H(7)	113.0
S(1)-C(7)-H(7)	113.0
N(1)-C(8)-H(8A)	109.5
N(1)-C(8)-H(8B)	109.5
H(8A)-C(8)-H(8B)	109.5
N(1)-C(8)-H(8C)	109.5
H(8A)-C(8)-H(8C)	109.5
H(8B)-C(8)-H(8C)	109.5

Symmetry transformations used to generate equivalent atoms:

Table 11. Anisotropic displacement parameters (A^2 x 10^3) for 190909f.
The anisotropic displacement factor exponent takes the form:
-2 pi^2 [h^2 a*^2 U11 + ... + 2 h k a* b* U12]

	U11	U22	U33	U23	U13	U12
F(1)	84(1)	114(2)	91(1)	-55(1)	18(1)	-21(1)
N(1)	39(1)	34(1)	42(1)	0(1)	0(1)	-2(1)
O(1)	41(1)	50(1)	59(1)	-4(1)	7(1)	-2(1)
O(2)	42(1)	69(1)	80(1)	2(1)	-15(1)	1(1)
O(3)	60(1)	50(1)	74(1)	7(1)	9(1)	-21(1)
O(4)	58(1)	54(1)	76(1)	9(1)	2(1)	-5(1)
S(1)	39(1)	52(1)	60(1)	-6(1)	6(1)	-7(1)
C(1)	39(1)	35(1)	42(1)	-8(1)	-1(1)	-8(1)
C(2)	47(1)	38(1)	41(1)	0(1)	4(1)	-12(1)
C(3)	49(1)	40(1)	41(1)	4(1)	-7(1)	-7(1)
C(4)	36(1)	39(1)	40(1)	-4(1)	-5(1)	-10(1)
C(5)	37(1)	37(1)	38(1)	-1(1)	0(1)	-9(1)
C(6)	40(1)	57(1)	44(1)	-11(1)	-6(1)	-7(1)
C(7)	38(1)	35(1)	49(1)	-4(1)	0(1)	-11(1)
C(8)	63(2)	49(1)	57(2)	9(1)	2(1)	8(1)

Table 12. Hydrogen coordinates (x 10^4) and isotropic displacement parameters (A^2 x 10^3) for 190909f.

	x	y	z	U(eq)
H(4C)	6322	3163	5828	79
H(4D)	4425	3556	6390	79
H(2)	-170	1591	5298	52
H(3)	3007	657	4946	54
H(4)	4808	3017	3607	45
H(5)	3336	4935	1938	45
H(6A)	3343	3052	451	56
H(6B)	1697	2044	1369	56
H(7)	4195	179	2434	49
H(8A)	-1577	6720	2436	92
H(8B)	-468	6055	1141	92
H(8C)	496	7225	1883	92

Table 13. Torsion angles [deg] for 190909f.

C(5)-N(1)-C(1)-O(1)	-174.2(2)
C(8)-N(1)-C(1)-O(1)	-0.9(3)
C(5)-N(1)-C(1)-C(2)	7.6(3)
C(8)-N(1)-C(1)-C(2)	-179.1(2)
O(1)-C(1)-C(2)-C(3)	-173.2(2)
N(1)-C(1)-C(2)-C(3)	5.0(3)
C(1)-C(2)-C(3)-C(4)	-1.9(4)
C(2)-C(3)-C(4)-C(5)	-11.8(3)
C(2)-C(3)-C(4)-C(7)	-109.3(2)
C(1)-N(1)-C(5)-C(4)	-21.6(3)
C(8)-N(1)-C(5)-C(4)	164.8(2)
C(1)-N(1)-C(5)-C(6)	84.2(3)
C(8)-N(1)-C(5)-C(6)	-89.4(3)
C(3)-C(4)-C(5)-N(1)	22.6(3)
C(7)-C(4)-C(5)-N(1)	135.16(18)
C(3)-C(4)-C(5)-C(6)	-99.0(2)
C(7)-C(4)-C(5)-C(6)	13.51(15)
N(1)-C(5)-C(6)-C(7)	-134.87(19)
C(4)-C(5)-C(6)-C(7)	-13.69(16)
C(5)-C(6)-C(7)-C(4)	13.49(16)
C(5)-C(6)-C(7)-S(1)	-100.81(16)
C(3)-C(4)-C(7)-C(6)	100.6(2)
C(5)-C(4)-C(7)-C(6)	-13.49(16)
C(3)-C(4)-C(7)-S(1)	-143.64(17)
C(5)-C(4)-C(7)-S(1)	102.30(16)
O(3)-S(1)-C(7)-C(6)	42.77(19)
O(2)-S(1)-C(7)-C(6)	169.02(16)
F(1)-S(1)-C(7)-C(6)	-74.87(18)
O(3)-S(1)-C(7)-C(4)	-56.89(18)
O(2)-S(1)-C(7)-C(4)	69.36(18)
F(1)-S(1)-C(7)-C(4)	-174.53(16)

Symmetry transformations used to generate equivalent atoms:

Table 14. Hydrogen bonds for 190909f [A and deg.].

D-H	d(D-H)	d(H..A)	<DHA	d(D..A)	A
O4-H4C	0.850	2.028	166.58	2.862	O1 [x+1, y, z]
O4-H4D	0.850	2.077	166.77	2.911	O1 [-x, -y+1, -z+1]