Supporting Information

Oxidative [3+2] Annulation of Activated Pyridines for the Synthesis of Indolizinyl Sulfonyl Fluorides: A Class of Important Pharmacophore

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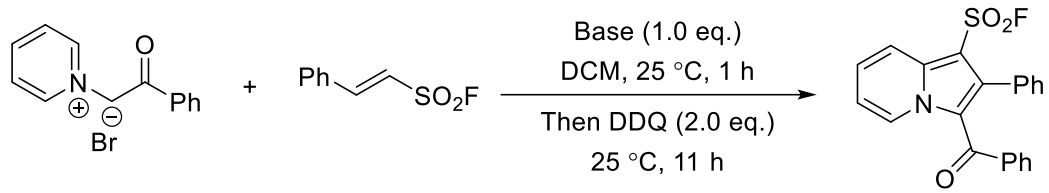
Table of Contents

1. General Information

All reactions were carried out under an air atmosphere unless otherwise specified. Reagents used in the reactions were all purchased from commercial sources and used without further purification. 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), and 126 MHz (for ^{13}C) Bruker Avance spectrometer, and were internally referenced to solvent residual signals (note: $CDCl_3$: δ H = 7.260 ppm, δ C = 77.16 ppm; DMSO-d_6: δ H = 2.500 ppm, δ C = 39.52 ppm). The following abbreviations were used to explain the multiplicities: s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet. All chemical shifts were reported in ppm relative to TMS (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 product spots on the thin layer chromatography (TLC) were visualized under ultraviolet light (254 nm or 365 nm) followed by staining with potassium permanganate or phosphomolybdic acid.

2. Optimization of the Reaction Conditions

Table S1 Screening of the base[a]

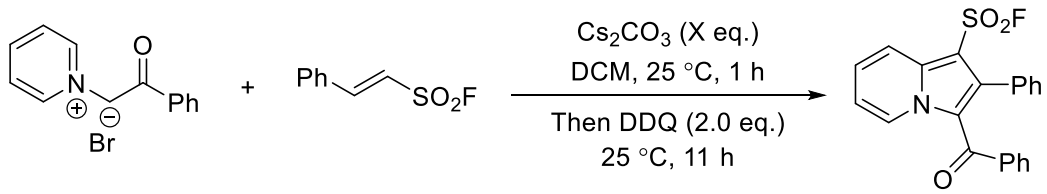


1a **2a** **3a**

Entry	Base (1.0 eq.)	Yield (3a, %) [b]
1	DBU	3
2	Et_3N	4
3	TMEDA	2
4	DIPEA	31
5	Na_2CO_3	13
6	$NaHCO_3$	N.D.
7	**Cs_2CO_3**	**57**
8	K_2CO_3	16
9	K_2HPO_4	41
10	KF	N.D.
11	/	N.D.

[a]Reaction conditions: **1a** (27.8 mg, 0.1 mmol, 1.0 eq.), **2a** (20.5 mg, 0.11 mmol, 1.1 eq.), base (0.1 mmol, 1.0 eq.), and DCM (0.05 M, 2.0 ml) were added to an oven-dried reaction tube (10 mL) at 25 °C for 1 h, then DDQ (45.4 mg, 0.2 mmol, 2.0 eq.) was added. After the addition was over, the resulting mixture was stirred at 25 °C for 11 h. [b]The yield was determined by HPLC using pure **3a** as the external standard (t_R = 4.898 min, λ_{max} = 242.9 nm; MeCN / H_2O = 80: 20 (v / v)). N.D. = Not detectable.

Table S2 Screening of the Cs_2CO_3 loading[a]

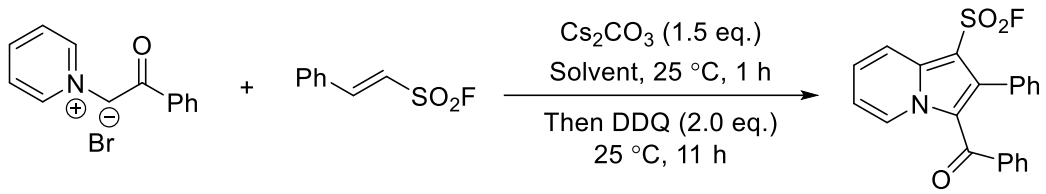


1a **2a** **3a**

Entry	Cs_2CO_3 (X eq.)	Yield (3a, %) [b]
1	0.8	52
2	1.0	55
3	1.2	60
4	**1.5**	**65**
5	2.0	64

[a]Reaction conditions: **1a** (27.8 mg, 0.1 mmol, 1.0 eq.), **2a** (20.5 mg, 0.11 mmol, 1.1 eq.), Cs_2CO_3 (X eq.), and DCM (0.05 M, 2.0 ml) were added to an oven-dried reaction tube (10 mL) at 25 °C for 1 h, then DDQ (45.4 mg, 0.2 mmol, 2.0 eq.) was added. After the addition was over, the resulting mixture was stirred at 25 °C for 11 h. [b]The yield was determined by HPLC using pure **3a** as the external standard (t_R = 4.898 min, λ_{max} = 242.9 nm; MeCN / H_2O = 80: 20 (v / v)).

Table S3 Screening of the solvent[a]

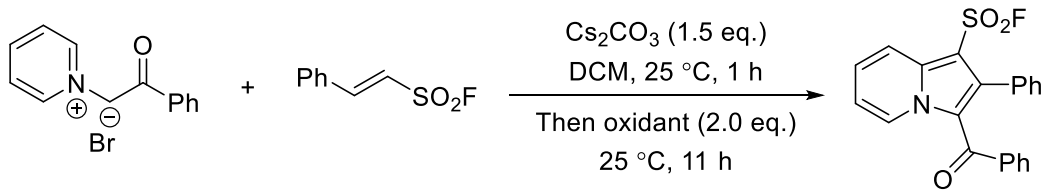


1a **2a** **3a**

Entry	Solvent	Yield (3a, %) [b]
1	CH_3Cl	2
2	DCE	55
3	**DCM**	**65**
4	Toluene	38
5	MeCN	5
6	THF	N.D.
7	DMSO	2

[a]Reaction conditions: **1a** (27.8 mg, 0.1 mmol, 1.0 eq.), **2a** (20.5 mg, 0.11 mmol, 1.1 eq.), Cs_2CO_3 (48.9 mg, 0.15 mmol, 1.5 eq.), and solvent (0.05 M, 2.0 ml) were added to an oven-dried reaction tube (10 mL) at 25 °C for 1 h, then DDQ (45.4 mg, 0.2 mmol, 2.0 eq.) was added. After the addition was over, the resulting mixture was stirred at 25 ℃ for 11 h. [b]The yield was determined by HPLC using pure **3a** as the external standard (t_R = 4.898 min, λ_{max} = 242.9 nm; MeCN / H_2O = 80: 20 (v / v)). N.D. = Not detectable.

Table S4 Screening of the oxidant[a]

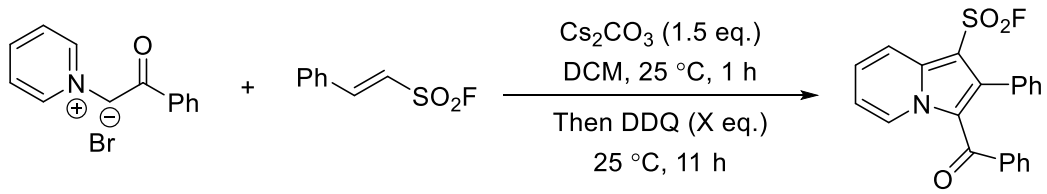


1a **2a** **3a**

Entry	Oxidant (2.0 eq.)	Yield (3a, %) [b]
1	TEMPO	N.D.
2	**DDQ**	**65**
3	CuO	N.D.
4	MnO_2	N.D.
5	$Cu(AcO)_2$	N.D.
6	I_2	18
7	/	N.D.

[a]Reaction conditions: **1a** (27.8 mg, 0.1 mmol, 1.0 eq.), **2a** (20.5 mg, 0.11 mmol, 1.1 eq.), Cs_2CO_3 (48.9 mg, 0.15 mmol, 1.5 eq.), and DCM (0.05 M, 2.0 ml) were added to an oven-dried reaction tube (10 mL) at 25 °C for 1 h, then oxidant (0.2 mmol, 2.0 eq.) was added. After the addition was over, the resulting mixture was stirred at 25 °C for 11 h. [b]The yield was determined by HPLC using pure **3a** as the external standard (t_R = 4.898 min, λ_{max} = 242.9 nm; MeCN / H_2O = 80: 20 (v / v)). N.D. = Not detectable.

Table S5 Screening of the DDQ loading[a]

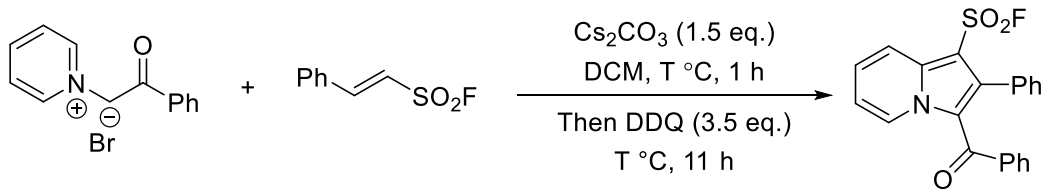


1a **2a** **3a**

Entry	DDQ (X eq.)	Yield (3a, %) [b]
1	1.5	50
2	2.0	63
3	2.5	65
4	3.0	67
5	**3.5**	**68**
6	4.0	67

[a]Reaction conditions: **1a** (27.8 mg, 0.1 mmol, 1.0 eq.), **2a** (20.5 mg, 0.11 mmol, 1.1 eq.), Cs_2CO_3 (48.9 mg, 0.15 mmol, 1.5 eq.), and DCM (0.05 M, 2.0 ml) were added to an oven-dried reaction tube (10 mL) at 25 °C for 1 h, then DDQ (X eq.) was added. After the addition was over, the resulting mixture was stirred at 25 ℃ for 11 h. [b]The yield was determined by HPLC using pure **3a** as the external standard (t_R = 4.898 min, λ_{max} = 242.9 nm; MeCN / H_2O = 80: 20 (v / v)).

Table S6 Screening of the temperature[a]

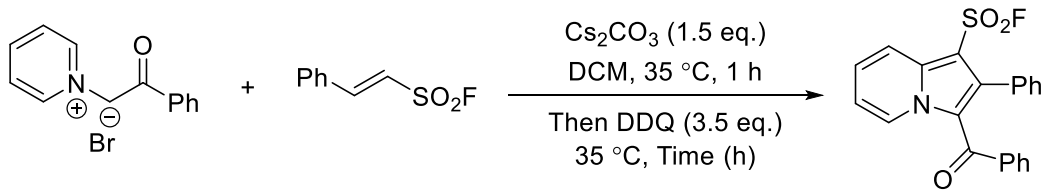


1a **2a** **3a**

Entry	Temperature (℃)	Yield (3a, %) [b]
1	0	2
2	15	53
3	25	68
4	**35**	**75**
5	45	71

[a]Reaction conditions: **1a** (27.8 mg, 0.1 mmol, 1.0 eq.), **2a** (20.5 mg, 0.11 mmol, 1.1 eq.), Cs_2CO_3 (48.9 mg, 0.15 mmol, 1.5 eq.), and DCM (0.05 M, 2.0 ml) were added to an oven-dried reaction tube (10 mL) at T °C for 1 h, then DDQ (79.5 mg, 0.35 mmol, 3.5 eq.) was added. After the addition was over, the resulting mixture was stirred at T ℃ for 11 h. [b]The yield was determined by HPLC using pure **3a** as the external standard (t_R = 4.898 min, λ_{max} = 242.9 nm; MeCN / H_2O = 80: 20 (v / v)).

Table S7 Screening of the time[a]

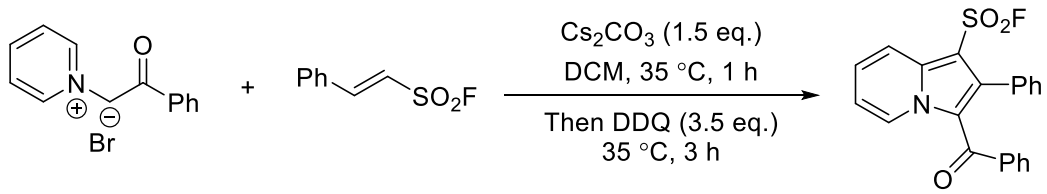


1a **2a** **3a**

Entry	Time (h)	Yield (3a, %) [b]
1	1.0	77
2	**3.0**	**80**
3	5.0	81
4	7.0	77
5	11.0	75
6	15.0	74

[a]Reaction conditions: **1a** (27.8 mg, 0.1 mmol, 1.0 eq.), **2a** (20.5 mg, 0.11 mmol, 1.1 eq.), Cs_2CO_3 (48.9 mg, 0.15 mmol, 1.5 eq.), and DCM (0.05 M, 2.0 ml) were added to an oven-dried reaction tube (10 mL) at 35 °C for 1 h, then DDQ (79.5 mg, 0.35 mmol, 3.5 eq.) was added. After the addition was over, the resulting mixture was stirred at 35 ℃ for the corresponding time. [b]The yield was determined by HPLC using pure **3a** as the external standard (t_R = 4.898 min, λ_{max} = 242.9 nm; MeCN / H_2O = 80: 20 (v / v)).

Table S8 Screening of the (E)-2-phenylethene-1-sulfonyl fluoride (**2a**) loading[a]



1a **2a, (X eq.)** **3a**

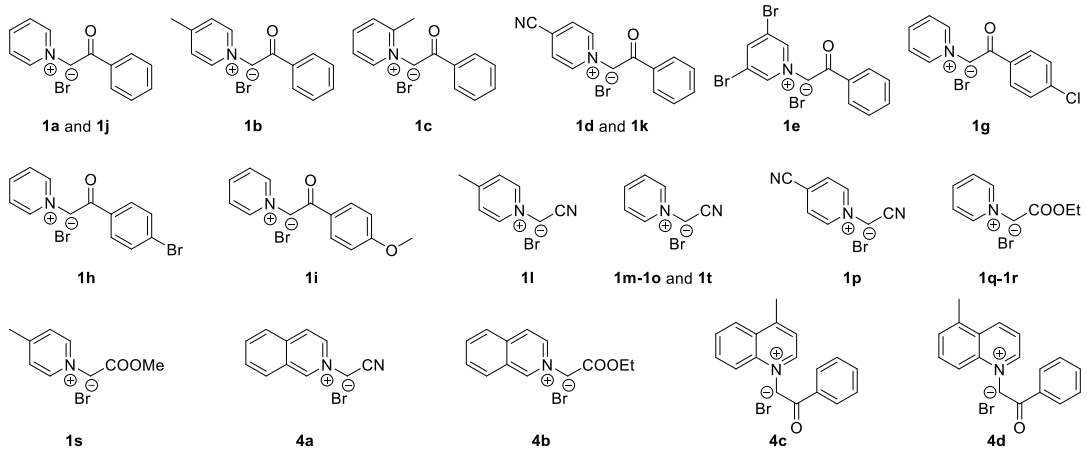
Entry	2a (X eq.)	Yield (3a, %) [b]
1	1.1	80
2	**1.3**	**85**
3	1.5	84
4	1.7	85

[a]Reaction conditions: **1a** (27.8 mg, 0.1 mmol, 1.0 eq.), **2a** (X eq.), Cs_2CO_3 (48.9 mg, 0.15 mmol, 1.5 eq.), and DCM (0.05 M, 2.0 ml) were added to an oven-dried reaction tube (10 mL) at 35 °C for 1 h, then DDQ (79.5 mg, 0.35 mmol, 3.5 eq.) was added. After the addition was over, the resulting mixture was stirred at 35 ℃ for 3 h. [b]The yield was determined by HPLC using pure **3a** as the external standard (t_R = 4.898 min, λ_{max} = 242.9 nm; MeCN / H_2O = 80: 20 (v / v)).

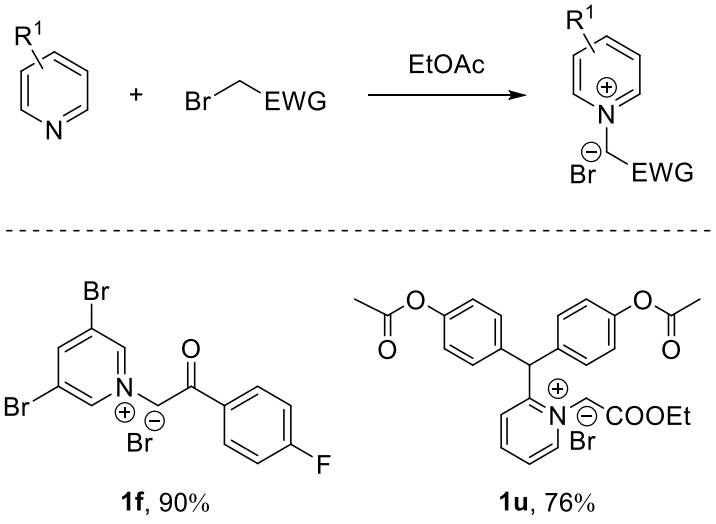
3. Experimental Procedures

3.1 Preparation of activated pyridines (1)

1a[1], **1b-1e**[2], **1f**[1], **1g-1i**[3], **1j**[1], **1k**[2], **1l-1p**[4], **1q-1s**[5], **1t**[4] **and 4a-4d**[6] are known compounds and were synthesized according to the literature.

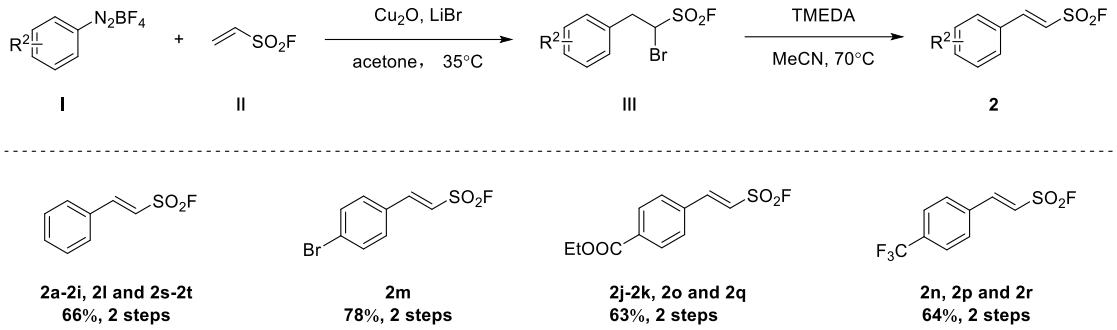


3.2 General procedures for synthesis of activated pyridines 1f and 1u (with 1f as an example)



3,5-Dibromopyridine (5 mmol) was added to a solution of the 2-bromo-1-(4-fluorophenyl) ethan-1-one (1.5 equiv.) in EtOAc (0.4 M) in a 50 mL round-bottom flask equipped with a magnetic stirring bar. The mixture was refluxed for 12 h, then cooled to room temperature upon completion. Filter the resulting precipitation and wash the residue with diethyl ether. Finally, the residue was dried in vacuum to obtain the product **1f**.

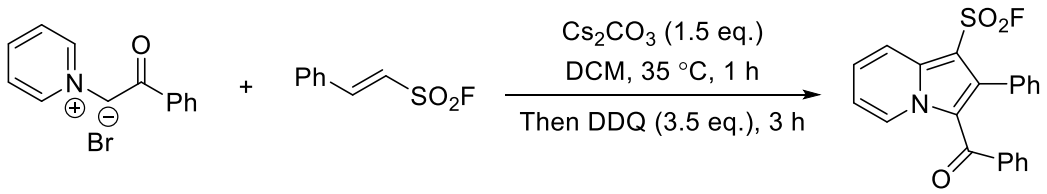
3.3 Preparation of β-arylethenesulfonyl fluorides (2)[7]



Step 1: An oven-dried round-bottom flask (100 mL) equipped with a magnetic stirring bar was charged with aryldiazonium tetrafluoroborates (**I** , 15 mmol, 1.0 eq.), Cu_2O (107 mg, 5 mol%) and ethenesulfonyl fluoride (**II** , 9900 mg, 90 mmol, 6.0 eq.), and acetone (60 mL). Then a solution of LiBr (1303 mg, 15 mmol, 1.0 eq.) in acetone (15 mL) was added dropwise to the above solution. The mixture was stirred at 35 °C for 5 hours under an air atmosphere. Once the reaction reached its completion, the mixture was diluted with water, extracted with ethyl acetate (3×60 mL) and the combined organic layers dried over anhydrous sodium sulfate. The solvent was concentrated under reduced pressure and the residue was further purified by column chromatography on silica gel via gradient elution with petroleum ether/ethyl acetate (40:1 to 1:1, v/v) as eluent to afford pure α-bromo arylethyl sulfonyl fluorides (**III**).

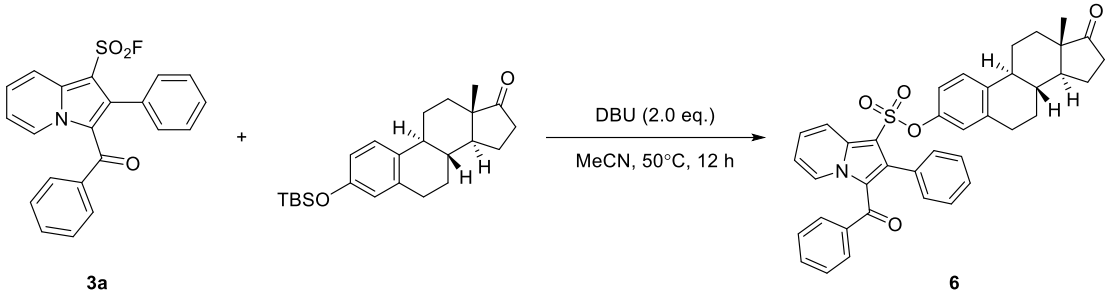
Step 2: An oven-dried round-bottom tube (100 mL) equipped with a magnetic stirring bar was charged with α-bromo arylethyl sulfonyl fluorides (**III**, 10 mmol, 1.0 eq.) and MeCN (50 mL). Then TMEDA (1394 mg, 12 mmol, 1.2 eq.) was added dropwise to the above solution. The mixture was stirred at 70 °C for 12 hours under an air atmosphere. Once the reaction reached its completion, the mixture was concentrated under reduced pressure and the residue was further purified by column chromatography on silica gel via gradient elution with petroleum ether/ethyl acetate (10:1 to 1:1, v/v) as eluent to afford pure β-arylethenesulfonyl fluorides (**2**).

3.4 General procedure for synthesis of compounds 3, 5 and 10 (with 3a as an example)



1-(2-oxo-2-phenylethyl)pyridin-1-ium bromide (**1a,** 139 mg, 0.5 mmol), (E)-2-phenylethene-1-sulfonyl fluoride (**2a**, 121mg, 0.65 mmol), Cs_2CO_3 (244 mg, 0.75 mmol), and DCM (0.05 M, 10.0 ml) were added to an oven-dried round-bottom flask (50 mL) equipped with a magnetic stirring bar at 35°C for 1 h, then DDQ (397 mg, 1.75 mmol) was added and the mixture was stirred at 35°C for 3h. After the reaction was completed, the mixture was filtered, and the filter cake was washed with ethyl acetate. The filtrate was extracted with ethyl acetate (3×20 mL) and the combined organic layers were further washed with brine, dried over anhydrous sodium sulfate. The solvent was concentrated under reduced pressure and the residue was further purified by column chromatography on silica gel with petroleum ether/ethyl acetate (10:1 to 3:1, v/v) as eluents to obtain the desired product **3a** as light yellow solid (153 mg, 81% yield).

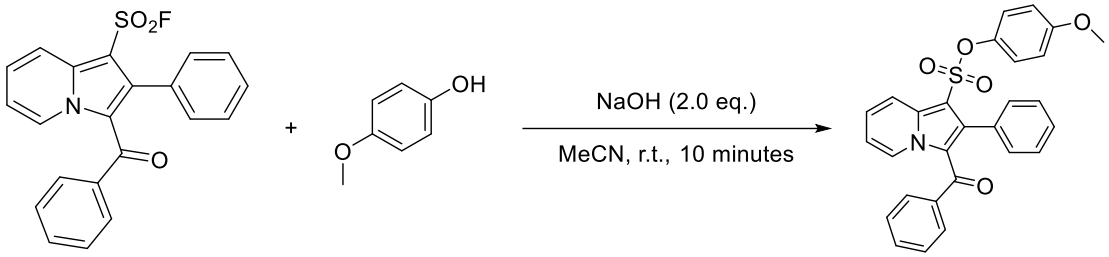
3.5 General procedure for synthesis of compound 6



To a solution of compound **3a** (152 mg, 0.4 mmol) and TBS-protected estrone (154 mg, 0.4 mmol) dissolved in acetonitrile (4 mL) was added DBU (122 mg,0.8 mmol), and the resulting mixture was stirred at 50 °C for 12 h. The reaction mixture was diluted with water, and the aqueous phase was extracted with ethyl acetate (3 × 20 mL). The combined organic layers were washed with brine and dried over anhydrous Na_2SO_4

before being concentrated to dryness under vacuum. The residue was purified through silica gel chromatography with petroleum ether/ethyl acetate (3:1, v/v) as eluents to obtain the desired product **6** as white solid (249 mg, 99% yield).

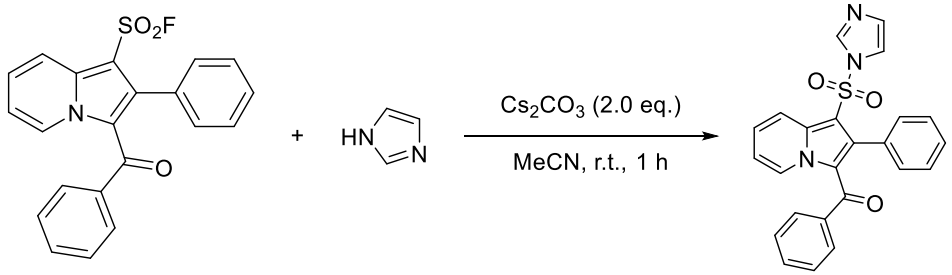
3.6 General procedure for synthesis of compound 7



3a **7**

3-benzoyl-2-phenylindolizine-1-sulfonyl fluoride (**3a**, 189.7 mg, 0.5 mmol), 4-methoxyphenol (74.5 mg, 0.6 mmol), NaOH (40 mg, 1.0 mmol) were added in a solution of acetonitrile (3 mL) and reacted at room temperature for 10 minutes. The reaction mixture was extracted with ethyl acetate (3×20 mL) and the combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified through silica gel chromatography with petroleum ether/ethyl acetate (3:1, v/v) as eluents to obtain the desired product **7** as light yellow solid (239 mg, 99% yield).

3.7 General procedure for synthesis of compound 8

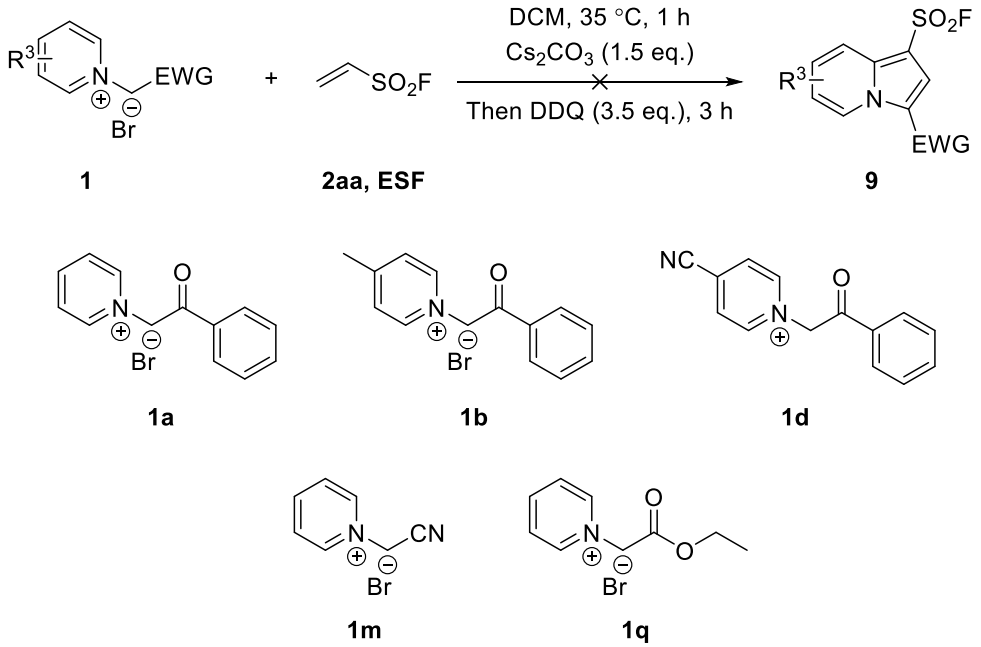


3a **8**

3-benzoyl-2-phenylindolizine-1-sulfonyl fluoride (**3a**, 189.7 mg, 0.5 mmol), imidazole (68 mg, 1.0 mmol) and Cs_2CO_3 (326 mg, 1.0 mmol) were added in mixed solution (3 mL) of acetonitrile, and reacted at room temperature for 1 h. The reaction mixture was extracted with ethyl acetate (3×20 mL) and the combined organic layers

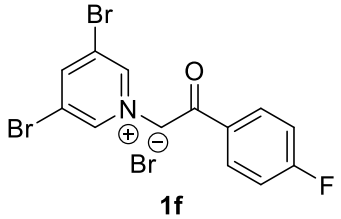
were dried over anhydrous sodium sulfate, filtered and concentrated under reduced pressure. The residue was purified through silica gel chromatography with petroleum ether/ethyl acetate (1:1, v/v) as eluents to obtain the desired product **8** as white solid (212 mg, 99% yield).

4. Unsuccessful experiments of activated pyridines and ESF



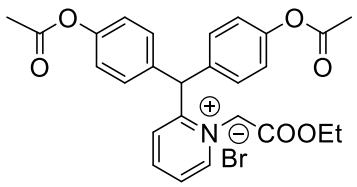
In our experimental work, attempts to synthesize indolizinyl sulfonyl fluorides via the reactions of activated pyridines (**1a, 1b, 1d, 1m, 1q**) with ESF did not achieve success. These reactions are quite complex, and further analysis results show that these target products have not been obtained. It is plausible that the high reactivity properties of ESF[8] led to the occurrence of other side reactions.

5. Characterization



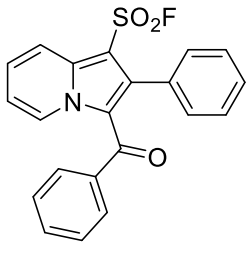
3,5-dibromo-1-(2-(4-fluorophenyl)-2-oxoethyl)pyridin-1-ium bromide (**1a**). White solid, 949 mg, 90% yield. M.p. 239−240 °C. General procedure for synthesis of salt **1f**

was followed. **^{1}H NMR** (500 MHz, DMSO-d_6) δ 9.55 (s, 2H), 9.46 (s, 1H), 8.16 (dd, J = 8.5, 5.5 Hz, 2H), 7.52 (t, J = 8.5 Hz, 2H), 6.51 (d, J = 3.5 Hz, 1H). **^{13}C NMR** (126 MHz, DMSO-d_6) δ 193.7, 171.1 (d, J = 254.3 Hz), 156.0 (d, J = 52.2 Hz), 151.7 (d, J = 61.3 Hz), 136.8 (dd, J = 20.1, 10.0 Hz), 135.4 (d, J = 2.9 Hz), 127.1, 121.7 (dd, J = 22.5, 6.1 Hz), 71.3. **HRMS-ESI** (m/z) calcd. for $[C_{13}H_9Br_2FNO]^+$ ([M-Br]$^+$):371.9029, found: 371.9021.



1u

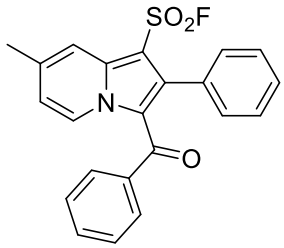
2-(bis(4-acetoxyphenyl)methyl)-1-(2-ethoxy-2-oxoethyl)pyridin-1-ium bromide (**1u**). Yellow solid, 2.06g, 78% yield. M.p. 194−195 ºC. General procedure for synthesis of salt **1u** was followed. **^{1}H NMR** (500 MHz, DMSO-d_6) δ 9.09 (d, J = 6.0 Hz, 1H), 8.66 (t, J = 8.0 Hz, 1H), 8.19 (t, J = 7.0 Hz, 1H), 7.60 (d, J = 8.0 Hz, 1H), 7.19 (t, J = 6.5 Hz, 8H), 6.62 (s, 1H), 5.85 (s, 2H), 3.84 (q, J = 7.0 Hz, 2H), 2.26 (s, 6H), 1.07 (t, J = 7.0 Hz, 3H). **^{13}C NMR** (126 MHz, DMSO-d_6) δ 169.0, 165.2, 158.4, 150.1, 148.7, 147.3, 134.9, 130.5, 129.4, 126.2, 122.5, 62.3, 57.3, 50.0, 20.8, 13.6. **HRMS-ESI** (m/z) calcd. for $[C_{26}H_{26}NO_6]^+$ ([M-Br]$^+$): 448.1755, found: 448.1758.



3a

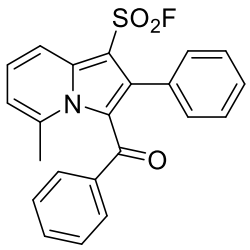
3-benzoyl-2-phenylindolizine-1-sulfonyl fluoride (**3a**). light yellow solid, 153 mg, 81% yield. M.p. 160−161 ºC. Purification by column chromatography on silica gel using petroleum ether / ethyl acetate (10:1, v/v) as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 9.50 (d, J = 7.0 Hz, 1H), 8.33 (d, J = 9.0 Hz, 1H), 7.57 (dd, J = 9.0, 7.0 Hz, 1H), 7.41 (d, J = 7.5 Hz, 2H), 7.22 – 7.16 (m, 4H), 7.09 – 7.03 (m, 5H). **^{19}F NMR** (471 MHz, $CDCl_3$)

δ 76.67 (s, 1F). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 188.4, 139.0, 138.6, 138.3, 132.4, 131.4, 130.9, 129.6, 129.3, 128.9, 128.7, 128.1, 127.9, 123.4, 118.6, 116.3, 103.3 (d, J = 30.2 Hz). **HRMS-ESI** (m/z) calcd. for $[C_{21}H_{15}FNO_3S]^+$ ($[M+H]^+$): 380.0751, found: 380.0750.



3b

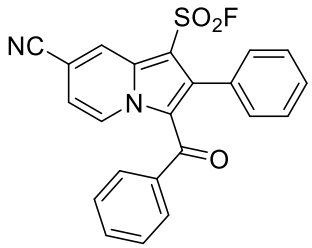
3-benzoyl-7-methyl-2-phenylindolizine-1-sulfonyl fluoride (**3b**). White solid, 122 mg, 62% yield. M.p. 192−193 ºC. Purification by column chromatography on silica gel using petroleum ether / ethyl acetate (10:1, v/v) as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 9.42 (d, J = 7.0 Hz, 1H), 8.09 (s, 1H), 7.41 – 7.37 (m, 2H), 7.21 – 7.15 (m, 3H), 7.08 – 7.00 (m, 6H), 2.55 (s, 3H). **^{19}F NMR** (471 MHz, $CDCl_3$) δ 76.74 (s, 1F). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 188.1, 141.2, 139.1, 138.5, 131.9, 131.1, 130.8, 129.3, 128.6, 128.0, 127.8, 127.6, 122.7, 118.5, 116.9, 101.7 (d, J = 29.8 Hz), 21.9. **HRMS-ESI** (m/z) calcd. for $[C_{22}H_{17}FNO_3S]^+$ ($[M+H]^+$): 394.0908, found: 394.0907.



3c

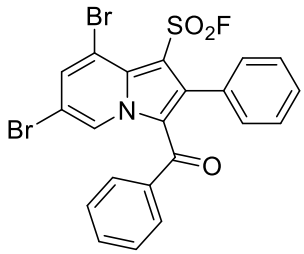
3-benzoyl-5-methyl-2-phenylindolizine-1-sulfonyl fluoride (**3c**). Light yellow solid, 93 mg, 47% yield. M.p. 158−159 ºC. Purification by column chromatography on silica gel using petroleum ether / ethyl acetate (10:1, v/v) as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.27 (d, J = 9.0 Hz, 1H), 7.71 – 7.65 (m, 2H), 7.47 (dd, J = 9.0, 7.0 Hz, 1H), 7.39 – 7.35 (m, 1H), 7.24 – 7.19 (m, 4H), 7.13 – 7.09 (m, 3H), 6.94 (d, J = 7.0 Hz, 1H), 2.43 (s, 3H). **^{19}F NMR** (471 MHz, $CDCl_3$) δ 76.34 (s, 1F). **^{13}C NMR** (126 MHz, $CDCl_3$) δ

188.3, 138.8 (d, J = 1.7 Hz), 138.1, 138.0, 135.2, 133.5, 130.5, 130.4, 130.3, 127.8, 127.7, 124.8, 117.2, 116.1, 101.9 (d, J = 28.9 Hz), 23.2. **HRMS-ESI** (m/z) calcd. for $[C_{22}H_{17}FNO_3S]^+$ ($[M+H]^+$): 394.0908, found: 394.0918.



3d

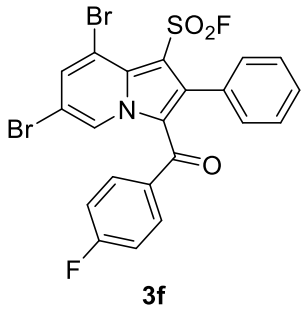
3-benzoyl-7-cyano-2-phenylindolizine-1-sulfonyl fluoride (**3d**). Yellow solid, 182 mg, 90% yield. M.p. 177−178 ºC. Purification by column chromatography on silica gel using petroleum ether / ethyl acetate (7:1, v/v) as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 9.49 (d, J = 7.5 Hz, 1H), 8.78 (s, 1H), 7.51 (d, J = 7.5 Hz, 2H), 7.33 (dd, J = 15.0, 7.0 Hz, 2H), 7.27 (d, J = 6.5 Hz, 2H), 7.22 – 7.15 (m, 5H). **^{19}F NMR** (471 MHz, $CDCl_3$) δ 76.79 (s, 1F). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 187.9, 139.0, 137.3, 135.2, 139.0, 131.0, 129.5, 129.5, 129.2, 128.7, 128.1, 128.0, 124.6, 124.2, 116.6, 115.6, 111.5, 106.5 (d, J = 31.3 Hz). **HRMS-ESI** (m/z) calcd. for $[C_{22}H_{14}FN_2O_3S]^+$ ($[M+H]^+$): 405.0704, found: 405.0713.



3e

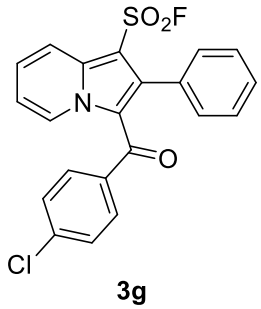
3-benzoyl-6,8-dibromo-2-phenylindolizine-1-sulfonyl fluoride (**3e**). White solid, 233 mg, 87% yield. M.p. 180−181 ºC. Purification by column chromatography on silica gel using petroleum ether / ethyl acetate (10:1, v/v) as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 9.51 (s, 1H), 7.93 (s, 1H), 7.37 (d, J = 8.0 Hz, 2H), 7.27 – 7.21 (m, 1H), 7.14 (d, J = 7.0 Hz, 2H), 7.07 (t, J = 7.5 Hz, 5H). **^{19}F NMR** (471 MHz, $CDCl_3$) δ 79.21 (s, 1F). **^{13}C**

NMR (126 MHz, $CDCl_3$) δ 188.2, 139.6, 137.6, 136.5, 133.2, 132.8, 131.2, 130.7, 129.5, 128.9, 128.0, 127.7, 127.1, 122.9, 111.7, 110.0, 106.7 (d, J = 33.1 Hz). **HRMS-ESI** (m/z) calcd. for $[C_{21}H_{13}Br_2FNO_3S]^+$ ($[M+H]^+$): 537.8961, found: 537.8951.



3f

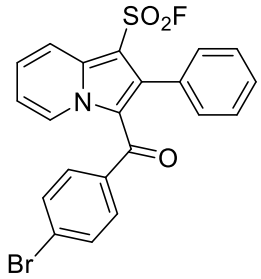
6,8-dibromo-3-(4-fluorobenzoyl)-2-phenylindolizine-1-sulfonyl fluoride (**3f**). White solid, 258 mg, 93% yield. M.p. 223−224 °C. Purification by column chromatography on silica gel using petroleum ether / ethyl acetate (10:1, v/v) as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 9.55 – 9.49 (m, 1H), 8.01 – 7.94 (m, 1H), 7.44 (dd, J = 8.5, 5.3 Hz, 2H), 7.15 (h, J = 7.5 Hz, 5H), 6.77 (t, J = 8.0 Hz, 2H). **^{19}F NMR** (471 MHz, $CDCl_3$) δ 79.18 (s, 1F), -104.53 (t, J = 6.6 Hz, 1F). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 186.5, 165.2 (d, J = 255.6 Hz), 139.4, 136.5, 133.8 (d, J = 2.8 Hz), 133.2, 132.0 (d, J = 9.5 Hz), 131.1, 130.6, 128.9, 127.7, 127.0, 122.5, 115.1 (d, J = 22.1 Hz), 111.6, 109.9, 106.6 (d, J = 33.5 Hz). **HRMS-ESI** (m/z) calcd. for $[C_{21}H_{12}Br_2F_2NO_3S]^+$ ($[M+H]^+$): 553.8867, found: 553.8859.



3g

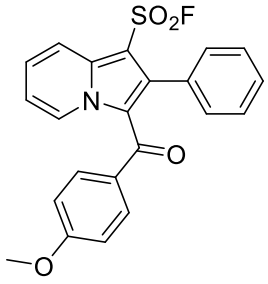
3-(4-chlorobenzoyl)-2-phenylindolizine-1-sulfonyl fluoride (**3g**). White solid, 126 mg, 61% yield. M.p. 128−129 °C. Purification by column chromatography on silica gel using petroleum ether / ethyl acetate (10:1, v/v) as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 9.51 (d, J = 7.0 Hz, 1H), 8.33 (d, J = 9.0 Hz, 1H), 7.58 (dd, J = 9.0, 6.9 Hz, 1H), 7.32

(d, J = 8.0 Hz, 2H), 7.18 (dd, J = 13.0, 6.9 Hz, 4H), 7.11 (t, J = 7.5 Hz, 2H), 7.01 (d, J = 8.0 Hz, 2H). **^{19}F NMR** (471 MHz, $CDCl_3$) δ 76.73 (s, 1F). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 186.8, 139.0, 138.3, 138.1, 136.8, 131.2, 130.6, 130.5, 129.4, 128.8, 128.5, 128.1, 127.8, 122.8, 118.4, 116.2, 103.2 (d, J = 30.0 Hz). **HRMS-ESI** (m/z) calcd. for $[C_{21}H_{14}ClFNO_3S]^+$ ($[M+H]^+$): 414.0361, found: 414.0355.



3h

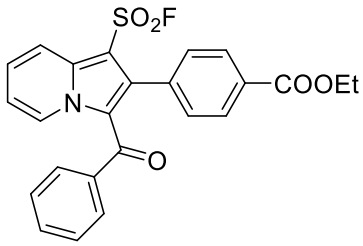
3-(4-bromobenzoyl)-2-phenylindolizine-1-sulfonyl fluoride (**3h**). Yellow solid, 172 mg, 75% yield. M.p. 119−120 ºC. Purification by column chromatography on silica gel using petroleum ether / ethyl acetate (10:1, v/v) as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 9.56 (d, J = 7.0 Hz, 1H), 8.36 (d, J = 9.0 Hz, 1H), 7.62 (dd, J = 9.0, 7.0 Hz, 1H), 7.28 (s, 2H), 7.21 (ddd, J = 13.5, 8.5, 6.0 Hz, 6H), 7.16 – 7.12 (m, 2H). **^{19}F NMR** (471 MHz, $CDCl_3$) δ 76.72 (s, 1F). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 187.0, 139.1, 138.2, 137.2, 131.2, 131.1, 130.7, 130.4, 129.4, 128.8, 128.5, 127.8, 126.9, 122.8, 118.4, 116.2, 103.3 (d, J = 30.2 Hz). **HRMS-ESI** (m/z) calcd. for $[C_{21}H_{14}BrFNO_3S]^+$ ($[M+H]^+$): 457.9856, found: 457.9846.



3i

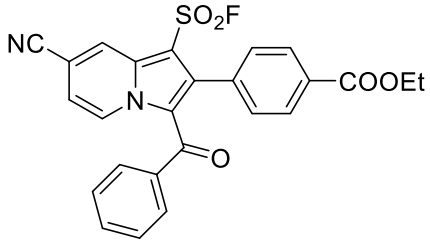
3-(4-methoxybenzoyl)-2-phenylindolizine-1-sulfonyl fluoride (**3i**). Light yellow solid, 160 mg, 78% yield. M.p. 108−109 ºC. Purification by column chromatography on silica

gel using petroleum ether / ethyl acetate (5:1, v/v) as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 9.27 (d, J = 7.0 Hz, 1H), 8.30 (d, J = 9.0 Hz, 1H), 7.52 (t, J = 8.0 Hz, 1H), 7.48 – 7.43 (m, 2H), 7.25 – 7.20 (m, 2H), 7.15 – 7.09 (m, 4H), 6.59 – 6.54 (m, 2H), 3.73 (s, 3H). **^{19}F NMR** (471 MHz, $CDCl_3$) δ 76.83 (s, 1F). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 186.6, 163.1, 137.9, 137.3, 132.0, 131.2, 130.8, 130.7, 128.6, 128.5, 128.2, 127.7, 123.3, 118.3, 115.7, 113.3, 102.3 (d, J = 29.5 Hz), 55.5 (d, J = 3.6 Hz). **HRMS-ESI** (m/z) calcd. for $[C_{22}H_{17}FNO_4S]^+$ ($[M+H]^+$): 410.0857, found: 410.0858.



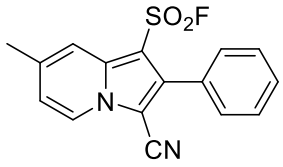
3j

Ethyl 4-(3-benzoyl-1-(fluorosulfonyl)indolizin-2-yl)benzoate (**3j**). Light yellow solid, 115 mg, 51% yield. M.p. 148−149 °C. Purification by column chromatography on silica gel using petroleum ether / ethyl acetate (10:1, v/v) as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 9.57 (d, J = 7.0 Hz, 1H), 8.40 (d, J = 9.0 Hz, 1H), 7.83 (d, J = 8.0 Hz, 2H), 7.67 (t, J = 8.0 Hz, 1H), 7.48 (d, J = 7.5 Hz, 2H), 7.31 (dd, J = 26.0, 7.5 Hz, 4H), 7.14 (t, J = 7.5 Hz, 2H), 4.40 (q, J = 7.0 Hz, 2H), 1.44 (t, J = 7.0 Hz, 3H). **^{19}F NMR** (471 MHz, $CDCl_3$) δ 76.93 (s, 1F). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 187.9, 166.1, 138.2, 138.0, 137.4, 135.33, 132.4, 131.2, 130.4, 129.3, 129.3, 128.8, 128.5, 128.0, 123.1, 118.4, 116.3, 103.1 (d, J = 30.2 Hz), 61.2, 14.4. **HRMS-ESI** (m/z) calcd. for $[C_{24}H_{19}FNO_5S]^+$ ($[M+H]^+$): 452.0962, found: 452.0960.



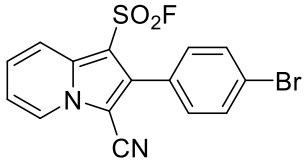
3k

Ethyl 4-(3-benzoyl-7-cyano-1-(fluorosulfonyl)indolizin-2-yl)benzoate (**3k**). Yellow solid, 222 mg, 93% yield. M.p. 224−226 °C. Purification by column chromatography on silica gel using petroleum ether / ethyl acetate (7:1, v/v) as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 9.38 (d, J = 7.5 Hz, 1H), 8.67 (s, 1H), 7.76 (d, J = 8.0 Hz, 2H), 7.40 (d, J = 7.5 Hz, 2H), 7.24 (d, J = 7.5 Hz, 4H), 7.07 (t, J = 7.5 Hz, 2H), 4.30 (q, J = 7.0 Hz, 2H), 1.33 (d, J = 14.5 Hz, 3H). **^{19}F NMR** (471 MHz, $CDCl_3$) δ 77.00 (s, 1F). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 187.6, 165.8, 137.7, 137.2, 135.3, 134.1, 133.3, 131.0, 131.0, 129.4, 129.0, 128.8, 128.3, 124.6, 124.2, 116.4, 115.9, 111.8, 106.6 (d, J = 31.6 Hz), 61.3, 14.4. **HRMS-ESI** (m/z) calcd. for $[C_{25}H_{18}FN_2O_5S]^+$ ($[M+H]^+$): 477.0915, found: 477.0925.



3l

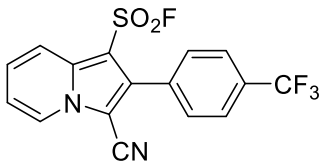
3-cyano-7-methyl-2-phenylindolizine-1-sulfonyl fluoride (**3l**). White solid, 112 mg, 71% yield. M.p. 167−168 °C. Purification by column chromatography on silica gel using petroleum ether / ethyl acetate (7:1, v/v) as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.33 (d, J = 7.0 Hz, 1H), 8.04 (s, 1H), 7.61 – 7.56 (m, 2H), 7.54 – 7.49 (m, 3H), 7.07 (d, J = 5.5 Hz, 1H), 2.54 (s, 3H). **^{19}F NMR** (471 MHz, $CDCl_3$) δ 76.53 (s, 1F). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 141.1, 140.8, 138.0, 130.1, 129.9, 128.7, 128.5, 125.5, 119.1, 117.8, 111.6, 100.8 (d, J = 31.6 Hz), 98.4, 21.9 (d, J = 2.2 Hz). **HRMS-ESI** (m/z) calcd. for $[C_{16}H_{12}FN_2O_2S]^+$ ($[M+H]^+$): 315.0598, found: 315.0605.



3m

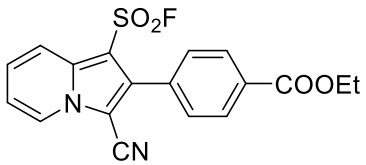
2-(4-bromophenyl)-3-cyanoindolizine-1-sulfonyl fluoride (**3m**). White solid, 173 mg, 91% yield. M.p. 182−183 °C. Purification by column chromatography on silica gel

using petroleum ether / ethyl acetate (7:1, v/v) as eluent. **^{1}H NMR** (500 MHz, Chloroform-*d*) δ 8.46 (d, J = 7.0 Hz, 1H), 8.28 (d, J = 9.0 Hz, 1H), 7.67 (d, J = 8.0 Hz, 2H), 7.59 (t, J = 8.0 Hz, 1H), 7.47 (d, J = 8.0 Hz, 2H), 7.28 (d, J = 7.0 Hz, 1H). **^{19}F NMR** (471 MHz, $CDCl_3$) δ 76.60 (s, 1F). **^{13}C NMR** (126 MHz, Chloroform-*d*) δ 139.4, 137.6, 132.2, 131.5, 129.2, 127.2, 126.2, 125.0, 119.3, 116.8, 111.2, 102.4 (d, J = 31.6 Hz), 99.0. **HRMS-ESI** (m/z) calcd. for $[C_{15}H_9BrFN_2O_2S]^+$ ($[M+H]^+$): 378.9547, found: 378.9540.



3n

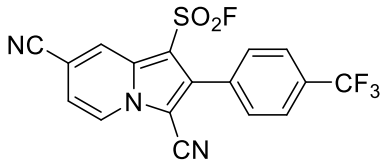
3-cyano-2-(4-(trifluoromethyl)phenyl)indolizine-1-sulfonyl fluoride (**3n**). White solid, 175 mg, 95% yield. M.p. 185−186 ºC. Purification by column chromatography on silica gel using petroleum ether / ethyl acetate (7:1, v/v) as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.49 (d, J = 7.0 Hz, 1H), 8.30 (d, J = 9.0 Hz, 1H), 7.80 (d, J = 8.0 Hz, 2H), 7.73 (d, J = 8.0 Hz, 2H), 7.61 (t, J = 8.0 Hz, 1H), 7.30 (t, J = 7.0 Hz, 1H). **^{19}F NMR** (471 MHz, $CDCl_3$) δ 76.65 (s, 1F), -62.89 (s, 3F). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 138.8, 137.6, 132.3, 132.1, 130.5, 129.4, 126.2, 125.8 (q, J = 3.7 Hz), 123.9 (d, J = 272.6 Hz), 119.3, 117.0, 111.0, 102.6 (d, J = 32.2 Hz), 99.3. **HRMS-ESI** (m/z) calcd. for $[C_{16}H_9F_4N_2O_2S]^+$ ($[M+H]^+$): 369.0315, found: 369.0324.



3o

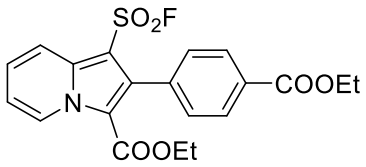
Ethyl 4-(3-cyano-1-(fluorosulfonyl)indolizin-2-yl)benzoate (**3o**). White solid, 171 mg, 92% yield. M.p. 162−163 ºC. Purification by column chromatography on silica gel using petroleum ether / ethyl acetate (7:1, v/v) as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.47 (d, J = 7.0 Hz, 1H), 8.28 (d, J = 9.0 Hz, 1H), 8.20 (d, J = 8.0 Hz, 2H), 7.67 (d, J

= 8.0 Hz, 2H), 7.59 (t, *J* = 8.0 Hz, 1H), 7.28 (d, *J* = 7.0 Hz, 1H), 4.42 (q, *J* = 7.0 Hz, 2H), 1.42 (d, *J* = 14.0 Hz, 3H). **^{19}F NMR** (471 MHz, $CDCl_3$) δ 76.65 (s, 1F). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 166.0, 139.4, 137.6, 132.7, 132.1, 130.0, 129.9, 129.2, 126.2, 119.3, 116.9, 111.0, 102.6 (d, *J* = 32.2 Hz), 99.2, 61.4, 14.4. **HRMS-ESI** (m/z) calcd. for $[C_{18}H_{14}FN_2O_4S]^+$ ($[M+H]^+$): 373.0653, found: 373.0652.



3p

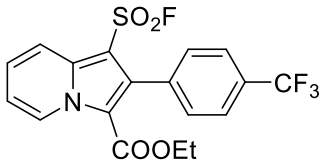
3,7-dicyano-2-(4-(trifluoromethyl)phenyl)indolizine-1-sulfonyl fluoride (**3p**). White solid, 159 mg, 81% yield. M.p. 210−212 °C. Purification by column chromatography on silica gel using petroleum ether / ethyl acetate (7:1, v/v) as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.67 (s, 1H), 8.56 (d, *J* = 7.0 Hz, 1H), 7.83 (d, *J* = 8.0 Hz, 2H), 7.72 (d, *J* = 8.0 Hz, 2H), 7.40 (d, *J* = 7.0 Hz, 1H). **^{19}F NMR** (471 MHz, $CDCl_3$) δ 76.82 (1F), -63.00 (3F). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 139.85, 135.07, 132.80 (q, *J* = 33.0 Hz), 130.90, 130.41, 126.92, 126.13 (q, *J* = 3.8 Hz), 125.04, 123.75 (d, *J* = 272.8 Hz), 116.87, 115.81, 112.53, 109.88, 106.49 (d, *J* = 33.2 Hz), 101.47. **HRMS-ESI** (m/z) calcd. for $[C_{17}H_8F_4N_3O_2S]^+$ ($[M+H]^+$): 394.0268, found: 394.0279.



3q

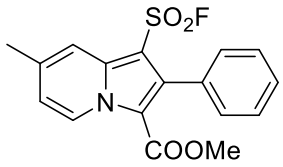
Ethyl 2-(4-(ethoxycarbonyl)phenyl)-1-(fluorosulfonyl)indolizine-3-carboxylate (**3q**). White solid, 203 mg, 97% yield. M.p. 130−131 °C. Purification by column chromatography on silica gel using petroleum ether / ethyl acetate (7:1, v/v) as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 9.72 (d, *J* = 7.0 Hz, 1H), 8.26 (d, *J* = 9.0 Hz, 1H), 8.11 (d, *J* = 8.0 Hz, 2H), 7.57 – 7.50 (m, 1H), 7.43 (d, *J* = 8.0 Hz, 2H), 7.18 (t, *J* = 7.0 Hz,

1H), 4.41 (q, *J* = 7.0 Hz, 2H), 4.06 (q, *J* = 7.0 Hz, 2H), 1.42 (t, *J* = 7.0 Hz, 3H), 0.85 (t, *J* = 7.0 Hz, 3H). **^{19}F NMR** (471 MHz, $CDCl_3$) *δ* 76.31 (s, 1F). **^{13}C NMR** (126 MHz, $CDCl_3$) *δ* 166.5, 160.9, 137.6, 137.5, 137.1, 130.5, 129.7, 128.8, 128.6, 128.5, 118.1, 116.0, 115.0, 103.6 (d, J = 29.4 Hz), 61.2, 60.9, 14.5, 13.6. **HRMS-ESI** (m/z) calcd. for $[C_{20}H_{19}FNO_6S]^+$ ($[M+H]^+$): 420.0912, found: 420.0913.



3r

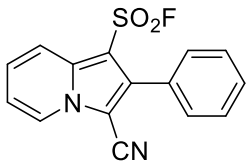
Ethyl 1-(fluorosulfonyl)-2-(4-(trifluoromethyl)phenyl)indolizine-3-carboxylate (**3r**). White solid, 181 mg, 87% yield. M.p. 126−127 ºC. Purification by column chromatography on silica gel using petroleum ether / ethyl acetate (7:1, v/v) as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) *δ* 9.73 (d, *J* = 7.0 Hz, 1H), 8.27 (d, *J* = 9.0 Hz, 1H), 7.70 (d, *J* = 8.0 Hz, 2H), 7.59 – 7.52 (m, 1H), 7.49 (d, *J* = 8.0 Hz, 2H), 7.20 (t, *J* = 7.0 Hz, 1H), 4.06 (q, *J* = 7.0 Hz, 2H), 0.83 (t, *J* = 7.0 Hz, 3H). **^{19}F NMR** (471 MHz, $CDCl_3$) *δ* 76.26 (s, 1F), -62.49 (s, 3F). **^{13}C NMR** (126 MHz, $CDCl_3$) *δ* 160.8, 137.5, 137.1, 136.3, 130.7 (q, *J* = 32.6 Hz), 130.1, 128.6 (d, *J* = 6.0 Hz), 125.4, 124.6 (q, *J* = 3.8 Hz), 123.2, 118.2, 116.2, 115.1, 103.6 (d, *J* = 29.6 Hz), 60.9, 13.3. **HRMS-ESI** (m/z) calcd. for $[C_{18}H_{14}F_4NO_4S]^+$ ($[M+H]^+$): 416.0574, found: 416.0577.



3s

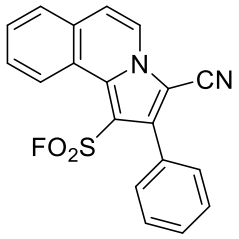
Methyl 1-(fluorosulfonyl)-7-methyl-2-phenylindolizine-3-carboxylate (**3s**). White solid, 127 mg, 73% yield. M.p. 163−164 ºC. Purification by column chromatography on silica gel using petroleum ether / ethyl acetate (10:1, v/v) as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) *δ* 9.56 (d, *J* = 7.0 Hz, 1H), 8.03 (s, 1H), 7.45 – 7.40 (m, 3H), 7.37 – 7.32 (m, 2H), 6.99 (d, *J* = 5.5 Hz, 1H), 3.57 (s, 3H), 2.52 (s, 3H). **^{19}F NMR** (471 MHz, $CDCl_3$)

δ 76.26 (s, 1F). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 161.7, 140.2, 139.1, 138.0, 132.0, 129.6, 128.4, 128.0, 127.5, 118.3, 116.8, 114.3, 102.4 (d, J = 29.1 Hz), 51.5, 21.7. **HRMS-ESI** (m/z) calcd. for $[C_{17}H_{15}FNO_4S]^+$ ($[M+H]^+$): 348.0700, found: 348.0699.



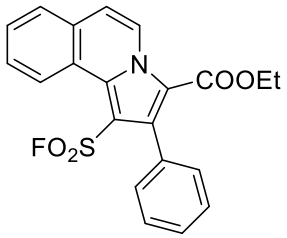
3t

3-cyano-2-phenylindolizine-1-sulfonyl fluoride (**3t**). White solid, 143 mg, 95% yield. M.p. 169−170 °C. Purification by column chromatography on silica gel using petroleum ether / ethyl acetate (7:1, v/v) as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.46 (d, J = 7.0 Hz, 1H), 8.28 (d, J = 9.0 Hz, 1H), 7.64 – 7.50 (m, 6H), 7.24 (d, J = 7.0 Hz, 1H). **^{19}F NMR** (471 MHz, $CDCl_3$) δ 76.55 (s, 1F). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 140.7, 137.6, 130.2, 129.9, 129.0, 128.8, 128.3, 126.2, 119.2, 116.6, 111.4, 102.4 (d, J = 31.8 Hz), 99.1. **HRMS-ESI** (m/z) calcd. for $[C_{15}H_{10}FN_2O_2S]^+$ ($[M+H]^+$): 301.0442, found: 301.0450.



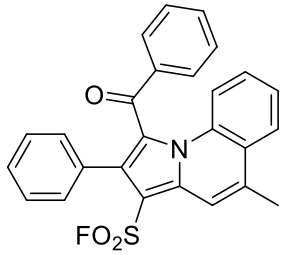
5a

3-cyano-2-phenylpyrrolo[2,1-a]isoquinoline-1-sulfonyl fluoride (**5a**). White solid, 163 mg, 93% yield. M.p. 245−247 °C. Purification by column chromatography on silica gel using petroleum ether / ethyl acetate (5:1, v/v) as eluent. **^{1}H NMR** (500 MHz, DMSO-d_6) δ 8.82 – 8.78 (m, 1H), 8.52 (d, J = 7.0 Hz, 1H), 8.16 – 8.12 (m, 1H), 7.91 – 7.87 (m, 2H), 7.81 (d, J = 7.0 Hz, 1H), 7.56 (s, 5H). **^{19}F NMR** (471 MHz, DMSO-d_6) δ 71.09 (s, 1F). **^{13}C NMR** (126 MHz, DMSO-d_6) δ 139.5, 133.4, 130.7, 130.6, 129.8, 129.5, 129.4, 129.3, 128.5, 128.2, 125.5, 123.4, 121.3, 117.8, 111.2, 104.5 (d, J = 32.7 Hz), 100.9. **HRMS-ESI** (m/z) calcd. for $[C_{19}H_{12}FN_2O_2S]^+$ ($[M+H]^+$): 351.0598, found: 351.0605.



5b

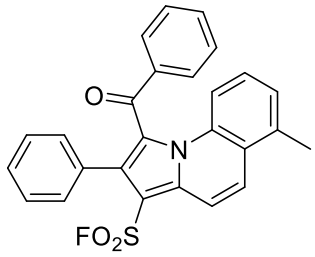
Ethyl 1-(fluorosulfonyl)-2-phenylpyrrolo[2,1-a]isoquinoline-3-carboxylate (**5b**). White solid, 198 mg, 99% yield. M.p. 187−188 °C. Purification by column chromatography on silica gel using petroleum ether / ethyl acetate (5:1, v/v) as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 9.48 (d, J = 7.5 Hz, 1H), 9.03 (d, J = 7.5 Hz, 1H), 7.83 (d, J = 6.0 Hz, 1H), 7.72 (p, J =8.0, 7.0 Hz, 2H), 7.42 (q, J = 4.0, 3.3 Hz, 3H), 7.35 (q, J = 5.5, 3.5 Hz, 3H), 4.05 (q, J = 7.0 Hz, 2H), 0.83 (t, J = 7.0 Hz, 3H). **^{19}F NMR** (471 MHz, $CDCl_3$) δ 70.73 (s, 1F). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 161.2, 138.1, 134.1, 133.5, 130.5, 130.0, 128.8, 128.0, 127.5, 127.5, 127.1, 127.0, 124.2, 122.5, 116.5, 116.2, 107.9 (d, J = 30.5 Hz), 60.9, 13.4. **HRMS-ESI** (m/z) calcd. for $[C_{21}H_{17}FNO_4S]^+$ ($[M+H]^+$): 398.0857, found: 398.0856.



5c

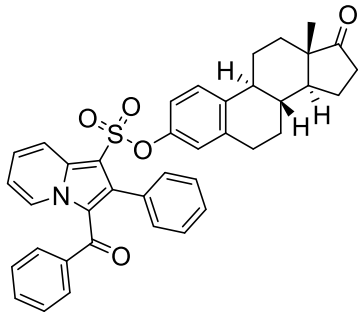
1-benzoyl-5-methyl-2-phenylpyrrolo[1,2-a]quinoline-3-sulfonyl fluoride (**5c**). Yellow solid, 144 mg, 65% yield. M.p. 207−208 °C. Purification by column chromatography on silica gel using petroleum ether / ethyl acetate (10:1, v/v) as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.00 (s, 1H), 7.93 (d, J = 8.0 Hz, 1H), 7.68 (d, J = 7.5 Hz, 2H), 7.58 (d, J = 8.5 Hz, 1H), 7.45 (t, J = 7.5 Hz, 1H), 7.37 (dt, J = 14.0, 7.5 Hz, 2H), 7.22 – 7.17 (m, 4H), 7.14 – 7.07 (m, 3H), 2.67 (s, 3H). **^{19}F NMR** (471 MHz, $CDCl_3$) δ 75.93 (s, 1F). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 189.4, 137.5, 136.9, 136.6, 134.0, 133.6, 132.1, 130.6, 130.2, 130.0, 129.5, 128.6, 128.5, 127.7, 126.6, 126.1, 126.0, 125.4, 119.2, 115.5,

104.2 (d, J = 29.0 Hz), 19.8. **HRMS-ESI** (m/z) calcd. for $[C_{26}H_{19}FNO_3S]^+$ ($[M+H]^+$): 444.1064, found:444.1069.



5d

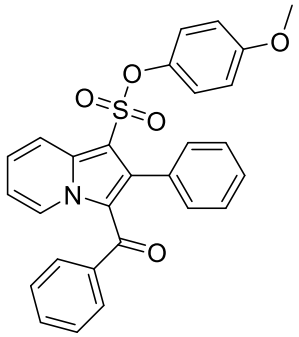
1-benzoyl-6-methyl-2-phenylpyrrolo[1,2-a]quinoline-3-sulfonyl fluoride (**5d**). Yellow solid, 122 mg, 55% yield. M.p. 208−209 °C. Purification by column chromatography on silica gel using petroleum ether / ethyl acetate (10:1, v/v) as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.26 (d, J = 9.5 Hz, 1H), 7.83 (d, J = 7.5 Hz, 2H), 7.76 (d, J = 9.5 Hz, 1H), 7.71 (s, 1H), 7.60 (d, J = 9.0 Hz, 1H), 7.52 (t, J = 7.5 Hz, 1H), 7.39 – 7.32 (m, 5H), 7.25 (d, J = 6.5 Hz, 3H), 2.54 (s, 3H). **^{19}F NMR** (471 MHz, $CDCl_3$) δ 75.98 (s, 1F). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 189.6, 137.4, 136.2, 136.1, 134.1, 133.2, 131.2, 130.60, 130.4, 130.1, 130.0, 129.2, 129.0, 128.7, 128.5, 127.8, 126.7, 125.1, 118.5, 116.0, 105.1 (d, J = 29.1 Hz), 21.0. **HRMS-ESI** (m/z) calcd. for $[C_{26}H_{19}FNO_3S]^+$ ($[M+H]^+$): 444.1064, found: 444.1062.



6

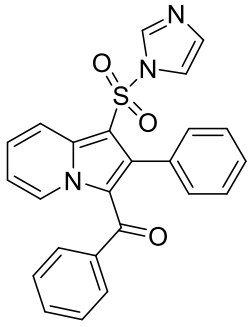
(8R,9S,13S,14S)-13-methyl-17-oxo-7,8,9,11,12,13,14,15,16,17-decahydro-6H-cyclopenta[a]phenanthren-3-yl 3-benzoyl-2-phenylindolizine-1-sulfonate (**6**). White solid, 249 mg, 99% yield. M.p. 210−211 °C. Purification by column chromatography on silica gel using petroleum ether / ethyl acetate (3:1, v/v) as eluent. **^{1}H NMR** (500

MHz, $CDCl_3$) δ 9.47 (d, J = 7.0 Hz, 1H), 8.28 (d, J = 9.0 Hz, 1H), 7.44 (t, J = 8.0 Hz, 1H), 7.38 (d, J = 7.5 Hz, 2H), 7.19 (t, J = 7.5 Hz, 1H), 7.12 – 6.96 (m, 9H), 6.55 (dd, J = 12.0, 3.1 Hz, 2H), 2.77 – 2.64 (m, 2H), 2.49 (dd, J = 19.0, 8.5 Hz, 1H), 2.32 (p, J = 7.0, 6.0 Hz, 1H), 2.25 – 2.04 (m, 3H), 1.95 (td, J = 12.0, 8.5, 3.5 Hz, 2H), 1.53 – 1.35 (m, 5H), 1.28 – 1.23 (m, 1H), 0.89 (s, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 188.3, 147.4, 138.7, 138.6, 138.5, 138.2, 137.9, 131.8, 131.7, 131.2, 131.0, 129.3, 128.9, 128.2, 128.0,127.9, 127.7, 127.2, 126.4, 122.7, 122.2, 119.1, 118.7, 115.5, 106.3, 50.5, 48.0, 44.2, 38.0, 35.9, 29.4, 26.3, 25.8, 21.7, 13.9. **HRMS-ESI** (m/z) calcd. for $[C_{39}H_{36}NO_5S]^+$ ($[M+H]^+$): 630.2309, found: 630.2318.



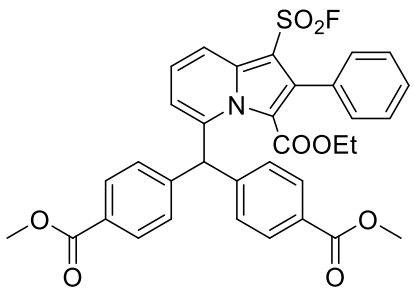
7

4-methoxyphenyl 3-benzoyl-2-phenylindolizine-1-sulfonate (**7**). Light yellow solid, 239 mg, 99% yield. M.p. 162−163 °C. Purification by column chromatography on silica gel using petroleum ether / ethyl acetate (3:1, v/v) as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 9.49 (d, J = 7.0 Hz, 1H), 8.19 (d, J = 9.0 Hz, 1H), 7.40 (dd, J = 23.0, 7.5 Hz, 3H), 7.19 (t, J = 7.5 Hz, 1H), 7.05 (ddd, J = 27.0, 14.0, 7.0 Hz, 8H), 6.77 (d, J = 8.5 Hz, 2H), 6.69 (d, J = 9.0 Hz, 2H), 3.73 (s, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 188.3, 158.2, 143.0, 138.7, 138.0, 131.8, 131.6, 131.1, 129.3, 128.2, 128.1, 127.8, 127.2, 123.3, 122.7, 118.6, 116.2, 115.5, 114.9, 114.5, 105.9, 55.7. **HRMS-ESI** (m/z) calcd. for $[C_{28}H_{22}NO_5S]^+$ ($[M+H]^+$): 484.1213, found: 484.1208.



8

(1-((1H-imidazol-1-yl)sulfonyl)-2-phenylindolizin-3-yl)(phenyl)methanone (**8**). White solid, 212 mg, 99% yield. M.p. 173−174 °C. Purification by column chromatography on silica gel using petroleum ether / ethyl acetate (1:1, v/v) as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 9.46 (d, J = 7.0 Hz, 1H), 8.52 (d, J = 9.0 Hz, 1H), 7.58 (t, J = 8.0 Hz, 1H), 7.36 (d, J = 7.5 Hz, 2H), 7.17 (q, J = 7.0, 5.5 Hz, 3H), 7.09 (t, J = 7.5 Hz, 1H), 7.03 (t, J = 7.5 Hz, 4H), 6.98 (d, J = 7.5 Hz, 2H), 6.79 (s, 1H), 6.74 (s, 1H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 188.0, 138.3, 137.9, 137.6, 136.3, 132.0, 131.6, 130.4, 129.8, 129.2, 129.1, 128.8, 128.5, 127.8, 127.5, 123.4, 118.3, 116.7, 116.0, 108.0. **HRMS-ESI** (m/z) calcd. for $[C_{24}H_{18}N_3O_3S]^+$ ($[M+H]^+$): 428.1063, found: 428.1072.



1u

Dimethyl 4,4'-((3-(ethoxycarbonyl)-1-(fluorosulfonyl)-2-phenylindolizin-5-yl)methylene)dibenzoate (**1u**). Yellow solid, 192 mg, 61% yield. M.p. 189−190 °C. Purification by column chromatography on silica gel using petroleum ether / ethyl acetate (5:1, v/v) as eluent. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.30 (d, J = 9.0 Hz, 1H), 7.44 – 7.34 (m, 4H), 7.28 – 7.23 (m, 2H), 7.06 (d, J = 9.0 Hz, 4H), 6.96 (d, J = 8.0 Hz, 4H), 6.57 (d, J = 9.0 Hz, 2H), 3.69 (q, J = 7.0 Hz, 2H), 2.31 (s, 6H), 0.55 (t, J = 7.0 Hz, 3H). **^{19}F NMR** (471 MHz, $CDCl_3$) δ 76.20 (s, 1F). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 169.2, 161.9, 150.2, 143.2, 138.4, 136.7, 136.1, 131.4, 130.6, 130.0, 128.4, 127.5, 126.9, 122.2,

120.9, 118.9, 117.0, 102.9 (d, J = 28.9 Hz), 61.8, 51.9, 21.2, 12.9. **HRMS-ESI** (m/z) calcd. for $[C_{34}H_{29}FNO_8S]^+$ ($[M+H]^+$): 630.1592, found: 630.1601.

6. References

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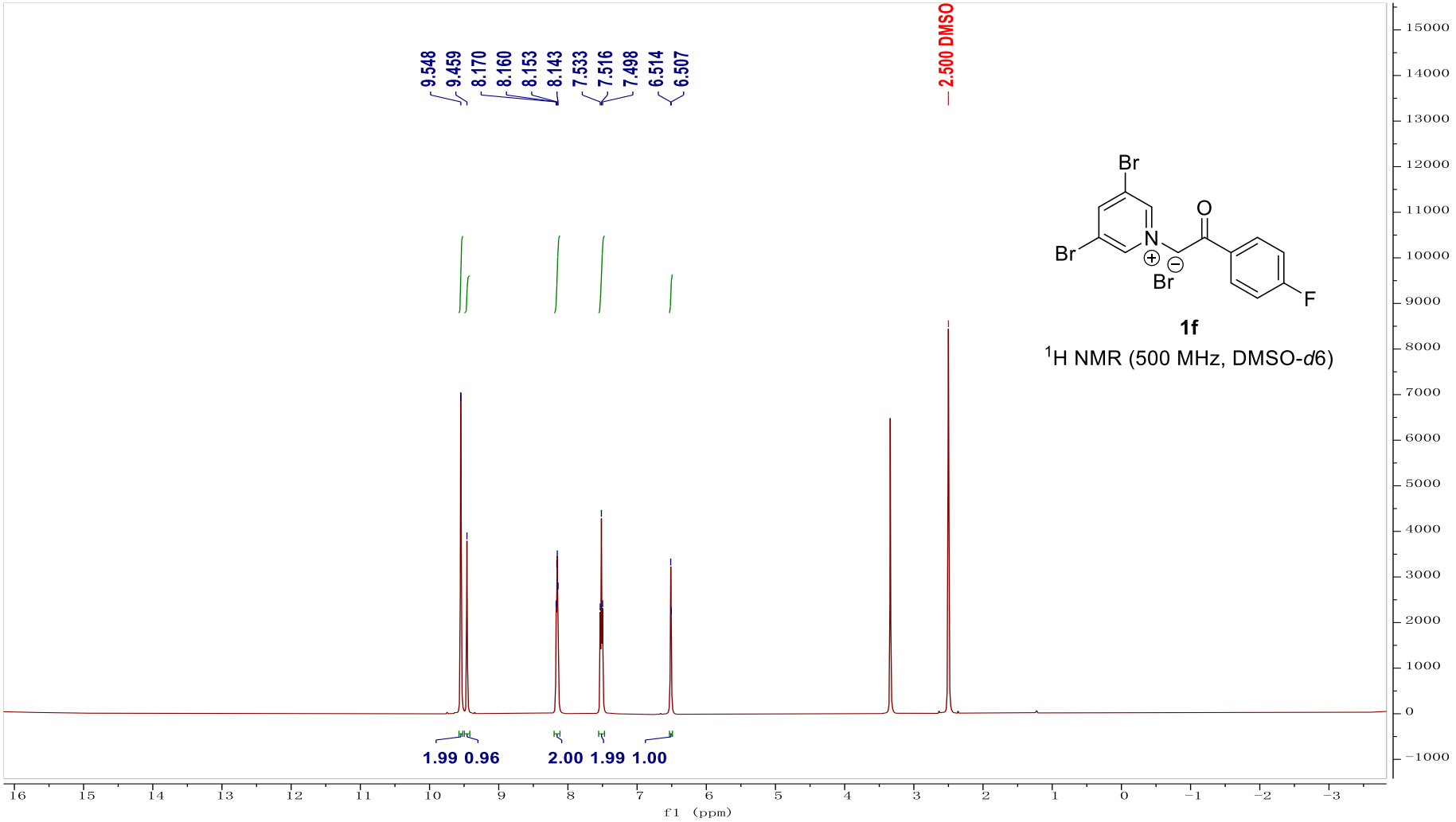
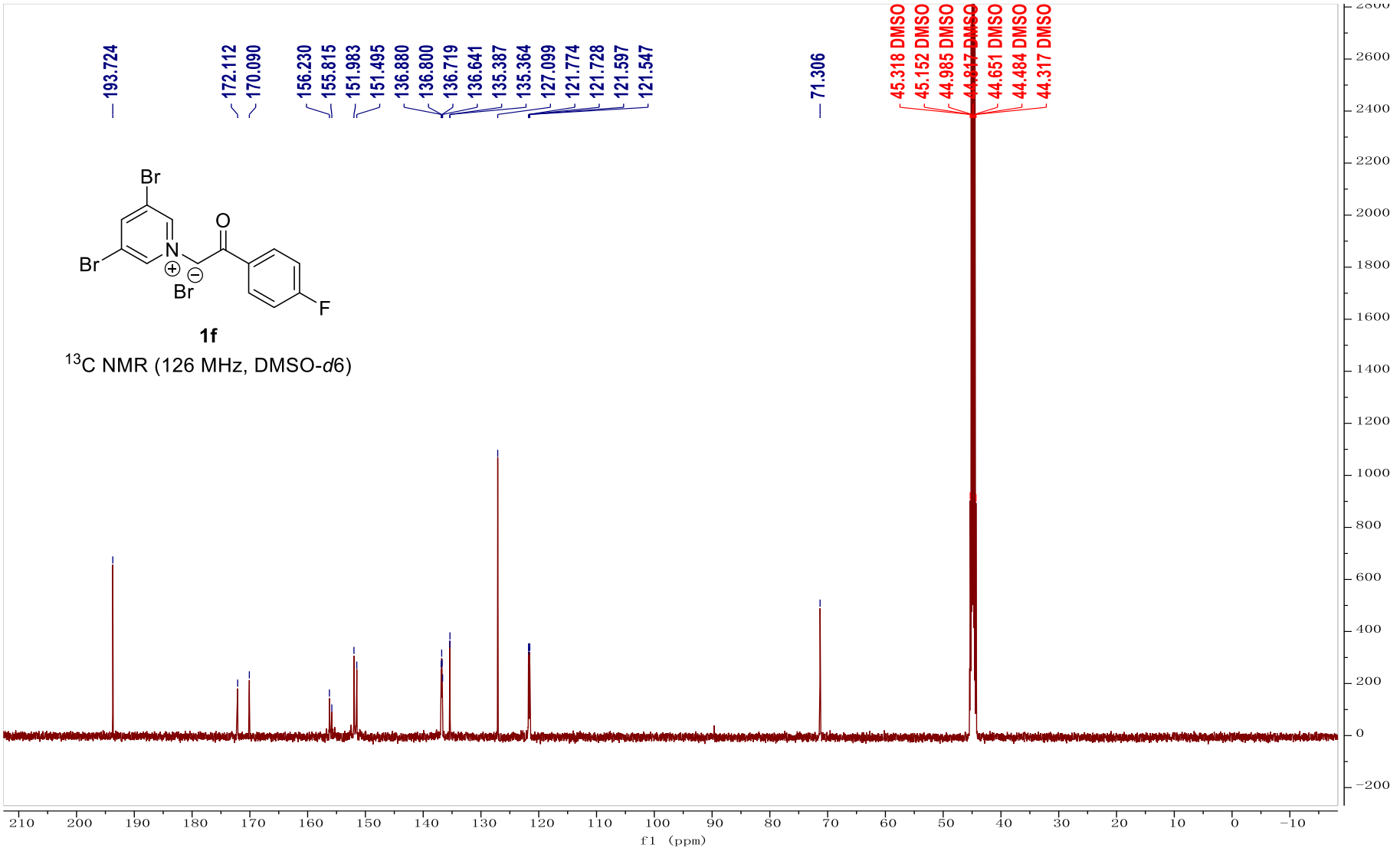
7. NMR spectra

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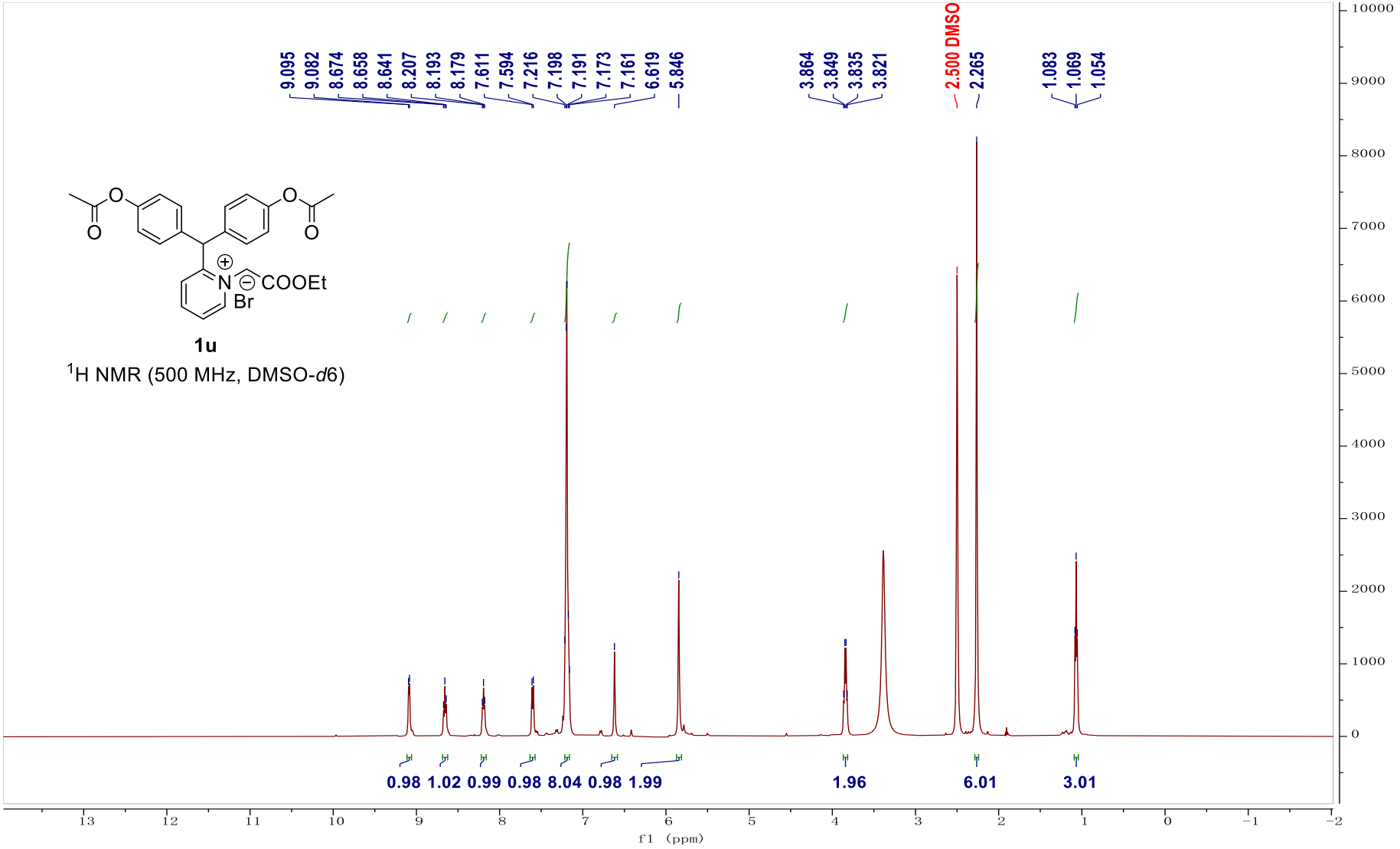
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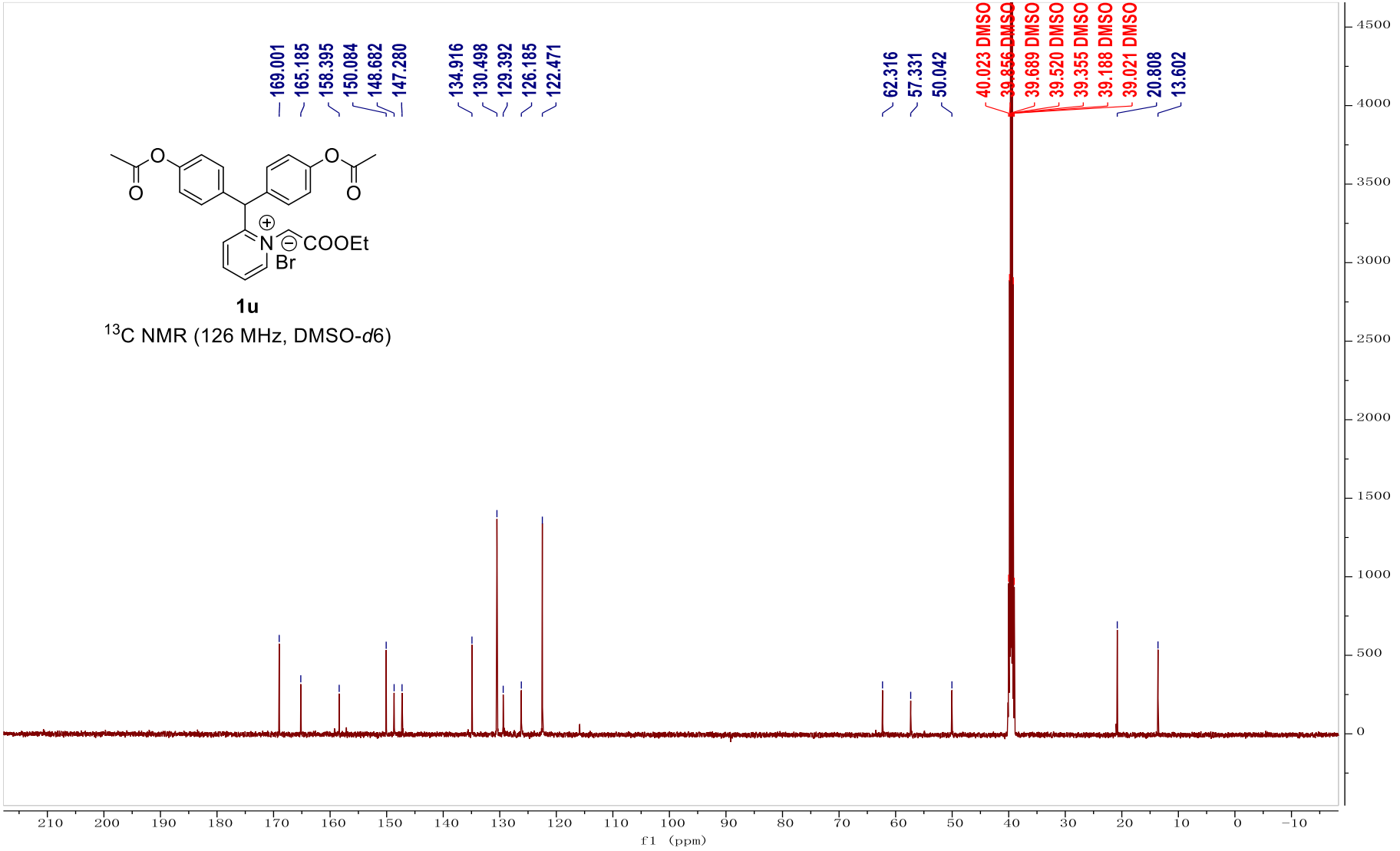
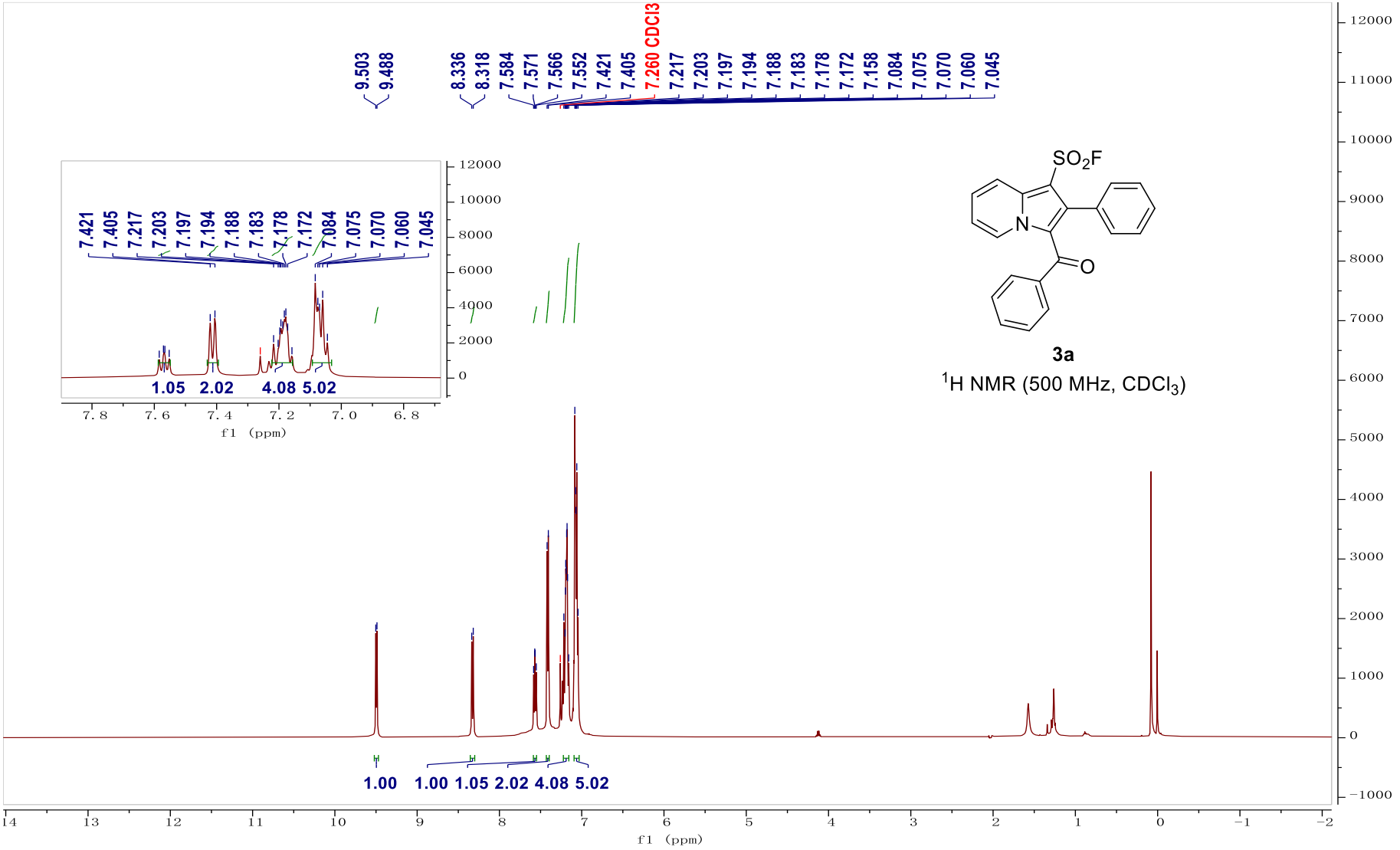
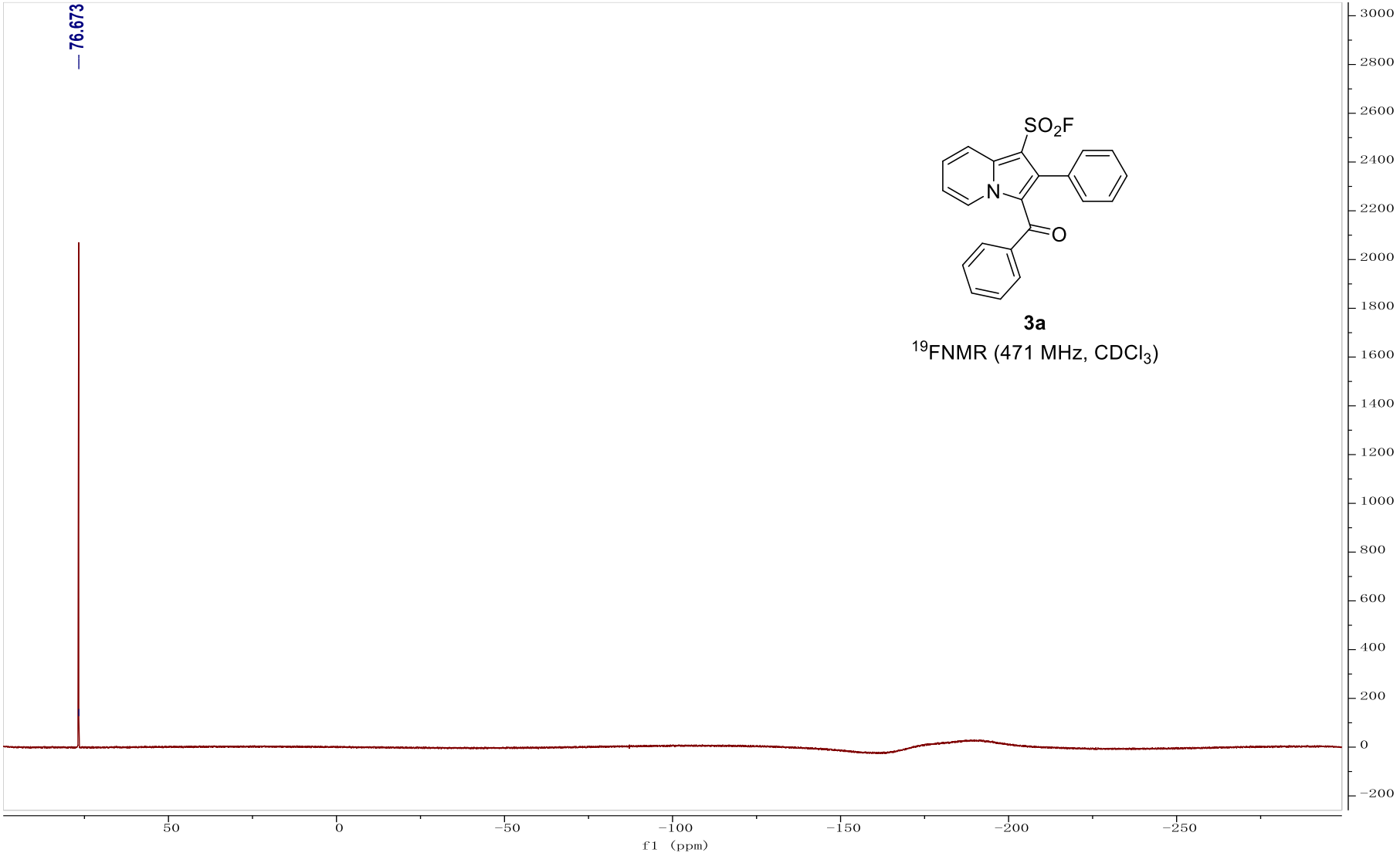
3.849
3.835
3.821
2.500 DMSO
2.265
1.083
1.069
1.054
COOEt
Br
1u
1H NMR (500 MHz, DMSO-d6)
0.98 1.02 0.99 0.98 8.04 0.98 1.99
1.96
6.01
3.01
f1 (ppm)

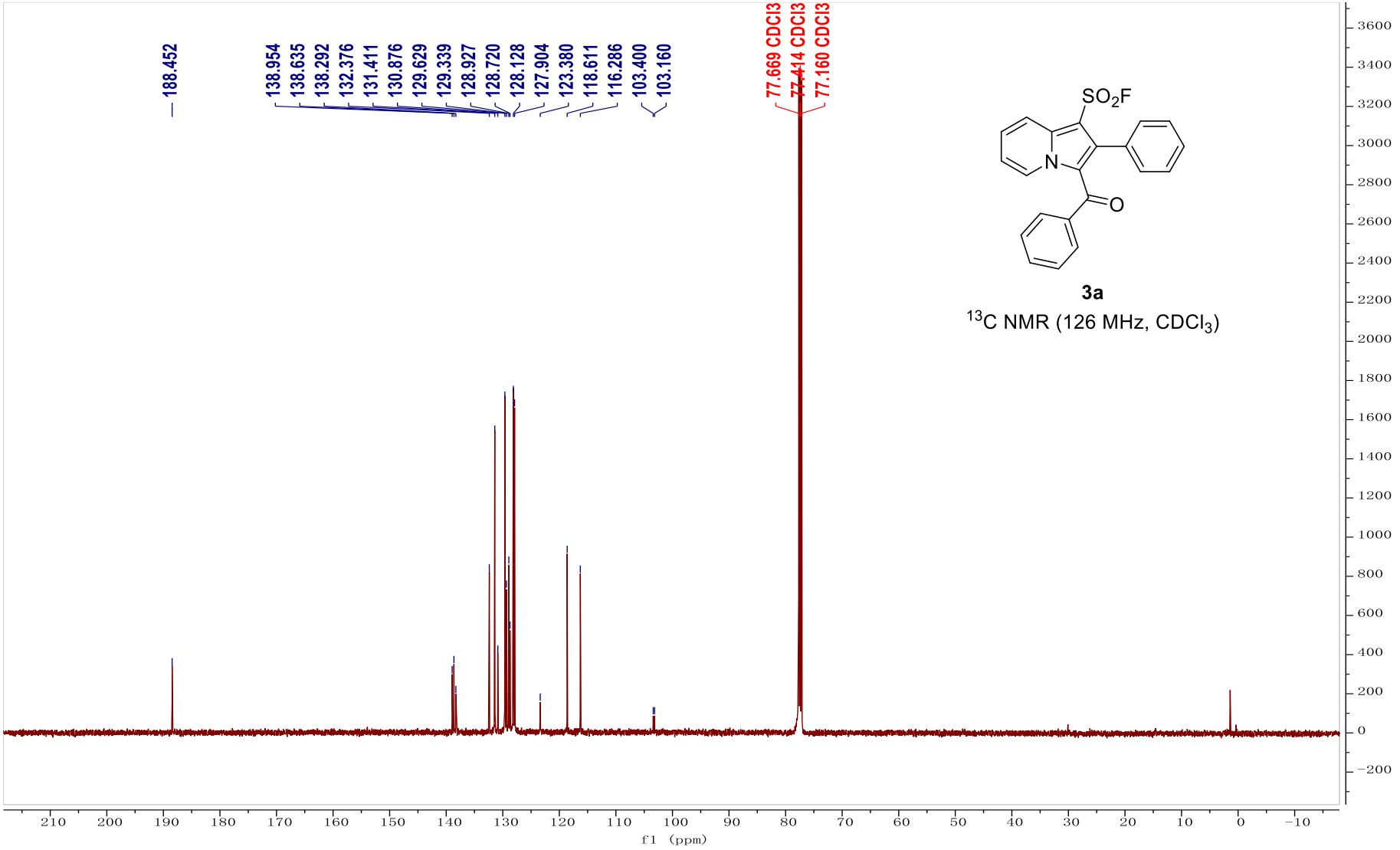


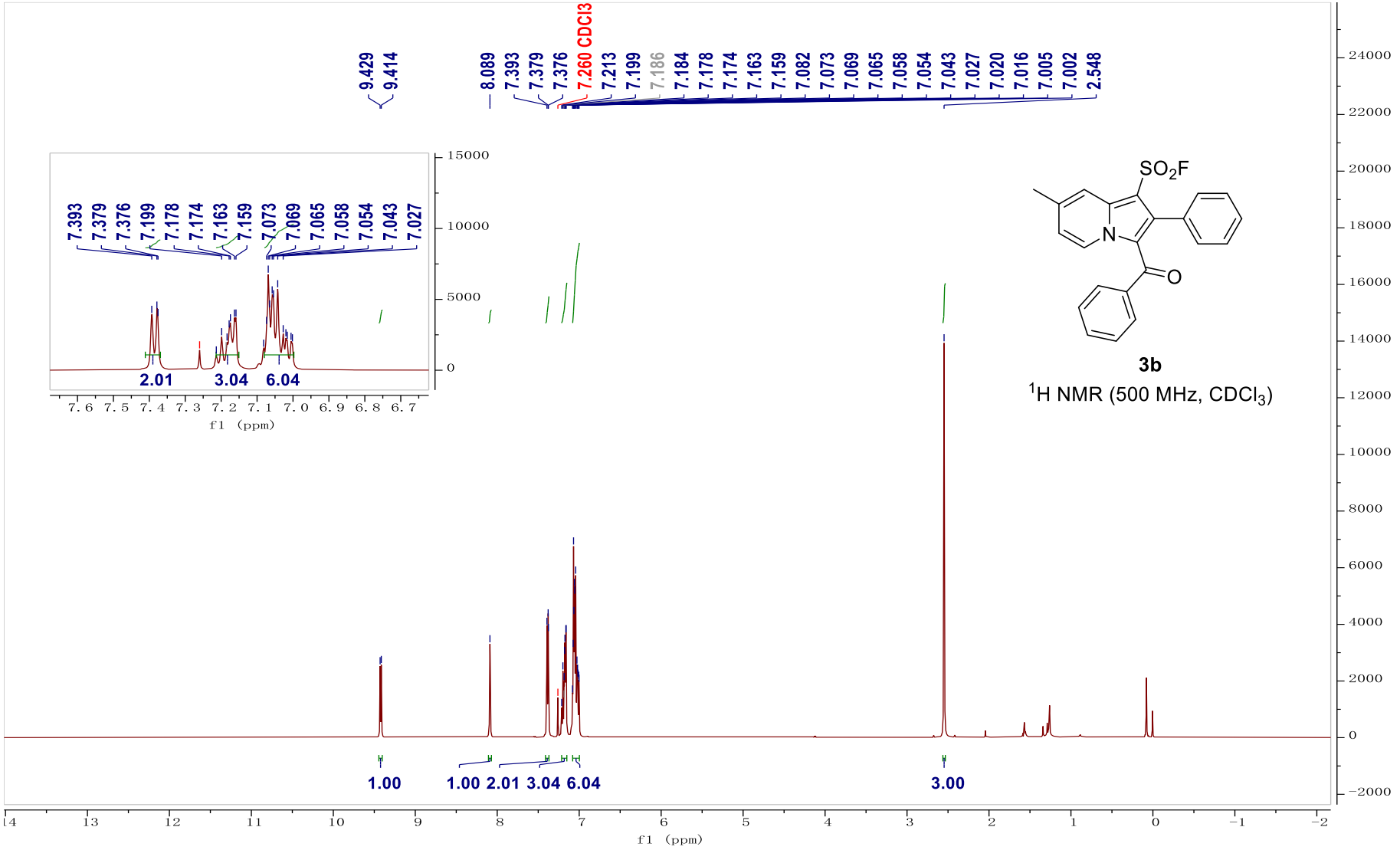
1u

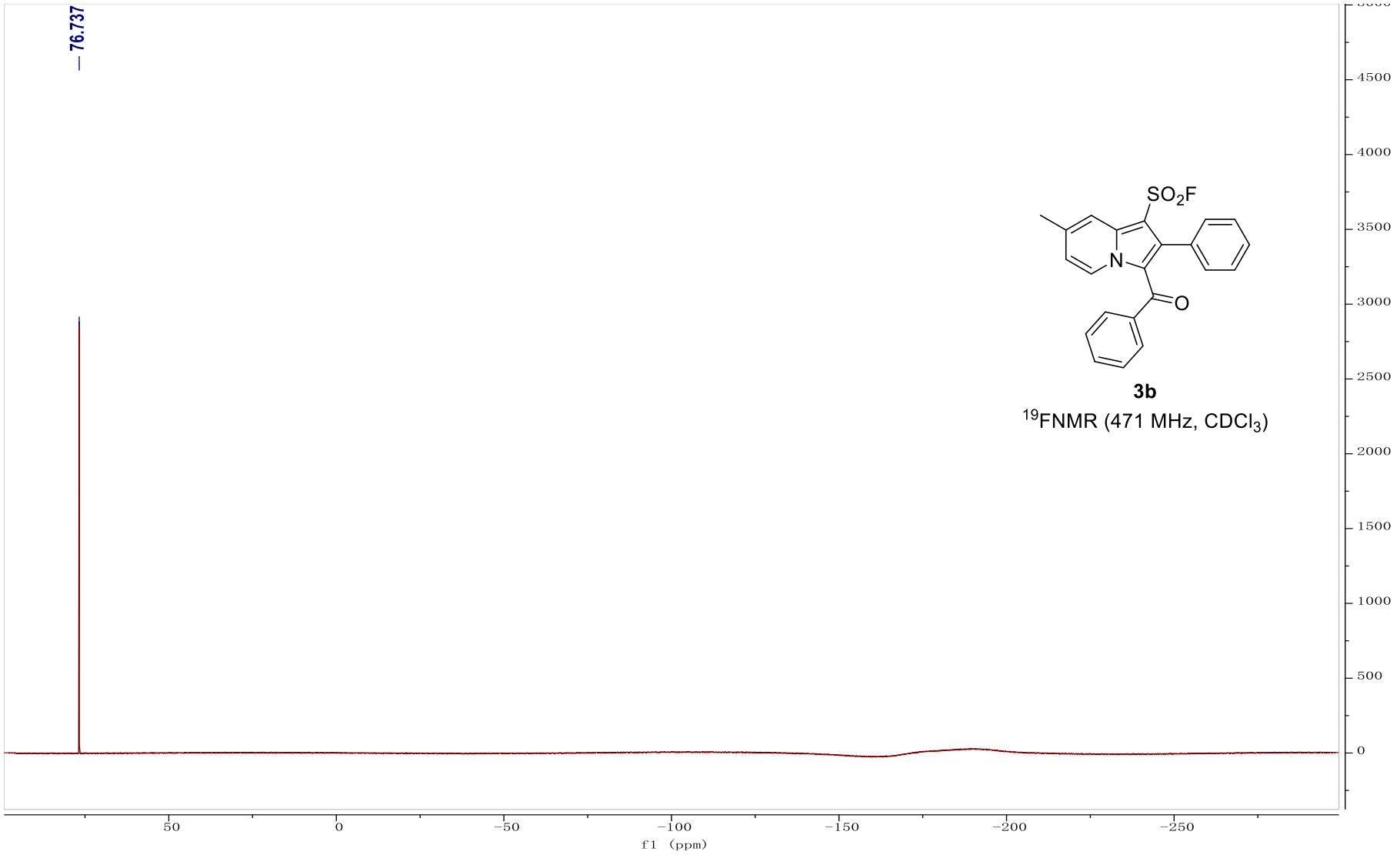
^{13}C NMR (126 MHz, DMSO-*d*6)

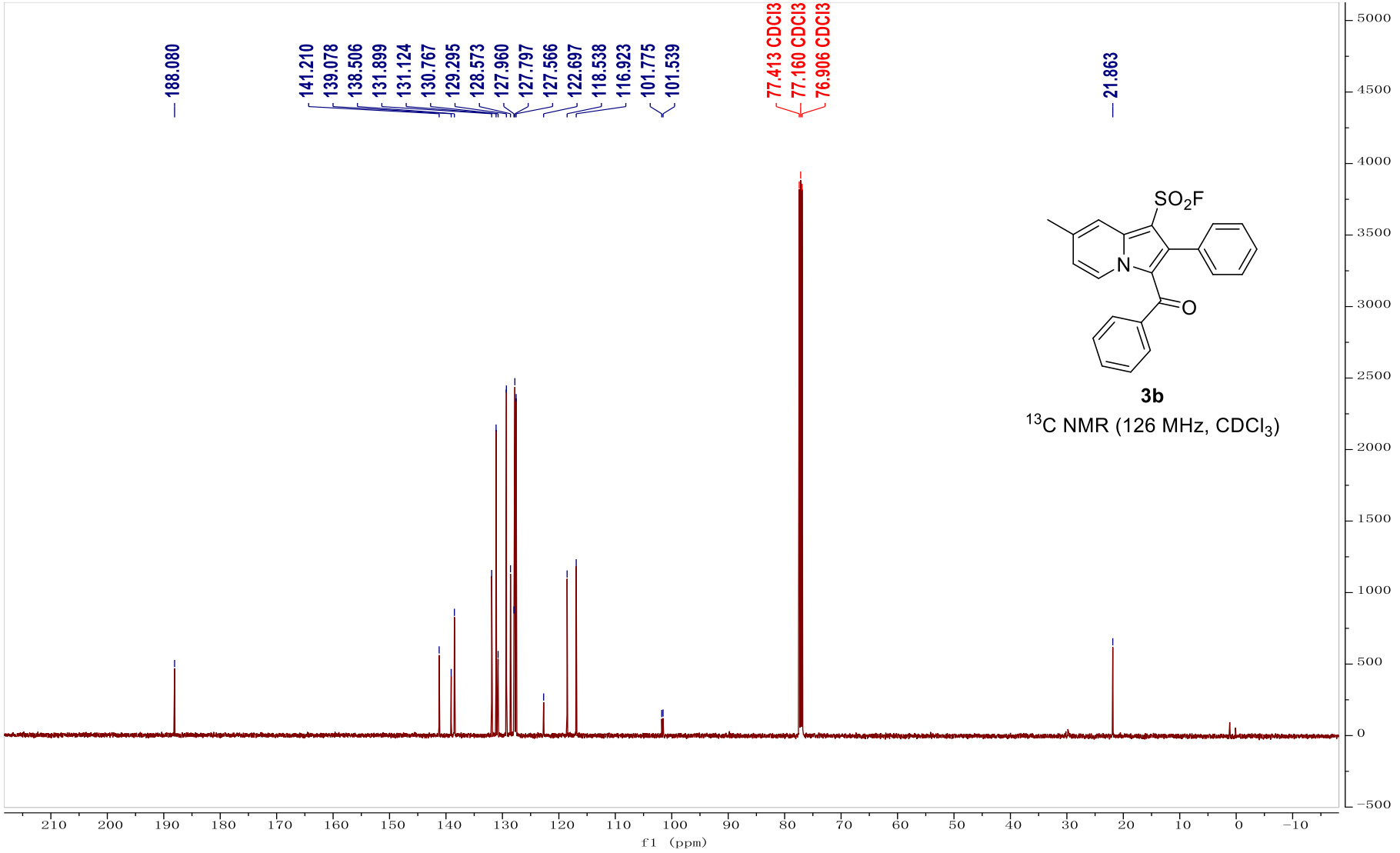

9.503
9.488
8.336
8.318
7.584
7.571
7.566
7.552
7.421
7.405
7.260 CDCl3
7.217
7.203
7.197
7.194
7.188
7.183
7.178
7.172
7.158
7.084
7.075
7.070
7.060
7.045
SO2F
N
O
3a
1H NMR (500 MHz, CDCl3)
1.05 2.02 4.08 5.02
f1 (ppm)
1.00 1.00 1.05 2.02 4.08 5.02
f1 (ppm)

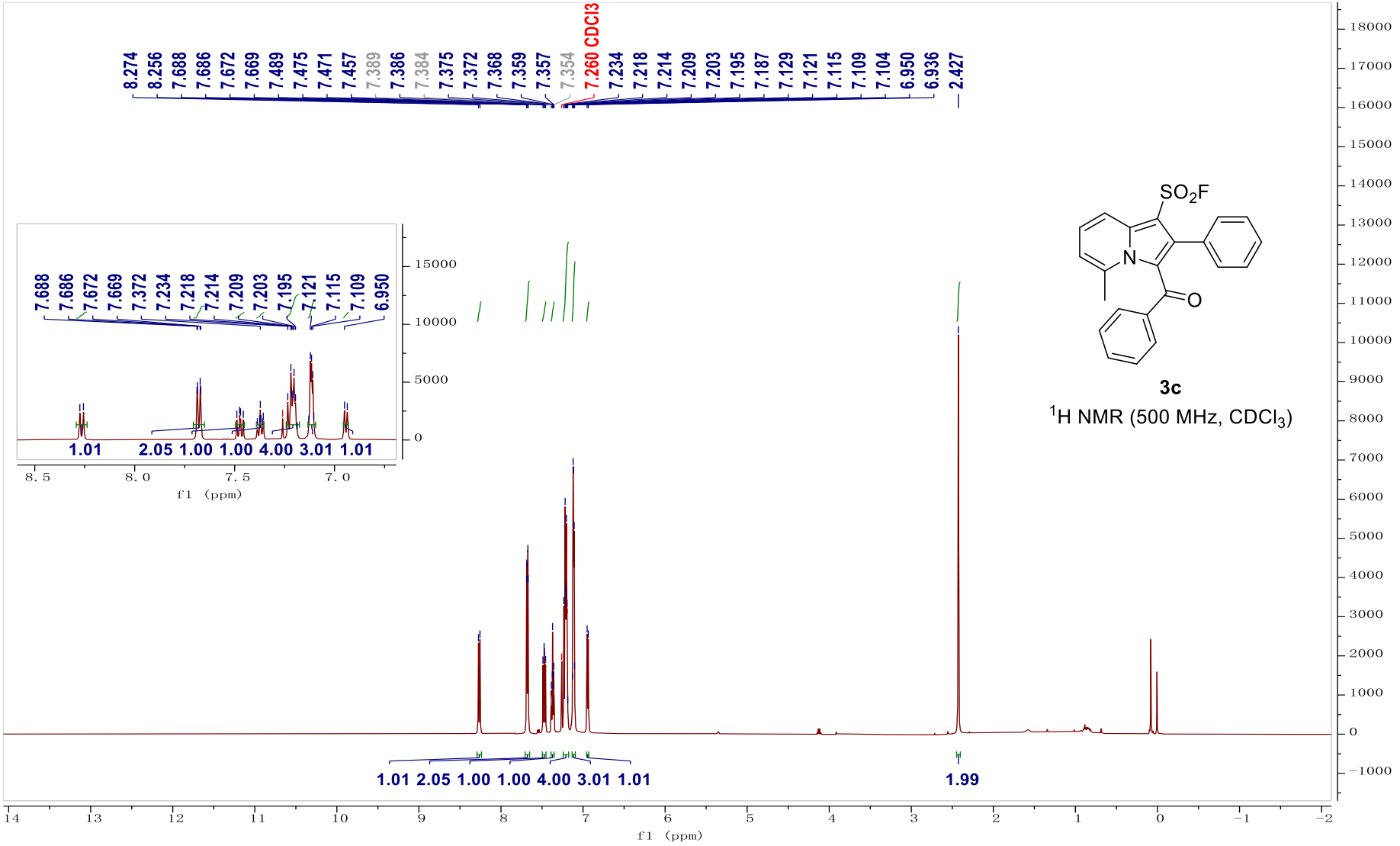

76.673
SO2F
N
O
3a
19FNMR (471 MHz, CDCl3)
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
−200
50
0
−50
−100
−150
−200
−250
f1 (ppm)

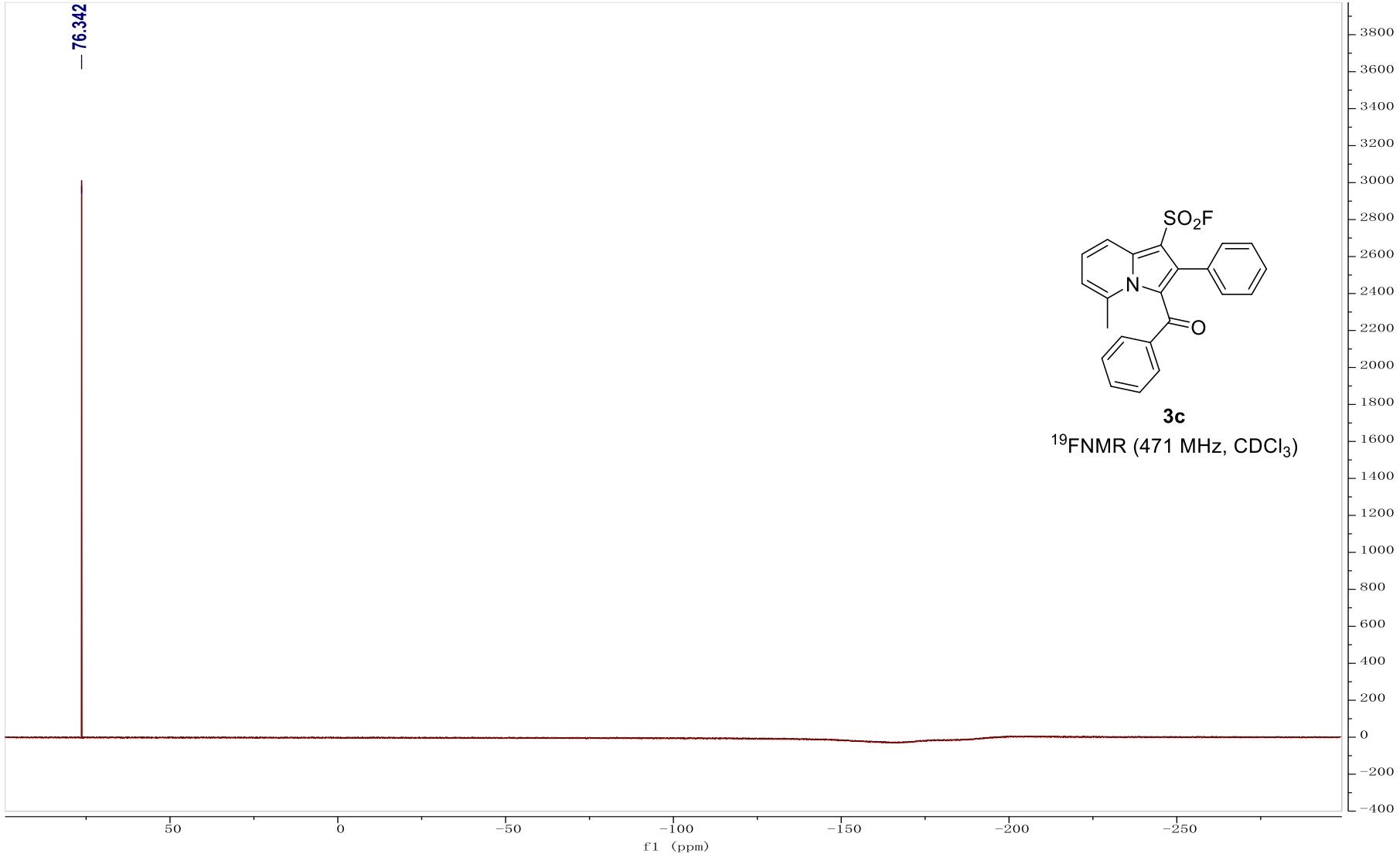

188.452
138.954
138.635
138.292
132.376
131.411
130.876
129.629
129.339
128.927
128.720
128.128
127.904
123.380
118.611
116.286
103.400
103.160
77.669 CDCl3
77.414 CDCl3
77.160 CDCl3
SO2F
N
O
3a
13C NMR (126 MHz, CDCl3)
f1 (ppm)

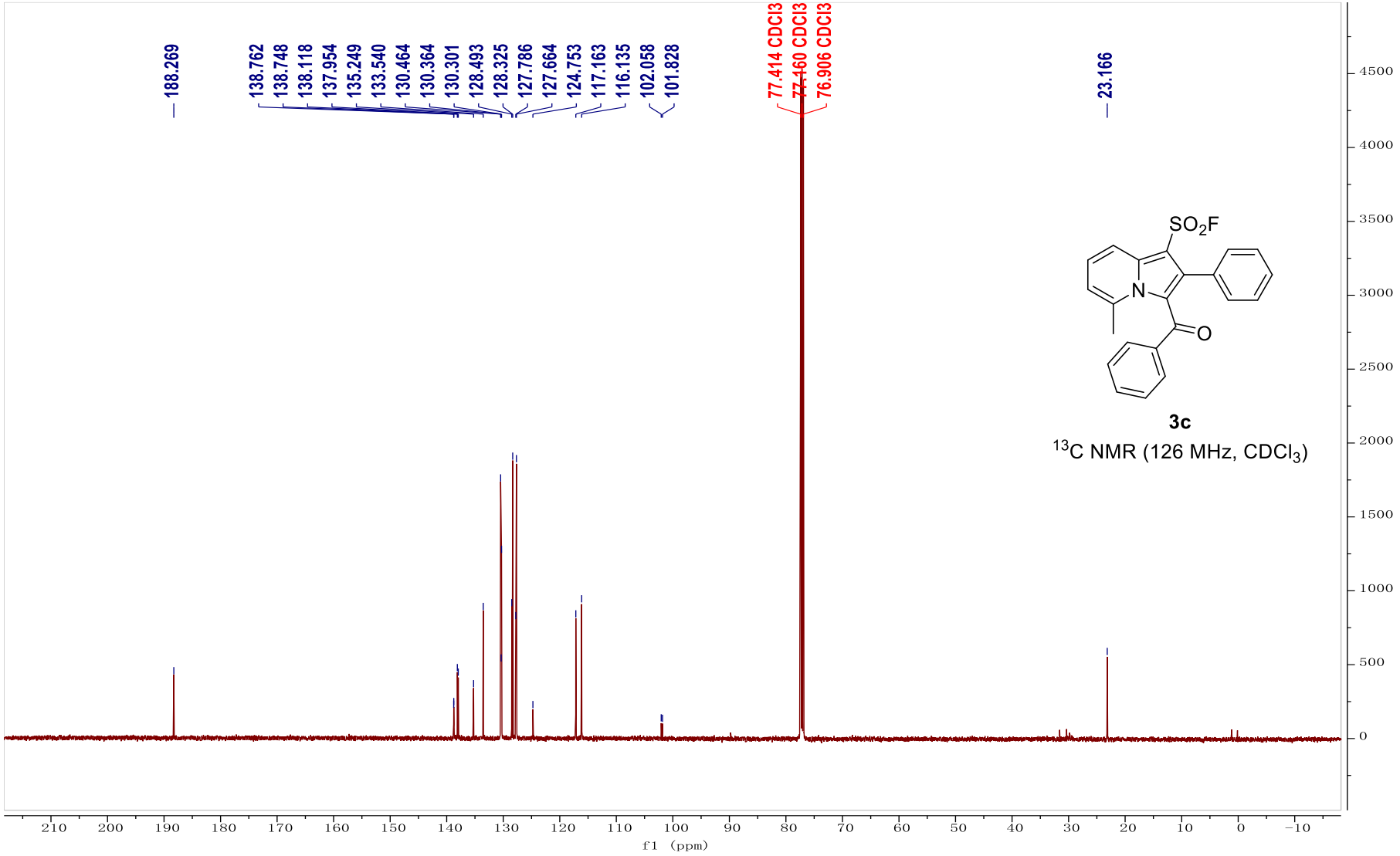

9.429
9.414
8.089
7.393
7.379
7.376
7.260 CDCl3
7.213
7.199
7.186
7.184
7.178
7.174
7.163
7.159
7.082
7.073
7.069
7.065
7.058
7.054
7.043
7.027
7.020
7.016
7.005
7.002
2.548
SO2F
N
O
3b
1H NMR (500 MHz, CDCl3)
2.01
3.04
6.04
1.00
1.00 2.01 3.04 6.04
3.00
f1 (ppm)

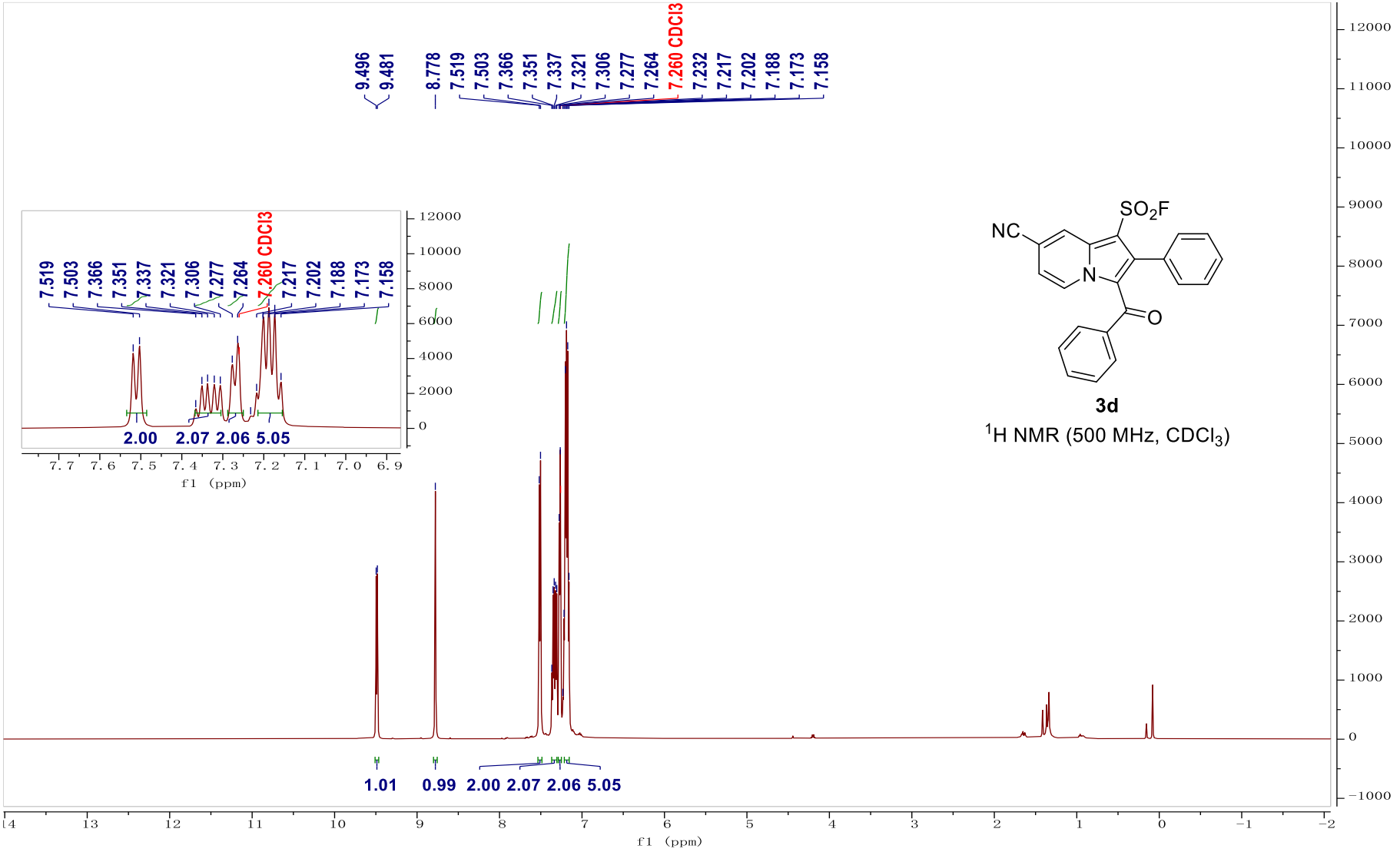

76.737
SO2F
N
O
3b
19FNMR (471 MHz, CDCl3)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
50
0
−50
−100
−150
−200
−250
f1 (ppm)

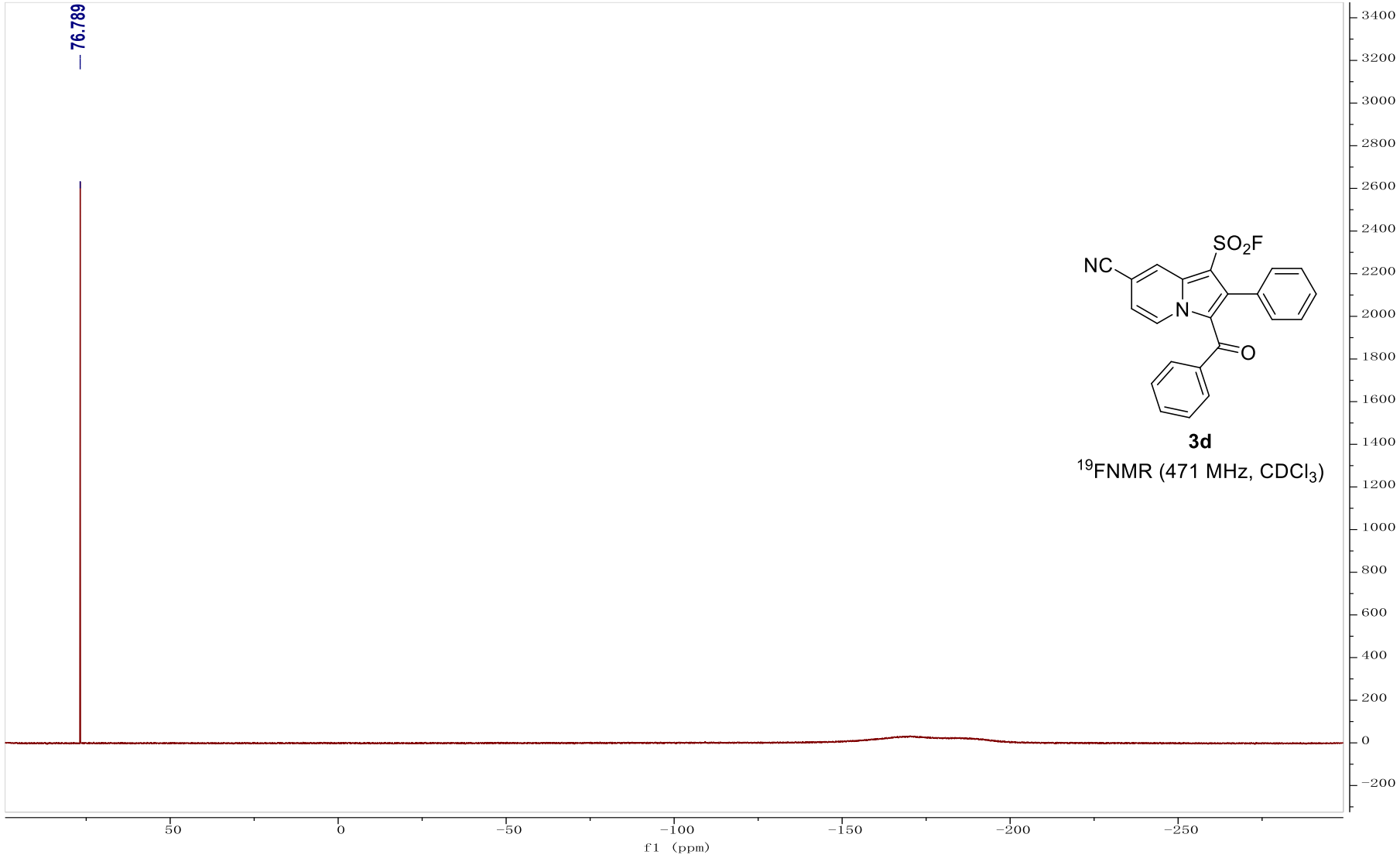

188.080
141.210
139.078
138.506
131.899
131.124
130.767
129.295
128.573
127.960
127.797
127.566
122.697
118.538
116.923
101.775
101.539
77.413 CDCl3
77.160 CDCl3
76.906 CDCl3
21.863
SO2F
N
O
3b
13C NMR (126 MHz, CDCl3)
f1 (ppm)

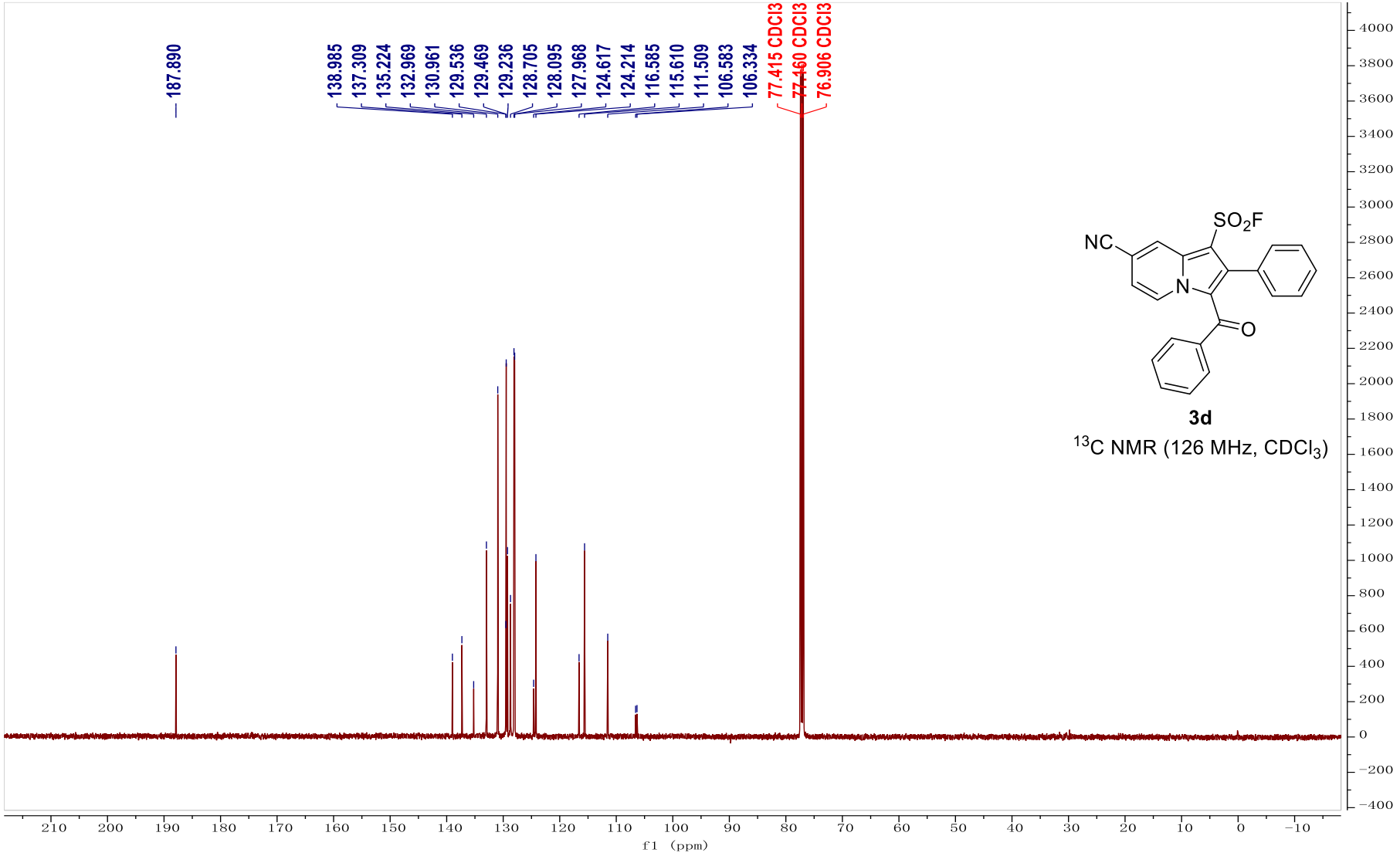

8.274
8.256
7.688
7.686
7.672
7.669
7.489
7.475
7.471
7.457
7.389
7.386
7.384
7.375
7.372
7.368
7.359
7.357
7.354
7.260 CDCl3
7.234
7.218
7.214
7.209
7.203
7.195
7.187
7.129
7.121
7.115
7.109
7.104
6.950
6.936
2.427
1.01 2.05 1.00 1.00 4.00 3.01 1.01
1.99
f1 (ppm)
SO2F
N
O
3c
1H NMR (500 MHz, CDCl3)

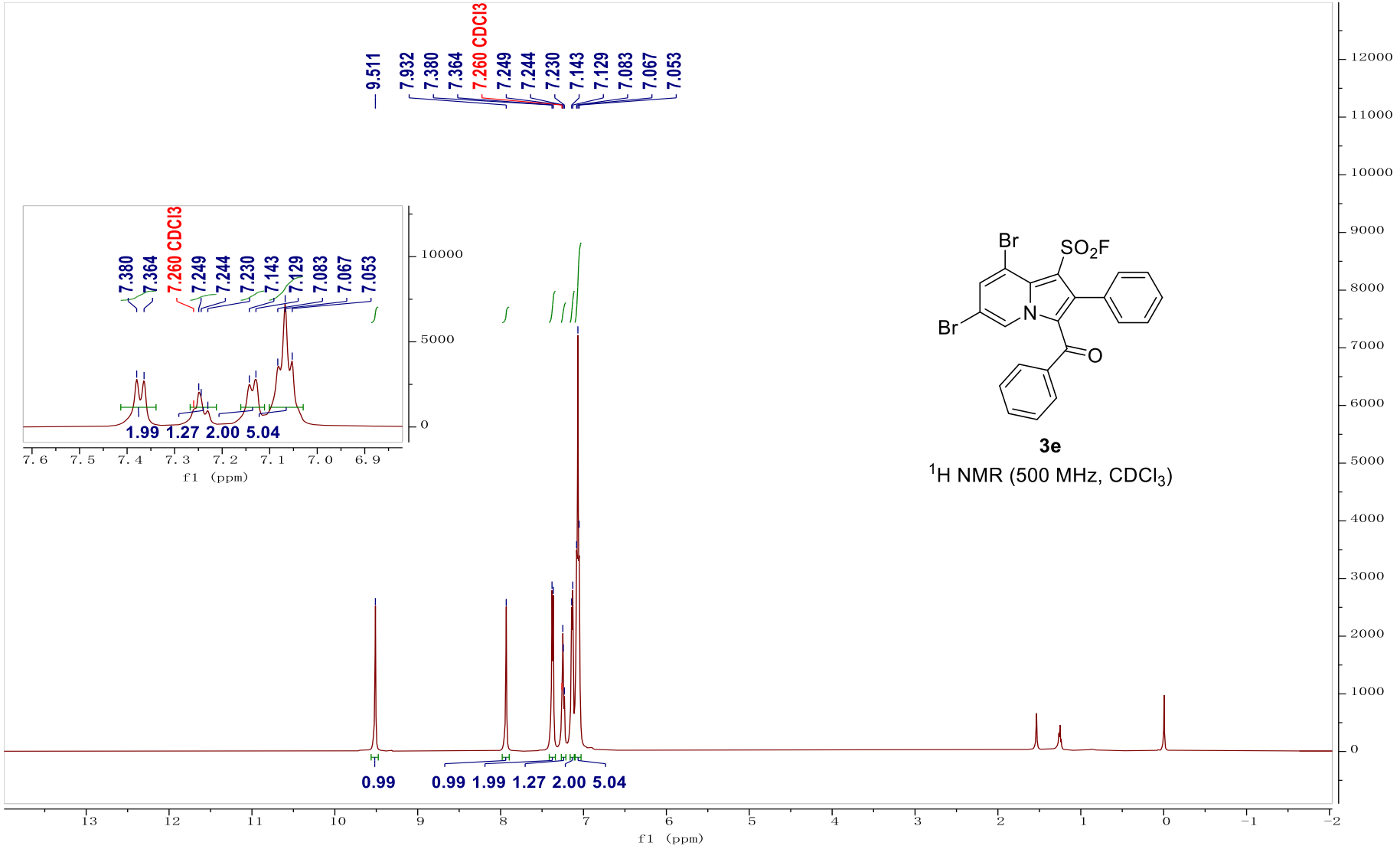

76.342
SO2F
N
O
3c
19FNMR (471 MHz, CDCl3)
3800
3600
3400
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
−200
−400
50
0
−50
−100
−150
−200
−250
f1 (ppm)

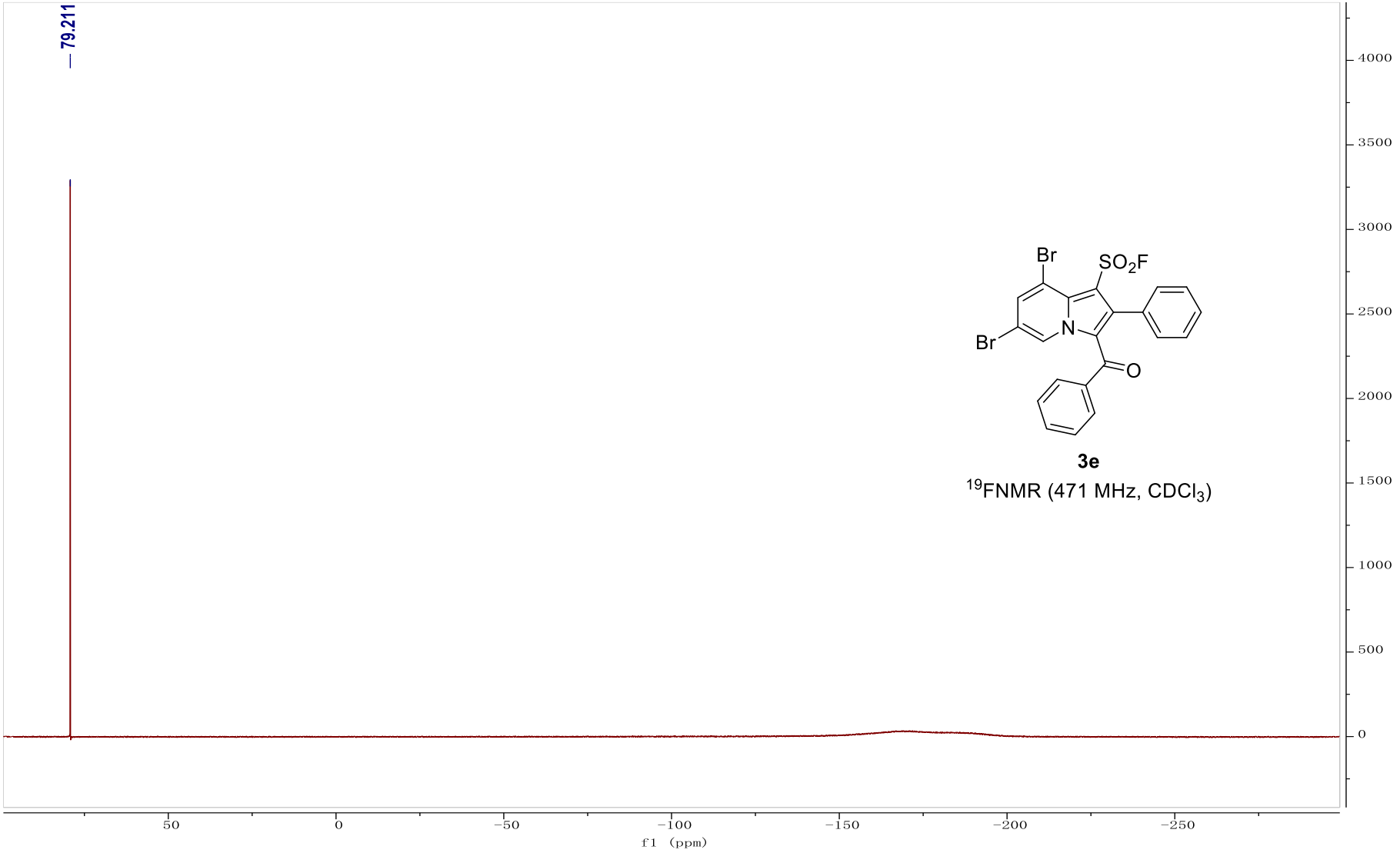

188.269
138.762
138.748
138.118
137.954
135.249
133.540
130.464
130.364
130.301
128.493
128.325
127.786
127.664
124.753
117.163
116.135
102.058
101.828
77.414 CDCl3
77.160 CDCl3
76.906 CDCl3
23.166
SO2F
N
O
3c
13C NMR (126 MHz, CDCl3)
f1 (ppm)


9.496
9.481
8.778
7.519
7.503
7.366
7.351
7.337
7.321
7.306
7.277
7.264
7.260 CDCl3
7.232
7.217
7.202
7.188
7.173
7.158
2.00 2.07 2.06 5.05
1.01 0.99 2.00 2.07 2.06 5.05
f1 (ppm)
NC
SO2F
N
O
3d
1H NMR (500 MHz, CDCl3)


76.789
3400
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
−200
50
0
−50
−100
−150
−200
−250
f1 (ppm)
NC
SO2F
N
O
3d
19FNMR (471 MHz, CDCl3)

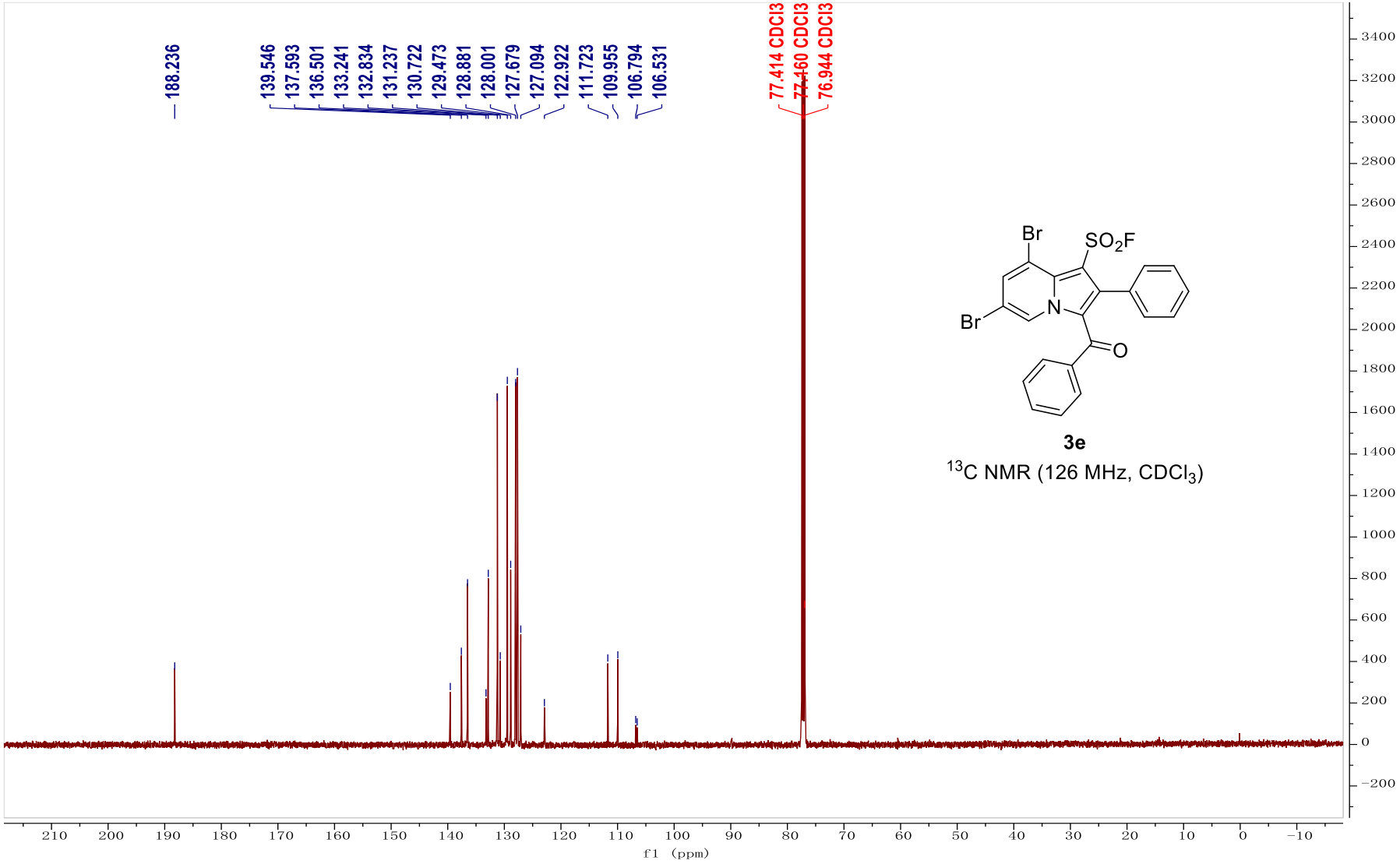

187.890
138.985
137.309
135.224
132.969
130.961
129.536
129.469
129.236
128.705
128.095
127.968
124.617
124.214
116.585
115.610
111.509
106.583
106.334
77.415 CDCl3
77.160 CDCl3
76.906 CDCl3
NC
SO2F
N
O
3d
13C NMR (126 MHz, CDCl3)
f1 (ppm)

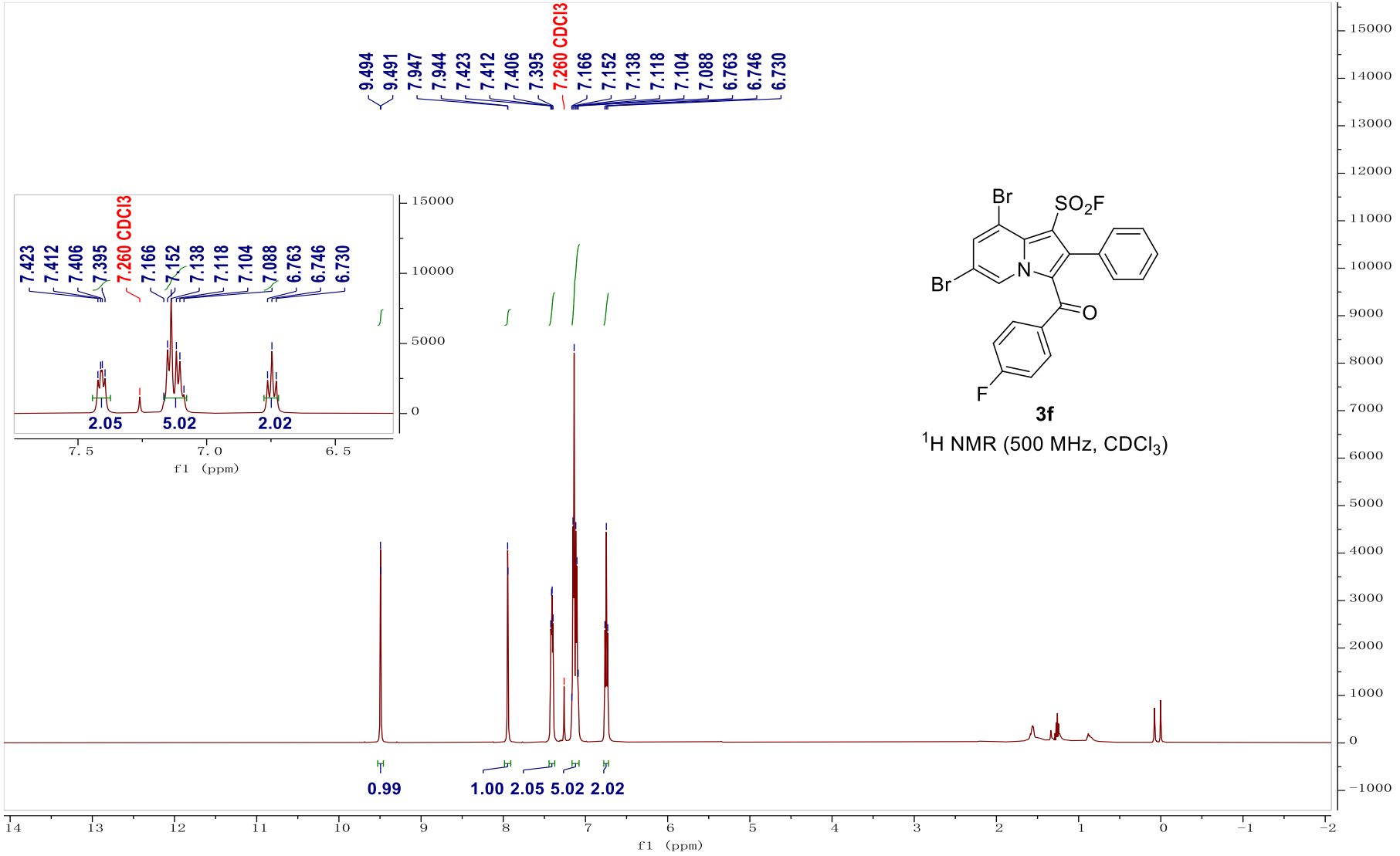

9.511
7.932
7.380
7.364
7.260 CDCl3
7.249
7.244
7.230
7.143
7.129
7.083
7.067
7.053
1.99 1.27 2.00 5.04
f1 (ppm)
0.99
0.99 1.99 1.27 2.00 5.04
f1 (ppm)
Br
SO2F
Br
N
O
3e
1H NMR (500 MHz, CDCl3)

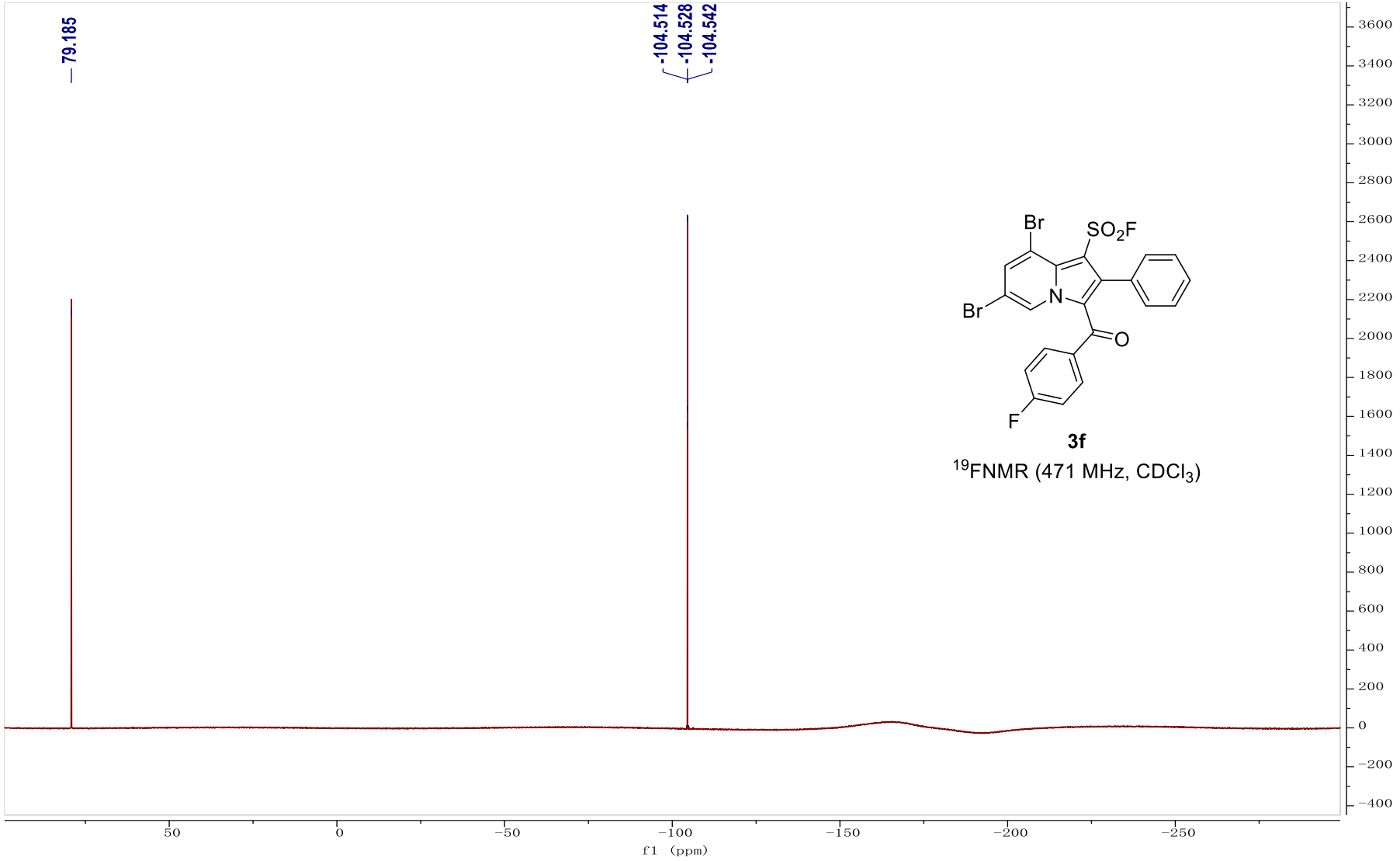


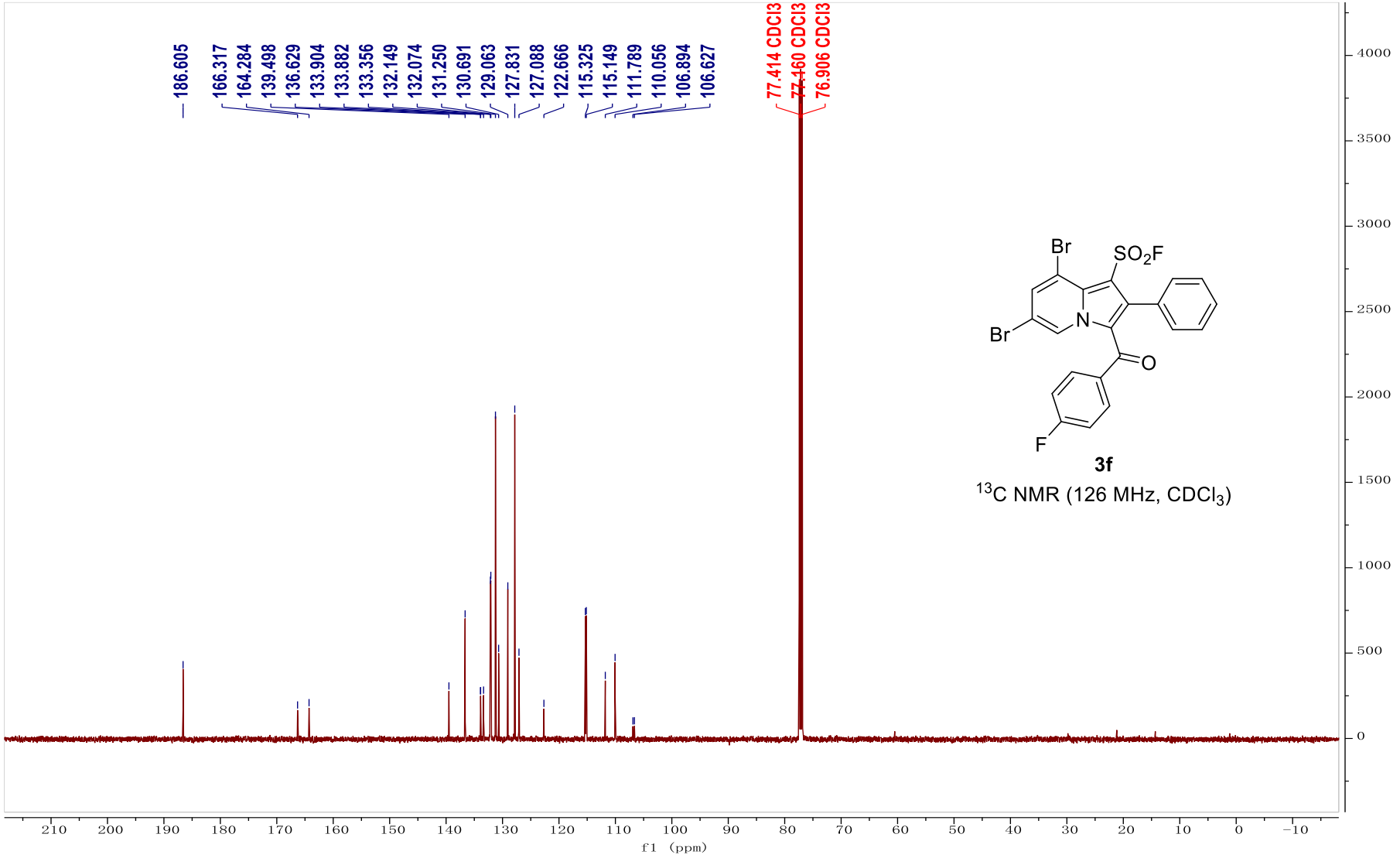
3e

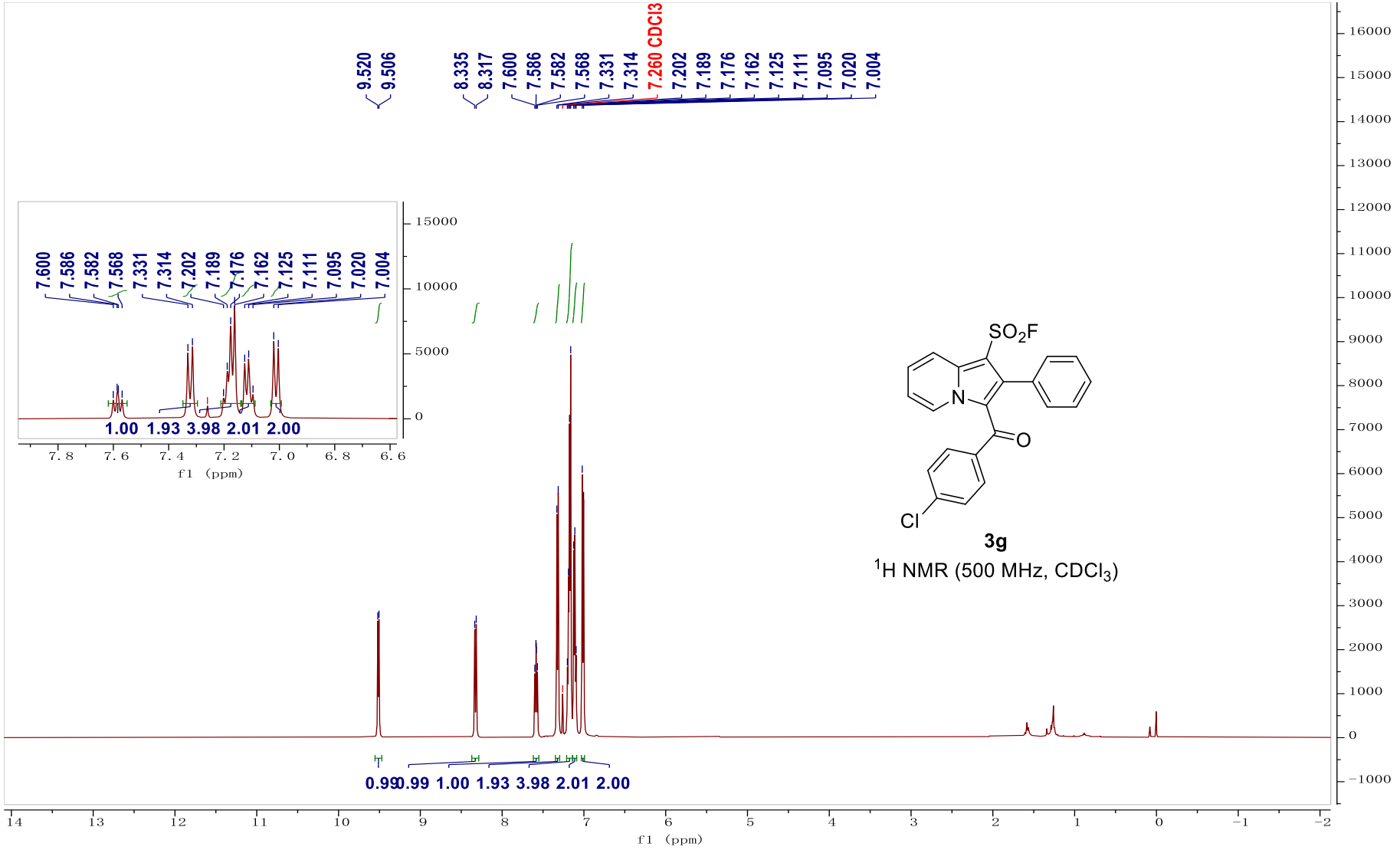
^{19}FNMR (471 MHz, $CDCl_3$)

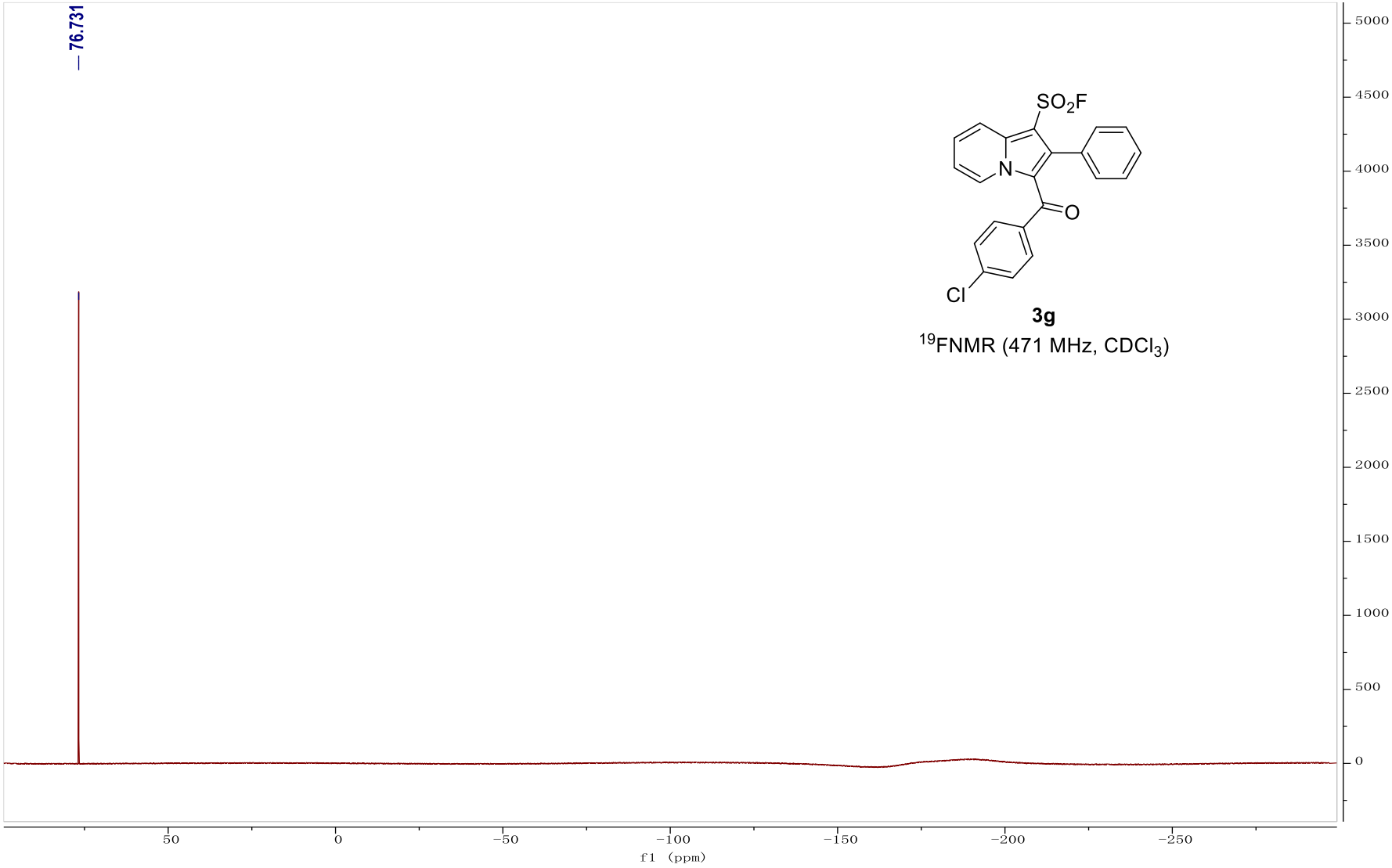

188.236
139.546
137.593
136.501
133.241
132.834
131.237
130.722
129.473
128.881
128.001
127.679
127.094
122.922
111.723
109.955
106.794
106.531
77.414 CDCl3
77.160 CDCl3
76.944 CDCl3
Br
SO2F
N
Br
O
3e
13C NMR (126 MHz, CDCl3)
f1 (ppm)

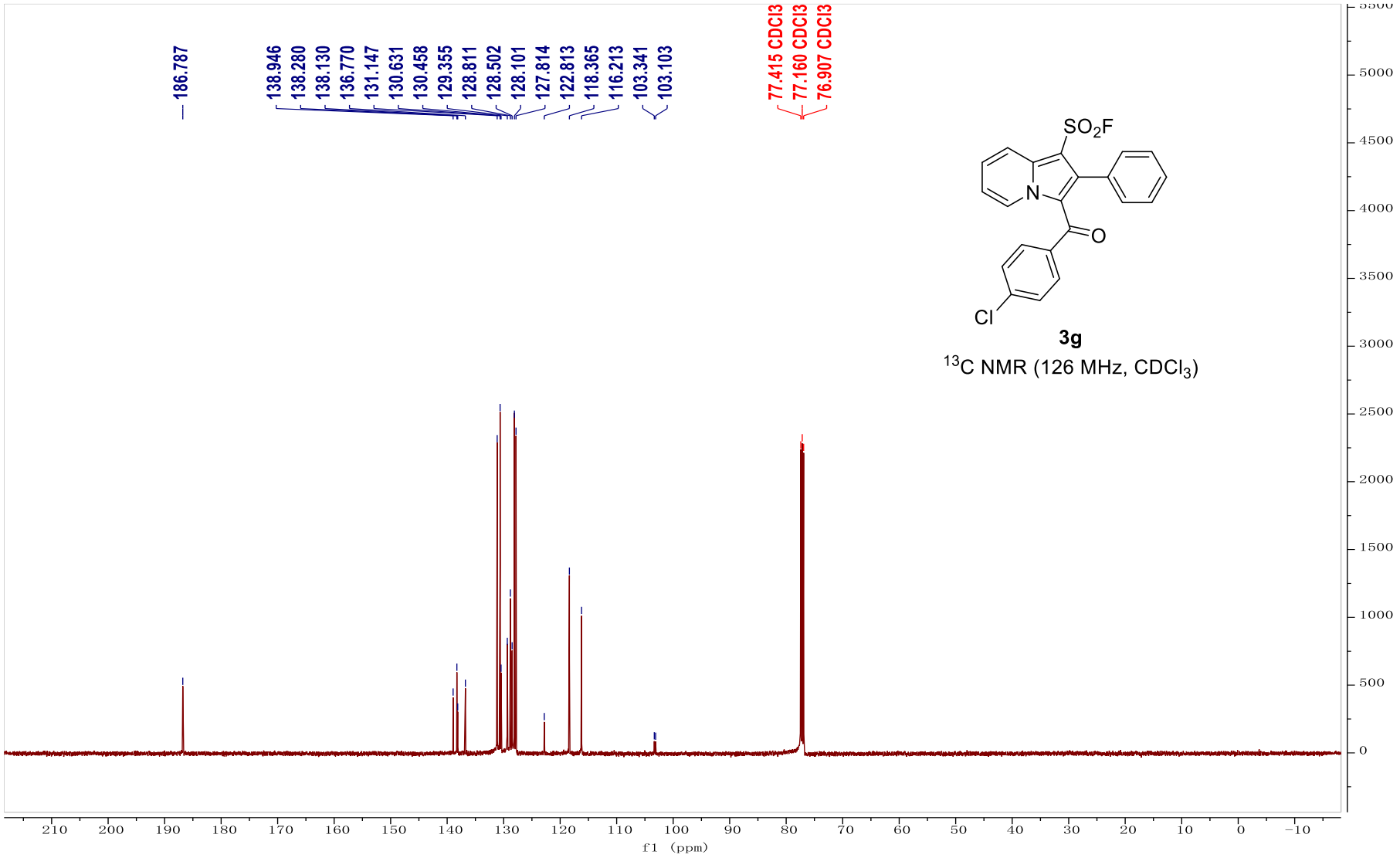

9.494
9.491
7.947
7.944
7.423
7.412
7.406
7.395
7.260 CDCl3
7.166
7.152
7.138
7.118
7.104
7.088
6.763
6.746
6.730
Br
SO2F
Br
N
O
F
3f
1H NMR (500 MHz, CDCl3)
2.05
5.02
2.02
0.99
1.00 2.05 5.02 2.02
f1 (ppm)

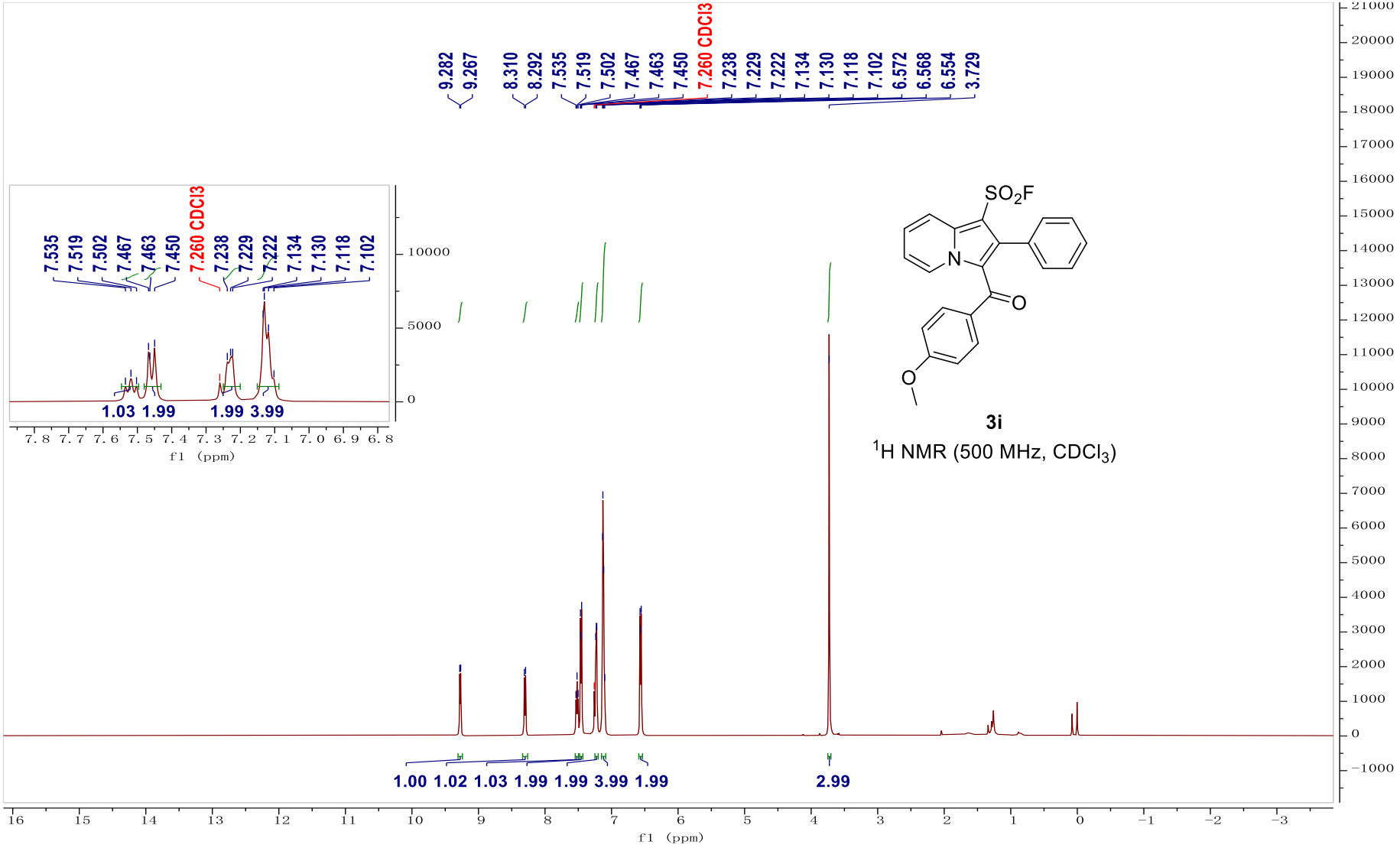

79.185
-104.514
-104.528
-104.542
Br
SO2F
Br
N
O
F
3f
19FNMR (471 MHz, CDCl3)
3600
3400
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
−200
−400
50
0
−50
−100
−150
−200
−250
f1 (ppm)

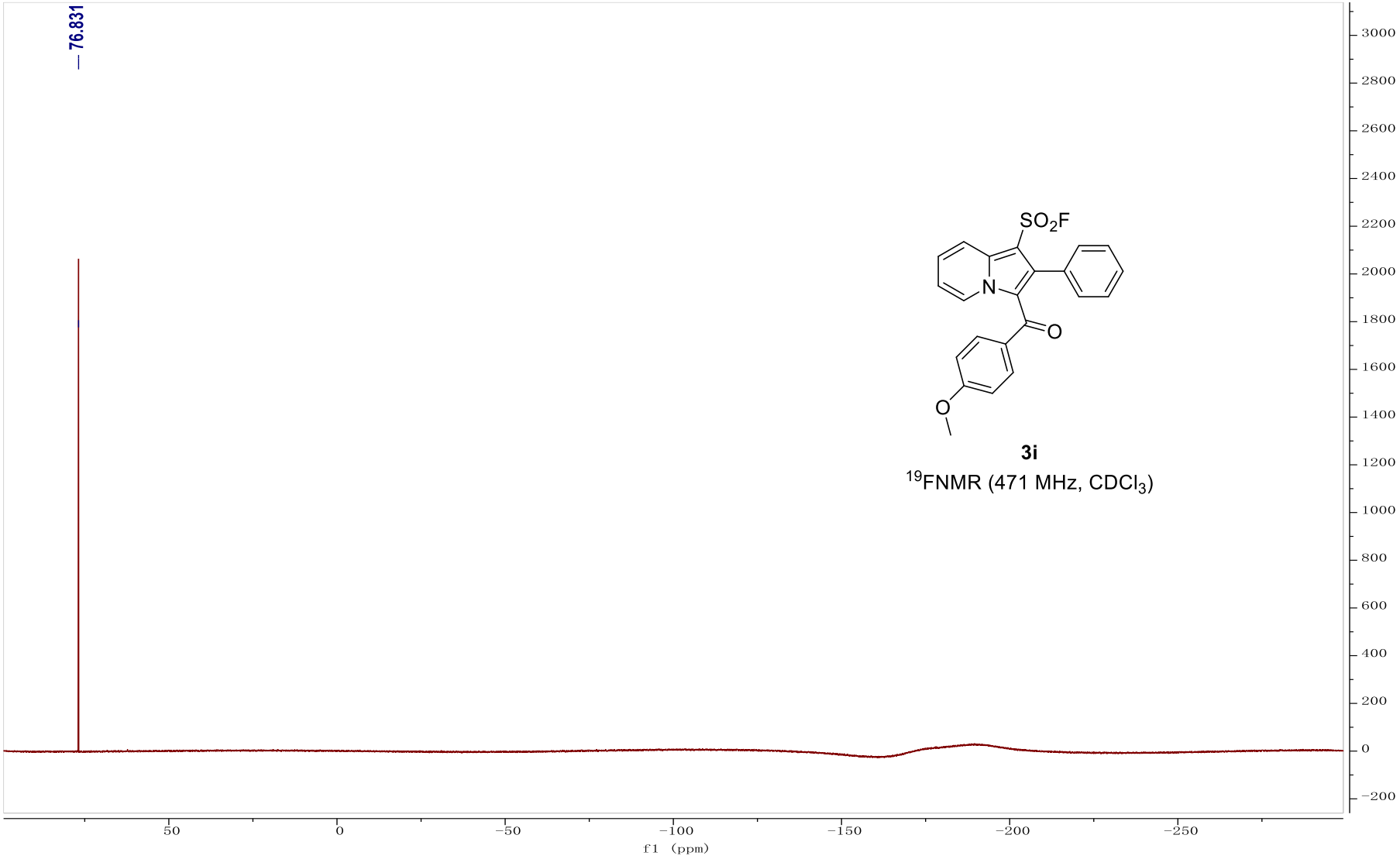

186.605
166.317
164.284
139.498
136.629
133.904
133.882
133.356
132.149
132.074
131.250
130.691
129.063
127.831
127.088
122.666
115.325
115.149
111.789
110.056
106.894
106.627
77.414 CDCl3
77.160 CDCl3
76.906 CDCl3
Br
SO2F
Br
N
O
F
3f
13C NMR (126 MHz, CDCl3)
f1 (ppm)


9.520
9.506
8.335
8.317
7.600
7.586
7.582
7.568
7.331
7.314
7.260 CDCl3
7.202
7.189
7.176
7.162
7.125
7.111
7.095
7.020
7.004
1.00 1.93 3.98 2.01 2.00
f1 (ppm)
SO2F
N
O
Cl
3g
1H NMR (500 MHz, CDCl3)
0.99 0.99 1.00 1.93 3.98 2.01 2.00
f1 (ppm)


76.731
SO2F
N
O
Cl
3g
19FNMR (471 MHz, CDCl3)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
50
0
−50
−100
−150
−200
−250
f1 (ppm)

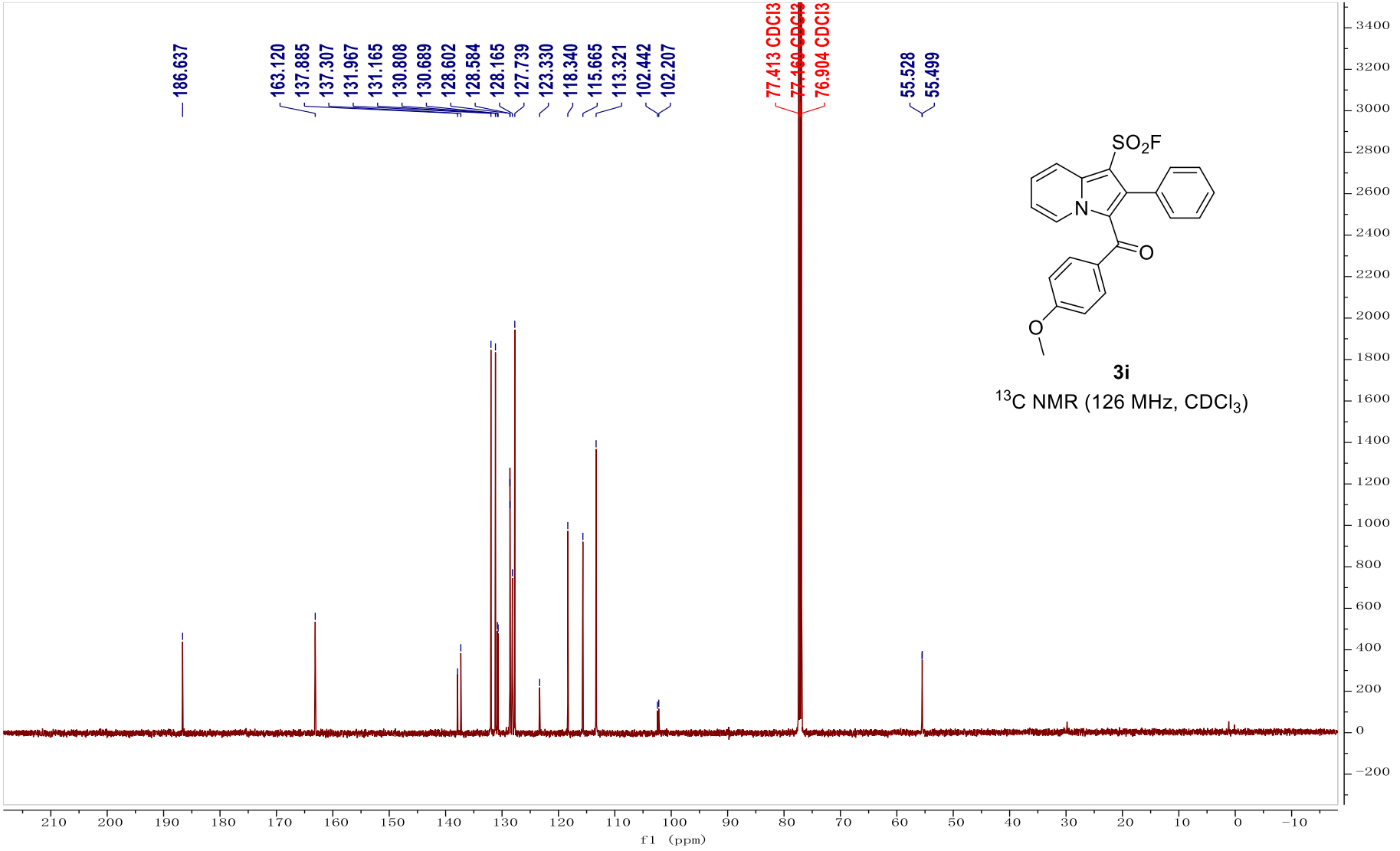

186.787
138.946
138.280
138.130
136.770
131.147
130.631
130.458
129.355
128.811
128.502
128.101
127.814
122.813
118.365
116.213
103.341
103.103
77.415 CDCl3
77.160 CDCl3
76.907 CDCl3
SO2F
N
O
Cl
3g
13C NMR (126 MHz, CDCl3)
f1 (ppm)

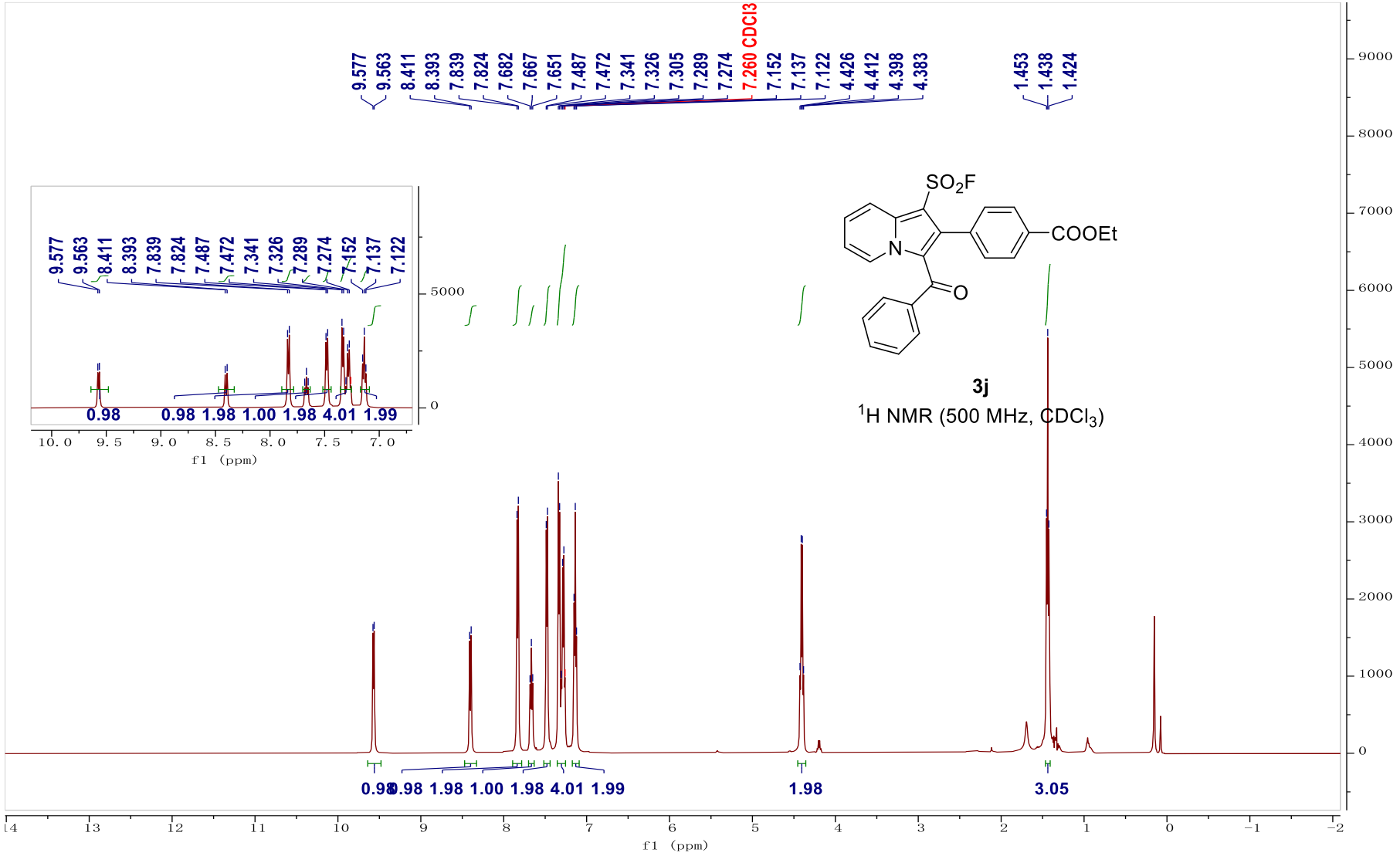

9.282
9.267
8.310
8.292
7.535
7.519
7.502
7.467
7.463
7.450
7.260 CDCl3
7.238
7.229
7.222
7.134
7.130
7.118
7.102
6.572
6.568
6.554
3.729
1.00 1.02 1.03 1.99 1.99 3.99 1.99
2.99
f1 (ppm)
1.03 1.99
1.99 3.99
SO2F
N
O
O
3i
1H NMR (500 MHz, CDCl3)

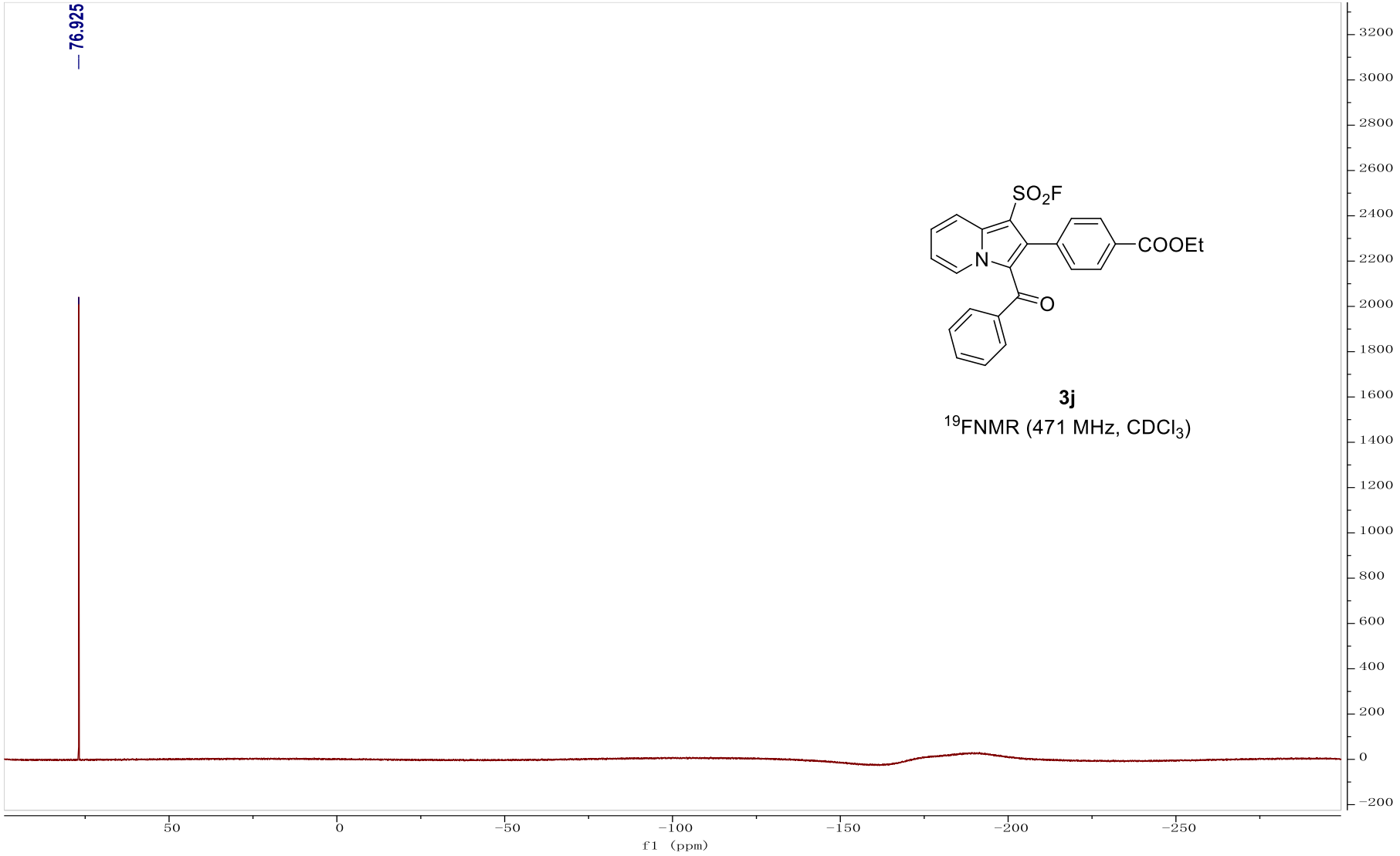


3i

^{19}FNMR (471 MHz, $CDCl_3$)

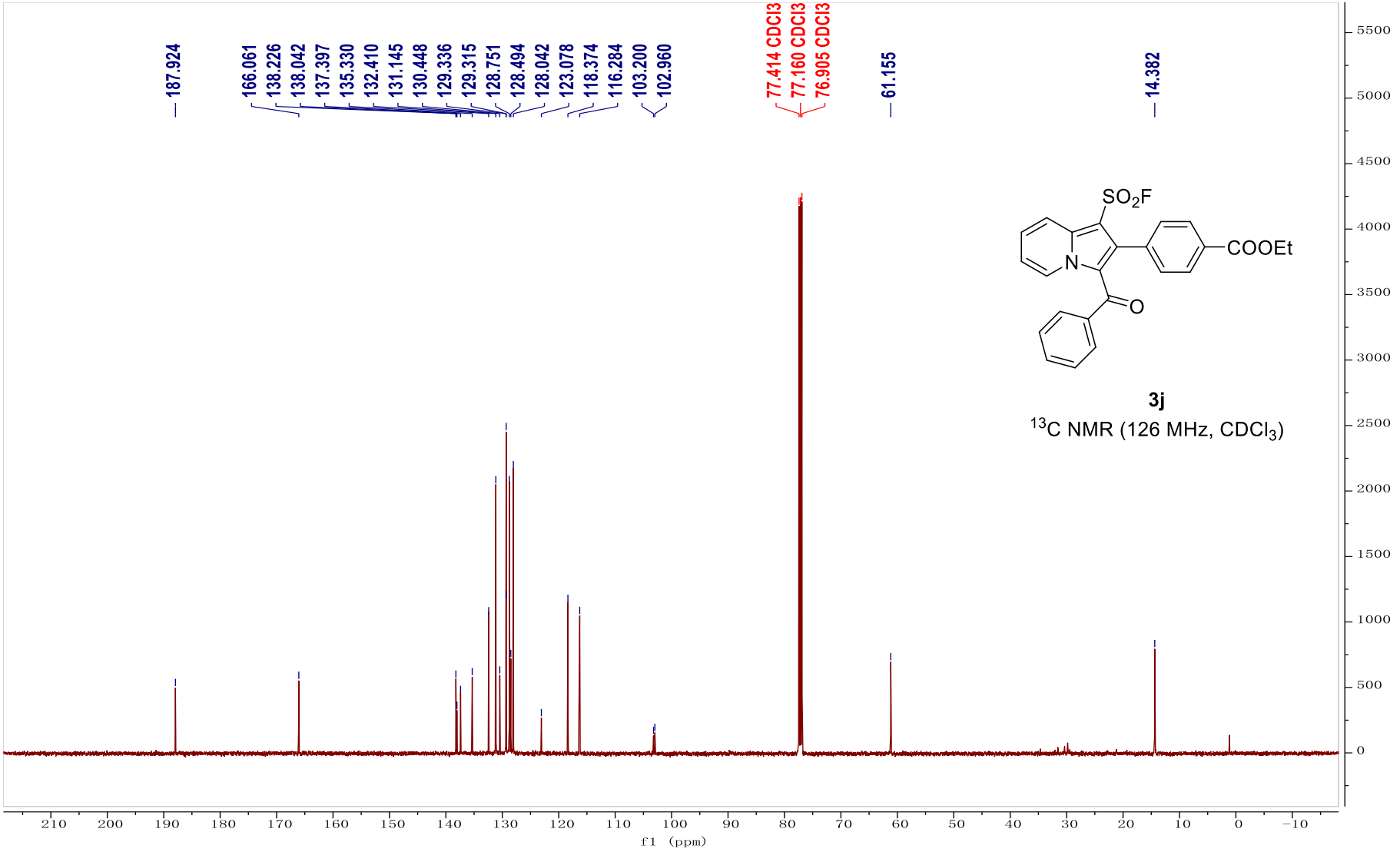

186.637
163.120
137.885
137.307
131.967
131.165
130.808
130.689
128.602
128.584
128.165
127.739
123.330
118.340
115.665
113.321
102.442
102.207
77.413 CDCl3
77.160 CDCl3
76.904 CDCl3
55.528
55.499
SO2F
N
O
O
3i
13C NMR (126 MHz, CDCl3)
f1 (ppm)

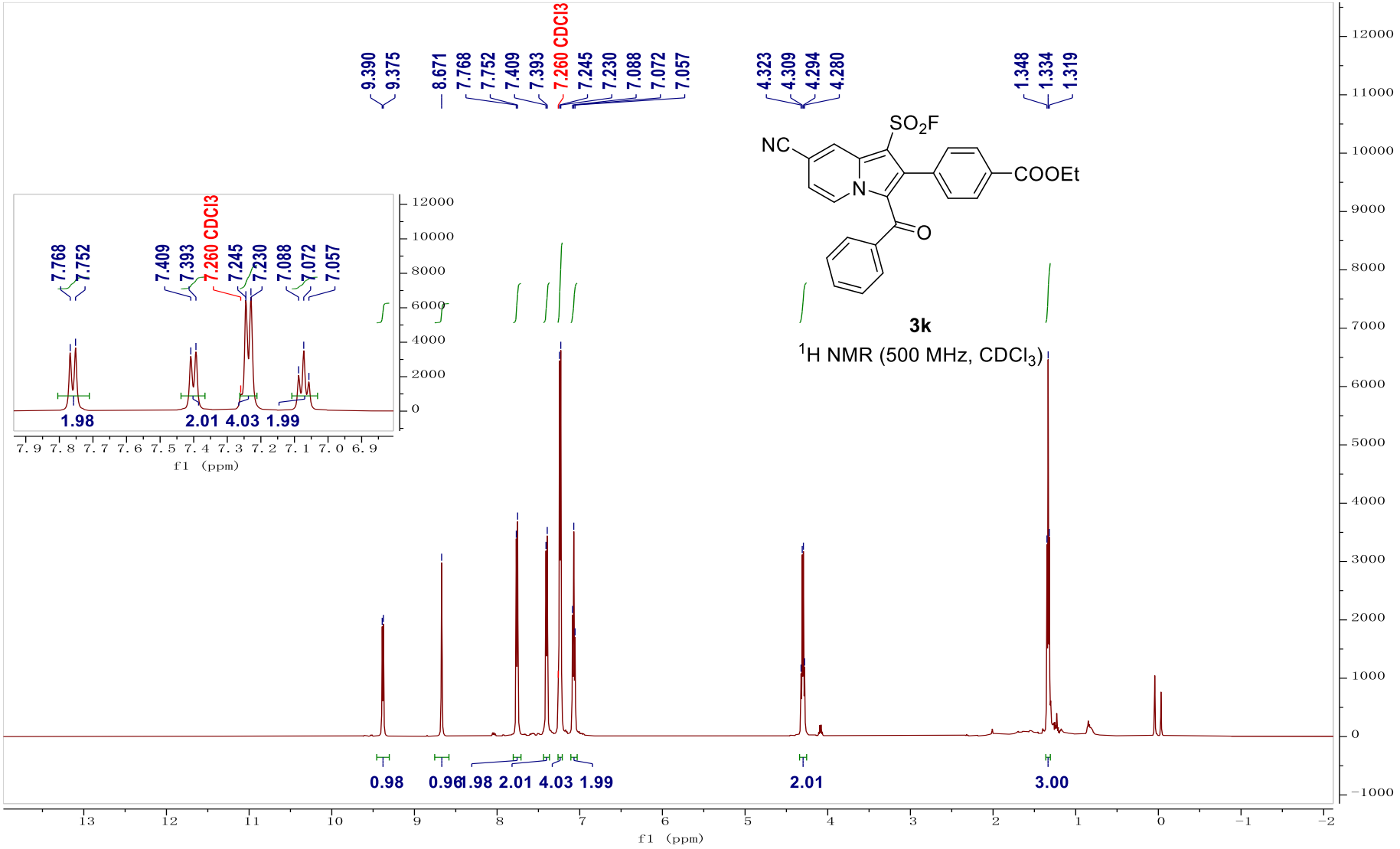

9.577
9.563
8.411
8.393
7.839
7.824
7.682
7.667
7.651
7.487
7.472
7.341
7.326
7.305
7.289
7.274
7.260 CDCl3
7.152
7.137
7.122
4.426
4.412
4.398
4.383
1.453
1.438
1.424
SO2F
COOEt
N
O
3j
1H NMR (500 MHz, CDCl3)
0.98
0.98 1.98 1.00 1.98 4.01 1.99
1.98
3.05
f1 (ppm)

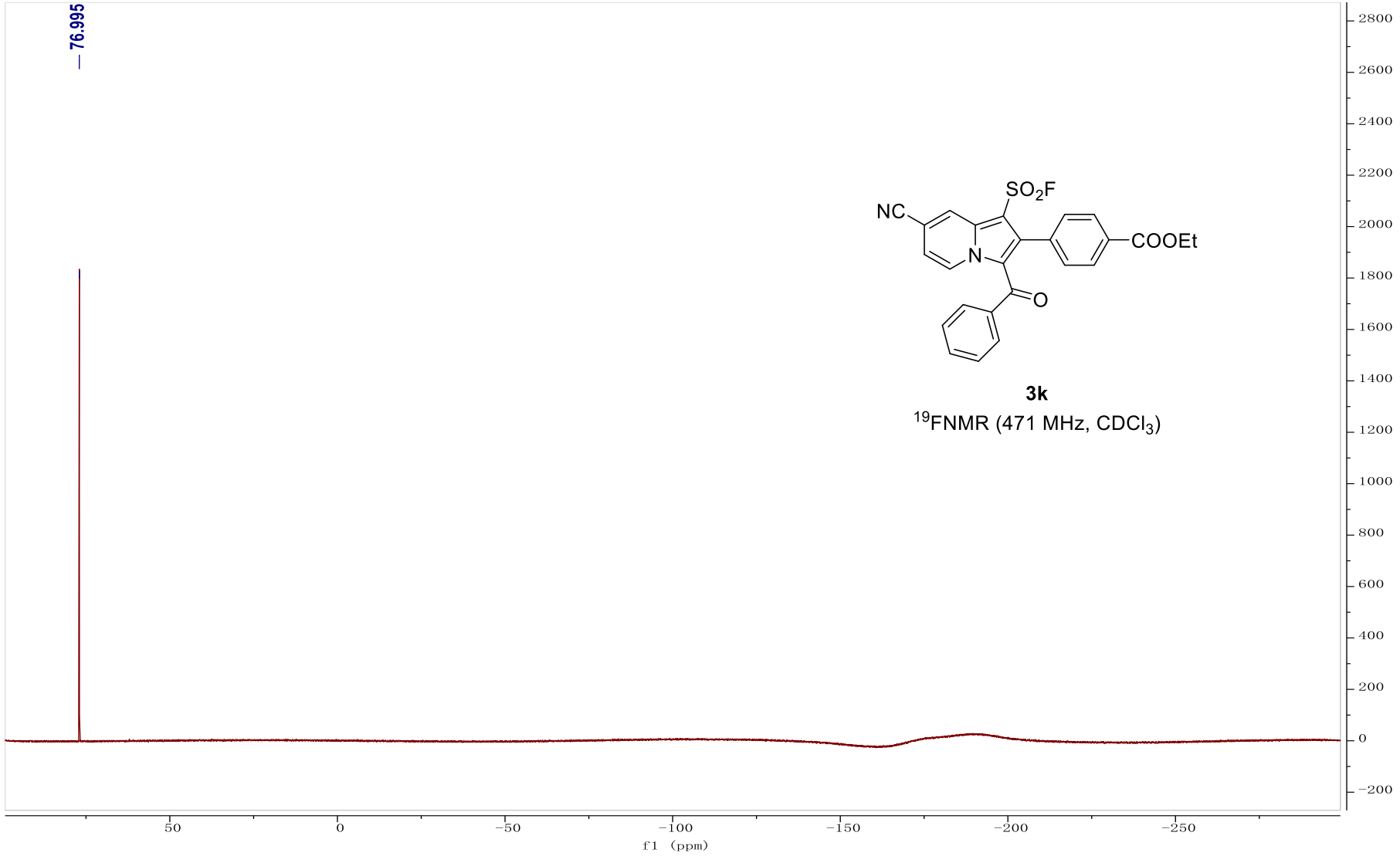


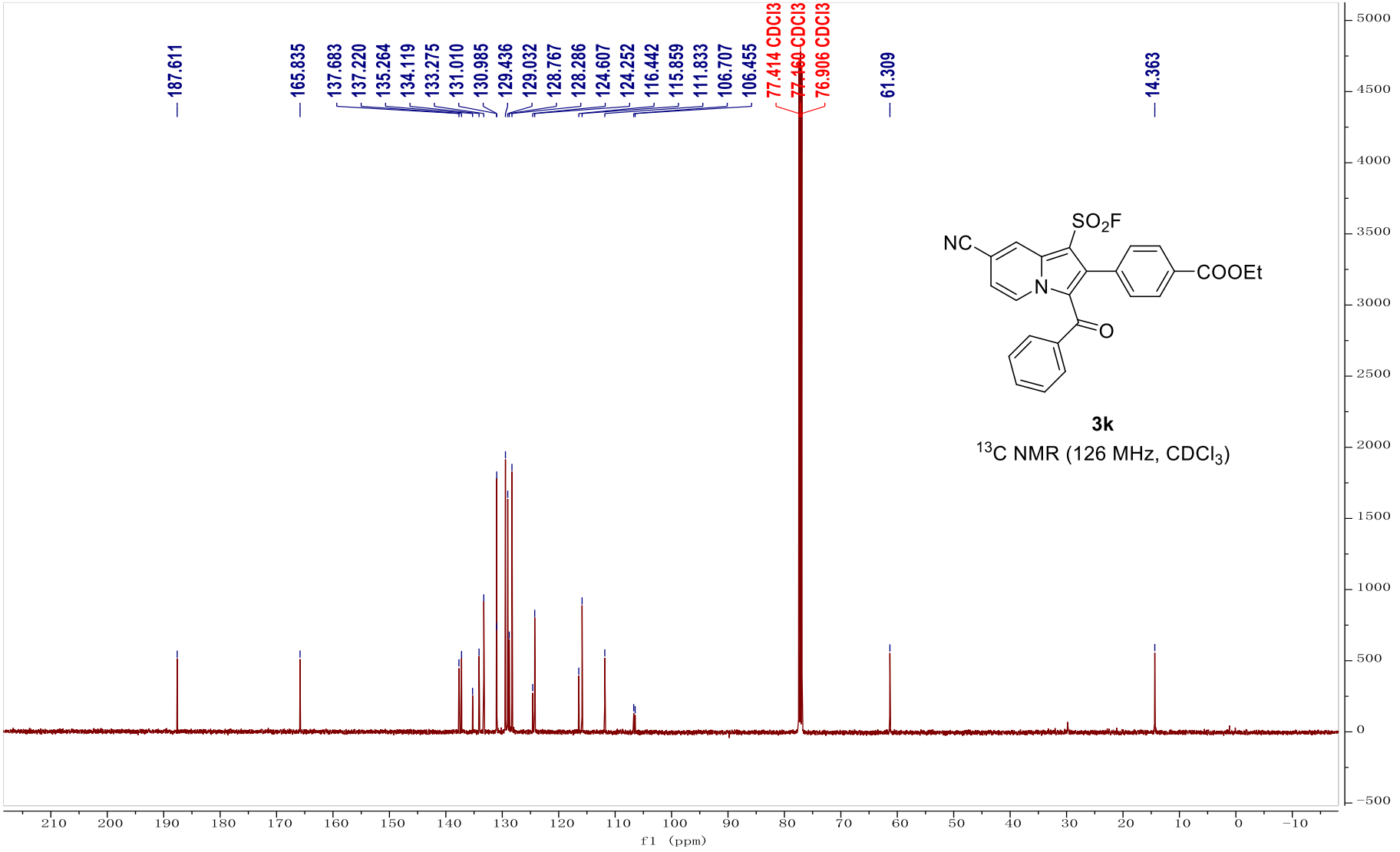
3j

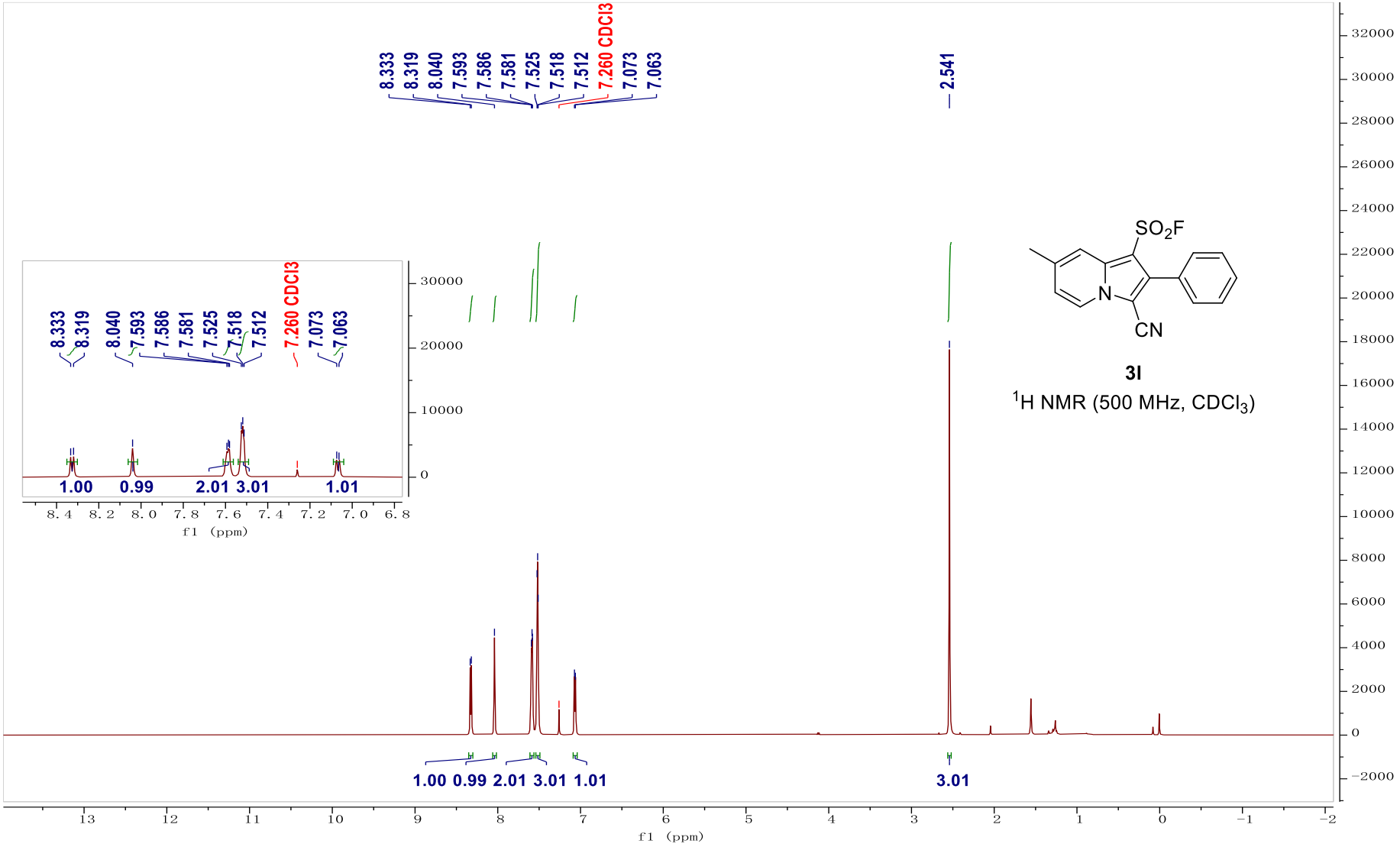
^{19}FNMR (471 MHz, $CDCl_3$)

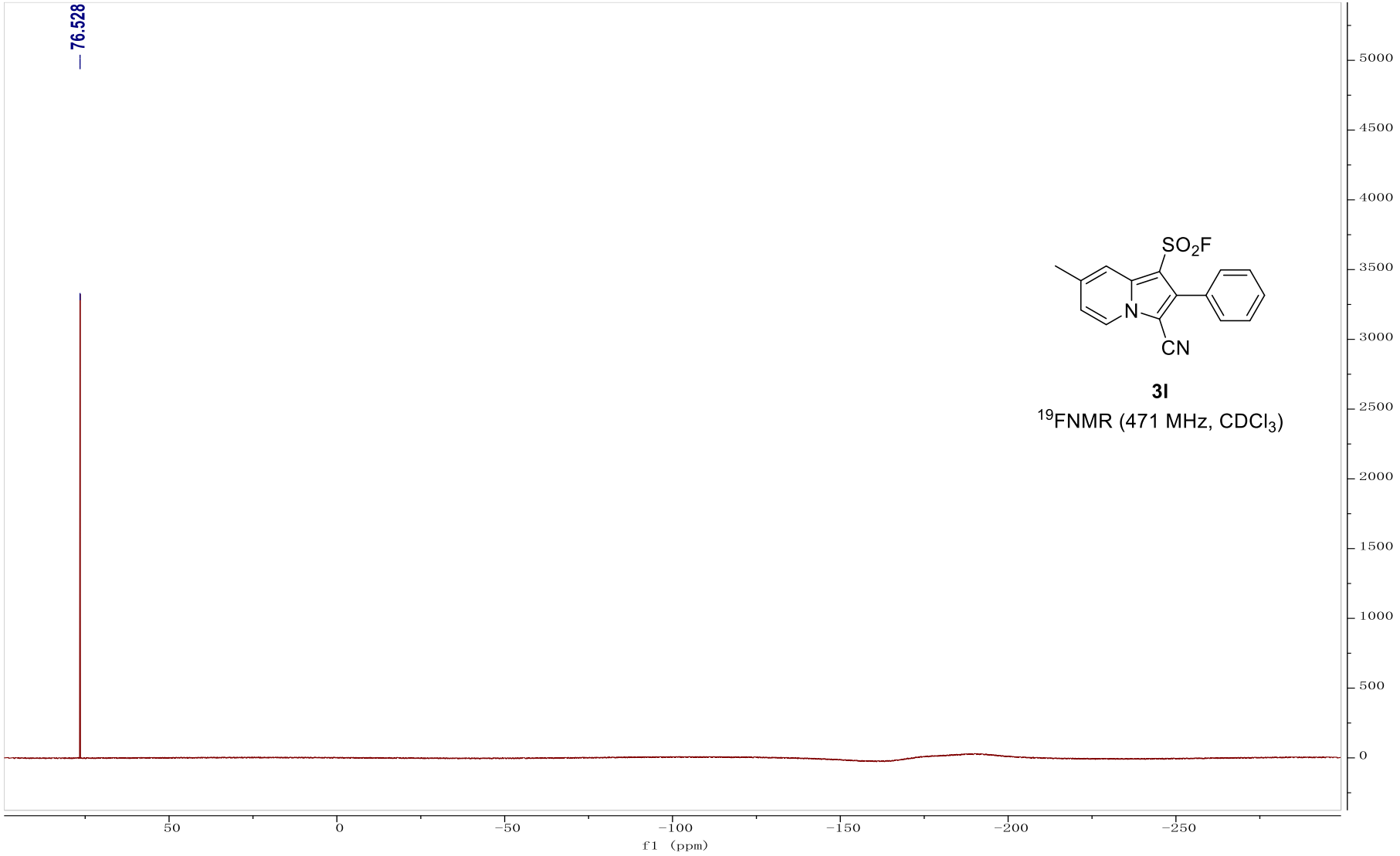

187.924
166.061
138.226
138.042
137.397
135.330
132.410
131.145
130.448
129.336
129.315
128.751
128.494
128.042
123.078
118.374
116.284
103.200
102.960
77.414 CDCl3
77.160 CDCl3
76.905 CDCl3
61.155
14.382
SO2F
N
O
COOEt
3j
13C NMR (126 MHz, CDCl3)
f1 (ppm)


9.390
9.375
8.671
7.768
7.752
7.409
7.393
7.260 CDCl3
7.245
7.230
7.088
7.072
7.057
4.323
4.309
4.294
4.280
1.348
1.334
1.319
SO2F
NC
N
O
COOEt
3k
1H NMR (500 MHz, CDCl3)
0.98
0.96
1.98
2.01
4.03
1.99
2.01
3.00
f1 (ppm)


76.995
SO2F
NC
N
COOEt
O
3k
19FNMR (471 MHz, CDCl3)
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
−200
50
0
−50
−100
−150
−200
−250
f1 (ppm)

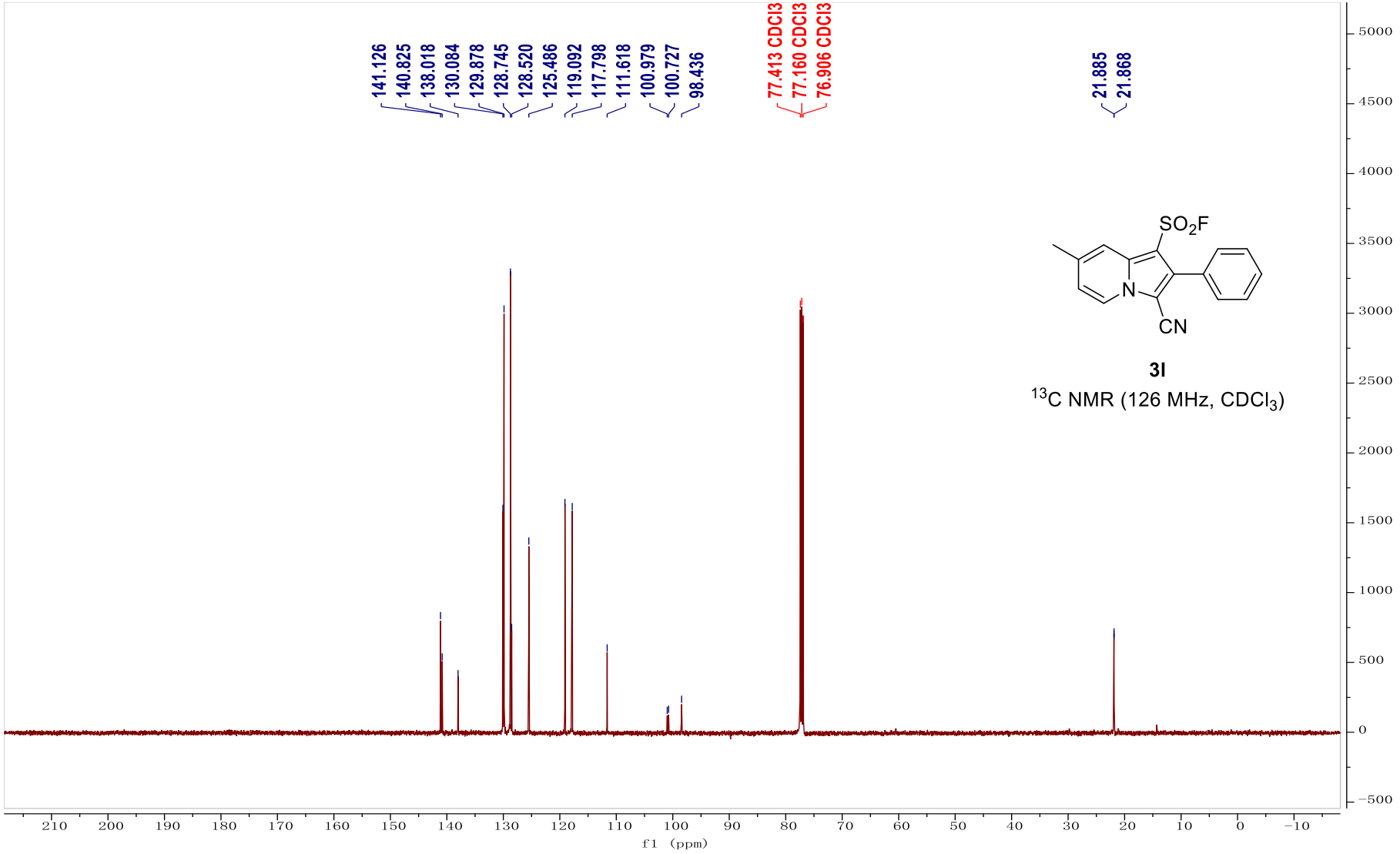

187.611
165.835
137.683
137.220
135.264
134.119
133.275
131.010
130.985
129.436
129.032
128.767
128.286
124.607
124.252
116.442
115.859
111.833
106.707
106.455
77.414 CDCl3
77.160 CDCl3
76.906 CDCl3
61.309
14.363
SO2F
NC
N
COOEt
O
3k
13C NMR (126 MHz, CDCl3)
f1 (ppm)

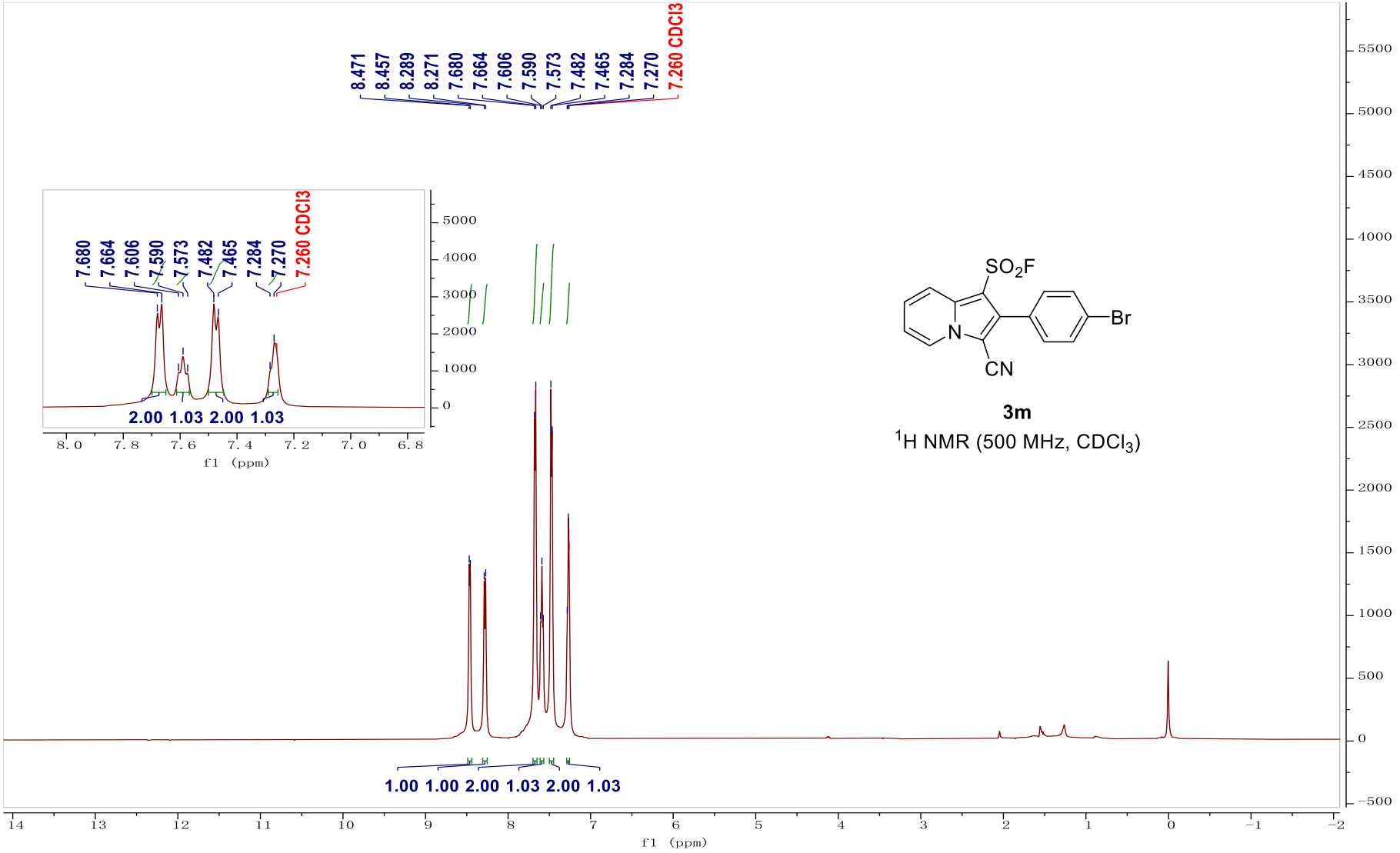

8.333
8.319
8.040
7.593
7.586
7.581
7.525
7.518
7.512
7.260 CDCl3
7.073
7.063
2.541
1.00 0.99 2.01 3.01 1.01
3.01
f1 (ppm)
SO2F
N
CN
3I
1H NMR (500 MHz, CDCl3)

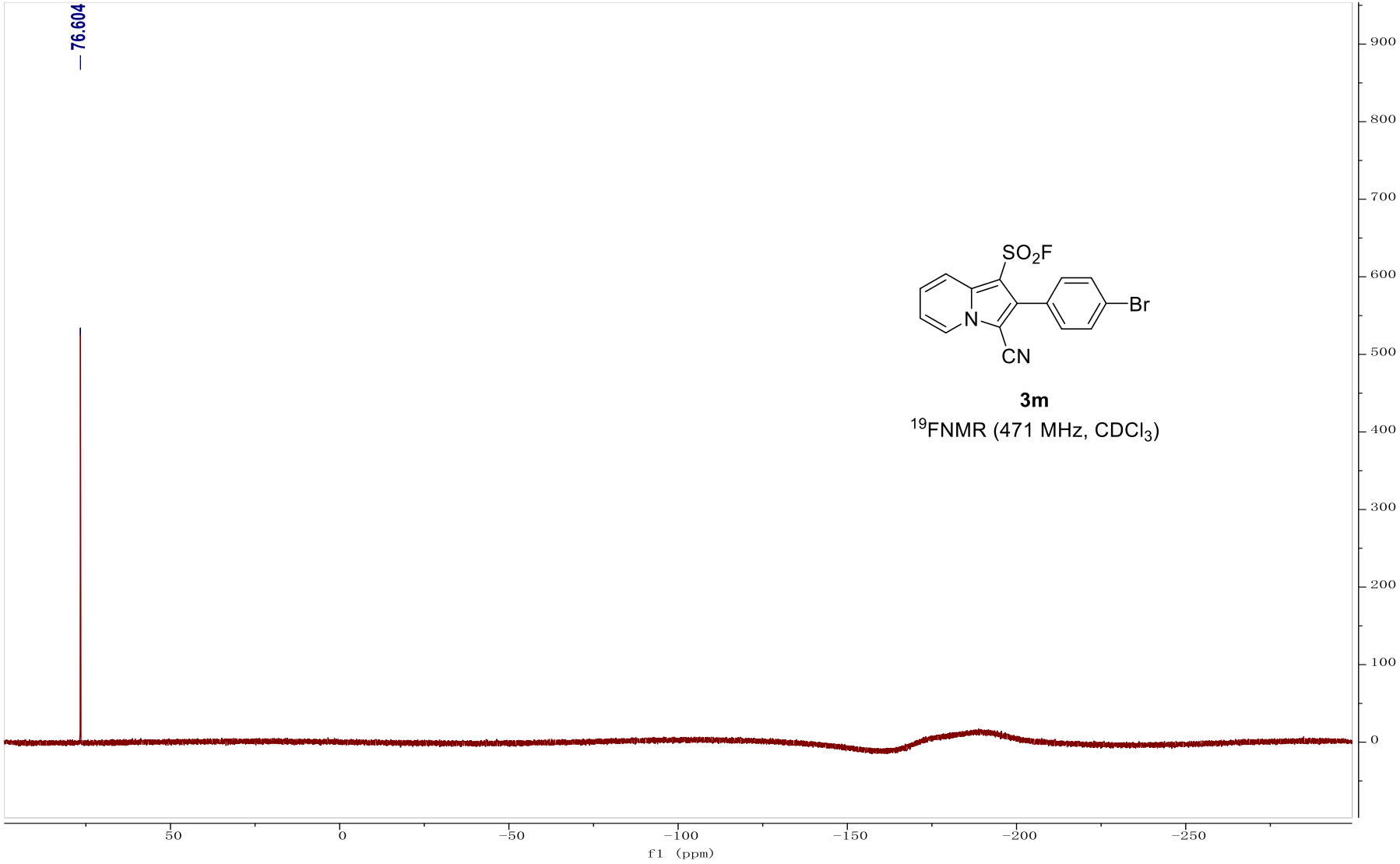


3l

^{19}FNMR (471 MHz, $CDCl_3$)

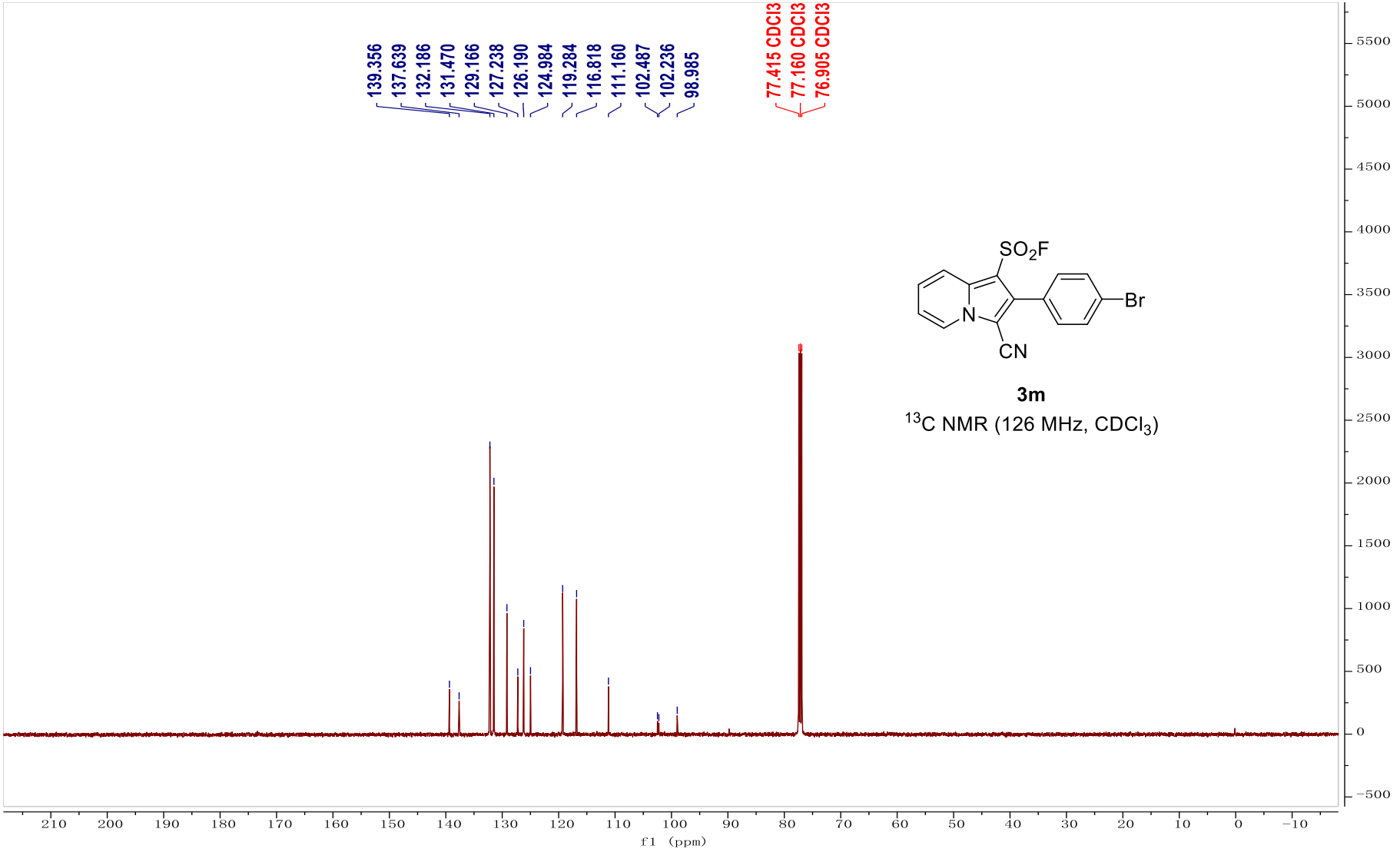

141.126
140.825
138.018
130.084
129.878
128.745
128.520
125.486
119.092
117.798
111.618
100.979
100.727
98.436
77.413 CDCl3
77.160 CDCl3
76.906 CDCl3
21.885
21.868
SO2F
N
CN
3l
13C NMR (126 MHz, CDCl3)
f1 (ppm)

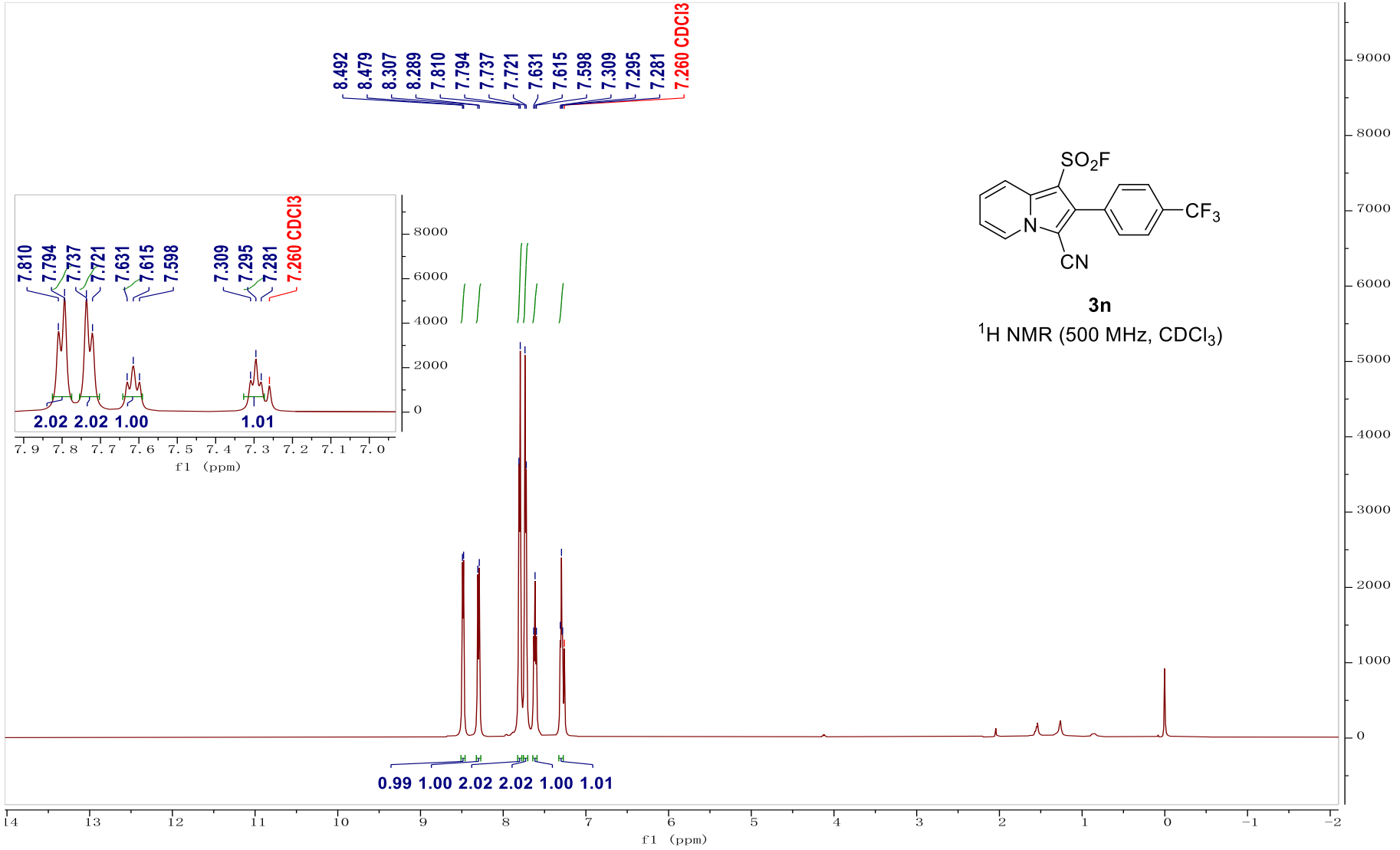

8.471
8.457
8.289
8.271
7.680
7.664
7.606
7.590
7.573
7.482
7.465
7.284
7.270
7.260 CDCl3
1.00 1.00 2.00 1.03 2.00 1.03
f1 (ppm)
2.00 1.03 2.00 1.03
SO2F
Br
N
CN
3m
1H NMR (500 MHz, CDCl3)

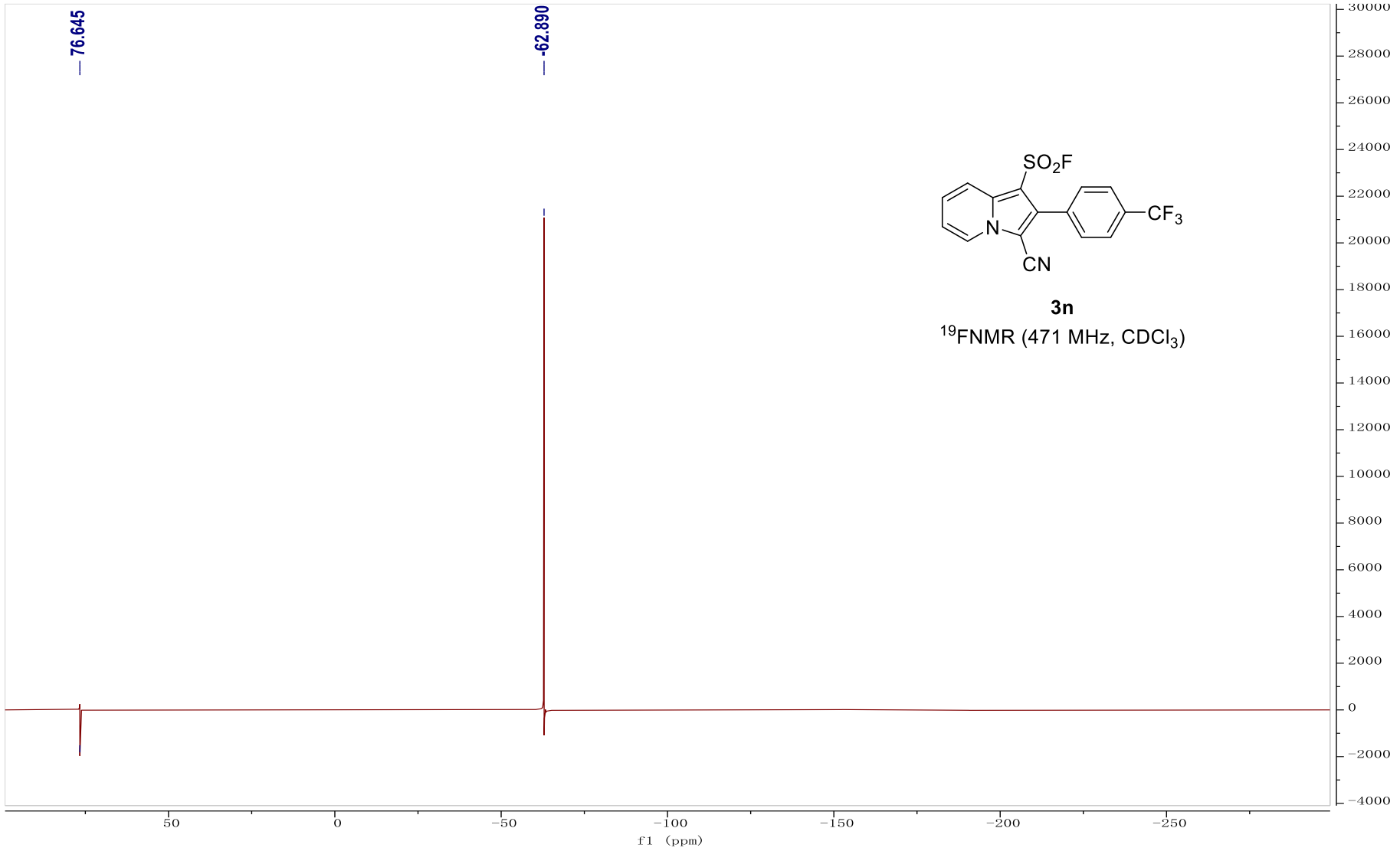


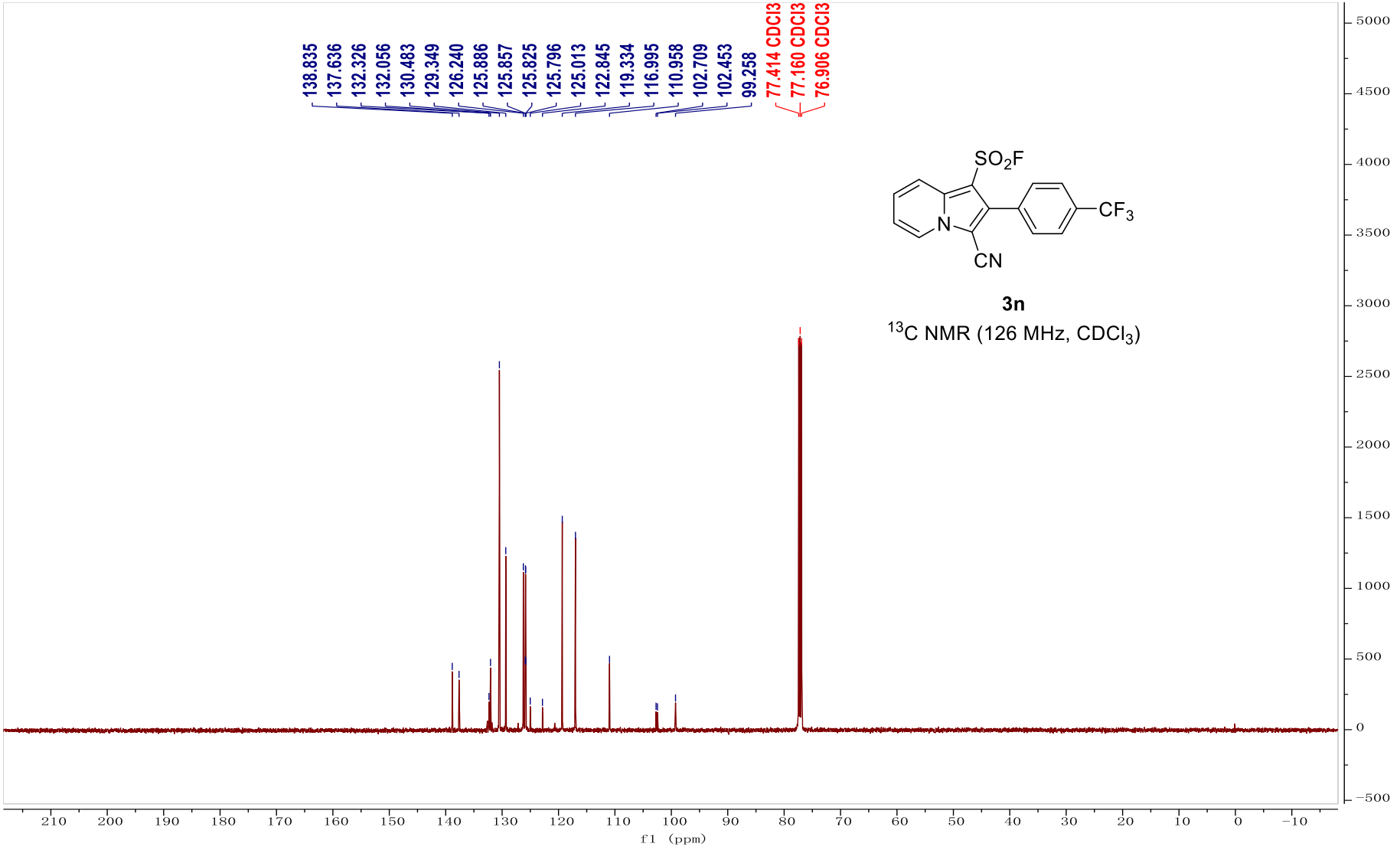
3m

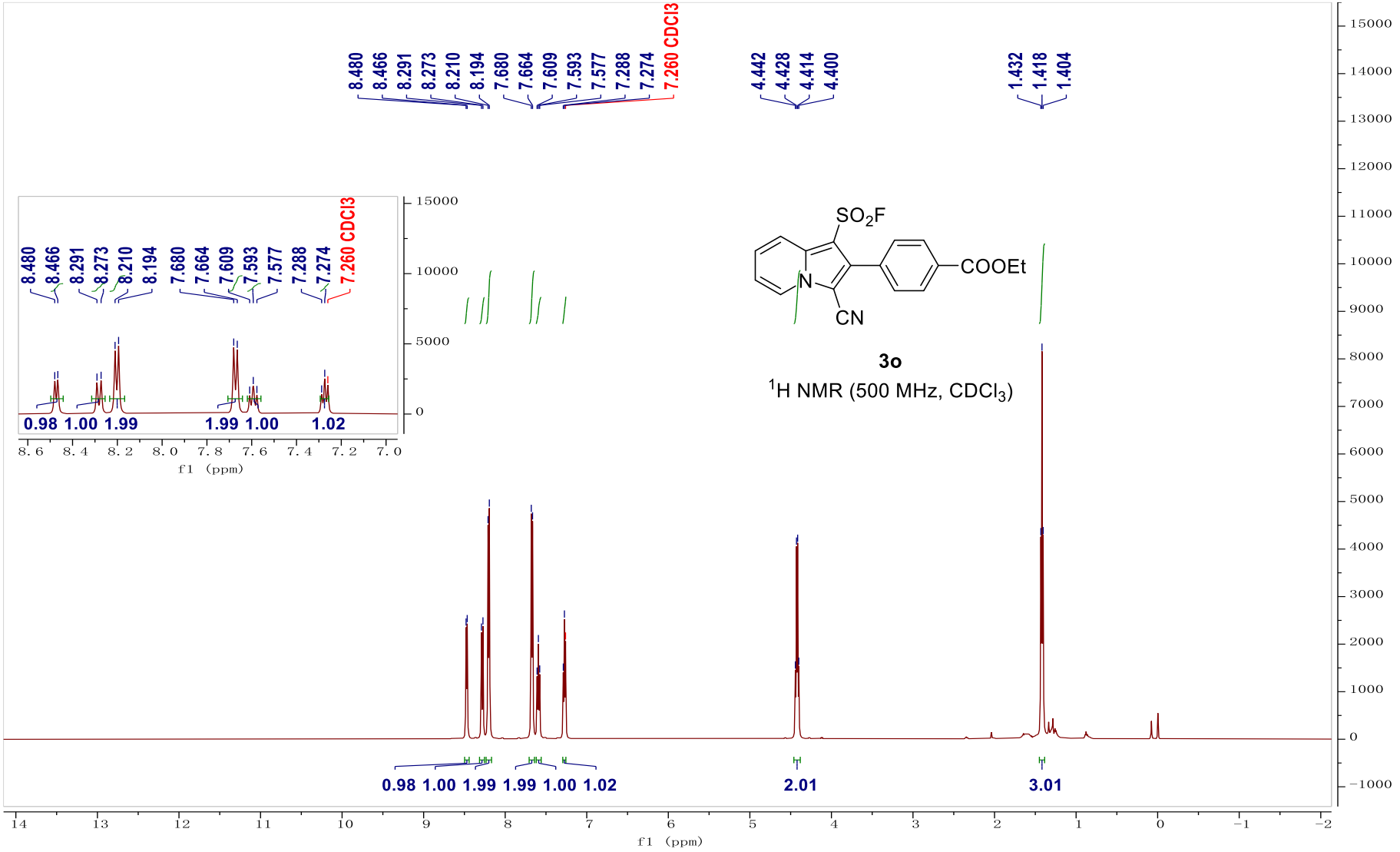
^{19}FNMR (471 MHz, $CDCl_3$)

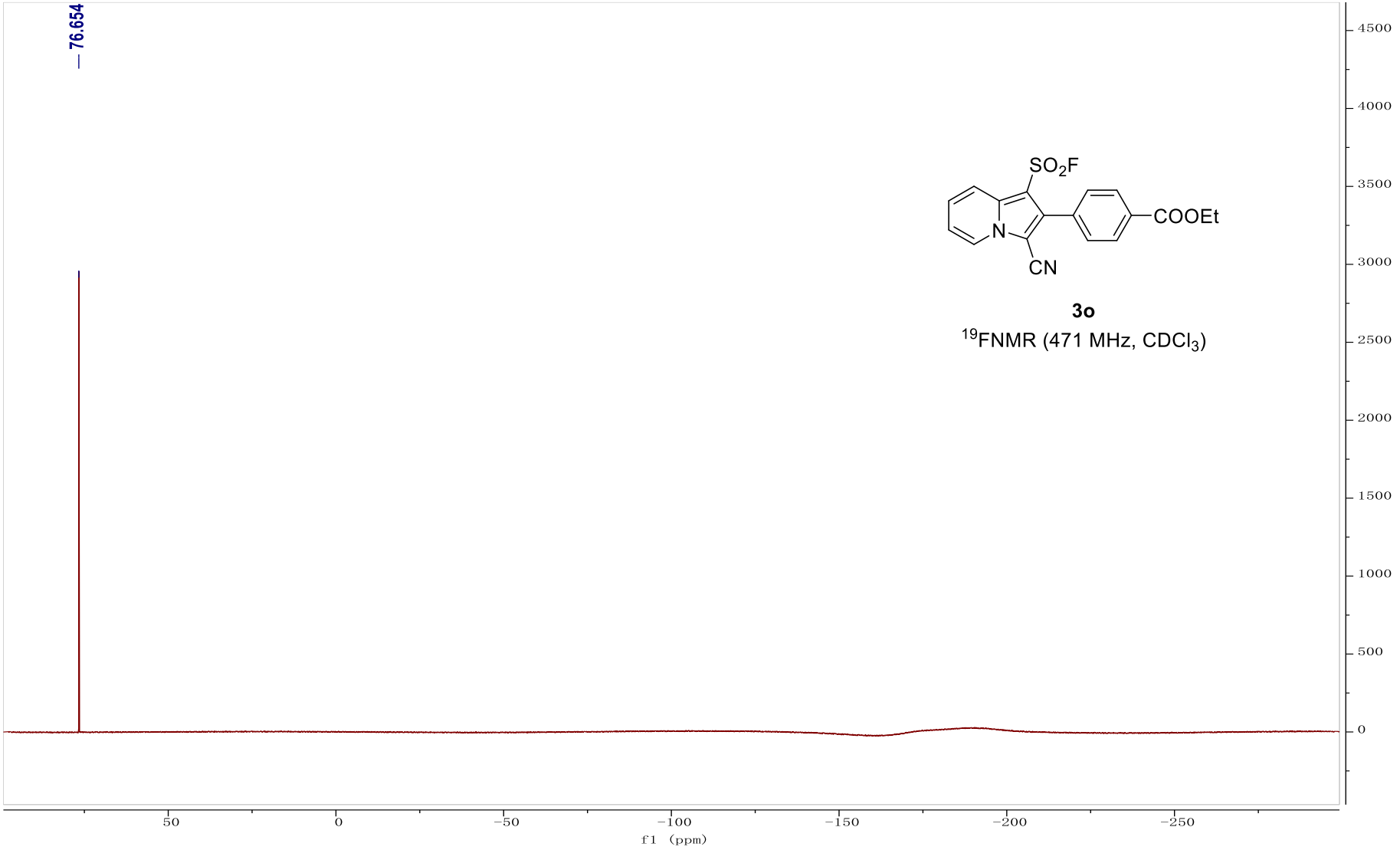

139.356
137.639
132.186
131.470
129.166
127.238
126.190
124.984
119.284
116.818
111.160
102.487
102.236
98.985
77.415 CDCl3
77.160 CDCl3
76.905 CDCl3
SO2F
Br
N
CN
3m
13C NMR (126 MHz, CDCl3)
f1 (ppm)

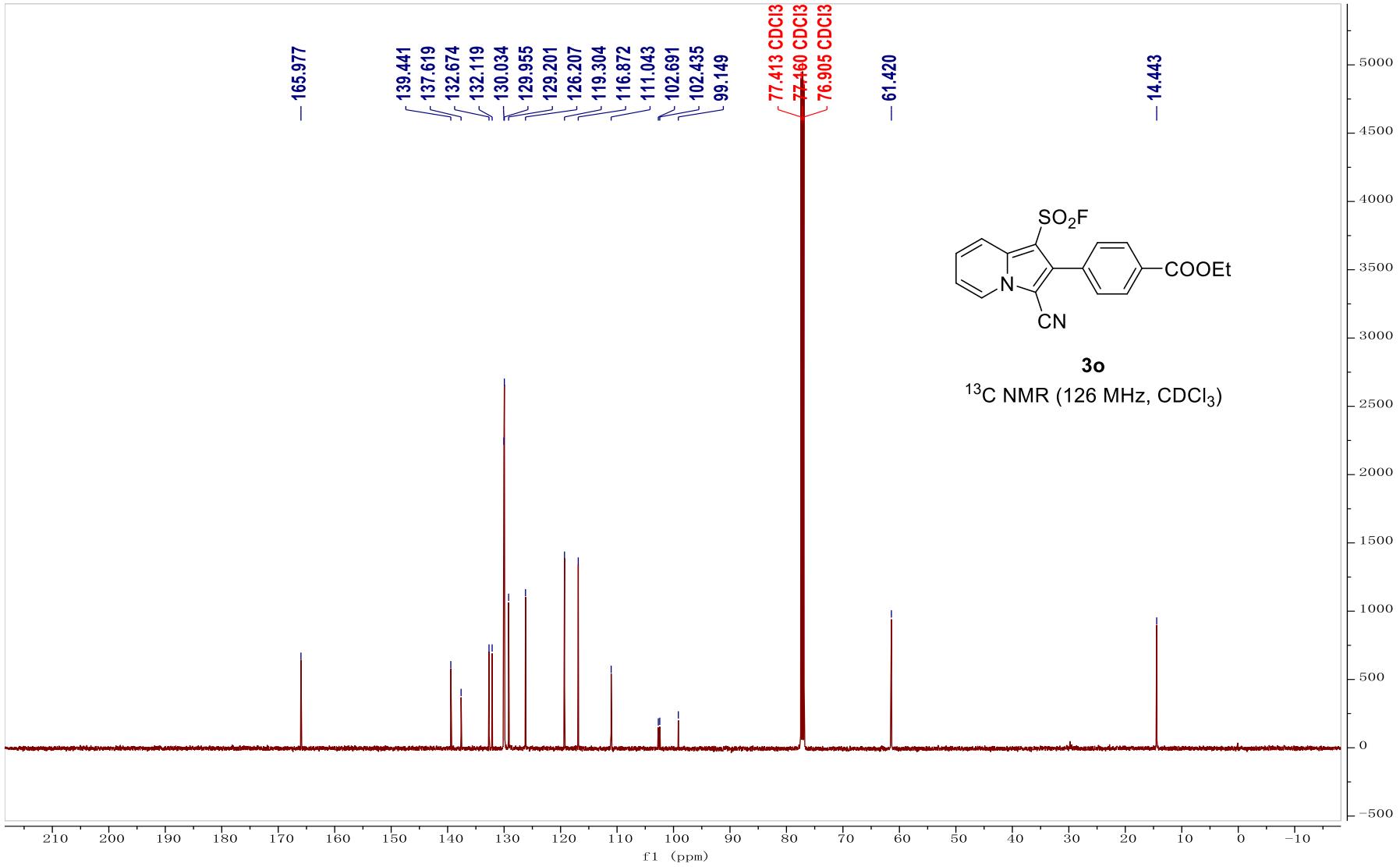

8.492
8.479
8.307
8.289
7.810
7.794
7.737
7.721
7.631
7.615
7.598
7.309
7.295
7.281
7.260 CDCl3
2.02 2.02 1.00
1.01
0.99 1.00 2.02 2.02 1.00 1.01
f1 (ppm)
SO2F
CF3
N
CN
3n
1H NMR (500 MHz, CDCl3)

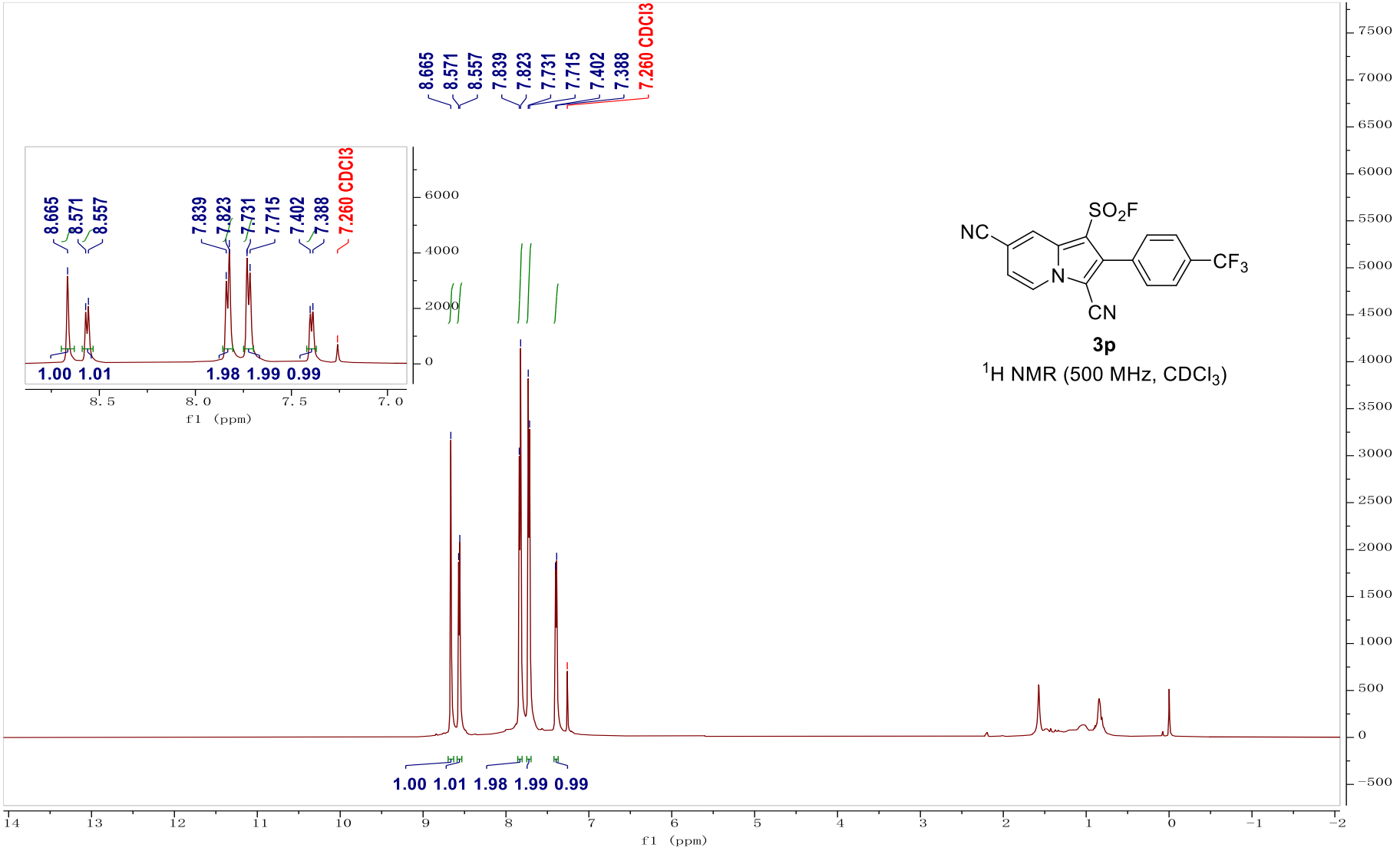

76.645
-62.890
SO2F
CF3
N
CN
3n
19FNMR (471 MHz, CDCl3)
30000
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
−2000
−4000
50
0
−50
−100
−150
−200
−250
f1 (ppm)

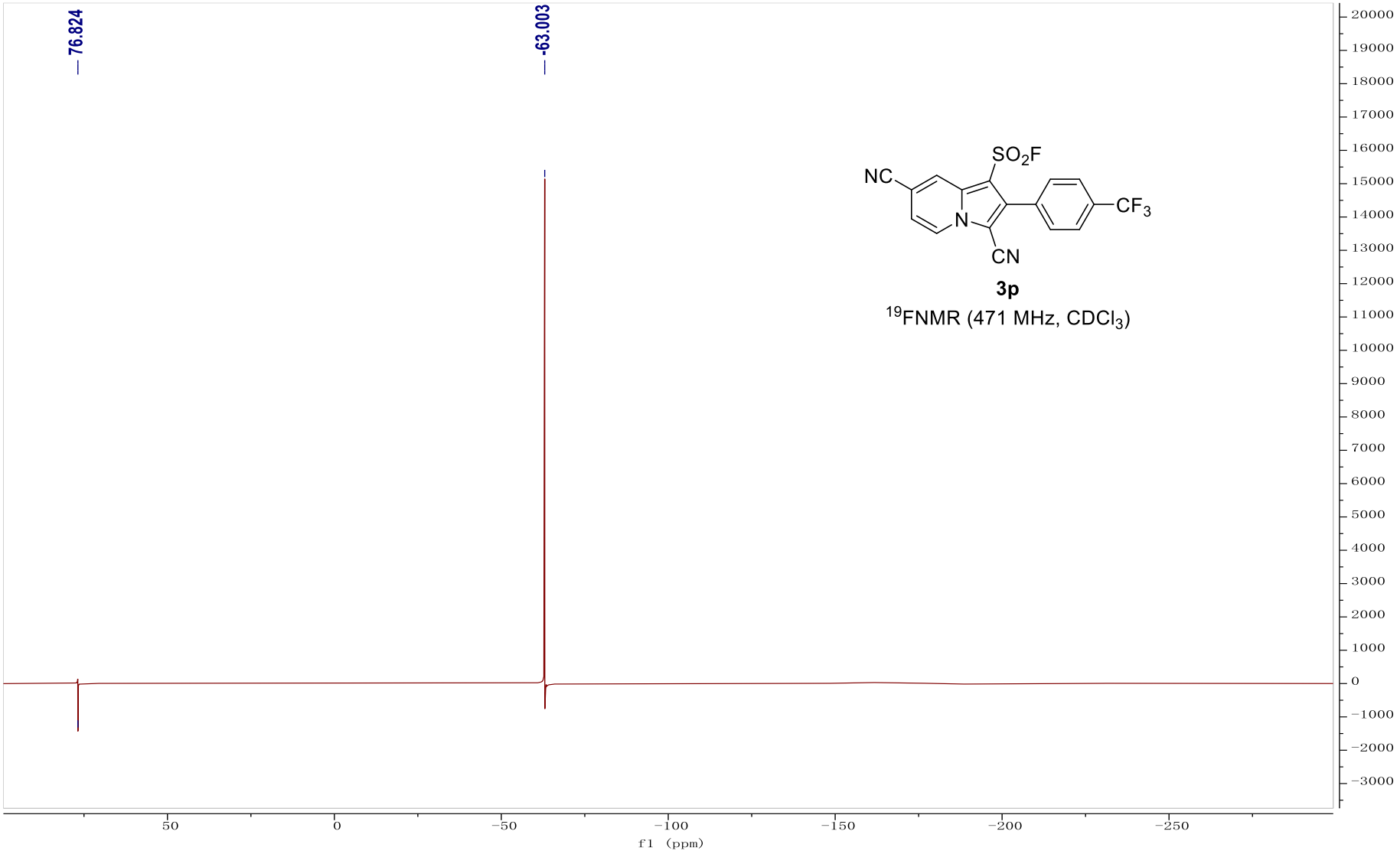

138.835
137.636
132.326
132.056
130.483
129.349
126.240
125.886
125.857
125.825
125.796
125.013
122.845
119.334
116.995
110.958
102.709
102.453
99.258
77.414 CDCl3
77.160 CDCl3
76.906 CDCl3
SO2F
CF3
N
CN
3n
13C NMR (126 MHz, CDCl3)
f1 (ppm)

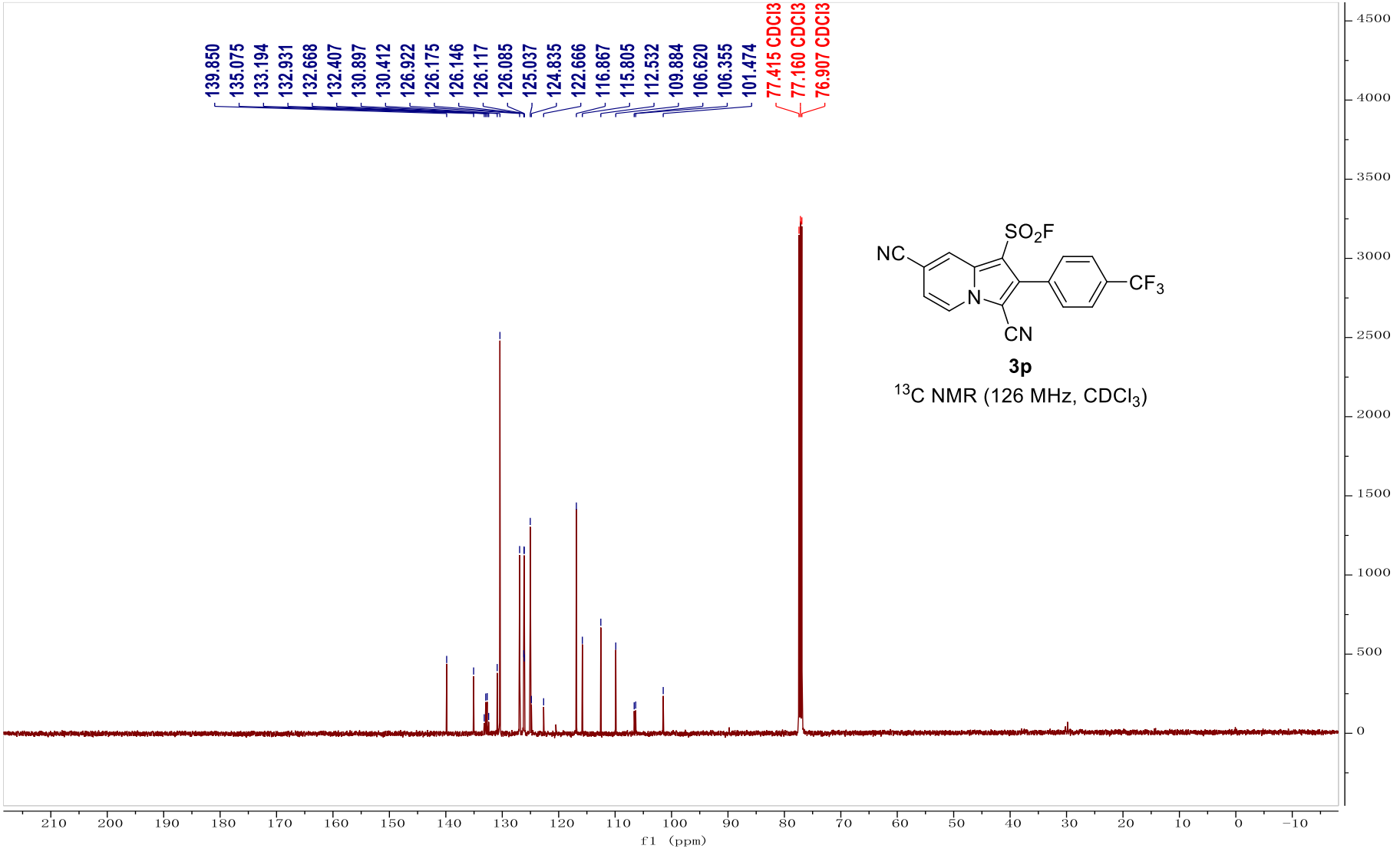

8.480
8.466
8.291
8.273
8.210
8.194
7.680
7.664
7.609
7.593
7.577
7.288
7.274
7.260 CDCl3
4.442
4.428
4.414
4.400
1.432
1.418
1.404
SO2F
COOEt
N
CN
3o
1H NMR (500 MHz, CDCl3)
0.98 1.00 1.99 1.99 1.00 1.02
2.01
3.01
f1 (ppm)

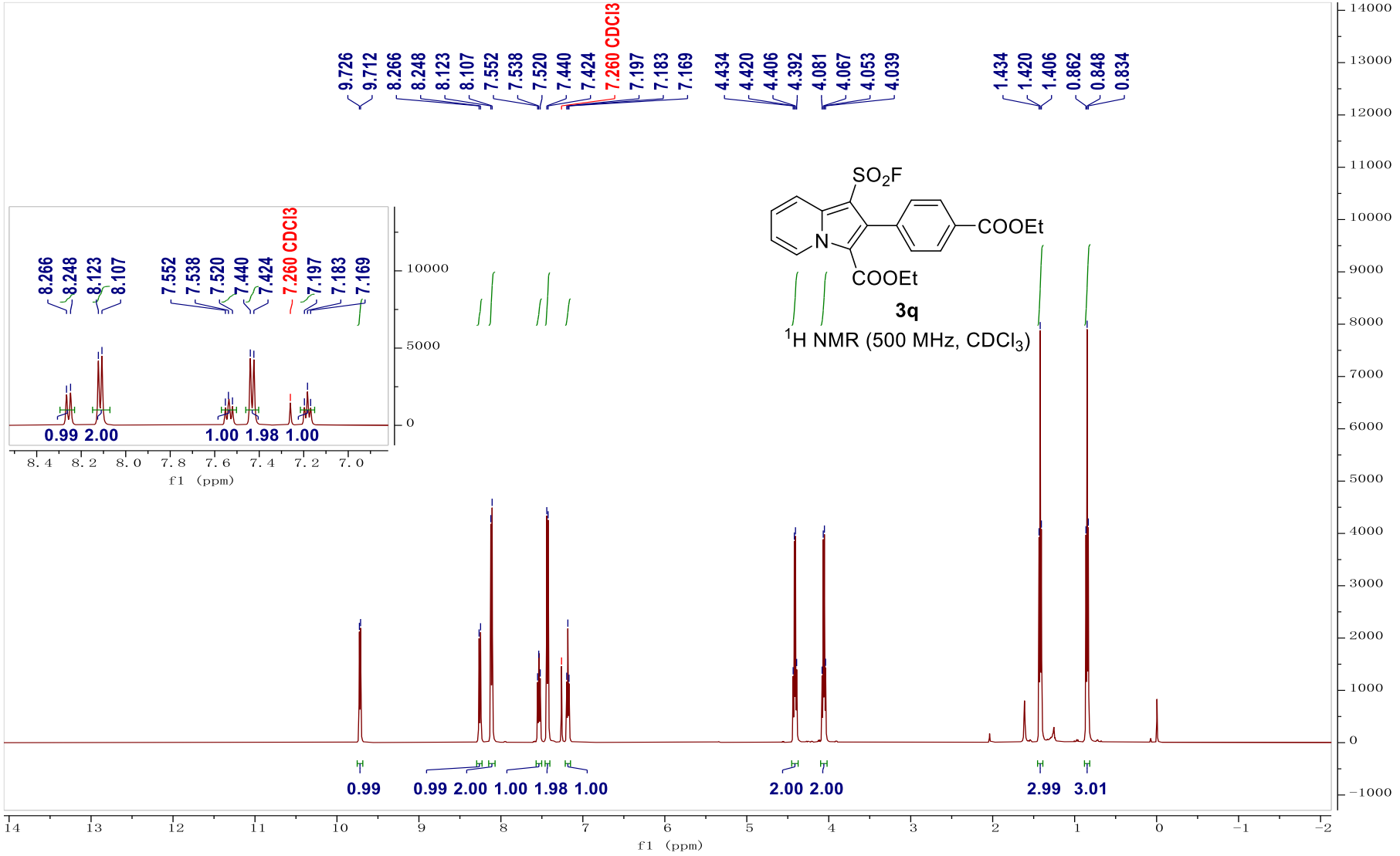

76.654
4500
4000
3500
3000
2500
2000
1500
1000
500
0
50
0
−50
−100
−150
−200
−250
f1 (ppm)
SO2F
COOEt
N
CN
3o
19FNMR (471 MHz, CDCl3)

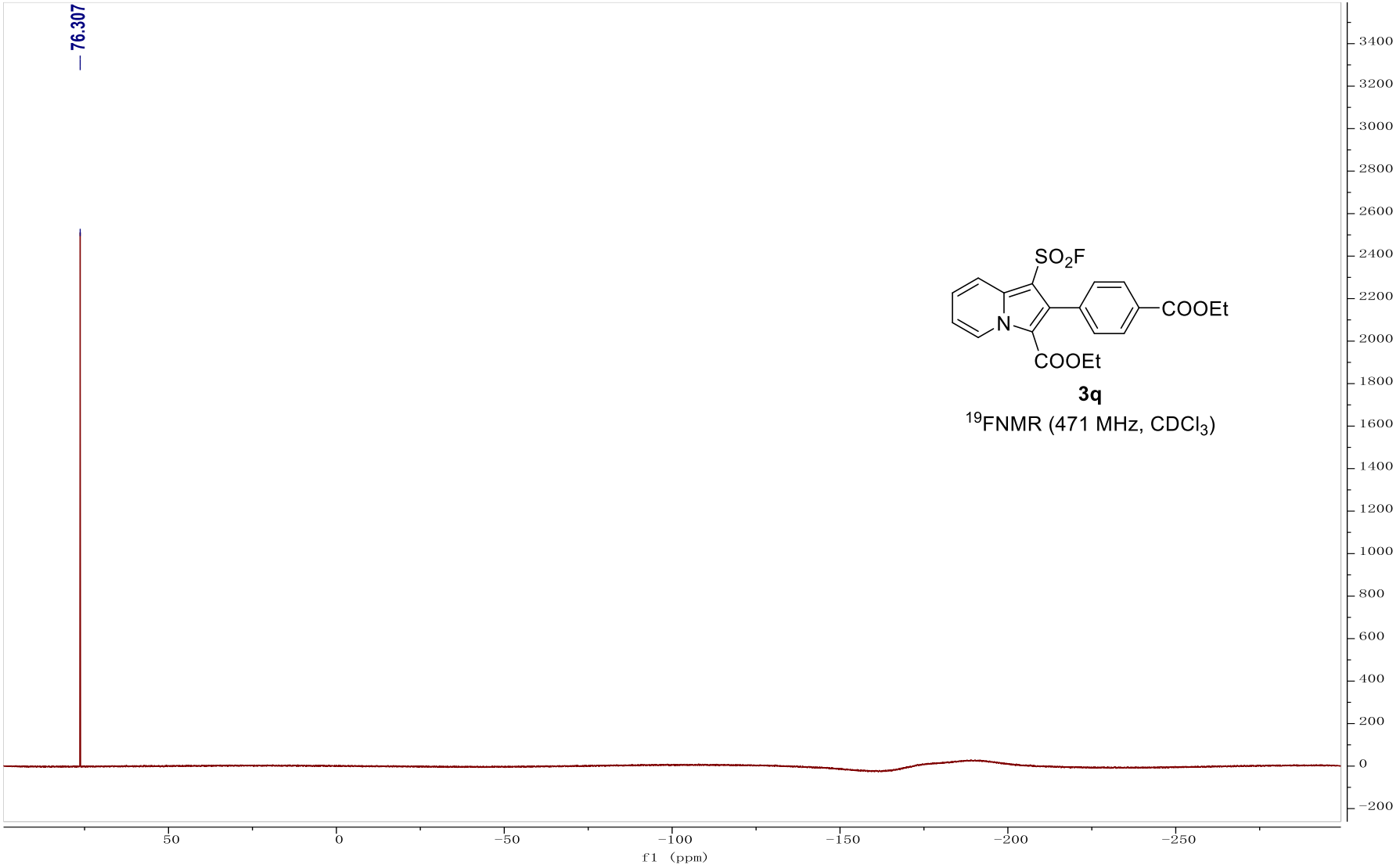

165.977
139.441
137.619
132.674
132.119
130.034
129.955
129.201
126.207
119.304
116.872
111.043
102.691
102.435
99.149
77.413 CDCl3
77.160 CDCl3
76.905 CDCl3
61.420
14.443
SO2F
COOEt
N
CN
3o
13C NMR (126 MHz, CDCl3)
f1 (ppm)


8.665
8.571
8.557
7.839
7.823
7.731
7.715
7.402
7.388
7.260 CDCl3
1.00 1.01 1.98 1.99 0.99
f1 (ppm)
NC
SO2F
CF3
N
CN
3p
1H NMR (500 MHz, CDCl3)


76.824
-63.003
SO2F
NC
N
CF3
CN
3p
19FNMR (471 MHz, CDCl3)
20000
19000
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
−1000
−2000
−3000
50
0
−50
−100
−150
−200
−250
f1 (ppm)

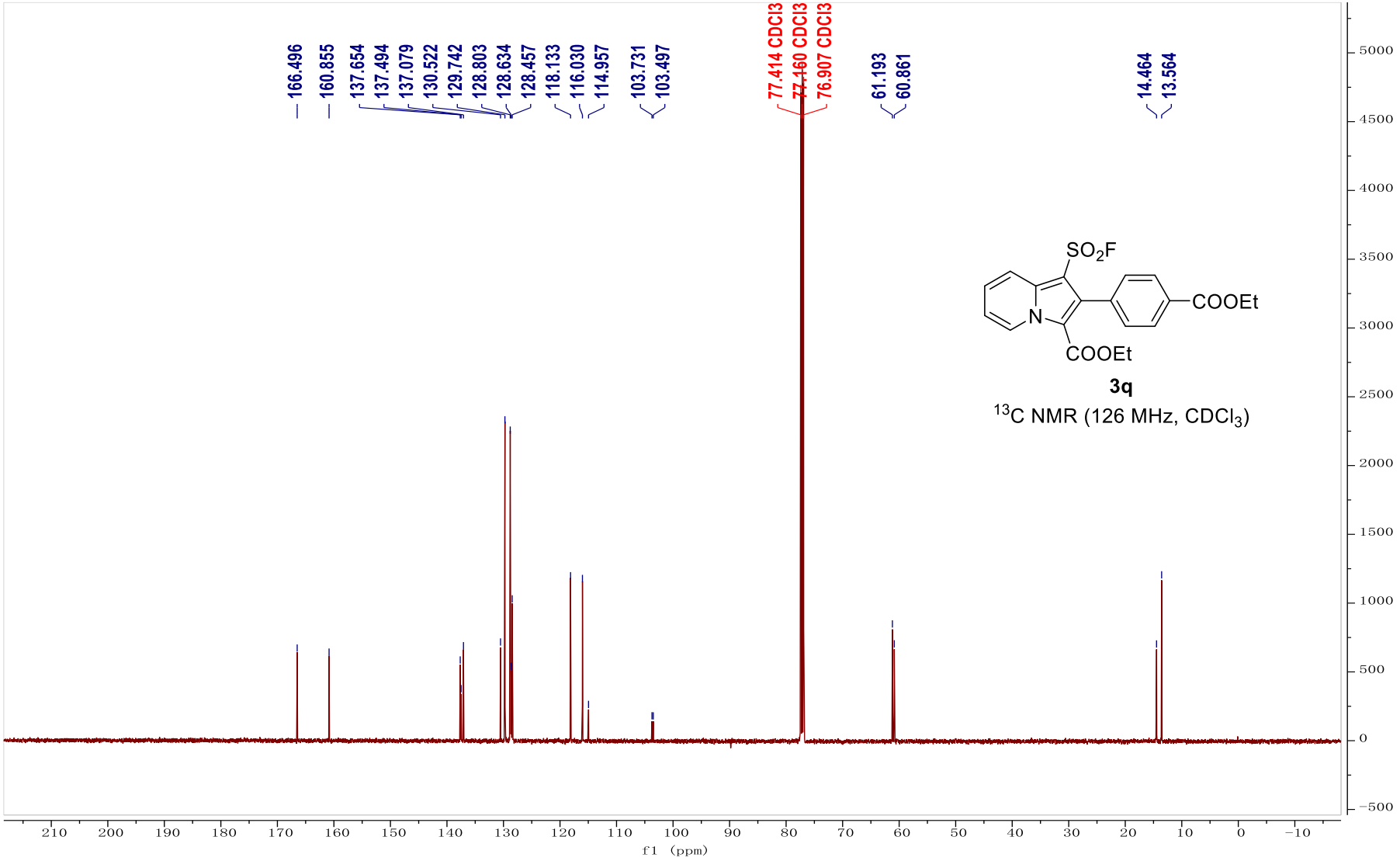

139.850
135.075
133.194
132.931
132.668
132.407
130.897
130.412
126.922
126.175
126.146
126.117
126.085
125.037
124.835
122.666
116.867
115.805
112.532
109.884
106.620
106.355
101.474
77.415 CDCl3
77.160 CDCl3
76.907 CDCl3
NC
SO2F
CF3
N
CN
3p
13C NMR (126 MHz, CDCl3)
f1 (ppm)

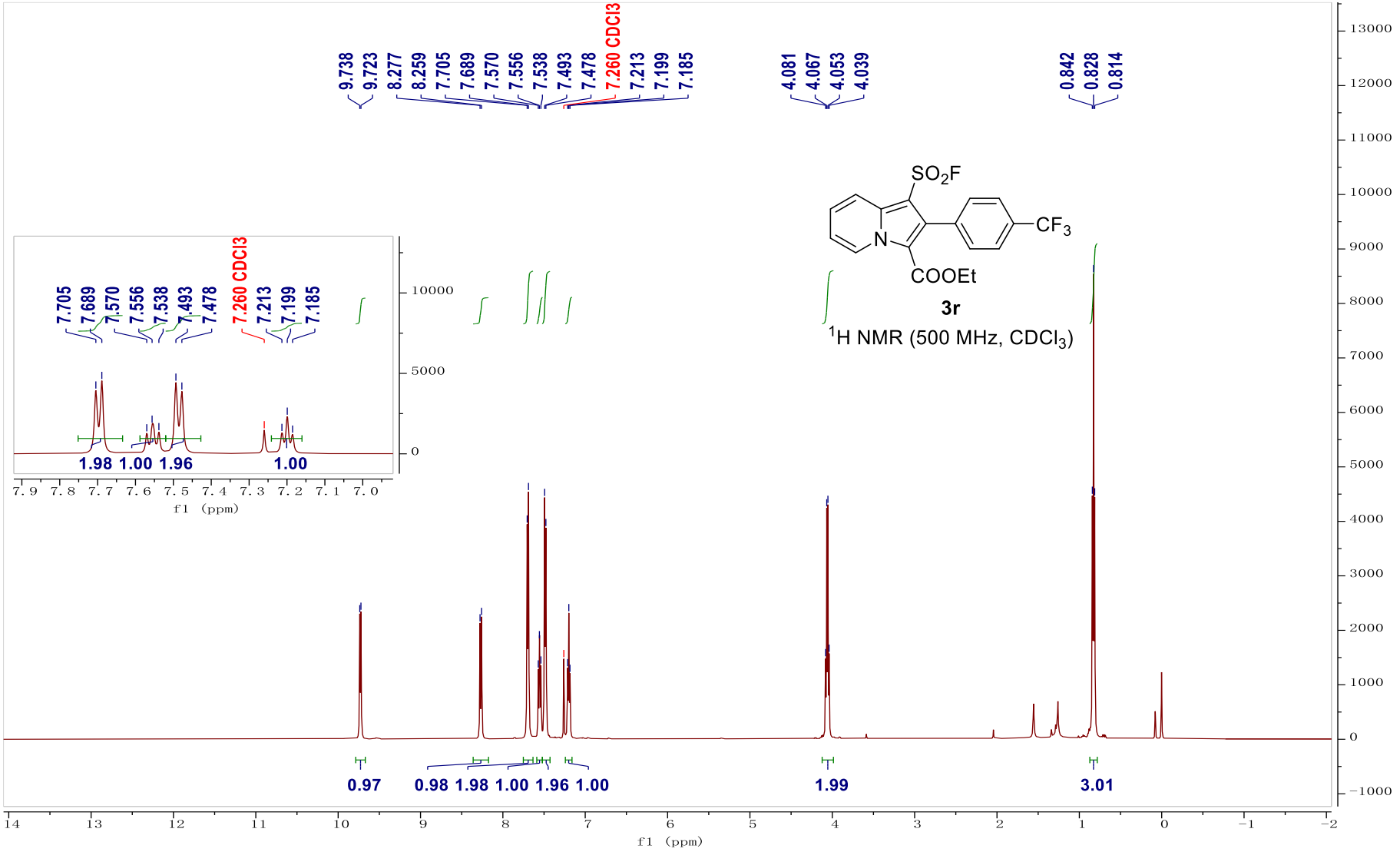

9.726
9.712
8.266
8.248
8.123
8.107
7.552
7.538
7.520
7.440
7.424
7.260 CDCl3
7.197
7.183
7.169
4.434
4.420
4.406
4.392
4.081
4.067
4.053
4.039
1.434
1.420
1.406
0.862
0.848
0.834
SO2F
COOEt
COOEt
3q
1H NMR (500 MHz, CDCl3)
0.99
0.99 2.00 1.00 1.98 1.00
2.00 2.00
2.99 3.01
0.99 2.00
1.00 1.98 1.00
f1 (ppm)

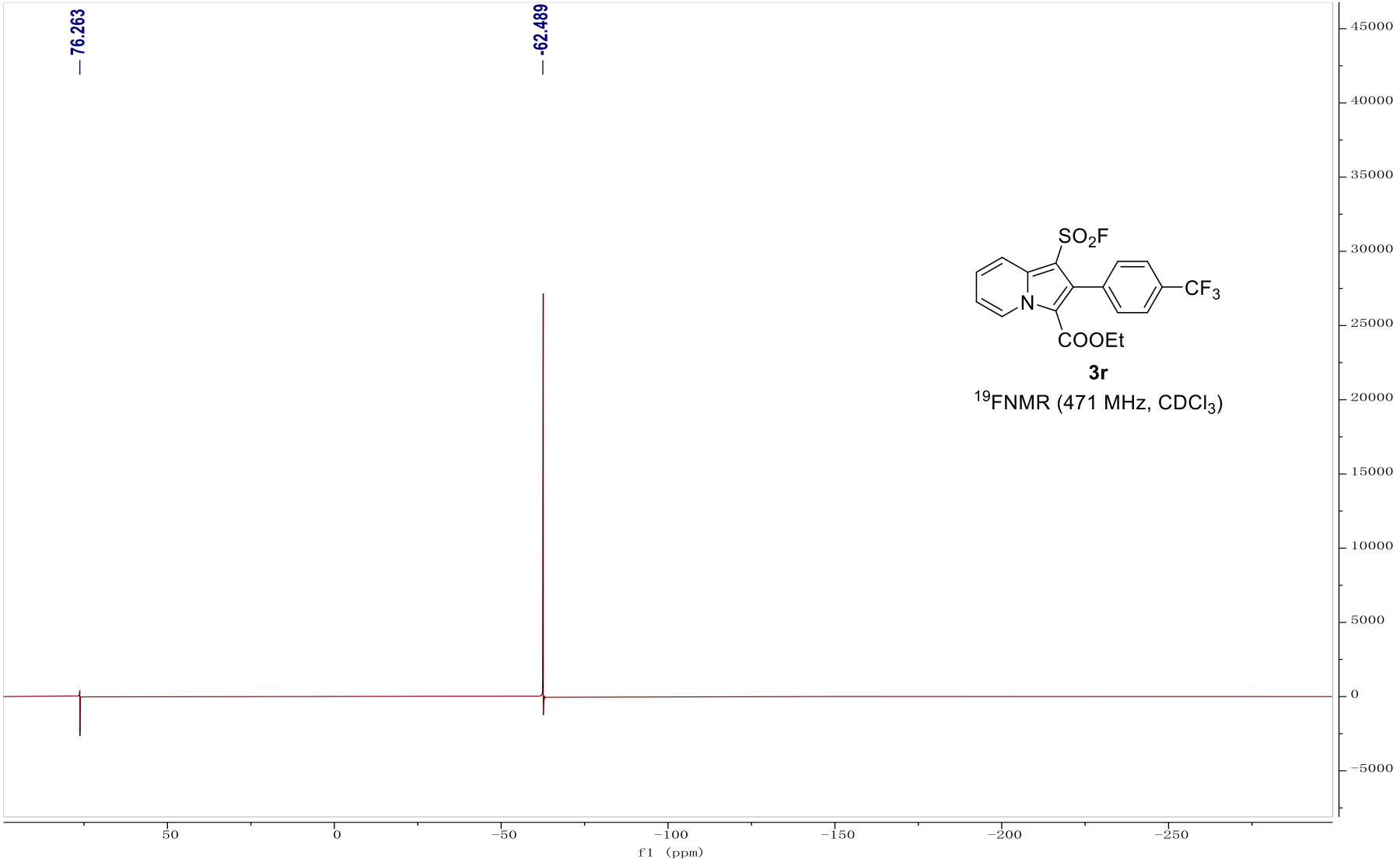


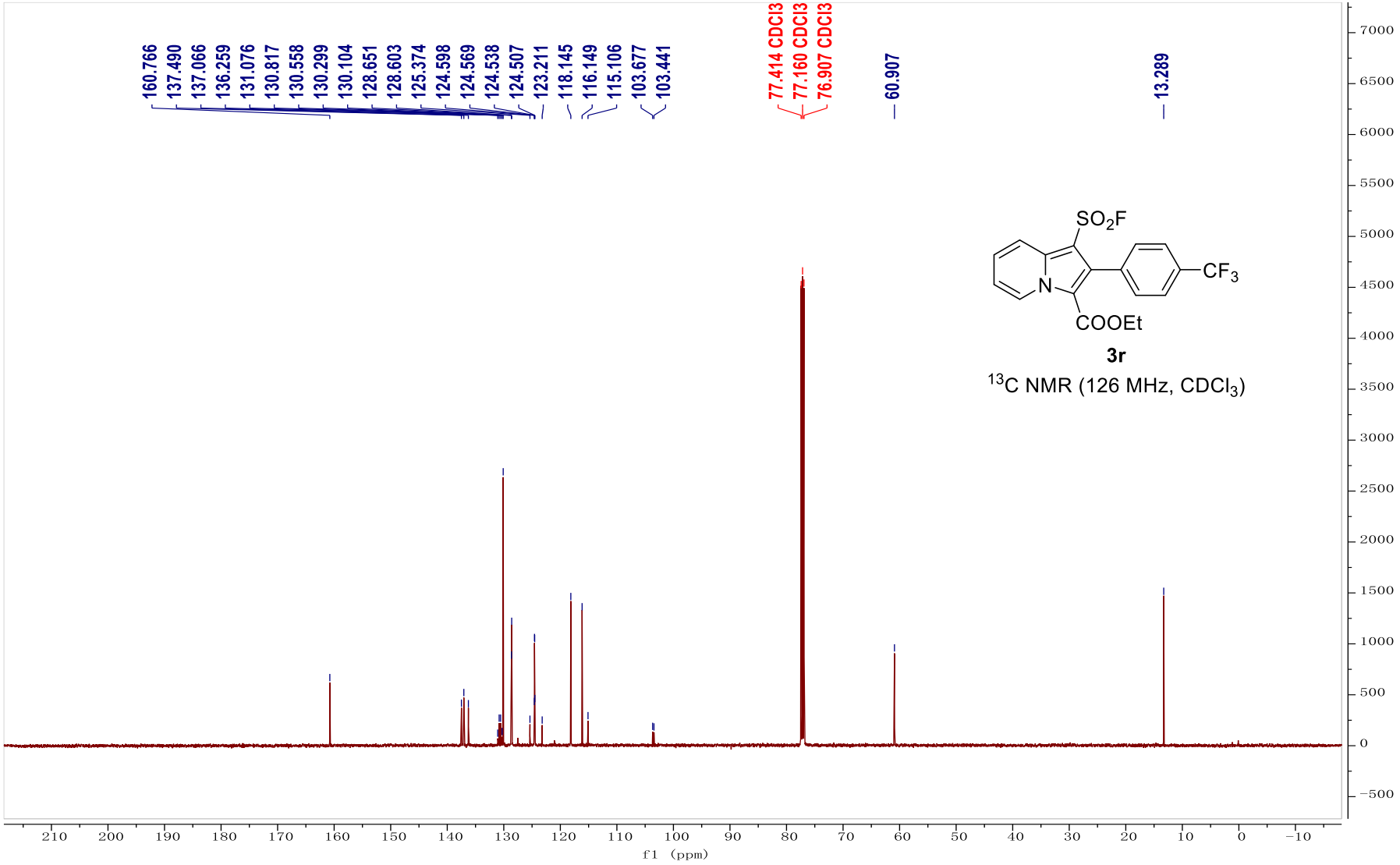
3q

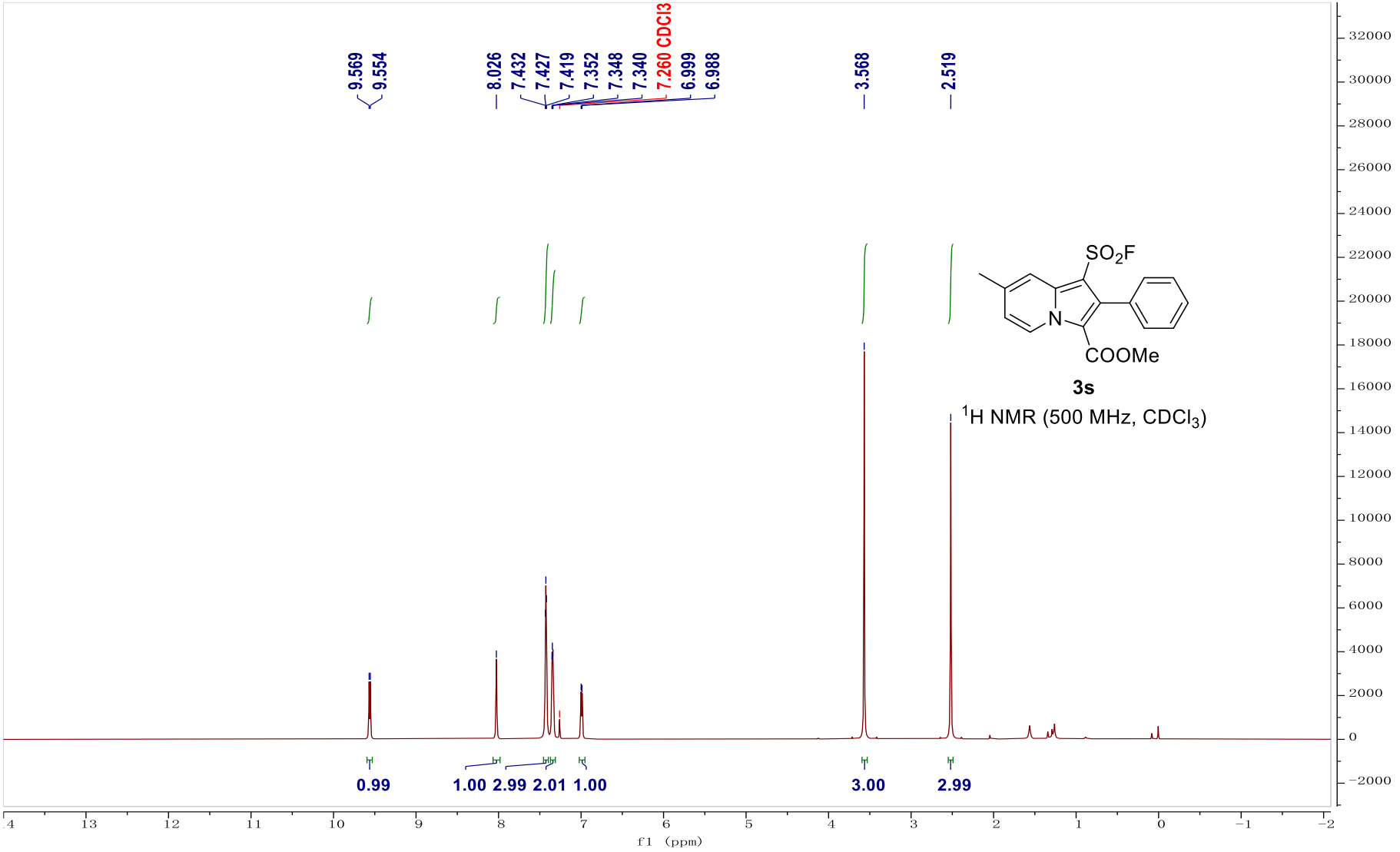
^{19}FNMR (471 MHz, $CDCl_3$)

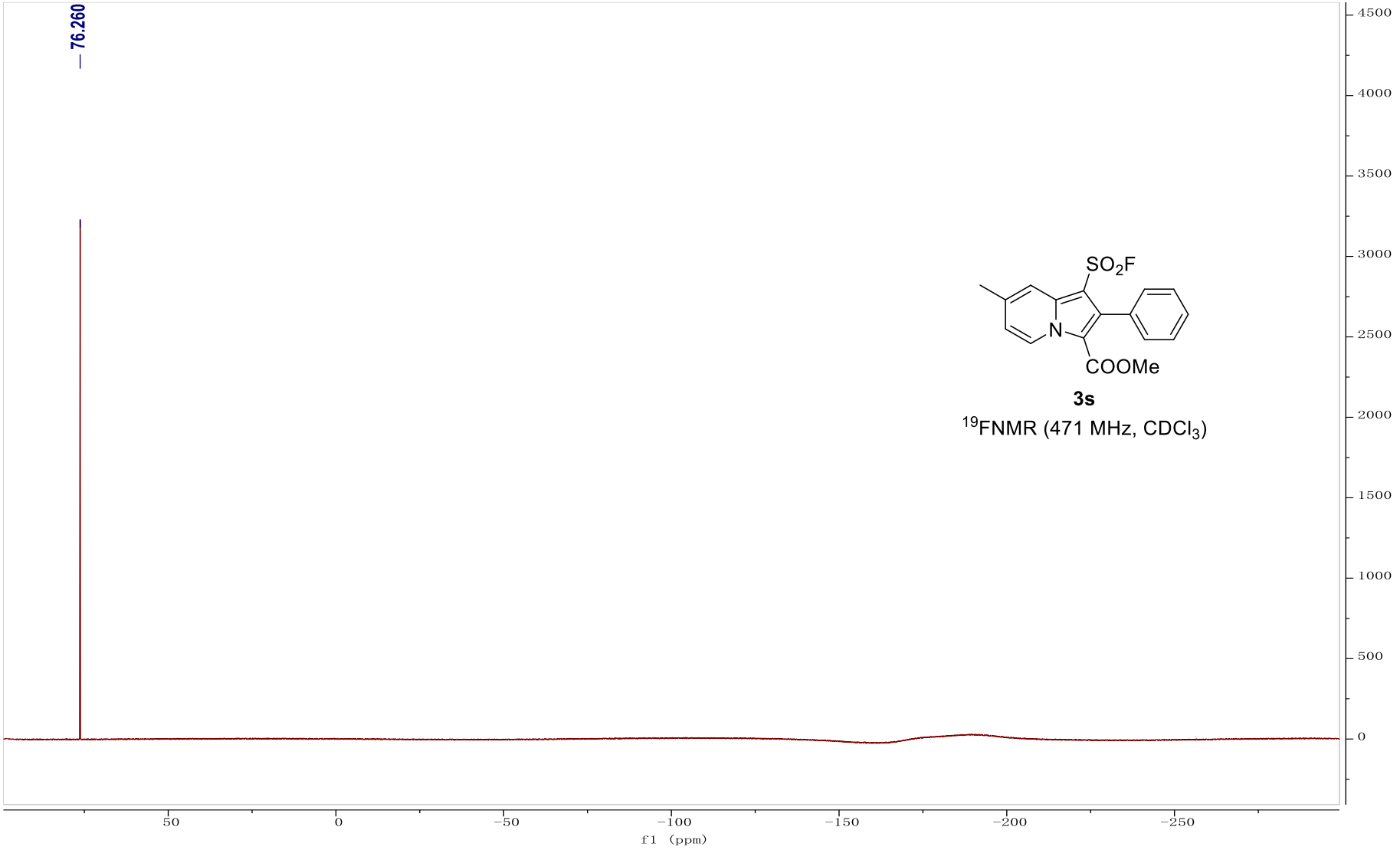

166.496
160.855
137.654
137.494
137.079
130.522
129.742
128.803
128.634
128.457
118.133
116.030
114.957
103.731
103.497
77.414 CDCl3
77.160 CDCl3
76.907 CDCl3
61.193
60.861
14.464
13.564
SO2F
N
COOEt
COOEt
3q
13C NMR (126 MHz, CDCl3)
f1 (ppm)


9.738
9.723
8.277
8.259
7.705
7.689
7.570
7.556
7.538
7.493
7.478
7.260 CDCl3
7.213
7.199
7.185
4.081
4.067
4.053
4.039
0.842
0.828
0.814
SO2F
CF3
N
COOEt
3r
1H NMR (500 MHz, CDCl3)
0.97
0.98 1.98 1.00 1.96 1.00
1.99
3.01
f1 (ppm)


— 76.263
— -62.489
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
−5000
50
0
−50
−100
−150
−200
−250
f1 (ppm)
SO2F
CF3
N
COOEt
3r
19FNMR (471 MHz, CDCl3)

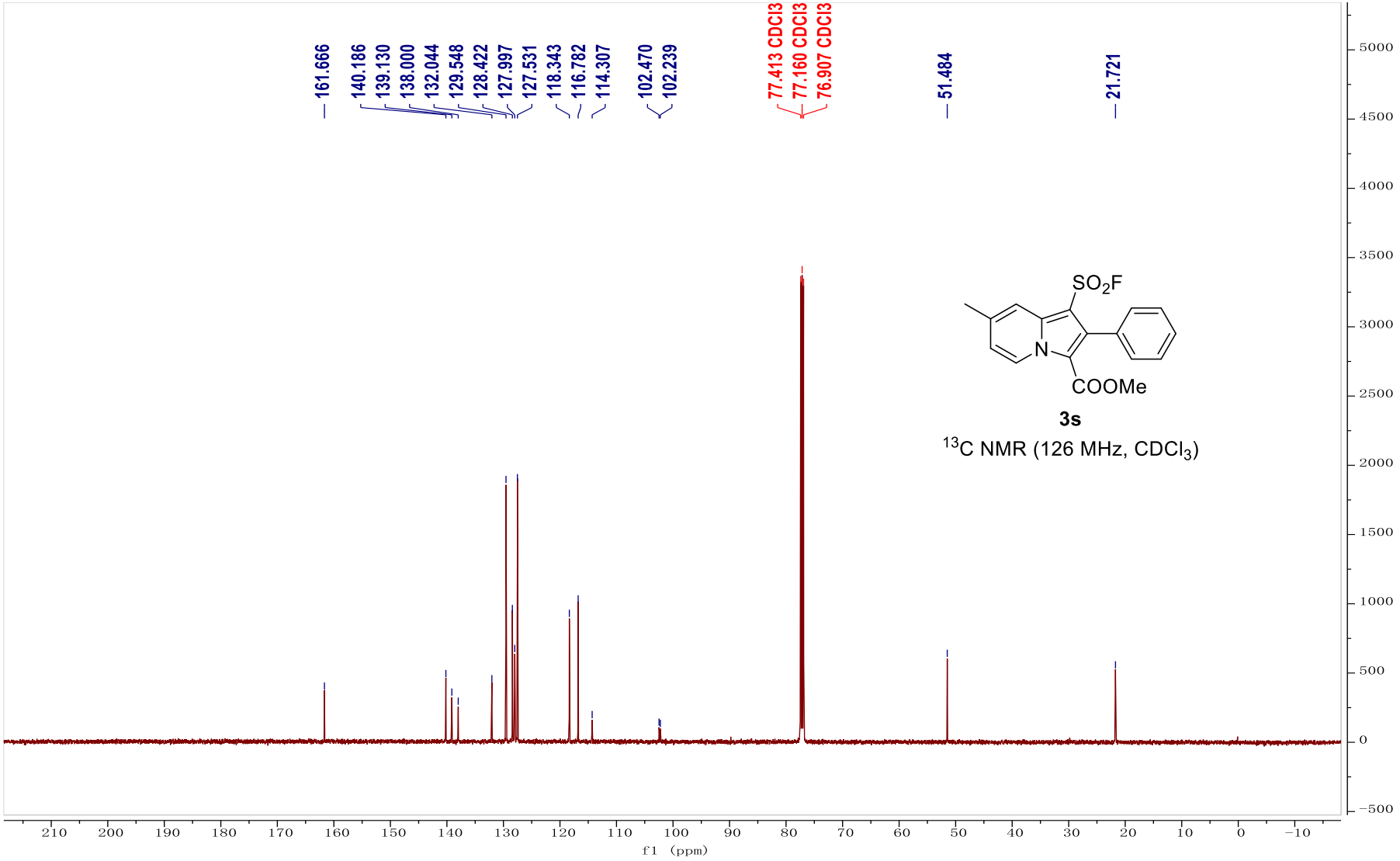

160.766
137.490
137.066
136.259
131.076
130.817
130.558
130.299
130.104
128.651
128.603
125.374
124.598
124.569
124.538
124.507
123.211
118.145
116.149
115.106
103.677
103.441
77.414 CDCl3
77.160 CDCl3
76.907 CDCl3
60.907
13.289
SO2F
CF3
N
COOEt
3r
13C NMR (126 MHz, CDCl3)
f1 (ppm)

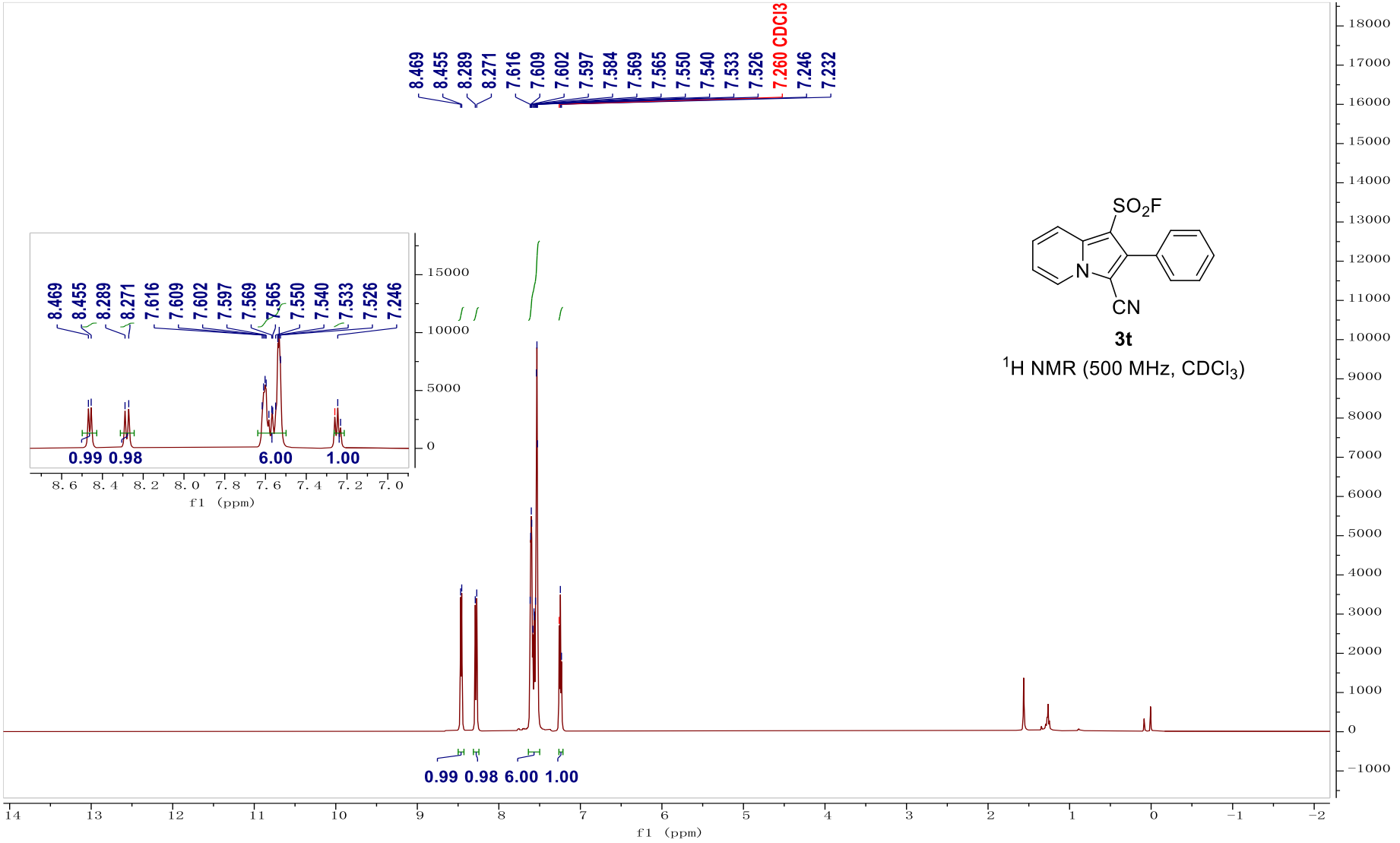

9.569
9.554
8.026
7.432
7.427
7.419
7.352
7.348
7.340
7.260 CDCl3
6.999
6.988
3.568
2.519
SO2F
N
COOMe
3s
1H NMR (500 MHz, CDCl3)
0.99
1.00
2.99
2.01
1.00
3.00
2.99
f1 (ppm)

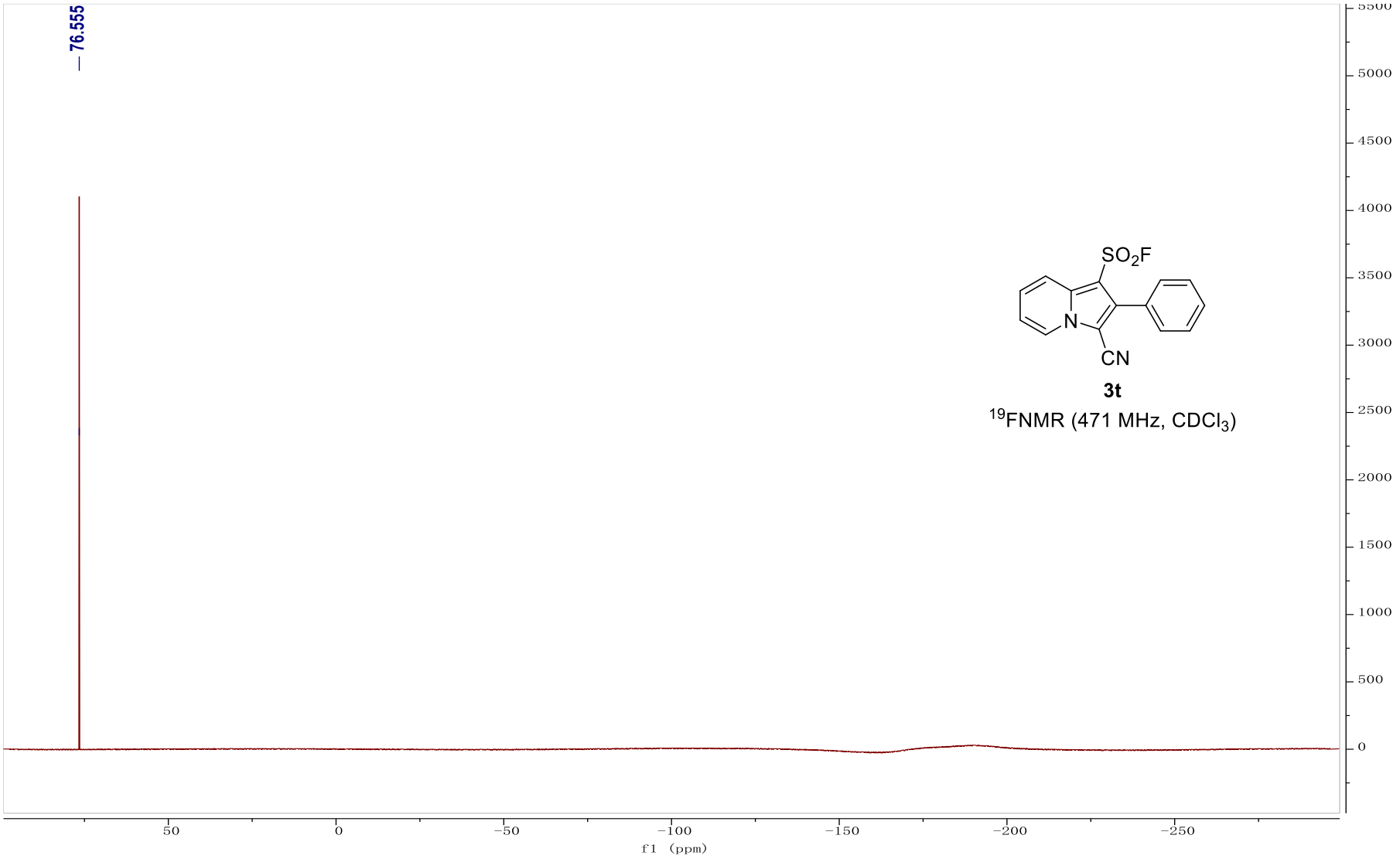


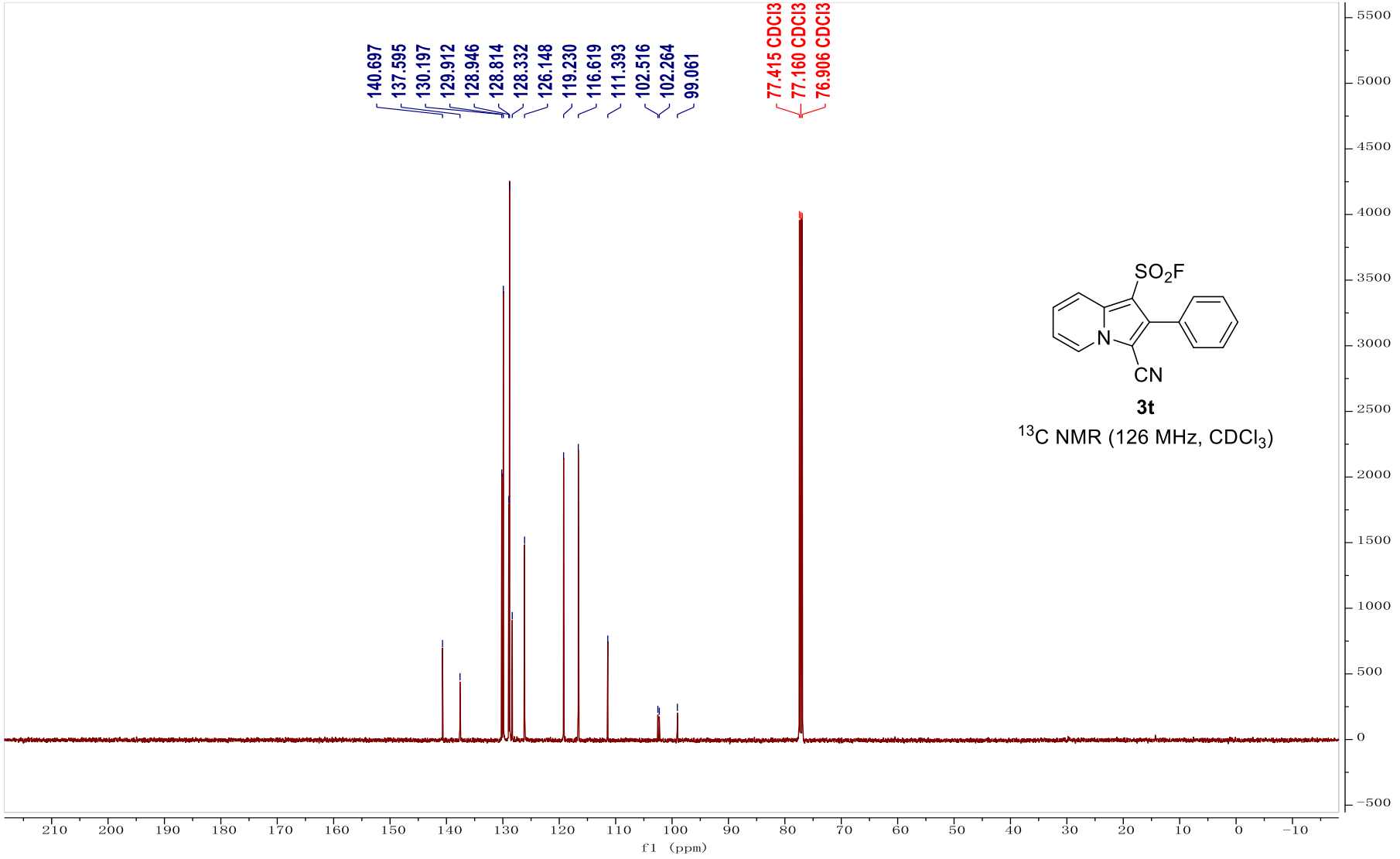
3s

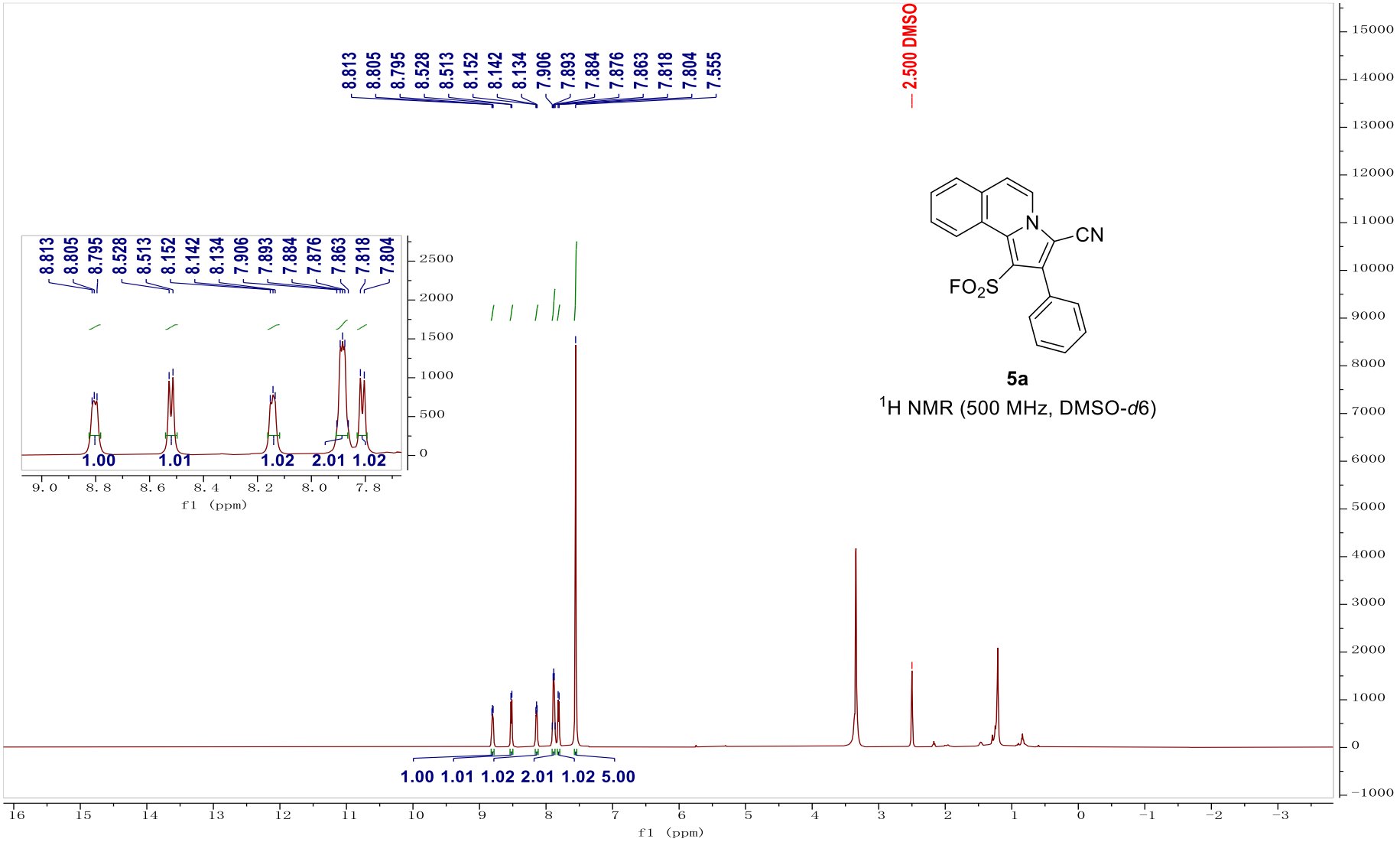
^{19}FNMR (471 MHz, $CDCl_3$)

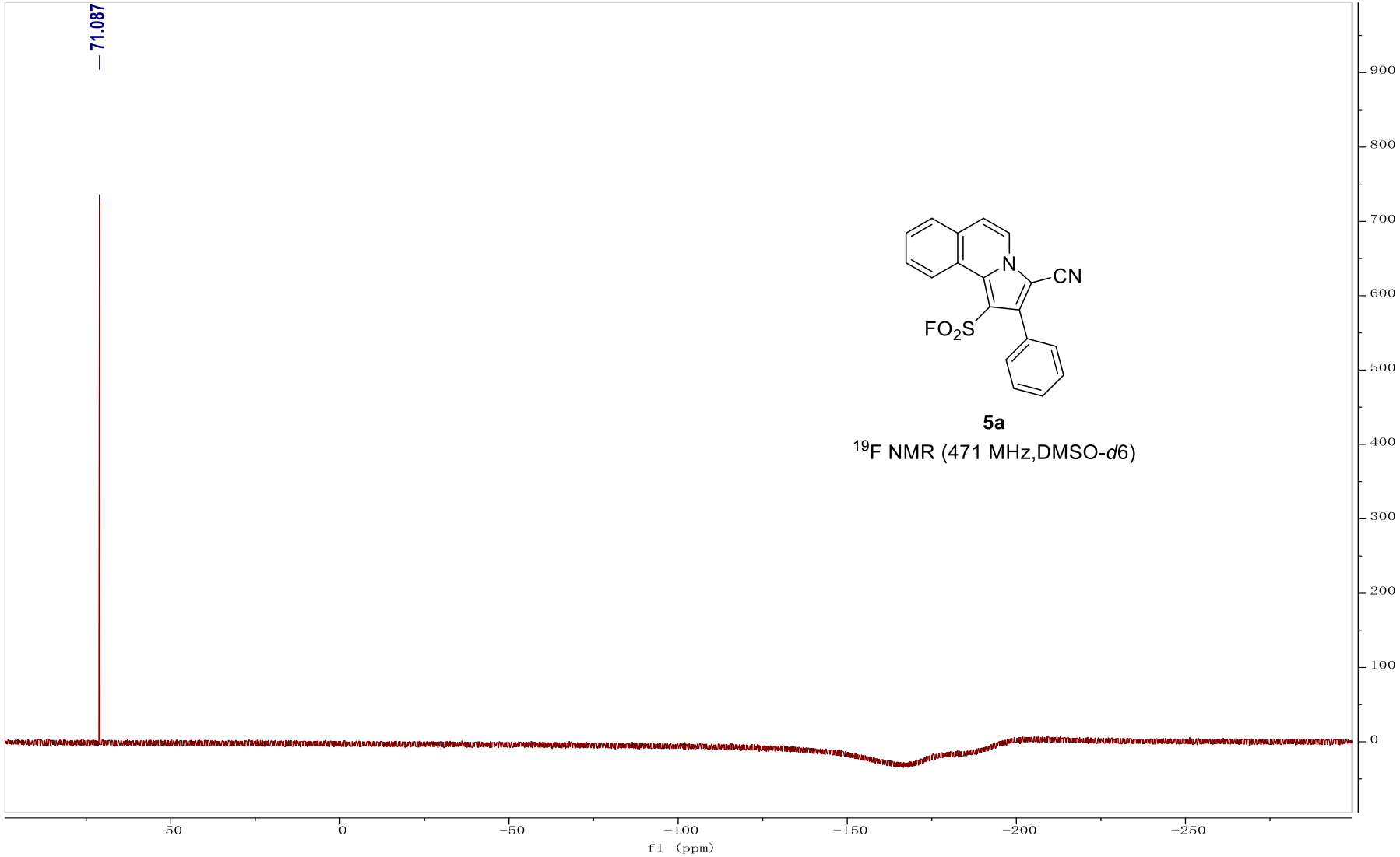

161.666
140.186
139.130
138.000
132.044
129.548
128.422
127.997
127.531
118.343
116.782
114.307
102.470
102.239
77.413 CDCl3
77.160 CDCl3
76.907 CDCl3
51.484
21.721
SO2F
N
COOMe
3s
13C NMR (126 MHz, CDCl3)
f1 (ppm)


8.469
8.455
8.289
8.271
7.616
7.609
7.602
7.597
7.584
7.569
7.565
7.550
7.540
7.533
7.526
7.260 CDCl3
7.246
7.232
0.99 0.98 6.00 1.00
f1 (ppm)
SO2F
N
CN
3t
1H NMR (500 MHz, CDCl3)


76.555
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
50
0
−50
−100
−150
−200
−250
f1 (ppm)
SO2F
N
CN
3t
19FNMR (471 MHz, CDCl3)

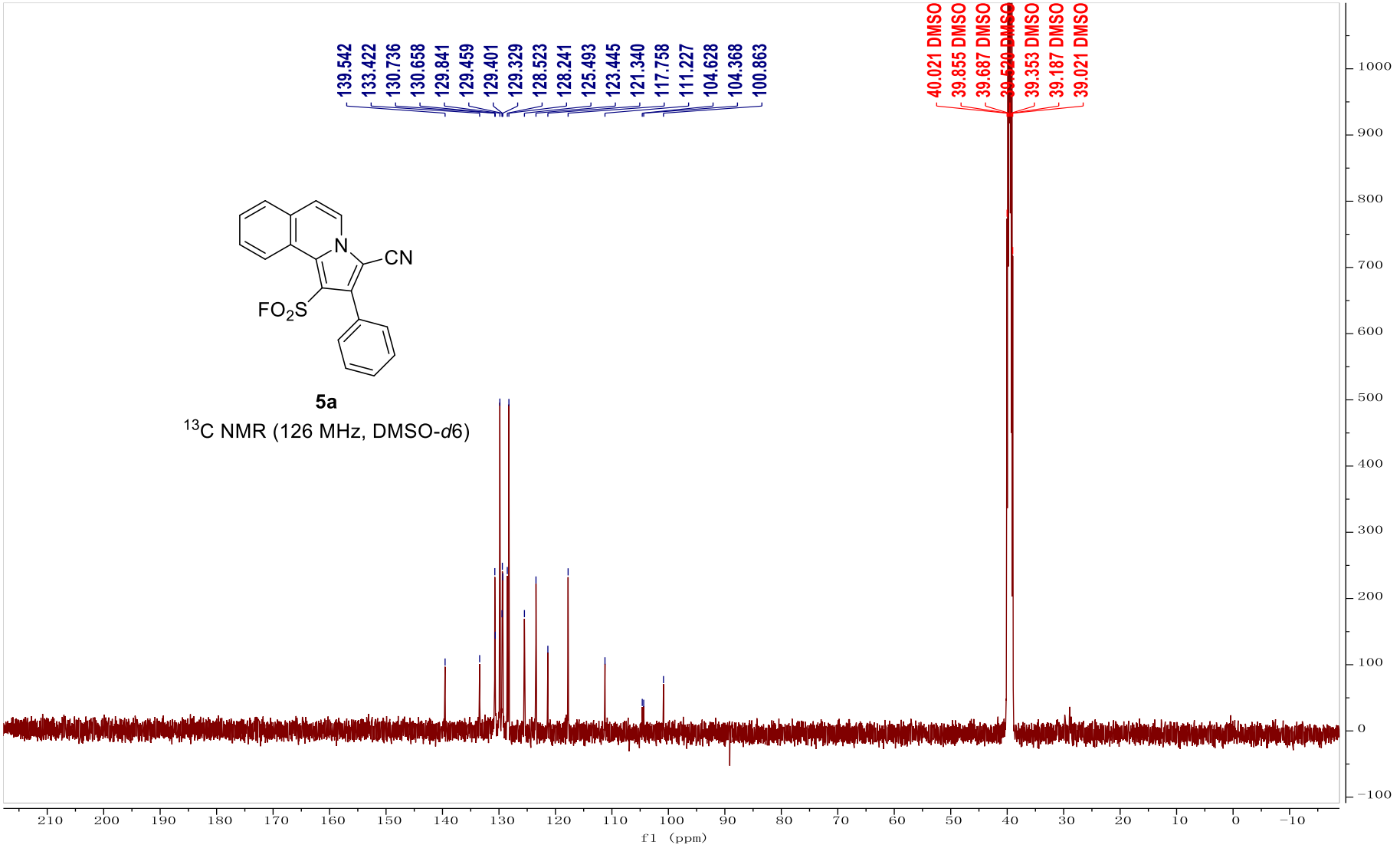

140.697
137.595
130.197
129.912
128.946
128.814
128.332
126.148
119.230
116.619
111.393
102.516
102.264
99.061
77.415 CDCl3
77.160 CDCl3
76.906 CDCl3
SO2F
N
CN
3t
13C NMR (126 MHz, CDCl3)
f1 (ppm)

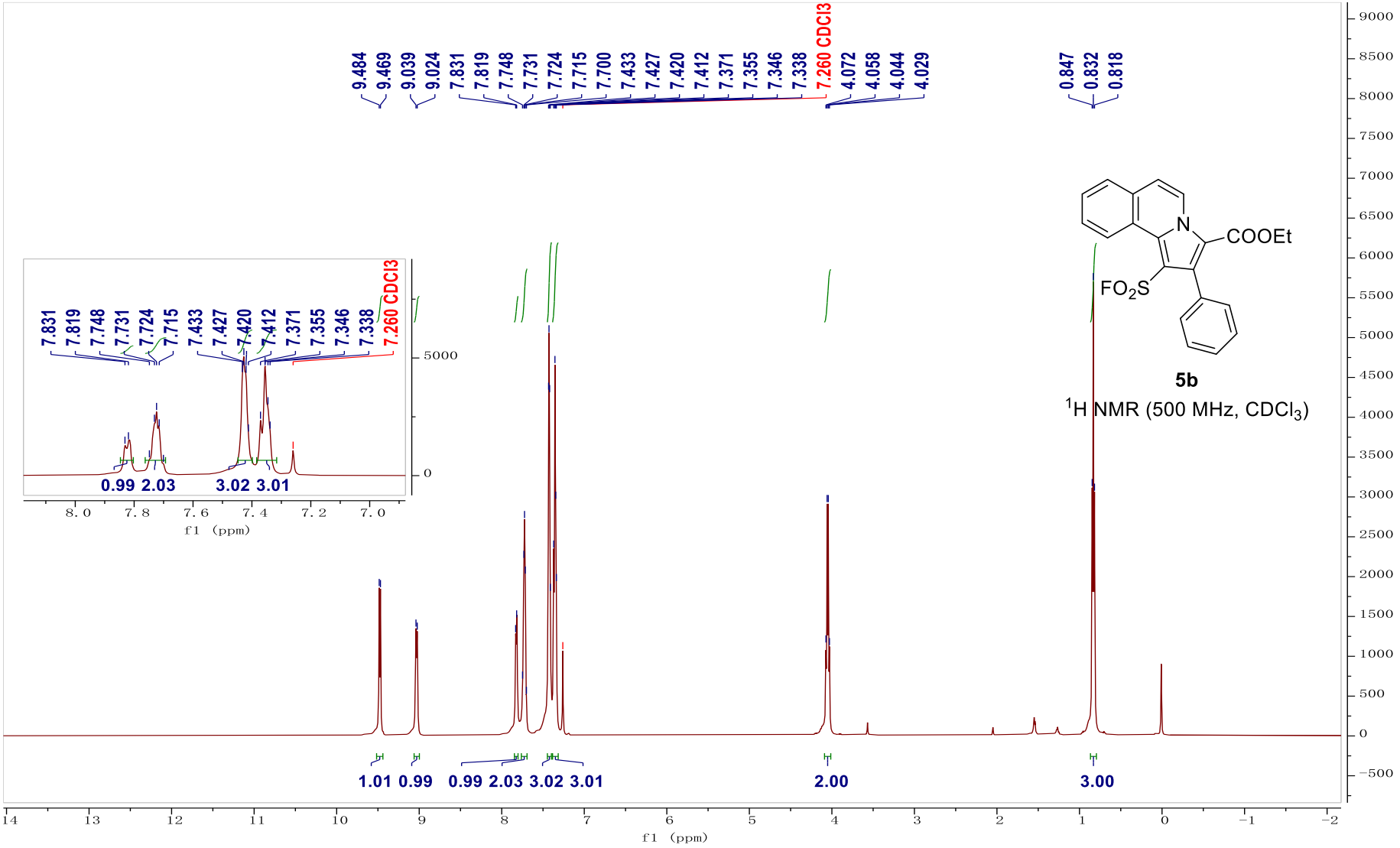

8.813
8.805
8.795
8.528
8.513
8.152
8.142
8.134
7.906
7.893
7.884
7.876
7.863
7.818
7.804
7.555
2.500 DMSO
N
CN
FO2S
5a
1H NMR (500 MHz, DMSO-d6)
1.00 1.01 1.02 2.01 1.02 5.00
f1 (ppm)

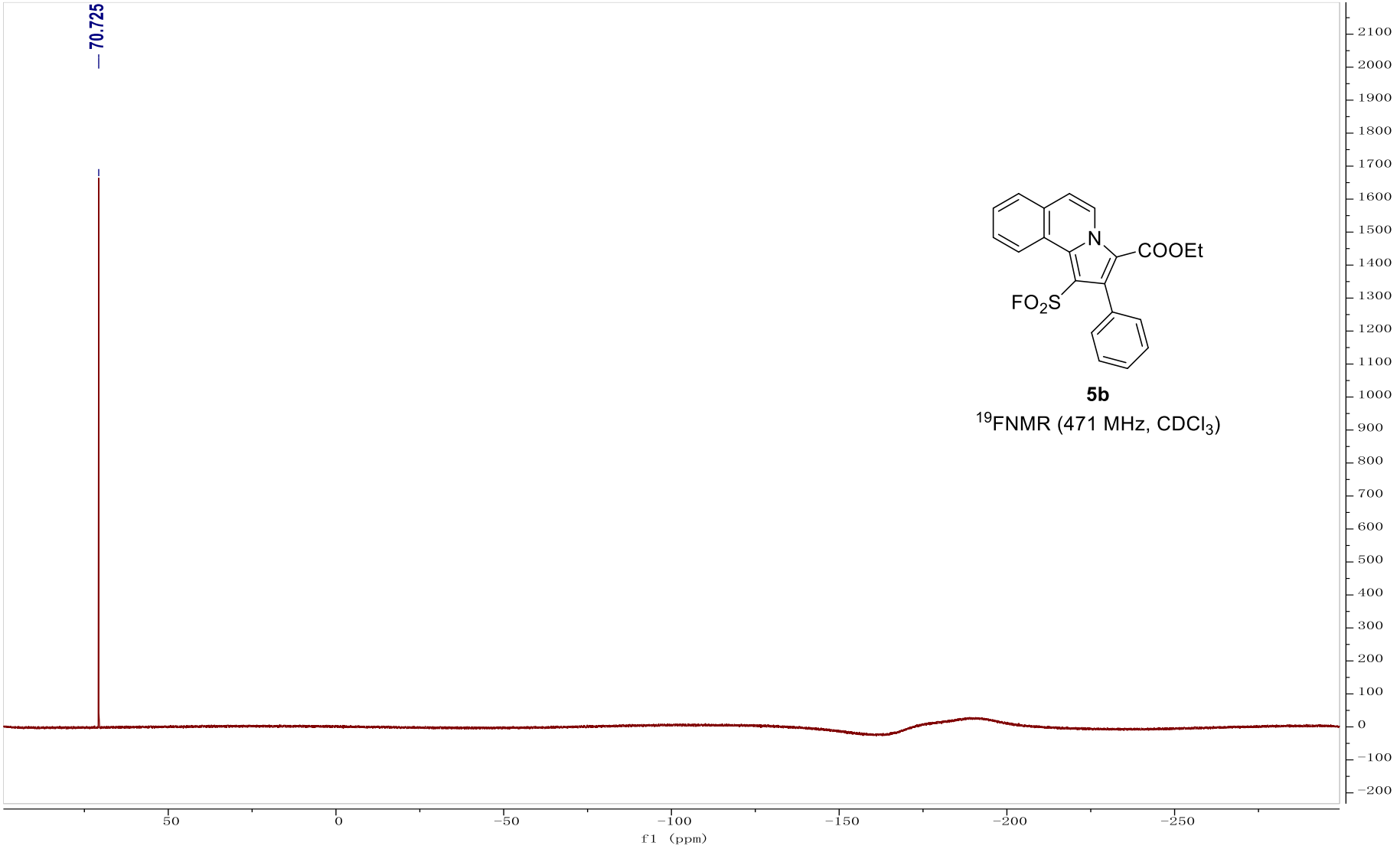


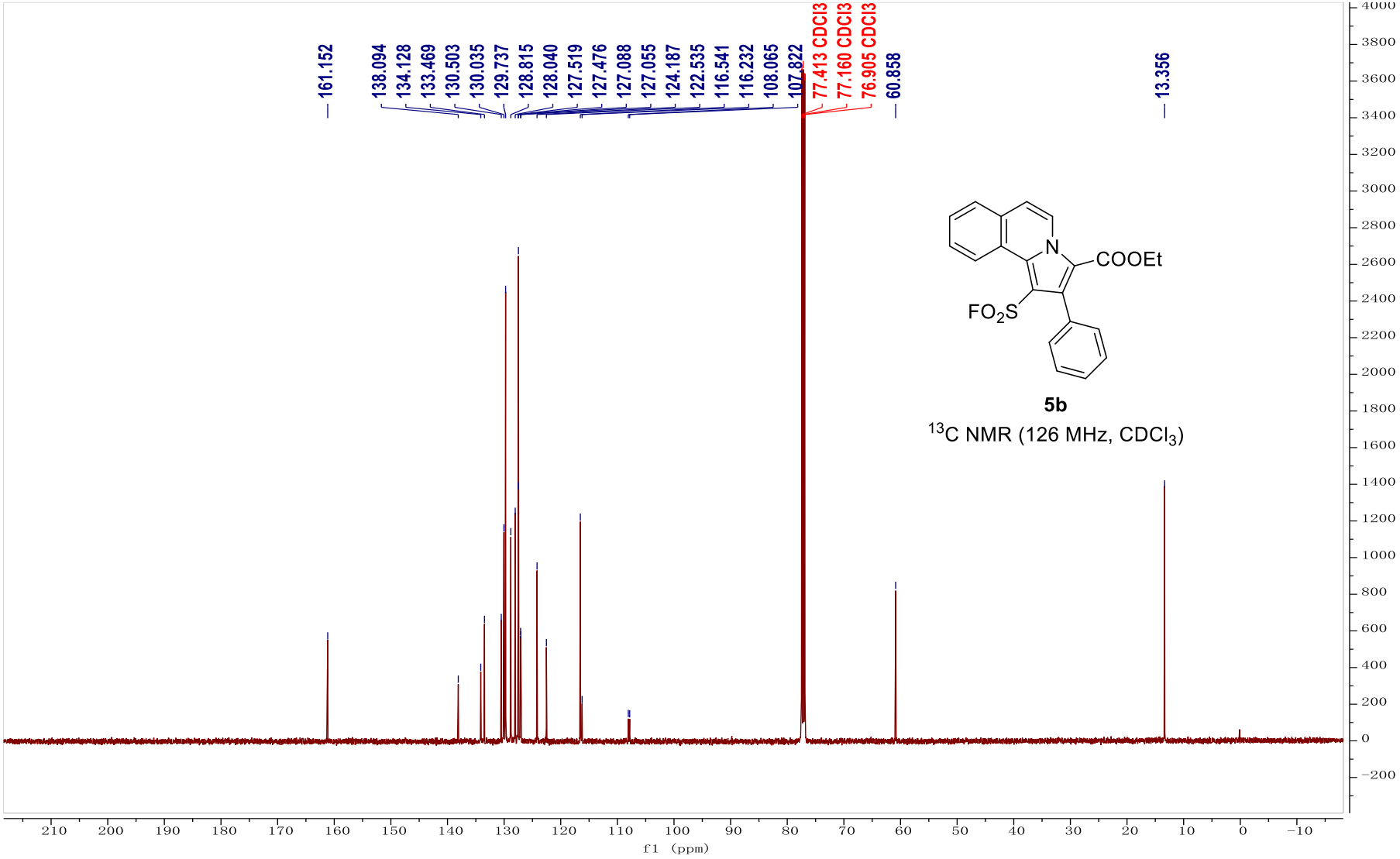
5a

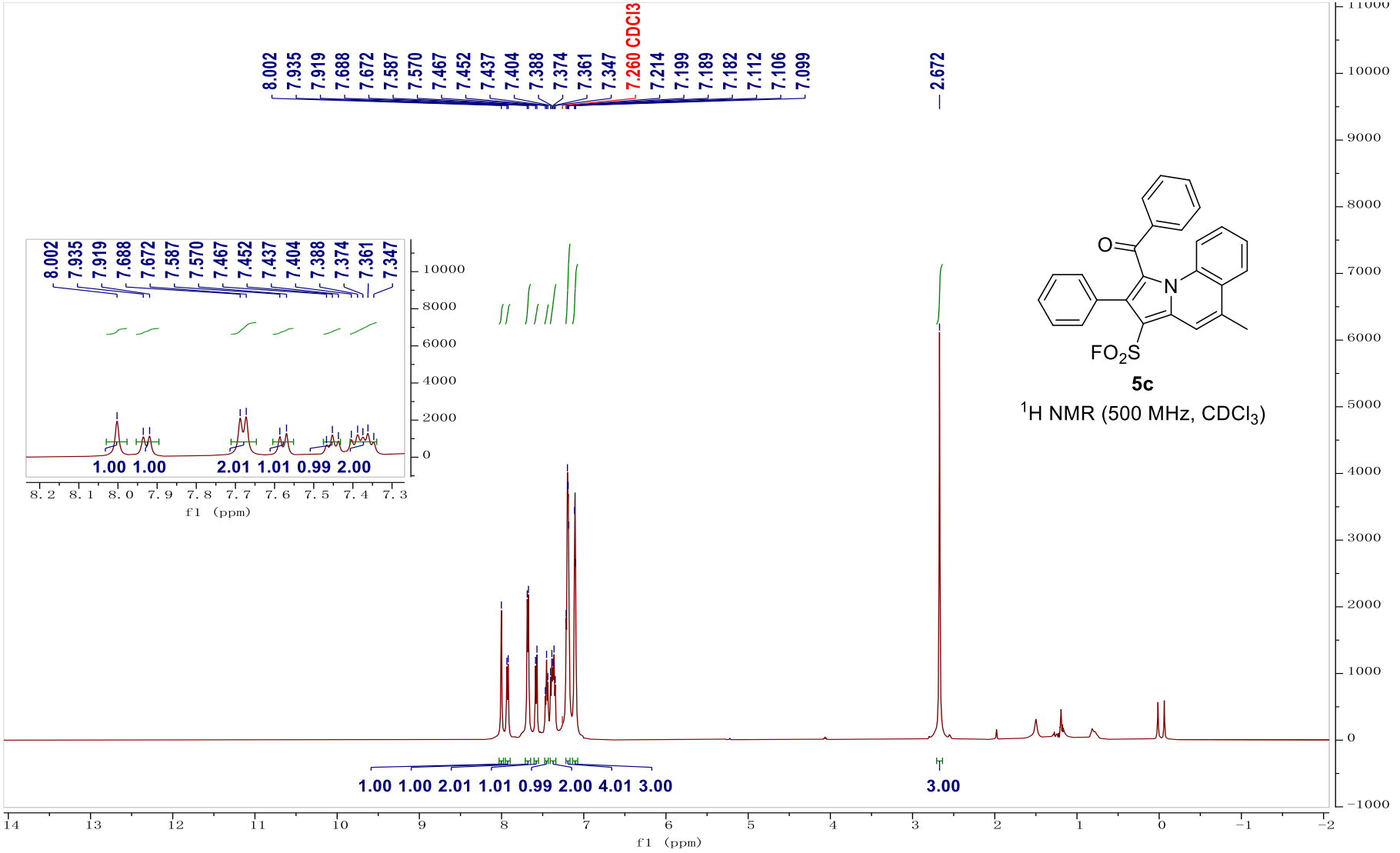
^{19}F NMR (471 MHz,DMSO-*d*6)

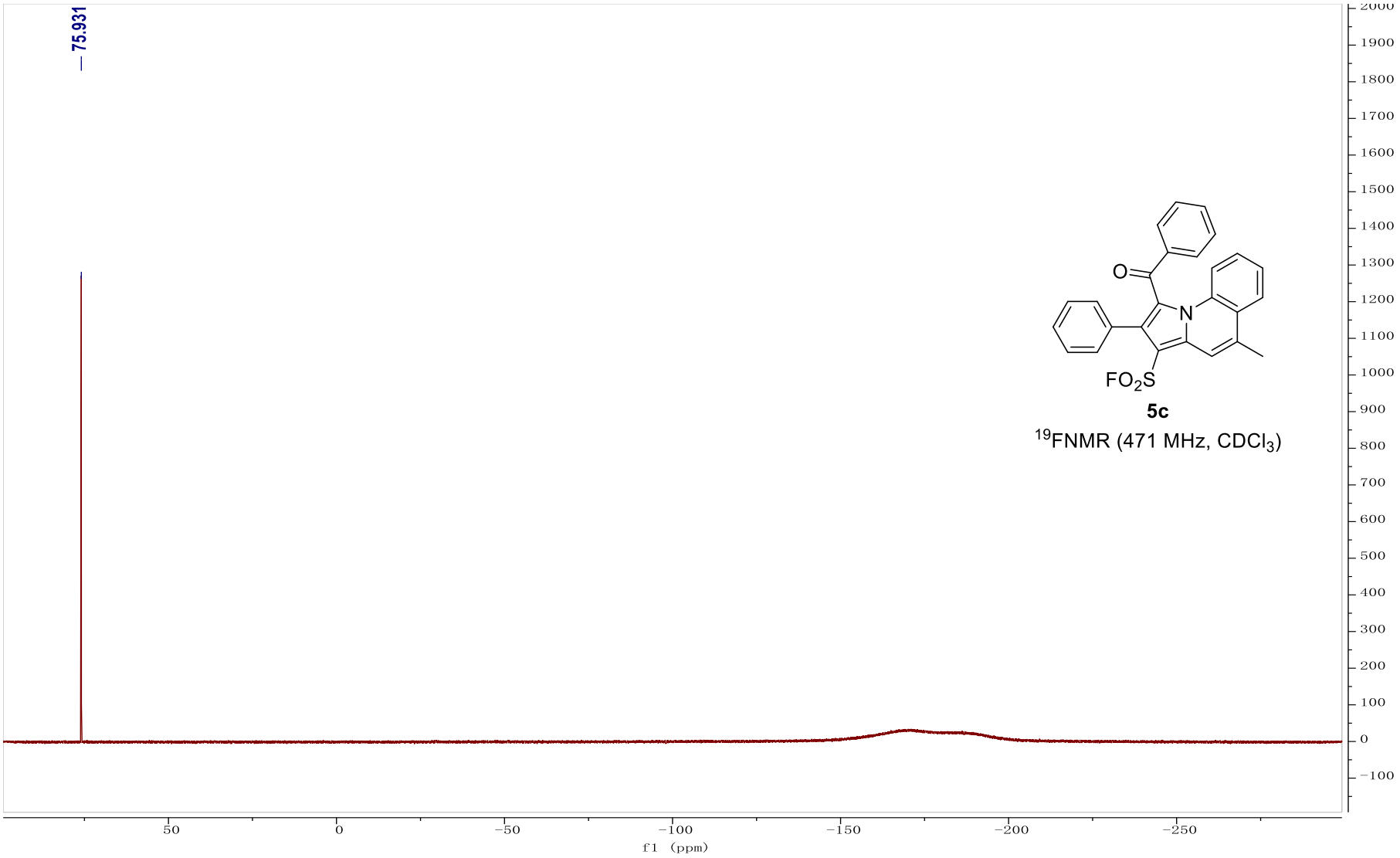

139.542
133.422
130.736
130.658
129.841
129.459
129.401
129.329
128.523
128.241
125.493
123.445
121.340
117.758
111.227
104.628
104.368
100.863
40.021 DMSO
39.855 DMSO
39.687 DMSO
39.520 DMSO
39.353 DMSO
39.187 DMSO
39.021 DMSO
N
CN
FO2S
5a
13C NMR (126 MHz, DMSO-d6)
f1 (ppm)

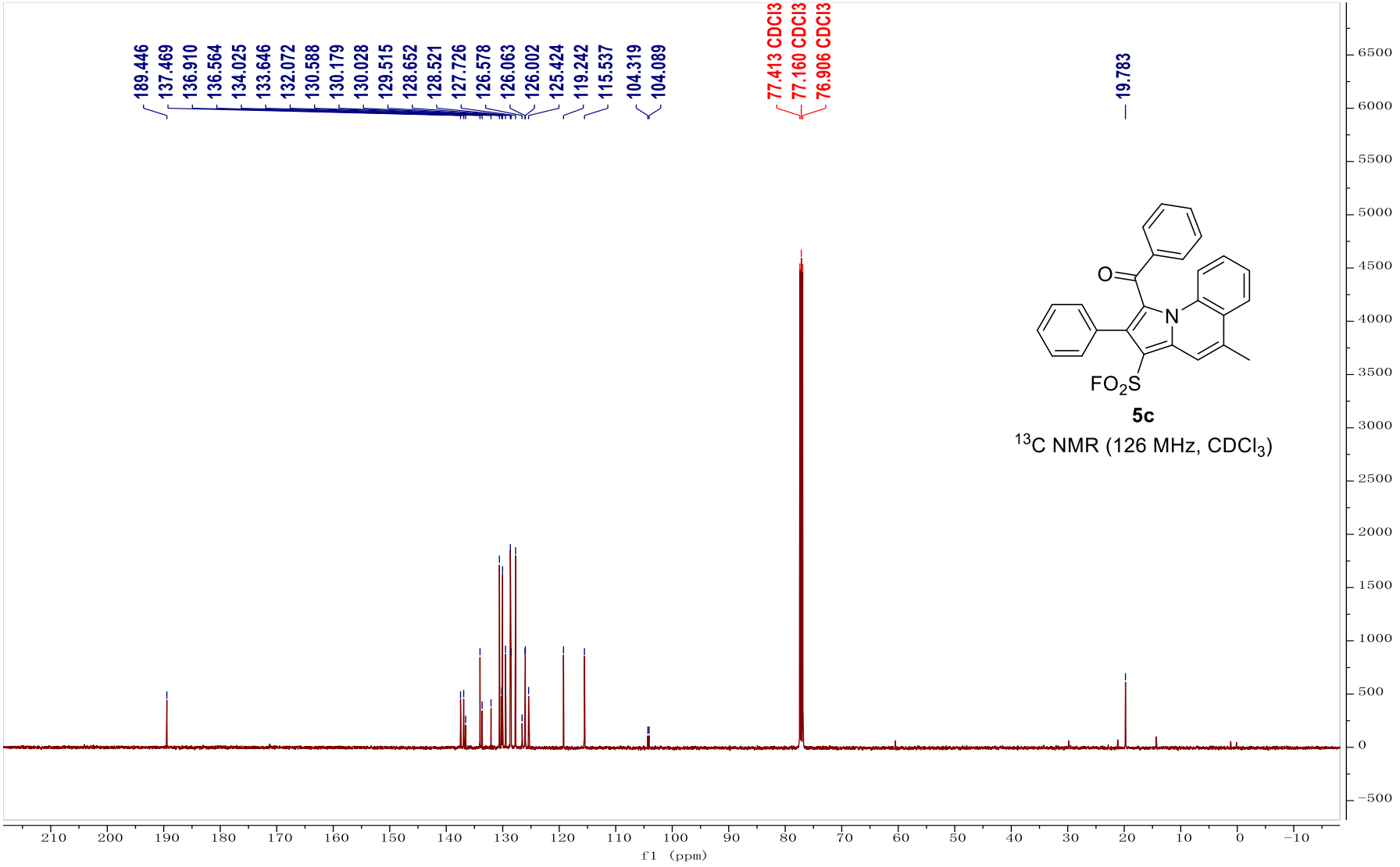

9.484
9.469
9.039
9.024
7.831
7.819
7.748
7.731
7.724
7.715
7.700
7.433
7.427
7.420
7.412
7.371
7.355
7.346
7.338
7.260 CDCl3
4.072
4.058
4.044
4.029
0.847
0.832
0.818
1.01 0.99 0.99 2.03 3.02 3.01
2.00
3.00
f1 (ppm)
0.99 2.03 3.02 3.01
COOEt
FO2S
N
5b
1H NMR (500 MHz, CDCl3)

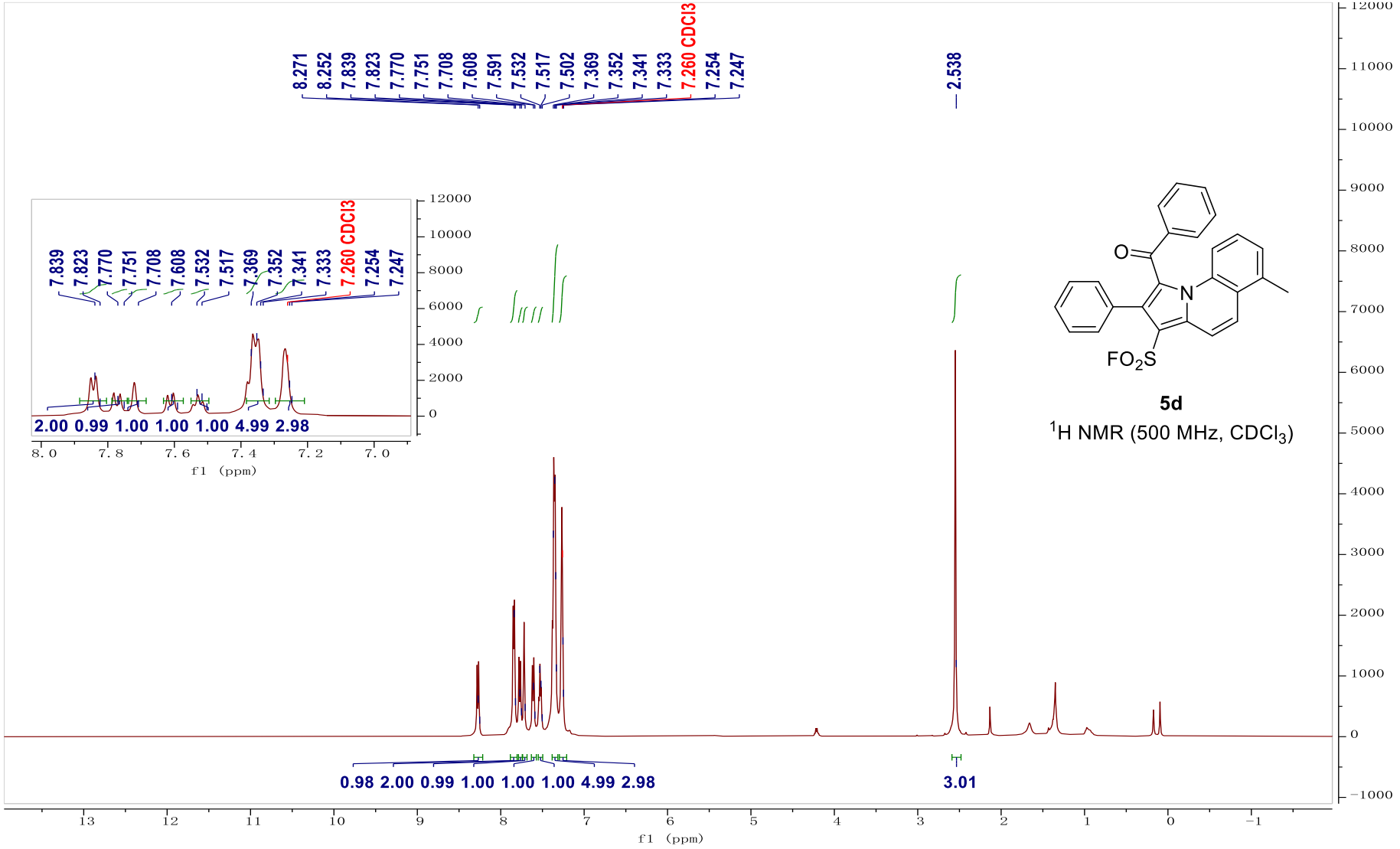

70.725
N
COOEt
FO2S
5b
19FNMR (471 MHz, CDCl3)
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
−100
−200
50
0
−50
−100
−150
−200
−250
f1 (ppm)

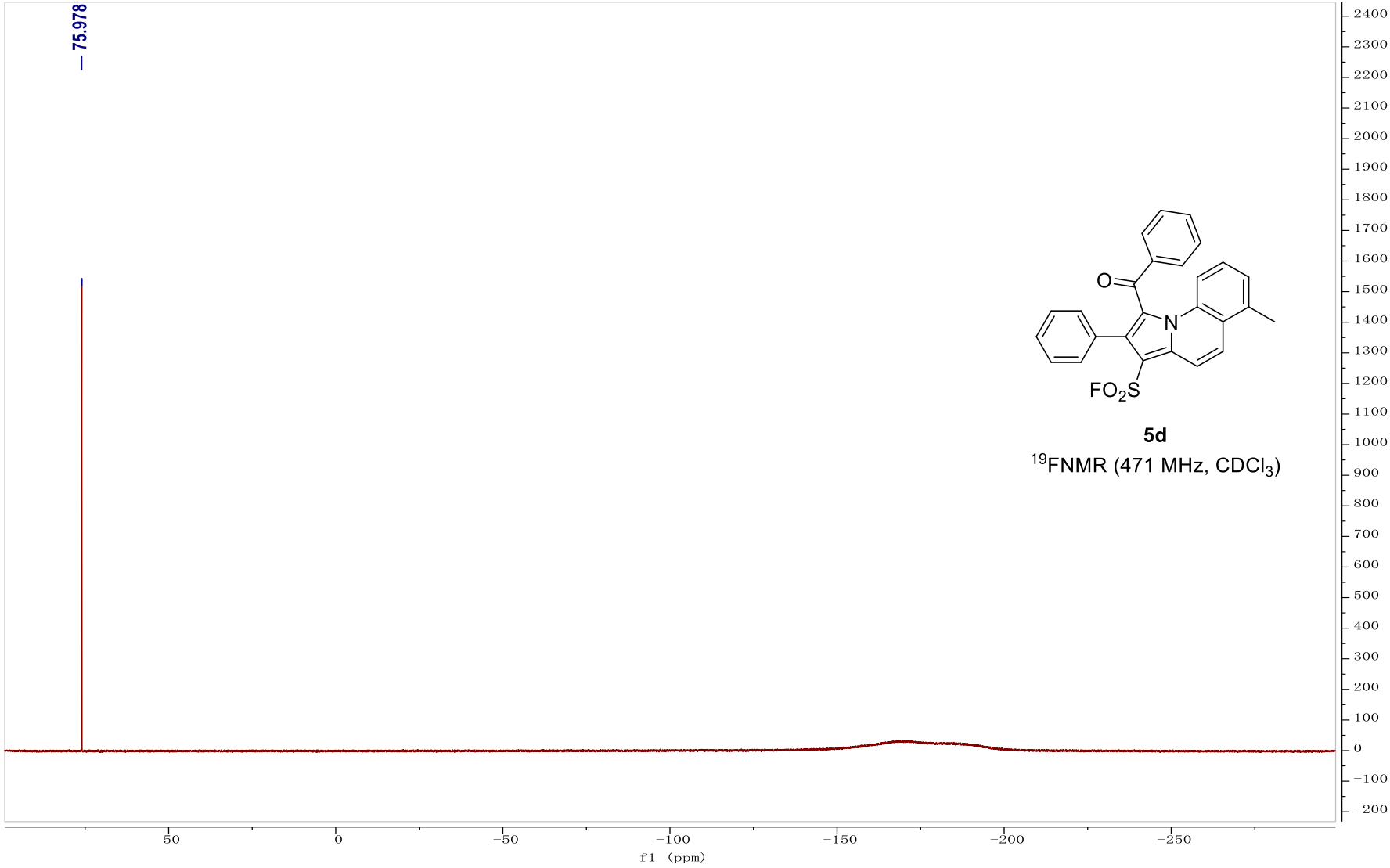

161.152
138.094
134.128
133.469
130.503
130.035
129.737
128.815
128.040
127.519
127.476
127.088
127.055
124.187
122.535
116.541
116.232
108.065
107.822
77.413 CDCl3
77.160 CDCl3
76.905 CDCl3
60.858
13.356
N
COOEt
FO2S
5b
13C NMR (126 MHz, CDCl3)
f1 (ppm)

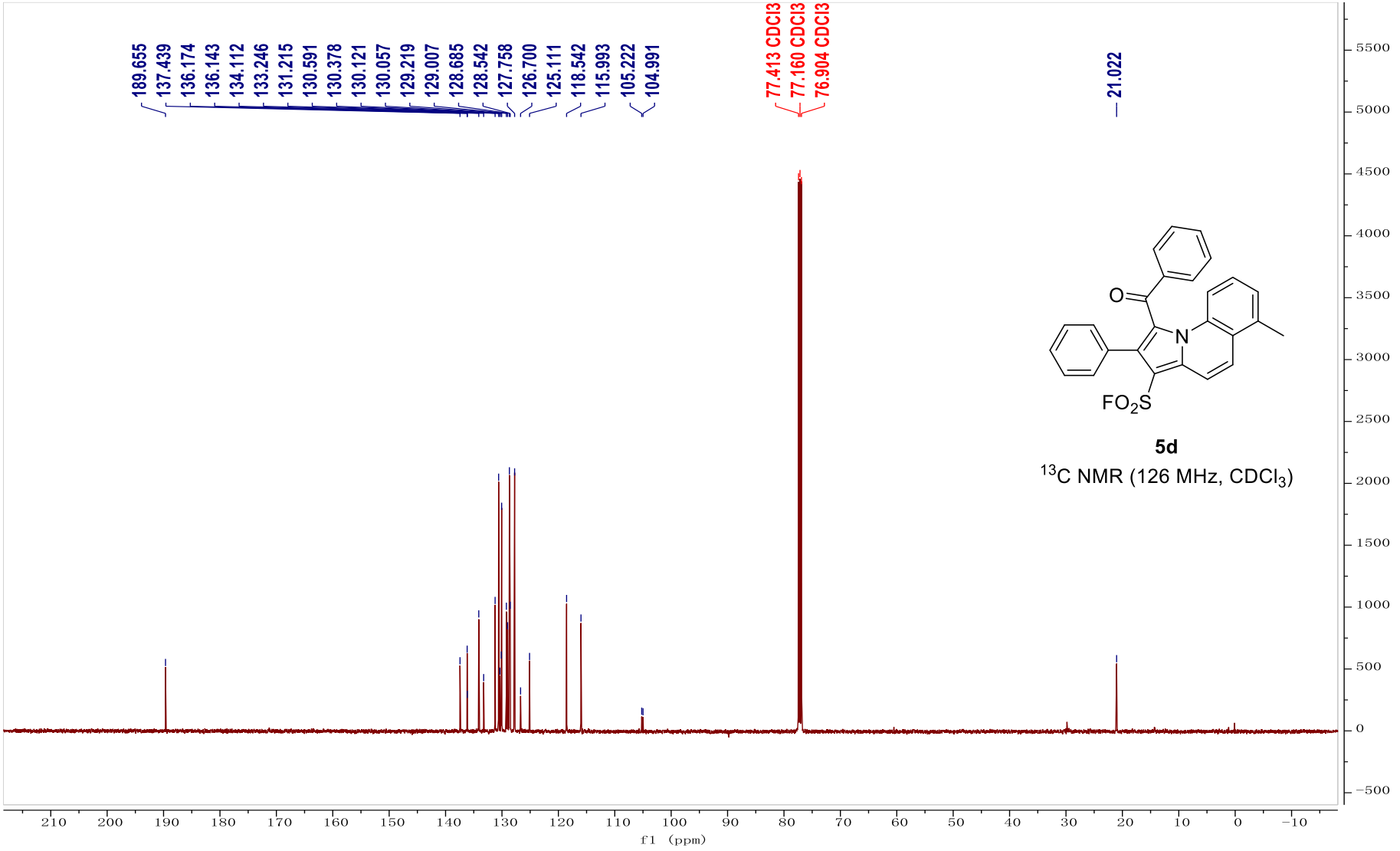

8.002
7.935
7.919
7.688
7.672
7.587
7.570
7.467
7.452
7.437
7.404
7.388
7.374
7.361
7.347
7.260 CDCl3
7.214
7.199
7.189
7.182
7.112
7.106
7.099
2.672
1.00 1.00 2.01 1.01 0.99 2.00 4.01 3.00
3.00
f1 (ppm)
1.00 1.00
2.01 1.01 0.99 2.00
O
N
FO2S
5c
1H NMR (500 MHz, CDCl3)

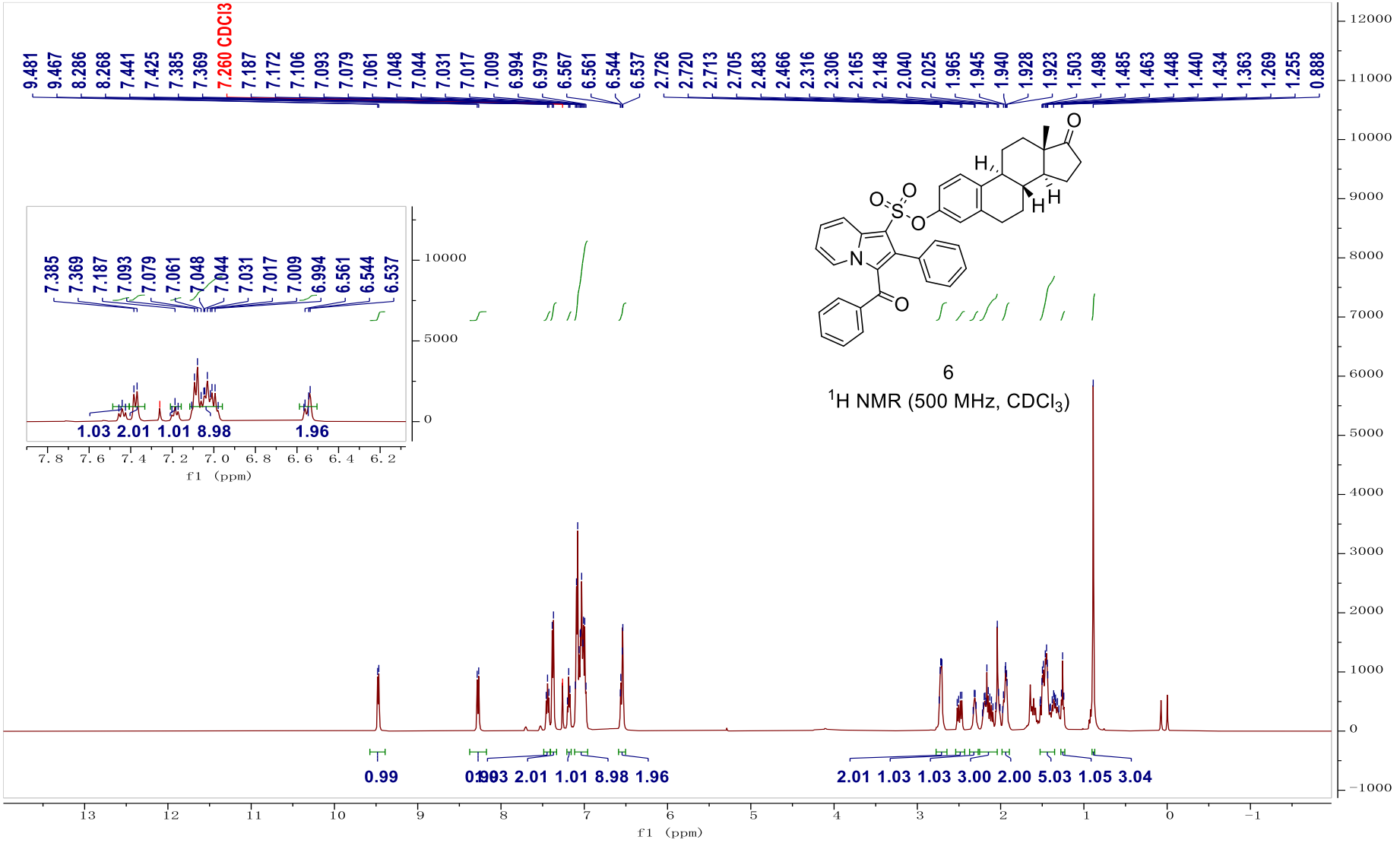

75.931
O
N
FO2S
5c
19FNMR (471 MHz, CDCl3)
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
−100
50
0
−50
−100
−150
−200
−250
f1 (ppm)

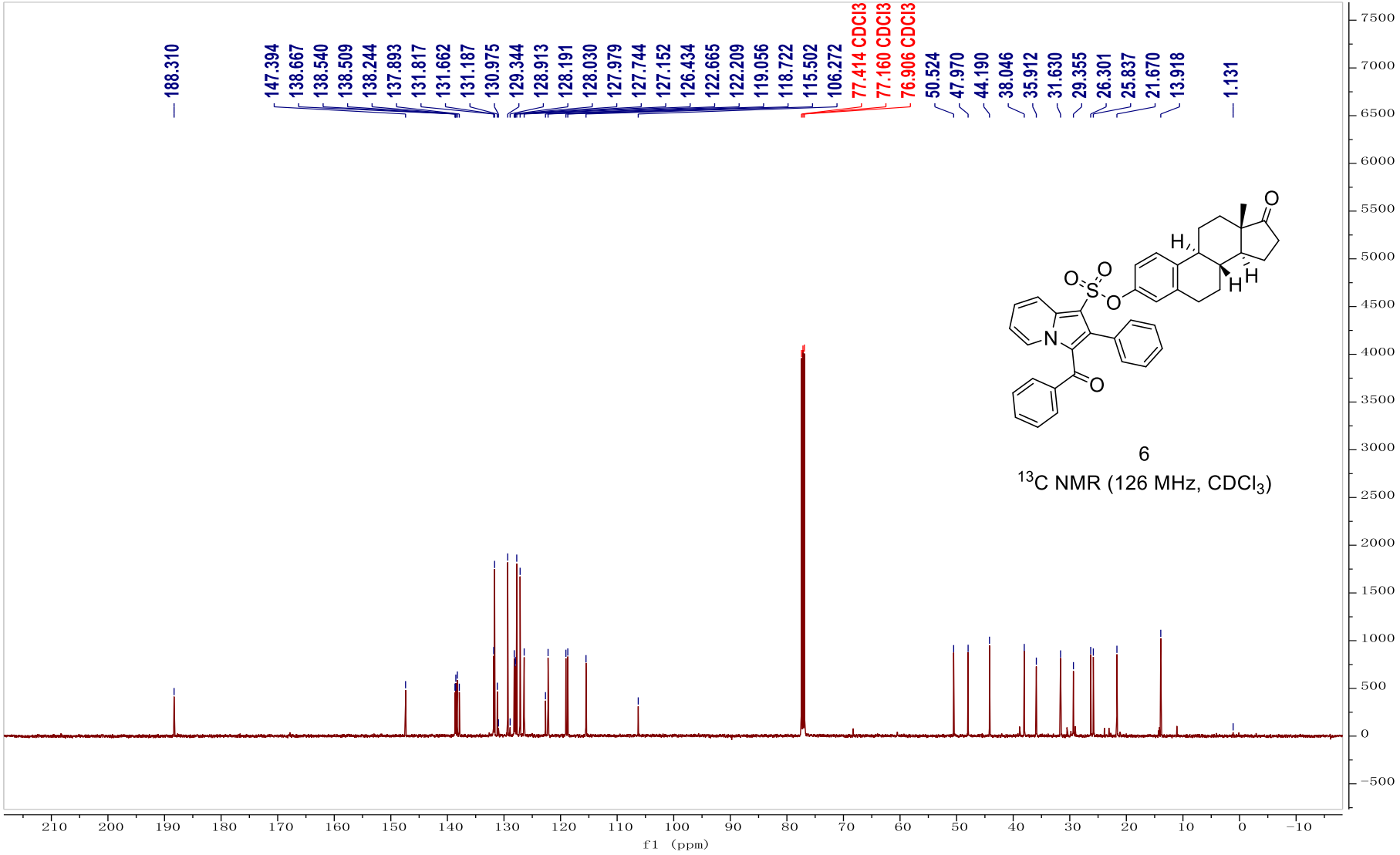

189.446
137.469
136.910
136.564
134.025
133.646
132.072
130.588
130.179
130.028
129.515
128.652
128.521
127.726
126.578
126.063
126.002
125.424
119.242
115.537
104.319
104.089
77.413 CDCl3
77.160 CDCl3
76.906 CDCl3
19.783
O
N
FO2S
5c
13C NMR (126 MHz, CDCl3)
f1 (ppm)

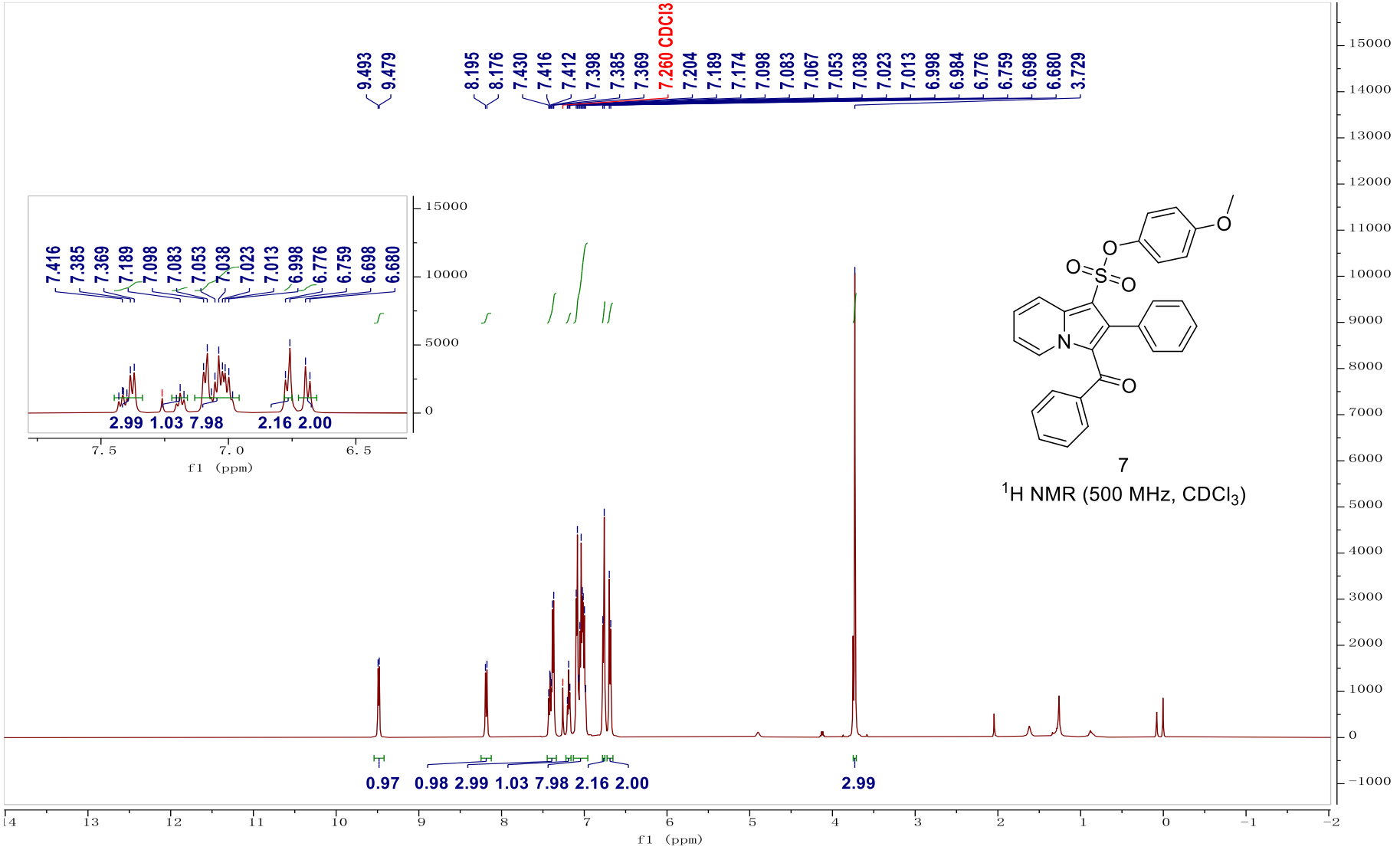

8.271
8.252
7.839
7.823
7.770
7.751
7.708
7.608
7.591
7.532
7.517
7.502
7.369
7.352
7.341
7.333
7.260 CDCl3
7.254
7.247
2.538
2.00 0.99 1.00 1.00 1.00 4.99 2.98
f1 (ppm)
0.98 2.00 0.99 1.00 1.00 1.00 4.99 2.98
3.01
f1 (ppm)
O
N
FO2S
5d
1H NMR (500 MHz, CDCl3)

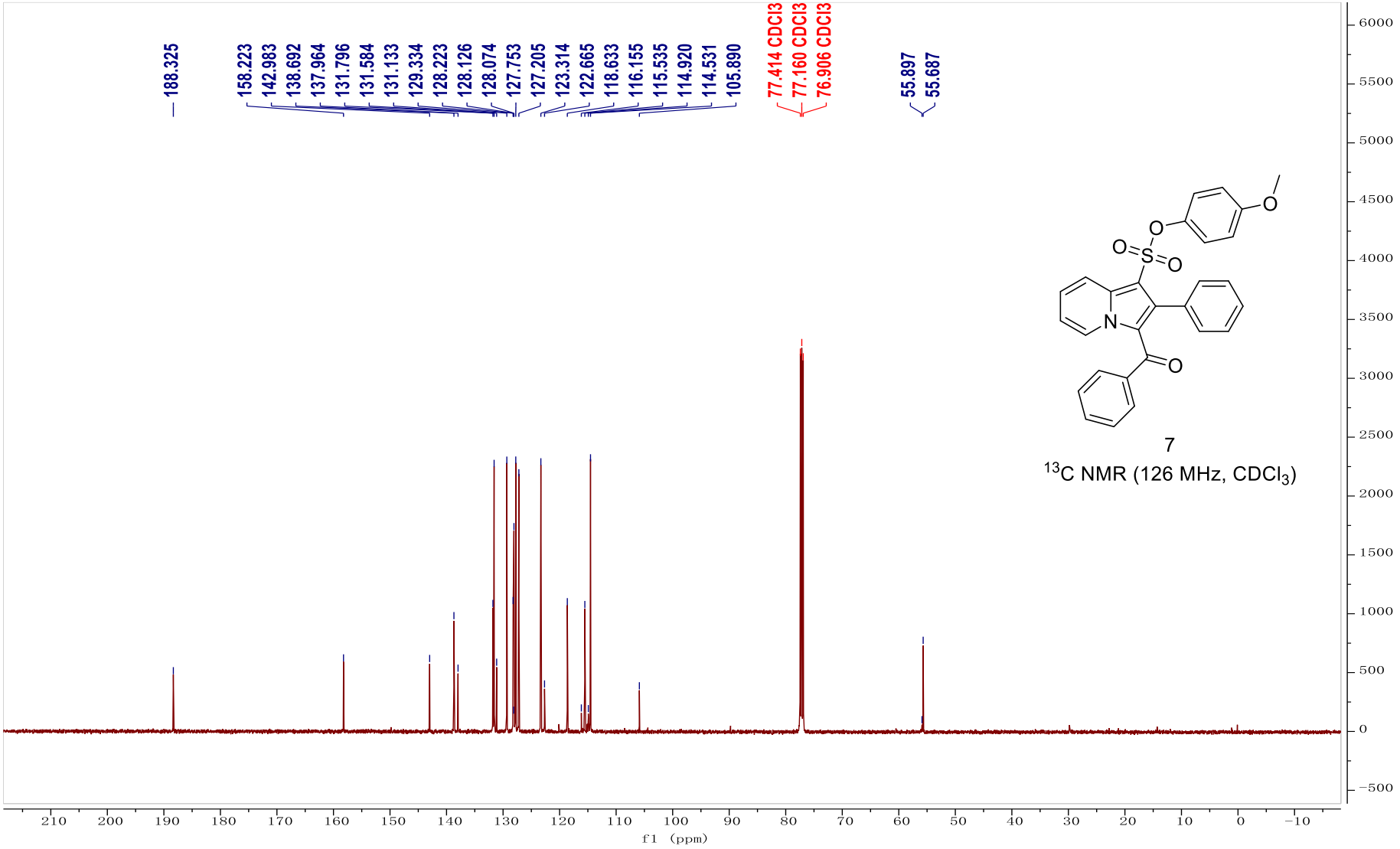

75.978
O
N
FO2S
5d
19FNMR (471 MHz, CDCl3)
2400
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
−100
−200
50
0
−50
−100
−150
−200
−250
f1 (ppm)

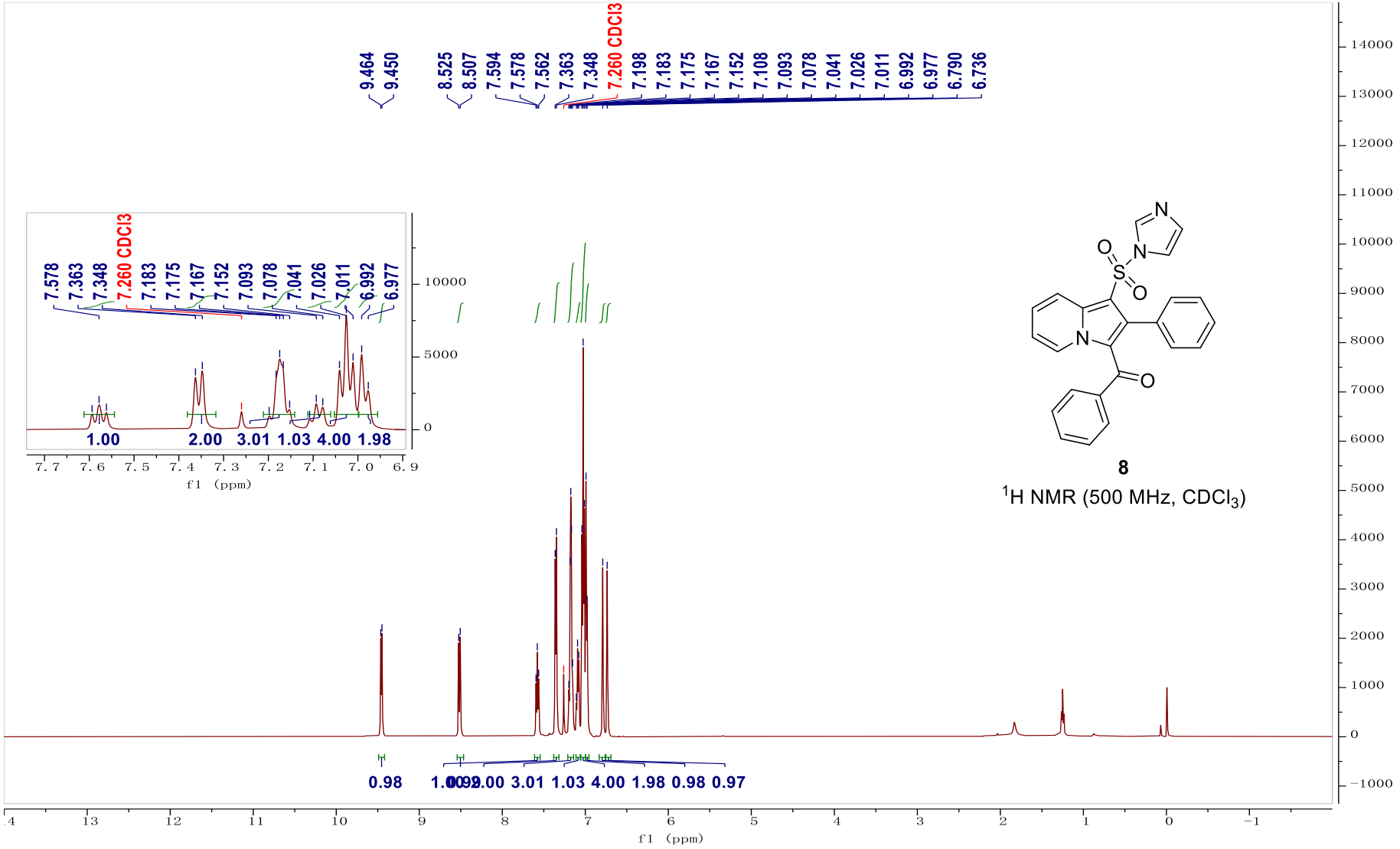

189.655
137.439
136.174
136.143
134.112
133.246
131.215
130.591
130.378
130.121
130.057
129.219
129.007
128.685
128.542
127.758
126.700
125.111
118.542
115.993
105.222
104.991
77.413 CDCl3
77.160 CDCl3
76.904 CDCl3
21.022
O
N
FO2S
5d
13C NMR (126 MHz, CDCl3)
f1 (ppm)

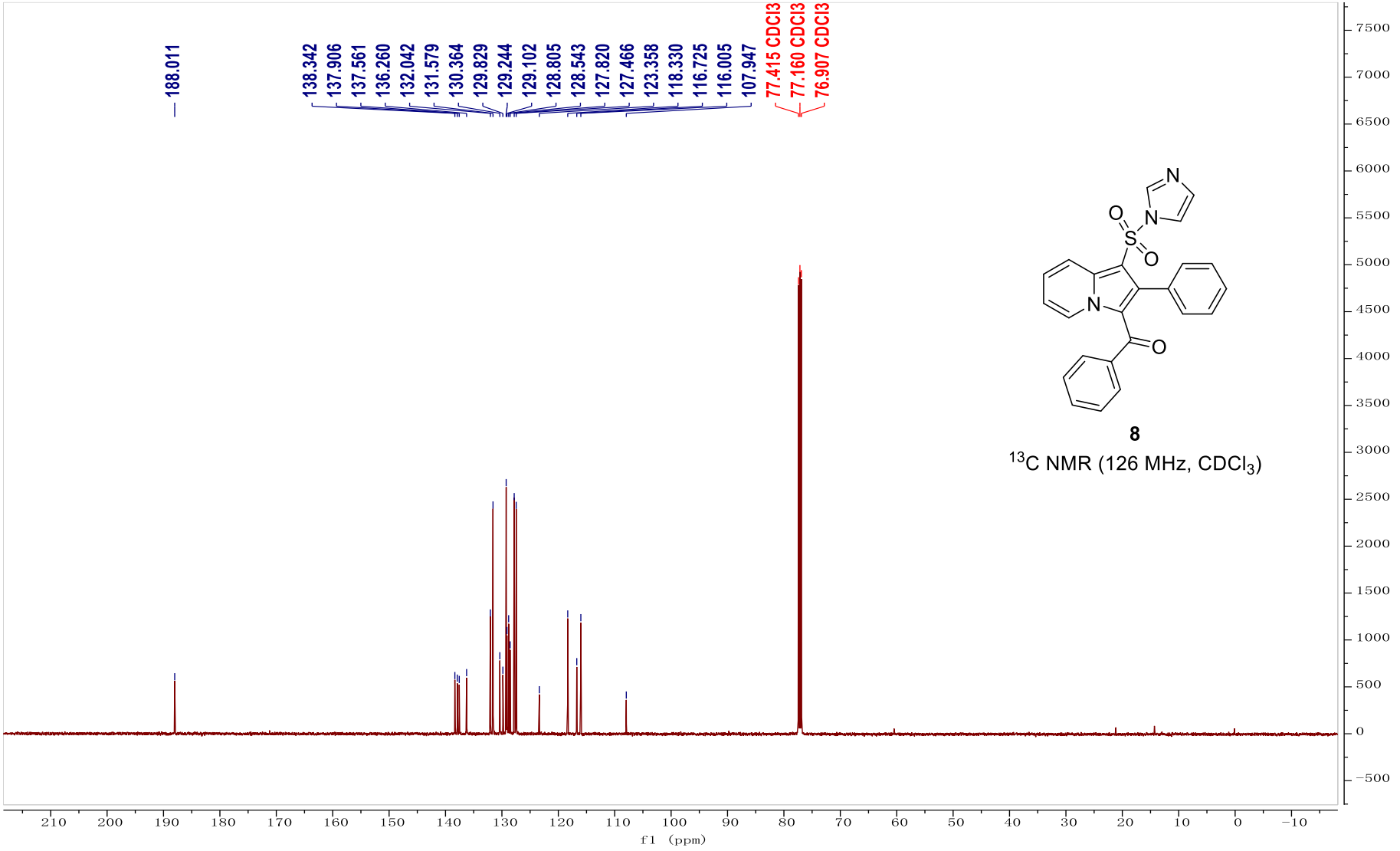

9.481 9.467 8.286 8.268 7.441 7.425 7.385 7.369 7.260 CDCl3 7.187 7.172 7.106 7.093 7.079 7.061 7.048 7.044 7.031 7.017 7.009 6.994 6.979 6.567 6.561 6.544 6.537 2.726 2.720 2.713 2.705 2.483 2.466 2.316 2.306 2.165 2.148 2.040 2.025 1.965 1.945 1.940 1.928 1.923 1.503 1.498 1.485 1.463 1.448 1.440 1.434 1.363 1.269 1.255 0.888
7.385 7.369 7.187 7.093 7.079 7.061 7.048 7.044 7.031 7.017 7.009 6.994 6.561 6.544 6.537
1.03 2.01 1.01 8.98 1.96
f1 (ppm)
6
1H NMR (500 MHz, CDCl3)
0.99 1.03 2.01 1.01 8.98 1.96
2.01 1.03 1.03 3.00 2.00 5.03 1.05 3.04
f1 (ppm)

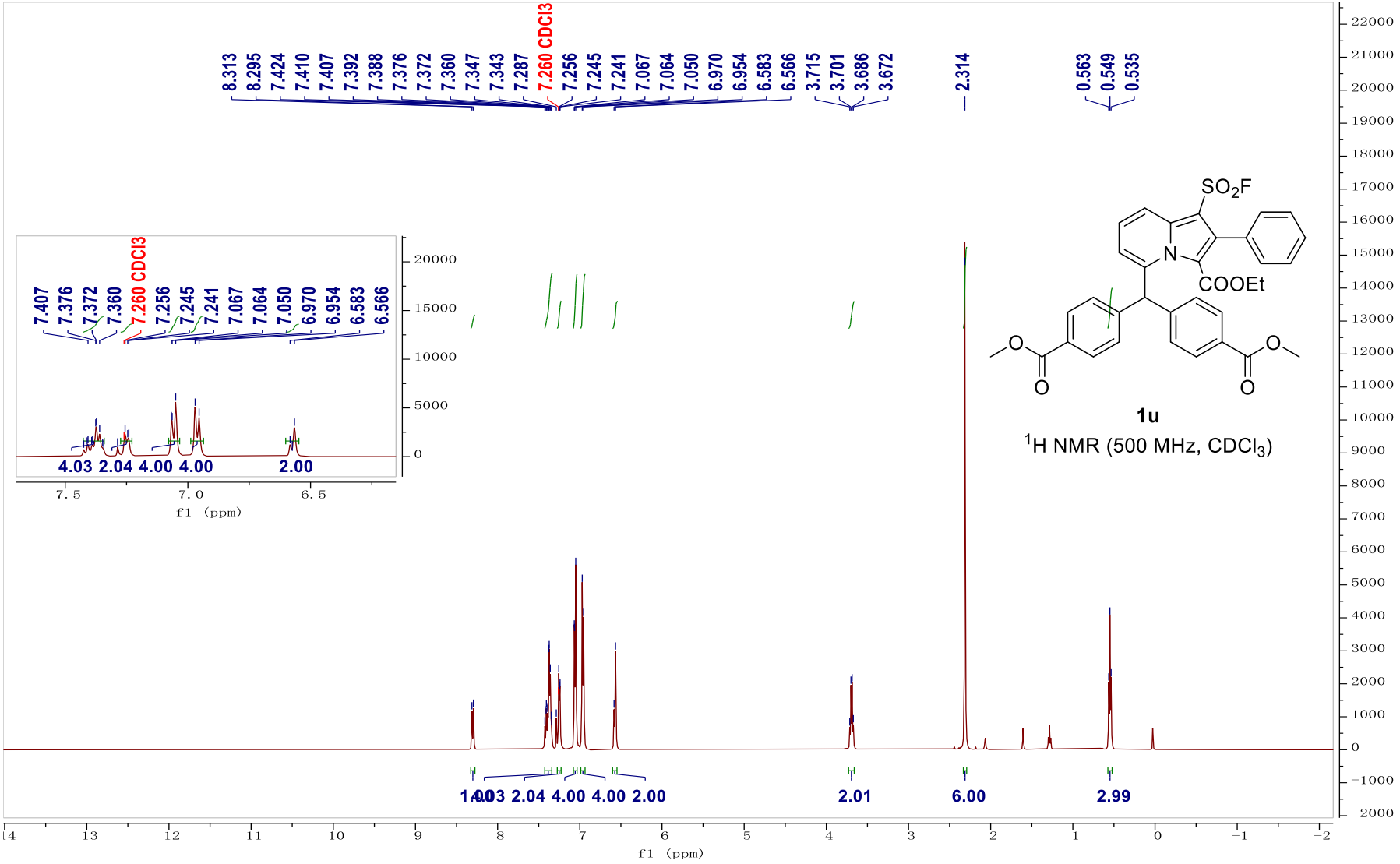

188.310
147.394
138.667
138.540
138.509
138.244
137.893
131.817
131.662
131.187
130.975
129.344
128.913
128.191
128.030
127.979
127.744
127.152
126.434
122.665
122.209
119.056
118.722
115.502
106.272
77.414 CDCl3
77.160 CDCl3
76.906 CDCl3
50.524
47.970
44.190
38.046
35.912
31.630
29.355
26.301
25.837
21.670
13.918
1.131
6
13C NMR (126 MHz, CDCl3)
f1 (ppm)

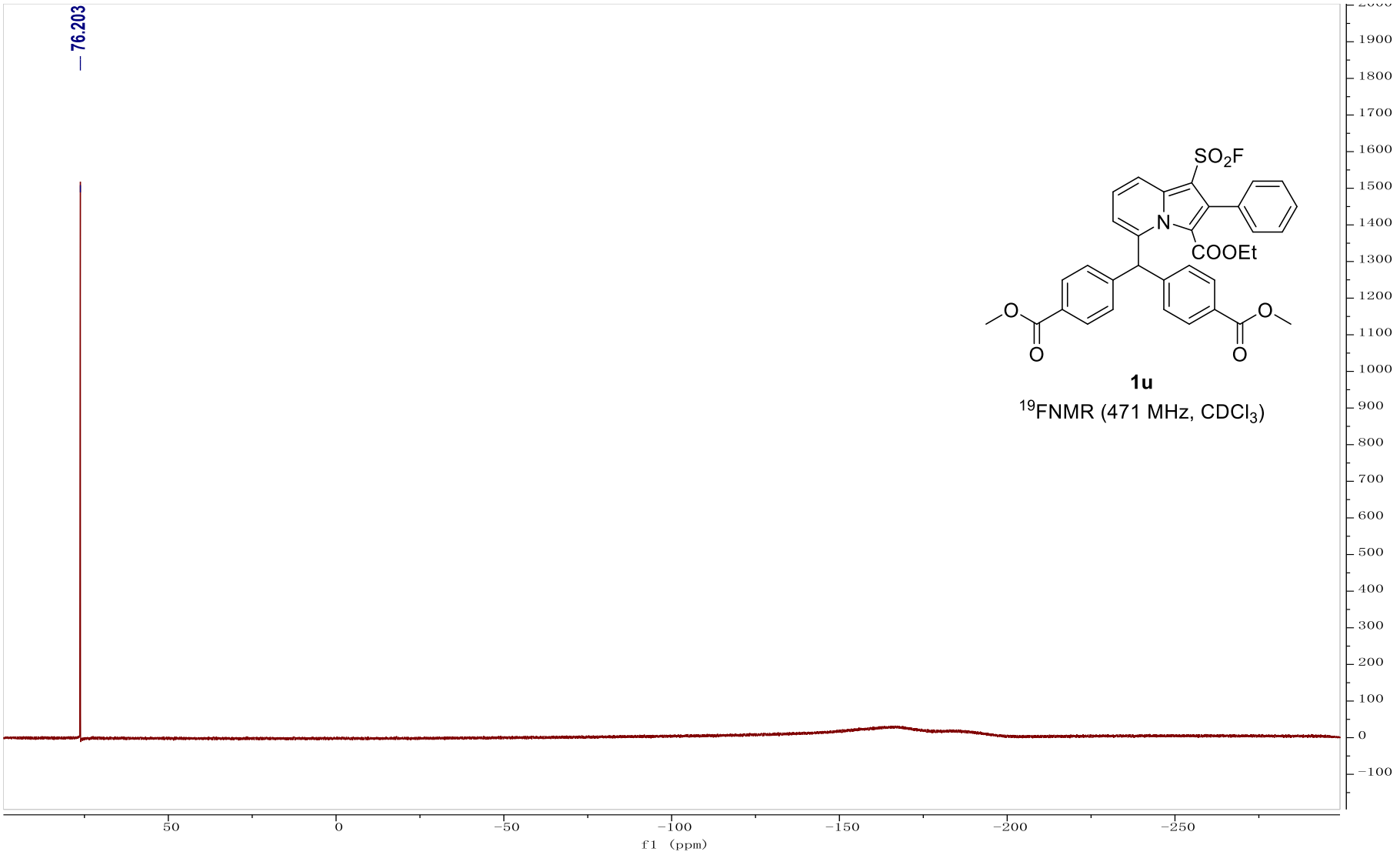

9.493
9.479
8.195
8.176
7.430
7.416
7.412
7.398
7.385
7.369
7.260 CDCl3
7.204
7.189
7.174
7.098
7.083
7.067
7.053
7.038
7.023
7.013
6.998
6.984
6.776
6.759
6.698
6.680
3.729
0.97
0.98
2.99
1.03
7.98
2.16
2.00
2.99
f1 (ppm)
7
1H NMR (500 MHz, CDCl3)

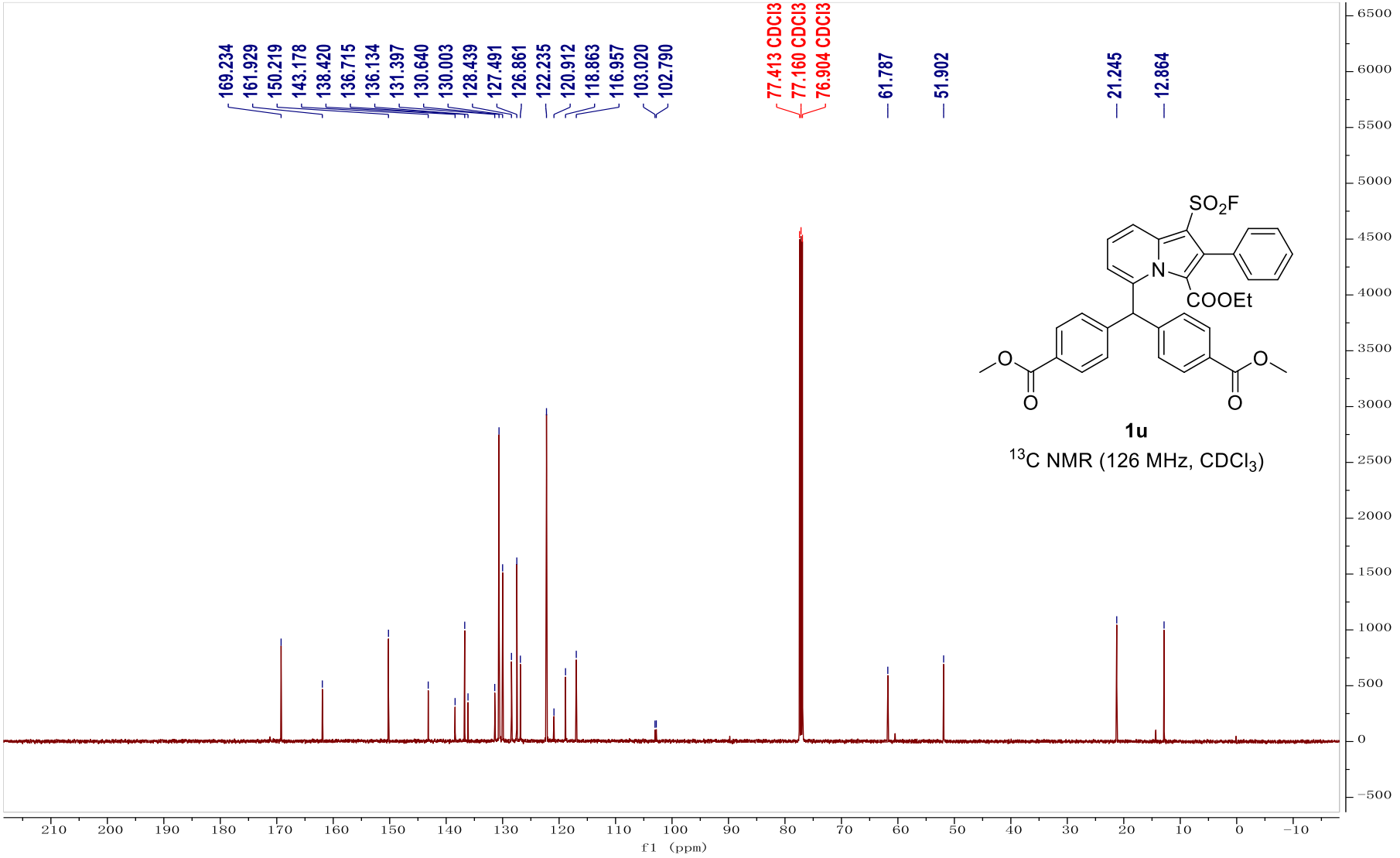

188.325
158.223
142.983
138.692
137.964
131.796
131.584
131.133
129.334
128.223
128.126
128.074
127.753
127.205
123.314
122.665
118.633
116.155
115.535
114.920
114.531
105.890
77.414 CDCl3
77.160 CDCl3
76.906 CDCl3
55.897
55.687
O
O
S
O
O
N
O
7
13C NMR (126 MHz, CDCl3)
f1 (ppm)


9.464
9.450
8.525
8.507
7.594
7.578
7.562
7.363
7.348
7.260 CDCl3
7.198
7.183
7.175
7.167
7.152
7.108
7.093
7.078
7.041
7.026
7.011
6.992
6.977
6.790
6.736
0.98
1.00
2.00
3.01
1.03
4.00
1.98
0.98
0.97
f1 (ppm)
8
1H NMR (500 MHz, CDCl3)

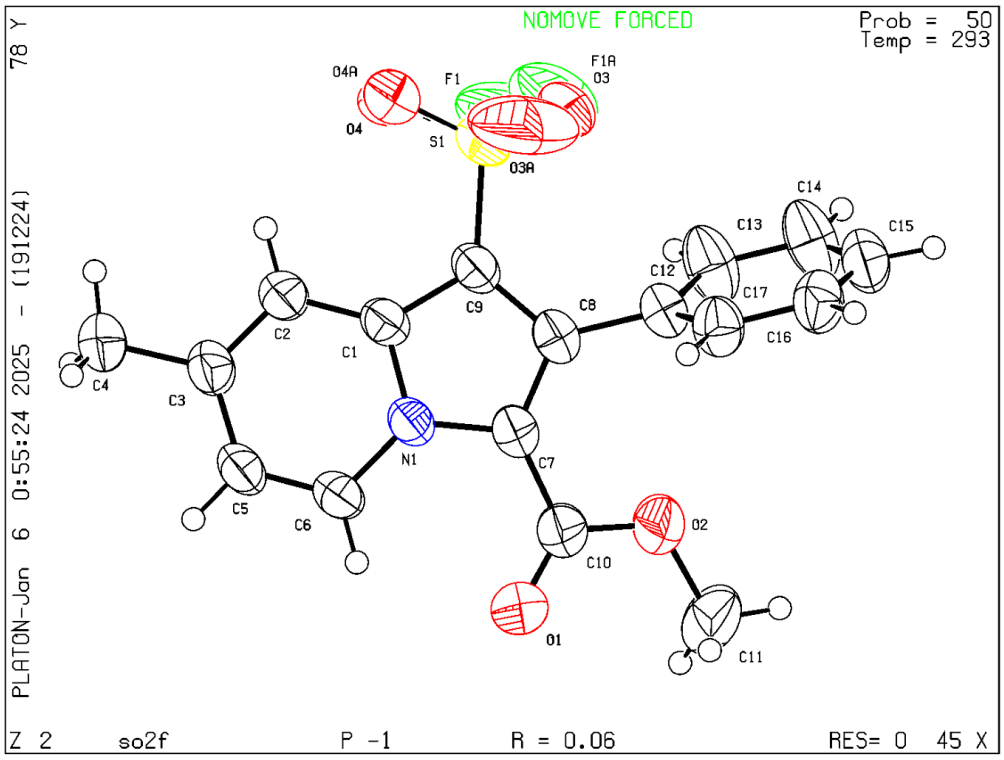

188.011
138.342
137.906
137.561
136.260
132.042
131.579
130.364
129.829
129.244
129.102
128.805
128.543
127.820
127.466
123.358
118.330
116.725
116.005
107.947
77.415 CDCl3
77.160 CDCl3
76.907 CDCl3
8
13C NMR (126 MHz, CDCl3)
f1 (ppm)


8.313
8.295
7.424
7.410
7.407
7.392
7.388
7.376
7.372
7.360
7.347
7.343
7.287
7.260 CDCl3
7.256
7.245
7.241
7.067
7.064
7.050
6.970
6.954
6.583
6.566
3.715
3.701
3.686
3.672
2.314
0.563
0.549
0.535
SO2F
N
COOEt
O
O
O
O
1u
1H NMR (500 MHz, CDCl3)
4.03 2.04 4.00 4.00 2.00
2.01
6.00
2.99
f1 (ppm)


76.203
SO2F
N
COOEt
O
O
O
O
1u
19FNMR (471 MHz, CDCl3)
50
0
−50
−100
−150
−200
−250
f1 (ppm)


169.234
161.929
150.219
143.178
138.420
136.715
136.134
131.397
130.640
130.003
128.439
127.491
126.861
122.235
120.912
118.863
116.957
103.020
102.790
77.413 CDCl3
77.160 CDCl3
76.904 CDCl3
61.787
51.902
21.245
12.864
SO2F
N
COOEt
O
O
O
O
1u
13C NMR (126 MHz, CDCl3)
f1 (ppm)

8. Data of Crystal Structure of 3s



Approximately 50 mg of the purified compound **3s** was dissolved in $CHCl_3$ and placed under dark conditions to evaporate slowly. After several days, colorless crystals were obtained. Data for **3s** were collected from a shock-cooled single crystal at 293(2) K on a XtaLAB Synergy, Dualflex, HyPix four-circle diffractometer with a micro-focus sealed X-ray tube using a mirror as monochromator and a HyPix detector. The diffractometer used Cu K_α radiation (λ = 1.54184 Å). All data were integrated with CrysAlisPro and a multi-scan absorption correction using SCALE3 ABSPACK was applied. The structure was solved by dual methods with SHELXT 2018/2 and refined by full-matrix least-squares methods against F^2 using SHELXL 2018/3. The crystal structure has been deposited at the Cambridge Crystallographic Data Centre (CCDC 2430334).

Table S9 Crystal data and structure refinement for **3s**

CCDC number	2430334
Empirical formula	$C_{17}H_{14}FNO_4S$
Formula weight	347.35
Temperature [K]	293(2)
Crystal system	triclinic
Space group	$P\bar{1}$
a [Å]	9.4933(3)
b [Å]	9.7205(2)
c [Å]	9.7983(2)
α [°]	89.993(2)
β [°]	77.842(2)
γ [°]	70.533(2)
Volume [Å^3]	830.96(4)
Z	2
ρ_{calc} [gcm^{-3}]	1.388
μ [mm^{-1}]	2.020
F(000)	360
Crystal size [mm^3]	0.1×0.11×0.12
Radiation	Cu K_α (λ=1.54184 Å)
2θ range [°]	9.26 to 133.20 (0.84 Å)
Index ranges	$-11 \le h \le 11$, $-10 \le k \le 11$, $-11 \le l \le 11$
Reflections collected	7922
Independent reflections	2896 [R_{int} = 0.0308, R_{sigma} = 0.0356]
Data / Restraints / Parameters	2896 / 27 / 247
Goodness-of-fit on F^2	1.110
Final *R* indexes [$I \ge 2\sigma(I)$]	R_1 = 0.0580, wR_2 = 0.1574
Final *R* indexes [all data]	R_1 = 0.0612, wR_2 = 0.1623
Largest peak/hole [eÅ^{-3}]	0.38/−0.48