# *Supporting Information*

## Photochemical acridone-mediated direct arylation of (hetero)arenes with aryl diazonium salts

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## Contents

# 1. Experimental Section

## 1.1 General information

The aryl diazonium tetrafluoroborates were synthesized according to the previously described methods.[1] Other chemicals were purchased from commercial sources and used without further purification. Melting points (m.p.) were obtained on a digital melting point apparatus and uncorrected. Column chromatography was performed on silica gel (200-300 mesh) by standard technique. Thin-layer chromatography was performed using silica gel plates F254. Visualization was accomplished with short wavelength UV light (254 nm) sources. UV-Vis and fluorescence measurements were performed with UV-2600 UV-visible spectrophotometer and F-7000 FL spectrofluorometer. Melting points were determined using a digital melting point apparatus and uncorrected. $^{1}$H NMR (400 MHz) and $^{13}$C NMR (101 MHz) were recorded with $CDCl_3$. Chemical shifts (δ) were referenced relative to residual solvent signal ($CDCl_3$: $^{1}$H NMR: δ 7.26 ppm, $^{13}$C NMR: 77.16 ppm). All chemical shifts were reported as δ values (ppm) relative to TMS and observed coupling constants (*J*) are given in Hertz (Hz). The followed abbreviations are used to describe peak patterns where appropriate: (s = singlet, d = doublet, t = triplet, q = quartet, dd = doublet of doublets, ddd = doublet of doublets of doublets, td = triplet of doublets, m = multiplet). High-resolution mass spectra were measured with HRMS-ESI-Q-TOF.

## 1.2 Synthesis of 4-bromobenzenediazonium tetrafluoroborate 1

Sodium nitrite (0.76 g, 11 mmol) dissolved in 1 mL of water was slowly added to the cold mixture of the appropriate aniline (1.27 g, 10 mmol) and 50% of $HBF_4$ (5 mL, 40 mmol) in 2 mL of water. The mixture was stirred for 1.5 h at 0°C and the precipitate was collected by filtration and redissolved in the least amount of acetone. Then the diazonium salt was recrystallized and washed several times using diethyl ether and dried under vacuum. The same procedure was followed by preparation of other

diazonium salts.

### 1.3 Reaction procedure for C-H arylation of benzene, furan and thiophene.

In a 10 mL Schlenk tube equipped with a magnetic stirrer bar was charged with acridone (0.1 equiv), aryl diazonium tetrafluoroborate **1** (0.5 mmol) and (hetero)arene (5 mmol) dissolved in dry DMSO (2 mL). The reaction mixture was stirred under irradiation of 10 W blue LEDs at room temperature for 6 h, then washed with brine and extracted with ethyl acetate. The organic layers were combined and dried over anhydrous $Na_2SO_4$. The solvent was removed under reduced pressure, and the residue was purified by flash column chromatography on silica gel using petroleum ether to afford the desired products.

### 1.4 Reaction procedure for C-H arylation of mesitylene.

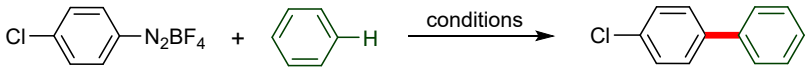
In a 10 mL Schlenk tube equipped with a magnetic stirrer bar was charged with acridone (0.1 equiv), aryl diazonium tetrafluoroborate **1** (0.5 mmol) and mesitylene (2.5 mmol) dissolved in dry DMSO (2 mL). The reaction mixture was stirred under irradiation of 10 W blue LEDs at room temperature for 6 h, then washed with brine and extracted with ethyl acetate. The organic layers were combined and dried over anhydrous $Na_2SO_4$. The solvent was removed under reduced pressure, and the residue was purified by flash column chromatography on silica gel using petroleum ether to afford the desired products.

### 1.5 Reaction procedure for C-H arylation of pyrrole and benzofuran

In a 10 mL Schlenk tube equipped with a magnetic stirrer bar was charged with acridone (0.1 equiv), aryl diazonium tetrafluoroborate **1** (0.5 mmol) and heteroarene (2.5 mmol) dissolved in dry DMSO (2 mL). The reaction mixture was stirred under irradiation of 10 W blue LEDs at room temperature for 6 h, then washed with brine and extracted with ethyl acetate. The organic layers were combined and dried over anhydrous $Na_2SO_4$. The solvent was removed under reduced pressure, and the residue

was purified by flash column chromatography on silica gel using petroleum ether to afford the desired products.

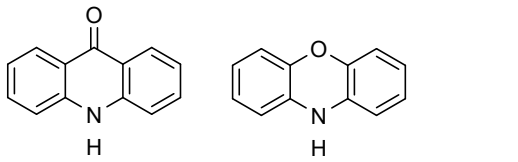
### 1.6 Screening of reaction conditions[a]




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

| Entry | Cat. (mol%) | Solvent | Time (h) | Yield[b](%) |
|---|---|---|---|---|
| 1 | PC 1(10.0) | DMSO | 12 | 76 |
| 2 | PC 1(10.0) | DMSO | 10 | 77 |
| 3 | PC 1(10.0) | DMSO | 8 | 77 |
| **4** | **PC 1(10.0)** | **DMSO** | **6** | **77** |
| 5 | PC 1(0) | DMSO | 6 | N.D. |
| 6[c] | PC 1(10.0) | DMSO | 6 | N.D. |
| 7[d] | PC 1(10.0) | DMSO | 6 | 77 |
| 8[e] | PC 1(10.0) | DMSO | 6 | 35 |
| 9[f] | PC 1(10.0) | DMSO | 6 | 72 |
| 10 | PC 1(5.0) | DMSO | 6 | 65 |
| 11 | PC 1(3.0) | DMSO | 12 | 50 |
| 12 | PC 1(20.0) | DMSO | 6 | 75 |
| 13 | PC 2(10.0) | DMSO | 6 | 45 |
| 14 | PC 3(10.0) | DMSO | 6 | 63 |
| 15 | PC 4(10.0) | DMSO | 6 | 60 |
| 16 | PC 5(10.0) | DMSO | 6 | 52 |
| 17 | PC 1(10.0) | DMF | 6 | 49 |
| 18 | PC 1(10.0) | THF | 6 | 30 |
| 19 | PC 1(10.0) | MeCN | 6 | 52 |

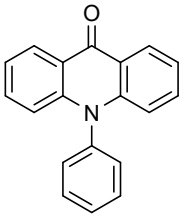
[a]Reaction conditions: **1a** (0.5 mmol), **2a** (5 mmoL), **PC** (10 mol%), DMSO (2 ml), blue LEDs, rt, 6h, air. [b]Isolated yields. [c]Reaction was conducted in the dark. [d]Benzene (20 equiv) was used. [e]With a 10 W green LEDs irradiation. [f]With a 10 W white LEDs irradiation.



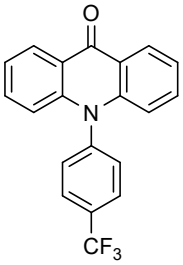
PC1



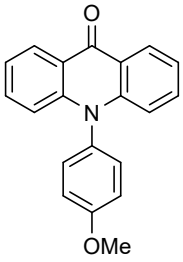
PC2



PC3

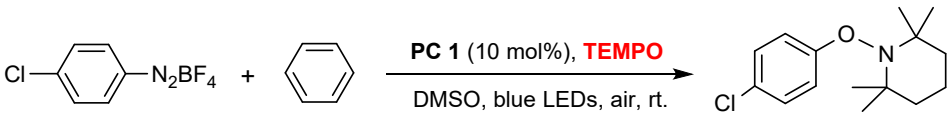


PC4



PC5

## 1.7 Radical Capturing Experiments




**1a** **2a** **5,** M = 267.14

In a 10 mL Schlenk tube equipped with a magnetic stirrer bar was charged with acridone (0.1 equiv), aryl diazonium tetrafluoroborate **1a** (0.5 mmol), benzene (**2a**) (5 mmol) and TEMPO (2 equiv) dissolved in dry DMSO (2 mL). The reaction mixture was stirred under irradiation of 10 W blue LEDs at room temperature for 6 h, then washed with brine and extracted with ethyl acetate. The organic layers were combined and dried over anhydrous $Na_2SO_4$. The solvent was removed under reduced pressure, and the residue was purified by flash column chromatography on silica gel using petroleum ether to afford the desired products.

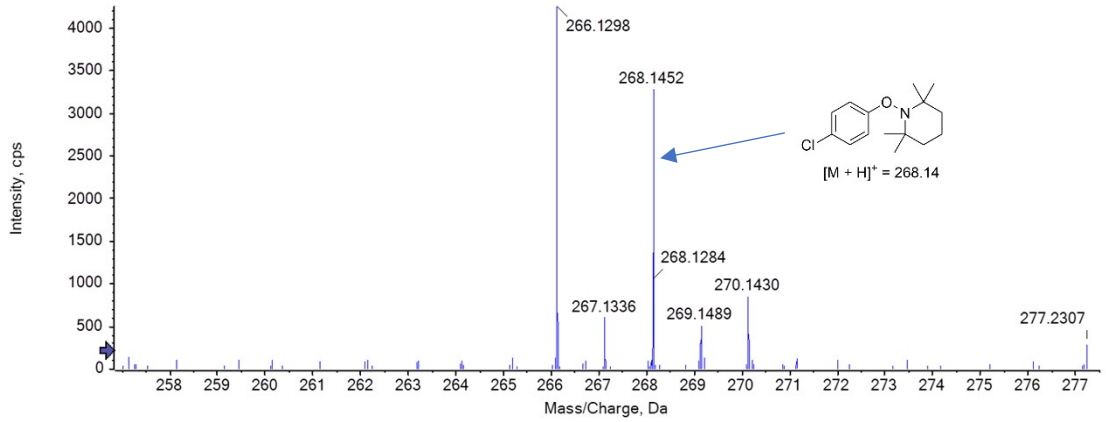
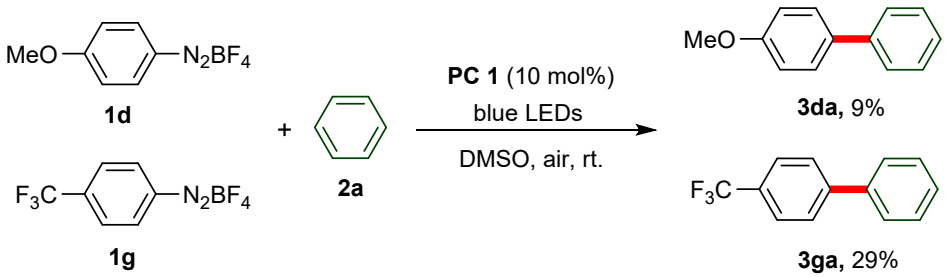


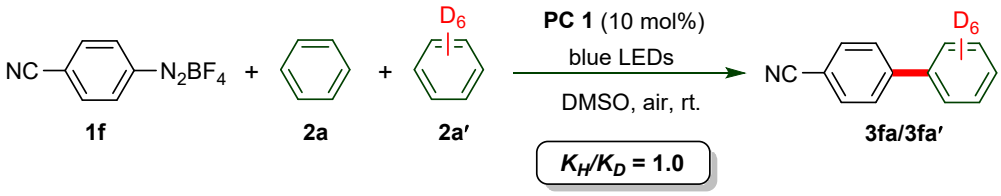

**Figure S1**. Mass spectra of radical trapped compounds with TEMPO.

### 1.8 Intermolecular Competition Experiments




In a 10 mL Schlenk tube equipped with a magnetic stirrer bar was charged with acridone (0.1 equiv), 4-methoxyphenyl diazonium tetrafluoroborate (**1d**) (75 mg, 0.25 mmol), 4-(trifluoromethyl)phenyl diazonium tetrafluoroborate (**1g**) (50.5 mg, 0.25 mmol) and benzene (**2a**) (10 mmol) dissolved in dry DMSO (2 mL). The reaction mixture was stirred under irradiation of 10 W blue LEDs at room temperature for 6 h, then washed with brine and extracted with ethyl acetate. The organic layers were combined and dried over anhydrous $Na_2SO_4$. The solvent was removed under reduced pressure, and the residue was purified by flash column chromatography on silica gel using petroleum ether to afford the desired products **3da** (4 mg, 9%) and **3ga** (16 mg, 29%)。

## 1.9 Intermolecular Competition Experiments




In a 10 mL Schlenk tube equipped with a magnetic stirrer bar was charged with acridone (0.1 equiv), 4-cyanophenyl diazonium tetrafluoroborate (**1f**) (0.5 mmol), benzene (**2a**) (5 mmol), benzene (**2a**) -$d_6$ (5 mmol) dissolved in dry DMSO (2 mL). The reaction mixture was stirred under irradiation of 10 W blue LEDs at room temperature for 6 h, then washed with brine and extracted with ethyl acetate. The organic layers were combined and dried over anhydrous $Na_2SO_4$. The solvent was removed under reduced pressure, and the residue was purified by flash column chromatography on silica gel using petroleum ether to afford the desired products **3fa**/**[D]$_5$-3fa** (31 mg, 35%).

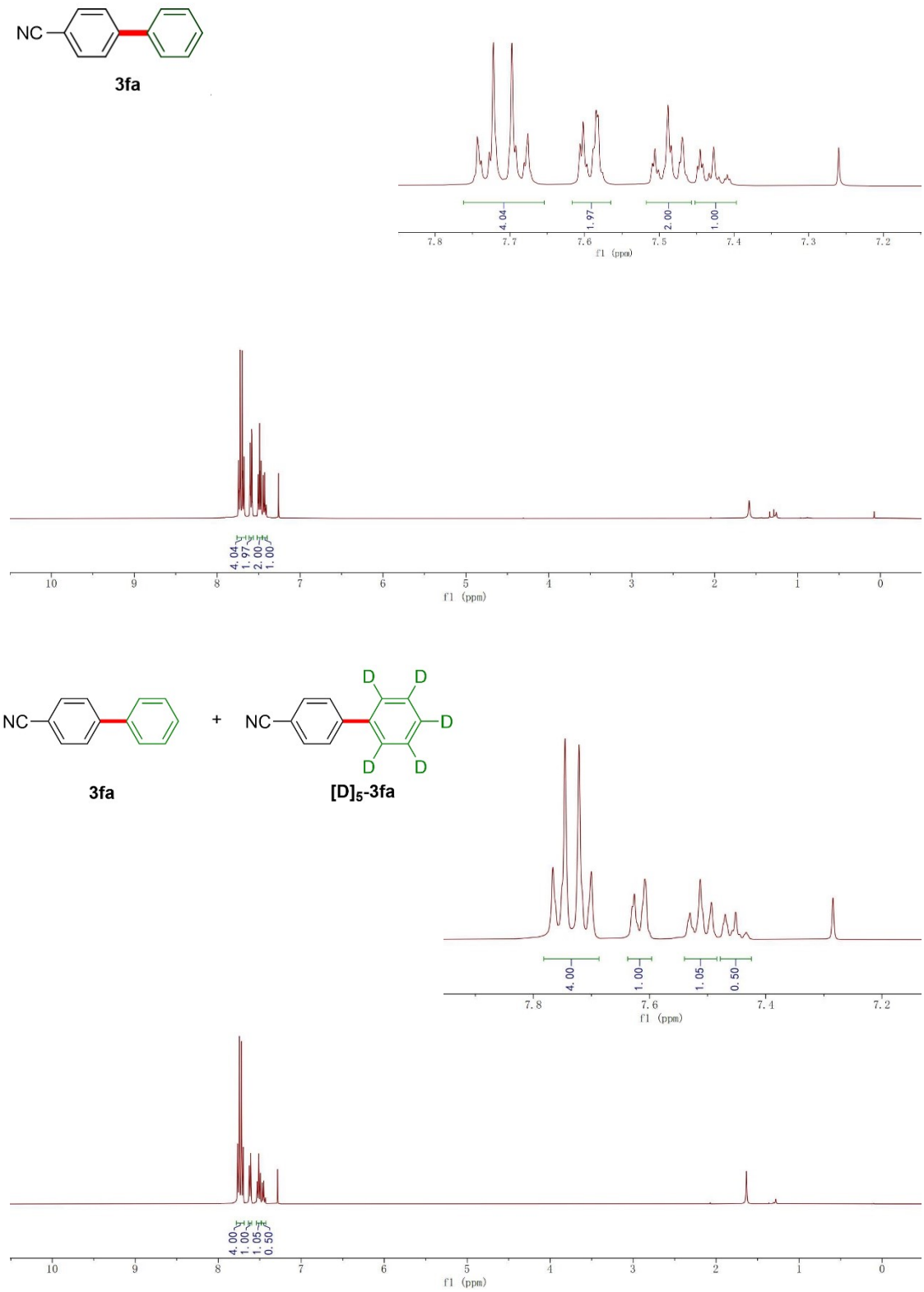



**Figure S2**. $^{1}$H NMR of **3fa** and **3fa**+**[D]$_5$-3fa**.

## 1.10 The UV-visible absorption experiment:

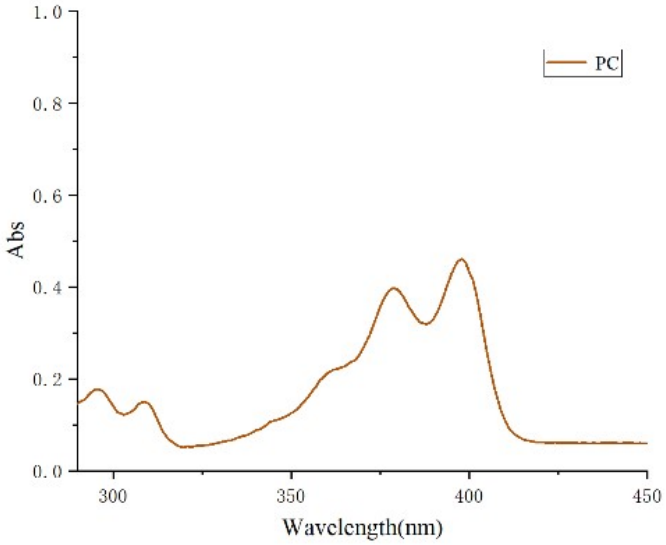
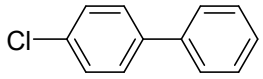


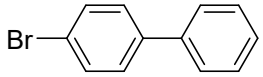

**Figure S3**. UV-visible spectra of acridone in DMSO.

## 2. Characterization data of products



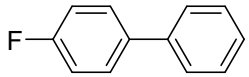
**4-chloro-1,1'-biphenyl (3aa)**[2]

Colorless solid; 77% yield. $R_f$ = 0.9 (Petroleum ether), m.p. = 78 °C. **$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.59-7.49 (m, 4H), 7.48-7.36 (m, 5H). **$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 13C NMR (101 MHz, Chloroform-d) δ 140.01, 139.69, 133.40, 128.93, 128.91, 128.42, 127.61, 127.01.



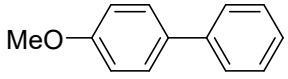
**4-bromo-1,1'-biphenyl (3ba)**[3]

Colorless solid; 67% yield. $R_f$ = 0.9 (Petroleum ether), m.p. = 91 °C. **$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.59-7.53 (m, 4H), 7.49-7.42 (m, 4H), 7.40-7.34 (m, 1H). **$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 140.16, 140.03, 131.89, 128.93, 128.77, 127.67, 126.97, 121.56.



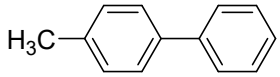
**4-fluoro-1,1'-biphenyl (3ca)**[2]

White solid; 69% yield. $R_f$ = 0.9 (Petroleum ether), m.p. = 74 °C. **$^1$H NMR** (400 MHz, $CDCl_3$) δ7.56 (dd, *J* = 8.2, 3.9 Hz, 4H), 7.45 (t, *J* = 7.6 Hz, 2H), 7.39-7.33 (m, 1H), 7.14 (t, *J* = 8.6 Hz, 2H). **$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 163.71, 161.27, 140.28, 137.35, 128.84, 128.75, 128.67, 127.28, 127.04, 115.74, 115.52.



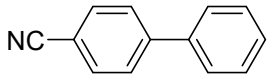
**4-methoxy-1,1'-biphenyl (3da)**[2]

Colorless solid; 34% yield. $R_f$ = 0.6 (Petroleum ether), m.p. = 90 °C. **$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.61-7.50 (m, 4H), 7.47-7.38 (m, 2H), 7.35-7.28 (m, 1H), 7.04-6.95 (m, 2H), 3.86 (s, 3H). **$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 159.16, 140.85, 133.80, 128.75, 128.18, 126.76, 126.68, 114.22, 55.37.



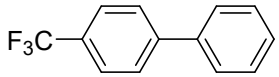
**4-methyl -1,1'-biphenyl (3ea)**[4]

White solid; 44% yield. $R_f$ = 0.9 (Petroleum ether), m.p. = 50 °C. **$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.70-7.53 (m, 4H), 7.52-7.45 (m, 2H), 7.38 (td, *J* = 7.2, 1.6 Hz, 1H), 7.31 (dd, *J* = 7.7, 4.7 Hz, 2H), 2.46 (s, 3H). **$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 141.26, 138.57, 138.46, 138.34, 137.08, 129.57, 128.80, 127.87, 127.81, 127.08, 127.06, 124.18, 121.17.



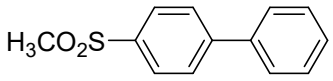
**[1,1'-biphenyl]-4-carbonitrile (3fa)**[5]

Off white solid; 65% yield. $R_f$ = 0.2 (Petroleum ether), m.p. = 85 °C. **$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.76-7.65 (m, 4H), 7.62-7.57 (m, 2H), 7.52-7.46 (m, 2H), 7.45-7.40 (m, 1H). **$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 145.70, 139.20, 132.61, 129.13, 128.67, 127.75, 127.24, 118.94, 110.95.



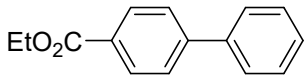
**4-trifluoromethyl -1,1'-biphenyl (3ga)**[3]

Colorless solid; 72% yield. $R_f$ = 0.9 (Petroleum ether), m.p. = 70 °C. **$^1$H NMR** (400 MHz, $CDCl_3$) δ7.70 (s, 4H), 7.63-7.58 (m, 2H), 7.48 (t, *J* = 7.4 Hz, 2H), 7.44-7.38 (m, 1H). **$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 144.75, 139.79, 129.52, 129.20, 129.00, 128.38, 128.20, 127.44, 127.30, 125.78, 125.74, 125.70, 125.67, 122.98.



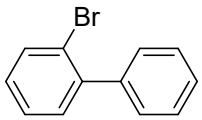
**4-methylsulfonyl -1,1'-biphenyl (3ha)**[6]

Colorless solid; 60% yield. $R_f$ = 0.5 (10% of Ethyl acetate in Petroleum ether), m.p. = 145 °C. **$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.07-8.01 (m, 2H), 7.83-7.77 (m, 2H), 7.67-7.61 (m, 2H), 7.55-7.49 (m, 2H), 7.49-7.43 (m, 1H), 3.12 (s, 3H). **$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 146.75, 139.15, 139.10, 129.14, 128.72, 128.02, 127.94, 127.42, 44.66.



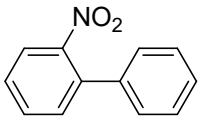
**ethyl [1,1'-biphenyl]-4-carboxylate (3ia)**[7]

Colorless solid; 70% yield. $R_f$ = 0.3 (Petroleum ether), m.p. = 93 °C. **$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.17-8.07 (m, 2H), 7.70-7.60 (m, 4H), 7.51-7.44 (m, 2H), 7.43-7.37 (m, 1H), 4.41 (q, *J* = 7.1 Hz, 2H), 1.42 (t, *J* = 7.1 Hz, 3H). **$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 166.66, 145.67, 140.21, 130.19, 129.40, 129.05, 128.23, 127.41, 127.13, 61.09, 14.49.



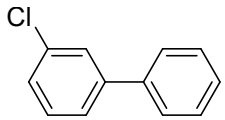
**2-bromo-1,1'-biphenyl (3ka)**[8]

Colorless oil; 65% yield. $R_f$ = 0.9 (Petroleum ether). **$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.71 (d, *J* = 7.5 Hz, 1H), 7.50-7.41 (m, 5H), 7.41-7.35 (m, 2H), 7.24 (ddd, *J* = 8.8, 6.6, 2.4 Hz, 1H). **$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 142.63, 141.15, 133.14, 131.31, 129.41, 128.74, 127.99, 127.63, 127.39, 122.67.



**2-nitro-1,1'-biphenyl (3la)**[9]

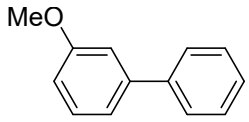
Yellow solid; 69% yield. $R_f$ = 0.2 (Petroleum ether), m.p. = 37 °C. **$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.86 (dd, *J* = 8.1, 1.3 Hz, 1H), 7.62 (td, *J* = 7.5, 1.3 Hz, 1H), 7.52-7.40 (m, 5H), 7.33 (dd, *J* = 7.4, 2.0 Hz, 2H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ149.33, 137.40, 136.37, 132.30, 131.98, 128.71, 128.26, 128.18, 127.91, 124.10.



**3-chloro-1,1'-biphenyl (3ma)**[10]

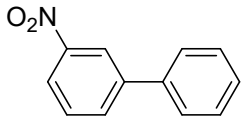
Colorless oil; 45% yield. $R_f$ = 0.9 (Petroleum ether). **$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.53-7.43 (m, 5H), 7.41 (dt, *J* = 5.7, 3.3 Hz, 1H), 7.33 (dtd, *J* = 16.1, 7.2, 2.3 Hz, 3H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 140.56, 139.44, 132.54, 131.41, 129.97, 129.48,

128.56, 128.07, 127.63, 126.85.



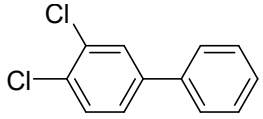

**3-methoxy-1,1'-biphenyl (3na)**[11]

White solid; 60% yield. $R_f$ = 0.6 (Petroleum ether), m.p. = 89 °C. **$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.59-7.50 (m, 4H), 7.42 (t, *J* = 7.7 Hz, 2H), 7.34-7.28 (m, 1H), 7.03-6.95 (m, 2H), 3.86 (s, 3H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 159.15, 140.84, 133.80, 128.74, 128.18, 126.76, 126.68, 114.21, 55.37.



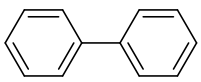

**3-nitro-1,1'-biphenyl (3oa)**[12]

Yellow solid; 65% yield. $R_f$ = 0.2 (Petroleum ether), m.p. = 62 °C. **$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.46 (t, *J* = 2.0 Hz, 1H), 8.20 (ddd, *J* = 8.2, 2.3, 1.1 Hz, 1H), 7.92 (dt, *J* = 7.8, 1.4 Hz, 1H), 7.66-7.58 (m, 3H), 7.54-7.47 (m, 2H), 7.47-7.41 (m, 1H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 146.88, 146.56, 143.07, 130.31, 129.95, 129.86, 125.21, 124.13, 119.27, 116.32.




**3,4-dichloro-1,1'-biphenyl (3pa)**[13]

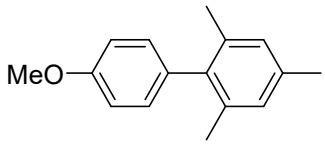
Little yellow solid; 60% yield. $R_f$ = 0.8 (Petroleum ether), m.p. = 46 °C. **$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.68 (s, 1H), 7.60-7.34 (m, 8H). **$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 141.26, 138.79, 132.84, 131.44, 130.70, 129.03, 128.14, 126.98, 126.39.



**1,1'-biphenyl (3qa)**[14]

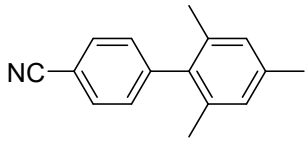
Colorless solid; 75% yield. $R_f$ = 0.9 (Petroleum ether). **$^1$H NMR** (400 MHz, $CDCl_3$) δ

7.72-7.66 (m, 4H), 7.53 (t, *J* = 7.6 Hz, 4H), 7.46-7.40 (m, 2H). **$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 141.34, 128.87, 127.37, 127.28.



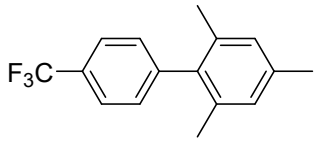

**4'-methoxy-2,4,6-trimethyl-1,1'-biphenyl (3db)**[2]

White solid; 32% yield. $R_f$ = 0.9 (Petroleum ether), m.p. = 74 °C. **$^{1}$H NMR** (400 MHz, $CDCl_3$) δ 7.10-7.05 (m, 2H), 7.00-6.94 (m, 4H), 3.87 (s, 3H), 2.35 (s, 3H), 2.04 (s, 6H). **$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 158.21, 138.70, 136.46, 133.32, 130.34, 128.05, 113.78, 55.23, 21.05, 20.84.



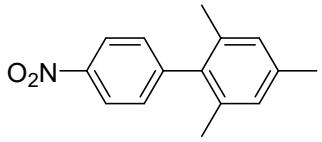

**2',4',6'-trimethyl-[1,1'-biphenyl]-4-carbonitrile (3fb)**[15]

White oil; 81% yield. $R_f$ = 0.2 (Petroleum ether). **$^{1}$H NMR** (400 MHz, $CDCl_3$) δ 7.75-7.71 (m, 2H), 7.28 (d, *J* = 8.3 Hz, 2H), 6.97 (s, 2H), 2.35 (s, 3H), 1.99 (s, 6H). **$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 146.45, 137.60, 137.17, 135.33, 132.34, 130.38, 128.39, 119.05, 110.67, 21.07, 20.64.



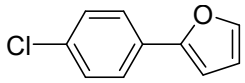

**2,4,6-trimethyl-4'-(trifluoromethyl)-1,1'-biphenyl (3gb)**[7]

White solid; 69% yield. $R_f$ = 0.9 (Petroleum ether), m.p. = 59 °C. **$^{1}$H NMR** (400 MHz, $CDCl_3$) δ 7.71 (d, *J* = 8.0 Hz, 2H), 7.30 (d, *J* = 7.9 Hz, 2H), 6.99 (s, 2H), 2.37 (s, 3H), 2.02 (s, 6H). **$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 145.08, 137.65, 137.28, 135.65, 129.81, 129.09, 128.77, 128.28, 125.76, 125.49, 125.45, 125.41, 125.37, 123.06, 21.05, 20.69.



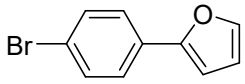
**2,4,6-trimethyl-4'-nitro-1,1'-biphenyl (3jb)**[16]

Yellow solid; 80% yield. $R_f$ = 0.3 (Petroleum ether), m.p. = 94 °C. **$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.36-8.26 (m, 2H), 7.38-7.29 (m, 2H), 6.97 (s, 2H), 2.35 (s, 3H), 1.99 (s, 6H). **$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 148.59, 146.87, 137.75, 136.79, 135.28, 130.49, 128.43, 123.78, 21.06, 20.65.



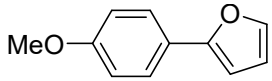
**2-(4-chlorophenyl) furan (3ac)**[17]

Colorless solid; 70% yield. $R_f$ = 0.8 (Petroleum ether), m.p. = 67 °C. **$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.63-7.57 (m, 2H), 7.47 (d, *J* = 1.3 Hz, 1H), 7.38-7.33 (m, 2H), 6.64 (d, *J* = 2.7 Hz, 1H), 6.48 (dd, *J* = 3.4, 1.8 Hz, 1H). **$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 152.95, 142.35, 132.97, 129.39, 128.89, 125.03, 111.80, 105.44.



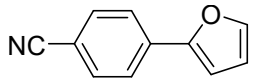
**2-(4-bromophenyl) furan (3bc)**[7]

Colorless solid; 76% yield. $R_f$ = 0.8 (Petroleum ether), m.p. = 85 °C. **$^1$H NMR** (400 MHz, $CDCl_3$) δ7.57-7.44 (m, 5H), 6.65 (d, *J* = 3.4 Hz, 1H), 6.47 (dd, *J* = 3.4, 1.8 Hz, 1H). **$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 152.96, 142.40, 131.81, 129.81, 125.30, 121.07, 111.81, 105.54.



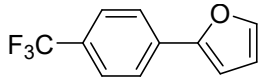
**2-(4-methoxyphenyl) furan (3dc)**[18]

Colorless solid; 33% yield. $R_f$ = 0.5 (Petroleum ether), m.p. = 58 °C. **$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.66-7.55 (m, 2H), 7.43 (dd, *J* = 1.9, 0.8 Hz, 1H), 6.97-6.87 (m, 2H), 6.48 (ddd, *J* = 28.0, 3.4, 1.3 Hz, 2H), 3.84 (s, 3H). **$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 159.06, 154.08, 141.38, 125.26, 124.09, 114.15, 103.37, 55.32.



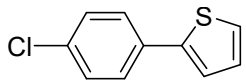
**4-(furan-2-yl) benzonitrile (3fc)**[17]

Pale orange solid; 80% yield. $R_f$ = 0.2 (Petroleum ether), m.p. = 49 °C. **$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.77-7.72 (m, 2H), 7.68-7.63 (m, 2H), 7.54 (d, *J* = 1.7 Hz, 1H), 6.81 (dd, *J* = 3.4, 0.7 Hz, 1H), 6.53 (dd, *J* = 3.4, 1.8 Hz, 1H). **$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 151.98, 143.71, 134.66, 132.61, 123.95, 118.99, 112.27, 110.27, 108.19.



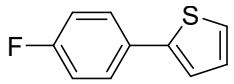
**2-(4-(trifluoromethyl) phenyl) furan (3gc)**[17]

Colorless solid; 74% yield. $R_f$ = 0.8 (Petroleum ether), m.p. = 88 °C. **$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.76 (d, *J* = 8.2 Hz, 2H), 7.63 (d, *J* = 8.3 Hz, 2H), 7.52 (d, *J* = 1.7 Hz, 1H), 6.77 (d, *J* = 3.4 Hz, 1H), 6.51 (dd, *J* = 3.4, 1.8 Hz, 1H). **$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 152.52, 143.10, 133.97, 129.12, 128.80, 125.77, 125.74, 125.70, 125.66, 125.54, 123.77, 122.84, 111.97, 106.98.



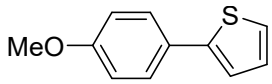
**2-(4-chlorophenyl) thiophene (3ad)**[7]

Colorless solid; 66% yield. $R_f$ = 0.9 (Petroleum ether), m.p. = 83 °C. **$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.56-7.52 (m, 2H), 7.36-7.33 (m, 2H), 7.31-7.28 (m, 2H), 7.10-7.06 (m, 1H). **$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 143.11, 133.22, 132.95, 129.05, 128.18, 127.13, 125.23, 123.48.



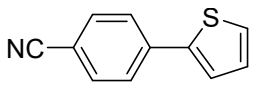
**2-(4-fluorophenyl) thiophene (3cd)**[7]

Colorless solid; 65% yield. $R_f$ = 0.9 (Petroleum ether), m.p. = 48 °C. **$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.61 (t, *J* = 6.9 Hz, 2H), 7.36-7.26 (m, 2H), 7.13 (d, *J* = 8.6 Hz, 3H). **$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 163.57, 161.12, 143.36, 130.76, 130.73, 128.09, 127.68, 127.60, 124.81, 123.13, 115.95, 115.74.



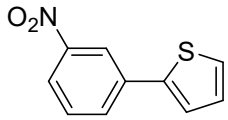

**2-(4-methoxyphenyl) thiophene (3dd)**[18]

Colorless solid; 40% yield. $R_f$ = 0.9 (Petroleum ether), m.p. = 103 °C. **$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.58-7.49 (m, 2H), 7.25-7.18 (m, 2H), 7.06 (dd, *J* = 5.1, 3.6 Hz, 1H), 6.95-6.89 (m, 2H), 3.84 (s, 3H). **$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 159.19, 144.35, 127.95, 127.32, 127.25, 123.86, 122.10, 114.29, 55.38.



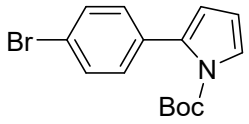

**4-(thiophen-2-yl) benzonitrile (3fd)**[19]

Colorless solid; 66% yield. $R_f$ = 0.9 (Petroleum ether), m.p. = 85 °C. **$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.71-7.63 (m, 4H), 7.43-7.38 (m, 2H), 7.13 (dd, *J* = 5.1, 3.7 Hz, 1H). **$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 142.08, 138.67, 132.76, 128.57, 127.10, 126.10, 125.14, 118.88, 110.56.




**2-(3-nitrophenyl) thiophene (3od)**[19]

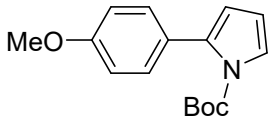
Yellow oil; 72% yield. $R_f$ = 0.9 (Petroleum ether). **$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.45 (t, *J* = 2.1 Hz, 1H), 8.14-8.08 (m, 1H), 7.91 (dt, *J* = 7.9, 1.5 Hz, 1H), 7.55 (t, *J* = 8.0 Hz, 1H), 7.45-7.37 (m, 2H), 7.14 (dd, *J* = 5.1, 3.6 Hz, 1H). **$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 146.88, 146.56, 143.07, 130.31, 129.95, 129.86, 125.21, 124.13, 119.27, 116.32.




**tert-butyl 2-(4-bromophenyl)-1H-pyrrole-1-carboxylate (3be)**[20]

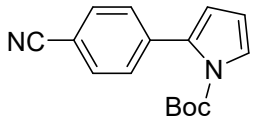
Colorless oil; 45% yield. $R_f$ = 0.5 (5% of Ethyl acetate in Petroleum ether). **$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.49-7.45 (m, 2H), 7.34 (dd, *J* = 3.3, 1.8 Hz, 1H), 7.24-7.19 (m, 2H), 6.22 (t, *J* = 3.3 Hz, 1H), 6.18 (dd, *J* = 3.3, 1.8 Hz, 1H), 1.39 (s, 9H). **$^{13}$C NMR**

(101 MHz, $CDCl_3$) δ 133.79, 133.27, 130.79, 130.72, 122.89, 121.29, 114.81, 110.70, 83.92, 27.69.



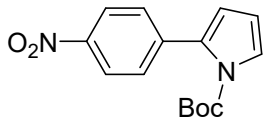

**tert-butyl 2-(4-methoxyphenyl)-1H-pyrrole-1-carboxylate (3de)**[21]

Colorless oil; 63% yield. $R_f$ = 0.3 (5% of Ethyl acetate in Petroleum ether). **$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.33 (dd, *J* = 3.3, 1.8 Hz, 1H), 7.30-7.26 (m, 2H), 6.92-6.87 (m, 2H), 6.21 (t, *J* = 3.3 Hz, 1H), 6.14 (dd, *J* = 3.3, 1.8 Hz, 1H), 3.83 (s, 3H), 1.39 (s, 9H). **$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 158.91, 149.43, 134.88, 130.41, 126.90, 122.18, 114.01, 113.05, 110.48, 83.44, 55.29, 27.72.



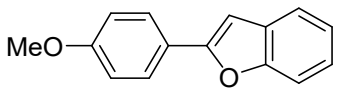

**tert-butyl 2-(4-cyanophenyl)-1H-pyrrole-1-carboxylate (3fe)**[22]

Colorless oil; 75% yield. $R_f$ = 0.2 (5% of Ethyl acetate in Petroleum ether). **$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.66-7.60 (m, 2H), 7.48-7.43 (m, 2H), 7.39 (dd, *J* = 3.2, 1.8 Hz, 1H), 6.29-6.24 (m, 2H), 1.41 (s, 9H). **$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 148.96, 138.82, 133.12, 131.41, 129.59, 123.99, 119.02, 116.12, 111.07, 110.53, 84.40, 27.71.



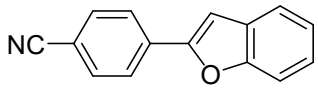

**tert-butyl 2-(4-nitrophenyl)-1H-pyrrole-1-carboxylate (3je)**[22]

Colorless oil; 66% yield. $R_f$ = 0.2 (5% of Ethyl acetate in Petroleum ether). **$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.26-8.17 (m, 2H), 7.56-7.48 (m, 2H), 7.41 (dd, *J* = 3.3, 1.8 Hz, 1H), 6.32 (dd, *J* = 3.4, 1.7 Hz, 1H), 6.27 (t, *J* = 3.4 Hz, 1H), 1.43 (s, 9H). **$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 148.92, 146.62, 140.71, 132.79, 129.56, 124.32, 122.96, 111.17, 84.55, 27.74.



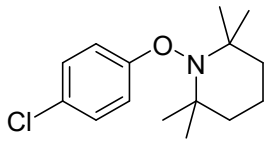

**2-(4-methoxyphenyl) benzofuran (3df)**[23]

Colorless solid; 40% yield. $R_f$ = 0.2 (Petroleum ether), m.p. = 152 °C. **$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.86-7.80 (m, 2H), 7.61-7.56 (m, 1H), 7.53 (d, *J* = 8.2 Hz, 1H), 7.31-7.22 (m, 2H), 7.04-6.98 (m, 2H), 6.92 (d, *J* = 0.9 Hz, 1H), 3.89 (s, 3H). **$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 160.00, 156.07, 154.71, 129.51, 126.44, 123.76, 123.36, 122.85, 120.59, 114.27, 111.01, 99.70, 55.39.




**4-(benzofuran-2-yl) benzonitrile (3ff)**[24]

Colorless solid; 71% yield. $R_f$ = 0.3 (Petroleum ether), m.p. = 143 °C. **$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.97 (d, *J* = 8.2 Hz, 2H), 7.75 (d, *J* = 8.1 Hz, 2H), 7.68-7.63 (m, 1H), 7.57 (d, *J* = 8.2 Hz, 1H), 7.44-7.24 (m, 3H). **$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 155.27, 153.57, 134.49, 132.66, 128.68, 125.58, 125.14, 123.47, 121.53, 118.78, 111.53, 111.46, 104.37.




**1-(4-chlorophenoxy)-2,2,6,6-tetramethylpiperidine (5)**.

Colorless oil; 51% yield. $R_f$ = 0.9 (Petroleum ether), m.p. = 320 °C. **$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.18-7.09 (m, 4H), 1.64-1.53 (m, 5H), 1.45-1.38 (m, 1H), 1.22 (s, 6H), 0.99 (s, 6H). **$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 162.22, 128.57, 124.33, 115.20, 60.47, 39.74, 32.50, 20.43, 17.00.

## 3. References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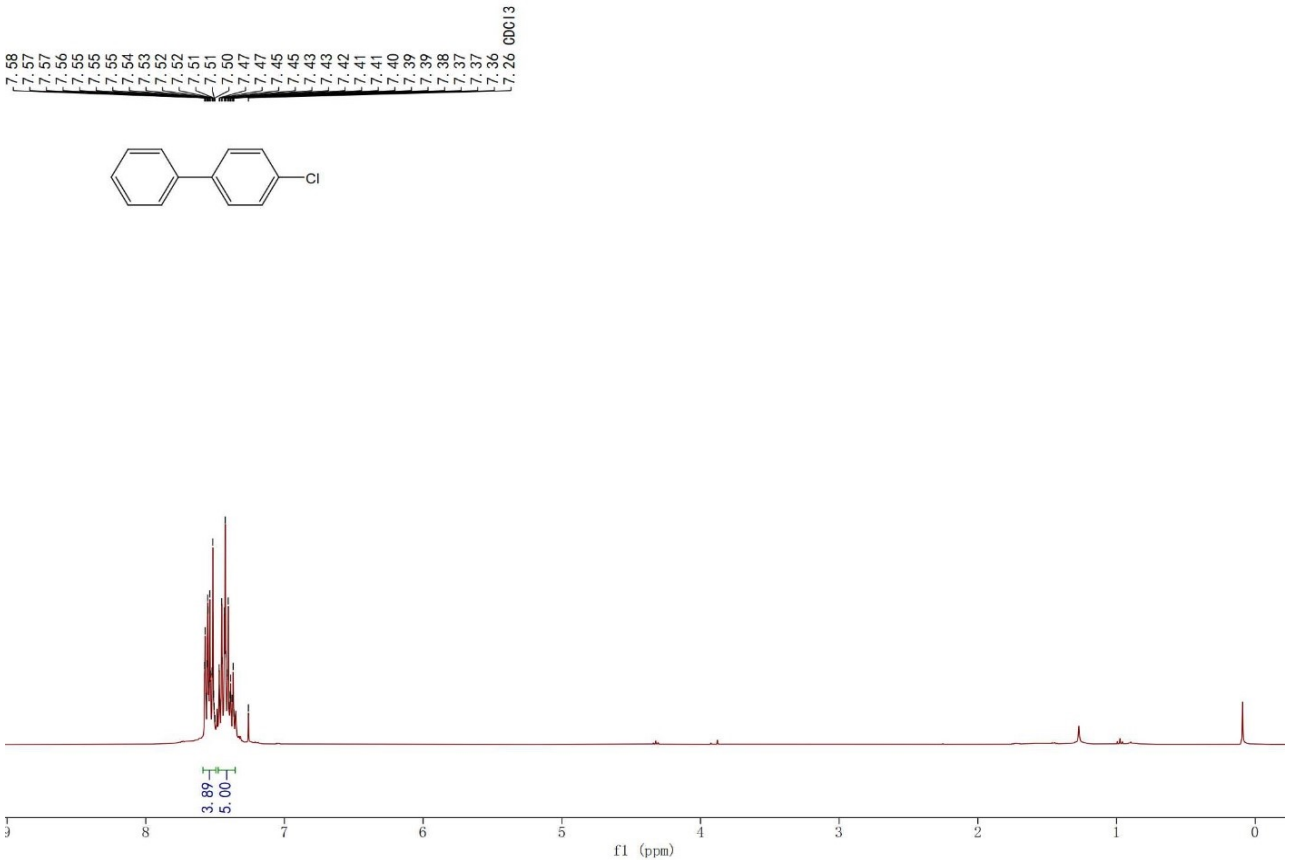
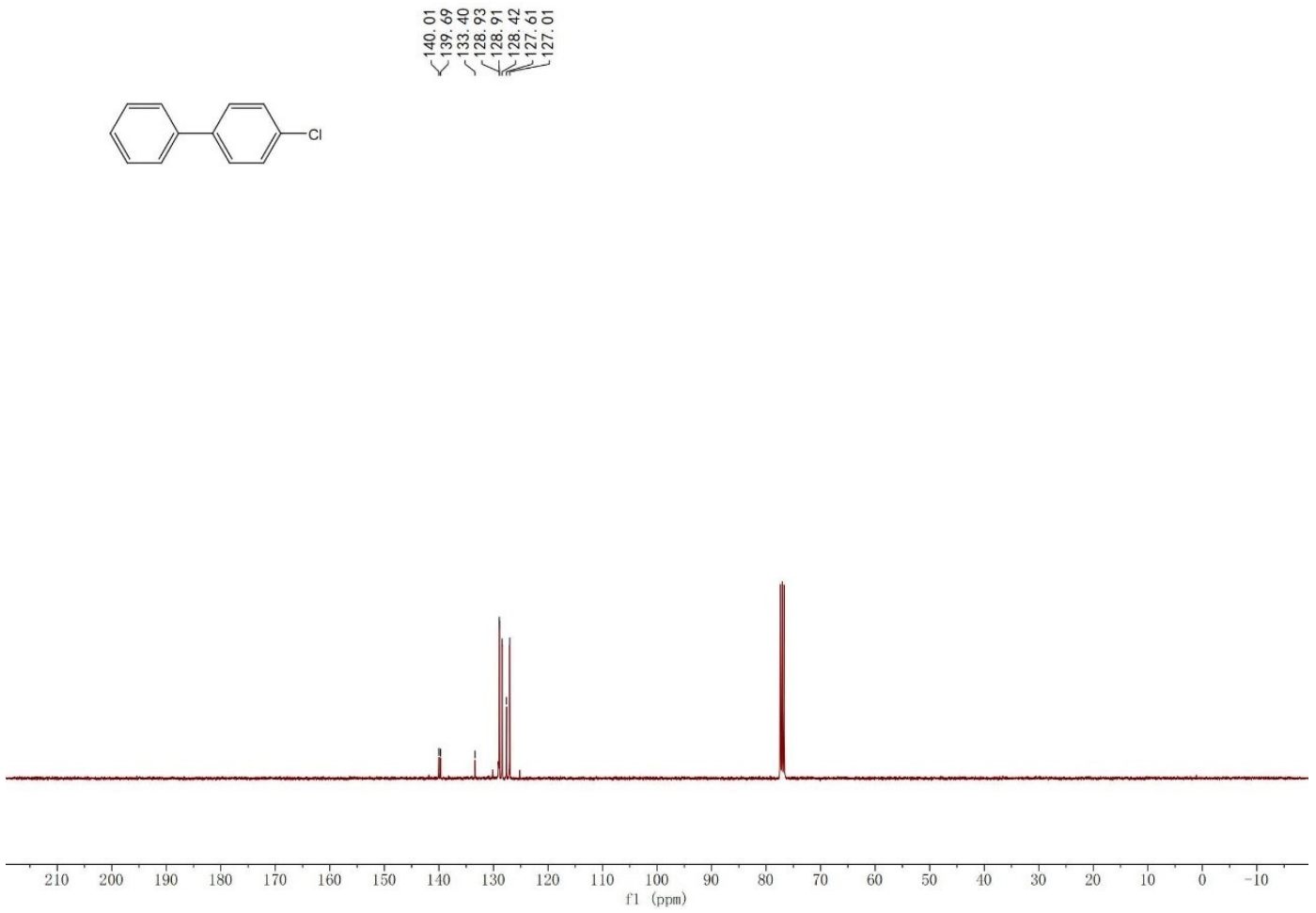
# 4. Copies of NMR spectra of 3aa-3ff

**3aa** $^{1}$H NMR



**3aa** $^{13}C$ NMR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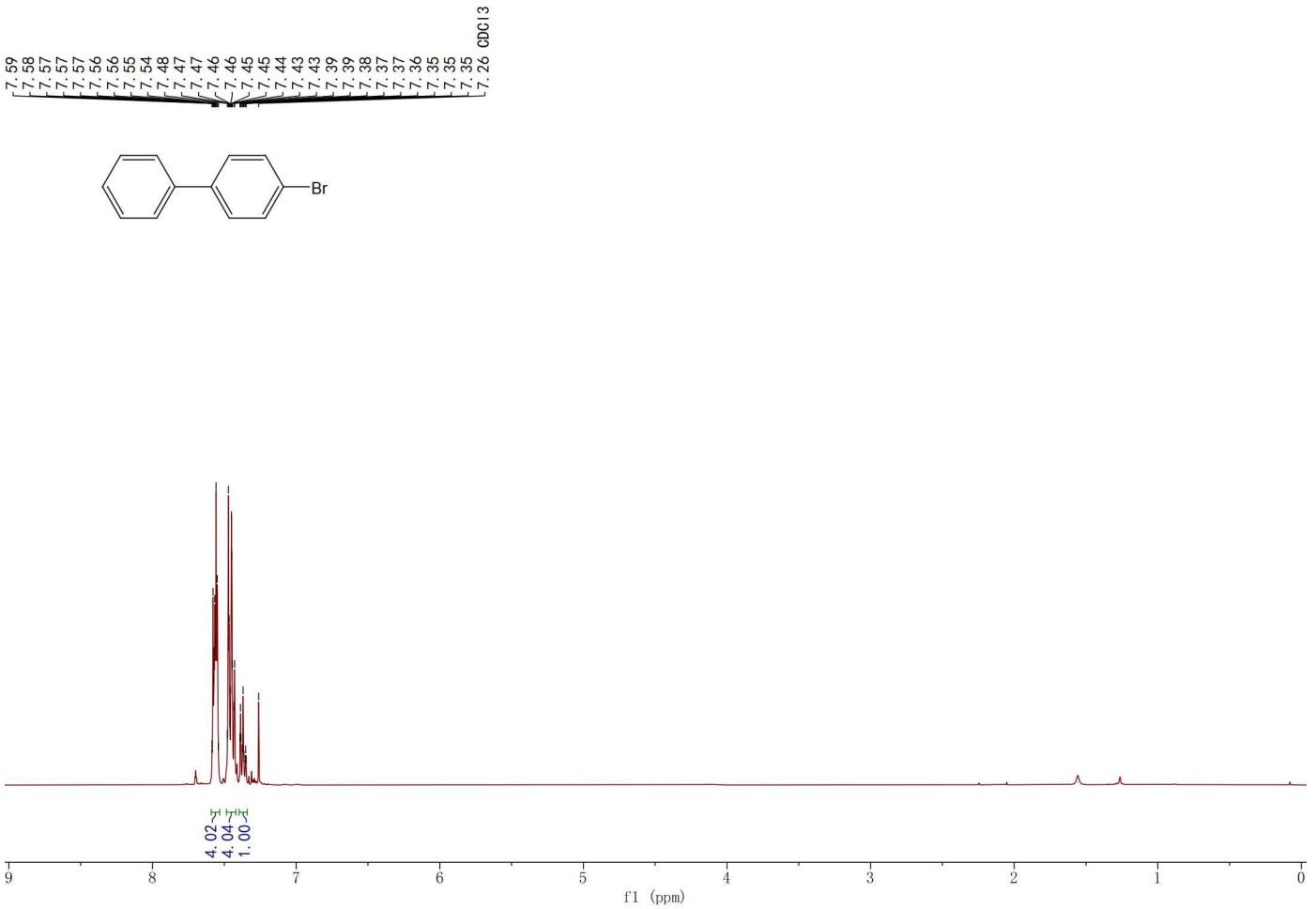
139.69
133.40
128.93
128.91
128.42
127.61
127.01
Cl
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

**3ba** $^{1}$H NMR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7.55
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7.48
7.47
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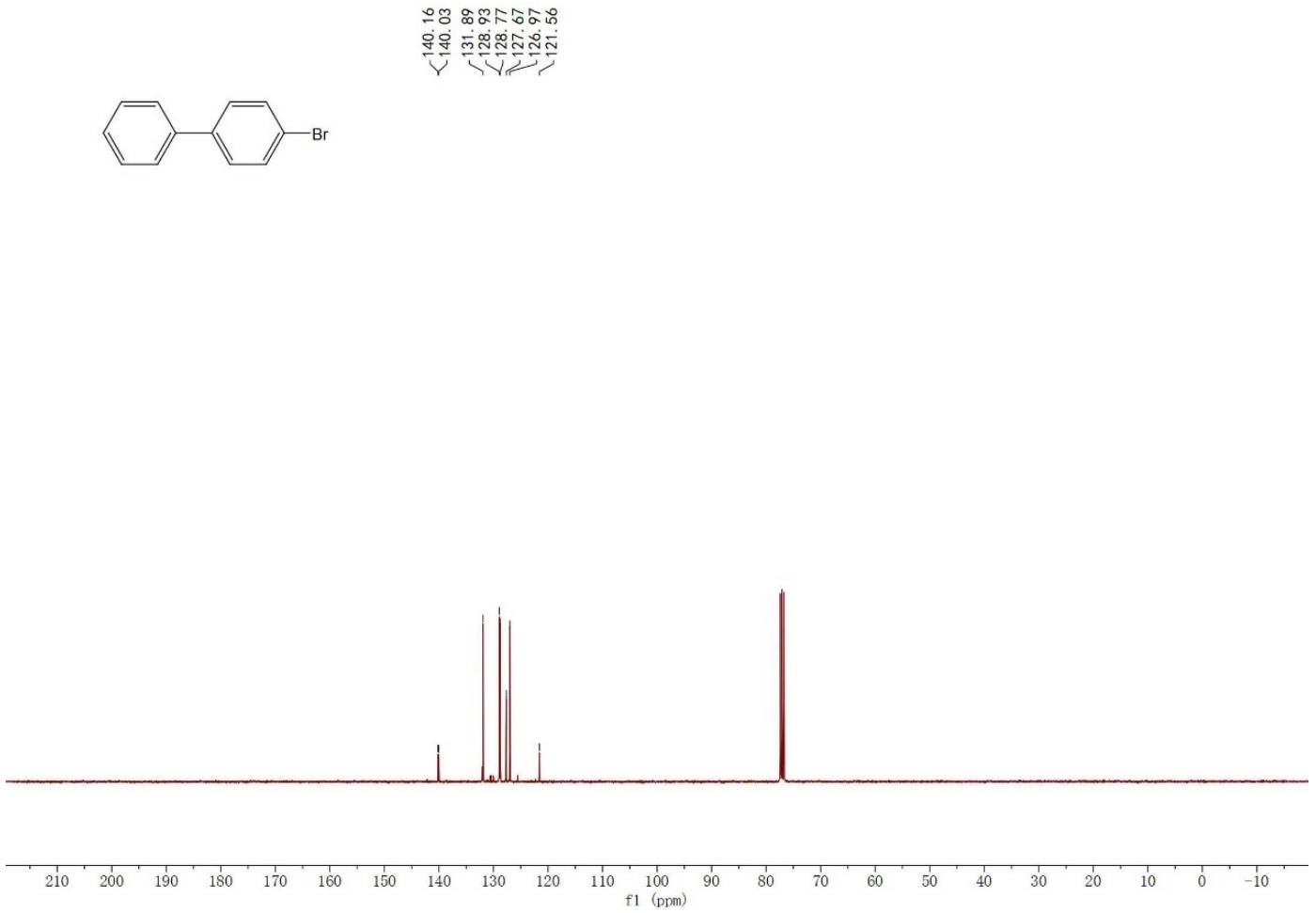
7.46
7.46
7.45
7.45
7.44
7.43
7.43
7.39
7.39
7.38
7.37
7.37
7.36
7.35
7.35
7.35
7.26
CDCl3
Br
4.02
4.04
1.00
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

**3ba** $^{13}$C NMR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160
150
140
130
120
110
100
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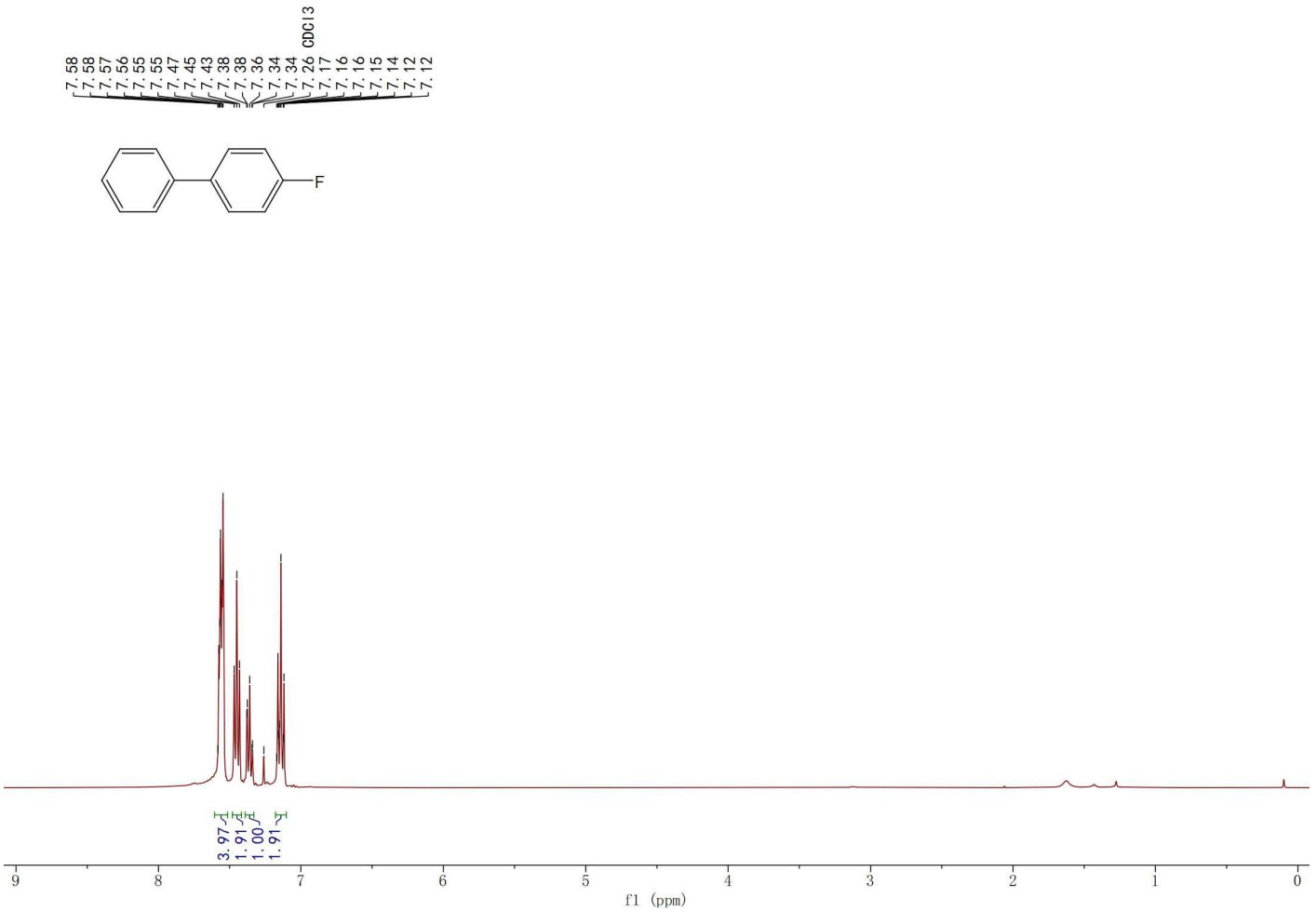
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

**3ca** $^{1}$H NMR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7.45
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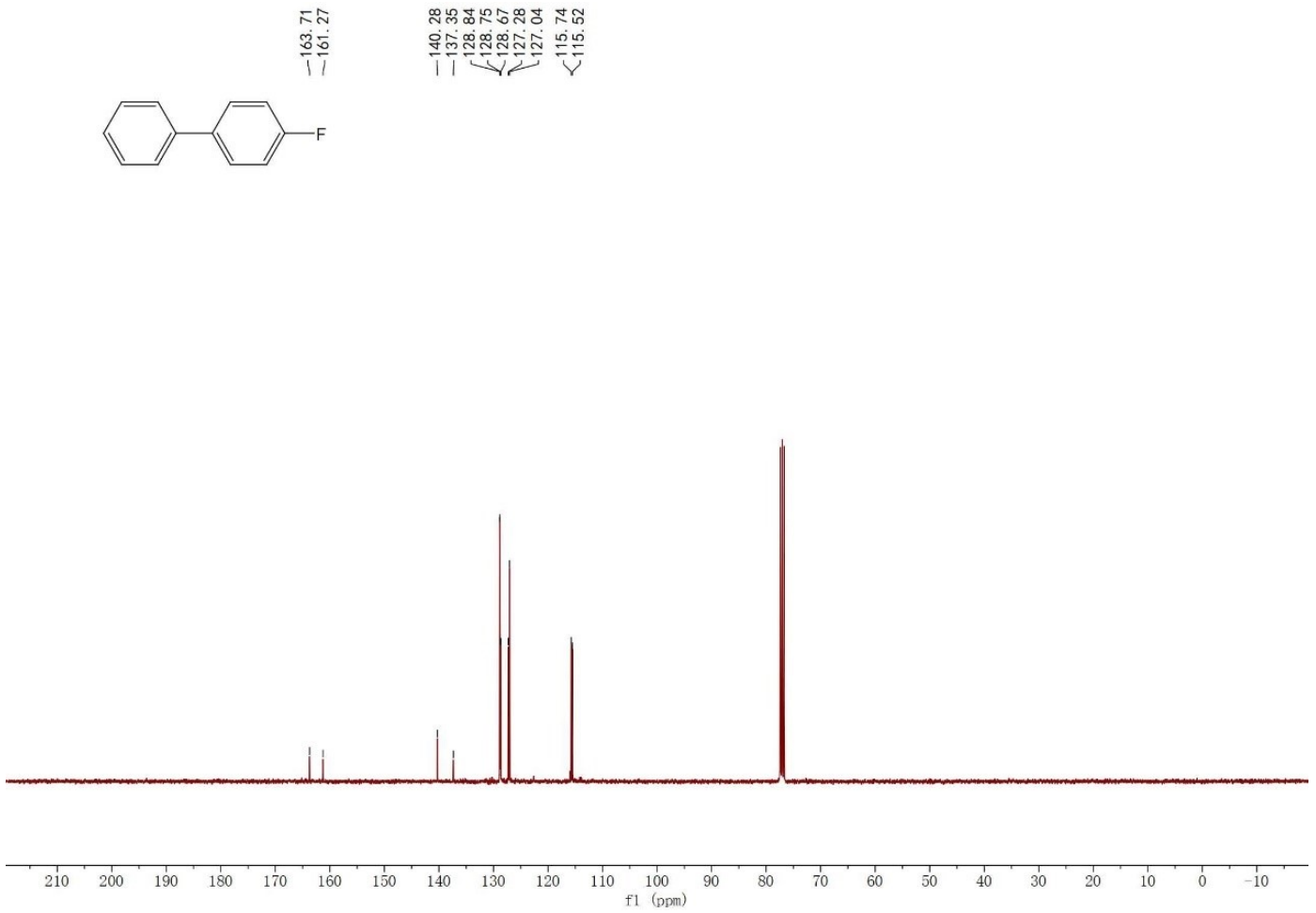
7.38
7.38
7.36
7.34
7.34
CDCl3
7.26
7.17
7.16
7.16
7.15
7.14
7.12
7.12
F
3.97
1.91
1.00
1.91
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

**3ca** $^{13}C$ NMR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128.67
127.28
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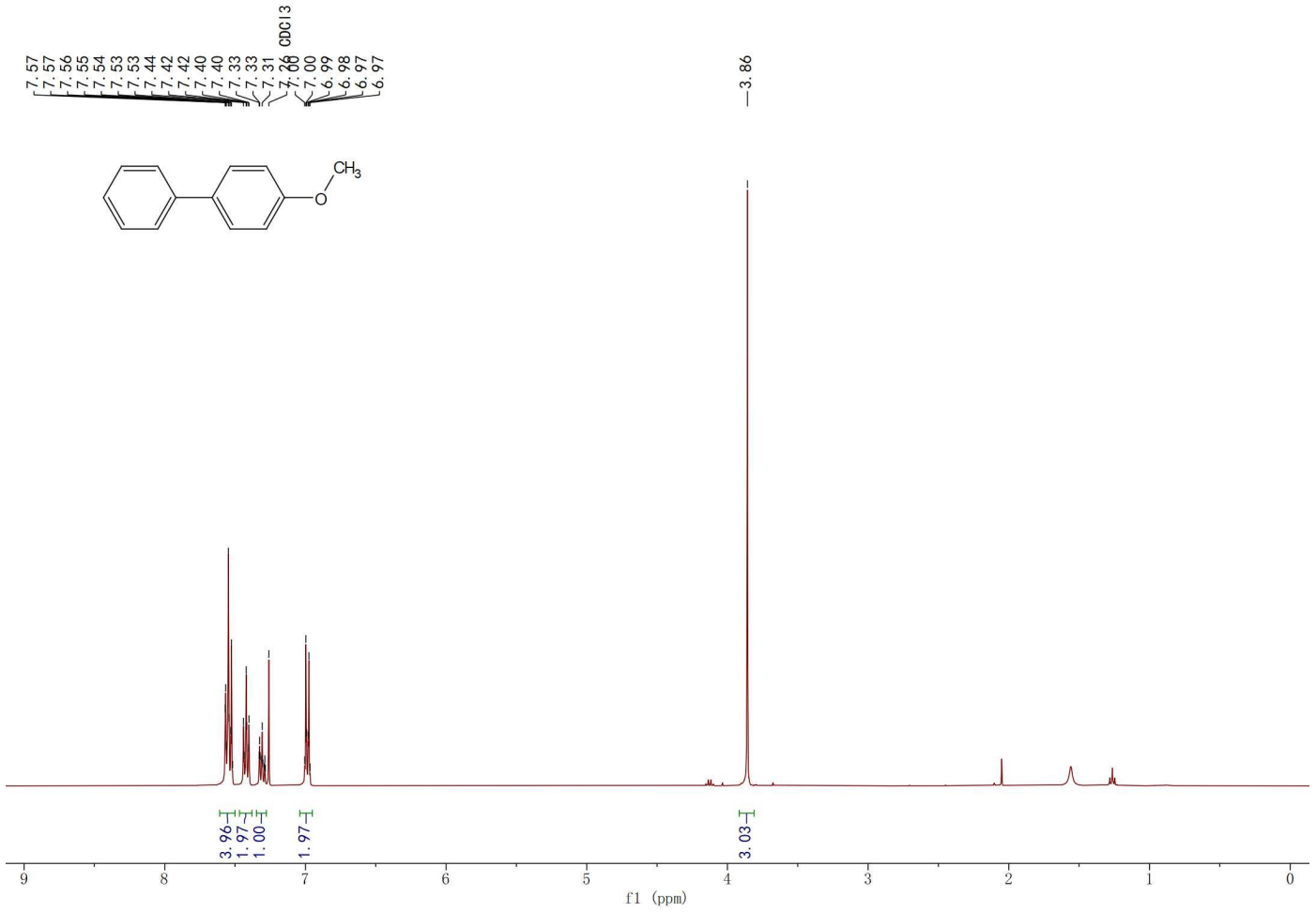
f1 (ppm)

**3da** $^{1}$H NMR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7.40
7.33
7.31
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7.00
6.99
6.98
6.97
6.97
3.86
CH3
O
3.96
1.97
1.00
1.97
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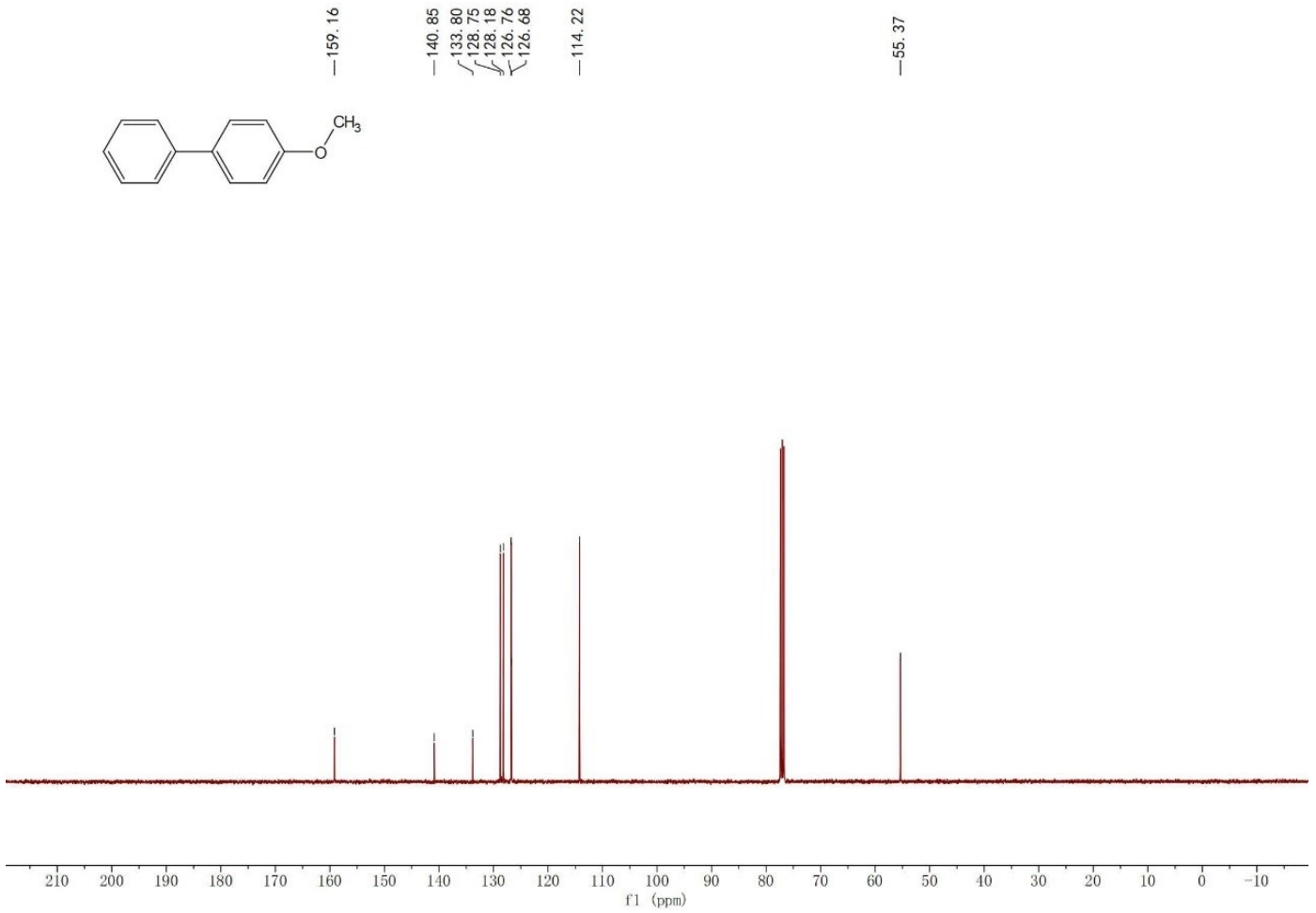
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

**3da** $^{13}C$ NMR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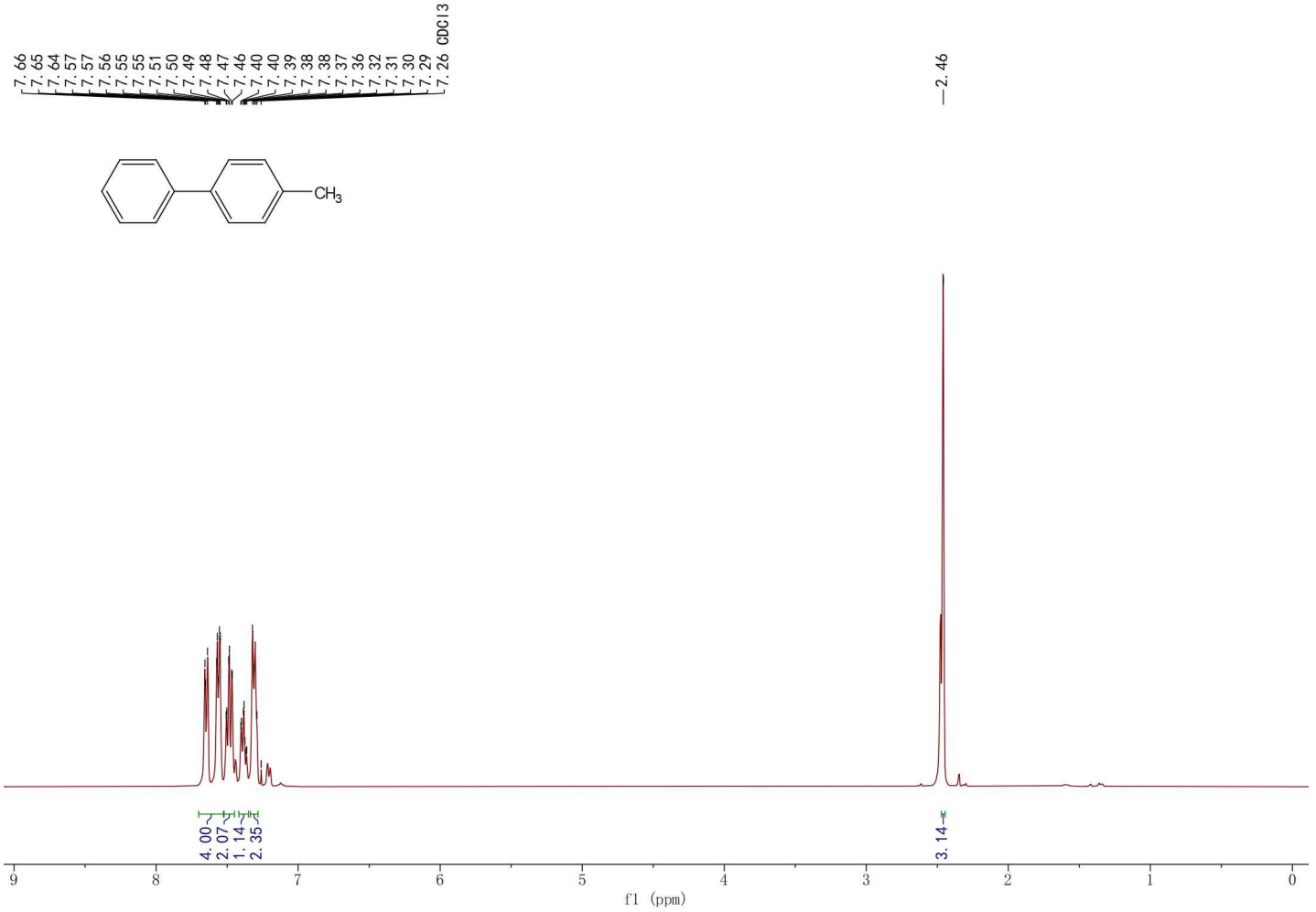
O
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

**3ea** $^{1}$H NMR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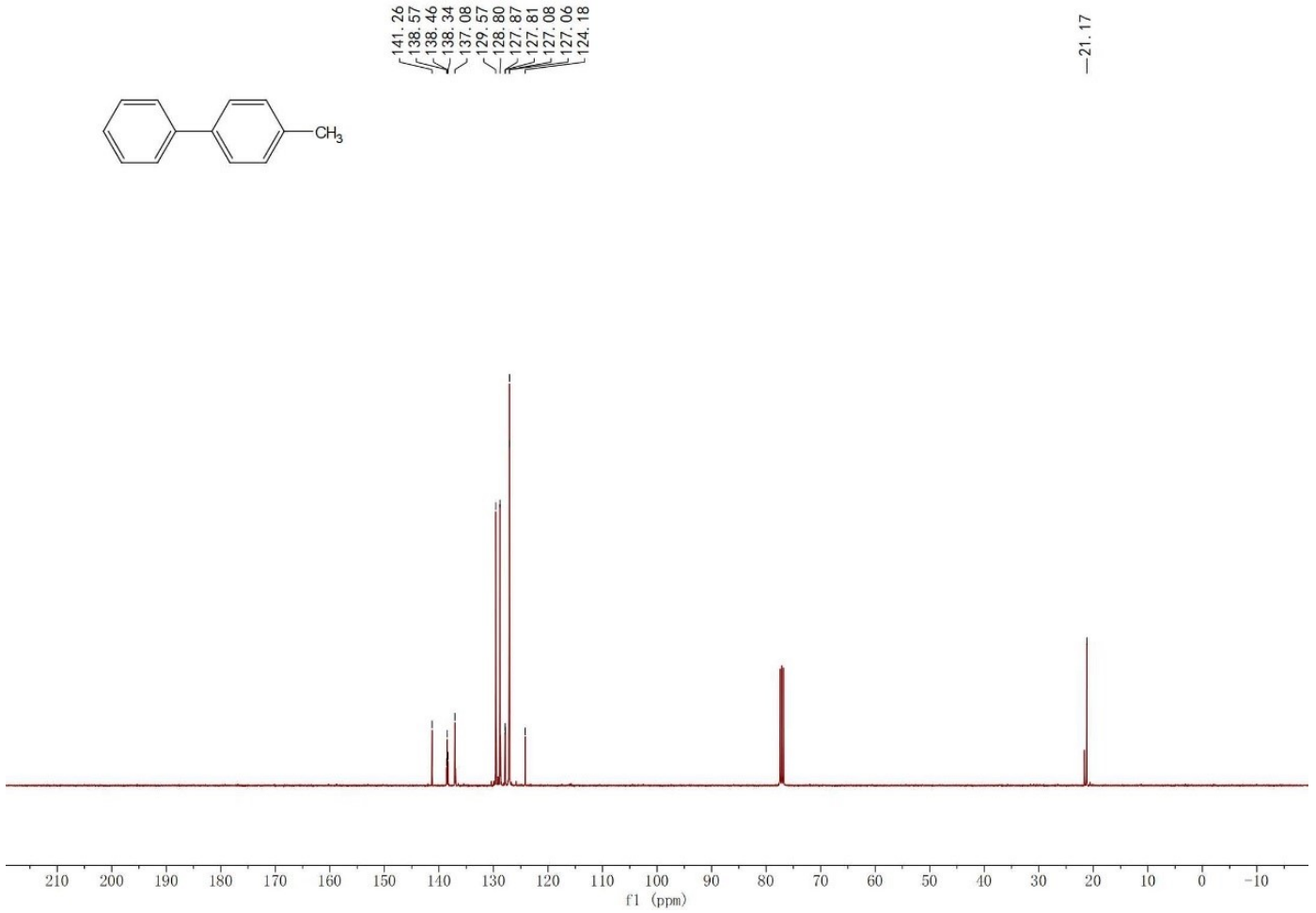
7.47
7.46
7.40
7.40
7.39
7.38
7.38
7.37
7.36
7.32
7.31
7.30
7.29
7.26
CDCl3
2.46
CH3
4.00
2.07
1.14
2.35
3.14
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

**3ea** $^{13}C$ NMR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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)

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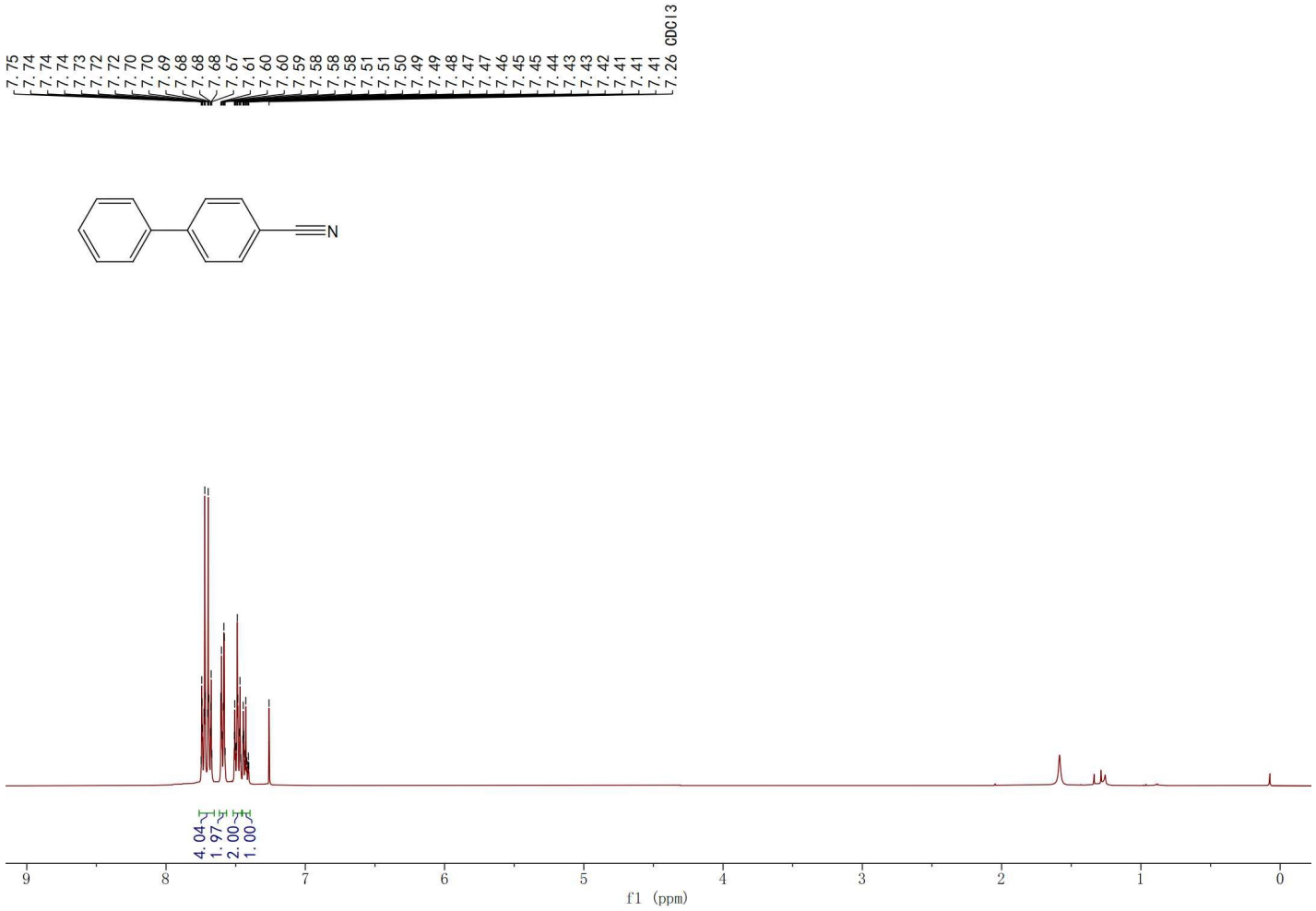
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7.45
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7.41
7.41
CDCl3
N
4.04
1.97
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9
8
7
6
5
4
3
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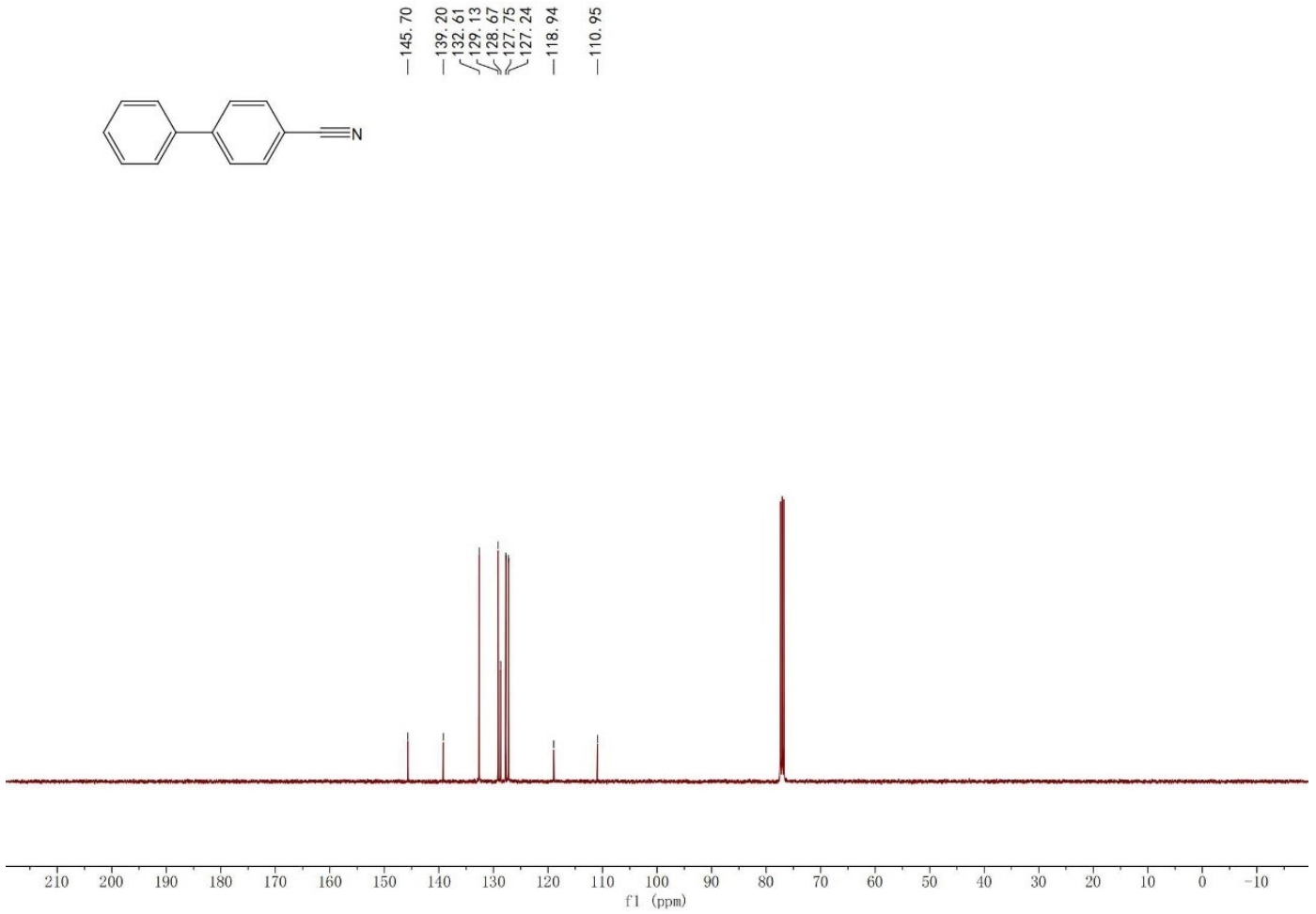
f1 (ppm)

**3fa** $^{13}C$ NMR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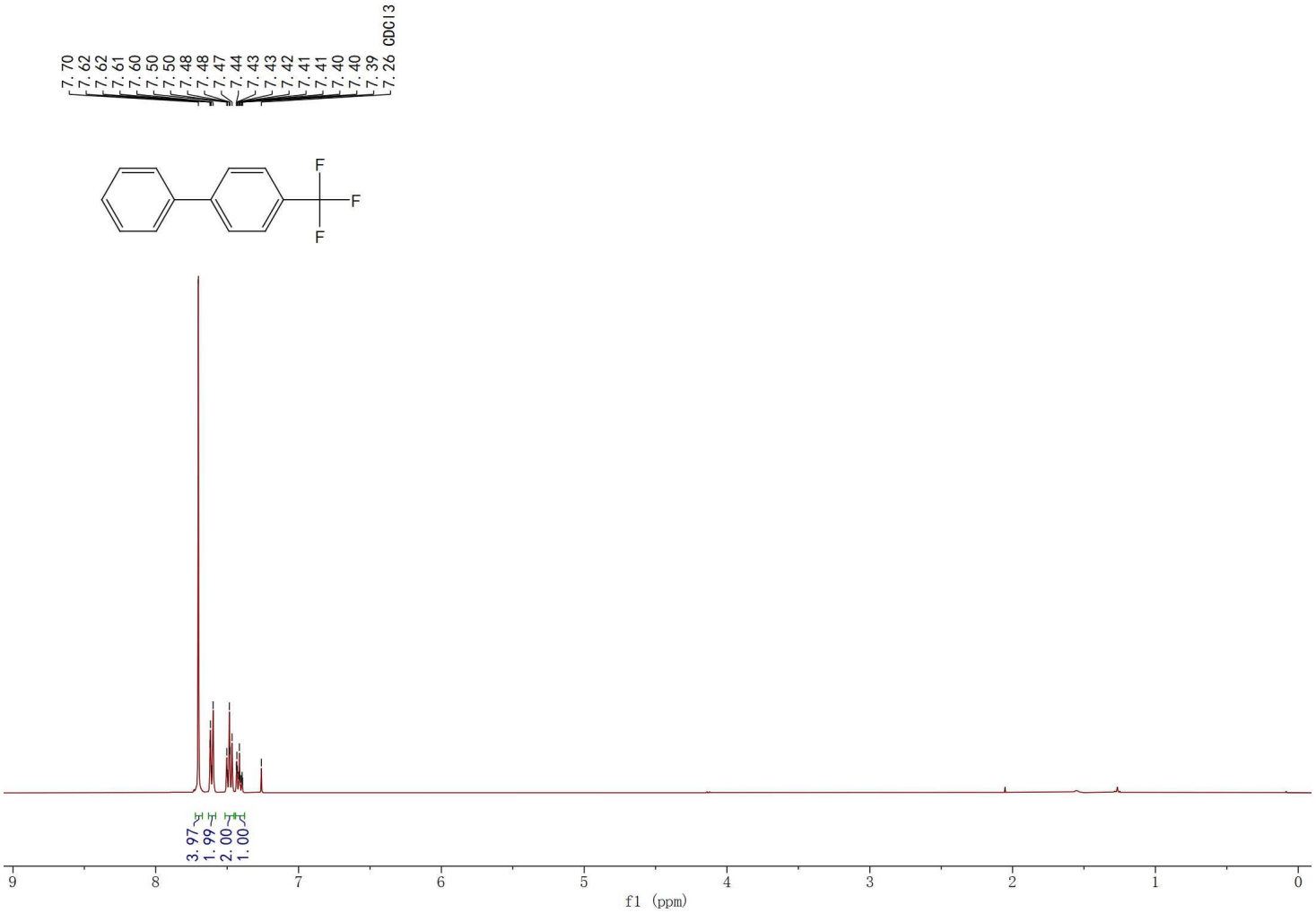
N
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

**3ga** $^{1}$H NMR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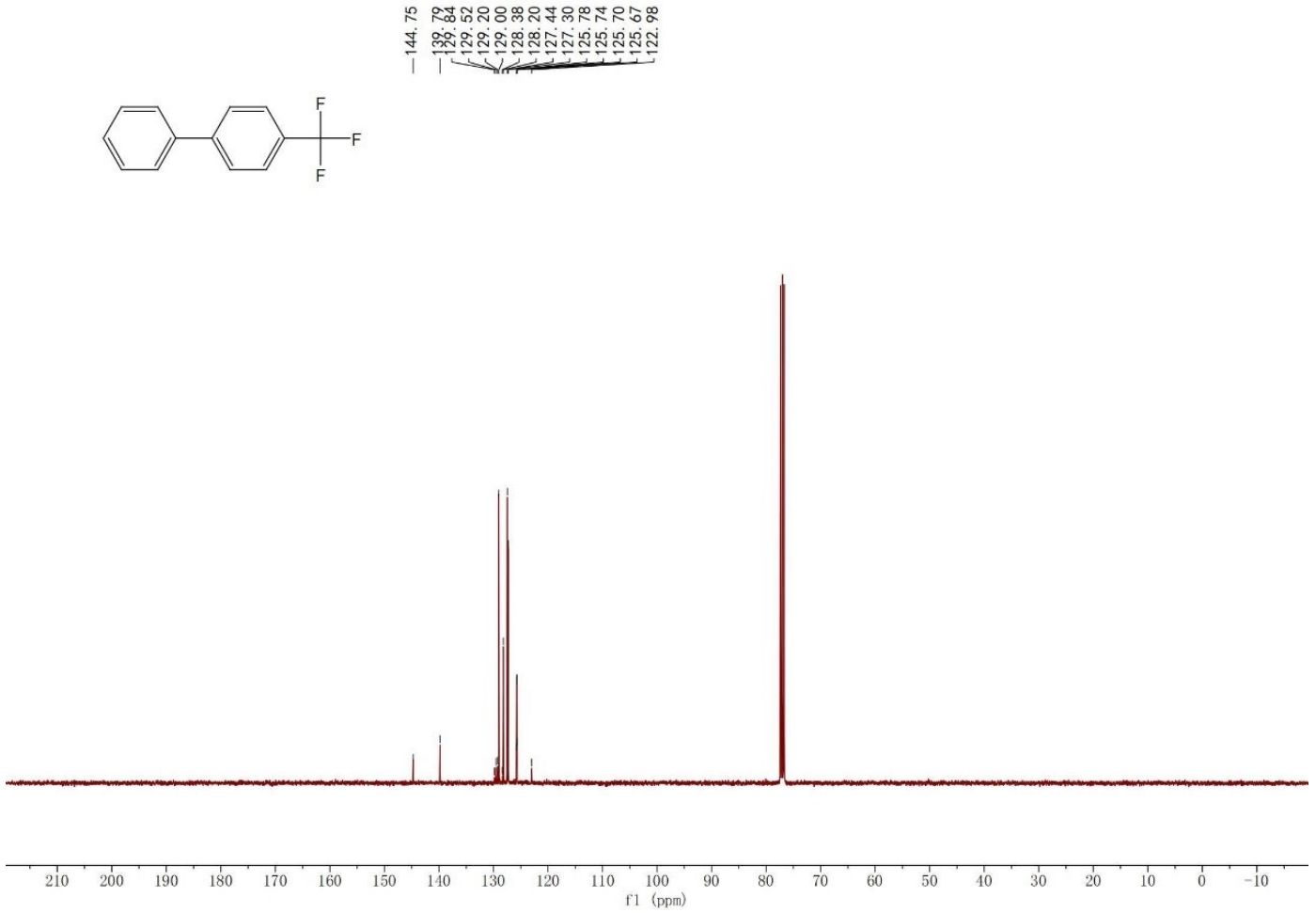
7.50
7.48
7.48
7.47
7.44
7.43
7.43
7.42
7.41
7.41
7.40
7.40
7.39
7.26
CDCl3
F
F
F
3.97
1.99
2.00
1.00
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

**3ga** $^{13}C$ NMR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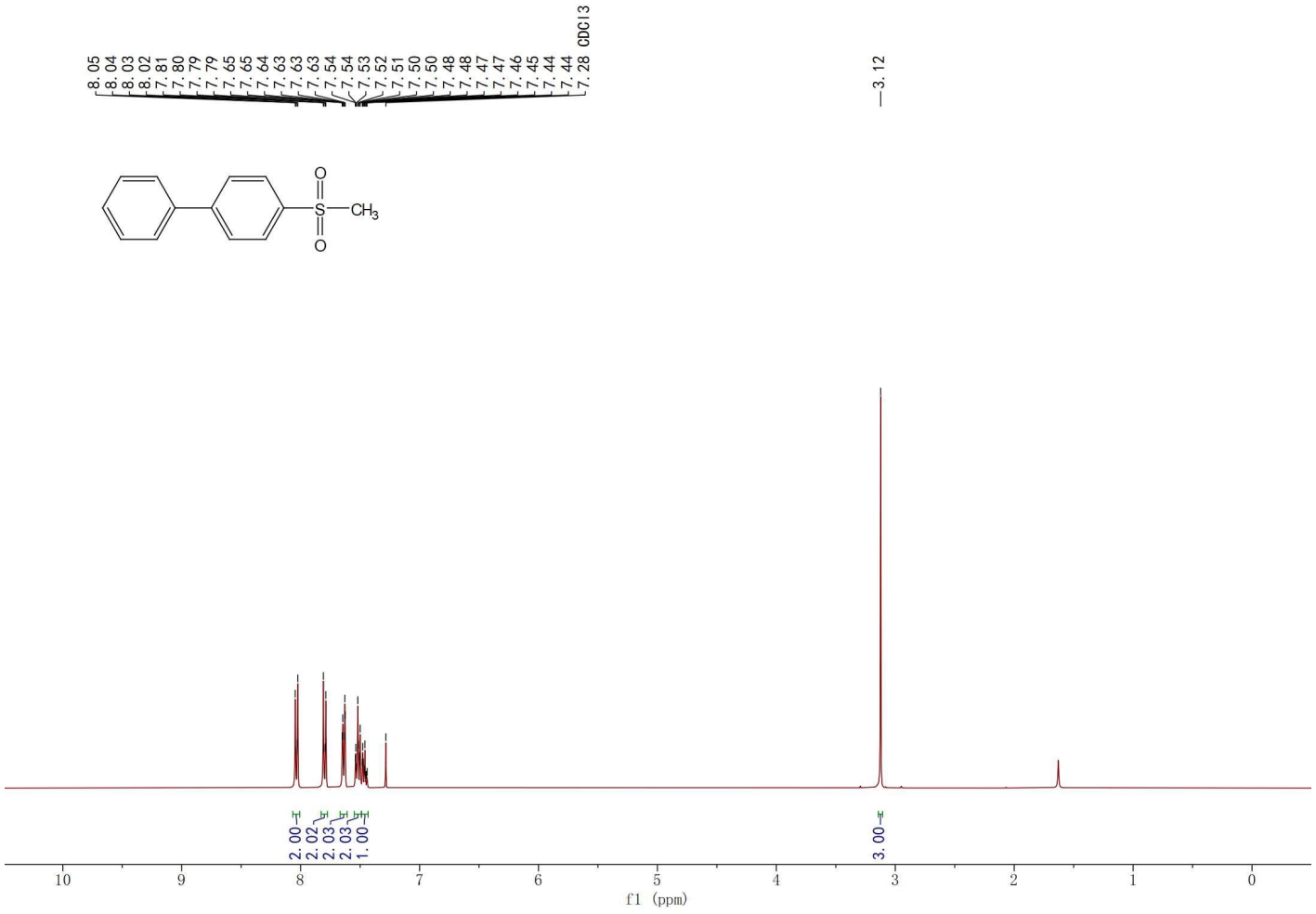
F
F
F
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

**3ha** $^{1}$H NMR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7.79
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7.65
7.64
7.63
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7.63
7.54
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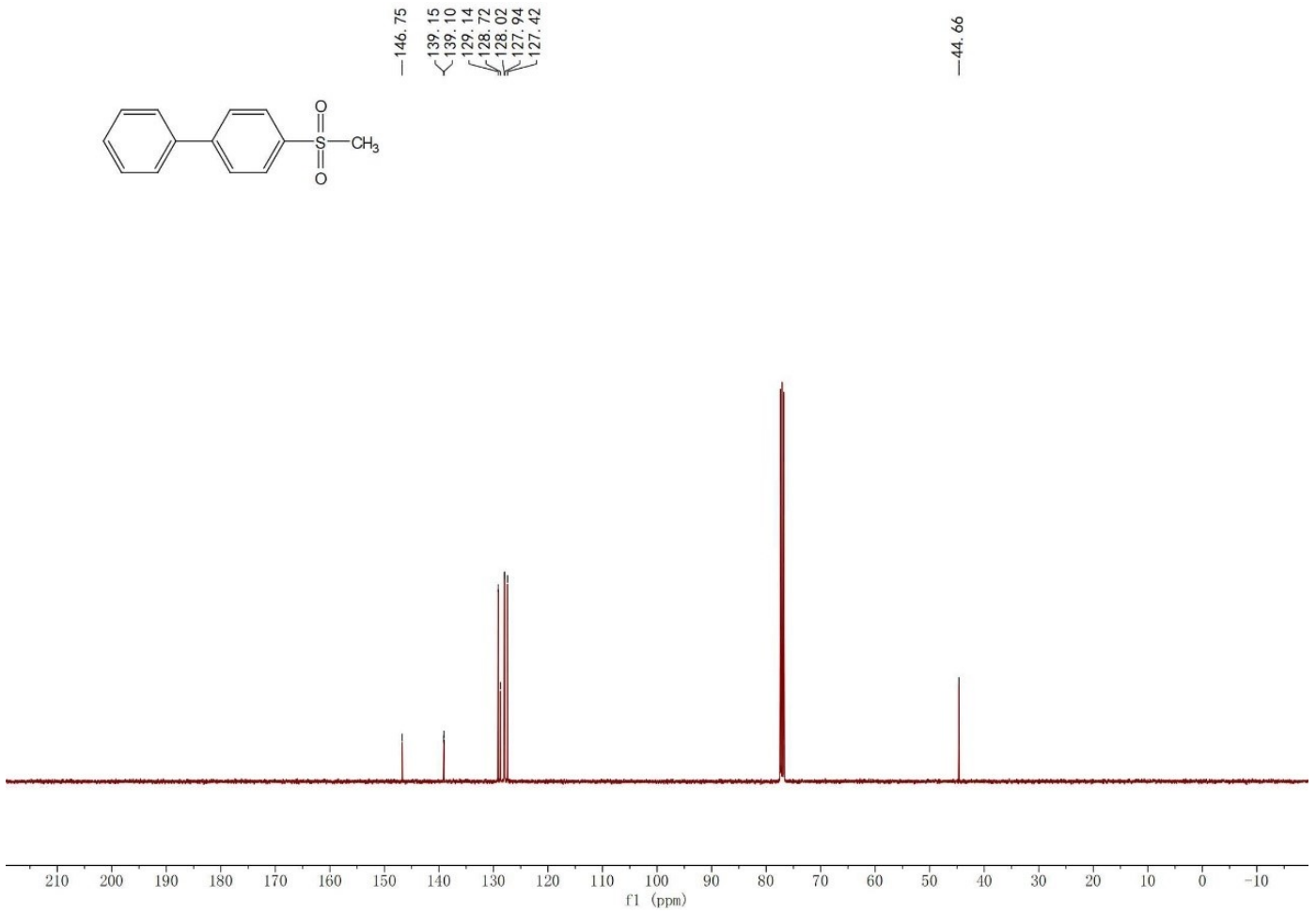
7.52
7.51
7.50
7.50
7.48
7.48
7.47
7.47
7.46
7.45
7.44
7.44
7.28
CDCl3
3.12
O
S
CH3
O
2.00
2.02
2.03
1.00
3.00
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

**3ha** $^{13}C$ NMR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127.94
127.42
44.66
O
S
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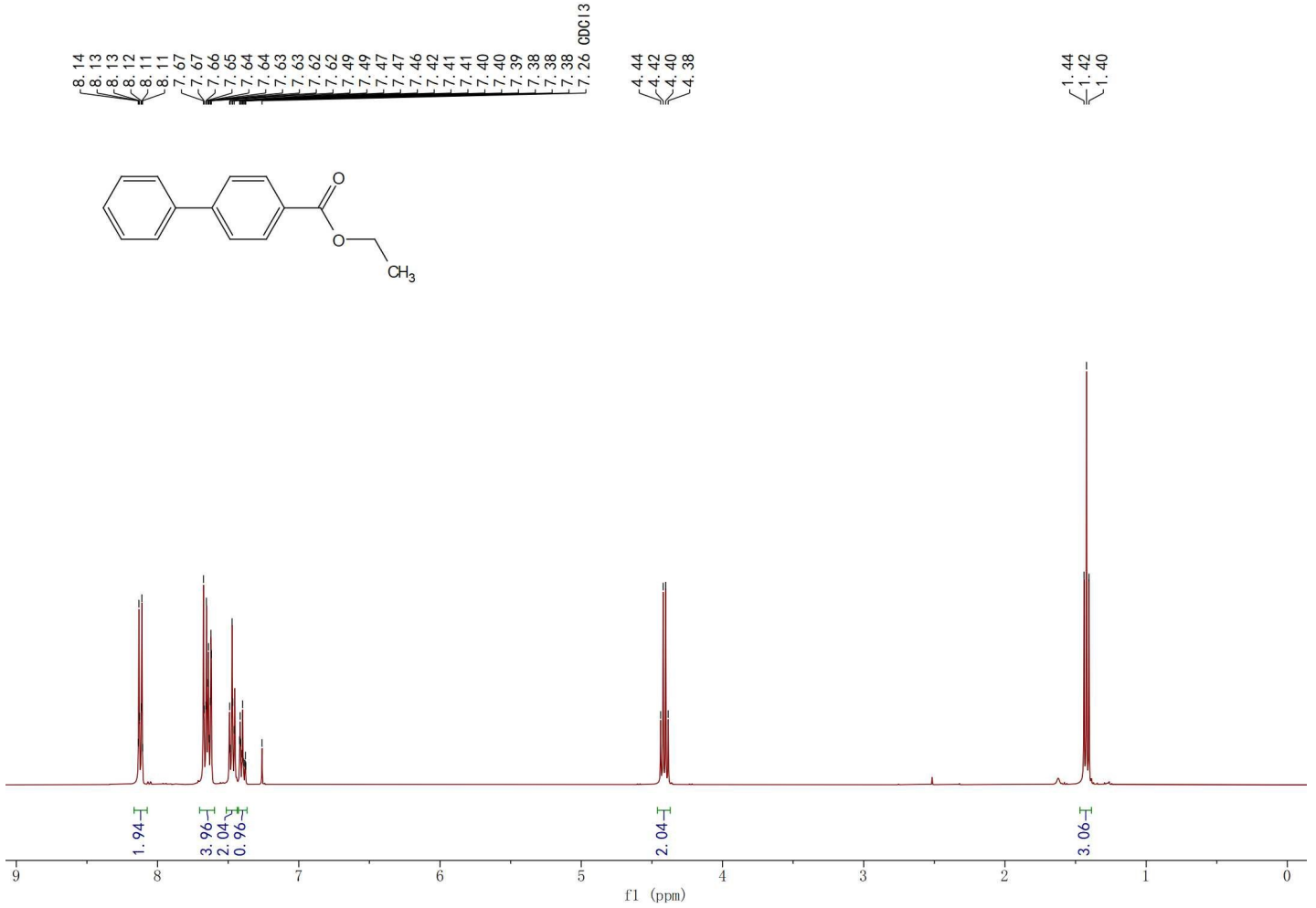
O
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

**3ia** $^{1}$H NMR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7.63
7.63
7.62
7.62
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7.49
7.47
7.47
7.46
7.42
7.41
7.41
7.40
7.40
7.39
7.38
7.38
7.38
7.26
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4.44
4.42
4.40
4.38
1.44
1.42
1.40
O
O
CH3
1.94
3.96
2.04
0.96
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9
8
7
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5
4
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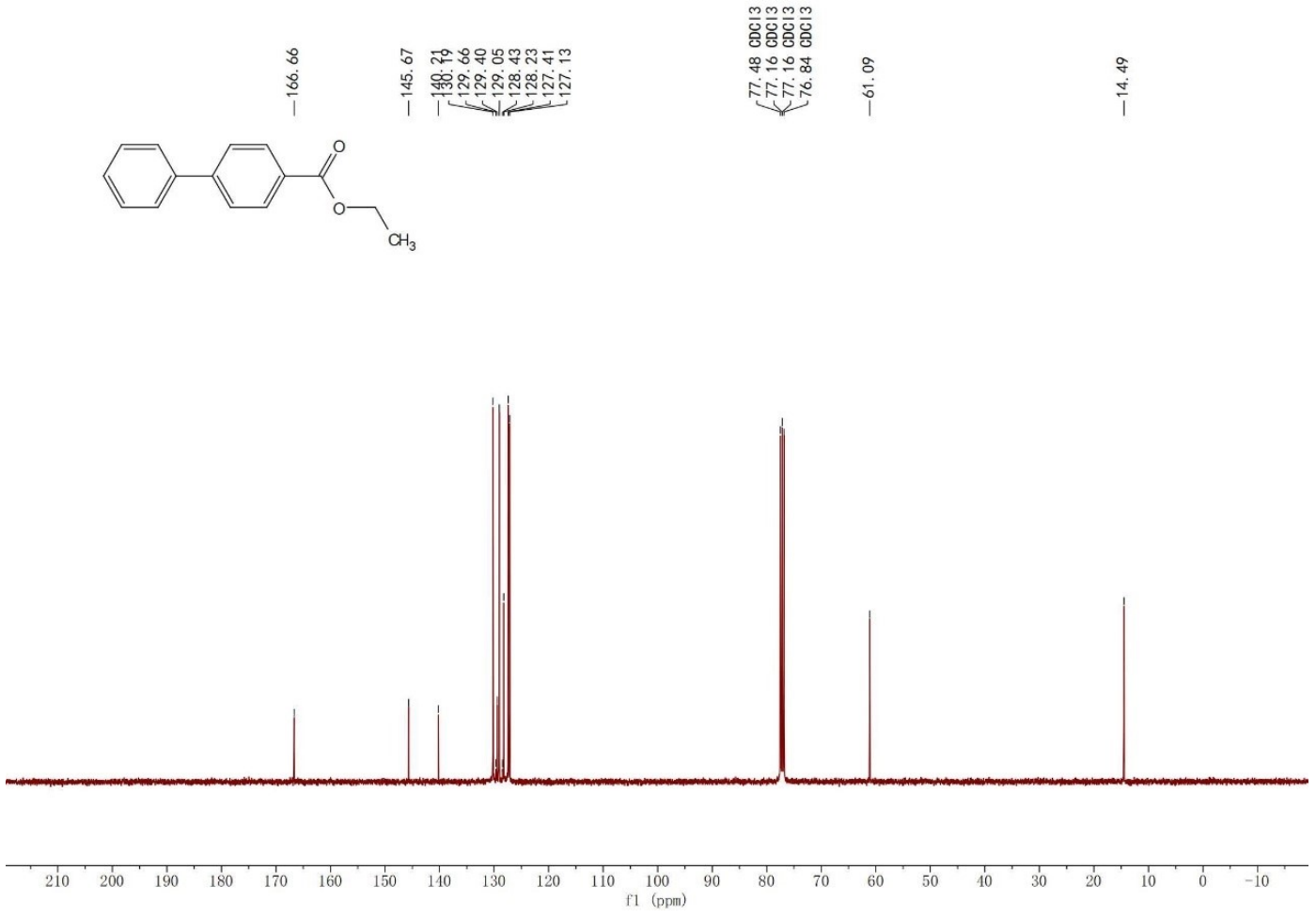
1
0
f1 (ppm)

**3ia** $^{13}C$ NMR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128.43
128.23
127.41
127.13
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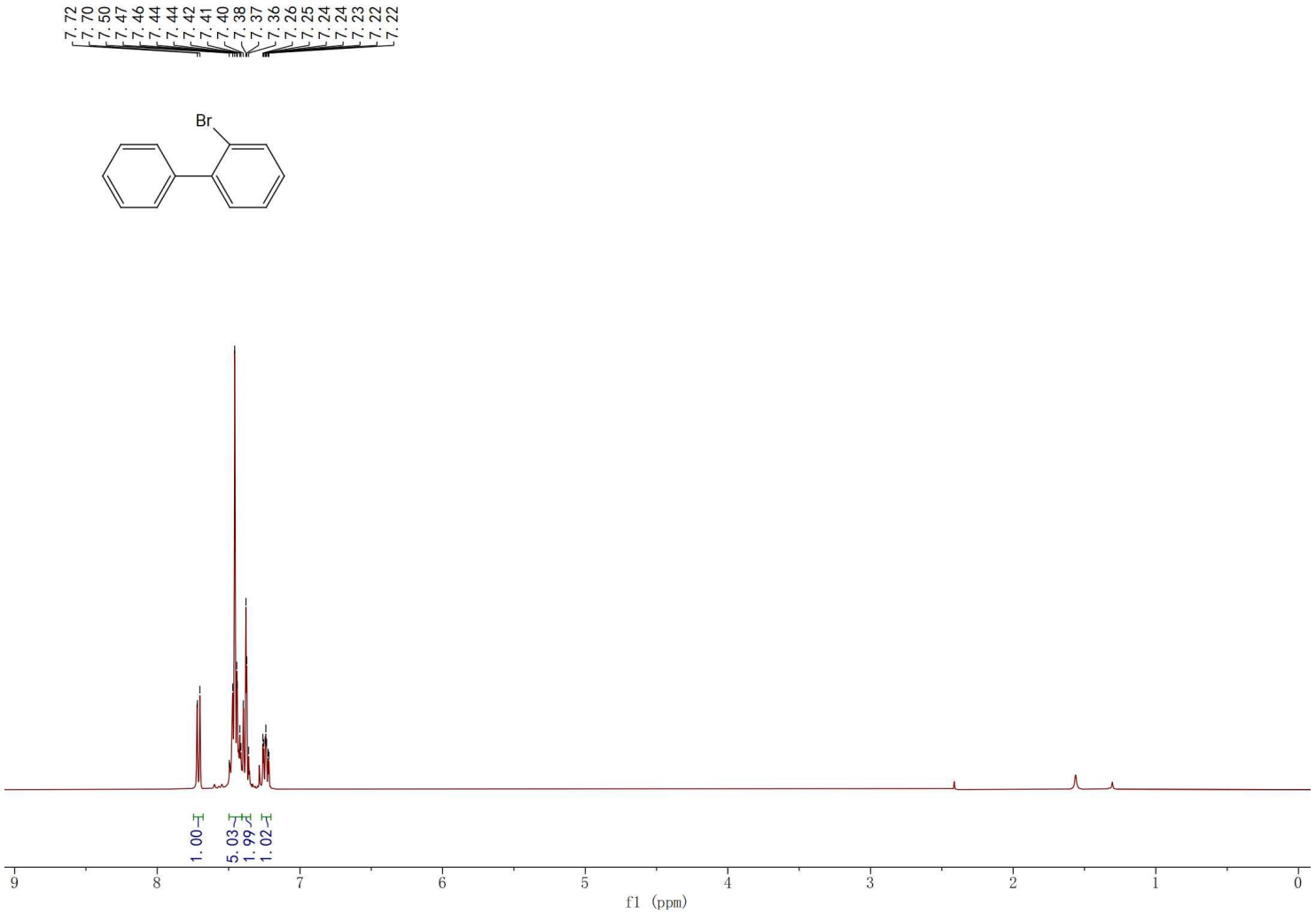
77.16 CDCl3
76.84 CDCl3
61.09
14.49
O
O
CH3
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

**3ka** $^{1}$H NMR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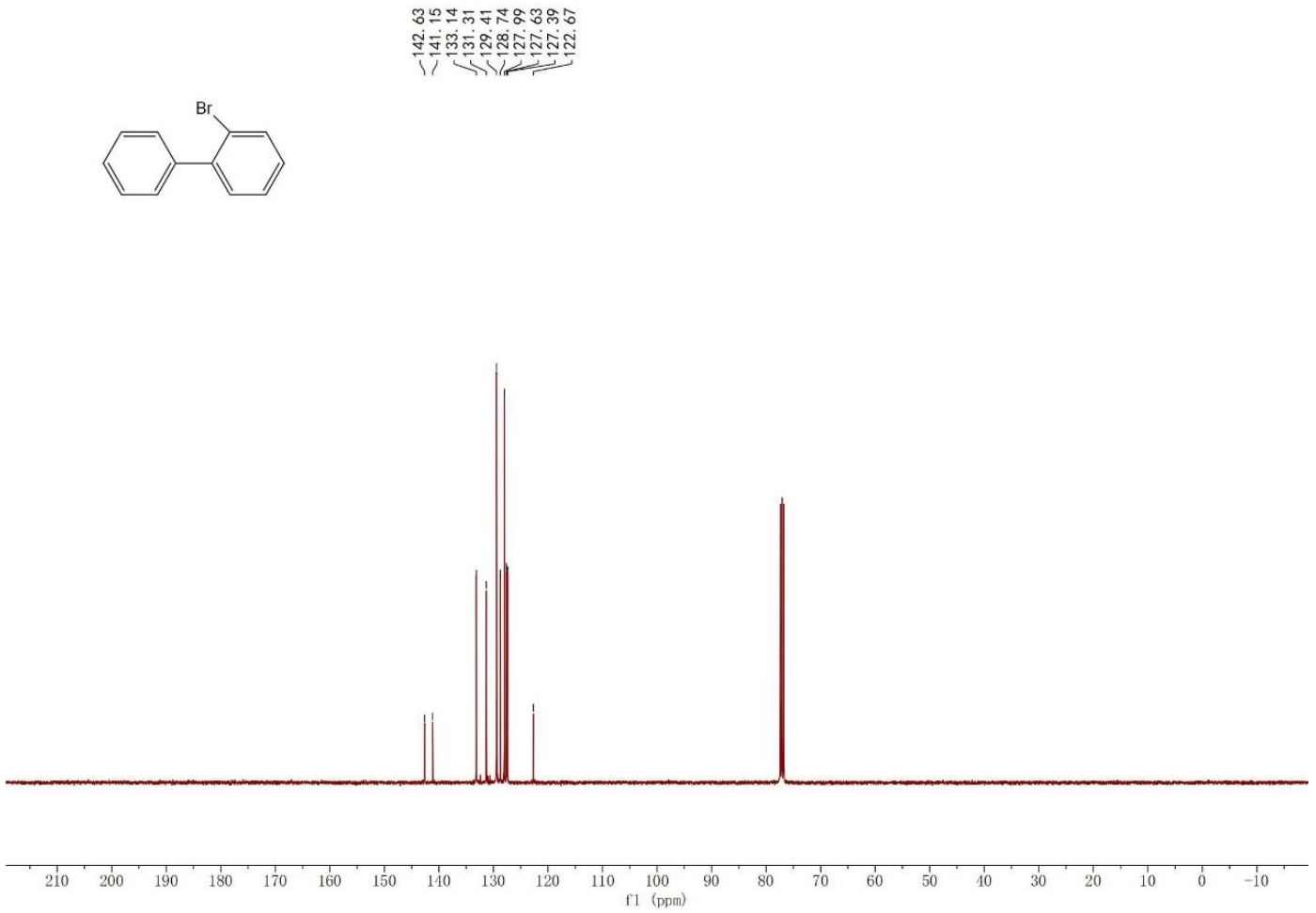
7.36
7.26
7.25
7.24
7.24
7.23
7.22
7.22
Br
1.00
5.03
1.99
1.02
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

**3ka** $^{13}C$ NMR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Br
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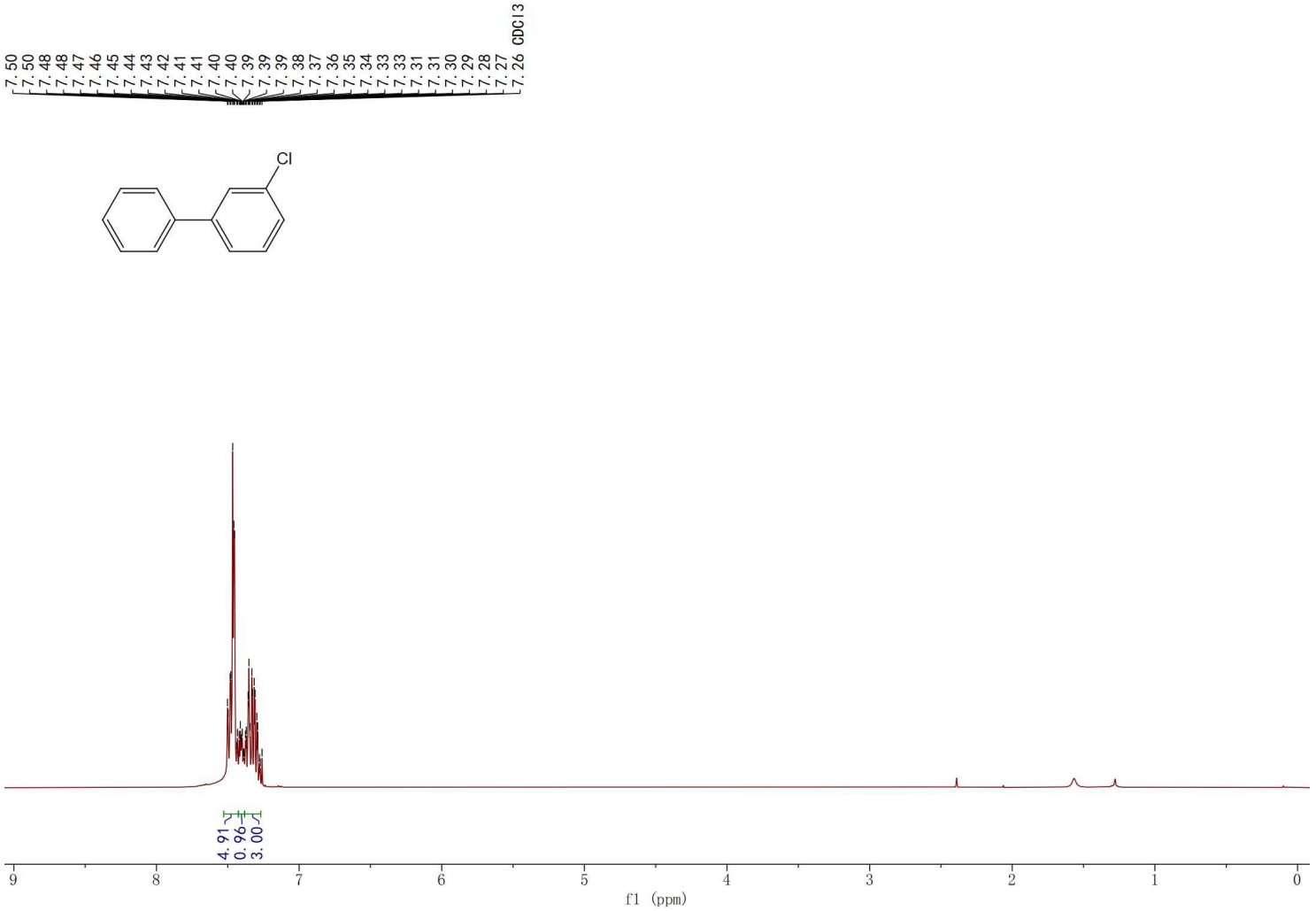
f1 (ppm)

**3ma** $^{1}$H NMR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7.27
CDCl3
7.26
Cl
4.91
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9
8
7
6
5
4
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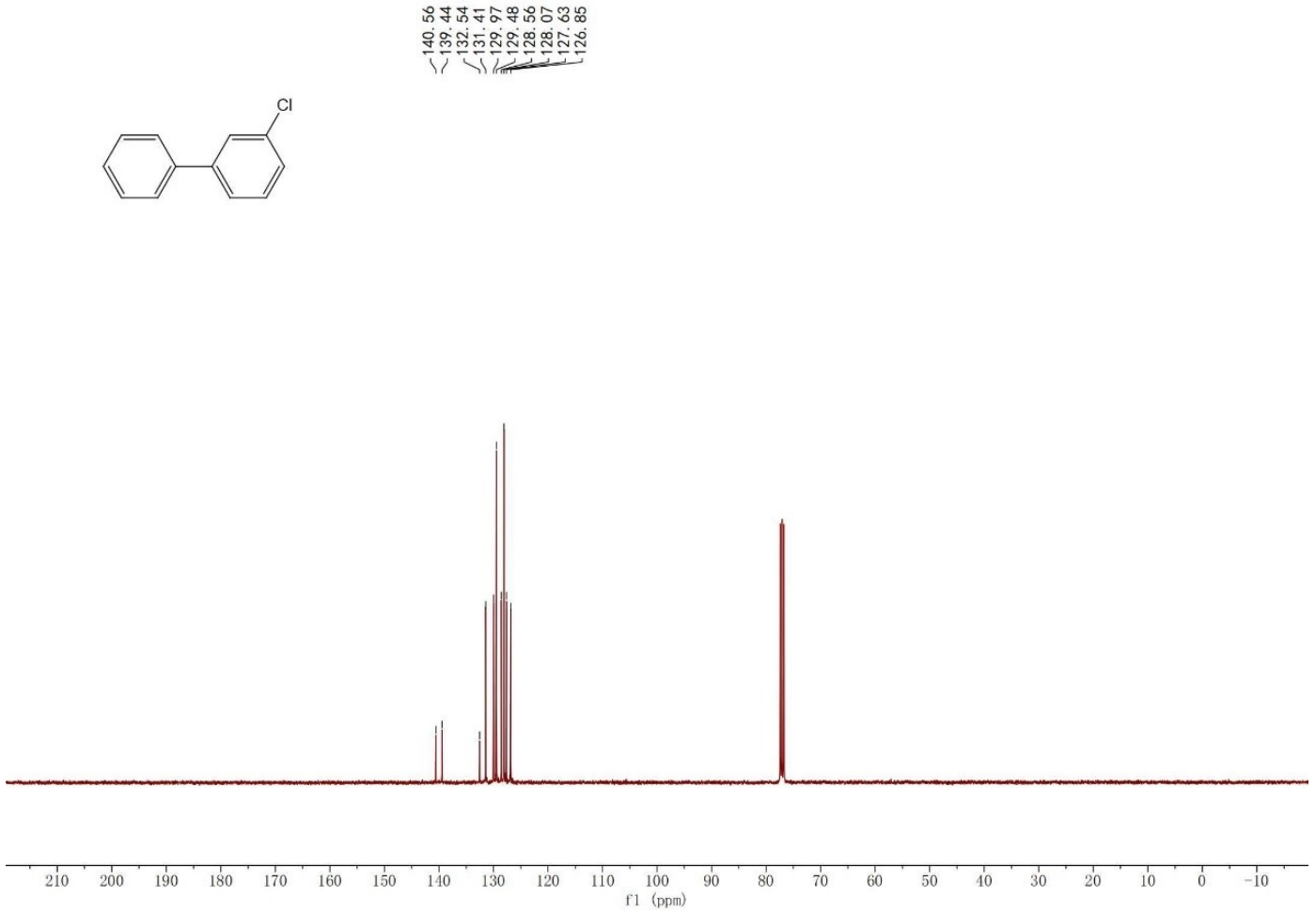
2
1
0
f1 (ppm)

**3ma** $^{13}C$ NMR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Cl
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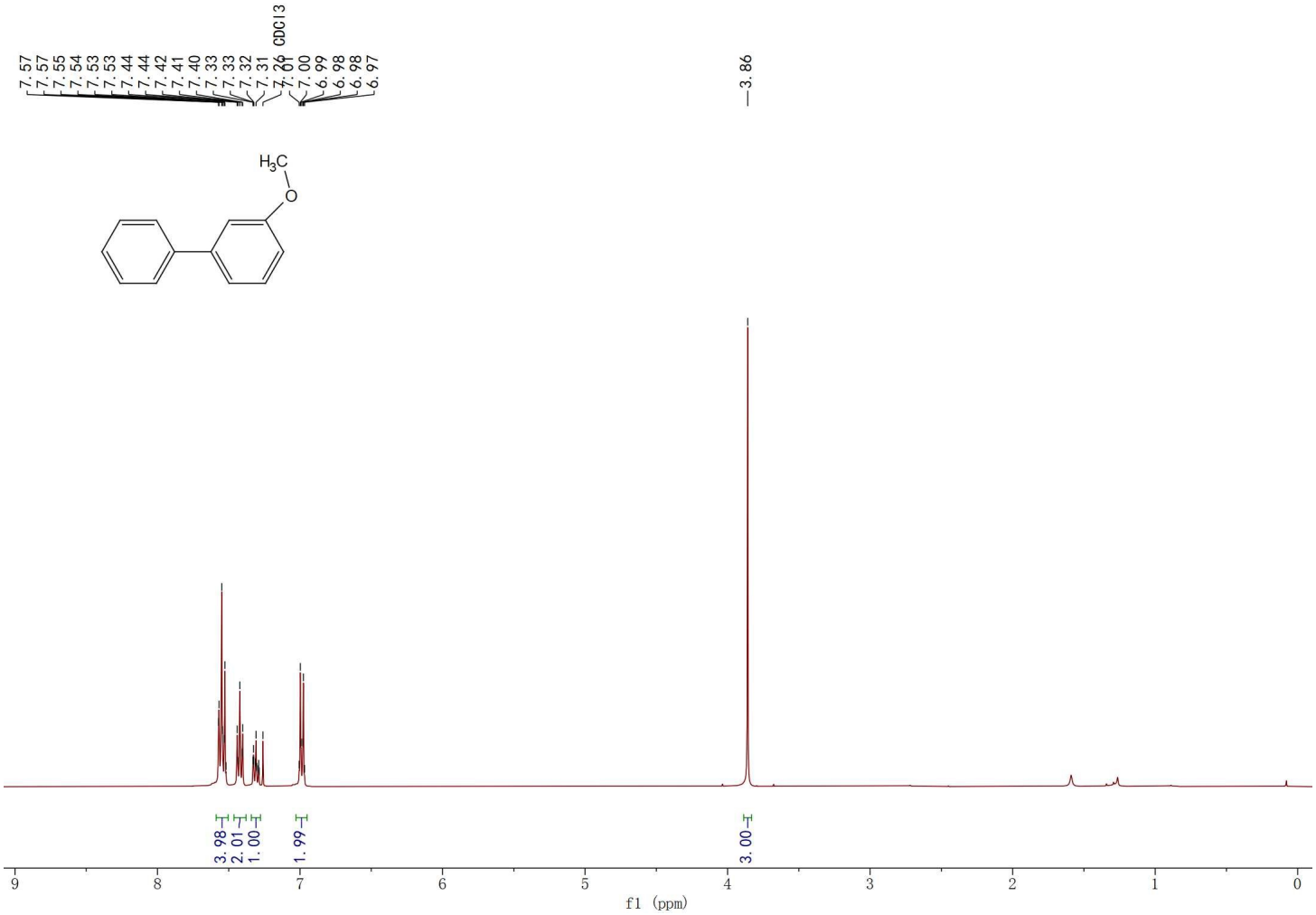
f1 (ppm)

**3na** $^{1}$H NMR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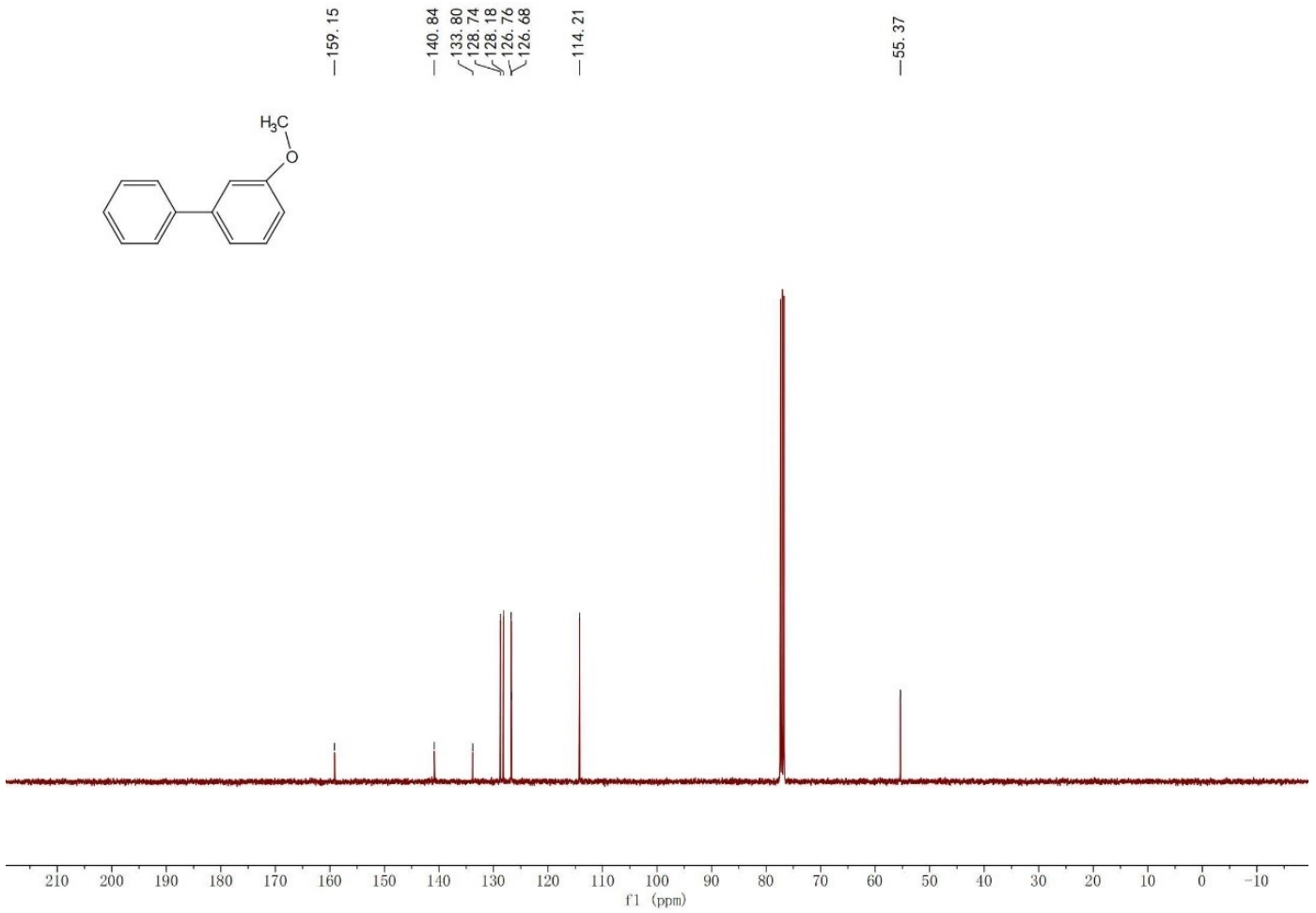
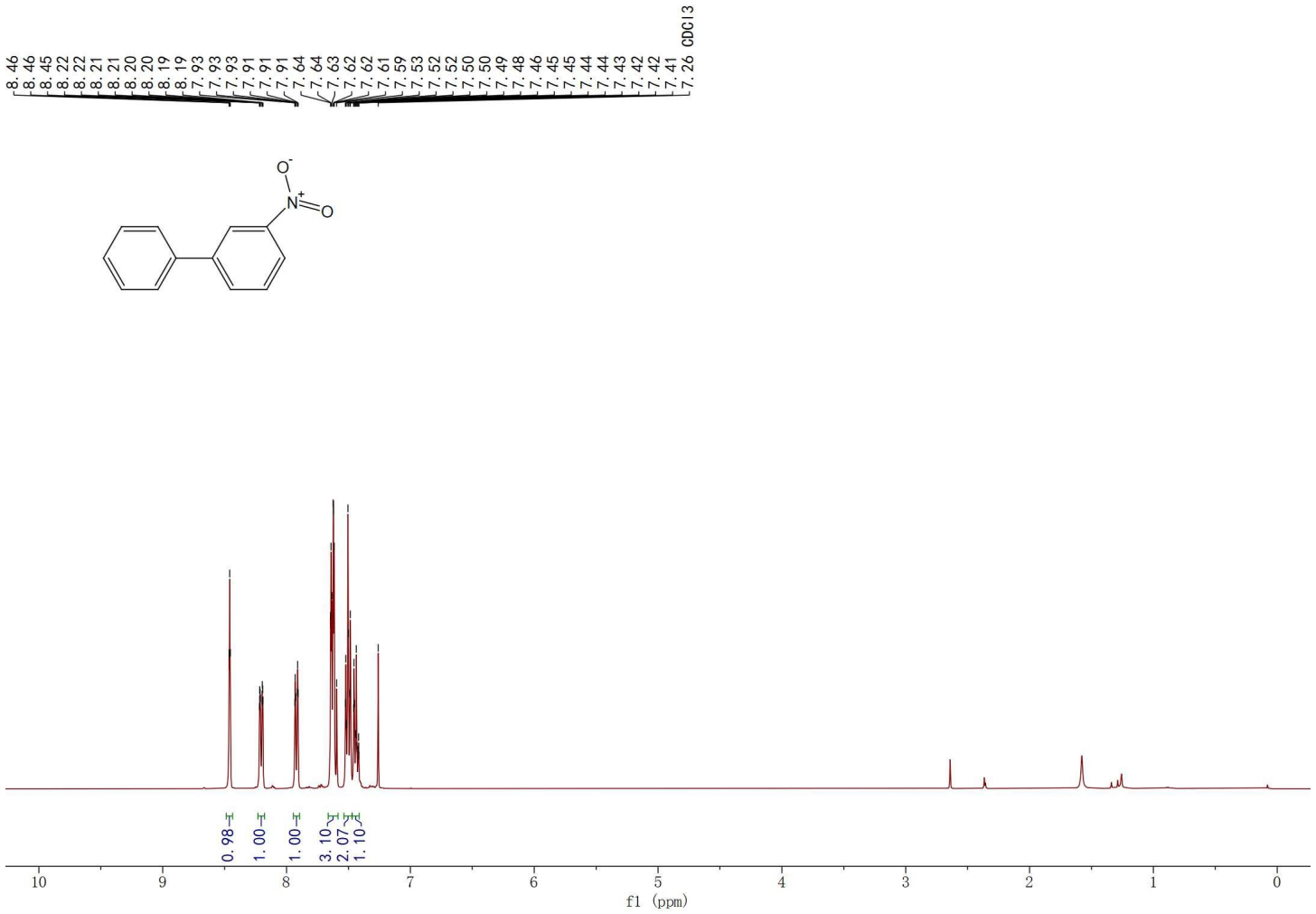
7.33
7.32
7.31
CDCl3
7.01
7.00
6.99
6.98
6.98
6.97
3.86
H3C
O
3.98
2.01
1.00
1.99
3.00
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

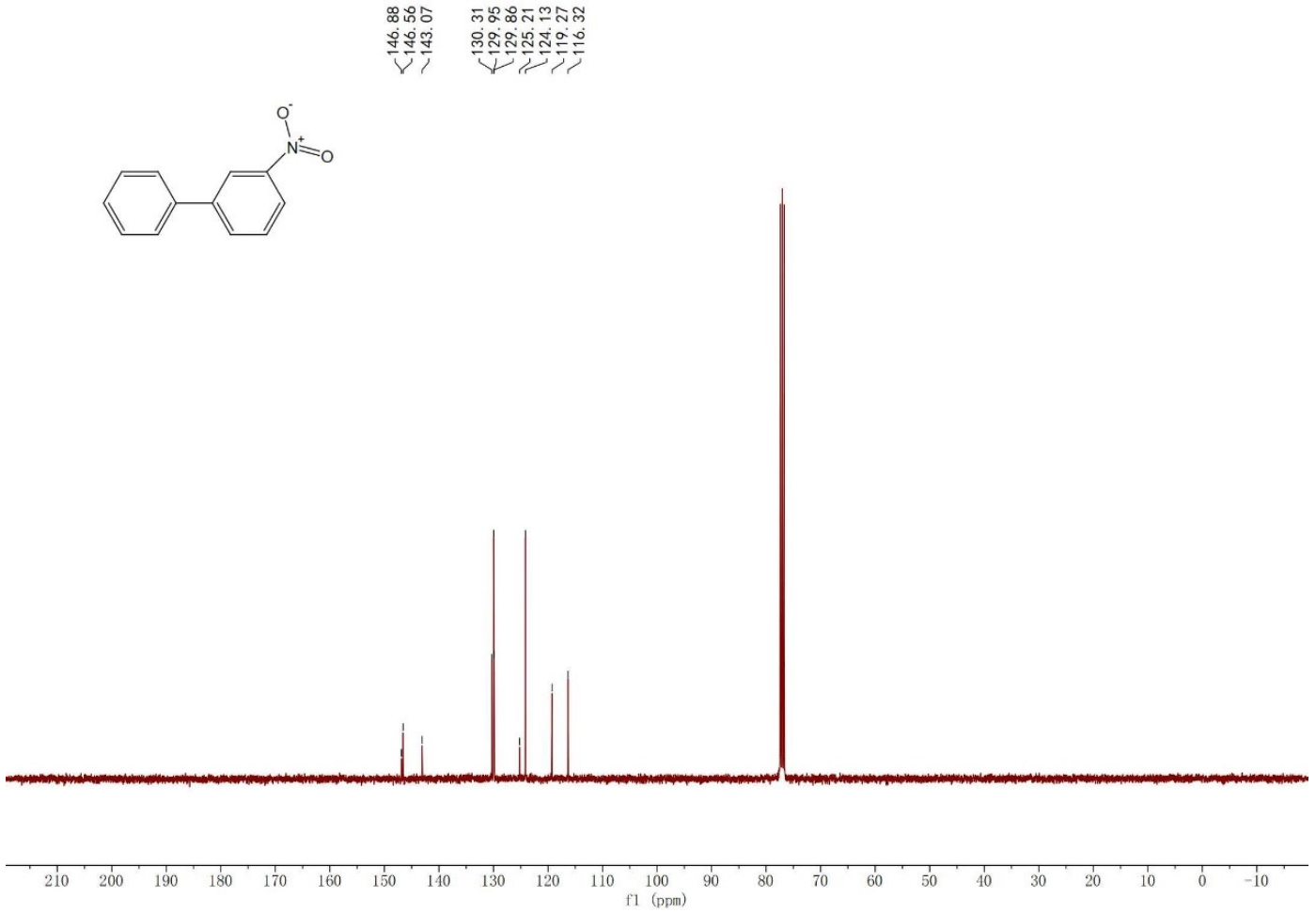
**3na** $^{13}C$ NMR


159.15
140.84
133.80
128.74
128.18
126.76
126.68
114.21
55.37
H3C
O
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)

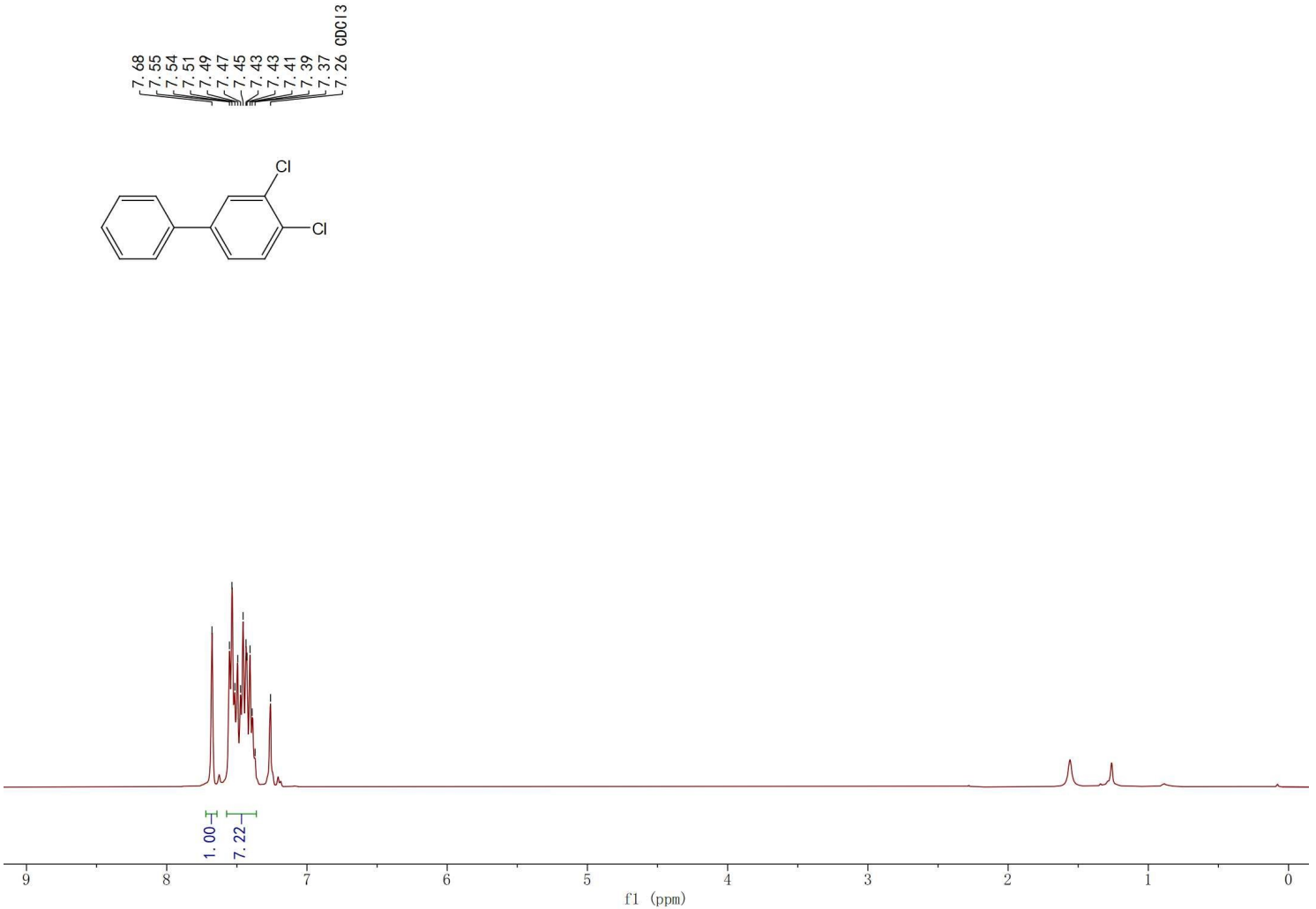
**3oa** $^{1}$H NMR


8.46
8.46
8.45
8.22
8.22
8.21
8.21
8.20
8.20
8.19
8.19
7.93
7.93
7.93
7.91
7.91
7.91
7.64
7.64
7.63
7.62
7.62
7.61
7.59
7.53
7.52
7.52
7.50
7.50
7.49
7.48
7.46
7.45
7.45
7.44
7.44
7.43
7.42
7.42
7.41
7.26
CDCl3
O
N
O
0.98
1.00
1.00
3.10
2.07
1.10
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

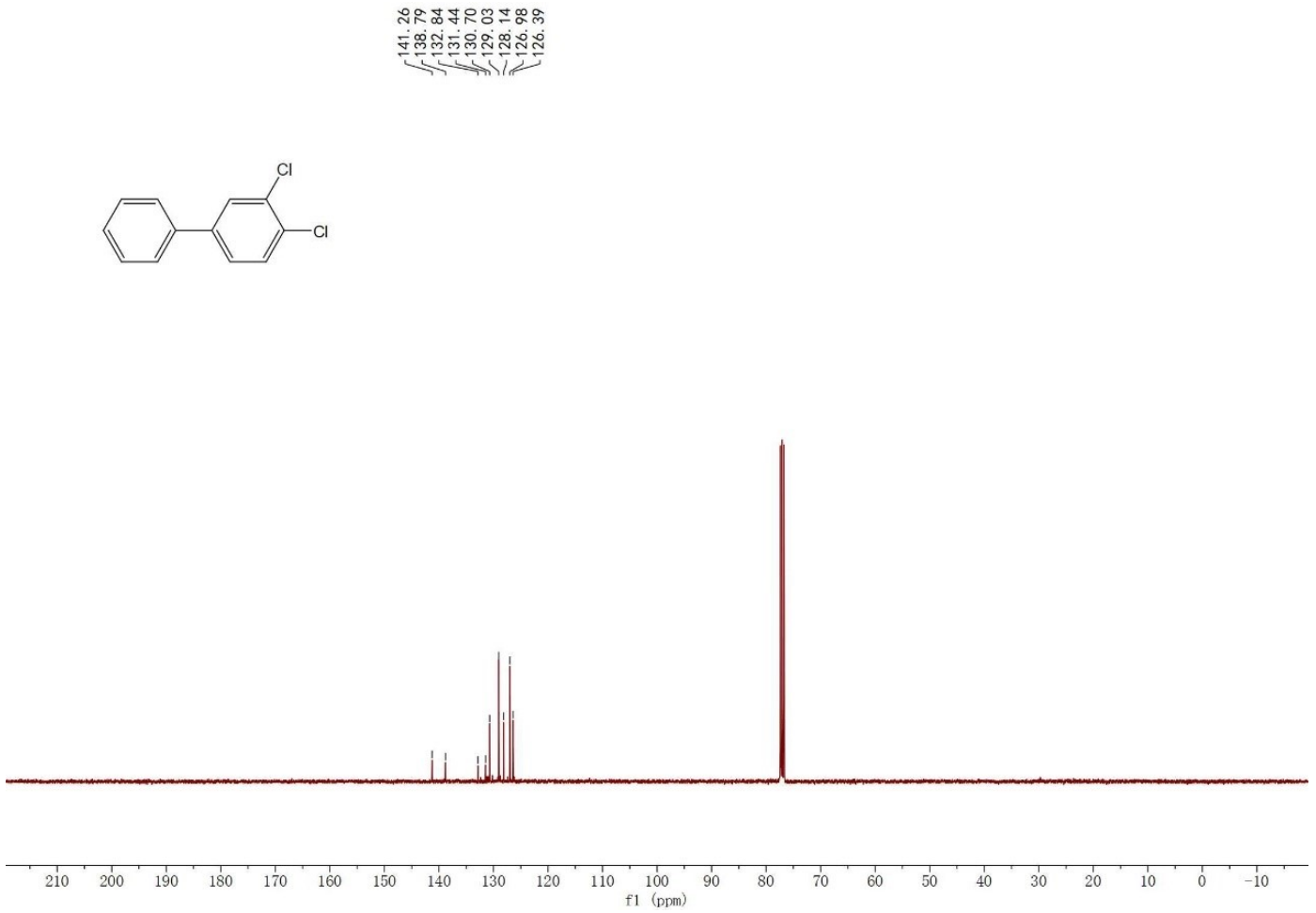
**3oa** $^{13}$C NMR


146.88
146.56
143.07
130.31
129.95
129.86
125.21
124.13
119.27
116.32
O
N
O
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)

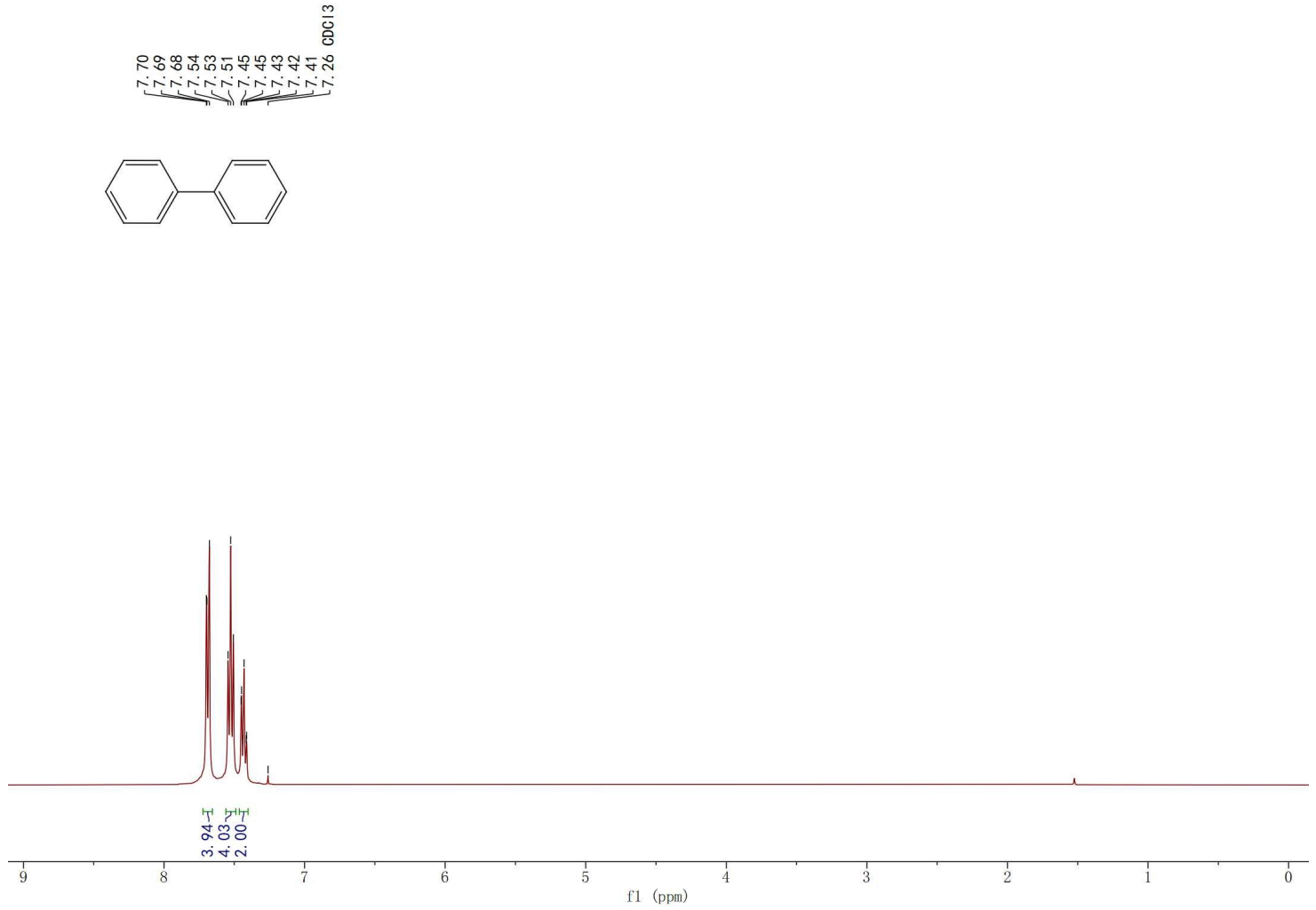
**3pa** $^{1}$H NMR


7.68
7.55
7.54
7.51
7.49
7.47
7.45
7.43
7.43
7.41
7.39
7.37
7.26 CDCl3
Cl
Cl
1.00
7.22
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

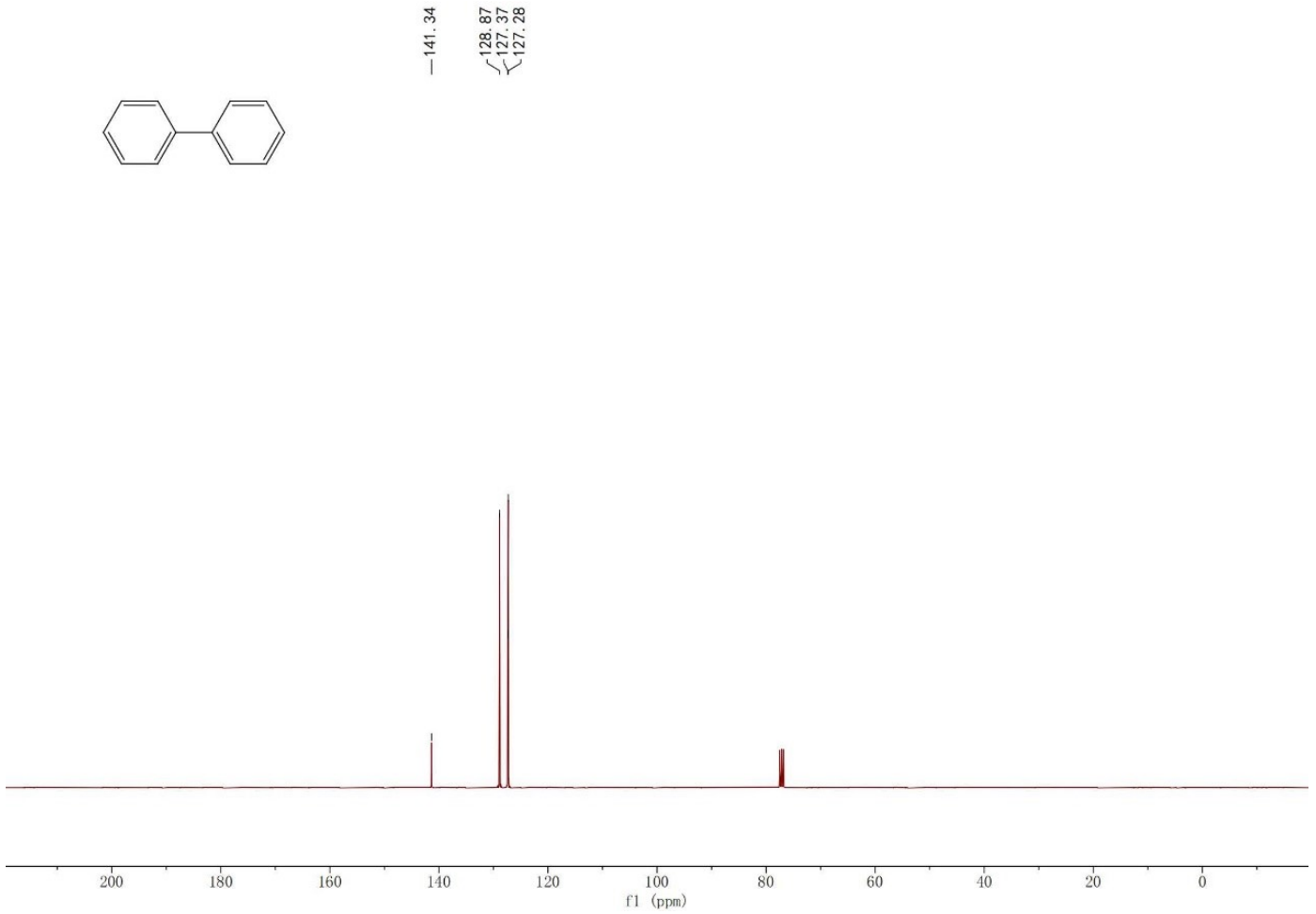
**3pa** $^{13}C$ NMR


141.26
138.79
132.84
131.44
130.70
129.03
128.14
126.98
126.39
Cl
Cl
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)

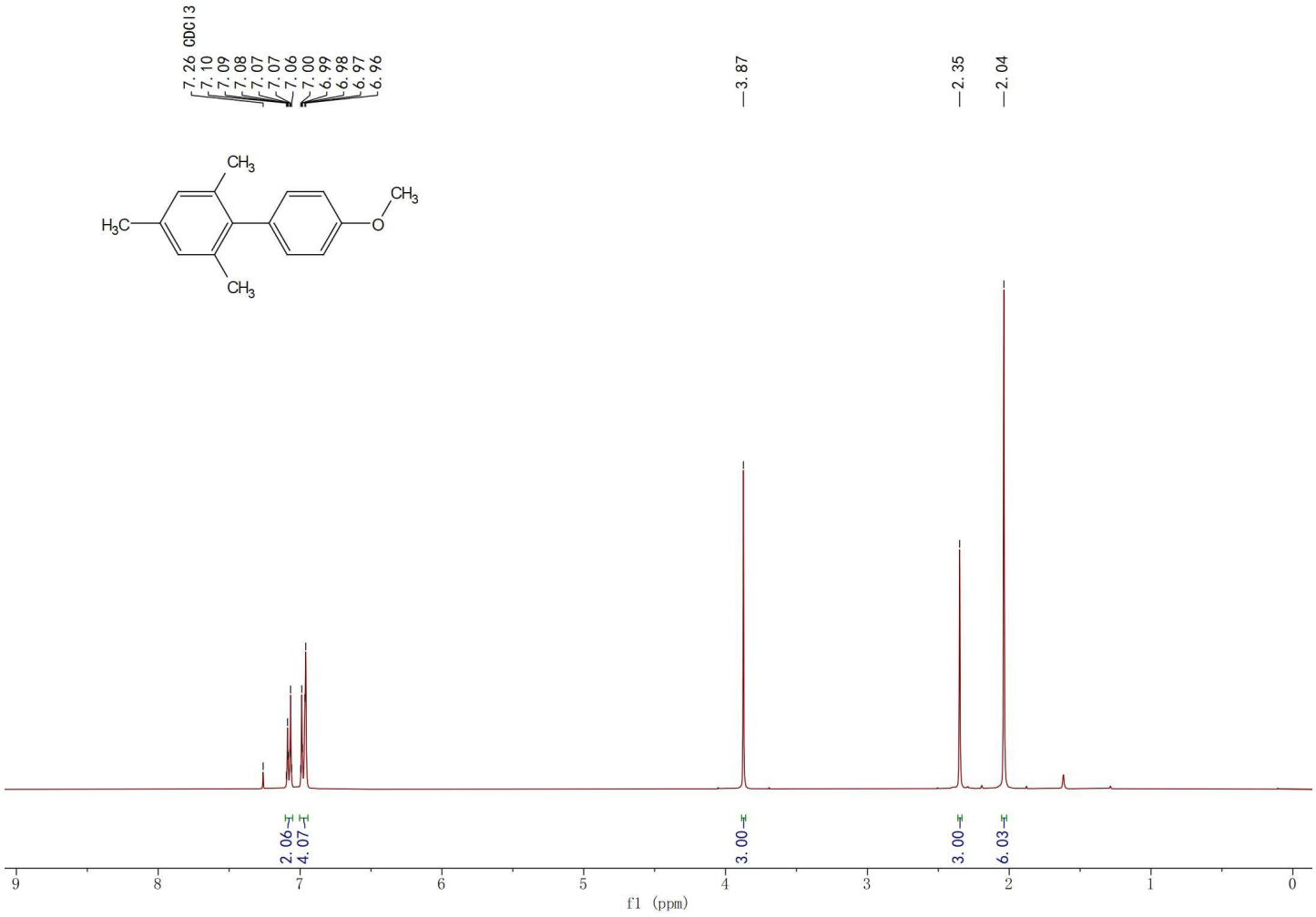
**3qa** $^{1}$H NMR


7.70
7.69
7.68
7.54
7.53
7.51
7.45
7.45
7.43
7.42
7.41
7.26
CDCl3
3.94
4.03
2.00
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

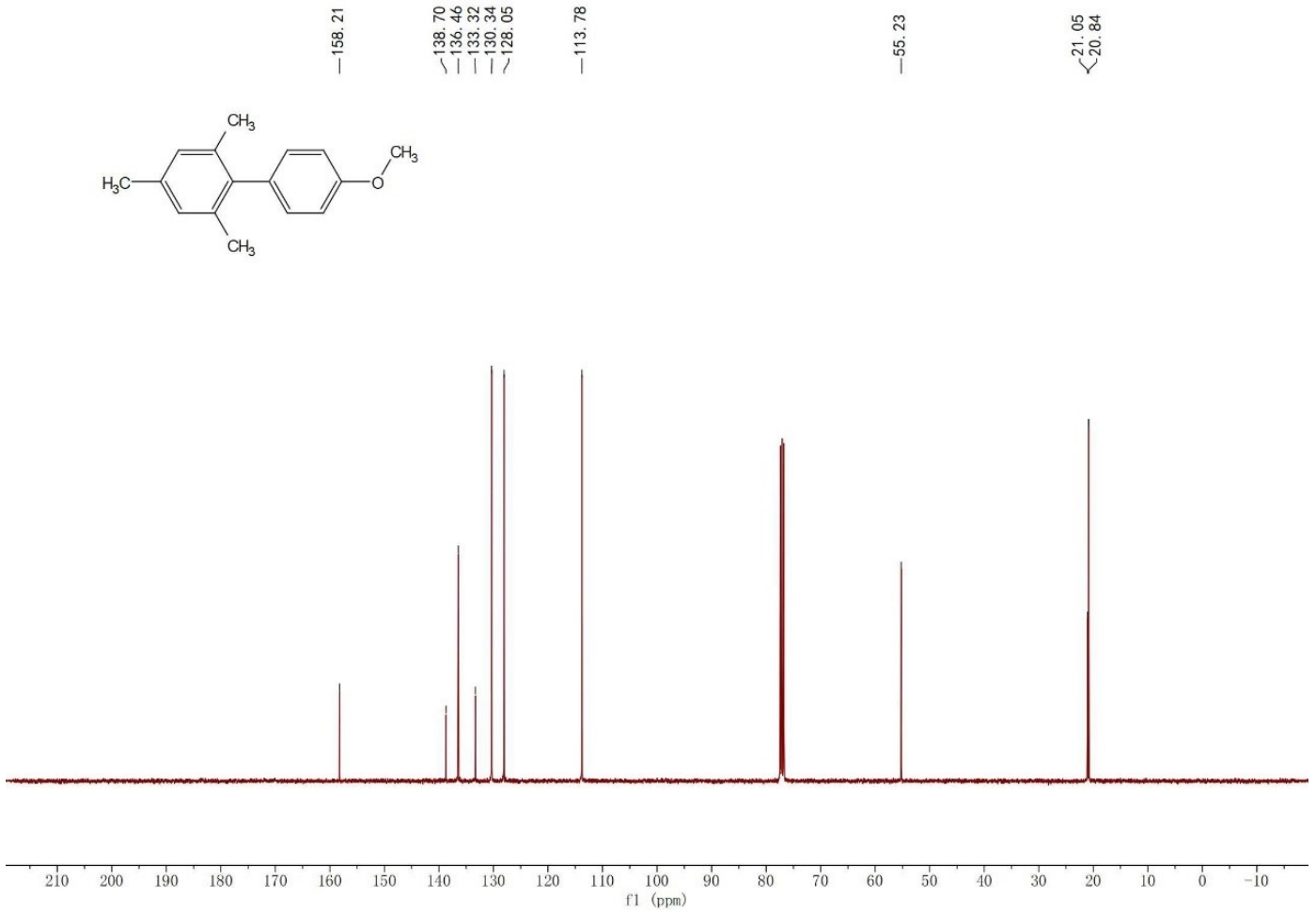
**3qa** $^{13}C$ NMR


141.34
128.87
127.37
127.28
200
180
160
140
120
100
80
60
40
20
0
f1 (ppm)

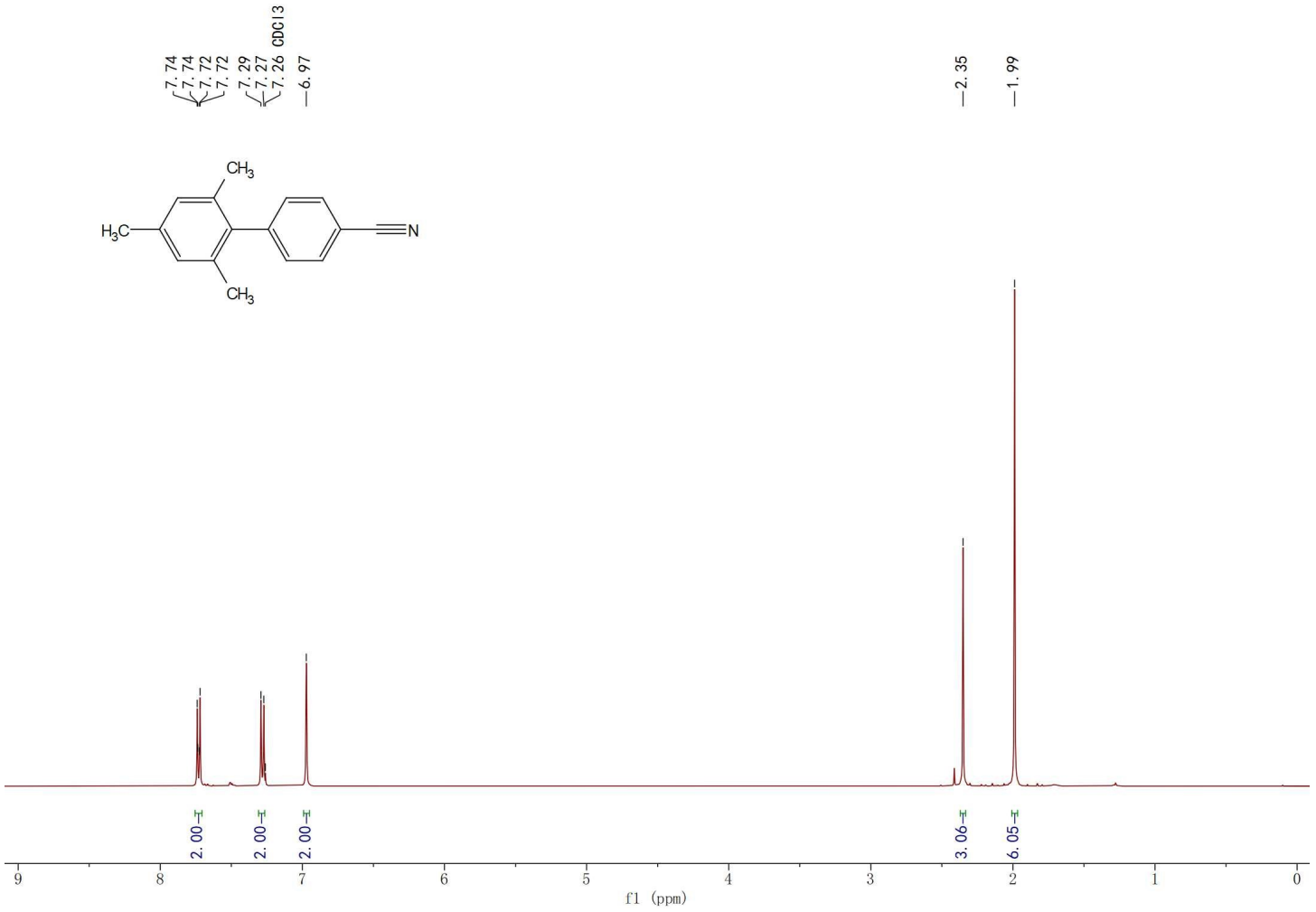
**3db** $^{1}$H NMR


7.26 CDCl3
7.10
7.09
7.08
7.07
7.07
7.06
7.00
6.99
6.98
6.97
6.96
3.87
2.35
2.04
CH3
H3C
O
CH3
CH3
2.06
4.07
3.00
3.00
6.03
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

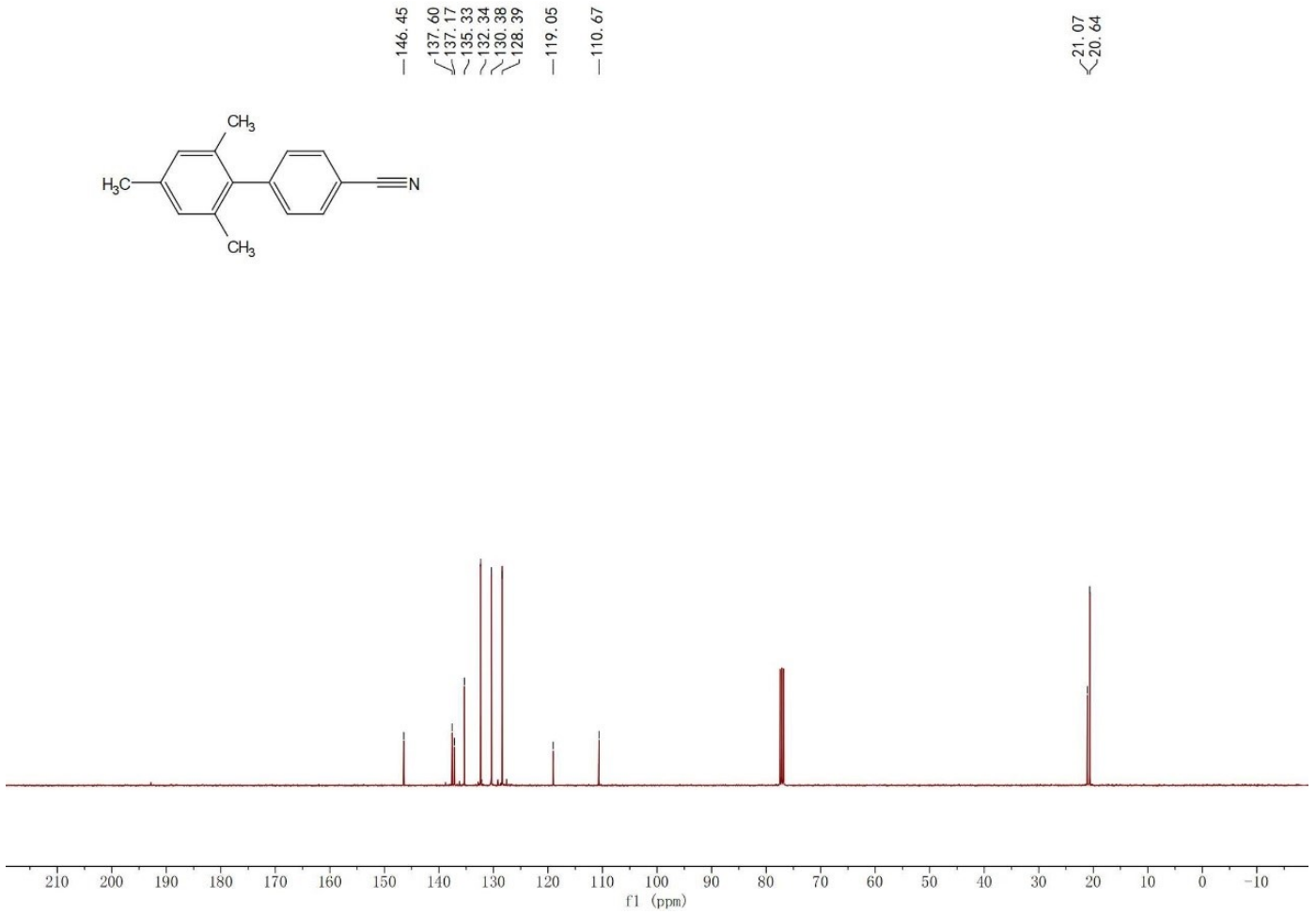
**3db** $^{13}$C NMR


158.21
138.70
136.46
133.32
130.34
128.05
113.78
55.23
21.05
20.84
CH3
H3C
O
CH3
CH3
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)

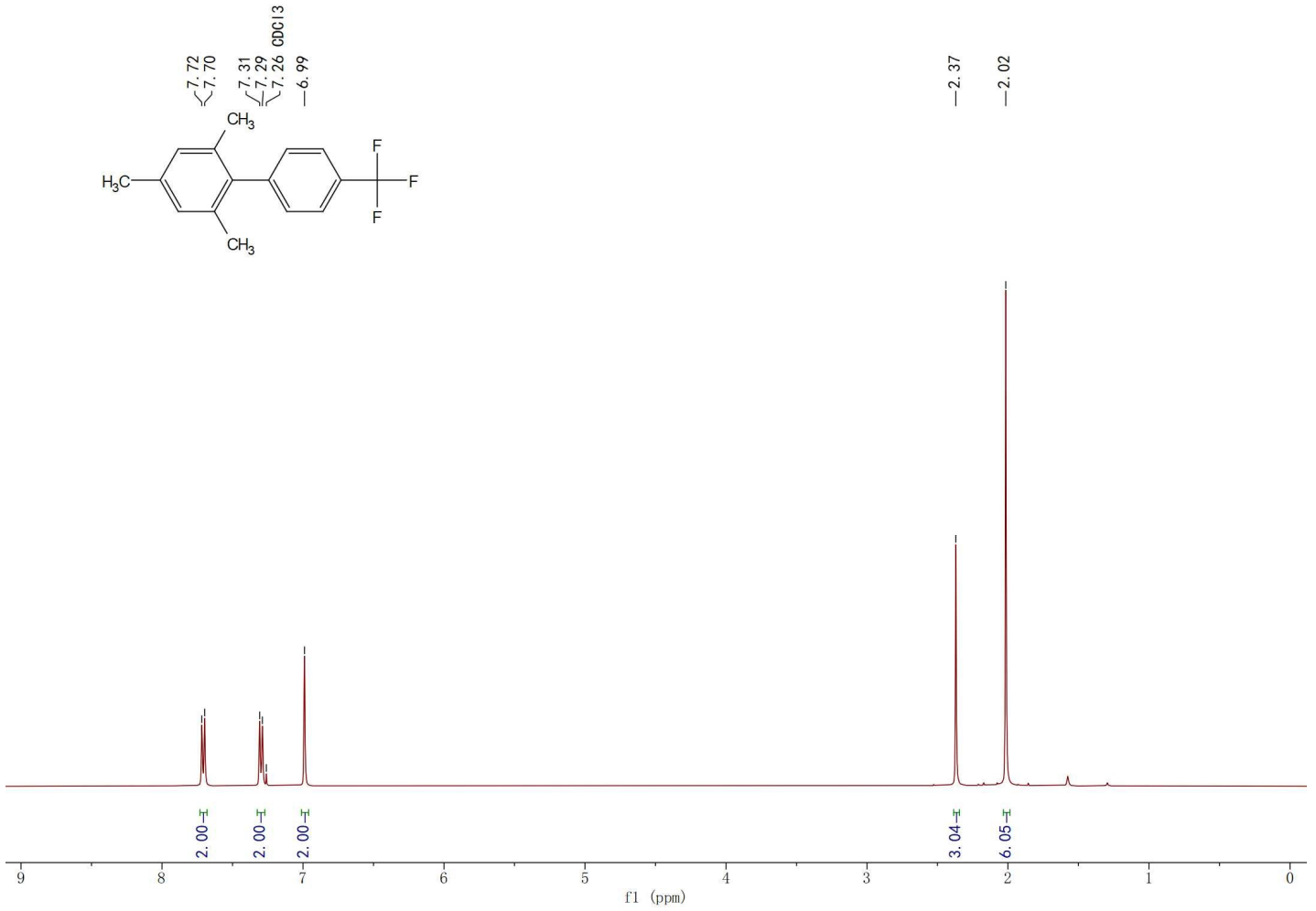
**3fb** $^{1}$H NMR


7.74
7.74
7.72
7.72
7.29
7.27
7.26 CDCl3
6.97
2.35
1.99
CH3
H3C
N
CH3
2.00
2.00
2.00
3.06
6.05
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

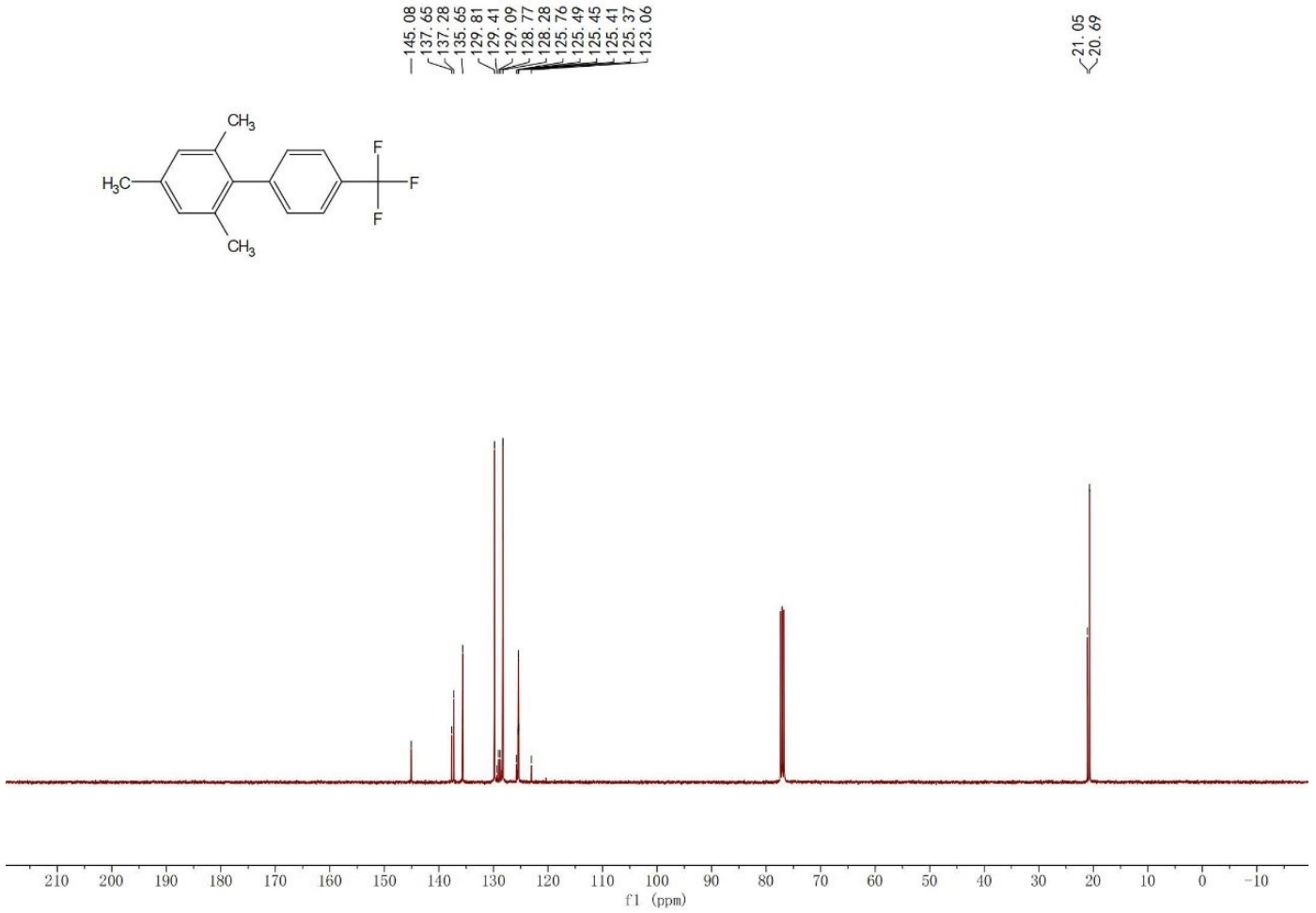
**3fb** $^{13}$C NMR


146.45
137.60
137.17
135.33
132.34
130.38
128.39
119.05
110.67
21.07
20.64
CH3
H3C
CH3
N
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)

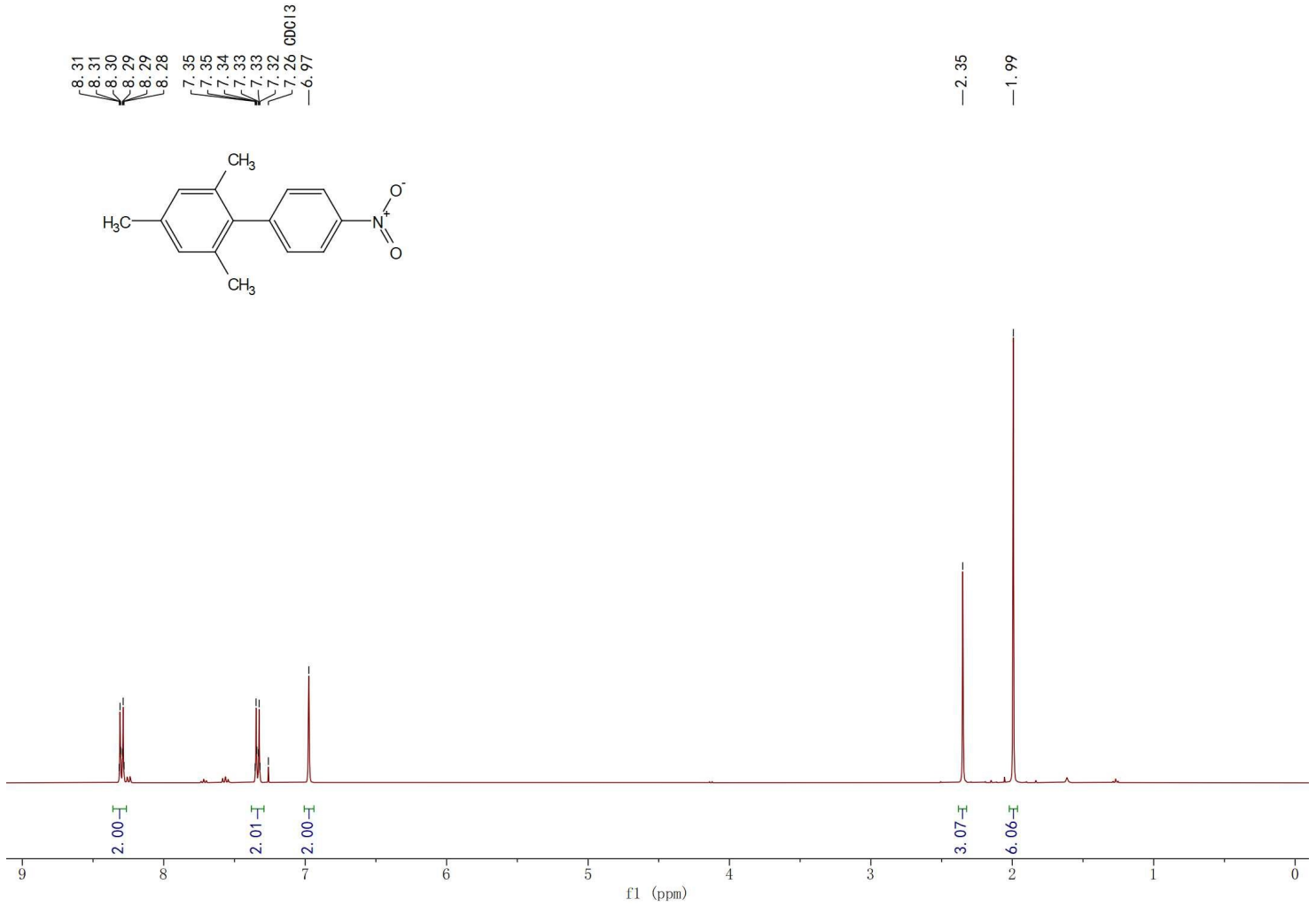
**3gb** $^{1}$H NMR


7.72
7.70
7.31
7.29
7.26
CDCl3
6.99
2.37
2.02
CH3
H3C
CH3
F
F
F
2.00
2.00
2.00
3.04
6.05
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

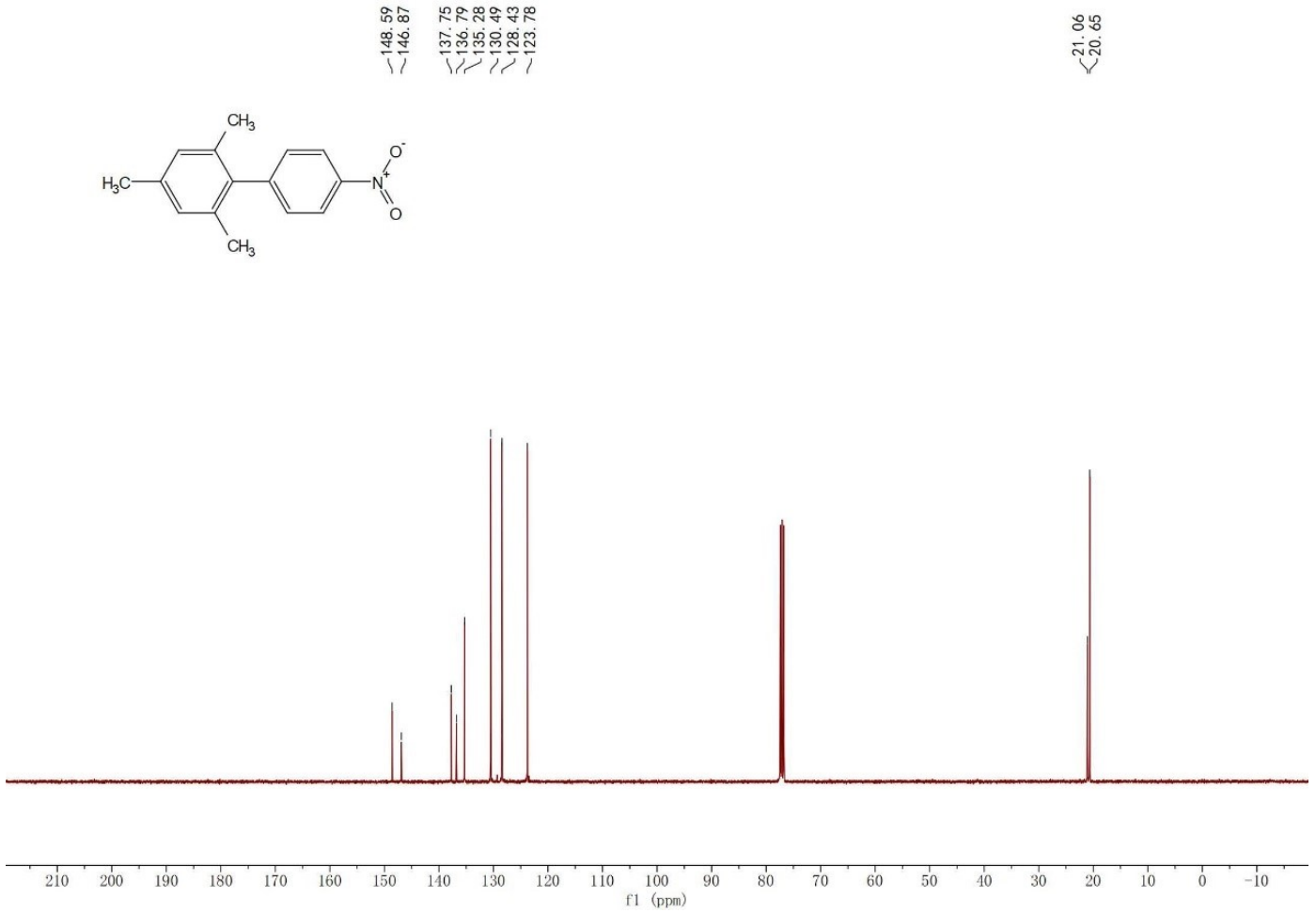
**3gb** $^{13}C$ NMR


145.08
137.65
137.28
135.65
129.81
129.41
129.09
128.77
128.28
125.76
125.49
125.45
125.41
125.37
123.06
21.05
20.69
CH3
H3C
CH3
F
F
F
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)

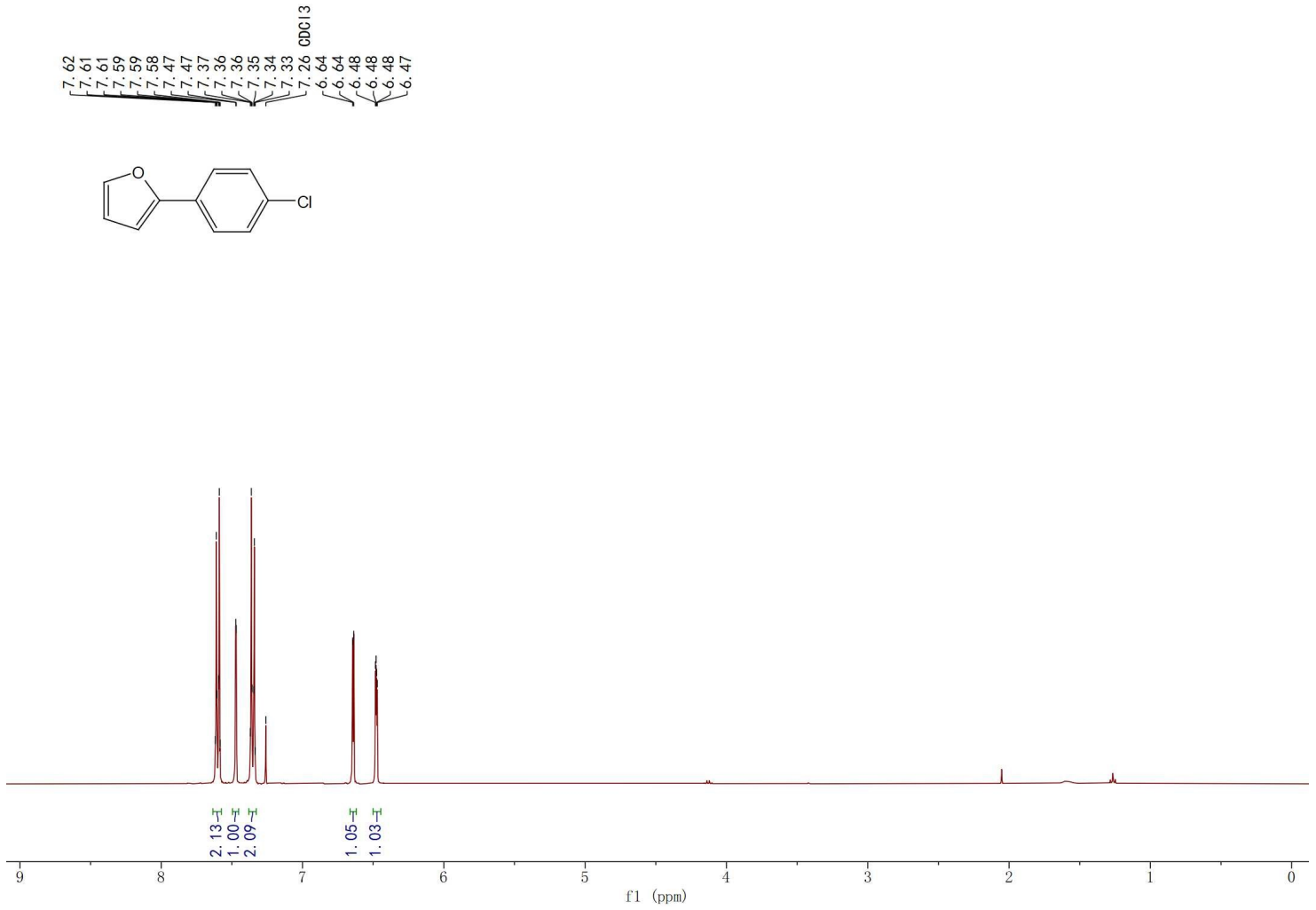
**3jb** $^{1}$H NMR


8.31
8.31
8.30
8.29
8.29
8.28
7.35
7.35
7.34
7.33
7.33
7.32
7.26 CDCl3
6.97
2.35
1.99
CH3
H3C
CH3
N+
O-
O
2.00
2.01
2.00
3.07
6.06
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

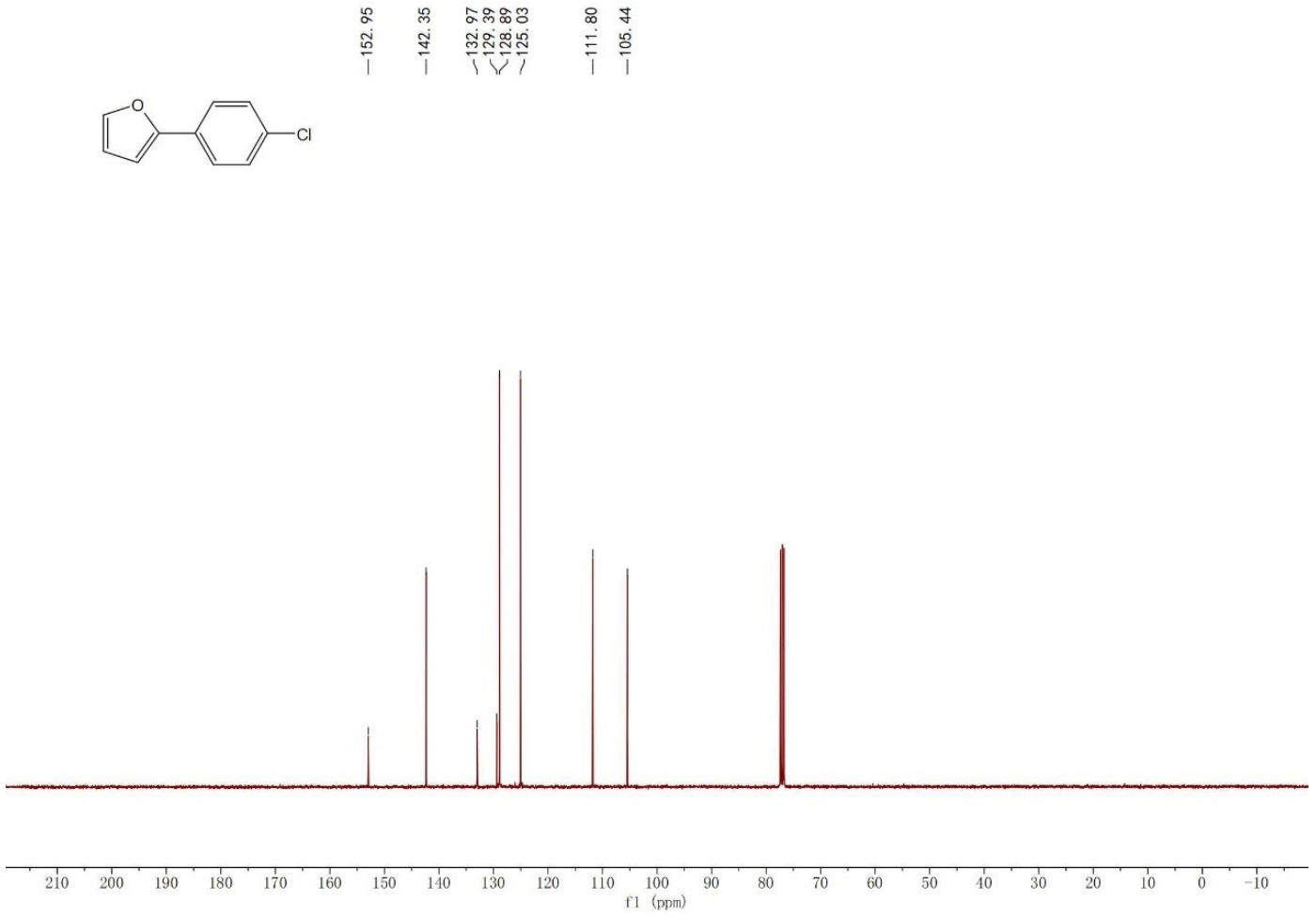
**3jb** $^{13}C$ NMR


148.59
146.87
137.75
136.79
135.28
130.49
128.43
123.78
21.06
20.65
CH3
H3C
CH3
O-
N+
O
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)

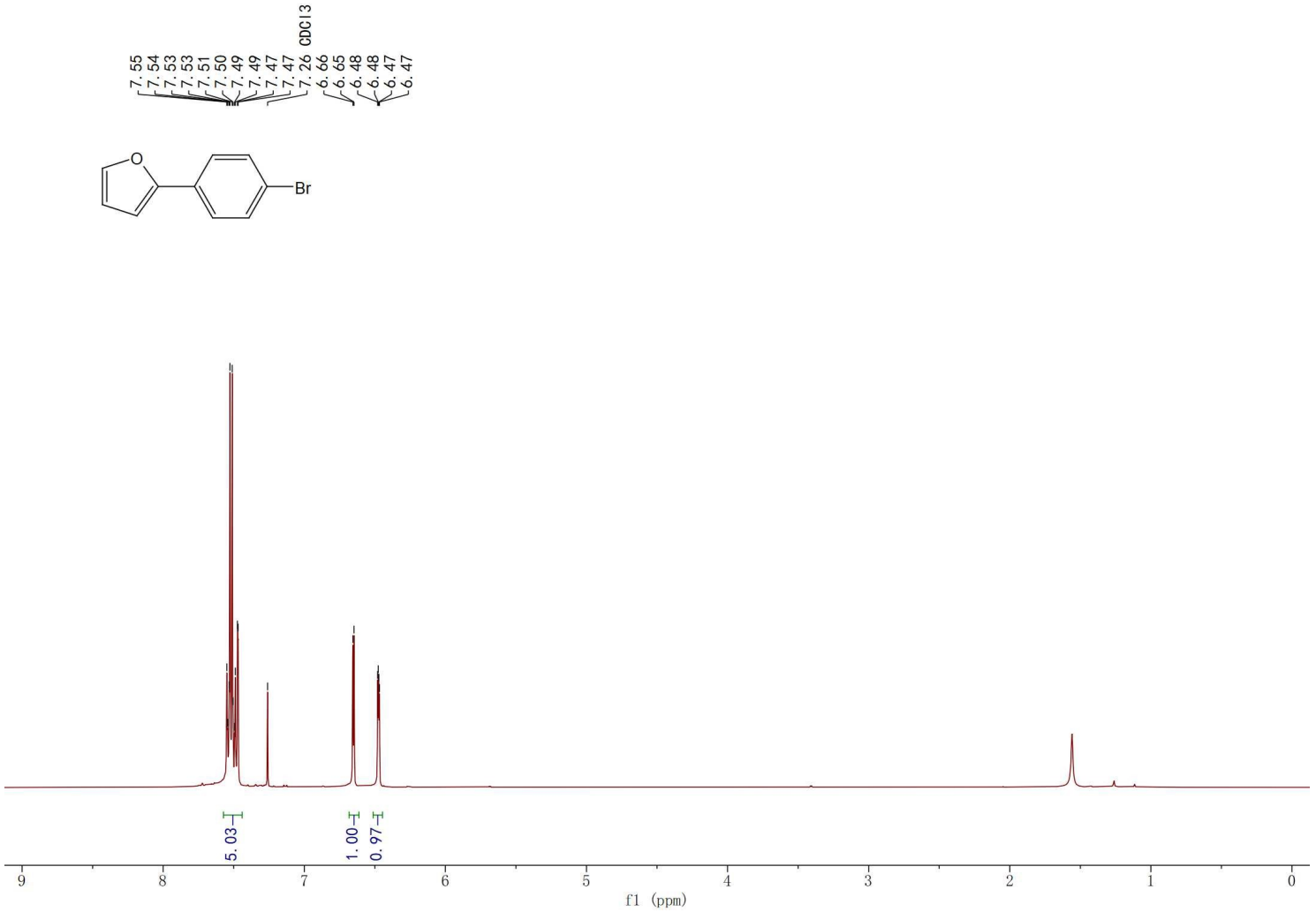
**3ac** $^{1}$H NMR


7.62
7.61
7.61
7.59
7.59
7.58
7.47
7.47
7.37
7.36
7.36
7.35
7.34
7.33
7.26
CDCl3
6.64
6.64
6.48
6.48
6.48
6.47
O
Cl
2.13
1.00
2.09
1.05
1.03
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

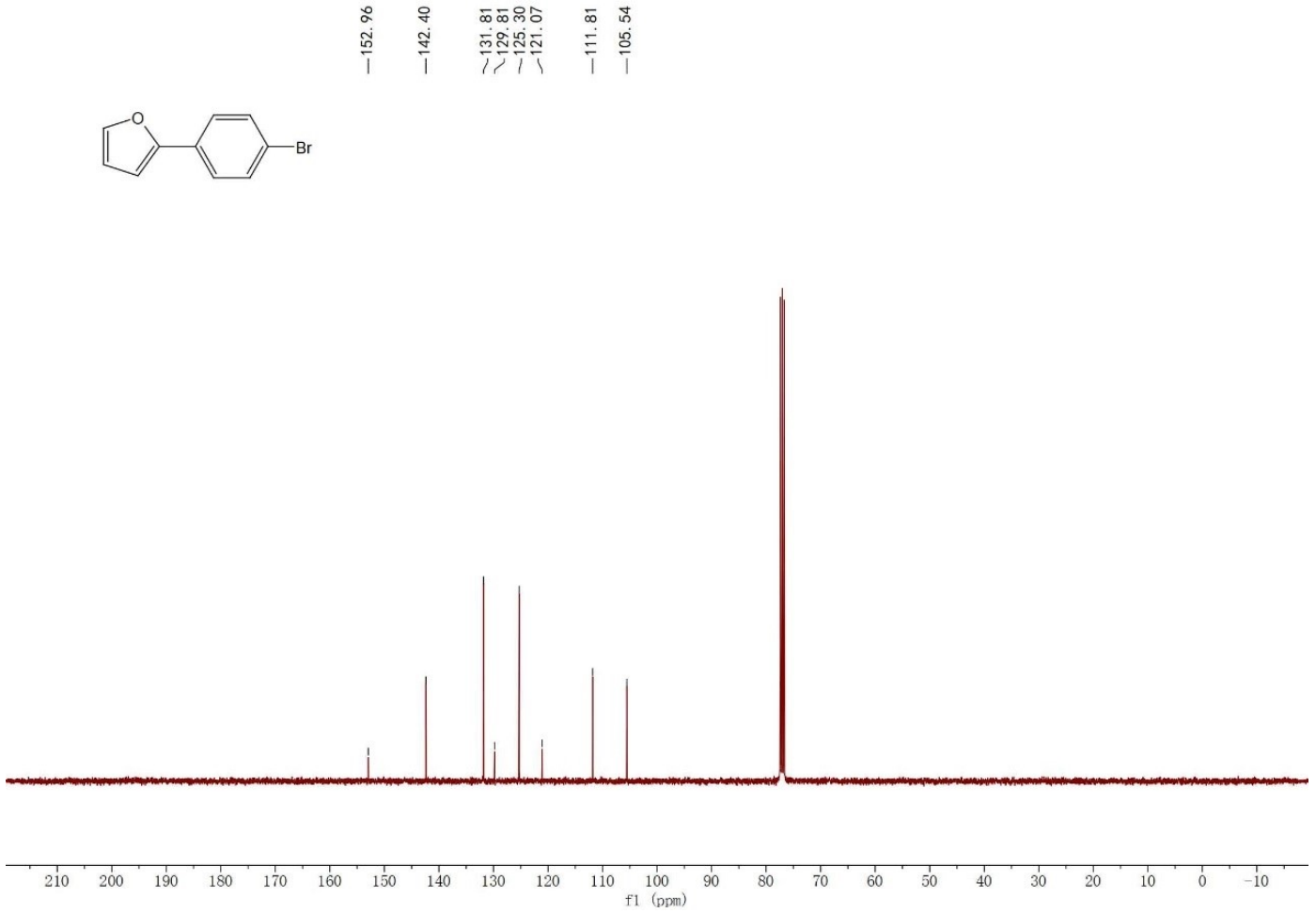
**3ac** $^{13}C$ NMR


152.95
142.35
132.97
129.39
128.89
125.03
111.80
105.44
O
Cl
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)

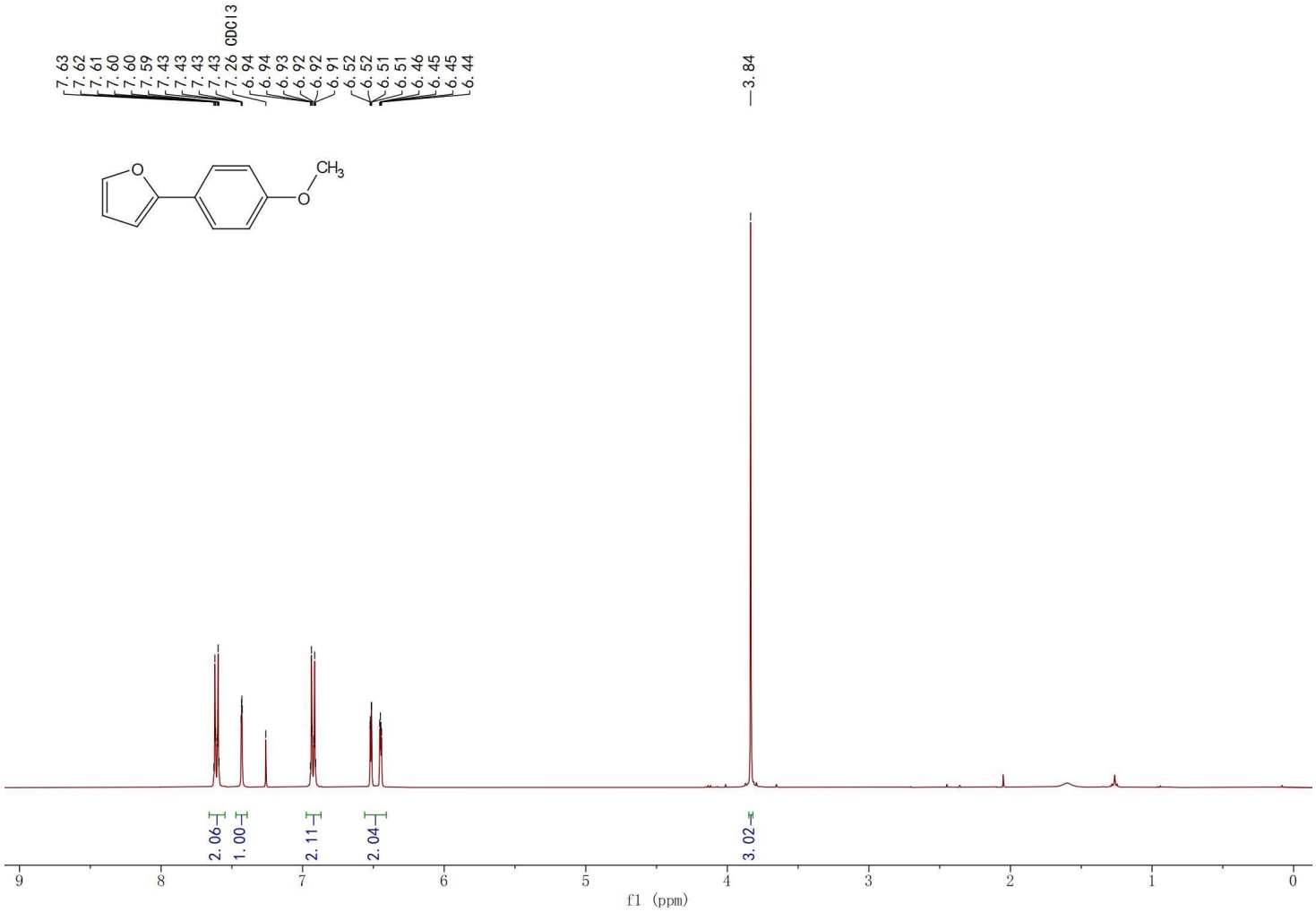
**3bc** $^{1}$H NMR


7.55
7.54
7.53
7.53
7.51
7.50
7.49
7.49
7.47
7.47
7.26
CDCl3
6.66
6.65
6.48
6.48
6.47
6.47
O
Br
5.03
1.00
0.97
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

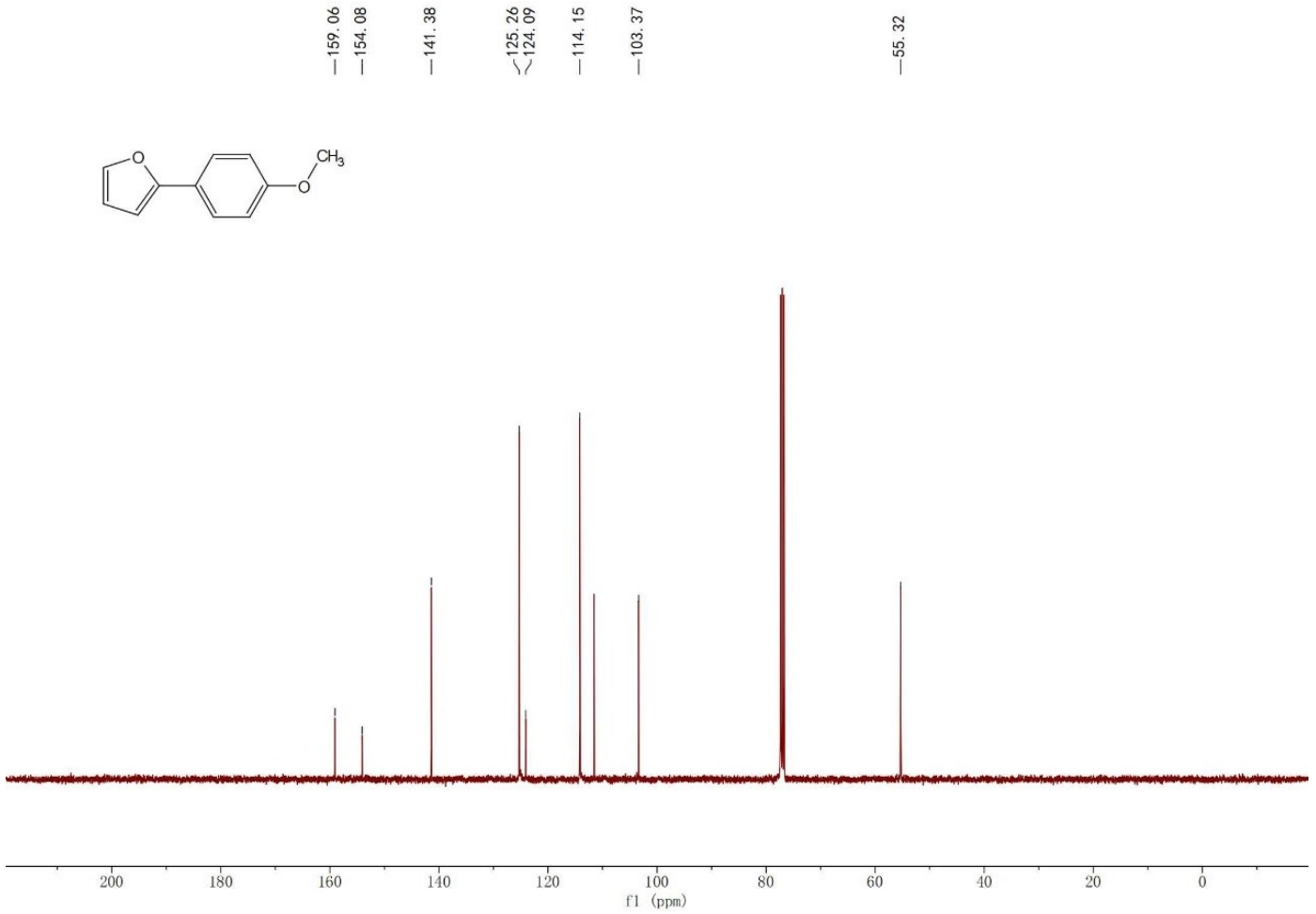
**3bc** $^{13}$C NMR


152.96
142.40
131.81
129.81
125.30
121.07
111.81
105.54
O
Br
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)

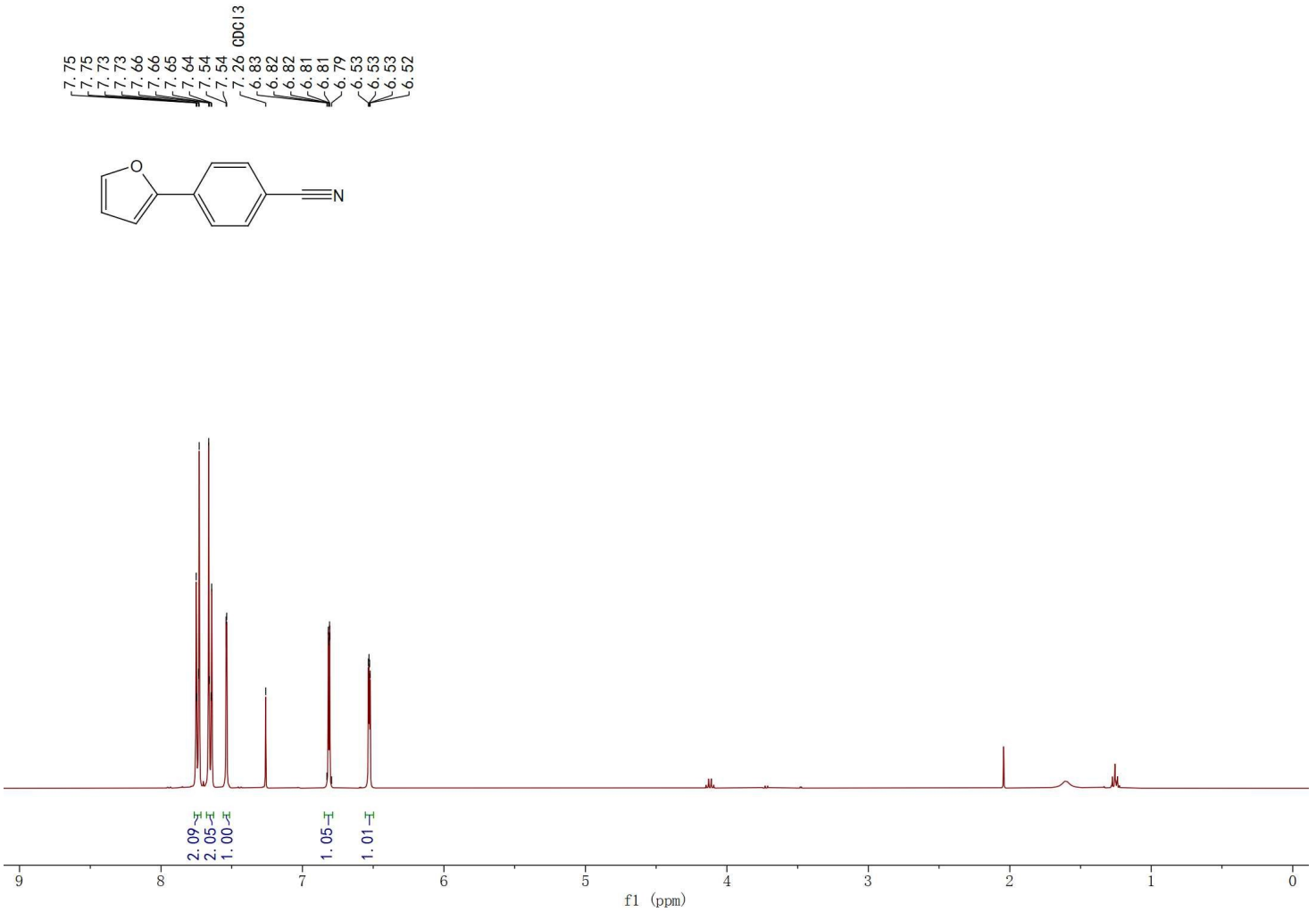
**3dc** $^{1}$H NMR


7.63
7.62
7.61
7.60
7.60
7.59
7.43
7.43
7.43
7.43
7.26
CDCl3
6.94
6.94
6.93
6.92
6.92
6.91
6.52
6.52
6.51
6.51
6.46
6.45
6.45
6.44
3.84
O
O
CH3
2.06
1.00
2.11
2.04
3.02
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

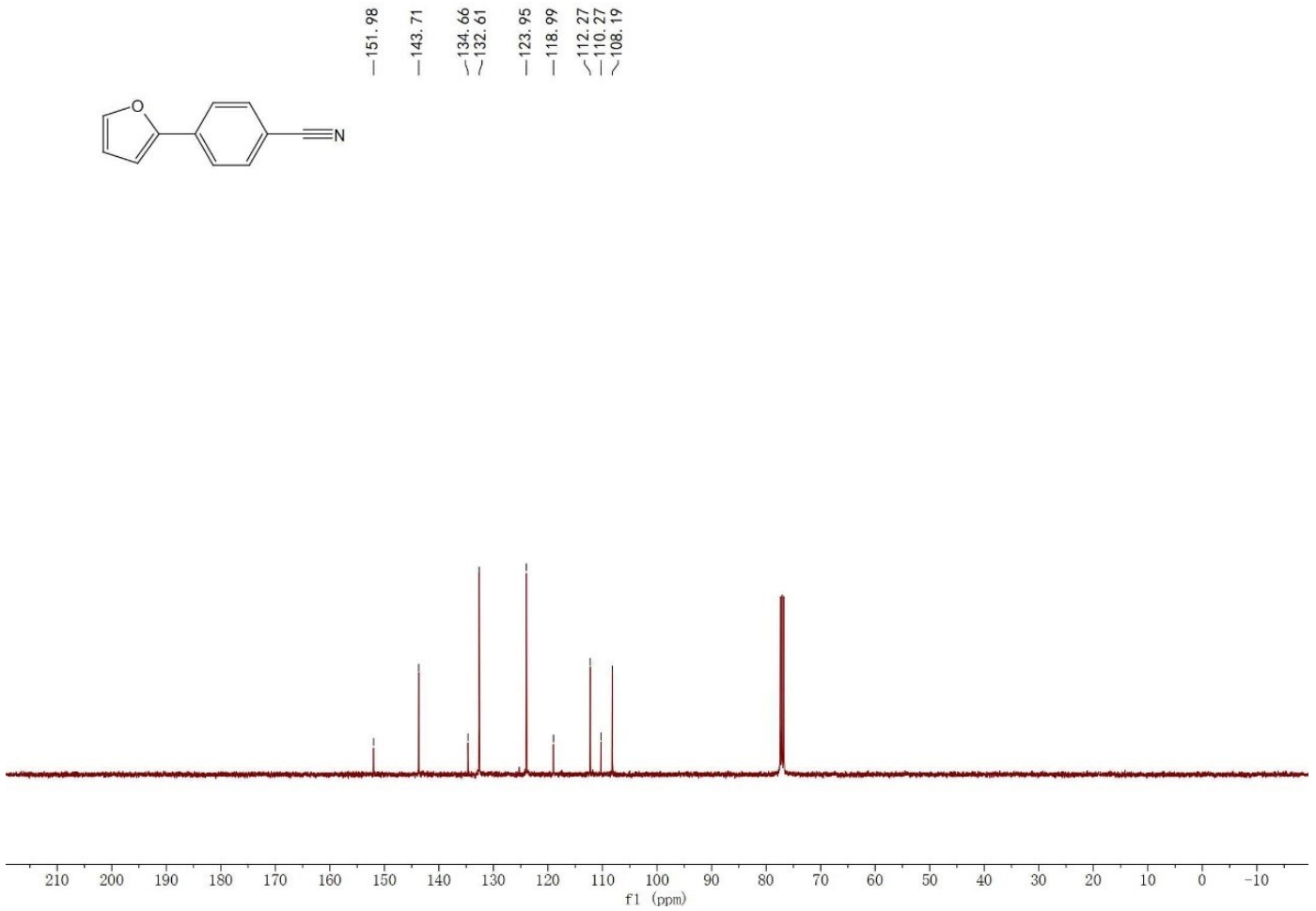
**3dc** $^{13}$C NMR


159.06
154.08
141.38
125.26
124.09
114.15
103.37
55.32
O
CH3
O
200
180
160
140
120
100
80
60
40
20
0
f1 (ppm)

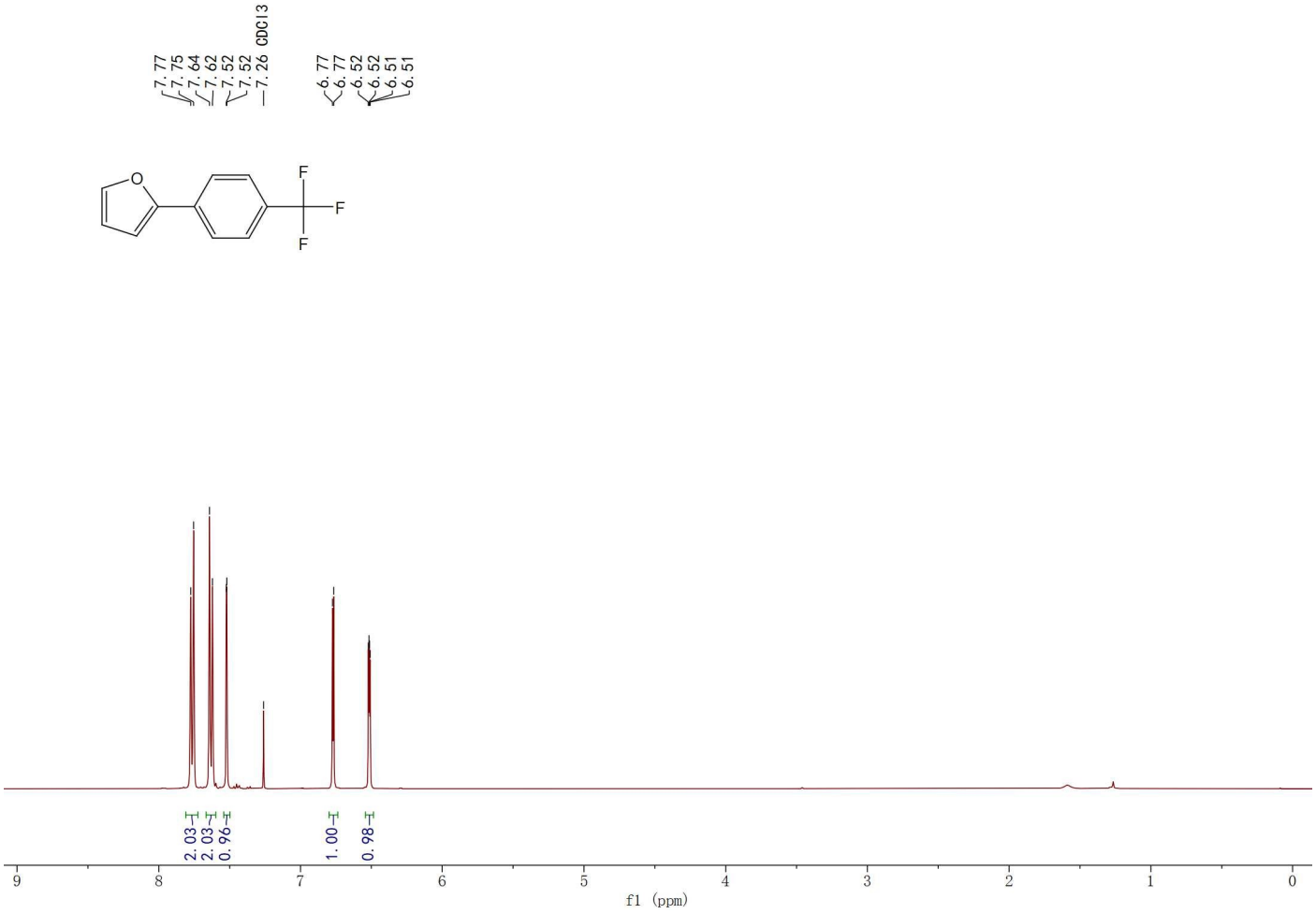
**3fc** $^{1}$H NMR


7.75
7.75
7.73
7.73
7.66
7.66
7.65
7.64
7.54
7.54
CDCl3
7.26
6.83
6.82
6.82
6.81
6.81
6.79
6.53
6.53
6.53
6.52
O
N
2.09
2.05
1.00
1.05
1.01
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

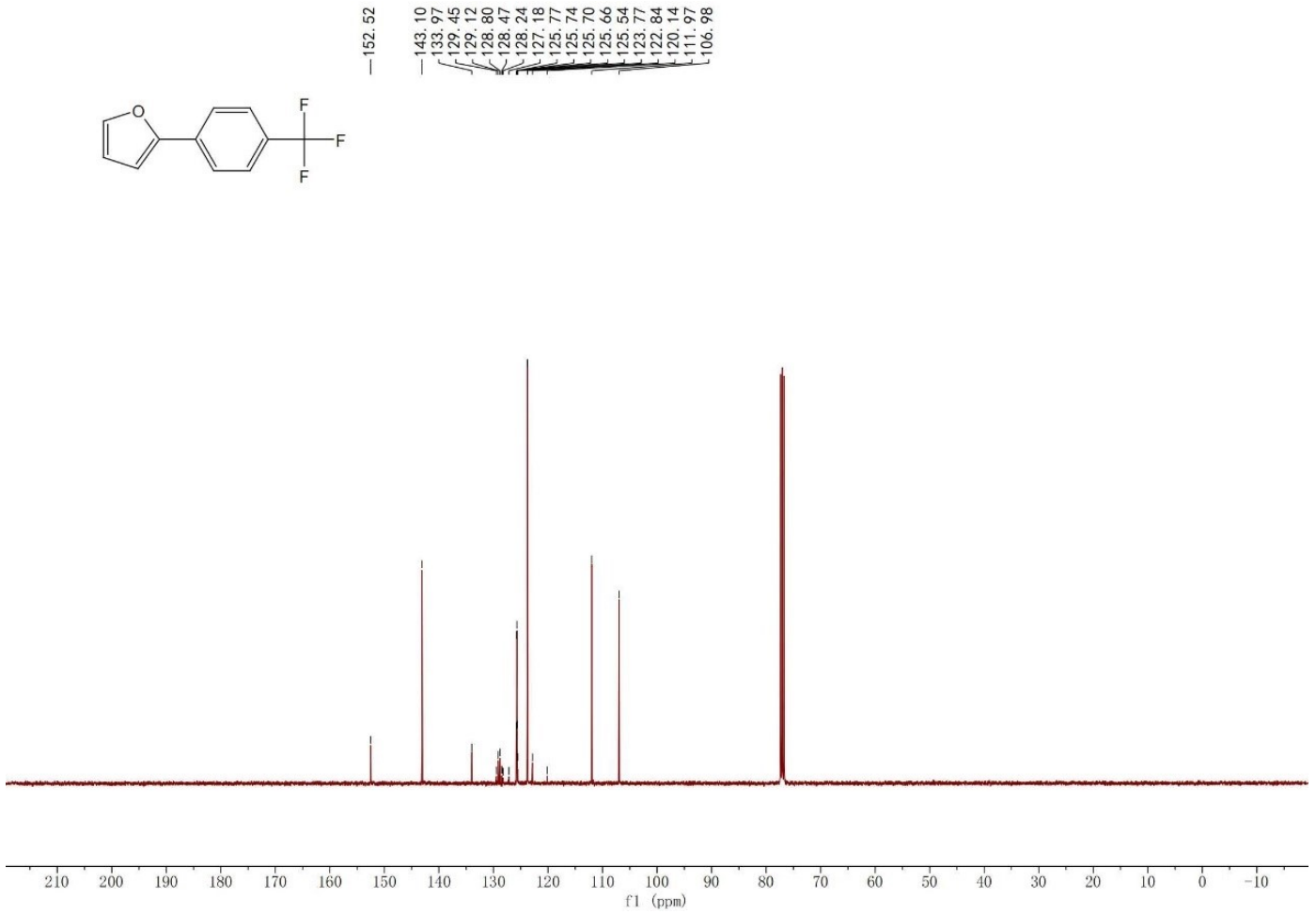
**3fc** $^{13}$C NMR


151.98
143.71
134.66
132.61
123.95
118.99
112.27
110.27
108.19
O
N
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)

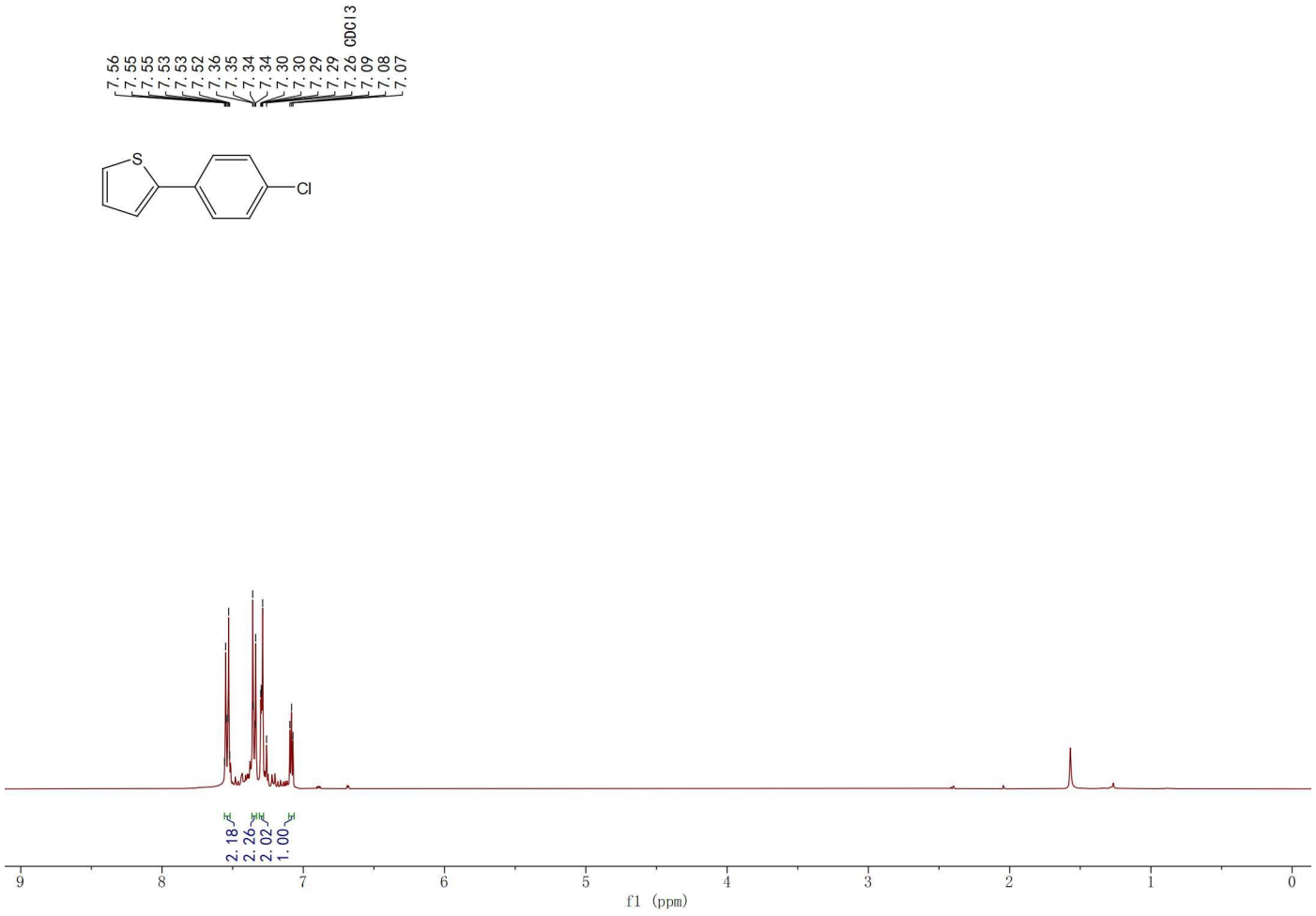
**3gc** $^{1}$H NMR


7.77
7.75
7.64
7.62
7.52
7.52
7.26 CDCl3
6.77
6.77
6.52
6.52
6.51
6.51
O
F
F
F
2.03
2.03
0.96
1.00
0.98
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

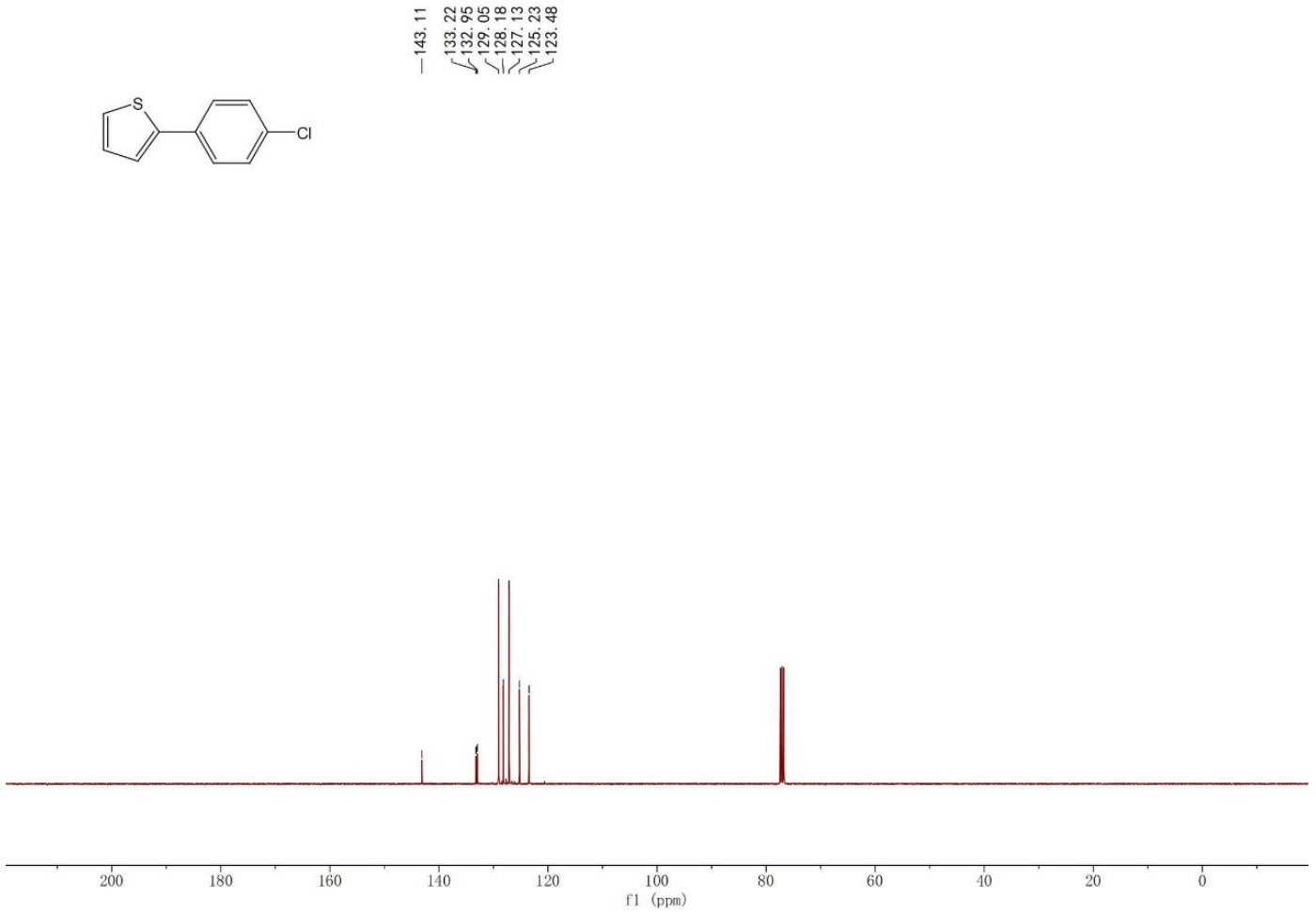
**3gc** $^{13}C$ NMR


152.52
143.10
133.97
129.45
129.12
128.80
128.47
128.24
127.18
125.77
125.74
125.70
125.66
125.54
123.77
122.84
120.14
111.97
106.98
O
F
F
F
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)

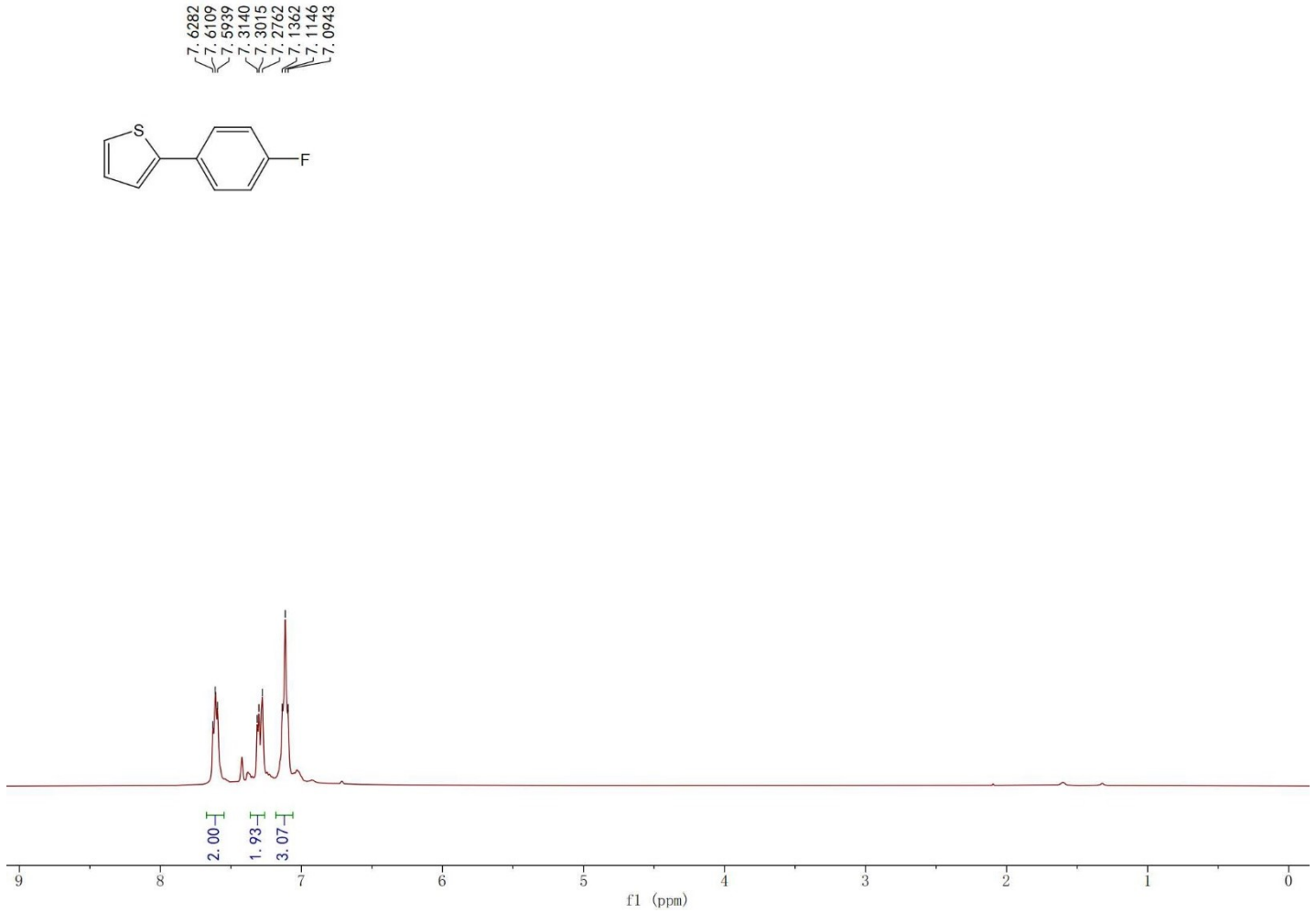
**3ad** $^{1}$H NMR


7.56
7.55
7.55
7.53
7.53
7.52
7.36
7.35
7.34
7.34
7.30
7.30
7.29
7.29
CDCl3
7.26
7.09
7.08
7.07
S
Cl
2.18
2.26
2.02
1.00
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

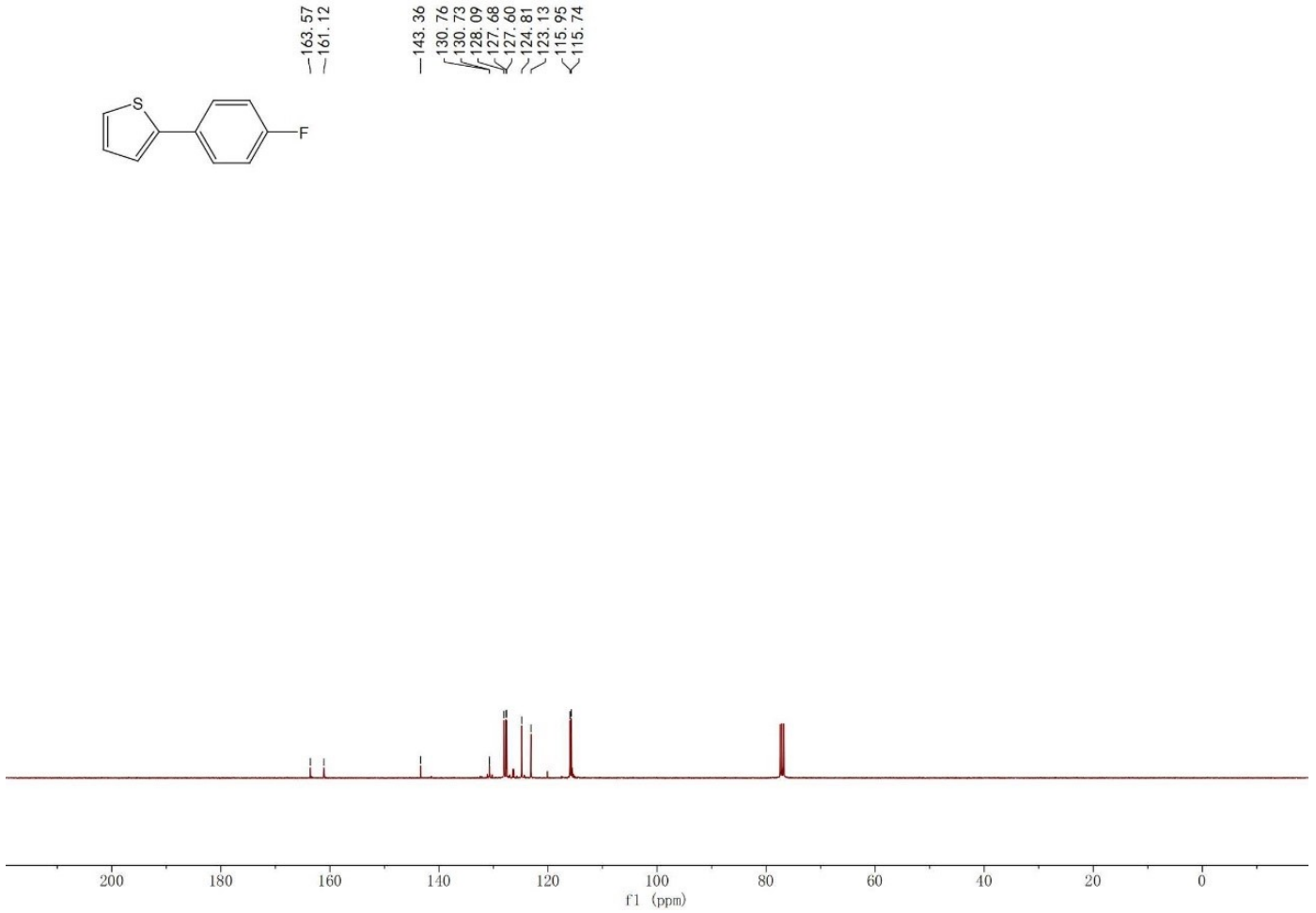
**3ad** $^{13}C$ NMR


143.11
133.22
132.95
129.05
128.18
127.13
125.23
123.48
S
Cl
200
180
160
140
120
100
80
60
40
20
0
f1 (ppm)

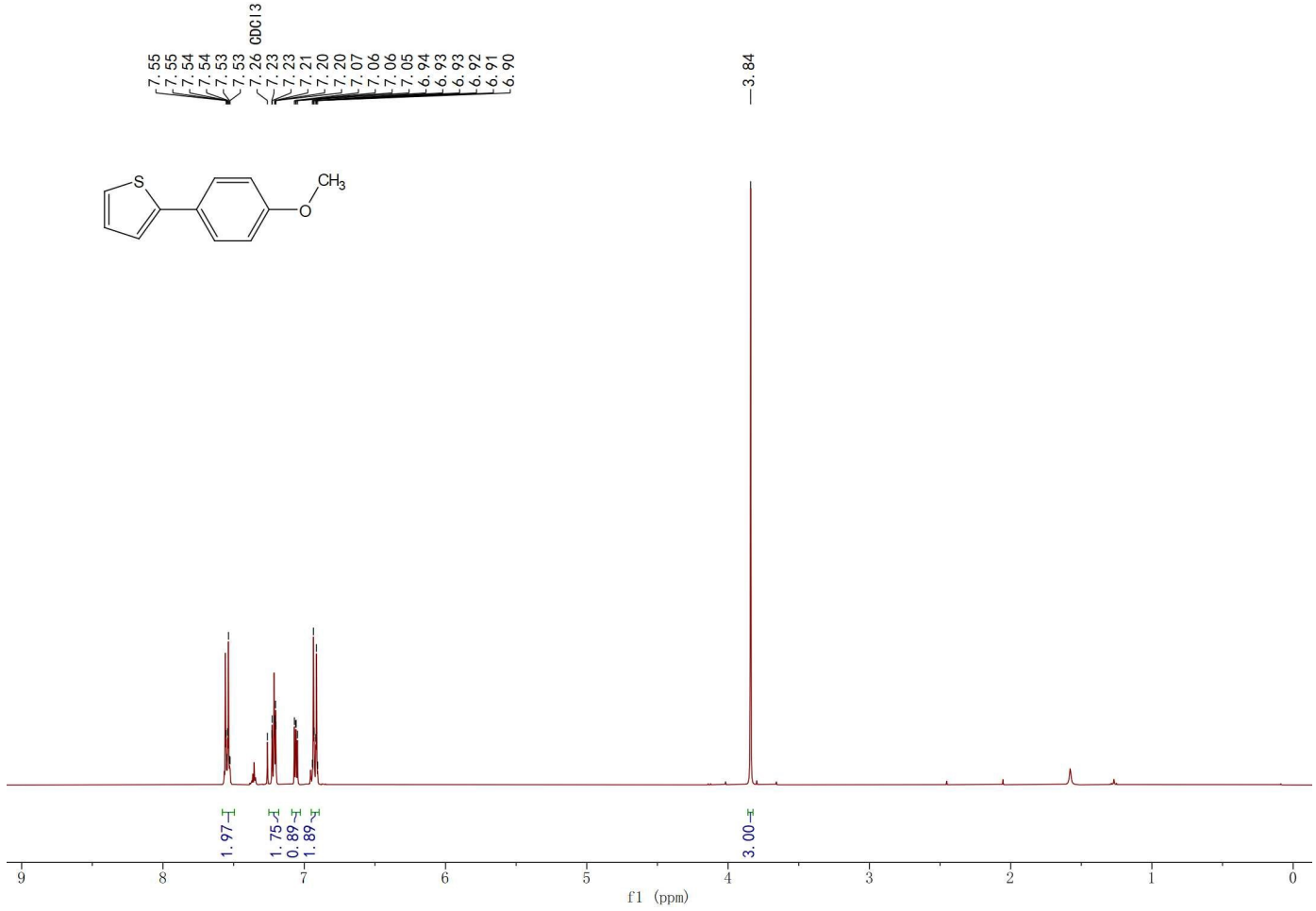
**3cd** $^{1}$H NMR


7.6282
7.6109
7.5939
7.3140
7.3015
7.2762
7.1362
7.1146
7.0943
S
F
2.00
1.93
3.07
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

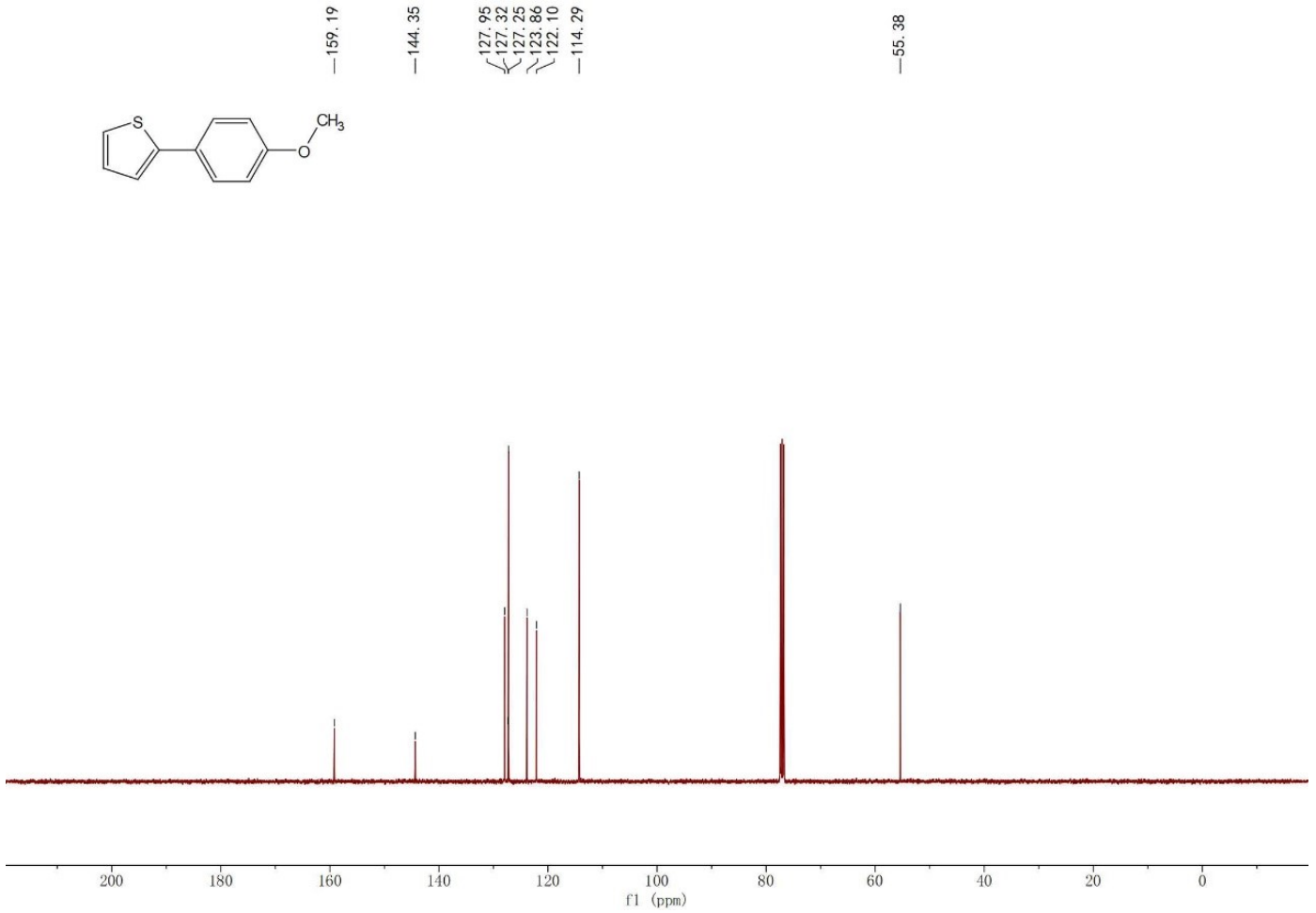
**3cd** $^{13}$C NMR


163.57
161.12
143.36
130.76
130.73
128.09
127.68
127.60
124.81
123.13
115.95
115.74
S
F
200
180
160
140
120
100
80
60
40
20
0
f1 (ppm)

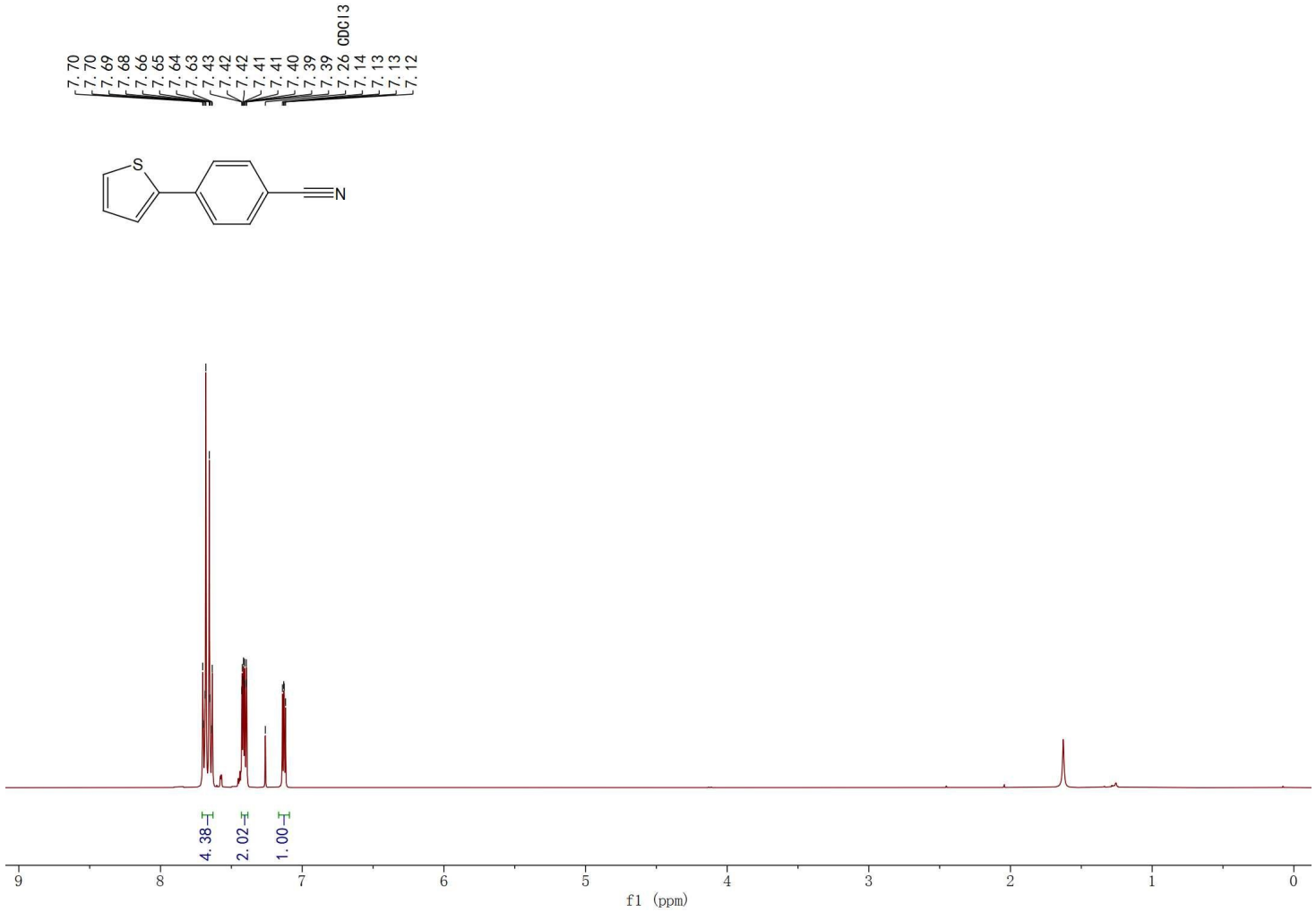
**3dd** $^{1}$H NMR


7.55
7.55
7.54
7.54
7.53
7.53
CDCl3
7.26
7.23
7.23
7.21
7.20
7.20
7.07
7.06
7.06
7.05
6.94
6.93
6.93
6.92
6.91
6.90
3.84
S
CH3
O
1.97
1.75
0.89
1.89
3.00
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

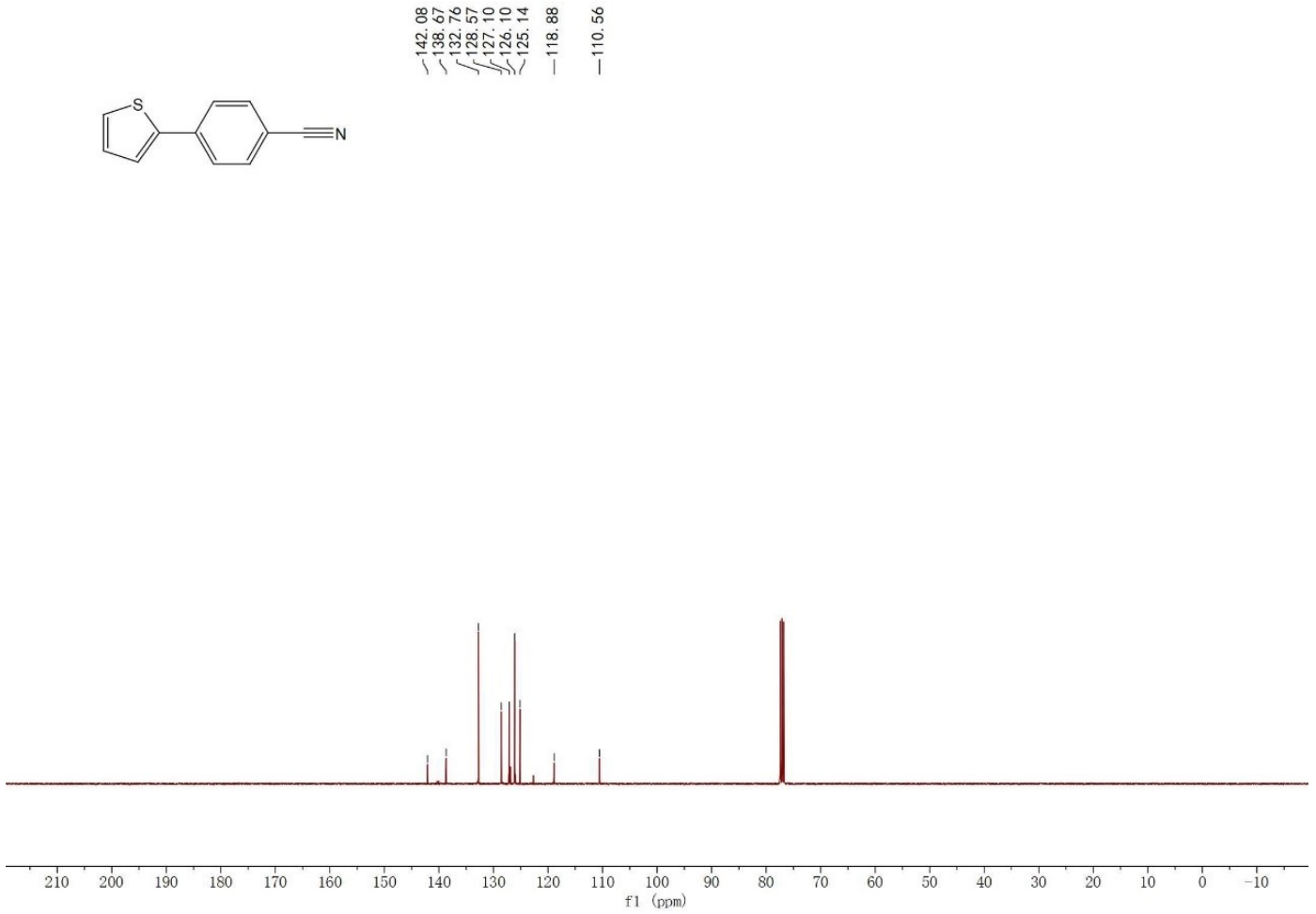
**3dd** $^{13}C$ NMR


159.19
144.35
127.95
127.32
127.25
123.86
122.10
114.29
55.38
S
O
CH3
200
180
160
140
120
100
80
60
40
20
0
f1 (ppm)

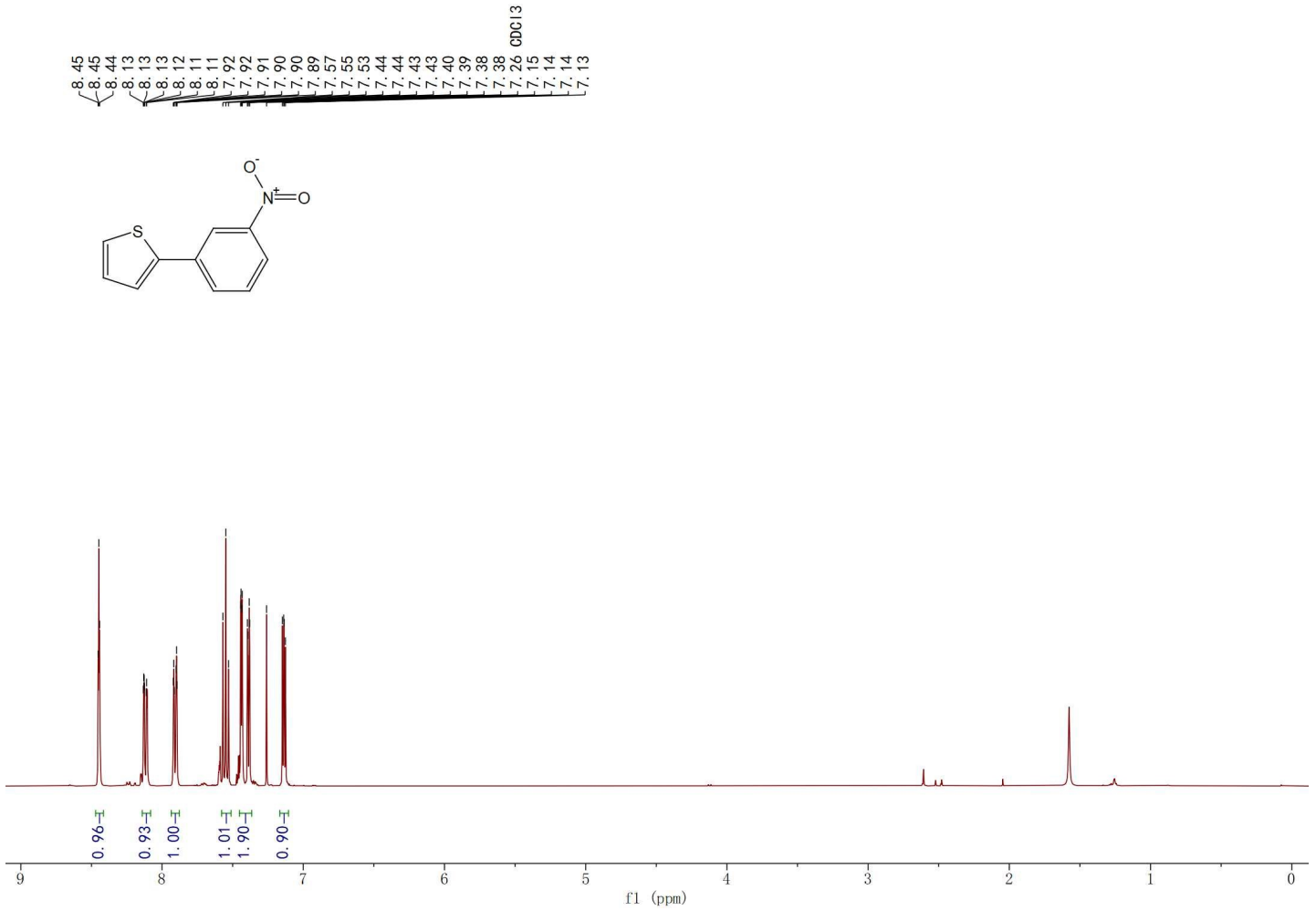
**3fd** $^{1}$H NMR


7.70
7.70
7.69
7.68
7.66
7.65
7.64
7.63
7.43
7.42
7.42
7.41
7.41
7.40
7.39
7.39
7.26 CDCl3
7.14
7.13
7.13
7.12
S
N
4.38
2.02
1.00
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

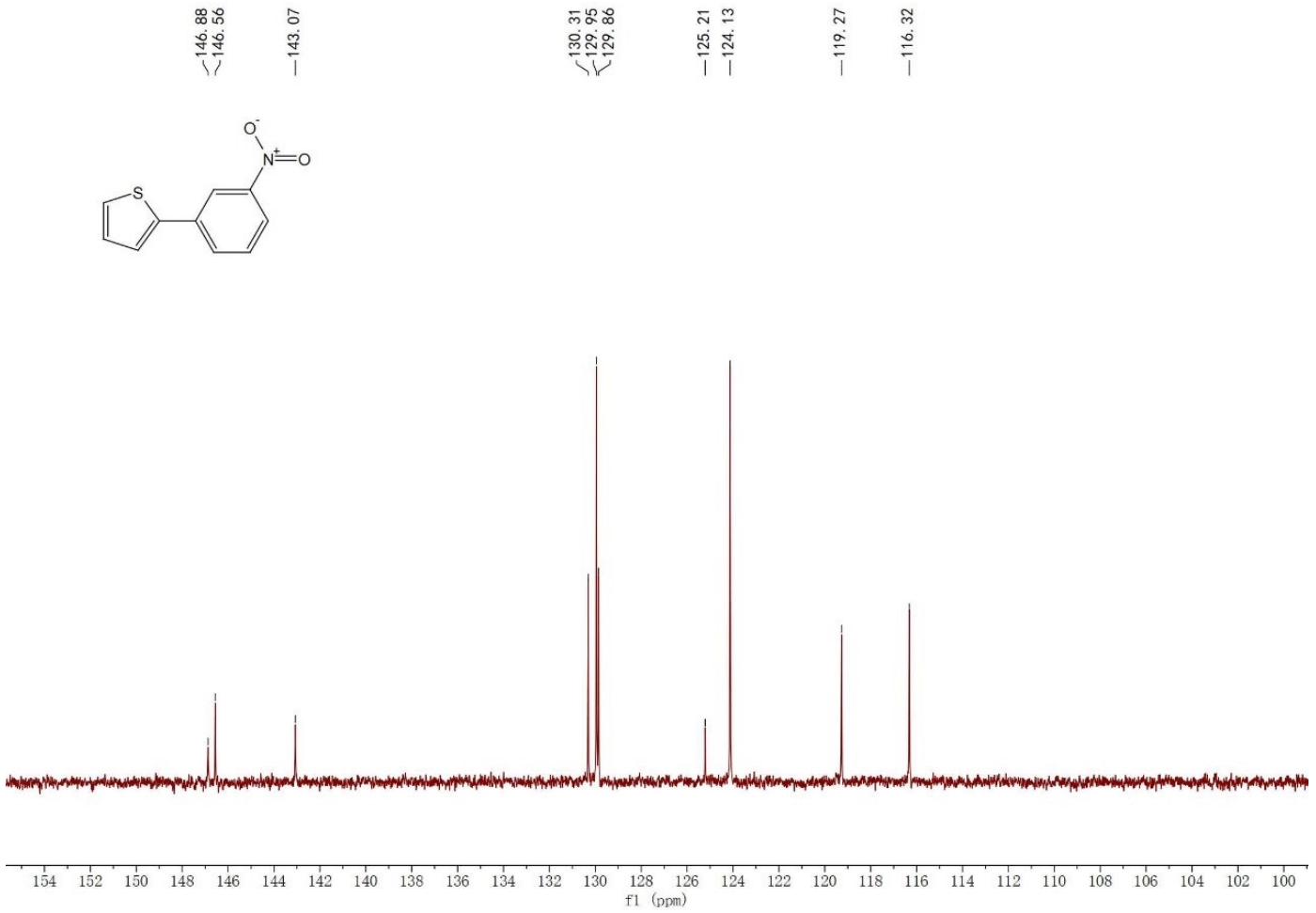
**3fd** $^{13}C$ NMR


142.08
138.67
132.76
128.57
127.10
126.10
125.14
118.88
110.56
S
N
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)

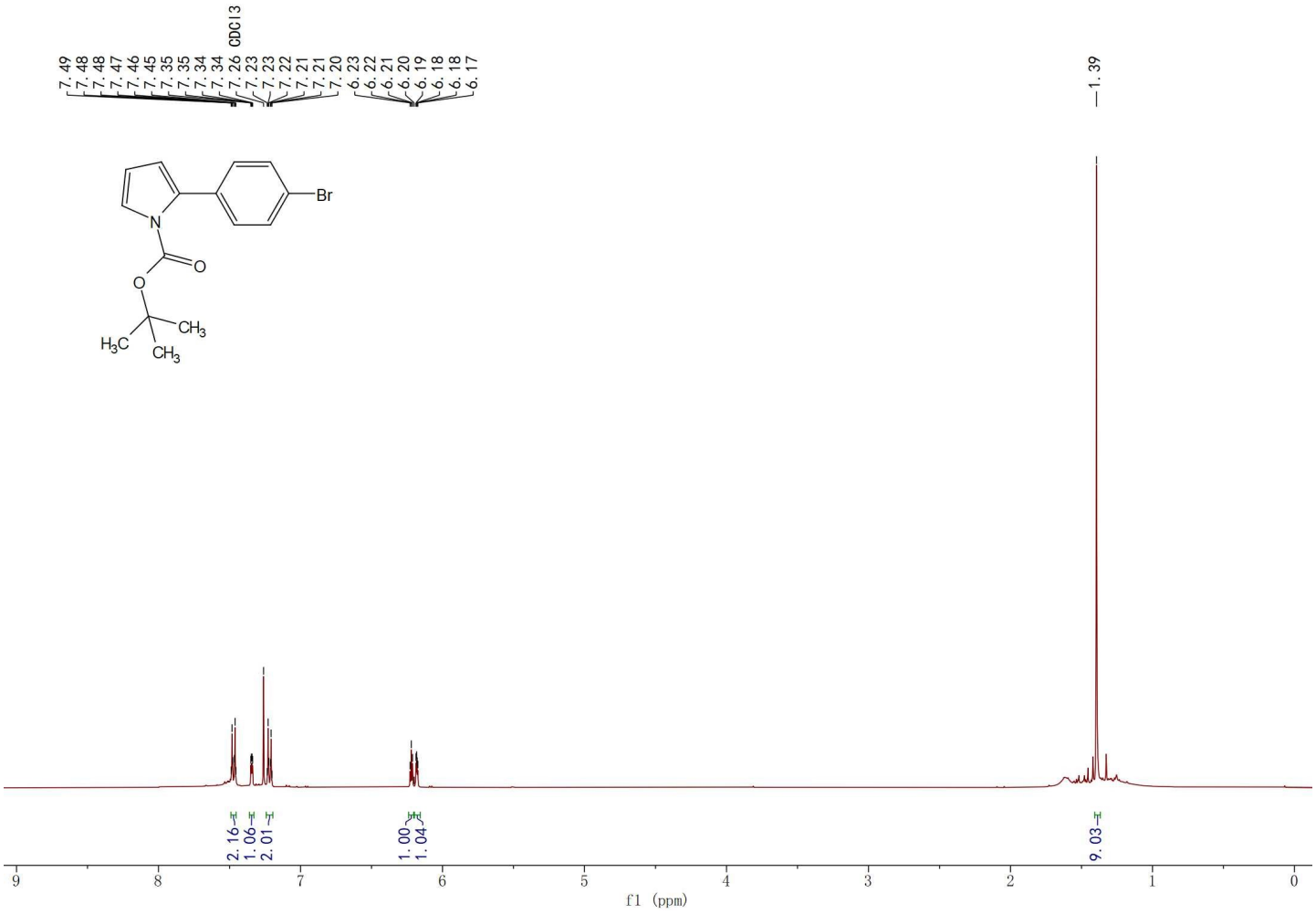
**3od** $^{1}$H NMR


8.45
8.45
8.44
8.13
8.13
8.12
8.11
8.11
7.92
7.92
7.91
7.90
7.90
7.89
7.57
7.55
7.53
7.44
7.44
7.43
7.43
7.40
7.39
7.38
7.38
7.26
CDCl3
7.15
7.14
7.14
7.13
O
N
O
S
0.96
0.93
1.00
1.01
1.90
0.90
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

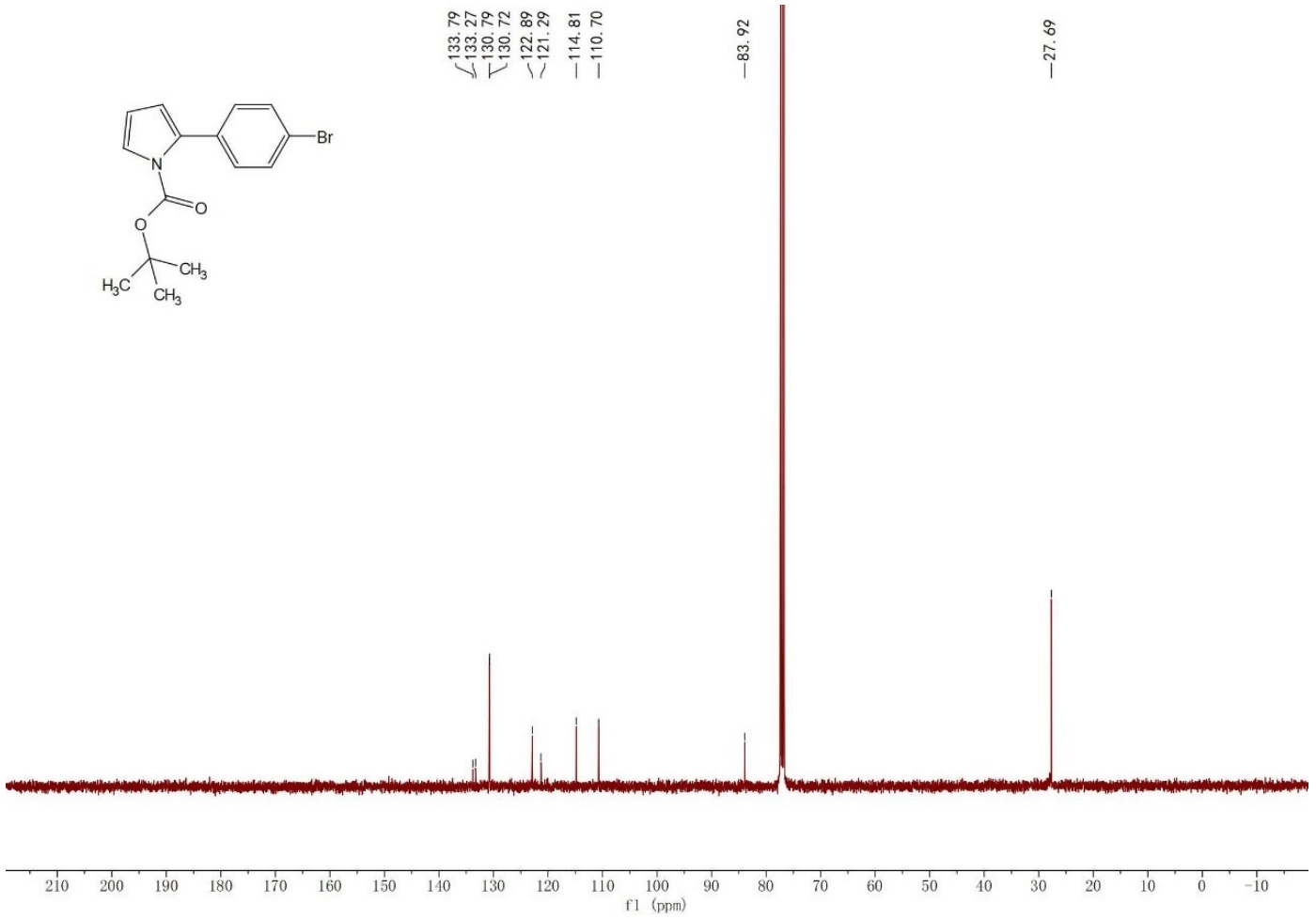
**3od** $^{13}C$ NMR


146.88
146.56
143.07
130.31
129.95
129.86
125.21
124.13
119.27
116.32
O
N
O
S
154 152 150 148 146 144 142 140 138 136 134 132 130 128 126 124 122 120 118 116 114 112 110 108 106 104 102 100
f1 (ppm)

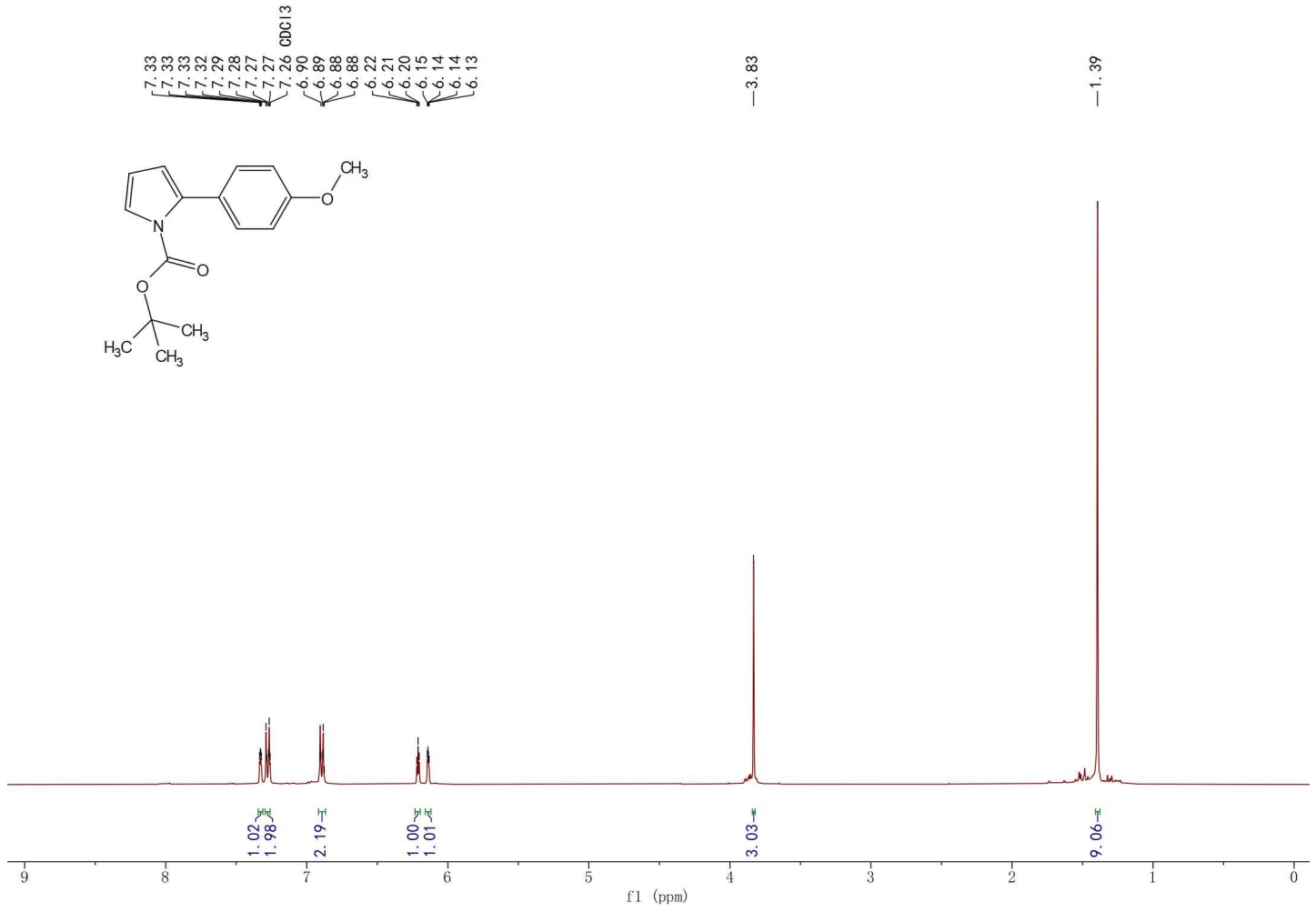
**3be** $^{1}$H NMR


7.49
7.48
7.48
7.47
7.46
7.45
7.35
7.35
7.34
7.34
CDCl3
7.26
7.23
7.23
7.22
7.21
7.21
7.20
6.23
6.22
6.21
6.20
6.19
6.18
6.18
6.17
1.39
Br
N
O
O
CH3
H3C
CH3
2.16
1.06
2.01
1.00
1.04
9.03
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

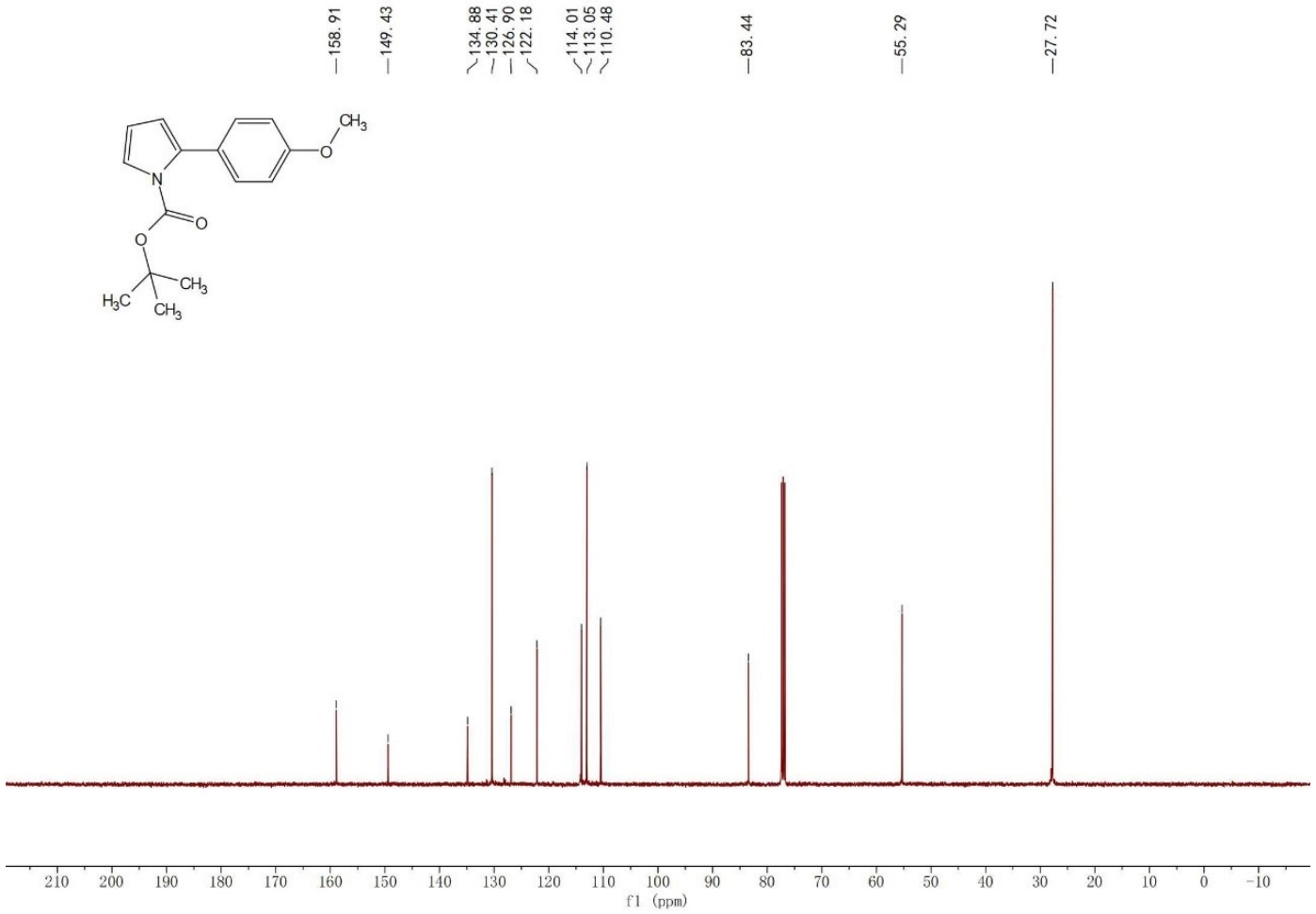
**3be** $^{13}$C NMR


133.79
133.27
130.79
130.72
122.89
121.29
114.81
110.70
83.92
27.69
Br
N
O
O
CH3
H3C
CH3
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)

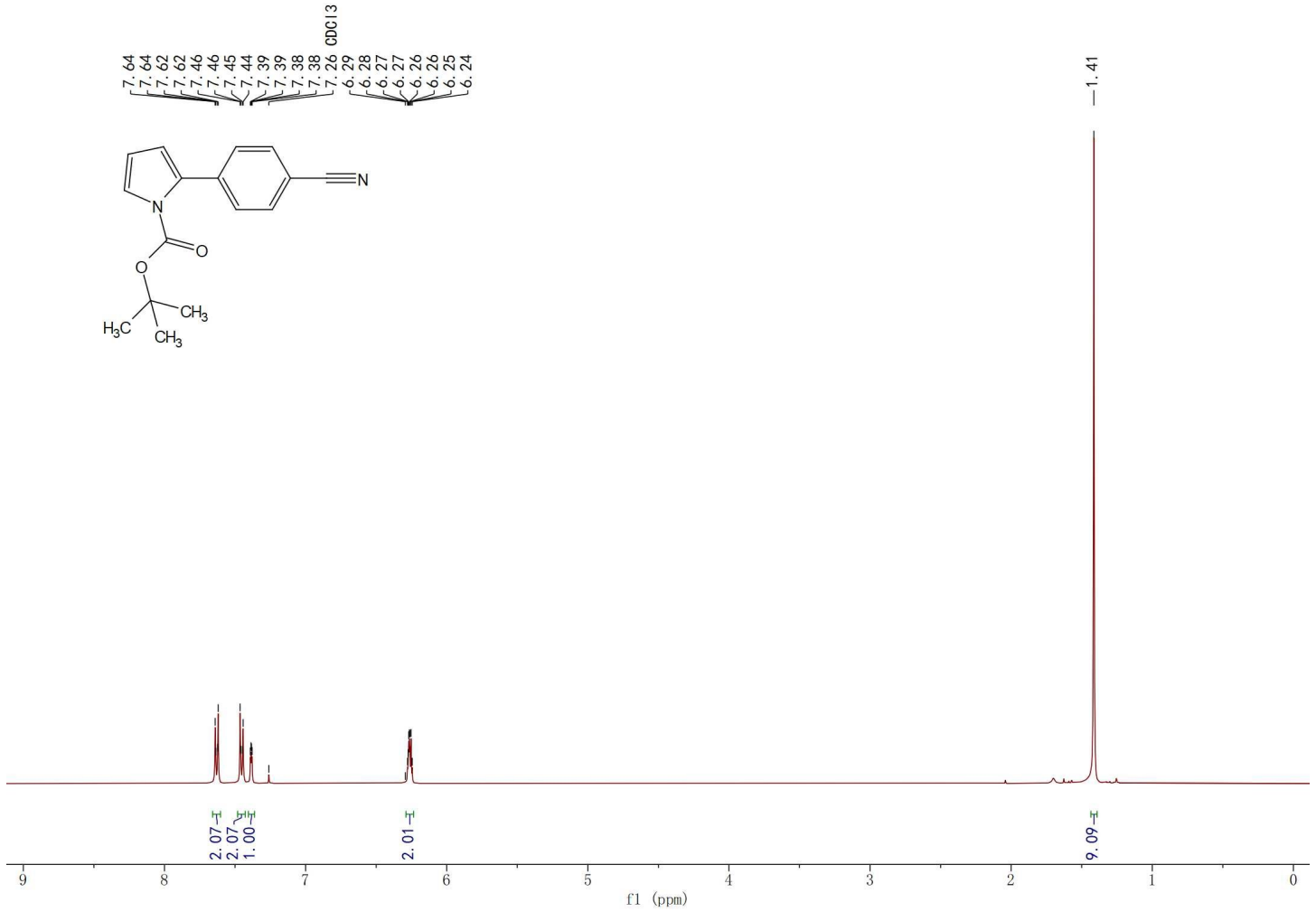
**3de** $^{1}$H NMR


7.33
7.33
7.33
7.32
7.29
7.28
7.27
7.27
7.26
CDCl3
6.90
6.89
6.88
6.88
6.22
6.21
6.20
6.15
6.14
6.13
3.83
1.39
CH3
O
N
O
O
CH3
H3C
CH3
1.02
1.98
2.19
1.00
1.01
3.03
9.06
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

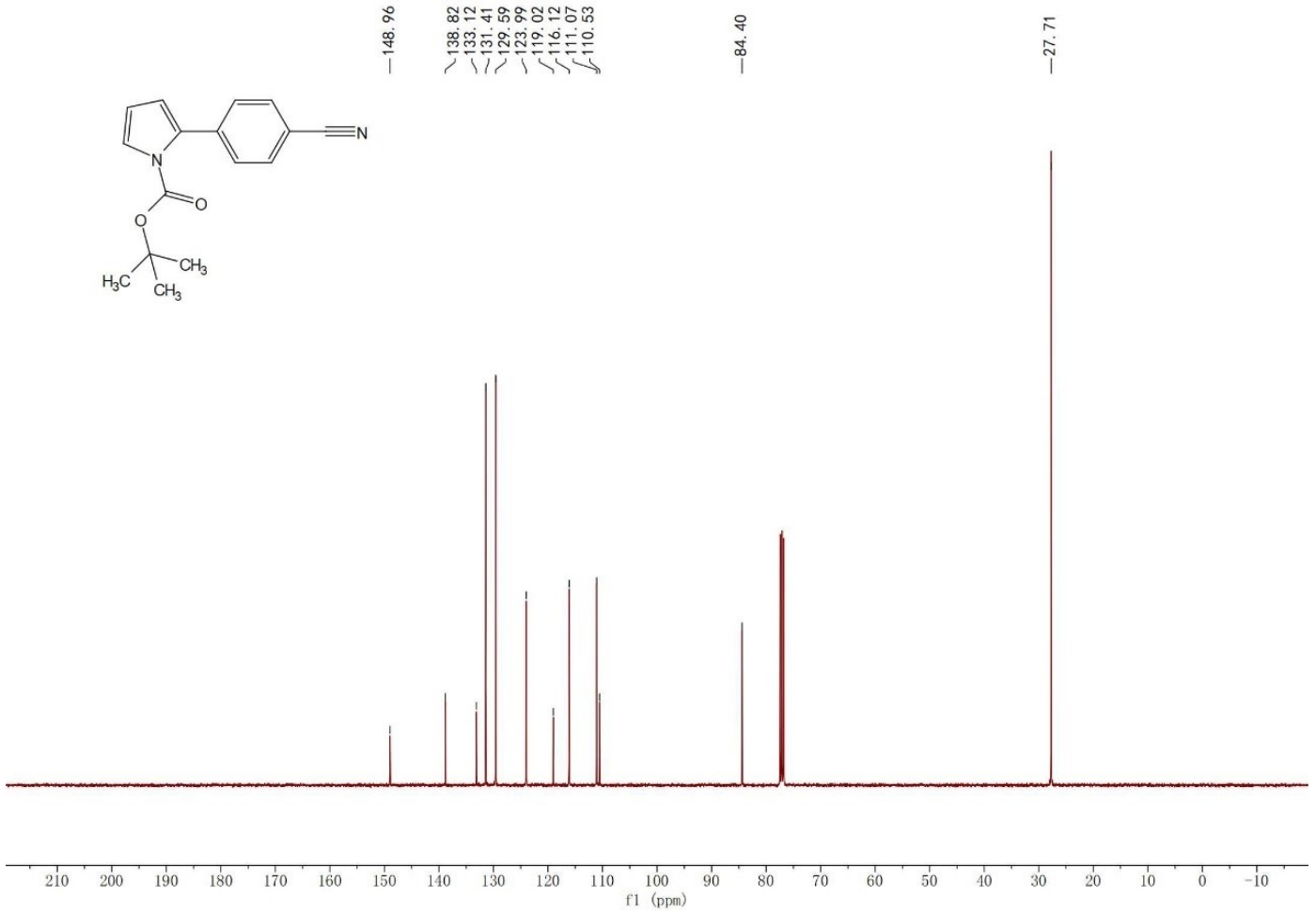
**3de** $^{13}C$ NMR


158.91
149.43
134.88
130.41
126.90
122.18
114.01
113.05
110.48
83.44
55.29
27.72
CH3
O
N
O
O
CH3
H3C
CH3
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)

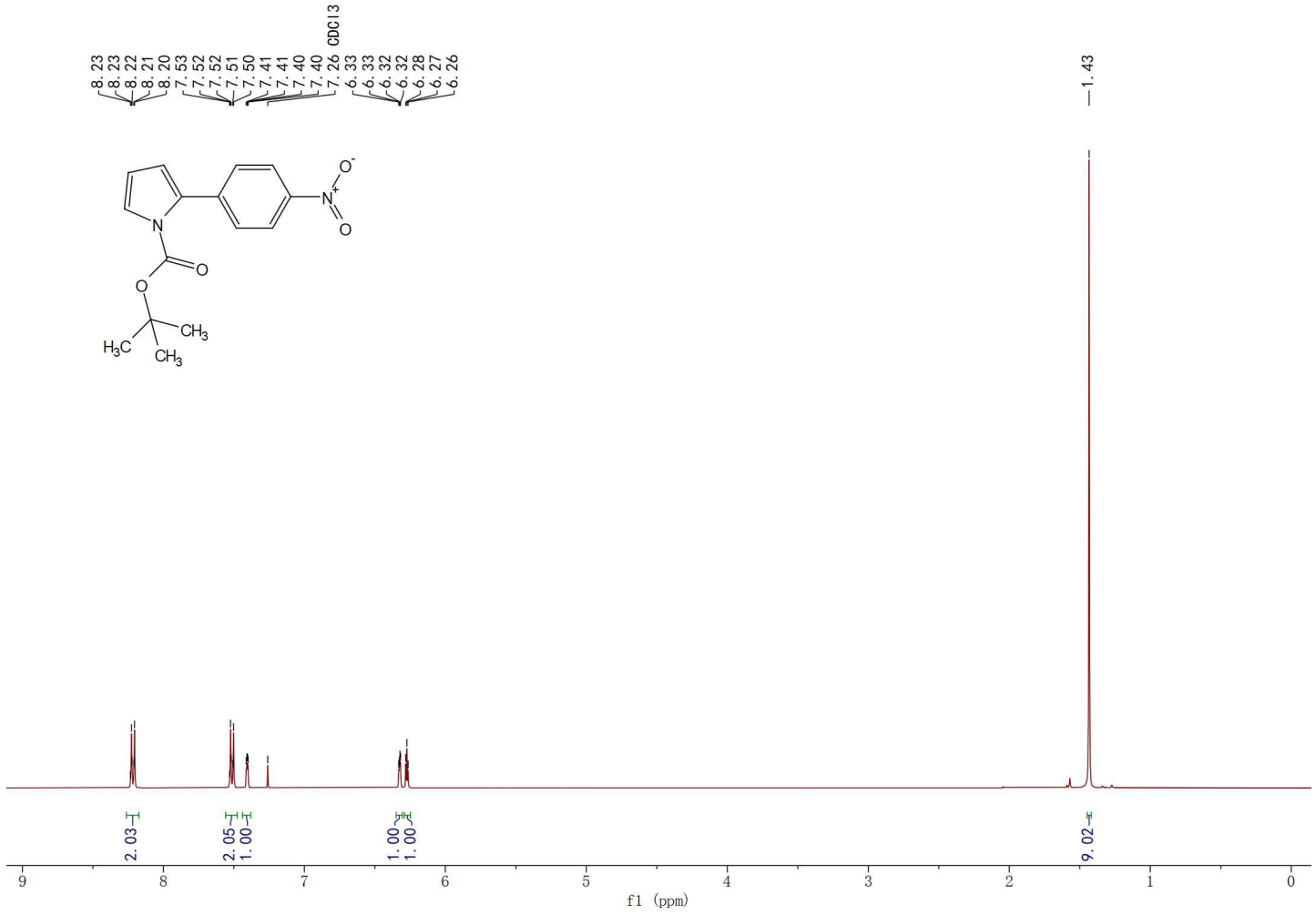
**3fe** $^{1}$H NMR


7.64
7.64
7.62
7.62
7.46
7.46
7.45
7.44
7.39
7.39
7.38
7.38
7.26 CDCl3
6.29
6.28
6.27
6.27
6.26
6.26
6.25
6.24
1.41
N
O
O
CH3
H3C
CH3
2.07
2.07
1.00
2.01
9.09
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

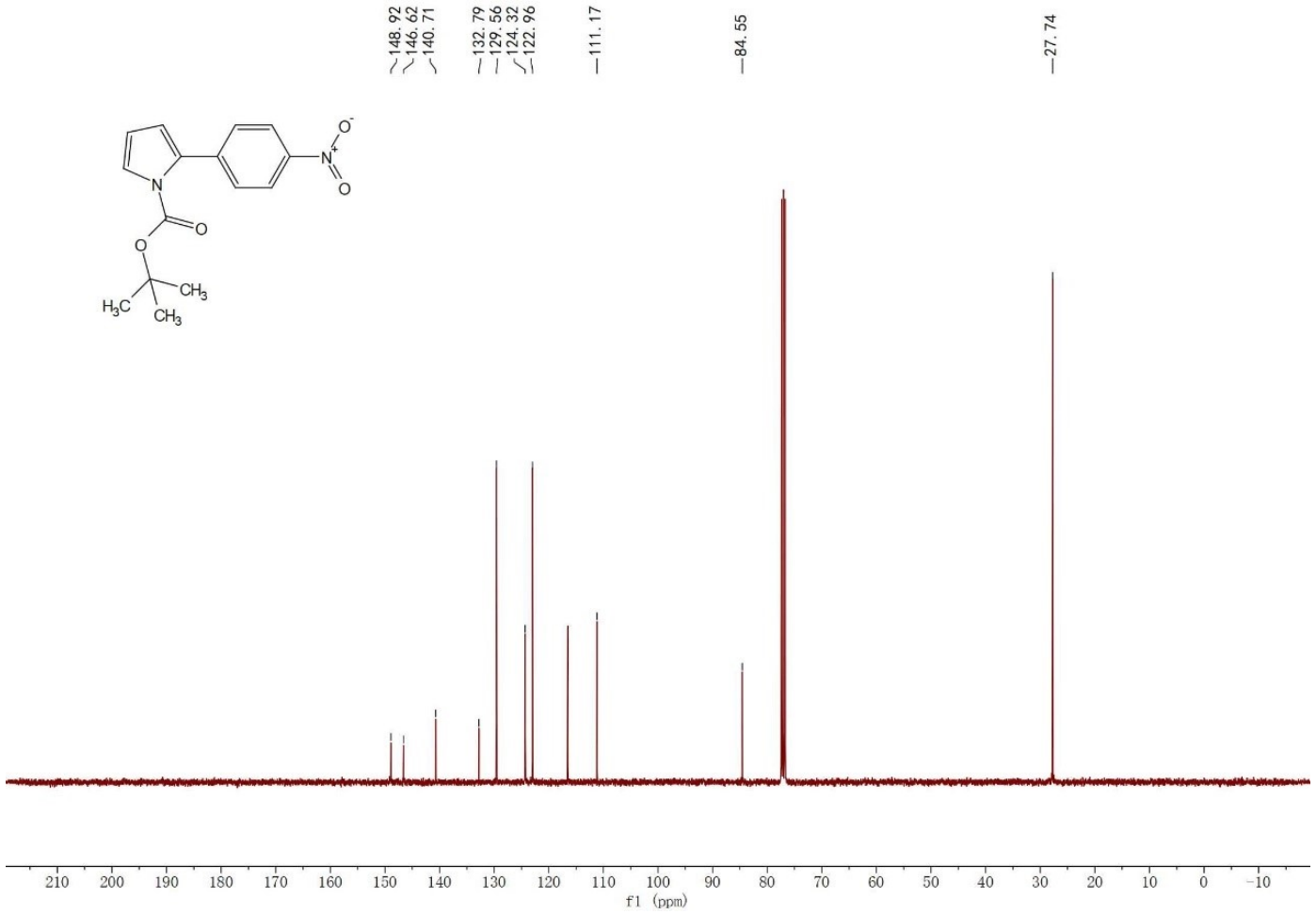
**3fe** $^{13}$C NMR


148.96
138.82
133.12
131.41
129.59
123.99
119.02
116.12
111.07
110.53
84.40
27.71
N
O
O
CH3
H3C
CH3
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)

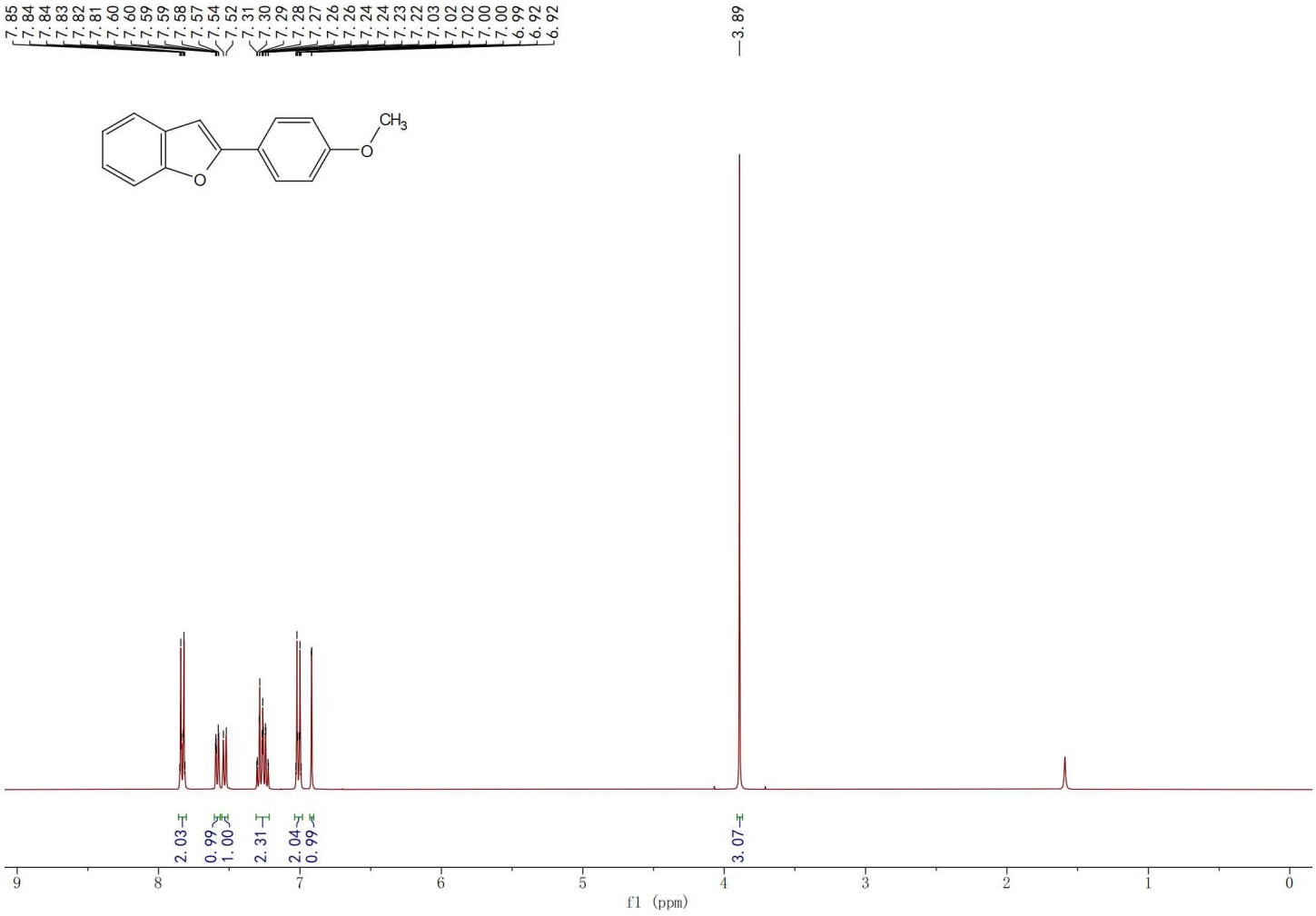
**3je** $^{1}$H NMR


8.23
8.23
8.22
8.21
8.20
7.53
7.52
7.52
7.51
7.50
7.41
7.41
7.40
7.40
7.26
CDCl3
6.33
6.33
6.32
6.32
6.28
6.27
6.26
1.43
2.03
2.05
1.00
1.00
1.00
9.02
f1 (ppm)

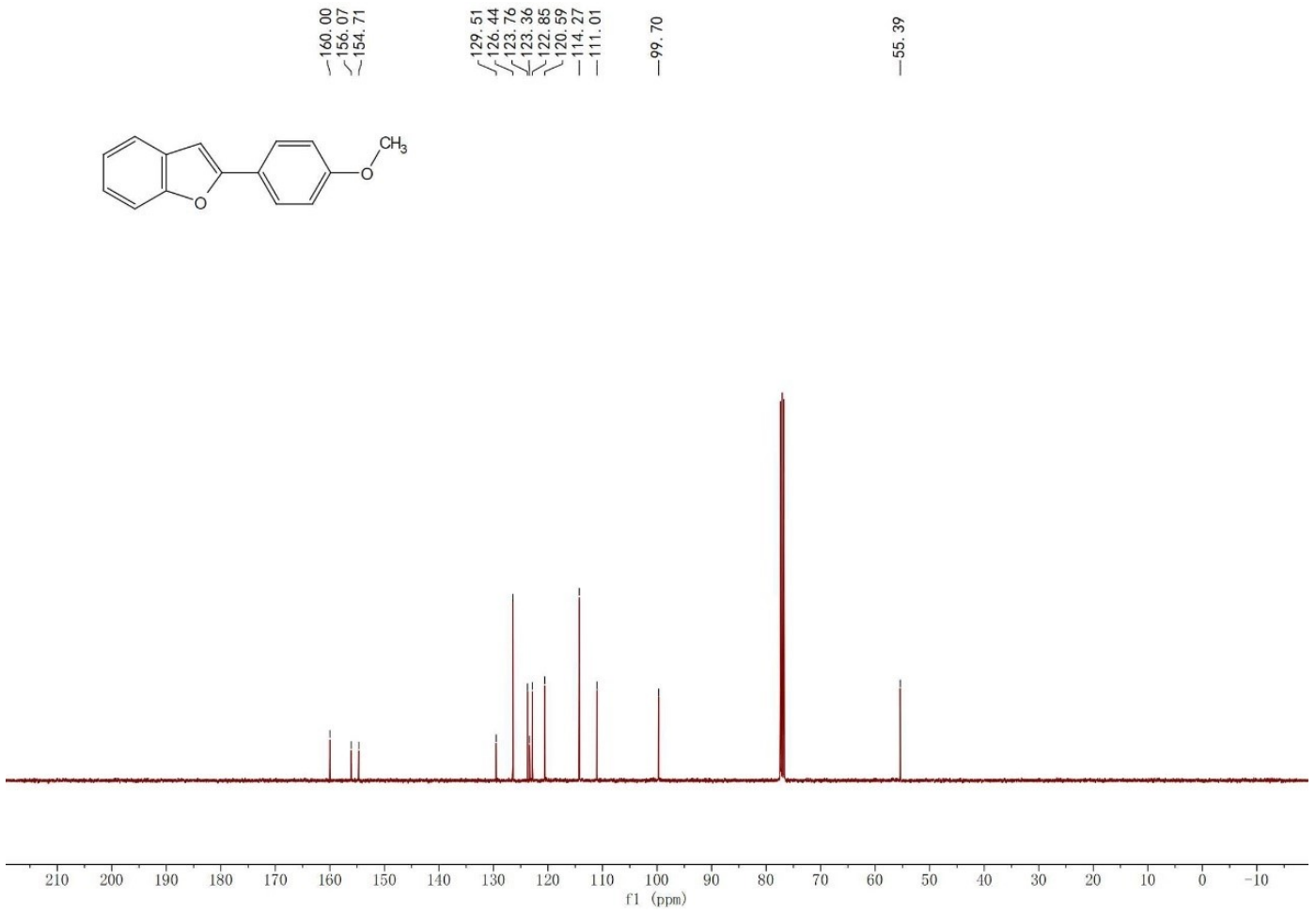
**3je** $^{13}C$ NMR


148.92
146.62
140.71
132.79
129.56
124.32
122.96
111.17
84.55
27.74
O
N+
O
N
O
O
CH3
H3C
CH3
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)

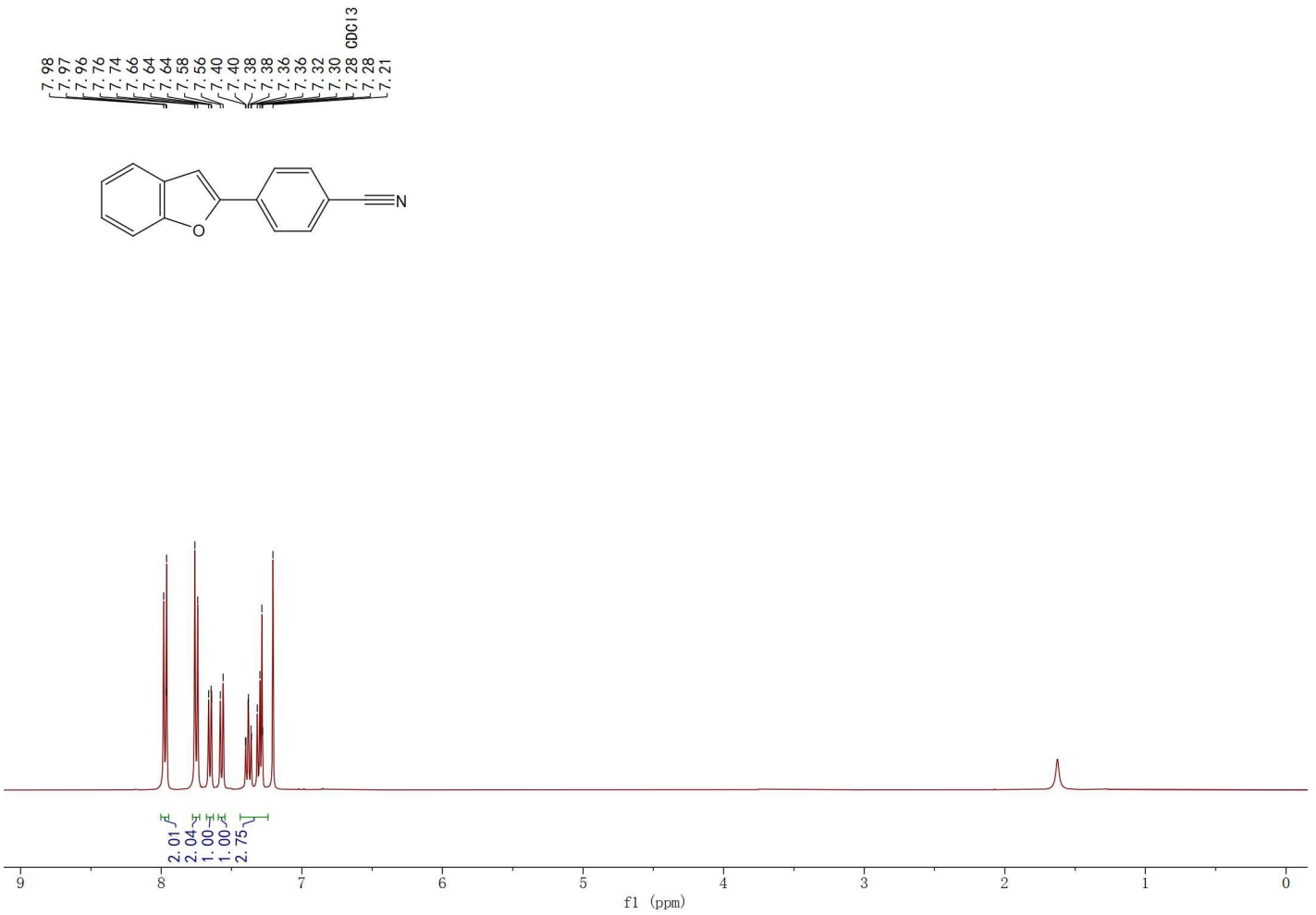
**3df** $^{1}$H NMR


7.85
7.84
7.84
7.83
7.82
7.81
7.60
7.59
7.59
7.58
7.57
7.54
7.52
7.31
7.30
7.29
7.28
7.27
7.26
7.26
7.24
7.24
7.23
7.22
7.03
7.02
7.02
7.00
7.00
6.99
6.92
6.92
3.89
CH3
O
O
2.03
0.99
1.00
2.31
2.04
0.99
3.07
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

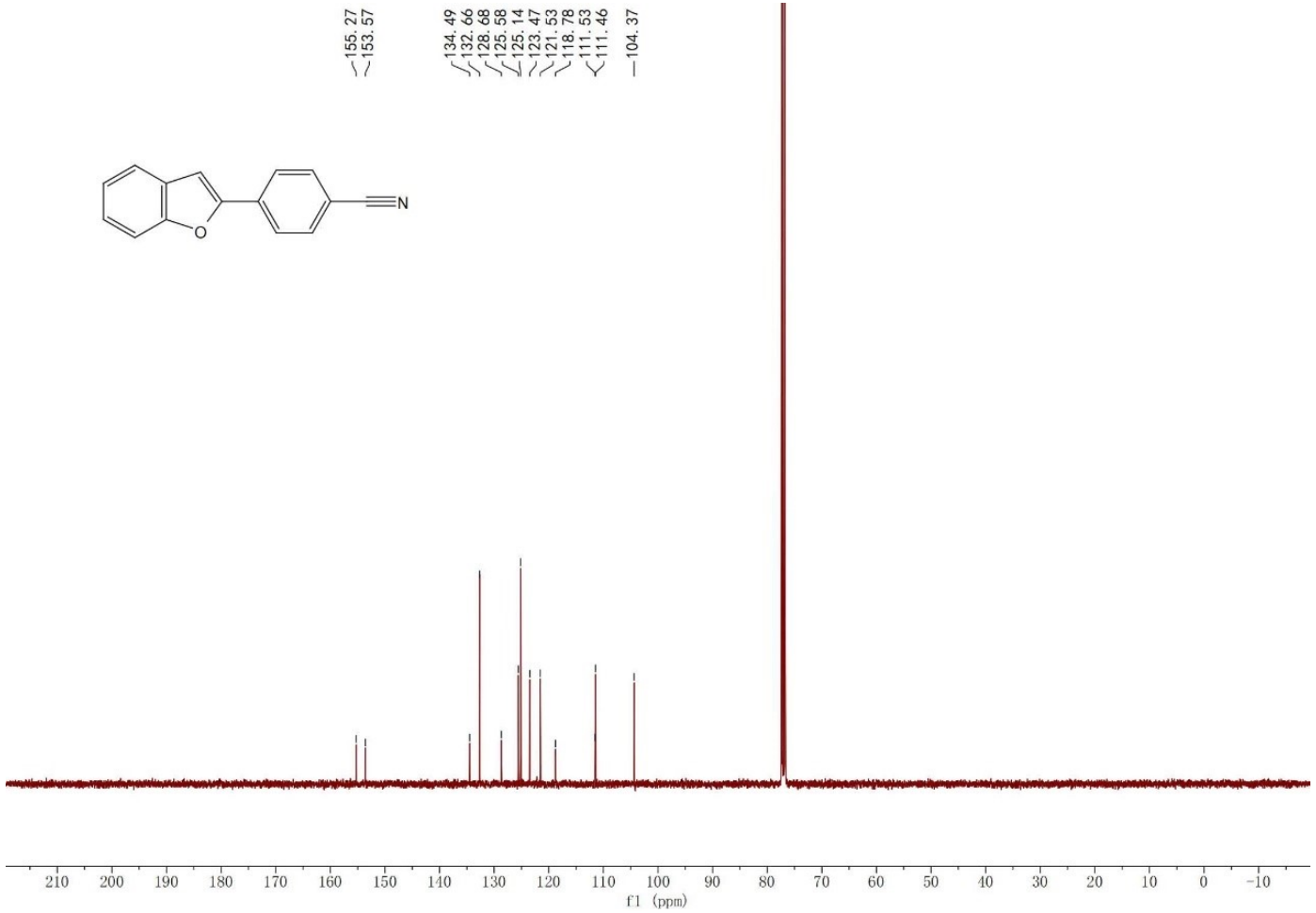
**3df** $^{13}$C NMR


160.00
156.07
154.71
129.51
126.44
123.76
123.36
122.85
120.59
114.27
111.01
99.70
55.39
CH3
O
O
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)

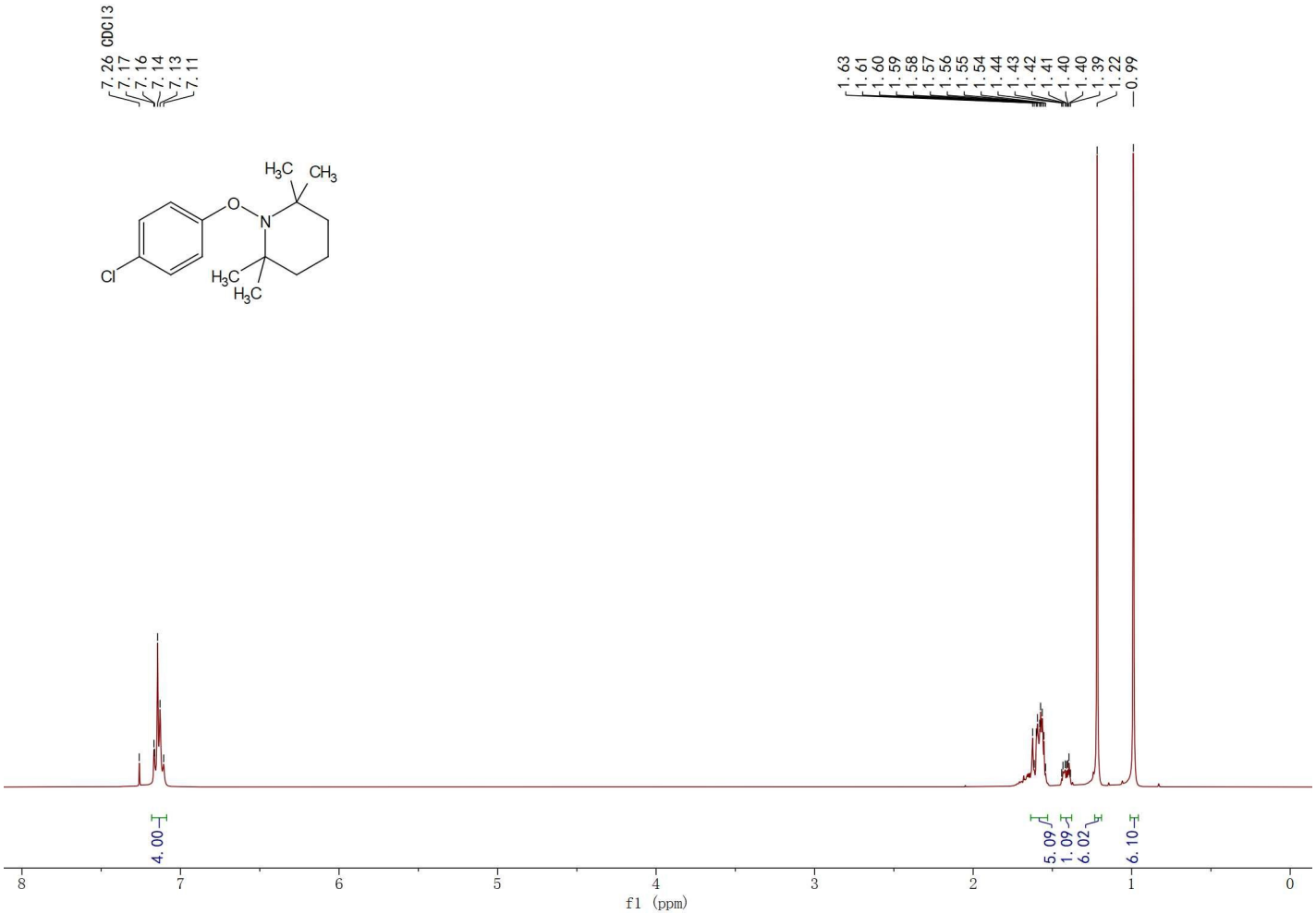
**3ff** $^{1}$H NMR


7.98
7.97
7.96
7.76
7.74
7.66
7.64
7.64
7.58
7.56
7.40
7.40
7.38
7.36
7.36
7.32
7.30
CDCl3
7.28
7.28
7.21
N
O
2.01
2.04
1.00
1.00
2.75
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

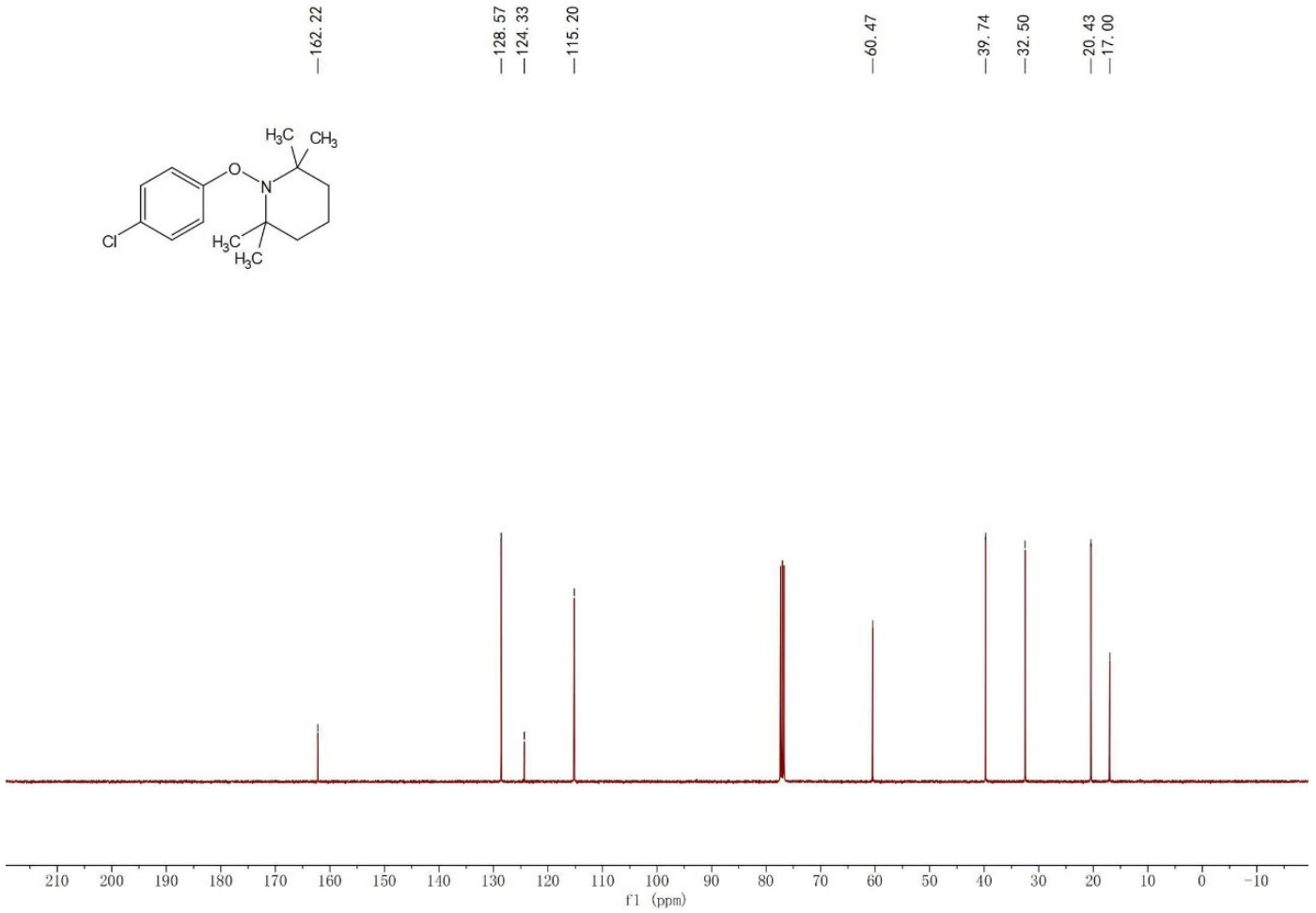
**3ff** $^{13}$C NMR


155.27
153.57
134.49
132.66
128.68
125.58
125.14
123.47
121.53
118.78
111.53
111.46
104.37
N
O
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)

**5** $^{1}$H NMR


7.26 CDCl3
7.17
7.16
7.14
7.13
7.11
1.63
1.61
1.60
1.59
1.58
1.57
1.56
1.55
1.54
1.44
1.43
1.42
1.41
1.40
1.40
1.39
1.22
0.99
H3C
CH3
O
N
Cl
H3C
H3C
4.00
5.09
1.09
6.02
6.10
8
7
6
5
4
3
2
1
0
f1 (ppm)

**5** $^{13}C$ NMR


162.22
128.57
124.33
115.20
60.47
39.74
32.50
20.43
17.00
H3C
CH3
O
N
Cl
H3C
H3C
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)