Supporting Information for

N-Heterocyclic carbene-catalyzed switchable reaction of 9-(trimethylsilyl)fluorene and aldehydes: chemoselective synthesis of dibenzofulvenes and fluorenyl alcohols

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Contents:

1. General methods and typical experimental procedures S2

2. Spectroscopic data for all products S4

3. References S26

4. Copies of ^{1}H NMR and ^{13}C NMR spectra S27

1.1 General experimental methods

Unless otherwise indicated, all reactions were conducted under nitrogen atmosphere in oven-dried glassware with magnetic stirring bar. Column chromatograph was performed with silica gel (200~300 mesh) and analytical TLC on silica gel 60-F_{254}. ^{1}H NMR (400 MHz, $CDCl_3$), ^{13}C NMR (100 MHz, $CDCl_3$) and ^{19}F NMR (376 MHz, $CDCl_3$) spectra were recorded on a Bruker-DMX 400 spectrometer in $CDCl_3$, with tetramethylsilane as an internal standard and reported in ppm (δ). 9-(Trimethylsilyl)fluorene **1a** and all other chemicals were obtained from commercial supplies and used as received without any further purification. Anhydrous THF and toluene were distilled from sodium and benzophenone. DMSO, DMF, CH_2Cl_2, $CHCl_3$ and CH_3CN were distilled from calcium hydride. 1, 2-dichloroethane was distilled from calcium chloride. Petroleum ether, where used, has a boiling point range of 60–90 ^{o}C.

1.2 Typical Procedure for the Synthesis of Compound 3a

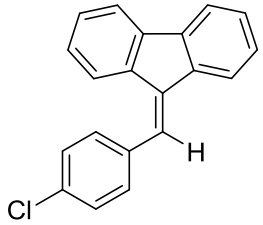
To a mixture of 9-(trimethylsilyl)fluorene **1a** (0.1 mmol, 23.8mg), *p*-chlorobenzaldehyde **2a** (0.1 mmol, 14 mg) and 4Å MS (0.1g) in 1.0 mL anhydrous DMSO was added NHC **A** (10 mol%). The mixture was stirred at room temperature until full consumption of **2a** that was indicated by TLC (12 h). Then, the mixture was diluted with 15.0 ml EtOAc and washed with water (2.0 ml × 3). The organic layer was separated, dried

over Na_2SO_4 and filtered. The solvent was then removed under reduced pressure and the crude material was purified by flash column chromatography (silica gel, PE/EtOAc (v : v) = 100:1) to give the desired product **3a**.

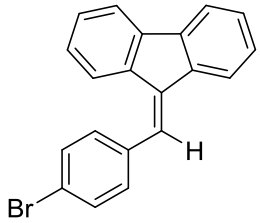
1.3 Typical Procedure for the Synthesis of Compound 4a

To a mixture of 9-(trimethylsilyl)fluorene **1a** (0.1 mmol, 23.8mg), *p*-chlorobenzaldehyde **2a** (0.1 mmol, 14 mg) and H_2O (100 μl) in 1.0 mL anhydrous DMSO was was added NHC **A** (1 mol%). The mixture was stirred at 10 ^oC until full consumption of **2a** that was indicated by TLC (12 h). Then, the mixture was diluted with 15.0 ml EtOAc and washed with water (2.0 ml × 3). The organic layer was separated, dried over Na_2SO_4 and filtered. The solvent was then removed under reduced pressure and the crude material was purified by flash column chromatography (silica gel, PE/EtOAc (v : v) = 20:1) to give the desired product **4a**.

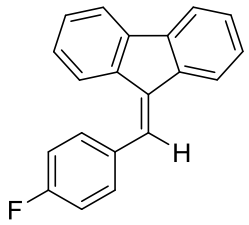
2. Spectroscopic data for all products



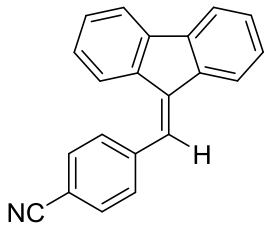
9-(4-chlorobenzylidene)-9H-fluorene (**3a**) [1] ： yield: 88%, 25 mg; white solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76 (d, *J* = 7.4 Hz, 1H), 7.71 (d, *J* = 7.6 Hz, 2H), 7.59 (s, 1H), 7.55 – 7.48 (m, 3H), 7.46 – 7.28 (m, 5H), 7.07 (td, *J* = 7.7, 1.1 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 141.38, 139.26, 139.24, 137.08, 136.28, 135.33, 133.88, 130.68, 128.80, 128.79, 128.44, 127.07, 126.76, 125.66, 124.33, 120.27, 119.84, 119.65.



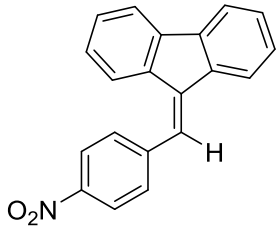
9-(4-bromobenzylidene)-9H-fluorene (**3b**) [2] : yield: 79%, 26 mg; white solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.75 (d, *J* = 7.4 Hz, 1H), 7.70 (d, *J* = 7.7 Hz, 2H), 7.60 – 7.53 (m, 3H), 7.51 (d, *J* = 7.8 Hz, 1H), 7.44 (d, *J* = 8.0 Hz, 2H), 7.37 (td, *J* = 7.4, 1.2 Hz, 1H), 7.31 (t, *J* = 7.3 Hz, 2H), 7.07 (td, *J* = 7.7, 1.1 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 141.39, 139.26, 139.25, 137.08, 136.28, 135.80, 131.75, 130.97, 128.82, 128.46, 127.09, 126.78, 125.65, 124.35, 122.08, 120.29, 119.86, 119.66.



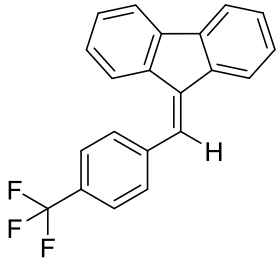
9-(4-fluorobenzylidene)-9H-fluorene (**3c**) [3] : yield: 98%, 26 mg; white solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76 (d, *J* = 7.3 Hz, 1H), 7.71 (d, *J* = 7.5 Hz, 2H), 7.61 (s, 1H), 7.54 (m, 2H), 7.50 (d, *J* = 7.8 Hz, 1H), 7.41 – 7.27 (m, 3H), 7.14 (t, *J* = 8.7 Hz, 2H), 7.06 (td, *J* = 7.7, 1.1 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 162.49 (d, *J* = 247.9 Hz), 141.32, 139.33, 139.19, 136.75, 136.38, 132.82 (d, *J* = 3.5 Hz), 131.07 (d, *J* = 8.0 Hz), 128.67, 128.32, 127.04, 126.71, 126.01, 124.24, 120.22, 119.82, 119.63, 115.62 (d, *J* = 21.5 Hz).; ^{19}F NMR (376 MHz, $CDCl_3$) δ -113.23 (s, 1F).



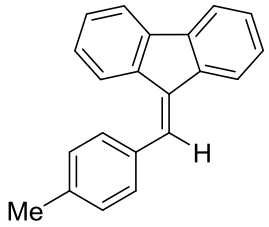
4-((9H-fluoren-9-ylidene)methyl)benzonitrile (**3d**) [1] : yield: 79%, 22 mg; white solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.78 – 7.64 (m, 7H), 7.56 (s, 1H), 7.43 – 7.30 (m, 4H), 7.06 (td, *J* = 7.7, 1.1 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 141.91, 141.69, 139.48, 138.92, 138.51, 135.88, 132.34, 130.05, 129.35, 128.99, 127.27, 126.91, 124.33, 124.29, 120.49, 120.05, 119.79, 118.81, 111.51.



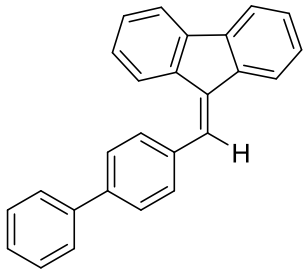
9-(4-nitrobenzylidene)-9H-fluorene (**3e**) [4] : yield: 80%, 24 mg, yellow solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.32 (d, *J* = 8.7 Hz, 2H), 7.82 – 7.66 (m, 5H), 7.60 (s, 1H), 7.43 – 7.33 (m, 4H), 7.06 (td, *J* = 7.7, 1.0 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 141.27, 139.55, 139.14, 138.99, 136.62, 136.20, 129.30, 128.78, 128.28, 127.62, 127.36, 127.03, 126.87, 124.42, 120.20, 119.80, 119.64, 119.02.



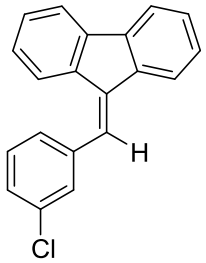
9-(4-(trifluoromethyl)benzylidene)-9H-fluorene (**3f**) [3] : yield: 83%, 27 mg, white solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76 (d, *J* = 7.4 Hz, 1H), 7.73 – 7.65 (m, 6H), 7.61 (s, 1H), 7.45 – 7.28 (m, 4H), 7.06 (td, *J* = 7.7, 1.1 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 141.55, 140.72, 139.40, 139.09, 137.91, 136.11, 129.91 (q, *J* = 32.6 Hz), 129.60, 129.08, 128.74, 127.18, 126.86, 125.52 (q, *J* = 3.8 Hz), 125.02, 124.35, 124.18 (q, *J* = 272.0 Hz), 120.40, 119.93, 119.72; ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.47 (s, 3F).



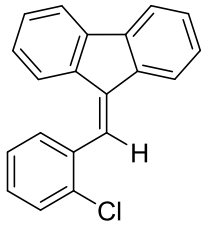
9-(4-methylbenzylidene)-9H-fluorene (**3g**)[1]: yield: 60%, 16 mg; yellow solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86 – 7.61 (m, 5H), 7.49 (d, *J* = 7.9 Hz, 2H), 7.44 – 7.23 (m, 5H), 7.07 (t, *J* = 7.6 Hz, 1H), 2.44 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 141.04, 139.31, 139.18, 136.89, 136.70, 136.68, 136.26, 130.20, 129.36, 128.39, 128.20, 126.97, 126.80, 126.56, 125.87, 124.45, 120.34, 119.63, 20.13.



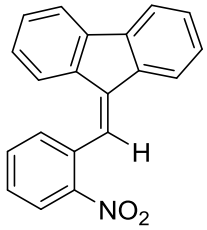
9-([1,1'-biphenyl]-4-ylmethylene)-9H-fluorene (**3h**) : yield: 77%, 26 mg, white solid; mp 176-178 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.79 (d, *J* = 7.1 Hz, 1H), 7.75 – 7.63 (m, 10H), 7.47 (t, *J* = 7.6 Hz, 2H), 7.40 – 7.28 (m, 4H), 7.07 (td, *J* = 7.5, 1.0 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 141.31, 140.79, 140.55, 139.57, 139.18, 136.56, 136.55, 135.85, 129.91, 128.91, 128.61, 128.23, 127.59, 127.14, 127.06, 127.02, 126.95, 126.71, 124.46, 120.28, 119.78, 119.62; HRMS (EI) m/z calcd for $C_{26}H_{18}^{+}$ $(M)^{+}$ 330.1403, found 330.1404.



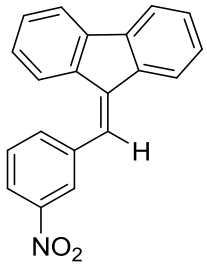
9-(3-chlorobenzylidene)-9H-fluorene (**3i**) [1] : yield: 57%, 16 mg; yellow solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.75 (d, *J* = 7.4 Hz, 1H), 7.70 (dd, *J* = 7.4, 0.6Hz, 2H), 7.57 (s, 1H), 7.56 – 7.55 (m, 1H), 7.48 – 7.42 (m, 2H), 7.40 – 7.28 (m, 5H), 7.07 (td, *J* = 7.7, 1.1 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 141.43, 139.34, 139.16, 138.78, 137.48, 136.21, 134.48, 129.84, 129.17, 128.89, 128.57, 128.05, 127.44, 127.11, 126.84, 125.24, 124.43, 120.34, 119.85, 119.67.



9-(2-chlorobenzylidene)-9H-fluorene (**3j**) : yield: 65%, 19 mg; colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83 (d, *J* = 7.1 Hz, 1H), 7.75 – 7.64 (m, 3H), 7.61 (s, 1H), 7.52 (dd, *J* = 7.7, 1.6 Hz, 1H), 7.43 – 7.27 (m, 6H), 7.03 (td, *J* = 7.6, 1.1 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 141.42, 139.39, 139.10, 137.49, 136.38, 135.41, 134.07, 131.46, 129.75, 129.52, 128.82, 128.56, 127.13, 126.77, 126.61, 124.40, 123.94, 120.64, 119.81, 119.64; HRMS (EI) m/z calcd for $C_{20}H_{13}Cl^{+}$ $(M)^{+}$ 288.0700, found 288.0702.

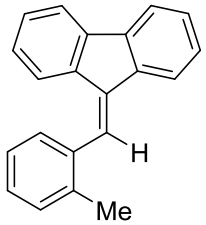


9-(2-nitrobenzylidene)-9H-fluorene (**3k**) : yield: 88%, 26 mg, yellow solid; mp 125-127 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.27 (dd, *J* = 8.2, 1.1 Hz, 1H), 7.90 – 7.80 (m, 2H), 7.79 – 7.57 (m, 5H), 7.42 – 7.33 (m, 2H), 7.29 (td, *J* = 7.4, 1.3 Hz, 1H), 7.03 – 6.86 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 147.70, 141.60, 139.35, 138.91, 137.08, 136.09, 133.45, 133.03, 132.75, 129.18, 128.93, 128.78, 127.28, 126.68, 125.11, 124.16, 122.91, 120.80, 120.00, 119.69; HRMS (EI) m/z calcd for $C_{20}H_{13}NO_2^+$ $(M)^+$ 299.0941, found 299.0944.

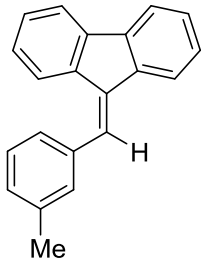


9-(3-nitrobenzylidene)-9H-fluorene (**3l**) : yield: 89%, 27 mg, yellow solid; mp 120-121 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.43 (s, 1H), 8.24 (dd, *J* = 8.2, 2.1 Hz, 1H), 7.90 (d, *J* = 7.6 Hz, 1H), 7.76 (d, *J* = 7.5 Hz, 1H), 7.70 (d, *J* = 7.3 Hz, 2H), 7.66 – 7.56 (m, 2H), 7.40 (t, *J* = 7.8 Hz, 1H), 7.36 – 7.29 (m, 3H), 7.05 (td, *J* = 7.6, 0.9 Hz, 1H).^{13}C NMR (100 MHz, $CDCl_3$) δ 148.46, 141.70, 139.48, 138.87, 138.69, 138.61, 135.84, 135.40, 129.56, 129.35, 128.98, 127.29, 126.97, 124.19, 124.11, 123.57, 122.77, 120.47,

120.08, 119.78; HRMS (EI) m/z calcd for $C_{20}H_{13}NO_2^+$ $(M)^+$ 299.0941, found 299.0944.

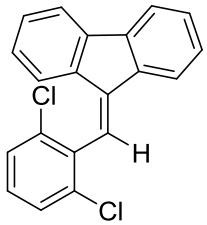


9-(2-methylbenzylidene)-9H-fluorene (**3m**) [5]: yield: 53%, 14 mg; white solid; 1H NMR (400 MHz, $CDCl_3$) δ 7.82 (d, *J* = 6.8 Hz, 1H), 7.75 – 7.68 (m, 2H), 7.67 (s, 1H), 7.47 (d, *J* = 7.6 Hz, 1H), 7.41 – 7.25 (m, 6H), 7.16 (d, *J* = 7.8 Hz, 1H), 7.01 (td, *J* = 7.7, 1.1 Hz, 1H), 2.34 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 141.17, 139.62, 139.07, 138.01, 136.63, 135.98, 133.86, 129.28, 129.23, 128.39, 128.03, 127.55, 126.93, 126.60, 124.38, 120.16, 119.68, 119.55, 21.46.

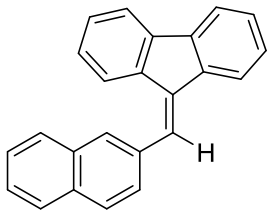


9-(3-methylbenzylidene)-9H-fluorene (**3n**) [3] : yield: 52%, 14 mg; white solid; ^1H NMR (400 MHz, $CDCl_3$) δ 7.78 (d, *J* = 7.1 Hz, 1H), 7.75 – 7.69 (m, 2H), 7.67 (s, 1H), 7.58 (d, *J* = 7.8 Hz, 1H), 7.43 – 7.26 (m, 6H), 7.20 (d, *J* = 7.5 Hz, 1H), 7.06 (td, *J* = 7.7, 1.1 Hz, 1H), 2.41 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 141.21, 139.54, 139.15, 138.17, 136.81,

136.63, 136.30, 129.85, 128.78, 128.45, 128.43, 128.13, 127.53, 126.96, 126.65, 126.33, 124.45, 120.20, 119.69, 119.57, 21.44.

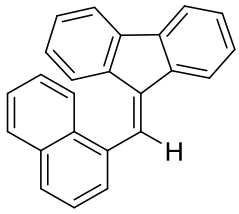


9-(2,6-dichlorobenzylidene)-9H-fluorene (**3o**) : yield: 89%, 29 mg, white solid; mp 129-130 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.84 (dt, *J* = 7.2, 0.7 Hz, 1H), 7.72 – 7.64 (m, 2H), 7.45 (s, 1H), 7.43 (s, 1H), 7.41 – 7.26 (m, 5H), 7.04 (td, *J* = 7.6, 1.1 Hz, 1H), 6.82 (d, *J* = 7.8 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 141.21, 139.84, 139.49, 138.44, 136.64, 135.16, 134.69, 129.53, 129.04, 128.85, 128.22, 127.25, 124.12, 120.87, 119.89, 119.76, 119.75; HRMS (EI) m/z calcd for $C_{20}H_{12}Cl_2^+$ $(M)^+$ 322.0311, found 322.0311.

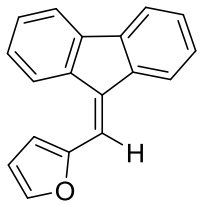


9-(naphthalen-2-ylmethylene)-9H-fluorene (**3p**) : yield: 87%, 26 mg, white solid; mp 99-102 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.05 (s, 1H), 7.95 – 7.78 (m, 5H), 7.75 – 7.66 (m, 3H), 7.60 (d, *J* = 7.8 Hz, 1H), 7.56 – 7.47 (m, 2H), 7.42 – 7.25 (m, 3H), 7.00 (td, *J* = 7.7, 1.1 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 141.19, 139.41, 139.18, 138.00, 136.73,

134.30, 133.68, 131.69, 128.54, 128.51, 128.48, 128.39, 127.16, 127.06, 126.71, 126.39, 126.28, 125.49, 125.30, 125.18, 124.73, 120.48, 119.69, 119.64; HRMS (EI) m/z calcd for $C_{24}H_{16}^{+}$ $(M)^{+}$ 304.1247, found 304.1246.

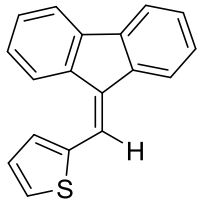


9-(naphthalen-1-ylmethylene)-9H-fluorene (**3q**) [2] : yield: 77%, 24 mg, white solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.05 (d, *J* = 6.2 Hz, 2H), 7.98 – 7.88 (m, 3H), 7.79 – 7.65 (m, 3H), 7.60 – 7.50 (m, 2H), 7.49 – 7.34 (m, 3H), 7.24 (td, *J* = 7.2, 1.0 Hz, 1H), 7.06 (d, *J* = 7.8 Hz, 1H), 6.88 (td, *J* = 7.8, 1.1 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 141.19, 139.41, 139.18, 138.00, 136.73, 134.30, 133.68, 131.69, 128.54, 128.51, 128.48, 128.39, 127.16, 127.06, 126.71, 126.39, 126.28, 125.49, 125.30, 125.18, 124.73, 120.48, 119.69, 119.64.

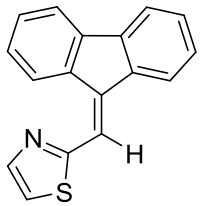


2-((9H-fluoren-9-ylidene)methyl)furan (**3r**) [1] : yield: 47%, 11 mg, yellow solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.76 (d, *J* = 7.2 Hz, 1H), 7.79 – 7.66 (m, 4H), 7.43 – 7.27 (m, 5H), 6.77 (d, *J* = 3.4 Hz, 1H), 6.59 (dd, *J* = 3.4, 1.8 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 152.16, 143.85,

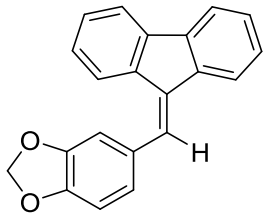
141.04, 140.26, 138.96, 136.12, 132.72, 128.48, 127.86, 127.11, 126.82, 125.68, 119.82, 119.59, 119.55, 115.54, 112.65, 112.45.



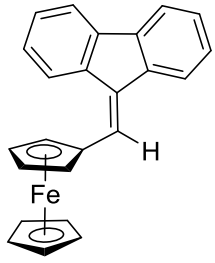
2-((9H-fluoren-9-ylidene)methyl)thiophene (**3s**) [6] : yield: 82%, 21 mg, yellow; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.10 (d, *J* = 7.8 Hz, 1H), 7.72 (q, *J* = 7.6 Hz, 3H), 7.61 (s, 1H), 7.49 – 7.41 (m, 2H), 7.38 – 7.28 (m, 3H), 7.21 – 7.11 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 141.27, 139.55, 139.14, 138.99, 136.62, 136.20, 129.30, 128.78, 128.28, 127.62, 127.36, 127.03, 126.87, 124.42, 120.20, 119.80, 119.64, 119.02.



2-((9H-fluoren-9-ylidene)methyl)thiazole (**3t**) : yield: 99%, 26 mg, yellow solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.38 (d, *J* = 7.8 Hz, 1H), 8.08 (d, *J* = 3.2 Hz, 1H), 7.76 (d, *J* = 7.6 Hz, 1H), 7.69 (t, *J* = 7.6 Hz, 2H), 7.56 (s, 1H), 7.48 (d, *J* = 3.3 Hz, 1H), 7.46 – 7.28 (m, 4H).^{13}C NMR (100 MHz, $CDCl_3$) δ 164.33, 144.63, 141.59, 140.06, 139.69, 139.05, 135.94, 129.91, 129.13, 127.69, 127.66, 127.11, 121.02, 120.47, 119.79, 119.49, 115.86.

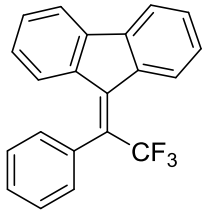


5-((9H-fluoren-9-ylidene)methyl)benzo[d][1,3]dioxole (**3u**) : yield: 50%, 15 mg, yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.74 (dd, *J* = 17.1, 7.7 Hz, 4H), 7.59 (s, 1H), 7.34 (dt, *J* = 20.7, 7.1 Hz, 3H), 7.14 – 7.04 (m, 3H), 6.90 (d, *J* = 7.9 Hz, 1H), 6.04 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 147.79, 147.53, 141.19, 139.56, 139.01, 136.43, 135.89, 130.59, 128.42, 128.06, 127.13, 126.94, 126.67, 124.37, 123.46, 120.11, 119.73, 119.56, 109.61, 108.52, 101.27; HRMS (EI) m/z calcd for $C_{21}H_{14}O_2^+$ $(M)^+$ 298.0988, found 299.0992.

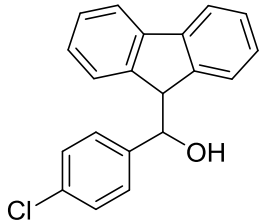


2-((9H-fluoren-9-ylidene)methyl)Ferrocene (**3v**) : yield: 43.3%, 16 mg, red solid; mp 148-149 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.16 (d, *J* = 7.8 Hz, 1H), 7.79 (dd, *J* = 6.5, 1.5 Hz, 1H), 7.74 – 7.71 (m, 2H), 7.47 (s, 1H), 7.37 – 7.30 (m, 3H), 7.18 (td, *J* = 7.7, 1.1 Hz, 1H), 4.71 (t, *J* = 1.8 Hz, 2H), 4.46 (t, *J* = 1.8 Hz, 2H), 4.20 (s, 5H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 140.57, 139.92, 138.22, 136.84, 133.70, 127.69, 127.31, 126.74, 126.47, 126.28, 124.24, 119.64, 119.59, 119.53, 81.35, 70.71, 69.76, 69.51;

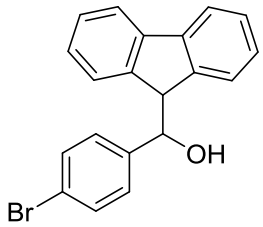
HRMS (ESI) m/z calcd for $C_{24}H_{18}Fe^{+}$ $(M)^{+}$ 362.0752, found 362.0757; IR (KBr, thin film): 3085, 3055, 3008, 1622, 1600, 1446, 1433, 1350, 1249, 1105, 1028, 825, 775, 727, 617, 499, 484 cm^{-1}.



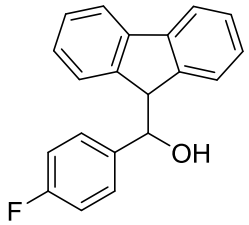
9-(2,2,2-trifluoro-1-phenylethylidene)-9H-fluorene (**3x**) : yield: 78%, 25mg, yellow solid; mp 95-97 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.16 (d, *J* = 8.0 Hz, 1H), 7.65 (dd, *J* = 7.5, 0.6 Hz, 1H), 7.57 (d, *J* = 7.3 Hz, 1H), 7.52 (qd, *J* = 4.3, 1.6 Hz, 3H), 7.45 – 7.28 (m, 4H), 7.21 (td, *J* = 7.5, 0.7 Hz, 1H), 6.79 (td, *J* = 8.1, 1.2 Hz, 1H), 5.88 (d, *J* = 8.0 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 142.27 (q, J = 3.2 Hz), 141.85, 141.26, 137.73, 135.39 (q, *J* = 2.9 Hz), 134.80, 130.17, 129.68, 129.63, 129.29, 129.13, 128.84 (q, *J* = 33.2 Hz), 127.71, 127.11, 127.00 (q, *J* = 8.1 Hz), 126.74, 123.43 (q, *J* = 273.0 Hz), 119.46, 119.26. HRMS (EI) m/z calcd for $C_{21}H_{13}F_3$ $(M)^{+}$ 322.0968, found 322.0965; IR (KBr thin film): 3053, 2925, 2848, 1598, 1446, 1315, 1276, 1224, 1163, 1136, 1110, 972, 854, 790, 765, 736, 717, 700, 644 cm^{-1}.



(4-chlorophenyl)(9H-fluoren-9-yl)methanol (**4a**) [7] : yield: 74%, 23 mg, white solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.69 (dd, *J* = 7.7, 2.5 Hz, 2H), 7.39 – 7.31 (m, 2H), 7.31 – 7.15 (m, 8H), 5.13 (dd, *J* = 5.7, 3.6 Hz, 1H), 4.36 (d, *J* = 5.6 Hz, 1H), 1.98 (d, *J* = 3.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 143.05, 142.95, 141.86, 141.77, 140.30, 133.40, 128.20, 128.11, 127.75, 127.74, 126.80, 126.72, 125.96, 125.52, 119.95, 119.87, 75.65, 54.63.

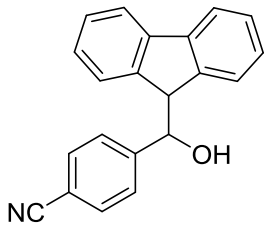


(4-bromophenyl)(9H-fluoren-9-yl)methanol (**4b**) [7] : yield: 65%, 23 mg, white solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72 – 7.67 (m, 2H), 7.43 – 7.32 (m, 4H), 7.27 (d, *J* = 7.7 Hz, 1H), 7.24 – 7.19 (m, 3H), 7.16 – 7.11 (m, 2H), 5.13 (dd, *J* = 5.5, 3.7 Hz, 1H), 4.36 (d, *J* = 5.6 Hz, 1H), 1.97 (d, *J* = 3.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 143.00, 142.94, 141.85, 141.78, 140.82, 131.15, 128.46, 127.77, 127.75, 126.82, 126.72, 125.95, 125.50, 121.57, 119.96, 119.89, 75.67, 54.57.

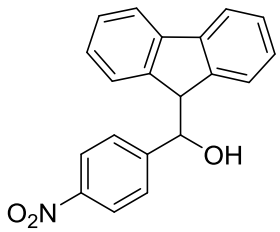


(9H-fluoren-9-yl)(4-fluorophenyl)methanol (**4c**) [7] : yield: 80%, 23 mg, white solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.69 (dd, *J* = 7.6, 3.5 Hz, 2H),

7.40 – 7.31 (m, 3H), 7.25 – 7.13 (m, 5H), 6.97 (t, *J* = 8.7 Hz, 2H), 5.10 (d, *J* = 5.8 Hz, 1H), 4.36 (d, *J* = 5.9 Hz, 1H), 1.99 (s, 1H);^{13}C NMR (100 MHz, $CDCl_3$) δ 162.27 (d, *J* = 245.9 Hz), 143.36, 143.04, 141.87, 141.73, 137.63 (d, *J* = 3.1 Hz), 128.43, 128.35, 127.70, 127.68, 126.73, 126.70, 126.03, 125.61, 119.87 (d, *J* = 8.4 Hz), 114.91 (d, *J* = 21.3 Hz), 75.76, 54.78; ^{19}F NMR (376 MHz, $CDCl_3$) δ -114.63 (s, 1F).

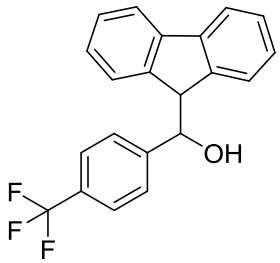


4-((9H-fluoren-9-yl)(hydroxy)methyl)benzonitrile (**4d**)[7]: yield: 62% 18 mg, white; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.67 (dd, *J* = 7.6, 2.8 Hz, 2H), 7.51 (d, *J* = 8.4 Hz, 2H), 7.40 – 7.33 (m, 3H), 7.30 (d, *J* = 8.1 Hz, 2H), 7.28 – 7.20 (m, 2H), 7.17 (d, *J* = 7.5 Hz, 1H), 5.37 – 5.32 (m, 1H), 4.40 (d, *J* = 5.0 Hz, 1H), 2.07 (d, *J* = 3.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 146.65, 142.50, 142.29, 141.83, 141.80, 131.66, 127.98, 127.96, 127.33, 126.96, 126.82, 125.56, 125.45, 120.10, 120.00, 118.80, 111.34, 75.50, 54.50.

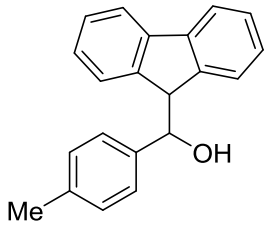


(9H-fluoren-9-yl)(4-nitrophenyl)methanol (**4e**) : yield: 91%, 29 mg, yellow solid; mp 169-171 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.04 (d, *J* =

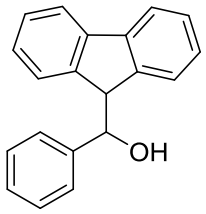
8.8 Hz, 2H), 7.65 (dd, *J* = 7.6, 3.8 Hz, 2H), 7.47 – 7.42 (m, 1H), 7.39 – 7.30 (m, 4H), 7.27 (dd, *J* = 7.5, 1.1 Hz, 1H), 7.25 – 7.16 (m, 2H), 5.53 – 5.30 (m, 1H), 4.42 (d, *J* = 4.9 Hz, 1H), 2.14 (d, *J* = 3.6 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 148.55, 147.26, 142.43, 142.15, 141.84, 141.78, 128.03, 128.01, 127.42, 127.01, 126.86, 125.50, 122.99, 120.15, 120.03, 75.35, 54.52; HRMS (ESI) m/z calcd for $C_{20}H_{16}NO_3^+$ $(M + H)^+$ 318.1125, found 318.1127; IR (KBr, thin film): 3178, 2894, 1502, 1475, 1444, 1294, 1176, 1143, 1078, 1051, 958, 881, 740, 622 cm^{-1}.



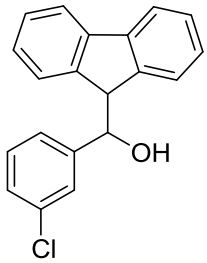
(9H-fluoren-9-yl)(4-(trifluoromethyl)phenyl)methanol (**4f**) [7]: yield: 89%, 30 mg, yellow solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72 – 7.67 (m, 2H), 7.54 (d, *J* = 8.2 Hz, 2H), 7.39 – 7.34 (m, 4H), 7.30 – 7.25 (m, 1H), 7.24 – 7.16 (m, 3H), 5.31 – 5.24 (m, 1H), 4.40 (d, *J* = 5.3 Hz, 1H), 1.98 (d, *J* = 3.8 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 145.67, 142.82, 142.61, 141.85, 129.81 (q, *J* = 32.3 Hz), 127.88, 127.86, 127.01, 126.92, 126.77, 125.82, 125.35, 124.97 (q, *J* = 3.7 Hz), 124.14 (q, *J* = 270.0 Hz), 120.03, 119.96, 75.58, 54.59; ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.38 (s, 3F).



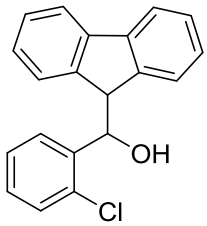
(9H-fluoren-9-yl)(p-tolyl)methanol (**4g**) [7] : yield: 40%, 11mg, white solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.70 (dd, *J* = 7.5, 4.8 Hz, 2H), 7.41 – 7.30 (m, 3H), 7.24 – 7.11 (m, 6H), 7.06 – 7.02 (m, 1H), 4.99 (d, *J* = 6.3 Hz, 1H), 4.37 (d, *J* = 6.3 Hz, 1H), 2.36 (s, 3H), 1.92 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 143.79, 143.42, 141.86, 141.73, 139.27, 137.48, 128.91, 127.56, 127.51, 126.75, 126.63, 126.35, 125.60, 119.79, 119.71, 76.26, 54.72, 21.23.



(9H-fluoren-9-yl)(phenyl)methanol (**4h**) [7] : yield：55%，15mg, white solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.69 (dd, J = 7.6, 4.5 Hz, 2H), 7.39 – 7.27 (m, 8H), 7.23 – 7.13 (m, 2H), 7.04 (d, J = 7.6 Hz, 1H), 5.04 (d, J = 6.1 Hz, 1H), 4.37 (d, J = 6.1 Hz, 1H), 1.97 (s, 1H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 143.61, 143.32, 142.17, 141.88, 141.76, 128.20, 127.84, 127.64, 127.59, 126.83, 126.69, 126.67, 126.29, 125.55, 119.83, 119.76, 76.33, 54.78.

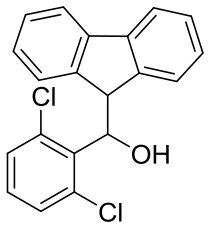


(3-chlorophenyl)(9H-fluoren-9-yl)methanol (**4i**) : yield: 64%, 20 mg white solid; mp 159-161℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.73 – 7.68 (m, 2H), 7.39 – 7.31 (m, 3H), 7.28 – 7.26 (m, 1H), 7.25 – 7.14 (m, 6H), 5.12 (dd, *J* = 5.4, 4.0 Hz, 1H), 4.36 (d, *J* = 5.6 Hz, 1H), 1.94 (d, *J* = 3.9 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.04, 142.92, 142.88, 141.86, 141.82, 134.14, 129.35, 127.87, 127.82, 127.80, 126.94, 126.87, 126.76, 126.03, 125.37, 124.90, 119.94, 119.89, 75.56, 54.61; HRMS (ESI) m/z calcd for $C_{20}H_{14}Cl^{+}$ $(M - OH)^{+}$ 289.0779, found 289.0773; IR (KBr thin film): 3450, 3060, 3024, 1571, 1473, 1442, 1386, 1294, 1193, 1078, 794, 750, 744, 738, 692, 624, 559 cm^{-1}.

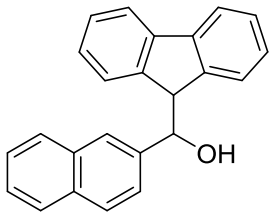


(2-chlorophenyl)(9H-fluoren-9-yl)methanol (**4j**) : yield: 78%, 24 mg, white solid; mp 124-125 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76 (dd, *J* = 7.9, 2.2 Hz, 2H), 7.53 (dd, *J* = 7.2, 2.1 Hz, 1H), 7.48 – 7.26 (m, 7H), 7.14 (t, *J* = 7.5 Hz, 1H), 6.88 (d, *J* = 7.6 Hz, 1H), 5.66 (s, 1H), 4.56 (d, *J* = 4.1 Hz, 1H), 1.70 (s, 1H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 143.93, 142.31,

142.25, 141.91, 139.73, 132.14, 129.54, 128.91, 128.64, 127.84, 127.73, 127.26, 126.79, 126.47, 126.45, 124.46, 119.97, 119.96, 72.47, 52.48; HRMS (ESI) m/z calcd for $C_{20}H_{14}Cl^+$ $(M - OH)^+$ 289.0779, found 289.0774; IR (KBr thin film): 3548, 3446, 3064, 2898, 1473, 1446, 1390, 1307, 1234, 1182, 1033, 771, 748, 696, 678 cm^{-1}.

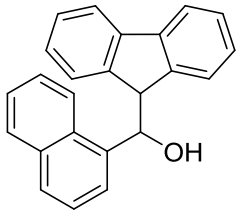


(2,6-dichlorophenyl)(9H-fluoren-9-yl)methanol (**4k**): yield: 89%, 30 mg, white solid; mp 58-59 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.98 (d, *J* = 7.2 Hz, 1H), 7.79 (d, *J* = 7.5 Hz, 1H), 7.73 (d, *J* = 7.6 Hz, 1H), 7.44 (t, *J* = 7.2 Hz, 1H), 7.40 – 7.23 (m, 5H), 6.95 (td, *J* = 7.6, 1.1 Hz, 1H), 6.25 – 6.14 (m, 1H), 5.08 (t, *J* = 9.5 Hz, 1H), 4.87 (d, *J* = 10.1 Hz, 1H), 3.27 (d, *J* = 9.2 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 145.48, 141.82, 141.81, 141.19, 136.74, 129.56, 129.43, 127.72, 127.50, 126.96, 126.91, 126.51, 125.10, 119.85, 119.73, 74.55, 51.47; HRMS (EI) m/z calcd for $C_{20}H_{14}Cl_2O^+$ $(M)^+$ 340.0416, found 340.0412.



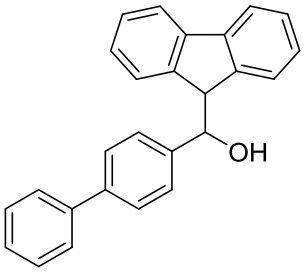
(9H-fluoren-9-yl)(naphthalen-2-yl)methanol (**4l**) : yield: 59%, 19mg; white solid; mp 133-134 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.85 (dd, *J* =

9.0, 4.9 Hz, 2H), 7.80 – 7.75 (m, 1H), 7.75 – 7.66 (m, 3H), 7.53 (dd, *J* = 8.5, 1.7 Hz, 1H), 7.51 – 7.44 (m, 2H), 7.34 (q, *J* = 7.0 Hz, 2H), 7.27 (d, *J* = 7.4 Hz, 1H), 7.19 – 7.13 (m, 2H), 7.08 (d, *J* = 7.3 Hz, 1H), 5.23 (d, *J* = 5.9 Hz, 1H), 4.50 (d, *J* = 5.9 Hz, 1H), 2.01 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 143.43, 143.34, 141.90, 141.81, 139.63, 133.09, 133.04, 128.20, 128.05, 127.72, 127.68, 127.64, 126.78, 126.70, 126.34, 126.17, 126.01, 125.83, 125.44, 124.72, 119.87, 119.82, 76.35, 54.56; HRMS (ESI) m/z calcd for $C_{24}H_{17}^+$ $(M\text{-}OH)^+$ 305.1325, found 305.1328; IR (KBr thin film): 3450, 3057, 2921, 2854, 1448, 1367, 1296, 1271, 1012, 825, 746, 557, 478, 428 cm^{-1}.

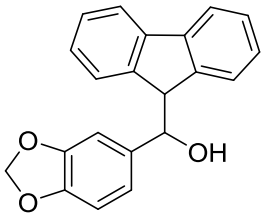


(9H-fluoren-9-yl)(naphthalen-1-yl)methanol (**4m**) : yield: 73%, 23mg, white solid; mp 137-138 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.31 – 8.23 (m, 1H), 7.99 – 7.93 (m, 1H), 7.90 (d, *J* = 8.0 Hz, 1H), 7.76 (d, *J* = 7.6 Hz, 2H), 7.62 – 7.49 (m, 4H), 7.36 (td, *J* = 7.5, 4.0 Hz, 2H), 7.20 – 7.08 (m, 3H), 6.96 (d, *J* = 7.5 Hz, 1H), 5.84 (d, *J* = 5.2 Hz, 1H), 4.62 (d, *J* = 5.2 Hz, 1H), 1.86 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 143.88, 143.01, 142.03, 141.93, 137.76, 133.90, 130.40, 129.22, 128.54, 127.73, 127.68, 126.96, 126.86, 126.50, 126.24, 125.67, 125.25, 124.90, 124.75, 123.06, 119.91, 119.85, 73.27, 53.69. HRMS (ESI) m/z calcd for $C_{24}H_{17}^+$ (M +

H)$^+$ 305.1325, found 305.1325; IR (KBr thin film): 3556, 3055, 3012, 2921, 1450, 1082, 808, 783, 740, 683 cm^{-1}.

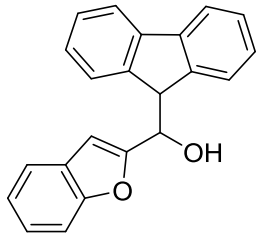


[1,1'-biphenyl]-4-yl(9H-fluoren-9-yl)methanol (**4n**) : yield: 83%, 29mg, white solid; mp 153-154 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.74 – 7.68 (m, 2H), 7.65 – 7.59 (m, 2H), 7.56 (d, *J* = 8.3 Hz, 2H), 7.44 (t, *J* = 7.5 Hz, 2H), 7.41 – 7.31 (m, 6H), 7.26 – 7.11 (m, 3H), 5.11 (d, *J* = 5.8 Hz, 1H), 4.42 (d, *J* = 6.0 Hz, 1H), 1.99 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 143.51, 143.29, 141.90, 141.79, 141.21, 140.65, 140.52, 128.81, 127.67, 127.63, 127.38, 127.26, 127.05, 126.83, 126.74, 126.69, 126.28, 125.54, 119.87, 119.81, 76.11, 54.73; HRMS (ESI) m/z calcd for $C_{26}H_{19}^+$ (M-OH)$^+$ 331.1481, found 331.1484; IR (KBr thin film): 3462, 3057, 3028, 2925, 1487, 1444, 1035, 1004, 846, 746, 696, 555 cm^{-1}.

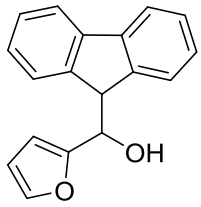


benzo[d][1,3]dioxol-5-yl(9H-fluoren-9-yl)methanol (**4o**) : yield: 40%, 13 mg white solid; mp 149-150 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.71 (dd, *J* = 7.5, 5.0 Hz, 2H), 7.44 (d, *J* = 6.9 Hz, 1H), 7.36 (dt, *J* = 10.0, 7.4 Hz,

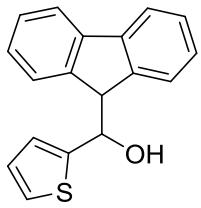
2H), 7.24 (td, *J* = 7.5, 1.1 Hz, 1H), 7.18 (td, *J* = 7.5, 1.1 Hz, 1H), 7.06 (d, *J* = 7.0 Hz, 1H), 6.87 (s, 1H), 6.76 – 6.70 (m, 2H), 5.99 – 5.94 (m, 2H), 4.92 (d, *J* = 6.3 Hz, 1H), 4.33 (d, *J* = 6.4 Hz, 1H), 1.95 (d, J = 1.9 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 147.60, 147.09, 143.71, 143.15, 141.82, 141.65, 136.28, 127.61, 127.57, 126.68, 126.66, 126.28, 125.65, 120.40, 119.81, 119.73, 107.81, 107.27, 101.04, 76.29, 54.74; HRMS (EI) m/z calcd for $C_{21}H_{16}O_3^+$ $(M)^+$ 316.1094, found 316.1091.



benzofuran-2-yl(9H-fluoren-9-yl)methanol (**4p**) : yield: 95% 30 mg, white solid; mp 141-143 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.75 (d, *J* = 7.6 Hz, 2H), 7.57 – 7.51 (m, 2H), 7.41 – 7.14 (m, 8H), 6.52 (s, 1H), 5.23 (t, *J* = 4.9 Hz, 1H), 4.67 (d, *J* = 5.5 Hz, 1H), 2.01 (d, *J* = 5.5 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 157.60, 154.71, 143.03, 142.29, 142.05, 141.85, 128.19, 127.94, 127.86, 127.17, 126.97, 126.02, 124.82, 124.34, 123.02, 121.31, 120.00, 119.96, 111.44, 104.26, 70.71, 52.08; HRMS (ESI) m/z calcd for $C_{22}H_{15}O^+$ $(M\text{-}OH)^+$ 295.1117, found 295.1113, IR (KBr, thin film): 3390, 3064, 3035, 2920, 1450, 1257, 1170, 1047, 1004, 939, 817, 738, 565 cm^{-1}.

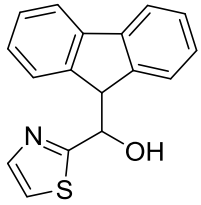


(9H-fluoren-9-yl)(furan-2-yl)methanol (**4q**) [7] : yield: 47%, 12 mg, white solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.74 (dd, *J* = 7.6, 3.1 Hz, 2H), 7.48 (dd, *J* = 1.8, 0.8 Hz, 1H), 7.41 – 7.31 (m, 3H), 7.26 – 7.19 (m, 2H), 7.07 – 7.03 (m, 1H), 6.38 (dd, *J* = 3.2, 1.8 Hz, 1H), 6.12 (d, *J* = 3.2 Hz, 1H), 5.02 (t, *J* = 5.3 Hz, 1H), 4.55 (d, *J* = 6.3 Hz, 1H), 1.97 (d, *J* = 5.0 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 154.94, 143.14, 142.99, 141.83, 141.79, 141.75, 127.75, 127.68, 126.95, 126.88, 126.05, 124.95, 119.85, 119.78, 110.61, 107.51, 70.42, 52.51.



(9H-fluoren-9-yl)(thiophen-2-yl)methanol (**4r**) : yield: 45%, 13 mg white solid; mp 117-118 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.71 (d, *J* = 7.6 Hz, 2H), 7.46 – 7.42 (m, 1H), 7.40 – 7.33 (m, 2H), 7.28 – 7.21 (m, 3H), 7.20 (dd, *J* = 5.1, 1.2 Hz, 1H), 6.90 (dd, *J* = 5.0, 3.5 Hz, 1H), 6.82 (dt, *J* = 3.5, 1.0 Hz, 1H), 5.42 – 5.36 (m, 1H), 4.44 (d, *J* = 5.9 Hz, 1H), 2.18 (d, *J* = 4.2 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 145.77, 143.01, 142.99, 141.91, 141.81, 127.76, 127.74, 126.84, 126.83, 126.37, 125.87, 125.71, 124.95, 124.85, 119.85, 119.73, 72.93, 54.88; HRMS (ESI) m/z calcd for

$C_{18}H_{13}S^+$ $(M + H)^+$ 261.0733, found 261.0732; IR (KBr thin film): 3544, 3066, 2904, 1444, 1236, 1029, 854, 752, 744, 694, 545 cm^{-1}.



(9H-fluoren-9-yl)(thiazol-2-yl)methanol (**4s**) : yield: 88%, 25 mg, white solid; mp 132-133 °C; ^1H NMR (400 MHz, $CDCl_3$) δ 7.79 – 7.67 (m, 3H), 7.59 (d, *J* = 7.4 Hz, 1H), 7.37 (td, *J* = 7.4, 3.0 Hz, 2H), 7.29 (t, *J* = 7.8 Hz, 1H), 7.24 – 7.15 (m, 2H), 6.92 (d, *J* = 7.6 Hz, 1H), 5.71 (d, *J* = 3.8 Hz, 1H), 4.80 (d, *J* = 3.6 Hz, 1H), 3.08 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 172.38, 143.00, 142.49, 141.87, 141.36, 128.09, 127.89, 127.24, 127.01, 125.36, 125.03, 120.06, 119.92, 119.51, 73.82, 53.57; HRMS (ESI) m/z calcd for $C_{17}H_{14}NOS^+$ $(M + H)^+$ 280.0791, found 280.0790; IR (KBr thin film): 3178, 2894, 1502, 1475, 1444, 1294, 1176, 1143, 1078, 1051, 958, 881, 740, 622 cm^{-1}.

3. References

[1] M. Paraja, C. Valdés, *Organic Letters* **2017**, *19*, 2034-2037.
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[3] C. Do, J. Hatfield, S. Patel, D. Vasudevan, C. Tirla, N. S. Mills, *The Journal of Organic Chemistry* **2011**, *76*, 181-187.
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[5] D. Casarini, L. Lunazzi, A. Mazzanti, *The Journal of Organic Chemistry* **2008**, *73*, 2811-2818.
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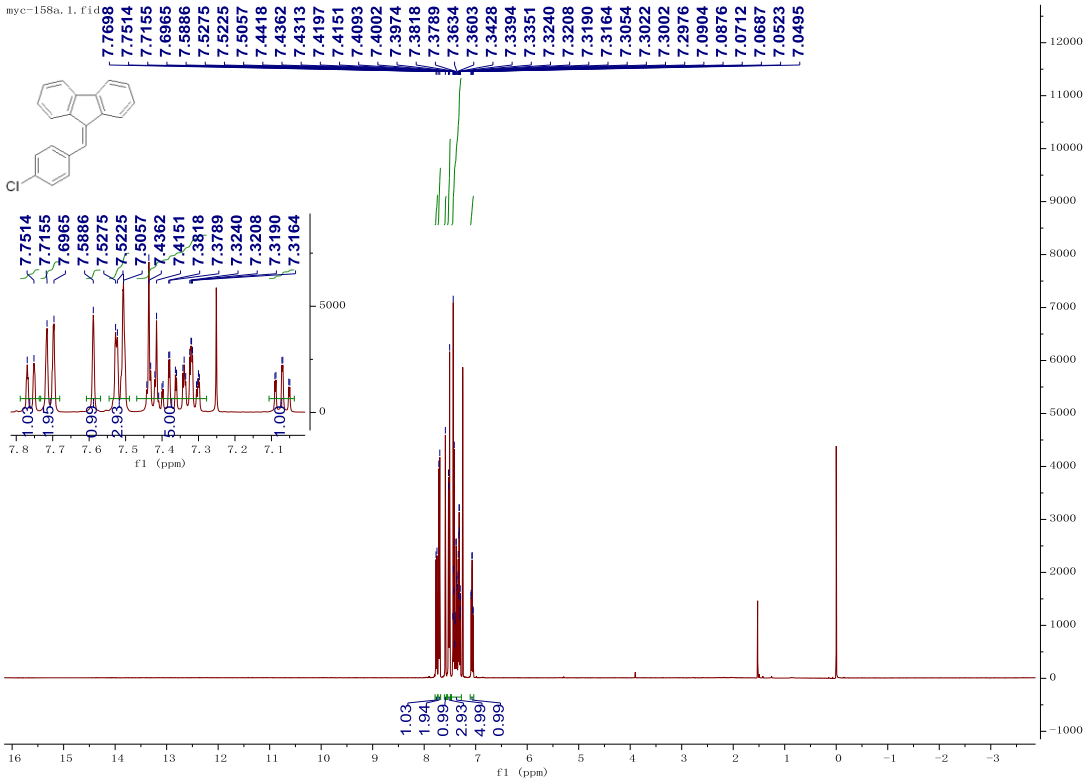
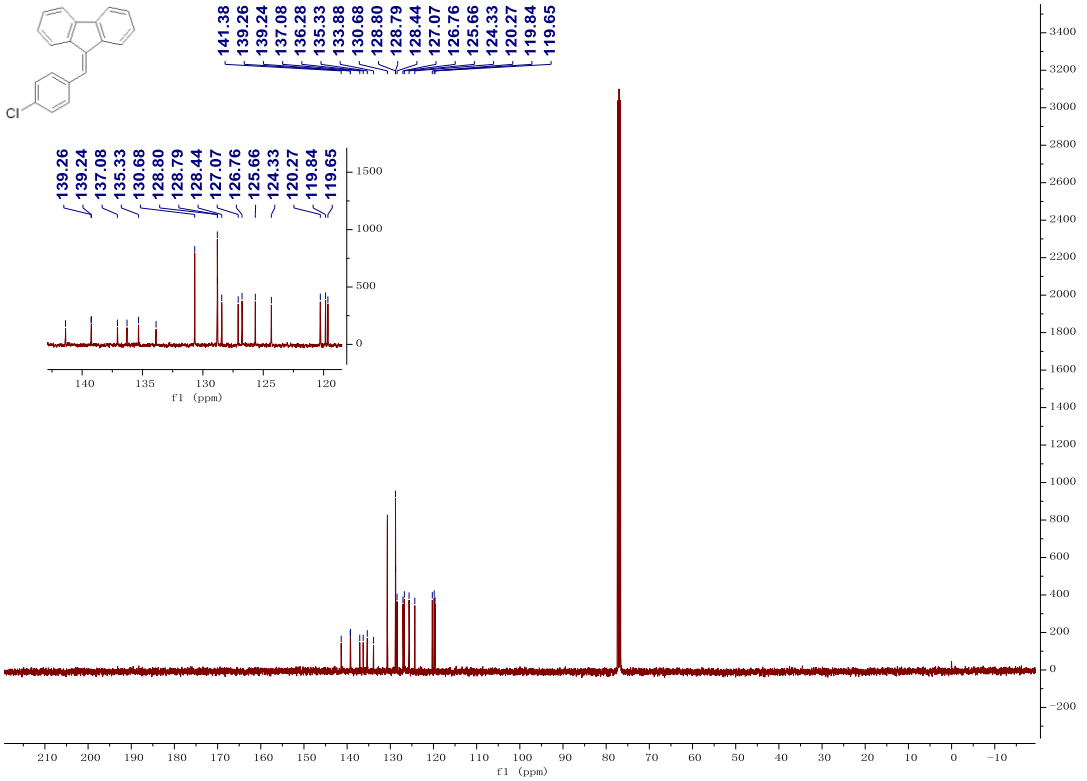
[7] A. G. Giuglio-Tonolo, T. Terme, P. Vanelle, *Molecules* **2016**, *21*, 1408.

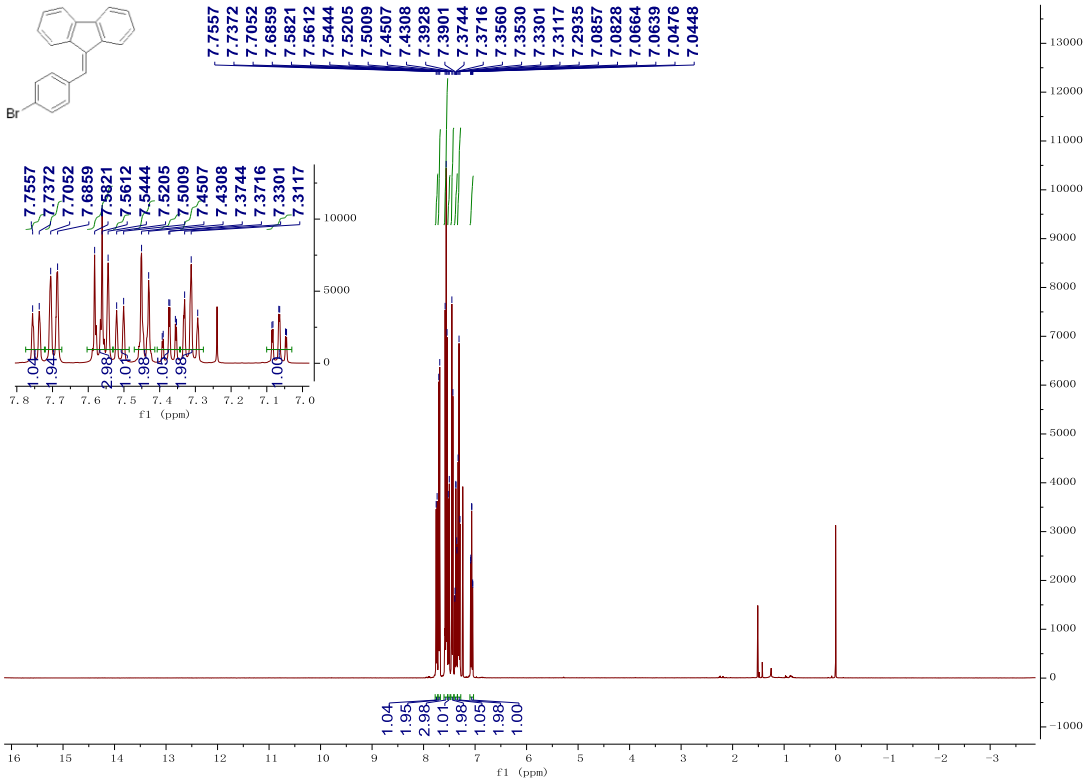
4. Copies of ^{1}H NMR and ^{13}C NMR spectra

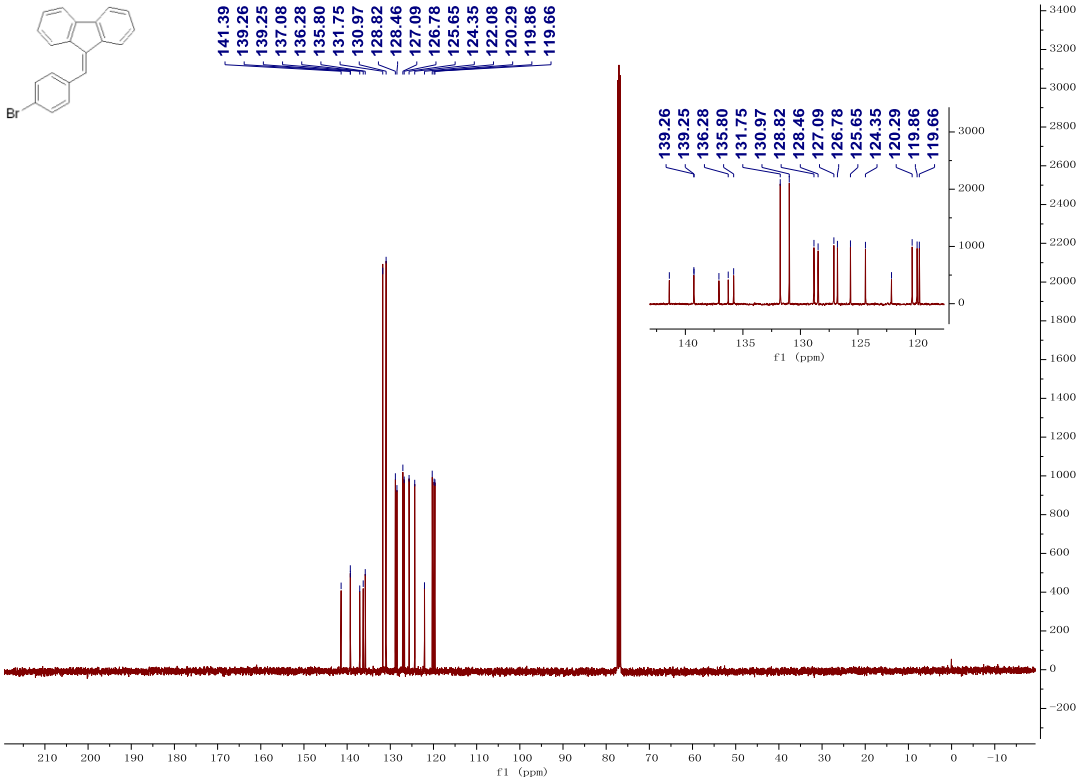
^{1}H NMR, ^{13}C NMR spectrum of **3a**



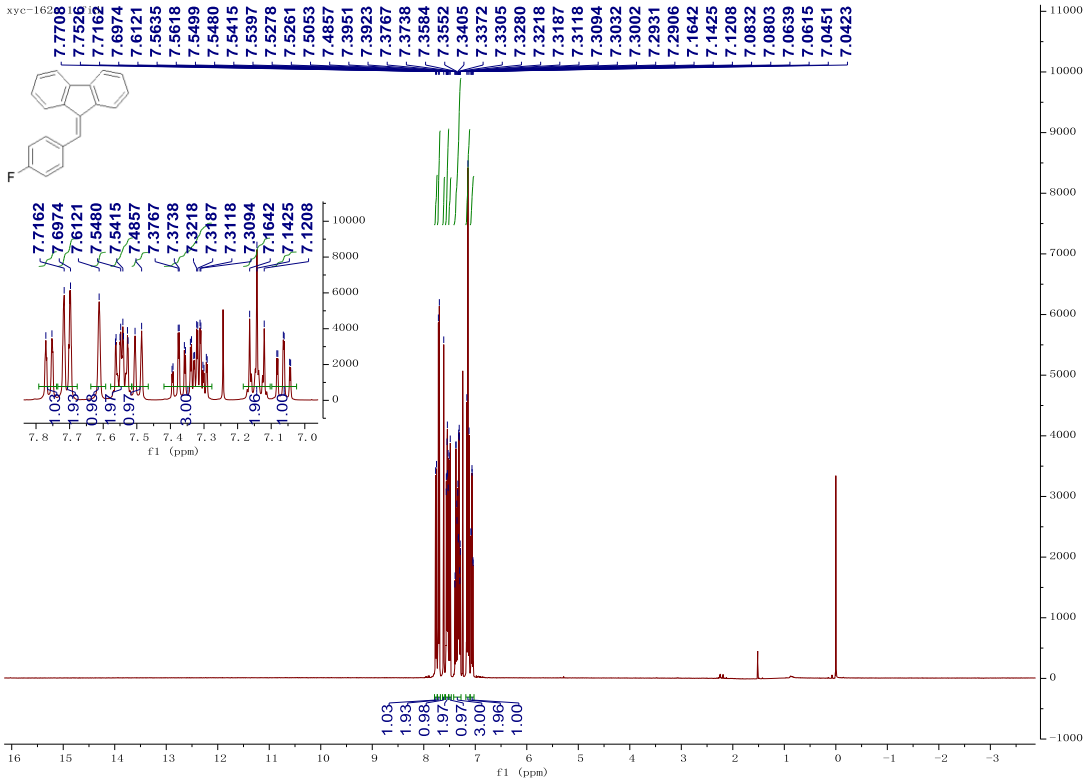


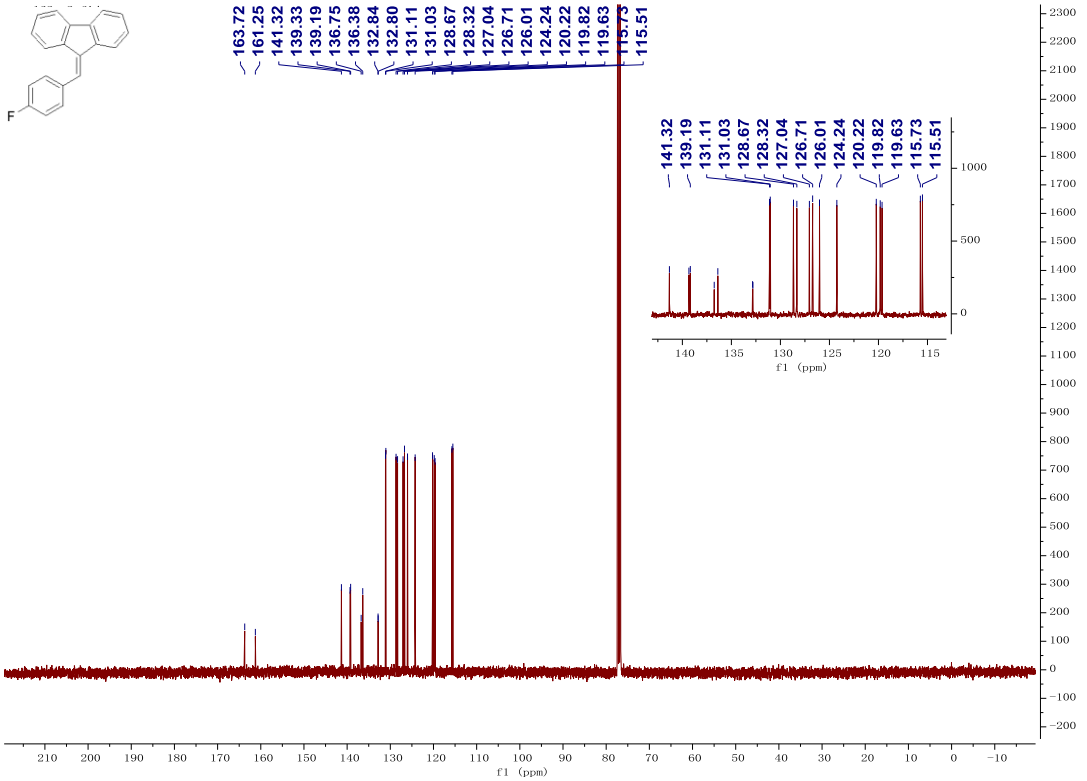
^{1}H NMR, ^{13}C NMR spectrum of **3b**

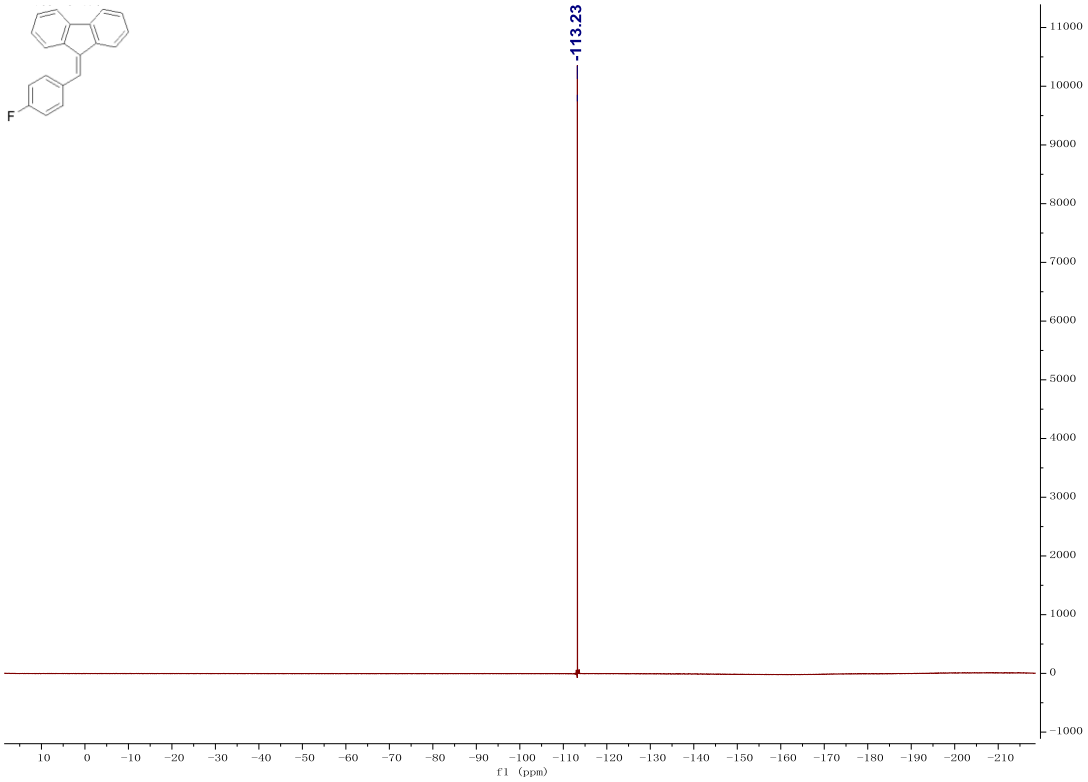




^{1}H NMR, ^{13}C NMR, ^{19}F NMR spectrum of **3c**



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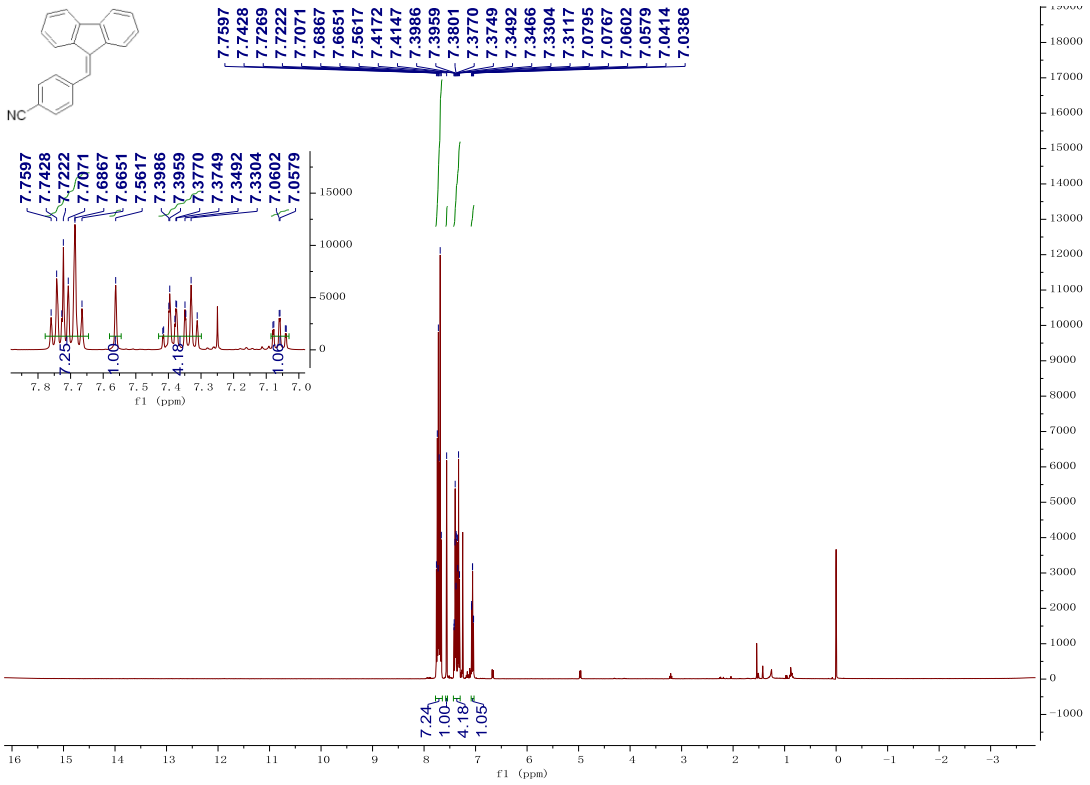
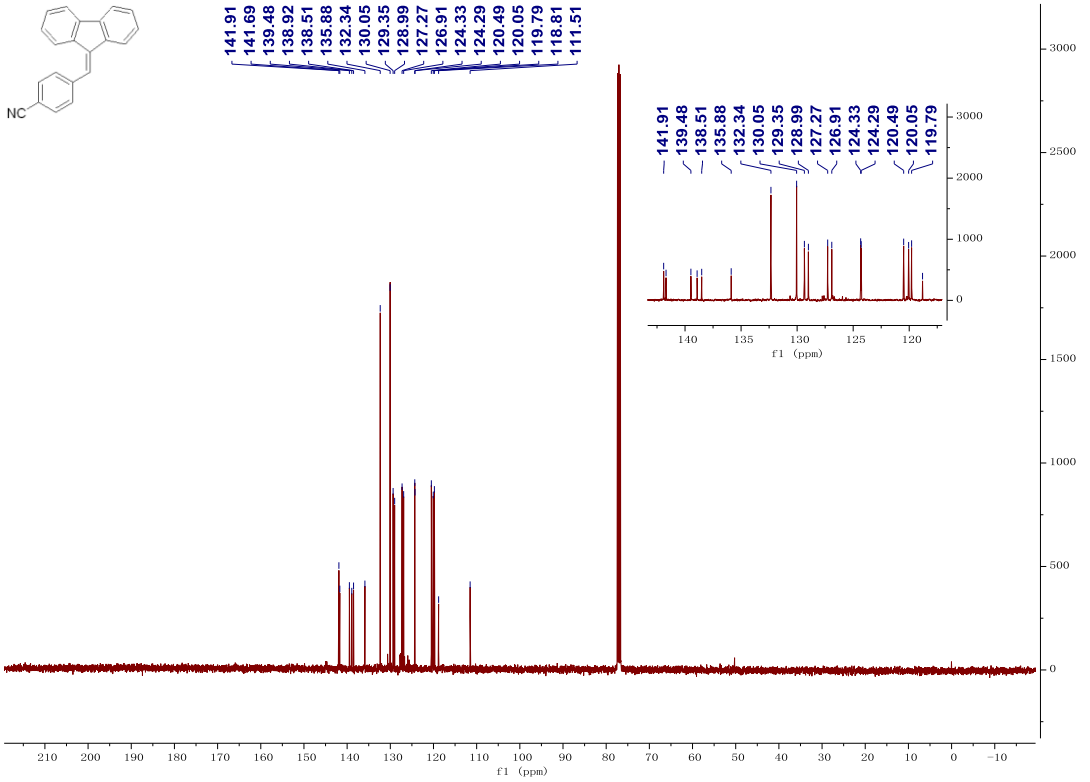
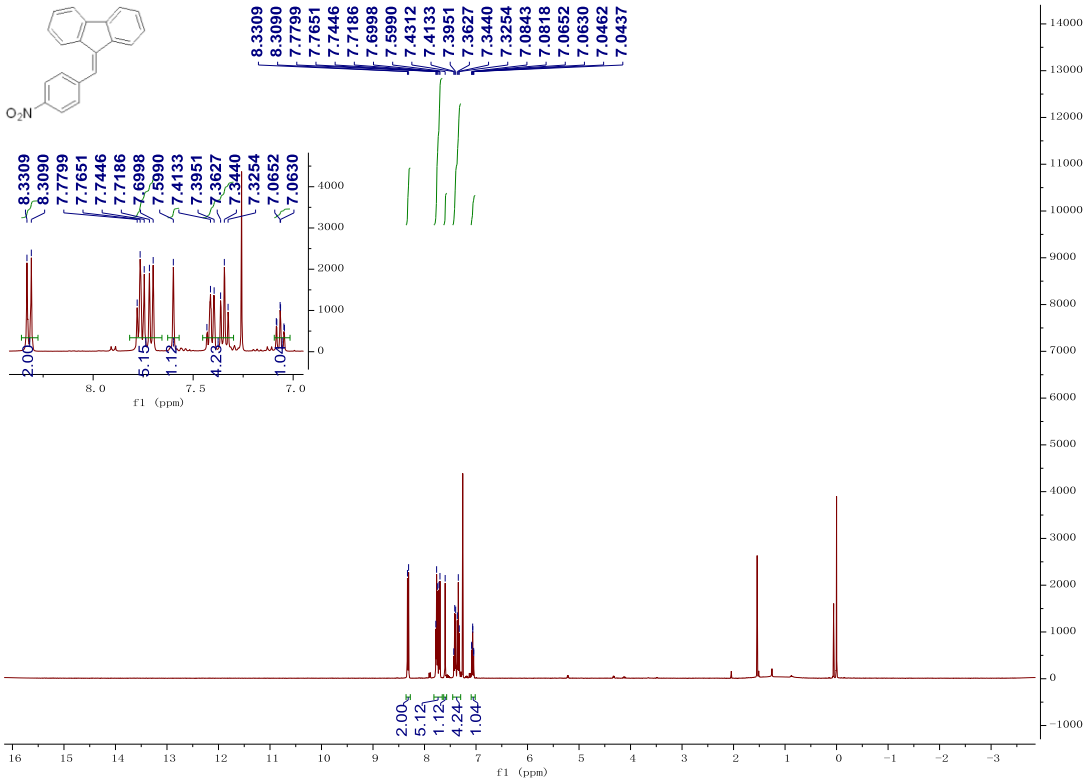
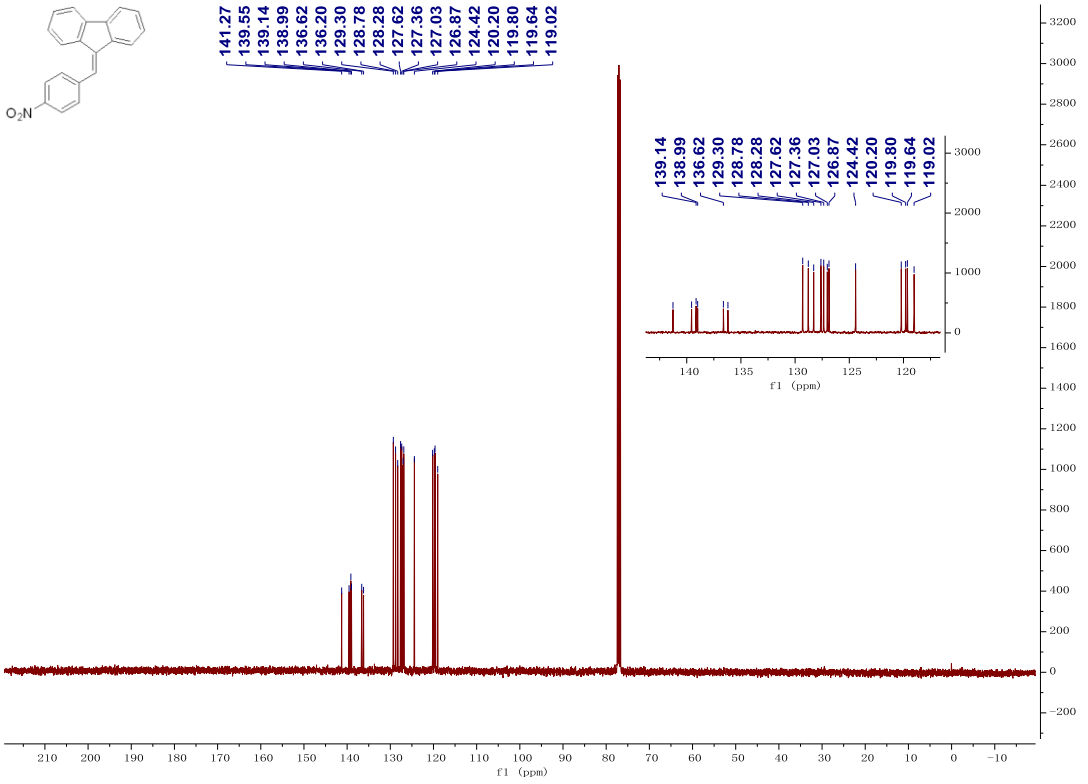
^{1}H NMR, ^{13}C NMR spectrum of **3d**



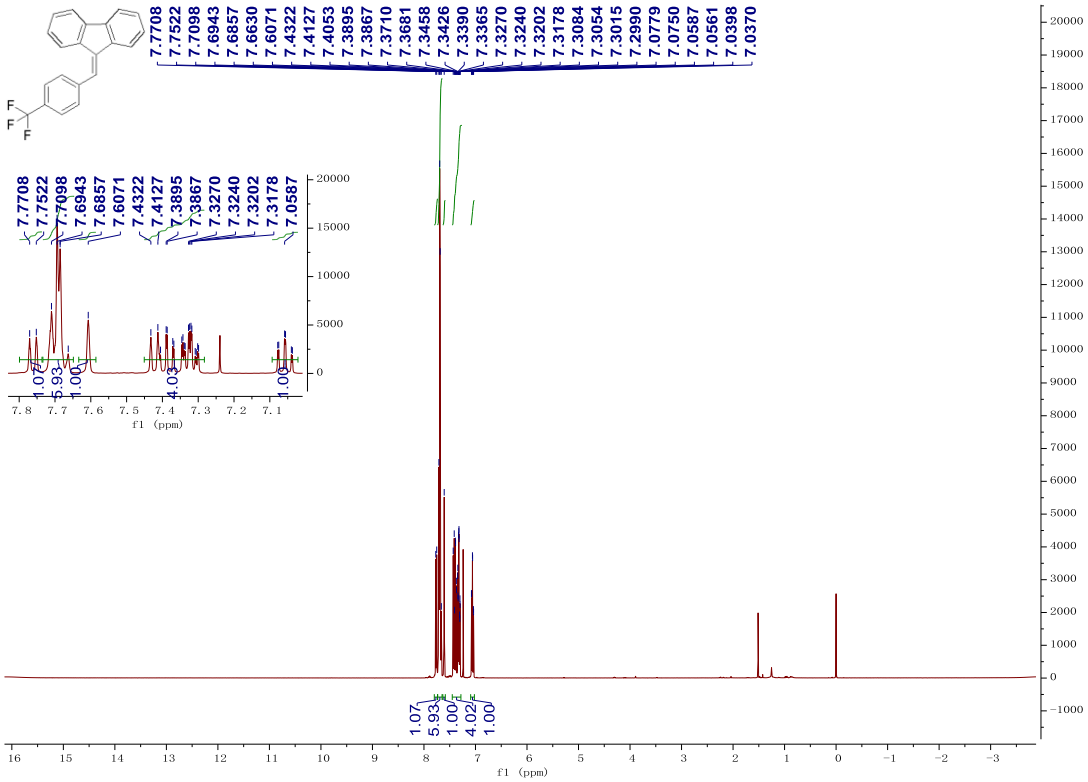


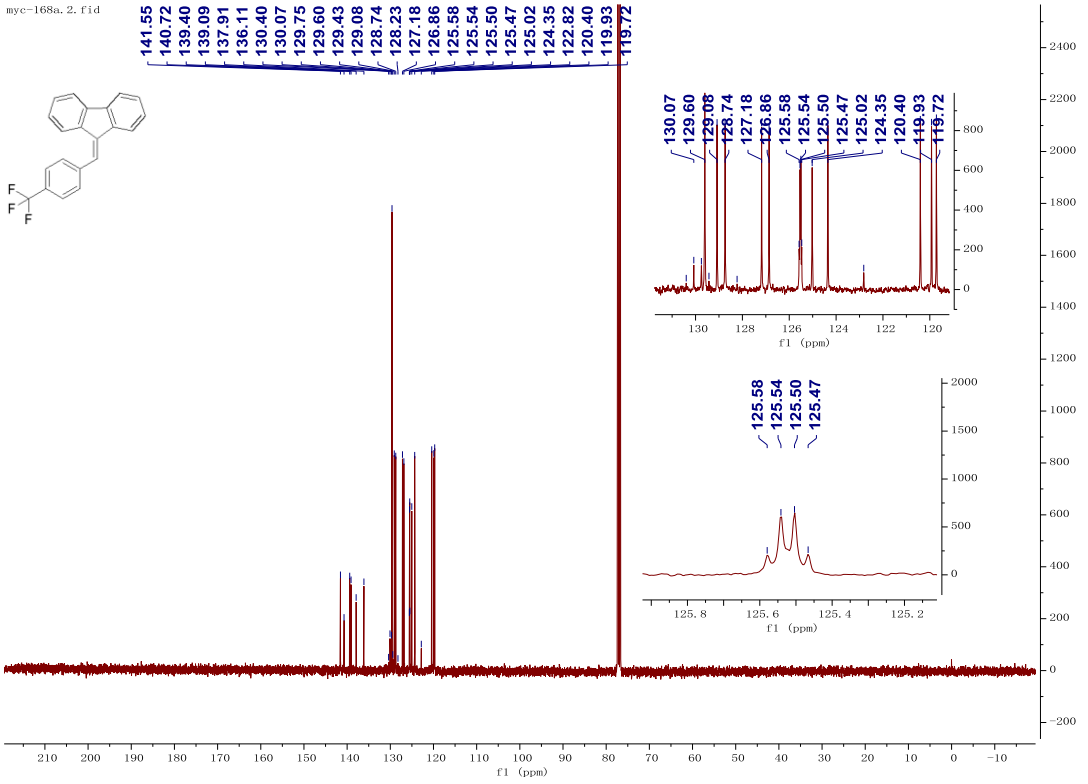
^{1}H NMR, ^{13}C NMR spectrum of **3e**

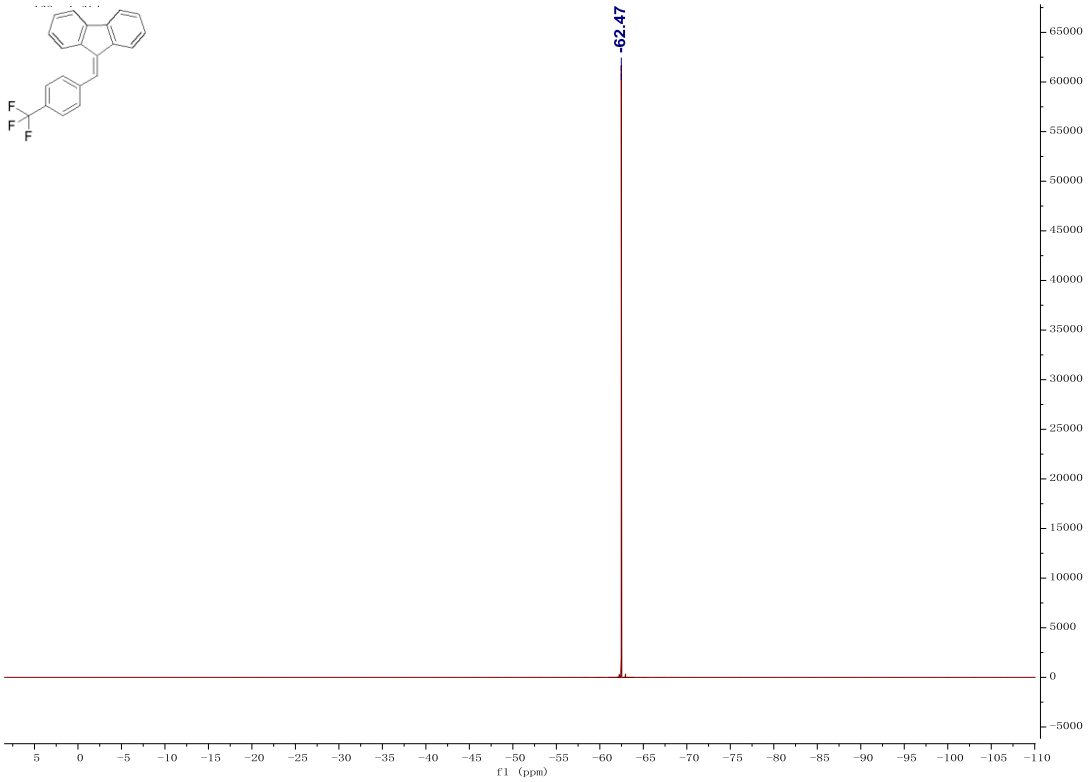




^{1}H NMR, ^{13}C NMR, ^{19}FNMR spectrum of **3f**



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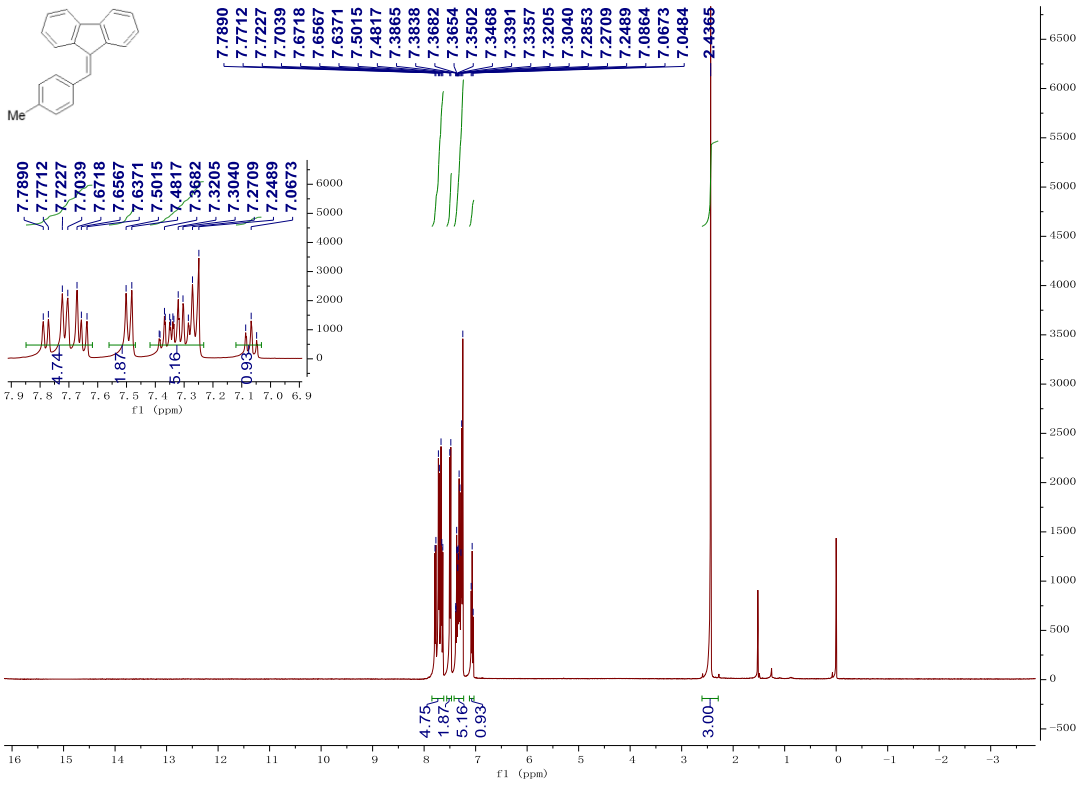
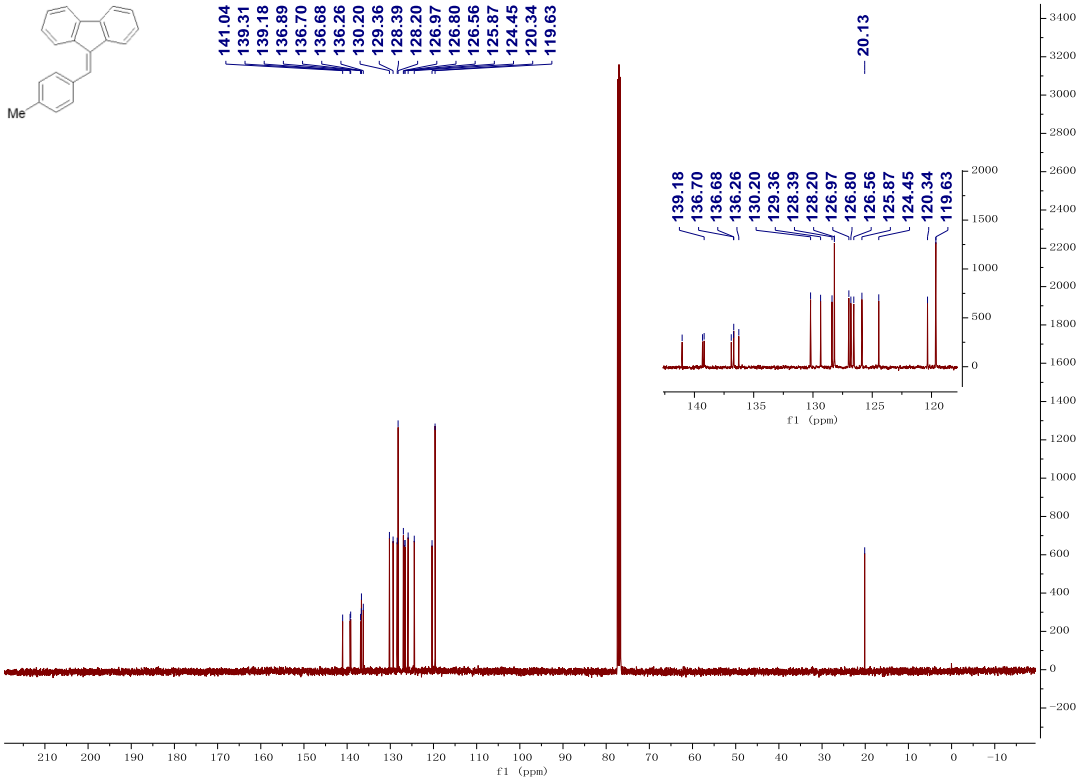
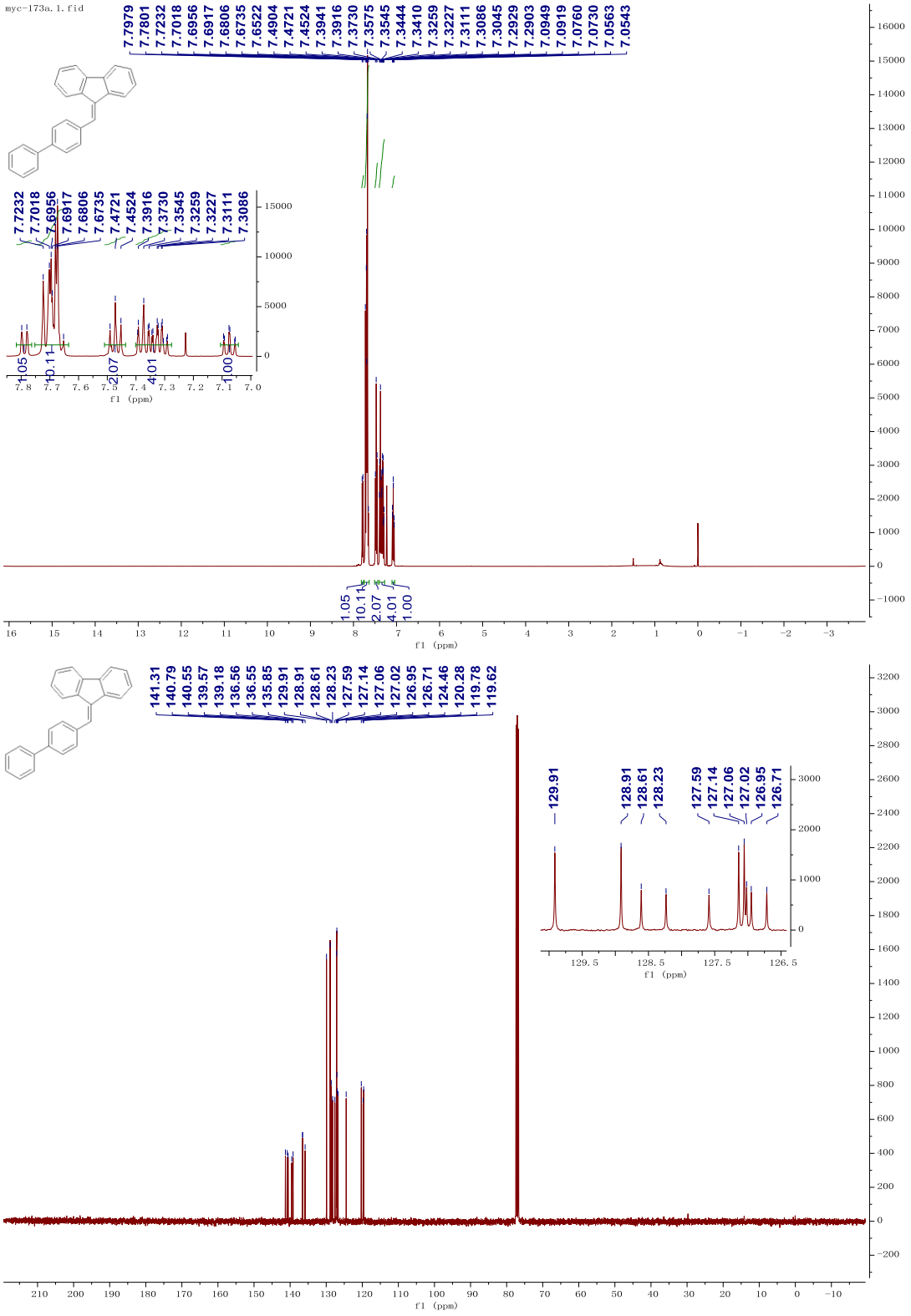
^{1}H NMR, ^{13}C NMR spectrum of **3g**

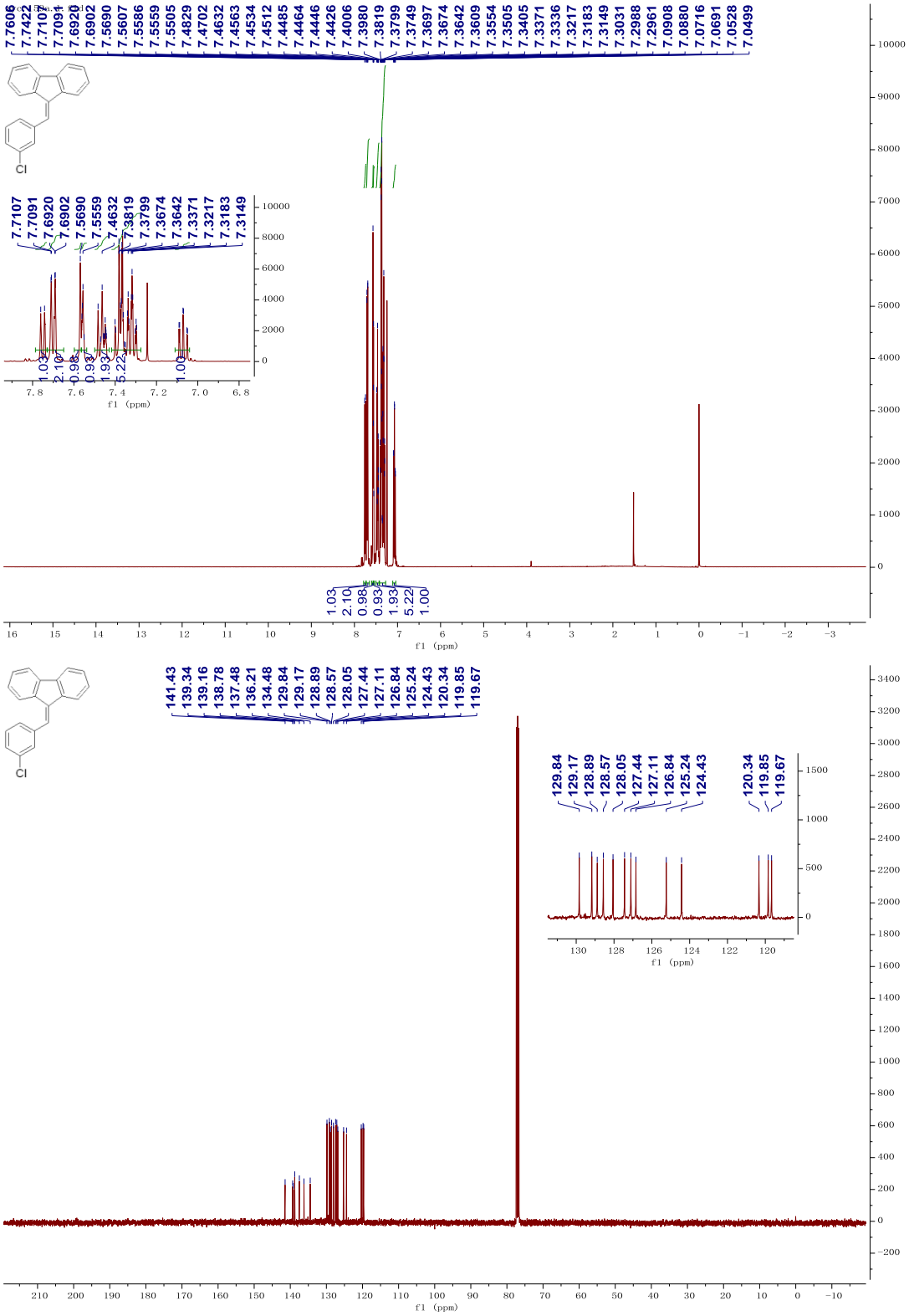




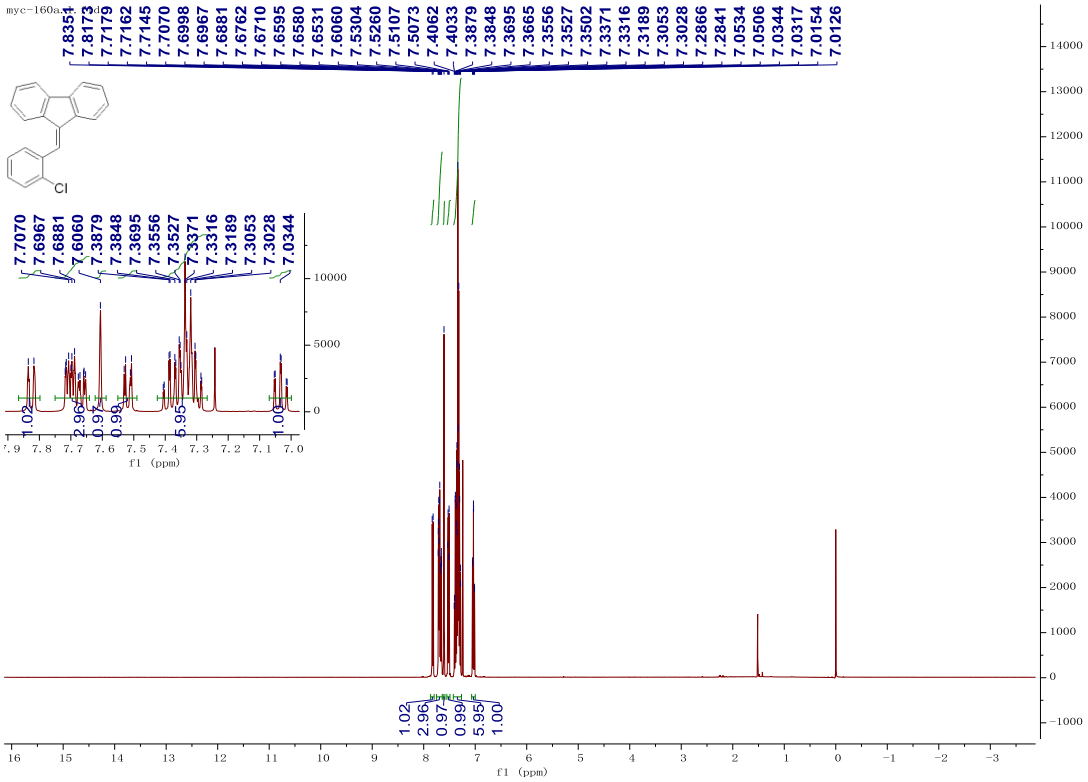
^{1}H NMR, ^{13}C NMR spectrum of **3h**

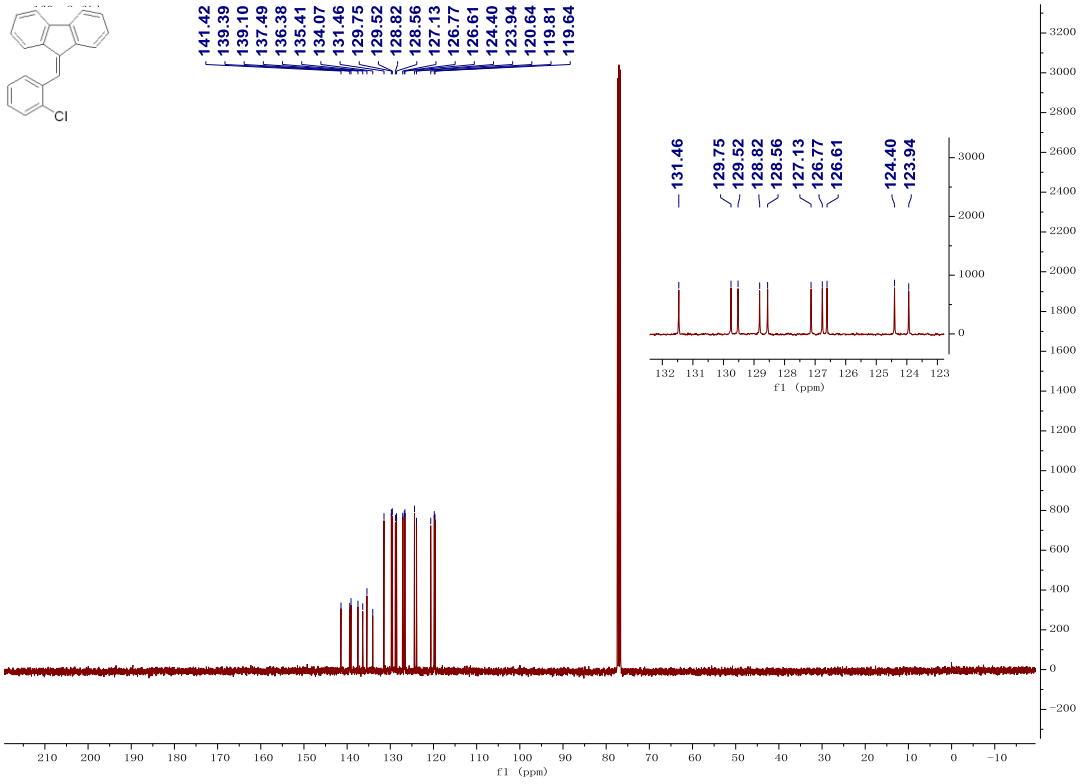


^{1}H NMR, ^{13}C NMR spectrum of **3i**

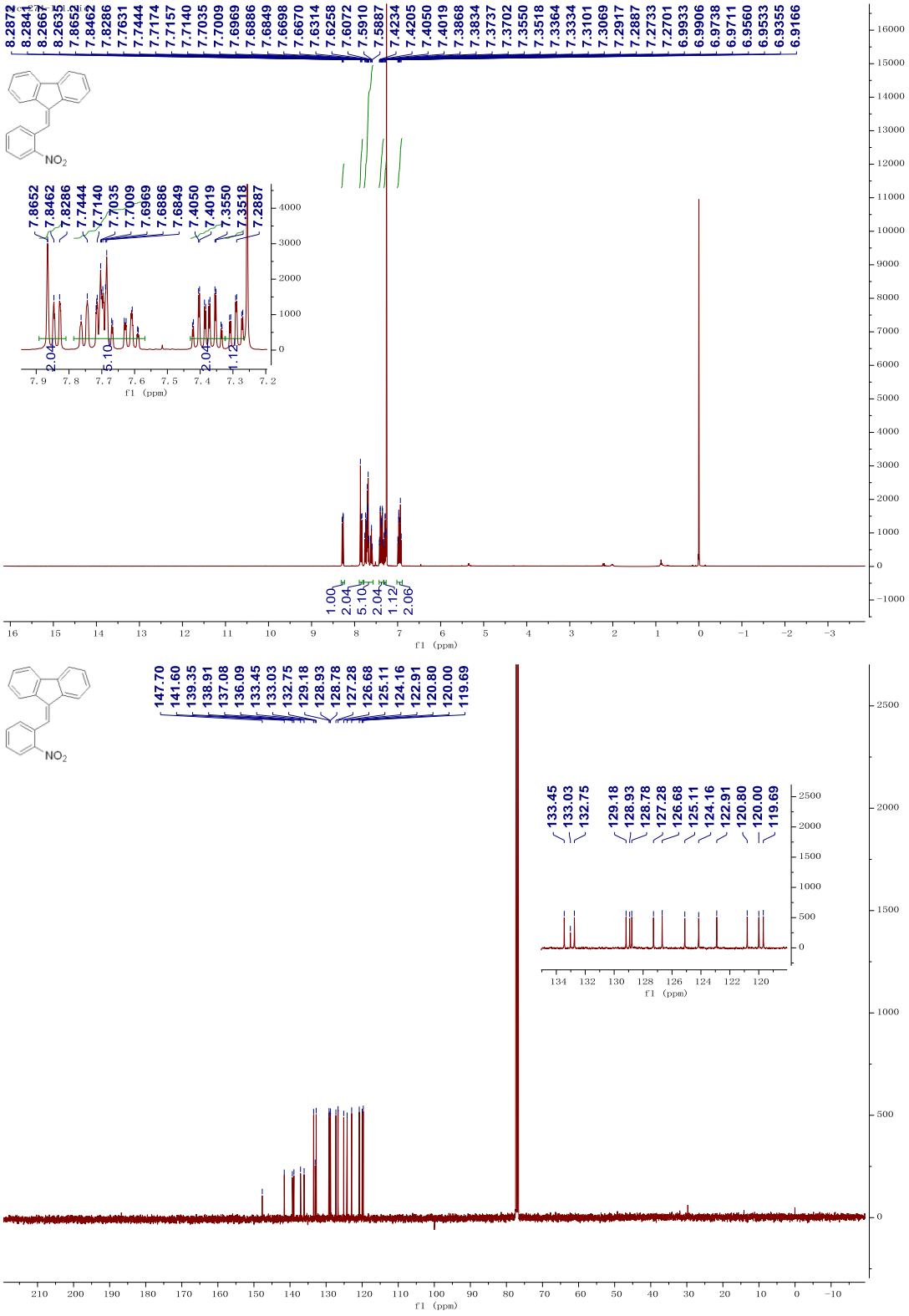


^{1}H NMR, ^{13}C NMR spectrum of **3j**

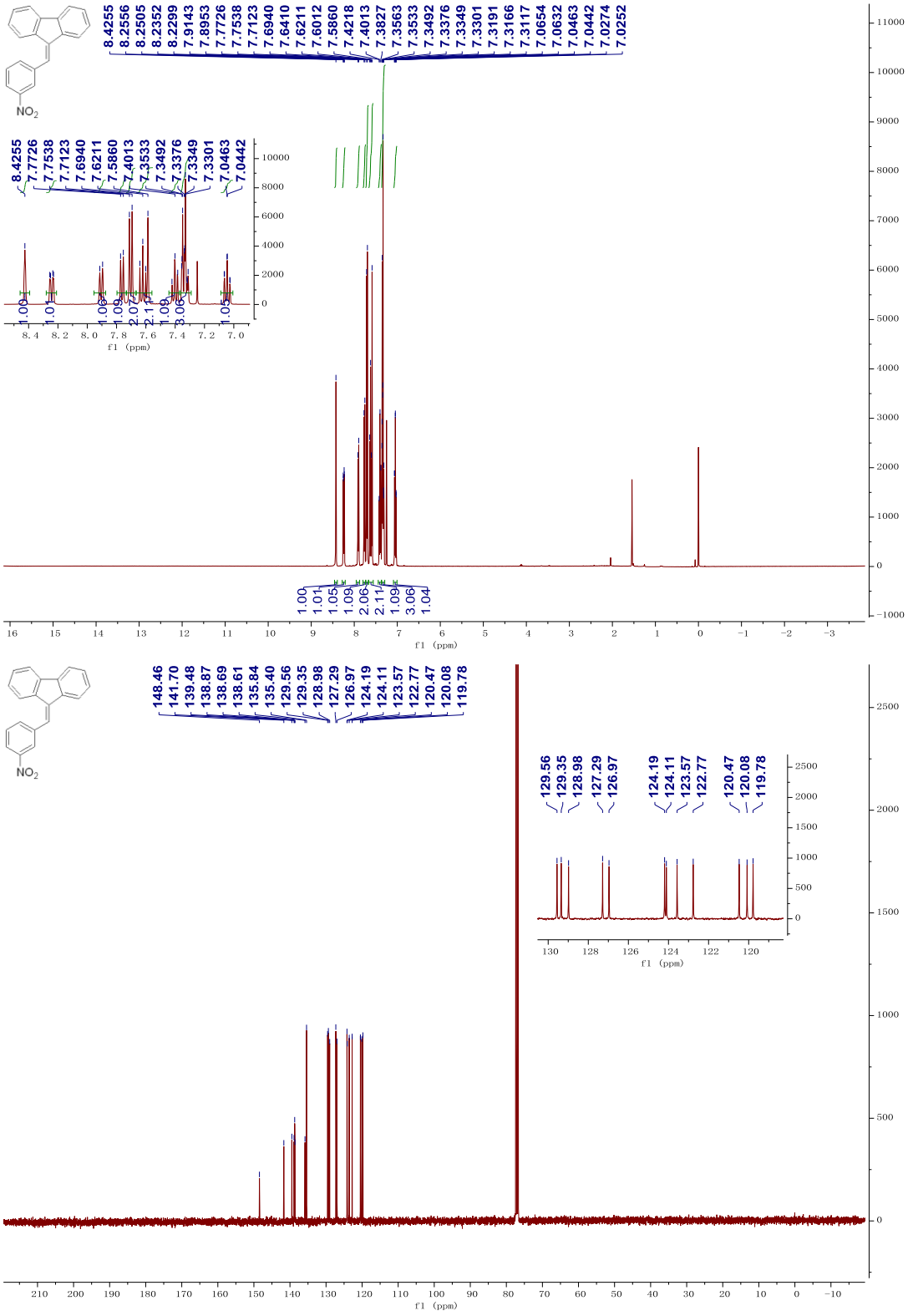




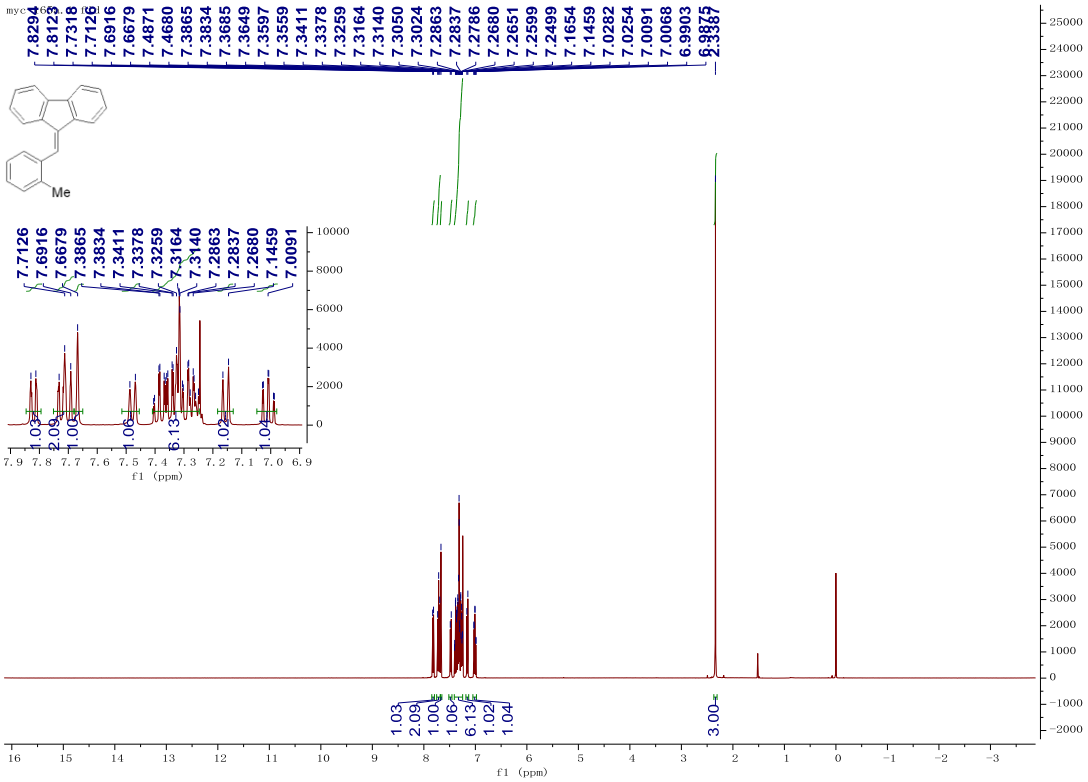
^{1}H NMR, ^{13}C NMR spectrum of **3k**

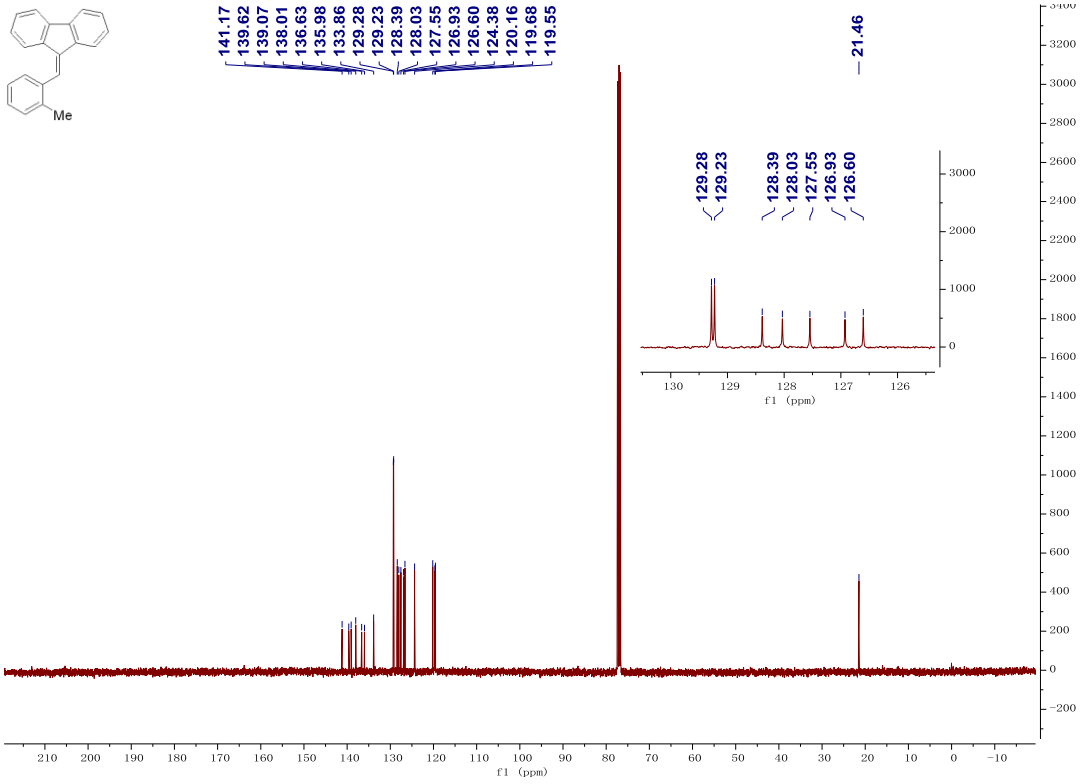


^{1}H NMR, ^{13}C NMR spectrum of **3l**

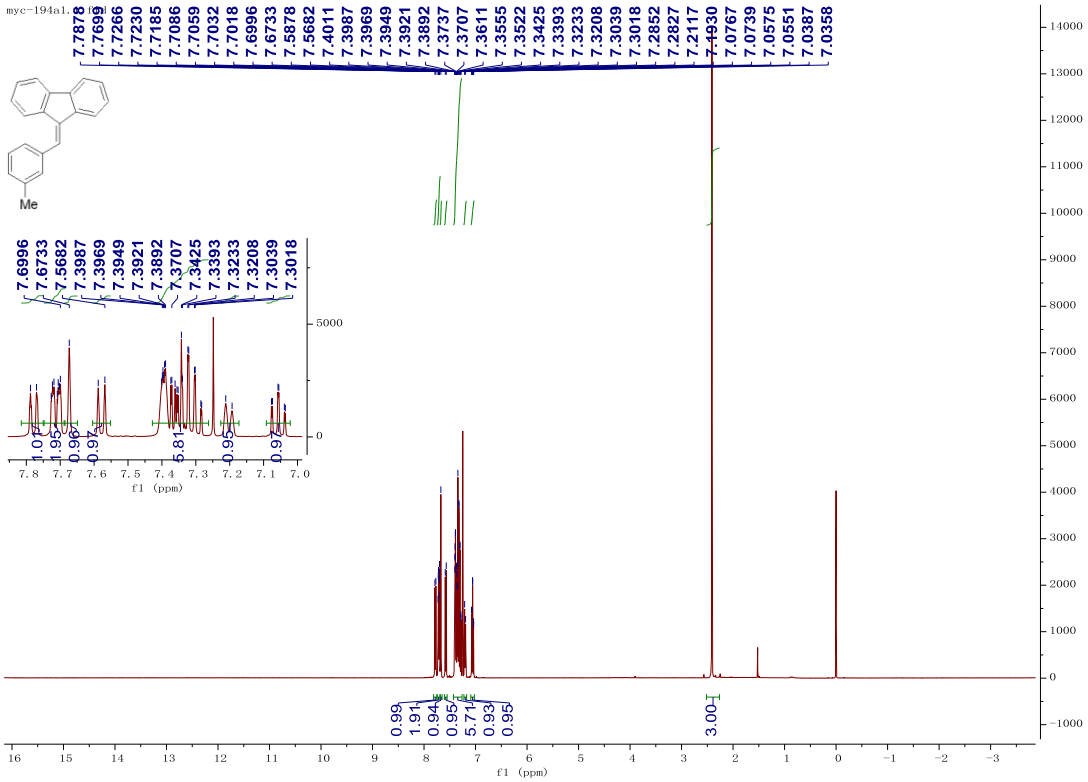


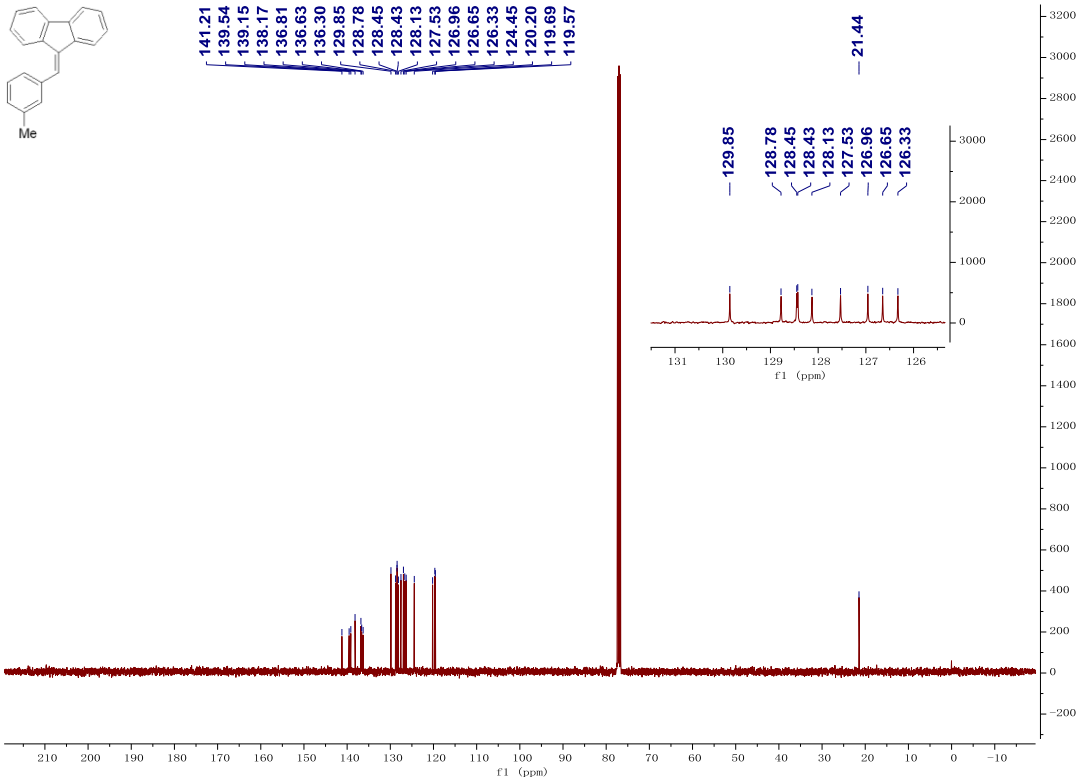
^{1}H NMR, ^{13}C NMR spectrum of **3m**



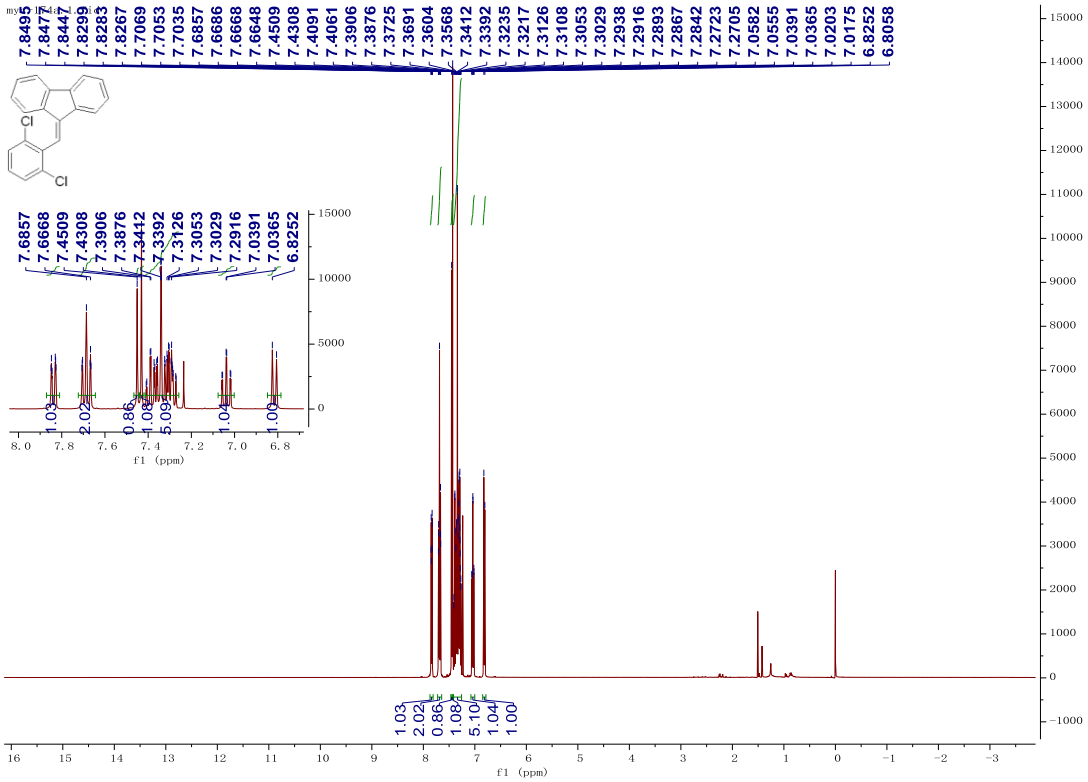


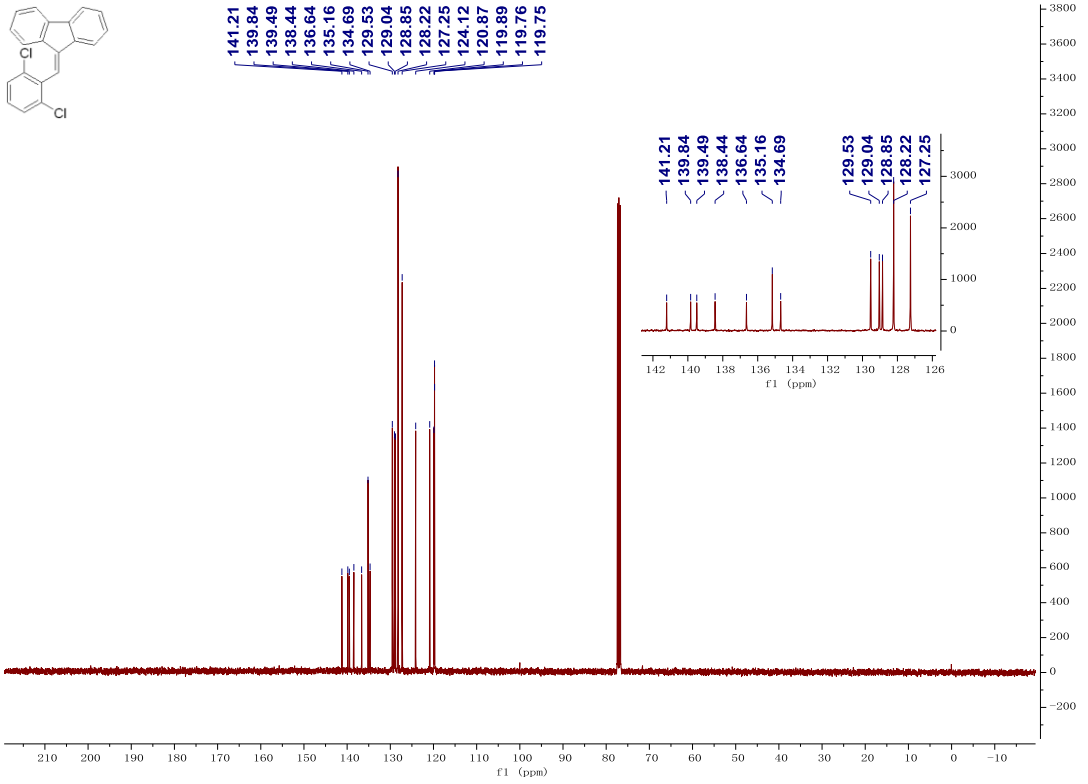
^{1}H NMR, ^{13}C NMR spectrum of **3n**



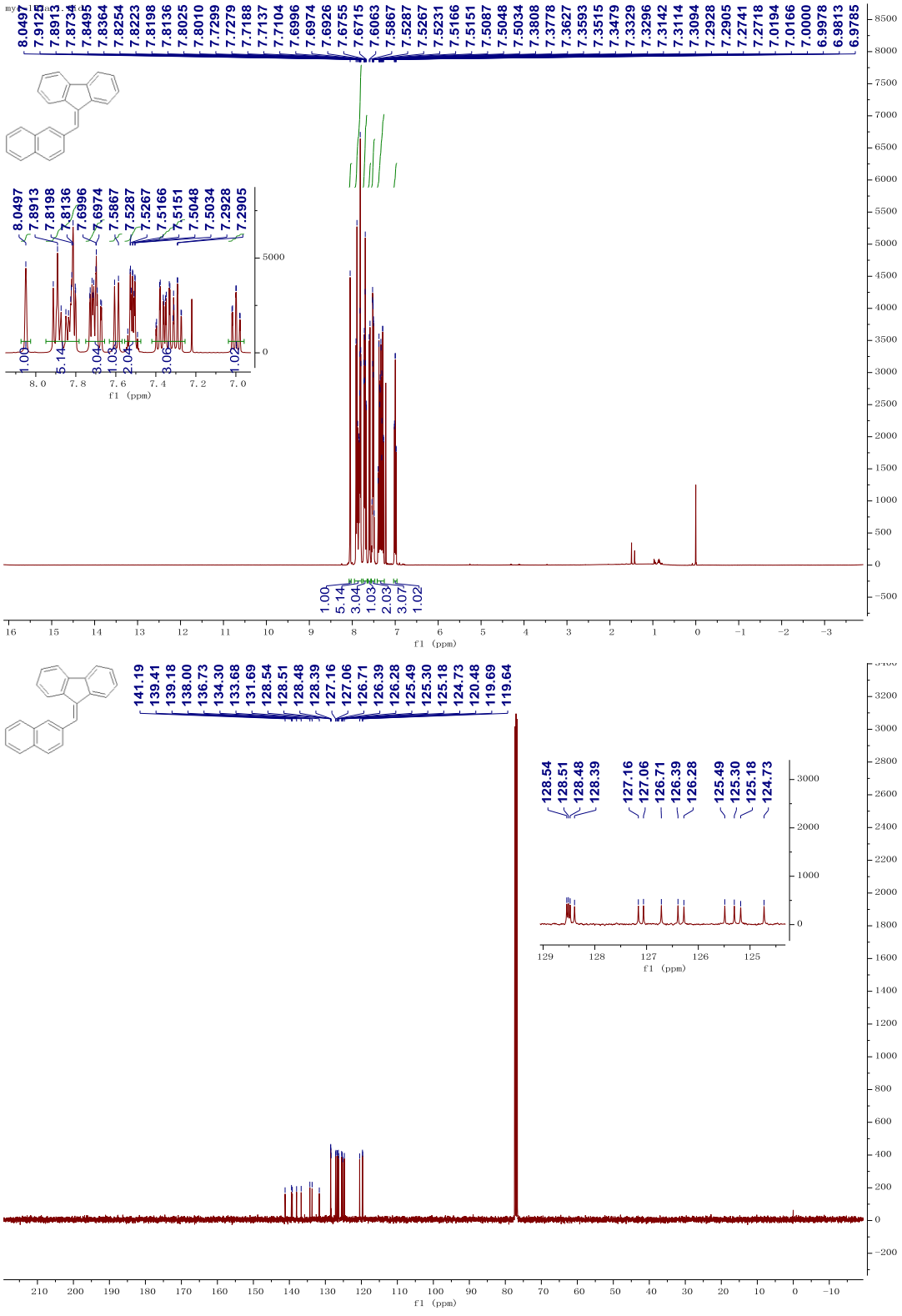


^{1}H NMR, ^{13}C NMR spectrum of **3o**

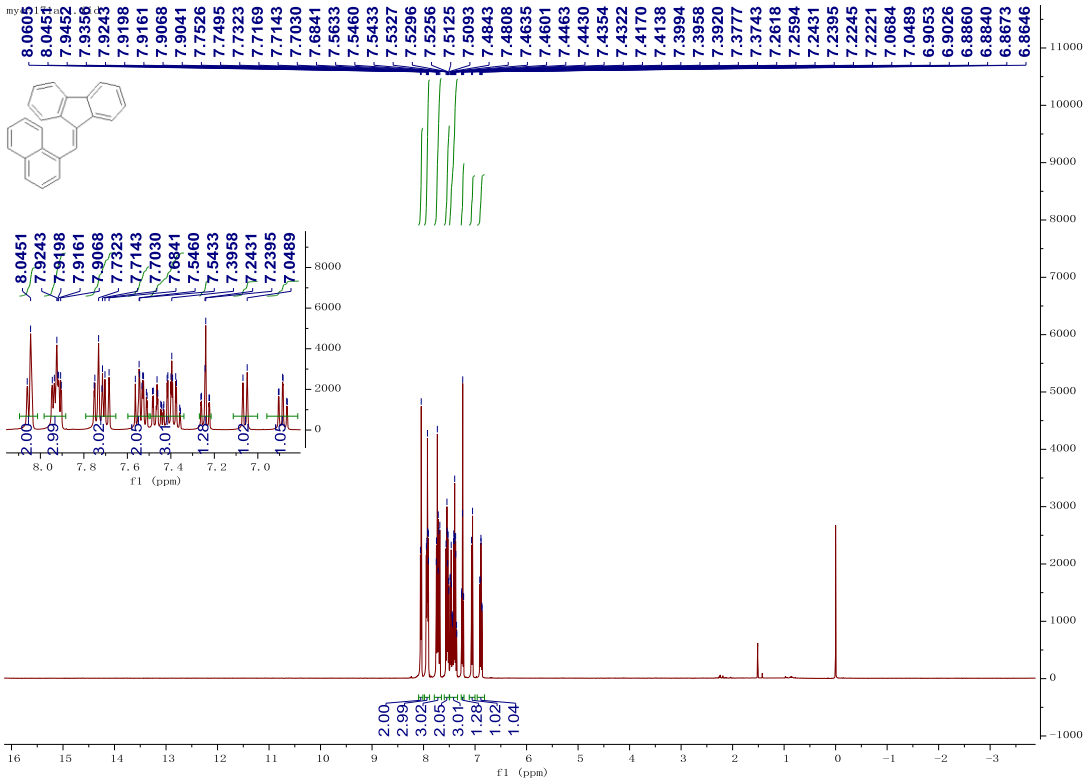


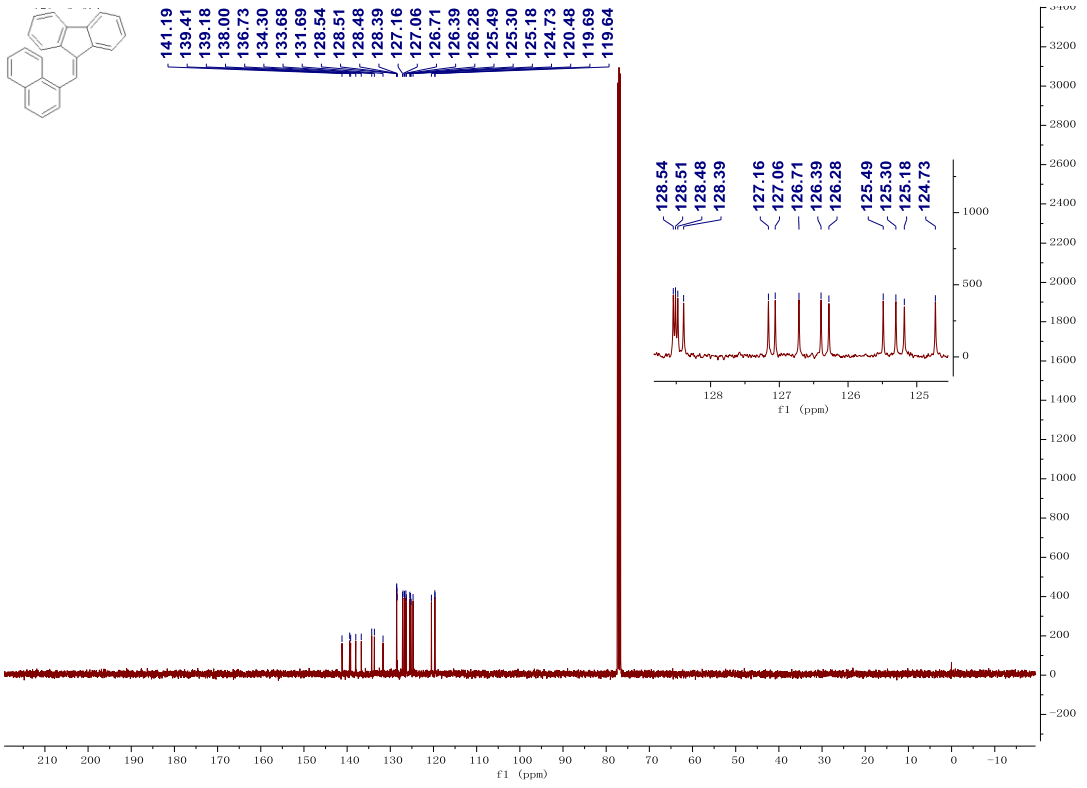


^{1}H NMR, ^{13}C NMR spectrum of **3p**

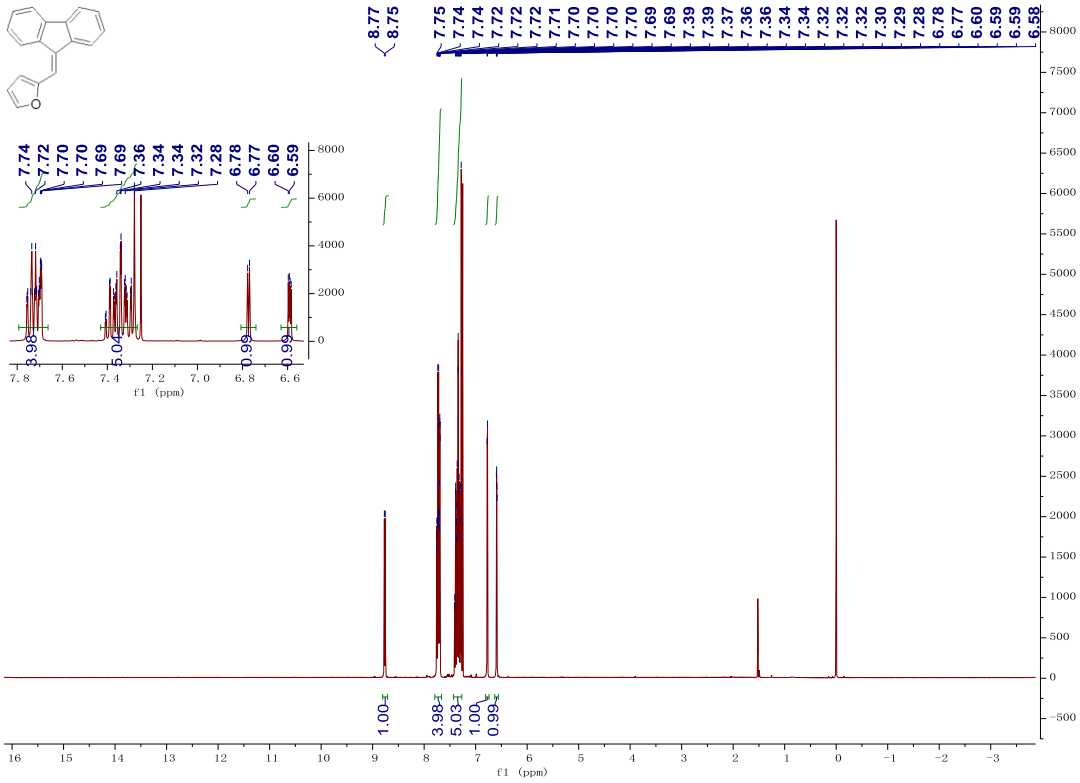


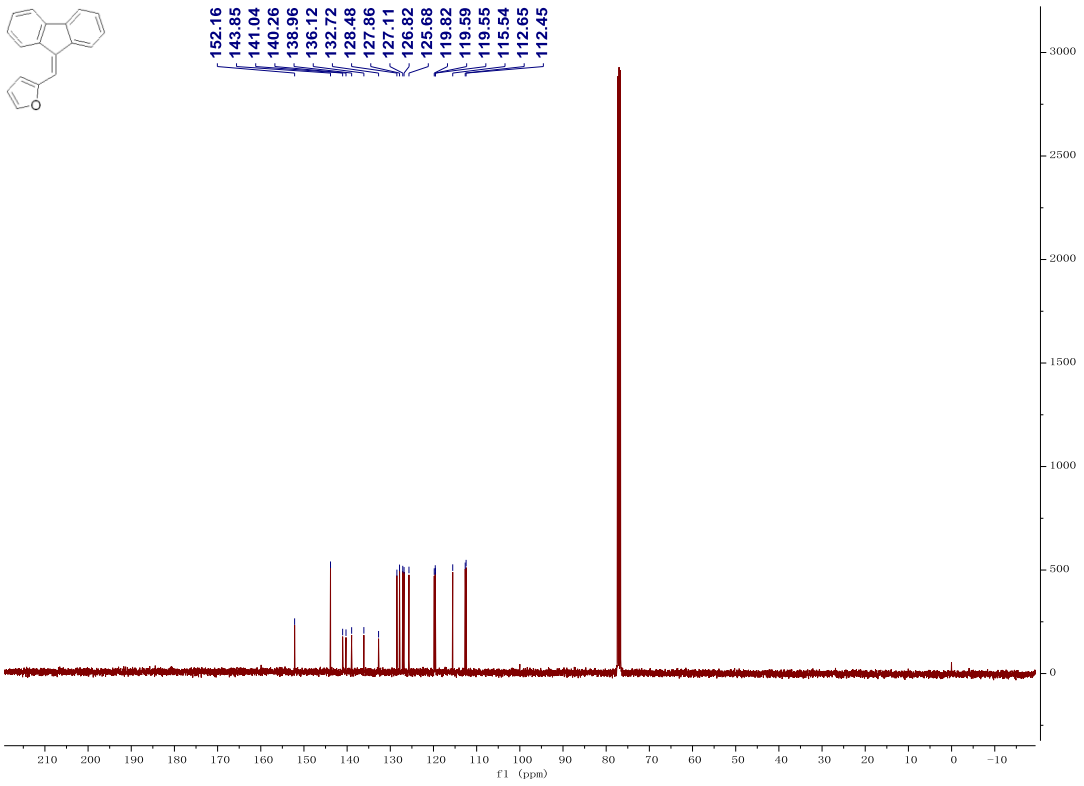
^{1}H NMR, ^{13}C NMR spectrum of **3q**



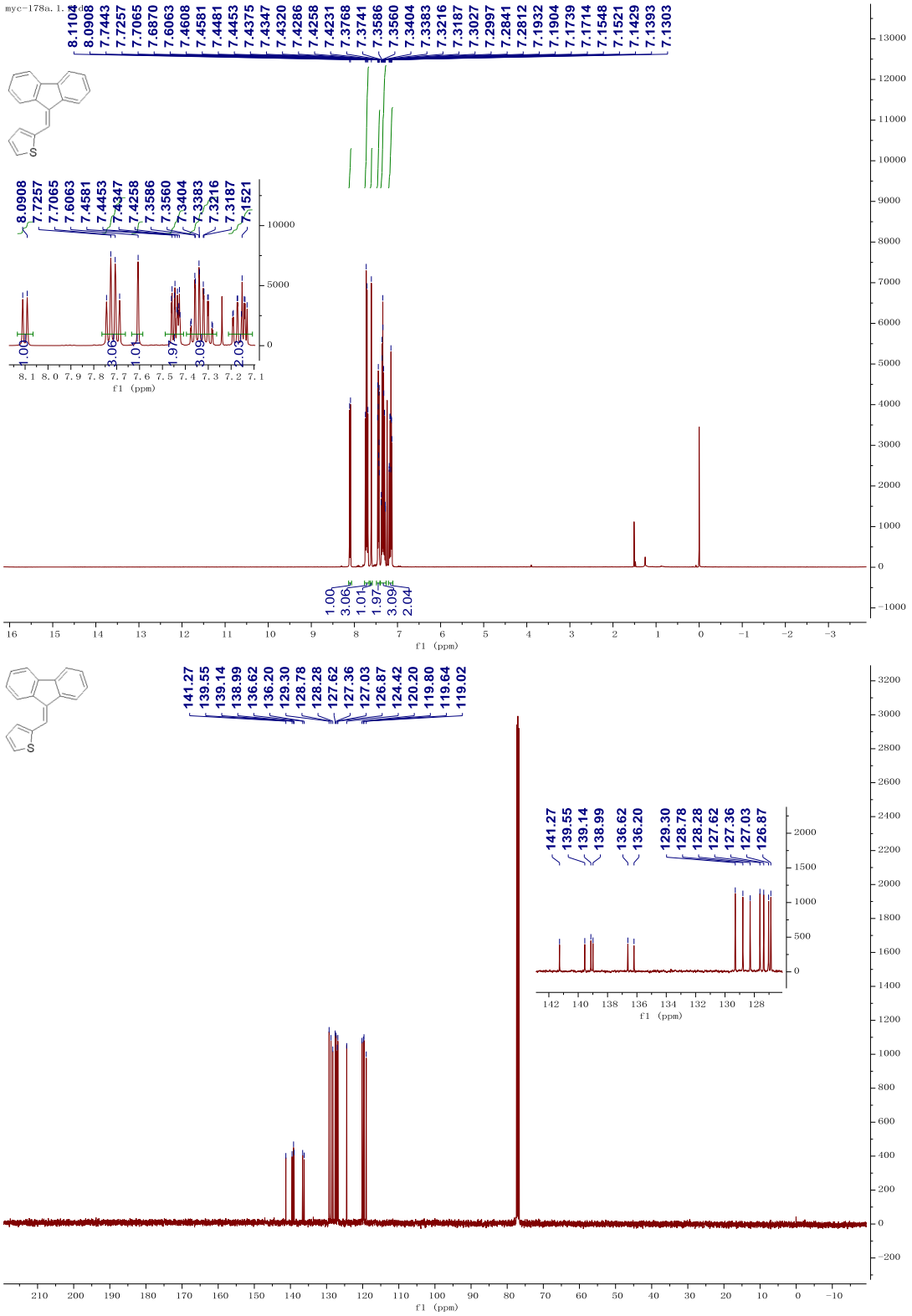


^{1}H NMR, ^{13}C NMR spectrum of **3r**

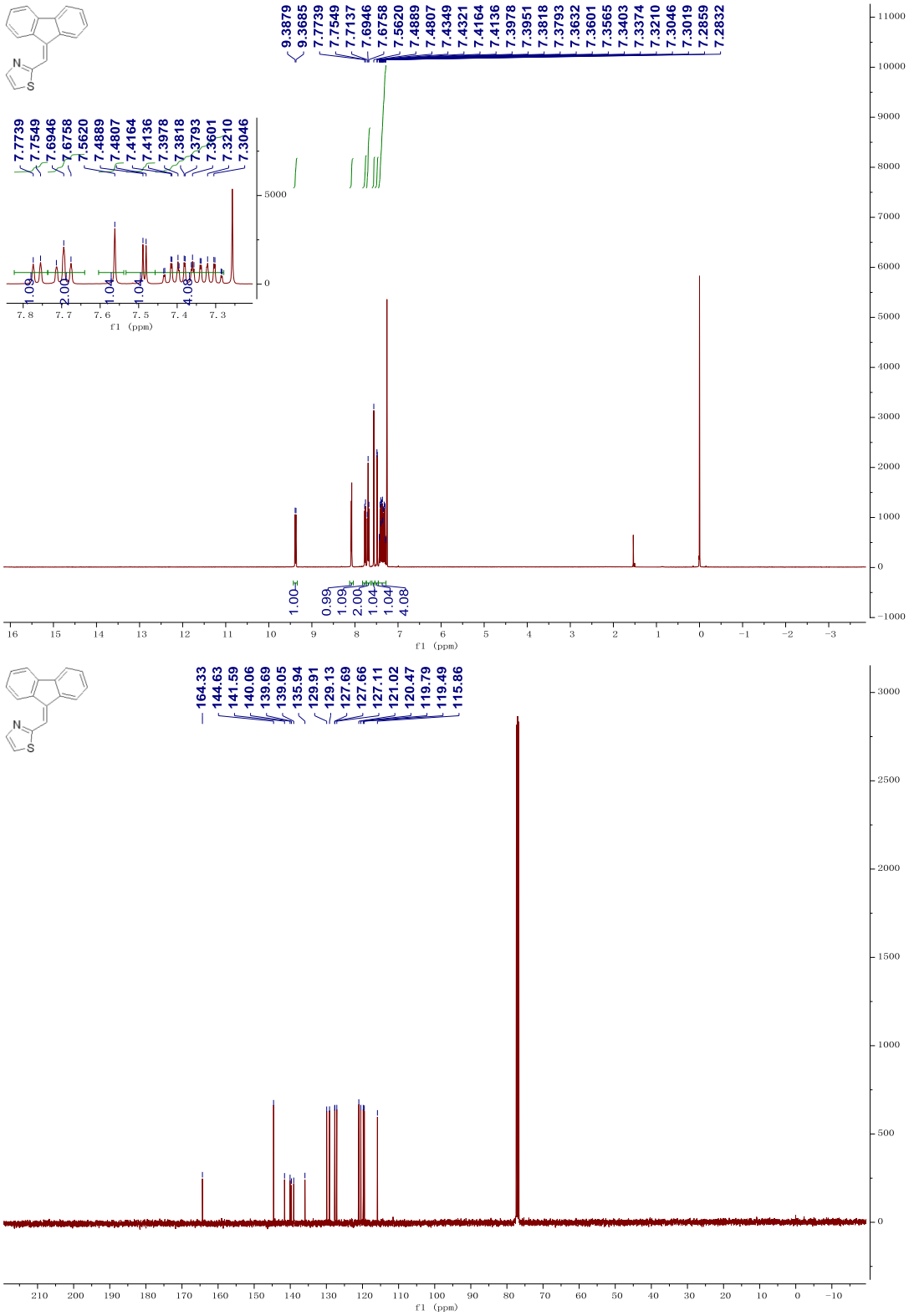



152.16
143.85
141.04
140.26
138.96
136.12
132.72
128.48
127.86
127.11
126.82
125.68
119.82
119.59
119.55
115.54
112.65
112.45
O
3000
2500
2000
1500
1000
500
0
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

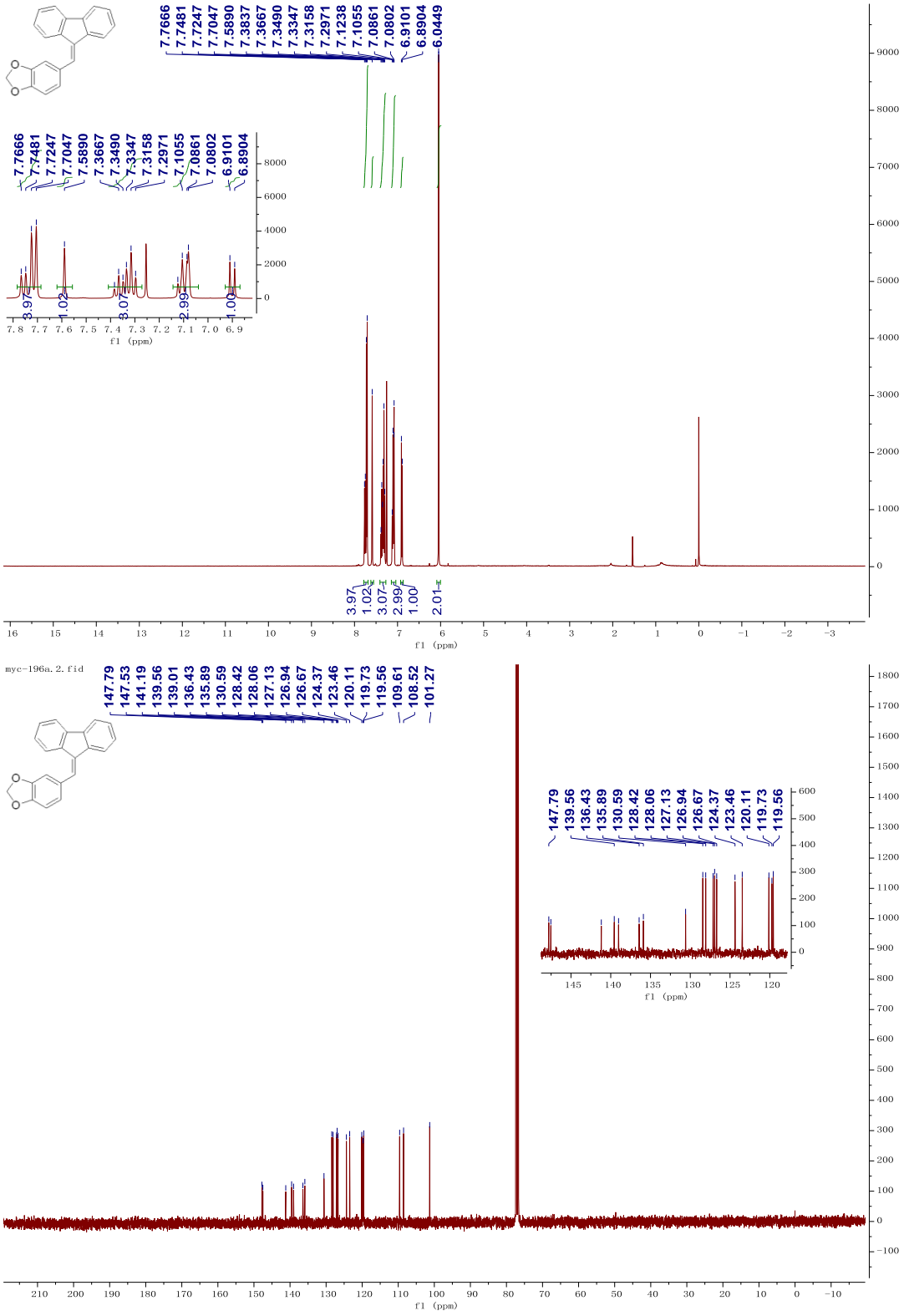
^{1}H NMR, ^{13}C NMR spectrum of **3s**



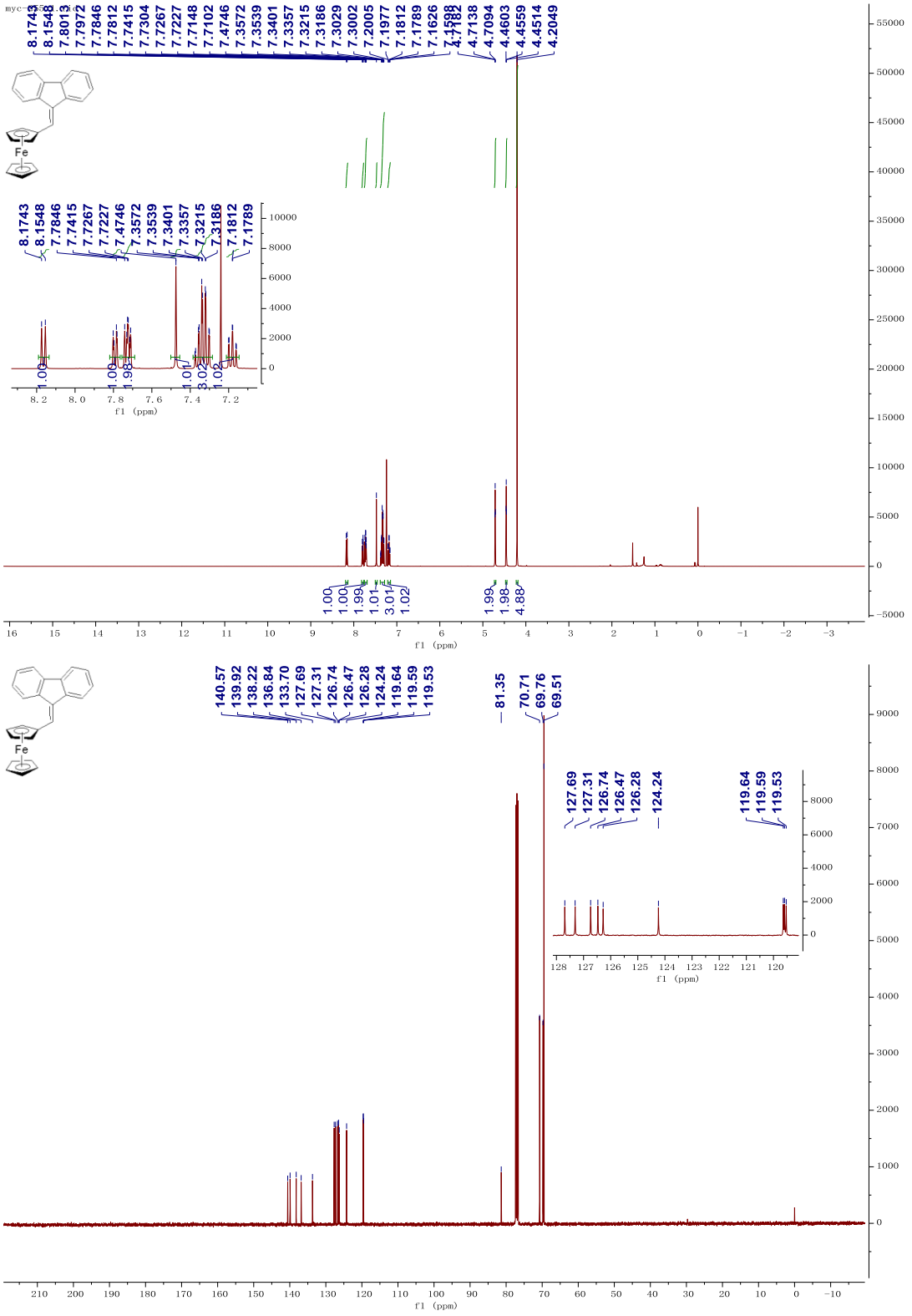
^{1}H NMR, ^{13}C NMR spectrum of **3t**



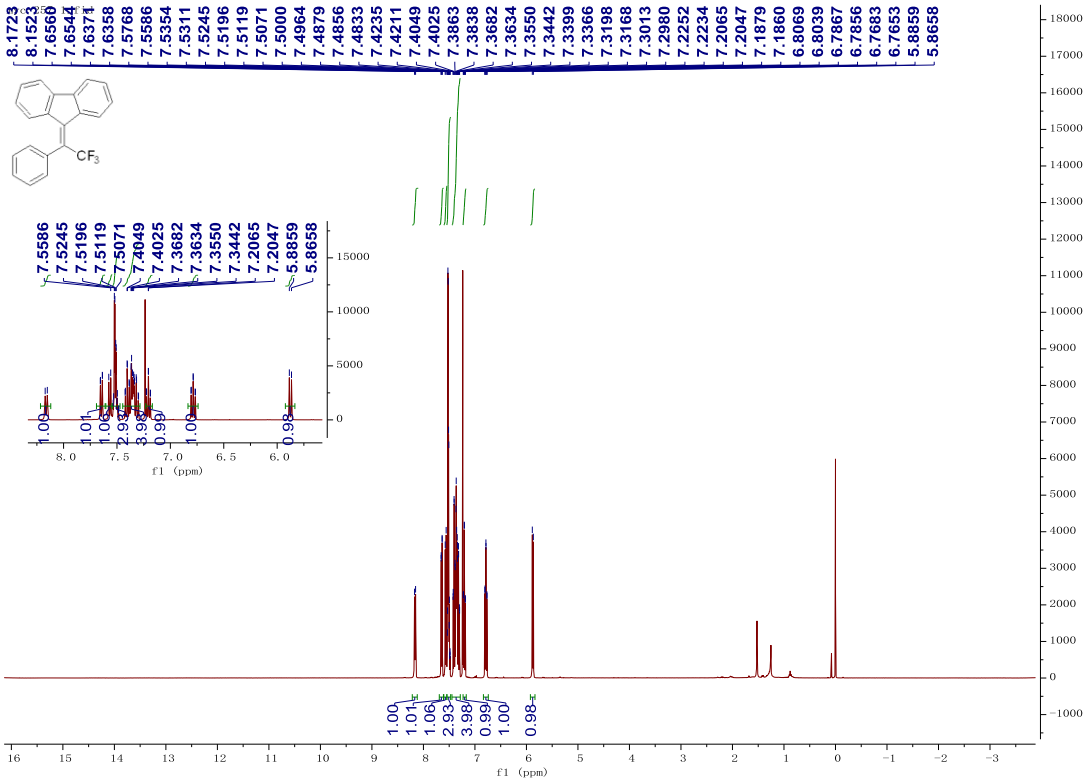
^{1}H NMR, ^{13}C NMR spectrum of **3u**

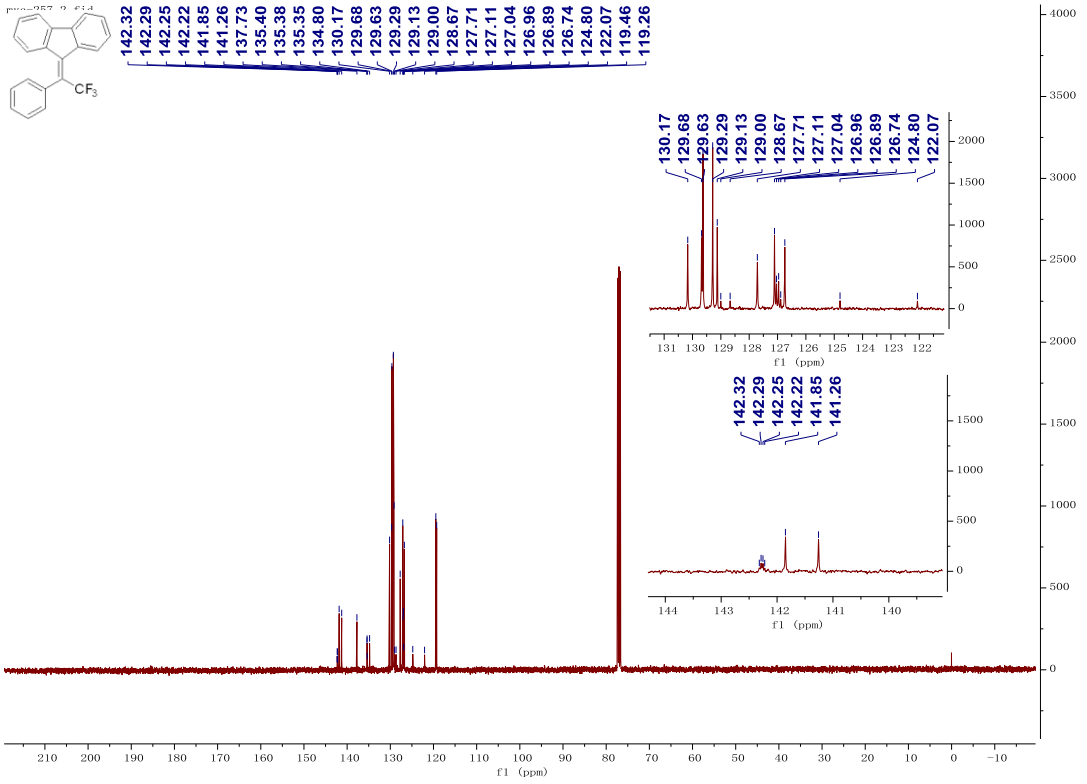


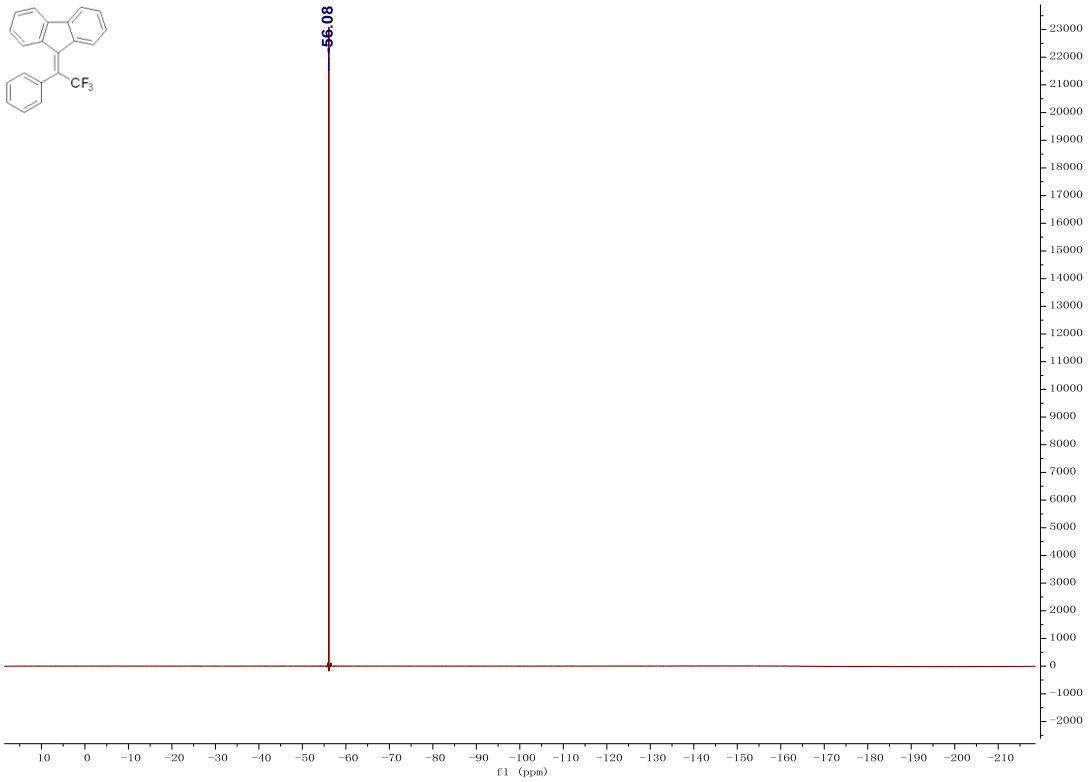
^{1}H NMR, ^{13}C NMR spectrum of **3v**



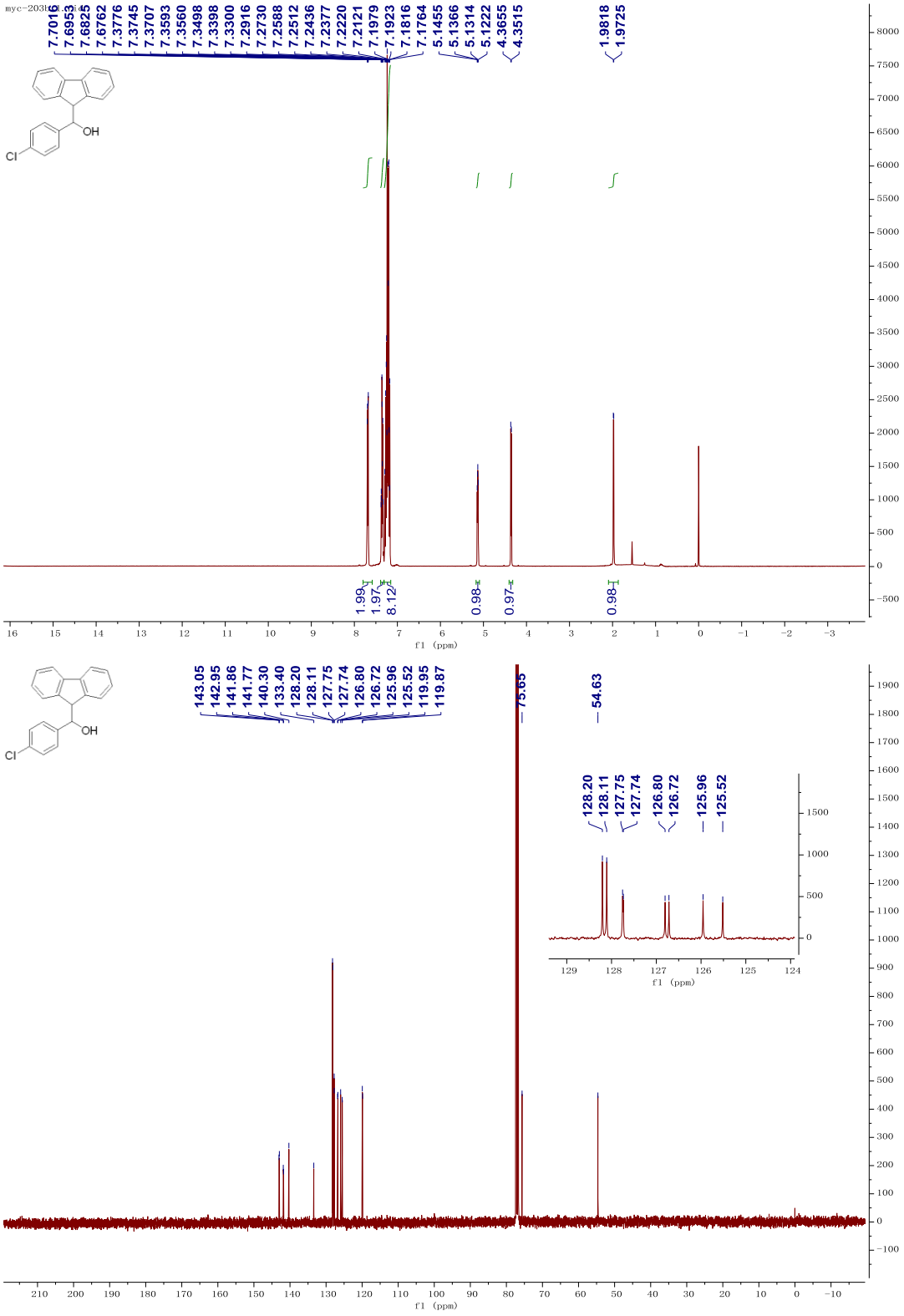
^{1}H NMR, ^{13}C NMR,^{19}F NMR spectrum of **3x**



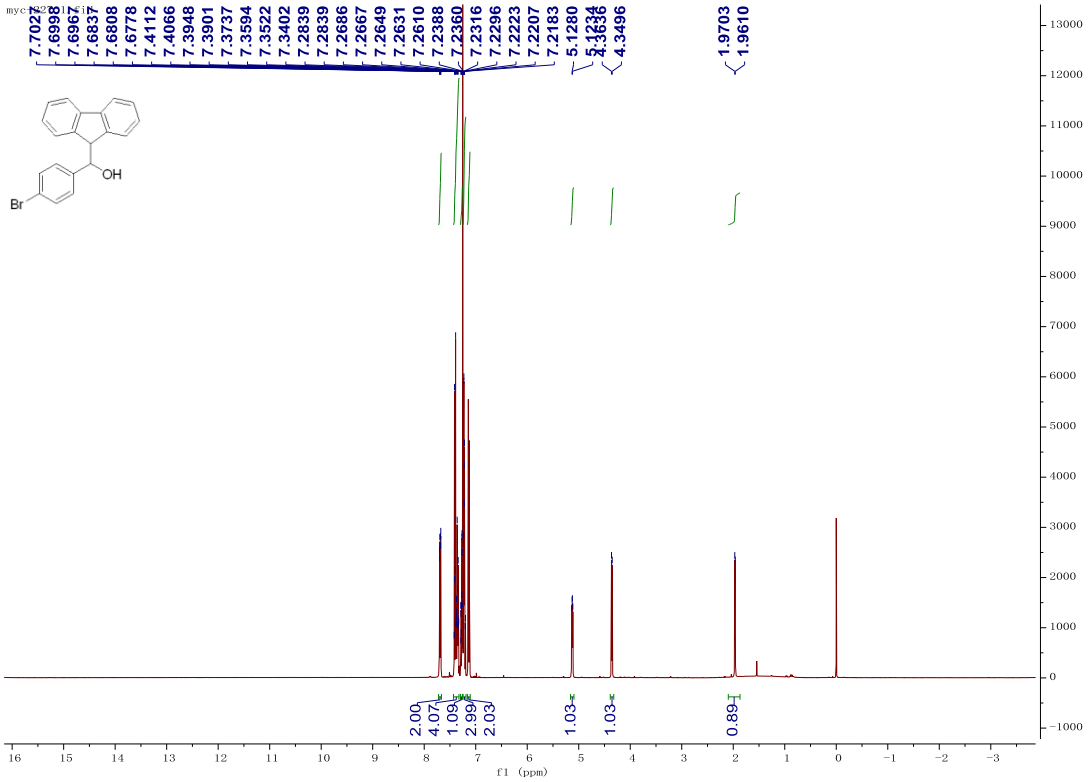


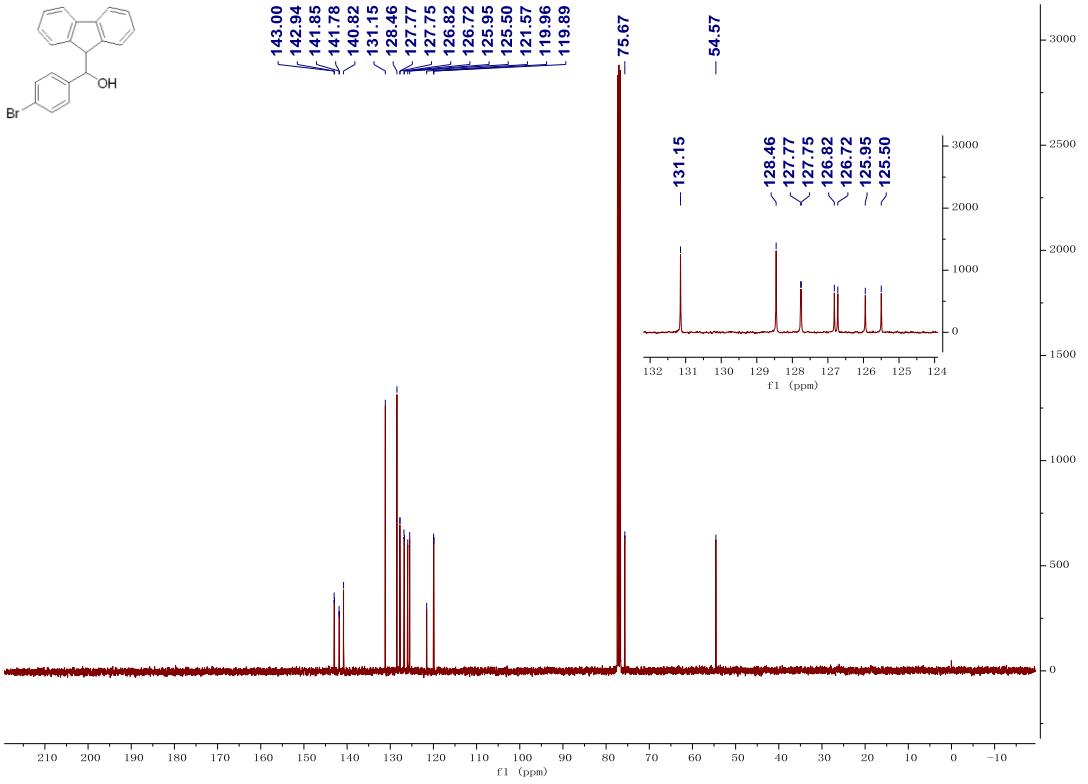

56.08
CF3
23000
22000
21000
20000
19000
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)

^{1}H NMR, ^{13}C NMR spectrum of **4a**

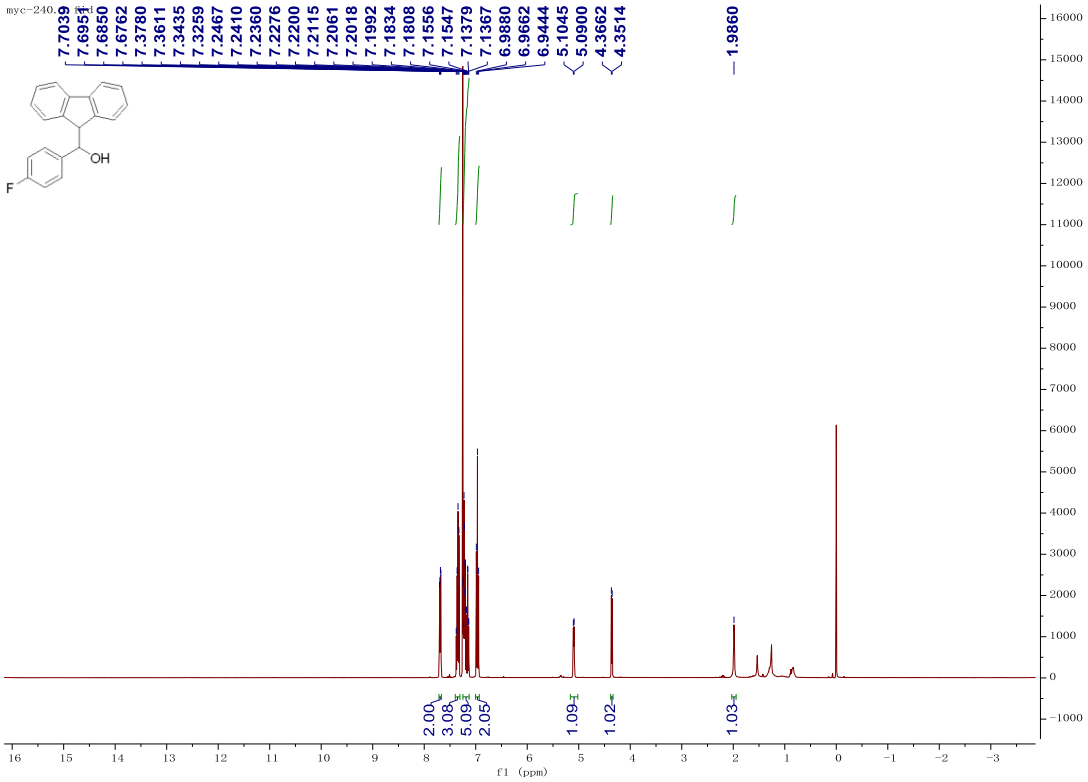


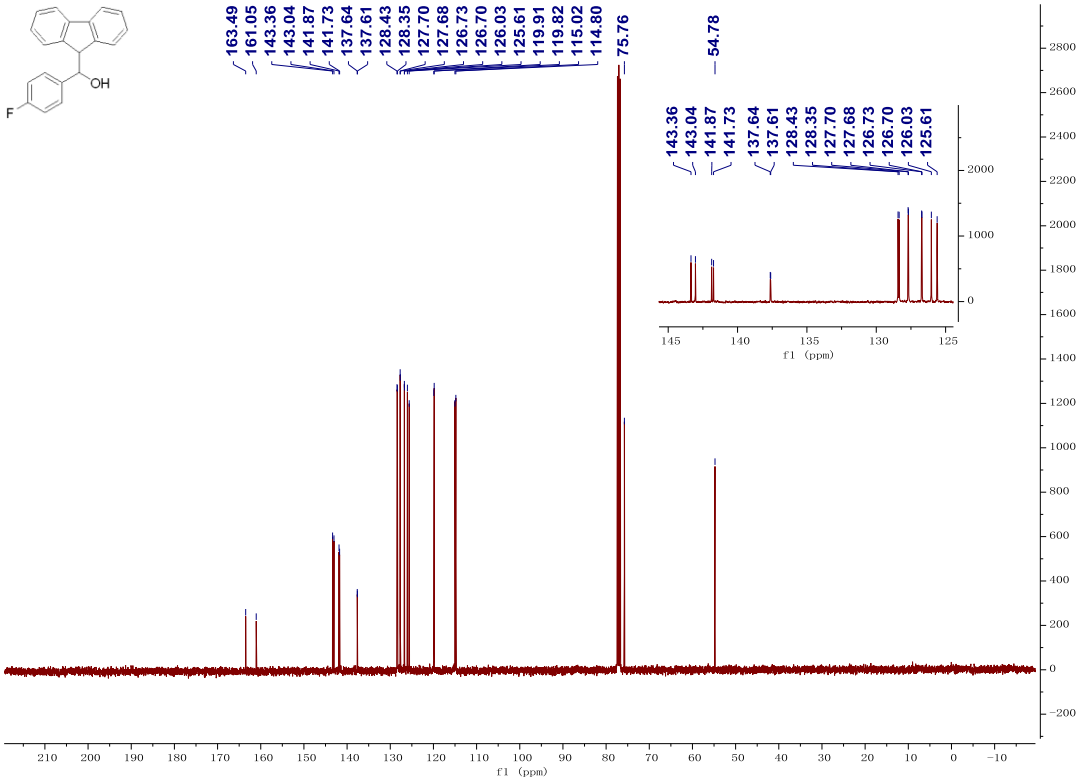
^{1}H NMR, ^{13}C NMR spectrum of **4b**

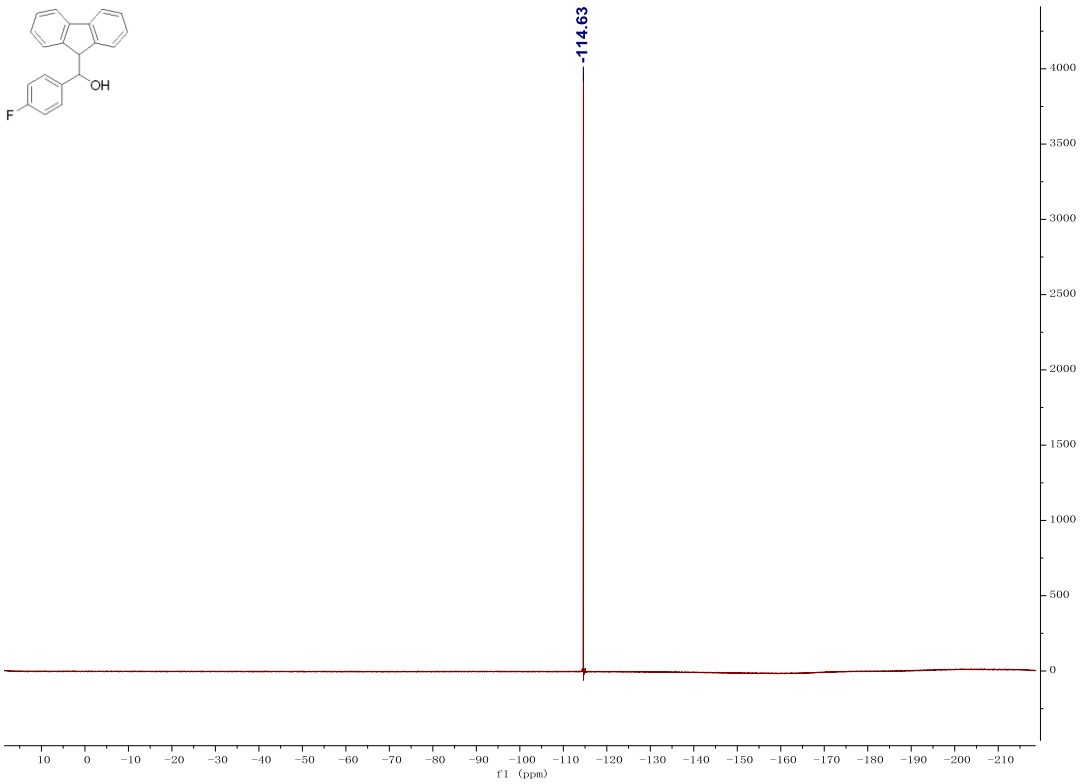




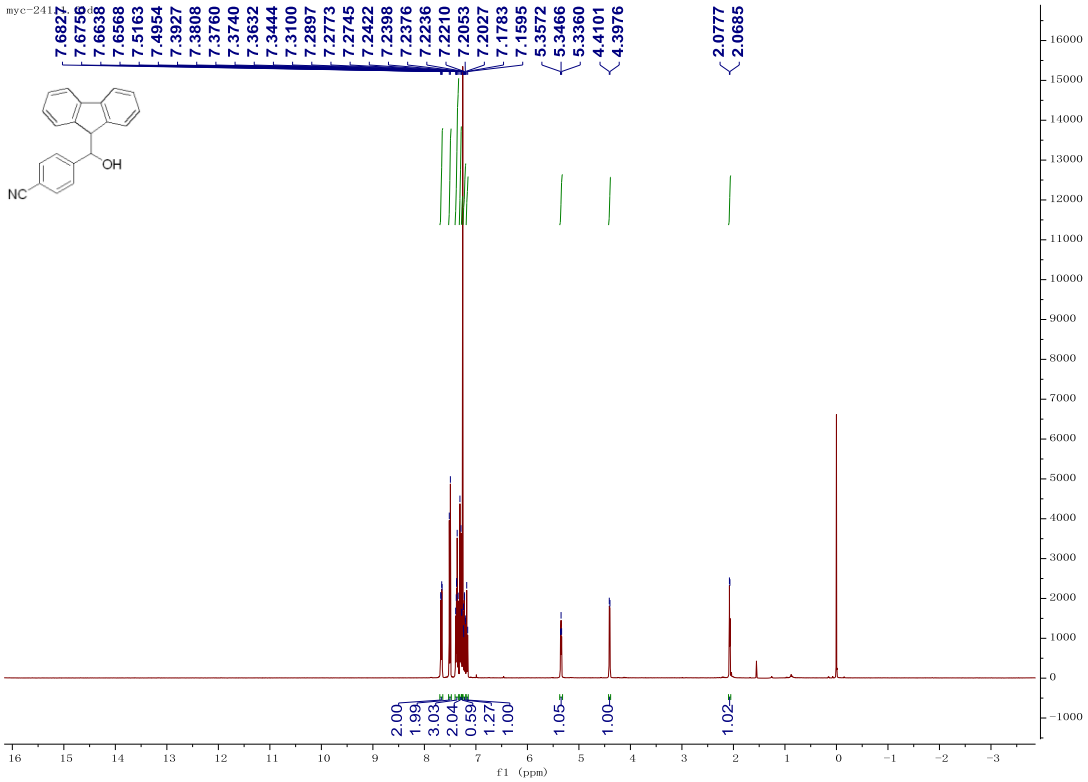
^{1}H NMR, ^{13}C NMR,^{19}F NMR spectrum of **4c**

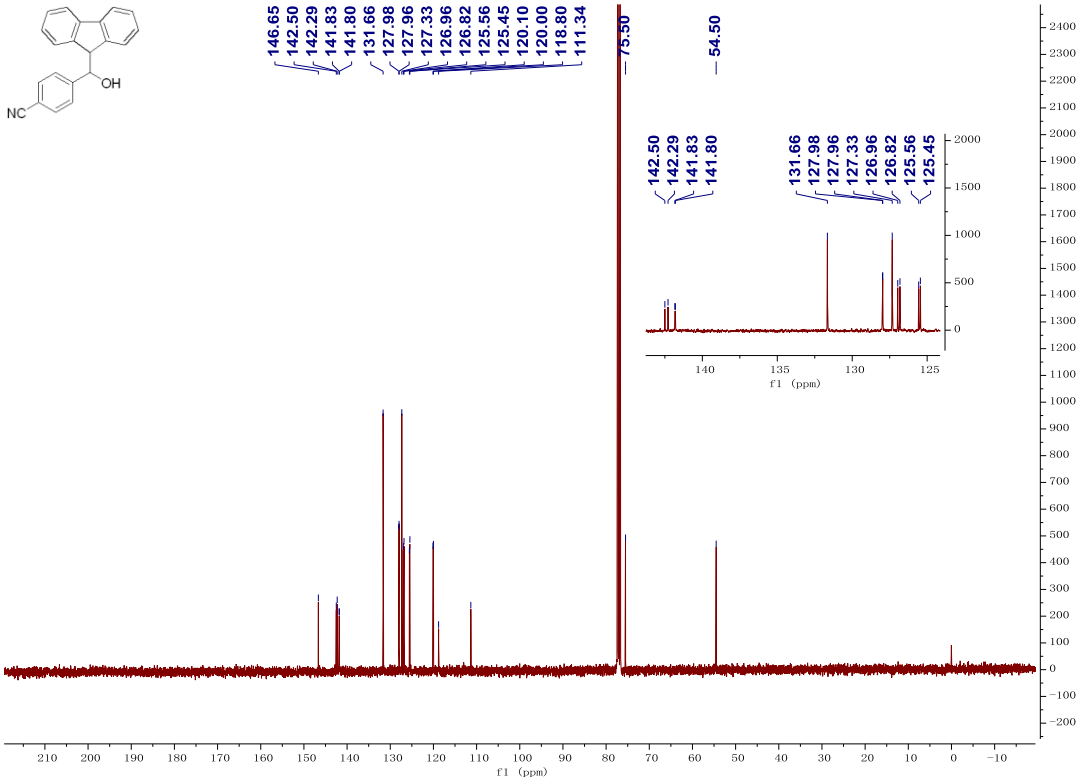




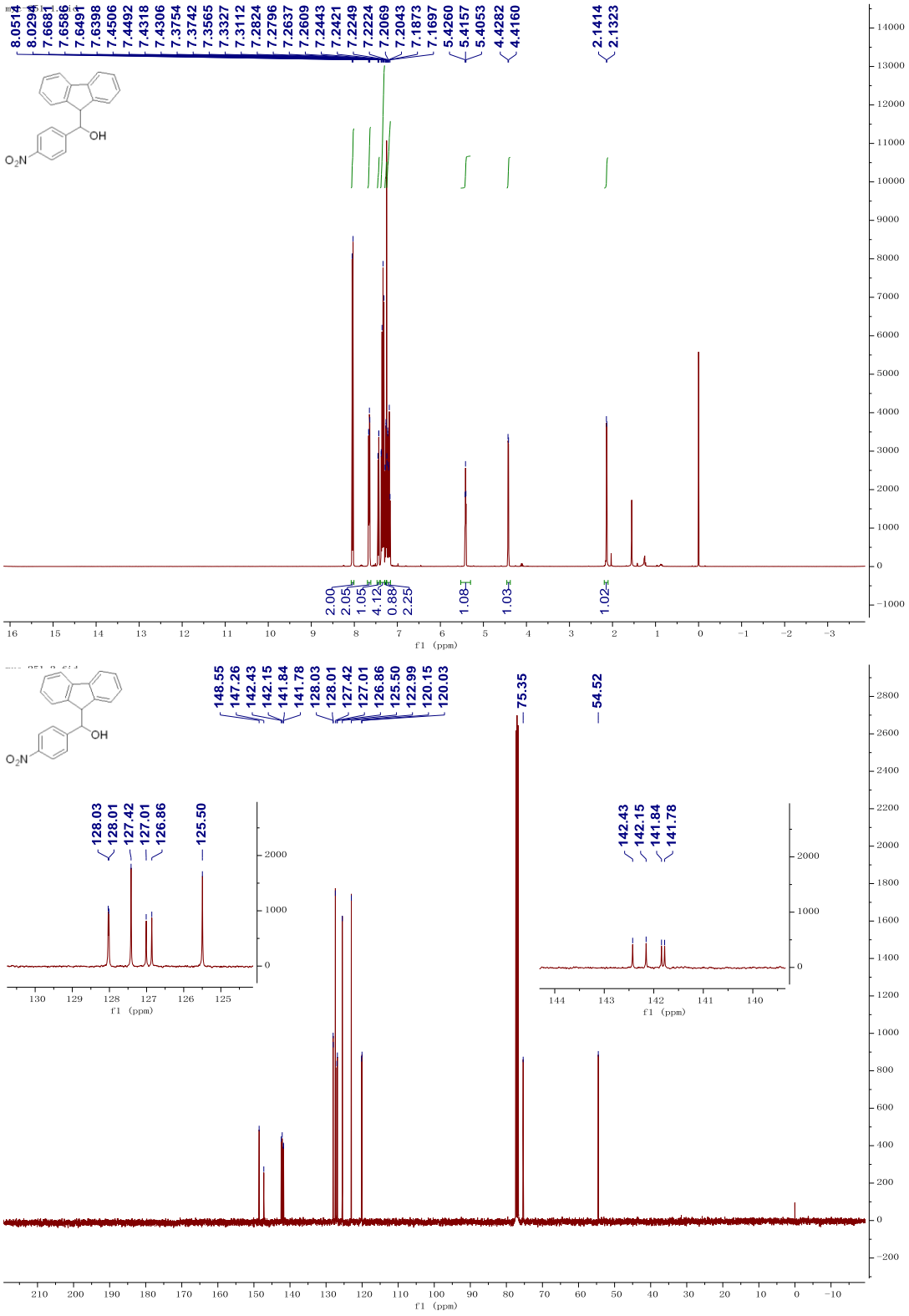

-114.63
OH
F
4000
3500
3000
2500
2000
1500
1000
500
0
10 0 −10 −20 −30 −40 −50 −60 −70 −80 −90 −100 −110 −120 −130 −140 −150 −160 −170 −180 −190 −200 −210
f1 (ppm)

^{1}H NMR, ^{13}C NMR spectrum of **4d**

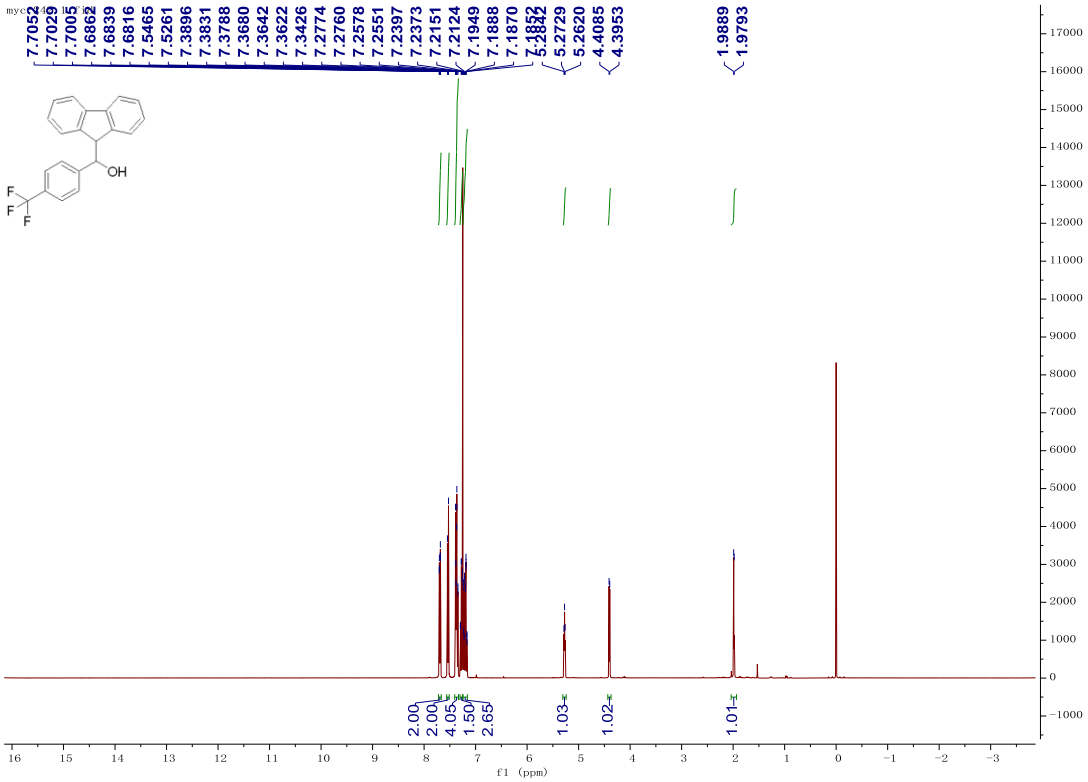


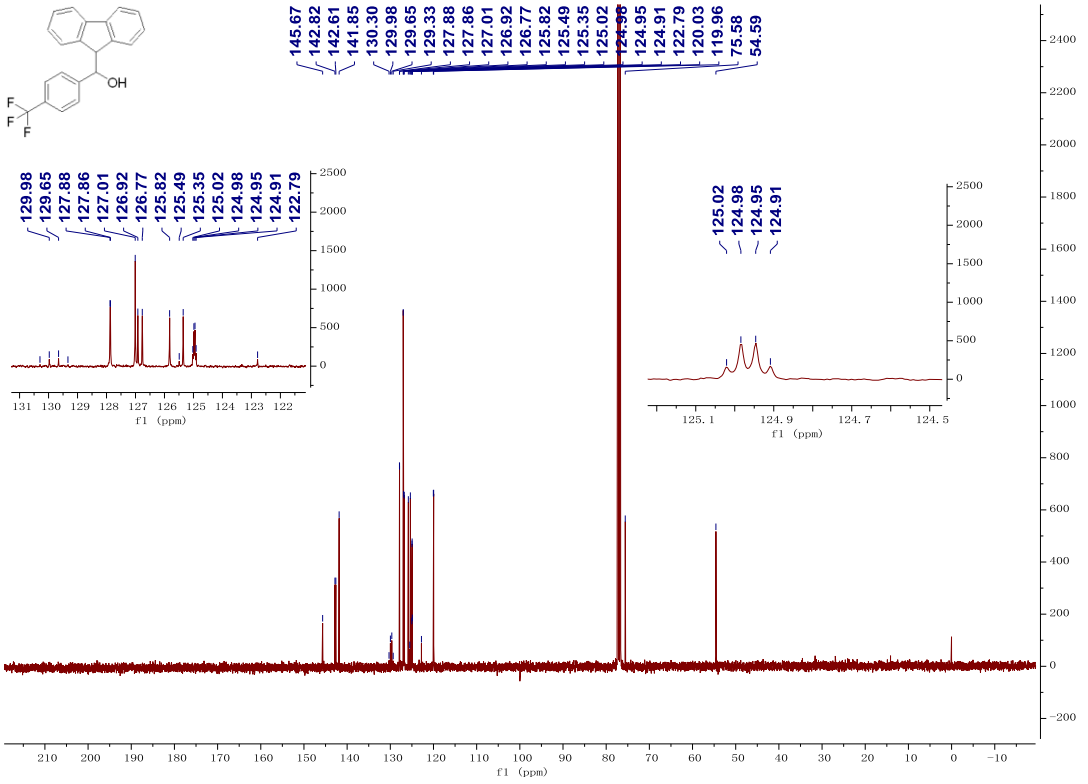


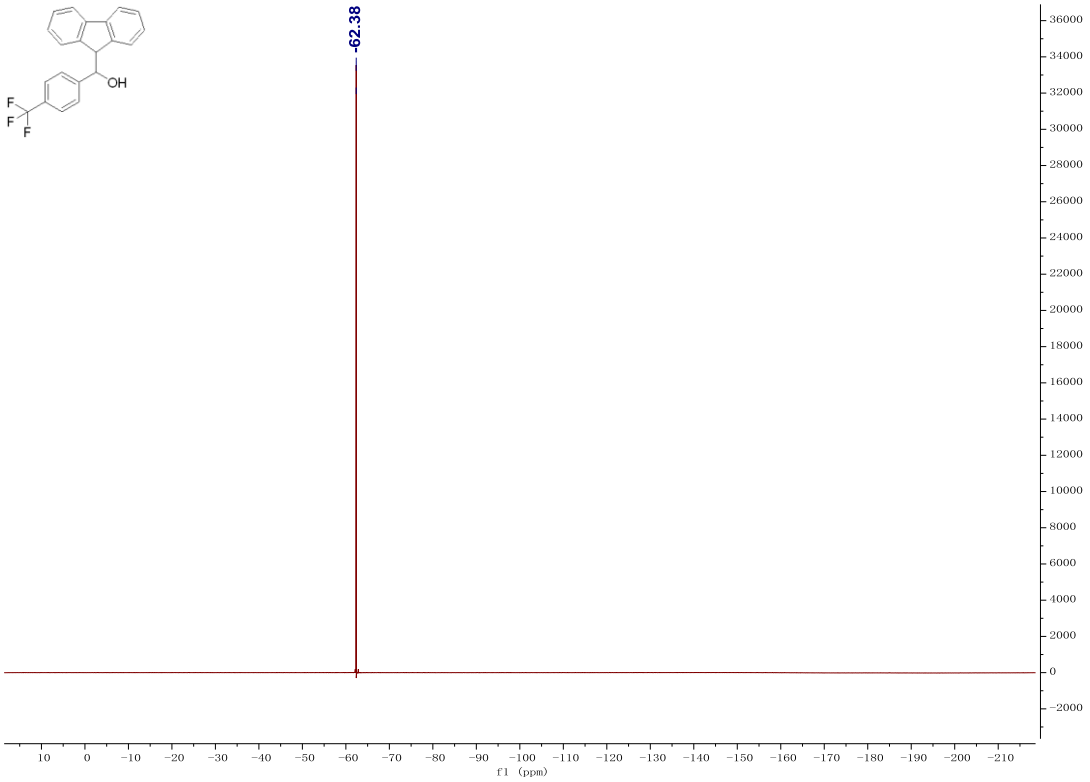
^{1}H NMR, ^{13}C NMR spectrum of **4e**



^{1}H NMR, ^{13}C NMR, ^{19}F NMR spectrum of **4f**






-62.38
OH
F
F
F
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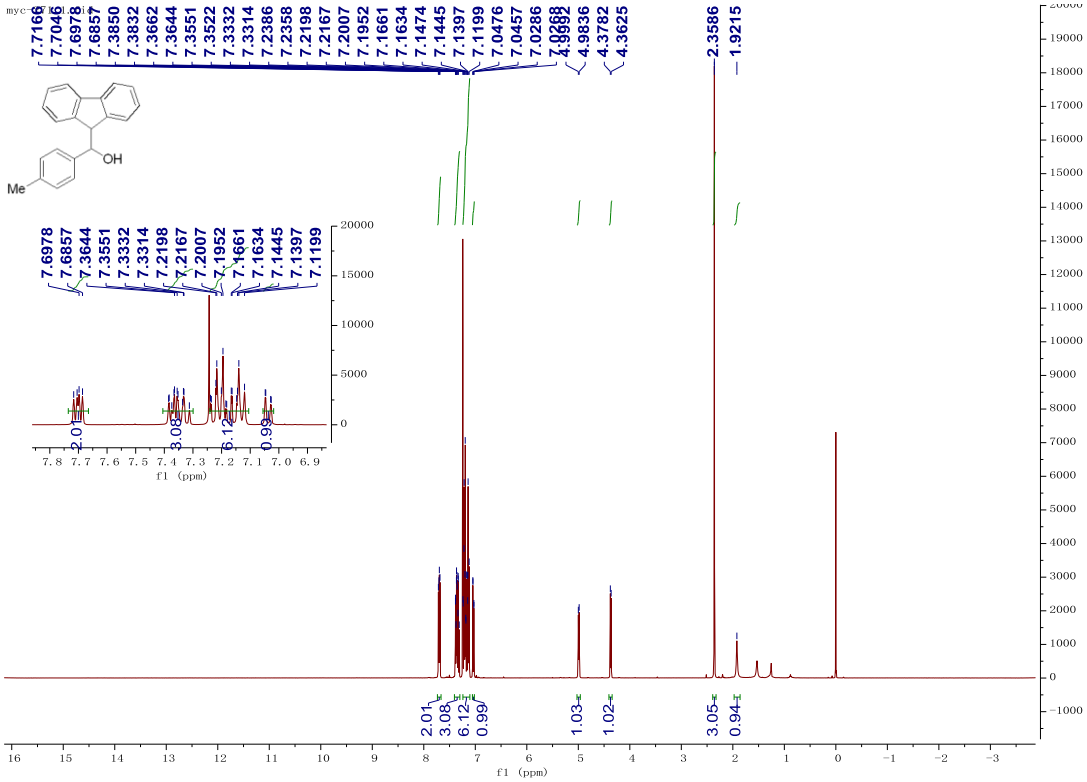
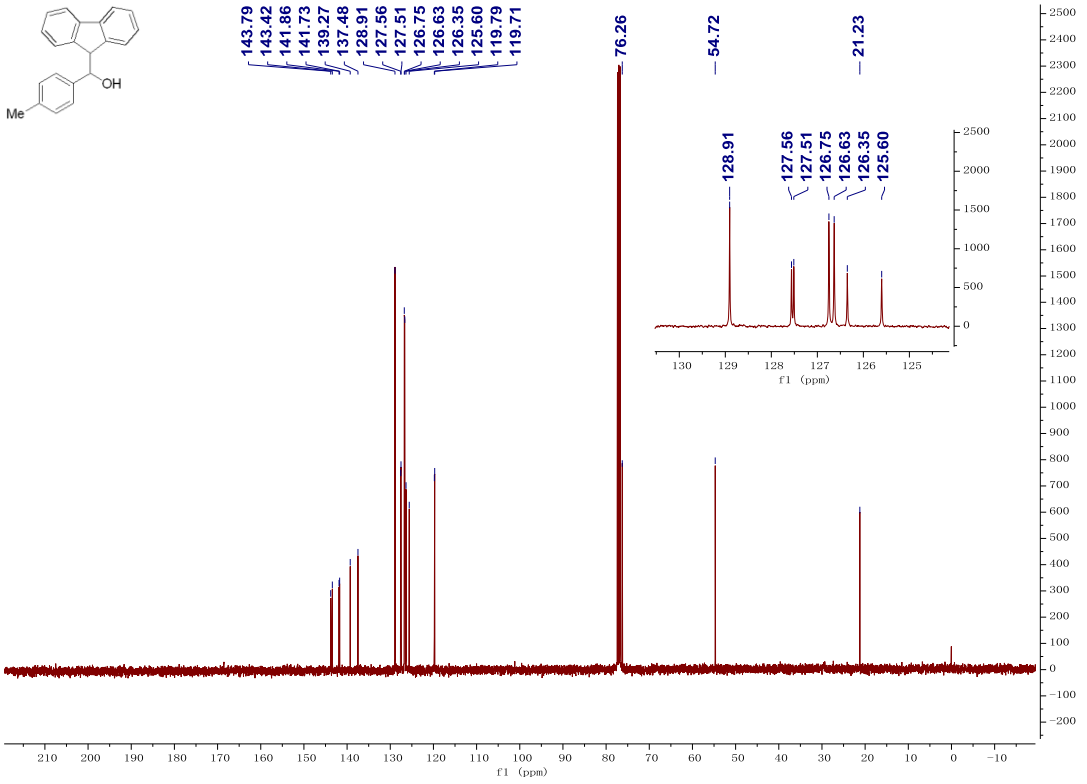
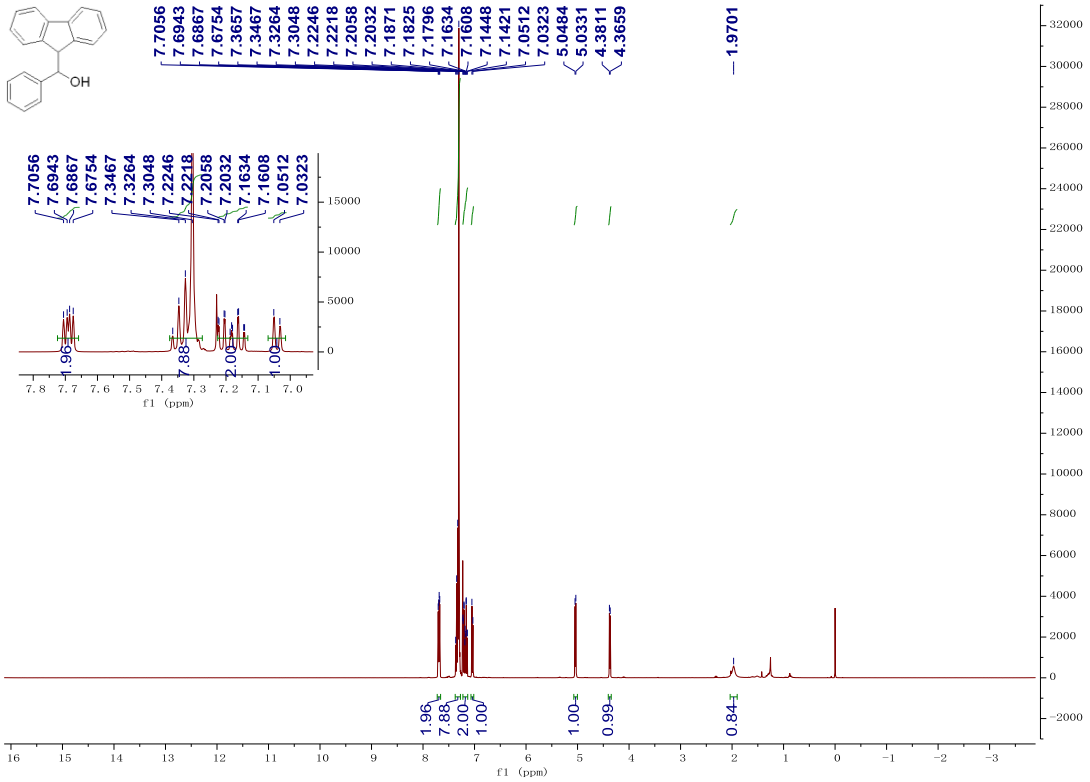
34000
32000
30000
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)

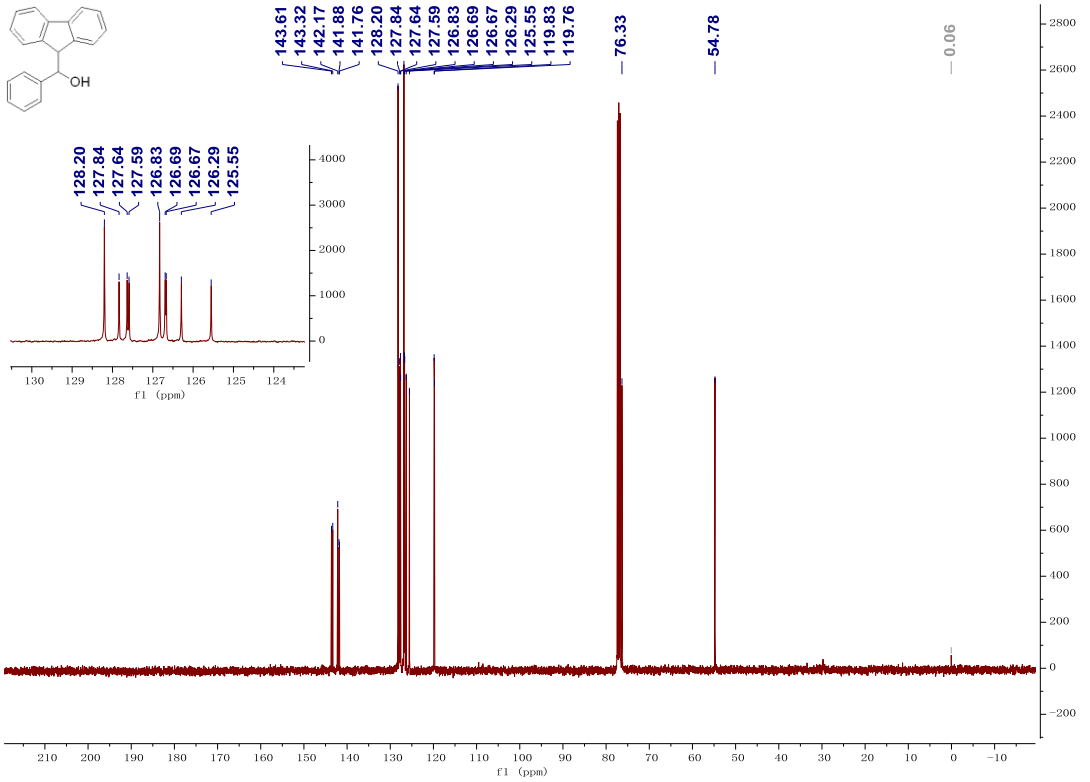
^{1}H NMR, ^{13}C NMR spectrum of **4g**



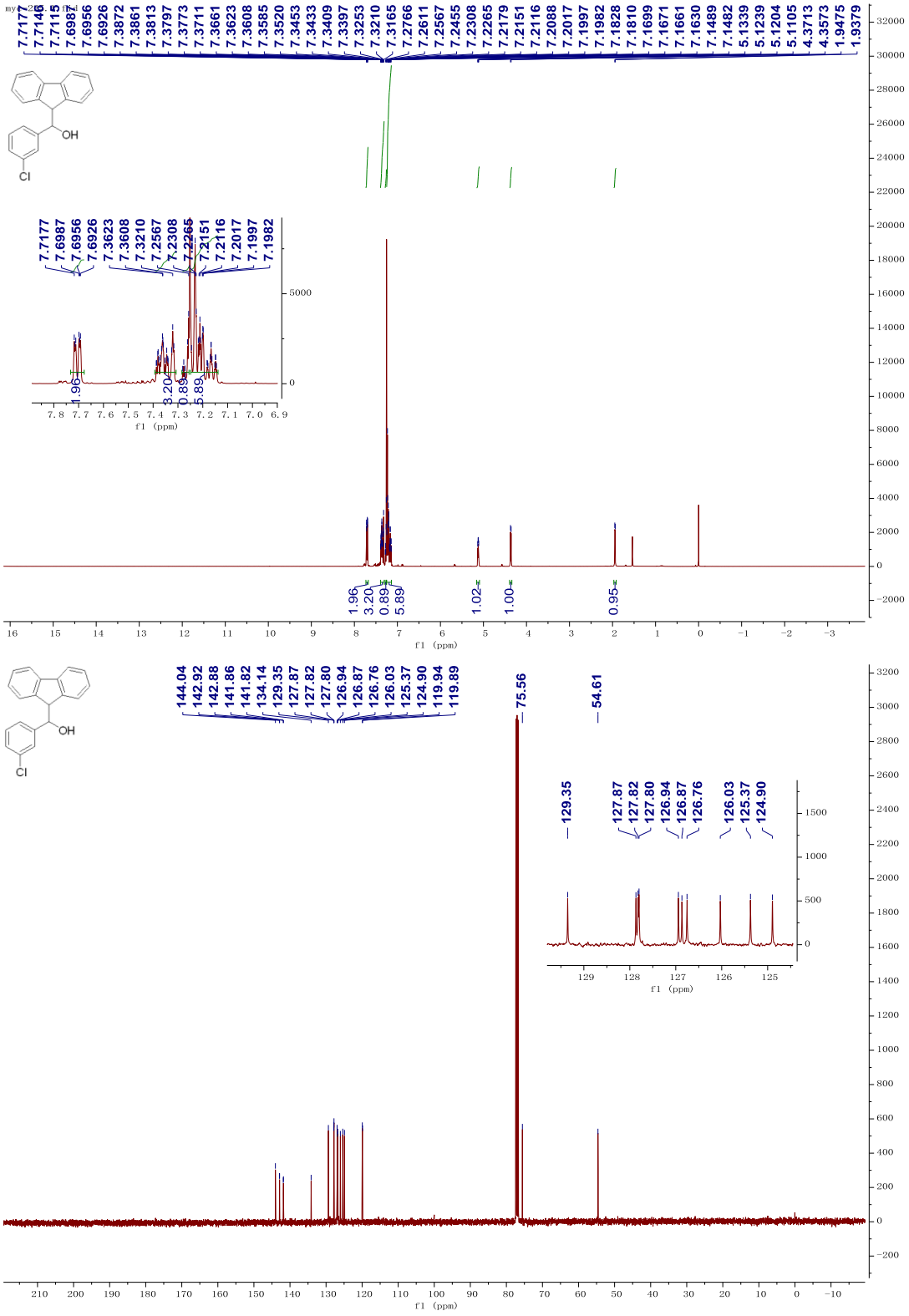


^{1}H NMR, ^{13}C NMR spectrum of **4h**

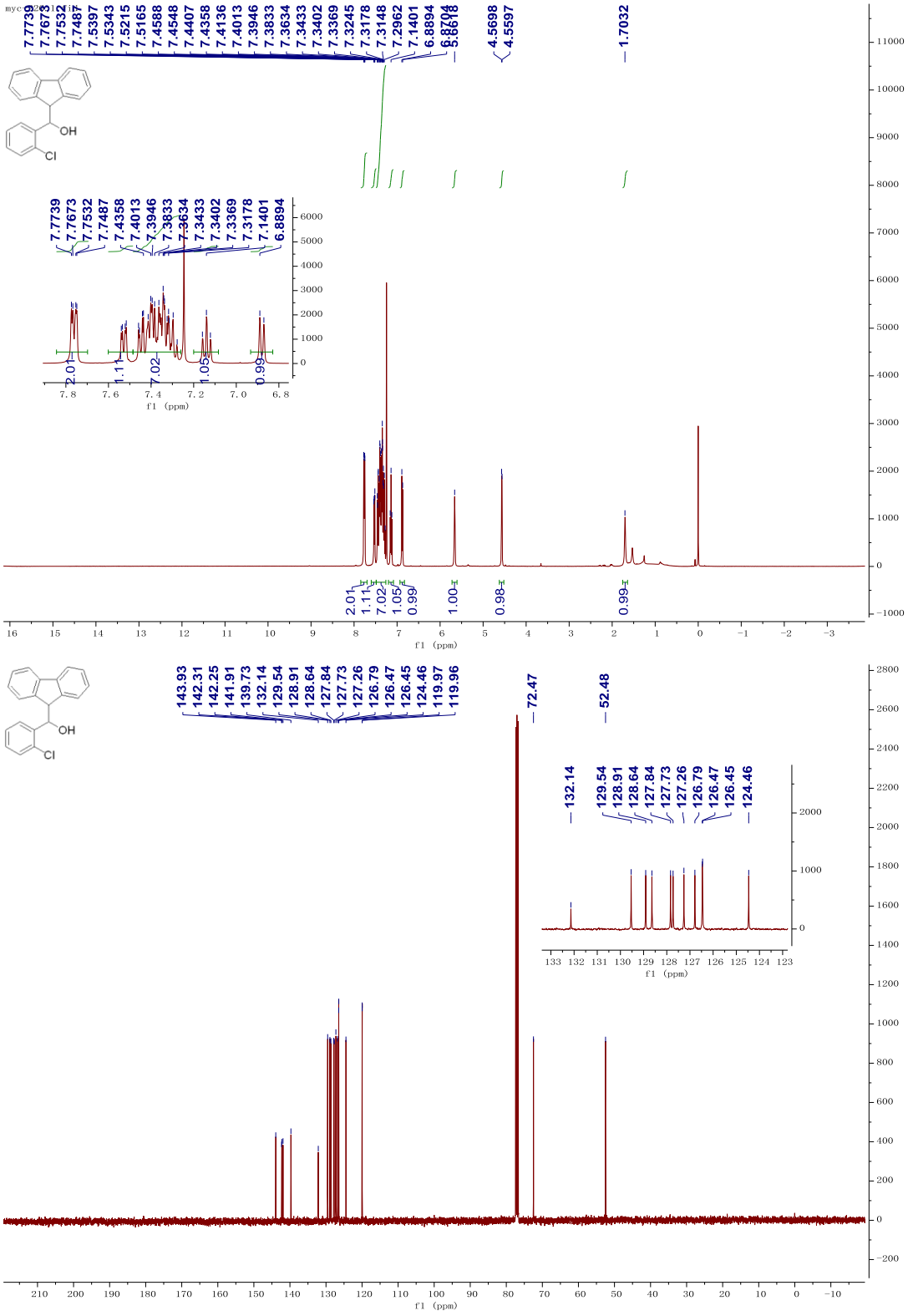




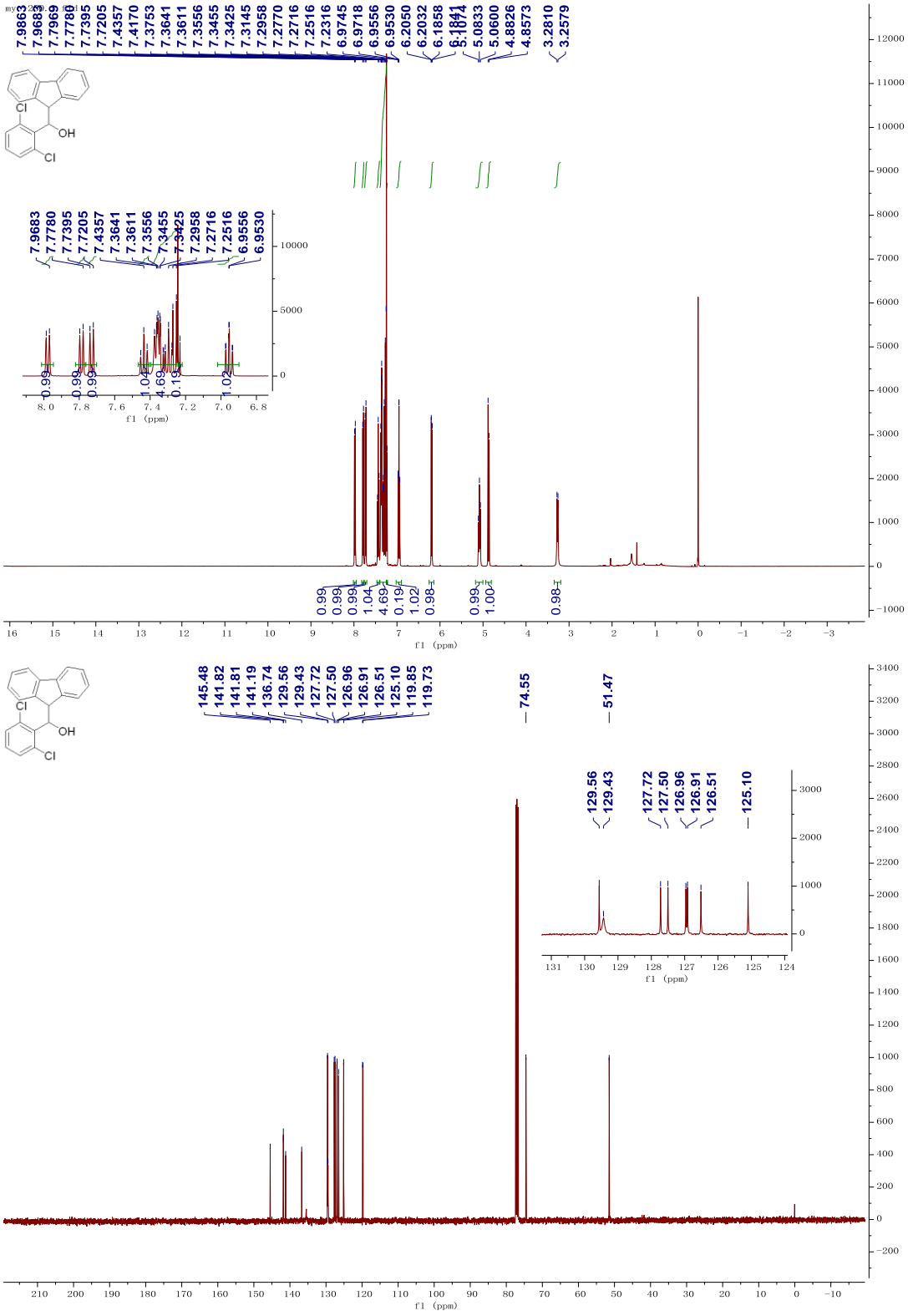
^{1}H NMR, ^{13}C NMR spectrum of **4i**



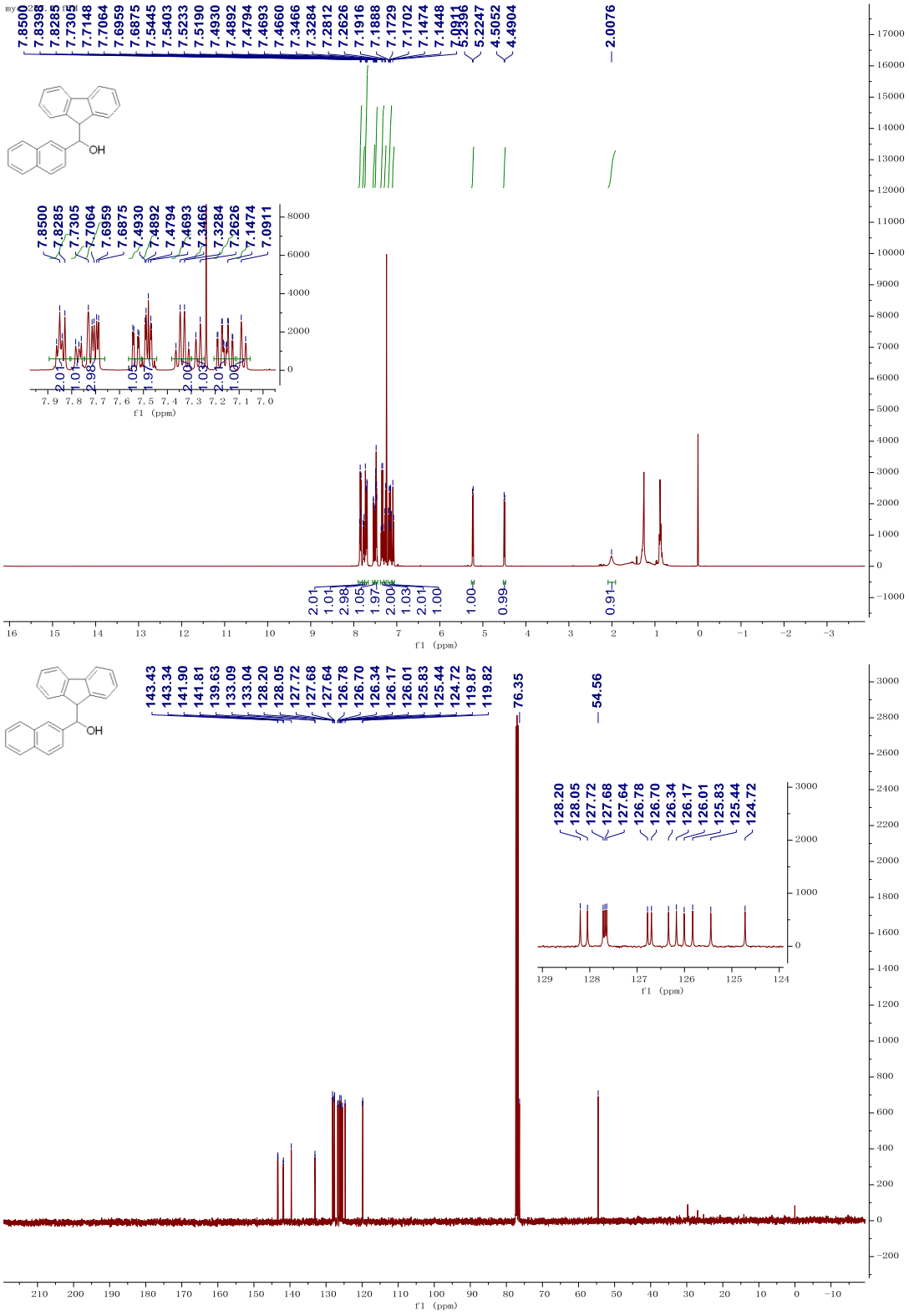
^{1}H NMR, ^{13}C NMR spectrum of **4j**



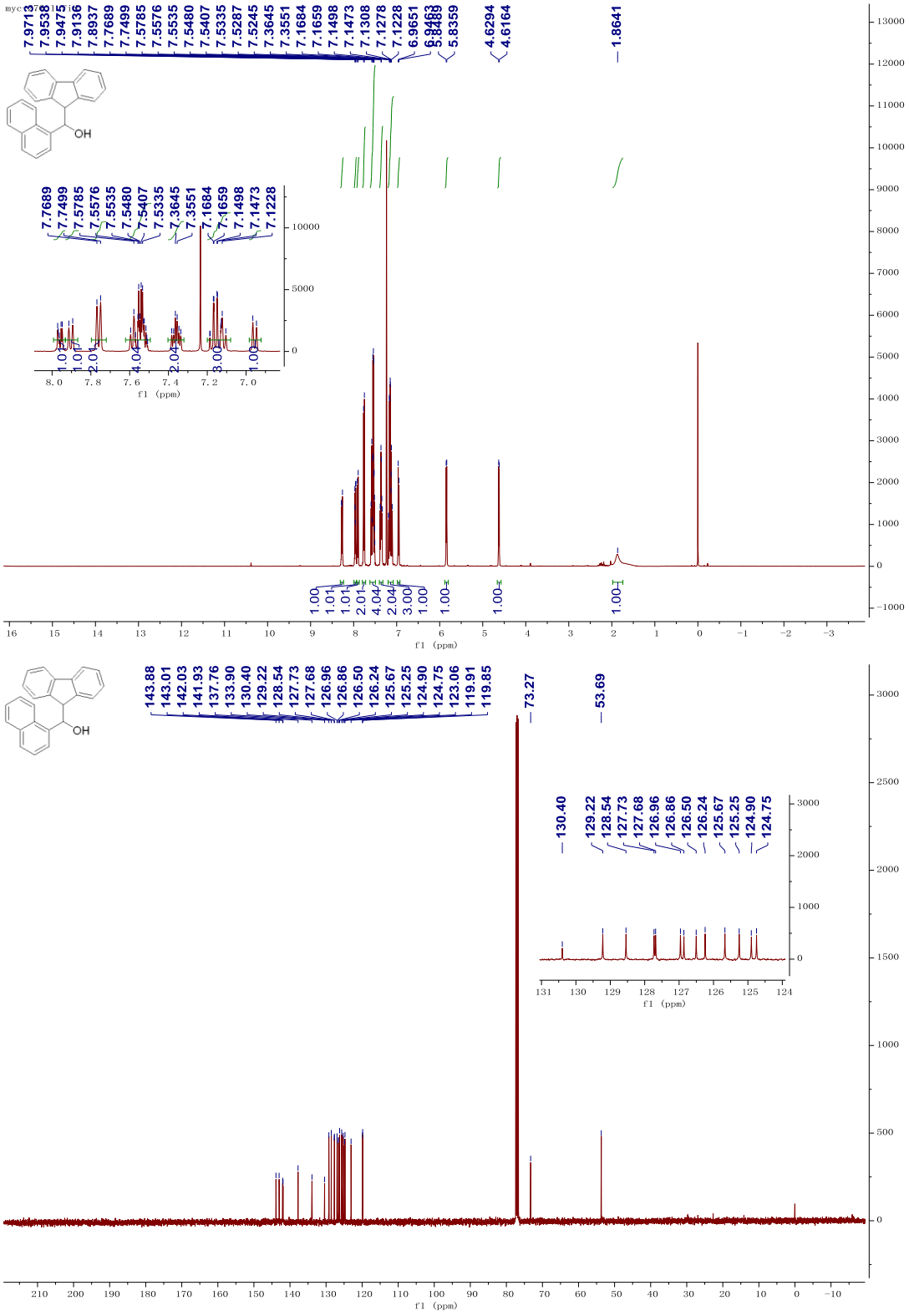
^{1}H NMR, ^{13}C NMR spectrum of **4k**



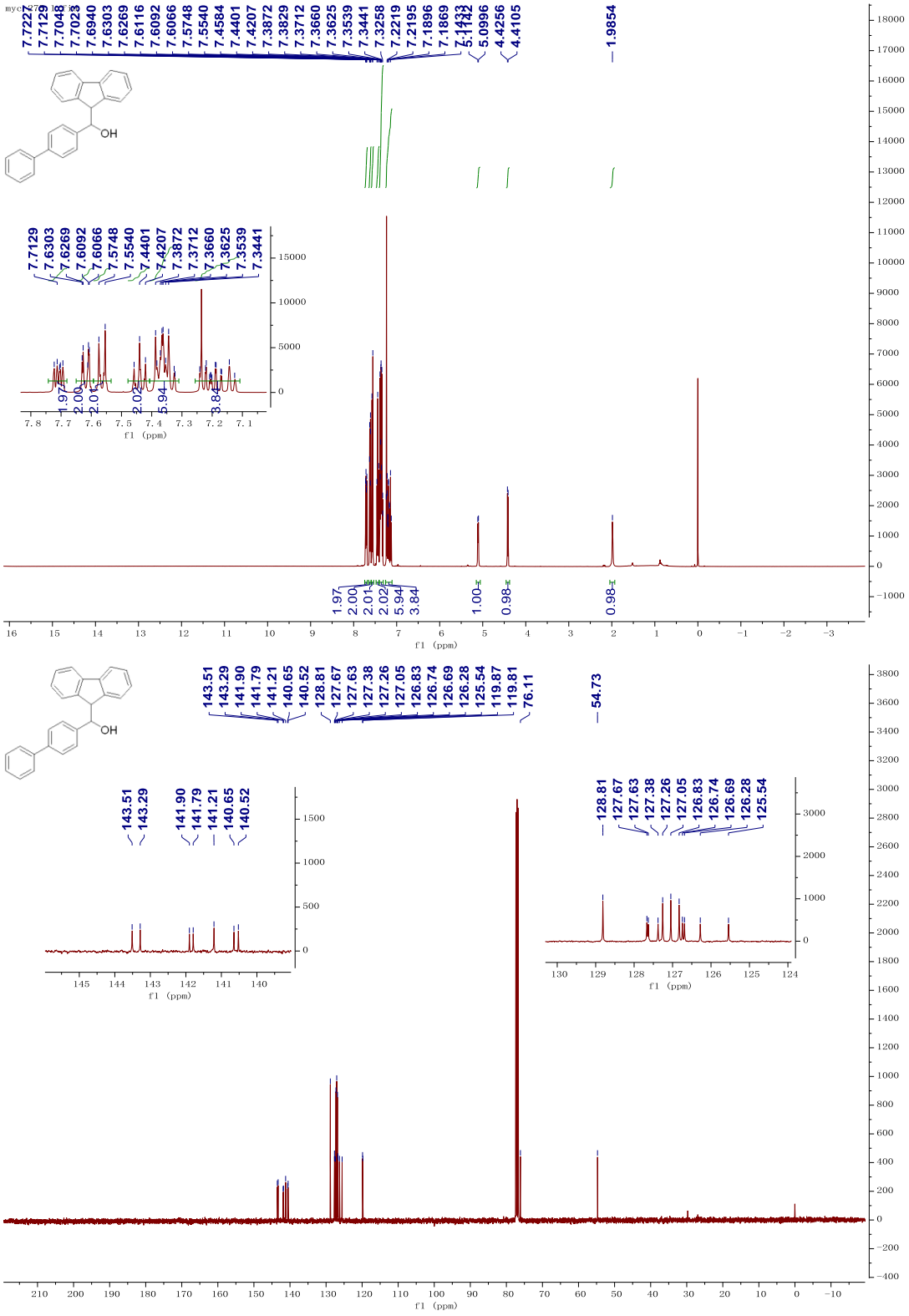
^{1}H NMR, ^{13}C NMR spectrum of **4l**



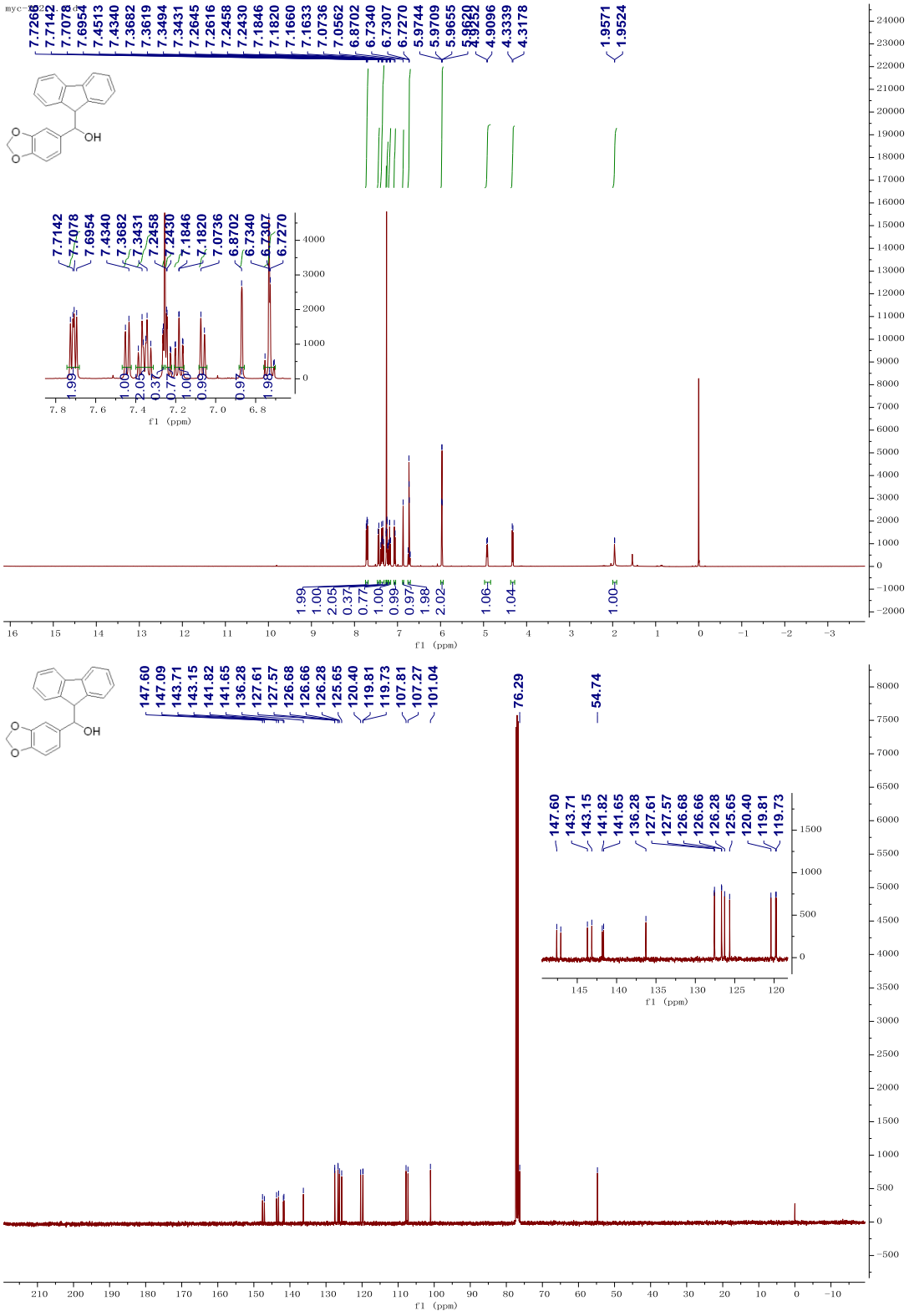
^{1}H NMR, ^{13}C NMR spectrum of **4m**



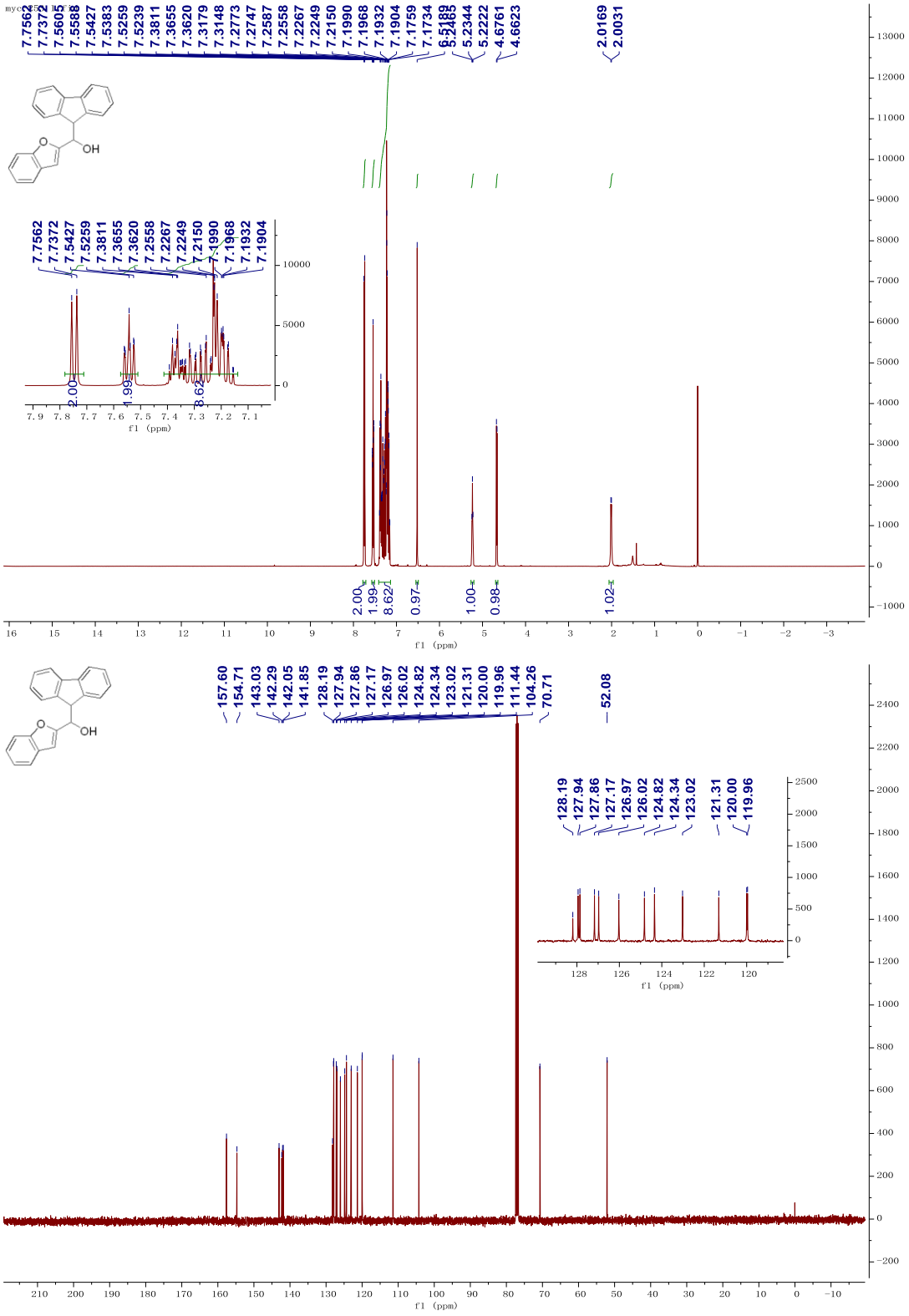
^{1}H NMR, ^{13}C NMR spectrum of **4n**



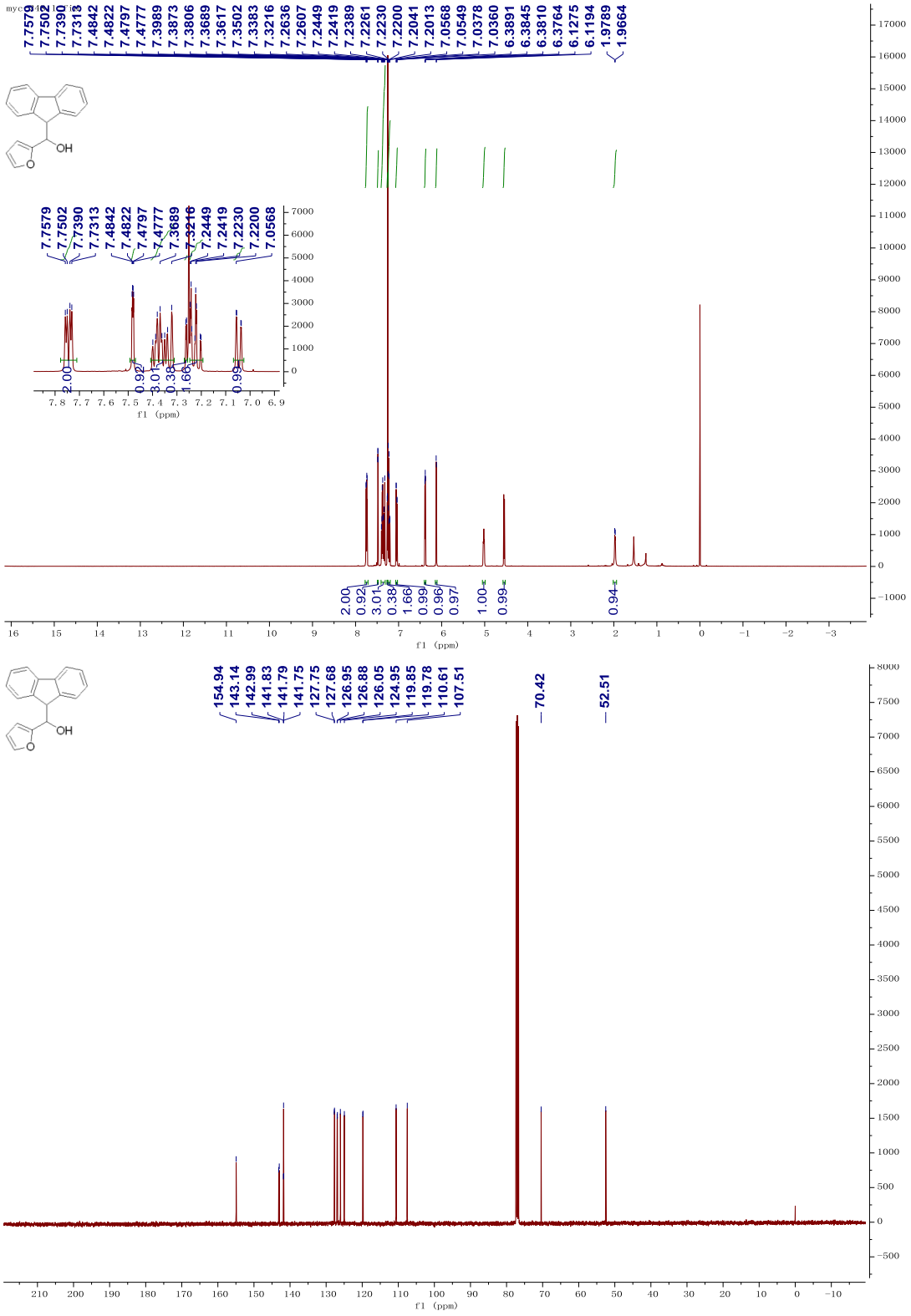
^{1}H NMR, ^{13}C NMR spectrum of **4o**



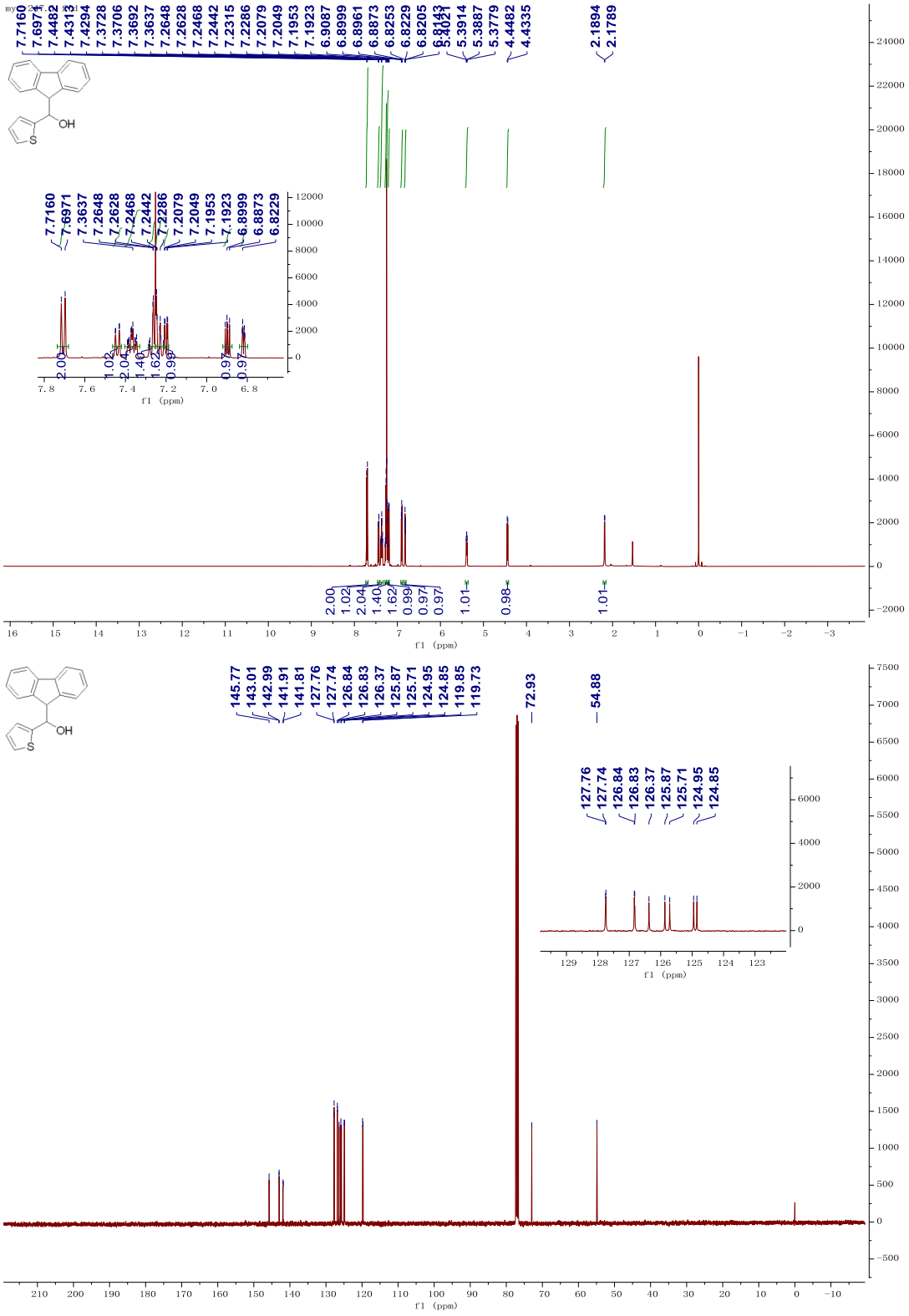
^{1}H NMR, ^{13}C NMR spectrum of **4p**



^{1}H NMR, ^{13}C NMR spectrum of **4q**



^{1}H NMR, ^{13}C NMR spectrum of **4r**



^{1}H NMR, ^{13}C NMR spectrum of **4s**