Supporting Information

Stereoselective synthesis of sulfonated 1-indenones *via* radical-triggered multi-component cyclization of *β*-alkynyl propenones

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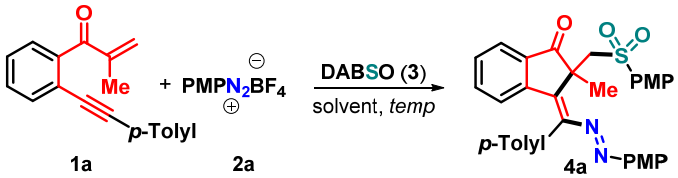
Context

Experimental

General Information

^{1}H NMR (^{13}C NMR) spectra were measured on a Bruker DPX 400 MHz spectrometer in $CDCl_3$ (DMSO-d_6) with chemical shift (δ) given in ppm relative to TMS as internal standard [(s = singlet, d = doublet, t = triplet, brs = broad singlet, m = multiplet), coupling constant (Hz)]. HRMS (ESI) was determined by using microTOF-QIIHRMS/MS instrument (BRUKER). X-Ray crystallographic analysis was performed with a Siemens SMART CCD and a Siemens P4 diffractometer.

Table 1. Optimization of Reaction Condition for Product 4a[a]



Entry	Substrate ratio	Solvent	*t* (°C)	Yield (%)[b]
1	1/2/2 (**1a**/**2a**/**3**)	DCE	60	32
2	1/3/2 (**1a**/**2a**/**3**)	DCE	60	40
3	1/3/3 (**1a**/**2a**/**3**)	DCE	60	68
4	1/3/3 (**1a**/**2a**/**3**)	THF	60	52
5	1/3/3 (**1a**/**2a**/**3**)	CH_3CN	60	62
6	1/3/3 (**1a**/**2a**/**3**)	1,4-dioxane	60	51
7	1/3/3 (**1a**/**2a**/**3**)	toluene	60	42
8	1/3/3 (**1a**/**2a**/**3**)	DCE	80	52
9	1/3/3 (**1a**/**2a**/**3**)	DCE	40	72
10	1/3/3 (**1a**/**2a**/**3**)	DCE	rt	74
11[c]	1/3/3 (**1a**/**2a**/**3**)	DCE	rt	45

[a]Reaction conditions: **1a** (0.2 mmol), **2a** (x equiv.), **3** (y equiv.), solvent (2.0 mL), under Ar conditions for 12.0 hours, [b]Isolated yield of product **3a** based on **1a**. [c]Under air conditions.

At the outset of our investigation, *β*-alkynyl propenone **1a** was selected as a radical acceptor and subjected with the reaction of *p*-methoxyphenyldiazonium tetrafluoroborate (**2a**) and DABSO (**3**) in 1:2:2 mole ratio. As shown in Table S1, the reaction proceeded smoothly in 1,2-dichloroethane (DCE) at 60 °C under argon conditions, enabling radical addition-cyclization to access the expected sulfonated (*Z*,*E*)-1-indenone **4a**, albeit with a low 32% yield (Table 1, entry S1). The stereo-structure of product **4** was confirmed by X-ray diffraction analysis. Fine-tuning the above reactants' ratio to 1:3:2 facilitated this reaction process, delivering in a slightly higher yield of 40% (entry S2). Further increasing the amount of DABSO could promote the transformation remarkably, leading to the expect product **4a** in 68% yield (entry S3), indicating the increase of the amount of reducing agent is beneficial to this transformation. Next, the investigation of the solvent effect revealed that other aprotic solvents, such as THF, CH_3CN, 1,4-dioxane and toluene proved to be less effective than DCE (entries S4-S7). It is found that the reaction temperature imposes an important impact on the efficiency of transformation. A lower conversion was observed with the reaction temperature at 80 °C (entry S8) whereas a slightly higher 74% yield was obtained when the reaction temperature was dropped to room temperature (r.t.) (entries S9 and S10). The reaction under air conditions gave a relatively inferior outcome as compared with Ar conditions (entry S11).

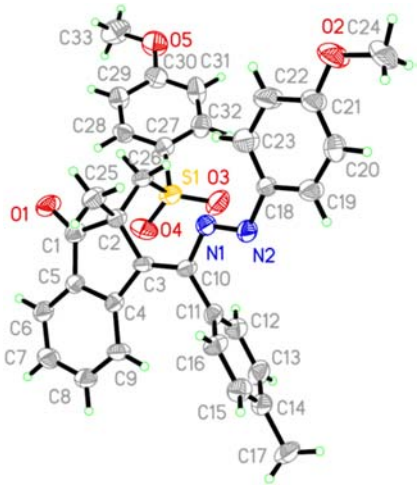


Figure 1 The ORTEP Drawing of **4a**

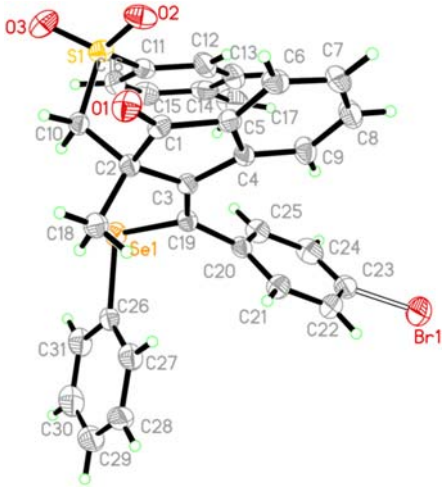
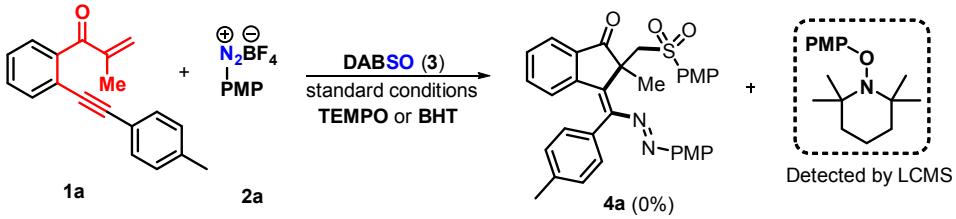


Figure 2 The ORTEP Drawing of **7f**

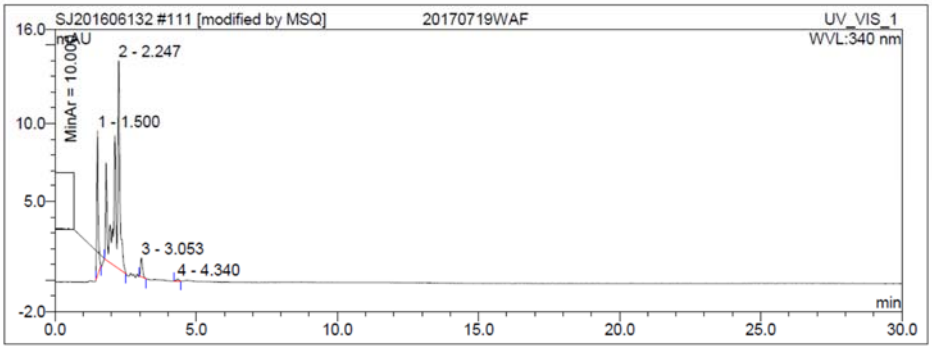
Radical-Trapping Experiment:

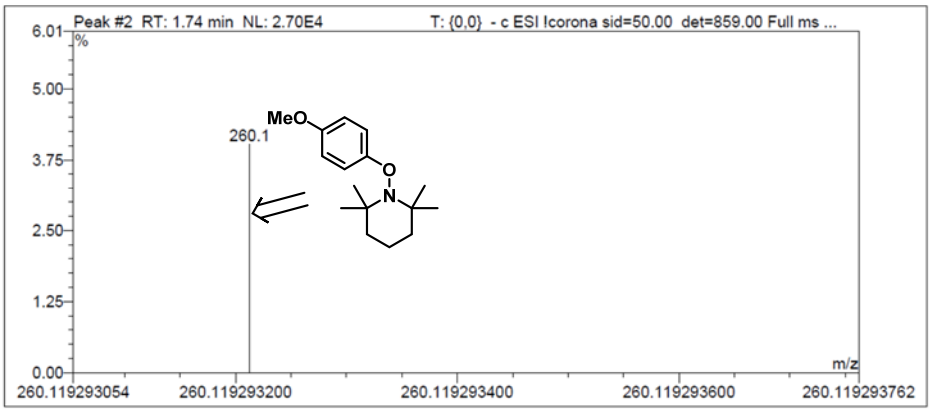
TEMPO as the radical trapping reagent —— General procedure



A mixture of 2-methyl-1-(2-(p-tolylethynyl)phenyl)prop-2-en-1-one (**1a**, 1.0 equiv., 0.20 mmol), **2a** (3.0 equiv., 0.6 mmol), DABSO (3.0 equiv., 0.6 mmol) and TEMPO (3.0 equiv, 0.6 mmol) in 1,2-dichloroethane (2.0 mL) was stirred at room temperature for 10 hours. After completion of the reaction, the solution was detected by LC-MS analysis.

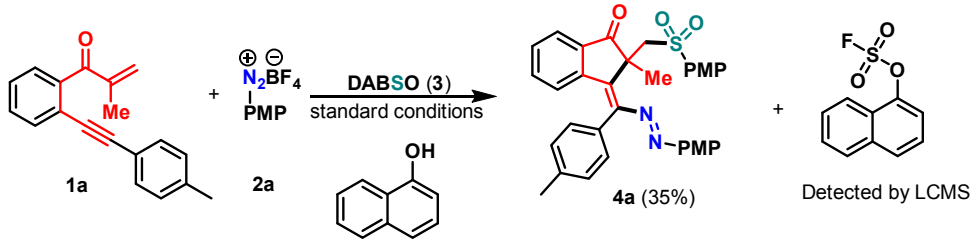
Overlay of Samples and Spectra from Integration View



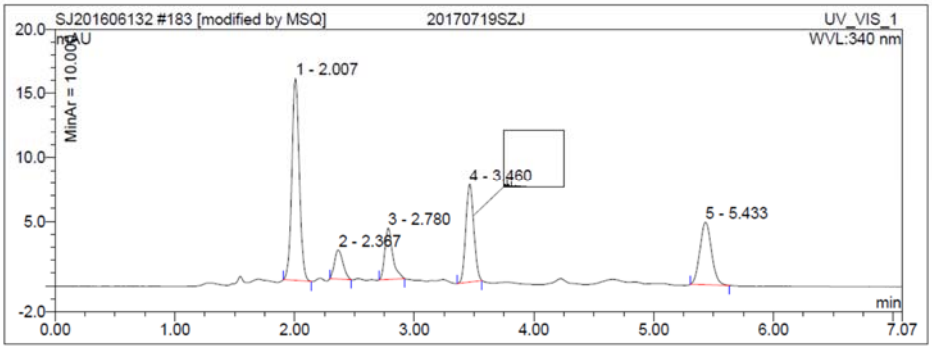


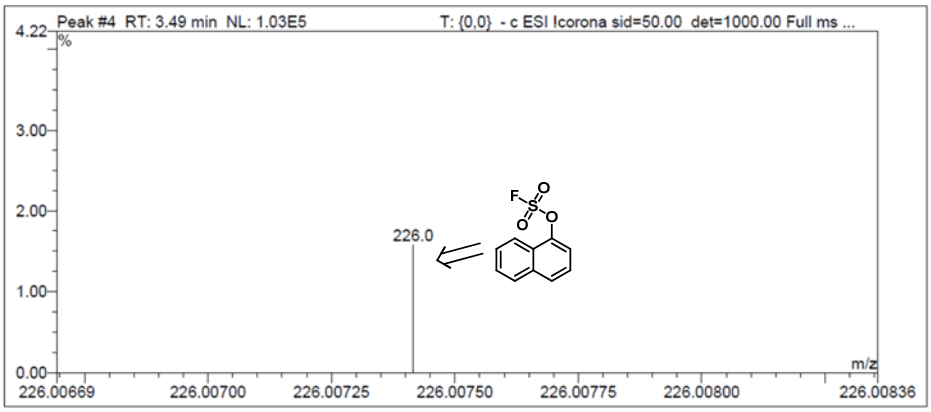
defltLCMS/Overlay UV/MS Spectra Print

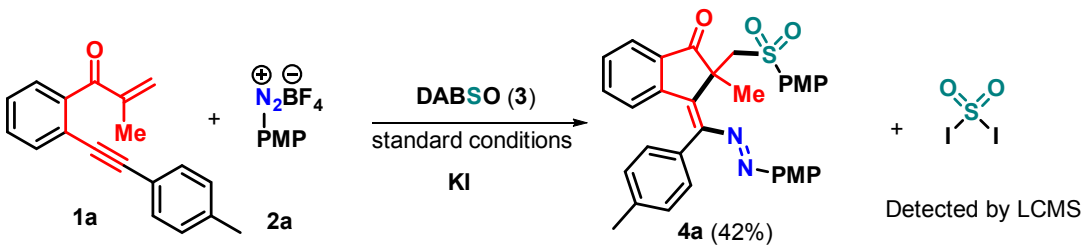
Chromeleon (c) Dionex 1996-2006
Version 6.80 SR15 Build 4656 (243203)



Overlay of Samples and Spectra from Integration View



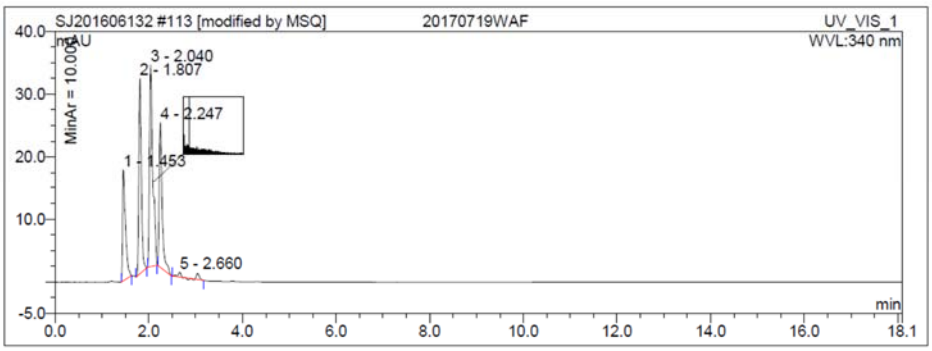


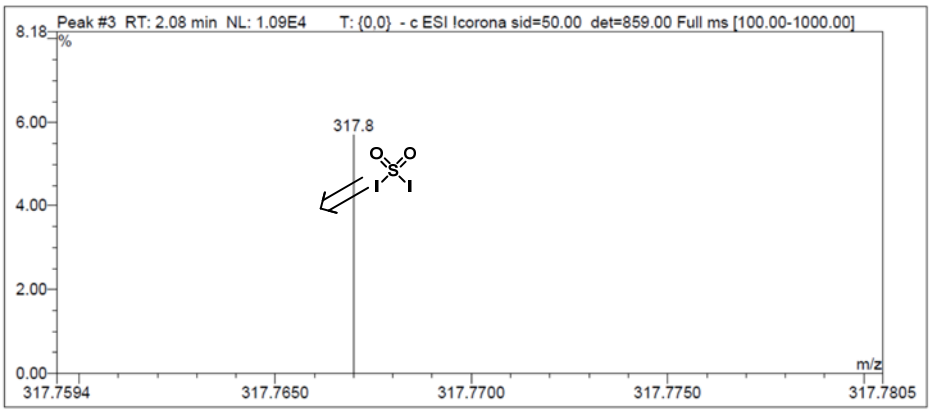


A mixture of 2-methyl-1-(2-(p-tolylethynyl)phenyl)prop-2-en-1-one (**1a**, 1.0 equiv., 0.20 mmol), **2a** (3.0 equiv.,0.6 mmol), DABSO (3.0 equiv., 0.6 mmol), and KI (3.0 equiv., 0.60 mmol) in 1,2-dichloroethane (2.0 mL) was

stirred at room temperature for 10 hours. After completion of the reaction, the solution was detected by LC-MS analysis.

Overlay of Samples and Spectra from Integration View



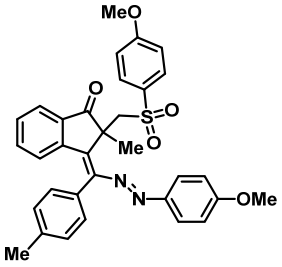


General procedure for the synthesis of compound 4a

Example for the synthesis of **4a**:

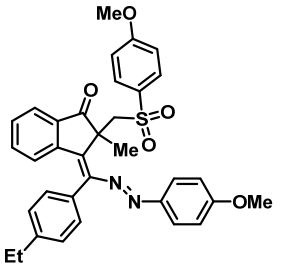
Under Ar conditions, *β*-alkynyl propenone **1a** (0.2 mmol, 52 mg), 4-methoxybenzenediazonium tetrafluoroborate (**2a**, 0.6 mmol, 133.2 mg), and DABSO (**3**, 0.6 mmol, 144 mg) were added into 10-mL reaction tube. Then, DCE (2.0 mL) was added into the reaction system. The mixture was stirred for 12 hours at room temperature. After completion of the reaction (TLC monitored), The solution was evaporated under vaccum. The residue was purified by column chromatography on silica gel (the eluent, petroleum ether/ethyl acetate = 9:1) to afford the desired product **4a**.

(Z)-3-(((E)-(4-methoxyphenyl)diazenyl)(p-tolyl)methylene)-2-(((4-methoxyphenyl)sulfonyl)methyl)-2-methyl-2,3-dihydro-1H-inden-1-one (4a)



Orange solid, mp 152-154 ^{o}C; ^{1}HNMR (400 MHz, $CDCl_3$;*δ*, ppm) 7.79 (d, *J* = 7.4 Hz, 1H), 7.64 (d, *J* = 8.8 Hz, 2H), 7.48 (d, *J* = 8.8 Hz, 2H), 7.37 (d, *J* = 7.4 Hz, 1H), 7.32-7.27 (m, 3H), 7.16 (d, *J* = 6.8 Hz, 1H), 7.03 (d, *J* = 7.2 Hz, 1H), 6.96 (d, *J* = 8.8 Hz, 2H), 6.74 (d, *J* = 8.8 Hz, 2H), 6.42 (d, *J* = 7.6 Hz, 1H), 4.61 (d, *J* = 13.6 Hz, 1H), 4.15 (d, *J* = 13.6 Hz, 1H), 3.88 (s, 3H), 3.81 (s, 3H), 2.48 (s, 3H), 1.69 (s, 3H). ^{13}CNMR (100 MHz, $CDCl_3$; *δ*, ppm) 204.3, 163.4, 162.1, 151.0, 147.8, 147.0, 142.5, 138.2, 136.0, 134.7, 132.0, 131.9, 130.1(1), 130.1(2), 129.8(1), 129.8(2), 129.5, 129.4, 126.9, 124.9, 124.3, 114.3, 114.0, 63.6, 55.6(1), 55.6(2), 51.2, 26.5, 21.6. IR (KBr, ν, cm^{-1}): 2964, 1712, 1573, 1470, 1315, 1083, 844, 574. HRMS (APCI-TOF): m/z calcd for: $C_{33}H_{31}N_2O_5S$, 567.1954 $[M+H]^+$; found: 567.1937.

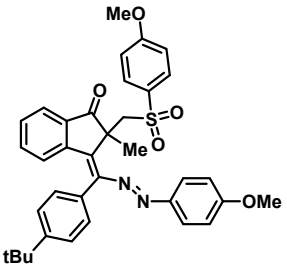
(Z)-3-((4-ethylphenyl)((E)-(4-methoxyphenyl)diazenyl)methylene)-2-(((4-methoxyphenyl)sulfonyl)methyl)-2-methyl-2,3-dihydro-1H-inden-1-one (4b)



Orange solid, mp 188-190^{o}C; ^{1}HNMR (400 MHz, $CDCl_3$; *δ*, ppm) 7.79 (d, *J* = 7.6 Hz, 1H), 7.65 (d, *J* = 8.8 Hz, 2H), 7.48 (d, *J* = 8.8 Hz, 2H), 7.37 (d, *J* = 7.6 Hz, 1H), 7.33-7.29 (m, 3H), 7.20 (s, 1H), 7.06 (s, 1H), 6.96 (d, *J* = 8.8 Hz, 2H), 6.74 (d, *J* = 8.8 Hz, 2H), 6.37 (d, *J* = 8.0 Hz, 1H), 4.61 (d, *J* = 13.6 Hz, 1H), 4.16 (d, *J* = 13.6 Hz, 1H), 3.88 (s, 3H), 3.81 (s, 3H), 2.78 (d, *J* = 7.6 Hz, 2H), 1.69 (s, 3H), 1.32-1.36 (m, 3H). ^{13}CNMR (100 MHz, $CDCl_3$; *δ*, ppm) 204.3, 163.4, 162.1, 151.0, 147.8, 147.0, 142.5, 138.2, 136.0, 134.7, 132.0, 131.9, 130.1(1),

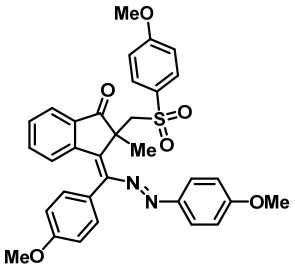
130.1(2), 129.8(1), 129.8(2), 129.6, 129.5, 126.9, 125.0, 124.2, 114.3, 114.0, 63.6, 55.6(1), 55.6(2), 51.2, 26.5, 21.6. IR (KBr, ν, cm^{-1}): 2984, 1720, 1584, 1467, 1310, 1093, 844, 539. HRMS (APCI-TOF): m/z calcd for: $C_{34}H_{33}N_2O_5S$, 581.2110 $[M+H]^+$; found: 581.2110.

(Z)-3-((4-(tert-butyl)phenyl)((E)-(4-methoxyphenyl)diazenyl)methylene)-2-(((4-methoxyphenyl)sulfonyl)methyl)-2-methyl-2,3-dihydro-1H-inden-1-one (4c)



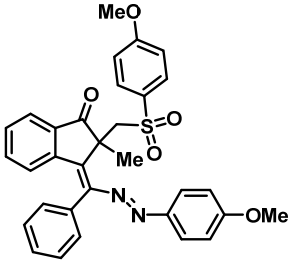
Orange solid, mp 208-210°C; ^{1}HNMR (400 MHz, $CDCl_3$; δ, ppm) 7.78 (d, J = 7.6 Hz, 1H), 7.66 (d, J = 8.8 Hz, 2H), 7.53–7.45 (m, 5H), 7.37 (s, 1H), 7.21 (d, J = 7.6 Hz, 1H), 7.06 (d, J = 7.6 Hz, 1H), 6.96 (d, J = 9.2 Hz, 2H), 6.74 (d, J = 9.2 Hz, 2H), 6.29 (d, J = 8.0 Hz, 1H), 4.61 (d, J = 13.6 Hz, 1H), 4.16 (d, J = 13.6 Hz, 1H), 3.88 (s, 3H), 3.81 (s, 3H), 1.69 (s, 3H), 1.42 (s, 9H). ^{13}CNMR (100 MHz, $CDCl_3$; δ, ppm) 204.3, 163.4, 162.1, 151.6, 151.2, 147.8, 147.2, 142.6, 136.0, 134.7, 132.0, 131.9, 130.1, 129.9, 129.7, 129.2, 126.9, 126.0, 125.5, 124.9, 124.2, 114.3, 114.0, 63.6, 55.6, 55.6, 51.3, 34.8, 31.5, 26.5. IR (KBr, ν, cm^{-1}): 2964, 1712, 1588, 1457, 1298, 1092, 845, 536. HRMS (APCI-TOF): m/z calcd for: $C_{36}H_{37}N_2O_5S$, 609.2423 $[M+H]^+$; found: 609.2474.

(Z)-3-((4-methoxyphenyl)((E)-(4-methoxyphenyl)diazenyl)methylene)-2-(((4-methoxyphenyl)sulfonyl)methyl)-2-methyl-2,3-dihydro-1H-inden-1-one (4d)



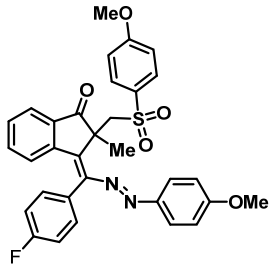
Red solid, mp 200-201°C; ^{1}HNMR (400 MHz, $CDCl_3$; δ, ppm) 7.80 (d, J = 7.2 Hz, 1H), 7.65 (d, J = 8.8 Hz, 2H), 7.48 (d, J = 8.8 Hz, 2H), 7.41-7.32 (m, 2H), 7.21 (s, 1H), 7.09-6.95 (m, 5H), 6.75 (d, J = 8.8 Hz, 2H), 6.48 (d, J = 7.6 Hz, 1H), 4.60 (d, J = 14.0 Hz, 1H), 4.15 (d, J = 13.6 Hz, 1H), 3.91 (s, 3H), 3.88 (s, 3H), 3.81 (s, 3H), 1.68 (s, 3H). ^{13}CNMR (100 MHz, $CDCl_3$; δ, ppm) 204.3, 163.4, 162.1, 159.6, 150.7, 147.8, 147.1, 142.7, 136.0, 134.8, 131.9, 131.6, 131.0(1), 130.1(2), 129.8, 127.2, 126.9, 124.9, 124.2, 114.3, 114.2, 114.0, 63.6, 55.6(1), 55.6(2), 55.3, 51.3, 26.4. IR (KBr, ν, cm^{-1}): 2954, 1712, 1582, 1477, 1311, 1092, 846, 524. HRMS (APCI-TOF): m/z calcd for: $C_{33}H_{31}N_2O_6S$, 583.1903 $[M+H]^+$; found: 583.1901.

(Z)-3-(((E)-(4-methoxyphenyl)diazenyl)(phenyl)methylene)-2-(((4-methoxyphenyl)sulfonyl)methyl)-2-methyl-2,3-dihydro-1H-inden-1-one (4e)



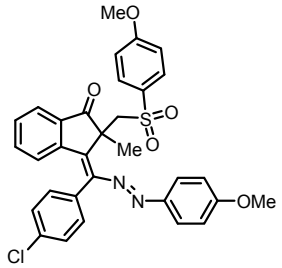
Orange solid, mp 183-185°C; ^{1}HNMR (400 MHz, $CDCl_3$; δ, ppm) 7.79 (d, J = 7.2 Hz, 1H), 7.64 (d, J = 9.2 Hz, 2H), 7.51-7.47 (m, 5H), 7.37 (d, J = 7.6 Hz, 1H), 1.71-1.67 (m, , 2H), 7.17–7.13 (m, 1H), 6.96 (d, J = 8.8 Hz, 2H), 6.75 (d, J = 9.2 Hz, 2H), 6.34 (d, J = 8.0 Hz, 1H), 4.61 (d, J = 13.6 Hz, 1H), 4.16 (d, J = 14.0 Hz, 1H), 3.88 (s, 3H), 3.81 (s, 3H), 1.70 (s, 3H). ^{13}CNMR (100 MHz, $CDCl_3$; δ, ppm) 204.3, 163.4, 162.1, 151.0, 147.8, 147.0, 142.5, 138.2, 136.0, 134.7, 132.0, 131.9, 130.1(1), 130.1(2), 129.8(1), 129.8(2), 129.5, 129.4, 126.9, 124.9, 124.2, 114.3, 114.0, 63.6, 55.6(1), 55.6(2), 51.2, 26.5. IR (KBr, ν, cm^{-1}): 2964, 1722, 1573, 1420, 1290, 1083, 845, 569. HRMS (APCI-TOF): m/z calcd for: $C_{32}H_{29}N_2O_5S$,553.1797 $[M+H]^+$; found: 553.1761.

(Z)-3-((4-fluorophenyl)((E)-(4-methoxyphenyl)diazenyl)methylene)-2-(((4-methoxyphenyl)sulfonyl)methyl)-2-methyl-2,3-dihydro-1H-inden-1-one (4f)



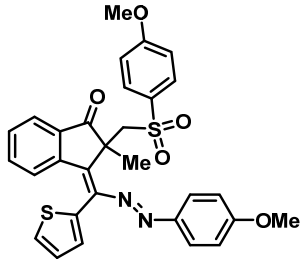
Orange solid, mp 208-210 °C; ^{1}HNMR (400 MHz, $CDCl_3$; δ, ppm) 7.82–7.78 (m, 1H), 7.67–7.63 (m, 2H), 7.52–7.48 (m, 2H), 7.43–7.33 (m, 3H), 7.22-7.13 (m, 3H), 6.99–6.95 (m, 2H), 6.80–6.75 (m, 2H), 6.43 (d, J = 8.0 Hz, 1H), 4.57 (d, J = 13.6 Hz, 1H), 4.14 (d, J = 13.6 Hz, 1H), 3.88 (s, 3H), 3.81 (s, 3H), 1.70 (s, 3H). ^{13}CNMR (100 MHz, $CDCl_3$; δ, ppm) 204.0, 164.1($^{1}J_{CF}$ = 246.0 Hz), 163.5, 162.3, 161.6, 150.0, 147.7, 146.7, 142.9, 136.0, 134.8, 132.3, 132.2, 131.9, 131.6($^{3}J_{CF}$ = 7.9 Hz), 131.5, 131.2($^{4}J_{CF}$ = 3.6 Hz), 131.1, 130.0, 126.7, 124.9, 124.4, 116.4($^{2}J_{CF}$ = 20.9 Hz), 116.2, 115.8, 115.6, 114.4, 114.1, 63.5, 55.7, 55.6, 51.3, 26.3. IR (KBr, ν, cm^{-1}): 2954, 1720, 1576, 1467, 1317, 1076, 846, 576. HRMS (APCI-TOF): m/z calcd for: $C_{32}H_{28}FN_2O_5S$,571.1703 $[M+H]^+$; found: 571.1704.

(Z)-3-((4-chlorophenyl)((E)-(4-methoxyphenyl)diazenyl)methylene)-2-(((4-methoxyphenyl)sulfonyl)methyl)-2-methyl-2,3-dihydro-1H-inden-1-one (4g)



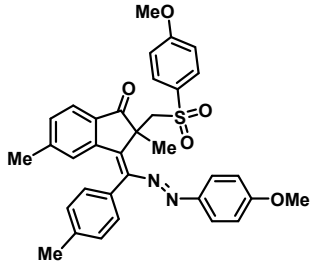
Red solid, mp 169-171 °C; ^{1}HNMR (400 MHz, $CDCl_3$; δ, ppm) 7.81 (d, J = 7.2 Hz, 1H), 7.65 (d, J = 8.4 Hz, 2H), 7.53–7.47 (m, 4H), 7.44–7.37 (m, 2H), 7.32 (s, 1H), 7.13 (s, 1H), 6.97 (d, J = 8.8 Hz, 2H), 6.77 (d, J = 8.8 Hz, 2H), 6.49 (s, 1H), 4.54 (s, 1H), 4.15 (s, 1H), 3.89 (s, 3H), 3.81 (s, 3H), 1.69 (s, 3H). ^{13}CNMR (100 MHz, $CDCl_3$; δ, ppm) 203.9, 163.5, 162.3, 149.8, 147.6, 146.6, 142.8, 136.0, 134.9, 134.4, 133.8, 131.9, 131.2, 130.1, 130.0, 129.5, 128.9, 126.7, 124.9, 124.4, 114.4, 114.1, 63.5, 55.7, 55.6, 51.3, 26.3. IR (KBr, ν, cm^{-1}): 2955, 1718, 1593, 1468, 1295, 1082, 846, 569. HRMS (APCI-TOF): m/z calcd for: $C_{32}H_{28}ClN_2O_5S$, 587.1407 $[M+H]^+$; found:587.1417.

(Z)-3-(((E)-(4-methoxyphenyl)diazenyl)(thiophen-2-yl)methylene)-2-(((4-methoxyphenyl)sulfonyl)methyl)-2-methyl-2,3-dihydro-1H-inden-1-one (4h)



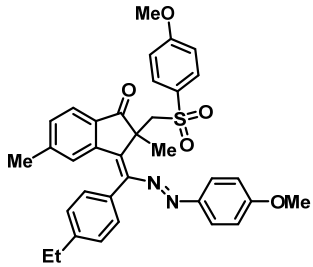
Orange solid, mp 160-162 °C; ^{1}HNMR (400 MHz, $CDCl_3$; δ, ppm) 7.85–7.83 (m, 1H), 7.64 (d, J = 8.8 Hz, 2H), 7.60 – 7.58 (m, 1H), 7.45–7.41 (m, 4H), 7.19-7.17 (m, , 1H), 6.98 (d, J = 8.8 Hz, 3H), 6.70 (d, J = 8.8 Hz, 2H), 6.54 (d, J = 7.6 Hz, 1H), 4.60 (d, J = 14.0 Hz, 1H), 4.19 (d, J = 14.0 Hz, 1H), 3.90 (s, 3H), 3.80 (s, 3H), 1.67 (s, 3H). ^{13}CNMR (100 MHz, $CDCl_3$; δ, ppm) 203.7, 163.4, 162.4, 147.5, 146.5, 145.3, 143.9, 136.3, 134.9, 134.3, 131.7, 130.4, 130.0, 129.0, 128.2, 127.3, 126.8, 125.0, 124.3, 114.4, 114.1, 63.6, 55.7, 55.6, 51.6, 26.3. IR (KBr, ν, cm^{-1}): 2864, 1722, 1583, 1477, 1325, 1088, 854, 578. HRMS (APCI-TOF): m/z calcd for: $C_{30}H_{27}N_2O_5S_2$, 559.1361 $[M+H]^+$; found: 559.1362.

(Z)-3-(((E)-(4-methoxyphenyl)diazenyl)(p-tolyl)methylene)-2-(((4-methoxyphenyl)sulfonyl)methyl)-2,5-dimethyl-2,3-dihydro-1H-inden-1-one (4i)



Red solid, mp 221-223 °C; ^{1}HNMR (400 MHz, $CDCl_3$; δ, ppm) 7.695-7.632 (m, 3H), 7.52–7.48 (m, 2H), 7.329-7.286 (m, 2H), 7.22–7.18 (m, 2H), 7.03 (d, J = 7.2 Hz, 1H), 6.96 (d, J = 9.2 Hz, 2H), 6.75 (d, J = 9.2 Hz, 2H), 6.11 (s, 1H), 4.59 (d, J = 13.6 Hz, 1H), 4.13 (d, J = 13.6 Hz, 1H), 3.88 (s, 3H), 3.81 (s, 3H), 2.48 (s, 3H), 2.14 (s, 3H), 1.68 (s, 3H). ^{13}CNMR (100 MHz, $CDCl_3$; δ, ppm) 203.6, 163.4, 162.0, 150.9, 147.9, 147.4, 145.7, 142.8, 138.1, 133.9, 132.3, 132.1, 131.1, 130.2, 130.1, 129.7, 129.5, 129.2, 127.4, 124.8, 124.0, 114.3, 114.0, 63.5, 55.6(1), 55.6(2), 51.5, 26.6, 22.4, 21.5. IR (KBr, ν, cm^{-1}): 2954, 1718, 1579, 1467, 1318, 1086, 849, 554. HRMS (APCI-TOF): m/z calcd for: $C_{34}H_{33}N_2O_5S$, 581.2110 $[M+H]^+$; found: 581.2114.

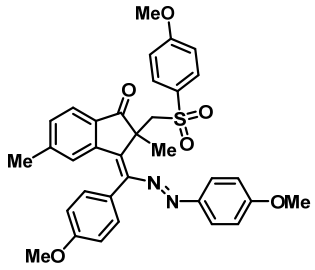
(Z)-3-((4-ethylphenyl)((E)-(4-methoxyphenyl)diazenyl)methylene)-2-(((4-methoxyphenyl)sulfonyl)methyl)-2,5-dimethyl-2,3-dihydro-1H-inden-1-one (4j)



Orange solid, mp 177-179 °C; ^{1}HNMR (400 MHz, $CDCl_3$; δ, ppm) 7.69–7.64 (m, 3H), 7.49 (d, J = 9.2 Hz, 2H), 7.33 (t, J = 6.2 Hz, 2H), 7.24-7.18 (m, , 2H), 7.06 (d, J = 7.6 Hz, 1H), 6.97 (s, 1H), 6.95 (s, 1H), 6.76 (s, 1H), 6.74 (s, 1H), 5.98 (s, 1H), 4.59 (d, J = 14.0 Hz, 1H), 4.13 (d, J = 14.0 Hz, 1H), 3.88 (s, 3H), 3.81 (s, 3H), 2.77 (d, J = 7.6 Hz, 2H), 2.12 (s, 3H), 1.68 (s, 3H), 1.34 (t, J = 7.6 Hz, 3H). ^{13}CNMR (100 MHz, $CDCl_3$; δ, ppm) 203.7, 163.4, 162.0, 151.0, 147.9, 147.4, 145.6, 144.7, 142.9, 133.9, 132.7, 132.0, 131.1, 130.2, 130.1, 129.6, 128.6,

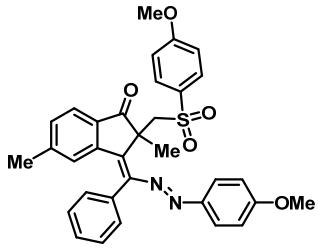
128.1, 127.5, 124.8, 124.0, 114.3, 114.0, 63.5, 55.6, 56.0, 51.4, 29.0, 26.6, 22.4, 16.2. IR (KBr, ν, cm^{-1}): 2956, 1719, 1578, 1472, 1296, 1089, 846, 574. HRMS (APCI-TOF): m/z calcd for: $C_{35}H_{35}N_2O_5S$, 595.2267 $[M+H]^+$; found: 595.2260.

(Z)-3-((4-methoxyphenyl)((E)-(4-methoxyphenyl)diazenyl)methylene)-2-(((4-methoxyphenyl)sulfonyl)methyl)-2,5-dimethyl-2,3-dihydro-1H-inden-1-one (4k)



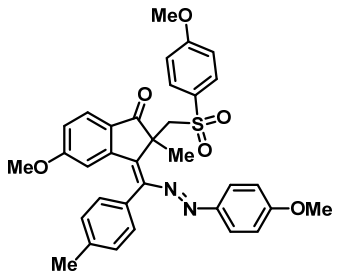
Orange solid, mp 199-201 °C; ^{1}HNMR (400 MHz, $CDCl_3$; δ, ppm) 7.70-7.64 (m, 3H), 7.51–7.47 (m, 2H), 7.25–7.18 (m, 2H), 7.09–7.06 (m, 1H), 7.048-7.010 (m, , 2H), 6.96 (d, J = 9.2 Hz, 2H), 6.75 (d, J = 8.8 Hz, 2H), 6.21 (s, 1H), 4.58 (d, J = 13.6 Hz, 1H), 4.12 (d, J = 14.0 Hz, 1H), 3.91 (s, 3H), 3.88 (s, 3H), 3.80 (s, 3H), 2.17 (s, 3H), 1.67 (s, 3H). ^{13}CNMR (100 MHz, $CDCl_3$; δ, ppm) 203.7, 163.4, 162.0 159.7, 150.6, 147.8, 147.4, 145.7, 143.0, 133.9, 132.1, 131.7, 131.2, 131.0, 130.0, 127.4(1), 127.4(2), 124.8, 124.1, 114.3, 114.1, 114.0, 63.5, 55.6(1), 55.6(2), 55.4, 51.5, 26.5, 22.5. IR (KBr, ν, cm-1): 2926, 1718, 1574, 1471, 1297, 1086, 835, 594. HRMS (APCI-TOF): m/z calcd for: $C_{34}H_{33}N_2O_6S$, 597.2059 $[M+H]^+$; found: 597.2056.

(Z)-3-(((E)-(4-methoxyphenyl)diazenyl)(phenyl)methylene)-2-(((4-methoxyphenyl)sulfonyl)methyl)-2,5-dimethyl-2,3-dihydro-1H-inden-1-one (4l)



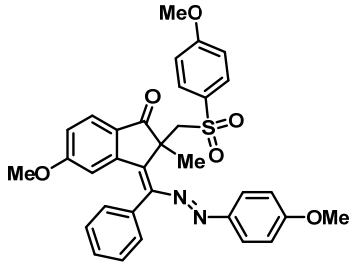
Orange solid, mp 175-177 °C; ^{1}H NMR (400 MHz, $CDCl_3$; δ, ppm) 7.70-7.63 (m, 3H), 7.531-7.480 (m, 5H), 7.35 (d, J = 6.8 Hz, 1H), 7.20 (d, J = 7.6 Hz, 1H), 7.15 (d, J = 5.2 Hz, 1H), 6.96 (d, J = 8.8 Hz, 2H), 6.76 (d, J = 8.8 Hz, 2H), 6.04 (s, 1H), 4.59 (d, J = 13.6 Hz, 1H), 4.13 (d, J = 13.6 Hz, 1H), 3.88 (s, 3H), 3.81 (s, 3H), 2.13 (s, 3H), 1.69 (s, 3H). ^{13}CNMR (100 MHz, $CDCl_3$; δ, ppm) 203.6, 163.4, 162.1, 150.8, 147.8, 145.7, 142.8, 135.5, 133.9, 132.0, 131.2, 130.3, 130.1, 129.6, 129.1, 128.5, 128.3, 127.4, 124.9, 124.1, 114.3, 114.0, 63.5, 55.6(1), 55.6(2), 51.5, 26.9, 26.5, 22.4. IR (KBr, ν, cm^{-1}): 2950, 1713, 1573, 1467, 1305, 1087, 844, 575. HRMS (APCI-TOF): m/z calcd for: $C_{33}H_{31}N_2O_5S$, 567.1954 $[M+H]^+$; found: 567.1935.

(Z)-5-methoxy-3-(((E)-(4-methoxyphenyl)diazenyl)(p-tolyl)methylene)-2-(((4-methoxyphenyl)sulfonyl)methyl)-2-methyl-2,3-dihydro-1H-inden-1-one (4m)



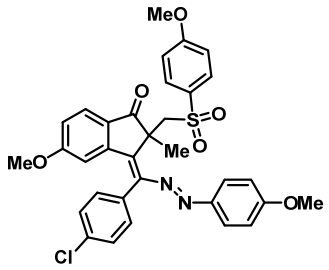
Orange solid, mp 206-208 °C; ^{1}H NMR (400 MHz, $CDCl_3$; δ, ppm) 7.62 (d, J = 8.8 Hz, 2H), 7.47 (d, J = 8.8 Hz, 2H), 7.28 (d, J = 6.4 Hz, 3H), 7.21 (d, J = 2.4 Hz, 1H), 7.09 (d, J = 7.2 Hz, 1H), 7.01 (d, J = 7.2 Hz, 1H), 6.95 (d, J = 9.2 Hz, 2H), 6.918-6.883 (m, 1H), 6.73 (d, J = 9.2 Hz, 2H), 6.29 (d, J = 8.8 Hz, 1H), 4.64 (d, J = 14.0 Hz, 1H), 4.13 (d, J = 14.0 Hz, 1H), 3.86 (d, J = 10.4 Hz, 6H), 3.80 (s, 3H), 2.47 (s, 3H), 1.69 (s, 3H). ^{13}CNMR (100 MHz, $CDCl_3$; δ, ppm) 204.1, 163.4, 161.8, 161.3, 149.5, 147.9, 142.4, 140.5, 138.0, 137.9, 132.2, 131.9, 130.3, 130.1, 129.7, 129.4, 128.0, 124.6, 124.2, 114.3, 114.0, 105.2, 63.5, 55.7, 55.6(1), 55.6(2), 51.8, 26.5, 21.6. IR (KBr, ν, cm^{-1}): 2927, 1720, 1596, 1482, 1315, 1092, 846, 570. HRMS (APCI-TOF): m/z calcd for: $C_{34}H_{33}N_2O_6S$, 597.2059 $[M+H]^+$; found: 597.2065.

(Z)-5-methoxy-3-(((E)-(4-methoxyphenyl)diazenyl)(phenyl)methylene)-2-(((4-methoxyphenyl)sulfonyl)methyl)-2-methyl-2,3-dihydro-1H-inden-1-one (4n)



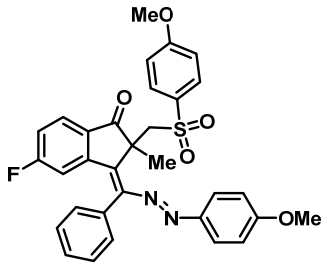
Red solid, mp 168-170 °C; ^{1}HNMR (400 MHz, $CDCl_3$; δ, ppm) 7.62 (d, J = 8.8 Hz, 2H), 7.48 (d, J = 8.8 Hz, 6H), 7.21 (d, J = 2.0 Hz, 1H), 7.14 (s, 1H), 6.95 (d, J = 8.8 Hz, 2H), 6.895-6.856 (m, 1H), 6.75 (d, J = 8.8 Hz, 2H), 6.21 (d, J = 8.8 Hz, 1H), 4.64 (d, J = 14.0 Hz, 1H), 4.14 (d, J = 13.6 Hz, 1H), 3.87 (s, 3H), 3.85 (s, 3H), 3.80 (s, 3H), 1.70 (s, 3H). ^{13}CNMR (100 MHz, $CDCl_3$; δ, ppm) 204.0, 163.4, 161.9, 161.4, 149.4, 147.8, 142.5, 140.3, 137.9, 135.5, 131.9, 130.4, 130.1, 129.8, 129.0, 128.6, 128.3, 127.9, 124.7, 124.2, 114.3, 114.0, 105.3, 63.5, 55.7, 55.6(1), 55.6(2), 51.8, 26.5. IR (KBr, ν, cm^{-1}): 2944, 1721, 1589, 1467, 1300, 1067, 846, 541. HRMS (APCI-TOF): m/z calcd for: $C_{33}H_{31}N_2O_6S$, 583.1903 $[M+H]^+$; found: 583.1905.

(Z)-3-((4-chlorophenyl)((E)-(4-methoxyphenyl)diazenyl)methylene)-5-methoxy-2-(((4-methoxyphenyl)sulfonyl)methyl)-2-methyl-2,3-dihydro-1H-inden-1-one (4o)



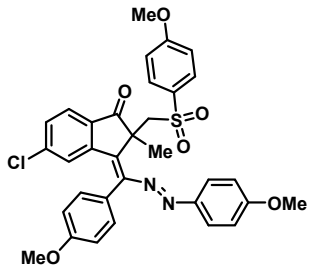
Orange solid, mp 180-181 °C; ^{1}HNMR (400 MHz, $CDCl_3$; δ, ppm) 7.62 (d, J = 8.8 Hz, 2H), 7.51–7.44 (m, 5H), 7.22 (d, J = 2.4 Hz, 1H), 7.11–7.08 (m, 1H), 6.97–6.93 (m, 3H), 6.76 (d, J = 8.8 Hz, 2H), 6.36 (d, J = 8.8 Hz, 1H), 4.58 (d, J = 13.6 Hz, 1H), 4.11 (d, J = 13.6 Hz, 1H), 3.88 (s, 3H), 3.86 (s, 3H), 3.81 (s, 3H), 1.69 (s, 3H). ^{13}CNMR (100 MHz, $CDCl_3$; δ, ppm) 203.8, 163.5, 162.0, 161.5, 148.2, 147.7, 142.7, 139.9, 138.0, 134.3, 134.0, 132.0, 131.9, 131.4, 130.1, 129.4, 128.9, 127.8, 124.7, 124.3, 114.4, 114.0, 105.5, 63.4, 55.7, 55.6(1), 55.6(2), 51.8, 26.3. IR (KBr, ν, cm^{-1}): 2840, 1722, 1579, 1469, 1295, 1089, 849, 543. HRMS (APCI-TOF): m/z calcd for: $C_{33}H_{30}ClN_2O_6S$, 617.1513 $[M+H]^+$; found: 617.1515.

(Z)-5-fluoro-3-(((E)-(4-methoxyphenyl)diazenyl)(phenyl)methylene)-2-(((4-methoxyphenyl)sulfonyl)methyl)-2-methyl-2,3-dihydro-1H-inden-1-one (4p)



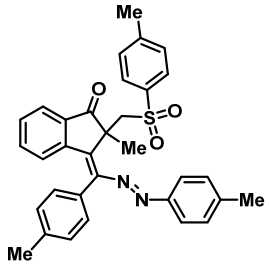
Red solid, mp 218-220 °C; ^{1}HNMR (400 MHz, $CDCl_3$; δ, ppm) 7.82-7.78 (m, 1H), 7.65 (d, J = 8.8 Hz, 2H), 7.54–7.50 (m, 5H), 7.33 (d, J = 2.8 Hz, 1H), 7.14 (d, J = 2.8 Hz, 1H), 7.08 (d, J = 2.4 Hz, 1H), 6.96 (d, J = 9.2 Hz, 2H), 6.78 (d, J = 8.8 Hz, 2H), 5.92-5.88 (m, 1H), 4.57 (d, J = 13.6 Hz, 1H), 4.13 (d, J = 14.0 Hz, 1H), 3.88 (s, 3H), 3.81 (s, 3H), 1.70 (s, 3H). ^{13}CNMR (100 MHz, $CDCl_3$; δ, ppm) 202.5, 168.0($^{1}J_{CF}$ = 262.3 Hz), 165.5, 163.5, 162.4, 151.8, 149.5 ($^{5}J_{CF}$ = 10.9 Hz), 149.4, 147.8, 141.4 ($^{6}J_{CF}$ = 3.6Hz), 141.3, 134.7, 132.4, 131.9, 130.0(1), 130.0(2), 129.4, 129.3, 128.7, 126.4($^{4}J_{CF}$ = 10.5 Hz), 126.3, 125.0, 118.1($^{2}J_{CF}$ = 24.4 Hz), 117.9, 114.4, 114.1, 113.4 ($^{3}J_{CF}$ =25.4 Hz), 113.1, 63.5, 55.7, 55.6(2), 51.6, 26.4. IR (KBr, ν, cm^{-1}): 2870, 1733, 1583, 1458, 1308, 1044, 836, 512. HRMS (APCI-TOF): m/z calcd for: $C_{32}H_{28}FN_2O_5S$, 571.1703 $[M+H]^+$; found: 571.1713.

(Z)-5-chloro-3-((4-methoxyphenyl)((E)-(4-methoxyphenyl)diazenyl)methylene)-2-(((4-methoxyphenyl)sulfonyl)methyl)-2-methyl-2,3-dihydro-1H-inden-1-one (4q)



Red solid, mp 158-160°C; ^{1}HNMR (400 MHz, $CDCl_3$; δ, ppm) 7.73 (d, J = 8.0 Hz, 1H), 7.67–7.64 (m, 2H), 7.51 (d, J = 8.8 Hz, 2H), 7.35 (d, J =1.6 Hz, 1H), 7.25–7.22 (m, 1H), 7.06 (d, J = 2.0 Hz, 2H), 6.97 (d, J = 8.8 Hz, 2H), 6.87 (d, J = 8.4 Hz, 1H), 6.78 (d, J = 8.8 Hz, 2H), 6.36 (d, J = 1.6 Hz, 1H), 4.55 (s, 1H), 4.12 (d, J = 14.0 Hz, 1H), 3.91 (s, 3H), 3.88 (s, 3H), 3.81 (s, 3H), 1.67 (s, 3H). ^{13}CNMR (100 MHz, $CDCl_3$; δ, ppm) 203.1, 163.5, 162.4, 160.0, 151.5, 148.5, 147.8, 141.4, 141.3, 134.2, 131.9, 131.4, 130.8, 130.1(1), 130.1(2), 130.0, 129.8, 126.9, 126.6, 125.2, 125.0, 114.6, 114.4, 114.2, 114.1, 63.6, 55.7, 55.6, 55.4, 51.5, 26.3. IR (KBr, ν, cm^{-1}): 2994, 1717, 1593, 1498, 1318, 1094, 846, 525. HRMS (APCI-TOF): m/z calcd for: $C_{33}H_{30}ClN_2O_6S$, 617.1513 $[M+H]^+$; found: 617.1513.

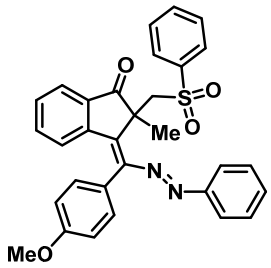
(Z)-2-methyl-3-(p-tolyl((E)-p-tolyldiazenyl)methylene)-2-(tosylmethyl)-2,3-dihydro-1H-inden-1-one (4r)



Orange solid, mp 152-154 °C; ^{1}HNMR (400 MHz, $CDCl_3$; δ, ppm) 7.81 (d, J = 7.6 Hz, 1H), 7.54 (d, J = 8.0 Hz, 2H), 7.47-7.39 (m, 3H), 7.35-7.28 (m, 3H), 7.24 (s, 2H), 7.13-7.08 (m, 3H), 7.04 (s, 1H), 6.43 (d, J = 8.0 Hz, 1H), 4.63 (d, J = 13.6 Hz, 1H), 4.15 (d, J = 13.6 Hz, 1H), 2.48 (s, 3H), 2.42 (s, 3H), 2.37 (s, 3H), 1.69 (s, 3H). ^{13}CNMR (100 MHz, $CDCl_3$; δ, ppm) 204.1, 151.6, 151.0, 146.8, 144.2, 143.6, 141.6, 138.2, 137.4, 136.1, 134.8,

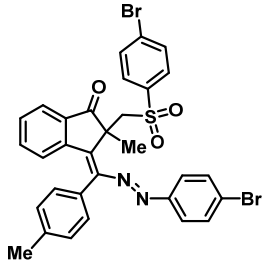
131.8, 130.1, 130.0, 129.8, 130.0, 129.5, 129.4, 127.9, 130.0, 124.2, 122.9, 63.3, 51.3, 26.5, 21.6(1), 21.6(2), 21.5. IR (KBr, ν, cm^{-1}): 2984, 1717, 1596, 1470, 1290, 1088, 834, 552. HRMS (APCI-TOF): m/z calcd for: $C_{33}H_{31}N_2O_3S$, 535.2055 $[M+H]^+$; found: 535.2075

(Z)-3-((4-methoxyphenyl)((E)-phenyldiazenyl)methylene)-2-methyl-2-((phenylsulfonyl)methyl)-2,3-dihydro-1H-inden-1-one (4s)



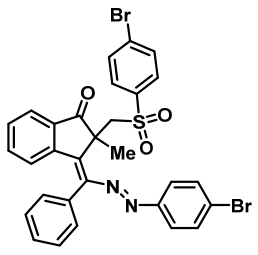
Red solid, mp 202-204 °C; ^{1}HNMR (400 MHz, $CDCl_3$; δ, ppm) 7.84 (d, J = 7.6Hz, 1H), 7.68–7.59 (m, 4H), 7.54-7.41 (m, 5H), 7.39-7.31 (m, 3H), 7.25 (d, J = 10.4 Hz, 1H), 7.10 (d, J = 7.6 Hz, 1H), 7.04 (d, J = 8.8 Hz, 2H), 6.53 (d, J = 8.0 Hz, 1H), 4.63 (d, J = 14.0 Hz, 1H), 4.18 (d, J = 14.0 Hz, 1H), 3.91 (s, 3H), 1.71 (s, 3H). ^{13}CNMR (100 MHz, $CDCl_3$; δ, ppm) 204.0, 159.8, 153.3, 150.8, 146.8, 144.6, 140.4, 136.0, 134.9, 133.4, 131.6, 131.0, 130.3, 129.2, 128.9, 127.8, 127.1, 126.8, 124.3, 122.9, 114.4, 114.3, 63.2, 55.3, 51.4, 26.4. IR (KBr, ν, cm^{-1}): 2969, 1719, 1593, 1472, 1319, 1086, 866, 531. HRMS (APCI-TOF): m/z calcd for: $C_{31}H_{27}N_2O_4S$, 523.1692 $[M+H]^+$; found: 523.1683.

(Z)-3-(((E)-(4-bromophenyl)diazenyl)(p-tolyl)methylene)-2-(((4-bromophenyl)sulfonyl)methyl)-2-methyl-2,3-dihydro-1H-inden-1-one (4t)



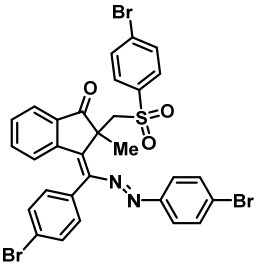
Orange solid, mp 178-180 °C; ^{1}HNMR (400 MHz, $CDCl_3$; δ, ppm) 7.81 (d, J = 7.6 Hz, 1H), 7.62–7.59 (m, 2H), 7.52–7.49 (m, 2H), 7.48–7.40 (m, 6H), 7.379-7.306 (m, 3H), 7.16 (d, J = 8.0 Hz, 1H), 7.04 (d, J = 8.0 Hz, 1H), 4.52 (d, J = 14.0 Hz, 1H), 4.18 (d, J = 14.0 Hz, 1H), 2.49 (s, 3H), 1.69 (s, 3H). ^{13}CNMR (100 MHz, $CDCl_3$; δ, ppm) 203.6, 152.1, 151.2, 146.6, 144.8, 139.2, 138.6, 136.0, 135.0, 132.5, 132.2, 131.4, 130.5, 130.1, 129.9, 129.5, 129.4, 128.9, 127.2, 125.4, 124.4, 124.2, 63.4, 51.3, 26.5, 21.6. IR (KBr, ν, cm^{-1}): 2910, 1714, 1589, 1464, 1302, 1074, 834, 564. HRMS (APCI-TOF): m/z calcd for: $C_{31}H_{25}Br_2N_2O_3S$, 664.9932 $[M+H]^+$; found: 664.9911.

(Z)-3-(((E)-(4-bromophenyl)diazenyl)(phenyl)methylene)-2-(((4-bromophenyl)sulfonyl)methyl)-2-methyl-2,3-dihydro-1H-inden-1-one (4u)



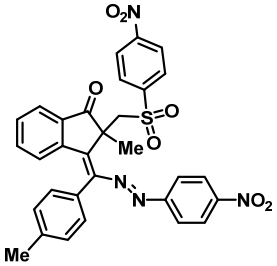
Orange solid, mp 178-180 °C; ^{1}HNMR (400 MHz, $CDCl_3$; δ, ppm) 7.81 (d, J = 7.6 Hz, 1H), 7.62–7.59 (m, 2H), 7.54-7.50 (m, 5H), 7.47–7.43 (m, 5H), 7.36-7.31 (m, 2H), 7.18-7.15 (m, 1H), 6.38 (d, J = 8.4 Hz, 1H), 4.52 (d, J = 14.0 Hz, 1H), 4.19 (d, J = 14.0 Hz, 1H), 1.70 (s, 3H). ^{13}CNMR (100 MHz, $CDCl_3$; δ, ppm) 203.3, 151.9, 149.9, 146.0, 145.2, 139.1, 136.0, 135.2, 133.5, 132.7, 132.6, 132.3, 132.0(1), 132.0(2), 131.5, 130.8, 129.4, 129.0, 127.0, 125.8, 124.6, 124.2, 123.1, 63.3, 51.4, 26.3. IR (KBr, ν, cm^{-1}): 2958, 1722, 1583, 1497, 1316, 1053, 816, 538. HRMS (APCI-TOF): m/z calcd for: $C_{30}H_{23}Br_2N_2O_3S$, 650.9776 $[M+H]^+$; found: 650.9777.

(Z)-3-((4-bromophenyl)((E)-(4-bromophenyl)diazenyl)methylene)-2-(((4-bromophenyl)sulfonyl)methyl)-2-methyl-2,3-dihydro-1H-inden-1-one (4v)



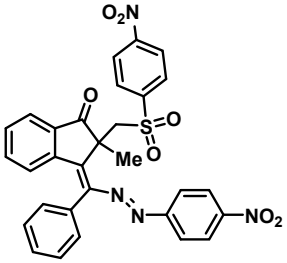
Red solid, mp 135-137 °C; ^{1}HNMR (400 MHz, $CDCl_3$; δ, ppm) 7.83 (d, J = 7.6 Hz, 1H), 7.67-7.60 (m, 4H), 7.53–7.40 (m, 8H), 7.25–7.22 (m, 1H), 7.08–7.05 (m, 1H), 6.53 (d, J = 8.0 Hz, 1H), 4.47 (d, J = 13.6 Hz, 1H), 4.16 (d, J = 13.6 Hz, 1H), 1.69 (s, 3H). ^{13}CNMR (100 MHz, $CDCl_3$; δ, ppm) 203.3, 151.9, 149.9, 146.0, 145.2, 139.1, 136.0, 135.2, 133.5, 132.7, 132.6, 132.3, 132.0, 131.9, 131.5, 130.8, 129.4, 129.0, 127.0, 125.8, 124.6, 124.2, 123.1, 63.3, 51.4, 26.3. IR (KBr, ν, cm^{-1}): 2927, 1717, 1595, 1434, 1305, 1099, 835, 519. HRMS (APCI-TOF): m/z calcd for: $C_{30}H_{22}Br_3N_2O_3S$, 728.8881 $[M+H]^+$; found: 728.8882.

(Z)-2-methyl-3-(((E)-(4-nitrophenyl)diazenyl)(p-tolyl)methylene)-2-(((4-nitrophenyl)sulfonyl)methyl)-2,3-dihydro-1H-inden-1-one (4w)



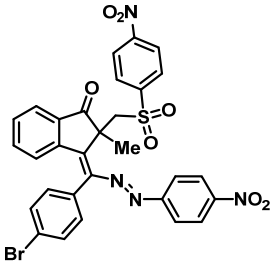
Orange solid, mp 163-164 °C; ^{1}HNMR (400 MHz, $CDCl_3$; δ, ppm) 7.81 (d, J = 7.2 Hz, 1H), 7.63–7.58 (m, 2H), 7.53–7.48 (m, 2H), 7.48–7.40 (m, 5H), 7.39-7.29 (m, 3H), 7.17 (s, 1H), 7.04 (d, J = 8.0 Hz, 1H), 6.46 (d, J = 8.0 Hz, 1H), 4.52 (d, J = 14.0 Hz, 1H), 4.18 (d, J = 13.6 Hz, 1H), 2.49 (s, 3H), 1.69 (s, 3H). ^{13}CNMR (100 MHz, $CDCl_3$; δ, ppm) 203.6, 152.3, 151.2, 146.5, 144.8, 139.1, 138.6, 136.0, 135.0, 132.5, 132.2, 131.3, 130.5, 130.1, 129.9, 129.5, 129.4, 128.9, 127.2, 125.5, 124.4, 124.2, 63.4, 51.3, 26.5, 21.6. IR (KBr, ν, cm^{-1}): 2923, 1713, 1596, 1468, 1294, 1066, 816, 523. HRMS (APCI-TOF): m/z calcd for: $C_{31}H_{25}N_4O_7S$, 597.1444 $[M+H]^+$; found: 597.1456.

(Z)-2-methyl-3-(((E)-(4-nitrophenyl)diazenyl)(phenyl)methylene)-2-(((4-nitrophenyl)sulfonyl)methyl)-2,3-dihydro-1H-inden-1-one (4x)



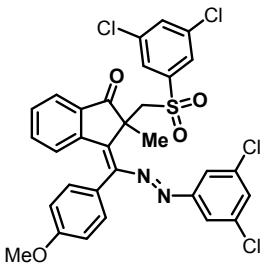
Red solid, mp 238-239 ºC; ^{1}HNMR (400 MHz, $CDCl_3$; δ, ppm) 8.35 (d, J = 8.8 Hz, 2H), 8.23 (d, J = 8.8 Hz, 2H), 7.86–7.75 (m, 5H), 7.59–7.54 (m, 3H), 7.49 (s, 1H), 7.4 –7.37 (m, 2H), 7.22 (s, 1H), 6.46 (d, J = 8.4 Hz, 1H), 4.53 (d, J = 14.0 Hz, 1H), 4.27 (d, J = 13.6 Hz, 1H), 1.73 (s, 3H). ^{13}CNMR (100 MHz, $CDCl_3$; δ, ppm) 203.6, 152.1, 151.2, 146.6, 144.8, 139.2, 138.6, 136.0, 135.0, 132. 5, 132.2, 131.4, 130.5, 130.1, 129.9, 129.5, 129.4, 128.9, 127.2, 125.5, 124.4, 124.2, 63.4, 51.3, 26.5, 21.6. IR (KBr, ν, cm^{-1}): 2963, 1717, 1598, 1465, 1315, 1073, 866, 517. HRMS (APCI-TOF): m/z calcd for: $C_{30}H_{23}N_4O_7S$, 583.1287 $[M+H]^+$; found: 583.1281.

(Z)-3-((4-bromophenyl)((E)-(4-nitrophenyl)diazenyl)methylene)-2-methyl-2-(((4-nitrophenyl)sulfonyl)methyl)-2,3-dihydro-1H-inden-1-one (4y)



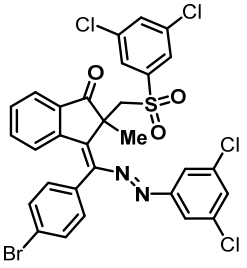
Orange solid, mp 180-182 ºC. ^{1}HNMR (400 MHz, $CDCl_3$; δ, ppm) 7.83 (d, J = 7.6 Hz, 1H), 7.69-7.59 (m, 5H), 7.53–7.48 (m, 4H), 7.46–7.39 (m, 3H), 7.25–7.22 (m, 1H), 7.07 (d, J = 7.2 Hz, 1H), 6.53 (d, J = 8.0 Hz, 1H), 4.47 (d, J = 13.6 Hz, 1H), 4.16 (d, J = 13.6 Hz, 1H), 1.69 (s, 3H). ^{13}CNMR (100 MHz, $CDCl_3$; δ, ppm) 203.1, 160.0, 154.5, 151.0, 146.7, 146.2, 143.1, 136.2, 135.9, 135.8, 135.3, 133.7, 131.4, 131.1, 130.8, 130.2, 127.5, 126.2, 126.0, 124.5, 121.2, 114.7, 114.6, 63.2, 55.3, 51.4, 26.5. IR (KBr, ν, cm^{-1}): 2910, 1717, 1593, 1457, 1310, 1087, 833, 569. HRMS (APCI-TOF): m/z calcd for: $C_{30}H_{22}BrN_4O_7S$, 661.0393 $[M+H]^+$; found: 661.0386.

(Z)-3-(((E)-(3,5-dichlorophenyl)diazenyl)(4-methoxyphenyl)methylene)-2-(((3,5-dichlorophenyl)sulfonyl)methyl)-2-methyl-2,3-dihydro-1H-inden-1-one (4z)



Red solid, mp 223-225 ºC; ^{1}HNMR (400 MHz, $CDCl_3$; δ, ppm) 7.88 (d, J = 7.6 Hz, 1H), 7.52 (s, 3H), 7.50 (d, J = 1.6 Hz, 3H), 7.44 -7.40 (m, 2H), 7.24 (s, 1H), 7.08–7.04 (m, 3H), 6.57 (d, J = 8.4 Hz, 1H), 4.49 (d, J = 14.0 Hz, 1H), 4.22 (d, J = 13.6 Hz, 1H), 3.92 (s, 3H), 1.69 (s, 3H). ^{13}CNMR (100 MHz, $CDCl_3$; δ, ppm) 203.6, 152.1, 151.2, 146.5, 144.8, 139.1, 138.4, 136.0, 135.0, 132.5, 132.2, 131.3, 130.5, 130.1, 129.9, 129.5, 129.4, 128.9, 127.2, 125.5, 124.4, 124.2, 63.4, 51.3, 26.5, 21.6. IR (KBr, ν, cm^{-1}): 2868, 1716, 1586, 1492, 1317, 1012, 857, 519. HRMS (APCI-TOF): m/z calcd for: $C_{31}H_{23}Cl_4N_2O_4S$, 661.0103 $[M+H]^+$; found: 661.0089.

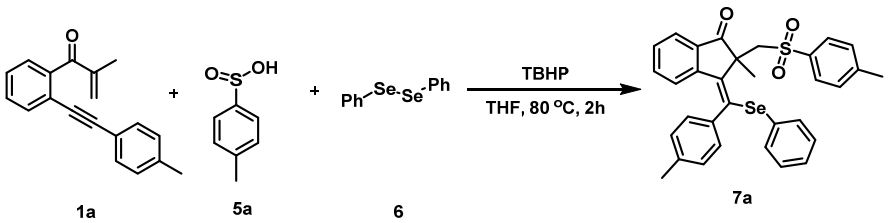
(Z)-3-((4-bromophenyl)((E)-(3,5-dichlorophenyl)diazenyl)methylene)-2-(((3,5-dichlorophenyl)sulfonyl)methyl)-2-methyl-2,3-dihydro-1H-inden-1-one (4aa)



Red solid, mp 213-215 °C; ^{1}HNMR (400 MHz, $CDCl_3$; δ, ppm) 7.89 (d, J = 7.2 Hz, 1H), 7.55-7.49 (m, 8H), 7.46–7.42 (m, 2H), 7.33–7.30 (m, 1H), 7.14–7.11 (m, 1H), 6.56 (d, J = 8.0 Hz, 1H), 4.46 (d, J = 14.0 Hz, 1H), 4.22 (d, J = 13.6 Hz, 1H), 1.70 (s, 3H). ^{13}CNMR (100 MHz, $CDCl_3$; δ, ppm) 203.6, 152.1, 151.2, 146.5, 144.8, 139.1, 138.6, 136.0, 135.0, 132.5, 132.2, 131.3, 130.5, 130.1, 129.9, 129.5, 129.4, 128.9, 127.2, 125.5, 124.37, 124.2, 63.4, 51.3, 26.5, 21.6. IR (KBr, ν, cm^{-1}): 2980, 1716, 1587, 1497, 1313, 1085, 834, 575. HRMS (APCI-TOF): m/z calcd for: $C_{30}H_{20}BrCl_4N_2O_3S$, 706.9132 $[M+H]^+$; found: 706.9154.

General procedure for the synthesis of compound 7a

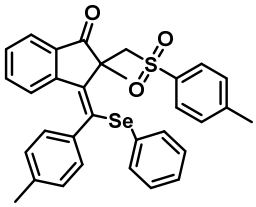
Example for the synthesis of **7a**:



1a 5a 6 7a

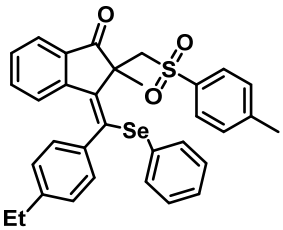
Under air conditions, β-alkynyl propenone **1a** (0.2 mmol, 52 mg) 4-methylbenzenesulfinic acid (**5a**, 0.4 mmol, 62.4 mg), and diphenyl diselenide (**6**, 0.1 mmol, 31.2 mg) were added into 10-mL reaction tube. Then, tert-butyl hydroperoxide (70% aq, 0.6 mmol, 77 mg) and THF (2.0 mL) were added into the reaction system. The mixture was stirred for 2 h at 80 °C. After completion of the reaction (TLC monitored), The solution was evaporated under vaccum. The residue was purified by column chromatography on silica gel (the eluent, petroleum ether/ethyl acetate = 15:1) to afford the desired product **7a**.

(Z)-2-methyl-3-((phenylselanyl)(p-tolyl)methylene)-2-(tosylmethyl)-2,3-dihydro-1H-inden-1-one (7a)



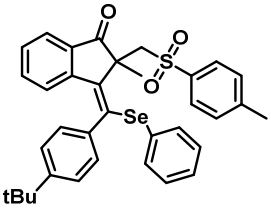
White solid: mp 186-188 °C; ^{1}H NMR (400 MHz, $CDCl_3$; δ, ppm) 7.73-7.68 (m, 3H), 7.45 (d, J = 7.2 Hz, 2H), 7.28 (s, 1H), 7.25-7.06 (m, 7H), 7.03-6.96 (m, 3H), 6.39 (d, J = 8.0 Hz, 1H), 5.02 (d, J = 14.4 Hz, 1H), 3.93 (d, J = 14.4 Hz, 1H), 2.43 (s, 3H), 2.30 (s, 3H), 1.63 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$; δ, ppm) 205.2, 148.6, 144.4, 137.7(1), 137.7(2), 137.6, 137.0, 136.2, 135.7, 134.9, 134.7, 130.0, 129.6, 129.3, 129.0, 128.6, 128.5, 128.3(1), 128.3(2), 128.1, 128.0, 128.0, 127.9, 125.5, 123.9, 60.2, 52.1, 24.6, 21.6, 21.3. IR (KBr, ν, cm^{-1}): 2975, 1727, 1575, 1475, 1316, 1086, 841, 570. HRMS (APCI -TOF): m/z calcd for: $C_{32}H_{28}NaO_3SSe$, 595.0822 $[M+Na]^+$; found: 595.0822.

(Z)-3-((4-ethylphenyl)(phenylselanyl)methylene)-2-methyl-2-(tosylmethyl)-2,3-dihydro-1H-inden-1-one (7b)



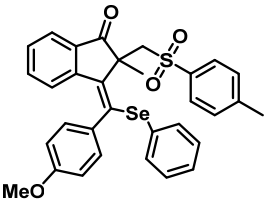
White solid: mp 158-159 °C; ^{1}H NMR (400 MHz, $CDCl_3$; δ, ppm) 7.71-7.66 (m, 3H), 7.43-7.39 (m, 2H), 7.23 (d, J = 7.6 Hz, 3H), 7.20-7.12 (m, 3H), 7.08-7.04 (m, 2H), 7.00 (s, 2H), 6.95 (d, J = 8.0 Hz, 1H), 6.38 (d, J = 8.0 Hz, 1H), 5.01 (d, J = 14.0 Hz, 1H), 3.90 (d, J = 14.0 Hz, 1H), 2.59-2.54 (m, 2H), 2.41 (s, 3H), 1.61 (s, 3H), 1.17-1.14 (m, 3H). ^{13}C NMR (100 MHz, $CDCl_3$; δ, ppm) 205.2, 148.6, 144.4, 137.7(1), 137.7(2), 137.5, 137.0, 136.2, 135.7, 134.9, 134.7, 130.0, 129.6, 129.3, 129.0, 128.6, 128.5, 128.3, 128.3, 128.1, 128.0, 128.0, 127.9, 125.5, 123.9, 60.2, 52.1, 24.6, 21.6, 21.3. IR (KBr, ν, cm^{-1}): 2961, 1709, 1571, 1467, 1321, 1088, 852, 574. HRMS (APCI -TOF): m/z calcd for: $C_{33}H_{30}NaO_3SSe$, 609.0979 $[M+Na]^+$; found: 609.0973.

(Z)-3-((4-(tert-butyl)phenyl)(phenylselanyl)methylene)-2-methyl-2-(tosylmethyl)-2,3-dihydro-1H-inden-1-one (7c)



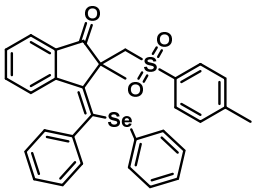
White solid: mp 180-182 °C; ^{1}H NMR (400 MHz, $CDCl_3$; δ, ppm) 7.70-7.66 (m, 3H), 7.40-7.35 (m, 2H), 7.22 (d, J = 8.0 Hz, 3H), 7.20-7.15 (m, 3H), 7.13-7.09 (m, 2H), 7.05-6.98 (m, 3H), 6.43 (d, J = 8.0 Hz, 1H), 5.01 (d, J = 14.4 Hz, 1H), 3.91 (d, J = 14.4 Hz, 1H), 2.40 (s, 3H), 1.60 (s, 3H), 1.25 (s, 9H). ^{13}C NMR (100 MHz, $CDCl_3$; δ, ppm) 205.2, 151.0, 148.7, 144.4, 138.1, 137.6, 137.0, 136.8, 136.2, 135.4, 134.8, 134.7, 129.7, 129.6, 129.5, 128.4, 128.3, 128.2, 128.1(1), 128.1(2), 128.1(3), 128.0, 127.9, 125.4(1), 125.4(2), 125.1, 123.9, 60.1, 52.0, 34.5, 31.3(1), 31.3(2), 24.6, 21.7. IR (KBr, ν, cm^{-1}): 2960, 1716, 1574, 1469, 1313, 1086, 816, 573. HRMS (APCI -TOF): m/z calcd for: $C_{35}H_{34}NaO_3SSe$, 637.1292 $[M+Na]^+$; found: 637.1246.

(Z)-3-((4-methoxyphenyl)(phenylselanyl)methylene)-2-methyl-2-(tosylmethyl)-2,3-dihydro-1H-inden-1-one (7d)



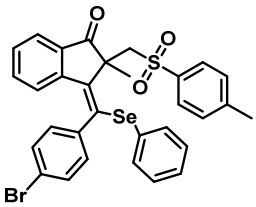
Yellow solid: mp 190-192 °C; ^{1}H NMR (400 MHz, $CDCl_3$; δ, ppm) 7.72-7.66 (m, 3H), 7.47-7.43 (m, 2H), 7.28-7.26 (m, 1H), 7.25-7.16 (m, 4H), 7.15-7.05 (m, 4H), 6.74-6.67 (m, 2H), 6.41 (d, J = 8.0 Hz, 1H), 5.02 (d, J = 14.4 Hz, 1H), 3.89 (d, J = 14.4 Hz, 1H), 3.75 (s, 3H), 2.41 (s, 3H), 1.59 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$; δ, ppm) 205.2, 148.6, 144.4, 137.7(1), 137.7(2), 137.6, 137.0, 136.2, 135.7, 134.9, 134.7, 130.0, 129.6, 129.3, 129.0, 128.6, 128.5, 128.3(1), 128.3(2), 128.1, 128.0, 127.97, 127.9, 125.5, 123.9, 60.2, 52.1, 24.6, 21.6, 21.3. IR (KBr, ν, cm^{-1}): 2973, 1724, 1565, 1475, 1314, 1086, 854, 569. HRMS (APCI -TOF): m/z calcd for: $C_{32}H_{28}NaO_4SSe$, 611.0771 $[M+Na]^+$; found: 617.0768.

(Z)-2-methyl-3-(phenyl(phenylselanyl)methylene)-2-(tosylmethyl)-2,3-dihydro-1H-inden-1-one (7e)



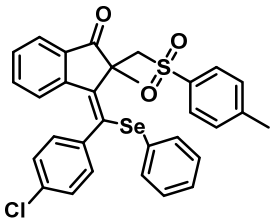
White solid: mp 155-156 ºC; ^{1}H NMR (400 MHz, $CDCl_3$; δ, ppm) 7.74-7.65 (m, 3H), 7.45 (d, J = 7.2 Hz, 2H), 7.32-7.30 (m, 1H), 7.26-7.11 (m, 9H), 7.09-7.06 (m, 2H), 6.30 (d, J = 8.4 Hz, 1H), 5.03 (d, J = 14.0 Hz, 1H), 3.92 (d, J = 14.0 Hz, 1H), 2.41 (d, J = 5.6 Hz, 3H), 1.62 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$; δ, ppm) 205.1, 148.4, 144.5, 139.9, 137.6, 137.5, 136.0, 134.9, 134.7, 130.1, 129.7, 128.6(1), 128.6(2), 128.4(1), 128.4(2), 128.2, 128.1, 128.0, 127.9, 125.4, 123.9, 60.1, 52.1, 24.6, 21.7. IR (KBr, ν, cm^{-1}): 2974, 1719, 1595, 1467, 1316, 1086, 847, 571. HRMS (APCI -TOF): m/z calcd for: $C_{31}H_{26}NaO_3SSe$, 581.0666 $[M+Na]^+$; found: 581.0667.

(Z)-3-((4-bromophenyl)(phenylselanyl)methylene)-2-methyl-2-(tosylmethyl)-2,3-dihydro-1H-inden-1-one (7f)



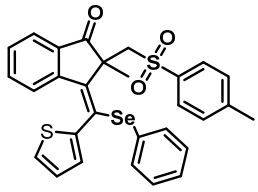
Yellow solid: mp 181-183 ºC; ^{1}H NMR (400 MHz, $CDCl_3$; δ, ppm) 7.75-7.71 (m, 1H), 7.67 (d, J = 8.4 Hz, 2H), 7.47-7.43 (m, 2H), 7.36-7.33 (m, 1H), 7.31-7.26 (m, 2H), 7.25-7.18 (m, 5H), 7.14-7.01 (m, 2H), 7.03-7.00 (m, 1H), 6.39 (d, J = 8.0 Hz, 1H), 4.99 (d, J = 14.0 Hz, 1H), 3.89 (d, J = 14.0 Hz, 1H), 2.42 (s, 3H), 1.60 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$; δ, ppm) δ 205.2, 148.6, 144.4, 137.7(1), 137.7(2), 137.6, 137.0, 136.2, 135.7, 134.9, 134.7, 130.0, 129.6, 129.3, 129.0, 128.6, 128.5, 128.3(1), 128.3(2), 128.1, 128.0, 127.97, 127.9, 125.5, 123.9, 60.2, 52.1, 24.6, 21.6, 21.3. IR (KBr, ν, cm^{-1}): 2970, 1714, 1574, 1467, 1313, 1069, 846, 570. HRMS (APCI -TOF): m/z calcd for: $C_{31}H_{25}BrNaO_3SSe$, 658.9771 $[M+Na]^+$; found: 658.9778.

(Z)-3-((4-chlorophenyl)(phenylselanyl)methylene)-2-methyl-2-(tosylmethyl)-2,3-dihydro-1H-inden-1-one (7g)



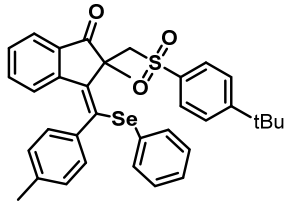
Yellow solid: mp 179-181 ºC; ^{1}H NMR (400 MHz, $CDCl_3$; δ, ppm) 7.75 (d, J = 6.8 Hz, 1H), 7.69 (d, J = 8.2 Hz, 2H), 7.49-7.45 (m, 2H), 7.32-7.28 (m, 4H), 7.25 (d, J = 0.8 Hz, 1H), 7.23-7.19 (m, 2H), 7.15-7.09 (m, 4H), 6.40 (d, J = 12.0 Hz, 1H), 5.02 (d, J = 14.0 Hz, 1H), 3.91 (d, J = 14.0 Hz, 1H), 2.44 (s, 3H), 1.62 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$; δ, ppm) 205.2, 148.6, 144.4, 137.7(1), 137.7(2), 137.6, 137.0, 136.2, 135.7, 134.9, 134.7, 130.0, 129.6, 129.3, 129.0, 128.6, 128.5, 128.3(1), 128.3(2), 128.1, 128.0(1), 128.0(2), 127.9, 125.5, 123.9, 60.2, 52.1, 24.6, 21.6, 21.3. IR (KBr, ν, cm^{-1}): 2961, 1725, 1595, 1476, 1319, 1082, 840, 568. HRMS (APCI -TOF): m/z calcd for: $C_{31}H_{25}ClNaO_3SSe$, 615.0276 $[M+Na]^+$; found: 615.0283.

(Z)-2-methyl-3-((phenylselanyl)(thiophen-2-yl)methylene)-2-(tosylmethyl)-2,3-dihydro-1H-inden-1-one (7h)



Yellow solid: mp 167-168 °C; ^{1}H NMR (400 MHz, $CDCl_3$; δ, ppm) 7.73-7.70 (m, 1H), 7.65 (d, J = 8.2 Hz, 2H), 7.52 (d, J = 7.2 Hz, 2H), 7.32-7.27 (m, 2H), 7.25-7.19 (m, 4H), 7.17-7.13 (m, 2H), 6.80-6.78 (m, 2H), 6.60-6.53 (m, 1H), 4.95 (d, J = 14.4 Hz, 1H), 3.92 (d, J = 14.4 Hz, 1H), 2.41 (s, 3H), 1.60 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$; δ, ppm) 205.2, 148.6, 144.4, 137.7(1), 137.7(2), 137.6, 137.0, 136.2, 135.7, 134.9, 134.7, 130.0, 129.6, 129.3, 129.0, 128.6, 128.5, 128.3(1), 1283(2), 128.1, 128.0, 128.0, 127.9, 125.5, 123.9, 60.2, 52.1, 24.6, 21.6, 21.3. IR (KBr, ν, cm^{-1}): 2966, 1723, 1574, 1475, 1321, 1083, 853, 571. HRMS (APCI -TOF): m/z calcd for: $C_{29}H_{24}NaO_3S_2Se$, 587.0230 $[M+Na]^+$; found: 587.0287.

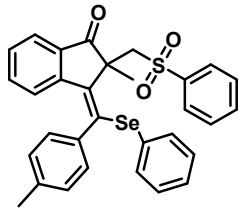
(Z)-2-(((4-(tert-butyl)phenyl)sulfonyl)methyl)-2-methyl-3-((phenylselanyl)(p-tolyl)methylene)-2,3-dihydro-1H-inden-1-one (7i)



White solid: mp 179-180 °C; ^{1}H NMR (400 MHz, $CDCl_3$; δ, ppm) 7.74 (d, J = 8.0 Hz, 2H), 7.60 (d, J = 8.0 Hz, 1H), 7.46 (d, J = 8.8 Hz, 5H), 7.34-7.32 (m, 1H), 7.17-7.13 (m, 4H), 7.11-7.07 (m, 3H), 6.01 (s, 1H), 4.99 (d, J = 14.0 Hz, 1H), 3.91 (d, J = 14.0 Hz, 1H), 2.03 (s, 3H), 1.62 (s, 3H), 1.34 (s, 9H). ^{13}C NMR (100 MHz, $CDCl_3$; δ, ppm) 204.7, 148.5, 138.3, 137.9, 137.7, 137.0, 136.0, 135.9, 134.8, 134.7, 134.6, 133.1, 131.8, 130.9, 129.8, 129.3, 129.1, 128.5, 128.3, 128.2, 128.1, 128.0, 127.1, 125.5, 123.84, 58.0, 51.8, 24.7, 21.3. IR (KBr, ν, cm^{-1}): 2966, 1717, 1575, 1474, 1317, 1085, 851, 578.

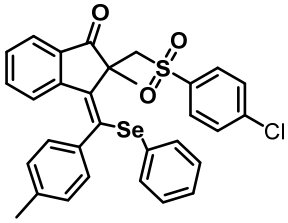
HRMS (APCI -TOF): m/z calcd for: $C_{35}H_{34}NaO_3SSe$, 637.1292 $[M+Na]^+$; found: 637.1316.

(Z)-2-methyl-3-((phenylselanyl)(p-tolyl)methylene)-2-((phenylsulfonyl)methyl)-2,3-dihydro-1H-inden-1-one (7j)



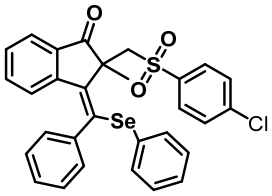
Yellow solid: mp 1148-149 °C; ^{1}H NMR (400 MHz, $CDCl_3$; δ, ppm) 7.83-7.80 (m, 2H), 7.74-7.70 (m, 1H), 7.58 (d, J = 7.6 Hz, 1H), 7.48-7.43 (m, 4H), 7.25-7.17 (m, 3H), 7.14 (d, J = 7.2 Hz, 1H), 7.10-7.06(m, 2H), 7.01 (s, 2H), 6.96 (d, J = 8.0 Hz, 1H), 6.38 (d, J = 8.4 Hz, 1H), 5.05 (d, J = 14.4 Hz, 1H), 3.92 (d, J = 14.0 Hz, 1H), 2.28 (s, 3H), 1.61 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$; δ, ppm) 205.2, 148.6, 144.4, 137.7(1), 137.7(2), 137.6, 137.0, 136.2, 135.7, 134.9, 134.7, 130.0, 129.6, 129.3, 129.0, 128.6, 128.5, 128.3(1), 128.3(2), 128.1, 128.0(1), 128.0(2), 127.9, 125.5, 123.9, 60.2, 52.1, 24.6, 21.6, 21.3. IR (KBr, ν, cm^{-1}): 2969, 1716, 1572, 1478, 1320, 1146, 826, 570. HRMS (APCI -TOF): m/z calcd for: $C_{31}H_{26}NaO_3SSe$, 581.0666 $[M+Na]^+$; found: 581.0646.

(Z)-2-(((4-chlorophenyl)sulfonyl)methyl)-2-methyl-3-((phenylselanyl)(p-tolyl)methylene)-2,3-dihydro-1H-inden-1-one (7k)



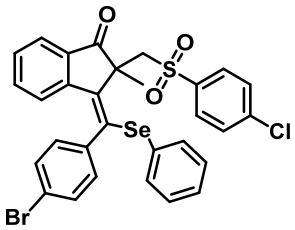
Yellow solid: mp 146-147 °C; ^{1}H NMR (400 MHz, $CDCl_3$; δ, ppm) 7.71-7.68 (m, 3H), 7.41 (d, J = 7.6 Hz, 4H), 7.22-7.12 (m, 4H), 7.10-7.06 (m, 2H), 7.01-6.95 (m, 3H), 6.36 (d, J = 8.0 Hz, 1H), 5.05 (d, J = 14.0 Hz, 1H), 3.93 (d, J = 14.0 Hz, 1H), 2.28 (s, 3H), 1.61 (d, J = 2.8 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$; δ, ppm) 205.2, 148.6, 144.4, 137.7(1), 137.7(2), 137.6, 137.0, 136.2, 135.7, 134.9, 134.7, 130.0, 129.6, 129.3, 129.0, 128.6, 128.5, 128.3(1), 128.3(2), 128.1, 128.0(1), 128.0(2), 127.9, 125.5, 123.9, 60.2, 52.1, 24.6, 21.6, 21.3. IR (KBr, ν, cm^{-1}): 2973, 1716, 1570, 1478, 1323, 1106, 856, 608. HRMS (APCI -TOF): m/z calcd for: $C_{31}H_{25}ClNaO_3SSe$, 615.0276 $[M+Na]^+$; found: 615.0291.

(Z)-2-(((4-chlorophenyl)sulfonyl)methyl)-2-methyl-3-(phenyl(phenylselanyl)methylene)-2,3-dihydro-1H-inden-1-one (7l)



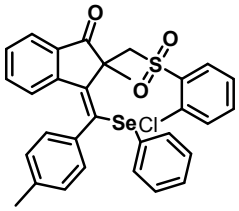
White solid: mp 193-195 °C; ^{1}H NMR (400 MHz, $CDCl_3$; δ, ppm) 7.73-7.69 (m, 3H), 7.45-7.40 (m, 4H), 7.27 (d, J = 2.4 Hz, 1H), 7.25-7.18 (m, 2H), 7.18-7.12 (m, 5H), 7.10-7.06 (m, 2H), 6.29 (d, J = 8.0 Hz, 1H), 5.07 (d, J = 14.0 Hz, 1H), 3.94 (d, J = 14.0 Hz, 1H), 1.62 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$; δ, ppm) 204.7, 148.5, 138.3, 137.9, 137.7, 137.0, 136.0, 135.9, 134.8, 134.7, 134.6, 133.1, 131.8, 130.9, 129.8, 129.3, 129.1, 128.5, 128.3, 128.2, 128.1, 128.0, 127.1, 125.5, 123.8, 58.0, 51.8, 24.7, 21.3. IR (KBr, ν, cm^{-1}): 2968, 1716, 1574, 1474, 1318, 1086, 845, 592. HRMS (APCI -TOF): m/z calcd for: $C_{30}H_{23}ClNaO_3SSe$, 601.0119 $[M+Na]^+$; found: 601.0119.

(Z)-3-((4-bromophenyl)(phenylselanyl)methylene)-2-(((4-chlorophenyl)sulfonyl)methyl)-2-methyl-2,3-dihydro-1H-inden-1-one (7m)



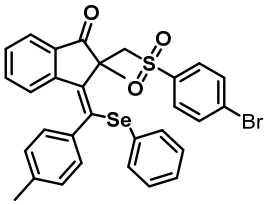
Yellow solid: mp 175-176 °C; ^{1}H NMR (400 MHz, $CDCl_3$; δ, ppm) 7.72-7.69 (m, 3H), 7.44-7.40 (m, 4H), 7.36-7.34 (m, 1H), 7.31-7.27 (m, 2H), 7.24 (d, J = 0.8 Hz, 1H), 7.20-7.15 (m, 2H), 7.14-7.10 (m, 2H), 7.03-7.00 (m, 1H), 6.39 (d, J = 8.0 Hz, 1H), 5.03 (d, J = 14.0 Hz, 1H), 3.91 (d, J = 14.4 Hz, 1H), 1.60 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$; δ, ppm) 205.2, 148.6, 144.4, 137.7(1), 137(2), 137.6, 137.0, 136.2, 135.7, 134.9, 134.65, 130.0, 129.6, 129.3, 129.0, 128.6, 128.5, 128.3(1), 128.3(2), 128.1, 128.0, 128.0, 127.9, 125.5, 123.9, 60.2, 52.1, 24.6, 21.6, 21.3. IR (KBr, ν, cm^{-1}): 2962, 1713, 1576, 1475, 1315, 1085, 846, 574. HRMS (APCI -TOF): m/z calcd for: $C_{30}H_{22}NaO_3SSe$, 678.9224 $[M+Na]^+$; found: 678.9241.

(Z)-2-(((2-chlorophenyl)sulfonyl)methyl)-2-methyl-3-((phenylselanyl)(p-tolyl)methylene)-2,3-dihydro-1H-inden-1-one (7n)



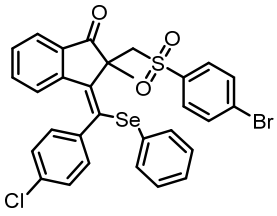
White solid: mp 152-153 °C; ^{1}H NMR (400 MHz, $CDCl_3$; δ, ppm) 7.78-7.76 (m, 1H), 7.69-7.65 (m, 1H), 7.55-7.48 (m, 2H), 7.44-7.40 (m, 2H), 7.26-7.20 (m, 2H), 7.20-7.12 (m, 3H), 7.08-7.04 (m, 2H), 7.01 (s, 2H), 6.93 (d, J = 7.6 Hz, 1H), 6.36 (d, J = 8.0 Hz, 1H), 5.42 (d, J = 14.4 Hz, 1H), 4.13 (d, J = 14.4 Hz, 1H), 2.27 (s, 3H), 1.65 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$; δ, ppm) 204.7, 148.5, 138.3, 137.9, 137.7, 137.0, 136.0, 135.9, 134.8, 134.7, 134.6, 133.1, 131.8, 130.9, 129.8, 129.3, 129.1, 128.5, 128.3, 128.2, 128.1, 128.0, 127.1, 125.5, 123.8, 58.0, 51.8, 24.7, 21.3. IR (KBr, ν, cm^{-1}): 2973, 1714, 1588, 1468, 1319, 1108, 851, 592. HRMS (APCI -TOF): m/z calcd for: $C_{31}H_{25}ClNaO_3SSe$, 615.0276 $[M+Na]^+$; found: 615.0284.

(Z)-2-(((4-bromophenyl)sulfonyl)methyl)-2-methyl-3-((phenylselanyl)(p-tolyl)methylene)-2,3-dihydro-1H-inden-1-one (7o)



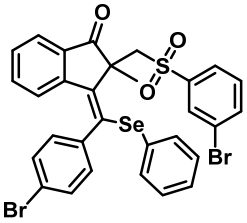
Yellow solid: mp 148-149 °C; ^{1}H NMR (400 MHz, $CDCl_3$; δ, ppm) 7.69-7.67 (m, 1H), 7.64-7.60 (m, 2H), 7.58-7.54 (m, 2H), 7.42-7.39 (m, 2H), 7.26-7.12 (m, 4H), 7.10-7.06 (m, 2H), 7.00-6.95 (m, 3H), 6.35 (d, J = 8.0 Hz, 1H), 5.04 (d, J = 14.0 Hz, 1H), 3.93 (d, J = 14.4 Hz, 1H), 2.28 (s, 3H), 1.61 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$; δ, ppm) 205.0, 148.6, 139.3, 138.1, 137.8, 136.9, 135.8, 135.7, 134.8(1), 134.8(2), 132.3, 129.8, 129.7, 129.4, 129.1, 128.9, 128.6, 128.3, 128.2, 128.1, 128.0, 125.5, 123.9, 60.2, 52.10, 24.6, 21.4. IR (KBr, ν, cm^{-1}): 2960, 1727, 1574, 1474, 1319, 1085, 850, 569. HRMS (APCI -TOF): m/z calcd for: $C_{31}H_{25}BrNaO_3SSe$, 658.9771 $[M+Na]^+$; found: 658.9772.

(Z)-2-(((4-bromophenyl)sulfonyl)methyl)-3-((4-chlorophenyl)(phenylselanyl)methylene)-2-methyl-2,3-dihydro-1H-inden-1-one (7p)



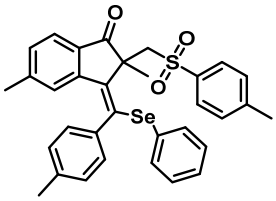
White solid: mp 173-175 °C; ^{1}H NMR (400 MHz, $CDCl_3$; δ, ppm) 7.73-7.71 (m, 1H), 7.65-7.62 (m, 2H), 7.60-7.56 (m, 2H), 7.44-7.42 (m, 2H), 7.31-7.28 (m, 1H), 7.25-7.16 (m, 4H), 7.14-7.07 (m, 4H), 6.38 (d, J = 8.0 Hz, 1H), 5.04 (d, J = 14.0 Hz, 1H), 3.92 (d, J = 14.0 Hz, 1H), 1.60 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$; δ, ppm) 204.6, 148.0, 139.3, 138.4, 136.5, 136.2, 135.9, 134.98, 134.9, 133.8, 132.4, 131.5, 129. 9, 129.6, 129.0, 128.9(1), 128.9(2), 128.7, 128.6, 128.5, 127.6, 125.2, 124.2, 59.9, 52.2, 24.5. IR (KBr, ν, cm^{-1}): 2971, 1723, 1573, 1476, 1316, 1086, 846, 567. HRMS (APCI -TOF): m/z calcd for: $C_{30}H_{22}BrClNaO_3SSe$, 678.9224 $[M+Na]^+$; found: 678.9243.

(Z)-3-((4-bromophenyl)(phenylselanyl)methylene)-2-(((3-bromophenyl)sulfonyl)methyl)-2-methyl-2,3-dihydro-1H-inden-1-one (7q)



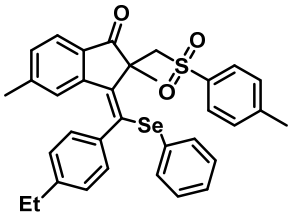
White solid: mp 172-174 °C; ^{1}H NMR (400 MHz, $CDCl_3$; δ, ppm) 7.89-7.88 (m, 1H), 7.77-7.71 (m, 3H), 7.46-7.31 (m, 5H), 7.30-7.27 (m, 2H), 7.21-7.09 (m, 4H), 7.04-7.02 (m, 1H), 6.40 (d, J = 12.0 Hz, 1H), 5.05 (d, J = 14.0 Hz, 1H), 3.92 (d, J = 14.4 Hz, 1H), 1.61 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$; δ, ppm) 204.7, 148.5, 138.3, 137.9, 137.7, 137.0, 136.0, 135.93, 134.8, 134.7, 134.6, 133.1, 131.8, 130.9, 129.8, 129.3, 129.1, 128.5, 128.3, 128.2, 128.1, 128.0, 127.1, 125.5, 123.84, 58.0, 51.8, 24.7, 21.3. IR (KBr, ν, cm^{-1}): 2970, 1716, 1570, 1478, 1320, 1098, 847, 599. HRMS (APCI -TOF): m/z calcd for: $C_{30}H_{22}Br_2NaO_3SSe$, 724.8699 [M+Na]$^+$; found: 724.8715.

(Z)-2,5-dimethyl-3-((phenylselanyl)(p-tolyl)methylene)-2-(tosylmethyl)-2,3-dihydro-1H-inden-1-one (7r)



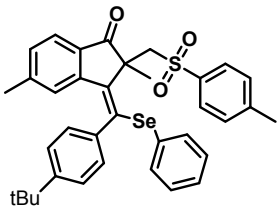
White solid: mp 210-211 °C; ^{1}H NMR (400 MHz, $CDCl_3$; δ, ppm) 7.68 (d, J = 8.0 Hz, 2H), 7.60 (d, J = 8.0 Hz, 1H), 7.45-7.43 (m, 2H), 7.24 (d, J = 8.0 Hz, 2H), 7.21-7.19 (m, 1H), 7.15-7.13 (m, 1H), 7.11-7.06 (m, 3H), 7.01-6.96 (m, 3H), 6.06 (s, 1H), 4.97 (d, J = 14.0 Hz, 1H), 3.88 (d, J = 14.0 Hz, 1H), 2.42 (s, 3H), 2.29 (s, 3H), 2.05 (s, 3H), 1.59 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$; δ, ppm) 204.5, 148.9, 145.5, 144.3, 137.7, 137.6, 137.2, 137.1, 136.4, 135.7, 132.8, 130.0, 129.6, 129.5, 129.2, 128.9, 128.6, 128.4, 128.3, 128.0, 127.9, 126.0, 123.67, 60.1, 52.3 24.7, 22.4, 21.6, 21.3. IR (KBr, ν, cm^{-1}): 2954, 1716, 1574, 1476, 1315, 1086, 851, 571. HRMS (APCI -TOF): m/z calcd for: $C_{33}H_{30}NaO_3SSe$, 609.0979 [M+Na]$^+$; found: 609.0940.

(Z)-3-((4-ethylphenyl)(phenylselanyl)methylene)-2,5-dimethyl-2-(tosylmethyl)-2,3-dihydro-1H-inden-1-one (7s)



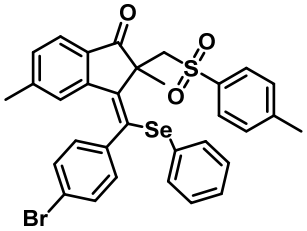
White solid: mp 157-158 °C; ^{1}H NMR (400 MHz, $CDCl_3$; δ, ppm) 7.68 (d, J = 8.4 Hz, 2H), 7.60 (d, J = 7.6 Hz, 1H), 7.46-7.41 (m, 2H), 7.25-7.18 (m, 3H), 7.13 (d, J = 7.2 Hz, 1H), 7.09-7.05 (m, 3H), 7.04-6.93 (m, 3H), 6.00 (s, 1H), 4.98 (d, J = 14.0 Hz, 1H), 3.89 (d, J = 14.0 Hz, 1H), 2.58-2.54 (m, 2H), 2.41 (s, 3H), 2.03 (s, 3H), 1.60 (s, 3H), 1.19-1.15 (m, 3H). ^{13}C NMR (100 MHz, $CDCl_3$; δ, ppm) 205.2, 148.6, 144.4, 137.7(1), 137.7(2), 137.6, 137.0, 136.2, 135.7, 134.9, 134.7, 130.0, 129.6, 129.3, 129.0, 128.6, 128.5, 128.3(1), 128.3(2), 128.1, 128.0(1), 128.0(2), 127.9, 125.5, 123.9, 60.2, 52.1, 24.6, 21.6, 21.3. IR (KBr, ν, cm^{-1}): 2960, 1705, 1577, 1477, 1314, 1087, 850, 571. HRMS (APCI -TOF): m/z calcd for: $C_{34}H_{32}NaO_3SSe$, 623.1135 [M+Na]$^+$; found: 623.1099.

(Z)-3-((4-(tert-butyl)phenyl)(phenylselanyl)methylene)-2,5-dimethyl-2-(tosylmethyl)-2,3-dihydro-1H-inden-1-one (7t)



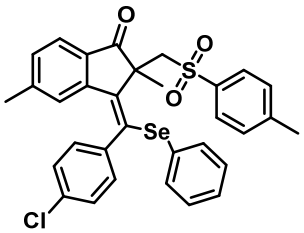
White solid: mp 172-173 °C; ^{1}H NMR (400 MHz, $CDCl_3$; δ, ppm) 7.69 (d, J = 8.0 Hz, 2H), 7.60 (d, J = 8.0 Hz, 1H), 7.45-7.42 (m, 2H), 7.28 (s, 1H), 7.24-7.18 (m, 4H), 7.16-7.12 (m, 1H), 7.10-7.06 (m, 3H), 7.02-6.99 (m, 1H), 5.97 (s, 1H), 4.98 (d, J = 14.0 Hz, 1H), 3.90 (d, J = 14.0Hz, 1H), 2.43 (s, 3H), 2.03 (s, 3H), 1.61 (s, 3H), 1.28 (s, 9H). ^{13}C NMR (100 MHz, $CDCl_3$; δ, ppm) 205.2, 148.6, 144.4, 137.7(1), 137.7(2), 137.6, 137.0, 136.2, 135.7, 134.9, 134.7, 130.0, 129.6, 129.3, 129.0, 128.6, 128.5, 128.3(1), 128.3(2), 128.1, 128.0(1), 128.0(2), 127.9, 125.5, 123.9, 60.2, 52.1, 24.6, 21.6, 21.3. IR (KBr, ν, cm^{-1}): 2963, 1723, 1572, 1466, 1316, 1084, 856, 577. HRMS (APCI -TOF): m/z calcd for: $C_{36}H_{36}NaO_3SSe$, 651.1448 $[M+Na]^+$; found:651.1432.

(Z)-3-((4-bromophenyl)(phenylselanyl)methylene)-2,5-dimethyl-2-(tosylmethyl)-2,3-dihydro-1H-inden-1-one (7u)



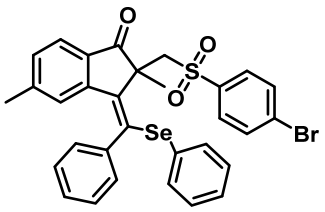
White solid: mp 175-177 °C; ^{1}H NMR (400 MHz, DMSO; δ, ppm) 7.59-7.57 (m, 3H), 7.52-7.49 (m, 1H), 7.49-7.46 (m, 1H), 7.42 (d, J = 8.4 Hz, 2H), 7.40-7.37 (m, 2H), 7.25-7.16 (m, 4H), 7.11-7.08 (m, 1H), 7.03-7.00 (m, 1H), 5.93 (s, 1H), 4.82 (d, J = 14.4 Hz, 1H), 3.89 (d, J = 14.4 Hz, 1H), 2.43 (s, 3H), 2.06 (s, 3H), 1.52 (s, 3H). ^{13}C NMR (100 MHz, DMSO; δ, ppm) 203.4, 148.1, 145.7, 145.1, 139.6, 138.1, 137.6, 135.3, 134.4, 133.2, 132.0, 131.9, 131.7, 131.1, 130.5, 130.4, 129.5, 128.7, 128.2, 127.9, 125.6, 124.1, 121.6, 60.4, 52.2, 24.3, 22.5, 21.6. IR (KBr, ν, cm^{-1}): 2962, 1716, 1570, 1477, 1320, 1145, 826, 570. HRMS (APCI -TOF): m/z calcd for: $C_{32}H_{27}BrNaO_3SSe$, 672.9927 $[M+Na]^+$; found: 672.9922.

(Z)-3-((4-chlorophenyl)(phenylselanyl)methylene)-2,5-dimethyl-2-(tosylmethyl)-2,3-dihydro-1H-inden-1-one (7v)

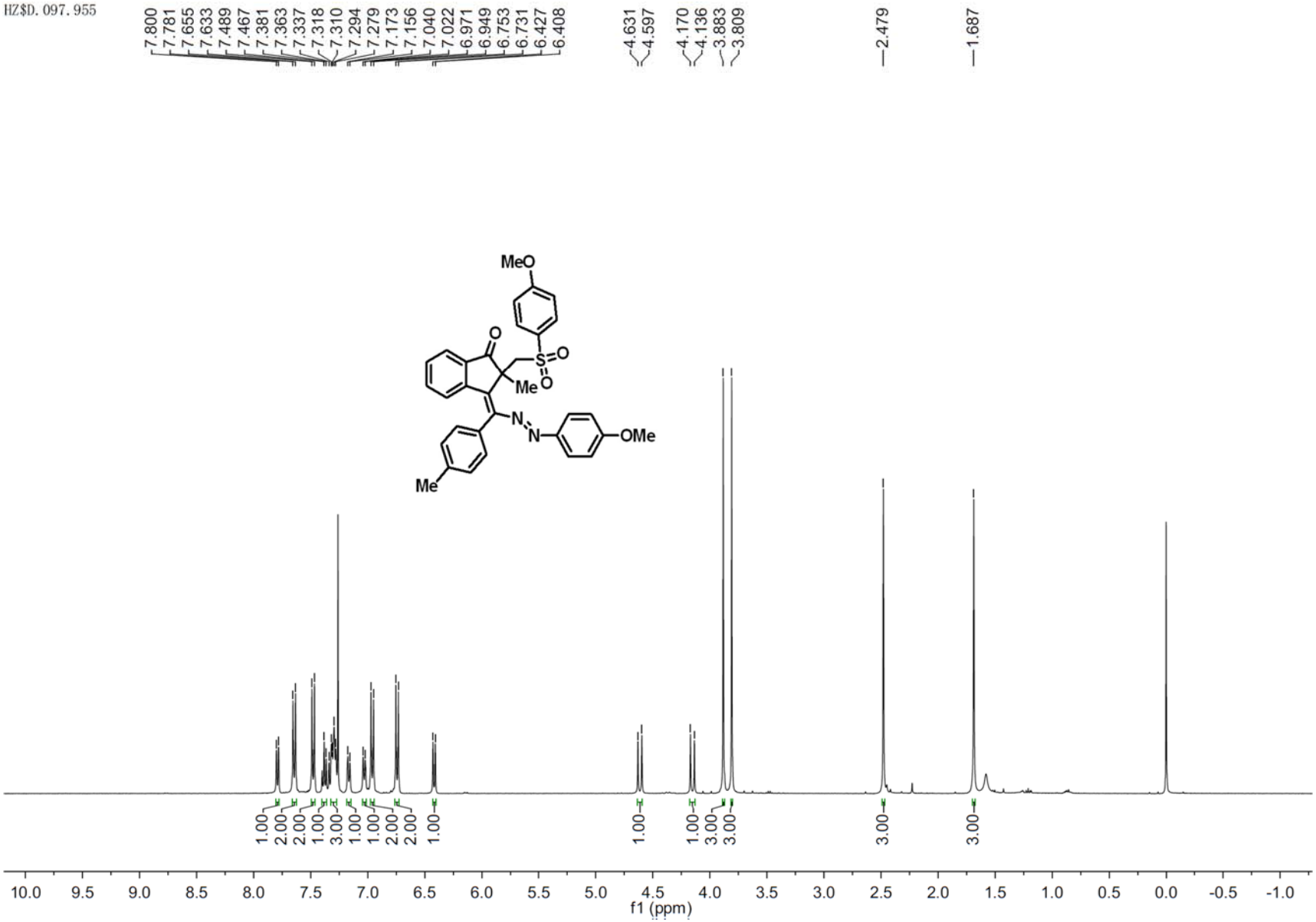


White solid: mp 198-199 °C; ^{1}H NMR (400 MHz, $CDCl_3$; δ, ppm) 7.68 (d, J = 8.4 Hz, 2H), 7.63 (d, J = 7.2 Hz, 1H), 7.48-7.44 (m, 2H), 7.31-7.26 (m, 2H), 7.25 (s, 1H), 7.22-7.17 (m, 2H), 7.15-7.07 (m, 5H), 6.11 (s, 1H), 4.97 (d, J = 14.0 Hz, 1H), 3.87 (d, J = 14.0 Hz, 1H), 2.42 (s, 3H), 2.09 (s, 3H), 1.59 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$; δ, ppm) 204.2, 148.4, 145. 8, 144.5, 138.7, 137.7, 136.9, 135.9, 135.4, 133.6, 132.9, 131.7, 129.9, 129.8, 129.7, 128.8, 128.7, 128.5, 128.3, 127.9, 127.8, 125.7, 123.9, 59.9, 52.3, 24.6, 22.5, 21.7. IR (KBr, ν, cm-1): 2970, 1716, 1572, 1478, 1320, 1085, 849, 570. HRMS (APCI -TOF): m/z calcd for: $C_{32}H_{27}ClNaO_3SSe$, 629.0423 $[M+Na]^+$; found: 629.0378.

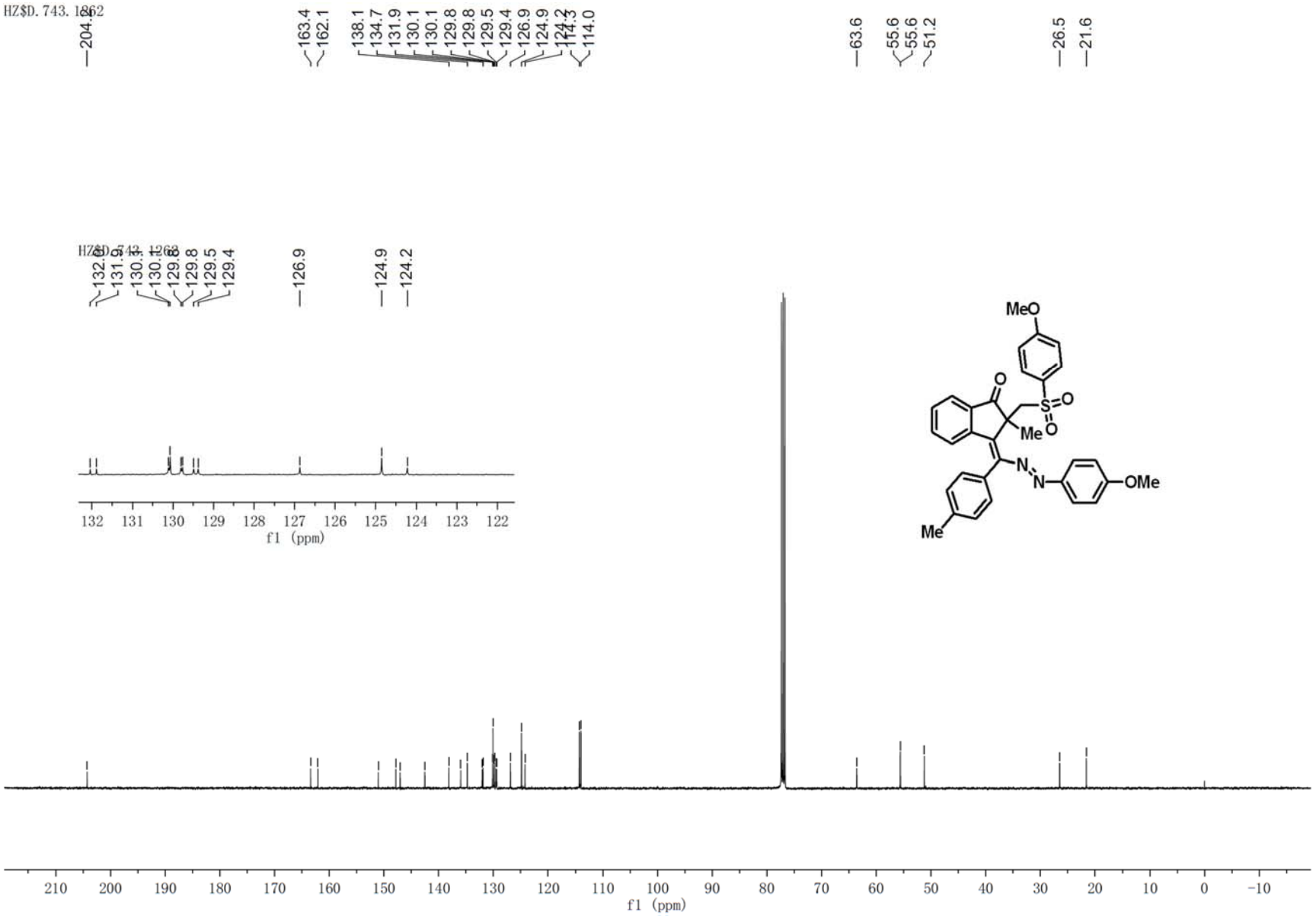
(Z)-2-(((4-bromophenyl)sulfonyl)methyl)-2,5-dimethyl-3-(phenyl(phenylselanyl)methylene)-2,3-dihydro-1H-inden-1-one (7w)



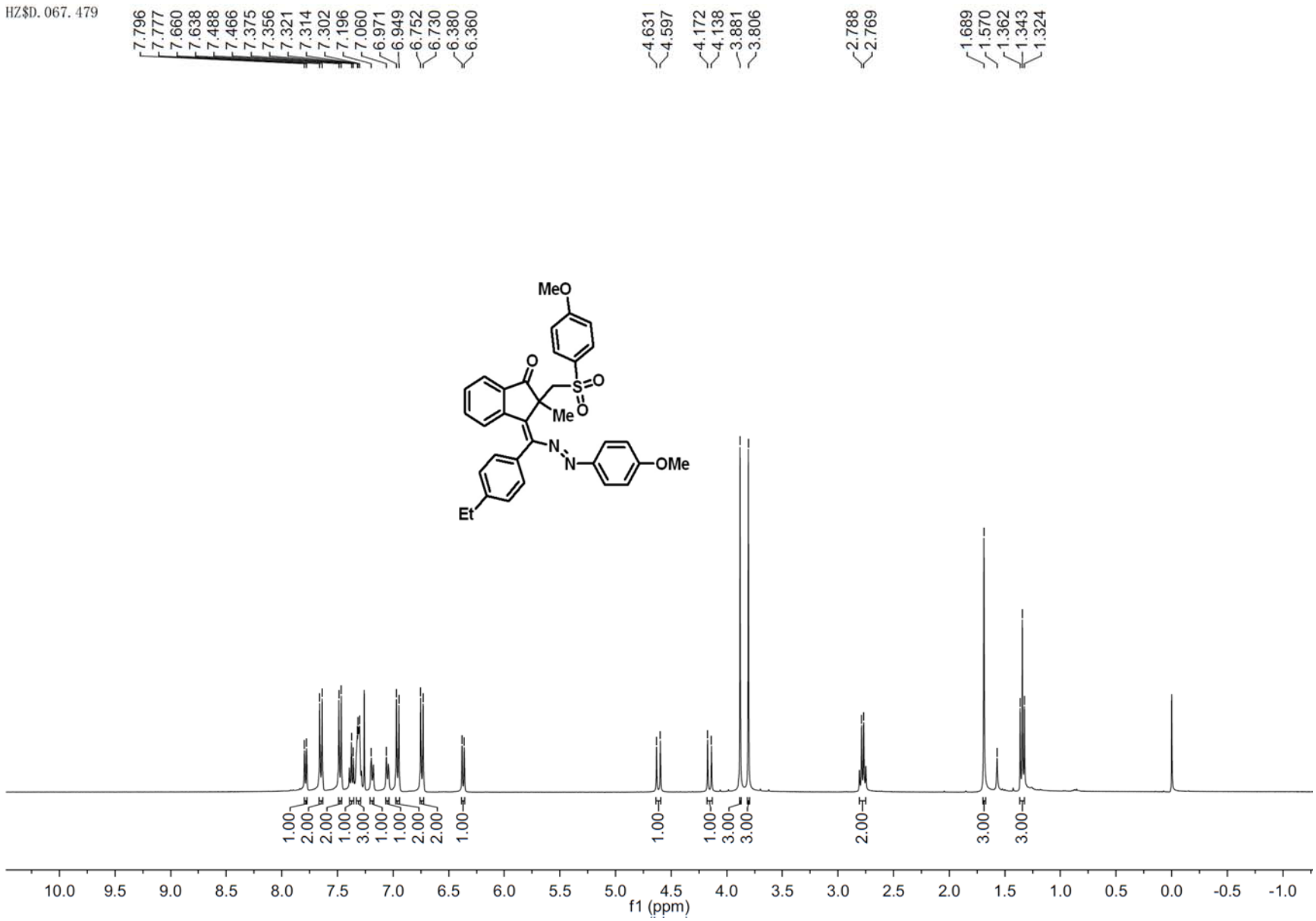
Yellow solid: mp 178-180 °C; ^{1}H NMR (400 MHz, $CDCl_3$; δ, ppm) 7.63-7.59 (m, 2H), 7.57-7.52 (m, 3H), 7.43-7.39 (m, 2H), 7.25-7.22 (m, 1H), 7.21-7.16 (m, 1H), 7.15-7.12 (m, 2H), 7.12-7.02 (m, 5H), 5.97 (s, 1H), 5.00 (d, J = 14.0 Hz, 1H), 3.89 (d, J = 14.0 Hz, 1H), 2.01 (s, 3H), 1.58 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$; δ, ppm) 204.2, 148.7, 145.8, 139.9, 139.4, 137.3, 136.0, 135.9, 132.7, 132.3, 130.0, 129.7, 129.6, 128.9, 128.6(1), 128.6(2), 128.4(1), 128.4(2), 128.2, 127.9, 127.8, 125.9, 123.8, 60.0, 52.3, 24.7, 22.4. IR (KBr, ν, cm^{-1}): 2961, 1712, 1572, 1475, 1314, 1083, 842, 565. HRMS (APCI -TOF): m/z calcd for: $C_{31}H_{25}BrNaO_3SSe$, 658.9771 $[M+Na]^+$; found: 658.9778.



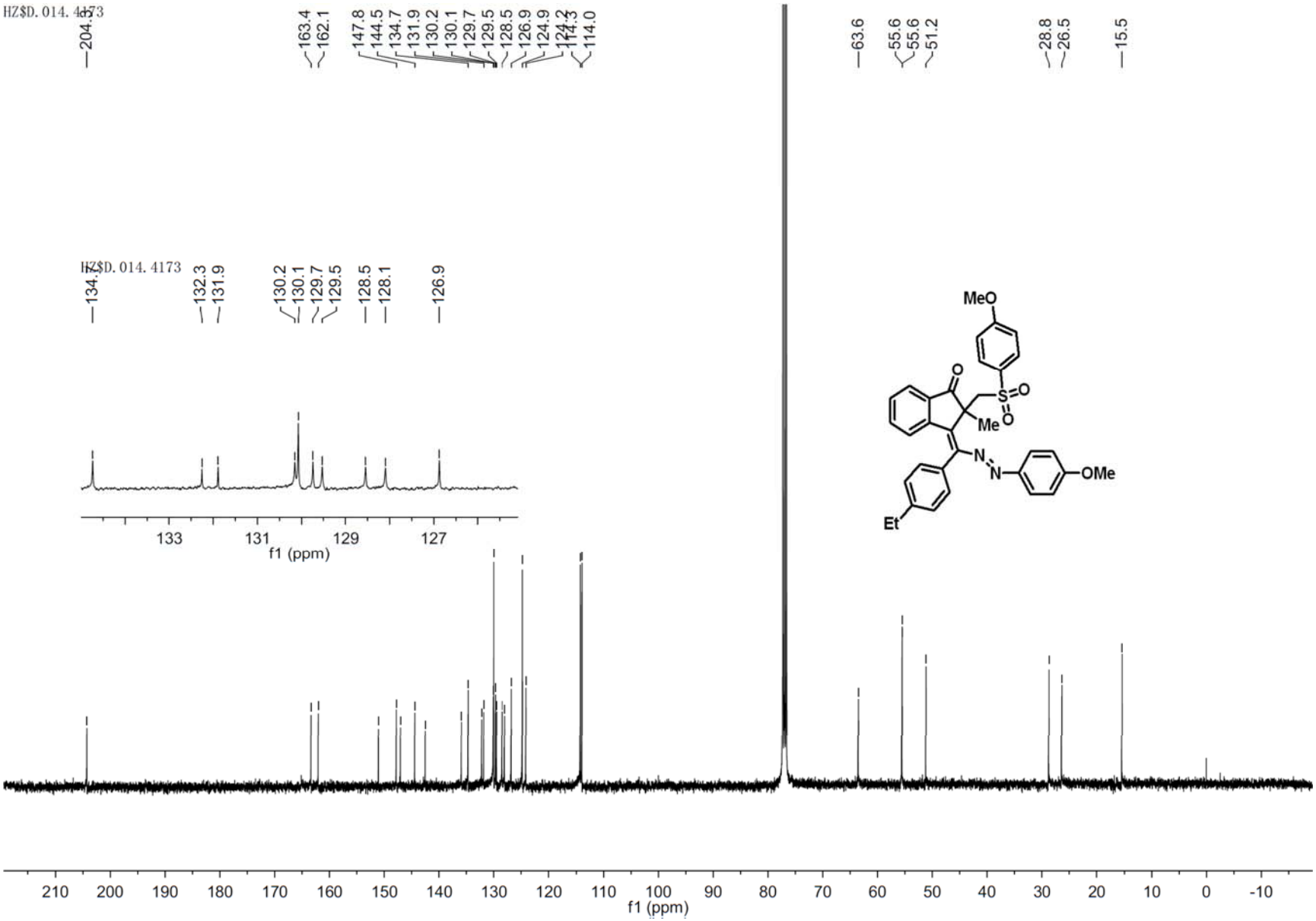
^{1}H NMR Spectrum of Compound 4a



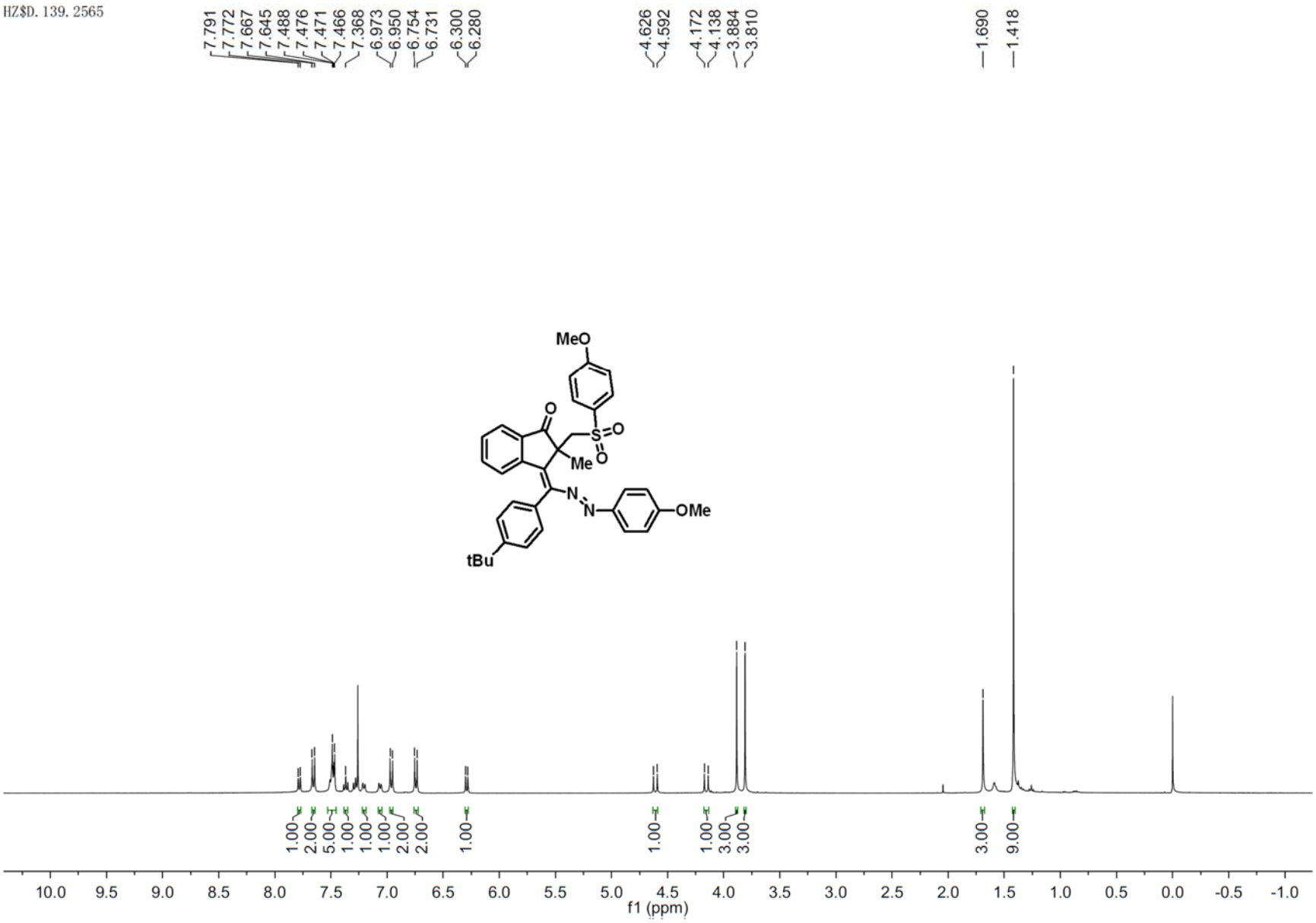
^{13}C NMR Spectrum of Compound 4a



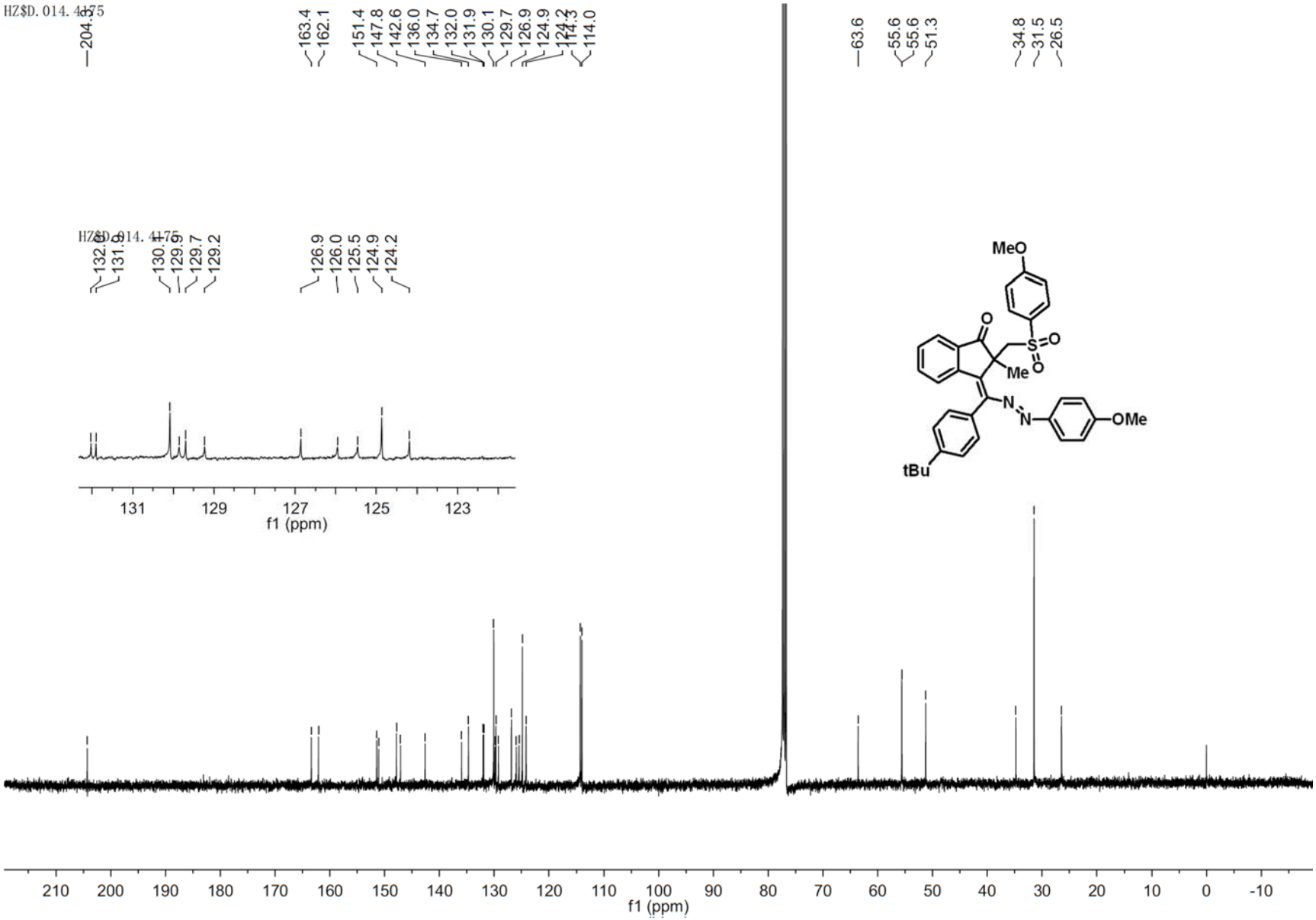
^{1}H NMR Spectrum of Compound 4b



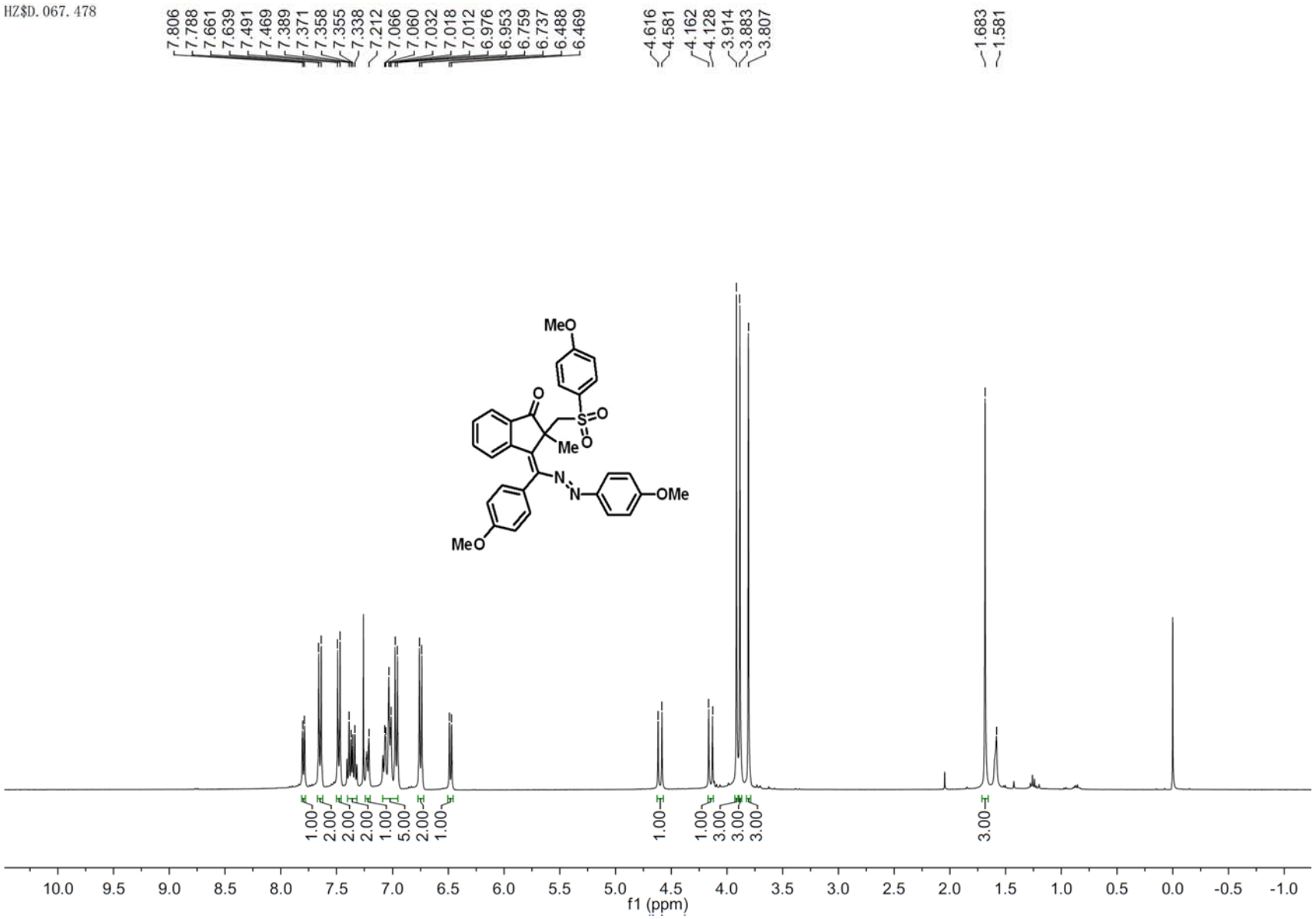
^{13}C NMR Spectrum of Compound 4b



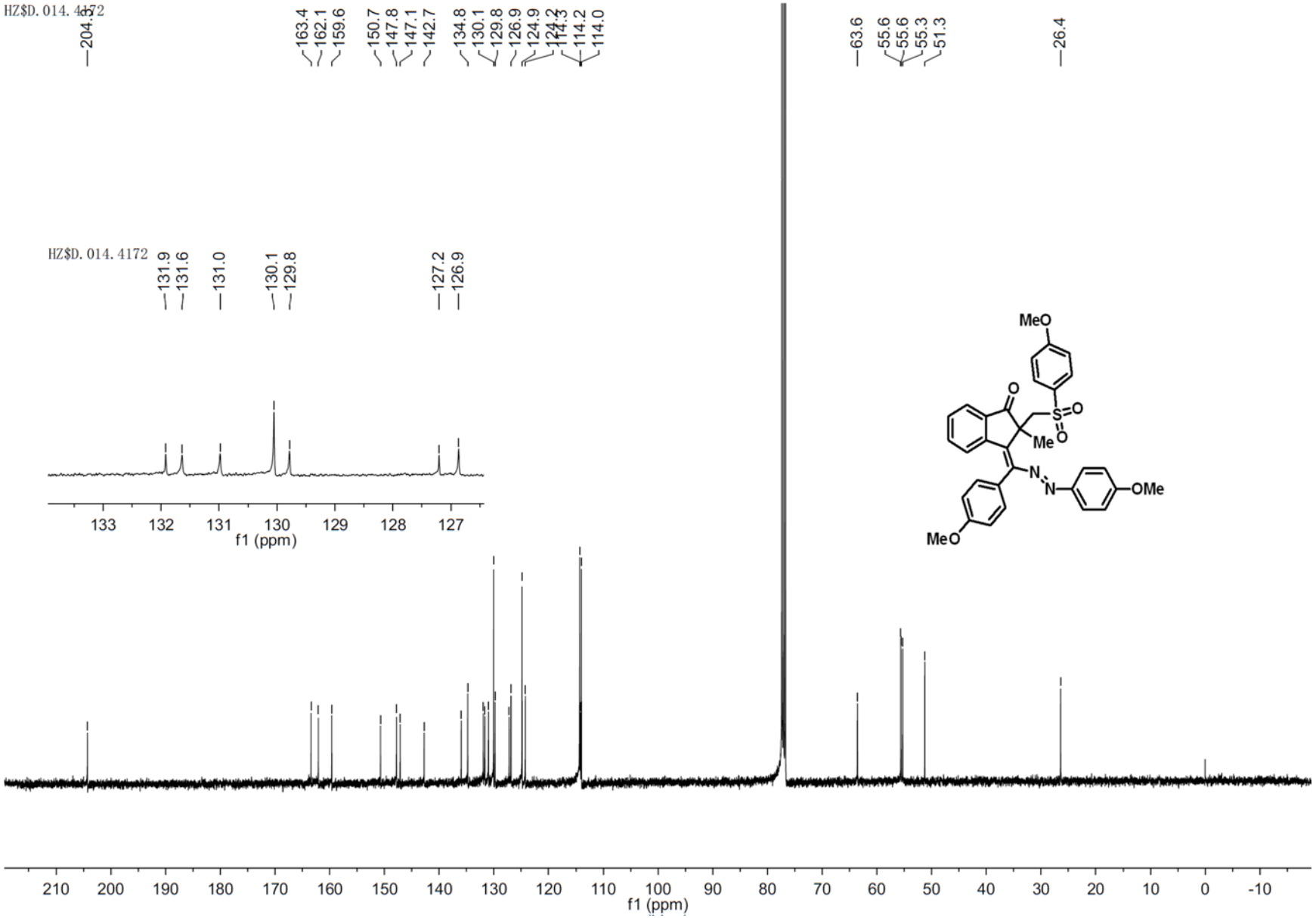
^{1}H NMR Spectrum of Compound 4c



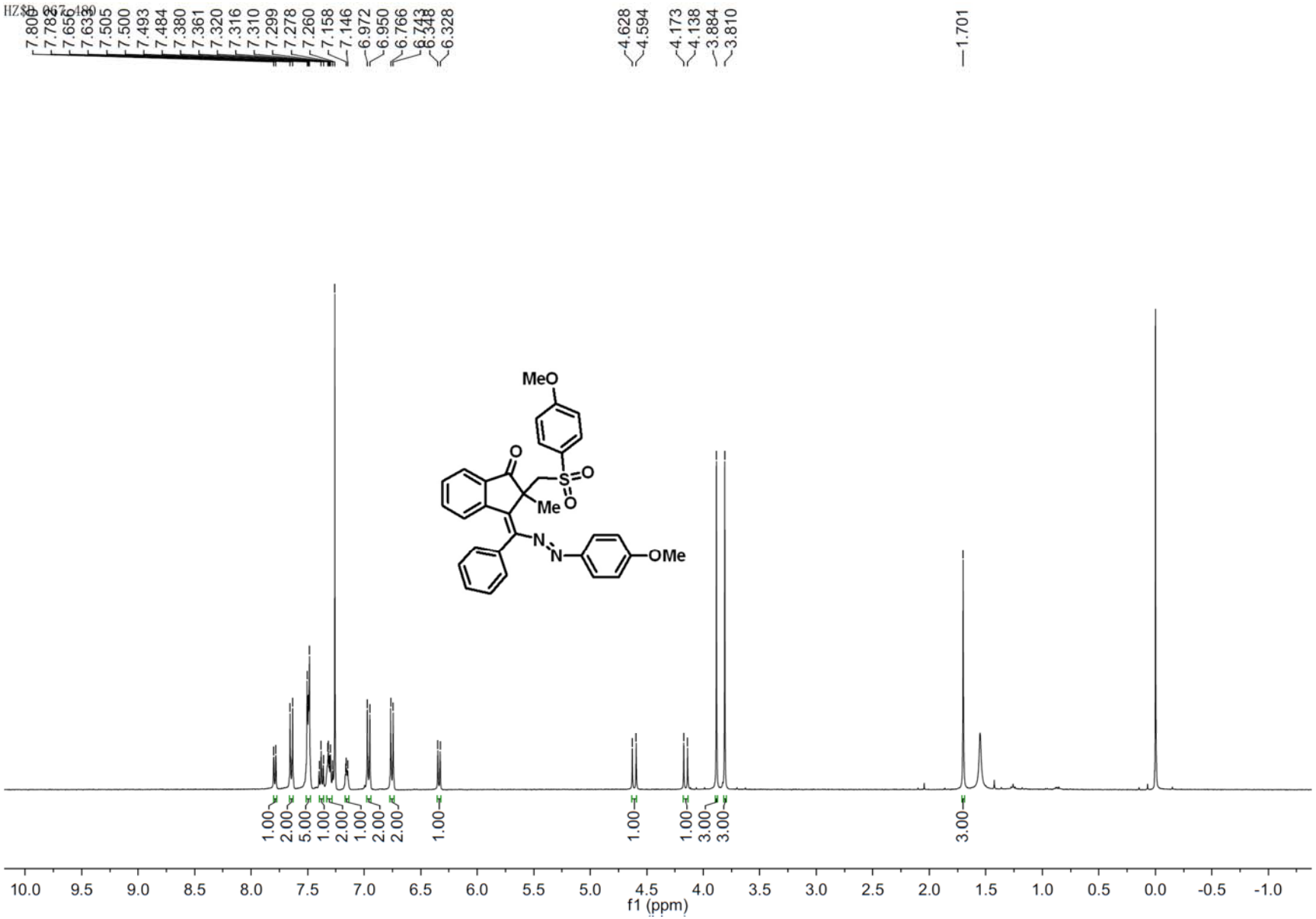
^{13}C NMR Spectrum of Compound 4c



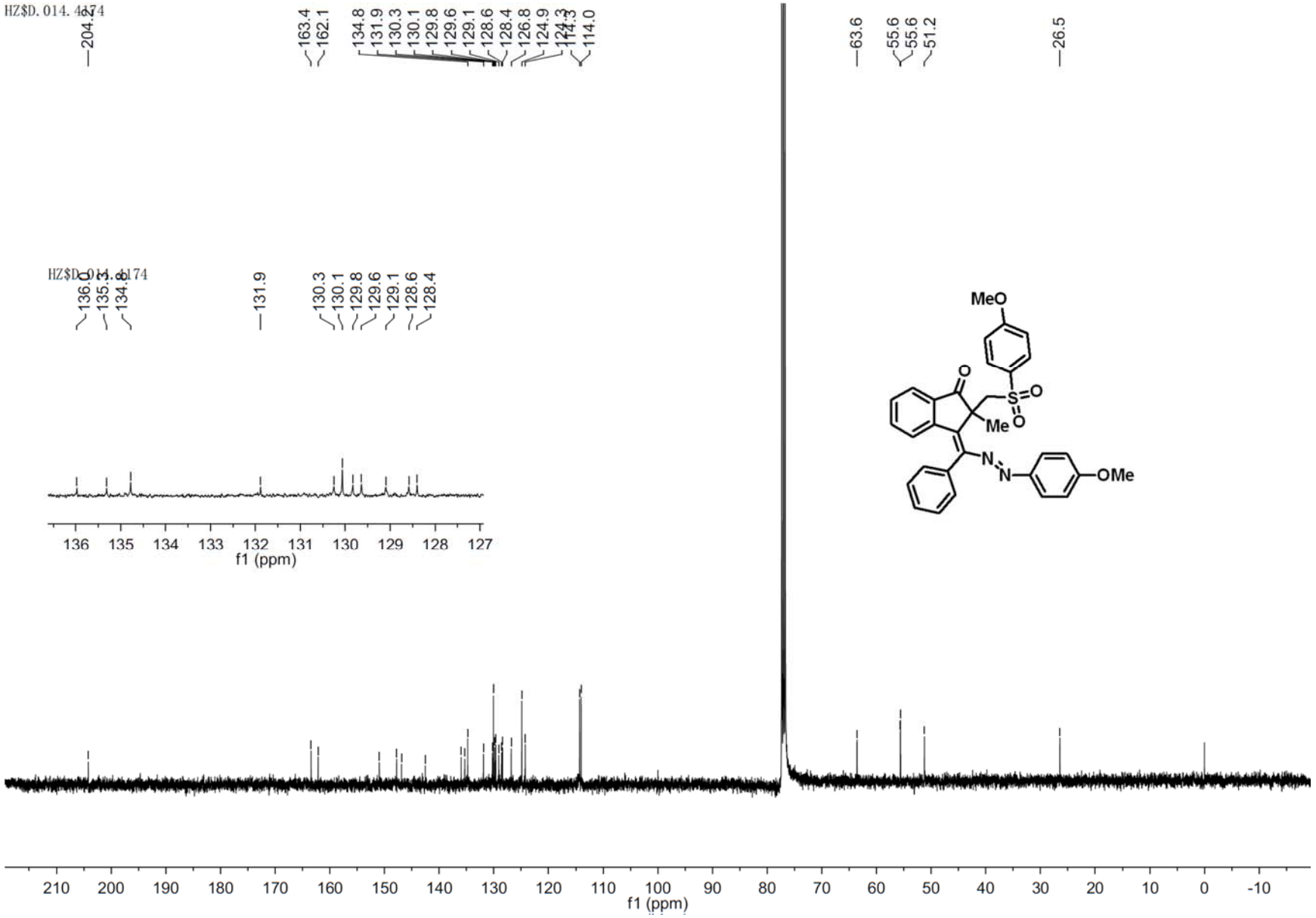
^{1}H NMR Spectrum of Compound 4d



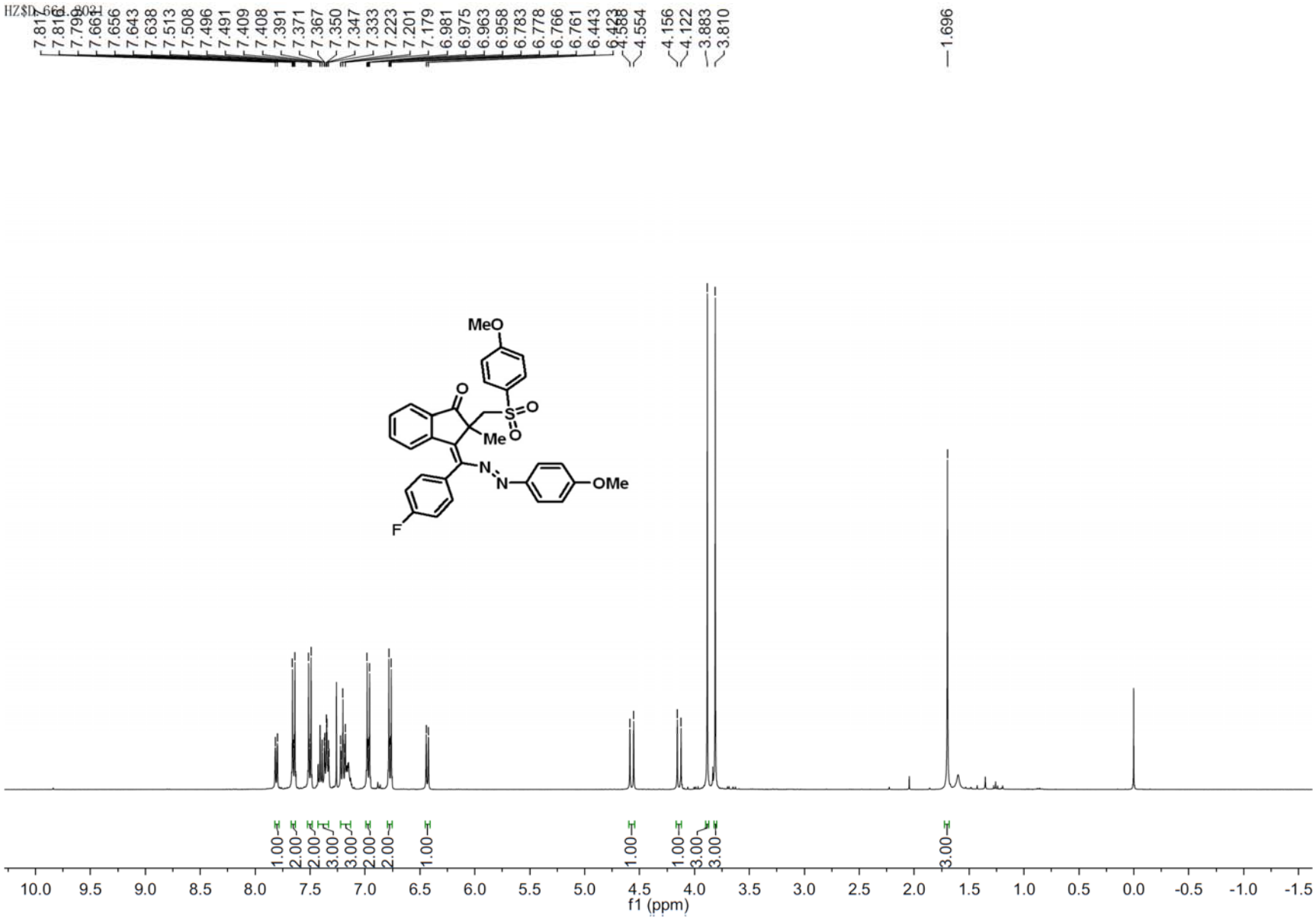
^{13}C NMR Spectrum of Compound 4d



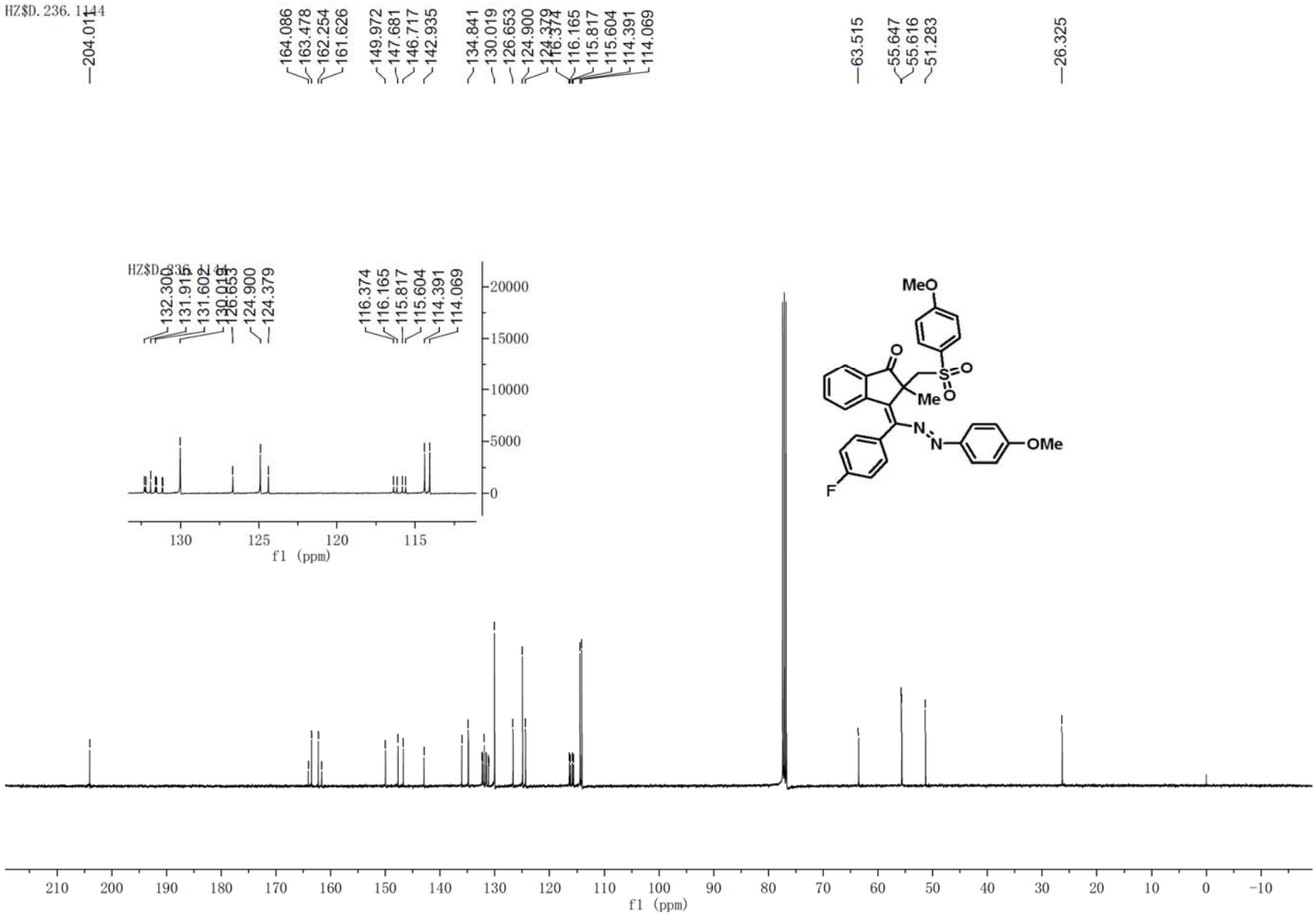
^{1}H NMR Spectrum of Compound 4e



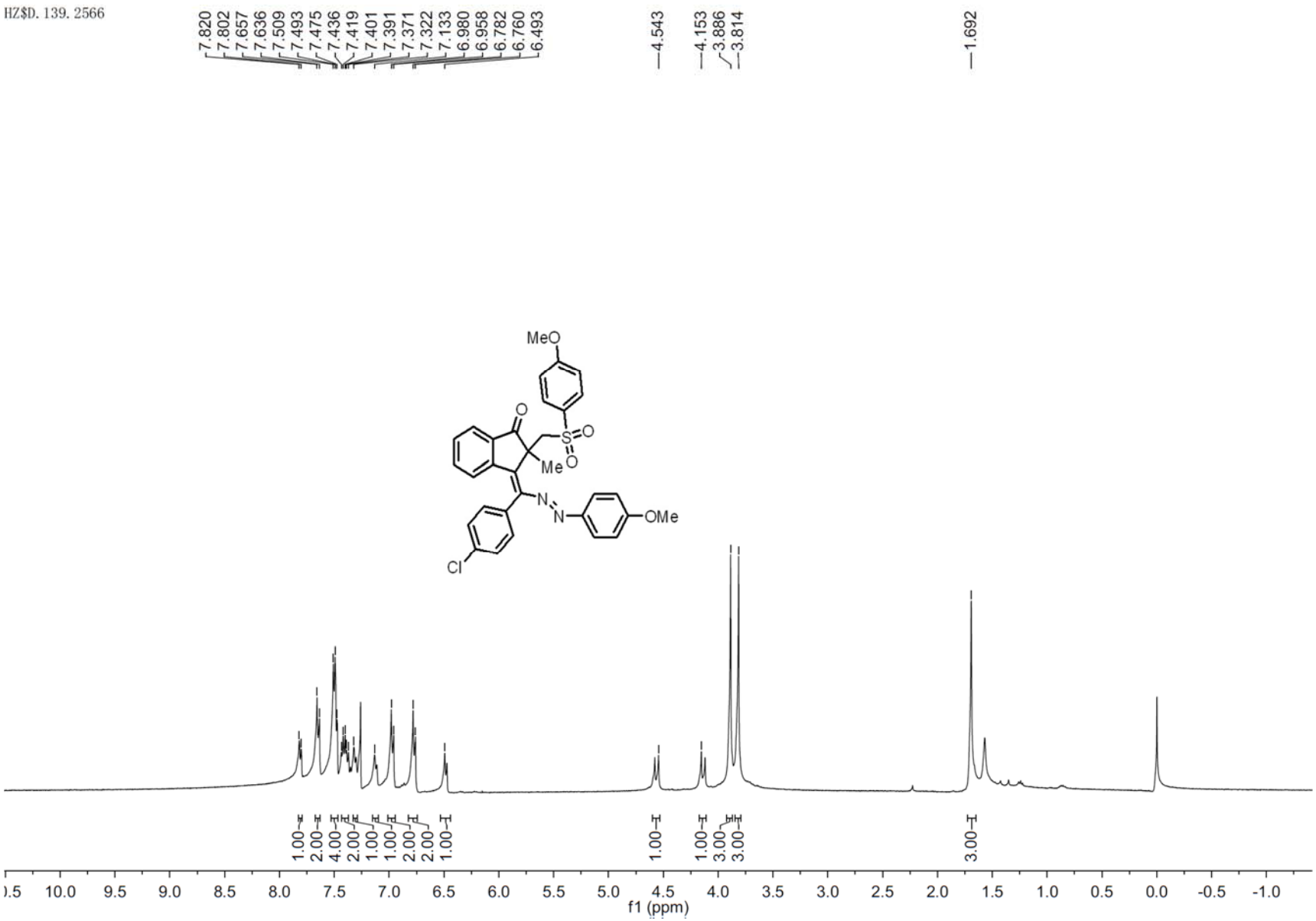
^{13}C NMR Spectrum of Compound 4e



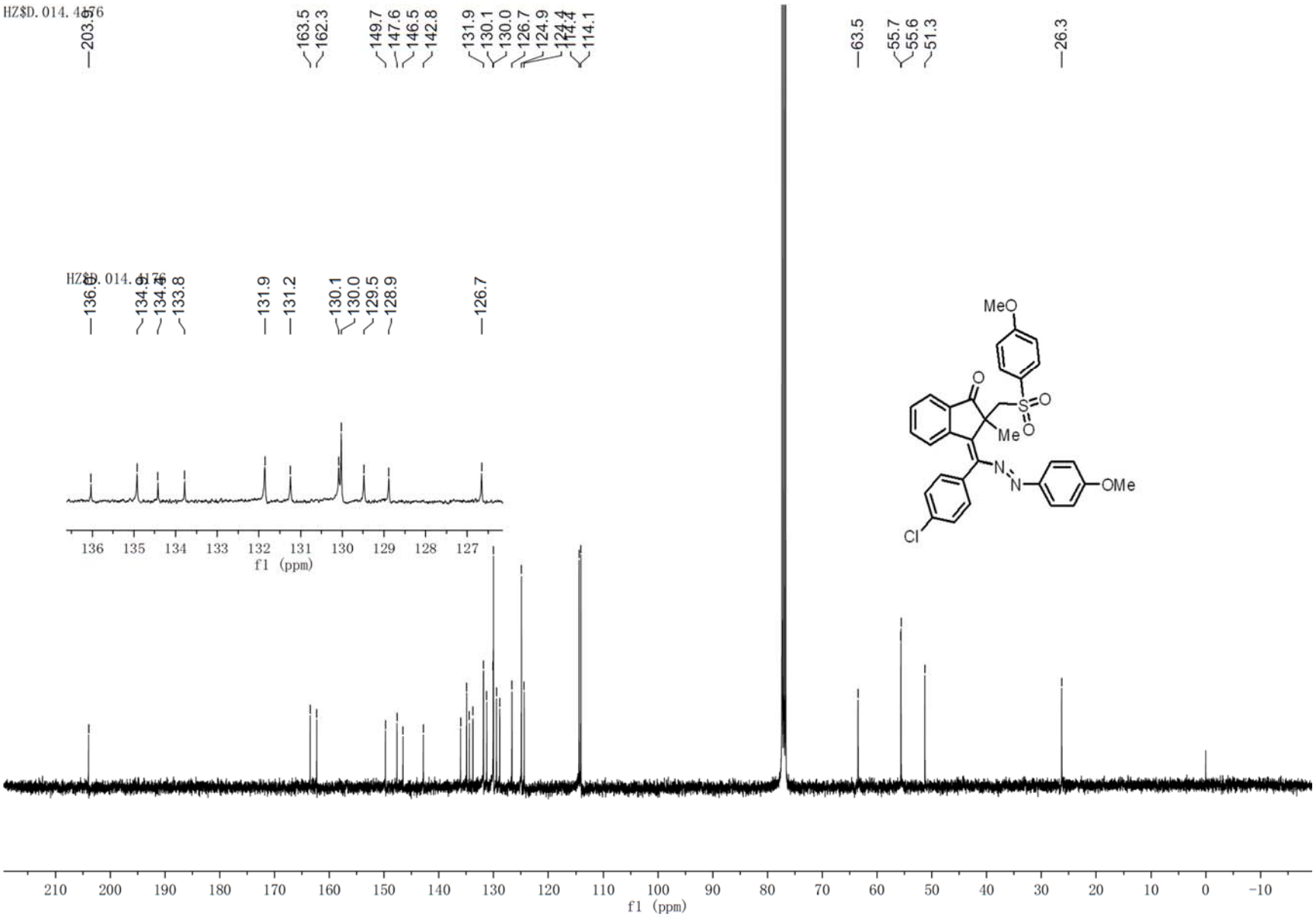
^{1}H NMR Spectrum of Compound 4f



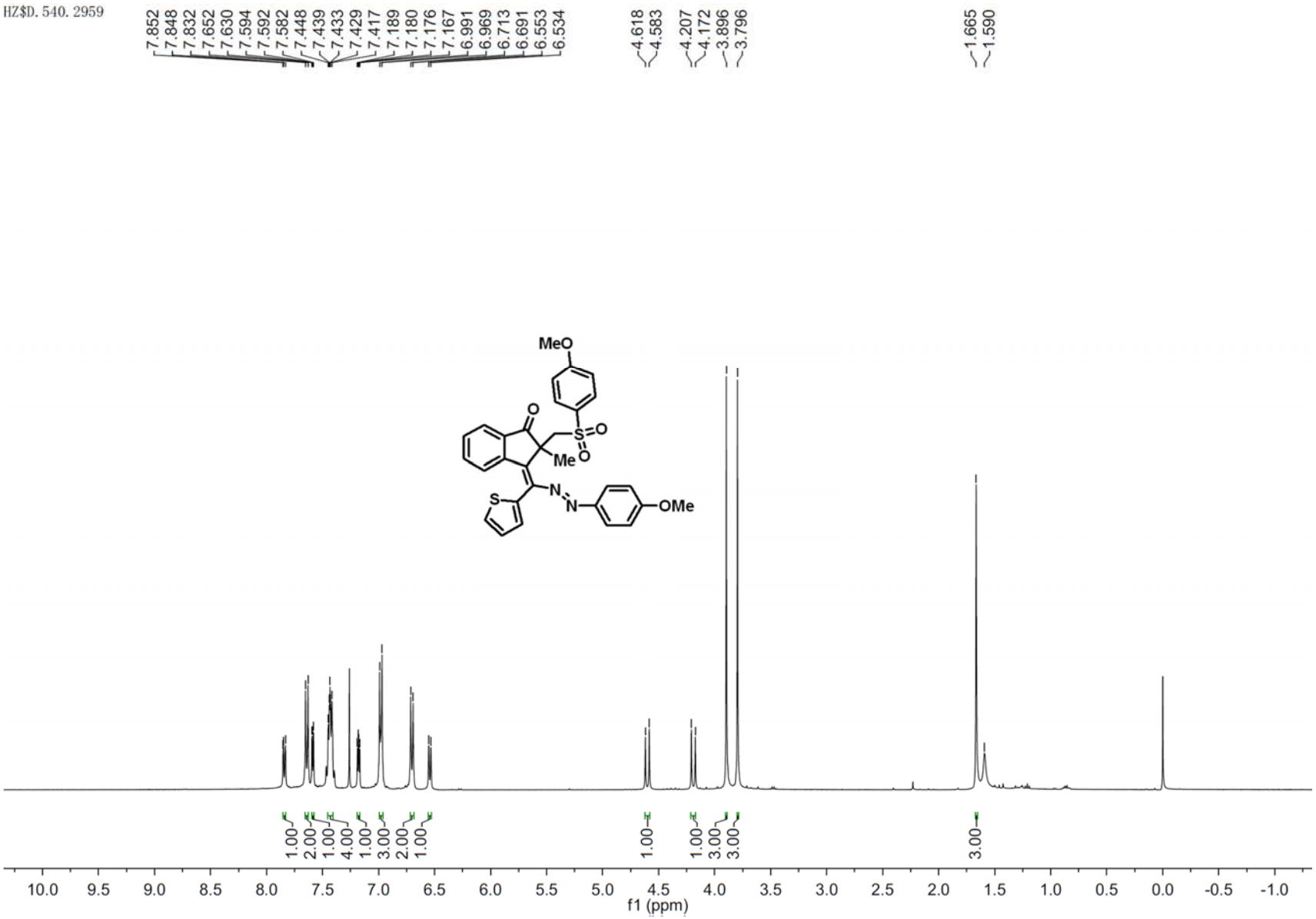
^{13}C NMR Spectrum of Compound 4f



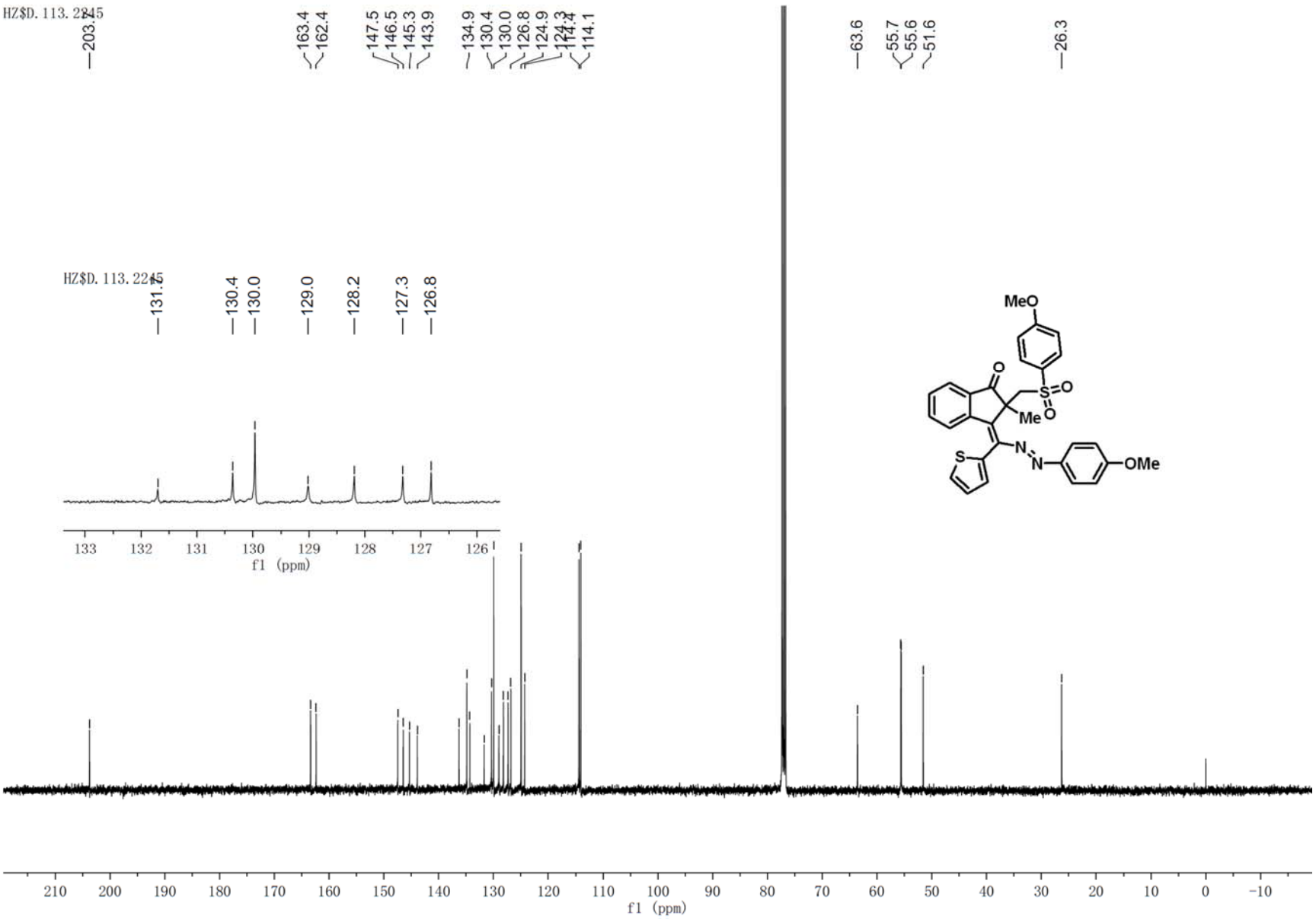
^{1}H NMR Spectrum of Compound 4g



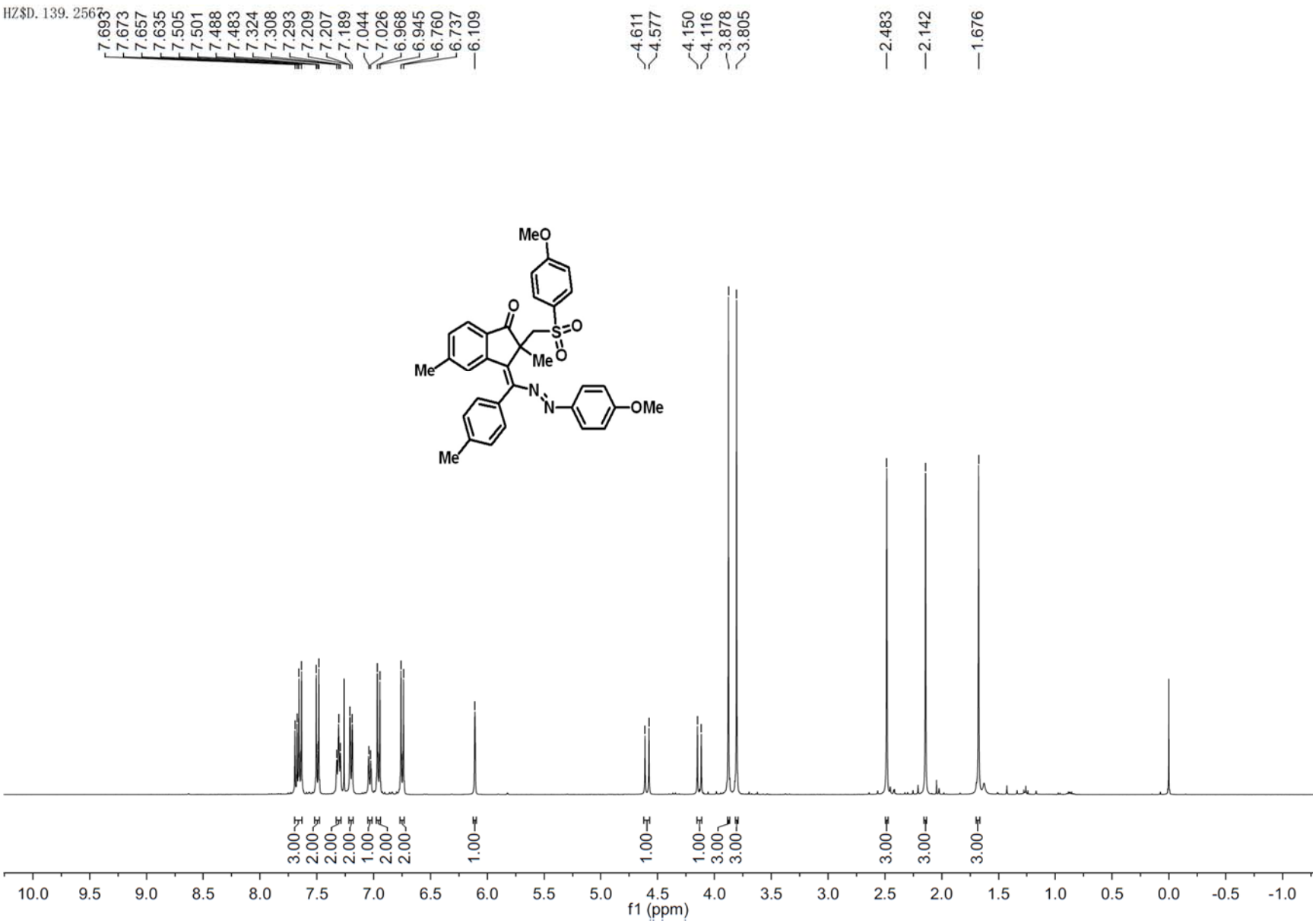
^{13}C NMR Spectrum of Compound 4g



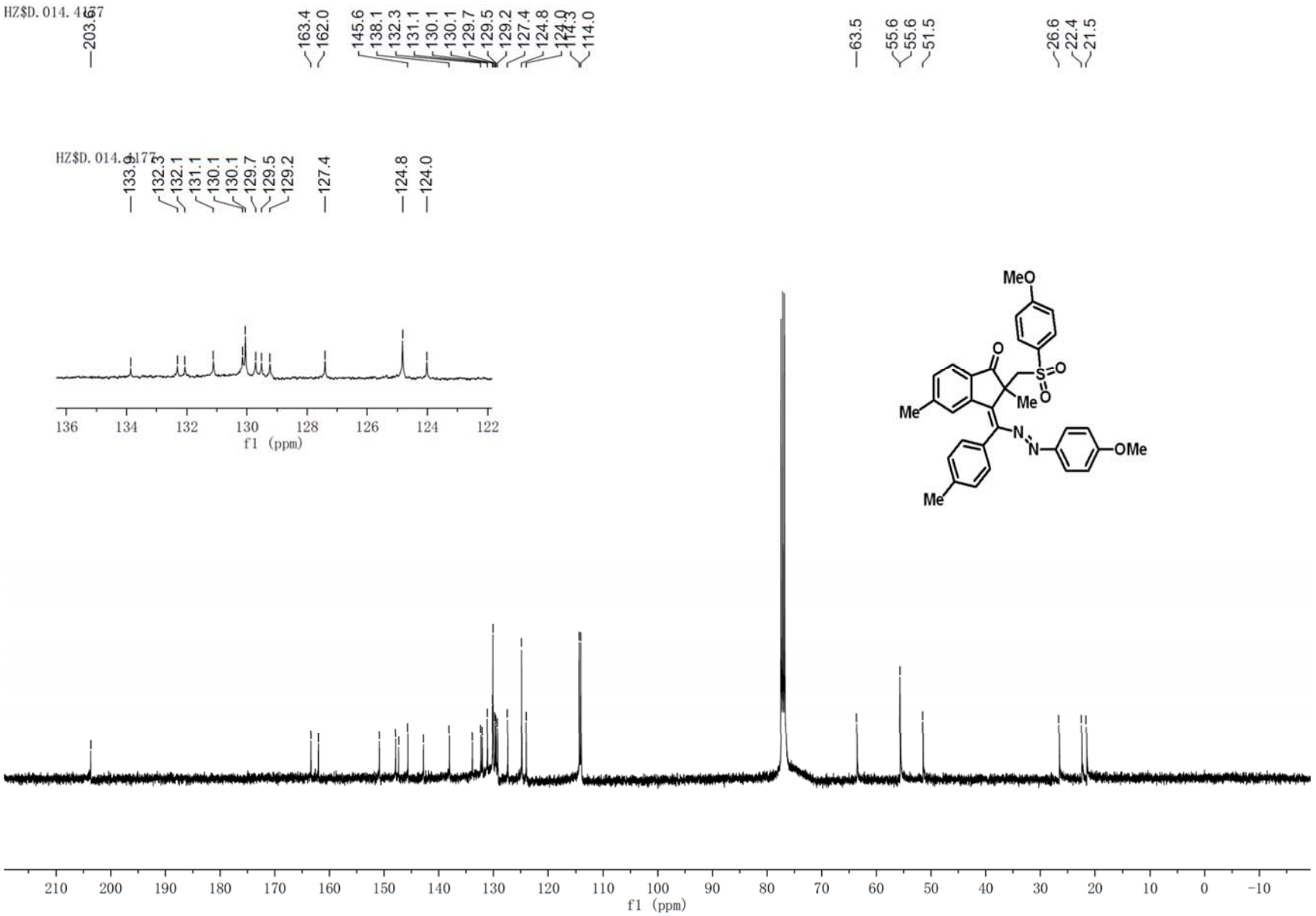
^{1}H NMR Spectrum of Compound 4h



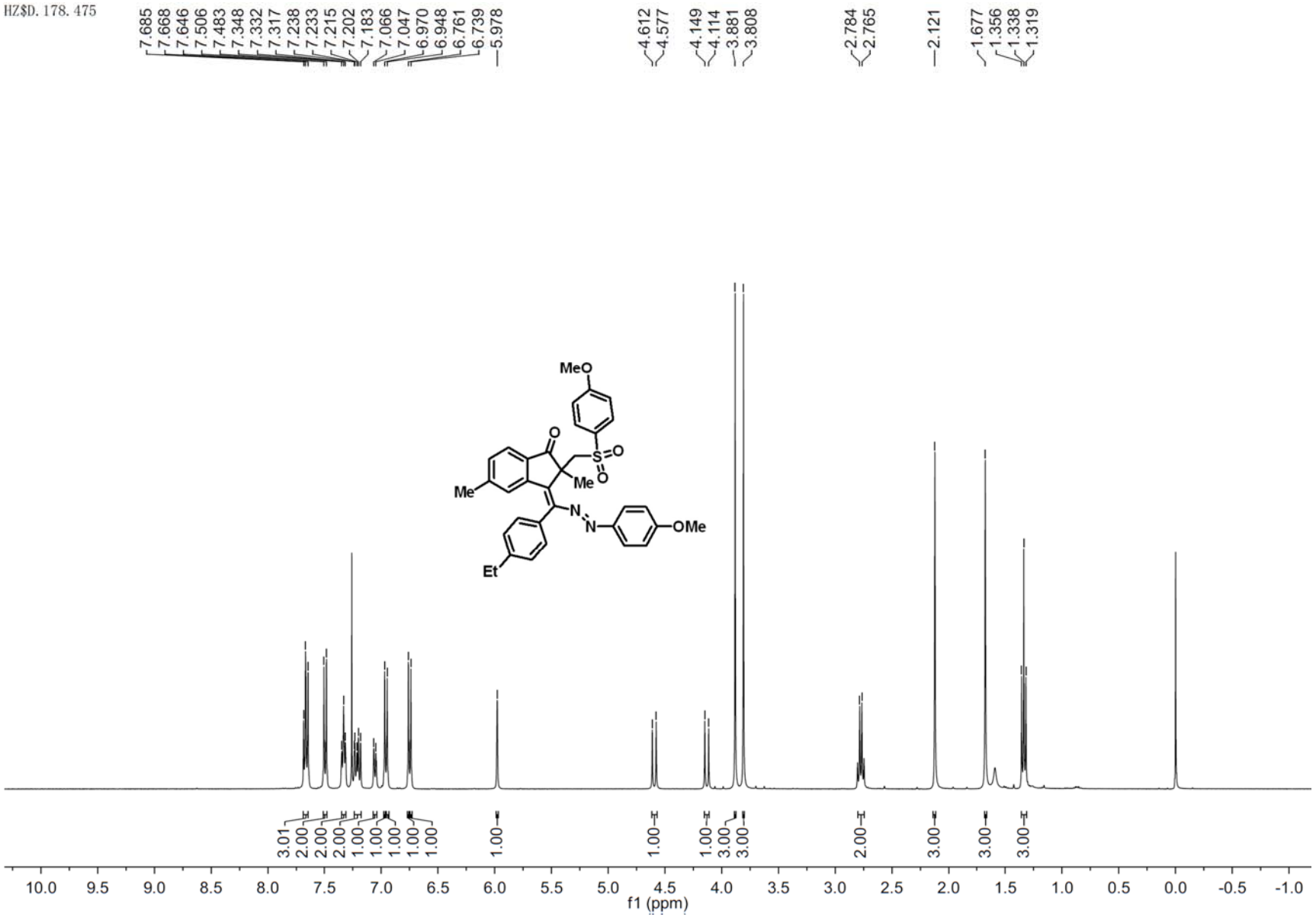
^{13}C NMR Spectrum of Compound 4h



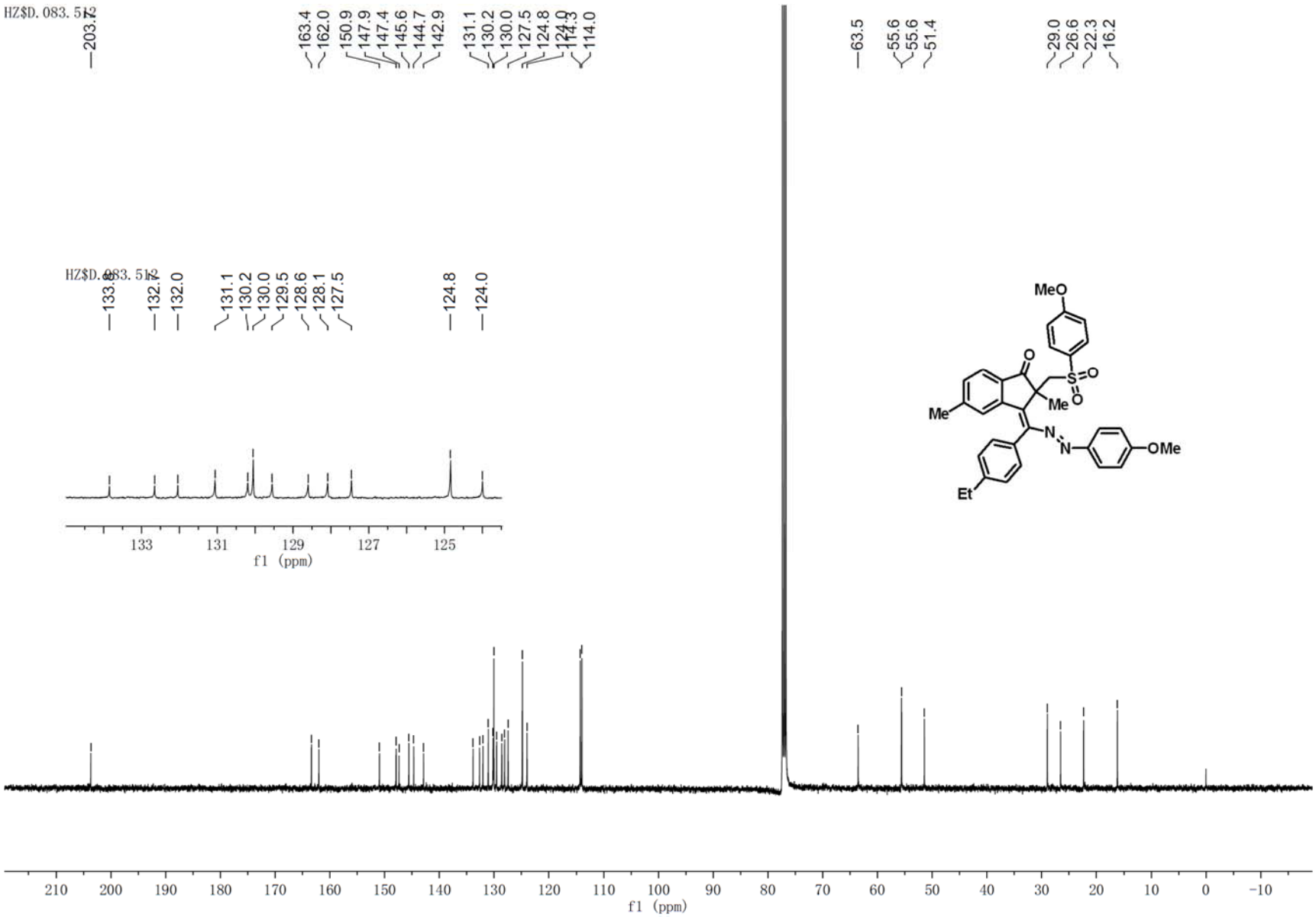
^{1}H NMR Spectrum of Compound 4i



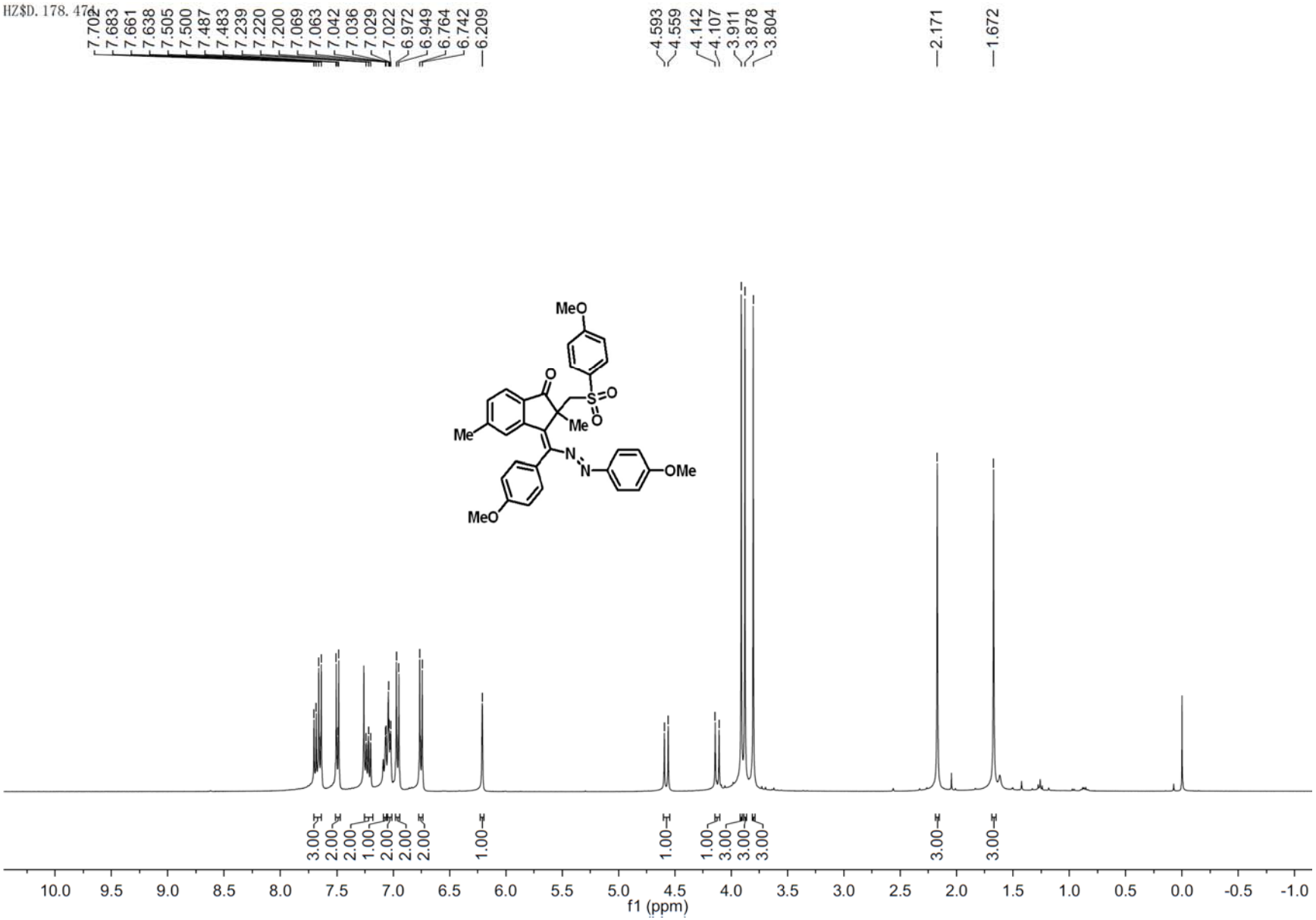
^{13}C NMR Spectrum of Compound 4i



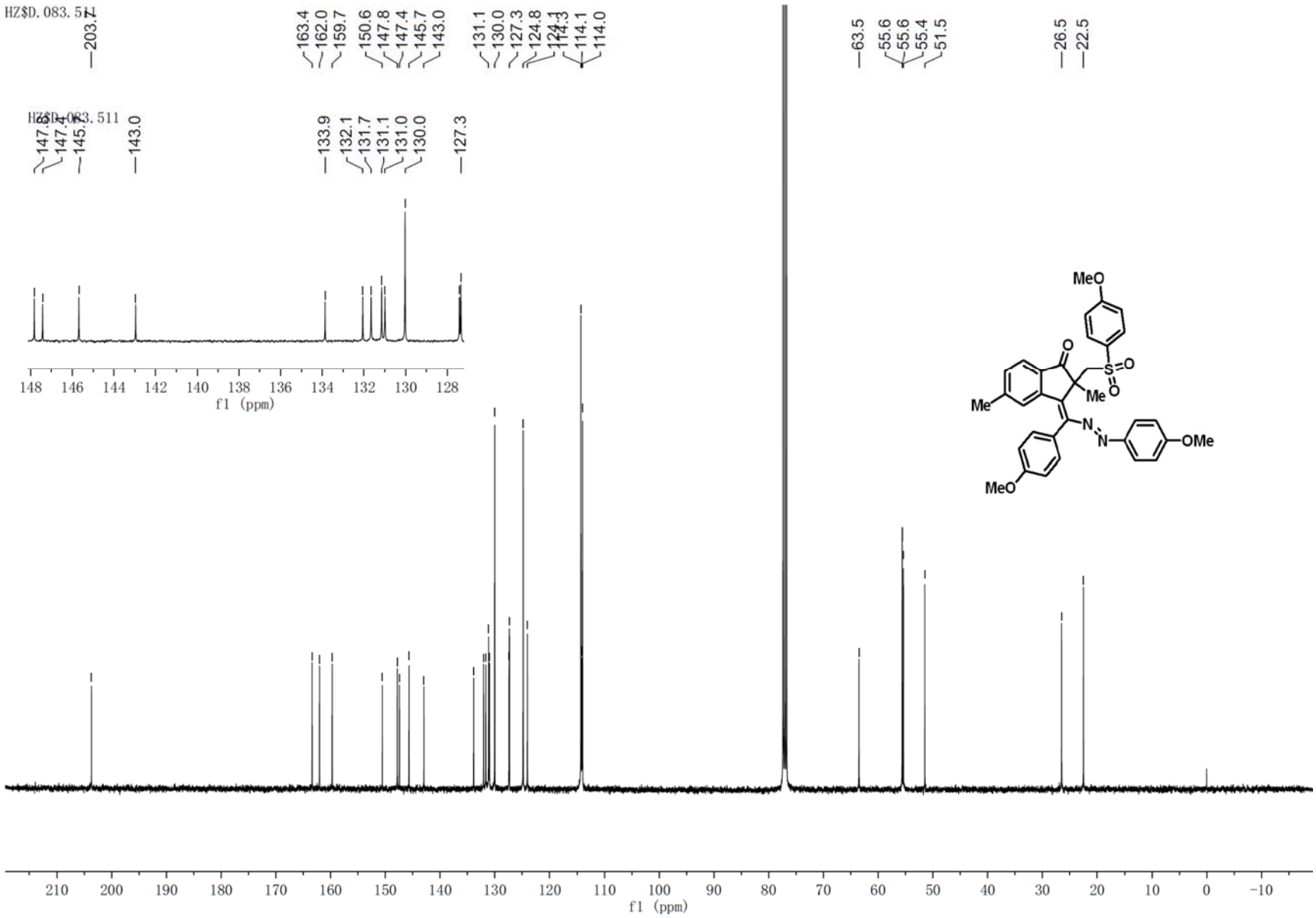
^{1}H NMR Spectrum of Compound 4j



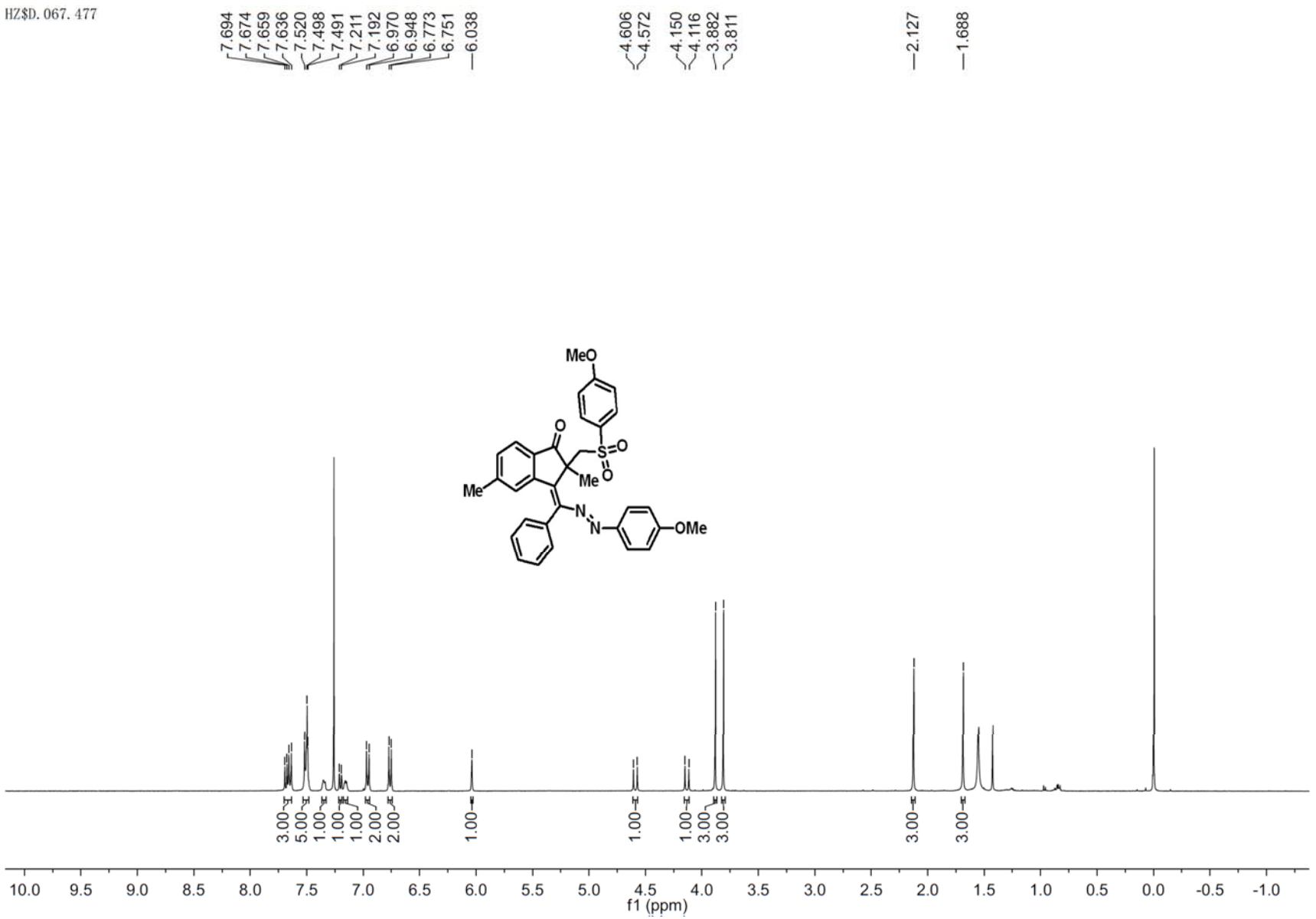
^{13}C NMR Spectrum of Compound 4j



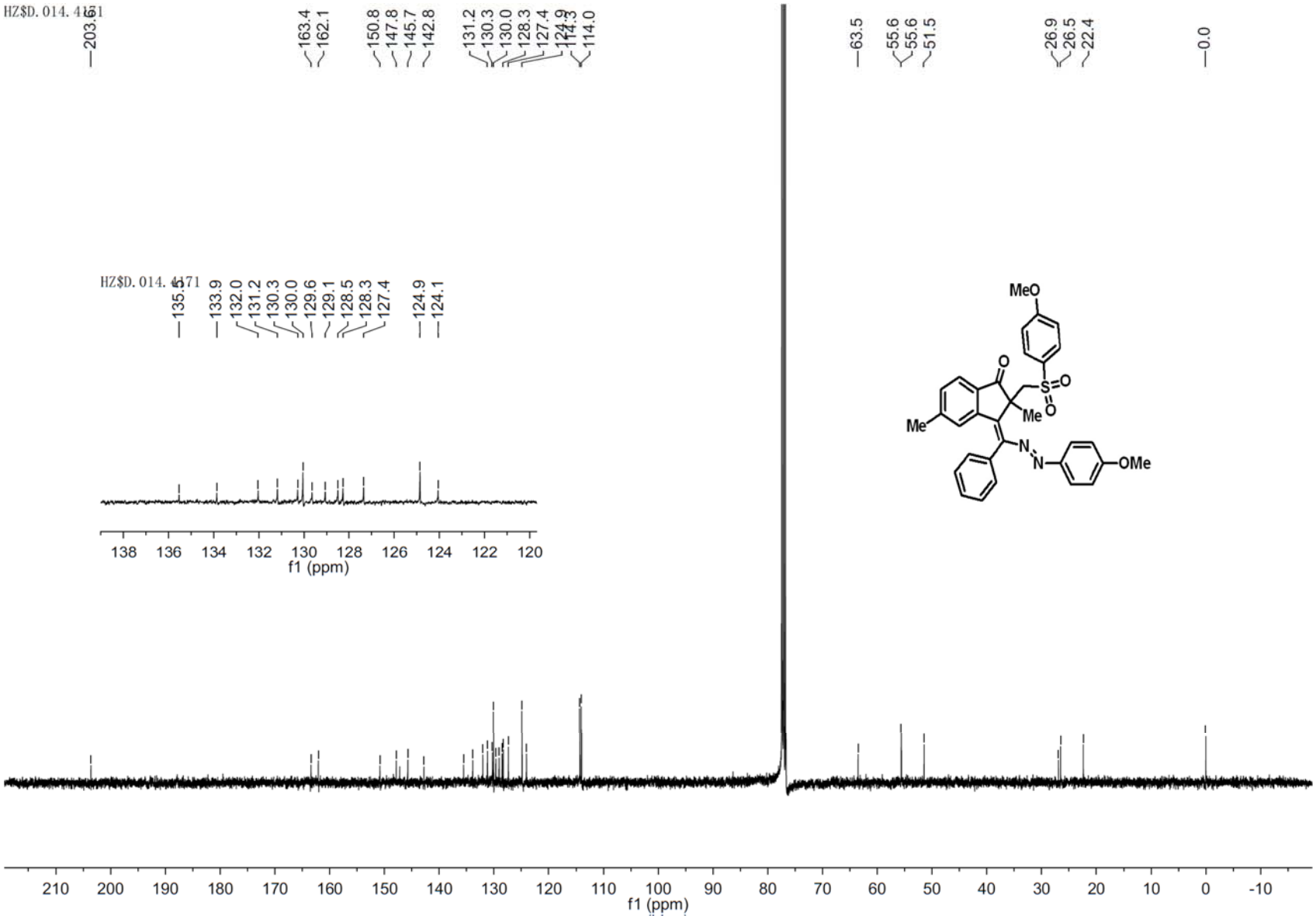
^{1}H NMR Spectrum of Compound 4k



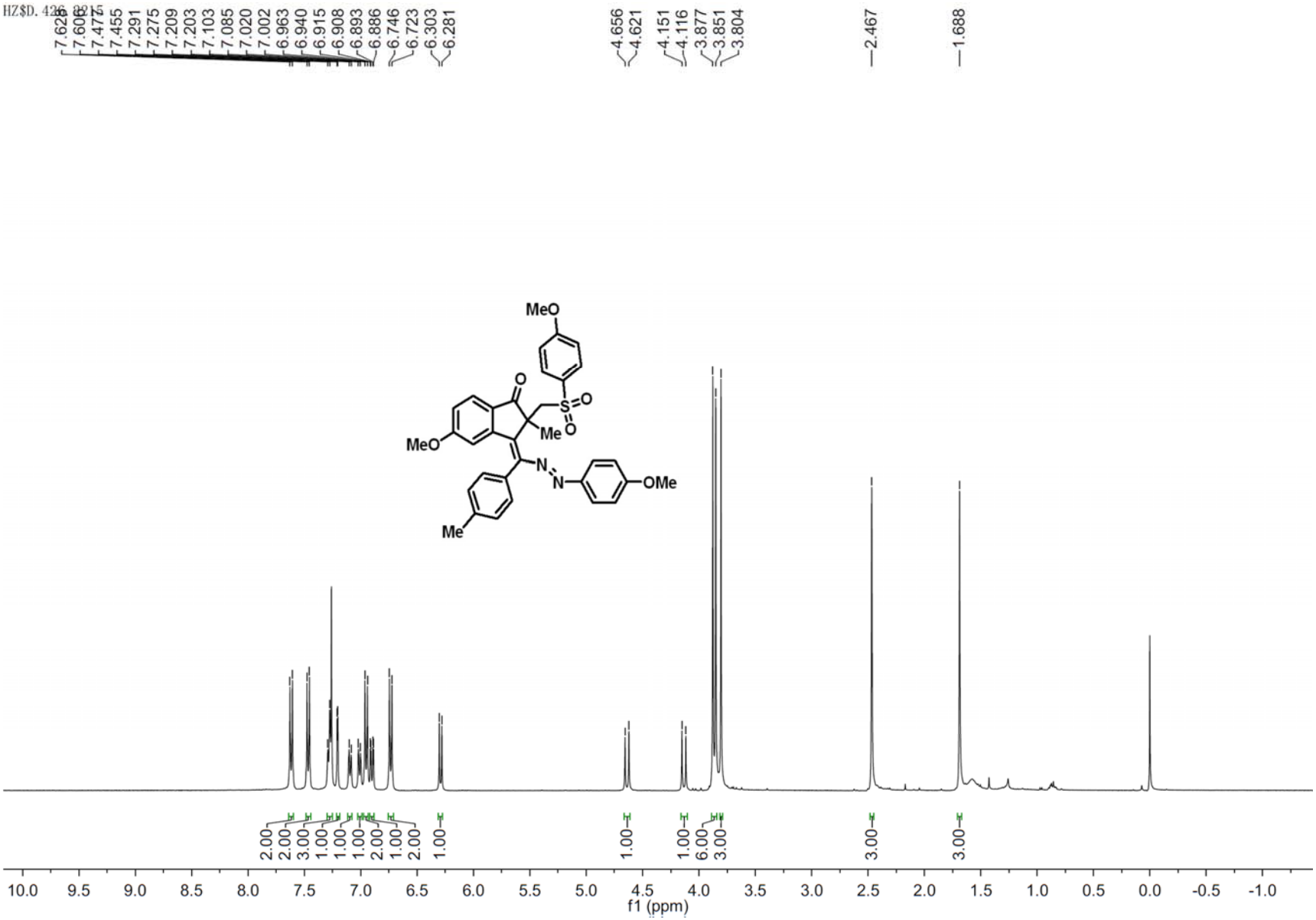
^{13}C NMR Spectrum of Compound 4k



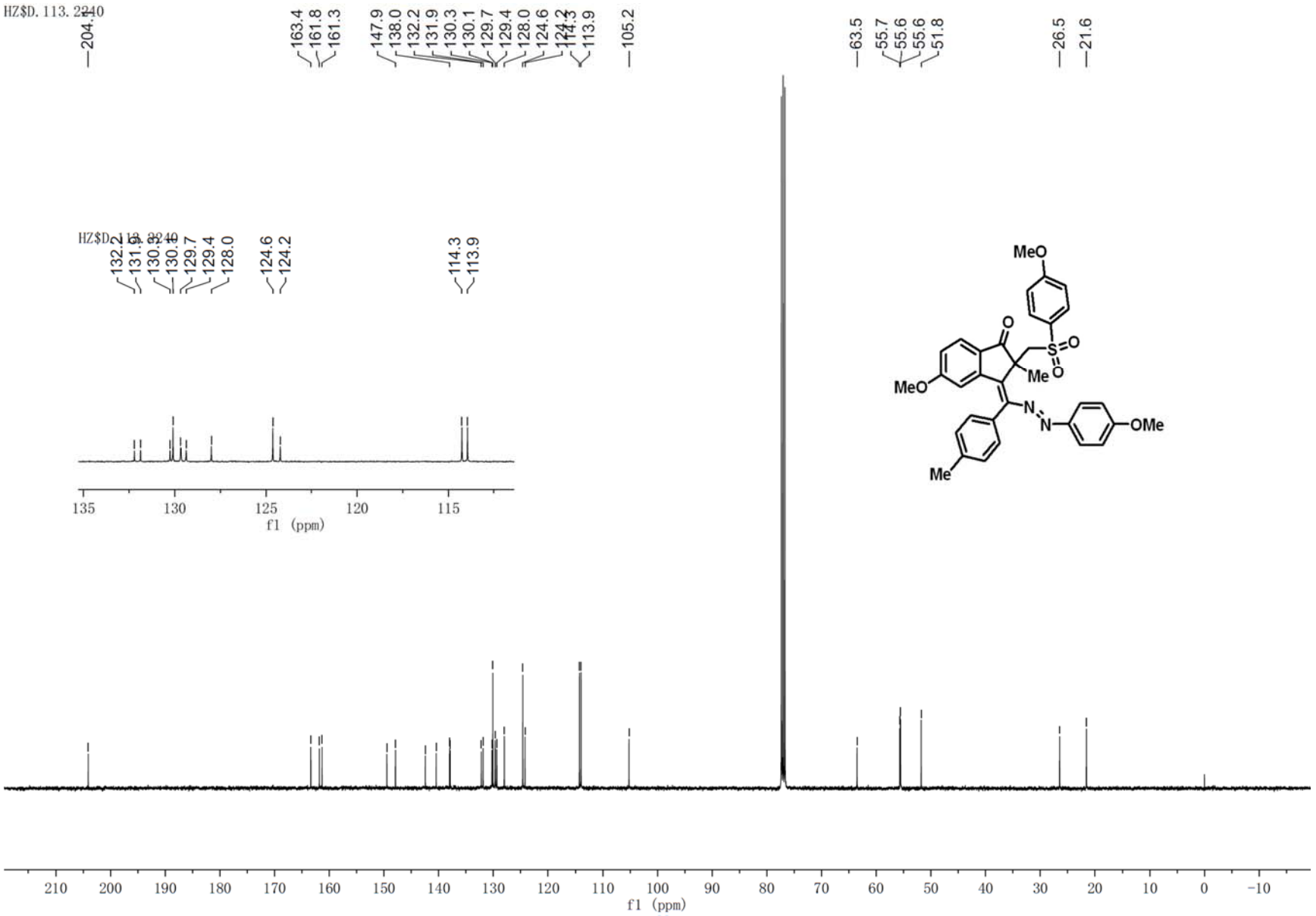
^{1}H NMR Spectrum of Compound 4l



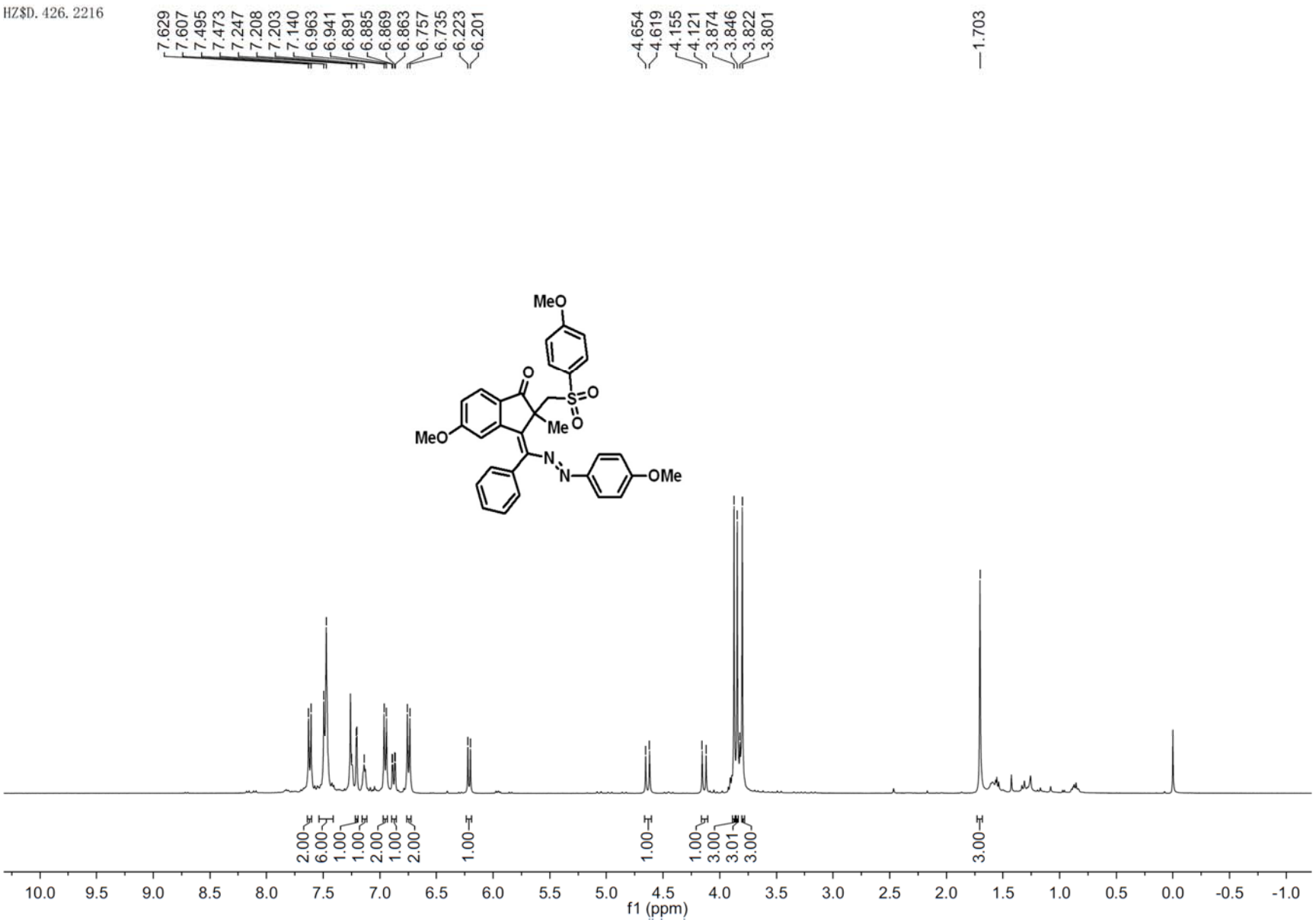
^{13}C NMR Spectrum of Compound 4l



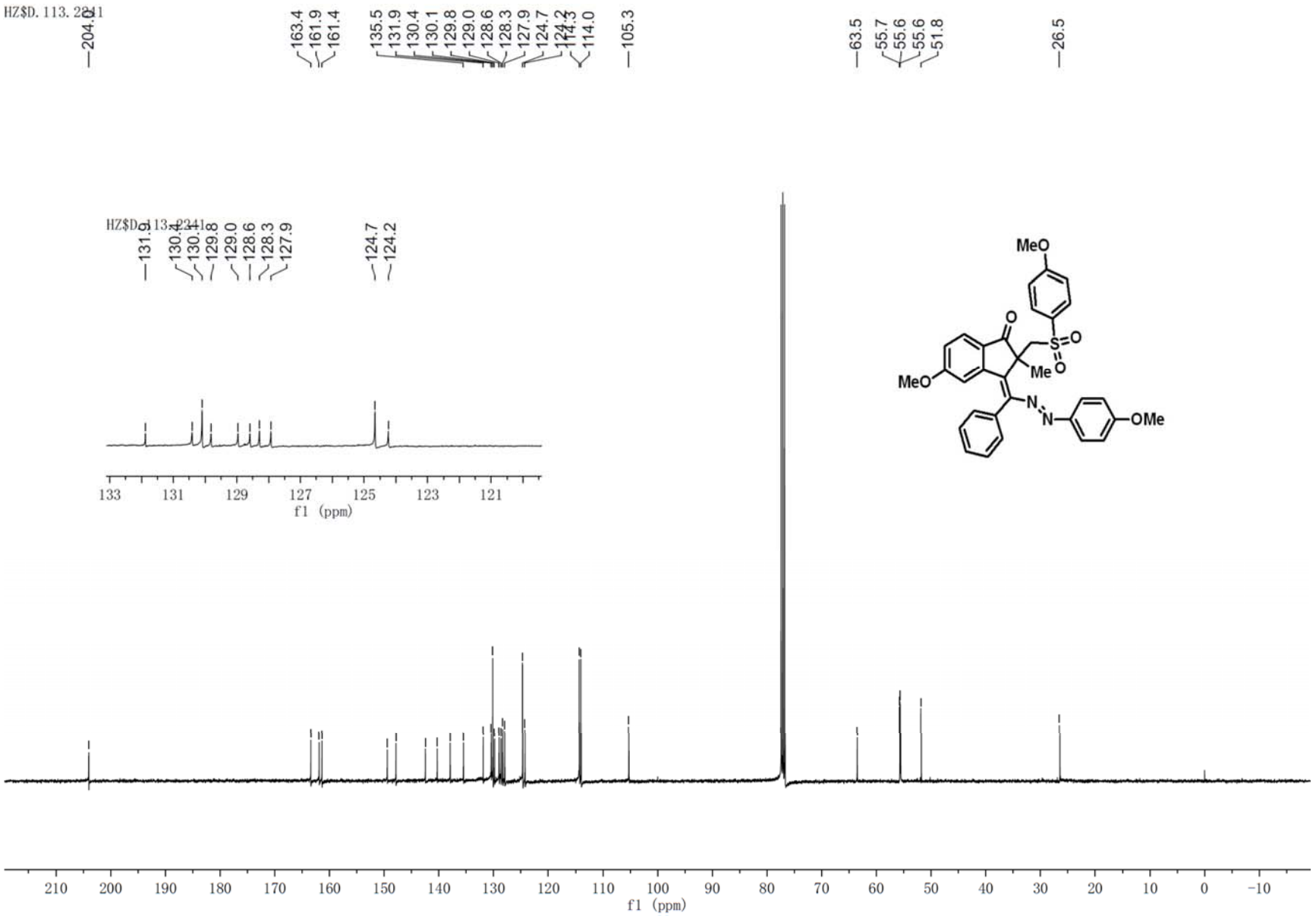
^{1}H NMR Spectrum of Compound 4m



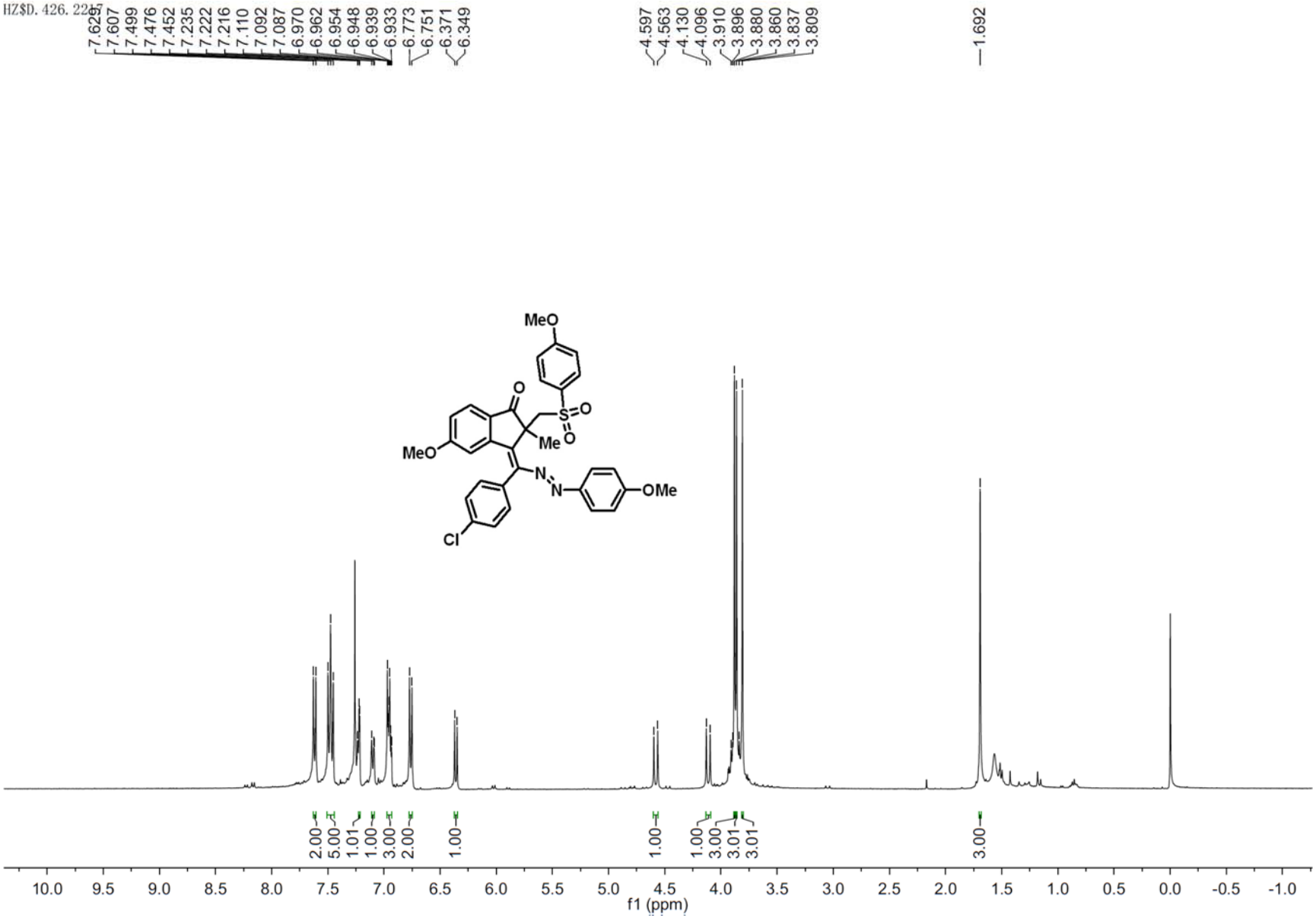
^{13}C NMR Spectrum of Compound 4m



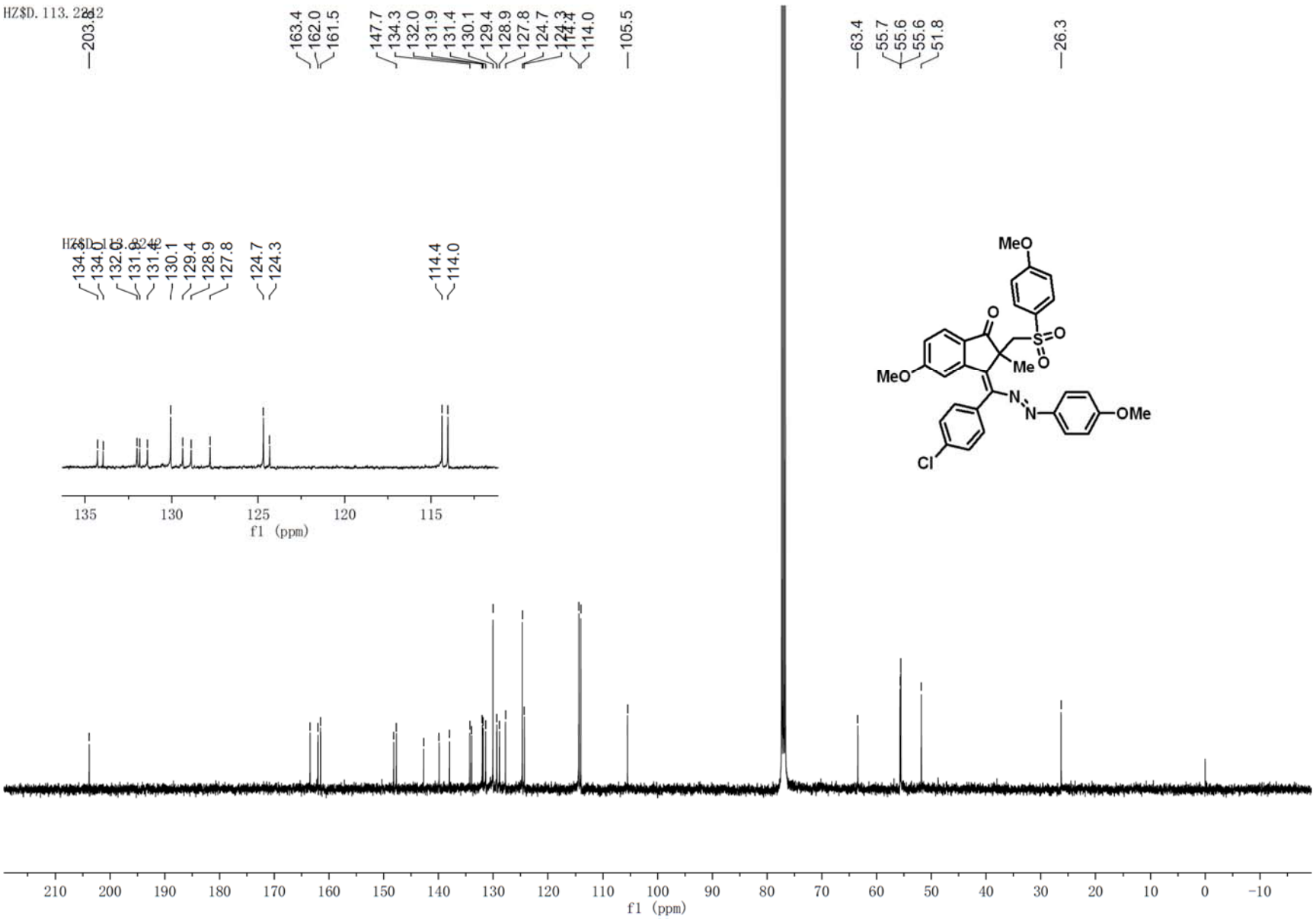
^{1}H NMR Spectrum of Compound 4n



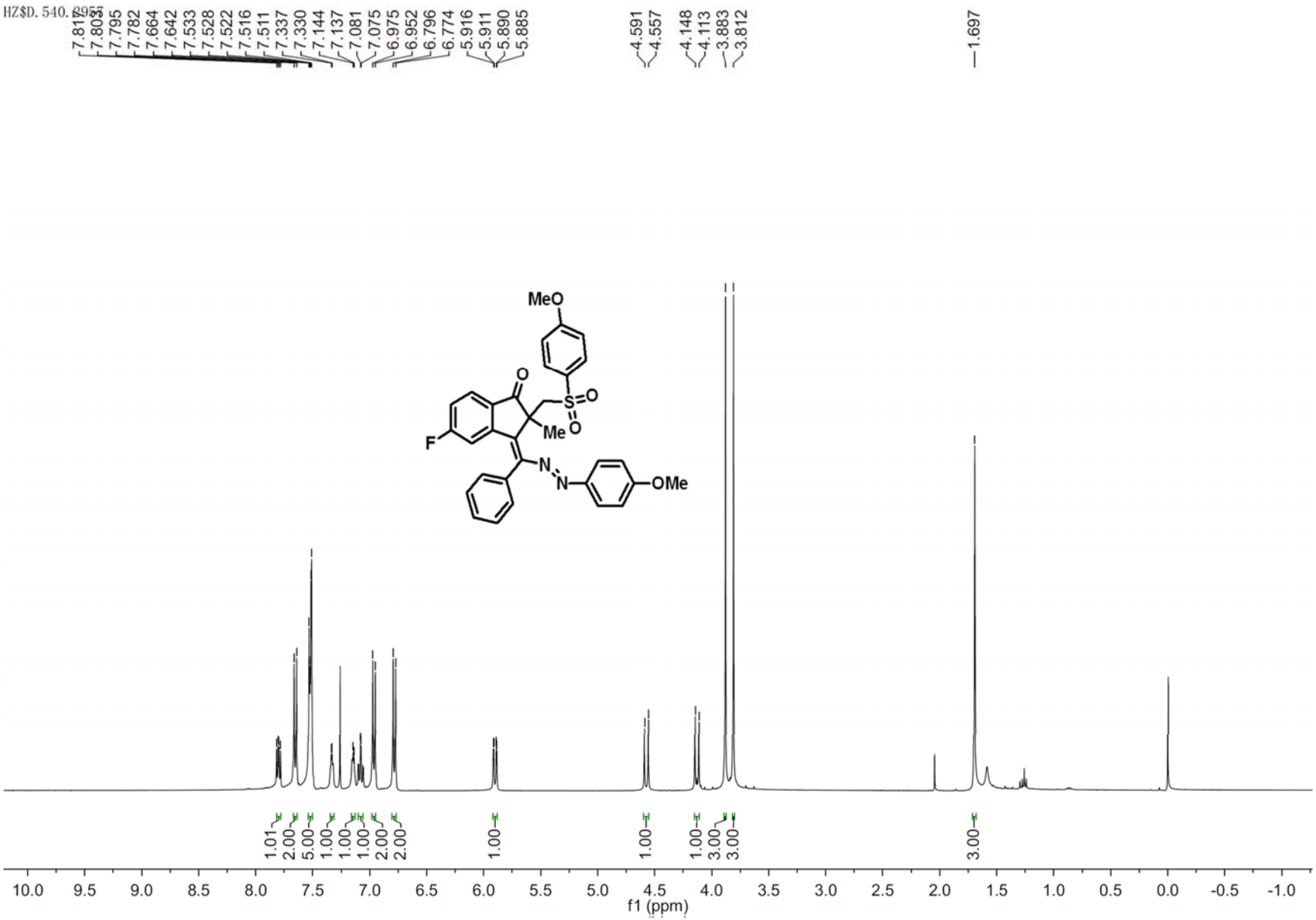
^{13}C NMR Spectrum of Compound 4n



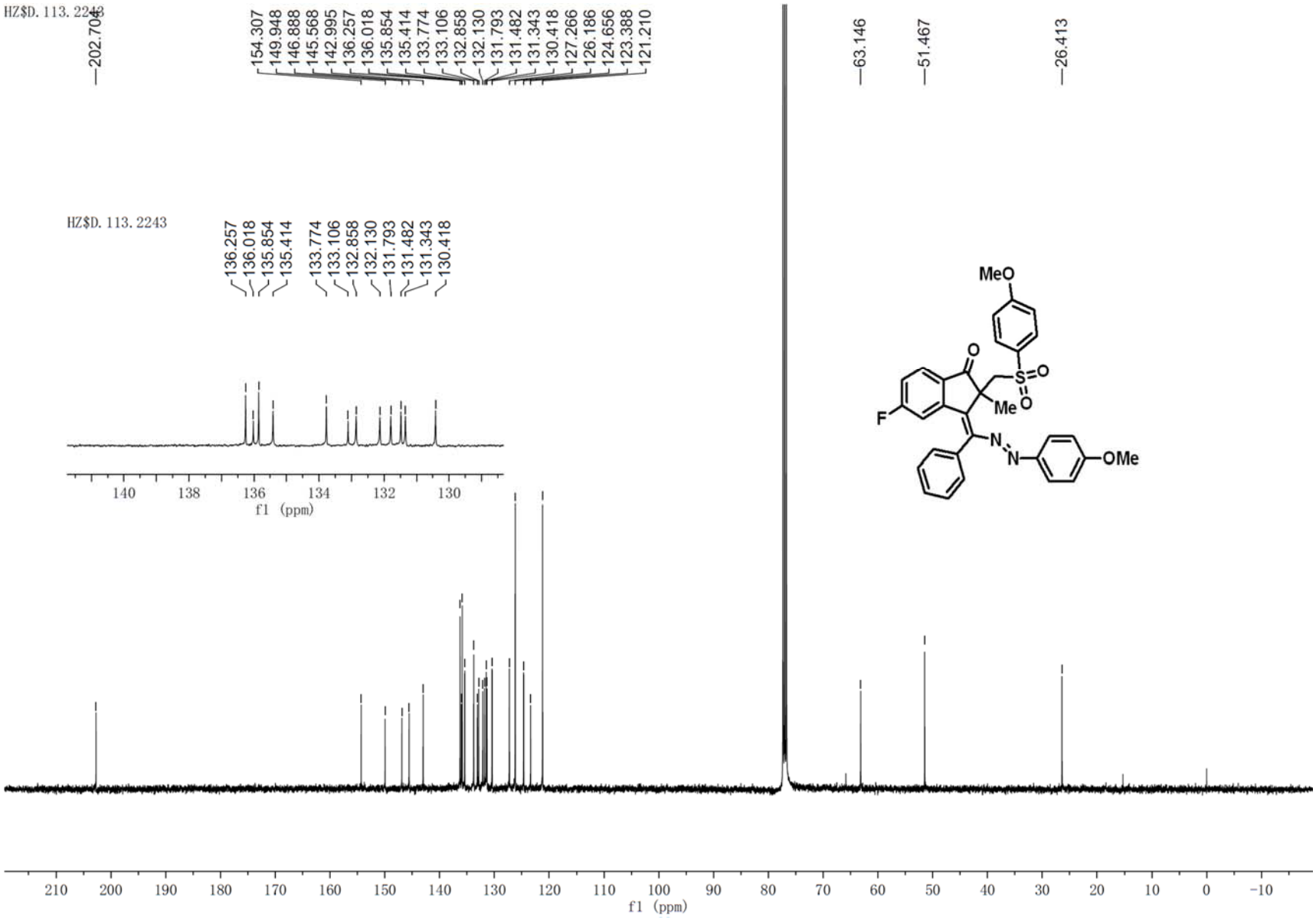
^{1}H NMR Spectrum of Compound 4o



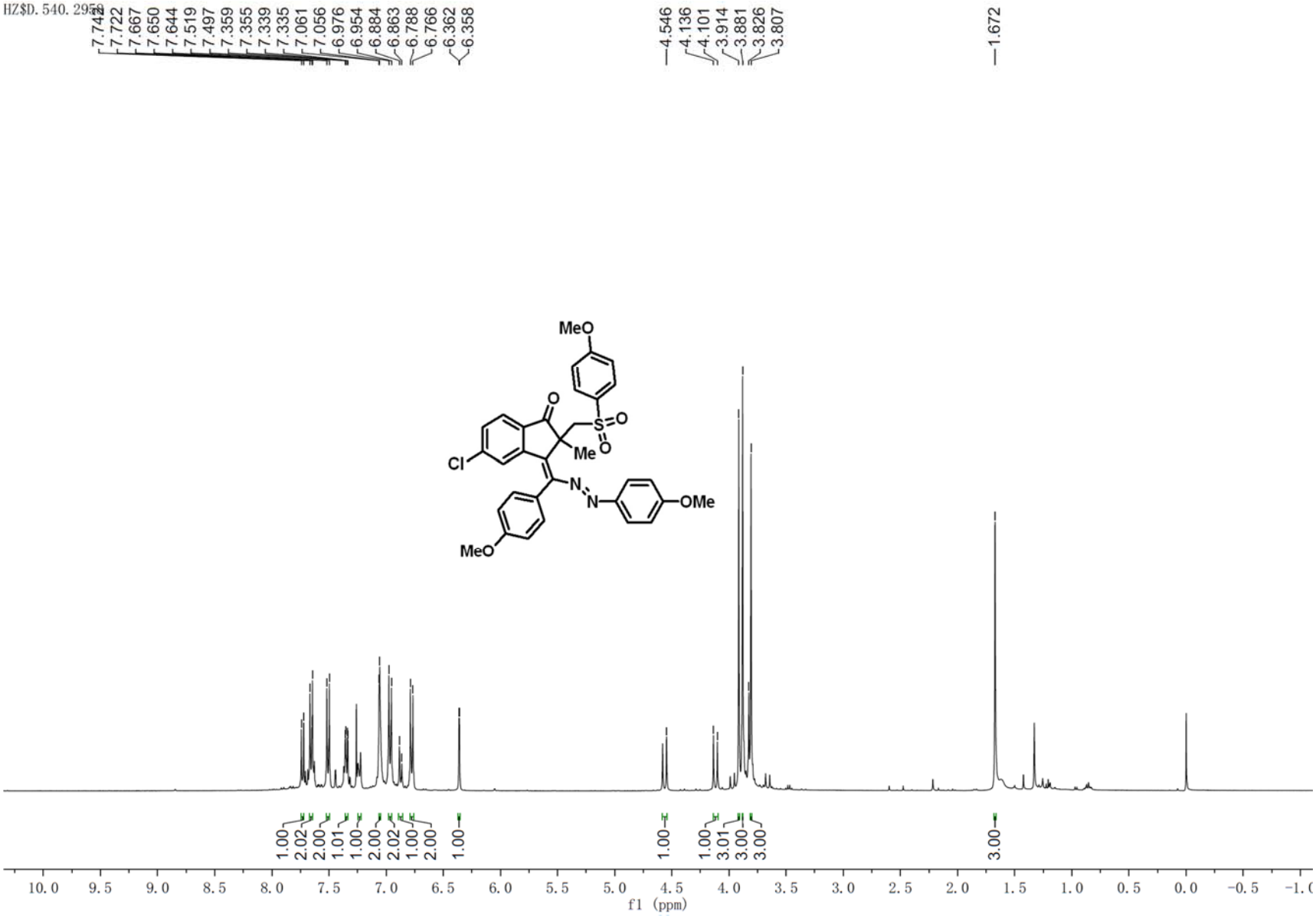
^{13}C NMR Spectrum of Compound 4o



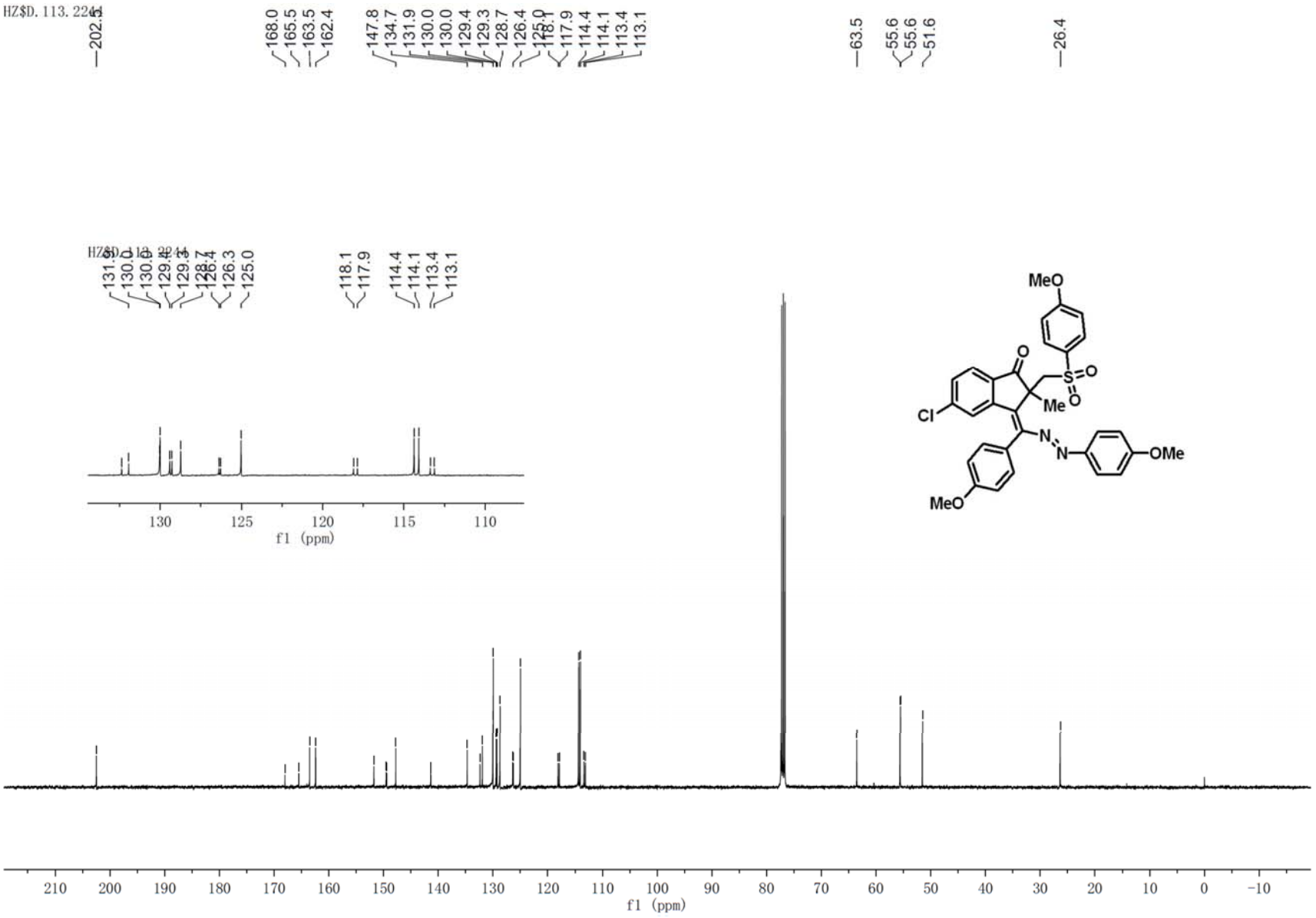
^{1}H NMR Spectrum of Compound 4p



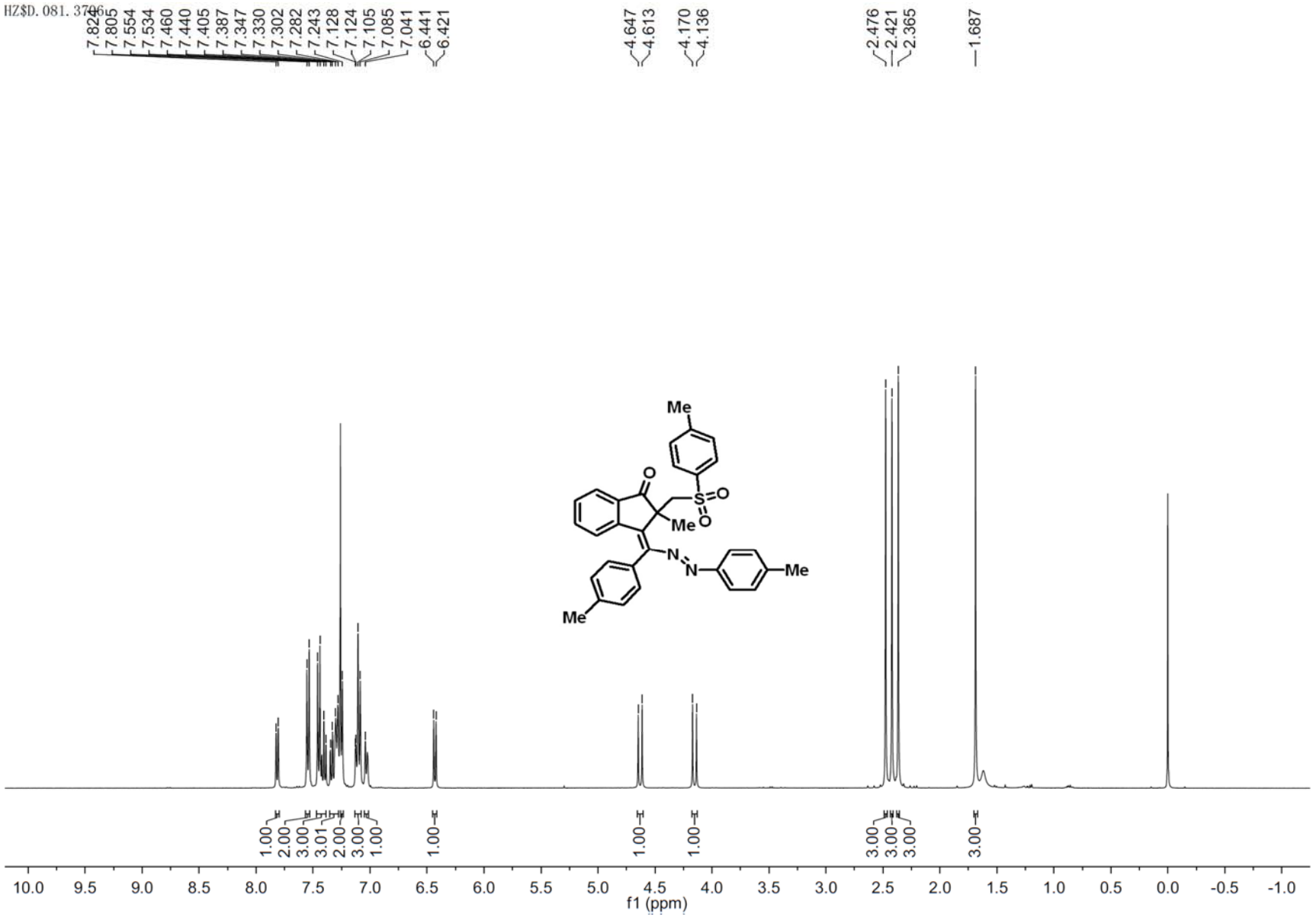
^{13}C NMR Spectrum of Compound 4p



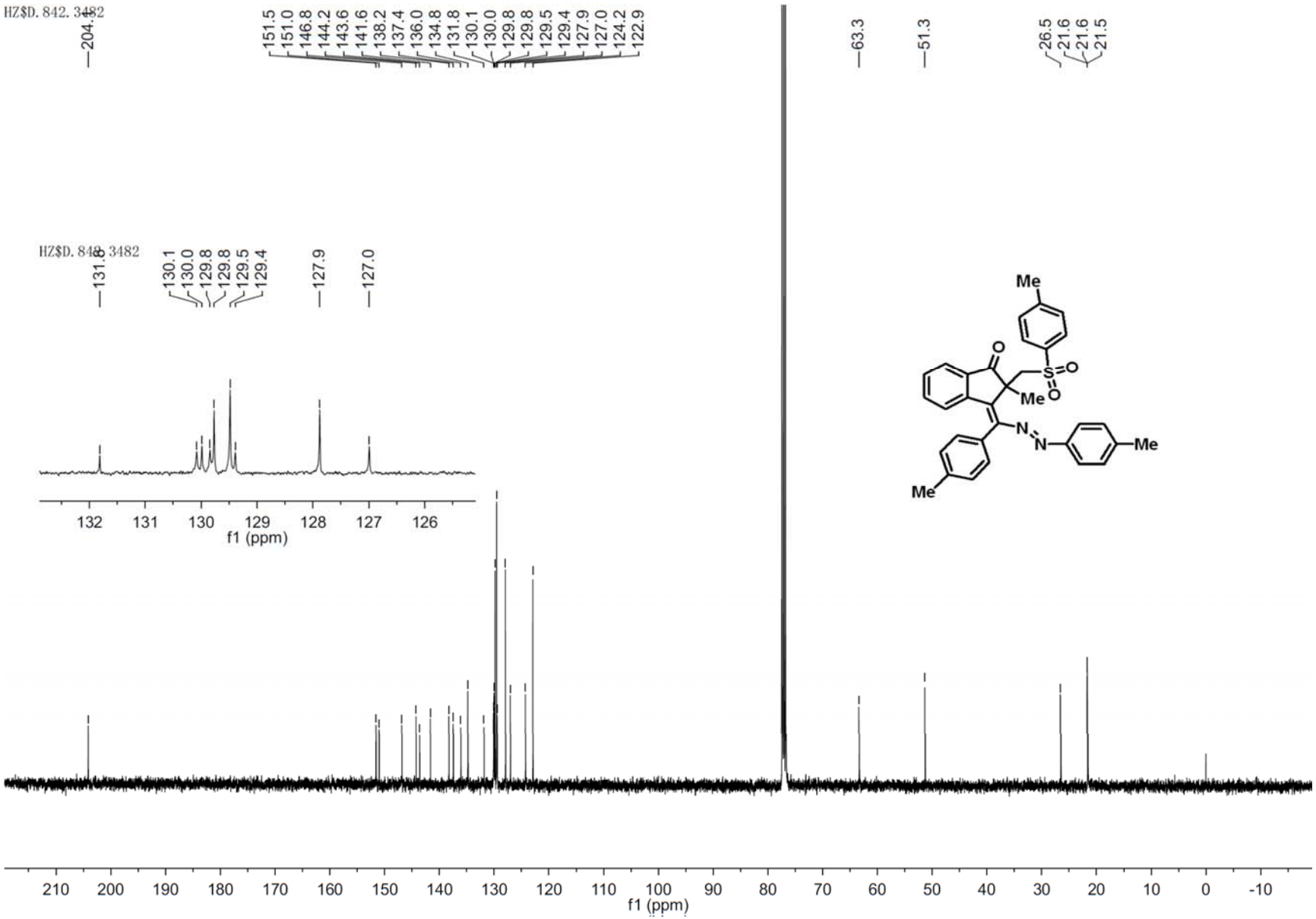
^{1}H NMR Spectrum of Compound 4q



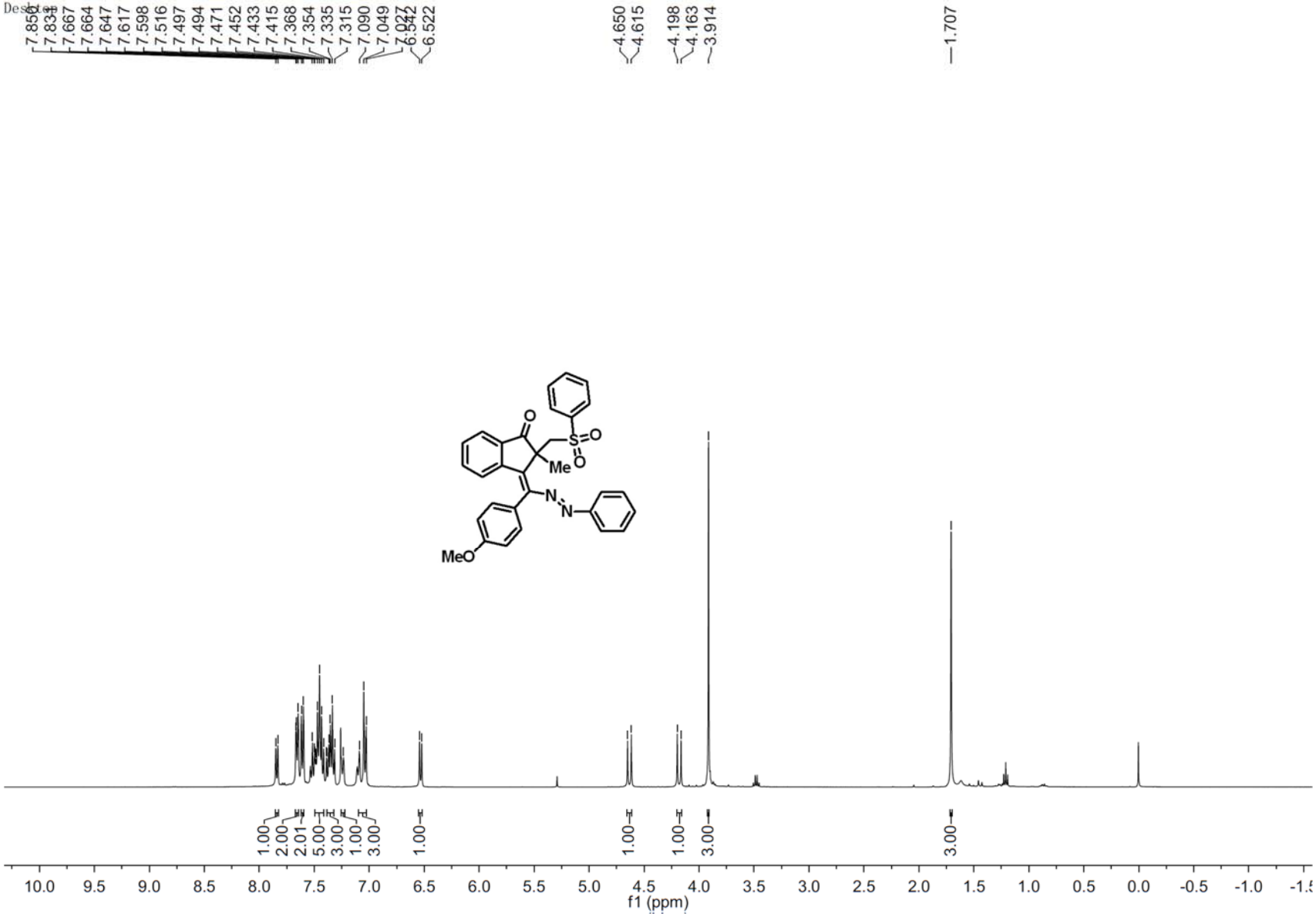
^{13}C NMR Spectrum of Compound 4q



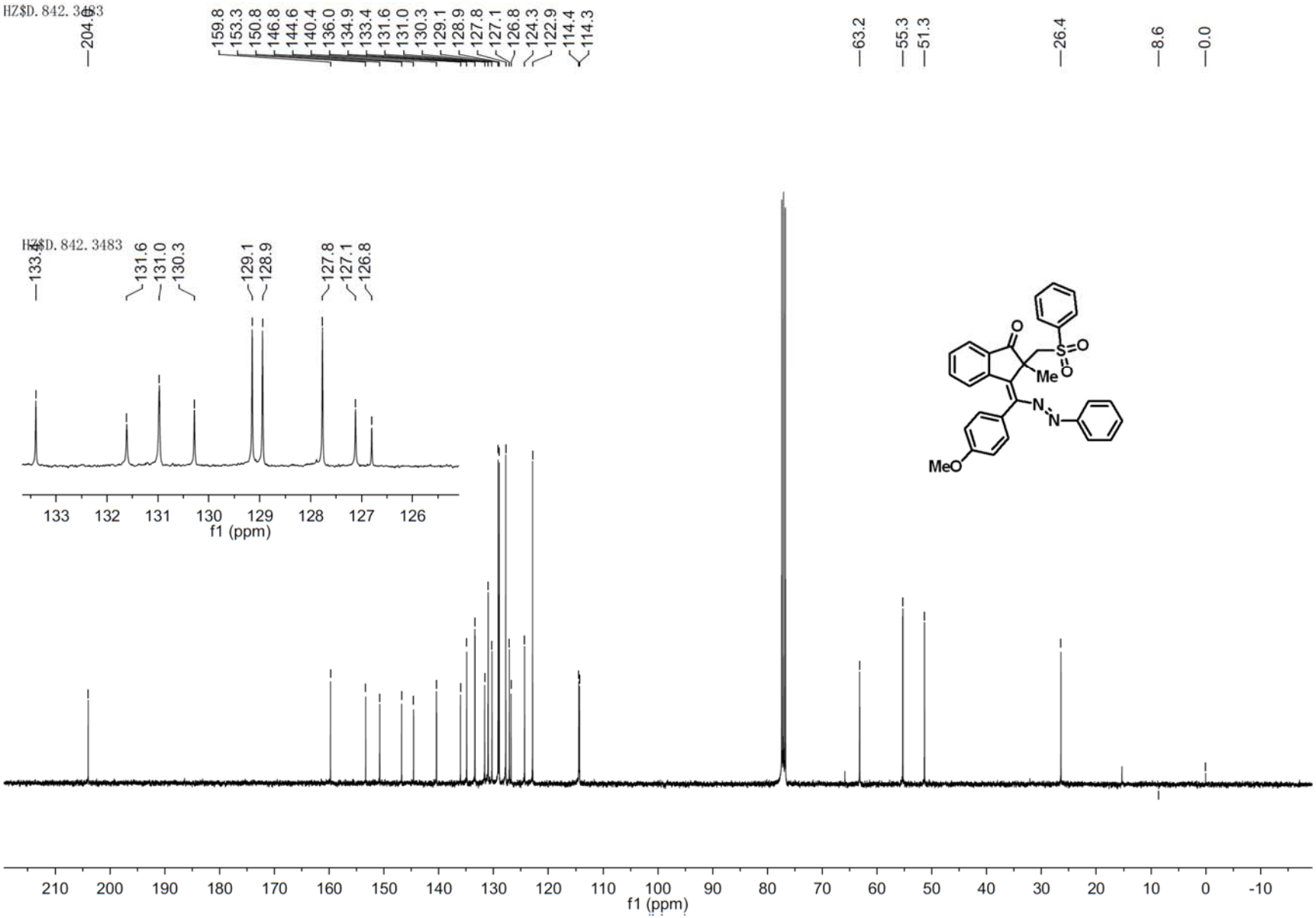
^{1}H NMR Spectrum of Compound 4r



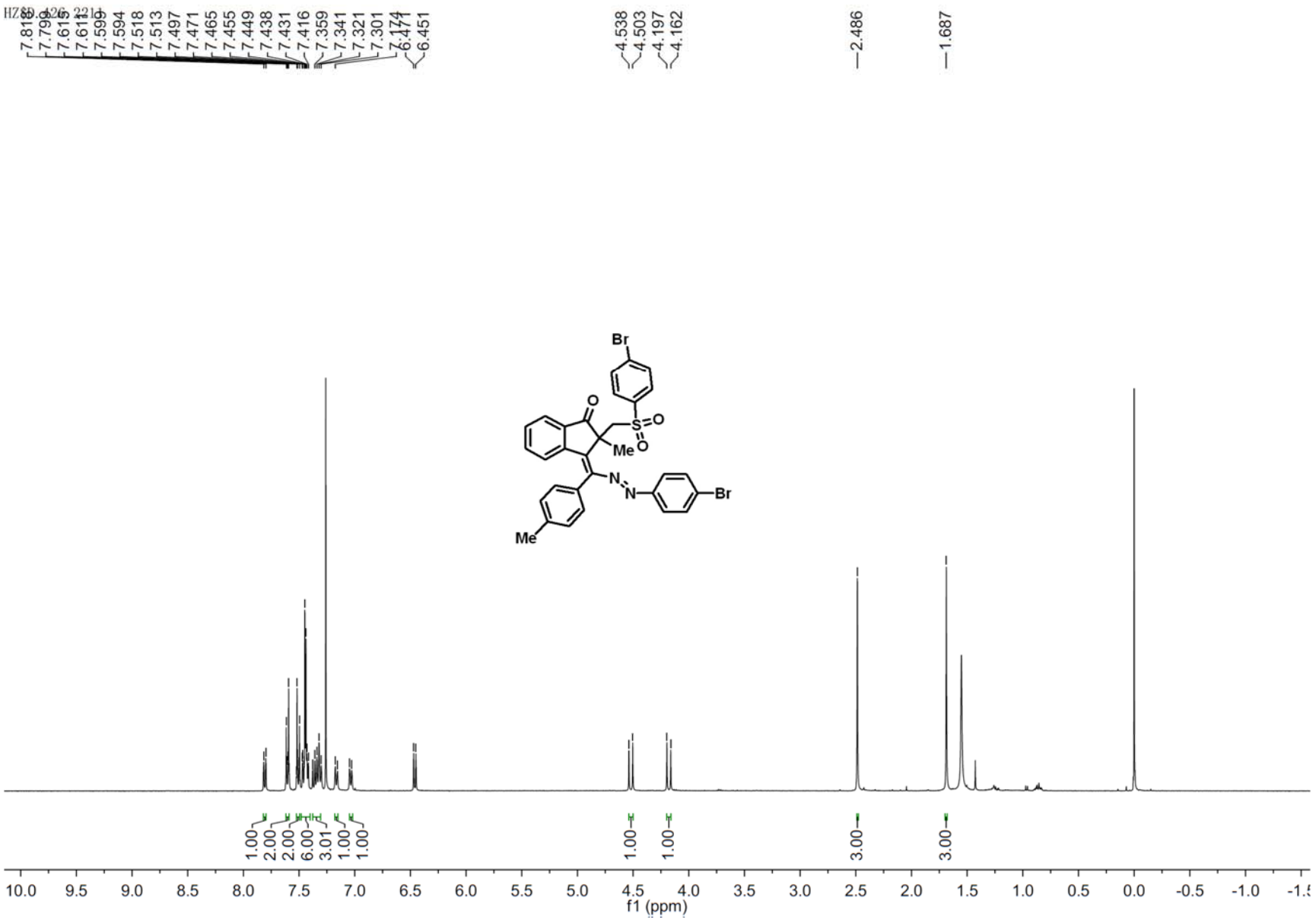
^{13}C NMR Spectrum of Compound 4r



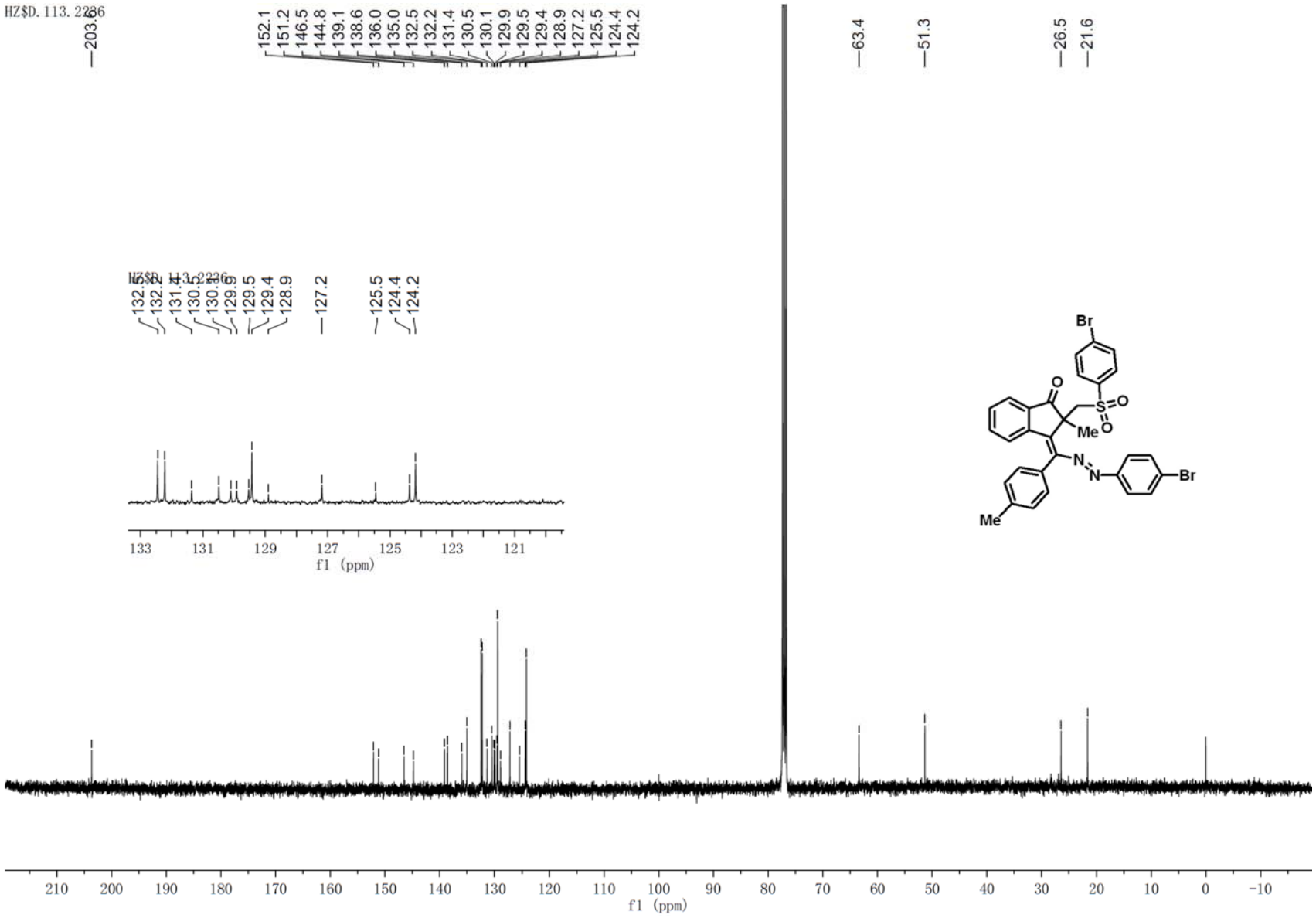
^{1}H NMR Spectrum of Compound 4s



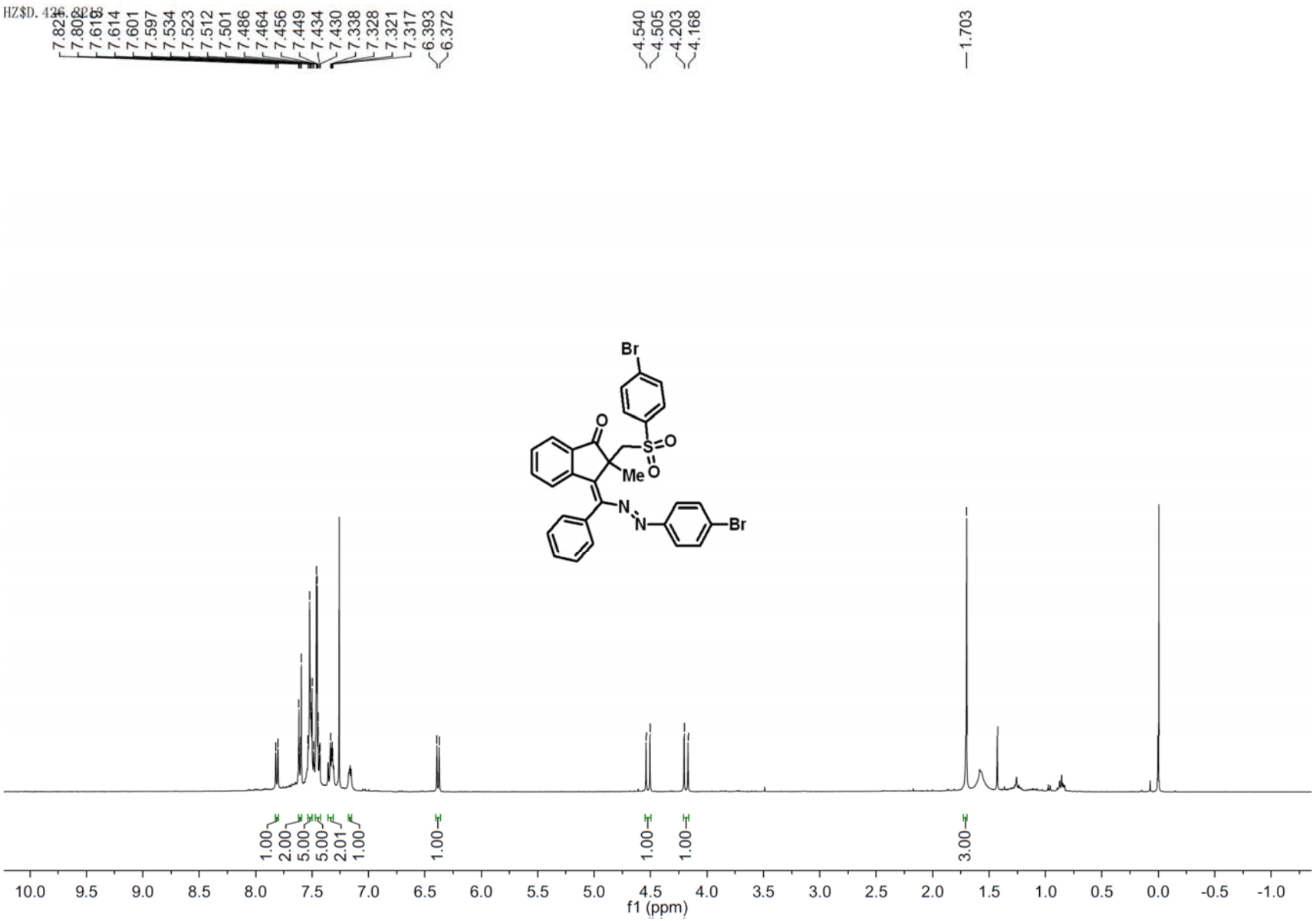
^{13}C NMR Spectrum of Compound 4s



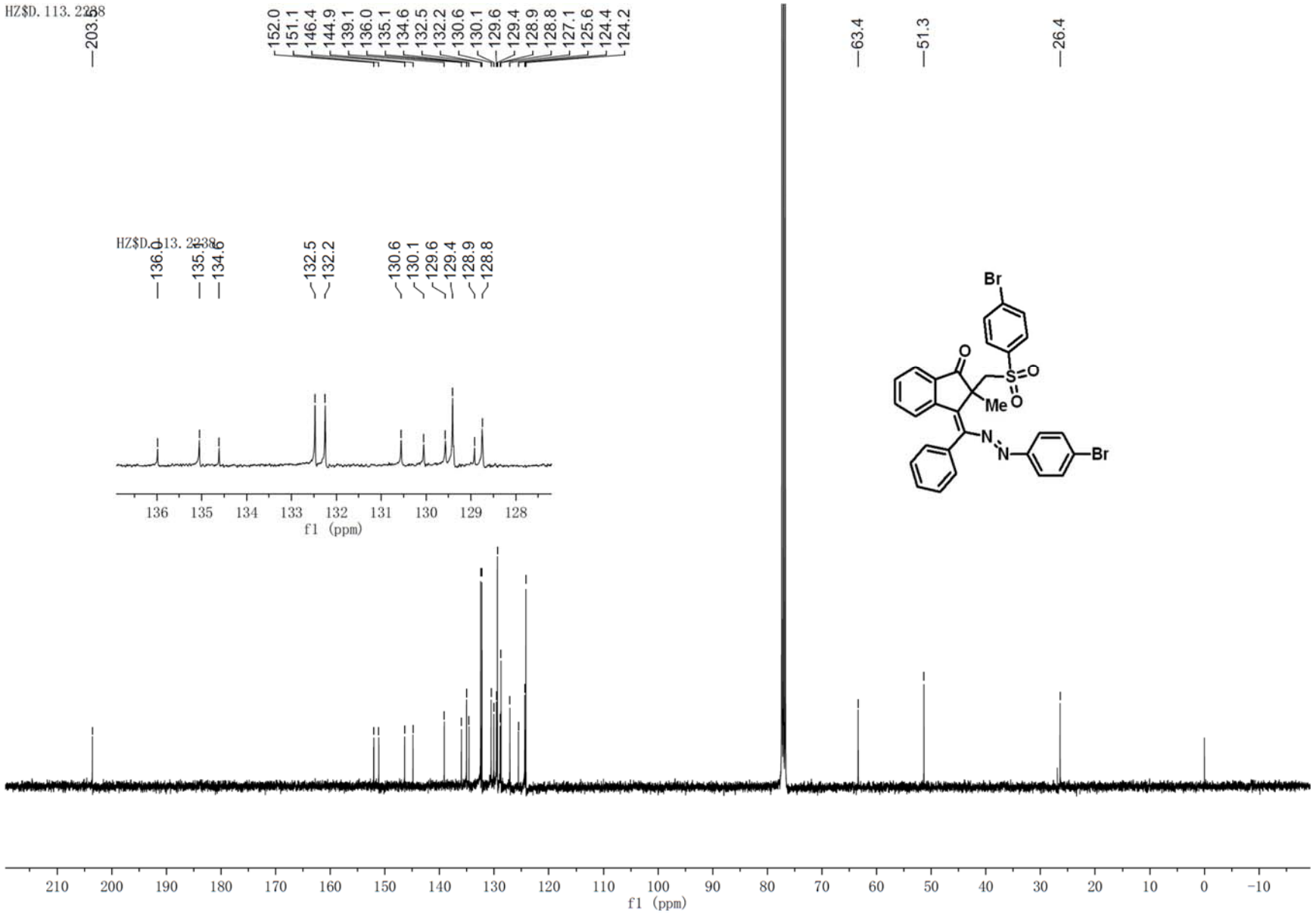
^{1}H NMR Spectrum of Compound 4t



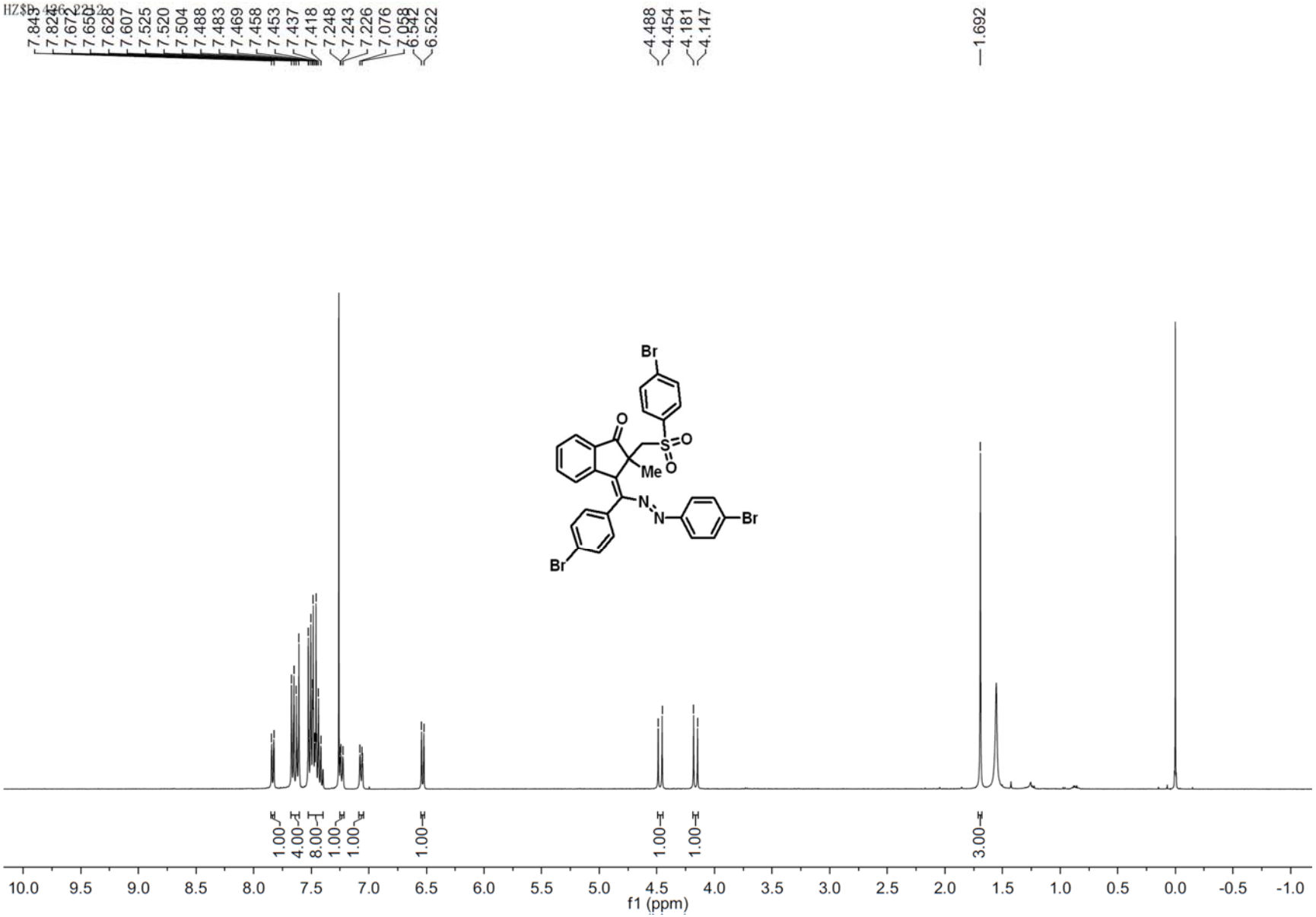
^{13}C NMR Spectrum of Compound 4t



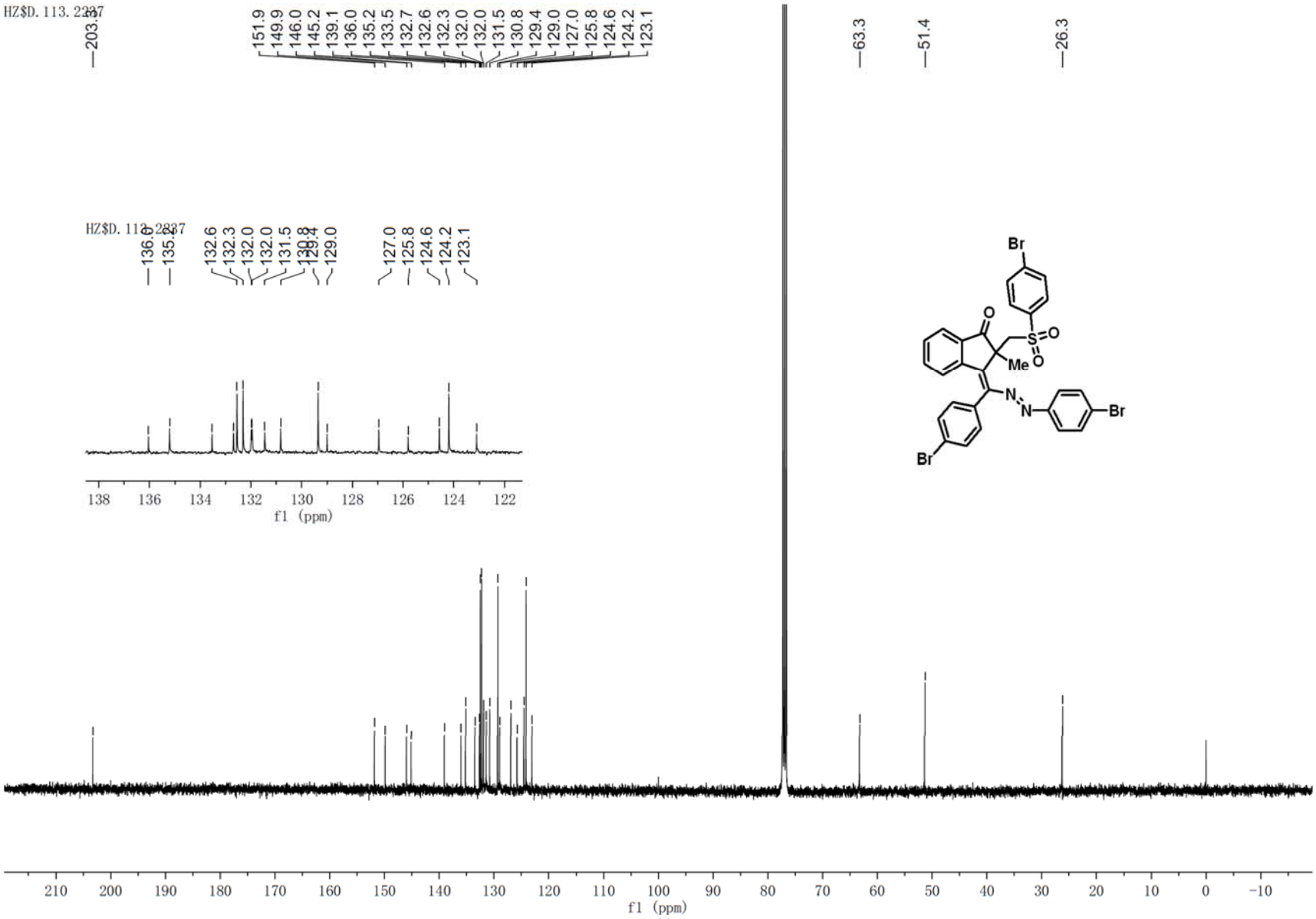
^{1}H NMR Spectrum of Compound 4u



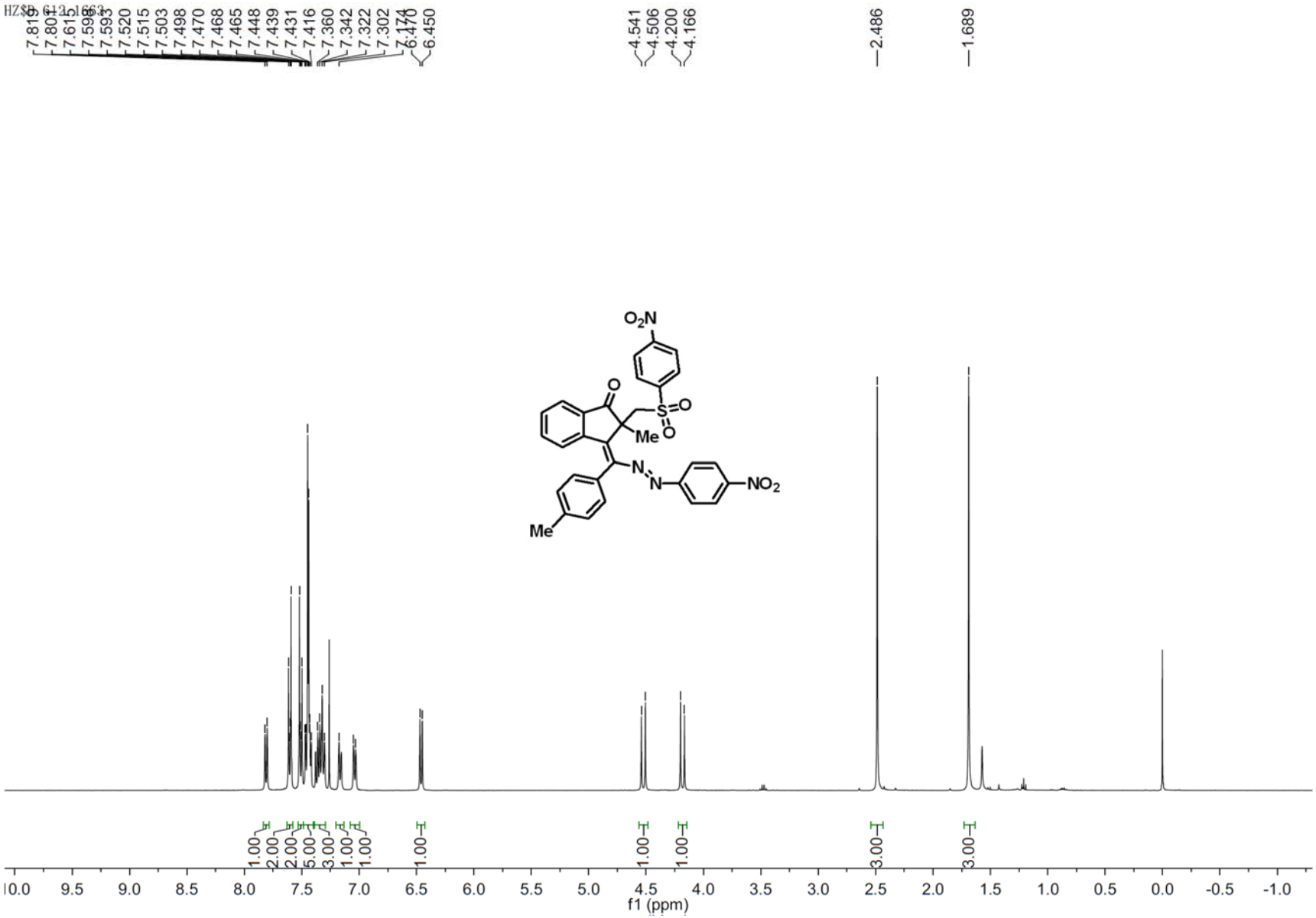
^{13}C NMR Spectrum of Compound 4u



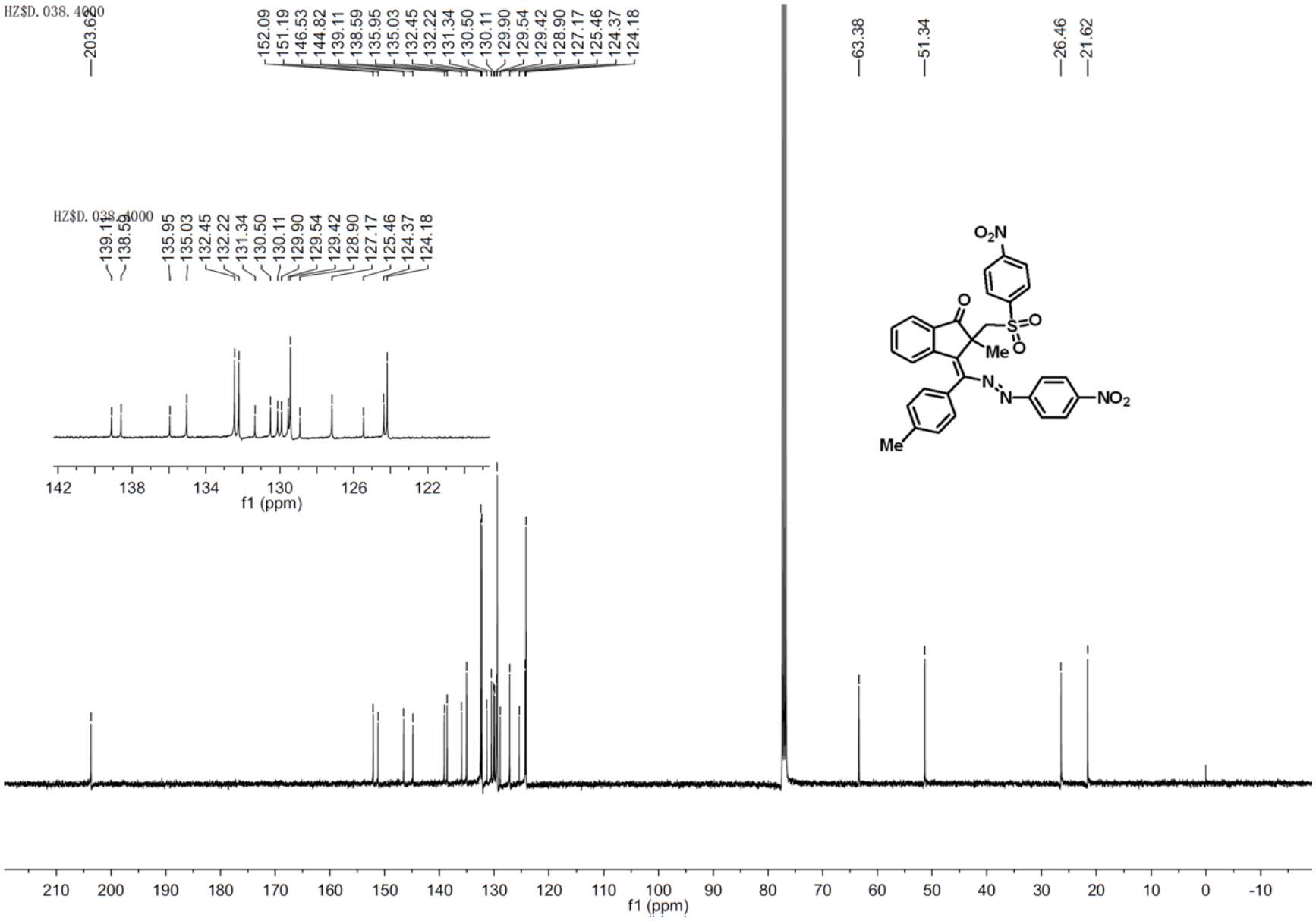
^{1}H NMR Spectrum of Compound 4v



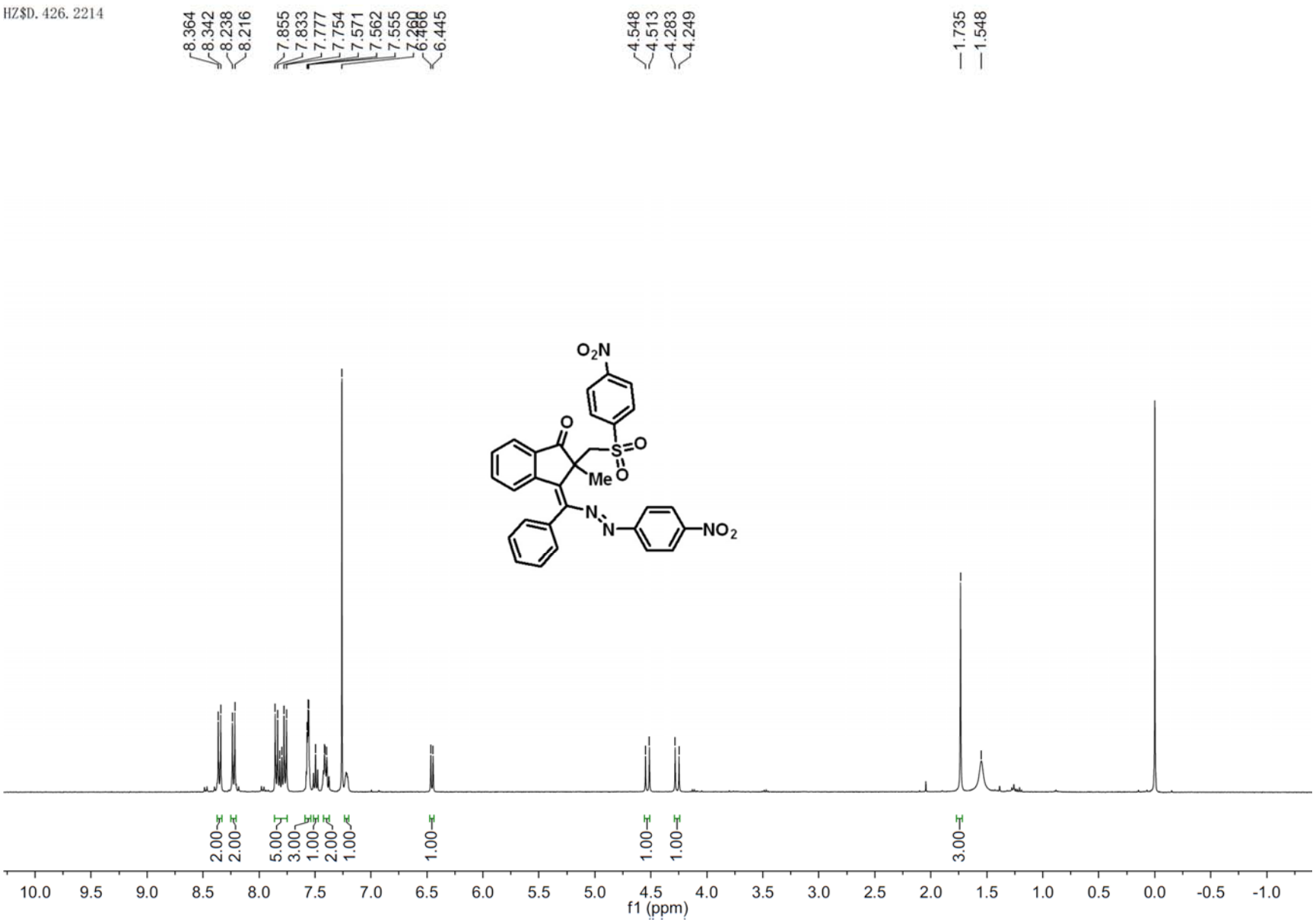
^{13}C NMR Spectrum of Compound 4v



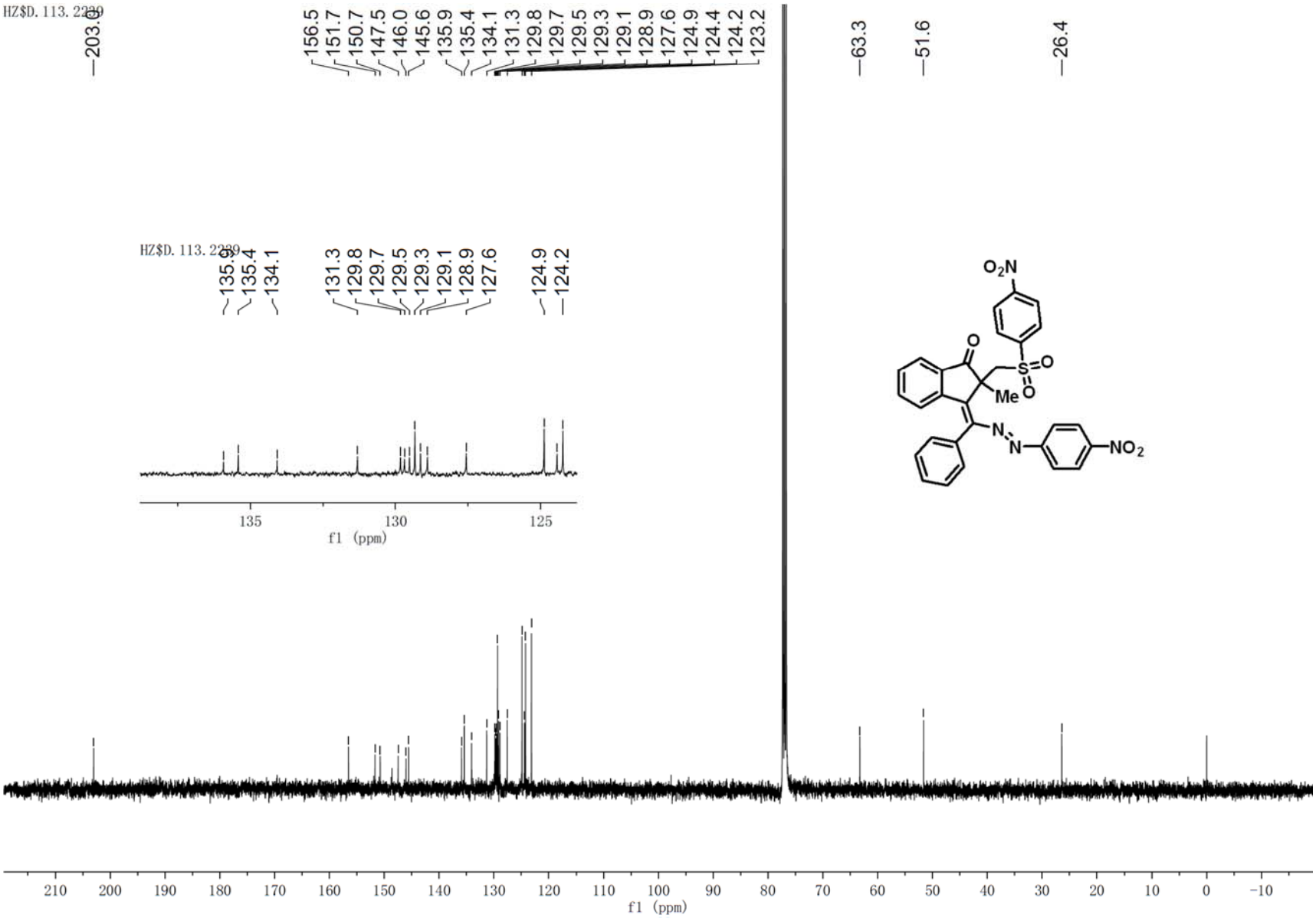
^{1}H NMR Spectrum of Compound 4w



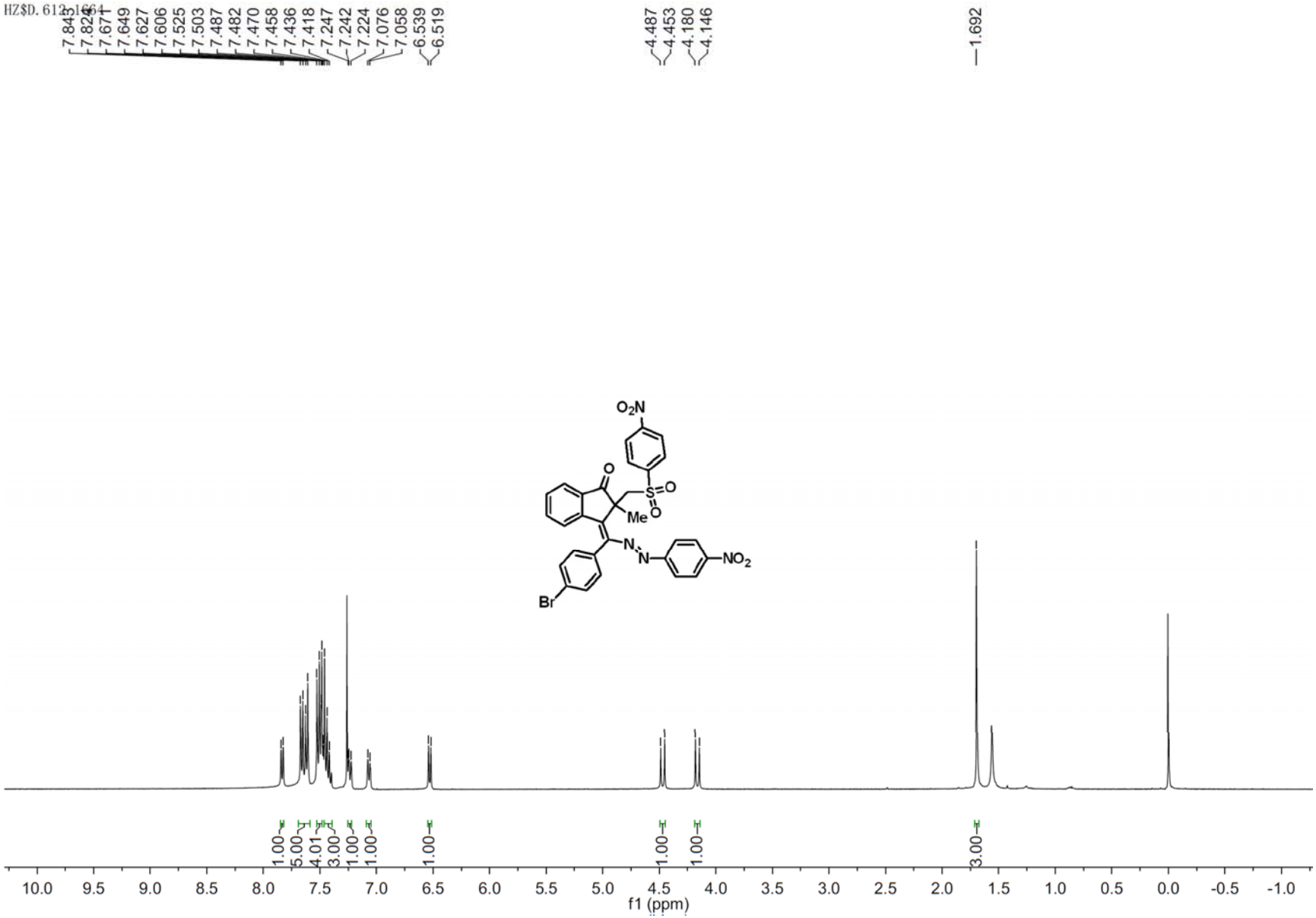
^{13}C NMR Spectrum of Compound 4w



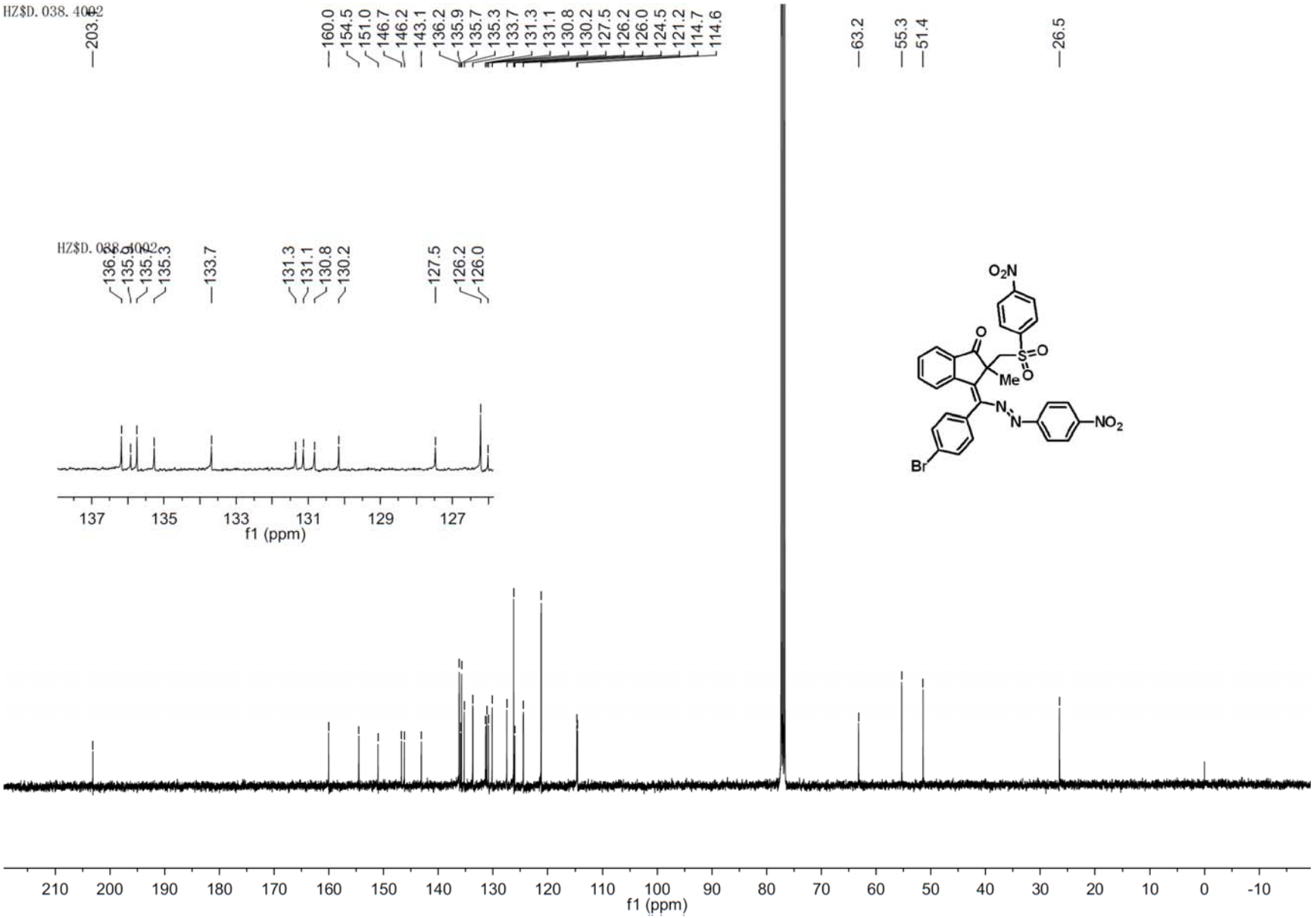
^{1}H NMR Spectrum of Compound 4x



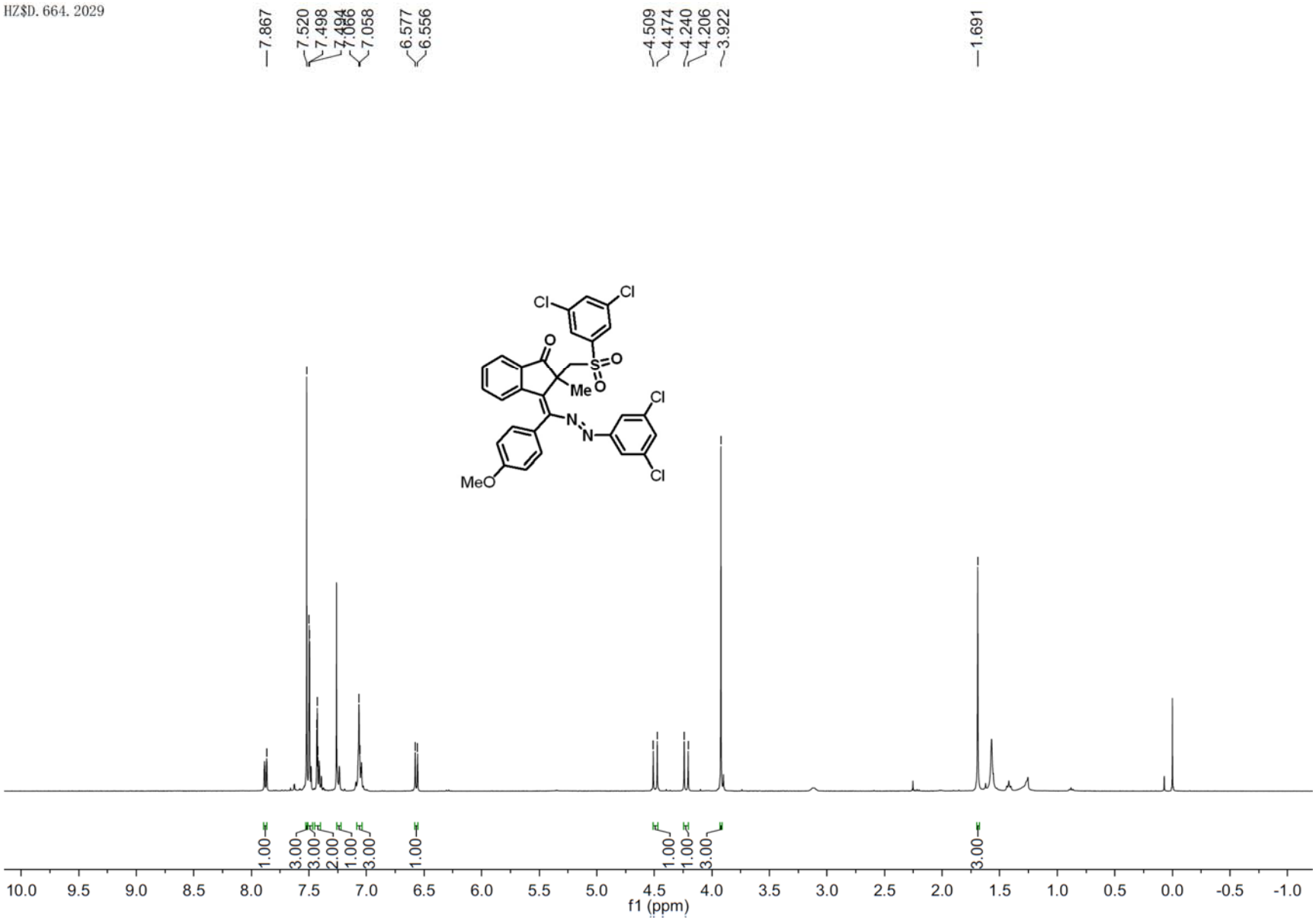
^{13}C NMR Spectrum of Compound 4x



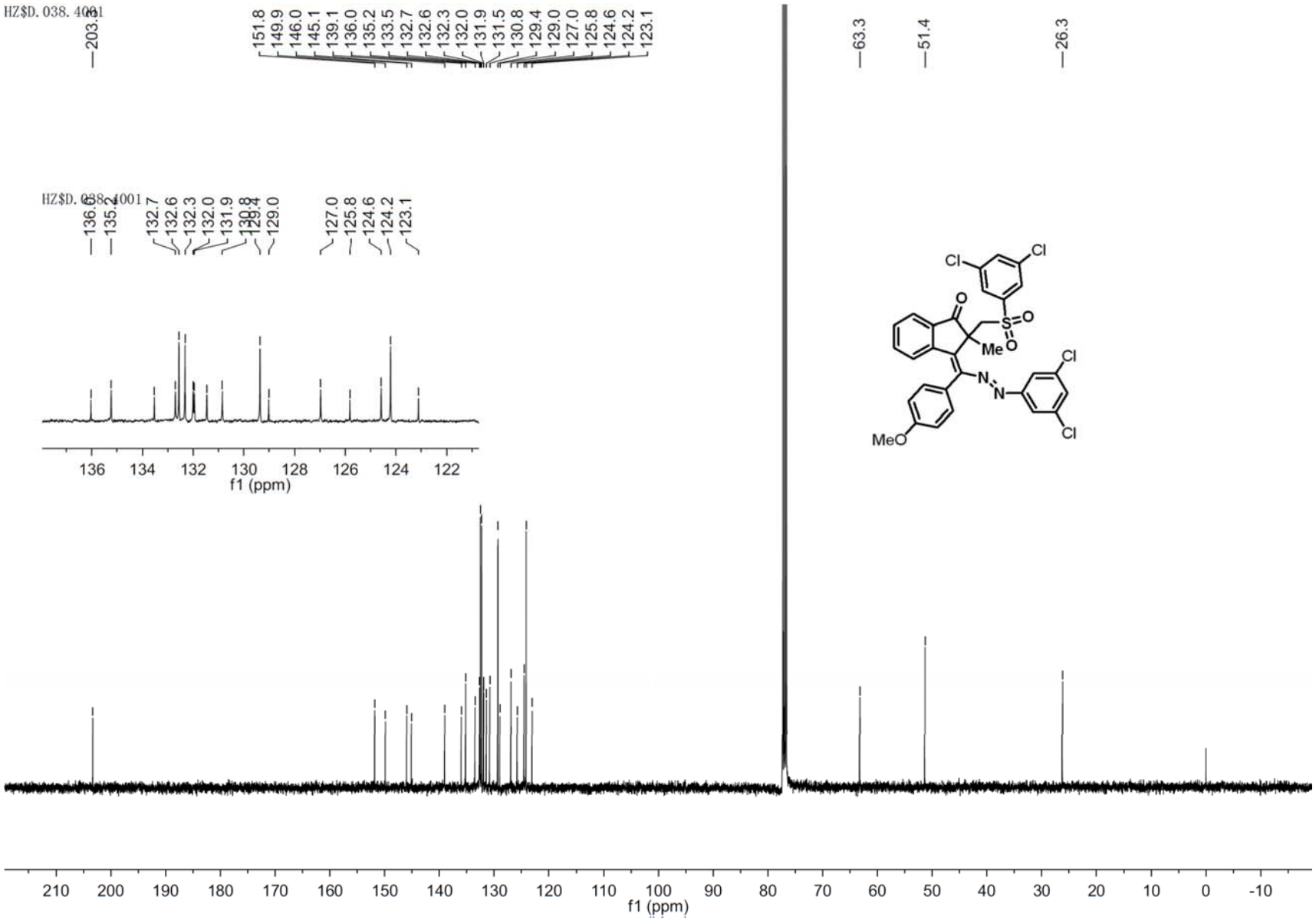
^{1}H NMR Spectrum of Compound 4y



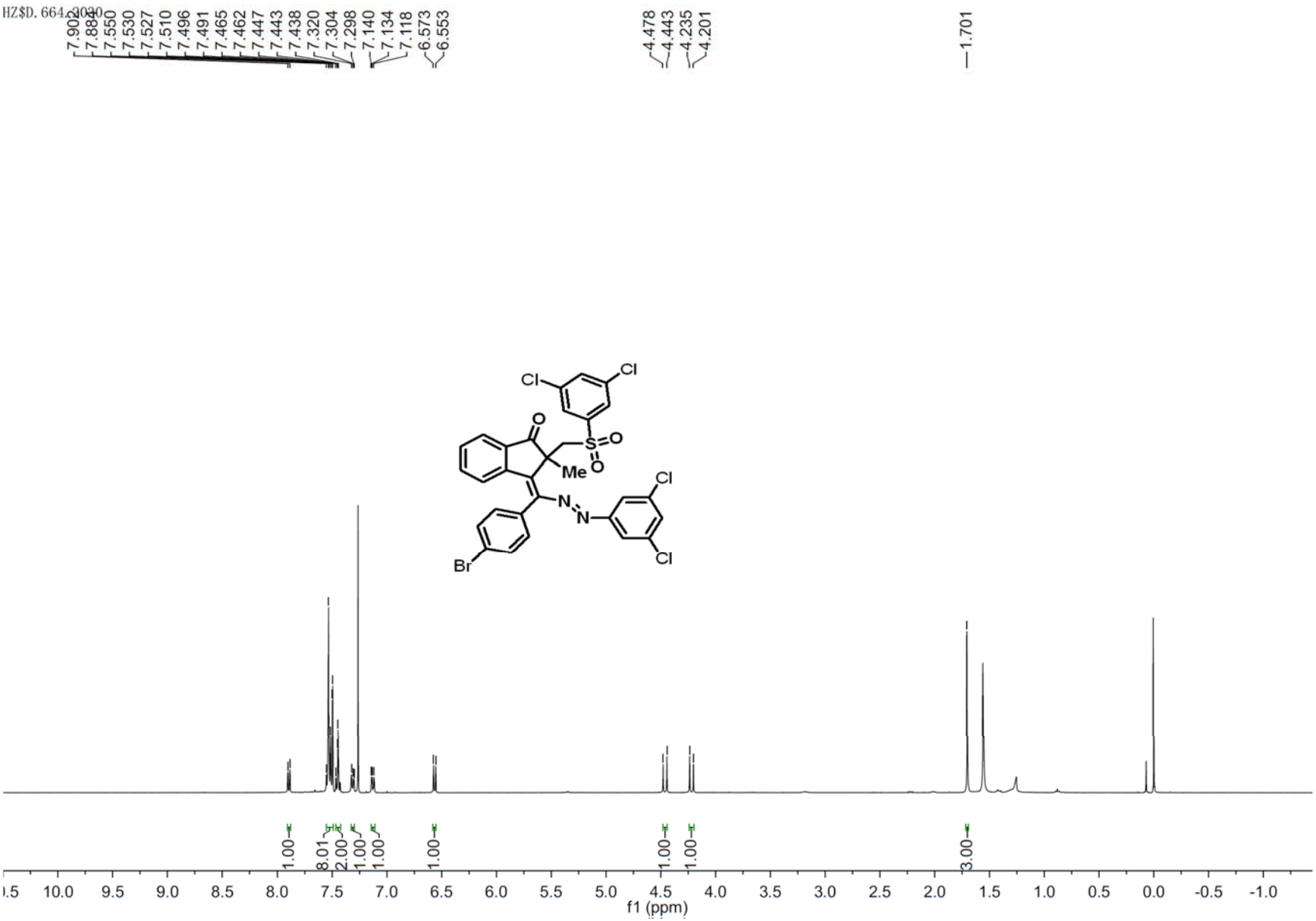
^{13}C NMR Spectrum of Compound 4y



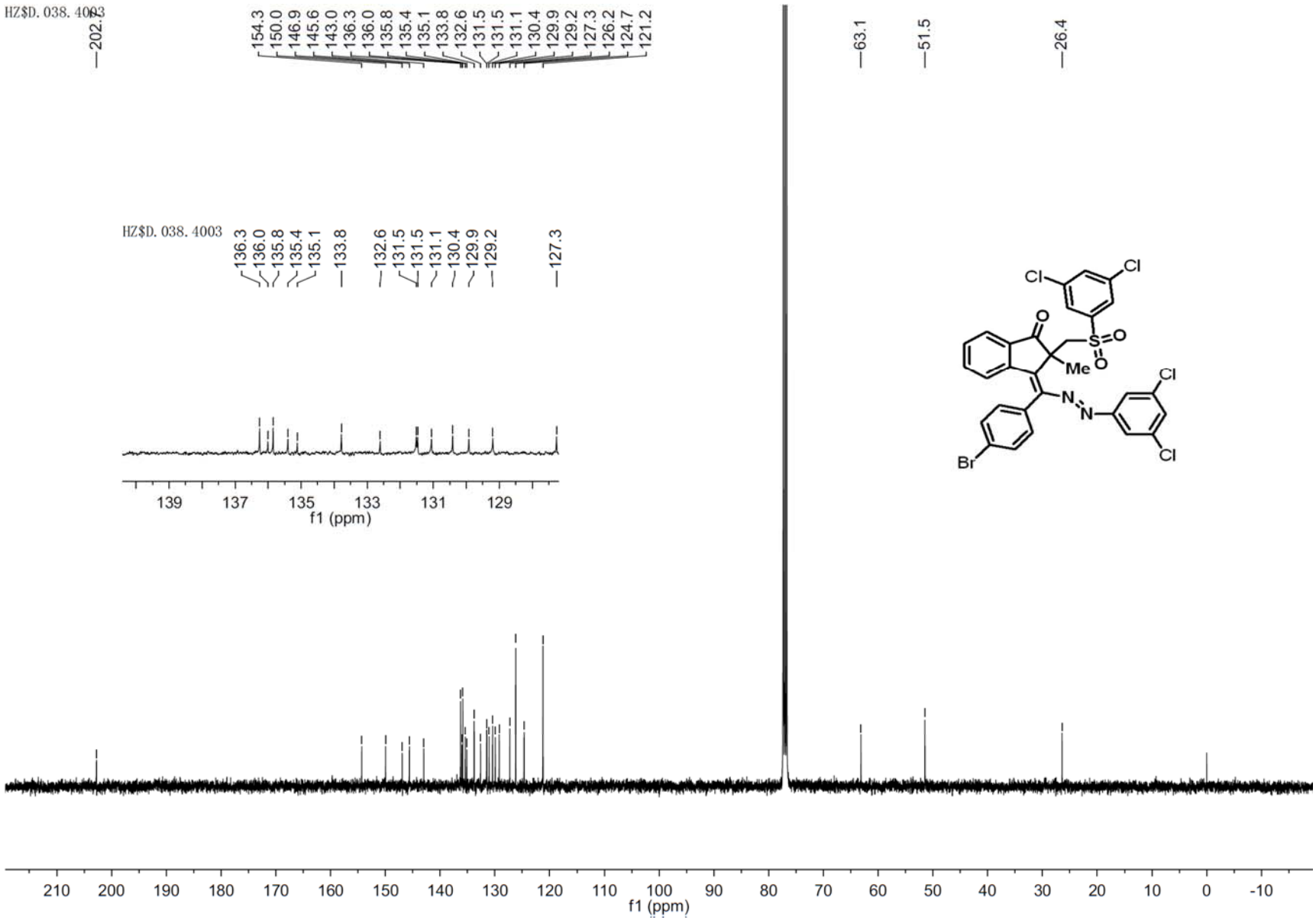
^{1}H NMR Spectrum of Compound 4z



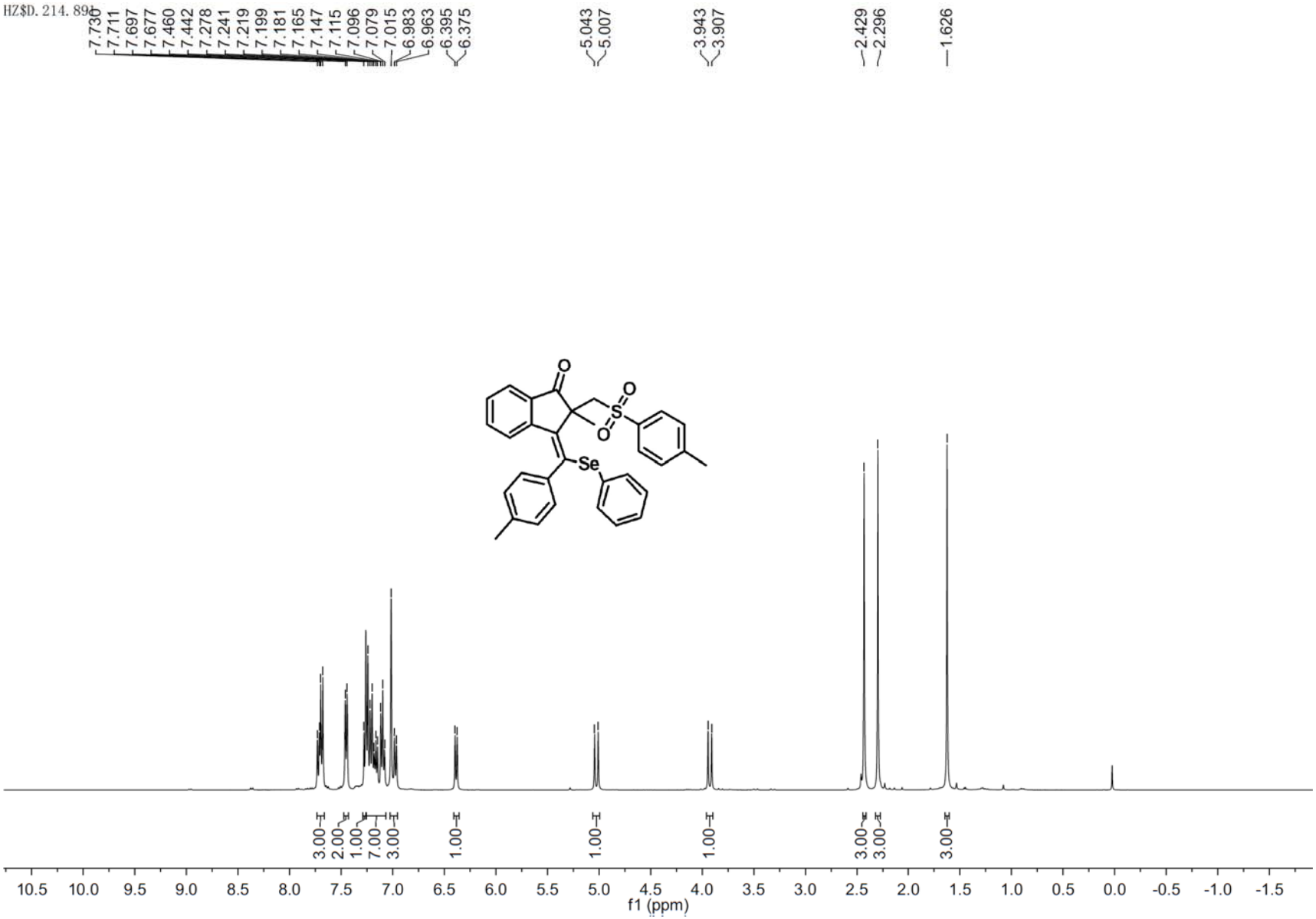
^{13}C NMR Spectrum of Compound 4z



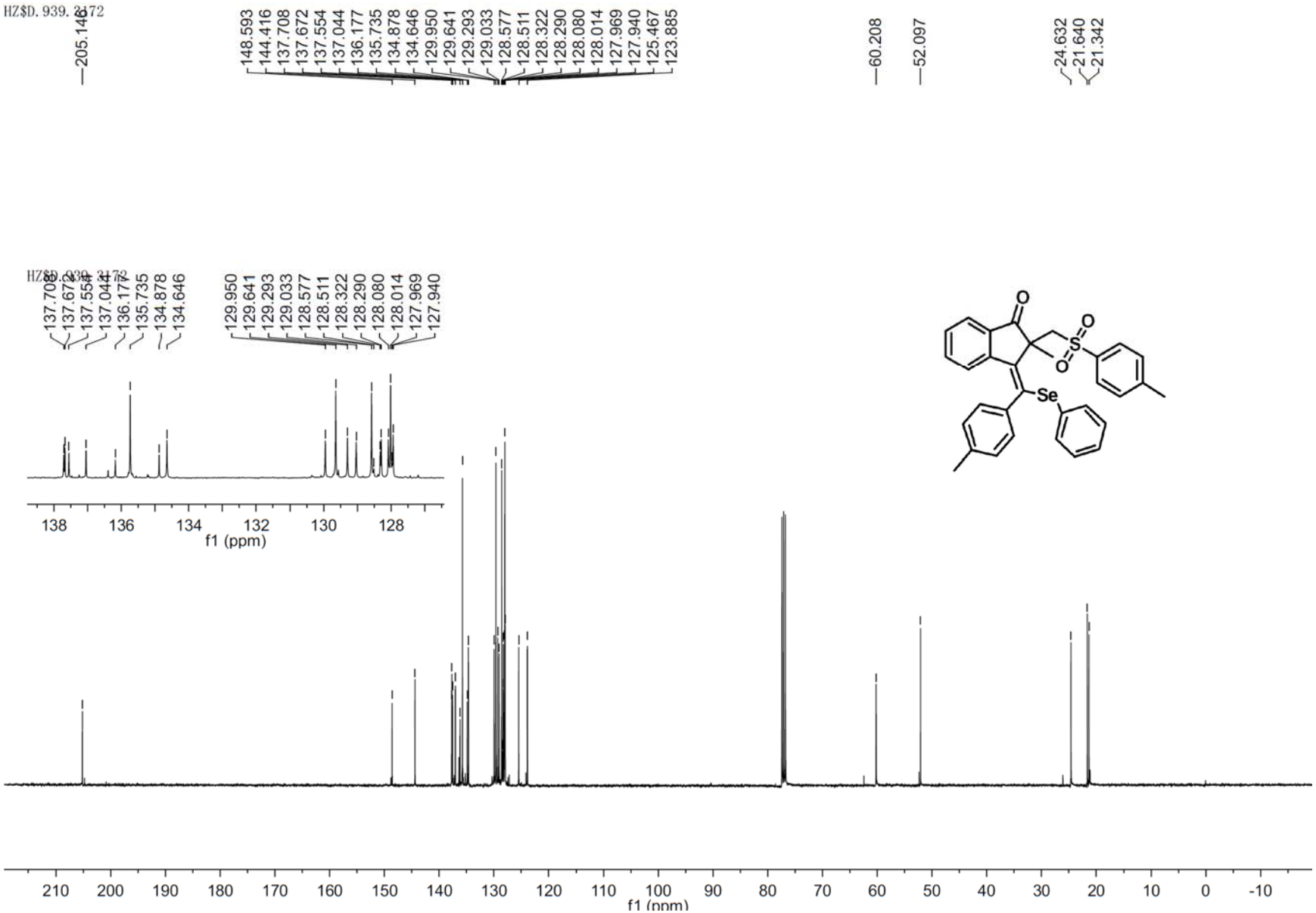
^{1}H NMR Spectrum of Compound 4aa



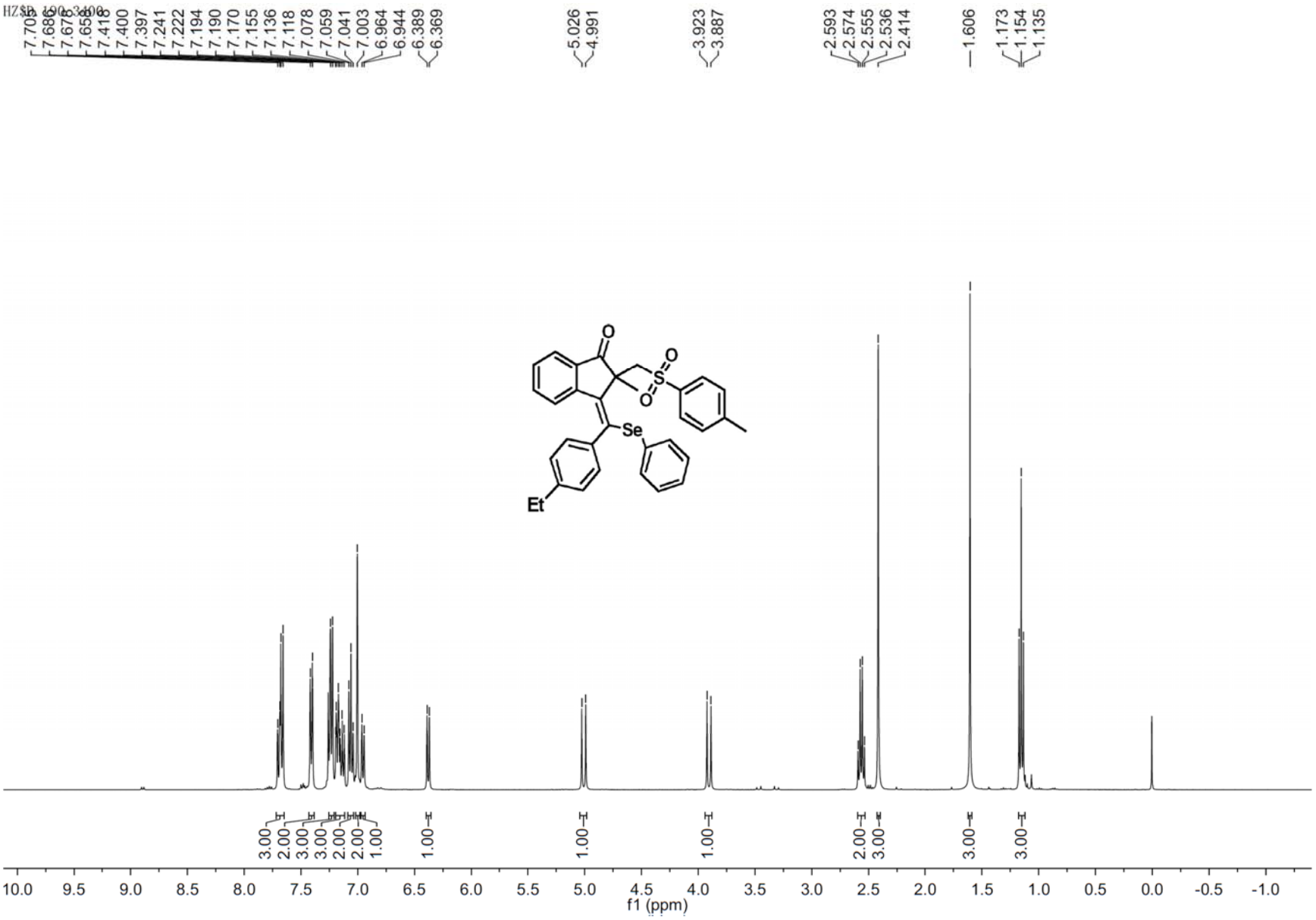
^{13}C NMR Spectrum of Compound 4aa



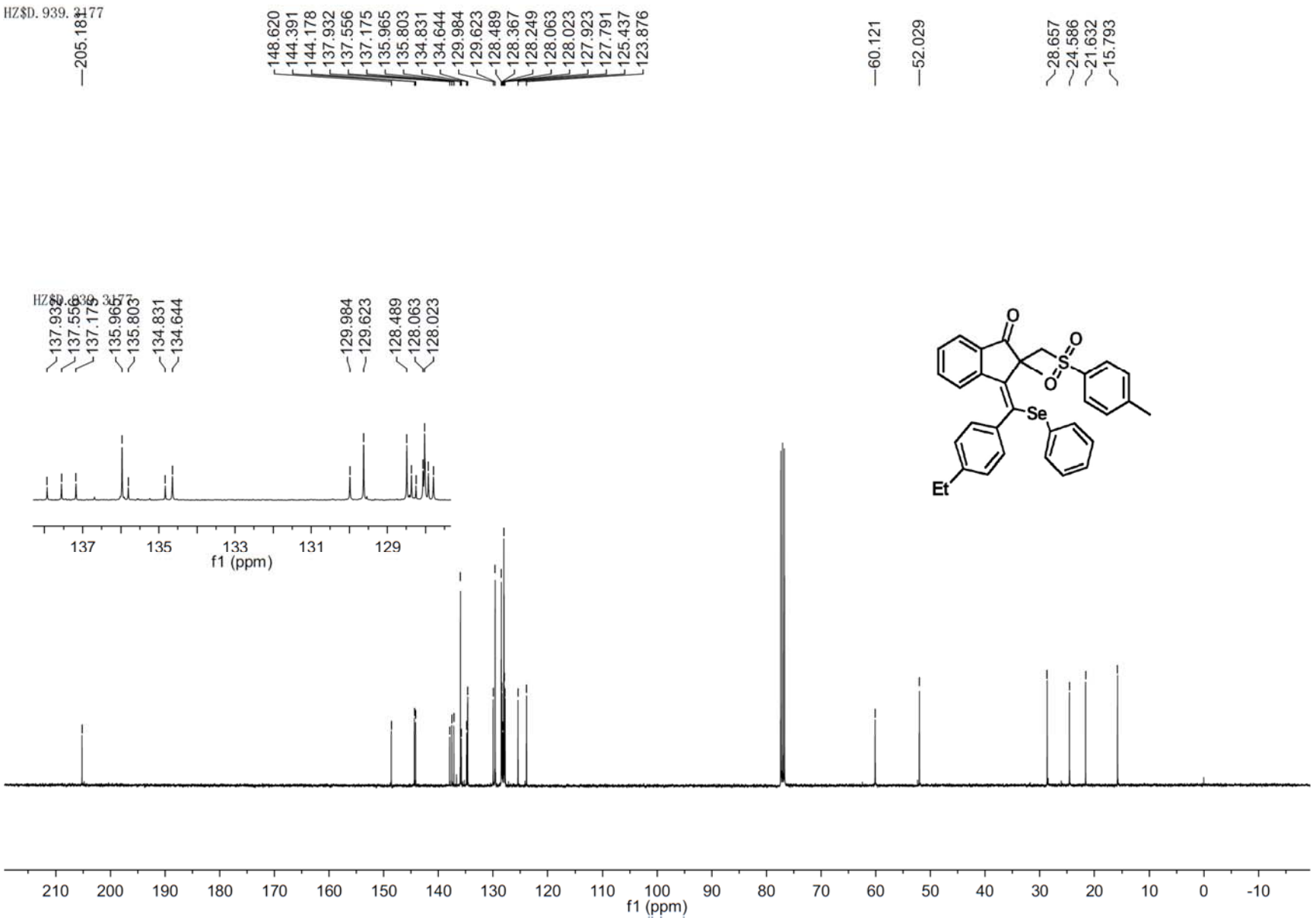
^{1}H NMR Spectrum of Compound 7a



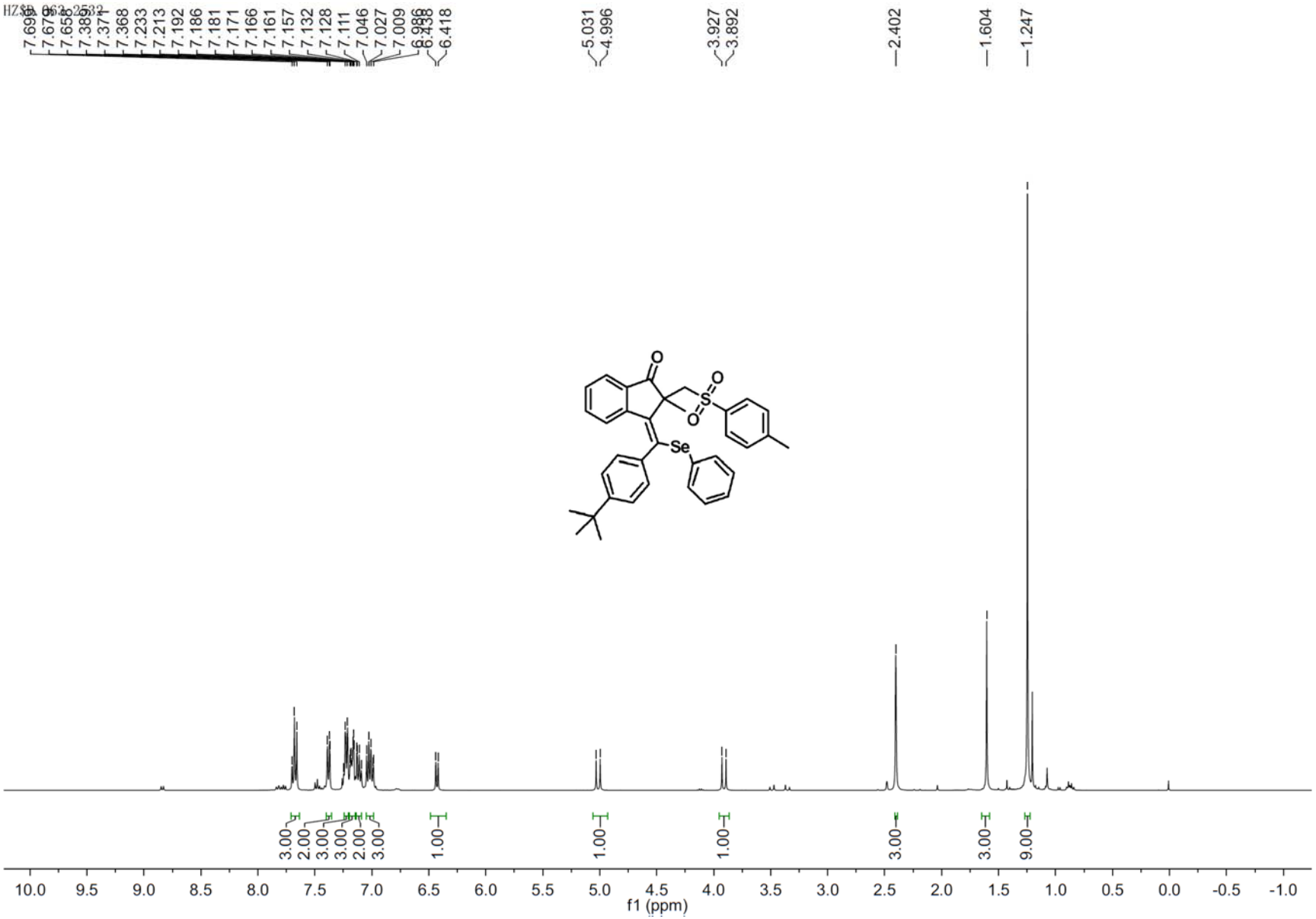
^{13}C NMR Spectrum of Compound 7a



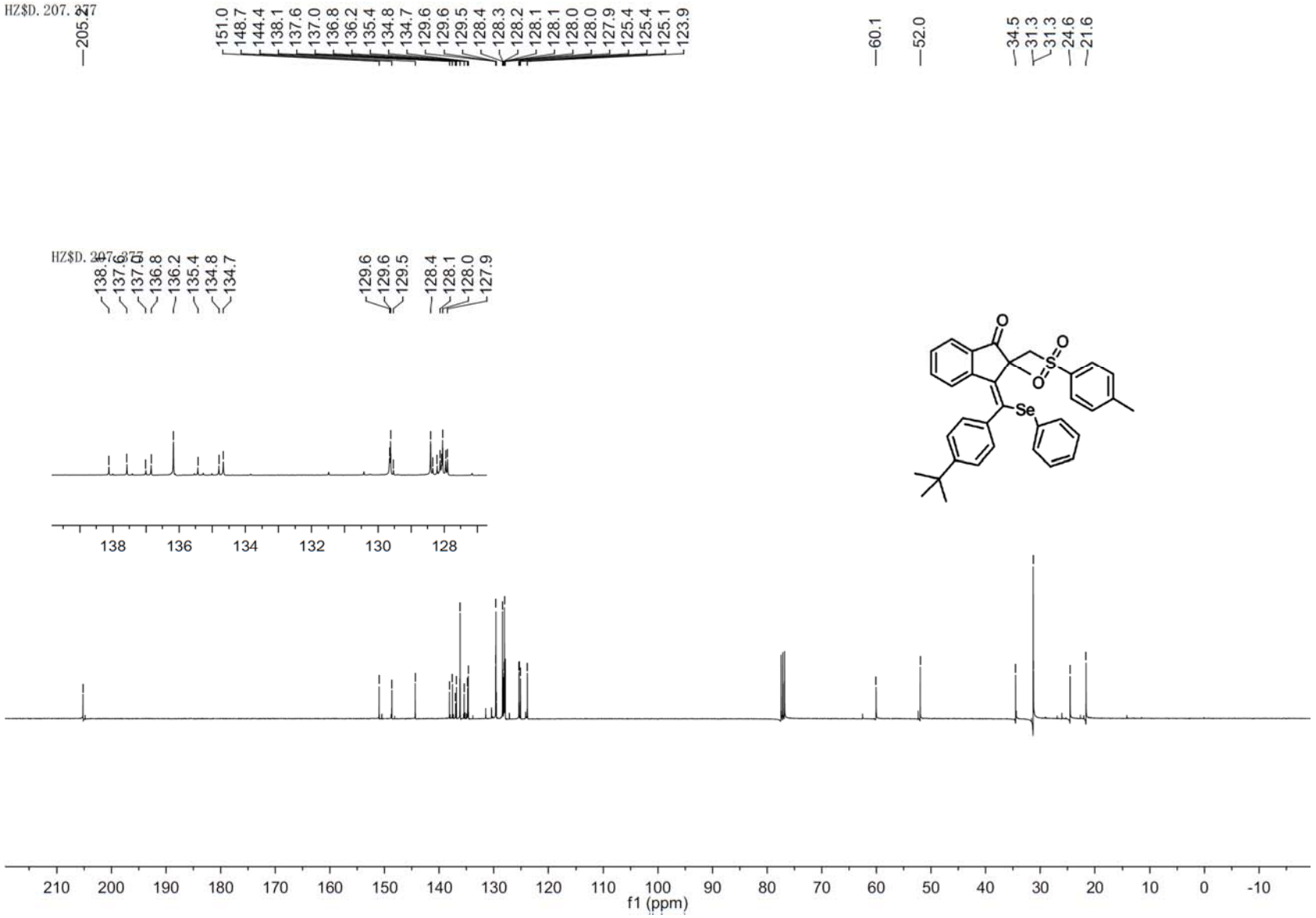
^{1}H NMR Spectrum of Compound 7b



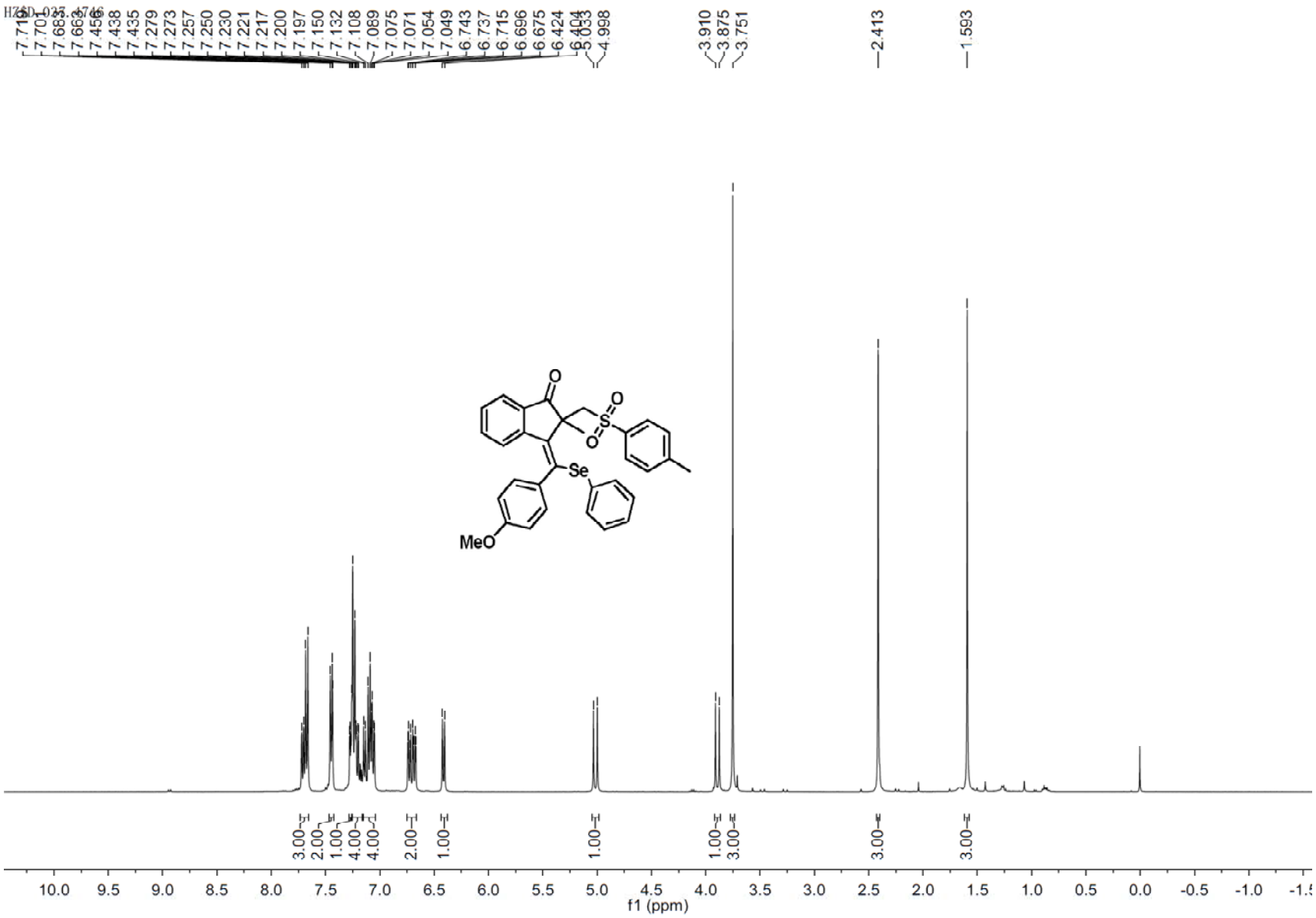
^{13}C NMR Spectrum of Compound 7b



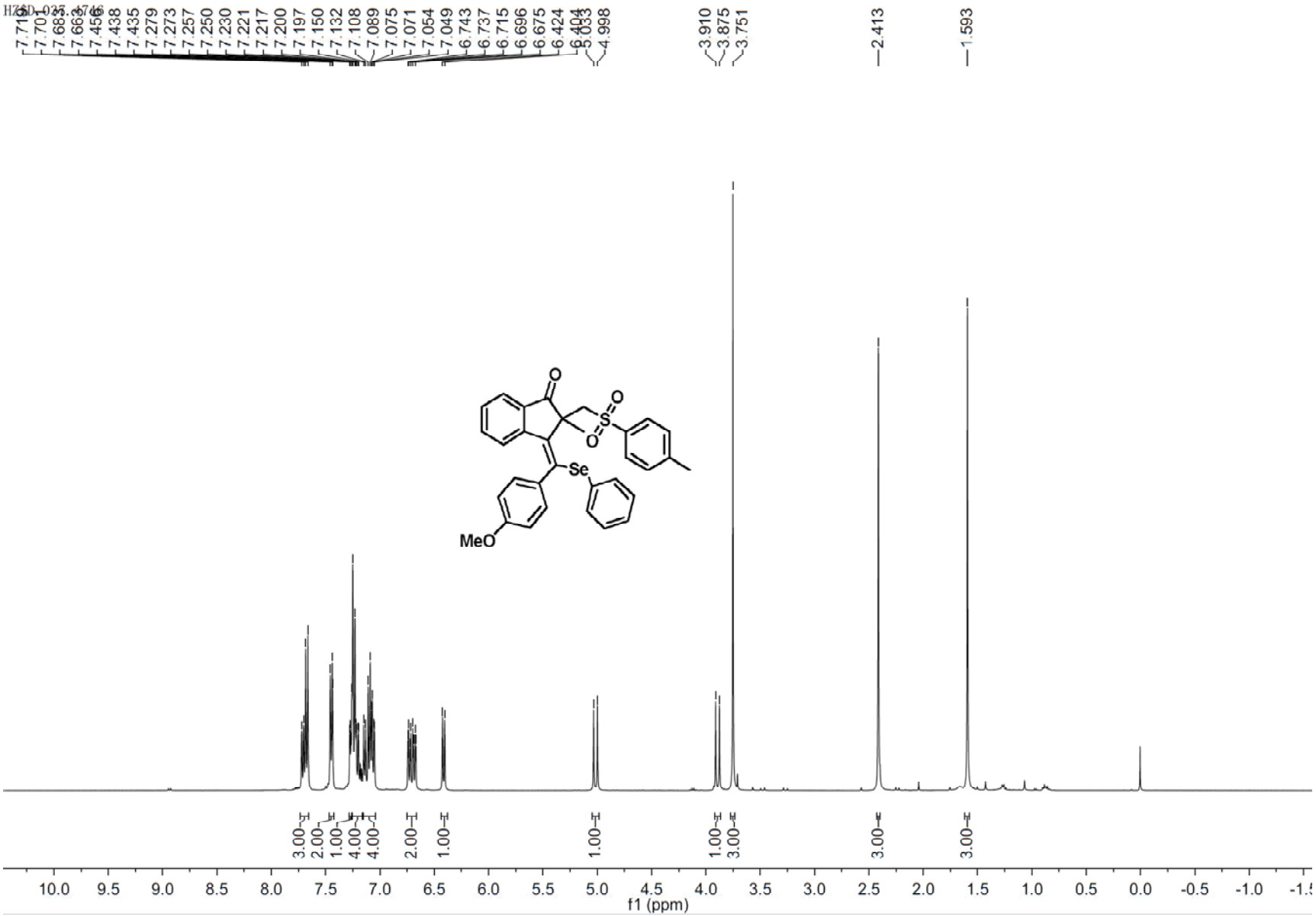
^{1}H NMR Spectrum of Compound 7c



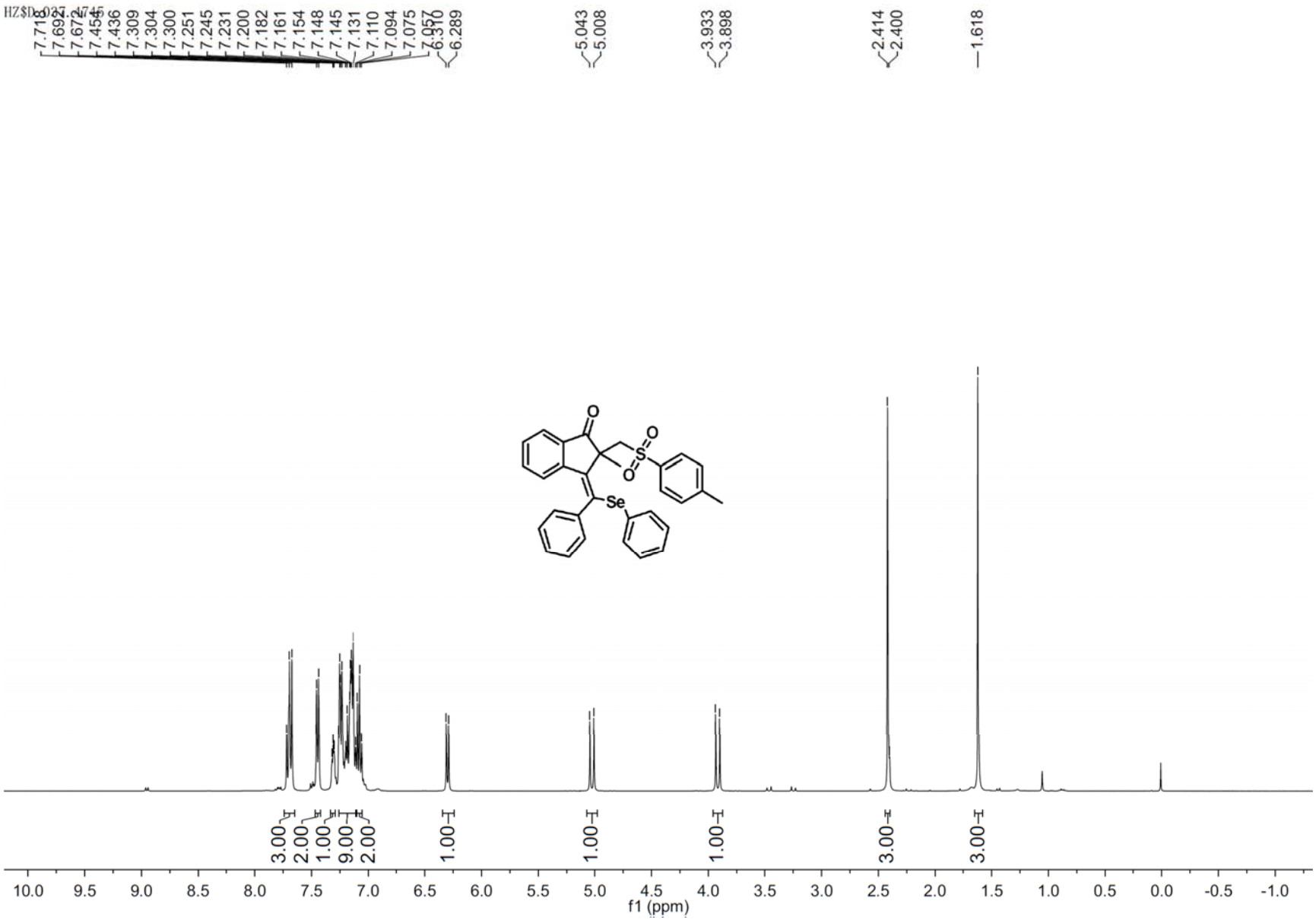
^{13}C NMR Spectrum of Compound 7c



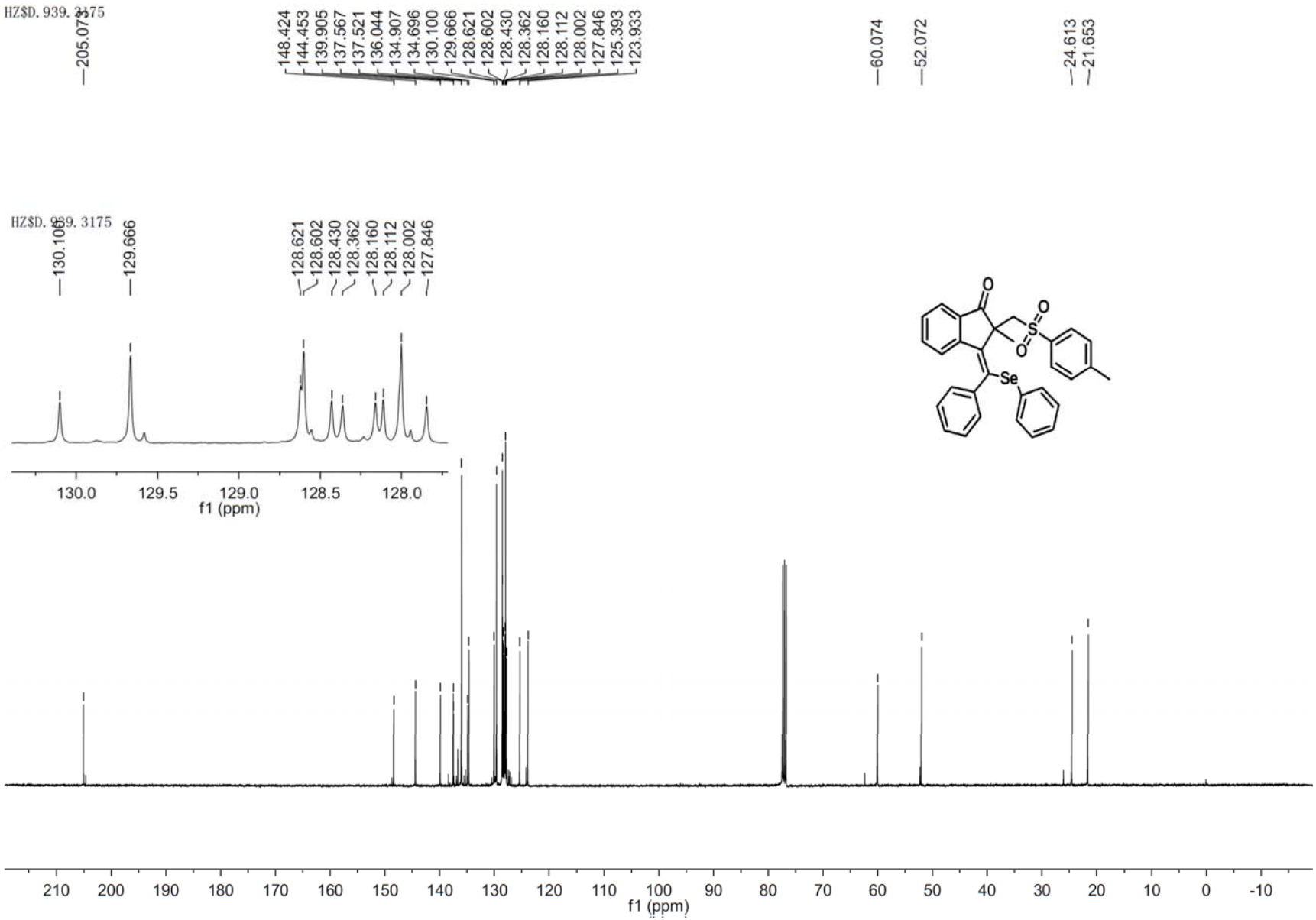
^{1}H NMR Spectrum of Compound 7d



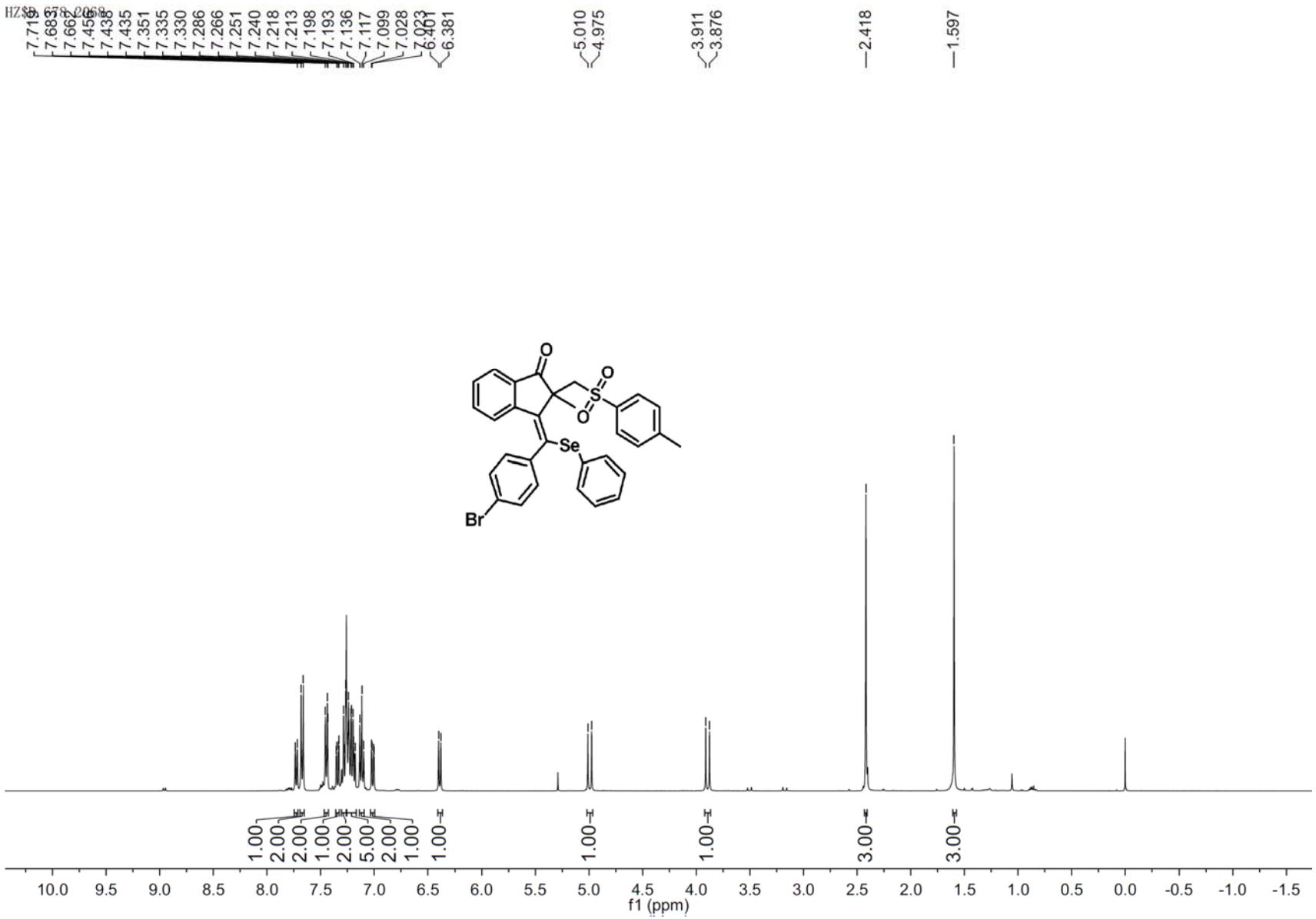
^{13}C NMR Spectrum of Compound 7d



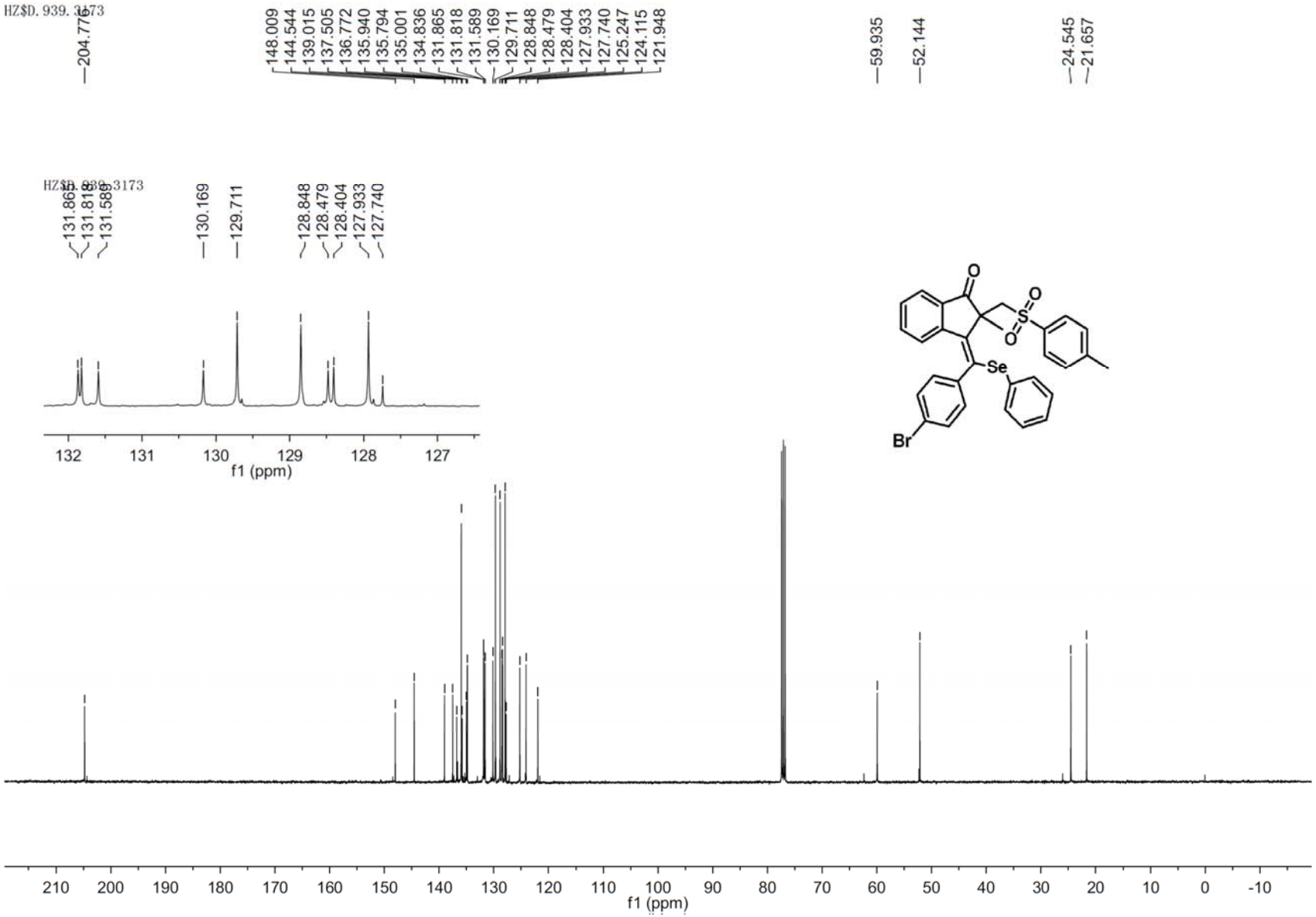
^{1}H NMR Spectrum of Compound 7e



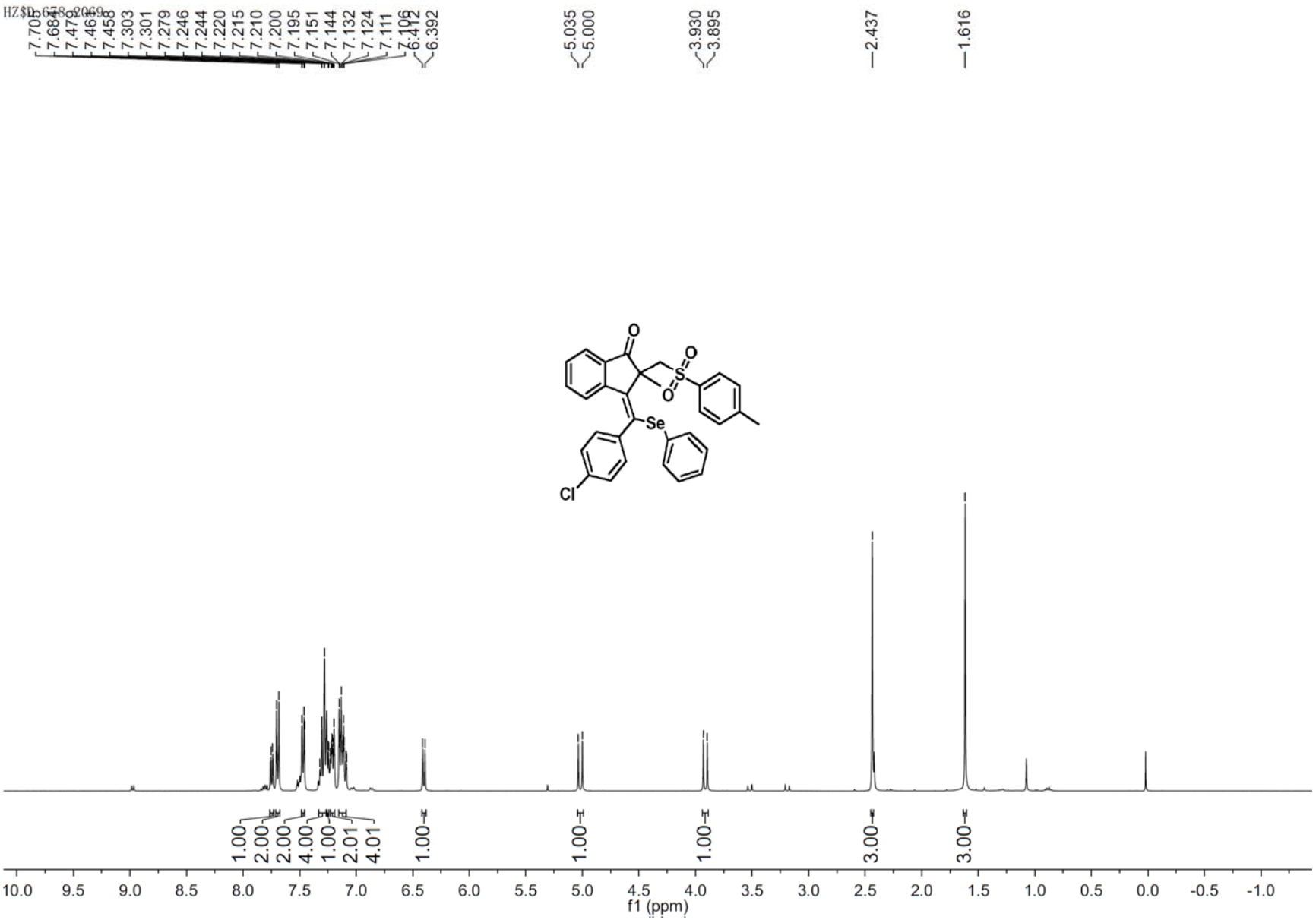
^{13}C NMR Spectrum of Compound 7e



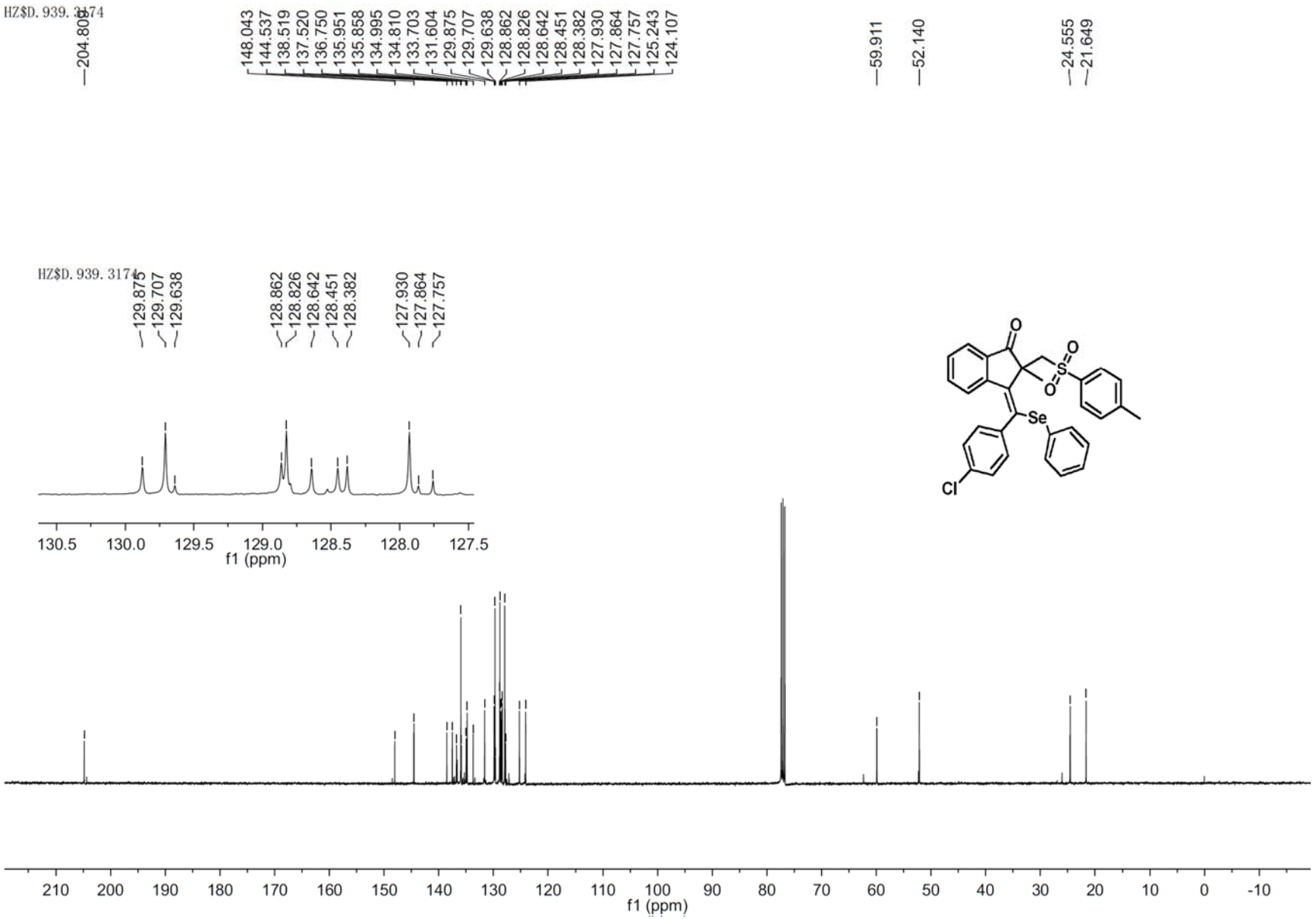
^{1}H NMR Spectrum of Compound 7f



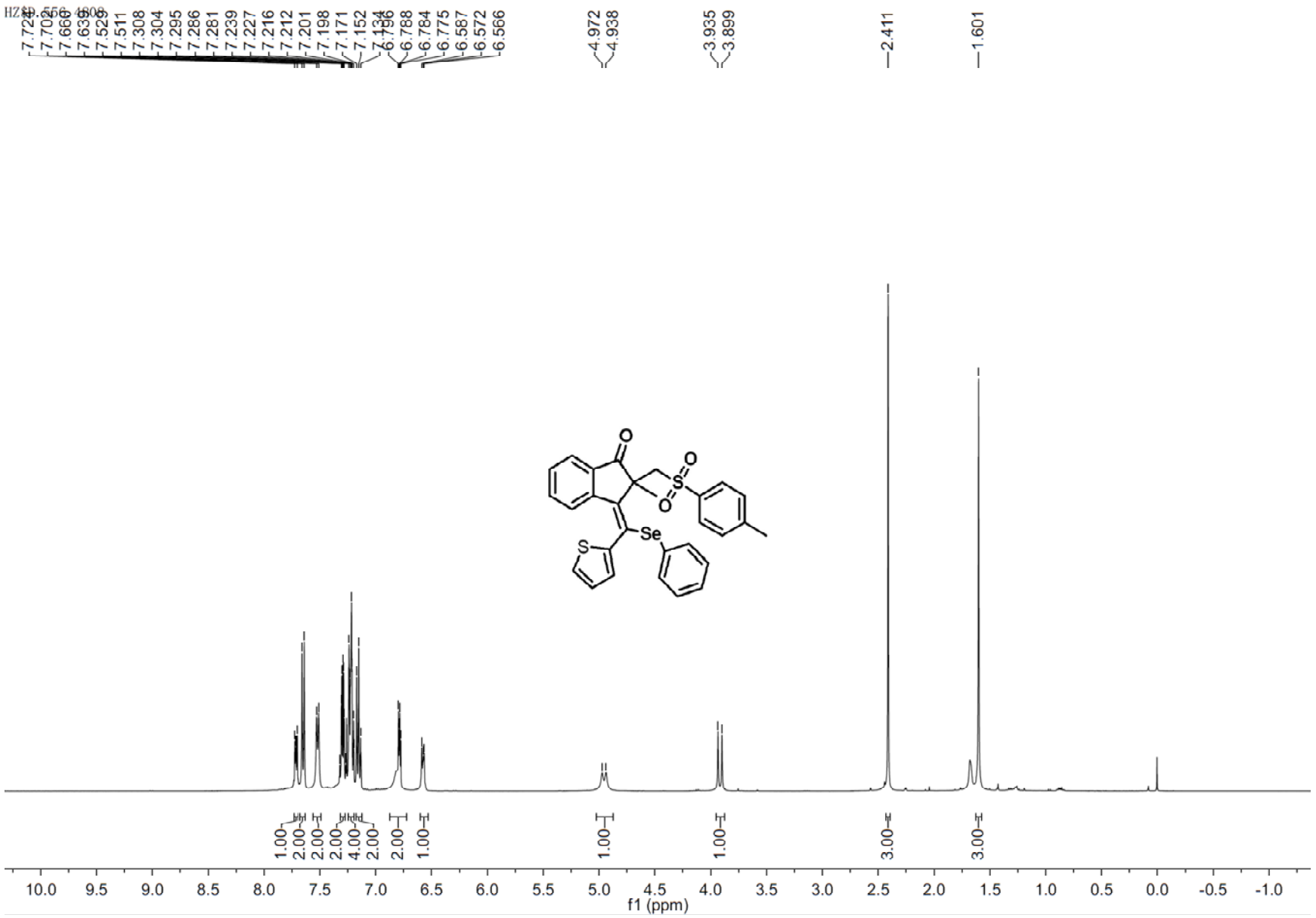
^{13}C NMR Spectrum of Compound 7f



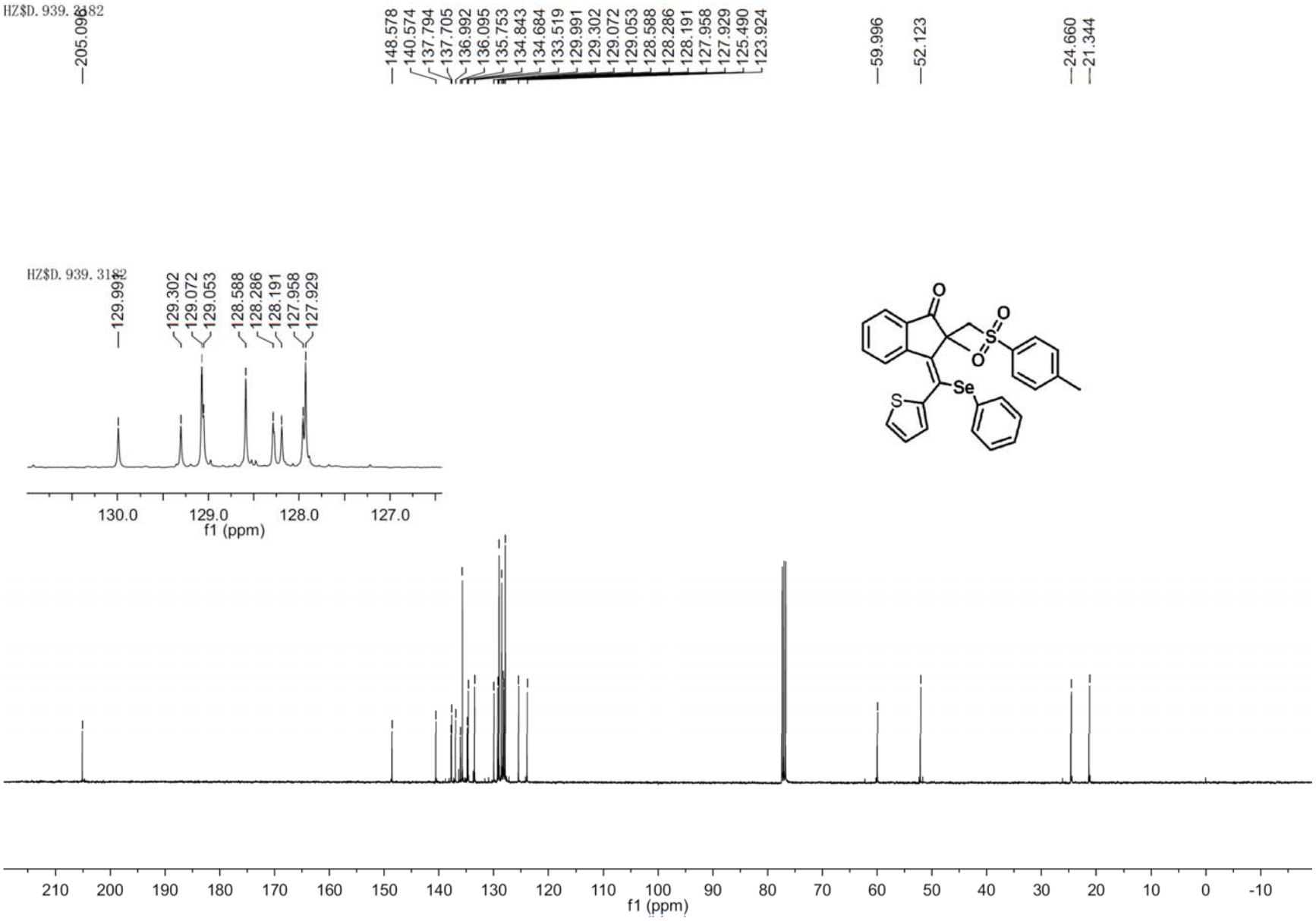
^{1}H NMR Spectrum of Compound 7g



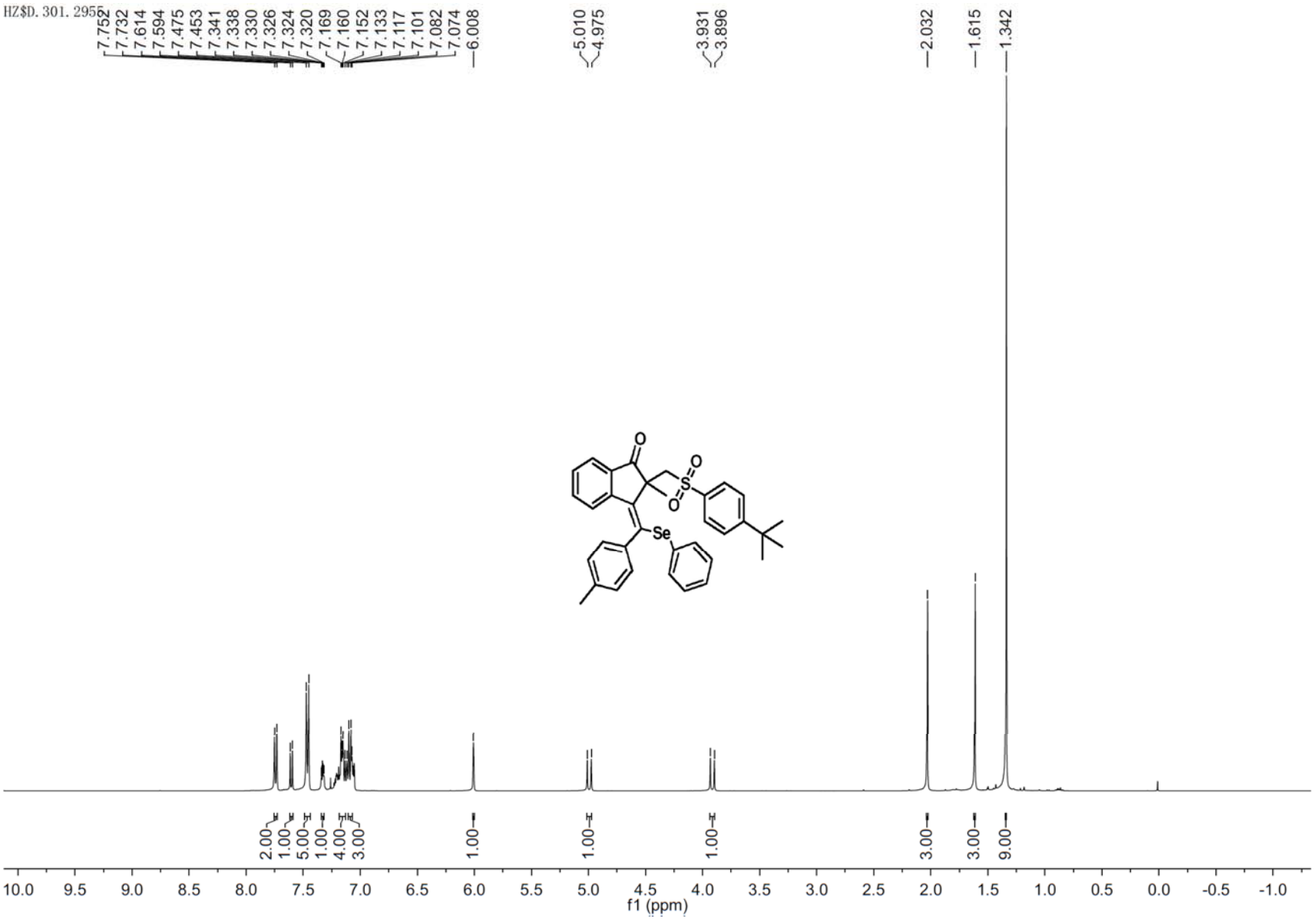
^{13}C NMR Spectrum of Compound 7g



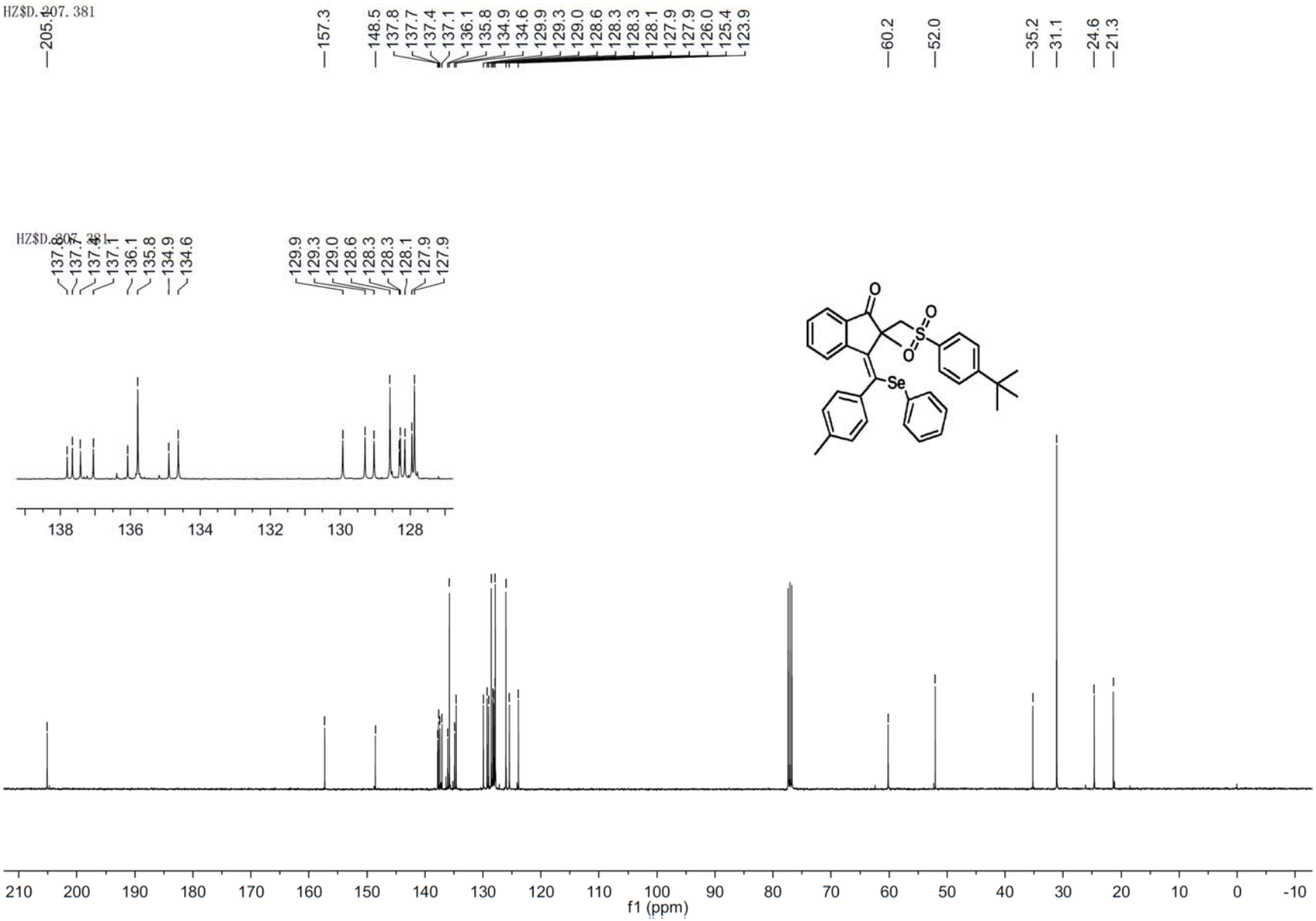
^{1}H NMR Spectrum of Compound 7h



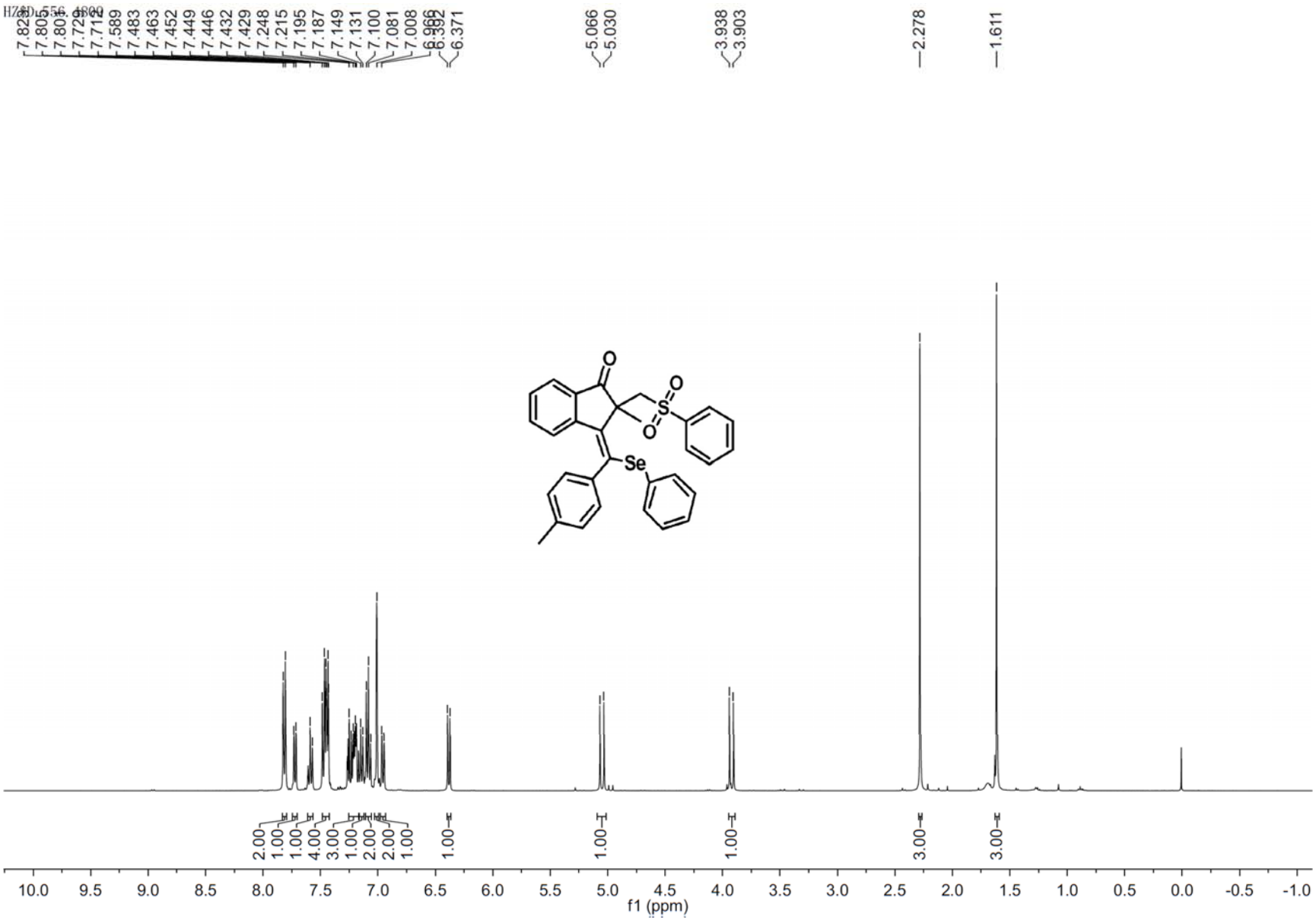
^{13}C NMR Spectrum of Compound 7h



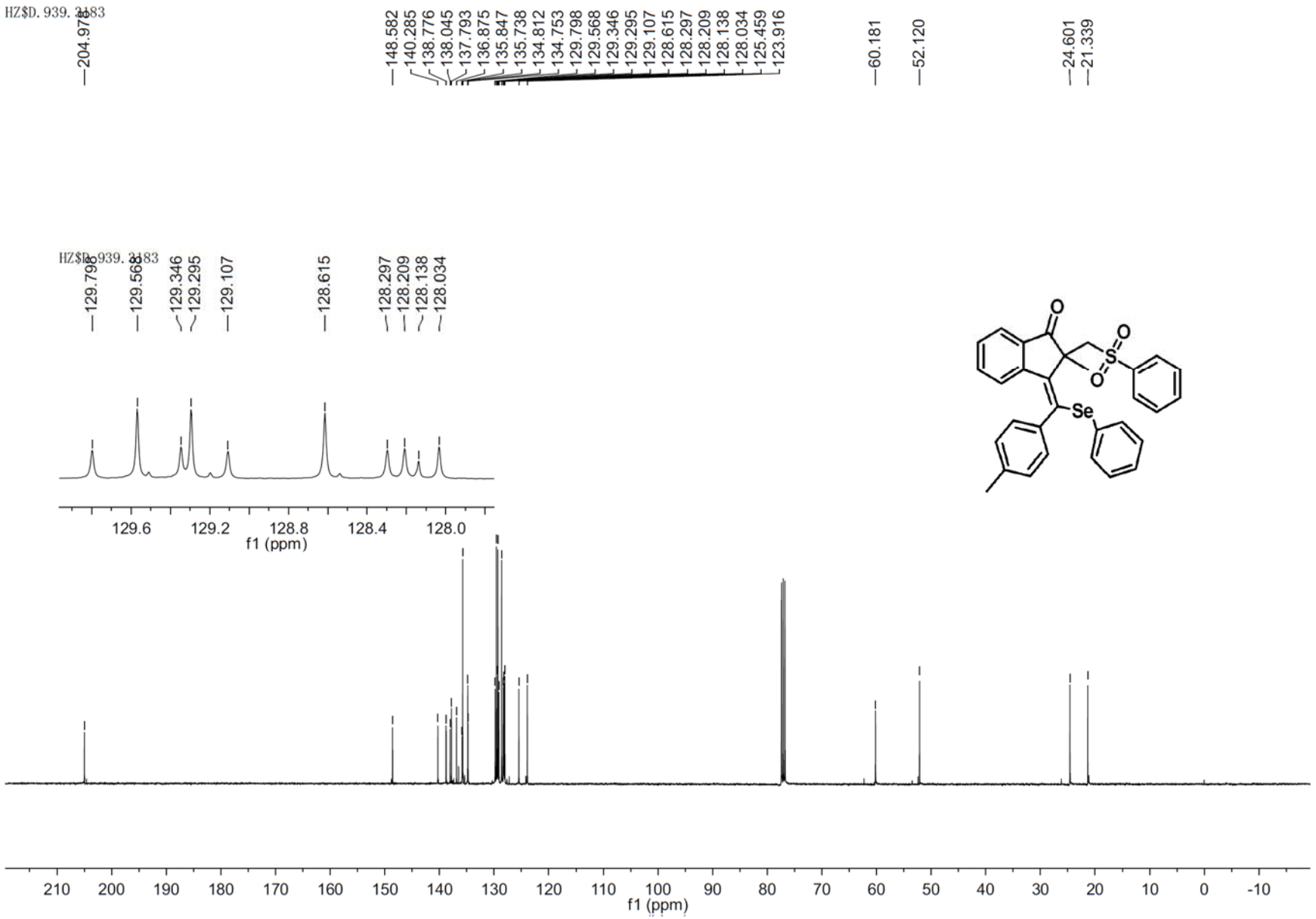
^{1}H NMR Spectrum of Compound 7i



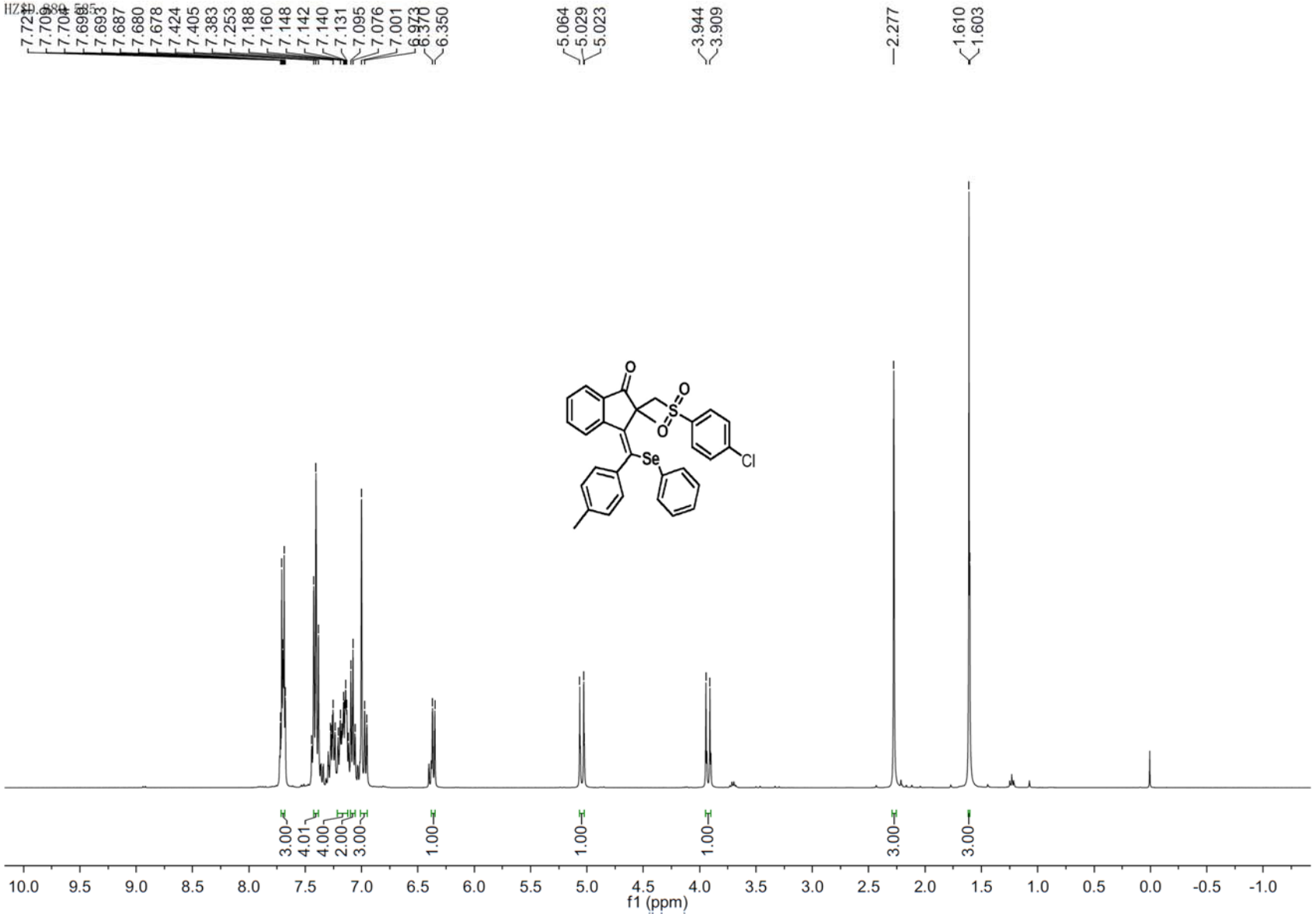
^{13}C NMR Spectrum of Compound 7i



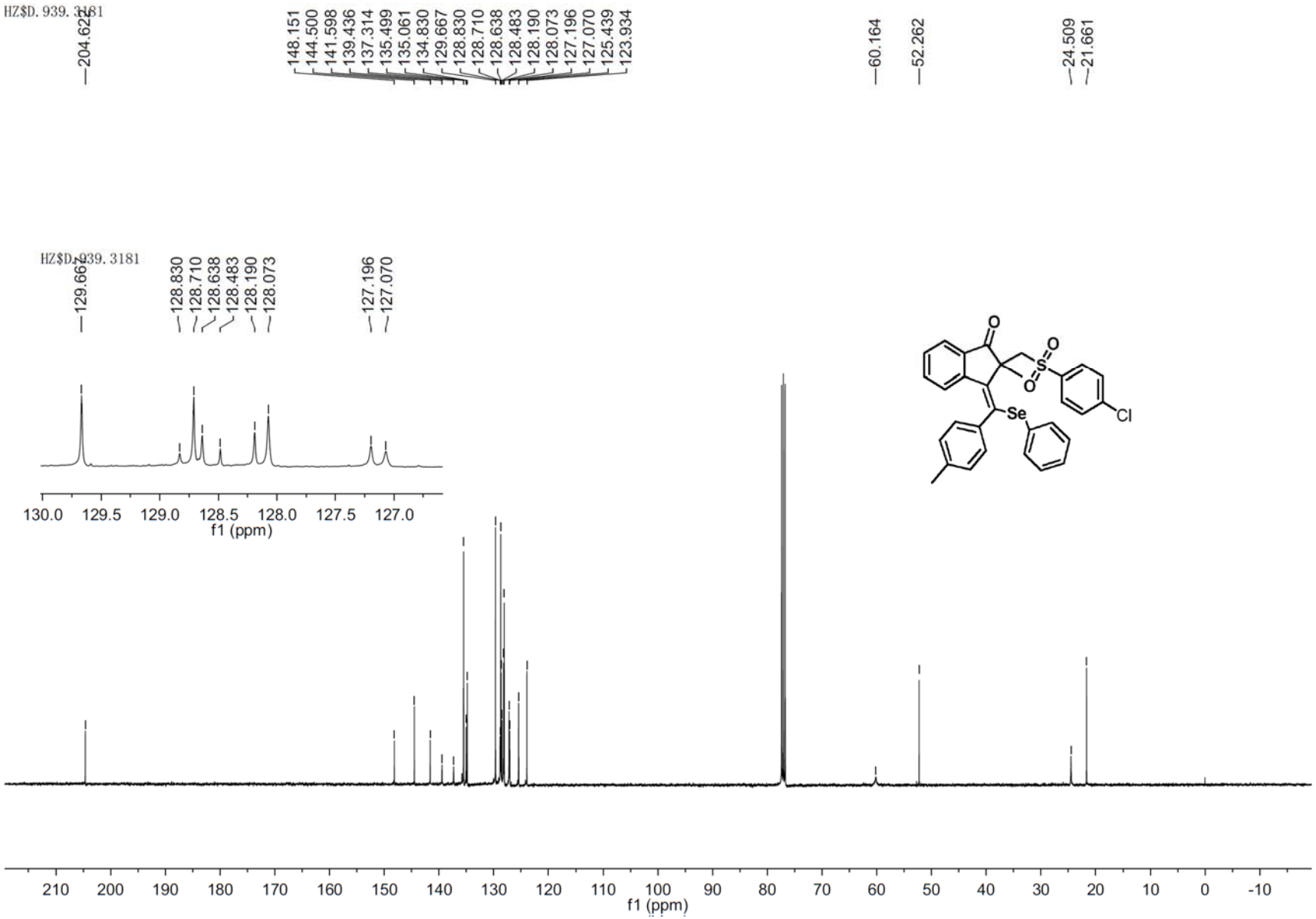
^{1}H NMR Spectrum of Compound 7j



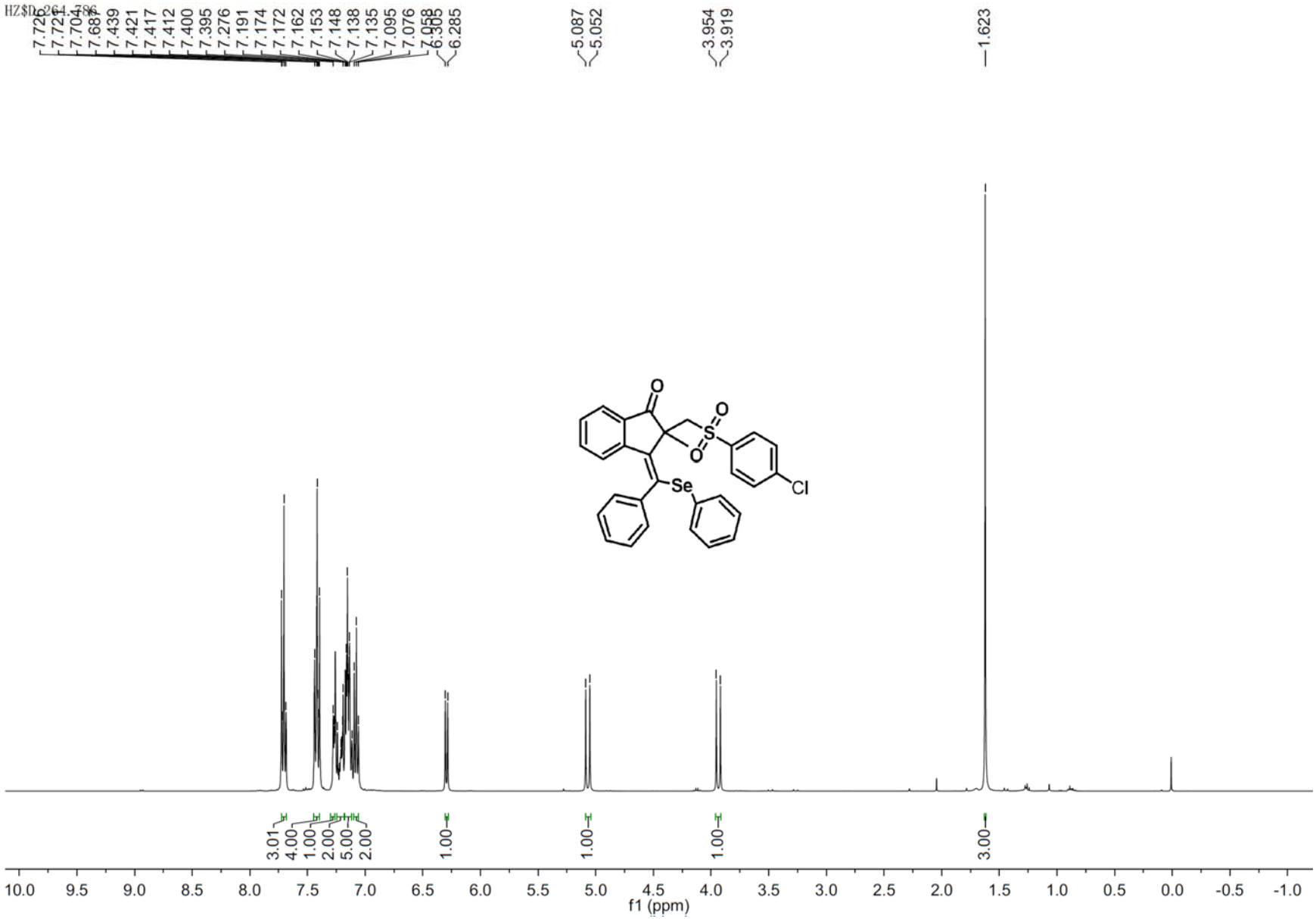
^{13}C NMR Spectrum of Compound 7j



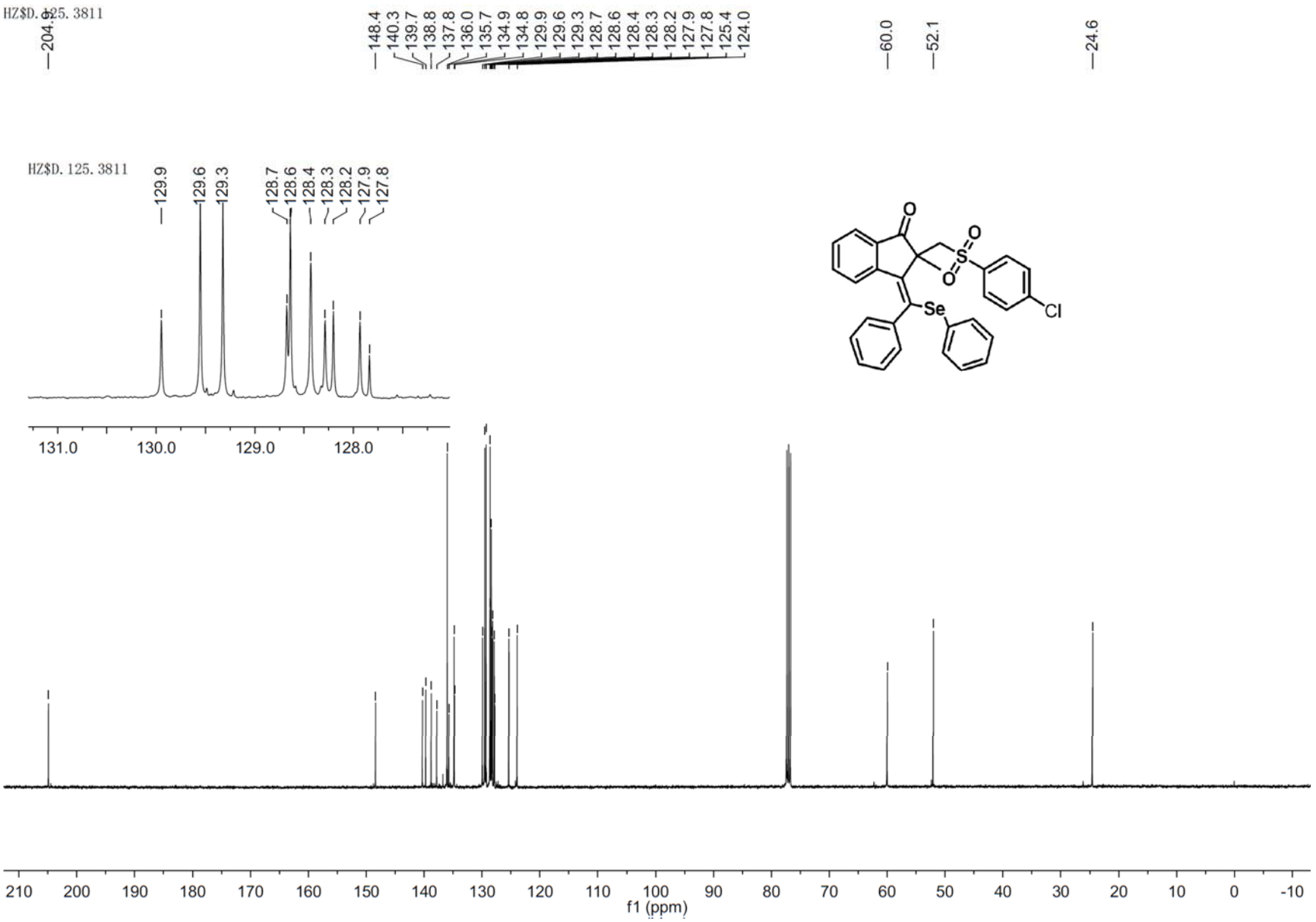
^{1}H NMR Spectrum of Compound 7k



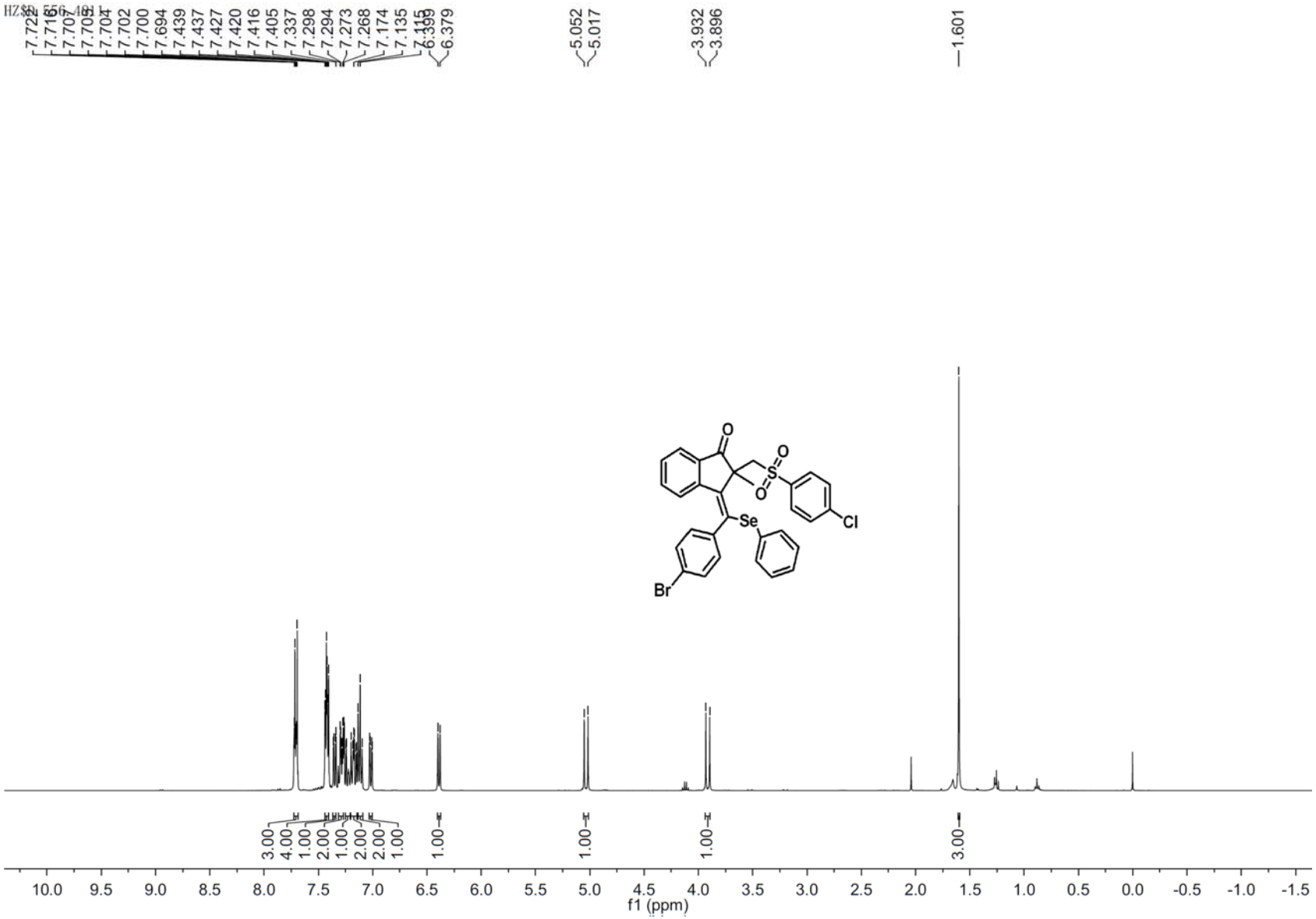
^{13}C NMR Spectrum of Compound 7k



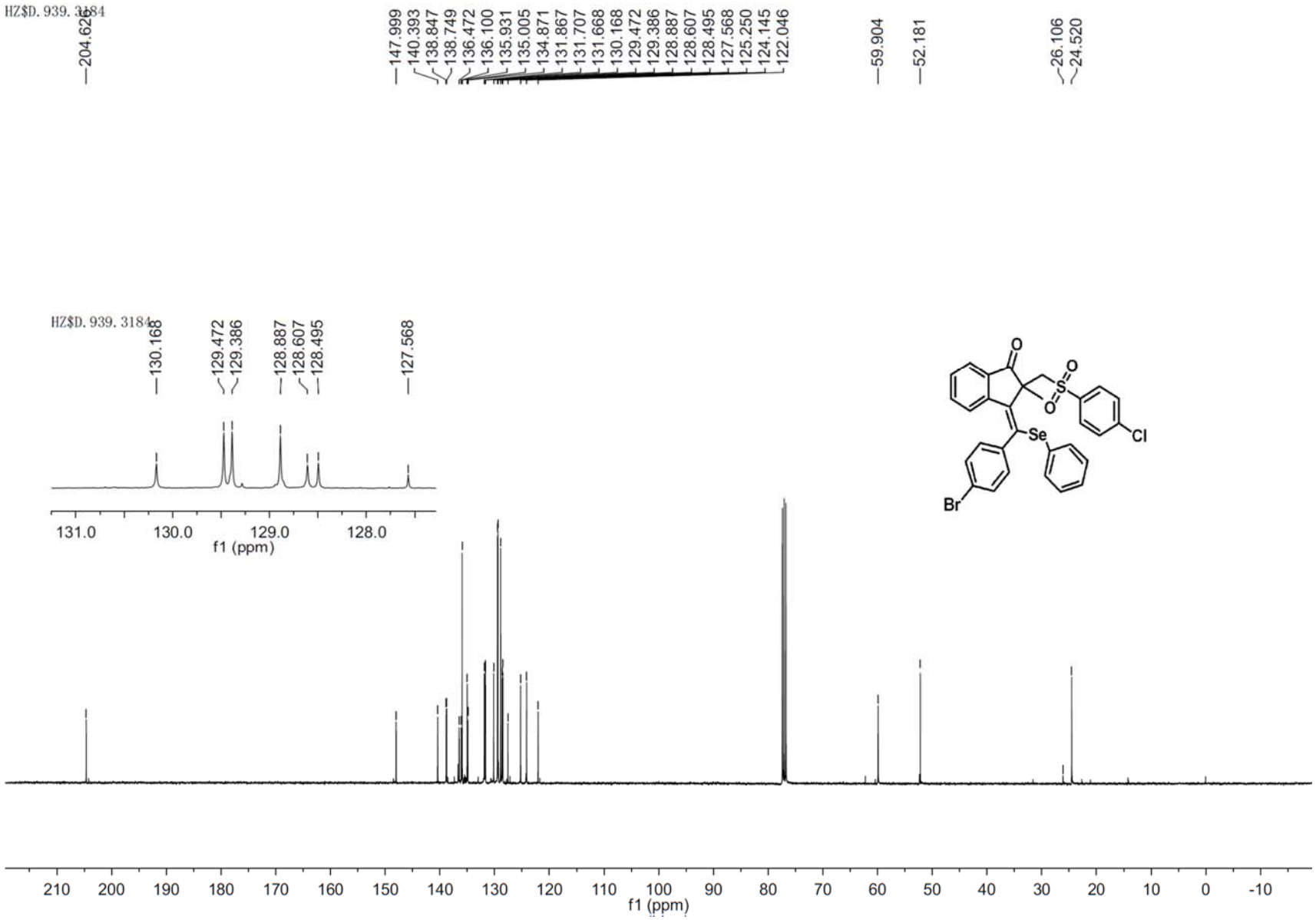
^{1}H NMR Spectrum of Compound 7l



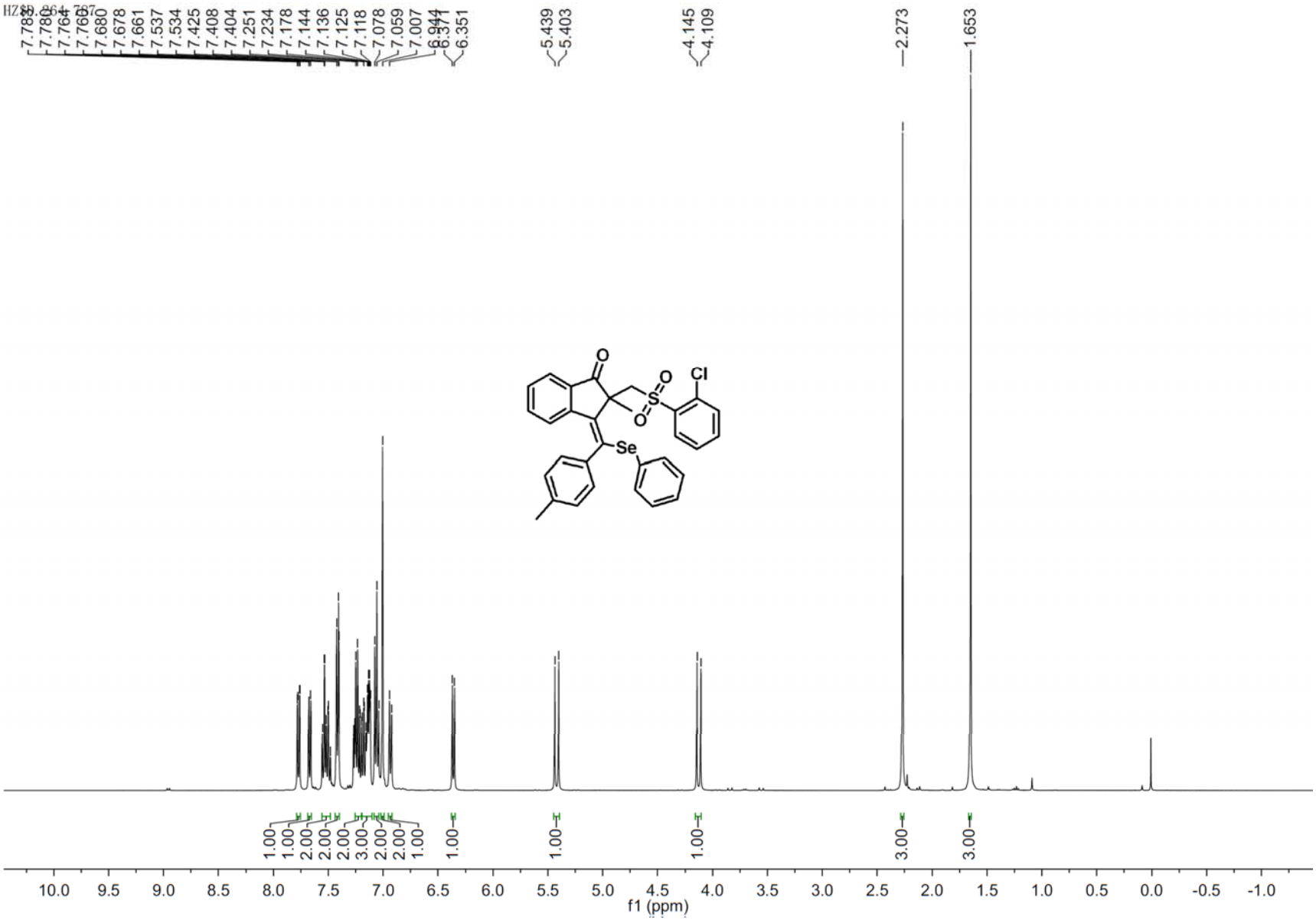
^{13}C NMR Spectrum of Compound 7l



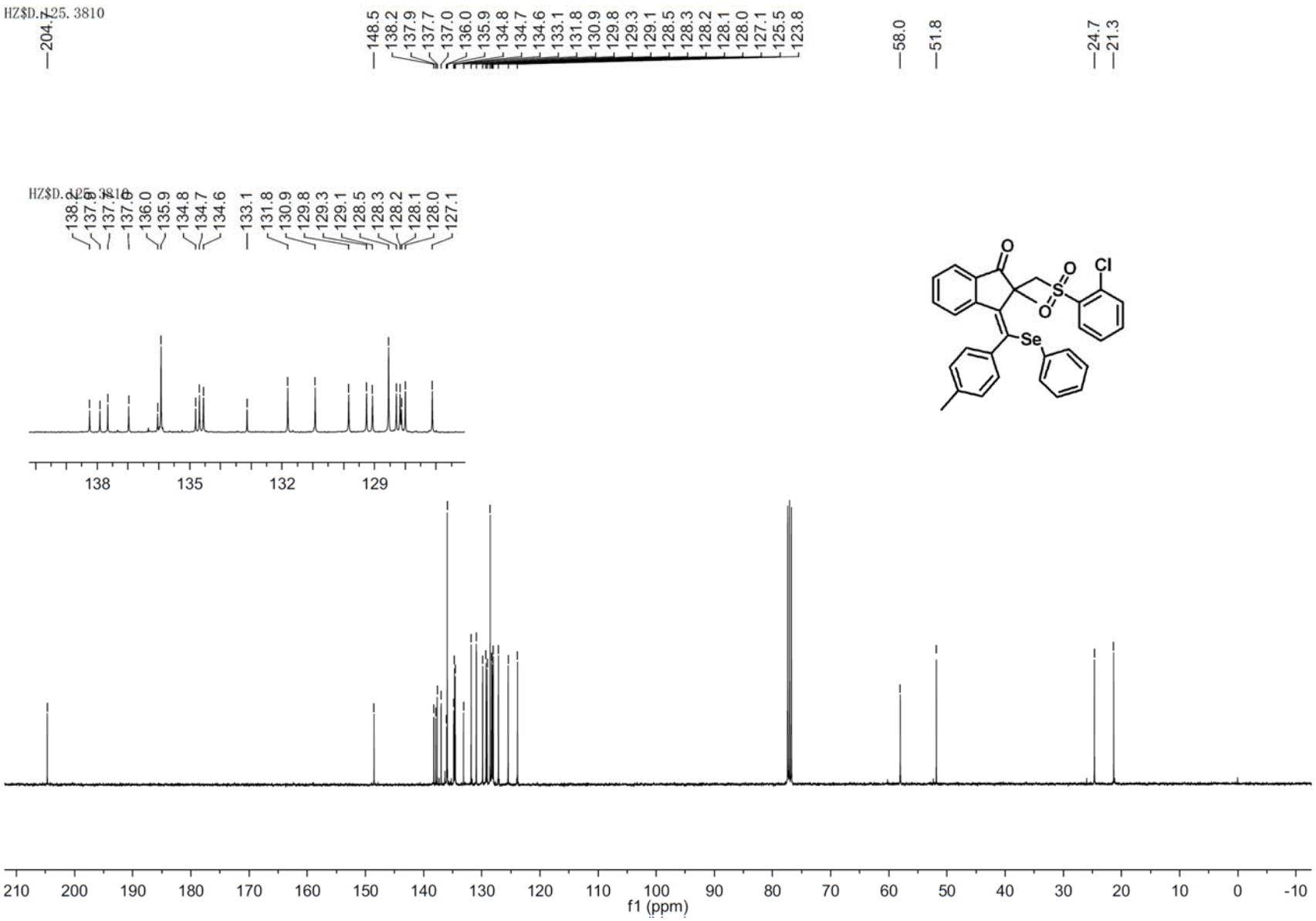
^{1}H NMR Spectrum of Compound 7m



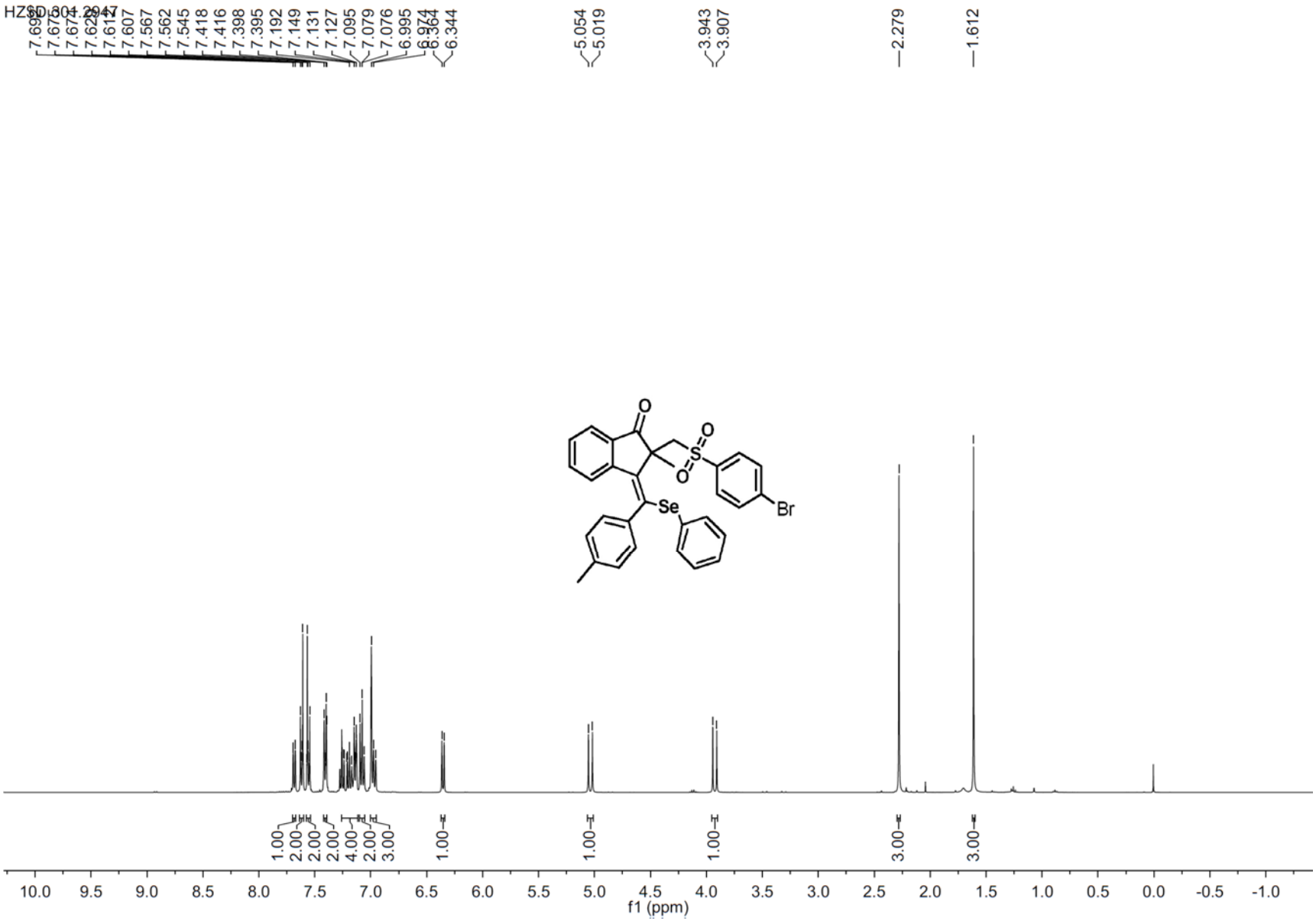
^{13}C NMR Spectrum of Compound 7m



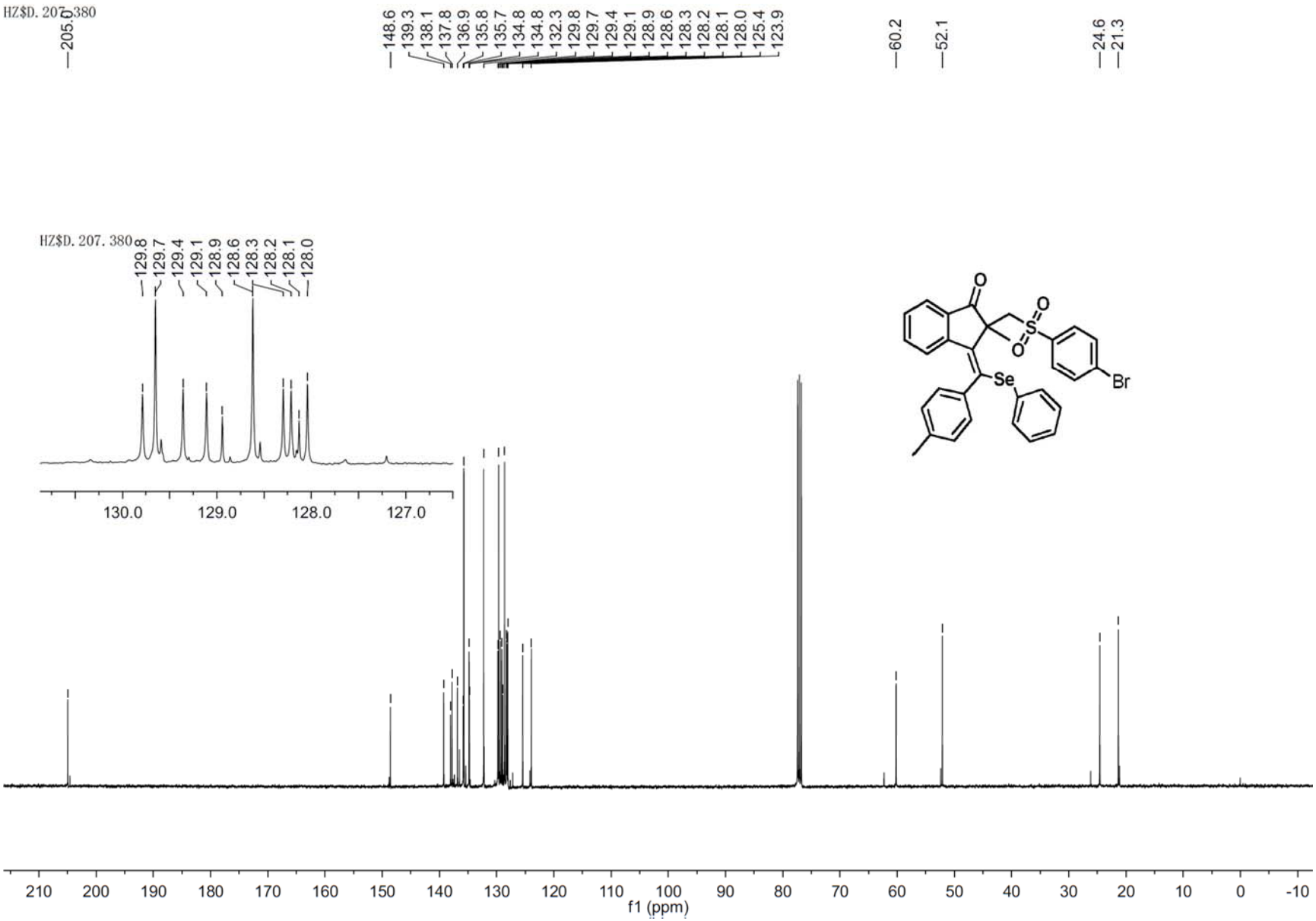
^{1}H NMR Spectrum of Compound 7n



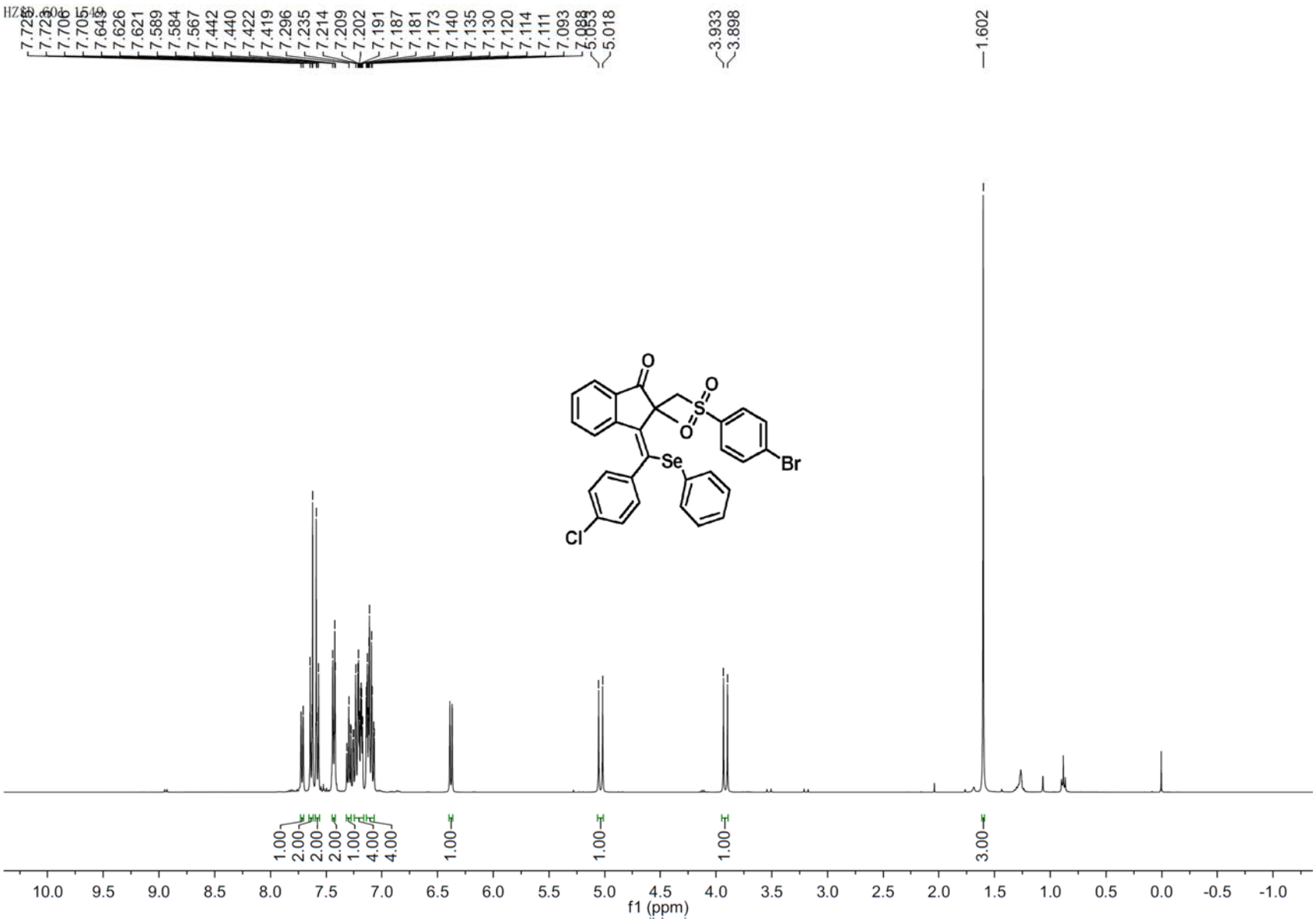
^{13}C NMR Spectrum of Compound 7n



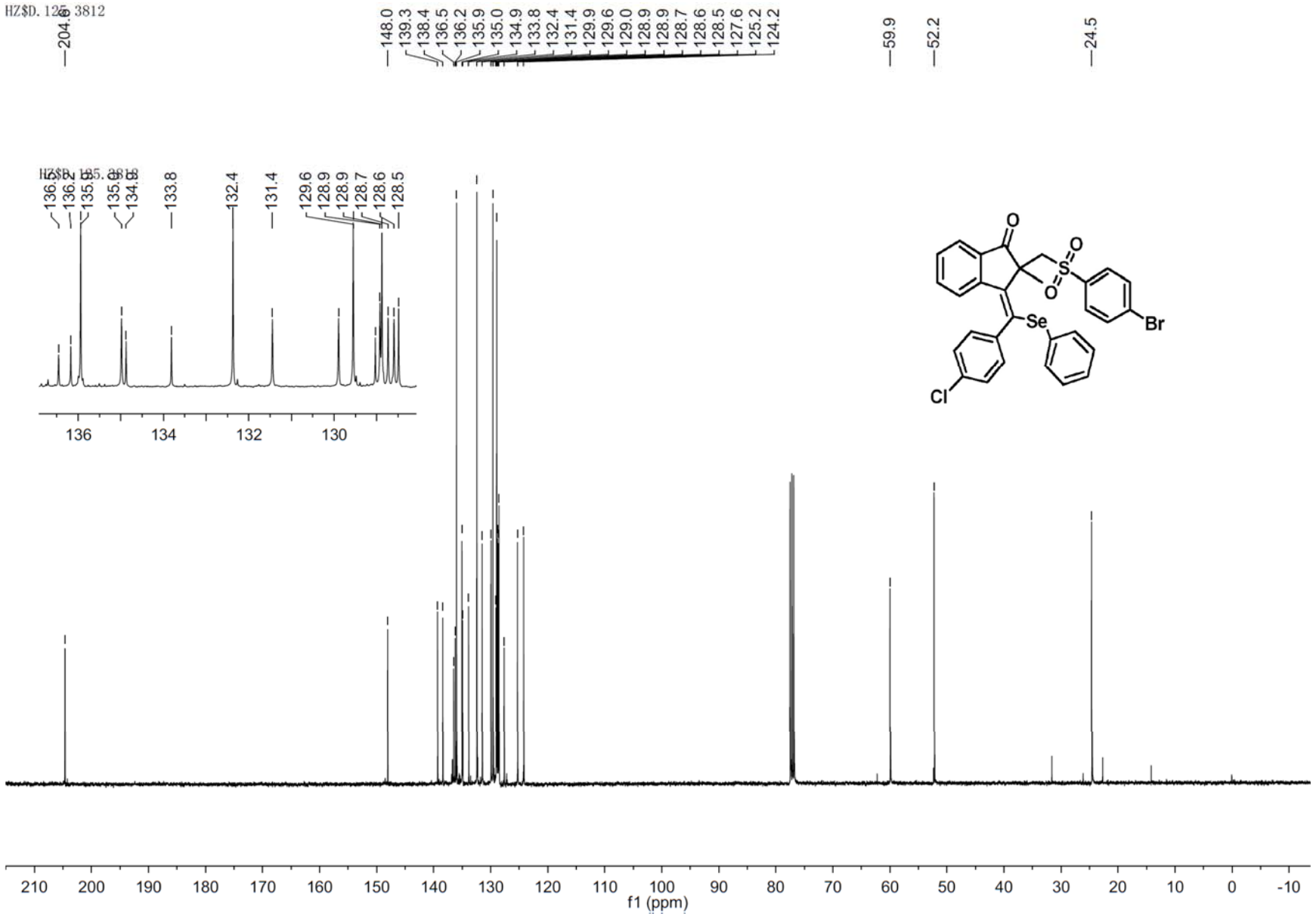
^{1}H NMR Spectrum of Compound 7o



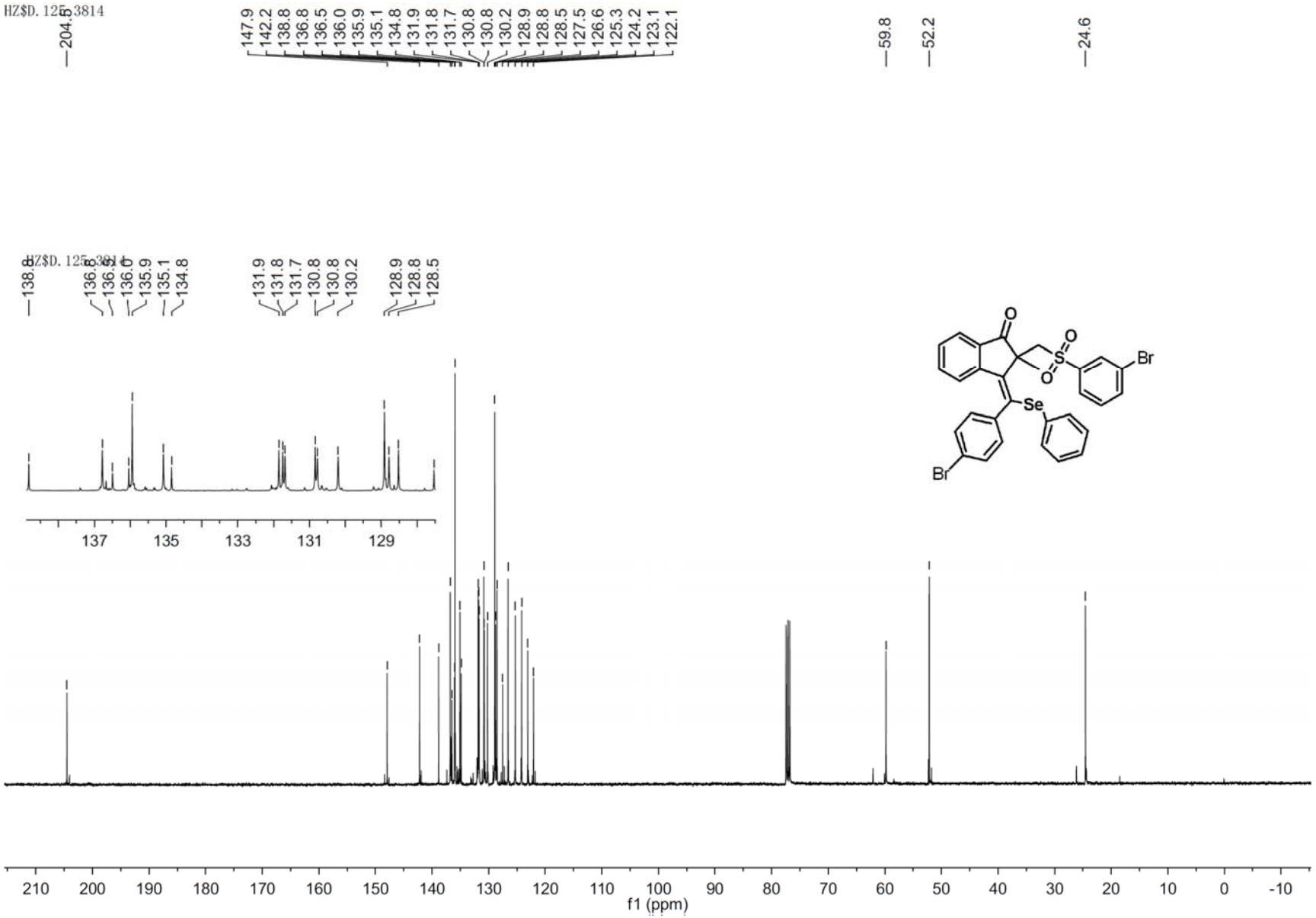
^{13}C NMR Spectrum of Compound 7o



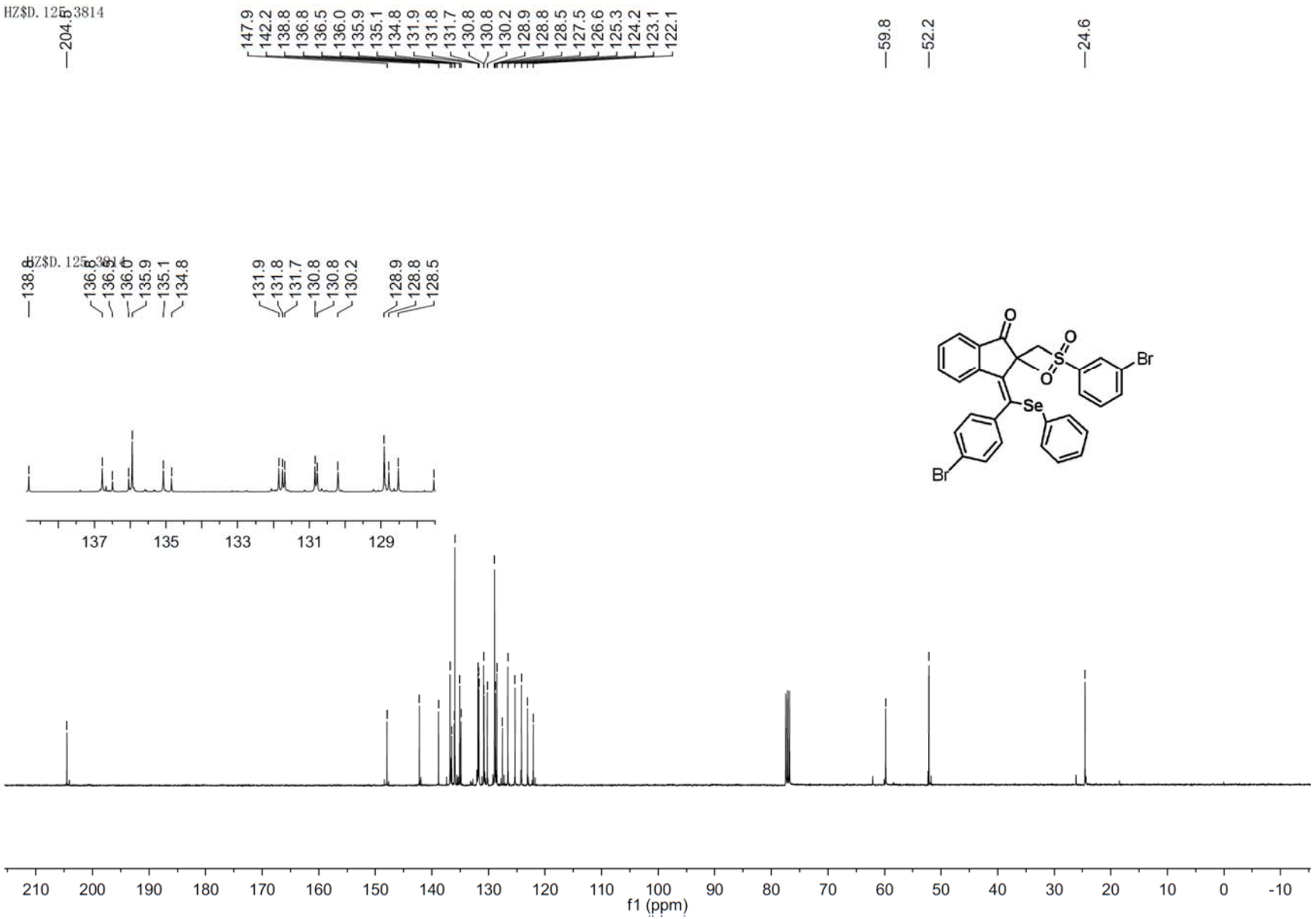
^{1}H NMR Spectrum of Compound 7p



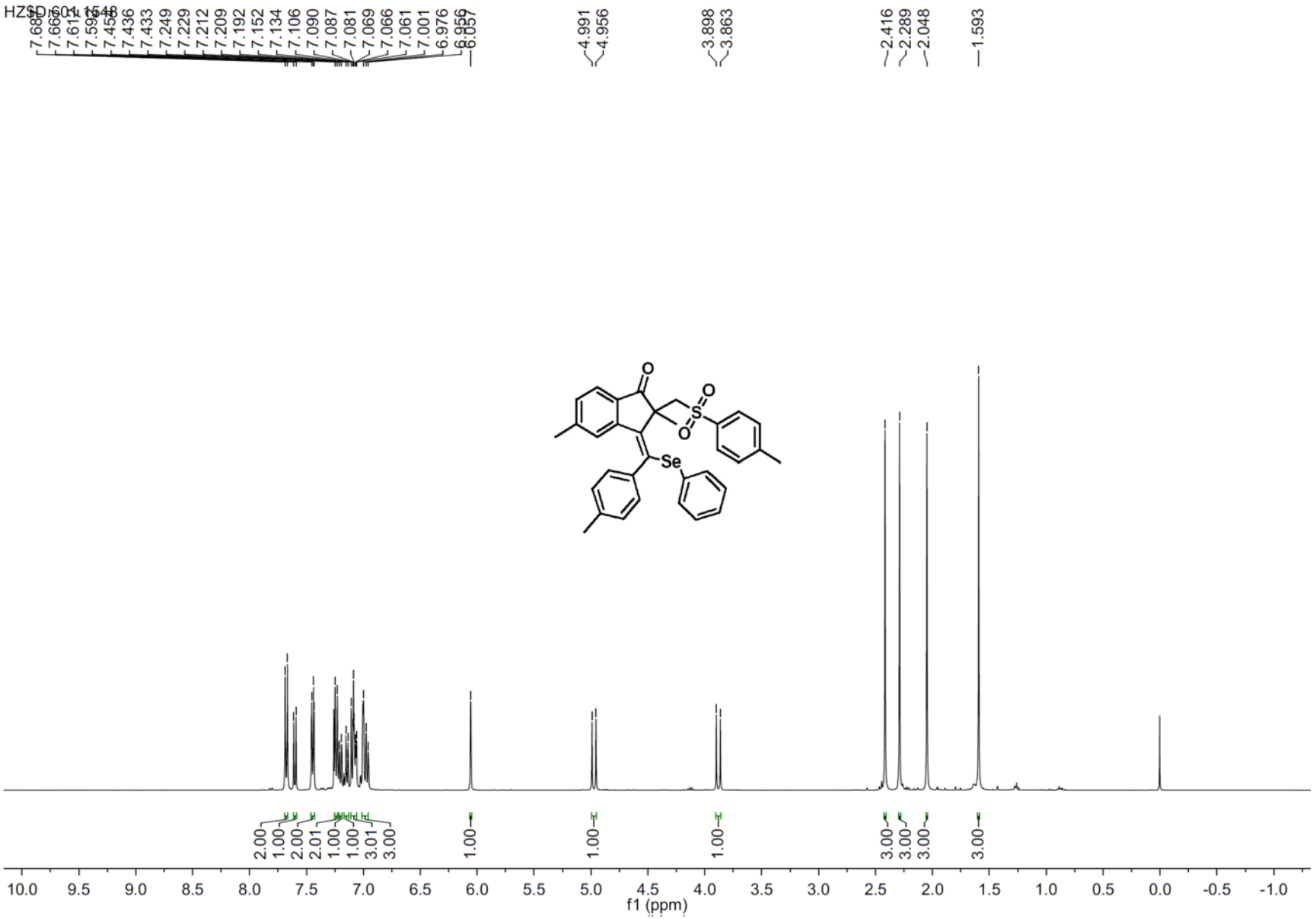
^{13}C NMR Spectrum of Compound 7p



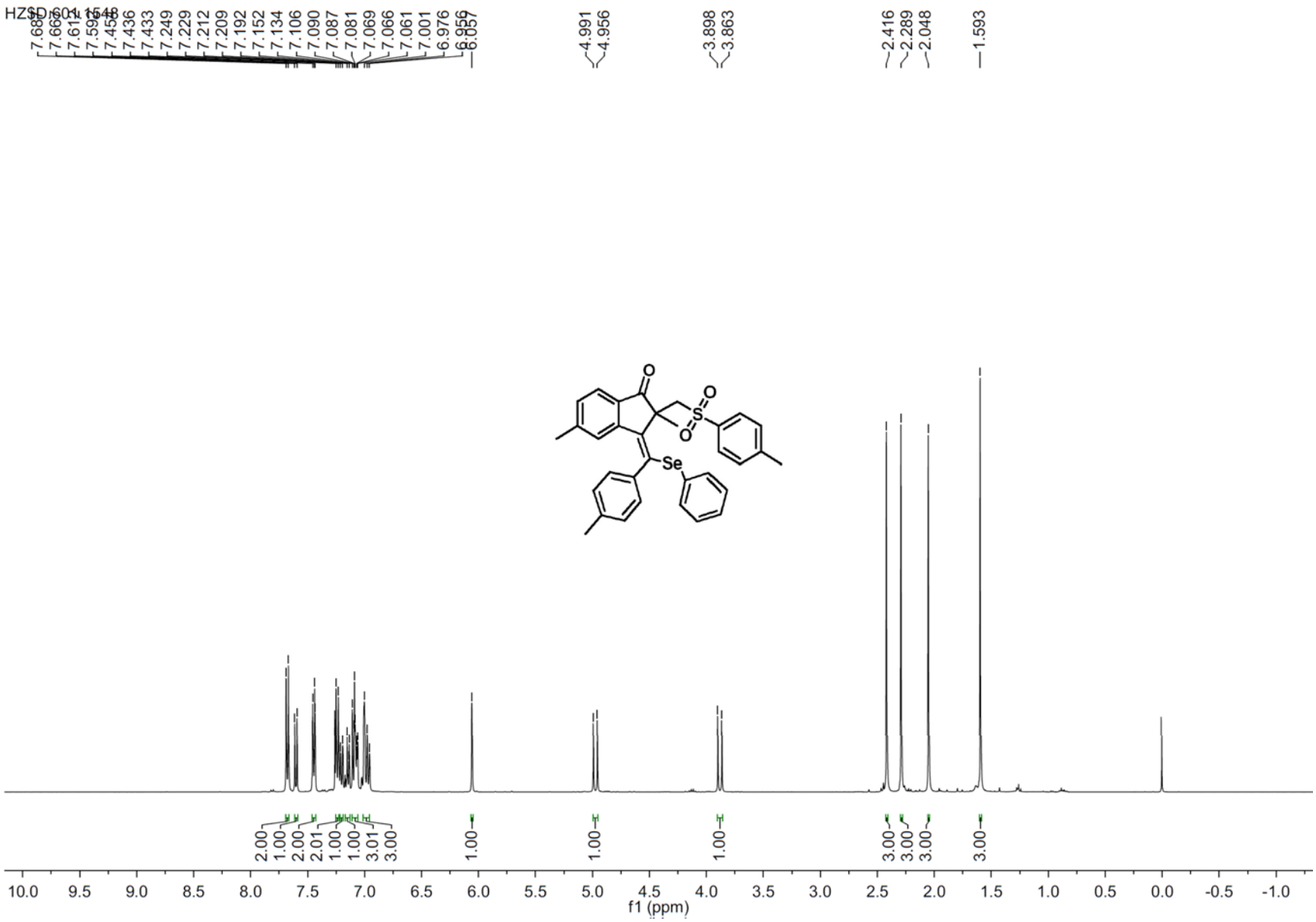
^{1}H NMR Spectrum of Compound 7q



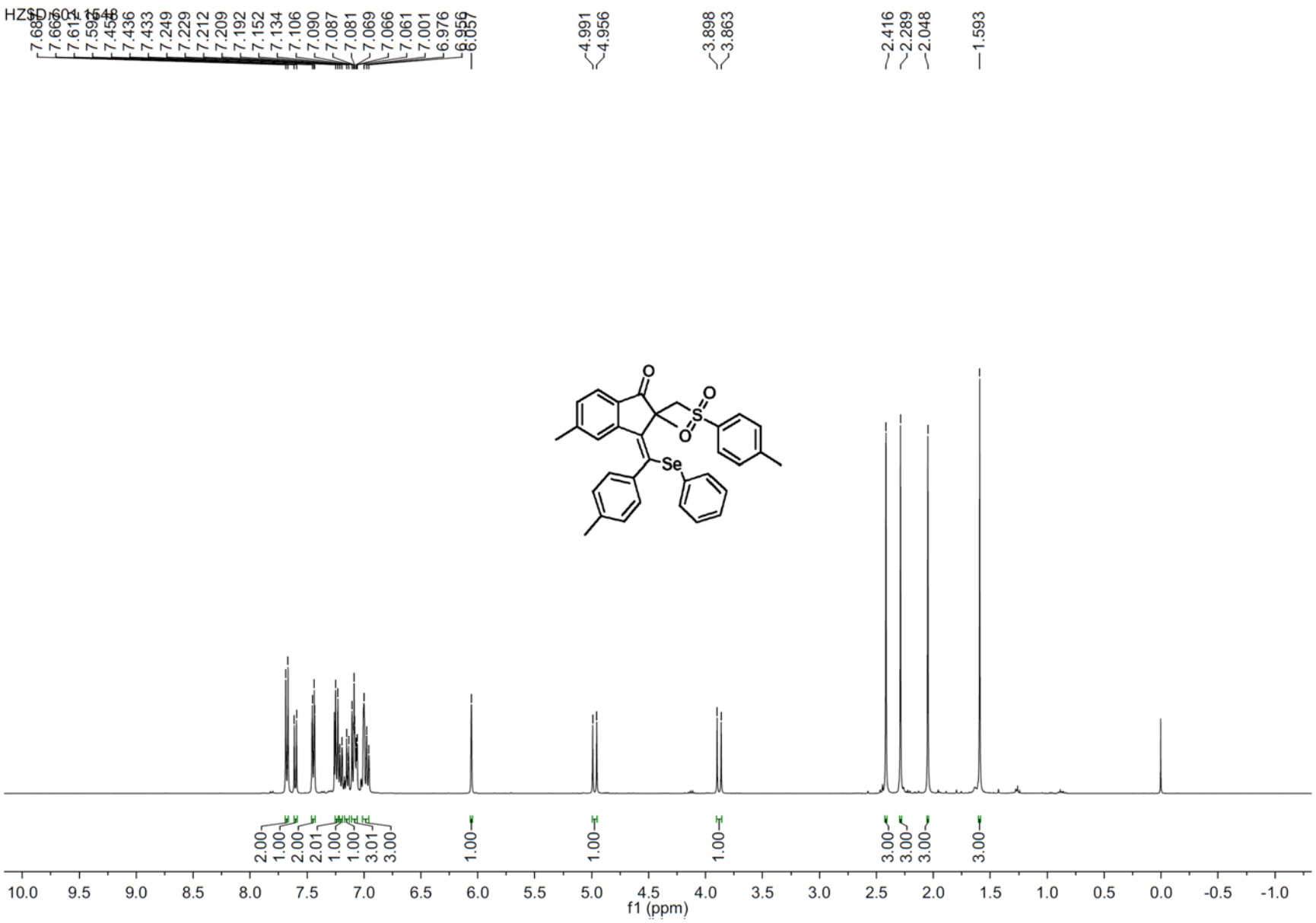
^{13}C NMR Spectrum of Compound 7q



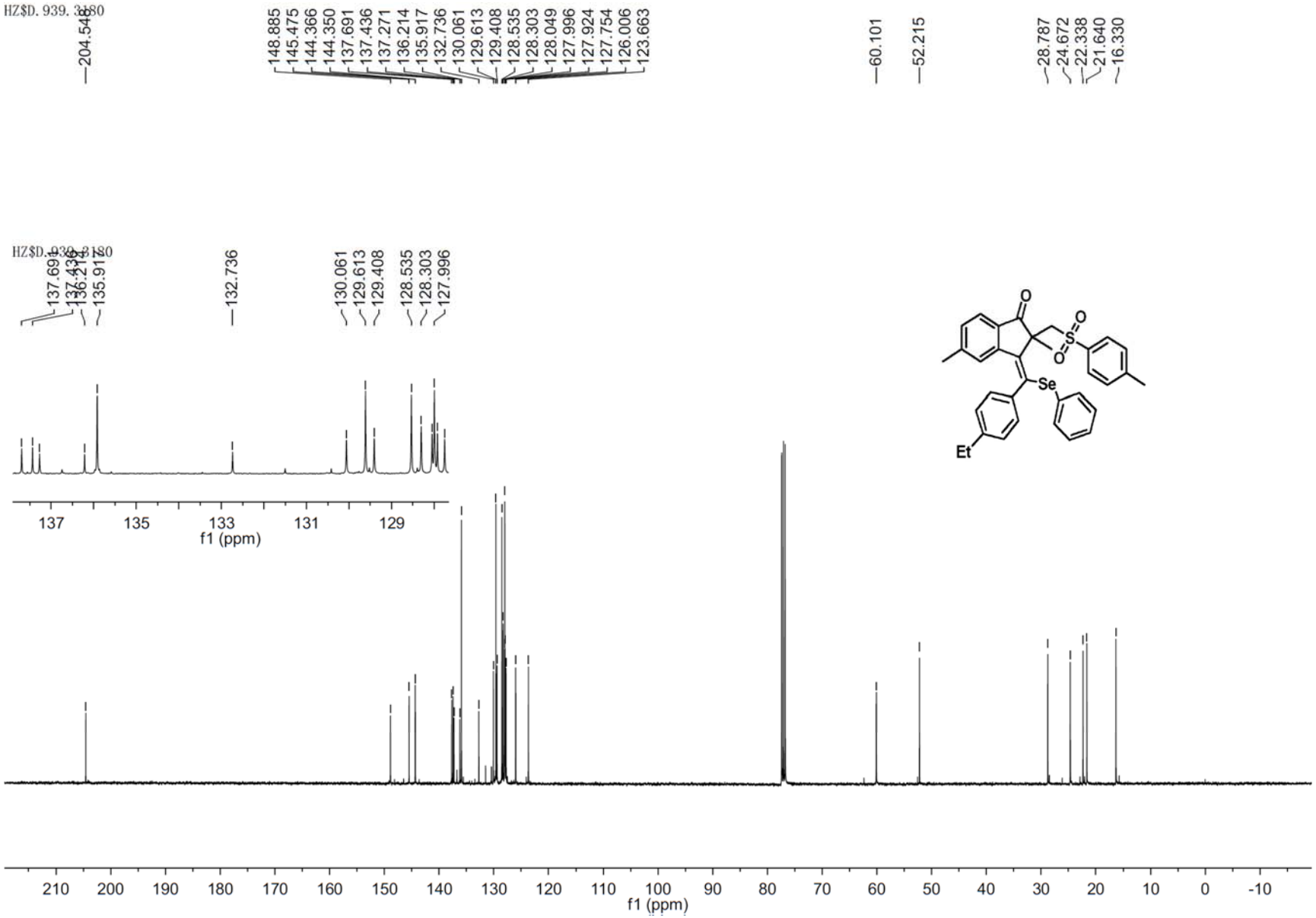
^{1}H NMR Spectrum of Compound 7r



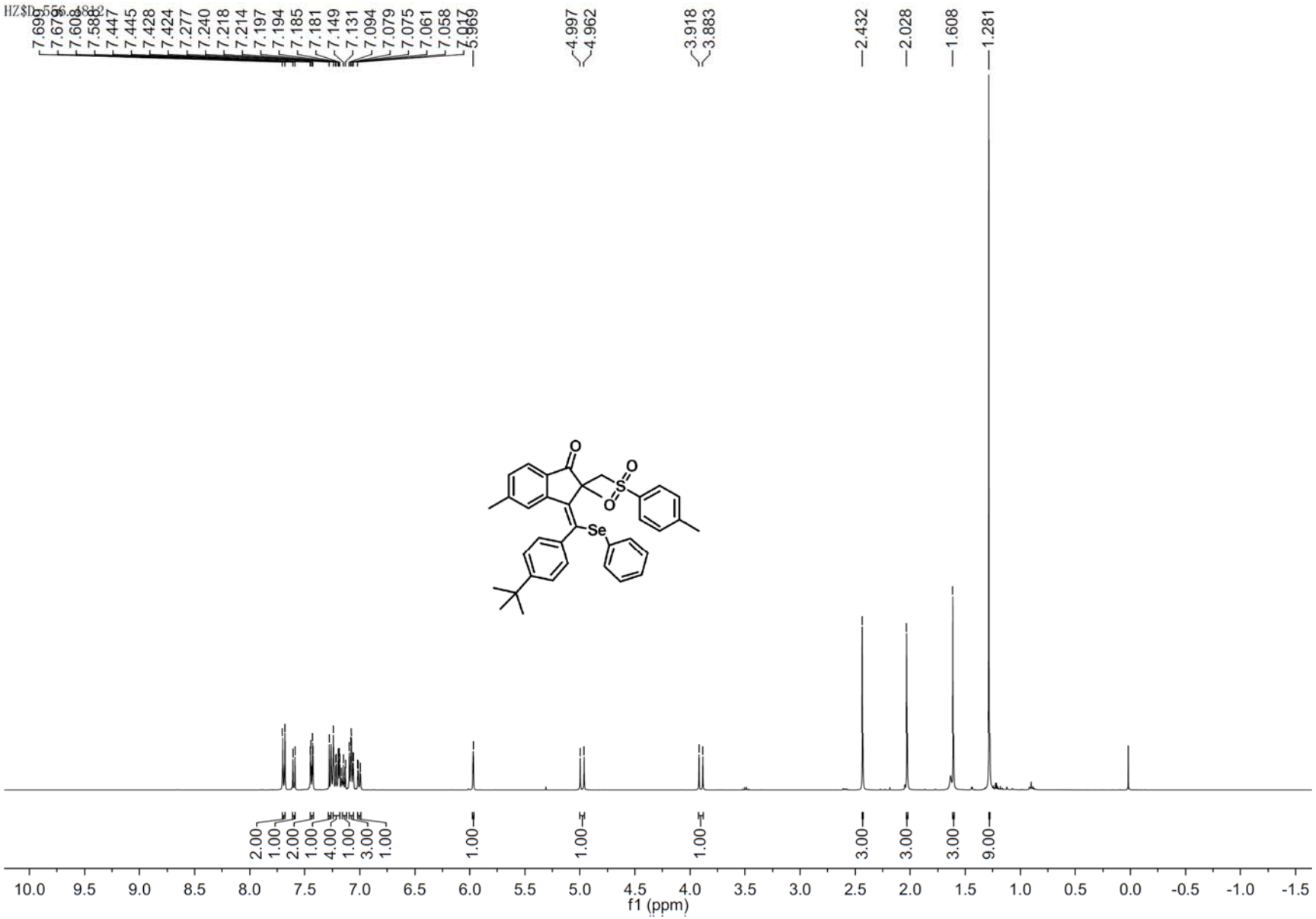
^{13}C NMR Spectrum of Compound 7r



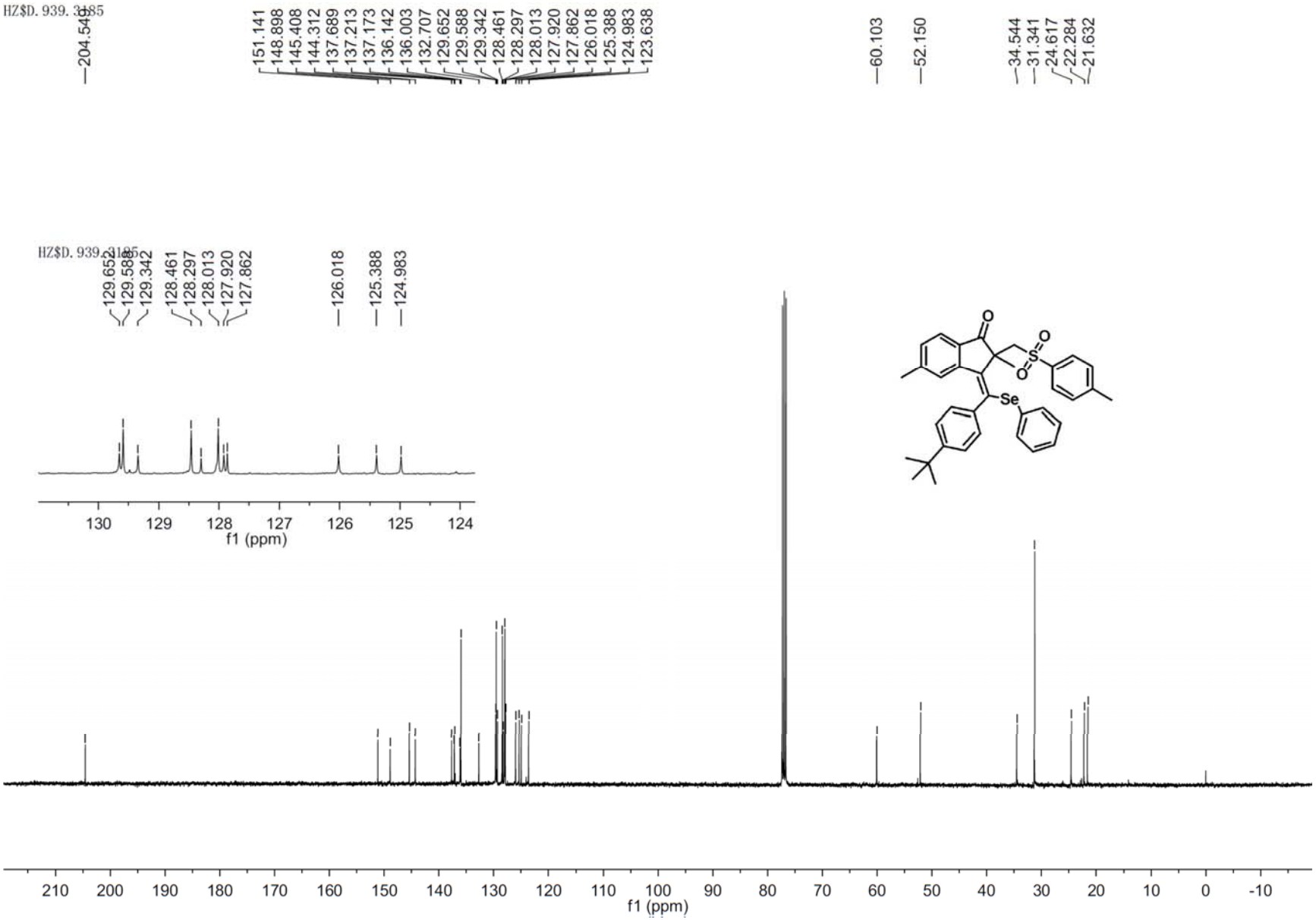
^{1}H NMR Spectrum of Compound 7s



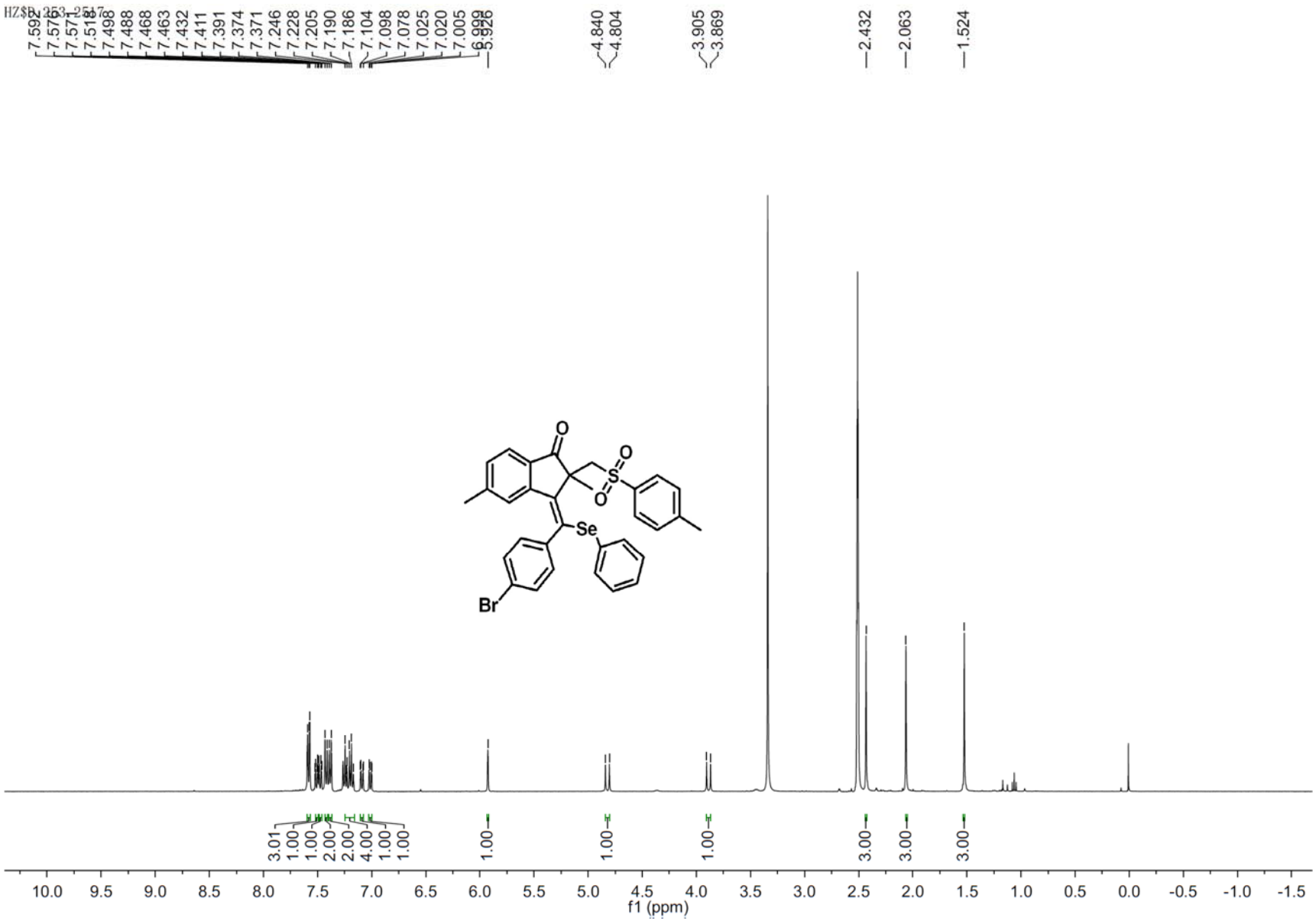
^{13}C NMR Spectrum of Compound 7s



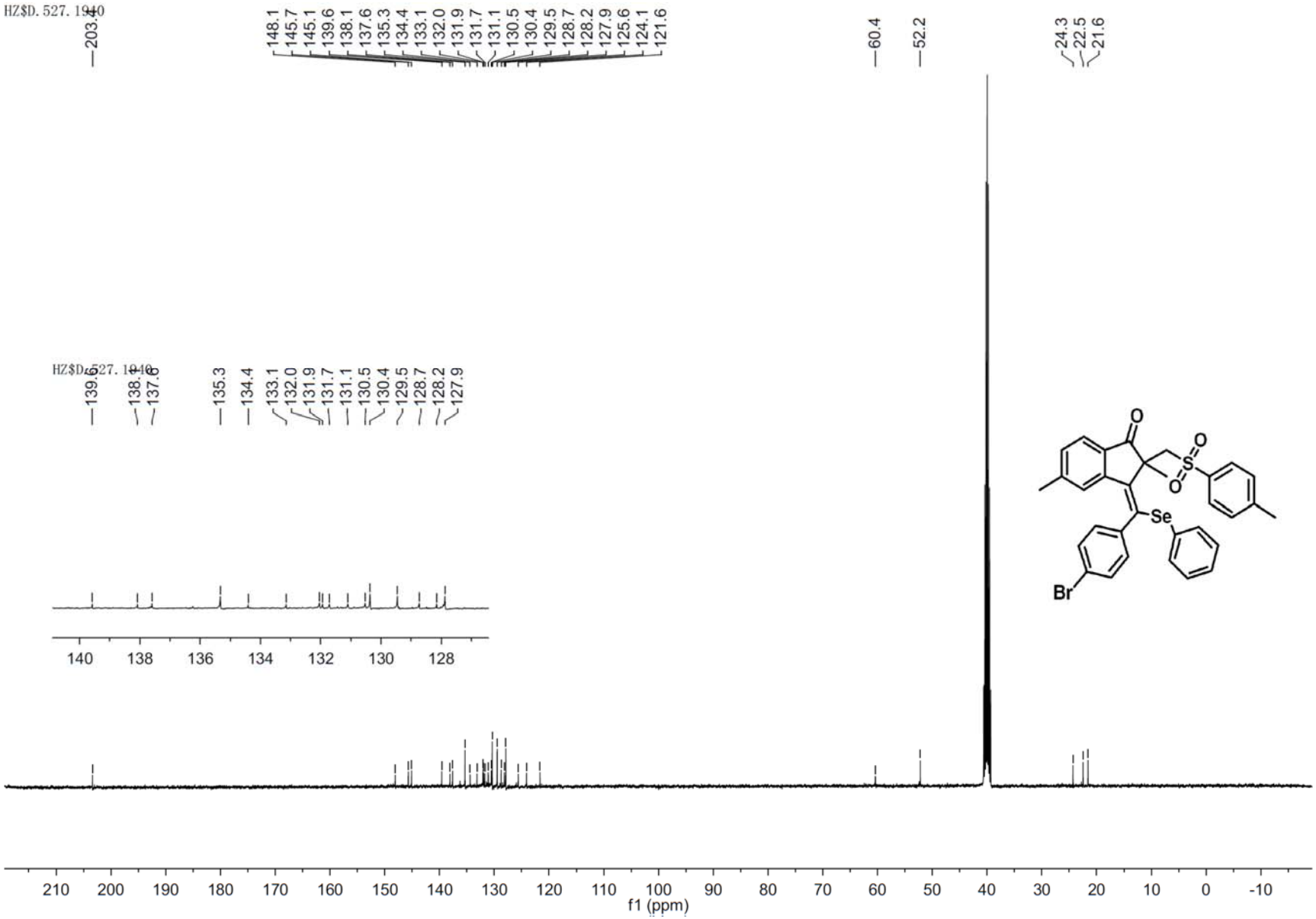
^{1}H NMR Spectrum of Compound 7t



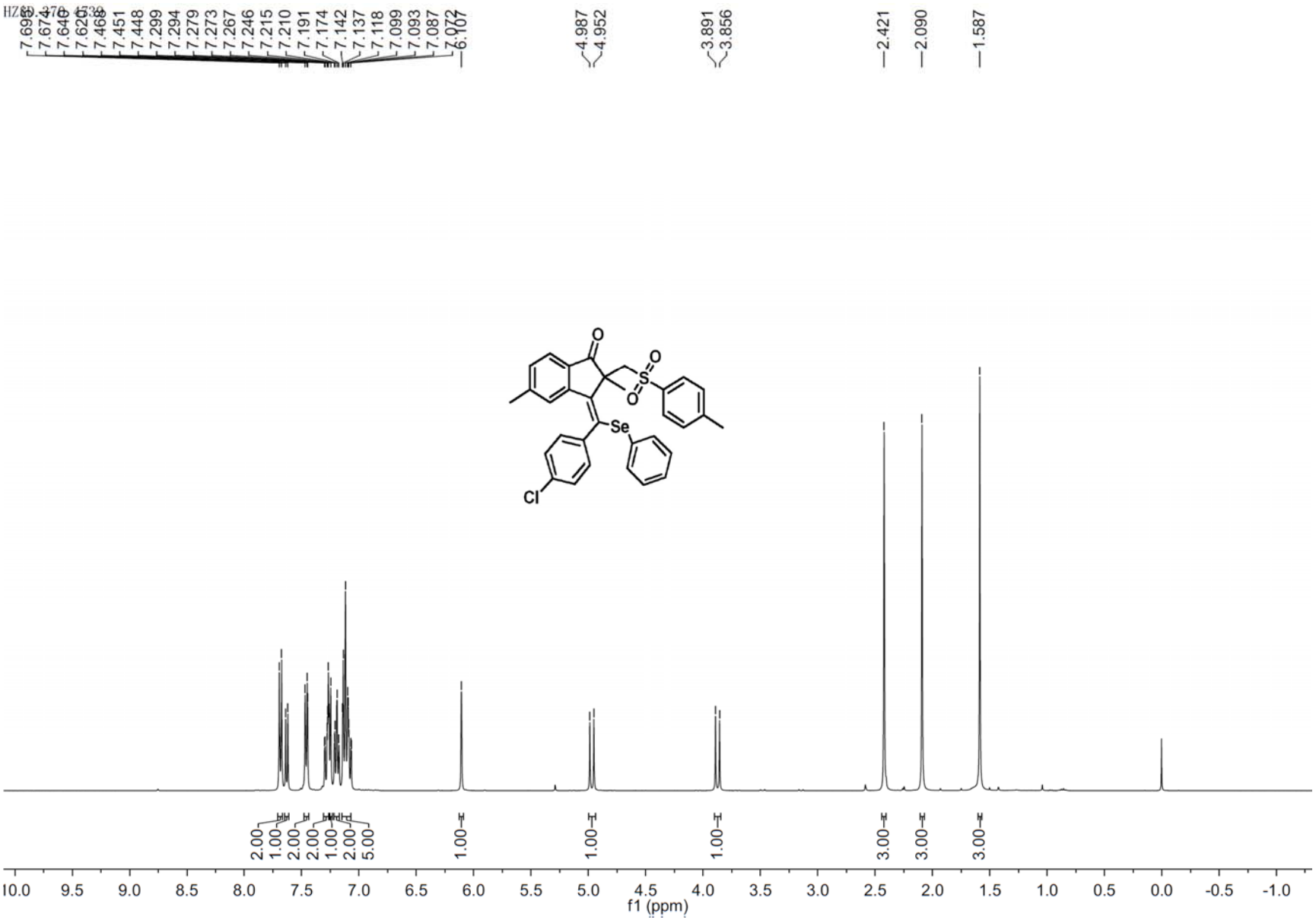
^{13}C NMR Spectrum of Compound 7t



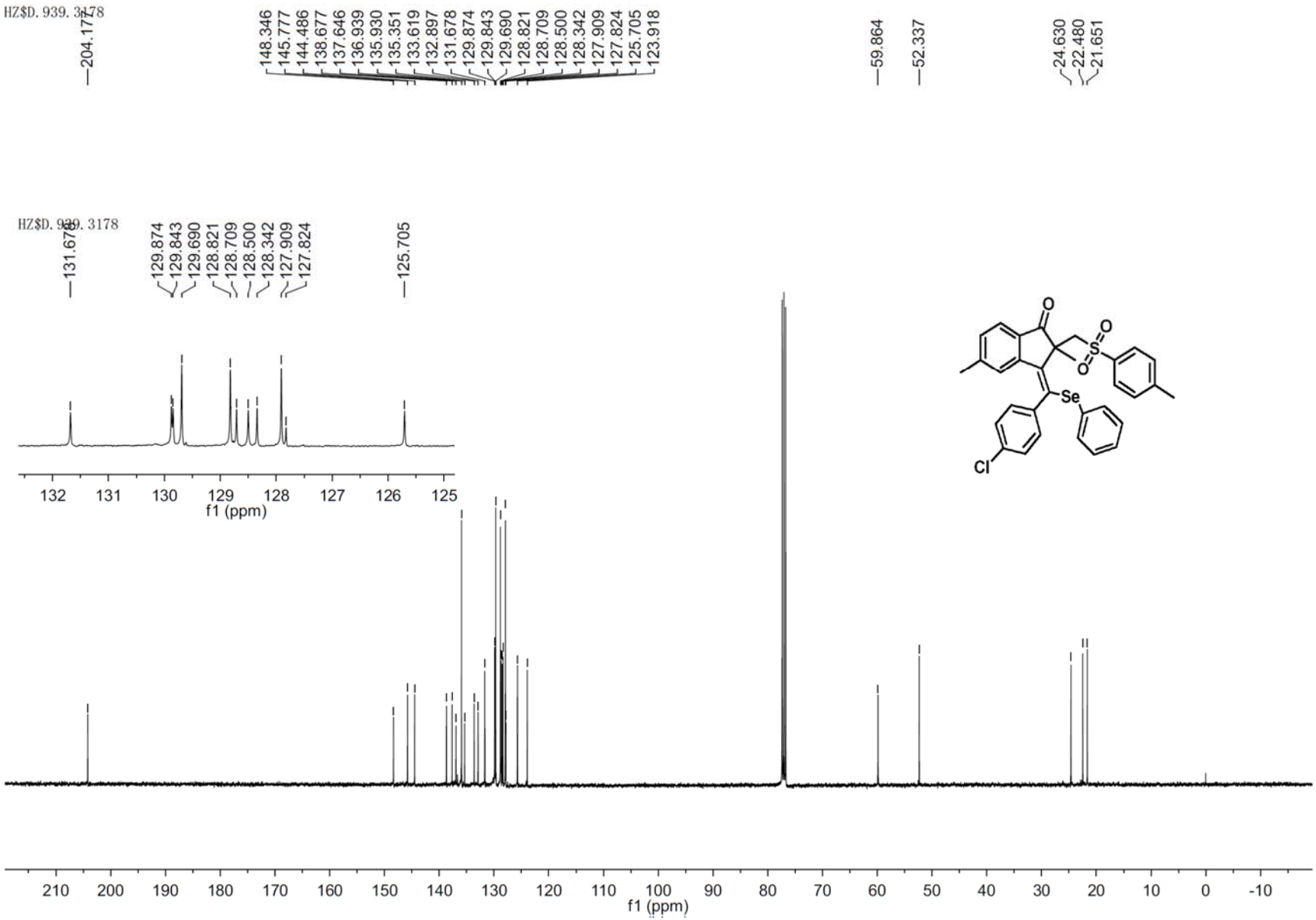
^{1}H NMR Spectrum of Compound 7u



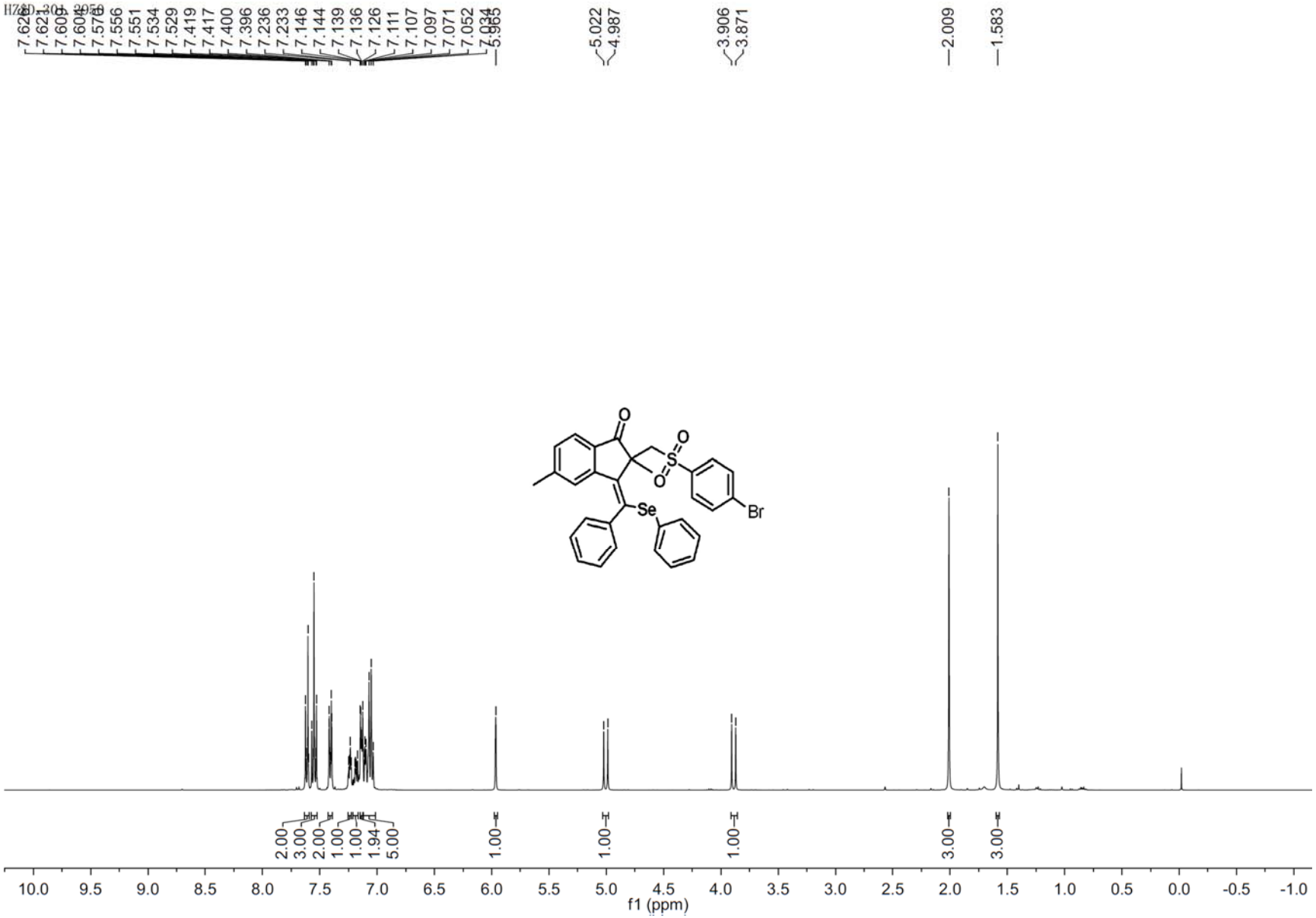
^{13}C NMR Spectrum of Compound 7u



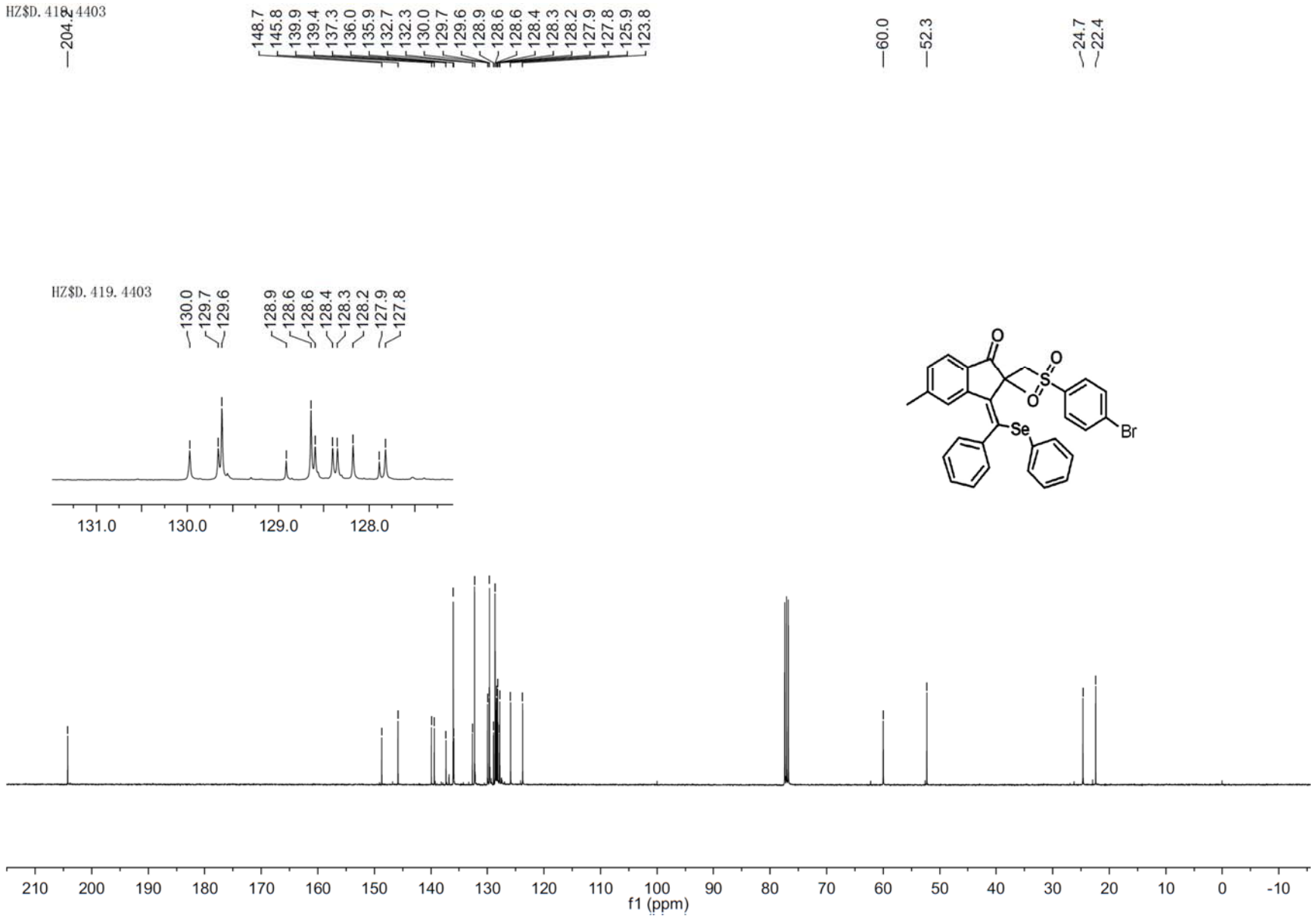
^{1}H NMR Spectrum of Compound 7v



^{13}C NMR Spectrum of Compound 7v



^{1}H NMR Spectrum of Compound 7w



^{13}C NMR Spectrum of Compound 7w