Supporting Information

Copper-catalyzed Buchner reaction and phenyl cyclopropanation through diyne cyclization

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1. General Information

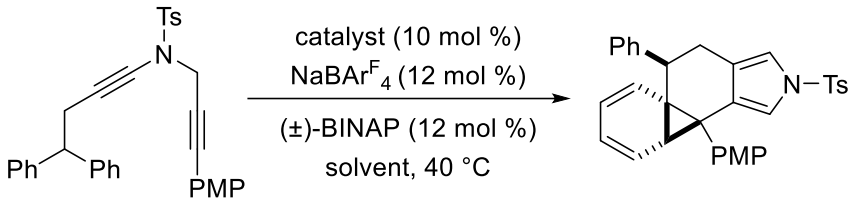
Ethyl acetate (ACS grade), hexanes (ACS grade) and anhydrous 1,2-dichloroethane (ACS grade) were obtained commercially and used without further purification. Methylene chloride, tetrahydrofuran and diethyl ether were purified according to standard methods unless otherwise noted. Commercially available reagents were used without further purification. Reactions were monitored by thin layer chromatography (TLC) using silicycle pre-coated silica gel plates. Flash column chromatography was performed over silica gel (300-400 mesh). Infrared spectra were recorded on a Nicolet AVATER FTIR330 spectrometer as thin film and are reported in reciprocal centimeter (cm^{-1}). Mass spectra were recorded with Micromass QTOF2 Quadrupole/Time-of-Flight Tandem mass spectrometer using electron spray ionization.

^{1}H NMR spectra were recorded on a Bruker AV-400 spectrometer and a Bruker AV-500 spectrometer in chloroform-d_3. Chemical shifts are reported in ppm with the internal TMS signal at 0.0 ppm as a standard. The data is being reported as (s = singlet, d = doublet, t = triplet, m = multiplet or unresolved, brs = broad singlet, coupling constant(s) in Hz, integration).

^{13}C NMR spectra were recorded on a Bruker AV-400 spectrometer and a Bruker AV-500 spectrometer in chloroform-d_3. Chemical shifts are reported in ppm with the internal chloroform signal at 77.0 ppm as a standard.

2. More Reaction Condition and Scope Studies

2.1 Screening of reaction conditions for the copper-catalyzed phenyl cyclopropanation reaction.[a]

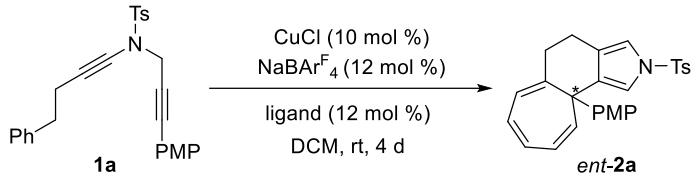


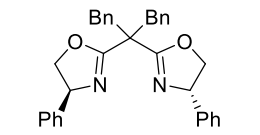
3a **4a**

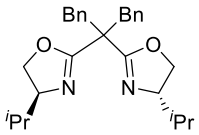
Entry	Catalyst	Reaction conditions	Yield (%)[b]
1	$Cu(CH_3CN)_4PF_6$	toluene, 48 h	50
2	$Cu(CH_3CN)_4PF_6$	DCE, 48 h	45
3	$Cu(CH_3CN)_4PF_6$	DCM, 48 h	73
4	$Cu(CH_3CN)_4PF_6$	THF, 48 h	<5
5	$Cu(CH_3CN)_4BF_4$	DCM, 48 h	78
6	$Cu(OTf)_2$	DCM, 48 h	<5
7	$Cu(PPh_3)_2BH_4$	DCM, 48 h	<5
8	$CuCl_2 \cdot 2H_2O$	DCM, 48 h	<5
9	CuI	DCM, 72 h	68
10	CuBr	DCM, 72 h	30
11	**CuCl**	**DCM, 53 h**	**95**
12[c,d]	CuCl	DCM 48 h	15
13[c]	CuCl	DCM, 48 h	18
14[d]	CuCl	DCM, 48 h	42

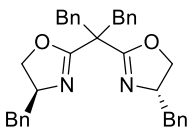
[a] Reaction conditions: **1** (0.05 mmol), [cat.] (0.005 mmol), (±)-BINAP (0.006 mmol), NaBAr$^F_4$ (0.006 mmol), solvent (1 mL), 40 ° C, 48-72 h. [b] Measured by ^{1}H NMR using diethyl phthalate as internal standard. [c] Without ligand. [d] Without NaBAr$^F_4$. PMP = 4-methoxyphenyl, NaBAr$^F_4$ = sodium tetrakis[3,5-bis(trifluoromethyl)phenyl]borate, DCM = dichloromethane.

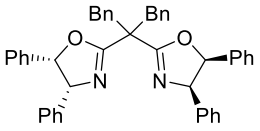
2.2 Screening of chiral ligands for the asymmetric Buchner reaction.

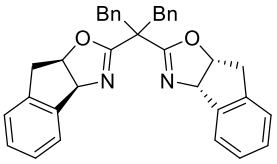


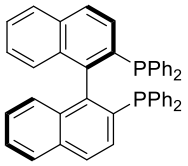

85%, 19% ee

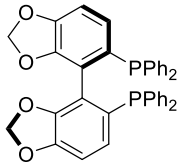

63%, <5% ee

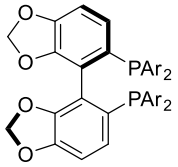

70%, 9% ee

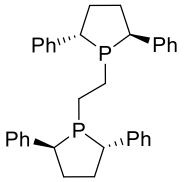

67%, 13% ee


75%, <5% ee

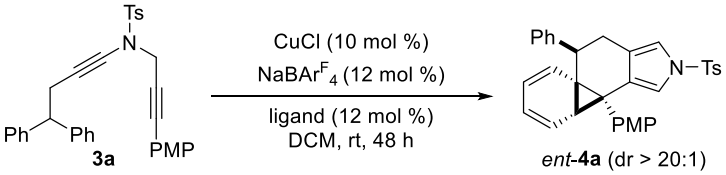

78%, <5% ee

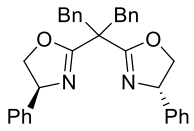

82%, <5% ee

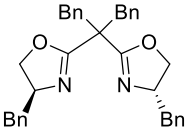

(Ar = 3,5-(^{t}Bu)$_2$-4-OMeC$_6$H$_2$)
85%, 23% ee

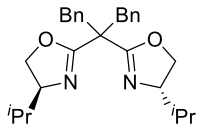

36%, <5% ee

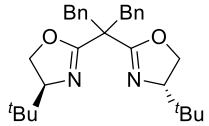
2.3 Screening of chiral ligands for the asymmetric phenyl cyclopropanation reaction.

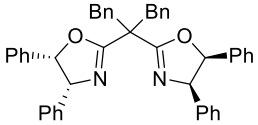


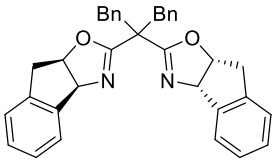

85%, 19% ee

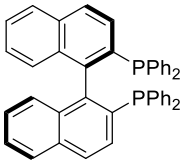

87%, 11% ee

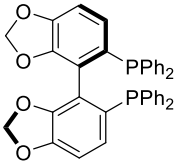

76%, 25% ee

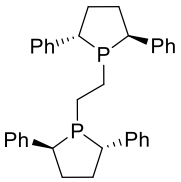

67%, <5% ee


88%, 29% ee

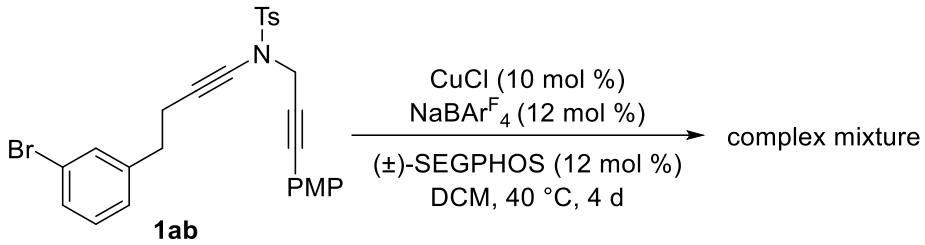

71%, 15% ee


72%, 16% ee


79%, 10% ee

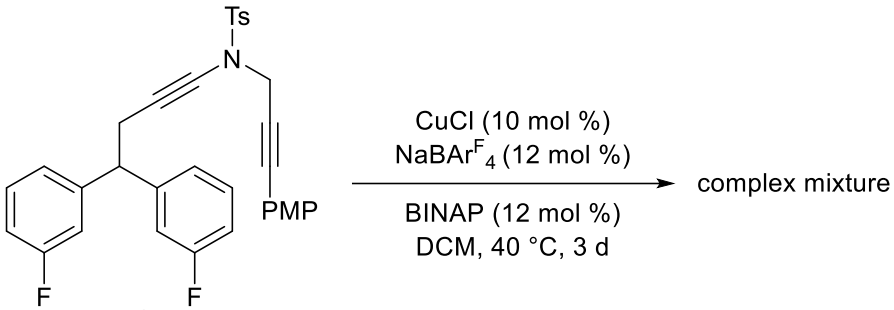

70%, 46% ee

2.4 The reaction of 3-bromophenyl-substituted diyne **1ab** under the standard reaction conditions only gave a complex mixture and no desired product was obtained.



1ab

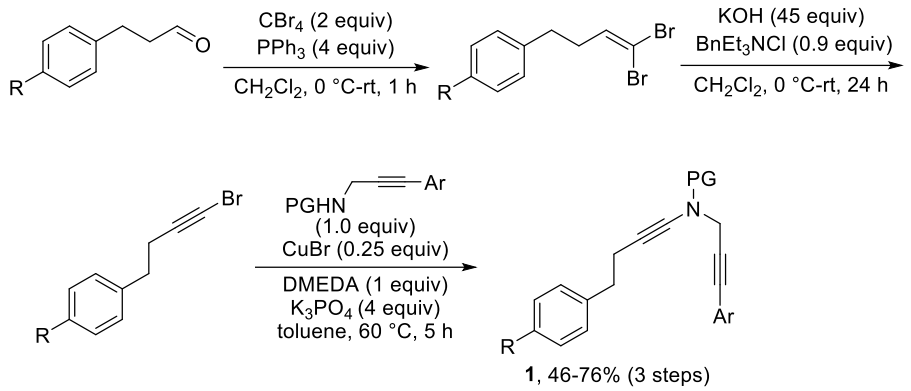
2.5 The reaction of 3-fluorophenyl-substituted diyne **3y** under the standard reaction conditions only gave a complex mixture and no desired product was obtained.



3y

3. Preparation of Starting Materials

General procedure for the preparation of diynes 1:

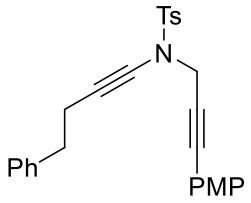


To a solution of PPh_3 (21.0 g, 80 mmol) in CH_2Cl_2 (25 mL) was added CBr_4 (13.3 g, 40 mmol) at 0 °C. The mixture was stirred at 0 °C for 30 min, followed by adding the corresponding aldehyde (20 mmol). Then the reaction mixture was stirred at room temperature for 1 h. Upon completion, the reaction mixture was diluted with petroleum ether, and filtered through a pad of silica gel. The filtrate was concentrated under reduced pressure, and purified by column chromatography on silica gel (eluent: petroleum ether) to afford the desired product.

To a solution of the above dibromoalkene (10 mmol) and benzyltriethylammonium chloride (2.0 g, 9 mmol) in CH_2Cl_2 (25 mL) was added a 10% aqueous solution of KOH (25.8 g solution, 450 mmol KOH) at 0 °C. The mixture was stirred at 0 °C for 30 min, and further stirred at room temperature 24 h. Upon completion, the reaction mixture was extracted with CH_2Cl_2, dried over Na_2SO_4, filtered and concentrated in vacuo. The desired alkynyl bromide product was used in the next step without further purification.

To a solution of the above alkynyl bromide (1.2 mmol) in toluene (6 mL) were added copper bromide (0.25 mmol, 0.036 g), DMEDA (1.0 mmol, 0.107 mL), K_3PO_4 (4.0 mmol, 0.849 g) and protected propargylamide derivative (1.2 mmol). The reaction was stirred at 60 °C for 5 h and the progress of the reaction was monitored by TLC. Upon completion, the solution was filtered and concentrated under reduced pressure. The residue was purified by silica gel column chromatography (eluent: hexanes/EtOAc) to afford the desired diyne **1** in 46-76% yields.

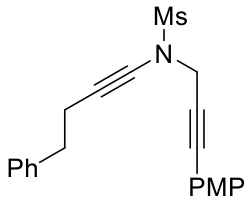
***N*-(3-(4-methoxyphenyl)prop-2-yn-1-yl)-4-methyl-*N*-(4-phenylbut-1-yn-1-yl)benzenesulfonamide (1a)**



1a

The compound was isolated in 73% yield according to the general procedure. Yellow solid. M.p = 75 – 76 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.77 (d, *J* = 8.0 Hz, 2H), 7.24 – 7.16 (m, 7H), 7.11 – 7.07 (m, 2H), 6.79 – 6.75 (m, 2H), 4.39 (s, 2H), 3.79 (s, 3H), 2.81 (t, *J* = 7.0 Hz, 2H), 2.59 (t, *J* = 7.5 Hz, 2H), 2.36 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 159.7, 144.4, 140.5, 134.5, 133.1, 129.4, 128.5, 128.3, 128.1, 126.2, 114.2, 113.7, 86.0, 80.1, 73.6, 70.0, 55.3, 42.8, 35.2, 21.5, 20.6; IR (neat): 3055, 2987, 2307, 1509, 1428, 1266, 894, 736; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{27}H_{25}NaO_3S^+$ 466.1447; Found 466.1444.

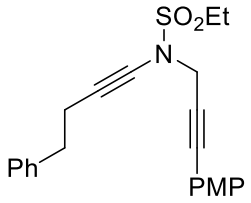
***N*-(3-(4-methoxyphenyl)prop-2-yn-1-yl)-*N*-(4-phenylbut-1-yn-1-yl)methanesulfonamide (1b)**



1b

The compound was isolated in 69% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.36 (d, *J* = 9.0 Hz, 2H), 7.29 – 7.12 (m, 5H), 6.85 (d, *J* = 9.0 Hz, 2H), 4.40 (s, 2H), 3.79 (s, 3H), 3.02 (s, 3H), 2.84 (t, *J* = 7.0 Hz, 2H), 2.62 (t, *J* = 7.0 Hz, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 160.1, 140.4, 133.3, 128.5, 128.3, 126.2, 114.0, 113.8, 86.4, 80.4, 73.4, 70.3, 55.3, 42.8, 37.9, 35.0, 20.5; IR (neat): 3053, 2986, 2330, 1607, 1509, 1032, 835, 741, 736; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{21}H_{21}NNaO_3S^+$ 390.1134; Found 390.1130.

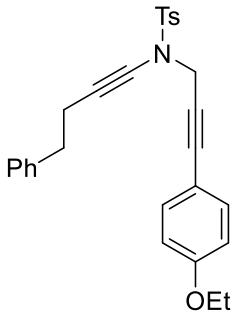
***N*-(3-(4-methoxyphenyl)prop-2-yn-1-yl)-*N*-(4-phenylbut-1-yn-1-yl)ethanesulfonamide (1c)**



1c

The compound was isolated in 68% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.37 (d, *J* = 8.5 Hz, 2H), 7.28 – 7.20 (m, 4H), 7.20 – 7.14 (m, 1H), 6.85 (d, *J* = 8.5 Hz, 2H), 4.42 (s, 2H), 3.81 (s, 3H), 3.22 (q, *J* = 14.5 Hz, 2H), 2.84 (t, *J* = 7.0 Hz, 2H), 2.62 (t, *J* = 7.0 Hz, 2H), 1.40 (t, *J* = 7.0 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 160.0, 140.5, 133.3, 128.5, 128.3, 126.2, 114.0, 86.2, 80.9, 73.5, 70.0, 55.3, 46.3, 42.5, 35.1, 20.6, 7.7; IR (neat): 3056, 2988, 2306, 1423, 1266, 896, 750, 706; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{22}H_{23}NNaO_3S^+$ 404.1291; Found 404.1293.

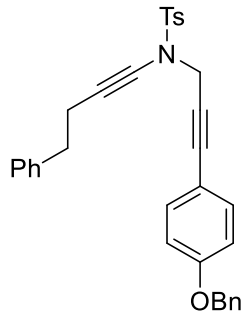
***N*-(3-(4-ethoxyphenyl)prop-2-yn-1-yl)-4-methyl-*N*-(4-phenylbut-1-yn-1-yl)benzenesulfonamide (1d)**



1d

The compound was isolated in 70% yield according to the general procedure. Yellow solid. M.p = 77 – 78 °C.^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, *J* = 8.4 Hz, 2H), 7.26 – 7.15 (m, 7H), 7.07 (d, *J* = 8.8 Hz, 2H), 6.76 (d, *J* = 8.8 Hz, 2H), 4.39 (s, 2H), 4.00 (q, *J* = 6.8 Hz, 2H), 2.80 (t, *J* = 7.2 Hz, 2H), 2.59 (t, *J* = 7.2 Hz, 2H), 2.35 (s, 3H), 1.40 (t, *J* = 6.8 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.1, 144.3, 140.5, 134.4, 133.1, 129.4, 128.4, 128.3, 128.1, 126.1, 114.2, 114.0, 86.1, 80.0, 73.6, 70.0, 63.5, 42.8, 35.2, 21.5, 20.6, 14.7; IR (neat): 3054, 2986, 2359, 1733, 1170, 741, 736, 705; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{28}H_{27}NNaO_3S^+$ 480.1604; Found 480.1600.

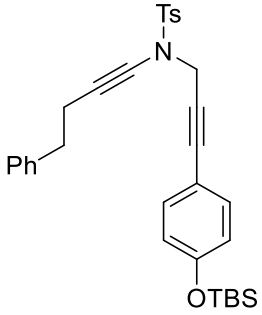
***N*-(3-(4-(benzyloxy)phenyl)prop-2-yn-1-yl)-*N*-(4-phenylbut-1-yn-1-yl)benzenesulfonamide (1e)**



1e

The compound was isolated in 89% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76 (d, *J* = 8.4 Hz, 2H), 7.43 – 7.28 (m, 5H), 7.26 – 7.13 (m, 7H), 7.07 (d, *J* = 8.8 Hz, 2H), 6.84 (d, *J* = 8.8 Hz, 2H), 5.04 (s, 2H), 4.38 (s, 2H), 2.79 (t, *J* = 7.2 Hz, 2H), 2.58 (t, *J* = 7.2 Hz, 2H), 2.32 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.8, 144.3, 140.5, 136.4, 134.4, 133.1, 129.3, 128.6, 128.4, 128.2, 128.1, 128.0, 127.3, 126.1, 114.6, 114.4, 85.9, 80.1, 73.5, 70.0, 69.9, 42.7, 35.1, 21.5, 20.5; IR (neat): 3056, 2988, 2307, 1509, 1266, 742, 737, 706; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{33}H_{29}NNaO_3S^+$ 542.1760; Found 542.1761.

***N*-(3-(4-((tert-butyldimethylsilyl)oxy)phenyl)prop-2-yn-1-yl)-4-methyl-*N*-(4-phenylbut-1-yn-1-yl)benzenesulfonamide (1f)**

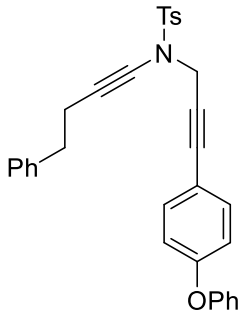


1f

The compound was isolated in 45% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, *J* = 8.4 Hz, 2H), 7.26 – 7.15 (m, 7H), 7.03 (d, *J* = 8.4 Hz, 2H), 6.71 (d, *J* = 8.8 Hz, 2H), 4.39 (s, 2H), 2.81 (t, *J* = 7.2 Hz, 2H), 2.59 (t, *J* = 7.2 Hz, 2H), 2.36 (s, 3H), 0.97 (s, 9H), 0.19 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 156.1, 144.3, 140.6, 134.5, 133.1, 129.4, 128.5, 128.3, 128.2, 126.2, 119.9, 114.9, 86.1, 80.2, 73.6, 70.0, 42.8, 35.2, 25.6, 21.6, 20.6, 18.2, -4.4; IR (neat): 3055, 2987, 2306, 1508, 897,

741, 736, 706; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{32}H_{37}NNaO_3SSi^+$ 566.2156; Found 566.2152.

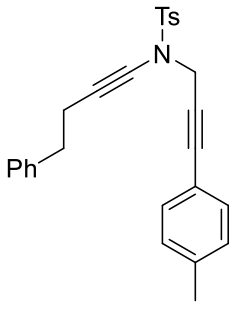
4-methyl-*N*-(3-(4-phenoxyphenyl)prop-2-yn-1-yl)-*N*-(4-phenylbut-1-yn-1-yl)benzenesulfonamide (1g)



1g

The compound was isolated in 74% yield according to the general procedure. Yellow solid. M.p = 96-97 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.79 – 7.75 (d, *J* = 8.0 Hz, 2H), 7.39 – 7.32 (m, 2H), 7.27 – 7.08 (m, 10H), 7.00 (d, *J* = 8.0 Hz, 2H), 6.86 (d, *J* = 8.8 Hz, 2H), 4.40 (s, 2H), 2.81 (t, *J* = 7.2 Hz, 2H), 2.59 (t, *J* = 7.2 Hz, 2H), 2.36 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 157.8, 156.2, 144.4, 140.5, 134.4, 133.2, 129.9, 129.4, 128.4, 128.3, 128.1, 126.2, 123.9, 119.4, 118.0, 116.6, 85.6, 80.8, 73.5, 70.1, 42.7, 35.2, 21.6, 20.6; IR (neat): 3055, 2987, 2306, 1504 1422, 1169, 896, 737; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{32}H_{27}NNaO_3S^+$ 528.1604; Found 528.1600.

***N*-(3-(4-ethylphenyl)prop-2-yn-1-yl)-4-methyl-*N*-(4-phenylbut-1-yn-1-yl)benzenesulfonamide (1h)**

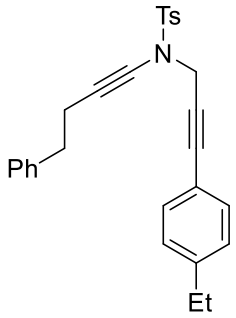


1h

The compound was isolated in 61% yield according to the general procedure. Yellow solid. M.p = 73 – 74 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, *J* = 8.0 Hz, 2H), 7.27 – 7.14 (m, 7H), 7.08 – 7.01 (m, 4H), 4.40 (s, 2H), 2.80 (t, *J* = 7.2 Hz, 2H), 2.59 (t, *J* = 7.2 Hz, 2H),

2.35 (s, 3H), 2.32 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.4, 140.5, 138.6, 134.4, 131.5, 129.4, 128.8, 128.4, 128.3, 128.1, 126.1, 119.0, 86.2, 80.7, 73.5, 70.0, 42.7, 35.2, 21.5, 21.4, 20.6; IR (neat): 3054, 2986, 2305, 1509, 1265, 896, 741, 736; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{27}H_{25}NNaO_2S^+$ 450.1498; Found 450.1495.

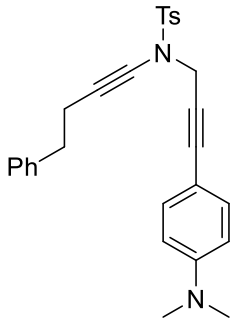
_N_-(3-(4-ethylphenyl)prop-2-yn-1-yl)-4-methyl-_N_-(4-phenylbut-1-yn-1-yl)benzenesulfonamide (1i)



1i

The compound was isolated in 88 % yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, J = 8.4 Hz, 2H), 7.26 – 7.14 (m, 7H), 7.10 – 7.03 (m, 4H), 4.40 (s, 2H), 2.80 (t, J = 7.2 Hz, 2H), 2.67 – 2.55 (m, 4H), 2.34 (s, 3H), 1.21 (t, J = 7.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.9, 144.4, 140.5, 134.4, 131.6, 129.4, 128.4, 128.3, 128.1, 127.6, 126.1, 119.3, 86.2, 80.7, 73.6, 70.0, 42.7, 35.2, 28.7, 21.5, 20.6, 15.3; IR (neat): 3055, 2987, 2306, 1423, 1266, 896, 748, 737; HRMS (ESI/QTOF) m/z: $[M +Na]^+$ Calcd for $C_{28}H_{27}NNaO_2S^+$ 464.1655; Found 464.1657.

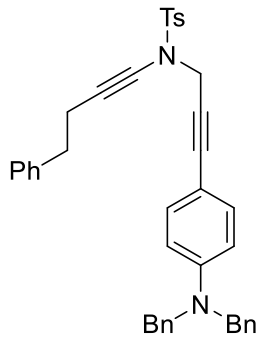
_N_-(3-(4-(dimethylamino)phenyl)prop-2-yn-1-yl)-4-methyl-_N_-(4-phenylbut-1-yn-1-yl)benzenesulfonamide (1j)



1j

The compound was isolated in 87% yield according to the general procedure. Yellow solid. M.p = 111 – 112 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.77 (d, *J* = 8.5 Hz, 2H), 7.25 – 7.18 (m, 7H), 7.04 (d, *J* = 9.0 Hz, 2H), 6.55 (d, *J* = 9.0 Hz, 2H), 4.40 (s, 2H), 2.96 (s, 6H), 2.80 (t, *J* = 7.5 Hz, 2H), 2.58 (t, *J* = 7.5 Hz, 2H), 2.37 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 150.6, 144.7, 141.0, 134.9, 133.2, 129.8, 128.9, 128.7, 128.5, 126.5, 111.9, 109.3, 87.6, 79.5, 74.1, 70.4, 43.4, 40.5, 35.6, 21.9(9), 21.9(6), 21.1; IR (neat): 2358, 2250, 1652, 1539, 1361, 1167, 814, 666, 579, 544; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{28}H_{28}N_2NaO_2S^+$ 479.1764; Found 479.1761.

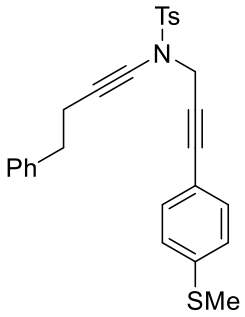
_N_-(3-(4-(dibenzylamino)phenyl)prop-2-yn-1-yl)-4-methyl-_N_-(4-phenylbut-1-yn-1-yl)benzenesulfonamide (1k)



1k

The compound was isolated in 48% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.75 (d, *J* = 7.6 Hz, 2H), 7.36 – 7.29 (m, 4H), 7.27 – 7.12 (m, 13H), 6.95 (d, *J* = 8.0 Hz, 2H), 6.57 (d, *J* = 8.0 Hz, 2H), 4.64 (s, 4H), 4.37 (s, 2H), 2.79 (t, *J* = 7.2 Hz, 2H), 2.61 (t, *J* = 7.2 Hz, 2H), 2.29 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 149.0, 144.3, 140.6, 137.8, 134.5, 132.9, 129.3, 128.7, 128.5, 128.3, 128.1, 127.1, 126.4, 126.1, 111.8, 109.6, 86.9, 79.2, 73.6, 69.9, 54.1, 43.0, 35.2, 21.5, 20.6; IR (neat): 3604, 3030, 2926, 2253, 2216, 1521, 1363, 815, 736, 698; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{40}H_{36}N_2NaO_2S^+$ 631.2390; Found 631.2392.

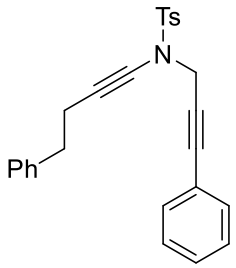
4-methyl-_N_-(3-(4-(methylthio)phenyl)prop-2-yn-1-yl)-_N_-(4-phenylbut-1-yn-1-yl)benzenesulfonamide (1l)



1l

The compound was isolated in 57% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76 (d, *J* = 8.4 Hz, 2H), 7.24 – 7.17 (m, 7H), 7.13 – 7.01 (m, 4H), 4.40 (s, 2H), 2.81 (t, *J* = 7.2 Hz, 2H), 2.59 (t, *J* = 7.2Hz, 2H), 2.46 (s, 3H), 2.36 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.4, 140.5, 139.8, 134.4, 131.9, 129.4, 128.4, 128.3, 128.1, 126.2, 125.6, 118.4, 85.8, 81.5, 73.5, 70.1, 42.7, 35.2, 21.6, 20.6, 15.3; IR (neat): 3056, 2988, 2306, 1423, 1366, 1171, 896, 748, 742, 706; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{27}H_{25}NNaO_2S_2^+$ 482.1219; Found 482.1216.

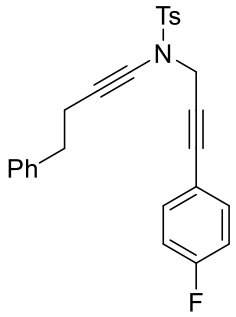
4-methyl-*N*-(4-phenylbut-1-yn-1-yl)-*N*-(3-phenylprop-2-yn-1-yl)benzenesulfonamide (1m)



1m

The compound was isolated in 76% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, *J* = 8.4 Hz, 2H), 7.32 – 7.10 (m, 12H), 4.41 (s, 2H), 2.81 (t, *J* = 7.2 Hz, 2H), 2.59 (t, *J* = 7.2 Hz, 2H), 2.34 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.4, 140.5, 134.4, 131.6, 129.4, 128.5, 128.4, 128.3, 128.1(3), 128.0(7), 126.2, 122.1, 86.0, 81.5, 73.5, 70.1, 42.7, 35.2, 21.5, 20.6; IR (neat): 3055, 2987, 2305, 2256, 1365, 1266, 1170, 896, 737, 705; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{26}H_{23}NNaO_2S^+$ 436.1342; Found 436.1340.

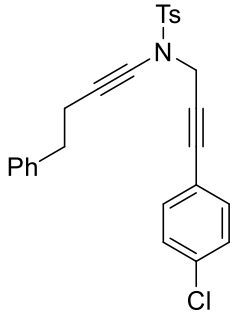
***N*-(3-(4-fluorophenyl)prop-2-yn-1-yl)-4-methyl-*N*-(4-phenylbut-1-yn-1-yl)benzenesulfonamide (1n)**



1n

The compound was isolated in 78% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76 (d, *J* = 8.0 Hz, 2H), 7.28 – 7.15 (m, 7H), 7.15 – 7.09 (m, 2H), 6.98 – 6.90 (m, 2H), 4.39 (s, 2H), 2.81 (t, *J* = 7.2 Hz, 2H), 2.59 (t, *J* = 7.2 Hz, 2H), 2.35 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 162.5 (d, *J* = 250.1 Hz), 144.4, 140.5, 134.4, 133.5 (d, *J* = 8.4 Hz), 129.4, 128.4, 128.3, 128.1, 126.2, 118.2 (d, *J* = 3.5 Hz), 115.4 (d, *J* = 22.1 Hz), 85.0, 81.3, 73.5, 70.1, 42.6, 35.2, 21.5, 20.6; ^{19}F NMR (471 MHz, $CDCl_3$) δ -110.2; IR (neat): 3056, 2989, 2687, 1603, 1423, 1367, 896, 839, 748, 737; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{26}H_{22}FNNaO_2S^+$ 454.1247; Found 454.1245.

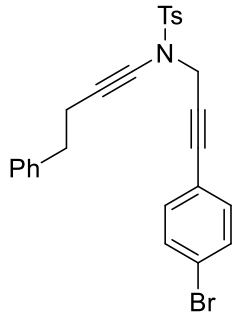
***N*-(3-(4-chlorophenyl)prop-2-yn-1-yl)-4-methyl-*N*-(4-phenylbut-1-yn-1-yl)benzenesulfonamide (1o)**



1o

The compound was isolated in 71% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.75 (d, *J* = 8.4 Hz, 2H), 7.26 – 7.15 (m, 9H), 7.05 (d, *J* = 8.4 Hz, 2H), 4.38 (s, 2H), 2.80 (t, *J* = 7.2 Hz, 2H), 2.59 (t, *J* = 7.2 Hz, 2H), 2.35 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.4, 140.4, 134.5, 134.3, 132.8, 129.4, 128.4, 128.2, 128.1, 126.1, 120.5, 84.9, 82.5, 73.5, 70.1, 42.6, 35.1, 21.5, 20.5; IR (neat): 3054, 2987, 2307, 1422, 1366, 1265, 1170, 1090, 896, 736, 706; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{26}H_{22}ClNNaO_2S^+$ 470.0952; Found 470.0945.

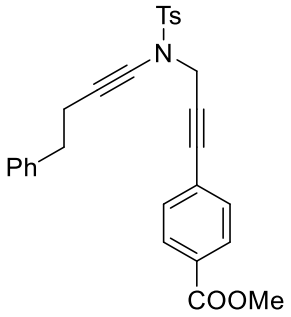
***N*-(3-(4-bromophenyl)prop-2-yn-1-yl)-4-methyl-*N*-(4-phenylbut-1-yn-1-yl)benzenesulfonamide (1p)**



1p

The compound was isolated in 78% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76 (d, *J* = 8.0 Hz, 2H), 7.38 (d, *J* = 8.4 Hz, 2H), 7.27 – 7.15 (m, 7H), 6.98 (d, *J* = 8.4 Hz, 2H), 4.38 (s, 2H), 2.81 (t, *J* = 7.2 Hz, 2H), 2.59 (t, *J* = 7.2 Hz, 2H), 2.36 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.5, 140.5, 134.4, 133.0, 131.4, 129.4, 128.4, 128.3, 128.1, 126.2, 122.8, 121.0, 85.0, 82.8, 73.5, 70.1, 42.6, 35.1, 21.6, 20.5; IR (neat): 3056, 2989, 2307, 1423, 1266, 897, 742, 737, 706; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{26}H_{22}BrNNaO_2S^+$ 514.0447; Found 514.0044.

methyl 4-(3-((4-methyl-*N*-(4-phenylbut-1-yn-1-yl)phenyl)sulfonamido)prop-1-yn-1-yl)benzoate (1q)

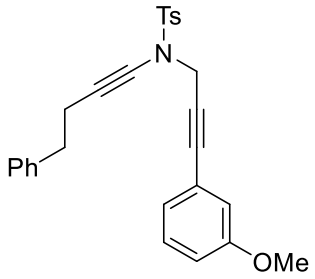


1q

The compound was isolated in 60% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92 (d, *J* = 8.4 Hz, 2H), 7.76 (d, *J* = 8.0 Hz, 2H), 7.28 – 7.12 (m, 9H), 4.42 (s, 2H), 3.91 (s, 3H), 2.81 (t, *J* = 7.2 Hz, 2H), 2.60 (t, *J* = 7.2 Hz, 2H), 2.34 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.3, 144.5, 140.4, 134.3, 131.5, 129.4, 129.2, 128.4, 128.3, 128.1, 126.7, 126.2, 85.2, 84.5, 73.4, 70.2, 52.2, 42.6, 35.1, 21.5, 20.5;

IR (neat): 3056, 2987, 2307, 1438, 1266, 897, 742, 732, 706; HRMS (ESI/QTOF) m/z: [M + Na]$^+$ Calcd for $C_{28}H_{25}NNaO_4S^+$ 494.1397; Found 494.1395.

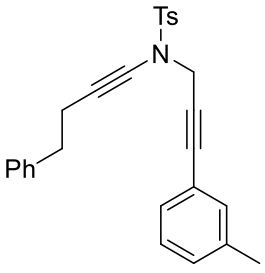
_N_-(3-(3-methoxyphenyl)prop-2-yn-1-yl)-4-methyl-_N_-(4-phenylbut-1-yn-1-yl)benzenesulfonamide (1r)



1r

The compound was isolated in 69% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, *J* = 8.4 Hz, 2H), 7.24 – 7.13 (m, 8H), 6.87 – 6.82 (m, 1H), 6.76 – 6.66 (m, 2H), 4.40 (s, 2H), 3.76 (s, 3H), 2.81 (t, *J* = 7.2 Hz, 2H), 2.59 (t, *J* = 7.2 Hz, 2H), 2.36 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.1, 144.5, 140.5, 134.4, 129.4, 129.2, 128.4, 128.3, 128.1, 126.2, 124.1, 123.1, 117.0, 114.6, 86.0, 81.3, 73.5, 70.1, 55.2, 42.7, 35.2, 21.5, 20.6; IR (neat): 3056, 2988, 2306, 1423, 1266, 896, 742, 737, 706; HRMS (ESI/QTOF) m/z: [M + Na]$^+$ Calcd for $C_{27}H_{25}NNaO_3S^+$ 466.1447; Found 466.1445.

4-methyl-_N_-(4-phenylbut-1-yn-1-yl)-_N_-(3-(m-tolyl)prop-2-yn-1-yl)benzenesulfonamide (1s)

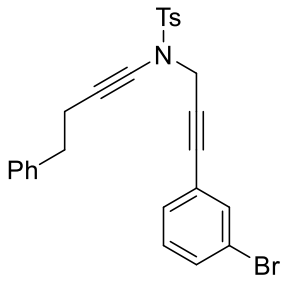


1s

The compound was isolated in 80% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, *J* = 8.4 Hz, 2H), 7.24 – 7.07 (m, 9H), 6.97 – 6.93 (d, *J* = 8.4 Hz, 2H), 4.40 (s, 2H), 2.81 (t, *J* = 7.2 Hz, 2H), 2.59 (t, *J* = 7.2 Hz, 2H), 2.35 (s, 3H), 2.29 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.4, 140.5, 137.7, 134.4, 132.1, 129.4(0), 129.3(6), 128.7, 128.4, 128.3, 128.1, 128.0, 126.1, 121.9, 86.2, 81.1, 73.5,

70.1, 42.7, 35.2, 21.5, 21.2, 20.6; IR (neat): 3056, 2988, 2306, 1423, 1266, 1051, 896, 737, 706; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{27}H_{25}NNaO_2S^+$ 450.1498; Found 450.1495.

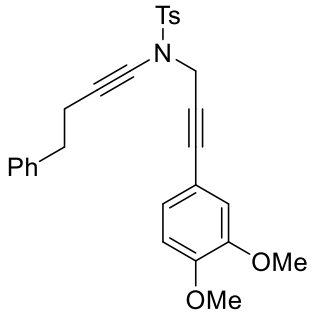
_N_-(3-(3-bromophenyl)prop-2-yn-1-yl)-4-methyl-_N_-(4-phenylbut-1-yn-1-yl)benzenesulfonamide (1t)



1t

The compound was isolated in 58% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76 (d, J = 8.4 Hz, 2H), 7.44 – 7.40 (m, 1H), 7.26 – 7.16 (m, 8H), 7.15 – 7.06 (m, 2H), 4.40 (s, 2H), 2.82 (t, J = 7.2 Hz, 2H), 2.61 (t, J = 7.2 Hz, 2H), 2.39 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.6, 140.4, 134.4, 131.7, 130.1, 129.6, 129.4, 128.4, 128.3, 128.2, 126.2, 124.0, 121.8, 84.4, 82.9, 73.4, 70.1, 42.6, 35.1, 21.6, 20.5; IR (neat): 3064, 2924, 2256, 1496, 1169, 1090, 1050, 785; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{26}H_{22}BrNNaO_2S^+$ 514.0447; Found 514.0446.

_N_-(3-(3,4-dimethoxyphenyl)prop-2-yn-1-yl)-4-methyl-_N_-(4-phenylbut-1-yn-1-yl)benzenesulfonamide (1u)

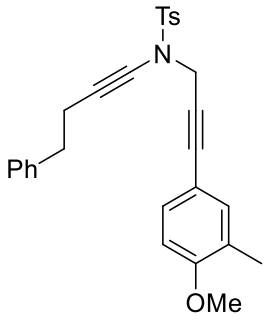


1u

The compound was isolated in 52% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, J = 8.4 Hz, 2H), 7.27 – 7.15 (m, 7H), 6.81 – 6.72 (m, 3H), 4.40 (s, 2H), 3.87 (s, 3H), 3.82 (s, 3H), 2.81 (t, J = 7.2 Hz, 2H), 2.59 (t, J = 7.2 Hz, 2H), 2.36 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 149.7, 148.4, 144.3, 140.5,

134.4, 129.3, 128.4, 128.3, 128.1, 126.2, 125.1, 114.4, 114.3, 110.8, 86.1, 80.0, 73.6, 70.1, 55.9, 42.8, 35.2, 21.6, 20.6; IR (neat): 3056, 2987, 2360, 1365, 1266, 896, 747, 742, 706; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{28}H_{27}NNaO_4S^+$ 496.1553; Found 496.1550.

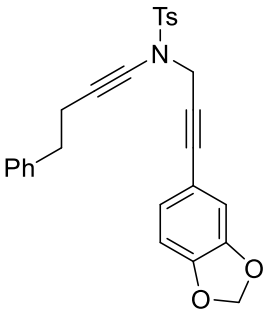
_N_-(3-(4-methoxy-3-methylphenyl)prop-2-yn-1-yl)-4-methyl-_N_-(4-phenylbut-1-yn-1-yl)benzenesulfonamide (1v)



1v

The compound was isolated in 77% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, J = 8.0 Hz, 2H), 7.27 – 7.14 (m, 7H), 7.03 – 6.98 (m, 1H), 6.92 (s, 1H), 6.68 (d, J = 8.8 Hz, 1H), 4.39 (s, 2H), 3.81 (s, 3H), 2.80 (t, J = 7.2 Hz, 2H), 2.58 (t, J = 7.2 Hz, 2H), 2.36 (s, 3H), 2.15 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.0, 144.3, 140.5, 134.5, 133.8, 130.7, 129.4, 128.4, 128.3, 128.1, 126.5, 126.1, 113.6, 109.5, 86.3, 79.6, 73.6, 70.0, 55.3, 42.8, 35.2, 21.6, 20.6, 16.0; IR (neat): 3057, 2927, 2231, 1503, 1266, 814, 742, 737, 704; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{28}H_{27}NNaO_3S^+$ 480.1604; Found 480.1611.

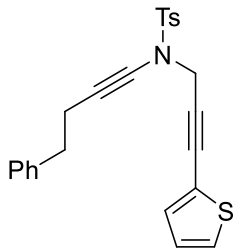
_N_-(3-(benzo[_d_][1,3]dioxol-5-yl)prop-2-yn-1-yl)-4-methyl-_N_-(4-phenylbut-1-yn-1-yl)benzenesulfonamide (1w)



1w

The compound was isolated in 75% yield according to the general procedure. Yellow solid. M.p = 72 – 73 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76 (d, *J* = 8.4 Hz, 2H), 7.27 – 7.14 (m, 7H), 6.67 (d, *J* = 0.8 Hz, 2H), 6.51 (s, 1H), 5.93 (s, 2H), 4.37 (s, 2H), 2.80 (t, *J* = 7.2 Hz, 2H), 2.59 (t, *J* = 7.2 Hz, 2H), 2.37 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 148.0, 147.1, 144.4, 140.5, 134.4, 129.4, 128.4, 128.2, 128.1, 126.2, 126.1, 115.2, 111.6, 108.1, 101.3, 85.9, 79.8, 73.5, 70.0, 42.7, 35.1, 21.5, 20.5; IR (neat): 3057, 2988, 2386, 1599, 1491, 1266, 896, 742, 737, 706; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{27}H_{23}NNaO_4S^+$ 480.1240; Found 480.1241.

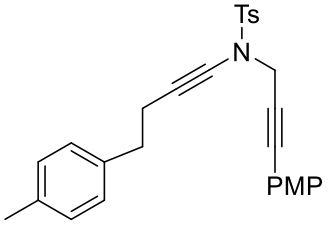
4-methyl-*N*-(4-phenylbut-1-yn-1-yl)-*N*-(3-(thiophen-2-yl)prop-2-yn-1-yl)benzenesulfonamide (1x)



1x

The compound was isolated in 58% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76 (d, *J* = 8.4 Hz, 2H), 7.28 – 7.14 (m, 8H), 7.00 (d, *J* = 2.8 Hz, 1H), 6.94 – 6.89 (m, 1H), 4.42 (s, 2H), 2.81 (t, *J* = 7.2 Hz, 2H), 2.59 (t, *J* = 7.2 Hz, 2H), 2.38 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.5, 140.5, 134.2, 132.5, 129.5, 128.5, 128.3, 128.1, 127.4, 126.8, 126.2, 122.0, 85.4, 79.4, 73.5, 70.2, 42.8, 35.2, 21.6, 20.6; IR (neat): 3096, 2932, 2307, 1606, 1369, 1249, 834, 728, 700, 672; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{24}H_{21}NNaO_2S_2^+$ 442.0906; Found 442.0904.

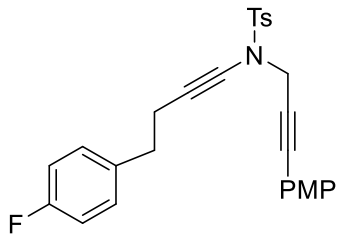
***N*-(3-(4-methoxyphenyl)prop-2-yn-1-yl)-4-methyl-*N*-(4-(p-tolyl)but-1-yn-1-yl)benzenesulfonamide (1y)**



1y

The compound was isolated in 46% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.78 (d, *J* = 8.4 Hz, 2H), 7.22 (d, *J* = 8.4 Hz, 2H), 7.12 – 7.01 (m, 6H), 6.77 (d, *J* = 8.8 Hz, 2H), 4.40 (s, 2H), 3.79 (s, 3H), 2.80 – 2.74 (t, *J* = 7.2 Hz, 2H), 2.56 (t, *J* = 7.2 Hz, 2H), 2.36 (s, 3H), 2.29 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.7, 144.3, 137.5, 135.6, 134.5, 133.1, 129.4, 129.0, 128.3, 128.2, 114.3, 113.7, 86.0, 80.1, 73.5, 70.2, 55.3, 42.8, 34.8, 21.6, 21.0, 20.7; IR (neat): 3056, 2988, 2307, 1511, 1266, 897, 747, 742, 706; HRMS (ESI/QTOF) m/z: [M + Na]+ Calcd for $C_{28}H_{27}NNaO_3S^+$ 480.1604; Found 480.1602.

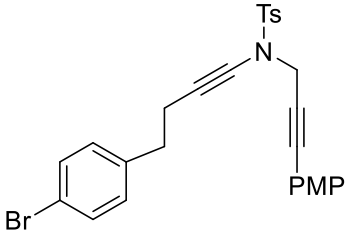
_N_-(4-(4-fluorophenyl)but-1-yn-1-yl)-_N_-(3-(4-methoxyphenyl)prop-2-yn-1-yl)-4-methylbenzenesulfonamide (1z)



1z

The compound was isolated in 44% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76 (d, *J* = 8.4 Hz, 2H), 7.22 (d, *J* = 8.0 Hz, 2H), 7.17 – 7.05 (m, 4H), 6.90 – 6.83 (m, 2H), 6.78 (d, *J* = 8.8 Hz, 2H), 4.39 (s, 2H), 3.80 (s, 3H), 2.76 (t, *J* = 7.2 Hz, 2H), 2.57 (t, *J* = 7.2 Hz, 2H), 2.37 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 161.4 (d, *J* = 242.0 Hz), 159.8, 144.4, 136.1 (d, *J* = 3.1 Hz), 134.5, 133.1, 129.9 (d, *J* = 8.0 Hz), 129.4, 128.1, 115.0 (d, *J* = 21.1 Hz), 114.1, 113.8, 86.0, 80.0, 73.8, 69.7, 55.3, 42.8, 34.2, 21.5, 20.8; ^{19}F NMR (471 MHz, $CDCl_3$) δ -117.1; IR (neat): 3053, 2986, 2305, 1421, 1265, 1033, 896, 834, 737; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{27}H_{24}FNNaO_3S^+$ 484.1353; Found 484.1345.

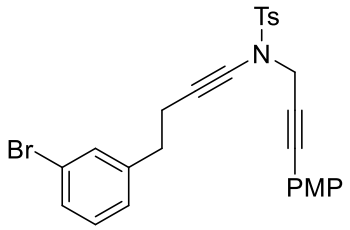
_N_-(4-(4-bromophenyl)but-1-yn-1-yl)-_N_-(3-(4-methoxyphenyl)prop-2-yn-1-yl)-4-methylbenzenesulfonamide (1aa)



1aa

The compound was isolated in 46% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.74 (d, *J* = 8.4 Hz, 2H), 7.29 (d, *J* = 8.0 Hz, 2H), 7.22 (d, *J* = 8.4 Hz, 2H), 7.11 – 7.02 (m, 4H), 6.79 (d, *J* = 8.8 Hz, 2H), 4.39 (s, 2H), 3.80 (s, 3H), 2.74 (t, *J* = 7.2 Hz, 2H), 2.58 (t, *J* = 7.2 Hz, 2H), 2.38 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.8, 144.5, 139.4, 134.5, 133.1, 131.3, 130.3, 129.4, 128.1, 120.0, 114.1, 113.8, 86.0, 80.0, 73.9, 69.5, 55.3, 42.8, 34.4, 21.6, 20.4; IR (neat): 3056, 2986, 2256, 1490, 1266, 897, 834, 737, 706; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{27}H_{24}BrNNaO_3S^+$ 544.0552; Found 544.0550.

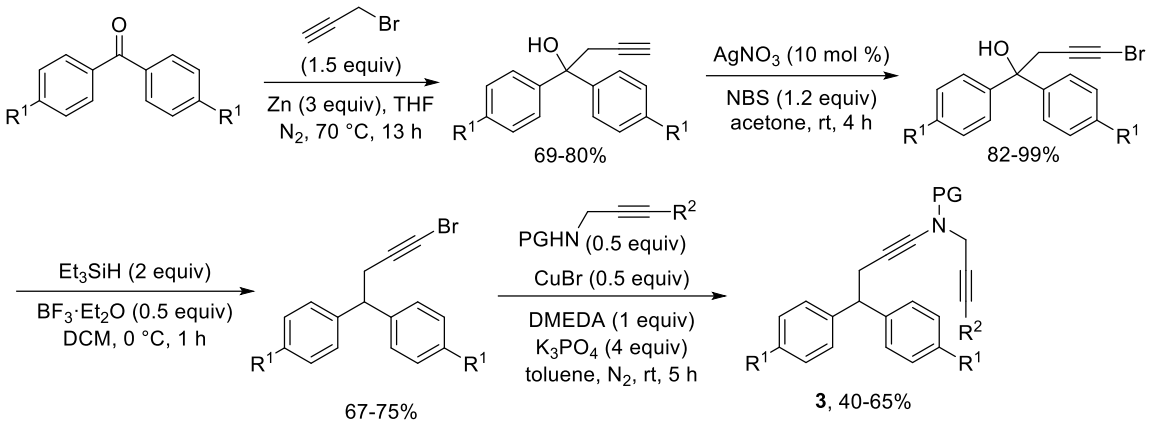
***N*-(4-(3-bromophenyl)but-1-yn-1-yl)-*N*-(3-(4-methoxyphenyl)prop-2-yn-1-yl)-4-methylbenzenesulfonamide (1ab)**



1ab

The compound was isolated in 35% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76 (d, J = 8.4 Hz, 2H), 7.35 – 7.29 (m, 2H), 7.23 (d, *J* = 8.0 Hz, 2H), 7.16 – 7.04 (m, 4H), 6.78 (d, *J* = 8.8 Hz, 2H), 4.39 (s, 2H), 3.80 (s, 3H), 2.77 (t, *J* = 7.2 Hz, 2H), 2.59 (t, *J* = 6.8 Hz, 2H), 2.37 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.7, 144.4, 142.8, 134.4, 133.1, 131.5, 129.9, 129.4, 129.3, 128.1, 127.2, 122.3, 114.2, 113.7, 86.1, 80.0, 74.0, 69.5, 55.3, 42.8, 34.7, 21.6, 20.4; IR (neat): 2928, 2836, 2250, 1605, 1566, 1425, 1168, 832, 799, 778, 689, 582, 545; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{27}H_{24}BrNNaO_3S^+$ 544.0552; Found 544.0551.

General procedure for the preparation of diynes 3:



Under N_2 atmosphere, zinc (3.9 g, 60 mmol) was suspended in dry THF (10 mL), and propargyl bromide (2.58 mL, 30 mmol) was added into the mixture dropwise at 0 °C. The reaction mixture was stirred for additional 1 h. Then, a solution of benzophenone derivative (20 mmol) in dry THF (10 mL) was added. The mixture was stirred at 70 °C for 13 h. Upon completion, the reaction was quenched with saturated aqueous NH_4Cl (20 mL). The mixture was then extracted with EtOAc (10 mL) for three times. The combined organic phase was washed with brine, dried over $MgSO_4$, filtered, and concentrated under reduced pressure. The resulting residue was purified by column chromatography on silica gel (eluent: hexanes/EtOAc) to give the desired propargyl alcohol in 69-80 % yields.

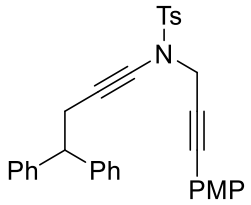
To a solution of propargyl alcohol (10 mmol) in acetone (20 mL) were added NBS (12 mmol, 2.1 g) and $AgNO_3$ (1 mmol, 0.17 g) at room temperature. Then, the reaction mixture was stirred at room temperature for 4 h. Upon completion, the mixture was filtered through a pad of celite and concentrated under reduced pressure. The crude alkynyl bromide was used in the next step without further purification (82-99% yields).

To a solution of above alkynyl bromide (3.0 g, 10 mmol) in CH_2Cl_2 (10 mL) was added triethylsilane (3.2 mL, 20 mmol) at room temperature. The reaction mixture was cooled to 0 °C before the addition of boron trifluoride diethyl etherate (0.62 mL, 5 mmol). After stirring for 1 h at 0 °C, the reaction was quenched with saturated aqueous $NaHCO_3$ (2 mL), extracted with CH_2Cl_2, washed with water, dried over Na_2SO_4, filtered and concentrated in vacuo. The residue was purified by silica gel column chromatography (eluent: hexanes/EtOAc) to afford the desired product in 67-75% yields.

To a solution of the above product (1 mmol) in toluene (6 mL) were added copper bromide (0.5 mmol, 72 mg), DMEDA (1.0 mmol, 0.107 mL), K_3PO_4 (4.0 mmol, 0.849 g) and protected propargylamide derivative (0.5 mmol). The reaction was stirred at room temperature for 5 h and the progress of the reaction was monitored by TLC. Upon

completion, the solution was filtered and concentrated under reduced pressure. The residue was purified by silica gel column chromatography (eluent: hexanes/EtOAc) to afford the desired diyne **3** in 40-65% yields.

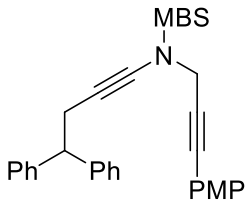
***N*-(4,4-diphenylbut-1-yn-1-yl)-*N*-(3-(4-methoxyphenyl)prop-2-yn-1-yl)-4-methylbenzenesulfonamide (3a)**



3a

Compound **3a** was prepared in 65% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 (d, *J* = 8.4 Hz, 2H), 7.30 – 7.18 (m, 10H), 7.14 (d, *J* = 8.4 Hz, 2H), 7.10 – 7.05 (m, 2H), 6.85 – 6.77 (m, 2H). 4.28 (s, 2H), 4.18 (t, *J* = 7.4 Hz, 1H), 3.77 (s, 3H), 3.00 (d, *J* = 7.6 Hz, 2H), 2.31 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.7, 144.1, 143.4, 134.4, 133.1, 129.3, 128.3, 127.9(5), 127.9(1), 126.3, 114.1, 113.6, 85.9 80.0, 74.5, 68.9, 55.2, 50.1, 42.7, 25.3, 21.5; IR (neat): 3027, 2925, 2252, 1508, 1369, 1249, 1169, 1032, 833, 582, 546; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{33}H_{29}NaO_3S^+$ 542.1760; Found 542.1754.

***N*-(3-(4-methoxyphenyl)prop-2-yn-1-yl)-4,4-diphenyl-*N*-((thioxoboraneyl)methyl)but-1-yn-1-amine (3b)**

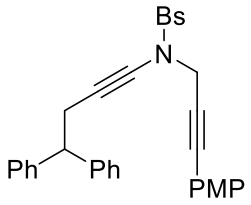


3b

Compound **3b** was prepared in 50% yield according to the general procedure. Pale yellow solid. M.p = 108.3 – 108.9 ºC. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.62 – 7.56 (m, 2H), 7.27 – 7.13 (m, 10H), 7.08 – 7.03 (m, 2H), 6.80 – 6.71 (m, 4H), 4.29 (s, 2H), 4.19 (t, *J* = 7.5 Hz, 1H), 3.78 (s, 3H), 3.74 (s, 3H), 3.01 (d, *J* = 7.5 Hz, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 163.4, 159.7, 143.5, 133.1, 130.2, 129.0, 128.3, 127.9, 126.4, 114.3, 113.9, 113.7, 85.9, 80.1, 74.7, 68.9, 55.4, 55.3, 50.2, 42.6, 25.4; IR (neat): 3027, 2931, 2841, 2254, 1597,

1509, 1363, 1261, 1164, 1031, 832, 701, 583; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{33}H_{29}NaO_4S^+$ 558.1710; Found 558.1709.

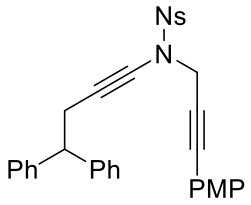
4-bromo-*N*-(4,4-diphenylbut-1-yn-1-yl)-*N*-(3-(4-methoxyphenyl)prop-2-yn-1-yl)benzenesulfonamide (3c)



3c

Compound **3c** was prepared in 45% yield according to the general procedure. Pale yellow solid. M.p = 90.4 – 91.5 ºC. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.51 – 7.37 (m, 4H), 7.30 – 7.17 (m, 10H), 7.02 (d, *J* = 8.4 Hz, 2H), 6.84 – 6.77 (m, 2H), 4.33 (s, 2H), 4.20 (t, *J* = 7.6 Hz, 1H), 3.82 (s, 3H), 3.02 (d, *J* = 7.6 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.9, 143.4, 136.3, 133.1, 132.0, 129.5, 128.5, 128.4, 127.9, 126.5, 113.9, 86.4, 79.6, 74.0, 69.4, 55.3, 50.2, 43.0, 25.3; IR (neat): 2927, 2219, 2307, 1607, 1510, 1371, 1250, 1173, 1033, 745, 701, 607, 572; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{32}H_{26}BrNNaO_3S^+$ 606.0709; Found 606.0706.

***N*-(4,4-diphenylbut-1-yn-1-yl)-*N*-(3-(4-methoxyphenyl)prop-2-yn-1-yl)-4-nitrobenzenesulfonamide (3d)**

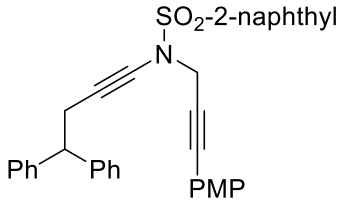


3d

Compound **3d** was prepared in 48% yield according to the general procedure. Pale yellow solid. M.p = 114.1 – 115.7 ºC. ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.01 – 7.98 (m, 2H), 7.74 – 7.71 (m, 2H), 7.30 – 7.17 (m, 10H), 6.98 – 6.95 (m, 2H), 6.77 – 6.73 (m, 2H), 4.37 (s, 2H), 4.21 (t, *J* = 7.5 Hz, 1H), 3.78 (s, 3H), 3.04 (d, *J* = 7.5 Hz, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 160.0, 150.0, 143.2, 142.5, 132.8, 129.1, 128.4, 127.8, 126.5, 123.7, 113.9, 113.3, 86.7, 79.3, 73.4, 69.7, 55.2, 50.1, 43.2, 25.1; IR (neat): 3028, 2932, 2256, 1605,

1510, 1349, 1176, 1032, 834, 701, 572; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{32}H_{26}N_2NaO_5S^+$ 573.1455; Found 573.1452.

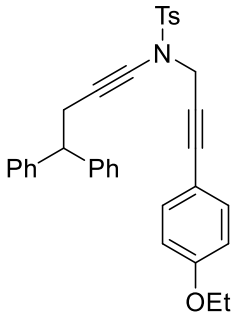
_N_-(4,4-diphenylbut-1-yn-1-yl)-_N_-(3-(4-methoxyphenyl)prop-2-yn-1-yl)naphthalene-2-sulfonamide (3e)



3e

Compound **3e** was prepared in 42% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.38 (s, 1H), 7.87 – 7.79 (m, 2H), 7.75 (d, J = 9.0 Hz, 1H), 7.69 – 7.62 (m, 2H), 7.57 – 7.51 (m, 1H), 7.23 – 7.13 (m, 10H), 6.75 – 6.71 (m, 2H), 6.61 – 6.57 (m, 2H), 4.37 (s, 2H), 4.18 (t, J = 7.5 Hz, 1H), 3.75 (s, 3H), 3.01 (d, J = 7.0 Hz, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 159.6, 143.4, 135.2, 134.5, 133.0, 131.9, 129.6, 129.5, 128.9, 128.3, 128.0, 127.8, 127.3, 126.4, 123.0, 113.9, 113.5, 86.0, 79.9, 74.5, 69.1, 55.2, 50.1, 42.9, 25.4; IR (neat): 2925, 2230, 1606, 1509, 1249, 1169, 1033, 832, 702, 666, 576, 545; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{36}H_{29}NNaO_3S^+$ 578.6812; Found 578.6810.

_N_-(4,4-diphenylbut-1-yn-1-yl)-_N_-(3-(4-ethoxyphenyl)prop-2-yn-1-yl)-4-methylbenzenesulfonamide (3f)

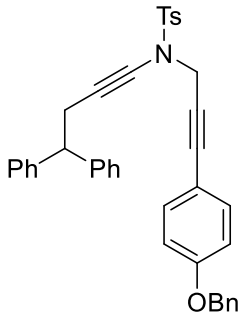


3f

Compound **3f** was prepared in 50% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60 – 7.55 (m, 2H), 7.29 – 7.15 (m, 10H), 7.11 (d, J = 8.0 Hz, 2H), 7.08 – 7.00 (m, 2H), 6.79 – 6.73 (m, 2H), 4.29 (s, 2H), 4.19 (t, J = 8.0 Hz, 1H), 4.01 (q, J = 7.2 Hz 2H), 3.01 (d, J = 8.0 Hz, 2H), 2.33 (s, 3H), 1.41 (t, J = 7.2 Hz,

3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.1, 144.1, 143.5, 134.4, 133.1, 129.3, 128.3, 128.0(1), 127.9(6), 126.4, 114.2, 114.0, 86.0, 79.9, 74.5, 69.0, 63.5, 50.2, 42.7, 25.4, 21.5, 14.7; IR (neat): 2979, 2923, 2252, 1603, 1508, 1364, 1248, 1044, 812, 738, 701, 546; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{34}H_{31}NNaO_3S^+$ 556.1917; Found 556.1716.

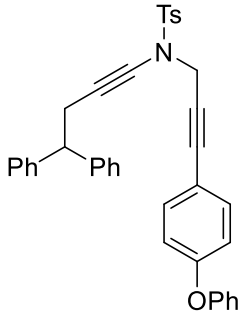
_N_-(3-(4-(benzyloxy)phenyl)prop-2-yn-1-yl)-_N_-(4,4-diphenylbut-1-yn-1-yl)-4-methylbenzenesulfonamide (3g)



3g

Compound **3g** was prepared in 59% yield according to the general procedure. Pale yellow solid. M.p = 65 – 65.9 ºC. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.59 – 7.54 (m, 2H), 7.45 – 7.29 (m, 5H), 7.27 – 7.14 (m, 10H), 7.10 (d, J = 8.0 Hz, 2H), 7.05 – 7.00 (m, 2H), 6.88 – 6.83 (m, 2H), 5.06 (s, 2H), 4.29 (s, 2H), 4.19 (t, J = 7.2 Hz, 1H), 3.01 (d, J = 7.6 Hz, 2H), 2.31 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 158.8, 144.2, 143.5, 136.5, 134.4, 133.1, 129.3, 128.6, 128.3, 128.1, 128.0(3), 127.9(8), 127.4, 126.4, 114.6, 114.5, 85.9, 80.1, 74.5, 70.0, 69.0, 50.2, 42.7, 25.4, 21.5; IR (neat): 3028, 2923, 2258, 1509, 1368, 1244, 1170, 838, 741, 701, 545; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{39}H_{33}NNaO_3S^+$ 618.2073; Found 618.2070.

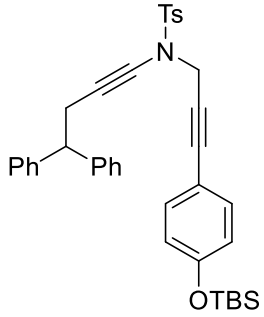
_N_-(4,4-diphenylbut-1-yn-1-yl)-4-methyl-_N_-(3-(4-phenoxyphenyl)prop-2-yn-1-yl)benzenesulfonamide (3h)



3h

Compound **3h** was prepared in 46% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.57 (d, *J* = 8.0 Hz, 2H), 7.36 – 7.31 (m, 2H), 7.25 – 7.07 (m, 13H), 7.06 – 6.97 (m, 4H), 6.87 – 6.84 (m, 2H), 4.29 (s, 2H), 4.19 (t, *J* = 7.5 Hz, 1H), 3.00 (d, *J* = 7.0 Hz, 2H), 2.31 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 157.7, 156.2, 144.2, 143.4, 134.4, 133.2, 129.8, 129.3, 128.3, 128.0, 127.9, 126.4, 123.9, 119.3, 118.0, 116.6, 85.5, 80.8, 74.4, 69.0, 50.1, 42.6, 25.3, 21.5; IR (neat): 3028, 2925, 2257, 1591, 1503, 1369,1091, 869, 701, 584, 546; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{38}H_{31}NNaO_3S^+$ 604.1917; Found 604.1916.

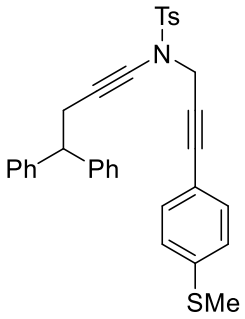
***N*-(3-(4-((tert-butyldimethylsilyl)oxy)phenyl)prop-2-yn-1-yl)-*N*-(4,4-diphenylbut-1-yn-1-yl)-4-methylbenzenesulfonamide (3i)**



3i

Compound **3i** was prepared in 41% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.59 – 7.55 (m, 2H), 7.28 – 7.14 (m, 10H), 7.11 (d, *J* = 8.0 Hz, 2H), 7.01 – 6.96 (m, 2H), 6.74 – 6.70 (m, 2H), 4.29 (s, 2H), 4.19 (t, *J* = 7.2 Hz, 1H), 3.01 (d, *J* = 7.2 Hz, 2H), 2.33 (s, 3H), 0.99 (s, 9H), 0.21 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 156.1, 144.1, 143.5, 134.4, 133.1, 129.3, 128.3, 128.0, 127.9(7), 126.4, 119.9, 114.9, 86.0, 80.1, 74.5, 69.0, 50.2, 42.7, 25.6, 25.4, 21.5, 18.2, -4.4; IR (neat): 3029, 2859, 2255, 1667, 1603, 1508, 1166, 1091, 783, 581, 545; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{38}H_{41}NNaO_3SSi^+$ 642.2469; Found 642.2465.

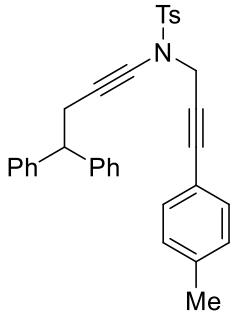
***N*-(4,4-diphenylbut-1-yn-1-yl)-4-methyl-*N*-(3-(4-(methylthio)phenyl)prop-2-yn-1-yl)benzenesulfonamide (3j)**



3j

Compound **3j** was prepared in 49% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.58 – 7.54 (m, 2H), 7.28 – 7.14 (m, 10H), 7.13 – 7.08 (m, 4H), 7.01 – 6.97 (m, 2H), 4.30 (s, 2H), 4.19 (t, *J* = 7.6 Hz, 1H), 3.01 (d, *J* = 7.2 Hz, 2H), 2.48 (s, 3H), 2.33 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.2, 143.5, 139.7, 134.4, 131.9, 129.4, 128.4, 128.0, 127.9(8), 126.4, 125.6, 118.4, 85.7, 81.5, 74.5, 69.1, 50.2, 42.7, 25.4, 21.5, 15.3; IR (neat): 3061, 3028, 2923, 2255, 1597, 1493, 1368, 1170, 816, 701, 544; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{33}H_{29}NNaO_2S_2^+$ 558.1532; Found 558.1532.

_N_-(4,4-diphenylbut-1-yn-1-yl)-4-methyl-_N_-(3-(p-tolyl)prop-2-yn-1-yl)benzenesulfonamide (3k)

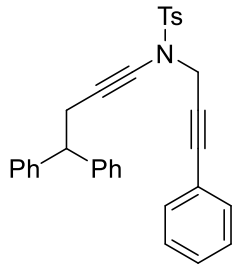


3k

Compound **3k** was prepared in 48% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.58 – 7.54 (m, 2H), 7.26 – 7.15 (m, 10H), 7.10 (d, *J* = 8.4 Hz, 2H), 7.06 (d, *J* = 8.0 Hz, 2H), 7.00 – 6.97 (m, 2H), 4.30 (s, 2H), 4.19 (t, *J* = 7.6 Hz, 1H), 3.01 (d, *J* = 7.6 Hz, 2H), 2.33 (s, 3H), 2.34 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.2, 143.5, 138.6, 134.4, 131.5, 129.4, 128.8, 128.3, 128.0, 127.9(7), 126.4, 119.1, 86.1, 80.7, 74.5, 69.0, 50.2, 42.7, 25.4, 21.5, 21.4; IR (neat): 3062, 3028, 2230, 1598,

1495, 1369, 1170, 1091, 759, 701, 594, 546; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{33}H_{29}NNaO_2S^+$ 526.1811; Found 526.1810.

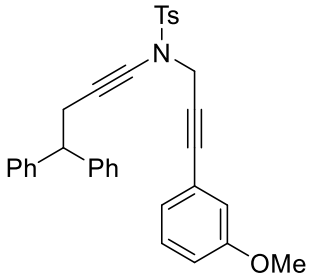
_N_-(4,4-diphenylbut-1-yn-1-yl)-4-methyl-_N_-(3-phenylprop-2-yn-1-yl)benzenesulfonamide) (3l)



3l

Compound **3l** was prepared in 58% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.58 – 7.52 (m, 2H), 7.27 – 7.11 (m, 13H), 7.09 – 7.02 (m, 4H), 4.30 (s, 2H), 4.19 (t, J = 7.6 Hz, 1H), 3.01 (d, J = 7.6 Hz, 2H), 2.30 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.2, 143.4, 134.3, 131.6, 129.3, 128.4, 128.3, 128.0(2), 127.9(9), 127.9, 126.4, 122.1, 85.9, 81.4, 74.4, 69.0, 50.2, 42.6, 25.3, 21.5; IR (neat): 3059, 3027, 2320, 1597, 1491, 1367, 1169, 1090, 757, 657, 546. HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{32}H_{27}NNaO_2S^+$ 512.1655; Found 512.1653.

_N_-(4,4-diphenylbut-1-yn-1-yl)-_N_-(3-(3-methoxyphenyl)prop-2-yn-1-yl)-4-methylbenzenesulfonamide (3m)

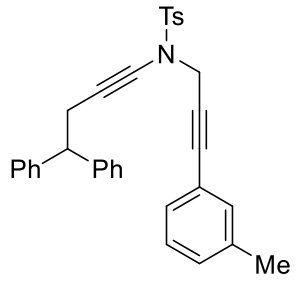


3m

Compound **3m** was prepared in 62% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.59 – 7.54 (m, 2H), 7.27 – 7.09 (m, 13H), 6.85 (dd, J = 8.4, 1.6 Hz, 1H), 6.71 – 6.63 (m, 2H), 4.30 (s, 2H), 4.19 (t, J = 7.6 Hz, 1H), 3.76 (s, 3H), 3.01 (d, J = 7.2 Hz, 2H), 2.33 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.1, 144.3, 143.4, 134.3, 129.4, 129.1, 128.3, 128.0, 127.9, 126.4, 124.1, 123.1, 117.1, 114.5, 85.8, 81.2, 74.4, 69.1, 55.2, 50.2, 42.6, 25.4, 21.5; IR (neat): 3063, 3029, 2925, 2256, 1574, 1483,

1320, 1091, 832, 739, 690, 546; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{33}H_{29}NNaO_3S^+$ 542.1760; Found 542.1758.

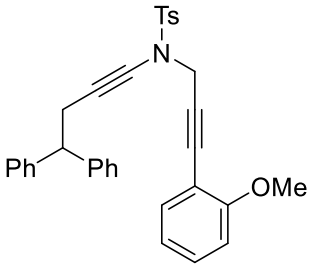
***N*-(4,4-diphenylbut-1-yn-1-yl)-4-methyl-*N*-(3-(m-tolyl)prop-2-yn-1-yl)benzenesulfonamide (3n)**



3n

Compound **3n** was prepared in 60% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.57 (d, *J* = 8.4 Hz, 2H), 7.27 – 7.08 (m, 14H), 6.93 – 6.88 (m, 2H), 4.31 (s, 2H), 4.20 (t, *J* = 7.2 Hz, 1H), 3.02 (d, *J* = 7.2 Hz, 2H), 2.33 (s, 3H), 2.31 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.2, 143.5, 137.7, 134.4, 132.2, 129.3(9), 129.3(6), 128.8, 128.4, 128.1, 128.0, 126.4, 122.0, 86.1, 81.0, 74.5, 69.0, 50.2, 42.6, 25.4, 21.5, 21.2; IR (neat): 3060, 3028, 2320, 1598, 1451, 1368, 1169, 1050, 813, 738, 546; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{33}H_{29}NNaO_2S^+$ 526.1811; Found 526.1810.

***N*-(4,4-diphenylbut-1-yn-1-yl)-*N*-(3-(2-methoxyphenyl)prop-2-yn-1-yl)-4-methylbenzenesulfonamide) (3o)**

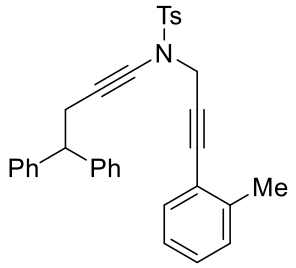


3o

Compound **3o** was prepared in 53% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.57 (d, *J* = 8.4 Hz, 2H), 7.29 – 7.14 (m, 11H), 7.08 (d, *J* = 8.0 Hz, 2H), 6.91 (dd, *J* = 8.0, 2.0 Hz, 1H), 6.85 – 6.80 (m, 2H), 4.37 (s, 2H), 4.19 (t, *J* = 7.2 Hz, 1H), 3.80 (s, 3H), 3.00 (d, *J* = 7.6 Hz, 2H), 2.31 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.0, 144.1, 143.8, 134.3, 133.9, 129.9, 129.3, 128.3, 128.0, 127.9, 126.4,

120.1, 111.3, 110.5, 85.3, 82.5, 74.4, 69.0, 55.6, 50.2, 42.9, 25.4, 21.5; IR (neat): 3028, 2252, 1597, 1494, 1454, 1263, 1165, 1025, 701, 549; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{33}H_{29}NNaO_3S^+$ 542.1760; Found 542.1758.

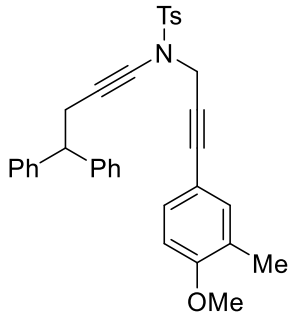
_N_-(4,4-diphenylbut-1-yn-1-yl)-4-methyl-_N_-(3-(_o_-tolyl)prop-2-yn-1-yl)benzenesulfonamide (3p)



3p

Compound **3p** was prepared in 60% yield according to the general procedure. Pale yellow solid. M.p = 59.5 – 60.3 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.54 – 7.51 (m, 2H), 7.27 – 7.16 (m, 11H), 7.14 – 7.11 (m, 1H), 7.08 – 7.04 (m, 4H), 4.35 (s, 2H), 4.19 (t, J = 7.6 Hz, 1H), 3.01 (d, J = 7.6 Hz, 2H), 2.27 (s, 3H), 2.16 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.3, 143.5, 140.2, 134.3, 132.0, 129.3, 129.2, 128.5, 128.4, 128.0, 127.9, 126.4, 125.3, 122.0, 85.2, 85.0, 74.4, 69.2, 50.3, 42.7, 25.4, 21.5, 20.4; IR (neat): 3063, 2924, 2250, 1596, 1368, 1170, 1049, 813, 701, 594, 546; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{33}H_{29}NNaO_2S^+$ 526.1811; Found 526.1810.

_N_-(4,4-diphenylbut-1-yn-1-yl)-_N_-(3-(4-methoxy-3-methylphenyl)prop-2-yn-1-yl)-4-methylbenzenesulfonamide (3q)

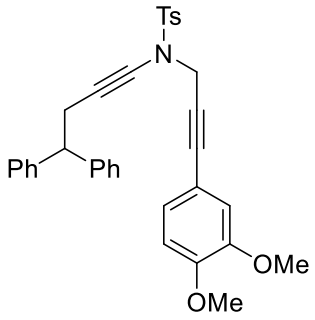


3q

Compound **3q** was prepared in 42% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.56 (d, J = 8.4 Hz, 2H), 7.26 – 7.14 (m, 10H), 7.11 (d, J = 8.4 Hz, 2H), 6.99 – 6.94 (m, 1H). 6.87 (s, 1H), 6.68 (d, J = 8.8 Hz, 1H), 4.29 (s, 2H),

4.19 (t, 1H), 3.81 (s, 3H), 3.00 (d, J = 7.6 Hz, 2H), 2.33 (s, 3H), 2.16 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.0, 144.1, 143.5, 134.5, 133.8, 130.7, 129.3, 128.3, 128.0, 127.9, 126.5, 126.3, 113.7, 109.5, 86.2, 79.6, 74.5, 68.9, 55.3, 50.2, 42.7, 25.4, 21.5, 16.0; IR (neat): 3030, 2925, 2253, 1606, 1503, 1368, 1243, 1170, 814, 703, 574, 547; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{34}H_{31}NNaO_3S^+$ 556.1917; Found 556.1916.

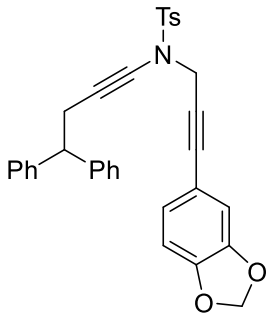
_N_-(3-(3,4-dimethoxyphenyl)prop-2-yn-1-yl)-_N_-(4,4-diphenylbut-1-yn-1-yl)-4-methylbenzenesulfonamide) (3r)



3r

Compound **3r** was prepared in 43% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60 – 7.56 (m, 2H), 7.29 – 7.11 (m, 12H), 6.76 – 6.68 (m, 3H), 4.31 (s, 2H), 4.19 (t, 1H), 3.88 (s, 3H), 3.82 (s, 3H), 3.01 (d, J = 7.2 Hz, 2H), 2.34 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 149.7, 148.5, 144.1, 143.5, 134.4, 129.3, 128.3, 128.0(3), 127.9(7), 126.4, 125.2, 114.5, 114.4, 110.8, 86.0, 80.0, 74.5, 69.1, 55.9(1), 55.8(9), 50.2, 42.7, 25.4, 21.6; IR (neat): 3061, 3024, 2330, 1598, 1514, 1364, 1244, 1026, 701, 584, 543; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{34}H_{31}NNaO_4S^+$ 575.1866; Found 572.1863.

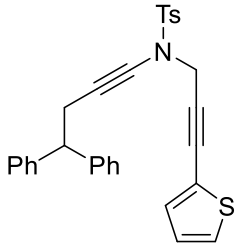
_N_--(3-(benzo[_d_][1,3]dioxol-5-yl)prop-2-yn-1-yl)-_N_-(4,4-diphenylbut-1-yn-1-yl)-4-methylbenzenesulfonamide (3s)



3s

Compound **3s** was prepared in 40% yield according to the general procedure. White oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.56 (d, *J* = 8.4 Hz, 2H), 7.30 – 7.09 (m, 12H), 6.69 – 6.60 (m, 2H), 6.45 (s, 1H), 5.95 (s, 2H), 4.28 (s, 2H), 4.19 (t, *J* = 7.2 Hz, 1H), 3.01 (d, *J* = 7.6 Hz, 2H), 2.35 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 148.0, 147.2, 144.2, 143.4, 134.4, 129.4, 128.3, 128.0(3), 127.9(6), 126.4, 126.2, 115.3, 111.7, 108.2, 101.3, 85.8, 79.7, 74.4, 69.0, 50.2, 42.6, 25.4, 21.5; IR (neat): 3063, 3029, 2922, 2256, 1598, 1444, 1214, 1091, 814, 702, 581, 546; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{33}H_{27}NNaO_4S^+$ 556.1553; Found 556.1552.

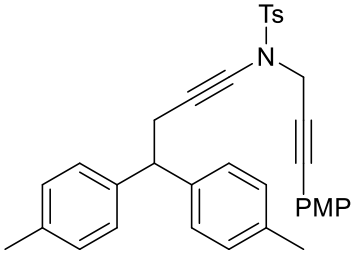
_N_-(4,4-diphenylbut-1-yn-1-yl)-4-methyl-_N_-(3-(thiophen-2-yl)prop-2-yn-1-yl)benzenesulfonamide (3t)



3t

Compound **3t** was prepared in 57% yield according to the general procedure. yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.57 – 7.53 (m, 2H), 7.28 – 7.11 (m, 13H), 6.98 – 6.90 (m, 2H), 4.32 (s, 2H), 4.20 (t, *J* = 7.6 Hz, 1H), 3.01 (d, *J* = 7.2 Hz, 2H), 2.35 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.3, 143.4, 134.2, 132.5, 129.5, 128.3, 128.0, 127.4, 126.8, 126.4, 123.9, 122.0, 85.4, 79.2, 74.4, 69.2, 50.2, 42.7, 25.4, 21.6; IR (neat): 3062, 2924, 2256, 1597, 1495, 1363, 1170, 1039, 813, 701, 546; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{30}H_{25}NNaO_2S_2^+$ 518.1219; Found 518.1216.

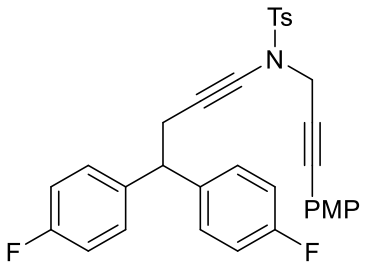
_N_-5-(3-chlorophenyl)-11-oxobicyclo[4.4.1]undeca-3,7,9-trien-3-yl)-2,2,2-trifluoroacetamide (3u)



3u

Compound **3u** was prepared in 46% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.62 – 7.56 (m, 2H), 7.14 – 7.09 (m, 6H), 7.08 – 7.02 (m, 6H), 6.81 – 6.75 (m, 2H), 4.30 (s, 2H), 4.13 (t, *J* = 7.2 Hz, 1H), 3.80 (s, 3H), 2.97 (d, *J* = 7.6 Hz, 2H), 2.33 (s, 3H), 2.28 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.7, 144.1, 140.8, 135.7, 134.5, 133.1, 129.3, 129.0, 128.1, 127.8, 114.3, 113.7, 85.9, 80.0, 74.3, 69.2, 55.3, 49.4, 42.7, 25.5, 21.5, 21.0; IR (neat): 3050, 2924, 2255, 1606, 1569, 1292, 1092, 833, 737, 585, 545; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{35}H_{33}NNaO_3S^+$ 570.2073; Found 570.2072.

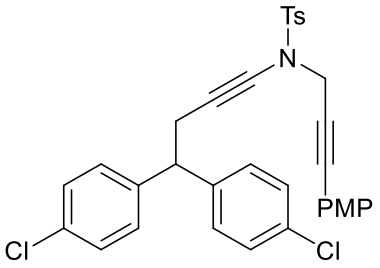
***N*-(4,4-bis(4-fluorophenyl)but-1-yn-1-yl)-*N*-(3-(4-methoxyphenyl)prop-2-yn-1-yl)-4-methylbenzenesulfonamide (3v)**



3v

Compound **3v** was prepared in 51% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.64 – 7.58 (m, 2H), 7.19 – 7.10 (m, 6H), 7.07 – 7.00 (m, 2H), 6.95 – 6.86 (m, 4H), 6.83 – 6.76 (m, 2H), 4.33 (s, 2H), 4.16 (t, *J* = 7.2 Hz, 1H), 3.81 (s, 3H), 2.96 (d, *J* = 7.2 Hz, 2H), 2.37 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 161.5 (d, *J* = 243.0 Hz), 159.8, 144.4, 138.9 (d, *J* = 3.0 Hz), 134.5, 133.1, 129.4 (d, *J* = 8.0 Hz),, 129.3(8), 128.0, 115.1 (d, *J* = 21.0 Hz), 114.1, 113.8, 86.0, 79.9, 74.9, 68.4, 55.3, 48.5, 42.7, 25.7, 21.5; ^{19}F NMR (471 MHz, $CDCl_3$) δ -116.2; IR (neat): 2961, 2925, 2256, 1604, 1514, 1364, 1170, 1034, 833, 671, 547. HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{33}H_{27}F_2NNaO_3S^+$ 578.1572; Found 578.1570.

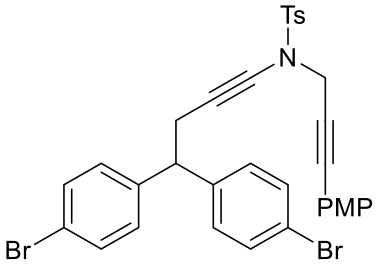
***N*-(4,4-bis(4-chlorophenyl)but-1-yn-1-yl)-*N*-(3-(4-methoxyphenyl)prop-2-yn-1-yl)-4-methylbenzenesulfonamide (3w)**



3w

Compound **3w** was prepared in 54% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 – 7.58 (m, 2H), 7.21 – 7.08 (m, 10H), 7.03 – 6.98 (m, 2H), 6.82 – 6.77 (m, 2H), 4.33 (s, 2H), 4.14 (t, *J* = 7.2 Hz, 1H), 3.81 (s, 3H), 2.96 (d, *J* = 7.2 Hz, 2H), 2.38 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.8, 144.5, 141.4, 134.5, 133.1, 132.4, 129.4, 129.3, 128.6, 128.0, 114.0, 113.8, 86.0, 79.9, 75.0, 68.2, 55.3, 48.7, 42.7, 25.3, 21.6; IR (neat): 2926, 2842, 2256, 1604, 1508, 1363, 1170, 1014, 814, 671, 545; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{33}H_{27}Cl_2NNaO_3S^+$ 610.0981; Found 610.0980.

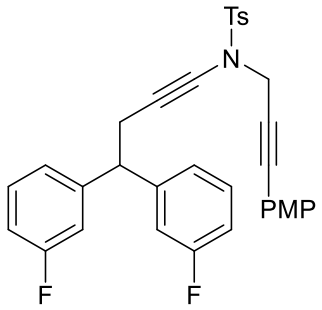
***N*-(4,4-bis(4-bromophenyl)but-1-yn-1-yl)-*N*-(3-(4-methoxyphenyl)prop-2-yn-1-yl)-4-methylbenzenesulfonamide (3x)**



3x

Compound **3x** was prepared in 57% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 – 7.57 (m, 2H), 7.36 – 7.30 (m, 4H), 7.16 (d, *J* = 8.0 Hz, 2H), 7.09 – 6.98 (m, 6H), 6.84 – 6.77 (m, 2H), 4.33 (s, 2H), 4.11 (t, *J* = 7.2 Hz, 1H), 3.81 (s, 3H), 2.96 (d, *J* = 7.2 Hz, 2H), 2.39 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.8, 144.5, 141.8, 134.5, 133.1, 131.5, 129.7, 129.5, 127.9, 120.5, 114.0, 113.8, 86.0, 79.9, 75.1, 68.1, 55.3, 48.8, 42.7, 25.1, 21.6; IR (neat): 3052, 2931, 2840, 2256, 1605, 1490, 1405, 1250, 1170, 833, 585, 545; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{33}H_{27}Br_2NNaO_3S^+$ 697.9971; Found 697.9970.

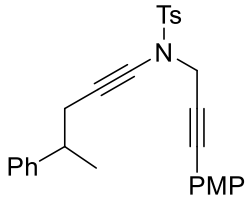
***N*-(4,4-bis(3-fluorophenyl)but-1-yn-1-yl)-*N*-(3-(4-methoxyphenyl)prop-2-yn-1-yl)-4-methylbenzenesulfonamide (3y)**



3y

Compound **3y** was prepared in 57% yield. according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.52 (d, *J* = 8.0 Hz, 2H), 7.31 – 7.20 (m, 2H), 7.17 – 7.09 (m, 6H), 7.02 (d, *J* = 8.8 Hz, 2H), 6.97 – 6.89 (m, 2H), 6.79 (d, *J* = 8.4 Hz, 2H), 4.34 (s, 2H), 3.81 (s, 3H), 3.22 (s, 2H), 3.16 – 3.11 (m, 1H), 2.35 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 162.7 (d, *J* = 244.0 Hz), 160.0, 147.7 (d, *J* = 7.0 Hz), 144.8, 134.0, 133.2, 129.8 (d, *J* = 8.0 Hz), 129.6, 127.9, 121.6 (d, *J* = 3.0 Hz), 114.3 (d, *J* = 21.0 Hz), 113.8, 113.7, 113.4 (d, *J* = 22.0 Hz), 86.4, 79.4, 77.6, 66.2, 55.3, 42.6, 34.1, 33.3, 21.6; ^{19}F NMR (471 MHz, $CDCl_3$) δ -112.3, -112.1; IR (neat): 2926, 2854, 2338, 1609, 1510, 1368, 1250, 1170, 1033, 780, 671, 587; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{33}H_{27}F_2NNaO_3S^+$ 578.1572; Found 578.1570.

***N*-(3-(4-methoxyphenyl)prop-2-yn-1-yl)-4-methyl-*N*-(4-phenylpent-1-yn-1-yl)benzenesulfonamide (3z)**



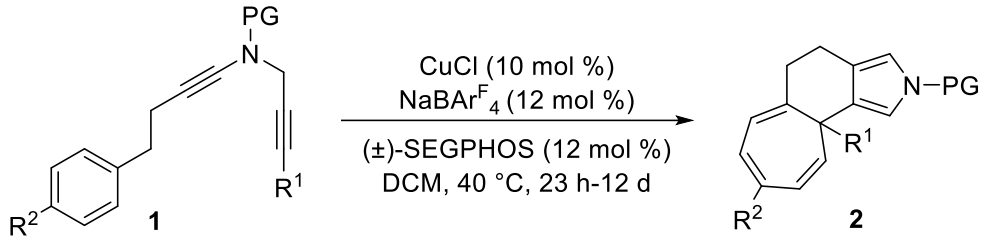
3z

The compound was isolated in 46% yield according to the general procedure. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76 (d, *J* = 8.0 Hz, 2H), 7.26 – 7.15 (m, 7H), 7.08 (d, *J* = 8.8 Hz, 2H), 6.77 (d, *J* = 8.8 Hz, 2H), 4.39 (s, 2H), 3.79 (s, 3H), 2.97 – 2.90 (m, 1H), 2.64 – 2.45 (m, 2H), 2.36 (s, 3H), 1.31 (d, *J* = 6.8 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.7, 145.7, 144.4, 134.5, 133.1, 129.4, 128.3, 128.1, 126.9, 126.2, 114.2, 113.7, 86.0, 80.1, 74.1, 69.3, 55.3, 42.8, 39.2, 27.6, 21.6, 20.6. IR (neat): 3028, 2962, 2925, 2252, 1606,

1568, 1495, 1292, 833, 762, 670, 583; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{28}H_{27}NNaO_3S^+$ 480.1604; Found 480.1602.

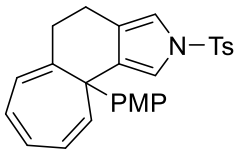
4. General Procedures

4.1 Synthesis of cycloheptatriene fused pyrroles 2



The powered CuCl (0.02 mmol, 2.0 mg), (±)-SEGPHOS (0.024 mmol, 14.6 mg) and $NaBAr^F_4$ (0.024 mmol, 21.3 mg) were introduced into an oven-dried Schlenk tube under nitrogen atmosphere. After DCM (1 mL) was injected into the Schlenk tube, the solution was stirred at 40 °C for 0.5 h. Then *N*-propargyl ynamide **1** (0.2 mmol) in DCM (1 mL) was introduced into the system dropwise. The resulting mixture was stirred at 40 °C for 23 h-12 d, and the progress of the reaction was monitored by TLC. Upon completion, the reaction was concentrated under reduced pressure, and the residue was purified by column chromatography on silica gel (eluent: hexanes/ethyl acetate) to give the cycloheptatriene fused pyrrole **2**.

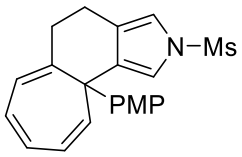
10a-(3-methoxyphenyl)-2-tosyl-2,4,5,10a-tetrahydrocyclohepta[*e*]isoindole (2a)



2a

Compound **2a** was prepared in 95% yield (84.2 mg) according to the general procedure. 23 h. Yellow solid. M.p = 121 – 122 °C. 18 h. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.61 (d, *J* = 8.0 Hz, 2H), 7.23 (d, *J* = 8.5 Hz, 2H),, 7.02 – 6.97 (m, 2H), 6.81 (s, 1H), 6.64 – 6.59 (m, 2H), 6.53 (d, *J* = 2.0 Hz, 1H), 6.28 – 6.22 (m, 2H), 6.16 – 6.08 (m, 2H), 4.69 (d, *J* = 8.5 Hz, 1H), 3.73 (s, 3H), 2.75 – 2.57 (m, 3H), 2.45 – 2.33 (m, 4H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 157.4, 144.5, 136.4, 135.8, 134.7, 129.8, 129.0, 128.0, 127.4, 126.6 125.1, 124.9, 124.2, 117.8, 115.1, 112.2, 106.9, 55.0, 41.3, 33.4, 21.6, 21.5; IR (neat): 3056, 2988, 1734, 1509, 1423, 1174, 896, 742, 737; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{27}H_{25}NNaO_3S^+$ 466.1447; Found 466.1444.

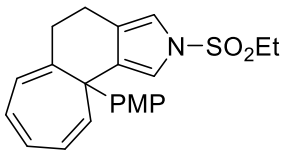
10a-(3-methoxyphenyl)-2-(methylsulfonyl)-2,4,5,10a-tetrahydrocyclohepta[e]isoindole (2b)



2b

Compound **2b** was prepared in 94% yield (69.7 mg) according to the general procedure. 3 d. Yellow solid. M.p = 151 – 153 ^{o}C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.04 (d, *J* = 8.5 Hz, 2H), 6.82 (s, 1H), 6.62 (d, *J* = 8.5 Hz, 2H), 6.48 (d, *J* = 2.0 Hz, 1H), 6.34 – 6.25 (m, 2H), 6.19 – 6.10 (m, 2H), 4.77 (d, *J* = 8.5 Hz, 1H), 3.72 (s, 3H), 3.03 (s, 3H), 2.83 – 2.64 (m, 3H), 2.55 – 2.40 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 157.5, 135.8, 134.6, 129.1, 128.1, 127.4, 125.1, 124.7, 124.2, 117.3, 114.9, 114.8, 112.3, 106.6, 55.0, 42.5, 41.3, 33.5, 21.5; IR (neat): 3054, 2937, 1609, 1443, 1266, 1067, 985, 736, 732; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{21}H_{21}NNaO_3S^+$ 390.1134; Found 390.1131.

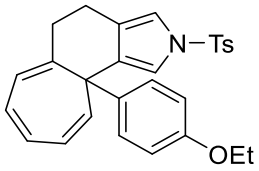
2-(ethylsulfonyl)-10a-(4-methoxyphenyl)-2,4,5,10a-tetrahydrocyclohepta[*e*]isoindole (2c)



2c

Compound **2c** was prepared in 73% yield (55.3 mg) according to the general procedure. 4 d. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.03 (d, *J* = 8.8 Hz, 2H), 6.80 (s, 1H), 6.61 (d, *J* = 8.4 Hz, 2H), 6.48 – 6.44 (d, *J* = 1.6 Hz, 1H), 6.32 – 6.26 (m, 2H), 6.20 – 6.10 (m, 2H), 4.81 (d, *J* = 8.8 Hz, 1H), 3.71 (s, 3H), 3.12 (q, *J* = 7.2 Hz, 2H), 2.85 – 2.64 (m, 3H), 2.51 – 2.42 (m, 1H), 1.16 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 157.4, 135.4, 134.8, 128.9, 128.1, 127.5, 125.2, 124.3, 124.1, 117.8, 116.7, 115.3, 112.2, 108.2, 55.0, 49.9, 41.7, 33.6, 21.6, 8.0; IR (neat): 3053, 2986, 1507, 1421, 1162, 896, 740, 736, 705; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{22}H_{23}NNaO_3S^+$ 404.1291; Found 404.1290.

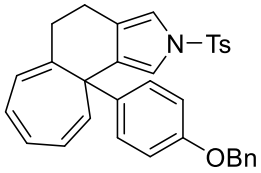
10a-(4-ethoxyphenyl)-2-tosyl-2,4,5,10a-tetrahydrocyclohepta[*e*]isoindole (2d)



2d

Compound **2d** was prepared in 77% yield (73.0 mg) according to the general procedure. 3 d. Yellow solid. M.p = 118 – 119 ºC. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.63 – 7.58 (d, *J* = 8.0 Hz, 2H), 7.22 (d, *J* = 8.4 Hz, 2H), 6.98 (d, *J* = 8.4 Hz, 2H), 6.80 (s, 1H), 6.59 (d, *J* = 8.4 Hz, 2H), 6.53 (d, *J* = 2.0 Hz, 1H), 6.27 – 6.21 (m, 2H), 6.16 – 6.00 (m, 2H), 4.68 (d, *J* = 8.8 Hz, 1H), 3.94 (q, *J* = 7.2 Hz, 2H), 2.75 – 2.57 (m, 3H), 2.44 – 2.36 (m, 4H), 1.36 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 156.9, 144.5, 136.5, 135.9, 134.6, 129.9, 129.1, 128.1, 127.5, 126.7, 125.2, 125.0, 124.3, 117.9, 115.2, 115.1, 112.8, 106.8, 63.2, 41.4, 33.5, 21.7, 21.6, 15.0; IR (neat): 3055, 2988, 1423, 1266, 1064, 896, 748, 743, 706; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{28}H_{27}NNaO_3S^+$ 480.1604; Found 480.1602.

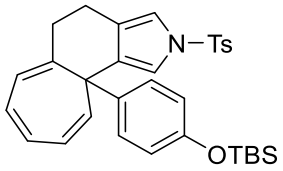
10a-(4-(benzyloxy)phenyl)-2-tosyl-2,4,5,10a-tetrahydrocyclohepta[*e*]isoindole (2e)



2e

Compound **2e** was prepared in 89% yield (95.0 mg) according to the general procedure. 27 h. yield Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60 (d, *J* = 8.4 Hz, 2H), 7.44 – 7.31 (m, 5H), 7.21 (d, *J* = 8.0 Hz, 2H), 7.00 (d, *J* = 8.8 Hz, 2H), 6.81 (s, 1H), 6.69 (d, *J* = 8.4 Hz, 2H), 6.54 (d, *J* = 2.0 Hz, 1H), 6.28 – 6.22 (m, 2H), 6.18 – 6.07 (m, 2H), 4.95 (s, 2H), 4.70 (d, *J* = 8.8 Hz, 1H), 2.74 – 2.59 (m, 3H), 2.39 – 2.35 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 156.8, 144.4, 137.2, 136.3, 135.7, 135.0, 129.8, 129.0, 128.5, 128.0, 127.8, 127.6, 127.4, 126.6, 125.1, 124.9, 124.1, 117.7, 115.5, 115.0, 113.1, 107.2, 69.9, 41.4, 33.4, 21.6, 21.5; IR (neat): 3054, 2926, 2306, 1459, 1265, 896, 742, 737, 706; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{33}H_{29}NNaO_3S^+$ 542.1760; Found 542.1764.

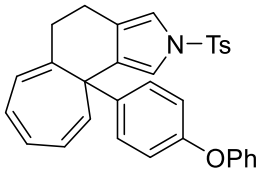
10a-(4-((*tert*-butyldimethylsilyl)oxy)phenyl)-2-tosyl-2,4,5,10a-tetrahydrocyclohepta[*e*]isoindole (2f)



2f

Compound **2f** was prepared in 74% yield (82.0 mg) according to the general procedure. 65 h. yield Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.45 (d, *J* = 8.4 Hz, 2H), δ 7.07 (d, *J* = 8.4 Hz, 2H). 6.77 (d, *J* = 8.8 Hz, 2H), 6.66 (s, 1H), 6.41 – 6.36 (m, 3H), 6.12 – 6.06 (m, 2H), 6.00 – 5.90 (m, 2H), 4.57 (d, *J* = 8.4 Hz, 1H), 2.60 – 2.45 (m, 3H), 2.30 – 2.18 (m, 4H), 0.80 (s, 9H), 0.00 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 153.3, 144.4, 136.3, 135.8, 135.4, 129.8, 129.0, 128.1, 127.4, 126.6, 125.1, 124.9, 124.1, 118.2, 117.7, 116.4, 115.0, 108.1, 41.7, 33.5, 25.6, 21.6, 21.5, 18.1, -4.4, -4.5; IR (neat): 3056, 2988, 1508, 1266, 1064, 896, 740, 705; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{32}H_{37}NNaO_3SSi^+$ 566.2156; Found 566.2147.

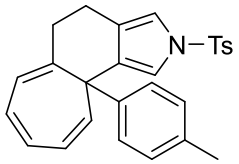
10a-(4-phenoxyphenyl)-2-tosyl-2,4,5,10a-tetrahydrocyclohepta[*e*]isoindole (2g)



2g

Compound **2g** was prepared in 90% yield (94.0 mg) according to the general procedure. 4 d. Yellow solid. M.p = 55 – 57 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.73 (d, *J* = 8.0 Hz, 2H), 7.33 – 7.23 (m, 5H), 7.21 – 7.17 (m, 2H), 7.15 – 7.10 (m, 1H), 7.08 – 7.03 (m, 2H), 6.96 (d, *J* = 7.6 Hz, 2H), 6.90 (s, 1H), 6.86 – 6.77 (m, 4H), 5.10 (s, 1H), 2.92 – 2.76 (m, 2H), 2.62 – 2.47 (m, 2H), 2.36 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 157.2, 155.3, 144.7, 141.9, 141.0, 138.7, 136.1, 130.4, 129.9, 129.8, 129.6, 128.6, 127.5, 126.9, 126.8, 126.4, 126.3, 123.1, 119.1, 118.8, 118.7, 118.3, 48.0, 31.1, 25.0, 21.5; IR (neat): 3055, 2988, 1590, 1490, 1371, 1266, 896, 748, 736, 706; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{32}H_{27}NNaO_3S^+$ 528.1604; Found 528.1603.

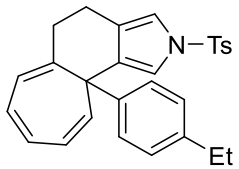
10a-(*p*-tolyl)-2-tosyl-2,4,5,10a-tetrahydrocyclohepta[*e*]isoindole (2h)



2h

Compound **2h** was prepared in 68% yield (60.0 mg) according to the general procedure. 5 d. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 (d, *J* = 8.4 Hz, 2H), 7.23 (d, *J* = 8.0 Hz, 2H), 6.97 (d, *J* = 8.0 Hz, 2H), 6.86 (d, *J* = 7.6 Hz, 2H), 6.80 (s, 1H), 6.56 (d, *J* = 2.0 Hz, 1H), 6.30 – 6.23 (m, 2H), 6.19 – 6.09 (m, 2H), 4.80 (d, *J* = 8.8 Hz, 1H), 2.77 – 2.60 (m, 3H), 2.41 – 2.37 (m, 4H), 2.23 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.5, 139.8, 136.4, 135.7, 135.1, 129.8, 128.2, 127.8, 127.6, 127.5, 126.6, 125.2, 125.0, 124.0, 117.8, 115.0, 109.9, 42.6, 33.7, 21.6(4), 21.5(9), 21.0; IR (neat): 3055, 2988, 2307, 1422, 1266, 1063, 896, 749, 736, 705; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{27}H_{25}NNaO_2S^+$ 450.1498; Found 450.1499.

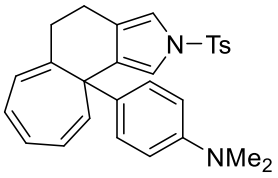
10a-(4-ethylphenyl)-2-tosyl-2,4,5,10a-tetrahydrocyclohepta[*e*]isoindole (2i)



2i

Compound **2i** was prepared in 75% yield (69.0 mg) according to the general procedure. 7 d. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 (d, *J* = 8.4 Hz, 2H), 7.23 (d, *J* = 8.0 Hz, 2H), 6.99 (d, *J* = 8.0 Hz, 2H), 6.89 (d, *J* = 8.0 Hz, 2H), 6.80 (s, 1H), 6.58 (d, *J* = 2.0 Hz, 1H), 6.32 – 6.25 (m, 2H), 6.22 – 6.11 (m, 2H), 4.84 (d, *J* = 8.8 Hz, 1H), 2.80 – 2.62 (m, 3H), 2.55 (q, *J* = 7.6 Hz, 2H), 2.48 – 2.37 (m, 4H), 1.18 (t, *J* = 7.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.5, 141.3, 140.2, 136.3, 135.8, 129.8, 128.3, 127.7, 127.6, 126.6, 126.3, 125.2, 125.1, 123.9, 117.9, 115.0, 111.0, 42.9, 33.7, 28.3, 21.7, 21.6, 15.2; IR (neat): 3055, 2988, 1590, 1490, 1371, 1266, 896, 748, 736, 706; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{28}H_{27}NNaO_2S^+$ 464.1655; Found 464.1662.

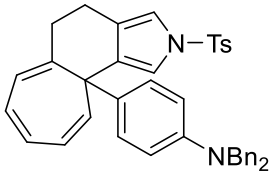
***N*,*N*-dimethyl-4-(2-tosyl-4,5-dihydrocyclohepta[*e*]isoindol-10a(2*H*)-yl)aniline (2j)**



2j

Compound **2j** was prepared in 65% yield (59.0 mg) according to the general procedure. 4 d. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.62 (d, *J* = 8.4 Hz, 2H), 7.23 (d, *J* = 8.4 Hz, 2H), 6.93 (d, *J* = 8.8 Hz, 2H), 6.79 (s, 1H), 6.57 (d, *J* = 2.4 Hz, 1H), 6.46 (d, *J* = 8.8 Hz, 2H), 6.27 – 6.21 (m, 2H), 6.18 – 6.08 (m, 2H), 4.66 (d, *J* = 8.4 Hz, 1H), 2.87 (s, 6H), 2.75 – 2.54 (m, 3H), 2.41 – 2.37 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 148.4, 144.4, 136.4, 136.2, 129.8, 128.7, 127.9, 127.2, 126.6, 125.0, 124.1, 117.7, 115.0, 114.5, 111.2, 106.4, 41.0, 40.6, 33.5, 21.6, 21.5; IR (neat): 3056, 2987, 2307, 1422, 1265, 896, 747, 741, 736; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{28}H_{28}N_2NaO_2S^+$ 479.1764; Found 479.1762.

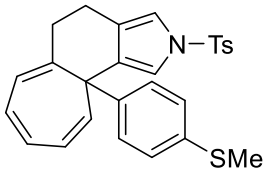
N,N-dibenzyl-3-(2-tosyl-4,5-dihydrocyclohepta[*e*]isoindol-10a(2*H*)-yl)aniline (2k)



2k

Compound **2k** was prepared in 71% yield (88.0 mg) according to the general procedure. 48 h. Yellow solid. M.p = 66 – 68 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60 (d, *J* = 8.4 Hz, 2H), 7.34 – 7.15 (m, 12H), 6.84 (d, *J* = 8.4 Hz, 2H), 6.78 (s, 1H), 6.59 (d, *J* = 2.0 Hz, 1H), 6.46 (d, *J* = 8.8 Hz, 2H), 6.24 – 6.08 (m, 4H), 4.68 (d, *J* = 8.8 Hz, 1H), 4.54 (s, 4H), 2.71 – 2.55 (m, 3H), 2.39 – 2.35 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 147.4, 144.3, 139.0, 136.4, 131.1, 129.7, 128.6, 128.5, 128.1, 127.4, 126.9, 126.7, 126.6, 125.2, 125.0, 123.9, 117.9, 117.2, 114.9, 111.3, 108.8, 54.2, 41.7, 33.7, 21.6; IR (neat): 3055, 2987, 1438, 1265, 896, 747, 742, 706; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{40}H_{36}N_2NaO_2S^+$ 631.2390; Found 631.2391.

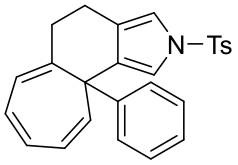
10a-(4-(methylthio)phenyl)-2-tosyl-2,4,5,10a-tetrahydrocyclohepta[*e*]isoindole (2l)



2l

Compound **2l** was prepared in 80% yield (53.0 mg) according to the general procedure. 12 d. Yellow solid. M.p = 121 – 122 ^{o}C.. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 (d, *J* = 8.0 Hz, 2H), 7.24 (d, *J* = 8.0 Hz, 2H), 7.04 – 6.92 (m, 4H), 6.81 (s, 1H), 6.56 (d, *J* = 1.2 Hz, 1H), 6.31 – 6.23 (m, 2H), 6.18 – 6.08 (m, 2H), 4.80 (d, *J* = 8.8 Hz, 1H), 2.76 – 2.67 (m, 3H), 2.44 – 2.40 (m, 4H), 2.39 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.5, 140.1, 136.3, 135.3, 135.1, 129.8, 128.4, 128.3, 127.6, 126.7, 125.2, 124.9, 124.0, 117.8, 117.8, 115.1, 109.5, 42.4, 33.5, 21.6, 15.8; IR (neat): 3055, 2987, 1422, 1266, 896, 747, 736, 706; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{27}H_{25}NNaO_2S_2^+$ 482.1219; Found 482.1216.

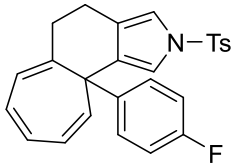
10a-phenyl-2-tosyl-2,4,5,10a-tetrahydrocyclohepta[*e*]isoindole (2m)



2m

Compound **2m** was prepared in 78% yield (67.0 mg) according to the general procedure. 4 d. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60 (d, *J* = 8.4 Hz, 2H), 7.23 (d, *J* = 8.4 Hz, 2H), 7.12 – 7.05 (m, 5H), 6.81 (s, 1H), 6.55 (d, *J* = 2.4 Hz, 1H), 6.32 – 6.26 (m, 2H), 6.19 – 6.08 (m, 2H), 4.84 (d, *J* = 8.8 Hz, 1H), 2.79 – 2.62 (m, 3H), 2.43 – 2.38 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.5, 143.0, 136.3, 135.5, 129.8, 128.3, 127.9, 127.6, 126.8, 126.6, 125.8, 125.2, 125.0, 124.0, 118.7, 117.9, 115.1, 110.4, 43.1, 33.7, 21.6(4), 21.5(8); IR (neat): 3054, 2987, 1422, 1266, 896, 741, 736, 705; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{26}H_{23}NNaO_2S^+$ 436.1342; Found 436.1335.

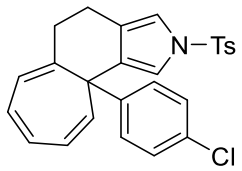
10a-(4-fluorophenyl)-2-tosyl-2,4,5,10a-tetrahydrocyclohepta[*e*]isoindole (2n)



2n

Compound **2n** was prepared in 77% yield (69.0 mg) according to the general procedure. 54 h. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 (d, *J* = 8.8 Hz, 2H), 7.22 (d, *J* = 8.0 Hz, 2H), 7.05 (dd, *J* = 6.0, 5.6 Hz, 2H), 6.82 (s, 1H), 6.78 – 6.70 (m, 2H), 6.52 (d, *J* = 1.6 Hz 1H), 6.30 – 6.22 (m, 2H), 6.11 (m, 2H), 4.74 (d, *J* = 8.4 Hz, 1H), 2.78 – 2.57 (m, 3H), 2.41 – 2.37 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.8 (d, *J* = 243.9 Hz), 144.6, 138.4 (d, *J* = 3.1 Hz), 136.2, 135.2, 129.8, 129.4 (d, *J* = 8.0 Hz), 128.2, 127.5, 126.6, 125.2, 124.7, 124.2, 117.6, 116.0, 115.2, 113.6 (d, *J* = 21.2 Hz) 107.7, 41.7, 33.3, 21.6, 21.5; ^{19}F NMR (471 MHz, $CDCl_3$) δ -117.2; IR (neat): 3055, 2988, 1422, 1266, 1064, 896, 739, 706; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{26}H_{22}FNNaO_2S^+$ 454.1247; Found 454.1244.

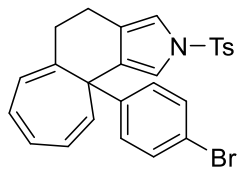
10a-(4-chlorophenyl)-2-tosyl-2,4,5,10a-tetrahydrocyclohepta[*e*]isoindole (2o)



2o

Compound **2o** was prepared in 83% yield (76.0 mg) according to the general procedure 29 h. Yellow solid. M.p = 89 – 91 ºC. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 (d, *J* = 8.4 Hz, 2H), 7.23 (d, *J* = 8.0 Hz, 2H), 7.06 – 7.00 (m, 4H), 6.83 (s, 1H), 6.54 (d, *J* = 2.0 Hz, 1H), 6.31 – 6.24 (m, 2H), 6.18 – 6.10 (m, 2H), 4.82 (d, *J* = 8.8 Hz, 1H), 2.78 – 2.59 (m, 3H), 2.46 – 2.38 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.6, 141.6, 136.2, 134.9, 131.2, 129.8, 129.2, 128.4, 127.7, 127.0, 126.6, 125.3, 124.8, 124.1, 118.4, 117.7, 115.2, 110.0, 42.5, 33.4, 21.6, 21.5; IR (neat): 3134, 2852, 1599, 1489, 1289, 1064, 814, 704, 673; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{26}H_{22}ClNNaO_2S^+$ 470.0952; Found 470.0950.

10a-(4-bromophenyl)-2-tosyl-2,4,5,10a-tetrahydrocyclohepta[*e*]isoindole (2p)

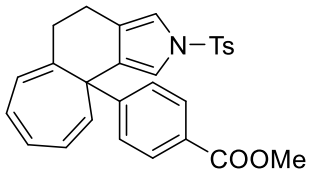


2p

Compound **2p** was prepared in 83% yield (94.1 mg) according to the general procedure. 81 h. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 (d, *J* = 8.8 Hz, 2H), 7.24 (d, *J* =

8.4 Hz, 2H), 7.17 (d, *J* = 8.4 Hz, 2H), 6.97 (d, *J* = 8.4 Hz, 2H), 6.82 (s, 1H), 6.55 (d, *J* = 2.0 Hz, 1H), 6.32 – 6.24 (m, 2H), 6.19 – 6.09 (m, 2H), 4.83 (d, *J* = 8.8 Hz, 1H), 2.78 – 2.61 (m, 3H), 2.41 – 2.37 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.6, 142.2, 136.2, 134.8, 129.9, 129.8, 129.6, 128.5, 127.8, 126.6, 125.3, 124.8, 124.1, 119.4, 118.7, 117.7, 115.2, 110.3, 42.7, 33.5, 21.6, 21.5; IR (neat): 3054, 2987, 1422, 1265, 896, 740, 736, 706; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{26}H_{22}BrNNaO_2S^+$ 514.0447; Found 514.0444.

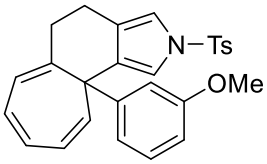
methyl 4-(2-tosyl-4,5-dihydrocyclohepta[*e*]isoindol-10a(2*H*)-yl)benzoate (2q)



2q

Compound **2q** was prepared in 80% yield (77.6 mg) according to the general procedure. 6 d. Yellow solid. M.p = 75 – 77 ºC. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.73 (d, *J* = 8.0 Hz, 2H), 7.59 (d, *J* = 8.0 Hz, 2H), 7.24 – 7.14 (m, 4H), 6.83 (s, 1H), 6.54 (s, 1H), 6.35 – 6.27 (m, 2H), 6.19 – 6.07 (m, 2H), 4.95 (d, *J* = 8.8 Hz, 1H), 3.86 (s, 3H), 2.80 – 2.64 (m, 3H), 2.41 – 2.38 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.0, 148.9, 144.6, 136.1, 134.5, 129.8, 128.6, 128.2, 127.9, 127.7, 126.6, 125.4, 124.8, 124.0, 121.3, 117.7, 115.2, 112.8, 51.9, 43.9, 33.6, 21.7, 21.6; IR (neat): 3055, 2987, 2305, 1720, 1437, 1266, 896, 747, 741, 706; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{28}H_{25}NNaO_4S^+$ 494.1397; Found 494.1398.

10a-(3-methoxyphenyl)-2-tosyl-2,4,5,10a-tetrahydrocyclohepta[*e*]isoindole (2r)

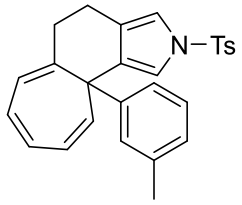


2r

Compound **2r** was prepared in 74% yield (68.0 mg) according to the general procedure. 46 h. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 (d, *J* = 8.0 Hz, 2H), 7.22 (d, *J* = 8.0 Hz, 2H), 7.00 – 6.97 (m, 1H), 6.81 (s, 1H), 6.73 – 6.56 (m, 4H), 6.29 – 6.27 (m, 2H), 6.20 – 6.17 (m, 2H), 4.92 (d, *J* = 8.8 Hz, 1H), 3.71 (s, 3H), 2.79 – 2.61 (m, 3H), 2.41 – 2.37 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.2, 145.0, 144.5, 136.3, 135.4, 129.8,

128.5, 127.8, 127.6, 126.6, 125.3, 125.1, 123.9, 122.3, 120.5, 117.9, 115.0, 114.5, 113.8, 110.3, 55.0, 44.1, 33.9, 21.8, 21.6; IR (neat): 3056, 2988, 1423, 1266, 896, 742, 737, 706; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{27}H_{25}NNaO_3S^+$ 466.1447; Found 466.1449.

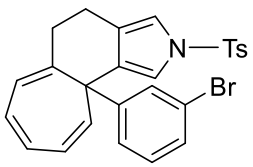
10a-(m-tolyl)-2-tosyl-2,4,5,10a-tetrahydrocyclohepta[*e*]isoindole (2s)



2s

Compound **2s** was prepared in 94% yield (83.0 mg) according to the general procedure. 48 h. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60 (d, *J* = 8.0 Hz, 2H), 7.22 (d, *J* = 8.0 Hz, 2H), 6.97 – 6.83 (m, 4H), 6.80 (s, 1H), 6.56 (d, *J* = 2.0 Hz, 1H), 6.31 – 6.23 (m, 2H), 6.16 – 6.12 (m, 2H), 4.83 (d, *J* = 8.8 Hz, 1H), 2.78 – 2.60 (m, 3H), 2.41 – 2.37 (m, 4H), 2.21 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.4, 143.0, 136.3, 136.1, 135.7, 129.7, 128.6, 128.2, 127.6, 126.6(1), 126.5(7), 126.5, 125.2, 125.1, 124.9, 124.0, 119.5, 117.9, 115.0, 111.2, 43.2, 33.8, 21.7, 21.6, 21.5; IR (neat): 3055, 2988, 2307, 1422, 1266, 1094, 1064, 896, 749, 706; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{27}H_{25}NNaO_2S^+$ 450.1498; Found 450.1500.

10a-(3-bromophenyl)-2-tosyl-2,4,5,10a-tetrahydrocyclohepta[*e*]isoindole (2t)

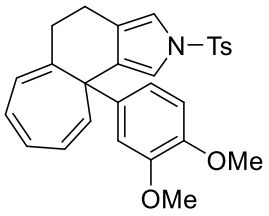


2t

Compound **2t** was prepared in 88% yield (89.0 mg) according to the general procedure. 48 h. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 (d, *J* = 8.0 Hz, 2H), 7.24 (d, *J* = 8.8 Hz, 2H), 7.17 (d, *J* = 7.6 Hz, 2H), 7.05 (d, *J* = 8.0 Hz, 1H), 6.95 – 6.91 (m, 1H), 6.82 (s, 1H), 6.56 (d, *J* = 2.0 Hz, 1H), 6.34 – 6.27 (m, 2H), 6.23 – 6.12 (m, 2H), 4.89 (d, *J* = 8.8 Hz, 1H), 2.71 (m, 3H), 2.41 – 2.37 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 145.7, 144.6, 136.2, 134.9, 130.8, 129.8, 128.9, 128.7, 128.4, 128.0, 126.7, 126.4, 125.5, 125.0, 124.1, 121.1, 121.0, 117.8, 115.3, 112.5, 43.6, 33.7, 21.7, 21.6; IR (neat): 3054, 2987, 1422, 1265,

1174, 1064, 896, 737, 705; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{26}H_{22}BrNNaO_2S^+$ 514.0447; Found 514.0444.

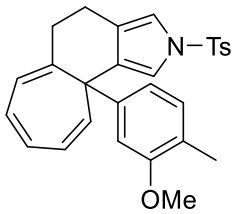
10a-(3,4-dimethoxyphenyl)-2-tosyl-2,4,5,10a-tetrahydrocyclohepta[*e*]isoindole (2u)



2u

Compound **2u** was prepared in 85% yield (82.4 mg) according to the general procedure. 48 h. Yellow solid. M.p = 145 – 147 ºC. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 (d, *J* = 8.0 Hz, 2H), 7.23 (d, *J* = 8.4 Hz, 2H), 6.82 (s, 1H), 6.66 – 6.55 (m, 4H), 6.30 – 6.23 (m, 2H), 6.20 – 6.10 (m, 2H), 4.76 (d, *J* = 8.4 Hz, 1H), 3.80 (s, 3H), 3.75 (s, 3H), 2.76 – 2.58 (m, 3H), 2.41 – 2.37 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 147.4, 146.9, 144.5, 136.3, 135.7, 135.4, 129.8, 128.2, 127.5, 126.7, 125.2, 124.9, 124.1, 120.4, 117.7, 116.7, 115.1, 112.0, 109.5, 108.4, 55.8, 55.6, 42.2, 33.5, 21.6(0), 21.5(8); IR (neat): 3056, 2988, 2307, 1514, 1423, 1266, 896, 738, 706; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{28}H_{27}NNaO_4S^+$ 496.1553; Found 496.1555.

10a-(3-methoxy-4-methylphenyl)-2-tosyl-2,4,5,10a-tetrahydrocyclohepta[*e*]isoindole (2v)

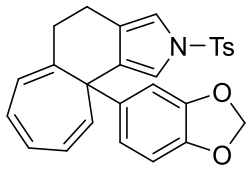


2v

Compound **2v** was prepared in 88% yield (83.0 mg) according to the general procedure. 35 h. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 (d, *J* = 8.4 Hz, 2H), 7.23 (d, *J* = 8.4 Hz, 2H), 6.87 (dd, *J* = 8.4, 2.0 Hz, 1H), 6.80 (s, 2H), 6.56 – 6.49 (m, 2H), 6.28 – 6.22 (m, 2H), 6.19 – 6.09 (m, 2H), 4.73 (d, *J* = 8.8 Hz, 1H), 3.75 (s, 3H), 2.77 – 2.57 (m, 3H), 2.41 – 2.35 (m, 4H), 2.08 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.6, 144.4, 136.4, 136.1, 134.3, 130.4, 129.7, 128.1, 127.4, 126.6, 126.0, 125.1(1), 125.0(7), 124.6, 124.1, 117.8, 117.1, 115.0, 108.7, 108.1, 55.1, 41.9, 33.7, 21.6(1), 21.5(9), 16.4; IR (neat): 3055,

2987, 1422, 1266, 1064, 896, 747, 742; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{28}H_{27}NNaO_3S^+$ 480.1604; Found 480.1607.

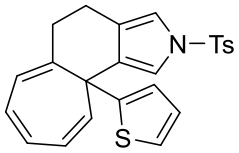
10a-(benzo[*d*][1,3]dioxol-5-yl)-2-tosyl-2,4,5,10a-tetrahydrocyclohepta[*e*]isoindole (2w)



2w

Compound **2w** was prepared in 86% yield (84.0 mg) according to the general procedure. 4 d. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.63 (d, *J* = 8.4 Hz, 2H), 7.24 (d, *J* = 8.0 Hz, 2H), 6.82 (s, 1H), 6.60 – 6.49 (m, 4H), 6.30 – 6.11 (m, 4H), 5.85 (d, *J* = 2.8 Hz, 2H), 4.73 (d, *J* = 8.4 Hz, 1H), 2.76 – 2.58 (m, 3H), 2.41 – 2.37 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 146.2, 145.3, 144.5, 136.8, 136.3, 135.5, 129.8, 128.2, 127.6, 126.7, 125.2, 124.9, 124.2, 121.1, 117.7, 117.0, 115.1, 108.9, 108.7, 106.7, 100.6, 42.3, 33.5, 21.6, 21.5; IR (neat): 3055, 2927, 1437, 1267, 1064, 896, 741, 737, 706; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{27}H_{23}NNaO_4S^+$ 480.1240; Found 480.1243.

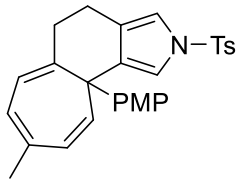
10a-(thiophen-3-yl)-2-tosyl-2,4,5,10a-tetrahydrocyclohepta[*e*]isoindole (2x)



2x

Compound **2x** was prepared in 76% yield (64.0 mg) according to the general procedure. 4 d. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.64 (d, *J* = 8.4 Hz, 2H), 7.24 (d, *J* = 8.0 Hz, 2H), 6.91 (d, *J* = 7.6 Hz, 1H), 6.86 (d, *J* = 2.4 Hz, 1H), 6.82 (s, 1H), 6.69 – 6.65 (m, 1H), 6.63 (d, *J* = 2.4 Hz, 1H), 6.36 – 6.24 (m, 4H), 5.16 (d, *J* = 8.8 Hz, 1H), 2.78 – 2.70 (m, 2H), 2.65 – 2.56 (m, 1H), 2.52 – 2.43 (m, 1H), 2.39 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 148.6, 144.6, 136.3, 135.4, 129.8, 129.1, 128.4, 126.6, 125.8, 125.2, 125.1, 124.8, 124.1, 122.1, 119.1, 117.9, 115.0, 41.8, 33.7, 21.9, 21.6; IR (neat): 3055, 2987, 1422, 1265, 1064, 896, 740, 705; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{24}H_{21}NNaO_2S_2^+$ 442.0906; Found 442.0905.

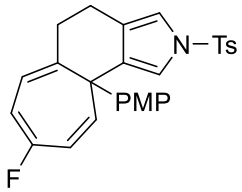
10a-(4-methoxyphenyl)-8-methyl-2-tosyl-2,4,5,10a-tetrahydrocyclohepta[*e*]isoindole (2y)



2y

Compound **2y** was prepared in 49% yield (46.0 mg) according to the general procedure. 3 h. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60 (d, *J* = 8.0 Hz, 2H), 7.22 (d, *J* = 8.0 Hz, 2H), 6.98 (d, *J* = 8.4 Hz, 2H), 6.80 (s, 1H), 6.61 (d, *J* = 8.4 Hz, 2H), 6.47 (s, 1H), 6.11 – 6.05 (d, *J* = 7.2 Hz, 1H), 5.99 (d, *J* = 8.4 Hz, 1H), 5.81 (d, *J* = 7.2 Hz, 1H), 4.39 (d, *J* = 8.4 Hz, 1H), 3.73 (s, 3H), 2.75 – 2.47 (m, 3H), 2.41 – 2.37 (m, 4H), 1.71 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 157.3, 144.4, 136.4, 135.6, 134.7, 129.7, 129.3, 126.9, 126.6, 125.4, 124.7, 117.7, 115.1, 112.2, 105.2, 98.3, 55.0, 39.0, 32.5, 22.4, 21.5, 21.1; IR (neat): 3054, 2932, 2854, 1609, 1266, 1064, 896, 736, 705, 672; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{28}H_{27}NNaO_3S^+$ 480.1604; Found 480.1600.

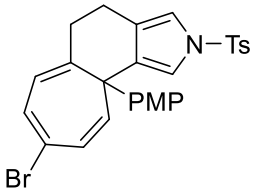
8-fluoro-10a-(4-methoxyphenyl)-2-tosyl-2,4,5,10a-tetrahydrocyclohepta[*e*]isoindole (2z)



2z

Compound **2z** was prepared in 61% yield (58.0 mg) according to the general procedure. 64 h. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 (d, *J* = 8.0 Hz, 2H), 7.23 (d, *J* = 8.0 Hz, 2H), 7.01 (d, *J* = 8.8 Hz, 2H), 6.81 (s, 1H), 6.62 – 5.58 (m, 3H), 6.25 – 6.21 (m, 2H), 5.93 – 5.89 (m, 1H), 5.16 – 5.12 (m, 1H), 3.73 (s, 3H), 2.80 – 2.61 (m, 3H), 2.41 – 2.37 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.7 (d, *J* = 244.4 Hz), 157.7, 144.6, 136.2, 135.5 (d, *J* = 24.9 Hz), 129.8, 128.1, 126.6, 125.1, 121.6 (d, *J* = 10.7 Hz), 120.3 (d, *J* = 12.5 Hz), 117.8, 117.0, 116.7, 115.1, 112.5, 111.7 (d, *J* = 26.5 Hz), 55.0, 44.7, 34.2, 22.1, 21.6; ^{19}F NMR (471 MHz, $CDCl_3$) δ -107.2; IR (neat): 3054, 2987, 2685, 1422, 1265, 1064, 896, 741, 736, 705; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{27}H_{24}FNNaO_3S^+$ 484.1353; Found 484.1350.

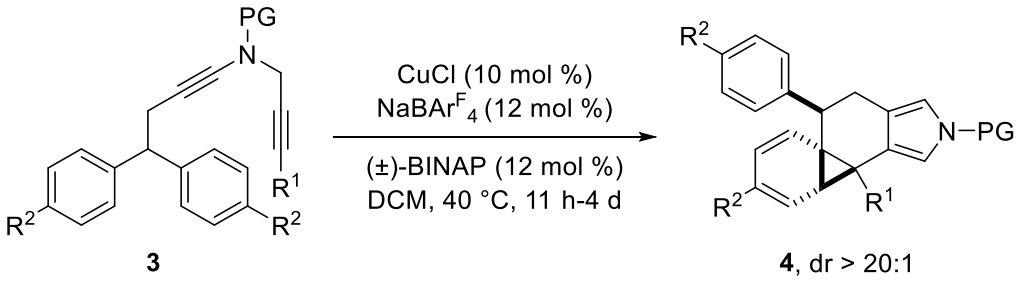
8-bromo-10a-(4-methoxyphenyl)-2-tosyl-2,4,5,10a-tetrahydrocyclohepta[*e*]isoindole (2aa)



2aa

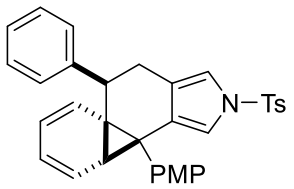
Compound **2aa** was prepared in 63% yield (67.0 mg) according to the general procedure. 48 h. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 (d, *J* = 8.0 Hz, 2H), 7.23 (d, *J* = 8.0 Hz, 2H), 6.97 (d, *J* = 8.4 Hz, 2H), 6.82 (s, 1H), 6.64 (d, *J* = 8.8 Hz, 2H), 6.51 (d, *J* = 2.0 Hz, 1H), 6.37 (d, *J* = 8.8 Hz, 2H), 6.11 (d, *J* = 7.6 Hz, 1H), 4.73 (d, *J* = 9.6 Hz, 1H), 3.74 (s, 3H), 2.77 – 2.56 (m, 3H), 2.41 – 2.37 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 157.7, 144.6, 136.2, 135.0, 134.3, 130.9, 129.8, 128.4, 127.7, 126.7, 124.6, 124.0, 121.4, 121.1, 117.9, 115.2, 112.6, 112.5, 55.1, 42.9, 33.4, 21.6, 21.5; IR (neat): 3054, 2987, 2685, 1422, 1266, 1064, 896, 747, 742, 731, 706; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{27}H_{24}BrNNaO_3S^+$ 544.0552; Found 544.0555.

4.2 Synthesis of norcaradiene derived pyrroles 4



The powered CuCl (0.02 mmol, 2.0 mg), (±)-BINAP (0.024 mmol, 14.9 mg) and $NaBAr^F_4$ (0.024 mmol, 21.3 mg) were introduced into an oven-dried Schlenk tube. After DCM (1 mL) was injected into the Schlenk tube, the solution was stirred at 40 °C for 0.5 h. Then compound **3** (0.2 mmol) in DCM (1 mL) was introduced into the system dropwise. The resulting mixture was stirred at 40 °C for 11 h-4 d, and the progress of the reaction was monitored by TLC. Upon completion, the reaction was concentrated under reduced pressure, and the residue was purified by column chromatography on silica gel (eluent: hexanes/ethyl acetate) to give the norcaradiene derived pyrrole **4**.

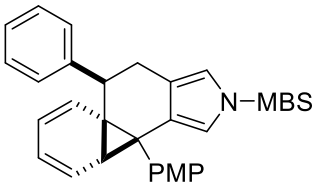
3b-(4-methoxyphenyl)-8-phenyl-2-tosyl-3b,3c,8,9-tetrahydro-2*H*-benzo[2,3]cyclopropa[1,2-*e*]isoindole (4a)



4a

Compound **4a** was prepared in 99% yield (103.8 mg) according to the general procedure. 53 h. White solid. M.p = 93.4 – 94.2 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.64 (d, *J* = 8.5 Hz, 2H), 7.28 – 7.10 (m, 7H), 7.05 – 7.00 (m, 2H), 6.84 – 6.82 (m, 1H), 6.72 – 6.67 (m, 2H), 6.37 (d, *J* = 2.5 Hz, 1H), 6.23 – 6.18 (m, 1H), 5.83 – 5.79 (m, 1H), 5.68 – 5.63 (m, 2H), 3.76 (s, 3H), 3.65 (dd, *J* = 12.0, 4.5 Hz, 1H), 3.50 (d, *J* = 8.0 Hz, 1H), 2.77 (dd, *J* = 16.0, 5.0 Hz, 1H), 2.43 – 2.33 (m, 4H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 157.6, 144.8, 144.5, 136.3, 133.6, 131.8, 130.8, 129.8, 128.4, 128.0, 127.8(9), 126.8, 126.5, 125.1, 124.8, 123.9, 122.8, 117.7, 115.5, 112.5, 67.7, 59.1, 55.0, 46.0, 29.5, 27.7, 21.6; IR (neat): 3034, 2933, 1532, 1370, 1246, 1172, 1062, 796, 703, 674, 585, 538; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{33}H_{29}NNaO_3S^+$ 558.2073; Found 558.2072.

3b-(4-methoxyphenyl)-2-((4-methoxyphenyl)sulfonyl)-8-phenyl-3b,3c,8,9-tetrahydro-2*H*-benzo[2,3]cyclopropa[1,2-*e*]isoindole (4b)

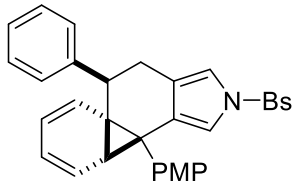


4b

Compound **4b** was prepared in 70% yield (77.2 mg) according to the general procedure. 42 h. Pale yellow solid. M.p = 77.7 – 78.4 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.71 – 7.65 (m, 2H), 7.28 – 7.21 (m, 2H), 7.20 – 7.14 (m, 1H), 7.12 (d, *J* = 7.0 Hz, 2H), 7.02 – 6.99 (m, 2H), 6.92 – 6.88 (m, 2H), 6.80 (s, 1H), 6.70 – 6.66 (m, 2H), 6.35 (d, *J* = 2.0 Hz, 1H), 6.25 – 6.19 (m, 1H), 5.82 – 5.78 (m, 1H), 5.67 – 5.61 (m, 2H), 3.83 (s, 3H), 3.76 (s, 3H), 3.65 (dd, *J* = 12.5, 5.0 Hz, 1H), 3.49 (d, *J* = 7.0 Hz, 1H), 2.77 (dd, *J* = 15.5, 5.0 Hz, 1H), 2.42 – 2.33 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 163.5, 157.5, 144.9, 133.5, 131.8, 130.8, 130.7, 129.0, 128.4, 127.9(4), 127.8(9), 126.5, 125.1, 124.8, 123.9, 122.7, 117.6,

115.4, 114.3, 112.5, 67.7, 59.1, 55.6, 55.0, 46.0, 29.5, 27.7; IR (neat): 2924, 1574, 1509, 1374, 1176, 1062, 745, 701, 631, 582; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{33}H_{29}NNaO_4S^+$ 574.2023; Found 574.2022.

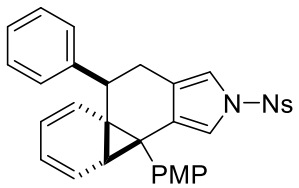
2-((4-bromophenyl)sulfonyl)-3b-(4-methoxyphenyl)-8-phenyl-3b,3c,8,9-tetrahydro-2*H*-benzo[2,3]cyclopropa[1,2-*e*]isoindole (4c)



4c

Compound **4c** was prepared in 87% yield (104.2 mg) according to the general procedure. 56 h. Pale yellow solid. M.p = 79.3 – 79.6 ºC. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.63 – 7.56 (m, 4H), 7.28 – 7.08 (m, 5H), 7.02 – 6.98 (m, 2H), 6.81 (s, 1H), 6.71 – 6.65 (m, 2H), 6.34 (d, *J* = 2.4 Hz, 1H), 6.25 – 6.20 (m, 1H), 5.82 – 5.76 (m, 1H), 5.67 – 5.61 (m, 2H), 3.77 (s, 3H), 3.65 (dd, *J* = 12.0, 4.8 Hz, 1H), 3.48 (d, *J* = 6.8 Hz, 1H), 2.78 (dd, *J* = 15.6, 4.8 Hz, 1H), 2.43 – 2.31 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 157.6, 144.7, 138.1, 134.4, 132.5, 131.9, 130.6, 128.7, 128.5, 128.2, 127.9(4), 127.9(0), 126.5, 125.2, 124.9, 123.9, 123.4, 117.7, 115.6, 112.6, 66.8, 58.3, 55.0, 45.8, 29.4, 27.5; IR (neat): 3034, 2925, 2853, 2183, 1656, 1510, 1375, 1176, 745, 583; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{32}H_{26}BrNNaO_3S^+$ 622.1022; Found 622.1020.

3b-(4-methoxyphenyl)-2-((4-nitrophenyl)sulfonyl)-8-phenyl-3b,3c,8,9-tetrahydro-2*H*-benzo[2,3]cyclopropa[1,2-*e*]isoindole (4d)

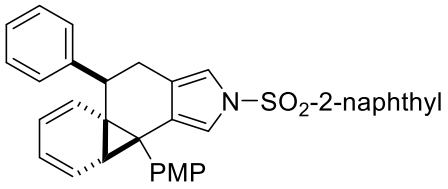


4d

Compound **4d** was prepared in 72% yield (83.8 mg) according to the general procedure. 56 h. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.41 – 8.36 (m, 2H), 8.02 – 7.96 (m, 2H), 7.37 – 7.26 (m, 3H), 7.23 – 7.18 (m, 2H), 7.12 – 7.06 (m, 2H), 6.92 (s, 1H), 6.81 – 6.75 (m, 2H), 6.44 (d, *J* = 2.4 Hz, 1H), 6.35 – 6.28 (m, 1H), 5.94 – 5.87 (m, 1H), 5.79 – 5.69 (m, 2H), 3.86 (s, 3H), 3.72 (dd, *J* = 12.4, 4.8 Hz, 1H), 3.54 (d, *J* = 6.8 Hz, 1H), 2.87

(dd, J = 15.6, 4.8 Hz, 1H), 2.52 – 2.42 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 157.7, 150.5, 144.5, 135.4, 131.9, 130.4, 128.5, 128.0, 127.9, 126.6, 125.3, 125.0, 124.5, 124.3, 123.8, 117.8, 115.8, 112.6, 57.6, 55.1, 45.7, 29.3, 27.3, 15.9; IR (neat): 2956, 2925, 2854, 1609, 1533, 1350, 1250, 1181, 1060, 741, 701; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{32}H_{26}NNaO_5S^+$ 605.2081; Found 605.2080.

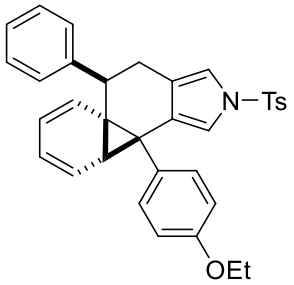
3b-(4-methoxyphenyl)-2-(naphthalen-2-yl)-8-phenyl-3b,3c,8,9-tetrahydro-2*H*-benzo[2,3]cyclopropa[1,2-*e*]isoindole (4e)



4e

Compound **4e** was prepared in 82% yield (93.7 mg) according to the general procedure. 54 h. Pale yellow oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.36 (s, 1H), 7.95 – 7.85 (m, 3H), 7.70 – 7.58 (m, 3H), 7.28 – 7.22 (m, 2H), 7.20 – 7.16 (m, 1H), 7.12 (d, J = 7.0 Hz, 2H), 7.04 – 7.01 (m, 2H), 6.91 (s, 1H), 6.73 – 6.69 (m, 2H), 6.46 (d, J = 2.5 Hz, 1H), 6.25 – 6.19 (m, 1H), 5.84 – 5.79 (m, 1H), 5.68 – 5.62 (m, 2H), 3.76 (s, 3H), 3.63 (dd, J = 12.5, 5.0 Hz, 1H), 3.48 (d, J = 6.5 Hz, 1H), 2.76 (dd, J = 16.0, 5.0 Hz, 1H), 2.43 – 2.33 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 157.6, 144.8, 136.0, 135.1, 133.9, 132.0, 131.9, 130.7, 129.6, 129.4, 129.3, 128.4, 128.3, 127.9(2), 127.8(9), 127.7, 126.5, 125.1, 124.8, 123.9, 123.0, 121.7, 117.9, 115.7, 112.5, 66.9, 58.3, 55.0, 45.9, 29.4, 27.5; IR (neat): 2925, 1510, 1365, 1245, 1174, 1061, 737, 641, 578; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{36}H_{29}NNaO_3S^+$ 594.2073; Found 594.2071.

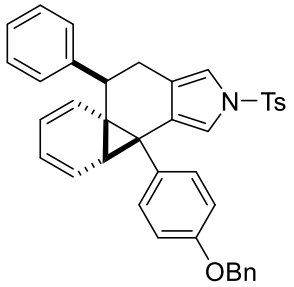
3b-(4-ethoxyphenyl)-8-phenyl-2-tosyl-3b,3c,8,9-tetrahydro-2*H*-benzo[2,3]cyclopropa[1,2-*e*]isoindole (4f)



4f

Compound **4f** was prepared in 79% yield (86.8 mg) according to the general procedure. 4 d. White solid. M.p = 156.7 – 157.4 ºC. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.66 – 7.62 (m, 2H), 7.28 – 7.10 (m, 7H), 7.03 – 6.99 (m, 2H), 6.84 – 6.81 (m, 1H), 6.71 – 6.66 (m, 2H), 6.37 (d, *J* = 2.0 Hz, 1H), 6.25 – 6.19 (m, 1H), 5.84 – 5.78 (m, 1H), 5.69 – 5.60 (m, 2H), 3.98 (q, *J* = 7.2 Hz, 2H), 3.65 (dd, *J* = 12.4, 4.8 Hz, 1H), 3.50 (d, *J* = 6.8 Hz, 1H), 2.77 (dd, *J* = 15.6, 4.8 Hz, 1H), 2.43 – 2.34 (m, 4H), 1.39 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 157.0, 144.9, 144.5, 136.3, 133.7, 131.8, 130.6, 129.8, 128.4, 128.0, 127.9, 126.8, 126.5, 125.1, 124.9, 123.9, 122.8, 117.8, 115.5, 113.0, 67.9, 63.1, 59.3, 46.0, 29.5, 27.8, 21.6, 14.9; IR (neat): 3033, 2979, 2927, 1609, 1509, 1369, 1243, 1171, 1061, 702, 674, 586; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{35}H_{35}NNaO_3S^+$ 572.2230; Found 572.2229.

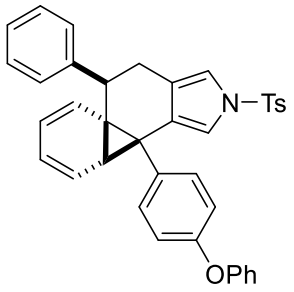
3b-(4-(benzyloxy)phenyl)-8-phenyl-2-tosyl-3b,3c,8,9-tetrahydro-2*H*-benzo[2,3]cyclopropa[1,2-*e*]isoindole (4g)



4g

Compound **4g** was prepared in 87% yield (106.3 mg) according to the general procedure. 96 h. Yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.67 – 7.62 (m, 2H), 7.46 – 7.18 (m, 10H), 7.16 – 7.12 (m, 2H), 7.06 – 7.01 (m, 2H), 6.85 – 6.76 (m, 3H), 6.39 (d, *J* = 2.4 Hz, 1H), 6.25 – 6.19 (m, 1H), 5.88 – 5.81 (m, 1H), 5.72 – 5.63 (m, 2H), 5.00 (s, 2H), 3.66 (dd, *J* = 12.4, 4.8 Hz, 1H), 3.52 (d, *J* = 6.8 Hz, 1H), 2.78 (dd, *J* = 15.6, 4.8 Hz, 1H), 2.44 – 2.34 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 157.0, 144.8, 144.5, 137.2, 136.3, 133.6, 131.8, 131.2, 129.9, 129.8, 128.5, 128.4, 128.0, 127.9, 127.8, 127.7, 126.8, 126.5, 125.2, 124.9, 123.9, 122.8, 117.8, 115.5, 113.4, 70.0, 59.9, 46.0, 29.5, 28.0, 21.6; IR (neat): 2925, 2855, 1603, 1508, 1351, 1164, 1093, 832, 737, 701. HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{40}H_{37}NNaO_3S^+$ 634.2386; Found 634.2385.

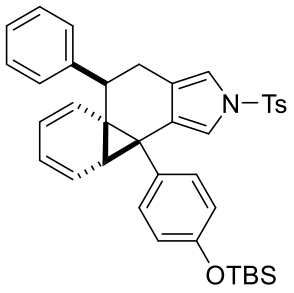
3b-(4-phenoxyphenyl)-8-phenyl-2-tosyl-3b,3c,8,9-tetrahydro-2*H*-benzo[2,3]cyclopropa[1,2-*e*]isoindole (4h)



4h

Compound **4h** was prepared in 83% yield (99.1 mg) according to the general procedure. 56 h. Pale yellow solid. M.p = 123.8 – 125.3 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.68 – 7.64 (m, 2H), 7.35 – 7.31 (m, 2H), 7.29 – 7.24 (m, 4H), 7.22 – 7.18 (m, 1H), 7.15 – 7.12 (m, 2H), 7.10 – 7.05 (m, 3H), 7.02 – 6.98 (m, 2H), 6.85 – 6.83 (m, 1H), 6.81 – 6.77 (m, 2H), 6.42 (d, *J* = 2.0 Hz, 1H), 6.26 – 6.20 (m, 1H), 5.89 – 5.80 (m, 1H), 5.73 – 5.63 (m, 2H), 3.67 (dd, *J* = 12.5, 5.0 Hz, 1H), 3.57 (d, *J* = 7.0 Hz, 1H), 2.79 (dd, *J* = 15.5, 5.0 Hz, 1H), 2.44 – 2.37 (m, 4H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 157.2, 155.2, 144.7, 144.6, 136.3, 133.6, 133.3, 132.0, 129.8, 129.6, 128.5, 128.0, 127.8, 126.8, 126.5, 125.3, 125.1, 123.9, 123.1, 122.8, 118.9, 117.7, 117.3, 115.6, 70.0, 61.2, 46.1, 29.5, 28.5, 21.6; IR (neat): 3035, 2923, 1590, 1504, 1489, 1237, 1172, 1061, 673, 584; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{39}H_{35}NNaO_3S^+$ 620.2230; Found 620.2228.

3b-(4-((tert-butyldimethylsilyl)oxy)phenyl)-8-phenyl-2-tosyl-3b,3c,8,9-tetrahydro-2*H*-benzo[2,3]cyclopropa[1,2-*e*]isoindole (4i)

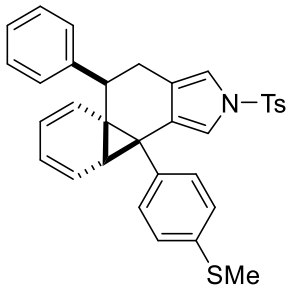


4i

Compound **4i** was prepared in 80% yield (101.6 mg) according to the general procedure. 11 h. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65 – 7.61 (m, 2H), 7.29 – 7.11 (m, 7H), 6.98 – 6.92 (m, 2H), 6.84 – 6.81 (m, 1H), 6.64 – 6.60 (m, 2H), 6.37 (d, *J* = 2.4 Hz, 1H), 6.25 – 6.19 (m, 1H), 5.83 – 5.77 (m, 1H), 5.67 – 5.60 (m, 2H), 3.65 (dd, *J* = 12.4, 5.2 Hz, 1H), 3.54 (d, *J* = 6.8 Hz, 1H), 2.77 (dd, *J* = 15.6, 4.8 Hz, 1H), 2.45 – 2.33 (m, 4H), 0.97 (s, 9H), 0.18 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 153.6, 144.9, 144.5, 136.3,

133.7, 131.7, 131.6, 129.8, 128.4, 128.0, 127.8, 126.8, 126.5, 125.2, 125.0, 123.9, 122.8, 118.6, 117.8, 115.5, 69.6, 60.9, 46.1, 29.5, 28.4, 25.7, 21.6, 18.2, -4.3(7), -4.3(9); IR (neat): 2931, 2858, 1604, 1508, 1255, 1173, 1062, 840, 781, 702, 585, 538; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{39}H_{45}NNaO_3SSi^+$ 658.2782; Found 658.2781.

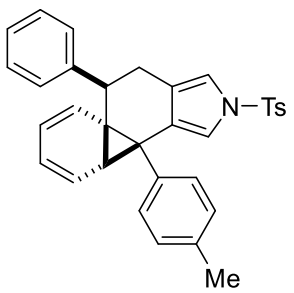
3b-(4-(methylthio)phenyl)-8-phenyl-2-tosyl-3b,3c,8,9-tetrahydro-2*H*-benzo[2,3]cyclopropa[1,2-*e*]isoindole (4j)



4j

Compound **4j** was prepared in 78% yield (86.0 mg) according to the general procedure 48 h. Pale yellow solid. M.p = 88.8 – 90.2 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72 – 7.67 (m, 2H), 7.35 – 7.15 (m, 7H), 7.11 – 7.02 (m, 4H), 6.83 (s, 1H), 6.38 (d, *J* = 2.4 Hz, 1H), 6.25 – 6.20 (m, 1H), 5.90 – 5.85 (m, 1H), 5.76 – 5.68 (m, 2H), 3.67 (dd, *J* = 12.4, 4.8 Hz, 1H), 3.59 (d, *J* = 7.2 Hz, 1H), 2.78 (dd, *J* = 15.6, 4.8 Hz, 1H), 2.52 – 2.39 (m, 7H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.7, 144.5, 136.3, 135.8, 135.6, 133.2, 131.1, 129.8, 128.5, 128.0, 127.7, 126.8, 126.5, 125.4, 125.3, 125.2, 123.9, 122.8, 117.7, 115.6, 71.1, 62.3, 46.2, 29.5, 29.0, 21.6, 15.7; IR (neat): 3029, 2923, 2855, 1597, 1494, 1369, 1171, 1062, 812, 674, 585, 538; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{34}H_{33}NNaO_2S_2^+$ 574.1845; Found 574.1842.

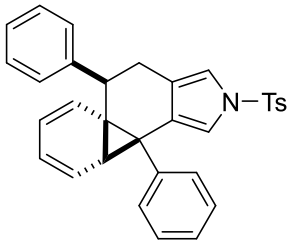
8-phenyl-3b-(*p*-tolyl)-2-tosyl-3b,3c,8,9-tetrahydro-2*H*-benzo[2,3]cyclopropa[1,2-*e*]isoindole (4k)



4k

Compound **4k** was prepared in 65% yield (67.5 mg) according to the general procedure. 3 d. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65 – 7.61 (m, 2H), 7.31 – 7.12 (m, 7H), 7.01 – 6.93 (m, 4H), 6.84 – 6.80 (m, 1H), 6.37 (d, *J* = 2.4 Hz, 1H), 6.25 – 6.20 (t, *J* = 7.6 Hz, 1H), 5.86 – 5.79 (m, 1H), 5.71 – 5.63 (m, 2H), 3.68 (dd, *J* = 12.4, 5.2 Hz, 1H), 3.58 (d, *J* = 6.8 Hz, 1H), 2.78 (dd, *J* = 15.6, 5.2 Hz, 1H), 2.45 – 2.36 (m, 4H), 2.28 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.8, 144.5, 136.4, 135.8, 135.4, 133.6, 130.5, 129.8, 128.4, 128.0, 127.8(3), 127.7(9), 126.8, 126.5, 125.2, 125.0, 124.0, 123.0, 117.9, 115.5, 71.0, 62.2, 46.2, 29.6, 29.1, 21.6, 21.2; IR (neat): 2949, 2925, 2856, 1453, 1369, 1172, 1061, 811, 674, 585; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{34}H_{33}NNaO_2S^+$ 542.2124; Found 542.2122.

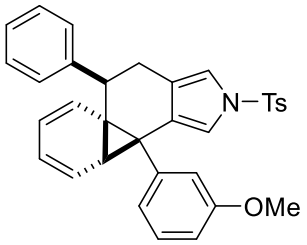
3b,8-diphenyl-2-tosyl-3b,3c,8,9-tetrahydro-2*H*-benzo[2,3]cyclopropa[1,2-*e*]isoindole (4l)



4l

Compound **4l** was prepared in 85% yield (85.9 mg) according to the general procedure. 96 h. Pale yellow oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.66 – 7.60 (m, 2H), 7.31 – 7.09 (m, 12H), 6.85 – 6.81 (m, 1H), 6.36 (d, *J* = 2.0 Hz, 1H), 6.26 – 6.20 (m, 1H), 5.85 – 5.80 (m, 1H), 5.67 (d, *J* = 4.5 Hz, 2H), 3.69 (dd, *J* = 12.0, 5.0 Hz, 1H), 3.64 (d, *J* = 7.0 Hz, 1H), 2.80 (dd, *J* = 15.5, 4.5 Hz, 1H), 2.46 – 2.38 (m, 4H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 144.7, 144.5, 139.0, 136.3, 133.4, 130.6, 129.8, 128.4, 128.0, 127.8, 127.0, 126.8, 126.5, 126.1, 125.3, 125.1, 124.0, 123.0, 117.8, 115.5, 72.1, 63.2, 46.3, 29.7, 29.6, 21.6; IR (neat): 3029, 2926, 1737, 1597, 1445, 1369, 1171, 1061, 812, 752, 674, 586, 524; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{33}H_{31}NNaO_2S^+$ 528.1968; Found 528.1967.

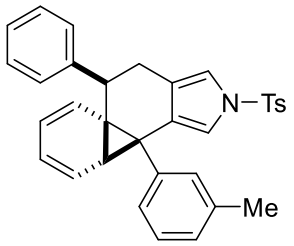
3b-(3-methoxyphenyl)-8-phenyl-2-tosyl-3b,3c,8,9-tetrahydro-2*H*-benzo[2,3]cyclopropa[1,2-*e*]isoindole (4m)



4m

Compound **4m** was prepared in 79% yield (84.6 mg) according to the general procedure. 89 h. Pale yellow solid. M.p = 171.5 – 172.2 ºC. ^{1}H NMR (400 MHz, $CDCl_3$) 7.65 – 7.58 (m, 2H), 7.28 – 7.20 (m, 4H), 7.20 – 7.10 (m, 4H), 7.01 – 6.98 (m, 1H), 6.81 – 6.72 (m, 3H), 6.36 (s, 1H), 6.20 – 6.14 (m, 1H), 5.67 – 5.64 (m, 1H), 5.54 (d, J = 9.6 Hz, 1H), 5.45 – 5.35 (m, 1H), 3.68 – 3.52 (m, 4H), 2.86 (d, J = 6.0 Hz, 1H), 2.71 (dd, J = 16.0, 5.2 Hz, 1H), 2.38 (s, 3H), 2.31 – 2.20 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.2, 145.5, 144.3, 136.5, 133.7, 129.7, 128.4, 128.0, 127.9, 126.7, 126.3, 124.6, 122.6, 119.0, 117.2, 115.6, 111.2, 55.2, 44.0, 36.9, 29.7, 29.1, 21.6, 18.7; IR (neat): 3039, 2931, 1596, 1494, 1369, 1172, 1062, 741, 675, 585; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{34}H_{33}NNaO_3S^+$ 558.2073; Found 558.2072.

8-phenyl-3b-(*m*-tolyl)-2-tosyl-3b,3c,8,9-tetrahydro-2*H*-benzo[2,3]cyclopropa[1,2-*e*]isoindole (4n)

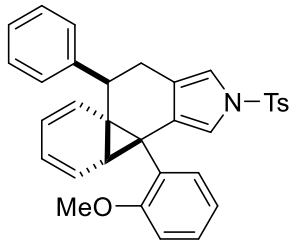


4n

Compound **4n** was prepared in 82% yield (85.1 mg) according to the general procedure. 65 h. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.63 – 7.59 (m, 2H), 7.27 – 7.09 (m, 9H), 7.04 – 6.99 (m, 1H), 6.94 – 6.86 (m, 3H), 6.82 – 6.79 (m, 1H), 6.37 (d, J = 2.4 Hz, 1H), 6.25 – 6.19 (m, 1H), 5.84 – 5.79 (m, 1H), 5.69 – 5.63 (m, 2H), 3.69 (dd, J = 12.4, 4.9 Hz, 1H), 3.63 (d, J = 7.2 Hz, 1H), 2.79 (dd, J = 15.6, 5.2 Hz, 1H), 2.44 – 2.33 (m, 4H), 2.26 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.8, 144.5, 138.9, 136.4, 136.3, 133.6, 131.3, 129.8, 128.4, 128.0, 127.7, 127.6, 126.9, 126.8, 126.7, 126.5, 125.3, 125.0, 124.0, 123.0, 117.9, 115.5, 72.5, 63.7, 46.3, 29.8, 29.6, 21.6, 21.4; IR (neat): 3027, 2921, 2852,

1598, 1449, 1352, 1163, 1092, 701, 544; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{34}H_{33}NNaO_2S^+$ 542.2124; Found 542.2123.

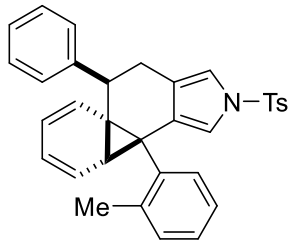
3b-(2-methoxyphenyl)-8-phenyl-2-tosyl-3b,3c,8,9-tetrahydro-2*H*-benzo[2,3]cyclopropa[1,2-*e*]isoindole (4o)



4o

Compound **4o** was prepared in 85% yield (91.0 mg) according to the general procedure. 56 h. White solid. M.p = 72.7 – 74.1 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.62 (d, *J* = 7.0 Hz, 2H), 7.28 – 7.22 (m, 4H), 7.19 – 7.12 (m, 4H), 7.02 (s, 1H), 6.83 – 6.71 (m, 3H), 6.37 (s, 1H), 6.22 – 6.14 (m, 1H), 5.67 (s, 1H), 5.55 (d, *J* = 9.5 Hz, 1H), 5.40 (s, 1H), 3.67 – 3.52 (m, 4H), 2.87 (d, *J* = 6.5 Hz, 1H), 2.72 (dd, *J* = 16.0, 5.5 Hz, 1H), 2.39 (s, 3H), 2.27 (t, *J* = 13.0 Hz, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 158.2, 145.4, 144.3, 136.5, 133.6, 132.0, 129.7, 129.3, 129.0, 128.3, 128.0, 127.9, 126.7, 126.3, 124.5, 123.8, 122.6, 121.5, 119.0, 117.1, 115.6, 111.1, 55.2, 44.5, 44.0, 36.8, 29.0, 21.5, 18.7; IR (neat): 3032, 2929, 1598, 1492, 1428, 1369, 1285, 1172, 1062, 737, 701, 584; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{34}H_{33}NNaO_3S^+$ 558.2073; Found 558.2072.

8-phenyl-3b-(*o*-tolyl)-2-tosyl-3b,3c,8,9-tetrahydro-2*H*-benzo[2,3]cyclopropa[1,2-*e*]isoindole (4p)

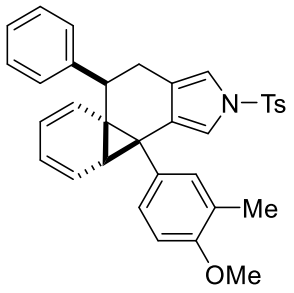


4p

Compound **4p** was prepared in 83% yield (83.5 mg) according to the general procedure. 70 h. White solid. M.p = 172.0 – 172.6 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.61 (d, *J* = 8.0 Hz, 2H), 7.27 – 7.22 (m, 4H), 7.14 – 6.96 (m, 7H), 6.82 (s, 1H), 6.34 – 6.25 (m, 2H), 5.75 – 5.70 (m, 1H), 5.59 (d, *J* = 9.5 Hz, 1H), 5.47 – 5.42 (m, 1H), 3.47 (dd, *J* = 12.5, 5.0 Hz,

1H), 2.88 (d, *J* = 6.0 Hz, 1H), 2.73 (dd, *J* = 15.5, 5.0 Hz, 1H), 2.39 (s, 3H), 2.28 (t, *J* = 13.0 Hz, 1H), 1.97 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 144.9, 144.4, 138.0, 136.2, 134.4, 133.0, 131.5, 130.6, 129.7, 128.4, 127.7, 127.1, 126.8, 126.6, 126.5, 124.0(3), 123.9(6), 123.5, 122.7, 122.4, 117.6, 115.9, 43.8, 42.7, 34.4, 28.9, 21.6, 20.8, 19.6; IR (neat): 3033, 2923, 1493, 1369, 1173, 1093, 1061, 750, 675, 614, 585; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{33}H_{29}NNaO_2S^+$ 526.1811; Found 526.1810.

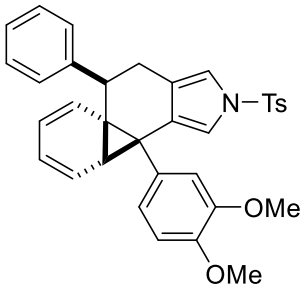
3b-(4-methoxy-3-methylphenyl)-8-phenyl-2-tosyl-3b,3c,8,9-tetrahydro-2*H*-benzo[2,3]cyclopropa[1,2-*e*]isoindole (4q)



4q

Compound **4q** was prepared in 72% yield (79.1 mg) according to the general procedure. 56 h. Pale yellow solid. M.p = 97 – 98.3 ºC. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.64 (d, *J* = 8.5 Hz, 2H), 7.29 – 7.18 (m, 5H), 7.15 – 7.11 (m, 2H), 6.89 (dd, *J* = 8.5, 2.5 Hz, 1H), 6.85 – 6.80 (m, 2H), 6.60 (d, *J* = 8.5 Hz, 1H), 6.38 (d, *J* = 2.0 Hz, 1H), 6.22 (t, *J* = 8.0 Hz, 1H), 5.82 (t, *J* = 7.0 Hz, 1H), 5.69 – 5.61 (m, 2H), 3.78 (s, 3H), 3.66 (dd, *J* = 12.5, 5.0 Hz, 1H), 3.50 (d, *J* = 7.0 Hz, 1H), 2.77 (dd, *J* = 15.5, 5.0 Hz, 1H), 2.43 – 2.36 (m, 4H), 2.12 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 155.7, 144.9, 144.5, 136.3, 133.9, 133.0, 130.3, 129.8, 128.9, 128.4, 128.0, 127.9, 126.7, 126.4, 125.1, 124.9, 124.8, 123.9, 122.9, 117.9, 115.5, 108.4, 68.8, 60.2, 55.0, 46.1, 29.5, 28.1, 21.6, 16.3; IR (neat): 2926, 2855, 1597, 1503, 1369, 1243, 1172, 1061, 810, 674, 585; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{35}H_{35}NNaO_3S^+$ 572.2230; Found 572.2229.

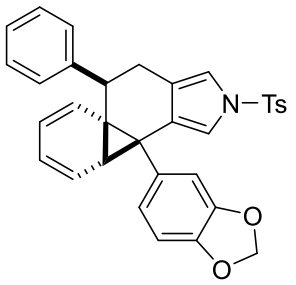
3b-(3,4-dimethoxyphenyl)-8-phenyl-2-tosyl-3b,3c,8,9-tetrahydro-2*H*-benzo[2,3]cyclopropa[1,2-*e*]isoindole (4r)



4r

Compound **4r** was prepared in 80% yield (90.4 mg) according to the general procedure. 58 h. Pale yellow solid. M.p = 72.6 – 73.9 ºC. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.65 (d, *J* = 8.5 Hz, 2H), 7.26 – 7.23 (m, 4H), 7.21 – 7.17 (m, 1H), 7.15 – 7.12 (m, 2H), 6.85 – 6.81 (m, 1H), 6.68 – 6.58 (m, 3H), 6.41 (d, *J* = 2.5 Hz, 1H), 6.26 – 6.19 (m, 1H), 5.85 – 5.81 (m, 1H), 5.70 – 5.61 (m, 2H), 3.83 (s, 3H), 3.77 (s, 3H), 3.67 (dd, *J* = 12.5, 5.0 Hz, 1H), 3.53 (d, *J* = 7.0 Hz, 1H), 2.78 (dd, *J* = 15.5, 5.0 Hz, 1H), 2.43 – 2.36 (m, 4H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 147.5, 147.0, 144.7, 144.5, 136.2, 133.5, 131.2, 129.8, 128.4, 127.9, 127.8, 126.7, 126.4, 125.2, 124.9, 123.8, 123.3, 122.7, 117.6, 115.5, 114.4, 109.8, 68.1, 59.5, 55.8, 55.6, 45.9, 29.4, 28.2, 21.5; IR (neat): 3031, 2932, 2856, 1598, 1369, 1188, 1093, 812, 737, 675, 584; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{35}H_{35}NNaO_4S^+$ 588.2179; Found 588.2178.

3b-(benzo[*d*][1,3]dioxol-5-yl)-8-phenyl-2-tosyl-3b,3c,8,9-tetrahydro-2*H*-benzo[2,3]cyclopropa[1,2-*e*]isoindole (4s)

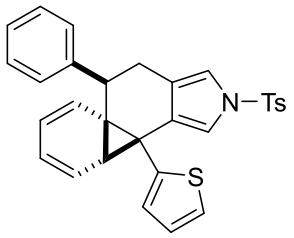


4s

Compound **4s** was prepared in 87% yield (95.5 mg) according to the general procedure. 55 h. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.68 – 7.64 (m, 2H), 7.28 – 7.10 (m, 7H), 6.84 – 6.82 (m, 1H), 6.64 – 6.55 (m, 3H), 6.44 (d, *J* = 2.0 Hz, 1H), 6.25 – 6.20 (m, 1H), 5.94 – 5.84 (m, 3H), 5.74 – 5.62 (m, 2H), 3.65 (dd, *J* = 12.4, 4.8 Hz, 1H), 3.56 (d, *J* = 6.8 Hz, 1H), 2.78 (dd, *J* = 15.6, 4.8 Hz, 1H), 2.46 – 2.34 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 146.2, 145.5, 144.7, 144.5, 136.3, 133.4, 132.6, 129.8, 128.4, 127.9, 127.7,

126.8, 126.5, 125.4, 125.1, 124.0, 123.8, 122.8, 117.7, 115.5, 111.3, 107.1, 100.7, 70.9, 62.1, 46.1, 29.5, 29.0, 21.6; IR (neat): 2925, 1490, 1369, 1226, 1061, 1040, 812, 702, 674, 585. HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{34}H_{31}NNaO_4S^+$ 572.1866; Found 572.1865.

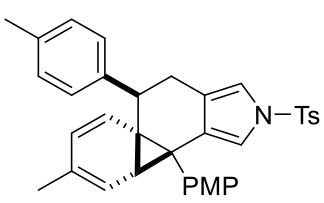
8-phenyl-3b-(thiophen-2-yl)-2-tosyl-3b,3c,8,9-tetrahydro-2*H*-benzo[2,3]cyclopropa[1,2-*e*]isoindole (4t)



4t

Compound **4t** was prepared in 87% yield (88.9 mg) according to the general procedure. 50 h. Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.67 – 7.63 (m, 2H), 7.29 – 7.22 (m, 4H), 7.22 – 7.16 (m, 1H), 7.13 – 7.09 (m, 2H), 7.02 (dd, *J* = 4.8, 1.2 Hz, 1H), 6.85 – 6.82 (m, 1H), 6.77 – 6.74 (m, 1H), 6.69 – 6.65 (m, 2H), 6.25 – 6.20 (m, 1H), 6.10 – 6.00 (m, 1H), 5.92 – 5.85 (m, 1H), 5.67 (d, *J* = 8.4 Hz, 1H), 4.05 (d, *J* = 7.2 Hz, 1H), 3.75 (dd, *J* = 12.0, 4.8 Hz, 1H), 2.83 (dd, *J* = 15.2, 4.8 Hz, 1H), 2.53 – 2.38 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.6, 144.3, 143.3, 136.3, 133.5, 129.8, 128.4, 128.2, 128.0, 127.5, 126.7, 126.6, 126.5, 126.3, 124.8, 124.1, 123.2, 123.0, 117.9, 115.6, 85.9, 46.5, 29.5, 28.2, 21.6; IR (neat): 3029, 2926, 2855, 1733, 1597, 1453, 1266, 1171, 1018, 814, 674, 586. HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{31}H_{29}NNaO_2S_2^+$ 534.1532; Found 534.1531.

3b-(4-methoxyphenyl)-5-methyl-8-(*p*-tolyl)-2-tosyl-3b,3c,8,9-tetrahydro-2*H*-benzo[2,3]cyclopropa[1,2-*e*]isoindole (4u)

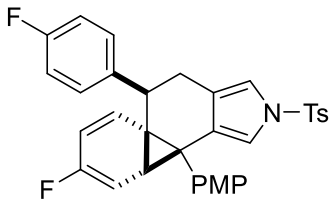


4u

Compound **4u** was prepared in 50% yield (54.7 mg) according to the general procedure. 40 h. yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65 – 7.61 (m, 2H), 7.27 – 7.23 (m, 3H),

7.09 – 6.97 (m, 5H), 6.81 – 6.78 (m, 1H), 6.72 – 6.66 (m, 2H), 6.34 (d, *J* = 2.4 Hz, 1H), 5.90 (d, *J* = 6.8 Hz, 1H), 5.56 (d, *J* = 9.6 Hz, 1H), 5.43 (d, *J* = 9.2 Hz, 1H), 3.77 (s, 3H), 3.56 (dd, *J* = 12.4, 4.8 Hz, 1H), 3.27 (d, *J* = 6.8 Hz, 1H), 2.72 (dd, *J* = 15.6, 5.2 Hz, 1H), 2.40 (s, 3H), 2.32 – 2.28 (s, 4H), 1.56 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 157.5, 144.4, 142.1, 136.4, 135.9, 133.8, 133.0, 132.1, 131.0, 129.8, 129.1, 128.3, 127.8, 127.0, 126.8, 122.9, 120.4, 117.6, 115.4, 112.4, 60.8, 55.1, 53.3, 45.0, 29.6, 26.5, 21.6, 21.4, 21.0; IR (neat): 3023, 2926, 2858, 1597, 1514, 1369, 1172, 1062, 814, 672, 539. HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{35}H_{33}NNaO_3S^+$ 570.2073; Found 570.2072.

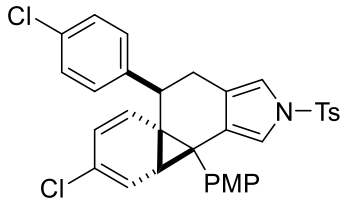
5-fluoro-8-(4-fluorophenyl)-3b-(4-methoxyphenyl)-2-tosyl-3b,3c,8,9-tetrahydro-2*H*-benzo[2,3]cyclopropa[1,2-*e*]isoindole (4v)



4v

Compound **4v** was prepared in 98% yield (108.8 mg) according to the general procedure. 40 h. Pale yellow solid. M.p = 92.2 – 93.5 ºC. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65 – 7.61 (m, 2H), 7.27 – 7.23 (m, 2H), 7.10 – 7.01 (m, 4H), 6.99 – 6.92 (m, 2H), 6.84 (s, 1H), 6.72 – 6.67 (m, 2H), 6.43 (d, *J* = 2.4 Hz, 1H), 5.97 – 5.91 (m, 1H), 5.75 – 5.70 (m, 1H), 5.65 – 5.58 (m, 1H), 4.03 – 3.97 (m, 1H), 3.78 – 3.67 (m, 4H), 2.81 (dd, *J* = 15.6, 4.8 Hz, 1H), 2.47 – 2.37 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 161.6 (d, *J* =243.0 Hz), 159.2 (d, *J* =233.0 Hz), 157.9, 144.6, 139.9 (d, *J* = 3.0 Hz), 136.2, 133.6, 131.5, 130.5, 129.8, 129.4 (d, *J* = 8.0 Hz), 128.4 (d, *J* = 10.0 Hz), 126.7, 122.8, 117.9, 115.6 (d, *J* =5.0 Hz), 115.4 (d, *J* =21.0 Hz), 115.3, 112.8, 108.3 (d, *J* = 27.0 Hz), 85.5, 55.0, 46.2, 33.4, 29.9, 21.6; ^{19}F NMR (471 MHz, $CDCl_3$) δ -116.1, -112.6; IR (neat): 2921, 2858, 1369, 1248, 1172, 1062, 825, 672, 540; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{33}H_{27}F_2NNaO_3S^+$ 578.1572; Found 578.1571.

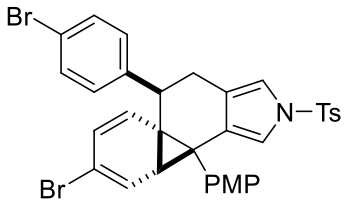
5-chloro-8-(4-chlorophenyl)-3b-(4-methoxyphenyl)-2-tosyl-3b,3c,8,9-tetrahydro-2*H*-benzo[2,3]cyclopropa[1,2-*e*]isoindole (4w)



4w

Compound **4w** was prepared in 57% yield (74.0 mg) according to the general procedure. 65 h. Pale yellow oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.64 (d, *J* = 8.5 Hz, 2H), 7.27 – 7.22 (m, 4H), 7.05 (d, *J* = 8.5 Hz, 2H), 6.99 (d, *J* = 9.0 Hz, 2H), 6.83 (s, 1H), 6.72 (d, *J* = 9.0 Hz, 2H), 6.39 (d, *J* = 2.5 Hz 1H), 6.23 (d, *J* = 7.5 Hz, 1H), 5.66 – 5.62 (m, 2H), 3.78 (s, 3H), 3.66 – 3.58 (m, 2H), 2.77 (dd, *J* = 15.5 Hz, 1H), 2.42 – 2.31 (m, 4H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 158.0, 144.7, 142.7, 136.2, 132.7, 132.5, 131.2, 130.4, 130.1, 129.8, 129.2, 129.1, 128.8, 126.8, 126.6, 122.2, 121.8, 118.1, 115.7, 112.9, 65.2, 55.1, 45.5, 31.5, 30.5, 22.6, 21.6; IR (neat): 3285, 2203, 1704, 1532, 1491, 1322, 1184, 1093, 830, 527; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{34}H_{31}Cl_2NNaO_3S^+$ 627.1924; Found 627.1923.

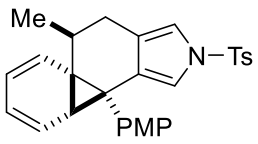
5-bromo-8-(4-bromophenyl)-3b-(4-methoxyphenyl)-2-tosyl-3b,3c,8,9-tetrahydro-2*H*-benzo[2,3]cyclopropa[1,2-*e*]isoindole (4x)



4x

Compound **4x** was prepared in 88% yield (110.6 mg) according to the general procedure. 55 h. Pale yellow oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.63 (d, *J* = 8.0 Hz, 2H), 7.39 (d, *J* = 8.5 Hz, 2H), 7.26 (d, *J* = 7.5 Hz, 2H), 7.02 – 6.95 (m, 4H), 6.83 (s, 1H), 6.72 (d, *J* = 8.5 Hz, 2H), 6.43 – 6.37 (m, 2H), 5.84 (d, *J* = 9.0 Hz, 1H), 5.57 (d, *J* = 9.0 Hz, 1H), 3.78 (s, 3H), 3.67 – 3.59 (m, 2H), 2.78 (dd, *J* = 15.5 Hz, 1H), 2.42 – 2.31 (m, 4H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 157.9, 144.7, 143.1, 136.1, 132.6, 131.7, 131.0, 130.4, 129.8, 129.6, 129.1, 128.9, 126.8, 125.2, 122.2, 120.5, 118.9, 118.0, 115.7, 112.8, 68.1, 55.1, 45.7, 31.0, 29.3, 21.6; IR (neat): 3051, 2932, 2837, 1609, 1489, 1369, 1248, 1171, 1062, 816, 738, 676, 538; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{34}H_{31}Br_2NNaO_3S^+$ 714.0284; Found 714.0284.

3b-(4-methoxyphenyl)-8-methyl-2-tosyl-3b,3c,8,9-tetrahydro-2*H*-benzo[2,3]cyclopropa[1,2-*e*]isoindole (4z)

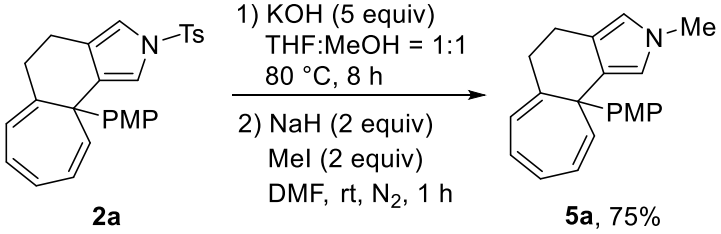


4z

Compound **4z** was prepared in 94% yield (86.0 mg) according to the general procedure. 48 h. Pale yellow oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.61 (d, *J* = 8.5 Hz, 2H), 7.22 (d, *J* = 8.0 Hz, 2H), 6.97 (d, *J* = 8.5 Hz, 2H), 6.80 – 6.76 (m, 1H), 6.64 (d, *J* = 8.5 Hz, 2H), 6.44 (d, *J* = 2.0 Hz, 1H), 6.19 – 6.13 (m, 1H), 6.06 (d, *J* = 8.0 Hz, 1H), 5.96 – 5.88 (m, 2H), 3.77 – 3.72 (m, 4H), 2.67 (dd, *J* = 15.0, 4.5 Hz, 1H), 2.60 – 2.55 (m, 1H), 2.38 (s, 3H), 2.09 – 2.02 (m, 1H), 1.06 (d, *J* = 6.5 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 157.4, 144.4, 136.4, 134.5, 132.8, 130.7, 129.7, 126.6, 126.4, 125.6, 125.2, 124.7, 123.2, 117.6, 115.4, 112.3, 55.0, 34.8, 34.4, 33.7, 28.3, 21.6, 21.6, 20.0. IR (neat): 2954, 2925, 2855, 1609, 1509, 1460, 1291, 1172, 1062, 812, 789, 674, 605, 583, 538; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{28}H_{27}NNaO_3S^+$ 480.1604; Found 480.1598.

4.3 Synthetic transformations

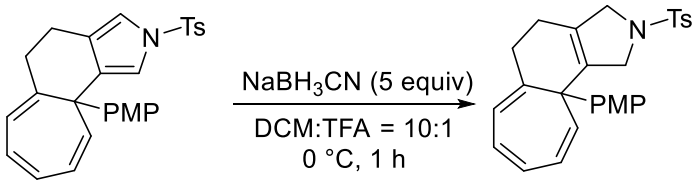
10a-(4-methoxyphenyl)-2-methyl-2,4,5,10a-tetrahydrocyclohepta[*e*]isoindole(5a)



2a **5a**, 75%

Compound **5a** was prepared in 75% yield according to the known procedure (0.1 mmol scale, 22.5 mg).[1,2] Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.07 (d, *J* = 8.8 Hz, 2H), 6.60 (d, *J* = 8.4 Hz, 2H), 6.36 – 6.25 (m, 3H), 6.21 – 6.15 (m, 2H), 6.00 (d, *J* = 2.0 Hz, 1H), 5.07 (d, J = 8.8 Hz, 1H), 3.70 (s, 3H), 3.48 (s, 3H), 2.85 – 2.69 (m, 3H), 2.59 – 2.44 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 157.0, 137.2, 130.4, 128.5, 128.4, 127.5, 125.6, 124.7, 123.4, 118.9, 118.5, 116.8, 116.3, 111.9, 54.9, 43.8, 36.0, 35.1, 21.8; IR (neat): 2924, 2849, 1702, 1607, 1459, 1394, 1243, 1174, 823, 789, 703; HRESIMS Calcd for $[C_{21}H_{21}NNaO]^+$ $[M + Na^+]$ 326.1515, found 326.1514.

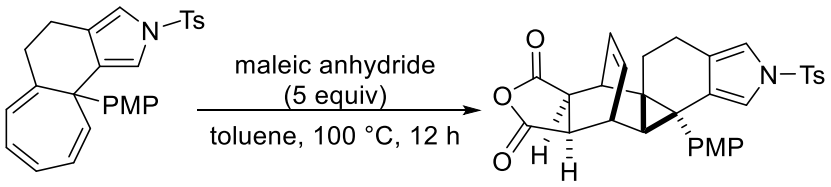
10a-(3-methoxyphenyl)-2-tosyl-1,2,3,4,5,10a-hexahydrocyclohepta[*e*]isoindole(5b)



2a **5b**, 85%

Compound **5b** was prepared in 85% yield according to the known procedure (0.1 mmol scale, 37.8 mg).[1] Pale yellow oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.73 (d, *J* = 8.0 Hz, 2H), 7.32 (d, *J* = 8.5 Hz, 2H), 7.22 – 7.13 (m, 3H), 7.04 (d, *J* = 8.0 Hz, 1H), 6.91 (d, *J* = 8.5 Hz, 2H), 6.71 (d, *J* = 9.0 Hz, 2H), 4.35 – 4.31 (m, 2H), 4.21 – 4.19 (m, 1H), 4.11 – 4.08 (m, 1H), 4.01 – 3.98 (m, 1H), 3.75 (s, 3H), 2.91 – 2.80 (m, 1H), 2.49 – 2.34 (m, 4H), 2.29 – 2.27 (m, 1H), 2.10 – 2.05 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 157.9, 143.4, 142.6, 140.0, 133.8, 133.3, 132.6, 130.2, 129.8, 129.3, 129.3, 128.1, 127.5, 127.3, 126.2, 113.6, 59.6, 59.4, 55.2, 48.0, 30.5, 27.1, 21.5; IR (neat): 2923, 1733, 1654, 1595, 1456, 1256, 1180, 1090, 700, 664, 583, 541; HRESIMS Calcd for $[C_{27}H_{27}NNaO_3S]^+$ [M + Na^+] 468.1604, found 468.1602.

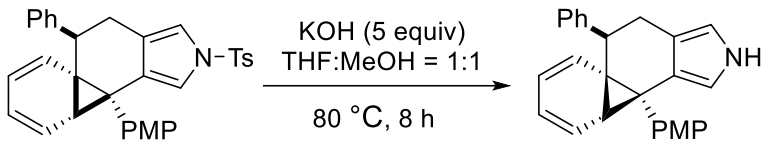
3b-(4-methoxyphenyl)-2-tosyl-3b,3c,4,4a,7a,8,9,10-octahydro-7*H*-4,8-ethenoisobenzofuro[5',6':2,3]cyclopropa[1,2-*e*]isoindole-5,7(2*H*)-dione(5c)



2a **5c**, 91%, dr > 20:1

Compound **5c** was prepared in 91% yield (dr > 20:1) according to the known procedure (0.1 mmol scale, 49.3 mg).[3] Pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.64 – 7.53 (d, *J* = 8.0 Hz, 2H), 7.23 (d, *J* = 8.0 Hz, 2H), 6.91 – 6.65 (m, 5H), 6.02 (s, 1H), 5.42 – 5.22 (m, 2H), 3.81 (s, 3H), 3.62 – 3.60 (m, 2H), 3.40 – 3.38 (m, 1H), 3.21 – 3.18 (m, 1H), 2.65 – 2.63 (m, 1H), 2.39 (s, 3H), 2.30 – 2.17 (m, 1H), 2.09 – 2.06 (m, 2H), 1.65 – 1.63 (m, 1H); ^{13}C NMR (100 MHz, CDCl3) δ 172.3, 171.7, 157.8, 144.6, 136.1, 133.3, 133.1, 131.0, 130.0, 129.8, 126.7, 122.1, 117.9, 115.7, 114.6, 113.6, 55.2, 45.5, 44.6, 38.8, 33.9, 32.5, 31.7, 29.5, 23.7, 21.6, 19.7; IR (neat): 2954, 2343, 1791, 1660, 1507, 1169, 1062, 932, 816, 702, 668; HRESIMS Calcd for $[C_{31}H_{27}NNaO_6S]^+$ [M + Na^+] 564.1451, found 564.1452.

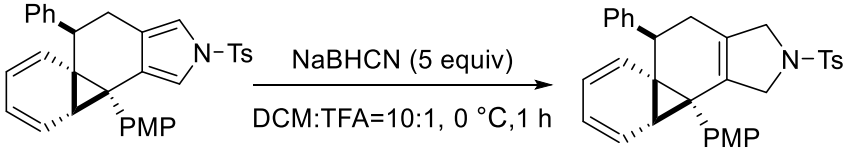
3b-(4-methoxyphenyl)-8-phenyl-3b,3c,8,9-tetrahydro-2*H*-benzo[2,3]cyclopropa[1,2-*e*]isoindole (5d)



4a **5d**, 83%

Compound **5d** was prepared in 83% yield (60.4 mg) according to the known procedure (0.2 mmol scale).[1] Yellow solid. M.p = 160.8 – 162.5 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.81 (s, 1H), 7.33 – 7.29 (m, 2H), 7.29 – 7.24 (m, 3H), 7.20 – 7.11 (m, 2H), 6.70 – 6.67 (m, 2H), 6.50 (s, 1H), 6.35 – 6.29 (m, 1H), 6.11 – 6.05 (m, 1H), 5.95 – 5.85 (m, 1H), 5.82 – 5.70 (m, 2H), 3.83 – 3.75 (m, 2H), 3.74 (s, 3H), 2.89 (dd, *J* = 15.5, 5.0 Hz, 1H), 2.65 – 2.49 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 157.2, 145.8, 133.0, 131.4, 128.3, 128.2, 127.7, 126.2, 125.1, 125.0, 124.2, 116.9, 115.3, 112.9, 112.2, 77.9, 68.8, 55.0, 47.5, 30.5, 30.1; IR (neat): 3357, 3337, 1612, 1511, 1246, 1060, 1034, 786, 768, 699, 531; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{26}H_{22}NNaOS^+$ 387.1594; Found 387.1593.

3b-(4-methoxyphenyl)-8-phenyl-2-tosyl-2,3,3b,3c,8,9-hexahydro-1*H*-benzo[2,3]cyclopropa[1,2-*e*]isoindole (5e)



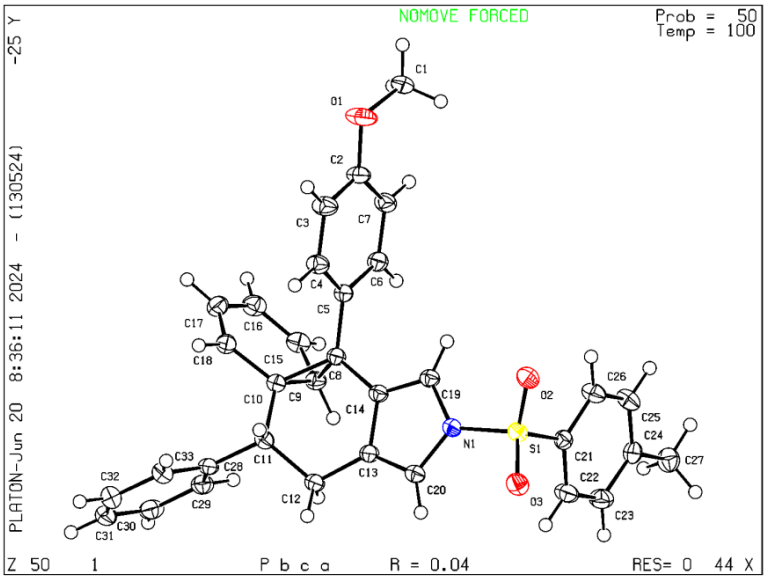
4a **5e**, 73%

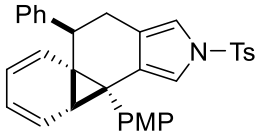
Compound **5e** was prepared in 73% yield (76.1 mg) according to the known procedure (0.2 mmol scale).[2] Yellow solid. M.p = 61.2 – 62.2 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.66 (d, *J* = 8.5 Hz, 2H), 7.31 (d, *J* = 8.0 Hz, 2H), 7.18 – 7.14 (m, 3H), 7.10 – 7.06 (m, 2H), 7.01 – 6.96 (m, 3H), 6.87 – 6.83 (m, 1H), 6.74 – 6.70 (m, 2H), 6.67 – 6.63 (m, 2H), 4.93 (s, 1H), 4.56 (dd, *J* = 9.0, 3.0 Hz, 1H), 4.26 – 4.18 (m, 1H), 4.09 (d, *J* = 11 Hz, 2H), 3.82 – 3.73 (m, 4H), 2.87 – 2.75 (m, 1H), 2.59 (d, *J* = 18.0 Hz, 1H), 2.44 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 158.0, 143.4, 143.1, 142.2, 141.1, 133.7, 131.0, 130.9, 130.2, 130.1, 129.7, 129.6, 129.2, 128.3, 127.8, 127.5, 126.8, 126.4, 126.3, 113.6, 60.1, 59.3, 55.2, 47.9, 46.2, 31.0, 21.5; IR (neat): 2925, 1609, 1509, 1344, 1253, 1163, 1098, 1033, 815, 736, 671; HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{33}H_{31}NNaO_3S^+$ 544.1917; Found 544.1916.

5. Crystal Data

Crystal data and structure refinement for **4a**. CCDC Number = 2410274

ORTEP drawing of **4a** (thermal ellipsoids set at 50% probability). Recrystallization from *n*-hexane/DCM afforded single crystals suitable for X-ray diffraction analysis.





Bond precision: C-C = 0.0021 A Wavelength=0.71073

Cell: a=13.4398(8) b=16.1210(9) c=24.2005(11)
alpha=90 beta=90 gamma=90

Temperature: 100 K

	Calculated	Reported
Volume	5243.4(5)	5243.4(5)
Space group	P b c a	P b c a
Hall group	-P 2ac 2ab	-P 2ac 2ab
Moiety formula	C33 H29 N O3 S	C33 H29 N O3 S
Sum formula	C33 H29 N O3 S	C33 H29 N O3 S
Mr	519.63	519.63
Dx,g cm-3	1.316	1.317
Z	8	8
Mu (mm-1)	0.160	0.160
F000	2192.0	2192.0
F000'	2193.89	
h,k,lmax	17,21,32	17,21,32
Nref	6523	6519
Tmin,Tmax	0.962,0.972	0.702,0.746
Tmin'	0.962	

Correction method= # Reported T Limits: Tmin=0.702 Tmax=0.746
AbsCorr = MULTI-SCAN

Data completeness= 0.999 Theta(max)= 28.321

R(reflections)= 0.0442(5445) wR2(reflections)= 0.1064(6519)

S = 1.070 Npar= 345

Reference

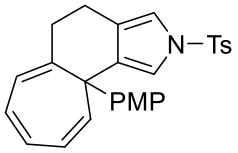
1. Y.-B. Chen, L.-G. Liu, Z.-Q. Wang, R. Chang, X. Lu, B. Zhou and L.-W. Ye, Enantioselective Functionalization of Unactivated C(sp^3)–H Bonds through Copper-Catalyzed Diyne Cyclization by Kinetic Resolution, *Nat. Commun.*, 2024, **15**, 2232.

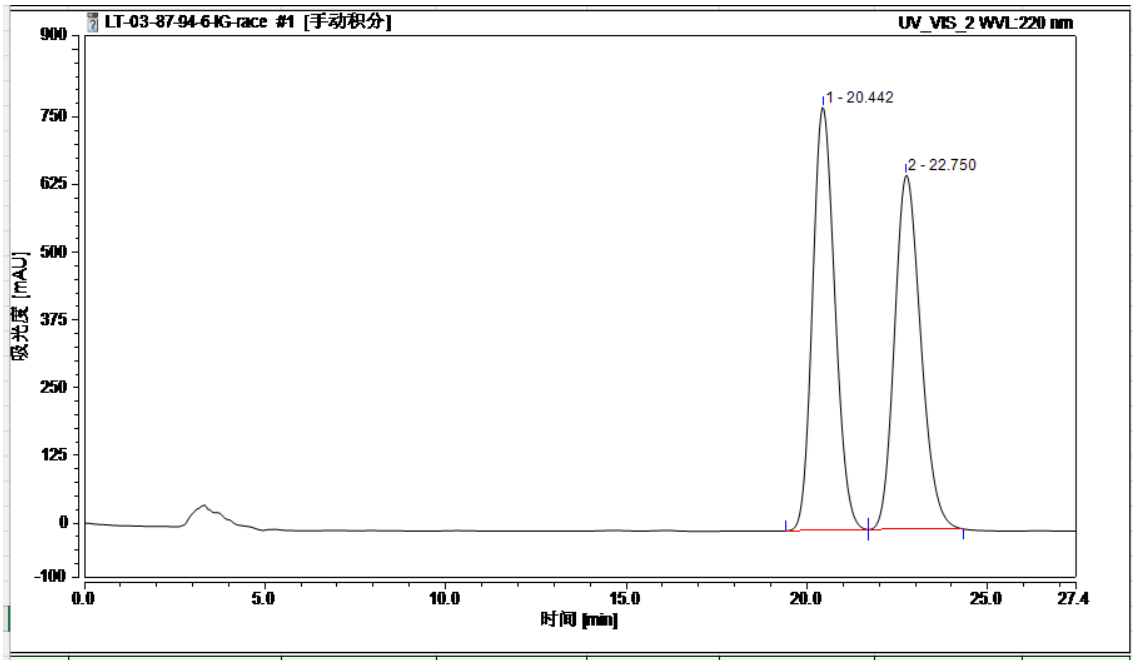
2. Y.-B. Chen, L.-G. Liu, C.-M. Chen, Y.-X. Liu, B. Zhou, X. Lu, Z. Xu, and L.-W. Ye, Construction of Axially Chiral Arylpyrroles via Atroposelective Diyne Cyclization, *Angew. Chem. Int. Ed.*, 2023, **62**, e202303670.

3. T. Ito, S. Harada, H. Homma, H. Takenaka, S. Hirose and T. Nemoto, Asymmetric Intramolecular Dearomatization of Nonactivated Arenes with Ynamides for Rapid Assembly of Fused Ring System under Silver Catalysis, *J. Am. Chem. Soc.*, 2021, **143**, 604.

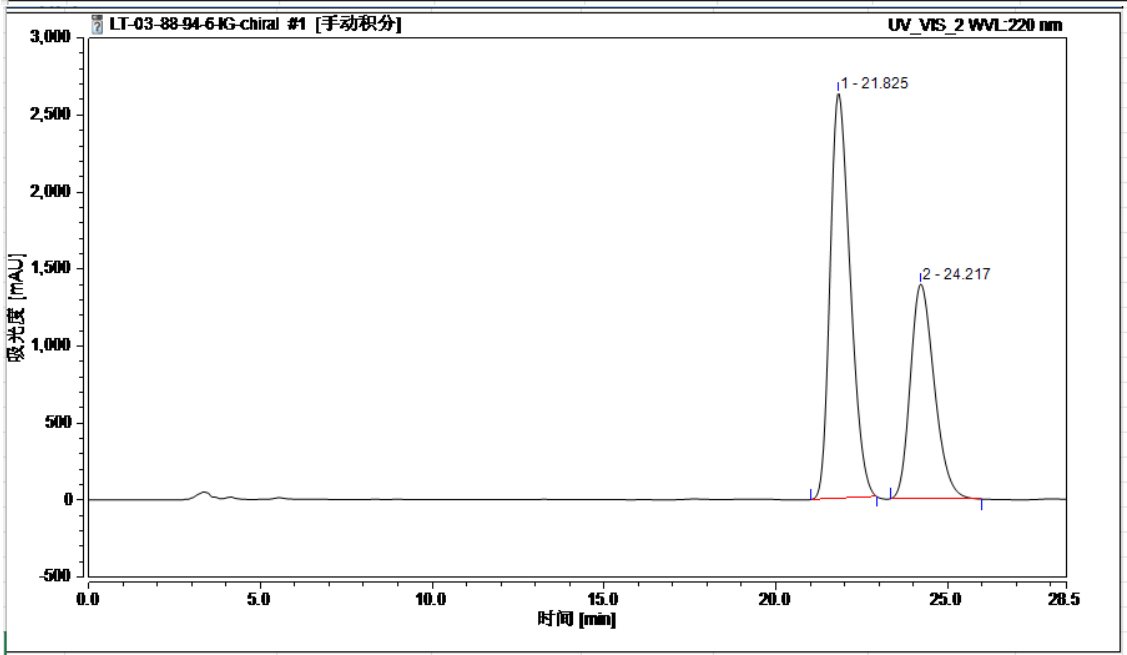
6. HPLC Chromatograms

ent-**2a**: IC, *n*-hexane/2-propanol = 94/6, v = 1.0 mL·min^{-1}, λ = 220 nm



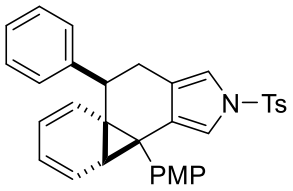


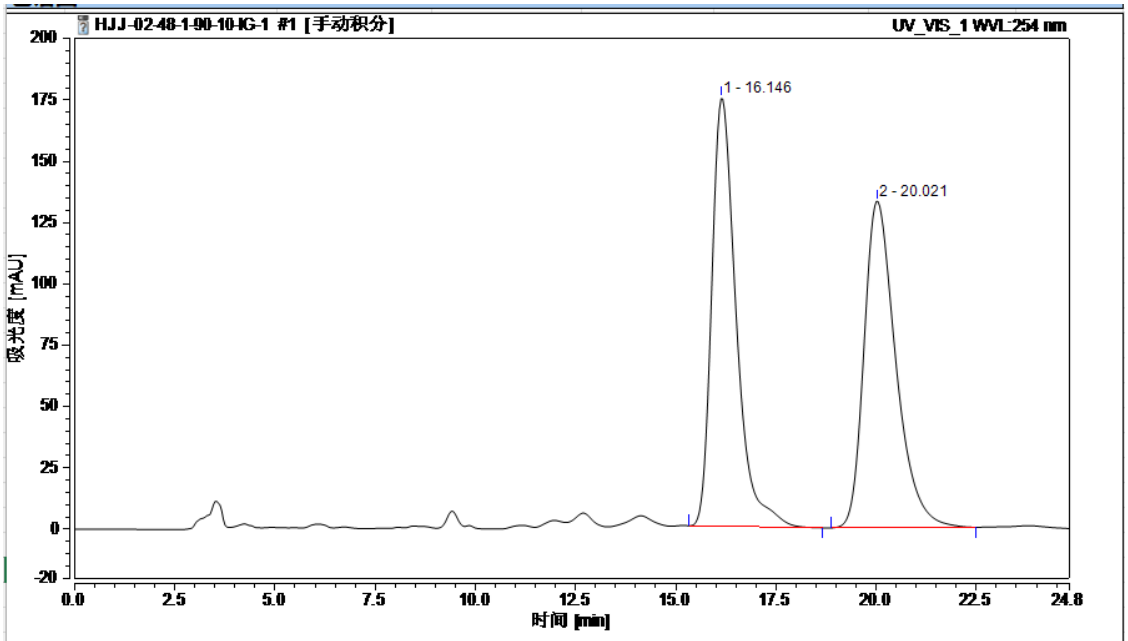
No.	Peak Name	Ret. Time min	Area mAU*min	Height mAU	Rel. Area %	Rel. Height %	Type
1		20.442	559.600	782.126	50.40	54.44	n.a.
2		22.750	550.823	654.632	49.60	45.56	n.a.
Total:			**1110.422**	**1436.758**	**100.00**	**100.00**	



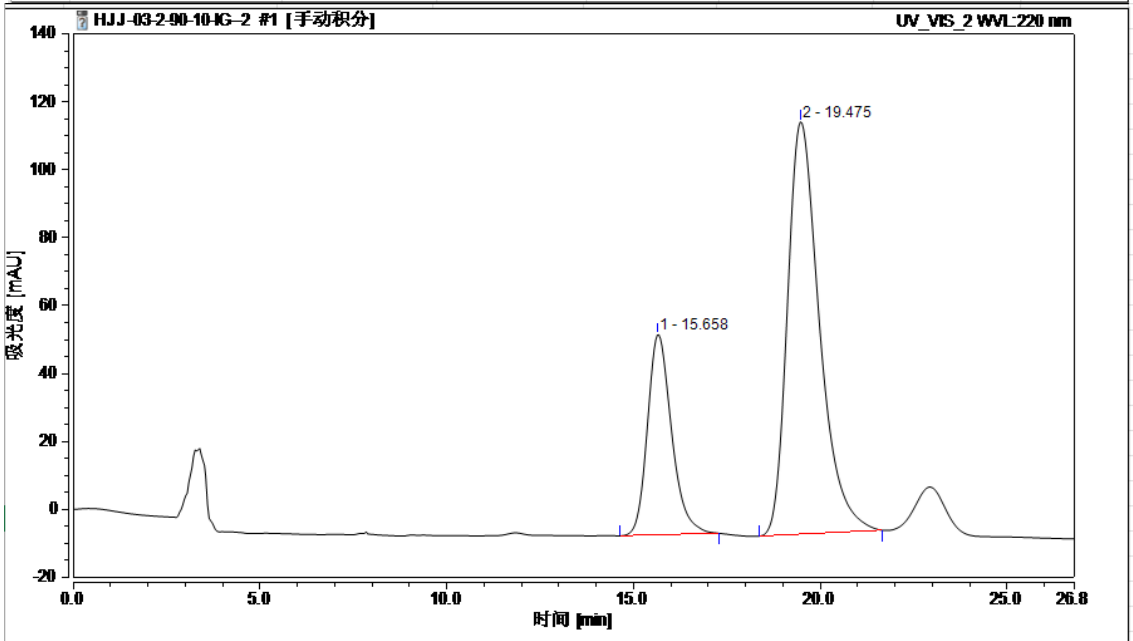
No.	Peak Name	Ret. Time min	Area mAU*min	Height mAU	Rel. Area %	Rel. Height %	Type
1		21.825	1784.571	2632.975	61.30	65.37	n.a.
2		24.217	1126.467	1394.726	38.70	34.63	n.a.
Total:			**2911.038**	**4027.701**	**100.00**	**100.00**	

ent-**4a**: IC, *n*-hexane/2-propanol = 90/10, v = 1.0 mL·min^{-1}, λ = 254 nm

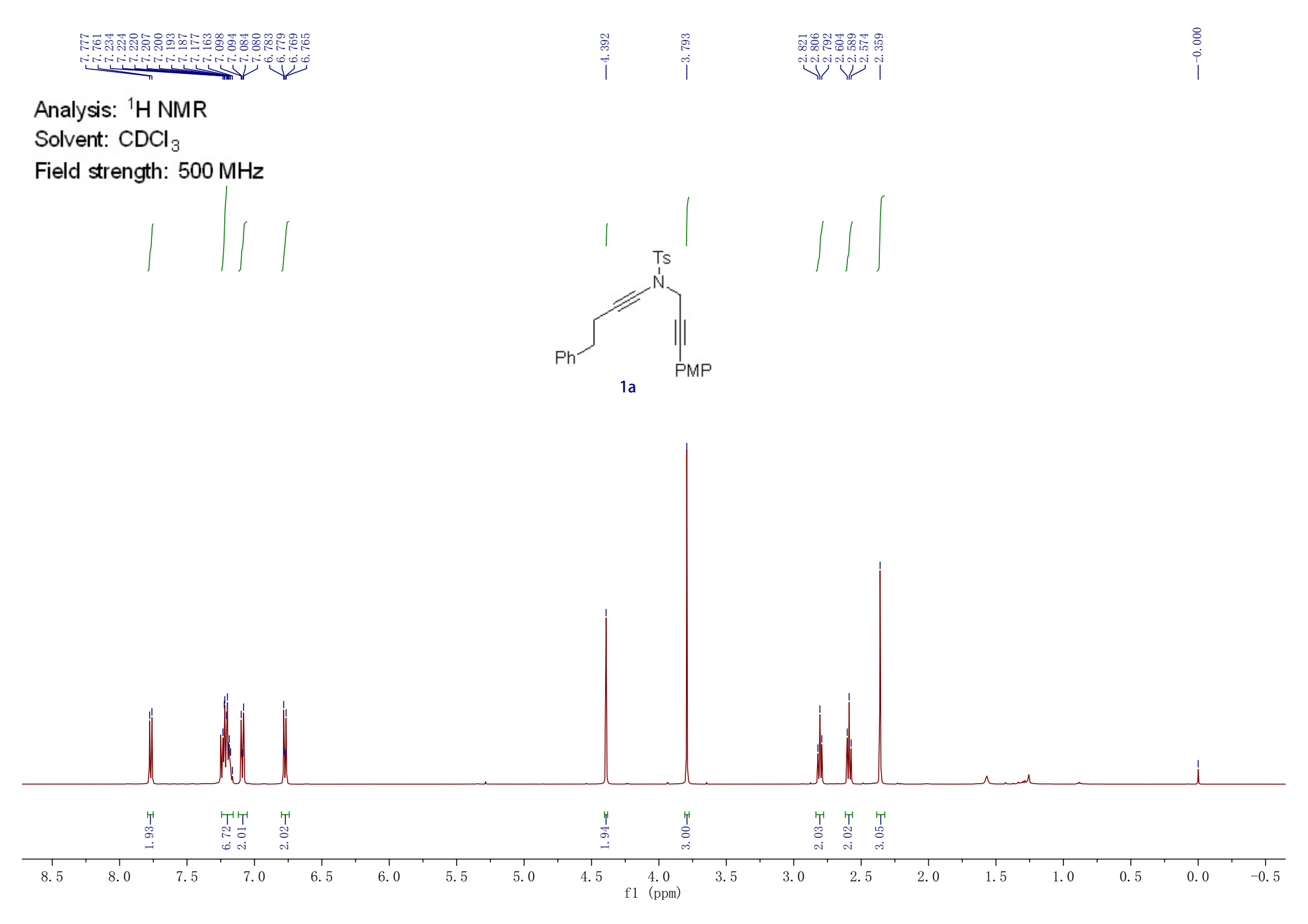




No.	Peak Name	Ret. Time min	Area mAU*min	Height mAU	Rel. Area %	Rel. Height %	Type
1		16.146	123.434	174.798	50.25	56.75	n.a.
2		20.021	122.226	133.233	49.75	43.25	n.a.
Total:			**245.659**	**308.032**	**100.00**	**100.00**	

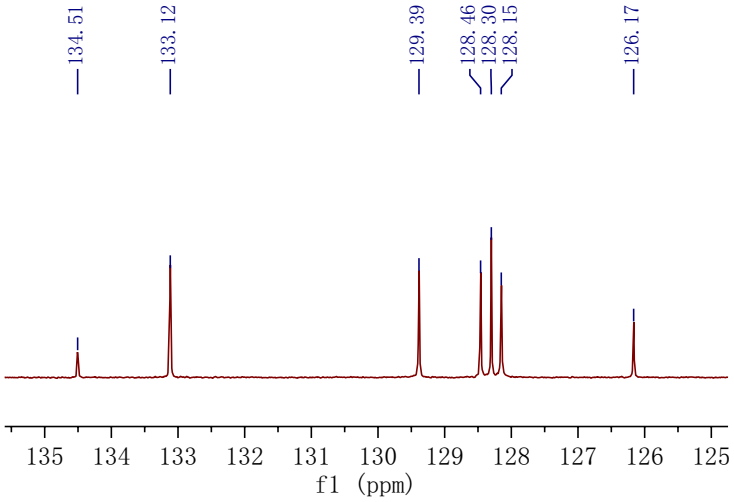


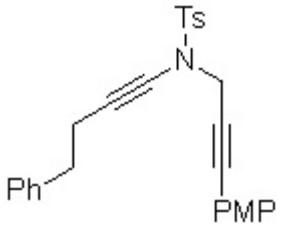
No.	Peak Name	Ret. Time min	Area mAU*min	Height mAU	Rel. Area %	Rel. Height %	Type
1		15.658	44.196	59.060	26.82	32.70	n.a.
2		19.475	120.602	121.549	73.18	67.30	n.a.
Total:			**164.798**	**180.609**	**100.00**	**100.00**	


7.777
7.761
7.234
7.224
7.220
7.207
7.200
7.193
7.187
7.177
7.163
7.098
7.094
7.084
7.080
6.783
6.779
6.769
6.765
4.392
3.793
2.821
2.806
2.792
2.604
2.589
2.574
2.359
-0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 500 MHz
Ts
N
Ph
PMP
1a
1.93
6.72
2.01
2.02
1.94
3.00
2.03
2.02
3.05
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

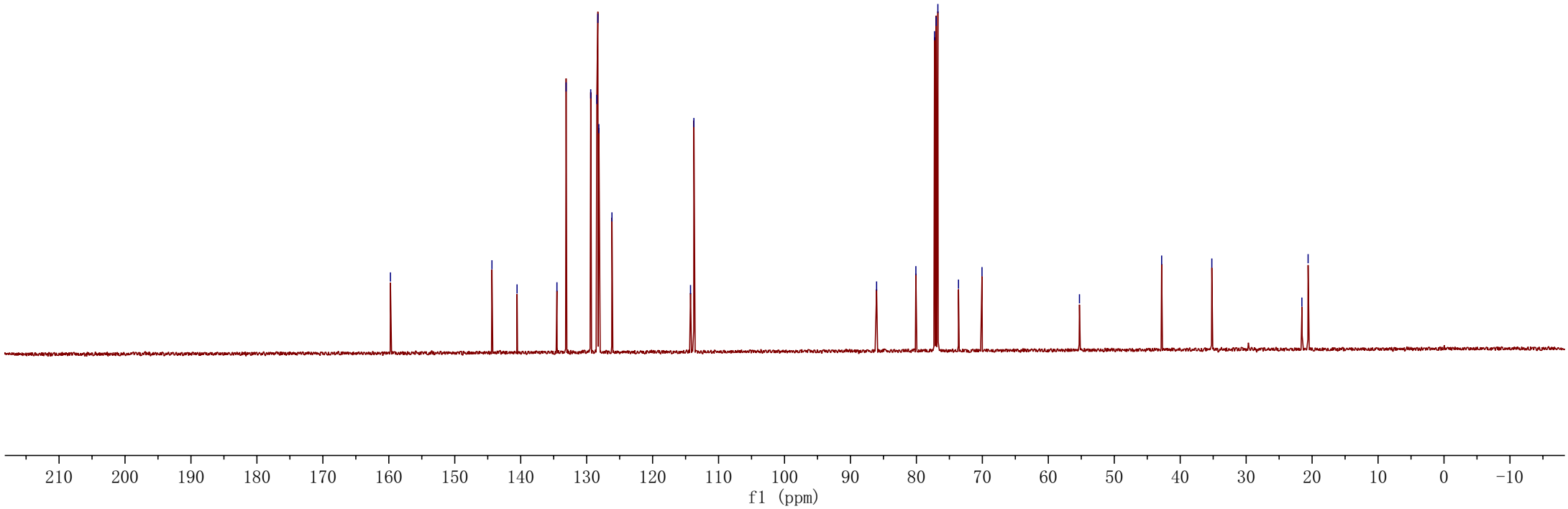
Analysis: ^{13}C NMR
Solvent: $CDCl_3$
Field strength: 125 MHz

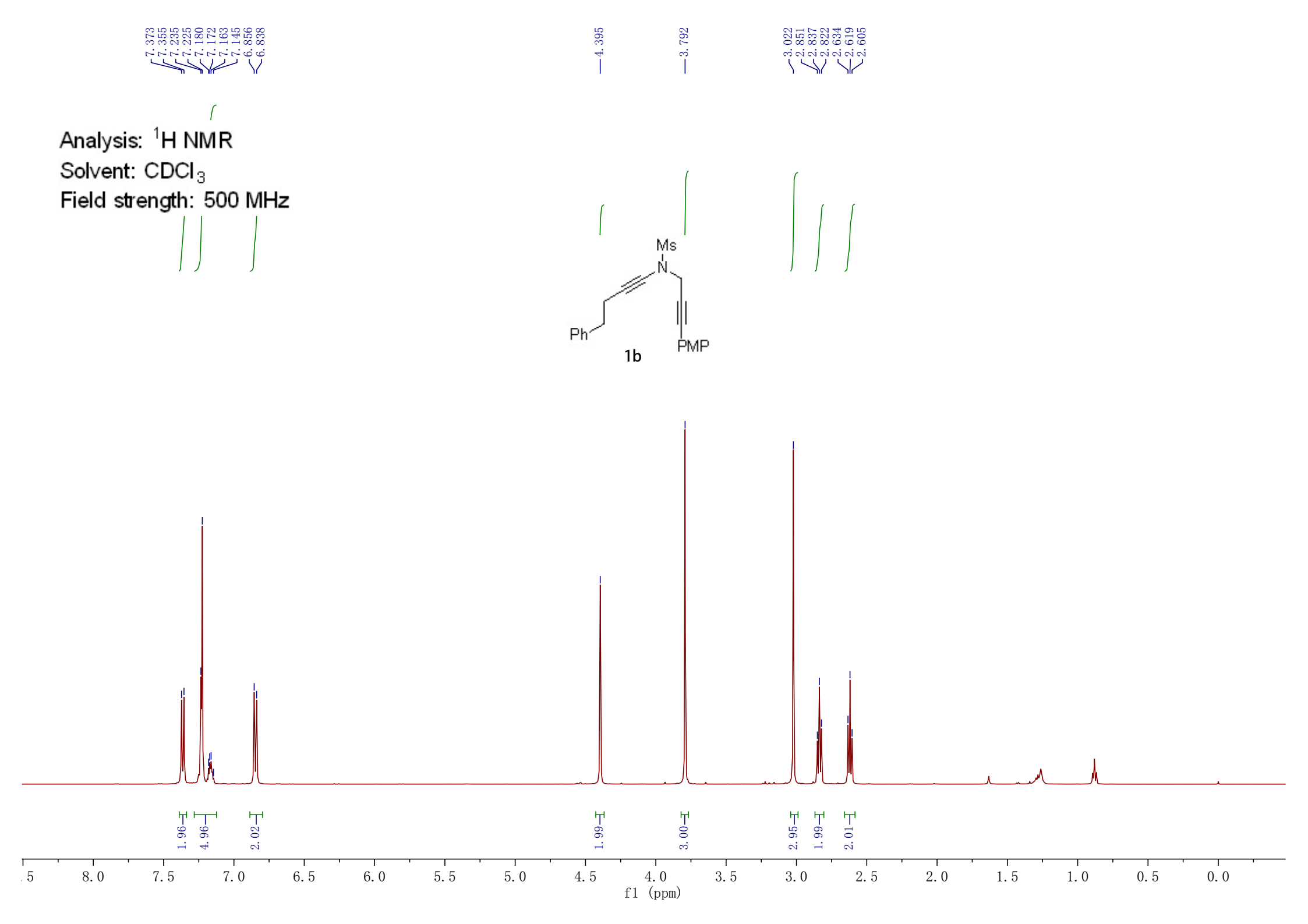
159.75
144.36
140.55
134.51
133.12
129.39
128.46
128.30
128.15
126.17
114.25
113.74
86.04
80.08
77.25
77.00
76.75
73.62
70.05
55.27
42.81
35.20
21.55
20.61





1a

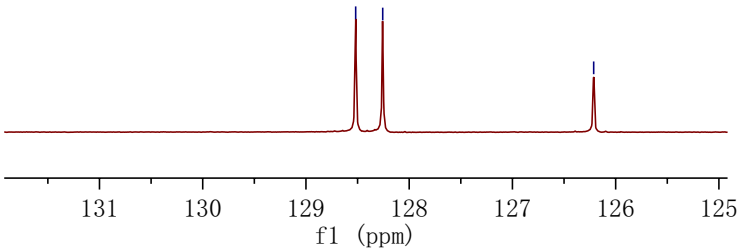


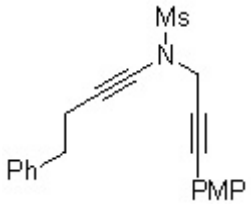

7.373
7.355
7.235
7.225
7.180
7.172
7.163
7.145
6.856
6.838
4.395
3.792
3.022
2.851
2.837
2.822
2.634
2.619
2.605
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 500 MHz
Ms
N
Ph
PMP
1b
1.96
4.96
2.02
1.99
3.00
2.95
1.99
2.01
f1 (ppm)

Analysis: ^{13}C NMR

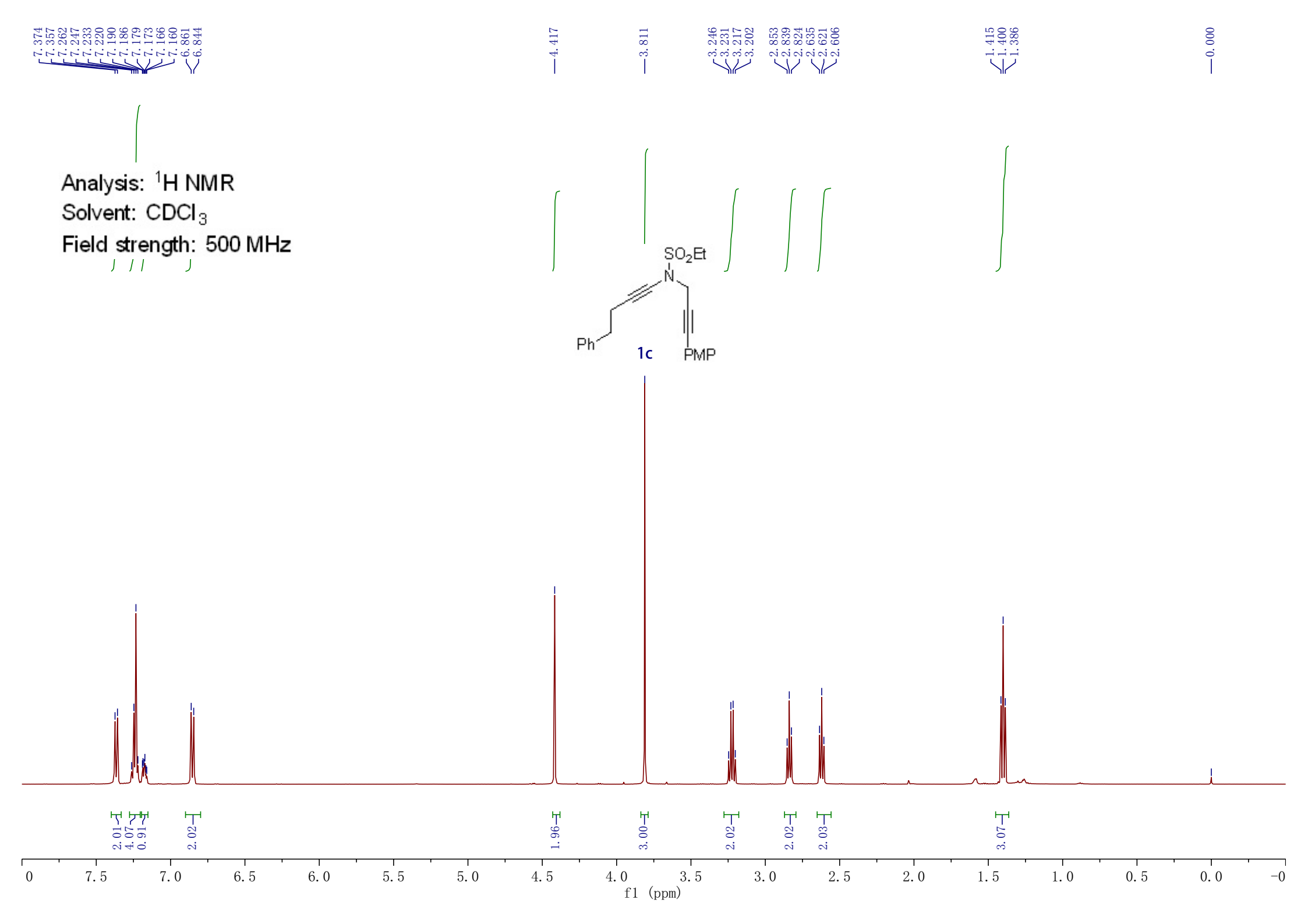
Solvent: $CDCl_3$

Field strength: 125 MHz



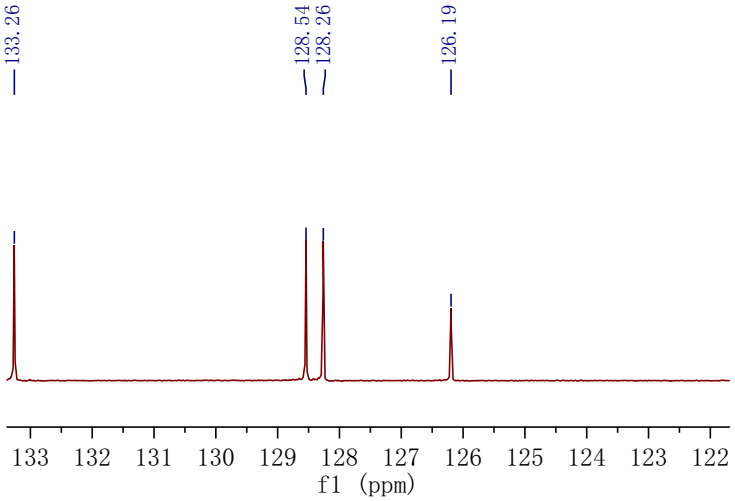


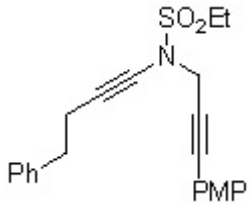
1b


7.374
7.357
7.262
7.247
7.233
7.220
7.190
7.186
7.179
7.173
7.166
7.160
6.861
6.844
4.417
3.811
3.246
3.231
3.217
3.202
2.853
2.839
2.824
2.635
2.621
2.606
1.415
1.400
1.386
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 500 MHz
SO2Et
N
Ph
PMP
1c
2.01
4.07
0.91
2.02
1.96
3.00
2.02
2.02
2.03
3.07
f1 (ppm)

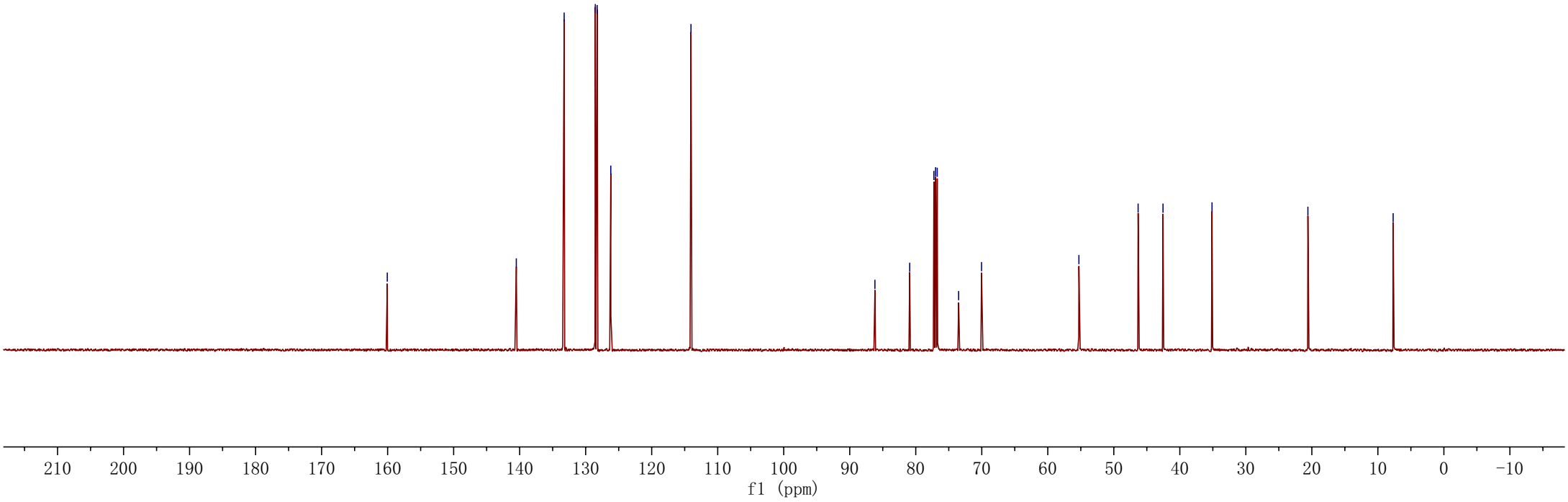
Analysis: ^{13}C NMR
Solvent: $CDCl_3$
Field strength: 125 MHz

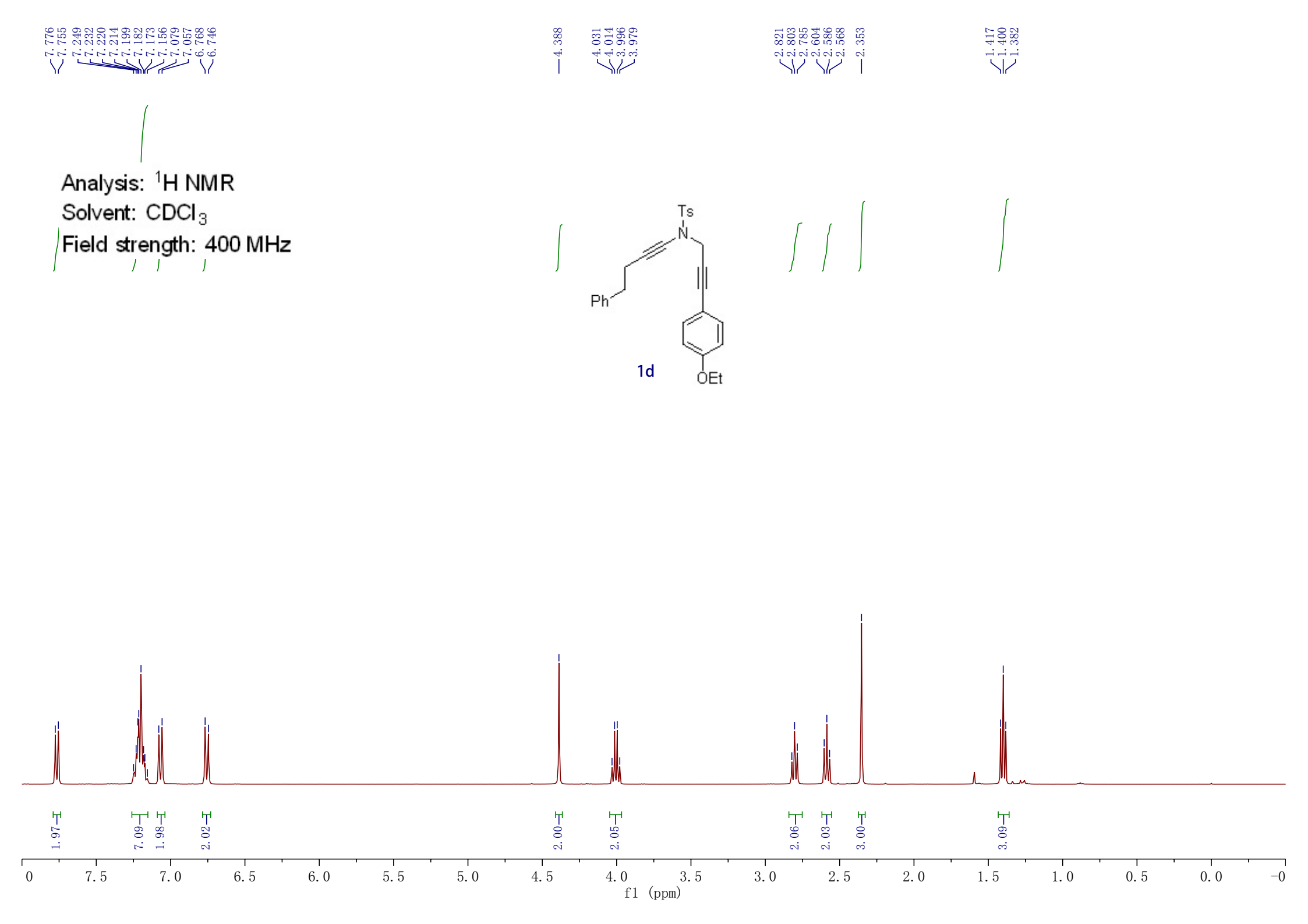
160.05 140.51 133.26 128.54 128.26 126.19 114.05 86.19 80.92 77.25 77.00 76.75 73.51 70.04 55.29 46.32 42.55 35.12 20.60 7.69





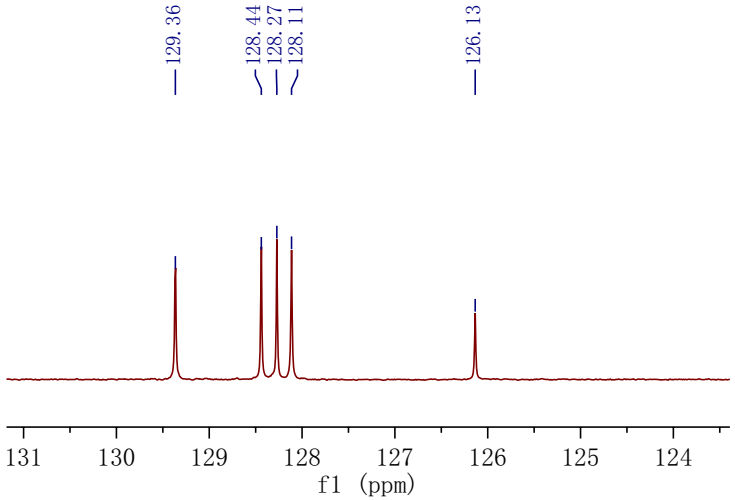
1c

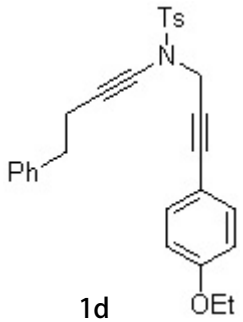



7.776
7.755
7.249
7.232
7.220
7.214
7.199
7.182
7.173
7.156
7.079
7.057
6.768
6.746
4.388
4.031
4.014
3.996
3.979
2.821
2.803
2.785
2.604
2.586
2.568
2.353
1.417
1.400
1.382
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
Ts
N
Ph
OEt
1d
1.97
7.09
1.98
2.02
2.00
2.05
2.06
2.03
3.00
3.09
0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0
f1 (ppm)

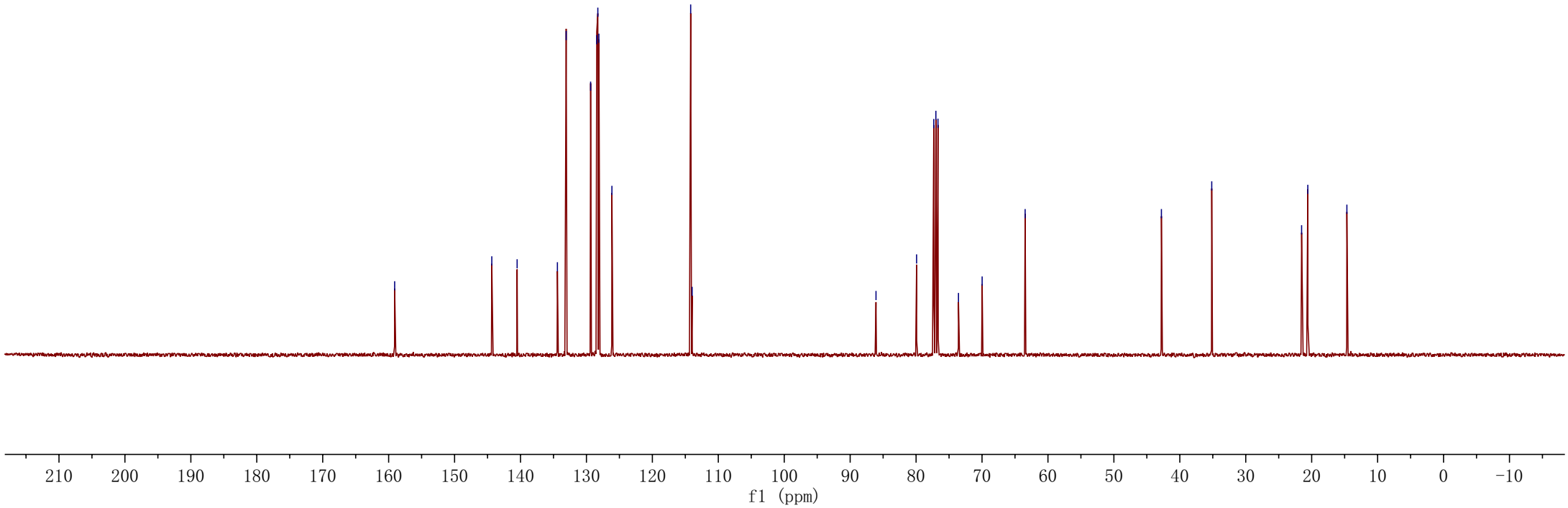
Analysis: ^{13}C NMR
Solvent: $CDCl_3$
Field strength: 100 MHz

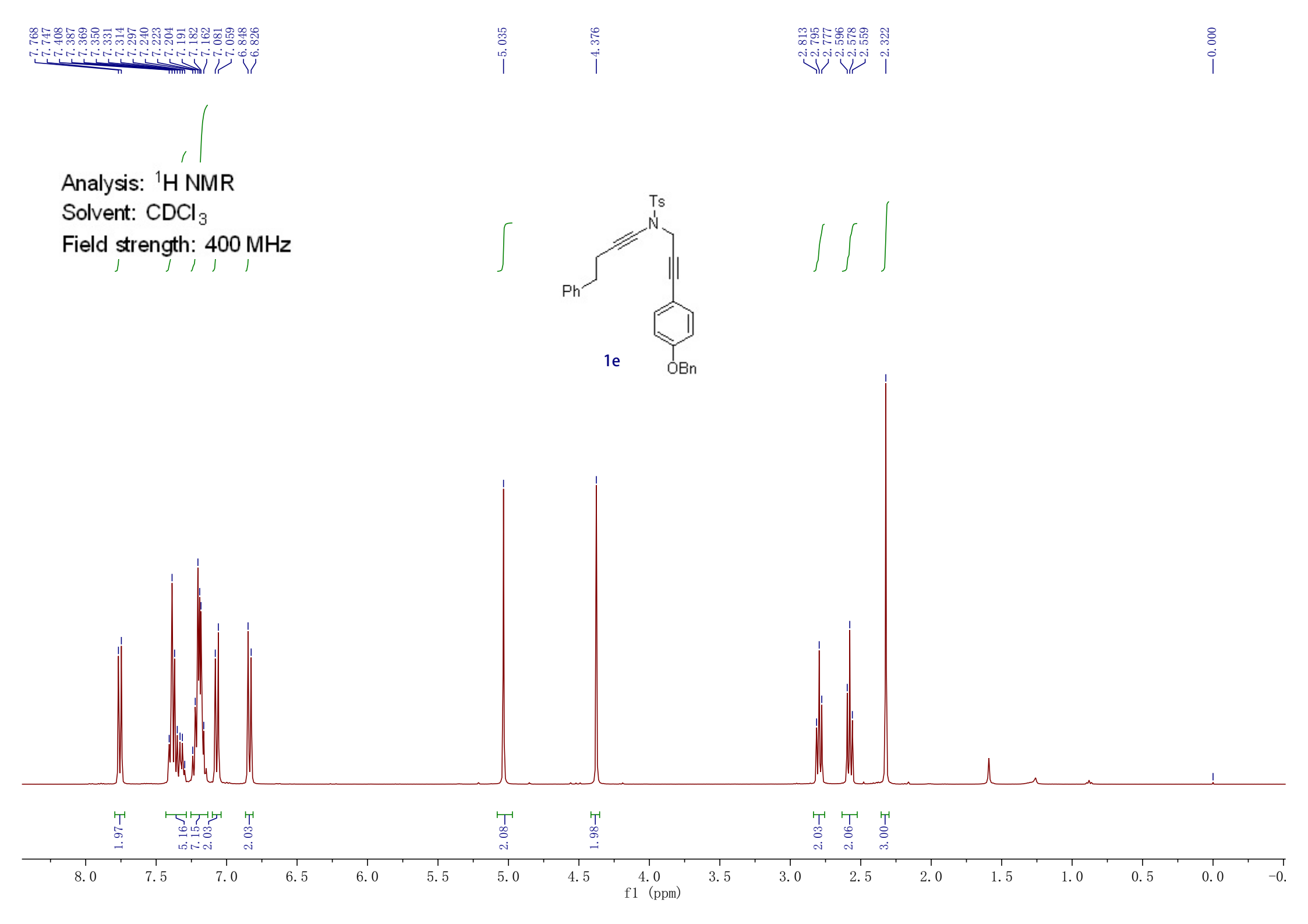
159.09
144.35
140.51
134.40
133.07
129.36
128.44
128.27
128.11
126.13
114.19
113.97
86.08
79.92
77.32
77.00
76.68
73.57
69.98
63.46
42.79
35.16
21.53
20.59
14.66





1d




7.768
7.747
7.408
7.387
7.369
7.350
7.331
7.314
7.297
7.240
7.223
7.204
7.191
7.182
7.162
7.081
7.059
6.848
6.826
5.035
4.376
2.813
2.795
2.777
2.596
2.578
2.559
2.322
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
Ts
N
Ph
OBn
1e
1.97
5.16
7.15
2.03
2.03
2.08
1.98
2.03
2.06
3.00
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.
f1 (ppm)

Analysis: ^{13}C NMR

Solvent: $CDCl_3$

Field strength: 100 MHz

158.82
144.35
140.48
136.40
134.36
133.08
129.35
128.56
128.42
128.25
128.08
128.05
127.35
126.12
114.60
114.41
85.94
80.10
77.32
77.00
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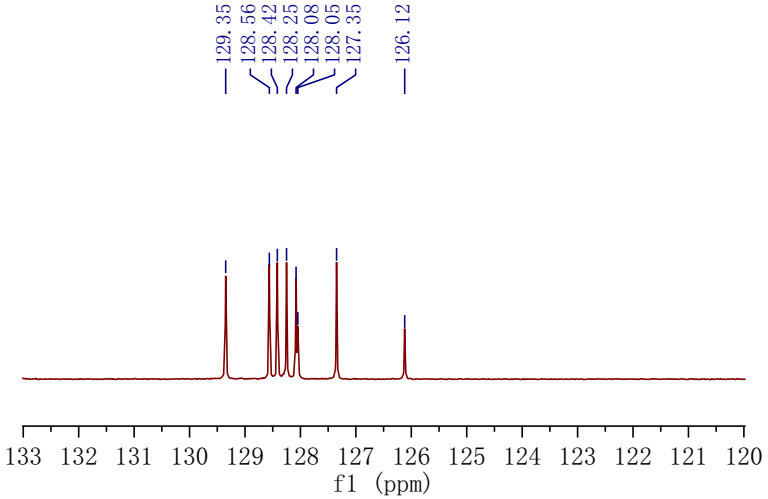
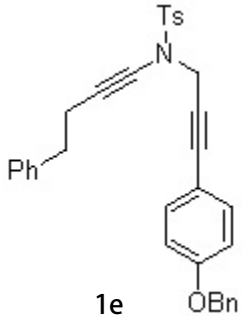
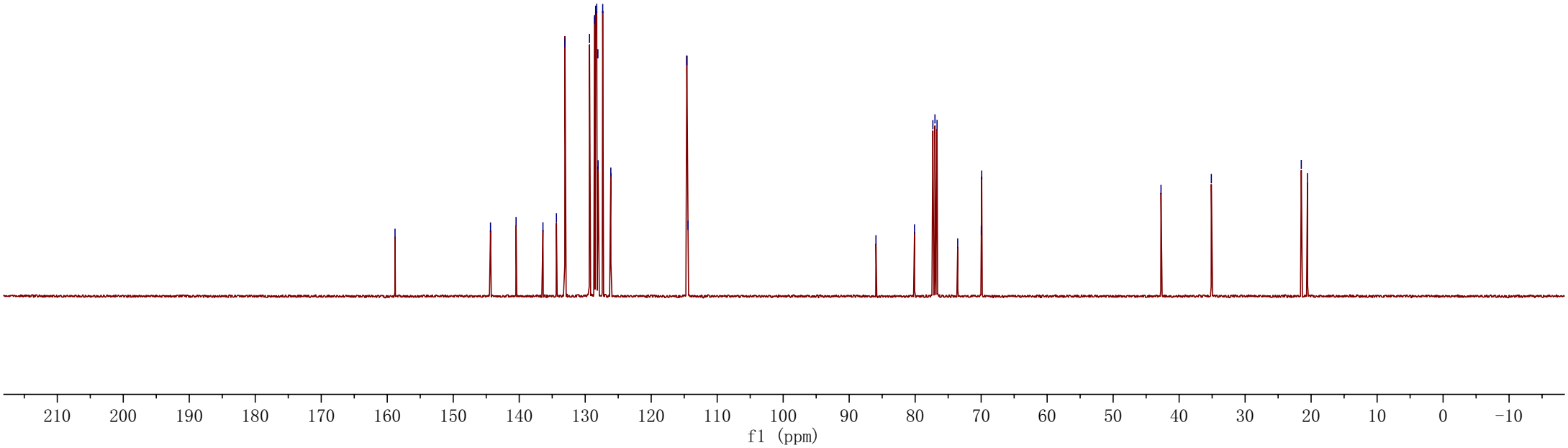
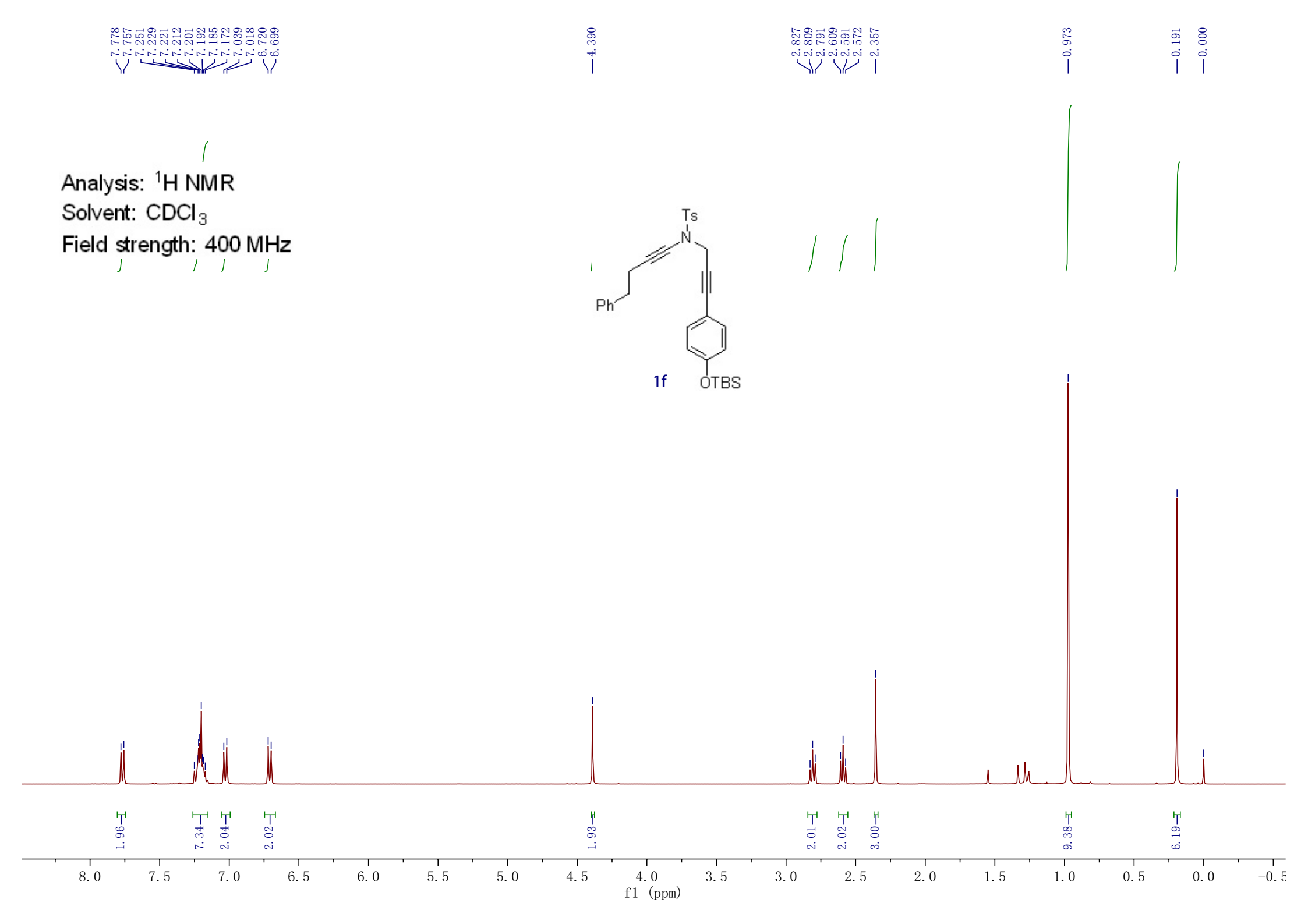
73.55
69.98
69.91
42.75
35.12
21.49
20.55





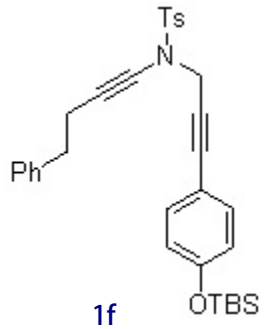
1e



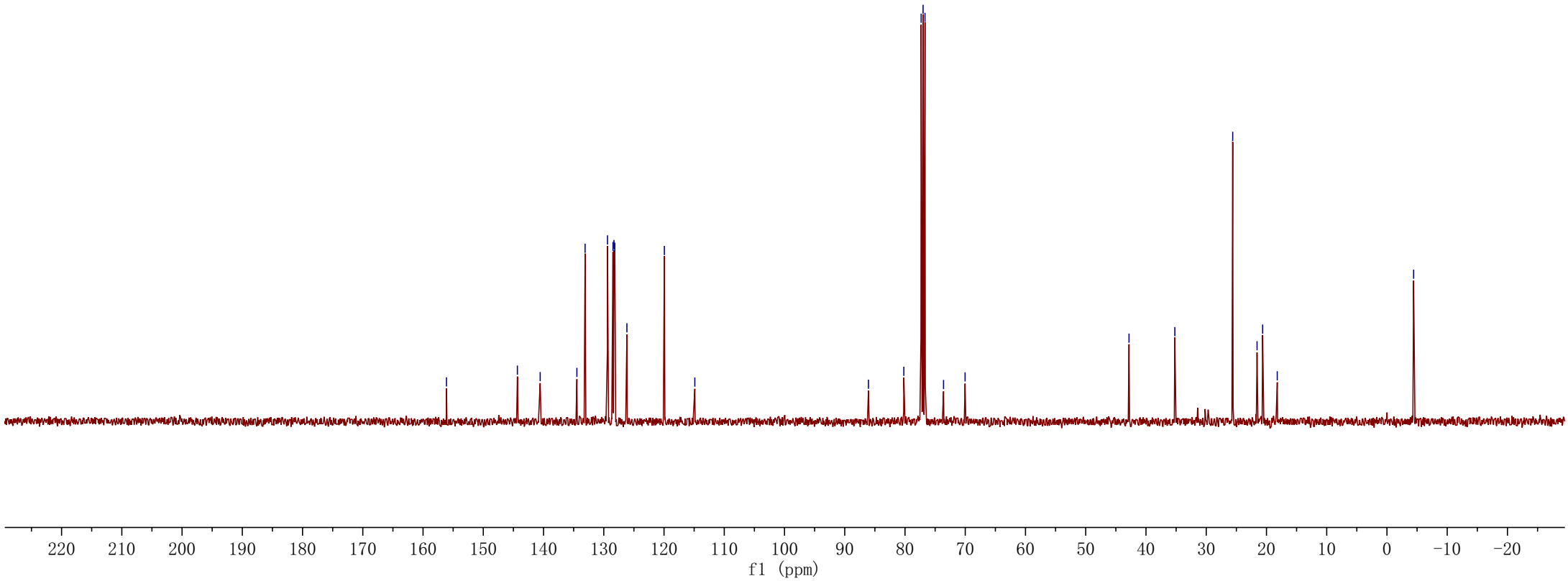

7.778
7.757
7.251
7.229
7.221
7.212
7.201
7.192
7.185
7.172
7.039
7.018
6.720
6.699
4.390
2.827
2.809
2.791
2.609
2.591
2.572
2.357
0.973
0.191
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
Ts
N
Ph
1f
OTBS
1.96
7.34
2.04
2.02
1.93
2.01
2.02
3.00
9.38
6.19
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

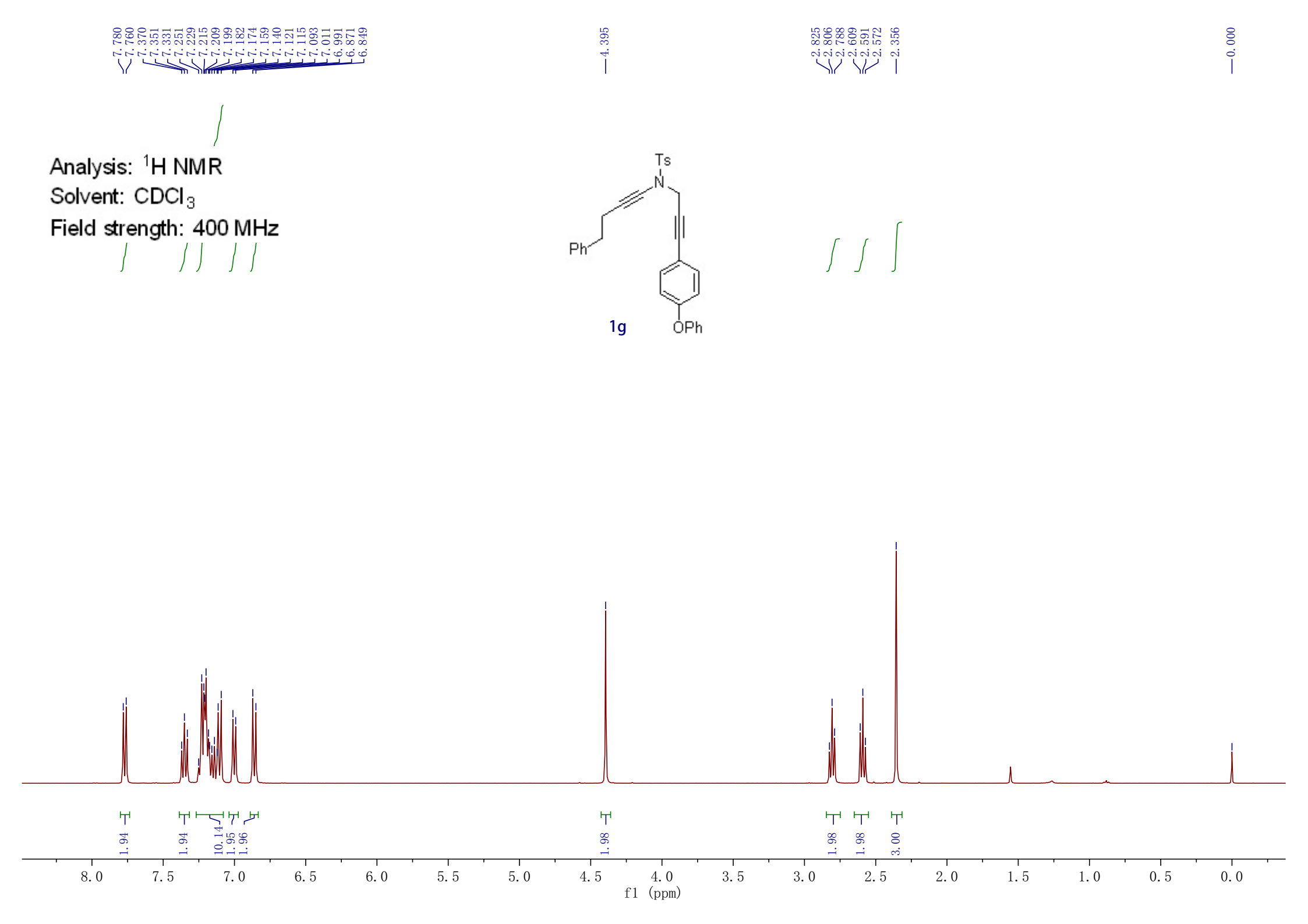
Analysis: ^{13}C NMR
Solvent: $CDCl_3$
Field strength: 100 MHz

156.11
144.34
140.56
134.46
133.10
129.38
128.47
128.30
128.17
126.16
119.94
114.89
86.07
80.19
77.32
77.00
76.68
73.60
70.03
42.82
35.21
25.60
21.56
20.64
18.21
-4.43



1f



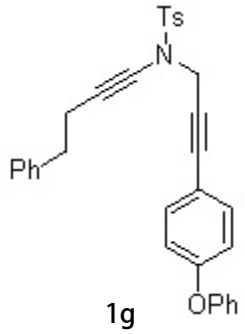

7.780
7.760
7.370
7.351
7.331
7.251
7.229
7.215
7.209
7.199
7.182
7.174
7.159
7.140
7.121
7.115
7.093
7.011
6.991
6.871
6.849
4.395
2.825
2.806
2.788
2.609
2.591
2.572
2.356
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
Ts
N
Ph
OPh
1g
1.94
1.94
10.14
1.95
1.96
1.98
1.98
1.98
3.00
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

Analysis: ^{13}C NMR

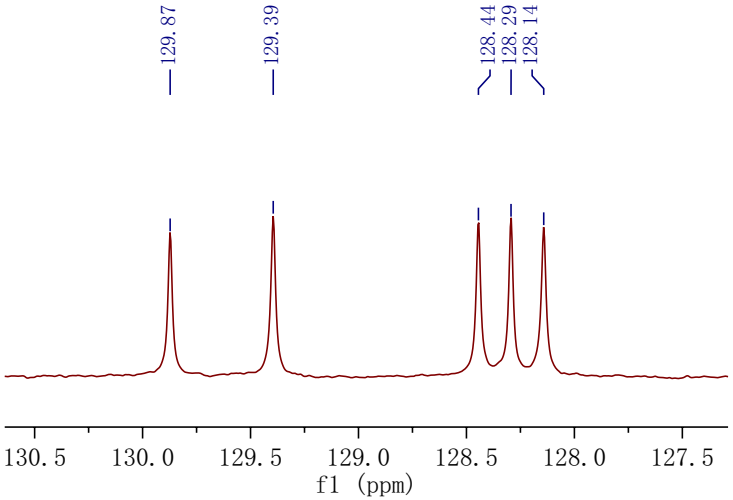
Solvent: $CDCl_3$

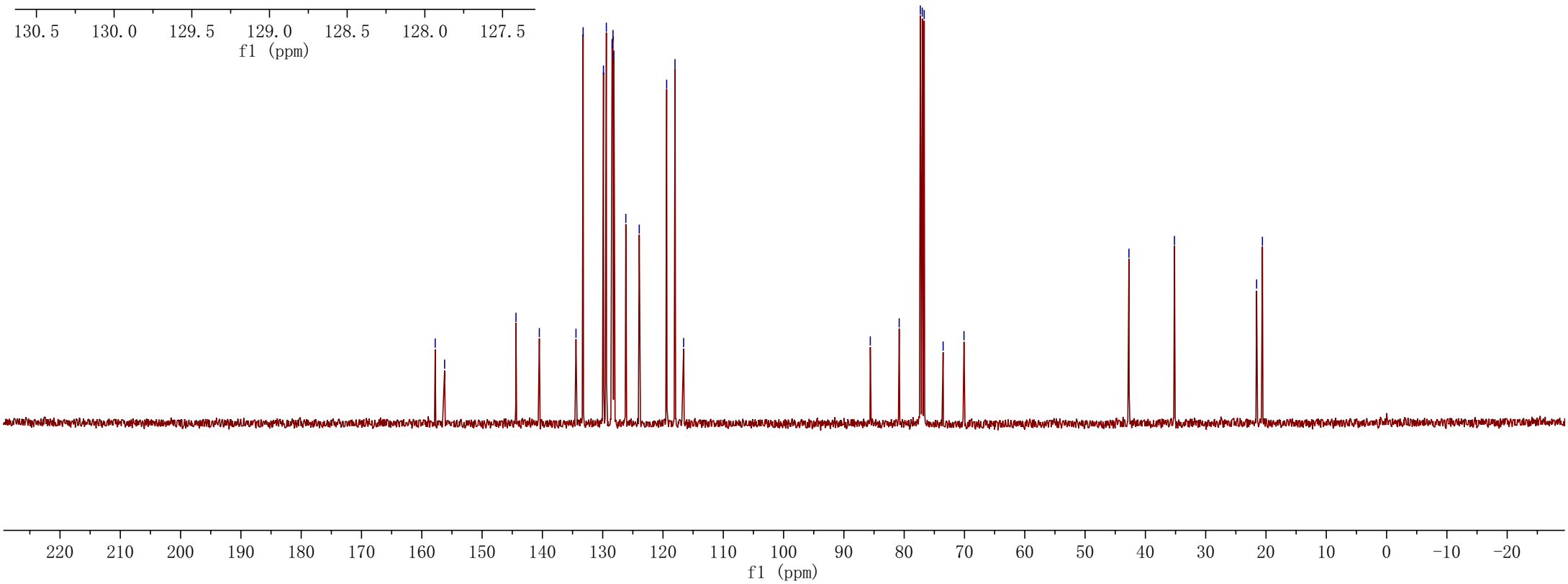
Field strength: 100 MHz

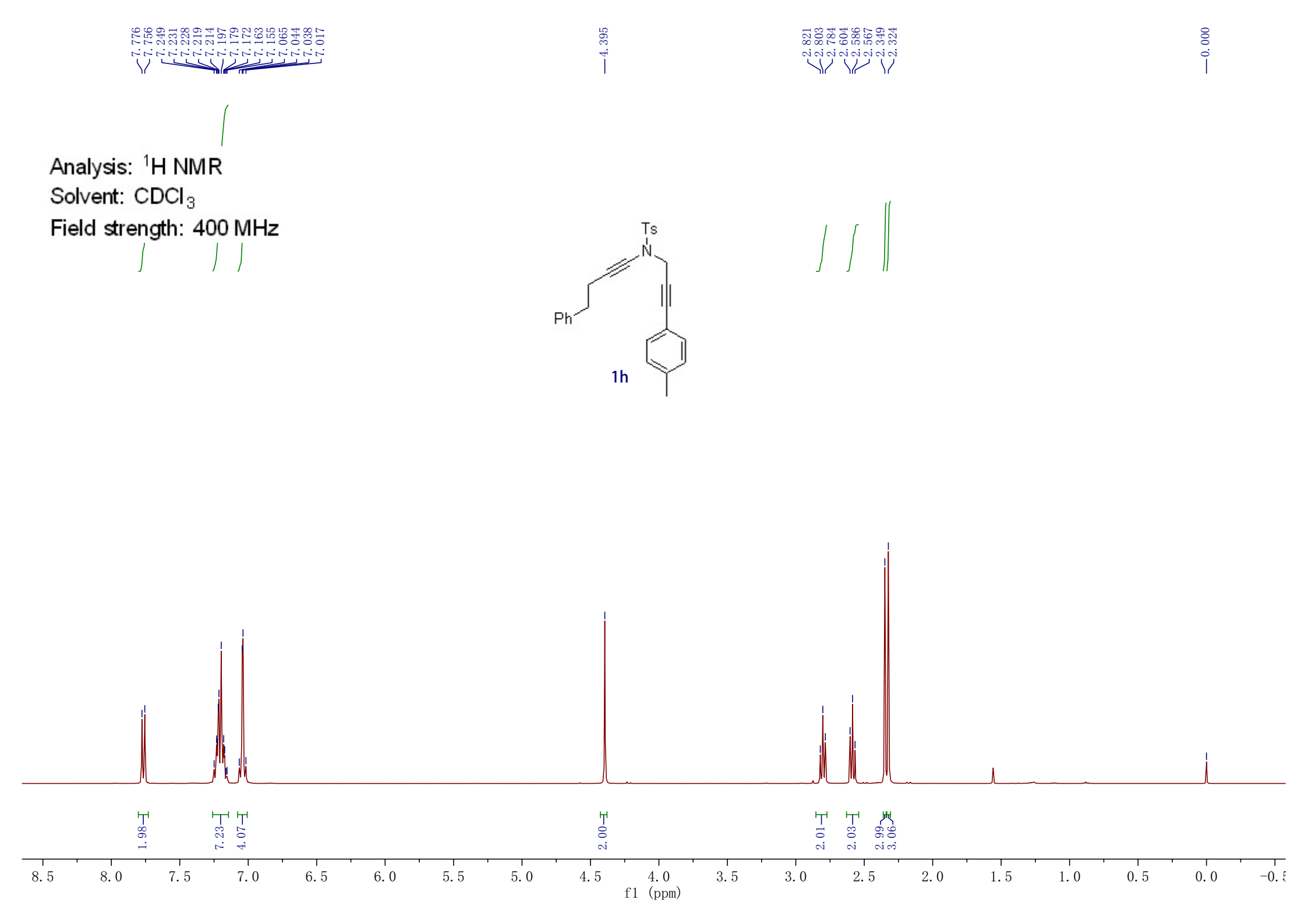
157.78
156.22
144.38
140.51
134.43
133.25
129.87
129.39
128.44
128.29
128.14
126.17
123.94
119.40
118.01
116.58
85.62
80.83
77.32
77.00
76.68
73.54
70.08
42.73
35.18
21.56
20.60



1g





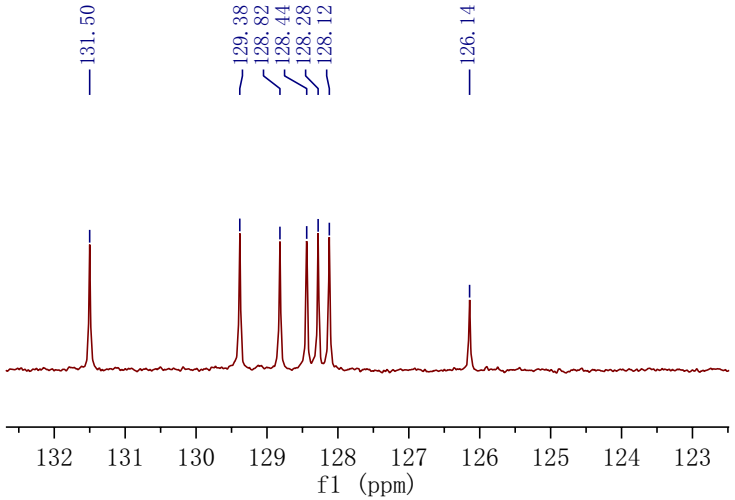

7.776
7.756
7.249
7.231
7.228
7.219
7.214
7.197
7.179
7.172
7.163
7.155
7.065
7.044
7.038
7.017
4.395
2.821
2.803
2.784
2.604
2.586
2.567
2.349
2.324
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
Ts
N
Ph
1h
1.98
7.23
4.07
2.00
2.01
2.03
2.99
3.06
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

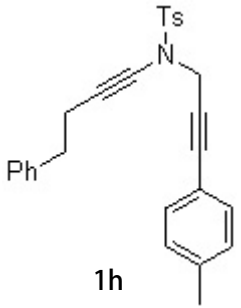
Analysis: ^{13}C NMR

Solvent: $CDCl_3$

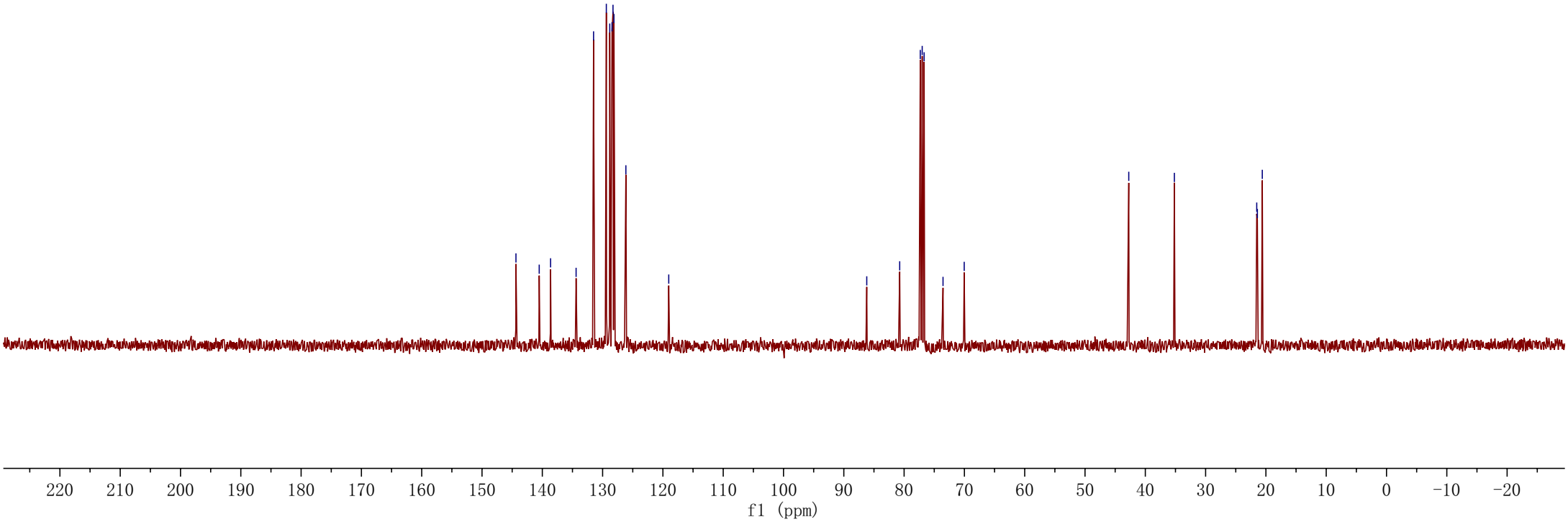
Field strength: 100 MHz

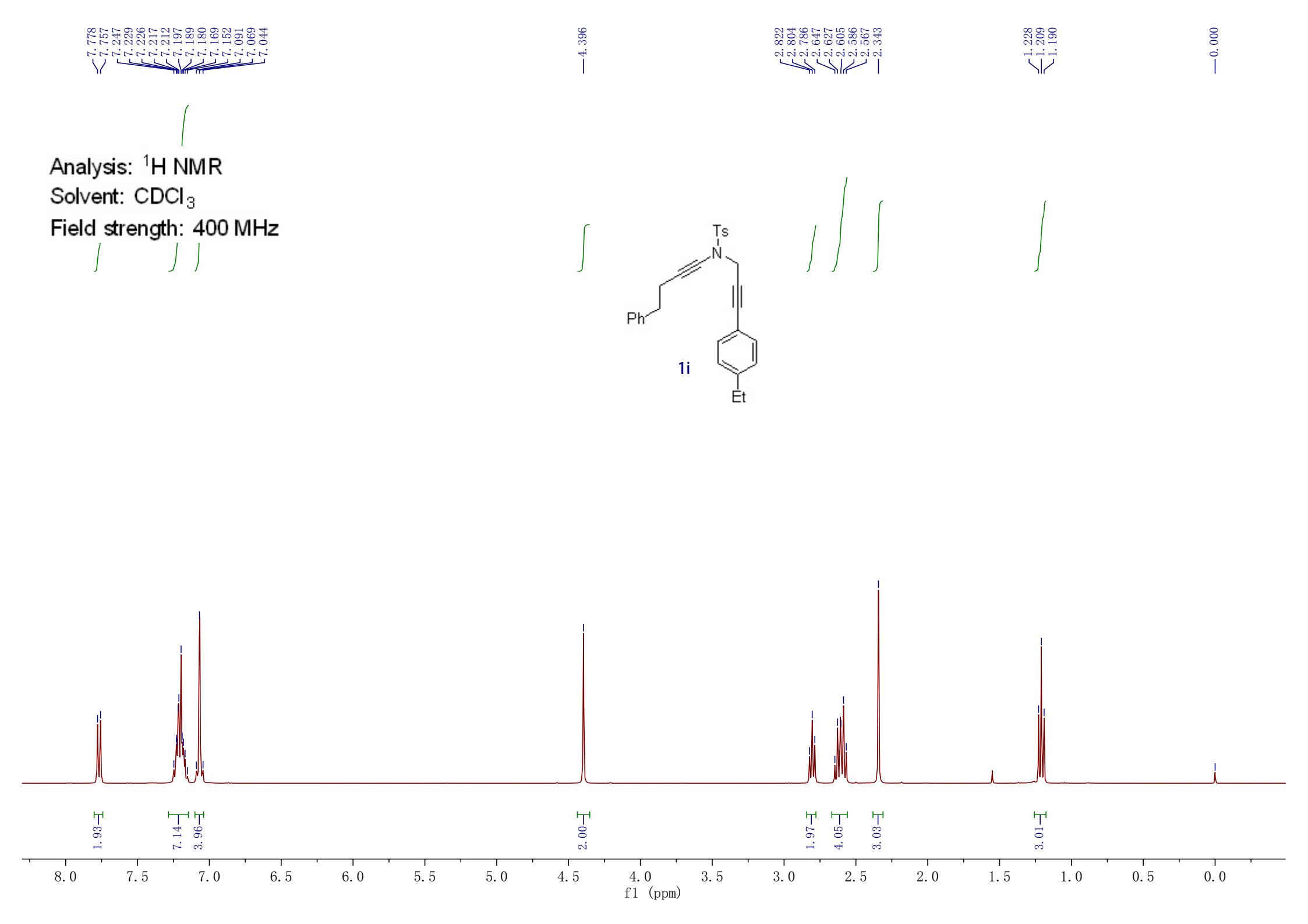
144.37
140.51
138.63
134.40
131.50
129.38
128.82
128.44
128.28
128.12
126.14
119.03
86.20
80.73
77.32
77.00
76.68
73.55
70.03
42.75
35.18
21.52
21.42
20.60





1h



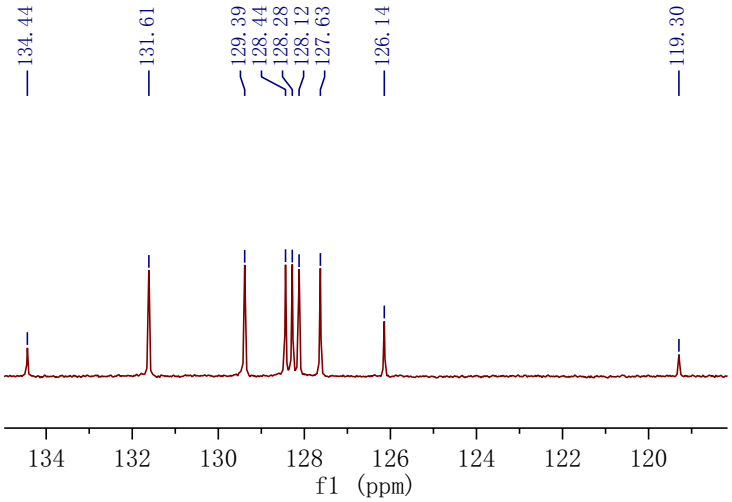

7.778
7.757
7.247
7.229
7.226
7.217
7.212
7.197
7.189
7.180
7.169
7.152
7.091
7.069
7.044
4.396
2.822
2.804
2.786
2.647
2.627
2.605
2.586
2.567
2.343
1.228
1.209
1.190
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
Ts
N
Ph
Et
1i
1.93
7.14
3.96
2.00
1.97
4.05
3.03
3.01
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

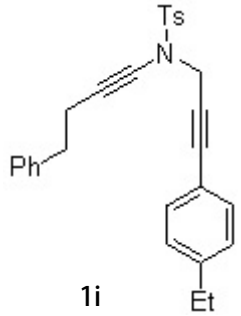
Analysis: ^{13}C NMR

Solvent: $CDCl_3$

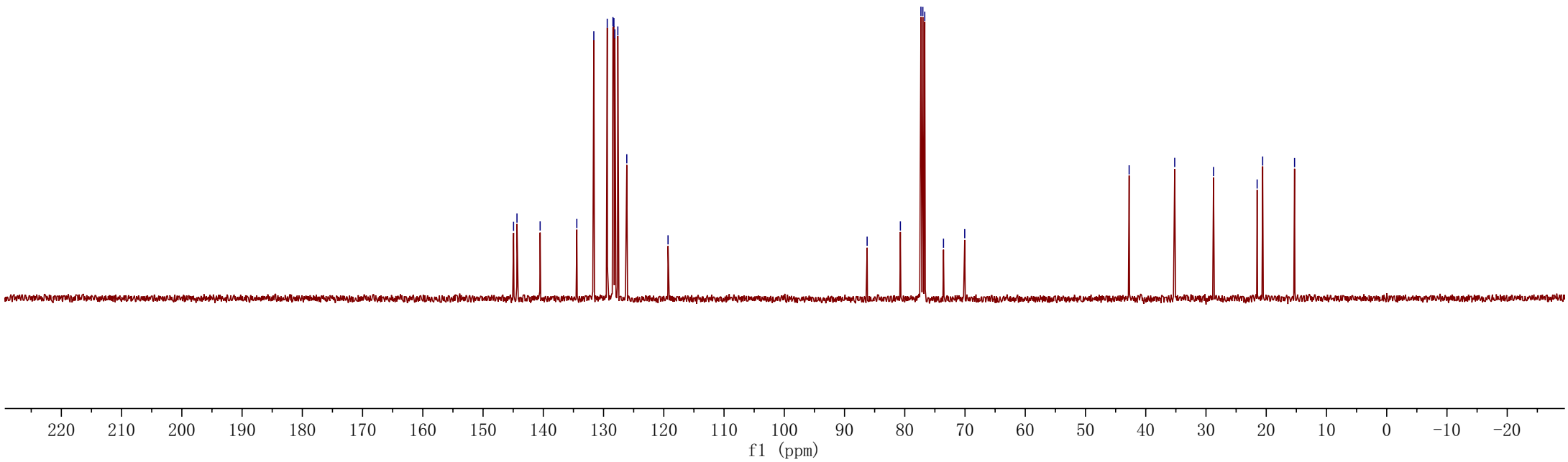
Field strength: 100 MHz

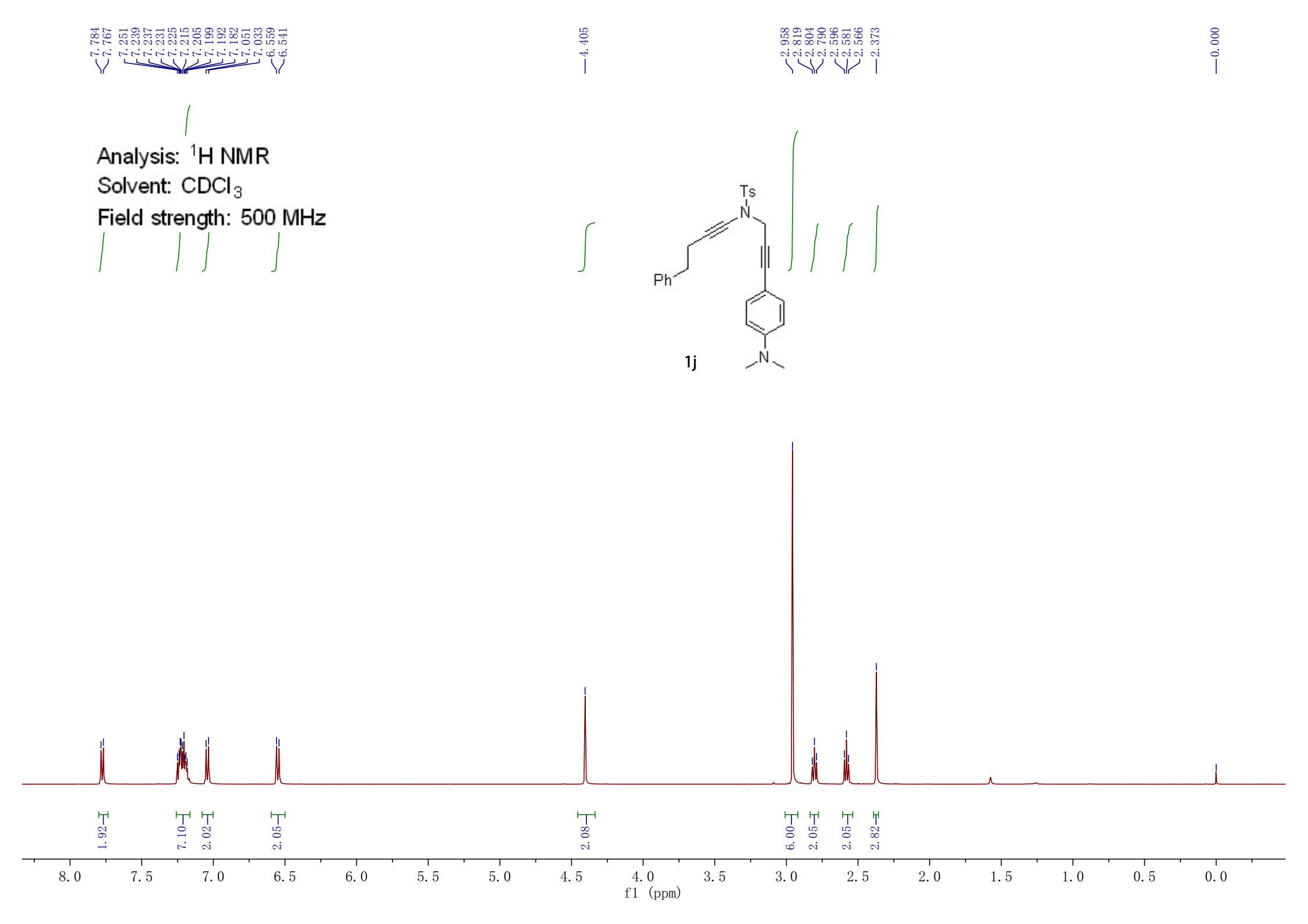
144.94, 144.37, 140.53, 134.44, 131.61, 129.39, 128.44, 128.28, 128.12, 127.63, 126.14, 119.30, 86.25, 80.73, 77.32, 77.00, 76.68, 73.57, 70.05, 42.75, 35.19, 28.75, 21.51, 20.59, 15.30

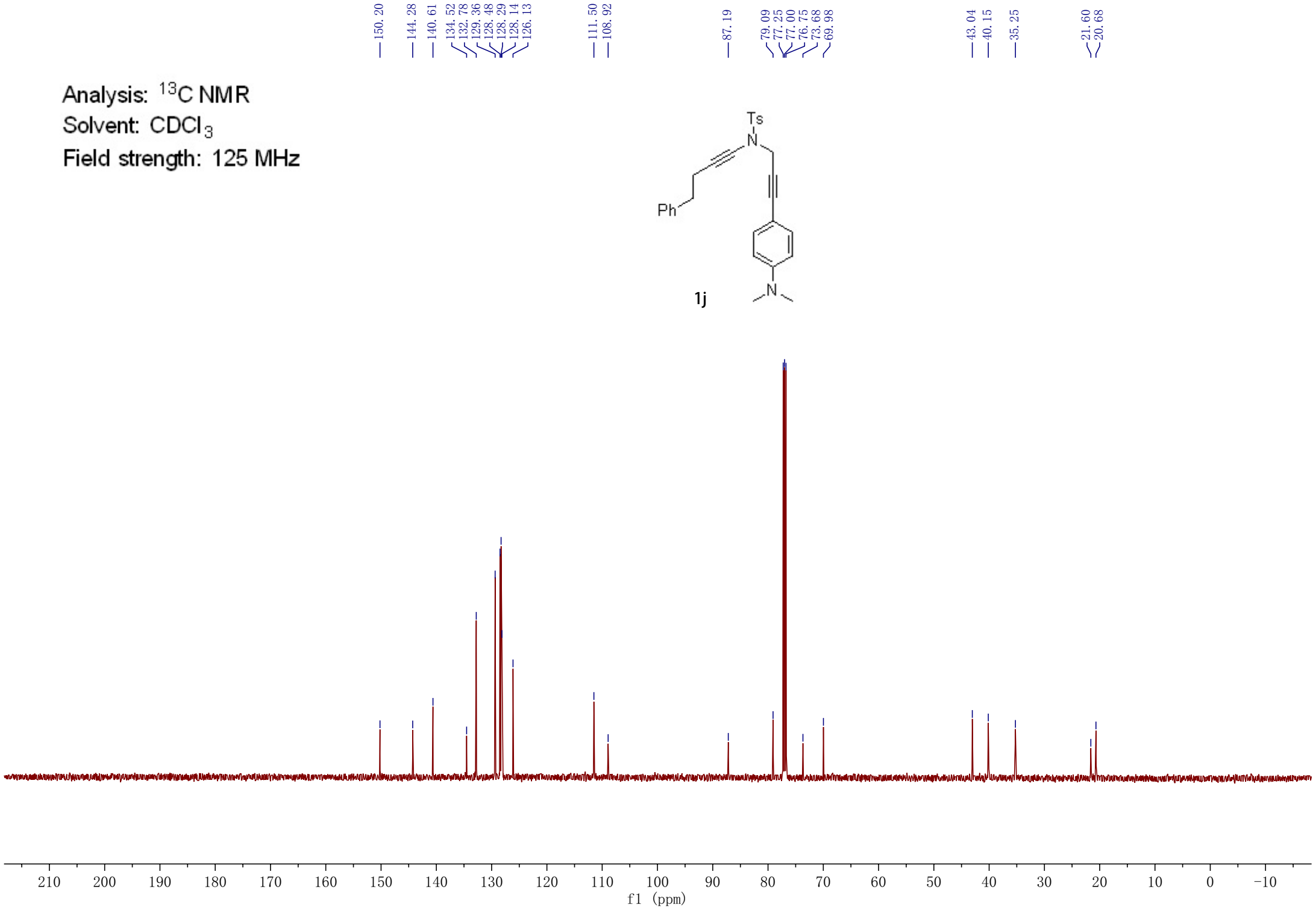




1i



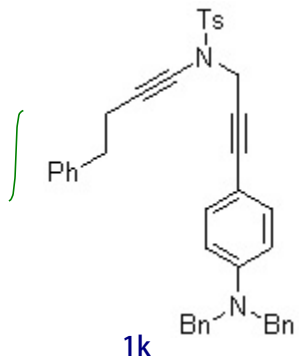

7.784
7.767
7.251
7.239
7.237
7.231
7.225
7.215
7.205
7.199
7.192
7.182
7.051
7.033
6.559
6.541
4.405
2.958
2.819
2.804
2.790
2.596
2.581
2.566
2.373
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 500 MHz
Ts
N
Ph
N
1j
1.92
7.10
2.02
2.05
2.08
6.00
2.05
2.05
2.82
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


150.20
144.28
140.61
134.52
132.78
129.36
128.48
128.29
128.14
126.13
111.50
108.92
87.19
79.09
77.25
77.00
76.75
73.68
69.98
43.04
40.15
35.25
21.60
20.68
Analysis: 13C NMR
Solvent: CDCl3
Field strength: 125 MHz
Ts
N
Ph
N
1j
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

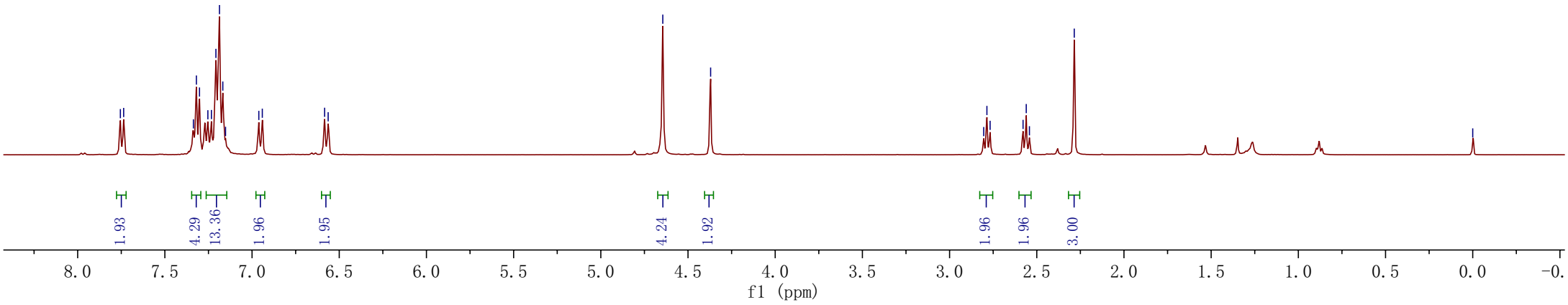
Analysis: ^{1}H NMR

Solvent: $CDCl_3$

Field strength: 400 MHz



1k

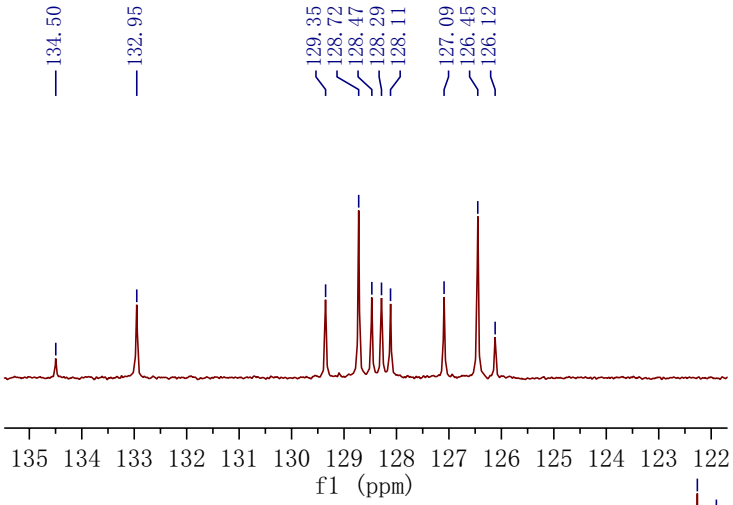


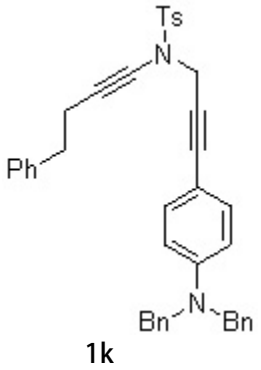
Analysis: ^{13}C NMR

Solvent: $CDCl_3$

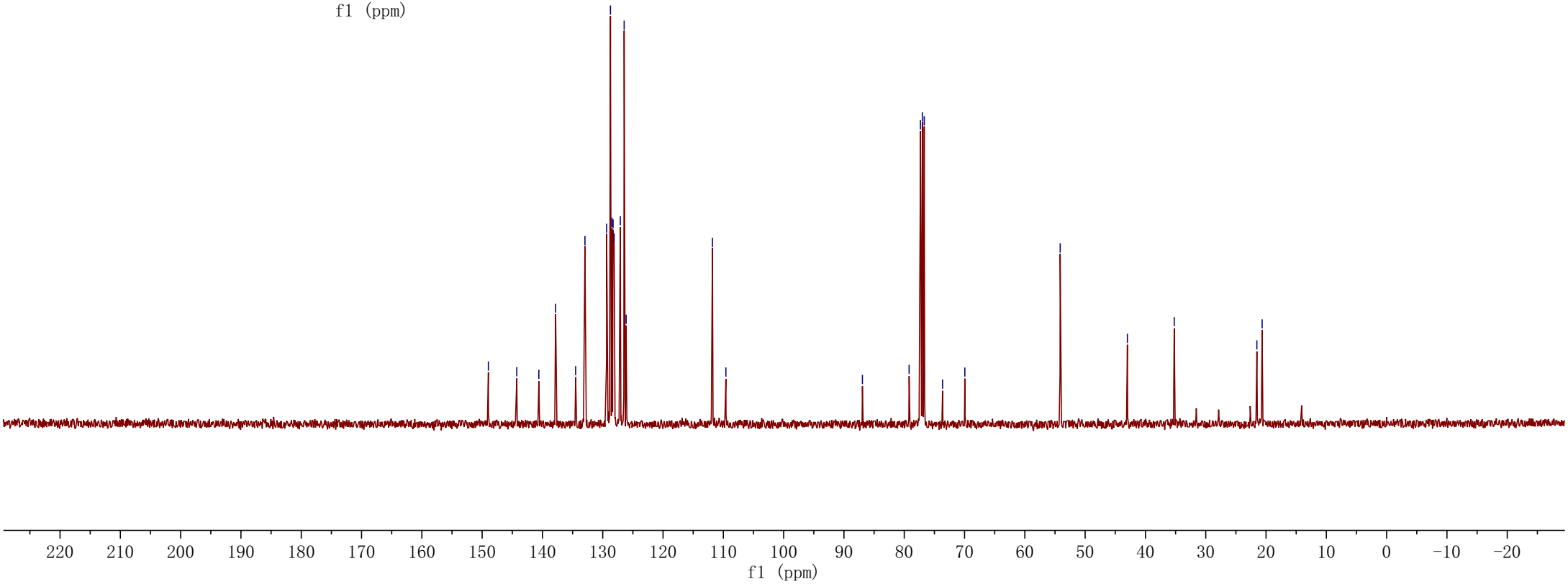
Field strength: 100 MHz

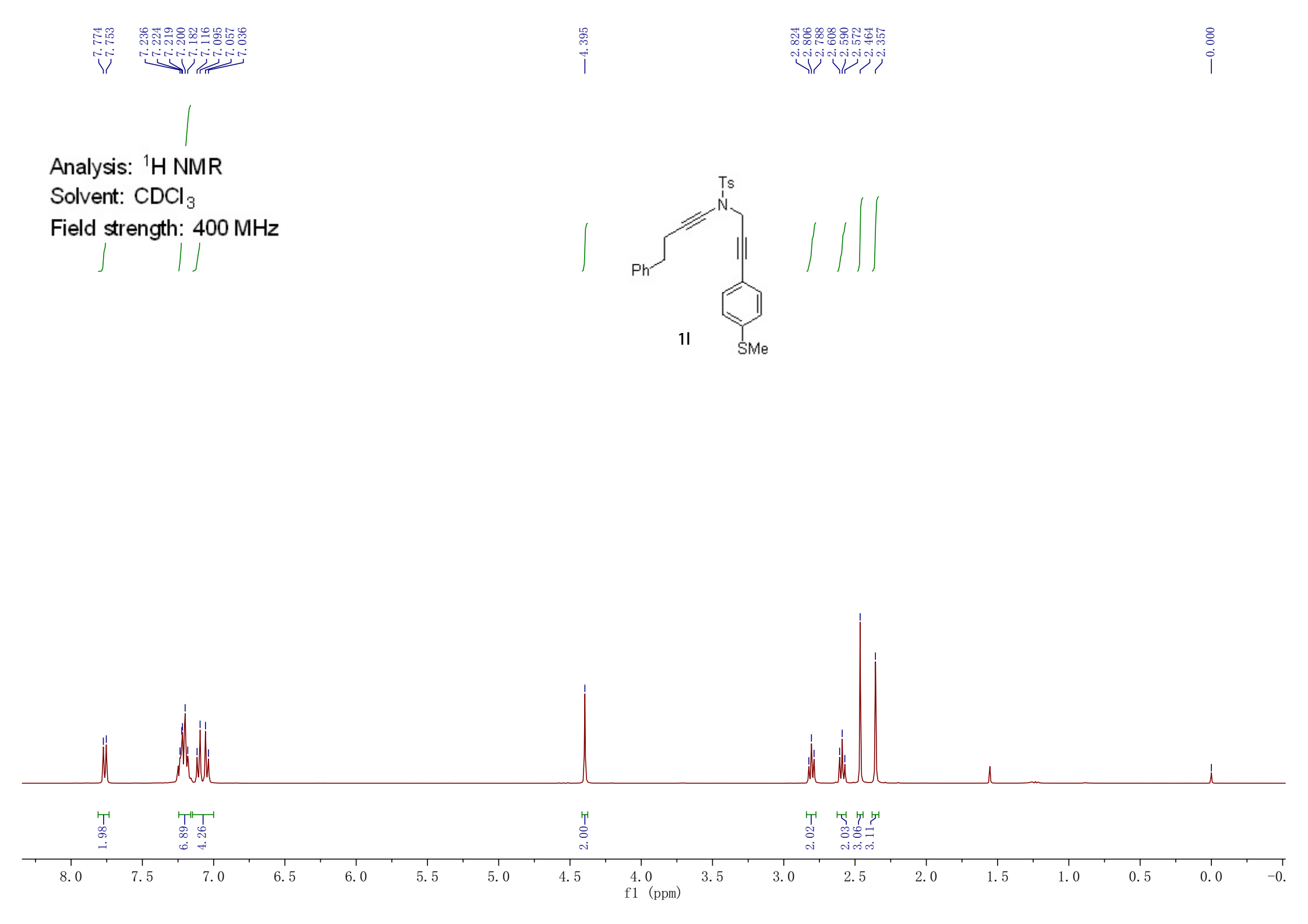
148.97
144.26
140.59
137.82
134.50
132.95
129.35
128.72
128.47
128.29
128.11
127.09
126.45
126.12
111.81
109.58
86.94
79.19
77.32
77.00
76.68
73.64
69.95
54.14
43.00
35.23
21.52
20.65





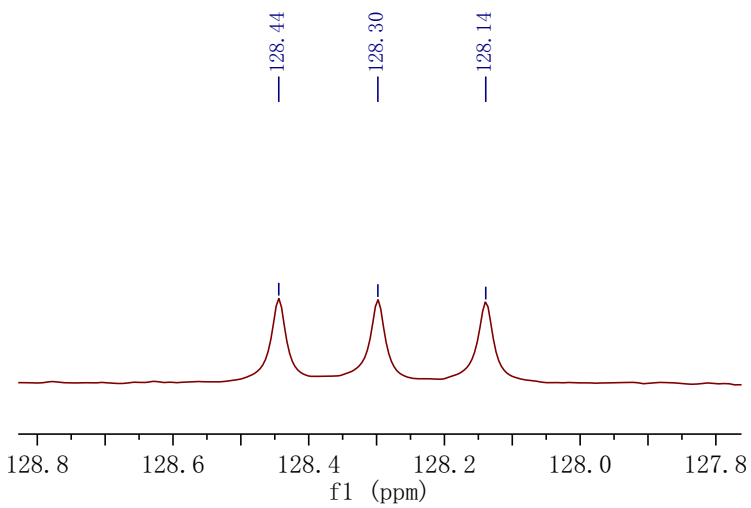
1k

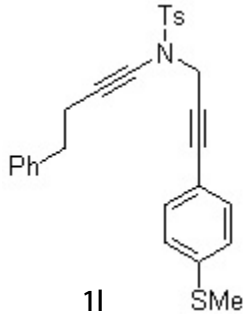



7.774
7.753
7.236
7.224
7.219
7.200
7.182
7.116
7.095
7.057
7.036
4.395
2.824
2.806
2.788
2.608
2.590
2.572
2.464
2.357
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
Ts
N
Ph
SMe
1l
1.98
6.89
4.26
2.00
2.02
2.03
3.06
3.11
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.
f1 (ppm)

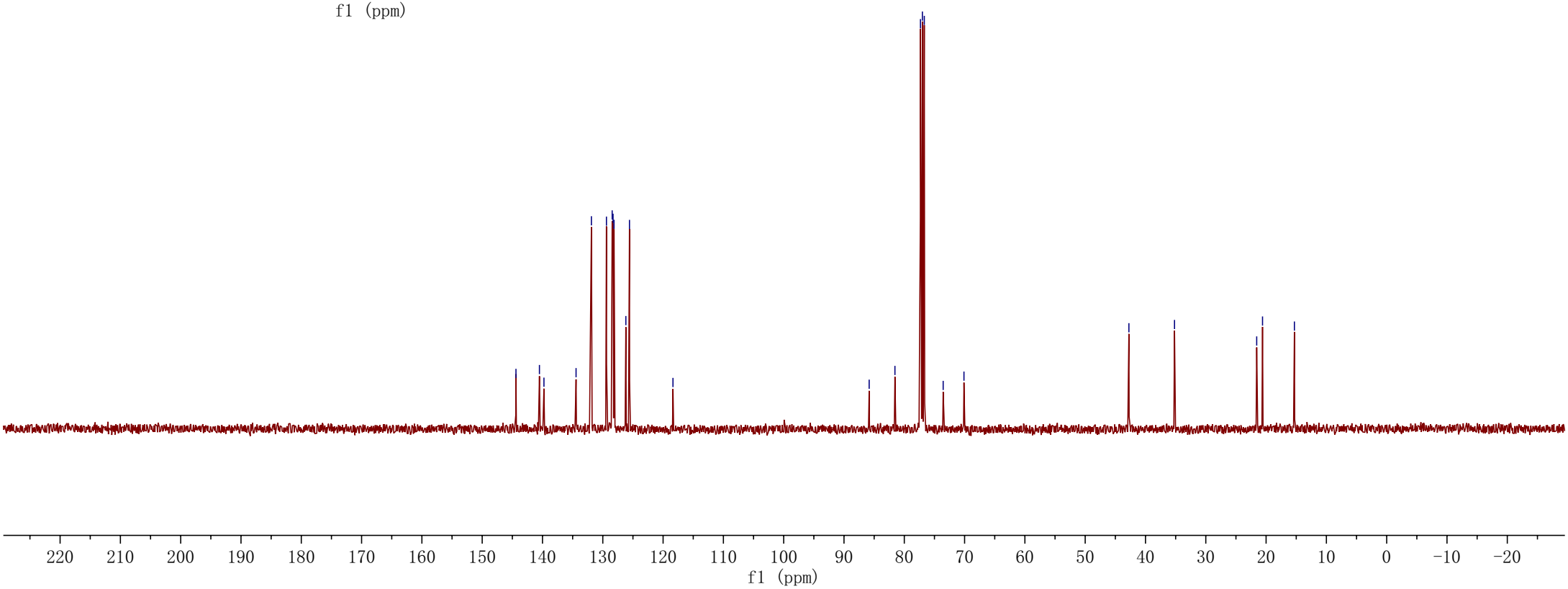
Analysis: ^{13}C NMR
Solvent: $CDCl_3$
Field strength: 100 MHz

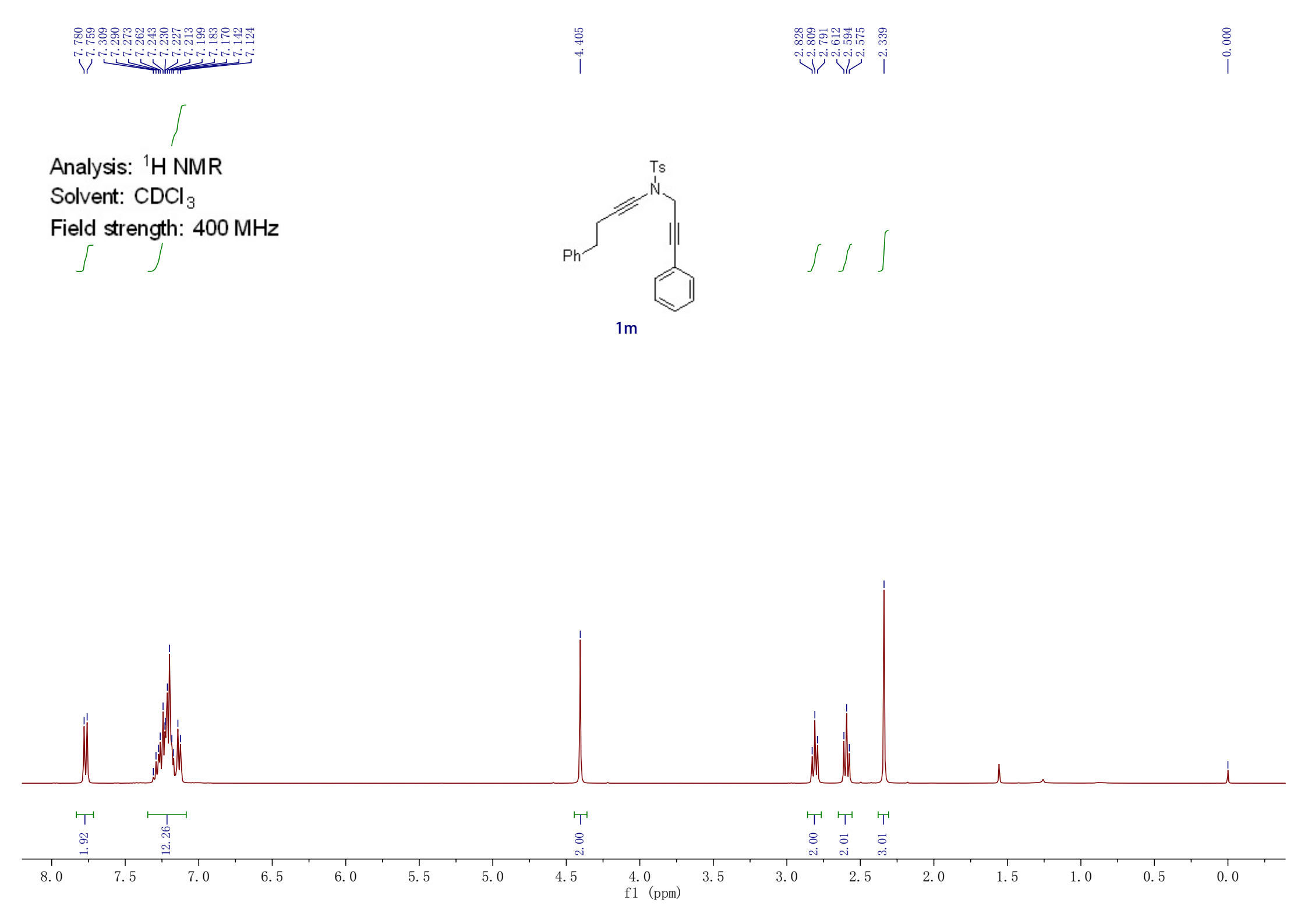
144.40
140.51
139.76
134.43
131.89
129.39
128.44
128.30
128.14
126.18
125.58
118.36
85.83
81.55
77.32
77.00
76.68
73.55
70.10
42.75
35.19
21.56
20.59
15.31





1l




7.780
7.759
7.309
7.290
7.273
7.262
7.243
7.230
7.227
7.213
7.199
7.183
7.170
7.142
7.124
4.405
2.828
2.809
2.791
2.612
2.594
2.575
2.339
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
Ts
N
Ph
1m
1.92
12.26
2.00
2.00
2.01
3.01
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

Analysis: ^{13}C NMR

Solvent: $CDCl_3$

Field strength: 100 MHz

144.44
140.50
131.39
131.60
129.40
128.48
128.44
128.29
128.13
128.07
126.16
122.12

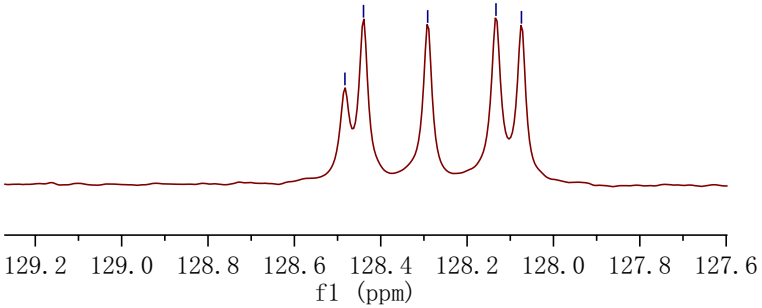
86.05
81.46
77.32
77.00
76.68
73.53
70.08

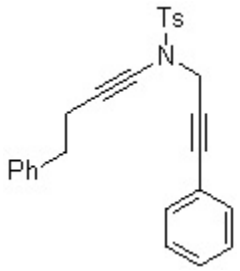
42.70

35.18

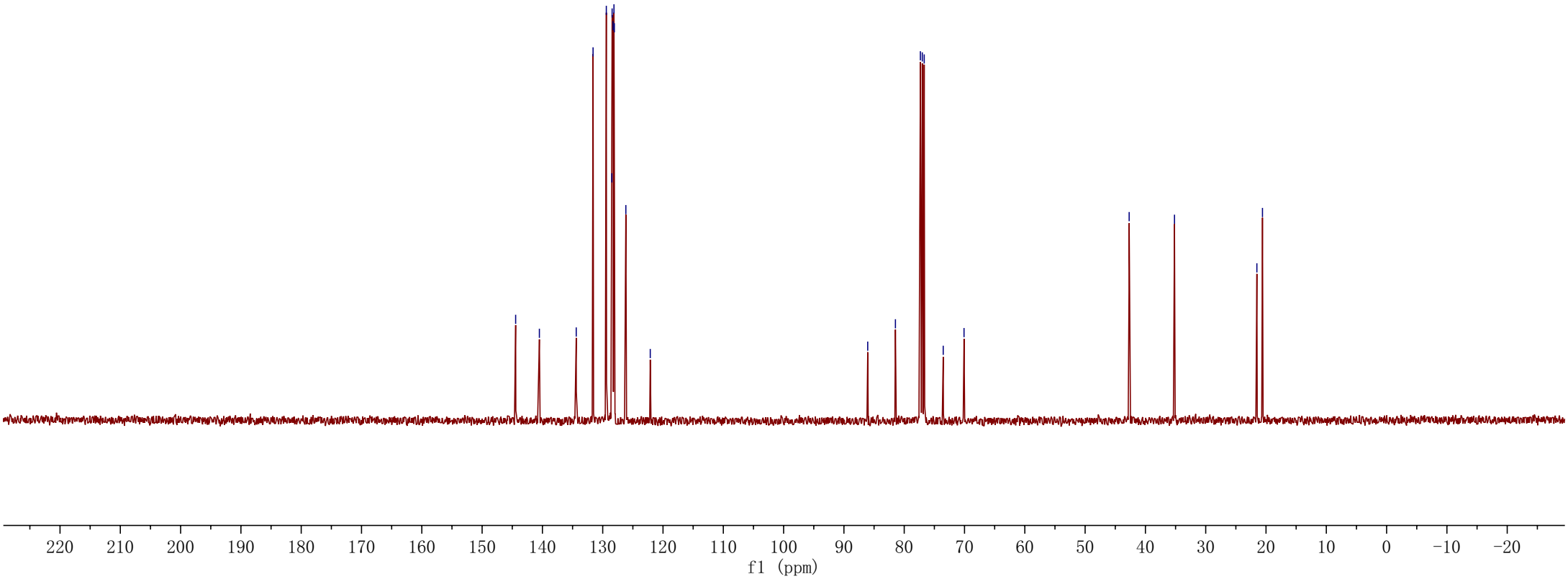
21.51
20.59

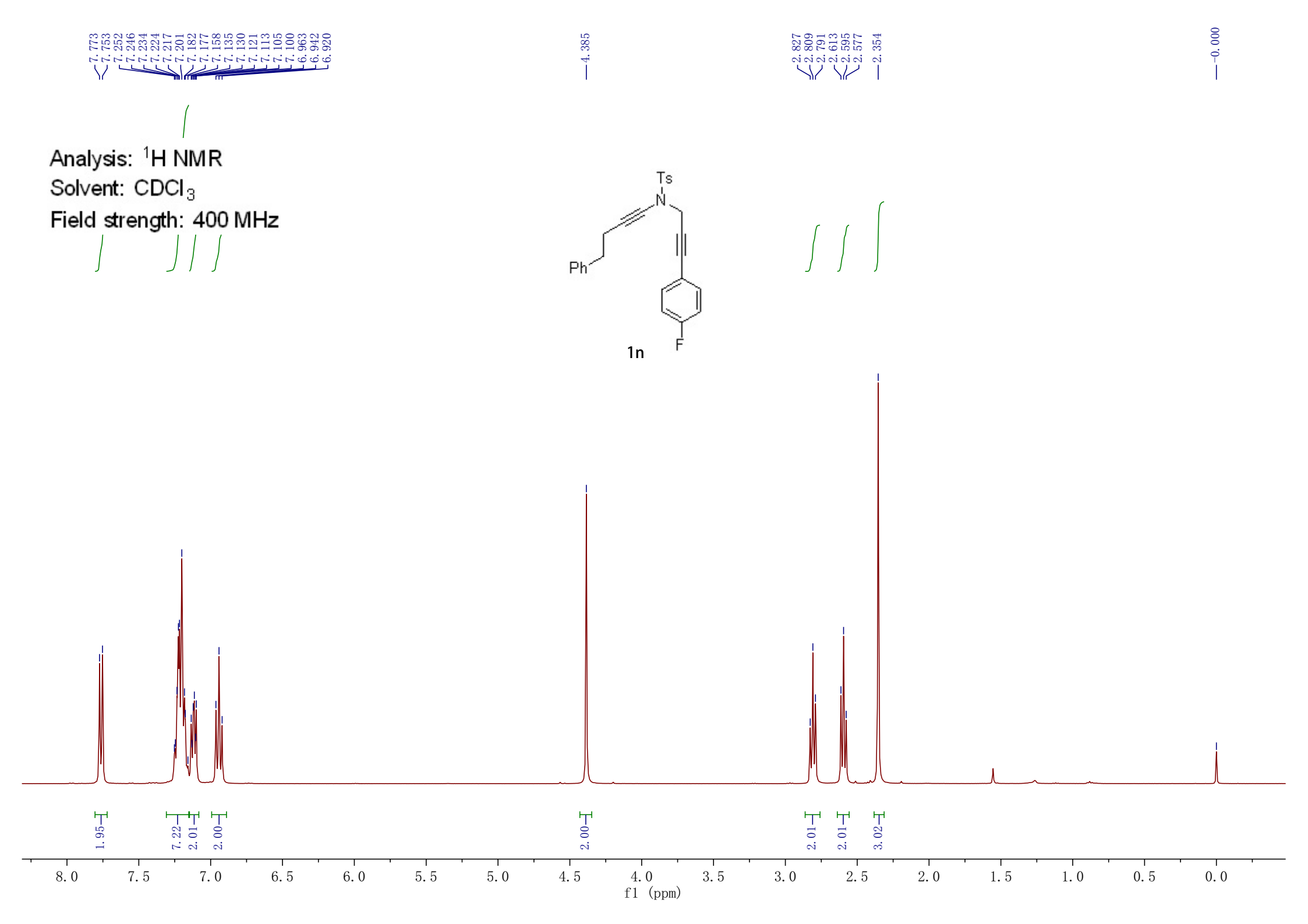
128.48
128.44
128.29
128.13
128.07





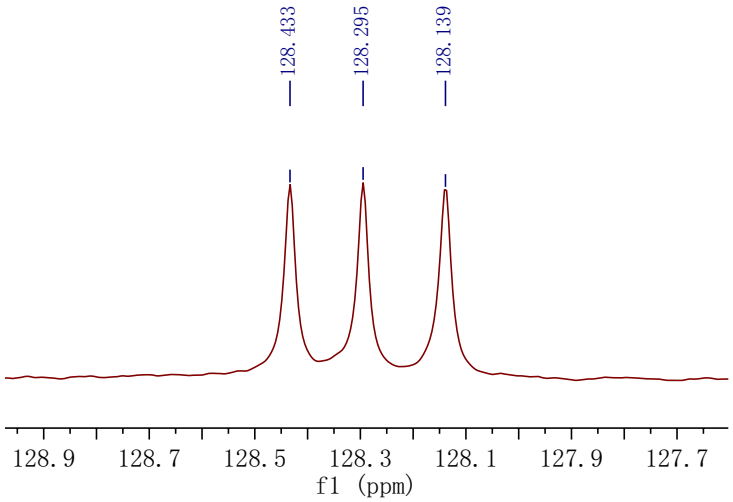
1m

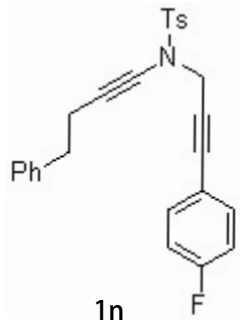



7.773
7.753
7.252
7.246
7.234
7.224
7.217
7.201
7.182
7.177
7.158
7.135
7.130
7.121
7.113
7.105
7.100
6.963
6.942
6.920
4.385
2.827
2.809
2.791
2.613
2.595
2.577
2.354
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
Ts
N
Ph
F
1n
1.95
7.22
2.01
2.00
2.00
2.01
2.01
3.02
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

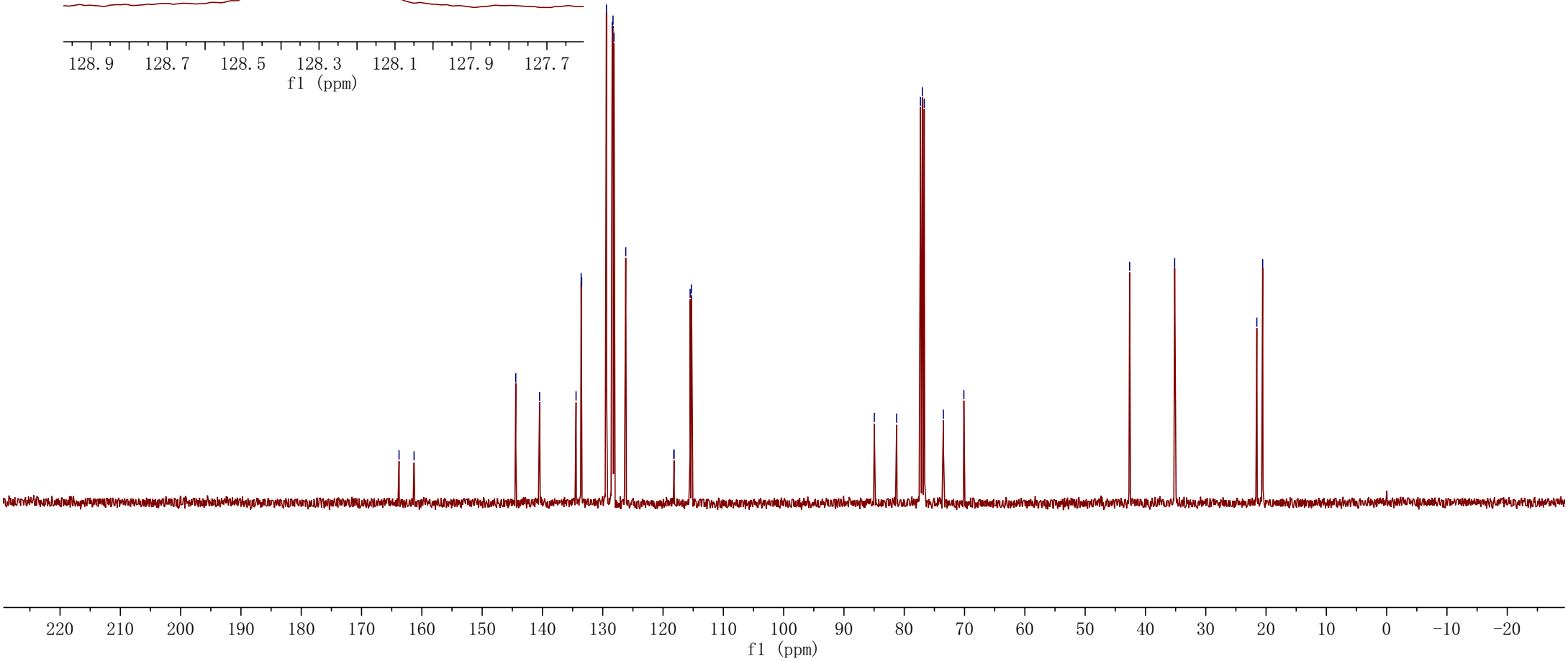
Analysis: ^{13}C NMR
Solvent: $CDCl_3$
Field strength: 100 MHz

163.780
161.293
144.426
140.478
134.428
133.581
133.498
129.392
128.433
128.295
128.139
126.185
118.213
118.178
115.502
115.283
84.966
81.262
77.318
77.000
76.683
73.512
70.110
42.622
35.155
21.529
20.560





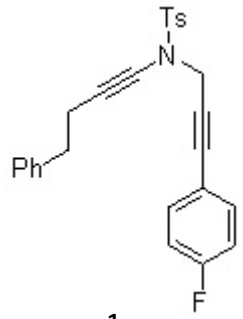
1n



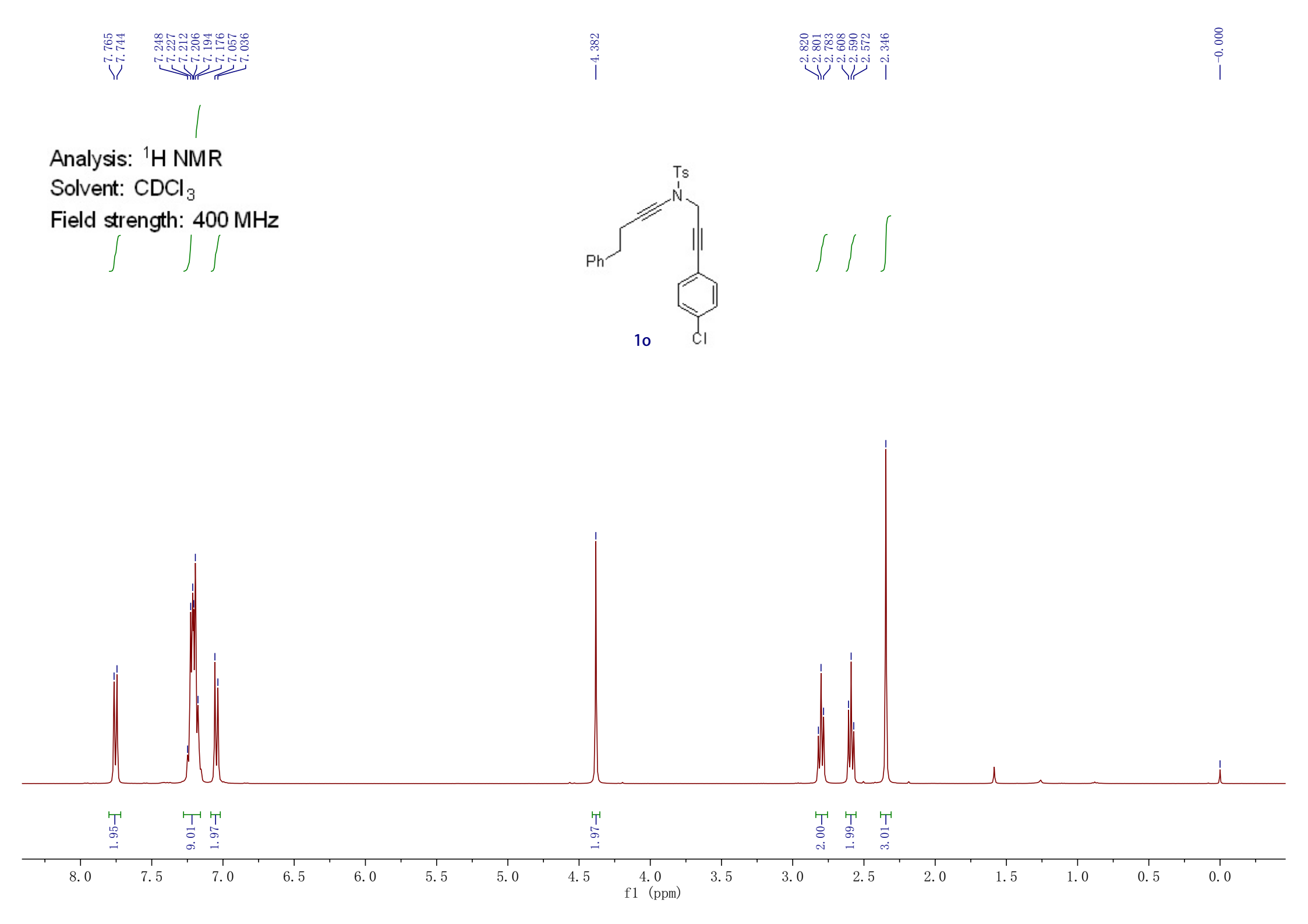
Analysis: ^{19}F NMR

Solvent: $CDCl_3$

Field strength: 471 MHz

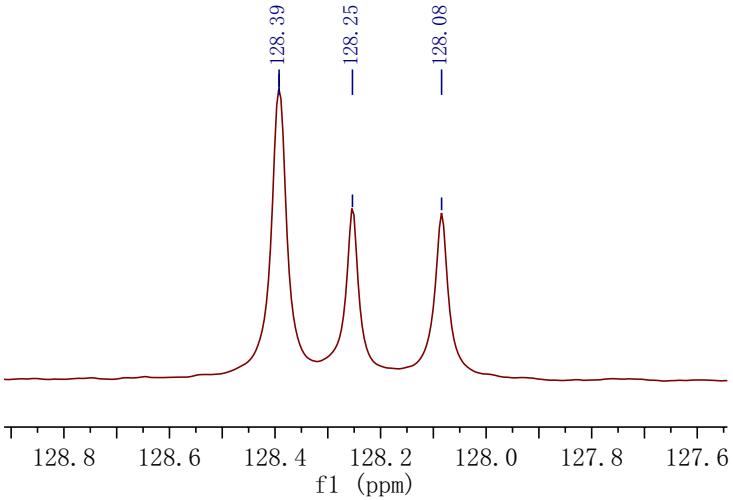


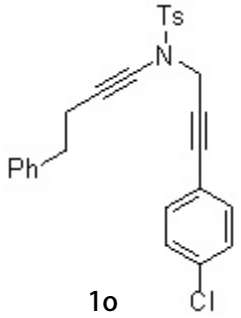
1n


7.765
7.744
7.248
7.227
7.212
7.206
7.194
7.176
7.057
7.036
4.382
2.820
2.801
2.783
2.608
2.590
2.572
2.346
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
Ts
N
Ph
Cl
1o
1.95
9.01
1.97
1.97
2.00
1.99
3.01
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

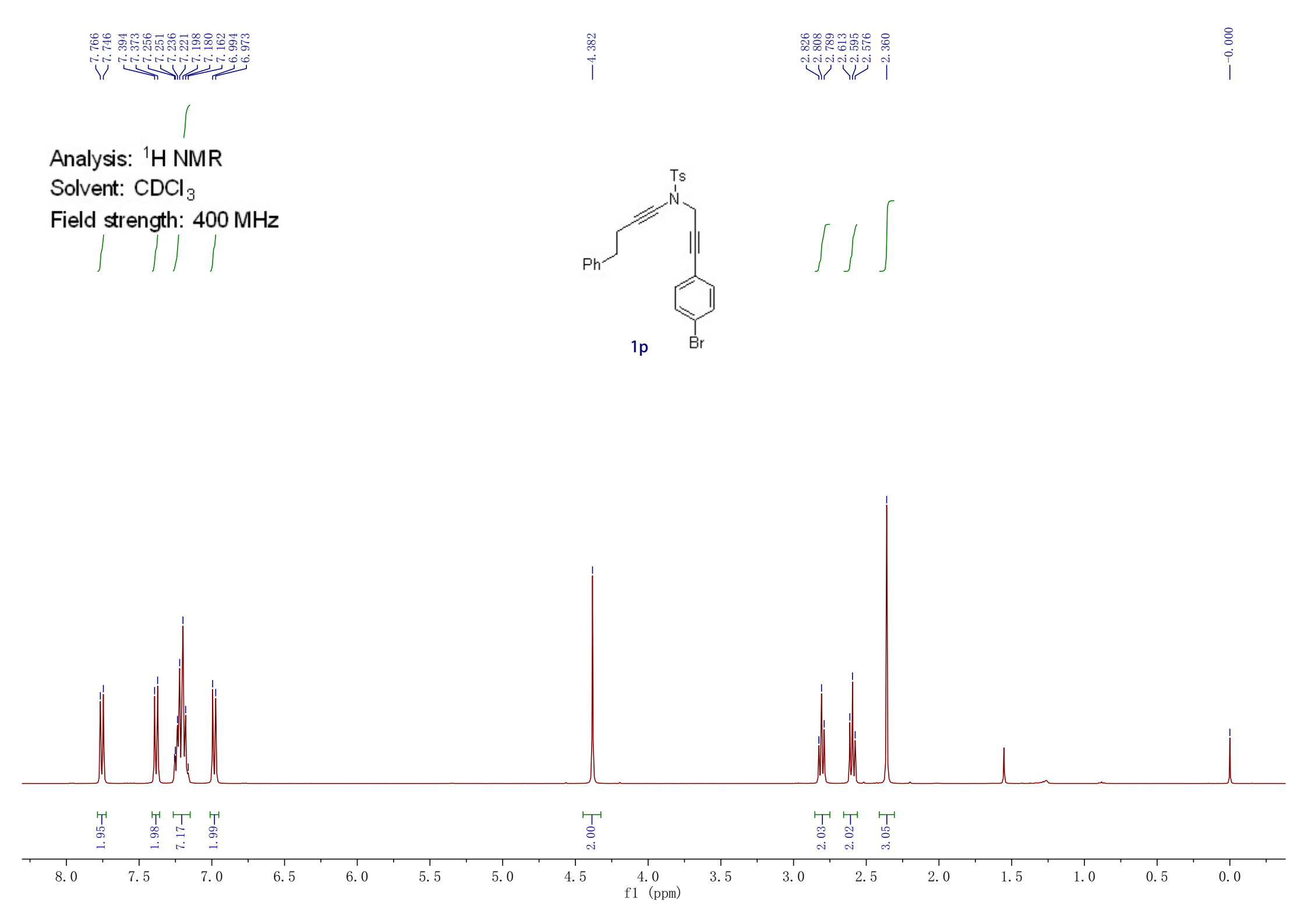
Analysis: ^{13}C NMR
Solvent: $CDCl_3$
Field strength: 100 MHz

144.43
140.41
134.53
134.34
132.79
129.37
128.39
128.25
128.08
126.15
120.53
84.86
82.54
77.32
77.00
76.68
73.46
70.10
42.57
35.09
21.49
20.49





1o

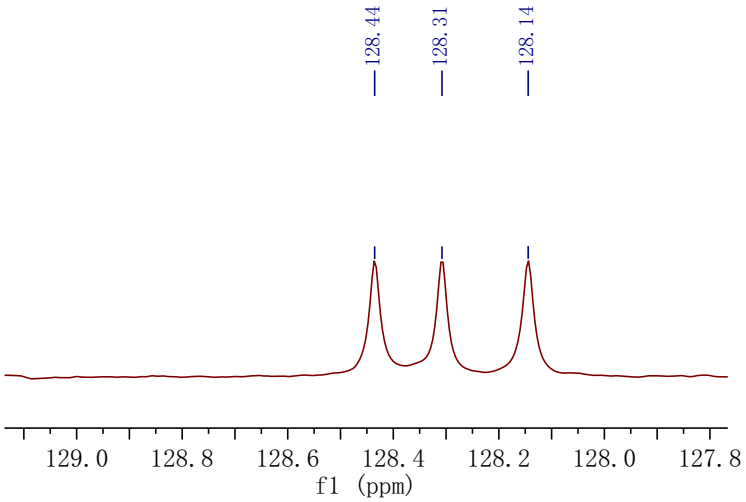

7.766
7.746
7.394
7.373
7.256
7.251
7.236
7.221
7.198
7.180
7.162
6.994
6.973
4.382
2.826
2.808
2.789
2.613
2.595
2.576
2.360
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
Ts
N
Ph
Br
1p
1.95
1.98
7.17
1.99
2.00
2.03
2.02
3.05
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

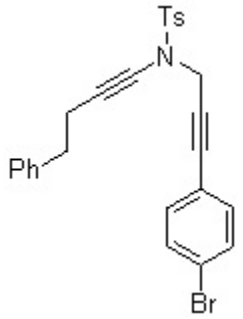
Analysis: ^{13}C NMR

Solvent: $CDCl_3$

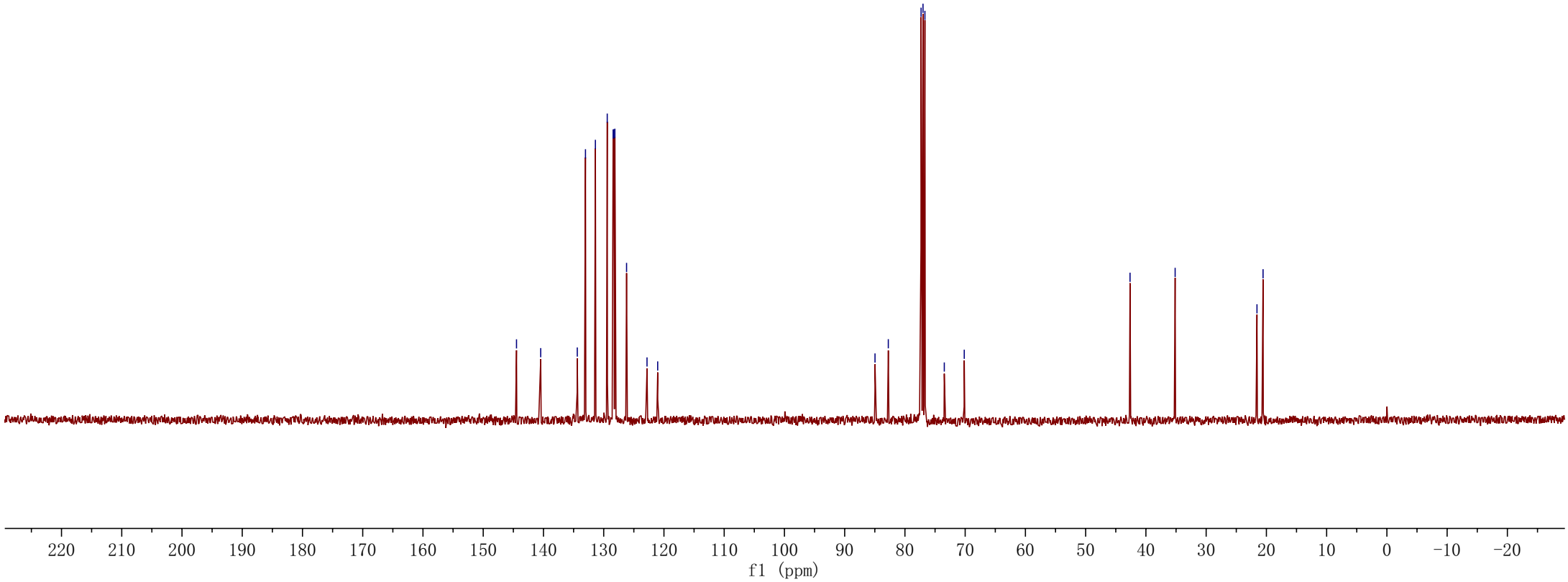
Field strength: 100 MHz

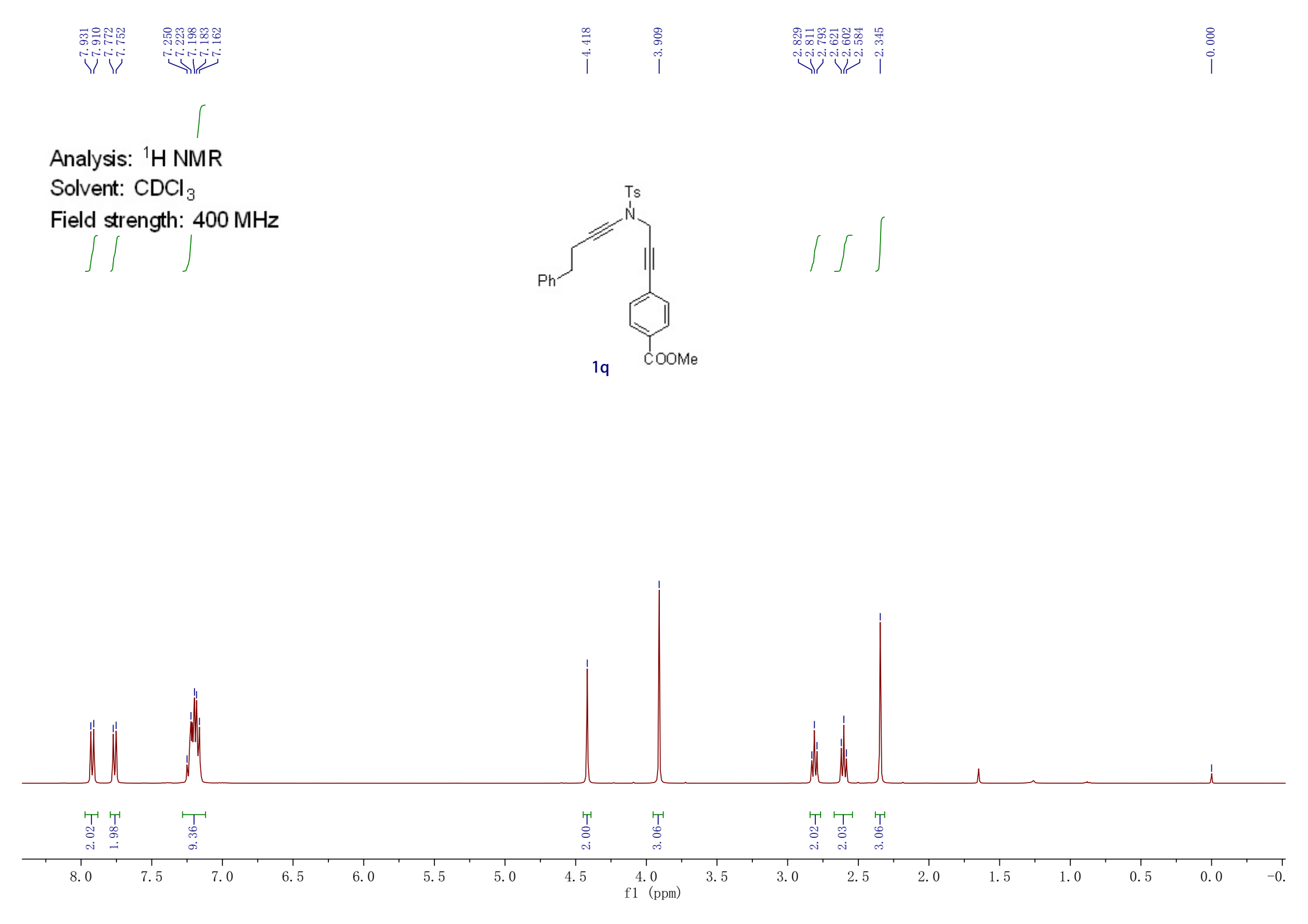
144.47, 140.46, 134.39, 133.03, 131.38, 129.41, 128.44, 128.31, 128.14, 126.21, 122.81, 121.04, 84.97, 82.76, 77.32, 77.00, 76.68, 73.47, 70.15, 42.63, 35.15, 21.56, 20.55





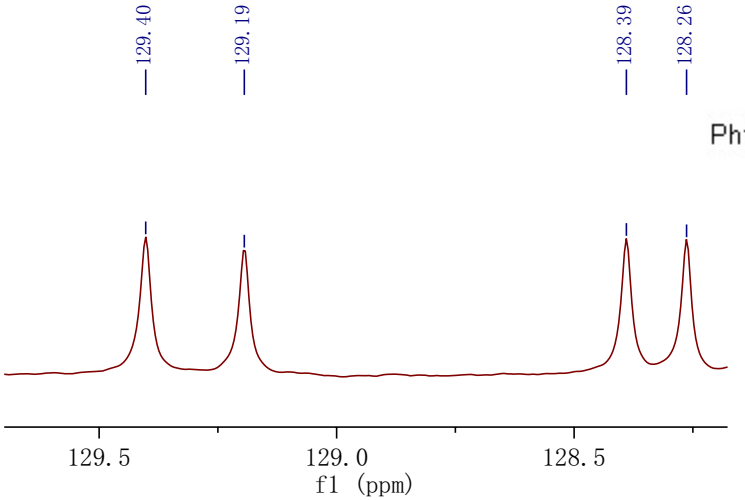
1p

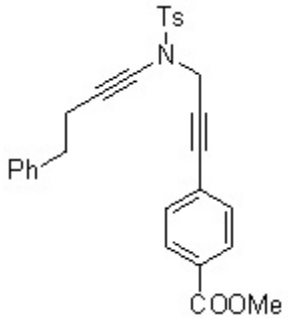



7.931
7.910
7.772
7.752
7.250
7.223
7.198
7.183
7.162
4.418
3.909
2.829
2.811
2.793
2.621
2.602
2.584
2.345
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
Ts
N
Ph
COOMe
1q
2.02
1.98
9.36
2.00
3.06
2.02
2.03
3.06
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.
f1 (ppm)

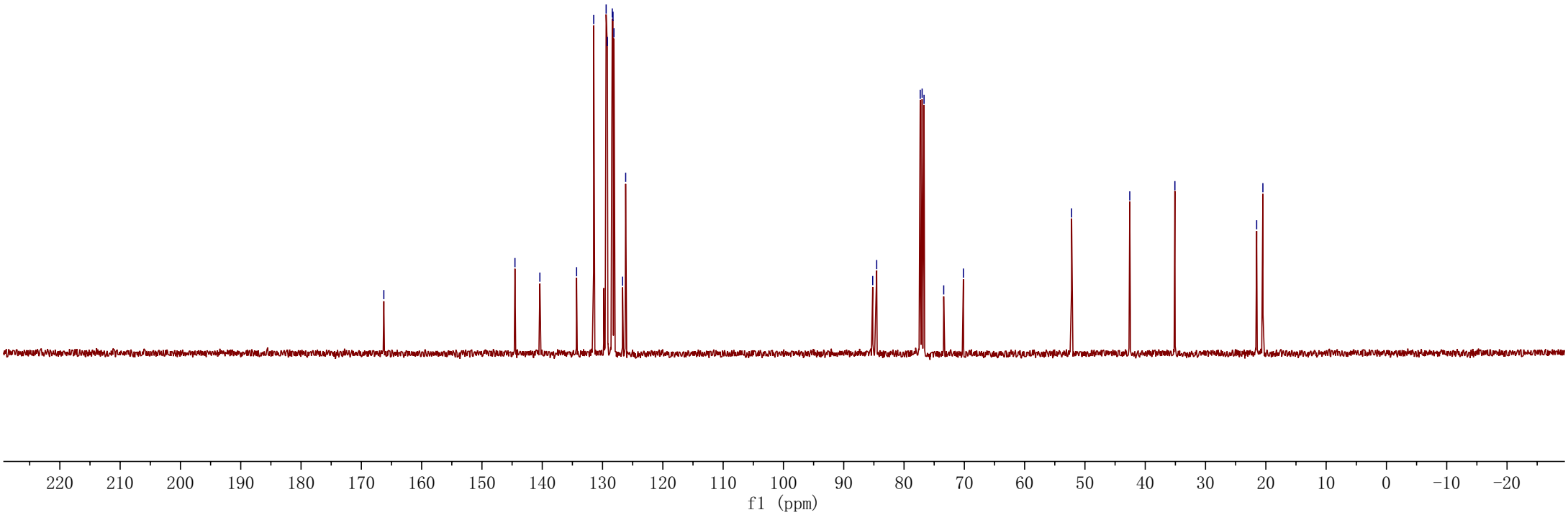
Analysis: ^{13}C NMR
Solvent: $CDCl_3$
Field strength: 100 MHz

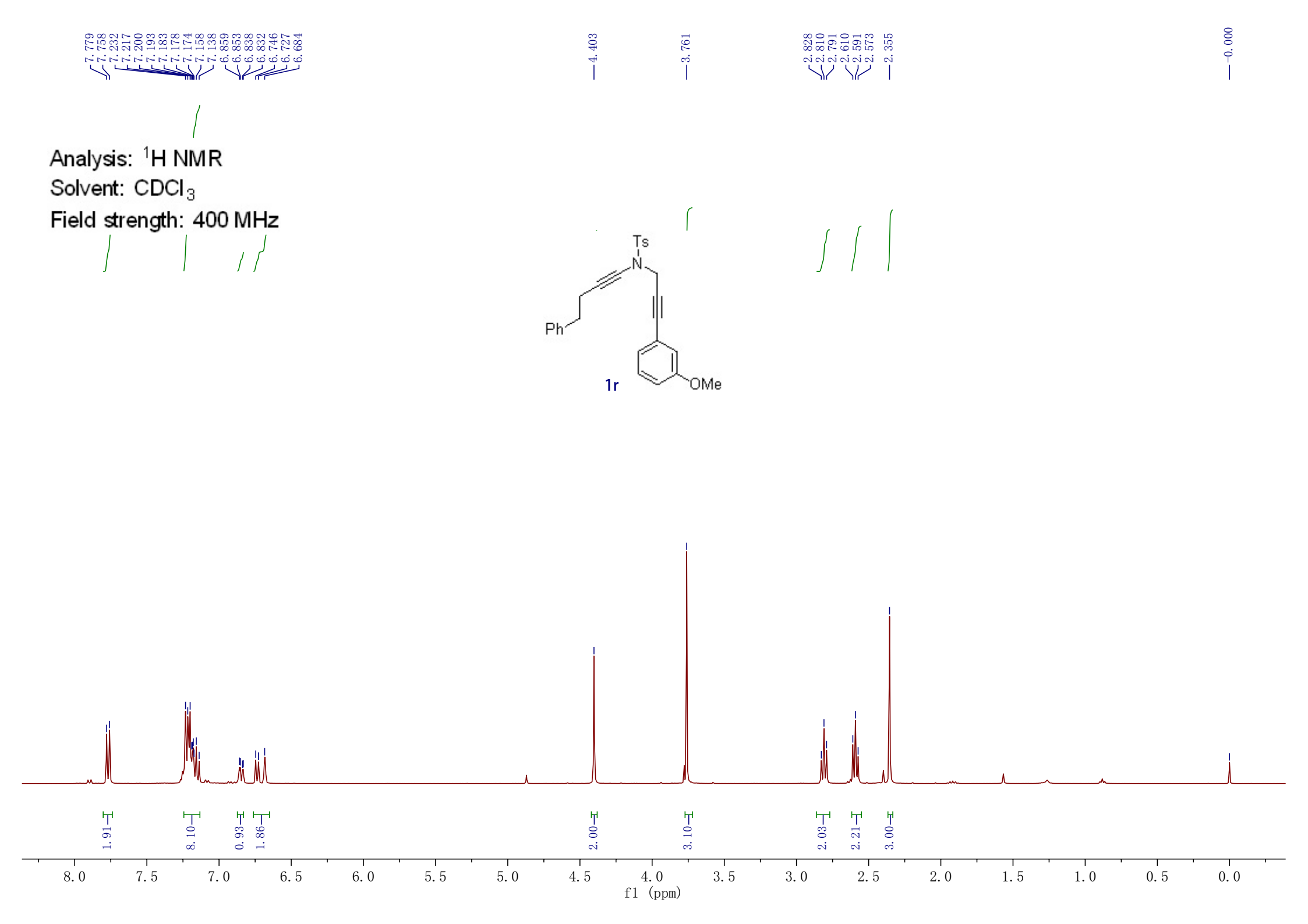
166.27
144.52
140.39
131.30
131.46
129.40
129.19
128.39
128.26
128.11
126.68
126.16
85.20
84.54
77.32
77.00
76.68
73.42
70.16
52.21
42.57
35.08
21.52
20.49





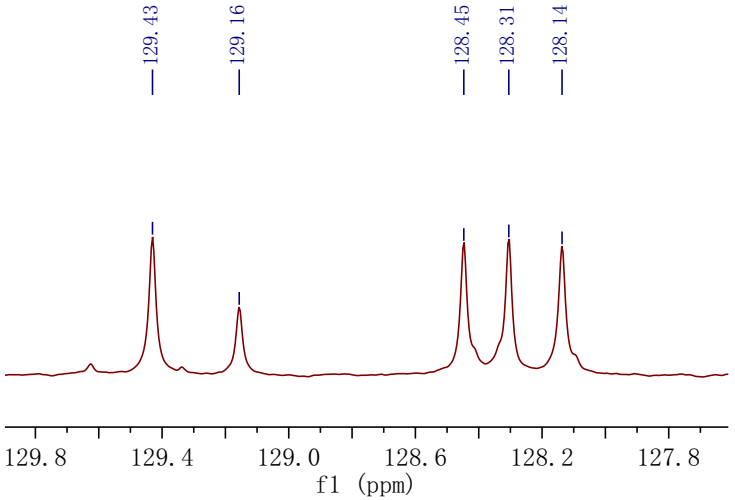
1q

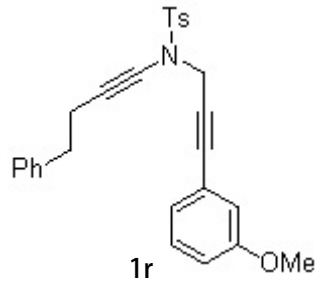



7.779
7.758
7.232
7.217
7.200
7.193
7.183
7.178
7.174
7.158
7.138
6.859
6.853
6.838
6.832
6.746
6.727
6.684
4.403
3.761
2.828
2.810
2.791
2.610
2.591
2.573
2.355
-0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
Ts
N
Ph
OMe
1r
1.91
8.10
0.93
1.86
2.00
3.10
2.03
2.21
3.00
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

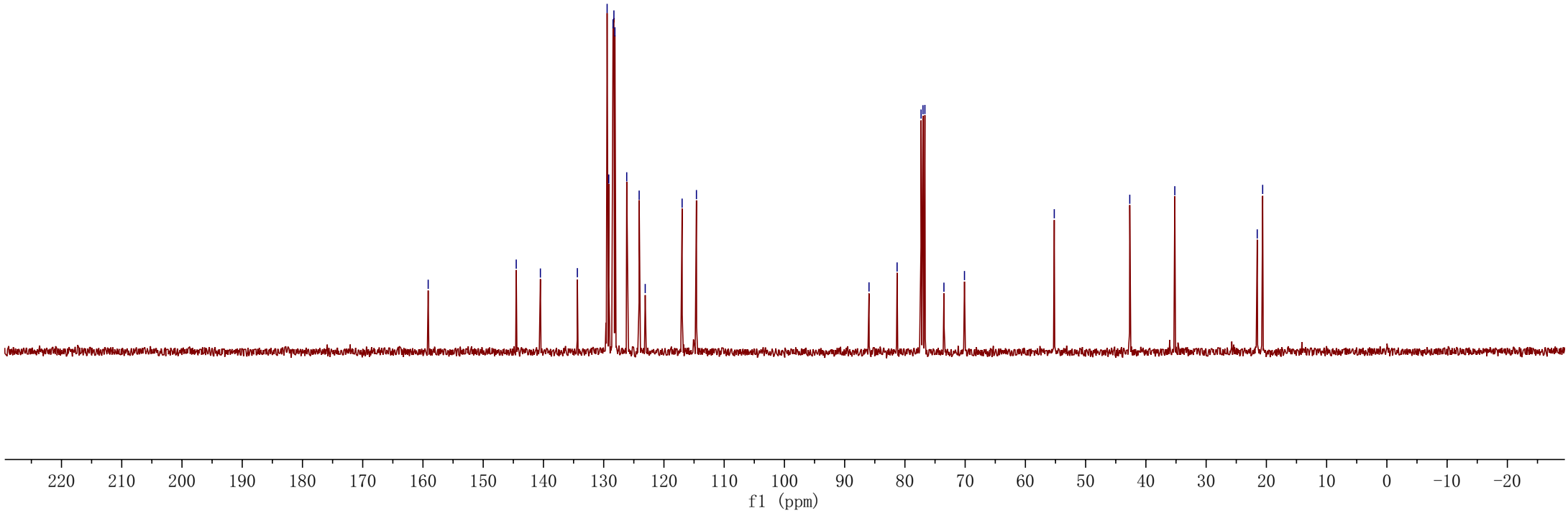
Analysis: ^{13}C NMR
Solvent: $CDCl_3$
Field strength: 100 MHz

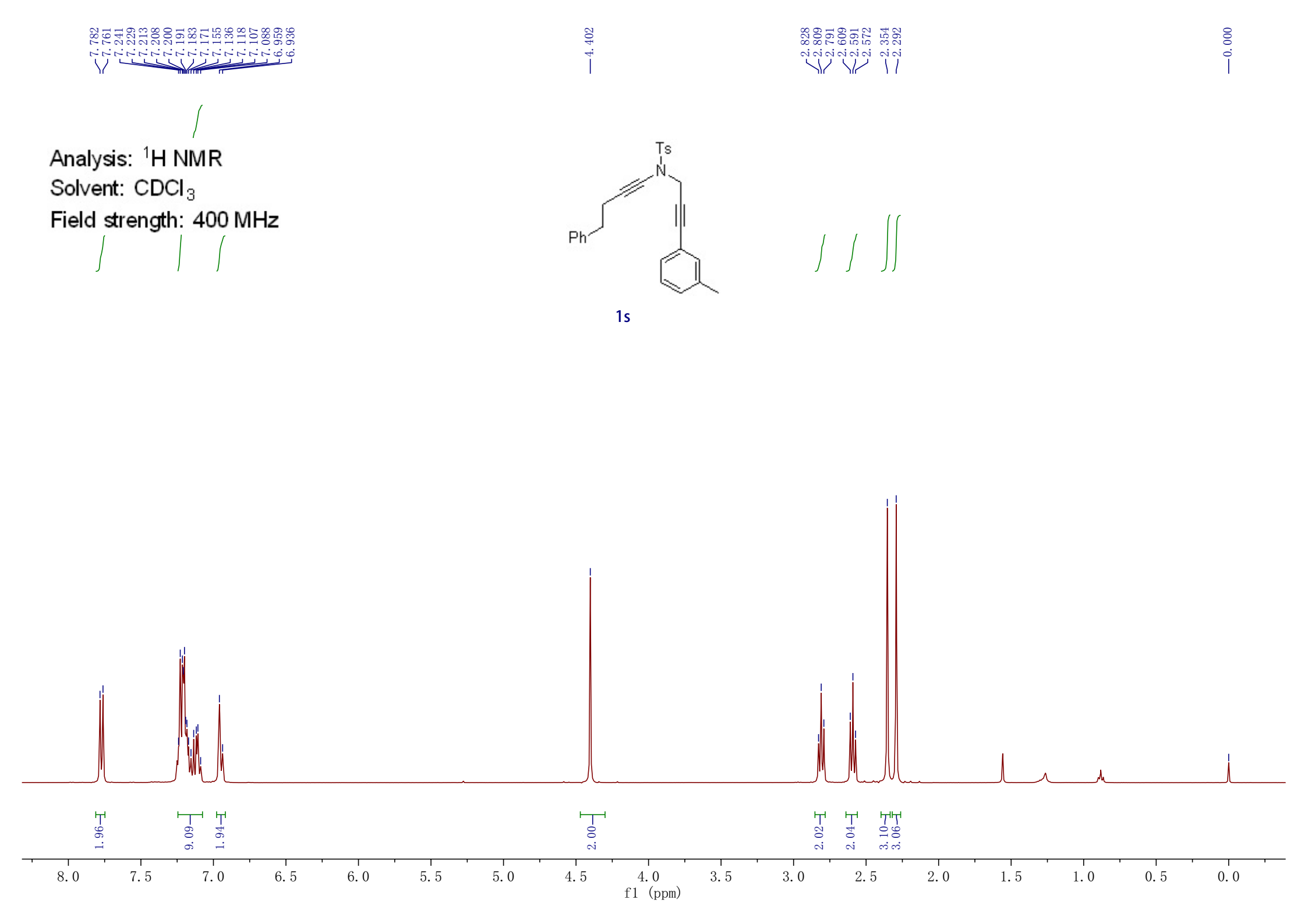
159.13
144.52
140.51
134.37
129.43
129.16
128.45
128.31
128.14
126.18
124.11
123.11
116.98
114.61
85.96
81.30
77.32
77.00
76.68
73.52
70.11
55.21
42.68
35.20
21.52
20.62





1r



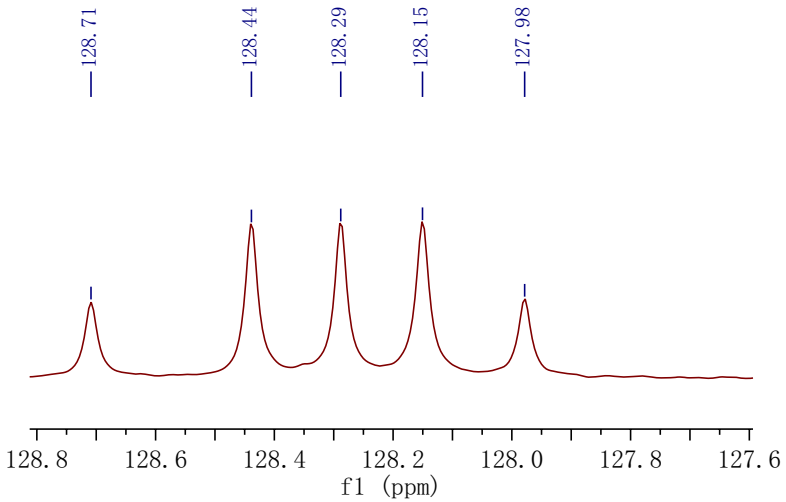

7.782
7.761
7.241
7.229
7.213
7.208
7.200
7.191
7.183
7.171
7.155
7.136
7.118
7.107
7.088
6.959
6.936
4.402
2.828
2.809
2.791
2.609
2.591
2.572
2.354
2.292
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
Ts
N
Ph
1s
1.96
9.09
1.94
2.00
2.02
2.04
3.10
3.06
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

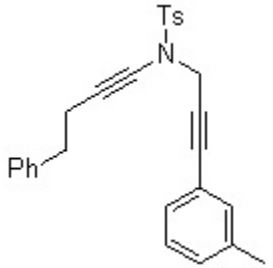
Analysis: ^{13}C NMR

Solvent: $CDCl_3$

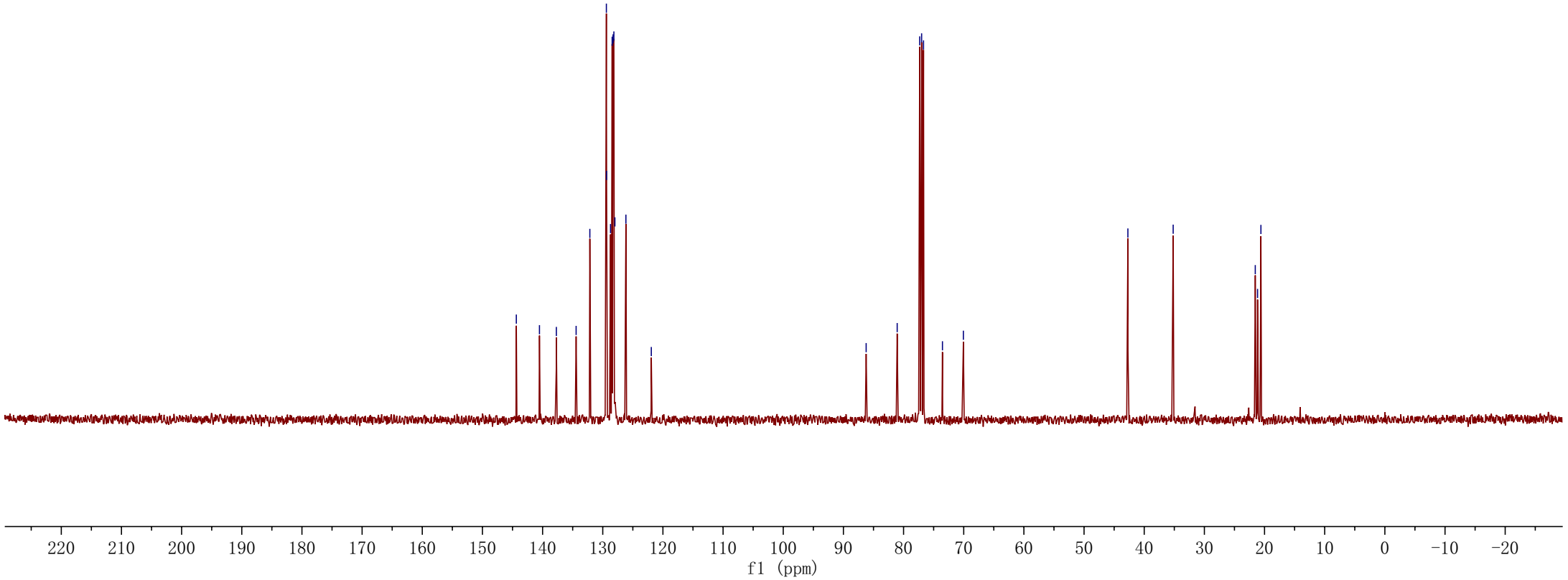
Field strength: 100 MHz

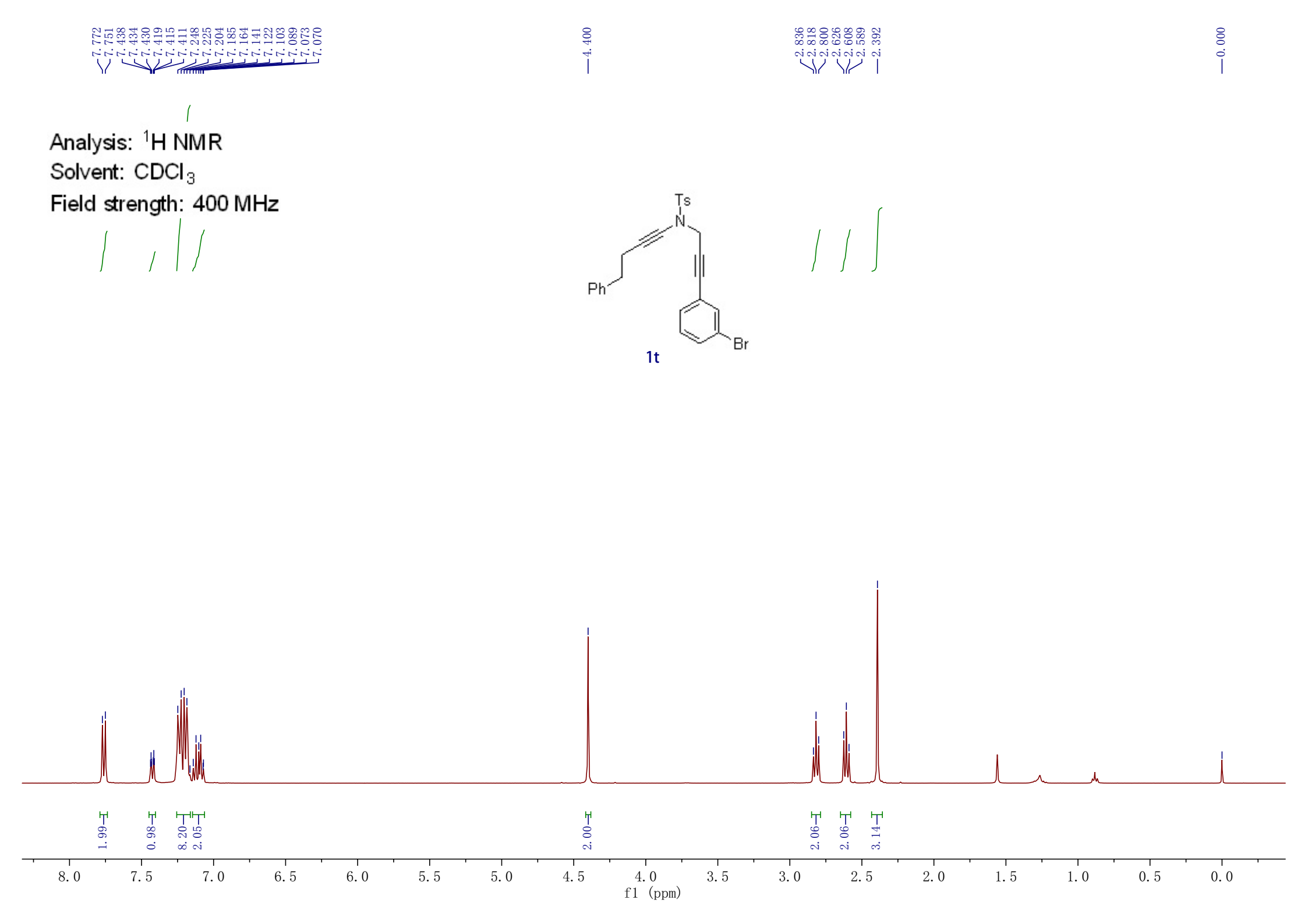
144.37
140.52
137.71
134.43
132.15
129.40
129.36
128.71
128.44
128.29
128.15
127.98
126.15
121.93
86.22
81.06
77.32
77.00
76.68
73.54
70.06
42.71
35.19
21.54
21.16
20.60





1s



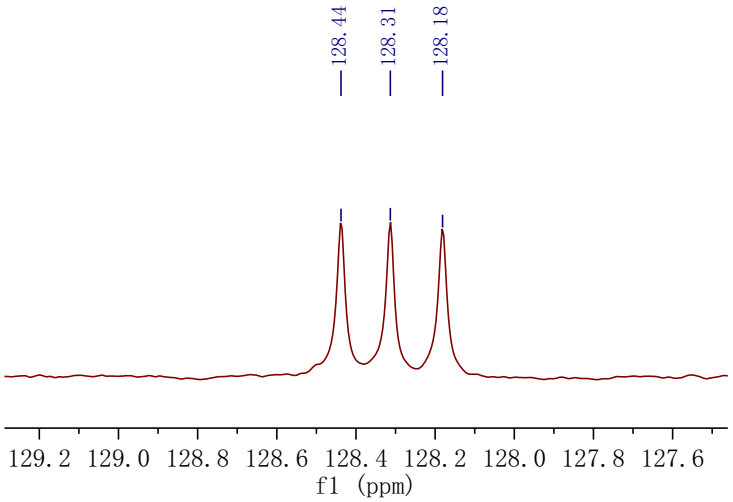

7.772
7.751
7.438
7.434
7.430
7.419
7.415
7.411
7.248
7.225
7.204
7.185
7.164
7.141
7.122
7.103
7.089
7.073
7.070
4.400
2.836
2.818
2.800
2.626
2.608
2.589
2.392
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
Ts
N
Ph
Br
1t
1.99
0.98
8.20
2.05
2.00
2.06
2.06
3.14
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

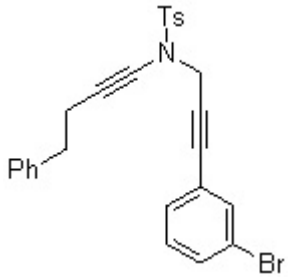
Analysis: ^{13}C NMR

Solvent: $CDCl_3$

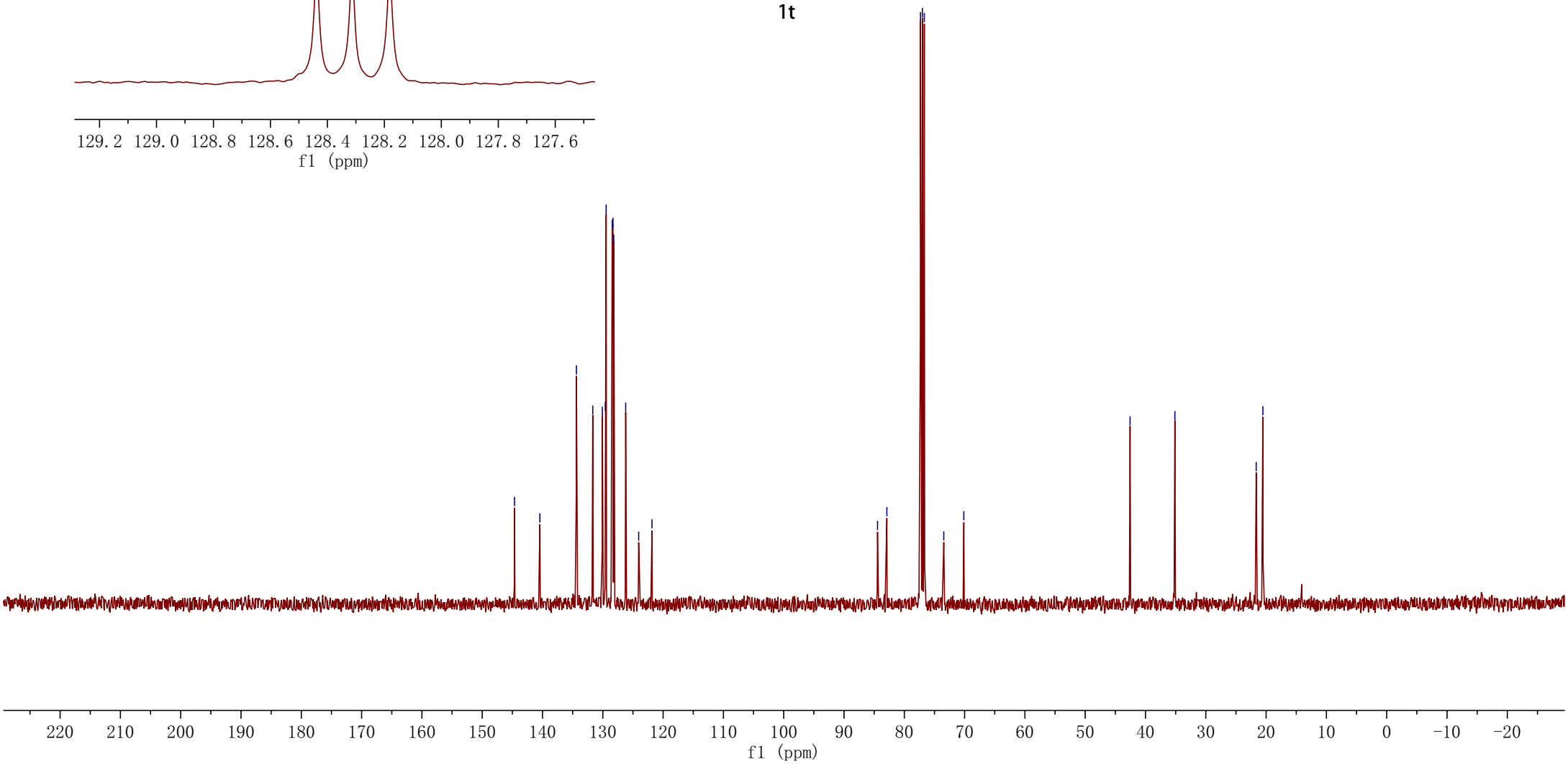
Field strength: 100 MHz

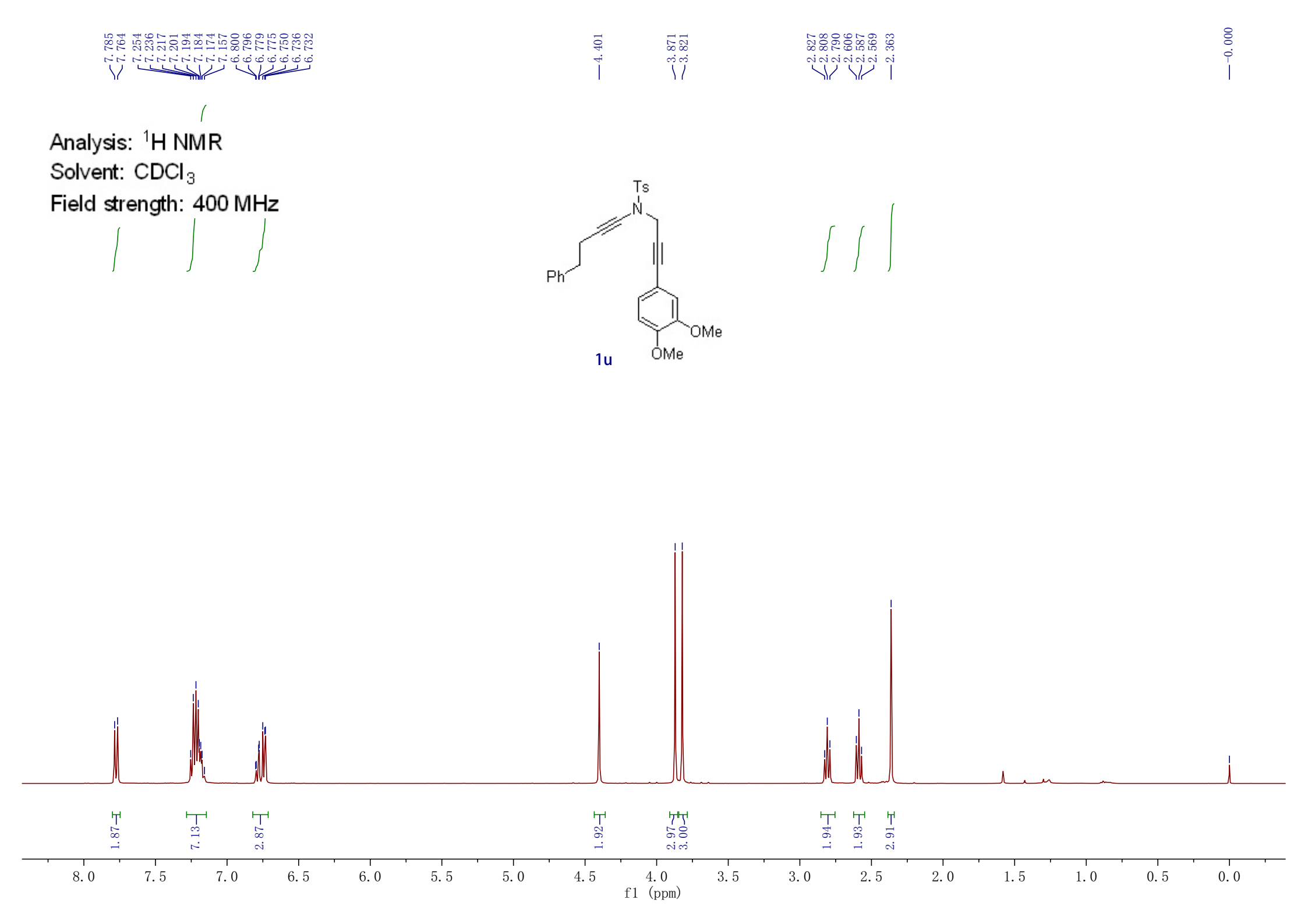
144.64, 140.44, 131.38, 131.67, 130.08, 129.58, 129.45, 128.44, 128.31, 128.18, 126.21, 124.05, 121.85, 84.44, 82.89, 77.32, 77.00, 76.68, 73.45, 70.13, 42.56, 35.13, 21.64, 20.54





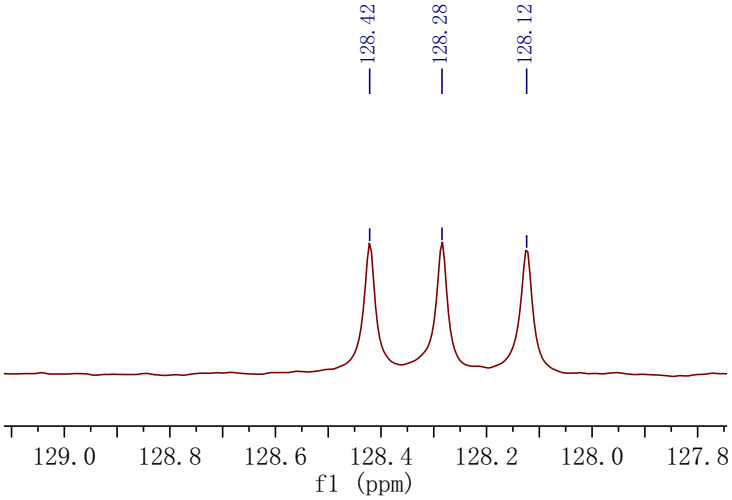
1t

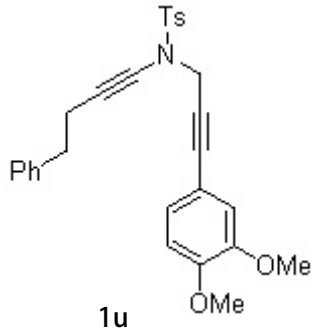



7.785
7.764
7.254
7.236
7.217
7.201
7.194
7.184
7.174
7.157
6.800
6.796
6.779
6.775
6.750
6.736
6.732
4.401
3.871
3.821
2.827
2.808
2.790
2.606
2.587
2.569
2.363
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
Ts
N
Ph
OMe
OMe
1u
1.87
7.13
2.87
1.92
2.97
3.00
1.94
1.93
2.91
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

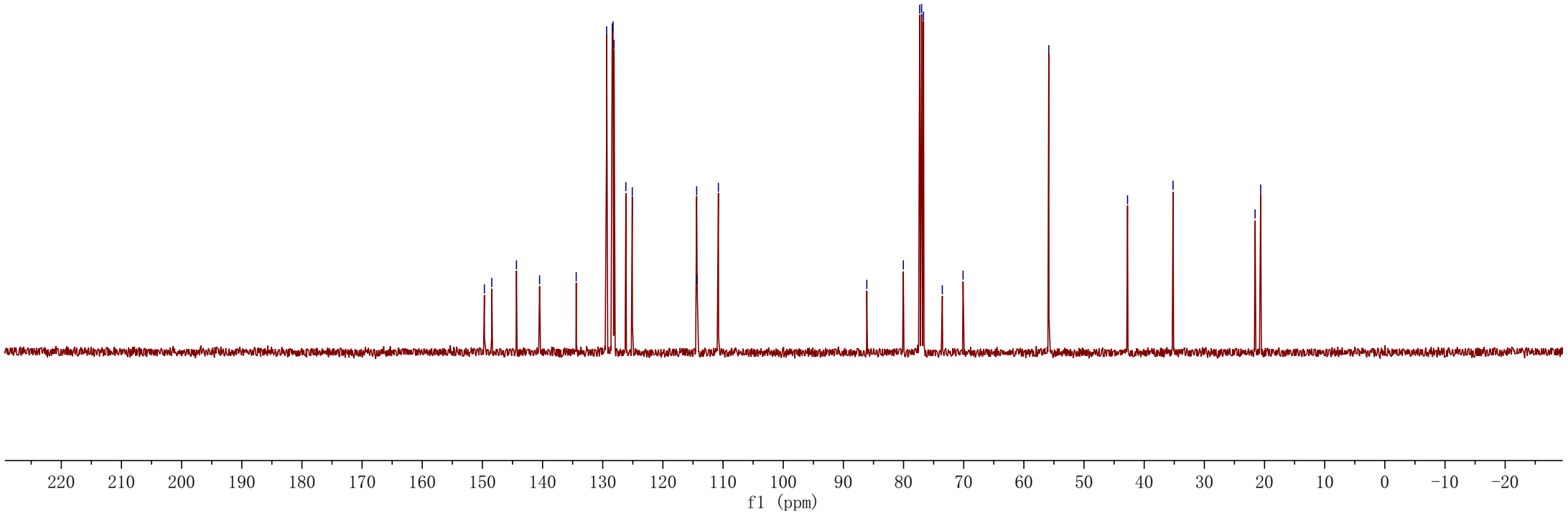
Analysis: ^{13}C NMR
Solvent: $CDCl_3$
Field strength: 100 MHz

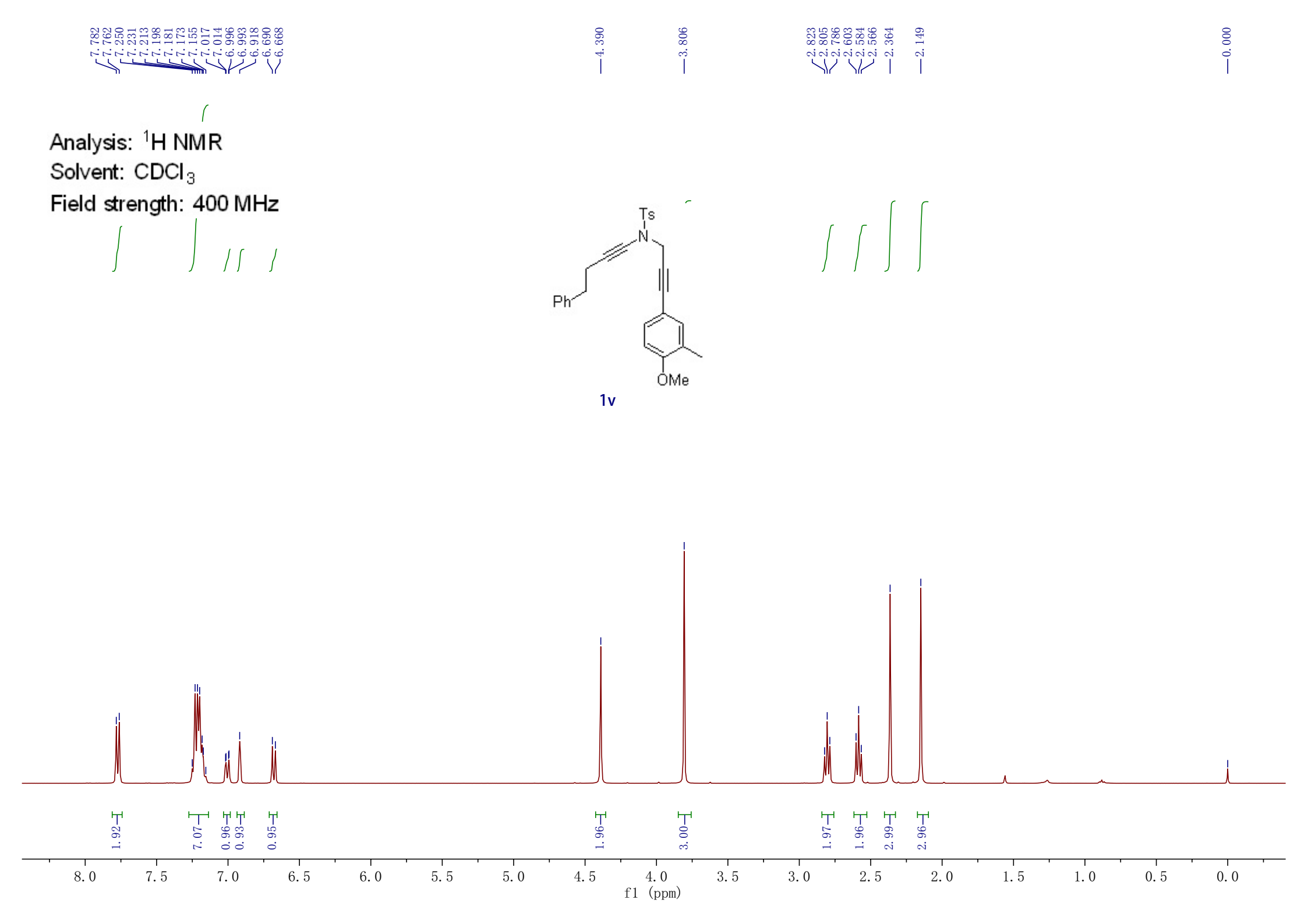
149.67
148.44
144.34
140.50
134.41
129.35
128.42
128.28
128.12
126.16
125.09
114.39
114.31
110.77
86.11
80.04
77.32
77.00
76.68
73.56
70.11
55.86
42.77
35.20
21.57
20.64





1u




7.782
7.762
7.250
7.231
7.213
7.198
7.181
7.173
7.155
7.017
7.014
6.996
6.993
6.918
6.690
6.668
4.390
3.806
2.823
2.805
2.786
2.603
2.584
2.566
2.364
2.149
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
Ts
N
Ph
OMe
1v
1.92
7.07
0.96
0.93
0.95
1.96
3.00
1.97
1.96
2.99
2.96
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

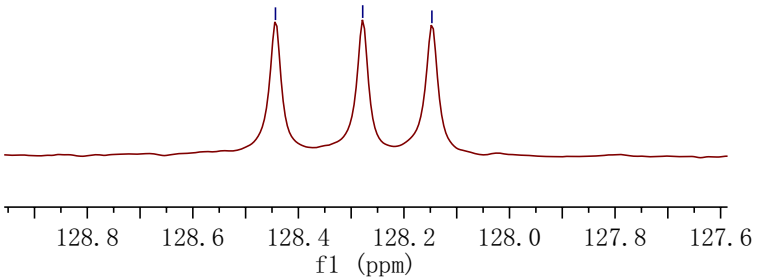
Analysis: ^{13}C NMR

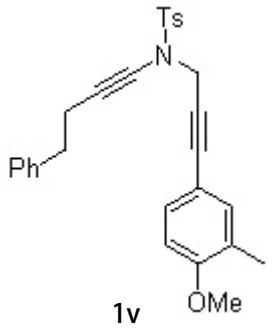
Solvent: $CDCl_3$

Field strength: 100 MHz

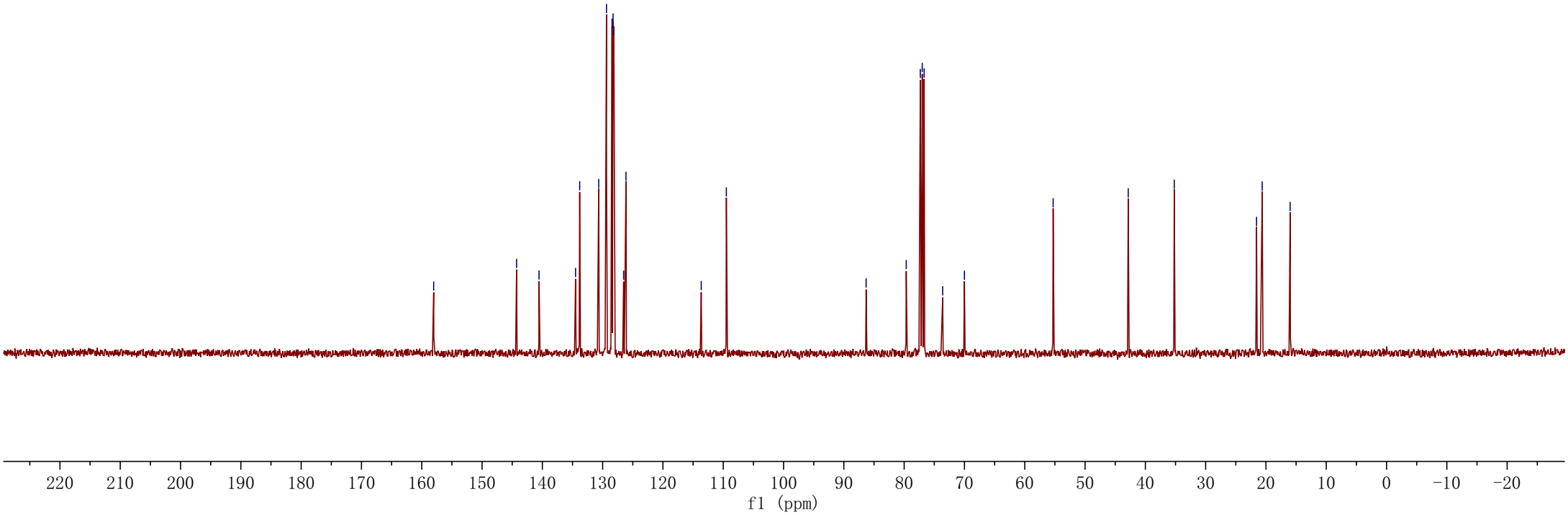
158.02 144.28 140.55 134.49 133.81 130.66 129.37 128.44 128.28 128.15 126.52 126.13 113.65 109.49 86.31 79.65 77.32 77.00 76.68 73.61 70.00 55.29 42.84 35.20 21.56 20.62 15.98

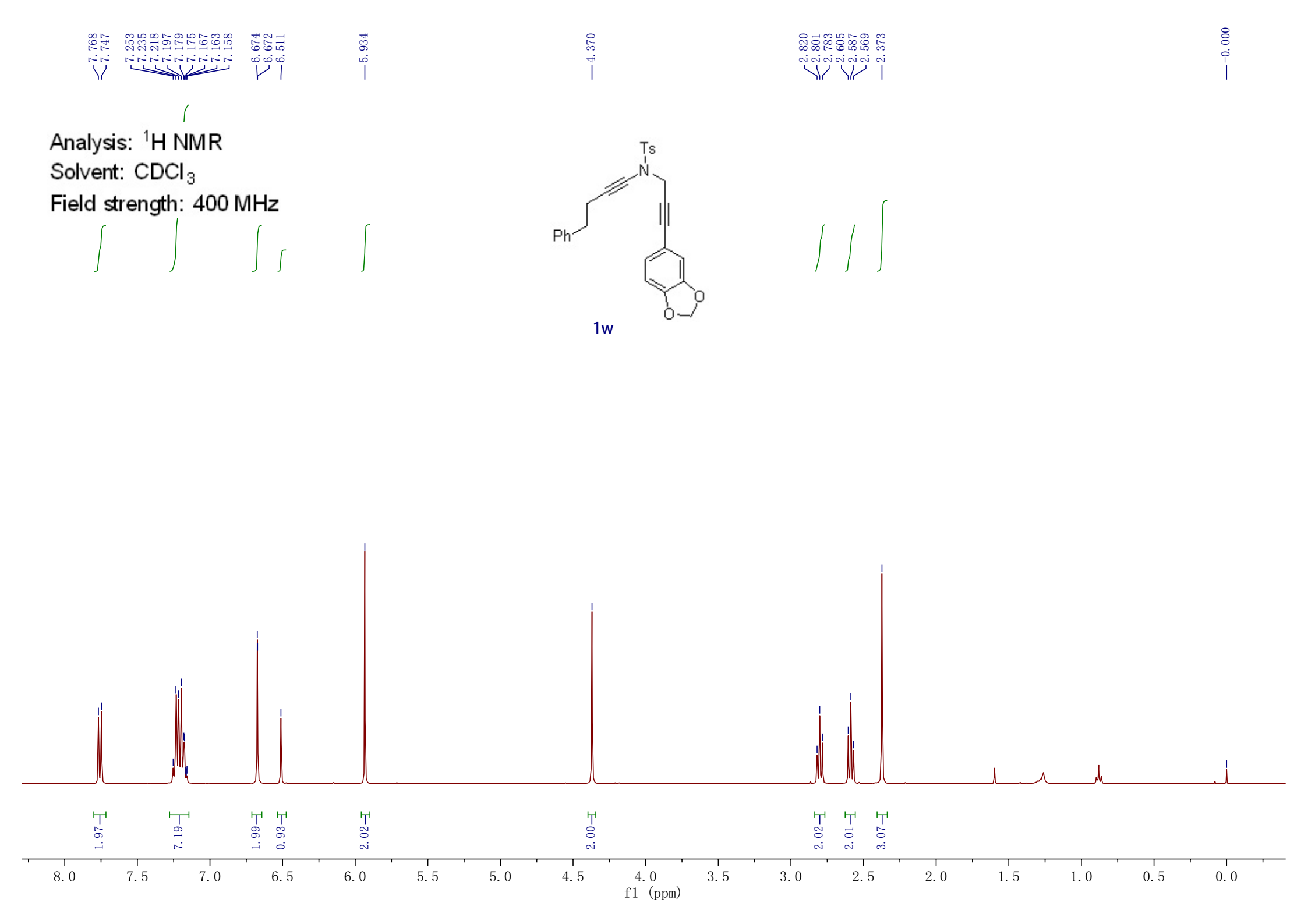
128.8 128.28 128.15





1v



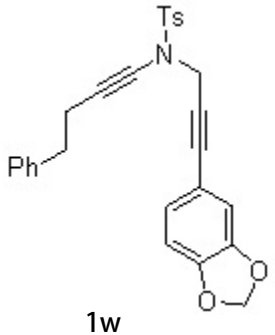

7.768
7.747
7.253
7.235
7.218
7.197
7.179
7.175
7.167
7.163
7.158
6.674
6.672
6.511
5.934
4.370
2.820
2.801
2.783
2.605
2.587
2.569
2.373
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
Ts
N
Ph
O
O
1w
1.97
7.19
1.99
0.93
2.02
2.00
2.02
2.01
3.07
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

Analysis: ^{13}C NMR

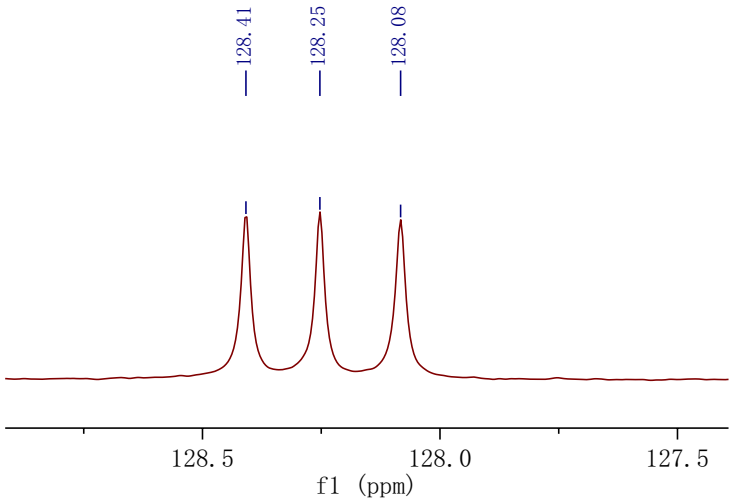
Solvent: $CDCl_3$

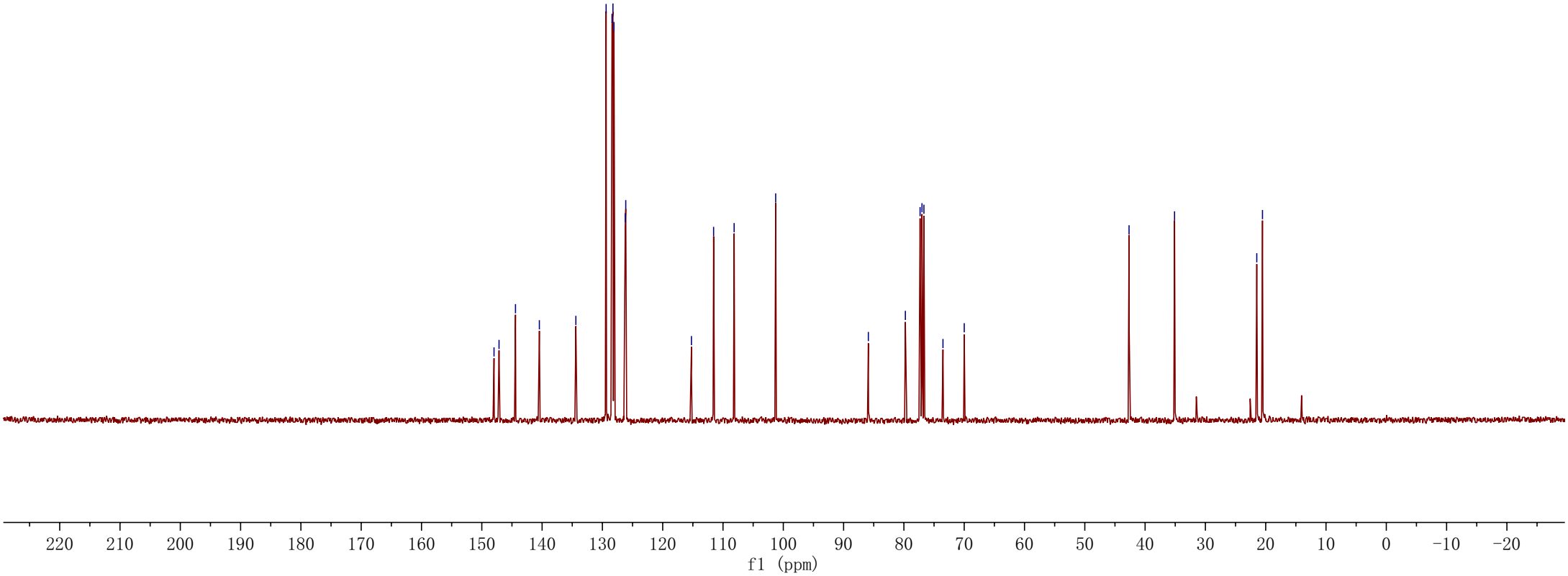
Field strength: 100 MHz

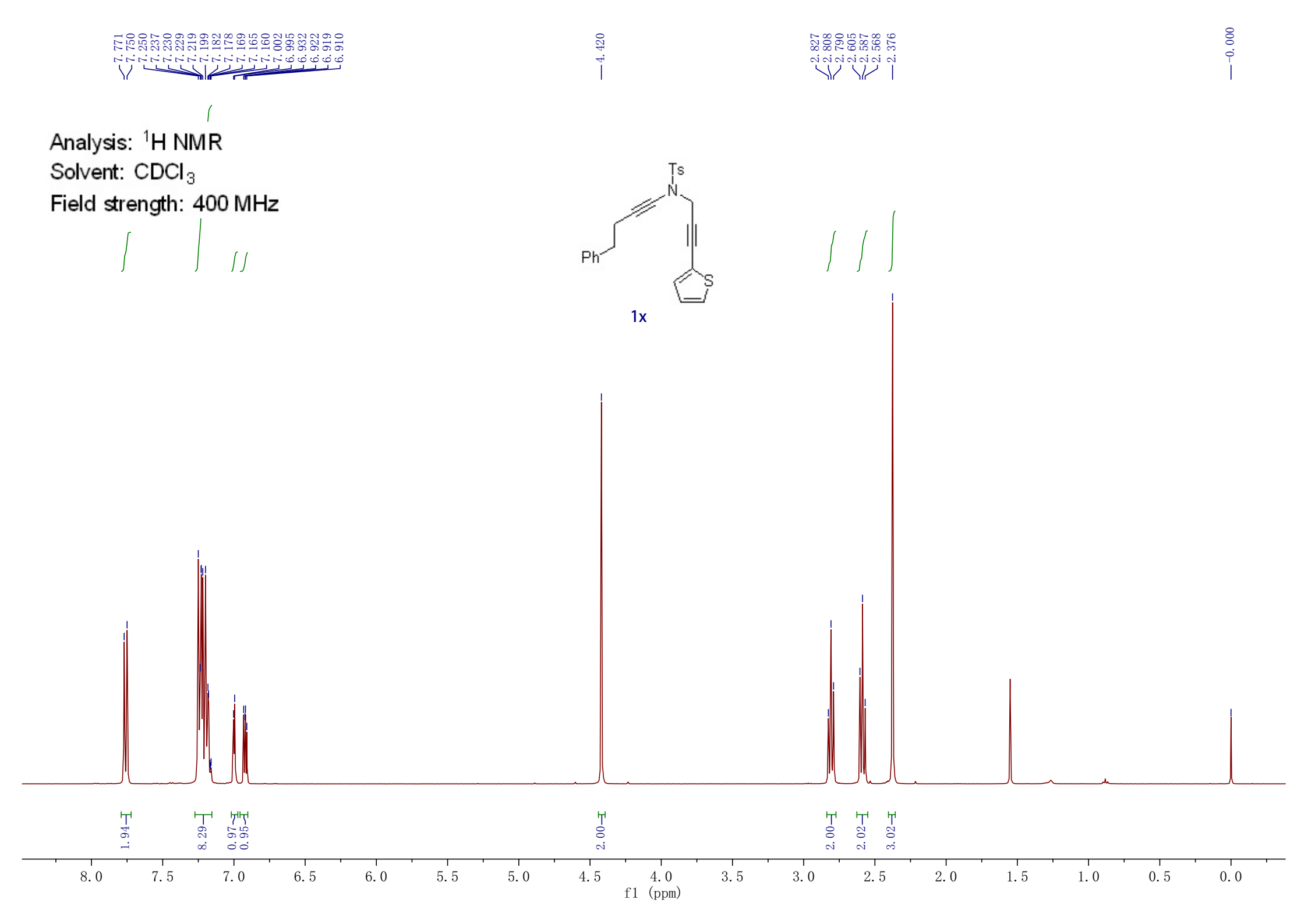
147.97
147.14
144.41
140.46
134.40
129.38
128.41
128.25
128.08
126.21
126.13
115.23
111.56
108.15
101.27
85.90
79.76
77.32
77.00
76.68
73.52
69.99
42.66
35.12
21.48
20.53



1w






7.771
7.750
7.250
7.237
7.230
7.229
7.219
7.199
7.182
7.178
7.169
7.165
7.160
7.002
6.995
6.932
6.922
6.919
6.910
4.420
2.827
2.808
2.790
2.605
2.587
2.568
2.376
-0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
Ts
N
Ph
S
1x
1.94
8.29
0.97
0.95
2.00
2.00
2.02
3.02
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

Analysis: ^{13}C NMR

Solvent: $CDCl_3$

Field strength: 100 MHz

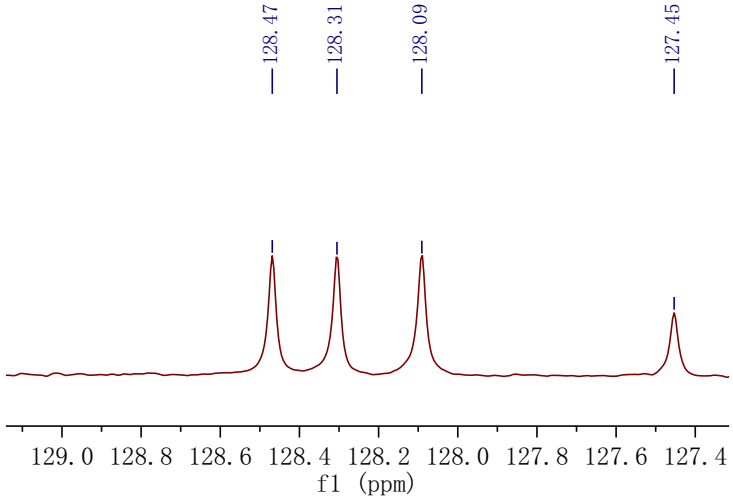
144.55 140.52 134.24 132.51 129.49 128.47 128.31 128.09 127.45 126.77 126.18 122.03

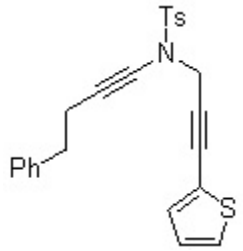
85.45 79.37 77.32 77.00 76.68 73.47 70.23

42.83

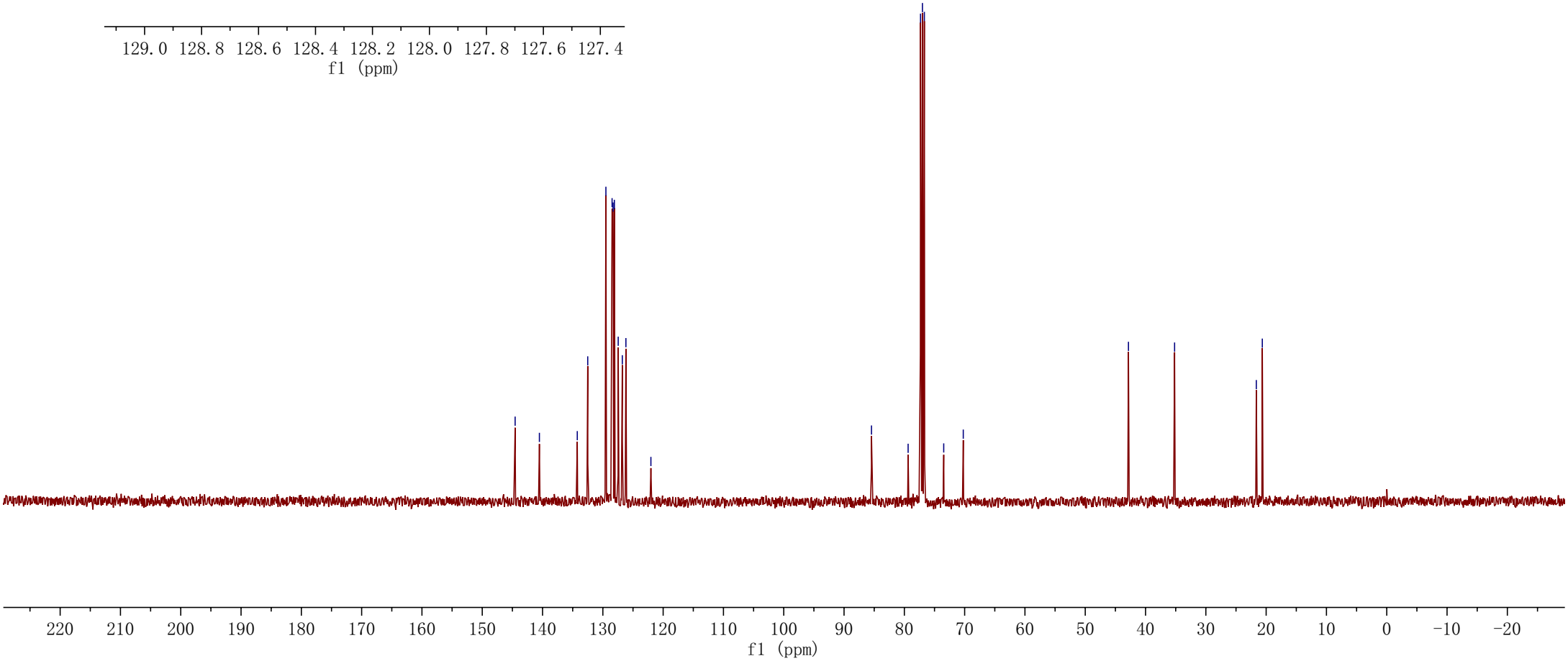
35.18

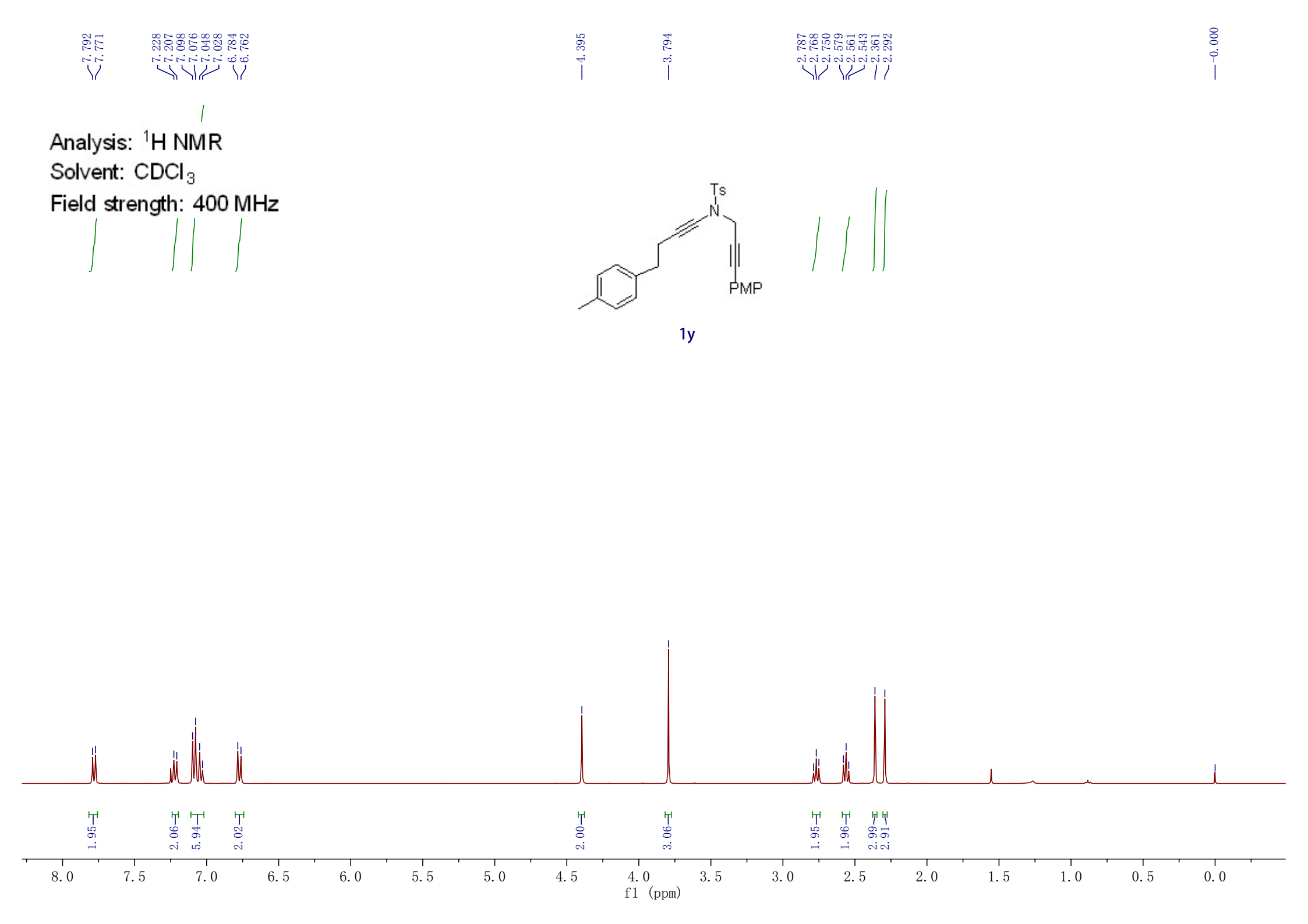
21.63 20.64





1x



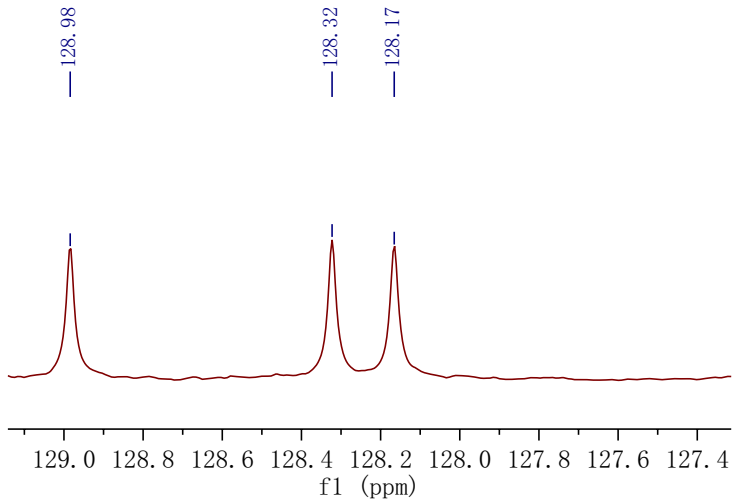

7.792
7.771
7.228
7.207
7.098
7.076
7.048
7.028
6.784
6.762
4.395
3.794
2.787
2.768
2.750
2.579
2.561
2.543
2.361
2.292
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
Ts
N
PMP
1y
1.95
2.06
5.94
2.02
2.00
3.06
1.95
1.96
2.99
2.91
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

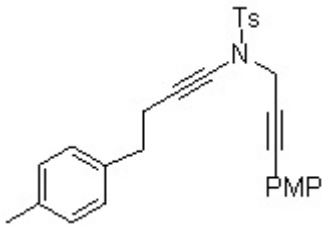
Analysis: ^{13}C NMR

Solvent: $CDCl_3$

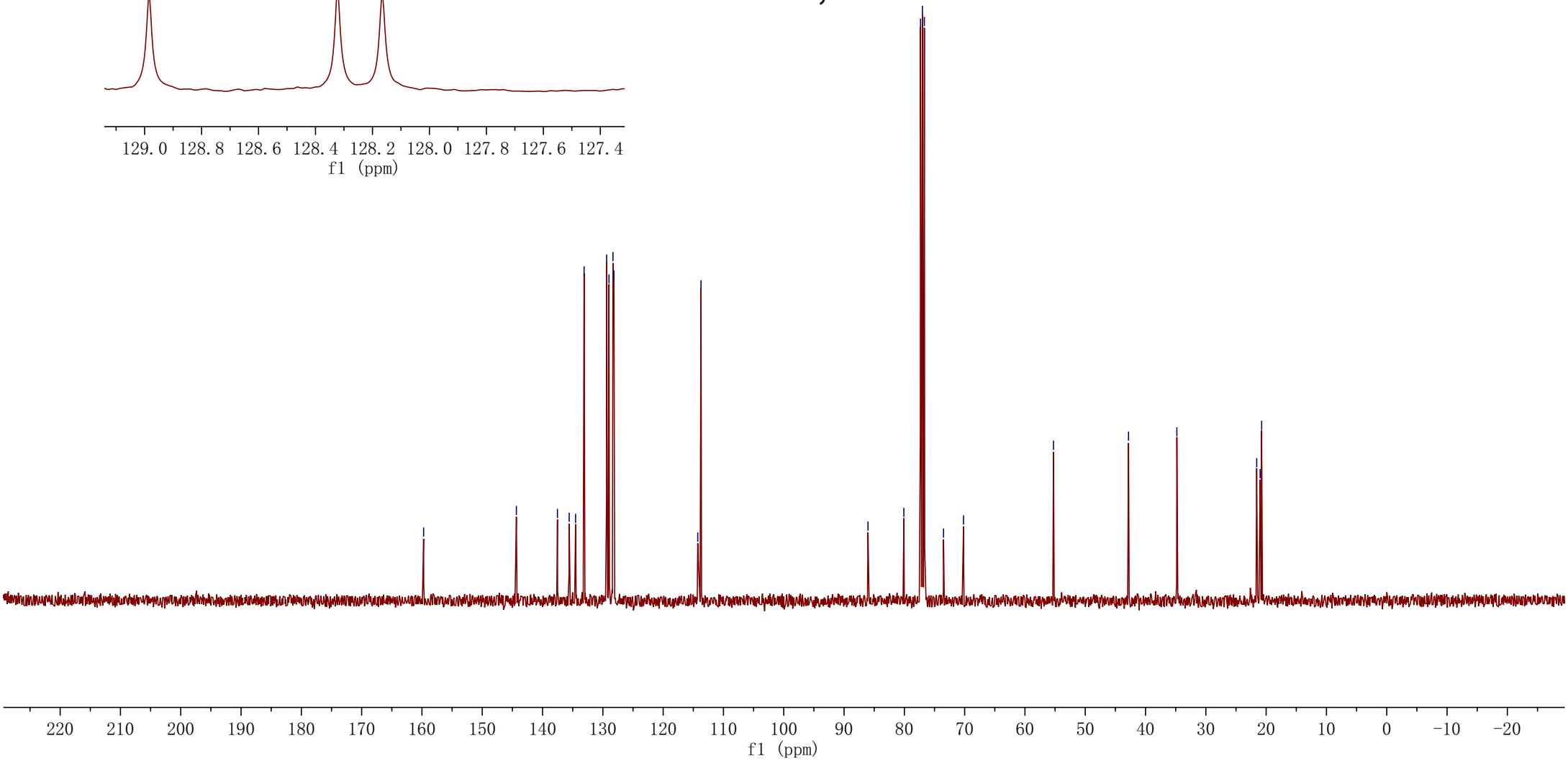
Field strength: 100 MHz

159.73
144.34
137.53
135.58
134.52
133.11
129.37
128.98
128.32
128.17
114.26
113.72
86.03
80.08
77.32
77.00
76.68
73.50
70.19
55.27
42.83
34.81
21.57
21.00
20.75





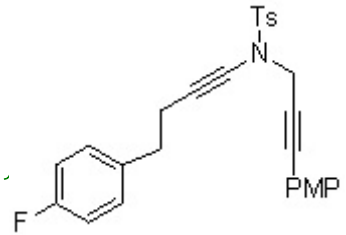
1y



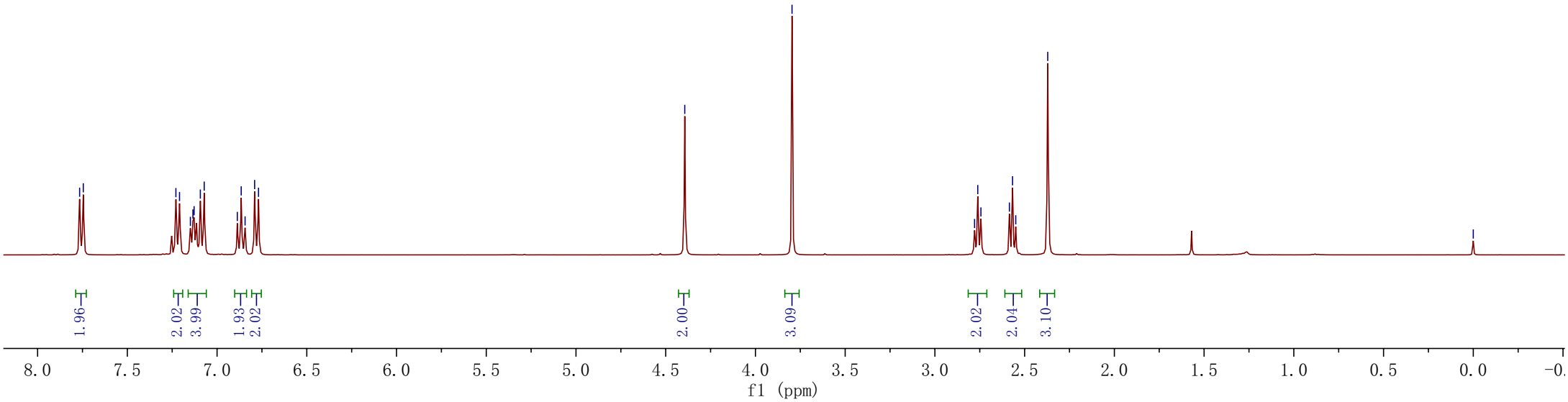
Analysis: ^{1}H NMR

Solvent: $CDCl_3$

Field strength: 400 MHz

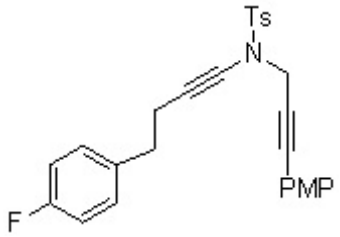


1z

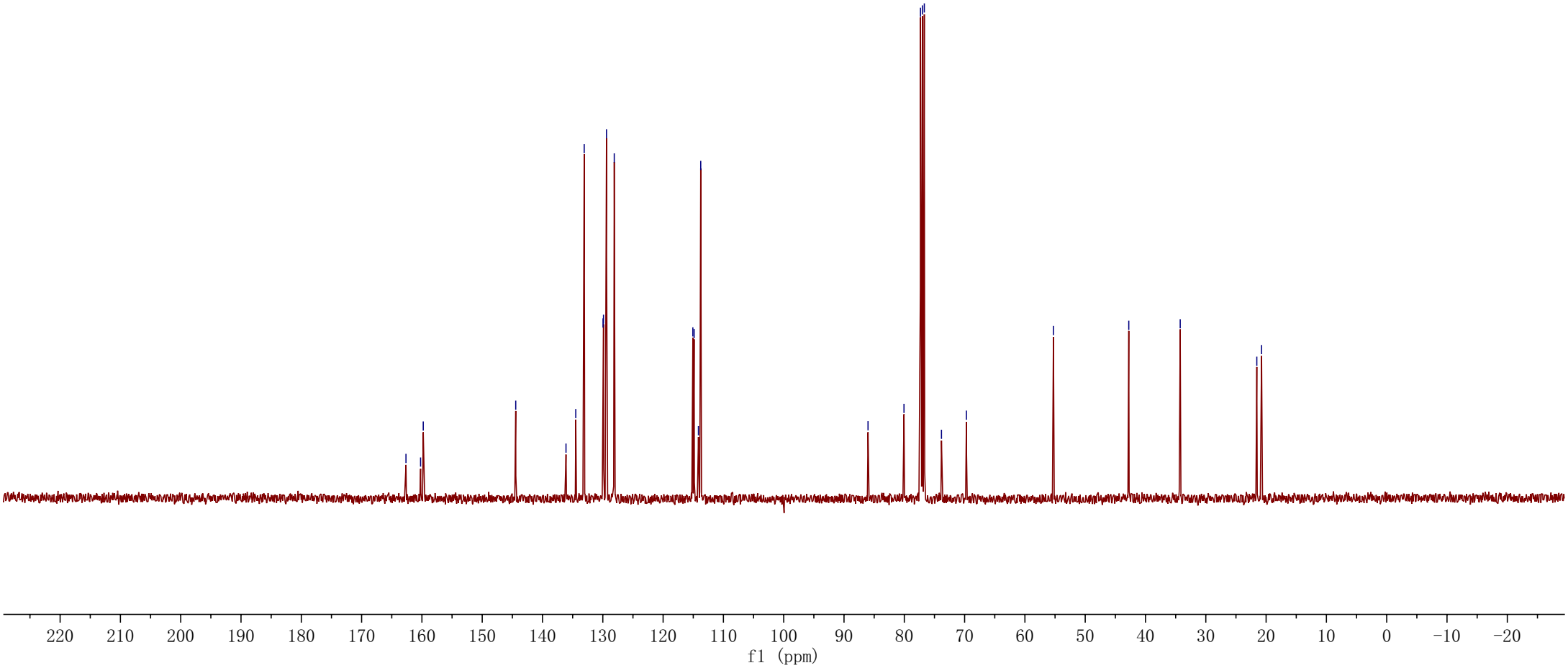


Analysis: ^{13}C NMR
Solvent: $CDCl_3$
Field strength: 100 MHz

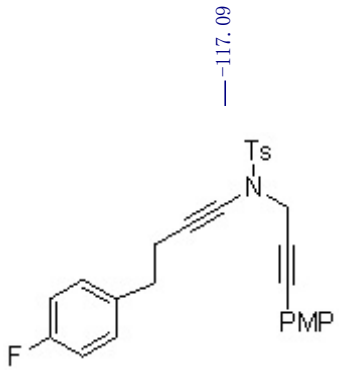
162.64
160.22
159.78
144.44
136.11
134.48
133.09
129.96
129.88
129.39
128.10
115.07
114.86
114.14
113.76
86.02
80.05
77.32
77.00
76.68
73.84
69.70
55.27
42.78
34.25
21.54
20.76



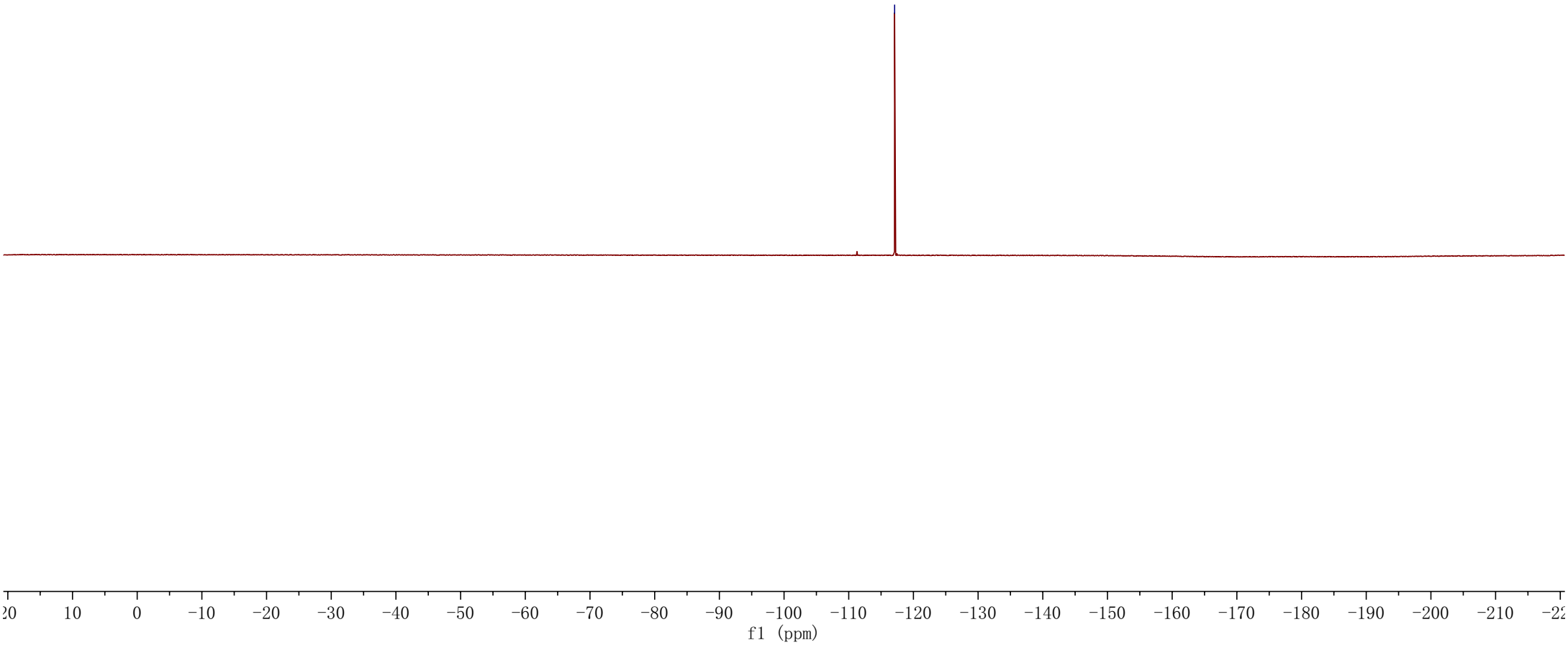
1z

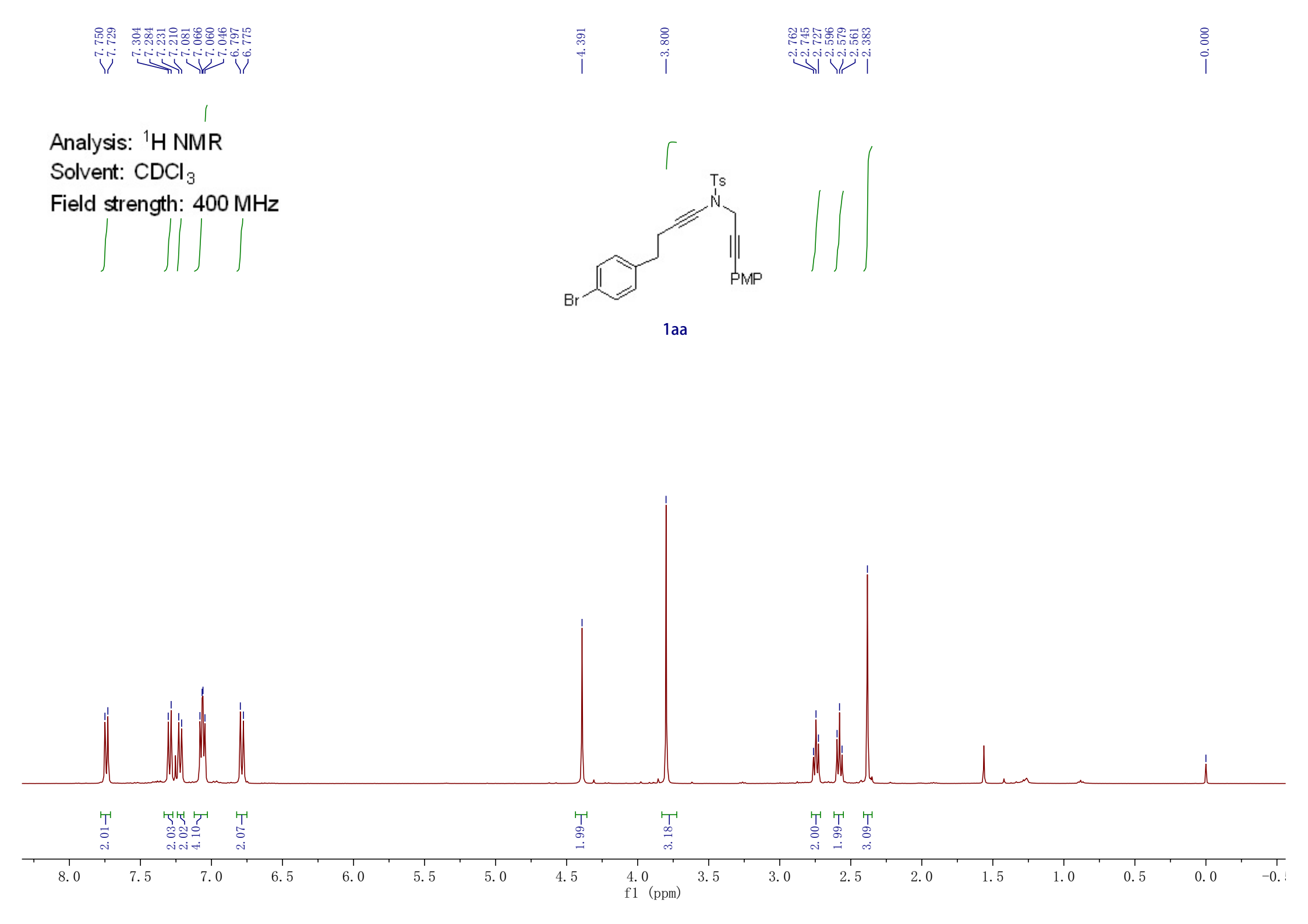


Analysis: ^{19}F NMR
Solvent: $CDCl_3$
Field strength: 471 MHz



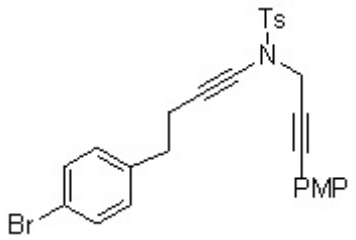
1z



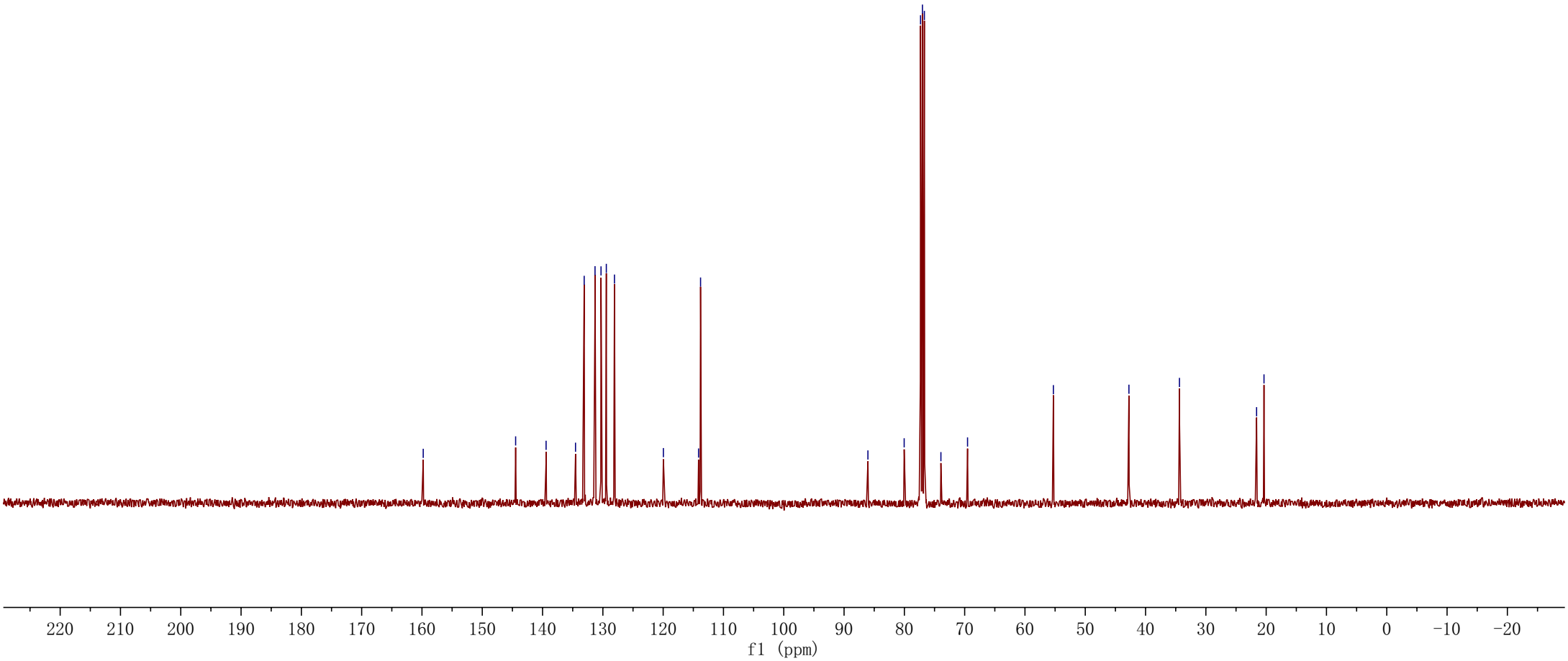

7.750
7.729
7.304
7.284
7.231
7.210
7.081
7.066
7.060
7.046
6.797
6.775
4.391
3.800
2.762
2.745
2.727
2.596
2.579
2.561
2.383
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
Ts
N
PMP
Br
1aa
2.01
2.03
2.02
4.10
2.07
1.99
3.18
2.00
1.99
3.09
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

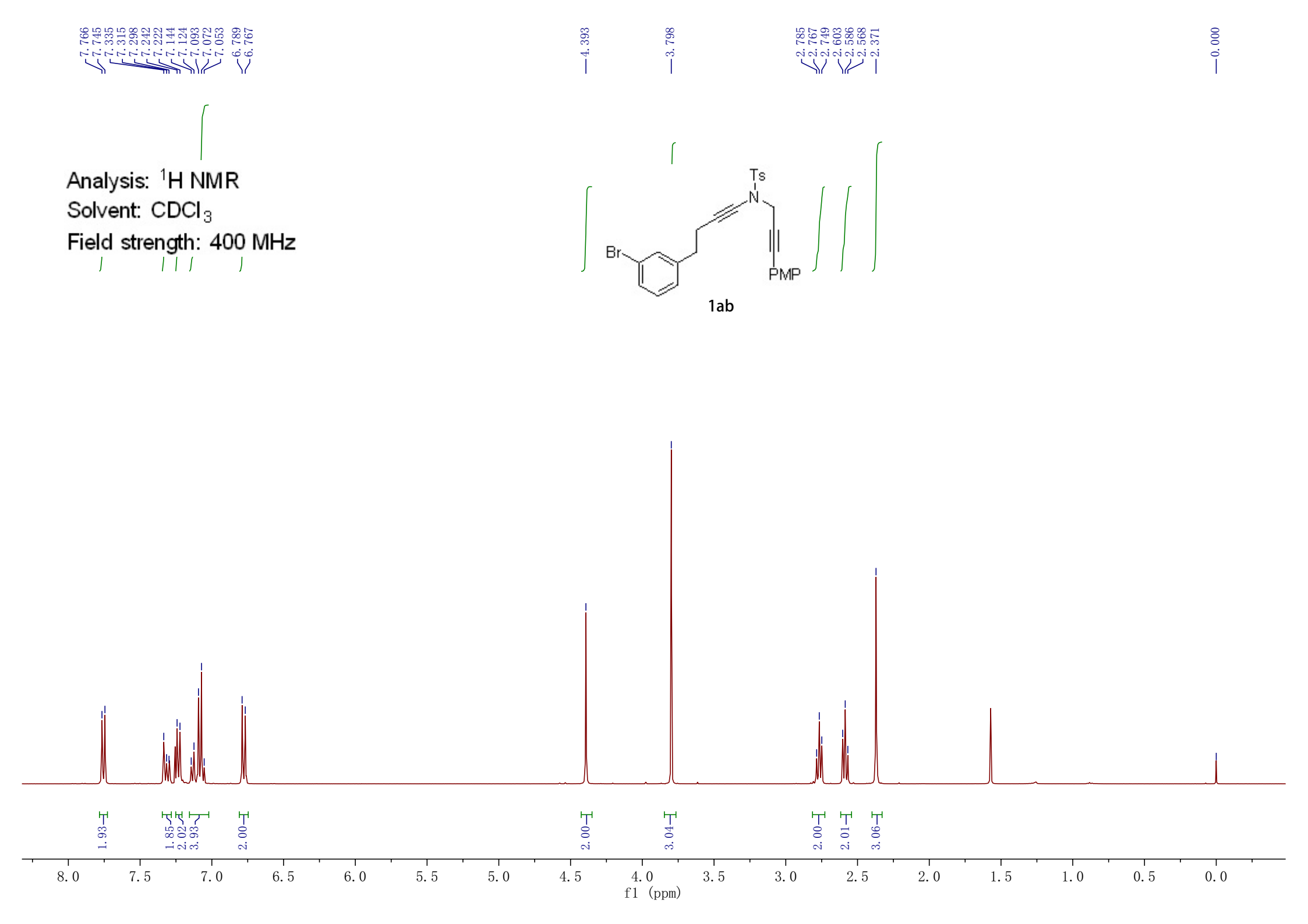
Analysis: ^{13}C NMR
Solvent: $CDCl_3$
Field strength: 100 MHz

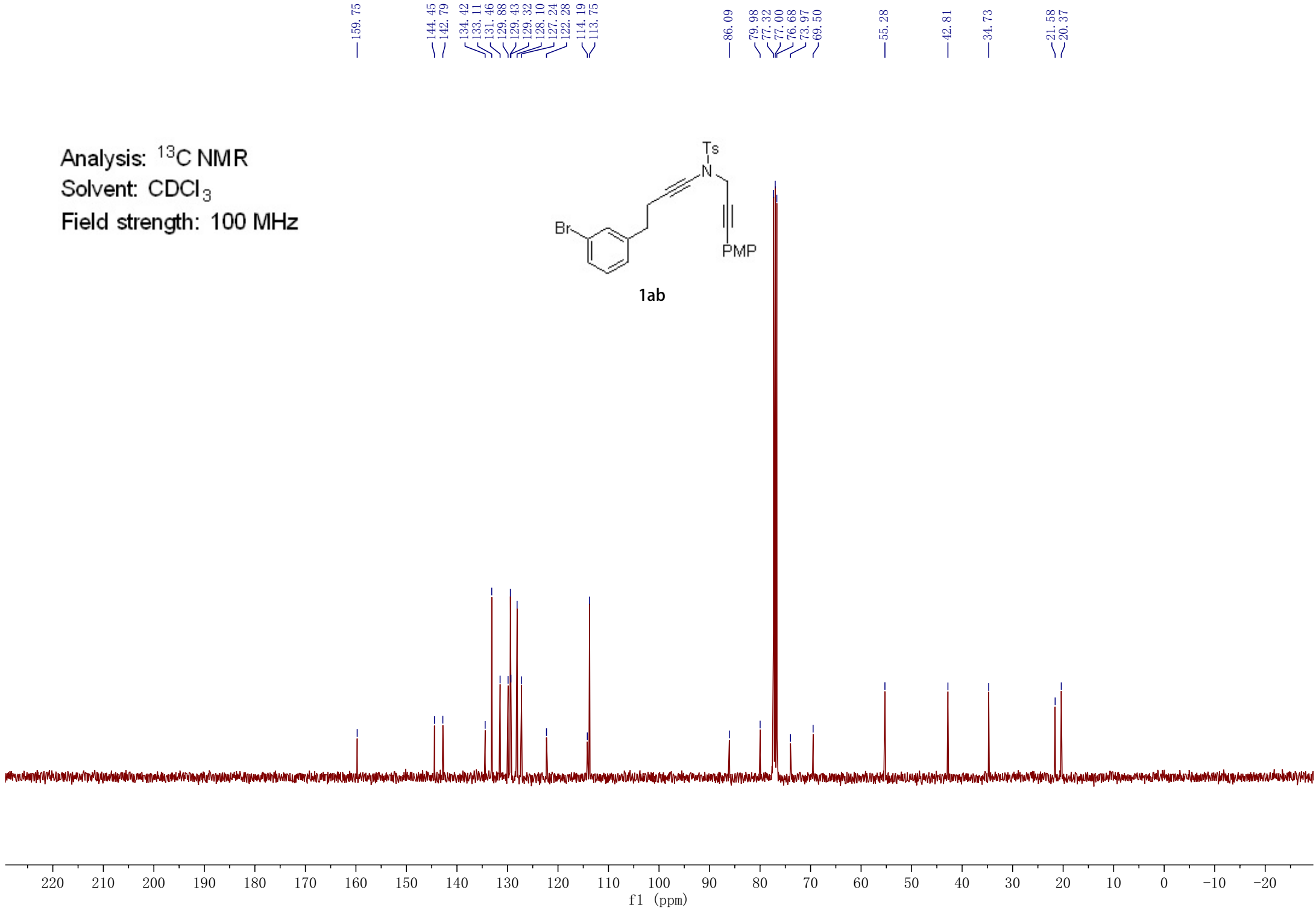
159.79
144.47
139.42
134.54
133.10
131.30
130.31
129.43
128.08
119.96
114.13
113.80
86.05
80.03
77.32
77.00
76.68
73.94
69.52
55.29
42.76
34.38
21.59
20.36

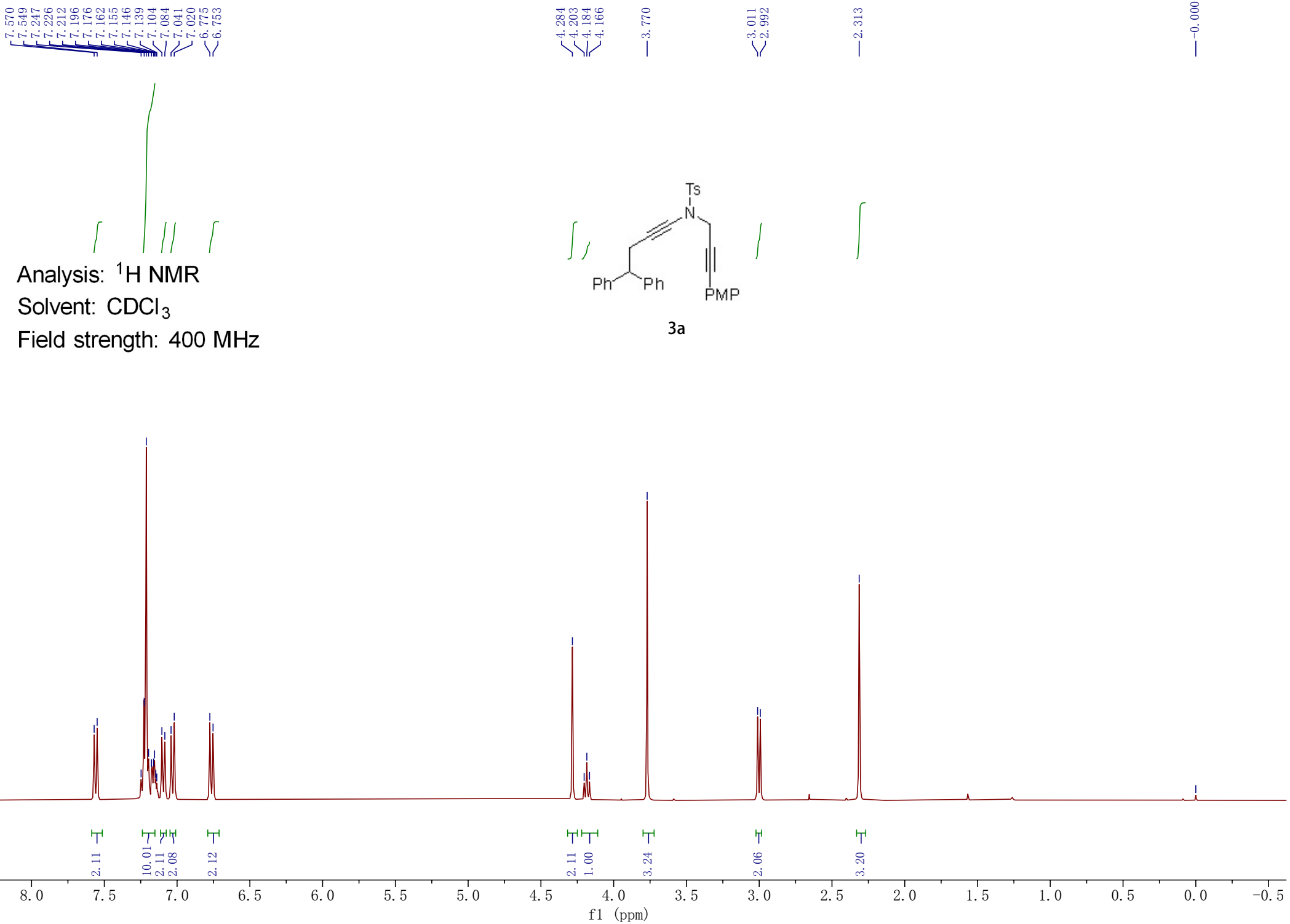


1aa




7.766
7.745
7.335
7.315
7.298
7.242
7.222
7.144
7.124
7.093
7.072
7.053
6.789
6.767
4.393
3.798
2.785
2.767
2.749
2.603
2.586
2.568
2.371
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
Ts
N
Br
PMP
1ab
1.93
1.85
2.02
3.93
2.00
2.00
3.04
2.00
2.01
3.06
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

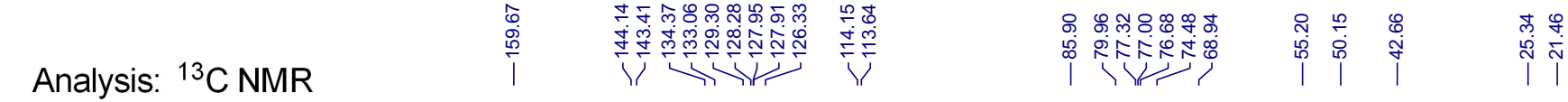

159.75
144.45
142.79
134.42
133.11
131.46
129.88
129.43
129.32
128.10
127.24
122.28
114.19
113.75
86.09
79.98
77.32
77.00
76.68
73.97
69.50
55.28
42.81
34.73
21.58
20.37
Analysis: 13C NMR
Solvent: CDCl3
Field strength: 100 MHz
Ts
N
Br
PMP
1ab
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
f1 (ppm)

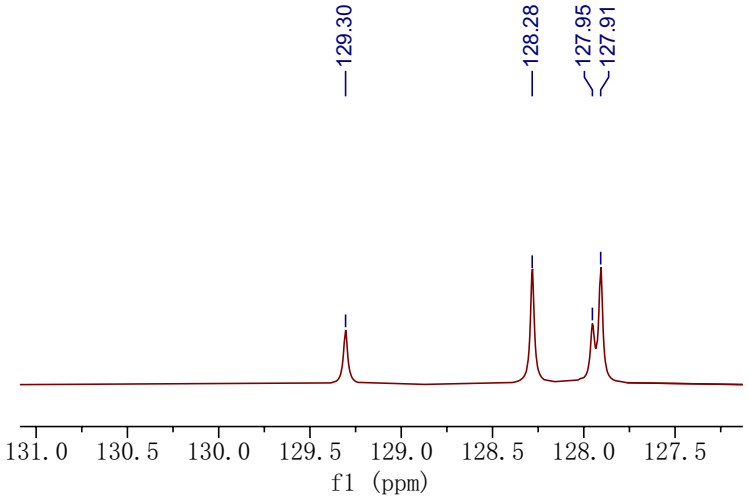

7.570
7.549
7.247
7.226
7.212
7.196
7.176
7.162
7.155
7.146
7.139
7.104
7.084
7.041
7.020
6.775
6.753
4.284
4.203
4.184
4.166
3.770
3.011
2.992
2.313
-0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
Ts
N
Ph
Ph
PMP
3a
2.11
10.01
2.11
2.08
2.12
2.11
1.00
3.24
2.06
3.20
f1 (ppm)

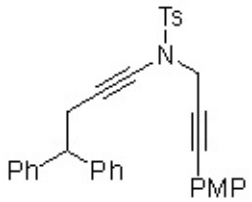
Analysis: ^{13}C NMR

Solvent: $CDCl_3$

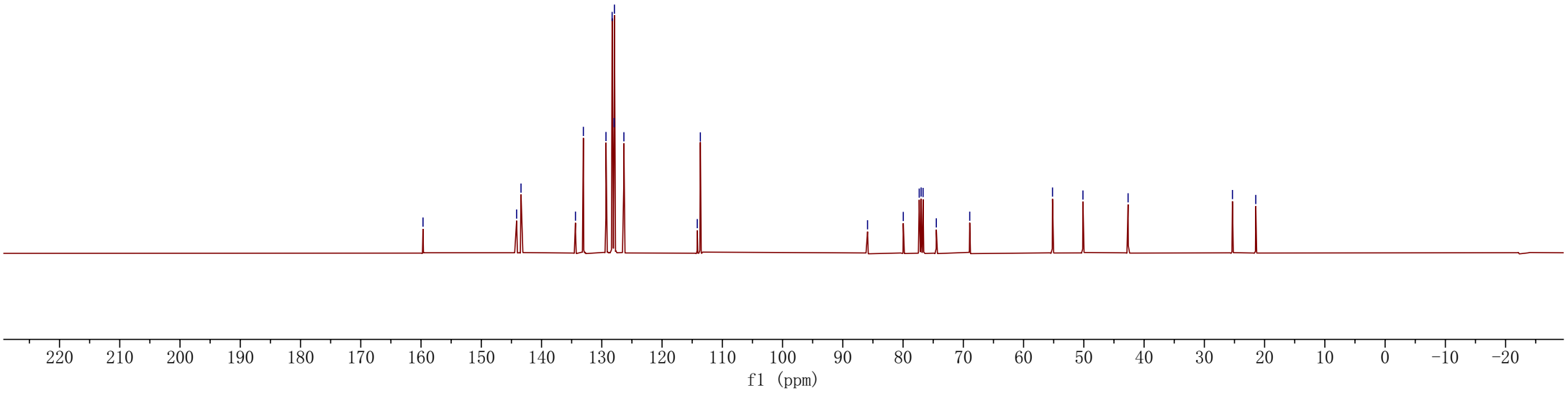
Field strength: 100 MHz

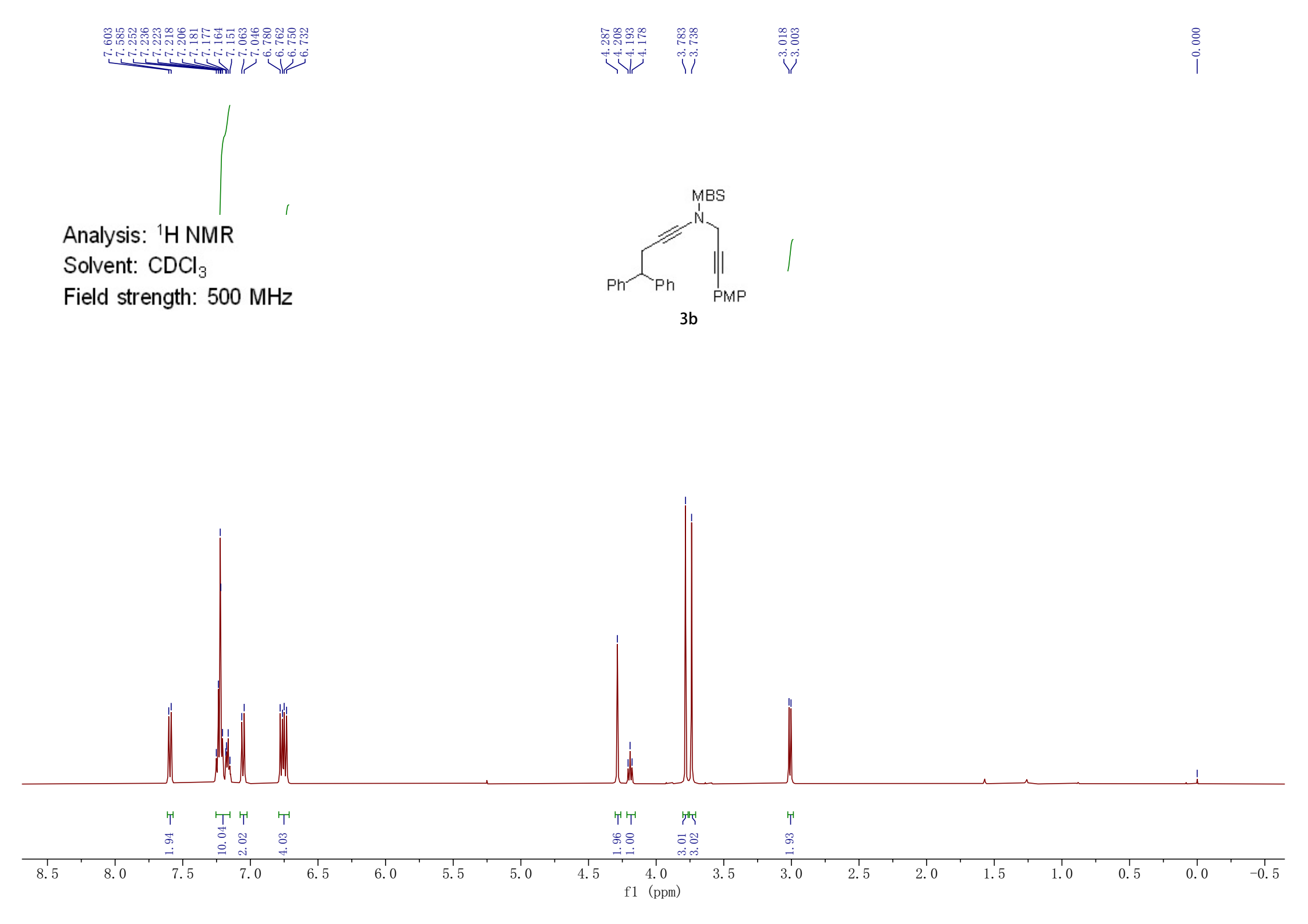




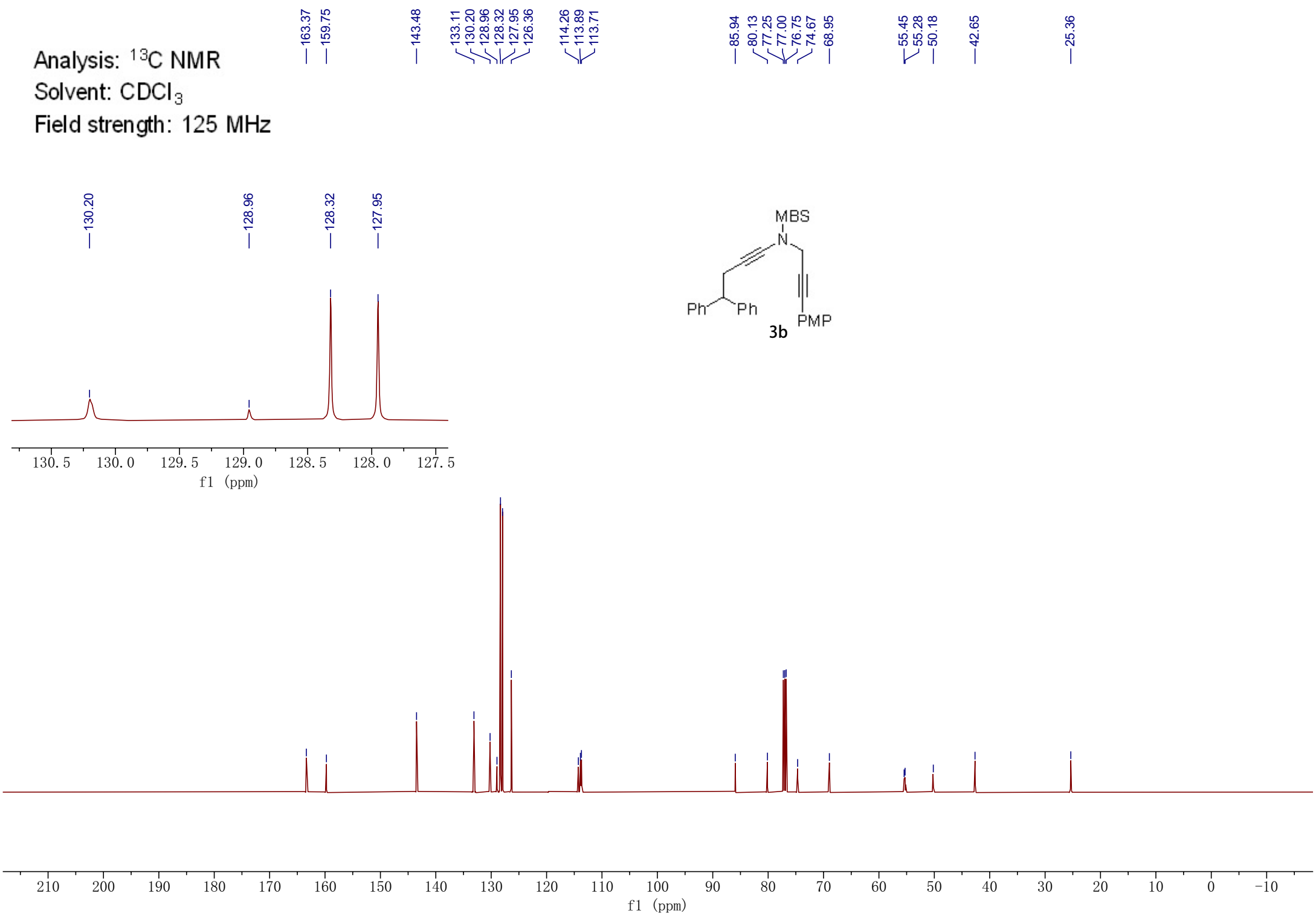


3a




7.603
7.585
7.252
7.236
7.223
7.218
7.206
7.181
7.177
7.164
7.151
7.063
7.046
6.780
6.762
6.750
6.732
4.287
4.208
4.193
4.178
3.783
3.738
3.018
3.003
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 500 MHz
MBS
N
Ph
Ph
PMP
3b
1.94
10.04
2.02
4.03
1.96
1.00
3.01
3.02
1.93
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

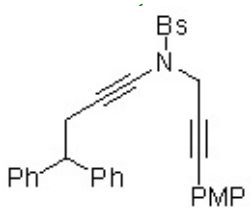
Analysis: ^{13}C NMR
Solvent: $CDCl_3$
Field strength: 125 MHz



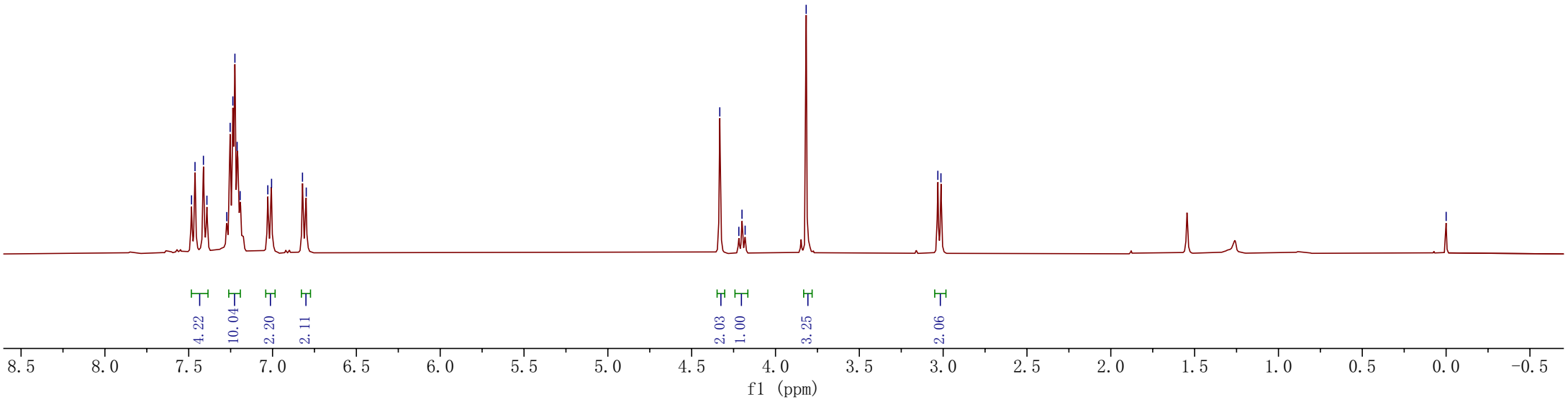
Analysis: ^{1}H NMR

Solvent: $CDCl_3$

Field strength: 400 MHz



3c

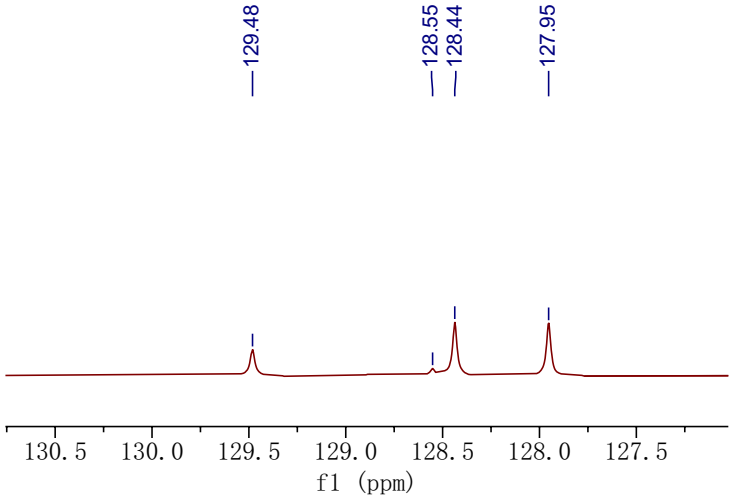


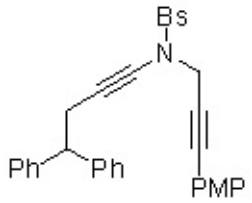
Analysis: ^{13}C NMR

Solvent: $CDCl_3$

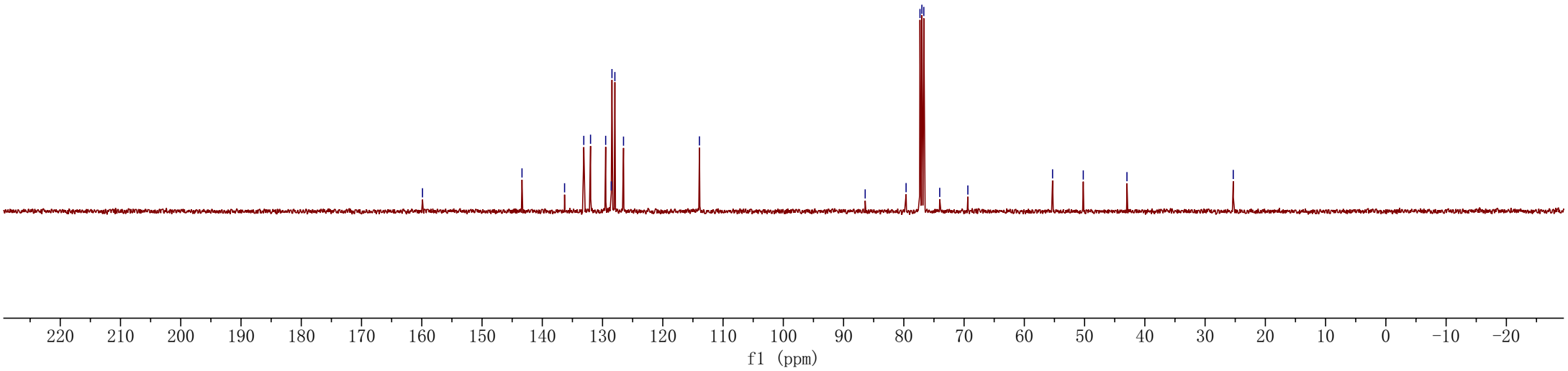
Field strength: 100 MHz

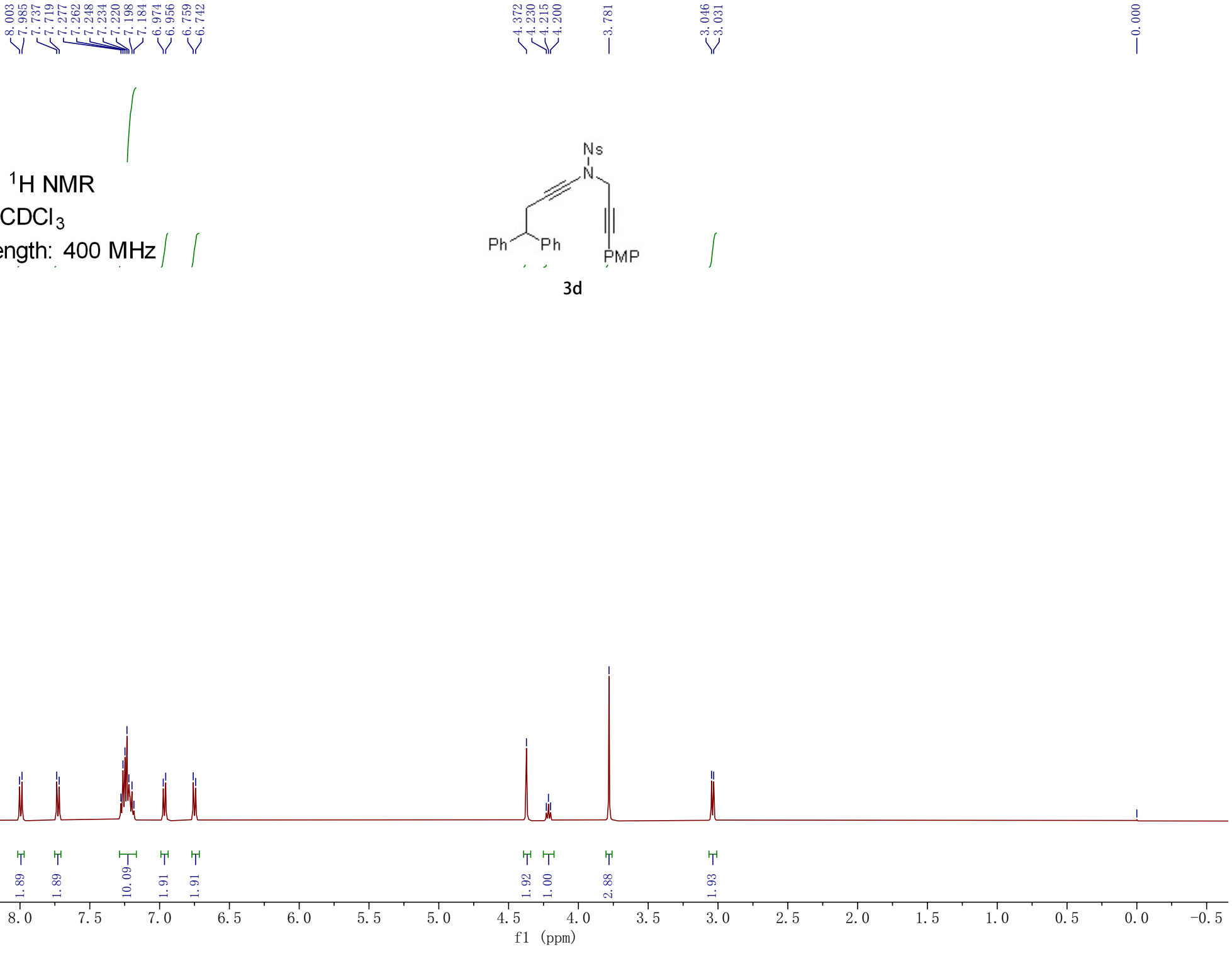
159.88
143.37
136.30
133.11
131.99
129.48
128.55
128.44
127.95
126.52
113.92
86.41
79.62
77.32
77.00
76.68
74.04
69.37
55.31
50.22
42.97
25.33





3c



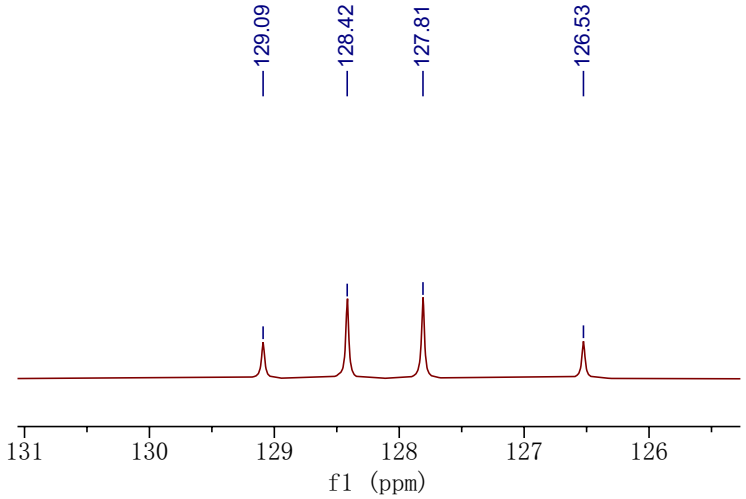

8.003
7.985
7.737
7.719
7.277
7.262
7.248
7.234
7.220
7.198
7.184
6.974
6.956
6.759
6.742
4.372
4.230
4.215
4.200
3.781
3.046
3.031
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
Ns
N
Ph
Ph
PMP
3d
1.89
1.89
10.09
1.91
1.91
1.92
1.00
2.88
1.93
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

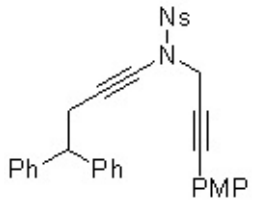
Analysis: ^{13}C NMR

Solvent: $CDCl_3$

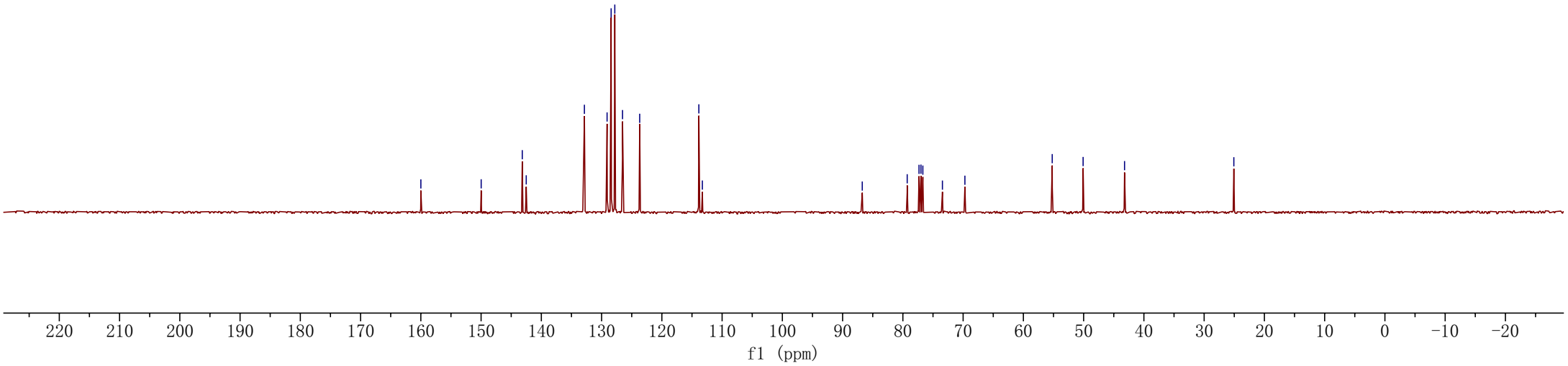
Field strength: 100 MHz

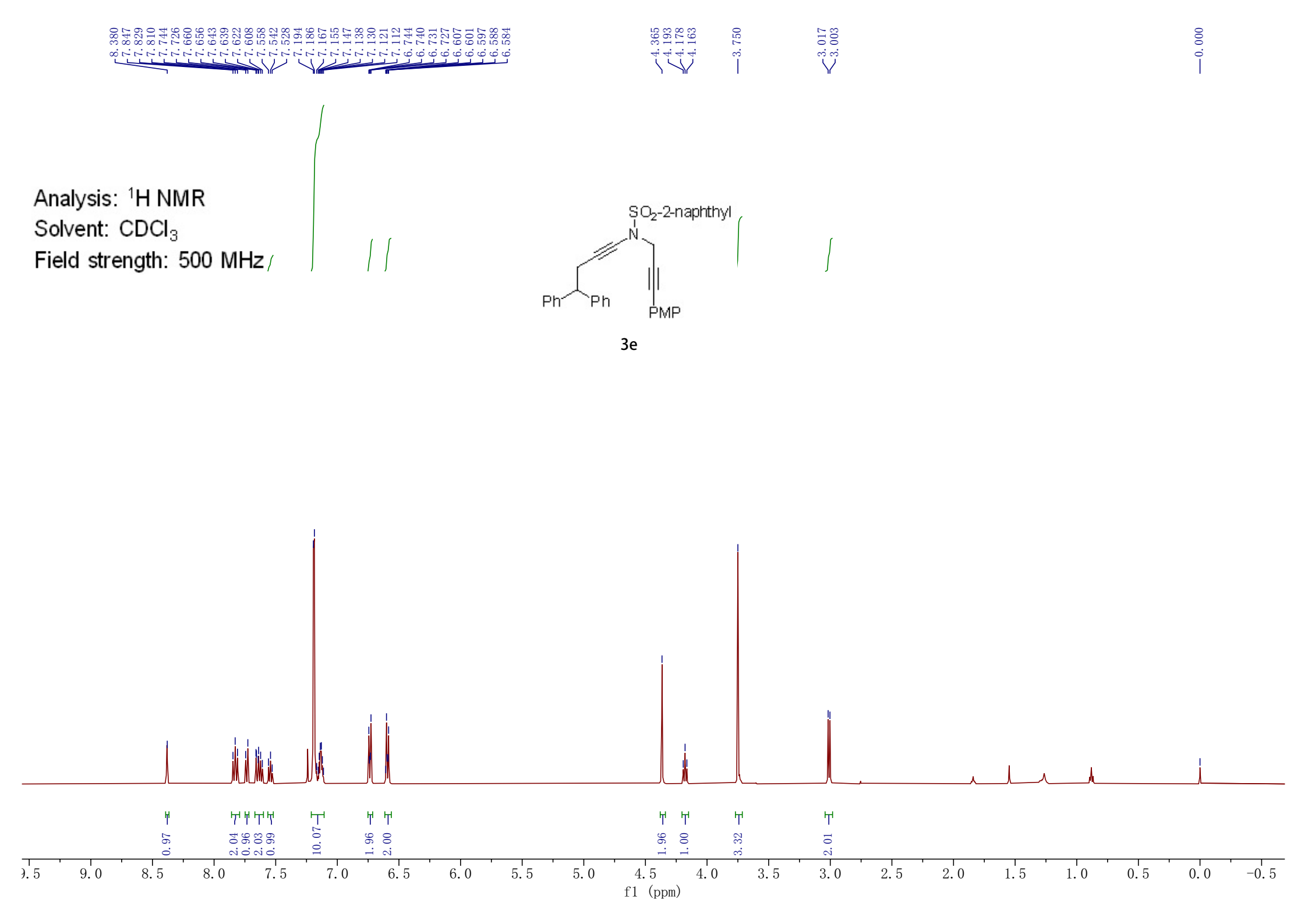
159.99 149.98 143.17 142.51 132.85 129.09 128.42 127.81 126.53 123.68 113.86 113.28 86.74 79.28 77.32 77.00 76.68 73.44 69.71 55.21 50.09 43.21 25.07





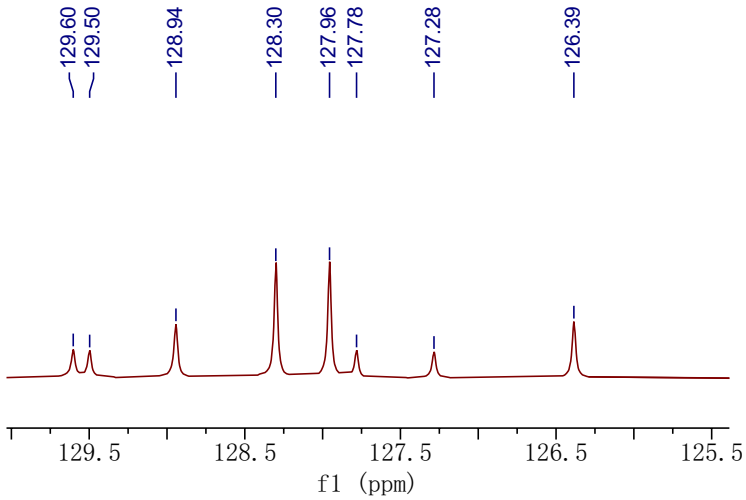
3d

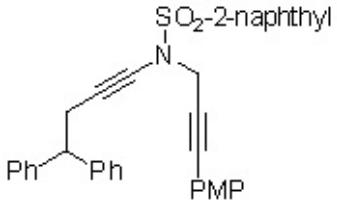



8.380
7.847
7.829
7.810
7.744
7.726
7.660
7.656
7.643
7.639
7.622
7.608
7.558
7.542
7.528
7.194
7.186
7.167
7.155
7.147
7.138
7.130
7.121
7.112
6.744
6.740
6.731
6.727
6.607
6.601
6.597
6.588
6.584
4.365
4.193
4.178
4.163
3.750
3.017
3.003
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 500 MHz
SO2-2-naphthyl
N
Ph
Ph
PMP
3e
0.97
2.04
0.96
2.03
0.99
10.07
1.96
2.00
1.96
1.00
3.32
2.01
f1 (ppm)

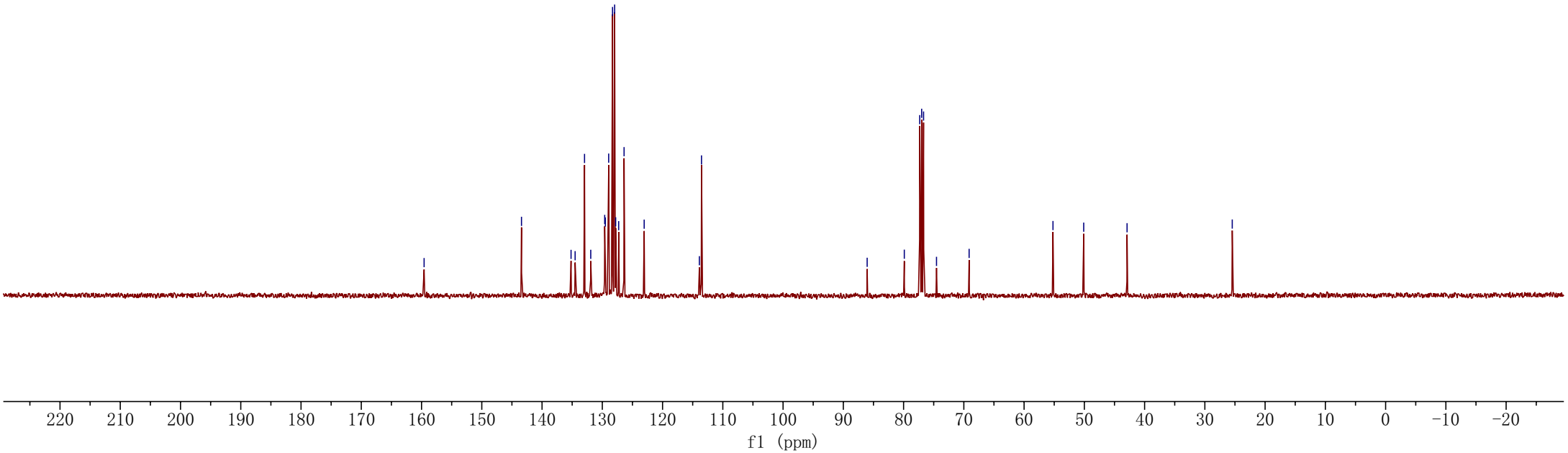
Analysis: ^{13}C NMR
Solvent: $CDCl_3$
Field strength: 125 MHz

159.57 143.41 135.19 134.51 132.95 131.92 129.60 129.50 128.94 128.30 127.96 127.78 127.28 126.39 123.05 113.89 113.54
86.04 79.88 77.32 77.00 76.68 74.53 69.12
55.20 50.10 42.91 25.45





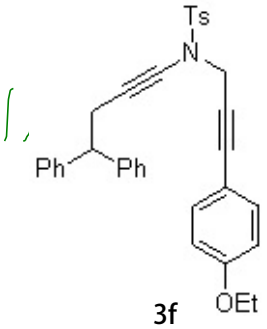
3e



Analysis: ^{1}H NMR

Solvent: $CDCl_3$

Field strength: 400 MHz



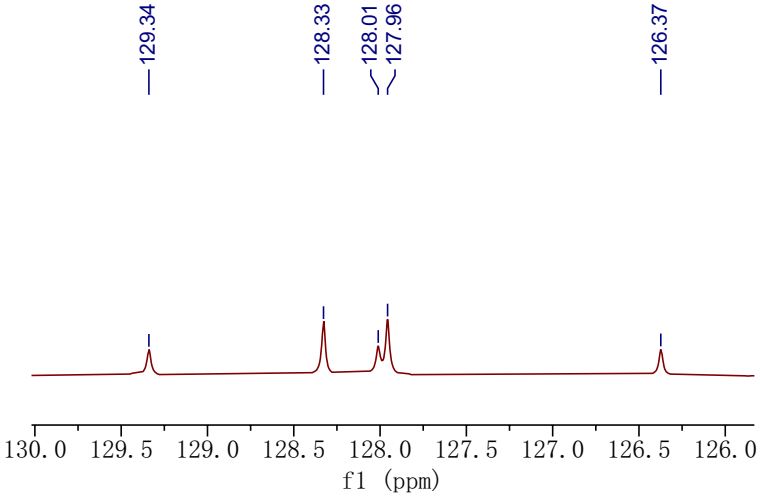
3f

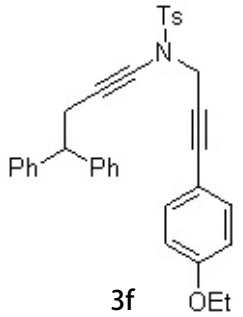
Analysis: ^{13}C NMR

Solvent: $CDCl_3$

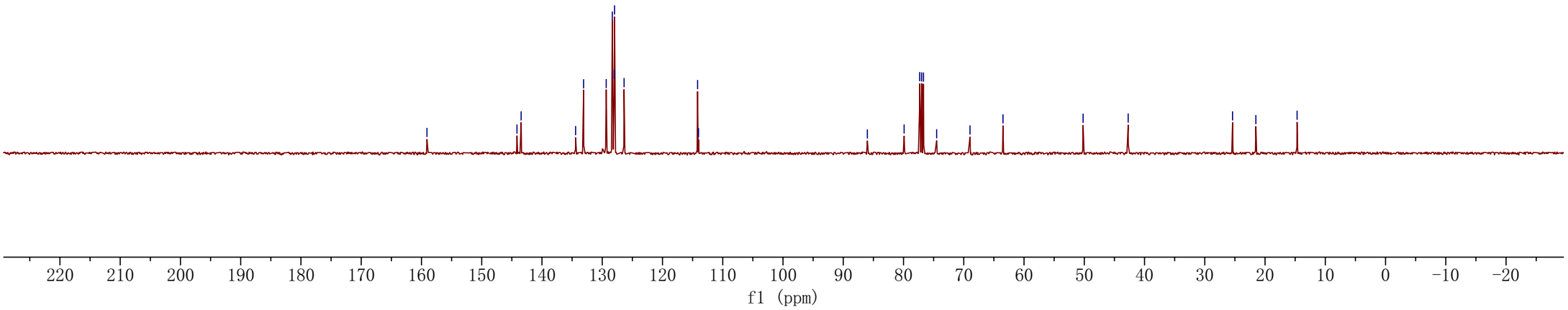
Field strength: 100 MHz

159.09, 144.15, 143.46, 134.42, 133.09, 129.34, 128.33, 128.01, 127.96, 126.37, 114.17, 114.02, 86.00, 79.90, 77.32, 77.00, 76.68, 74.50, 68.96, 63.49, 50.20, 42.72, 25.39, 21.52, 14.68





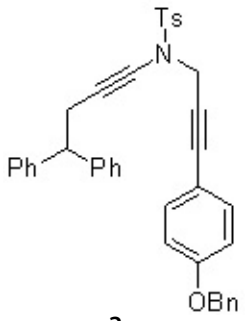
3f



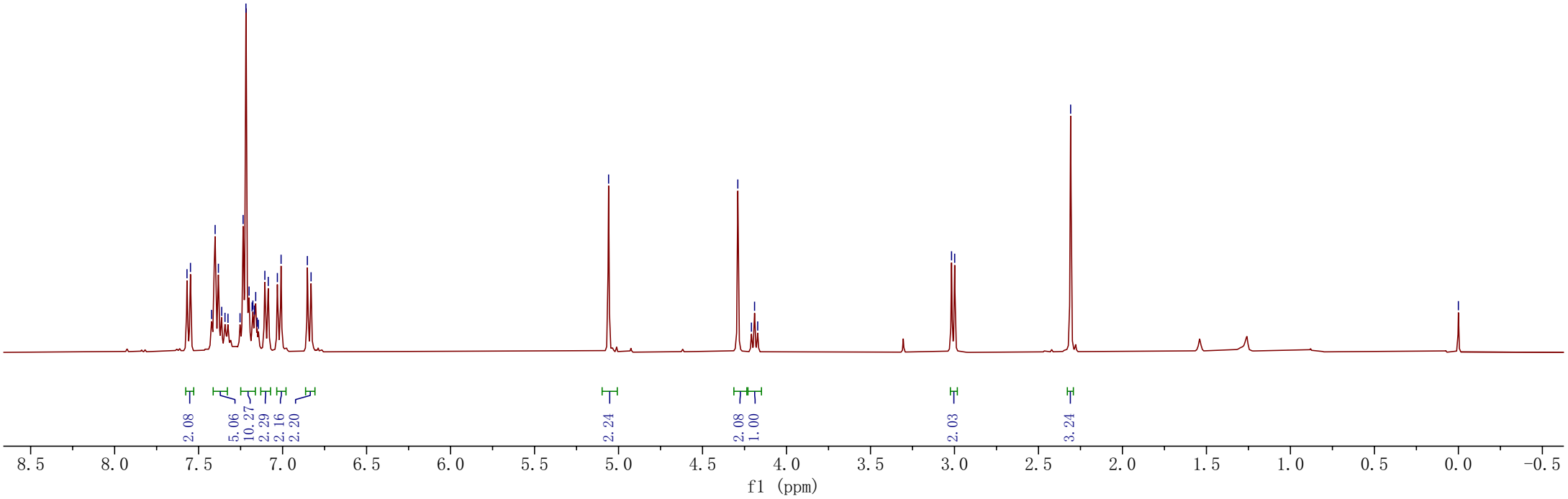
Analysis: ^{1}H NMR

Solvent: $CDCl_3$

Field strength: 400 MHz



3g

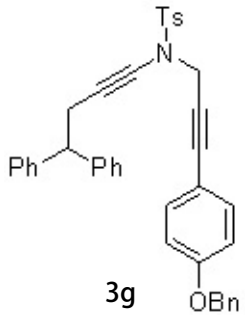


Analysis: ^{13}C NMR

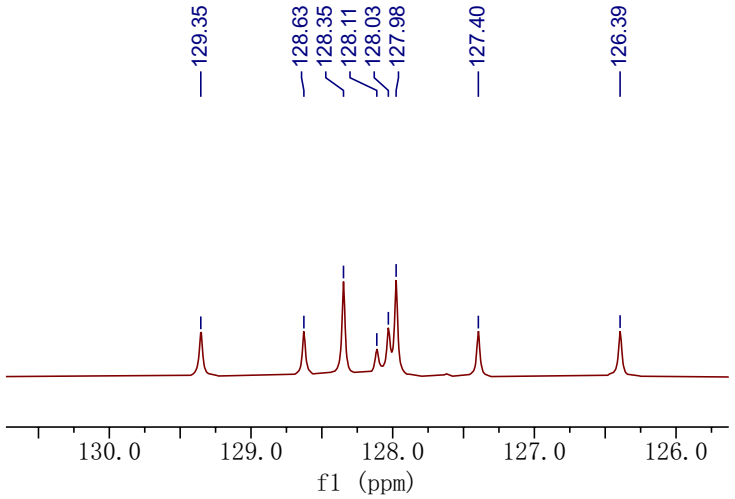
Solvent: $CDCl_3$

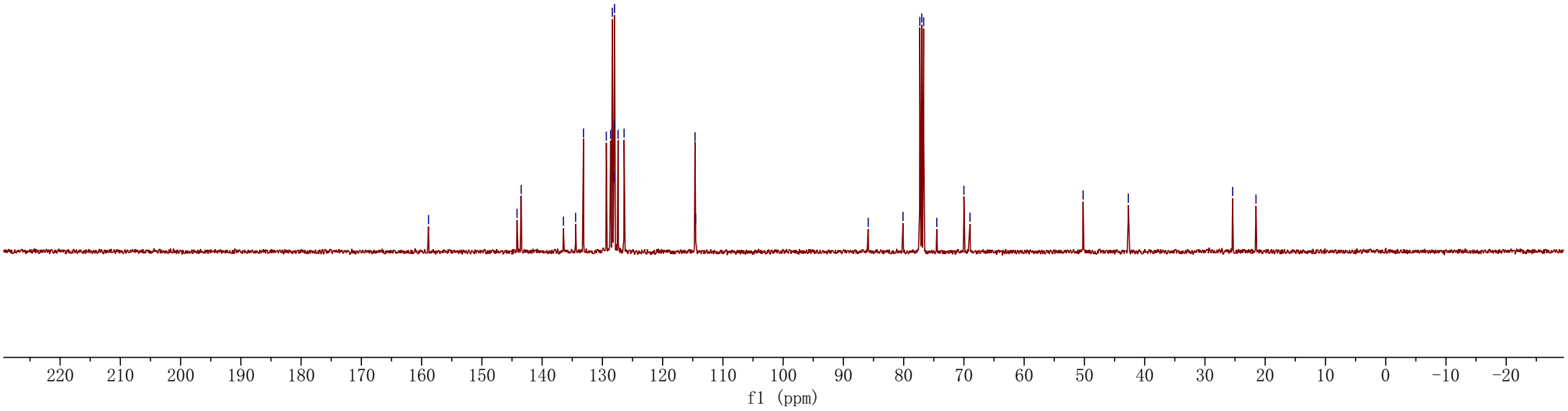
Field strength: 100 MHz

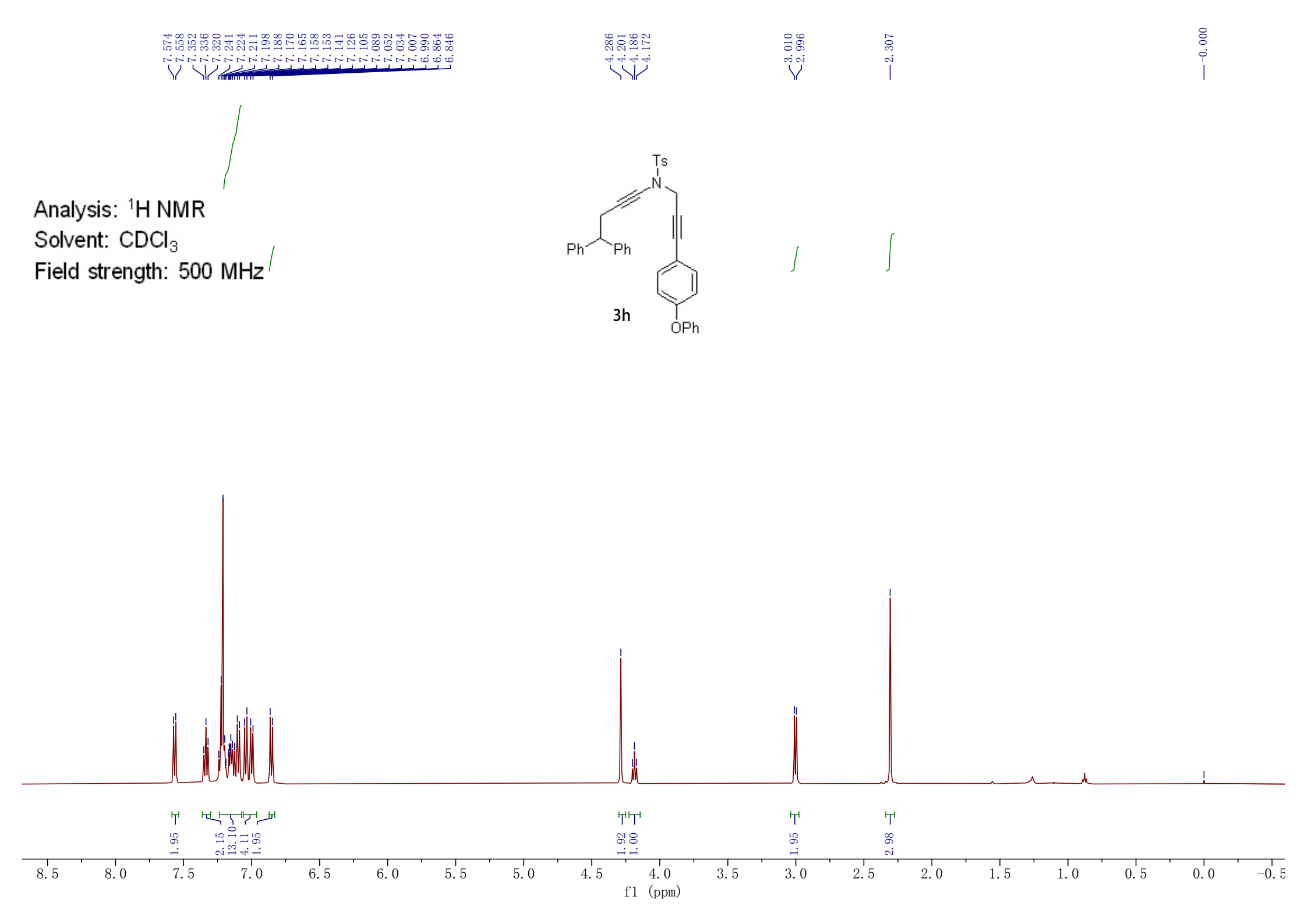
158.85, 144.17, 143.47, 136.48, 134.44, 133.13, 129.35, 128.63, 128.35, 128.11, 128.03, 127.98, 127.40, 126.39, 114.62, 114.52, 85.88, 80.11, 77.32, 77.00, 76.68, 74.50, 70.00, 68.99, 50.21, 42.71, 25.41, 21.53



3g





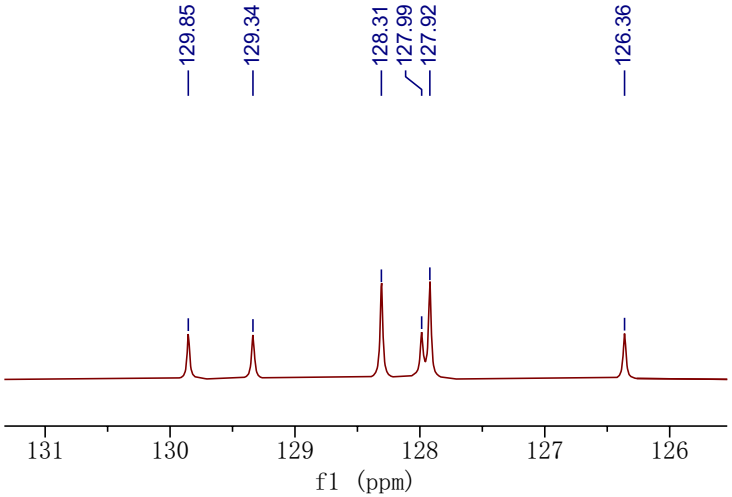

7.574
7.558
7.352
7.336
7.320
7.241
7.224
7.211
7.198
7.188
7.170
7.165
7.158
7.153
7.141
7.126
7.105
7.089
7.052
7.034
7.007
6.990
6.864
6.846
4.286
4.201
4.186
4.172
3.010
2.996
2.307
-0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 500 MHz
Ts
N
Ph
Ph
OPh
3h
1.95
2.15
13.10
4.11
1.95
1.92
1.00
1.95
2.98
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

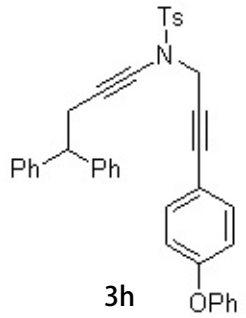
Analysis: ^{13}C NMR

Solvent: $CDCl_3$

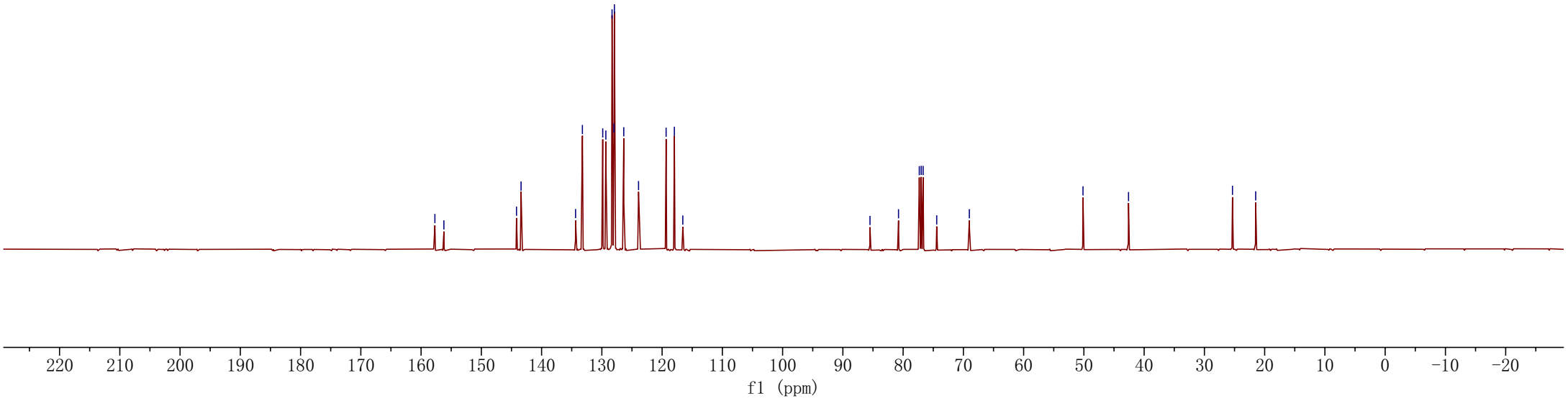
Field strength: 125 MHz

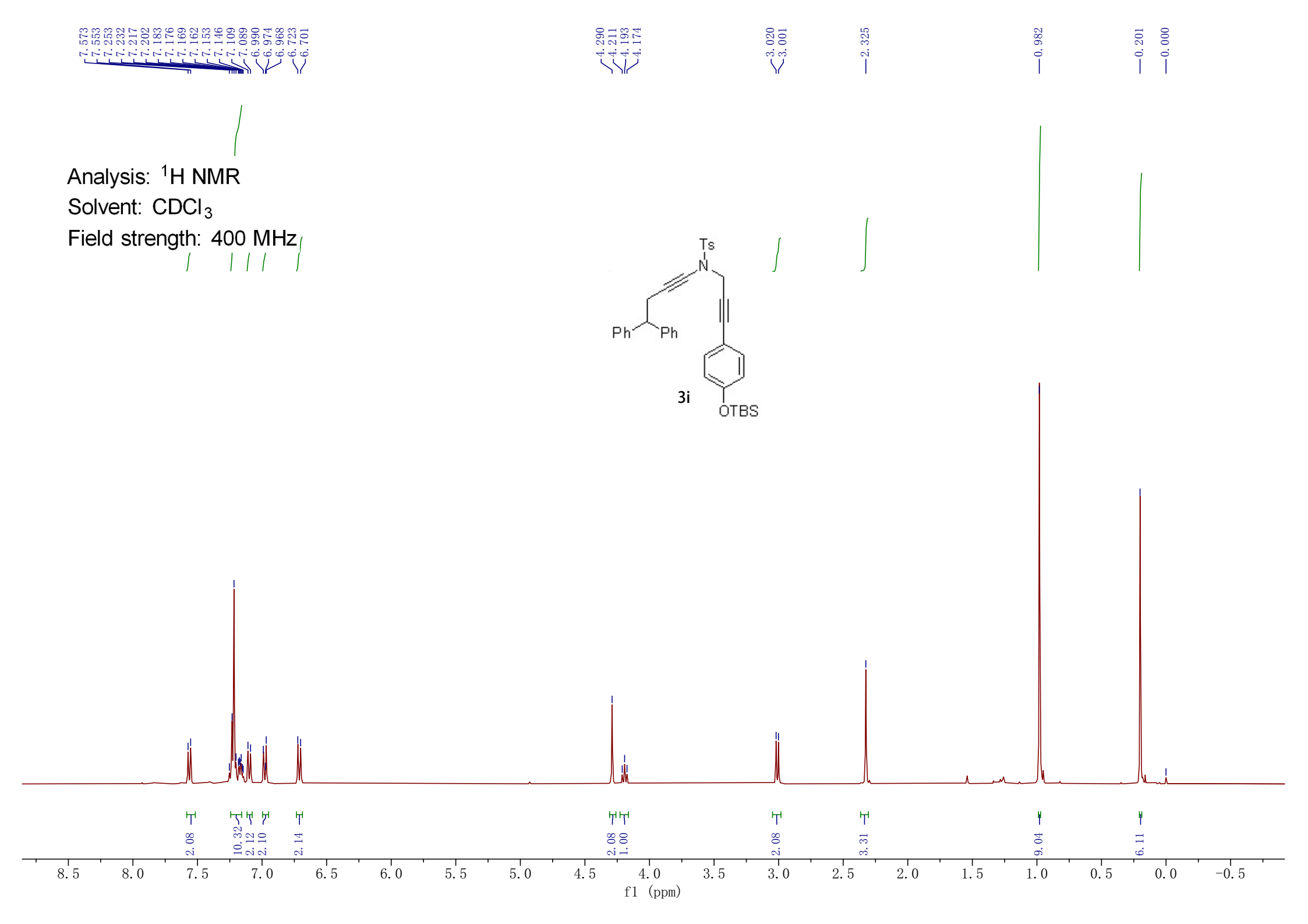
157.71
156.21
144.16
143.41
134.36
133.23
129.85
129.34
128.31
127.99
127.92
126.36
123.91
119.34
117.97
116.56
85.50
80.76
77.32
77.00
76.68
74.43
69.01
50.15
42.59
25.34
21.49





3h

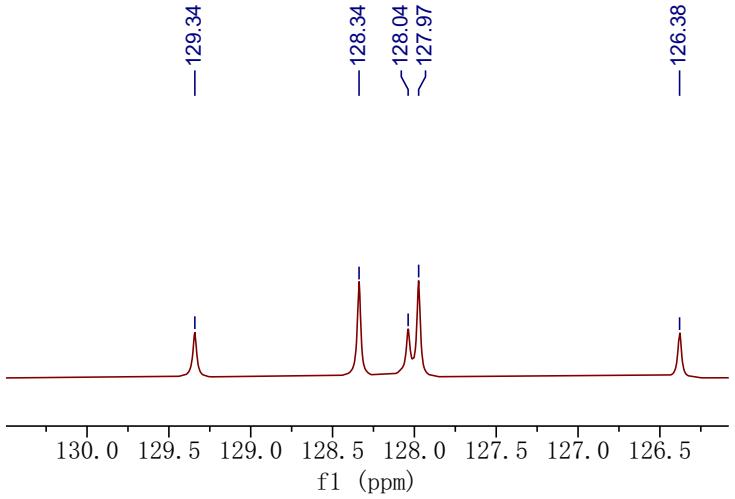


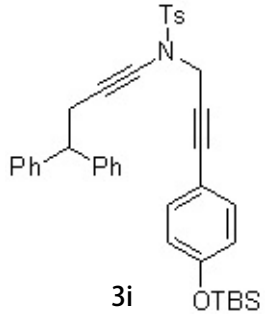

7.573
7.553
7.253
7.232
7.217
7.202
7.183
7.176
7.169
7.162
7.153
7.146
7.109
7.089
6.990
6.974
6.968
6.723
6.701
4.290
4.211
4.193
4.174
3.020
3.001
2.325
0.982
0.201
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
Ts
N
Ph
Ph
3i
OTBS
2.08
10.32
2.12
2.10
2.14
2.08
1.00
2.08
3.31
9.04
6.11
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

Analysis: ^{13}C NMR

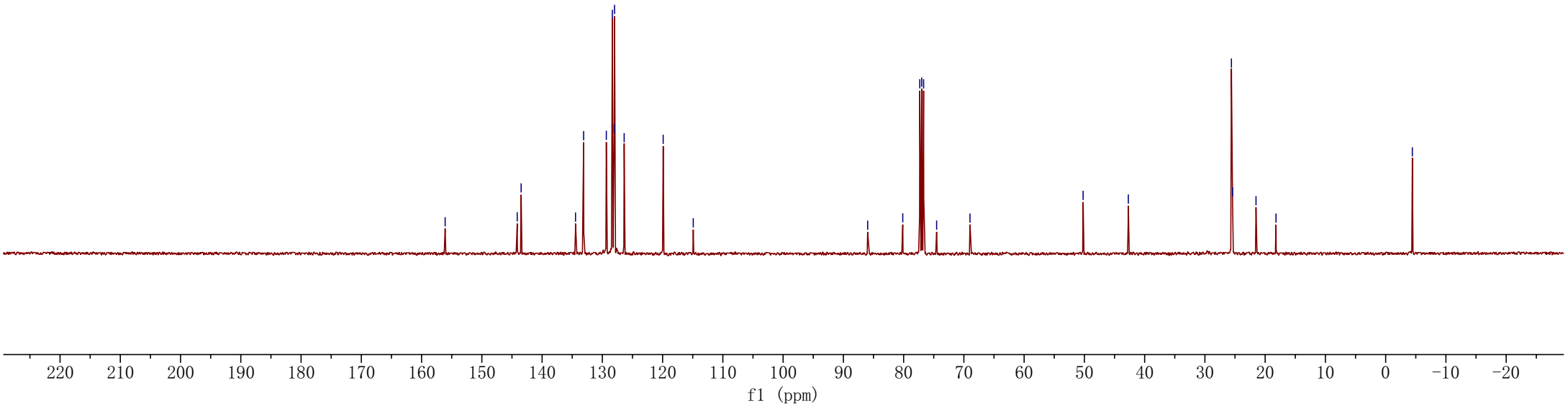
Solvent: $CDCl_3$

Field strength: 100 MHz





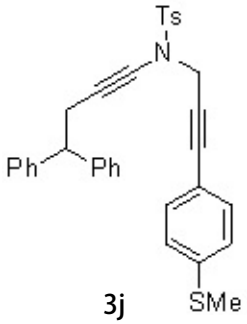
3i



Analysis: ^{1}H NMR

Solvent: $CDCl_3$

Field strength: 400 MHz



3j

Analysis: ^{13}C NMR

Solvent: $CDCl_3$

Field strength: 100 MHz

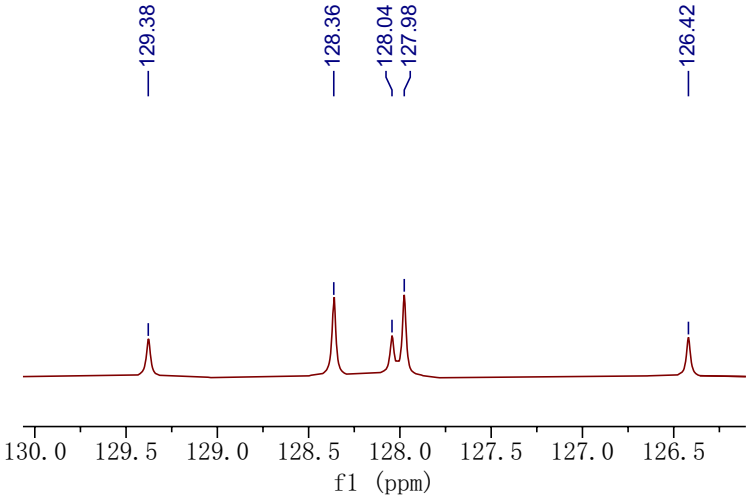
144.22 143.46 139.72 134.43 131.92 129.38 128.36 128.04 127.98 126.42 125.56 118.40

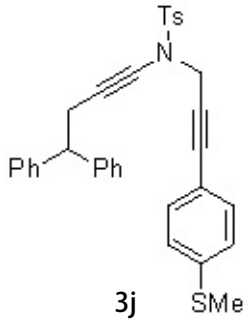
85.73 81.51 77.32 77.00 76.68 74.46 69.07

50.23

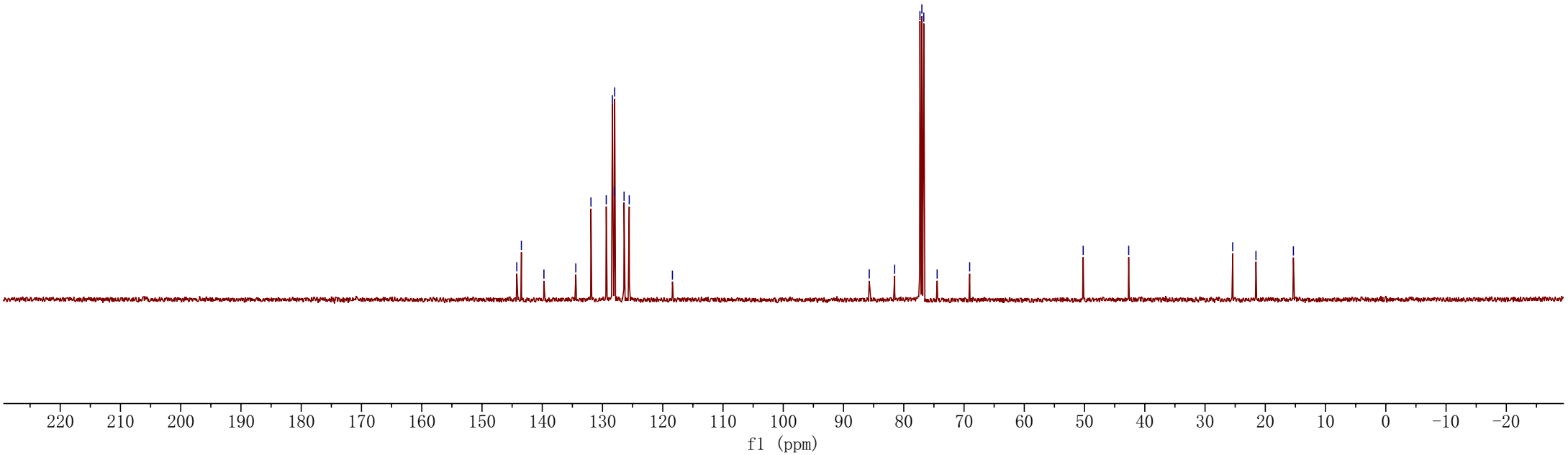
42.67

25.41 21.55 15.34





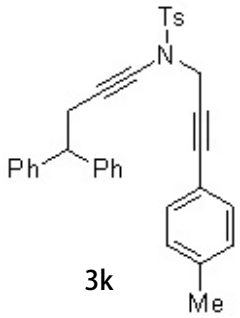
3j



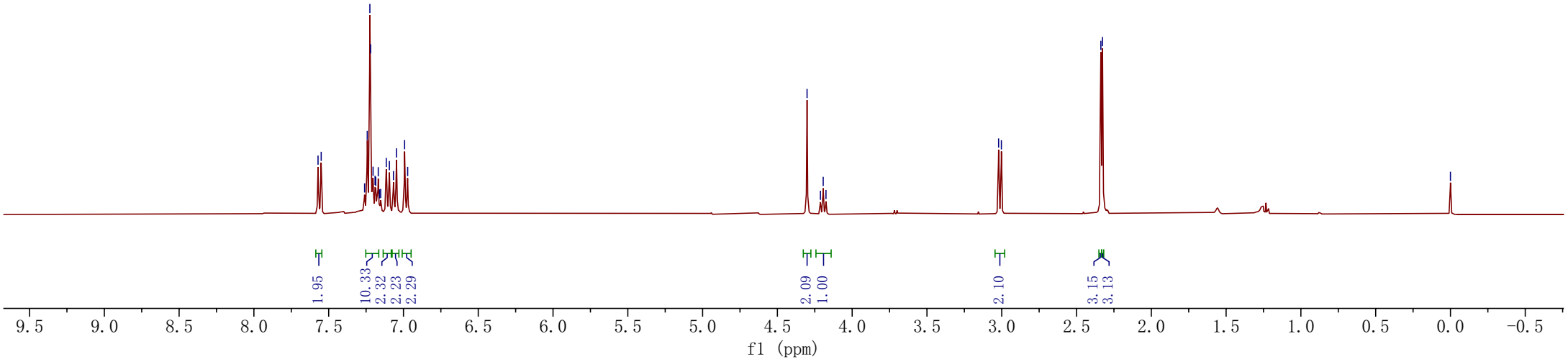
Analysis: ^{1}H NMR

Solvent: $CDCl_3$

Field strength: 400 MHz



3k

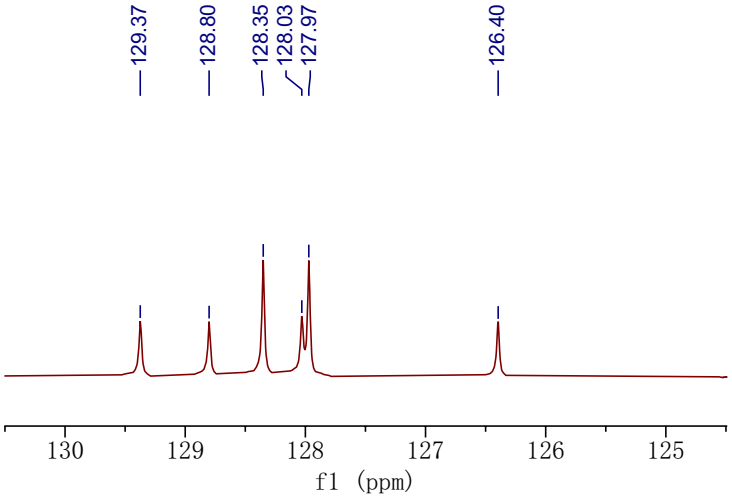


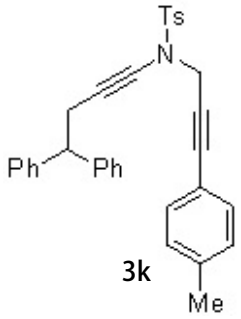
Analysis: ^{13}C NMR

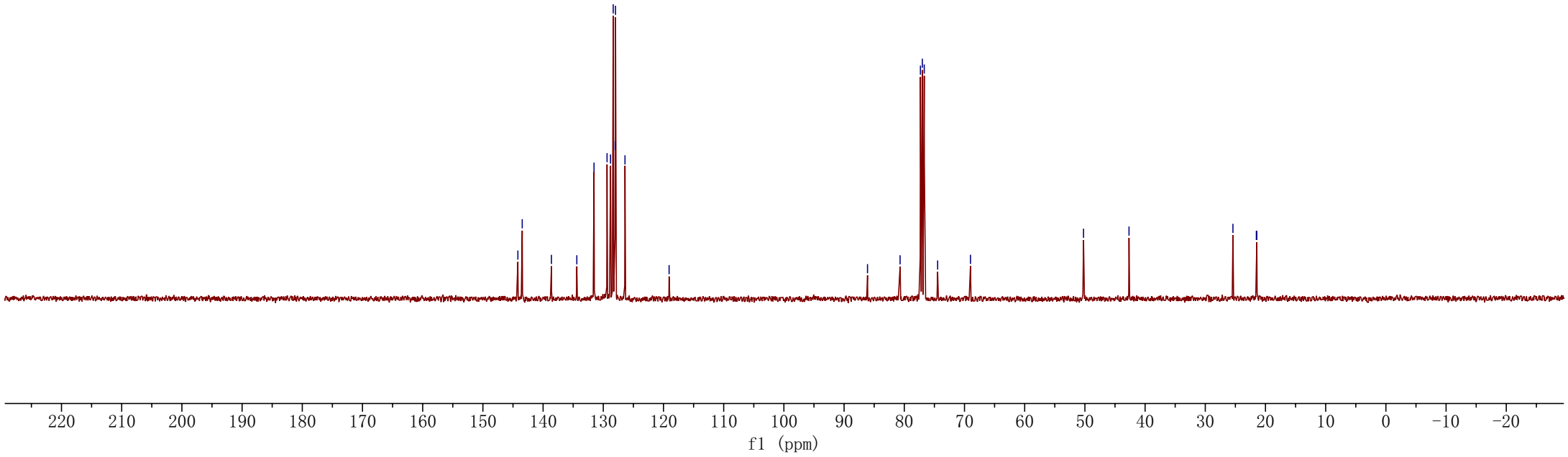
Solvent: $CDCl_3$

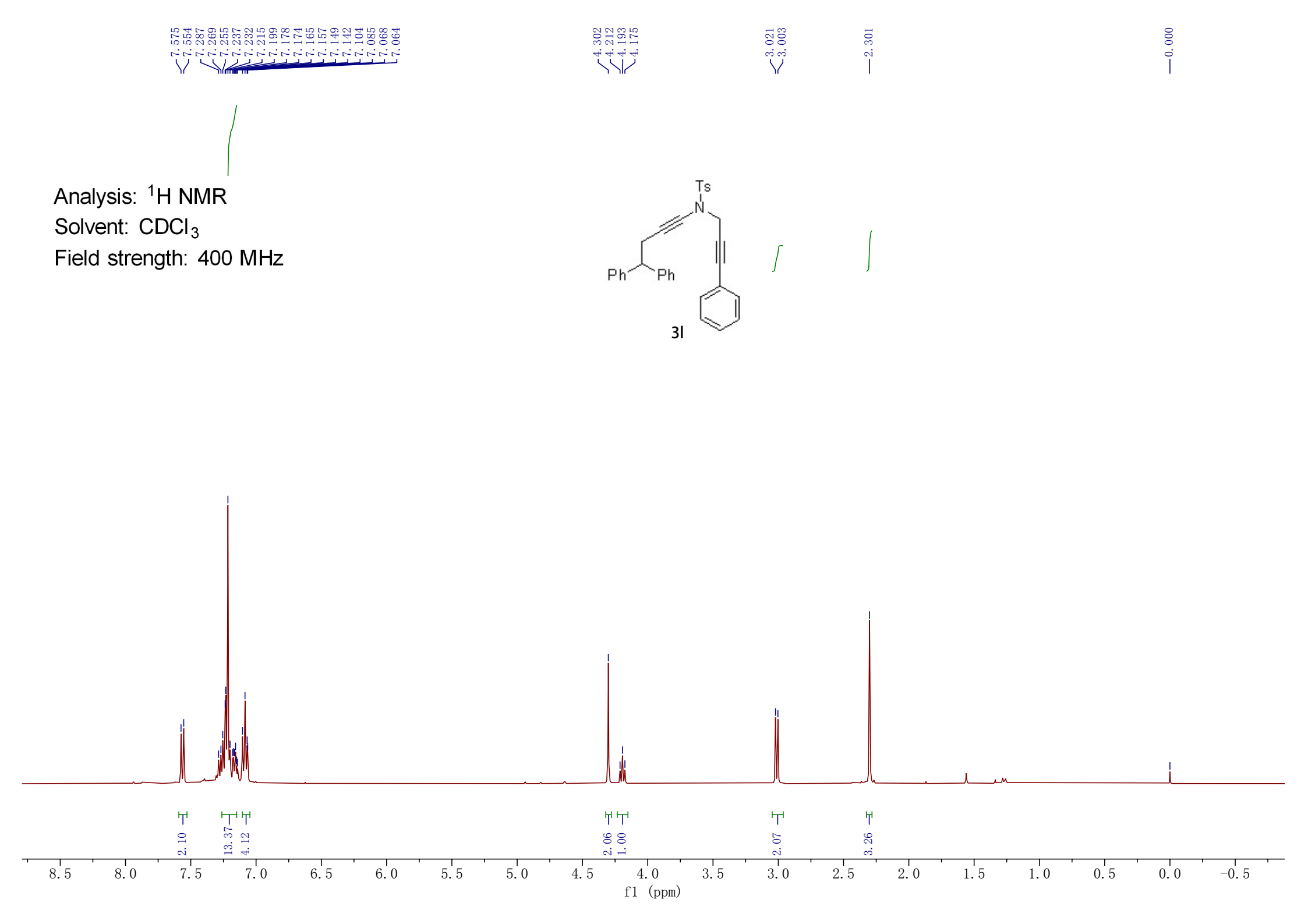
Field strength: 100 MHz

144.19
143.47
138.61
134.40
131.54
129.37
128.80
128.35
128.03
127.97
126.40
119.07
86.11
80.70
77.32
77.00
76.68
74.46
69.01
50.23
42.67
25.41
21.52
21.44





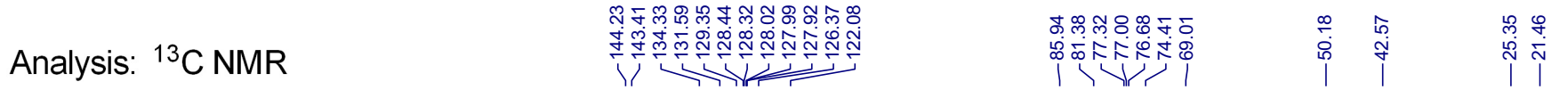


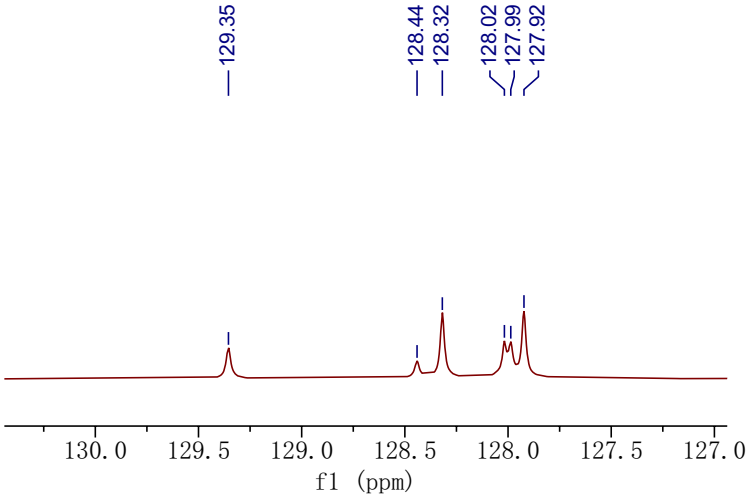

7.575
7.554
7.287
7.269
7.255
7.237
7.232
7.215
7.199
7.178
7.174
7.165
7.157
7.149
7.142
7.104
7.085
7.068
7.064
4.302
4.212
4.193
4.175
3.021
3.003
2.301
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
Ts
N
Ph
Ph
3l
2.10
13.37
4.12
2.06
1.00
2.07
3.26
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

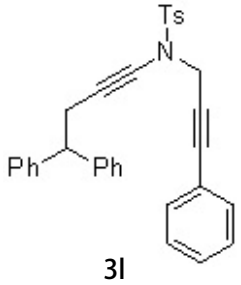
Analysis: ^{13}C NMR

Solvent: $CDCl_3$

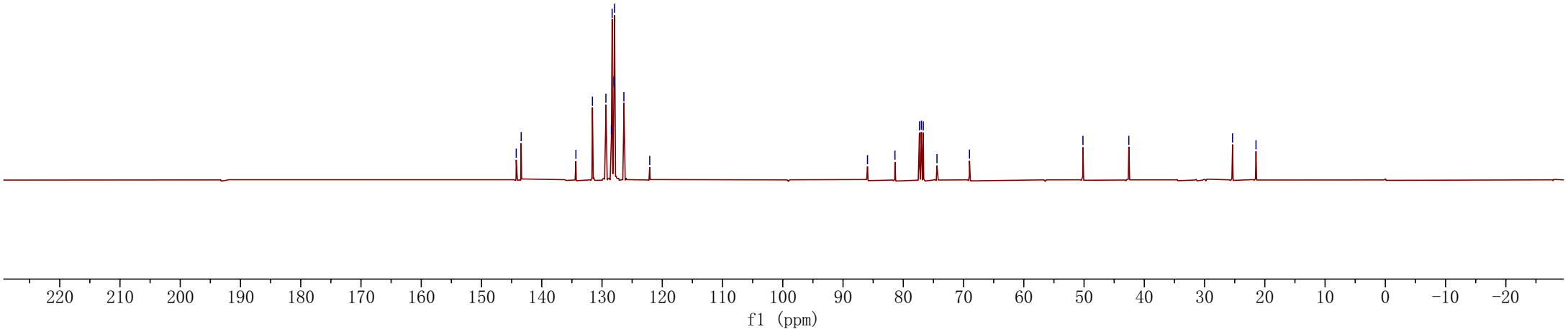
Field strength: 100 MHz

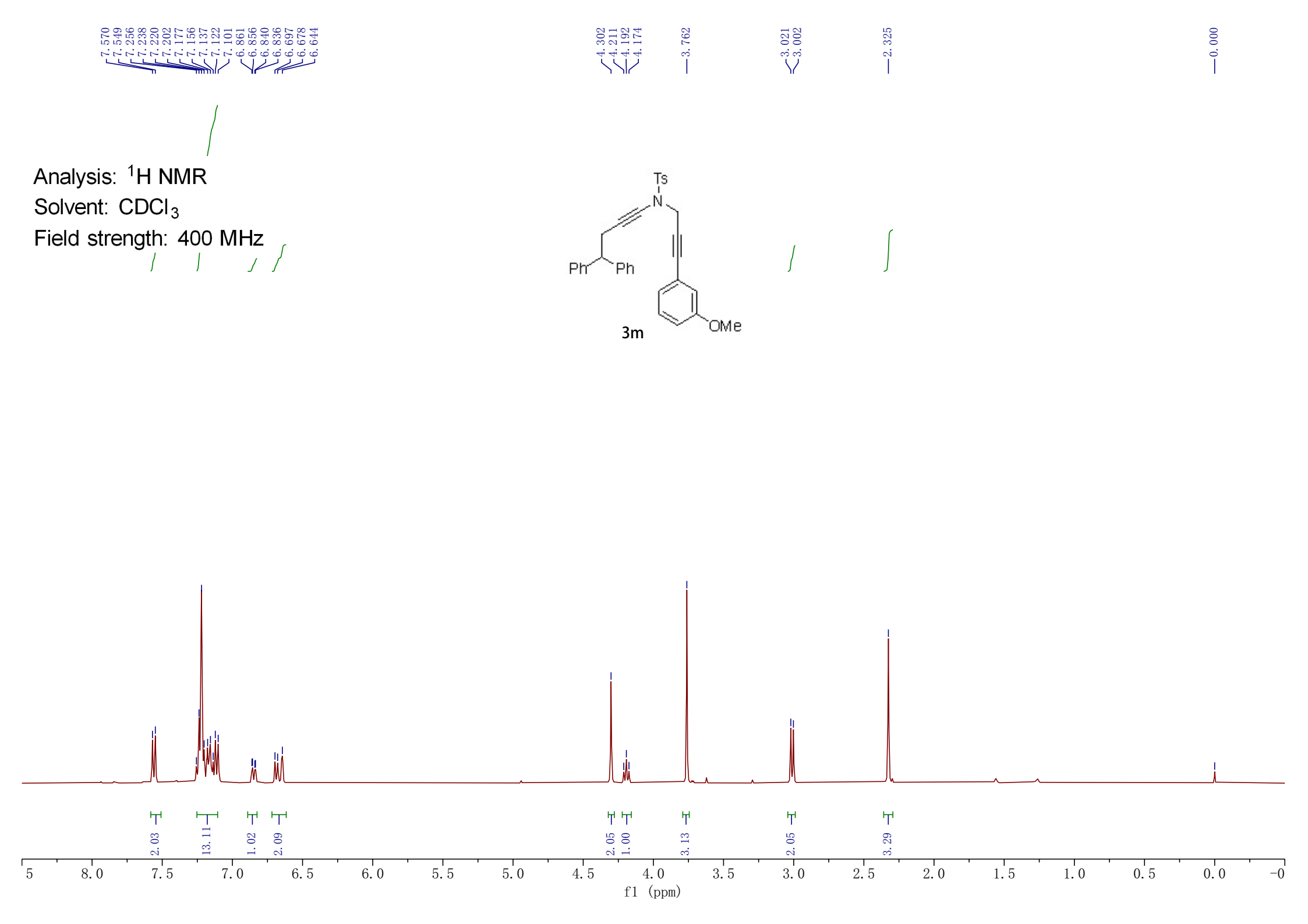






3l



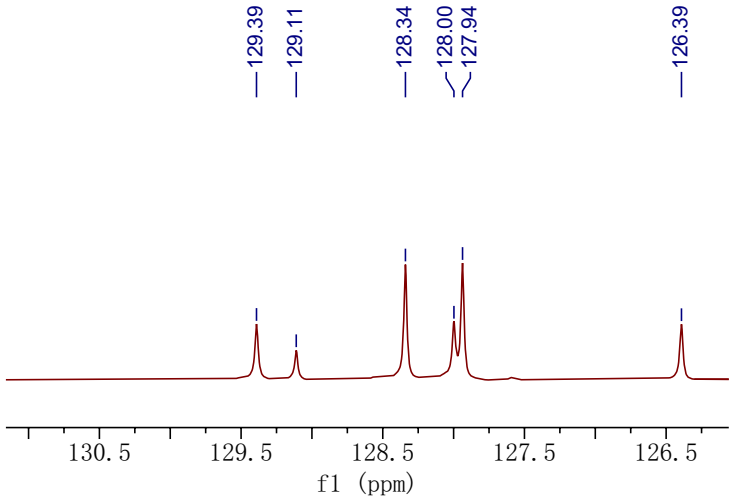

7.570
7.549
7.256
7.238
7.220
7.202
7.177
7.156
7.137
7.122
7.101
6.861
6.856
6.840
6.836
6.697
6.678
6.644
4.302
4.211
4.192
4.174
3.762
3.021
3.002
2.325
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
Ts
N
Ph
Ph
OMe
3m
2.03
13.11
1.02
2.09
2.05
1.00
3.13
2.05
3.29
f1 (ppm)

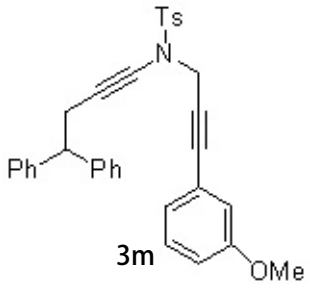
Analysis: ^{13}C NMR

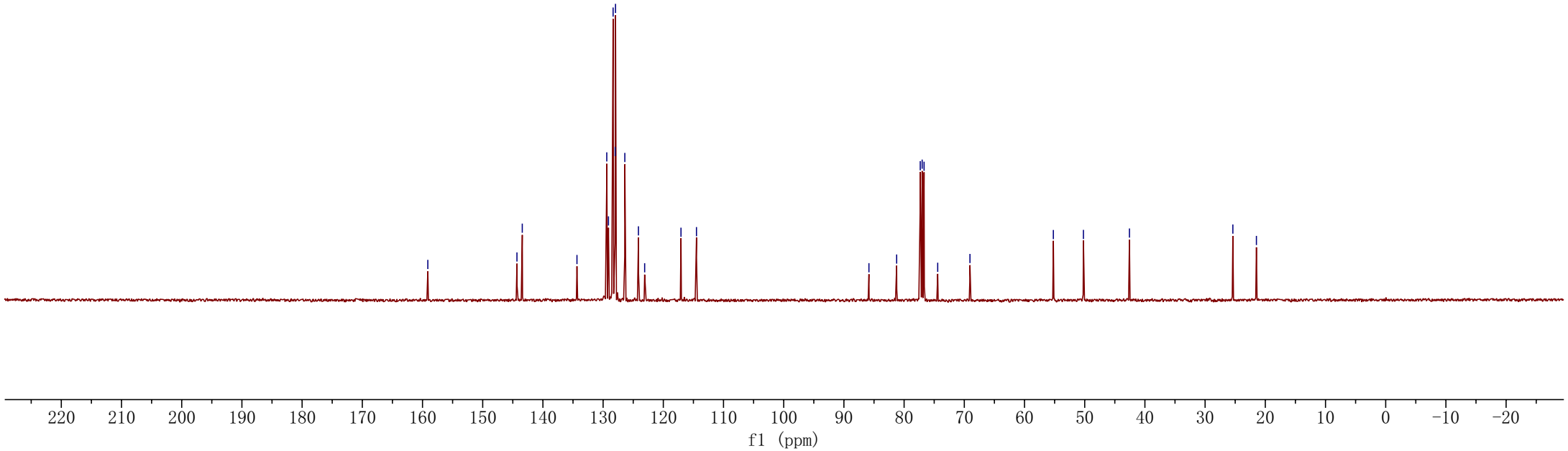
Solvent: $CDCl_3$

Field strength: 100 MHz

159.12
144.31
143.43
134.34
129.39
129.11
128.34
128.00
127.94
126.39
124.13
123.10
117.06
114.49
85.84
81.24
77.32
77.00
76.68
74.42
69.06
55.21
50.21
42.57
25.39
21.48



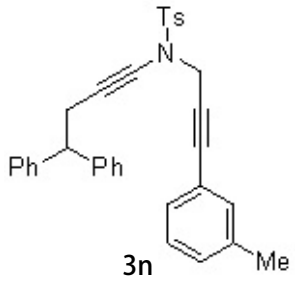




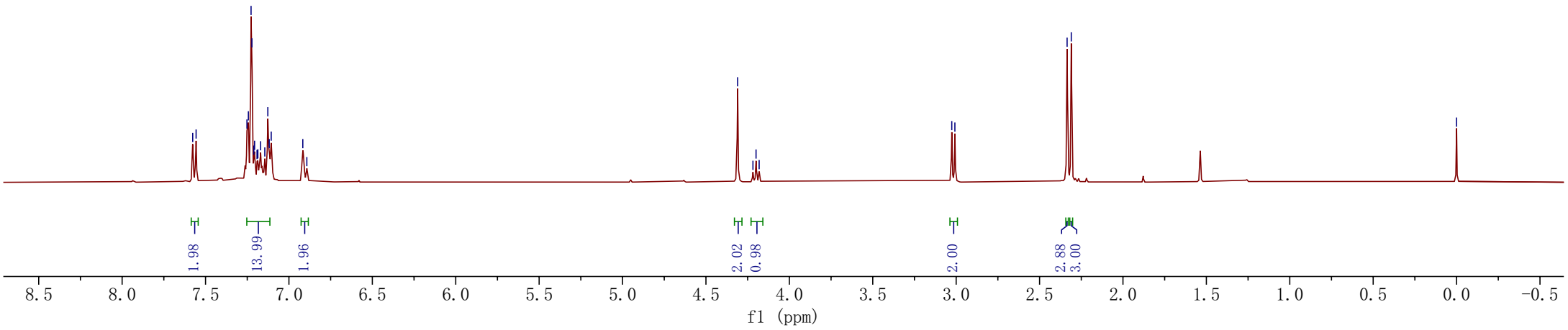
Analysis: ^{1}H NMR

Solvent: $CDCl_3$

Field strength: 400 MHz



3n

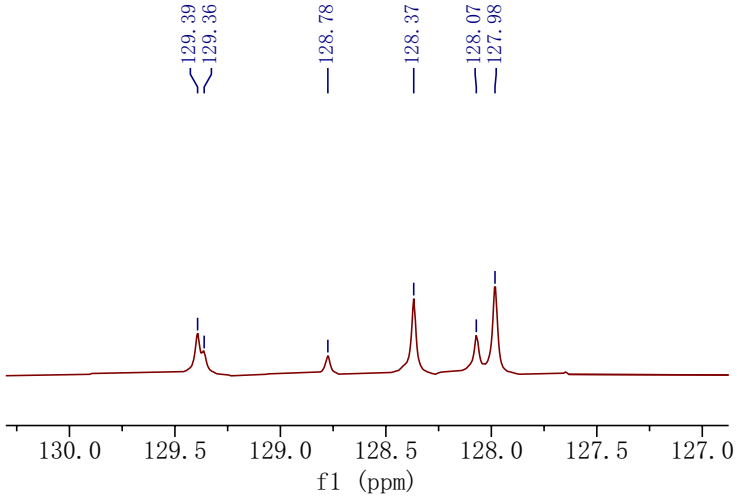


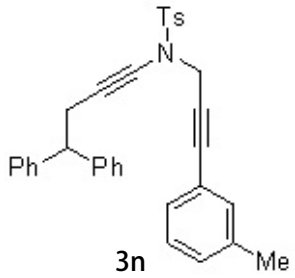
Analysis: ^{1}H NMR

Solvent: $CDCl_3$

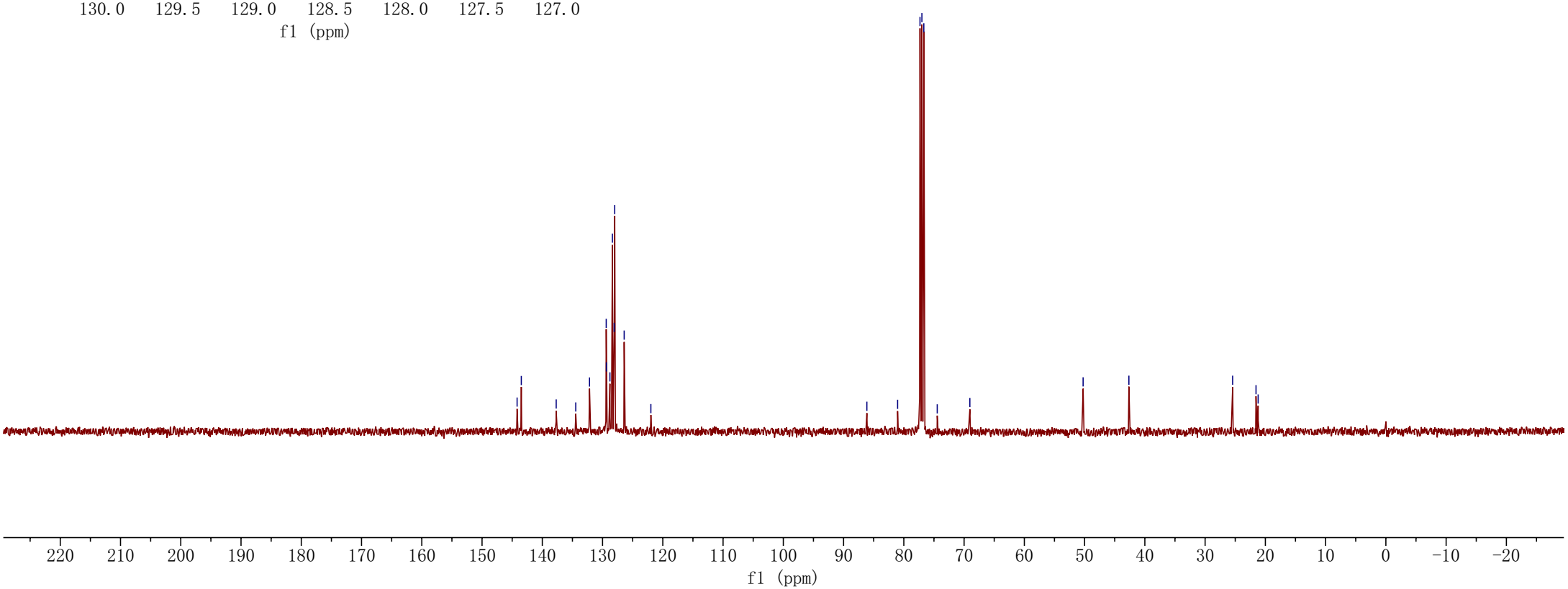
Field strength: 400 MHz

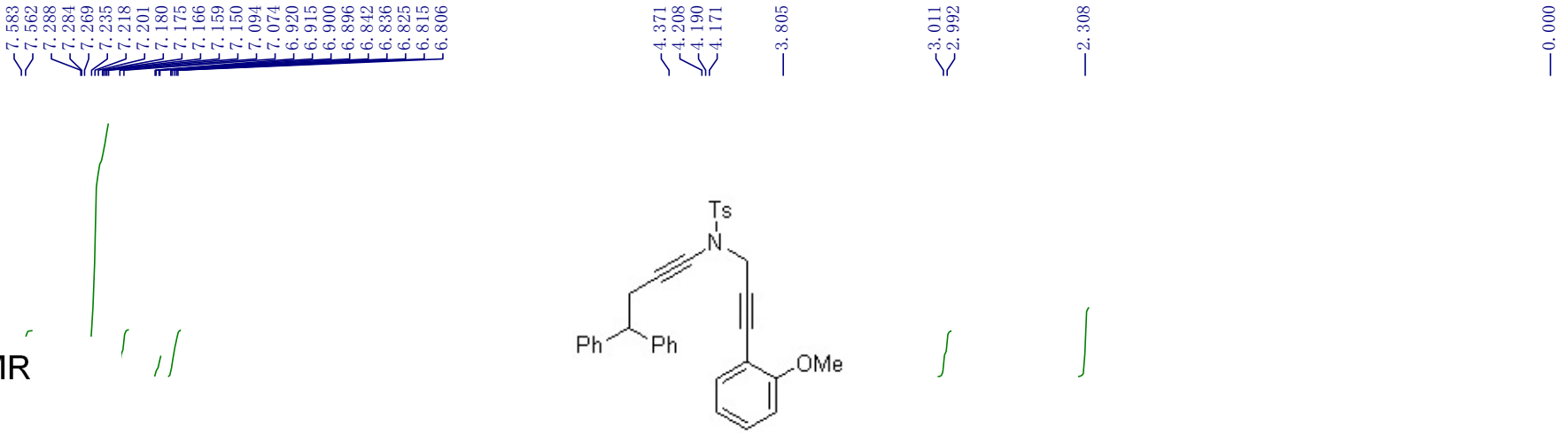
144.18
143.48
137.69
134.45
132.16
129.39
129.36
128.78
128.37
128.07
127.98
126.41
121.98
86.13
81.03
77.32
77.00
76.68
74.46
69.04
50.25
42.65
25.43
21.55
21.20





3n



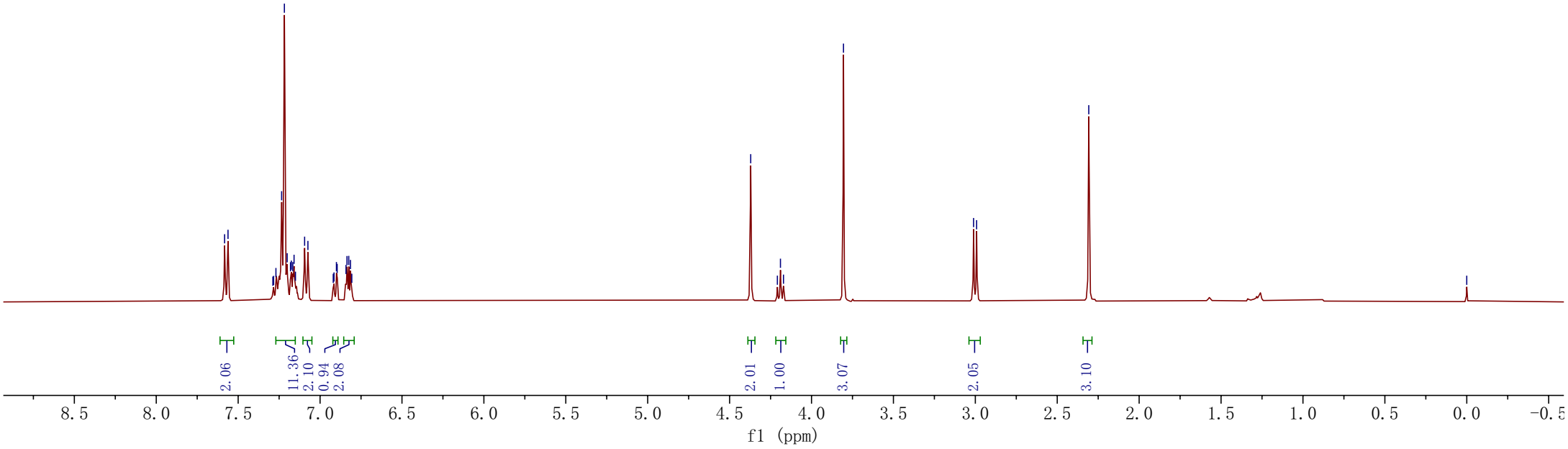


Analysis: ^{1}H NMR

Solvent: $CDCl_3$

Field strength: 400 MHz

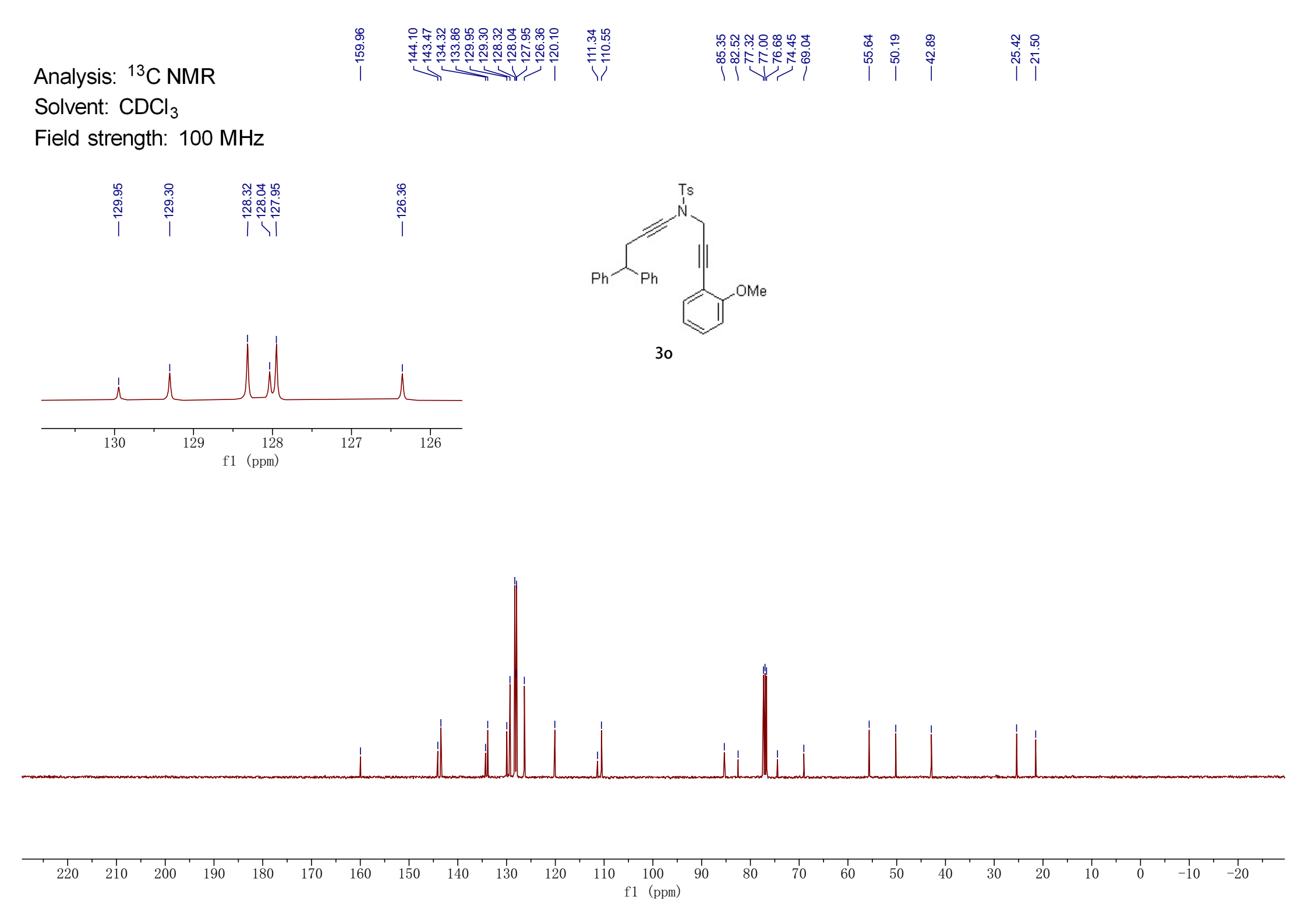
3o



Analysis: ^{13}C NMR

Solvent: $CDCl_3$

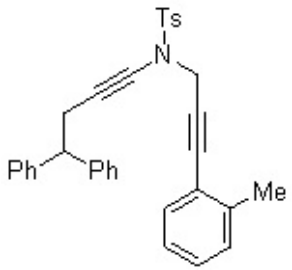
Field strength: 100 MHz



Analysis: ^{1}H NMR

Solvent: $CDCl_3$

Field strength: 400 MHz

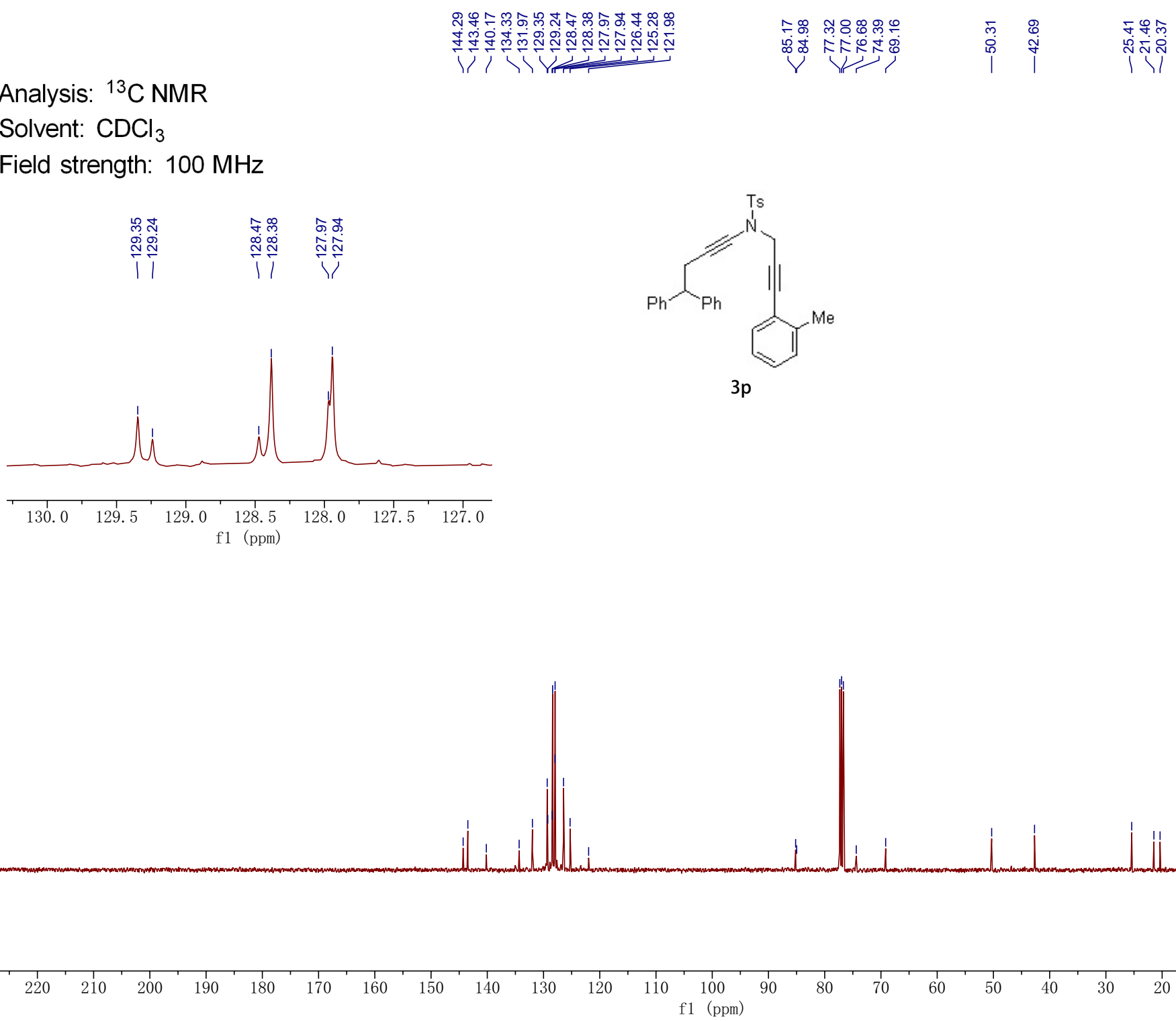


3p

Analysis: ^{13}C NMR

Solvent: $CDCl_3$

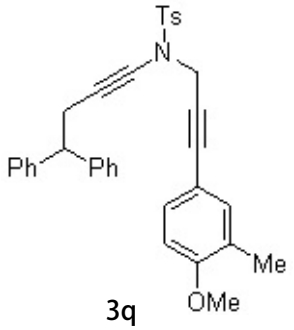
Field strength: 100 MHz



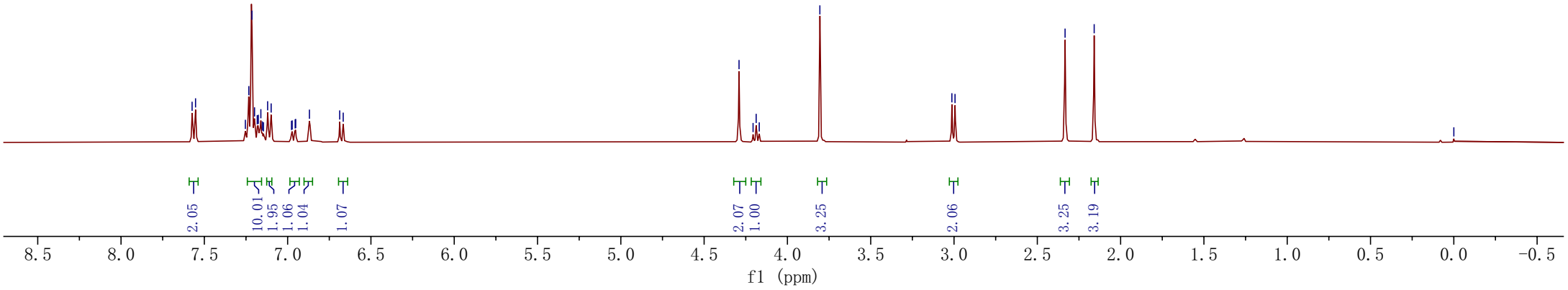
Analysis: ^{1}H NMR

Solvent: $CDCl_3$

Field strength: 400 MHz



3q

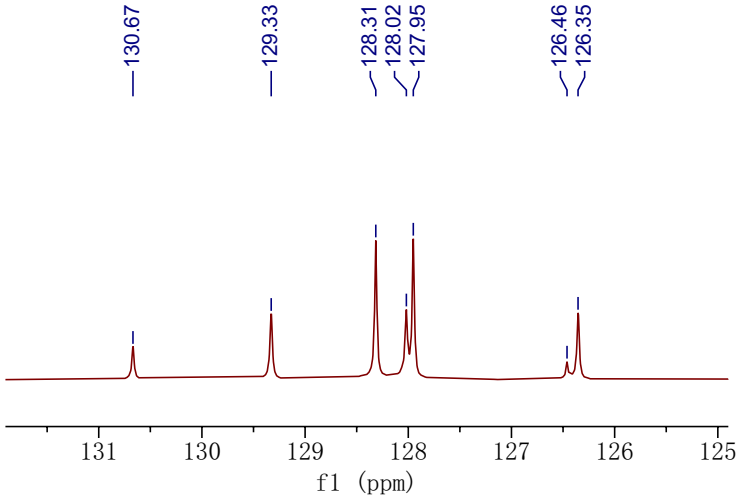


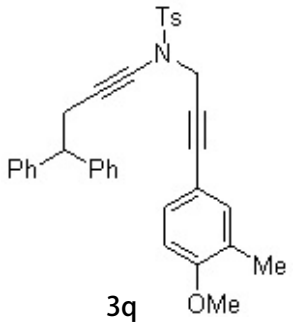
Analysis: ^{13}C NMR

Solvent: $CDCl_3$

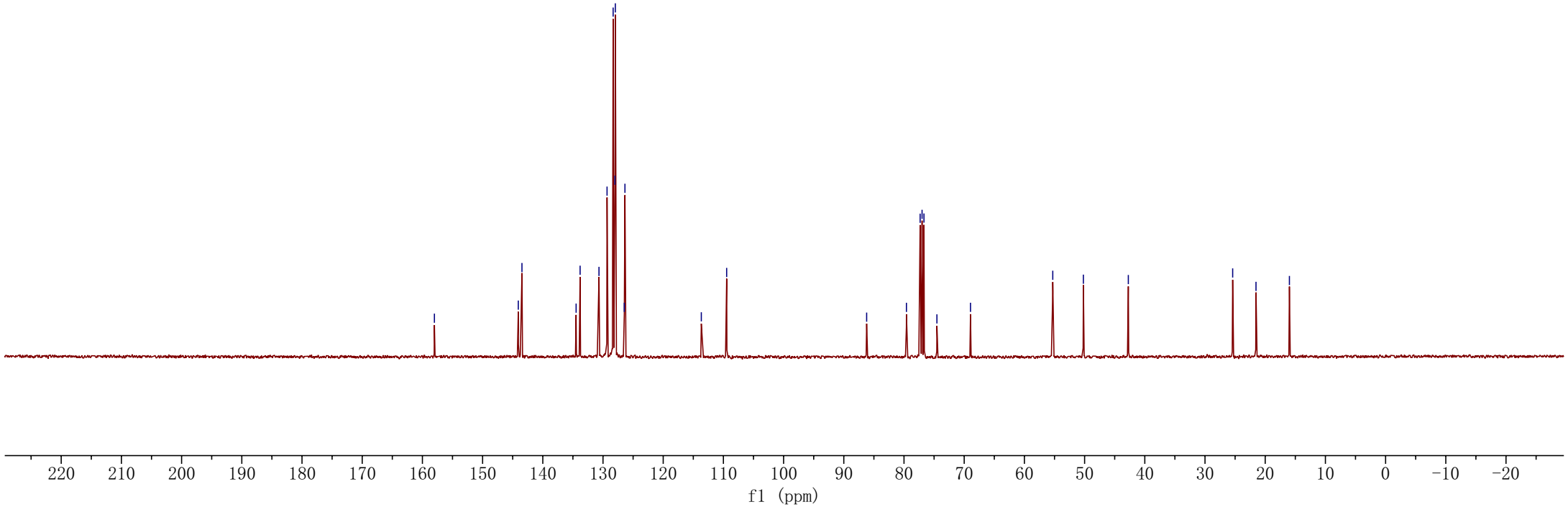
Field strength: 100 MHz

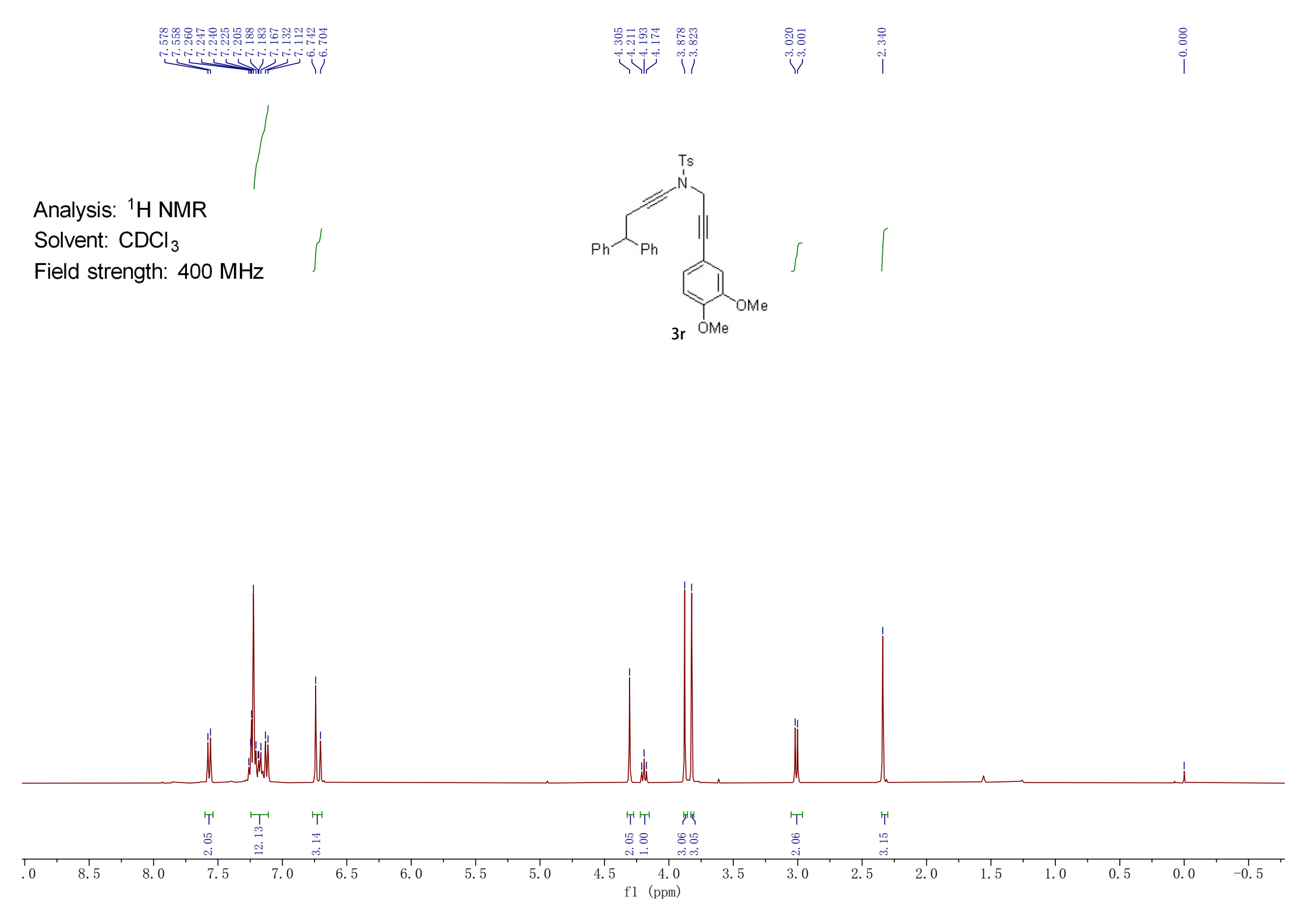
158.01, 144.07, 143.46, 134.47, 133.80, 130.67, 129.33, 128.31, 128.02, 127.95, 126.46, 126.35, 113.67, 109.46, 86.20, 79.60, 77.32, 77.00, 76.68, 74.53, 68.95, 55.29, 50.20, 42.74, 25.40, 21.53, 15.98





3q



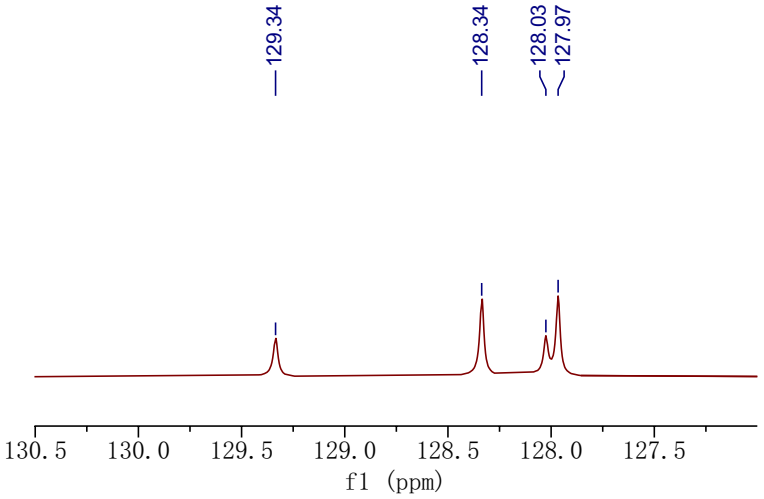

7.578
7.558
7.260
7.247
7.240
7.225
7.205
7.188
7.183
7.167
7.132
7.112
6.742
6.704
4.305
4.211
4.193
4.174
3.878
3.823
3.020
3.001
2.340
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
Ts
N
Ph
Ph
OMe
OMe
3r
2.05
12.13
3.14
2.05
1.00
3.06
3.05
2.06
3.15
f1 (ppm)

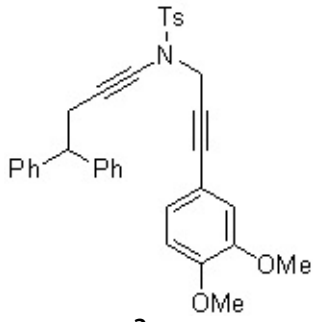
Analysis: ^{13}C NMR

Solvent: $CDCl_3$

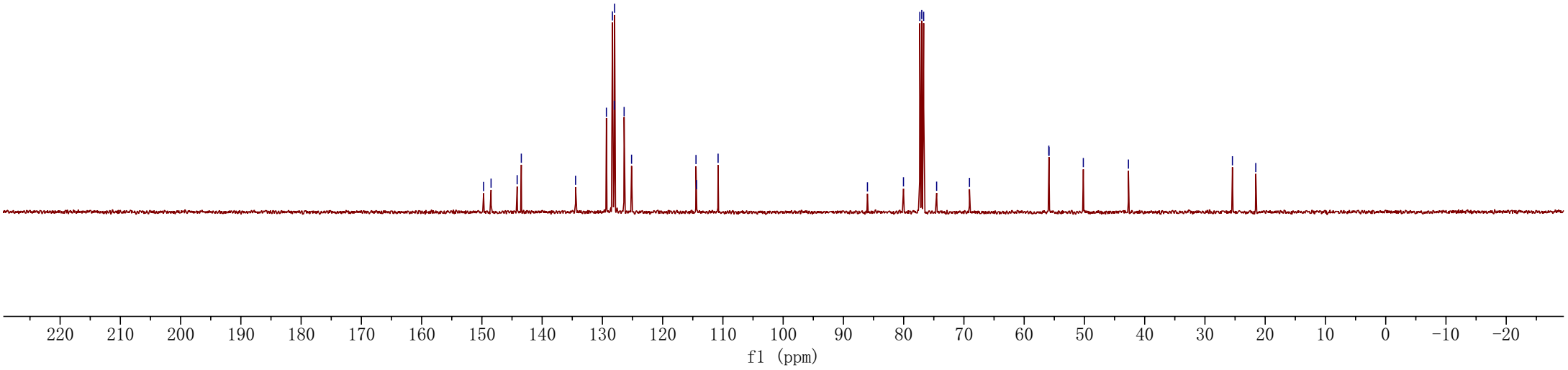
Field strength: 100 MHz

149.72 148.48 144.14 143.46 134.45 129.34 128.34 128.03 127.97 126.39 125.16 114.47 114.37 110.80 86.01 80.03 77.32 77.00 76.68 74.53 69.08 55.91 55.89 50.18 42.70 25.44 21.56





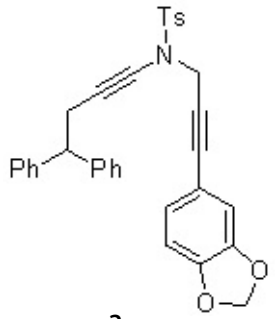
3r



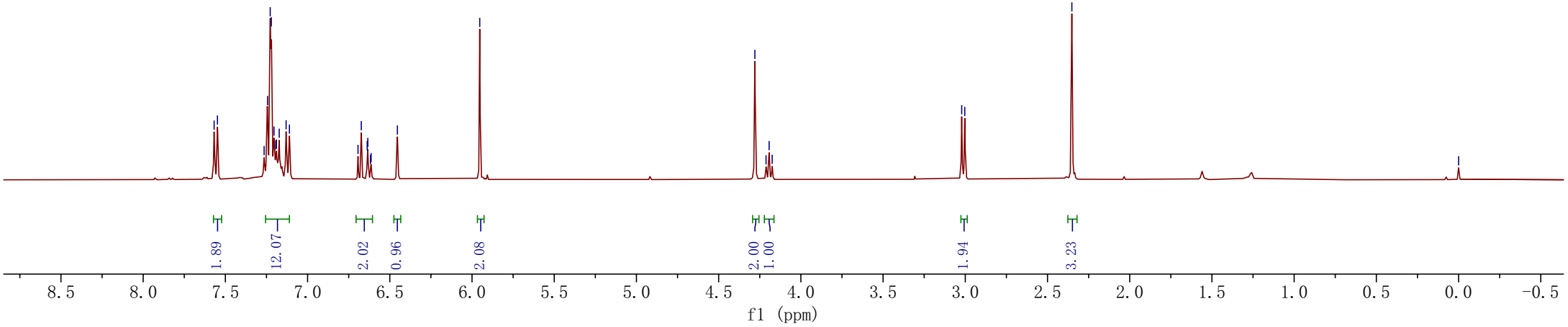
Analysis: ^{1}H NMR

Solvent: $CDCl_3$

Field strength: 400 MHz



3s

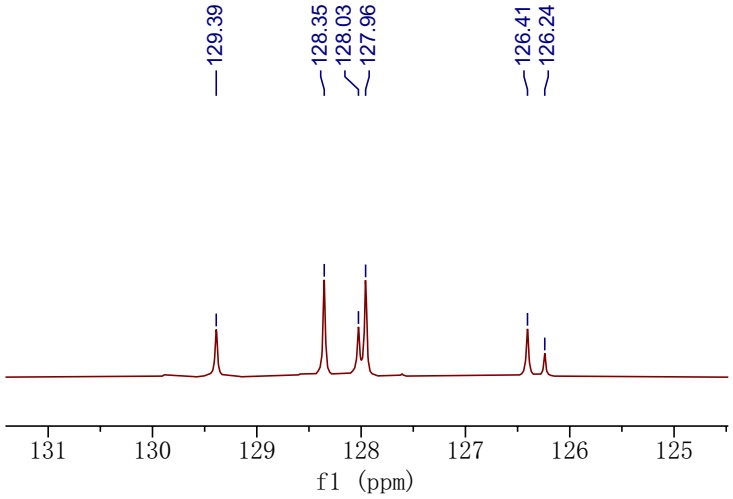


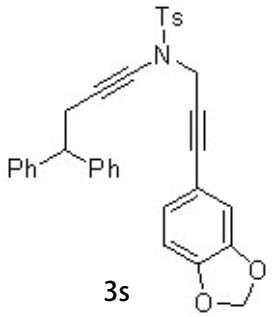
Analysis: ^{13}C NMR

Solvent: $CDCl_3$

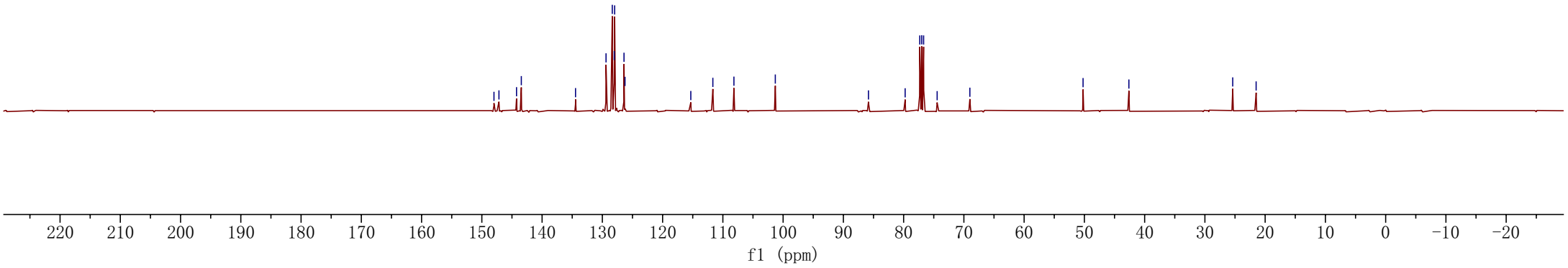
Field strength: 100 MHz

147.99
147.16
144.24
143.45
134.45
129.39
128.35
128.03
127.96
126.41
126.24
115.32
111.66
108.16
101.30
85.83
79.75
77.32
77.00
76.68
74.44
69.01
50.22
42.62
25.38
21.50





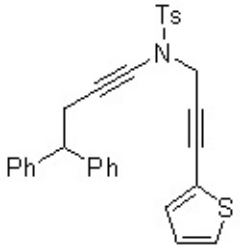
3s



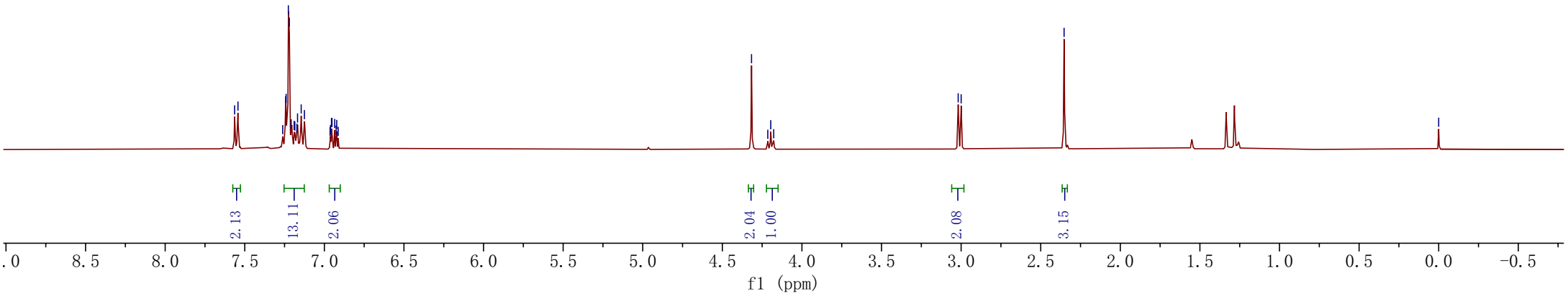
Analysis: ^{1}H NMR

Solvent: $CDCl_3$

Field strength: 400 MHz



3t

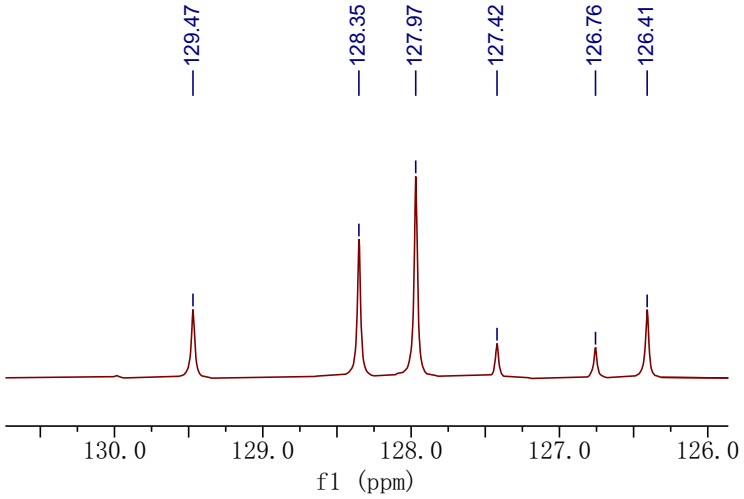


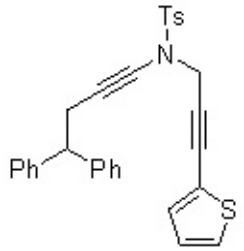
Analysis: ^{13}C NMR

Solvent: $CDCl_3$

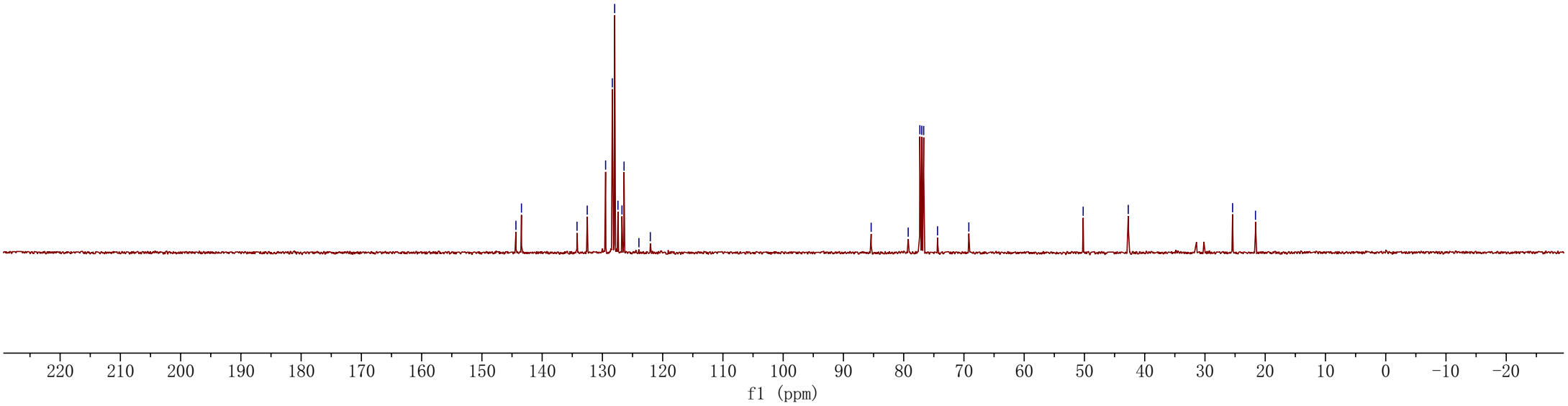
Field strength: 100 MHz

144.35
143.44
134.21
132.52
129.47
128.35
127.97
127.42
126.76
126.41
123.94
122.05
85.40
79.25
77.32
77.00
76.68
74.38
69.19
50.21
42.73
25.42
21.62





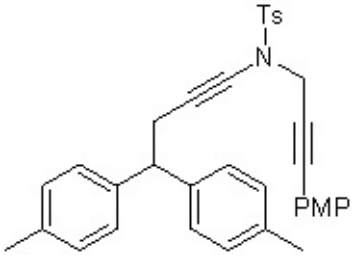
3t



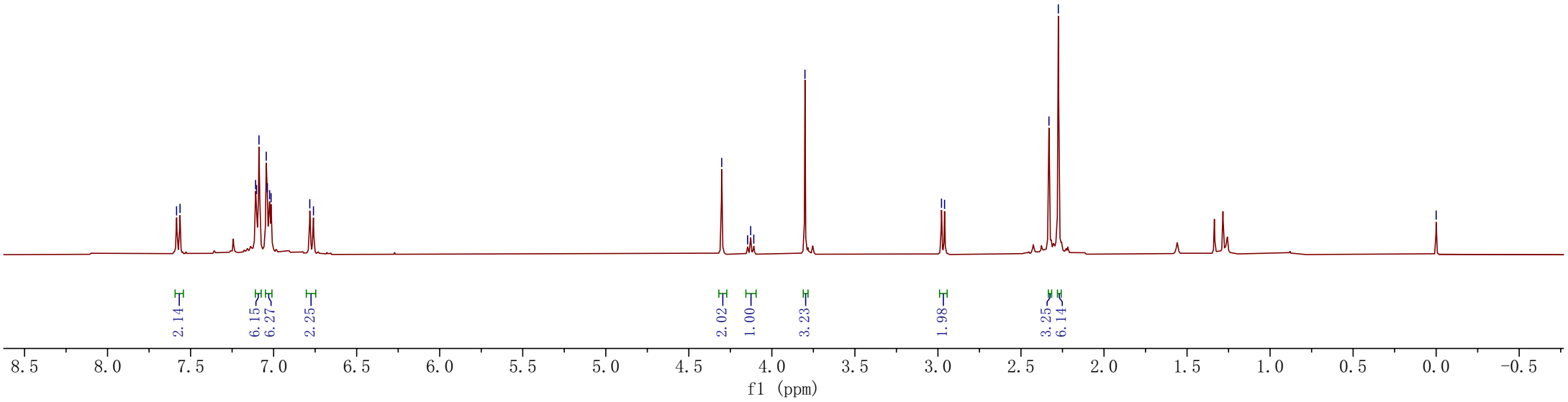
Analysis: ^{1}H NMR

Solvent: $CDCl_3$

Field strength: 400 MHz



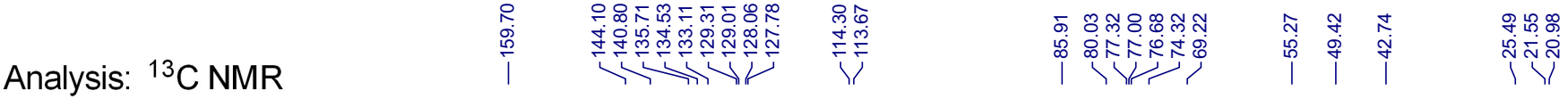
3u

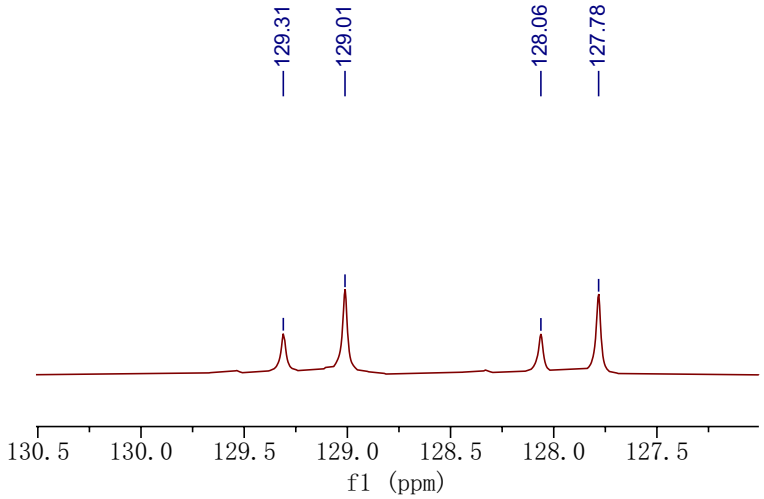


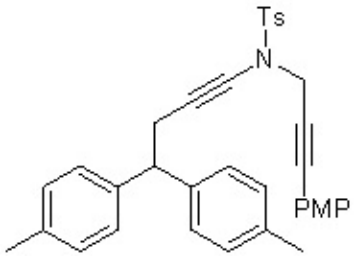
Analysis: ^{13}C NMR

Solvent: $CDCl_3$

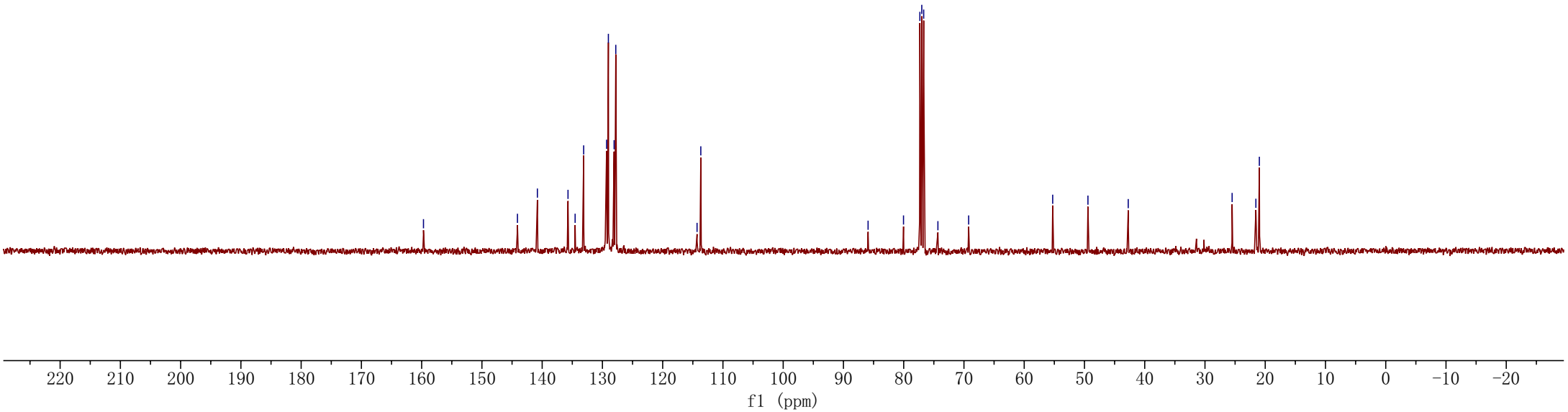
Field strength: 100 MHz

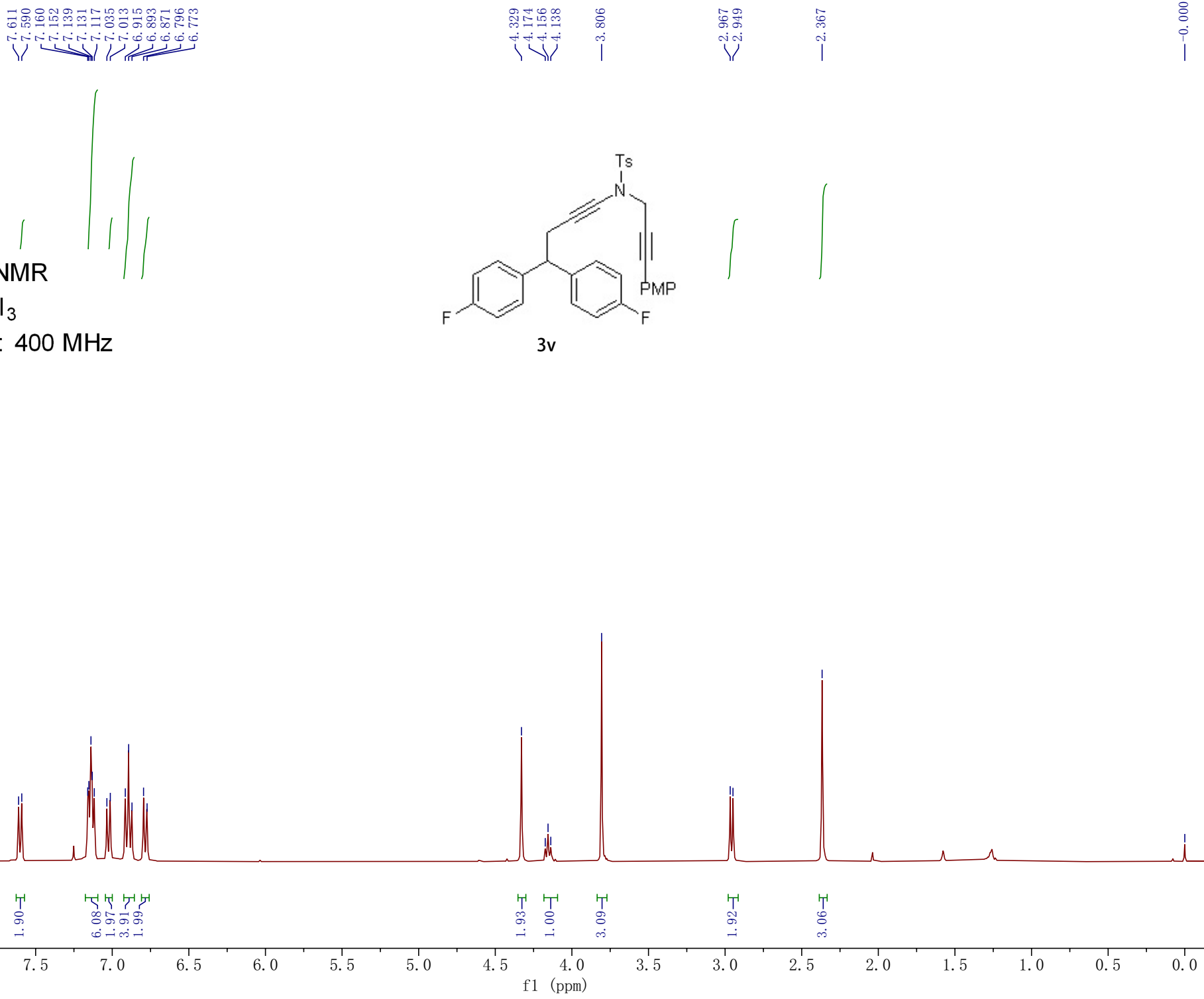






3u

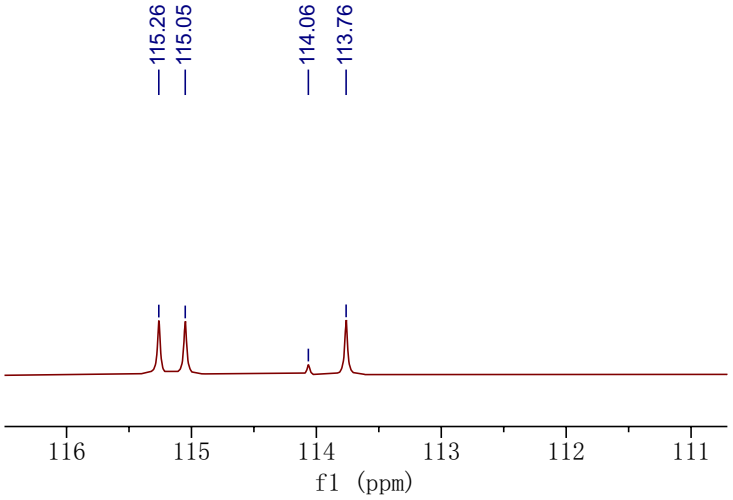


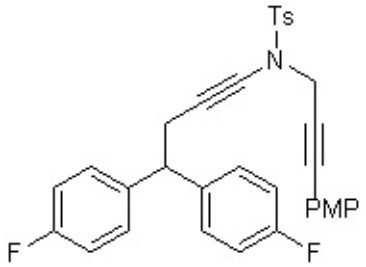

7.611
7.590
7.160
7.152
7.139
7.131
7.117
7.035
7.013
6.915
6.893
6.871
6.796
6.773
4.329
4.174
4.156
4.138
3.806
2.967
2.949
2.367
-0.000
Ts
N
PMP
F
F
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
3v
1.90
6.08
1.97
3.91
1.99
1.93
1.00
3.09
1.92
3.06
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

Analysis: ^{13}C NMR

Solvent: $CDCl_3$

Field strength: 100 MHz



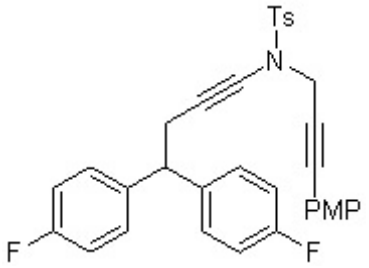


3v

Analysis: ^{19}F NMR

Solvent: $CDCl_3$

Field strength: 471 MHz

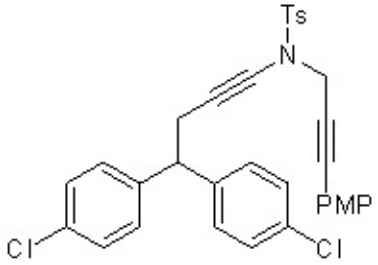


3v

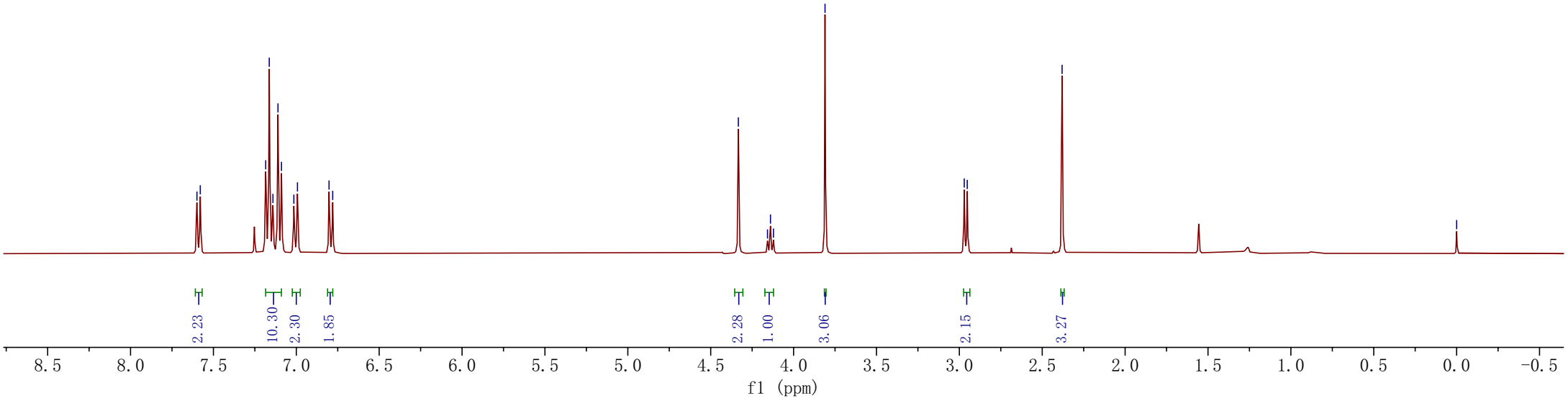
Analysis: ^{1}H NMR

Solvent: $CDCl_3$

Field strength: 400 MHz



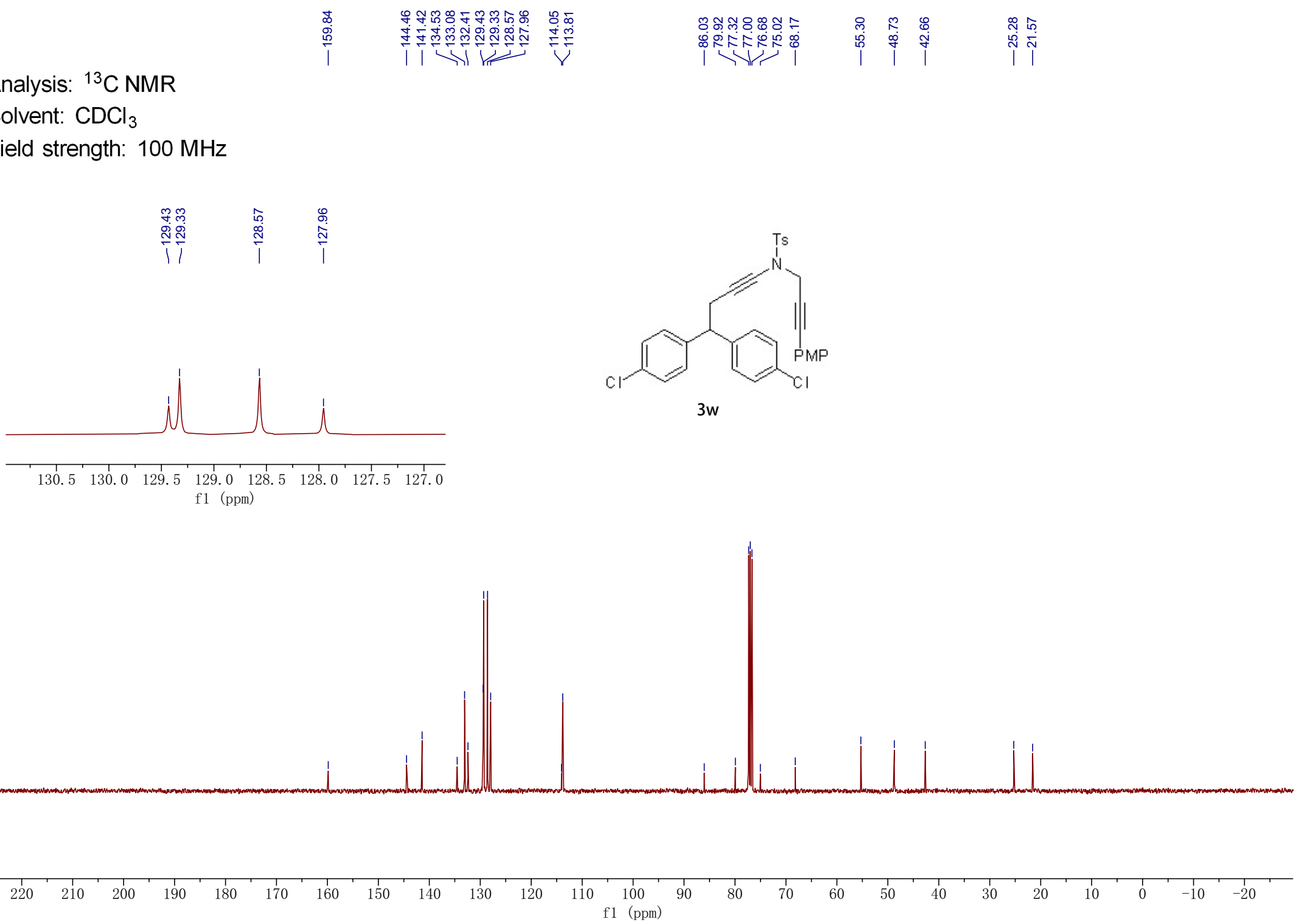
3w



Analysis: ^{13}C NMR

Solvent: $CDCl_3$

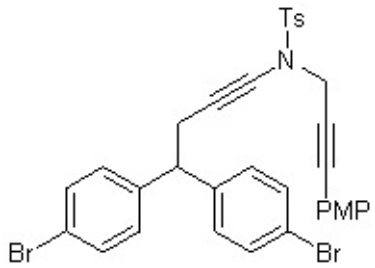
Field strength: 100 MHz



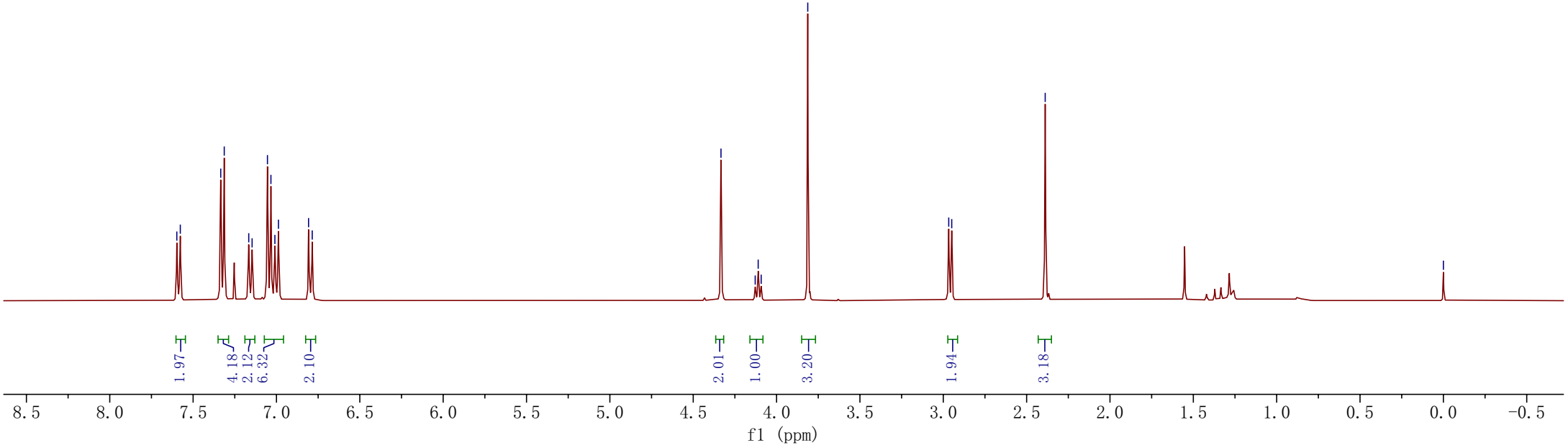
Analysis: ^{1}H NMR

Solvent: $CDCl_3$

Field strength: 400 MHz



3x

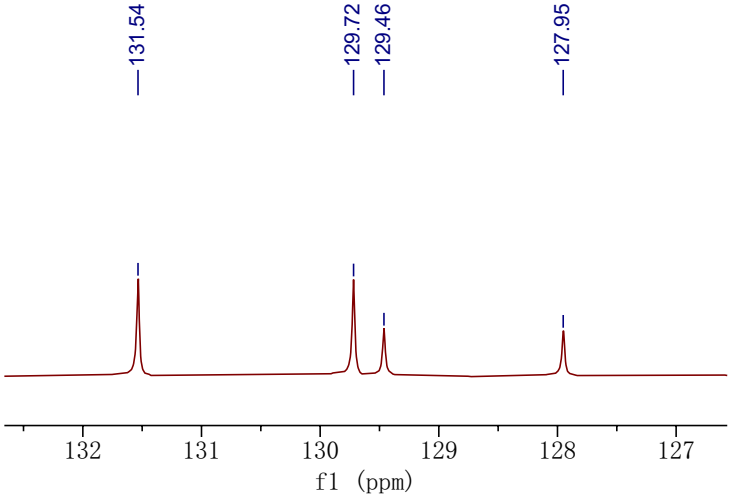


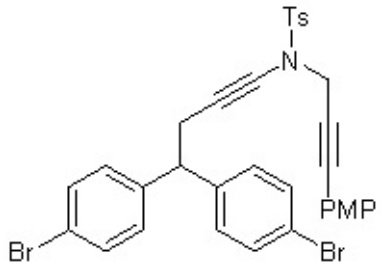
Analysis: ^{13}C NMR

Solvent: $CDCl_3$

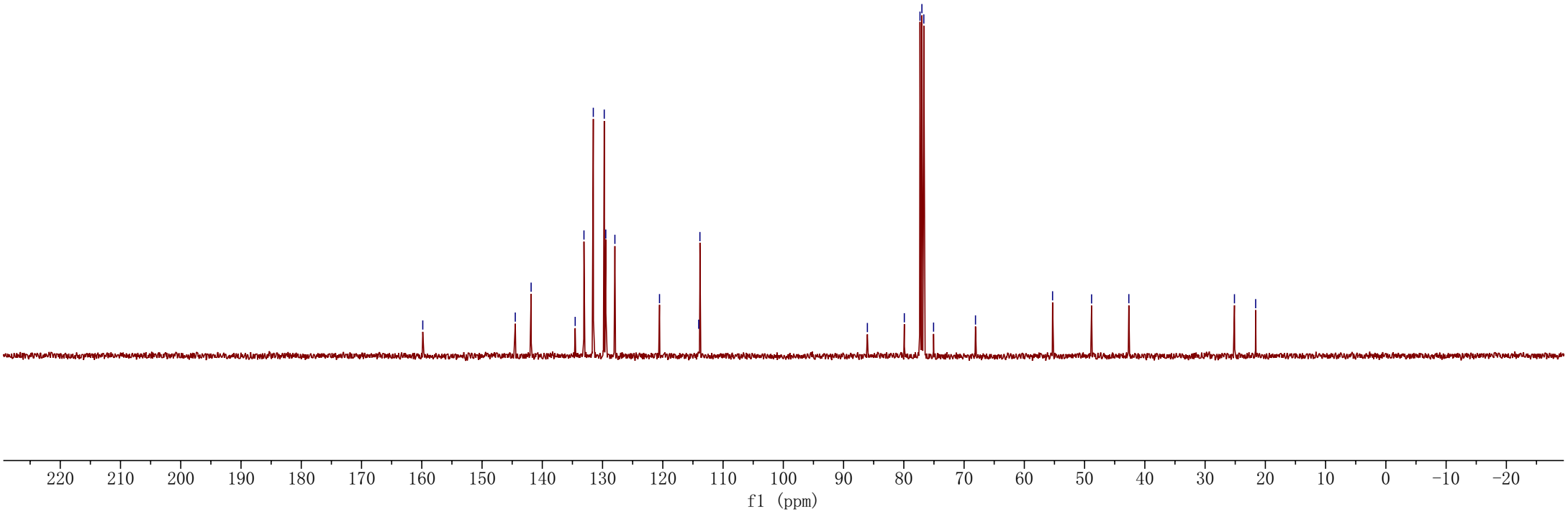
Field strength: 100 MHz

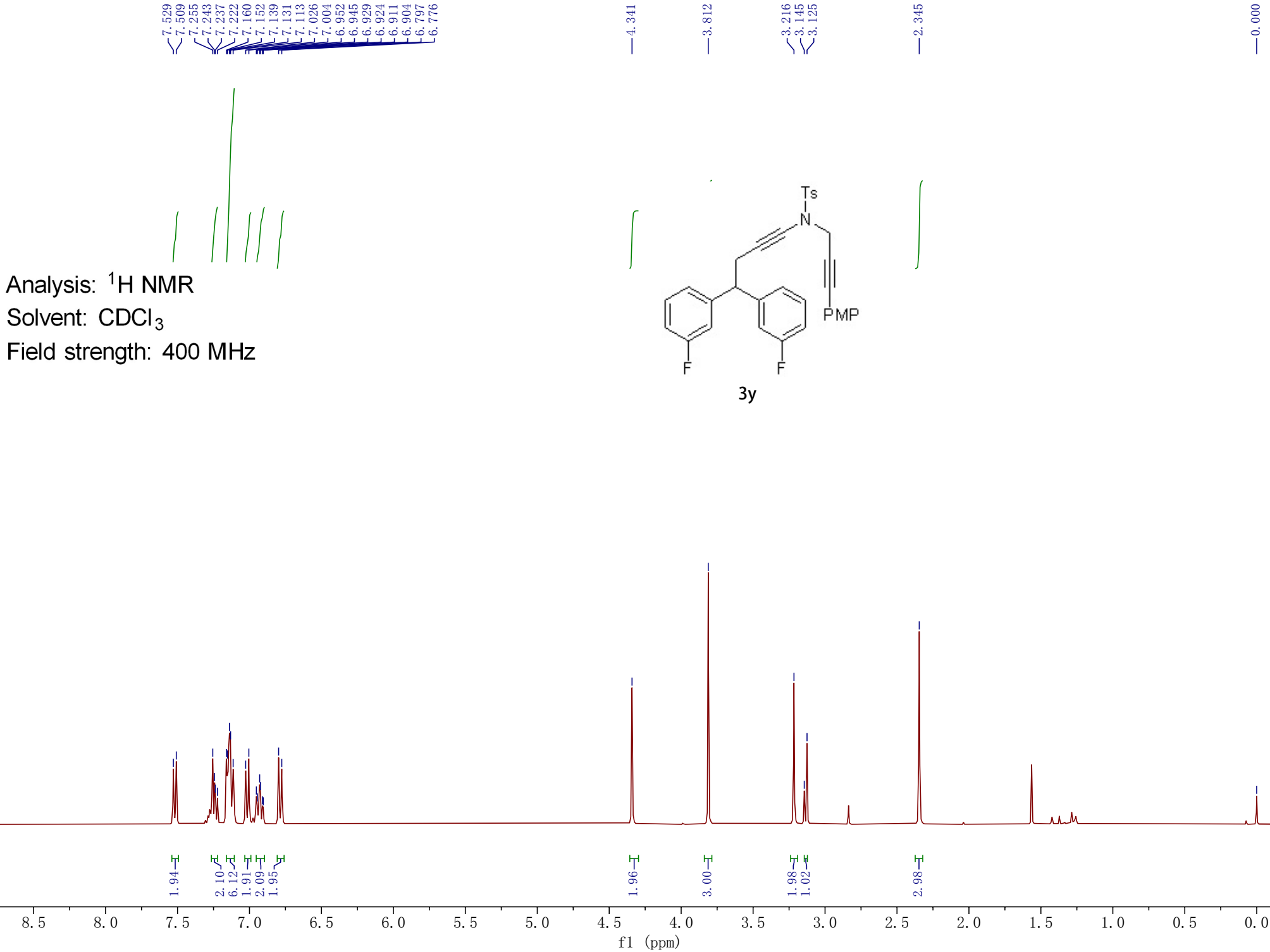
159.84
144.48
141.85
134.54
133.09
131.54
129.72
129.46
127.95
120.55
114.04
113.84
86.05
79.92
77.32
77.00
76.68
75.06
68.11
55.31
48.84
42.66
25.13
21.61





3x

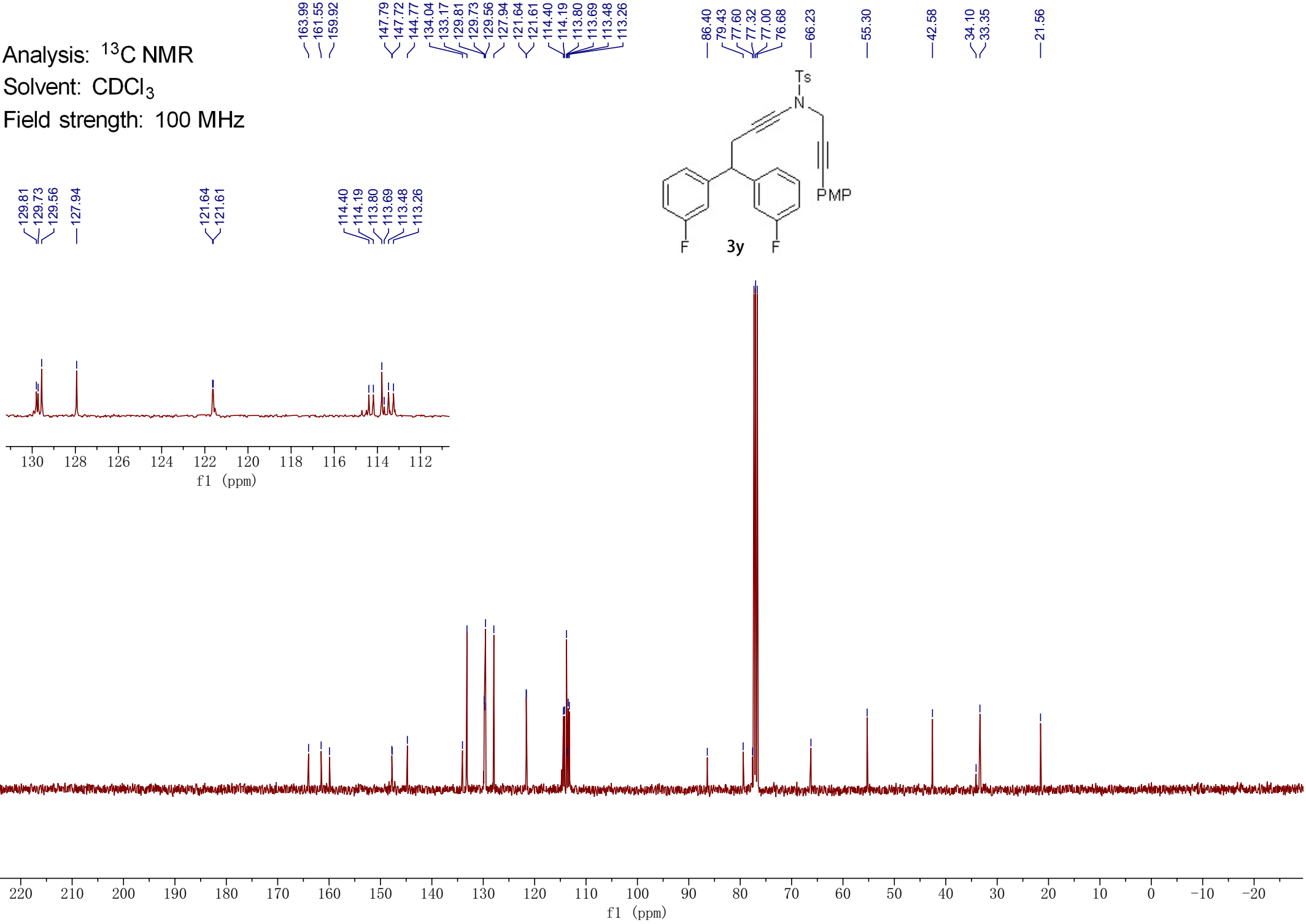



7.529
7.509
7.255
7.243
7.237
7.222
7.160
7.152
7.139
7.131
7.113
7.026
7.004
6.952
6.945
6.929
6.924
6.911
6.904
6.797
6.776
4.341
3.812
3.216
3.145
3.125
2.345
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
Ts
N
PMP
F
F
3y
1.94
2.10
6.12
1.91
2.09
1.95
1.96
3.00
1.98
1.02
2.98
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.
f1 (ppm)

Analysis: ^{13}C NMR

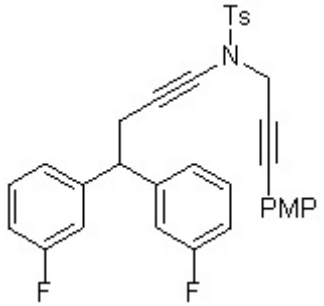
Solvent: $CDCl_3$

Field strength: 100 MHz

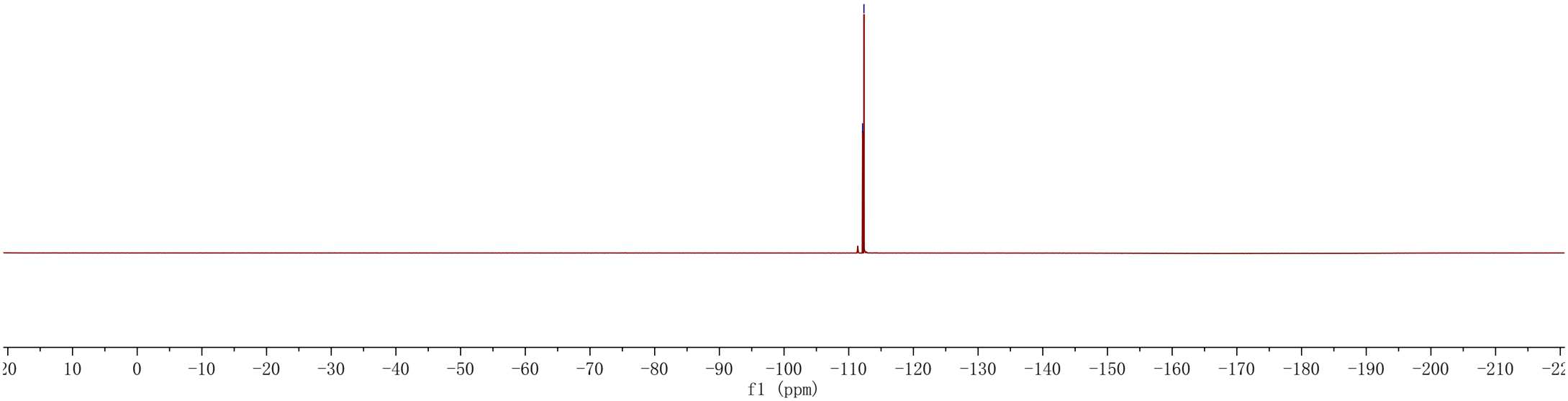


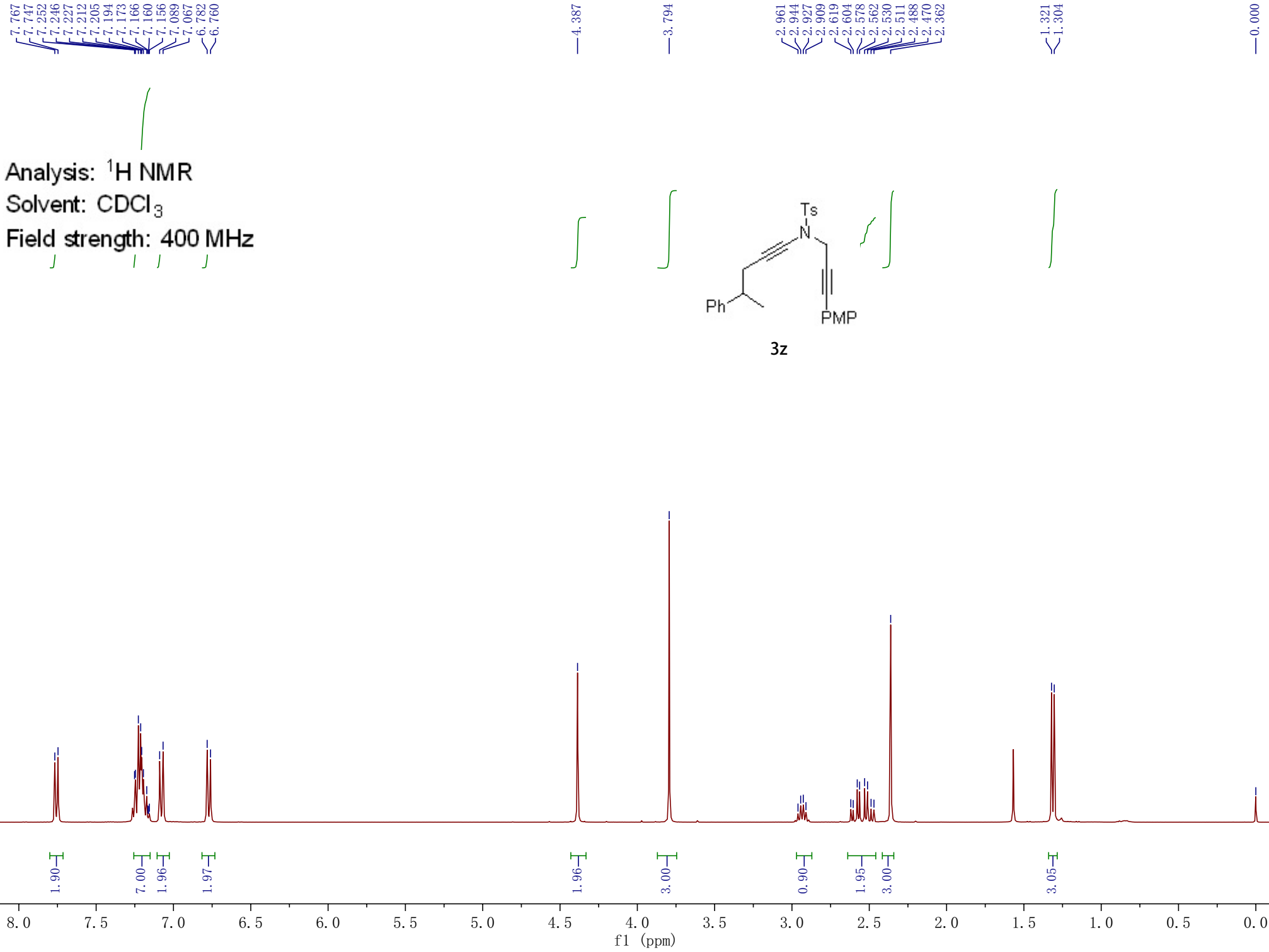
-112.14
-112.35

Analysis: ^{19}F NMR
Solvent: $CDCl_3$
Field strength: 471 MHz



3y



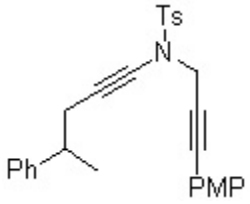

7.767
7.747
7.252
7.246
7.227
7.212
7.205
7.194
7.173
7.166
7.160
7.156
7.089
7.067
6.782
6.760
4.387
3.794
2.961
2.944
2.927
2.909
2.619
2.604
2.578
2.562
2.530
2.511
2.488
2.470
2.362
1.321
1.304
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
Ts
N
Ph
PMP
3z
1.90
7.00
1.96
1.97
1.96
3.00
0.90
1.95
3.00
3.05
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

Analysis: ^{13}C NMR

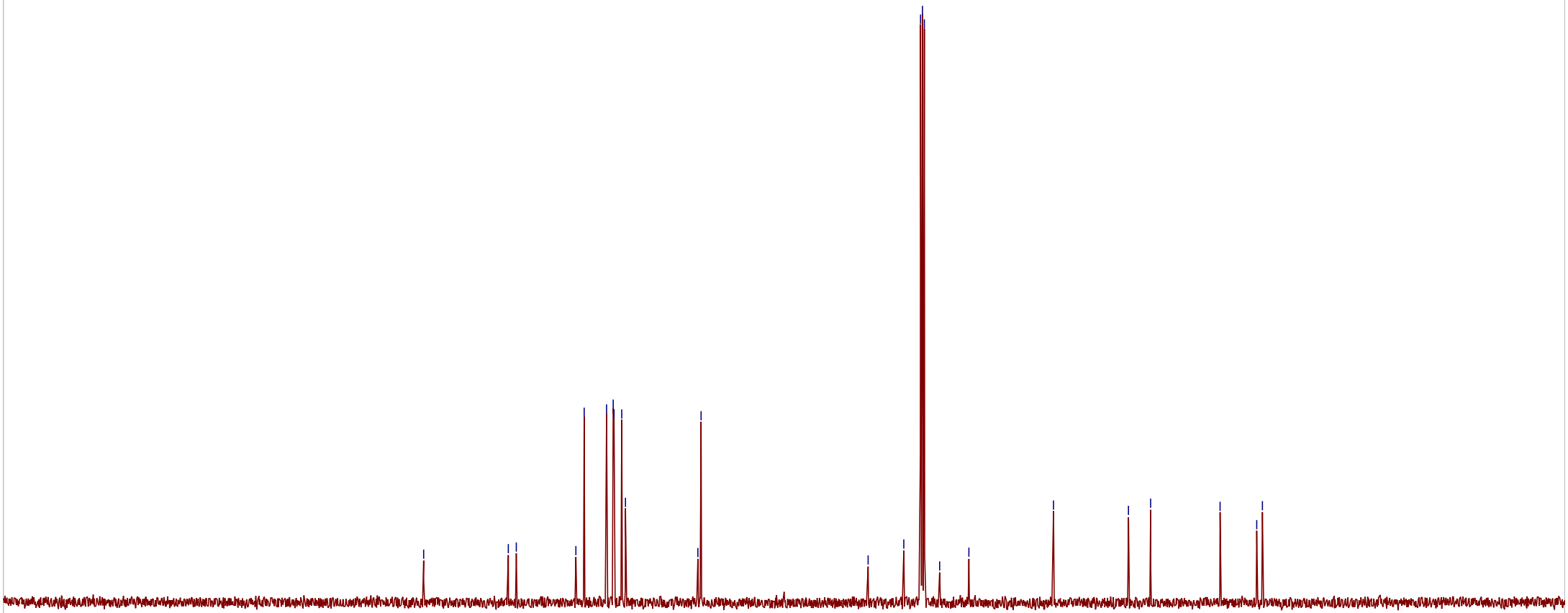
Solvent: $CDCl_3$

Field strength: 100 MHz

159.72
145.68
144.36
134.48
133.10
129.39
128.29
128.15
126.87
126.25
114.24
113.71
86.01
80.09
77.32
77.00
76.68
74.15
69.30
55.27
42.84
39.16
27.64
21.56
20.62



3z



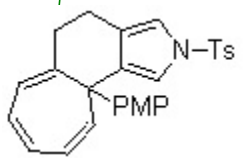
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10 -20

f1 (ppm)

Analysis: ^{1}H NMR

Solvent: $CDCl_3$

Field strength: 500 MHz

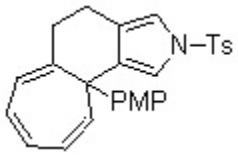


2a

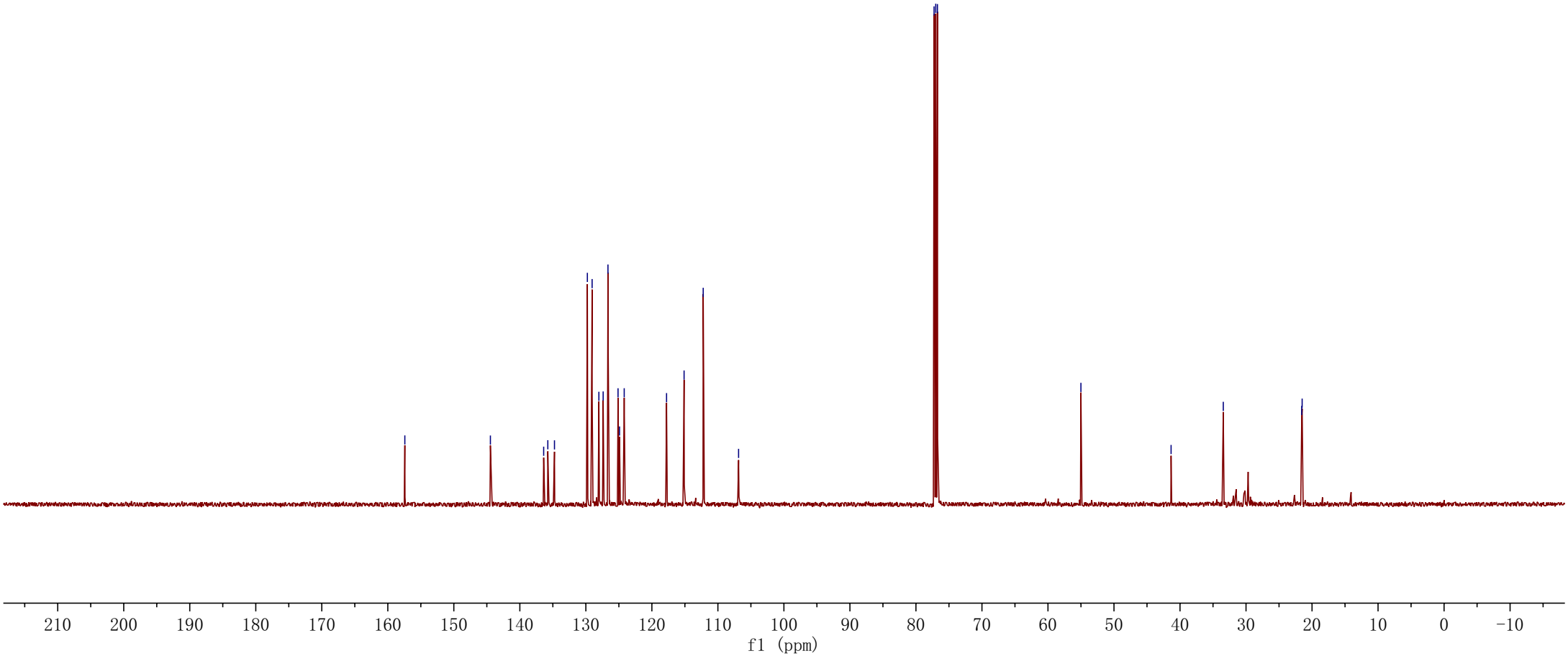
f1 (ppm)

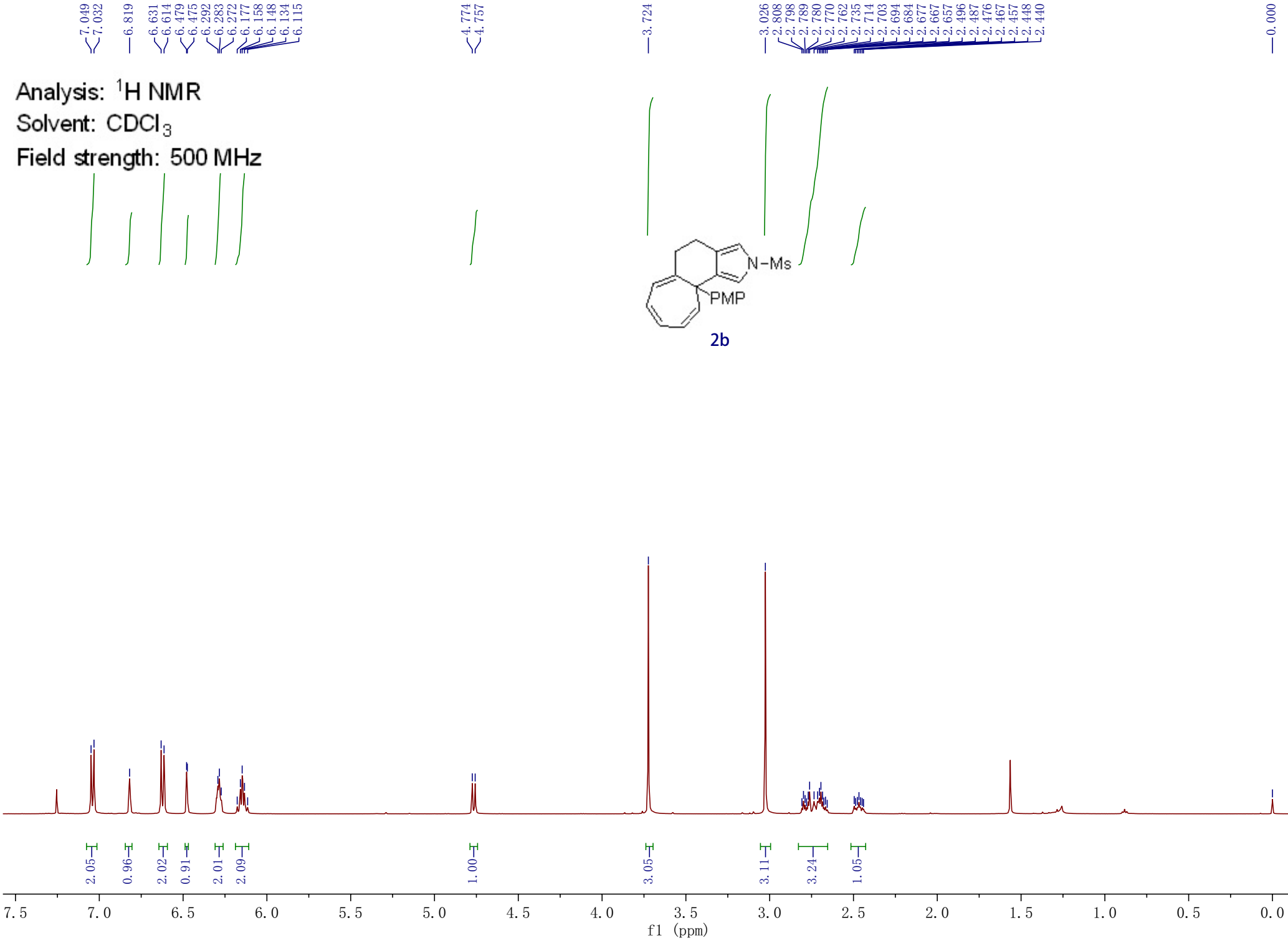
Analysis: ^{13}C NMR
Solvent: $CDCl_3$
Field strength: 125MHz

157.42
144.46
136.39
135.76
134.75
129.77
129.05
128.03
127.38
126.65
125.13
124.90
124.19
117.78
115.12
112.22
106.87
77.25
77.00
76.75
55.01
41.35
33.44
21.56
21.50



2a



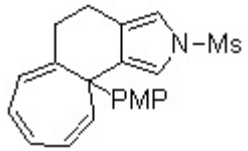

7.049
7.032
6.819
6.631
6.614
6.479
6.475
6.292
6.283
6.272
6.177
6.158
6.148
6.134
6.115
4.774
4.757
3.724
3.026
2.808
2.798
2.789
2.780
2.770
2.762
2.735
2.714
2.703
2.694
2.684
2.677
2.667
2.657
2.496
2.487
2.476
2.467
2.457
2.448
2.440
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 500 MHz
N-Ms
PMP
2b
2.05
0.96
2.02
0.91
2.01
2.09
1.00
3.05
3.11
3.24
1.05
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

Analysis: ^{13}C NMR

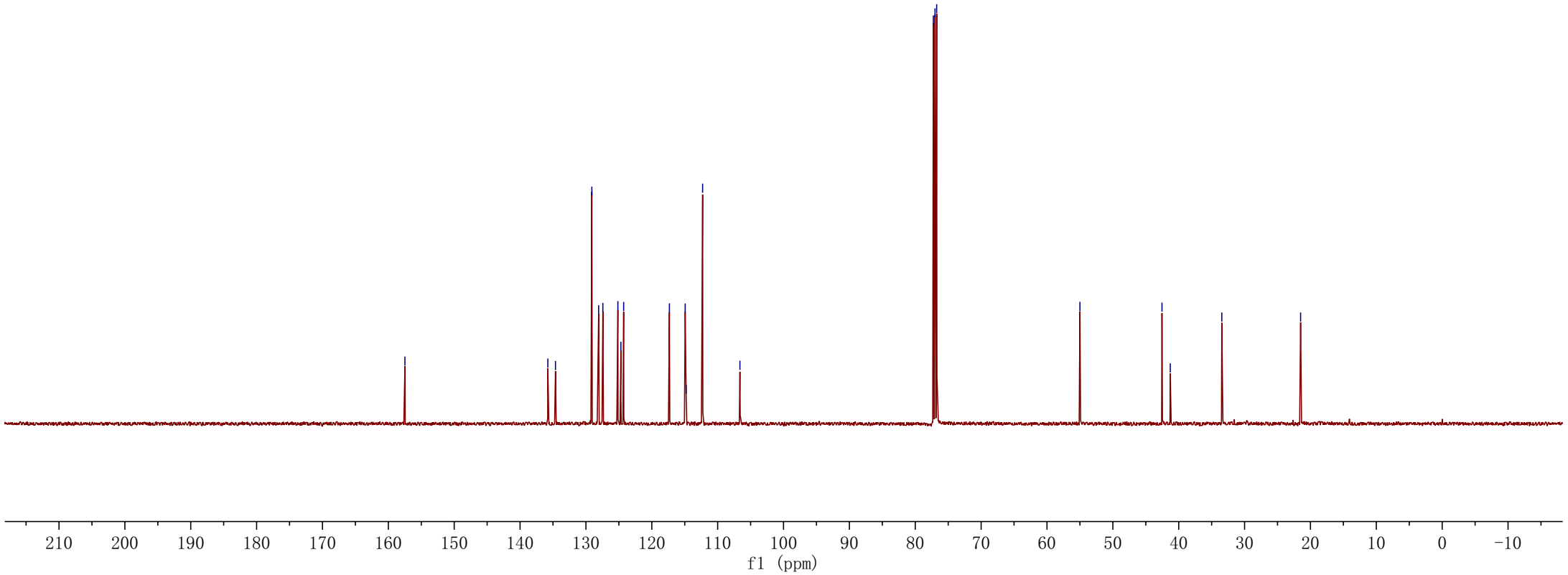
Solvent: $CDCl_3$

Field strength: 125MHz

157.48
135.78
134.62
129.10
128.07
127.43
125.15
124.69
124.27
117.33
114.93
114.79
112.28
106.62
77.25
77.00
76.75
55.00
42.54
41.28
33.46
21.50



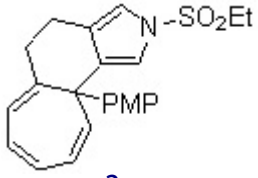
2b



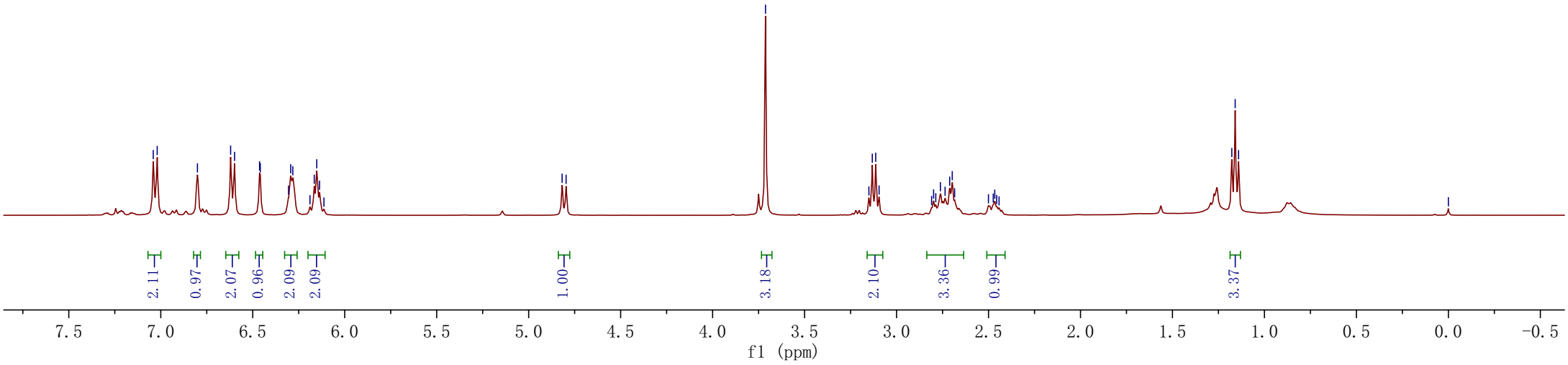
Analysis: ^{1}H NMR

Solvent: $CDCl_3$

Field strength: 400 MHz

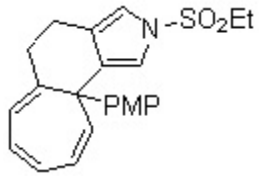


2c

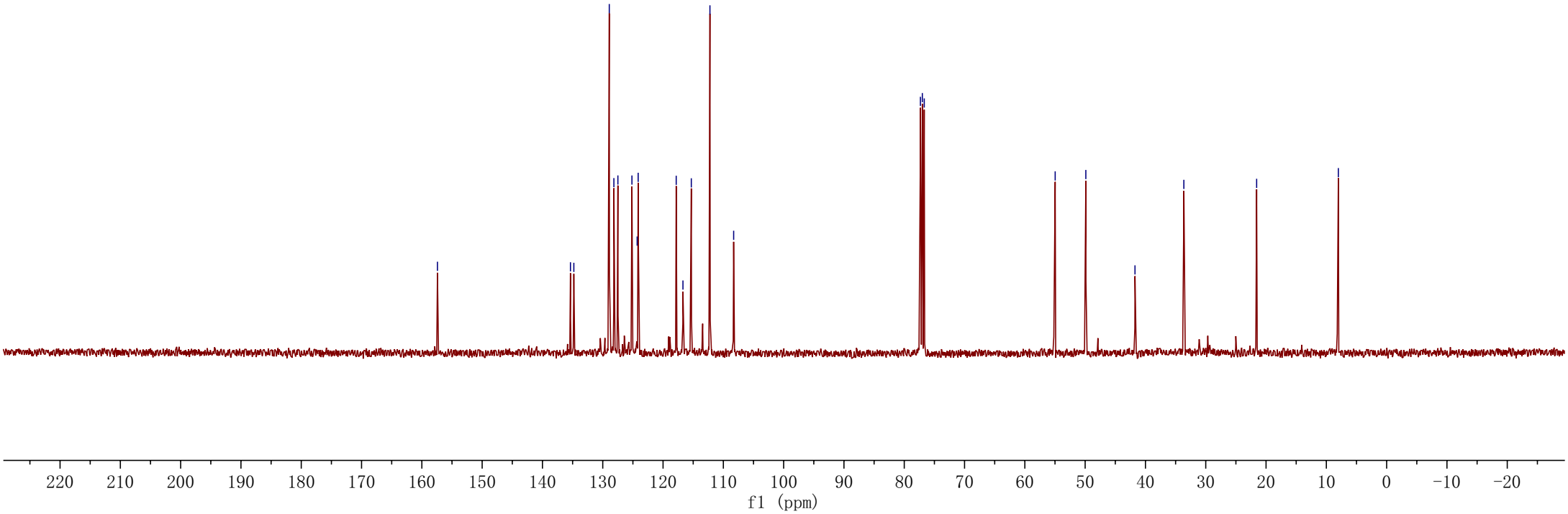


Analysis: ^{13}C NMR
Solvent: $CDCl_3$
Field strength: 100 MHz

157.41
135.36
134.80
128.92
128.15
127.49
125.16
124.30
124.13
117.82
116.70
115.31
112.22
108.29
77.32
77.00
76.68
54.97
49.89
41.73
33.63
21.56
8.01



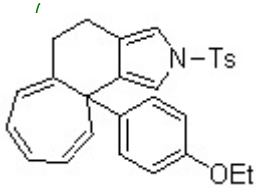
2c



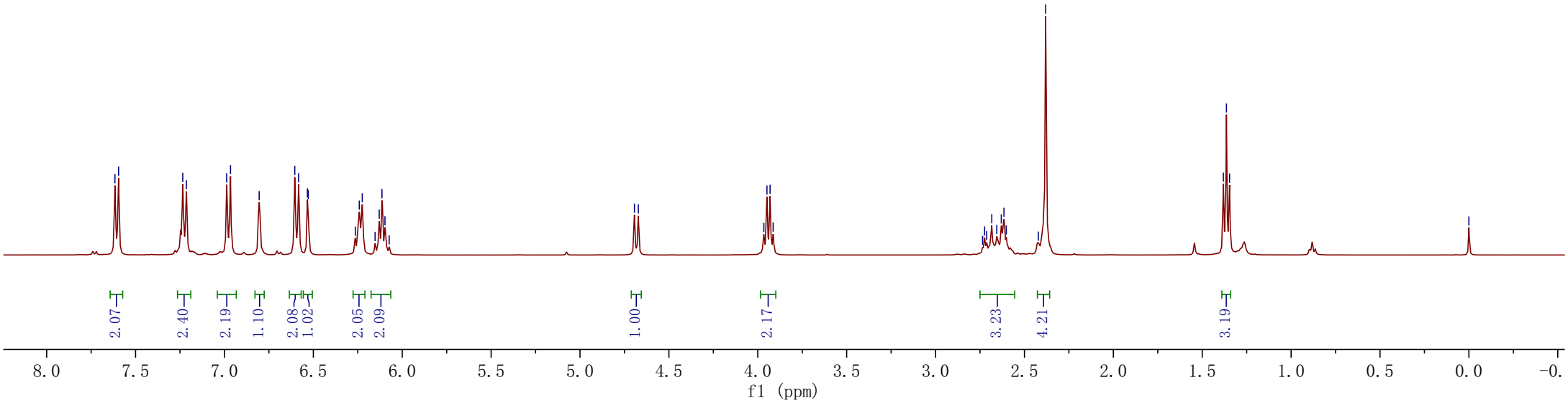
Analysis: ^{1}H NMR

Solvent: $CDCl_3$

Field strength: 400 MHz



2d

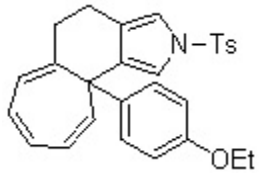


Analysis: ^{13}C NMR

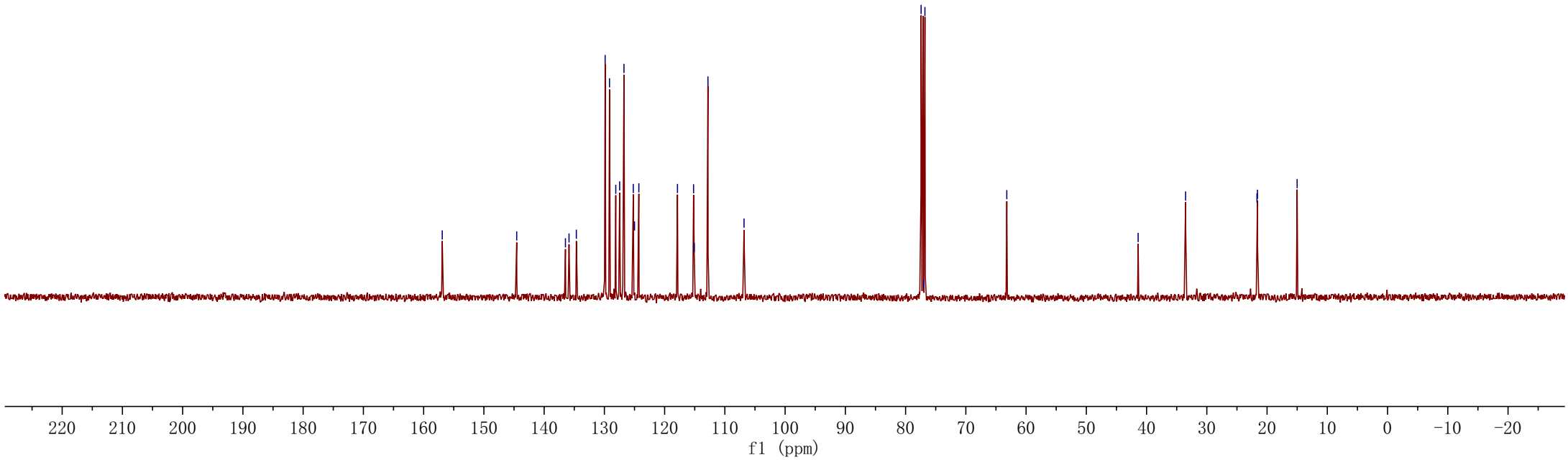
Solvent: $CDCl_3$

Field strength: 100 MHz

156.91
144.55
136.46
135.87
134.65
129.87
129.15
128.11
127.46
126.75
125.20
125.00
124.28
117.87
115.20
115.08
112.81
106.82
77.43
77.00
76.79
63.20
41.40
33.53
21.68
21.59
15.01



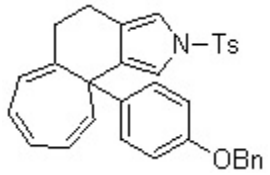
2d



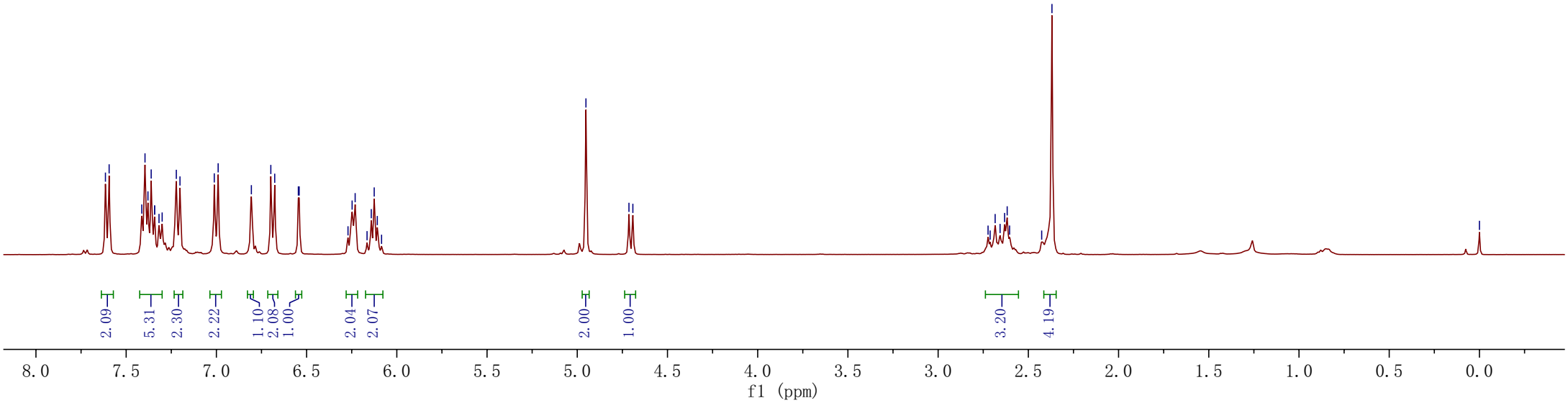
Analysis: ^{1}H NMR

Solvent: $CDCl_3$

Field strength: 400 MHz



2e

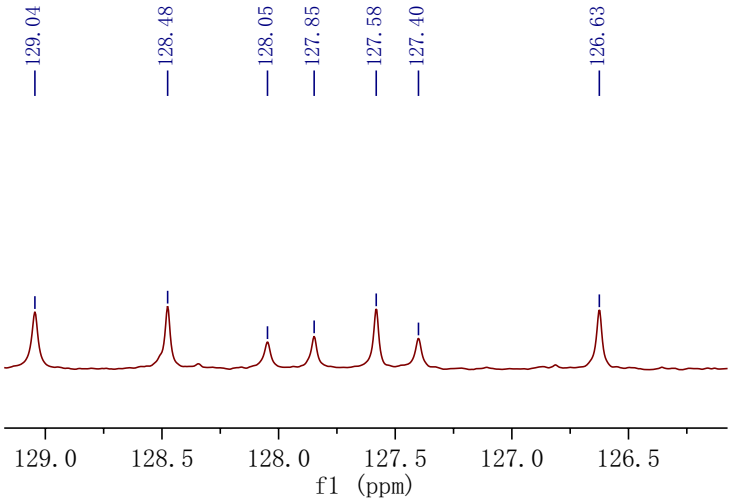


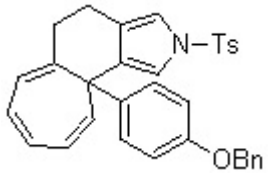
Analysis: ^{13}C NMR

Solvent: $CDCl_3$

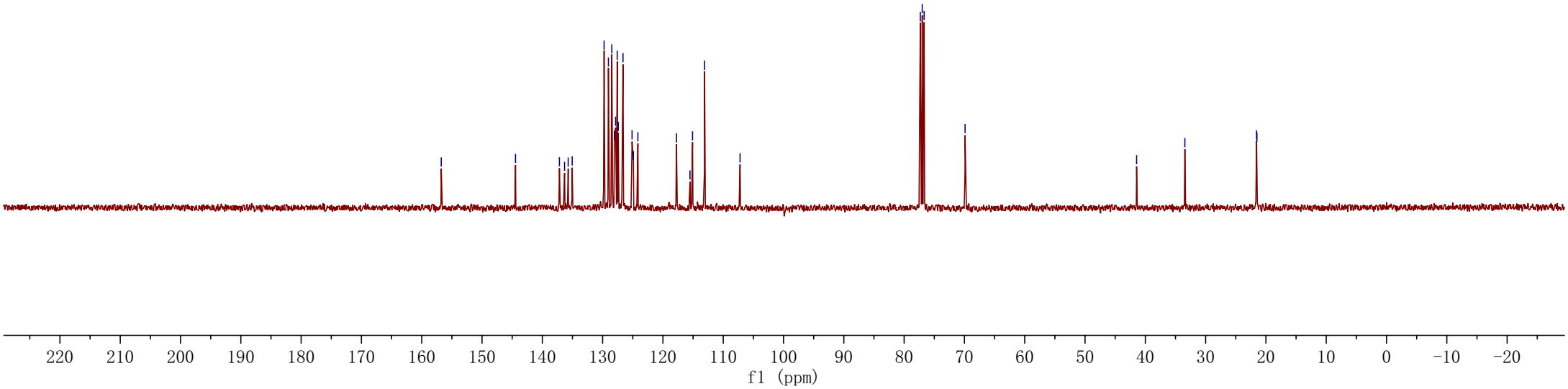
Field strength: 100 MHz

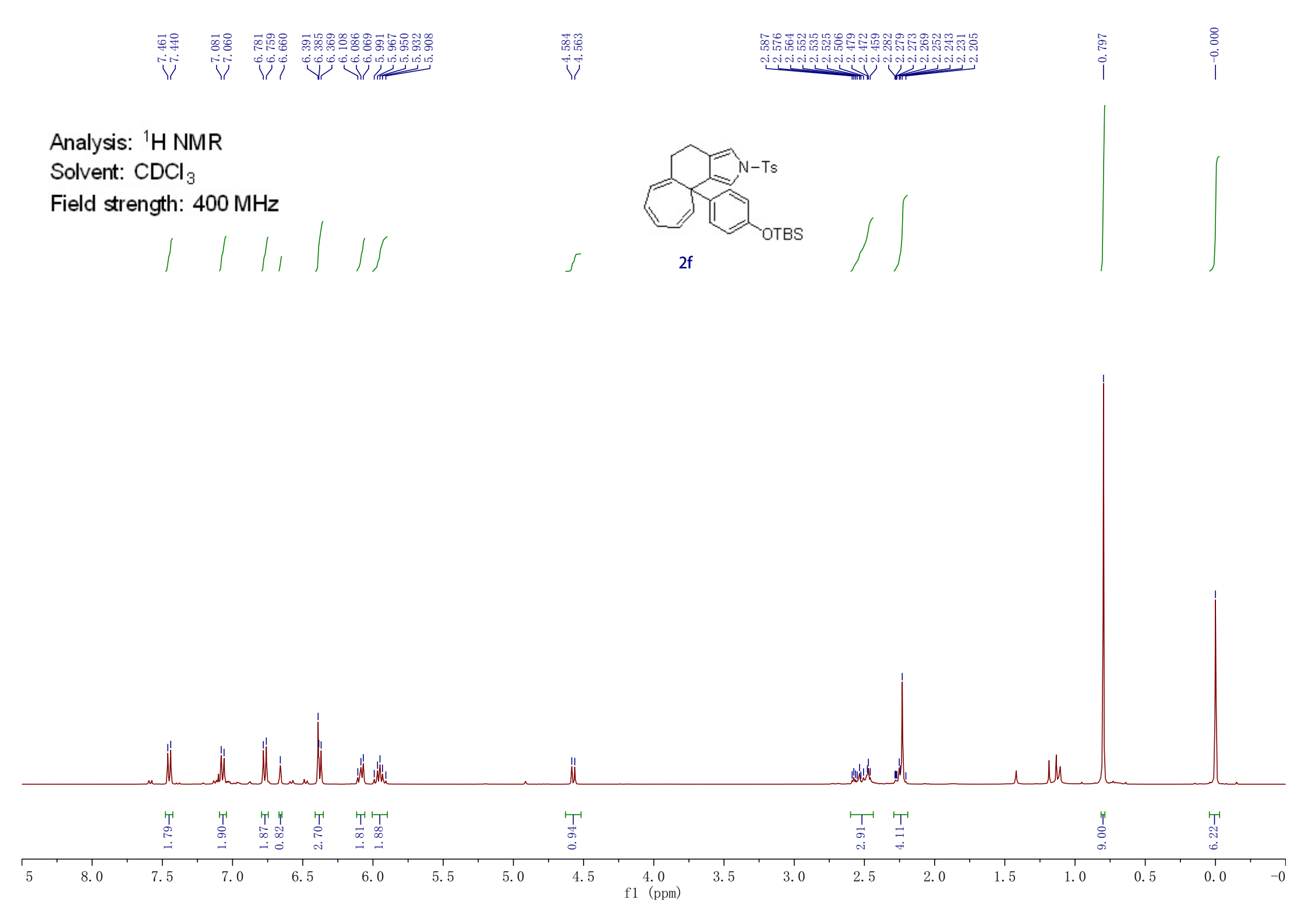
156.76
144.45
137.17
136.32
135.71
135.05
129.76
129.04
128.48
128.05
127.85
127.58
127.40
126.63
125.12
124.89
124.15
117.75
115.51
115.09
113.09
107.21
77.32
77.00
76.68
69.89
41.45
33.44
21.56
21.49





2e



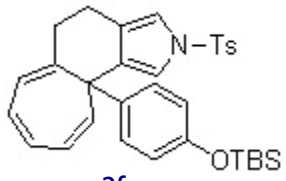

7.461
7.440
7.081
7.060
6.781
6.759
6.660
6.391
6.385
6.369
6.108
6.086
6.069
5.991
5.967
5.950
5.932
5.908
4.584
4.563
2.587
2.576
2.564
2.552
2.535
2.525
2.506
2.479
2.472
2.459
2.282
2.279
2.273
2.269
2.252
2.243
2.231
2.205
0.797
-0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
N-Ts
OTBS
2f
1.79
1.90
1.87
0.82
2.70
1.81
1.88
0.94
2.91
4.11
9.00
6.22
f1 (ppm)

Analysis: ^{13}C NMR

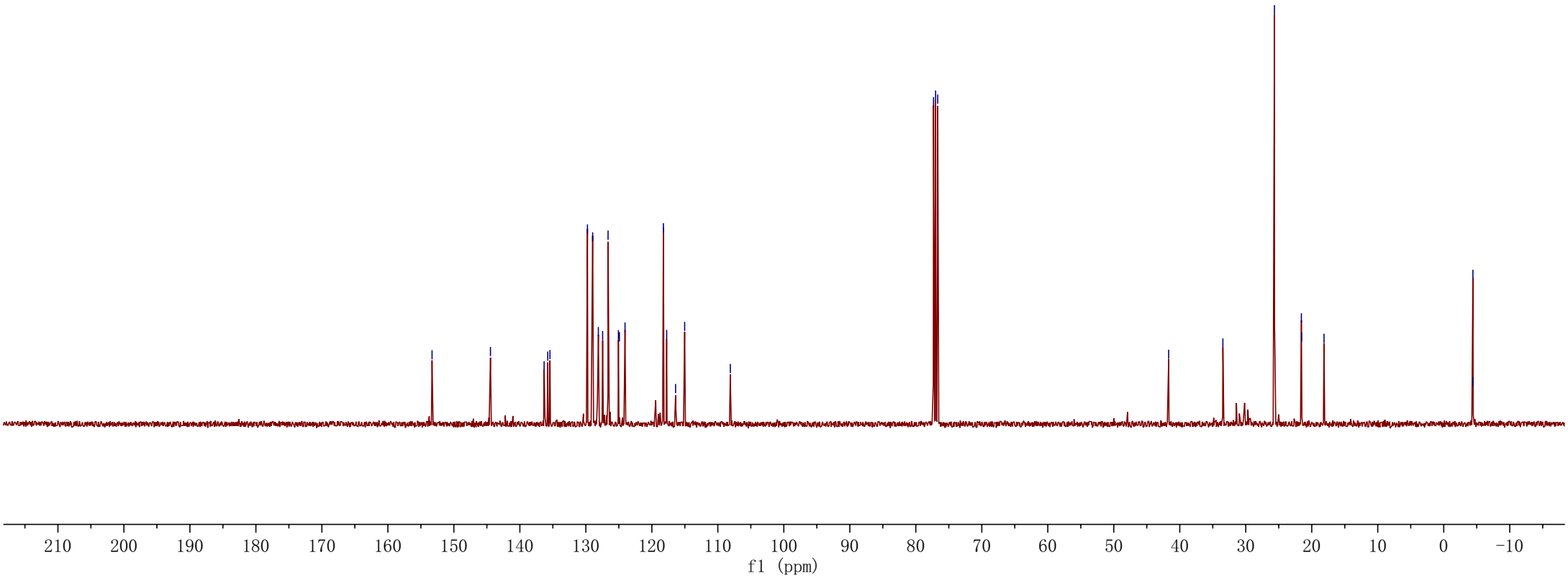
Solvent: $CDCl_3$

Field strength: 100 MHz

153.31
144.45
136.32
135.77
135.44
129.76
128.97
128.10
127.46
126.63
125.07
124.92
124.07
118.25
117.75
116.40
115.03
108.11
77.32
77.00
76.68
41.68
33.47
25.65
21.57
21.54
18.14
-4.42
-4.45



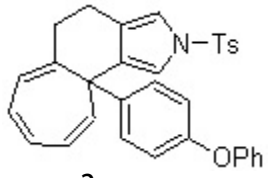
2f



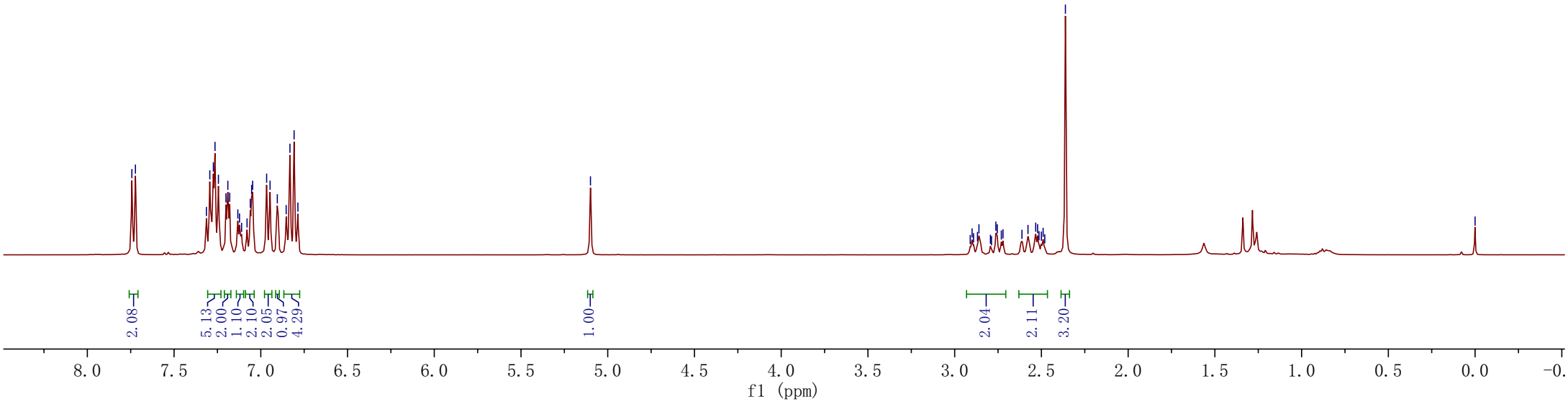
Analysis: ^{1}H NMR

Solvent: $CDCl_3$

Field strength: 400 MHz



2g

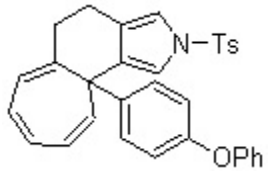


Analysis: ^{13}C NMR

Solvent: $CDCl_3$

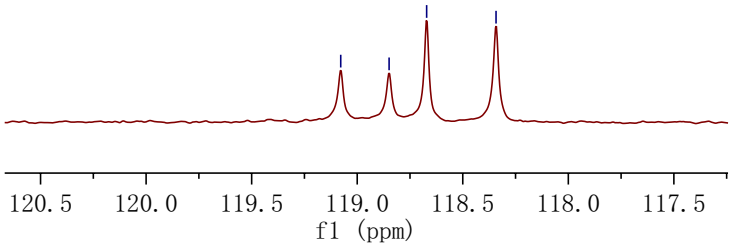
Field strength: 100 MHz

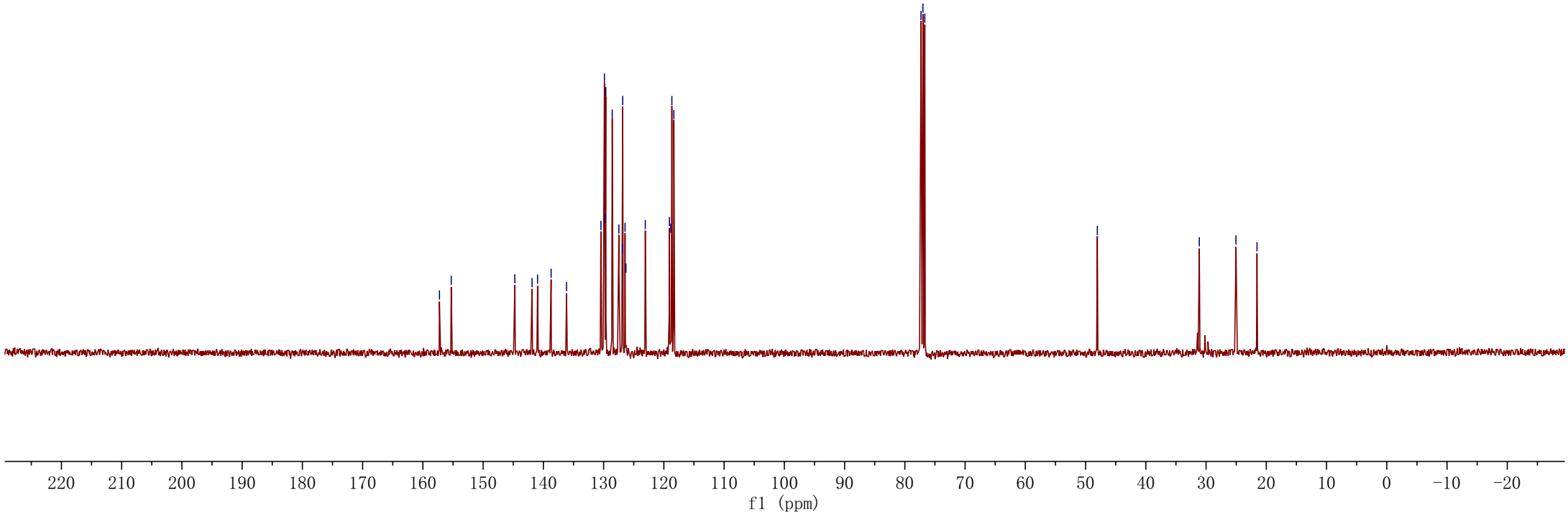
157.25
155.30
144.74
141.88
140.97
138.71
136.15
130.44
129.87
129.80
129.64
128.57
127.47
126.87
126.83
126.44
126.30
123.08
119.08
118.85
118.67
118.34
77.32
77.00
76.68
48.05
31.12
25.03
21.55

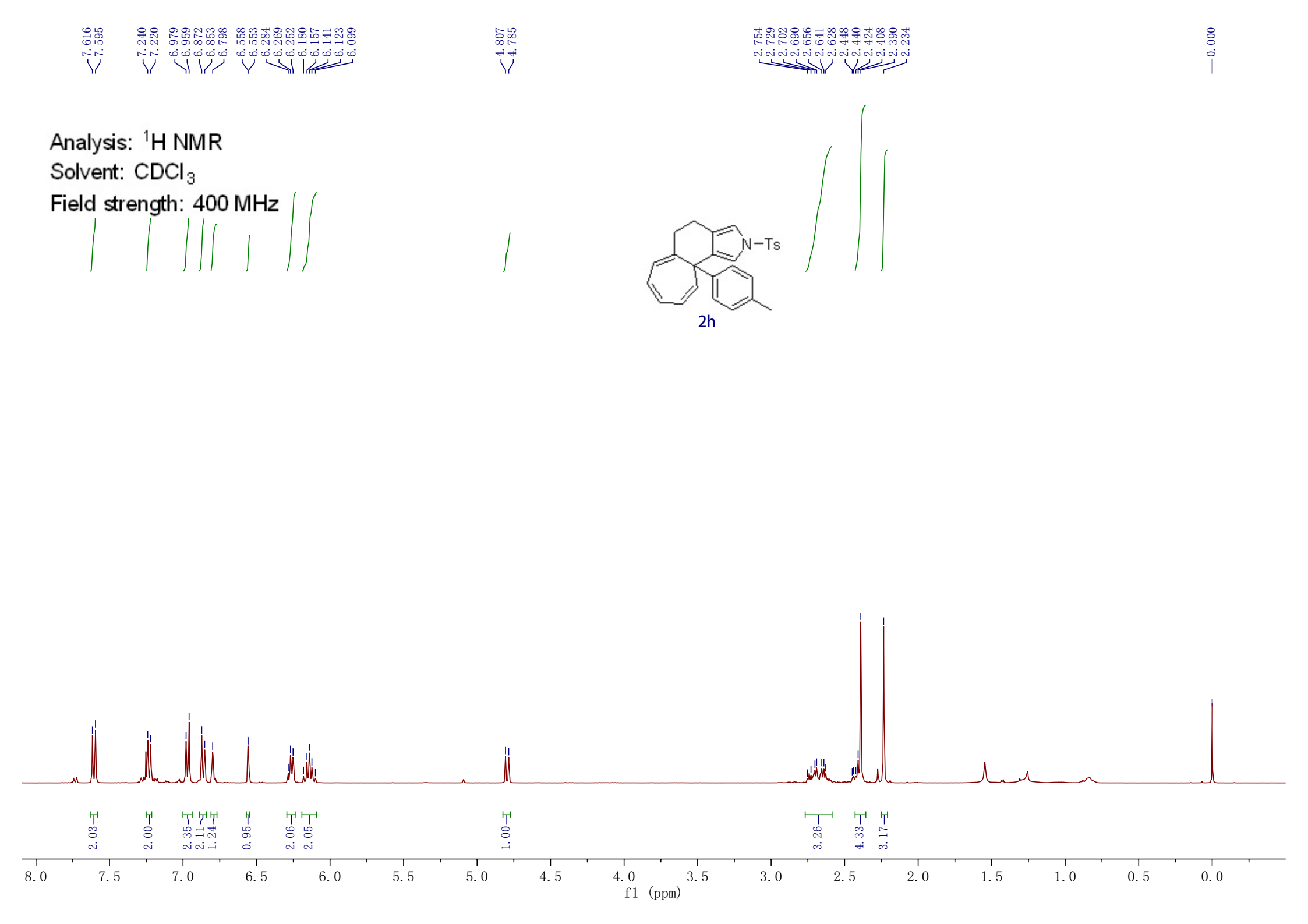


2g

119.08
118.85
118.67
118.34





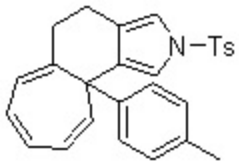

7.616
7.595
7.240
7.220
6.979
6.959
6.872
6.853
6.798
6.558
6.553
6.284
6.269
6.252
6.180
6.157
6.141
6.123
6.099
4.807
4.785
2.754
2.729
2.702
2.690
2.656
2.641
2.628
2.448
2.440
2.424
2.408
2.390
2.234
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
N−Ts
2h
2.03
2.00
2.35
2.11
1.24
0.95
2.06
2.05
1.00
3.26
4.33
3.17
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

Analysis: ^{13}C NMR

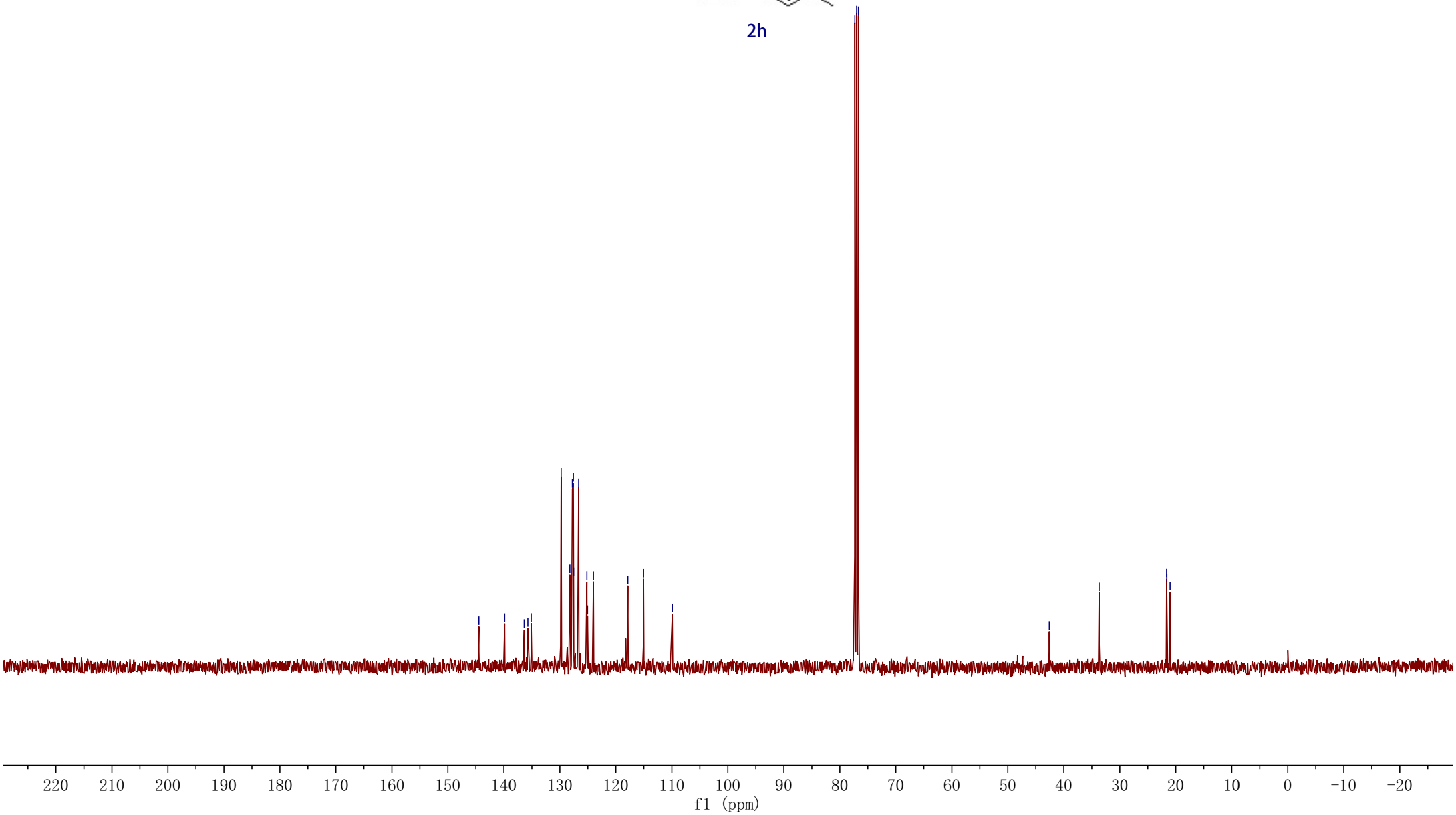
Solvent: $CDCl_3$

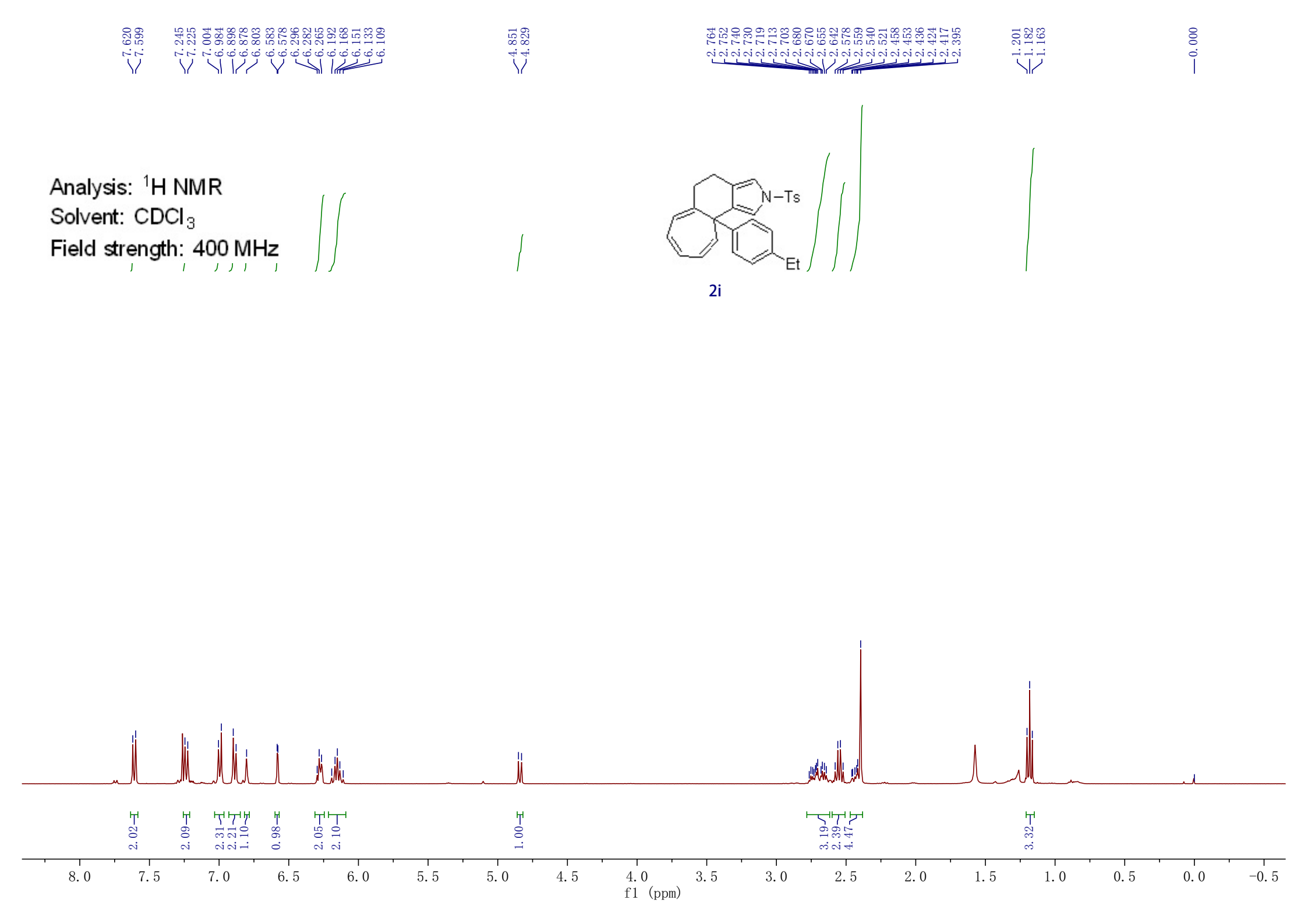
Field strength: 100 MHz

144.46
139.85
136.38
135.72
135.11
129.77
128.21
127.77
127.59
127.54
126.64
125.17
125.05
124.01
117.85
115.05
109.91
77.32
77.00
76.68
42.59
33.68
21.64
21.59
21.02



2h



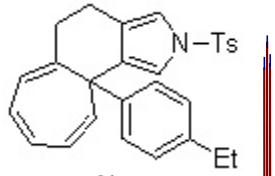

7.620
7.599
7.245
7.225
7.004
6.984
6.898
6.878
6.803
6.583
6.578
6.296
6.282
6.265
6.192
6.168
6.151
6.133
6.109
4.851
4.829
2.764
2.752
2.740
2.730
2.719
2.713
2.703
2.680
2.670
2.655
2.642
2.578
2.559
2.540
2.521
2.458
2.453
2.436
2.424
2.417
2.395
1.201
1.182
1.163
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
N–Ts
Et
2i
2.02
2.09
2.31
2.21
1.10
0.98
2.05
2.10
1.00
3.19
2.39
4.47
3.32
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

Analysis: ^{13}C NMR

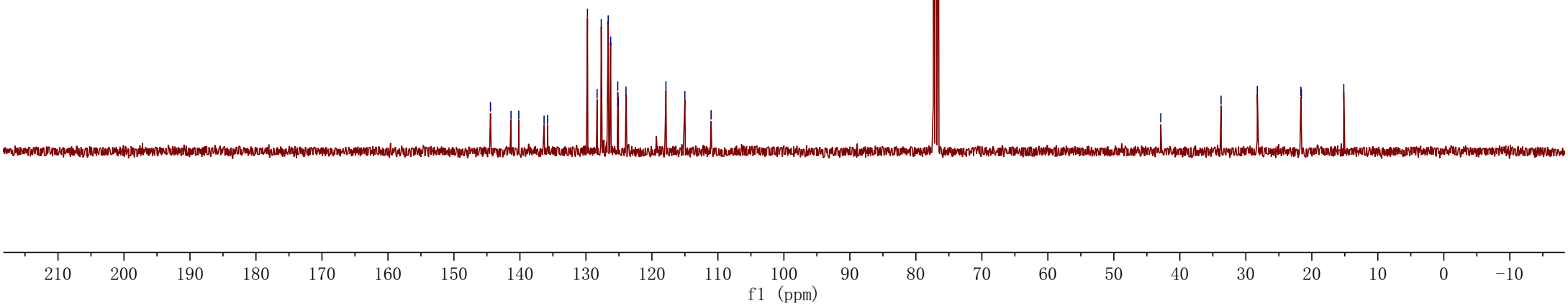
Solvent: $CDCl_3$

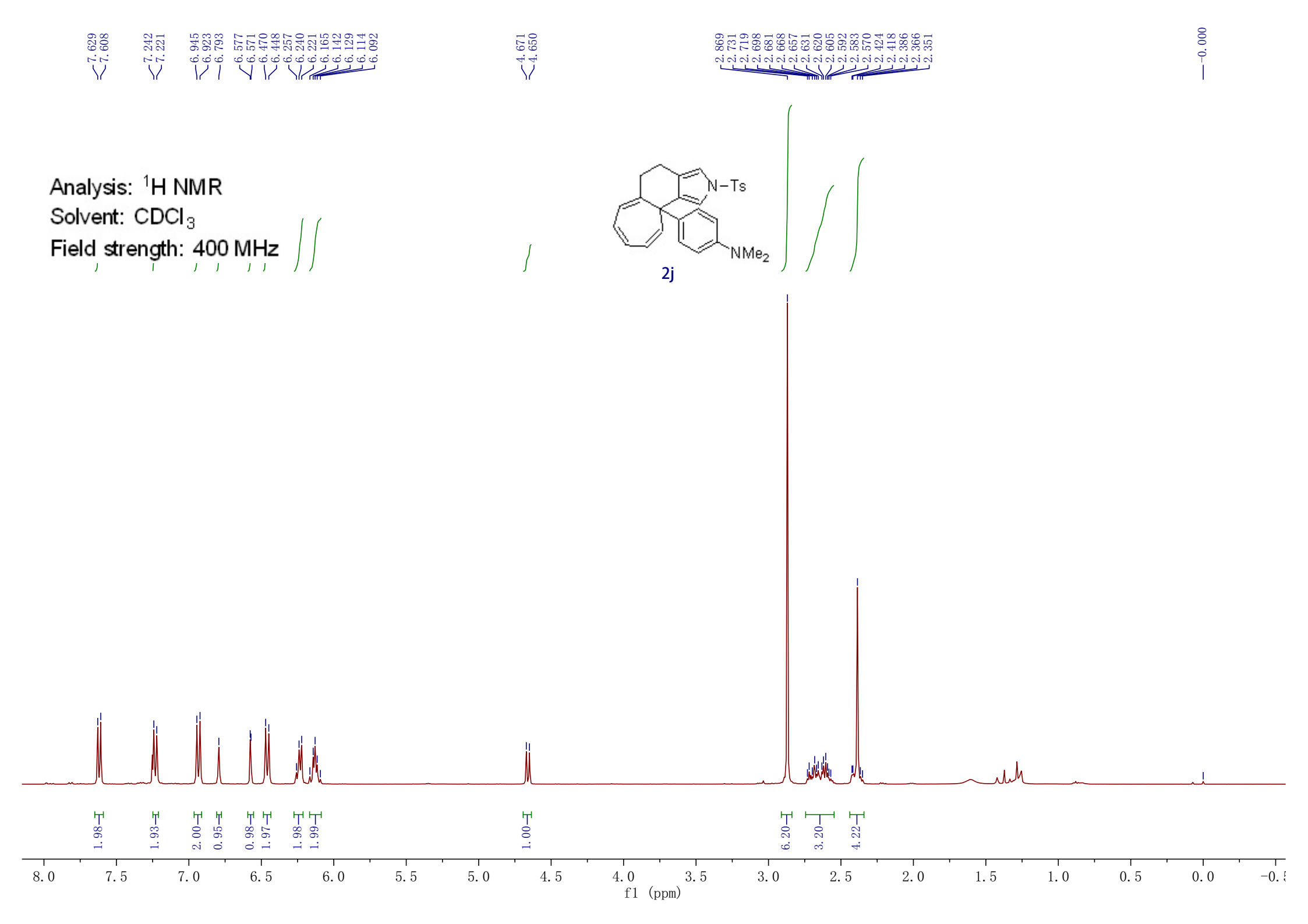
Field strength: 100 MHz

144.46
141.35
140.17
136.34
135.81
129.77
128.31
127.68
127.61
126.62
126.26
125.17
125.12
123.93
117.87
115.01
111.03
77.32
77.00
76.68
42.89
33.75
28.26
21.66
21.58
15.16



2i



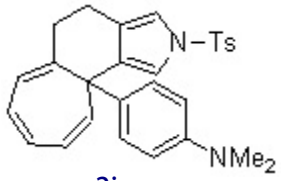

7.629
7.608
7.242
7.221
6.945
6.923
6.793
6.577
6.571
6.470
6.448
6.257
6.240
6.221
6.165
6.142
6.129
6.114
6.092
4.671
4.650
2.869
2.731
2.719
2.698
2.681
2.668
2.657
2.631
2.620
2.605
2.592
2.583
2.570
2.424
2.418
2.386
2.366
2.351
-0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
N-Ts
NMe2
2j
1.98
1.93
2.00
0.95
0.98
1.97
1.98
1.99
1.00
6.20
3.20
4.22
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

148.43
144.38
136.40
136.17
130.68
129.76
128.72
127.91
127.23
126.64
125.01
124.09
117.73
114.98
114.54
111.15
106.40
77.32
77.00
76.68
41.05
40.56
33.46
21.58
21.47

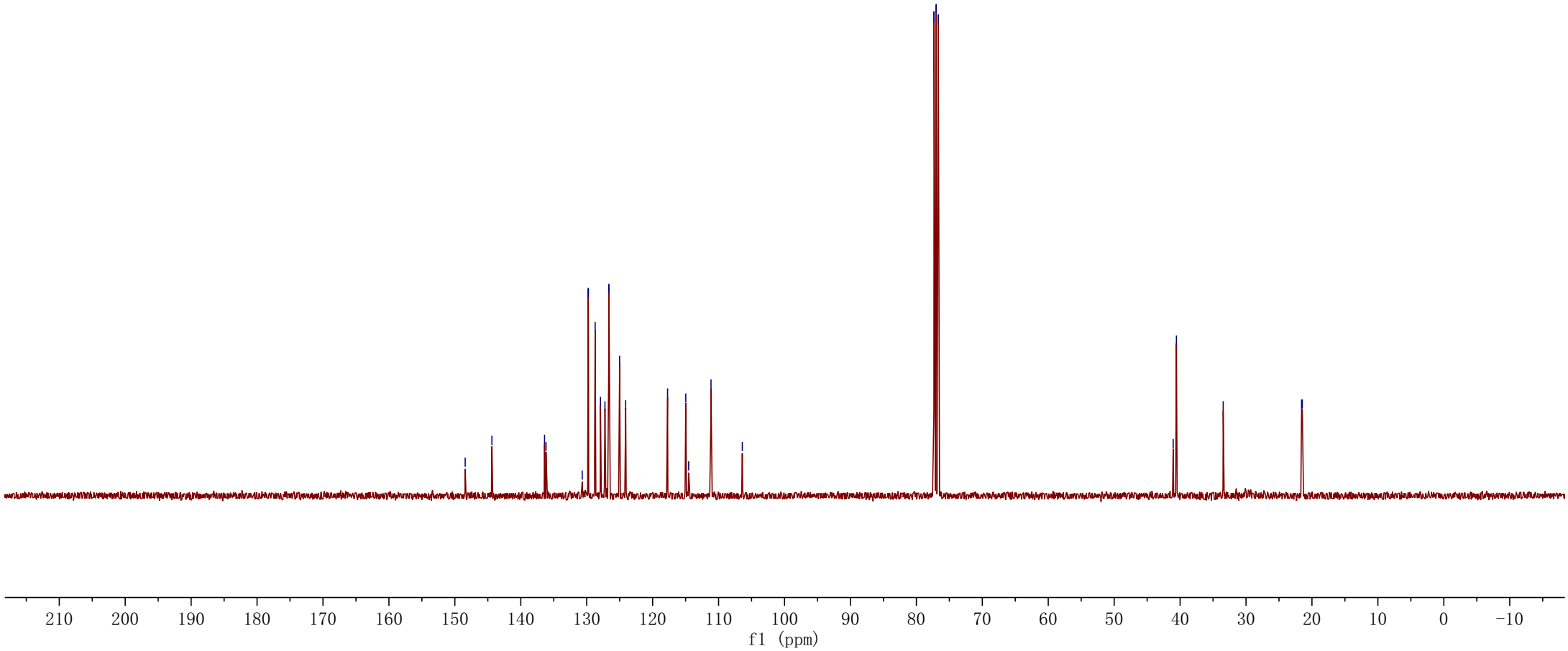
Analysis: ^{13}C NMR

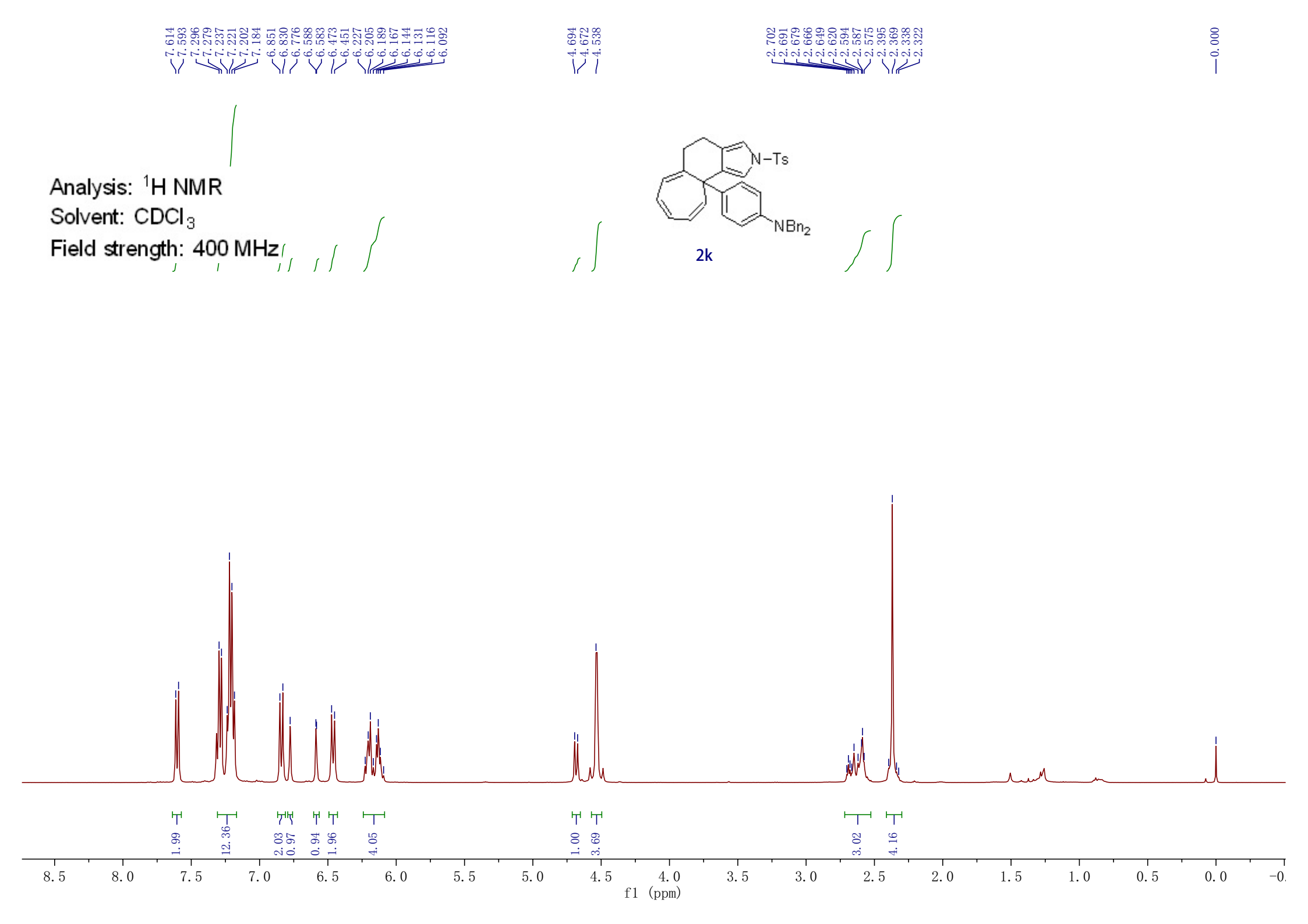
Solvent: $CDCl_3$

Field strength: 100 MHz



2j



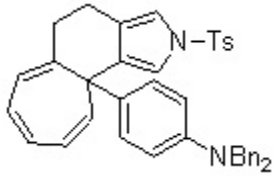

7.614
7.593
7.296
7.279
7.237
7.221
7.202
7.184
6.851
6.830
6.776
6.588
6.583
6.473
6.451
6.227
6.205
6.189
6.167
6.144
6.131
6.116
6.092
4.694
4.672
4.538
2.702
2.691
2.679
2.666
2.649
2.620
2.594
2.587
2.575
2.395
2.369
2.338
2.322
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
N-Ts
NBn2
2k
1.99
12.36
2.03
0.97
0.94
1.96
4.05
1.00
3.69
3.02
4.16
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

Analysis: ^{13}C NMR

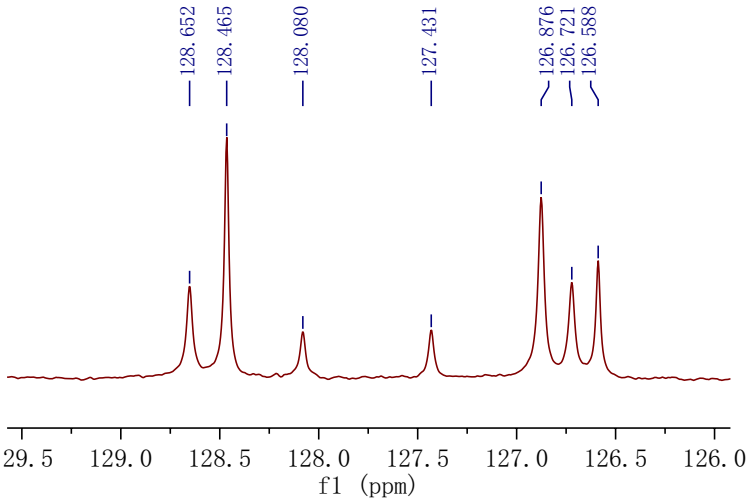
Solvent: $CDCl_3$

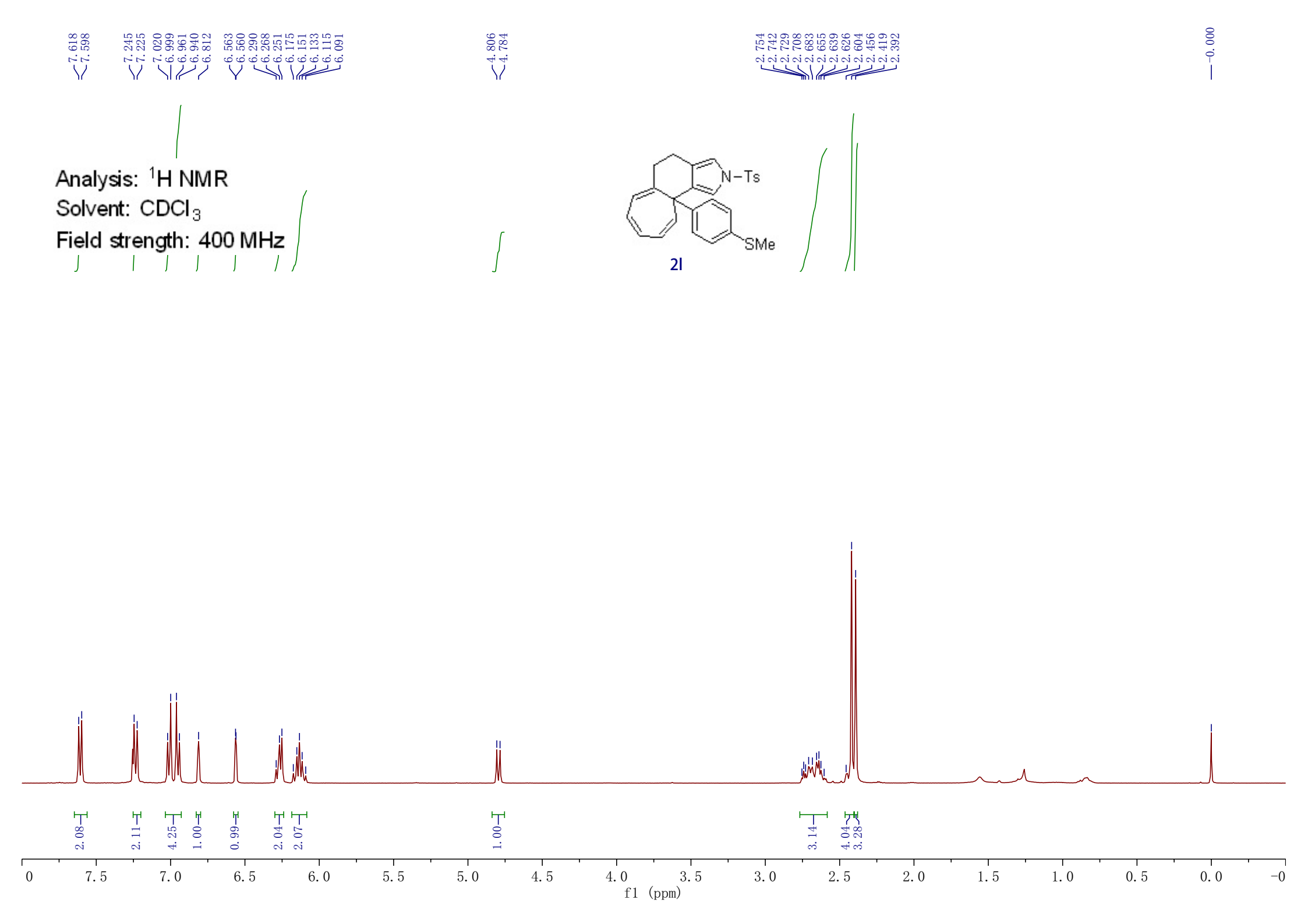
Field strength: 100 MHz

147.403
144.346
138.956
136.401
131.073
129.733
128.652
128.465
128.080
127.431
126.876
126.721
126.588
125.242
125.024
123.935
117.919
117.165
114.945
111.331
108.757
77.318
77.000
76.682
54.212
41.702
33.704
21.600



2k



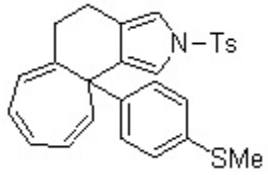

7.618
7.598
7.245
7.225
7.020
6.999
6.961
6.940
6.812
6.563
6.560
6.290
6.268
6.251
6.175
6.151
6.133
6.115
6.091
4.806
4.784
2.754
2.742
2.729
2.708
2.683
2.655
2.639
2.626
2.604
2.456
2.419
2.392
-0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
N-Ts
SMe
2l
2.08
2.11
4.25
1.00
0.99
2.04
2.07
1.00
3.14
4.04
3.28
0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0
f1 (ppm)

Analysis: ^{13}C NMR

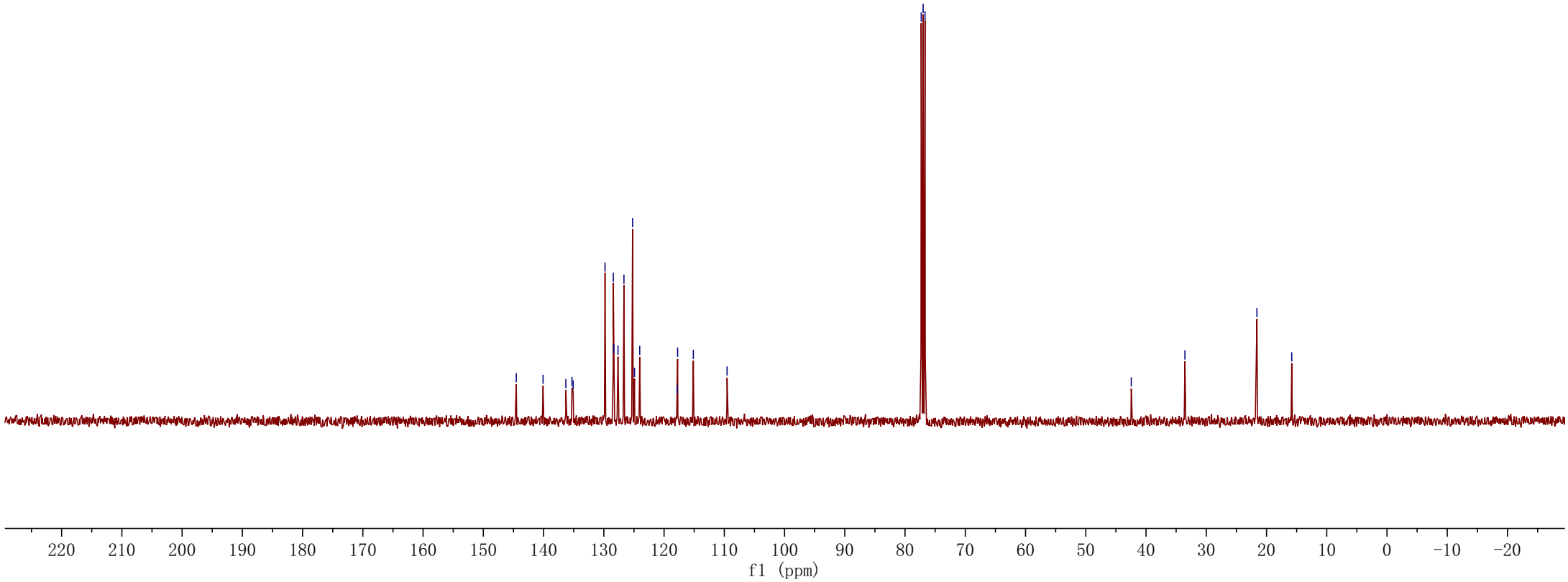
Solvent: $CDCl_3$

Field strength: 100 MHz

144.53
140.09
136.30
135.29
135.09
129.80
128.43
128.34
127.65
126.66
125.23
124.91
124.04
117.85
117.76
115.15
109.54
77.32
77.00
76.68
42.45
33.55
21.59
15.81

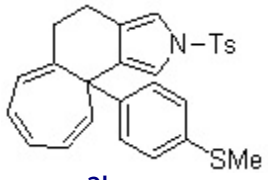


2l

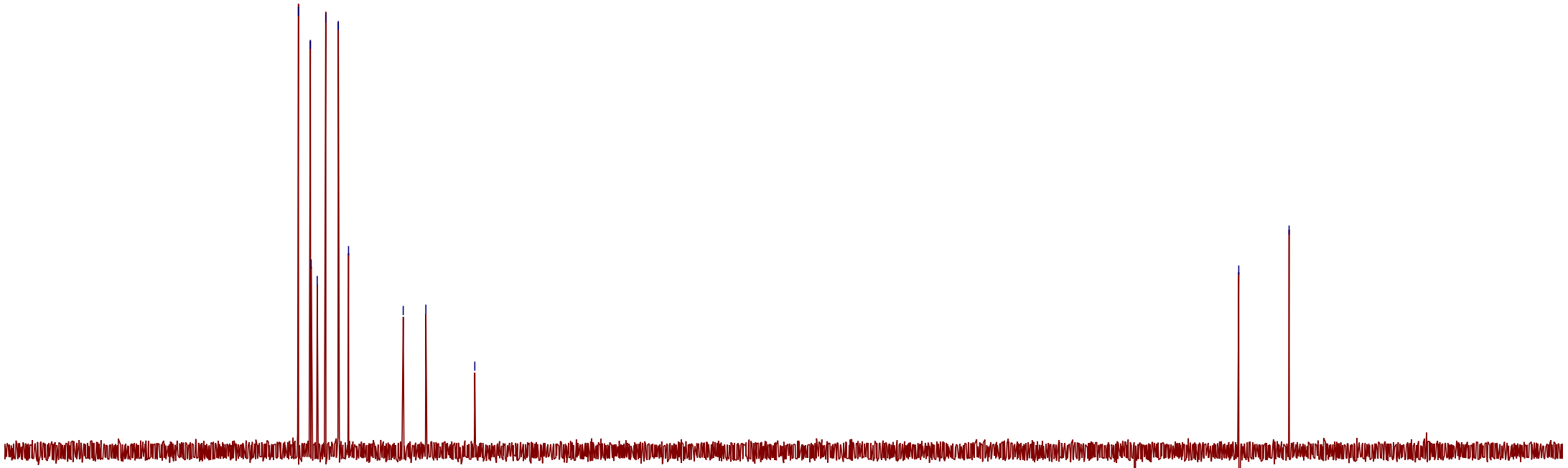


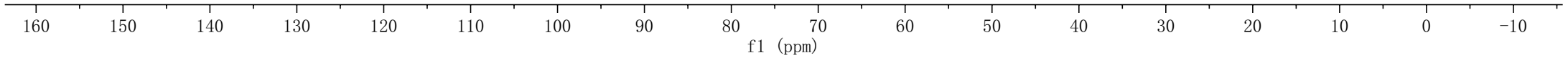
129.82
128.44
128.35
127.65
126.67
125.22
124.05
117.76
115.15
109.52
33.55
21.61
21.59
15.81

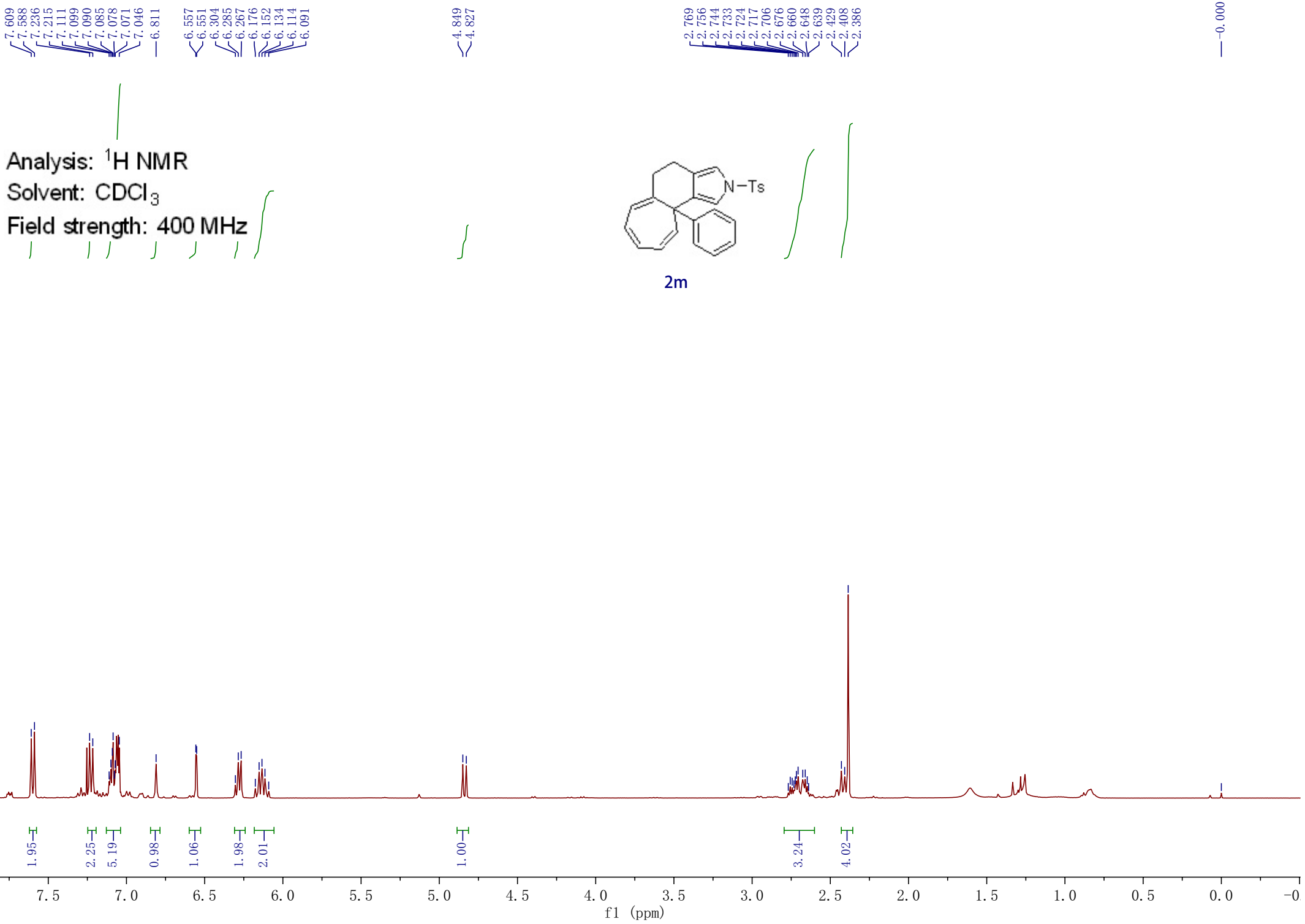
Analysis: ^{13}C NMR DEPT135
Solvent: $CDCl_3$
Field strength: 100 MHz



2l





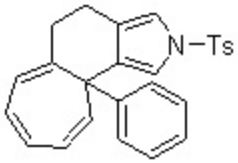

7.609
7.588
7.236
7.215
7.111
7.099
7.090
7.085
7.078
7.071
7.046
6.811
6.557
6.551
6.304
6.285
6.267
6.176
6.152
6.134
6.114
6.091
4.849
4.827
2.769
2.756
2.744
2.733
2.724
2.717
2.706
2.676
2.660
2.648
2.639
2.429
2.408
2.386
-0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
N-Ts
2m
1.95
2.25
5.19
0.98
1.06
1.98
2.01
1.00
3.24
4.02
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0
f1 (ppm)

Analysis: ^{13}C NMR

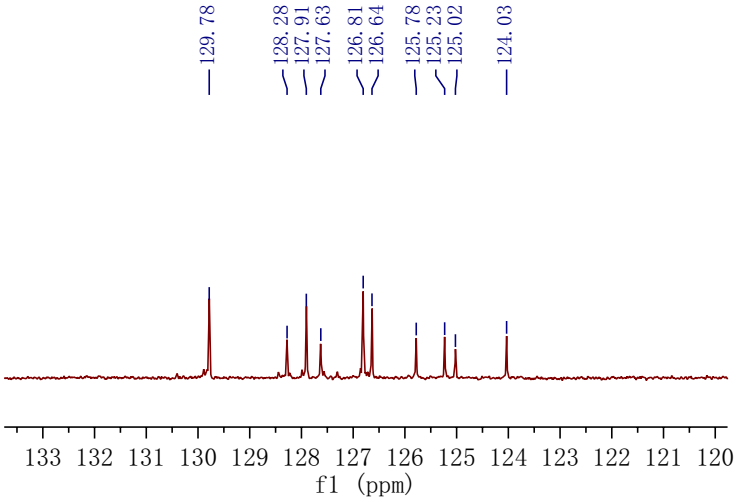
Solvent: $CDCl_3$

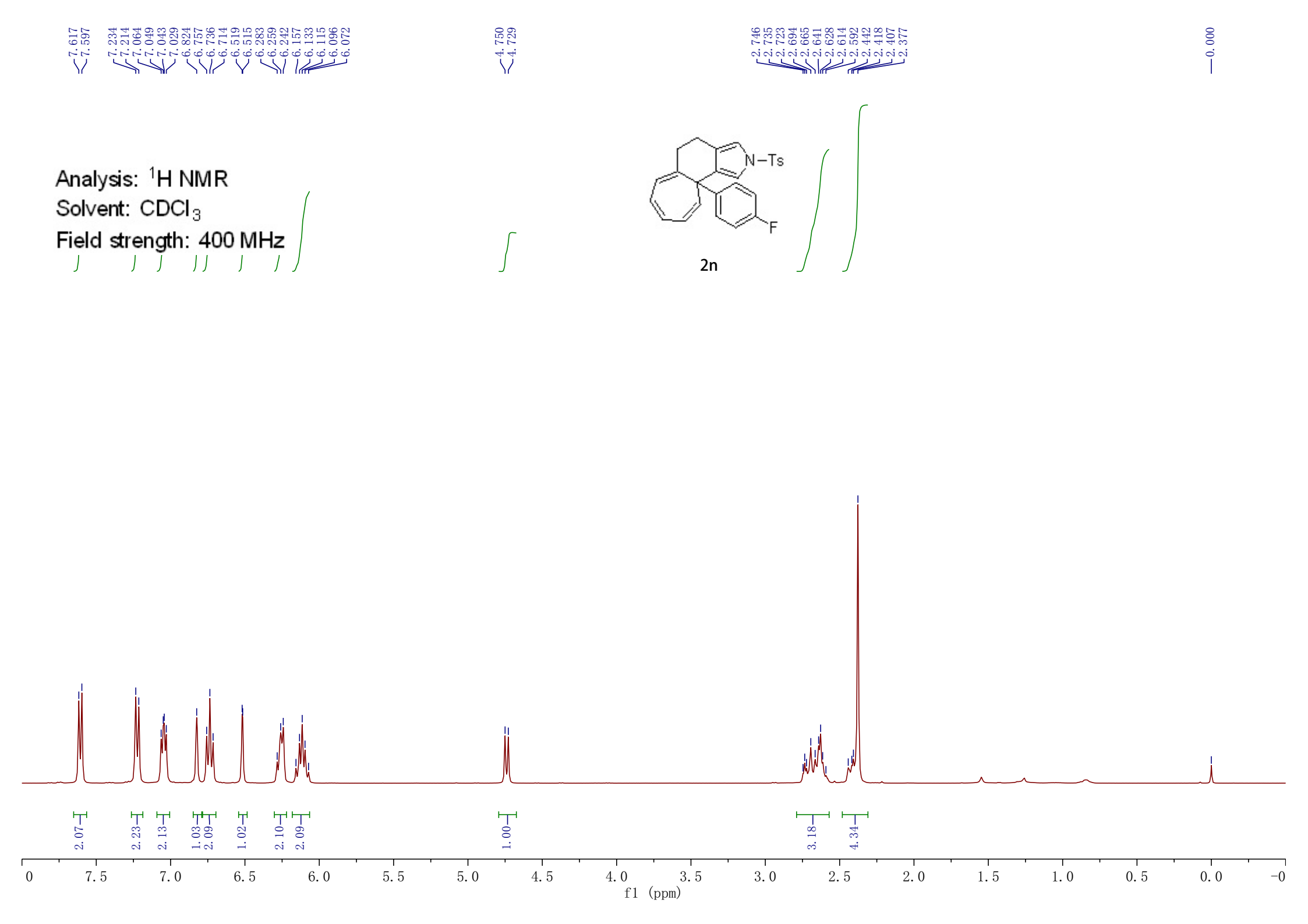
Field strength: 100 MHz

144.50
143.02
136.30
135.47
129.78
128.28
127.91
127.63
126.81
126.64
125.78
125.23
125.02
124.03
118.75
117.88
115.09
110.39
77.32
77.00
76.68
43.06
33.66
21.64
21.58



2m



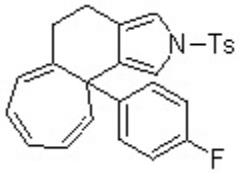

7.617
7.597
7.234
7.214
7.064
7.049
7.043
7.029
6.824
6.757
6.736
6.714
6.519
6.515
6.283
6.259
6.242
6.157
6.133
6.115
6.096
6.072
4.750
4.729
2.746
2.735
2.723
2.694
2.665
2.641
2.628
2.614
2.592
2.442
2.418
2.407
2.377
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
N–Ts
F
2n
2.07
2.23
2.13
1.03
2.09
1.02
2.10
2.09
1.00
3.18
4.34
0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0
f1 (ppm)

Analysis: ^{13}C NMR

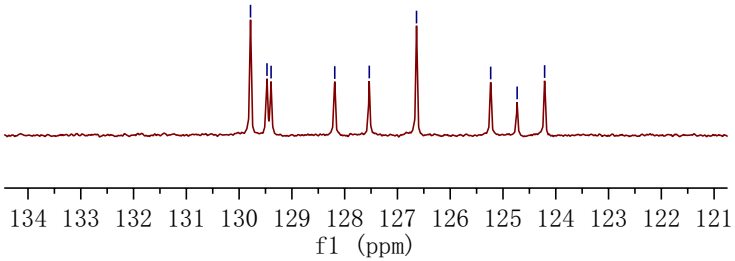
Solvent: $CDCl_3$

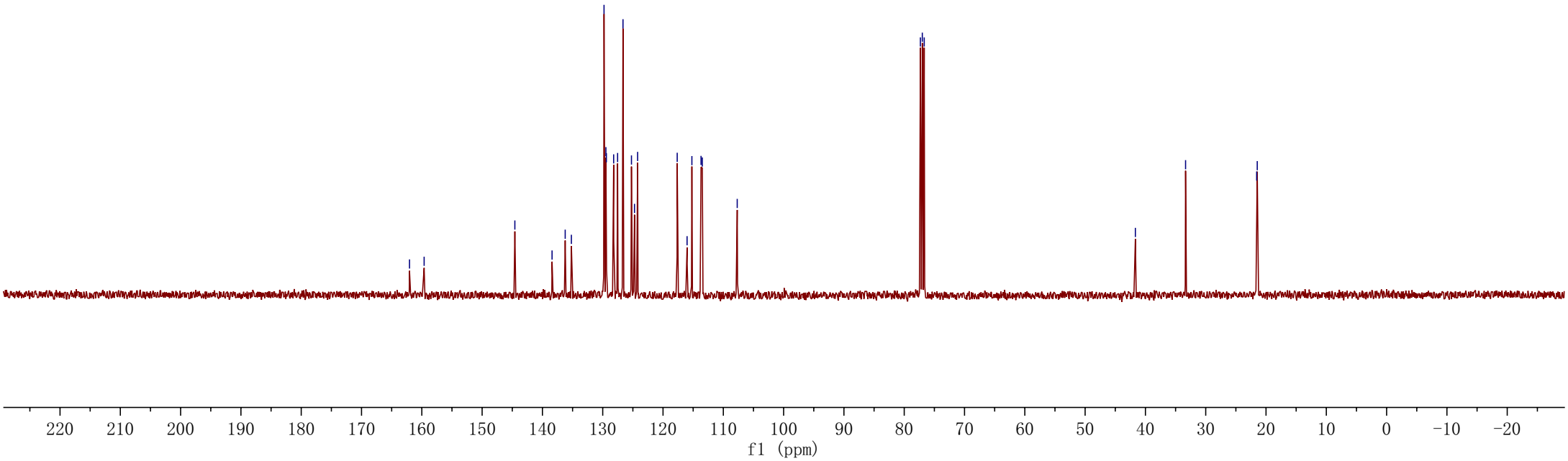
Field strength: 100 MHz

162.04
159.62
144.57
138.40
136.22
135.20
129.78
129.47
129.39
128.19
127.53
126.64
125.23
124.73
124.21
117.65
116.01
115.21
113.69
113.48
107.70
77.32
77.00
76.68
41.67
33.34
21.55
21.46

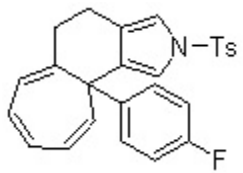


2n

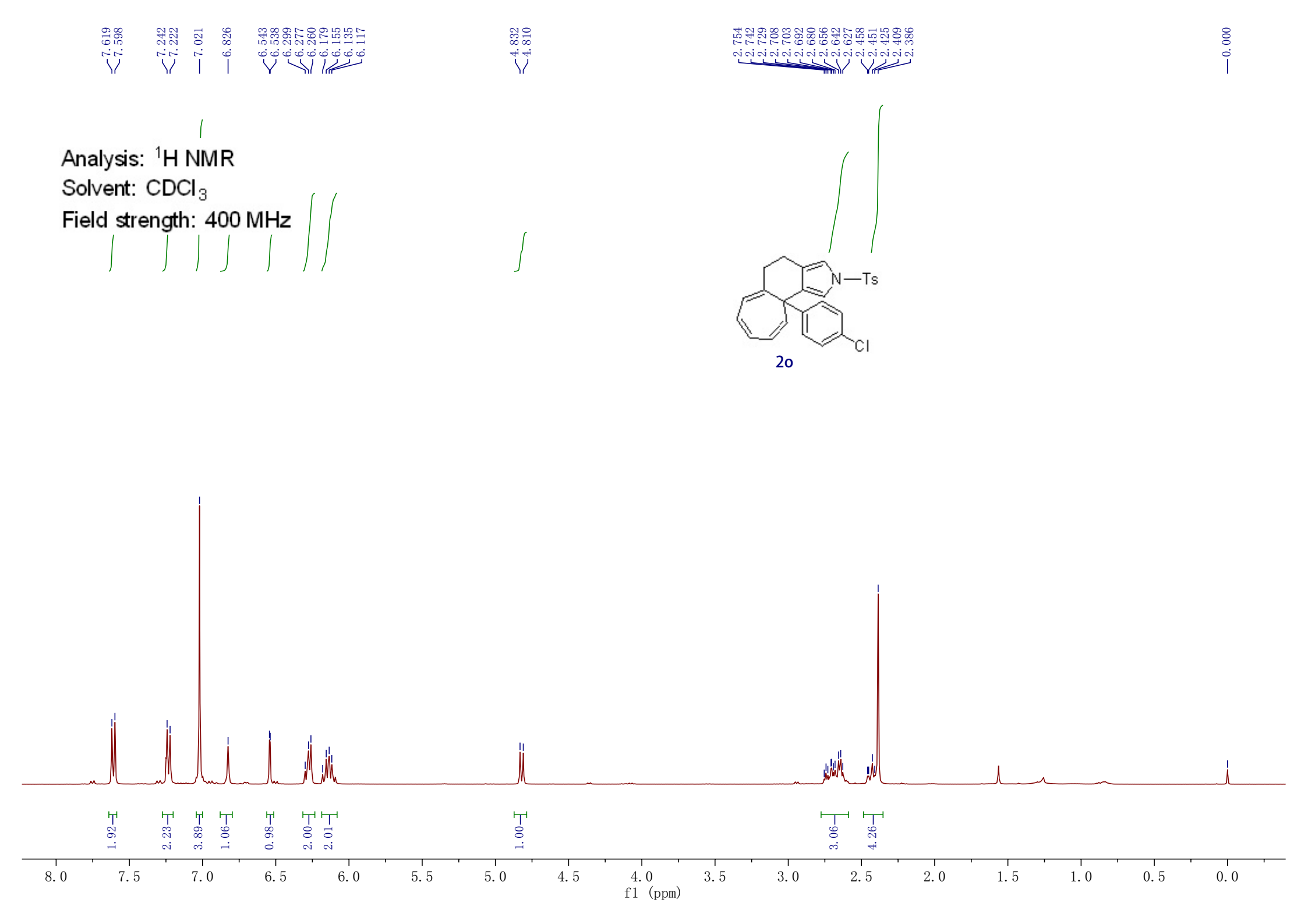




Analysis: ^{13}F NMR
Solvent: $CDCl_3$
Field strength: 471 MHz



2n

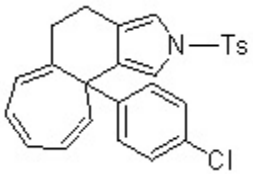

7.619
7.598
7.242
7.222
7.021
6.826
6.543
6.538
6.299
6.277
6.260
6.179
6.155
6.135
6.117
4.832
4.810
2.754
2.742
2.729
2.708
2.703
2.692
2.680
2.656
2.642
2.627
2.458
2.451
2.425
2.409
2.386
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
N—Ts
Cl
2o
1.92
2.23
3.89
1.06
0.98
2.00
2.01
1.00
3.06
4.26
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

Analysis: ^{13}C NMR

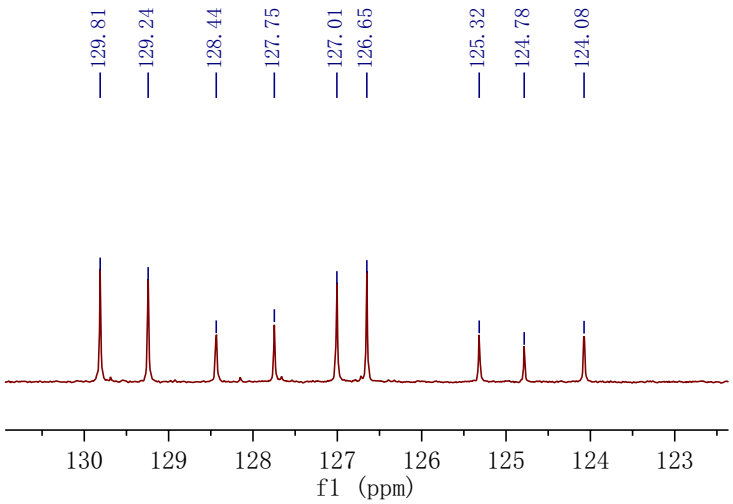
Solvent: $CDCl_3$

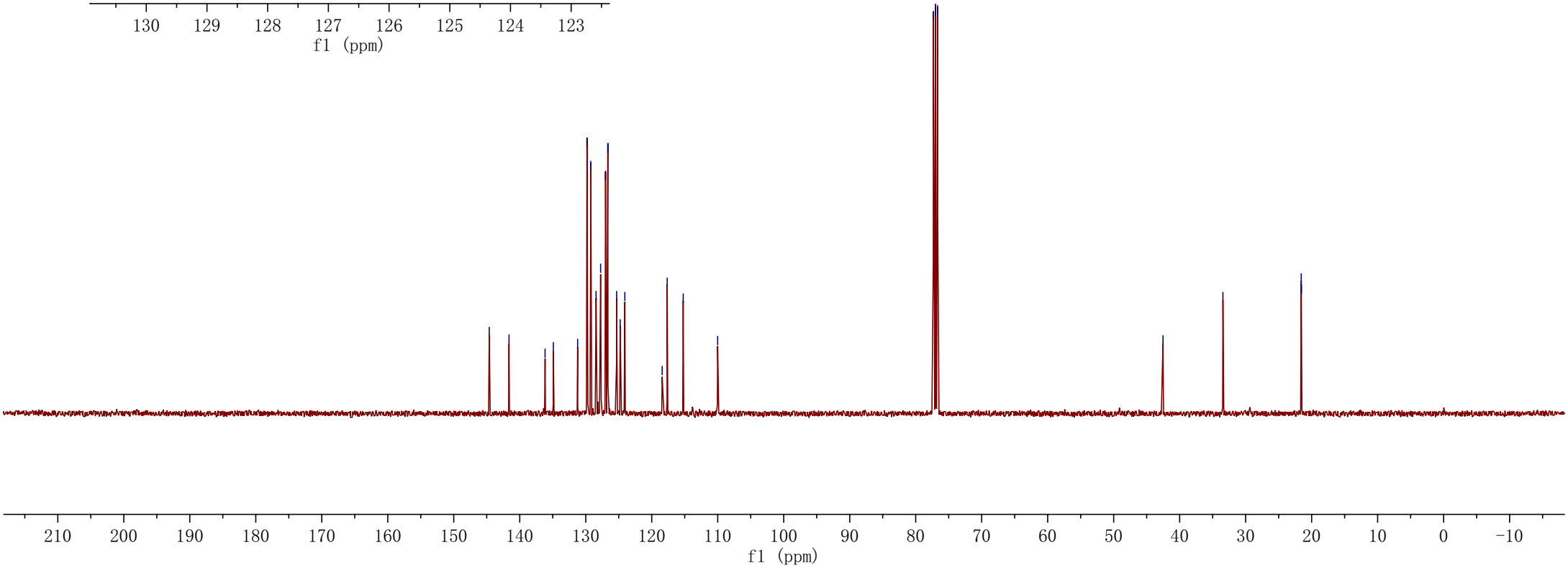
Field strength: 100 MHz

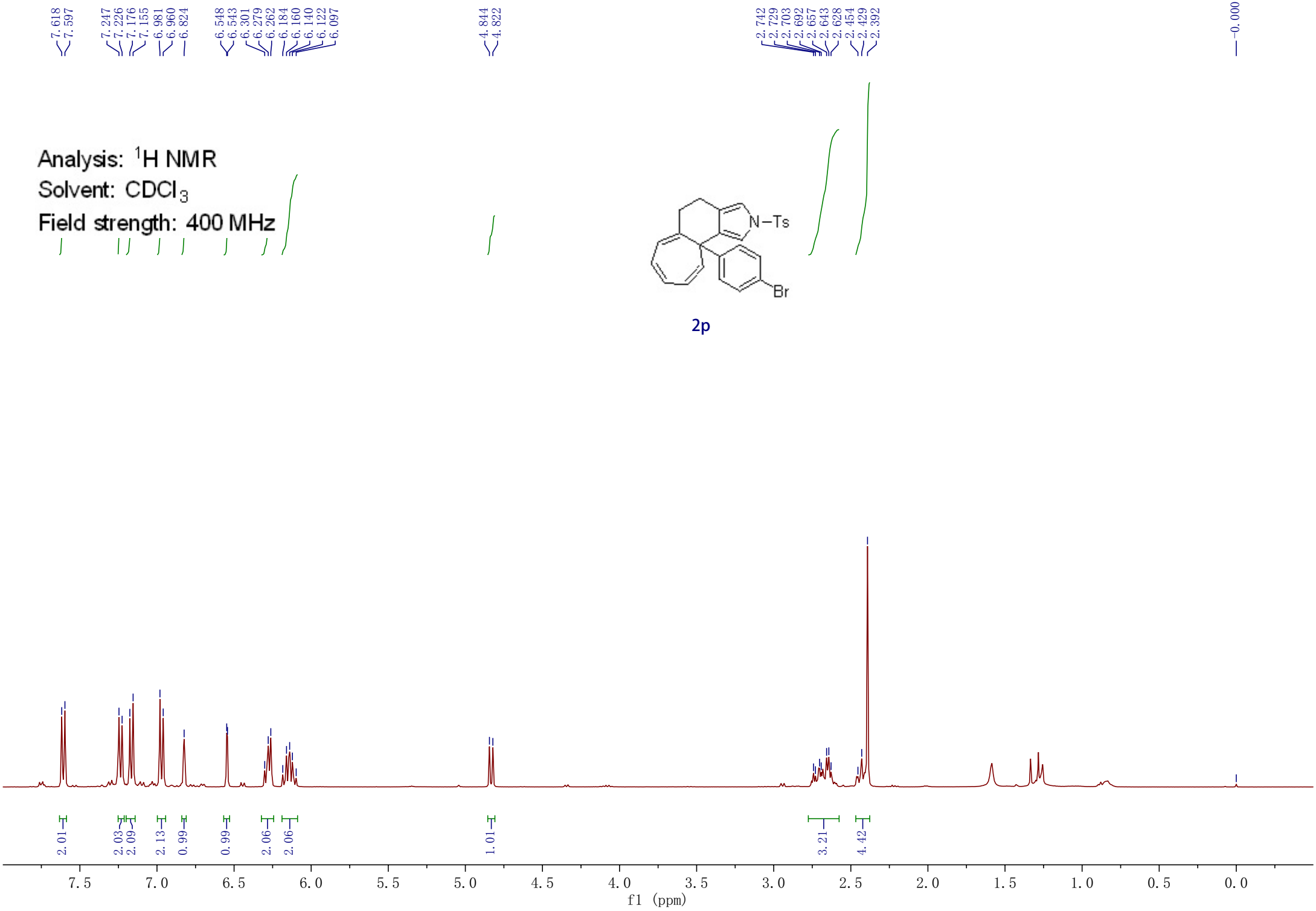
144.62
141.63
136.16
134.91
131.23
129.81
129.24
128.44
127.75
127.01
126.65
125.32
124.78
124.08
118.41
117.66
115.23
110.01
77.32
77.00
76.68
42.53
33.44
21.58
21.54



2o






7.618
7.597
7.247
7.226
7.176
7.155
6.981
6.960
6.824
6.548
6.543
6.301
6.279
6.262
6.184
6.160
6.140
6.122
6.097
4.844
4.822
2.742
2.729
2.703
2.692
2.657
2.643
2.628
2.454
2.429
2.392
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
N–Ts
Br
2p
2.01
2.03
2.09
2.13
0.99
0.99
2.06
2.06
1.01
3.21
4.42
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

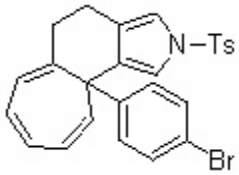
Analysis: ^{13}C NMR

Solvent: $CDCl_3$

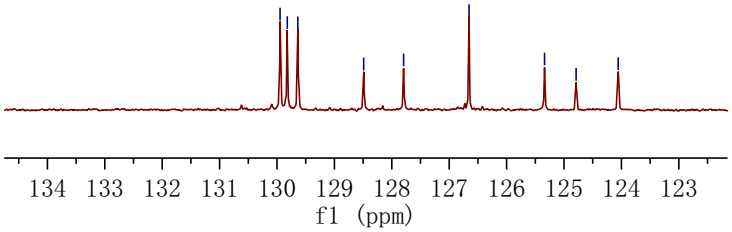
Field strength: 100 MHz

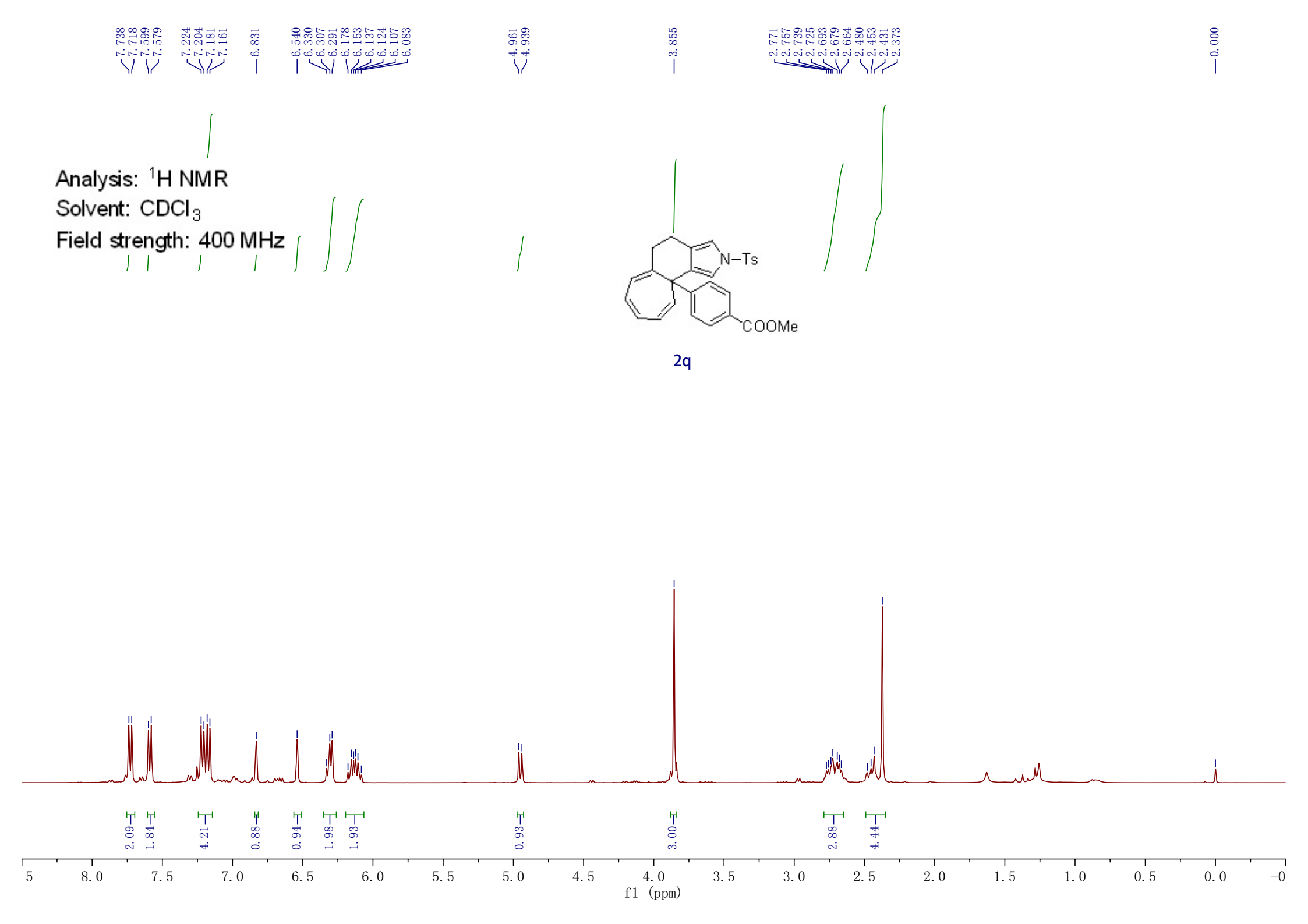
144.63 142.25 136.17 134.83 129.95 129.82 129.64 128.49 127.79 126.65 125.34 124.79 124.06 119.41 118.75 117.68 115.24 110.35 77.32 77.00 76.68 42.72 33.46 21.59 21.55

129.95 129.82 129.64 128.49 127.79 126.65 125.34 124.79 124.06



2p



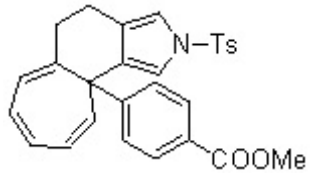

7.738
7.718
7.599
7.579
7.224
7.204
7.181
7.161
6.831
6.540
6.330
6.307
6.291
6.178
6.153
6.137
6.124
6.107
6.083
4.961
4.939
3.855
2.771
2.757
2.739
2.725
2.693
2.679
2.664
2.480
2.453
2.431
2.373
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
N–Ts
COOMe
2q
2.09
1.84
4.21
0.88
0.94
1.98
1.93
0.93
3.00
2.88
4.44
f1 (ppm)

Analysis: ^{13}C NMR

Solvent: $CDCl_3$

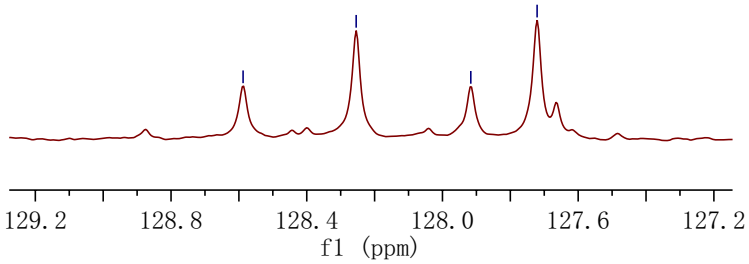
Field strength: 100 MHz

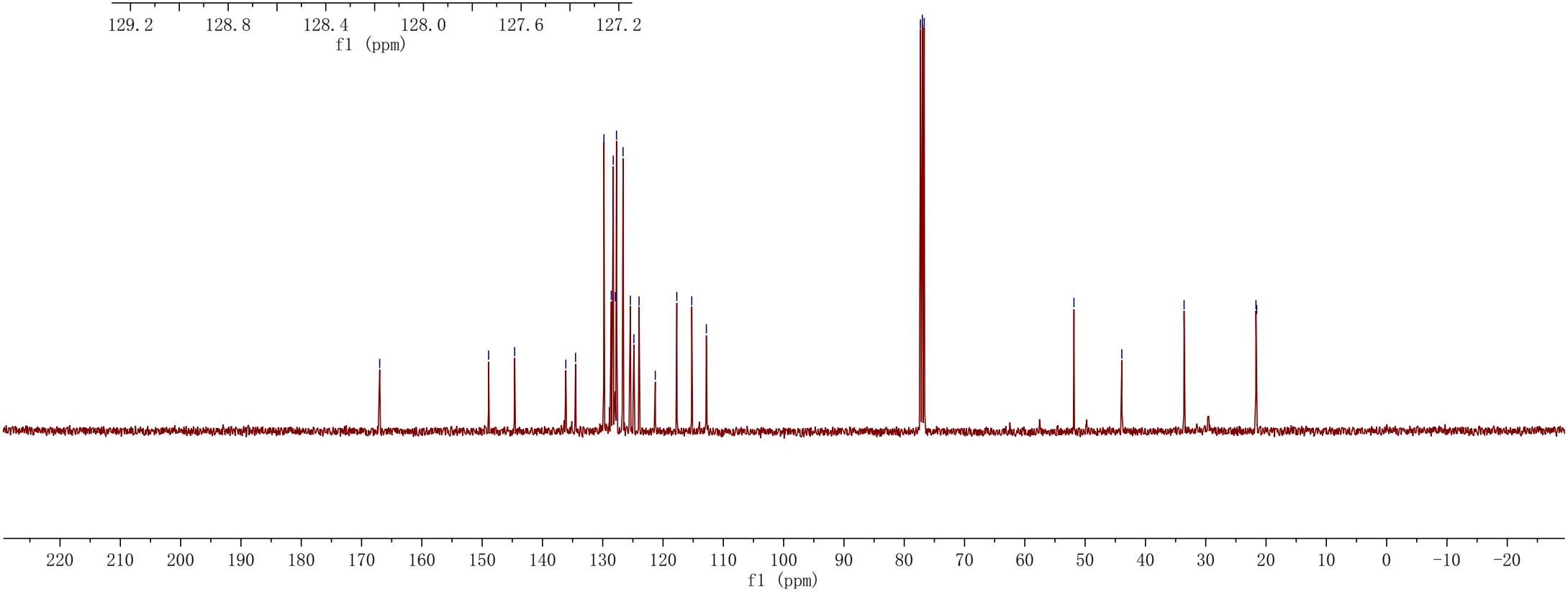
166.99 148.93 144.61 136.12 134.51 129.80 128.59 128.25 127.92 127.72 126.63 125.42 124.83 123.98 121.29 117.72 115.24 112.82 77.32 77.00 76.68 51.86 43.92 33.59 21.67 21.55

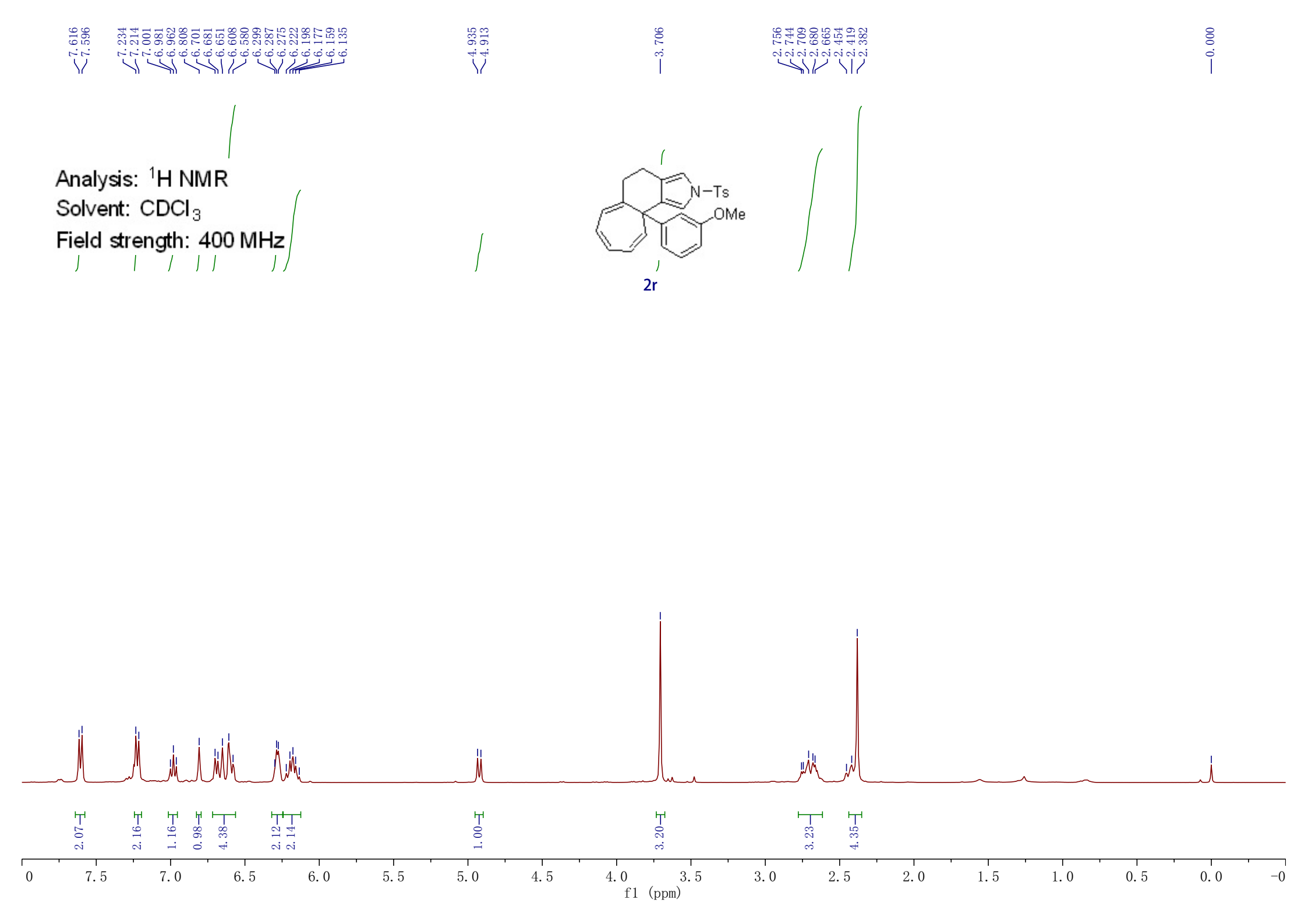


2q

128.59 128.25 127.92 127.72





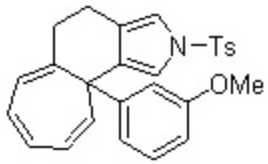

7.616
7.596
7.234
7.214
7.001
6.981
6.962
6.808
6.701
6.681
6.651
6.608
6.580
6.299
6.287
6.275
6.222
6.198
6.177
6.159
6.135
4.935
4.913
3.706
2.756
2.744
2.709
2.680
2.665
2.454
2.419
2.382
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
N−Ts
OMe
2r
2.07
2.16
1.16
0.98
4.38
2.12
2.14
1.00
3.20
3.23
4.35
0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0
f1 (ppm)

Analysis: ^{13}C NMR

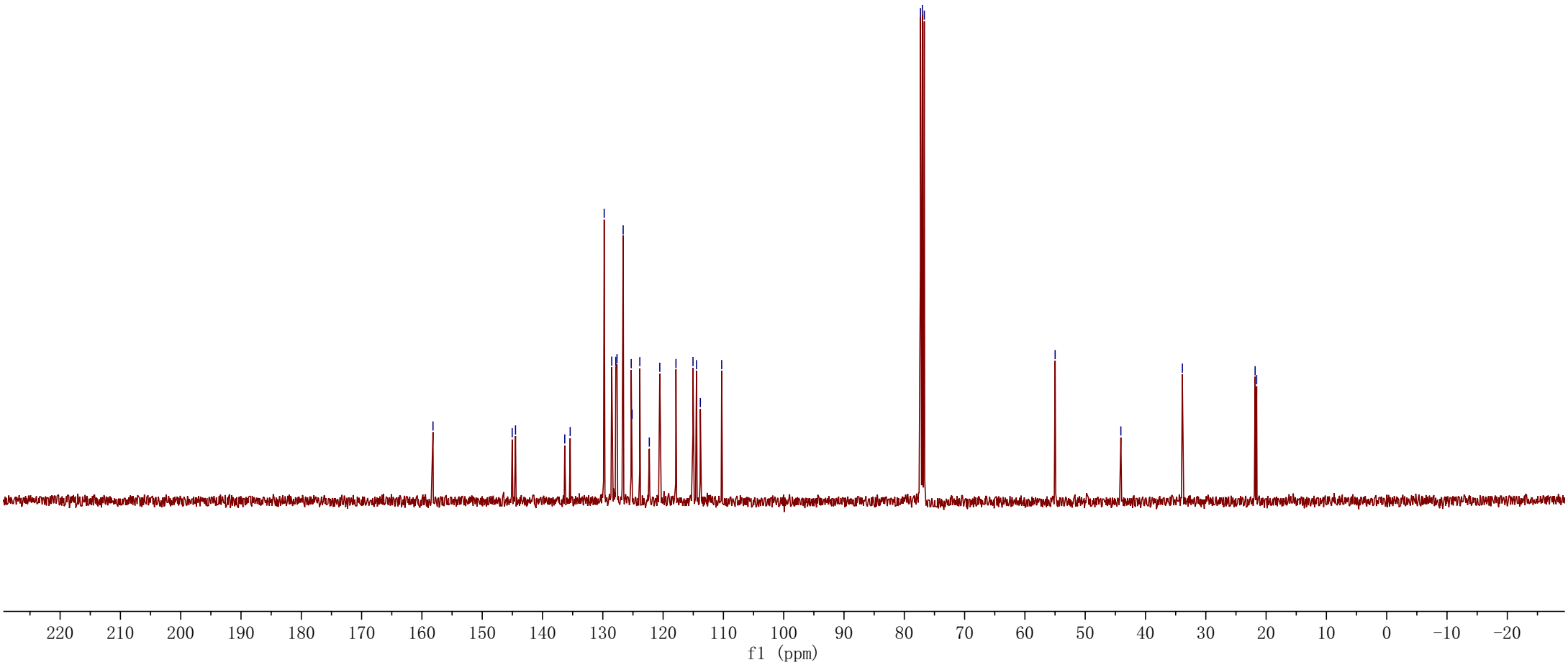
Solvent: $CDCl_3$

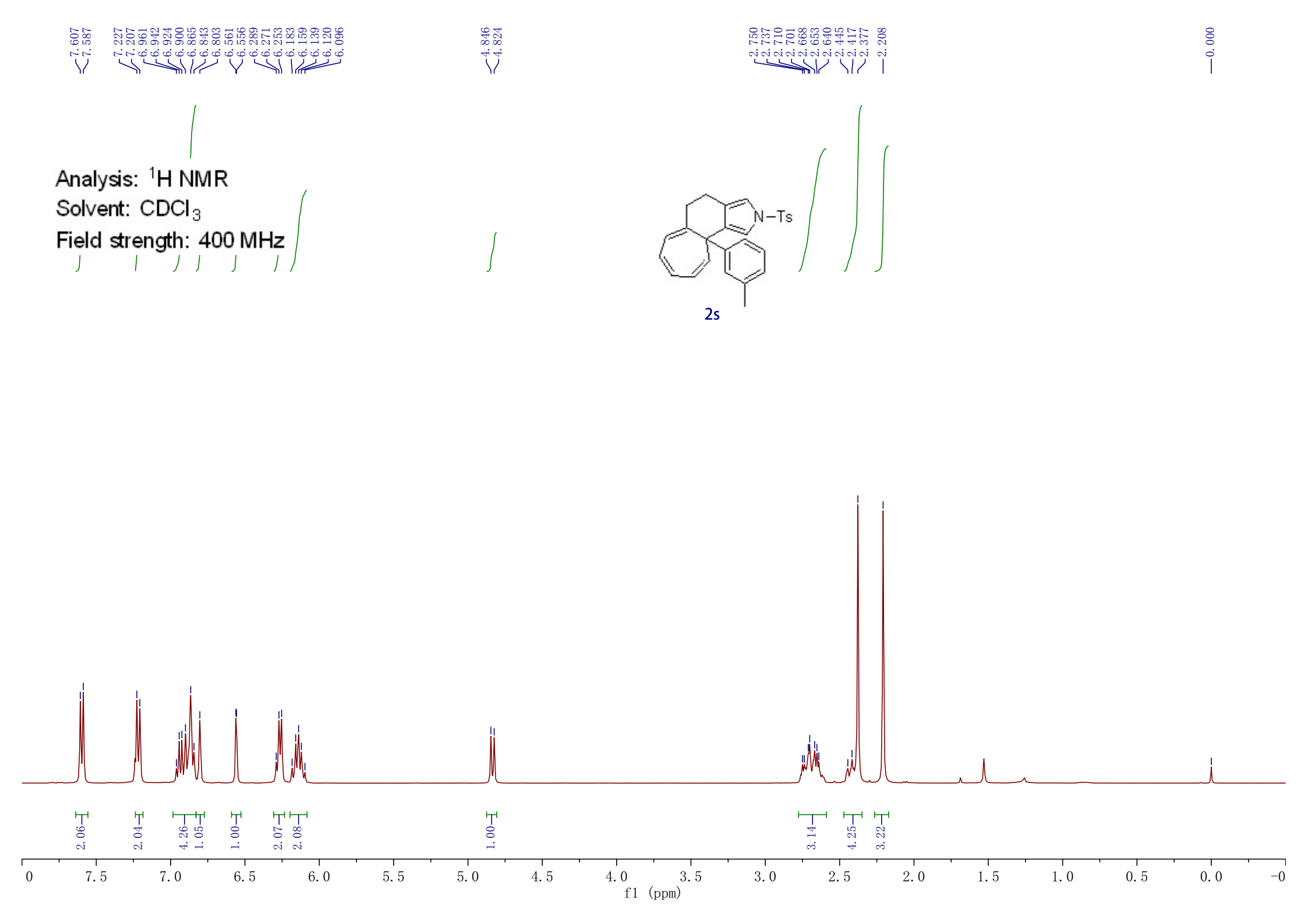
Field strength: 100 MHz

158.16
145.03
144.48
136.31
135.41
129.77
128.52
127.84
127.65
126.63
125.29
125.14
123.86
122.29
120.55
117.87
115.04
114.46
113.82
110.28
77.32
77.00
76.68
54.99
44.09
33.89
21.82
21.57



2r



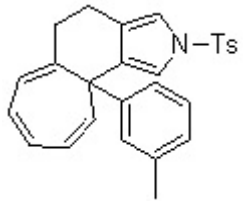

7.607
7.587
7.227
7.207
6.961
6.942
6.924
6.900
6.865
6.843
6.803
6.561
6.556
6.289
6.271
6.253
6.183
6.159
6.139
6.120
6.096
4.846
4.824
2.750
2.737
2.710
2.701
2.668
2.653
2.640
2.445
2.417
2.377
2.208
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
N–Ts
2s
2.06
2.04
4.26
1.05
1.00
2.07
2.08
1.00
3.14
4.25
3.22
0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0
f1 (ppm)

Analysis: ^{13}C NMR

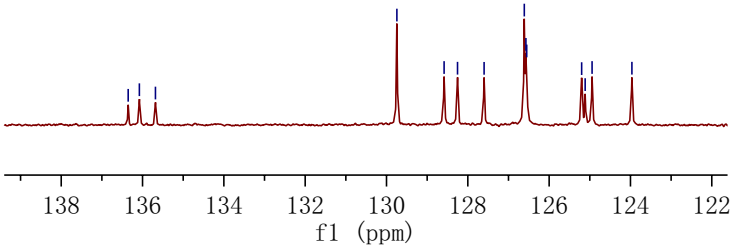
Solvent: $CDCl_3$

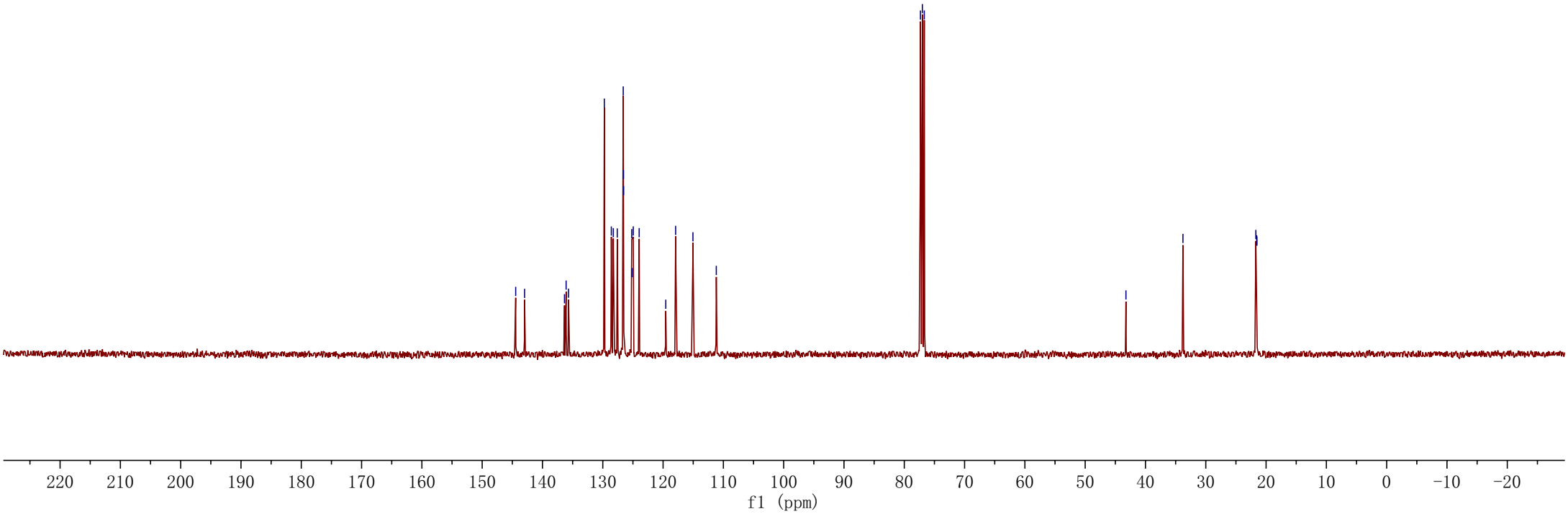
Field strength: 100 MHz

144.45
142.97
136.35
136.08
135.68
129.74
128.58
128.25
127.60
126.61
126.57
126.55
125.20
125.11
124.94
123.96
119.55
117.92
115.05
111.17
77.32
77.00
76.68
43.24
33.79
21.70
21.56
21.52



2s

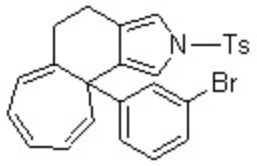




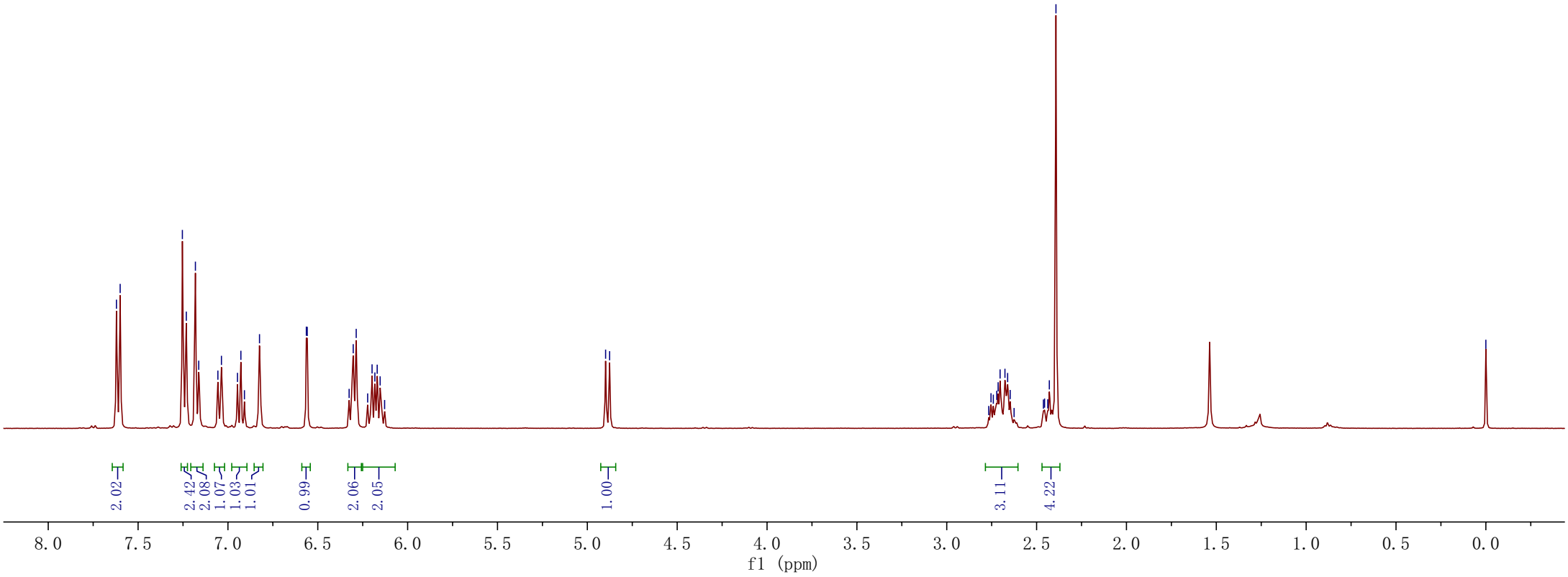
Analysis: ^{1}H NMR

Solvent: $CDCl_3$

Field strength: 400 MHz



2t



Analysis: ^{13}C NMR

Solvent: $CDCl_3$

Field strength: 100 MHz

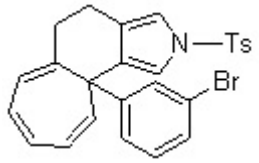
145.75
144.63
136.19
134.87
130.77
129.84
128.94
128.67
128.41
127.98
126.67
126.44
125.49
124.96
124.08
121.06
120.95
117.85
115.27
112.46

77.32
77.00
76.68

43.57

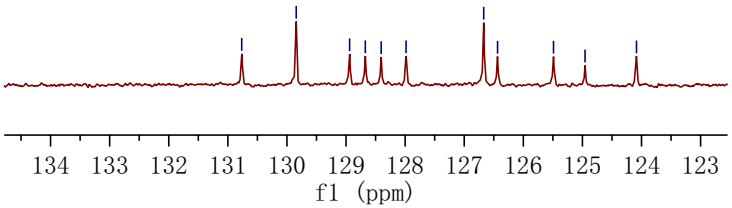
33.67

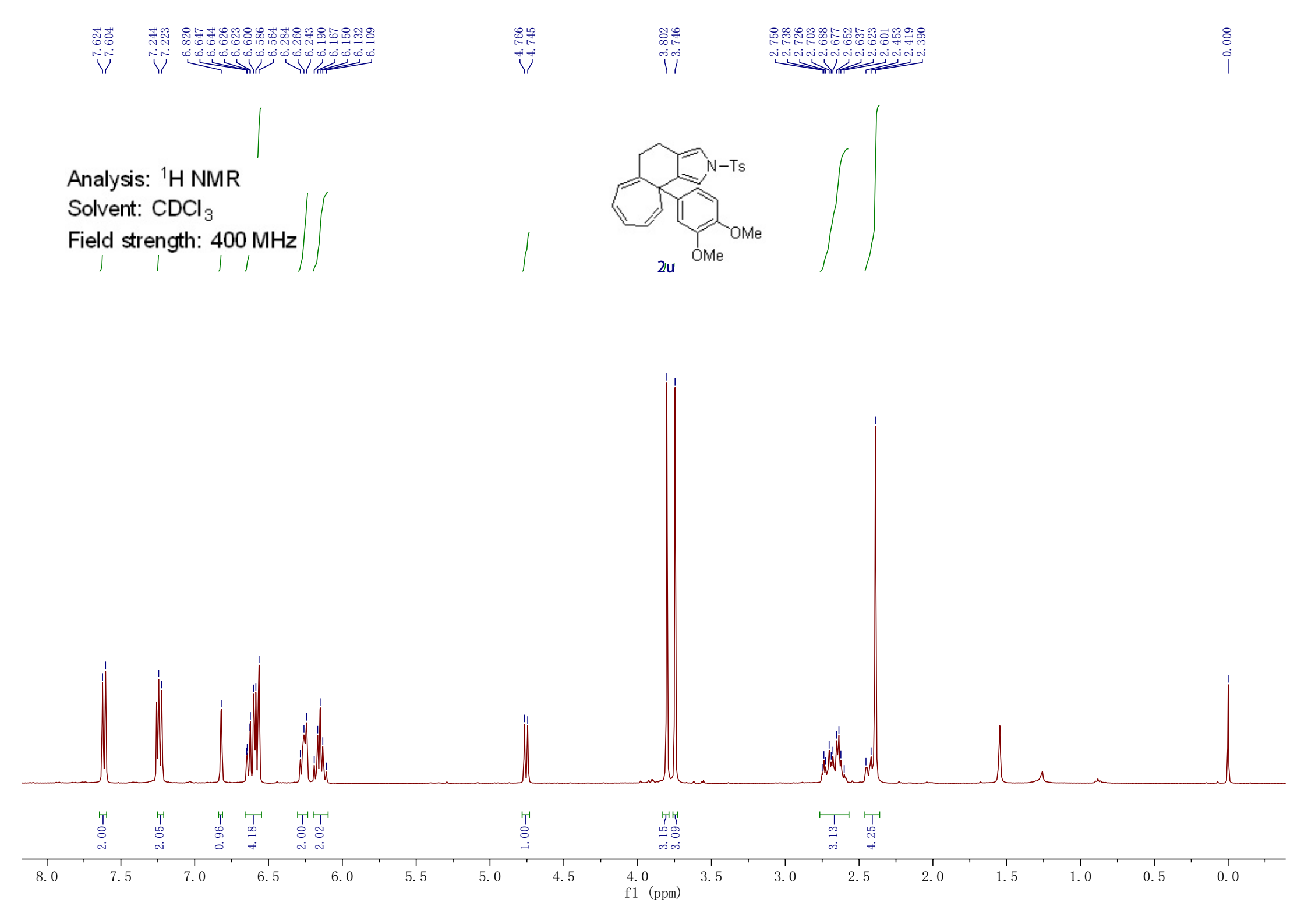
21.70
21.60



2t

130.77
129.84
128.94
128.67
128.41
127.98
126.67
126.44
125.49
124.96
124.08



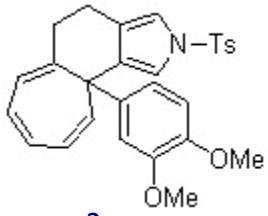

7.624
7.604
7.244
7.223
6.820
6.647
6.644
6.626
6.623
6.600
6.586
6.564
6.284
6.260
6.243
6.190
6.167
6.150
6.132
6.109
4.766
4.745
3.802
3.746
2.750
2.738
2.726
2.703
2.688
2.677
2.652
2.637
2.623
2.601
2.453
2.419
2.390
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
N–Ts
OMe
OMe
2u
2.00
2.05
0.96
4.18
2.00
2.02
1.00
3.15
3.09
3.13
4.25
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

Analysis: ^{13}C NMR

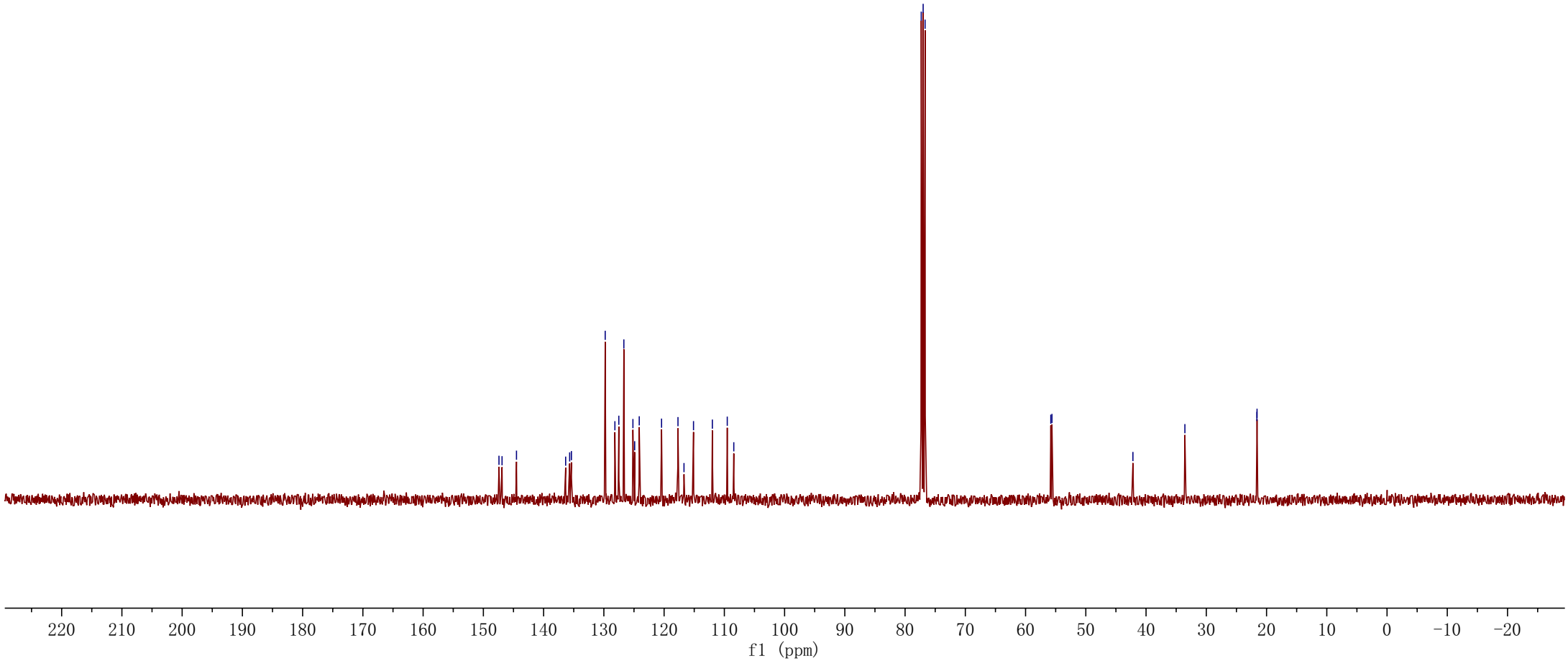
Solvent: $CDCl_3$

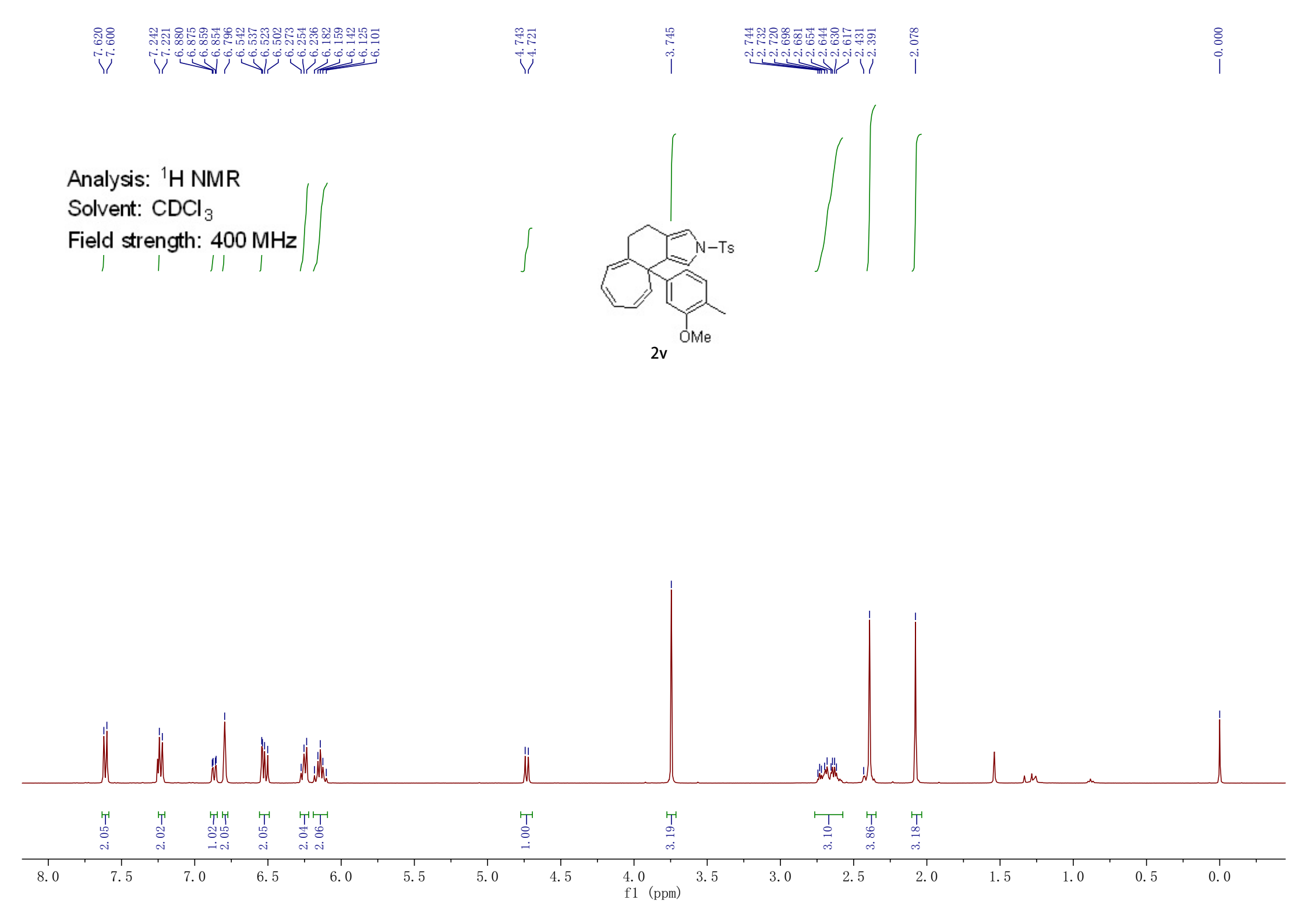
Field strength: 100 MHz

147.41
146.90
144.50
136.34
135.68
135.39
129.78
128.17
127.52
126.68
125.18
124.89
124.13
120.42
117.70
116.70
115.12
111.99
109.52
108.43
77.32
77.00
76.68
55.81
55.62
42.18
33.55
21.60
21.58



2u



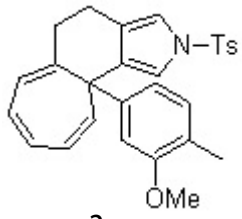

7.620
7.600
7.242
7.221
6.880
6.875
6.859
6.854
6.796
6.542
6.537
6.523
6.502
6.273
6.254
6.236
6.182
6.159
6.142
6.125
6.101
4.743
4.721
3.745
2.744
2.732
2.720
2.698
2.681
2.654
2.644
2.630
2.617
2.431
2.391
2.078
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
N–Ts
OMe
2v
2.05
2.02
1.02
2.05
2.05
2.04
2.06
1.00
3.19
3.10
3.86
3.18
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

Analysis: ^{13}C NMR

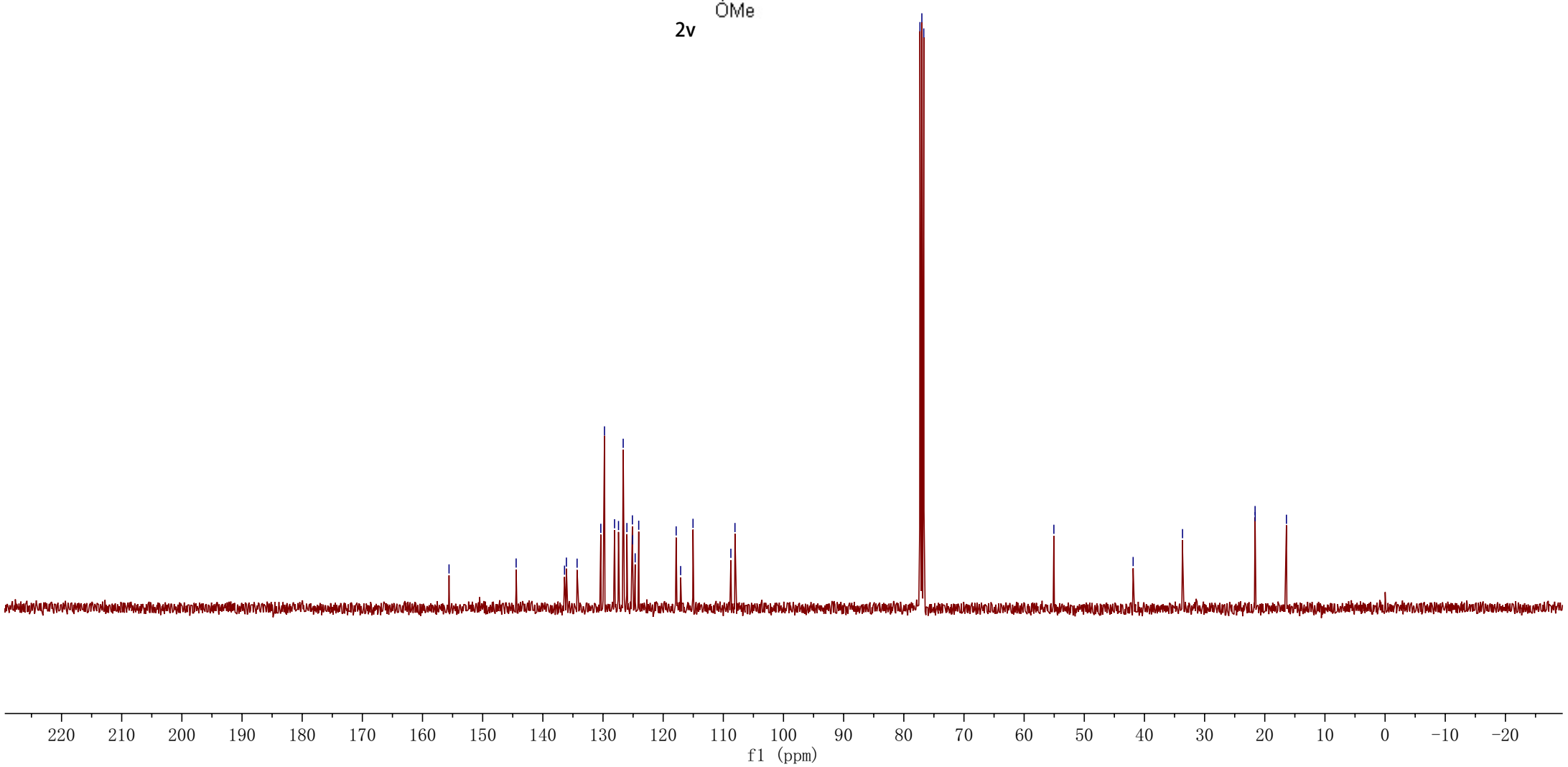
Solvent: $CDCl_3$

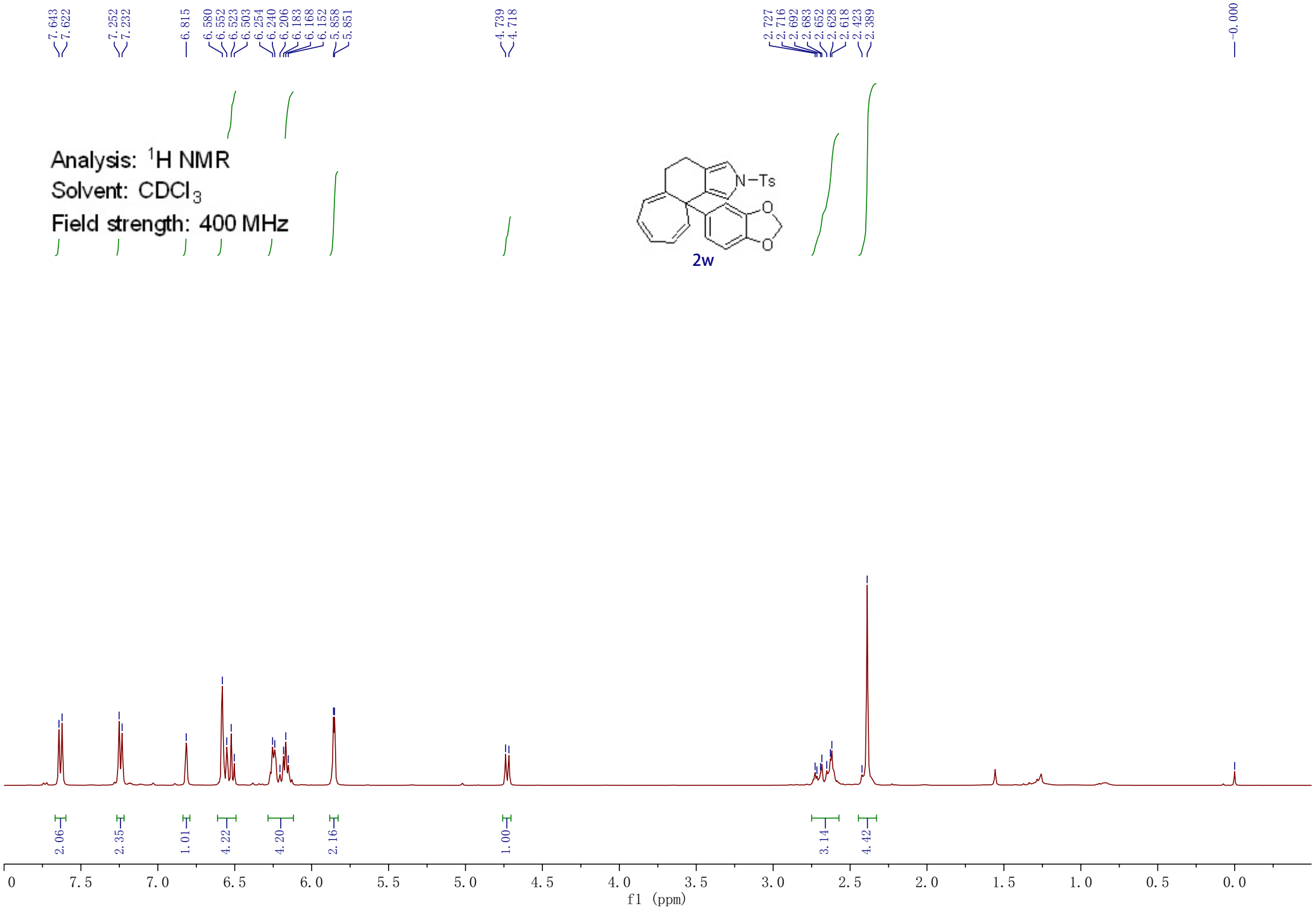
Field strength: 100 MHz

155.59
144.44
136.40
136.08
134.31
130.37
129.75
128.08
127.42
126.64
126.03
125.11
125.07
124.65
124.06
117.84
117.09
115.04
108.75
108.06
77.32
77.00
76.68
55.06
41.88
33.67
21.61
21.59
16.40



2v



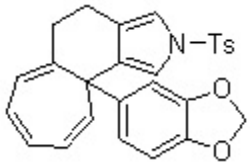

7.643
7.622
7.252
7.232
6.815
6.580
6.552
6.523
6.503
6.254
6.240
6.206
6.183
6.168
6.152
5.858
5.851
4.739
4.718
2.727
2.716
2.692
2.683
2.652
2.628
2.618
2.423
2.389
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
N–Ts
O
O
2w
2.06
2.35
1.01
4.22
4.20
2.16
1.00
3.14
4.42
0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

Analysis: ^{13}C NMR

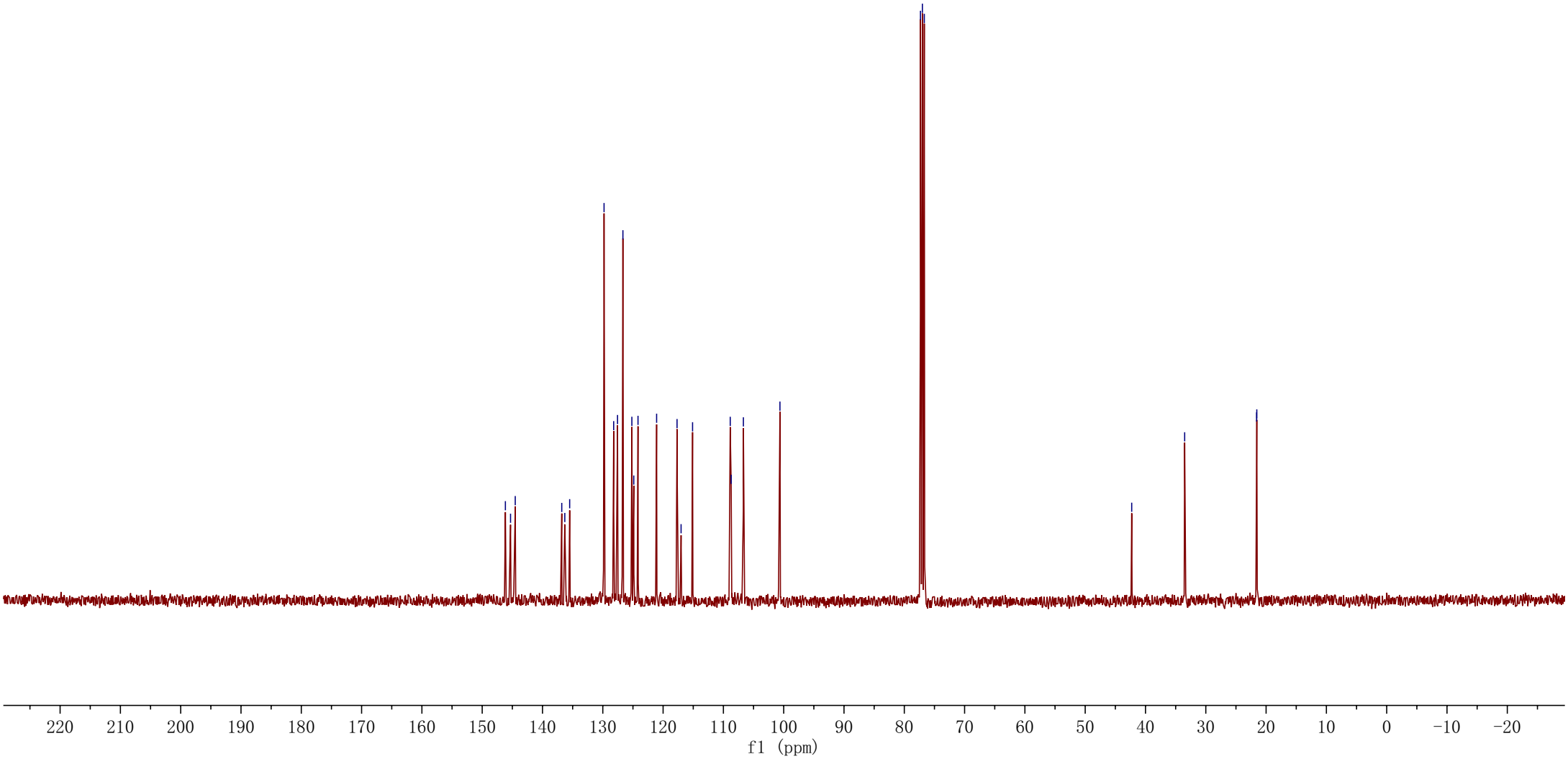
Solvent: $CDCl_3$

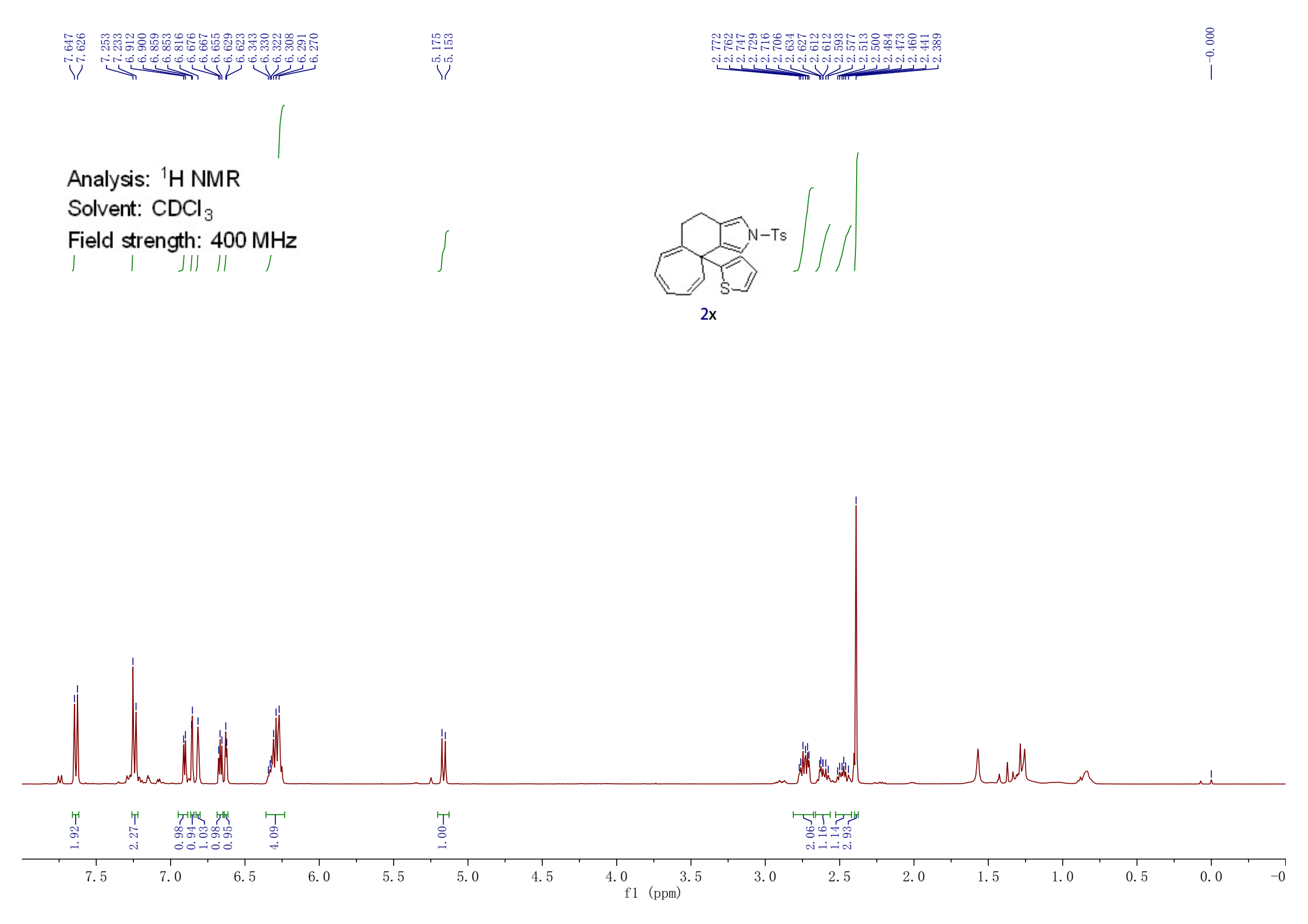
Field strength: 100 MHz

146.16
145.30
144.52
136.81
136.30
135.49
129.79
128.20
127.56
126.67
125.18
124.86
124.16
121.08
117.69
117.02
115.11
108.87
108.71
106.69
100.62
77.32
77.00
76.68
42.29
33.51
21.57
21.54



2w



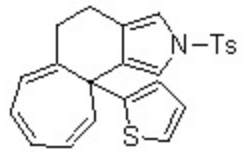

7.647
7.626
7.253
7.233
6.912
6.900
6.859
6.853
6.816
6.676
6.667
6.655
6.629
6.623
6.343
6.330
6.322
6.308
6.291
6.270
5.175
5.153
2.772
2.762
2.747
2.729
2.716
2.706
2.634
2.627
2.612
2.612
2.593
2.577
2.513
2.500
2.484
2.473
2.460
2.441
2.389
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
N–Ts
S
2x
1.92
2.27
0.98
0.94
1.03
0.98
0.95
4.09
1.00
2.06
1.16
1.14
2.93
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0
f1 (ppm)

Analysis: ^{13}C NMR

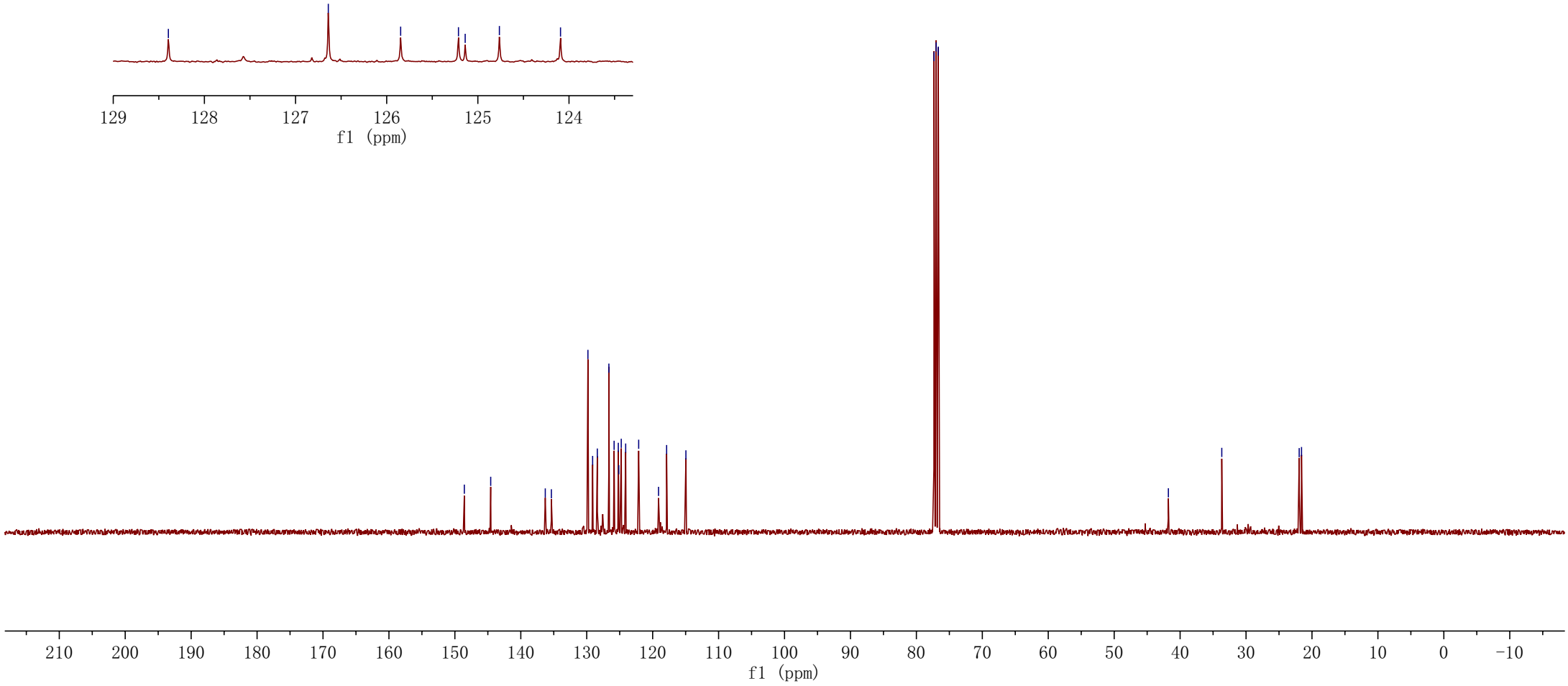
Solvent: $CDCl_3$

Field strength: 100 MHz

148.57
144.56
136.29
135.36
129.82
129.11
128.40
126.64
125.85
125.21
125.14
124.76
124.09
122.12
119.11
117.88
114.96
77.32
77.00
76.68
41.78
33.68
21.94
21.58



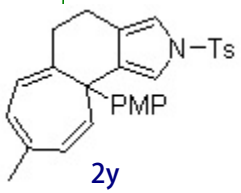
2x



Analysis: ^{1}H NMR

Solvent: $CDCl_3$

Field strength: 400 MHz



2y

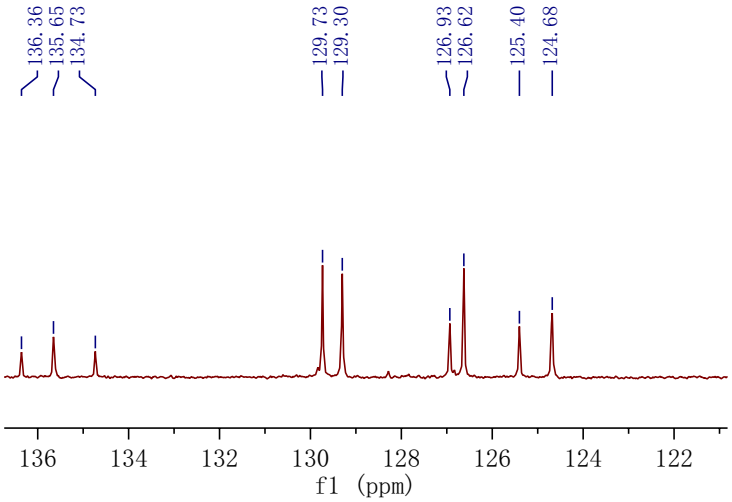
f1 (ppm)

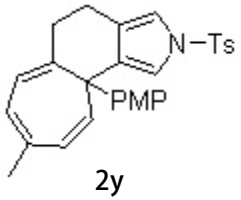
Analysis: ^{13}C NMR

Solvent: $CDCl_3$

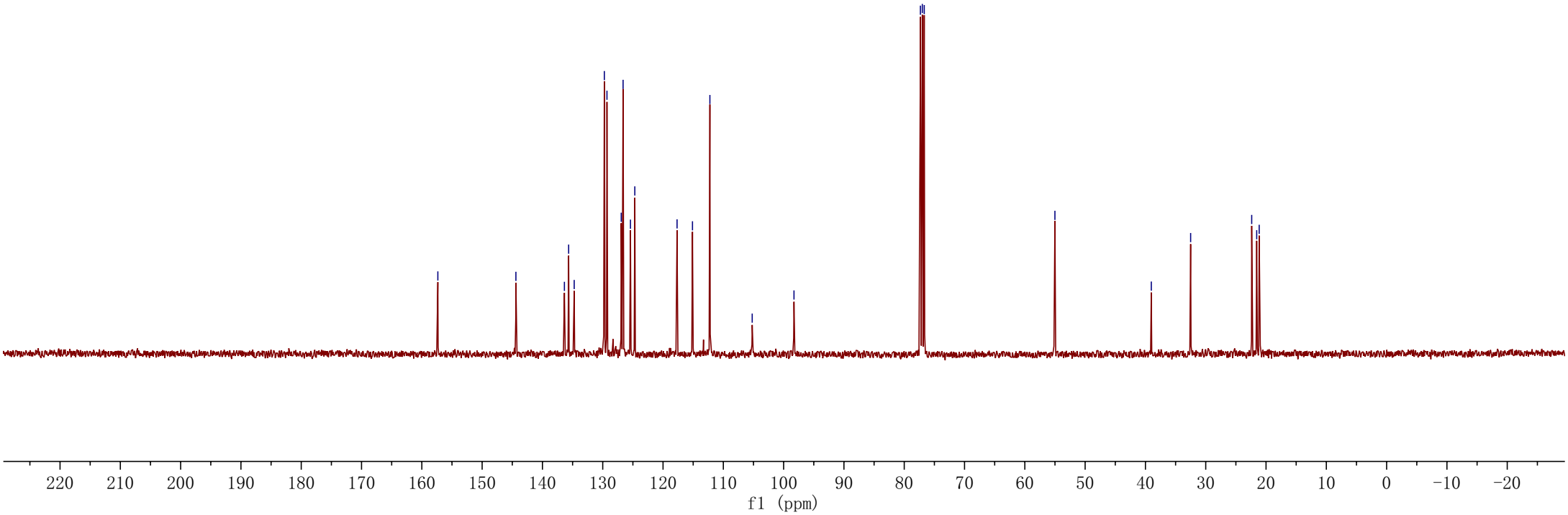
Field strength: 100 MHz

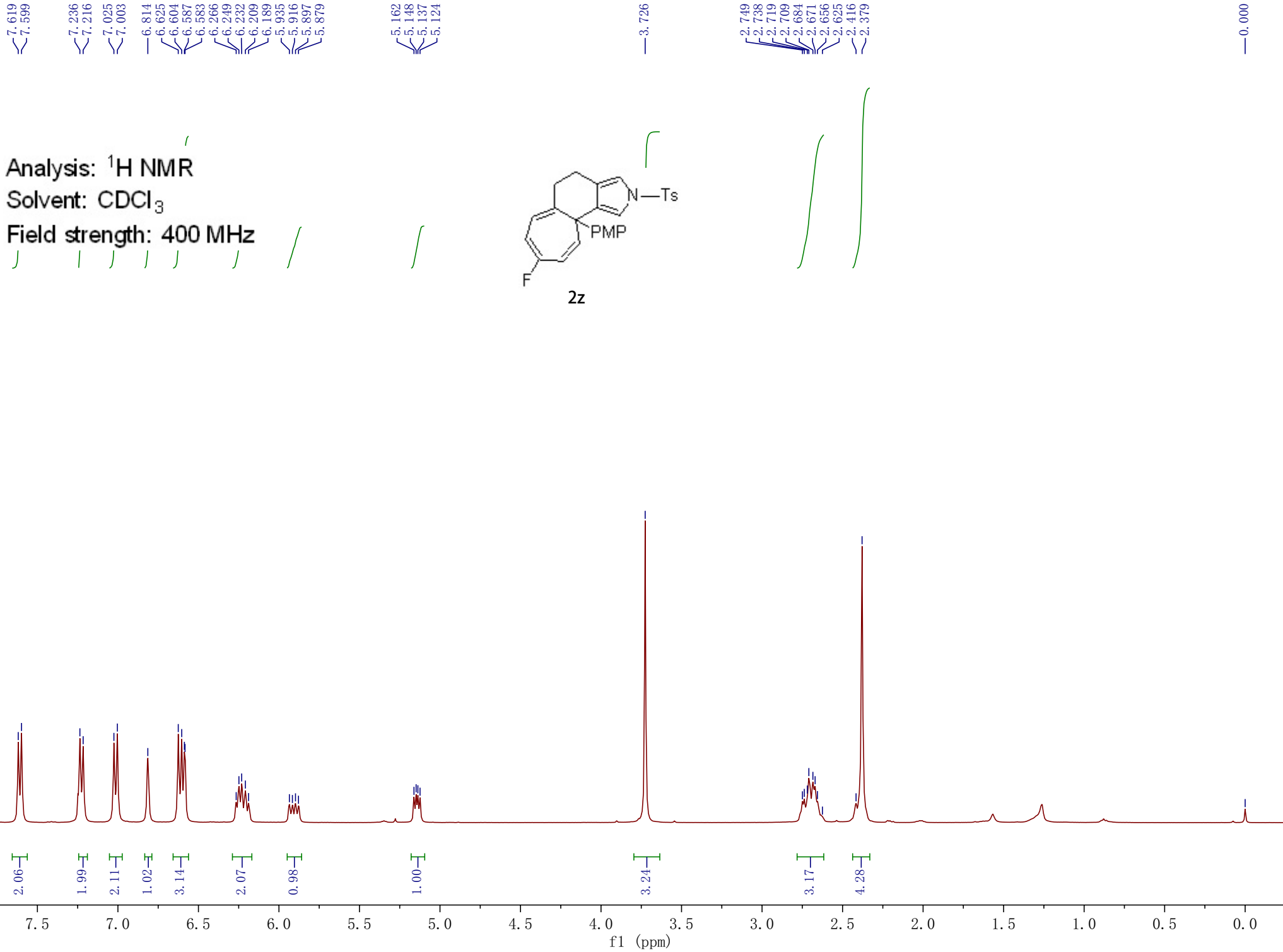
157.34
144.40
136.36
135.65
134.73
129.73
129.30
126.93
126.62
125.40
124.68
117.67
115.12
112.23
105.21
98.28
77.32
77.00
76.68
55.01
39.03
32.50
22.38
21.55
21.13





2y



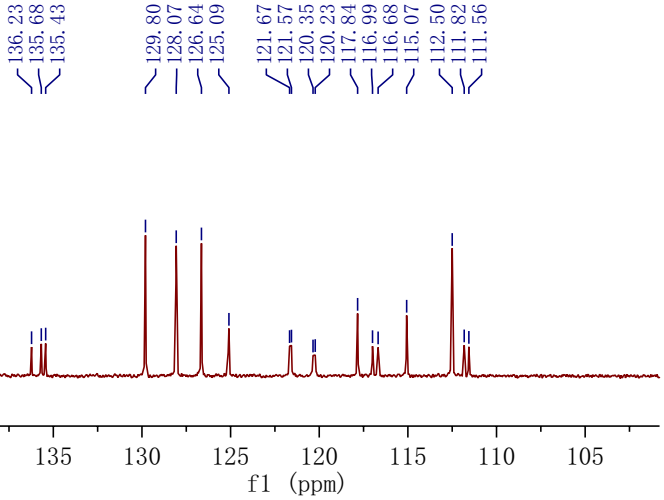

7.619
7.599
7.236
7.216
7.025
7.003
6.814
6.625
6.604
6.587
6.583
6.266
6.249
6.232
6.209
6.189
5.935
5.916
5.897
5.879
5.162
5.148
5.137
5.124
3.726
2.749
2.738
2.719
2.709
2.684
2.671
2.656
2.625
2.416
2.379
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
N—Ts
PMP
F
2z
2.06
1.99
2.11
1.02
3.14
2.07
0.98
1.00
3.24
3.17
4.28
0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0
f1 (ppm)

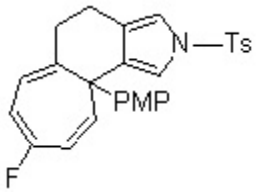
Analysis: ^{13}C NMR

Solvent: $CDCl_3$

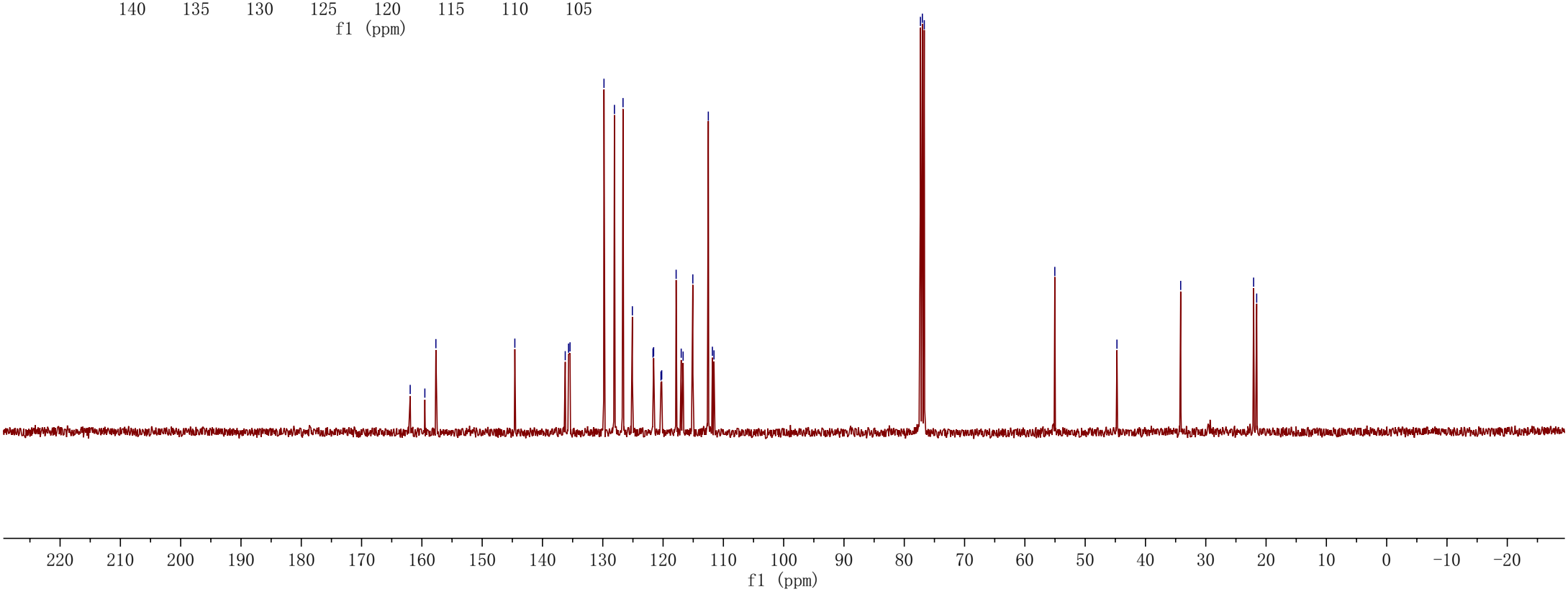
Field strength: 100 MHz

161.94, 159.51, 157.68, 144.58, 136.23, 135.68, 135.43, 129.80, 128.07, 126.64, 125.09, 121.67, 121.57, 120.35, 120.23, 117.84, 116.99, 116.68, 115.07, 112.50, 111.82, 111.56, 77.32, 77.00, 76.68, 55.04, 44.73, 34.16, 22.07, 21.56

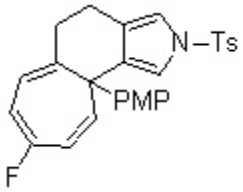




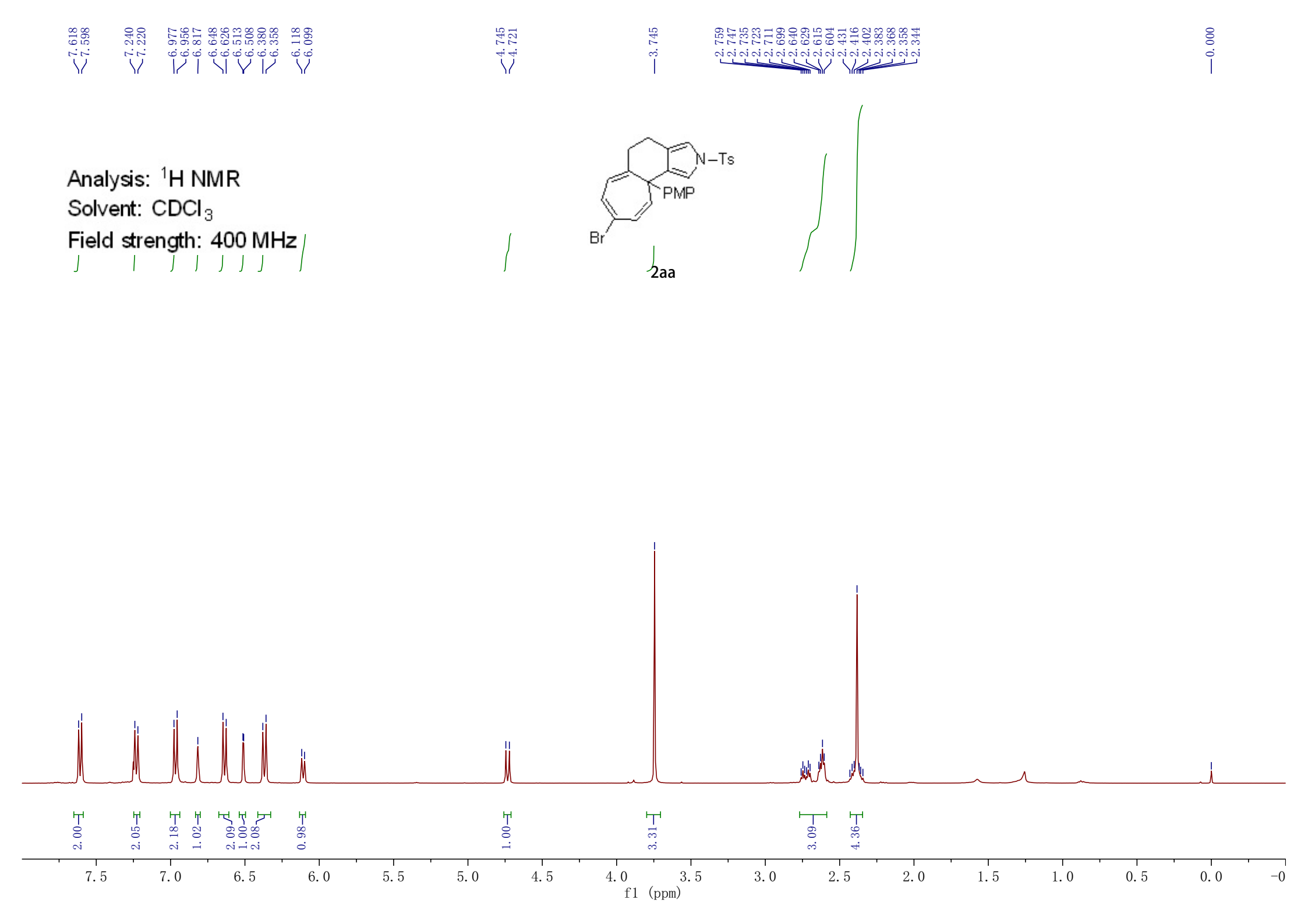
2z



Analysis: ^{13}F NMR
Solvent: $CDCl_3$
Field strength: 471 MHz



2z

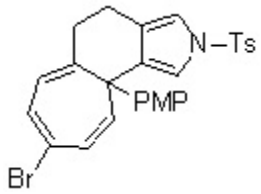

7.618
7.598
7.240
7.220
6.977
6.956
6.817
6.648
6.626
6.513
6.508
6.380
6.358
6.118
6.099
4.745
4.721
3.745
2.759
2.747
2.735
2.723
2.711
2.699
2.640
2.629
2.615
2.604
2.431
2.416
2.402
2.383
2.368
2.358
2.344
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
N–Ts
PMP
Br
2aa
2.00
2.05
2.18
1.02
2.09
1.00
2.08
0.98
1.00
3.31
3.09
4.36
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0
f1 (ppm)

Analysis: ^{13}C NMR

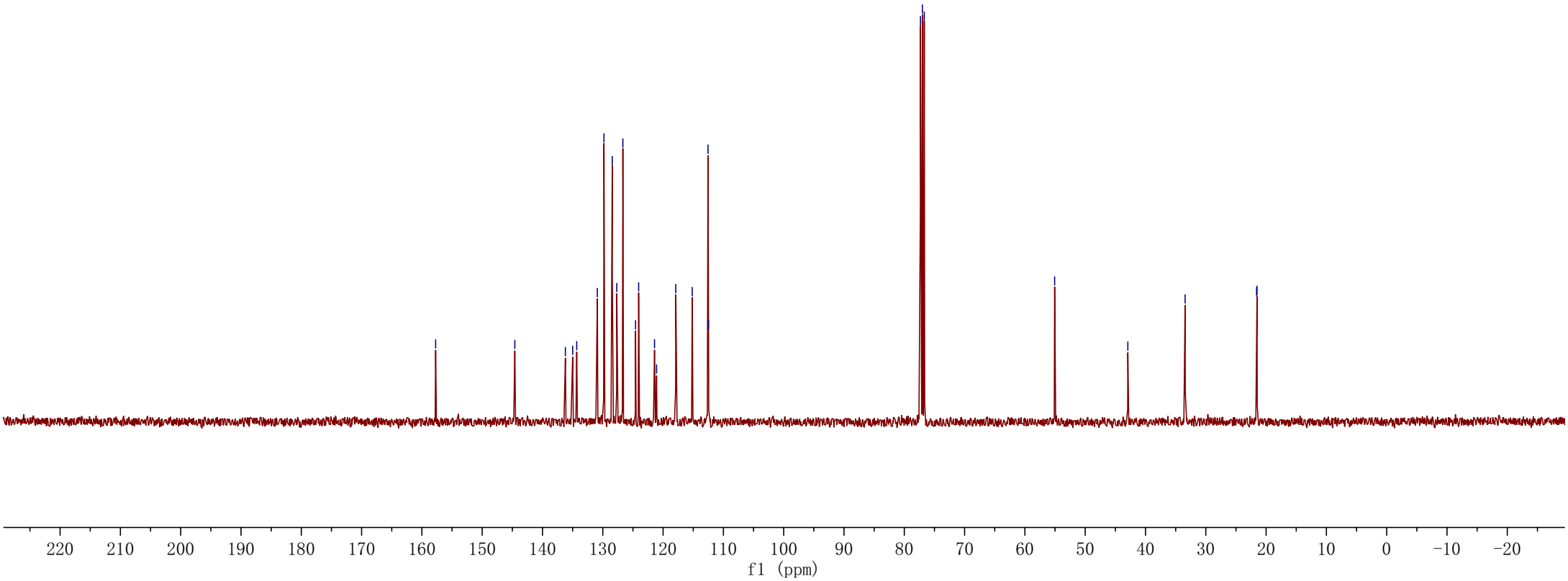
Solvent: $CDCl_3$

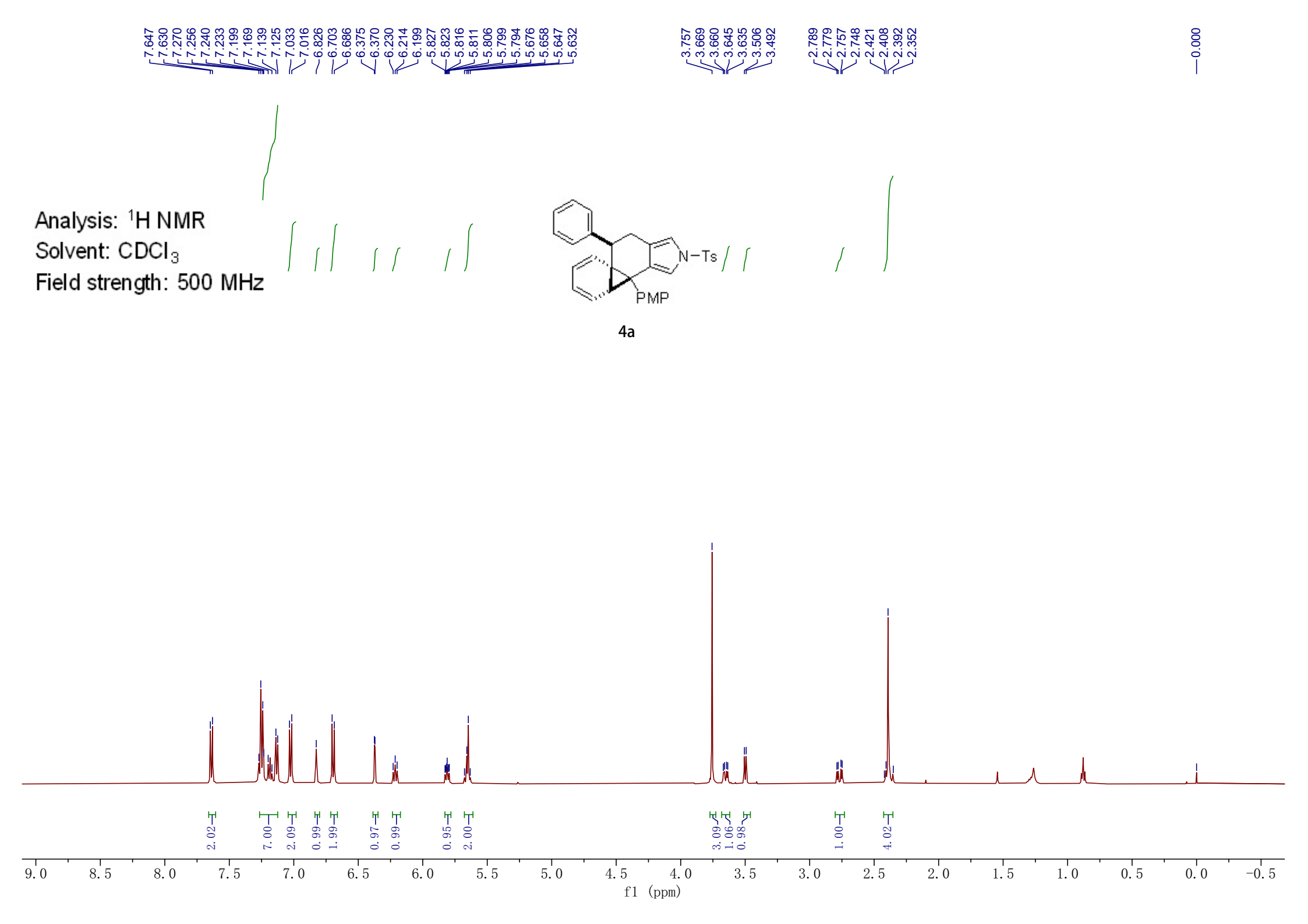
Field strength: 100 MHz

157.72
144.59
136.21
135.00
134.32
130.91
129.81
128.43
127.68
126.67
124.56
124.05
121.42
121.08
117.89
115.17
112.55
112.48
77.32
77.00
76.68
55.07
42.93
33.43
21.57
21.50



2aa

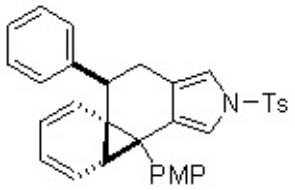



7.647
7.630
7.270
7.256
7.240
7.233
7.199
7.169
7.139
7.125
7.033
7.016
6.826
6.703
6.686
6.375
6.370
6.230
6.214
6.199
5.827
5.823
5.816
5.811
5.806
5.799
5.794
5.676
5.658
5.647
5.632
3.757
3.669
3.660
3.645
3.635
3.506
3.492
2.789
2.779
2.757
2.748
2.421
2.408
2.392
2.352
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 500 MHz
N−Ts
PMP
4a
2.02
7.00
2.09
0.99
1.99
0.97
0.99
0.95
2.00
3.09
1.06
0.98
1.00
4.02
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
f1 (ppm)

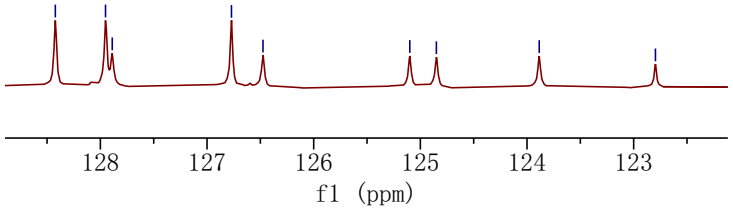
Analysis: ^{13}C NMR
Solvent: $CDCl_3$
Field strength: 125 MHz

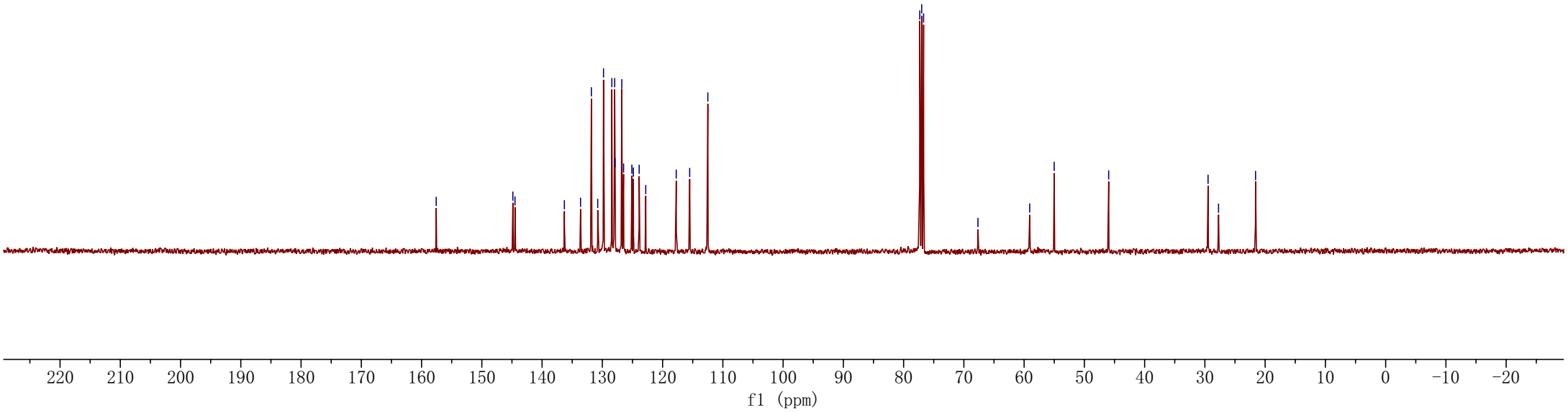
157.57
144.85
144.50
136.30
133.62
131.82
130.77
129.81
128.42
127.95
127.89
126.77
126.48
125.10
124.85
123.89
122.80
117.74
115.51
112.49
77.32
77.00
76.68
67.66
59.07
55.01
45.97
29.47
27.73
21.59

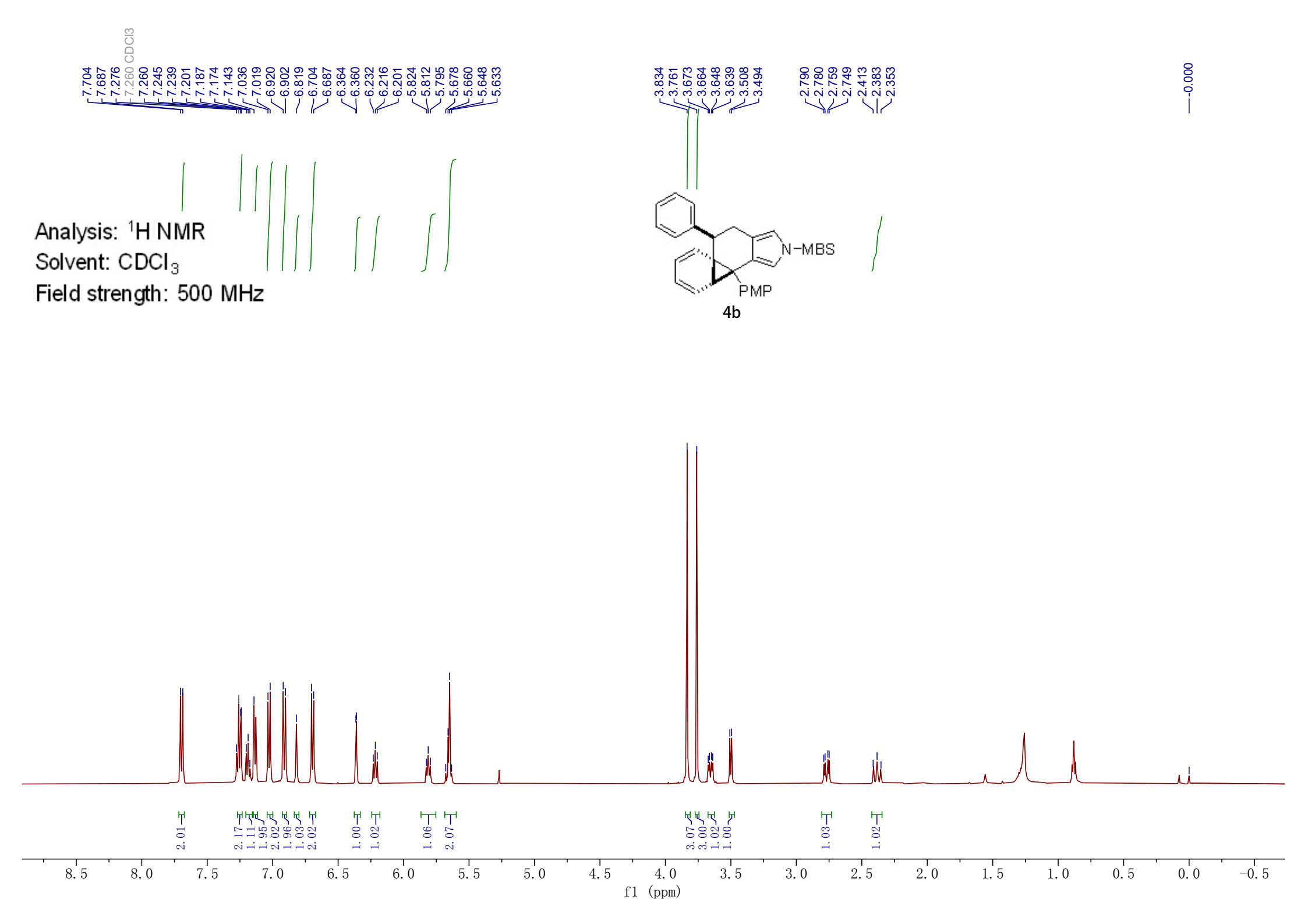
128.42
127.95
127.89
126.77
126.48
125.10
124.85
123.89
122.80



4a





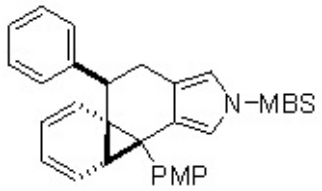

7.704
7.687
7.276
7.260 CDCl3
7.260
7.245
7.239
7.201
7.187
7.174
7.143
7.036
7.019
6.920
6.902
6.819
6.704
6.687
6.364
6.360
6.232
6.216
6.201
5.824
5.812
5.795
5.678
5.660
5.648
5.633
3.834
3.761
3.673
3.664
3.648
3.639
3.508
3.494
2.790
2.780
2.759
2.749
2.413
2.383
2.353
-0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 500 MHz
N-MBS
PMP
4b
2.01
2.17
1.11
1.95
2.02
1.96
1.03
2.02
1.00
1.02
1.06
2.07
3.07
3.00
1.02
1.00
1.03
1.02
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

Analysis: ^{13}C NMR

Solvent: $CDCl_3$

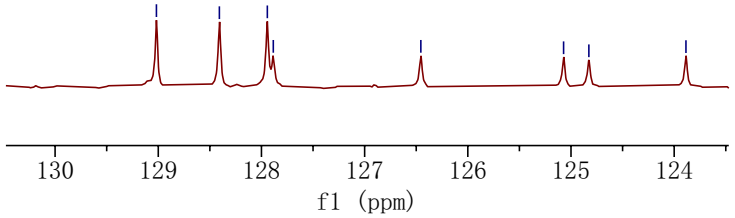
Field strength: 125 MHz

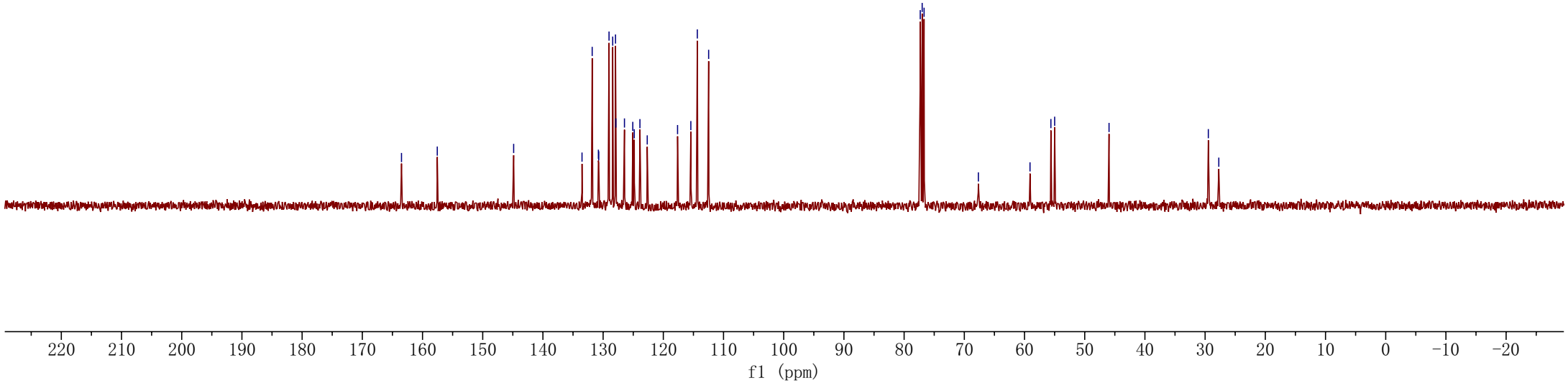
163.49 157.55 144.86 133.51 131.82 130.79 130.73 129.02 128.41 127.94 127.89 126.46 125.07 124.83 123.89 122.67 117.63 115.43 114.35 112.47 77.32 77.00 76.68 67.66 59.09 55.62 54.99 45.96 29.47 27.73

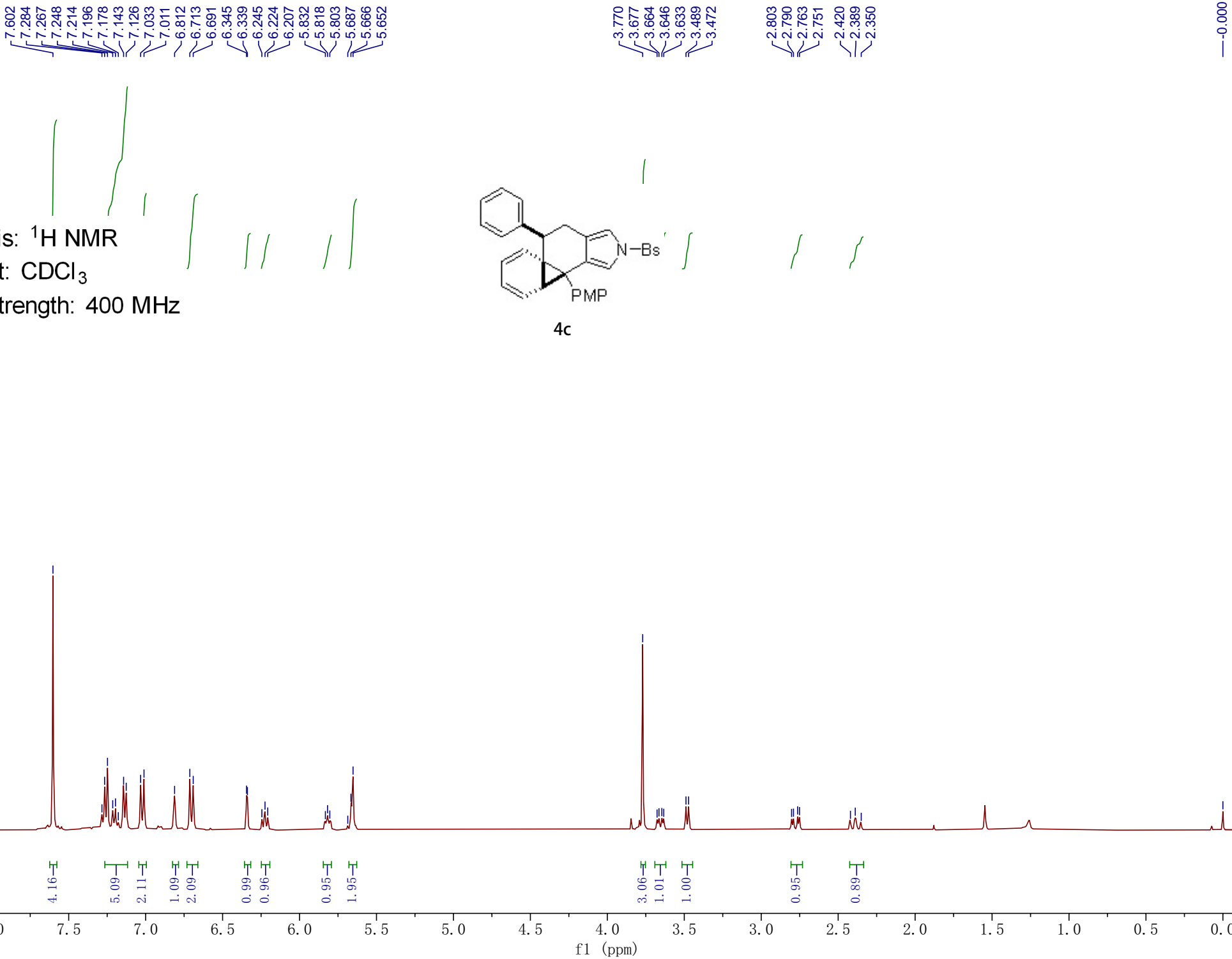


4b

129.02 128.41 127.94 127.89 126.46 125.07 124.83 123.89





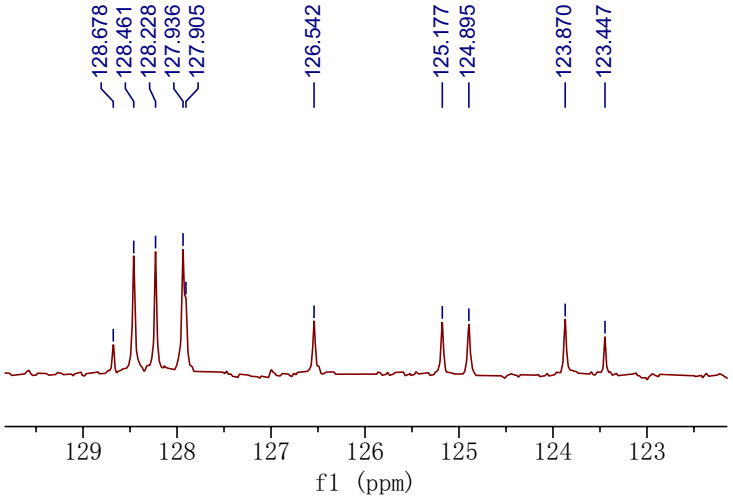

7.602
7.284
7.267
7.248
7.214
7.196
7.178
7.143
7.126
7.033
7.011
6.812
6.713
6.691
6.345
6.339
6.245
6.224
6.207
5.832
5.818
5.803
5.687
5.666
5.652
3.770
3.677
3.664
3.646
3.633
3.489
3.472
2.803
2.790
2.763
2.751
2.420
2.389
2.350
-0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
N—Bs
PMP
4c
4.16
5.09
2.11
1.09
2.09
0.99
0.96
0.95
1.95
3.06
1.01
1.00
0.95
0.89
f1 (ppm)

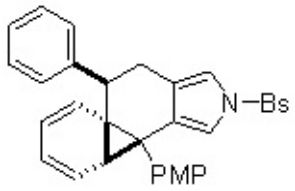
Analysis: ^{13}C NMR

Solvent: $CDCl_3$

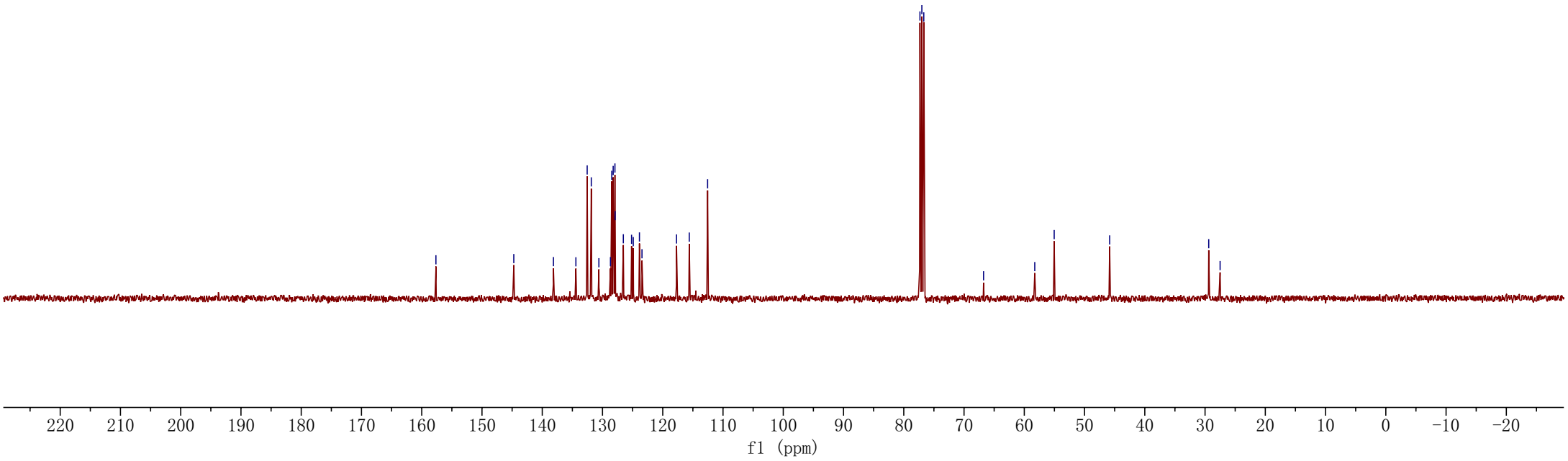
Field strength: 100 MHz

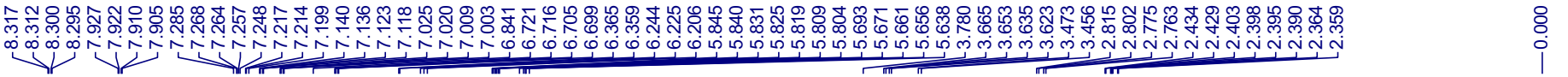
157.646
144.721
138.144
134.416
132.543
131.860
130.600
128.678
128.461
128.228
127.936
127.905
126.542
125.177
124.895
123.870
123.447
117.716
115.602
112.557
77.316
77.000
76.681
66.757
58.261
55.038
45.832
29.391
27.502



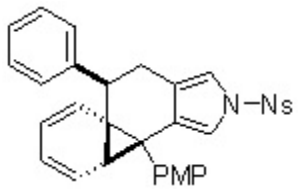


4c

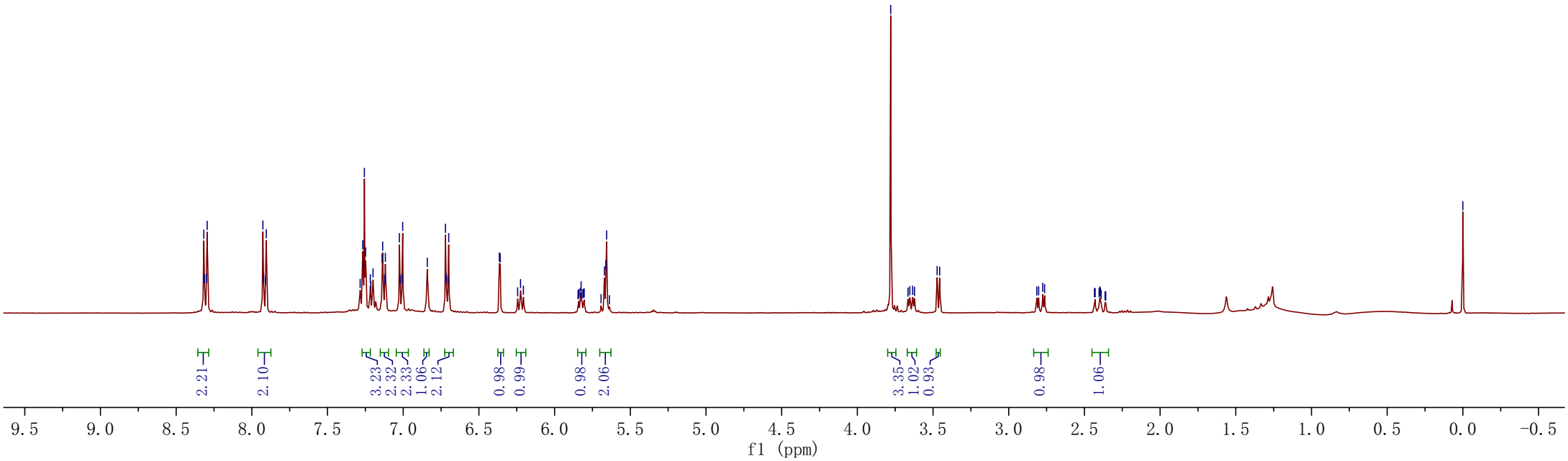




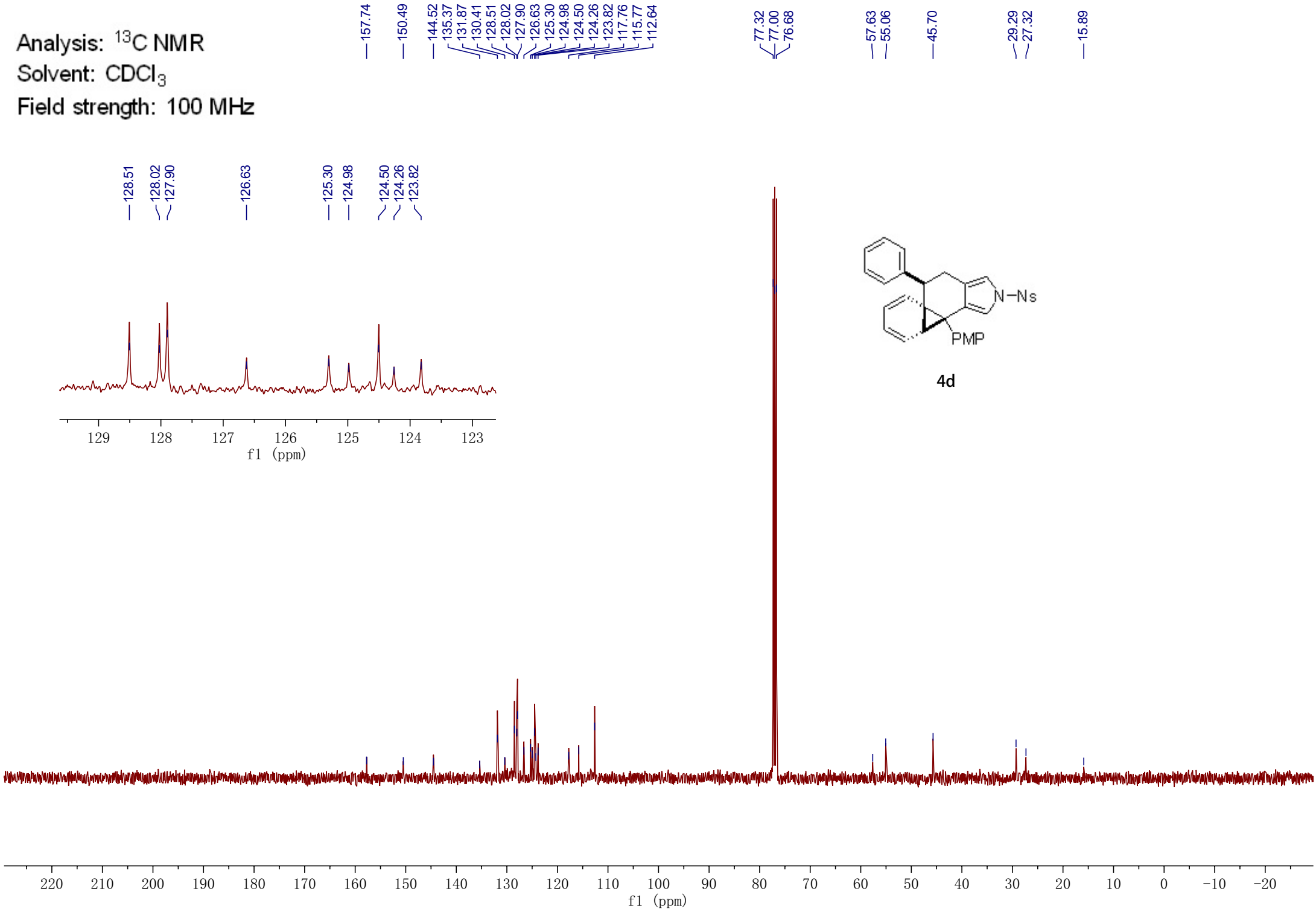
Analysis: ^{1}H NMR
Solvent: $CDCl_3$
Field strength: 400 MHz



4d



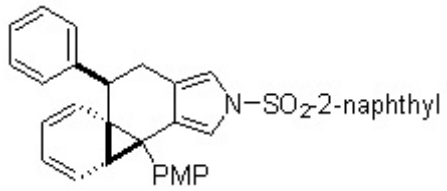
Analysis: ^{13}C NMR
Solvent: $CDCl_3$
Field strength: 100 MHz



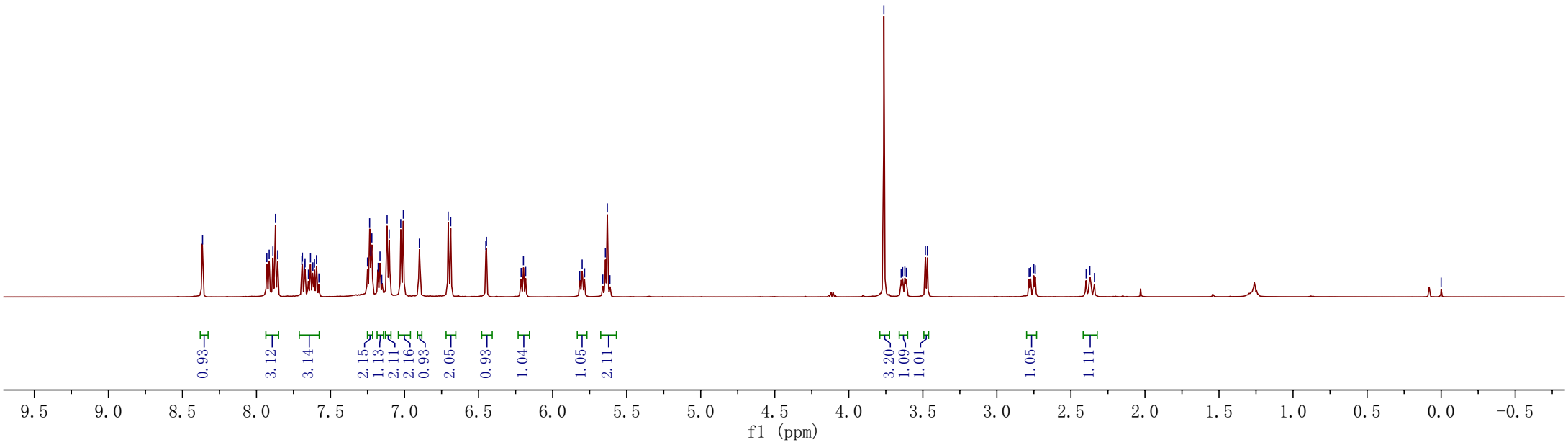
4d

HJJ-02-94-1.fid

Analysis: ^{1}H NMR
Solvent: $CDCl_3$
Field strength: 500 MHz

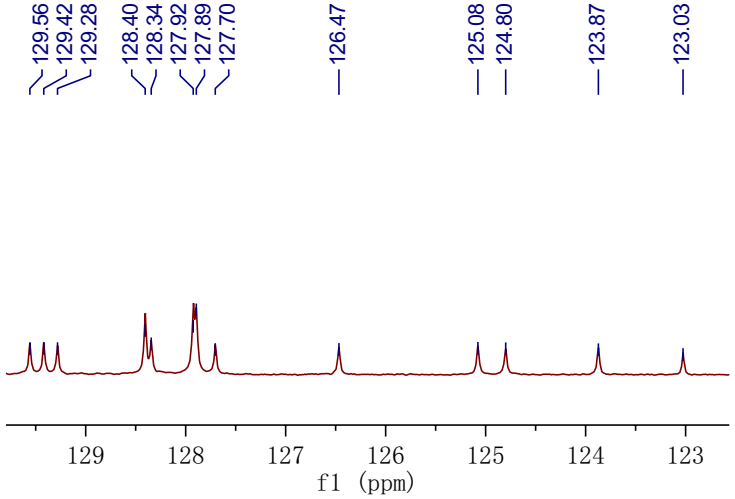


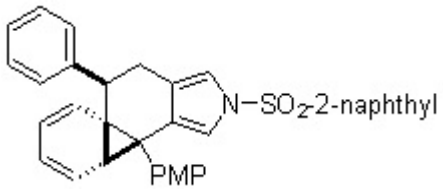
4e



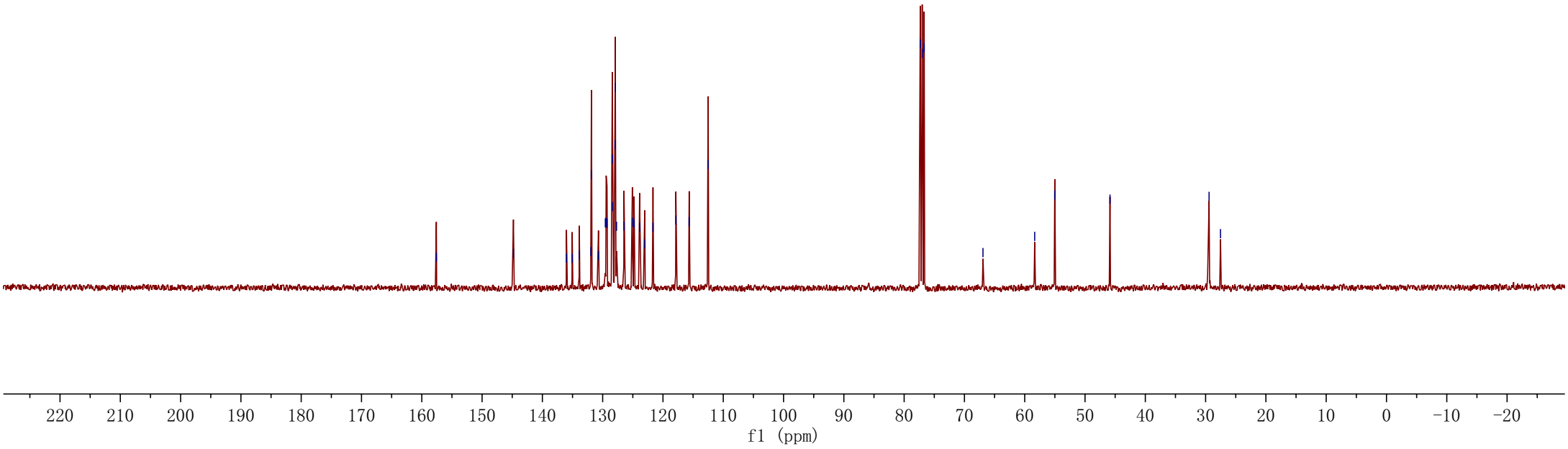
Analysis: ^{13}C NMR
Solvent: $CDCl_3$
Field strength: 100 MHz

157.59 144.80 136.01 135.06 133.87 131.95 131.87 130.70 129.56 129.42 129.28 128.40 128.34 127.92 127.89 127.70 126.47 125.08 124.80 123.87 123.03 121.66 117.86 115.66 112.51 77.32 77.00 76.68 66.93 58.35 55.02 45.86 29.42 27.53





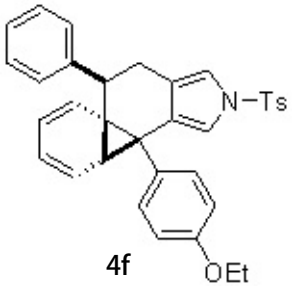
4e



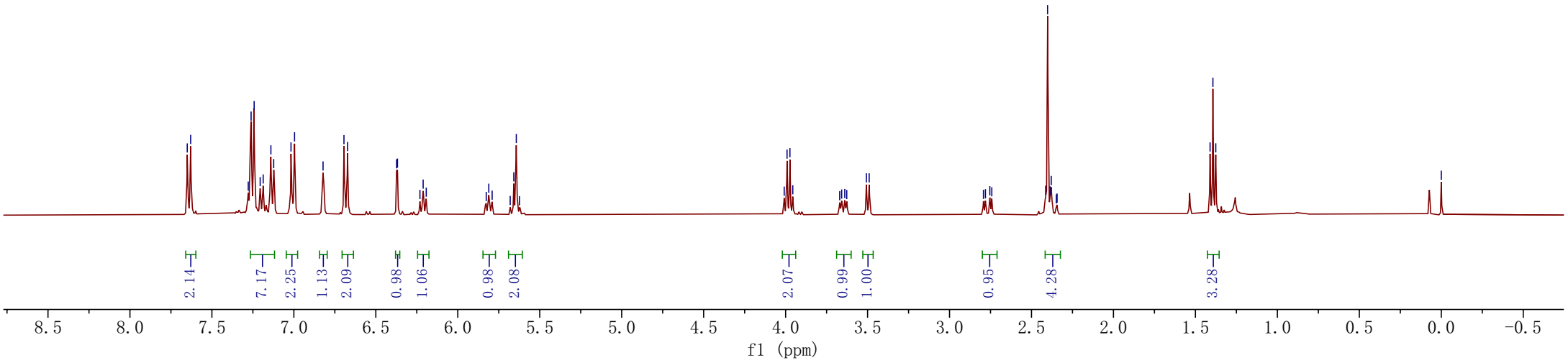
Analysis: ^{1}H NMR

Solvent: $CDCl_3$

Field strength: 400 MHz



4f

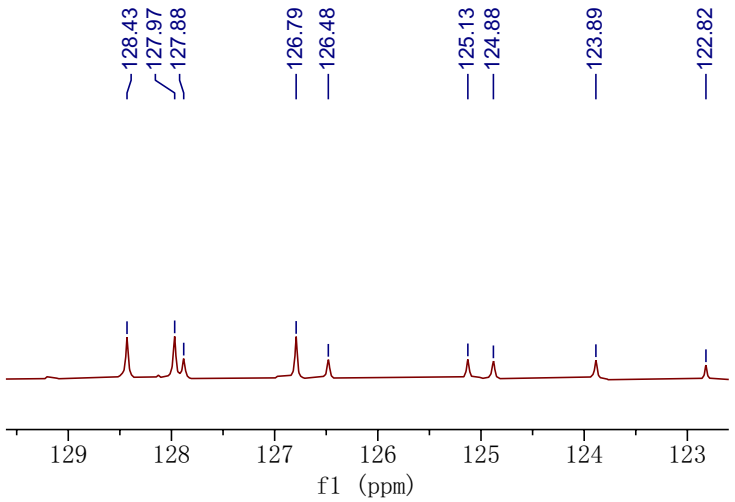


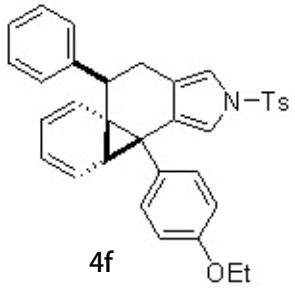
Analysis: ^{13}C NMR

Solvent: $CDCl_3$

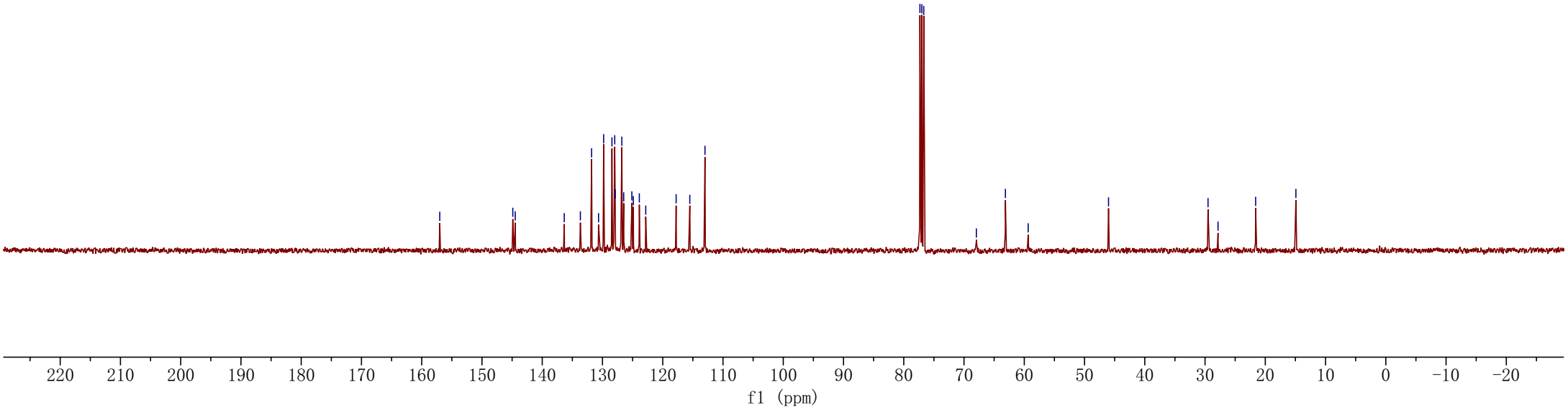
Field strength: 100 MHz

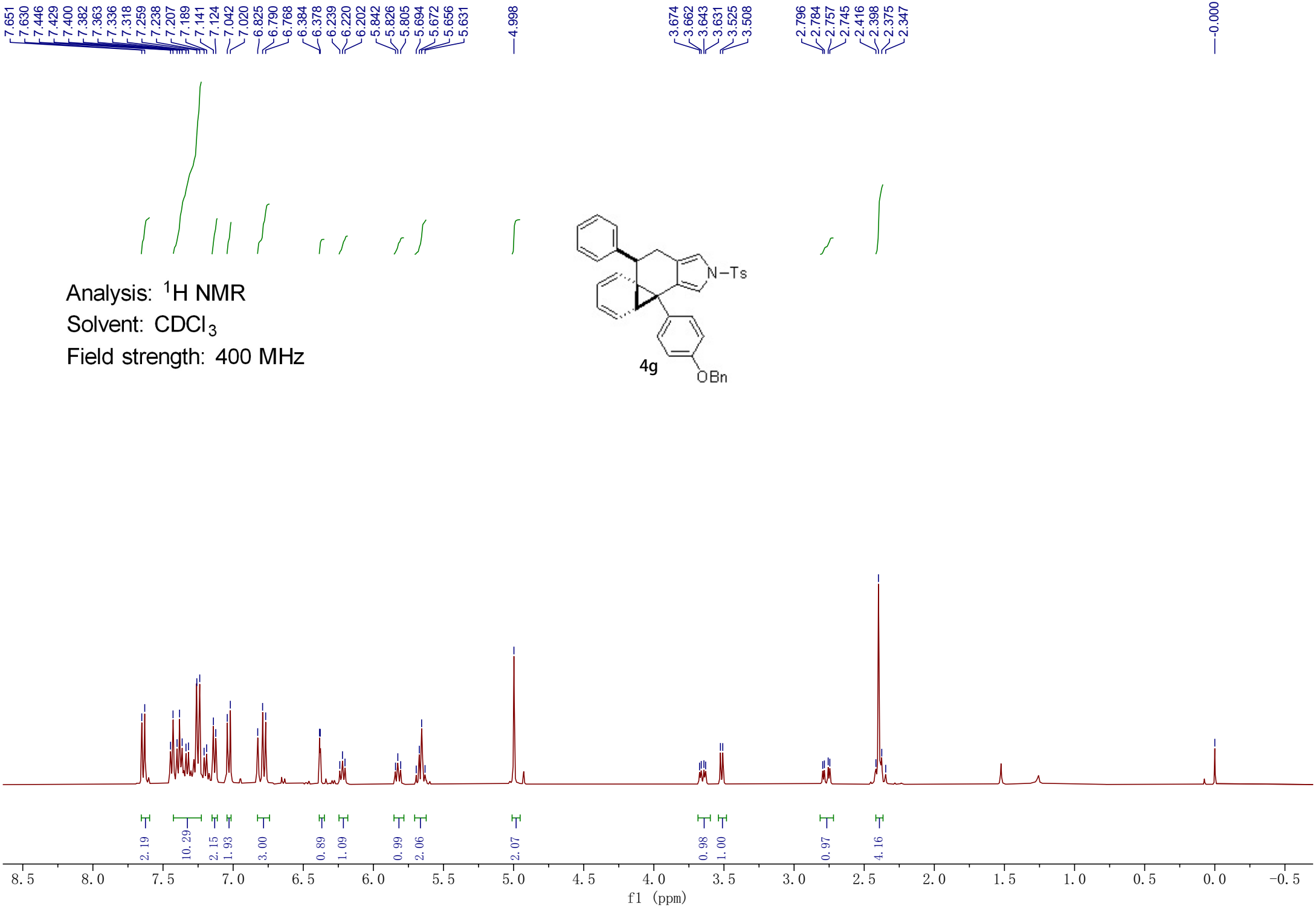
157.01
144.88
144.48
136.35
133.67
131.81
130.65
129.81
128.43
127.97
127.88
126.79
126.48
125.13
124.88
123.89
122.82
117.78
115.51
112.99
77.32
77.00
76.68
67.95
63.13
59.35
46.02
29.50
27.84
21.60
14.92





4f



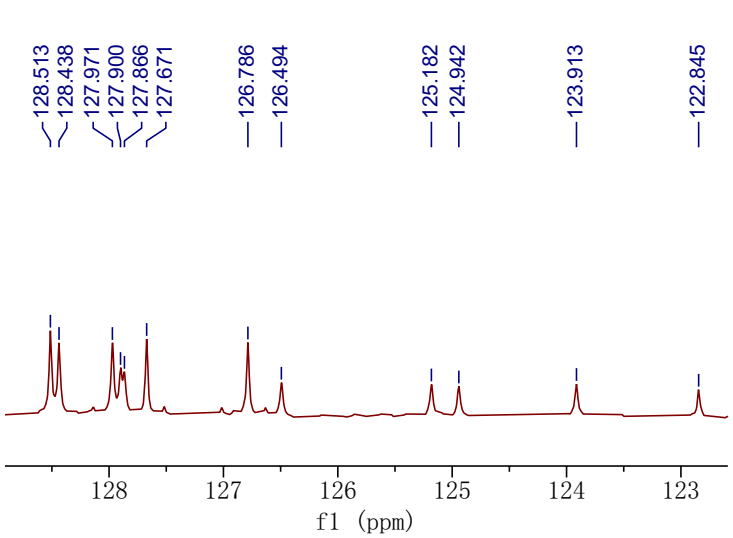

7.651
7.630
7.446
7.429
7.400
7.382
7.363
7.336
7.318
7.259
7.238
7.207
7.189
7.141
7.124
7.042
7.020
6.825
6.790
6.768
6.384
6.378
6.239
6.220
6.202
5.842
5.826
5.805
5.694
5.672
5.656
5.631
4.998
3.674
3.662
3.643
3.631
3.525
3.508
2.796
2.784
2.757
2.745
2.416
2.398
2.375
2.347
-0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
N–Ts
OBn
4g
2.19
10.29
2.15
1.93
3.00
0.89
1.09
0.99
2.06
2.07
0.98
1.00
0.97
4.16
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

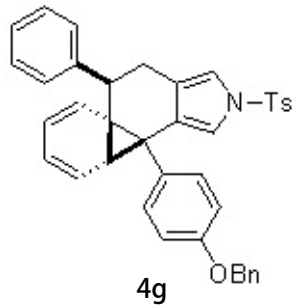
Analysis: ^{13}C NMR

Solvent: $CDCl_3$

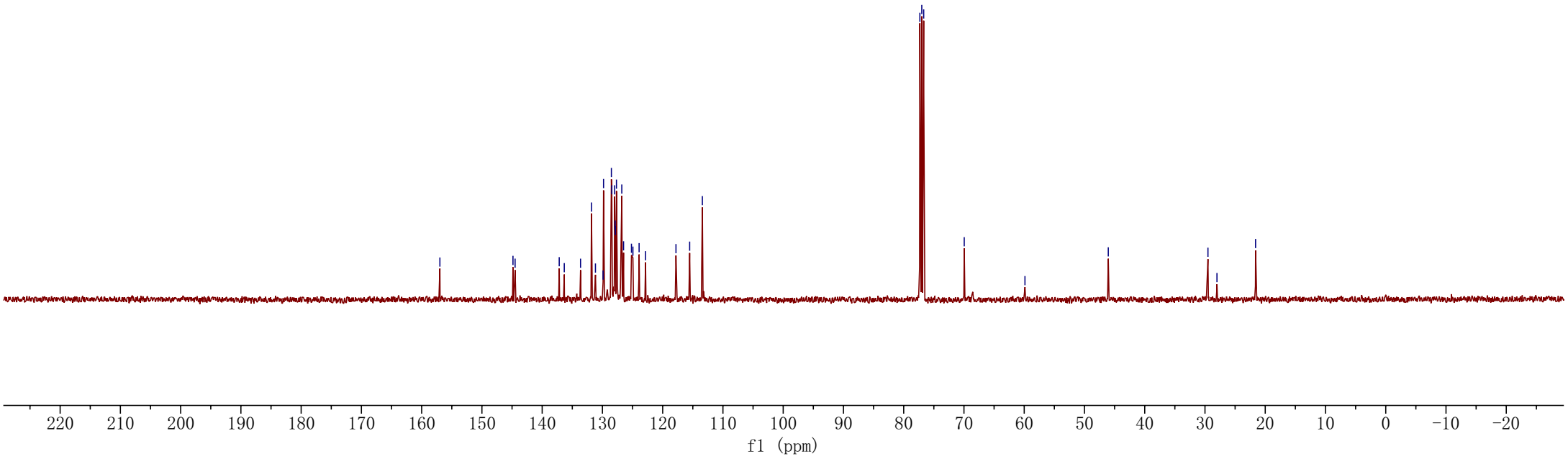
Field strength: 100 MHz

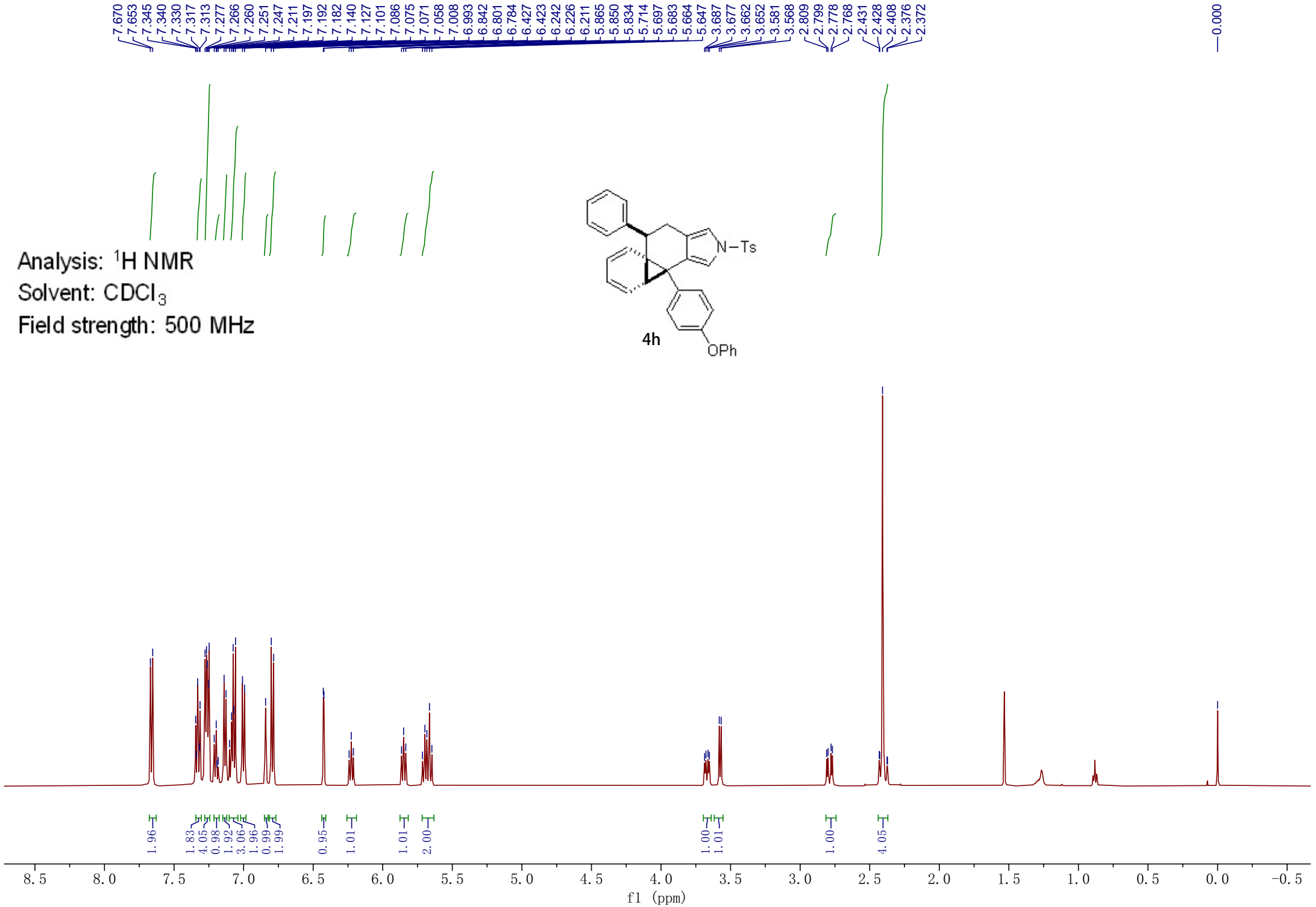
156.976
144.846
144.495
137.171
136.334
133.631
131.818
131.160
129.892
129.813
128.513
128.438
127.971
127.900
127.866
127.671
126.786
126.494
125.182
124.942
123.913
122.845
117.796
115.523
113.417
77.317
77.000
76.683
69.955
59.877
46.049
29.506
28.011
21.603





4g




7.670
7.653
7.345
7.340
7.330
7.317
7.313
7.277
7.266
7.260
7.251
7.247
7.211
7.197
7.192
7.182
7.140
7.127
7.101
7.086
7.075
7.071
7.058
7.008
6.993
6.842
6.801
6.784
6.427
6.423
6.242
6.226
6.211
5.865
5.850
5.834
5.714
5.697
5.683
5.664
5.647
3.687
3.677
3.662
3.652
3.581
3.568
2.809
2.799
2.778
2.768
2.431
2.428
2.408
2.376
2.372
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 500 MHz
N–Ts
OPh
4h
1.96
1.83
4.05
0.98
1.92
3.06
1.96
0.99
1.99
0.95
1.01
1.01
2.00
1.00
1.01
1.00
4.05
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

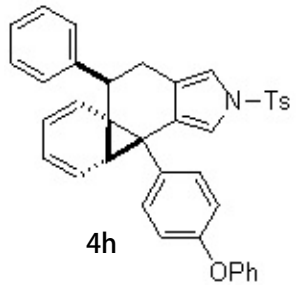
157.16
155.20
144.74
144.58
136.30
133.63
133.34
132.05
129.84
129.64
128.46
127.97
127.83
126.79
126.53
125.35
125.13
123.94
123.09
122.85
118.92
117.73
117.32
115.59
77.32
77.00
76.68
69.98
61.25
46.08
29.49
28.48
21.62

Analysis: ^{13}C NMR

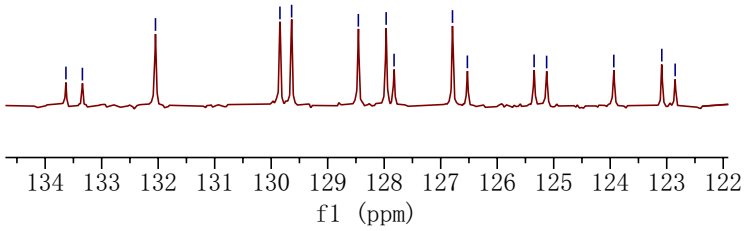
Solvent: $CDCl_3$

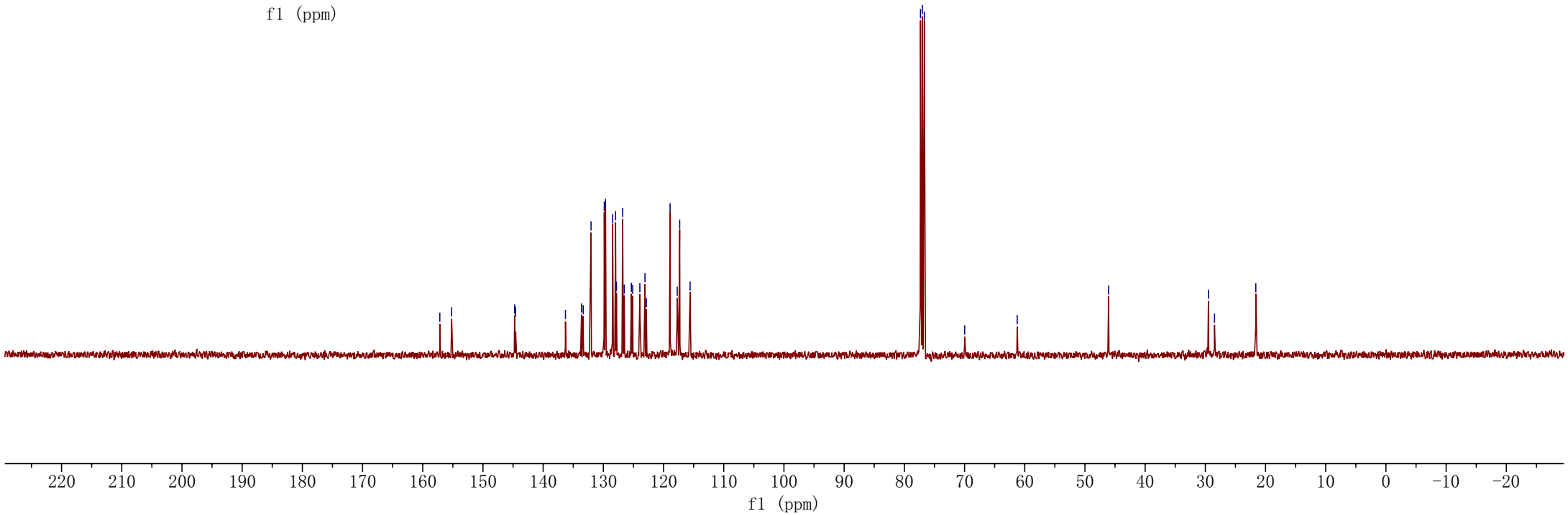
Field strength: 125 MHz

133.63
133.34
132.05
129.84
129.64
128.46
127.97
127.83
126.79
126.53
125.35
125.13
123.94
123.09
122.85

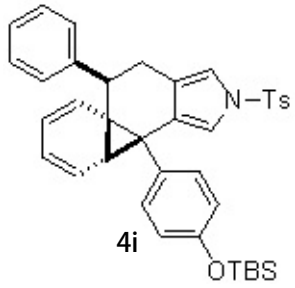


4h

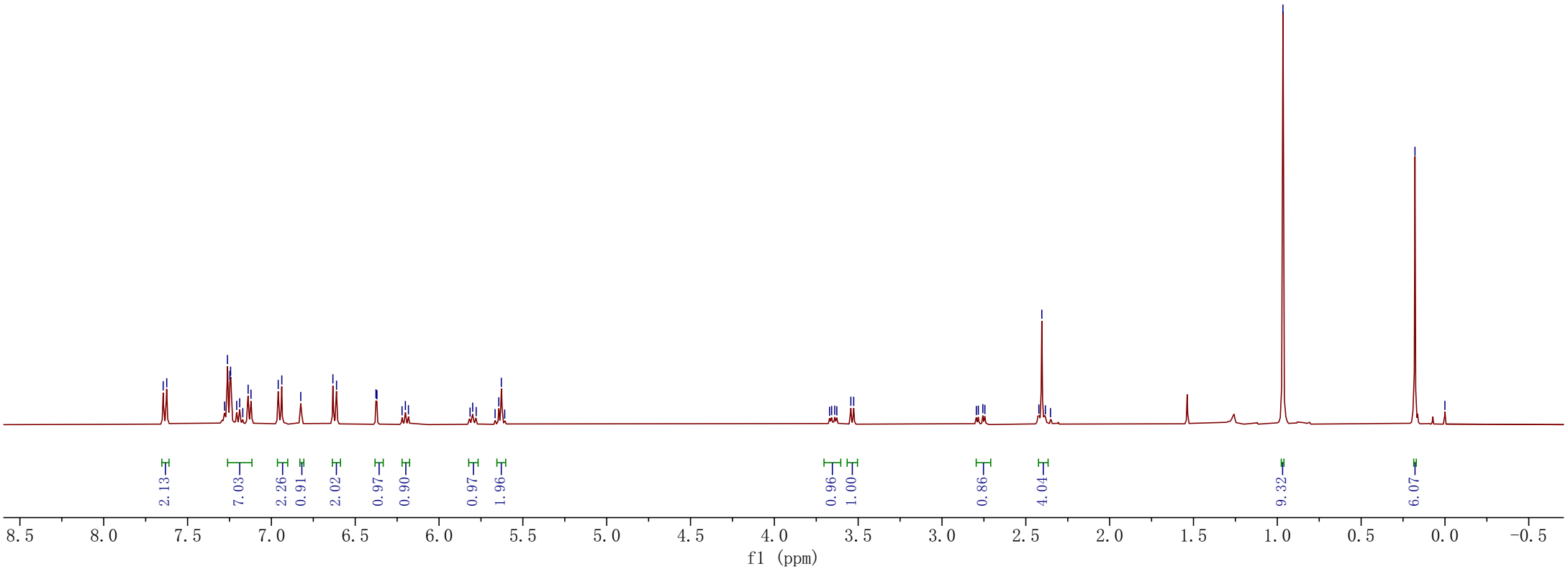




Analysis: ^{1}H NMR
Solvent: $CDCl_3$
Field strength: 400 MHz



4i

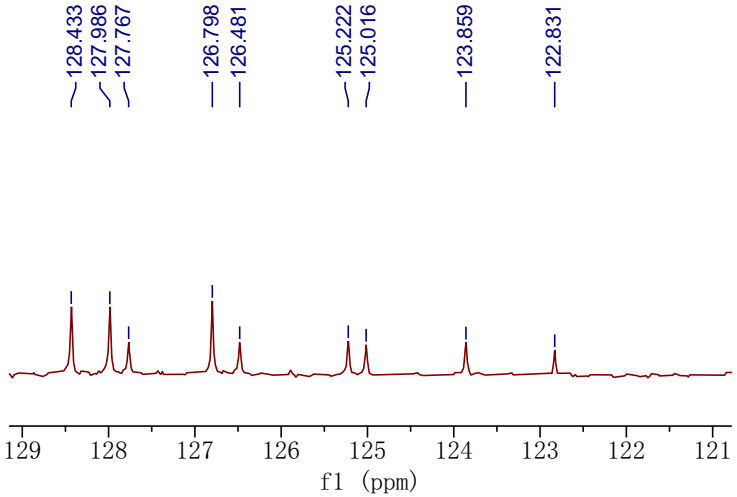


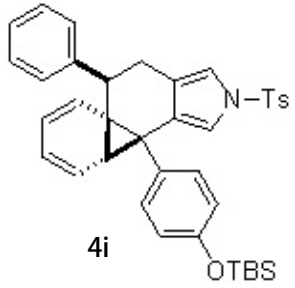
Analysis: ^{13}C NMR

Solvent: $CDCl_3$

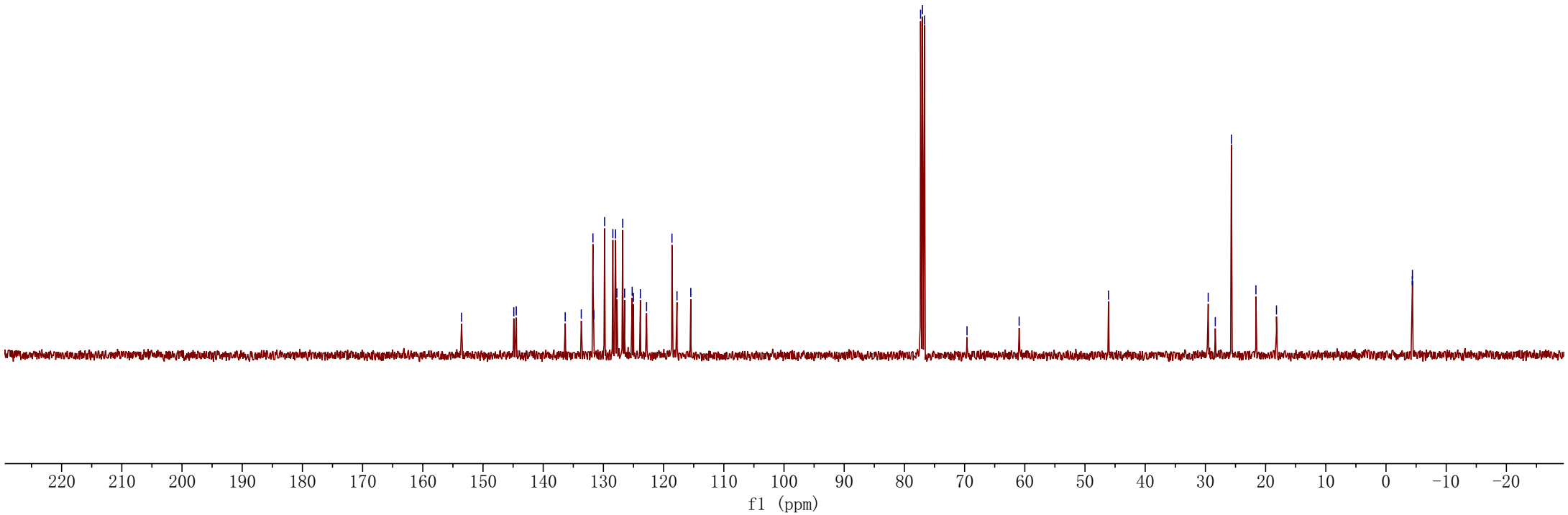
Field strength: 100 MHz

153.569
144.886
144.478
136.347
133.678
131.742
131.594
129.796
128.433
127.986
127.767
126.798
126.481
125.222
125.016
123.859
122.831
118.609
117.777
115.482
77.316
77.000
76.681
69.603
60.939
46.101
29.535
28.360
25.683
21.606
18.195
-4.370
-4.392





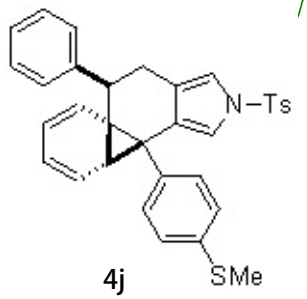
4i



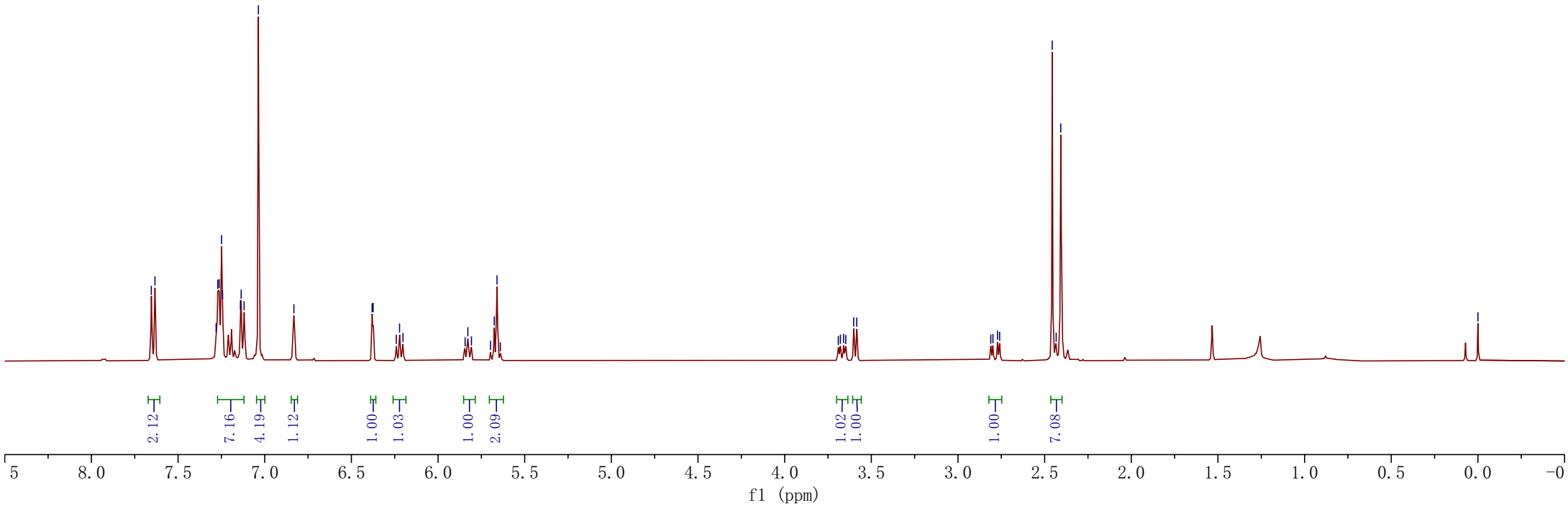
Analysis: ^{1}H NMR

Solvent: $CDCl_3$

Field strength: 400 MHz



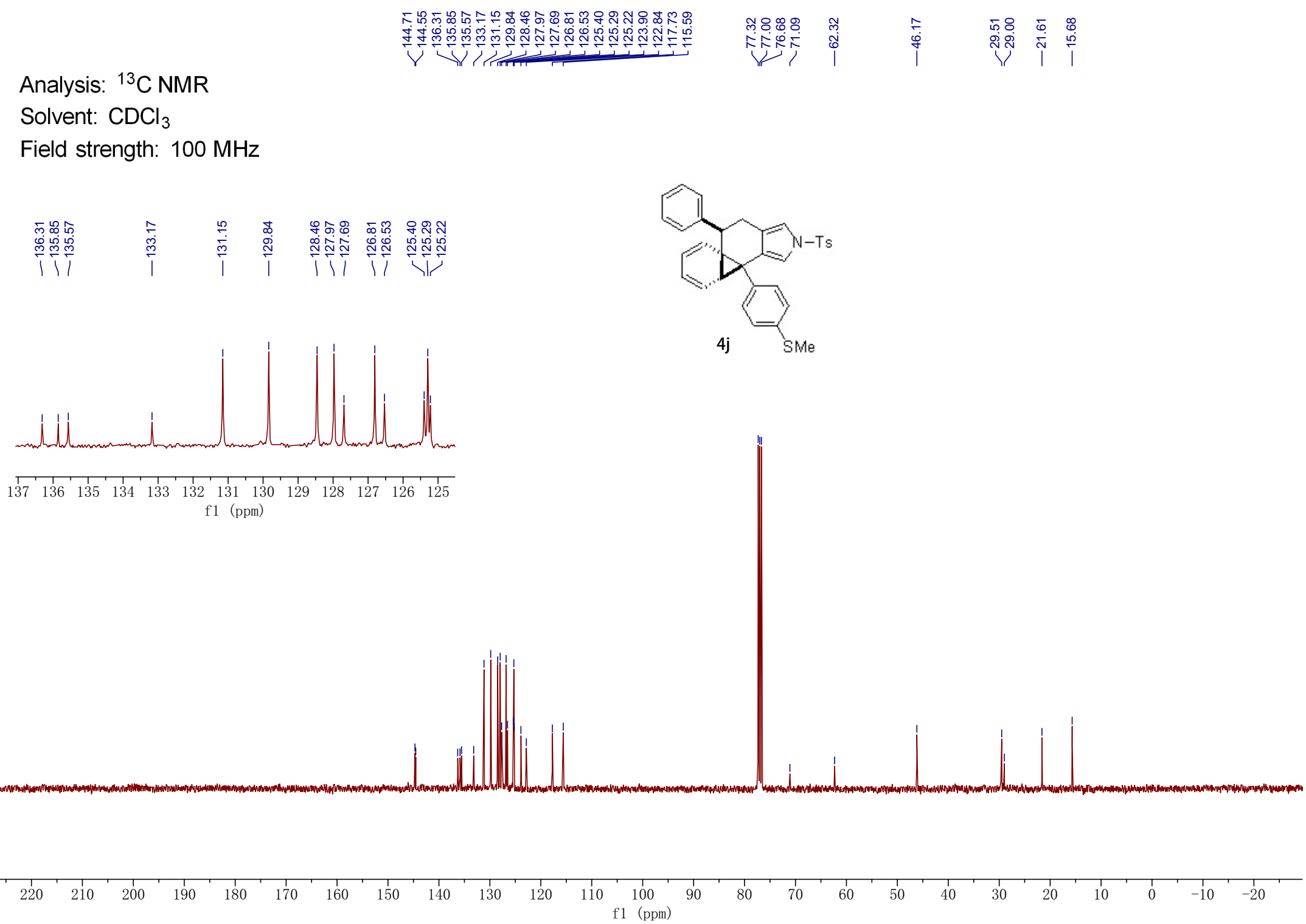
4j

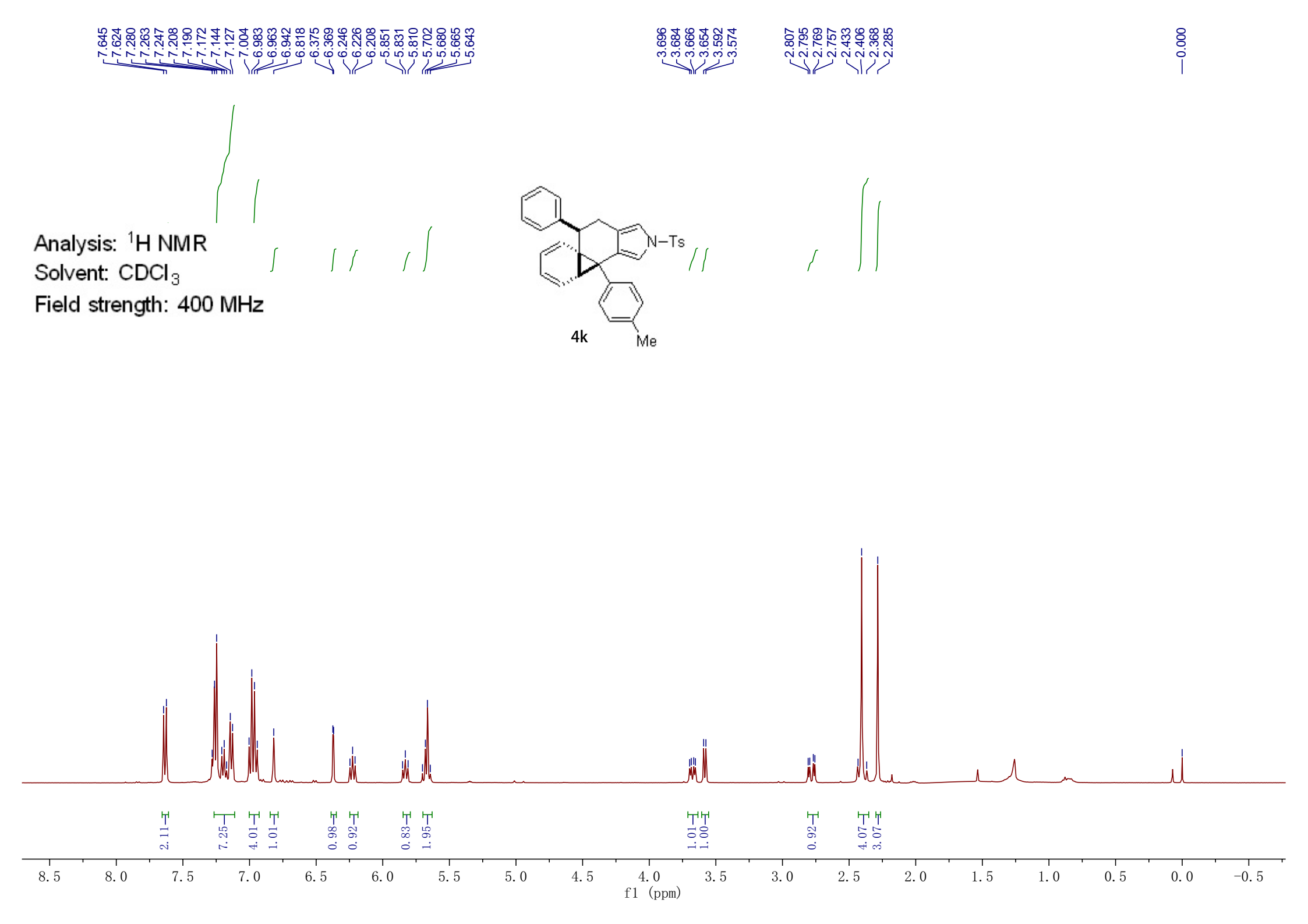


Analysis: ^{13}C NMR

Solvent: $CDCl_3$

Field strength: 100 MHz




7.645
7.624
7.280
7.263
7.247
7.208
7.190
7.172
7.144
7.127
7.004
6.983
6.963
6.942
6.818
6.375
6.369
6.246
6.226
6.208
5.851
5.831
5.810
5.702
5.680
5.665
5.643
3.696
3.684
3.666
3.654
3.592
3.574
2.807
2.795
2.769
2.757
2.433
2.406
2.368
2.285
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
N–Ts
Me
4k
2.11
7.25
4.01
1.01
0.98
0.92
0.83
1.95
1.01
1.00
0.92
4.07
3.07
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

Analysis: ^{13}C NMR

Solvent: $CDCl_3$

Field strength: 100 MHz

144.84
144.48
136.37
135.82
135.43
133.61
130.47
129.81
128.43
128.00
127.83
127.79
126.76
126.49
125.21
125.01
123.99
122.98
117.88
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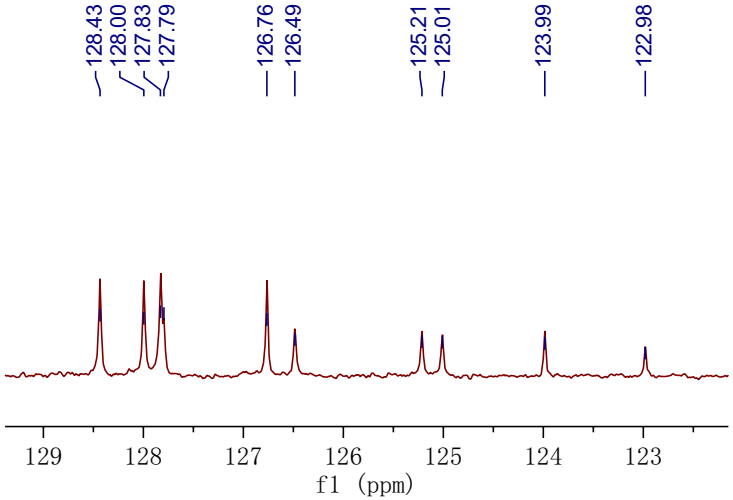
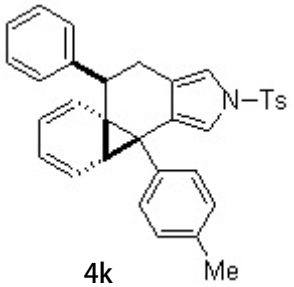
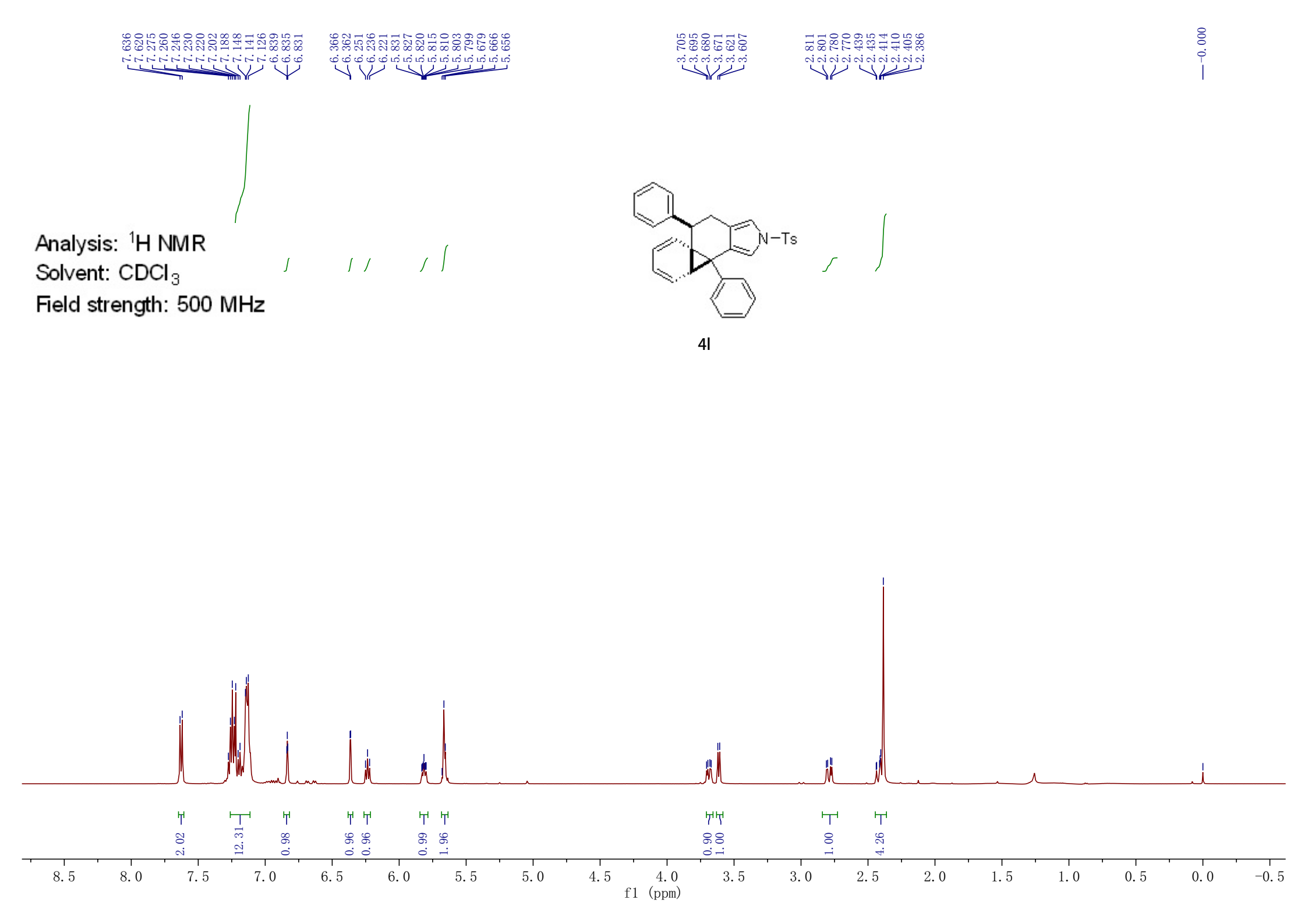
62.23
46.23
29.56
29.08
21.61
21.16





4k


7.636
7.620
7.275
7.260
7.246
7.230
7.220
7.202
7.188
7.148
7.141
7.126
6.839
6.835
6.831
6.366
6.362
6.251
6.236
6.221
5.831
5.827
5.820
5.815
5.810
5.803
5.799
5.679
5.666
5.656
3.705
3.695
3.680
3.671
3.621
3.607
2.811
2.801
2.780
2.770
2.439
2.435
2.414
2.410
2.405
2.386
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 500 MHz
N−Ts
4l
2.02
12.31
0.98
0.96
0.96
0.99
1.96
0.90
1.00
1.00
4.26
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

Analysis: ^{13}C NMR

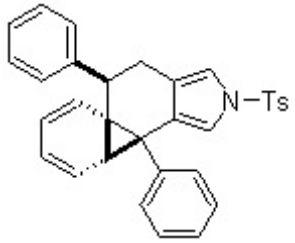
Solvent: $CDCl_3$

Field strength: 100 MHz

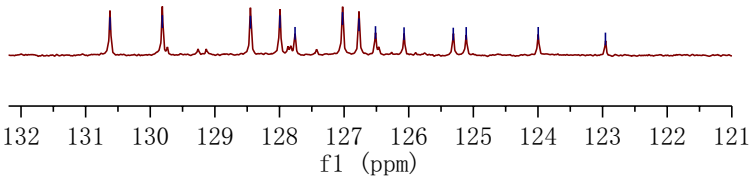
144.75, 144.52, 138.98, 136.31, 133.39, 130.62, 129.81, 128.45, 127.99, 127.76, 127.02, 126.77, 126.51, 126.07, 125.31, 125.11, 124.00, 122.96, 117.84, 115.54

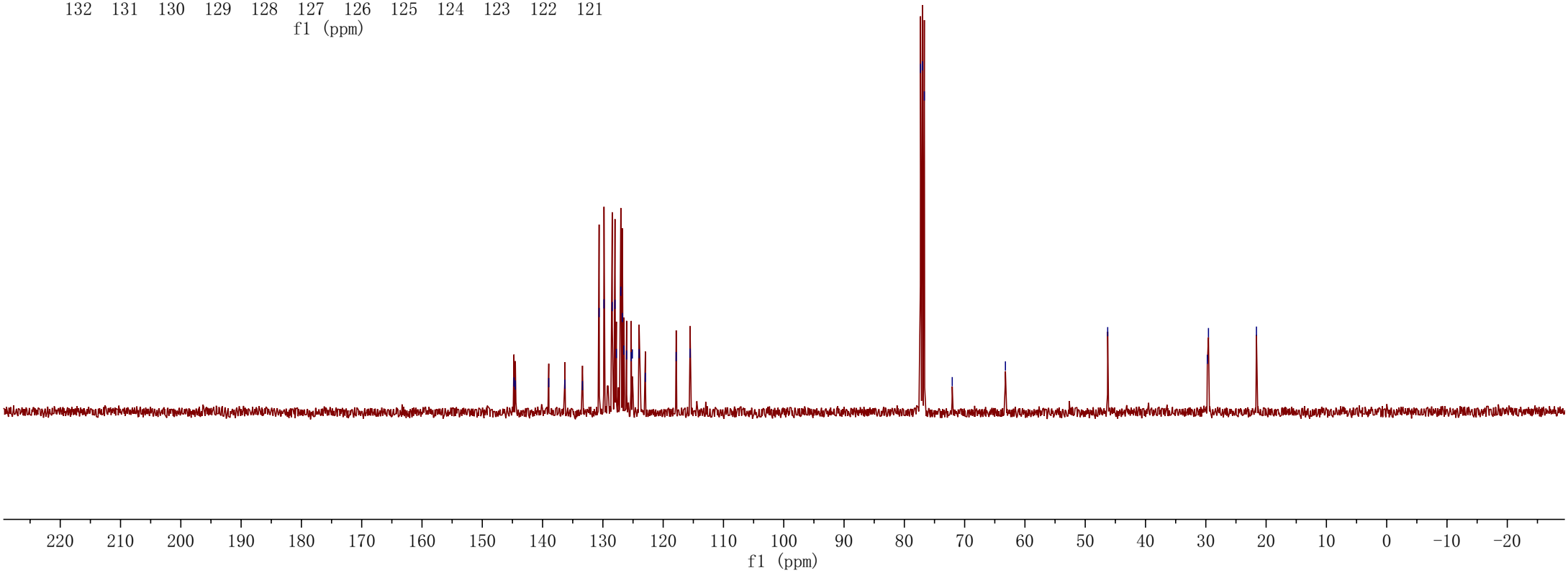
77.32, 77.00, 76.68, 72.06, 63.24, 46.28, 29.75, 29.56, 21.60

130.62, 129.81, 128.45, 127.99, 127.76, 127.02, 126.77, 126.51, 126.07, 125.31, 125.11, 124.00, 122.96



4l

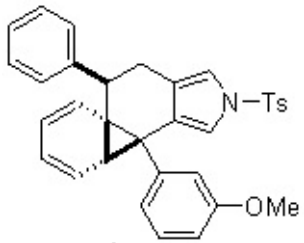




Analysis: ^{1}H NMR

Solvent: $CDCl_3$

Field strength: 400 MHz



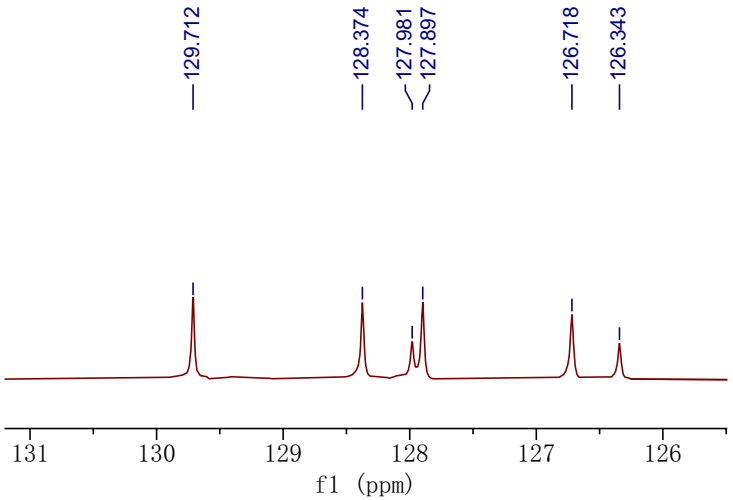
4m

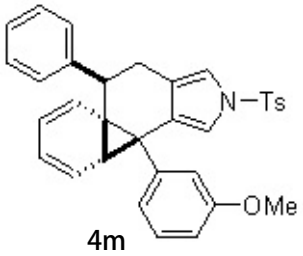
Analysis: ^{13}C NMR

Solvent: $CDCl_3$

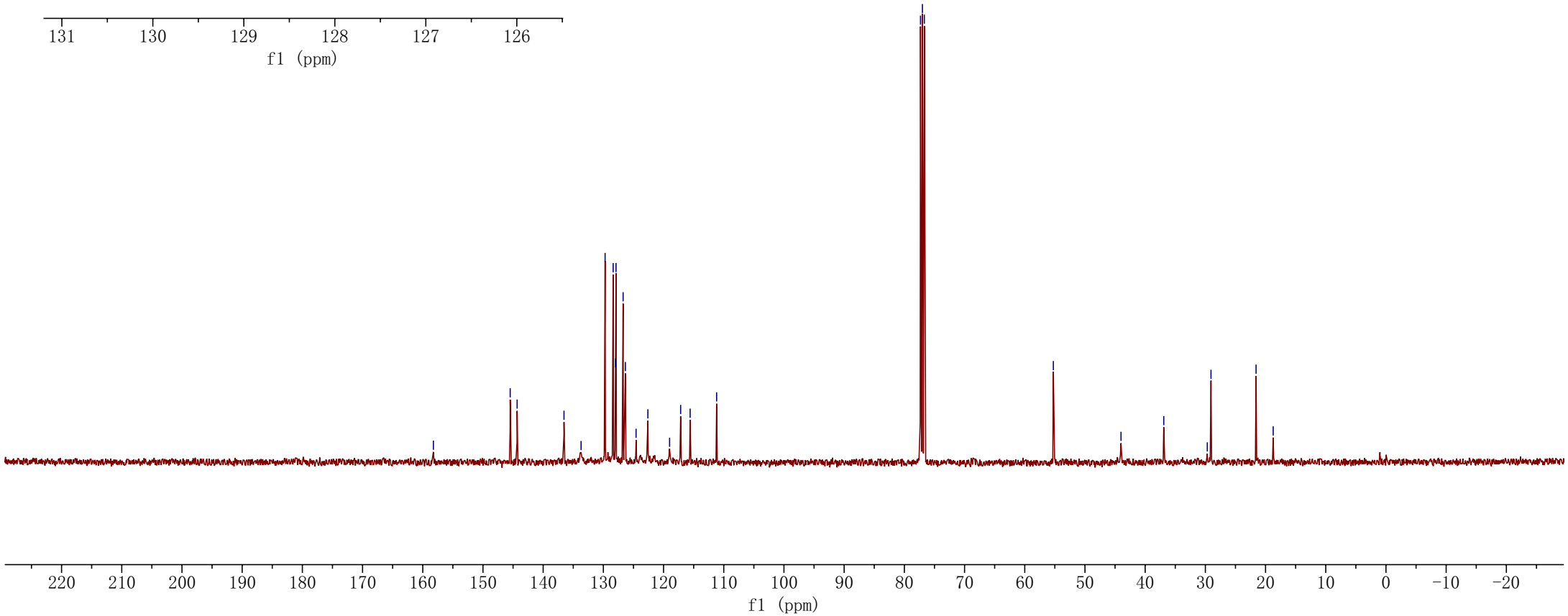
Field strength: 100 MHz

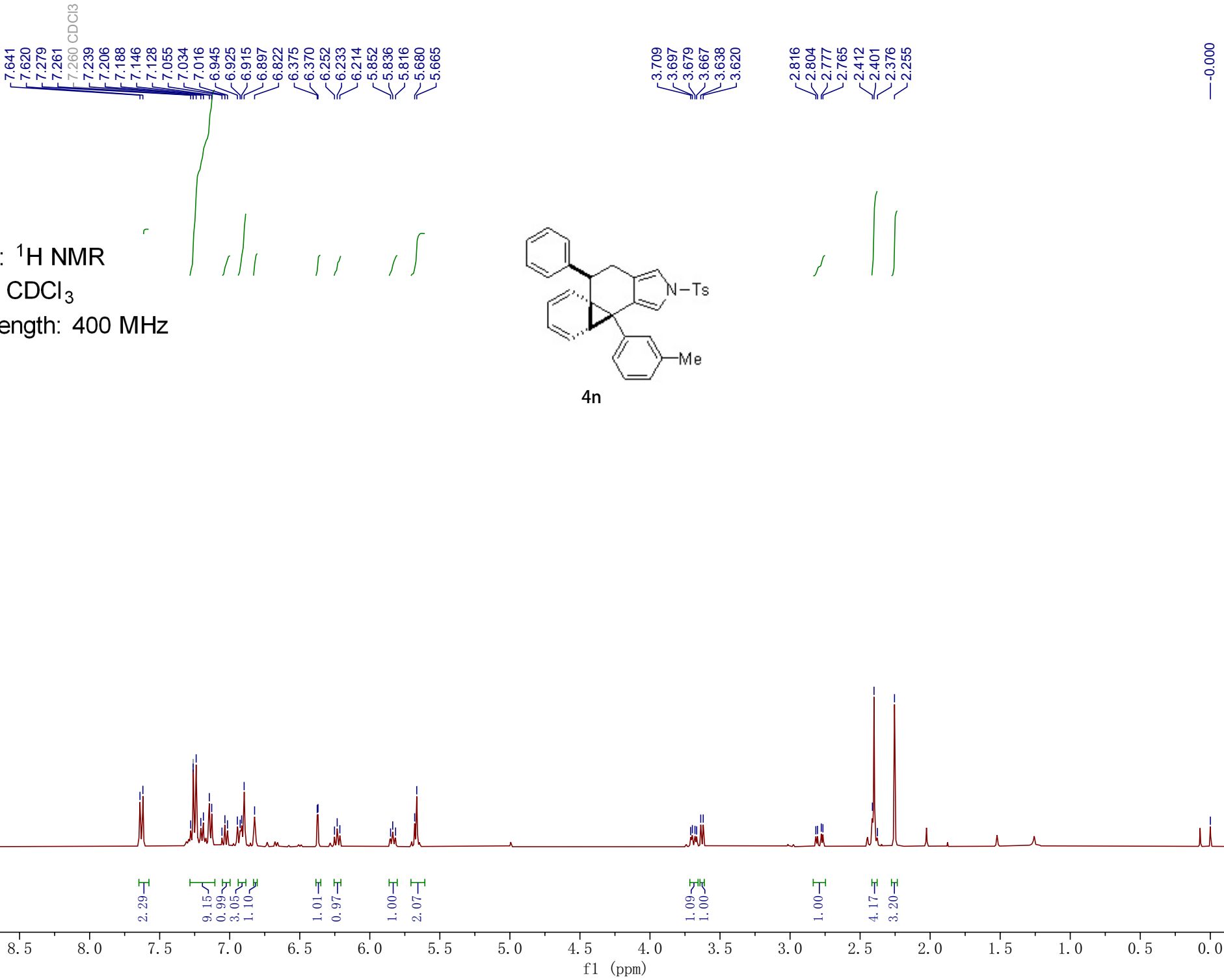
158.235
145.478
144.324
136.539
133.701
129.712
128.374
127.981
127.897
126.718
126.343
124.567
122.604
118.997
117.163
115.586
111.183
77.319
77.000
76.683
55.253
44.011
36.907
29.680
29.064
21.578
18.732





4m




7.641
7.620
7.279
7.261
7.260 CDCl3
7.239
7.206
7.188
7.146
7.128
7.055
7.034
7.016
6.945
6.925
6.915
6.897
6.822
6.375
6.370
6.252
6.233
6.214
5.852
5.836
5.816
5.680
5.665
3.709
3.697
3.679
3.667
3.638
3.620
2.816
2.804
2.777
2.765
2.412
2.401
2.376
2.255
-0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
N–Ts
Me
4n
2.29
9.15
0.99
3.05
1.10
1.01
0.97
1.00
2.07
1.09
1.00
1.00
4.17
3.20
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

Analysis: ^{13}C NMR

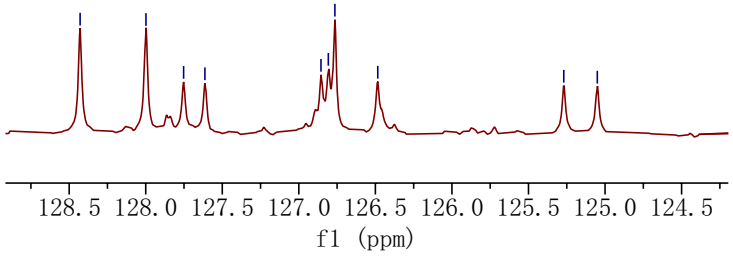
Solvent: $CDCl_3$

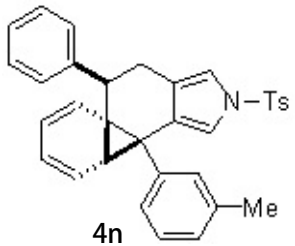
Field strength: 100 MHz

144.82 144.49 138.92 136.36 136.30 133.58 131.32 129.80 128.43 128.00 127.75 127.61 126.86 126.81 126.76 126.48 125.27 125.05 123.98 123.02 117.92 115.51

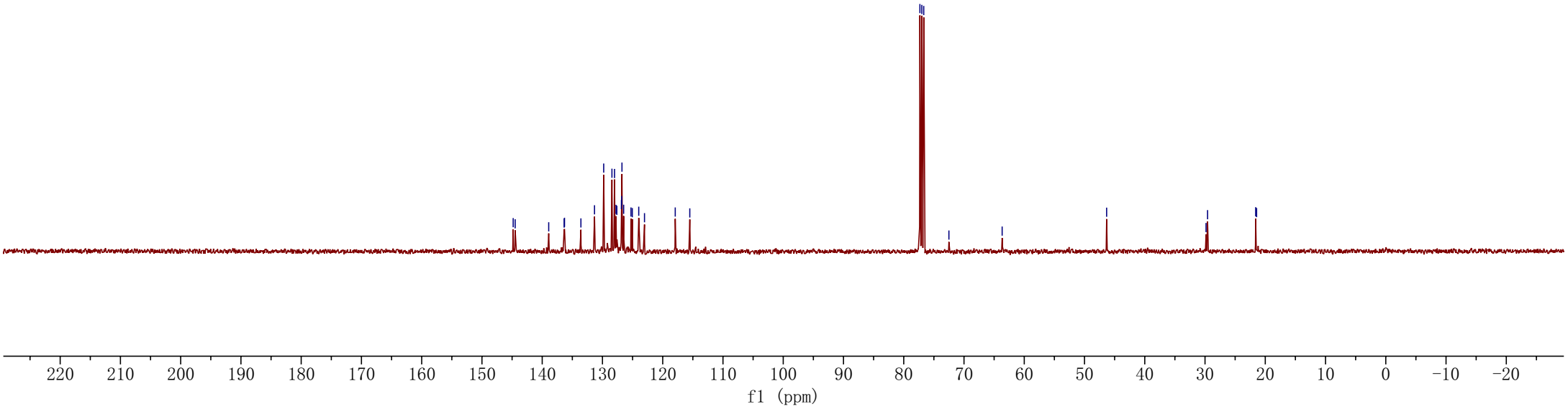
77.32 77.00 76.68 72.50 63.67 46.33 29.83 29.58 21.60 21.44

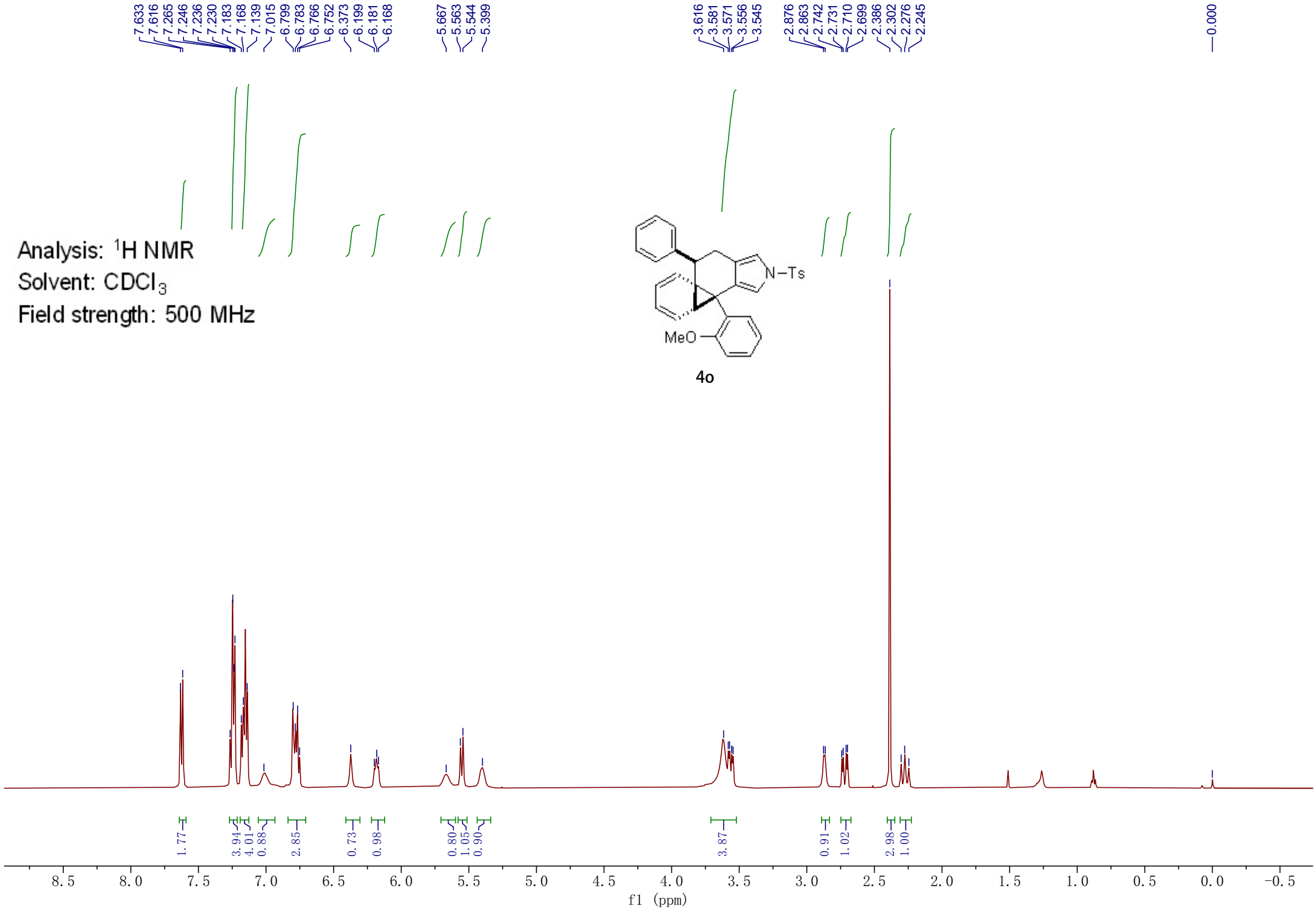
128.43 128.00 127.75 127.61 126.86 126.81 126.76 126.48 125.27 125.05





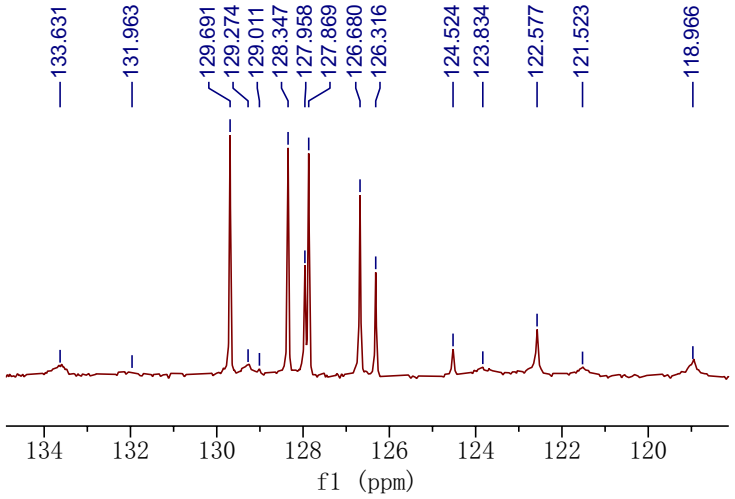
4n

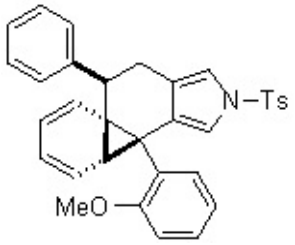



7.633
7.616
7.265
7.246
7.236
7.230
7.183
7.168
7.139
7.015
6.799
6.783
6.766
6.752
6.373
6.199
6.181
6.168
5.667
5.563
5.544
5.399
3.616
3.581
3.571
3.556
3.545
2.876
2.863
2.742
2.731
2.710
2.699
2.386
2.302
2.276
2.245
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 500 MHz
N–Ts
MeO
4o
1.77
3.94
4.01
0.88
2.85
0.73
0.98
0.80
1.05
0.90
3.87
0.91
1.02
2.98
1.00
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

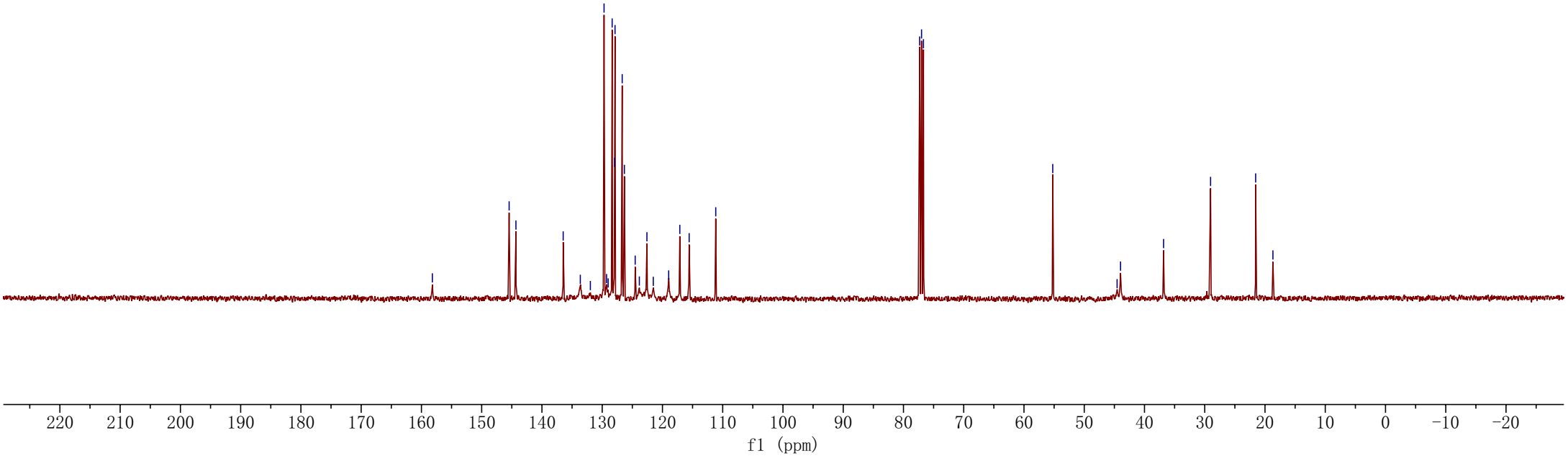
Analysis: ^{13}C NMR
Solvent: $CDCl_3$
Field strength: 125 MHz

158.188
145.443
144.316
136.474
133.631
131.963
129.691
129.274
129.011
128.347
127.958
127.869
126.680
126.316
124.524
123.834
122.577
121.523
118.966
117.119
115.567
111.153
77.318
77.001
76.682
55.226
44.545
43.974
36.833
29.032
21.552
18.686

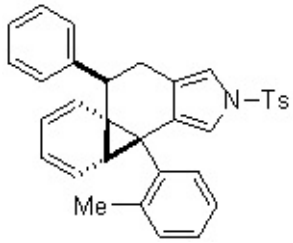




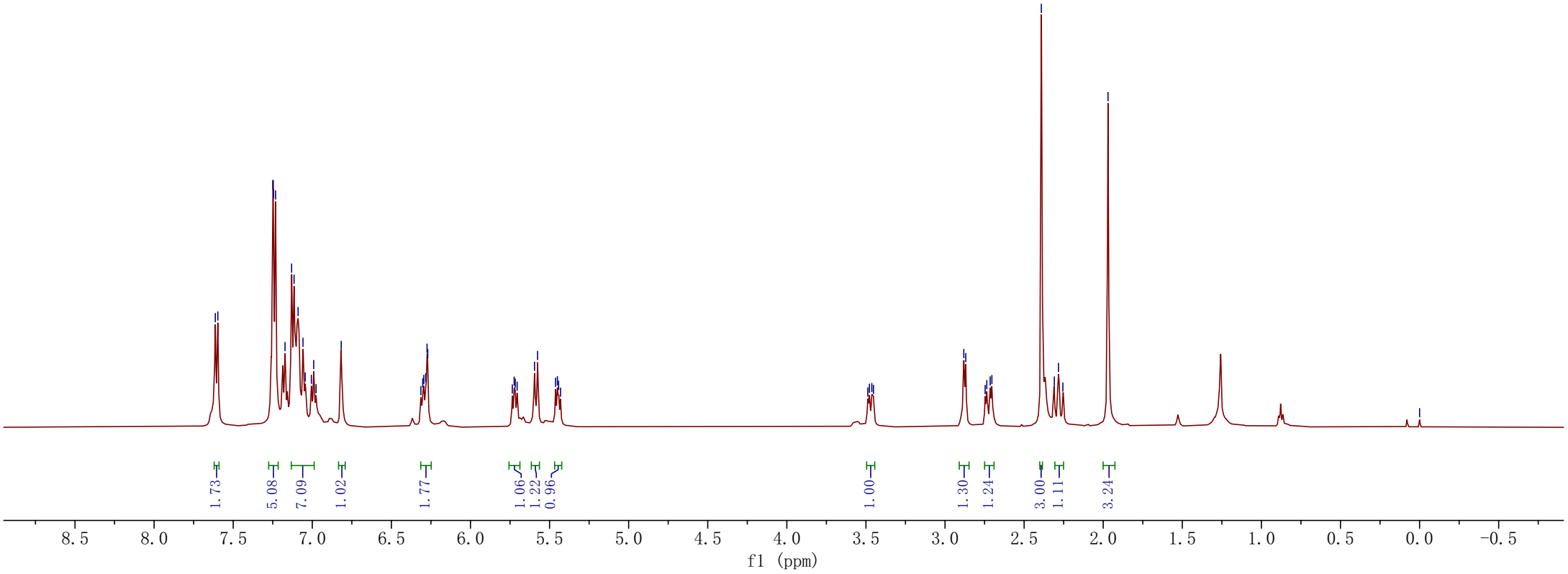
4o



Analysis: ^{1}H NMR
Solvent: $CDCl_3$
Field strength: 500 MHz

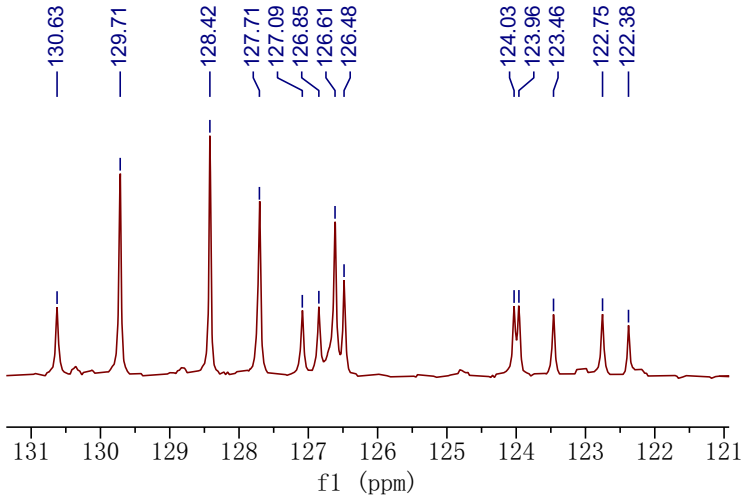


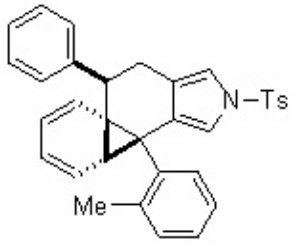
4p



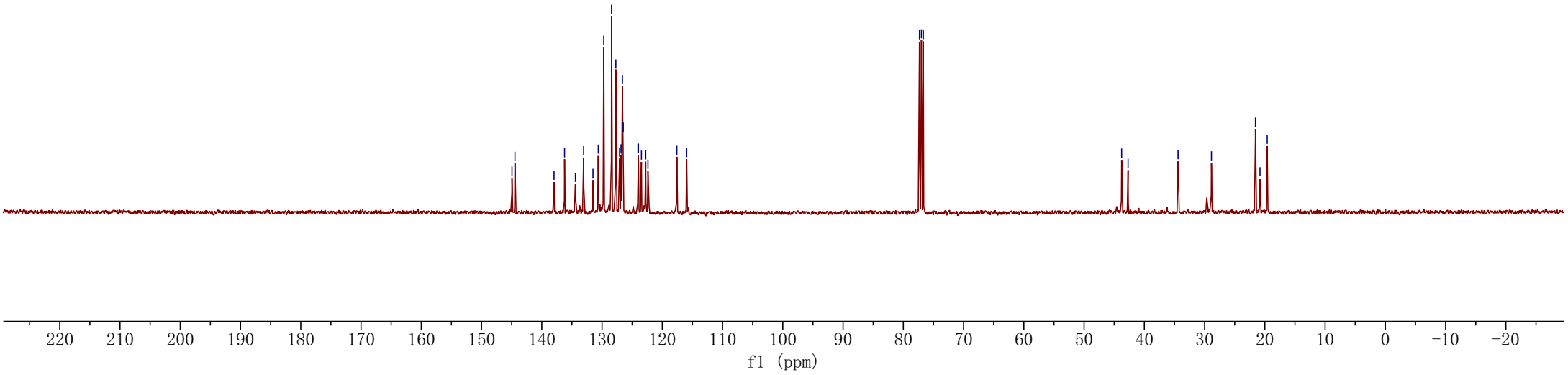
Analysis: ^{13}C NMR
Solvent: $CDCl_3$
Field strength: 125 MHz

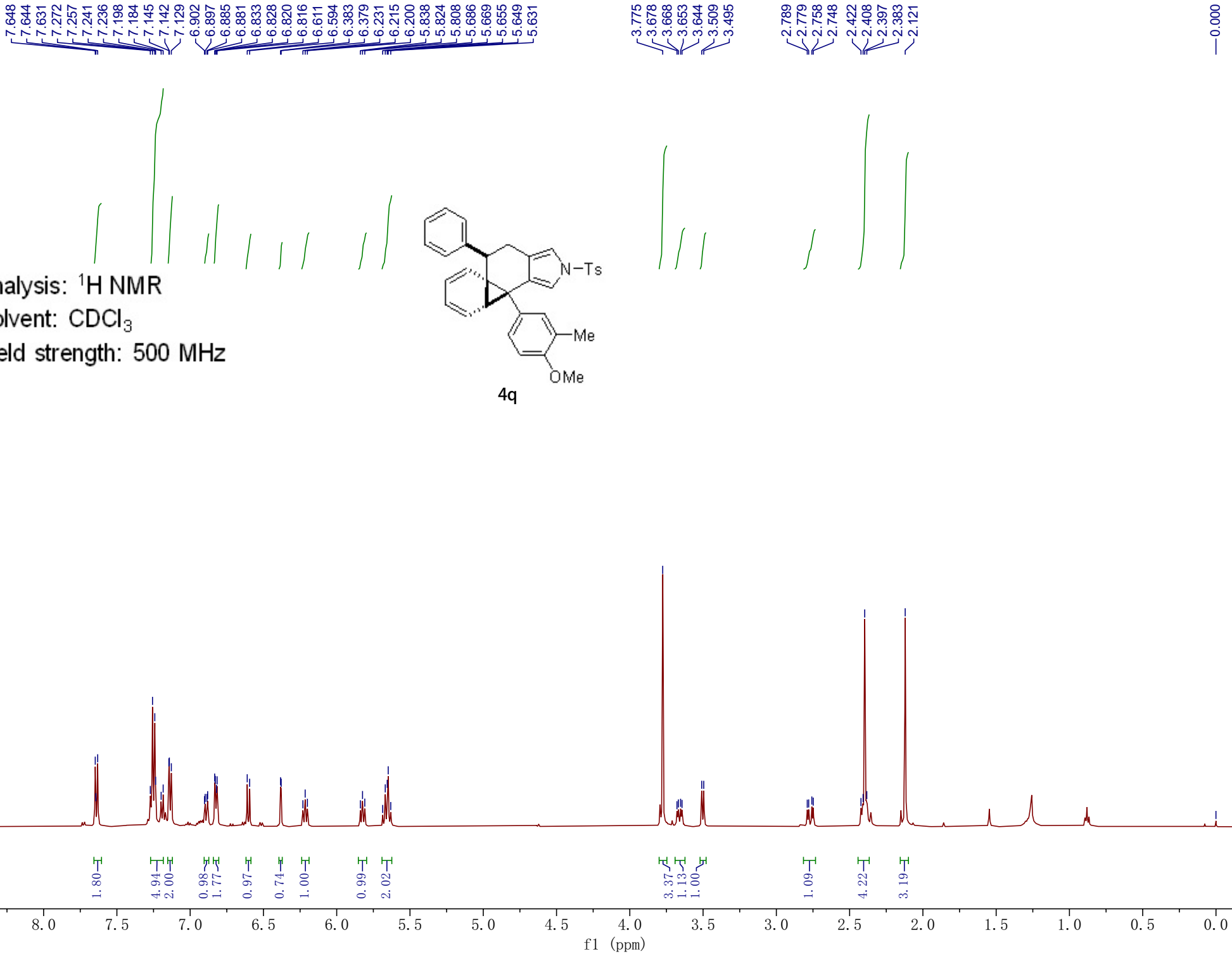
144.94 144.45 137.97 136.22 134.42 133.05 131.50 130.63 129.71 128.42 127.71 127.09 126.85 126.61 126.48 124.03 123.96 123.46 122.75 122.38 117.58 115.95 77.32 77.00 76.68 43.77 42.70 34.41 28.86 21.56 20.81 19.61





4p




7.648
7.644
7.631
7.272
7.257
7.241
7.236
7.198
7.184
7.145
7.142
7.129
6.902
6.897
6.885
6.881
6.833
6.828
6.820
6.816
6.611
6.594
6.383
6.379
6.231
6.215
6.200
5.838
5.824
5.808
5.686
5.669
5.655
5.649
5.631
3.775
3.678
3.668
3.653
3.644
3.509
3.495
2.789
2.779
2.758
2.748
2.422
2.408
2.397
2.383
2.121
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 500 MHz
N–Ts
Me
OMe
4q
1.80
4.94
2.00
0.98
1.77
0.97
0.74
1.00
0.99
2.02
3.37
1.13
1.00
1.09
4.22
3.19
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

Analysis: ^{13}C NMR
Solvent: $CDCl_3$
Field strength: 125 MHz

155.75
144.92
144.46
136.35
133.92
133.00
130.34
129.78
128.92
128.40
127.96
127.87
126.75
126.44
125.08
124.86
124.82
123.89
122.91
117.86
115.46
108.40
77.32
77.00
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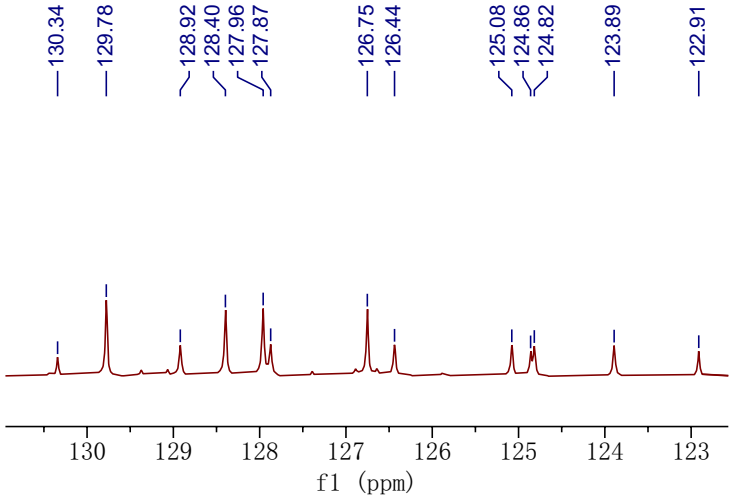
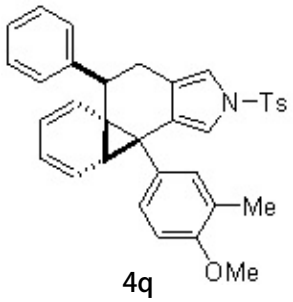
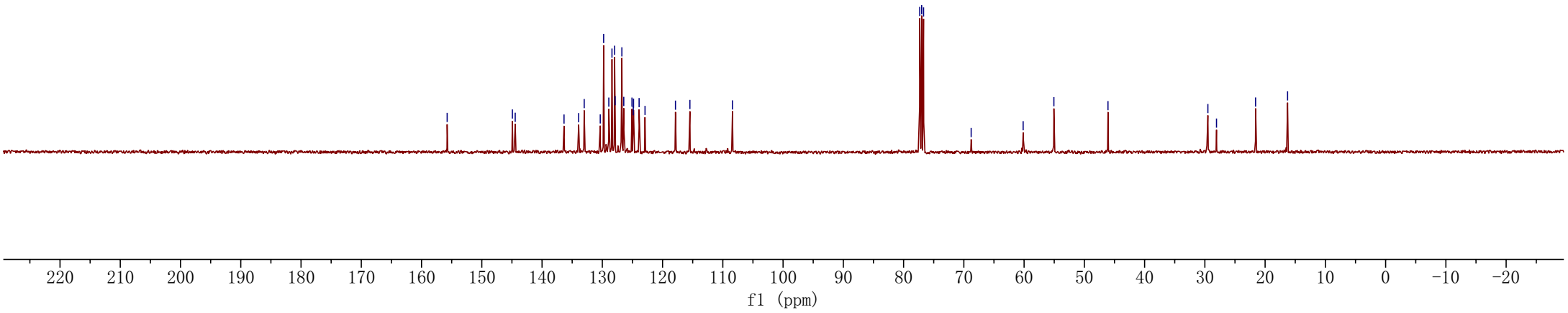
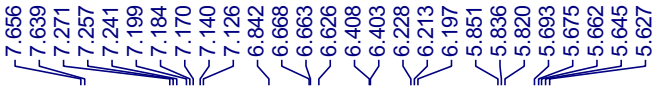
60.16
55.05
46.08
29.50
28.07
21.58
16.27

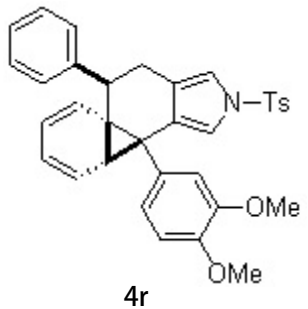




4q





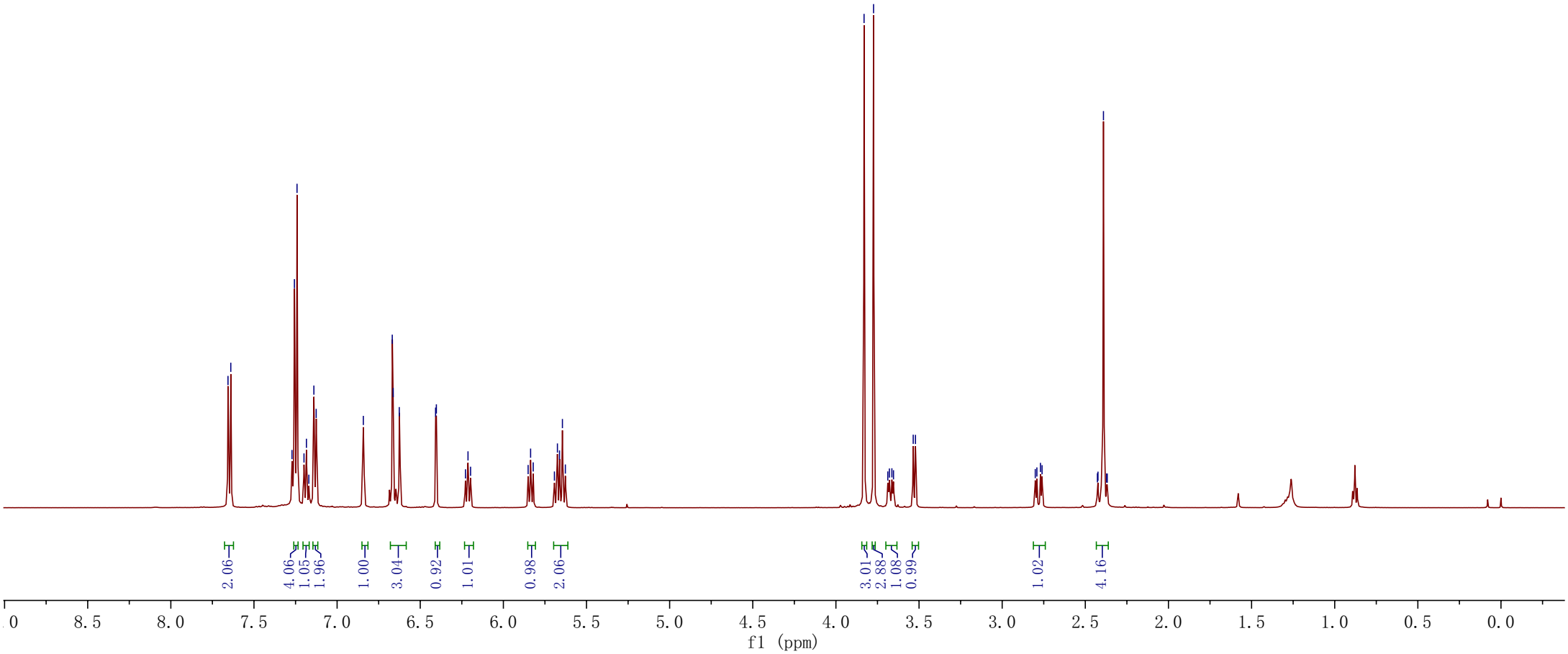


4r

Analysis: ^{1}H NMR

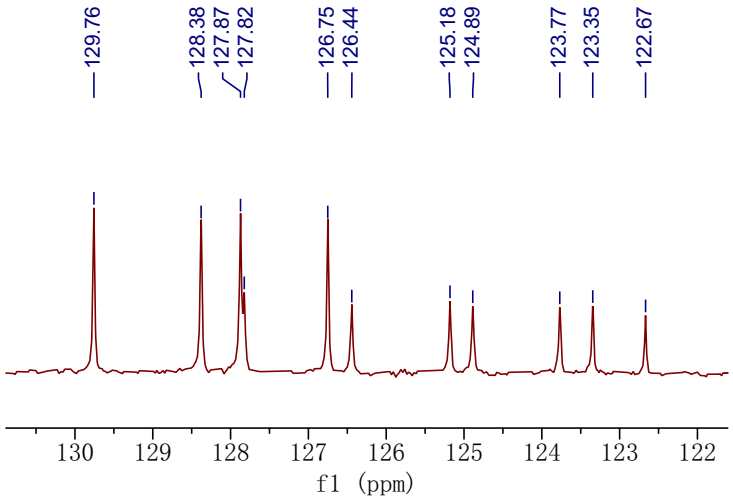
Solvent: $CDCl_3$

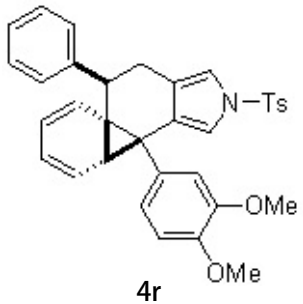
Field strength: 500 MHz



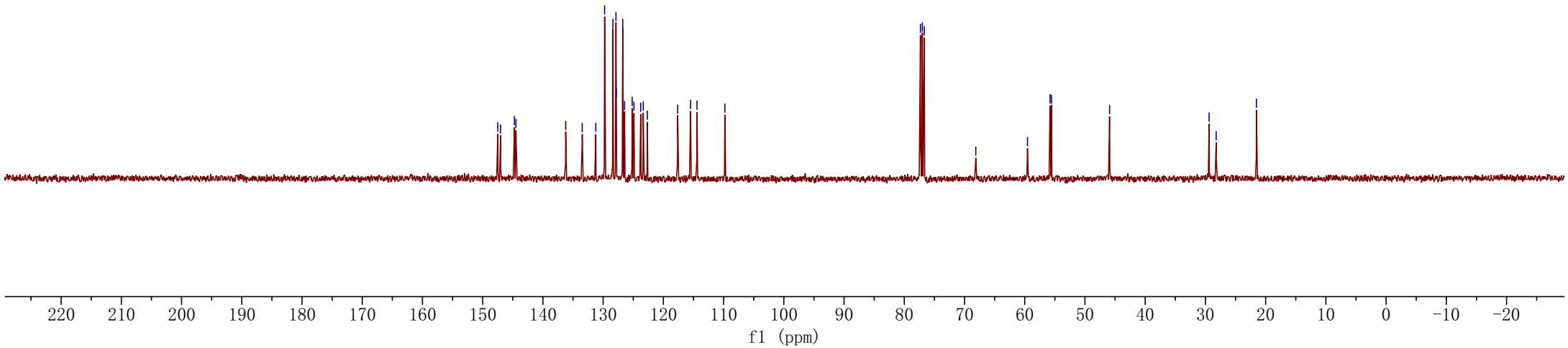
Analysis: ^{13}C NMR
Solvent: $CDCl_3$
Field strength: 125 MHz

147.50 147.03 144.73 144.48 136.22 133.48 131.22 129.76 128.38 127.87 127.82 126.75 126.44 125.18 124.89 123.77 123.35 122.67 117.63 115.48 114.42 109.79 77.32 77.00 76.68 68.13 59.54 55.80 55.56 45.92 29.39 28.22 21.53

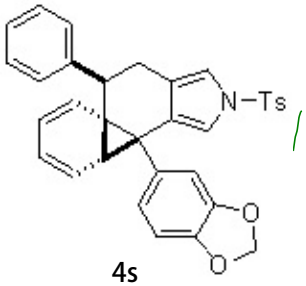




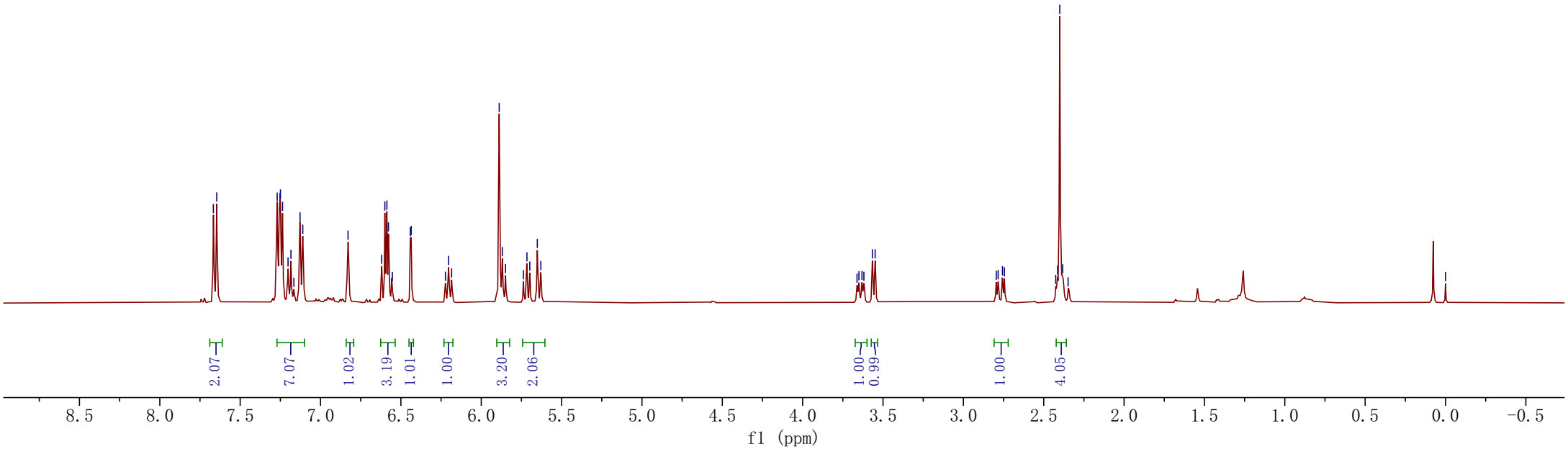
4r



Analysis: ^{1}H NMR
Solvent: $CDCl_3$
Field strength: 400 MHz



4s



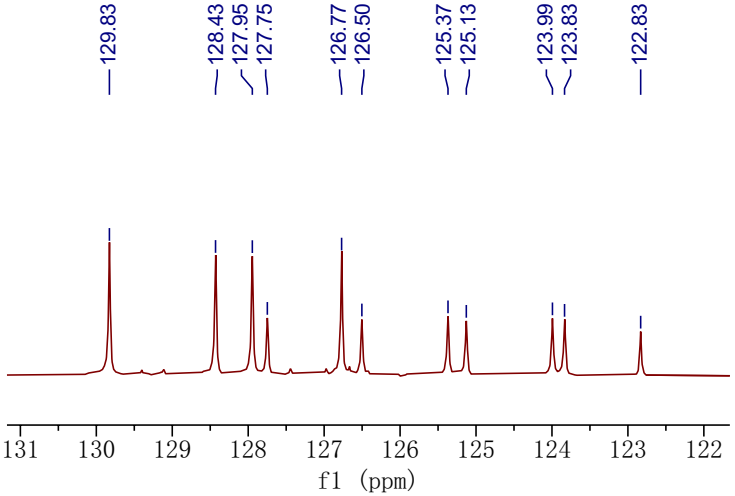
Analysis: ^{13}C NMR

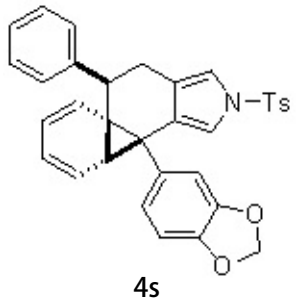
Solvent: $CDCl_3$

Field strength: 100 MHz

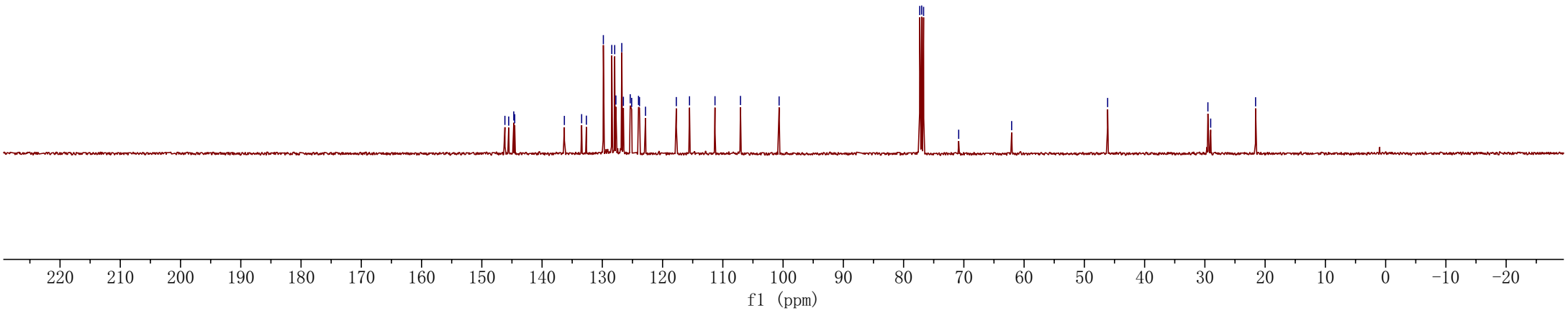
146.17
145.54
144.70
144.54
136.30
133.43
132.64
129.83
128.43
127.95
127.75
126.77
126.50
125.37
125.13
123.99
123.83
122.83
117.72
115.53
111.30
107.07
100.66

77.32
77.00
76.68
70.86
62.07
46.14
29.50
29.04
21.58





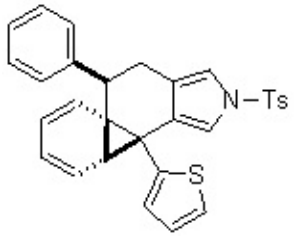
4s



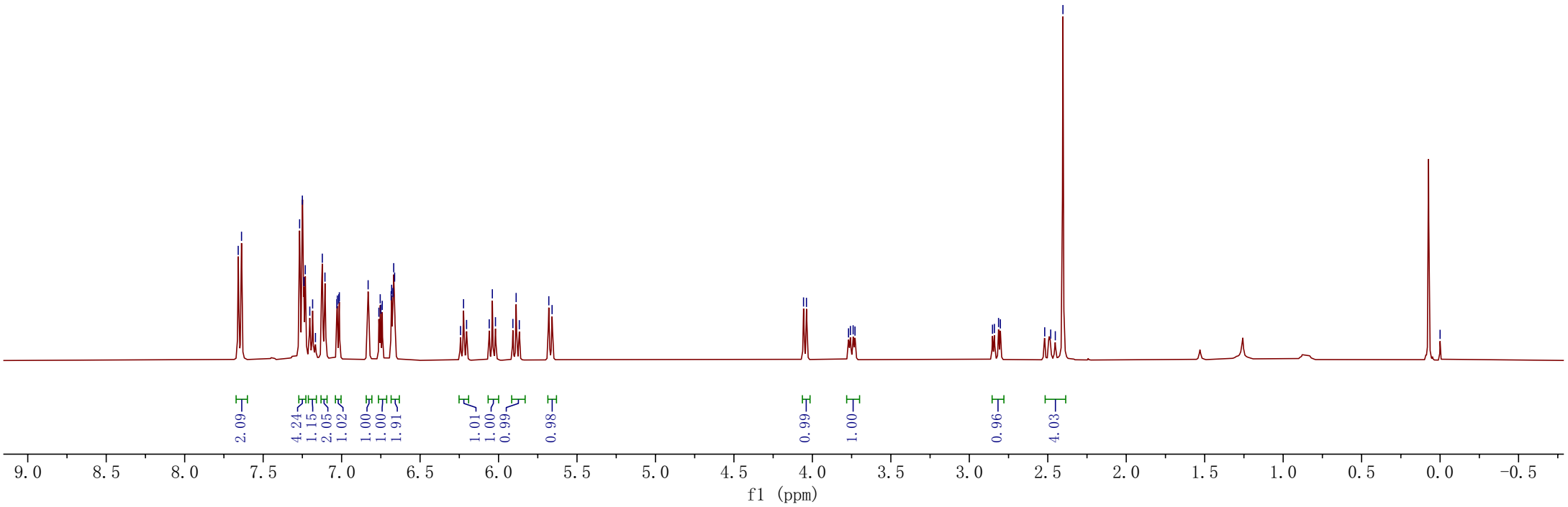
Analysis: ^{1}H NMR

Solvent: $CDCl_3$

Field strength: 400 MHz



4t



Analysis: ^{13}C NMR

Solvent: $CDCl_3$

Field strength: 100 MHz

144.562
144.281
143.271
136.313
133.554
129.841
128.434
128.167
127.995
127.464
126.725
126.612
126.533
126.308
124.850
124.071
123.212
122.974
117.926
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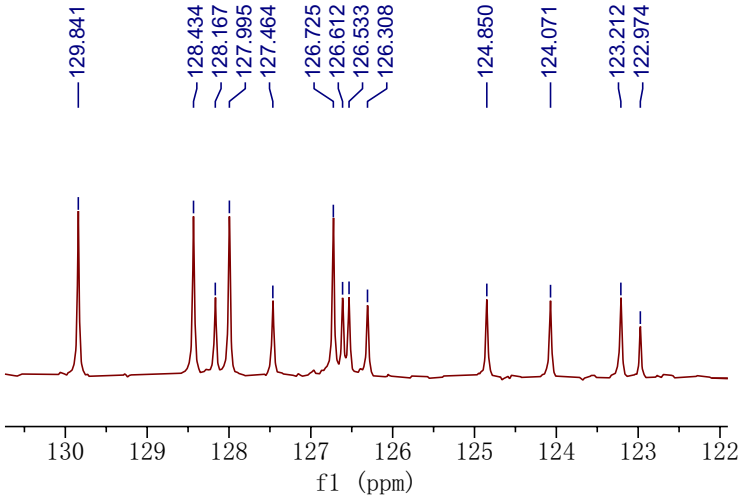
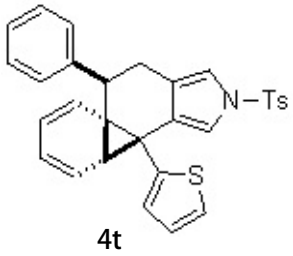
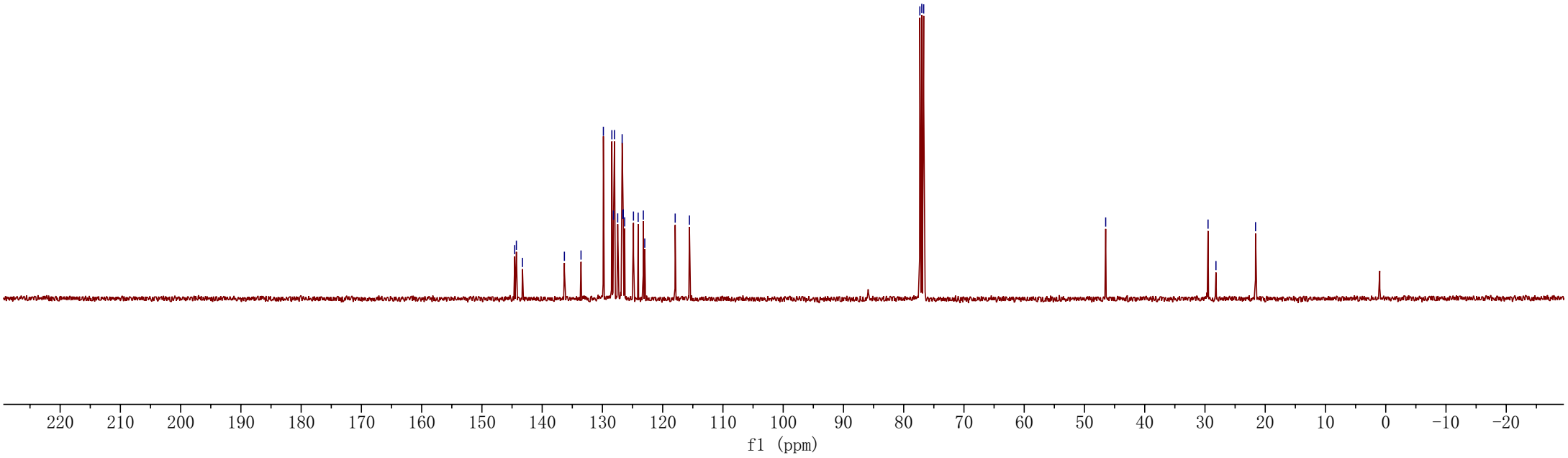
77.000
76.684
46.480
29.490
28.178
21.606





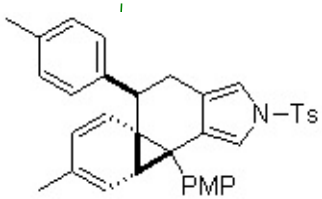
4t



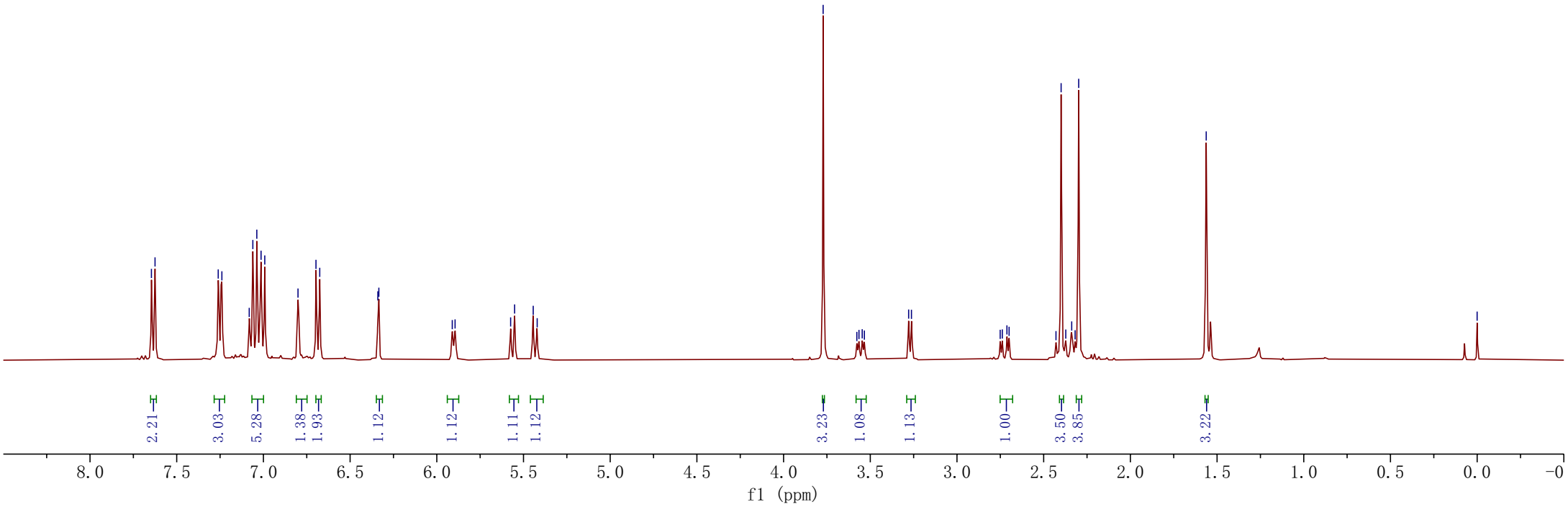
Analysis: ^{1}H NMR

Solvent: $CDCl_3$

Field strength: 400 MHz



4u



Analysis: ^{13}C NMR

Solvent: $CDCl_3$

Field strength: 100 MHz

157.49 144.42 142.06 136.40 135.90 133.79 132.98 132.14 130.98 129.78 129.15 128.30 127.80 127.01 126.78 122.90 120.42 117.57 115.44 112.45

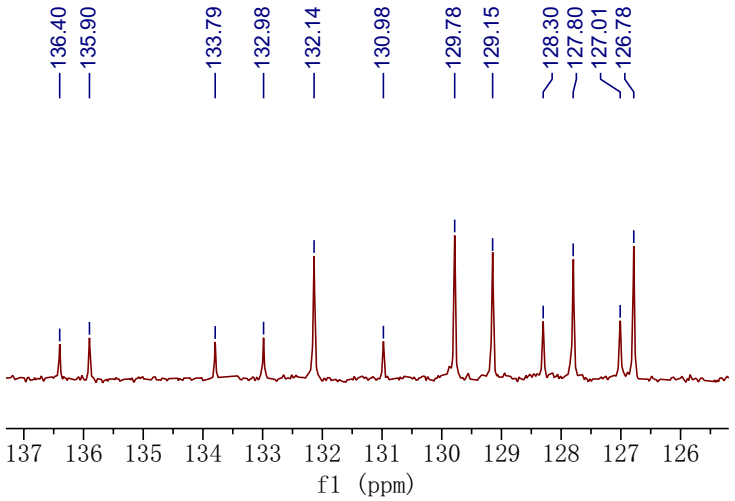
77.32 77.00 76.68

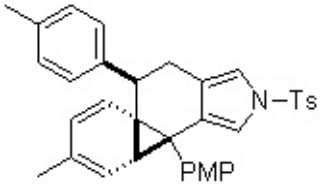
60.85

55.06 53.27

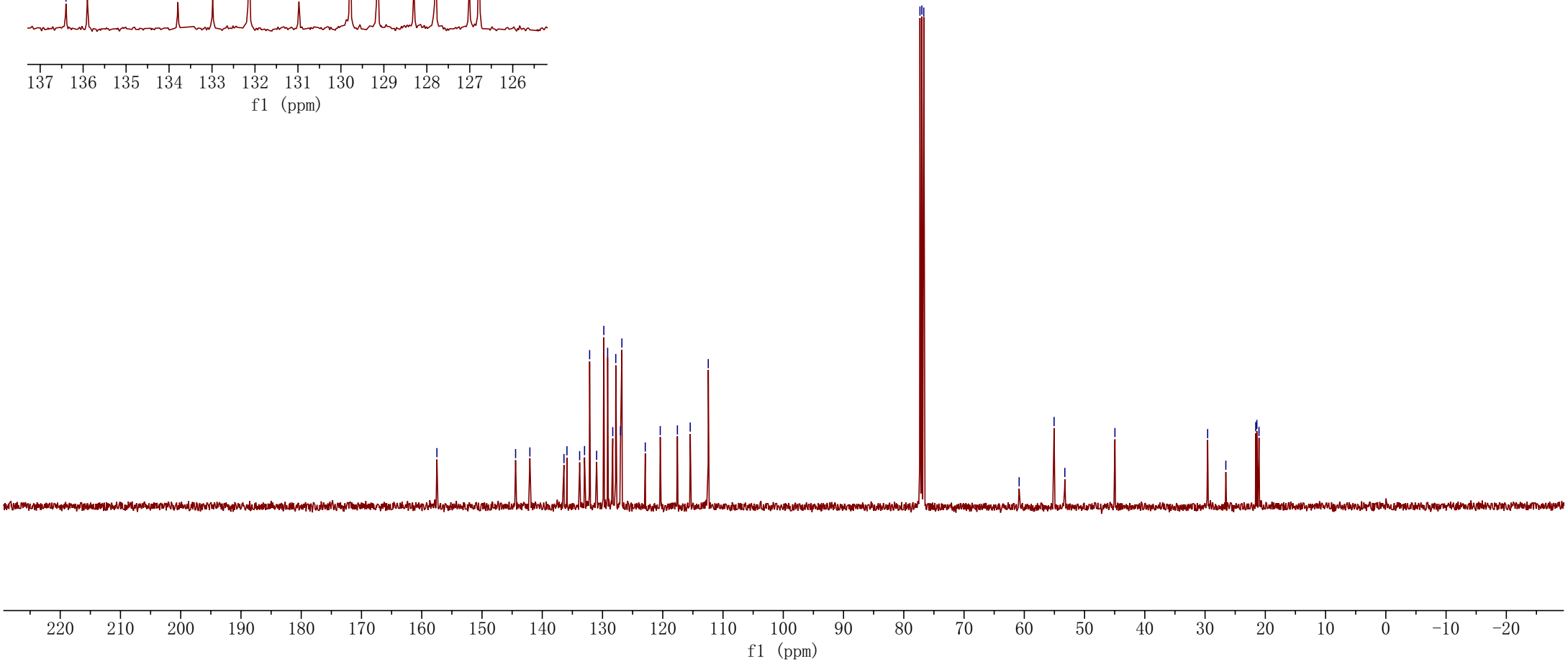
44.96

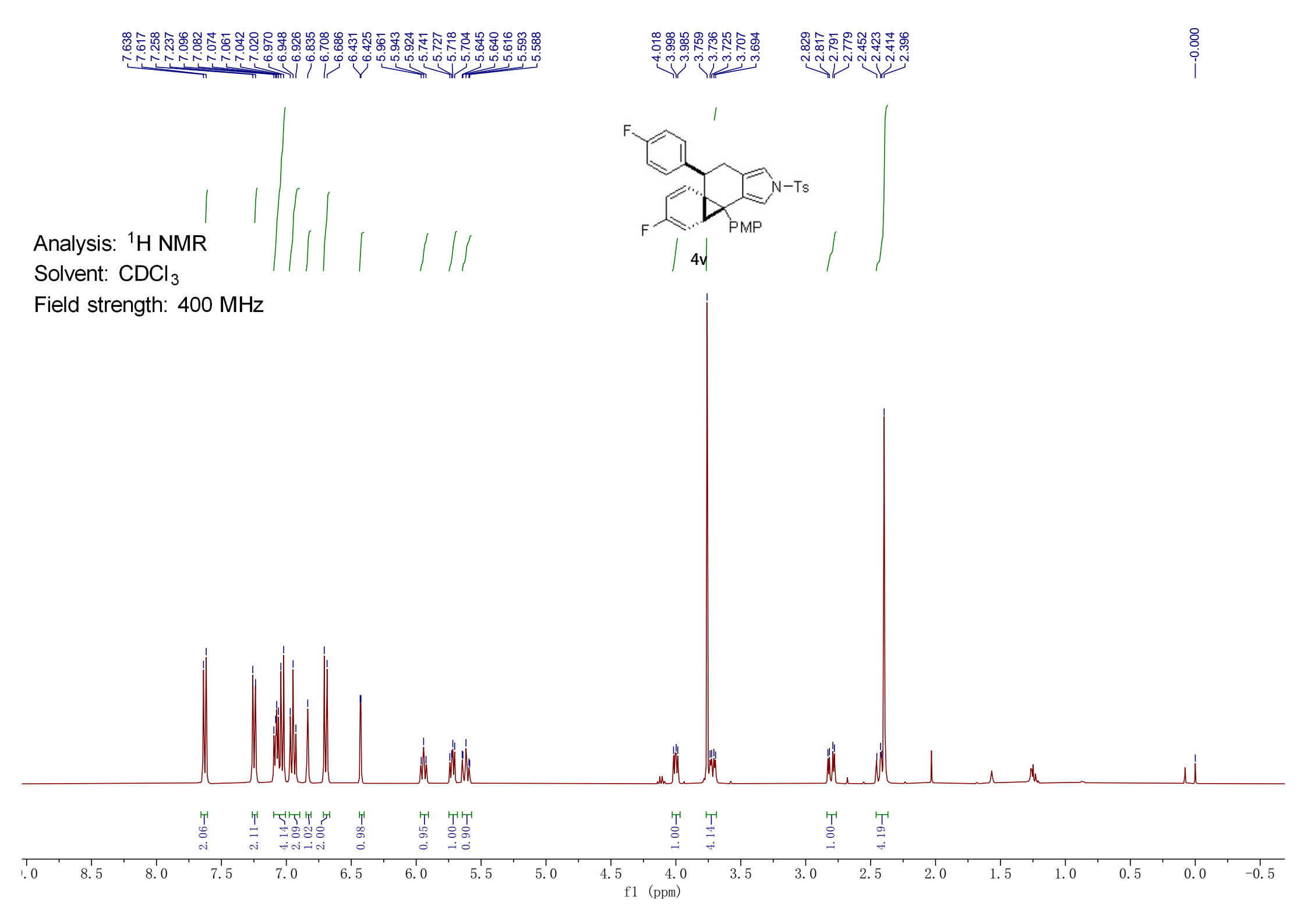
29.57 26.55 21.59 21.41 21.05





4u

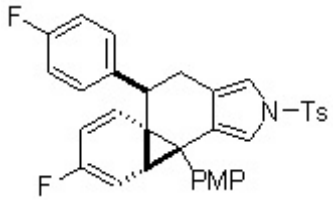



7.638
7.617
7.258
7.237
7.096
7.082
7.074
7.061
7.042
7.020
6.970
6.948
6.926
6.835
6.708
6.686
6.431
6.425
5.961
5.943
5.924
5.741
5.727
5.718
5.704
5.645
5.640
5.616
5.593
5.588
4.018
3.998
3.985
3.759
3.736
3.725
3.707
3.694
2.829
2.817
2.791
2.779
2.452
2.423
2.414
2.396
-0.000
F
N–Ts
F
PMP
4v
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
2.06
2.11
4.14
2.09
1.02
2.00
0.98
0.95
1.00
0.90
1.00
4.14
1.00
4.19
f1 (ppm)

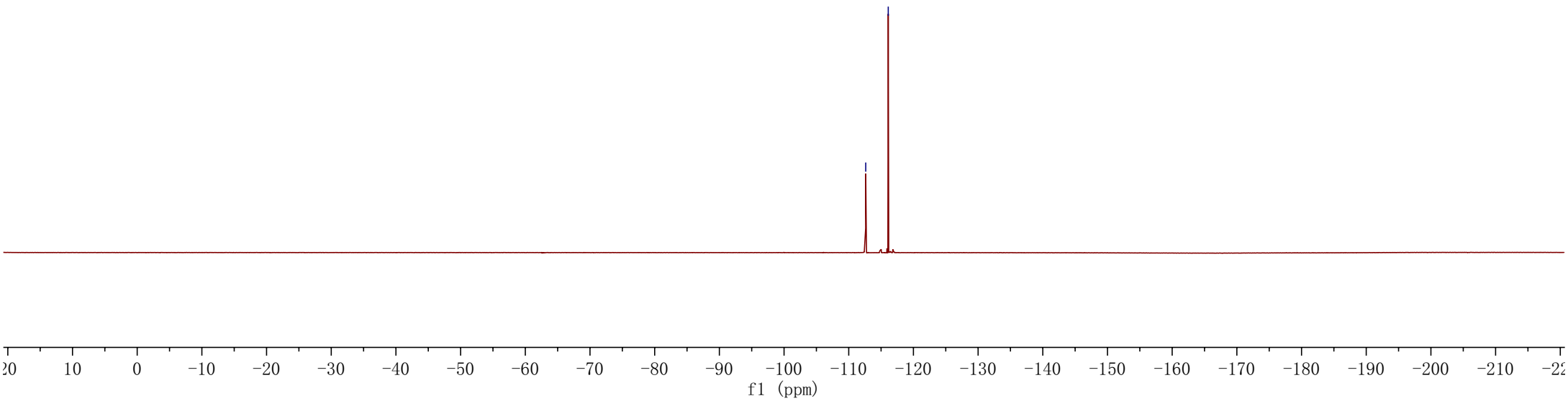
Analysis: ^{19}F NMR

Solvent: $CDCl_3$

Field strength: 471 MHz



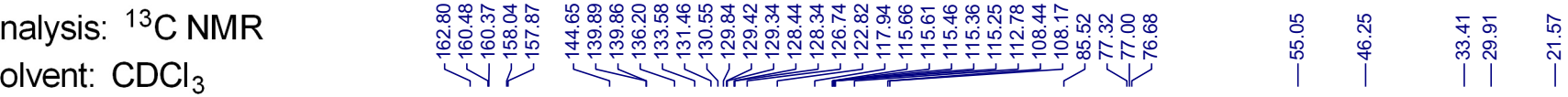
4v

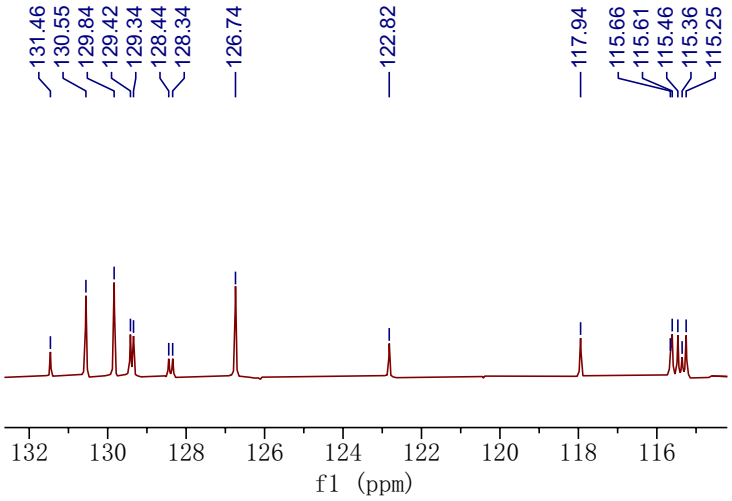


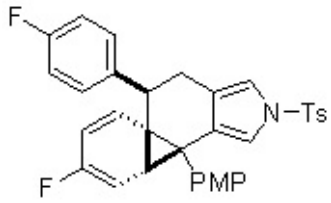
Analysis: ^{13}C NMR

Solvent: $CDCl_3$

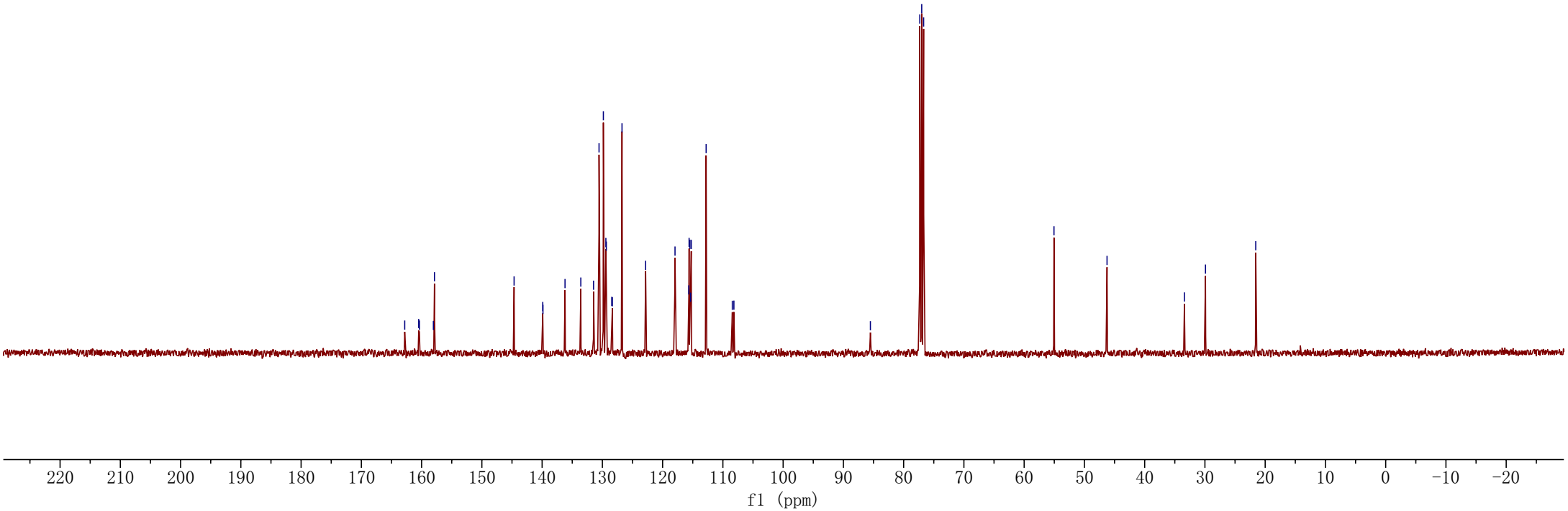
Field strength: 100 MHz







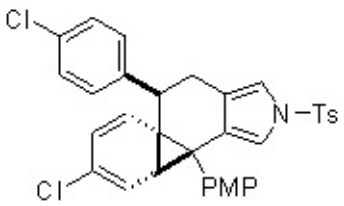
4v



Analysis: ^{1}H NMR

Solvent: $CDCl_3$

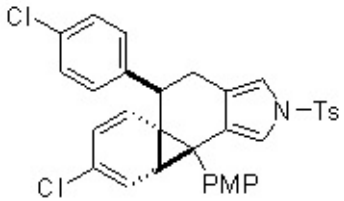
Field strength: 500 MHz



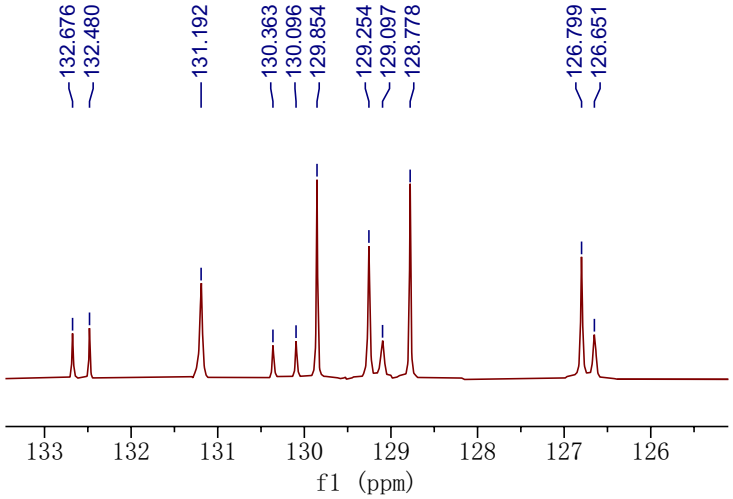
4w

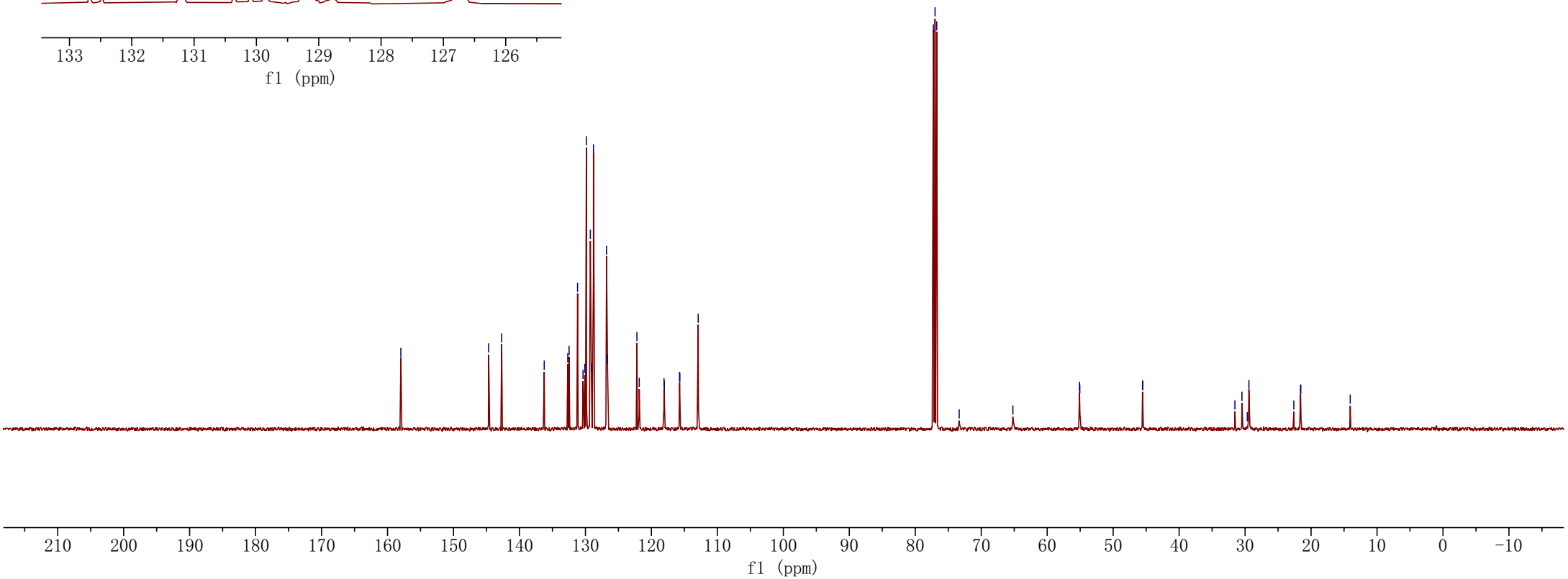
Analysis: ^{13}C NMR
Solvent: $CDCl_3$
Field strength: 125 MHz

157.980
144.671
142.699
136.243
132.676
132.480
131.192
130.363
130.096
129.854
129.254
129.097
128.778
126.799
126.651
122.190
121.839
118.084
118.044
115.726
115.696
112.903
77.255
77.000
76.747
73.341
65.201
55.106
55.056
45.549
45.509
31.546
30.478
29.666
29.418
22.611
21.597
21.559
14.062



4w

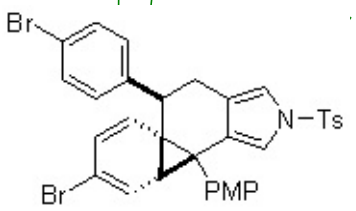




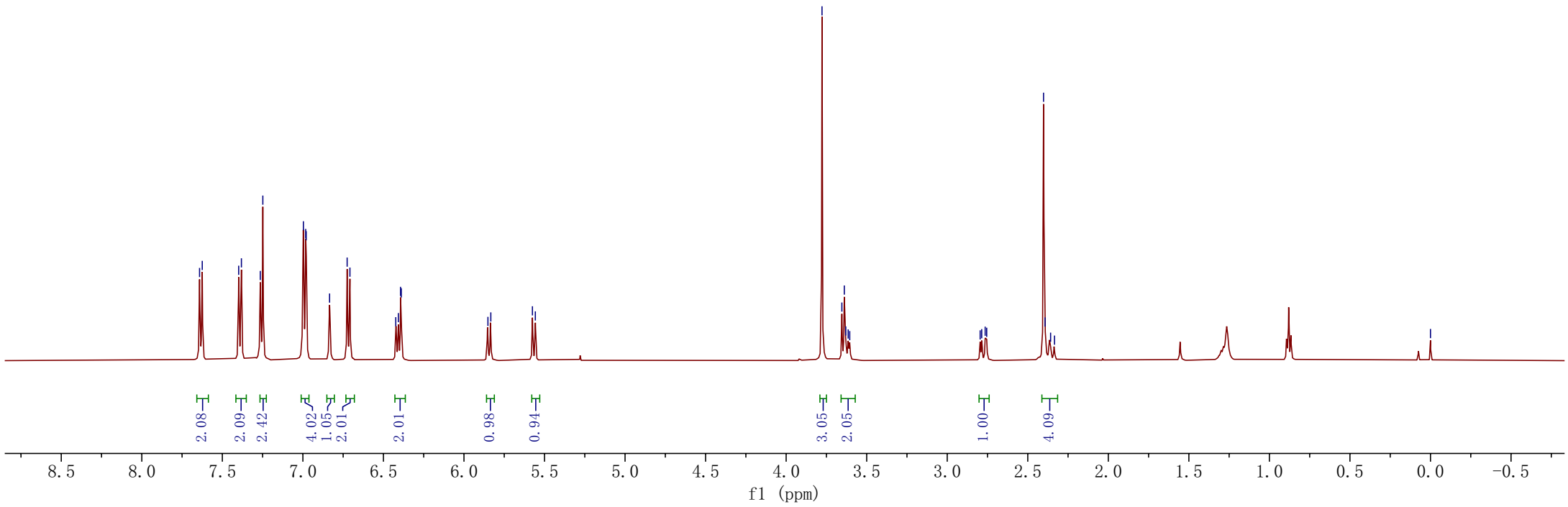
Analysis: ^{1}H NMR

Solvent: $CDCl_3$

Field strength: 500 MHz



4x

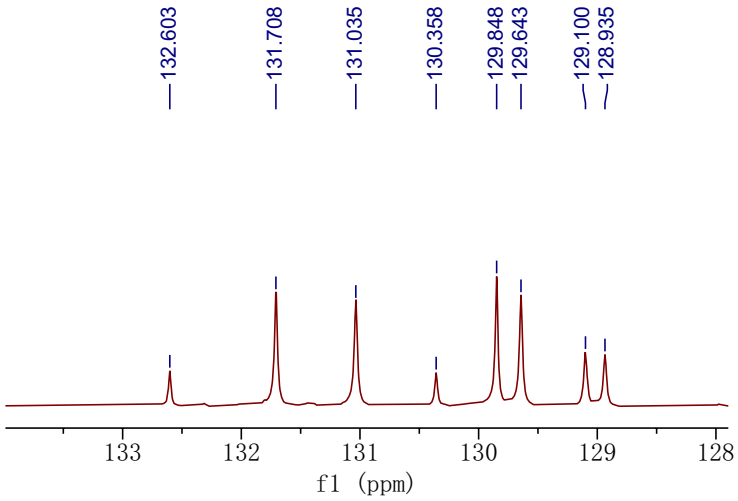


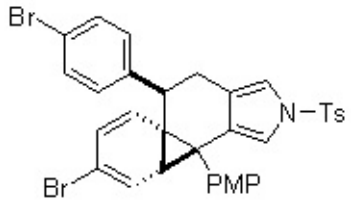
Analysis: ^{13}C NMR

Solvent: $CDCl_3$

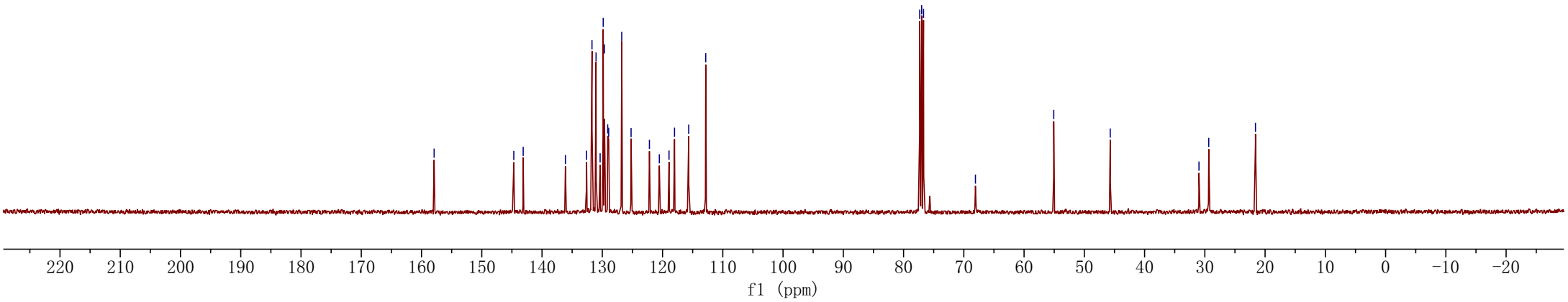
Field strength: 100 MHz

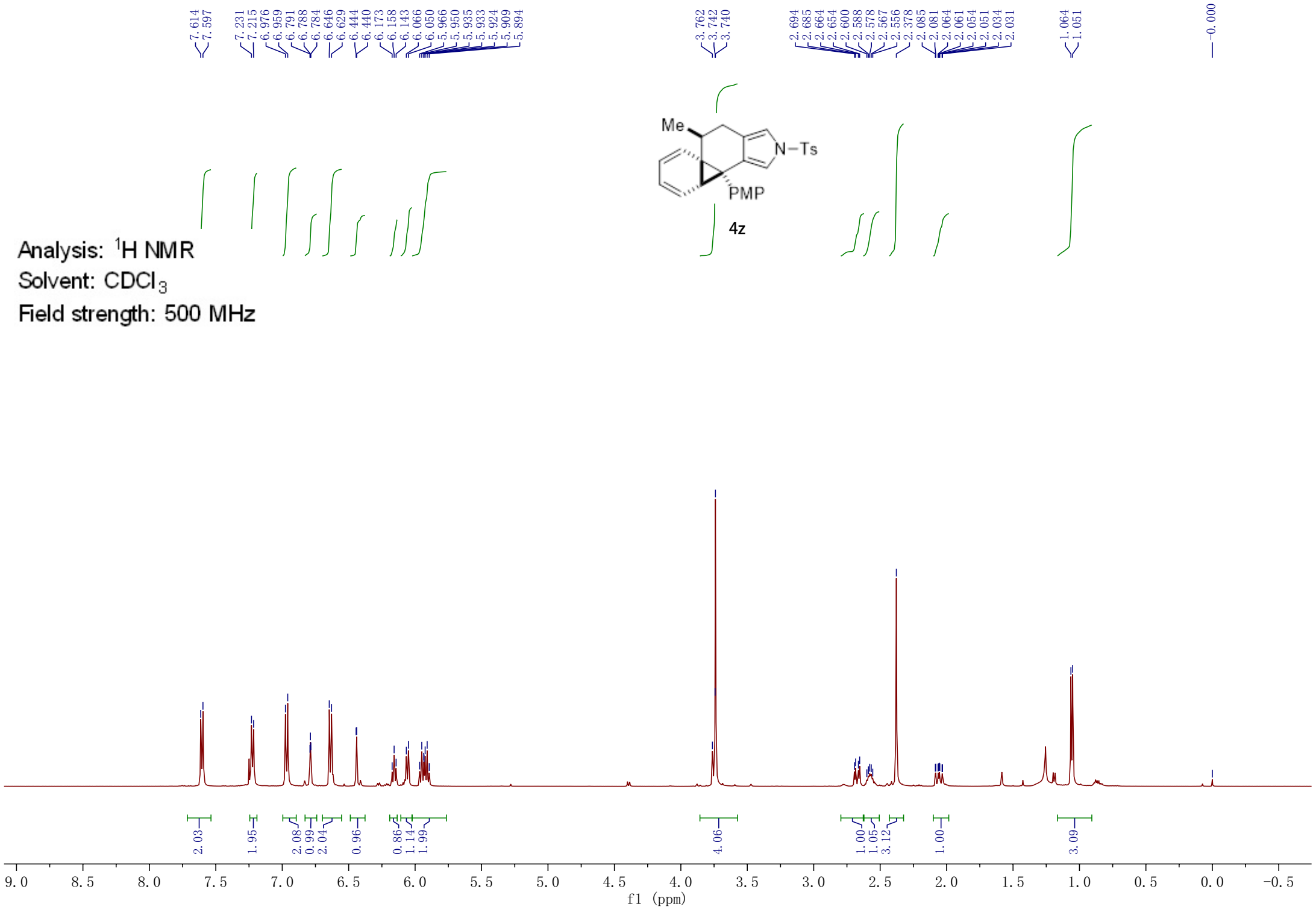
157.91, 144.68, 143.13, 136.12, 132.60, 131.71, 131.03, 130.36, 129.85, 129.64, 129.10, 128.94, 126.77, 125.22, 122.18, 120.53, 118.92, 118.01, 115.66, 112.83, 77.32, 77.00, 76.68, 68.07, 55.07, 45.70, 30.97, 29.35, 21.60





4x



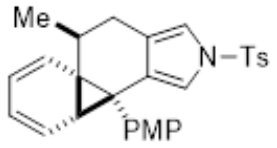

7.614
7.597
7.231
7.215
6.976
6.959
6.791
6.788
6.784
6.646
6.629
6.444
6.440
6.173
6.158
6.143
6.066
6.050
5.966
5.950
5.935
5.933
5.924
5.909
5.894
3.762
3.742
3.740
2.694
2.685
2.664
2.654
2.600
2.588
2.578
2.567
2.556
2.378
2.085
2.081
2.064
2.061
2.054
2.051
2.034
2.031
1.064
1.051
-0.000
Me
N–Ts
PMP
4z
Analysis: ^{1}H NMR
Solvent: $CDCl_3$
Field strength: 500 MHz
2.03
1.95
2.08
0.99
2.04
0.96
0.86
1.14
1.99
4.06
1.00
1.05
3.12
1.00
3.09
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

Analysis: ^{13}C NMR

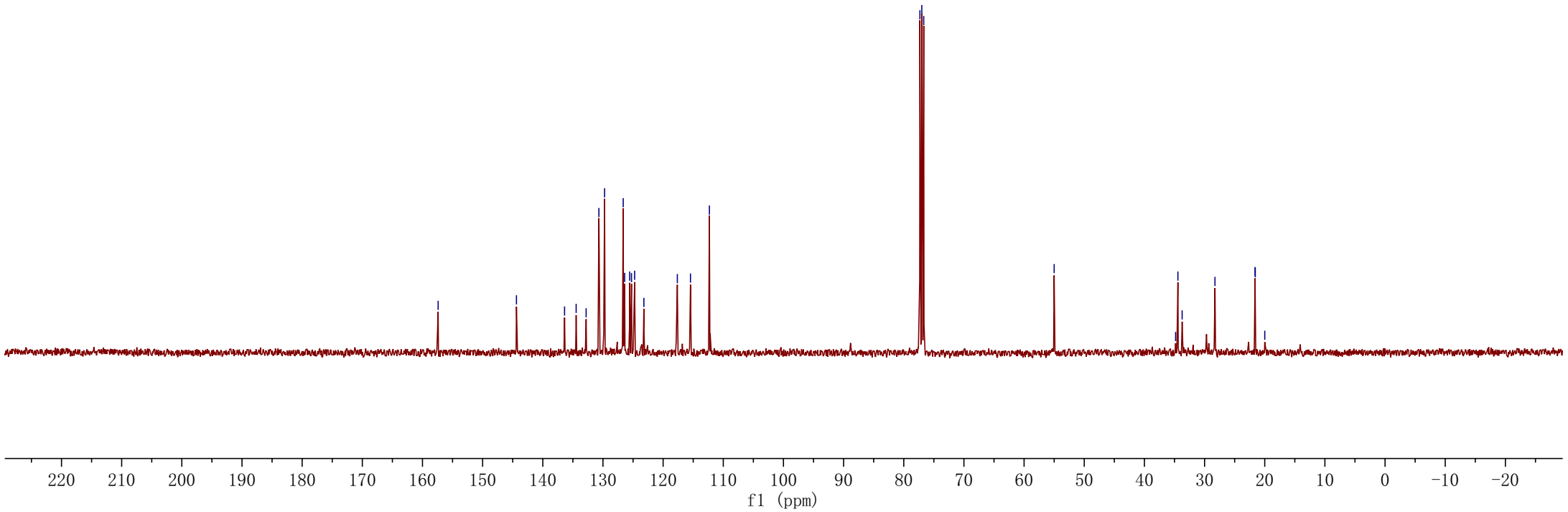
Solvent: $CDCl_3$

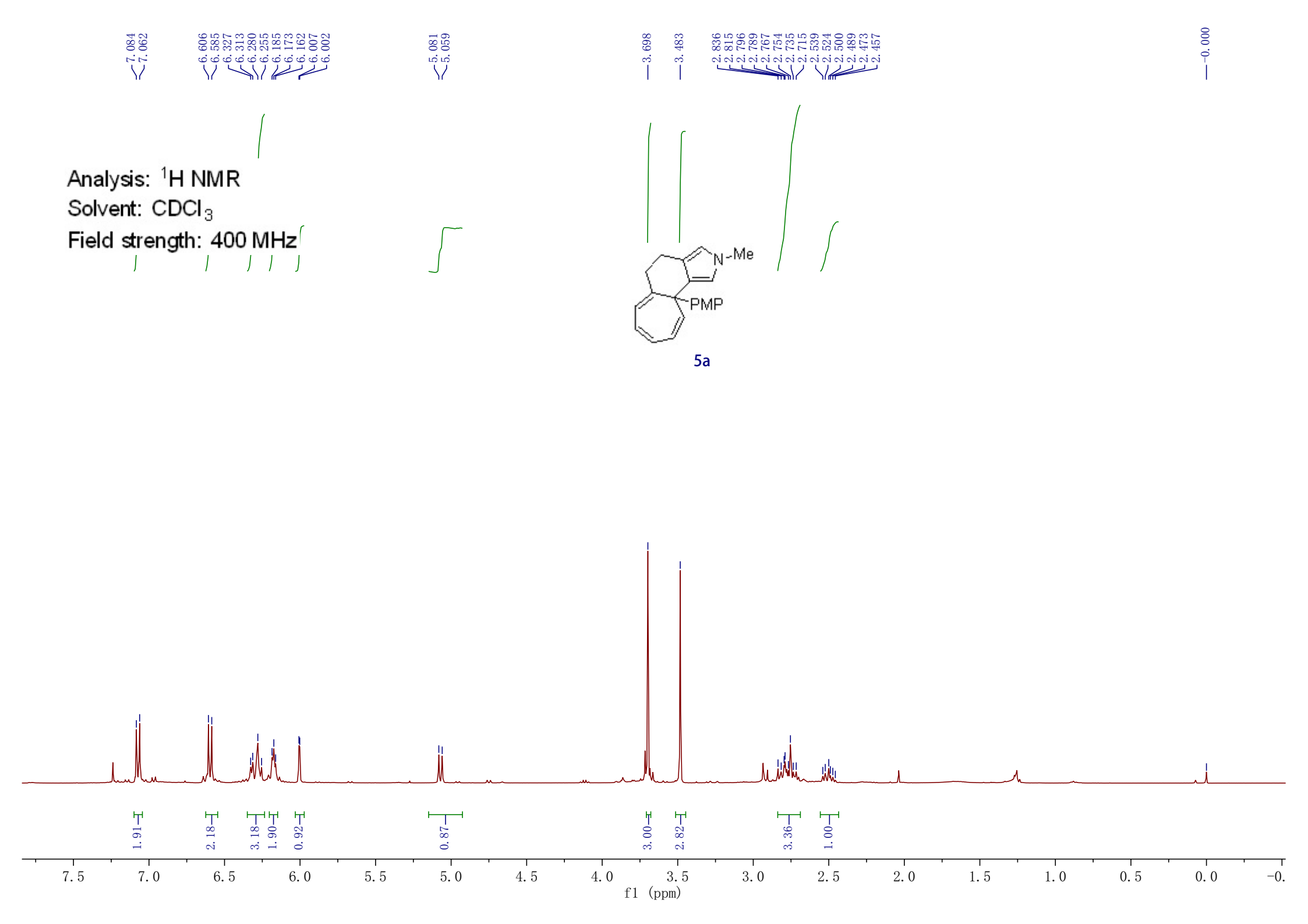
Field strength: 100 MHz

157.40
144.38
136.38
134.46
132.80
130.68
129.73
126.63
126.40
125.56
125.25
124.74
123.20
117.64
115.45
112.31
77.32
77.00
76.68
55.00
34.82
34.43
33.73
28.27
21.61
21.57
20.00



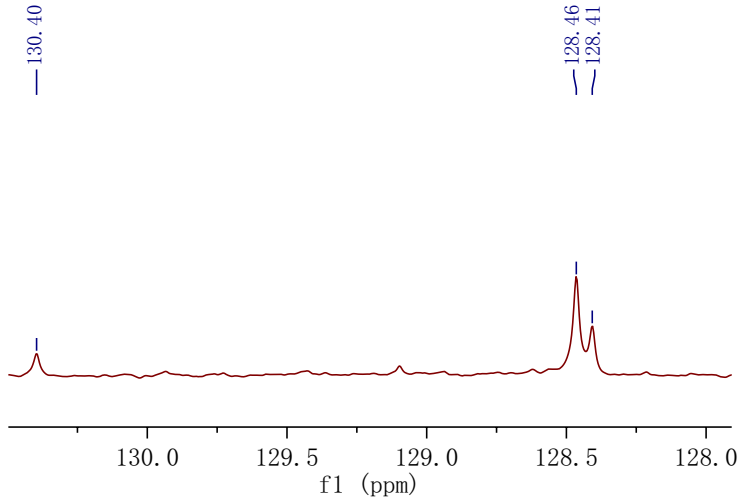
4z

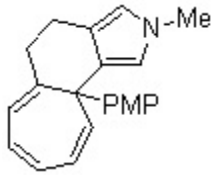



7.084
7.062
6.606
6.585
6.327
6.313
6.280
6.255
6.185
6.173
6.162
6.007
6.002
5.081
5.059
3.698
3.483
2.836
2.815
2.796
2.789
2.767
2.754
2.735
2.715
2.539
2.524
2.500
2.489
2.473
2.457
-0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
N-Me
PMP
5a
1.91
2.18
3.18
1.90
0.92
0.87
3.00
2.82
3.36
1.00
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.
f1 (ppm)

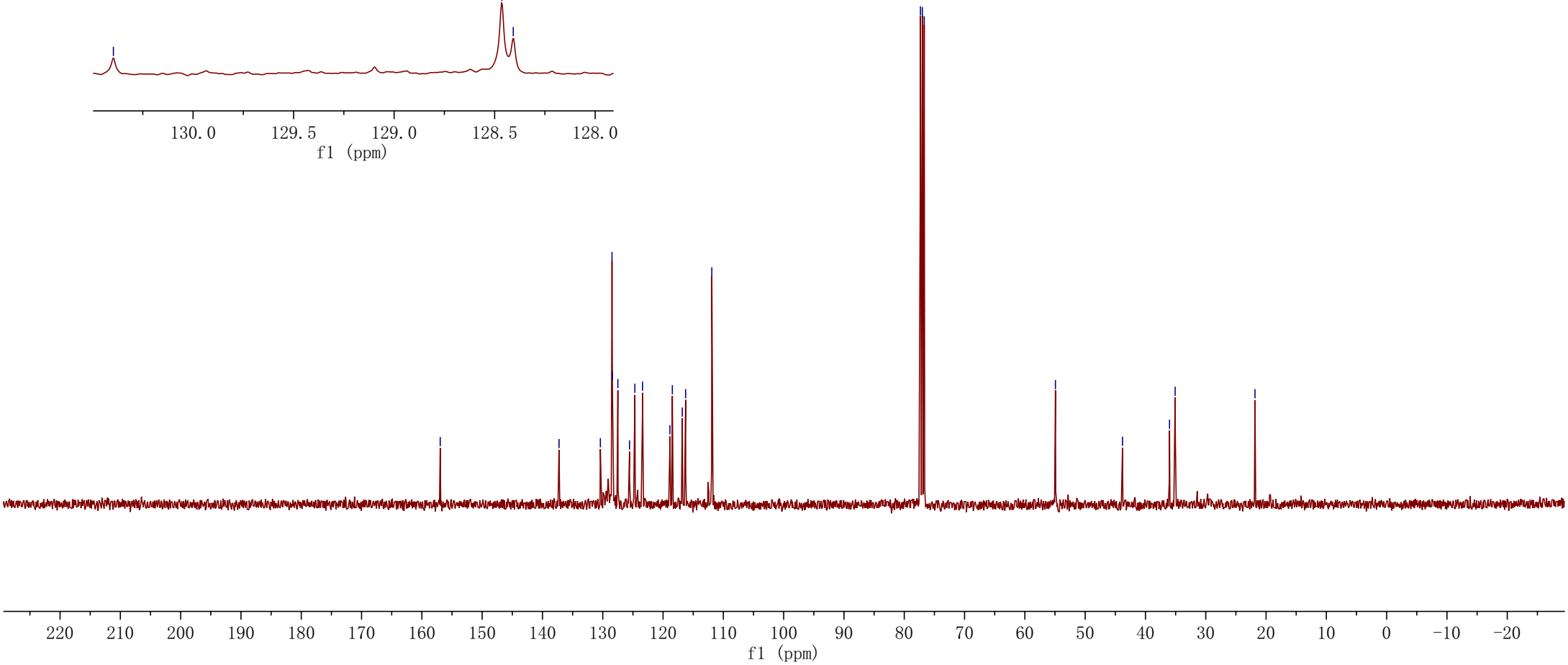
Analysis: ^{13}C NMR
Solvent: $CDCl_3$
Field strength: 100 MHz

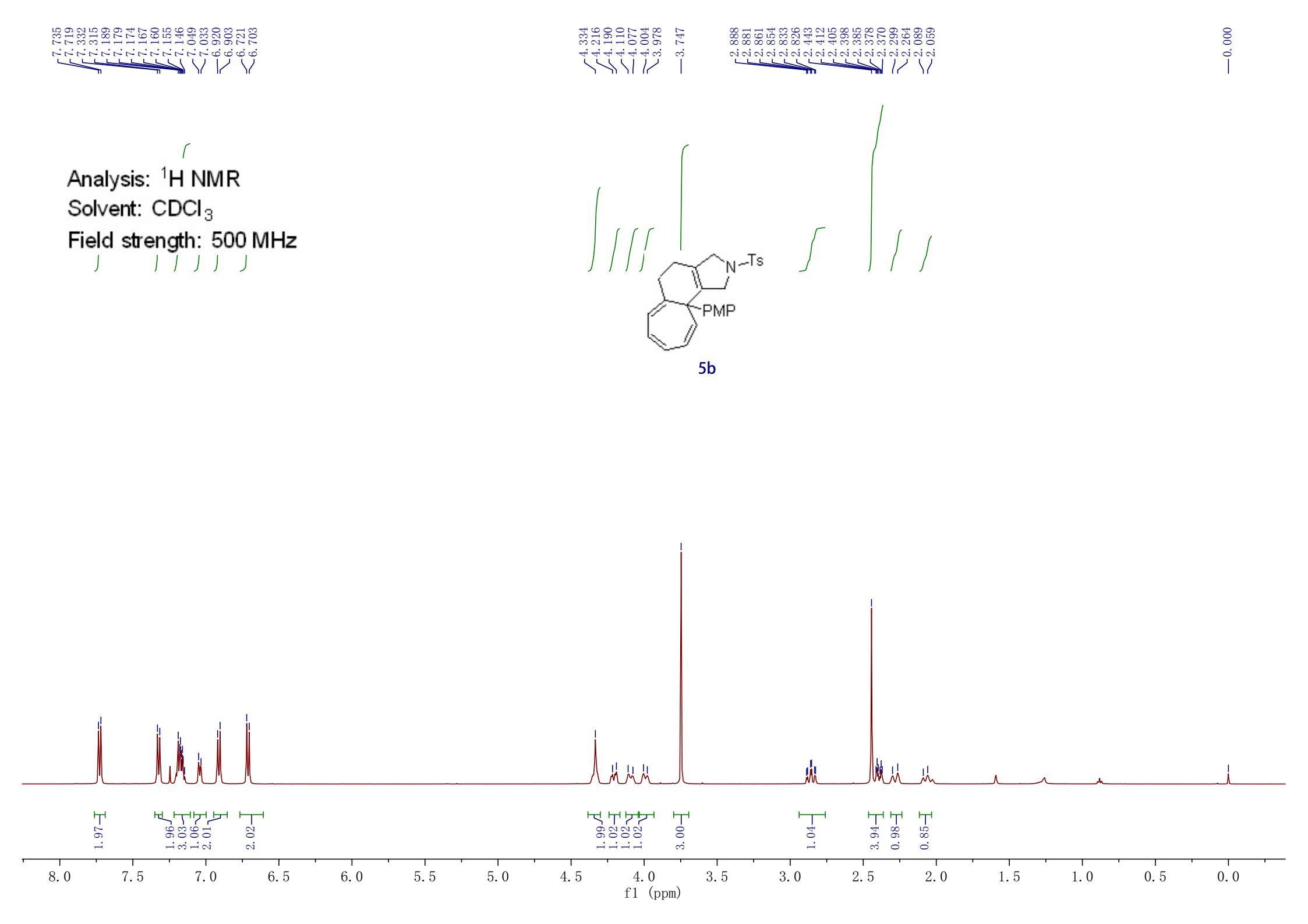
156.96
137.25
130.40
128.46
128.41
127.49
125.57
124.68
123.40
118.87
118.46
116.82
116.26
111.91
77.32
77.00
76.68
54.93
43.81
36.01
35.08
21.84





5a



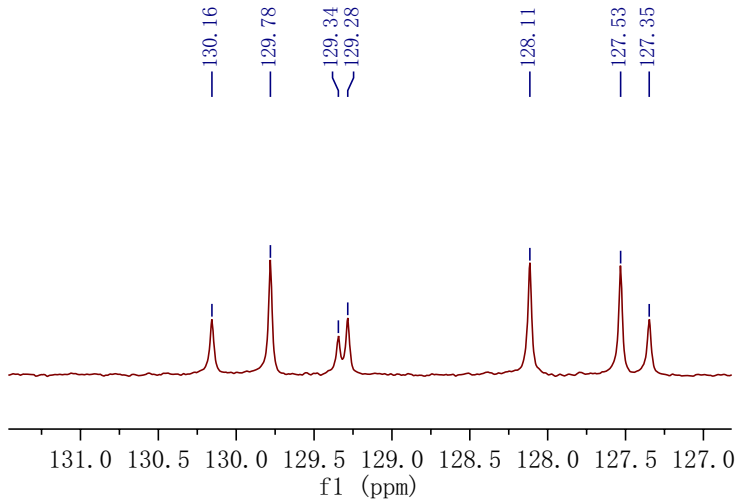

7.735
7.719
7.332
7.315
7.189
7.179
7.174
7.167
7.160
7.155
7.146
7.049
7.033
6.920
6.903
6.721
6.703
4.334
4.216
4.190
4.110
4.077
4.004
3.978
3.747
2.888
2.881
2.861
2.854
2.833
2.826
2.443
2.412
2.405
2.398
2.385
2.378
2.370
2.299
2.264
2.089
2.059
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 500 MHz
N
Ts
PMP
5b
1.97
1.96
3.03
1.06
2.01
2.02
1.99
1.02
1.02
1.02
3.00
1.04
3.94
0.98
0.85
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

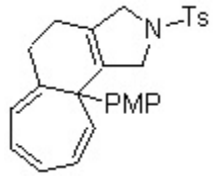
Analysis: ^{13}C NMR

Solvent: $CDCl_3$

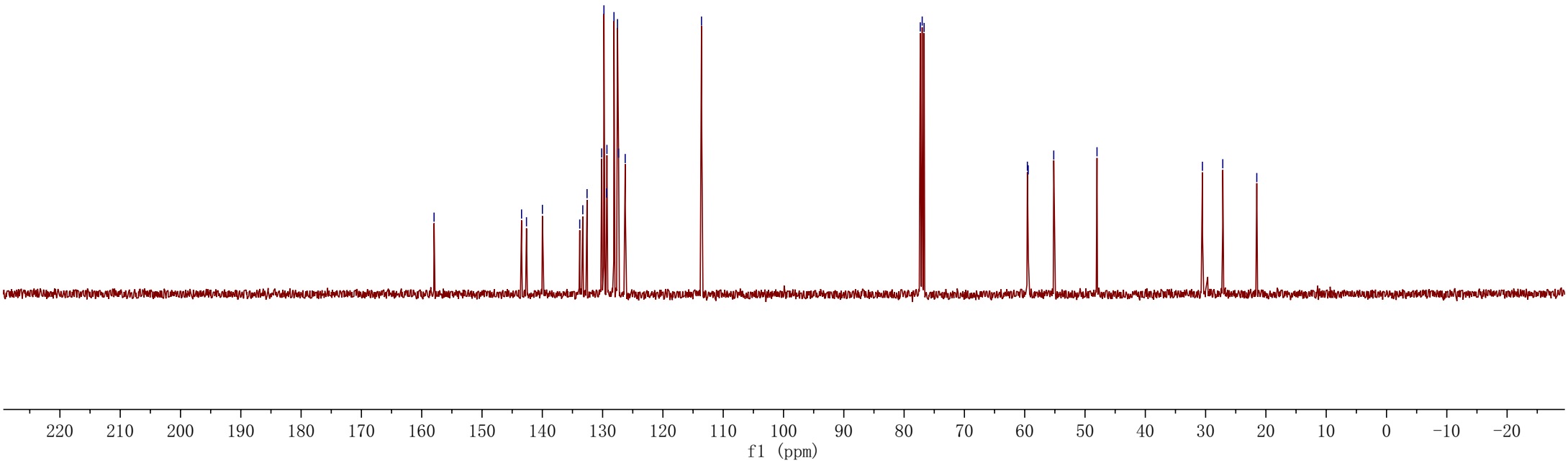
Field strength: 125 MHz

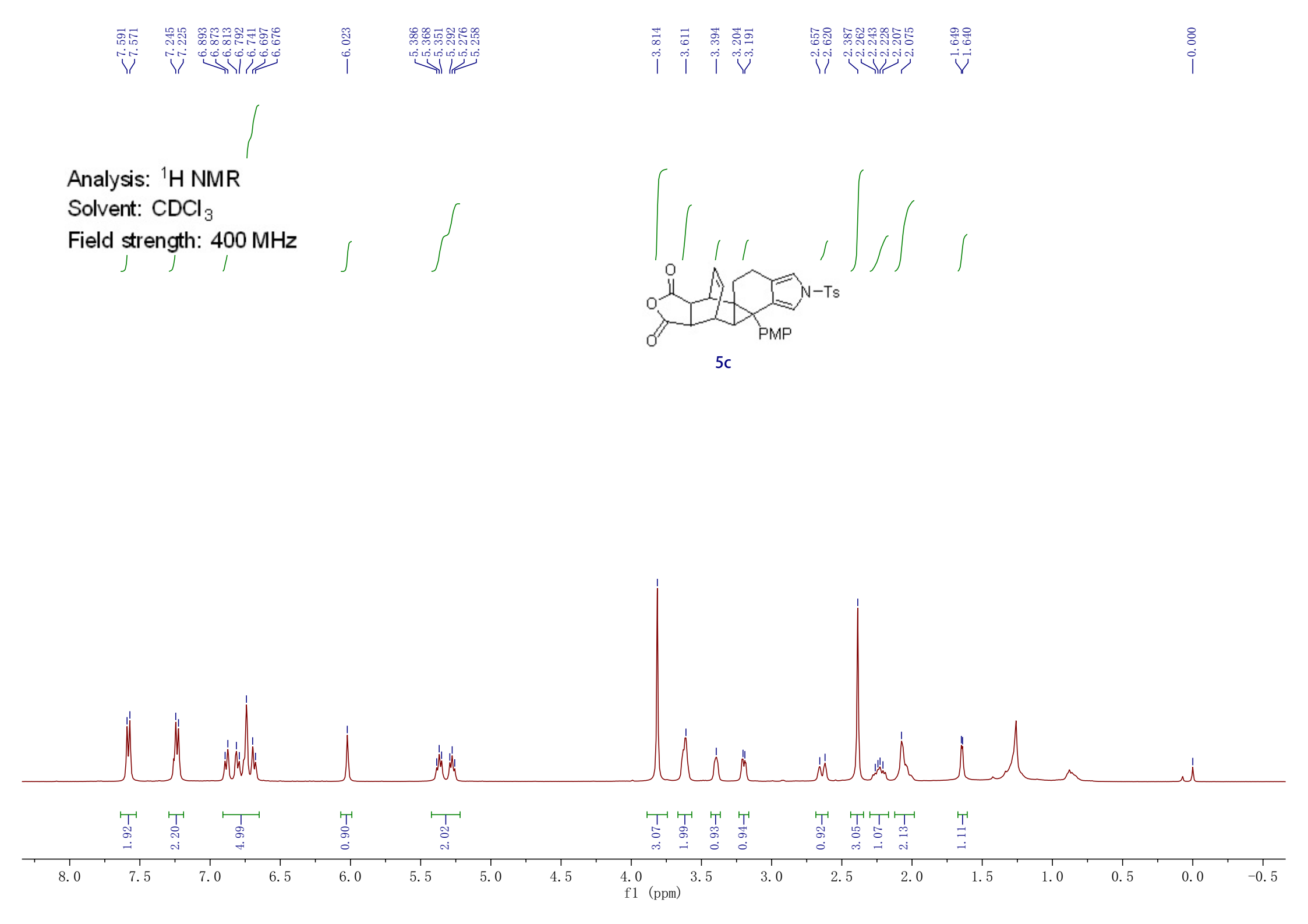
157.95
143.44
142.63
139.98
133.79
133.29
132.58
130.16
129.78
129.34
129.28
128.11
127.53
127.35
126.25
113.60
77.32
77.00
76.68
59.56
59.42
55.19
48.01
30.52
27.15
21.51





5b



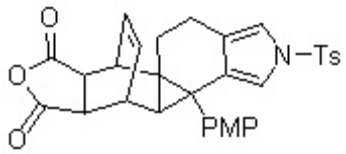

7.591
7.571
7.245
7.225
6.893
6.873
6.813
6.792
6.741
6.697
6.676
6.023
5.386
5.368
5.351
5.292
5.276
5.258
3.814
3.611
3.394
3.204
3.191
2.657
2.620
2.387
2.262
2.243
2.228
2.207
2.075
1.649
1.640
0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 400 MHz
O
O
O
N–Ts
PMP
5c
1.92
2.20
4.99
0.90
2.02
3.07
1.99
0.93
0.94
0.92
3.05
1.07
2.13
1.11
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

172.30
171.67
157.83
144.59
136.12
133.27
133.09
131.01
130.02
129.79
126.74
122.13
117.88
115.72
114.64
113.61
77.32
77.00
76.68
55.17
45.52
44.57
38.84
33.93
32.55
31.67
29.54
23.68
21.57
19.71

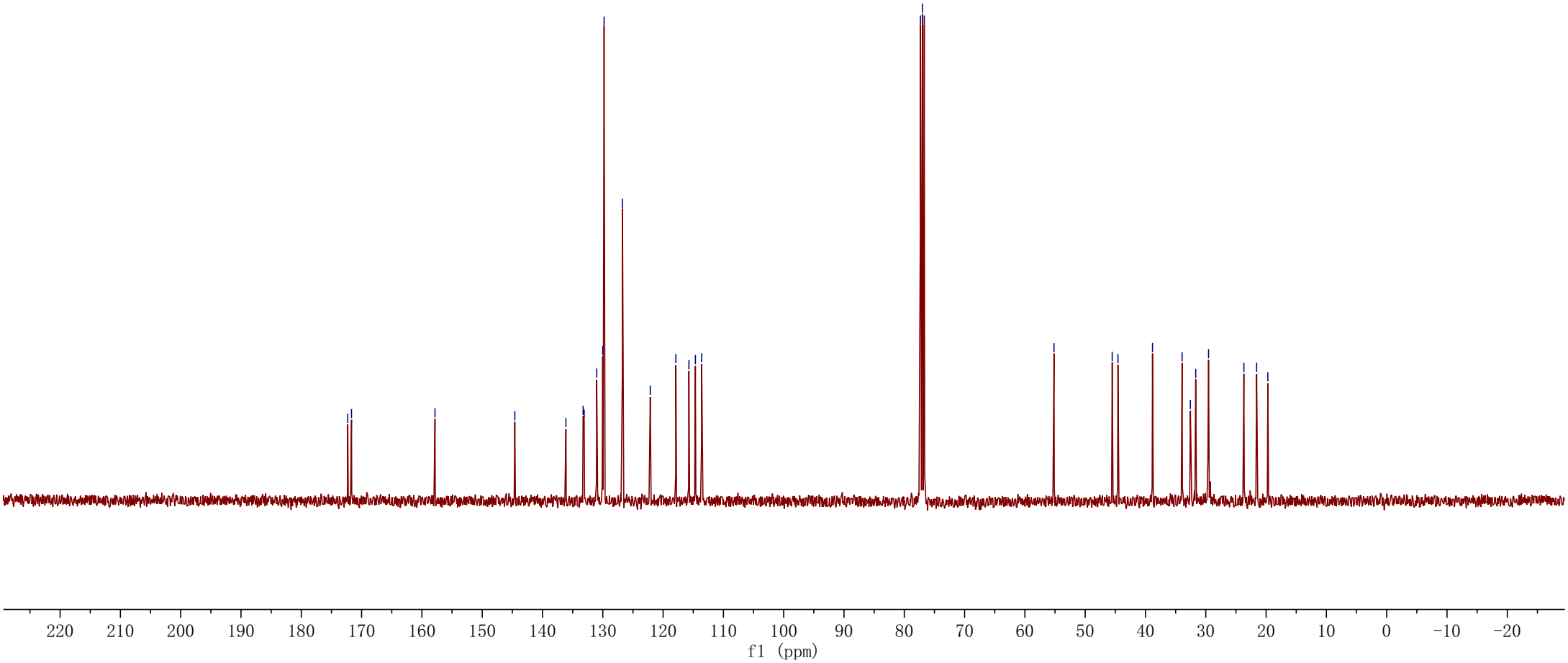
Analysis: ^{13}C NMR

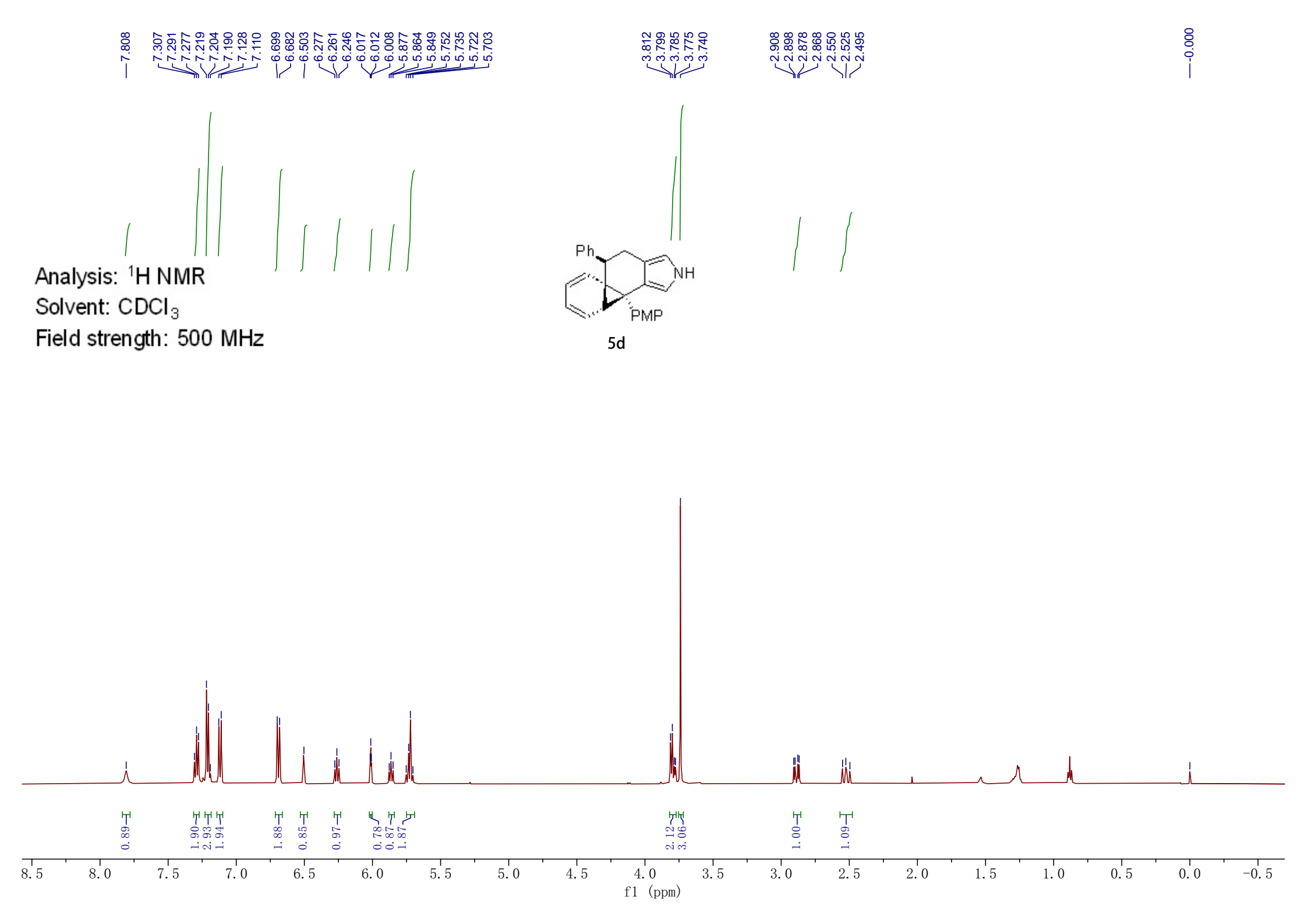
Solvent: $CDCl_3$

Field strength: 100 MHz



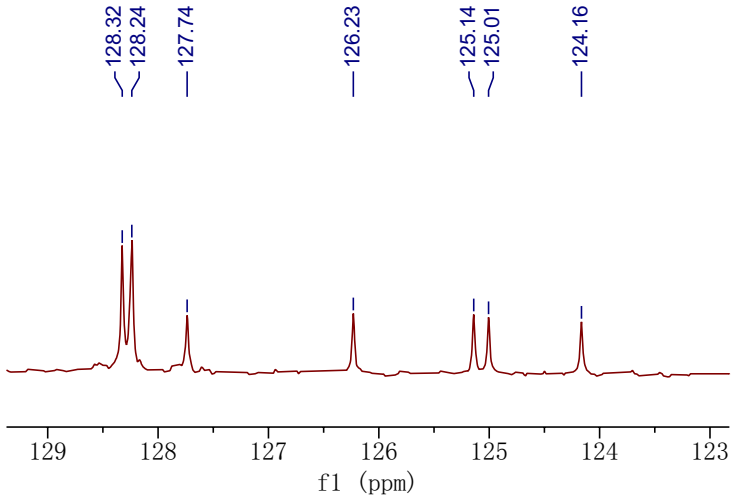
5c

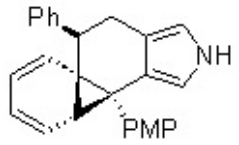



7.808
7.307
7.291
7.277
7.219
7.204
7.190
7.128
7.110
6.699
6.682
6.503
6.277
6.261
6.246
6.017
6.012
6.008
5.877
5.864
5.849
5.752
5.735
5.722
5.703
3.812
3.799
3.785
3.775
3.740
2.908
2.898
2.878
2.868
2.550
2.525
2.495
-0.000
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 500 MHz
Ph
NH
PMP
5d
0.89
1.90
2.93
1.94
1.88
0.85
0.97
0.78
0.87
1.87
2.12
3.06
1.00
1.09
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

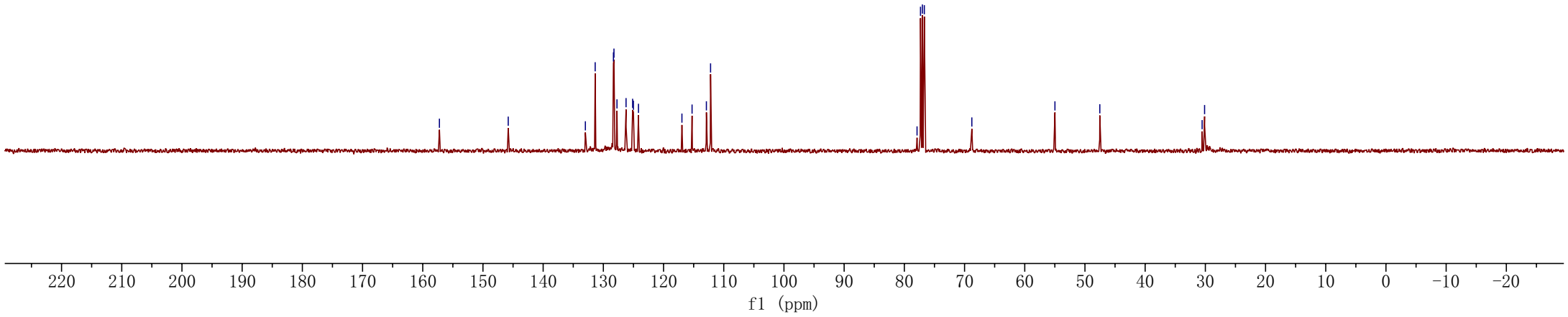
Analysis: ^{13}C NMR
Solvent: $CDCl_3$
Field strength: 125 MHz

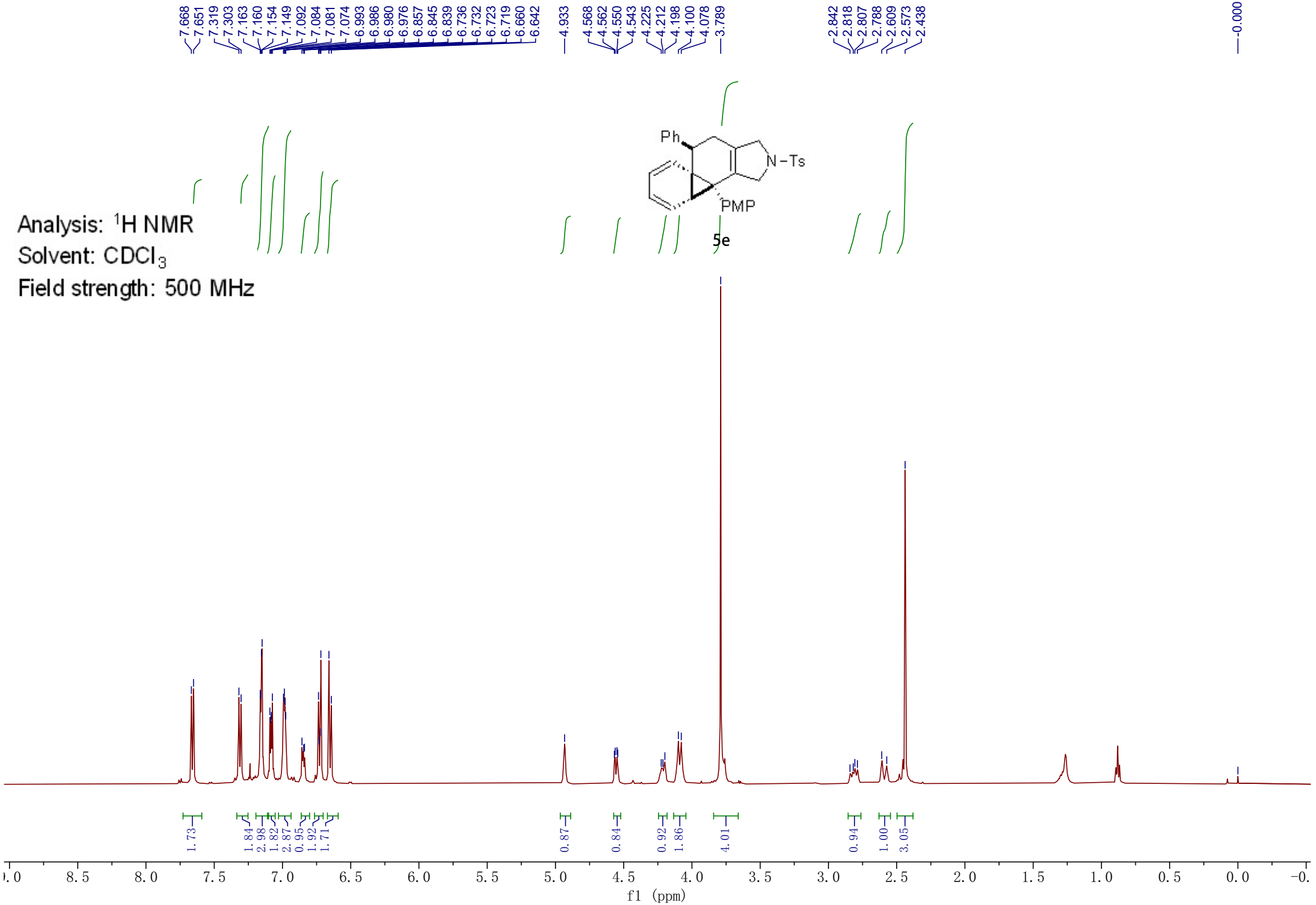
157.23
145.80
132.99
131.36
128.32
128.24
127.74
126.23
125.14
125.01
124.16
116.95
115.26
112.88
112.19
77.89
77.32
77.00
76.68
68.79
54.99
47.53
30.54
30.13





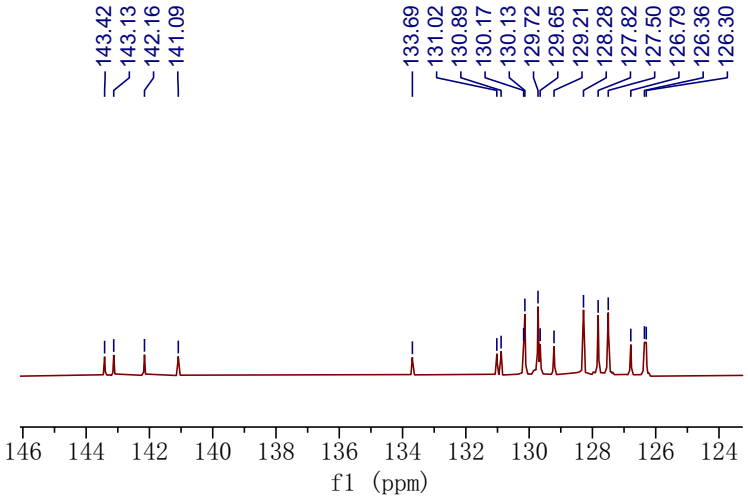
5d

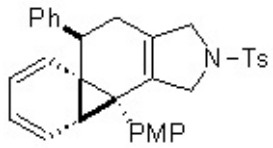



7.668
7.651
7.319
7.303
7.163
7.160
7.154
7.149
7.092
7.084
7.081
7.074
6.993
6.986
6.980
6.976
6.857
6.845
6.839
6.736
6.732
6.723
6.719
6.660
6.642
4.933
4.568
4.562
4.550
4.543
4.225
4.212
4.198
4.100
4.078
3.789
2.842
2.818
2.807
2.788
2.609
2.573
2.438
-0.000
Ph
N-Ts
PMP
5e
Analysis: 1H NMR
Solvent: CDCl3
Field strength: 500 MHz
1.73
1.84
2.98
1.82
2.87
0.95
1.92
1.71
0.87
0.84
0.92
1.86
4.01
0.94
1.00
3.05
f1 (ppm)

Analysis: ^{13}C NMR
Solvent: $CDCl_3$
Field strength: 125 MHz

158.01
143.42
143.13
142.16
141.09
133.69
131.02
130.89
130.17
130.13
129.72
129.65
129.21
128.28
127.82
127.50
126.79
126.36
126.30
113.58
77.32
77.00
76.68
60.09
59.32
55.21
47.95
46.20
31.01
21.51





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