Supplemental Information

Organic photosensitized aziridination of alkenes

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1. General Information

If no special indicated, commercially available reagents and dry solvents were used without further purification. Column chromatographic purification of all products was conducted using 200-300 dry mesh silica gel. ^{1}H and ^{13}C NMR spectra were measured on a JEOL JNM-ECZ400S/L1 spectrometers, NMR (400 MHz for ^{1}H NMR, 101 MHz for ^{13}C NMR). Multiplicity (s = singlet, D = doublet, t = triplet, m = multiplet, Q = quartet, Coupling Constant (J) in Hz). $CHCl_3$ (δ = 7.26 ppm) served as the internal standard for ^{1}H NMR, and $CDCl_3$ (δ = 77.16 ppm) served as the internal standard for ^{13}C NMR. Infrared spectra were collected on a Thermo Fisher Nicolet 6700 FT-IR spectrometer using ATR (Attenuated Total Reflectance) method. High-resolution mass spectra (HRSM) were obtained on a Waters I-Class VION IMS QTof and are reported as m/z (relative intensity). UV-vis spectra experiments were measured on an Ultraviolet-visible Spectrophotometer (YOKE T2600). Fluorescence emission spectrums were recorded using an Edinburgh FLS9 Fluorescence Spectrometer. Electron paramagnetic resonance (EPR) studies were measured on a Bruker A300 EPR spectrometer. The UV light (275 nm) was obtained on UVGO.

1.1 The structure of photocatalysts

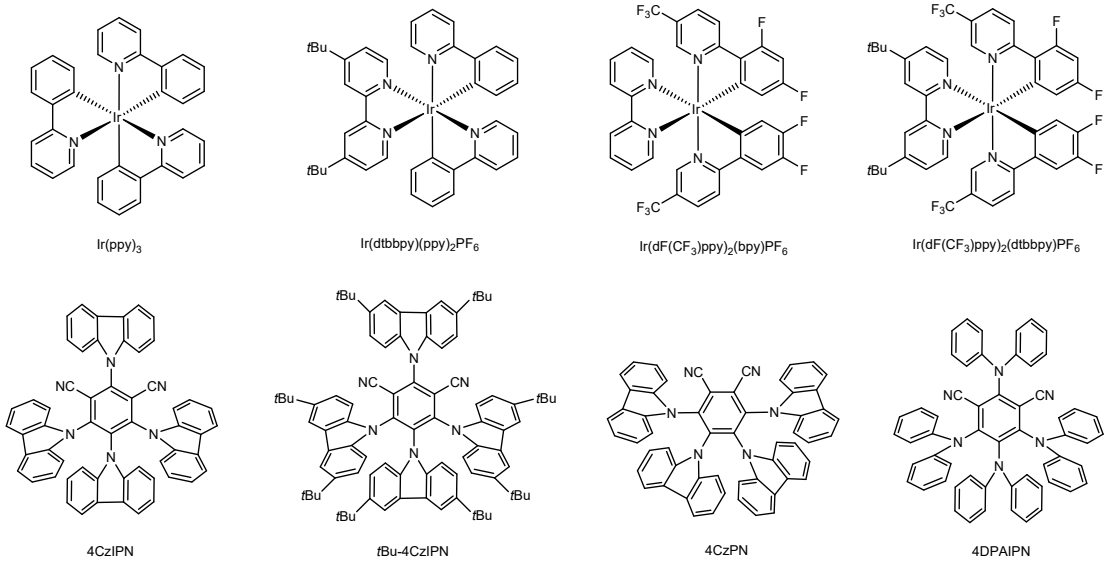


Figure S1: The structure of photocatalysts

1.2 Emission spectra of blue light lamp

The blue LED is commercial available and purchased from Xuzhou Aijia Electronic Technology Co., Ltd. Its power output is 45 W. The emission spectrum of the blue LED is shown in the figure below.

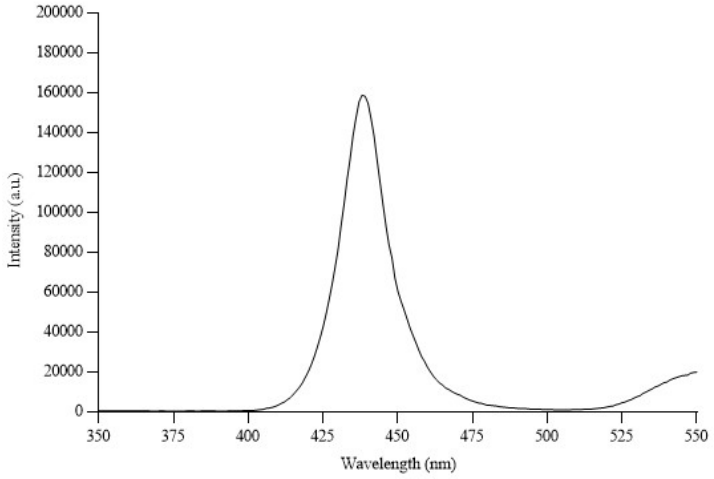
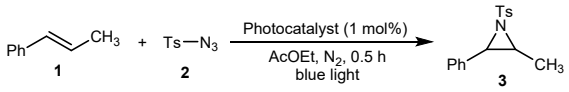


Figure S2: The emission spectrum of the blue LED

2. General Experimental Procedure

A 10 mL of Schlenk tube equipped with magnetic bar was added the photocatalyst 4DPAIPN (1 mol%), the tube was evacuated and backfilled with N_2 (2 times). Then, alkenes (0.2 mmol, 1 equiv.), tosyl azide (0.39 mmol, 1.9 equiv., 88 μL, 75%w/w in ethyl acetate), 3.0 mL ethyl acetate as a solvent were added. The Schlenk tube was sealed with a Teflon lined cap and degassed by two freeze-pump-thaw cycles. The reaction mixture was placed about 2 cm away from light source and irradiated with blue light for 3 h at room temperature. The solvent was removed under reduced pressure and purified by column chromatography (hexane/ethyl acetate) to afford the title product.

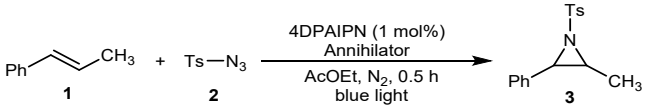


Entry	Photocatalyst	E_T (kcal/mol)	$E_{1/2}(P^+/^*P)$ (V)	Yield (%)	D.r.
1	$Ir(ppy)_3$	55.2	-1.73	9%	10:1
2	$Ir(dtbbpy)(ppy)_2PF_6$	49.2	-0.96	55%	13:1
3	$Ir(dF(CF_3)ppy)_2(bpy)PF_6$	60.4	-0.97	0%	--
4	$Ir(dF(CF_3)ppy)_2(dtbbpy)PF_6$	60.1	-0.89	2%	--
5	4CzIPN	58.3	-1.18	17%	8:1
6	*t*Bu-4CzIPN	56.7	-1.31	11%	13:1
7	4CzPN	56.5	-1.16	47%	11:1
8	4DPAIPN	60.4	-1.28	95%	15:1
9	No photocatalyst	--	--	0%	--
10	No light	--	--	0%	--

Table S1: Reaction Optimization

3. Energy Quenching Experiments

A 10 mL of Schlenk tube equipped with magnetic bar was added the photocatalyst 4DPAIPN (1 mol%), triplet quenchers (1.0 equiv.), the tube was evacuated and backfilled with N_2 (2 times). Then, *β*-methylstyrene (0.2 mmol, 1 equiv.), tosyl azide (0.39 mmol, 1.9 equiv., 88 μL, 75%w/w in ethyl acetate), 3.0 mL ethyl acetate as a solvent were added. The Schlenk tube was sealed with a Teflon lined cap and degassed by two freeze-pump-thaw cycles. The reaction mixture was placed 2 cm away from light source and irradiated with blue light for 0.5 h at room temperature. The solvent was removed under reduced pressure and purified by column chromatography (hexane/ethyl acetate) to afford the title product.



Annihilator (1 equiv)	Yield (%)
2,7-di-tert-butylpyrene	10%
perylene	0%
anthracene	0%

Figure S3: Energy quenching experiments of the standard reaction

4. Uv-vis Absorption Spectrum

In order to detect EDA complex, Uv-vis absorption spectra were recorded using the mixed solution in ethyl acetate (2.6 mL) at room temperature. ([4DPAIPN] = 5.56×10^{-5} M, [β-methylstyrene] = 3.2×10^{-4} M, [tosyl azide] = 3.2×10^{-4} M)

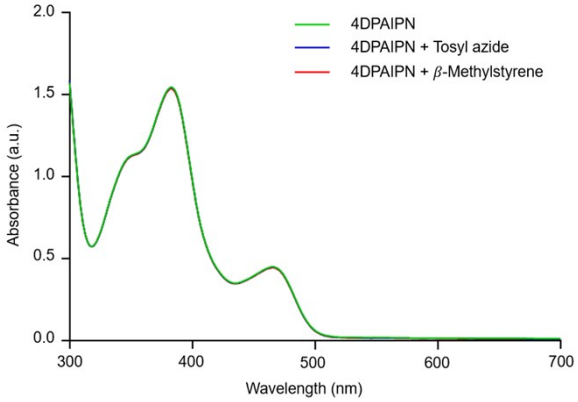


Figure S4: Uv-vis absorption spectrum

5. Stern-Volmer Fluorescence Quenching

In a typical experiment, a 1.33 μM solution of 4DPAIPN in ethyl acetate was added to variable concentrations of quenchers, tosyl azide or β-methylstyrene, in a screw-top 1.0 cm quartz cuvette, after degassing by bubbling a stream of nitrogen, the emission spectrum of the sample was collected. All solutions were excited at λ = 450 nm and their maximum emission intensity were recorded. The ratio of I_0/I was plotted as a function of the quencher concentration (I_0 = emission intensity of the 4DPAIPN; I = observed emission intensity of the mixed solution).

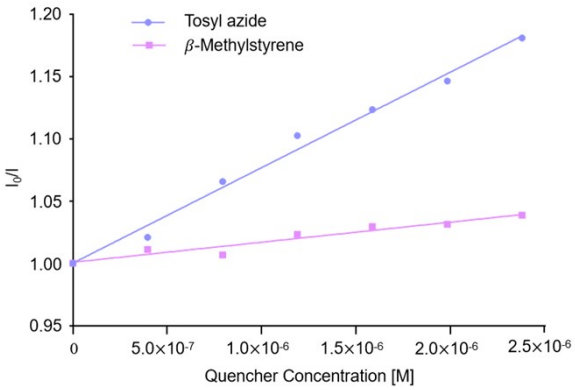
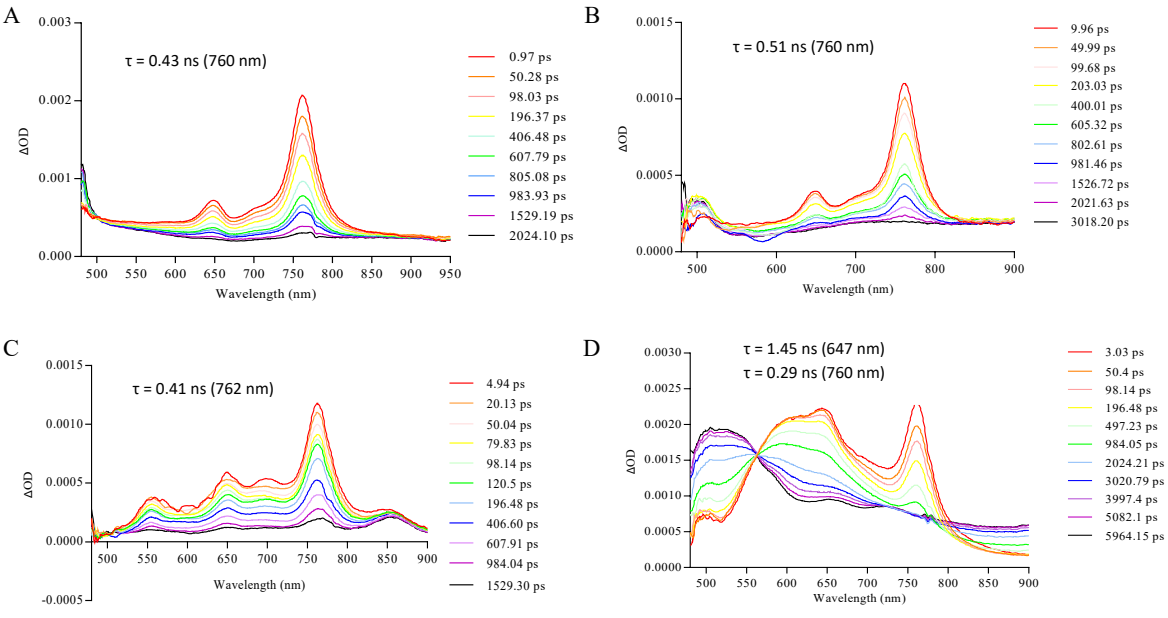


Figure S5: Stern-Volmer fluorescence quenching

6. Transient Absorption Spectroscopy

Femtosecond transient absorption was carried out by the following equipment setup. A femtosecond laser (PHAROS, light conversion) operating at a 100 kHz repetition rate was selected as the light source of the Femto-TA100 spectrometer (Time-Tech Spectra, Co., Ltd). It is tuned to pump 390 nm pulses, the pulse duration was around 290 fs and the energy of the pulse was 200 μJ /cm^2 at the sample position, and the spectral range is 480-1020 nm. Then, the fundamental laser beam was split into two. One was introduced into an optical parametric amplifier (OPA, light conversion) to produce a specific wavelength laser as the pump light of Femto-TA100 system. The other was focused onto a sapphire plate or YaG to generate super-continuum white light that served as the probe light. A motorized delay stage was utilized to regulate the time delay between pump and probe light. The sample is placed in a quartz cuvette with an optical path length of 1 mm and a capacity of 0.35 mL at room temperature. Measurements were taken immediately after solution preparation, and all operations were performed in a nitrogen atmosphere.

Under nitrogen atmosphere, a 55.6 μM solution (0.3 mL) of these photocatalysts in ethyl acetate was placed in a sealed quartz cuvette, and the TAS data was recorded. The singlet state lifetime of the corresponding photocatalyst (A, B, C and D) was obtained by first order kinetic approximation fitting. The triplet state lifetime of 4DPAIPN (D) was also obtained by first order kinetic approximation fitting.



E

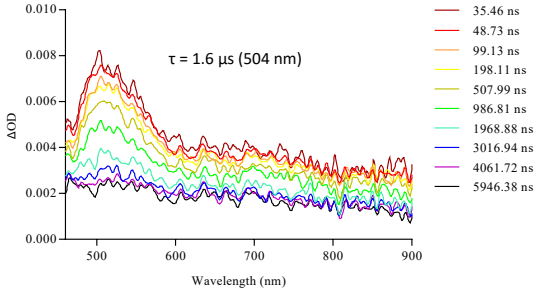


Figure S6: The ps-TA spectra of $Ir(dF(CF_3)ppy)_2(dtbbpy)PF_6$ (A), $Ir(dtbbpy)(ppy)_2PF_6$ (B), 4CzPN (C), 4DPAIPN (D), and ns-TA spectra of 4DPAIPN (E) at different delay times.

Nanosecond transient absorption was TAS measurements were carried out using commercially available transient absorption spectrometer with a white light laser (LEUKOS, France) and an Optical Parametric Amplifier (OPA, ORPHEUS). It is tuned to pump 390 nm pulses at 1 kHz repetition rate. The pulse duration was around 290 fs and the energy of the pulse was 50 μJ/cm^2 at the sample position. The white light laser was used as a light source with a spectral range of 460-1020 nm. The sample is placed in a quartz cuvette with an optical path length of 1 mm and a capacity of 0.35 mL at room temperature. Measurements were taken immediately after solution preparation, and all operations were performed in a nitrogen atmosphere.

Under nitrogen atmosphere, a 55.6 μM solution (0.3 mL) of 4DPAIPN in ethyl acetate was placed in a sealed quartz cuvette, and the TAS data was recorded. To the solution was added 22 μmol, and 43 μmol TsN_3 in sequence and recorded the TAS data. The same procedure was applied to *β*-methylstyrene, it was found that the degree of quenching was very weak, which was consistent with the results of Stern-Volmer fluorescence quenching.

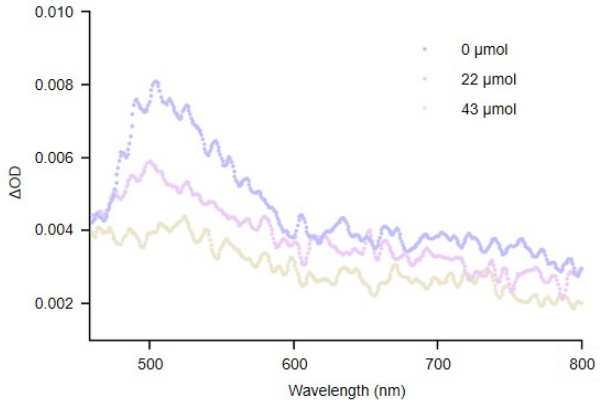


Figure S7: Transient absorption spectroscopy of 4DPAIPN in the presence of TsN_3

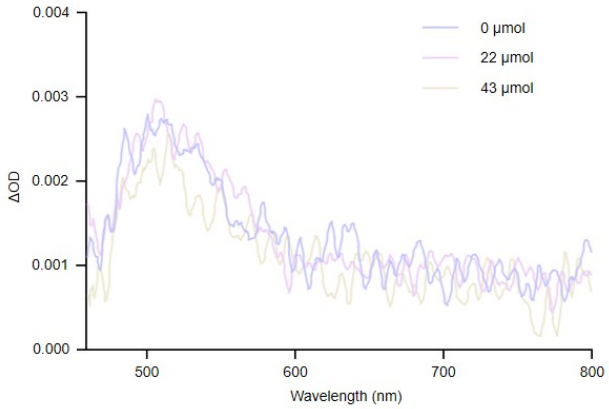


Figure S8: Transient absorption spectroscopy of 4DPAIPN in the presence of *β*-methylstyrene

7. Irradiation with UV Light

A 10 mL of quartz tube equipped with magnetic bar was added *β*-methylstyrene (0.2 mmol, 1 equiv.), tosyl azide (0.39 mmol, 1.9 equiv., 88 µL, 75%w/w in ethyl acetate), 3.0 mL ethyl acetate as a solvent were added. The quartz tube was sealed with a rubber stopper and bubbled with N_2 for 5 min. The reaction mixture was irradiated with UV light for 3 h at room temperature. The solvent was removed under reduced pressure and purified by column chromatography (hexane/ethyl acetate) to afford the title product.

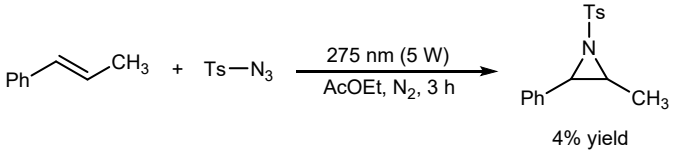
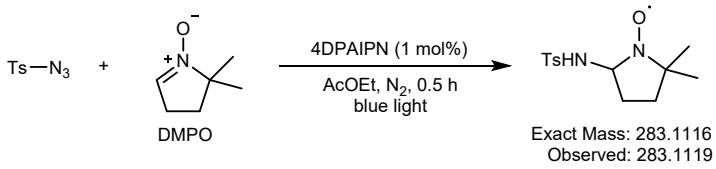
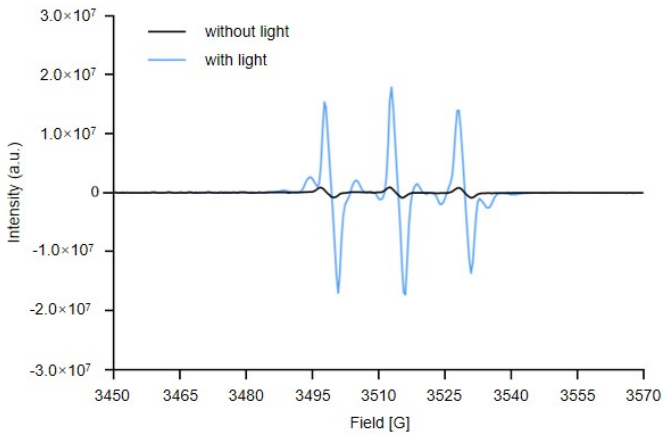


Figure S9: UV light of *β*-methylstyrene and tosyl azide

8. EPR Experiments

A 10 mL of Schlenk tube equipped with magnetic bar was added the photocatalyst 4DPAIPN (1 mol%), tosyl azide (0.1 mmol), 5,5-dimethyl-1-pyrroline *N*-oxide (0.1 mmol), 1.0 mL ethyl acetate as a solvent were added under nitrogen atmosphere. The Schlenk tube was sealed with a Teflon lined cap and degassed by two freeze-pump-thaw cycles. The reaction mixture was placed about 2 cm away from light source and irradiated with blue light for 0.5 h at room temperature. The resulting mixture was analyzed by EPR and HRMS.





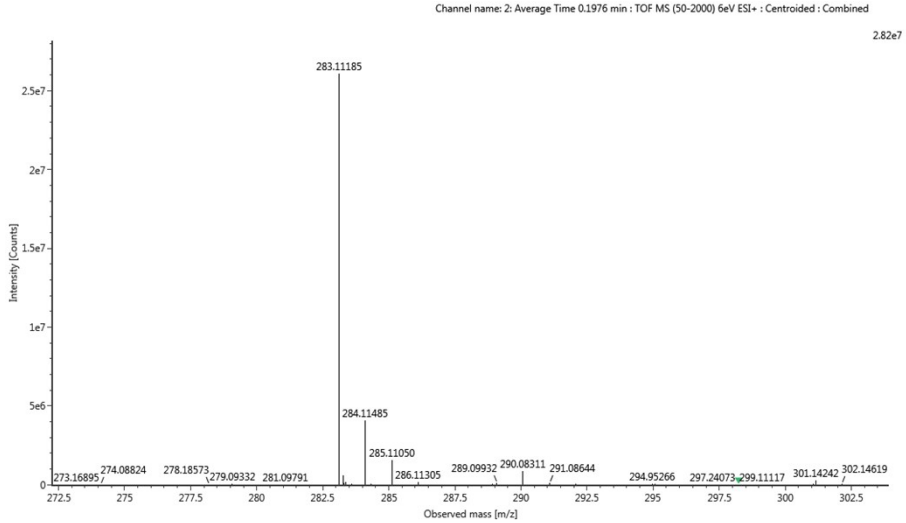


Figure S10: EPR and HRMS analysis of the triplet toluenesulfonyl nitrene

9. A stepwise pathway of triplet nitrene

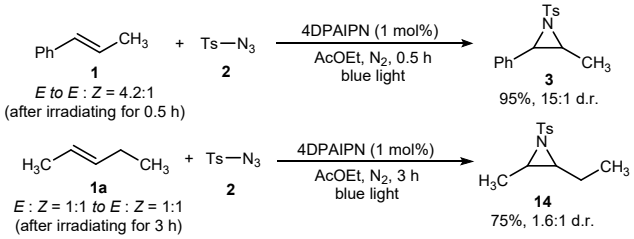


Figure S11: A stepwise pathway of triplet nitrene

10. The Proposed Mechanism

Based on these mechanistic findings and literature survey, a proposed mechanism is outlined in Figure S8. The excited 4DPAIPN sensitizes TsN_3 into T_1 state by energy transfer, which gives rise to the triplet toluenesulfonyl nitrene **II** after dissociating a N_2. N-radical addition to alkenes affords the biradical intermediates **III** and **IV**. Due to steric hindrance between R^1 and R^2 group, **III** is the major equilibrium isomer. Finally, radical coupling furnishes the aziridine ring.

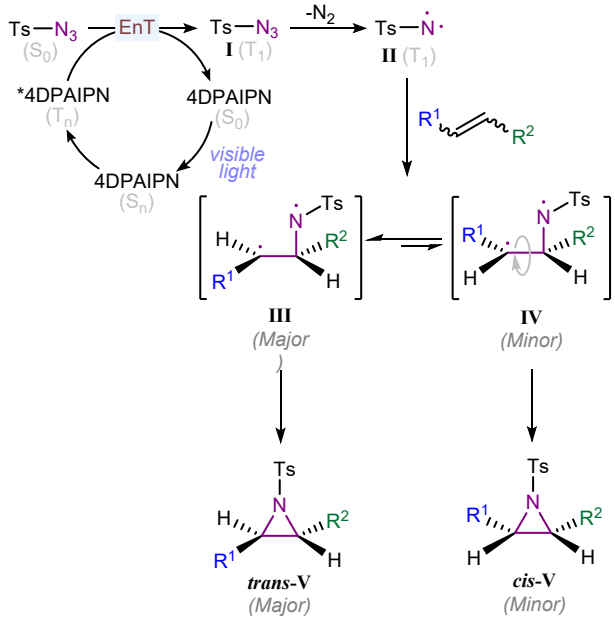
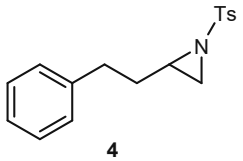


Figure S12: The Proposed Mechanism

11. Characterization of Products



4

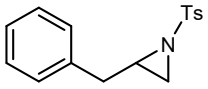
According to the general procedure, the title product was obtained in 69% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.84 (d, *J* = 8.2 Hz, 2H), 7.35 (d, *J* = 8.4 Hz, 2H), 7.30 – 7.24 (m, 2H), 7.19 (t, *J* = 7.3 Hz, 1H), 7.12 (d, *J* = 7.3 Hz, 2H), 2.81 – 2.75 (m, 1H), 2.65 – 2.56 (m, 3H), 2.45 (s, 3H), 2.06 (d, *J* = 4.6 Hz, 1H), 1.94 – 1.83 (m, 1H), 1.72 – 1.60 (m, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.65, 140.79, 135.07, 129.78, 128.56, 128.42, 128.11, 126.22, 39.84, 34.01, 33.23, 33.08, 21.76.

HRMS (ESI) m/z Calcd. for $C_{17}H_{20}NO_2S$ $[M+H]^+$, 302.1209, found: 302.1221.

IR (film) ν_{max} (cm^{-1}) 2924, 1597, 1495, 1454, 1320, 1157, 1090, 927, 815, 746, 712, 694, 563, 547.



5

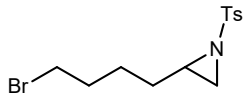
According to the general procedure, the title product was obtained in 60% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.71 – 7.66 (m, 2H), 7.21 (d, *J* = 8.1 Hz, 2H), 7.19 – 7.13 (m, 3H), 7.05 (dt, *J* = 7.5, 3.8 Hz, 2H), 2.95 (tt, *J* = 7.0, 4.9 Hz, 1H), 2.81 (dd, *J* = 14.5, 5.2 Hz, 1H), 2.73 – 2.65 (m, 2H), 2.42 (s, 3H), 2.16 (d, *J* = 4.5 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.42, 137.10, 134.94, 129.69, 128.82, 128.55, 127.96, 126.60, 41.29, 37.59, 32.93, 21.71.

HRMS (ESI) m/z Calcd. for $C_{16}H_{18}NO_2S$ $[M+H]^+$ 288.1053, found: 288.1064.

IR (film) ν_{max} (cm^{-1}) 2922, 1595, 1494, 1455, 1394, 1315, 1303, 1291, 1233, 1157, 1088, 934, 873, 812, 744, 713, 659, 562, 546, 497.



6

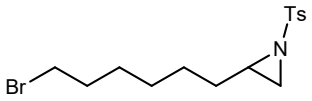
According to the general procedure, the title product was obtained in 70% yield as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82 (d, *J* = 8.3 Hz, 2H), 7.37 – 7.31 (m, 2H), 3.31 – 3.25 (m, 2H), 2.70 (tt, *J* = 7.2, 4.5 Hz, 1H), 2.64 (d, *J* = 7.0 Hz, 1H), 2.44 (s, 3H), 2.07 (d, *J* = 4.5 Hz, 1H), 1.83 – 1.73 (m, 2H), 1.67 – 1.59 (m, 1H), 1.43 – 1.24 (m, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.73, 135.06, 129.82, 128.10, 40.03, 33.83, 33.38, 31.98, 30.51, 25.58, 21.78.

HRMS (ESI) m/z Calcd. for $C_{13}H_{19}BrNO_2S$ $[M+H]^+$ 332.0314, found: 332.0323.

IR (film) ν_{max} (cm^{-1}) 2927, 2863, 1597, 1455, 1320, 1305, 1291, 1157, 1091, 929, 860, 814, 712, 692, 660, 568, 549.



7

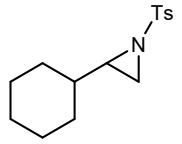
According to the general procedure, the title product was obtained in 73% yield as a light yellow oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.85 – 7.79 (m, 2H), 7.34 (d, *J* = 8.1 Hz, 2H), 3.36 (t, *J* = 6.8 Hz, 2H), 2.71 (tt, *J* = 7.3, 4.6 Hz, 1H), 2.63 (d, *J* = 7.0 Hz, 1H), 2.44 (s, 3H), 2.05 (d, *J* = 4.6 Hz, 1H), 1.82 – 1.72 (m, 2H), 1.60 – 1.53 (m, 1H), 1.36 – 1.21 (m, 7H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.60, 135.19, 129.75, 128.09, 40.39, 33.97, 33.88, 32.58, 31.25, 28.18, 27.99, 26.70, 21.76.

HRMS (ESI) m/z Calcd. for $C_{15}H_{23}BrNO_2S$ $[M+H]^+$ 360.0627, found: 360.0630.

IR (film) ν_{max} (cm^{-1}) 2931, 2857, 1597, 1455, 1321, 1305, 1291, 1158, 1091, 923, 868, 815, 712, 692, 660, 568, 550.



8

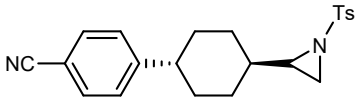
According to the general procedure, the title product was obtained in 56% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82 (d, *J* = 8.3 Hz, 2H), 7.36 – 7.31 (m, 2H), 2.60 (d, *J* = 7.0 Hz, 1H), 2.53 (td, *J* = 7.2, 4.6 Hz, 1H), 2.44 (s, 3H), 2.10 (d, *J* = 4.6 Hz, 1H), 1.73 – 1.56 (m, 4H), 1.49 (d, *J* = 12.6 Hz, 1H), 1.19 – 0.84 (m, 6H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.50, 135.16, 129.69, 128.16, 45.26, 39.48, 32.76, 30.28, 29.71, 26.10, 25.65, 25.46, 21.75.

HRMS (ESI) m/z Calcd. for $C_{15}H_{22}NO_2S$ $[M+H]^+$ 280.1366, found: 280.1383.

IR (film) ν_{max} (cm^{-1}) 2923, 2852, 1597, 1448, 1313, 1303, 1291, 1155, 1092, 953, 887, 815, 719, 697, 663, 567, 558, 537.



9

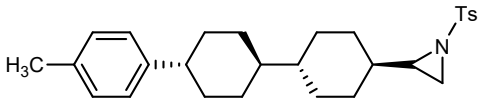
According to the general procedure, the title product was obtained in 62% yield as a light yellow oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.85 – 7.80 (m, 2H), 7.56 – 7.52 (m, 2H), 7.34 (d, *J* = 8.1 Hz, 2H), 7.24 (d, *J* = 8.3 Hz, 2H), 2.63 – 2.55 (m, 2H), 2.53 – 2.42 (m, 4H), 2.14 (d, *J* = 4.2 Hz, 1H), 1.93 – 1.78 (m, 3H), 1.73 – 1.66 (m, 1H), 1.42 – 1.27 (m, 2H), 1.25 – 1.09 (m, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 152.47, 144.64, 135.00, 132.30, 129.73, 128.14, 127.68, 119.14, 109.87, 44.67, 44.08, 38.83, 32.97, 32.84, 32.75, 30.03, 29.65, 21.73.

HRMS (ESI) m/z Calcd. for $C_{22}H_{25}N_2O_2S$ $[M+H]^+$ 381.1631, found: 381.1633.

IR (film) ν_{max} (cm^{-1}). 2925, 2853, 2226, 1606, 1504, 1449, 1407, 1320, 1305, 1291, 1158, 1091, 937, 892, 878, 828, 718, 698, 666, 565, 538.



10

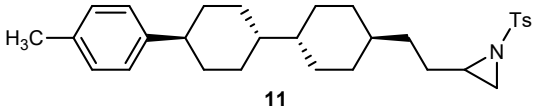
According to the general procedure, the title product was obtained in 66% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83 (d, *J* = 8.0 Hz, 2H), 7.34 (d, *J* = 8.1 Hz, 2H), 7.09 (s, 4H), 2.60 (d, *J* = 7.0 Hz, 1H), 2.53 (dd, *J* = 11.4, 6.5 Hz, 1H), 2.46 (s, 3H), 2.44 – 2.34 (m, 1H), 2.31 (s, 3H), 2.11 (d, *J* = 4.6 Hz, 1H), 1.89 (d, *J* = 12.6 Hz, 2H), 1.83 – 1.66 (m, 5H), 1.59 (t, *J* = 7.2 Hz, 2H), 1.39 (dd, *J* = 21.4, 9.1 Hz, 2H), 1.11 – 0.86 (m, 8H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.85, 144.51, 135.33, 135.24, 129.71, 129.07, 128.19, 126.75, 45.30, 44.27, 42.90, 42.80, 39.73, 34.71, 32.75, 30.50, 30.43, 29.94, 29.35, 29.20, 21.78, 21.09.

HRMS (ESI) m/z Calcd. for $C_{28}H_{38}NO_2S$ $[M+H]^+$ 452.2618, found: 452.2617.

IR (film) ν_{max} (cm^{-1}) 2918, 2850, 1598, 1513, 1450, 1318, 1307, 1292, 1160, 1093, 931, 886, 809, 722, 696, 671, 568, 544, 528.



11

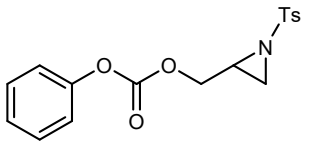
According to the general procedure, the title product was obtained in 66% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.87 – 7.81 (m, 2H), 7.34 (d, *J* = 8.0 Hz, 2H), 7.10 (s, 4H), 2.70 (tt, *J* = 7.2, 4.7 Hz, 1H), 2.64 (d, *J* = 6.9 Hz, 1H), 2.45 (s, 3H), 2.40 (ddd, *J* = 12.1, 7.7, 3.1 Hz, 1H), 2.32 (s, 3H), 2.06 (d, *J* = 4.5 Hz, 1H), 1.90 (d, *J* = 12.4 Hz, 2H), 1.85 – 1.78 (m, 2H), 1.69 (dd, *J* = 21.1, 12.3 Hz, 4H), 1.59 – 1.53 (m, 1H), 1.46 – 1.25 (m, 4H), 1.16 – 1.06 (m, 5H), 0.97 (dt, *J* = 22.0, 13.5 Hz, 3H), 0.79 (dd, *J* = 22.5, 11.0 Hz, 2H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.97, 144.53, 135.35, 135.30, 129.73, 129.07, 128.15, 126.78, 44.33, 43.39, 42.97, 40.86, 37.29, 34.79, 34.31, 33.93, 33.52, 33.31, 30.51, 30.00, 28.83, 21.76, 21.10.

HRMS (ESI) m/z Calcd. for $C_{30}H_{42}NO_2S$ $[M+H]^+$ 480.2931, found: 480.2932.

IR (film) ν_{max} (cm^{-1}) 2915, 2848, 1596, 1515, 1447, 1316, 1306, 1290, 1156, 1092, 922, 813, 714, 694, 664, 565, 551, 533.



12

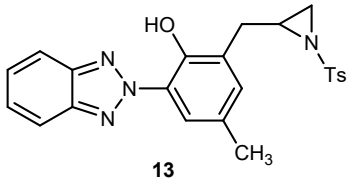
According to the general procedure, the title product was obtained in 54% yield as a light yellow solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.88 – 7.83 (m, 2H), 7.42 – 7.32 (m, 4H), 7.27– 7.23 (m, 1H), 7.14 – 7.09 (m, 2H), 4.31 (dd, *J* = 11.9, 4.6 Hz, 1H), 4.12 (dd, *J* = 11.9, 6.4 Hz, 1H), 3.13 (tt, *J* = 6.7, 4.5 Hz, 1H), 2.77 (d, *J* = 7.0 Hz, 1H), 2.41 (s, 3H), 2.32 (d, *J* = 4.4 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 153.28, 151.01, 145.04, 134.58, 129.91, 129.63, 128.15, 126.31, 120.92, 67.10, 36.90, 31.31, 21.75.

HRMS (ESI) m/z Calcd. for $C_{17}H_{18}NO_5S$ $[M+H]^+$ 348.0900, found: 348.0905.

IR (film) ν_{max} (cm^{-1}) 2958, 1760, 1595, 1493, 1456, 1324, 1239, 1208, 1157, 1090, 926, 814, 771, 711, 688, 660, 568, 549.



13

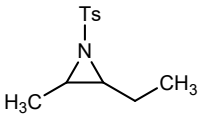
According to the general procedure, the title product was obtained in 63% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 11.29 (s, 1H), 7.99 (d, *J* = 1.5 Hz, 1H), 7.96 (dd, *J* = 6.6, 3.1 Hz, 2H), 7.60 (d, *J* = 8.3 Hz, 2H), 7.51 (dd, *J* = 6.6, 3.1 Hz, 2H), 6.97 (d, *J* = 8.2 Hz, 2H), 6.79 (d, *J* = 1.8 Hz, 1H), 3.21 – 3.13 (m, 2H), 2.85 (d, *J* = 6.6 Hz, 1H), 2.47 (dd, *J* = 15.1, 9.2 Hz, 1H), 2.31 (d, *J* = 4.3 Hz, 1H), 2.24 (s, 3H), 2.22 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 145.52, 144.18, 142.88, 134.81, 132.58, 129.25, 128.98, 127.95, 127.80, 127.15, 124.64, 119.78, 117.77, 40.32, 33.38, 33.02, 21.59, 20.54.

HRMS (ESI) m/z Calcd. for $C_{23}H_{23}N_4O_3S$ $[M+H]^+$ 435.1485, found: 435.1498.

IR (film) ν_{max} (cm^{-1}) 2920, 1320, 1307, 1258, 1165, 1091, 944, 926, 757, 710, 695, 666, 629, 564, 544, 534.



14

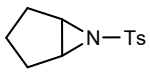
According to the general procedure, the title product was obtained in 75% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) Unknown NMR (400 MHz,) δ 7.86 – 7.79 (m, 2H), 7.35 – 7.28 (m, 2H), 2.96 – 2.87 and 2.74 – 2.62 (m, 2H), 2.435 and 2.426 (s, 3H), 1.75 – 1.64 and 1.53 – 1.36 (m, 2H), [1.55 (d) and 1.20 (dd), 3H], 0.84 (t, *J* = 7.4 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.29, 143.86, 138.20, 135.66, 129.67, 129.55, 127.94, 127.45, 51.09, 46.65, 45.78, 40.43, 23.94, 21.73, 21.70, 19.93, 14.86, 12.00, 11.58, 11.50.

HRMS (ESI) m/z Calcd. for $C_{12}H_{18}NO_2S$ $[M+H]^+$ 240.1053, found: 240.1066.

IR (film) ν_{max} (cm^{-1}) 2968, 2921, 2850, 1595, 1452, 1307, 1288, 1243, 1147, 1084, 1048, 964, 918, 855, 819, 743, 725, 711, 687, 667, 587, 576, 545.



15

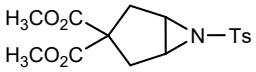
According to the general procedure, the title product was obtained in 55% yield as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83 – 7.78 (m, 2H), 7.31 (d, *J* = 8.0 Hz, 2H), 3.32 (s, 2H), 2.43 (s, 3H), 1.93 (dd, *J* = 13.3, 7.8 Hz, 2H), 1.68 – 1.51 (m, 3H), 1.47 – 1.31 (m, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.18, 136.09, 129.69, 127.69, 46.84, 27.04, 21.72, 19.62.

HRMS (ESI) m/z Calcd. for $C_{12}H_{16}NO_2S$ $[M+H]^+$ 238.0896, found: 238.0908.

IR (film) ν_{max} (cm^{-1}) 2958, 2928, 1598, 1318, 1303, 1153, 1093, 973, 870, 812, 721, 671, 622, 564, 544.



16

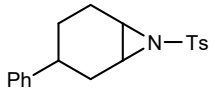
According to the general procedure, the title product was obtained in 81% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.75 – 7.70 (m, 2H), 7.31 (d, *J* = 8.1 Hz, 2H), 3.67 (s, 3H), 3.67 (s, 3H), 3.39 (d, *J* = 1.0 Hz, 2H), 2.97 (d, *J* = 14.3 Hz, 2H), 2.43 (s, 3H), 2.23 (d, *J* = 14.4 Hz, 2H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 171.20, 170.74, 144.46, 135.91, 129.70, 127.41, 57.15, 53.38, 53.01, 44.53, 35.74, 21.75.

HRMS (ESI) m/z Calcd. for $C_{16}H_{20}NO_6S$ $[M+H]^+$ 354.1006, found: 354.1020.

IR (film) ν_{max} (cm^{-1}) 2956, 2921, 1744, 1724, 1432, 1315, 1259, 1211, 1150, 1075, 1017, 972, 962, 949, 884, 861, 800, 727, 679, 663, 568, 548.



17

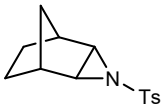
According to the general procedure, the title product was obtained in 75% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.84 (dd, *J* = 8.3, 2.9 Hz, 2H), 7.34 (dd, *J* = 8.2, 1.9 Hz, 2H), 7.26 (ddd, *J* = 7.6, 4.6, 1.6 Hz, 2H), 7.20 – 7.14 (m, 1H), 7.12 (dd, *J* = 10.6, 4.1 Hz, 2H), 3.20 – 3.01 (m, 2H), 2.77 – 2.67 and 2.43 – 2.36 (m, 1H) , 2.44 (s, 3H), 2.26 – 2.05 (m, 2H), 1.88 – 1.73 (m, 2H), 1.68 – 1.58 (m, 1H), 1.57 – 1.32 (m, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 145.84, 145.61, 144.31, 135.77, 129.77, 128.58, 127.74, 126.90, 126.88, 126.44, 41.48, 40.13, 39.57, 39.45, 39.04, 35.96, 31.24, 31.02, 28.37, 25.67, 24.45, 22.68, 21.73.

HRMS (ESI) m/z Calcd. for $C_{19}H_{22}NO_2S$ $[M+H]^+$ 328.1366, found: 328.1373.

IR (film) ν_{max} (cm^{-1}) 2923, 1316, 1306, 1289, 1154, 1092, 982, 966, 928, 896, 873, 814, 726, 696, 669, 660, 576, 548.



18

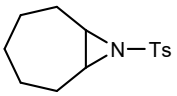
According to the general procedure, the title product was obtained in 78% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.79 (d, *J* = 8.2 Hz, 2H), 7.31 (d, *J* = 8.2 Hz, 2H), 2.90 (s, 2H), 2.43 (s, 5H), 1.45 (t, *J* = 9.6 Hz, 3H), 1.23 (qd, *J* = 5.6, 2.6 Hz, 2H), 0.74 (d, *J* = 10.1 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.19, 135.94, 129.69, 127.74, 42.06, 35.93, 28.37, 25.70, 21.74.

HRMS (ESI) m/z Calcd. for $C_{14}H_{18}NO_2S$ $[M+H]^+$ 264.1053, found: 264.1067.

IR (film) ν_{max} (cm^{-1}) 2967, 2924, 1597, 1351, 1318, 1288, 1152, 1089, 968, 902, 863, 821, 772, 754, 668, 573, 550.



19

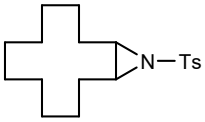
According to the general procedure, the title product was obtained in 54% yield as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.81 (d, *J* = 8.3 Hz, 2H), 7.31 (d, *J* = 8.2 Hz, 2H), 3.00 – 2.92 (m, 2H), 2.43 (s, 3H), 1.91 – 1.78 (m, 4H), 1.59 – 1.51 (m, 1H), 1.44 (dt, *J* = 10.9, 5.4 Hz, 4H), 1.17 (dt, *J* = 11.7, 5.0 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.10, 136.05, 129.70, 129.69, 129.68, 127.68, 127.67, 127.66, 127.64, 44.40, 31.15, 28.20, 25.32, 21.74.

HRMS (ESI) m/z Calcd. for $C_{14}H_{20}NO_2S$ $[M+H]^+$ 266.1209, found: 266.1216.

IR (film) ν_{max} (cm^{-1}) 2924, 2850, 1598, 1451, 1422, 1318, 1304, 1155, 1088, 1034, 961, 931, 858, 807, 733, 712, 698, 666, 572, 548.



20

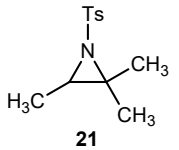
According to the general procedure, the title product was obtained in 81% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83 – 7.77 (m, 2H), 7.30 (t, *J* = 7.7 Hz, 2H), 2.79 – 2.66 (m, 2H), 2.43 and 2.41 (s, 3H), 2.22 – 2.11 (m, 1H), 1.68 – 1.20 (m, 19H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.24, 143.77, 138.41, 135.80, 129.73, 129.61, 127.69, 127.16, 50.07, 45.57, 28.83, 27.30, 26.31, 25.70, 25.29, 24.66, 24.07, 23.71, 22.36, 21.72, 21.67.

HRMS (ESI) m/z Calcd. for $C_{19}H_{30}NO_2S$ $[M+H]^+$ 336.1992, found: 336.2001.

IR (film) ν_{max} (cm^{-1}) 2927, 2844, 1470, 1445, 1317, 1303, 1290, 1153, 1092, 990, 811, 709, 696, 670, 561, 537, 528, 511.



21

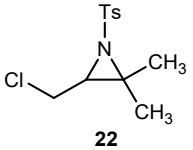
According to the general procedure, the title product was obtained in 73% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.79 (d, *J* = 8.3 Hz, 2H), 7.29 (d, *J* = 8.1 Hz, 2H), 2.95 (q, *J* = 5.8 Hz, 1H), 2.41 (s, 3H), 1.69 (s, 3H), 1.26 (s, 3H), 1.13 (d, *J* = 5.9 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 143.56, 138.84, 129.56, 127.04, 51.87, 48.00, 21.66, 21.22, 21.00, 12.98.

HRMS (ESI) m/z Calcd. for $C_{12}H_{18}NO_2S$ $[M+H]^+$ 240.1053, found: 240.1064.

IR (film) ν_{max} (cm^{-1}) 2925, 2855, 1597, 1460, 1315, 1303, 1288, 1156, 1088, 1067, 974, 924, 815, 776, 708, 662, 580, 539.



22

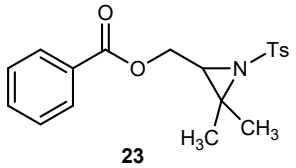
According to the general procedure, the title product was obtained in 84% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82 (d, *J* = 8.2 Hz, 2H), 7.30 (d, *J* = 8.1 Hz, 2H), 3.42 (d, *J* = 6.9 Hz, 2H), 3.18 (t, *J* = 6.9 Hz, 1H), 2.42 (s, 3H), 1.76 (s, 3H), 1.34 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.11, 137.81, 129.56, 127.60, 52.50, 51.56, 41.60, 21.72, 21.25, 21.11.

HRMS (ESI) m/z Calcd. for $C_{12}H_{17}ClNO_2S$ $[M+H]^+$ 274.0663, found: 274.0675.

IR (film) ν_{max} (cm^{-1}) 2925, 1595, 1456, 1407, 1318, 1307, 1154, 1091, 1081, 918, 814, 736, 717, 706, 672, 658, 581, 532.



23

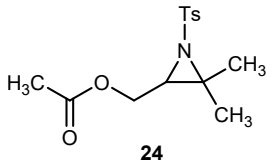
According to the general procedure, the title product was obtained in 74% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.84 – 7.76 (m, 4H), 7.57 (t, *J* = 7.5 Hz, 1H), 7.40 (t, *J* = 7.8 Hz, 2H), 7.12 (d, *J* = 8.3 Hz, 2H), 4.44 (dd, *J* = 11.9, 4.6 Hz, 1H), 4.12 (dd, *J* = 11.9, 8.1 Hz, 1H), 3.29 (dd, *J* = 8.1, 4.6 Hz, 1H), 2.31 (s, 3H), 1.82 (s, 3H), 1.43 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 166.04, 143.80, 137.88, 133.25, 129.73, 129.49, 128.35, 127.41, 62.60, 51.23, 49.43, 21.78, 21.64, 21.27.

HRMS (ESI) m/z Calcd. for $C_{19}H_{22}NO_4S$ $[M+H]^+$ 360.1264, found: 360.1277.

IR (film) ν_{max} (cm^{-1}) 2972, 2927, 1718, 1600, 1451, 1317, 1269, 1155, 1111, 1087, 1070, 935, 814, 734, 708, 666, 586, 539.



24

According to the general procedure, the title product was obtained in 65% yield as a white solid.

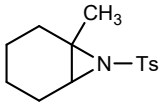
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.81 (d, *J* = 8.3 Hz, 2H), 7.29 (d, *J* = 8.1 Hz, 2H), 4.10 (dd, *J* = 11.9, 5.2 Hz, 1H), 3.87 (dd, *J* = 11.9, 7.7 Hz, 1H), 3.12 (dd, *J* = 7.6, 5.2

Hz, 1H), 2.42 (s, 3H), 1.88 (s, 3H), 1.76 (s, 3H), 1.33 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 170.55, 143.97, 138.05, 129.50, 127.57, 62.10, 51.36, 49.22, 21.70, 21.64, 21.22, 20.65.

HRMS (ESI) m/z Calcd. for $C_{14}H_{19}NaNO_4S$ $[M+Na]^+$ 320.0927, found: 320.0928.

IR (film) ν_{max} (cm^{-1}) 2925, 1736, 1451, 1370, 1318, 1223, 1153, 1087, 1033, 929, 818, 803, 735, 681, 665, 584, 541, 523.



25

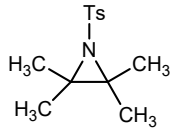
According to the general procedure, the title product was obtained in 48% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.85 – 7.78 (m, 2H), 7.29 (d, *J* = 8.4 Hz, 2H), 3.05 (d, *J* = 5.3 Hz, 1H), 2.42 (s, 3H), 2.04 (dt, *J* = 14.0, 4.8 Hz, 1H), 1.85 – 1.77 (m, 1H), 1.71 (s, 3H), 1.59 – 1.48 (m, 2H), 1.44 – 1.24 (m, 4H), 1.17 – 1.05 (m, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 143.45, 139.12, 129.52, 127.06, 51.36, 47.44, 32.20, 22.97, 21.68, 20.63, 19.93, 19.68.

HRMS (ESI) m/z Calcd. for $C_{14}H_{20}NO_2S$ $[M+H]^+$ 266.1209, found: 266.1213.

IR (film) ν_{max} (cm^{-1}) 2939, 2862, 1596, 1439, 1305, 1294, 1145, 1089, 1040, 1010, 980, 939, 851, 810, 782, 717, 708, 663, 578, 535.



26

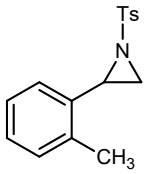
According to the general procedure, the title product was obtained in 70% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72 (d, *J* = 8.3 Hz, 2H), 7.24 – 7.17 (m, 2H), 2.34 (s, 3H), 1.39 (s, 12H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 143.20, 139.96, 129.44, 126.85, 53.17, 21.62, 20.29.

HRMS (ESI) m/z Calcd. for $C_{13}H_{20}NO_2S$ $[M+H]^+$ 254.1209, found: 254.1221.

IR (film) ν_{max} (cm^{-1}) 2968, 2926, 1609, 1370, 1300, 1151, 1087, 1040, 928, 810, 764, 718, 707, 663, 639, 581, 541, 522.



27

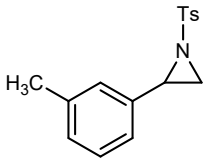
According to the general procedure, the title product was obtained in 73% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.90 (d, *J* = 8.2 Hz, 2H), 7.35 (d, *J* = 8.3 Hz, 2H), 7.21 – 7.09 (m, 4H), 3.87 (dd, *J* = 7.1, 4.6 Hz, 1H), 2.99 (d, *J* = 7.2 Hz, 1H), 2.45 (s, 3H), 2.39 (s, 3H), 2.32 (d, *J* = 4.6 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.80, 136.85, 135.09, 133.34, 130.06, 129.87, 128.17, 128.14, 126.21, 126.02, 39.62, 35.15, 21.76, 19.16.

HRMS (ESI) m/z Calcd. for $C_{16}H_{18}NO_2S$ $[M+H]^+$ 288.1053, found: 288.1062.

IR (film) ν_{max} (cm^{-1}) 2924, 1597, 1493, 1460, 1378, 1322, 1158, 1092, 909, 815, 766, 724, 710, 693, 661, 571, 557.



28

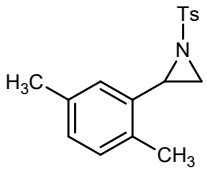
According to the general procedure, the title product was obtained in 66% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.90 – 7.85 (m, 2H), 7.33 (d, *J* = 8.0 Hz, 2H), 7.18 (t, *J* = 7.9 Hz, 1H), 7.08 (d, *J* = 7.5 Hz, 1H), 7.04 – 7.00 (m, 2H), 3.75 (dd, *J* = 7.2, 4.5 Hz, 1H), 2.96 (d, *J* = 7.2 Hz, 1H), 2.43 (s, 3H), 2.38 (d, *J* = 4.5 Hz, 1H), 2.30 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.73, 138.41, 135.09, 135.03, 129.85, 129.18, 128.55, 128.05, 127.25, 123.79, 41.14, 35.98, 21.74, 21.40.

HRMS (ESI) m/z Calcd. for $C_{16}H_{18}NO_2S$ $[M+H]^+$ 288.1053, found: 288.1061.

IR (film) ν_{max} (cm^{-1}) 2922, 1596, 1452, 1322, 1305, 1215, 1157, 1091, 927, 865, 815, 785, 717, 690, 663, 578, 553.



29

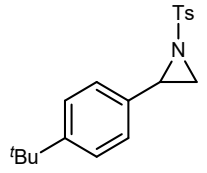
According to the general procedure, the title product was obtained in 67% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94 – 7.89 (m, 2H), 7.35 (d, *J* = 8.1 Hz, 2H), 7.05 – 6.96 (m, 2H), 6.92 (s, 1H), 3.85 (dd, *J* = 7.2, 4.6 Hz, 1H), 2.97 (d, *J* = 7.2 Hz, 1H), 2.45 (s, 3H), 2.34 (s, 3H), 2.32 (d, *J* = 4.6 Hz, 1H), 2.24 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.79, 135.73, 135.02, 133.67, 132.99, 130.01, 129.85, 128.84, 128.16, 126.60, 39.50, 35.24, 21.75, 21.04, 18.68.

HRMS (ESI) m/z Calcd. for $C_{17}H_{20}NO_2S$ $[M+H]^+$ 302.1209, found: 302.1219.

IR (film) ν_{max} (cm^{-1}) 2922, 1597, 1504, 1450, 1322, 1305, 1291, 1158, 1092, 930, 876, 812, 731, 711, 693, 663, 571, 555, 534.



30

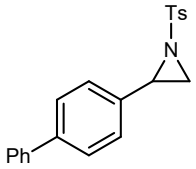
According to the general procedure, the title product was obtained in 80% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.88 (d, *J* = 8.3 Hz, 2H), 7.37 – 7.30 (m, 4H), 7.19 – 7.13 (m, 2H), 3.78 (dd, *J* = 7.2, 4.5 Hz, 1H), 2.97 (d, *J* = 7.2 Hz, 1H), 2.44 (s, 3H), 2.39 (d, *J* = 4.5 Hz, 1H), 1.29 (s, 9H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 151.52, 144.69, 135.14, 132.11, 129.85, 129.84, 128.07, 128.05, 126.42, 125.63, 125.62, 41.07, 35.88, 34.67, 31.38, 31.37, 31.36, 31.35, 31.34, 31.33, 21.76.

HRMS (ESI) m/z Calcd. for $C_{19}H_{24}NO_2S$ $[M+H]^+$ 330.1522, found: 330.1529.

IR (film) ν_{max} (cm^{-1}) 2961, 2868, 1597, 1456, 1320, 1159, 1092, 913, 814, 713, 695, 671, 577, 557.



31

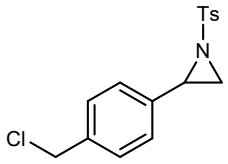
According to the general procedure, the title product was obtained in 65% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.89 (d, *J* = 8.3 Hz, 2H), 7.56 – 7.50 (m, 4H), 7.43 (dd, *J* = 10.3, 4.8 Hz, 2H), 7.37 – 7.32 (m, 3H), 7.29 (d, *J* = 8.3 Hz, 2H), 3.82 (dd, *J* = 7.2, 4.5 Hz, 1H), 3.02 (d, *J* = 7.2 Hz, 1H), 2.45 – 2.42 (d, *J* = 4.4 Hz, 4H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.83, 141.44, 140.58, 135.11, 134.18, 129.92, 128.94, 128.10, 127.63, 127.44, 127.16, 127.14, 41.00, 36.12, 21.80.

HRMS (ESI) m/z Calcd. for $C_{21}H_{20}NO_2S$ $[M+H]^+$ 350.1209, found: 350.1207.

IR (film) ν_{max} (cm^{-1}) 2923, 1597, 1488, 1447, 1319, 1307, 1291, 1156, 1093, 911, 814, 765, 733, 713, 688, 660, 589, 569, 552.



32

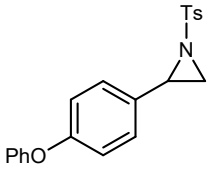
According to the general procedure, the title product was obtained in 68% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86 (d, *J* = 8.3 Hz, 2H), 7.32 (t, *J* = 8.1 Hz, 4H), 7.21 (d, *J* = 8.2 Hz, 2H), 4.54 (s, 2H), 3.76 (dd, *J* = 7.2, 4.4 Hz, 1H), 2.98 (d, *J* = 7.2 Hz, 1H), 2.43 (s, 3H), 2.36 (d, *J* = 4.4 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.88, 137.70, 135.50, 134.92, 129.91, 128.94, 128.05, 127.05, 45.84, 40.72, 36.12, 21.77.

HRMS (ESI) m/z Calcd. for $C_{16}H_{17}ClNO_2S$ $[M+H]^+$ 322.0663, found: 322.0680.

IR (film) ν_{max} (cm^{-1}) 2921, 1595, 1445, 1316, 1303, 1291, 1158, 1091, 906, 813, 786, 756, 710, 672, 656, 571, 558.



33

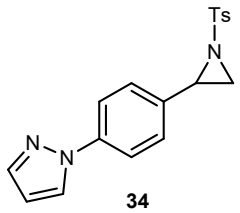
According to the general procedure, the title product was obtained in 81% yield as a light yellow oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.87 (d, *J* = 8.3 Hz, 2H), 7.37 – 7.30 (m, 4H), 7.20 – 7.15 (m, 2H), 7.14 – 7.08 (m, 1H), 6.97 (dt, *J* = 9.0, 1.8 Hz, 2H), 6.94 – 6.89 (m, 2H), 3.77 (dd, *J* = 7.1, 4.5 Hz, 1H), 2.97 (d, *J* = 7.2 Hz, 1H), 2.44 (s, 3H), 2.38 (d, *J* = 4.5 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 157.59, 156.87, 144.79, 135.05, 129.89, 129.73, 128.17, 128.05, 123.66, 119.16, 118.83, 40.73, 36.02, 21.76.

HRMS (ESI) m/z Calcd. for $C_{21}H_{20}NO_3S$ $[M+H]^+$ 366.1158, found: 366.1163.

IR (film) ν_{max} (cm^{-1}) 2924, 1588, 1506, 1488, 1327, 1234, 1156, 1092, 1071, 871, 813, 734, 692, 661, 549, 490.



34

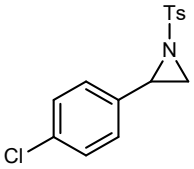
According to the general procedure, the title product was obtained in 74% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.87 (dd, *J* = 8.3, 1.9 Hz, 3H), 7.72 – 7.69 (m, 1H), 7.65 – 7.59 (m, 2H), 7.34 (d, *J* = 8.0 Hz, 2H), 7.31 – 7.27 (m, 2H), 6.45 (dd, *J* = 2.3, 1.9 Hz, 1H), 3.79 (dd, *J* = 7.2, 4.4 Hz, 1H), 3.01 (d, *J* = 7.2 Hz), 1H, 2.44 (s, 3H), 2.41 (d, *J* = 4.4 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.92, 141.39, 140.21, 134.96, 133.29, 129.93, 128.05, 127.81, 126.81, 119.31, 107.95, 40.61, 36.15, 21.79.

HRMS (ESI) m/z Calcd. for $C_{18}H_{18}N_3O_2S$ $[M+H]^+$ 340.1114, found: 340.1117.

IR (film) ν_{max} (cm^{-1}) 2921, 2852, 1528, 1395, 1316, 1302, 1156, 1124, 1091, 937, 912, 817, 769, 737, 710, 694, 666, 571, 553, 527.



35

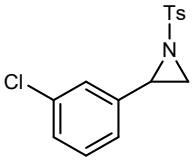
According to the general procedure, the title product was obtained in 71% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82 (d, *J* = 8.3 Hz, 2H), 7.29 (d, *J* = 8.4 Hz, 2H), 7.24 – 7.19 (m, 2H), 7.11 (dd, *J* = 6.3, 4.4 Hz, 2H), 3.69 (dd, *J* = 7.1, 4.4 Hz, 1H), 2.93 (d, *J* = 7.2 Hz, 1H), 2.39 (s, 3H), 2.30 (d, *J* = 4.4 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.93, 134.91, 134.29, 133.76, 129.91, 128.87, 128.03, 40.37, 36.14, 21.76.

HRMS (ESI) m/z Calcd. for $C_{15}H_{15}ClNO_2S$ $[M+H]^+$ 308.0507, found: 308.0517.

H**IR (film)** ν_{max} (cm^{-1}) 2923, 1595, 1493, 1320, 1305, 1292, 1157, 1090, 1014, 978, 910, 814, 730, 707, 694, 668, 643, 571, 553, 520.



36

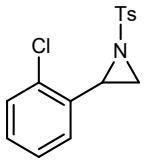
According to the general procedure, the title product was obtained in 75% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86 (d, *J* = 8.2 Hz, 2H), 7.34 (d, *J* = 8.5 Hz, 2H), 7.24 – 7.17 (m, 3H), 7.12 (dt, *J* = 6.6, 1.7 Hz, 1H), 3.73 (dd, *J* = 7.2, 4.4 Hz, 1H), 2.99 – 2.94 (m, 1H), 2.44 (s, 3H), 2.34 (d, *J* = 4.4 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.99, 137.32, 134.81, 134.67, 129.94, 128.61, 128.08, 126.65, 125.02, 40.20, 36.22, 21.76.

HRMS (ESI) m/z Calcd. for $C_{15}H_{15}ClNO_2S$ $[M+H]^+$ 308.0507, found: 308.0512.

IR (film) ν_{max} (cm^{-1}) 2923, 1597, 1575, 1323, 1305, 1292, 1158, 1091, 916, 837, 814, 784, 720, 686, 661, 581, 553, 536.



37

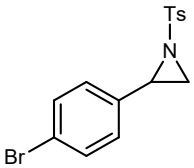
According to the general procedure, the title product was obtained in 79% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.89 (d, *J* = 8.2 Hz, 2H), 7.38 – 7.29 (m, 3H), 7.23 – 7.14 (m, 3H), 4.04 (dd, *J* = 7.2, 4.4 Hz, 1H), 3.03 (d, *J* = 7.2 Hz, 1H), 2.44 (s, 3H), 2.29 (d, *J* = 4.4 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.96, 134.69, 133.85, 133.17, 129.91, 129.38, 129.30, 128.20, 127.58, 127.11, 39.05, 35.71, 21.77.

HRMS (ESI) m/z Calcd. for $C_{15}H_{15}ClNO_2S$ $[M+H]^+$ 308.0507, found: 308.0509.

IR (film) ν_{max} (cm^{-1}) 2923, 1596, 1479, 1444, 1379, 1324, 1306, 1291, 1159, 1092, 907, 814, 757, 729, 709, 691, 658, 569, 555.



38

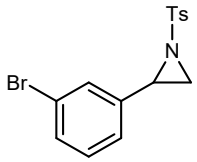
According to the general procedure, the title product was obtained in 63% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.85 (d, *J* = 8.3 Hz, 2H), 7.44 – 7.39 (m, 2H), 7.33 (d, *J* = 8.0 Hz, 2H), 7.11 – 7.06 (m, 2H), 3.72 (dd, *J* = 7.1, 4.4 Hz, 1H), 2.98 (d, *J* = 7.2 Hz, 1H), 2.44 (s, 3H), 2.34 (d, *J* = 4.4 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.96, 134.89, 134.30, 131.84, 129.94, 128.34, 128.06, 122.43, 40.44, 36.14, 21.80.

HRMS (ESI) m/z Calcd. for $C_{15}H_{15}BrNO_2S$ $[M+H]^+$ 352.0001, found: 352.0011.

IR (film) ν_{max} (cm^{-1}) 2917, 2849, 1594, 1488, 1318, 1301, 1158, 1092, 1069, 906, 813, 723, 692, 665, 571, 550, 514.



39

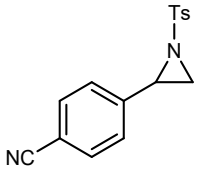
According to the general procedure, the title product was obtained in 73% yield as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.91 – 7.83 (m, 2H), 7.44 – 7.31 (m, 4H), 7.20 – 7.14 (m, 2H), 3.72 (dd, *J* = 7.2, 4.4 Hz, 1H), 2.96 (d, *J* = 7.2 Hz, 1H), 2.44 (s, 3H), 2.34 (d, *J* = 4.4 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 145.00, 137.55, 134.76, 131.53, 130.22, 129.94, 129.55, 128.08, 125.48, 122.76, 40.10, 36.24, 21.77.

HRMS (ESI) m/z Calcd. for $C_{15}H_{15}BrNO_2S$ $[M+H]^+$ 352.0001, found: 352.0006.

IR (film) ν_{max} (cm^{-1}) 2923, 1597, 1569, 1323, 1305, 1292, 1158, 1091, 914, 814, 782, 719, 685, 660, 577, 552, 532.



40

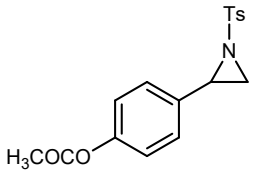
According to the general procedure, the title product was obtained in 83% yield as a light yellow solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.87 – 7.82 (m, 2H), 7.60 – 7.55 (m, 2H), 7.34 (dd, *J* = 8.2, 1.6 Hz, 4H), 3.79 (dd, *J* = 7.2, 4.3 Hz, 1H), 3.01 (d, *J* = 7.2 Hz, 1H), 2.43 (s, 3H), 2.34 (d, *J* = 4.3 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 145.20, 140.64, 134.54, 132.48, 129.99, 128.06, 127.39, 118.50, 112.22, 39.99, 36.54, 21.77.

HRMS (ESI) m/z Calcd. for $C_{16}H_{15}N_2O_2S$ $[M+H]^+$ 299.0849, found: 299.0855.

IR (film) ν_{max} (cm^{-1}) 2921, 2230, 1452, 1385, 1319, 1307, 1292, 1161, 1093, 983, 916, 850, 814, 782, 742, 712, 697, 655, 573, 557, 542.



41

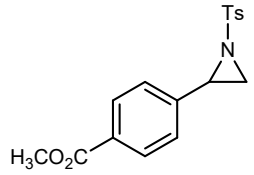
According to the general procedure, the title product was obtained in 72% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86 (d, *J* = 7.8 Hz, 2H), 7.33 (d, *J* = 7.8 Hz, 2H), 7.22 (d, *J* = 8.0 Hz, 2H), 7.01 (d, *J* = 8.0 Hz, 2H), 3.79 – 3.71 (m, 1H), 2.98 (d, *J* = 7.1 Hz, 1H), 2.43 (s, 3H), 2.35 (d, *J* = 3.1 Hz, 1H), 2.27 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 169.52, 150.68, 144.90, 134.94, 132.79, 129.93, 128.05, 127.77, 121.91, 40.60, 36.13, 21.77, 21.19.

HRMS (ESI) m/z Calcd. for $C_{17}H_{18}NO_4S$ $[M+H]^+$ 332.0951, found: 332.0960.

IR (film) ν_{max} (cm^{-1}) 2988, 2924, 1757, 1510, 1369, 1323, 1187, 1158, 1091, 907, 852, 813, 723, 709, 693, 665, 571, 549.



42

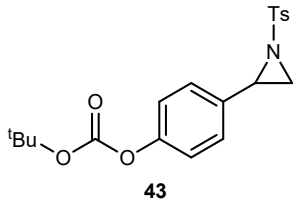
According to the general procedure, the title product was obtained in 87% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97 – 7.93 (m, 2H), 7.88 – 7.83 (m, 2H), 7.33 (d, *J* = 8.0 Hz, 2H), 7.30 – 7.26 (m, 2H), 3.88 (s, 3H), 3.79 (dd, *J* = 7.2, 4.4 Hz, 1H), 3.01 (d, *J* = 7.2 Hz, 1H), 2.42 (s, 3H), 2.38 (d, *J* = 4.4 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 166.67, 144.99, 140.25, 134.76, 130.17, 129.92, 128.04, 126.64, 52.28, 40.50, 36.33, 21.75.

HRMS (ESI) m/z Calcd. for $C_{17}H_{18}NO_4S$ $[M+H]^+$ 332.0951, found: 332.0953.

IR (film) ν_{max} (cm^{-1}) 2954, 2925, 1711, 1612, 1434, 1325, 1278, 1160, 1106, 1093, 908, 868, 820, 777, 765, 721, 705, 688, 666, 569, 552.



43

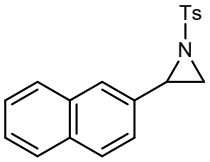
According to the general procedure, the title product was obtained in 68% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.85 (d, *J* = 8.3 Hz, 2H), 7.32 (d, *J* = 8.2 Hz, 2H), 7.24 – 7.19 (m, 2H), 7.11 – 7.06 (m, 2H), 3.74 (dd, *J* = 7.1, 4.4 Hz, 1H), 2.98 (d, *J* = 7.2 Hz, 1H), 2.42 (s, 3H), 2.35 (d, *J* = 4.4 Hz, 1H), 1.53 (s, 9H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 151.79, 151.04, 144.85, 134.94, 132.66, 129.90, 128.00, 127.67, 121.57, 83.85, 40.61, 36.04, 27.74, 21.73.

HRMS (ESI) m/z Calcd. for $C_{20}H_{23}NNaO_5S$ $[M+H]^+$ 412.1189, found: 412.0091.

IR (film) ν_{max} (cm^{-1}) 3001, 2984, 1743, 1509, 1369, 1334, 1275, 1258, 1237, 1215, 1160, 1140, 1092, 907, 895, 816, 717, 691, 567, 548.



44

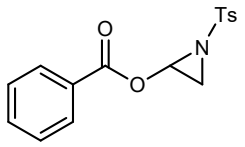
According to the general procedure, the title product was obtained in 57% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.89 (d, *J* = 8.3 Hz, 2H), 7.77 (t, *J* = 8.9 Hz, 3H), 7.72 (s, 1H), 7.46 (p, *J* = 6.2 Hz, 2H), 7.32 (d, *J* = 8.3 Hz, 2H), 7.27 (dd, 1H), 3.92 (dd, *J* = 7.1, 4.5 Hz, 1H), 3.06 (d, *J* = 7.2 Hz, 1H), 2.49 (d, *J* = 4.4 Hz, 1H), 2.41 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 169.52, 150.68, 144.90, 134.94, 132.79, 129.93, 128.05, 127.77, 121.91, 40.60, 36.13, 21.77, 21.19.

HRMS (ESI) m/z Calcd. for $C_{19}H_{18}NO_2S$ $[M+H]^+$ 324.1053, found: 324.1056.

IR (film) ν_{max} (cm^{-1}) 2919, 2849, 1646, 1597, 1313, 1306, 1156, 1093, 953, 925, 859, 818, 750, 722, 665, 640, 570, 556, 482.



45

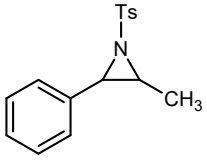
According to the general procedure, the title product was obtained in 68% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.93 (ddd, *J* = 10.8, 7.3, 1.3 Hz, 4H), 7.60 – 7.53 (m, 1H), 7.40 (dd, *J* = 10.8, 4.8 Hz, 2H), 7.35 (d, *J* = 8.1 Hz, 2H), 5.59 (dd, *J* = 5.4, 3.0 Hz, 1H), 2.97 (dd, *J* = 5.4, 1.5 Hz, 1H), 2.74 (dd, *J* = 3.0, 1.5 Hz, 1H), 2.44 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 165.63, 145.15, 134.38, 133.99, 130.01, 129.84, 128.60, 128.40, 128.35, 63.08, 32.56, 21.80.

HRMS (ESI) m/z Calcd. for $C_{16}H_{15}NNaO_4S$ $[M+Na]^+$ 340.0614, found: 340.0621.

IR (film) ν_{max} (cm^{-1}) 2925, 1734, 1597, 1451, 1334, 1268, 1246, 1161, 1112, 1085, 1068, 1052, 950, 879, 812, 704, 664, 572, 546, 513.



3

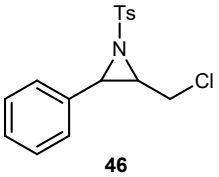
According to the general procedure, the title product was obtained in 95% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82 (d, *J* = 8.3 Hz, 2H), 7.24 (t, *J* = 5.3 Hz, 5H), 7.17 – 7.11 (m, 2H), 3.79 (d, *J* = 4.3 Hz, 1H), 2.96 – 2.85 (m, 1H), 2.37 (s, 3H), 1.84 (d, *J* = 6.0 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 143.93, 137.92, 135.57, 129.56, 128.52, 128.09, 127.19, 126.31, 49.16, 49.14, 21.57, 14.14.

HRMS (ESI) m/z Calcd. for $C_{16}H_{18}NO_2S$ $[M+H]^+$ 288.1053, found: 288.1057.

IR (film) ν_{max} (cm^{-1}) 2932, 1598, 1497, 1456, 1413, 1318, 1290, 1156, 1089, 970, 885, 814, 747, 710, 697, 682, 587, 535.



46

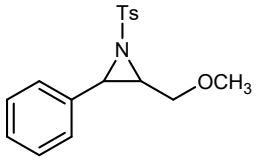
According to the general procedure, the title product was obtained in 82% yield as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.87 – 7.81 (m, 2H), 7.32 – 7.26 (m, 5H), 7.20 – 7.16 (m, 2H), 4.24 (dd, *J* = 11.6, 5.2 Hz, 1H), 4.10 (dd, *J* = 11.6, 8.7 Hz, 1H), 3.97 (d, *J* = 4.1 Hz, 1H), 3.19 (ddd, *J* = 9.1, 5.1, 4.2 Hz, 1H), 2.41 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.69, 136.66, 134.05, 129.78, 128.70, 128.63, 127.63, 126.77, 50.92, 48.67, 41.23, 21.74.

HRMS (ESI) m/z Calcd. for $C_{16}H_{17}ClNO_2S$ $[M+H]^+$ 322.0663, found: 322.0676.

IR (film) ν_{max} (cm^{-1}) 3035, 1597, 1497, 1456, 1416, 1322, 1292, 1268, 1157, 1086, 947, 901, 813, 738, 709, 691, 604, 583, 538.



47

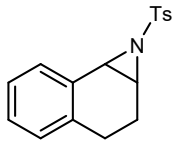
According to the general procedure, the title product was obtained in 63% yield as a light yellow oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.84 – 7.79 (m, 2H), 7.28 – 7.23 (m, 5H), 7.17 (dd, *J* = 6.8, 2.9 Hz, 2H), 4.15 (dd, *J* = 10.9, 5.5 Hz, 1H), 3.95 (dd, *J* = 10.9, 6.6 Hz, 1H), 3.90 (d, *J* = 4.3 Hz, 1H), 3.43 (s, 3H), 3.10 (ddd, *J* = 6.6, 5.5, 4.3 Hz, 1H), 2.39 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.28, 137.19, 134.64, 129.64, 128.63, 128.44, 127.53, 126.80, 69.43, 59.20, 50.50, 47.25, 21.71.

HRMS (ESI) m/z Calcd. for $C_{17}H_{20}NO_3S$ $[M+H]^+$ 318.1158, found: 318.1172.

IR (film) ν_{max} (cm^{-1}) 2920, 2850, 1598, 1456, 1321, 1157, 1103, 1087, 906, 814, 710, 694, 590, 545.



48

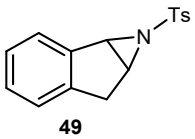
According to the general procedure, the title product was obtained in 89% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82 (d, *J* = 8.2 Hz, 2H), 7.30 (d, *J* = 8.0 Hz, 3H), 7.25 – 7.13 (m, 2H), 7.05 (d, *J* = 7.3 Hz, 1H), 3.82 (d, *J* = 7.0 Hz, 1H), 3.56 (d, *J* = 7.0 Hz, 1H), 2.84 – 2.69 (m, 1H), 2.54 (dd, *J* = 15.6, 5.4 Hz, 1H), 2.42 (s, 3H), 2.30 – 2.21 (m, 1H), 1.72 – 1.63 (m, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.40, 136.74, 135.70, 130.11, 129.81, 129.54, 128.69, 128.57, 127.73, 126.45, 42.18, 41.87, 24.82, 21.75, 20.09.

HRMS (ESI) m/z Calcd. for $C_{17}H_{18}NO_2S$ $[M+H]^+$ 300.1053, found: 300.1063.

IR (film) ν_{max} (cm^{-1}) 2921, 2849, 1595, 1493, 1453, 1393, 1313, 1303, 1289, 1149, 1088, 984, 941, 907, 879, 815, 757, 713, 667, 600, 571, 557, 530.



49

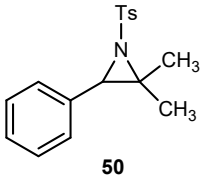
According to the general procedure, the title product was obtained in 71% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83 (d, *J* = 8.3 Hz, 2H), 7.40 (d, *J* = 7.3 Hz, 1H), 7.32 (d, *J* = 8.2 Hz, 2H), 7.25–7.13 (m, 3H), 4.30 (d, *J* = 5.3 Hz, 1H), 3.90 (ddd, *J* = 5.1, 3.4, 1.5 Hz, 1H), 3.14 (d, *J* = 3.4 Hz, 2H), 2.44 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.55, 143.64, 138.31, 135.48, 129.79, 128.81, 127.83, 126.79, 125.70, 125.15, 50.24, 45.04, 34.72, 21.74.

HRMS (ESI) m/z Calcd. for $C_{16}H_{16}NO_2S$ $[M+H]^+$ 286.0896, found: 286.0908.

IR (film) ν_{max} (cm^{-1}) 2921, 2851, 1595, 1323, 1312, 1303, 1288, 1152, 1090, 927, 871, 814, 768, 730, 717, 677, 665, 572, 556, 531.



50

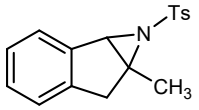
According to the general procedure, the title product was obtained in 84% yield as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.89 – 7.84 (m, 2H), 7.32 – 7.27 (m, 2H), 7.25 – 7.20 (m, 3H), 7.06 – 7.01 (m, 2H), 4.05 (s, 1H), 2.42 (s, 3H), 1.90 (s3H), 1.06 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 143.91, 138.34, 134.29, 129.62, 128.33, 127.69, 127.38, 127.10, 53.85, 53.70, 21.72, 21.34, 21.17.

HRMS (ESI) m/z Calcd. for $C_{17}H_{20}NO_2S$ $[M+H]^+$ 302.1209, found: 302.1225.

IR (film) ν_{max} (cm^{-1}) 2967, 2927, 1598, 1497, 1452, 1378, 1320, 1304, 1291, 1154, 1092, 1044, 939, 867, 836, 814, 768, 735, 699, 684, 669, 586, 535.



51

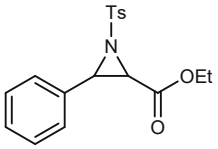
According to the general procedure, the title product was obtained in 90% yield as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, J = 8.3 Hz, 2H), 7.30 (d, *J* = 7.4 Hz, 1H), 7.24 (d, *J* = 8.9 Hz, 2H), 7.22 – 7.08 (m, 3H), 4.22 (s, 1H), 3.35 (d, *J* = 17.7 Hz, 1H), 2.99 (d, *J* = 17.7 Hz, 1H), 2.37 (s, 3H), 2.06 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.03, 143.77, 139.57, 138.31, 129.58, 128.49, 127.08, 126.53, 125.43, 124.60, 57.18, 56.17, 42.57, 21.64, 16.21.

HRMS (ESI) m/z Calcd. for $C_{17}H_{18}NO_2S$ $[M+H]^+$ 300.1053, found: 324.1062.

IR (film) ν_{max} (cm^{-1}) 2923, 1598, 1318, 1305, 1291, 1148, 1089, 991, 912, 851, 732, 708, 674, 580, 543, 531, 508.



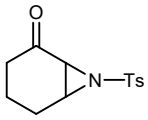
52

According to the general procedure, the title product was obtained in 37% yield as a colorless oil.

^{1}H NMR of *trans*-52 (400 MHz, $CDCl_3$) δ 7.78 (d, *J* = 8.3 Hz, 2H), 7.33 – 7.23 (m, 7H), 4.44 (d, *J* = 4.0 Hz, 1H), 4.32 (dtt, *J* = 10.8, 7.3, 3.6 Hz, 2H), 3.51 (d, *J* = 4.0 Hz, 1H), 2.41 (s, 3H), 1.35 (t, *J* = 7.2 Hz, 3H).

^{13}C NMR of *trans*-52 (101 MHz, $CDCl_3$) δ 165.90, 144.42, 137.27, 132.80, 129.68, 129.01, 128.70, 127.60, 127.46, 62.57, 47.83, 47.22, 21.74, 14.09.

The data is consistent with that reported in the literature (*Chem. Commun*. **2011**, *47*, 2967 – 2969; *J. Am. Chem. Soc*. **2007**, *129*, 7185 – 7194).



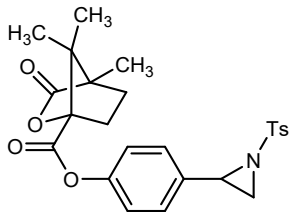
53

According to the general procedure, the title product was obtained in 28% yield as a colorless oil.

^{1}H NMR of (400 MHz, $CDCl_3$) δ 7.81 (d, *J* = 8.3 Hz, 2H), 7.35 (d, *J* = 8.1 Hz, 2H), 3.45 (dd, *J* = 6.5, 2.5 Hz, 1H), 3.14 (d, *J* = 6.6 Hz, 1H), 2.48 – 2.37 (m, 4H), 2.21 – 2.14 (m, 1H), 2.08 – 1.96 (m, 1H), 1.92 – 1.80 (m, 2H), 1.70 – 1.62 (m, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 201.52, 145.21, 134.50, 130.04, 128.05, 44.02, 41.04, 37.19, 21.89, 21.82, 17.19.

The data is consistent with that reported in the literature (*J. Org. Chem*. **2015**, *80*, 3067 – 3074).



54

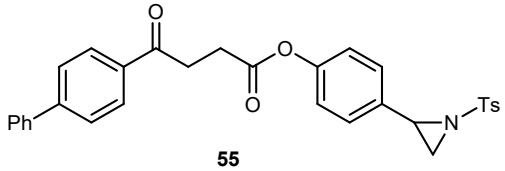
According to the general procedure, the title product was obtained in 62% yield as a light yellow solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86 (d, *J* = 8.3 Hz, 2H), 7.34 (d, *J* = 8.1 Hz, 2H), 7.29 – 7.23 (m, 2H), 7.08 – 7.03 (m, 2H), 3.77 (dd, *J* = 7.1, 4.4 Hz, 1H), 2.99 (d, *J* = 7.2 Hz, 1H), 2.54 (ddd, *J* = 13.5, 10.8, 4.2 Hz, 1H), 2.44 (s, 3H), 2.36 (d, *J* = 4.4 Hz, 1H), 2.17 (ddd, *J* = 13.6, 9.3, 4.5 Hz, 1H), 1.99 (ddd, *J* = 13.2, 10.8, 4.6 Hz, 1H), 1.75 (ddd, *J* = 13.2, 9.3, 4.0 Hz, 1H), 1.16 (s, 3H), 1.13 (s, 3H), 1.08 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 177.96, 166.17, 149.89, 144.98, 134.75, 133.49, 129.94, 128.03, 127.93, 121.65, 90.88, 54.99, 54.84, 40.43, 36.19, 30.82, 29.00, 21.77, 16.94, 9.81.

HRMS (ESI) m/z Calcd. for $C_{25}H_{28}NO_6S$ $[M+H]^+$ 470.1632, found: 470.1640.

IR (film) ν_{max} (cm^{-1}) 2970, 1771, 1598, 1510, 1449, 1322, 1262, 1195, 1159, 1092, 1046, 910, 814, 731, 706, 693, 663, 573, 555, 541.



55

According to the general procedure, the title product was obtained in 75% yield as a white solid.

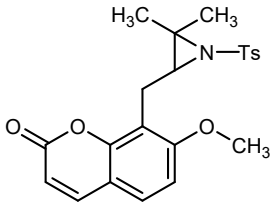
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.09 – 8.04 (m, 2H), 7.88 – 7.83 (m, 2H), 7.72 – 7.67 (m, 2H), 7.63 (dd, *J* = 5.3, 3.3 Hz, 2H), 7.51 – 7.45 (m, 2H), 7.44 – 7.38 (m, 1H), 7.33 (d, *J* = 8.1 Hz, 2H), 7.24 – 7.19 (m, 2H), 7.08 – 7.03 (m, 2H), 3.75 (dd, *J* = 7.1, 4.4 Hz, 1H), 3.44 (t, *J* = 6.5 Hz, 2H), 3.04 – 2.96 (m, 3H), 2.43 (s, 3H), 2.36 (d, *J* = 4.4 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 197.51, 171.62, 150.78, 146.14, 144.87, 139.86,

135.17, 134.95, 132.71, 129.92, 129.08, 128.76, 128.41, 128.03, 127.73, 127.40, 127.37, 121.92, 40.69, 36.08, 33.53, 28.57, 21.76.

HRMS (ESI) m/z Calcd. for $C_{31}H_{28}NO_5S$ $[M+H]^+$ 526.1683, found: 526.1685.

IR (film) ν_{max} (cm^{-1}) 3259, 2910, 1760, 1680, 1600, 1316, 1306, 1207, 1191, 1157, 1140, 1091, 916, 895, 847, 815, 764, 734, 727, 710, 690, 661, 569, 557, 540.



56

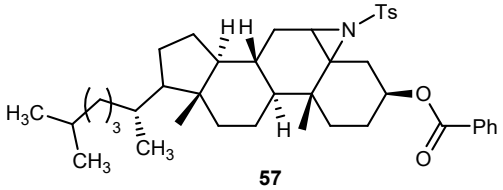
According to the general procedure, the title product was obtained in 43% yield as a light yellow oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.52 – 7.44 (m, 3H), 7.22 (d, *J* = 8.6 Hz, 1H), 7.01 (d, *J* = 7.9 Hz, 2H), 6.71 (d, *J* = 8.6 Hz, 1H), 6.15 (d, *J* = 9.4 Hz, 1H), 3.84 (s, 3H), 3.18 (t, *J* = 6.4 Hz, 1H), 2.89 (d, *J* = 6.5 Hz, 2H), 2.33 (s, 3H), 1.74 (s, 3H), 1.52 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 160.76, 160.46, 152.90, 143.38, 142.85, 138.25, 129.76, 129.13, 127.18, 126.96, 126.51, 114.44, 113.14, 112.81, 107.14, 56.18, 52.39, 52.02, 21.77, 21.68, 21.45, 21.28.

HRMS (ESI) m/z Calcd. for $C_{22}H_{24}NO_5S$ $[M+H]^+$ 414.1370, found: 414.1373.

IR (film) ν_{max} (cm^{-1}) 2927, 1714, 1606, 1315, 1303, 1281, 1252, 1153, 1109, 1089, 937, 920, 833, 813, 733, 706, 664, 581, 556, 540.



57

According to the general procedure, the title product was obtained in 80% yield as a white solid.

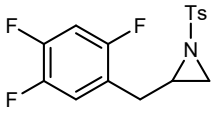
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.04 (dd, *J* = 5.2, 3.3 Hz, 2H), 7.82 – 7.78 (m, 2H), 7.58 – 7.53 (m, 1H), 7.44 (dd, *J* = 10.6, 4.7 Hz, 2H), 7.29 (d, *J* = 8.0 Hz, 2H), 5.18 (dq, *J* = 11.7, 5.9 Hz, 1H), 3.20 (s, 1H), 2.72 (dd, *J* = 13.1, 11.2 Hz, 1H), 2.48 – 2.38 (m, 4H), 2.01 – 1.84 (m, 3H), 1.81 – 1.71 (m, 2H), 1.70 – 1.63 (m, 1H), 1.54 – 1.42

(m, 3H), 1.39 – 1.24 (m, 9H), 1.14 – 1.01 (m, 9H), 0.90 – 0.80 (m, 11H), 0.59 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 166.11, 143.55, 139.22, 133.07, 130.47, 129.80, 129.49, 128.43, 126.99, 71.31, 57.16, 56.19, 56.09, 50.27, 48.35, 42.32, 39.83, 39.60, 36.40, 36.20, 35.83, 34.27, 32.71, 30.61, 30.05, 28.22, 28.12, 26.84, 24.24, 23.90, 22.94, 22.68, 22.19, 21.73, 20.88, 18.77, 11.87.

HRMS (ESI) m/z Calcd. for $C_{41}H_{57}NNaO_4S$ $[M+Na]^+$ 682.3901, found: 682.3899.

IR (film) ν_{max} (cm^{-1}) 2925, 2864, 1710, 1452, 1311, 1274, 1158, 1149, 1111, 1091, 962, 808, 737, 711, 692, 568.



59

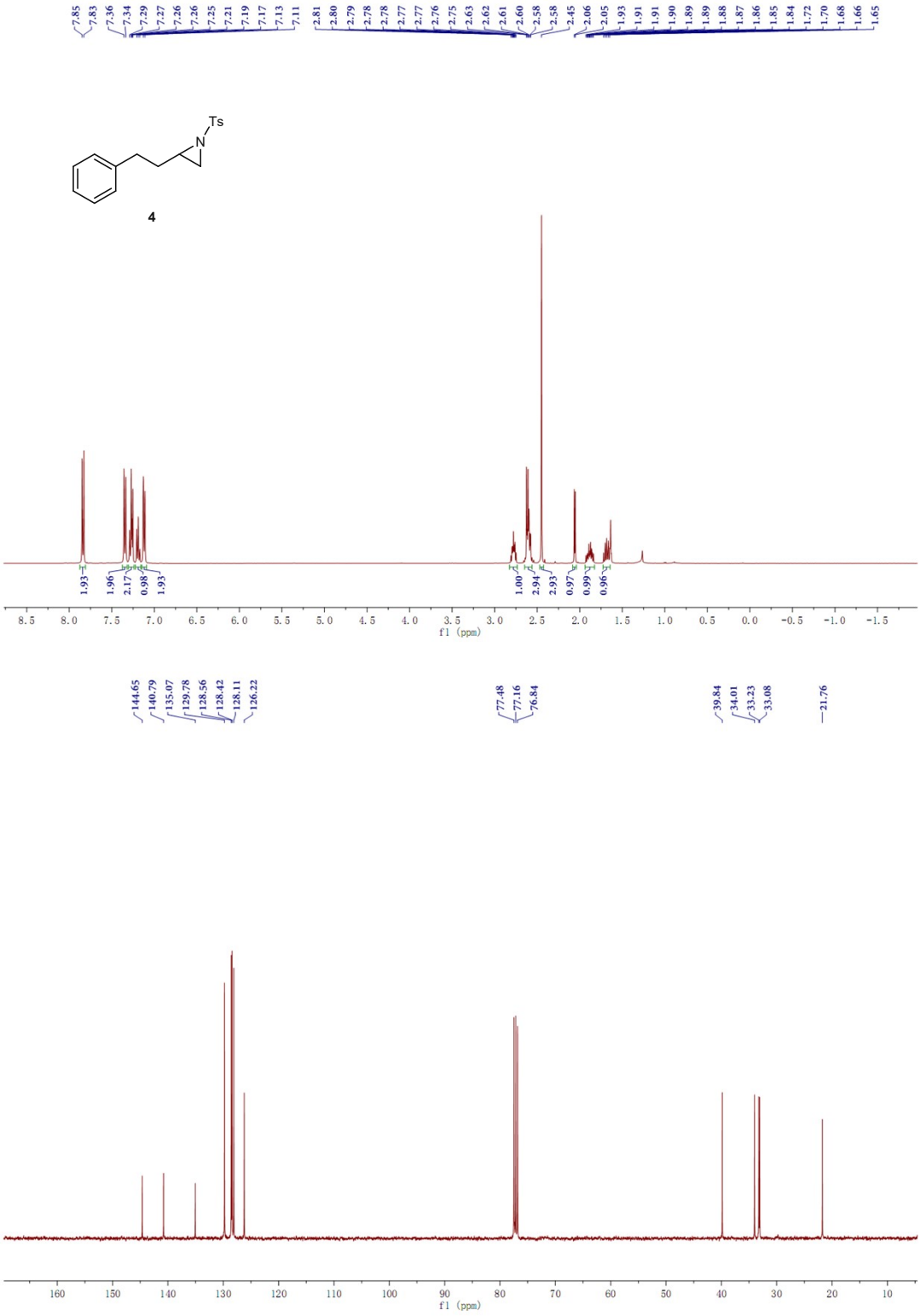
According to the general procedure, the title product was obtained in 60% yield as a white solid.

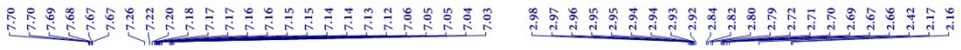
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 (d, *J* = 8.3 Hz, 2H), 7.19 (d, *J* = 8.2 Hz, 2H), 6.78 – 6.63 (m, 2H), 3.03 (dd, *J* = 14.5, 3.0 Hz, 1H), 2.87 – 2.77 (m, 2H), 2.41 (s, 3H), 2.25 (dd, *J* = 14.6, 8.1 Hz, 1H), 2.21 (d, *J* = 3.9 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 156.80, 156.78, 156.71, 156.69, 154.37, 154.35, 154.28, 154.25, 150.43, 150.30, 150.29, 150.16, 147.94, 147.82, 147.80, 147.68, 147.60, 147.56, 147.47, 147.44, 145.17, 145.13, 145.04, 145.00, 144.94, 134.42, 129.61, 127.84, 120.88, 120.83, 120.78, 120.69, 120.65, 120.60, 118.79, 118.74, 118.60, 118.54, 105.40, 105.19, 105.12, 104.91, 40.08, 32.72, 30.40, 21.55.

Spectroscopic data for **59** match the literature previously reported. (A. K. Ravn, M. B. T. Vilstrup, P. Noerby, D. U. Nielsen, K. Daasbjerg, T. Skrydstrup, *J. Am. Chem. Soc.* **2019**, *141*, 11821−1182)

12. NMR Spectral Data

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7.70
7.69
7.68
7.67
7.67
7.26
7.22
7.20
7.18
7.17
7.17
7.16
7.16
7.15
7.15
7.14
7.14
7.13
7.12
7.06
7.05
7.05
7.04
7.03
2.98
2.97
2.96
2.95
2.94
2.94
2.93
2.92
2.84
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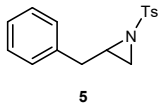
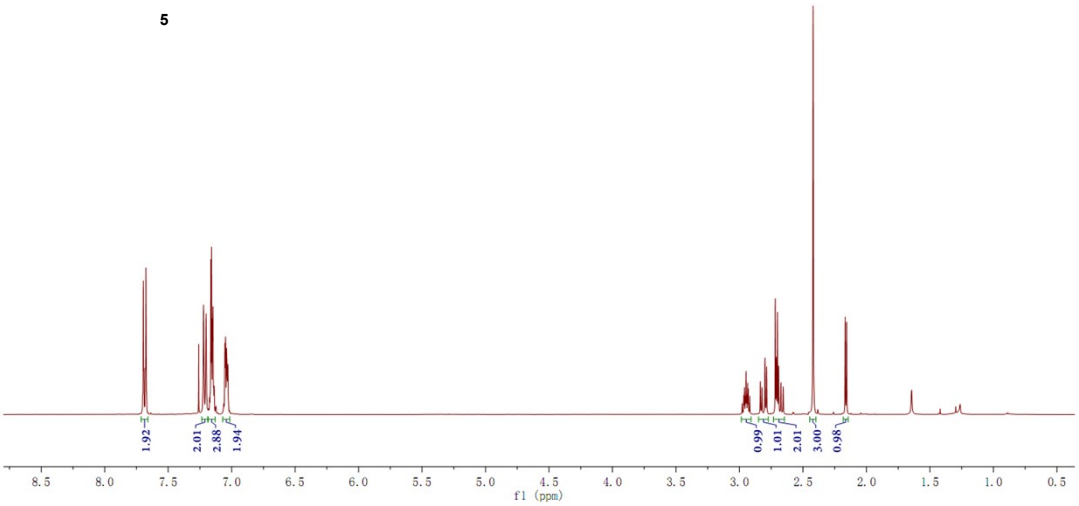
2.69
2.67
2.66
2.42
2.17
2.16


Ts
N

5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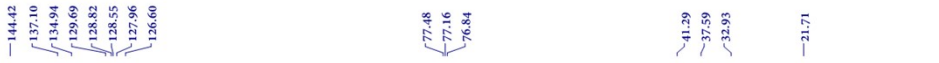
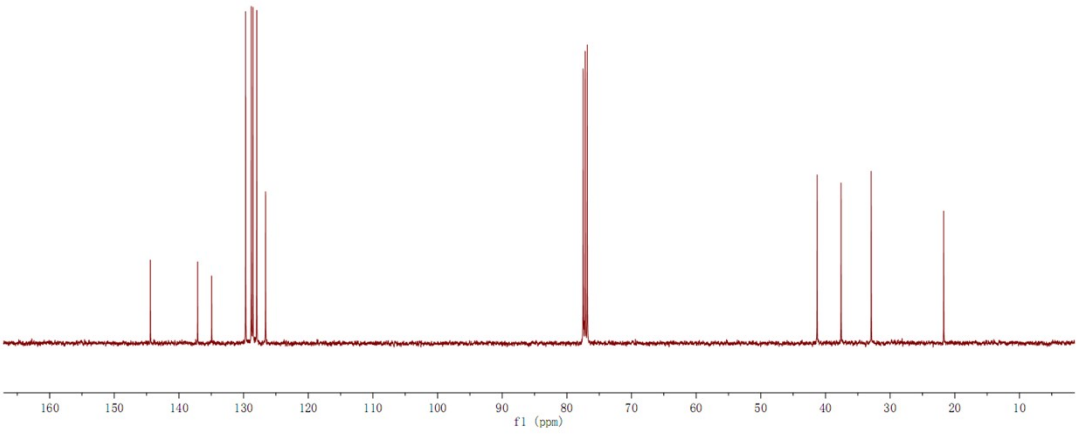
2.01
2.88
1.94
0.99
1.01
2.01
3.00
0.98
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
f1 (ppm)


144.42
137.10
134.94
129.69
128.82
128.55
127.96
126.60
77.48
77.16
76.84
41.29
37.59
32.93
21.71


160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)


7.83
7.81
7.35
7.35
7.33
7.26
3.30
3.28
3.28
3.27
3.26
2.72
2.72
2.70
2.70
2.69
2.69
2.65
2.63
2.44
2.07
2.06
1.80
1.79
1.78
1.77
1.76
1.76
1.75
1.65
1.64
1.63
1.62
1.62
1.61
1.60
1.40
1.39
1.39
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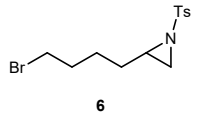
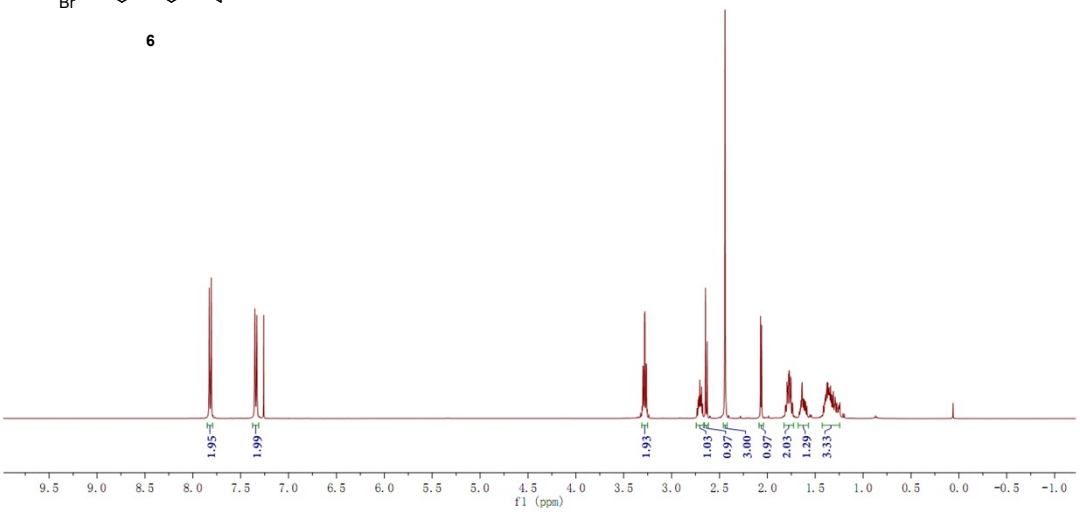
1.32
1.31
1.29
1.29
1.24
0.06


Ts
N
Br

6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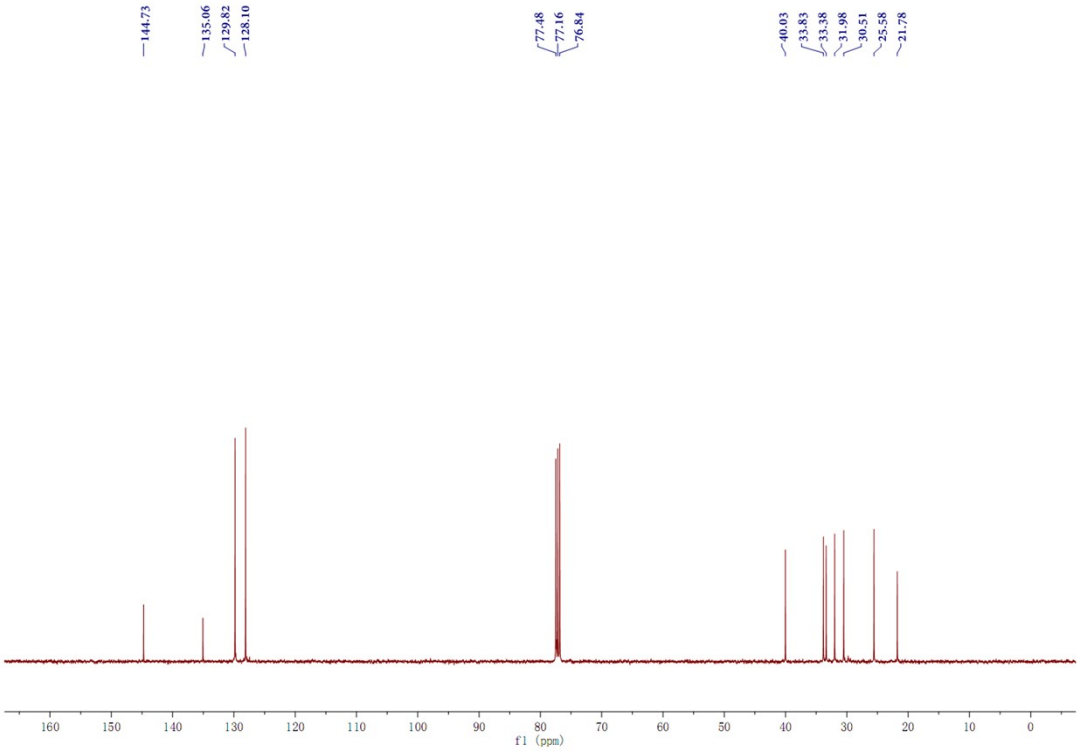
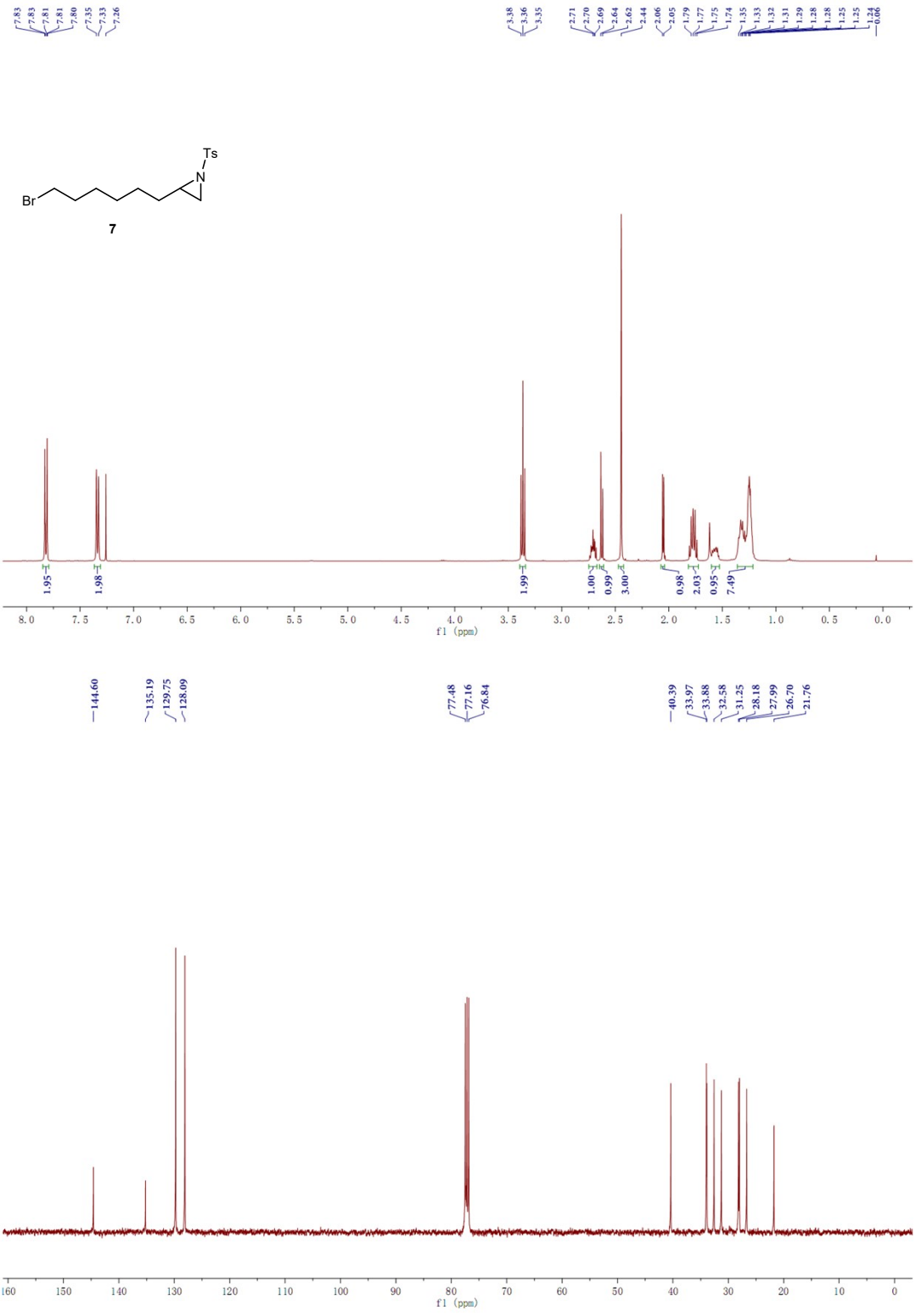
1.99
1.93
1.03
0.97
3.00
0.97
2.03
1.29
3.33
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)


144.73
135.06
129.82
128.10
77.48
77.16
76.84
40.03
33.83
33.38
31.98
30.51
25.58
21.78
160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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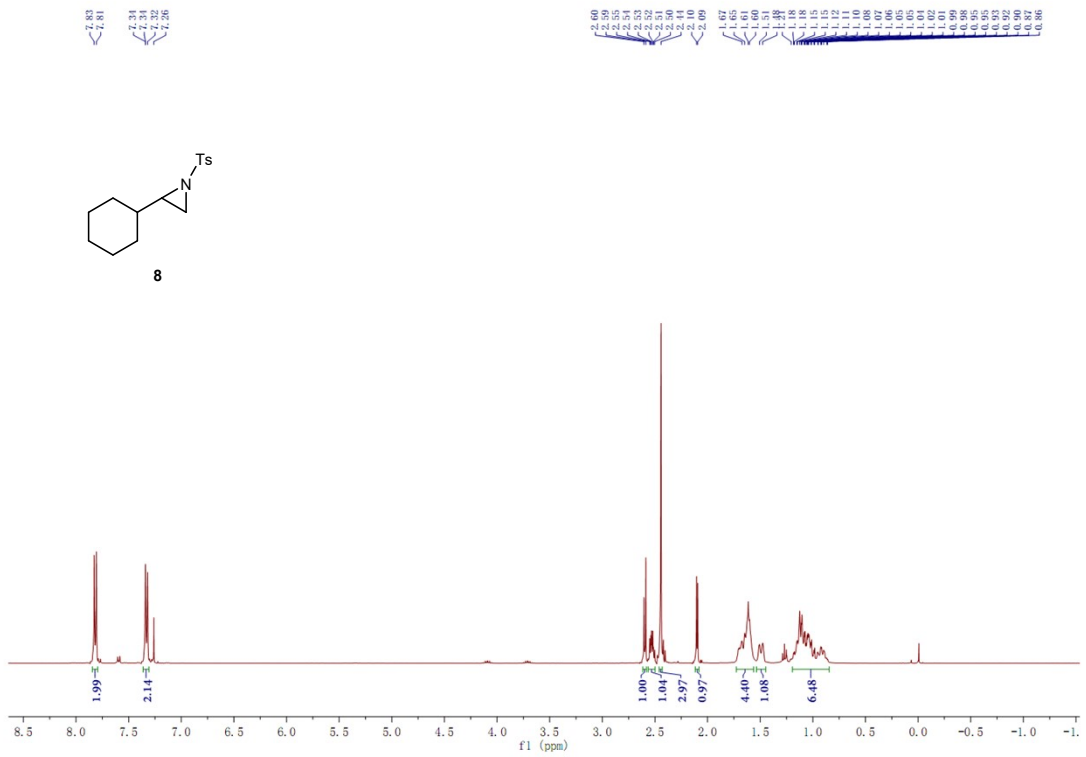
7.83
7.81
7.81
7.80
7.35
7.33
7.26
3.38
3.36
3.35
2.71
2.70
2.69
2.64
2.62
2.44
2.06
2.05
1.79
1.77
1.75
1.74
1.35
1.33
1.32
1.31
1.29
1.28
1.28
1.25
1.25
1.24
0.06
Ts
N
Br
7
1.95
1.98
1.99
1.00
0.99
3.00
0.98
2.03
0.95
7.49
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)
144.60
135.19
129.75
128.09
77.48
77.16
76.84
40.39
33.97
33.88
32.58
31.25
28.18
27.99
26.70
21.76
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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7.26
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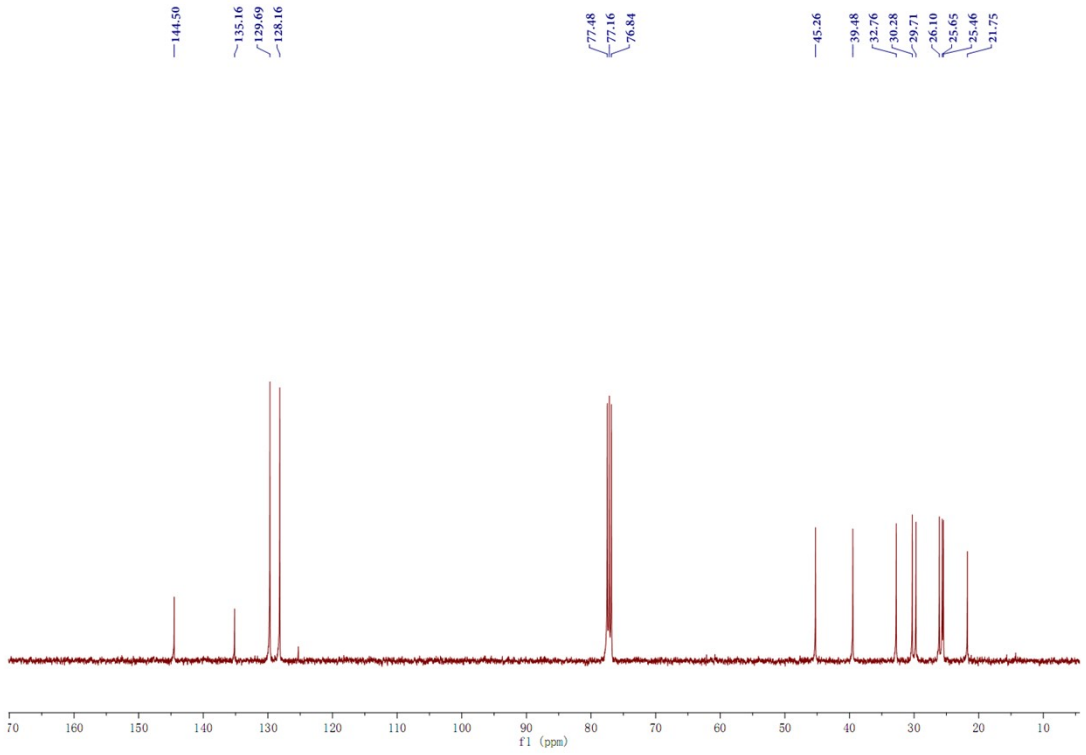
2.53
2.52
2.51
2.50
2.14
2.10
2.09
1.67
1.65
1.64
1.60
1.51
1.18
1.18
1.15
1.15
1.12
1.11
1.10
1.08
1.07
1.06
1.05
1.05
1.04
1.02
1.01
1.00
0.98
0.95
0.93
0.92
0.90
0.87
0.86
Ts
N
8
1.99
2.14
1.00
1.04
2.97
0.97
4.40
1.08
6.48
f1 (ppm)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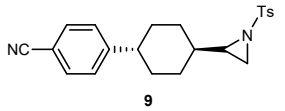
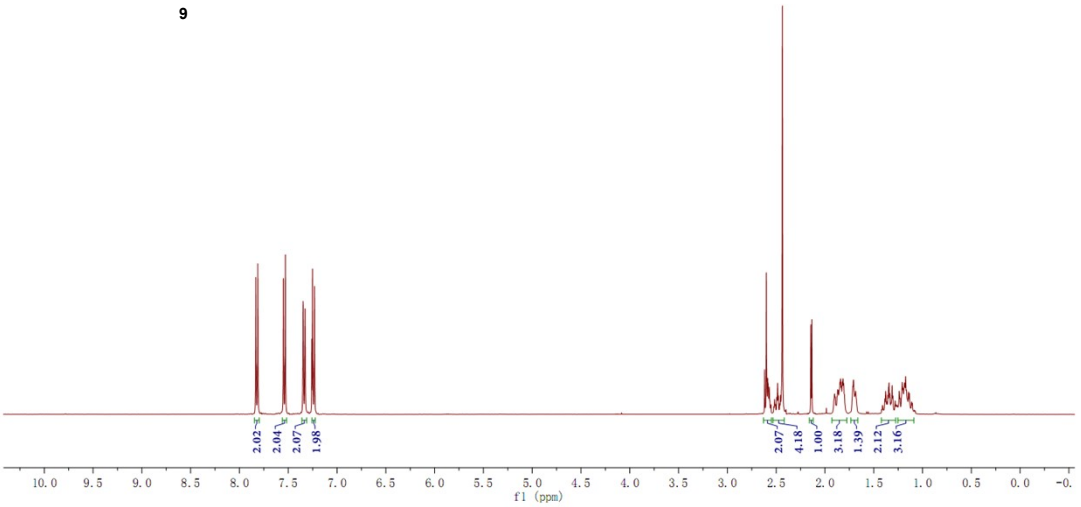
135.16
129.69
128.16
77.48
77.16
76.84
45.26
39.48
32.76
30.28
29.71
26.10
25.65
25.46
21.75
f1 (ppm)


7.83
7.83
7.81
7.55
7.55
7.53
7.53
7.35
7.33
7.26
7.25
7.23
2.62
2.60
2.59
2.58
2.57
2.49
2.49
2.48
2.45
2.44
2.14
2.13
1.90
1.90
1.88
1.87
1.86
1.85
1.84
1.83
1.82
1.82
1.81
1.71
1.71
1.69
1.38
1.36
1.34
1.34
1.31
1.30
1.24
1.23
1.21
1.20
1.18
1.17
1.17
1.14
1.14


NC
Ts
N

9


2.02
2.04
2.07
1.98
2.07
4.18
1.00
3.18
1.39
2.12
3.16
10.0 9.5 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.
f1 (ppm)


152.47
144.64
135.00
132.30
129.73
128.14
127.68
119.14
109.87
77.48
77.16
76.84
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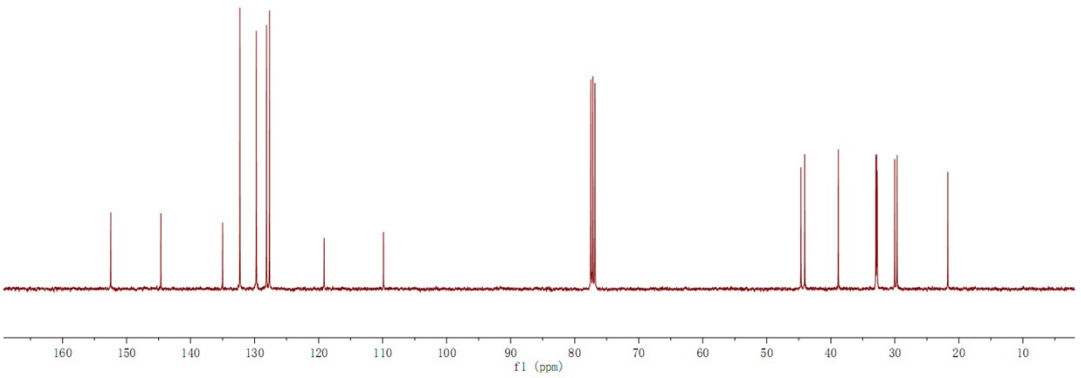
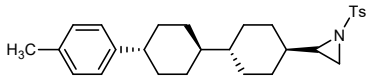
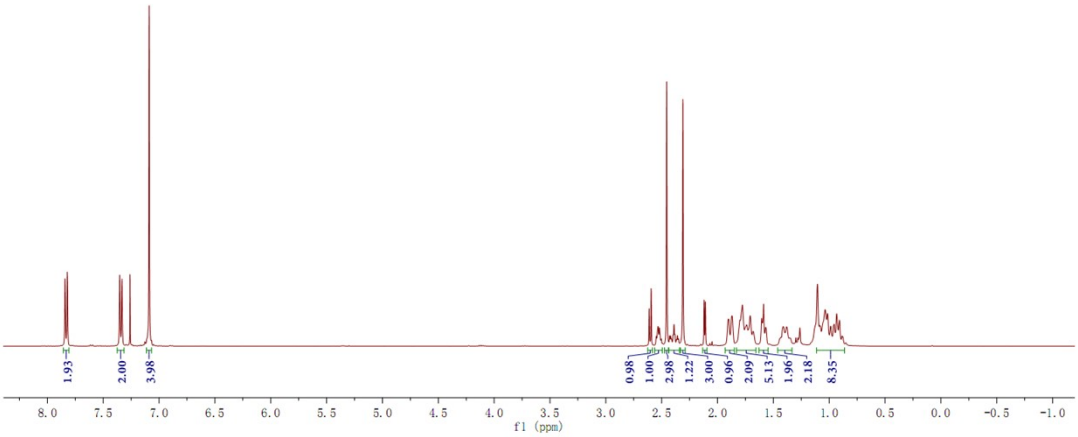
32.97
32.84
32.75
30.03
29.65
21.73


160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)


7.84
7.82
7.35
7.33
7.26
7.09
2.61
2.59
2.55
2.53
2.52
2.50
2.46
2.43
2.42
2.41
2.40
2.39
2.38
2.37
2.36
2.35
2.31
2.12
2.11
1.90
1.87
1.80
1.78
1.74
1.71
1.68
1.61
1.59
1.57
1.43
1.41
1.38
1.35
1.11
1.08
1.04
1.02
0.99
0.96
0.93
0.91
0.89


Ts
N
H3C

10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3.98
0.98
1.00
2.98
1.22
3.00
0.96
2.09
5.13
1.96
2.18
8.35
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
-1.0
f1 (ppm)


144.85
144.51
135.33
135.24
129.71
129.07
128.19
126.75
77.48
77.16
76.84
45.30
44.27
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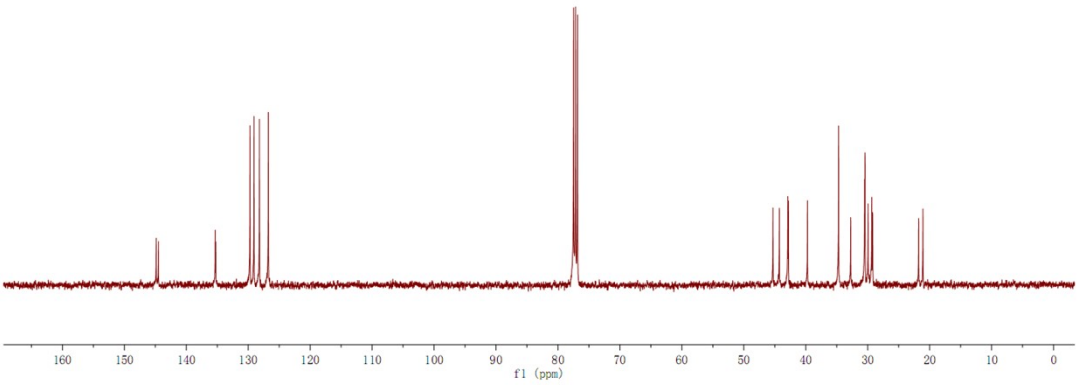
29.94
29.35
29.20
21.78
21.09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150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


7.85
7.84
7.83
7.83
7.82
7.35
7.33
7.26
7.10
2.70
2.69
2.68
2.65
2.63
2.45
2.44
2.43
2.41
2.32
2.07
2.06
1.92
1.89
1.83
1.81
1.81
1.73
1.70
1.68
1.65
1.61
1.60
1.59
1.42
1.40
1.36
1.34
1.33
1.30
1.28
1.26
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1.04
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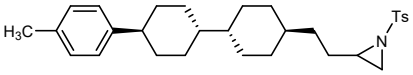
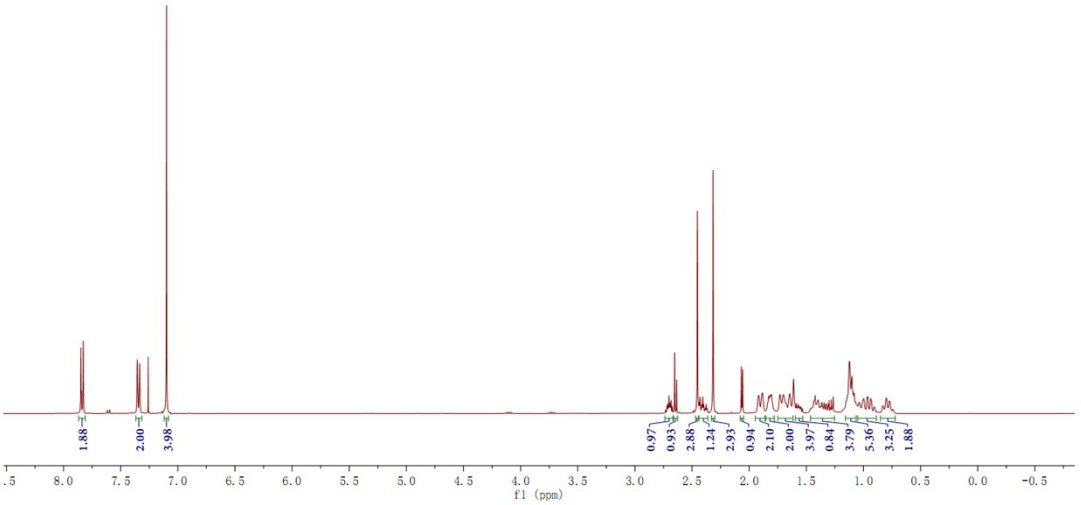
0.80
0.77


H3C
Ts
N

11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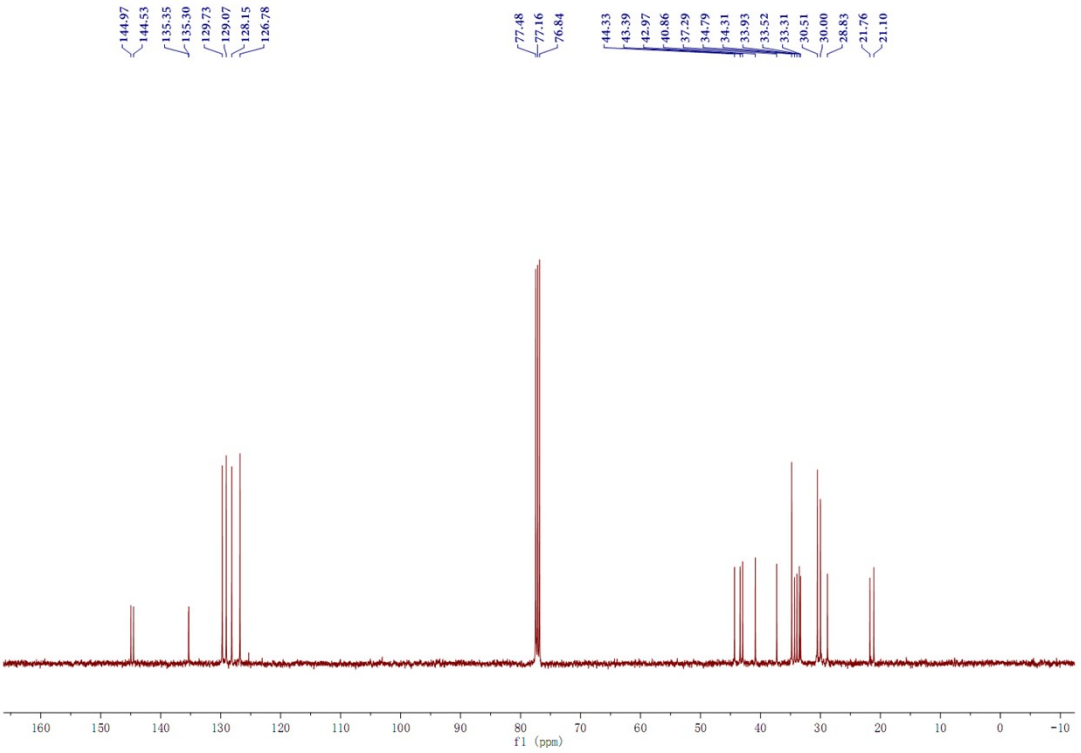
2.00
3.98
0.97
0.93
2.88
1.24
2.93
0.94
2.10
2.00
3.97
0.84
3.79
5.36
3.25
1.88
f1 (ppm)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144.53
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135.30
129.73
129.07
128.15
126.78
77.48
77.16
76.84
44.33
43.39
42.97
40.86
37.29
34.79
34.31
33.93
33.52
33.31
30.51
30.00
28.83
21.76
21.10
f1 (ppm)


7.86
7.86
7.85
7.84
7.40
7.40
7.39
7.38
7.36
7.36
7.34
7.27
7.26
7.26
7.25
7.24
7.23
7.23
7.23
7.13
7.13
7.13
7.12
7.11
7.11
7.11
4.33
4.32
4.31
4.29
4.15
4.13
4.12
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3.16
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3.10
2.78
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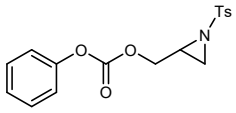
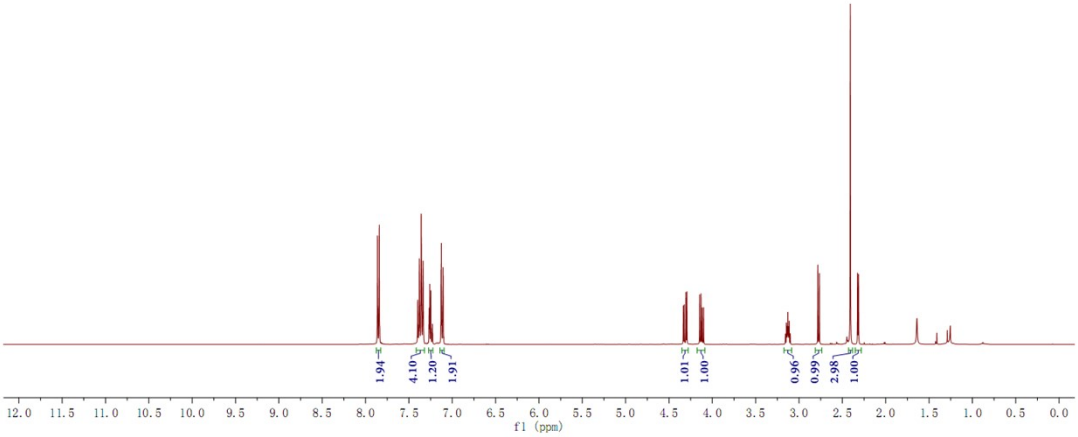
2.41
2.32
2.31


Ts
N
O
O
O

12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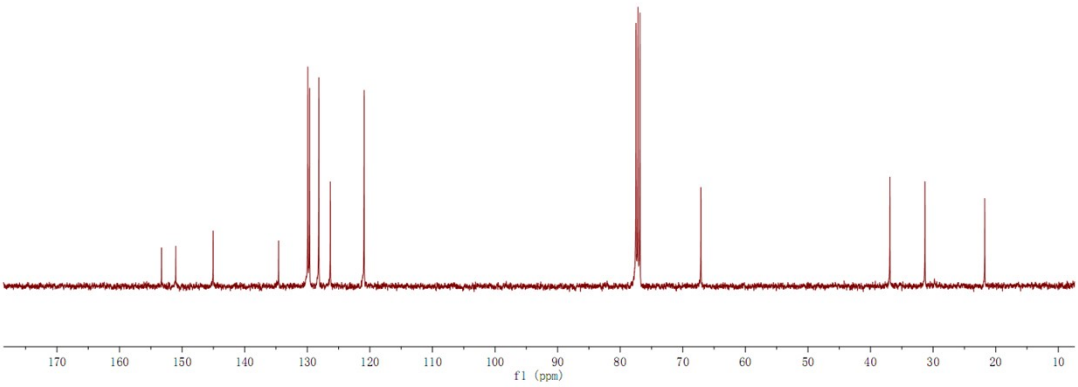
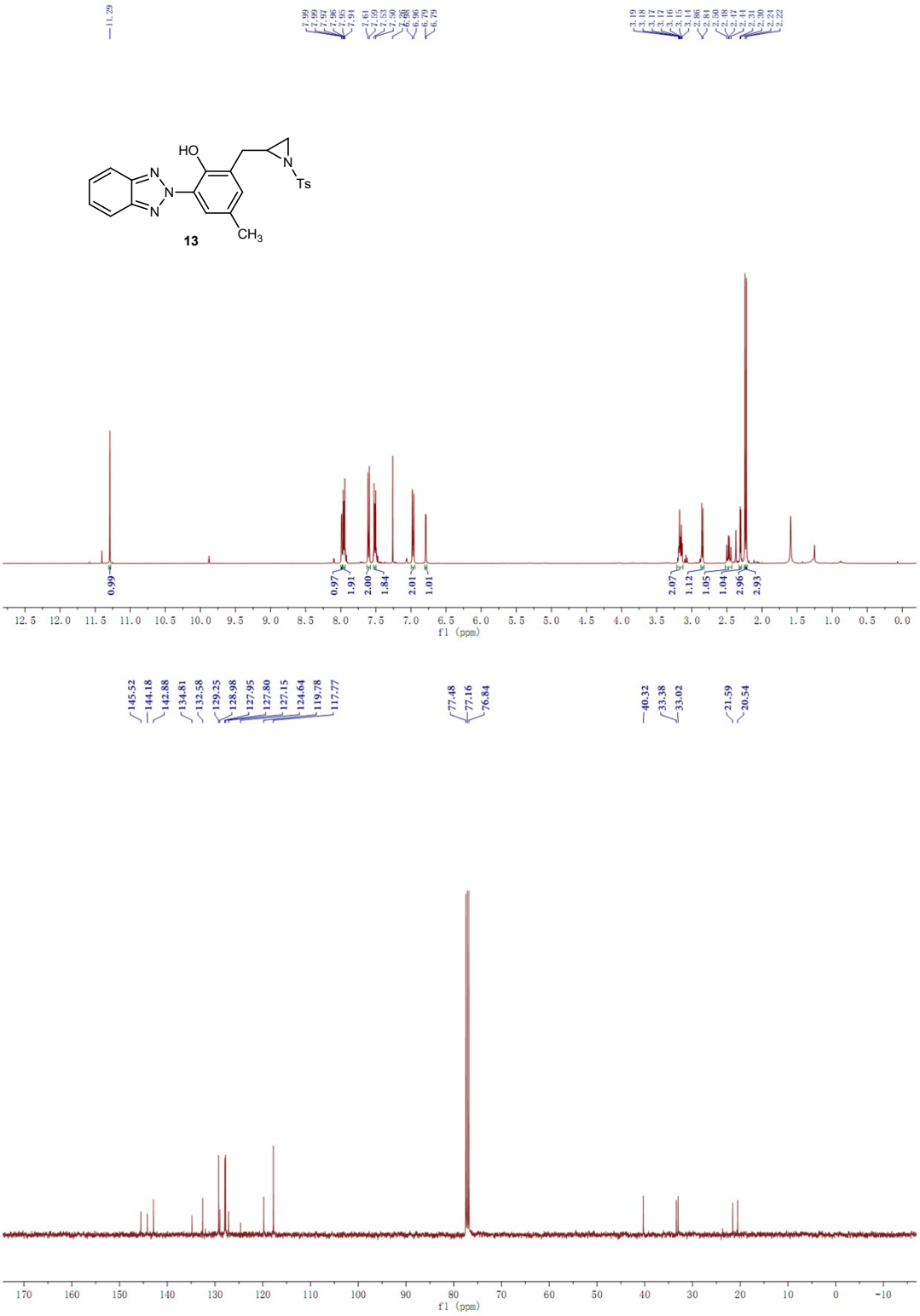
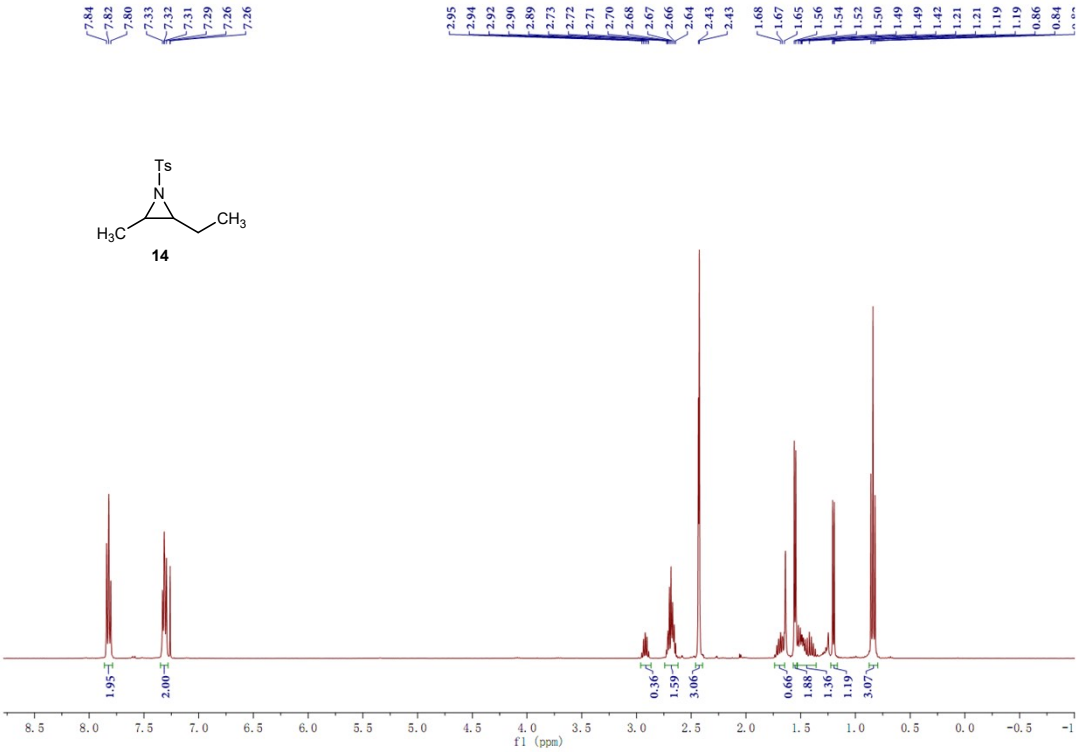
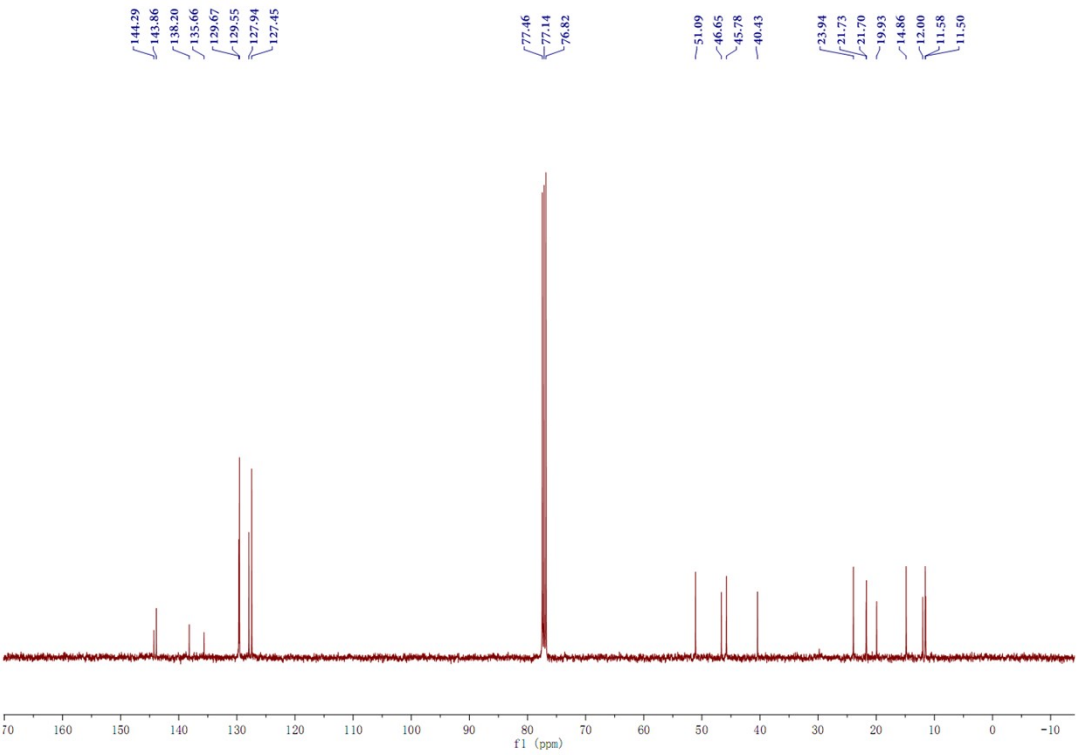
4.10
1.20
1.91
1.01
1.00
0.96
0.99
2.98
1.00
12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

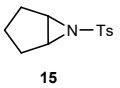

153.28
151.01
145.04
134.58
129.91
129.63
128.15
126.31
120.92
77.48
77.16
76.84
67.10
36.90
31.31
21.75


170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)

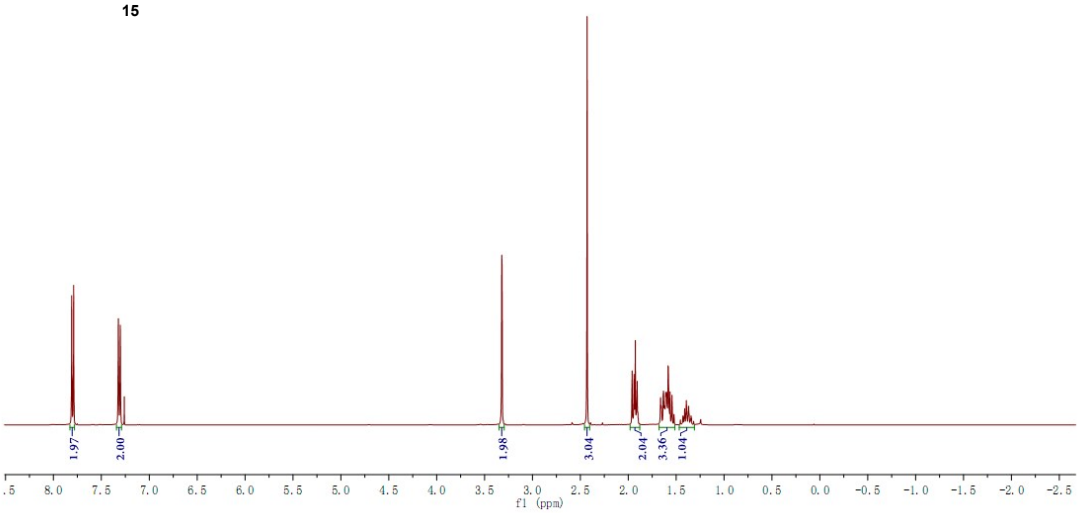

11.29
7.99
7.99
7.97
7.96
7.95
7.91
7.61
7.59
7.53
7.50
6.98
6.96
6.79
6.79
3.19
3.18
3.17
3.17
3.16
3.15
3.11
2.86
2.84
2.50
2.48
2.47
2.44
2.33
2.30
2.24
2.22
HO
N
N
N
N
Ts
CH3
13
0.99
0.97
1.91
2.00
1.84
2.01
1.01
2.07
1.12
1.05
1.04
2.96
2.93
f1 (ppm)
145.52
144.18
142.88
134.81
132.58
129.25
128.98
127.95
127.80
127.15
124.64
119.78
117.77
77.48
77.16
76.84
40.32
33.38
33.02
21.59
20.54
f1 (ppm)

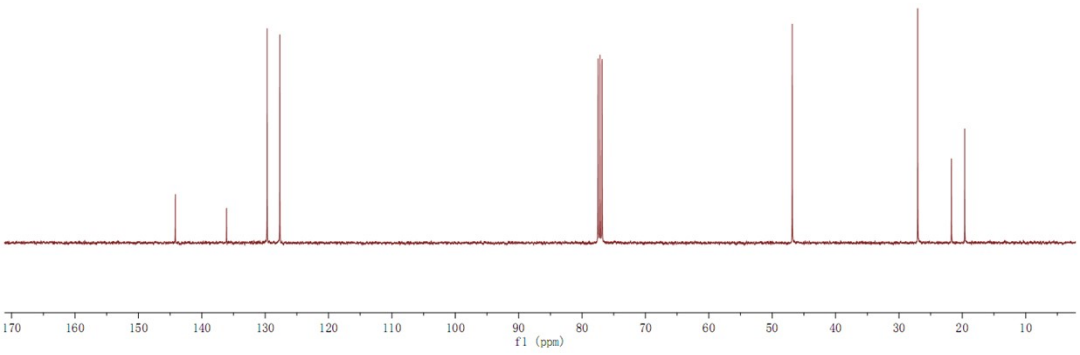

7.84
7.82
7.80
7.33
7.32
7.31
7.29
7.26
7.26
2.95
2.94
2.92
2.90
2.89
2.73
2.72
2.71
2.70
2.68
2.67
2.66
2.64
2.43
2.43
1.68
1.67
1.65
1.56
1.54
1.52
1.50
1.49
1.49
1.42
1.21
1.21
1.19
1.19
0.86
0.84
Ts
N
H3C
CH3
14
1.95
2.00
0.36
1.59
3.06
0.66
1.88
1.36
1.19
3.07
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

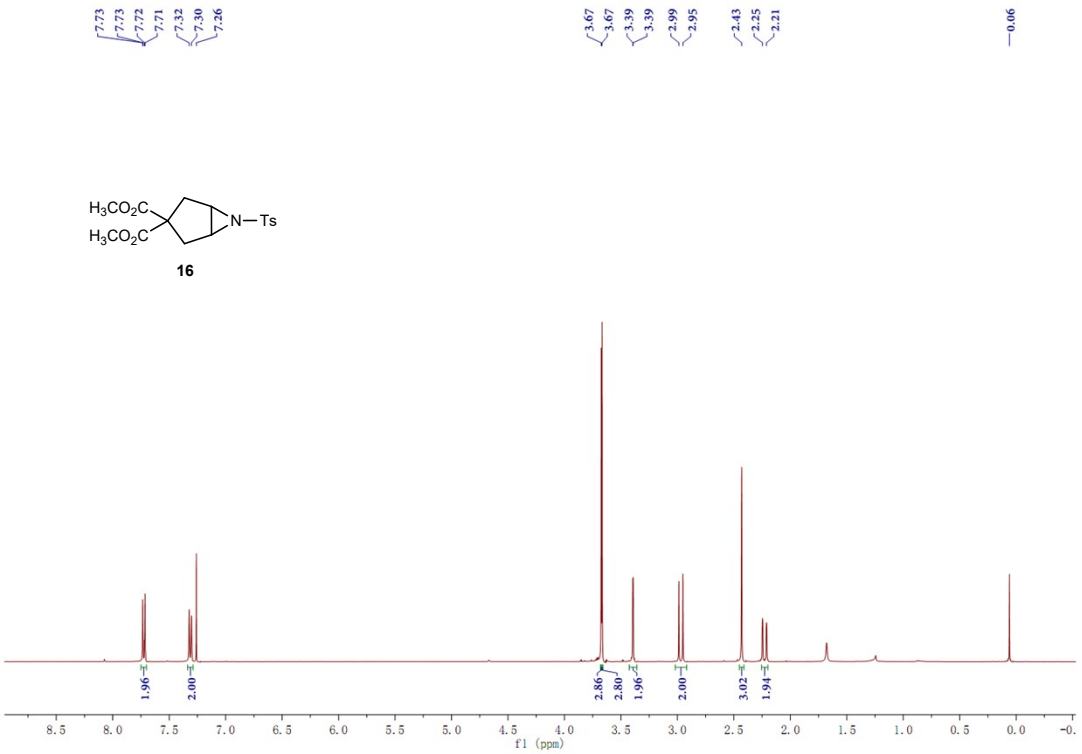

144.29
143.86
138.20
135.66
129.67
129.55
127.94
127.45
77.46
77.14
76.82
51.09
46.65
45.78
40.43
23.94
21.73
21.70
19.93
14.86
12.00
11.58
11.50
70
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

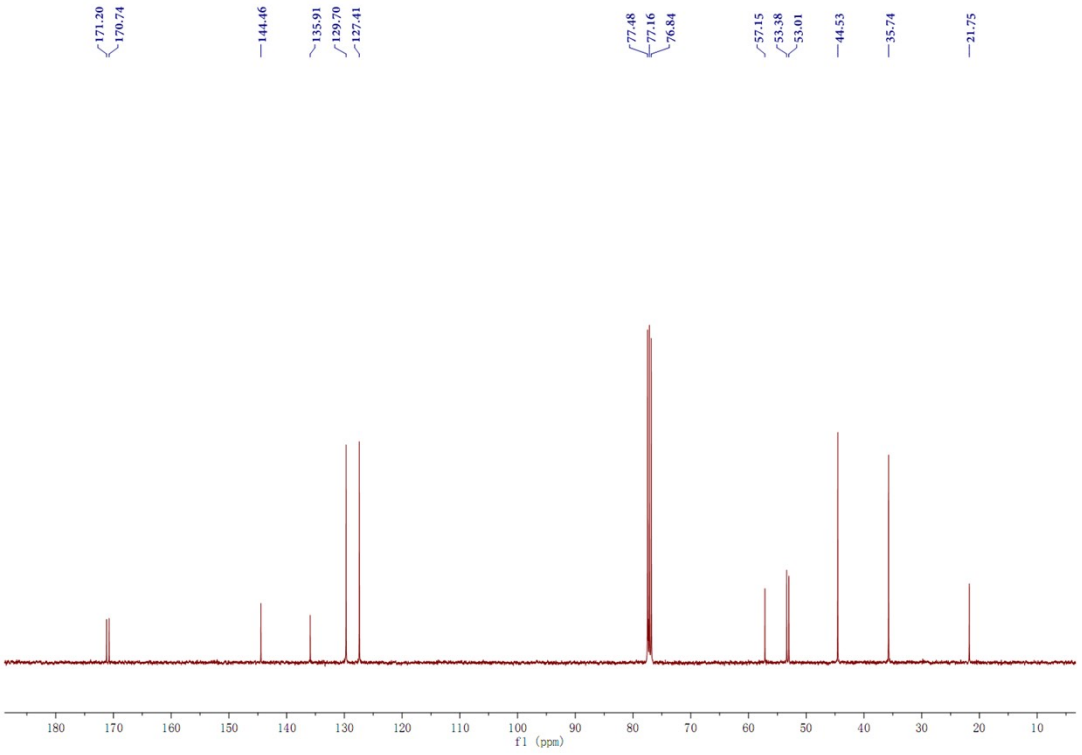


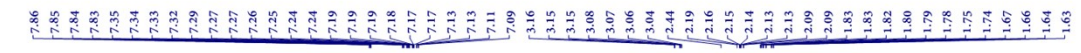
15

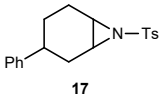





7.73
7.73
7.72
7.71
7.32
7.30
7.26
3.67
3.67
3.39
3.39
2.99
2.95
2.43
2.25
2.21
0.06
H3CO2C
H3CO2C
N—Ts
16
1.96
2.00
2.86
2.80
1.96
2.00
3.02
1.94
f1 (ppm)


171.20
170.74
144.46
135.91
129.70
127.41
77.48
77.16
76.84
57.15
53.38
53.01
44.53
35.74
21.75
f1 (ppm)

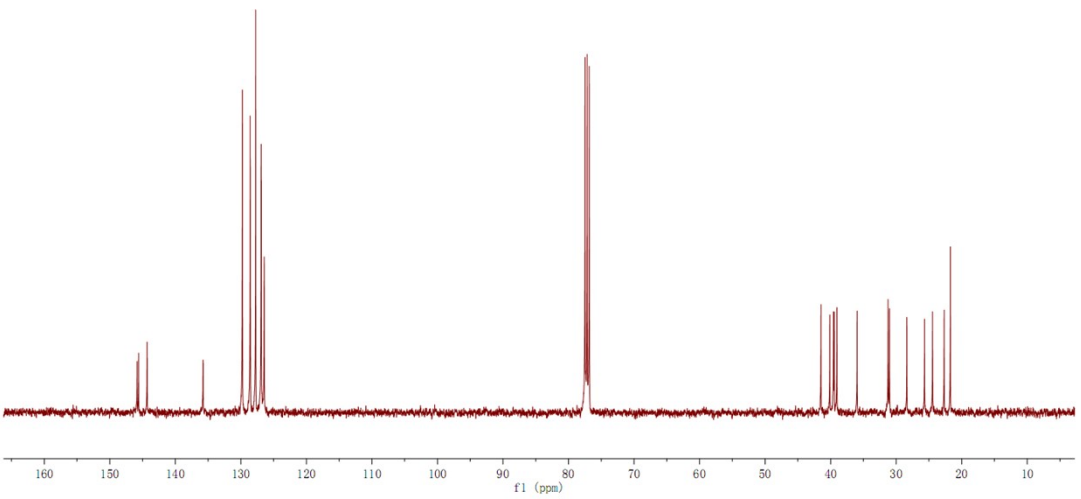

7.86 7.85 7.84 7.83 7.35 7.34 7.33 7.32 7.29 7.27 7.27 7.26 7.25 7.24 7.24 7.19 7.19 7.19 7.18 7.17 7.17 7.13 7.13 7.11 7.09
3.16 3.15 3.15 3.08 3.07 3.06 3.04 2.44 2.19 2.16 2.15 2.14 2.13 2.13 2.09 2.09 1.83 1.83 1.82 1.80 1.79 1.78 1.75 1.74 1.67 1.66 1.64 1.63

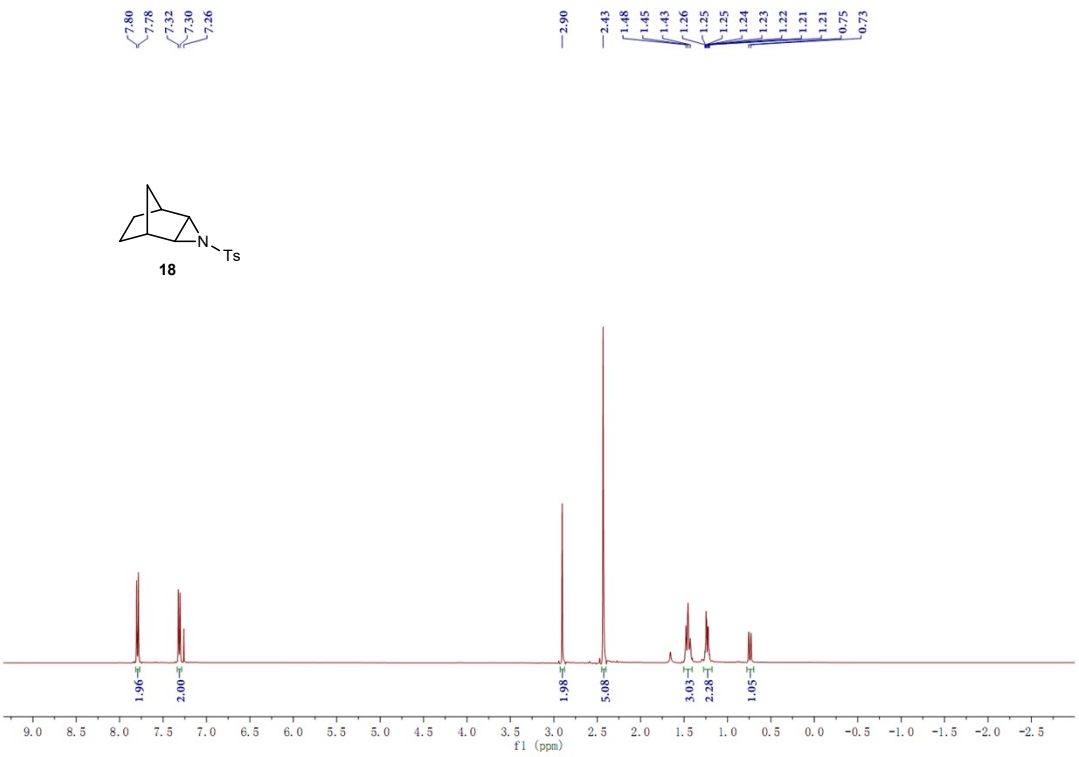

N—Ts
Ph

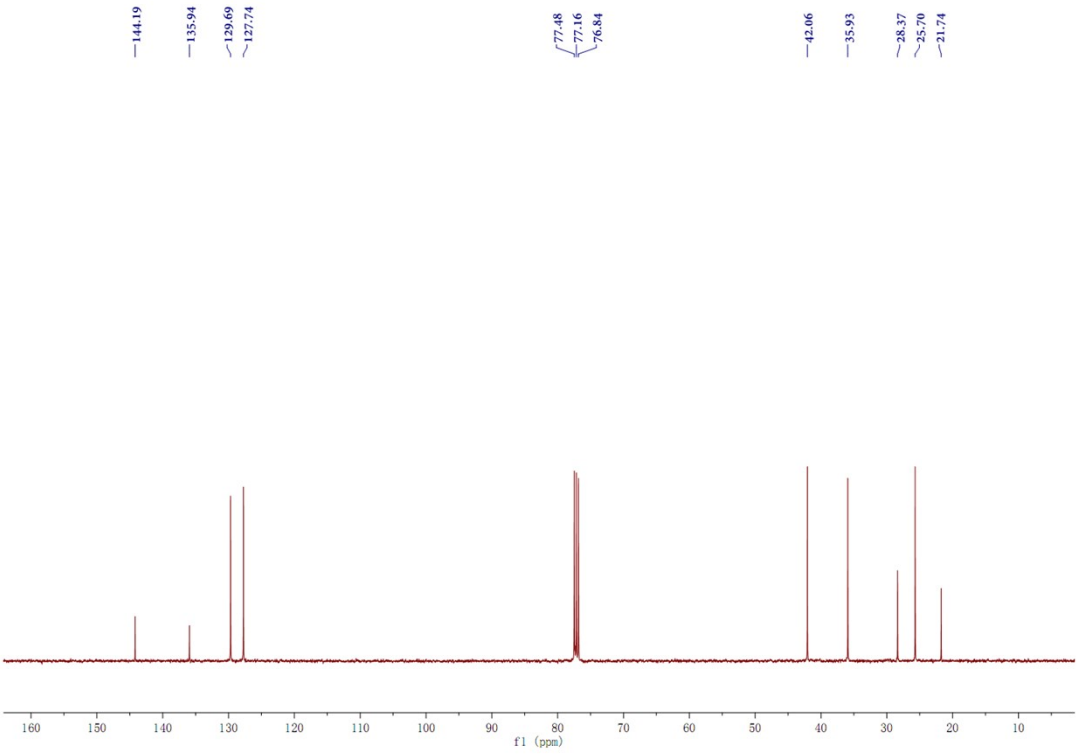
17

1.92 2.00 2.16 0.98 1.96
1.96 0.50 2.95 0.42 1.97 1.89 1.06 0.98
13 12 11 10 9 8 7 6 5 4 3 2 1 0 -1 -2
f1 (ppm)


145.84 145.61 144.31 135.77 129.77 128.58 127.74 126.90 126.88 126.44
77.48 77.16 76.84
41.48 40.13 39.57 39.45 39.04 35.96 31.24 31.02 28.37 25.67 24.45 22.68 21.73

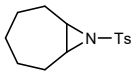

160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)


7.80
7.78
7.32
7.30
7.26
2.90
2.43
1.48
1.45
1.43
1.26
1.25
1.25
1.24
1.23
1.22
1.21
1.21
0.75
0.73
N
Ts
18
1.96
2.00
1.98
5.08
3.03
2.28
1.05
f1 (ppm)

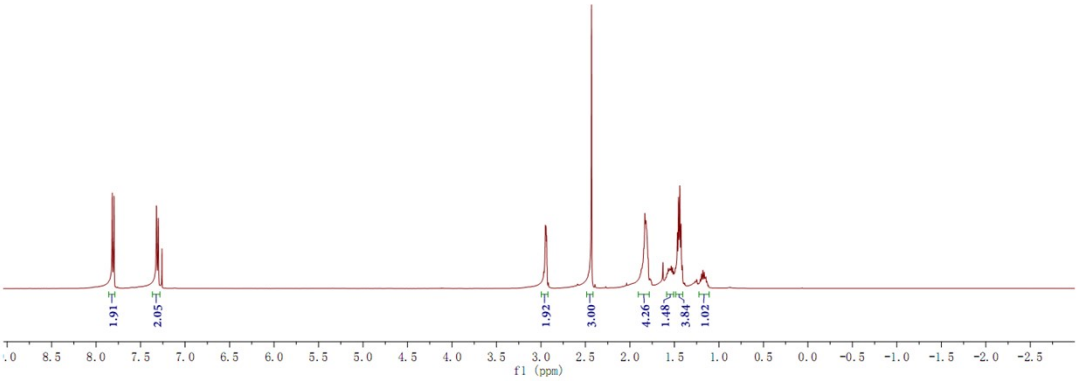

144.19
135.94
129.69
127.74
77.48
77.16
76.84
42.06
35.93
28.37
25.70
21.74
f1 (ppm)


7.82
7.80
7.32
7.30
7.26

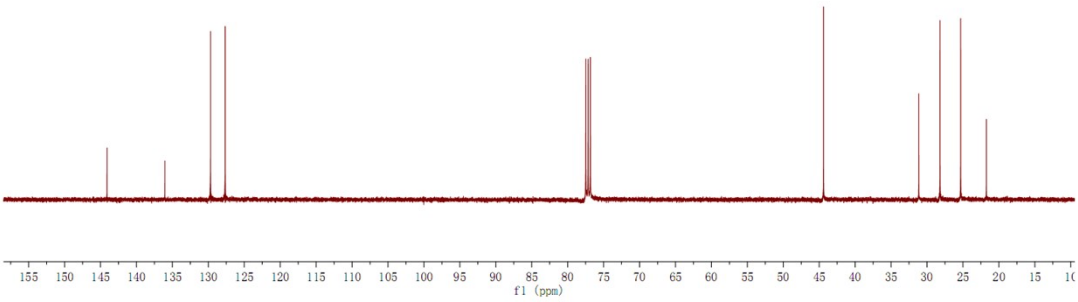

2.97
2.95
2.95
2.94
2.94
2.92
2.43
1.85
1.83
1.82
1.82
1.80
1.58
1.57
1.55
1.54
1.52
1.51
1.49
1.47
1.45
1.44
1.43
1.41
1.21
1.20
1.18
1.16
1.15
1.14

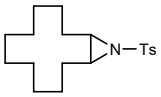

N—Ts

19

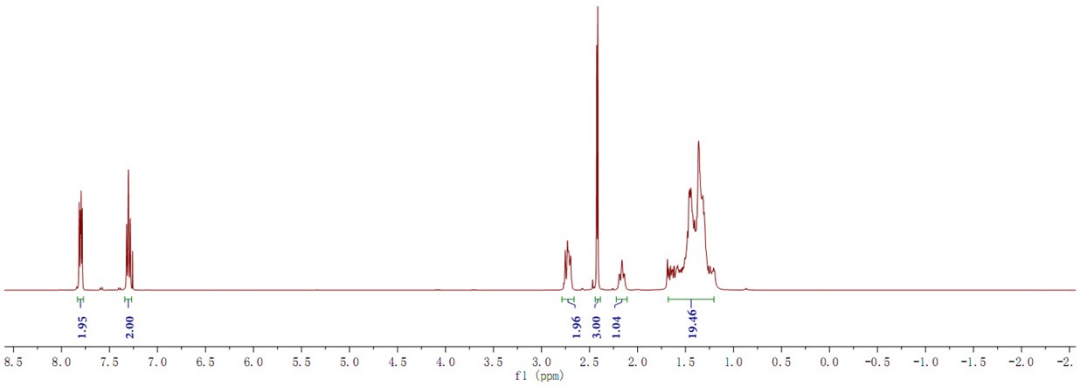

1.91
2.05
1.92
3.00
4.26
1.48
3.84
1.02
f1 (ppm)

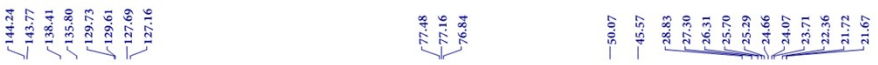

144.10
136.05
129.70
129.69
129.68
127.68
127.67
127.66
127.64
77.48
77.16
76.84
44.40
31.15
28.20
25.32
21.74

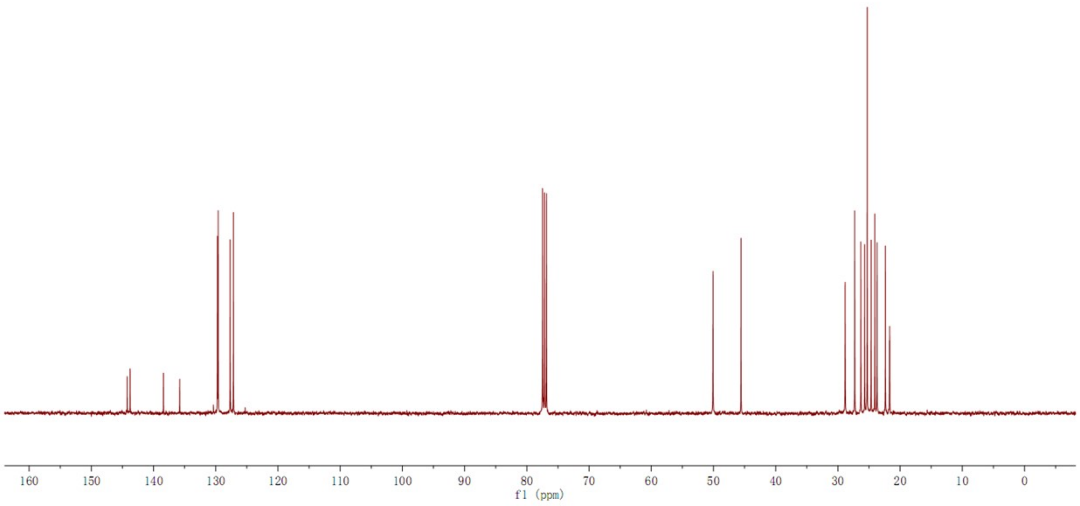

f1 (ppm)

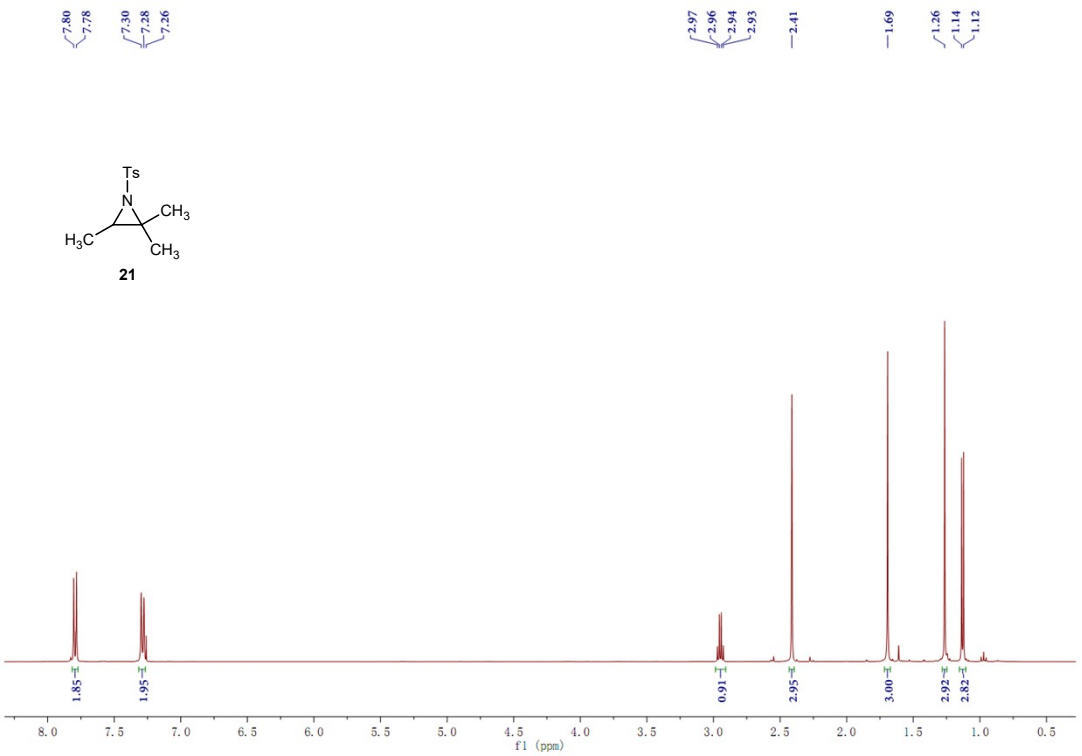


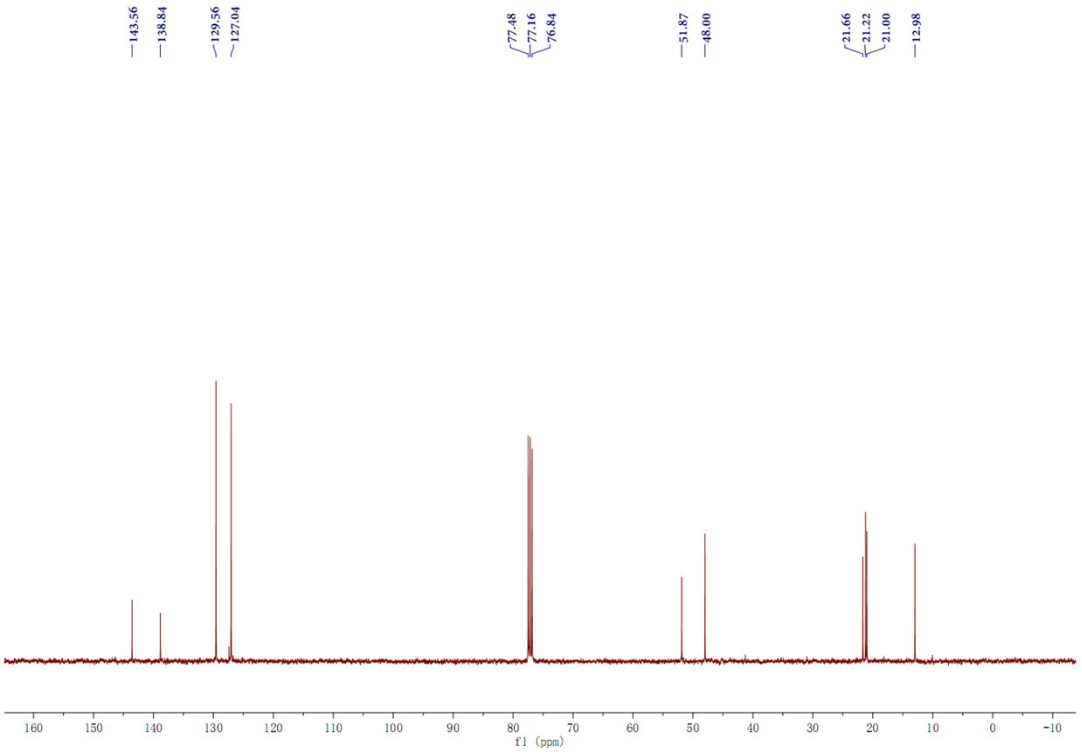
20

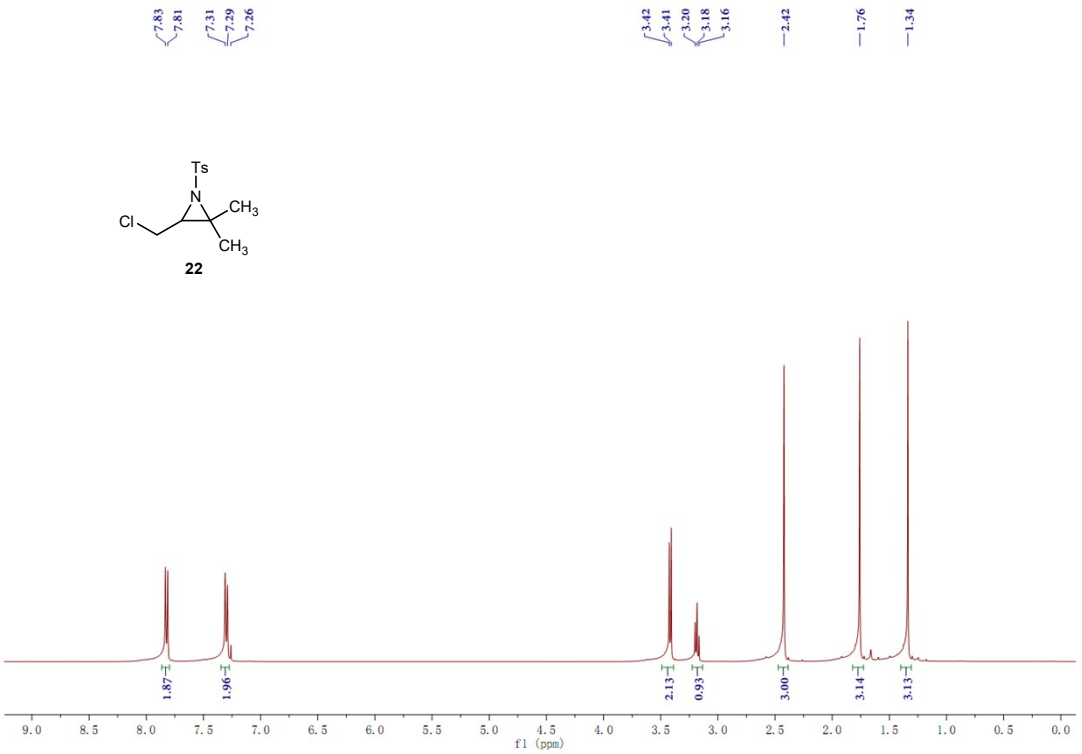


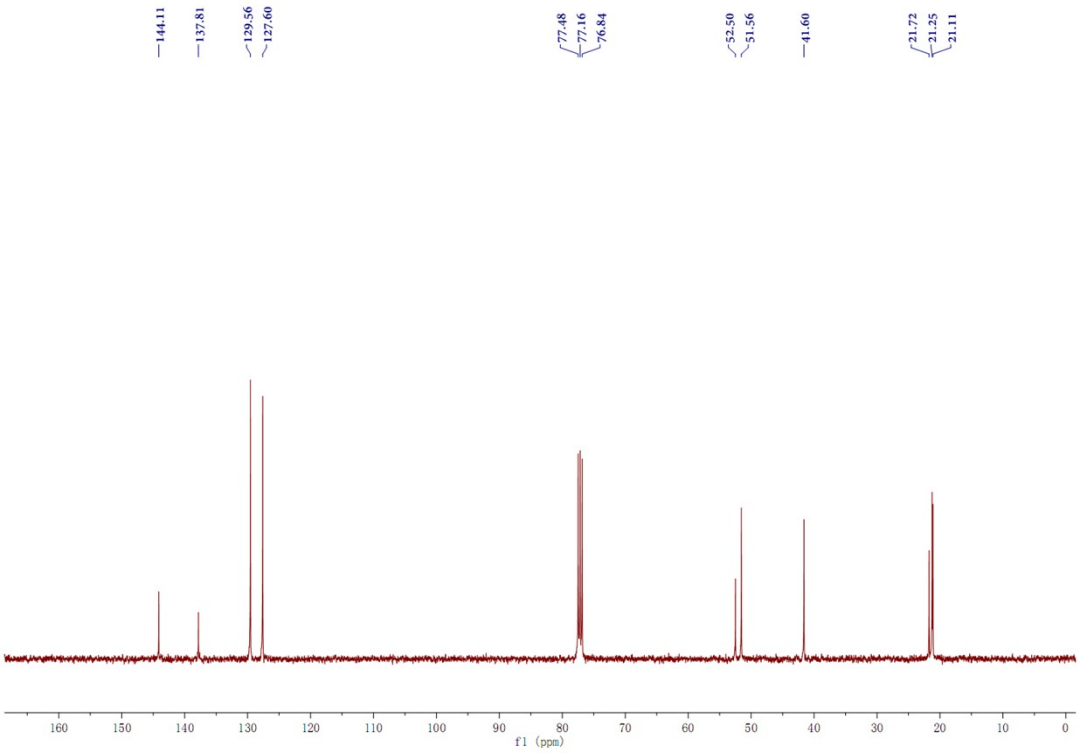


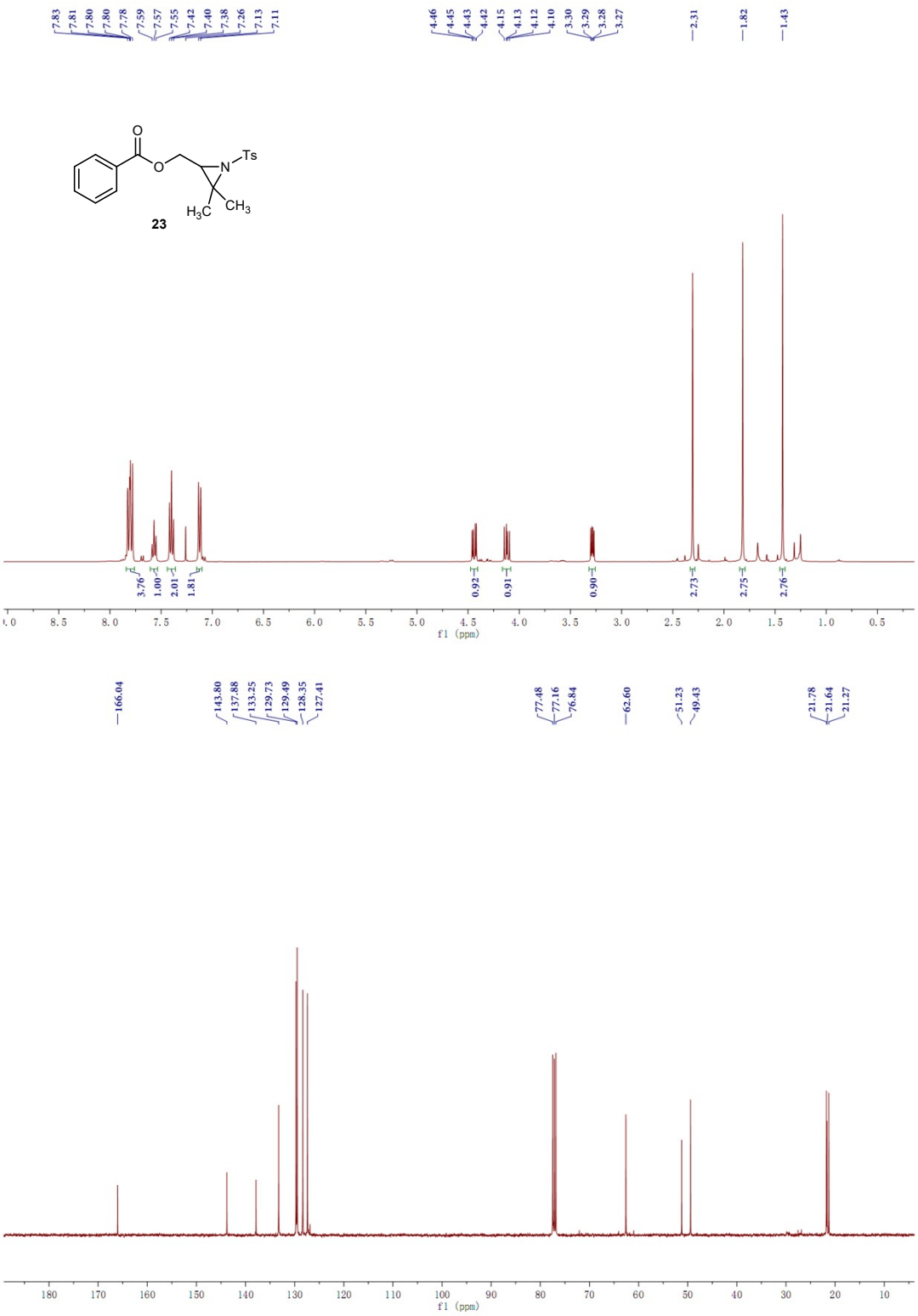


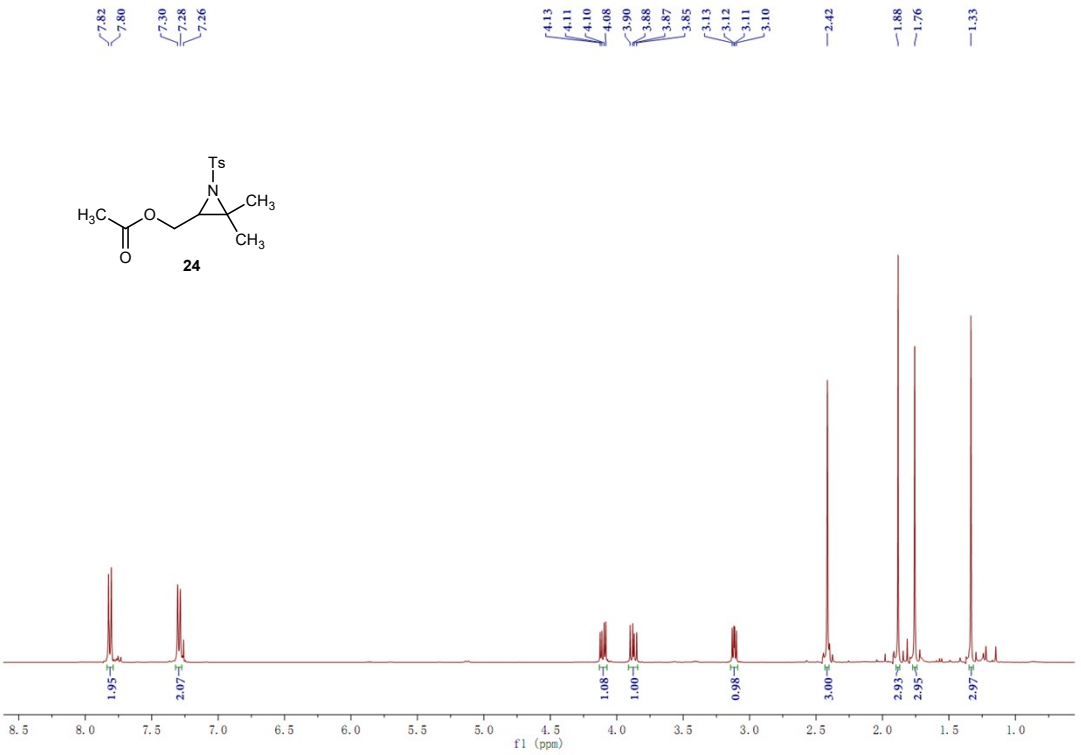

7.80
7.78
7.30
7.28
7.26
2.97
2.96
2.94
2.93
2.41
1.69
1.26
1.14
1.12
Ts
N
CH3
H3C
CH3
21
1.85
1.95
0.91
2.95
3.00
2.92
2.82
f1 (ppm)

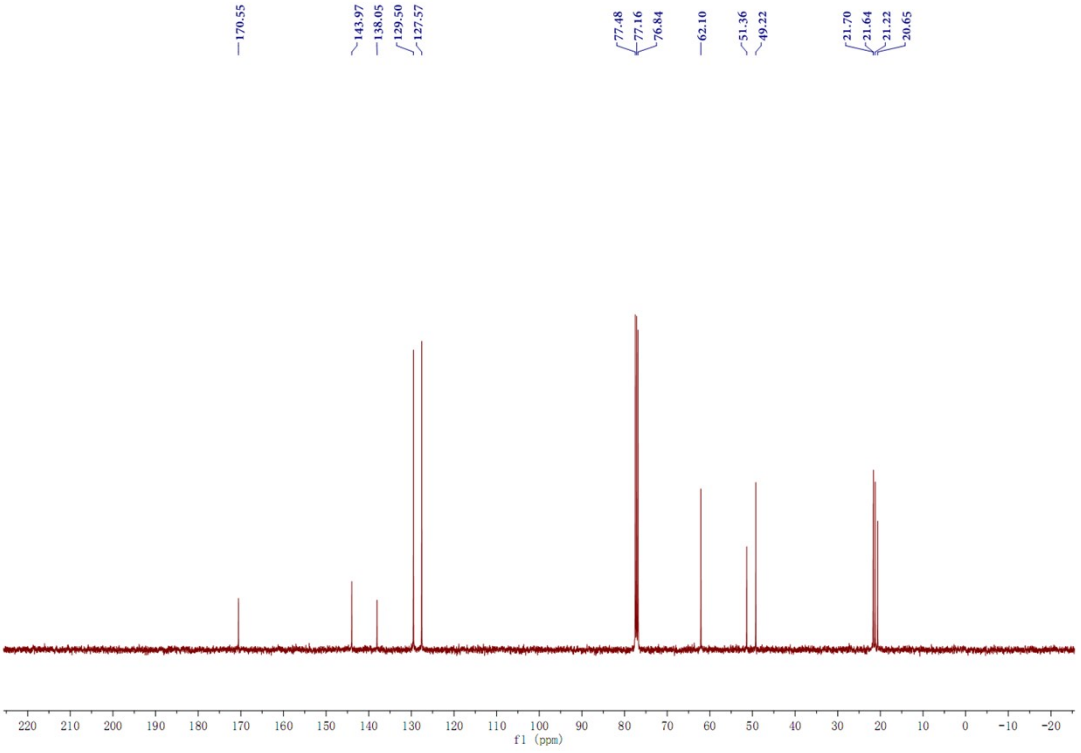

143.56
138.84
129.56
127.04
77.48
77.16
76.84
51.87
48.00
21.66
21.22
21.00
12.98
f1 (ppm)


7.83
7.81
7.31
7.29
7.26
3.42
3.41
3.20
3.18
3.16
2.42
1.76
1.34
Ts
N
Cl
CH3
CH3
22
1.87
1.96
2.13
0.93
3.00
3.14
3.13
f1 (ppm)

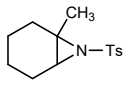

144.11
137.81
129.56
127.60
77.48
77.16
76.84
52.50
51.56
41.60
21.72
21.25
21.11
f1 (ppm)


7.83
7.81
7.80
7.80
7.78
7.59
7.57
7.55
7.42
7.40
7.38
7.26
7.13
7.11
4.46
4.45
4.43
4.42
4.15
4.13
4.12
4.10
3.30
3.29
3.28
3.27
2.31
1.82
1.43
O
O
N
Ts
H3C
CH3
23
3.76
1.00
2.01
1.81
0.92
0.91
0.90
2.73
2.75
2.76
f1 (ppm)
166.04
143.80
137.88
133.25
129.73
129.49
128.35
127.41
77.48
77.16
76.84
62.60
51.23
49.43
21.78
21.64
21.27
f1 (ppm)


7.82
7.80
7.30
7.28
7.26
4.13
4.11
4.10
4.08
3.90
3.88
3.87
3.85
3.13
3.12
3.11
3.10
2.42
1.88
1.76
1.33
Ts
N
CH3
H3C
O
CH3
O
24
1.95
2.07
1.08
1.00
0.98
3.00
2.93
2.95
2.97
f1 (ppm)


170.55
143.97
138.05
129.50
127.57
77.48
77.16
76.84
62.10
51.36
49.22
21.70
21.64
21.22
20.65
f1 (ppm)

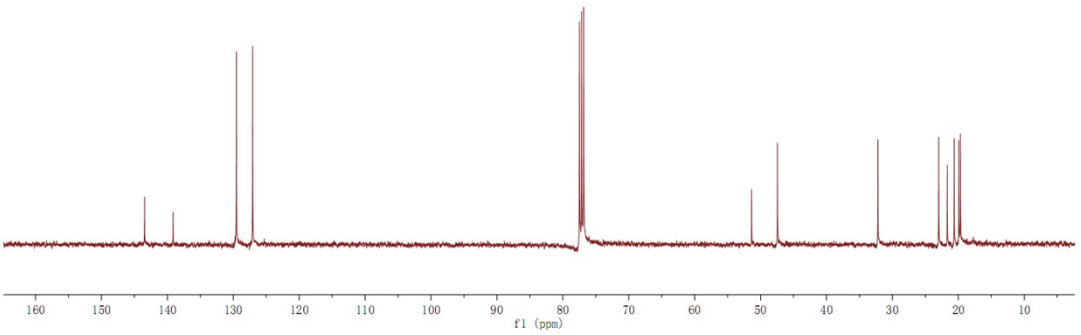

7.82 7.80 7.80 7.30 7.28 7.26 3.05 3.04 2.42 2.06 2.04 2.03 1.84 1.83 1.82 1.82 1.81 1.80 1.79 1.71 1.59 1.57 1.56 1.55 1.55 1.54 1.53 1.52 1.52 1.51 1.51 1.49 1.48 1.43 1.41 1.40 1.40 1.39 1.38 1.37 1.37 1.36 1.35 1.34 1.33 1.29 1.28 1.28 1.27 1.26 1.25 1.10 0.06

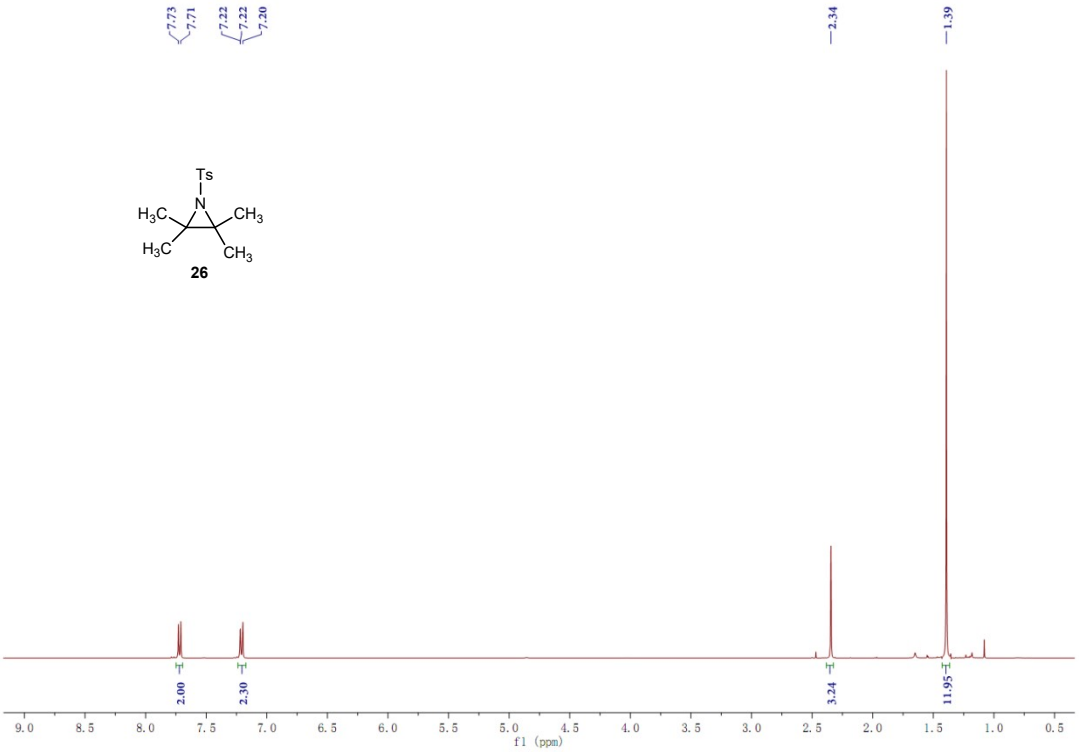

CH3
N—Ts

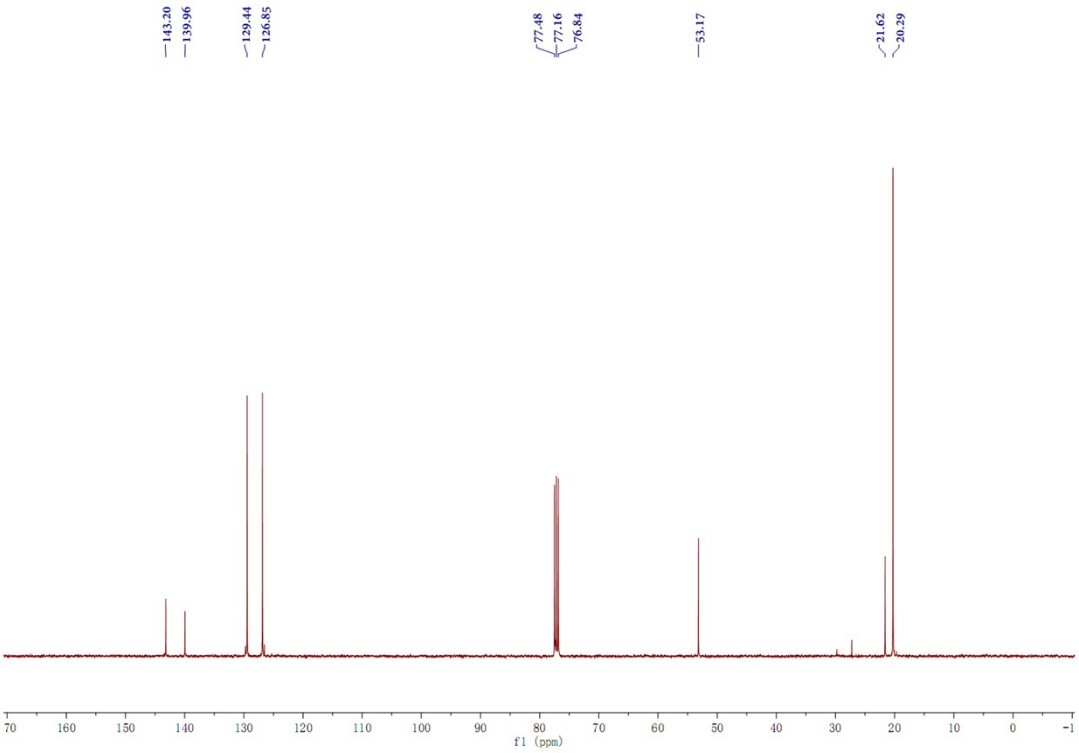
25

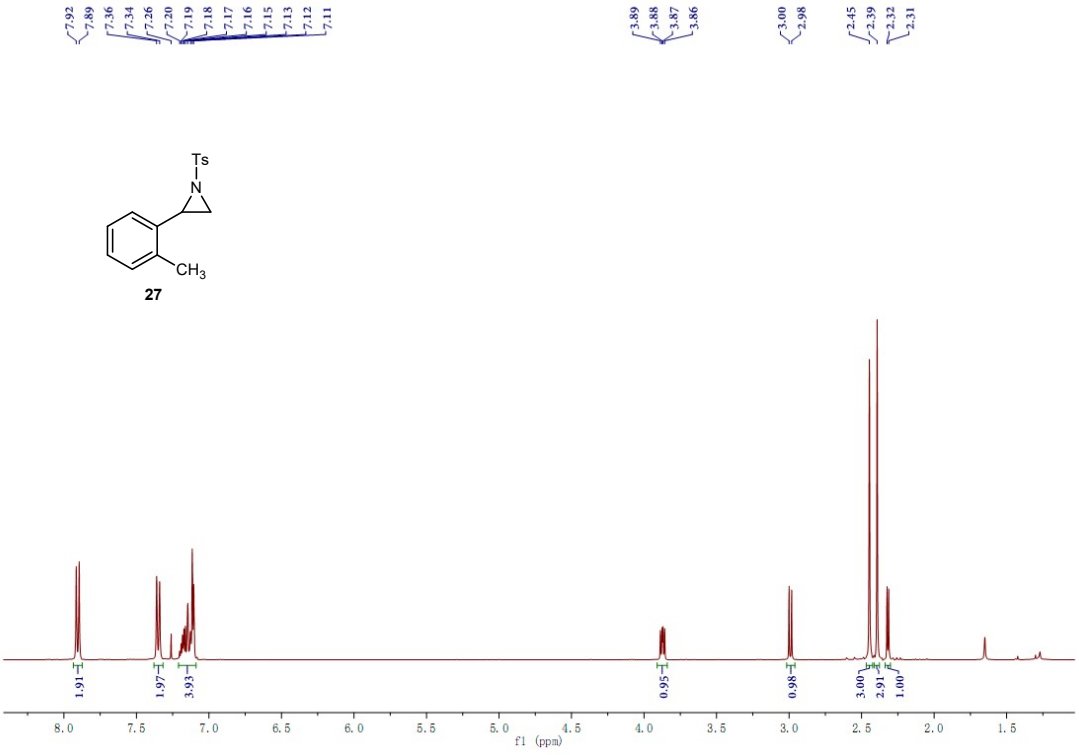
1.75
1.86
0.88
3.00
1.01
1.32
2.90
2.24
3.64
0.94
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2.0
f1 (ppm)

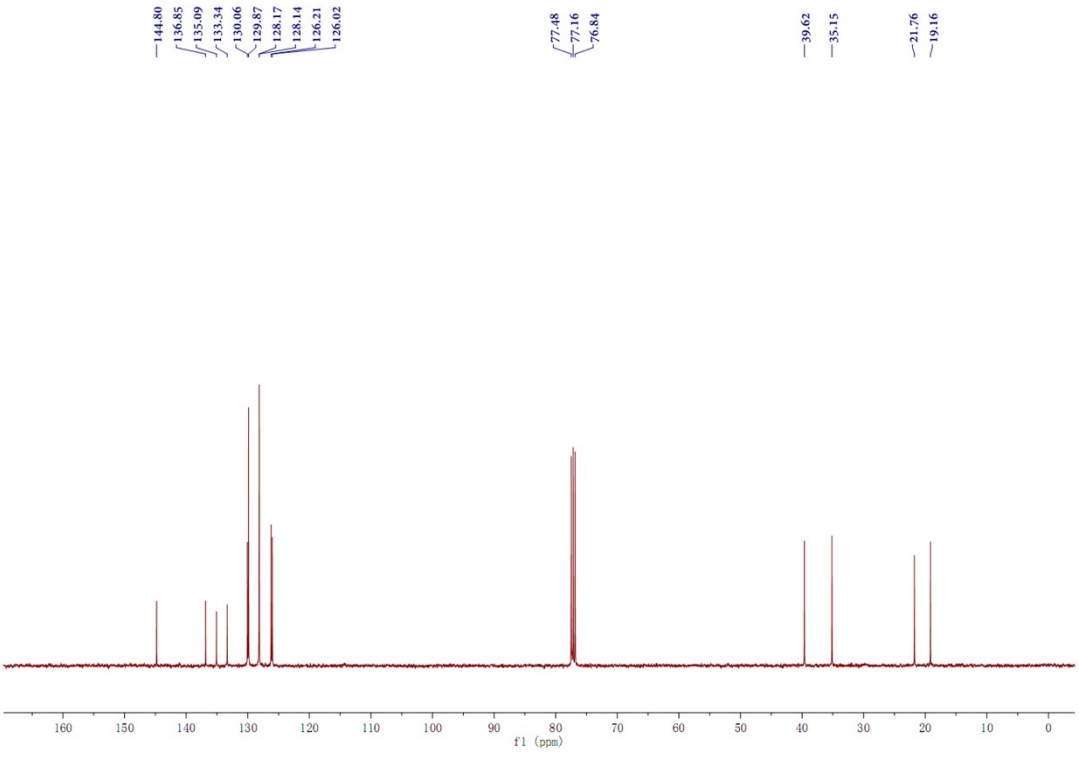

143.45
139.12
129.52
127.06
77.48
77.16
76.84
51.36
47.44
32.20
22.97
21.68
20.63
19.93
19.68


160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)

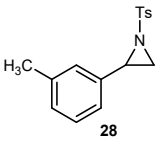

7.73
7.71
7.22
7.22
7.20
2.34
1.39
Ts
N
H3C
CH3
H3C
CH3
26
2.00
2.30
3.24
11.95
f1 (ppm)


143.20
139.96
129.44
126.85
77.48
77.16
76.84
53.17
21.62
20.29
f1 (ppm)

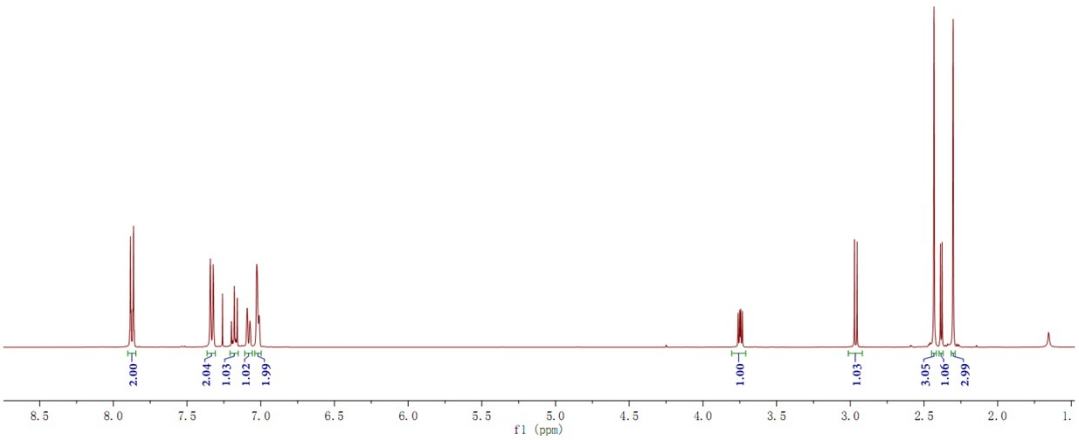

7.92
7.89
7.36
7.34
7.26
7.20
7.19
7.18
7.17
7.16
7.15
7.13
7.12
7.11
3.89
3.88
3.87
3.86
3.00
2.98
2.45
2.39
2.32
2.31
Ts
N
CH3
27
1.91
1.97
3.93
0.95
0.98
3.00
2.91
1.00
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
f1 (ppm)


144.80
136.85
135.09
133.34
130.06
129.87
128.17
128.14
126.21
126.02
77.48
77.16
76.84
39.62
35.15
21.76
19.16
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


7.89
7.88
7.88
7.87
7.86
7.86
7.34
7.32
7.26
7.20
7.18
7.16
7.09
7.07
7.03
7.01
7.01
3.76
3.75
3.74
3.73
2.97
2.95
2.43
2.39
2.38
2.30


Ts
N
H3C

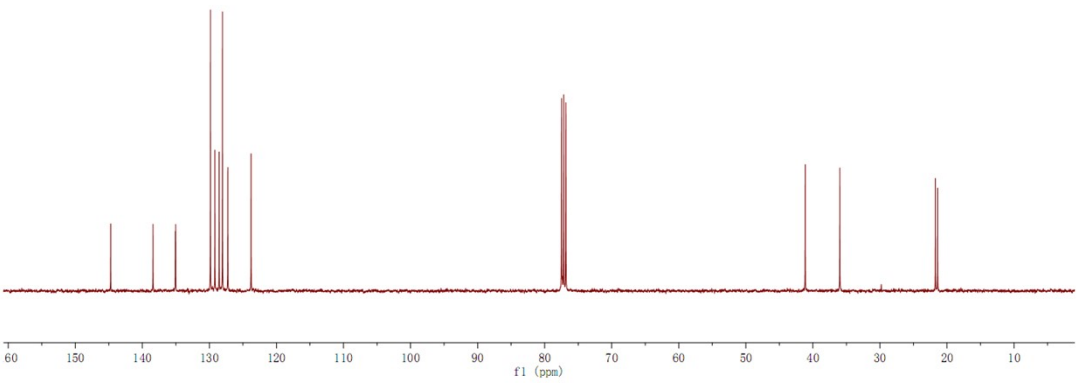
28


2.00
2.04
1.03
1.02
1.99
1.00
1.03
3.05
1.06
2.99
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.
f1 (ppm)


144.73
138.41
135.09
135.03
129.85
129.18
128.55
128.05
127.25
123.79

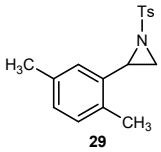

77.48
77.16
76.84


41.14
35.98
21.74
21.40

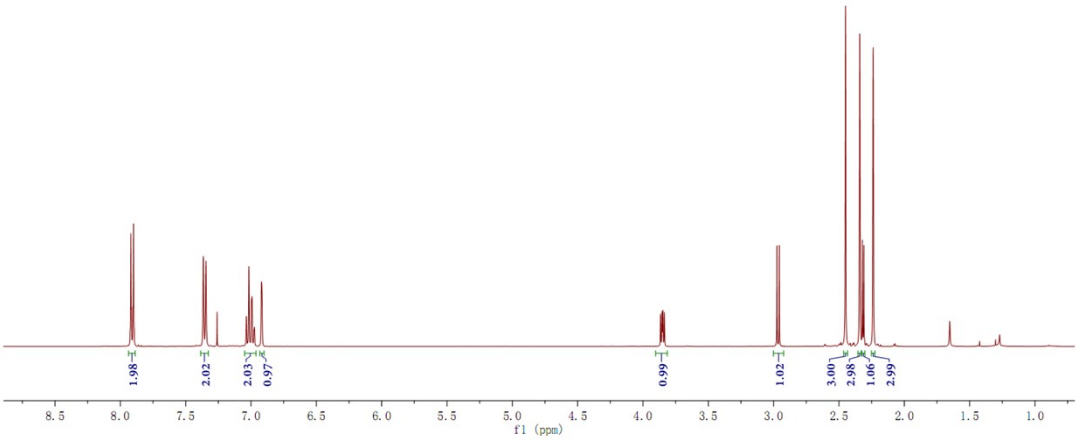

60
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)


7.92
7.92
7.92
7.90
7.90
7.89
7.36
7.34
7.26
7.04
7.02
7.00
6.99
6.97
6.92

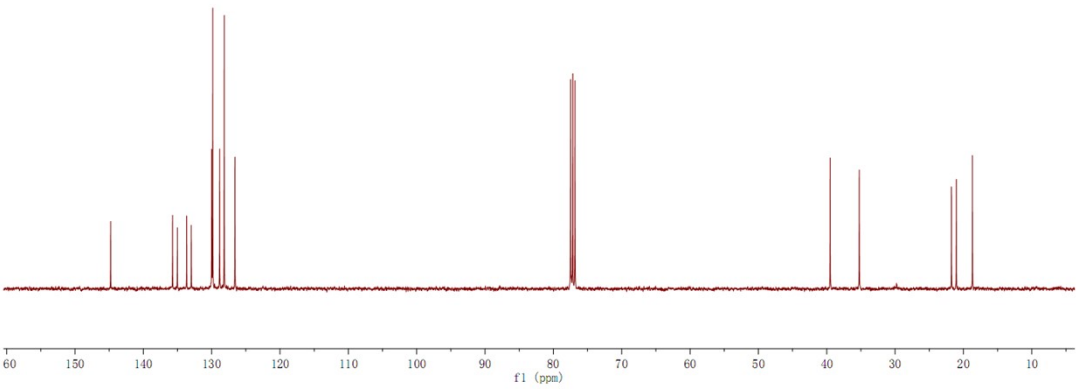

3.87
3.85
3.85
3.84
2.97
2.96
2.45
2.34
2.32
2.31
2.24

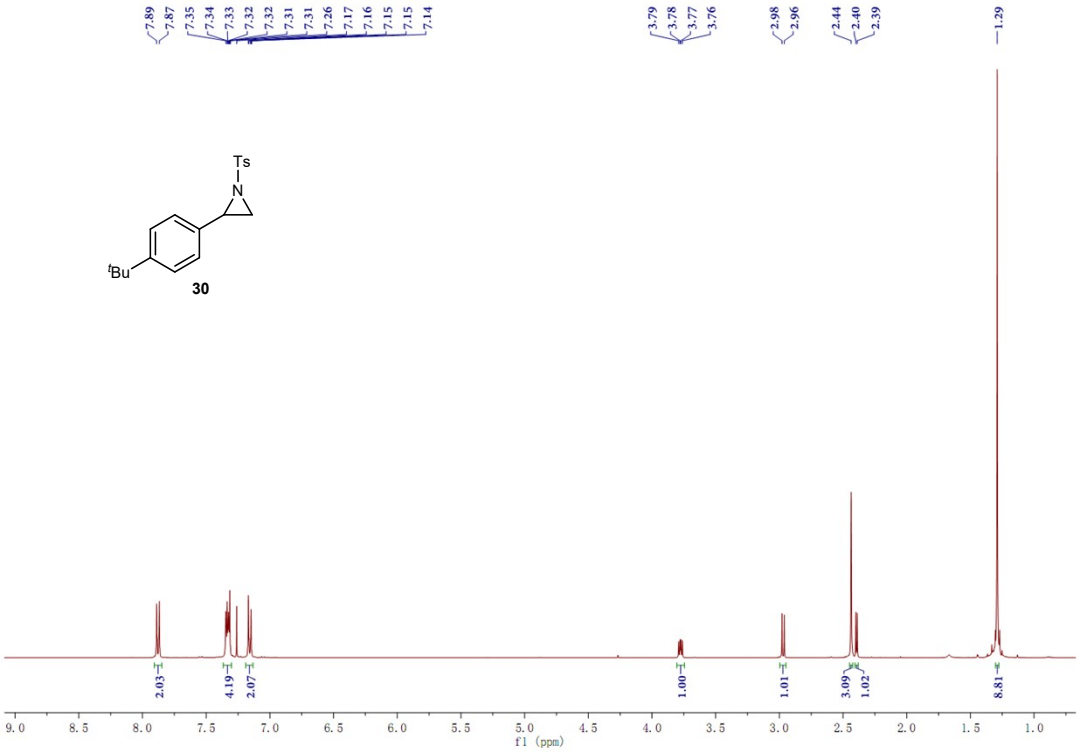

Ts
N
H3C
CH3

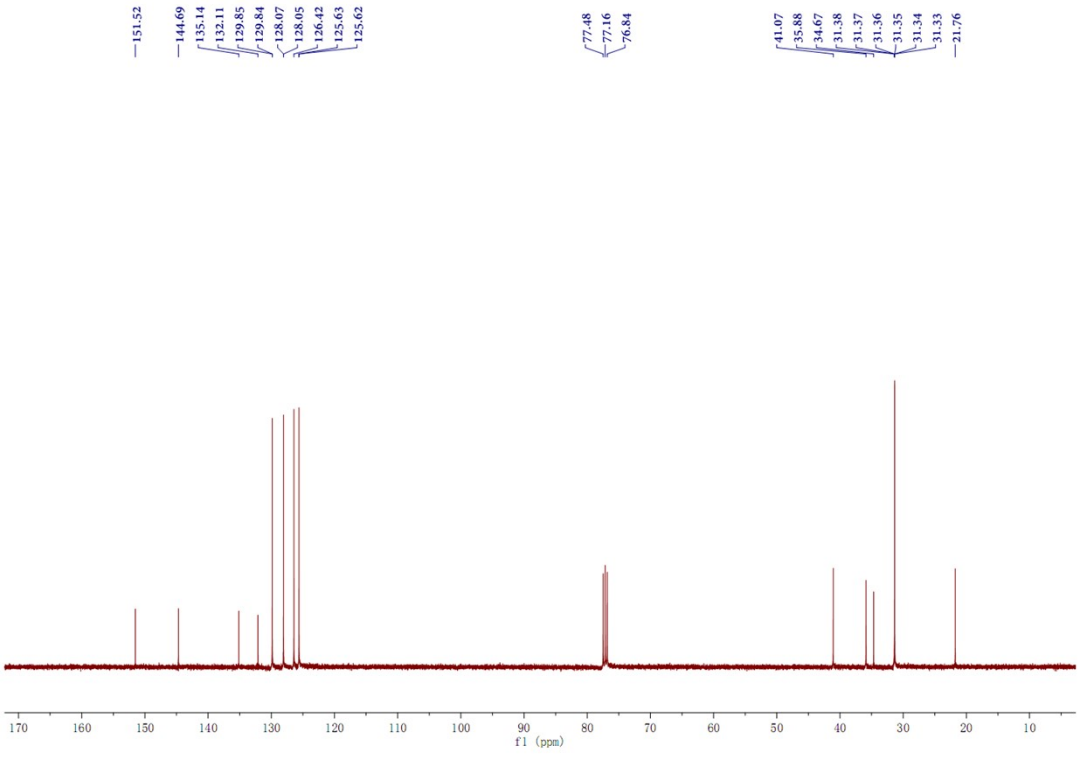
29

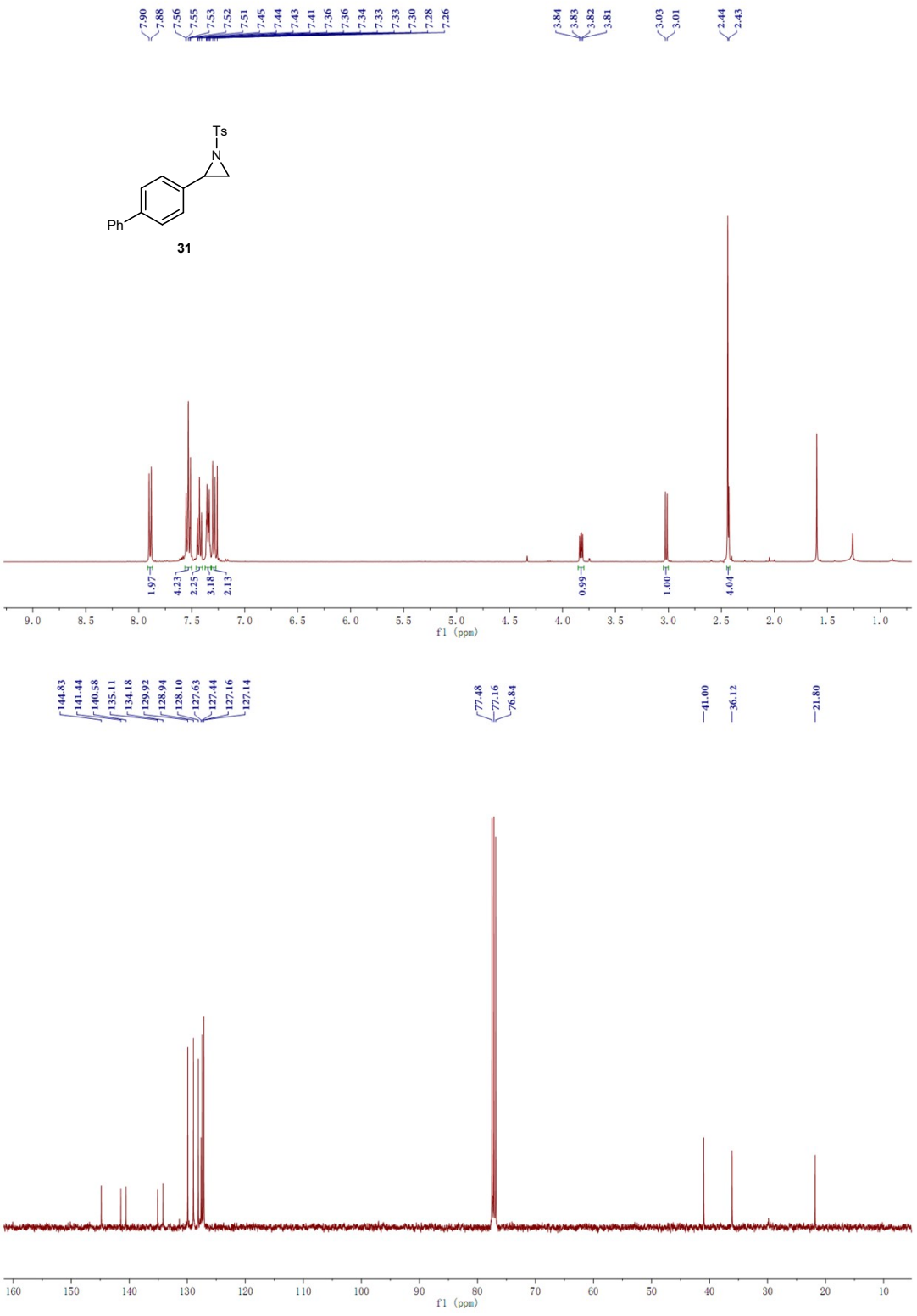

1.98
2.02
2.03
0.97
0.99
1.02
3.00
2.98
1.06
2.99
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
f1 (ppm)

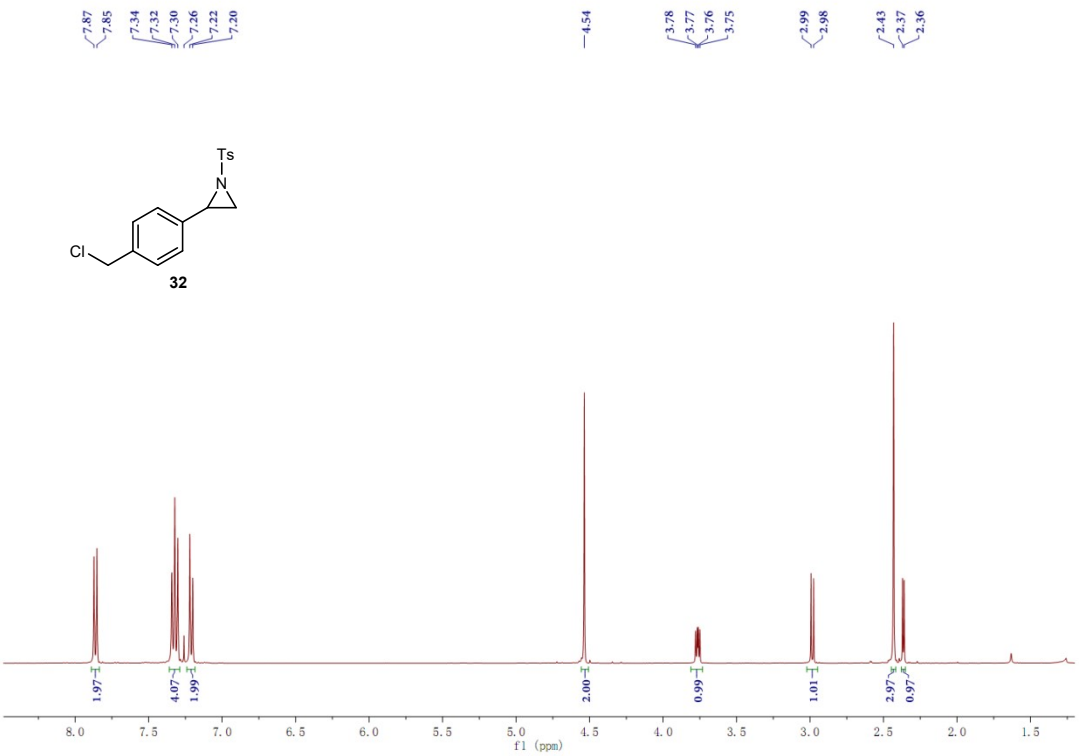

144.79
135.73
135.02
133.67
132.99
130.01
129.85
128.84
128.16
126.60
77.48
77.16
76.84
39.50
35.24
21.75
21.04
18.68

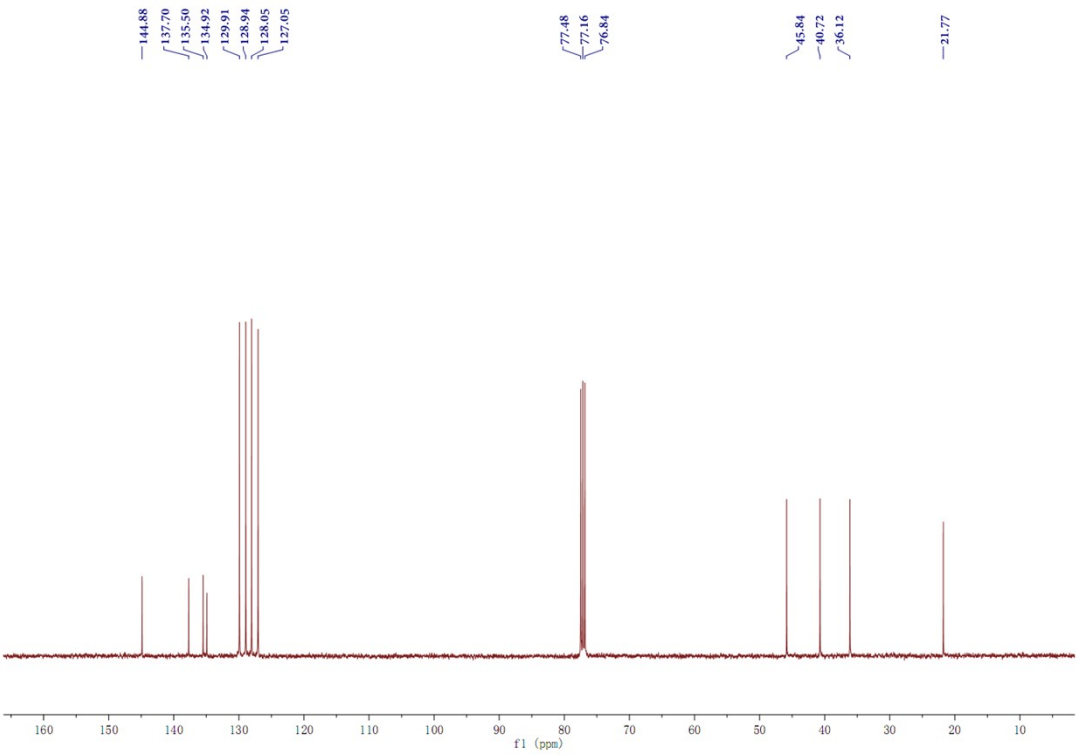

60
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)

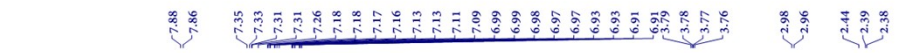

7.89
7.87
7.35
7.34
7.33
7.32
7.32
7.31
7.31
7.26
7.17
7.16
7.15
7.15
7.14
3.79
3.78
3.77
3.76
2.98
2.96
2.44
2.40
2.39
1.29
Ts
N
tBu
30
2.03
4.19
2.07
1.00
1.01
3.09
1.02
8.81
f1 (ppm)

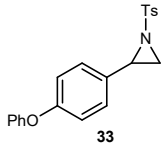

151.52
144.69
135.14
132.11
129.85
129.84
128.07
128.05
126.42
125.63
125.62
77.48
77.16
76.84
41.07
35.88
34.67
31.38
31.37
31.36
31.35
31.34
31.33
21.76
f1 (ppm)


7.90
7.88
7.56
7.55
7.53
7.52
7.51
7.45
7.44
7.43
7.41
7.36
7.36
7.34
7.33
7.33
7.30
7.28
7.26
3.84
3.83
3.82
3.81
3.03
3.01
2.44
2.43
Ts
N
Ph
31
1.97
4.23
2.25
3.18
2.13
0.99
1.00
4.04
f1 (ppm)
144.83
141.44
140.58
135.11
134.18
129.92
128.94
128.10
127.63
127.44
127.16
127.14
77.48
77.16
76.84
41.00
36.12
21.80
f1 (ppm)

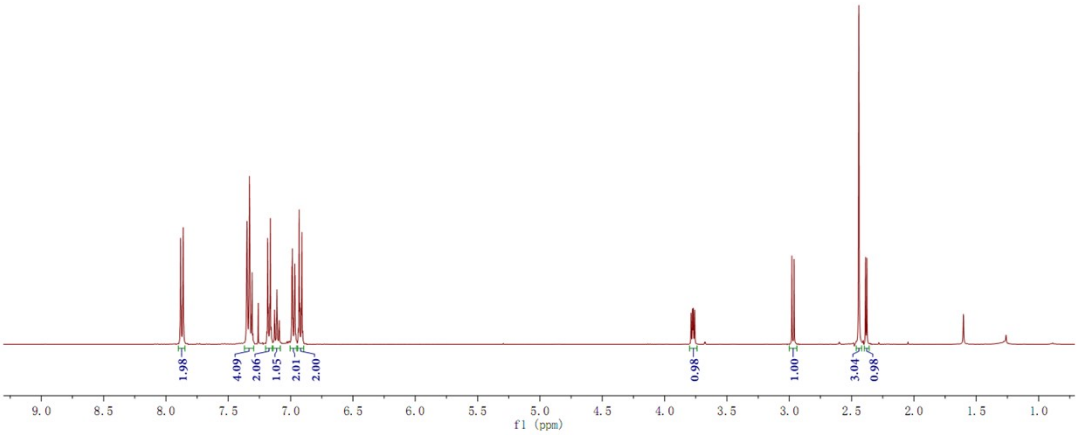

7.87
7.85
7.34
7.32
7.30
7.26
7.22
7.20
4.54
3.78
3.77
3.76
3.75
2.99
2.98
2.43
2.37
2.36
Ts
N
Cl
32
1.97
4.07
1.99
2.00
0.99
1.01
2.97
0.97
f1 (ppm)


144.88
137.70
135.50
134.92
129.91
128.94
128.05
127.05
77.48
77.16
76.84
45.84
40.72
36.12
21.77
f1 (ppm)

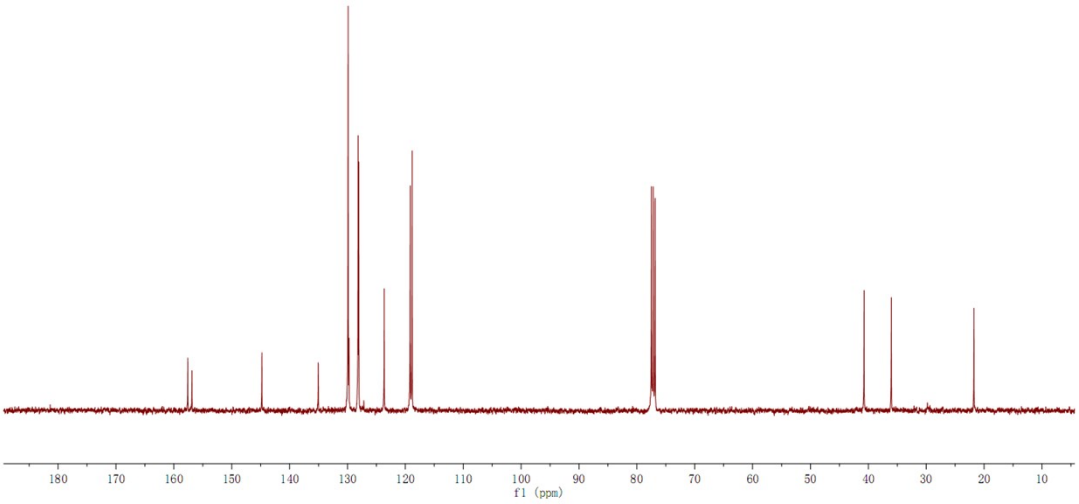

7.88
7.86
7.35
7.33
7.31
7.31
7.26
7.18
7.18
7.17
7.16
7.13
7.13
7.11
7.09
6.99
6.99
6.98
6.97
6.97
6.93
6.93
6.91
6.91
3.79
3.78
3.77
3.76
2.98
2.96
2.44
2.39
2.38


Ts
N
PhO

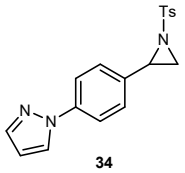
33


1.98
4.09
2.06
1.05
2.01
2.00
0.98
1.00
3.04
0.98
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
f1 (ppm)

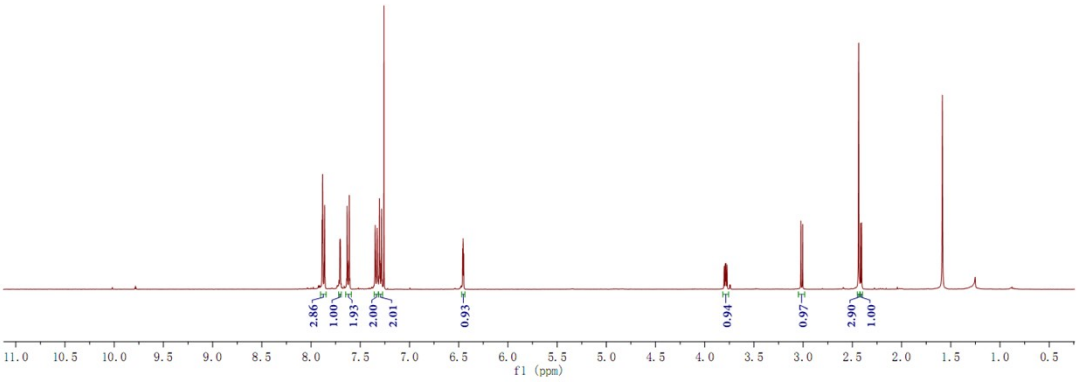

157.59
156.87
144.79
135.05
129.89
129.73
128.17
128.05
123.66
119.16
118.83
77.48
77.16
76.84
40.73
36.02
21.76

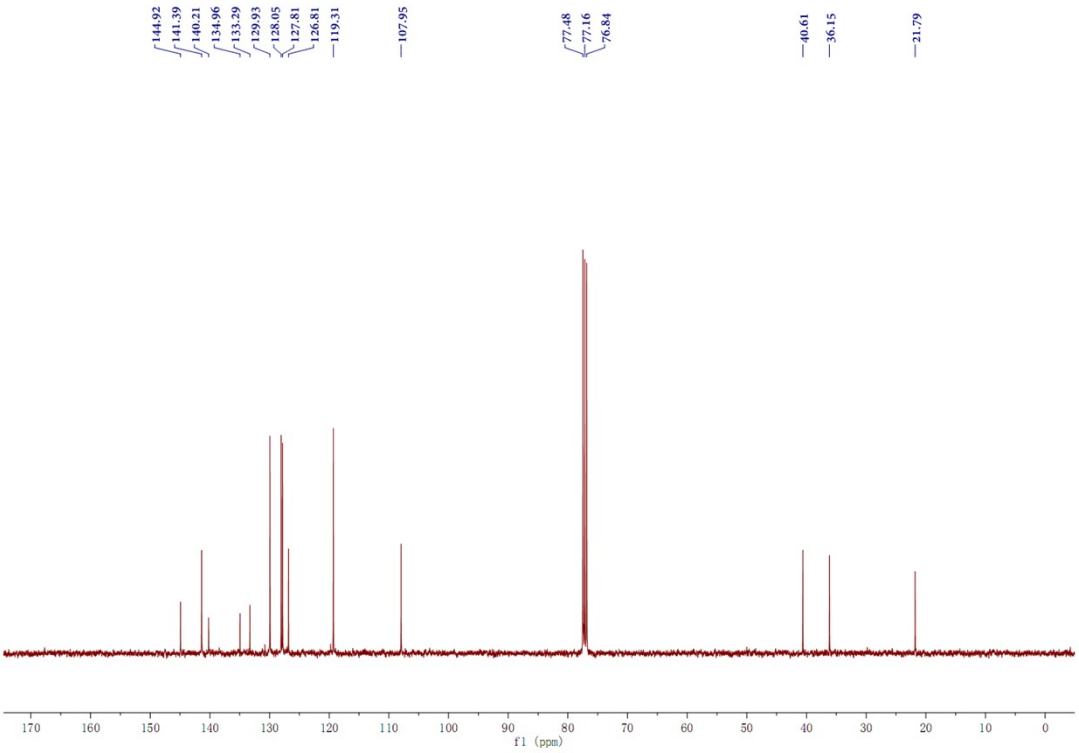

180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)


7.89
7.88
7.87
7.86
7.71
7.70
7.64
7.63
7.63
7.62
7.61
7.61
7.35
7.33
7.31
7.31
7.30
7.29
7.28
7.28
7.26
6.46
6.45
6.45
3.80
3.79
3.78
3.77
3.02
3.01
2.44
2.42
2.41

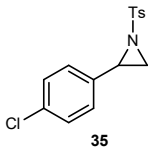

Ts
N
N
N

34

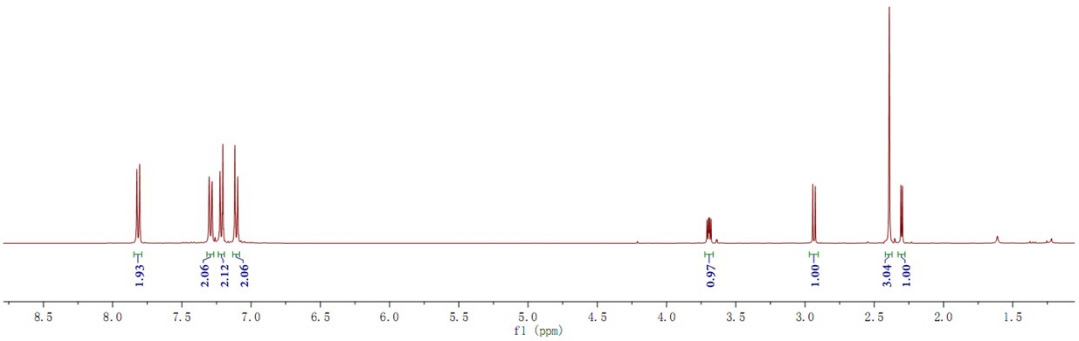

2.86
1.00
1.93
2.00
2.01
0.93
0.94
0.97
2.90
1.00
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
f1 (ppm)


144.92
141.39
140.21
134.96
133.29
129.93
128.05
127.81
126.81
119.31
107.95
77.48
77.16
76.84
40.61
36.15
21.79
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


7.83
7.80
7.30
7.28
7.26
7.23
7.23
7.21
7.20
7.20
7.12
7.12
7.11
7.10
3.71
3.70
3.69
3.68
2.94
2.93
2.39
2.31
2.30


Ts
N
Cl

35


1.93
2.06
2.12
2.06
0.97
1.00
3.04
1.00
8.5
8.0
7.5
7.0
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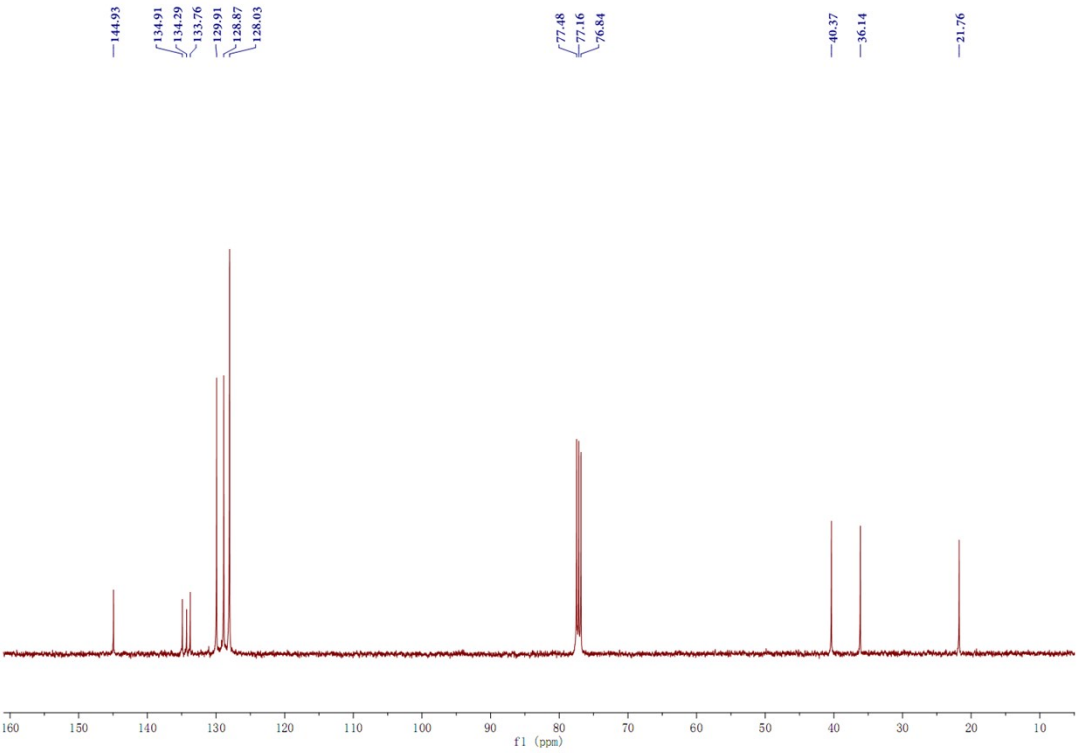
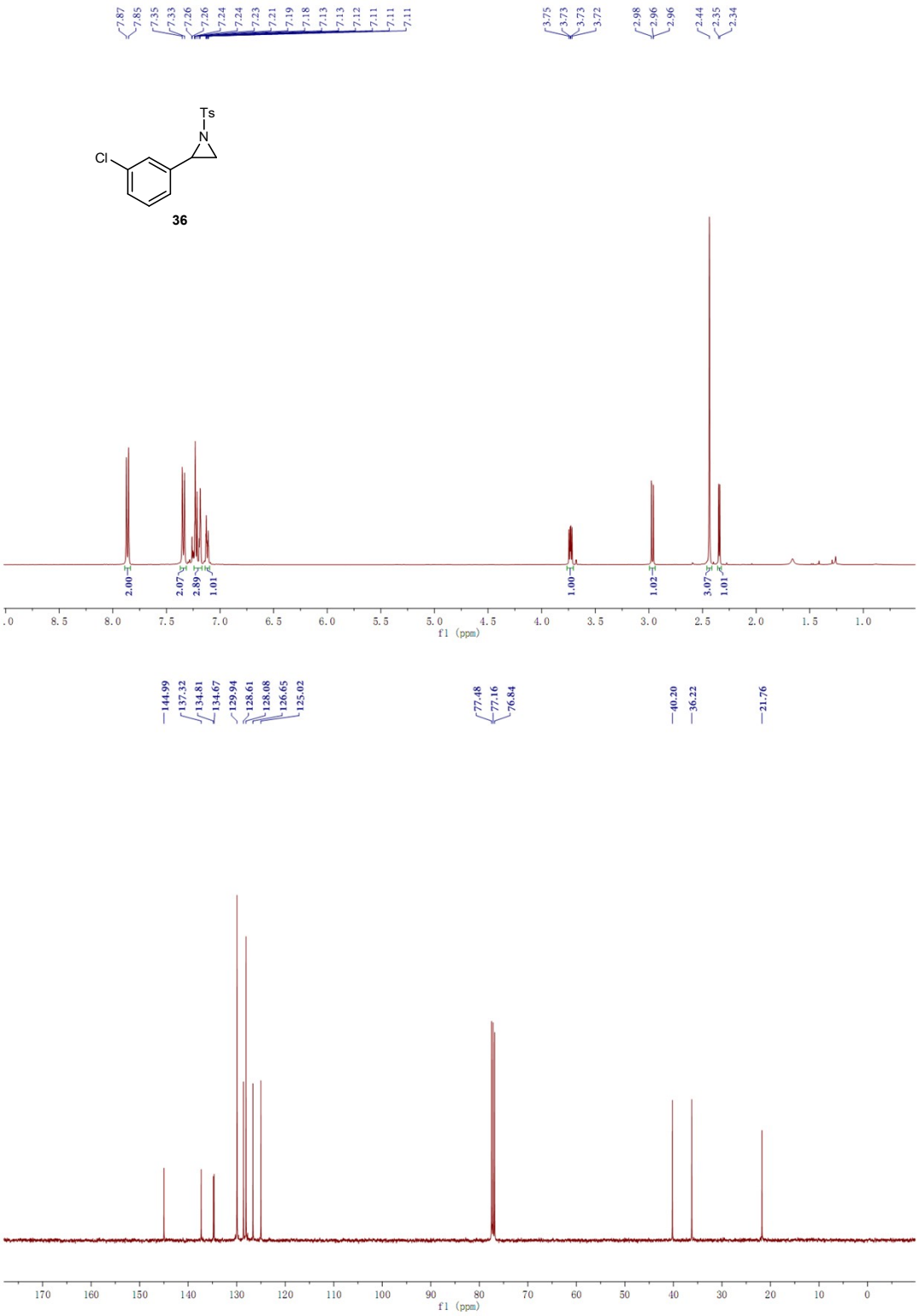
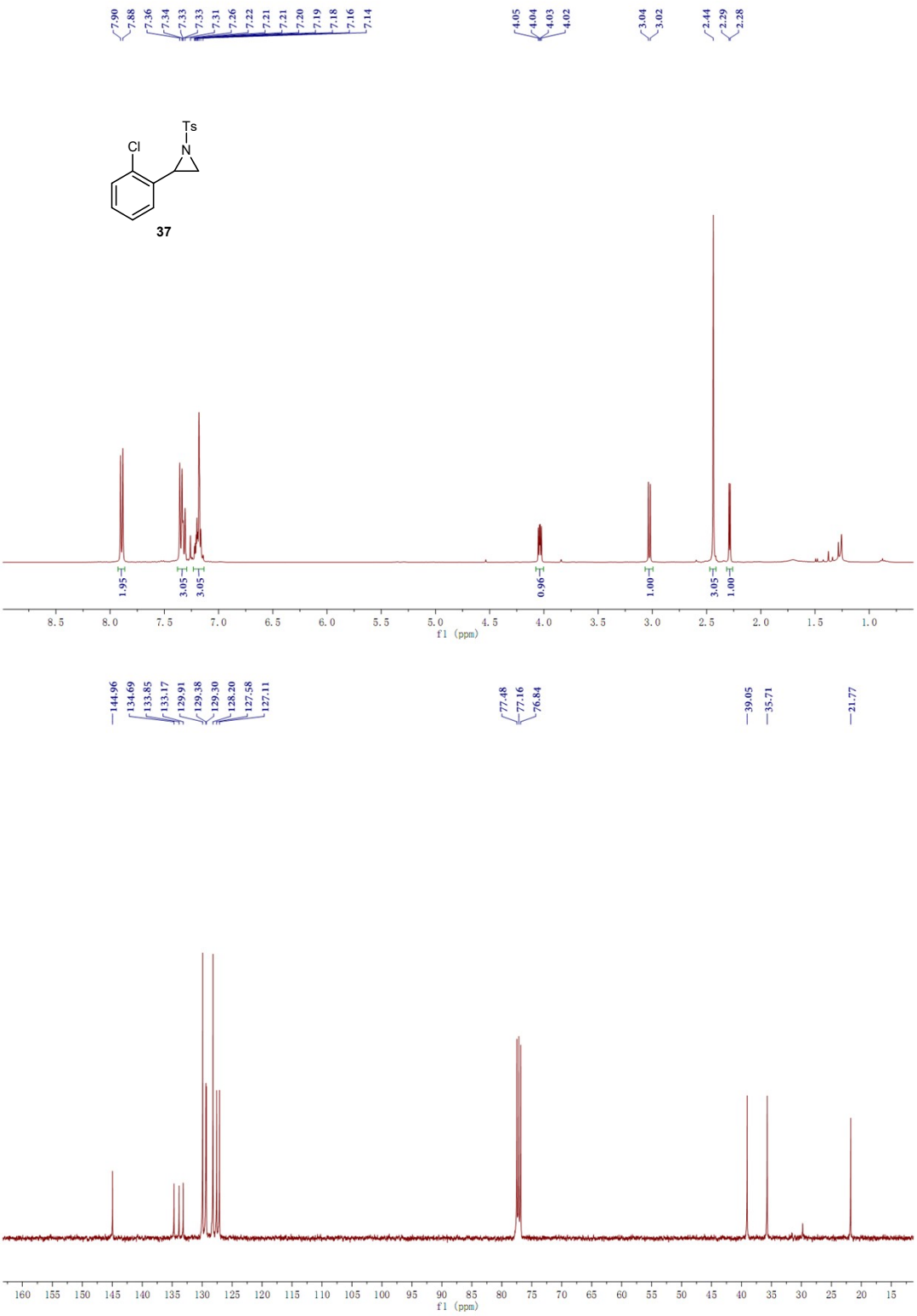
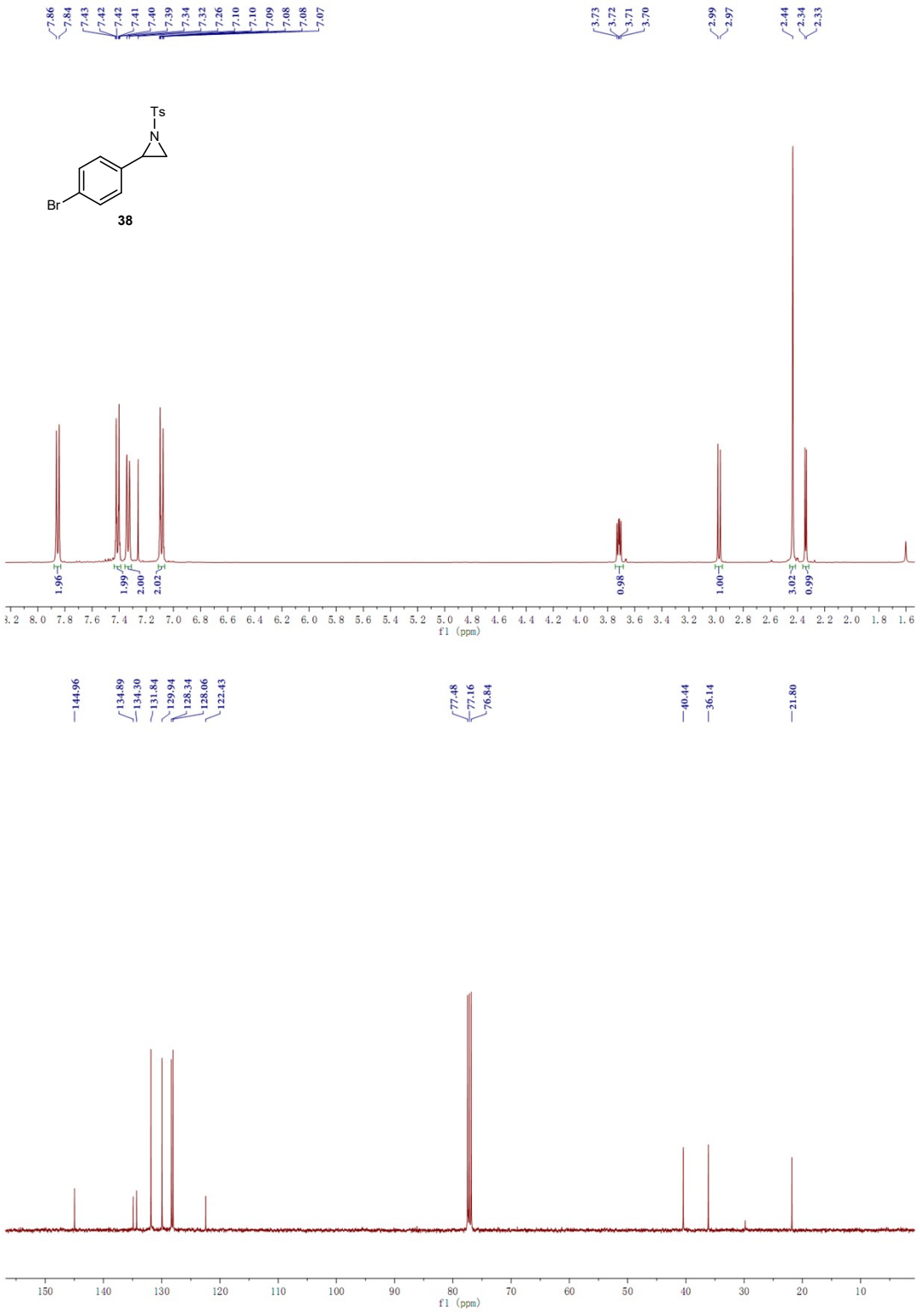
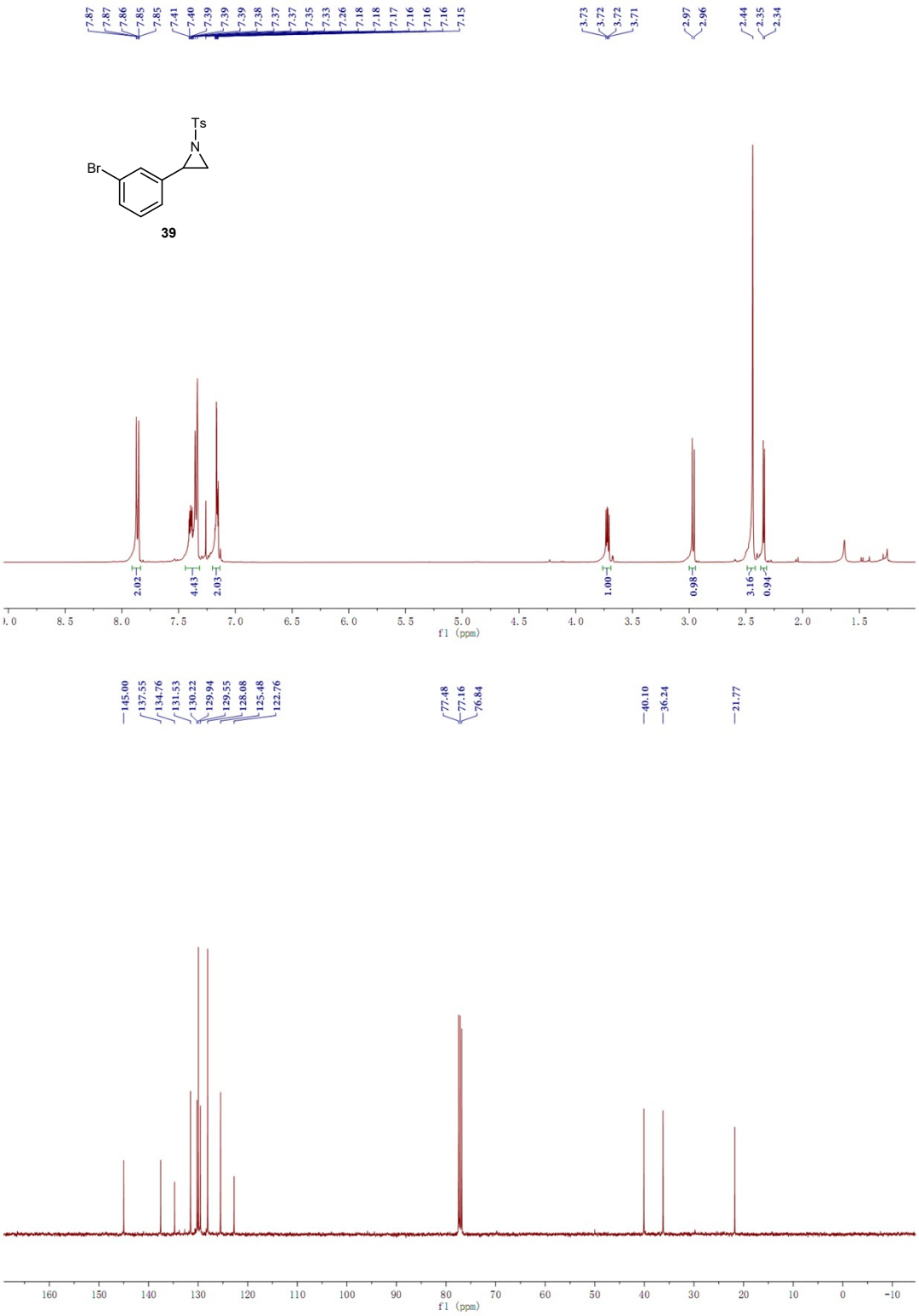
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
f1 (ppm)

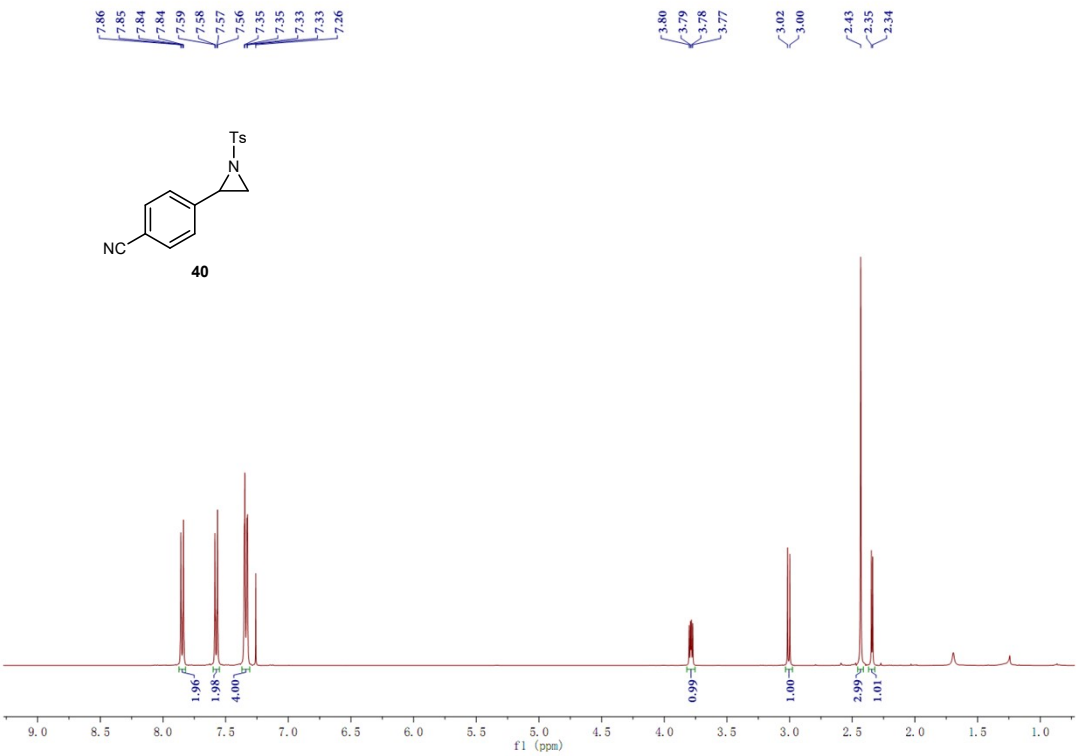

144.93
134.91
134.29
133.76
129.91
128.87
128.03
77.48
77.16
76.84
40.37
36.14
21.76
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)

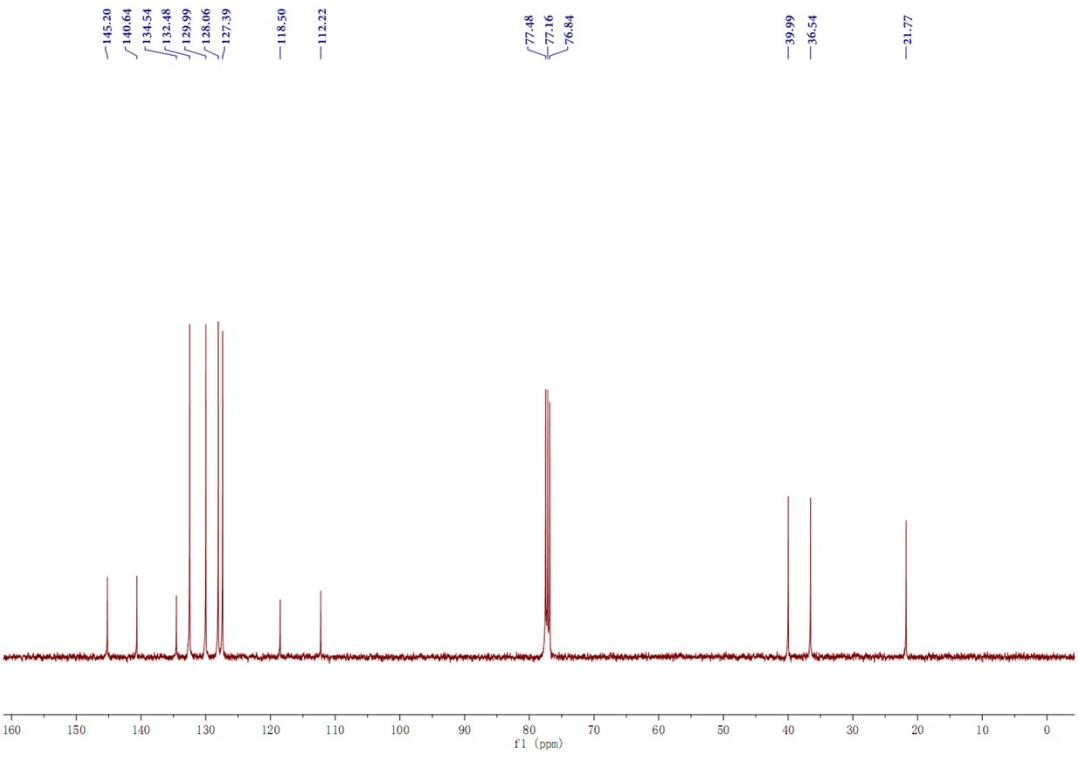

7.87
7.85
7.35
7.33
7.26
7.26
7.24
7.24
7.23
7.21
7.19
7.18
7.13
7.13
7.12
7.11
7.11
7.11
3.75
3.73
3.73
3.72
2.98
2.96
2.96
2.44
2.35
2.34
Ts
N
Cl
36
2.00
2.07
2.89
1.01
1.00
1.02
3.07
1.01
f1 (ppm)
144.99
137.32
134.81
134.67
129.94
128.61
128.08
126.65
125.02
77.48
77.16
76.84
40.20
36.22
21.76
f1 (ppm)

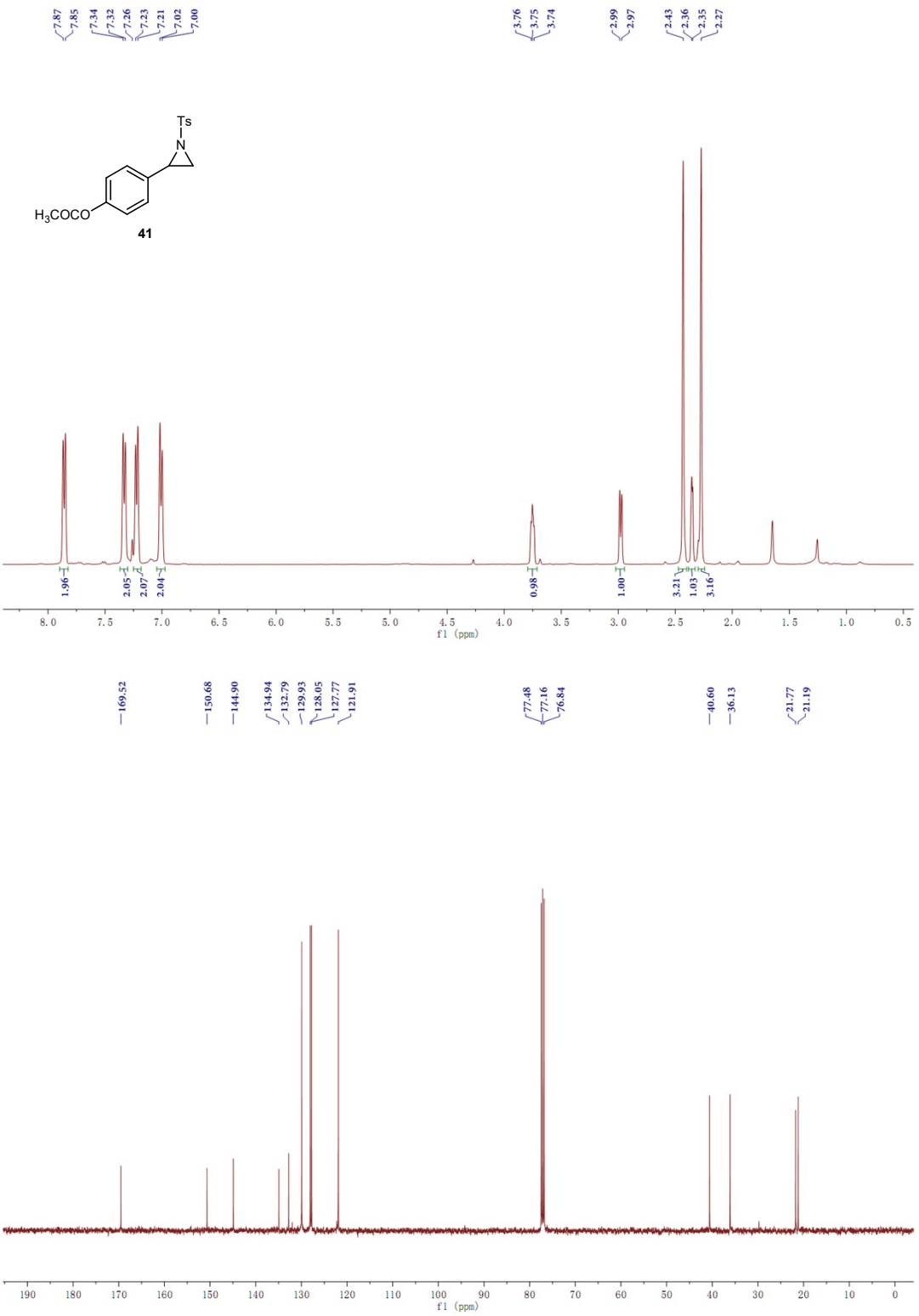

7.90
7.88
7.36
7.34
7.33
7.33
7.31
7.26
7.22
7.21
7.21
7.20
7.19
7.18
7.16
7.14
4.05
4.04
4.03
4.02
3.04
3.02
2.44
2.29
2.28
Ts
N
Cl
37
1.95
3.05
3.05
0.96
1.00
3.05
1.00
f1 (ppm)
144.96
134.69
133.85
133.17
129.91
129.38
129.30
128.20
127.58
127.11
77.48
77.16
76.84
39.05
35.71
21.77
f1 (ppm)


7.86
7.84
7.43
7.42
7.42
7.41
7.40
7.39
7.34
7.32
7.26
7.10
7.10
7.09
7.08
7.08
7.07
3.73
3.72
3.71
3.70
2.99
2.97
2.44
2.34
2.33
Ts
N
Br
38
1.96
1.99
2.00
2.02
0.98
1.00
3.02
0.99
f1 (ppm)
144.96
134.89
134.30
131.84
129.94
128.34
128.06
122.43
77.48
77.16
76.84
40.44
36.14
21.80
f1 (ppm)


7.87
7.87
7.86
7.85
7.85
7.41
7.40
7.39
7.39
7.39
7.38
7.37
7.37
7.35
7.33
7.26
7.18
7.18
7.17
7.16
7.16
7.16
7.15
3.73
3.72
3.72
3.71
2.97
2.96
2.44
2.35
2.34
Ts
N
Br
39
2.02
4.43
2.03
1.00
0.98
3.16
0.94
f1 (ppm)
145.00
137.55
134.76
131.53
130.22
129.94
129.55
128.08
125.48
122.76
77.48
77.16
76.84
40.10
36.24
21.77
f1 (ppm)


7.86
7.85
7.84
7.84
7.59
7.58
7.57
7.56
7.35
7.35
7.33
7.33
7.26
3.80
3.79
3.78
3.77
3.02
3.00
2.43
2.35
2.34
Ts
N
NC
40
1.96
1.98
4.00
0.99
1.00
2.99
1.01
f1 (ppm)


145.20
140.64
134.54
132.48
129.99
128.06
127.39
118.50
112.22
77.48
77.16
76.84
39.99
36.54
21.77
f1 (ppm)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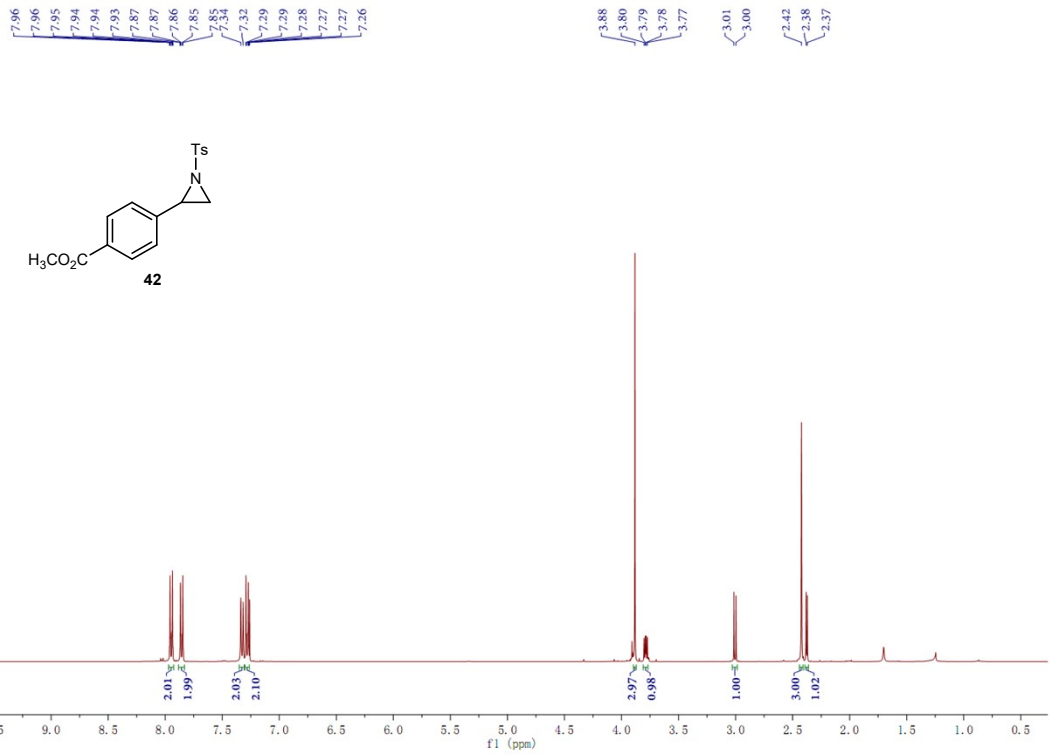
7.85
7.34
7.32
7.26
7.23
7.21
7.02
7.00
3.76
3.75
3.74
2.99
2.97
2.43
2.36
2.35
2.27
Ts
N
H3COCO
41
1.96
2.05
2.07
2.04
0.98
1.00
3.21
1.03
3.16
f1 (ppm)
169.52
150.68
144.90
134.94
132.79
129.93
128.05
127.77
121.91
77.48
77.16
76.84
40.60
36.13
21.77
21.19
f1 (ppm)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7.95
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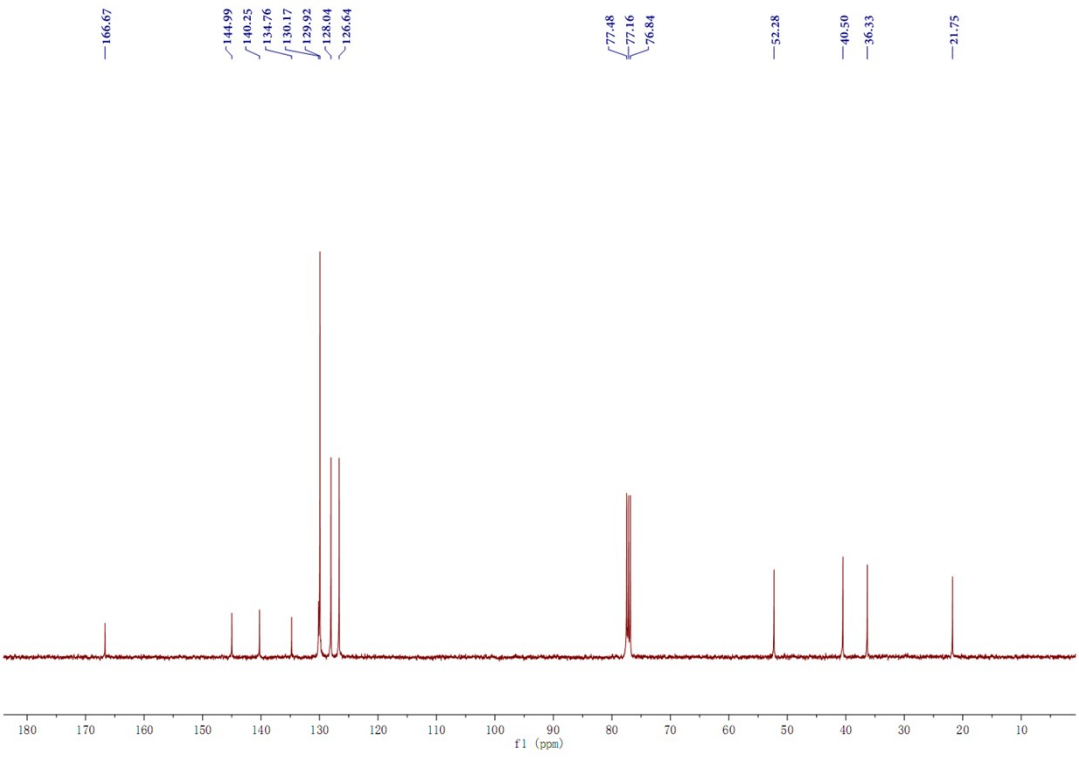
7.94
7.93
7.87
7.87
7.86
7.85
7.85
7.34
7.32
7.29
7.29
7.28
7.27
7.27
7.26
3.88
3.80
3.79
3.78
3.77
3.01
3.00
2.42
2.38
2.37
Ts
N
H3CO2C
42
2.01
1.99
2.03
2.10
2.97
0.98
1.00
3.00
1.02
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
f1 (ppm)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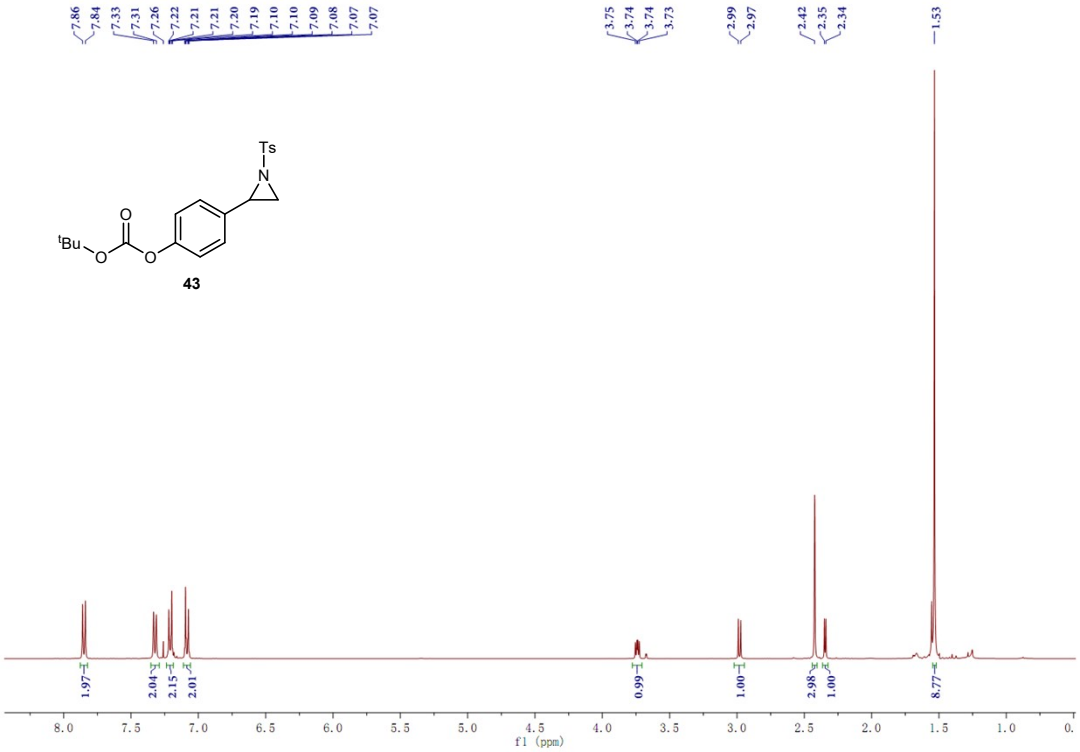
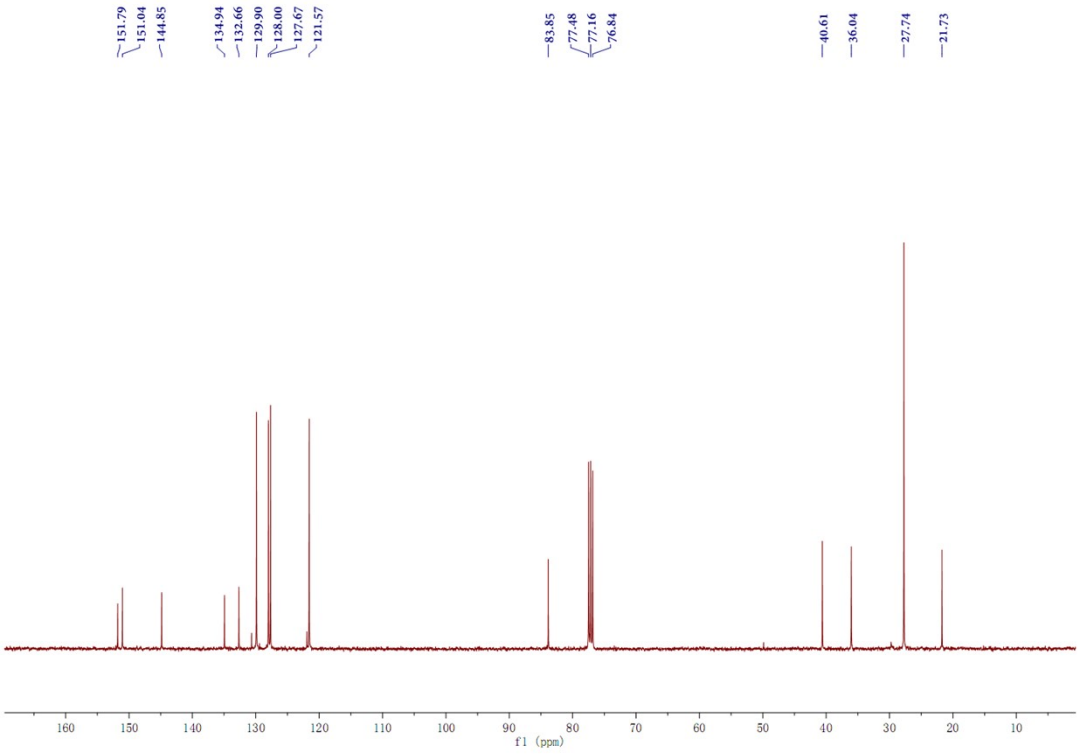
129.92
128.04
126.64
77.48
77.16
76.84
52.28
40.50
36.33
21.75
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)


7.86
7.84
7.33
7.31
7.26
7.22
7.21
7.21
7.20
7.19
7.10
7.10
7.09
7.08
7.07
7.07
3.75
3.74
3.74
3.73
2.99
2.97
2.42
2.35
2.34
1.53
Ts
N
O
O
O
tBu
43
1.97
2.04
2.15
2.01
0.99
1.00
2.98
1.00
8.77
f1 (ppm)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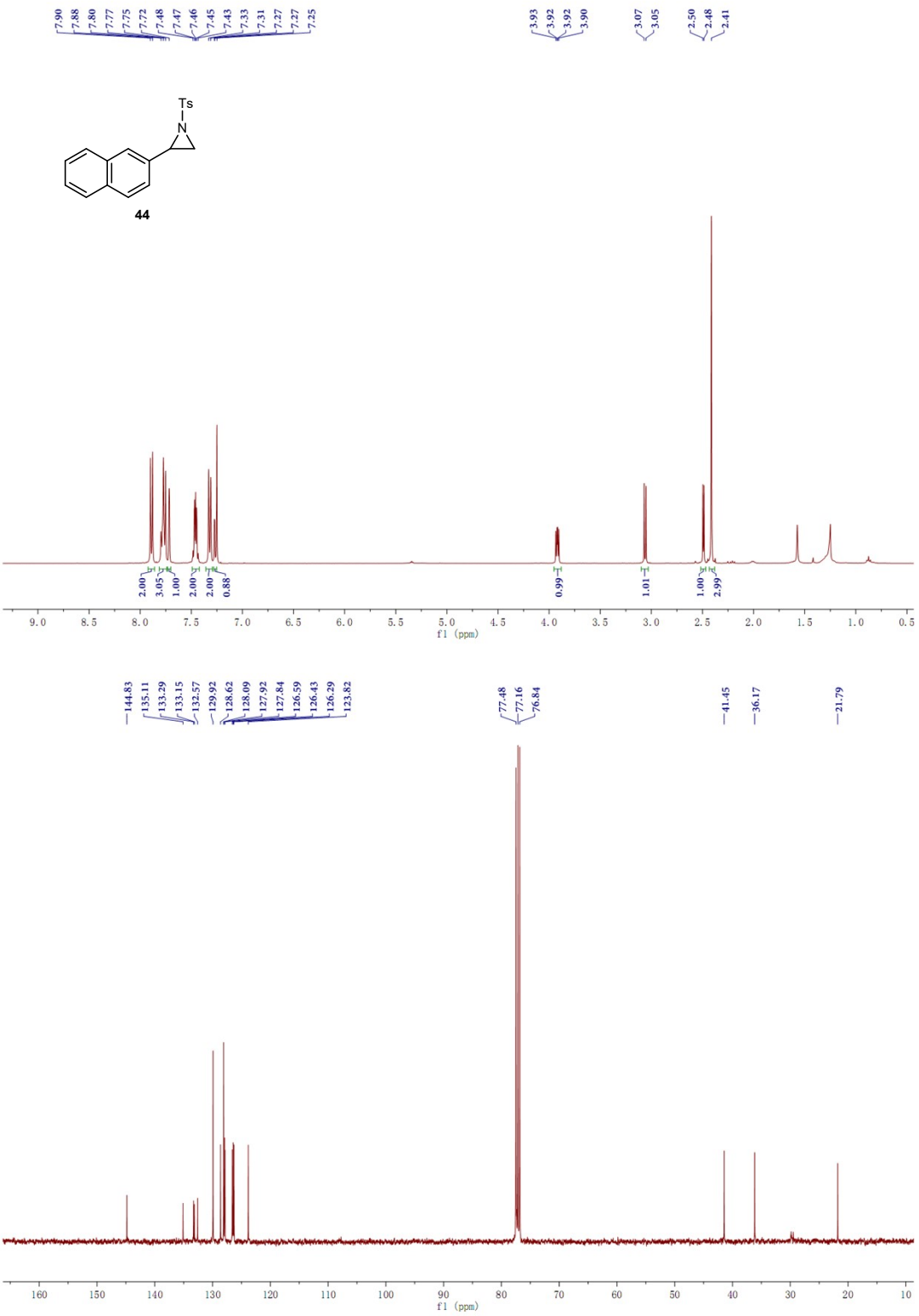
151.04
144.85
134.94
132.66
129.90
128.00
127.67
121.57
83.85
77.48
77.16
76.84
40.61
36.04
27.74
21.73
f1 (ppm)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7.88
7.80
7.77
7.75
7.72
7.48
7.47
7.46
7.45
7.43
7.33
7.31
7.27
7.27
7.25
3.93
3.92
3.92
3.90
3.07
3.05
2.50
2.48
2.41
Ts
N
44
2.00
3.05
1.00
2.00
2.00
0.88
0.99
1.01
1.00
2.99
f1 (ppm)
144.83
135.11
133.29
133.15
132.57
129.92
128.62
128.09
127.92
127.84
126.59
126.43
126.29
123.82
77.48
77.16
76.84
41.45
36.17
21.79
f1 (ppm)


7.96
7.95
7.94
7.94
7.93
7.93
7.91
7.91
7.59
7.58
7.58
7.57
7.55
7.55
7.54
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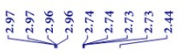
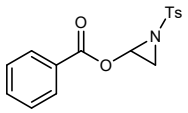
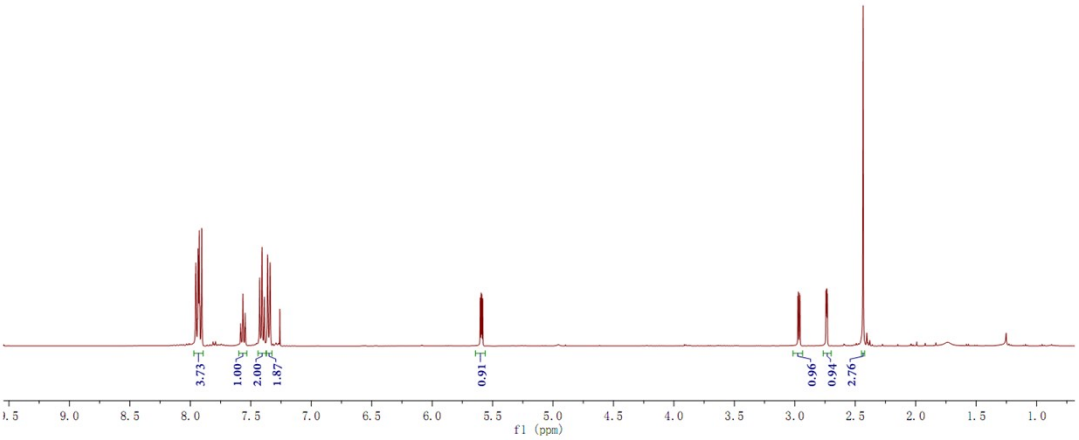
7.39
7.39
7.36
7.34
7.26
5.60
5.59
5.59
5.58


2.97
2.97
2.96
2.96
2.74
2.74
2.73
2.73
2.44


O
O
N
Ts

45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1.00
2.00
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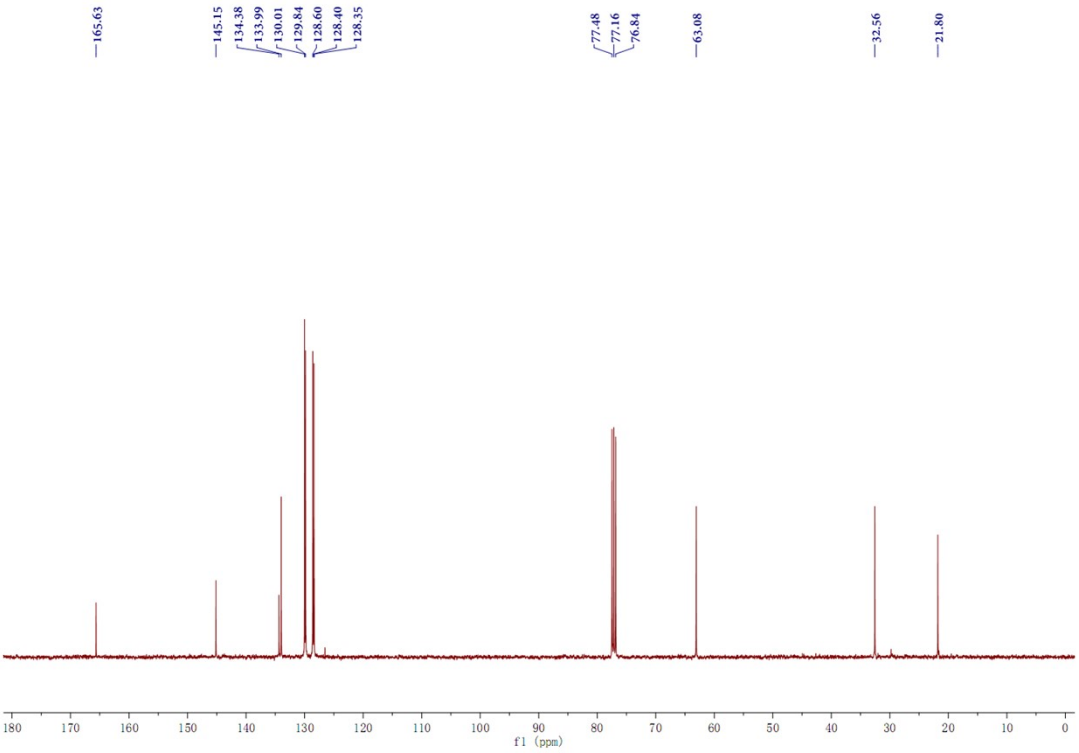
0.91
0.96
0.94
2.76
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
f1 (ppm)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145.15
134.38
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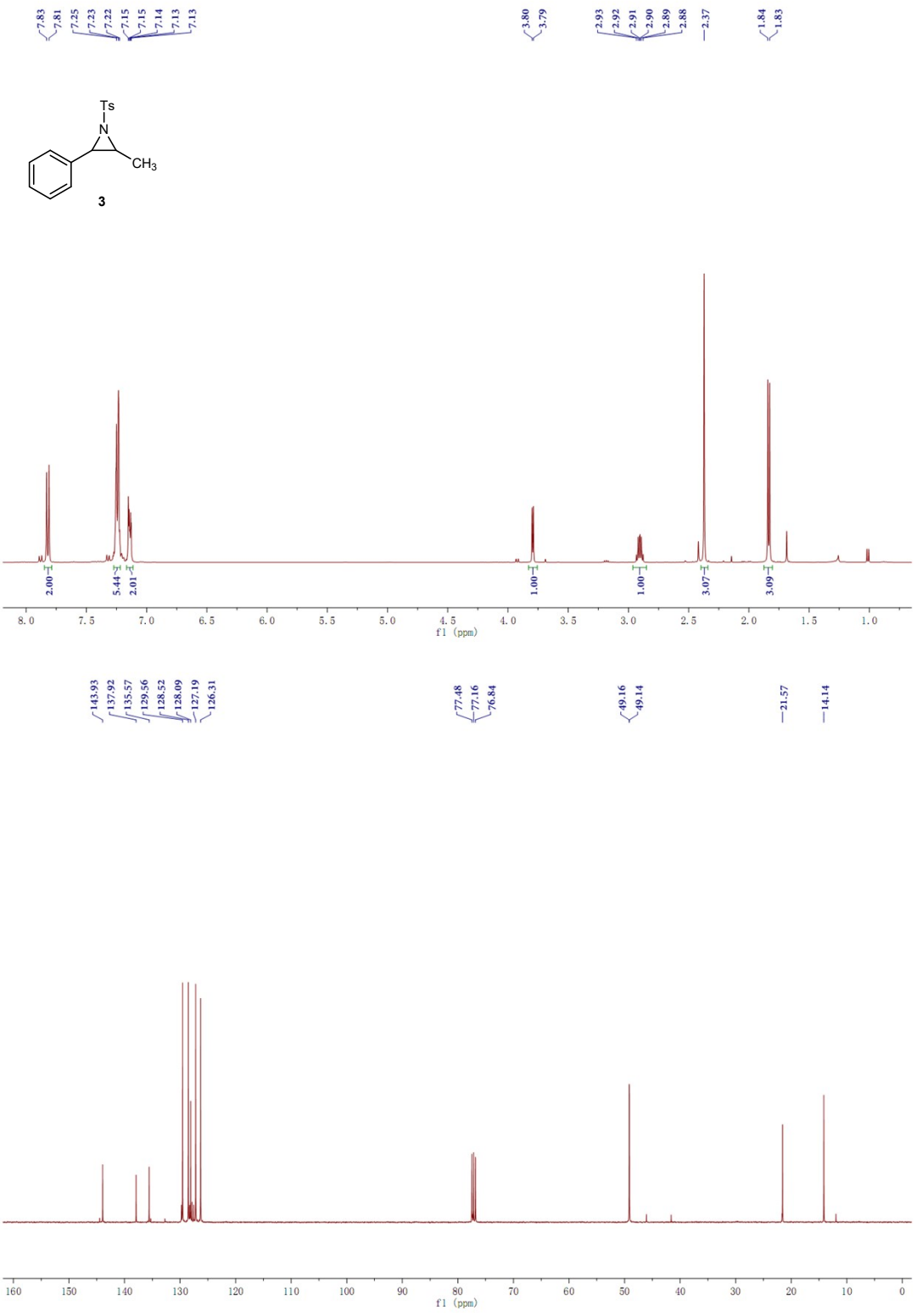
129.84
128.60
128.40
128.35
77.48
77.16
76.84
63.08
32.56
21.80
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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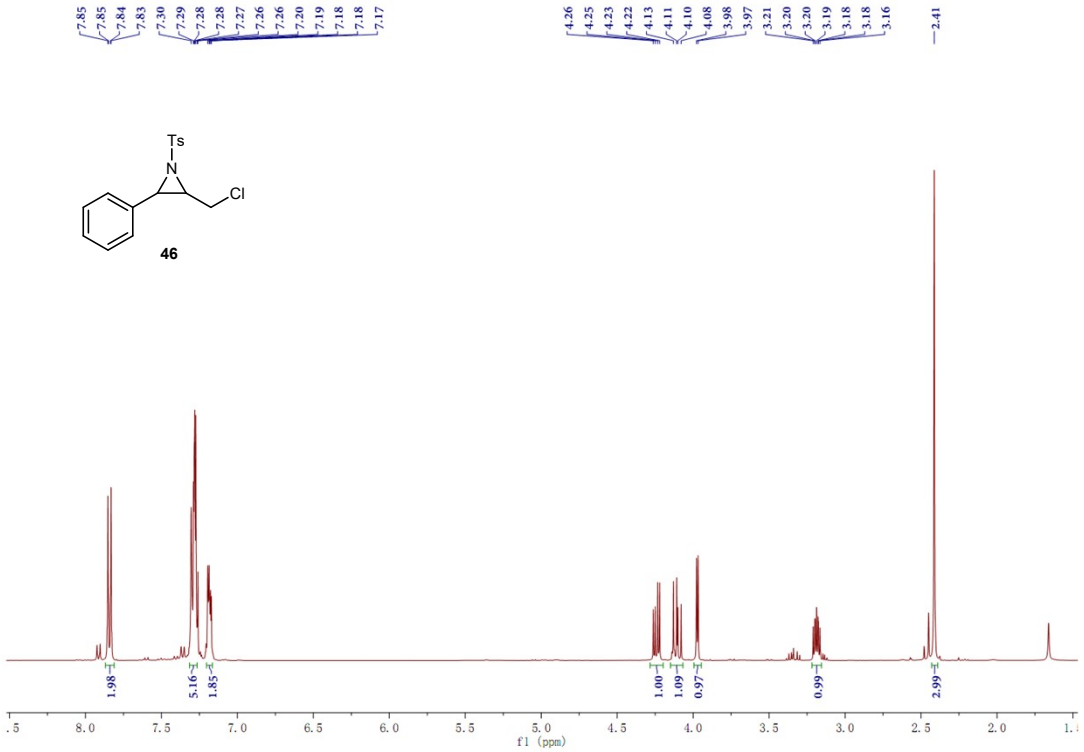
7.81
7.25
7.23
7.22
7.15
7.15
7.14
7.13
7.13
3.80
3.79
2.93
2.92
2.91
2.90
2.89
2.88
2.37
1.84
1.83
Ts
N
CH3
3
2.00
5.44
2.01
1.00
1.00
3.07
3.09
f1 (ppm)
143.93
137.92
135.57
129.56
128.52
128.09
127.19
126.31
77.48
77.16
76.84
49.16
49.14
21.57
14.14
f1 (ppm)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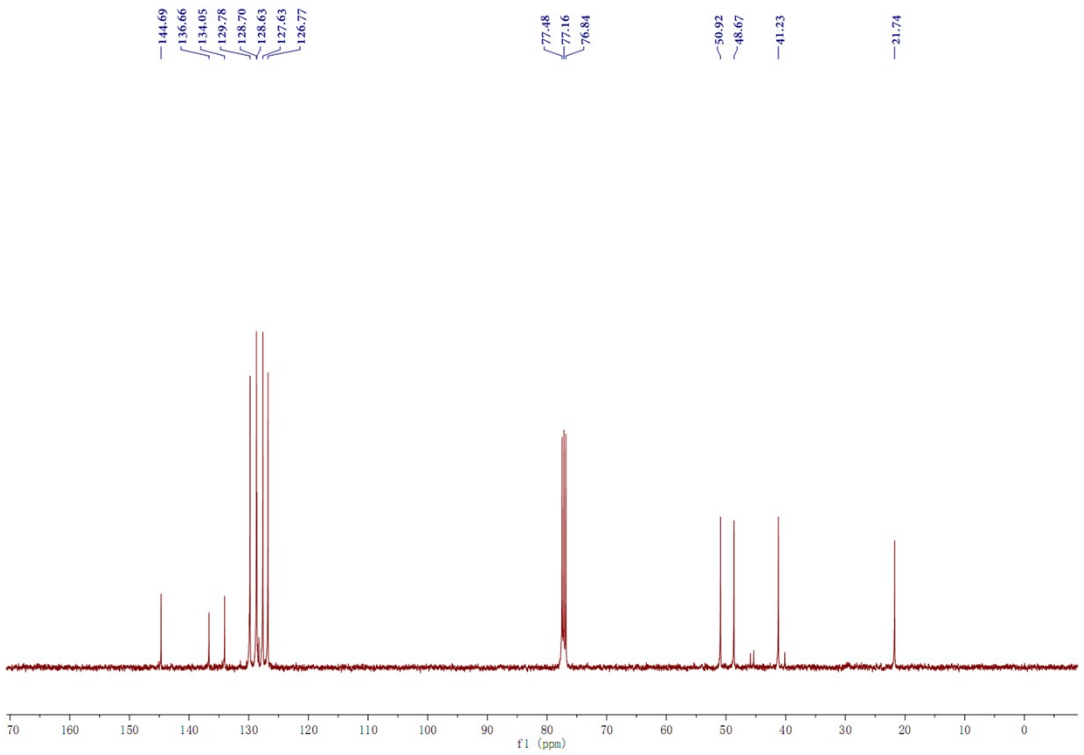
7.85
7.84
7.83
7.30
7.29
7.28
7.28
7.27
7.26
7.26
7.20
7.19
7.18
7.18
7.17
4.26
4.25
4.23
4.22
4.13
4.11
4.10
4.08
3.98
3.97
3.21
3.20
3.20
3.19
3.18
3.18
3.16
2.41
Ts
N
Cl
46
1.98
5.16
1.85
1.00
1.09
0.97
0.99
2.99
f1 (ppm)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128.63
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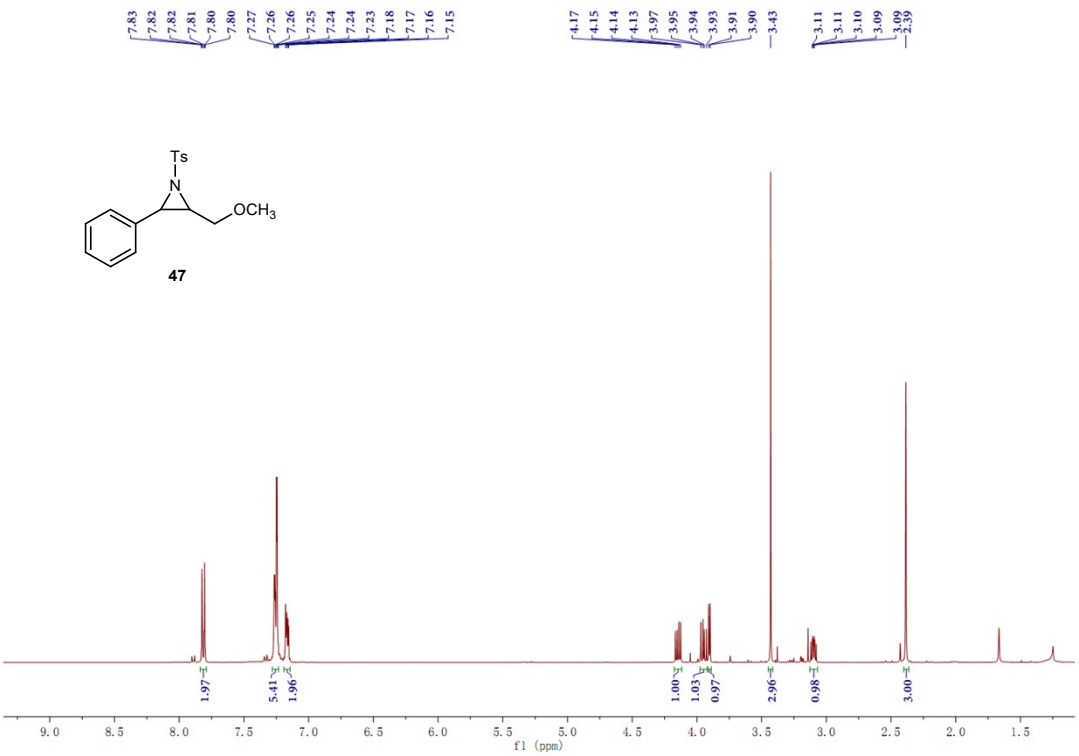
126.77
77.48
77.16
76.84
50.92
48.67
41.23
21.74
f1 (ppm)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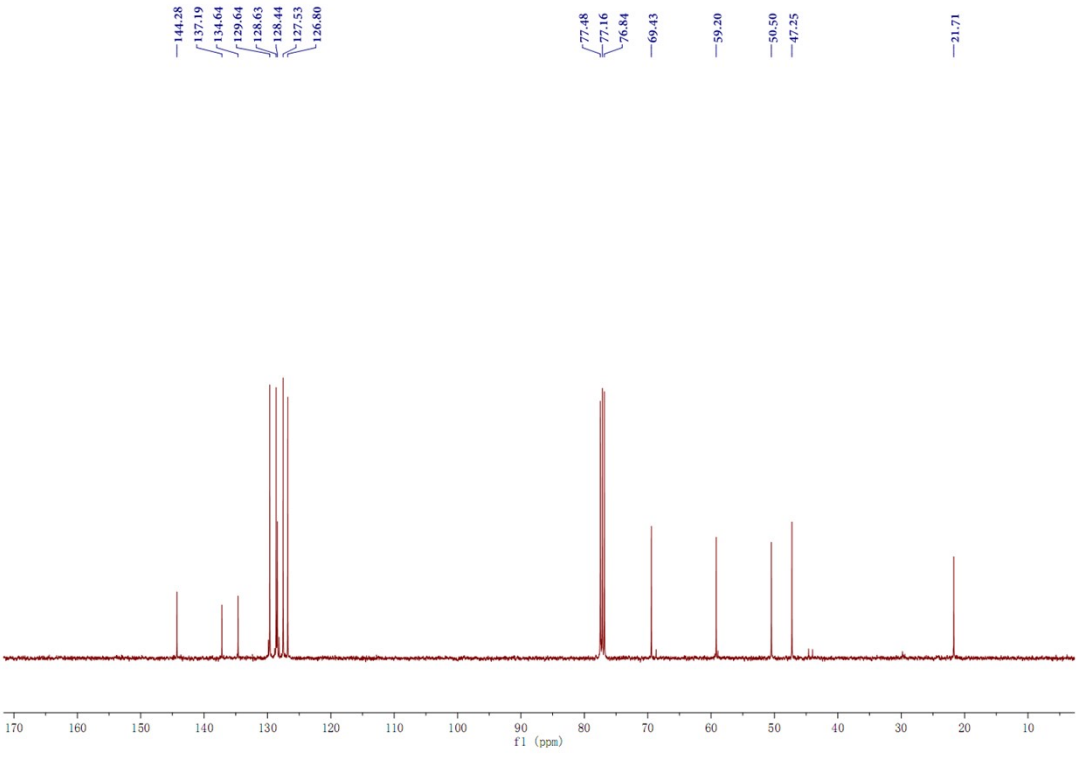
7.82
7.81
7.80
7.80
7.27
7.26
7.26
7.25
7.24
7.24
7.23
7.18
7.17
7.16
7.15
4.17
4.15
4.14
4.13
3.97
3.95
3.94
3.93
3.91
3.90
3.43
3.11
3.11
3.10
3.09
3.09
2.39
Ts
N
OCH3
47
1.97
5.41
1.96
1.00
1.03
0.97
2.96
0.98
3.00
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
f1 (ppm)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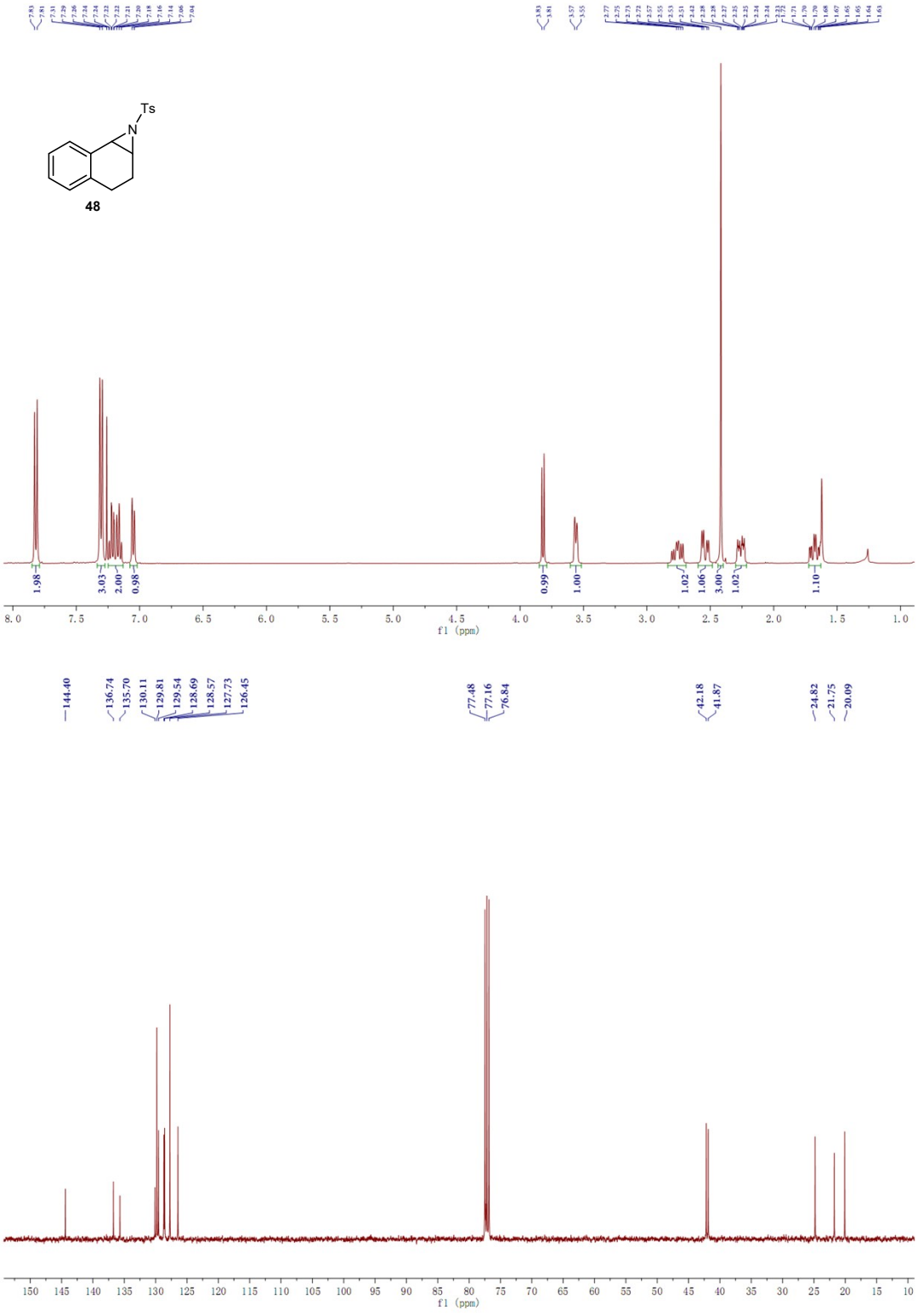
137.19
134.64
129.64
128.63
128.44
127.53
126.80
77.48
77.16
76.84
69.43
59.20
50.50
47.25
21.71
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)


Ts
N
48
1.98
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0.98
0.99
1.00
1.02
1.06
3.00
1.02
1.10
f1 (ppm)
144.40
136.74
135.70
130.11
129.81
129.54
128.69
128.57
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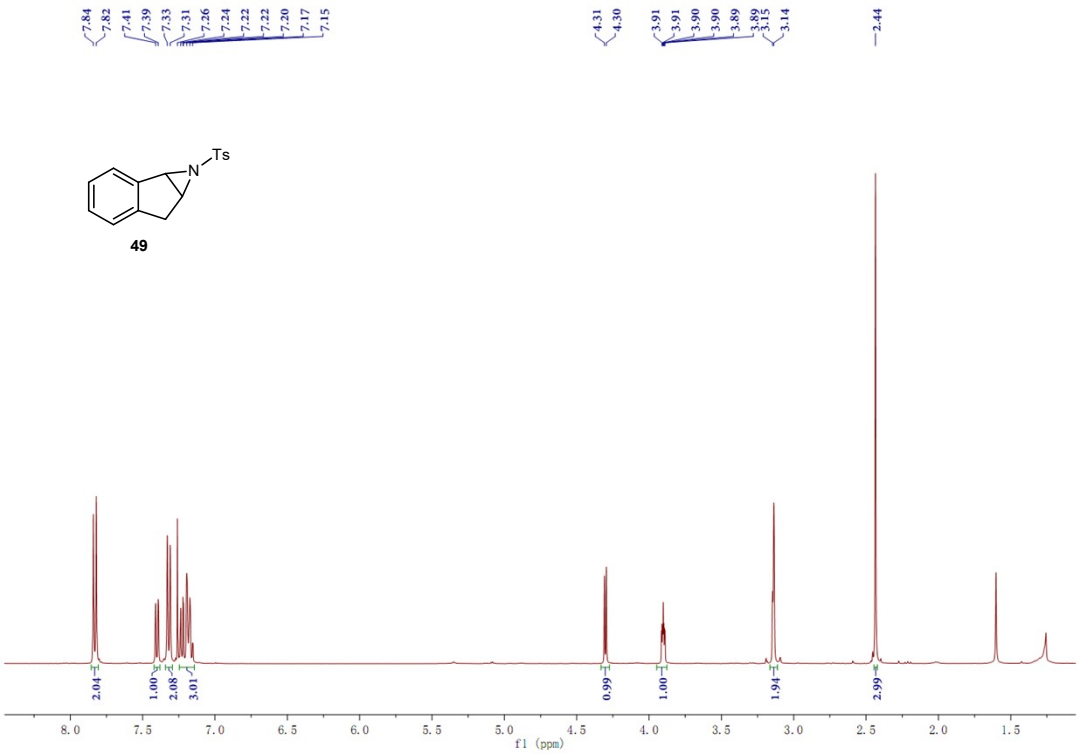
77.48
77.16
76.84
42.18
41.87
24.82
21.75
20.09
f1 (ppm)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7.82
7.41
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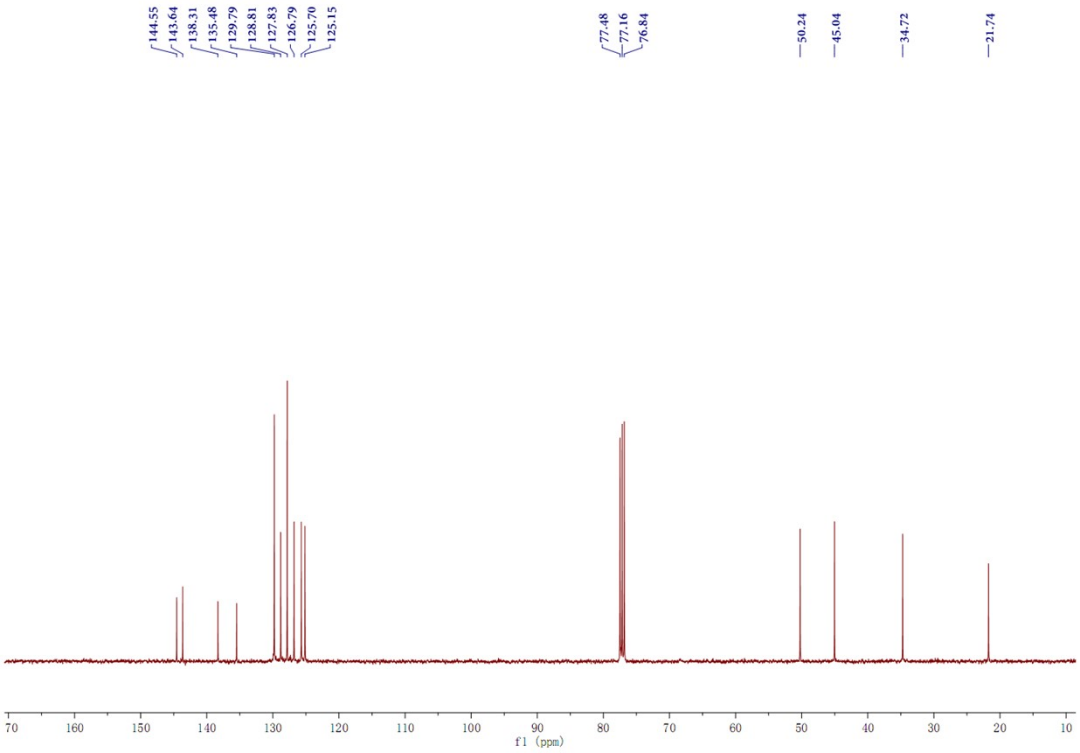
7.26
7.24
7.22
7.22
7.20
7.17
7.15
4.31
4.30
3.91
3.91
3.90
3.90
3.89
3.15
3.14
2.44
Ts
N
2.04
1.00
2.08
3.01
0.99
1.00
1.94
2.99
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
f1 (ppm)

49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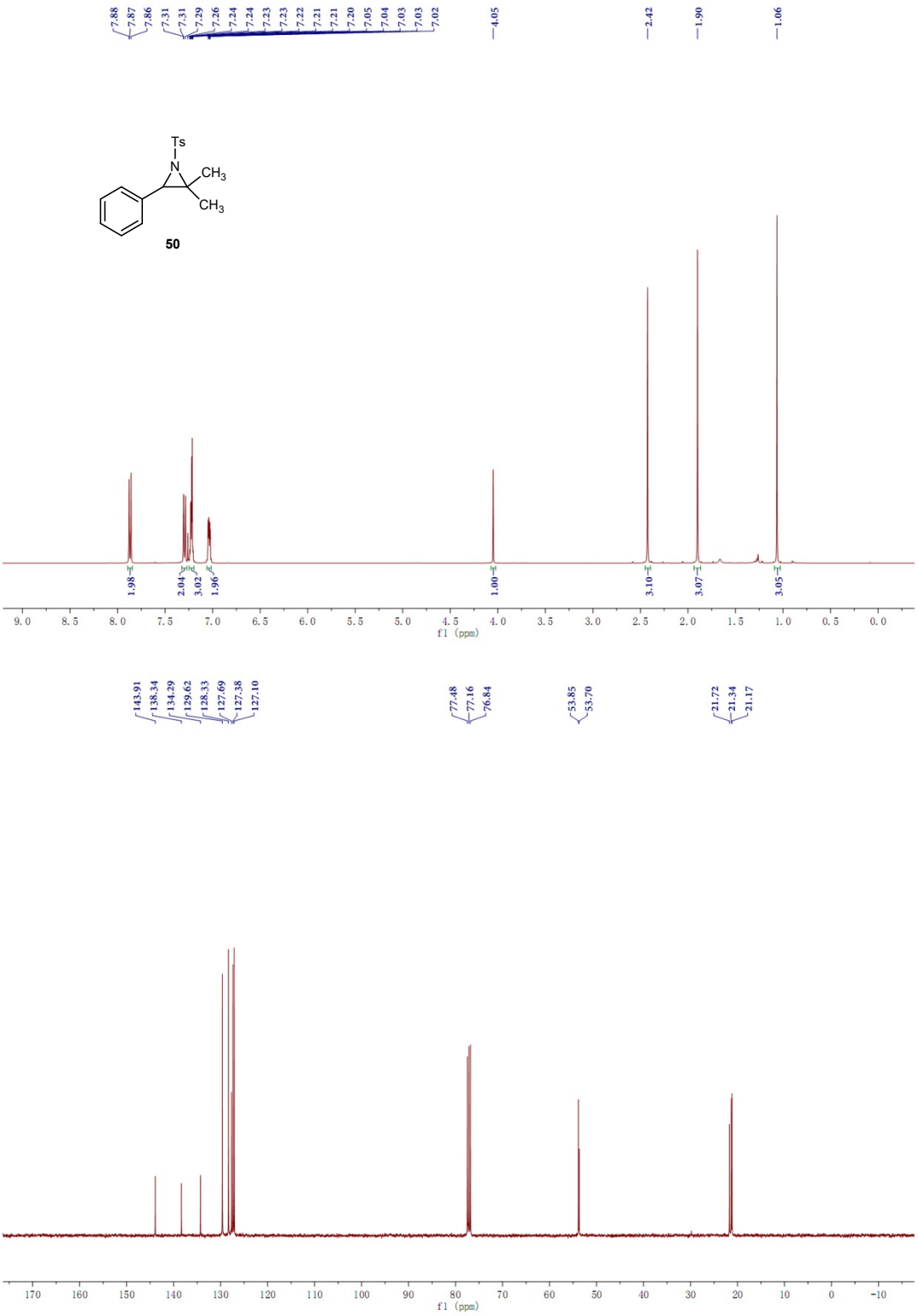
126.79
125.70
125.15
77.48
77.16
76.84
50.24
45.04
34.72
21.74
70
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)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7.86
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7.29
7.26
7.24
7.24
7.23
7.23
7.22
7.21
7.21
7.20
7.05
7.04
7.03
7.03
7.02
4.05
2.42
1.90
1.06
Ts
N
CH3
CH3
50
1.98
2.04
3.02
1.96
1.00
3.10
3.07
3.05
f1 (ppm)
143.91
138.34
134.29
129.62
128.33
127.69
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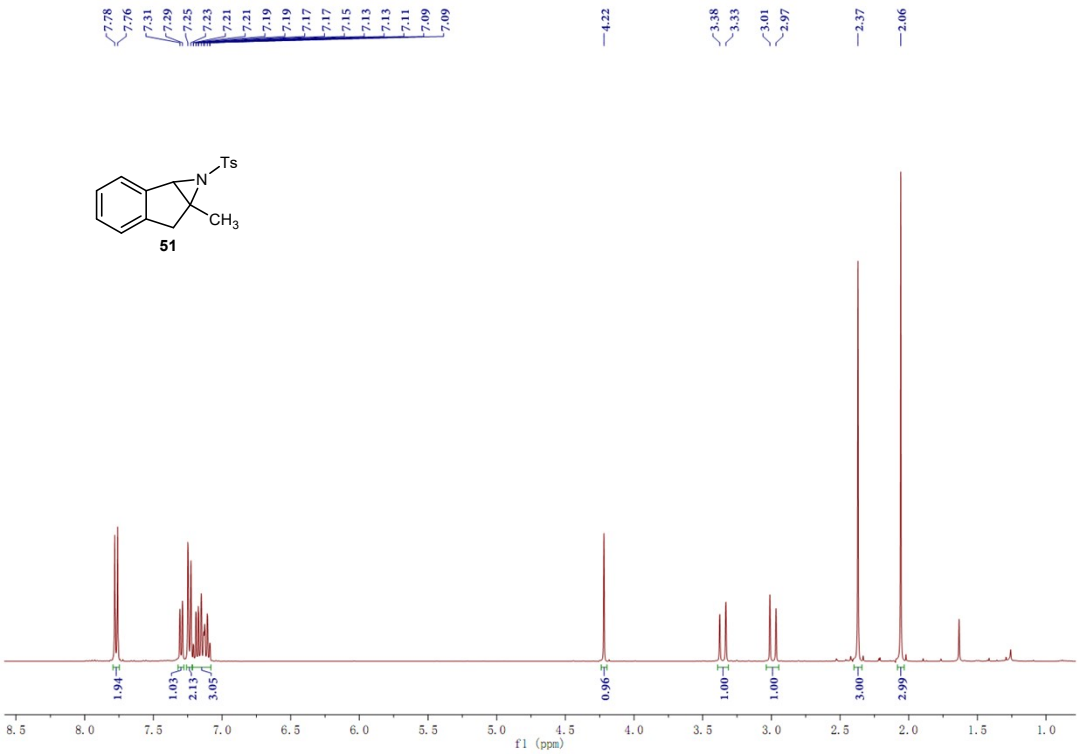
77.16
76.84
53.85
53.70
21.72
21.34
21.17
f1 (ppm)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7.19
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7.17
7.15
7.13
7.13
7.11
7.09
7.09
4.22
3.38
3.33
3.01
2.97
2.37
2.06
Ts
N
CH3
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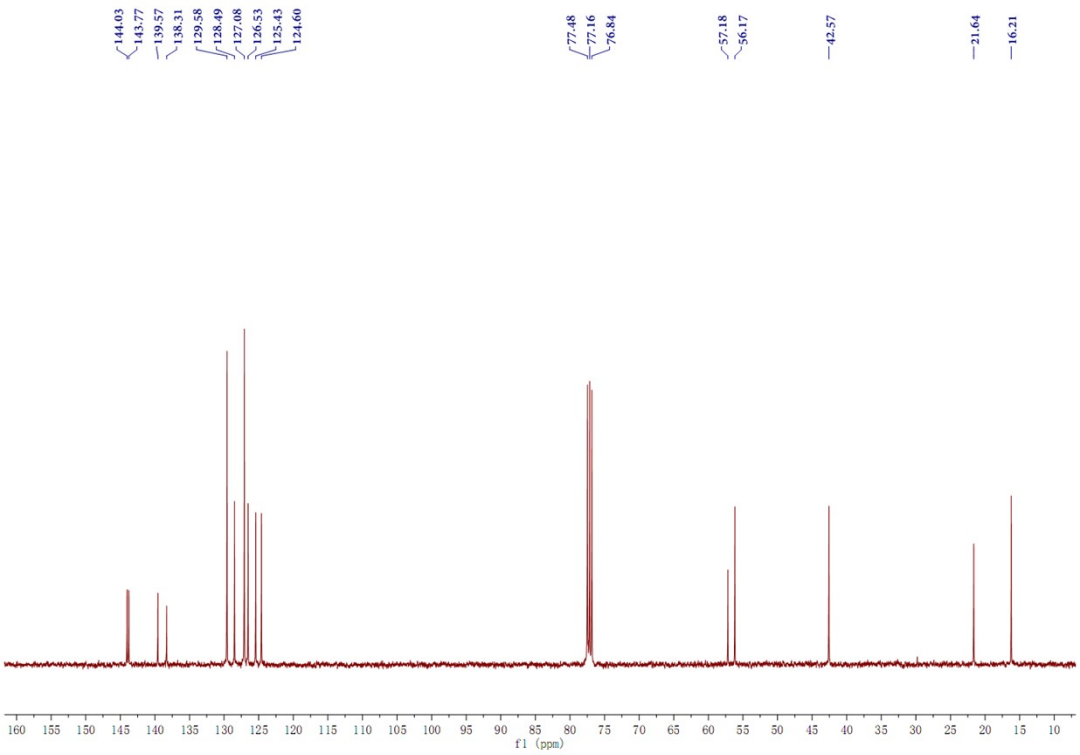
1.03
2.13
3.05
0.96
1.00
1.00
3.00
2.99
f1 (ppm)

51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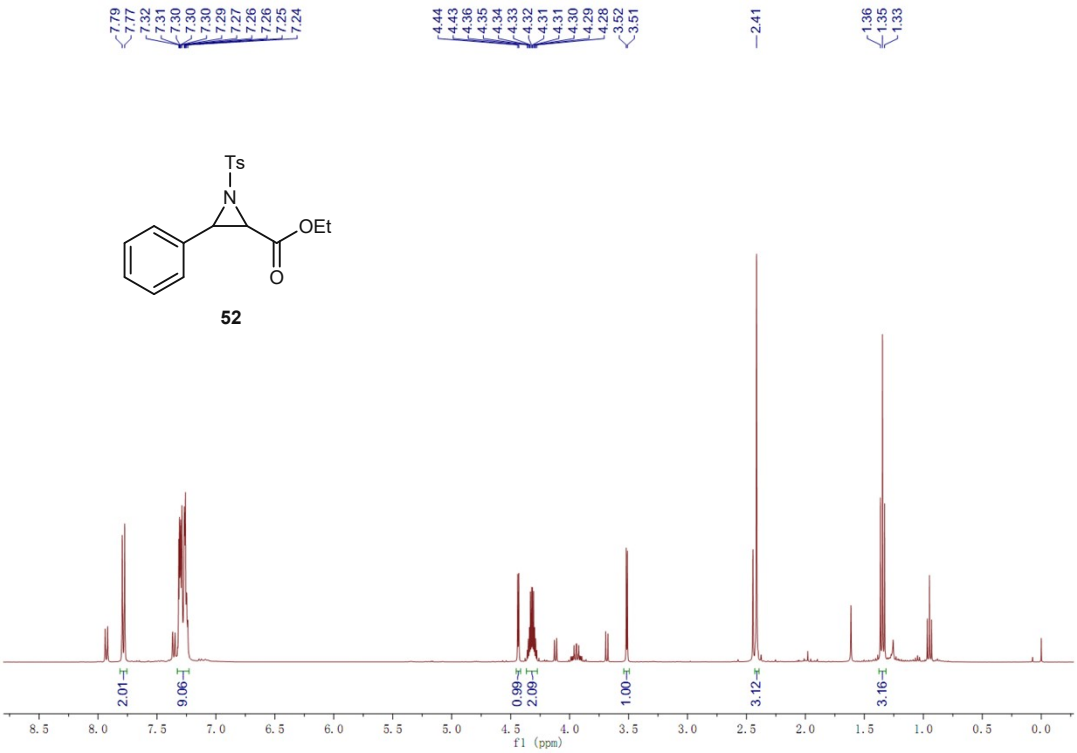
56.17
42.57
21.64
16.21
f1 (ppm)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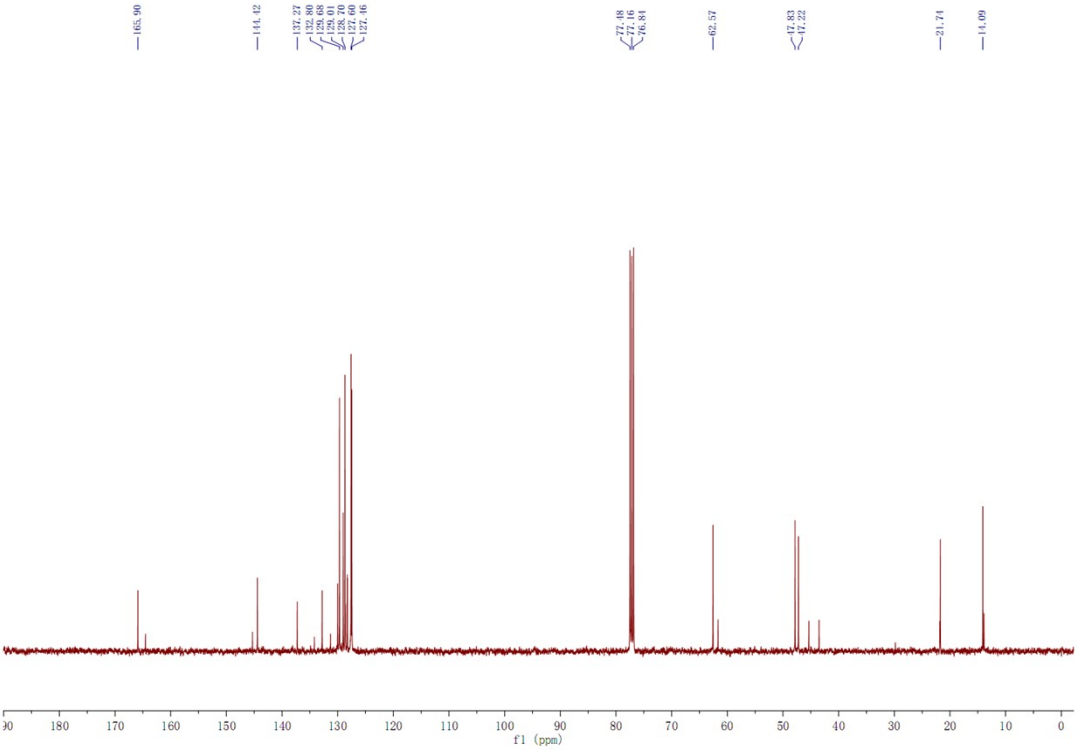
7.26
7.26
7.25
7.24
4.44
4.43
4.36
4.35
4.34
4.33
4.32
4.31
4.31
4.30
4.29
4.28
3.52
3.51
2.41
1.36
1.35
1.33
Ts
N
OEt
O
2.01
9.06
0.99
2.09
1.00
3.12
3.16
f1 (ppm)

52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77.16
76.84
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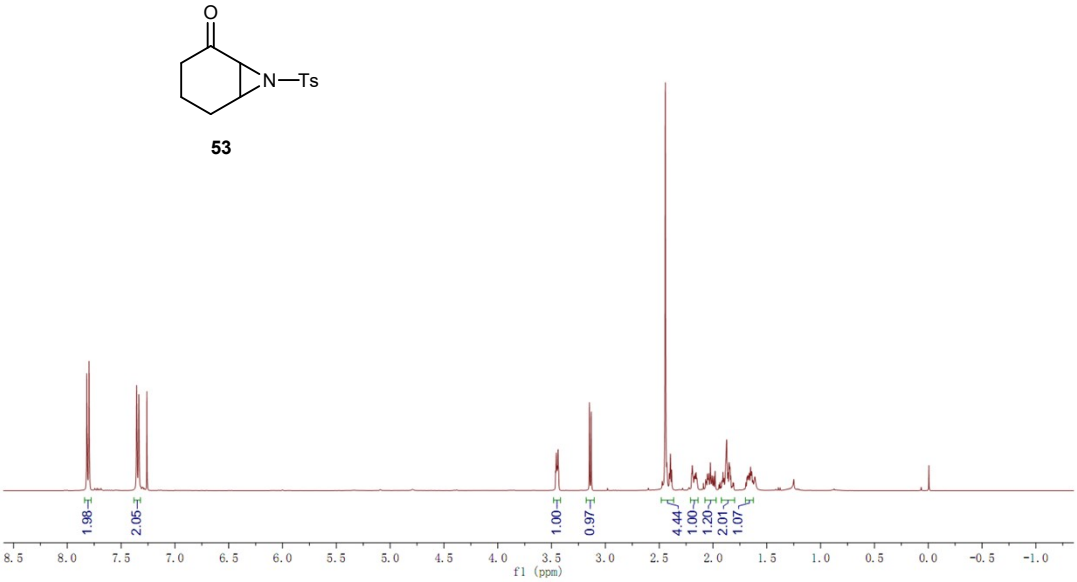
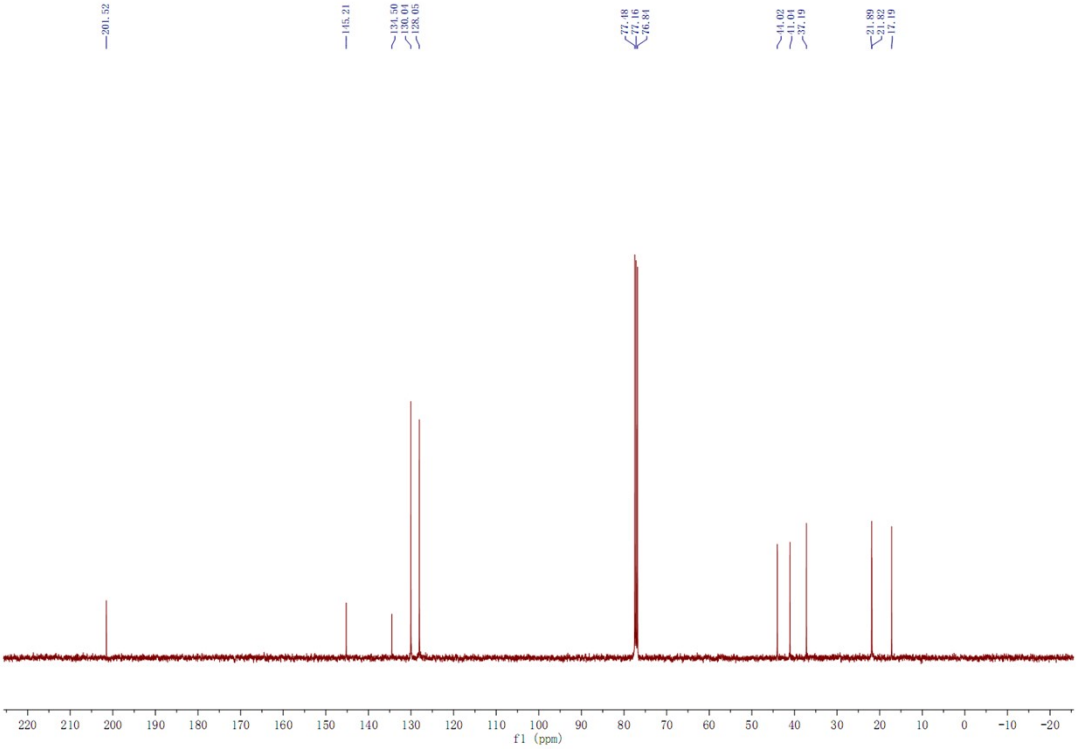
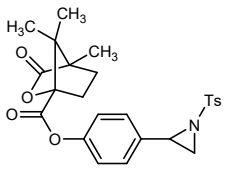
47.83
47.22
21.74
14.09
f1 (ppm)

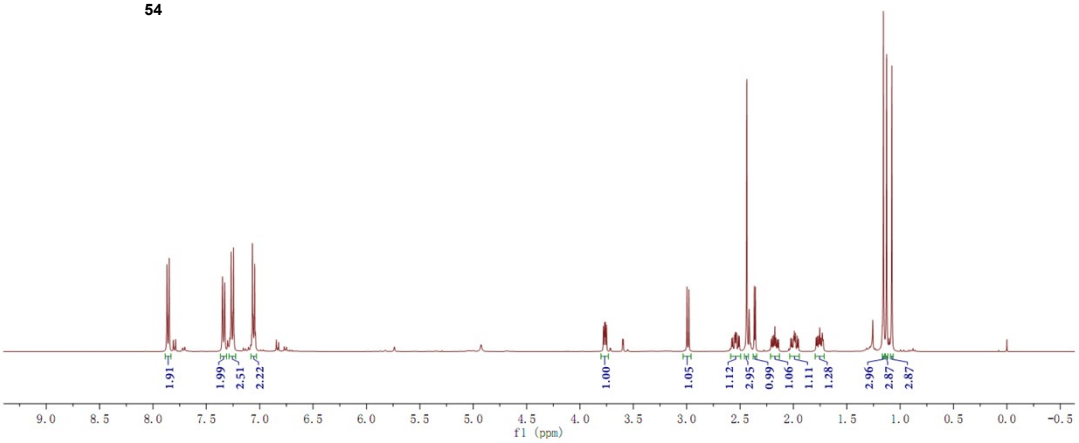


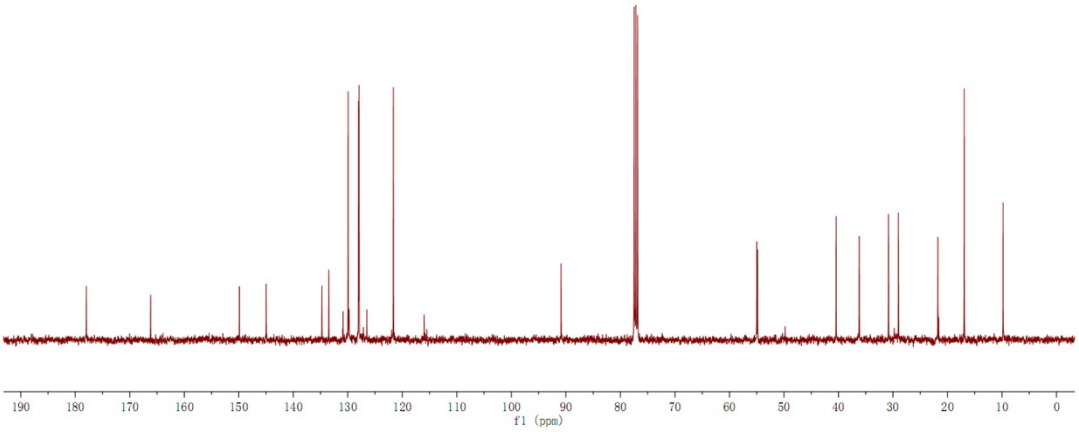
53

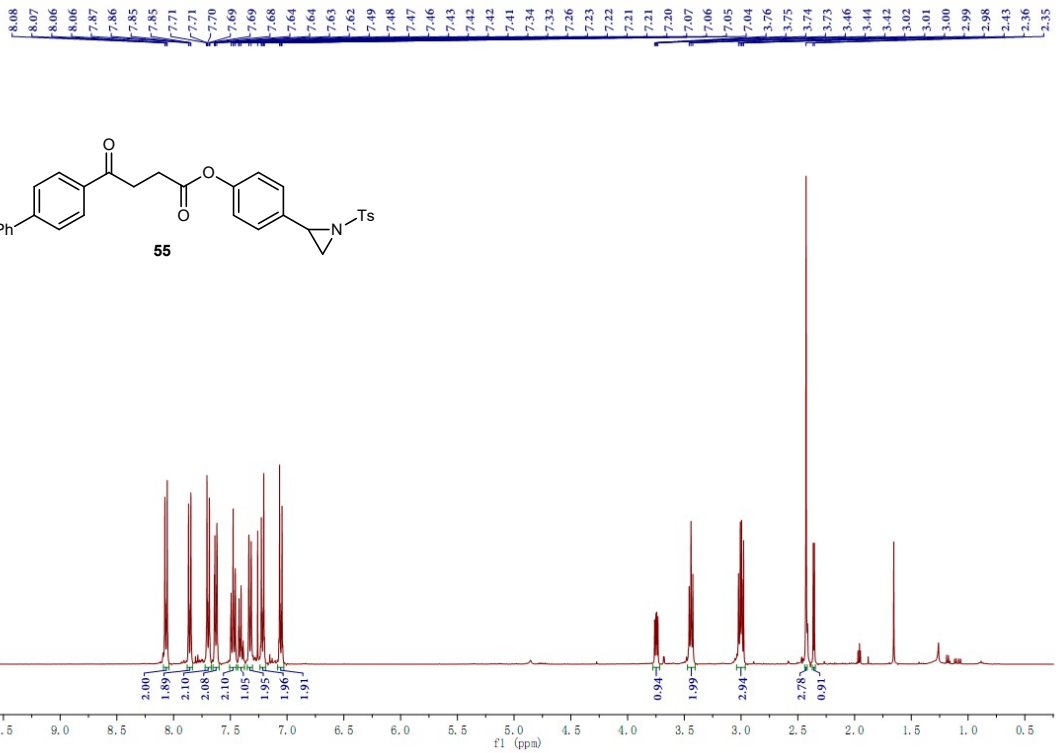




54



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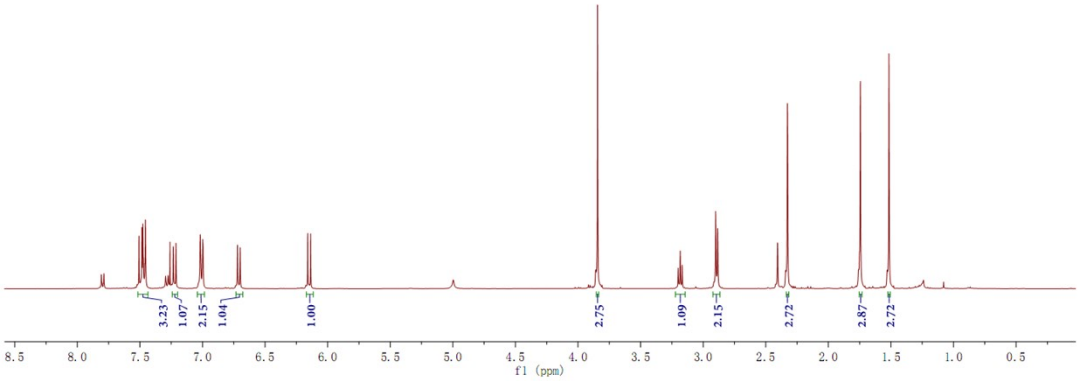
O
O
O
O
Ph
N
Ts
55
2.00 1.89 2.10 2.08 2.10 1.05 1.95 1.96 1.91 0.94 1.99 2.94 2.78 0.91
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
f1 (ppm)
197.51 171.62 150.78 146.14 144.87 139.86 135.17 134.95 132.71 129.92 129.08 128.76 128.41 128.03 127.73 127.40 127.37 121.92 77.48 77.16 76.84 40.69 36.08 33.53 28.57 21.76
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


7.51
7.48
7.48
7.47
7.46
7.46
7.26
7.23
7.21
7.02
7.00
6.72
6.70
6.16
6.14
3.84
3.20
3.18
3.17
2.90
2.88
2.33
1.74
1.52

H3C
CH3
N—Ts
O
O
O
CH3

56


3.23
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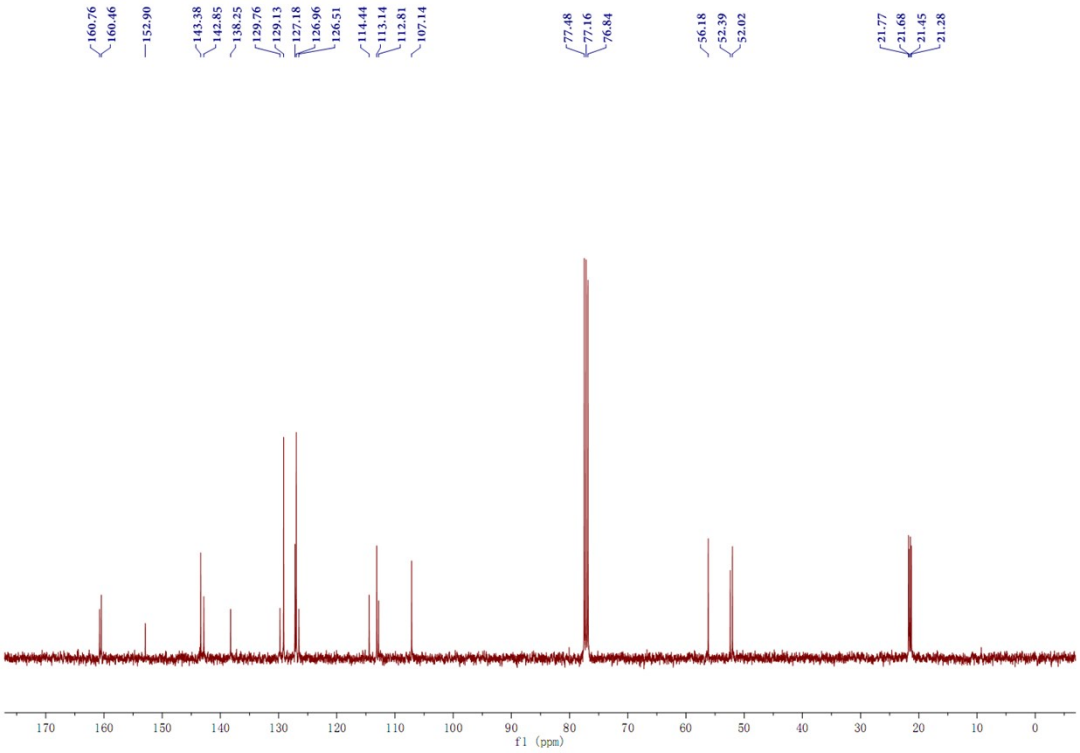
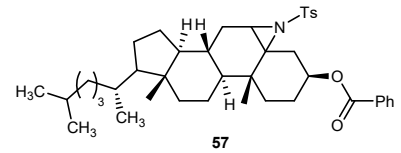
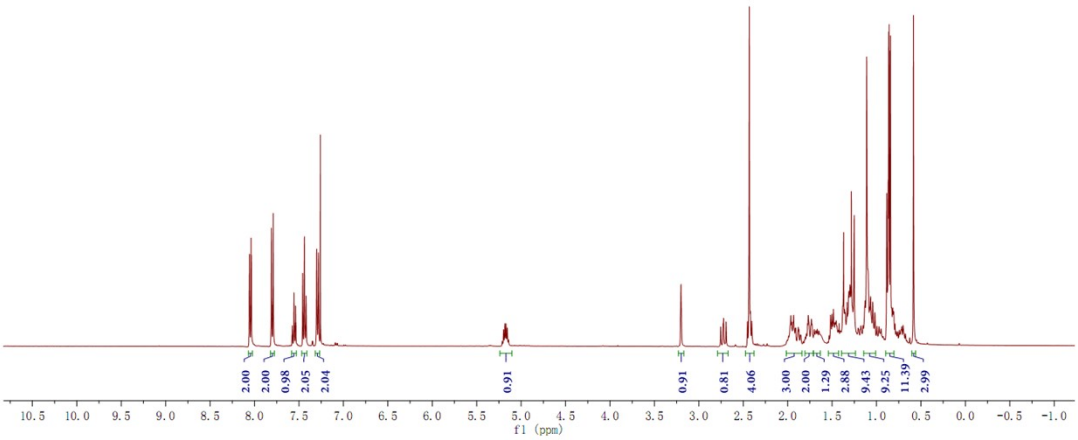
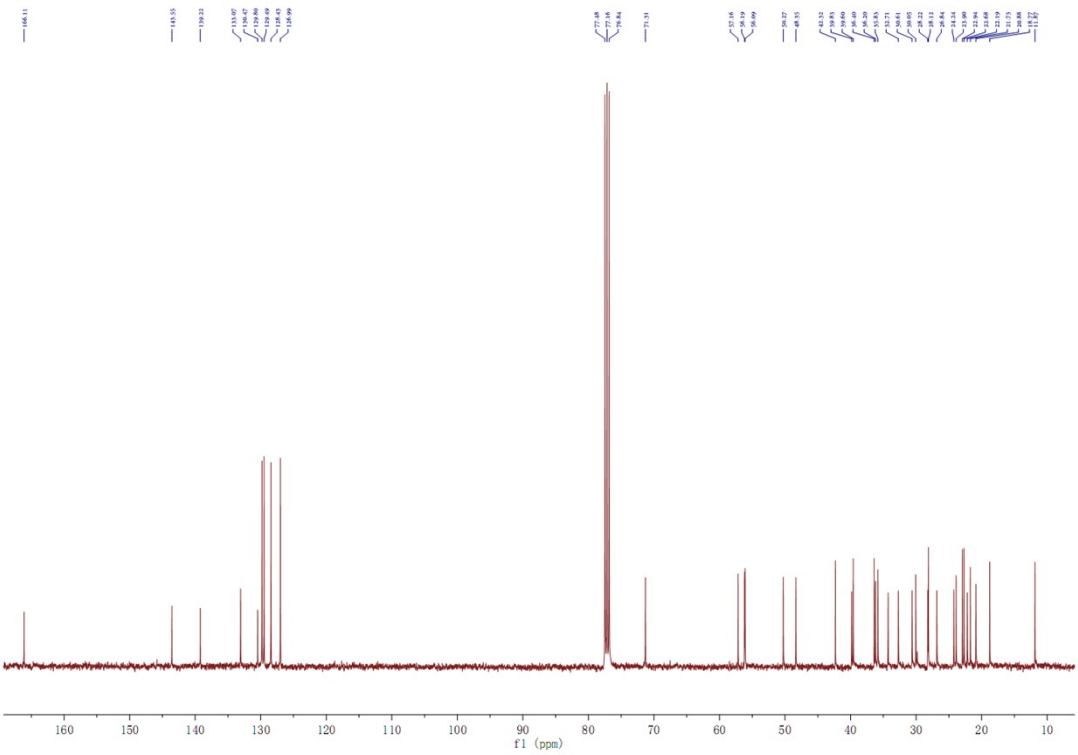
2.15
1.04
1.00
2.75
1.09
2.15
2.72
2.87
2.72
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
f1 (ppm)

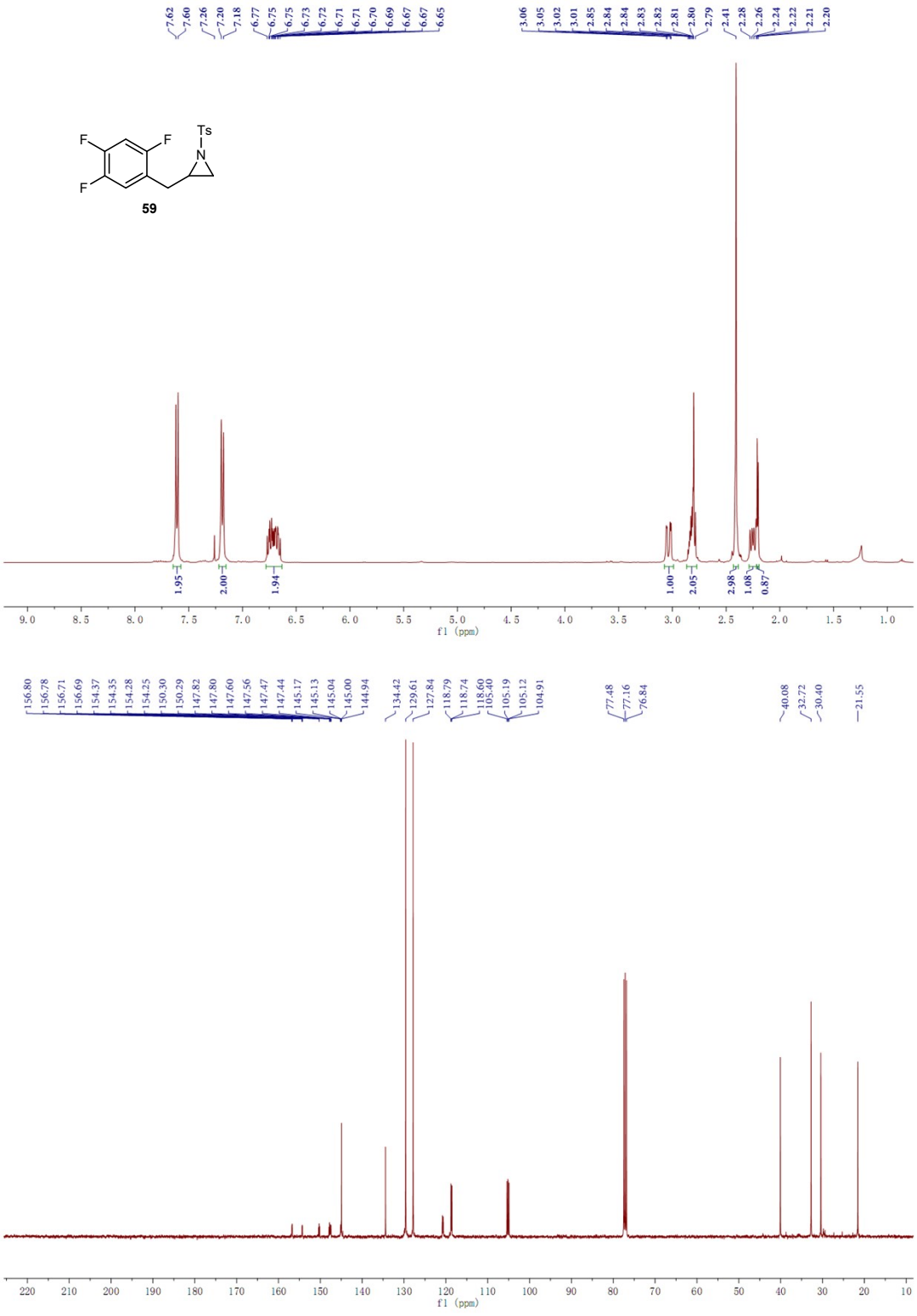

160.76
160.46
152.90
143.38
142.85
138.25
129.76
129.13
127.18
126.96
126.51
114.44
113.14
112.81
107.14
77.48
77.16
76.84
56.18
52.39
52.02
21.77
21.68
21.45
21.28
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


HH
N
Ts
H3C
3
CH3
CH3
H
O
O
Ph

57


2.00
2.00
0.98
2.05
2.04
0.91
0.91
0.81
4.06
3.00
2.00
1.29
2.88
9.43
9.25
11.39
2.99
f1 (ppm)


f1 (ppm)


7.62
7.60
7.26
7.20
7.18
6.77
6.75
6.75
6.73
6.72
6.71
6.71
6.70
6.69
6.67
6.67
6.65
3.06
3.05
3.02
3.01
2.85
2.84
2.84
2.83
2.82
2.81
2.80
2.79
2.41
2.28
2.26
2.24
2.22
2.21
2.20
F
F
F
Ts
N
59
1.95
2.00
1.94
1.00
2.05
2.98
1.08
0.87
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
f1 (ppm)
156.80
156.78
156.71
156.69
154.37
154.35
154.28
154.25
150.30
150.29
147.82
147.80
147.60
147.56
147.47
147.44
145.17
145.13
145.04
145.00
144.94
134.42
129.61
127.84
118.79
118.74
118.60
105.40
105.19
105.12
104.91
77.48
77.16
76.84
40.08
32.72
30.40
21.55
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)