# Brønsted Acid-Promoted Hydroamination of Unsaturated Hydrazones via an Ionic Pathway: Access to Biologically Important 5-Arylpyrazolines

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**Supporting Information**

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**General information.** All commercially available reagents were used without further purification. Column chromatography was performed on silica gel (200-300 mesh). $^{1}H$ NMR (400 MHz) and $^{13}C$ NMR (100 MHz) spectra were recorded on a 400 MHz spectrometer. Chemical shifts ($\delta$) were reported in ppm, and coupling constants ($J$) were given in Hertz (Hz). Data were reported as s = singlet, d = doublet, t = triplet, q = quartet, dd = doublet of doublets, m = multiplet. High-resolution mass spectra (HRMS) were recorded on an AB SCIEX Triple TOF 5600+ mass spectrometer. Melting points were uncorrected. Alkenyl hydrazone substrates **1a**–**1ac** were prepared according to the reported methods.[1-4]

**General procedure for the hydroamination reaction (Scheme 2).** To a reaction tube equipped with a magnetic stir bar were added alkenyl hydrazone **1** (0.20 mmol), conc. $H_2SO_4$ (11 μL, 0.20 mmol), and $CH_3CN$ (2.0 mL). The reaction mixture was stirred at 50 $^{o}$C under nitrogen atmosphere for 12 h, cooled to room temperature, and concentrated under reduced pressure. The residue was purified by column chromatography on silica gel (eluent: petroleum ether/ethyl acetate = 10:1) to give product **2**.

**Mechanistic studies**

**The experiment of the addition of radical scavenger BHT (Scheme 3a).** To a reaction tube equipped with a magnetic stir bar were added alkenyl hydrazone **1a** (78.1 mg, 0.20 mmol), conc. $H_2SO_4$ (11 μL, 0.20 mmol), BHT (121.2 mg, 0.60 mmol), and $CH_3CN$ (2.0 mL). The reaction mixture was stirred at 50 $^{o}$C under nitrogen atmosphere for 12 h, cooled to room temperature, and concentrated under reduced pressure. The residue was purified by column chromatography on silica gel (eluent: petroleum ether/ethyl acetate = 10:1) to give product **2a** (71.5 mg, 92%) as a white solid. The addition of a radical scavenger did not inhibit the reaction, still generating product **2a** in 92% yield, which indicated a radical pathway might not be involved in the reaction process.

**Procedure for the preparation of intermediates *Z*-3 and *E*-3 from 1a (Scheme 3b).**

To a reaction tube equipped with a magnetic stir bar were added alkenyl hydrazone **1a** (781.2 mg, 2.0 mmol), conc. $H_2SO_4$ (110 μL, 2.0 mmol), and $CH_3CN$ (20.0 mL). The reaction mixture was stirred at 50 $^oC$ under nitrogen atmosphere for a much shorter reaction time (0.5 h). Thin-layer chromatography (TLC) analysis indicated that substrate **1a** was completely consumed, and pyrazoline **2a** was not observed. The crude reaction mixture was concentrated under reduced pressure. The residue was purified by column chromatography on silica gel (eluent: petroleum ether/ethyl acetate = 20:1 ~ 10:1) to afford intermediate product *Z*-**3** (228.6 mg, 29%, white solid) and *E*-**3** (443.2 mg, 57%, white solid).

**Procedure for the preparation of pyrazoline product 2a from intermediate *Z*-3 (Scheme 3c).**

To a reaction tube equipped with a magnetic stir bar were added *Z*-**3** (78.1 mg, 0.20 mmol), conc. $H_2SO_4$ (11 μL, 0.20 mmol), and $CH_3CN$ (2.0 mL). The reaction mixture was stirred at 50 $^oC$ under nitrogen atmosphere for 12 h, cooled to room temperature, and concentrated under reduced pressure. The residue was purified by column chromatography on silica gel (eluent: petroleum ether/ethyl acetate = 10:1) to give product **2a** (70.1 mg, 90%) as a white solid.

**Procedure for the preparation of pyrazoline product 2a from intermediate *E*-3 (Scheme 3c).**

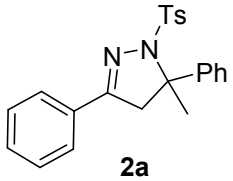
To a reaction tube equipped with a magnetic stir bar were added *E*-**3** (78.1 mg, 0.20 mmol), $H_2SO_4$ (11 μL, 0.20 mmol), and $CH_3CN$ (2.0 mL). The reaction mixture was stirred at 50 $^oC$ under nitrogen atmosphere for 12 h, cooled to room temperature, and concentrated under reduced pressure. The residue was purified by column chromatography on silica gel (eluent: petroleum ether/ethyl acetate = 10:1) to provide product **2a** (65.3 mg, 84%) as a white solid.

**The investigation of the formation of pyrazoline product 2a from the intermediate *Z*-3 or *E*-3 in the absence of $H_2SO_4$ (Scheme 3d).**

To a reaction tube equipped with a magnetic stir bar were added *Z*-**3** or *E*-**3** (78.1 mg, 0.20 mmol) and $CH_3CN$ (2.0 mL). The reaction mixture was stirred at 50 °C under nitrogen atmosphere for 12 h and cooled to room temperature. Thin-layer chromatography (TLC) analysis indicated that the intermediate *Z*-**3** or *E*-**3** kept intact, and the formation of product **2a** was not observed. The results suggest that the Brønsted acid plays an important role in the formation of the pyrazoline product from the intermediate.

**Characterization data**

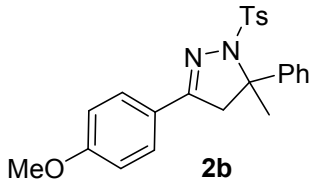
**5-methyl-3,5-diphenyl-1-tosyl-4,5-dihydro-1*H*-pyrazole (2a)**




**2a**

White solid (73.7 mg, 94%); mp 81–83 °C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.75 – 7.66 (m, 2H) 7.58 (d, $J$ = 8.2 Hz, 2H), 7.45 – 7.38 (m, 3H), 7.36 – 7.30 (m, 2H), 7.27 – 7.19 (m, 3H), 7.14 (d, $J$ = 8.1 Hz, 2H), 3.50 (d, $J$ = 17.2 Hz, 1H), 3.37 (d, $J$ = 17.2 Hz, 1H), 2.37 (s, 3H), 2.03 (s, 3H); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 152.5, 143.4, 143.0, 136.9, 131.1, 130.1, 129.0, 128.6, 128.2, 127.60, 127.55, 126.5, 125.8, 71.8, 52.8, 25.2, 21.5; HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{23}H_{23}N_2O_2S$ 391.1475, found 391.1478.

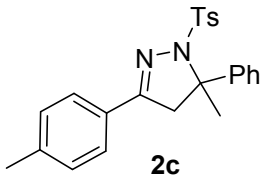
**3-(4-methoxyphenyl)-5-methyl-5-phenyl-1-tosyl-4,5-dihydro-1*H*-pyrazole (2b)**




**2b**

White solid (71.1 mg, 85%); mp 109–110 °C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.64 (d, $J$ = 8.8 Hz, 2H), 7.57 (d, $J$ = 8.2 Hz, 2H), 7.33 (dd, $J$ = 7.6, 2.1 Hz, 2H), 7.25 – 7.18 (m, 3H), 7.13 (d, $J$ = 8.2 Hz, 2H), 6.92 (d, $J$ = 8.8 Hz, 2H), 3.84 (s, 3H), 3.46 (d, $J$ = 17.1 Hz, 1H), 3.34 (d, $J$ = 17.1 Hz, 1H), 2.36 (s, 3H), 2.01 (s, 3H); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 161.1, 152.3, 143.5, 142.9, 136.9, 128.9, 128.2, 128.1, 127.6, 127.5, 125.8, 123.8, 114.0, 71.6, 55.4, 53.0, 25.2, 21.5; HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{24}H_{25}N_2O_3S$ 421.1580, found 421.1582.

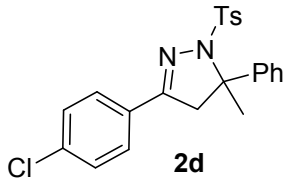
**5-methyl-5-phenyl-3-(*p*-tolyl)-1-tosyl-4,5-dihydro-1*H*-pyrazole (2c)**




**2c**

White solid (70.1 mg, 87%); mp 146–147 °C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.60 (d, $J$ = 8.2 Hz, 2H), 7.57 (d, $J$ = 8.3 Hz, 2H), 7.32 (dd, $J$ = 7.7, 1.8 Hz, 2H), 7.25 – 7.18 (m, 5H), 7.12 (d, $J$ = 8.1 Hz, 2H), 3.48 (d, $J$ = 17.2 Hz, 1H), 3.35 (d, $J$ = 17.2 Hz, 1H), 2.39 (s, 3H), 2.36 (s, 3H), 2.02 (s, 3H); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 152.6, 143.4, 143.0, 140.4, 136.9, 129.3, 128.9, 128.3, 128.2, 127.6, 127.5, 126.5, 125.8, 71.6, 52.9, 25.3, 21.48, 21.45; HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{24}H_{25}N_2O_2S$ 405.1631, found 405.1634.

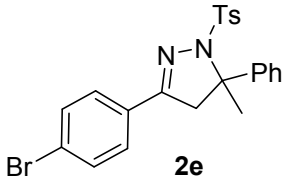
**3-(4-chlorophenyl)-5-methyl-5-phenyl-1-tosyl-4,5-dihydro-1*H*-pyrazole (2d)**




**2d**

White solid (71.1 mg, 84%); mp 130–132 °C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.62 (d, $J$ = 8.6 Hz, 2H), 7.56 (d, $J$ = 8.3 Hz, 2H), 7.37 (d, $J$ = 8.6 Hz, 2H), 7.32 (dd, $J$ = 7.6, 2.0 Hz, 3H), 7.27 – 7.19 (m, 2H), 7.15 (d, $J$ = 8.1 Hz, 2H), 3.46 (d, $J$ = 17.2 Hz, 1H), 3.34 (d, $J$ = 17.2 Hz, 1H), 2.37 (s, 3H), 2.03 (s, 3H); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 151.3, 143.3, 143.2, 136.8, 136.0, 129.6, 129.0, 128.8, 128.3, 127.7, 127.64, 127.58, 125.7, 72.1, 52.7, 25.3, 21.5; HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{23}H_{22}ClN_2O_2S$ 425.1085, found 425.1083.

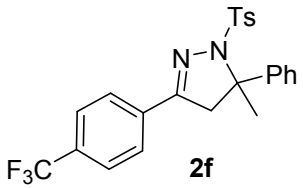
**3-(4-bromophenyl)-5-methyl-5-phenyl-1-tosyl-4,5-dihydro-1*H*-pyrazole (2e)**



**2e**

White solid (89.5 mg, 95%); mp 133–135 °C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.59 – 7.50 (m, 6H), 7.31 (dd, $J$ = 7.6, 1.9 Hz, 2H), 7.28 – 7.20 (m, 3H), 7.14 (d, $J$ = 8.1 Hz, 2H), 3.46 (d, $J$ = 17.2 Hz, 1H), 3.34 (d, $J$ = 17.2 Hz, 1H), 2.37 (s, 3H), 2.03 (s, 3H); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 151.4, 143.3, 143.2, 136.8, 131.8, 130.1, 129.0, 128.3, 127.9, 127.7, 127.6, 125.7, 124.4, 72.1, 52.7, 25.3, 21.5; HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{23}H_{22}BrN_2O_2S$ 469.0580, found 469.0580.

**5-methyl-5-phenyl-1-tosyl-3-(4-(trifluoromethyl)phenyl)-4,5-dihydro-1*H*-pyrazole (2f)**

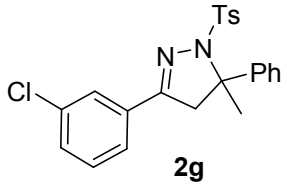


**2f**

White solid (77.2 mg, 84%); mp 133–134 °C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.79 (d, $J$ = 8.2 Hz, 2H), 7.63 (d, $J$ = 8.3 Hz, 2H), 7.55 (d, $J$ = 8.3 Hz, 2H), 7.31 (dd, $J$ = 7.7, 1.8 Hz, 2H), 7.26 – 7.18 (m, 3H), 7.14 (d, $J$ = 8.1 Hz, 2H), 3.49 (d, $J$ = 17.3 Hz, 1H), 3.38 (d, $J$ = 17.3 Hz, 1H), 2.36 (s, 3H), 2.03 (s, 3H); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 151.0, 143.3, 143.1, 136.7, 134.4, 131.4 (q, $J$ = 33.0 Hz), 129.0, 128.3, 127.7, 127.5,

126.6, 125.6, 125.4 (q, $J$ = 4.0 Hz), 123.7 (q, $J$ = 270.0 Hz), 72.3, 52.5, 25.2, 21.4; HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{24}H_{22}F_3N_2O_2S$ 459.1349, found 459.1348.

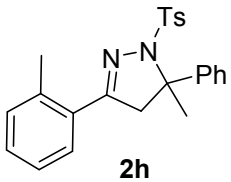
**3-(3-chlorophenyl)-5-methyl-5-phenyl-1-tosyl-4,5-dihydro-1*H*-pyrazole (2g)**




**2g**

Yellow oil (84.0 mg, 99%); $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.69 (s, 1H), 7.55 (t, $J$ = 9.2 Hz, 3H), 7.39 – 7.31 (m, 3H), 7.31 (d, $J$ = 2.0 Hz, 1H), 7.28 – 7.20 (m, 3H), 7.16 (d, $J$ = 8.1 Hz, 2H), 3.47 (d, $J$ = 17.3 Hz, 1H), 3.34 (d, $J$ = 17.3 Hz, 1H), 2.38 (s, 3H), 2.04 (s, 3H); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 151.1, 143.2, 136.8, 134.7, 132.9, 130.0, 129.9, 129.1, 128.3, 127.7, 127.6, 126.4, 125.7, 124.6, 72.1, 52.7, 25.3, 21.5; HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{23}H_{22}ClN_2O_2S$ 425.1085, found 425.1087.

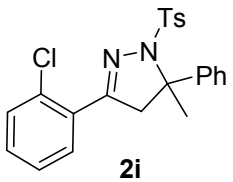
**5-methyl-5-phenyl-3-(*o*-tolyl)-1-tosyl-4,5-dihydro-1*H*-pyrazole (2h)**




**2h**

Yellow oil (59.2 mg, 73%); $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.58 (d, $J$ = 8.1 Hz, 2H), 7.36 (dd, $J$ = 6.5, 2.8 Hz, 2H), 7.29 – 7.21 (m, 6H), 7.19 (dd, $J$ = 8.1, 4.3 Hz, 1H), 7.14 (d, $J$ = 8.2 Hz, 2H), 3.54 (d, $J$ = 17.0 Hz, 1H), 3.40 (d, $J$ = 17.0 Hz, 1H), 2.65 (s, 3H), 2.37 (s, 3H), 2.04 (s, 3H); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 153.3, 143.6, 143.2, 138.1, 136.6, 131.8, 129.8, 129.3, 128.9, 128.5, 128.3, 127.9, 127.5, 125.8, 70.8, 55.1, 25.0, 23.6, 21.5; HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{24}H_{25}N_2O_2S$ 405.1631, found 405.1633.

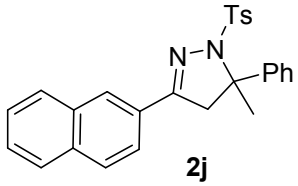
**3-(2-chlorophenyl)-5-methyl-5-phenyl-1-tosyl-4,5-dihydro-1*H*-pyrazole (2i)**




**2i**

White solid (71.8 mg, 85%); mp 116–118 °C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.77 – 7.68 (m, 1H), 7.59 (d, $J$ = 8.2 Hz, 2H), 7.43 – 7.33 (m, 3H), 7.33 – 7.27(m,2H), 7.25 (q, $J$ = 3.7 Hz, 3H), 7.15 (d, $J$ = 8.1 Hz, 2H), 3.66 (d, $J$ = 17.6 Hz, 1H), 3.54 (d, $J$ = 17.6 Hz, 1H), 2.37 (s, 3H), 2.01 (s, 3H); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 152.3, 143.2, 143.2, 136.8, 132.6, 130.7, 130.6, 130.4, 130.3, 128.9, 128.2, 127.7, 127.6, 126.8, 125.7, 72.5, 55.5, 24.8, 21.5; HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{23}H_{22}ClN_2O_2S$ 425.1085, found 425.1085.

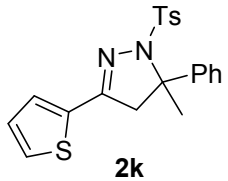
**5-methyl-3-(naphthalen-2-yl)-5-phenyl-1-tosyl-4,5-dihydro-1*H*-pyrazole (2j)**




**2j**

White solid (77.5 mg, 88%); mp 169–170 °C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 8.08 (dd, $J$ = 8.7, 1.6 Hz, 1H), 7.92 – 7.83 (m, 3H), 7.83 – 7.78 (m, 1H), 7.60 (d, $J$ = 8.3 Hz, 2H), 7.56 – 7.46 (m, 2H), 7.35 (dd, $J$ = 7.7, 1.9 Hz, 2H), 7.29 – 7.19 (m, 3H), 7.15 (d, $J$ = 8.1 Hz, 2H), 3.64 (d, $J$ = 17.1 Hz, 1H), 3.51 (d, $J$ = 17.1 Hz, 1H), 2.36 (s, 3H), 2.07 (s, 3H); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 152.6, 143.4, 143.1, 136.9, 134.0, 132.9, 129.0, 128.8, 128.4, 128.31, 128.29, 127.8, 127.64, 127.62, 127.2, 126.71, 126.69, 125.8, 123.5, 72.0, 52.8, 25.4, 21.5; HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{27}H_{25}N_2O_2S$ 441.1631, found 441.1632.

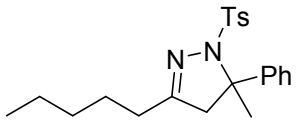
**5-methyl-5-phenyl-3-(thiophen-2-yl)-1-tosyl-4,5-dihydro-1*H*-pyrazole (2k)**




**2k**

White solid (63.9 mg, 81%); mp 162–163 °C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.55 (d, $J$ = 8.1 Hz, 2H), 7.41 (d, $J$ = 5.0 Hz, 1H), 7.32 (d, $J$ = 6.4 Hz, 2H), 7.28 – 7.18 (m, 3H), 7.13 (d, $J$ = 7.8 Hz, 3H), 7.07 – 7.00 (m, 1H), 3.48 (d, $J$ = 17.0 Hz, 1H), 3.36 (d, $J$ = 17.0 Hz, 1H), 2.36 (s, 3H), 2.01 (s, 3H); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 148.4, 143.1, 143.0, 136.7, 134.7, 128.9, 128.6, 128.2, 128.1, 127.6, 127.4, 125.8, 72.0, 53.4, 25.2, 21.5; HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{21}H_{21}N_2O_2S_2$ 397.1039, found 397.1040.

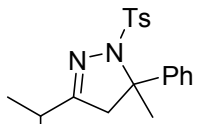
**5-methyl-3-pentyl-5-phenyl-1-tosyl-4,5-dihydro-1*H*-pyrazole (2l)**




**2l**

Yellow oil (75.6 mg, 98%); $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.54 (d, $J$ = 8.3 Hz, 2H), 7.34 – 7.27 (m, 2H), 7.25 – 7.19(m, 3H), 7.14 (d, $J$ = 8.1 Hz, 2H), 3.04 (d, $J$ = 17.6 Hz, 1H), 2.91 (d, $J$ = 17.6 Hz, 1H), 2.38 (s, 3H), 2.34 (t, $J$ = 7.7 Hz, 2H), 1.88 (s, 3H),1.61 – 1.49 (m, 2H), 1.38 – 1.23 (m, 4H), 0.88 (t, $J$ = 6.9 Hz, 3H); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 157.5, 143.7, 142.8, 137.1, 128.8, 128.1, 127.5, 127.3, 125.6, 70.8, 55.2, 31.3, 30.0, 25.8, 24.9, 22.3, 21.4, 13.9; HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{22}H_{29}N_2O_2S$ 385.1944, found 385.1947.

**3-isopropyl-5-methyl-5-phenyl-1-tosyl-4,5-dihydro-1*H*-pyrazole (2m)**

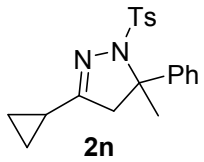



**2m**

White solid (63.6 mg, 89%); mp 121–123 °C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.53 (d, $J$ = 8.3 Hz, 2H), 7.32 – 7.26 (m, 2H), 7.25 – 7.18 (m, 3H), 7.13 (d, $J$ = 8.1 Hz, 2H), 3.04 (d, $J$ = 17.5 Hz, 1H), 2.92 (d, $J$ = 17.5 Hz, 1H), 2.75 – 2.62 (m, 1H), 2.37 (s, 3H), 1.86 (s, 3H), 1.15 (d, $J$ = 6.9 Hz, 6H); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 161.9, 143.6,

142.7, 136.9, 128.7, 128.0, 127.5, 127.2, 125.5, 70.9, 52.9, 29.7, 24.6, 21.4, 19.8, 19.7; HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{20}H_{25}N_2O_2S$ 357.1631, found 357.1633.

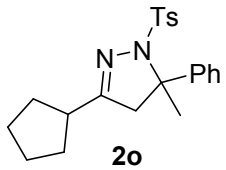
**3-cyclopropyl-5-methyl-5-phenyl-1-tosyl-4,5-dihydro-1*H*-pyrazole (2n)**




**2n**

White solid (45.7 mg, 65%); mp 100–101 °C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.52 (d, $J$ = 8.1 Hz, 2H), 7.33 – 7.27 (m, 2H), 7.25 – 7.20 (m, 3H), 7.14 (d, $J$ = 8.0 Hz, 2H), 2.88 (d, $J$ = 17.2 Hz, 1H), 2.75 (d, $J$ = 17.2 Hz, 1H), 2.38 (s, 3H), 1.90 (s, 3H), 1.86 – 1.76 (m, 1H), 0.96 – 0.82 (m, 2H), 0.80 – 0.66 (m, 2H); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 159.0, 143.5, 142.8, 136.9, 128.9, 128.1, 127.6, 127.4, 125.6, 70.7, 52.7, 24.8, 21.5, 11.5, 6.5, 6.3; HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{20}H_{23}N_2O_2S$ 355.1475, found 355.1472.

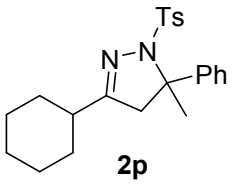
**3-cyclopentyl-5-methyl-5-phenyl-1-tosyl-4,5-dihydro-1*H*-pyrazole (2o)**




**2o**

White solid (71.1 mg, 90%); mp 48–49 °C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.53 (d, $J$ = 8.0 Hz, 2H), 7.33 – 7.27 (m, 2H), 7.25 – 7.18 (m, 3H), 7.13 (d, $J$ = 8.0 Hz, 2H), 3.05 (d, $J$ = 17.4 Hz, 1H), 2.91 (d, $J$ = 17.4 Hz, 1H), 2.87 – 2.78 (m, 1H), 2.38 (s, 3H), 1.87 – 1.81 (m, 5H), 1.74 – 1.52 (m, 6H); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 160.4, 143.7, 142.8, 137.0, 128.8, 128.1, 127.6, 127.3, 125.6, 70.9, 53.7, 40.4, 30.2, 30.1, 25.3, 24.7, 21.5; HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{22}H_{27}N_2O_2S$ 383.1788, found 383.1789.

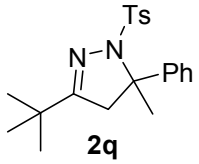
**3-cyclohexyl-5-methyl-5-phenyl-1-tosyl-4,5-dihydro-1*H*-pyrazole (2p)**




**2p**

White solid (77.5 mg, 98%); mp 97–98 °C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.52 (d, $J$ = 8.3 Hz, 2H), 7.31 – 7.25 (m, 2H), 7.24 – 7.16 (m, 3H), 7.12 (d, $J$ = 8.0 Hz, 2H), 3.04 (d, $J$ = 17.5 Hz, 1H), 2.91 (d, $J$ = 17.5 Hz, 1H), 2.44 – 2.39 (m, 1H), 2.37 (s, 3H), 1.87 (s, 3H), 1.86 – 1.64 (m, 5H), 1.41 – 1.17 (m, 5H); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 161.1, 143.6, 142.7, 137.0, 128.8, 128.1, 127.5, 127.3, 125.6, 70.6, 53.4, 39.2, 30.1, 30.0, 25.8, 25.63, 25.61, 24.8, 21.5; HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{23}H_{29}N_2O_2S$ 397.1944, found 397.1946.

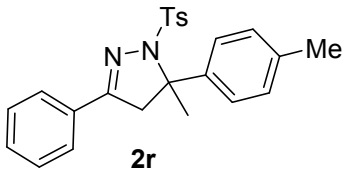
**3-(*tert*-butyl)-5-methyl-5-phenyl-1-tosyl-4,5-dihydro-1*H*-pyrazole (2q)**




**2q**

White solid (63.7 mg, 86%); mp 83–85 °C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.55 (d, $J$ = 8.3 Hz, 2H), 7.32 – 7.27 (m, 2H), 7.24 – 7.20 (m, 3H), 7.14 (d, $J$ = 8.0 Hz, 2H), 3.07 (d, $J$ = 17.3 Hz, 1H), 2.94 (d, $J$ = 17.3 Hz, 1H), 2.38 (s, 3H), 1.84 (s, 3H), 1.18 (s, 9H); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 164.1, 143.7, 142.8, 137.0, 128.7, 128.1, 127.7, 127.3, 125.6, 71.5, 52.1, 34.1, 27.8, 24.5, 21.5; HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{21}H_{27}N_2O_2S$ 371.1788, found 371.1785.

**5-methyl-3-phenyl-5-(p-tolyl)-1-tosyl-4,5-dihydro-1*H*-pyrazole (2r)**

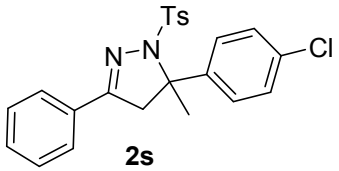



**2r**

White solid (78.8 mg, 97%); mp 137–138 °C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.75 – 7.67 (m, 2H), 7.57 (d, $J$ = 8.3 Hz, 2H), 7.45 – 7.37 (m, 3H), 7.21 (d, $J$ = 8.2 Hz, 2H), 7.13 (d, $J$ = 8.1 Hz, 2H), 7.01 (d, $J$ = 8.0 Hz, 2H), 3.49 (d, $J$ = 17.2 Hz, 1H), 3.36 (d, $J$

= 17.2 Hz, 1H), 2.37 (s, 3H), 2.33 (s, 3H), 2.01 (s, 3H); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 152.5, 142.9, 140.4, 137.3, 136.9, 131.1, 130.1, 128.82, 128.79, 128.6, 127.5, 126.5, 125.7, 71.7, 52.7, 25.3, 21.5, 21.0; HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{24}H_{25}N_2O_2S$ 405.1631, found 405.1630.

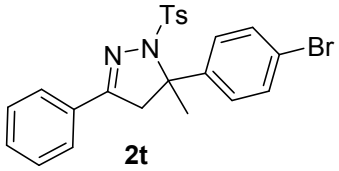
**5-(4-chlorophenyl)-5-methyl-3-phenyl-1-tosyl-4,5-dihydro-1*H*-pyrazole (2s)**




**2s**

White solid (83.5 mg, 98%); mp 70–71 °C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.75 – 7.63 (m, 2H), 7.58 (d, $J$ = 8.3 Hz, 2H), 7.45 – 7.38 (m, 3H), 7.28 – 7.21 (m, 2H), 7.20 – 7.12 (m, 4H), 3.45 (d, $J$ = 17.2 Hz, 1H), 3.37 (d, $J$ = 17.2 Hz, 1H), 2.38 (s, 3H), 2.01 (s, 3H); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 152.5, 143.3, 141.9, 136.7, 133.6, 130.9, 130.3, 129.0, 128.7, 128.3, 127.5, 127.2, 126.5, 71.3, 52.6, 25.2, 21.5; HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{23}H_{22}ClN_2O_2S$ 425.1085, found 425.1083.

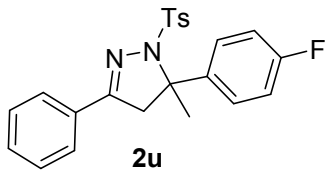
**5-(4-bromophenyl)-5-methyl-3-phenyl-1-tosyl-4,5-dihydro-1*H*-pyrazole (2t)**




**2t**

White solid (89.6 mg, 95%); mp 67–69 °C; $^1$H NMR (400 MHz, CDCl) $\delta$ 7.74 – 7.67 (m, 2H), 7.58 (d, $J$ = 8.4 Hz, 2H), 7.45 – 7.38 (m, 3H), 7.34 – 7.27 (m, 2H), 7.21 – 7.13 (m, 4H), 3.45 (d, $J$ = 17.2 Hz, 1H), 3.37 (d, $J$ = 17.2 Hz, 1H), 2.39 (s, 3H), 2.00 (s, 3H); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 152.6, 143.3, 142.3, 136.6, 131.2, 130.8, 130.3, 129.0, 128.6, 127.5, 127.4, 126.5, 121.7, 71.3, 52.5, 25.1, 21.5; HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{23}H_{22}BrN_2O_2S$ 469.0580, found 469.0578.

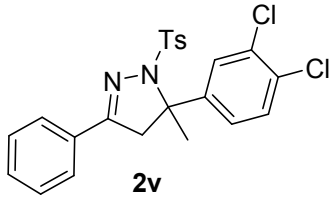
**5-(4-fluorophenyl)-5-methyl-3-phenyl-1-tosyl-4,5-dihydro-1*H*-pyrazole (2u)**




**2u**

White solid (80.2 mg, 98%); mp 130–131 °C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.74 – 7.66 (m, 2H), 7.58 (d, $J$ = 8.3 Hz, 2H), 7.45 – 7.37 (m, 3H), 7.33 – 7.26 (m, 2H), 7.16 (d, $J$ = 8.1 Hz, 2H), 6.95 – 6.82 (m, 2H), 3.47 (d, $J$ = 17.2 Hz, 1H), 3.37 (d, $J$ = 17.2 Hz, 1H), 2.37 (s, 3H), 2.02 (s, 3H); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 162.1 (d, $J$ = 245.0 Hz), 152.5, 143.3, 139.3 (d, $J$ = 3.0 Hz), 136.8, 131.1, 130.2, 129.0, 128.6, 127.6 (d, $J$ = 8.0 Hz), 127.5, 126.5, 115.0 (d, $J$ = 21.0 Hz), 71.3, 52.7, 25.5, 21.5; HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{23}H_{22}FN_2O_2S$ 409.1381, found 409.1382.

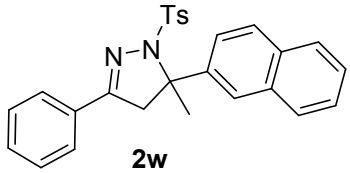
**5-(3,4-dichlorophenyl)-5-methyl-3-phenyl-1-tosyl-4,5-dihydro-1*H*-pyrazole (2v)**




**2v**

White solid (77.7 mg, 85%); mp 152–153 °C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.74 – 7.65 (m, 2H), 7.60 (d, $J$ = 8.1 Hz, 2H), 7.47 – 7.38 (m, 3H), 7.33 – 7.27 (m, 2H), 7.24 – 7.15 (m, 3H), 3.44 (d, $J$ = 17.3 Hz, 1H), 3.38 (d, $J$ = 17.3 Hz, 1H), 2.39 (s, 3H), 1.99 (s, 3H); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 152.5, 143.7, 143.5, 136.4, 132.4, 131.9, 130.7, 130.4, 130.1, 129.2, 128.7, 128.0, 127.4, 126.6, 125.3, 70.8, 52.2, 25.1, 21.6; HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{23}H_{21}Cl_2N_2O_2S$ 459.0695, found 459.0695.

**5-methyl-5-(naphthalen-2-yl)-3-phenyl-1-tosyl-4,5-dihydro-1*H*-pyrazole (2w)**

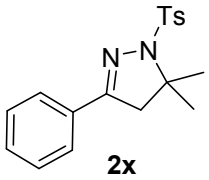



**2w**

White solid (80.4 mg, 91%); mp 174–176 °C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.82 – 7.70 (m, 5H), 7.63 (d, $J$ = 8.7 Hz, 1H), 7.55 – 7.46 (m, 4H), 7.46 – 7.41 (m, 3H), 7.36 (dd, $J$ = 8.7, 2.0 Hz, 1H), 6.95 (d, $J$ = 8.1 Hz, 2H), 3.60 (d, $J$ = 17.3 Hz, 1H), 3.44 (d,

*J* = 17.3 Hz, 1H), 2.29 (s, 3H), 2.17 (s, 3H); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 152.6, 143.0, 140.2, 136.7, 132.7, 132.6, 131.1, 130.1, 128.8, 128.6, 128.3, 128.0, 127.4, 127.3, 126.5, 126.2, 126.1, 124.6, 123.9, 71.8, 52.6, 25.4, 21.4; HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{27}H_{25}N_2O_2S$ 441.1631, found 441.1630.

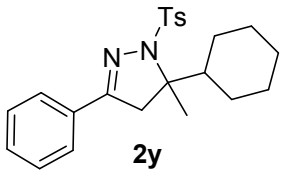
**5,5-dimethyl-3-phenyl-1-tosyl-4,5-dihydro-1*H*-pyrazole (2x)**




**2x**

White solid (39.1 mg, 60%); mp 53-55 $^{o}$C; $^{1}$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.93 (d, *J* = 8.3 Hz, 2H), 7.68 – 7.61 (m, 2H), 7.43 – 7.34 (m, 3H), 7.27 (d, *J* = 10.3 Hz, 2H), 3.04 (s, 2H), 2.40 (s, 3H), 1.56 (s, 6H); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 153.4, 143.4, 137.3, 131.4, 130.0, 129.2, 128.5, 128.1, 126.4, 69.1, 49.2, 27.1, 21.5; HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{18}H_{21}N_2O_2S$ 329.1318, found 329.1315.

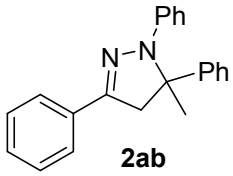
**5-cyclohexyl-5-methyl-3-phenyl-1-tosyl-4,5-dihydro-1*H*-pyrazole (2y)**




**2y**

White solid (55.4 mg, 72%); mp 57–58 $^{o}$C; $^{1}$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.92 (d, *J* = 8.3 Hz, 2H), 7.70 – 7.62 (m, 2H), 7.44 – 7.33 (m, 3H), 7.28 (d, *J* = 8.2 Hz, 2H), 3.22 (d, *J* = 17.0 Hz, 1H), 2.66 (d, *J* = 17.0 Hz, 1H), 2.39 (s, 3H), 2.36 – 2.18 (m, 1H), 1.92 – 1.77 (m, 3H), 1.77 – 1.66 (m, 2H), 1.42 (s, 3H), 1.26 – 1.30 (m, 1H), 1.30 – 1.24 (m, 1H), 1.15 – 1.04 (m, 1H), 0.94 – 0.82 (m, 2H); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 152.7, 143.2, 137.6, 131.4, 129.8, 129.2, 128.4, 127.8, 126.3, 75.9, 45.2, 42.4, 28.4, 27.6, 26.3, 26.3, 25.8, 24.3, 21.5; HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{23}H_{29}N_2O_2S$ 397.1944, found 397.1943.

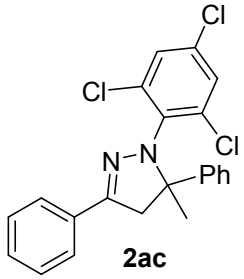
**5-methyl-1,3,5-triphenyl-4,5-dihydro-1*H*-pyrazole (2ab)**




**2ab**

Yellow solid (39.5 mg, 63%); mp 166–167 °C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.76 – 7.69 (m, 2H), 7.57 – 7.49 (m, 2H), 7.43 – 7.37 (m, 4H), 7.36 – 7.29 (m, 2H), 7.14 – 7.09 (m, 2H), 7.06 – 6.99 (m, 2H), 6.82 – 6.74 (m, 1H), 3.44 (d, $J$ = 16.8 Hz, 1H), 3.43 (d, $J$ = 16.8 Hz, 1H), 1.82 (s, 3H); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 145.9, 145.2, 143.6, 133.0, 129.0, 128.6, 128.5, 128.4, 127.2, 125.6, 125.5, 119.4, 115.3, 69.9, 53.5, 22.2; HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{22}H_{20}N_2$ 312.1626, found 312.1628.

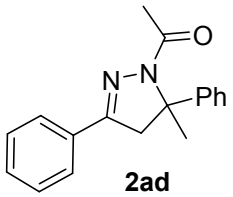
**5-methyl-3,5-diphenyl-1-(2,4,6-trichlorophenyl)-4,5-dihydro-1*H*-pyrazole (2ac)**




**2ac**

Yellow solid (76.8 mg, 92%); mp 127–128 °C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.75 – 7.67 (m, 2H), 7.48 – 7.43 (m, 2H), 7.42 – 7.35 (m, 3H), 7.33 – 7.21 (m, 5H), 3.63 (d, $J$ = 16.7 Hz, 1H), 3.49 (d, $J$ = 16.7 Hz, 1H), 1.77 (s, 3H); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 150.5, 145.4, 138.2, 137.0, 132.8, 132.3, 128.8, 128.6, 128.0, 127.1, 125.92, 125.85, 70.9, 51.4, 24.0; HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{22}H_{18}Cl_3N_2$ 415.0530, found 415.0533.

**1-(5-methyl-3,5-diphenyl-4,5-dihydro-1*H*-pyrazol-1-yl)ethan-1-one (2ad)**

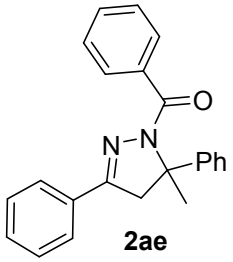



**2ad**

White solid (34.1 mg, 61%); mp 146–147 °C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.74 – 7.68 (m, 2H), 7.46 – 7.39 (m, 3H), 7.37 – 7.28 (m, 4H), 7.28 – 7.21 (m, 1H), 3.46 (d, $J$ = 17.6 Hz, 1H), 3.40 (d, $J$ = 17.6 Hz, 1H), 2.42 (s, 3H), 2.07 (s, 3H); $^{13}$C NMR (100

MHz, $CDCl_3$) $\delta$ 168.8, 151.5, 144.9, 131.5, 130.1, 128.7, 128.6, 127.0, 126.4, 124.4, 67.5, 52.3, 24.5, 23.2; HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{18}H_{19}N_2O$ 279.1492, found 279.1492.

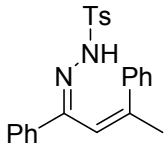
**(5-methyl-3,5-diphenyl-4,5-dihydro-1*H*-pyrazol-1-yl)(phenyl)methanone (2ae)**




**2ae**

White solid (49.0 mg, 70%); mp 100–101 °C; $^1H$ NMR (400 MHz, $CDCl_3$) $\delta$ 7.97 – 7.89 (m, 2H), 7.68 – 7.62 (m, 2H), 7.50 – 7.43 (m, 2H), 7.43 – 7.36 (m, 6H), 7.36 – 7.31 (m, 2H), 7.28 – 7.22 (m, 1H), 3.50 (d, $J$ = 17.6 Hz, 1H), 3.43 (d, $J$ = 17.6 Hz, 1H), 2.19 (s, 3H); $^{13}C$ NMR (100 MHz, $CDCl_3$) $\delta$ 166.3, 152.3, 144.7, 135.5, 131.5, 130.6, 130.2, 130.0, 128.69, 128.65, 127.5, 127.1, 126.6, 124.4, 68.8, 51.7, 24.4; HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{23}H_{21}N_2O$ 341.1648, found 341.1646.

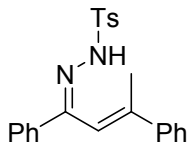
***N*'-((1*E*,2*Z*)-1,3-diphenylbut-2-en-1-ylidene)-4-methylbenzenesulfonohydrazide (*Z*-3)**




***Z*-3**

White solid (228.6 mg, 29%); mp 157–159 °C; $^1H$ NMR (400 MHz, $CDCl_3$) $\delta$ 7.86 (s, 1H), 7.68 – 7.62 (m, 2H), 7.58 (d, $J$ = 8.2 Hz, 2H), 7.32 – 7.24 (m, 3H), 7.21 (d, $J$ = 8.2 Hz, 2H), 7.14 – 7.07 (m, 1H), 7.00 (d, $J$ = 4.3 Hz, 4H), 5.92 (s, 1H), 2.41 (s, 3H), 2.33 (s, 3H); $^{13}C$ NMR (100 MHz, $CDCl_3$) $\delta$ 151.1, 147.1, 143.6, 138.8, 135.9, 135.4, 129.5, 129.3, 128.7, 128.4, 128.2, 127.7, 126.9, 126.2, 116.7, 24.8, 21.6; HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{23}H_{23}N_2O_2S$ 391.1475, found 391.1475.

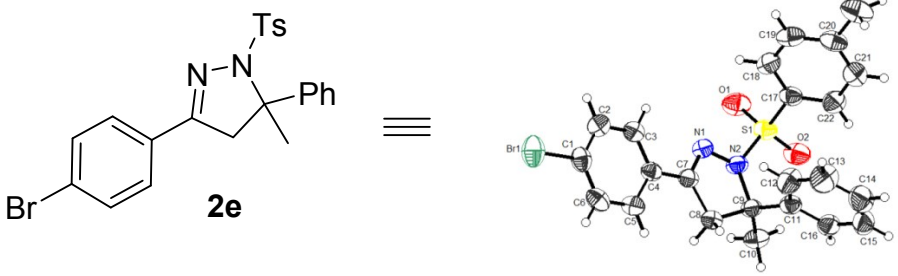
***N'*-((1*E*,2*E*)-1,3-diphenylbut-2-en-1-ylidene)-4-methylbenzenesulfonohydrazide[5] (*E*-3)**




***E*-3**

White solid (443.2 mg, 57%); mp 99–101 °C; $^{1}$H NMR (400 MHz, $CDCl_3$) $\delta$ 8.00 (s, 1H), 7.92 (d, $J$ = 7.9 Hz, 2H), 7.72 – 7.66 (m, 2H), 7.56 (d, J = 7.8 Hz, 2H), 7.45 – 7.38 (m, 3H), 7.38 – 7.30 (m, 5H), 6.23 (s, 1H), 2.42 (s, 3H), 1.88 (s, 3H); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 151.8, 146.2, 144.0, 139.6, 135.7, 135.6, 129.8, 129.5, 128.7, 128.6, 128.4, 127.9, 126.8, 125.8, 115.8, 21.5, 18.1; HRMS (ESI-TOF) m/z: $[M + H]^+$ calcd for $C_{23}H_{23}N_2O_2S$ 391.1475, found 391.1478.

**X-ray structure of 2e (CCDC 2018227)**




**Crystal data and structure refinement for 2e**

| | |
|---|---|
| Identification code | **2e** |
| Empirical formula | $C_{23}H_{21}BrN_2O_2S$ |
| Formula weight | 469.39 |
| Temperature | 296(2) K |
| Wavelength | 0.71073 Å |
| Crystal system | Monoclinic |

| | | |
|---|---|---|
| Space group | $P2_1/n$ | |
| Unit cell dimensions | a = 12.3545(4) Å | α = 90°. |
| | b = 11.9990(4) Å | β = 94.0510(10)°. |
| | c = 14.3274(6) Å | γ = 90°. |
| Volume | 2118.61(13) $Å^3$ | |
| Z | 4 | |
| Density (calculated) | 1.472 $Mg/m^3$ | |
| Absorption coefficient | 2.061 $mm^{-1}$ | |
| F(000) | 960 | |
| Crystal size | 0.320 x 0.250 x 0.220 $mm^3$ | |
| Theta range for data collection | 2.104 to 27.567°. | |
| Index ranges | -13<=h<=16, -14<=k<=15, -18<=l<=18 | |
| Reflections collected | 32627 | |
| Independent reflections | 4888 [R(int) = 0.0397] | |
| Completeness to theta = 25.242° | 99.8 % | |
| Absorption correction | Semi-empirical from equivalents | |
| Max. and min. transmission | 0.7456 and 0.4795 | |
| Refinement method | Full-matrix least-squares on $F^2$ | |
| Data / restraints / parameters | 4888 / 0 / 264 | |
| Goodness-of-fit on $F^2$ | 1.016 | |
| Final R indices [I>2sigma(I)] | R1 = 0.0430, wR2 = 0.1048 | |
| R indices (all data) | R1 = 0.0672, wR2 = 0.1167 | |
| Extinction coefficient | n/a | |
| Largest diff. peak and hole | 0.675 and -0.744 $e.Å^{-3}$ | |

**References**

(1) Tripathi, C. B.; Mukherjee, S. *Org. Lett.* **2014**, *16*, 3368.

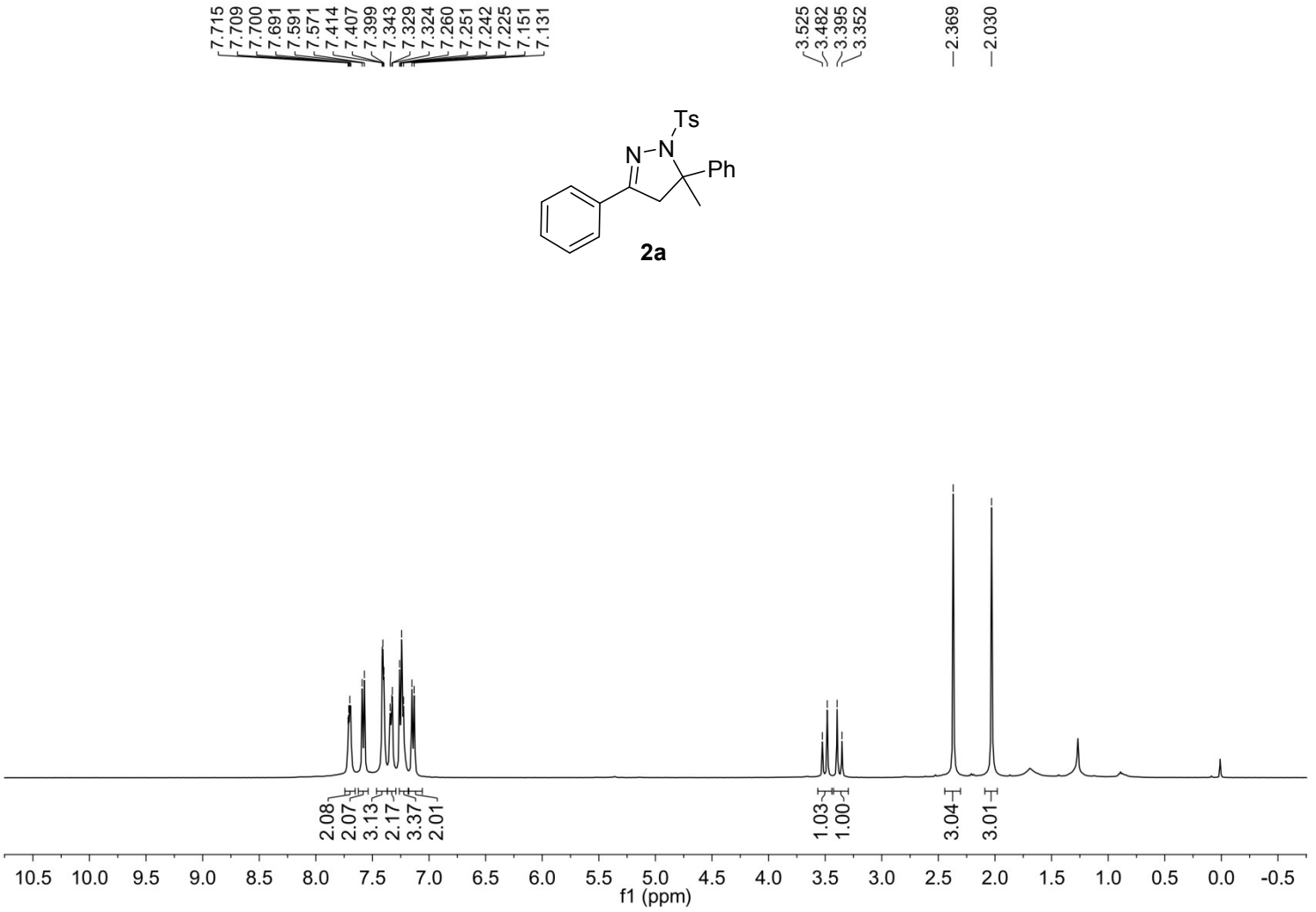
(2) Imai, T.; Nishida, S. *Synthesis* **1993**, *1993*, 395.

(3) Rajam, S.; Jadhav, A. V.; Li, Q.; Sarkar, S. K.; Singh, P. N. D.; Rohr, A.; Pace, T.

C. S.; Li, R.; Krause, J. A.; Bohne, C.; Ault, B. S.; Gudmundsdottir, A. D. *J. Org. Chem.* **2014**, *79*, 9325.

(4) Hu, X.-Q.; Qi, X.; Chen, J.-R.; Zhao, Q.-Q.; Wei, Q.; Lan, Y.; Xiao, W.-J. *Nat. Chem.* **2016**, *7*, 11188.

(5) Liu, W.; Wang, H.; Zhao, H; Li, B.; Chen, S. *Synlett* **2015**, *26*, 2170.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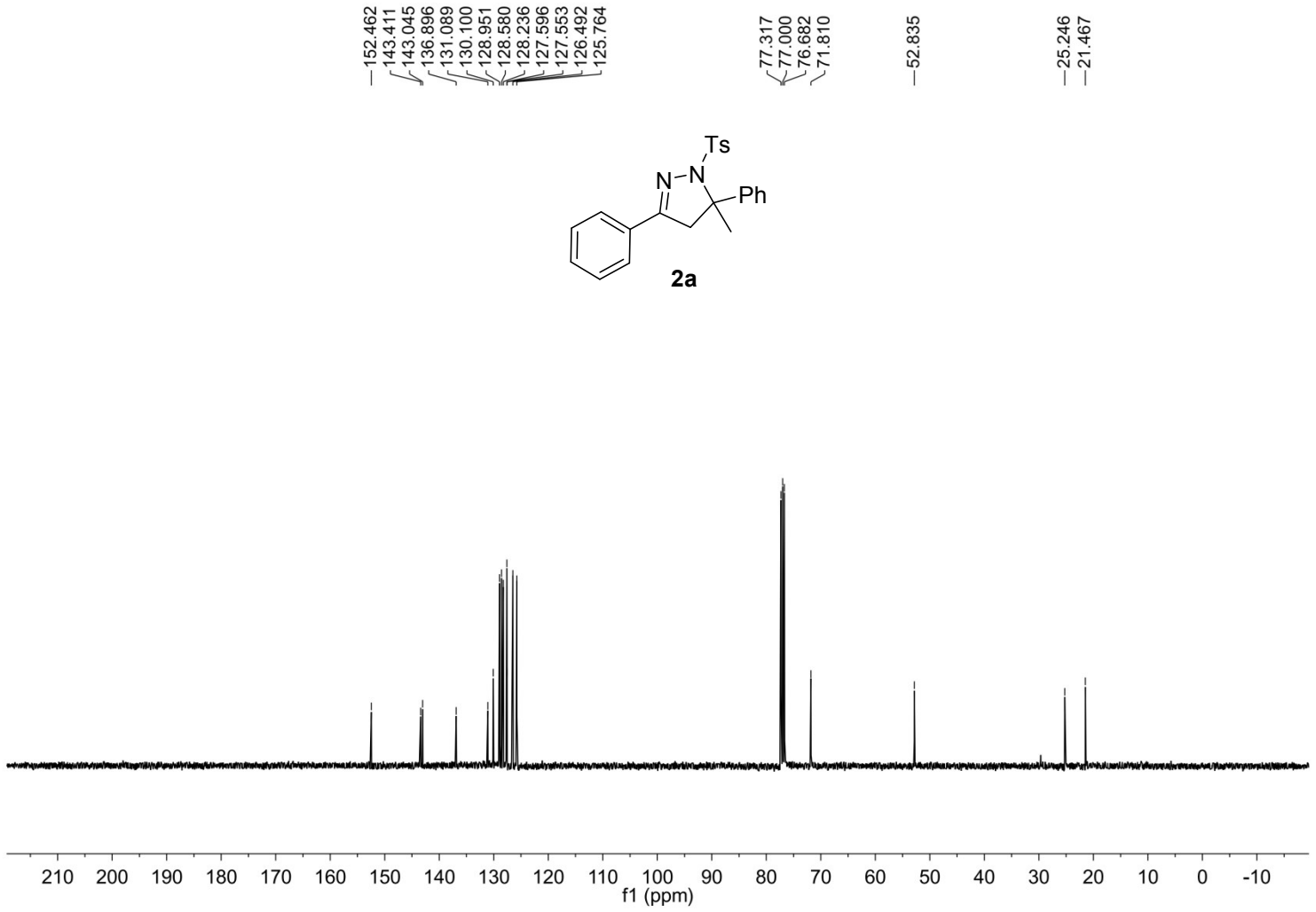
7.700
7.691
7.591
7.571
7.414
7.407
7.399
7.343
7.329
7.324
7.260
7.251
7.242
7.225
7.151
7.131
3.525
3.482
3.395
3.352
2.369
2.030
Ts
N
N
Ph
2a
2.08
2.07
3.13
2.17
3.37
2.01
1.03
1.00
3.04
3.01
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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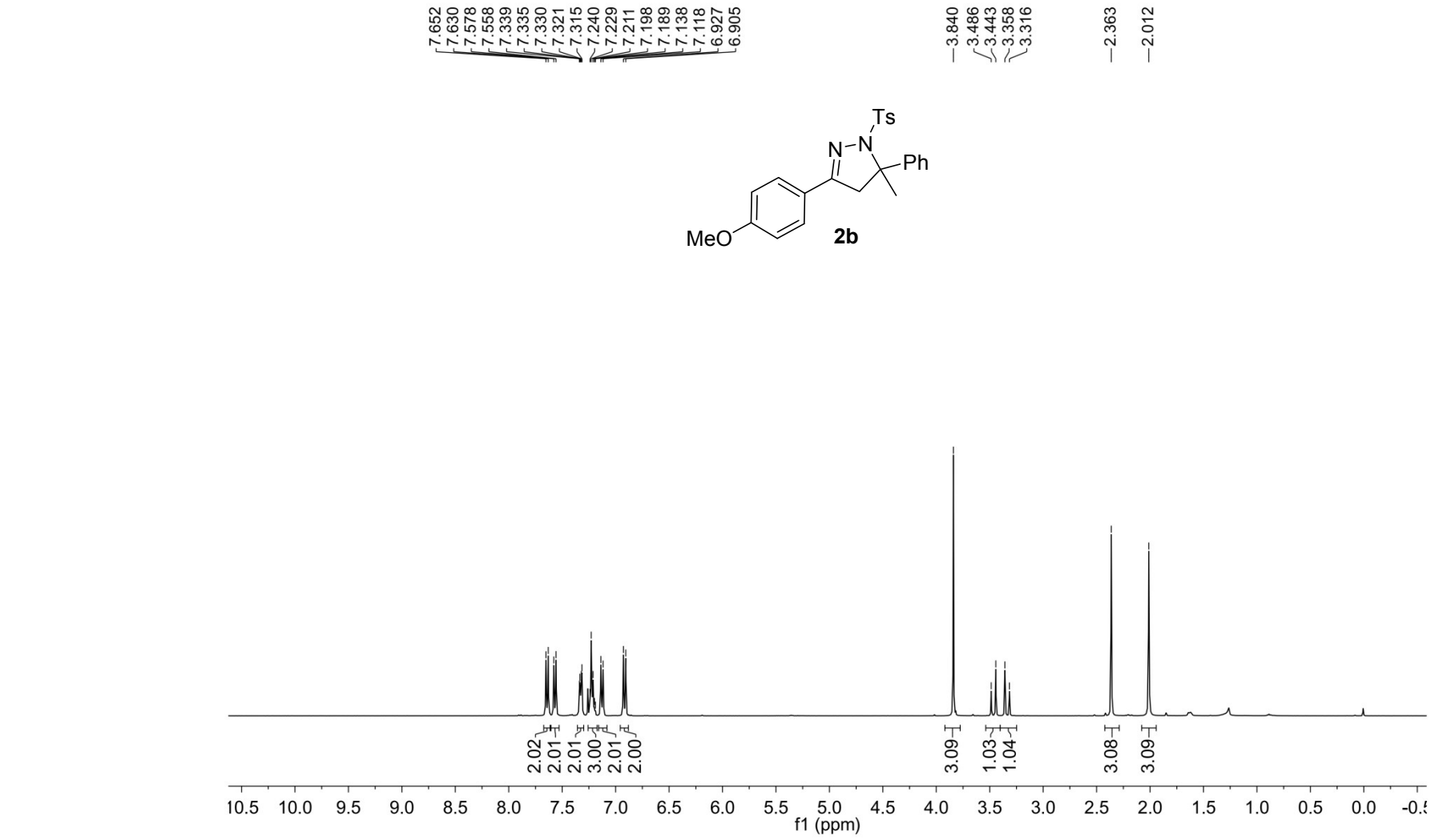
143.411
143.045
136.896
131.089
130.100
128.951
128.580
128.236
127.596
127.553
126.492
125.764
77.317
77.000
76.682
71.810
52.835
25.246
21.467
Ts
N
N
Ph
2a
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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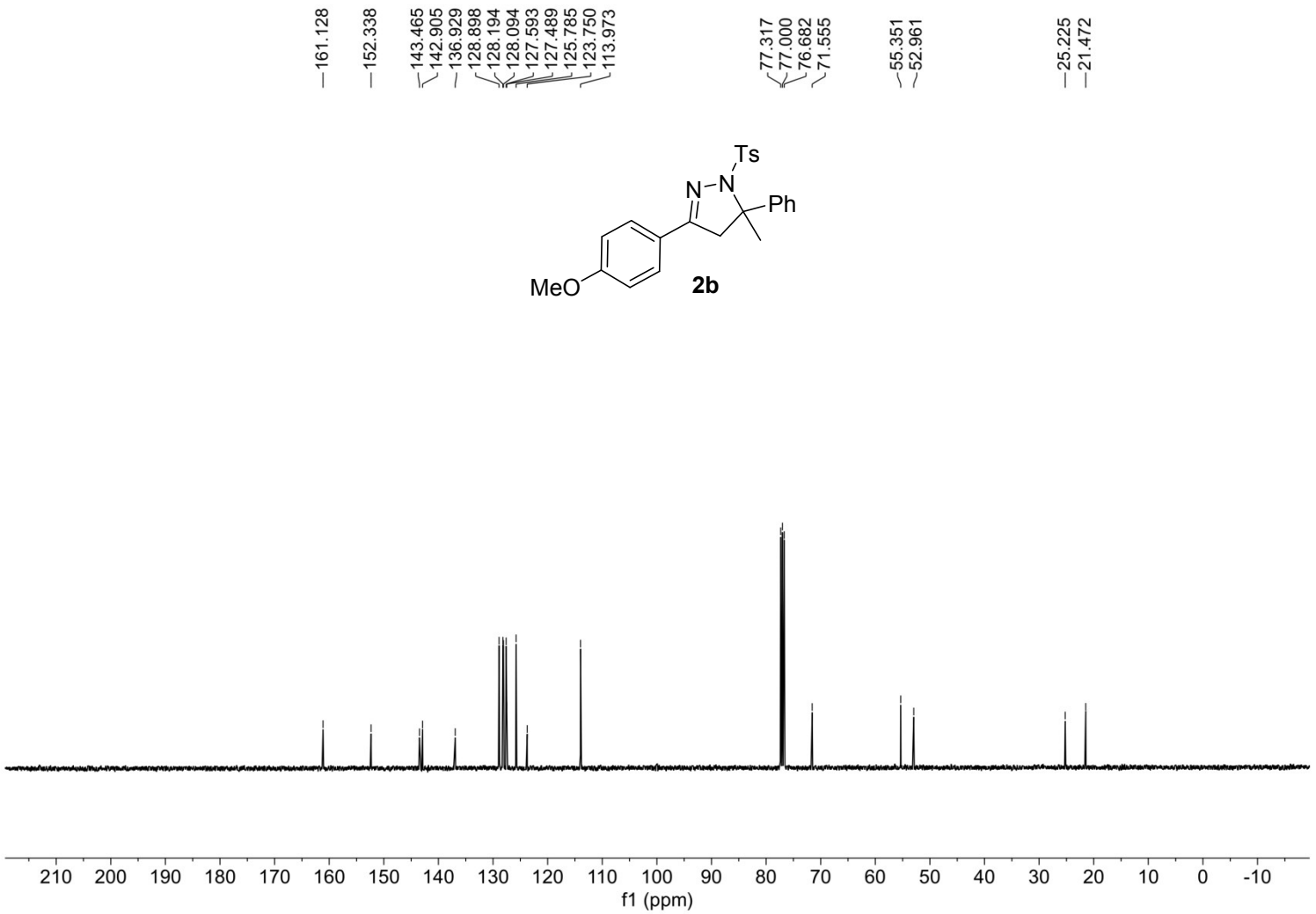
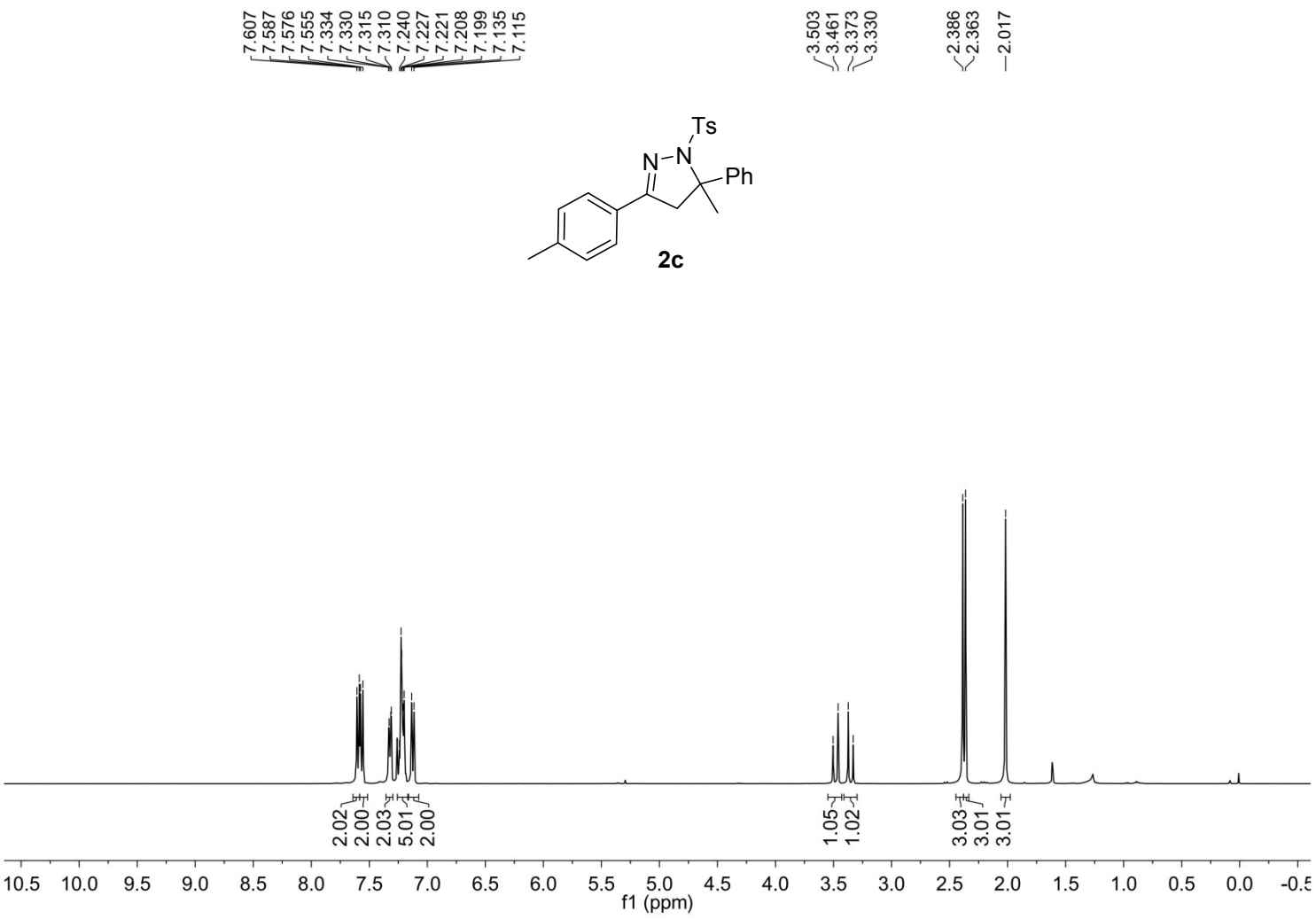
7.630
7.578
7.558
7.339
7.335
7.330
7.321
7.315
7.240
7.229
7.211
7.198
7.189
7.138
7.118
6.927
6.905
3.840
3.486
3.443
3.358
3.316
2.363
2.012
Ts
N
N
Ph
MeO
2b
2.02
2.01
2.01
3.00
2.01
2.00
3.09
1.03
1.04
3.08
3.09
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


161.128
152.338
143.465
142.905
136.929
128.898
128.194
128.094
127.593
127.489
125.785
123.750
113.973
77.317
77.000
76.682
71.555
55.351
52.961
25.225
21.472
Ts
N
N
Ph
MeO
2b
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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7.555
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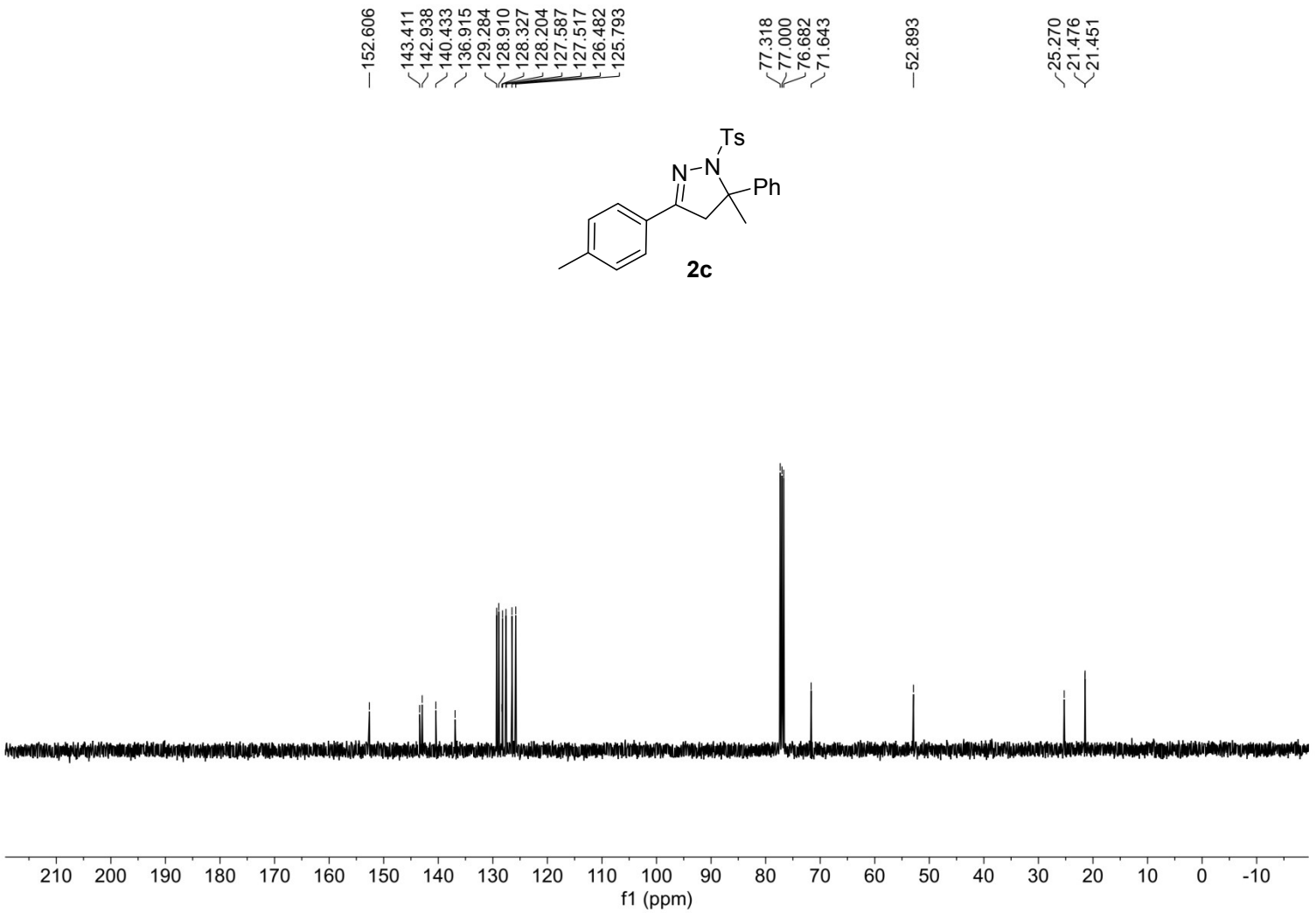
7.330
7.315
7.310
7.240
7.227
7.221
7.208
7.199
7.135
7.115
3.503
3.461
3.373
3.330
2.386
2.363
2.017
Ts
N
N
Ph
2c
2.02
2.00
2.03
5.01
2.00
1.05
1.02
3.03
3.01
3.01
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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142.938
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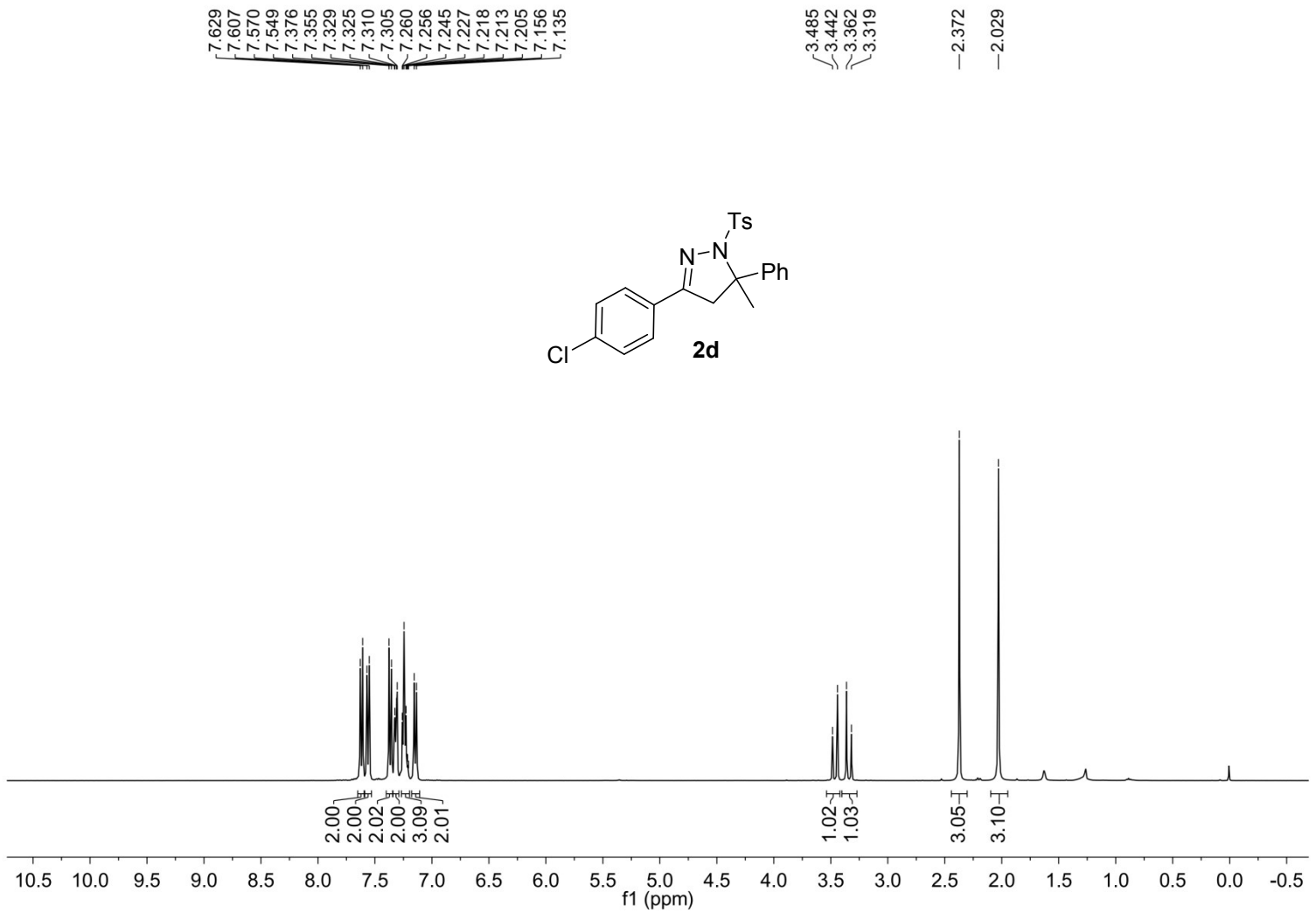
136.915
129.284
128.910
128.327
128.204
127.587
127.517
126.482
125.793
77.318
77.000
76.682
71.643
52.893
25.270
21.476
21.451
Ts
N
N
Ph
2c
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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7.325
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7.305
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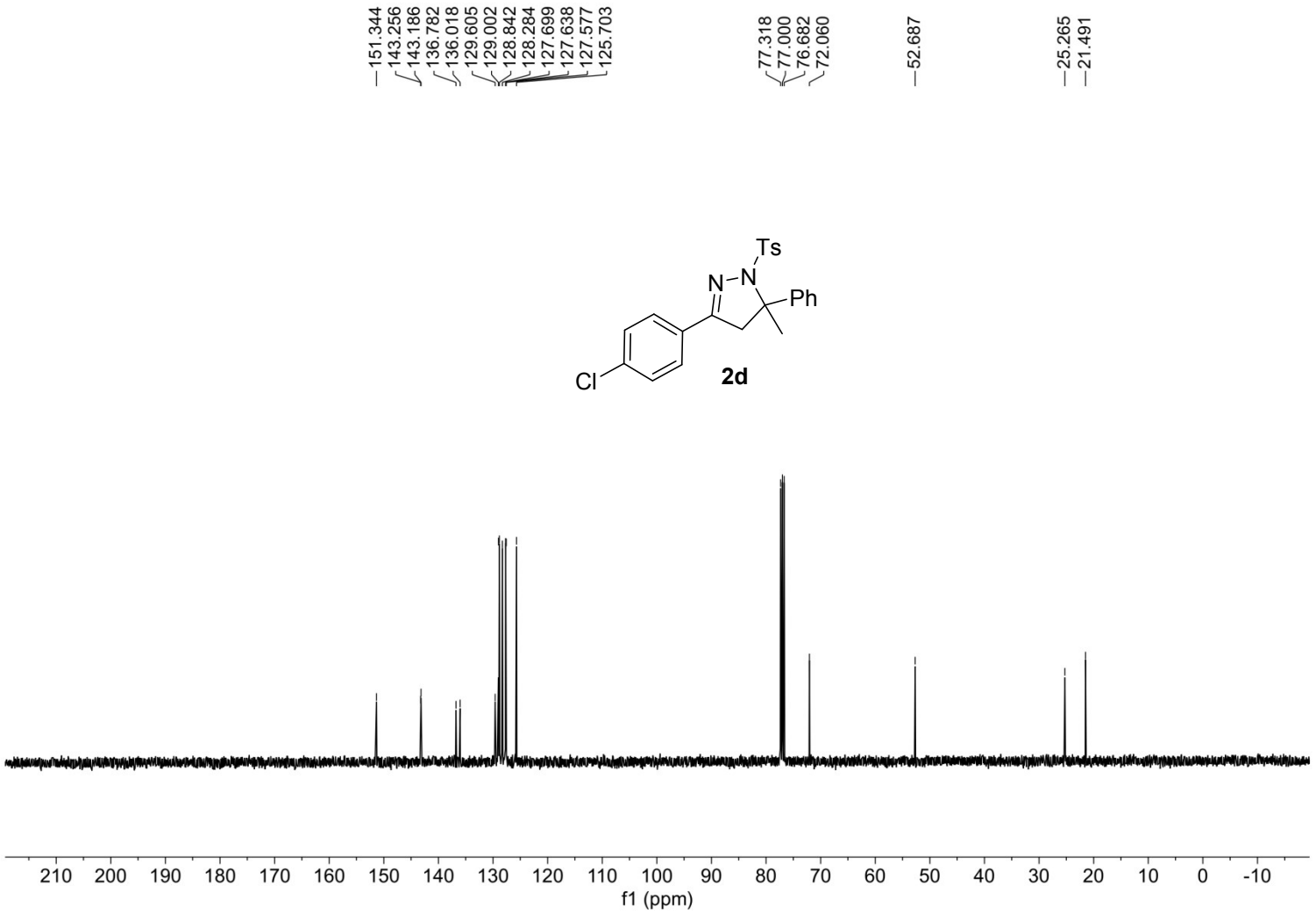
7.245
7.227
7.218
7.213
7.205
7.156
7.135
3.485
3.442
3.362
3.319
2.372
2.029
Ts
N
N
Ph
Cl
2d
2.00
2.00
2.02
2.00
3.09
2.01
1.02
1.03
3.05
3.10
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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128.842
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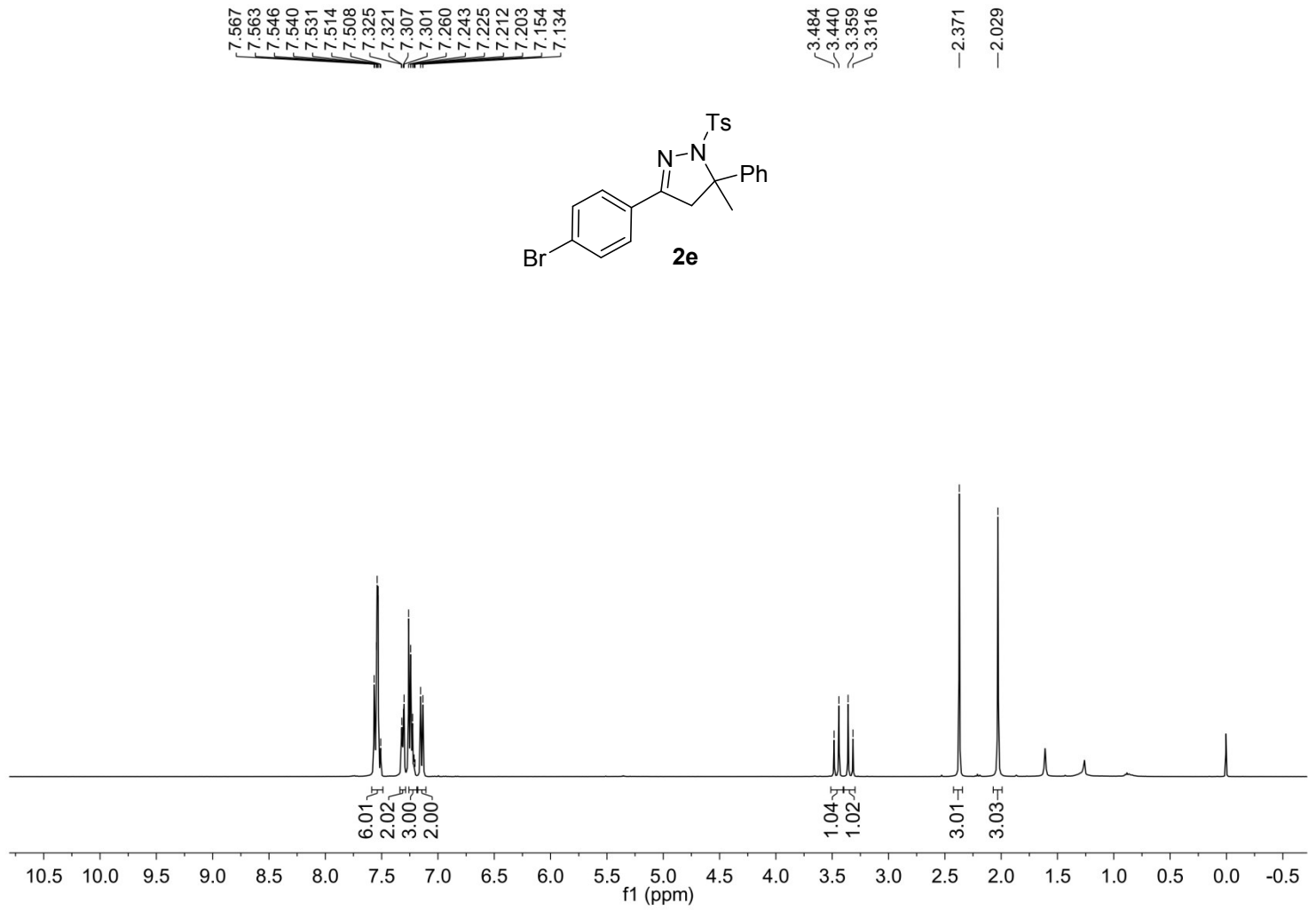
127.577
125.703
77.318
77.000
76.682
72.060
52.687
25.265
21.491
Ts
N
N
Ph
Cl
2d
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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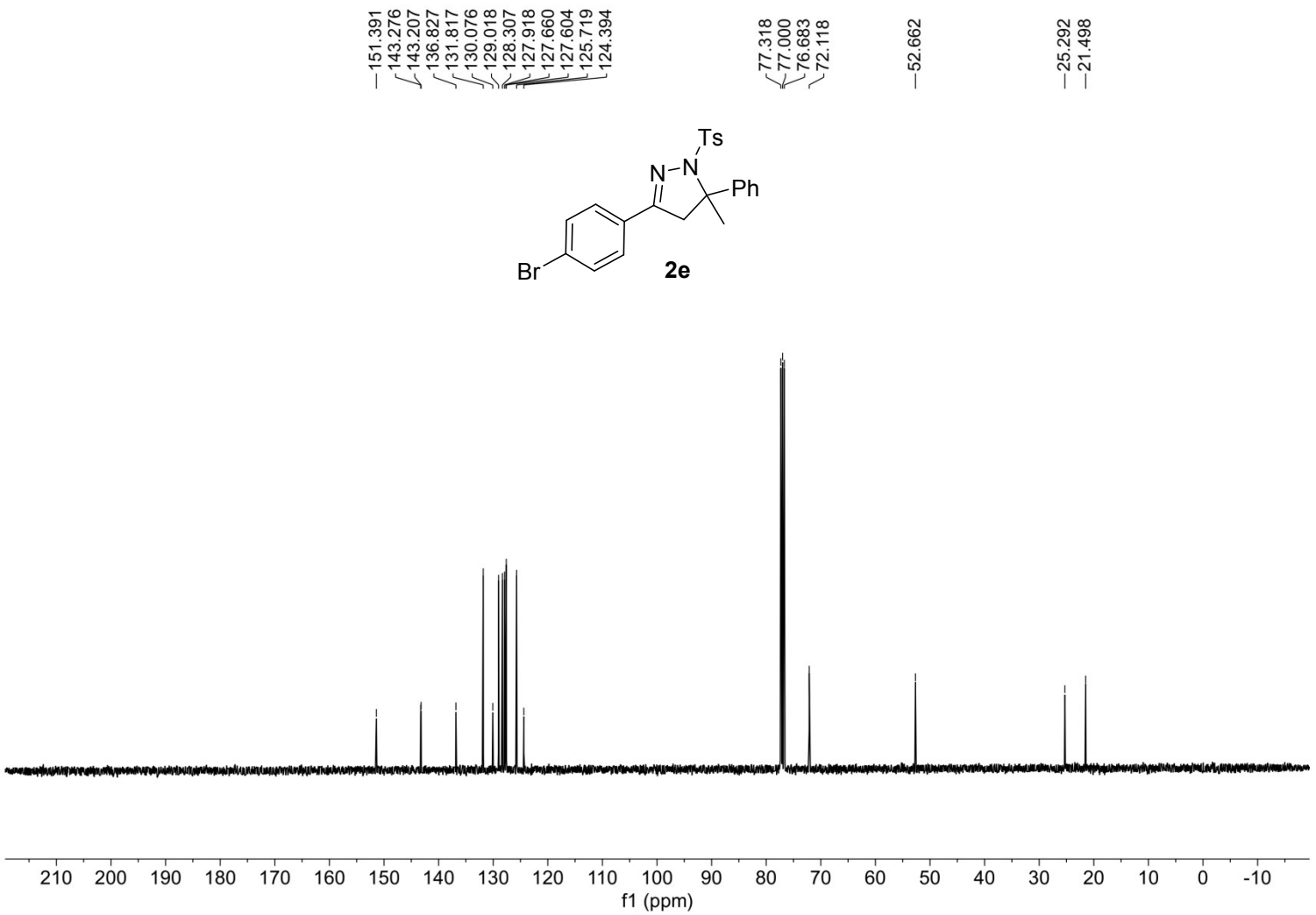
7.325
7.321
7.307
7.301
7.260
7.243
7.225
7.212
7.203
7.154
7.134
3.484
3.440
3.359
3.316
2.371
2.029
Ts
N
N
Ph
Br
2e
6.01
2.02
3.00
2.00
1.04
1.02
3.01
3.03
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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77.318
77.000
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72.118
52.662
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N
Ph
Br
2e
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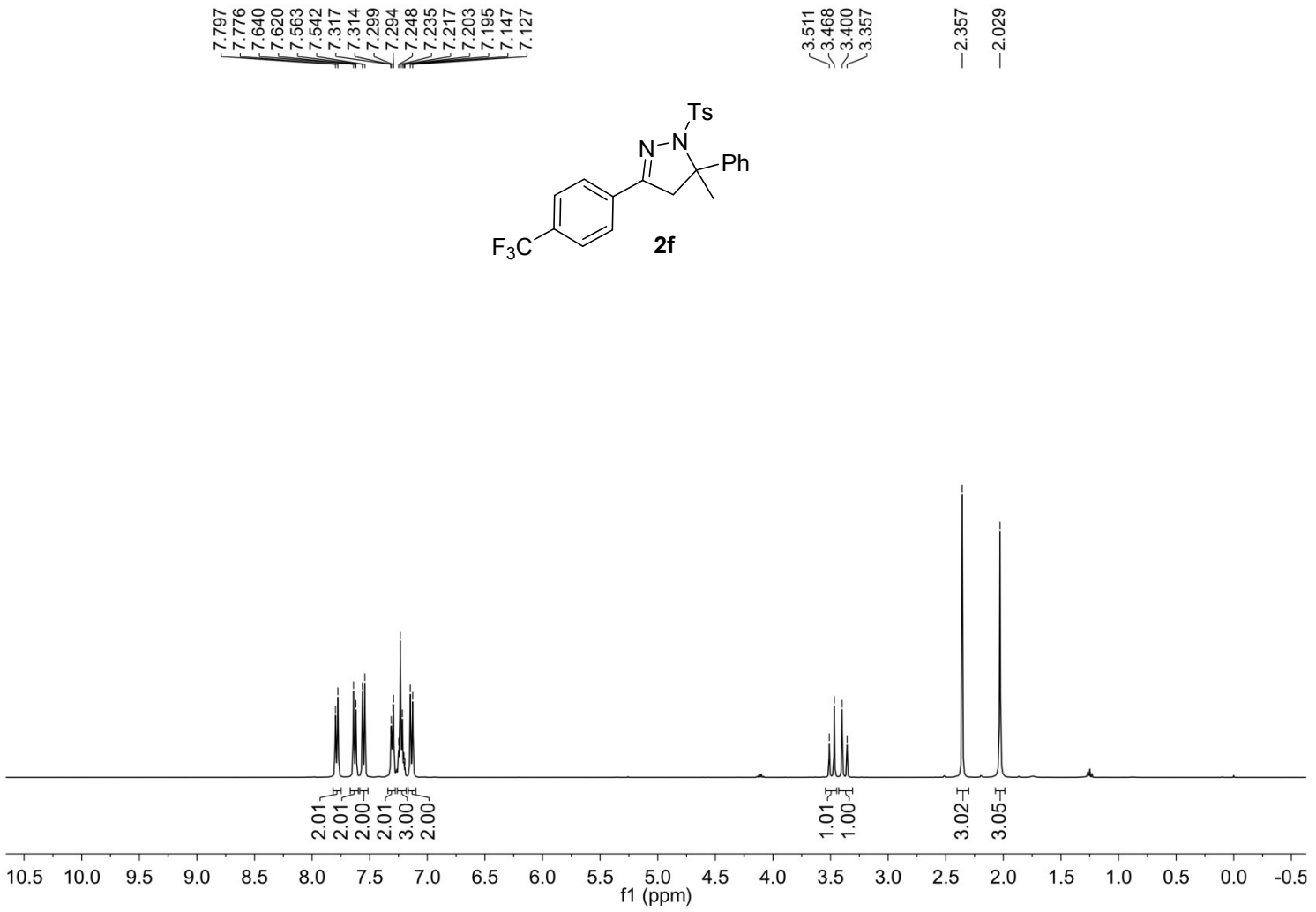
f1 (ppm)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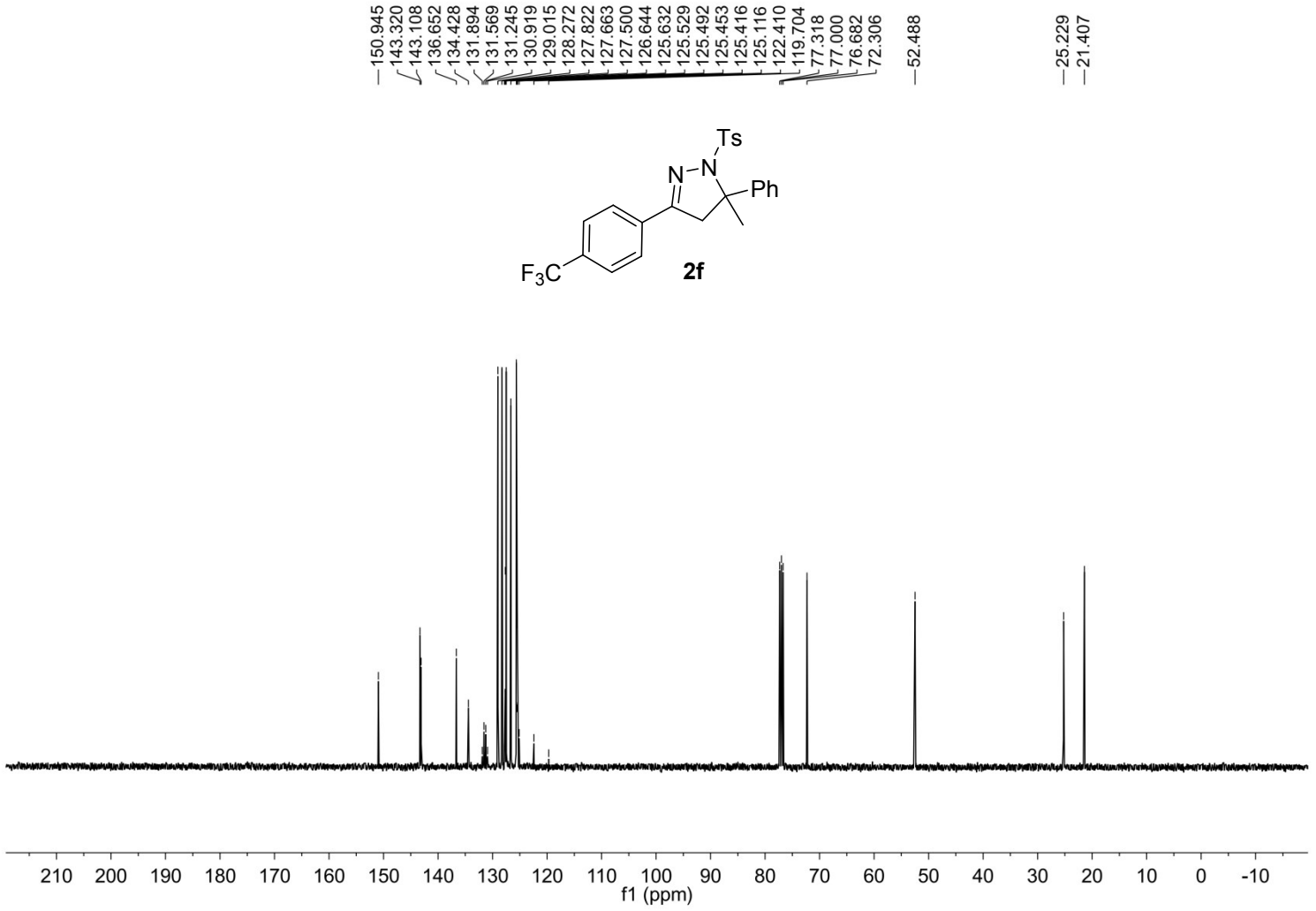
7.294
7.248
7.235
7.217
7.203
7.195
7.147
7.127
3.511
3.468
3.400
3.357
2.357
2.029
Ts
N
N
Ph
F3C
2f
2.01
2.01
2.00
2.01
3.00
2.00
1.01
1.00
3.02
3.05
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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134.428
131.894
131.569
131.245
130.919
129.015
128.272
127.822
127.663
127.500
126.644
125.632
125.529
125.492
125.453
125.416
125.116
122.410
119.704
77.318
77.000
76.682
72.306
52.488
25.229
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N
Ph
F3C
2f
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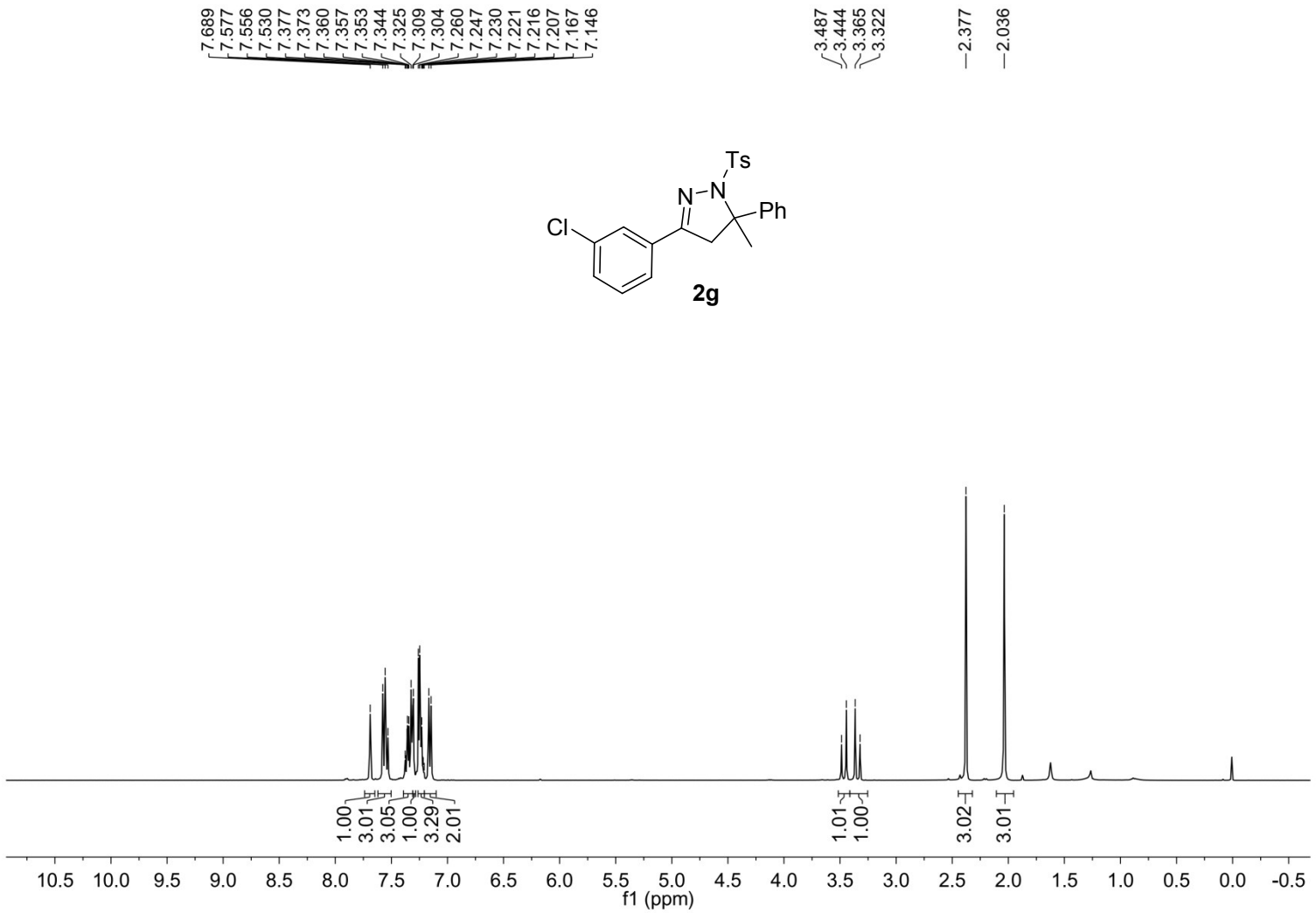
f1 (ppm)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7.344
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7.309
7.304
7.260
7.247
7.230
7.221
7.216
7.207
7.167
7.146
3.487
3.444
3.365
3.322
2.377
2.036
Ts
N
N
Ph
Cl
2g
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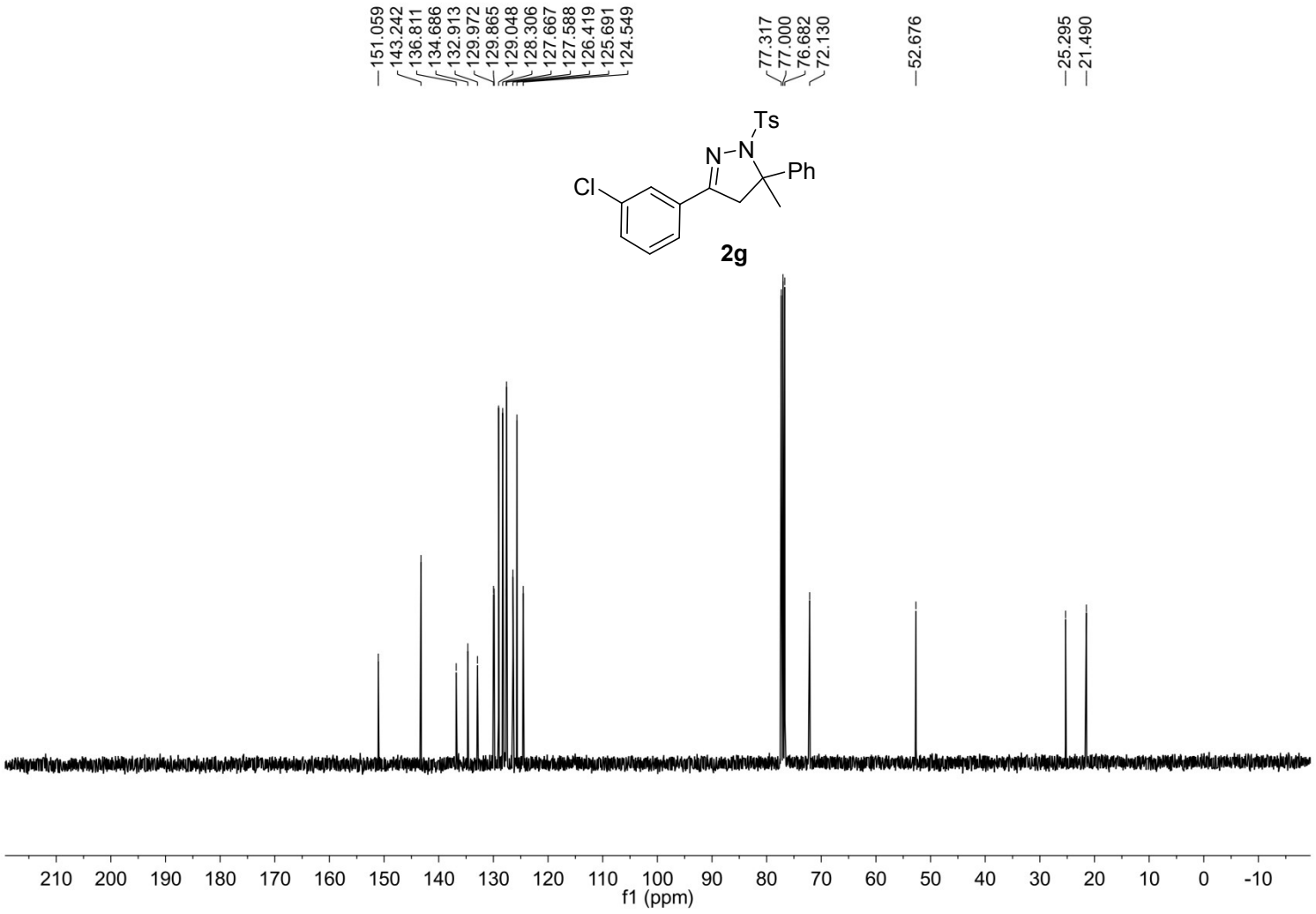
3.01
3.05
1.00
3.29
2.01
1.01
1.00
3.02
3.01
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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125.691
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77.000
76.682
72.130
52.676
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Cl
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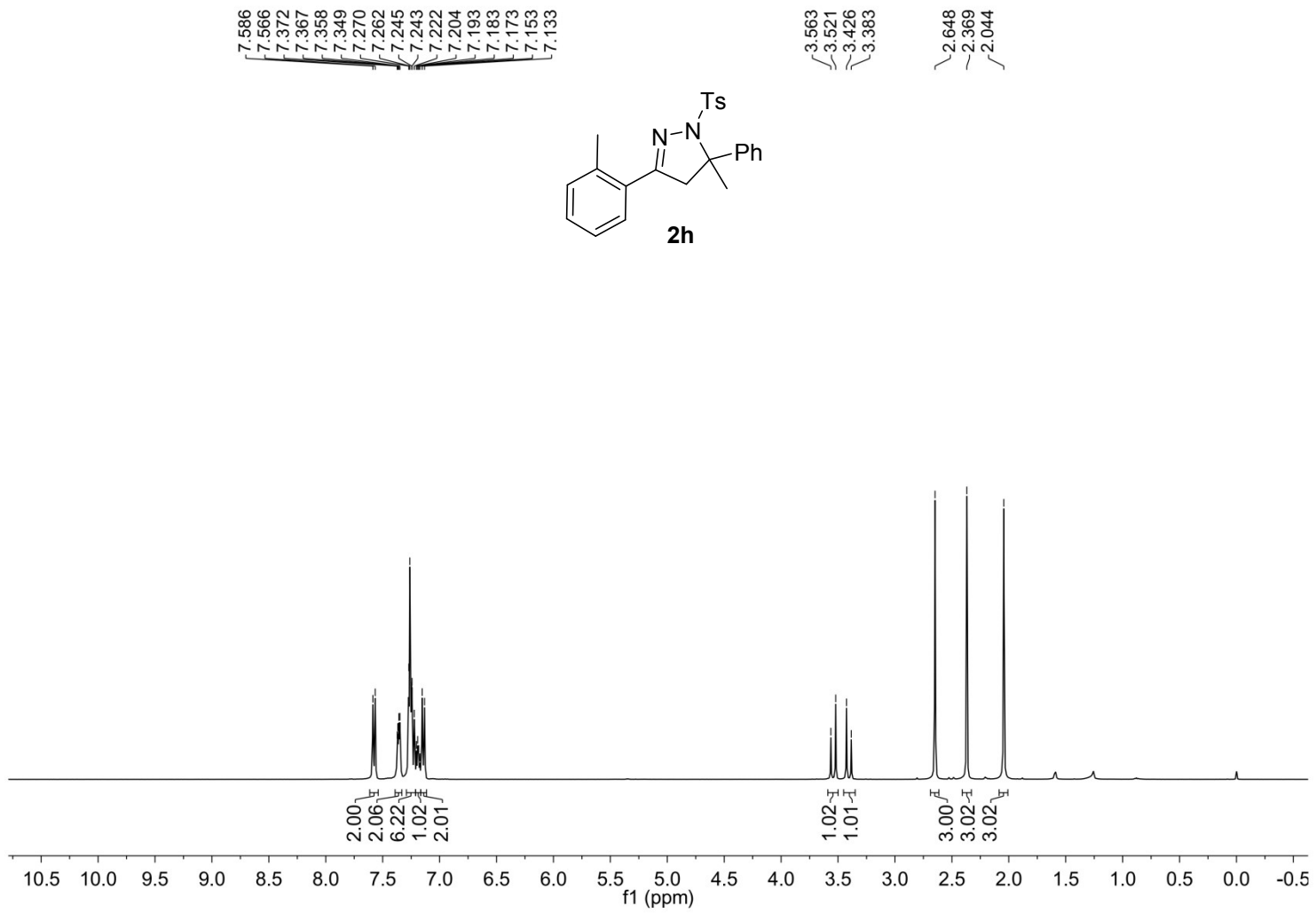
f1 (ppm)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7.262
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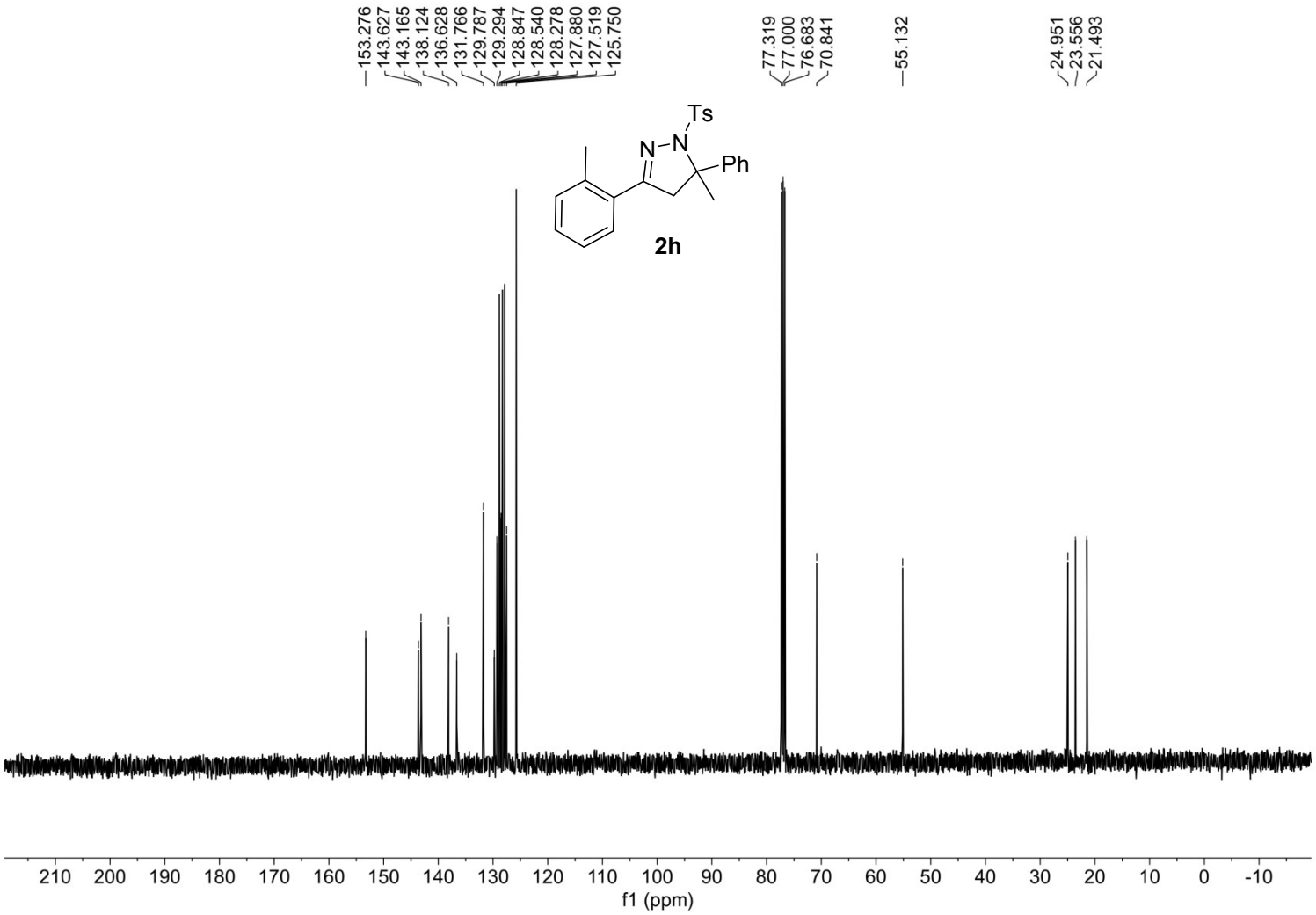
7.243
7.222
7.204
7.193
7.183
7.173
7.153
7.133
3.563
3.521
3.426
3.383
2.648
2.369
2.044
Ts
N
N
Ph
2h
2.00
2.06
6.22
1.02
2.01
1.02
1.01
3.00
3.02
3.02
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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129.787
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128.540
128.278
127.880
127.519
125.750
77.319
77.000
76.683
70.841
55.132
24.951
23.556
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Ts
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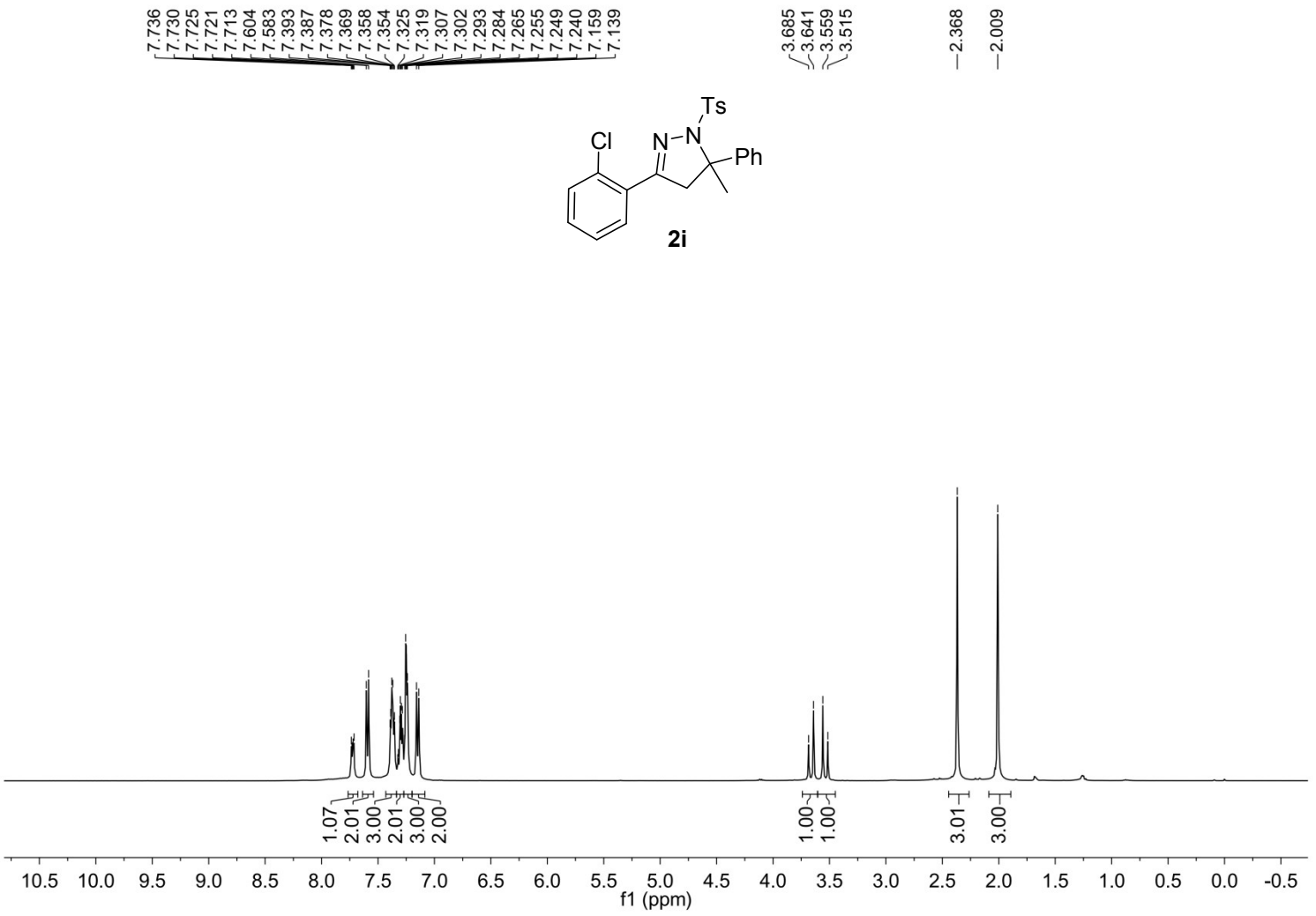
Ph
2h
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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7.713
7.604
7.583
7.393
7.387
7.378
7.369
7.358
7.354
7.325
7.319
7.307
7.302
7.293
7.284
7.265
7.255
7.249
7.240
7.159
7.139
3.685
3.641
3.559
3.515
2.368
2.009
Ts
Cl
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N
Ph
2i
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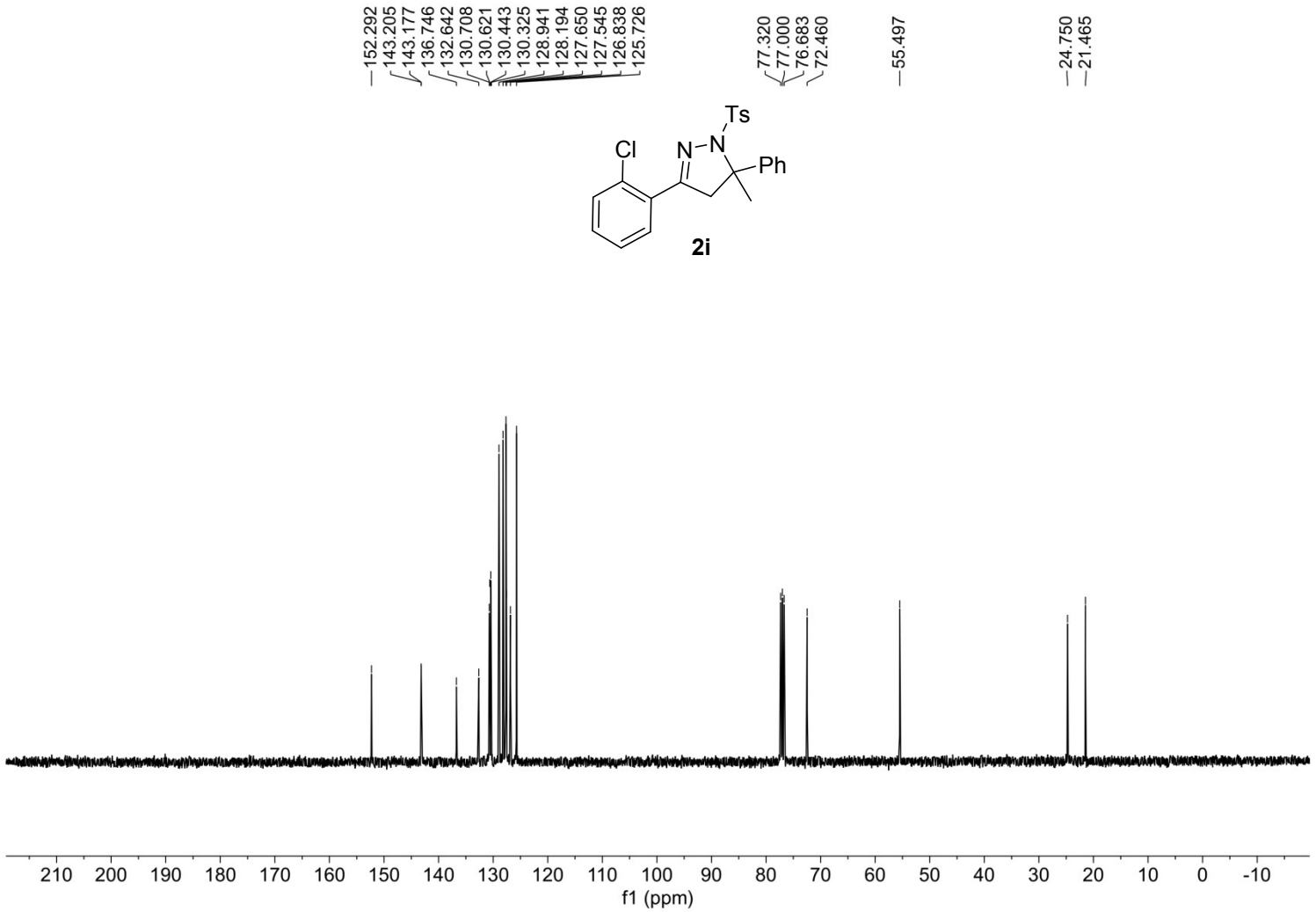
2.01
3.00
2.01
3.00
2.00
1.00
1.00
3.01
3.00
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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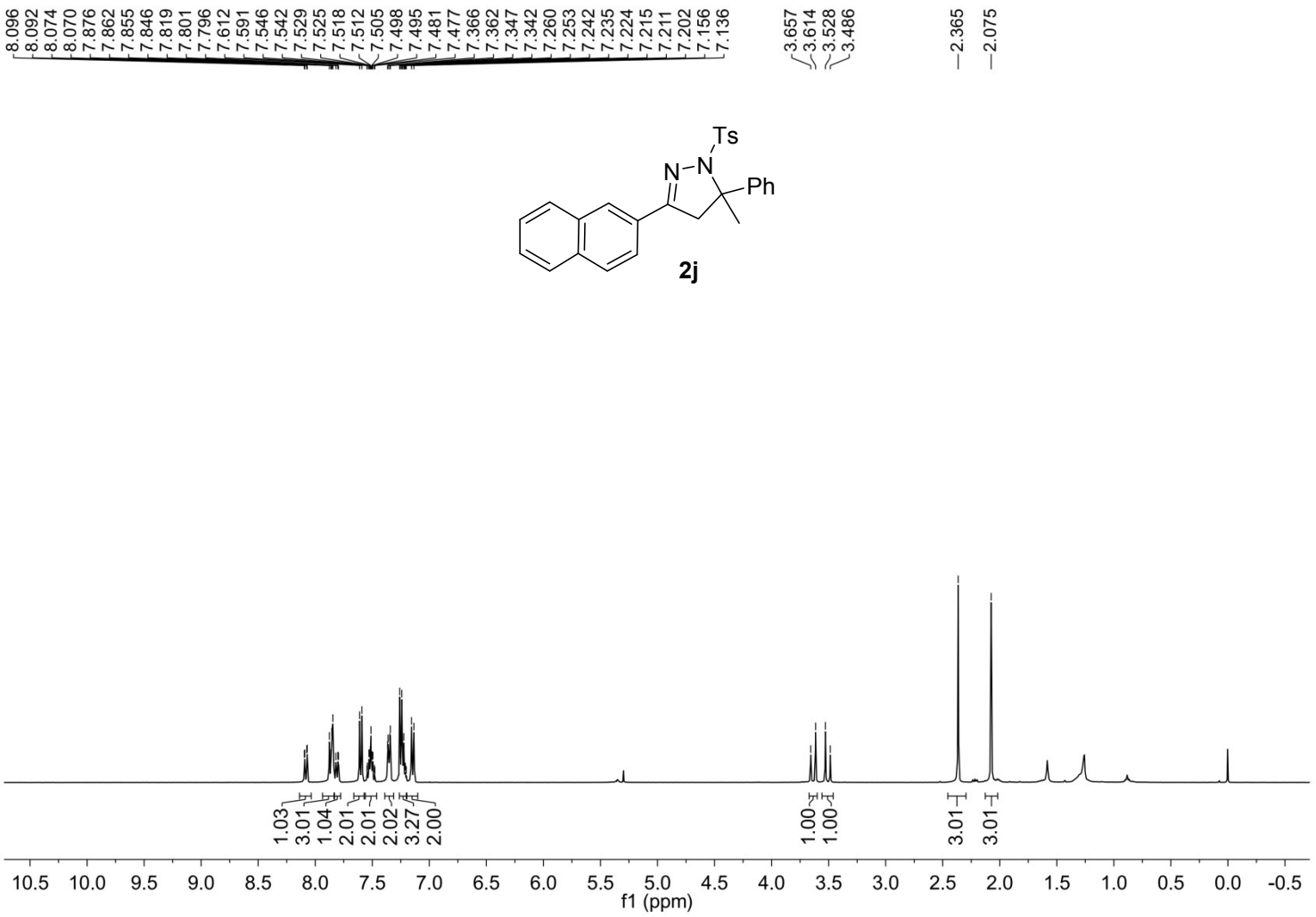
130.325
128.941
128.194
127.650
127.545
126.838
125.726
77.320
77.000
76.683
72.460
55.497
24.750
21.465
Ts
Cl
N
N
Ph
2i
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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7.846
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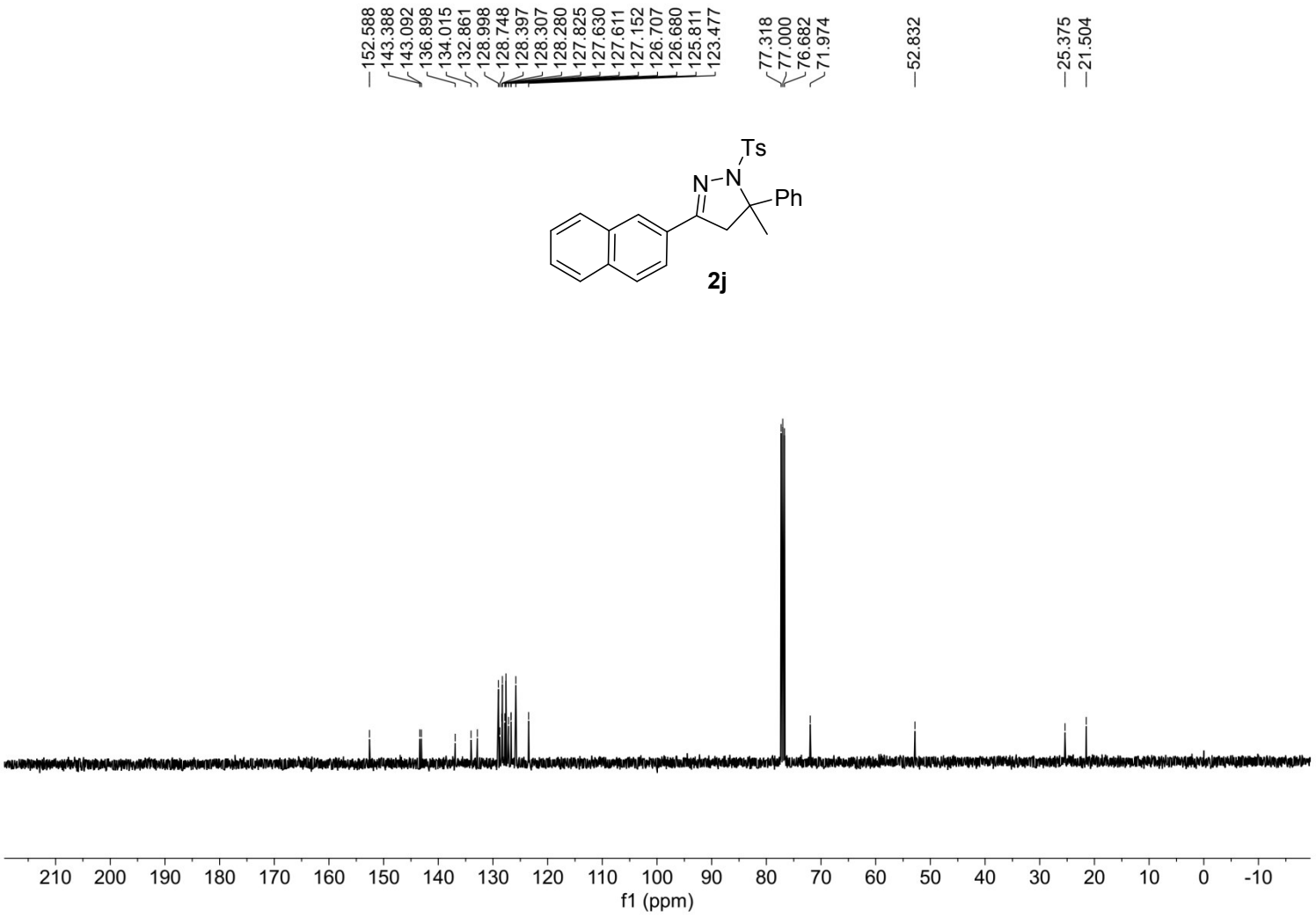
7.612
7.591
7.546
7.542
7.529
7.525
7.518
7.512
7.505
7.498
7.495
7.481
7.477
7.366
7.362
7.347
7.342
7.260
7.253
7.242
7.235
7.224
7.215
7.211
7.202
7.156
7.136
3.657
3.614
3.528
3.486
2.365
2.075
Ts
N
N
Ph
2j
1.03
3.01
1.04
2.01
2.01
2.02
3.27
2.00
1.00
1.00
3.01
3.01
10.5 10.0 9.5 9.0 8.5 8.0 7.5 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 -0.5
f1 (ppm)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128.748
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128.280
127.825
127.630
127.611
127.152
126.707
126.680
125.811
123.477
77.318
77.000
76.682
71.974
52.832
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21.504
Ts
N
N
Ph
2j
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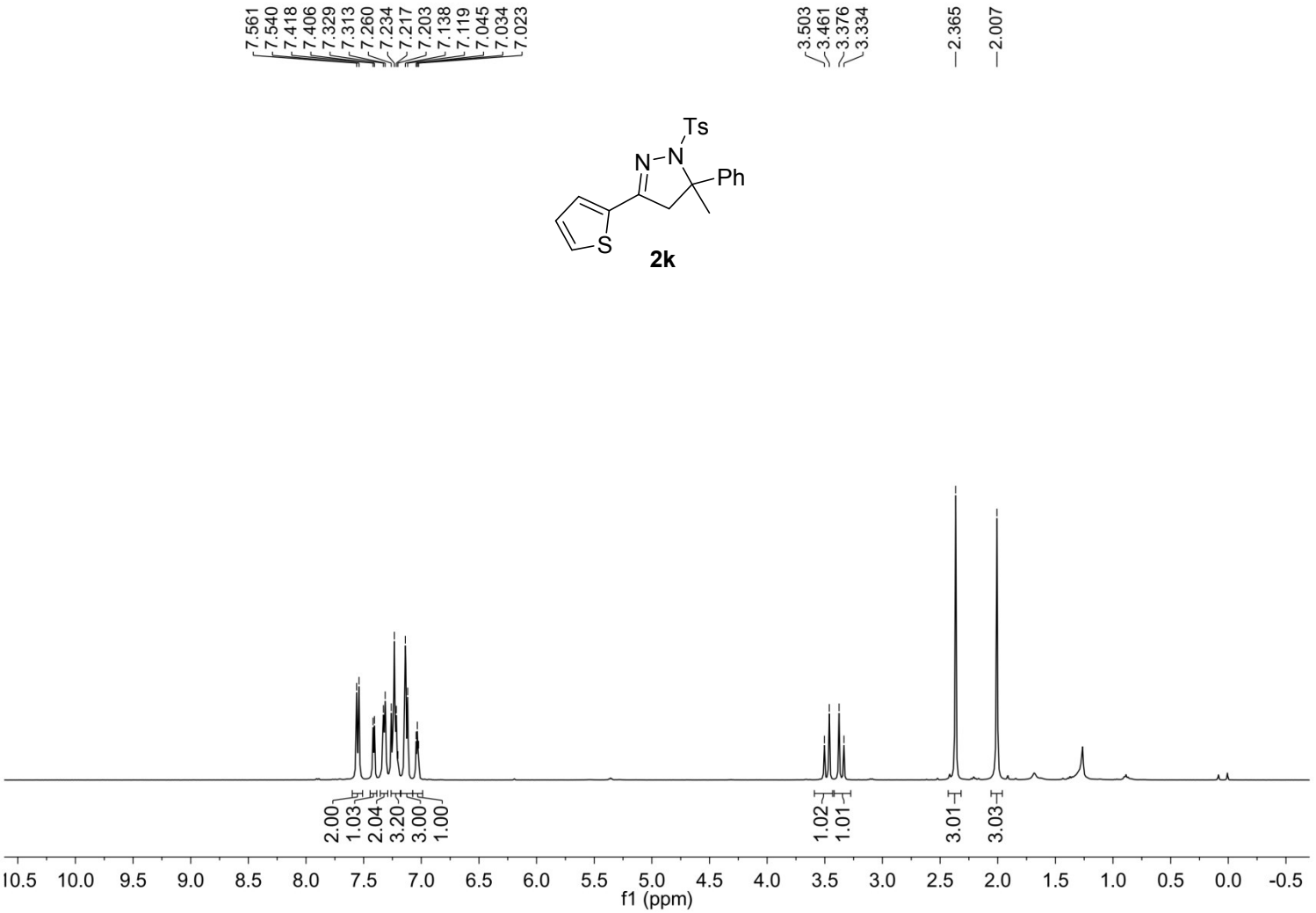
f1 (ppm)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7.203
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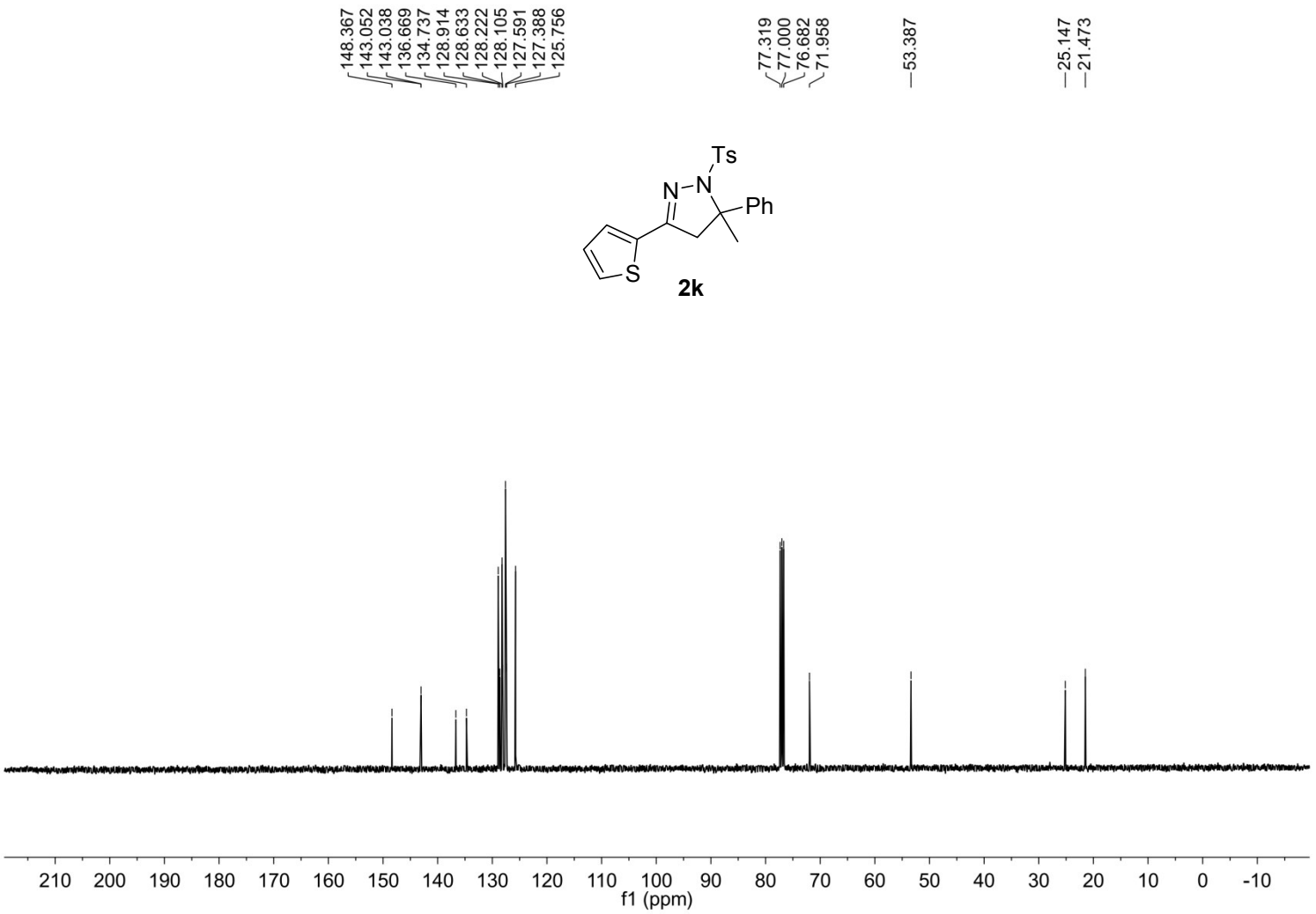
7.119
7.045
7.034
7.023
3.503
3.461
3.376
3.334
2.365
2.007
Ts
N
N
Ph
S
2k
2.00
1.03
2.04
3.20
3.00
1.00
1.02
1.01
3.01
3.03
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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143.038
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128.105
127.591
127.388
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77.319
77.000
76.682
71.958
53.387
25.147
21.473
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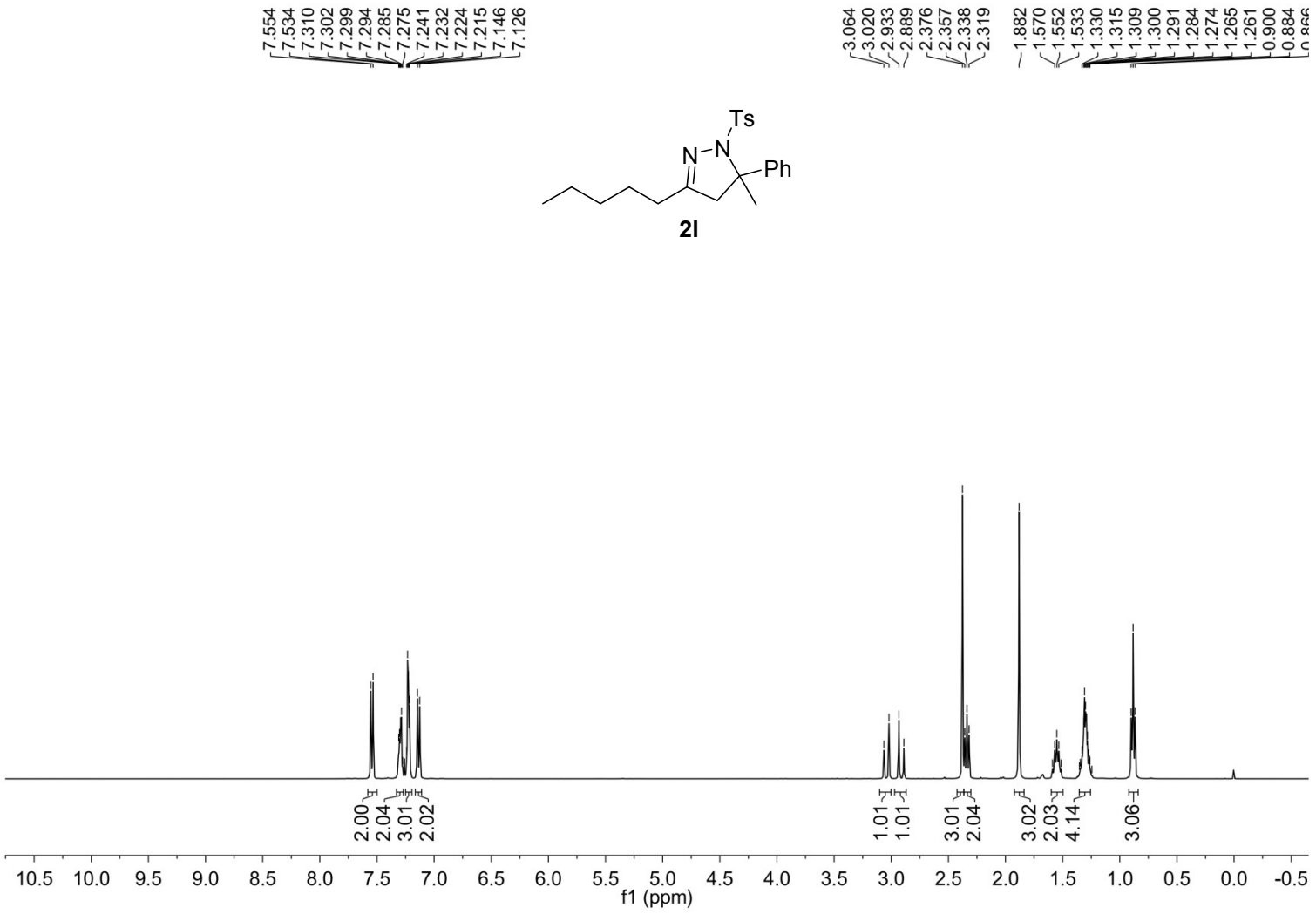
N
N
Ph
S
2k
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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7.275
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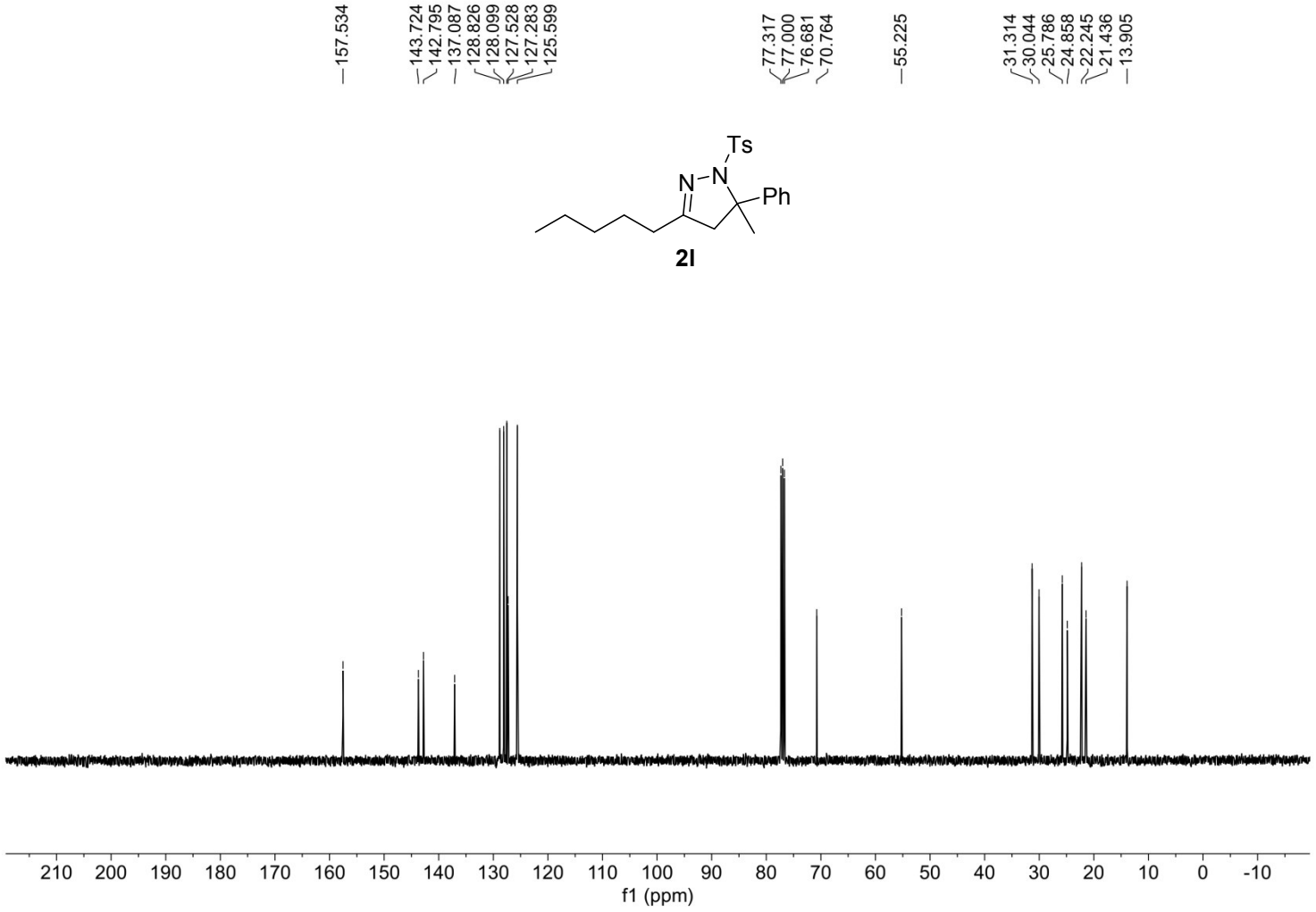
7.232
7.224
7.215
7.146
7.126
3.064
3.020
2.933
2.889
2.376
2.357
2.338
2.319
1.882
1.570
1.552
1.533
1.330
1.315
1.309
1.300
1.291
1.284
1.274
1.265
1.261
0.900
0.884
Ts
N
N
Ph
2.00
2.04
3.01
2.02
1.01
1.01
3.01
2.04
3.02
2.03
4.14
3.06
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

**2l**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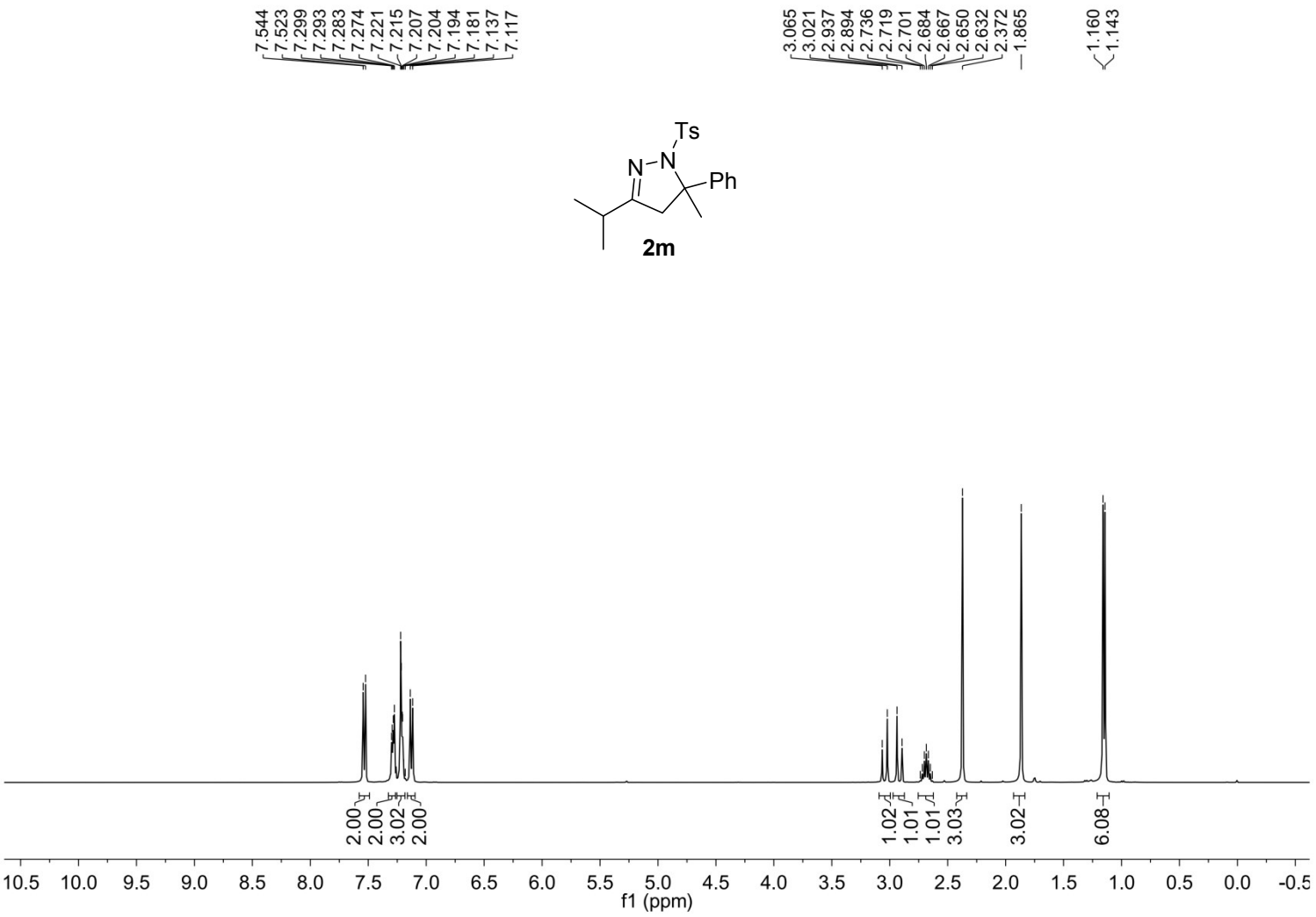
142.795
137.087
128.826
128.099
127.528
127.283
125.599
77.317
77.000
76.681
70.764
55.225
31.314
30.044
25.786
24.858
22.245
21.436
13.905
Ts
N
N
Ph
2l
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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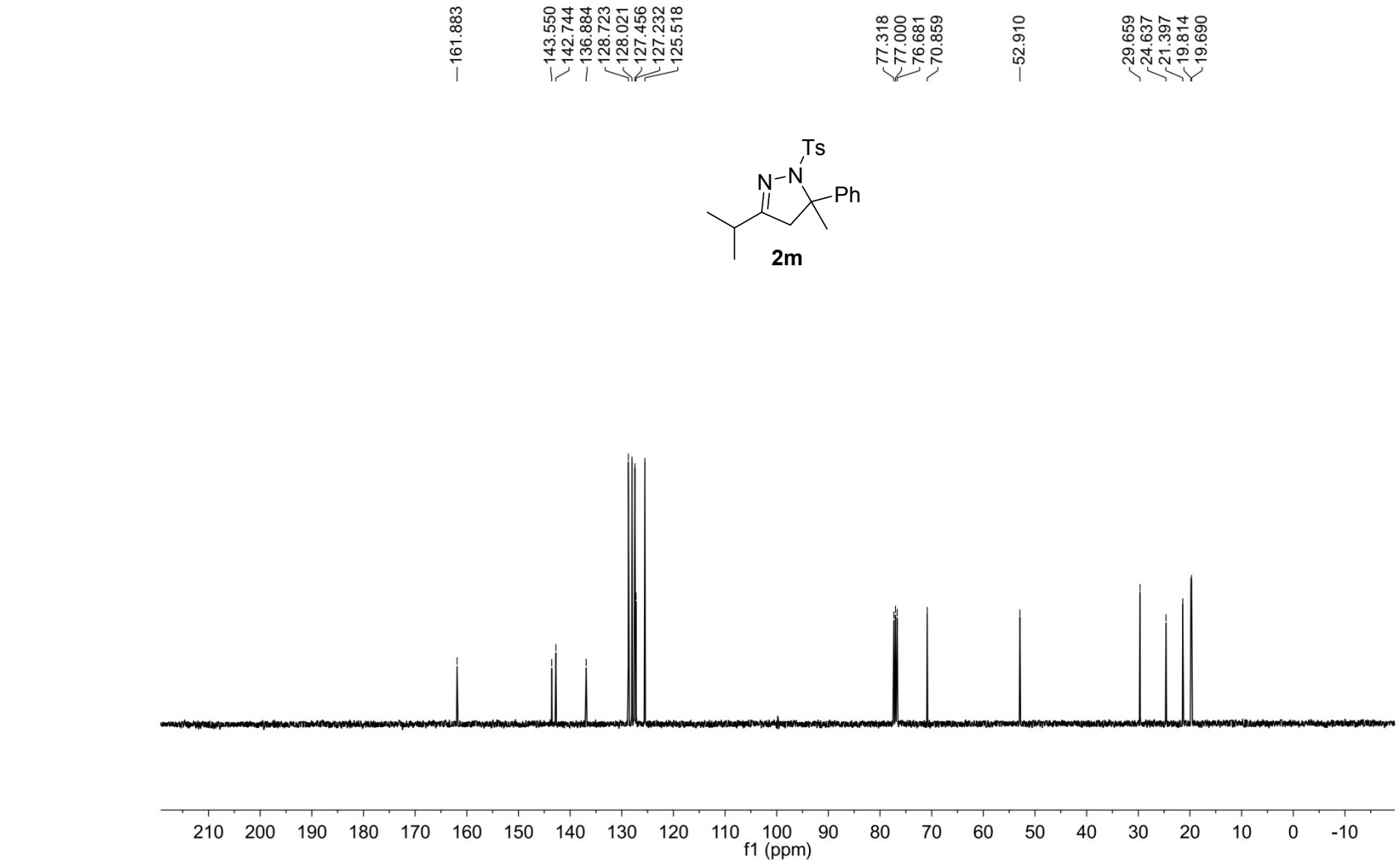
7.523
7.299
7.293
7.283
7.274
7.221
7.215
7.207
7.204
7.194
7.181
7.137
7.117
3.065
3.021
2.937
2.894
2.736
2.719
2.701
2.684
2.667
2.650
2.632
2.372
1.865
1.160
1.143
Ts
N
N
Ph
2m
2.00
2.00
3.02
2.00
1.02
1.01
1.01
3.03
3.02
6.08
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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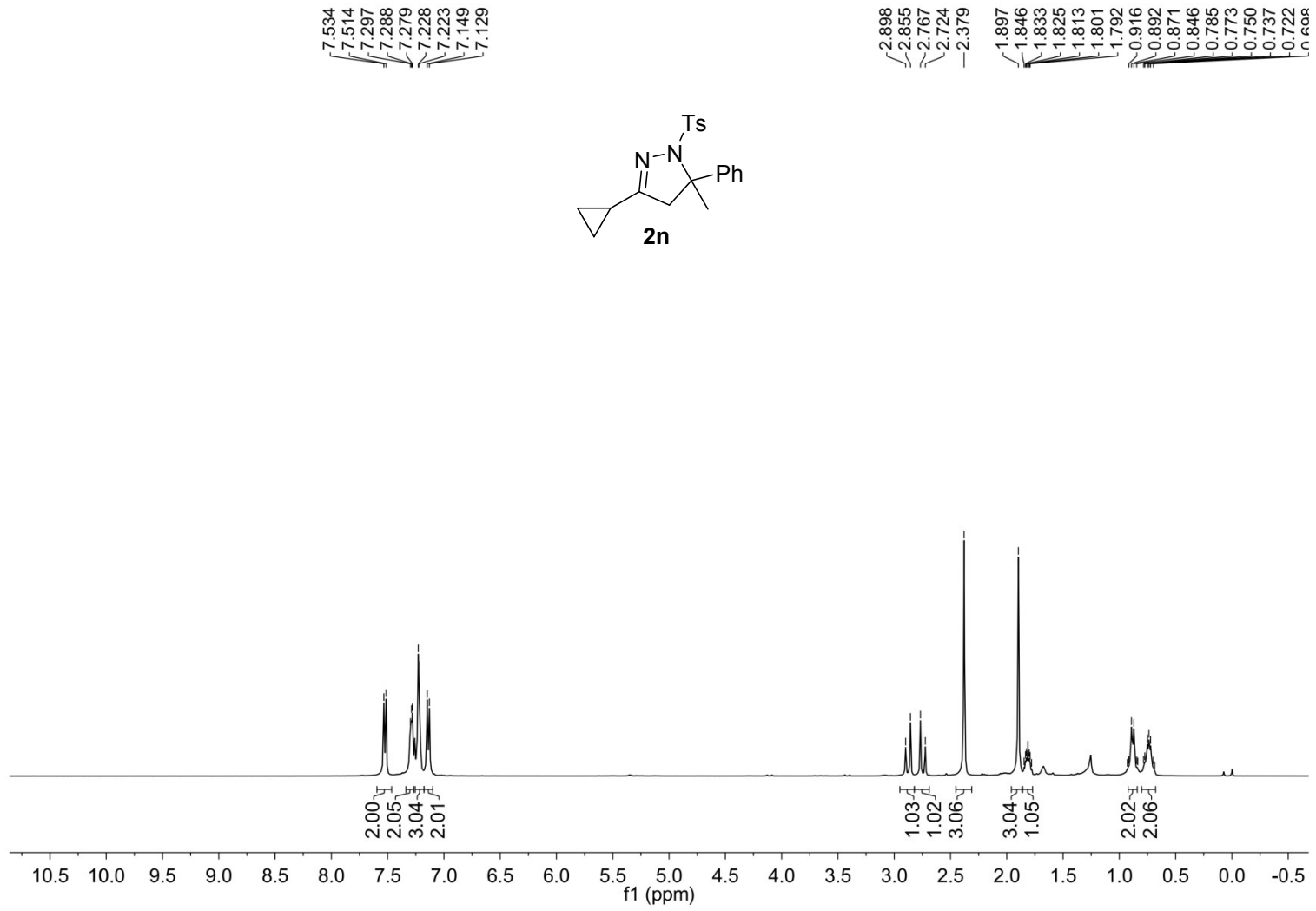
142.744
136.884
128.723
128.021
127.456
127.232
125.518
77.318
77.000
76.681
70.859
52.910
29.659
24.637
21.397
19.814
19.690
Ts
N
N
Ph
2m
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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7.288
7.279
7.228
7.223
7.149
7.129
2.898
2.855
2.767
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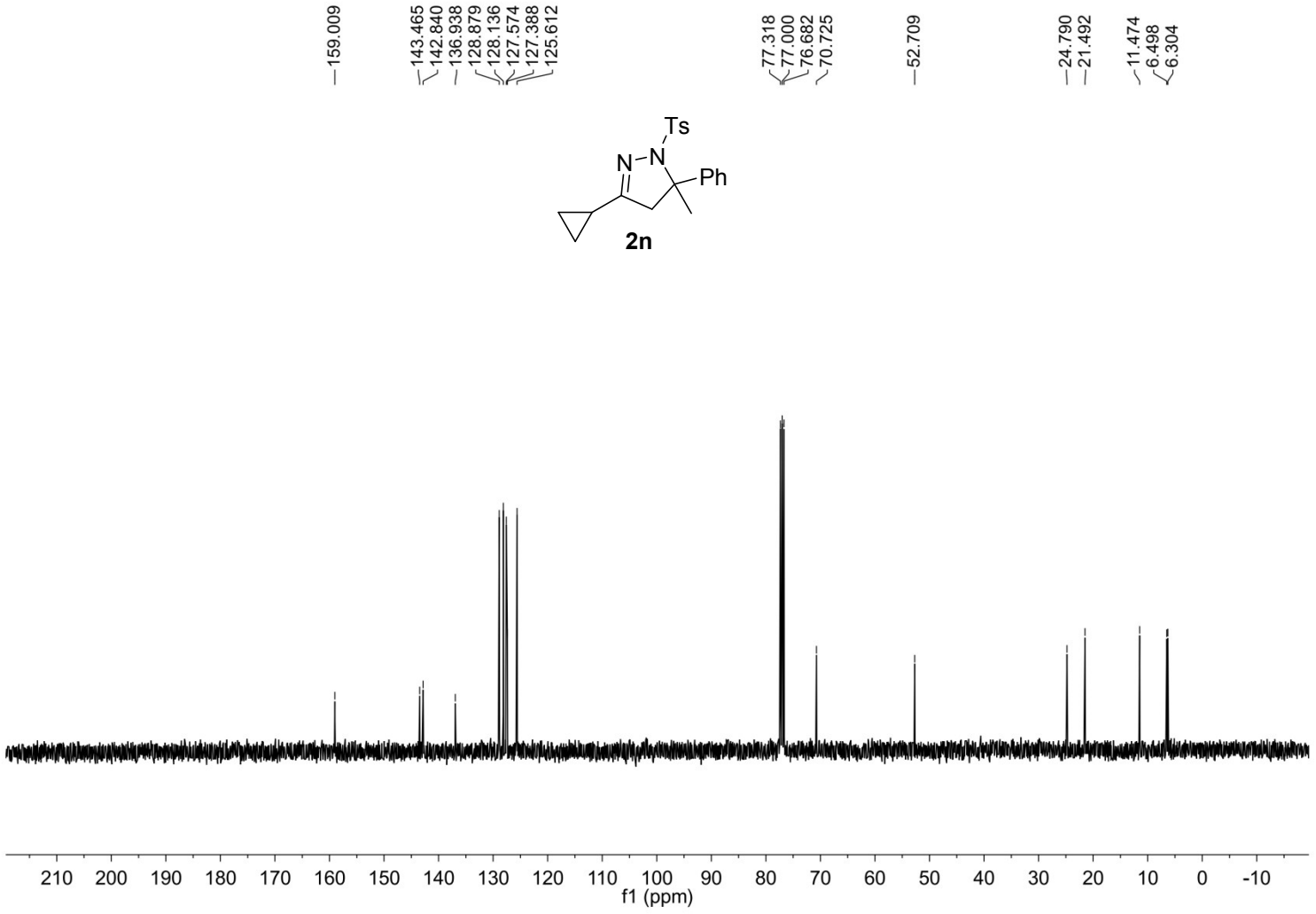
2.379
1.897
1.846
1.833
1.825
1.813
1.801
1.792
0.916
0.892
0.871
0.846
0.785
0.773
0.750
0.737
0.722
Ts
N
N
Ph
2n
2.00
2.05
3.04
2.01
1.03
1.02
3.06
3.04
1.05
2.02
2.06
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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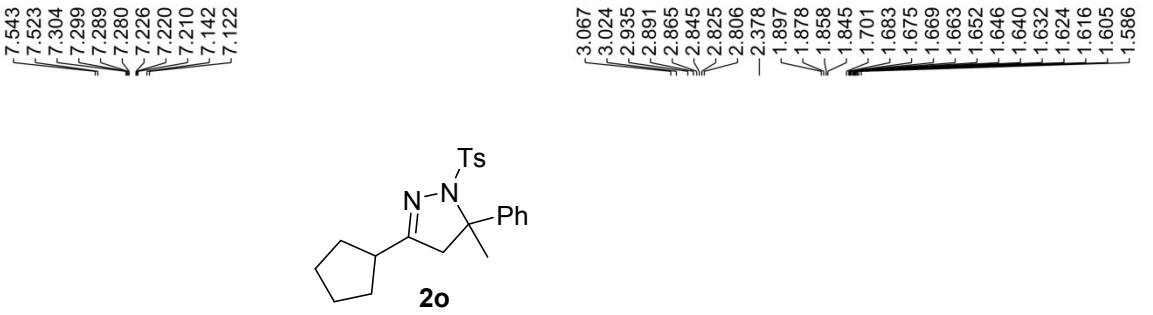
142.840
136.938
128.879
128.136
127.574
127.388
125.612
77.318
77.000
76.682
70.725
52.709
24.790
21.492
11.474
6.498
6.304
Ts
N
N
Ph
2n
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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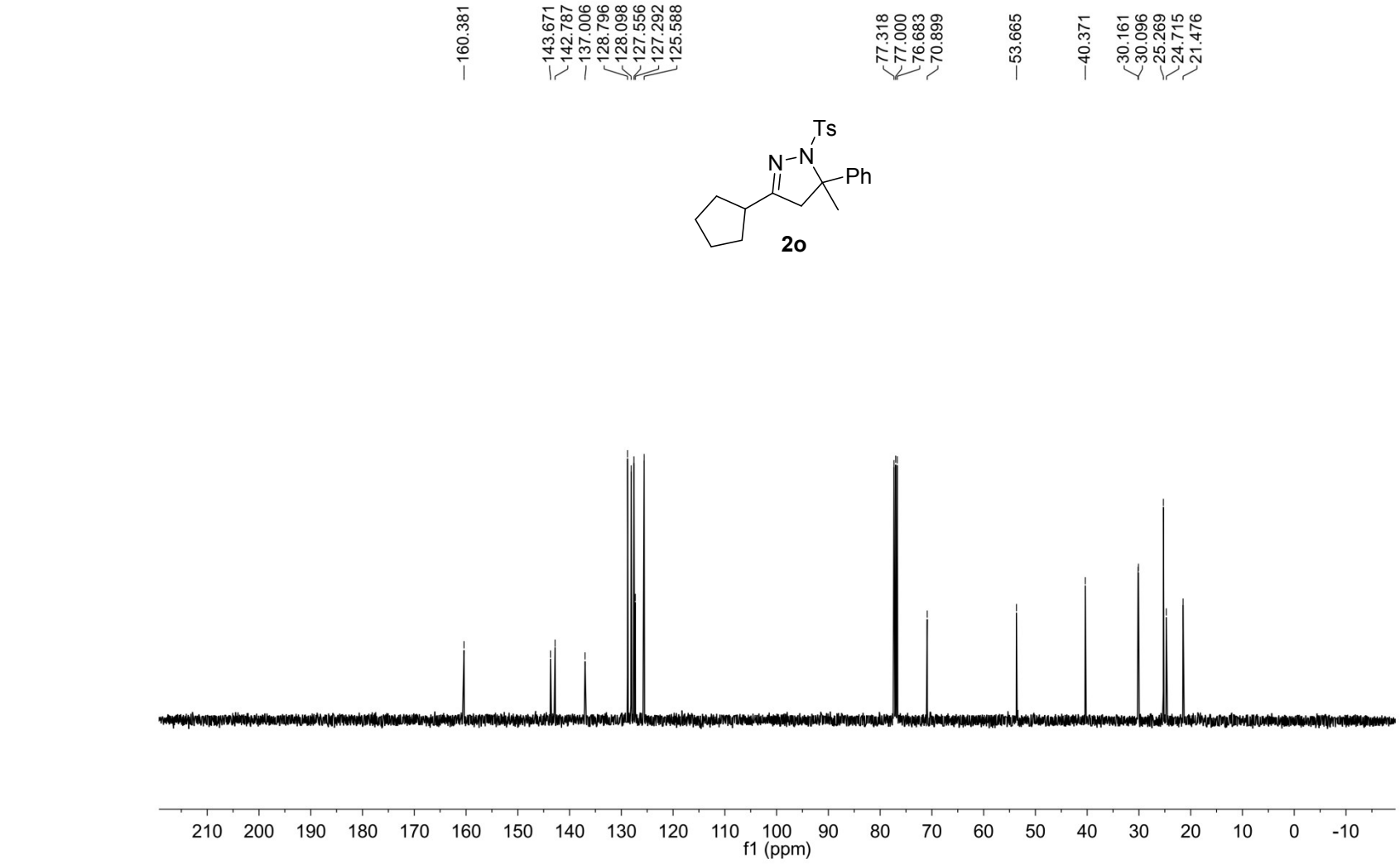
7.304
7.299
7.289
7.280
7.226
7.220
7.210
7.142
7.122
3.067
3.024
2.935
2.891
2.865
2.845
2.825
2.806
2.378
1.897
1.878
1.858
1.845
1.701
1.683
1.675
1.669
1.663
1.652
1.646
1.640
1.632
1.624
1.616
1.605
1.586
Ts
N
N
Ph
2o
2.00
2.00
3.01
2.00
1.03
1.02
1.02
3.07
5.04
6.15
10.5 10.0 9.5 9.0 8.5 8.0 7.5 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 -0.5
f1 (ppm)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128.098
127.556
127.292
125.588
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77.000
76.683
70.899
53.665
40.371
30.161
30.096
25.269
24.715
21.476
Ts
N
N
Ph
2o
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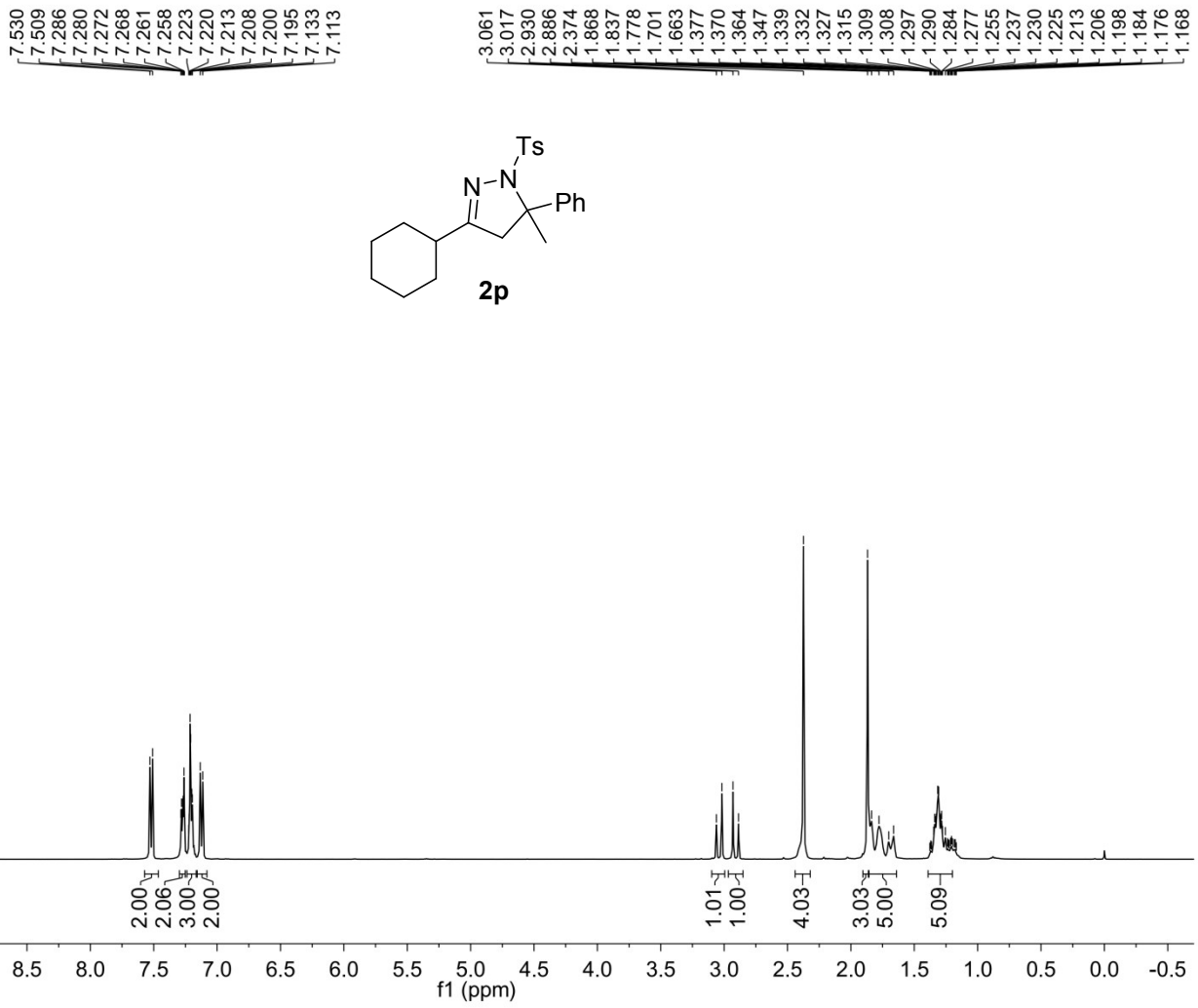
f1 (ppm)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7.272
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7.261
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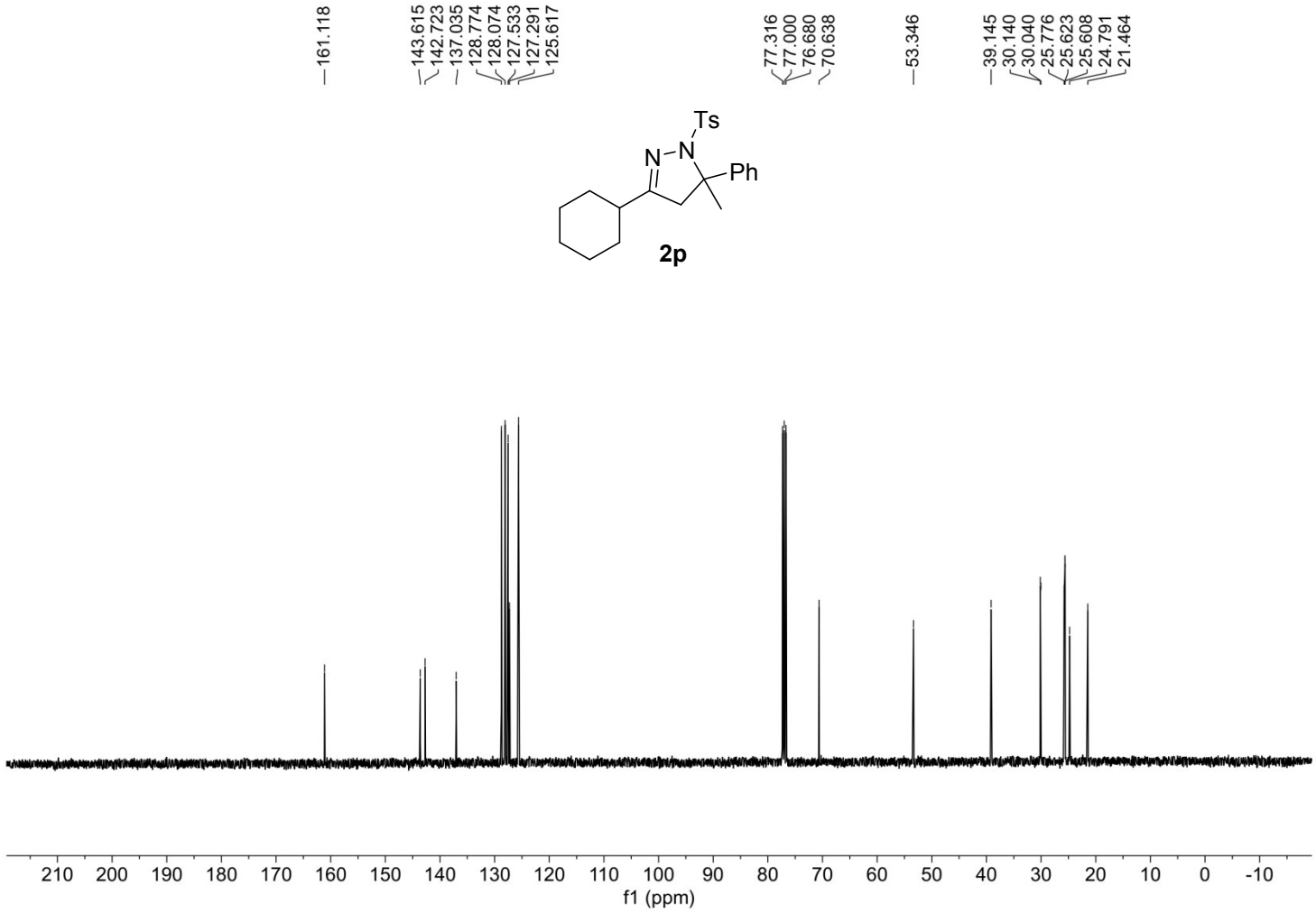
7.223
7.220
7.213
7.208
7.200
7.195
7.133
7.113
3.061
3.017
2.930
2.886
2.374
1.868
1.837
1.778
1.701
1.663
1.377
1.370
1.364
1.347
1.339
1.332
1.327
1.315
1.309
1.308
1.297
1.290
1.284
1.277
1.255
1.237
1.230
1.225
1.213
1.206
1.198
1.184
1.176
1.168
Ts
N
N
Ph
2p
2.00
2.06
3.00
2.00
1.01
1.00
4.03
3.03
5.00
5.09
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 -0.5
f1 (ppm)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127.291
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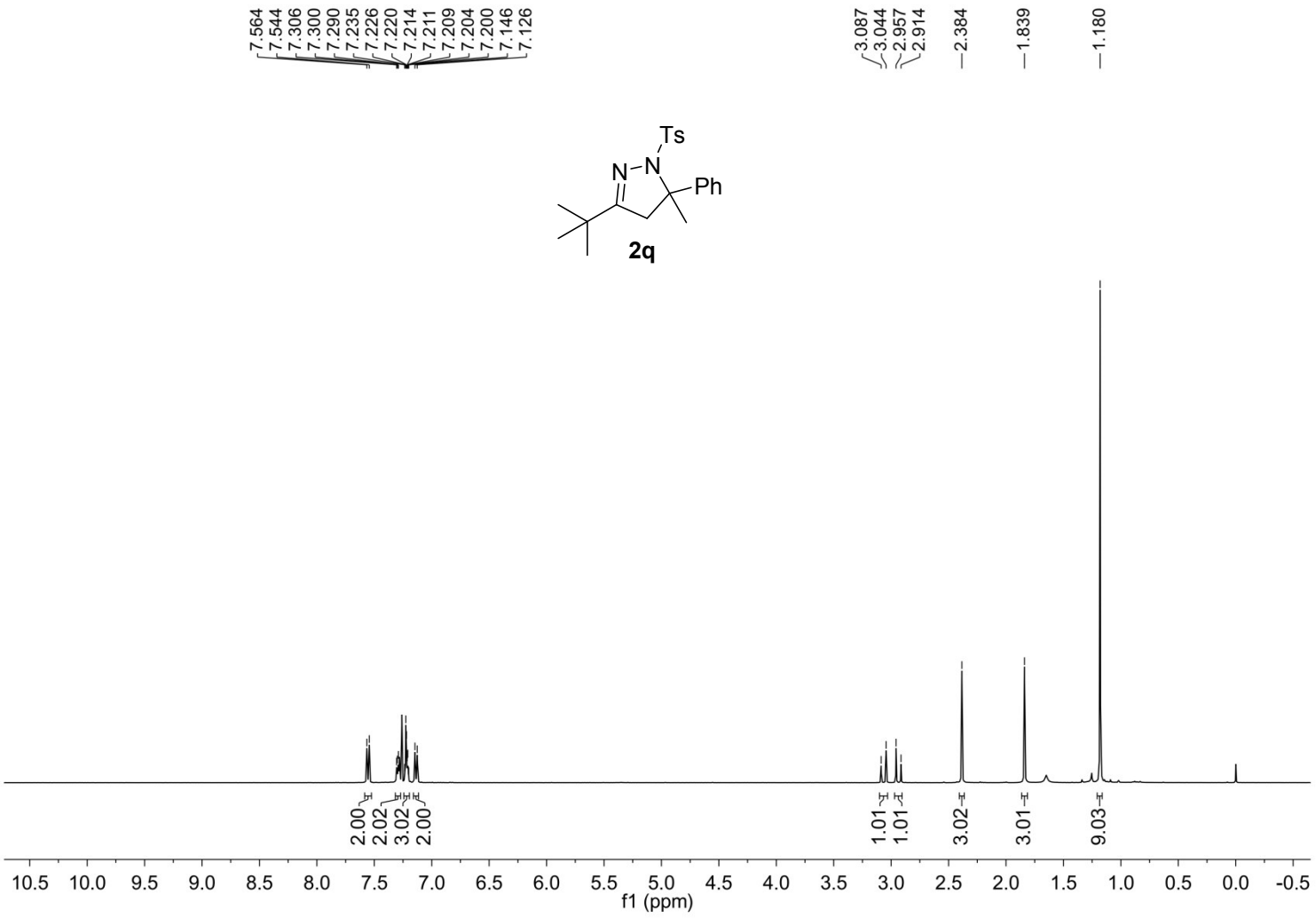
77.000
76.680
70.638
53.346
39.145
30.140
30.040
25.776
25.623
25.608
24.791
21.464
Ts
N
N
Ph
2p
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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7.235
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7.220
7.214
7.211
7.209
7.204
7.200
7.146
7.126
3.087
3.044
2.957
2.914
2.384
1.839
1.180
Ts
N
N
Ph
2q
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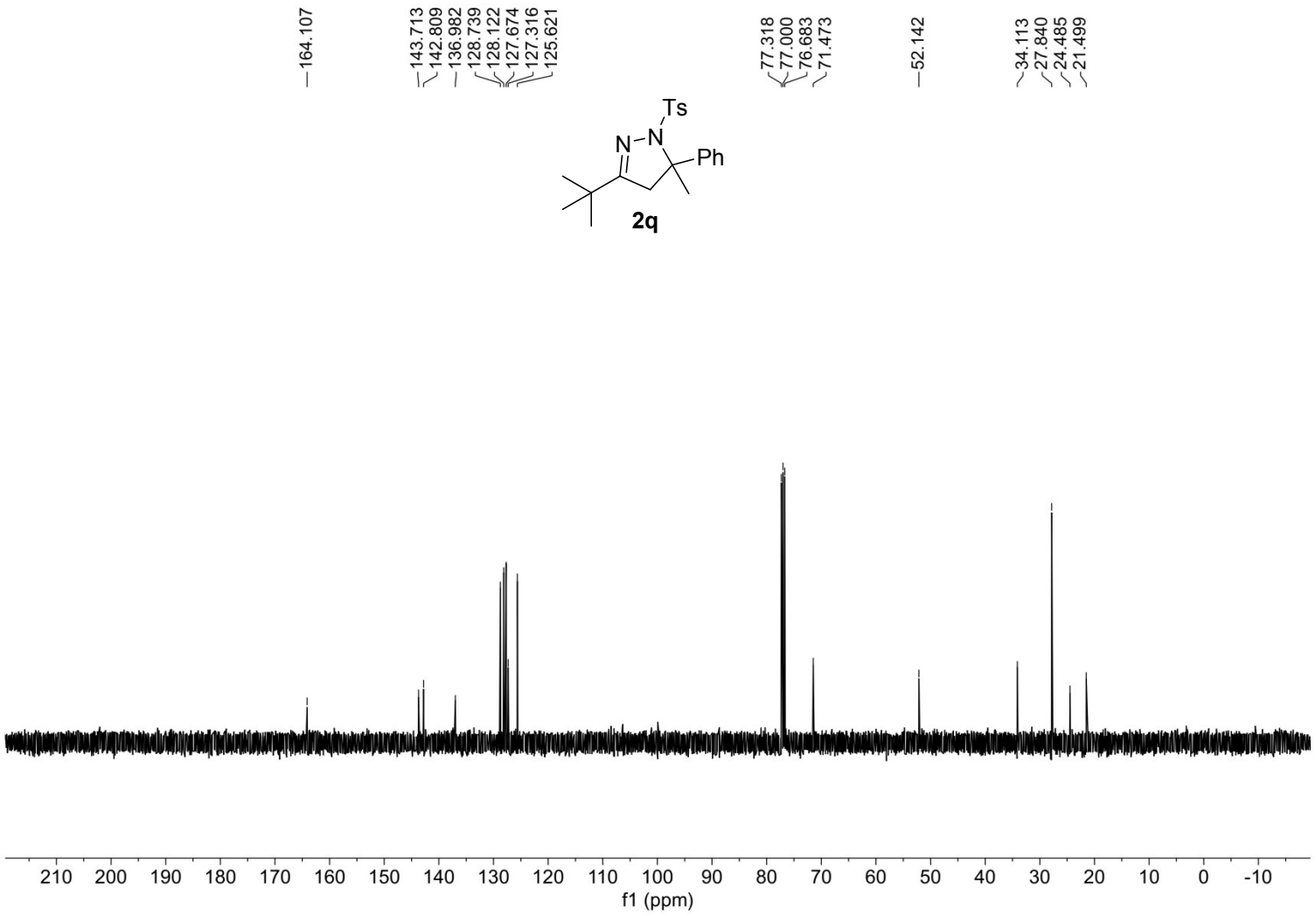
2.02
3.02
2.00
1.01
1.01
3.02
3.01
9.03
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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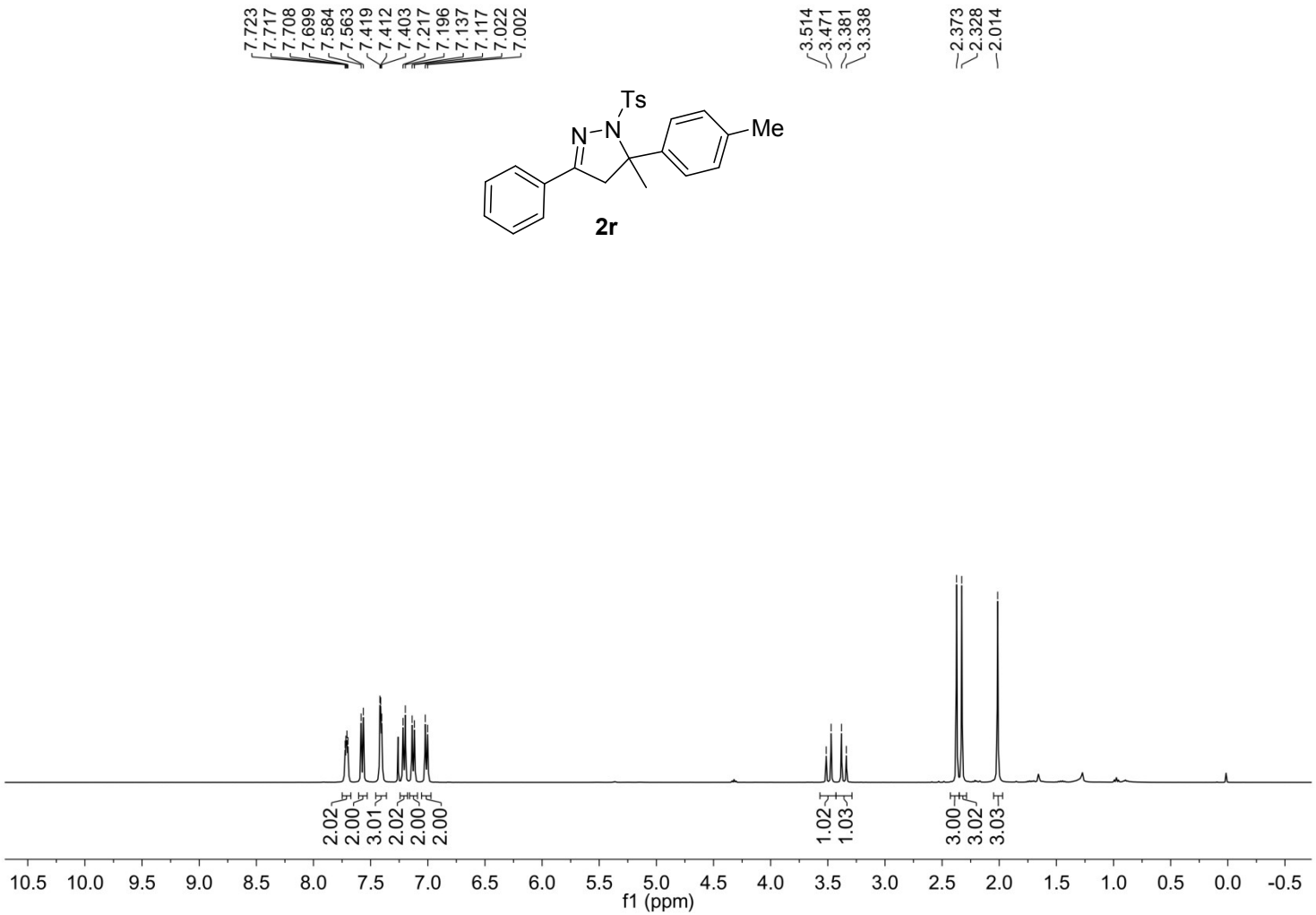
142.809
136.982
128.739
128.122
127.674
127.316
125.621
77.318
77.000
76.683
71.473
52.142
34.113
27.840
24.485
21.499
Ts
N
N
Ph
2q
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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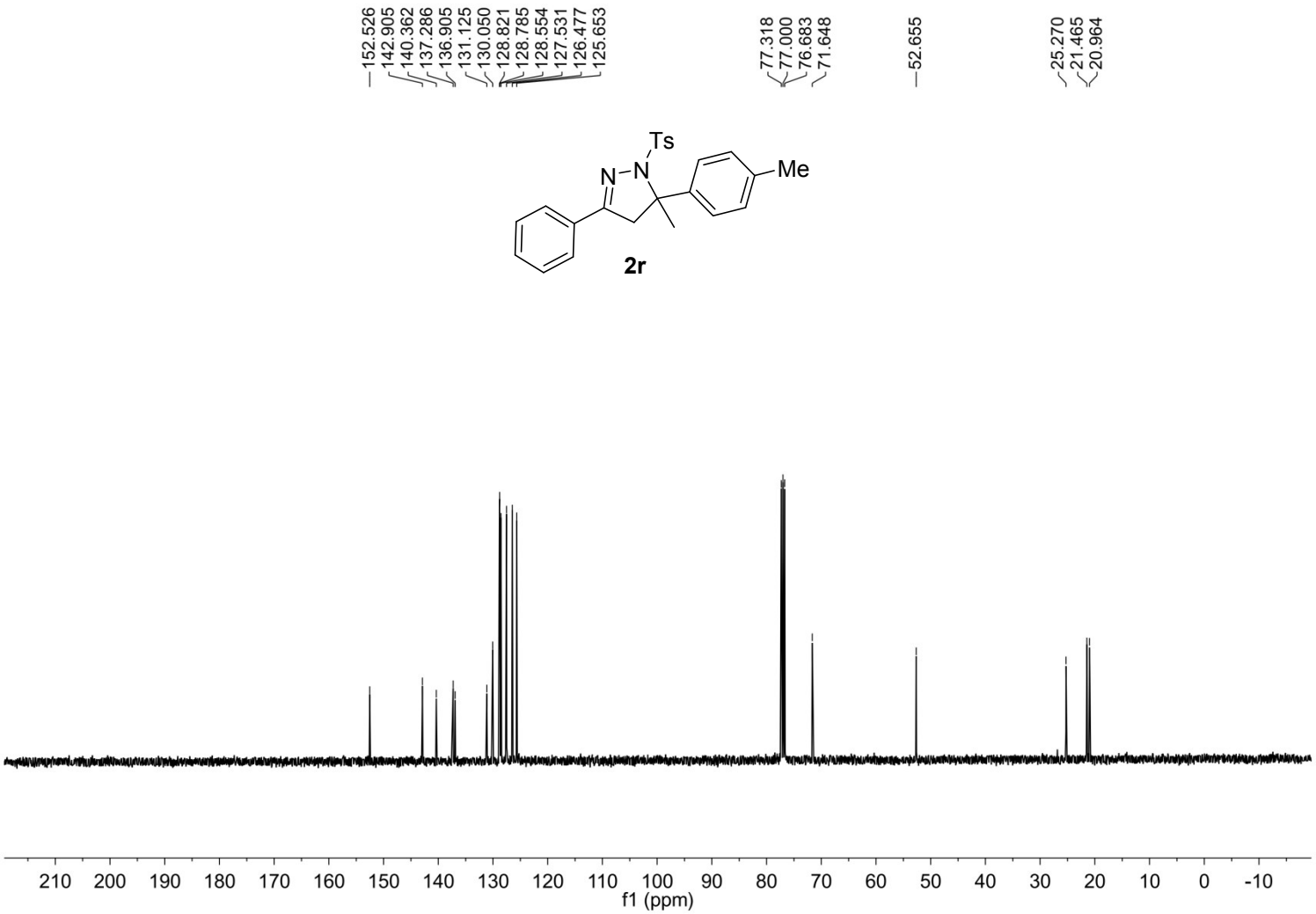
7.137
7.117
7.022
7.002
3.514
3.471
3.381
3.338
2.373
2.328
2.014
Ts
N
N
Me
2r
2.02
2.00
3.01
2.02
2.00
2.00
1.02
1.03
3.00
3.02
3.03
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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128.785
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127.531
126.477
125.653
77.318
77.000
76.683
71.648
52.655
25.270
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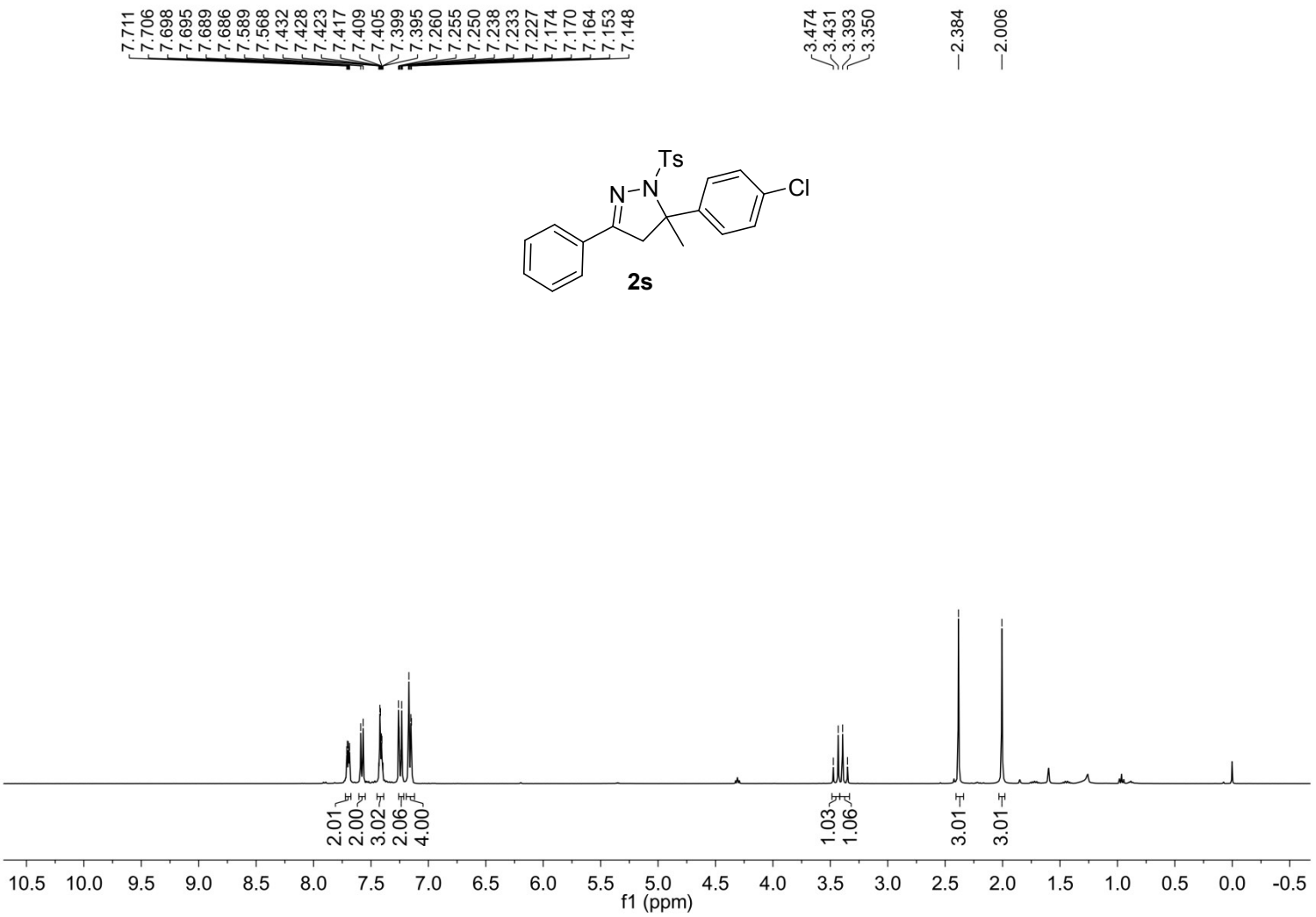
20.964
Ts
N
N
Me
2r
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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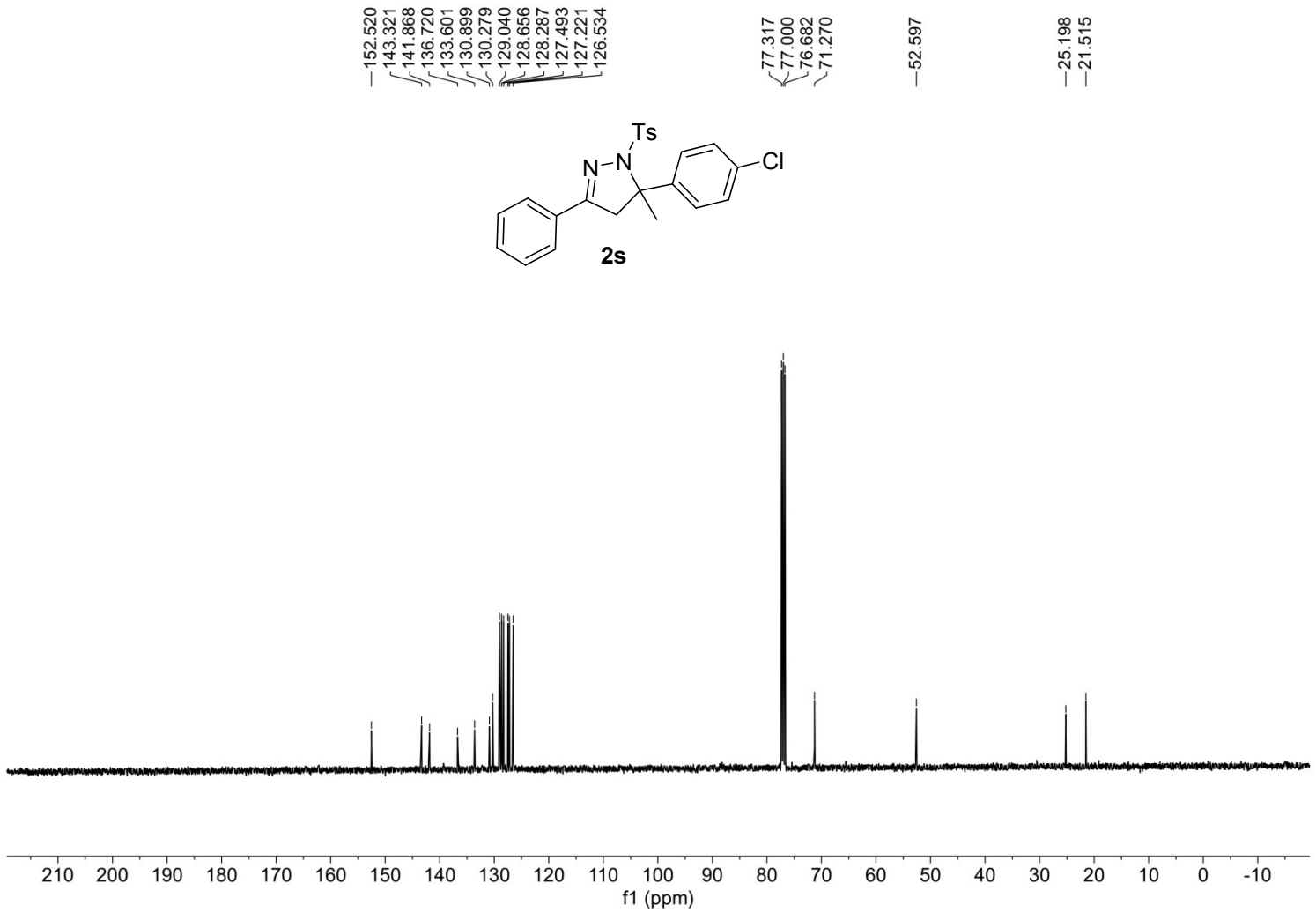
7.405
7.399
7.395
7.260
7.255
7.250
7.238
7.233
7.227
7.174
7.170
7.164
7.153
7.148
3.474
3.431
3.393
3.350
2.384
2.006
Ts
N
N
Cl
2s
2.01
2.00
3.02
2.06
4.00
1.03
1.06
3.01
3.01
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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130.279
129.040
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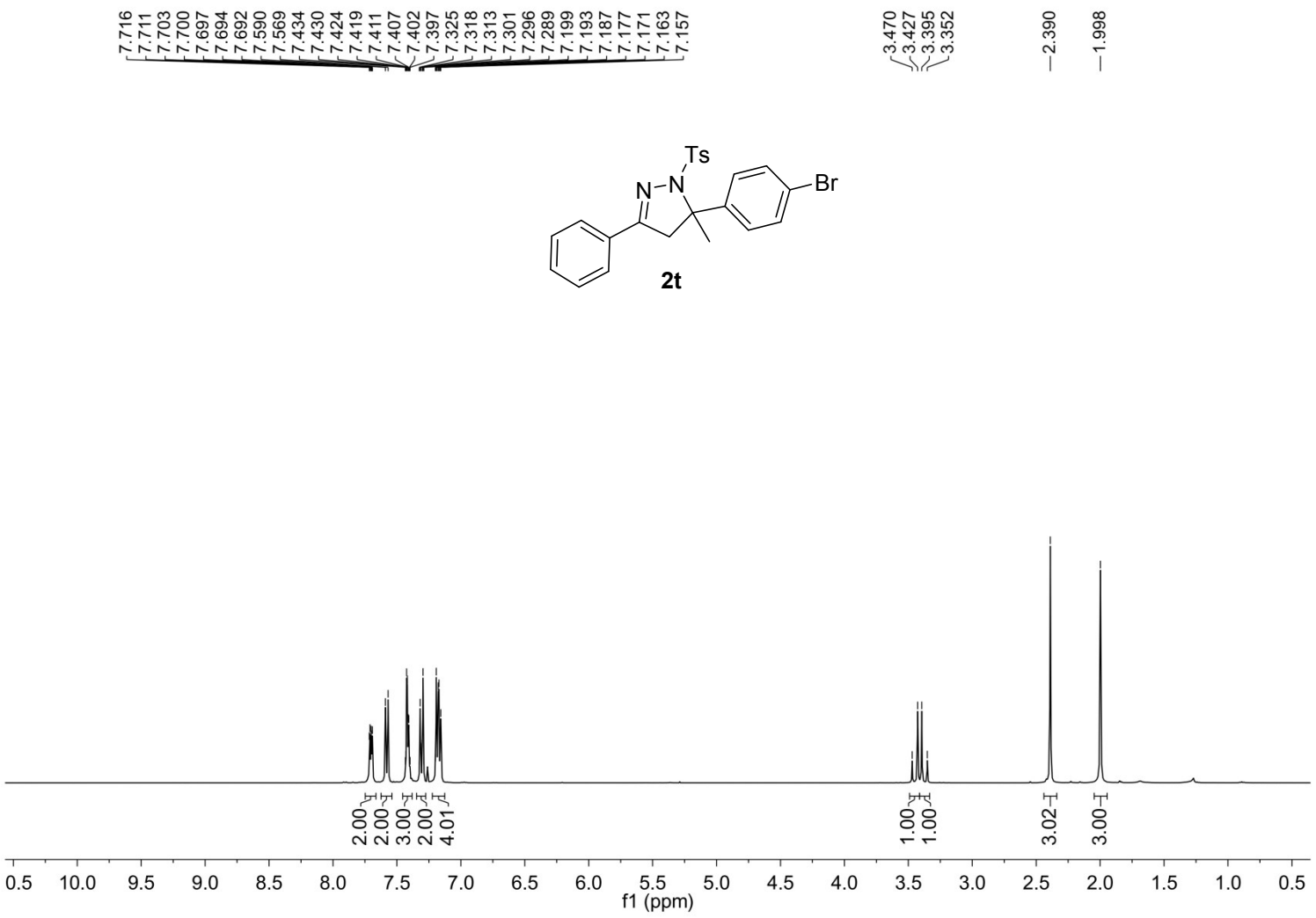
128.287
127.493
127.221
126.534
77.317
77.000
76.682
71.270
52.597
25.198
21.515
Ts
N
N
Cl
2s
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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7.419
7.411
7.407
7.402
7.397
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7.318
7.313
7.301
7.296
7.289
7.199
7.193
7.187
7.177
7.171
7.163
7.157
3.470
3.427
3.395
3.352
2.390
1.998
Ts
N
N
Br
2t
2.00
2.00
3.00
2.00
4.01
1.00
1.00
3.02
3.00
0.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
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5.0
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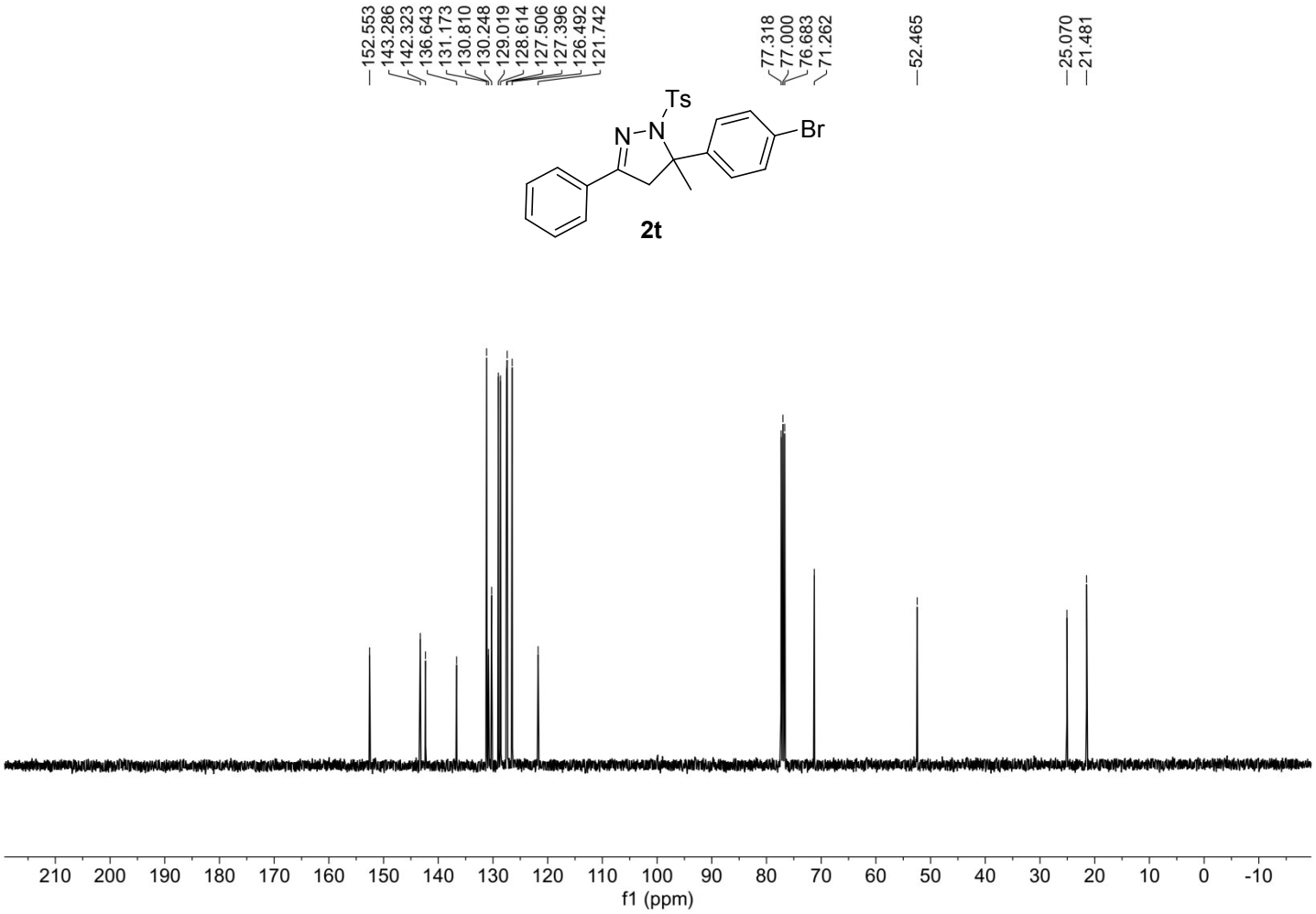
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
f1 (ppm)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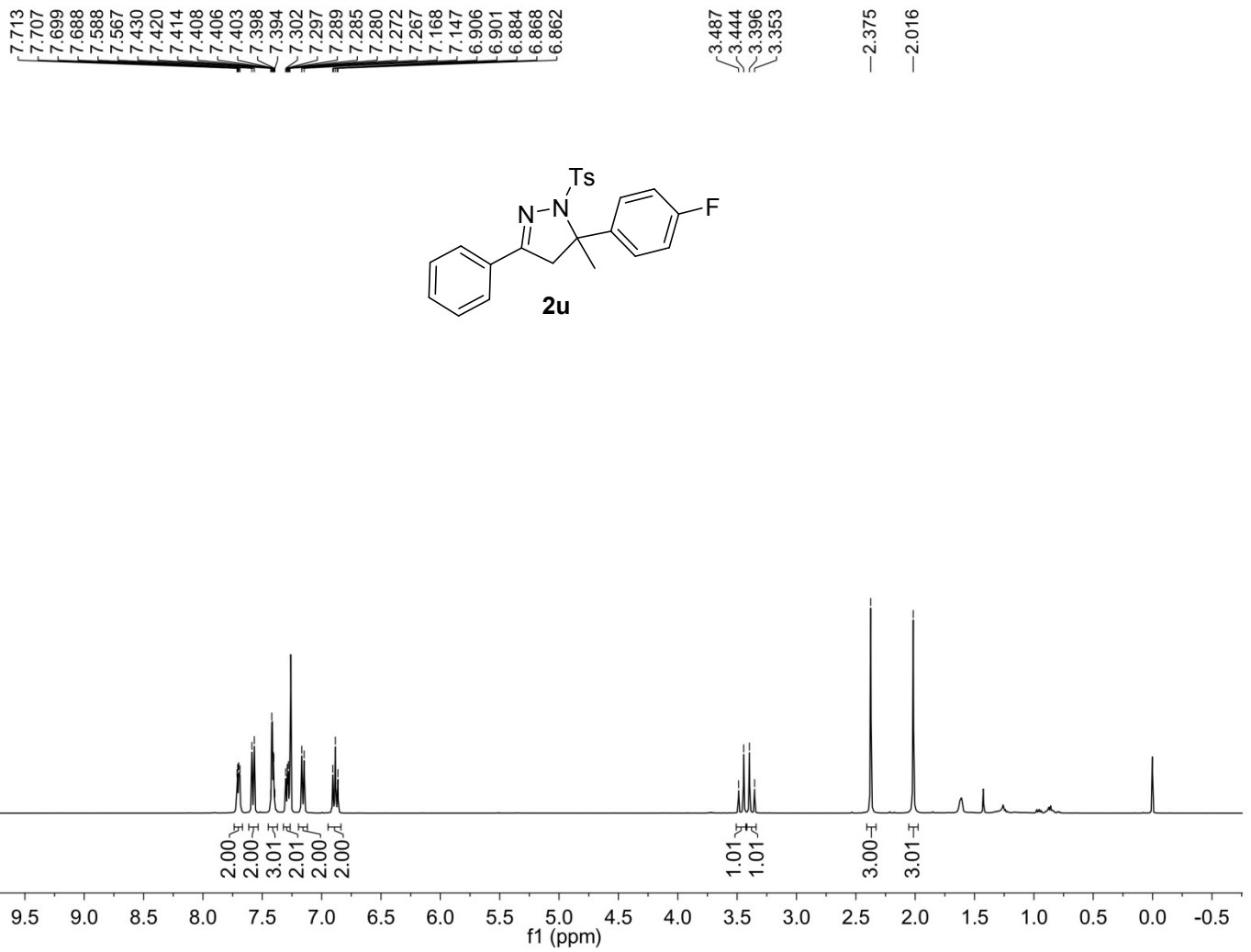
127.506
127.396
126.492
121.742
77.318
77.000
76.683
71.262
52.465
25.070
21.481
Ts
N
N
Br
2t
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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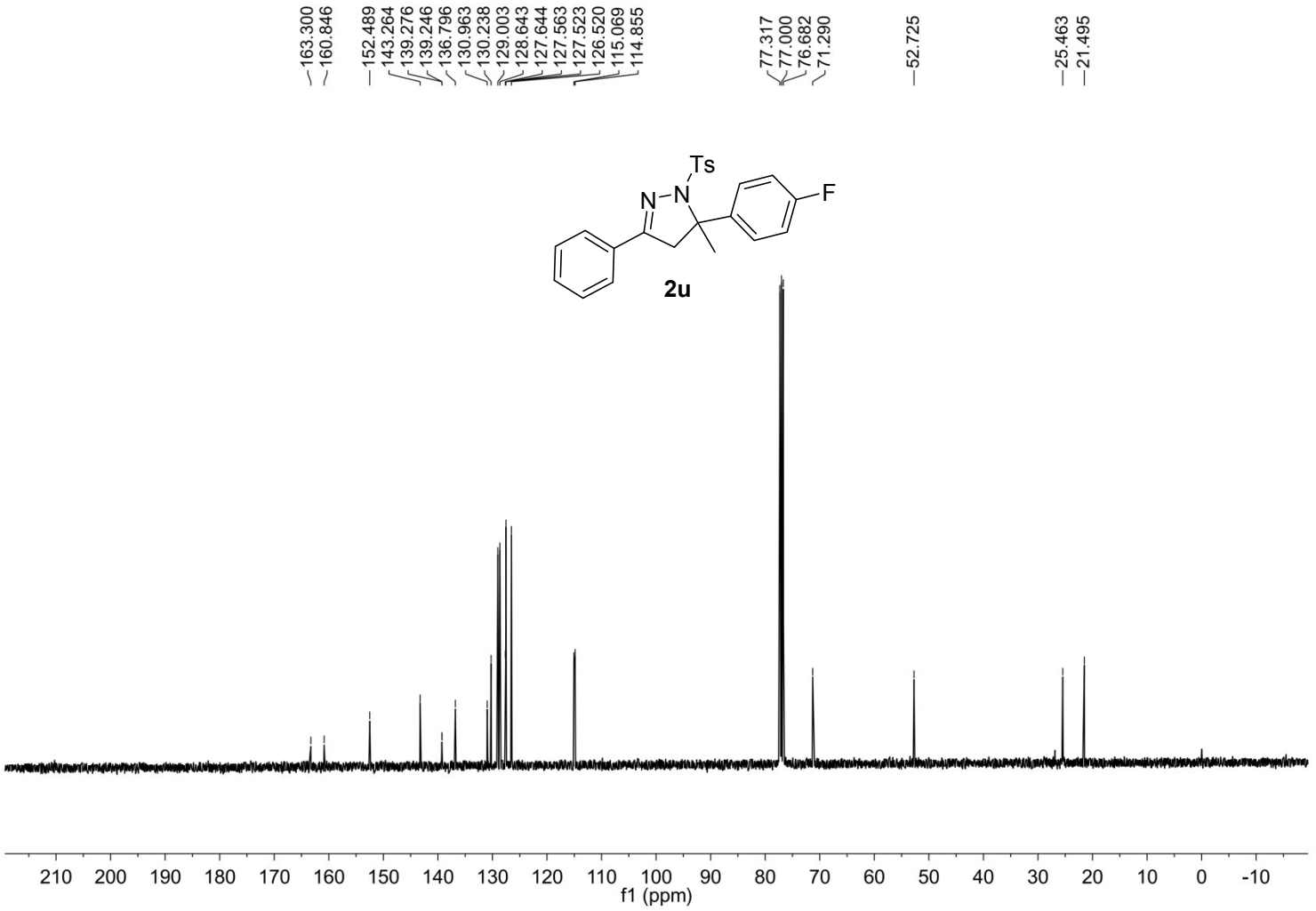
7.688
7.588
7.567
7.430
7.420
7.414
7.408
7.406
7.403
7.398
7.394
7.302
7.297
7.289
7.285
7.280
7.272
7.267
7.168
7.147
6.906
6.901
6.884
6.868
6.862
3.487
3.444
3.396
3.353
2.375
2.016
Ts
N
N
F
2u
2.00
2.00
3.01
2.01
2.00
2.00
1.01
1.01
3.00
3.01
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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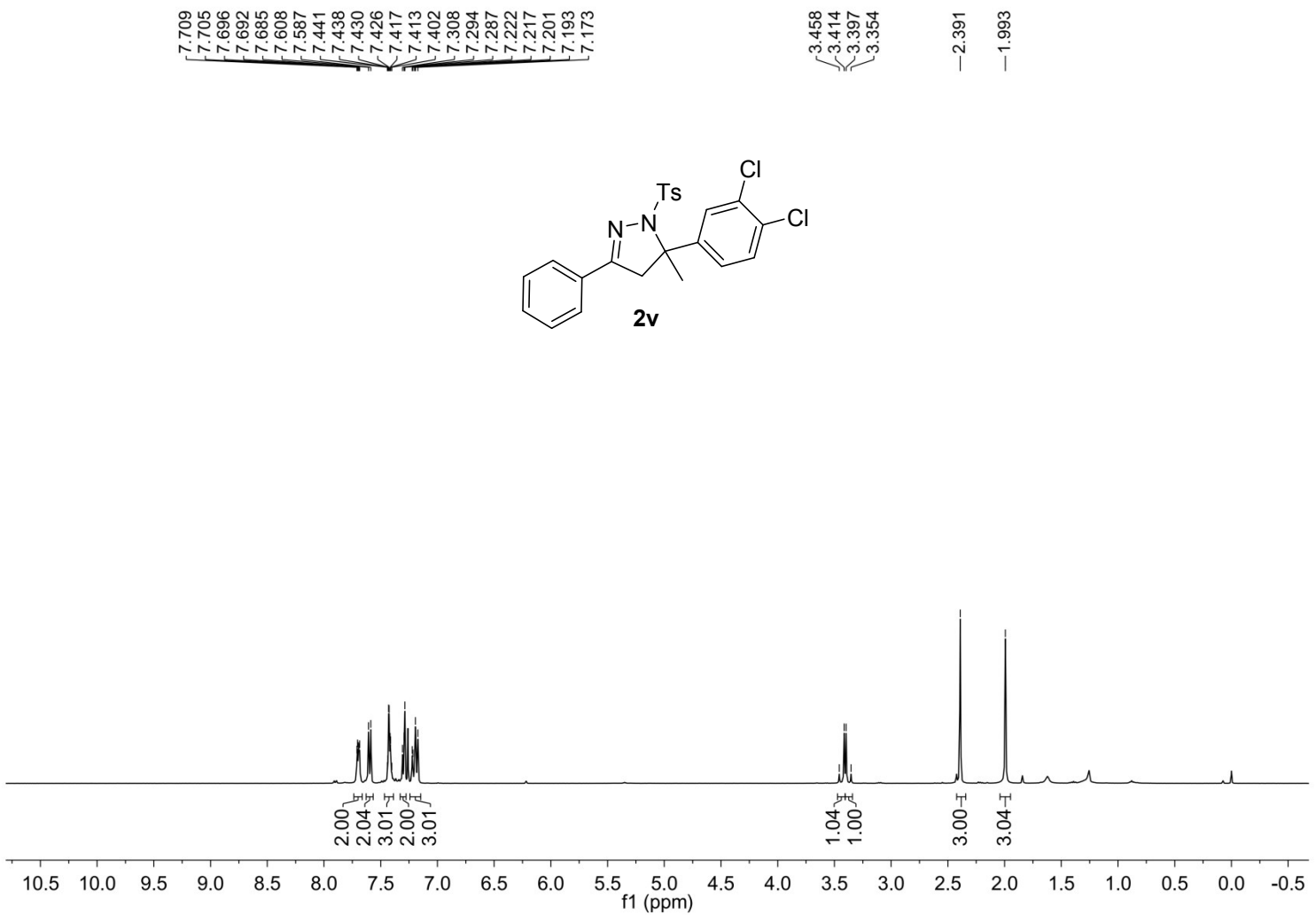
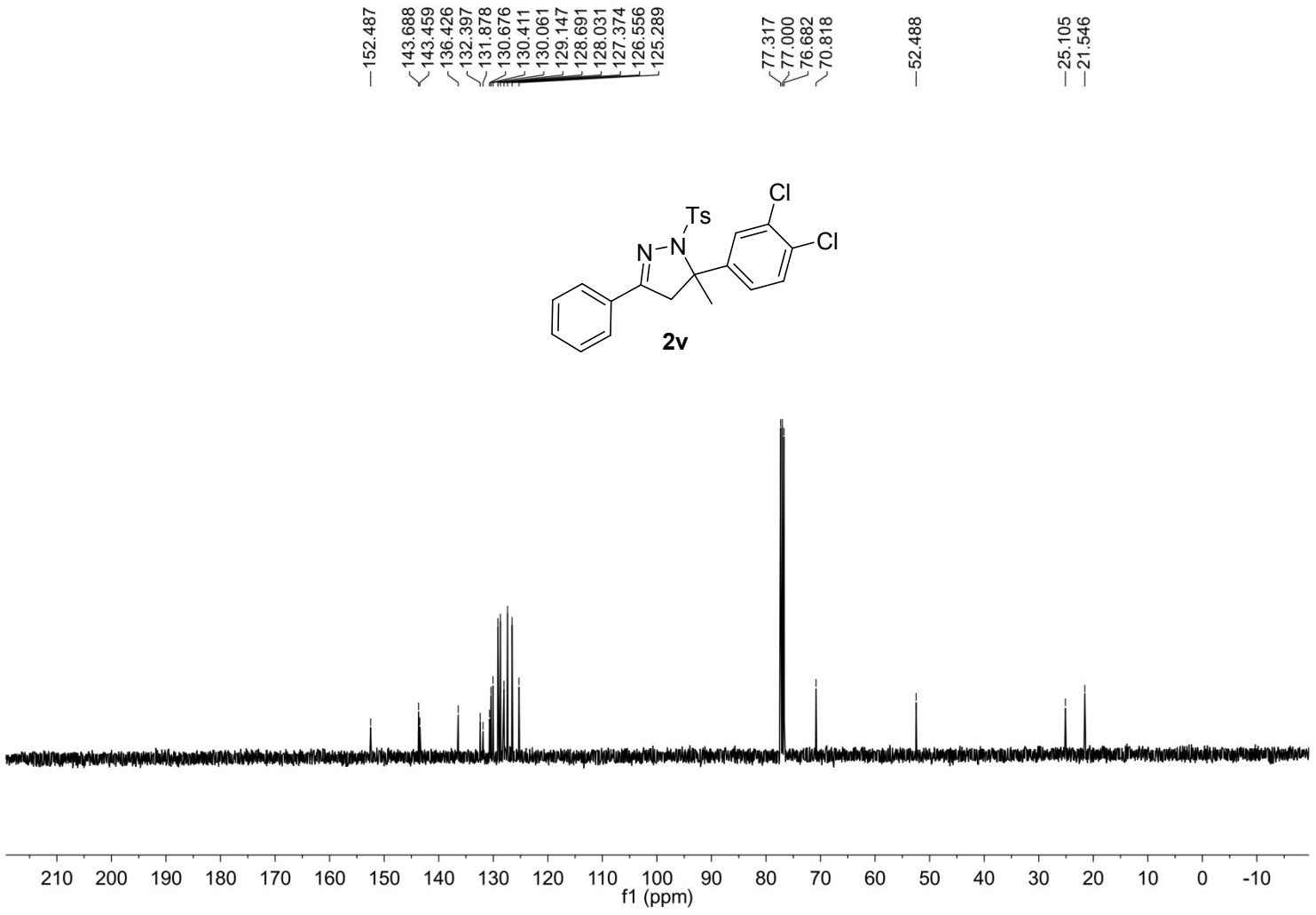
160.846
152.489
143.264
139.276
139.246
136.796
130.963
130.238
129.003
128.643
127.644
127.563
127.523
126.520
115.069
114.855
77.317
77.000
76.682
71.290
52.725
25.463
21.495
Ts
N
N
F
2u
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


7.709
7.705
7.696
7.692
7.685
7.608
7.587
7.441
7.438
7.430
7.426
7.417
7.413
7.402
7.308
7.294
7.287
7.222
7.217
7.201
7.193
7.173
3.458
3.414
3.397
3.354
2.391
1.993
Ts
N
N
Cl
Cl
2v
2.00
2.04
3.01
2.00
3.01
1.04
1.00
3.00
3.04
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 -0.5
f1 (ppm)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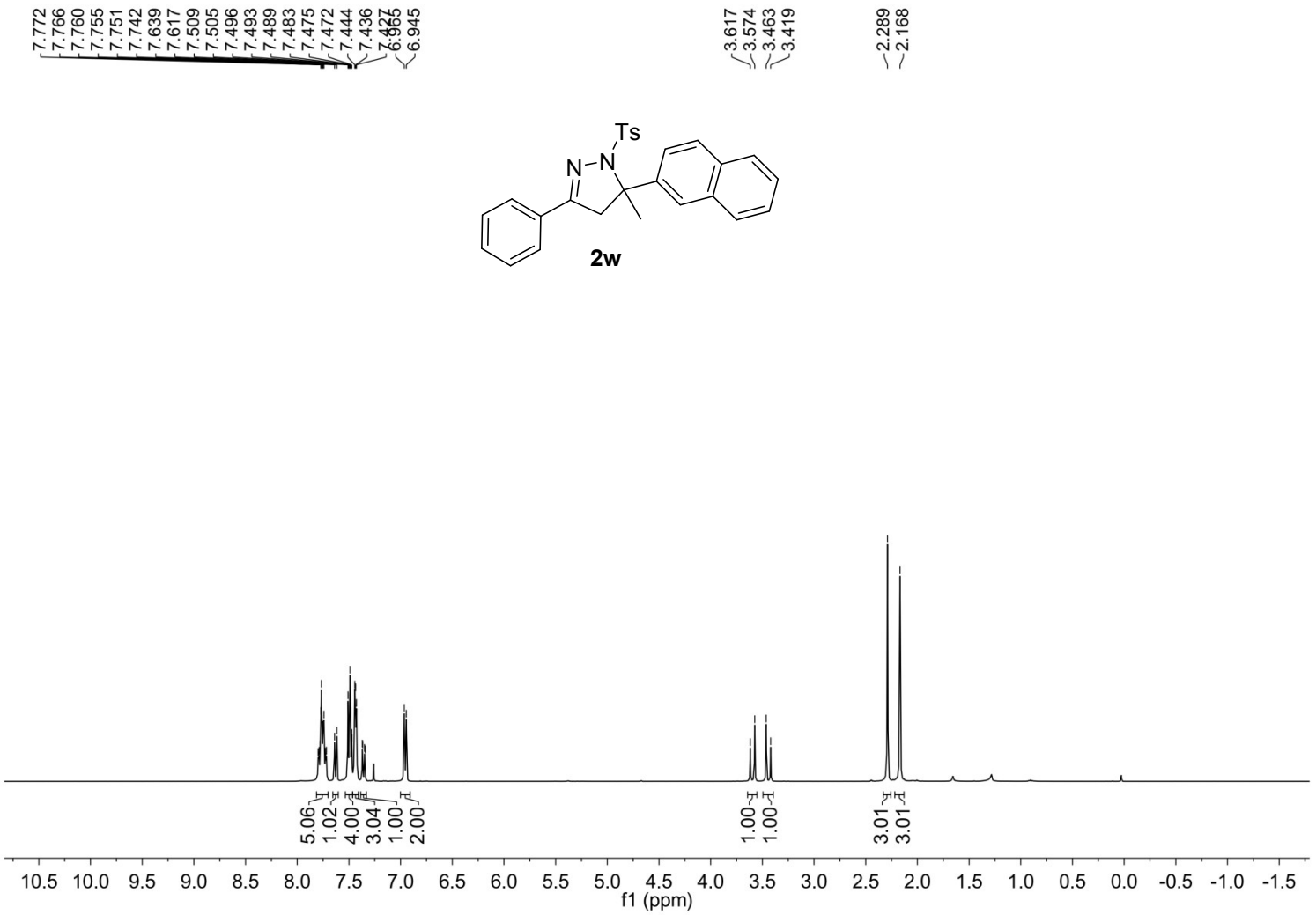
143.688
143.459
136.426
132.397
131.878
130.676
130.411
130.061
129.147
128.691
128.031
127.374
126.556
125.289
77.317
77.000
76.682
70.818
52.488
25.105
21.546
Ts
N
N
Cl
Cl
2v
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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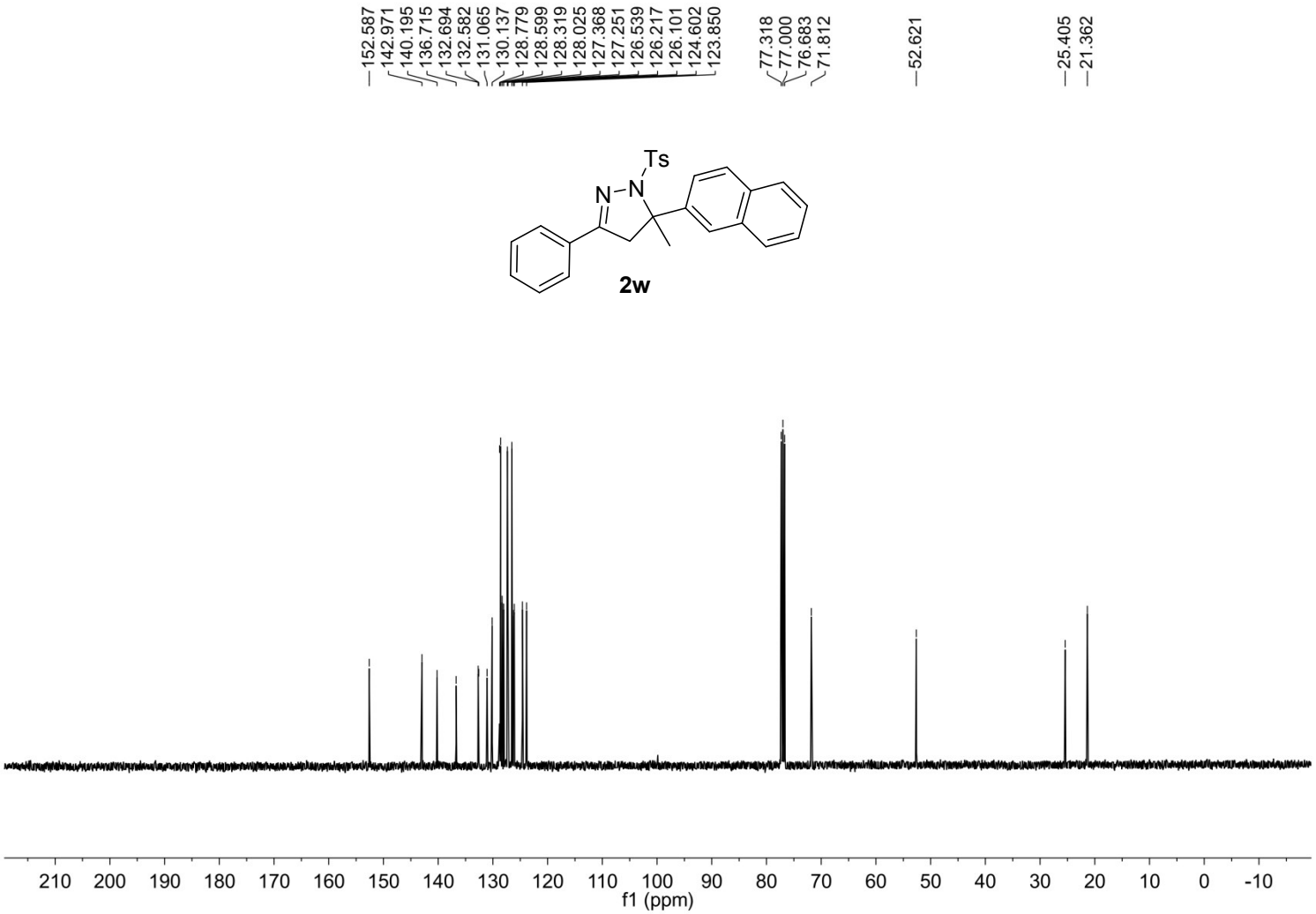
7.766
7.760
7.755
7.751
7.742
7.639
7.617
7.509
7.505
7.496
7.493
7.489
7.483
7.475
7.472
7.444
7.436
6.965
6.945
3.617
3.574
3.463
3.419
2.289
2.168
Ts
N
N
2w
5.06
1.02
4.00
3.04
1.00
2.00
1.00
1.00
3.01
3.01
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5
f1 (ppm)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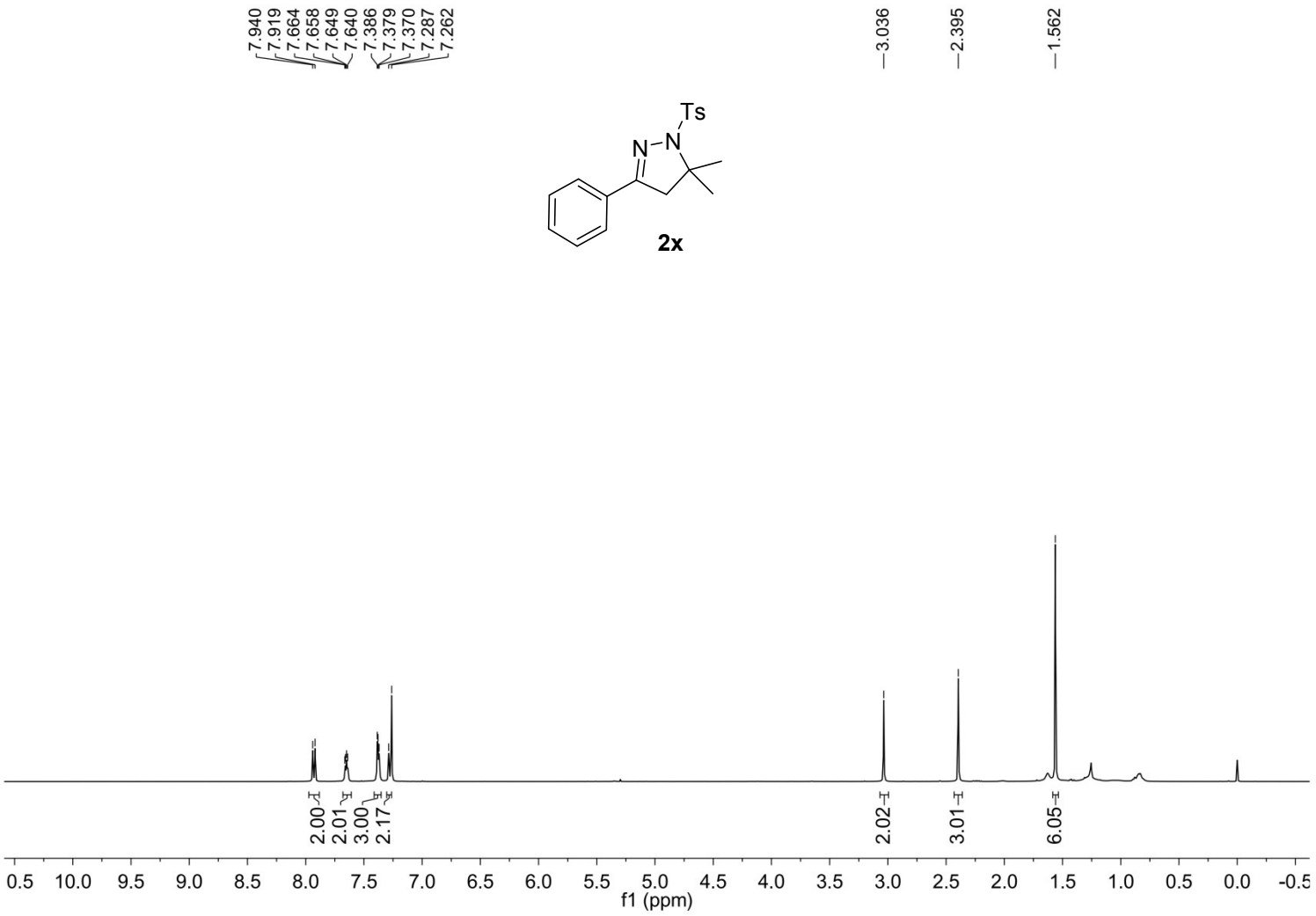
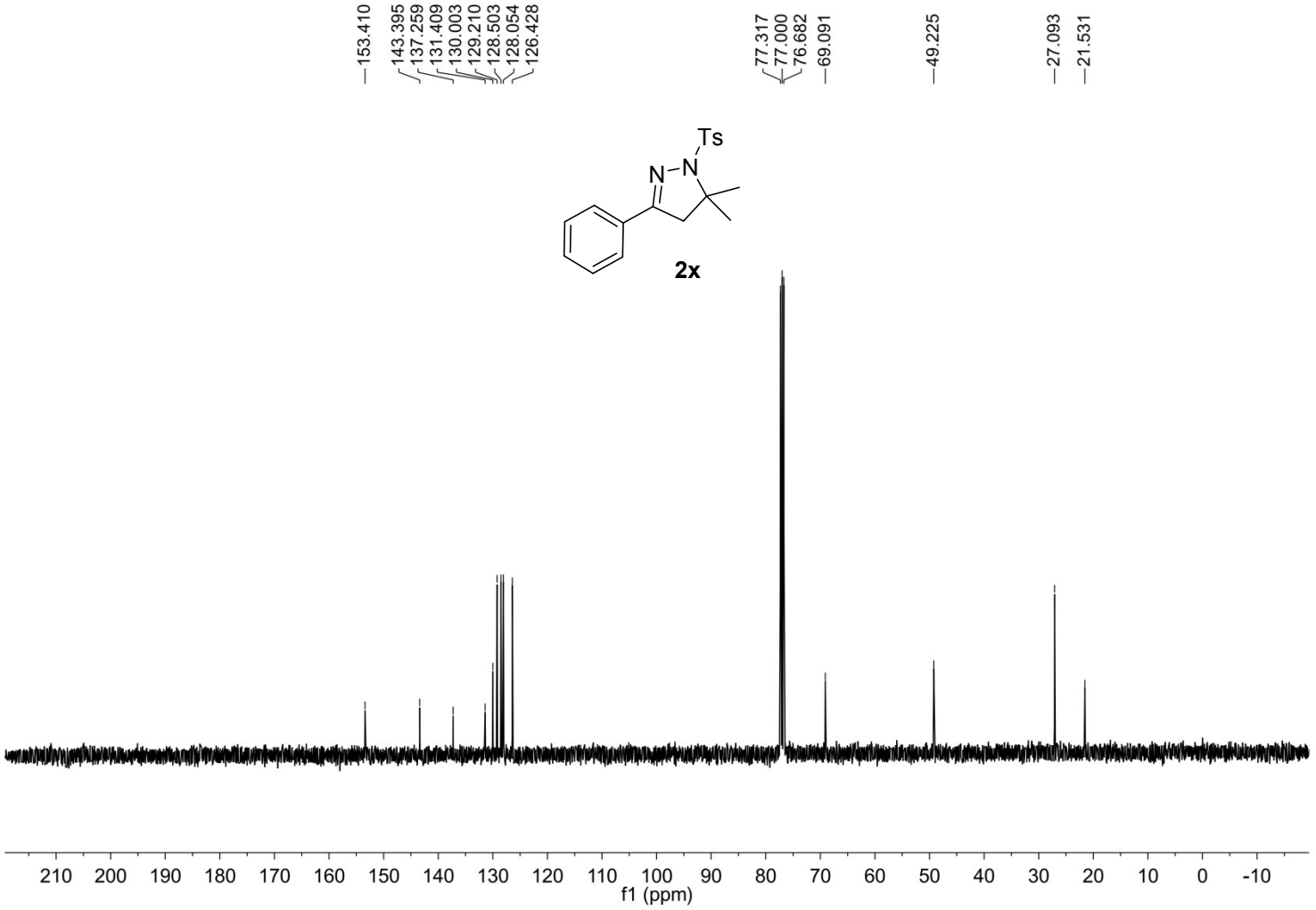
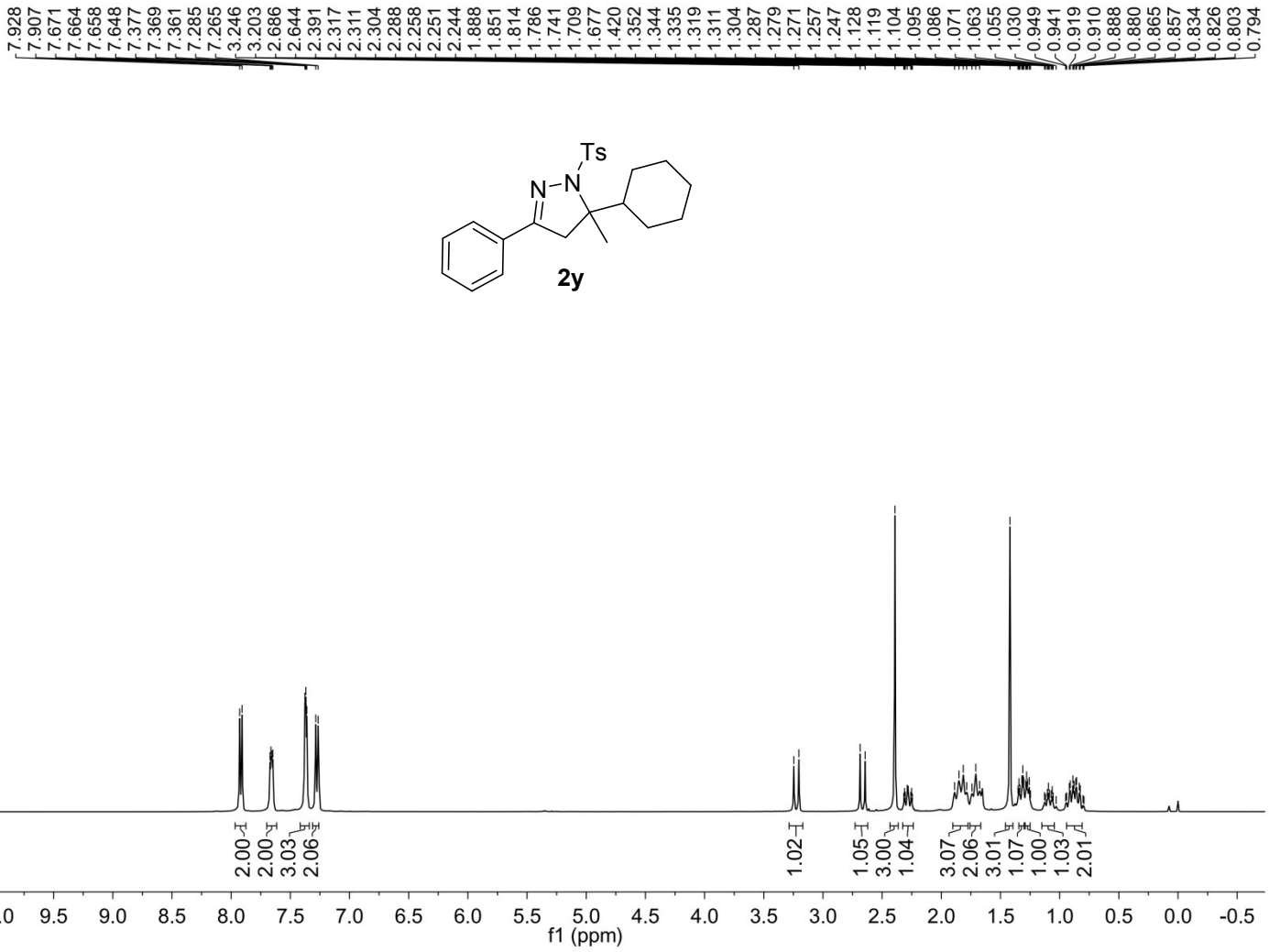
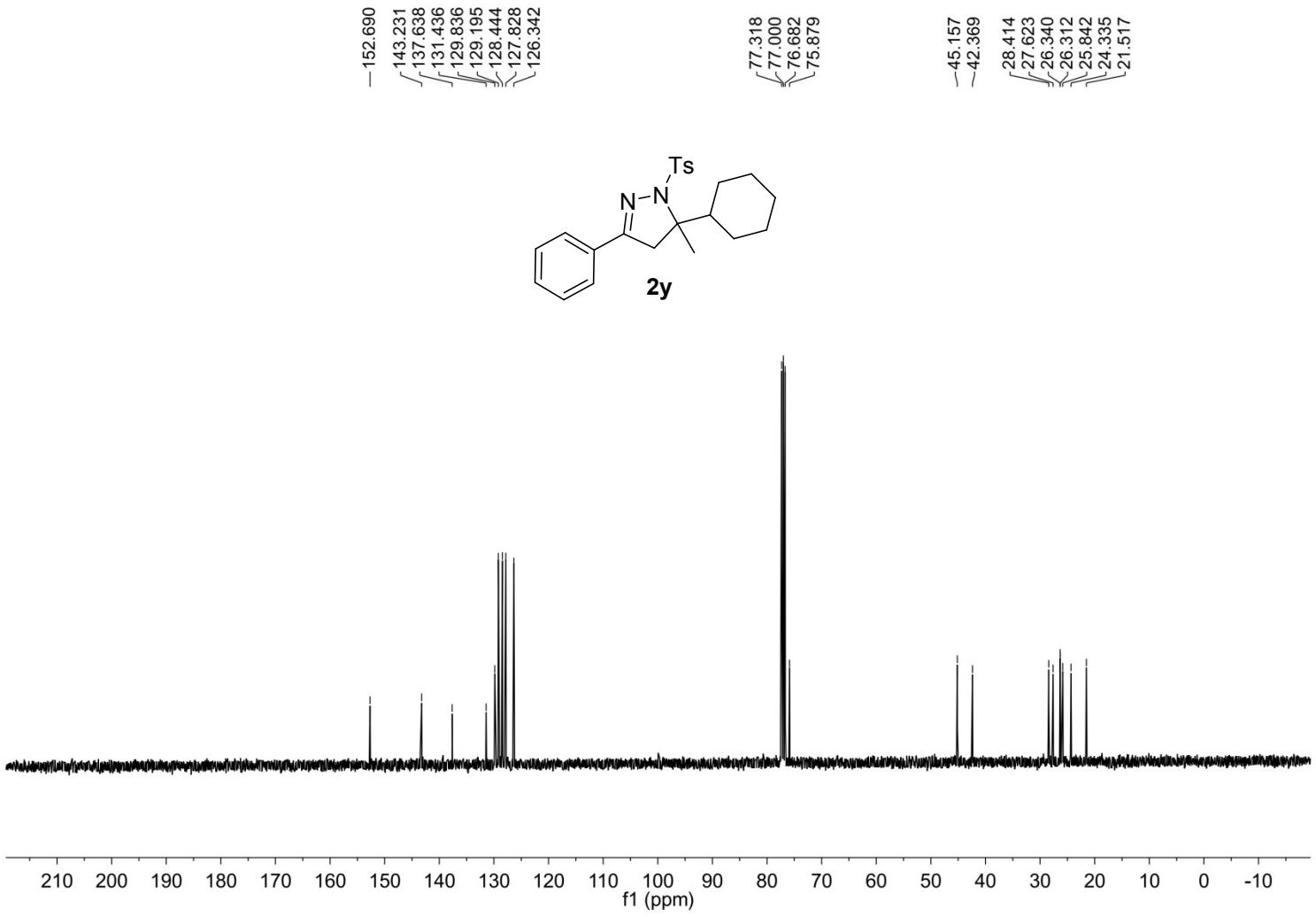
142.971
140.195
136.715
132.694
132.582
131.065
130.137
128.779
128.599
128.319
128.025
127.368
127.251
126.539
126.217
126.101
124.602
123.850
77.318
77.000
76.683
71.812
52.621
25.405
21.362
Ts
N
N
2w
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


7.940
7.919
7.664
7.658
7.649
7.640
7.386
7.379
7.370
7.287
7.262
3.036
2.395
1.562
Ts
N
N
2x
2.00
2.01
3.00
2.17
2.02
3.01
6.05
f1 (ppm)


153.410
143.395
137.259
131.409
130.003
129.210
128.503
128.054
126.428
77.317
77.000
76.682
69.091
49.225
27.093
21.531
Ts
N
N
2x
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


7.928
7.907
7.671
7.664
7.658
7.648
7.377
7.369
7.361
7.285
7.265
3.246
3.203
2.686
2.644
2.391
2.317
2.311
2.304
2.288
2.258
2.251
2.244
1.888
1.851
1.814
1.786
1.741
1.709
1.677
1.420
1.352
1.344
1.335
1.319
1.311
1.304
1.287
1.279
1.271
1.257
1.247
1.128
1.119
1.104
1.095
1.086
1.071
1.063
1.055
1.030
0.949
0.941
0.919
0.910
0.888
0.880
0.865
0.857
0.834
0.826
0.803
0.794
Ts
N
N
2y
2.00
2.00
3.03
2.06
1.02
1.05
3.00
1.04
3.07
2.06
3.01
1.07
1.00
1.03
2.01
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 -0.5
f1 (ppm)


152.690
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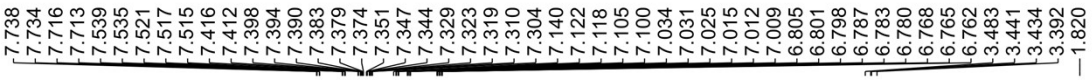
137.638
131.436
129.836
129.195
128.444
127.828
126.342
77.318
77.000
76.682
75.879
45.157
42.369
28.414
27.623
26.340
26.312
25.842
24.335
21.517
Ts
N
N
2y
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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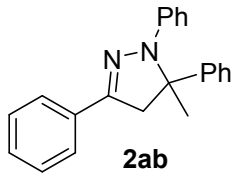
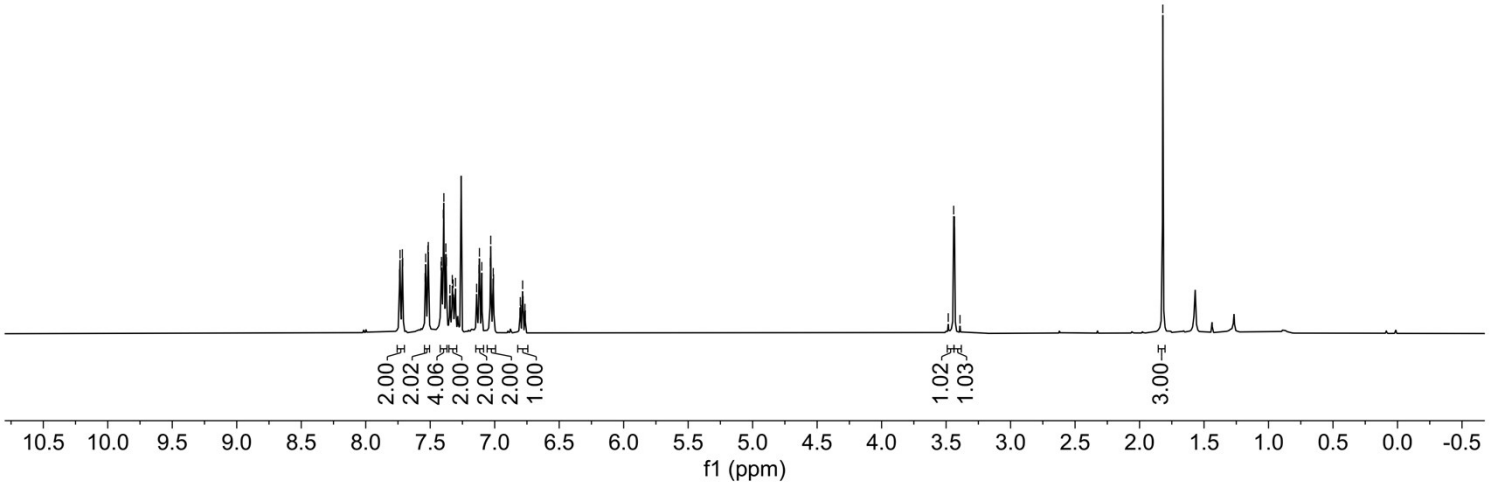
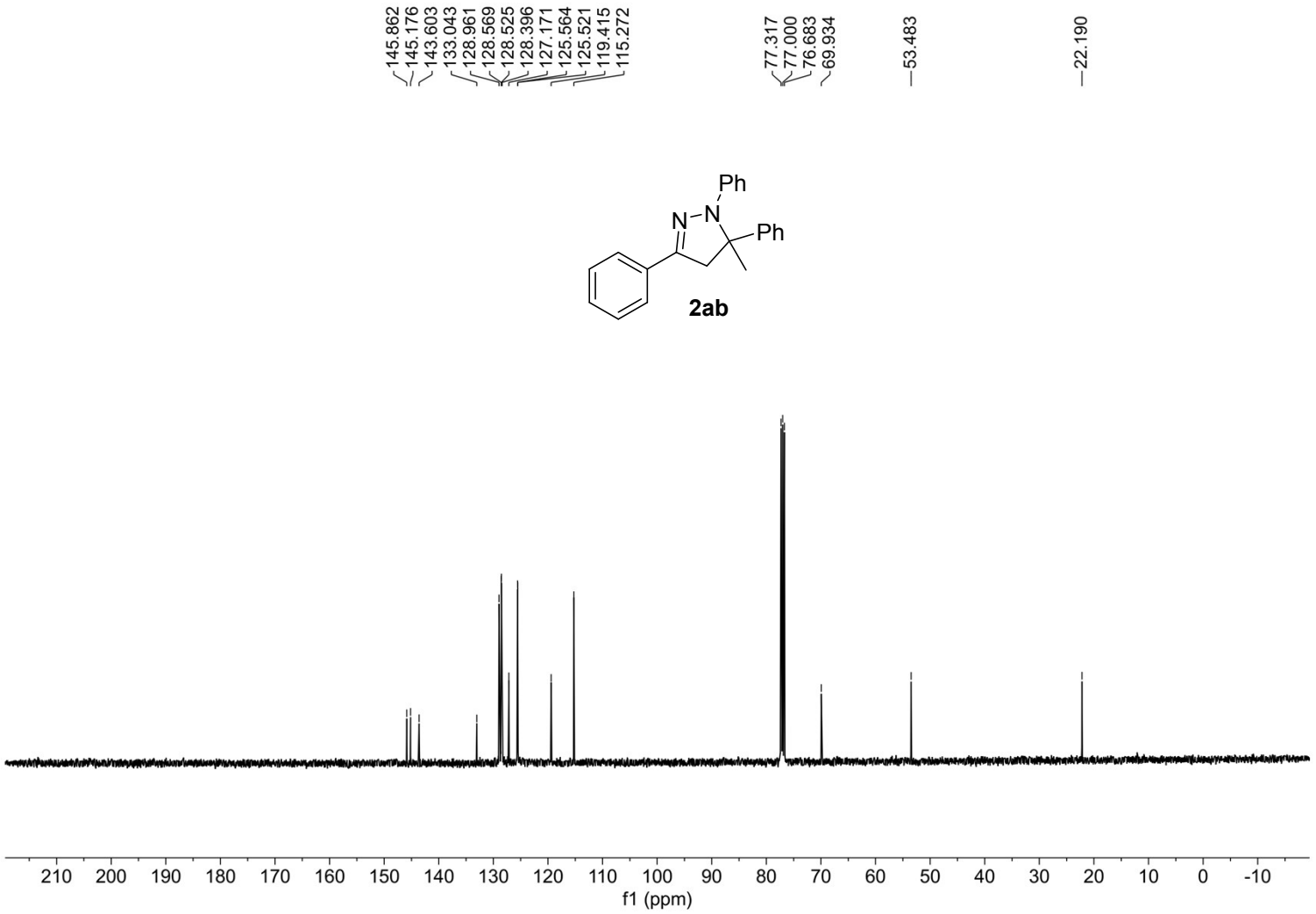
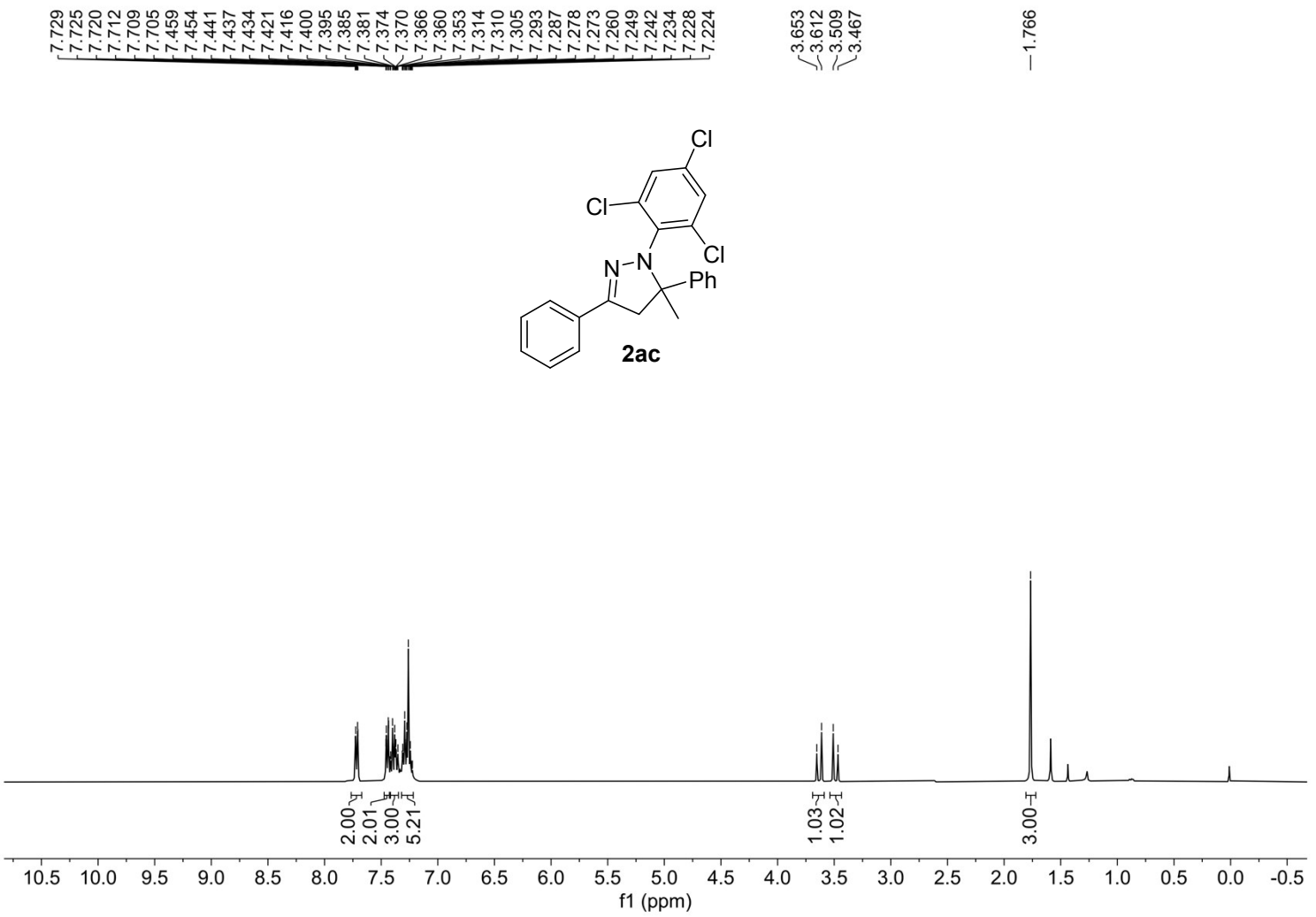
7.734
7.716
7.713
7.539
7.535
7.521
7.517
7.515
7.416
7.412
7.398
7.394
7.390
7.383
7.379
7.374
7.351
7.347
7.344
7.329
7.323
7.319
7.310
7.304
7.140
7.122
7.118
7.105
7.100
7.034
7.031
7.025
7.015
7.012
7.009
6.805
6.801
6.798
6.787
6.783
6.780
6.768
6.765
6.762
3.483
3.441
3.434
3.392
1.820

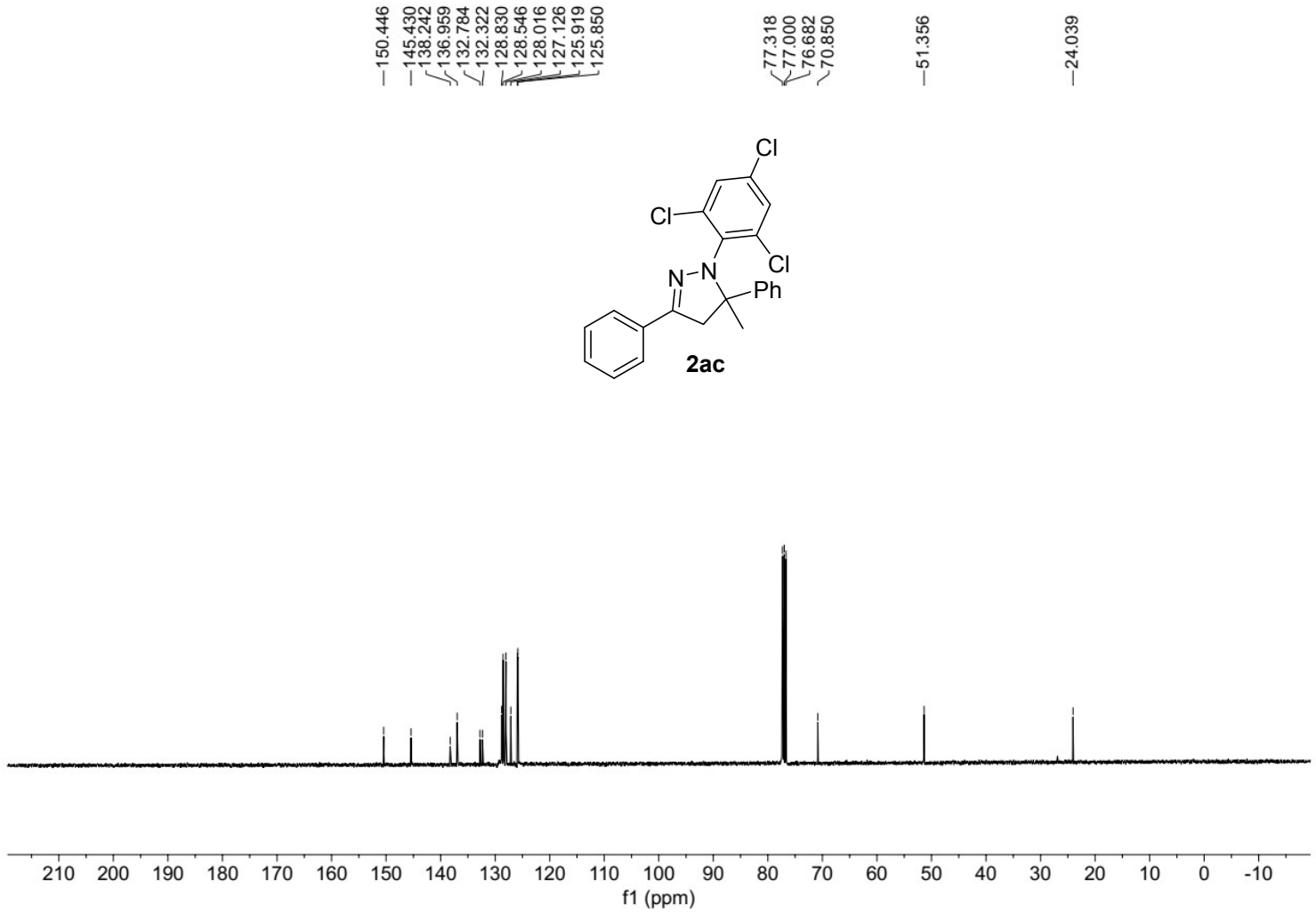

Ph
N
N
Ph

**2ab**


2.00
2.02
4.06
2.00
2.00
2.00
1.00
1.02
1.03
3.00
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 -0.5
f1 (ppm)


145.862
145.176
143.603
133.043
128.961
128.569
128.525
128.396
127.171
125.564
125.521
119.415
115.272
77.317
77.000
76.683
69.934
53.483
22.190
Ph
N
N
Ph
2ab
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)


7.729
7.725
7.720
7.712
7.709
7.705
7.459
7.454
7.441
7.437
7.434
7.421
7.416
7.400
7.395
7.385
7.381
7.374
7.370
7.366
7.360
7.353
7.314
7.310
7.305
7.293
7.287
7.278
7.273
7.260
7.249
7.242
7.234
7.228
7.224
3.653
3.612
3.509
3.467
1.766
Cl
Cl
Cl
N
N
Ph
2ac
2.00
2.01
3.00
5.21
1.03
1.02
3.00
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 -0.5
f1 (ppm)


150.446
145.430
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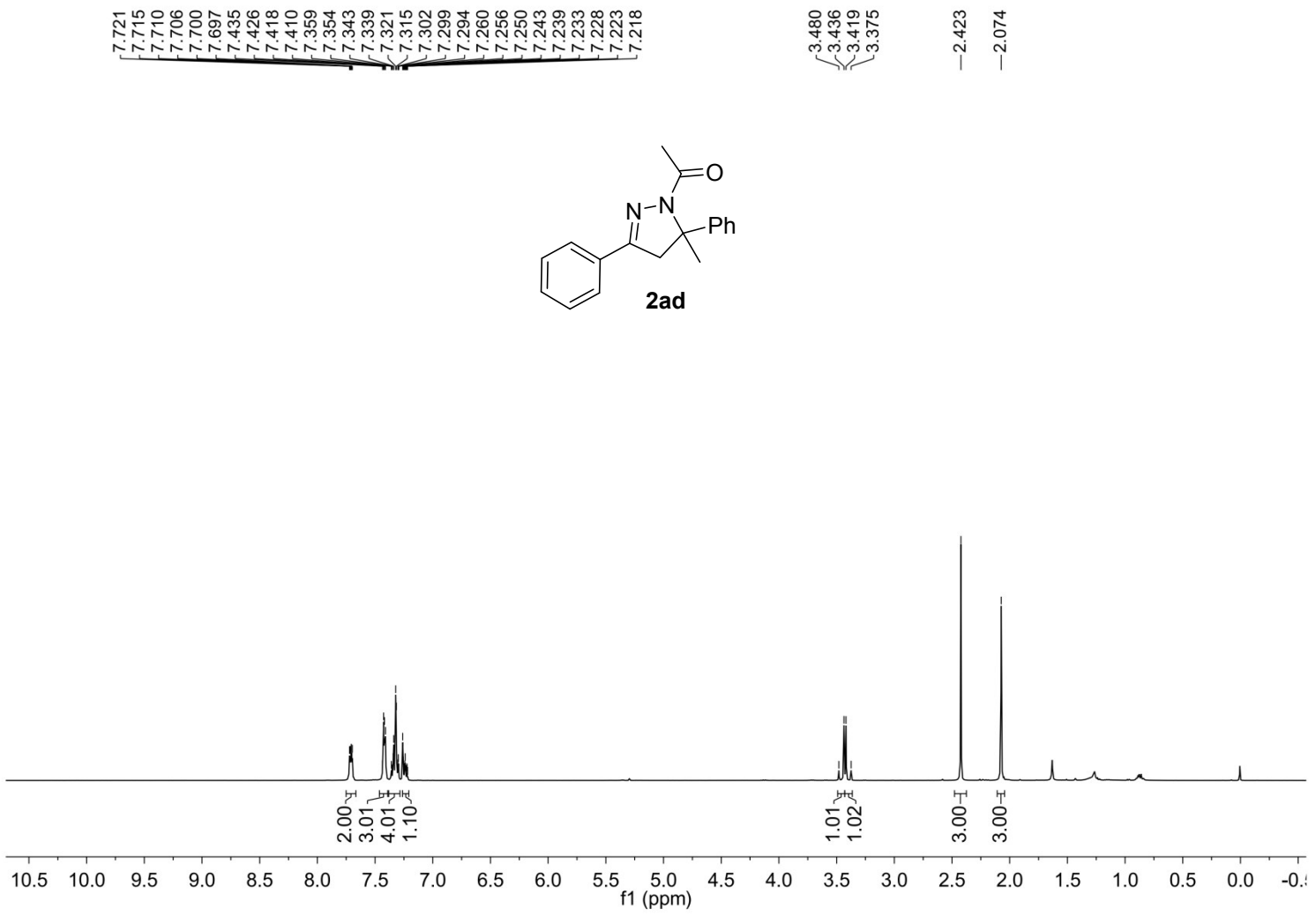
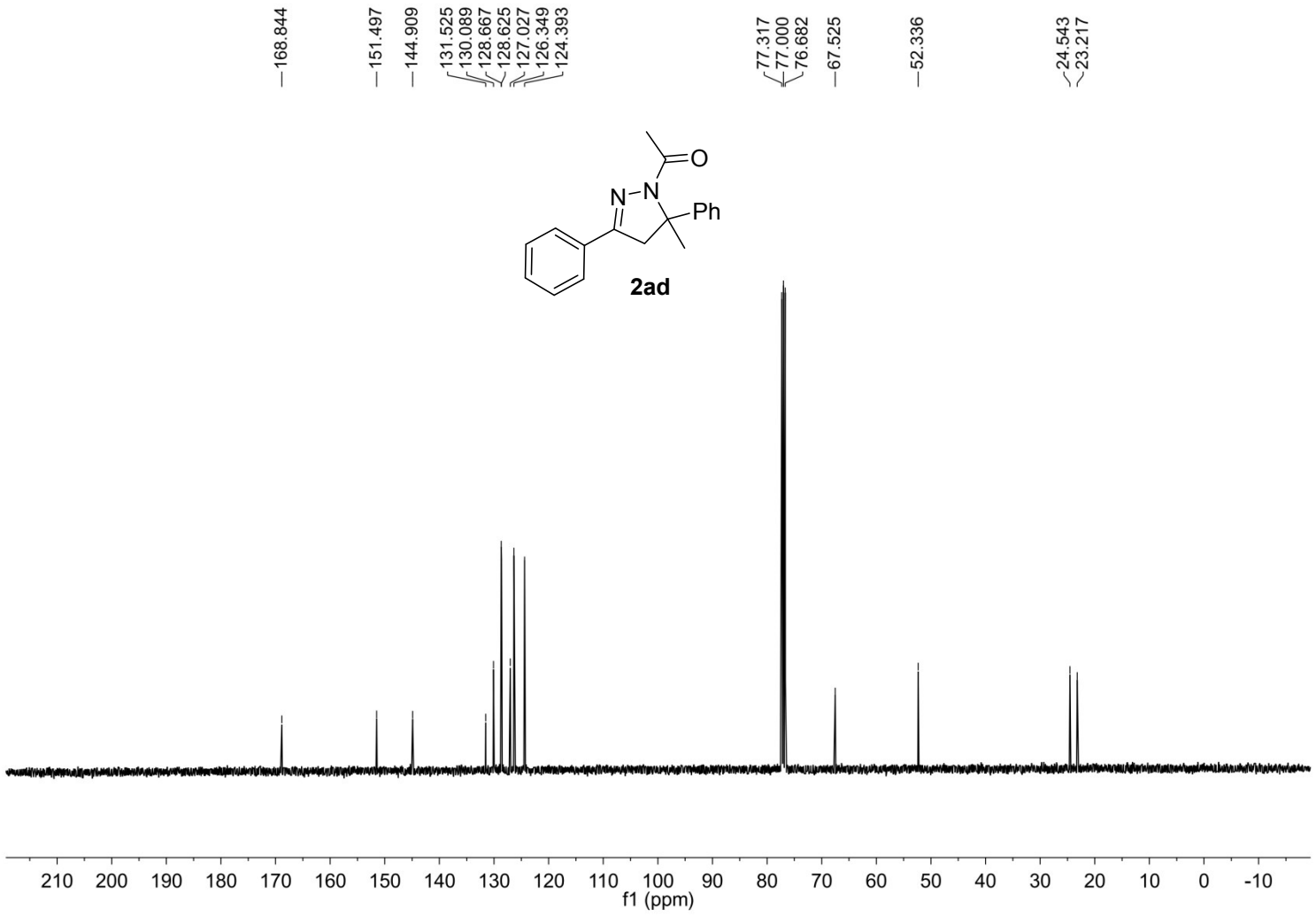
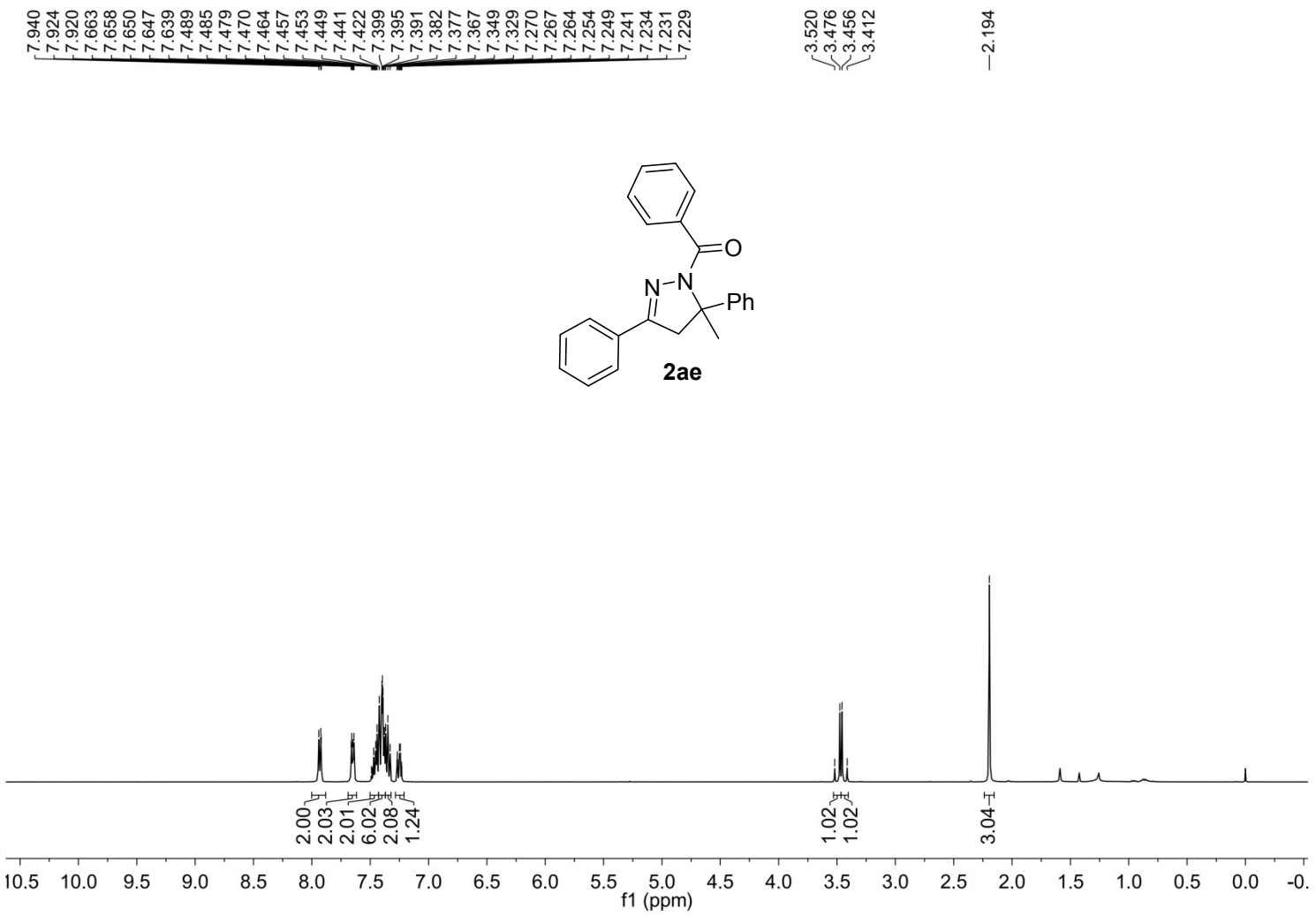
136.959
132.784
132.322
128.830
128.546
128.016
127.126
125.919
125.850
77.318
77.000
76.682
70.850
51.356
24.039
Cl
Cl
Cl
N
N
Ph
2ac
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


7.721
7.715
7.710
7.706
7.700
7.697
7.435
7.426
7.418
7.410
7.359
7.354
7.343
7.339
7.321
7.315
7.302
7.299
7.294
7.260
7.256
7.250
7.243
7.239
7.233
7.228
7.223
7.218
3.480
3.436
3.419
3.375
2.423
2.074
O
N
N
Ph
2ad
2.00
3.01
4.01
1.10
1.01
1.02
3.00
3.00
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)


168.844
151.497
144.909
131.525
130.089
128.667
128.625
127.027
126.349
124.393
77.317
77.000
76.682
67.525
52.336
24.543
23.217
O
N
N
Ph
2ad
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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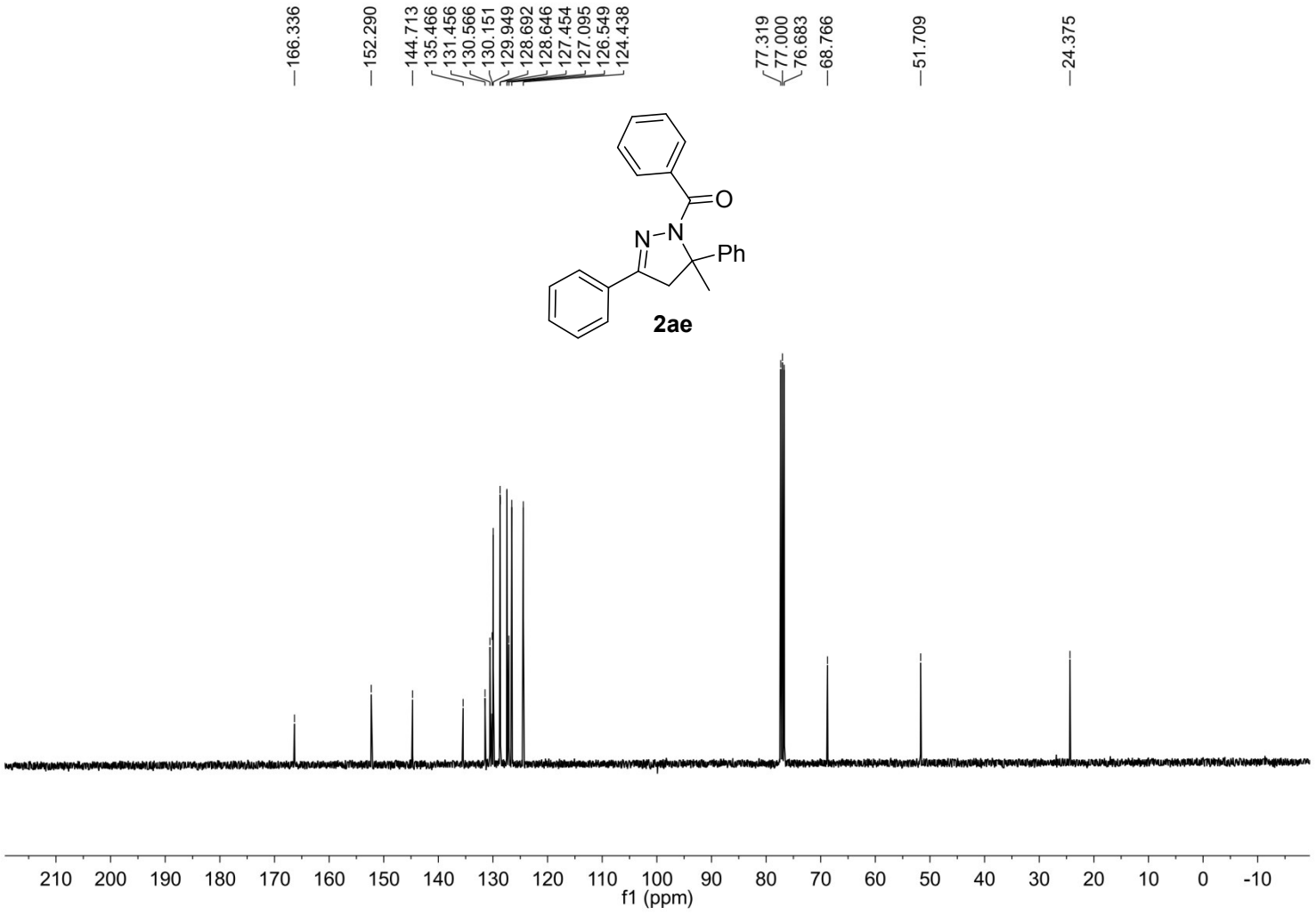
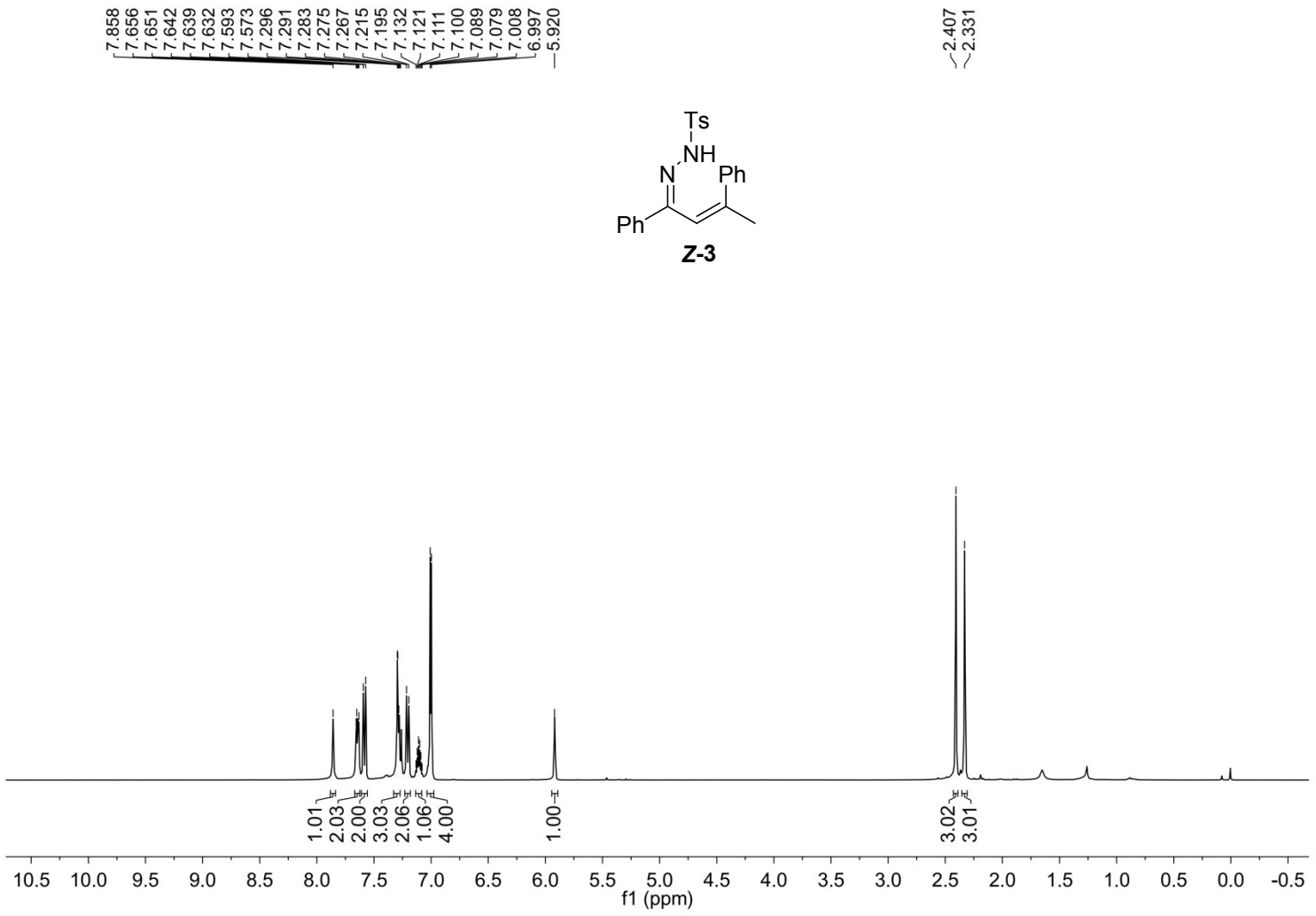
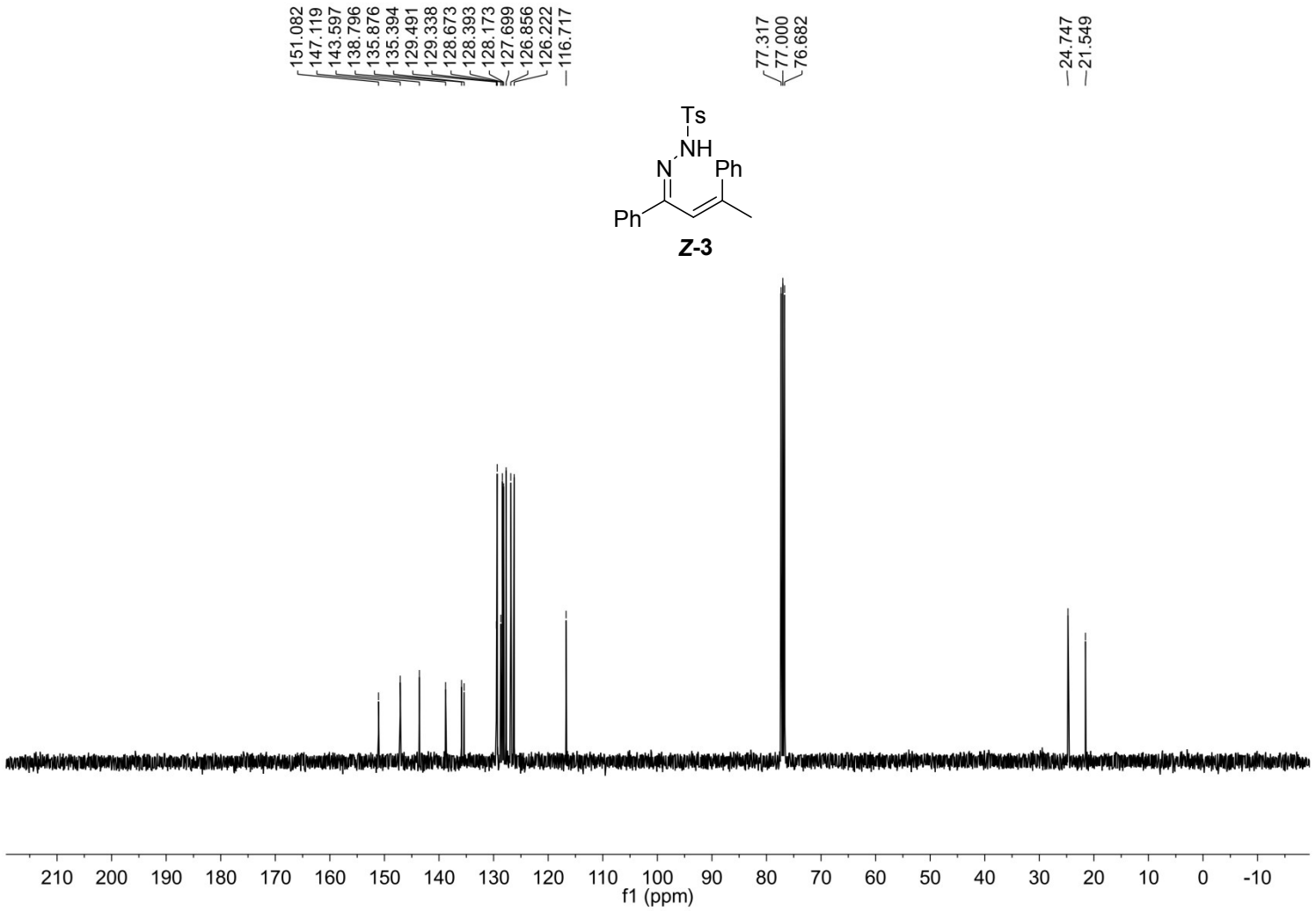
7.920
7.663
7.658
7.650
7.647
7.639
7.489
7.485
7.479
7.470
7.464
7.457
7.453
7.449
7.441
7.422
7.399
7.395
7.391
7.382
7.377
7.367
7.349
7.329
7.270
7.267
7.264
7.254
7.249
7.241
7.234
7.231
7.229
3.520
3.476
3.456
3.412
2.194
O
N
N
Ph
2.00
2.03
2.01
6.02
2.08
1.24
1.02
1.02
3.04
10.5 10.0 9.5 9.0 8.5 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 -0.
f1 (ppm)

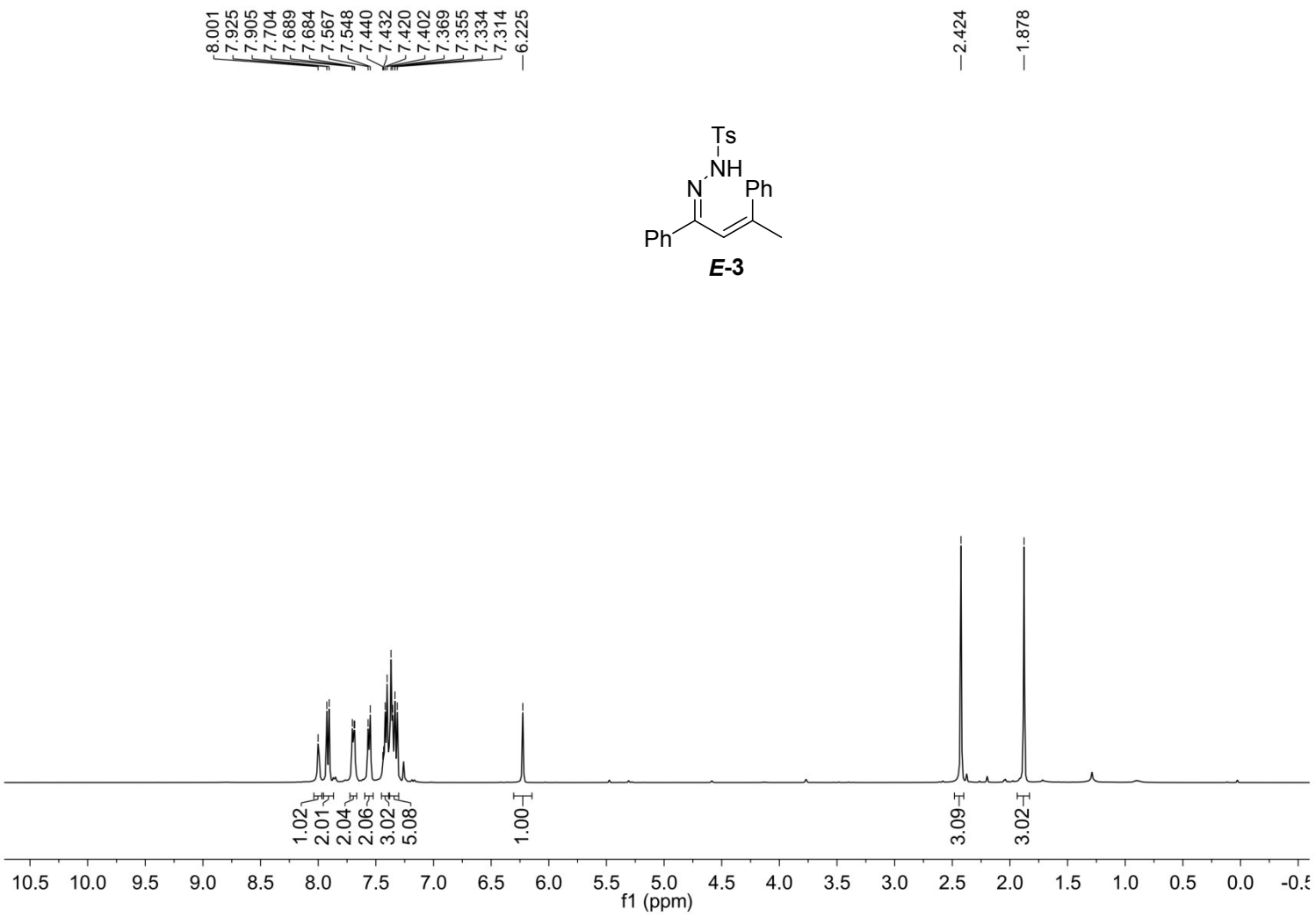
**2ae**


166.336
152.290
144.713
135.466
131.456
130.566
130.151
129.949
128.692
128.646
127.454
127.095
126.549
124.438
77.319
77.000
76.683
68.766
51.709
24.375
O
N
N
Ph
2ae
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

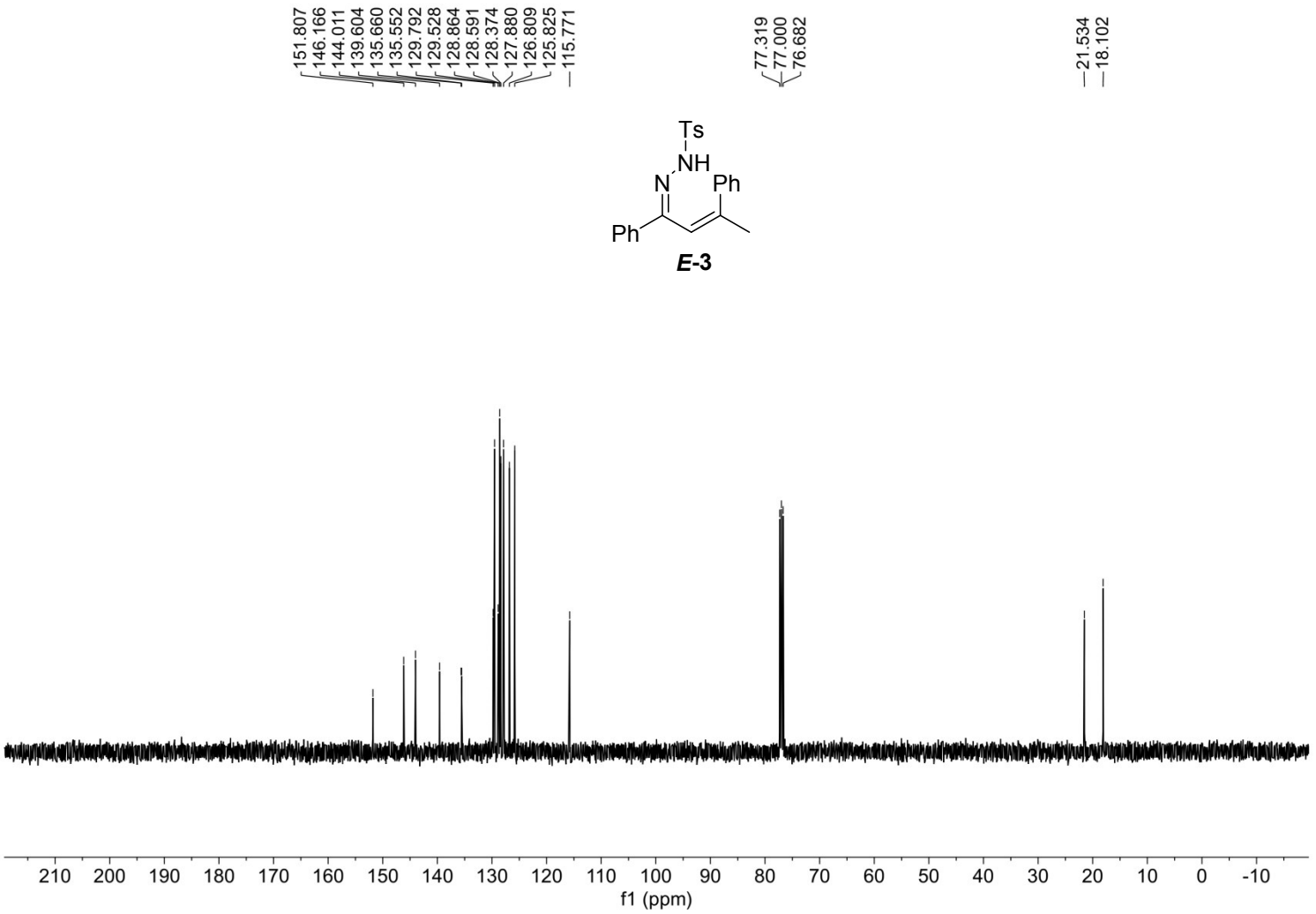

7.858
7.656
7.651
7.642
7.639
7.632
7.593
7.573
7.296
7.291
7.283
7.275
7.267
7.215
7.195
7.132
7.121
7.111
7.100
7.089
7.079
7.008
6.997
5.920
2.407
2.331
Ts
NH
N
Ph
Ph
1.01
2.03
2.00
3.03
2.06
1.06
4.00
1.00
3.02
3.01
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

***Z*-3**


151.082
147.119
143.597
138.796
135.876
135.394
129.491
129.338
128.673
128.393
128.173
127.699
126.856
126.222
116.717
77.317
77.000
76.682
24.747
21.549
Ts
NH
N
Ph
Ph
Z-3
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


8.001
7.925
7.905
7.704
7.689
7.684
7.567
7.548
7.440
7.432
7.420
7.402
7.369
7.355
7.334
7.314
6.225
2.424
1.878
Ts
NH
N
Ph
Ph
1.02
2.01
2.04
2.06
3.02
5.08
1.00
3.09
3.02
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)

***E*-3**


151.807
146.166
144.011
139.604
135.660
135.552
129.792
129.528
128.864
128.591
128.374
127.880
126.809
125.825
115.771
77.319
77.000
76.682
21.534
18.102
Ts
NH
N
Ph
Ph
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

***E*-3**