Electronic Supplementary Information

Gold(I)-catalyzed Cycloisomerization of Alkynyl Hydroxyallyl Tosylamides to 4-Oxa-6-azatricyclo[3.3.0.0^{2,8}]octanes

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I. General information

All solvents were dried and distilled according to standard methods before use. $Au(PPh_3)Cl$ was prepared according to the literature procedures. Commercially available reagents were used as received without further purfication. Reactions were carried out in a flame-dried glassware equipped with a stirring bar and sealed with a rubber septum under N_2, unless otherwise indicated. Elevated temperatures were maintained in thermostat-controlled oil baths. Reactions were monitored by thin-layer chromatography carried out on 0.25 mm E. Merck silica gel plates (60F-254) using UV light as a visualizing agent and acidic *p*-anisaldehyde, and heat as a developing agent. Flash chromatography was carried out on Merck 60 silica gel (230 – 400 mesh). ^{1}H and ^{13}C NMR spectra were recorded with Bruker (300 MHz) spectrometer and Varian spectrometer (500 MHz). ^{1}H NMR spectra were referenced to residual TMS (0 ppm) and reported as follows: chemical shift, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, br = broad, m = multiplet). Chemical shifts of the ^{13}C NMR spectra were measured relative to $CDCl_3$ (77.00 ppm). Mass spectral data were obtained from the Korea Basic Science Institute (Daegu) on a Jeol JMS 700 high resolution mass spectrometer. Single crystal data for **1a** were collected on an Enraf-Nonius CCD single crystal X-ray diffractometer at room temperature using graphite-monochromated Mo K α radiation (λ = 0.71073Å). Structures were solved by direct methods using SHELXS-97 and refined by full-matrix least-squares with SHELXL-97. Compounds **1, 2, 3, 6, 1b, 2b, 3b,** and **6b** were known.[1]

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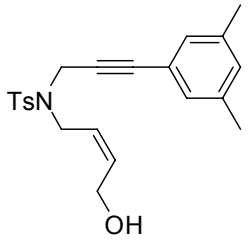
1 M.-C. P. Yeh, M.-N. Lin, W.-J. Chang, J.-L. Liou and Y.-F. Shih, *J. Org. Chem.* **2010**, *75*, 6031-6034.

II. General Procedure for Au(I)-Catalyzed Cycloisomerization

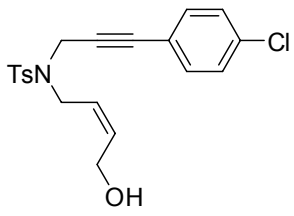
To a flame-dried 15 ml Schlenck flask capped with a rubber septum was injucted 6 ml of dichloromethane via syringe under N_2 flow. $Au(PPh_3)Cl$ (7 mg, 10 mol%) and $AgSbF_6$ (7 mg, 14 mol %) were added sequentially. The Au solution was stirred for 10 min at 85 ℃. A alkynyl allyl alcohols (0.15 mmol) was put into the flaxk under N_2 flow. The reaction was monitored by thin-layer chromatography. After reactant disappeared, solvent was removed under reduced pressure. Flash chromatography on silica gel eluting with hexane and ethyl acetate(*v*/*v* = 6:1)gave the product.

III. Characterization Data



(*Z*)-N-(3-(3,5-dimethylphenyl)prop-2-ynyl)-N-(4-hydroxybut-2-enyl)-4-methylbenzenesulfonamide (4)

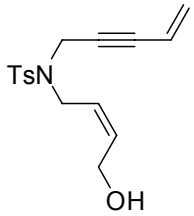
^{1}H NMR (300 MHz, $CDCl_3$) δ 1.63 (s, 1 H), 2.25 (s, 6 H), 2.37 (s, 3 H), 3.95 (d, *J* = 7.3 Hz, 2 H), 4.22 (d, *J* = 6.5 Hz, 2 H), 4.30 (s, 2 H), 5.57 (dt, *J* = 10.9, 7.3 Hz, 1 H), 5.90 (dt, *J* = 10.9, 6.5 Hz, 1 H), 6.69 (s, 2 H), 6.92 (s, 1 H), 7.29 (d, *J* = 8.1 Hz, 2 H), 7.78 (d, *J* = 8.1 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 21.0, 21.5, 36.9, 43.0, 58.0, 80.7, 86.2, 121.5, 125.6, 127.9, 129.1, 129.6, 130.5, 134.3, 135.7, 137.7, 143.5 ppm. **HRMS (EI)** calc. for $[C_{22}H_{25}NO_3S]^+$: 383.1555, found: 383.1552.



(*Z*)-N-(3-(4-chlorophenyl)prop-2-ynyl)-N-(4-hydroxybut-2-enyl)-4-methylbenzenesulfonamide (5)

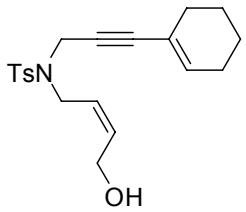
^{1}H NMR (300 MHz, $CDCl_3$) δ 1.65 (s, 1 H), 2.35 (s, 3 H), 3.95 (d, *J* = 7.3 Hz, 2 H), 4.23 (d, *J* = 6.6 Hz, 2 H), 4.29 (s, 2 H), 5.56 (dt, *J* = 10.9, 7.4 Hz, 1 H), 5.90 (dt, *J* = 10.9, 6.6 Hz, 1 H), 7.00 (d, *J* =

8.4 Hz, 2 H), 7.22 (d, *J* = 8.4 Hz, 2 H), 7.27 (d, *J* = 8.1 Hz, 2 H), 7.76 (d, *J* = 8.1 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 21.4, 36.8, 43.2, 58.0, 82.7, 84.6, 120.3, 125.6, 127.8, 128.5, 129.6, 132.7, 134.3, 134.6, 135.6, 143.7 ppm. **HRMS (EI)** calc. for $[C_{20}H_{20}ClNO_3S]^+$: 389.0852, found: 389.0855



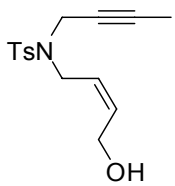
(*Z*)-N-(4-hydroxybut-2-enyl)-4-methyl-N-(pent-4-en-2-ynyl)benzenesulfonamide (7)

^{1}H NMR (300 MHz, $CDCl_3$) δ 1.78 (s, 1 H), 2.42 (s, 3 H), 3.88 (d, *J* = 7.3 Hz, 2 H), 4.19 (br s, 4 H) ppm 5.33 (dd, *J* = 16.9, 2.5Hz, 1 H), 5.39 (dd, *J* = 11.2, 2.5 Hz, 1 H), 5.46 – 5.56 (m, 2 H), 5.88 (dt, *J* = 11.0, 6.8 Hz, 1 H), 7.30 (d, *J* = 8.1 Hz, 2 H), 7.74 (d, *J* = 8.2 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 21.5, 36.8, 43.0, 58.0, 82.3, 84.4, 115.9, 125.7, 127.7, 127.8, 129.5, 134.2, 135.5, 143.6 ppm. **HRMS (EI)** calc. for $[C_{16}H_{19}NO_3S]^+$: 305.1086, found: 305.1087.



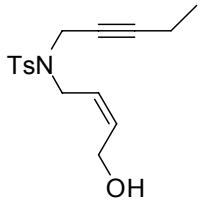
(*Z*)-N-(3-cyclohexenylprop-2-ynyl)-N-(4-hydroxybut-2-enyl)-4-methylbenzenesulfonamide (8)

^{1}H NMR (300 MHz, $CDCl_3$) δ 1.52 (br s, 4 H), 1.79 (br s, 2 H), 2.01 (br s, 2 H), 2.26 (br s, 1 H), 2.41 (s, 3 H), 3.88 (d, *J* = 7.3 Hz, 2 H), 4.18 (s, 2 H), 4.20 (d, *J* = 7.0 Hz, 2 H), 5.50 (dt, *J* = 10.6, 7.3 Hz, 1 H), 5.78 (br s, 1 H), 5.86 (dt, *J* = 10.6, 7.0 Hz, 1 H), 7.30 (d, *J* = 8.1 Hz, 2 H), 7.72 (d, J = 8.1 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 21.2, 21.4, 22.0, 25.4, 28.6, 36.7, 42.8, 57.8, 78.5, 87.6, 119.4, 125.4, 127.7, 129.4, 134.2, 135.4, 135.5, 143.4 ppm. **HRMS (FAB)** calc. for $[C_{20}H_{26}NO_3S]^+$: 360.1633, found: 360.1635.



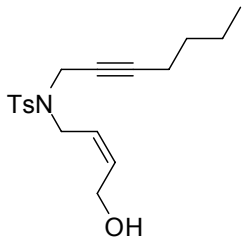
(*Z*)-N-(but-2-ynyl)-N-(4-hydroxybut-2-enyl)-4-methylbenzenesulfonamide (9)

^{1}H NMR (300 MHz, $CDCl_3$) δ 1.55 (t, *J* = 2.2 Hz, 3 H), 2.04 (s, 1 H), 2.43 (s, 3 H), 3.86 (d, *J* = 7.3 Hz, 2 H), 4.01 (d, *J* = 2.2 Hz, 2 H), 4.20 (s, 2 H), 5.49 (dt, *J* = 10.9, 7.3 Hz, 1 H), 5.86 (dt, *J* = 10.9, 6.8Hz, 1 H), 7.31 (d, *J* = 8.1 Hz, 2 H), 7.73 (d, *J* = 8.1 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 3.1, 21.4, 36.4, 42.8, 57.8, 71.6, 81.8, 125.6, 127.8, 129.3, 134.0, 135.6, 143.4 ppm. **HRMS (FAB)** calc. for $[C_{15}H_{20}NO_3S]^+$: 294.1164, found: 294.1161.



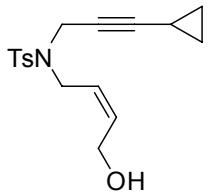
(*Z*)-N-(4-hydroxybut-2-enyl)-4-methyl-N-(pent-2-ynyl)benzenesulfonamide (10)

^{1}H NMR (300 MHz, $CDCl_3$) δ 0.90 (t, *J* = 7.5 Hz, 3 H), 1.74 – 1.79 (m, 1 H), 1.92 (q, *J* = 7.5 Hz, 2 H), 2.43 (s, 3 H), 3.88 (d, *J* = 7.3 Hz, 2 H), 4.05 (s, 2 H), 4.21 (dt, *J* = 6.6, 5.9 Hz, 2 H), 5.51 (dt, *J* = 11.0, 7.3 Hz, 1 H), 5.87 (dd, *J* = 11.0, 6.6 Hz, 1 H), 7.31 (d, *J* = 8.1 Hz, 2 H), 7.73 (d, *J* = 8.1 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 12.0, 13.4, 21.5, 36.4, 42.7, 57.9, 71.7, 87.7, 125.8, 127.8, 129.4, 134.0, 135.7, 143.4 ppm. **HRMS (FAB)** calc. for $[C_{16}H_{22}NO_3S]^+$: 308.1320, found: 308.1324.



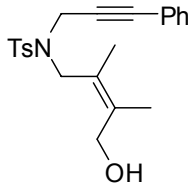
(*Z*)-N-(hept-2-ynyl)-N-(4-hydroxybut-2-enyl)-4-methylbenzenesulfonamide (11)

^{1}H NMR (300 MHz, $CDCl_3$) δ 0.85 (t, *J* = 6.8 Hz, 3 H), 1.16 – 1.28 (m, 4 H), 1.55 – 1.58 (m, 1 H), 1.90 – 1.95 (m, 2 H), 2.43 (s, 3 H), 3.89 (d, *J* = 7.3 Hz, 2 H), 4.07 (t, *J* = 2.0 Hz, 2 H), 4.21 (t, *J* = 6.9 Hz, 2 H), 5.52 (dt, *J* = 10.9, 7.4 Hz, 1 H), 5.88 (dt, *J* = 10.9, 6.9 Hz, 1 H), 7.30 (d, *J* = 8.1 Hz, 2 H), 7.73 (d, *J* = 8.1 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 13.5, 18.1, 21.5, 21.9, 30.4, 36.5, 42.7, 58.0, 86.5, 90.1, 126.0, 127.8, 129.4, 133.9, 143.4, 151.9 ppm. **HRMS (FAB)** calc. for $[C_{18}H_{26}NO_3S]^+$: 336.1633, found: 336.1630.



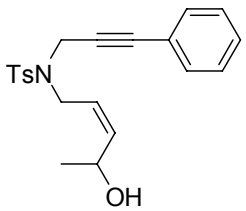
(*Z*)-N-(3-cyclopropylprop-2-ynyl)-N-(4-hydroxybut-2-enyl)-4-methylbenzenesulfonamide (12)

^{1}H NMR (500 MHz, $CDCl_3$) δ 0.30 - 0.36 (m, 2 H), 0.60 – 0.66 (m, 2 H), 0.93 – 1.02 (m, 1 H), 2.45 (s, 3 H), 3.87 (d, J = 7.4 Hz, 2 H), 4.03 (s, 2 H), 4.21 (d, J = 6.8 Hz, 2 H), 5.51 (dt, J = 11.0, 7.4 Hz, 1 H), 5.88 (dt, J = 11.0, 6.9 Hz, 1 H), 7.31 (d, J = 8.1 Hz, 2 H), 7.72 (d, J = 8.1 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ -1.0, 7.8, 21.5, 36.5, 42.7, 58.0, 67.7, 80.6, 89.5, 125.9, 127.8, 129.4, 134.0, 135.7, 143.5 ppm. **HRMS (FAB)** calc. for $[C_{17}H_{22}NO_3S]^+$: 320.1320, found: 320.1318.



(*Z*)-N-(4-hydroxy-2,3-dimethylbut-2-enyl)-4-methyl-N-(3-phenylprop-2-ynyl)benzenesulfonamide (13)

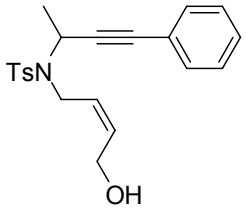
^{1}H NMR (500 MHz, $CDCl_3$) δ 1.50 (s, 1 H), 1.79 (s, 3 H), 1.83 (s, 3 H), 2.32 (s, 3 H), 3.94 (s, 2 H), 4.16 (s, 2 H), 4.20 (s, 2 H), 7.04 (d, J = 7.0 Hz, 2 H), 7.21 – 7.26 (m, 5 H), 7.78 (d, J = 7.9 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 16.7, 17.5, 21.4, 36.1, 47.9, 62.5, 81.9, 85.9, 121.8, 126.5, 127.8, 128.2, 128.6, 129.5, 131.5, 135.6, 135.8, 143.5 ppm. **HRMS (EI)** calc. for $[C_{22}H_{25}NO_3S]^+$: 383.1555, found: 383.1558.



(*Z*)-N-(4-hydroxypent-2-enyl)-4-methyl-N-(3-phenylprop-2-ynyl)benzenesulfonamide (14)

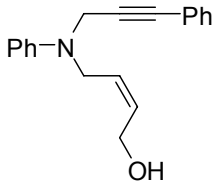
^{1}H NMR (300 MHz, $CDCl_3$) δ 1.24 (d, *J* = 6.3 Hz, 3 H), 2.34 (s, 3 H), 3.98 (d, *J* = 7.4 Hz, 2 H), 4.31 (s, 2 H), 4.70 (br s, 1 H), 5.46 (dt, *J* = 10.9, 7.4 Hz, 1 H), 5.72 (dd, *J* = 10.9, 9.0 Hz, 1 H), 7.07 (d, *J* = 7.9 Hz, 2 H), 7.25 (m, 5 H), 7.78 (d, *J* = 8.1 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 21.4, 23.3, 36.9, 43.3, 63.2, 81.6, 85.8 121.8, 124.0, 127.8, 128.2, 128.6, 129.6, 131.5, 1356, 139.3, 143.7 ppm.

HRMS (EI) calc. for $[C_{21}H_{23}NO_3S]^+$: 369.1399, found: 369.1396.



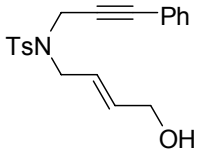
(*Z*)-N-(4-hydroxybut-2-enyl)-4-methyl-N-(4-phenylbut-3-yn-2-yl)benzenesulfonamide (15)

^{1}H NMR (300 MHz, $CDCl_3$) δ 1.51 (d, *J* = 7.1 Hz, 3 H), 2.34 (s, 3 H), 2.67 (br s, 1 H), 3.87 (dd, *J* = 16.2, 5.9 Hz, 1 H), 4.02 (dd, *J* = 16.2, 5.3 Hz, 1 H), 4.18 – 4.29 (m, 2 H), 5.06 (q, *J* = 7.1 Hz, 1 H), 5.62 – 5.76 (m, 2 H), 7.09 (d, *J* = 7.8 Hz, 2 H), 7.20 – 7.30 (m, 5 H), 7.76 (d, *J* = 8.1 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 21.5, 22.6, 41.5, 46.9, 58.1, 85.1, 86.4, 122.0, 127.6, 128.2, 128.5, 129.6, 129.9, 130.4, 131.5, 136.0, 143.5 ppm. **HRMS (EI)** calc. for $[C_{21}H_{23}NO_3S]^+$: 369.1399, found: 369.1403.



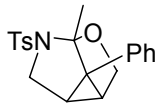
(*Z*)-4-(phenyl(3-phenylprop-2-ynyl)amino)but-2-en-1-ol (16)

^{1}H NMR (300 MHz, $CDCl_3$) δ 1.86 (s, 1 H), 4.07 (d, *J* = 6.4 Hz, 2 H), 4.22 (s, 2 H), 4.31 (d, *J* = 6.4 Hz, 2 H), 5.71 (dt, *J* = 11.3, 6.4 Hz, 1 H), 5.85 (dt, *J* = 11.3, 6.4 Hz, 1 H), 6.85 (t, *J* = 7.3 Hz, 1 H), 6.96 (d, *J* = 8.1 Hz, 2 H), 7.24-7.31 (m, 5 H), 7.36-7.39 (m, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 40.8, 47.9, 58.5, 84.4, 85.0, 115.6, 119.1, 122.7, 128.20, 128.23, 128.7, 129.1, 131.6, 132.0, 148.5 ppm. **HRMS (FAB)** calc. for $[C_{19}H_{20}NO]^+$: 278.1545, found: 278.1547.



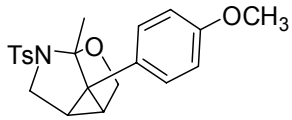
(*E*)-N-(4-hydroxybut-2-enyl)-4-methyl-N-(3-phenylprop-2-ynyl)benzenesulfonamide (1-trans)

^{1}H NMR (300 MHz, $CDCl_3$) δ 1.61 (t, *J* = 5.1 Hz, 1 H), 2.33 (s, 3 H), 3.90 (d, *J* = 6.3 Hz, 2 H), 4.16 (br s, 2 H), 4.30 (s, 2 H), 5.71 (dt, *J* = 6.3, 15.5 Hz, 1 H), 5.92 (dt, *J* = 15.4, 5.1 Hz, 1 H), 7.06 (dd, *J* = 7.8, 1.3 Hz, 2 H), 7.21 – 7.31 (m, 5 H), 7.77 (d, *J* = 8.1 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 21.4, 36.8, 48.0, 62.7, 81.6, 85.7, 122.1, 124.9, 127.8, 128.1, 128.4, 129.5, 131.4, 134.6, 135.8, 143.5 ppm. **HRMS (EI)** calc. for $[C_{20}H_{21}NO_3S]^+$: 355.1242, found: 355.1238



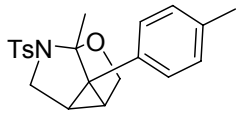
(1a)

^{1}H NMR (300 MHz, $CDCl_3$) δ 1.60 (s, 3 H), 2.06 – 2.17 (m, 2 H), 2.44 (s, 3 H), 2.82 (dd, J = 9.8, 1.3 Hz, 1 H), 3.44 (d, *J* = 10.2 Hz, 1 H), 3.97 (dd, *J* = 9.8, 5.4 Hz, 1 H), 4.14 (dd, *J* = 10.2, 5.4 Hz, 1 H), 7.26 – 7.37 (m, 7 H), 7.83 (d, J = 8.1 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 21.6, 22.8, 28.7, 32.2, 48.7, 53.5, 65.1, 105.9, 127.9, 128.5, 128.7, 128.9, 130.4, 135.6, 136.4, 143.2 ppm. **HRMS (EI)** calc. for $[C_{20}H_{21}NO_3S]^+$: 355.1242, found: 355.1246.



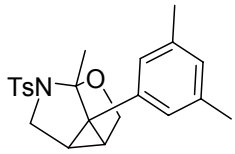
(2a)

^{1}H NMR (300 MHz, $CDCl_3$) δ 1.59 (s, 3 H), 2.02 – 2.12 (m, 2 H), 2.43 (s, 3 H), 2.81 (dd, *J* = 9.8, 1.3 Hz, 1 H), 3.42 (d, *J* = 10.1 Hz, 1 H), 3.80 (s, 3 H), 3.95 (dd, *J* = 9.8, 5.4 Hz, 1 H), 4.12 (dd, *J* = 10.1, 5.4 Hz, 1 H), 6.86 (d, *J* = 8.6 Hz, 2 H), 7.21 (d, *J* = 8.6 Hz, 2 H), 7.28 (d, *J* = 8.1 Hz, 2 H), 7.82 (d, *J* = 8.1 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 21.5, 22.8, 28.8, 32.3, 48.7, 52.8, 55.3, 65.1, 105.9, 113.9, 128.5, 128.7, 128.9, 131.5, 135.6, 143.2, 159.3 ppm. **HRMS (EI)** calc. for $[C_{21}H_{23}NO_3S]^+$: 385.1348, found: 385.1347.



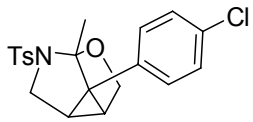
(3a)

^{1}H NMR (300 MHz, $CDCl_3$) δ 1.60 (s, 3 H), 2.03 – 2.13 (m, 2 H), 2.35 (s, 3 H), 2.43 (s, 3 H), 2.81 (dd, *J* = 9.8 1.3 Hz, 1 H), 3.42 (d, *J* = 10.2 Hz, 1 H), 3.95 (dd, *J* = 9.8, 5.3 Hz, 1 H), 4.12 (dd, *J* = 10.1, 5.6 Hz, 1 H), 7.14 (d, *J* = 8.1 Hz, 2 H), 7.19 (d, *J* = 8.1 Hz, 2 H), 7.29 (d, *J* = 8.1 Hz, 2 H), 7.82 (d, *J* = 8.1 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 21.1, 21.5, 22.8, 28.7, 32.2, 48.7, 53.1, 65.1, 105.9, 128.7, 128.9, 129.2, 130.3, 133.3, 135.5, 137.7, 143.2 ppm. **HRMS (EI)** calc. for $[C_{21}H_{23}NO_3S]^+$: 369.1399, found: 369.1402.



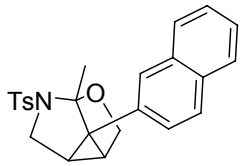
(4a)

^{1}H NMR (300 MHz, $CDCl_3$) δ 1.61 (s, 3 H), 2.02 – 2.13 (m, 2 H), 2.30 (s, 6 H), 2.43 (s, 3 H), 2.81 (dd, *J* = 9.8, 1.3 Hz, 1 H), 3.41 (d, *J* = 10.1 Hz, 1 H), 3.96 (dd, *J* = 9.8, 5.5 Hz, 1 H), 4.12 (dd, *J* = 10.1, 5.5 Hz, 1 H), 6.91 (s, 2 H), 6.93 (s, 1 H), 7.29 (d, *J* = 8.1 Hz, 2 H), 7.83 (d, *J* = 8.1 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 21.1, 21.5, 22.8, 28.6, 32.1, 48.7, 53.3, 65.1, 106.0, 128.1, 128.7, 128.9, 129.5, 135.6, 136.2, 138.1, 143.2 ppm. **HRMS (EI)** calc. for $[C_{22}H_{25}NO_3S]^+$: 383.1555, found: 383.1559.



(5a)

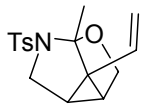
^{1}H NMR (300 MHz, $CDCl_3$) δ 1.59 (s, 3 H), 2.05 – 2.16 (m, 2 H), 2.44 (s, 3 H), 2.81 (dd, *J* = 9.9, 1.2 Hz, 1 H), 3.43 (d, *J* = 10.2 Hz, 1 H), 3.96 (dd, *J* = 9.9, 5.4 Hz, 1 H), 4.12 (dd, *J* = 10.2, 5.5 Hz, 1 H), 7.24 (d, *J* = 8.4 Hz, 2 H), 7.27 - 7.33 (m, 4 H), 7.82 (d, *J* = 8.1 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 21.6, 22.8, 28.8, 32.3, 48.6, 52.8, 65.1, 105.7, 128.7, 128.8, 129.0, 131.7, 134.9, 135.4, 143.3, 153.3 ppm. **HRMS (EI)** calc. for $[C_{20}H_{20}ClNO_3S]^+$: 389.0852, found: 389.0851.



(6a/6a'=1/1)

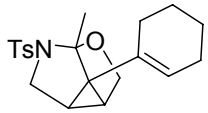
^{1}H NMR (300 MHz, $CDCl_3$) δ 1.55 (s, 3 H), 1.59 (s, 3 H), 2.11 (dd, J = 7.4, 5.7 Hz, 1 H), 2.18 – 2.33 (m, 3 H), 2.45 (s, 6 H), 2.92 (d, *J* = 11.2 Hz, 1 H), 2.97 (d, *J* = 9.8 Hz, 1 H), 3.55 (d, *J* = 10.2 Hz, 1 H), 3.66 (d, *J* = 10.4 Hz, 1 H), 4.06 (dd, *J* = 9.8, 5.6Hz, 1 H), 4.23 – 4.29 (m, 2 H), 4.40 (dd, *J* = 10.4, 5.6 Hz, 1 H), 7.32 (d, *J* = 8.0 Hz, 4 H), 7.38 – 7.60 (m, 8 H), 7.81 – 7.89 (m, 8 H), 7.99 - 8.05 (m, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 21.6, 21.7, 22.6, 28.8, 29.7, 31.6, 32.4, 33.3, 48.7, 49.0, 51.4, 52.0, 64.8, 65.3, 106.1, 106.3, 124.7, 124.9, 125.2, 125.5, 125.9, 126.1, 126.7, 126.9, 128.6, 128.73, 128.75, 128.8, 129.0, 129.1, 133.15, 133.24, 133.36, 133.43, 133.7, 133.8, 135.7, 135.8, 143.3, 143.4

ppm. **HRMS (EI)** calc. for $[C_{24}H_{23}NO_3S]^+$: 405.1399, found: 405.1394



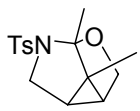
(7a)

^{1}H NMR (300 MHz, $CDCl_3$) δ 1.89 (s, 3 H), 1.94 – 2.05 (m, 2 H), 2.43 (s, 3 H), 2.74 (dd, *J* = 9.7, 1.4 Hz, 1 H), 3.31 (d, *J* = 10.1 Hz, 1 H), 3.79 (dd, *J* = 9.7, 5.5 Hz, 1 H), 3.92 (dd, *J* = 10.1, 5.5 Hz, 1 H), 5.03 (dd, *J* = 17.0, 1.2 Hz, 1 H), 5.13 (dd, *J* = 10.3, 1.2 Hz, 1 H), 6.27 (dd, *J* = 17.0, 10.3 Hz, 1 H), 7.27 (d, *J* = 8.1 Hz, 2 H) ppm 7.80 (d, *J* = 8.1 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 21.5, 21.9, 29.6, 32.8, 48.2, 50.9, 64.6, 104.7, 116.1, 128.7, 128.9, 132.1, 134.1, 143.2 ppm. **HRMS (EI)** calc. for $[C_{16}H_{19}NO_3S]^+$: 305.1086, found: 305.1090.



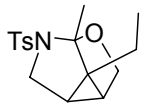
(8a)

^{1}H NMR (300 MHz, $CDCl_3$) δ 1.56 – 1.63 (m, 4 H), 1.75 – 1.90 (m, 2H), 1.83 (s, 3 H), 1.98 - 2.08 (m, 4 H), 2.42 (s, 3 H), 2.66 (dd, *J* = 9.7, 1.3 Hz, 1 H), 3.29 (d, *J* = 10.1 Hz, 1 H), 3.78 (dd, *J* = 9.7, 5.6 Hz, 1 H), 3.95 (dd, *J* = 10.1, 5.6 Hz, 1 H), 5.70 (br s, 1 H), 7.26 (d, *J* = 8.1 Hz, 2 H), 7.79 (d, *J* = 8.1 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 21.3, 21.5, 22.1, 22.7, 25.3, 27.7, 28.5, 31.5, 48.7, 54.4, 64.9, 105.4, 128.7, 128.8, 129.1, 132.9, 135.6, 143.1 ppm. **HRMS (EI)** calc. for $[C_{20}H_{25}NO_3S]^+$: 359.1555, found: 359.1552.



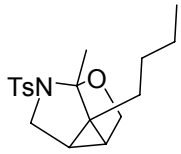
(9a)

^{1}H NMR (300 MHz, $CDCl_3$) δ 1.36 (s, 3 H), 1.65 (br s, 2 H), 1.86 (s, 3 H), 2.42 (s, 3 H), 2.65 (d, *J* = 9.8 Hz, 1 H), 3.24 (d, *J* = 10.0 Hz, 1 H), 3.73 (ddd, *J* = 9.8, 3.4, 2.0 Hz, 1 H) ppm 3.86 (ddd, *J* = 10.0, 3.4, 2.0 Hz, 1 H), 7.27 (d, *J* = 8.0 Hz, 2 H), 7.79 (d, *J* = 8.2 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 14.9, 21.1, 21.5, 28.8, 32.2, 43.8, 48.1, 64.5, 105.1, 128.6, 128.9, 135.5, 143.1 ppm. **HRMS (EI)** calc. for $[C_{15}H_{19}NO_3S]^+$: 293.1086, found: 293.1082.



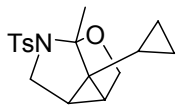
(10a)

^{1}H NMR (300 MHz, $CDCl_3$) δ 0.83 (t, *J* = 7.4 Hz, 3 H), 1.68 – 1.80 (m, 1 H), 1.73 (br s, 2H), 1.82 – 1.92 (m, 1 H), 1.90 (s, 3 H), 2.42 (s, 3 H), 2.67 (d, *J* = 9.7 Hz, 1 H), 3.27 (d, *J* = 10.0 Hz, 1 H), 3.70 (ddd, *J* = 9.7, 3.5, 1.9 Hz, 1 H) ppm 3.85 (ddd, *J* = 10.0, 3.4, 1.9 Hz, 1 H), 7.27 (d, *J* = 8.1 Hz, 2 H), 7.80 (d, *J* = 8.1 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 10.6, 20.0, 20.8, 21.5, 25.7, 29.6, 48.3, 64.7, 105.2, 128.7, 128.9, 135.6, 143.1 ppm. **HRMS (EI)** calc. for $[C_{16}H_{21}NO_3S]^+$: 307.1242, found: 307.1238.



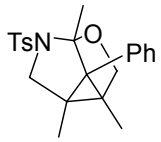
(11a)

^{1}H NMR (300 MHz, $CDCl_3$) δ 0.90 (t, *J* = 7.2 Hz, 3 H), 1.07- 1.39 (m, 4 H), 1.62 – 1.74 (m, 1 H), 1.71 – 1.74 (m, 2 H), 1.79 – 1.93 (m, 1 H), 1.90 (s, 3 H), 2.42 (s, 3 H), 2.66 (d, *J* = 9.7 Hz, 1 H), 3.27 (d, *J* = 10.0 Hz, 1 H), 3.70 (ddd, 9.7, 3.5, 2.0 Hz, 1 H), 3.85 (ddd, *J* =10.0, 3.4, 2.0 Hz, 1 H), 7.26 (d, *J* = 8.1 Hz, 2 H), 7.79 (d, *J* = 8.1 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 14.0, 21.0, 21.5, 22.8, 26.4, 27.2, 28.8, 30.3, 48.2, 48.3, 64.6, 105.4, 128.7, 128.9, 135.7, 143.1 ppm. **HRMS (EI)** calc. for $[C_{18}H_{25}NO_3S]^+$: 335.1555, found: 335.1551.



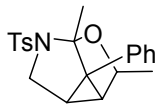
(12a)

^{1}H NMR (300 MHz, $CDCl_3$) δ -0.02 - 0.1 (m, 2 H), 0.49 – 0.61 (m, 2 H), 1.24 – 1.32 (m, 1 H), 1.53 – 1.62 (m, 2 H), 2.02 (s, 3 H), 2.42 (s, 3 H), 2.62 (d, *J* = 9.7 Hz, 1 H), 3.23 (d, *J* = 10.1 Hz, 1 H), 3.66 (dd, *J* = 9.7, 4.9 Hz, 1 H), 3.82 (dd, *J* = 10.1, 5.1 Hz, 1 H), 7.26 (d, *J* = 7.9 Hz, 2 H), 7.79 (d, *J* = 8.1 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 2.7, 3.3, 7.9, 21.2, 21.5, 26.3, 29.3, 48.2, 51.2, 64.5, 105.4, 128.6, 128.8, 135,5 143.1 ppm. **HRMS (EI)** calc. for $[C_{17}H_{21}NO_3S]^+$: 319.1242, found: 319.1241



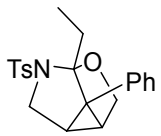
(13a)

^{1}H NMR (300 MHz, $CDCl_3$) δ 1.05 (s, 3 H), 1.08 (s, 3 H), 1.49 (s, 3 H), 2.44 (s, 3 H), 2.97 (d, *J* = 9.6 Hz, 1 H), 3.57 (d, *J* = 9.9 Hz, 1 H), 3.63 (d, *J* = 9.6 Hz, 1 H), 3.84 (d, *J* = 9.9 Hz, 1 H), 7.15 (d, *J* = 6.6 Hz, 2 H), 7.29 (d, *J* = 8.1 Hz, 2 H), 7.28 – 7.40 (m, 3 H), 7.83 (d, *J* = 8.2 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 13.9, 14.7, 21.6, 23.1, 29.7, 35.4, 40.0, 56.2, 72.6, 107.6, 127.7, 128.7, 128.8, 128.9, 129.5, 131.8, 135.6, 143.2 ppm. **HRMS (EI)** calc. for $[C_{22}H_{25}NO_3S]^+$: 383.1555, found: 383.1558.



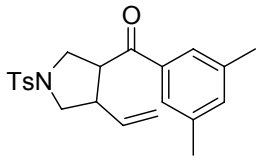
(14a)

^{1}H NMR (300 MHz, $CDCl_3$) δ 1.18 (d, *J* = 6.1 Hz, 3 H), 1.60 (s, 3 H), 1.79 (dd, *J* = 7.6, 0.9 Hz, 1 H), 2.03 (dd, *J* = 7.6, 5.7 Hz, 1 H), 2.44 (s, 3 H), 3.04 (q, *J* = 6.1 Hz, 1 H), 3.44 (d, *J* = 10.1 Hz, 1 H), 4.12 (dd, *J* = 10.1, 5.7 Hz, 1 H), 7.27 – 7.35 (m, 7 H), 7.84 (d, *J* = 8.1 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 21.0, 21.6, 23.2, 28.3, 37.8, 49.2, 53.9, 72.0, 105.5, 127.9, 128.5, 128.6, 128.75, 128.79, 130.5, 136.4, 143.2 ppm. **HRMS (EI)** calc. for $[C_{21}H_{23}NO_3S]^+$: 369.1399, found: 369.1396.



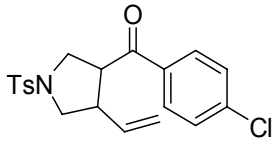
(15a)

^{1}H NMR (300 MHz, $CDCl_3$) δ 0.66 (t, *J* = 7.3 Hz, 3 H), 1.92 – 2.05 (m, 2 H), 2.16 (dd, *J* = 7.2, 5.7 Hz, 1 H), 2.44 (s, 3 H), 2.48 – 2.55 (m, 1 H), 2.67 (dd, *J* = 10.1, 1.4 Hz, 1 H), 3.48 (d, *J* = 10.0 Hz, 1 H), 3.93 (dd, *J* = 10.1, 5.7 Hz, 1 H), 4.12 (dd, *J* = 10.0, 5.6 Hz, 1 H), 7.26 – 7.33 (m, 7 H), 7.85 (d, *J* = 8.1 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 8.8, 21.6, 26.7, 28.4, 33.4, 49.1, 52.2, 64.7, 109.2, 127.8, 128.3, 128.9, 129.0, 140.7, 135.4, 136.5, 143.3 ppm. **HRMS (EI)** calc. for $[C_{21}H_{23}NO_3S]^+$: 369.1399, found: 369.1396.



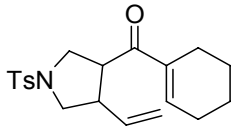
(3,5-Dimethylphenyl)(1-tosyl-4-vinylpyrrolidin-3-yl)methanone (4b)

^{1}H NMR (300 MHz, $CDCl_3$) δ 2.34 (s, 6 H), 2.46 (s, 3 H), 3.13 – 3.23 (m, 1 H), 3.26 (dd, *J* = 9.7, 5.1 Hz, 1 H), 3.59 – 3.70 (m, 3 H), 4.07 (dd, *J* = 15.2, 7.7 Hz, 1 H), 4.75 (d, *J* = 16.9 Hz, 1 H), 4.80 (d, *J* = 10.1 Hz, 1 H), 5.27 (ddd, *J* = 16.9, 10.1, 9.0 Hz, 1 H), 7.19 (s, 1 H), 7.36 (d, *J* = 8.1 Hz, 2 H), 7.40 (s, 2 H), 7.77 (d, *J* = 8.2 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 21.2, 21.6, 46.1, 48.5, 49.1, 52.8, 117.8, 126.0, 127.6, 129.7, 133.6, 133.8, 135.1, 136.7, 138.3, 143.6, 197.8 ppm. **HRMS (FAB)** calc. for $[C_{22}H_{26}NO_3S]^+$: 384.1633, found: 384.1635.



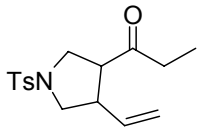
(4-Chlorophenyl)(1-tosyl-4-vinylpyrrolidin-3-yl)methanone (5b)

^{1}H NMR (300 MHz, $CDCl_3$) δ 2.46 (s, 3 H), 3.14 – 3.25 (m, 2 H), 3.60 – 3.72 (m, 3 H), 4.01 – 4.12 (m, 1 H), 4.75 (d, *J* = 16.6 Hz, 1 H), 4.79 (d, *J* = 9.2 Hz, 1 H), 5.17 – 5.29 (m, 1 H), 7.36 (d, *J* = 8.1 Hz, 2 H), 7.41 (d, *J* = 8.5 Hz, 2 H), 7.75 (d, *J* = 8.5 Hz, 2 H), 7.76 (d, *J* = 8.1 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 21.6, 46.2, 48.4, 49.1, 52.9, 118.2, 127.7, 129.1, 129.6, 129.8, 133.55, 133.64, 134.9, 140.0, 143.7, 196.3 ppm. **HRMS (EI)** calc. for $[C_{20}H_{20}ClNO_3S]^+$: 389.0852, found: 389.0850.



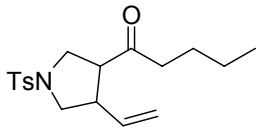
Cyclohexenyl(1-tosyl-4-vinylpyrrolidin-3-yl)methanone (8b)

^{1}H NMR (300 MHz, $CDCl_3$) δ 1.57 – 1.59 (m, 4 H), 2.02 (br s, 1 H), 2.16 (br s, 1 H), 2.23 (br s, 2 H), 2.45 (s, 3 H), 3.03 (td, *J* = 13.8, 7.1 Hz, 1 H), 3.15 (dd, *J* = 9.8, 5.2 Hz, 1 H), 3.52 (dd, *J* = 7.7, 1.9 Hz, 2 H), 3.59 (dd, *J* = 9.8, 6.6 Hz, 1 H), 3.81 (q, *J* = 7.7 Hz, 1 H), 4.87 (d, *J* = 11.7 Hz, 1 H), 4.88 (d, *J* = 15.3 Hz, 1 H), 5.17 – 5.30 (m, 1 H), 6.78 (s, 1 H), 7.34 (d, *J* = 8.1 Hz, 2 H), 7.74 (d, *J* = 8.1 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 21.1, 21.6, 21.7, 23.0, 26.1, 46.4, 47.6, 48.6, 52.8, 117.3, 127.6, 129.7, 133.4, 134.4, 139.5, 140.8, 143.5, 198.2 ppm. **HRMS (EI)** calc. for $[C_{20}H_{25}NO_3S]^+$: 359.1555, found: 359.1554.



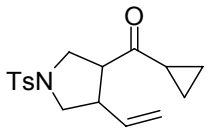
1-(1-Tosyl-4-vinylpyrrolidin-3-yl)propan-1-one (10b)

^{1}H NMR (300 MHz, $CDCl_3$) δ 0.95 (t, *J* = 7.2 Hz, 3 H), 2.25 - 2.41 (m, 2 H), 2.44 (s, 3 H), 3.03 - 3.12 (m, 1 H), 3.16 – 3.27 (m, 2 H), 3.45 – 3.57 (m, 3 H), 4.98 (dd, *J* = 10.1, 1.0 Hz, 1 H), 5.04 (d, *J* = 16.8 Hz, 1 H), 5.25 – 5.37 (ddd, *J* = 16.8, 10.1, 9.7, 1 H), 7.34 (d, *J* = 8.1 Hz, 2 H), 7.73 (d, *J* = 8.2 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 7.1, 36.4, 43.4, 45.3, 47.5, 52.9, 53.5, 118.1, 127.6, 129.7, 133.5, 134.1, 143.6, 208.2 ppm. **HRMS (FAB)** calc. for $[C_{16}H_{22}NO_3S]^+$: 308.1320, found: 308.1324.



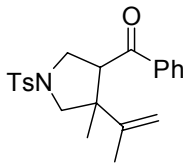
1-(1-Tosyl-4-vinylpyrrolidin-3-yl)pentan-1-one (11b)

^{1}H NMR (300 MHz, $CDCl_3$) δ 0.86 (t, *J* = 7.3 Hz, 3 H), 1.17 – 1.29 (m, 4 H), 1.37 – 1.53 (m, 2 H), 2.31 (dt, *J* = 7.6, 1.4 Hz, 2 H), 2.44 (s, 3 H), 3.03 – 3.12 (m, 1 H), 3.16 – 3.25 (m, 2 H), 3.44 - 3.56 (m, 3 H) ppm 4.98 (dd, *J* = 10.2, 1.0 Hz, 1 H), 5.04 (d, *J* = 16.9 Hz, 1 H), 5.31 (ddd, *J* = 16.9, 10.2, 9.8 Hz, 1 H), 7.34 (d, *J* = 8.0 Hz, 1 H), 7.73 (d, *J* = 8.2 Hz, 1 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 13.8, 21.5, 22.2, 25.1, 42.9, 45.3, 47.5, 52.9, 53.5, 118.1, 127.6, 129.7, 133.5, 134.1, 143.6, 207.8 ppm. **HRMS (FAB)** calc. for $[C_{18}H_{26}NO_3S]^+$: 336.1633, found: 336.1631.



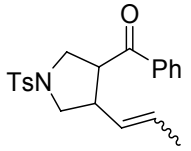
Cyclopropyl(1-tosyl-4-vinylpyrrolidin-3-yl)methanone (12b)

^{1}H NMR (300 MHz, $CDCl_3$) δ 0.75 - 0.84 (m, 2 H), 0.86 – 0.94 (m, 2 H), 1.71 - 1.79 (m, 1 H), 2.44 (s, 3 H), 3.07 – 3.17 (m, 2 H), 3.35 – 3.43 (m, 1 H), 3.46 – 3.59 (m, 3 H), 4.99 (d, *J* =9.9 Hz, 1 H), 5.05 (d, *J* = 17.2 Hz, 1 H), 5.37 (ddd, 1H, *J* = 17.2, 9.9, 8.9 Hz, 1 H), 7.33 (d, *J* = 8.1 Hz, 2 H), 7.73 (d, *J* = 8.1 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 11.5, 11.7, 20.9, 21.5, 45.1, 47.5, 52.7, 55.0, 117.9, 127.6, 129.7, 133.6, 134.3, 143.6, 207.5 ppm. **HRMS (EI)** calc. for $[C_{17}H_{21}NO_3S]^+$: 319.1242, found: 319.1241



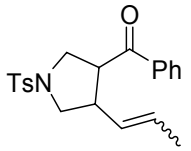
(4-Methyl-4-(prop-1-en-2-yl)-1-tosylpyrrolidin-3-yl)(phenyl)methanone (13b)

^{1}H NMR (300 MHz, $CDCl_3$) δ 1.25 (s, 3 H), 1.49 (s, 3 H), 2.44 (s, 3 H), 3.40 – 3.47 (m, 2 H), 3.79 – 3.90 (m, 3 H), 4.54 (s, 1 H), 4.69 (s, 1 H), 7.30 (d, *J* = 8.1 Hz, 2 H), 7.40 – 7.45 (m, 2 H), 7.55 (t, *J* = 7.3 Hz, 1 H), 7.70 (d, *J* = 7.9 Hz, 4 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 20.6, 21.5, 27.0, 28.5, 49.8, 51.7, 60.0, 111.5, 127.4, 128.1, 128.7, 129.6, 133.3, 134.2, 136.6, 143.3, 146.2, 199.2 ppm. **HRMS (FAB)** calc. for $[C_{22}H_{26}NO_3S]^+$: 384.1633, found: 384.1631.



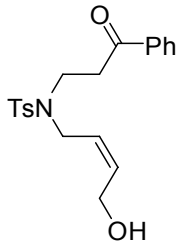
Phenyl(4-(prop-1-enyl)-1-tosylpyrrolidin-3-yl)methanone (14b)

^{1}H NMR (300 MHz, $CDCl_3$) δ 1.30 (dd, *J* = 6.4, 1.3 Hz, 3 H), 2.46 (s, 3 H), 3.09 – 3.21 (m, 2 H), 3.58 – 3.72 (m, 3 H), 4.04 (q, *J* = 7.6 Hz, 1 H), 4.76 (ddd, *J* = 15.2, 9.0, 1.3 Hz, 1 H), 5.09 (dq, *J* = 15.2, 6.4 Hz, 1 H), 7.36 (d, *J* = 8.0 Hz, 2 H), 7.40 – 7.45 (m, 2 H), 7.55 (t, *J* = 7.3 Hz, 1 H), 7.77 (d, *J* = 7.9 Hz, 4 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 17.6, 21.6, 45.3, 48.4, 49.4, 53.5, 126.4, 127.7, 128.1, 128.6, 128.8, 129.7, 133.3, 133.5, 136.8, 143.6, 197.8 ppm. **HRMS (FAB)** calc. for $[C_{21}H_{24}NO_3S]^+$: 370.1477, found: 370.1479.



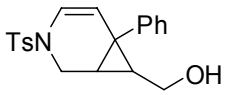
Phenyl(4-(prop-1-enyl)-1-tosylpyrrolidin-3-yl)methanone (14b')

^{1}H NMR (300 MHz, $CDCl_3$) δ 1.55 (d, *J* = 6.3 Hz, 3 H), 2.46 (s, 3 H), 2.99 – 3.09 (m, 1 H), 3.20 (dd, *J* = 9.8, 7.7 Hz, 1 H), 3.29 – 3.37 (m, 1 H), 3.45 (dd, *J* = 9.8, 7.8 Hz, 1 H), 3.67 – 3.78 (m, 2 H), 5.26 (ddd, *J* = 15.2, 8.0, 1.2 Hz, 1 H), 5.45 (dq, *J* = 15.2, 6.3 Hz, 1 H), 7.34 (d, *J* = 8.0 Hz, 2 H), 7.45 (t, *J* = 7.3 Hz, 2 H), 7.58 (t, *J* = 7.4 Hz, 1 H), 7.72 (d, *J* = 8.1 Hz, 2 H), 7.83 (d, *J* = 7.3 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 17.8, 21.6, 44.9, 50.6, 50.9, 52.6, 127.6, 128.4, 128.5, 128.7, 128.9, 129.8, 133.4, 133.6, 136.1, 143.7, 197.8 ppm. **HRMS (EI)** calc. for $[C_{21}H_{24}NO_3S]^+$: 370.1477, found: 370.1481.



(*Z*)-N-(4-hydroxybut-2-enyl)-4-methyl-N-(3-oxo-3-phenylpropyl)benzenesulfonamide (1c)

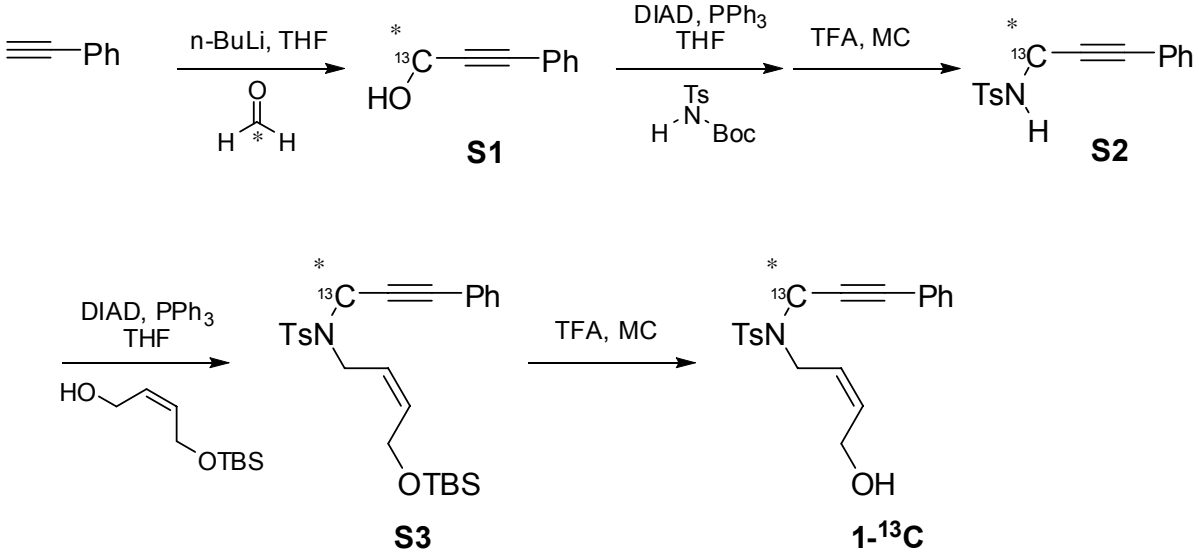
^{1}H NMR (500 MHz, $CDCl_3$) δ 2.24 (s, 1 H), 2.43 (s, 3 H), 3.36 (t, *J* = 6.7 Hz, 2 H), 3.55 (t, *J* = 6.7 Hz, 2 H), 3.94 (d, *J* = 7.1 Hz, 2 H), 4.18 (d, *J* = 6.9 Hz, 2 H), 5.39 (dt, *J* = 11.0, 7.2 Hz, 1 H), 5.78 (dt, *J* = 11.0, 6.9 Hz, 1 H), 7.31 (d, *J* = 8.0 Hz, 2 H), 7.48 (t, *J* = 7.6 Hz, 2 H), 7.60 (t, *J* = 7.3 Hz, 1 H), 7.71 (d, *J* = 8.1 Hz, 2 H), 7.94 (d, *J* = 7.4 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 21.5, 39.2, 43.2, 45.9, 57.8, 126.8, 127.1, 128.2, 128.7, 129.8, 132.9, 133.6, 136.3, 136.4, 143.6, 199.0 ppm. **HRMS (FAB)** calc. for $[C_{20}H_{24}NO_4S]^+$: 374.1426, found: 374.1423.

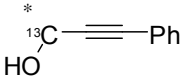


(6-Phenyl-3-tosyl-3-azabicyclo[4.1.0]hept-4-en-7-yl)methanol

^{1}H NMR (300 MHz, $CDCl_3$) δ 1.41 (dd, *J* = 13.4, 5.6 Hz, 1 H), 1.57 (s, 1 H), 1.96 – 1.98 (m, 1 H), 2.44 (s, 3 H), 3.12 (dd, *J* = 11.8, 7.8 Hz, 1 H), 3.17 (dd, *J* = 11.7, 2.6 Hz, 1 H), 3.30 (dd, *J* = 11.8, 5.6 Hz, 1 H), 4.09 (d, *J* = 11.7 Hz, 1 H), 5.45 (d, *J* = 8.3 Hz, 1 H), 6.38 (d, *J* = 8.2 Hz, 1 H), 7.20 – 7.36 (m, 5 H), 7.34 (d, *J* = 8.3 Hz, 2 H), 7.69 (d, *J* = 8.1 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 21.6, 27.1, 27.4, 34.6, 40.3, 62.1, 116.3, 120.4, 127.1, 127.8, 128.8, 129.9, 131.5, 134.6, 139.7, 144.0 ppm. **HRMS (EI)** calc. for $[C_{20}H_{21}NO_3S]^+$: 355.1242, found: 355.1240

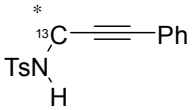
IV. General procedure for preperation of C-13 labeled reactant.





3-Phenylprop-2-yn-1-ol (S1)

A 100 mL schlenck equipped with magnetic stirring bar and rubber septum was charged with phenyl acetylene (0.6 ml, 5.5 mmol) and 20 ml of tetrahydrofuran. The resulting mixture was cooled to -78 ^{o}C and 2.2 ml of n-BuLi (5.5 mmol, 2.5 M in hexane solution) was added dropwise. The solution was stirred for 30 min. Then C-13 labeled paraformaldehyde (0.16 g, 5 mmol) was added and the reaction mixture allowed to warm to room temperature. After stirring at room temperature overnight, the solution was washed with saturated NH_4Cl solution and extracted with three 10ml portion of diethyl ether. The combined ether extracts were dried over anhydrous magnesium sulfate. After filtration, the solvent was removed by rotoevaporation to give crude product. The crude product was purified by flash column chromatography (hexane/ethyl acetate=5/1) and 3-phenylprop-2-yn-1-ol was obtained in 93 % yield. (0.61 g, 4.63 mmol) **^{1}H NMR (500 MHz, $CDCl_3$)** δ 1.81 (s, 1 H), 4.50 (d, *J* = 148.3 Hz, 2 H), 7.32 - 7.33 (m, 3 H), 7.44 – 7.46 (m, 2 H) ppm. **^{13}C NMR (125 MHz, $CDCl_3$)** δ 51.6 ppm. **HRMS (EI)** calc. for $[^{13}C_1C_8H_8O]^+$: 133.0609, found: 133.0612

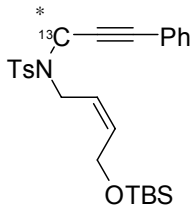


4-Methyl-N-(3-phenylprop-2-ynyl)benzenesulfonamide (S2)

1.21 g of triphenylphosphine (4.63 mmol), 0.92 mL of diisopropylazodicarboxylate(4.63 mmol) and 20 mL of tetrahydrofuran was added to flame dried 100ml schlenk, and stirred for 10 min. Then tert-

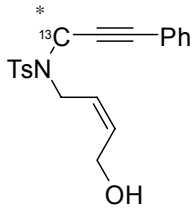
butyl tosylcarbamate (1.26 g, 4.63 mmol) was added and 0.61 g of 3-phenylprop-2-yn-1-ol **S1** was injected another 10 min later. The reaction mixture was stirred overnight and solvent was removed by rotoevaporation. Flash column chromatography with hexane and ethyl acetate (10/1) give 1.73 g of tert-butyl 3-phenylprop-2-ynyl(tosyl)carbamate.

The purified tert-butyl 3-phenylprop-2-ynyl(tosyl)carbamate (1.73 g, 4.5 mmol) was treated with trifluoroacetic acid (1.7 mL, 22.5 mmol) in 20 mL of dichloromethane. After 1 hr, the mixture was washed with $NaHCO_3$. The organic layer was combined and dried over anhydrous magnesium sulfate. After Flash column chromatography(hexane/ethyl acetate=3/1), 1.04 g (3.96 mmol) of 4-methyl-N-(3-phenylprop-2-ynyl)benzenesulfonamide **S2** was obtained. **^{1}H NMR (500 MHz, $CDCl_3$)** δ 2.36 (s, 3 H), 4.09 (dd, *J* = 145.1, 6.2 Hz, 2 H), 4.60 (s, 1 H), 7.13 (d, *J* = 8.2 Hz, 2 H), 7.24 – 7.30 (m, 5 H), 7.82 (d, *J* = 8.2 Hz, 2 H) ppm. **^{13}C NMR (125 MHz, $CDCl_3$)** δ 33.8 ppm. **HRMS (EI)** calc. for $[^{13}C_1C_{15}H_{15}NO_2S]^+$: 286.0857, found: 286.0858.



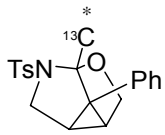
(*Z*)-N-(4-(tert-butyldimethylsilyloxy)but-2-enyl)-4-methyl-N-(3-phenylprop-2-ynyl)benzenesulfonamide (S3)

To 100 ml Schlenck flask, 1.04 g of triphenylphosphine (3.96 mmol), 0.79 mL of diisopropylazodicarboxylate (3.96 mmol) and 20 mL of tetrahydrofuran was added and stirred for 10 min. 4-methyl-N-(3-phenylprop-2-ynyl)benzenesulfonamide **S2** (1.13 g, 3.96 mmol) was then added. After 10 min, (*Z*)-4-(tert-butyldimethylsilyloxy)but-2-en-1-ol(0.8 g, 3.96 mmol) was injected. The reaction mixture was stirred overnight and solvent was removed by rotoevaporation. Flash column chromatography with hexane and ethyl acetate (8/1) give 1.7 g (3.6 mmol) of (Z)-N-(4-(tert-butyldimethylsilyloxy)but-2-enyl)-4-methyl-N-(3-phenylprop-2-ynyl)benzenesulfonamide **S3**. **^{1}H NMR (500 MHz, $CDCl_3$)** δ 0.85 (s, 9 H), 2.36 (s, 3 H), 3.94 – 3.97 (m, 2 H), 4.28 (d, *J* = 5.6Hz, 2 H), 4.32 (d, *J* = 145.8 Hz, 2 H), 5.44 – 5.52 (m, 1 H), 5.82 (dt, *J* = 11.3, 5.6 Hz, 1 H), 7.06 (d, *J* = 6.6 Hz, 2 H), 7.23 – 7.33 (m, 5 H), 7.80 (d, *J* = 8.2 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 36.7 ppm. **HRMS (FAB)** calc. for $[^{13}C_1C_{25}H_{36}NO_2S]^+$: 471.2219, found: 471.2217.



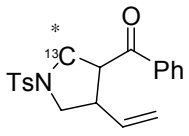
(*Z*)-N-(4-hydroxybut-2-enyl)-4-methyl-N-(3-phenylprop-2-ynyl)benzenesulfonamide (1-^{13}C)

To a solution of tetrabutylammonium fluoride (1.14 g, 3.6 mmol) in 20 mL of tetrahydrofuran, 1.7 g (3.6 mmol) of (Z)-N-(4-(tert-butyldimethylsilyloxy)but-2-enyl)-4-methyl-N-(3-phenylprop-2-ynyl)benzenesulfonamide **S3** was added. The reaction mixture was stirred for 1 hr and the solvent was removed by rotoevaporation. The crude product was purified by flash column chromatography(hexane/ethyl acetate=2/1), then (Z)-N-(4-hydroxybut-2-enyl)-4-methyl-N-(3-phenylprop-2-ynyl)benzenesulfonamide **S4** was obtained in 80 % yield. (1.03 g, 2.88 mmol) **^{1}H NMR (500 MHz, $CDCl_3$)** δ 1.64 (t, *J* = 5.7 Hz, 1 H), 2.34 (s, 3 H), 3.96 (dd, *J* = 6.6, 4.5 Hz, 2 H), 4.23 (t, *J* = 5.8 Hz, 2 H), 4.30 (d, *J* = 145.9 Hz, 2 H), 5.57 (dt, *J* = 10.9, 7.4 Hz, 1 H), 5.91 (dt, *J* = 10.9, 6.7 Hz, 1 H), 7.07 (dd, J = 7.8, 1.3 Hz, 2 H), 7.22 – 7.28 (m, 5 H), 7.77 (d, J = 8.2 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 36.8 ppm. **HRMS (EI)** calc. for $[^{13}C_1C_{19}H_{21}NO_3S]^+$: 356.1276, found: 356.1273.



(1a-^{13}C)

^{1}H NMR (500 MHz, $CDCl_3$) δ 1.60 (d, J = 129.5 Hz, 3 H), 2.06 – 2.17 (m, 2 H), 2.44 (s, 3 H), 2.82 (dd, J = 9.8, 1.4 Hz, 1 H), 3.44 (d, J = 10.2 Hz, 1 H), 3.97 (dd, J = 9.8, 5.4 Hz, 1 H), 4.14 (dd, J = 10.2, 5.4 Hz, 1 H), 7.26 – 7.37 (m, 7 H), 7.83 (d, J = 8.2 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 22.8 ppm. **HRMS (EI)** calc. for $[^{13}C_1C_{19}H_{21}NO_3S]^+$: 356.1276, found: 356.1278.



Phenyl(1-tosyl-4-vinylpyrrolidin-3-yl)methanone (1b-^{13}C)

^{1}H NMR (500 MHz, $CDCl_3$) δ 2.46 (s, 3 H), 3.14 – 3.26 (m, 2 H), 3.37 – 3.48 (m, 1 H), 3.64 – 3.70 (m, 1 H), 3.85 – 3.93 (m, 1 H), 4.05 – 4.13 (m, 1 H), 4.72 (d, *J* = 17.3 Hz, 1 H), 4.78 (d, *J* = 10.4 Hz, 1 H), 5.25 (ddd, *J* = 17.3, 10.4, 9.1Hz, 1 H), 7.36 (d, *J* = 8.2 Hz, 2 H), 7.41 – 7.47 (m, 2 H), 7.56 (t, *J*

= 7.3 Hz, 1 H), 7.77 (d, *J* = 8.8 Hz, 2 H), 7.81 (d, *J* = 7.5 Hz, 2 H) ppm. **^{13}C NMR (75 MHz, $CDCl_3$)** δ 48.4 ppm. **HRMS (EI)** calc. for $[^{13}C_1C_{19}H_{21}NO_3S]^+$: 356.1276, found: 356.1281.

V. X-ray analysis

Diffraction data were measured by a Bruker-Nonius CCD single-crystal X-ray diffractometer at room temperature by using graphite-monochromated Mo K□ radiation (□= 0.71073 Å). Preliminary orientation matrices and unit cell parameters were obtained from the peaks of the first 10 frames and then refined using the whole data set. Frames were integrated and corrected for Lorentz and polarization effects using DENZO. The structure was solved by direct methods using SHELXS-97, and refined by full-matrix least-squares with SHELXL-97. All non-hydrogen atoms were refined anisotropically and hydrogen atoms except some were treated as idealized contributions.

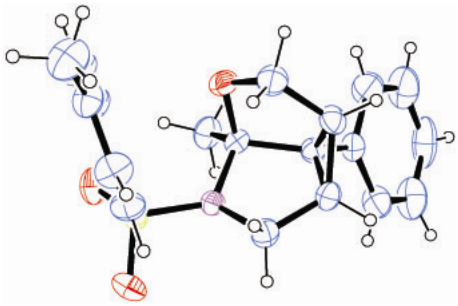


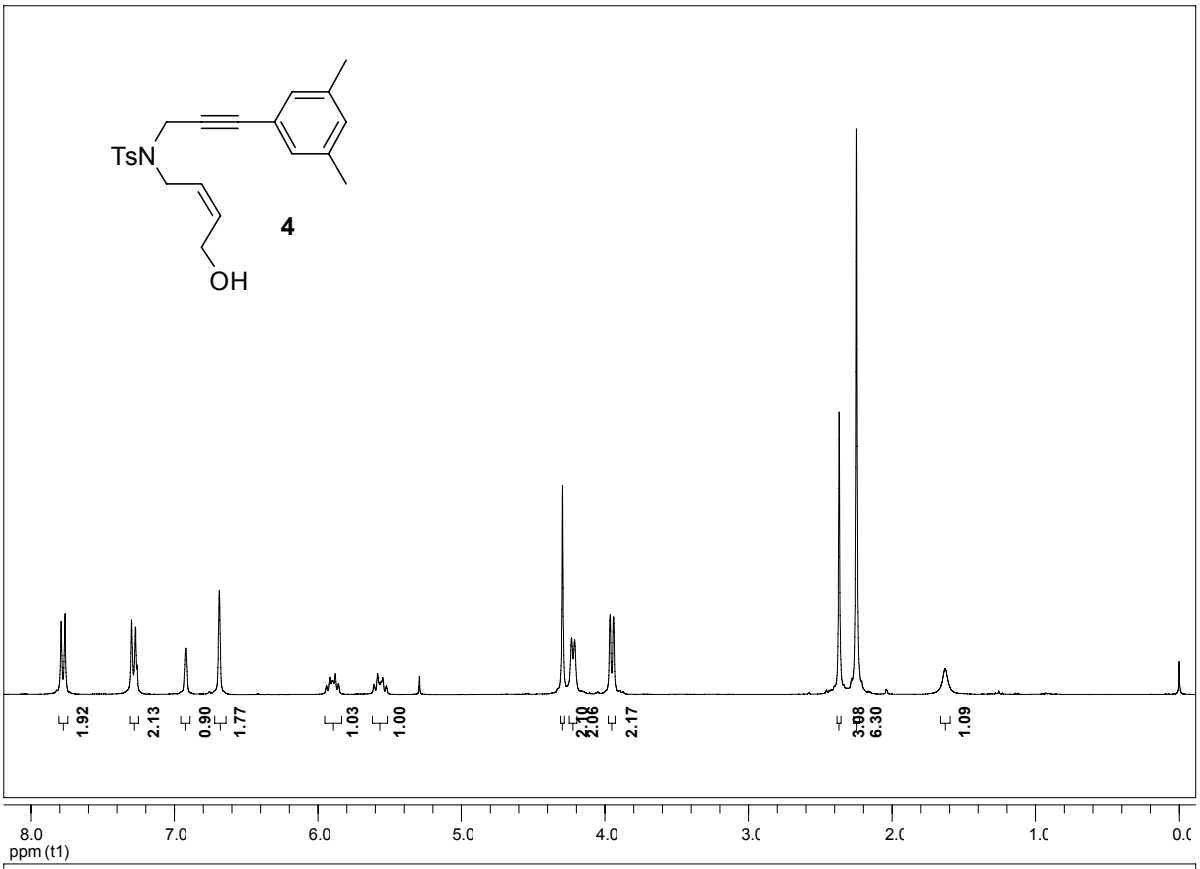
Figure S_A1. An ORTEP drawing of **1a** with 30% probability of thermal ellipsoids.

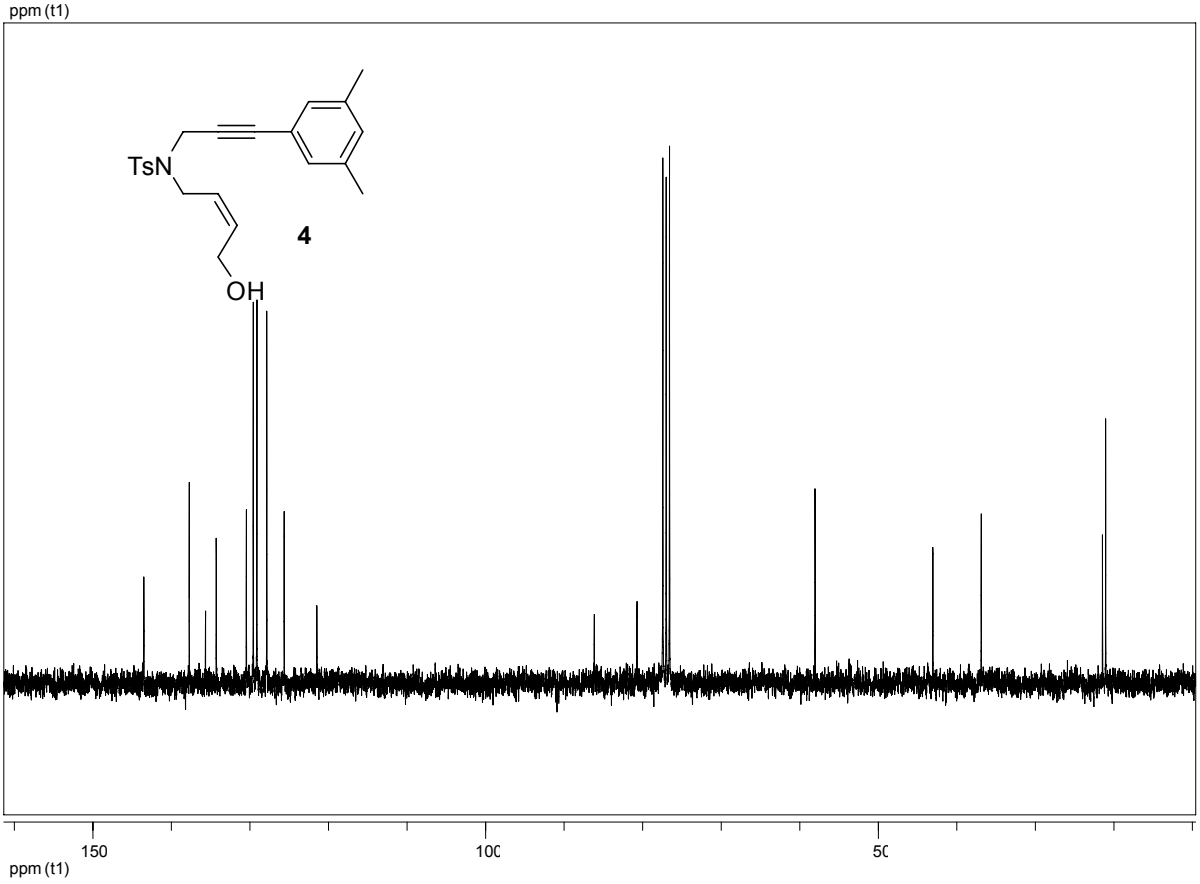
Table S_A1. Crystal data and structure refinement for **1a**.

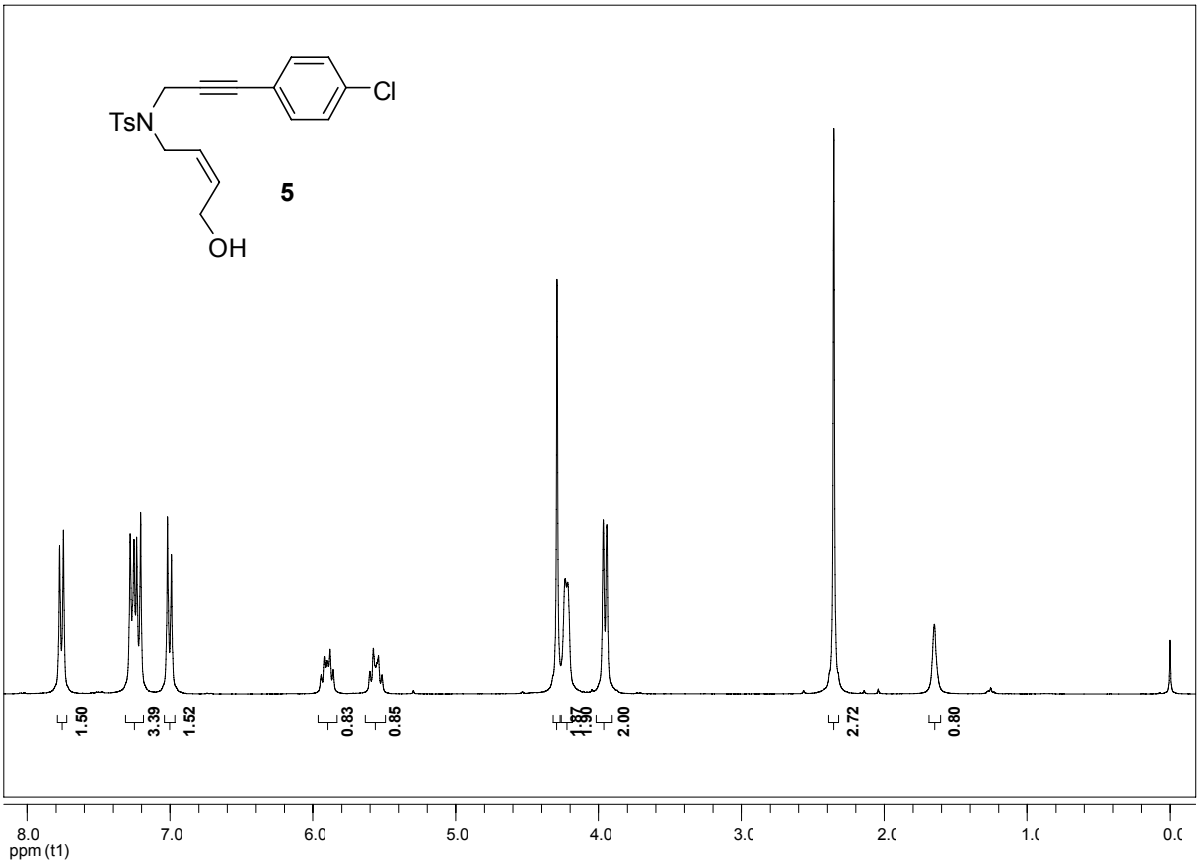
Identification code	1a	
Empirical formula	C20 H21 N O3 S	
Formula weight	355.44	
Temperature	293(2) K	
Wavelength	0.71073 Å	
Crystal system	Monoclinic	
Space group	P21/a	
Unit cell dimensions	a = 7.8824(4) Å	a= 90°.
	b = 13.2869(7) Å	b= 98.799(3)°.
	c = 17.5082(9) Å	g = 90°.
Volume	1812.10(16) Å^3	

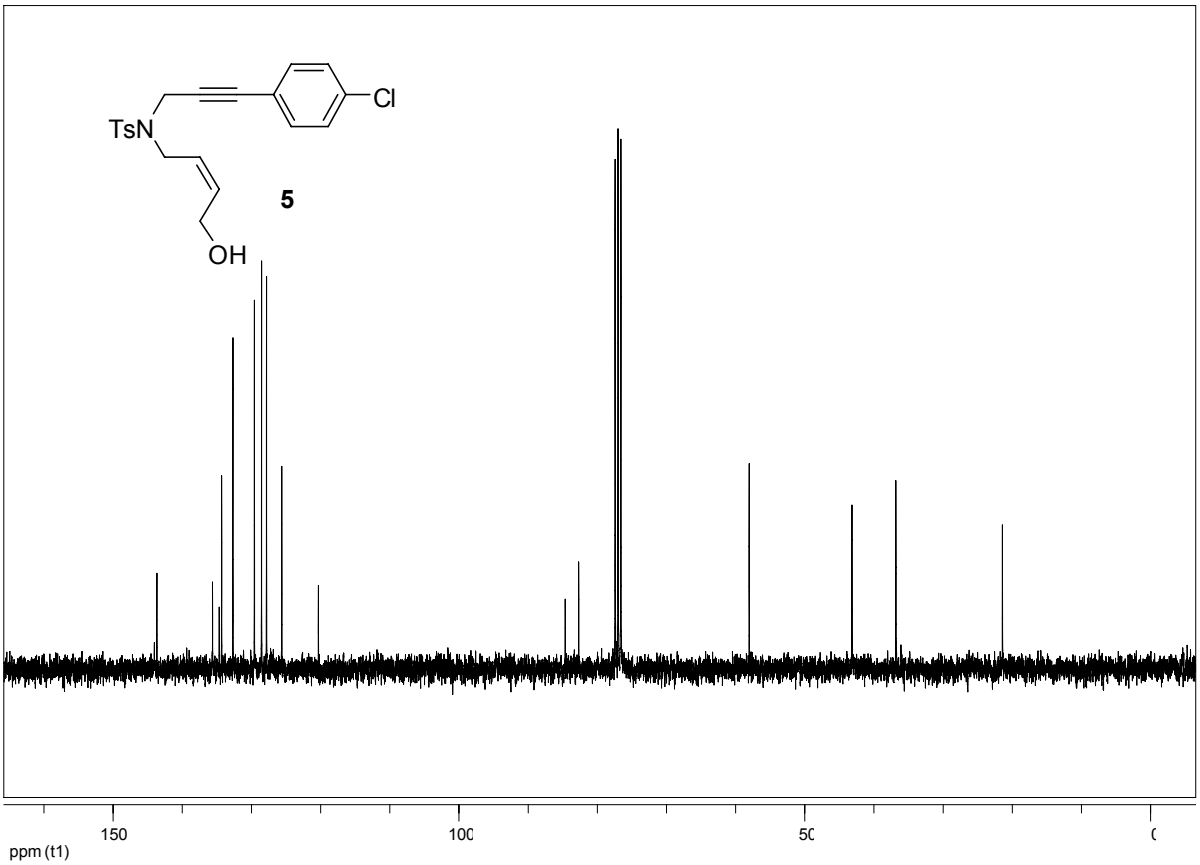
Z	4
Density (calculated)	1.303 Mg/m^3
Absorption coefficient	0.197 mm^{-1}
F(000)	752
Crystal size	0.2 x 0.2 x 0.2 mm^3
Theta range for data collection	3.07 to 27.47°.
Index ranges	-10<=h<=10, -17<=k<=15, -22<=l<=22
Reflections collected	7365
Independent reflections	4130 [R(int) = 0.0414]
Completeness to theta = 27.47°	99.4 %
Absorption correction	None
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	4130 / 0 / 310
Goodness-of-fit on F^2	1.029
Final R indices [I>2sigma(I)]	R1 = 0.0516, wR2 = 0.1192
R indices (all data)	R1 = 0.0996, wR2 = 0.1383
Largest diff. peak and hole	0.178 and -0.215 $e.Å^{-3}$

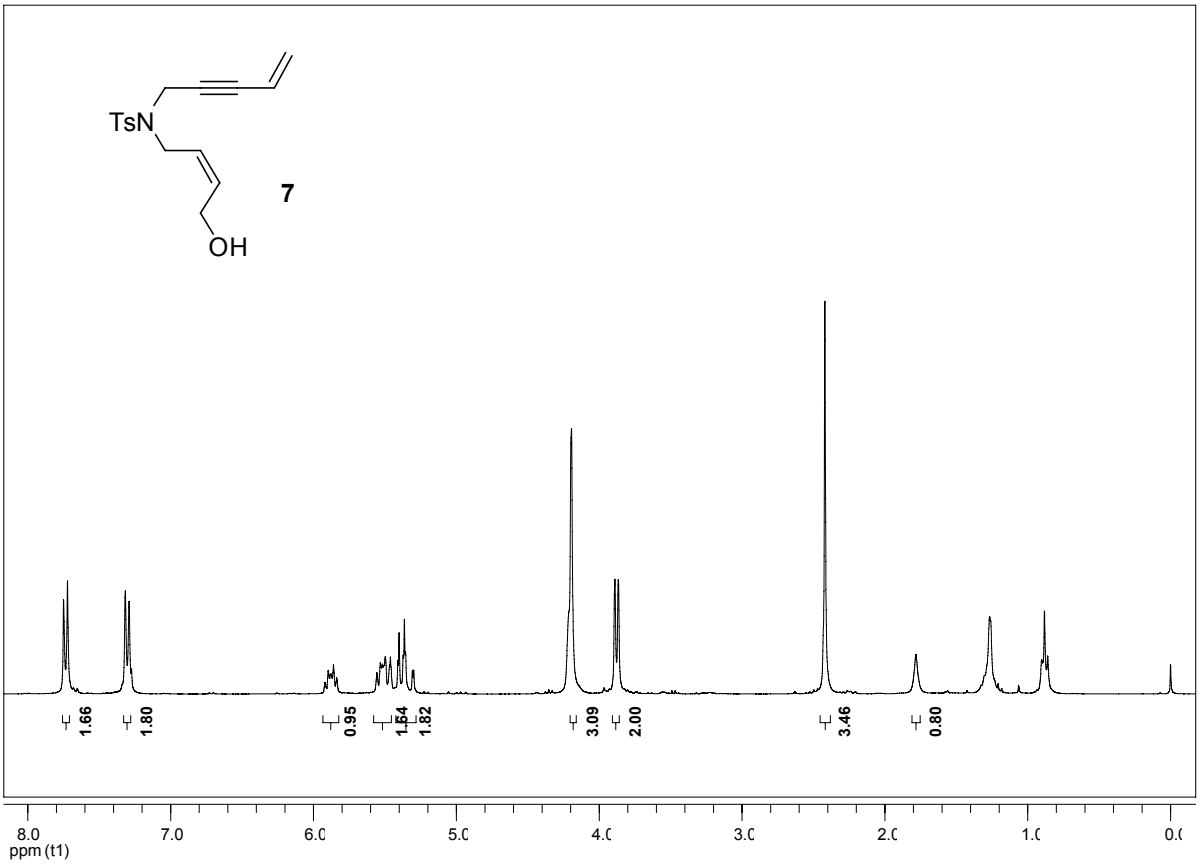
VI. NMR Spectra

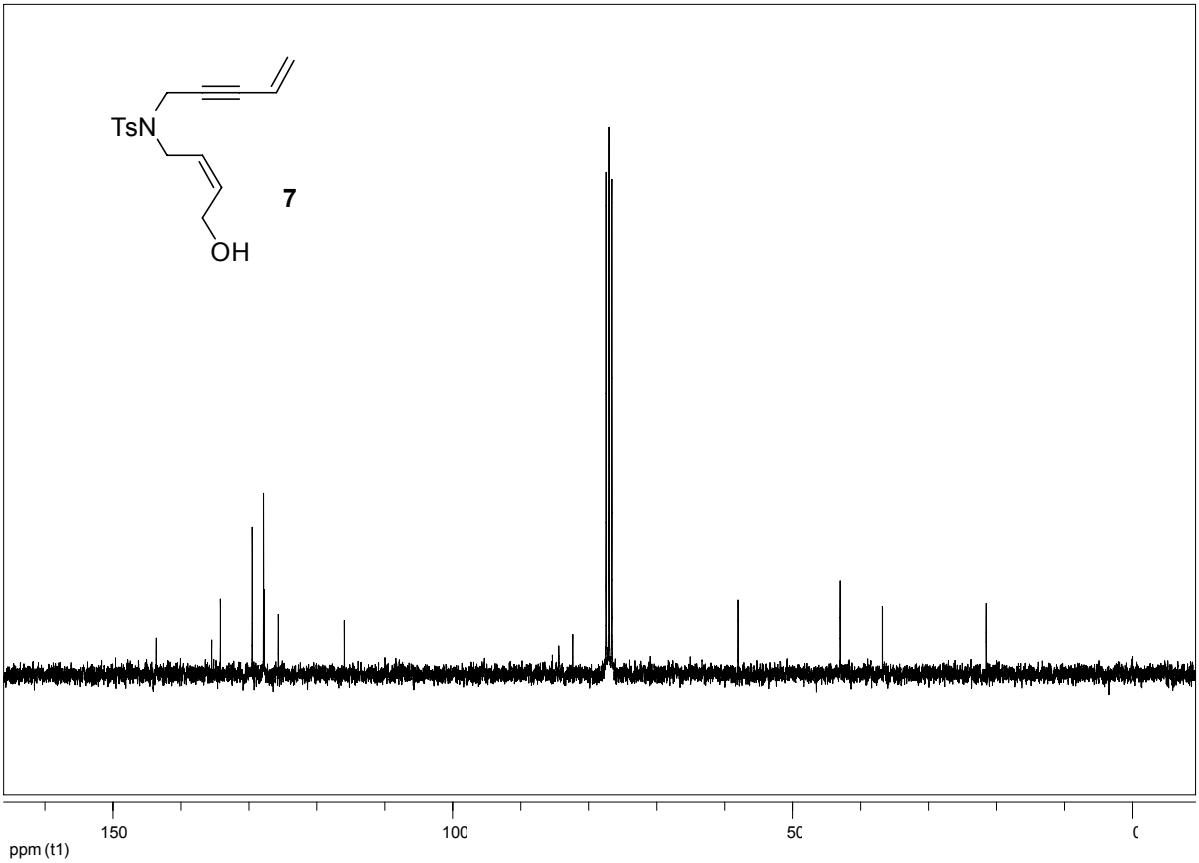


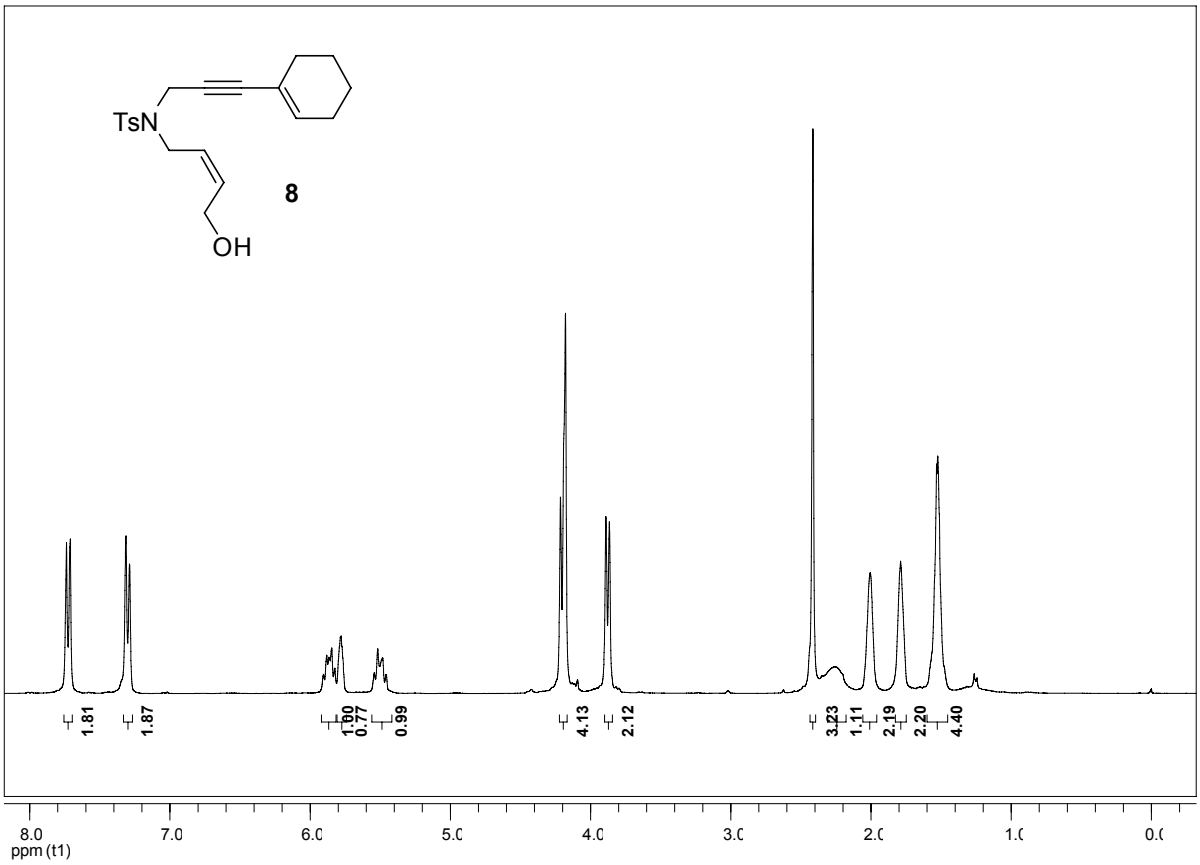


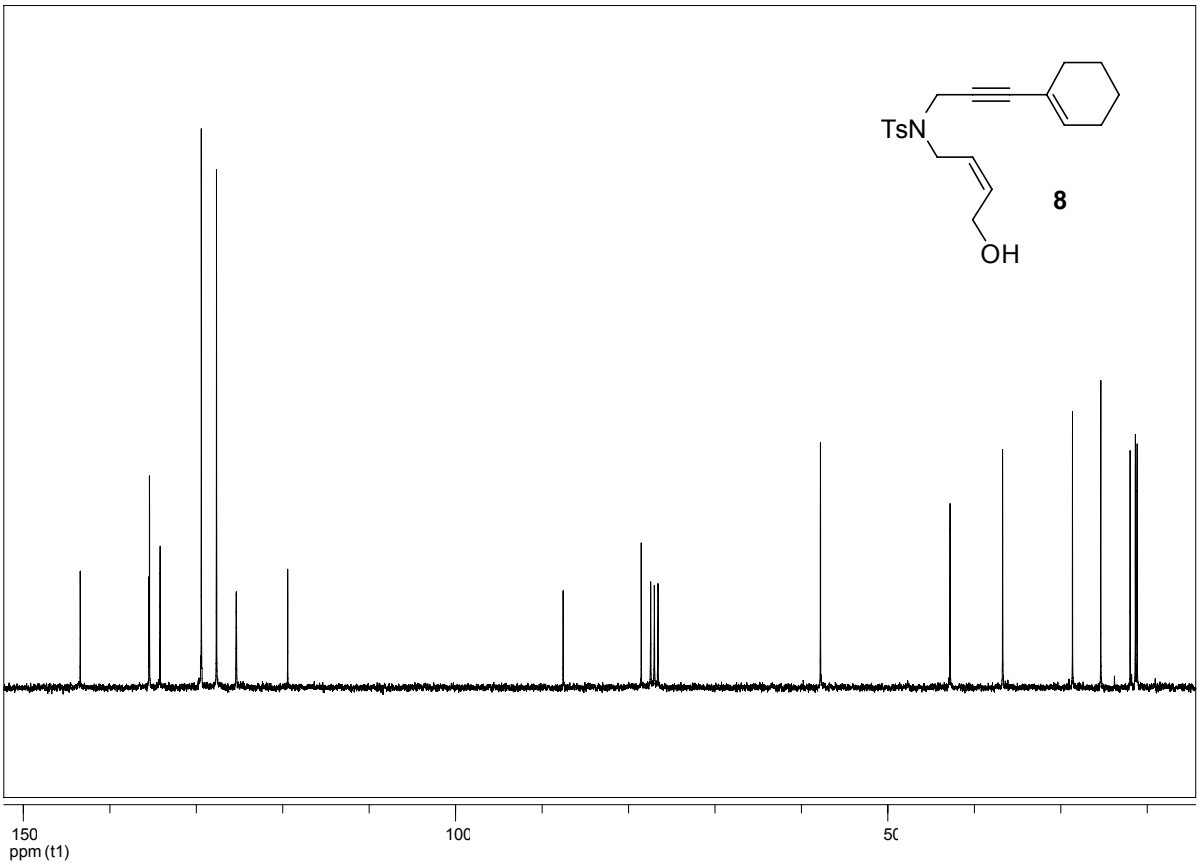

TsN
Cl
OH
5
1.50
3.39
1.52
0.83
0.85
1.87
1.90
2.00
2.72
0.80
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

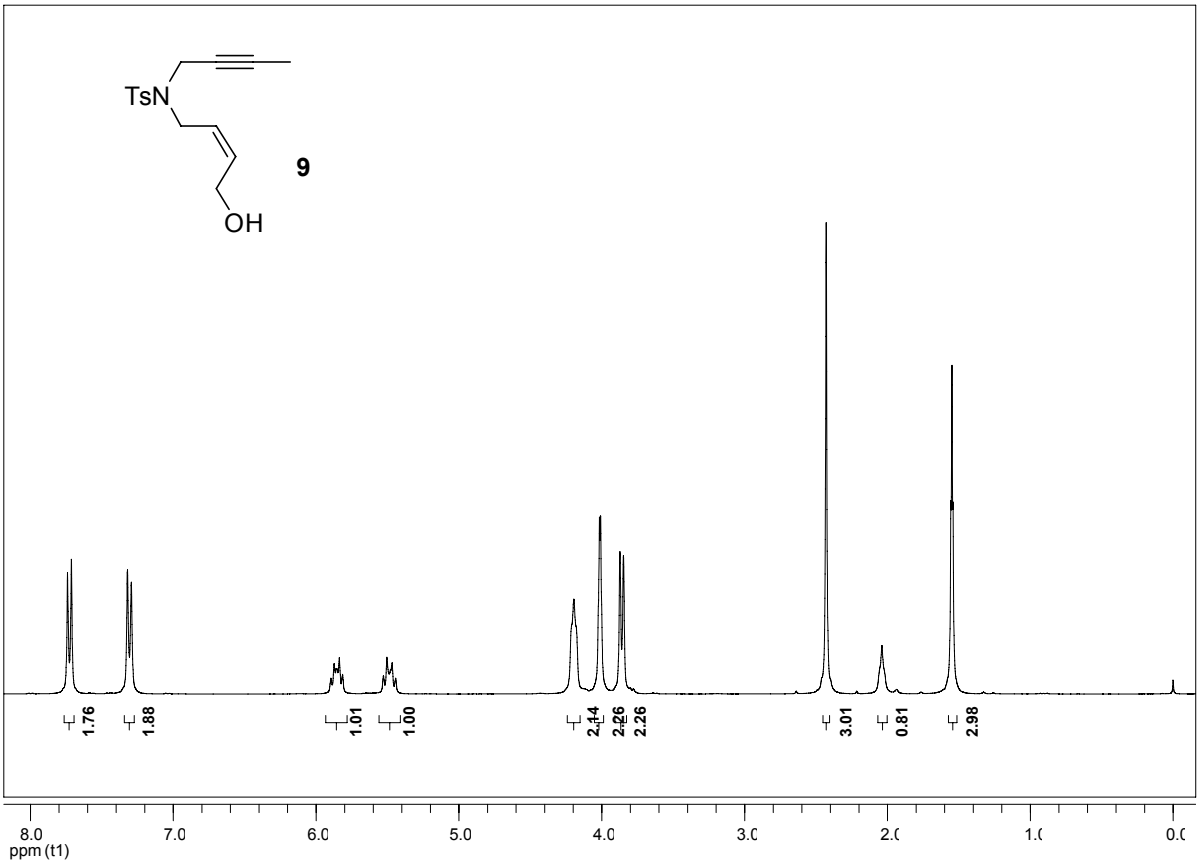

TsN
Cl
OH
5
150
100
50
ppm (t1)

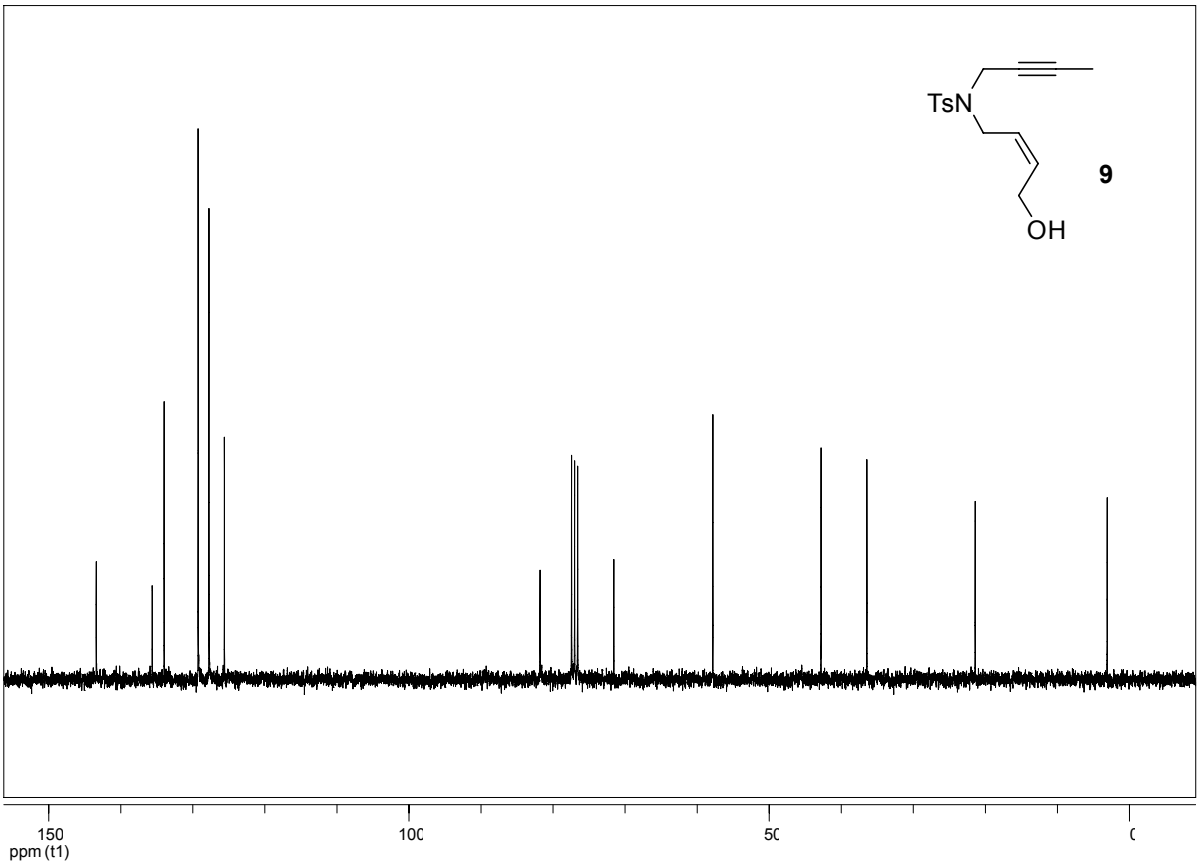

TsN
OH
7
1.66
1.80
0.95
1.54
1.82
3.09
2.00
3.46
0.80
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

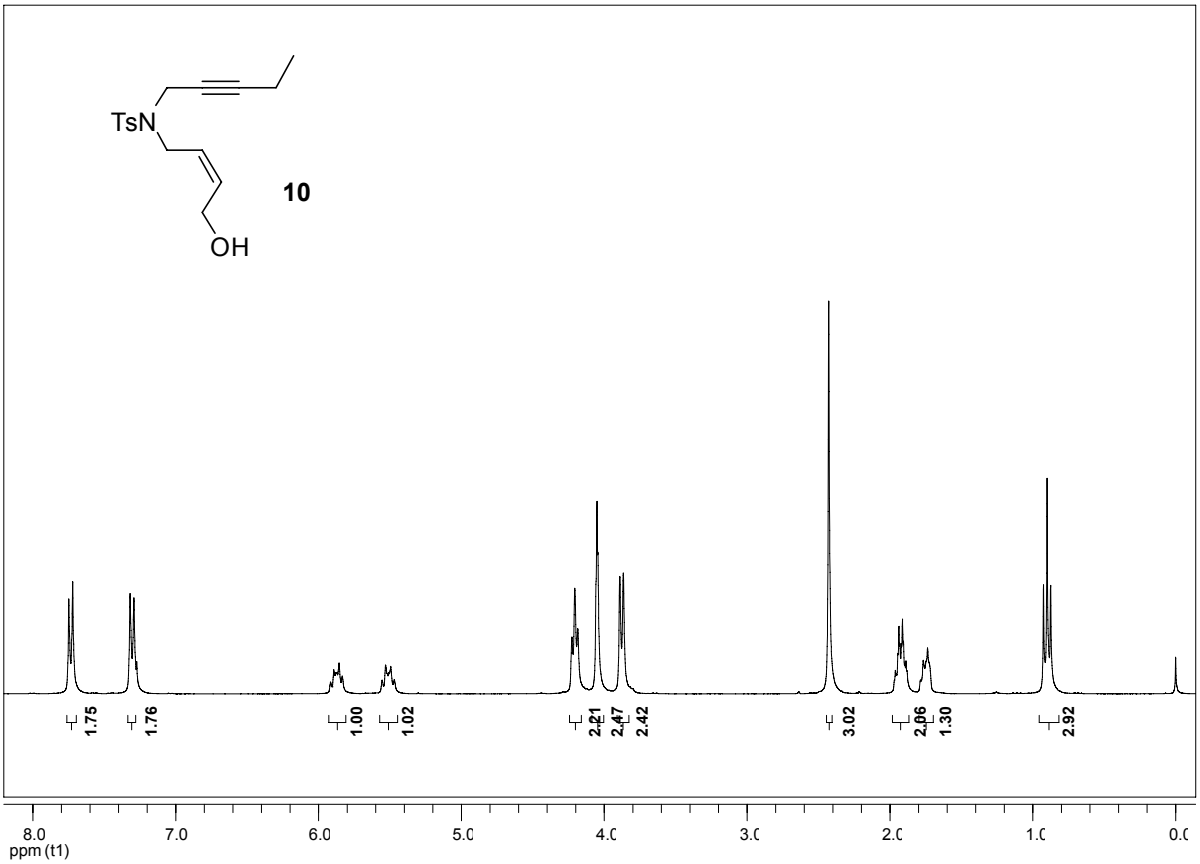

TsN
OH
7
150
100
50
0
ppm (t1)

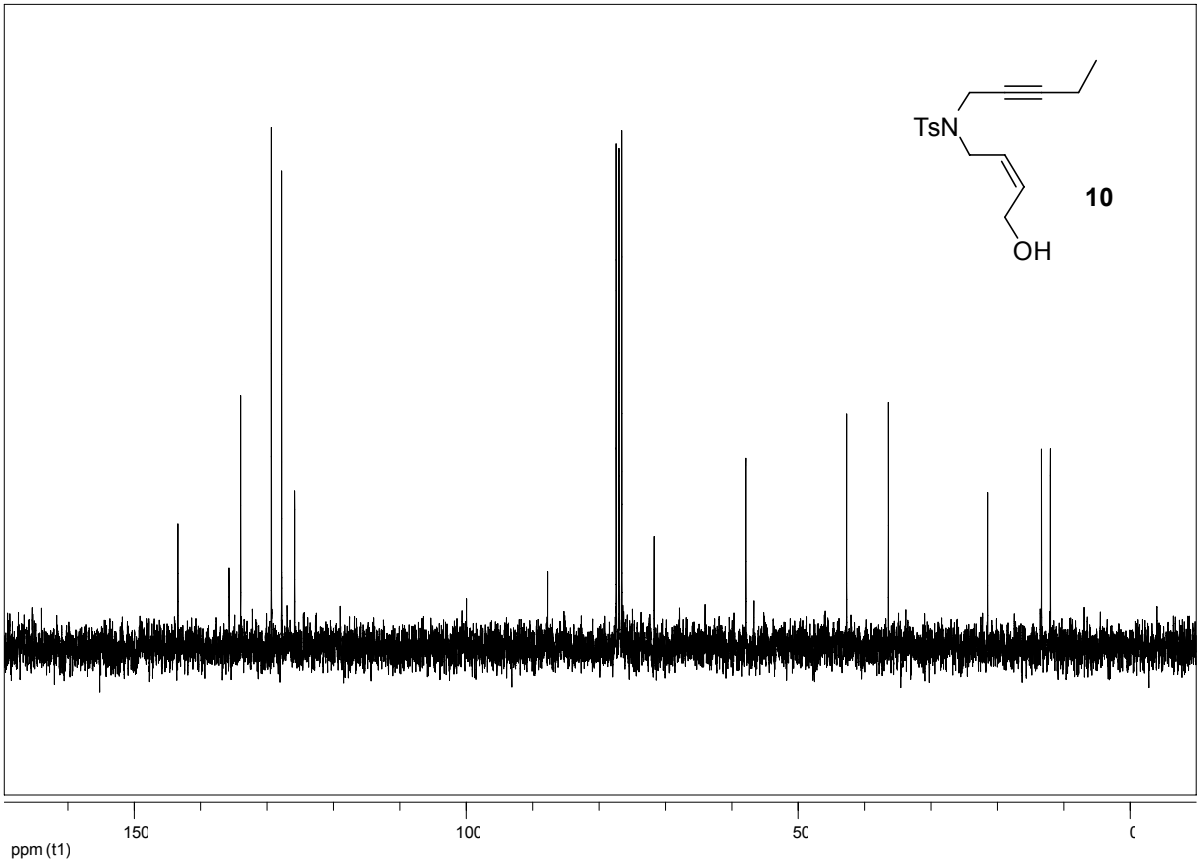

TsN
OH
8
1.81
1.87
1.00
0.77
0.99
4.13
2.12
3.23
1.11
2.19
2.20
4.40
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

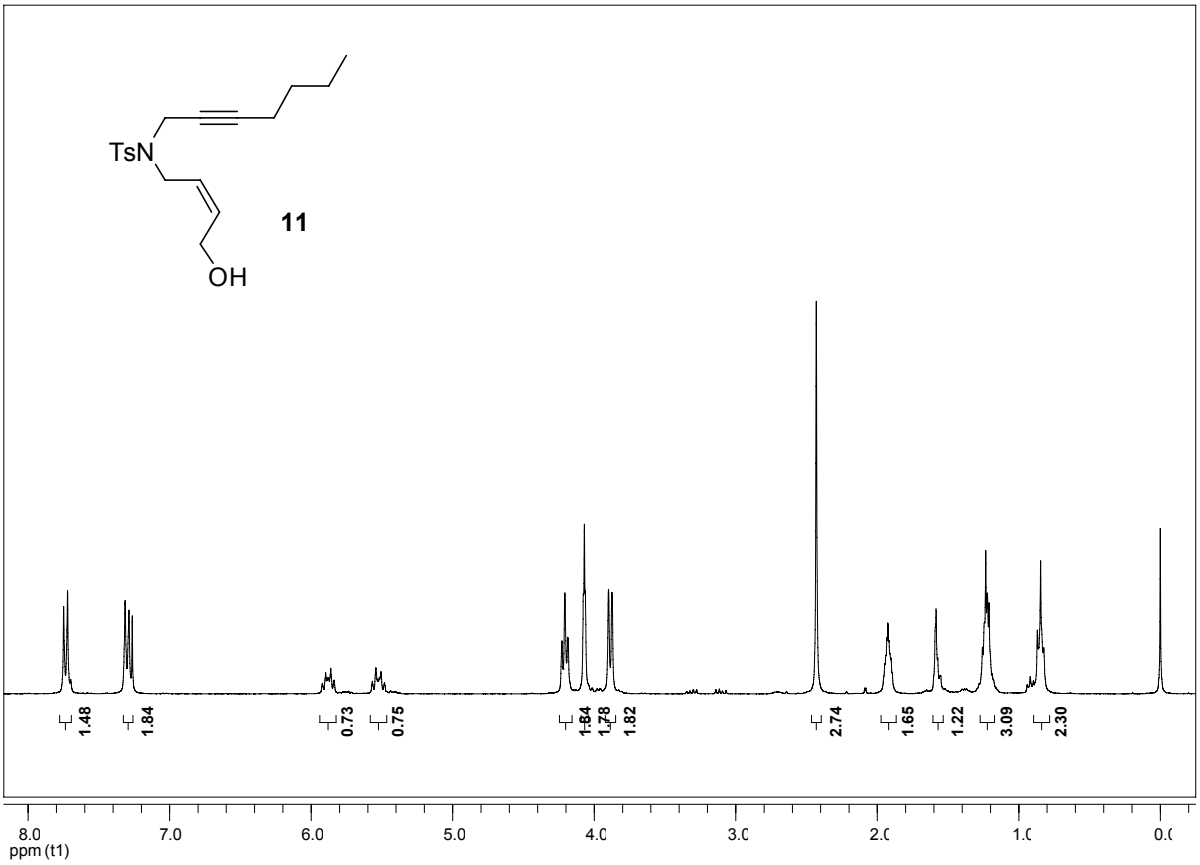

TsN
OH
8
150
100
50
ppm (t1)

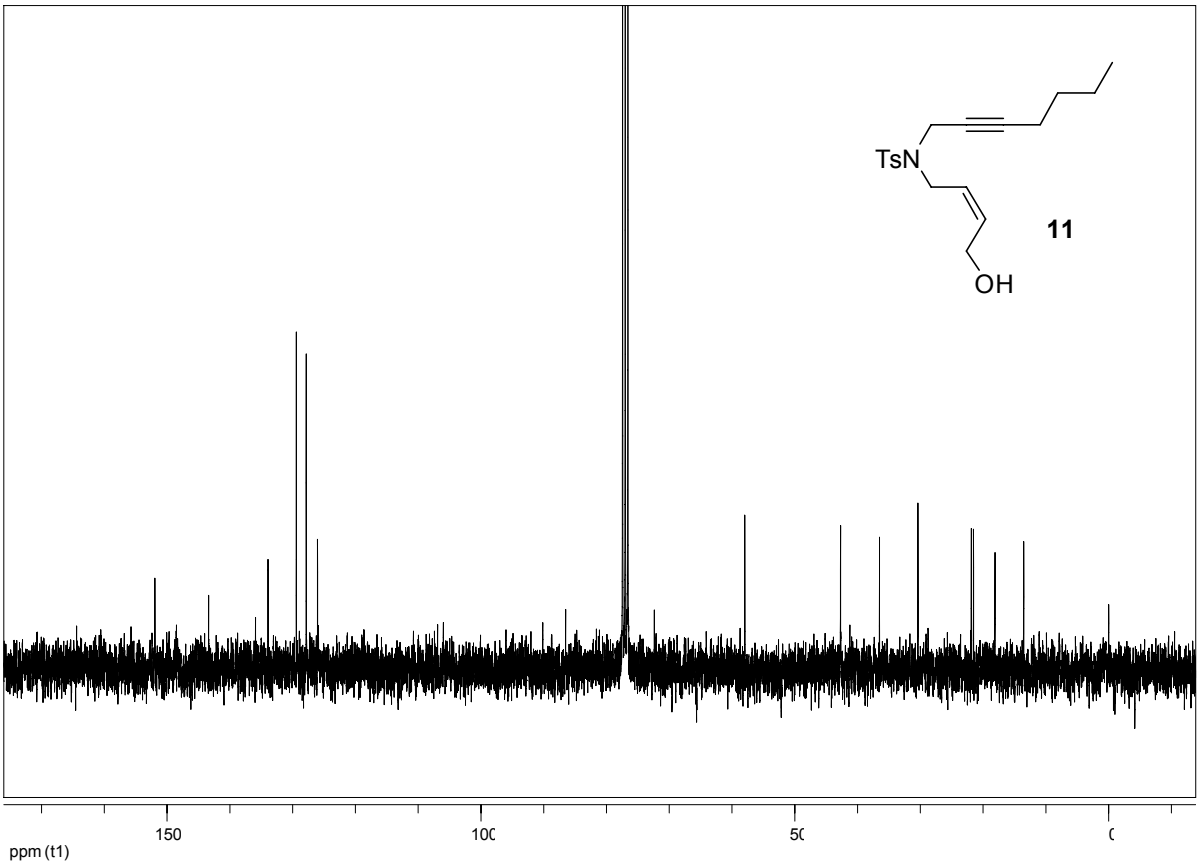

TsN
OH
9
1.76
1.88
1.01
1.00
2.44
2.26
2.26
3.01
0.81
2.98
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

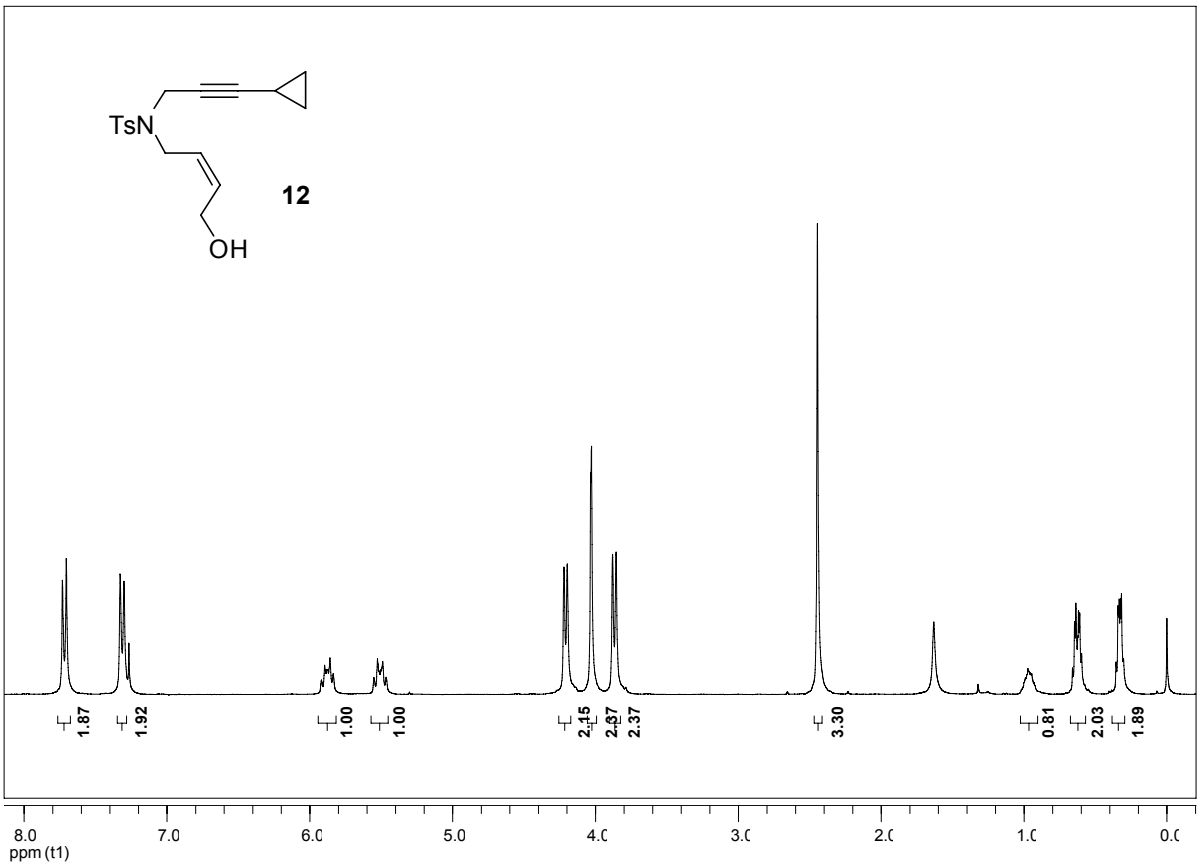

TsN
OH
9
150
100
50
0
ppm (t1)

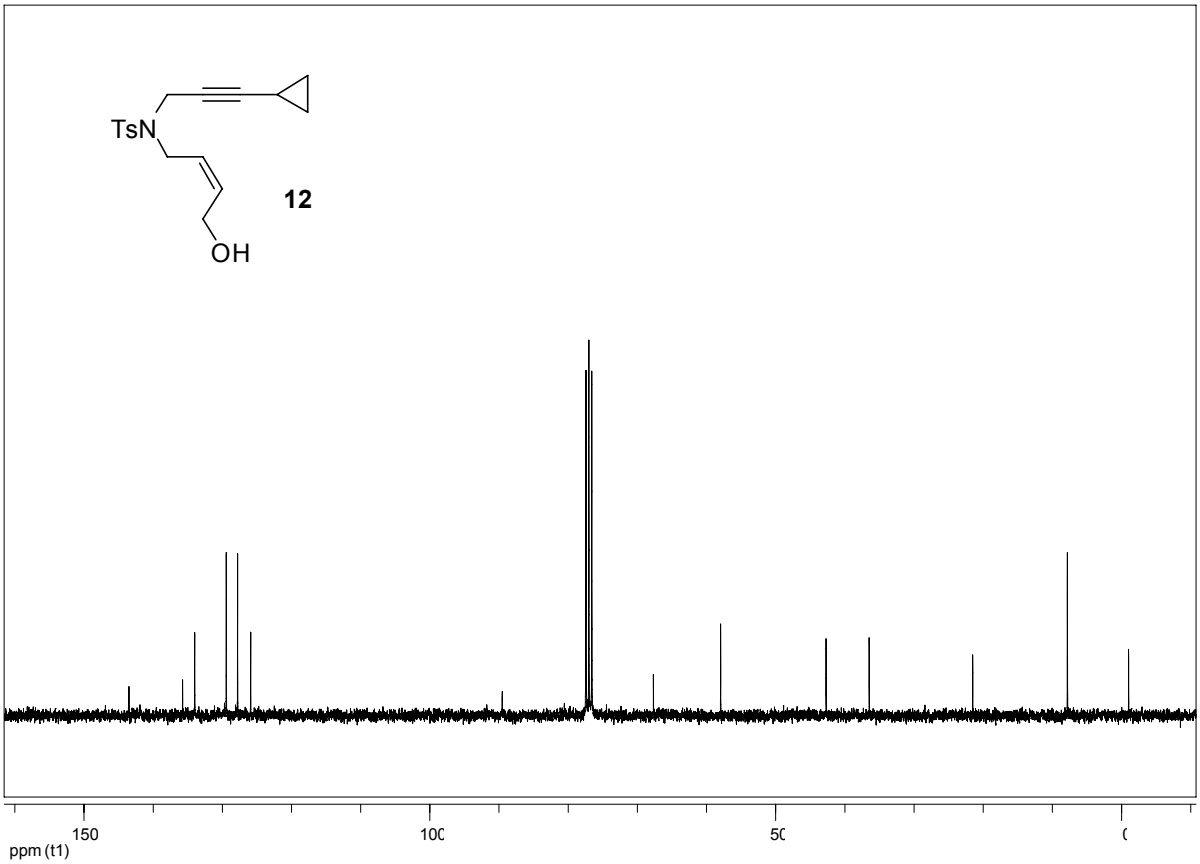

TsN
OH
10
1.75
1.76
1.00
1.02
2.21
2.47
2.42
3.02
2.06
1.30
2.92
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

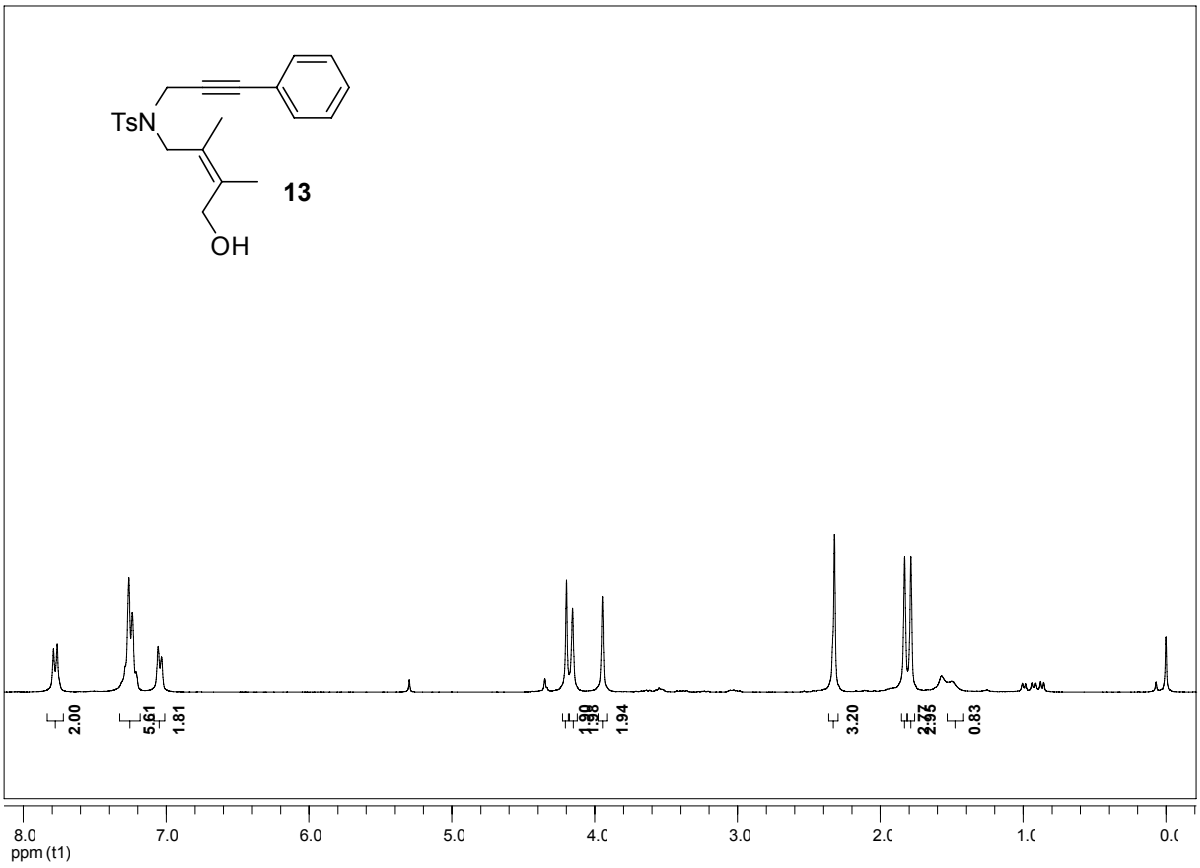

TsN
OH
10
150
100
50
ppm (t1)

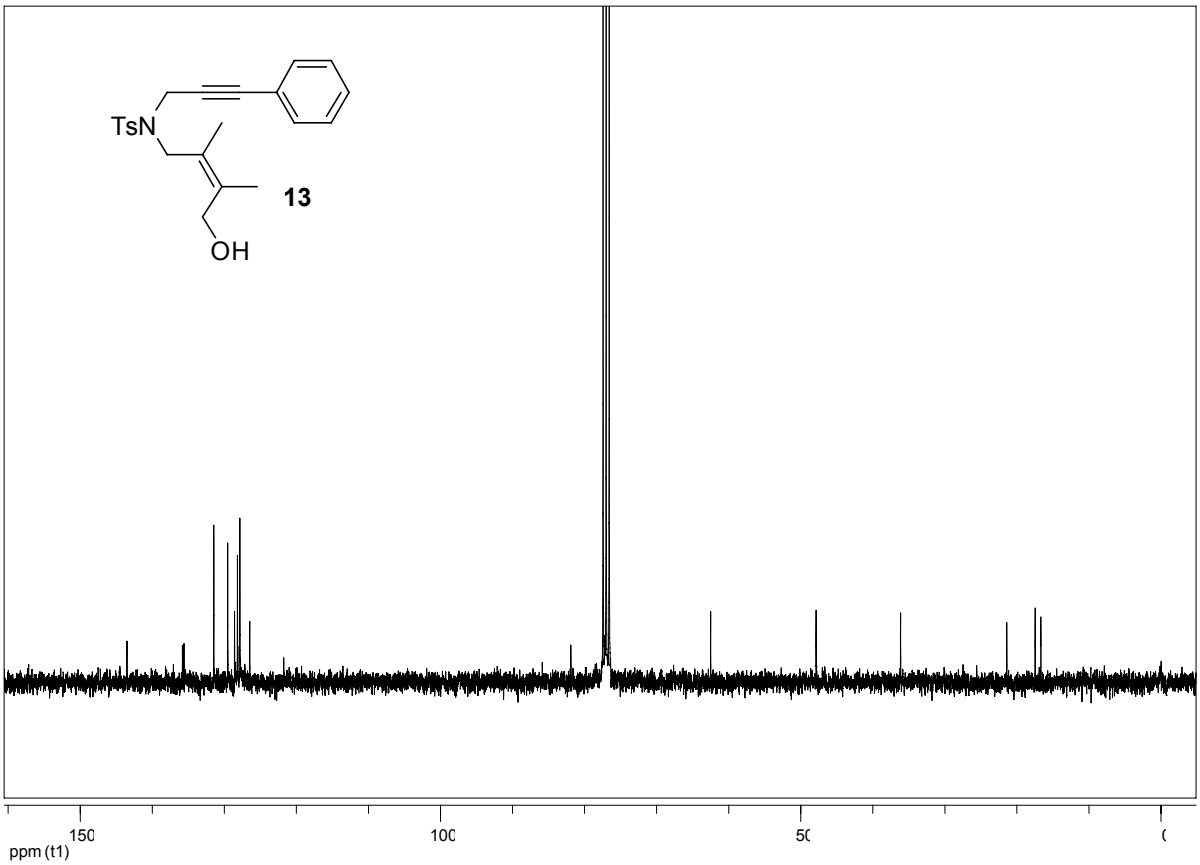

TsN
OH
11
1.48
1.84
0.73
0.75
1.84
1.78
1.82
2.74
1.65
1.22
3.09
2.30
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

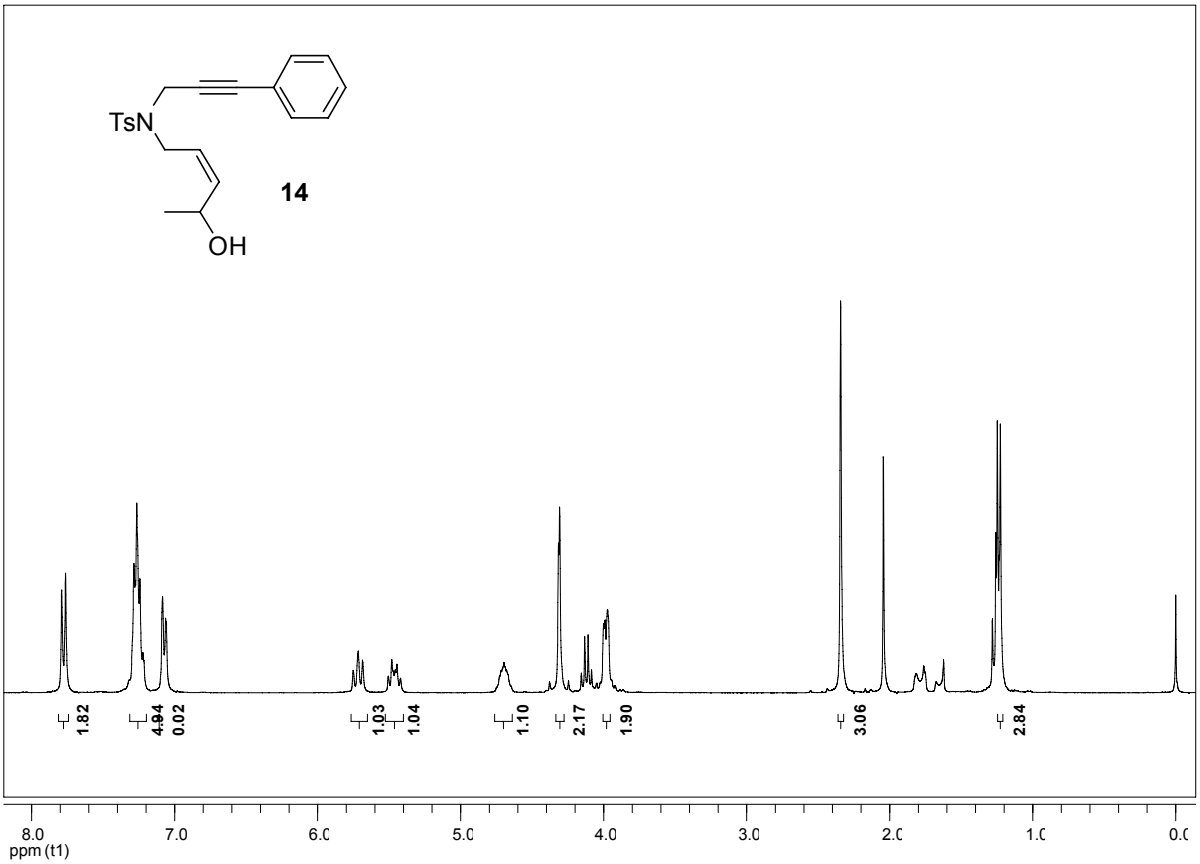

TsN
OH
11
150
100
50
0
ppm (t1)

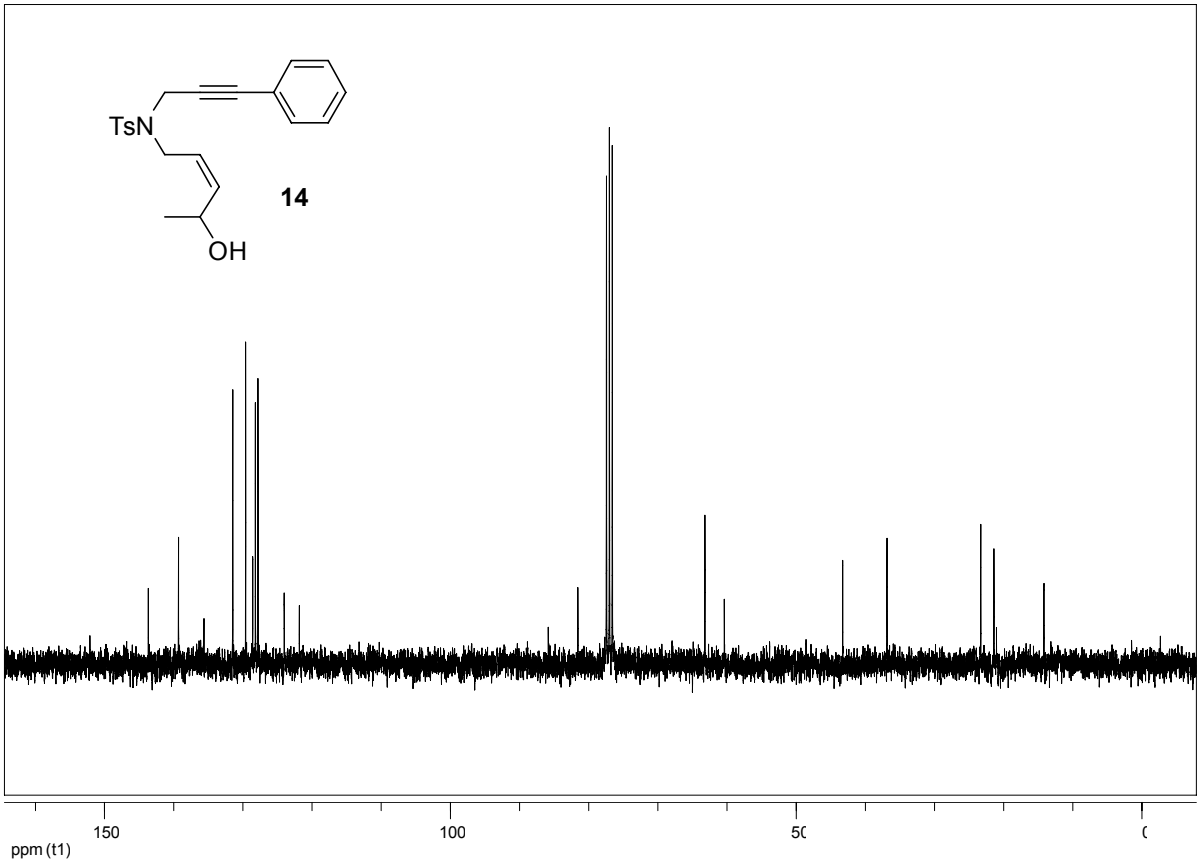

TsN
OH
12
1.87
1.92
1.00
1.00
2.15
2.37
3.30
0.81
2.03
1.89
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

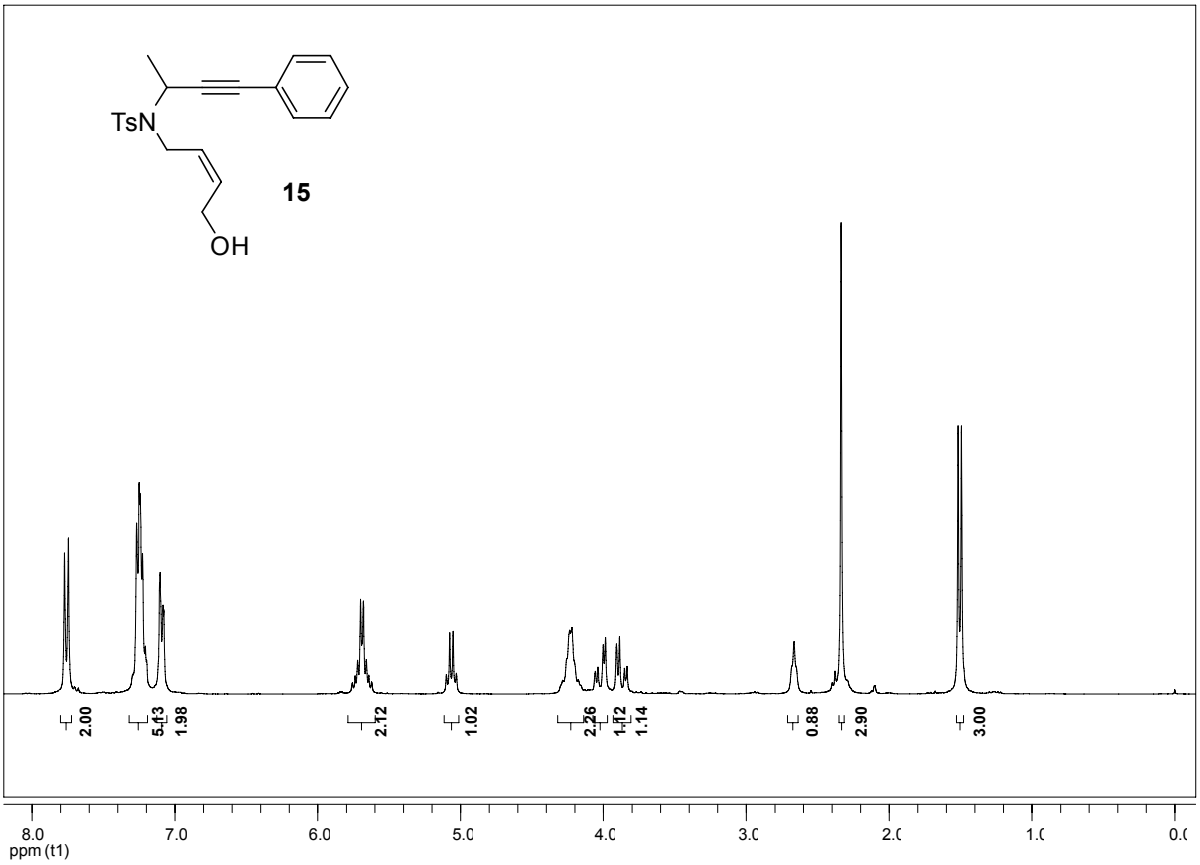

TsN
OH
12
150
100
50
ppm (t1)

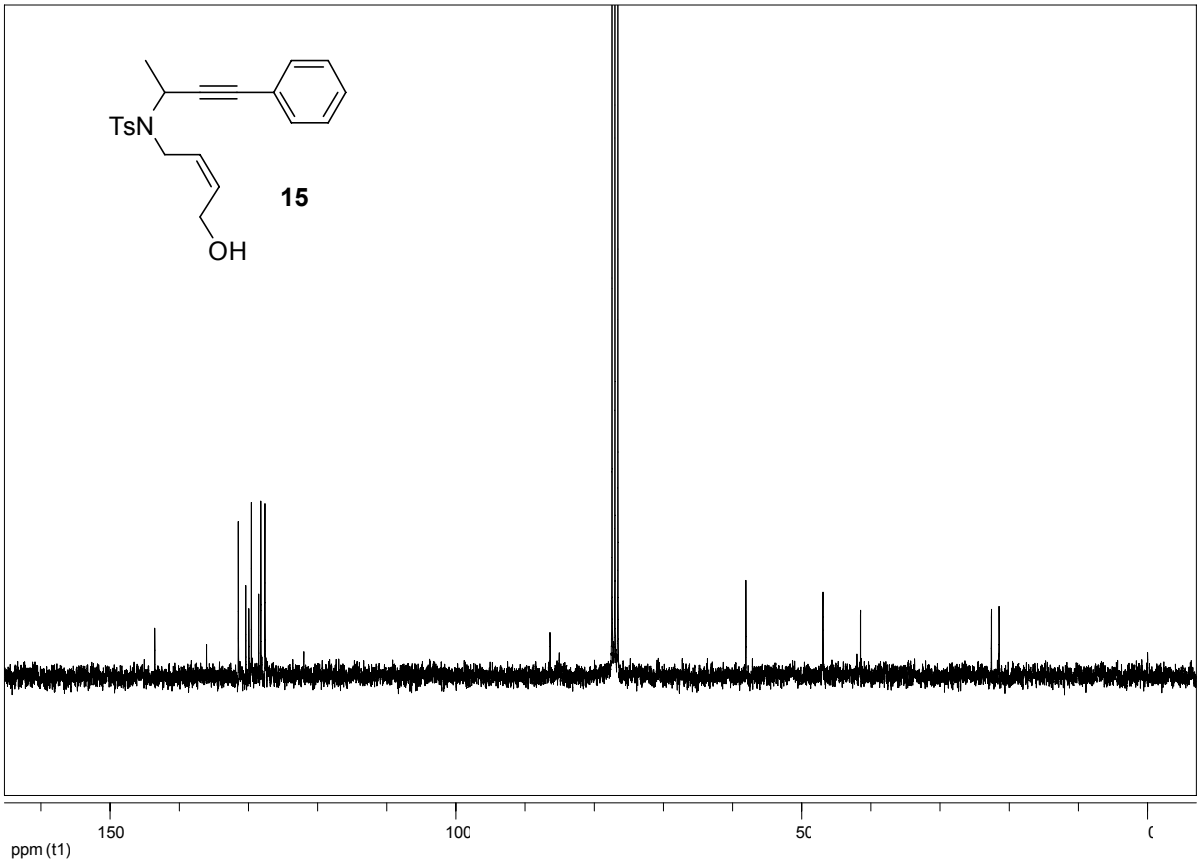

TsN
13
OH
2.00
5.61
1.81
1.94
3.20
0.83
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

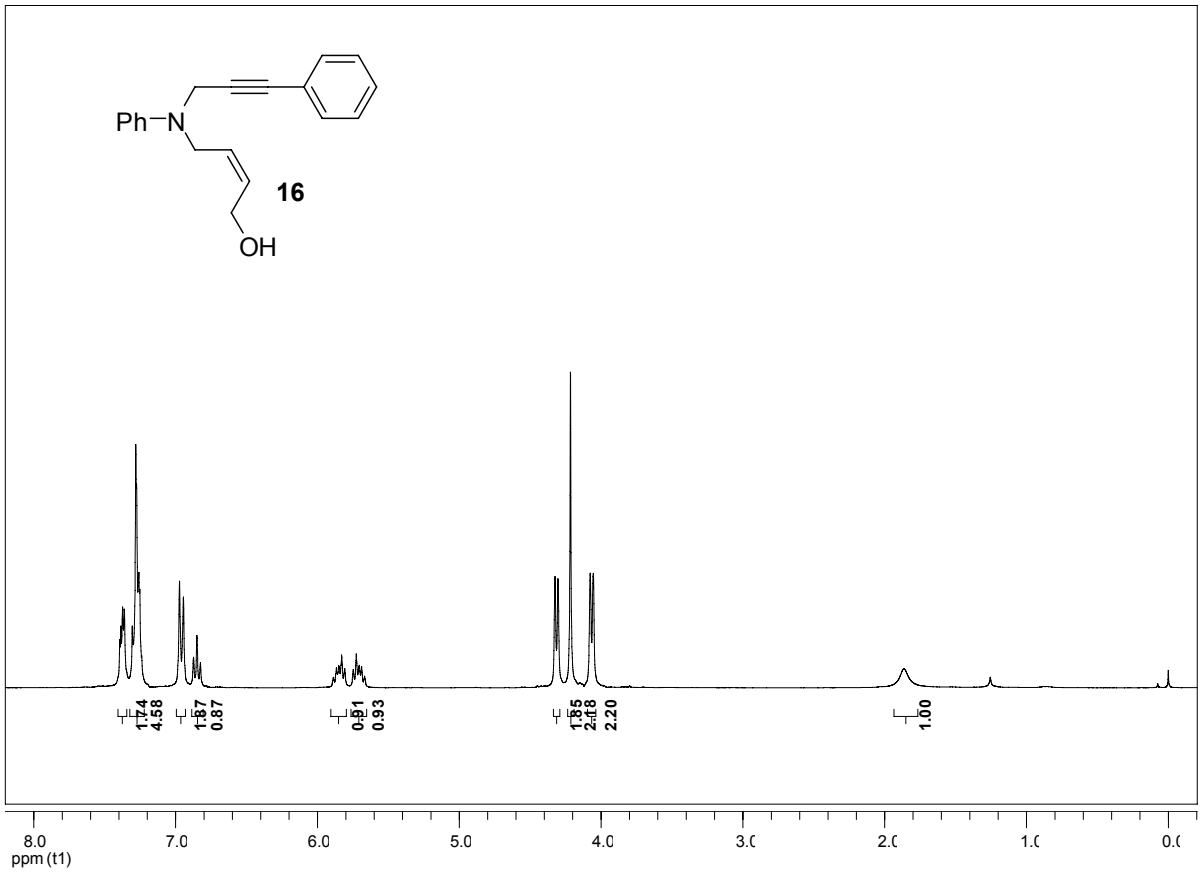

TsN
13
OH
150
100
50
ppm (t1)

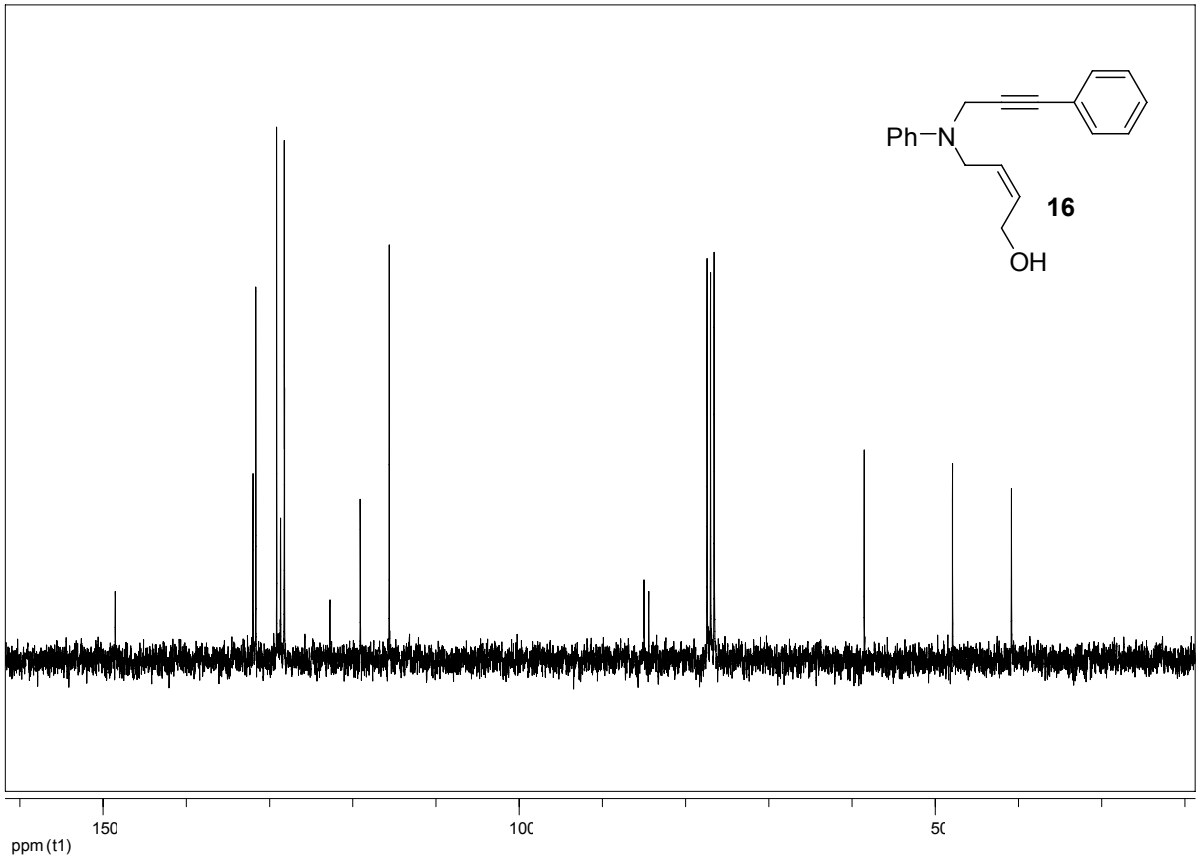

TsN
OH
14
1.82
4.04
0.02
1.03
1.04
1.10
2.17
1.90
3.06
2.84
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

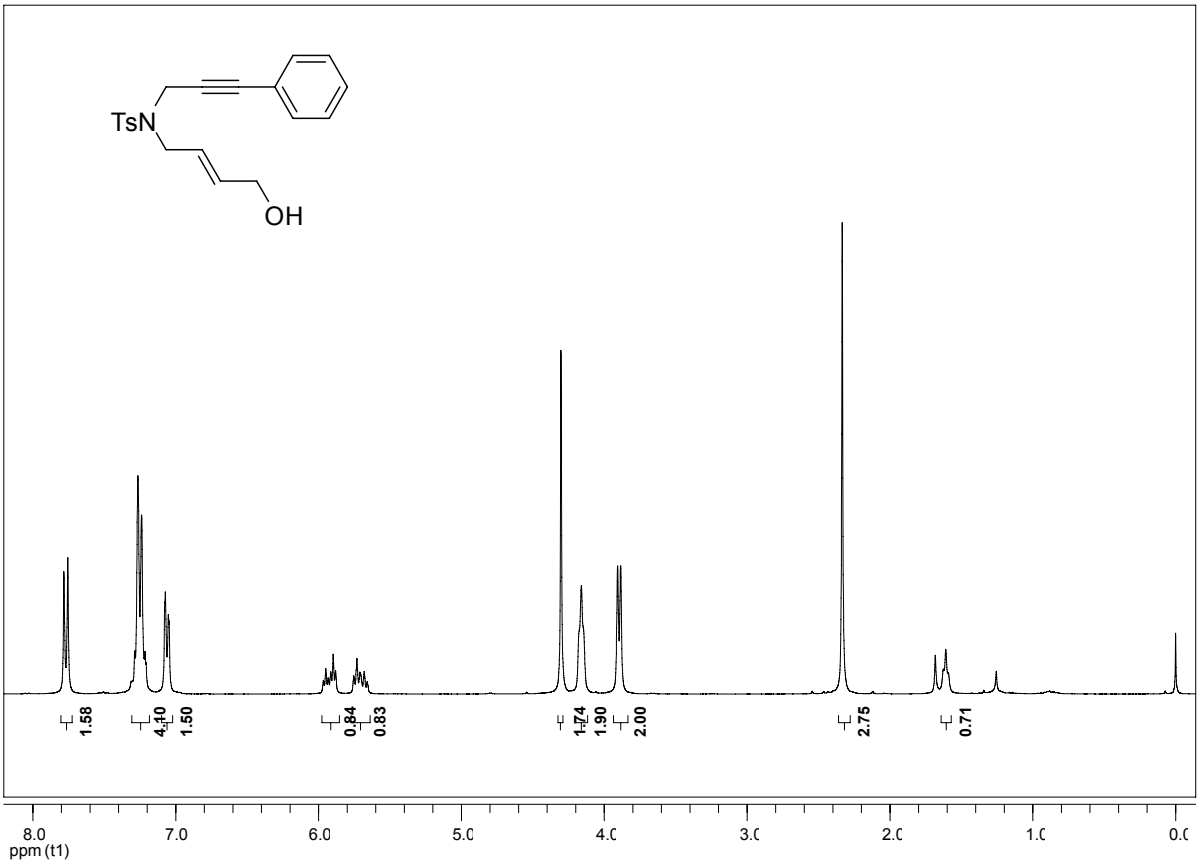

TsN
OH
14
150
100
50
0
ppm (t1)

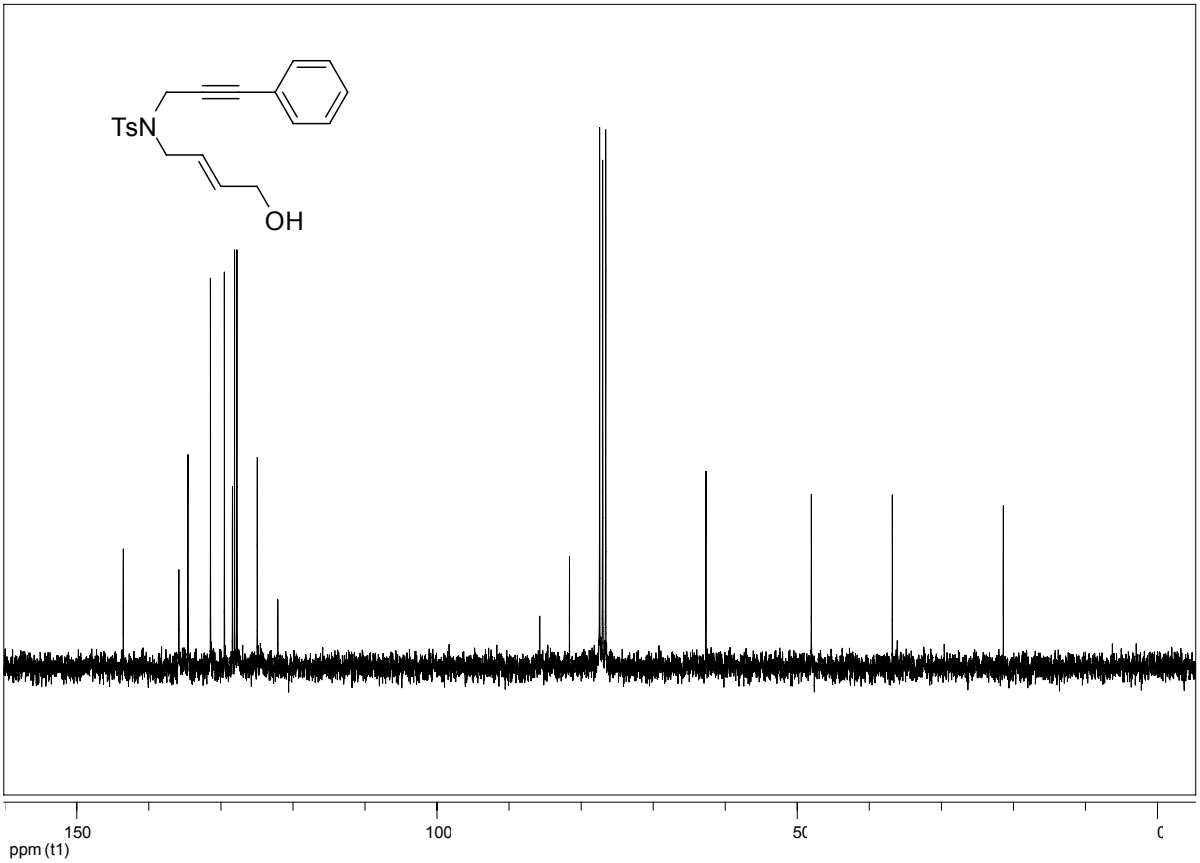

TsN
OH
15
2.00
5.13
1.98
2.12
1.02
2.26
1.12
1.14
0.88
2.90
3.00
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

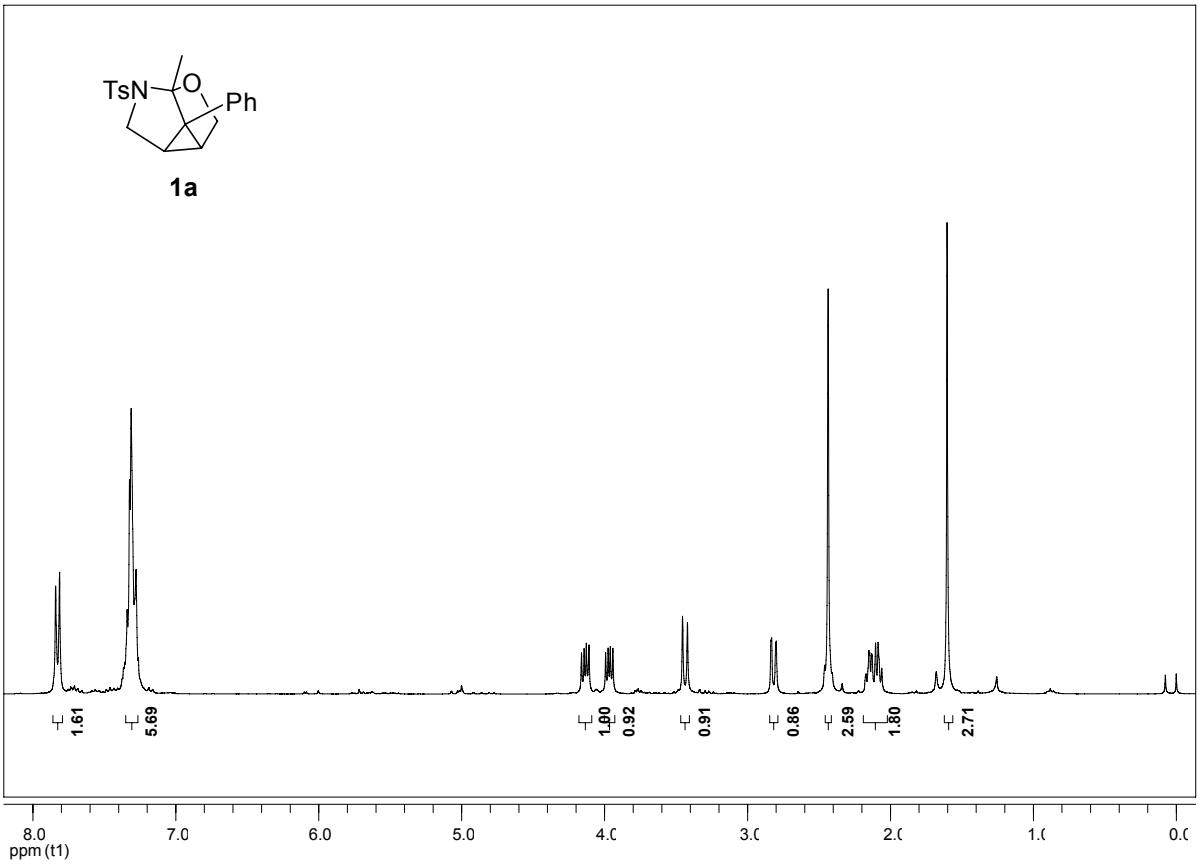

TsN
OH
15
150
100
50
ppm (t1)

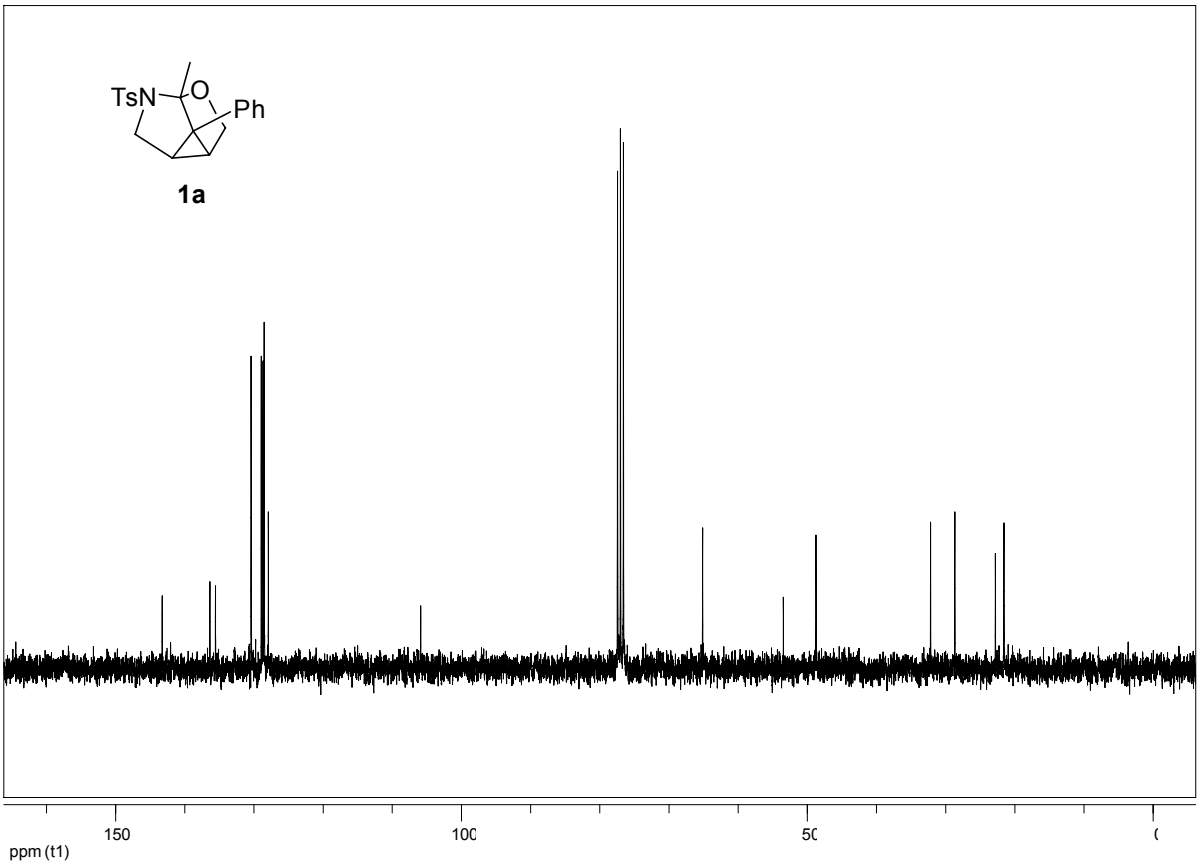

Ph−N
16
OH
1.74
4.58
1.67
0.87
0.91
0.93
1.35
2.18
2.20
1.00
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

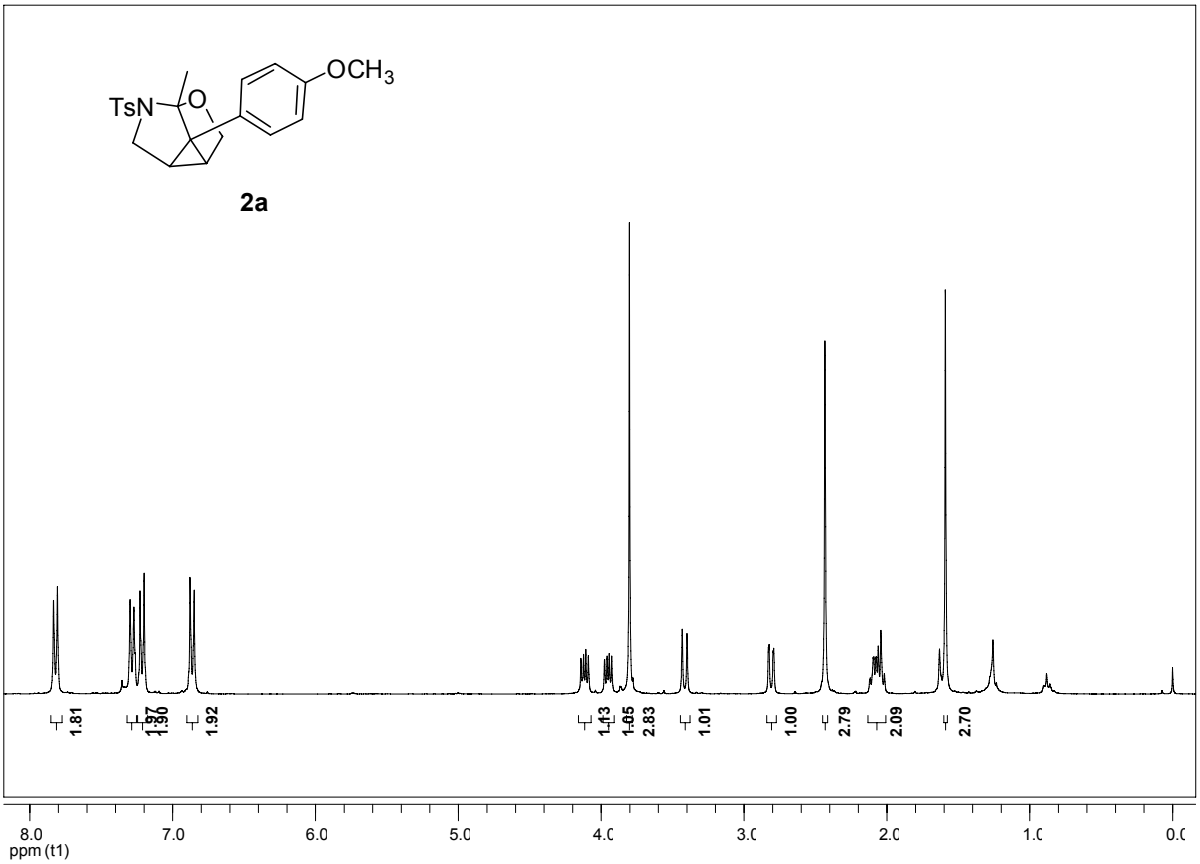

Ph−N
16
OH
150
100
50
ppm (t1)

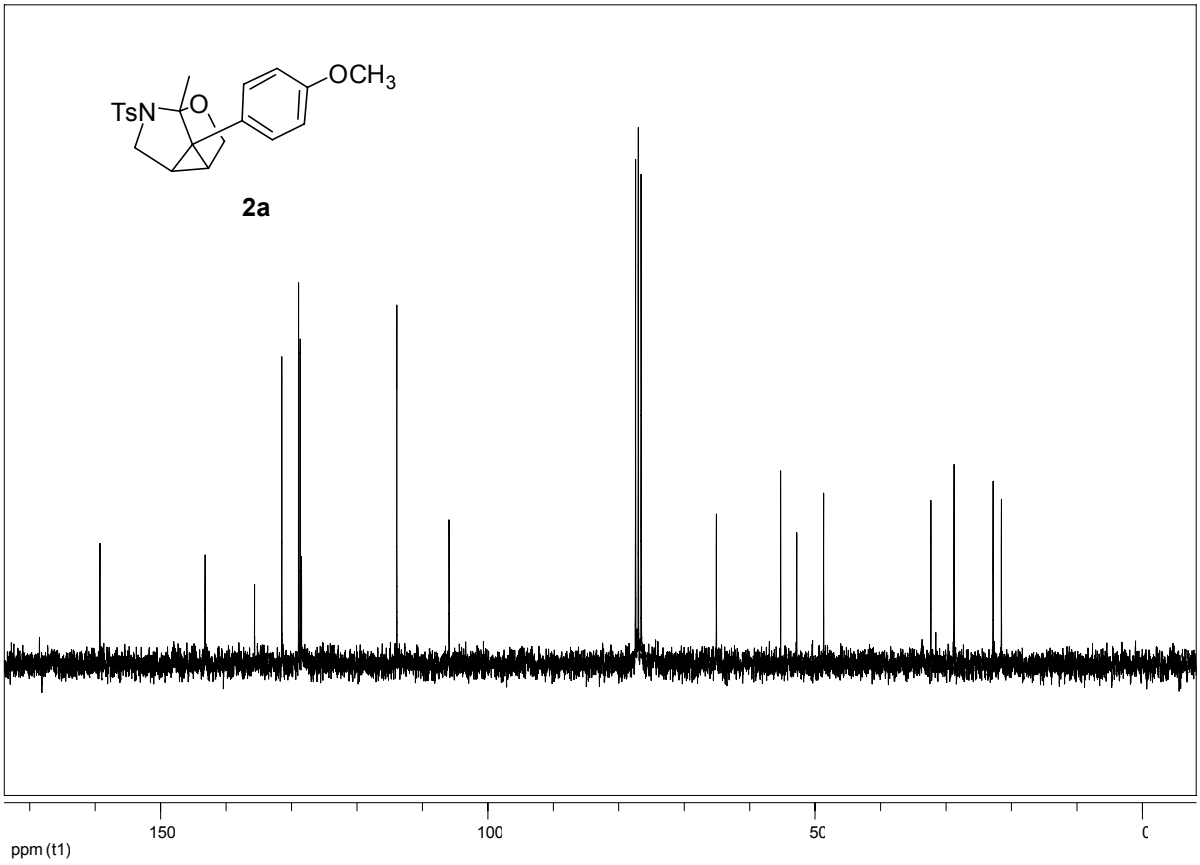

TsN
OH
1.58
4.10
1.50
0.84
0.83
1.74
1.90
2.00
2.75
0.71
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

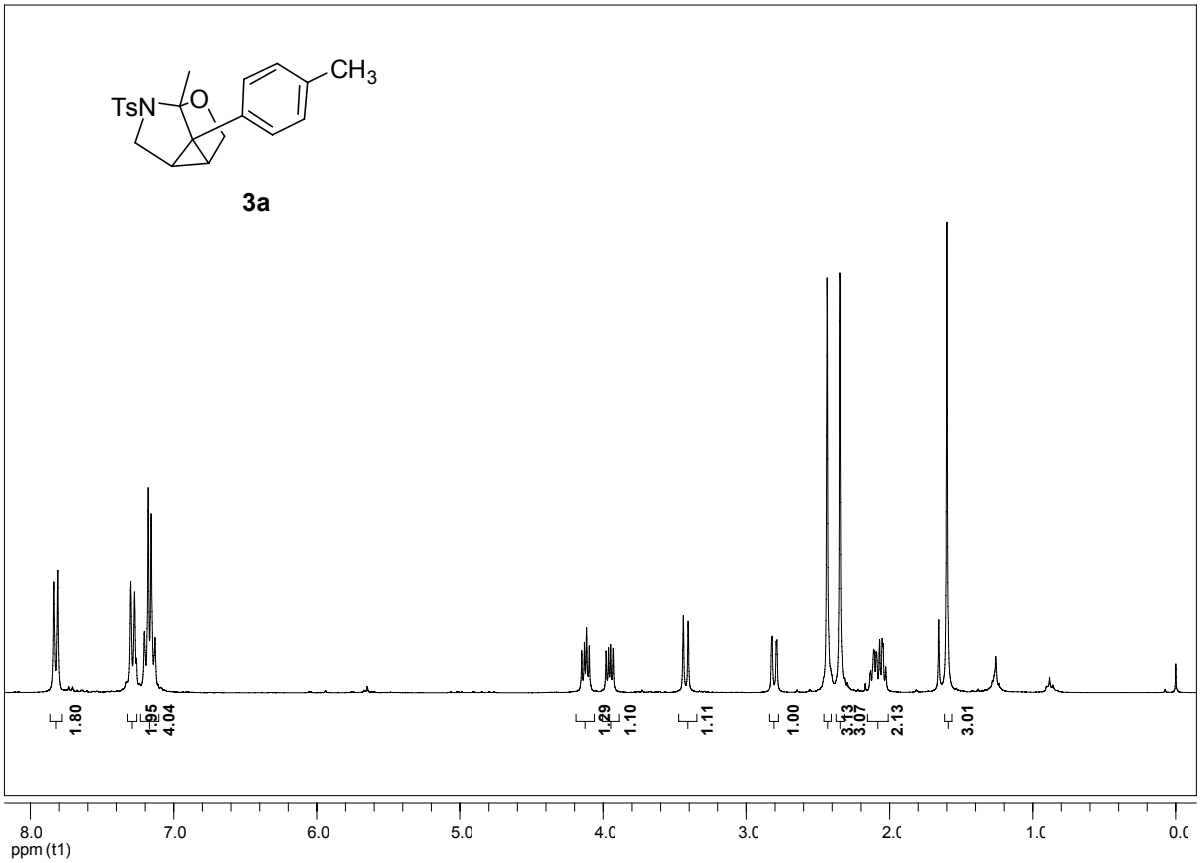

TsN
OH
150
100
50
0
ppm (t1)

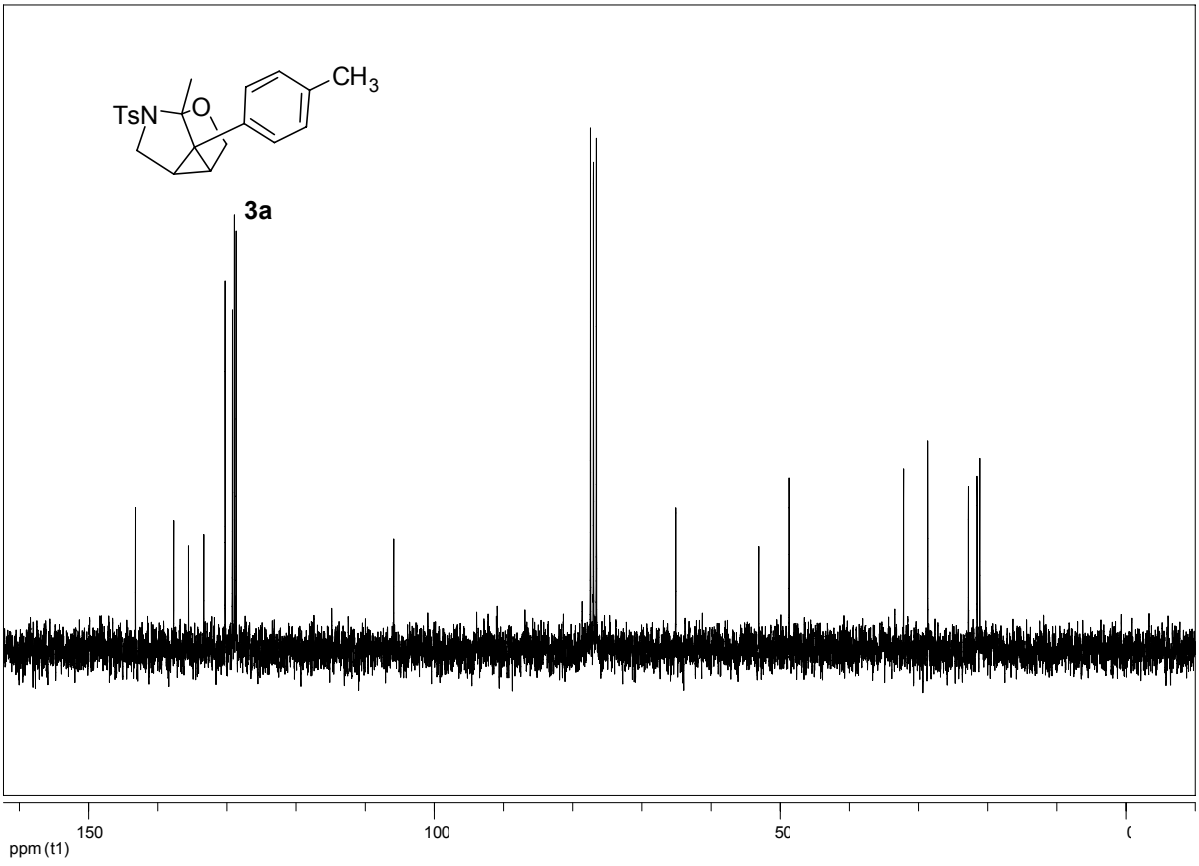

TsN
O
Ph
1a
1.61
5.69
1.00
0.92
0.91
0.86
2.59
1.80
2.71
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

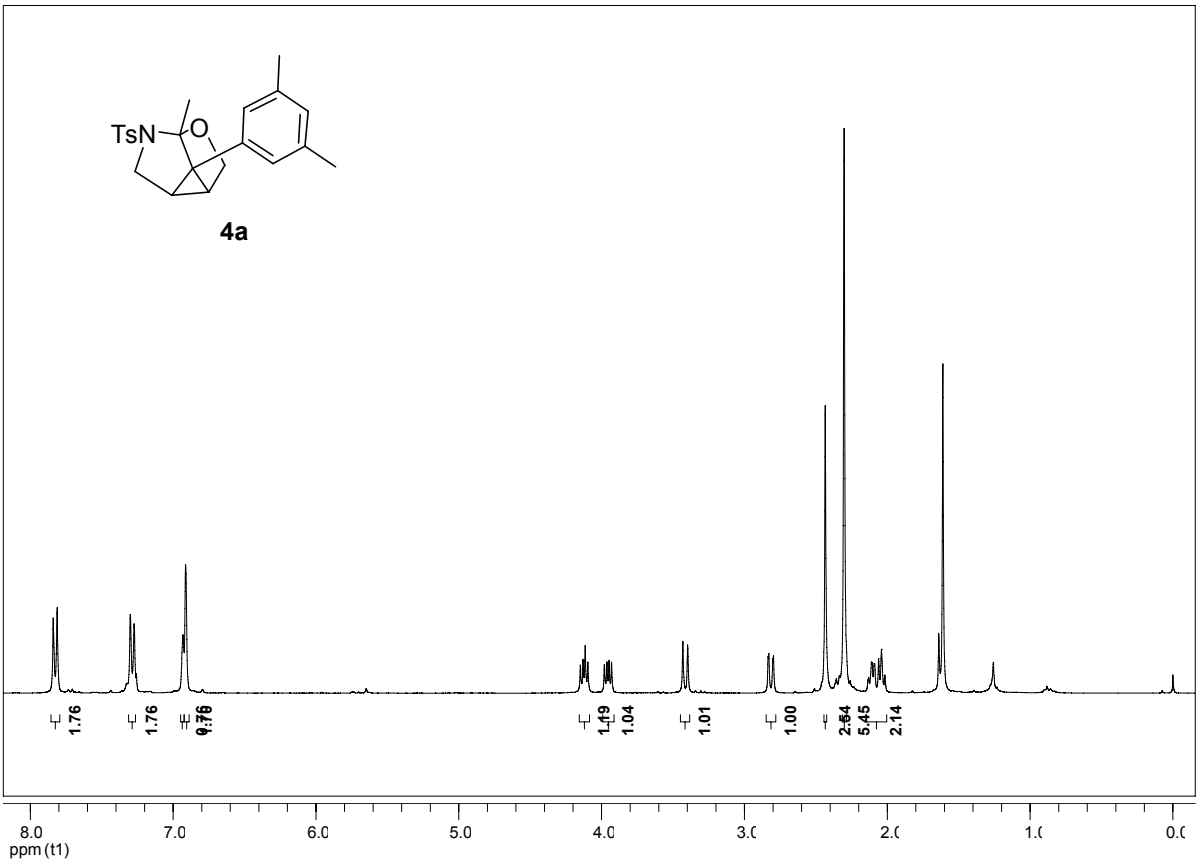

TsN
O
Ph
1a
150
100
50
ppm (t1)

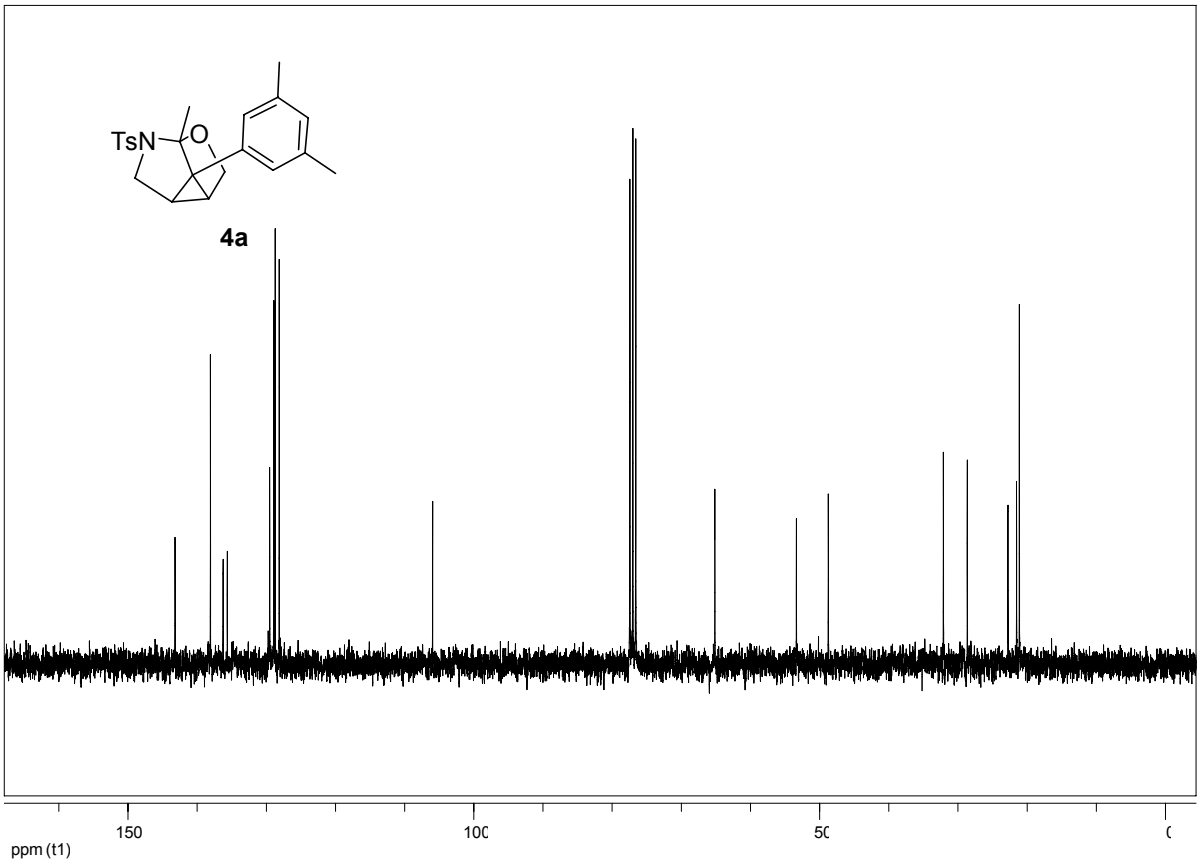

TsN
O
OCH3
2a
1.81
1.97
1.90
1.92
1.13
1.05
2.83
1.01
1.00
2.79
2.09
2.70
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

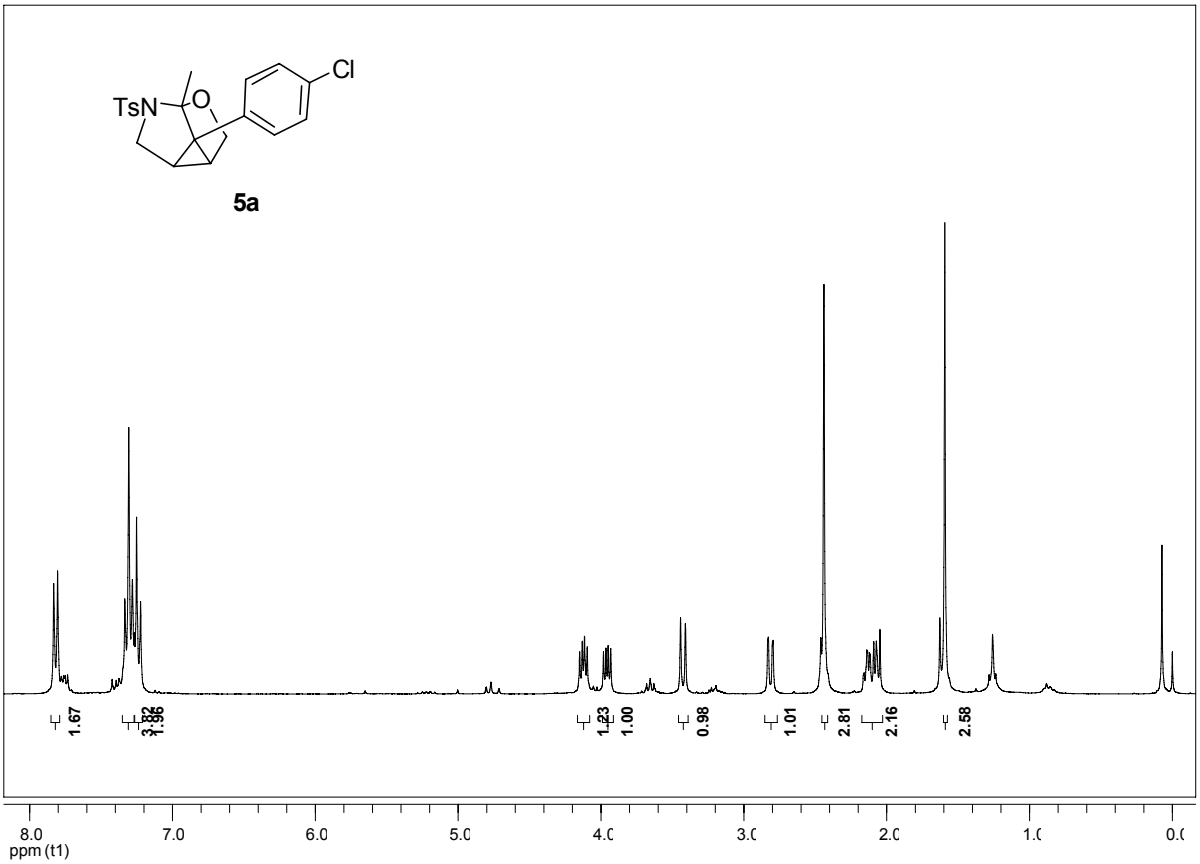

TsN
O
OCH3
2a
150
100
50
0
ppm (t1)

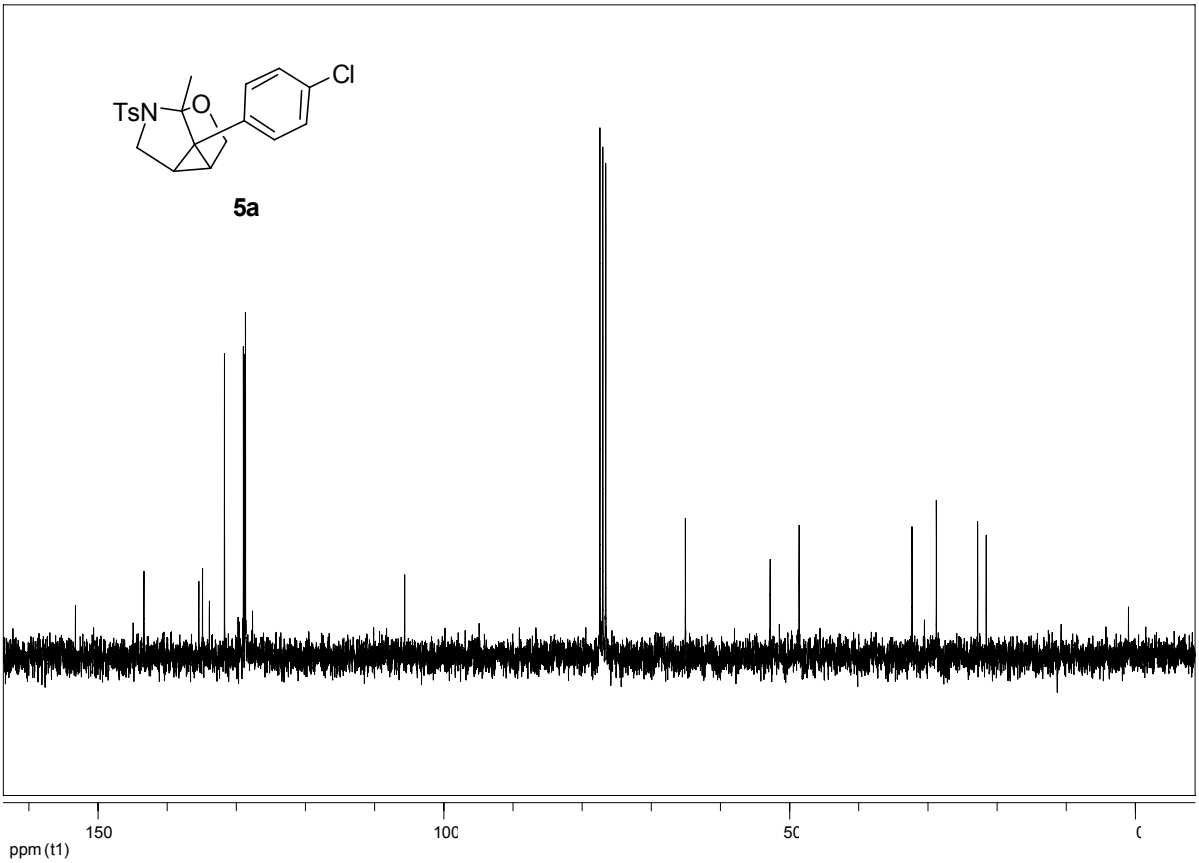

TsN
O
CH3
3a
1.80
1.95
4.04
1.29
1.10
1.11
1.00
3.03
3.07
2.13
3.01
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

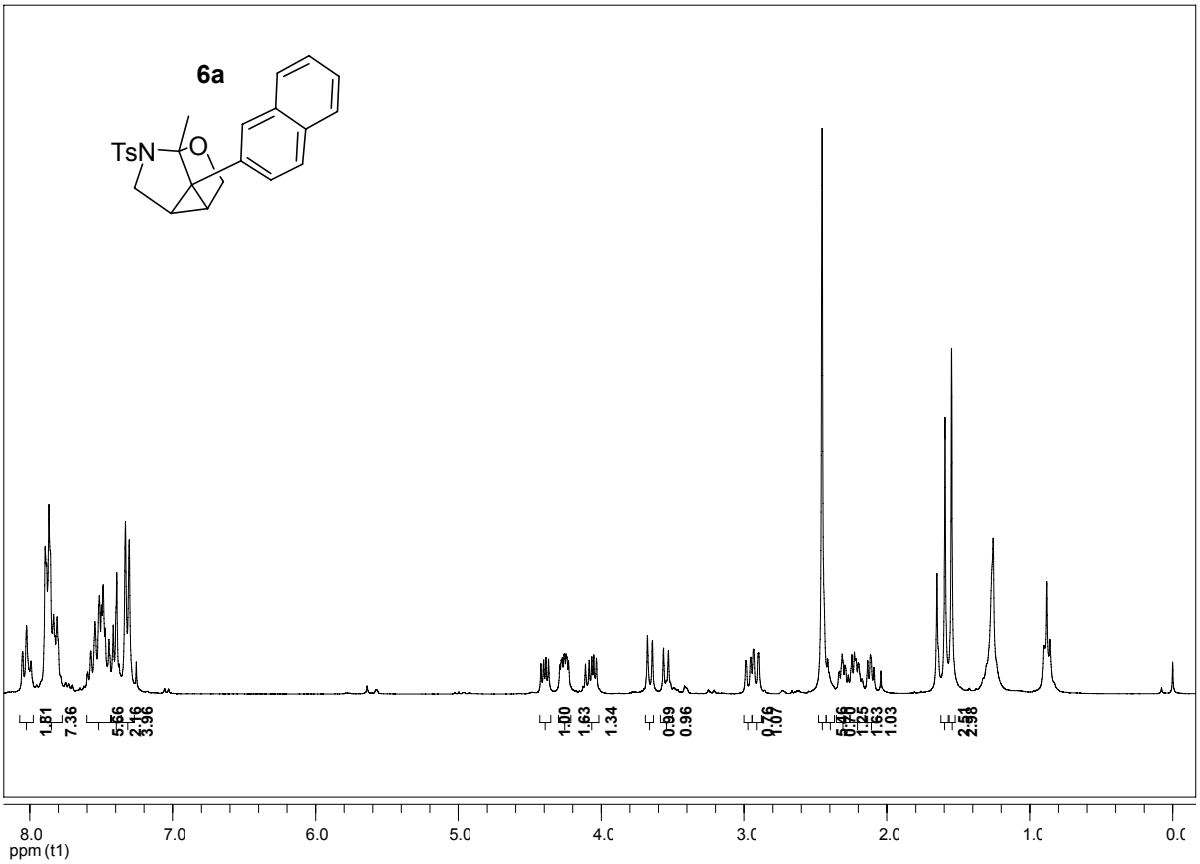

TsN
O
CH3
3a
150
100
50
ppm (t1)

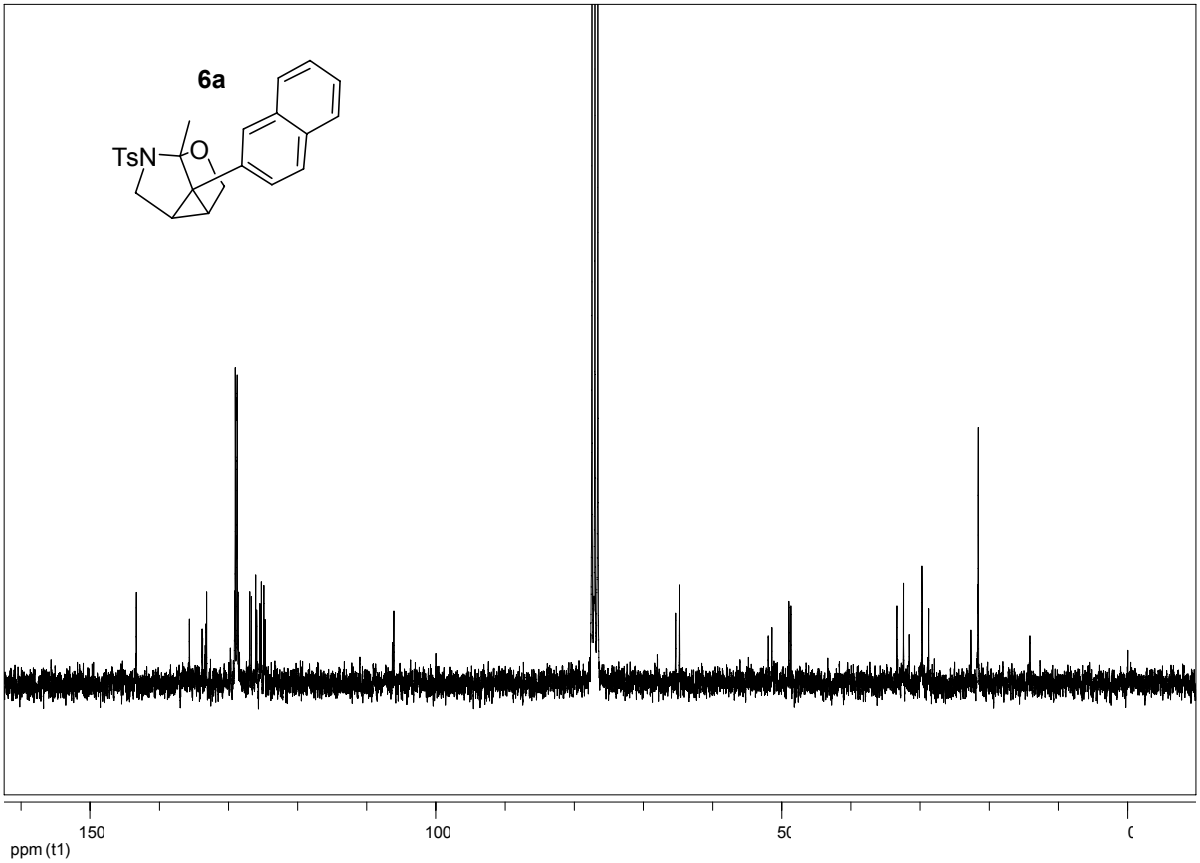

TsN
O
4a
1.76
1.76
1.19
1.04
1.01
1.00
2.14
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

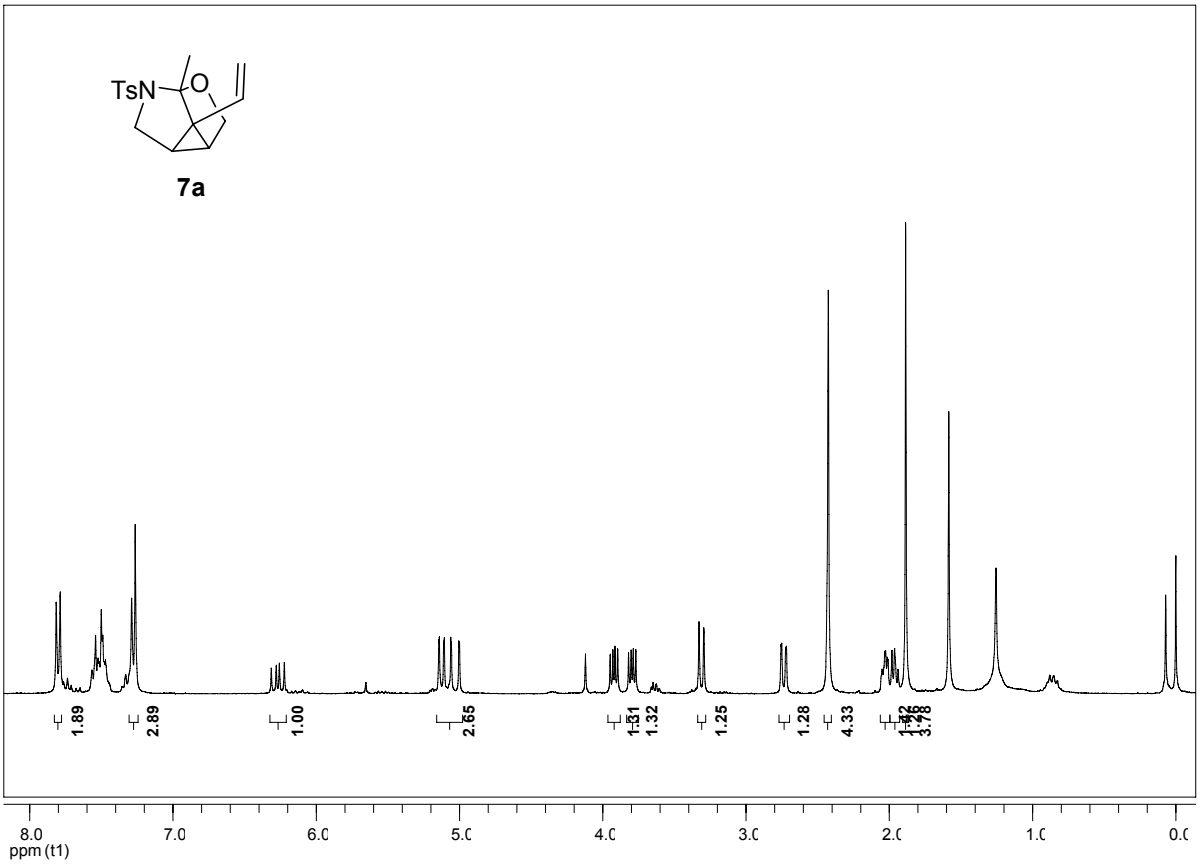

TsN
O
4a
150
100
50
ppm (t1)

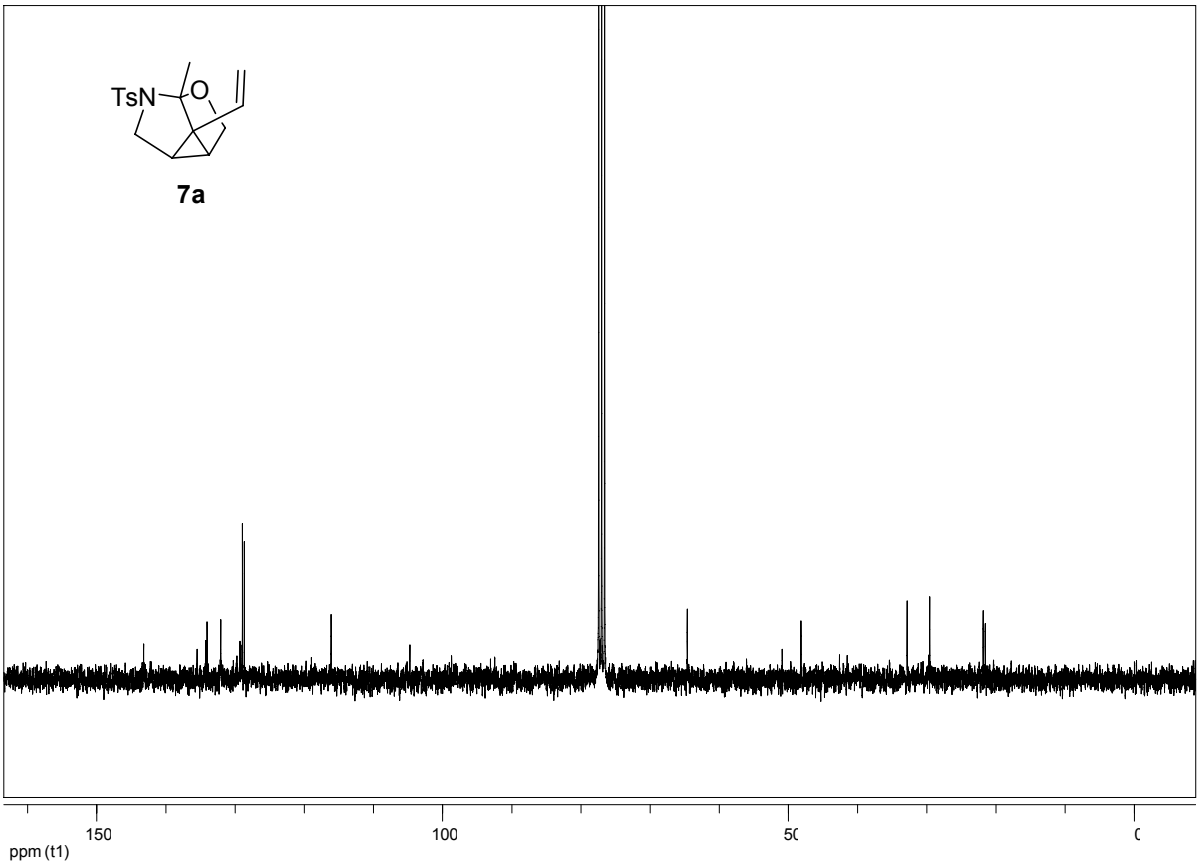

TsN
O
Cl
5a
1.67
1.23
1.00
0.98
1.01
2.81
2.16
2.58
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

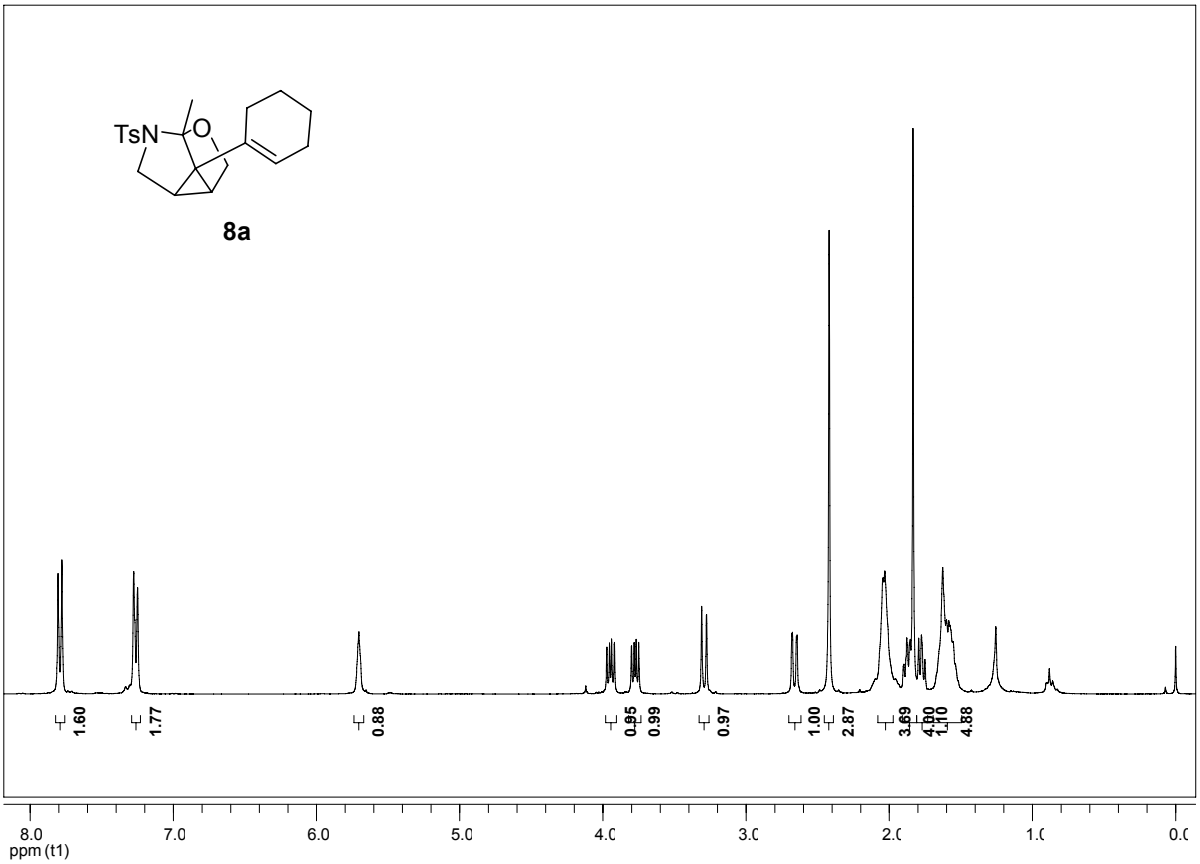

TsN
O
Cl
5a
150
100
50
ppm (t1)

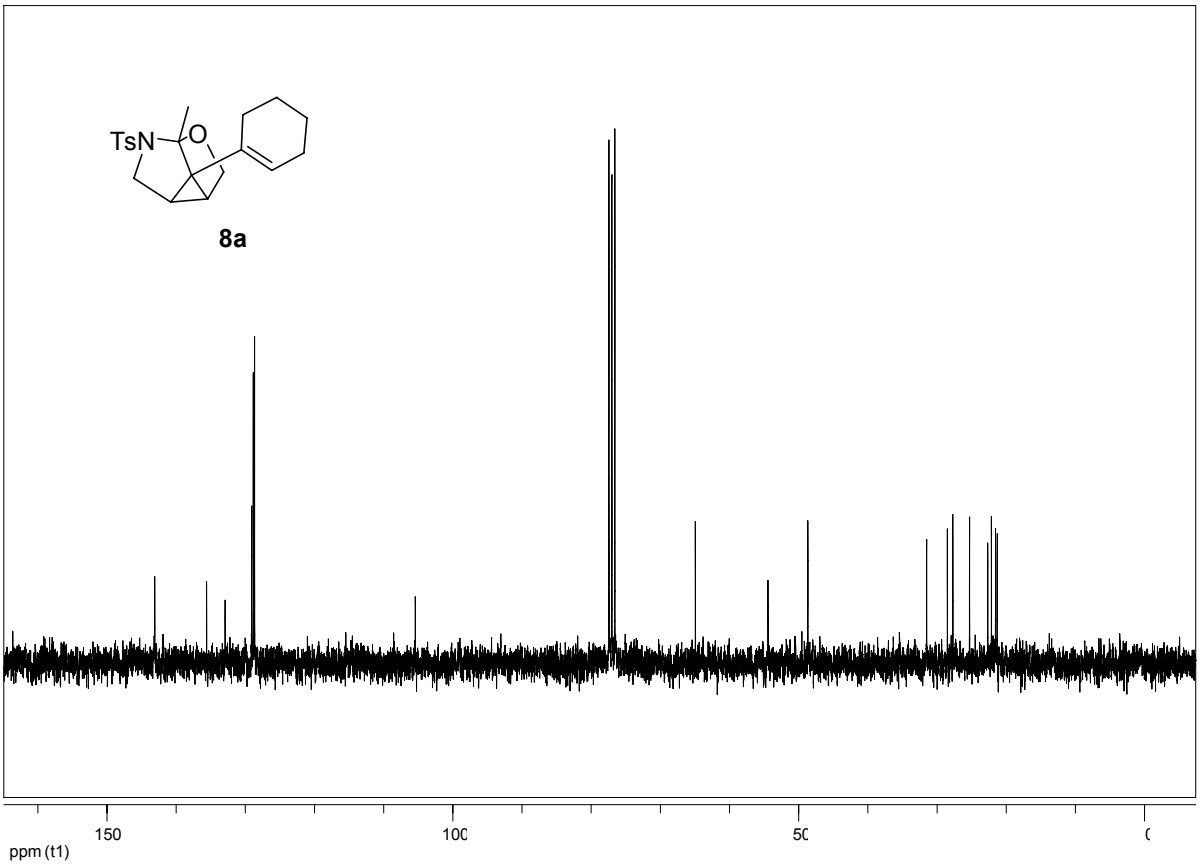

6a
TsN
O
1.81
7.36
5.56
2.16
3.96
1.00
1.63
1.34
0.99
0.96
1.07
1.25
1.03
2.98
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

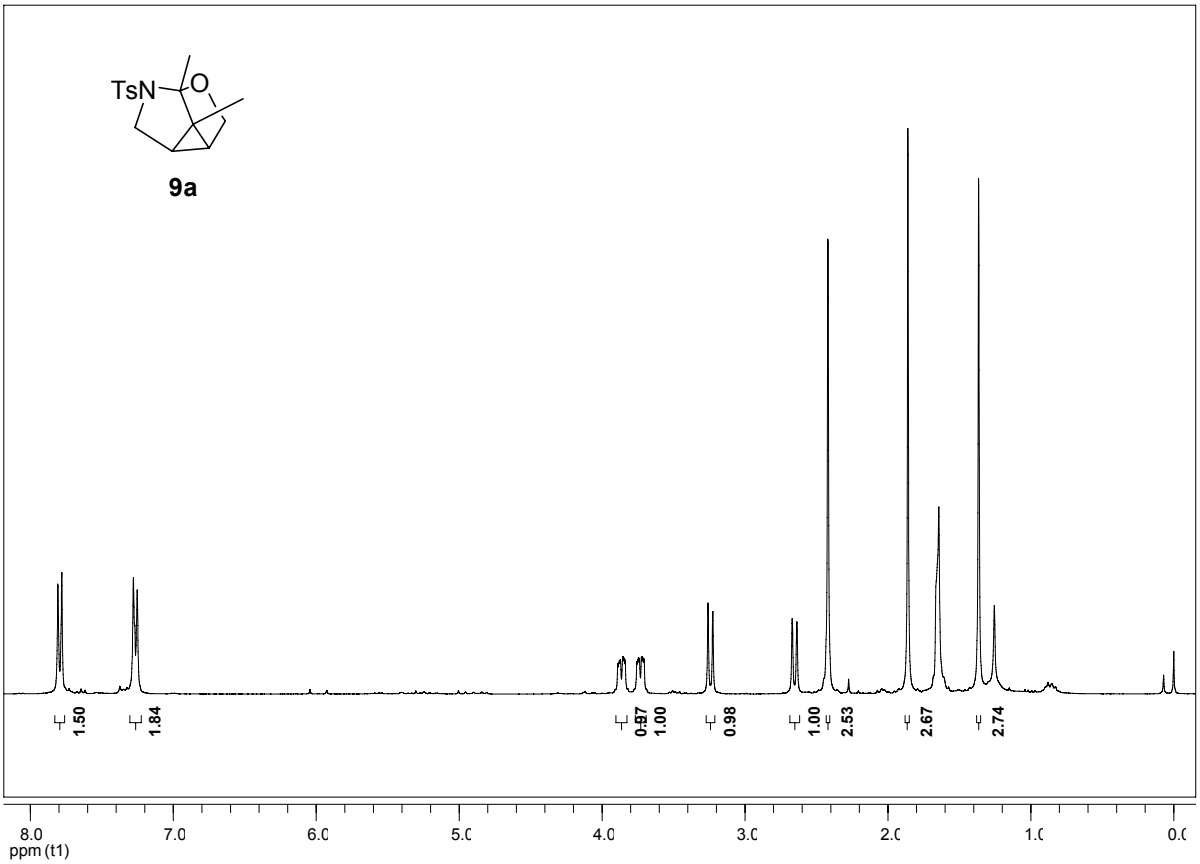

6a
TsN
O
150
100
50
ppm (t1)

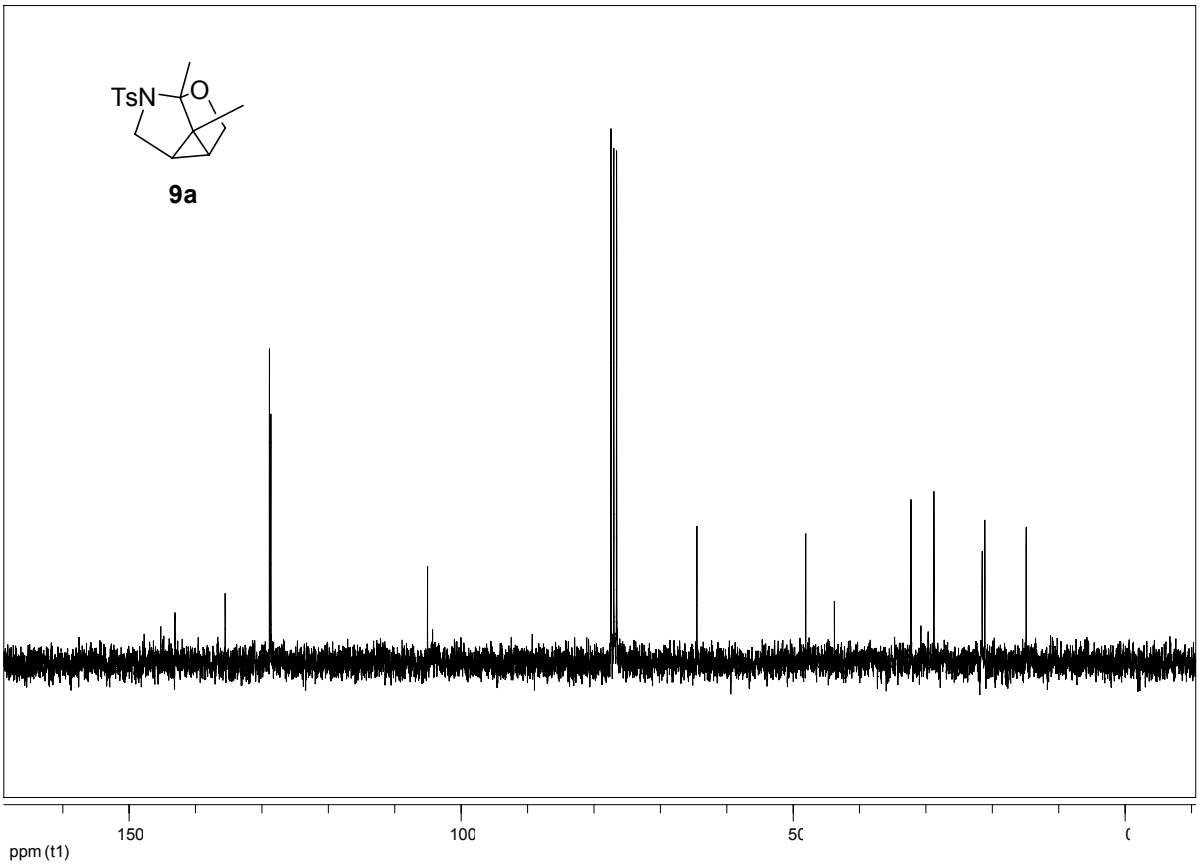

TsN
O
7a
1.89
2.89
1.00
2.65
1.51
1.32
1.25
1.28
4.33
3.78
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

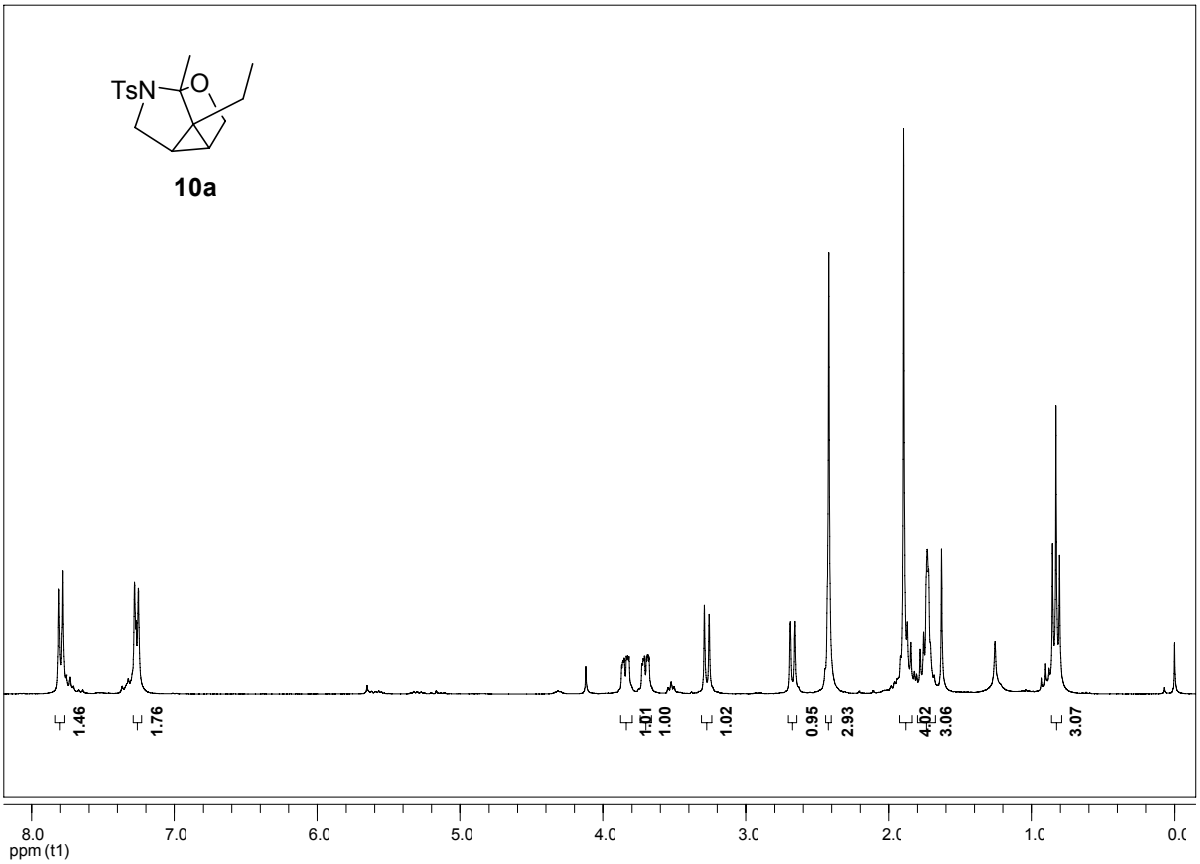

TsN
O
7a
150
100
50
ppm (t1)

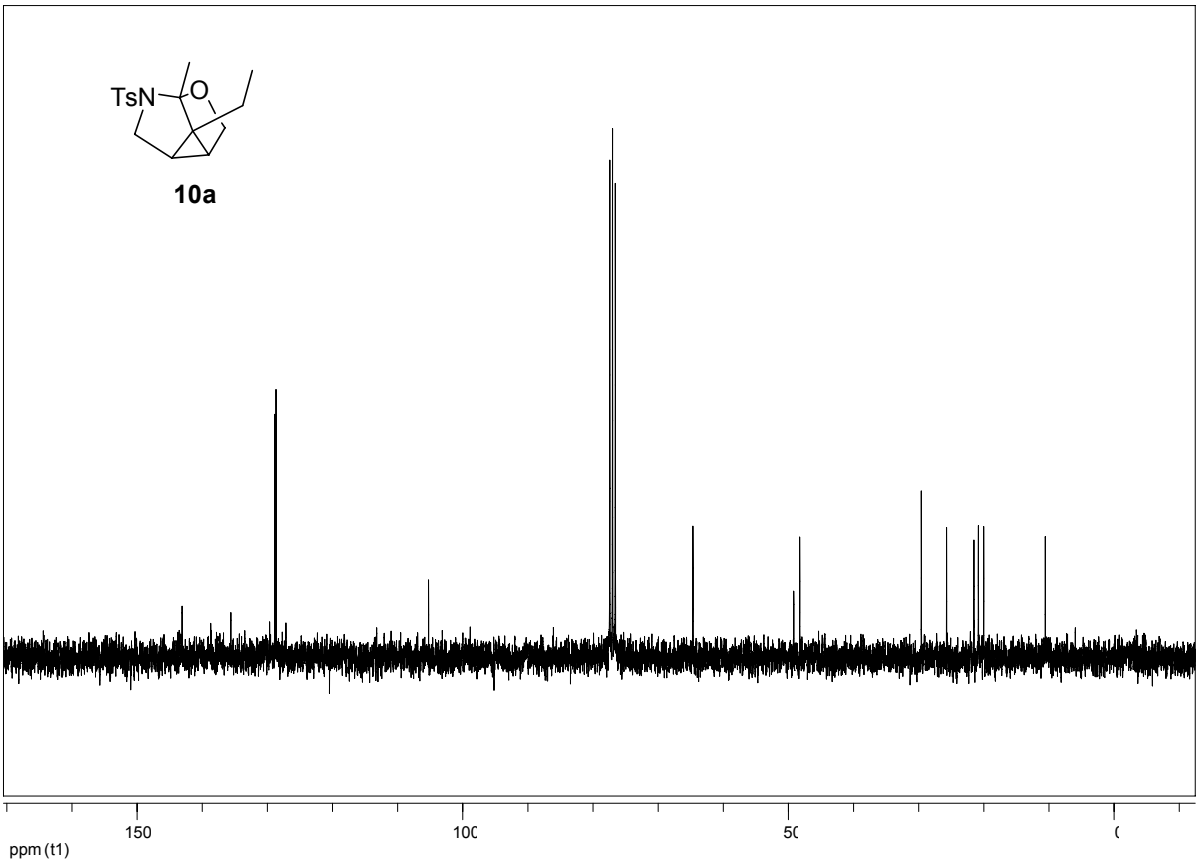

TsN
O
8a
1.60
1.77
0.88
0.95
0.99
0.97
1.00
2.87
3.69
4.00
1.10
4.88
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

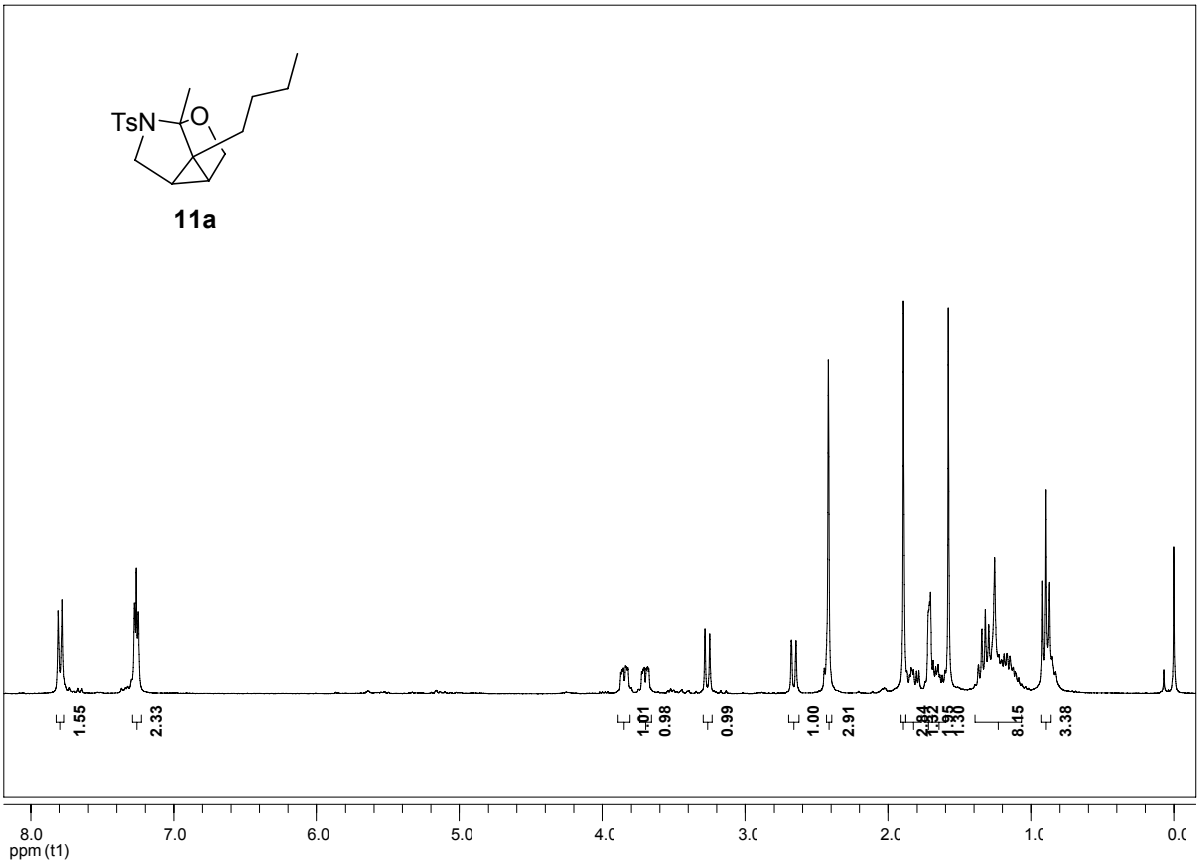

TsN
O
8a
150
100
50
0
ppm (t1)

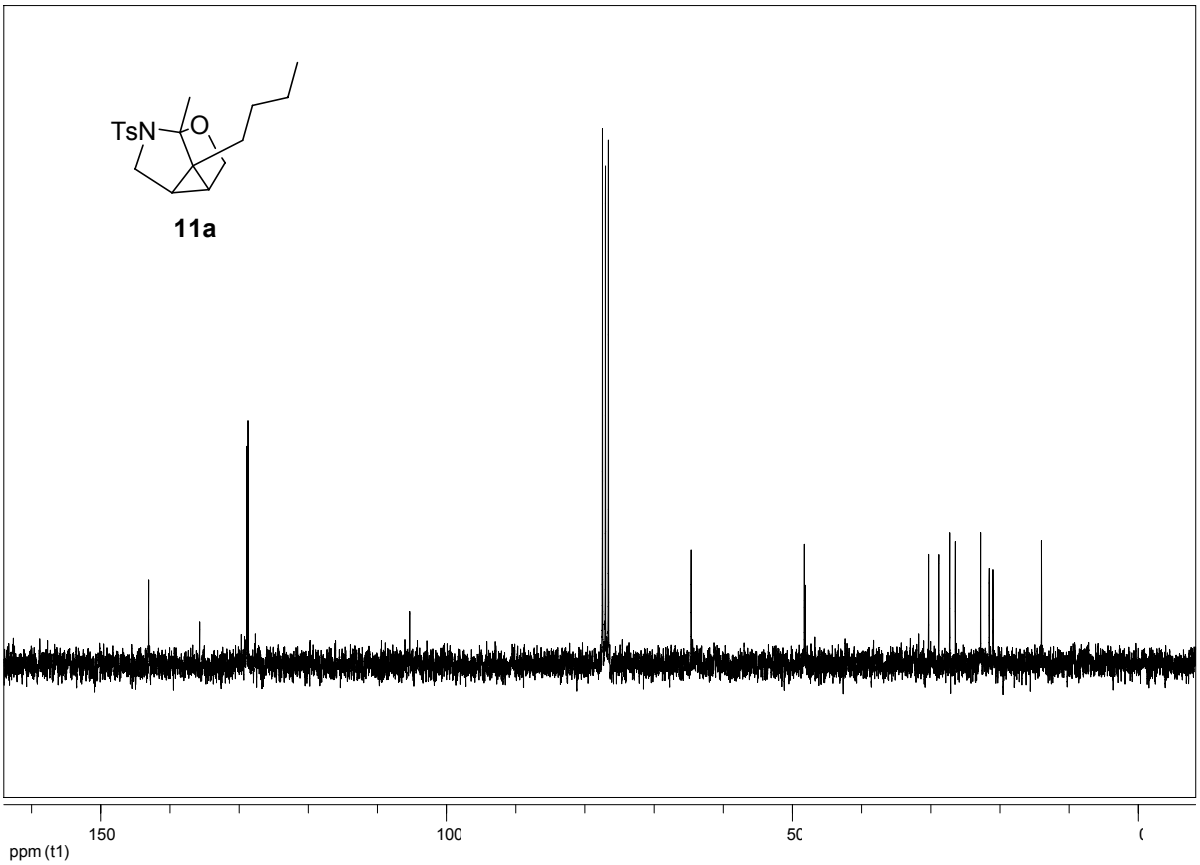

TsN
O
9a
1.50
1.84
0.97
1.00
0.98
1.00
2.53
2.67
2.74
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

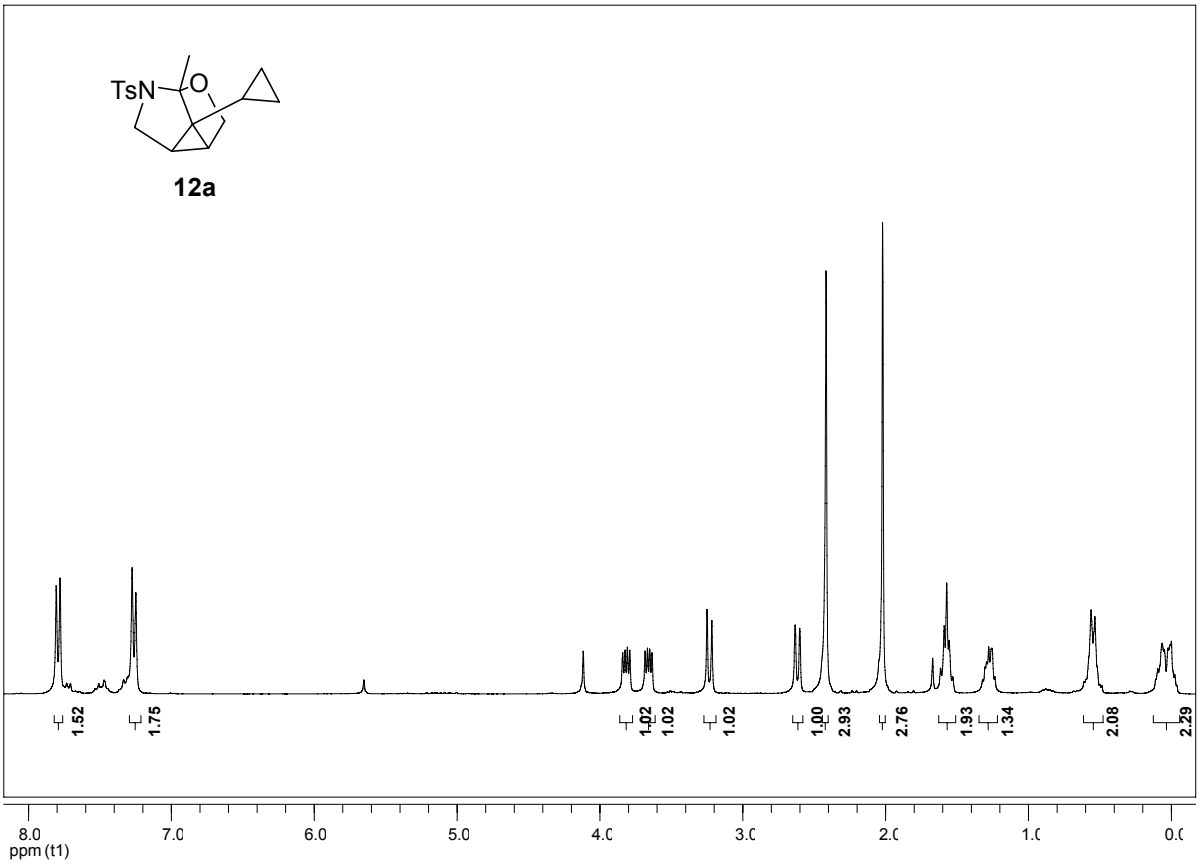

TsN
O
9a
150
100
50
ppm (t1)

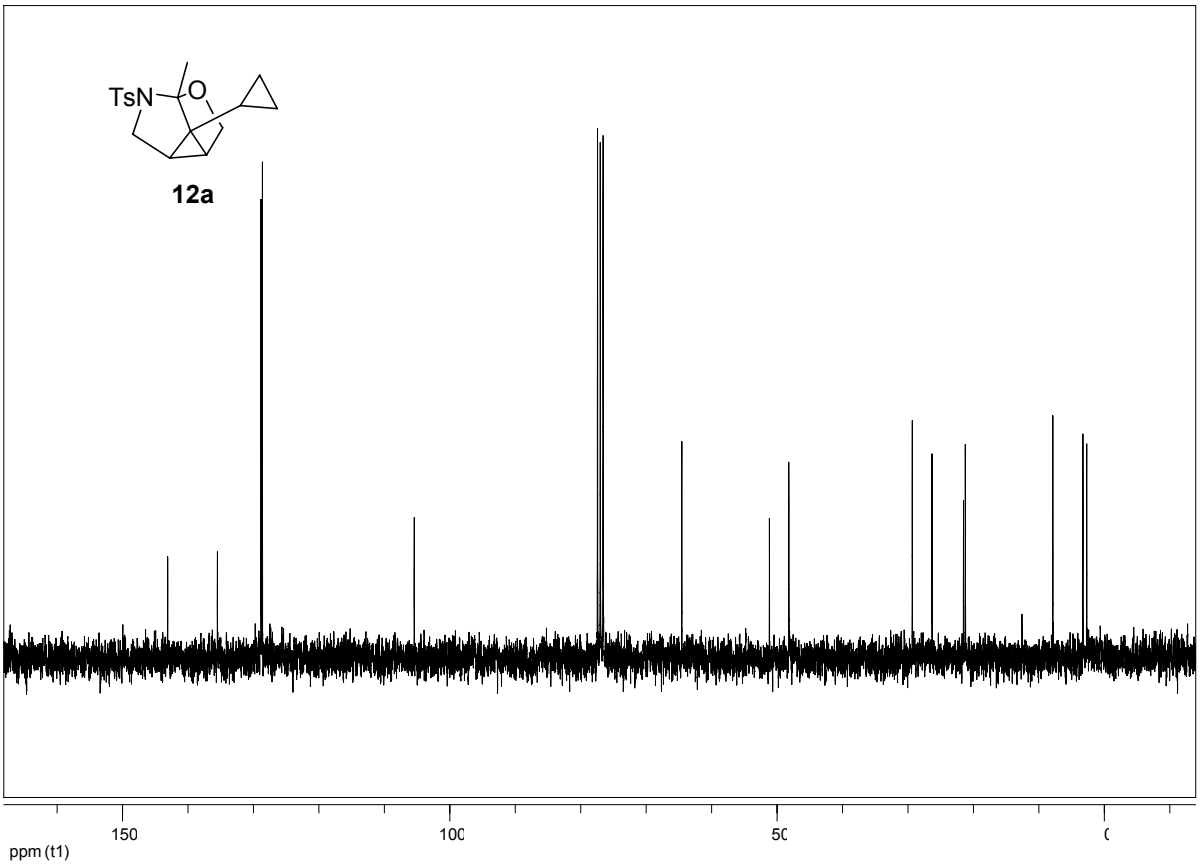

TsN
O
10a
1.46
1.76
1.01
1.00
1.02
0.95
2.93
4.02
3.06
3.07
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

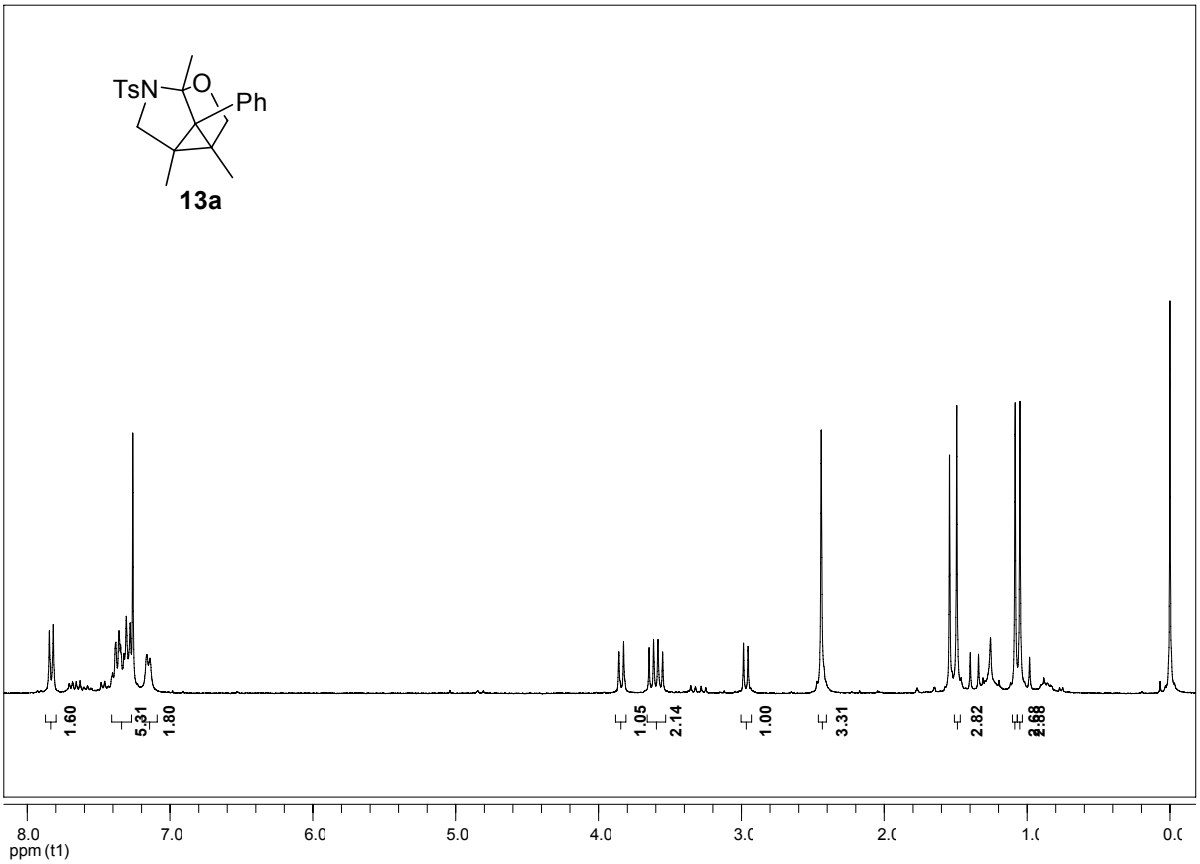

TsN
O
10a
150
100
50
ppm (t1)

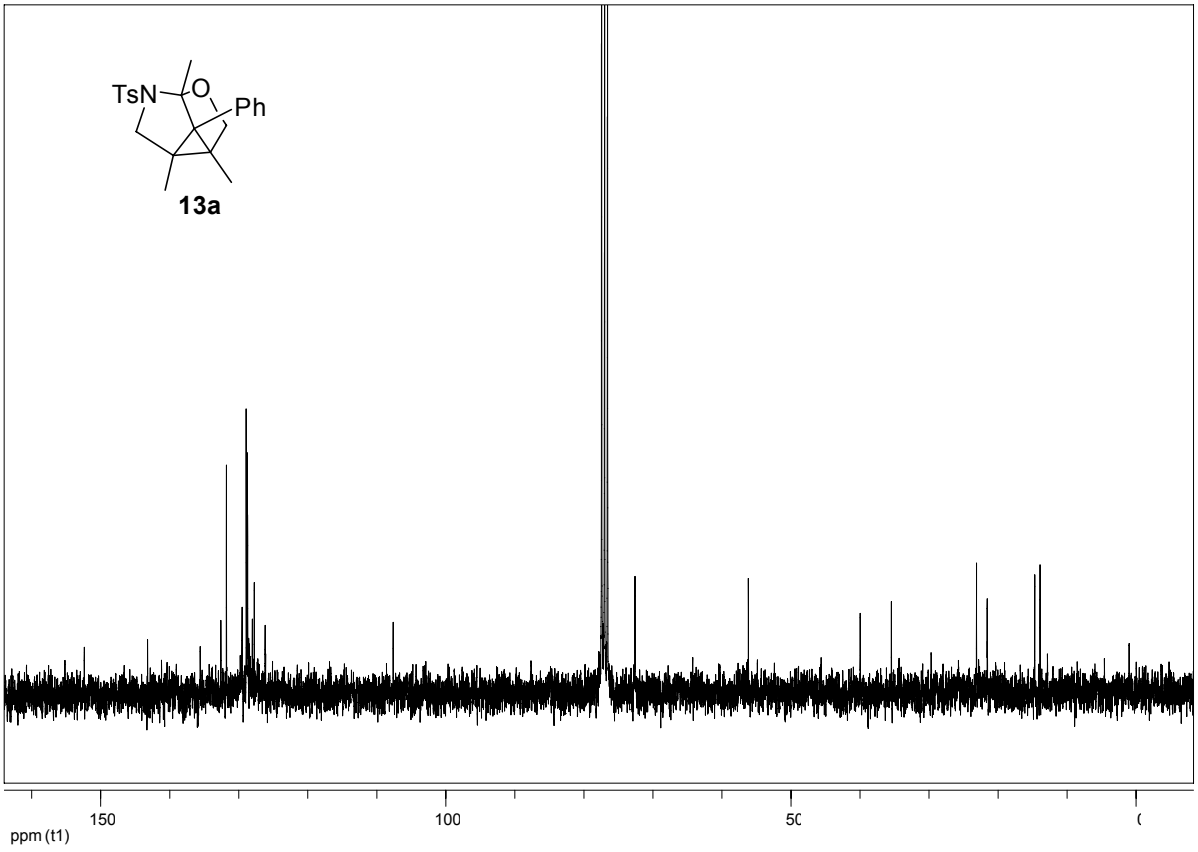

TsN
O
11a
1.55
2.33
1.01
0.98
0.99
1.00
2.91
8.15
3.38
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

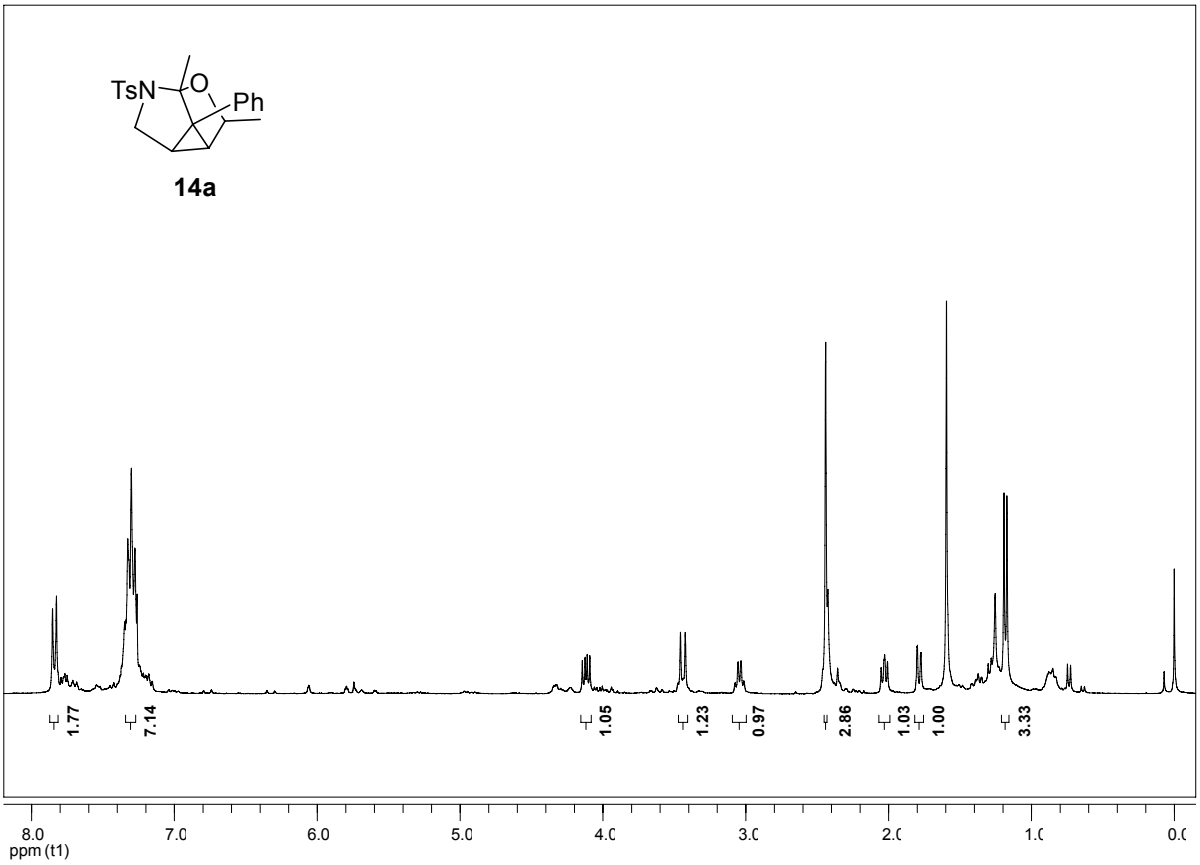

TsN
O
11a
150
100
50
ppm (t1)

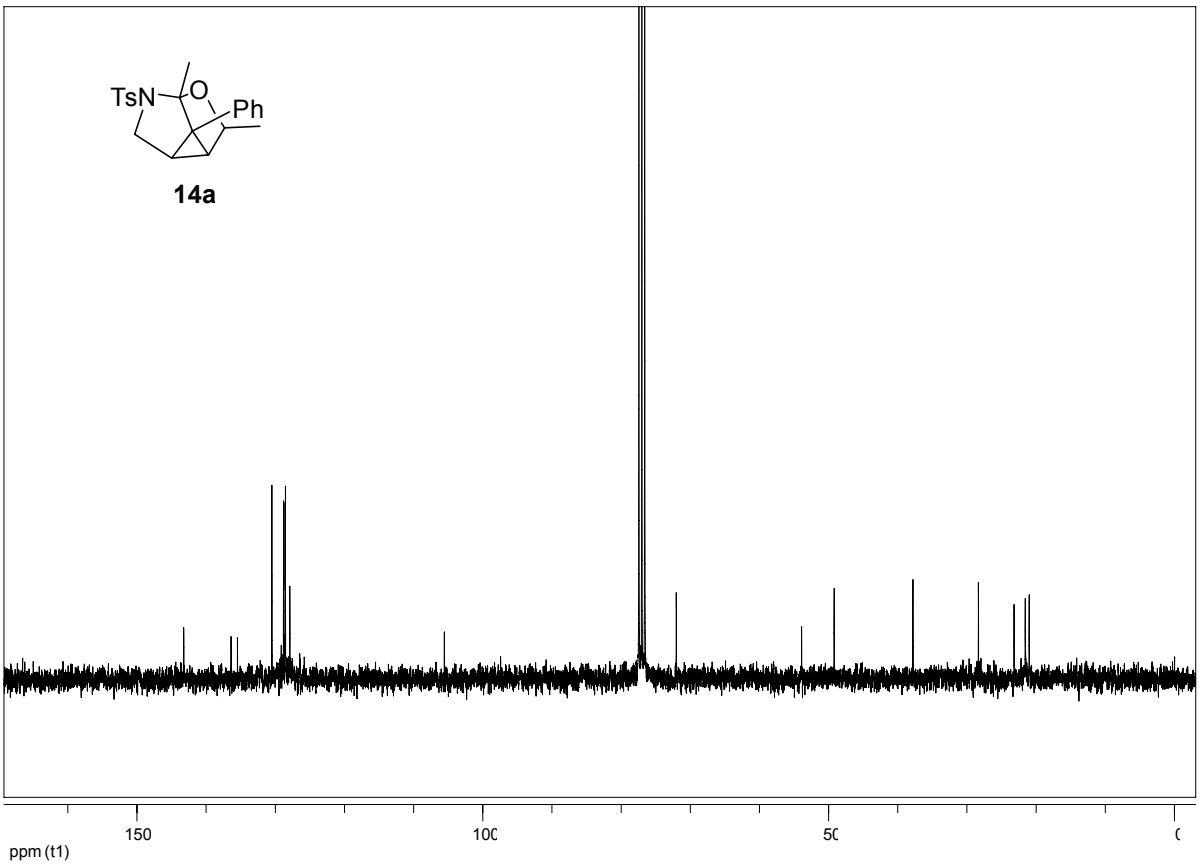

TsN
O
12a
1.52
1.75
1.02
1.02
1.02
1.00
2.93
2.76
1.93
1.34
2.08
2.29
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

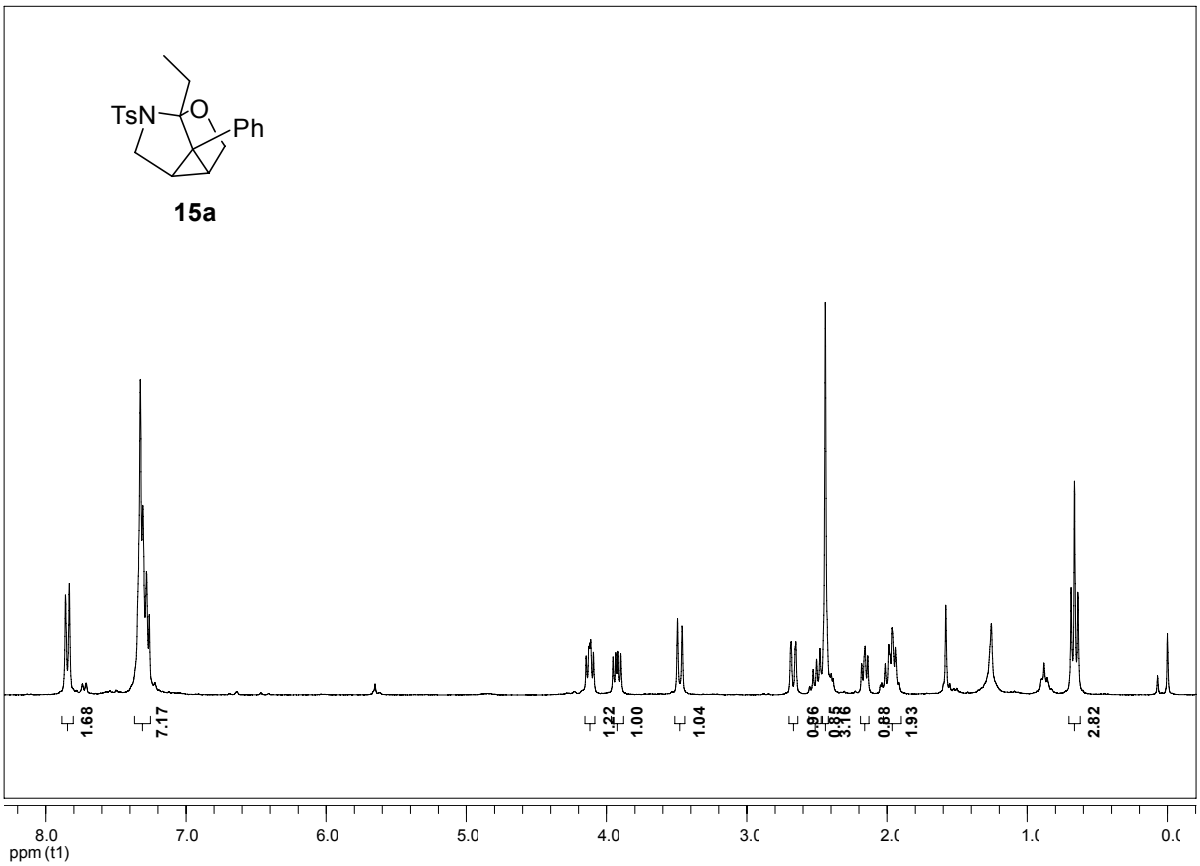

TsN
O
12a
150
100
50
0
ppm (t1)

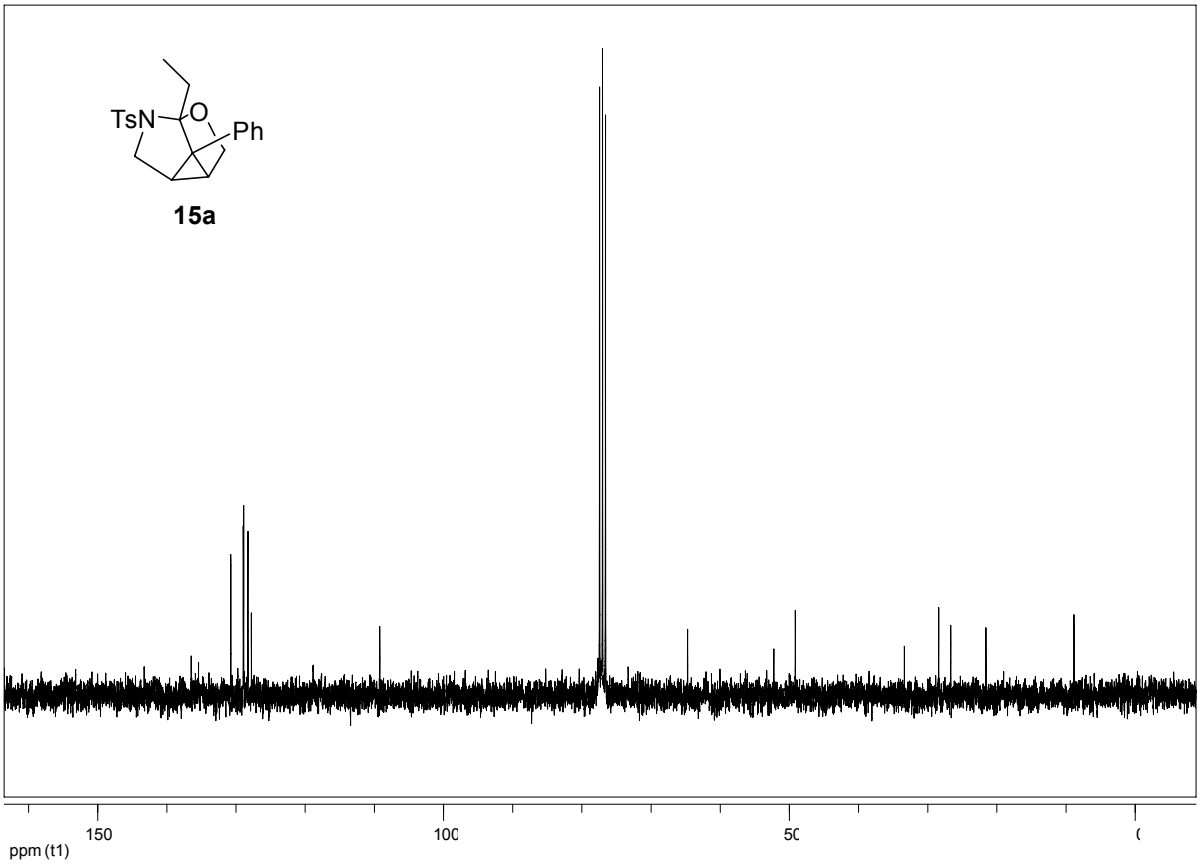

TsN
O
Ph
13a
1.60
5.31
1.80
1.05
2.14
1.00
3.31
2.82
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

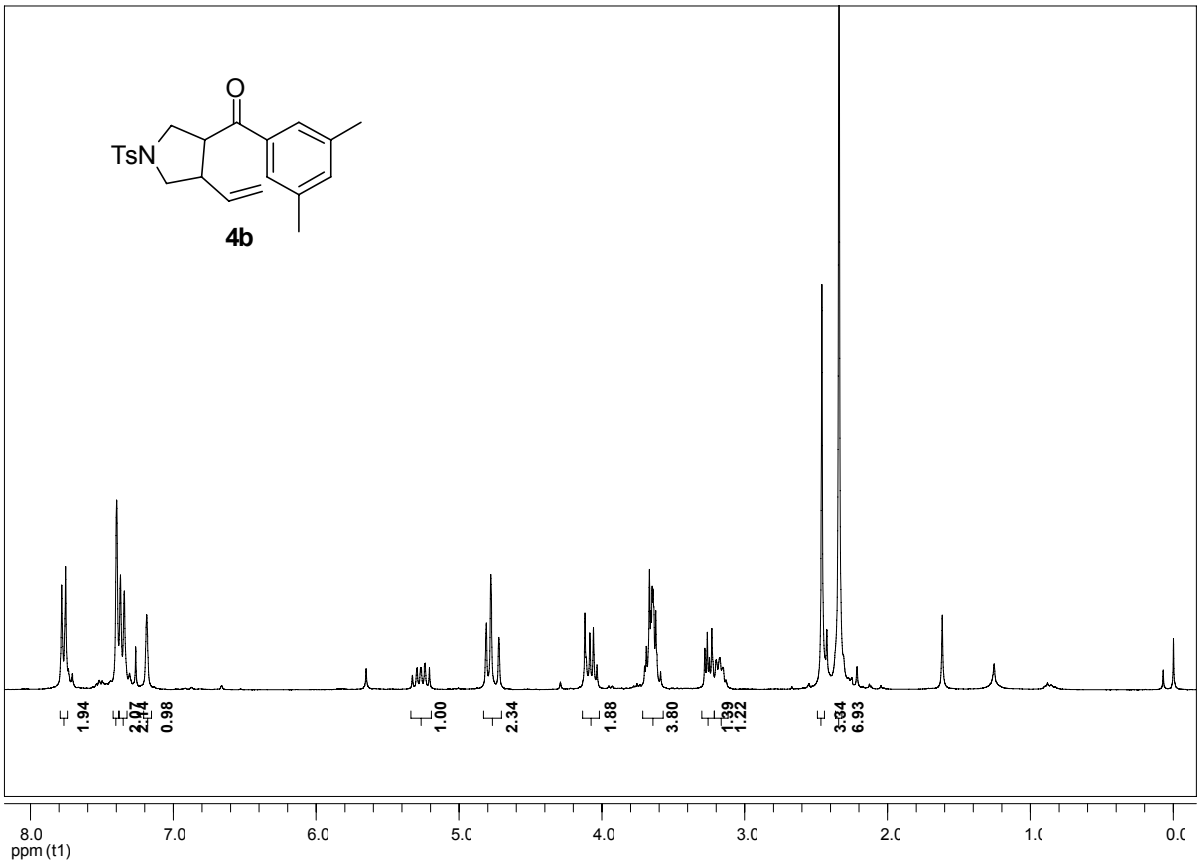

TsN
O
Ph
13a
150
100
50
ppm (t1)

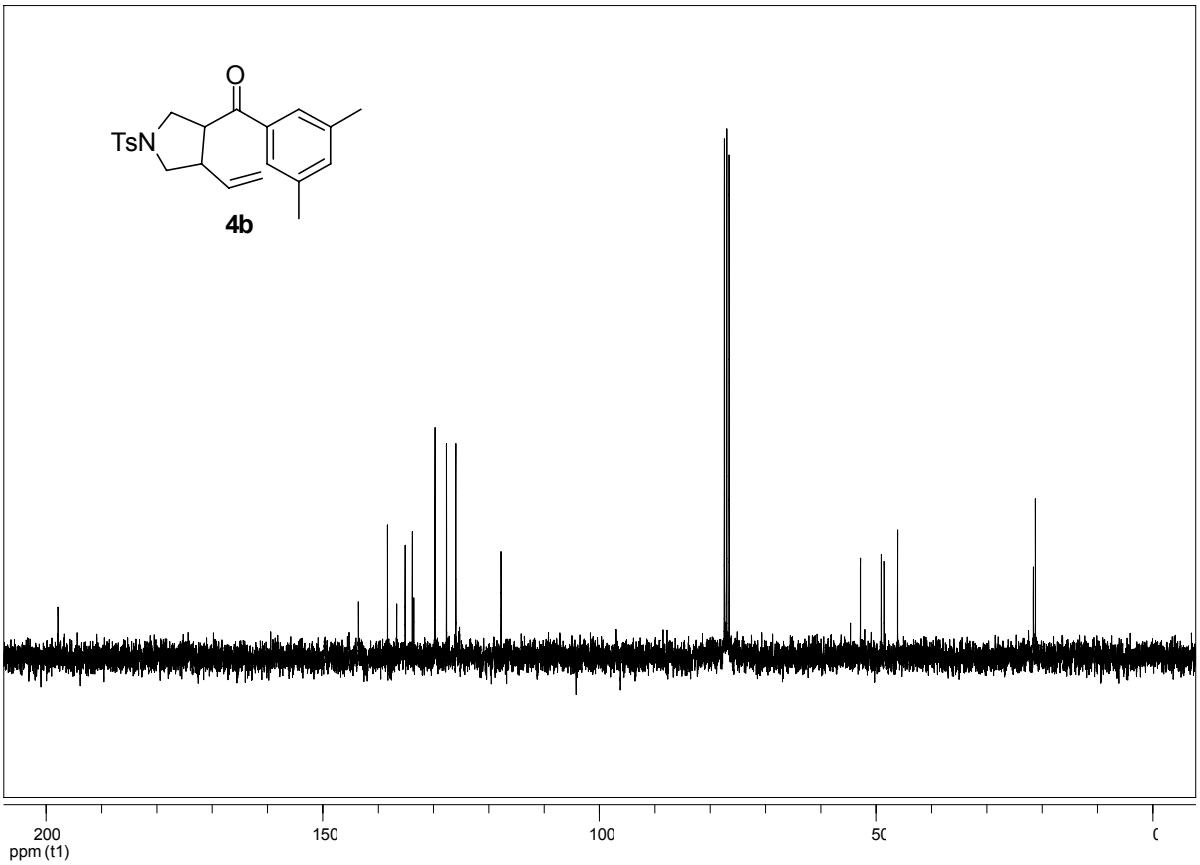

TsN
O
Ph
14a
1.77
7.14
1.05
1.23
0.97
2.86
1.03
1.00
3.33
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

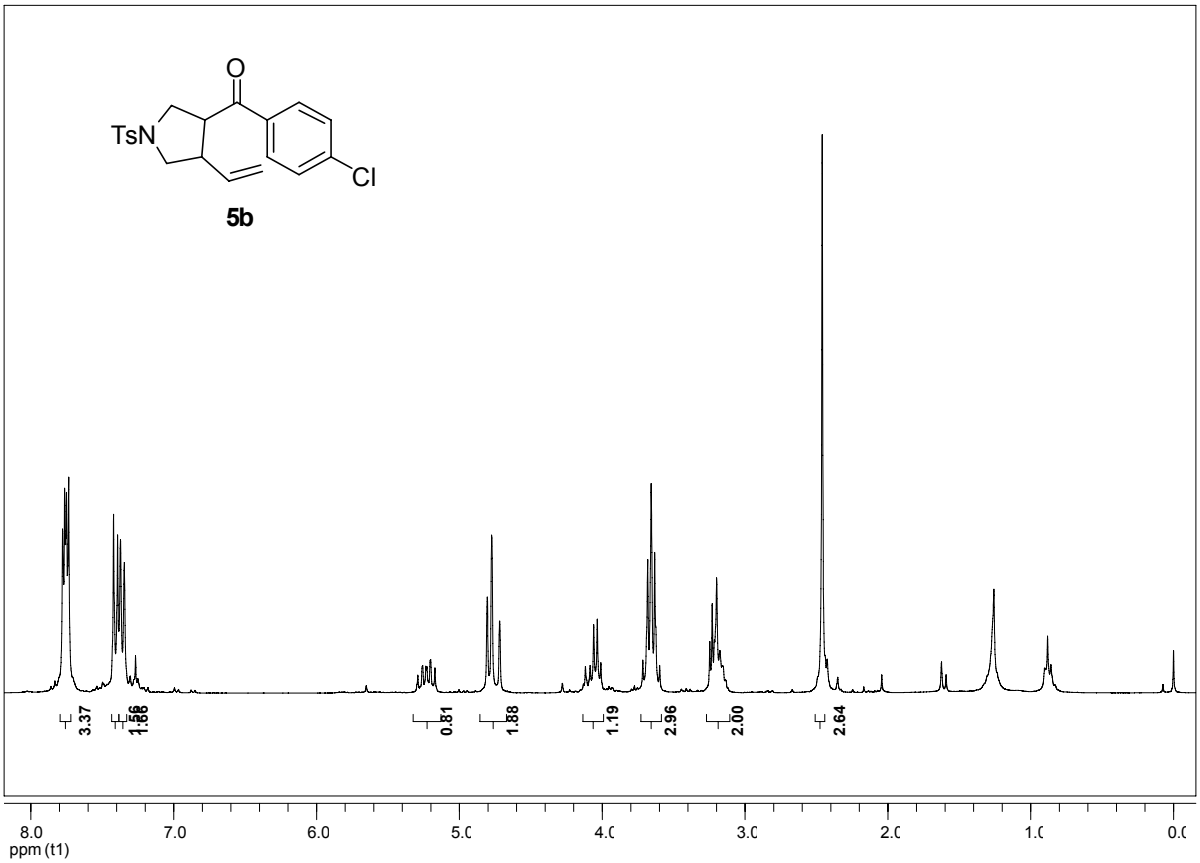

TsN
O
Ph
14a
150
100
50
ppm (t1)

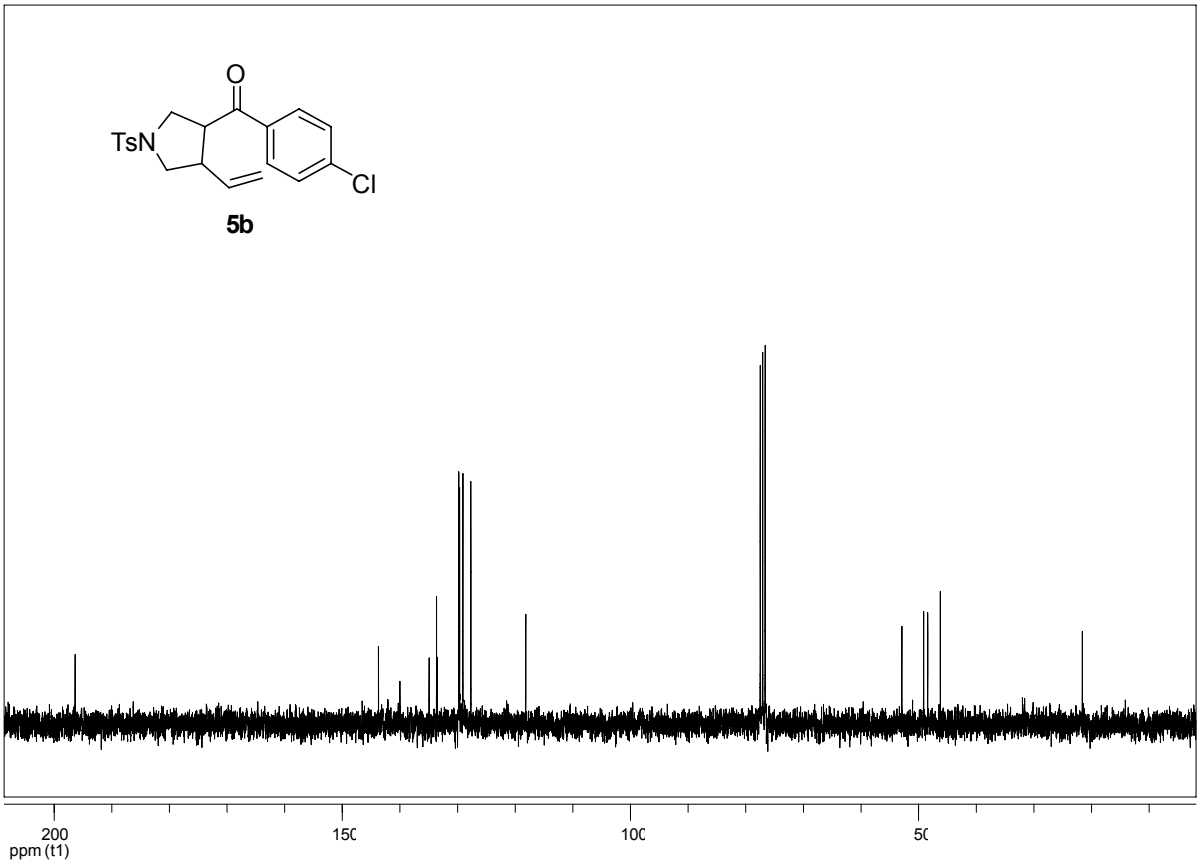

TsN
O
Ph
15a
1.68
7.17
1.22
1.00
1.04
0.96
1.55
3.16
0.88
1.93
2.82
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

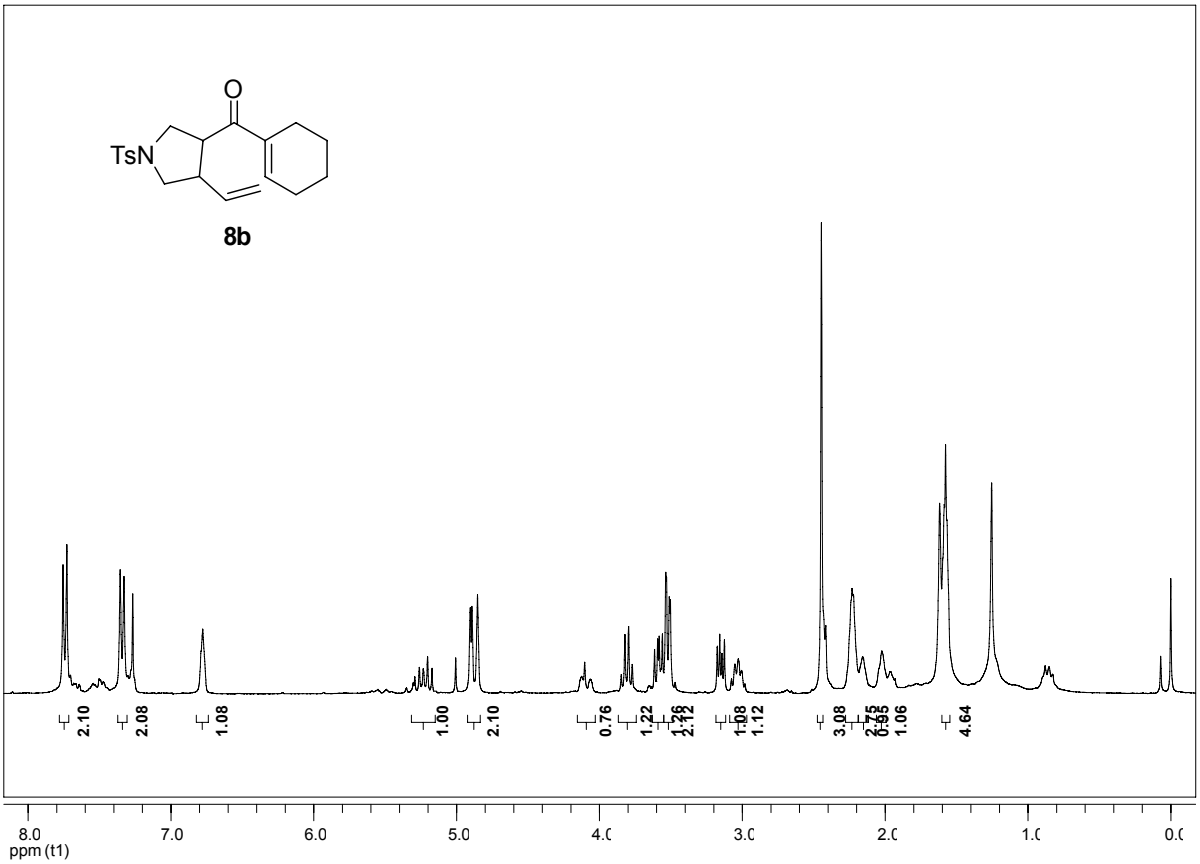

TsN
O
Ph
15a
150
100
50
ppm (t1)

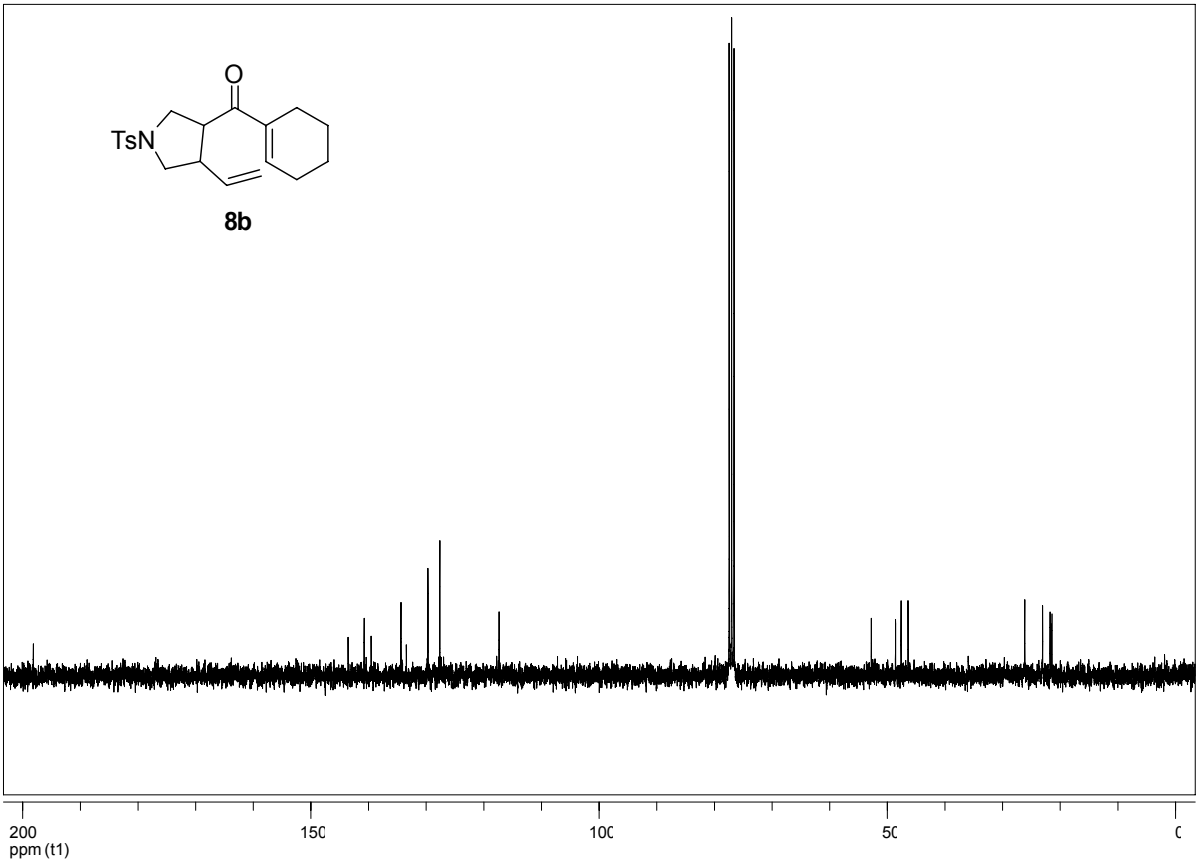

O
TsN
4b
1.94
2.07
2.04
0.98
1.00
2.34
1.88
3.80
1.99
1.22
3.04
6.93
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

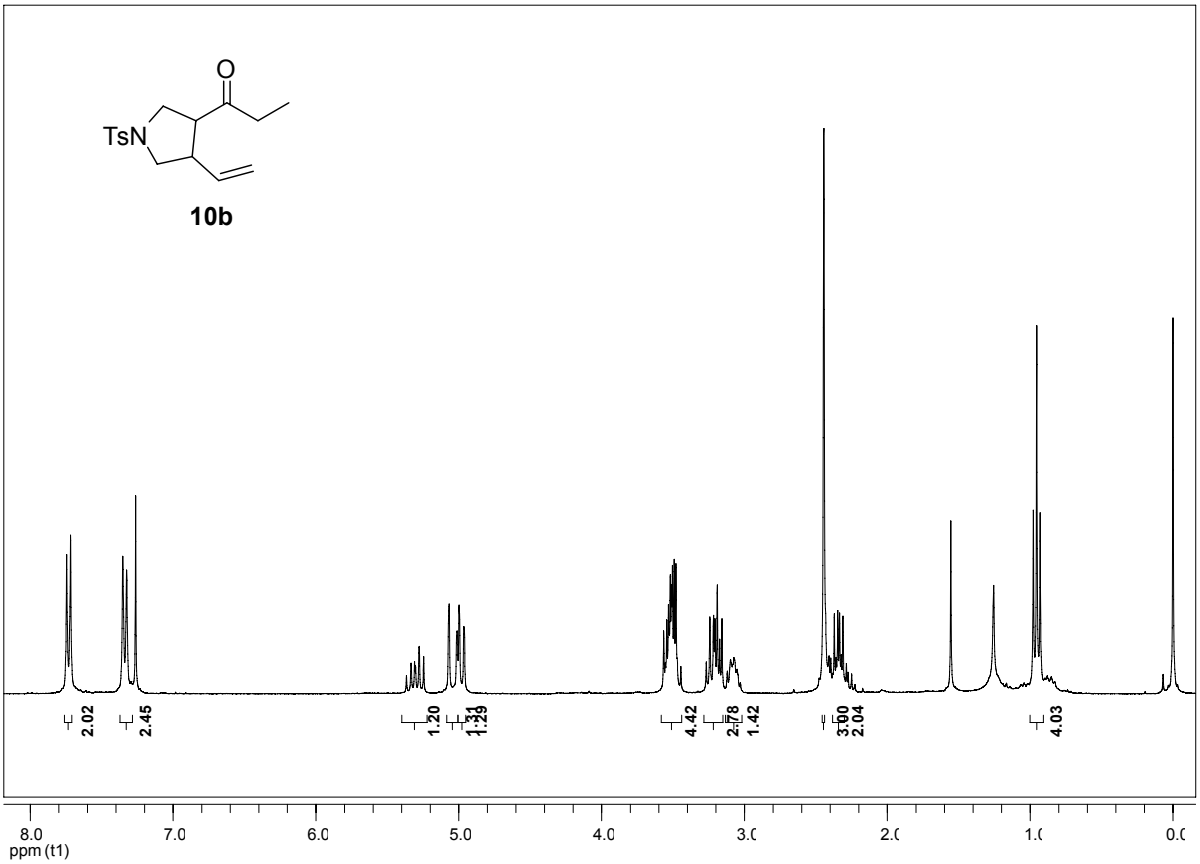

O
TsN
4b
200
150
100
50
ppm (t1)

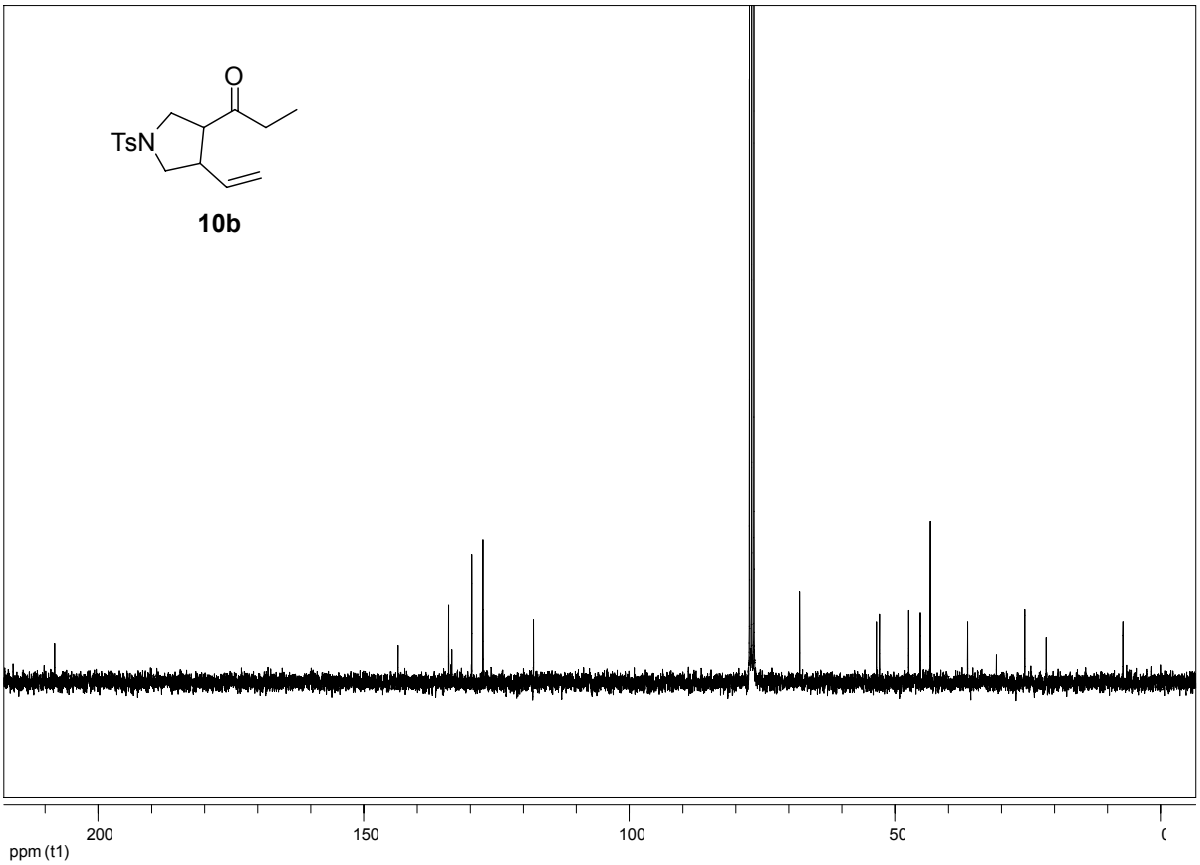

O
TsN
Cl
5b
3.37
0.81
1.88
1.19
2.96
2.00
2.64
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

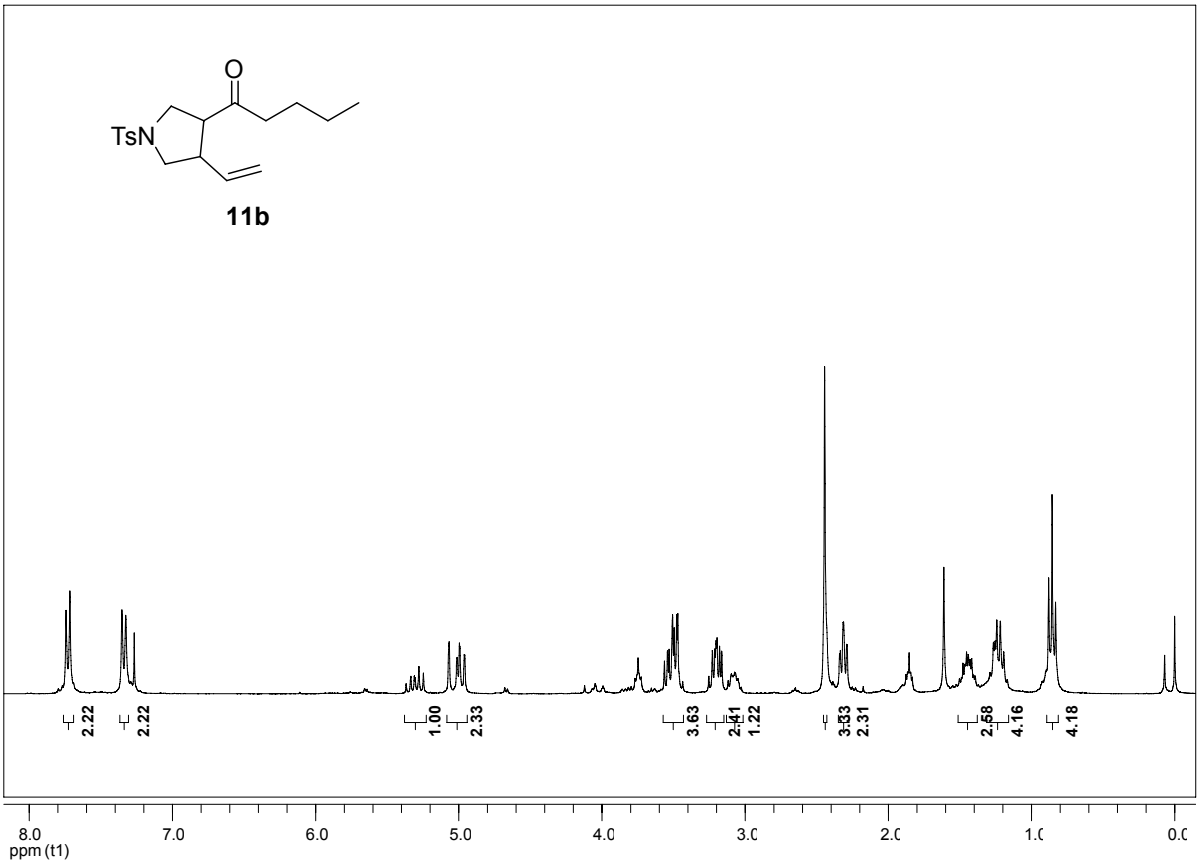

O
TsN
Cl
5b
200
150
100
50
ppm (t1)

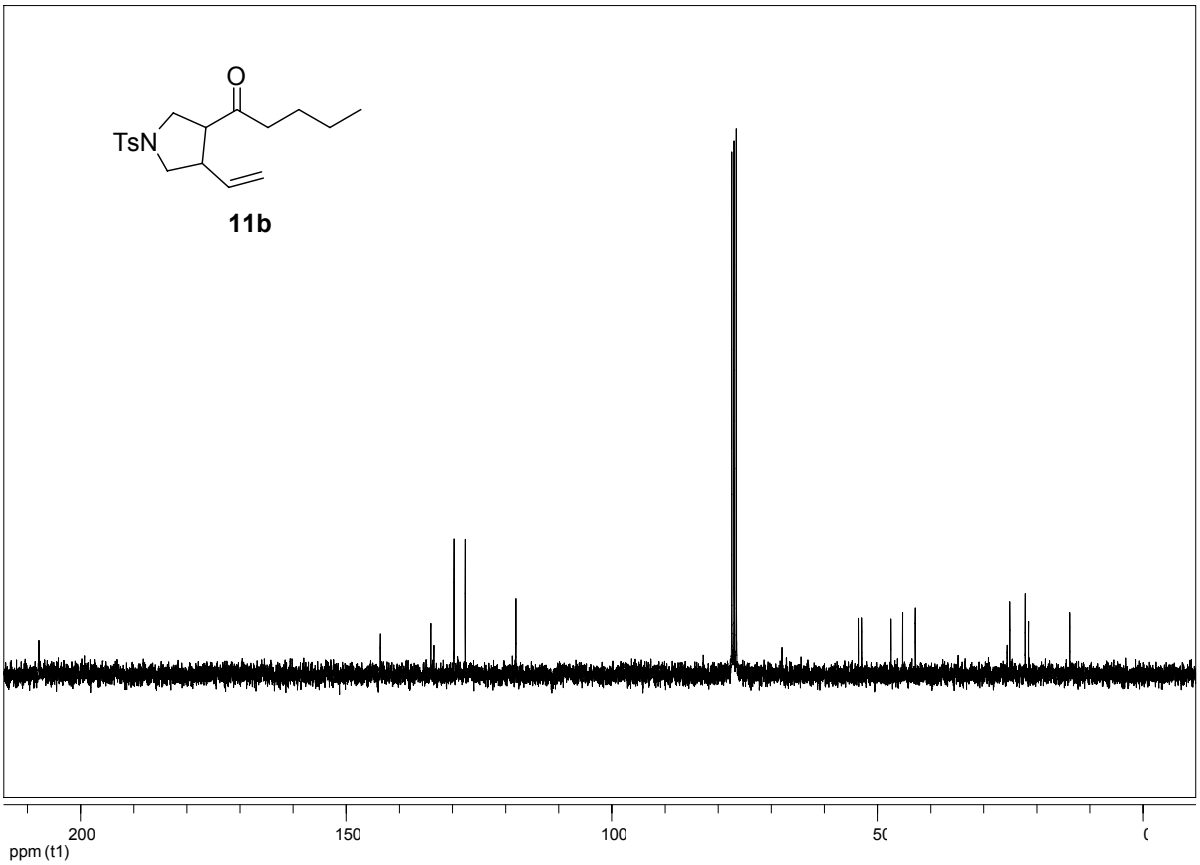

O
TsN
8b
2.10
2.08
1.08
1.00
2.10
0.76
1.22
1.08
1.12
3.08
1.06
4.64
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

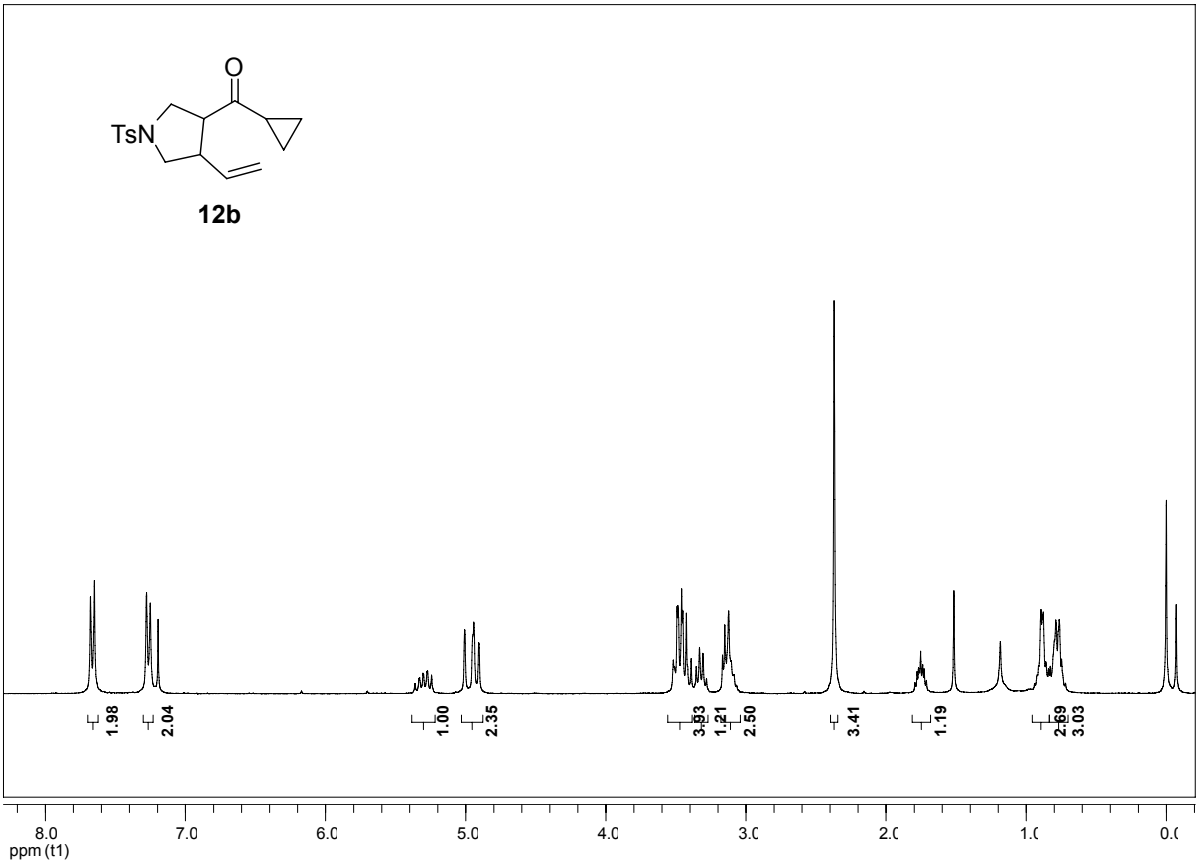

O
TsN
8b
200
150
100
50
0
ppm (t1)

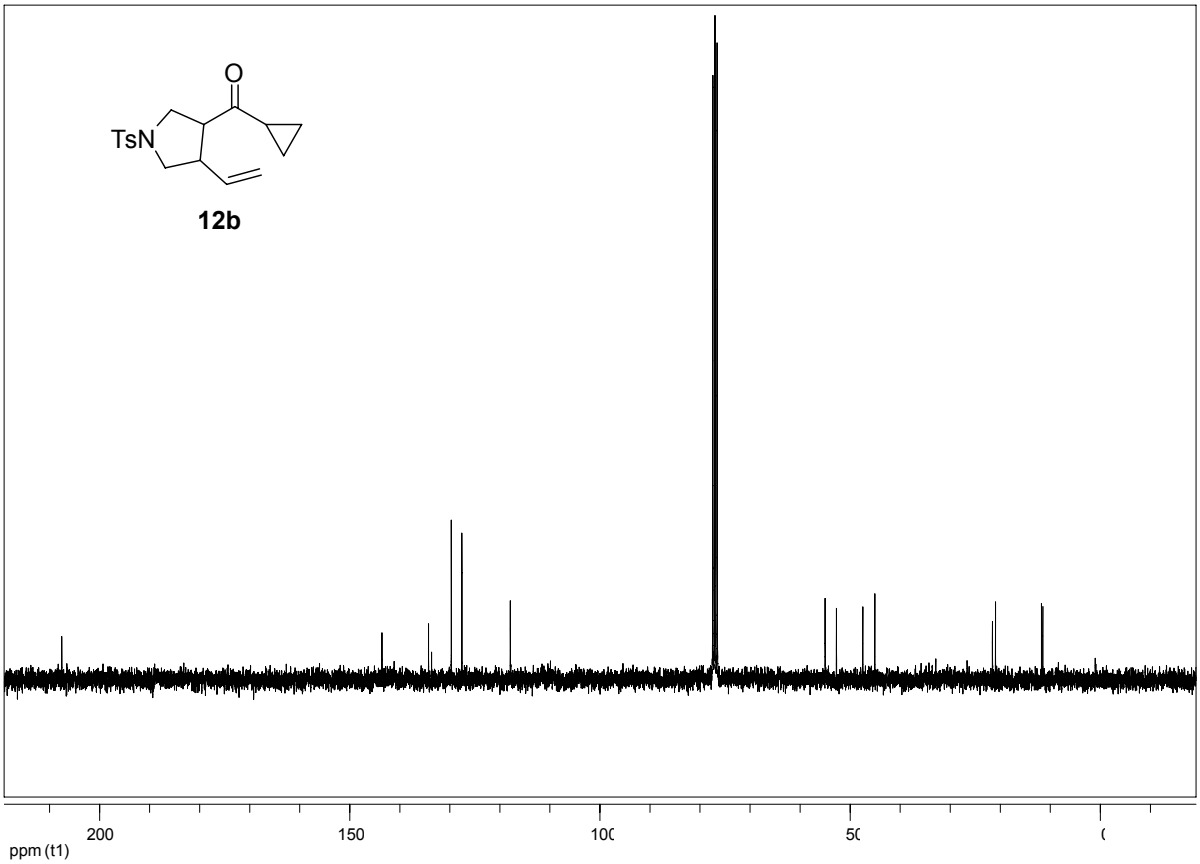

O
TsN
10b
2.02
2.45
1.20
1.34
1.29
4.42
2.78
1.42
3.00
2.04
4.03
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

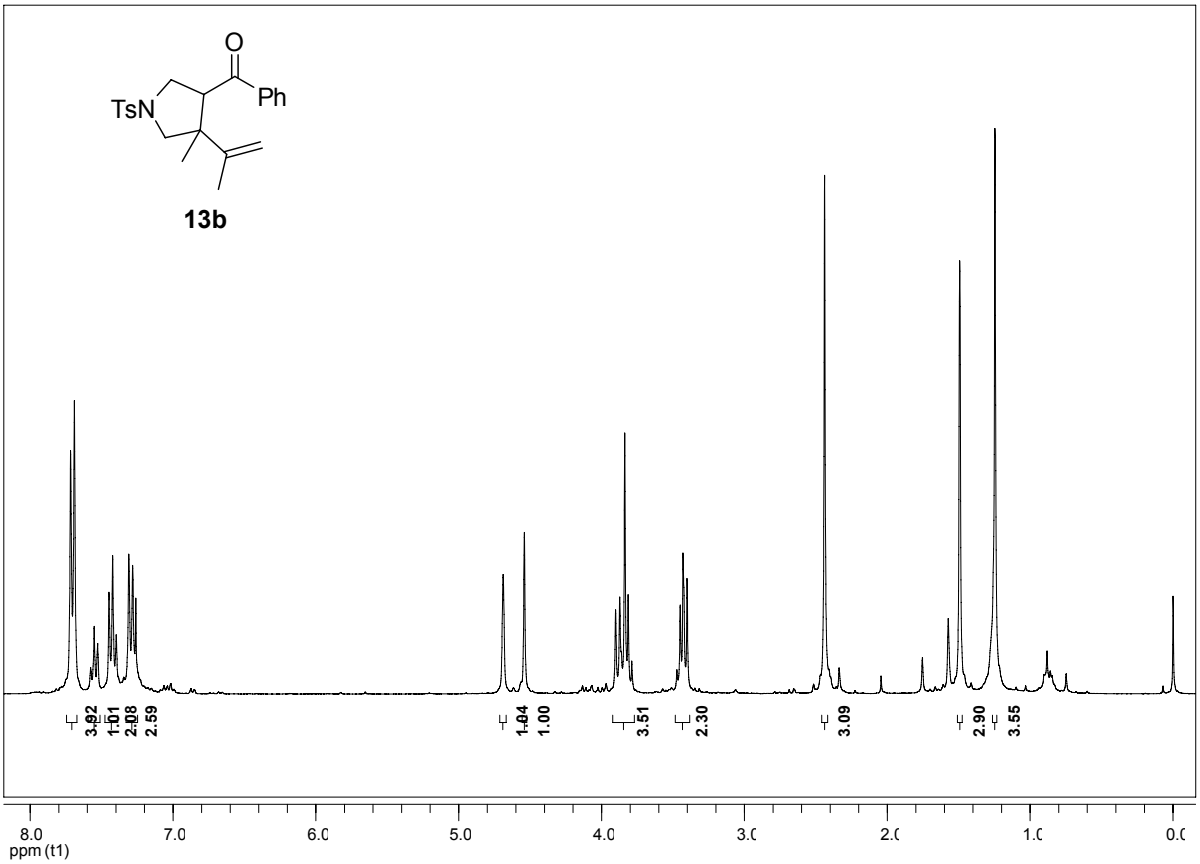

O
TsN
10b
200
150
100
50
ppm (t1)

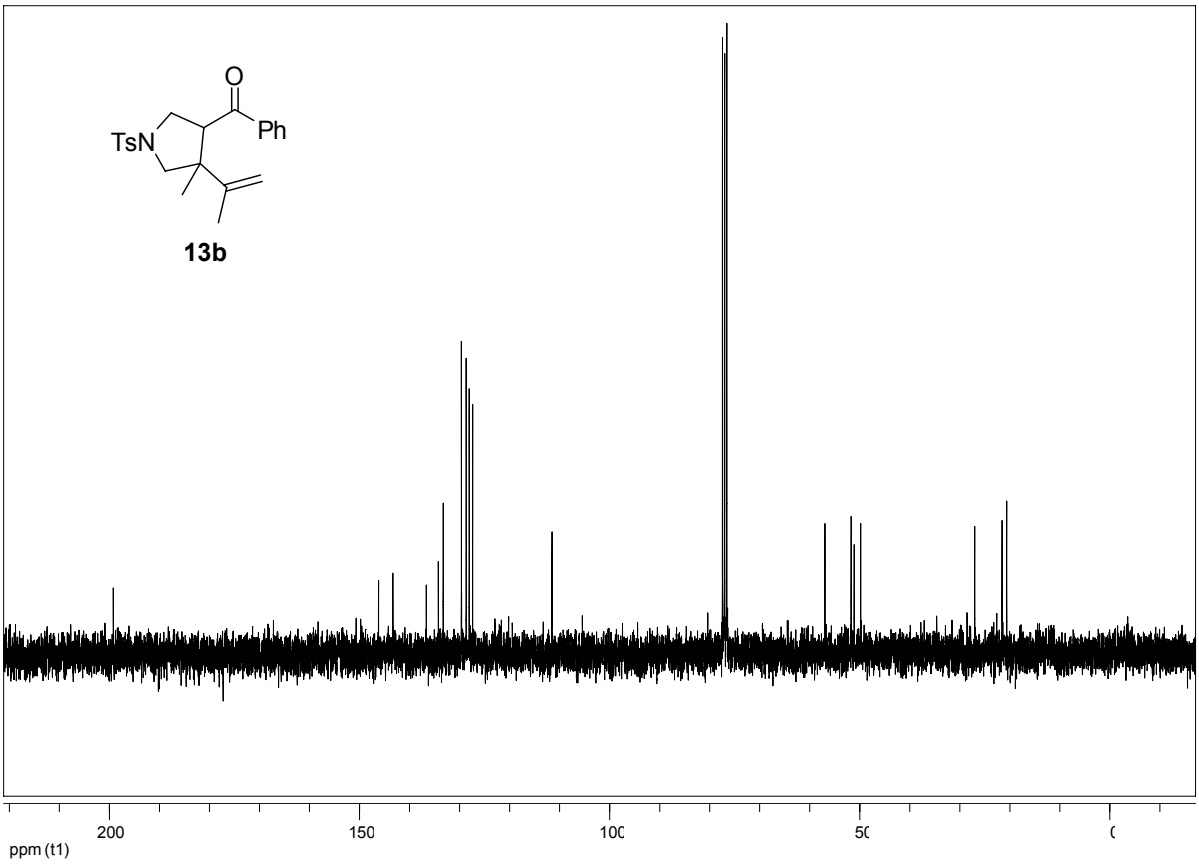

O
TsN
11b
2.22
2.22
1.00
2.33
3.63
2.41
1.22
3.33
2.31
2.68
4.16
4.18
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

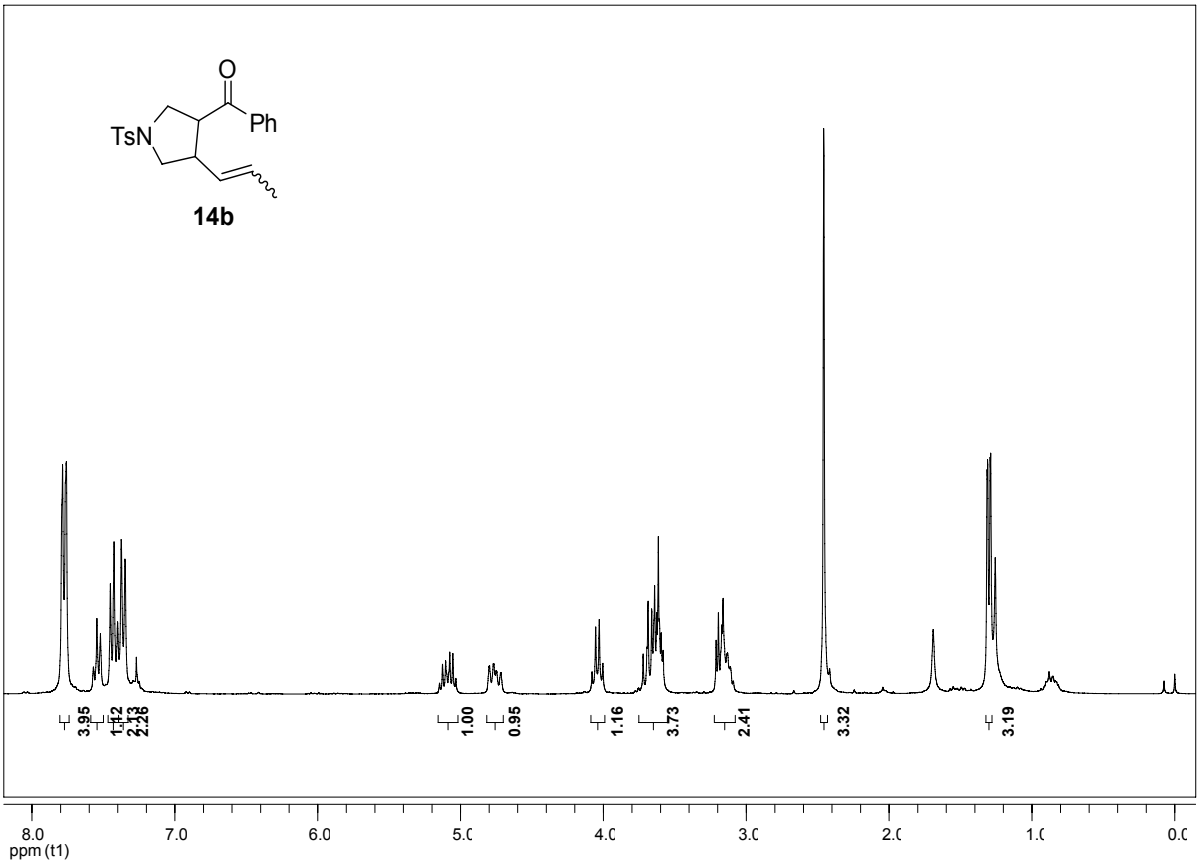

O
TsN
11b
200
150
100
50
0
ppm (t1)

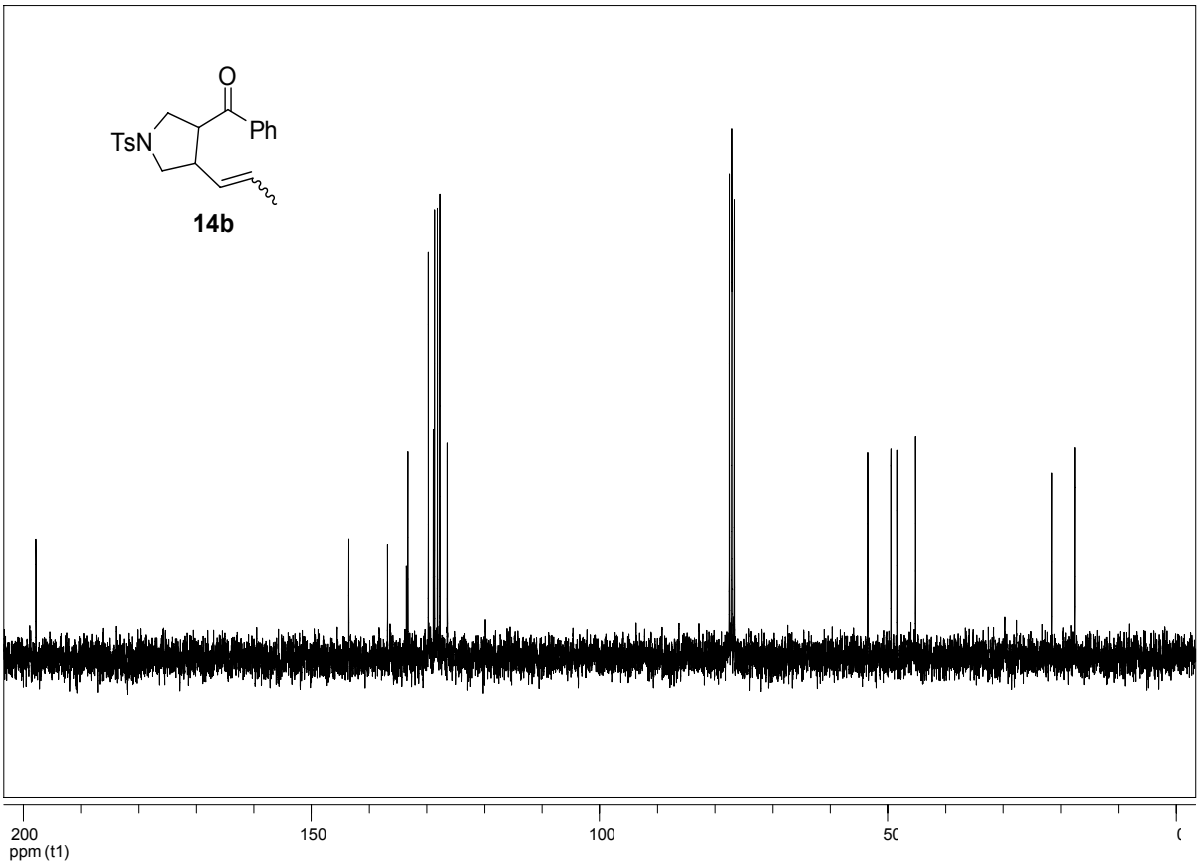

O
TsN
12b
1.98
2.04
1.00
2.35
3.93
1.21
2.50
3.41
1.19
2.69
3.03
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

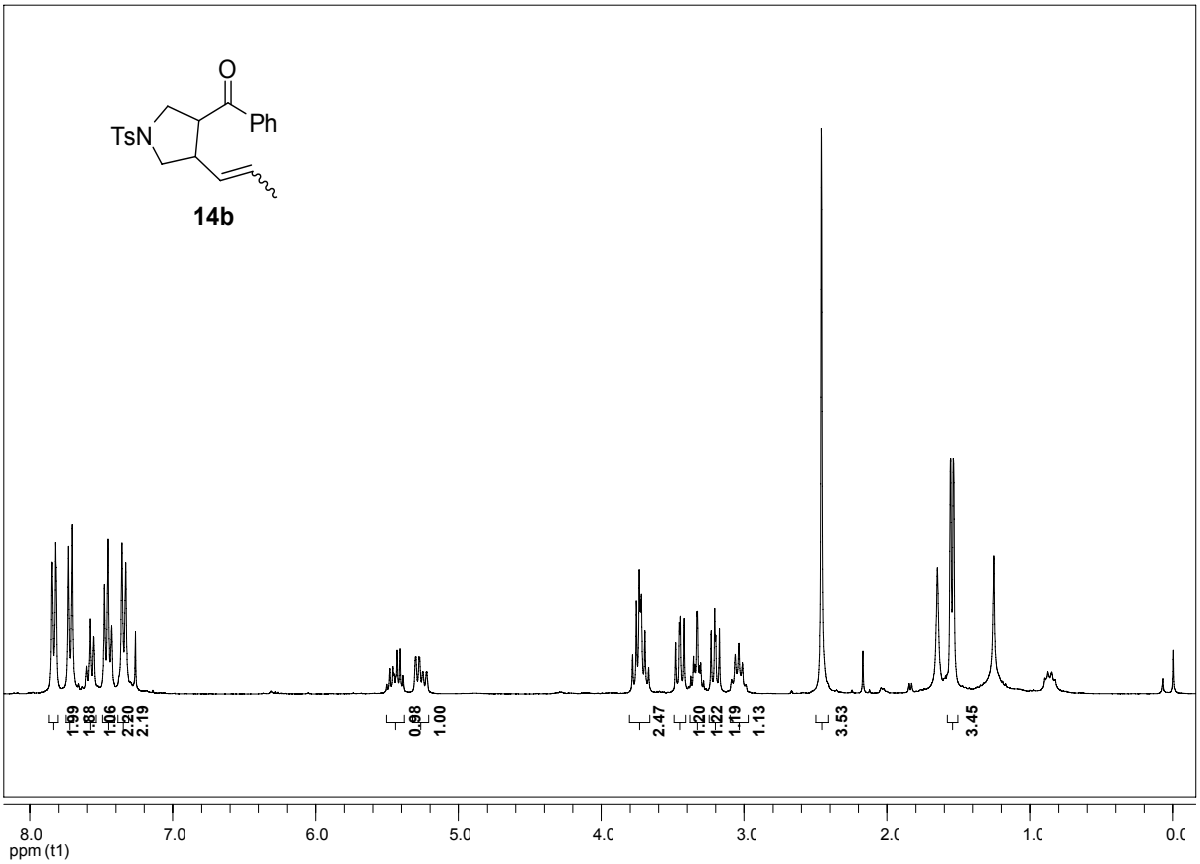

O
TsN
12b
200
150
100
50
ppm (t1)

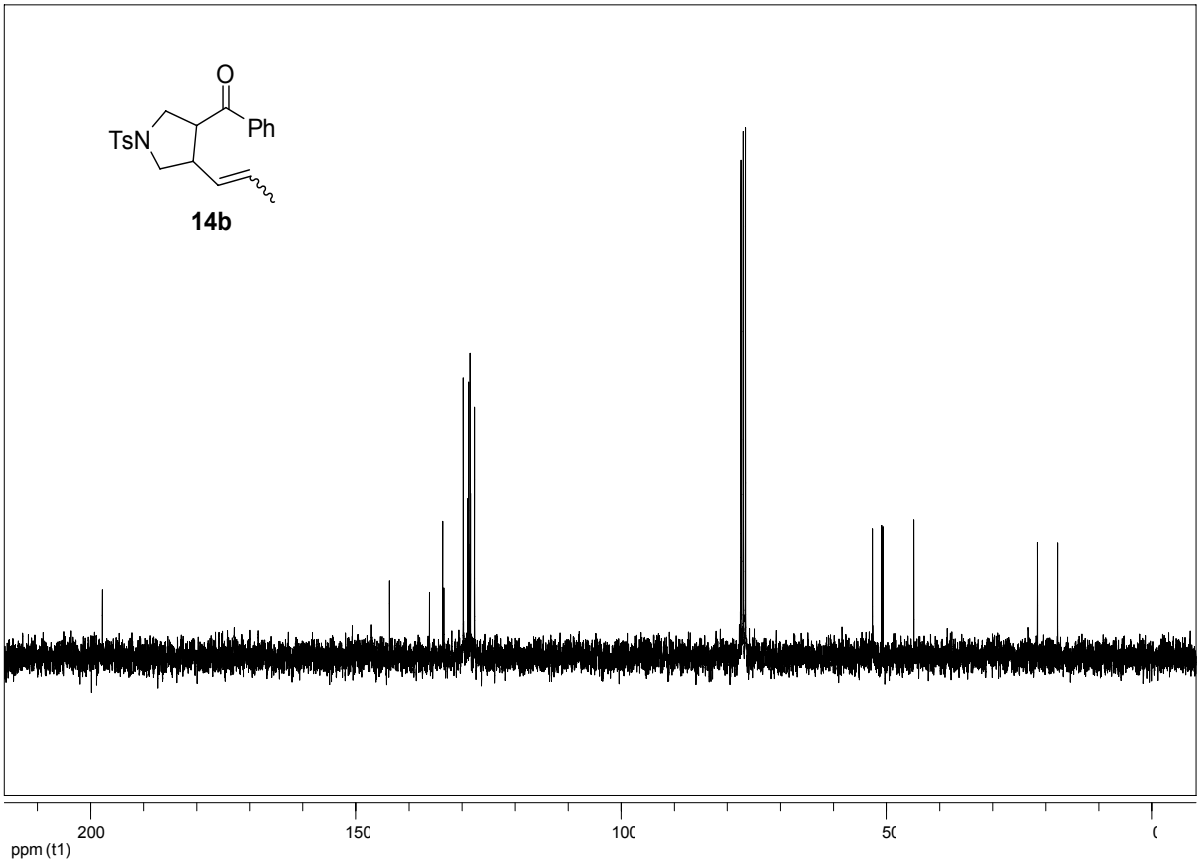

O
Ph
TsN
13b
3.92
1.01
2.08
2.59
1.04
1.00
3.51
2.30
3.09
2.90
3.55
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

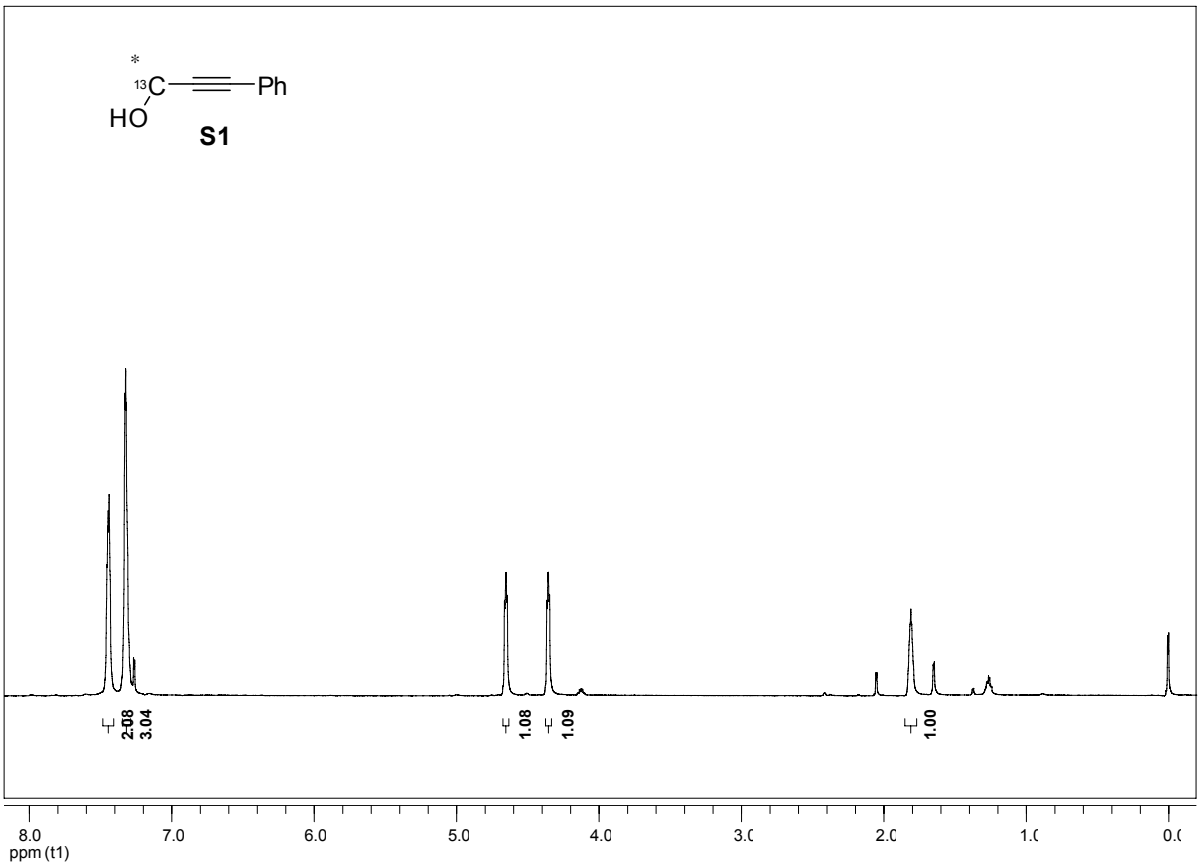

O
Ph
TsN
13b
200
150
100
50
ppm (t1)

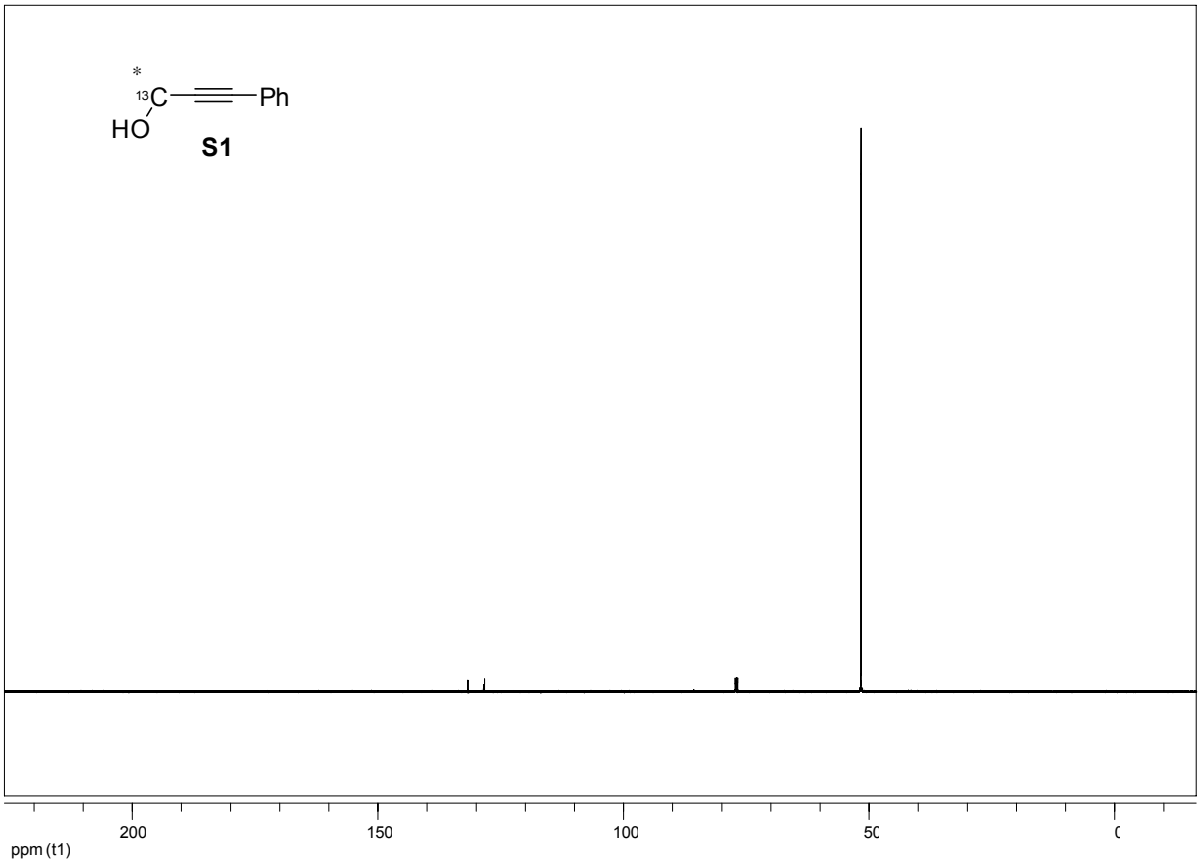

O
Ph
TsN
14b
3.95
1.52
2.13
2.26
1.00
0.95
1.16
3.73
2.41
3.32
3.19
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

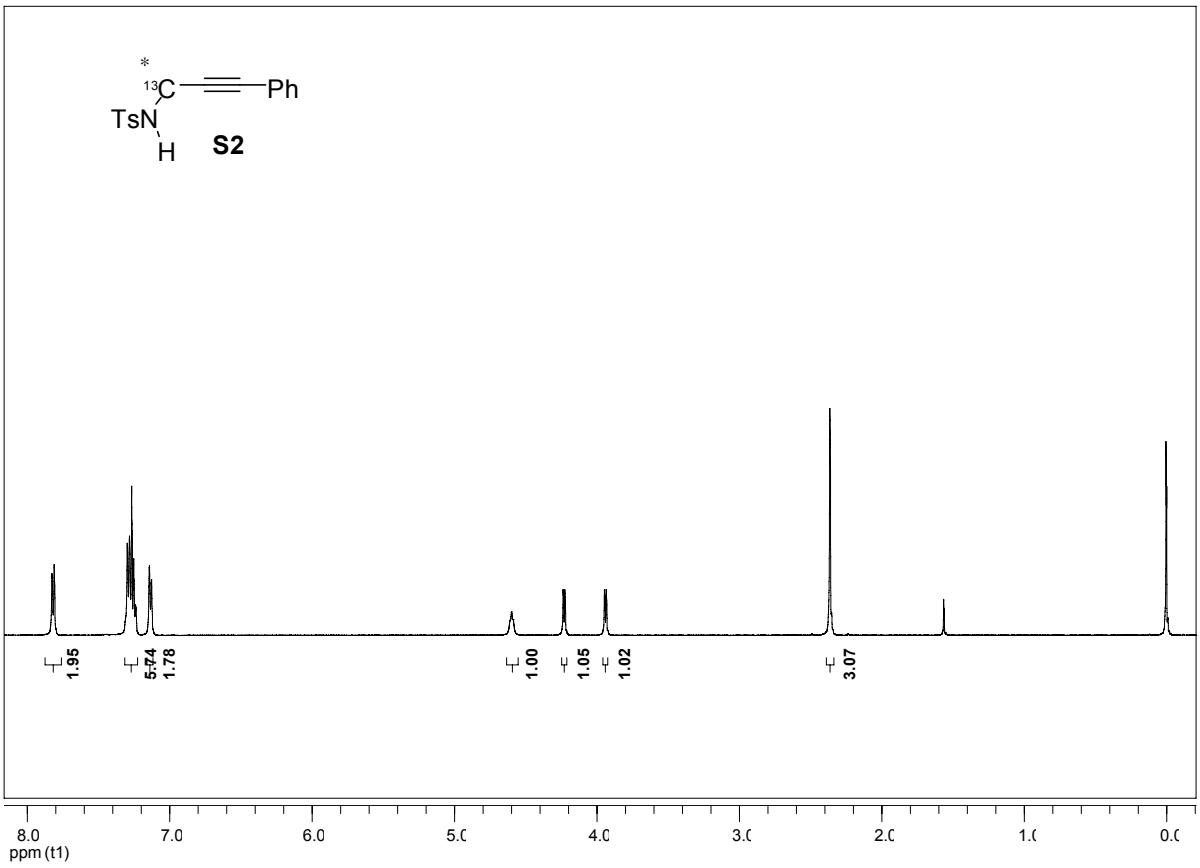

O
Ph
TsN
14b
200
150
100
50
ppm (t1)

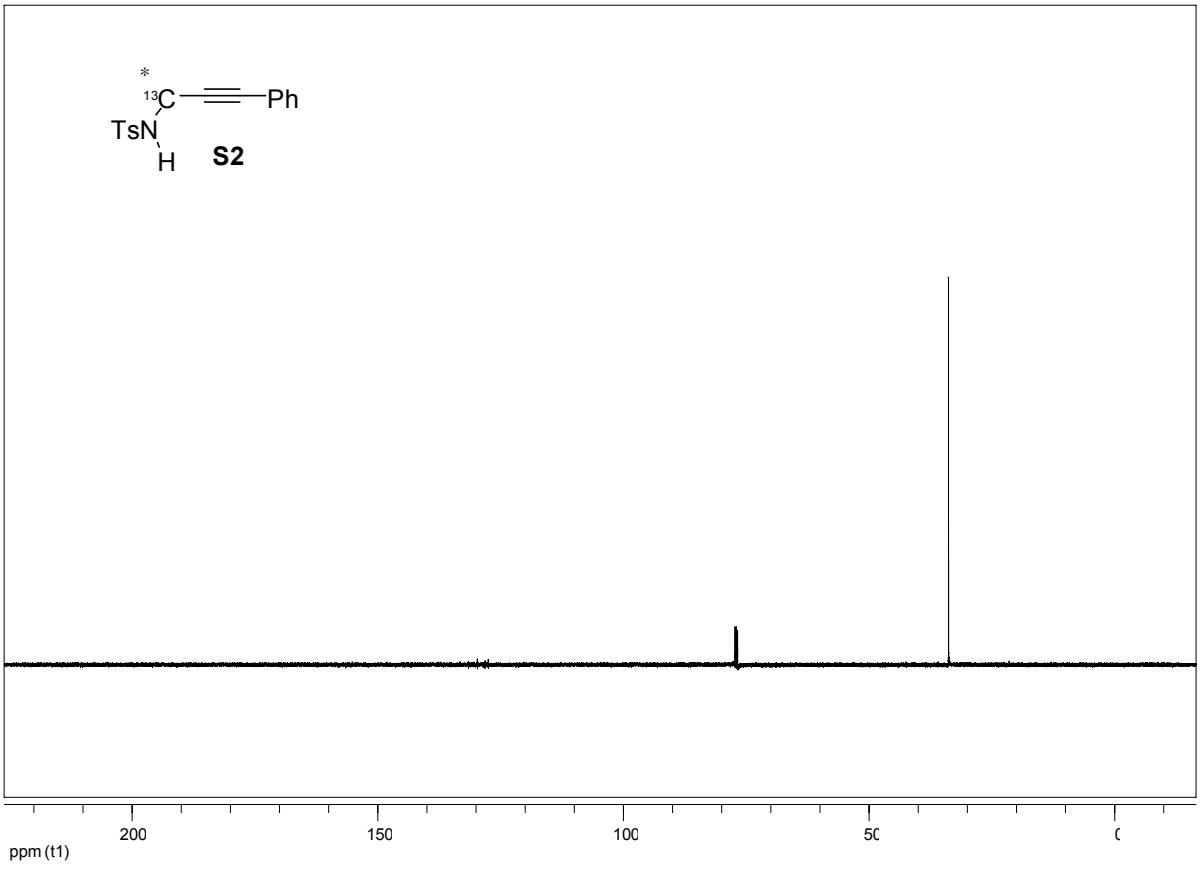

O
Ph
TsN
14b
1.59
1.88
1.06
2.20
2.19
0.98
1.00
2.47
1.20
1.22
1.19
1.13
3.53
3.45
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

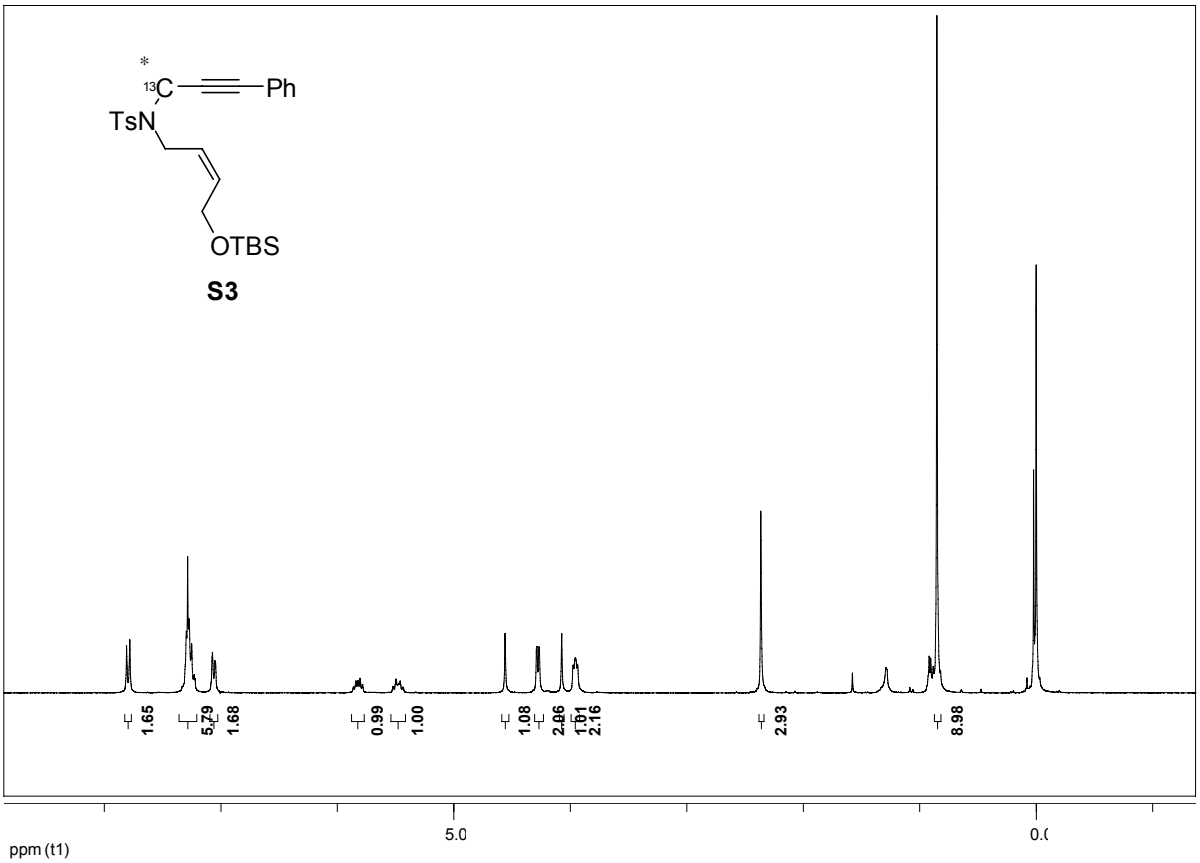

O
Ph
TsN
14b
200
150
100
50
ppm (t1)

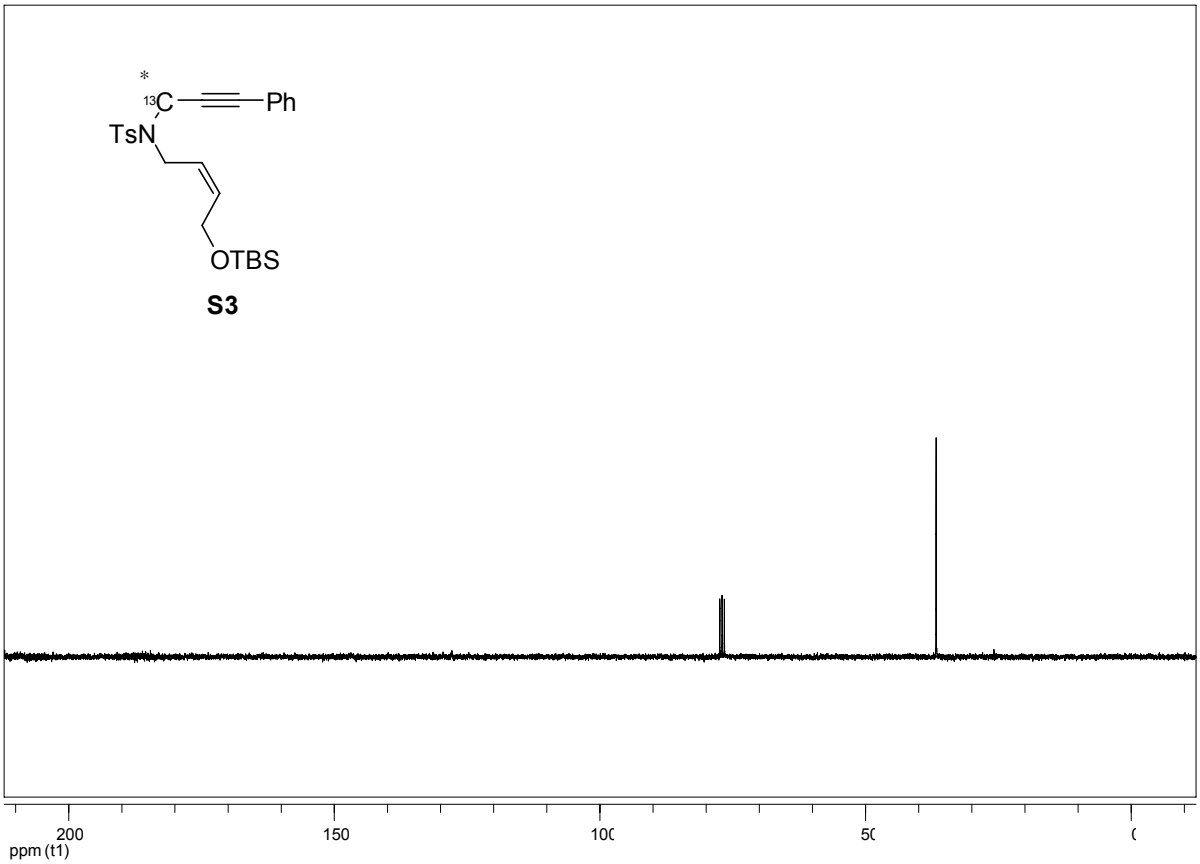

*
13C
Ph
HO
S1
2.08
3.04
1.08
1.09
1.00
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

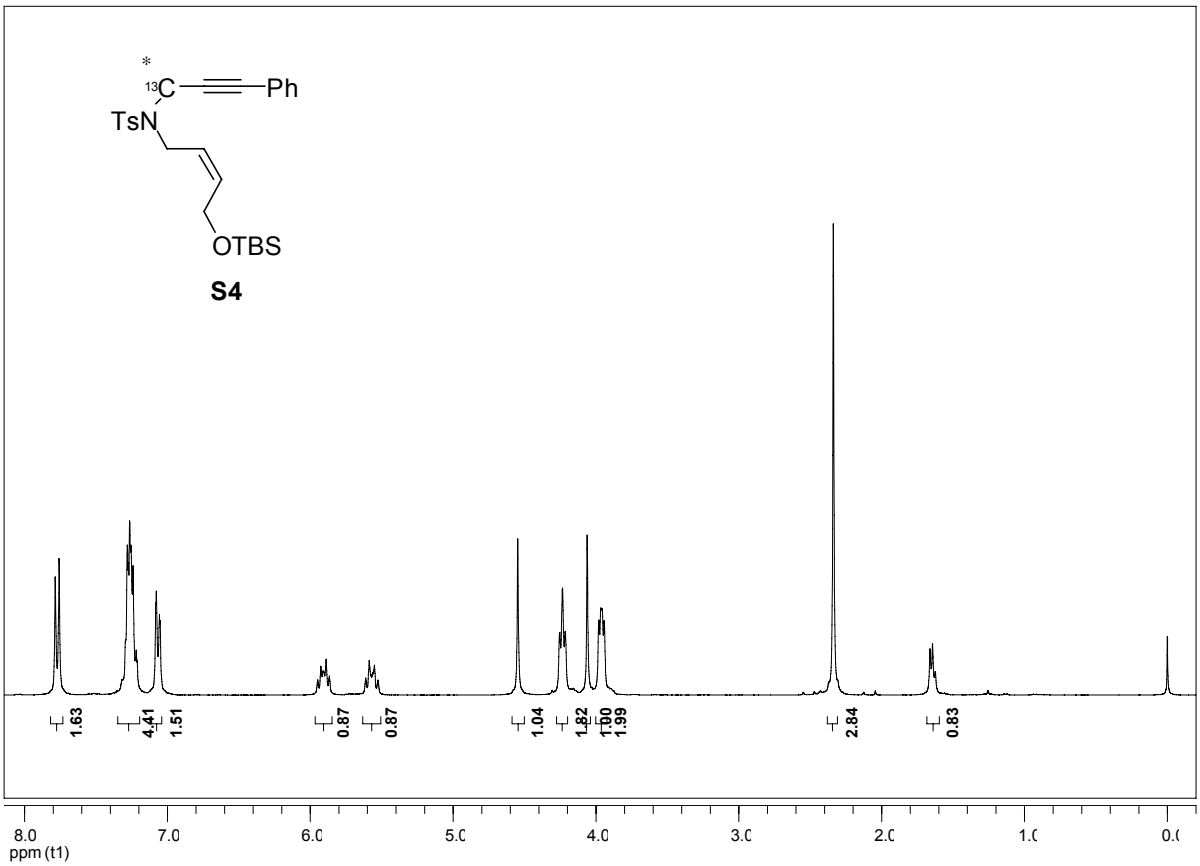

*
13C
Ph
HO
S1
200
150
100
50
0
ppm (t1)

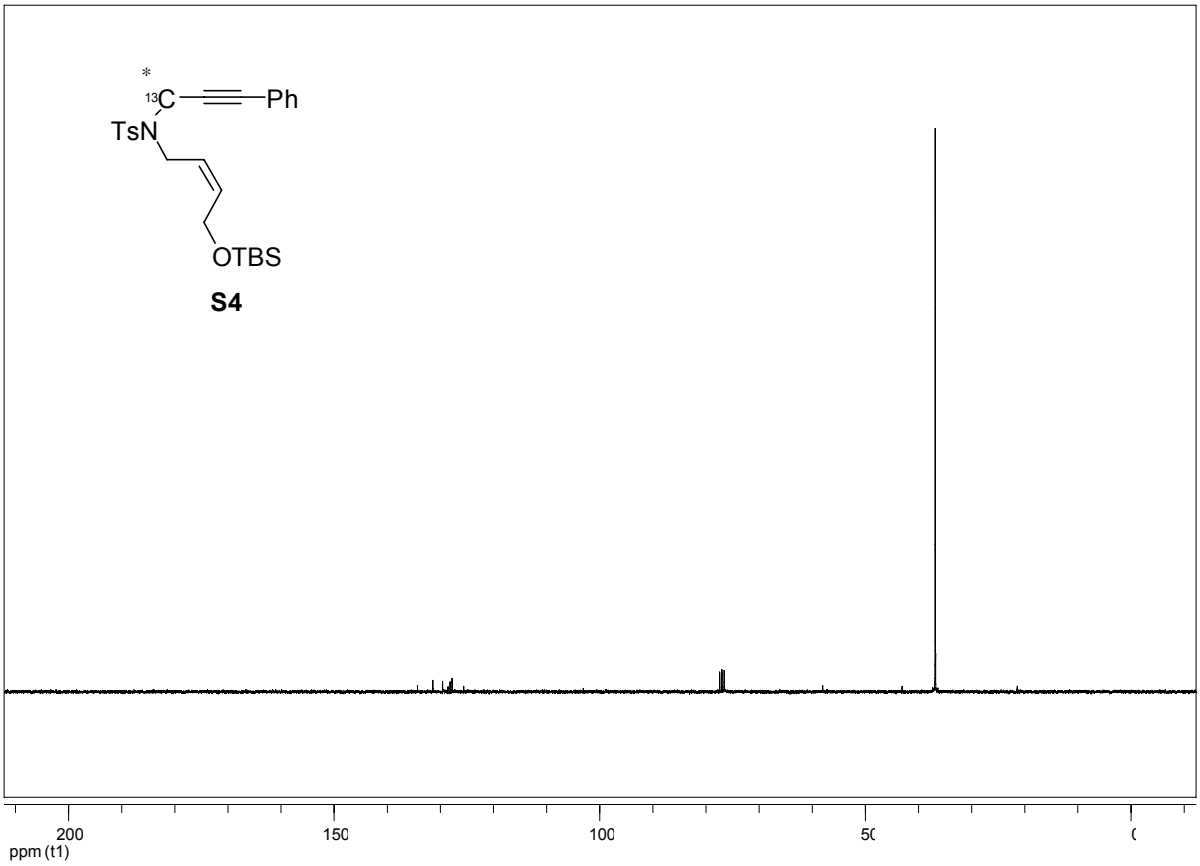

*
13C
Ph
TsN
H
S2
1.95
5.74
1.78
1.00
1.05
1.02
3.07
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

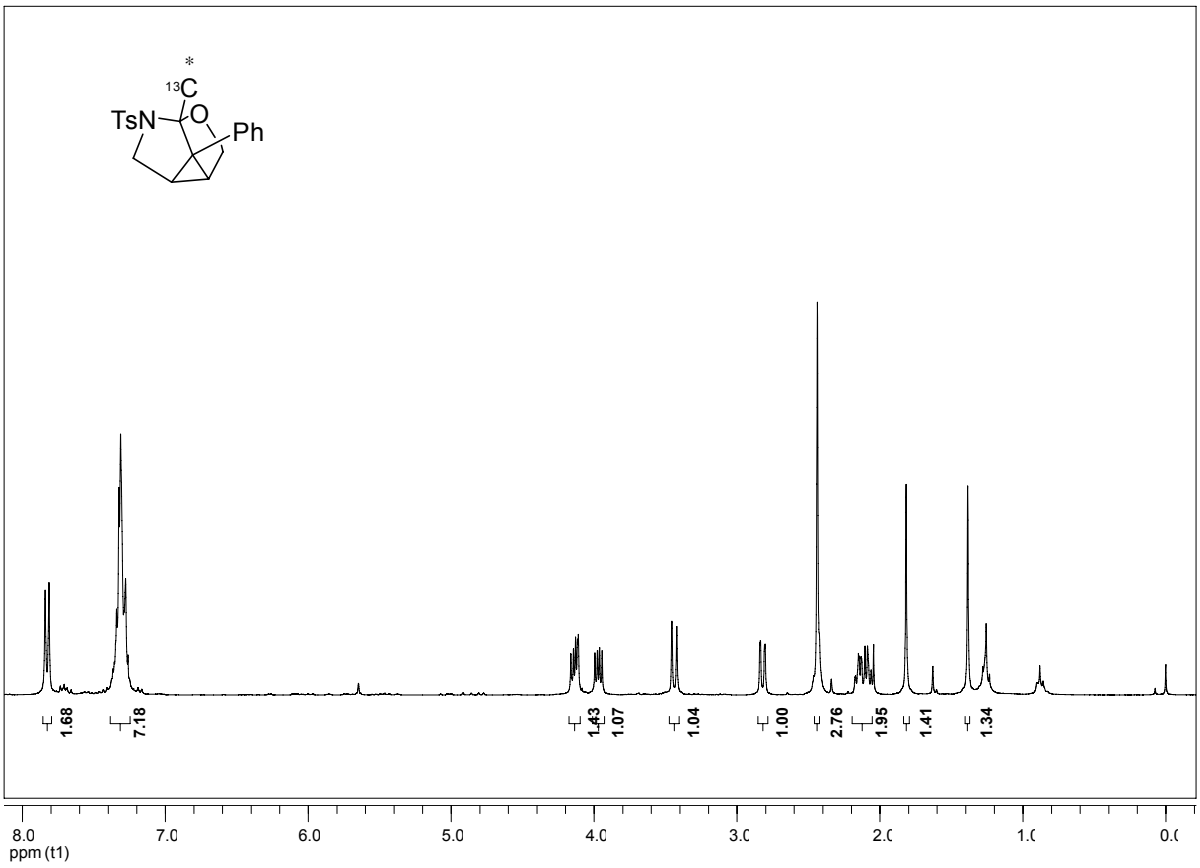

*
13C
Ph
TsN
H
S2
200
150
100
50
0
ppm (t1)

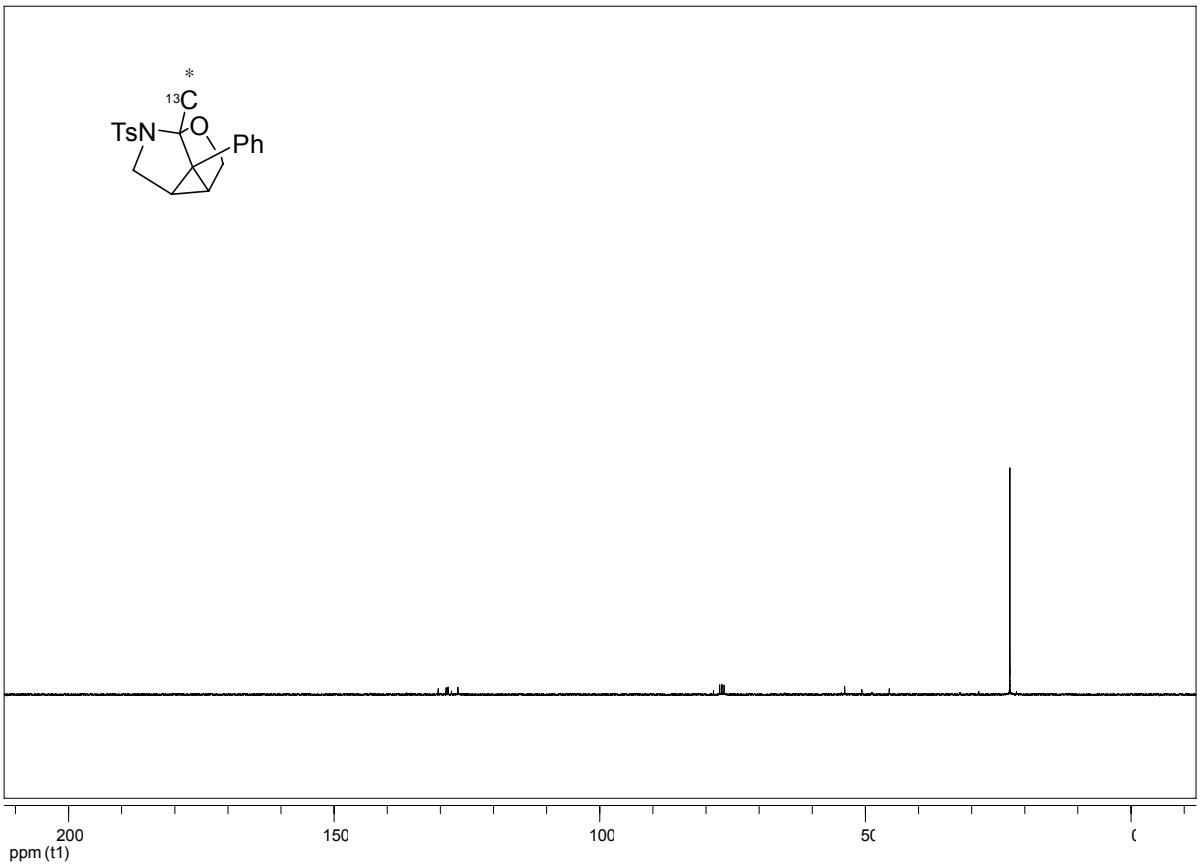

*
13C
Ph
TsN
OTBS
S3
1.65
5.79
1.68
0.99
1.00
1.08
2.06
1.01
2.16
2.93
8.98
5.0
0.(
ppm (t1)

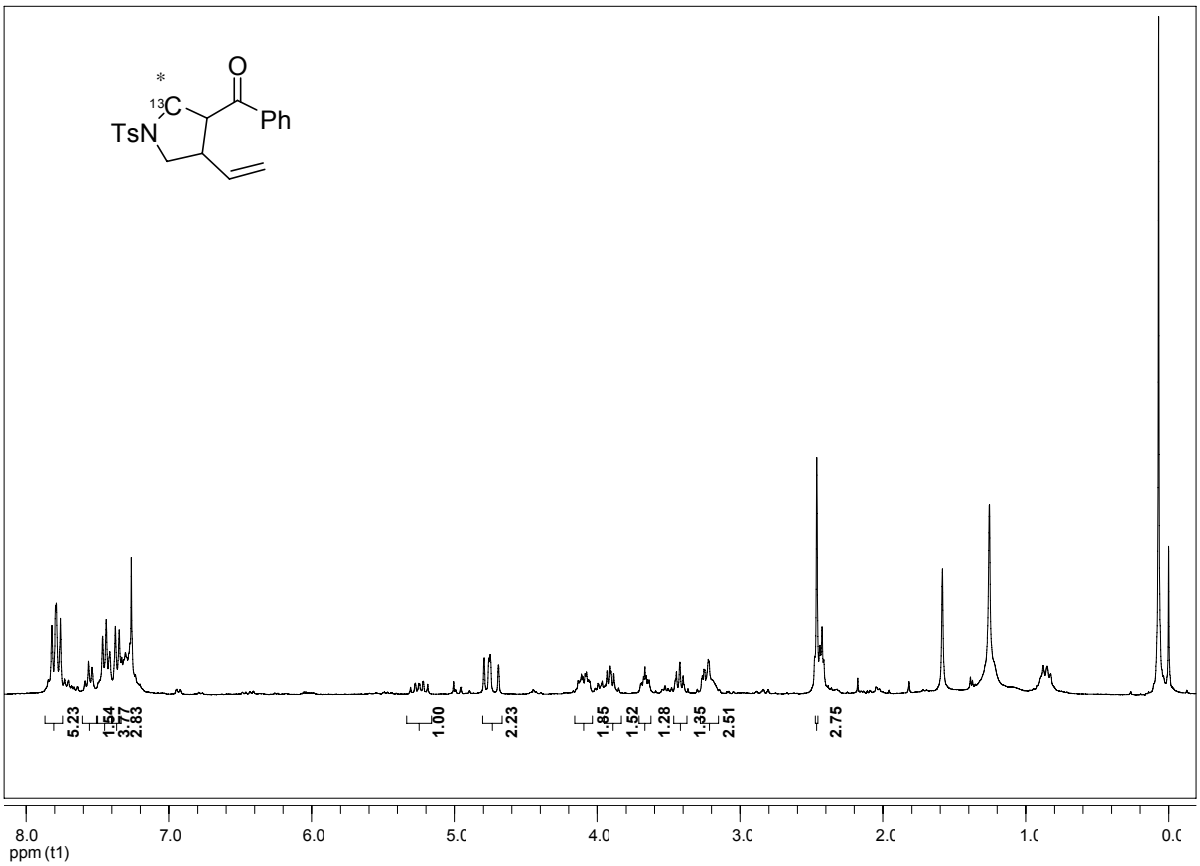

*
13C
Ph
TsN
OTBS
S3
200
150
100
50
(
ppm (t1)

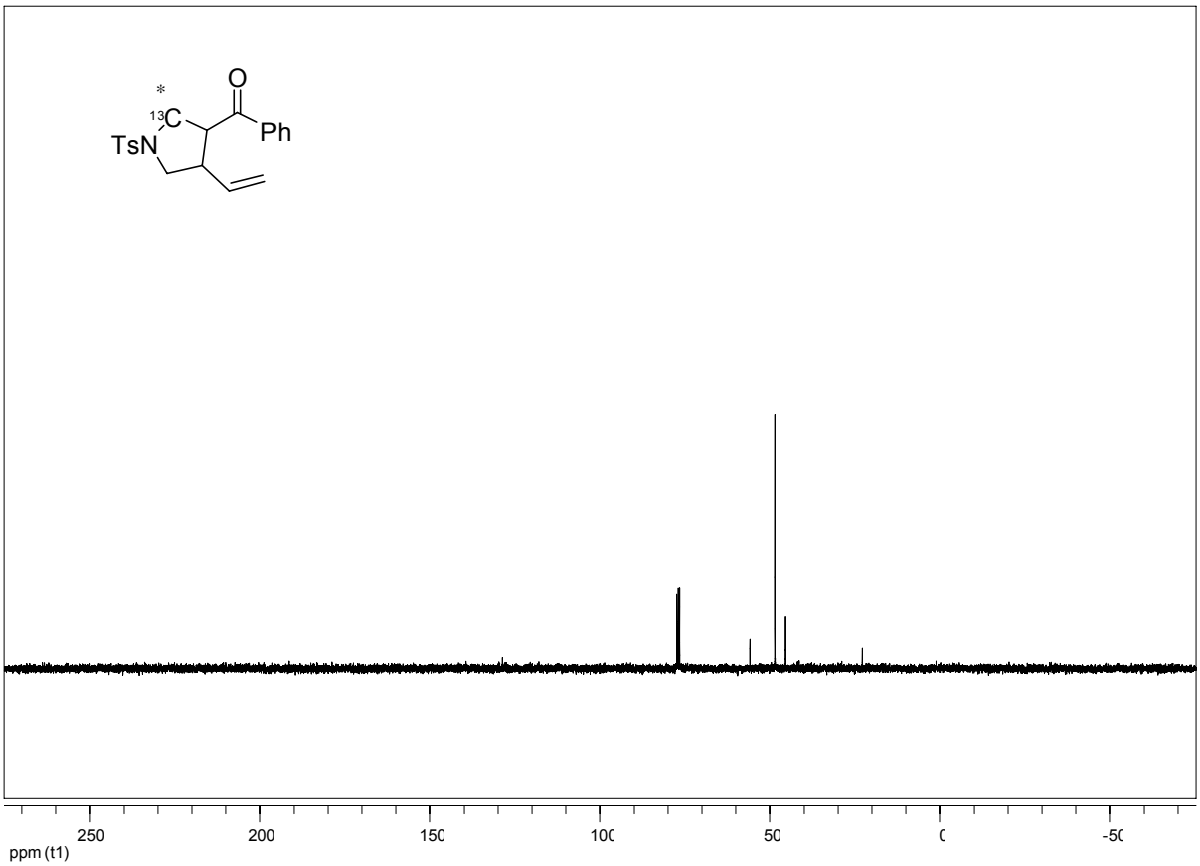

*
13C
Ph
TsN
OTBS
S4
1.63
4.41
1.51
0.87
0.87
1.04
1.82
1.00
1.99
2.84
0.83
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)


*
13C
Ph
TsN
OTBS
S4
200
150
100
50
0
ppm (t1)


*
13C
TsN
O
Ph
1.68
7.18
1.43
1.07
1.04
1.00
2.76
1.95
1.41
1.34
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)


*
13C
TsN
O
Ph
200
150
100
50
ppm (t1)


O
*
13C
TsN
Ph
5.23
1.54
3.77
2.83
1.00
2.23
1.85
1.52
1.28
1.35
2.51
2.75
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)


O
*
13C
TsN
Ph
250
200
150
100
50
0
-50
ppm (t1)