Supporting Information

A Synthetic and Computational Study of Tin-Free Reductive Tandem Cyclizations of Neutral Aminyl Radicals

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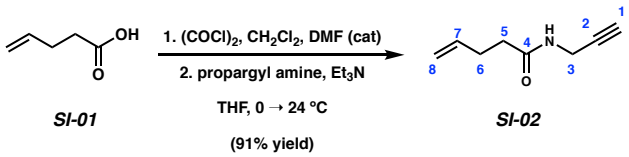
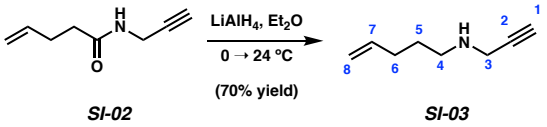
General Information. Unless otherwise specified, all commercially available reagents were purchased from Sigma-Aldrich, Oakwood, or Alfa aesar and used without further purification. Grubbs' catalysts for all metathesis reactions were generously provided by Materia. Anhydrous PhMe, DMF, and CH_2Cl_2 were purchased from Fisher, anhydrous THF was purchased from EMD. These were passed through a commercial solvent purification system (2 columns of alumina) and used without further drying. Triethylamine was distilled over CaH_2 immediately prior to use. Unless otherwise noted, all reactions were performed in flame-dried glassware under 1 atm of pre-purified anhydrous N_2 or argon gas at ambient temperature (24 ± 1 ºC). ^{1}H NMR spectra and ^{13}C NMR spectra were recorded on a Varian Mercury-400 MHz or a Varian VNMRS-500MHz spectrometer with a multinuclear broadband probe at ambient temperature unless otherwise stated. Chemical shifts are reported in parts per million relative to residual solvent peaks (as established by Stoltz, et. al. in *Organometallics* **2010**, *29*, 2176). All ^{13}C spectra are recorded with complete proton decoupling. High-resolution mass spectral analyses were performed by the Lumigen Instrument Center, Wayne State University. All purifications were performed on SiliaFlash® P60 40-63μm (230-400 mesh) 60Å Irregular Silica Gels (cat. # R12030B) or on a Biotage Isolera IV flash purification system using SNAP cartridges (cat. # FSKO-1107-XXXX). Thin layer chromatography was performed using glass-backed SilicaPlate™ TLC Plates (cat. # TLG-R10011B-323) cut to the desired size then visualized with short-wave UV lamps and $KMnO_4$, CAM, PMA, or Anisaldehyde stains prepared according to standard recipes. All yields refer to chromatographically and spectroscopically pure products. IR data was obtained on a Varian/Digilab Excalibur 3100 High Resolution FT-IR, and optical rotation data was collected on a Perkin-Elmer 341 automated Polarimeter at the concentration noted.

Experimental Procedures and Spectroscopic Data



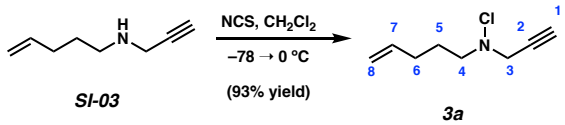
***N*-(prop-2-yn-1-yl)pent-4-enamide (SI-02).** To a cooled solution (0 ºC) of 5-pentenoic acid (4.0 g, 39.95 mmol) in CH_2Cl_2 (133 mL) was added $(COCl)_2$ (6.76 mL, 79.9 mmol) followed by DMF (2.9 µL, 0.04 mmol). The reaction mixture was then warmed up to room temperature, and was stirred for 1 h. upon completion, the solvent was removed under reduced pressure and the product was obtained as colorless oil. To a cooled (0 ºC) solution of the crude material (4.73 g, 39.95 mmol) in CH_2Cl_2 (133 mL) was added propargyl amine (3.3 mL, 51.94mmol) drop wise followed by Et_3N (7.2 mL, 51.94 mmol). The reaction was then brought to room temperature, and was stirred for 6 h. The reaction was quenched with water (50 mL) and the aqueous layer was extracted with EtOAc (3 × 50 mL). The combined organic layer was dried with anhydrous Na_2SO_4. The solvent was removed under reduced pressure and the orange crude was purified by column chromatography eluted with 30% EtOAc/Hexanes. Product was isolated as a yellow solid (5.0 g, 91%) R_f=0.35 (30% EtOAc/Hexanes). ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.98 (s, 1H, N), 5.80 (ddt, *J* = 16.8, 10.22, 6.46 Hz, 1H, C_7), 5.10 – 5.03 (m, 1H, C_8), 5.02 – 4.96 (m, 1H, C_8), 4.03, (dd, *J* = 5.24, 2.56 Hz, 2H, C_3), 2.42 – 2.36 (m, 2H, C_5), 2.33 – 2.28 (m, 2H, C_6), 2.21 (td, *J* = 2.56, 0.73 Hz, 1H, C_1); ^{13}C NMR (101 MHz, $CDCl_3$) δ 172.02 (C_4), 136.81 (C_7), 115.73 (C_8), 79.63 (C_2), 71.51 (C_1), 35.54 (C_3), 29.43 (C_5), 29.12 (C_6). Spectral data matches the reported characterization data.[1]



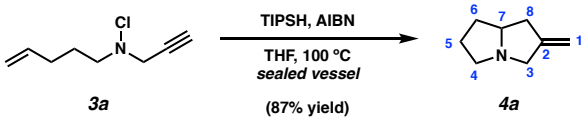
***N*-(prop-2-yn-1-yl)pent-4-en-1-amine (SI-03).** To a cooled (0 ºC) suspension of $LiAlH_4$ (2.0 g, 52.70 mmol) in Et_2O (50 mL) was added the amide (1.8 g, 13.13 mmol) in Et_2O (69 mL) under argon. The reaction was allowed to warm to room temperature and was run under argon for 12 h. Upon completion, the reaction was cooled to 0 ºC and water (30 mL) was added carefully drop wise followed by aqueous solution of Rochelle (potassium sodium tartrate) salt (50 mL). The aqueous layer was extracted with EtOAc (3 × 60 mL). The combined organic layer was dried with anhydrous Na_2SO_4 and concentrated under reduced pressure. Crude product was purified by column chromatography (40% EtOAc/Haxane). Product was isolated as yellow oil (1.2 g, 70% yield). R_f = 0.5 (5% MeOH/CH_2Cl_2). ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.80 (ddt, *J* = 16.92, 10.16, 6.66 Hz, 1H, C_7), 5.01 (dq, *J* = 17.12, 1.54 Hz, 1H, C_8), 4.98 – 4.90(m, 1H, C_8), 3.40 (d, *J* = 2.41 Hz, 2H, C_3), 2.68 (t, *J* = 7.24 Hz, 2H, C_4), 2.19 (t, *J* = 2.42 Hz, 1H, C_1), 2.10 (q, *J* = 6.91 Hz, 2H, C_6), 1.57 (p, *J* = 7.36 Hz, 2H, C_5); ^{13}C NMR (101 MHz, $CDCl_3$) δ 138.32 (C_7),

[1] Poh, J.; Makai, S.; Keutz, T.; Tran, D. C.; Battilocchio, C.; Pasau, P.; Ley, A. V. Rapid Asymmetric Synthesis of Disubstituted Allenes by Coupling of Flow-Generated Diazo Coumpounds and Propargylated Amines. *Angew. Chem. Int. Ed.* **2017**, *56*, 1864–1868.

114.74 (C_8), 82.33 (C_2), 71.23 (C_1), 48.12 (C_3), 38.12 (C_4), 31.41 (C_6), 28.96 (C_5). Spectral data matches the reported characterization data.[2]



***N*-chloro-*N*-(prop-2-yn-1-yl)pent-4-en-1-amine (3a).** To a cooled (–78 °C) solution of the amine (200 mg, 1.62 mmol) in CH_2Cl_2 (10 mL) was added *N*-chlorosuccinamide (238.4 mg, 1.79 mmol). The reaction mixture was warmed up to 0 °C, over 2 hours. The reaction was diluted with hexanes (15 mL) and passed through a plug of silica (15 × 2.5 cm). Product was eluted with 5% Et_2O/Hexanes as a colorless oil (239 mg, 93% yield). R_f=0.5 (5% EtOAc/Hexane). ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.81 (ddt, *J* = 16.90, 10.21, 6.66 Hz, 1H, C_7), 5.04 (dq, J = 17.13, 1.57 Hz, 1H, C_8), 5.00 – 4.93 (m, 1H, C_8), 3.82 (d, *J* = 2.38 Hz, 2H, C_3), 3.00 (t, *J* = 7.8 Hz, 2H, C_4), 2.41 (t, *J* = 2.38 Hz, 1H, C_1), 2.13 (q, *J* = 6.84 Hz, 2H, C_6), 1.74 (p, *J* = 7.36 Hz, 2H, C_5); ^{13}C NMR (101 MHz, $CDCl_3$) δ 137.83 (C_7), 115.23 (C_8), 77.62 (C_2) 74.71 (C_1), 61.32 (C_3), 52.65 (C_4), 30.73 (C_6), 27.06 (C_5); HRMS [M+H$^+$] m/z ES calc'd for $[C_8H_{13}NCl]^+$: 158.0731; observed: 158.0724; IR 3297, 2938.9, 2844, 1636, 1446, 1088, 985 cm^{-1}.

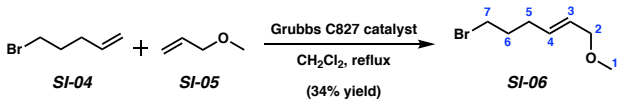


2-methylenehexahydro-1*H*-pyrrolizine (4a). To a flame dried microwave vessel under argon was added the chloroamine **3a** (35.0 mg, 0.22 mmol) and AIBN (7.3 mg, 0.044 mmol) in THF (20 mL). Then was added TIPSH (91.0 μL, 0.44 mmol) to the reaction solution. The microwave tube was sealed and, and the reaction tube was dipped in a hot oil bath (100 ºC) and stirred for 3 h. **CAUTION:** REACTIONS UNDER PRESSURE SHOULD BE HANDLED IN A FUME HOOD BEHIND A BLAST SHIELD. Upon completion the reaction was brought to room temperature and the solvent was removed under reduced pressure and was purified by column chromatograph. Product was eluted with 10% (MeOH/CH_2Cl_2) and obtained as orange oil (23.5 mg, 87% yield). R_f=0.3 (10% MeOH/CH_2Cl_2). ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.19 (d, *J* = 1.89 Hz, 2H, C_1), 4.44 – 4.36 (m, 1H, C_7), 4.22 (d, *J* = 14.76 Hz, 1H, C_3), 3.82 (dt, *J* = 11.65, 5.90 Hz, 1H, C_4), 3.48 (d, *J* = 14.76 Hz, 1H, C_3), 2.98 – 2.91 (m, 1H, C_4), 2.84 (dt, *J* = 11.52, 7.96 Hz, 1H, C_8), 2.42 – 2.32 (m, 2H, C_8, C_6), 2.09 (tt, *J* = 8.00, 5.36 Hz, 2H, C_5), 1.70 (dq, *J* = 13.24, 7.77 Hz, 1H, C_6); ^{13}C NMR (101 MHz, $CDCl_3$) δ 139.93 (C_2), 112.62 (C_1), 66.35 (C_3), 57.42 (C_4), 54.91 (C_7), 36.52 (C_8), 31.31 (C_6), 25.02 (C_5); HRMS [M+H$^+$] m/z ES calc'd for $[C_8H_{14}N]^+$: 124.1121; observed: 124.115; IR 3426, 3024, 2924, 1605, 1458, 1265, 1034, 735 cm^{-1}.

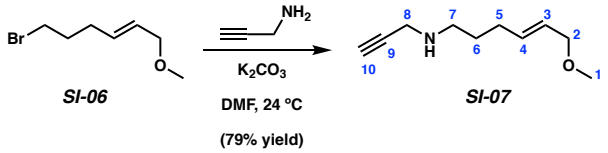
Reaction on 1 mmol scale: To a 200 mL ChemGlass pressure vessel, heavy wall, round bottom (CG-1880-R-03) under argon was added the chloroamine **3a** (173.4 mg, 1.1 mmol) and AIBN (36.1 mg, 0.22 mmol) in THF (70 mL). Then was added TIPSH (0.45 mL, 2.2 mmol) to the reaction solution. The vessel was sealed and placed in a hot oil bath (100 ºC) and stirred for 3

[2] Li, Y.; Marks. T. J. Organolanthanide-Catalyzed Intra- and Intermolecular Tandem C–N and C–C Bond-Forming Processes of Aminodialkenes, Aminodialkynes, Aminoalkeneynes, and Aminoalkynes. New Regiospecific Approaches to Pyrrolizidine, Indolizidine, Pyrrole, and Pyrazine Skeletons. *J. Am. Chem. Soc.* **1998,** *120,* 1757–1771.

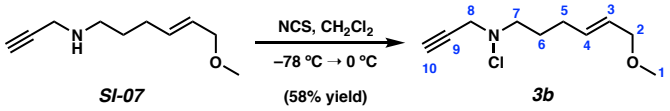
h. **CAUTION:** REACTIONS UNDER PRESSURE SHOULD BE HANDLED IN A FUME HOOD BEHIND A BLAST SHIELD. Upon completion, the reaction was brought to room temperature and the solvent was removed under reduced pressure and was purified by flash column chromatography. Product was eluted with 7% ($MeOH/CH_2Cl_2$) and obtained as orange oil (109.6 mg, 81% yield). Spectroscopic data were identical to the small-scale reaction above.



(*E*)-6-bromo-1-methoxyhex-2-ene (SI-06). To a solution of Grubbs' C827 catalyst (69 mg, 0.083 mmol) in CH_2Cl_2 (40 mL) was added the 5-bromo-1-pentene (2.46 g, 16.64 mmol) and allylic ether (0.6 g, 8.32 mmol) under argon via syringe. The reaction was refluxed under argon at 40 ºC for 20 h. The reaction was cooled to room temperature, and the solvent was removed under reduced pressure. Crude material was purified by column chromatography eluted with 0 – 5% Ether/Hexane to afford the product as a dark orange oil (0.55 g, 34% yield) R_f=0.45 (10% EtOAc/Hexane). ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.70 – 5.58 (m, 2H, C_4, C_3), 3.86 (d, J = 4.83 Hz, 2H, C_2), 3.40 (t, J = 6.7 Hz, 2H, C_7), 3.32 (s, 3H, C_1), 2.21 (q, J = 6.2, 5.7 Hz, 2H, C_5), 1.95 (dq, J = 8.20, 6.7 Hz, 2H, C_6); ^{13}C NMR (101 MHz, $CDCl_3$) δ 132.11 (C_4), 127.82 (C_3), 73.01 (C_2), 57.81 (C_1), 33.14 (C_7), 31.92 (C_5), 30.63 (C_6); IR 2930, 2848, 1442, 1239, 1123, 967 cm^{-1}.

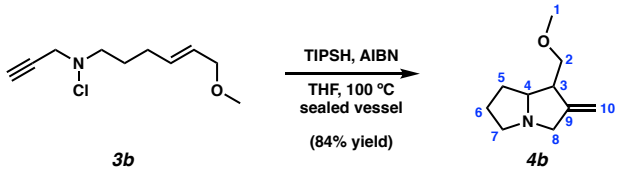


(*E*)-6-methoxy-*N*-(prop-2-yn-1-yl)hex-4-en-1-amine (SI-07). To a dry round-bottom flask under an atmosphere of argon was added 10 mL DMF, propargyl amine (0.13 mL, 2.0 mmol) and K_2CO_3 (0.276 g, 2.0 mmol). After few minutes was added **SI-06** (0.15 g, 1.0 mmol) and allowed stirred at room temperature for 4 h. The reaction mixture was diluted with H_2O (10 mL) and extracted with EtOAc (3 × 20 mL). The combined organic layer was washed with brine solution and dried with anhydrous Na_2SO_4. Solvent was removed under reduced pressure and purified by column chromatography eluted with 0–3% MeOH/ CH_2Cl_2 to afford product as a brown liquid (128 mg, 79% yield) R_f=0.3 (3% MeOH/ CH_2Cl_2). ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.70 (dtt, J = 15.48, 6.5. 1.15 Hz, 1H, C_4), 5.56 (dtt, J = 15.23, 6.09, 1.26 Hz 1H, C_3), 3.85 (d, J = 6.1 Hz, 2H, C_2), 3.41 (d, J = 2.4 Hz, 2H, C_8), 3.30 (s, 3H, C_1), 2.69 (t, J = 7.2 Hz, 2H, C_7), 2.19 (dq, J = 2.52, 1.56, Hz, 1H, C_{10}), 2.10 (q, J = 7.6 Hz, 2H, C_5), 1.58 (p, J = 7.61 Hz, 2H, C_6), 1.2 (s, 1H, N); ^{13}C NMR (101 MHz, $CDCl_3$) δ 134.03 (C_4), 126.63 (C_3), 82.31 (C_9), 73.12 (C_2), 71.23 (C_{10}), 57.73 (C_1), 48.12 (C_8), 38.16 (C_7), 30.07 (C_5), 29.23 (C_6); HRMS [M+H$^+$] m/z ES calc'd for $[C_{10}H_{17}NO]^+$: 168.1383; observed: 168.1379; IR 3302, 3009, 2963, 2931, 2856, 2824, 1265, 1119, 1018, 972, 910 cm^{-1}.



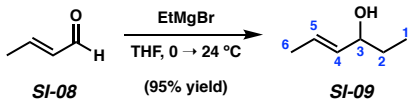
SI-07 *3b*

(*E*)-*N*-chloro-6-methoxy-*N*-(prop-2-yn-1-yl)hex-4-en-1-amine (3b). To a cooled (–78 °C) solution of the amine (100 mg, 0.59 mmol) in CH_2Cl_2 (6 mL) was added *N*-Chlorosuccinamide (87.8 mg, 0.66 mmol) and was warmed up to 0 °C over 2 h. upon completion, the reaction was diluted with hexanes (5 mL) and purified by column chromatography. Product was eluted 7.5% Et_2O/Hexanes as a colorless oil (70 mg, 58% yield). R_f= 0.4 (7.5% Et_2O/Hexane). ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.74 – 5.65 (m, 1H, C_4), 5.59 – 5.54 (m, 1H, C_3), 3.85 (dq, *J* = 5.85, 0.94 Hz, 2H, C_2), 3.80 (dd, *J* = 2.4, 0.55 Hz, 2H, C_8), 3.30 (s, 3H, C_1), 2.98 (dd, *J* = 7.72, 6.27 Hz, 2H, C_7), 2.40 (t, *J* = 2.37 Hz, 1H, C_{10}), 2.15 – 2.09 (m, 2H, C_5), 1.75 – 1.71 (m, 2H, C_6); ^{13}C NMR (101 MHz, $CDCl_3$) δ 133.44 (C_4), 127.06 (C_3), 77.53 (C_9), 74.72 (C_{10}), 73.02 (C_2), 61.33 (C_1), 57.74 (C_8), 52.62 (C_7), 29.27 (C_5), 27.25 (C_6); HRMS [M+H$^+$] m/z ES calc'd for [$C_{10}H_{17}NOCl$]$^+$: 202.0993; observed: 202.0991; IR 3297, 2921, 2848, 1442, 1386, 1114, 971, 661 cm^{-1}.



3b *4b*

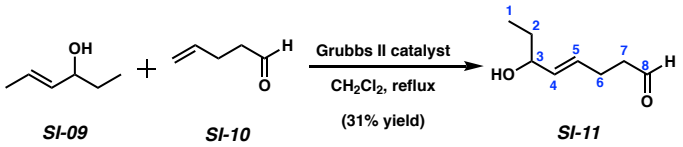
1-(methoxymethyl)-2-methylenehexahydro-1*H*-pyrrolizine (4b). To a flame dried microwave vessel under argon was added the chloroamine (60 mg, 0.30 mmol) and AIBN (9.8 mg, 0.06 mmol) in THF (25 mL). Then was added TIPSH (0.12 mL, 0.59) to the reaction solution. The microwave vessel was sealed and dipped in a hot oil bath (100 °C) and stirred for 3 h. **CAUTION:** REACTIONS UNDER PRESSURE SHOULD BE HANDLED IN A FUME HOOD BEHIND A BLAST SHIELD. Solvent was removed under reduced pressure and was purified by column chromatography. Product was eluted with 10% (MeOH/ CH_2Cl_2) to obtain the product as orange oil (42.0 mg, 84% yield, dr ≥ 19:1). R_f=0.4 (10% MeOH/ CH_2Cl_2). ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.23 (dq, *J* = 12.13, 2.06 Hz, 2H, C_{10}), 4.35 (dd, *J* = 15.05, 2.1 Hz, 1H, C_8), 4.23 (q, *J* = 6.46 Hz 1H, C_8), 3.87 – 3.79 (m, 1H, C_7), 3.54 – 3.46 (m, 2H, C_2), 3.36 (d, *J* = 0.61 Hz, 3H, C_1), 3.30 (dt, *J* = 8.44, 5.16, 1.22 Hz, 1H, C_7), 2.86 (dt, *J* = 11.65, 7.81 Hz, 1H, C_4), 2.76 (dtd, *J* = 7.61, 5.61, 1.73 Hz, 1H, C_3), 2.38 (dtd, *J* = 13.28, 7.40, 5.67 Hz, 1H, C_5), 2.19 – 2.10 (m, 2H, C_6), 1.86 (dq, *J* = 13.79 Hz, 1, 7.24 Hz, 1H, C_5); ^{13}C NMR (101 MHz, $CDCl_3$) δ 141.74 (C_9), 112.72 (C_{10}), 73.33 (C_1), 70.03 (C_2), 59.31 (C_4), 57.42 (C_8), 54.76 (C_7), 48.74 (C_3), 31.02 (C_5), 24.81 (C_6); HRMS [M+H$^+$] m/z ES calc'd for [$C_{10}H_{18}NO$]$^+$: 168.1383; observed: 168.1379; IR 3102, 3040, 1589, 1450, 1435, 1265, 1196, 1119, 1088, 1072 cm^{-1}.



SI-08 *SI-09*

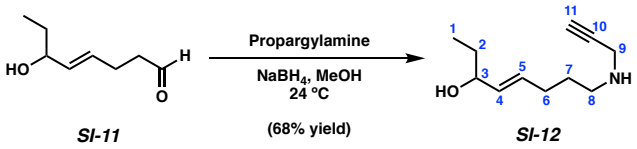
(*E*)-hex-4-en-3-ol (SI-09). To a cooled (0 °C) solution of crotonaldehyde (1.0 g, 14.3 mmol) in THF (7 mL) was added ethyl magnesium bromide (1M in THF, 17.1 mL, 17.1 mmol) dropwise and was stirred for 15 minutes. The reaction was brought to 0 °C and stirred for additional 1 h. The reaction was quenched with NH_4Cl (14 ml) and the aqueous layer was extracted with

EtOAc (3 × 20 mL). The combined organic layer was washed with brine (20 mL), dried over anhydrous Na_2SO_4 and concentrated under reduced pressure. Crude product was purified by column chromatography (20% EtOAc/Haxane) to isolate the product as colorless oil (1.35 g, 95% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.62 (dqd, *J* = 15.23, 6.40, 0.85 Hz, 1H, C_5), 5.44 (ddq, *J* = 15.27, 7.16, 1.54 Hz, 1H, C_4), 3.92 (q, *J* = 6.65 Hz, 1H, C_3), 1.86 (bs, 1H, OH), 1.67 (ddd, *J* = 6.43, 1.49, 0.53 Hz, 3H, C_6), 1.60 – 1.41 (m, 2H, C_2), 0.86 (t, *J* = 7.46 Hz, 3H, C_1); ^{13}C NMR (101 MHz, $CDCl_3$) δ 134.02 (C_5), 126.80 (C_4), 74.43 (C_3), 30.05 (C_6), 17.63 (C_2), 9.73 (C_1). Data matched with the reported data.[3]



SI-09 *SI-10* *SI-11*

(*E*)-6-hydroxyoct-4-enal (SI-11). To a solution of 4-pentenal (0.62 g, 7.37 mmol) and Grubbs' 2nd generation catalyst (0.12 g, 0.15 mmol) in CH_2Cl_2 (25.4 mL) was added the **SI-09** (1.10 g, 11.06 mmol) drop wise via a syringe pump. The reaction was refluxed at 40 ºC for 18 h. Upon completion, the reaction was cooled to room temperature, and the solvent was removed under reduced pressure. Crude material was purified by column chromatography and the product was eluted with 30% EtOAc/Hexane as orange solid (322 mg, 31% yield). R_f = 0.3 (30% EtOAc/Hexane). ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.77 (t, *J* = 1.39 Hz, 1H, C_8), 5.65 (dt, *J* = 15.10, 6.38 Hz, 1H, C_5), 5.53 (dd, *J* = 15.43, 6.38 Hz, 1H, C_4), 3.97 (q, *J* = 6.52 Hz, 1H, C_3), 2.56 – 2.52 (m, 2H, C_7), 2.38 (q, *J* = 6.96 Hz, 2H, C_6), 1.63 (s, 1H, OH), 1.52 (dtd, *J* = 17.12, 13.66, 6.38 Hz, 2H, C_2), 0.89 (t, *J* = 7.45 Hz, 3H, C_1); ^{13}C NMR (101 MHz, $CDCl_3$) δ 201.80 (C_8), 134.11 (C_5), 129.36 (C_4), 74.10 (C_3), 43.11 (C_6), 30.09 (C_7), 24.67 (C_2), 9.69 (C_1). Characterization data matched with the reported data.[4]



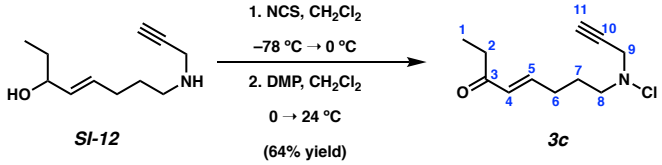
SI-11 *SI-12*

(*E*)-8-(prop-2-yn-1-ylamino)oct-4-en-3-ol (SI-12). To a solution of the **SI-11** (322 mg, 2.26 mmol) in MeOH (10 mL) was added propargylamine (0.16 mL, 2.49 mmol) and stirred for 3 h to from the aldimine. Then the reaction mixture was carefully treated with $NaBH_4$ (137.0 mg, 3.62 mmol) and the reaction was run for additional 2 h. Upon completion reaction was quenched with 1M NaOH (15mL) and the aqueous layer was extracted with EtOAc (3 × 15 mL). The combined organic layer was washed with brine solution (20 mL), and dried over anhydrous Na_2SO_4. The crude product was purified by column chromatography and eluted with 10% MeOH/ CH_2Cl_2. The product was obtained as yellow oil (280 mg, 68% yield). R_f = 0.3 (30% EtOAc/Hexane). ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.66 – 5.60 (m, 1H, C_4), 5.46 (ddt, *J* = 15.36, 6.99, 1.36 Hz, 1H, C_5), 3.95 (q, *J* = 6.61 Hz, 1H, C_3), 3.41 (d, *J* = 2.48 Hz, 2H, C_9), 2.69 (t, *J* = 7.23 Hz, 2H, C_8), 2.20 (t, *J* =

[3] Chen, M. Z.; Mclaughlin, M.; Takahashi, M.; Tarselli, M. A.; Yang, D.; Umemura, S.; Micalizio, G. C. Preparation of Stereodefined Homoallylic Amines from the Reductive Cross-Coupling of Allylic Alcohols with Imines. *J. Org. Chem.* **2010**, *75*, 8048–8059.

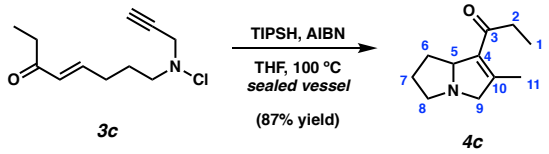
[4] Dérien, S.; Ropartz, L.; Le Paih, J.; Dixneul, P. H, Synthesis of 2-Alkoxy-5-methylenetetrahydropyrans: A Regioselective Ruthenium-Catalyzed C–C Coupling Reaction of Prop-2-yn-1-ols with Allyl Alcohol. *J. Org. Chem.* **1999**, *64*, 3524–3531.

2.38 Hz, 1H, C_{11}), 2.07 (q, *J* = 5.61 Hz, 2H, C_6), 1.65 (s, 1H, N), 1.53 (ddq, *J* = 14.18, 13.65, 7.12 Hz, 4H, C_6, C_7), 0.88 (t, *J* = 7.45 Hz, 3H, C_1); ^{13}C NMR (101 MHz, $CDCl_3$) δ 133.41 (C_4), 131.32 (C_5), 82.01 (C_{10}), 74.31 (C_3), 71.43 (C_{11}), 48.04 (C_9), 38.03 (C_8), 30.12 (C_6), 29.91 (C_7), 29.11 (C_2), 9.84 (C_1); HRMS [M+H$^+$] m/z ES calc'd for $[C_{11}H_{20}NO]^+$: 182.1539; observed: 182.1534; IR 3302, 3009, 2963, 2932, 2839, 2250, 1597, 1504, 1481, 1265, 1119, 1003, 972 cm^{-1}.



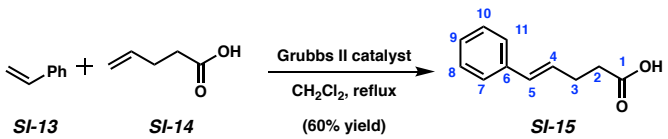
SI-12 *3c*

(*E*)-8-(chloro(prop-2-yn-1-yl)amino)oct-4-en-3-one (3c). To a cooled (–78 °C) solution of the amine (247 mg, 1.363 mmol) in CH_2Cl_2 (15 mL) was added *N*-Chlorosuccinamide (200 mg, 1.5 mmol) and was warmed up to 0 °C over 2 h and run for an additional 1 h. Then to the reaction mixture at 0 ºC was added DMP (867 mg, 2 mmol) and stirred for 18 h. upon completion, the reaction was purified by column chromatography. Product was eluted 20% Et_2O/Hexanes as a colorless oil (187 mg, 64% yield). R_f = 0.6 (40% Et_2O/ Hexane). ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.81 (dt, *J* = 15.99, 6.84 Hz, 1H, C_5), 6.11 (d, *J* = 15.9, 1.6 Hz, 1H, C_4), 3.80 (d, *J* = 2.4 Hz, 2H, C_9), 2.98 (t, *J* = 6.8, Hz, 2H, C_8), 2.54 (q, *J* = 7.3 Hz, 2H, C_2), 2.4 (t, *J* = 2.4, 0.66 Hz, 1H, C_{11}), 2.31 – 2.26 (m, 2H, C_6), 1.81 (p, *J* = 7.3 Hz, 2H, C_7), 1.07 (t, *J* = 7.3 Hz, 3H, C_1); ^{13}C NMR (101 MHz, $CDCl_3$) δ 201.01 (C_3), 145.61 (C_5), 130.52 (C_4), 77.31 (C_{10}), 74.94 (C_{11}), 60.87 (C_9), 52.72 (C_8), 33.35 (C_2), 29.34 (C_6), 26.23 (C_7), 8.08 (C_1); HRMS [M+H$^+$] m/z ES calc'd for $[C_{11}H_{17}NOCl]^+$: 214.0993; observed: 214.0992; IR 3301, 2930, 2844, 1675, 1628, 1446, 1477, 1196, 1100, 968, 661 cm^{-1}.

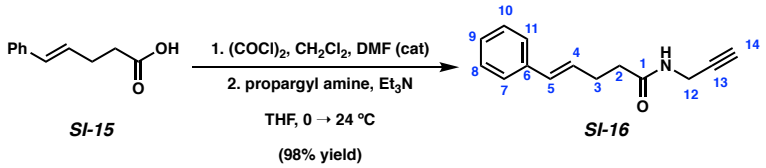


3c *4c*

1-(6-methyl-2,3,5,7a-tetrahydro-1*H*-pyrrolizin-7-yl)propan-1-one (4c). To a flame dried microwave vessel under argon was added the chloroamine (22.0 mg, 0.103 mmol) and AIBN (3.40 mg, 0.021 mmol) in THF (11.4 mL). Then was added TIPSH (42.2 µL, 0.206 mmol to the reaction solution. The microwave tube was sealed and, and the reaction tube was dipped in a hot oil bath (100 ºC) and stirred for 3 h. **CAUTION:** REACTIONS UNDER PRESSURE SHOULD BE HANDLED IN A FUME HOOD BEHIND A BLAST SHIELD. Upon completion solvent was removed under reduced pressure and was purified by column chromatography. Product was eluted with 10% (MeOH/ CH_2Cl_2) to obtain the product as orange oil (16 mg, 87% yield). R_f=0.25 (10% MeOH/CH_2Cl_2). ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.21 (t, *J* = 7.88 Hz, 1H, C_5), 4.62 (d, *J* = 17.3 Hz, 1H, C_9), 3.80 (dd, *J* = 11.6, 5.3 Hz, 2H, C_9, C_8), 2.98 – 2.92 (m, 1H, C_8), 2.58 (qt, *J* = 7.1, 1.64 Hz, 2H, C_2), 2.46 (m, *J* = 13.0, 6.0 Hz, 1H, C_6), 2.12 – 2.00 (m, 5H, C_{11}, C_7), 1.80 (dq, *J* = 14.0, 7.4 Hz, 1H, C_6), 1.07 (t, *J* = 8.69 Hz, 3H, C_1); ^{13}C NMR (101 MHz, $CDCl_3$) δ 196.66 (C_3), 142.15 (C_{10}), 133.59 (C_4), 74.4 (C_5), 64.6 (C_9), 56.4 (C_8), 36.0 (C_2), 31.3 (C_6), 25.1 (C_{11}), 14.0 (C_7), 7.3 (C_1); HRMS [M+H$^+$] m/z ES calc'd for $[C_{11}H_{18}NO]^+$: 180.1383; observed: 180.1378; IR 3071, 3017, 1612, 1597, 1504, 1481, 1265, 1018 cm^{-1}.

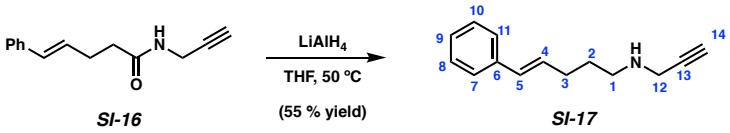


(*E*)-5-phenylpent-4-enoic acid (SI-15). 4-pentenoic acid (0.5 g, 4.99 mmol), and styrene (1.15 mL, 9.99 mmol) with Grubbs' 2nd generation catalyst (0.085 g, 0.10 mmol) in CH_2Cl_2 was heated to reflux for 12 h. Upon completion the reaction mixture was cooled to room temperature and solvent was removed under reduced pressure. The dark green solid crude was dissolved in EtOAc (17 mL) and extracted with $NaHCO_3$ (3 × 34 mL). Combined aqueous layer was acidified to pH 1 with 10 % HCl and then extracted with EtOAc (2 × 15 mL). The combined organic extract was washed with brine and dried over anhydrous $MgSO_4$. The solvent was removed under reduced pressure to give a pale yellow solid (0.53 g, 60% yield). ^{1}H NMR and ^{13}C NMR matched reported spectra.[5]



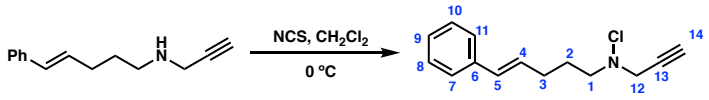
(*E*)-5-phenyl-*N*-(prop-2-yn-1-yl)pent-4-enamide (SI-16). To a cooled solution of the acid (0.53 g, 2.98 mmol) in CH_2Cl_2 (20 mL) was added $(COCl)_2$ (0.51 mL, 5.97 mmol) followed by DMF (2.2 µL, 0.03 mmol). The reaction mixture was then warmed up to room temperature and was stirred for 1 h. upon completion, the solvent was removed under reduced pressure and the product was obtained as green oil. To a cooled (0 ºC) solution of the crude material in THF (11 mL) was added propargyl amine (0.29 mL, 4.31 mmol) drop wise using a 500 µL micro syringe followed by Et_3N (0.60 mL, 4.32 mmol). The reaction was stirred for 30 minutes, quenched with water and the aqueous layer was extracted with EtOAc (3 x 10 mL). The combined organic layer was washed with brine and dried over anhydrous $MgSO_4$. The solvent was removed under reduced pressure and the crude material was purified by column chromatography (EtOAc/hexane, 20% to 80%) to give a yellow solid (0.69 g, 98% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35 – 7.30 (m, 4H, C_7, C_8, C_{10}, C_{11}), 7.24 – 7.18 (m, 1H, C_9), 6.44 (d, J = 15.83, 1 H, C_5), 6.20 (dt, J = 15.80, 6.88 Hz, 1H, C_4), 5.80 (s, 1H, N), 4.06 (dd, J = 5.24, 2.53 Hz, 2H, C_{12}), 2.56 (q, J = 7.39 Hz, 2H, C_3), 2.37 (t, J = 2.77 Hz, 2H, C_2), 2.20 (s, 1H, C_{14}); ^{13}C NMR (400 MHz, $CDCl_3$) δ 171.81 (C_1), 137.32 (C_6), 131.22 (C_7, C_{11}), 128.51 (C_5), 127.23 (C_8, C_{10}), 126.11 (C_4), 79.52 (C_{13}), 71.65 (C_{14}), 36.01 (C_{12}), 29.22 (C_2), 28.80 (C_3); HRMS [M+H$^+$] m/z ES calc'd for $[C_{14}H_{16}NO]^+$: 214.1226; observed: 214.1222; IR (neat) 3293, 3029, 2921, 1634, 1542, 966, 690 cm^{-1}.

[5] Cottrell, I. F.; Cowley, A. R.; Croft, L. J.; Hymns, L.; Moloney, M. G.; Nettleton, E. J.; Kirsty Smithies, H.; Thompson, A. L. Acyloxylactonisations Mediated by Lead Tetracarboxylates. *Tetrahedron*. **2009,** *65*, 2537–2550



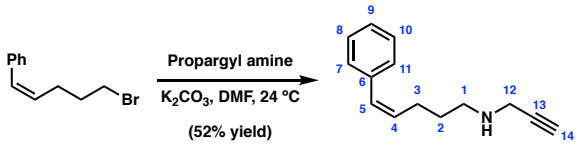
SI-16 *SI-17*

(*E*)-5-phenyl-*N*-(prop-2-yn-1-yl)pent-4-en-1-amine (SI-17). To a cooled (0 ºC) suspension of the amide (0.3 g, 1.4 mmol) in THF (10 mL) was added $LiAlH_4$ (0.13 g, 3.5 mmol) and the reaction was heated to 50 ºC and stirred for 12 h. Upon completion, the reaction was cooled to 0 ºC and water (5 mL) was added drop wise followed by aqueous solution of Rochelle salt (15 mL). The reaction mixture was vigorously stirred at room temperature for 20 minutes. The aqueous layer was extracted with EtOAc (3 × 15 mL). The combined organic layer was washed with brine and dried with anhydrous $MgSO_4$ and concentrated under reduced pressure. Crude product was purified by column chromatography (EtOAc/hexane containing 1% triethylamine, 5% to 25%) to isolate the product as yellow oil (0.152 g, 55% yield). R_f =0.5 (5% MeOH/ CH_2Cl_2). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.36 – 7.31 (m, 4H, C_7, C_8, C_{10}, C_{11}), 7.25 – 7.17 (m, 1H, C_9), 6.41 (d, *J* = 15.82 Hz, 1 H, C_5), 6.22 (dt, *J* = 15.84, 6.85 Hz, 1H, C_4), 3.44 (d, *J* = 2.44 Hz, 2H, C_{12}), 2.75 (t, *J* = 7.19 Hz, 2H, C_1), 2.28 (q, *J* = 7.38 Hz, 2H, C_3), 2.21 (t, *J* = 2.45 Hz, 1H, C_{14}), 1.67 (p, *J* = 7.29 Hz, 2H, C_2), 1.36 (s, 1H, N); ^{13}C NMR (400 MHz, $CDCl_3$) δ 137.69 (C_6), 130.21 (C_5), 128.49 (C_7, C_{11}), 128.39 (C_9), 126.90 (C_4), 125.94 (C_8, C_{10}), 82.31 (C_{13}), 71.24 (C_{14}), 48.15 (C_{12}), 38.17 (C_1), 30.72 (C_3), 29.46 (C_2); HRMS [M+H$^+$] m/z ES calc'd for $[C_{14}H_{18}N]^+$: 200.1434; observed: 200.1429; IR (neat) 3306, 2931, 2851, 1449, 1125, 964, 741, 630 cm^{-1}.



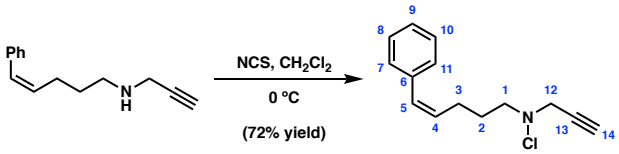
SI-17 *trans-3d*

(*E*)-*N*-chloro-5-phenyl-*N*-(prop-2-yn-1-yl)pent-4-en-1-amine (*trans*-3d). To a solution of the amine (0.2 g, 1.00 mmol) in CH_2Cl_2 (15 mL) at 0 °C under nitrogen was added *N*-chlorosuccinamide (0.15 g, 1.10 mmol) in portions over 5 minutes. The reaction mixture was stirred for 2 hours at the same temperature, and the solvent was evaporated under vacuum. The crude product was purified by column chromatography, product was eluted with 3-5% EtOAc/Hexanes as a colorless oil (0.15 g, 63% yield). R_f =0.7 (10% EtOAc/Hexane). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 – 7.25 (m, 4H, C_7, C_8, C_{10}, C_{11}), 7.20 (t, *J* = 7.1 Hz, 1H, C_9), 6.42 (d, *J* = 15.8 Hz, 1H, C_5), 6.21 (dt, *J* = 15.8, 6.9 Hz, 1H, C_4), 3.84 (d, *J* = 2.3 Hz, 2H, C_{12}), 3.05 (t, *J* = 8.0 Hz, 2H, C_1), 2.41 (t, *J* = 2.3 Hz, 1H, C_{14}), 2.30 (q, *J* = 7.3 Hz, 2H, C_3), 1.83 (p, *J* = 7.2 Hz, 2H, C_2); ^{13}C NMR (101 MHz, $CDCl_3$) δ 137.57 (C_6), 130.62 (C_5), 129.67 (C_4), 128.48 (C_7, C_{11}), 126.97 (C_9), 125.95 (C_8, C_{10}), 77.49 (C_{13}), 74.76 (C_{14}), 61.25 (C_{12}), 52.62 (C_1), 29.93 (C_3), 27.48 (C_2); HRMS [M+H$^+$] m/z ES calc'd for $[C_{14}H_{17}NCl]^+$: 234.1044; observed: 234.1046; IR (neat) 3297, 2926, 1606, 1498, 1446, 1252, 967, 691 cm^{-1}.

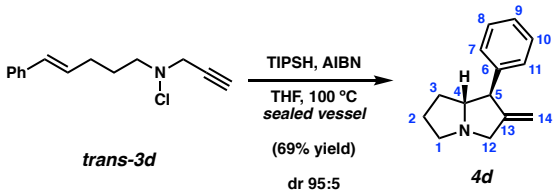


SI-18 *SI-19*

(*Z*)-5-phenyl-*N*-(prop-2-yn-1-yl)pent-4-en-1-amine (SI-19). To a solution of propargylamine (0.96 mL, 15.0 mmol) in DMF (20 mL) under nitrogen was added K_2CO_3 (1.38 g, 10.0 mmol) followed by dropwise addition of **SI-18** (1.12 g, 5.0 mmol) in DMF (10 mL). The reaction mixture was stirred at room temperature for 6 h. Then the reaction was diluted with H_2O (25 mL) and extracted with EtOAc (3 × 30 mL). The combined organic layer was washed with brine solution (2 × 25 mL). The separated organic layer was dried over anhydrous Na_2SO_4. Solvent was removed under reduced pressure and purified by flash chromatography, the product was eluted with 25–30% EtOAc/Hexanes as colorless liquid (0.42 g, 52% yield). R_f=0.3 (20% EtOAc/Hexane). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.36 – 7.14 (m, 5H, C_7, C_8, C_9, C_{10}, C_{11}), 6.44 (d, *J* = 11.6 Hz, 1H, C_5), 5.67 (dt, *J* = 11.6, 7.3 Hz, 1H, C_4), 3.41 (d, *J* = 2.4 Hz, 2H, C_{12}), 2.72 (t, *J* = 7.2 Hz, 2H, C_1), 2.39 (qd, *J* = 7.5, 1.6 Hz, 2H, C_3), 2.20 (t, *J* = 2.4 Hz, 1H, C_{14}), 1.66 (p, *J* = 7.4 Hz, 2H, C_2), 1.26 (t, *J* = 7.1 Hz, 1H, N); ^{13}C NMR (101 MHz, $CDCl_3$) δ 137.55 (C_6), 132.23 (C_5), 129.28 (C_9), 128.71 (C_7, C_{11}), 128.13 (C_8, C_{10}), 126.53 (C_4), 82.25 (C_{13}), 71.19 (C_{14}), 48.20 (C_{12}), 38.14 (C_1), 30.07 (C_3), 26.30 (C_2); HRMS [M+H$^+$] m/z ES calc'd for $[C_{14}H_{18}N]^+$: 200.1434; observed: 200.1433; IR (neat) 3300, 2922, 1493, 1441, 1115, 917, 698 cm^{-1}.

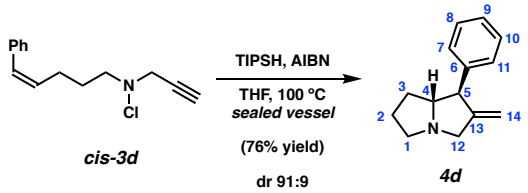


(*Z*)-*N*-chloro-5-phenyl-*N*-(prop-2-yn-1-yl)pent-4-en-1-amine (*cis*-3d). To a solution of the amine (0.2 g, 1.00 mmol) in CH_2Cl_2 (15 mL) at 0 °C under nitrogen was added *N*-chlorosuccinamide (0.15 g, 1.10 mmol) in portions over 5 minutes. The reaction mixture was stirred for 2 hours at the same temperature, and the solvent was evaporated under vacuum. The crude product was purified by column chromatography, product was eluted with 3-5% EtOAc/Hexanes as a colorless oil (0.17 g, 72% yield). R_f=0.7 (10% EtOAc/Hexane). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 – 7.17 (m, 5H, C_7, C_8, C_9, C_{10}, C_{11}), 6.46 (d, *J* = 11.7 Hz, 1H, C_5), 5.66 (dt, *J* = 11.6, 7.3 Hz, 1H, C_4), 3.80 (d, *J* = 2.4 Hz, 2H, C_{12}), 3.01 (t, *J* = 8.0 Hz, 2H, C_1), 2.47 – 2.35 (m, 3H, C_3, C_{14}), 1.80 (p, *J* = 7.4 Hz, 2H, C_2); ^{13}C NMR (101 MHz, $CDCl_3$) δ 137.45 (C_6), 131.71 (C_5), 129.64 (C_9), 128.72 (C_7, C_{11}), 128.16 (C_8, C_{10}), 126.60 (C_4), 77.44 (C_{13}), 74.77 (C_{14}), 61.42 (C_{12}), 52.57 (C_1), 28.14 (C_3), 25.68 (C_2); HRMS [M+H$^+$] m/z ES calc'd for $[C_{14}H_{17}NCl]^+$: 234.1044; observed: 234.1042; IR (neat) 3292, 2930, 2861, 1606, 1498, 1446, 1330, 1071, 959 cm^{-1}.

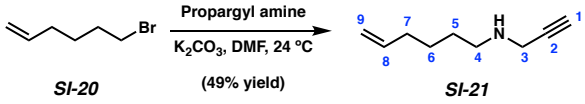


2-methylene-1-phenylhexahydro-1*H*-pyrrolizine (4d). To a flame dried microwave vessel under argon was added ***trans*-3d** (23.3 mg, 0.1 mmol) and AIBN (3.3 mg, 0.02 mmol) in THF (12 mL). Then was added TIPSH (41.2 µL, 0.2 mmol) to the reaction solution. The microwave vessel was sealed and, and the reaction tube was dipped in a hot oil bath (100 ºC) and stirred for 2 h. **CAUTION:** REACTIONS UNDER PRESSURE SHOULD BE HANDLED IN A FUME

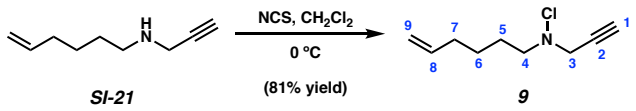
HOOD BEHIND A BLAST SHIELD. Upon completion solvent was removed under reduced pressure and was purified by column chromatograph. Product was eluted with 3-4% (MeOH/ CH_2Cl_2) to obtain the product as colorless oil (13.8 mg, 69% yield, dr 95:5). R_f =0.35 (10% MeOH/ CH_2Cl_2). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.38 – 7.13 (m, 5H, C_7, C_8, C_9, C_{10}, C_{11}), 5.01 (d, *J* = 2.3 Hz, 1H, C_{14}), 4.60 (q, *J* = 2.2 Hz, 1H, C_{14}), 3.92 (dd, *J* = 15.2, 1.7 Hz, 1H, C_{12}), 3.60 – 3.53 (m, 1H, C_4), 3.52 (d, *J* = 15.8 Hz, 1H, C_{12}), 3.33 (d, *J* = 8.7 Hz, 1H, C_5), 3.15 (tt, *J* = 7.6, 4.1 Hz, 1H, C_1), 2.74 – 2.60 (m, 1H, C_1), 2.07 – 1.82 (m, 3H, C_2, C_3), 1.72 (tt, *J* = 7.8, 4.1 Hz, 1H, C_3); ^{13}C NMR (400 MHz, $CDCl_3$) δ 154.90 (C_6), 141.54 (C_{13}), 128.66 (C_8, C_{10}), 128.50 (C_7, C_{11}), 126.53 (C_9), 107.17 (C_{14}), 73.71 (C_4), 59.45 (C_{12}), 55.97 (C_5), 54.85 (C_1), 29.74 (C_3), 25.02 (C_2); HRMS [M+H$^+$] m/z ES calc'd for $[C_{14}H_{18}N]^+$: 200.1434; observed: 200.1430; IR (neat) 3026, 2962, 1453, 1097, 890, 750, 696, 518 cm-1.



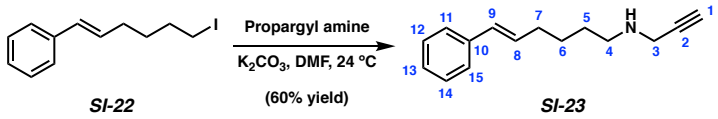
2-methylene-1-phenylhexahydro-1*H*-pyrrolizine (4d). To a flame dried microwave vessel under argon was added the ***cis*-3d** (46.6 mg, 0.2 mmol) and AIBN (6.6 mg, 0.04 mmol) in THF (16 mL). Then was added TIPSH (82.3 µL, 0.4 mmol) to the reaction solution. The microwave vessel was sealed and, and the reaction tube was dipped in a hot oil bath (100 ºC) and stirred for 2 h. **CAUTION:** REACTIONS UNDER PRESSURE SHOULD BE HANDLED IN A FUME HOOD BEHIND A BLAST SHIELD. Upon completion solvent was removed under reduced pressure and was purified by column chromatograph. Product was eluted with 3-4% (MeOH/ CH_2Cl_2) to obtain the product as colorless oil (34.4 mg, 86% yield, dr 91:9). Experimental data matches with 4d obtained from *trans*-3d (*trans*-3d and *cis*-3d produced same diastereomer as major product).



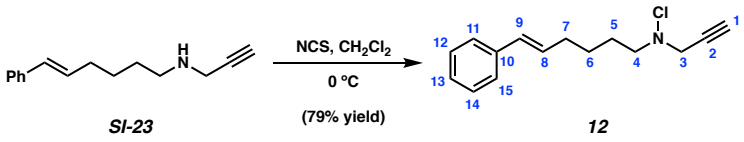
***N*-(prop-2-yn-1-yl)hex-5-en-1-amine (SI-21).** To a solution of propargylamine (1.65 mL, 30.0 mmol) in DMF (30 mL) under nitrogen was added K_2CO_3 (2.76 g, 20.0 mmol) followed by dropwise addition of **SI-20** (1.62 g, 10.0 mmol) in DMF (10 mL). The reaction mixture was stirred at room temperature for 6 h. Then the reaction was diluted with H_2O (30 mL) and extracted with EtOAc (3 × 40 mL). The combined organic layer was washed with brine solution (2 × 25 mL). The separated organic layer was dried over anhydrous Na_2SO_4. Solvent was removed under reduced pressure and purified by flash chromatography, the product was eluted with 20–25% EtOAc/Hexanes as colorless liquid (0.66 g, 49% yield). R_f=0.3 (20% EtOAc/Hexane). ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.80 (ddt, *J* = 16.9, 10.2, 6.7 Hz, 1H, C_8), 5.05 – 4.90 (m, 2H, C_9), 3.42 (d, *J* = 2.4 Hz, 2H, C_3), 2.69 (t, *J* = 6.9 Hz, 2H, C_4), 2.20 (t, *J* = 2.4 Hz, 1H, C_1), 2.07 (q, *J* = 7.0 Hz, 2H, C_7), 1.55 – 1.40 (m, 4H, C_5, C_6); ^{13}C NMR (101 MHz, $CDCl_3$) δ 138.67 (C_8), 114.51 (C_9), 82.33 (C_2), 71.11 (C_1), 48.48 (C_3), 38.16 (C_4), 33.57 (C_7), 29.27 (C_5), 26.53 (C_6); HRMS [M+H$^+$] m/z ES calc'd for $[C_9H_{16}N]^+$: 138.1277; observed: 138.1272; IR (neat) 3303, 3076, 2928, 1640, 1117, 910, 631 cm^{-1}.



***N*-chloro-*N*-(prop-2-yn-1-yl)hex-5-en-1-amine (9).** To a stirred solution of **SI-21** (0.41 g, 3.00 mmol) in CH_2Cl_2 (20 mL) at 0 °C under nitrogen was added *N*-chlorosuccinamide (0.44 g, 3.30 mmol) in portions over 10 minutes. The reaction mixture was stirred at same temperature for 2 hours, and the solvent was evaporated under vacuum. The crude product was purified by column chromatography, product was eluted with 4-8% EtOAc/Hexanes as a colorless oil (0.41 g, 81% yield). R_f=0.8 (10% EtOAc/Hexane). ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.83 – 5.79 (m, 1H, C_8), 5.07 – 4.93 (m, 2H, C_9), 3.81 (d, *J* = 2.4 Hz, 2H, C_3), 3.00 (t, *J* = 7.6 Hz, 2H, C_4), 2.41 (t, *J* = 2.4 Hz, 1H, C_1), 2.10 (q, *J* = 7.2 Hz, 2H, C_7), 1.68 – 1.60 (m, 2H, C_5), 1.48 – 1.41 (m, 2H, C_6); ^{13}C NMR (101 MHz, $CDCl_3$) δ 138.43 (C_8), 114.74 (C_9), 77.52 (C_2), 74.71 (C_1), 61.80 (C_3), 52.54 (C_4), 33.41 (C_7), 27.35 (C_5), 25.91 (C_6); HRMS [M+H$^+$] m/z ES calc'd for $[C_9H_{15}NCl]^+$: 172.0880; observed: 172.0888; IR (neat) 3300, 2931, 2853, 1613, 1454, 917, 638 cm^{-1}.

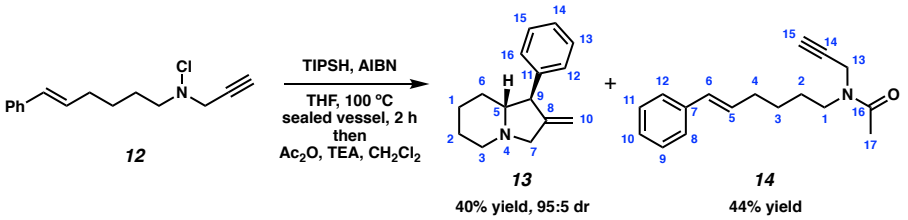


(*E*)-6-phenyl-*N*-(prop-2-yn-1-yl)hex-5-en-1-amine (SI-23). To a stirred solution of propargylamine (0.64 mL, 10.00 mmol) in DMF (20 mL) under nitrogen was added K_2CO_3 (1.38 g, 10.0 mmol) followed by dropwise addition of **SI-22** (1.43 g, 5.00 mmol) in of DMF (10 mL). The reaction mixture was stirred at room temperature for 6 h. Then the reaction was diluted with H_2O (30 mL) and extracted with EtOAc (3 × 25 mL). The combined organic layer was washed with Brine solution (2 × 15 mL). The separated organic layer was dried with Na_2SO_4. Solvent was removed under reduced pressure and purified by column chromatography eluted with 10–15% EtOAc/Hexanes to afford product as light yellow liquid (0.64 g, 60% yield). R_f=0.3 (20% EtOAc/Hexane). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.31 (dt, *J* = 15.18, 7.5 Hz, 4H, $C_{11,}$ $C_{12,}$ $C_{14,}$ C_{15}), 7.19 (t, *J* = 7.14 Hz 1H, C_{13}), 6.39 (d, *J* = 15.84 Hz, 1H, C_9), 6.22 (dt, *J* = 15.79, 6.86 Hz, 1H, C_8), 3.43 (d, *J* = 2.38 Hz, 2H, C_3), 2.72 (t, *J* = 6.62 Hz, 2H, C_4), 2.26 – 2.20 (m, 3H, $C_{7,}$ C_1), 1.58 – 1.52 (m, 4H, $C_{5,}$ C_6), 1.31 (s, 1H, N); ^{13}C NMR (101 MHz, $CDCl_3$) δ 137.77 (C_{10}), 130.61 (C_{13}), 130.05 (C_9), 128.45 ($C_{11,}$ C_{15}), 126.81 (C_8), 125.90 ($C_{12,}$ C_{14}), 82.32 (C_2), 71.18 (C_1), 48.49 (C_3), 38.17 (C_4), 32.82 (C_7), 29.36 (C_5), 26.99 (C_6); HRMS [M+H$^+$] m/z ES calc'd for $[C_{15}H_{20}N]^+$: 214.1591; observed: 214.1590; IR 3301, 2923, 2856, 1605, 1454, 1256, 962, 743 cm^{-1}.



(*E*)-*N*-chloro-6-phenyl-*N*-(prop-2-yn-1-yl)hex-5-en-1-amine (12). To a stirred solution of **SI-23** (0.85 g, 4.00 mmol) in CH_2Cl_2 (20 mL) at 0 °C under nitrogen was added *N*-chlorosuccinamide (0.53 g, 4.00 mmol) in portions over 10 minutes. The reaction mixture was stirred at same

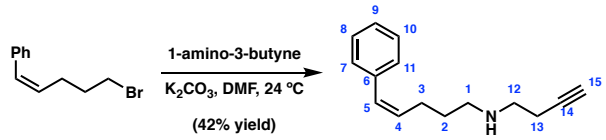
temperature for 2 h, and the solvent was evaporated under vacuum. The crude product was purified by column chromatography, product was eluted with 3-5% EtOAc/Hexanes as a colorless oil (0.79 g, 80.7% yield). R_f=0.7 (10% EtOAc/Hexane). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37 – 7.24 (m, 4H, $C_{11,}$ $C_{12,}$ $C_{13,}$ C_{14}), 7.20 (t, *J* = 7.1 Hz, 1H, C_{13}), 6.40 (d, *J* = 15.9 Hz, 1H, C_9), 6.22 (td, *J* = 11.67, 7.28 Hz, 1H, C_8), 3.83 (d, *J* = 2.3 Hz, 2H, C_3), 3.03 (t, *J* = 7.0 Hz, 2H, C_4), 2.41 (d, *J* = 2.3 Hz, 1H, C_1), 2.25 (q, *J* = 7.2 Hz, 2H, C_7), 1.70 (p, *J* = 7.2 Hz, 2H, C_6), 1.60 – 1.50 (m, 2H, C_5); ^{13}C NMR (101 MHz, $CDCl_3$) δ 137.72 (C_{10}), 130.35 (C_9), 130.20 (C_{13}), 128.47 ($C_{11,}$ C_{15}), 126.86 (C_8), 125.92 ($C_{12,}$ C_{14}), 77.33 (C_2), 74.73 (C_1), 61.79 (C_3), 52.52 (C_4), 32.67 (C_7), 27.38 (C_6), 26.37 (C_5); HRMS [M+H$^+$] m/z ES calc'd for $[C_{15}H_{19}NCl]^+$: 248.1201; observed: 248.1200; IR 3292, 2938, 2857, 1601, 1446, 1256, 971, 635 cm^{-1}.



2-methylene-1-phenyloctahydroindolizine (13). To a flame dried microwave vessel under argon was added the chloroamine (61.8 mg, 0.25 mmol) and AIBN (8.2 mg, 0.05 mmol) in THF (18.0 mL). Then was added TIPSH (0.10 mL, 0.50 mmol) to the reaction solution. The vessel was sealed and was dipped in a hot oil bath (100 ºC) and stirred for 2 h. **CAUTION:** REACTIONS UNDER PRESSURE SHOULD BE HANDLED IN A FUME HOOD BEHIND A BLAST SHIELD. The reaction mixture was evaporated and dissolved in CH_2Cl_2 (8 mL) and was subjected to acetylation (for the ease of separation of reduced product and 13) (with 0.028 mL of Ac_2O and 0.08 mL of Et_3N, for about 0.5 h). The reaction mixture was evaporated, was added 10% HCl (4 mL). The aqueous layer was washed with Et_2O (3 × 6 mL), the separated aqueous layer was basified to pH ~ 9 using 6N NaOH and the cyclized product was extracted with CH_2Cl_2 (3 × 8 mL). Combined organic layer was dried over anhydrous Na_2SO_4 and excess solvent was removed under reduced pressure. Crude product was purified by column chromatograph (basic alumina) (6-10% EtOAc/Hexanes to obtain as colorless oil (21.5 mg, 40% yield: dr 95:5). R_f = 0.35 (10% MeOH/CH_2Cl_2). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35 – 7.14 (m, 5H, $C_{12,}$ $C_{13,}$ $C_{14,}$ $C_{15,}$ C_{16}), 5.03 (d, *J* = 4.0 Hz, 1H, C_{10}), 4.67 – 4.59 (m, 1H, C_{10}), 3.81 (d, *J* = 13.4 Hz, 1H, C_7), 3.34 (dd, *J* = 10.3, 2.6 Hz, 1H, C_9), 3.17 – 3.04 (m, 2H, $C_{7,}$ C_3), 2.14 – 1.97 (m, 2H, $C_{3,}$ C_5), 1.76 (td, *J* = 11.3, 3.6 Hz, 1H, C_6), 1.70 – 1.58 (m, 2H, C_2), 1.33 – 1.12 (m, 3H, $C_{6,}$ C_1); ^{13}C NMR (101 MHz, $CDCl_3$) δ 151.25 (C_{11}), 141.21 (C_8), 129.14 ($C_{12,}$ C_{16}), 128.24 ($C_{13,}$ C_{15}), 126.48 (C_{14}), 106.96 (C_{10}), 72.40 (C_5), 60.43 (C_7), 56.91 (C_9), 53.12 (C_3), 29.31 (C_6), 25.54 (C_1), 24.05 (C_2); HRMS [M+H$^+$] m/z ES calc'd for $[C_{15}H_{20}N]^+$: 214.1590; observed: 214.1595; IR (neat) 2928, 1496, 1449, 1376, 1131, 750.

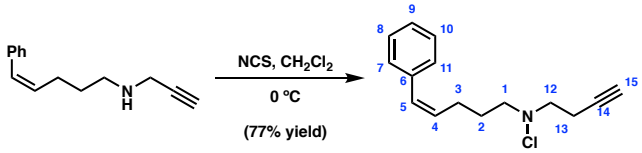
(*E*)-*N*-(6-phenylhex-5-en-1-yl)-*N*-(prop-2-yn-1-yl)acetamide (14). The combined Et_2O layer from above was dried over anhydrous Na_2SO_4 and solvent was removed under reduced pressure. Crude product was purified by column chromatograph (10-15% EtOAc/Hexanes to obtain as colorless oil (28.1 mg, 44% yield; mixture of rotamers A & B). R_f = 0.50 (40% EtOAc/Hexane). ^{1}H NMR (400 MHz, $CDCl_3$) 7.37 – 7.25 (m, 4H, $C_{8,}$ $C_{9,}$ $C_{11,}$ C_{12}), 7.22 – 7.16(m, 1H, C_{10}), 6.39 (d, *J* = 15.8 Hz, 1H, C_6), 6.27 – 6.13 (m, 1H, C_5), 4.20 (d, *J* = 2.4 Hz, 1.26H, C_{13} of rotamer A), 3.99 (d, *J* = 2.3 Hz, 0.81H, C_{13} of rotamer B), 3.44 (dt, *J* = 15.6, 7.5 Hz, 2H, C_1), 2.31

– 2.20 (m, 2H, C_4), 2.17 (d, J = 2.17 Hz, 1.66H, $C_{17,}$ C_{15} of rotamer A), 2.11 (s, 1.75H, $C_{17,}$, C_{15} of rotamer B), 1.72 – 1.59 (m, 2H, C_2), 1.57 – 1.40 (m, 2H, C_3); ^{13}C NMR (101 MHz, $CDCl_3$) (mixture of rotamers A, B) δ 170.2, 169.9 (C_{16}), 137.60, 137.48 (C_7), 130.60, 130.44 (C_6), 130.15 , 129.77 (C_{10}), 128.52, 128.45 ($C_{8,}$ C_{12}), 127.04, 126.83 (C_5), 125.92 ($C_{9,}$ C_{11}), 79.27, 78.72 (C_{14}), 72.42, 71.49 (C_{15}), 47.94, 45.98 (C_{13}), 38.32, 34.07 (C_1), 32.68, 32.58 (C_4), 27.85, 27.06 (C_{17}), 26.52, 26.43 (C_3), 21.77, 21.37 (C_2); HRMS [M+Na$^+$] m/z ES calc'd for [$C_{17}H_{21}NONa$]$^+$: 278.1515; observed: 278.1505; IR 3353, 3292, 2956, 2926, 1640, 1485, 1282, 967 cm^{-1}.



SI-18 *SI-24*

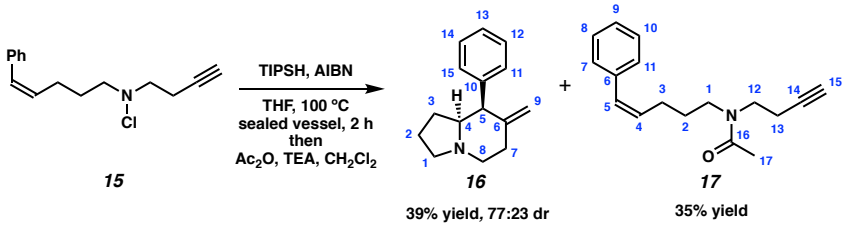
(*Z*)-*N*-(but-3-yn-1-yl)-5-phenylpent-4-en-1-amine (SI-24). To a solution of 1-amino-3-butyne (0.66 mL, 8.0 mmol) in DMF (20 mL) under nitrogen was added K_2CO_3 (1.1 g, 8.0 mmol) followed by dropwise addition of **SI-18** (0.89 g, 4.0 mmol) in DMF (5 mL). The reaction mixture was stirred at room temperature for 6 h. Then the reaction was diluted with H_2O (25 mL) and extracted with EtOAc (3 × 30 mL). The combined organic layer was washed with brine solution (2 × 25 mL). The separated organic layer was dried over anhydrous Na_2SO_4. Solvent was removed under reduced pressure and purified by flash chromatography, the product was eluted with 25–30% EtOAc/Hexanes as colorless liquid (0.34 g, 42% yield). R_f = 0.3 (20% EtOAc/Hexane). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.36 – 7.17 (m, 5H, $C_{7,}$ $C_{8,}$ $C_{9,}$ $C_{10,}$ C_{11}), 6.43 (d, J = 11.6 Hz, 1H, C_5), 5.66 (dt, J = 11.6, 7.3 Hz, 1H, C_4), 2.75 (t, J = 6.6 Hz, 2H, C_1), 2.64 (t, J = 7.24 Hz, 2H, C_{12}), 2.43 – 2.31 (m, 4H, $C_{3,}$ C_{13}), 2.01 – 1.92 (m, 1H, C_{15}), 1.64 (q, J = 7.3 Hz, 2H, C_2), 1.34 (s, 1H, N); ^{13}C NMR (101 MHz, $CDCl_3$) δ 137.56 (C_6), 132.29 (C_5), 129.25 (C_9), 128.71 ($C_{7,}$ C_{11}), 128.12 ($C_{8,}$ C_{10}), 126.51 (C_4), 82.49 (C_{14}), 69.42 (C_{15}), 48.83 (C_{12}), 47.91 (C_1), 30.25 (C_{13}), 26.28 (C_3), 19.55 (C_2); HRMS [M+H$^+$] m/z ES calc'd for [$C_{15}H_{20}N$]$^+$: 214.1590; observed: 214.1584; IR (neat) 3305, 2930, 1498, 1450, 1127, 769, 700 cm^{-1}.



SI-24 *15*

(*Z*)-*N*-(but-3-yn-1-yl)-*N*-chloro-5-phenylpent-4-en-1-amine (15). To a solution of the amine (0.21 g, 1.00 mmol) in CH_2Cl_2 (15 mL) at 0 °C under nitrogen was added *N*-chlorosuccinamide (0.15 g, 1.10 mmol) in portions over 5 minutes. The reaction mixture was stirred for 2 hours at the same temperature, and the solvent was evaporated under vacuum. The crude product was purified by column chromatography, product was eluted with 3-5% EtOAc/Hexanes as a colorless oil (0.19 g, 77% yield). R_f=0.8 (10% EtOAc/Hexane). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.39 – 7.13 (m, 5H, $C_{7,}$ $C_{8,}$ $C_{9,}$ $C_{10,}$ C_{11}), 6.45 (d, J = 11.6 Hz, 1H, C_5), 5.65 (dt, J = 11.7, 7.3 Hz, 1H, C_4), 3.08 (t, J = 7.3 Hz, 2H, C_{12}), 2.97 (t, J = 8.0 Hz, 2H, C_1), 2.56 (td, J = 7.3, 2.6 Hz, 2H, C_3), 2.40 (qd, J = 7.5, 1.7 Hz, 2H, C_{13}), 1.97 (t, J = 2.6 Hz, 1H, C_{15}), 1.83 (p, J = 7.4 Hz, 2H, C_2); ^{13}C NMR (101 MHz, $CDCl_3$) δ 137.46 (C_6), 131.78 (C_5), 129.63 (C_9), 128.71 ($C_{7,}$ C_{11}), 128.15 (C_8, C_{10}), 126.58 (C_4), 81.40 (C_{14}), 69.43 (C_{15}), 63.53 (C_{12}), 62.35 (C_1), 27.97

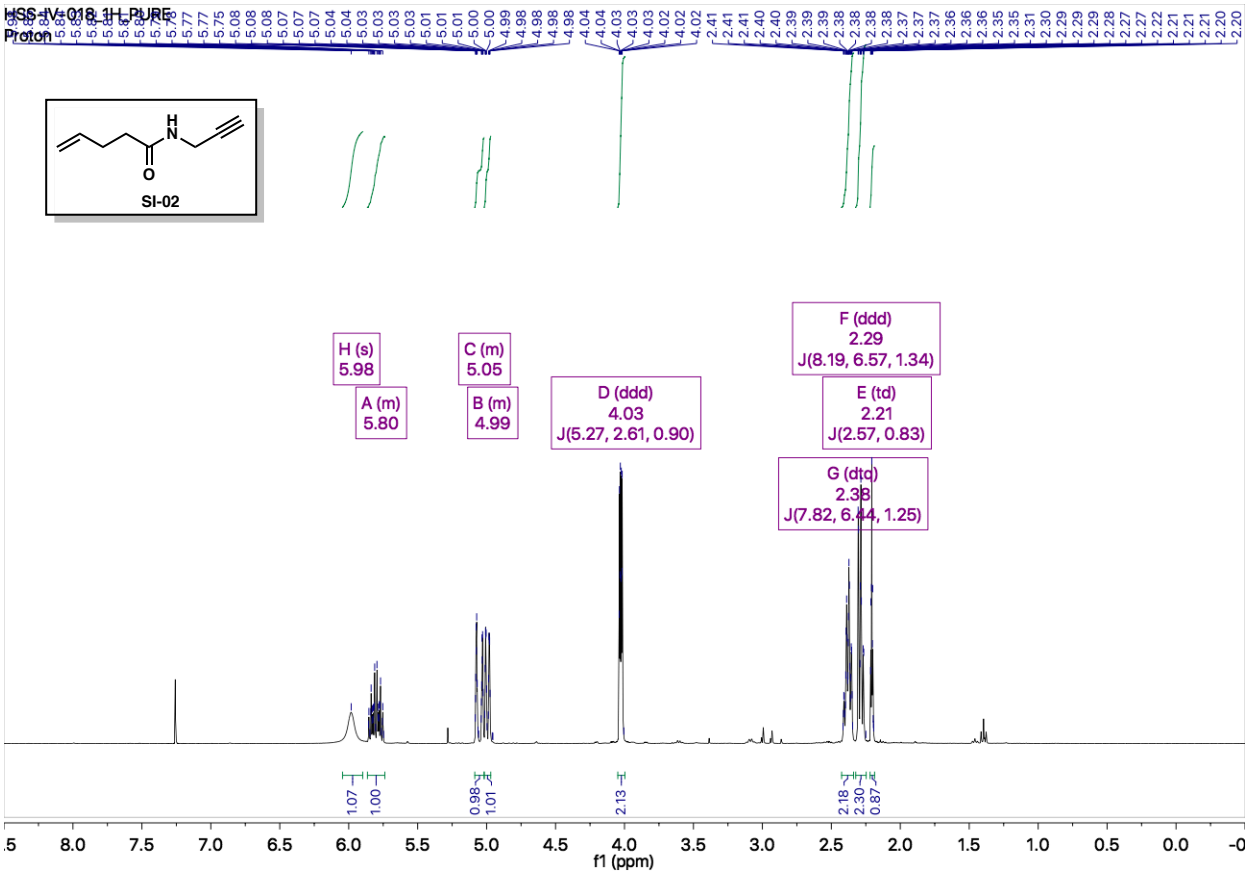
(C_3), 25.64 (C_{13}), 17.80 (C_2); HRMS [M+H$^+$] m/z ES calc'd for [$C_{15}H_{19}NCl$]$^+$: 248.1201; observed: 248.1199; IR (neat) 3300, 2935, 2836, 1493, 1445, 1106, 763, 703 cm^{-1}.

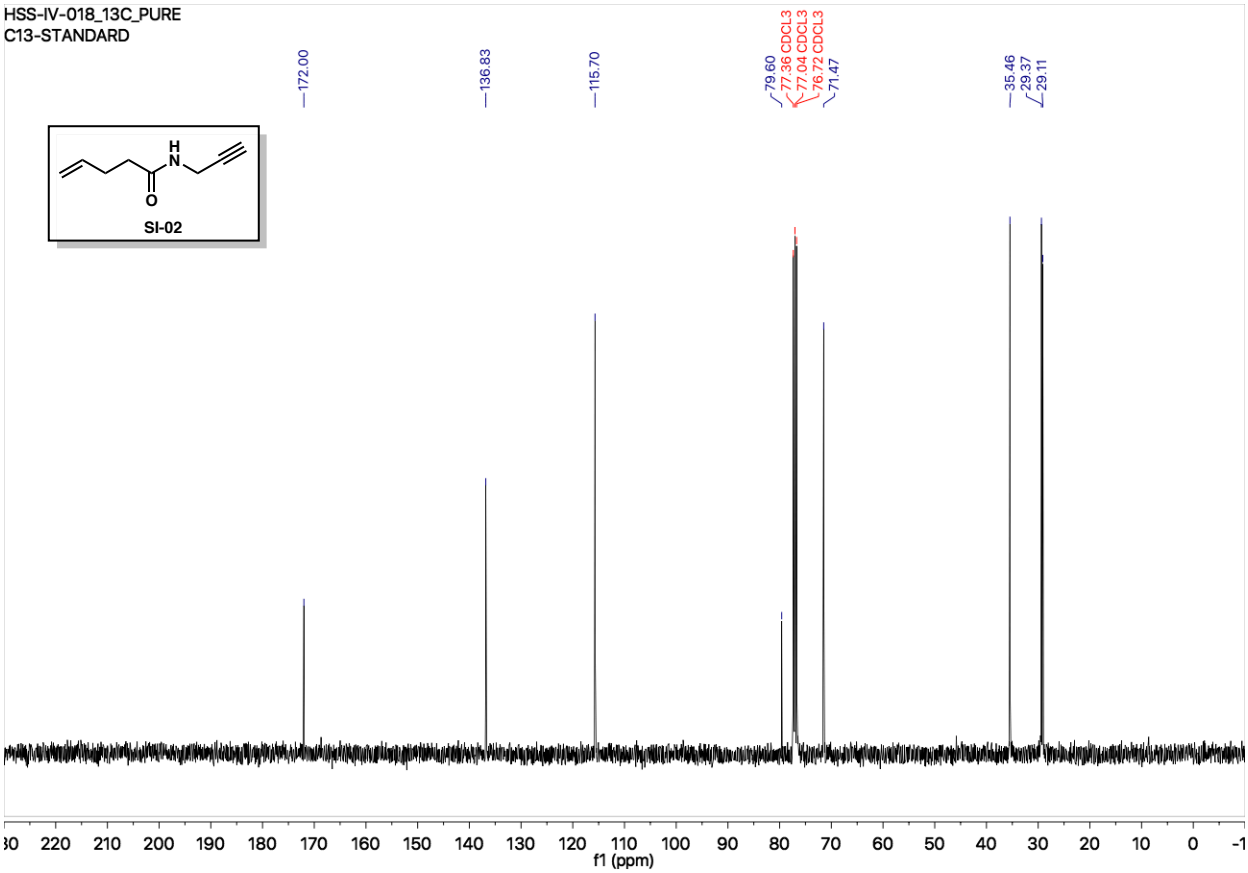


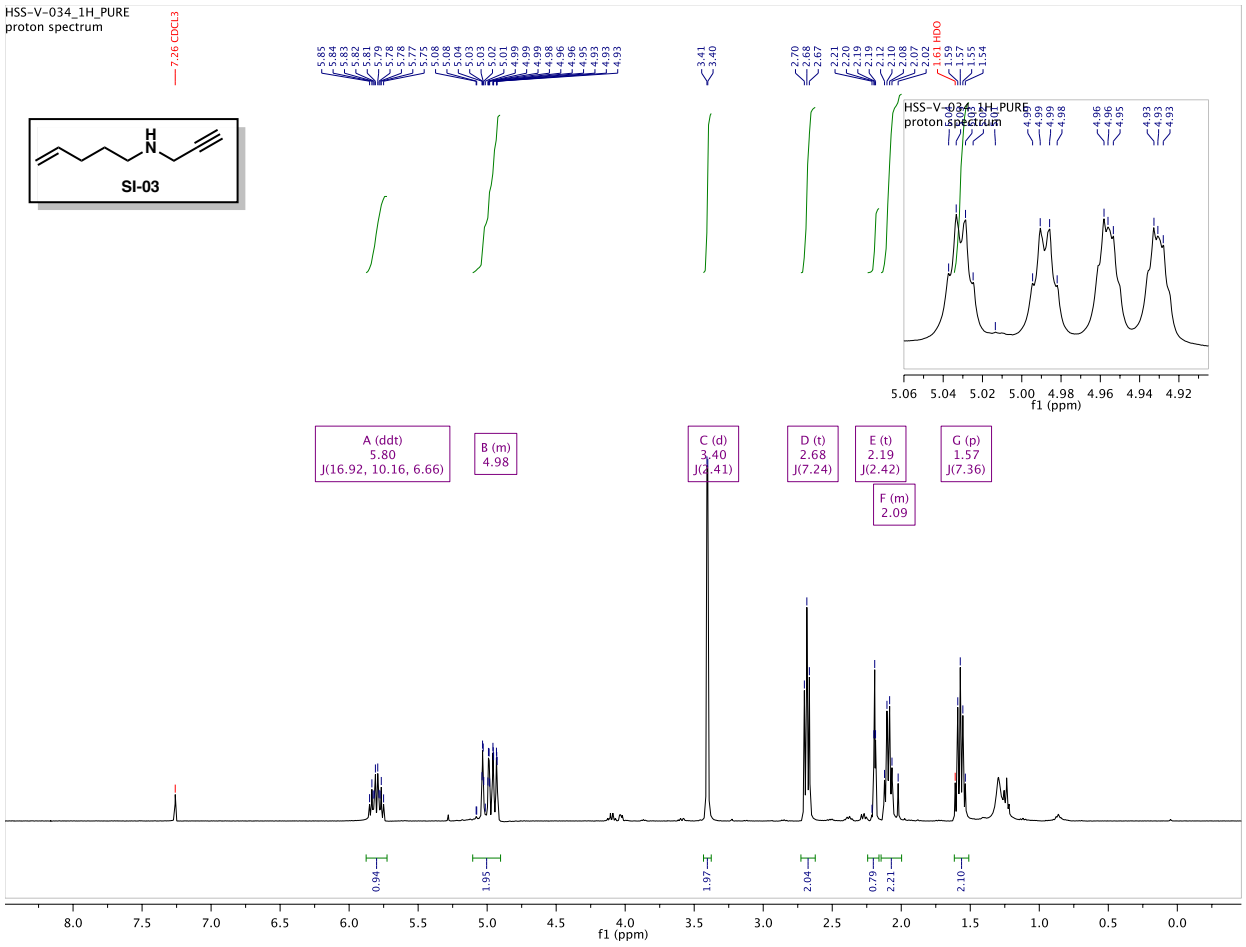
7-methylene-8-phenyloctahydroindolizine (16). To a flame dried microwave vessel under argon was added the chloroamine **15** (99.1 mg, 0.40 mmol) and AIBN (13.14 mg, 0.08 mmol) in THF (22 mL). Then was added TIPSH (0.16 mL, 0.80 mmol) to the reaction solution. The vessel was sealed and was dipped in a hot oil bath (100 ºC) and stirred for 2 h. **CAUTION:** REACTIONS UNDER PRESSURE SHOULD BE HANDLED IN A FUME HOOD BEHIND A BLAST SHIELD. The reaction mixture was evaporated and dissolved in CH_2Cl_2 (10 mL) and was subjected to acetylation (for the ease of separation of reduced product and 16) (with 0.045 mL of Ac_2O and 0.11 mL of Et_3N, for about 0.5 h). The reaction mixture was evaporated, was added 10% HCl (4 mL). The aqueous layer was washed with Et_2O (3 × 8 mL), the separated aqueous layer was basified to pH ~ 9 using 6N NaOH and the cyclized product was extracted with CH_2Cl_2 (3 × 10 mL). Combined organic layer was dried over anhydrous Na_2SO_4 and excess solvent was removed under reduced pressure. Crude product was purified by column chromatograph (basic alumina) (6-9% EtOAc/Hexanes to obtain as colorless oil (33.3 mg, 39% yield: dr 77:23). R_f= 0.30 (5% MeOH/CH_2Cl_2). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.36 – 7.10 (m, 5H, $C_{11,}$ $C_{12,}$ $C_{13,}$ $C_{14,}$ C_{15}), 4.79 (d, *J* = 1.8 Hz, 1H, C_9), 4.13 (d, *J* = 1.7 Hz, 1H, C_9), 3.22 (ddd, *J* = 10.5, 5.2, 1.8 Hz, 1H, C_1), 3.19 – 3.08 (m, 2H, $C_{5,}$ C_1), 2.64 – 2.51 (m, 1H, C_7), 2.41 (dt, *J* = 13.7, 2.4 Hz, 1H, C_7), 2.27 – 2.13 (m, 3H, $C_{8,}$ C_4), 1.88 – 1.74 (m, 1H, C_3), 1.68 – 1.52(m, 2H, C_3, C_2), 1.40 – 1.27 (m, 1H, C_2); ^{13}C NMR (101 MHz, $CDCl_3$) δ 149.71 (C_{10}), 140.12 (C_6), 129.26 ($C_{12,}$ C_{14}), 128.12 ($C_{11,}$ C_{15}), 126.46 (C_{13}), 110.04 (C_9), 69.06 (C_4), 55.42 (C_5), 54.20 (C_1), 53.00 (C_8), 35.30 (C_7), 29.87 (C_2), 24.05 (C_3); HRMS [M+H$^+$] m/z ES calc'd for [$C_{15}H_{20}N$]$^+$: 214.1590; observed: 214.1585; IR (neat) 3305, 2921, 1498, 1450, 1105, 773, 635.

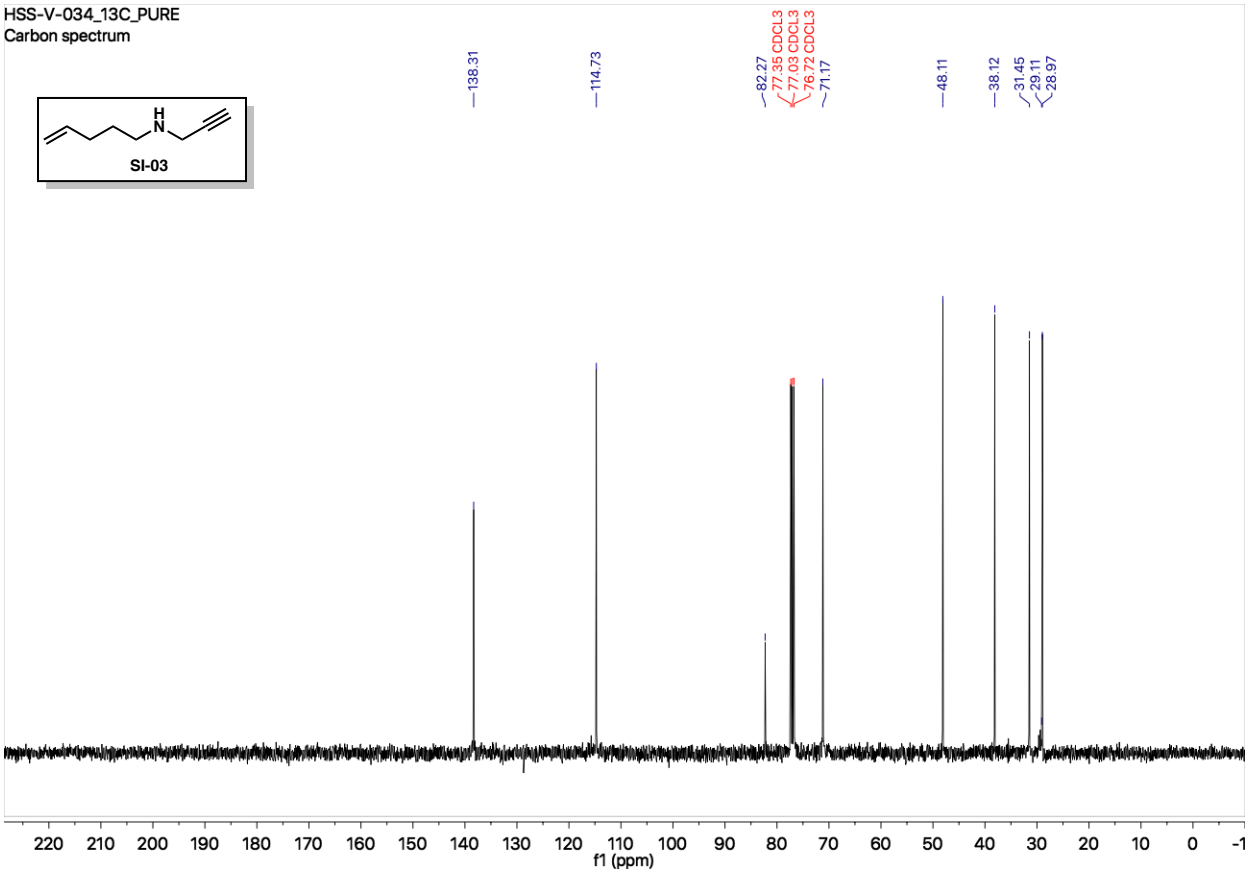
(*Z*)-*N*-(but-3-yn-1-yl)-*N*-(5-phenylpent-4-en-1-yl)acetamide (17). The combined Et_2O layer from above was dried over anhydrous Na_2SO_4 and solvent was removed under reduced pressure. Crude product was purified by column chromatograph (12-15% EtOAc/Hexanes to obtain as colorless oil (35.7 mg, 35% yield; mixture of rotamers A & B). R_f = 0.50 (40% EtOAc/Hexane). ^{1}H NMR (400 MHz, $CDCl_3$) 7.35 – 7.15 (m, 5H, $C_{7,}$ $C_{8,}$ $C_{9,}$ $C_{10,}$ C_{11}), 6.48 (d, *J* = 11.6 Hz, 0.57H, C_5 of rotamer A), 6.43 (d, *J* = 11.6 Hz, 0.41H, C_5 of rotamer B), 5.70 – 5.55 (m, 1H, C_4), 3.40 (dt, *J* = 14.2, 7.0 Hz, 2H, C_{12}), 3.36 – 3.26 (m, 2H, C_1), 2.49 – 2.27 (m, 4H, $C_{3,}$ C_{13}), 2.11 (s, 1.23H, C_{17} of rotamer B), 2.04 (s, 1.86H, C_{17} of rotamer A), 2.01 (t, *J* = 2.54 Hz, 0.36H, C_{15} of rotamer B), 1.94 (d, *J* = 2.58 Hz, 0.51H, C_{15} of rotamer A), 1.77 – 1.63 (m, 2H, C_2); ^{13}C NMR (101 MHz, $CDCl_3$) (mixture of rotamers A, B) δ 170.35 (C_{16}), 137.43, 137.17 (C_6), 131.74, 130.82 (C_5), 130.25, 129.52 (C_9), 128.70, 128.64 ($C_{7,}$ C_{11}), 128.24, 128.14 ($C_{8,}$ C_{10}), 126.83, 126.58 (C_4), 82.05, 80.42 (C_{14}), 70.84, 69.56 (C_{15}), 49.30, 47.25 (C_{12}), 45.30, 45.07 (C_1), 29.07, 27.82 (C_{17}), 25.97, 25.65 (C_3), 21.70, 21.42 (C_{13}), 18.82, 17.64 (C_2); HRMS [M+Na$^+$] m/z ES calc'd for [$C_{17}H_{22}NO$]$^+$: 256.1696; observed: 256.1697; IR 3342, 2945, 2910, 1636, 1456, 1145, 958 cm^{-1}.

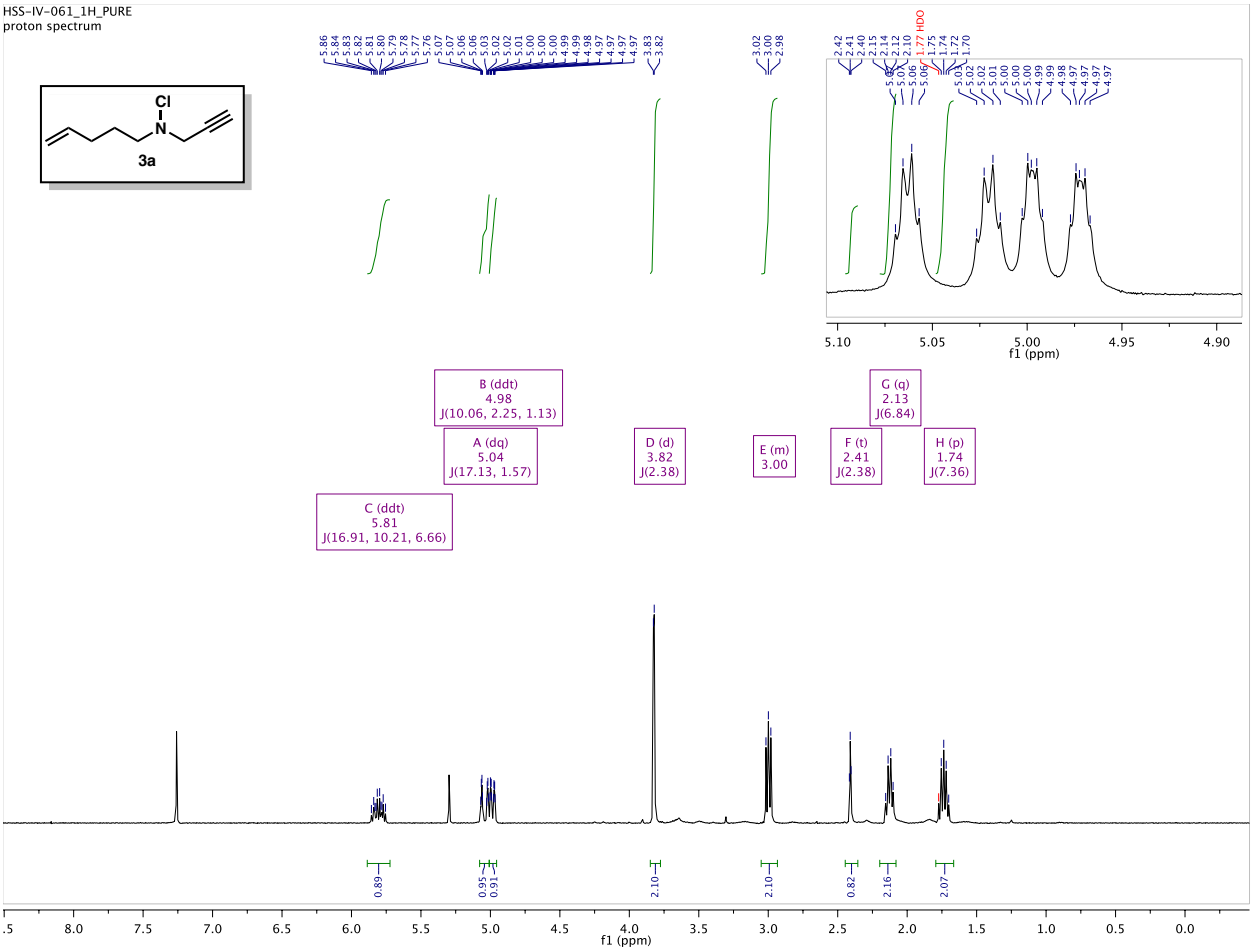
^{1}H, ^{13}C NMR Spectra

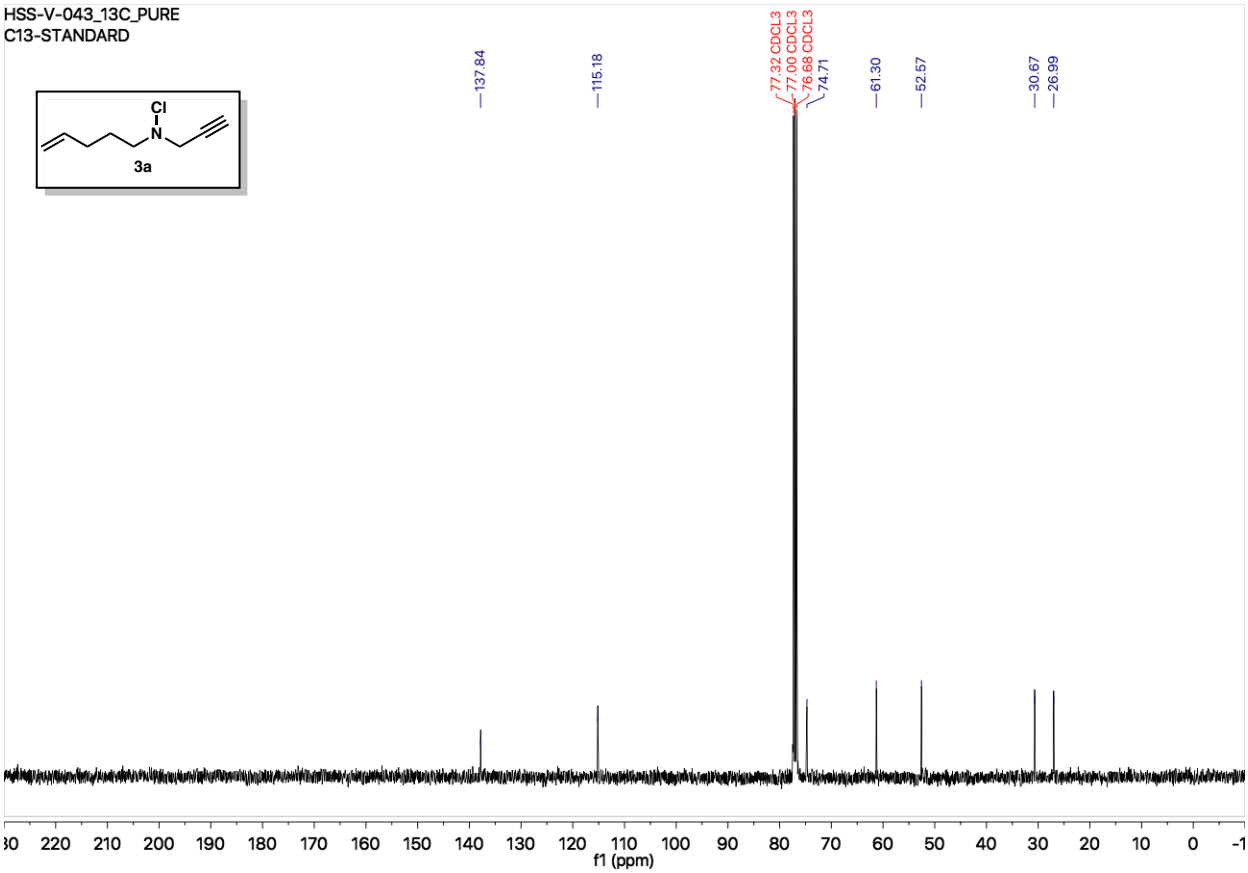


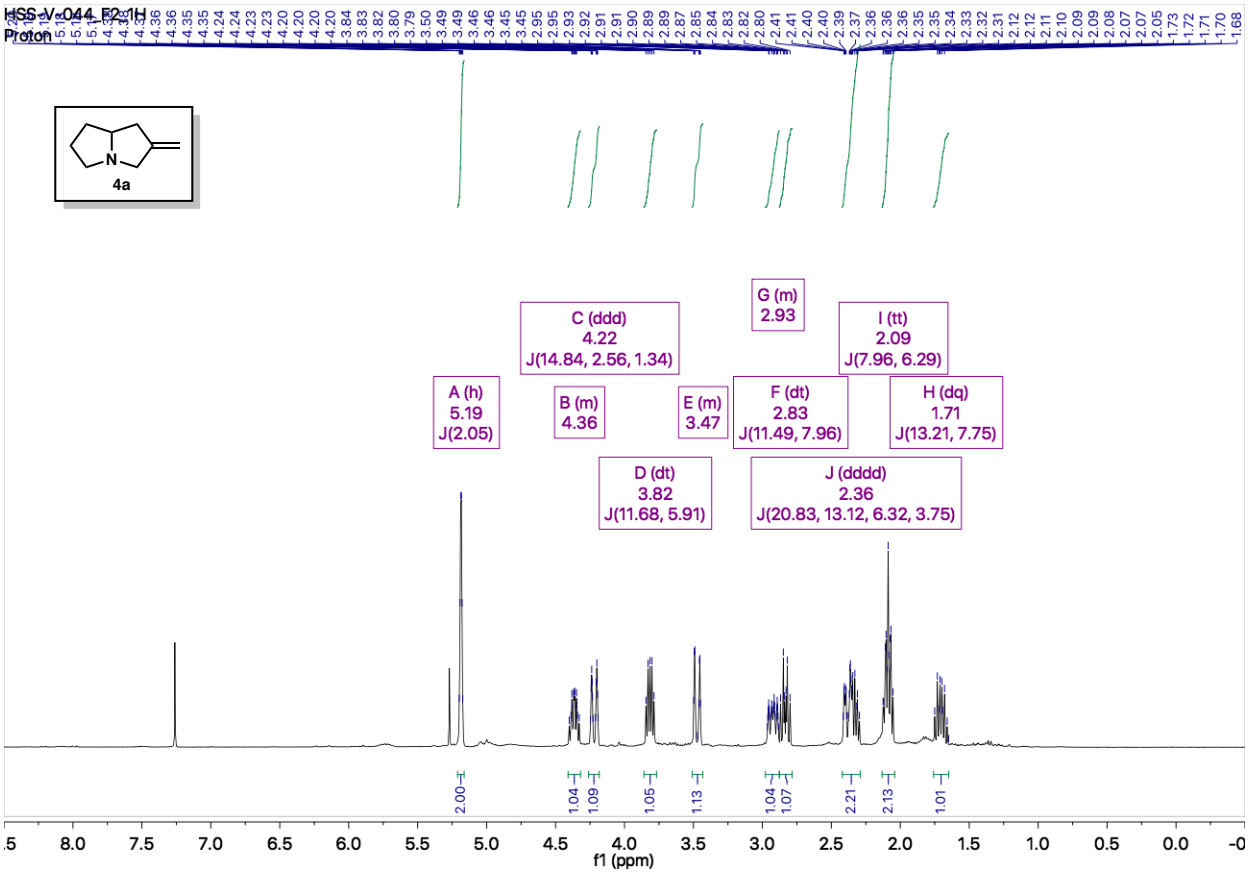

HSS-IV-018_13C_PURE
C13-STANDARD
172.00
136.83
115.70
79.60
77.36 CDCL3
77.04 CDCL3
76.72 CDCL3
71.47
35.46
29.37
29.11
SI-02
f1 (ppm)

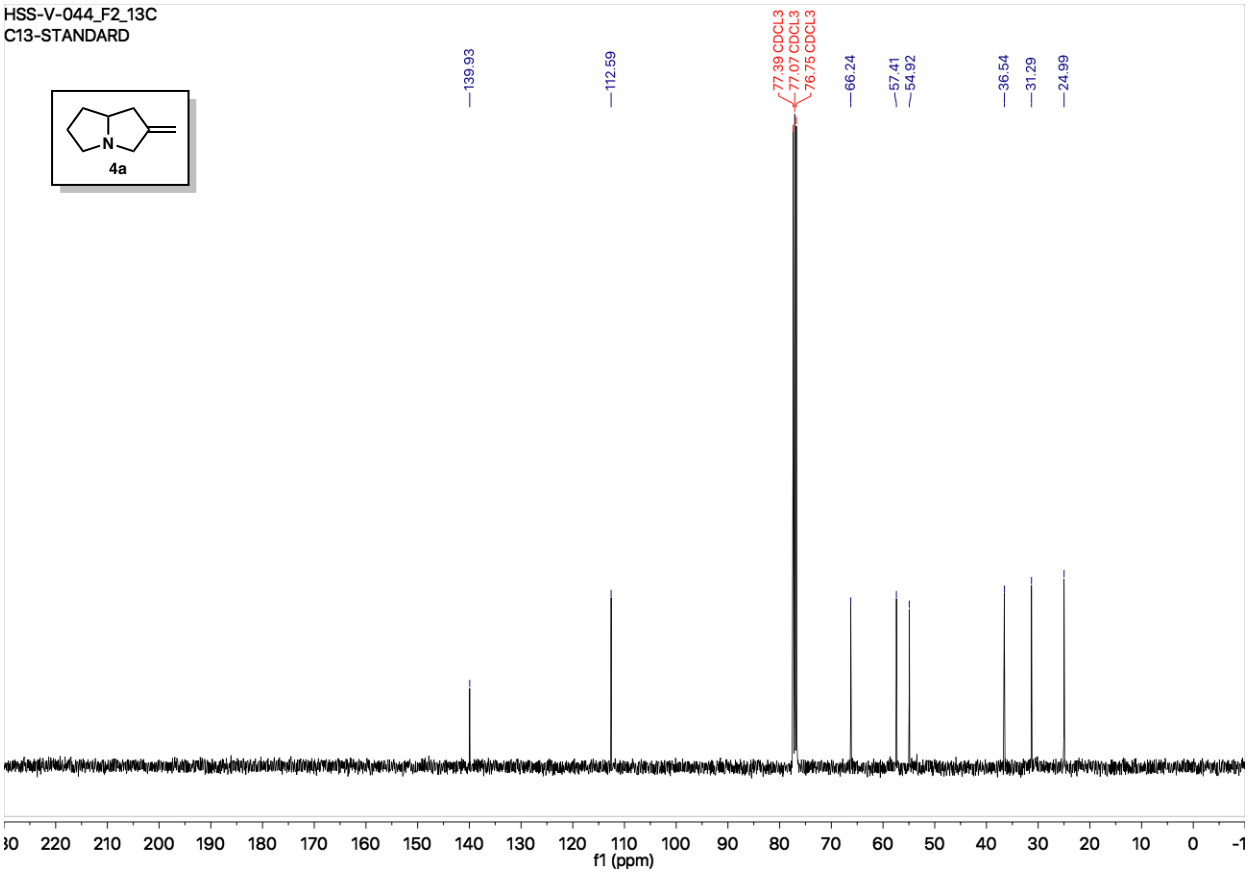

HSS-V-034_1H_PURE
proton spectrum
SI-03
A (ddt)
5.80
J(16.92, 10.16, 6.66)
B (m)
4.98
C (d)
3.40
J(7.41)
D (t)
2.68
J(7.24)
E (t)
2.19
J(2.42)
F (m)
2.09
G (p)
1.57
J(7.36)
f1 (ppm)

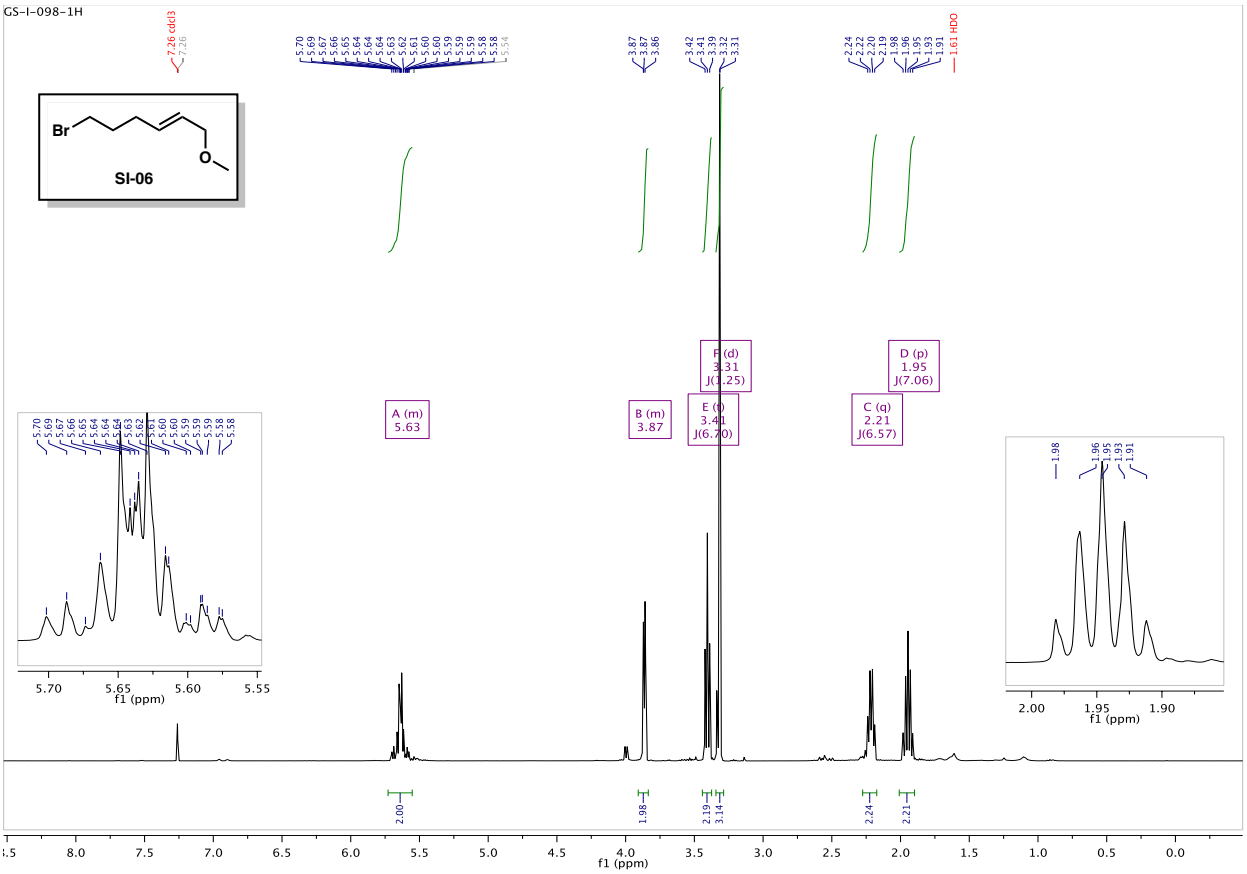

HSS-V-034_13C_PURE
Carbon spectrum
SI-03
138.31
114.73
82.27
77.35 CDCL3
77.03 CDCL3
76.72 CDCL3
71.17
48.11
38.12
31.45
29.11
28.97
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -1
f1 (ppm)

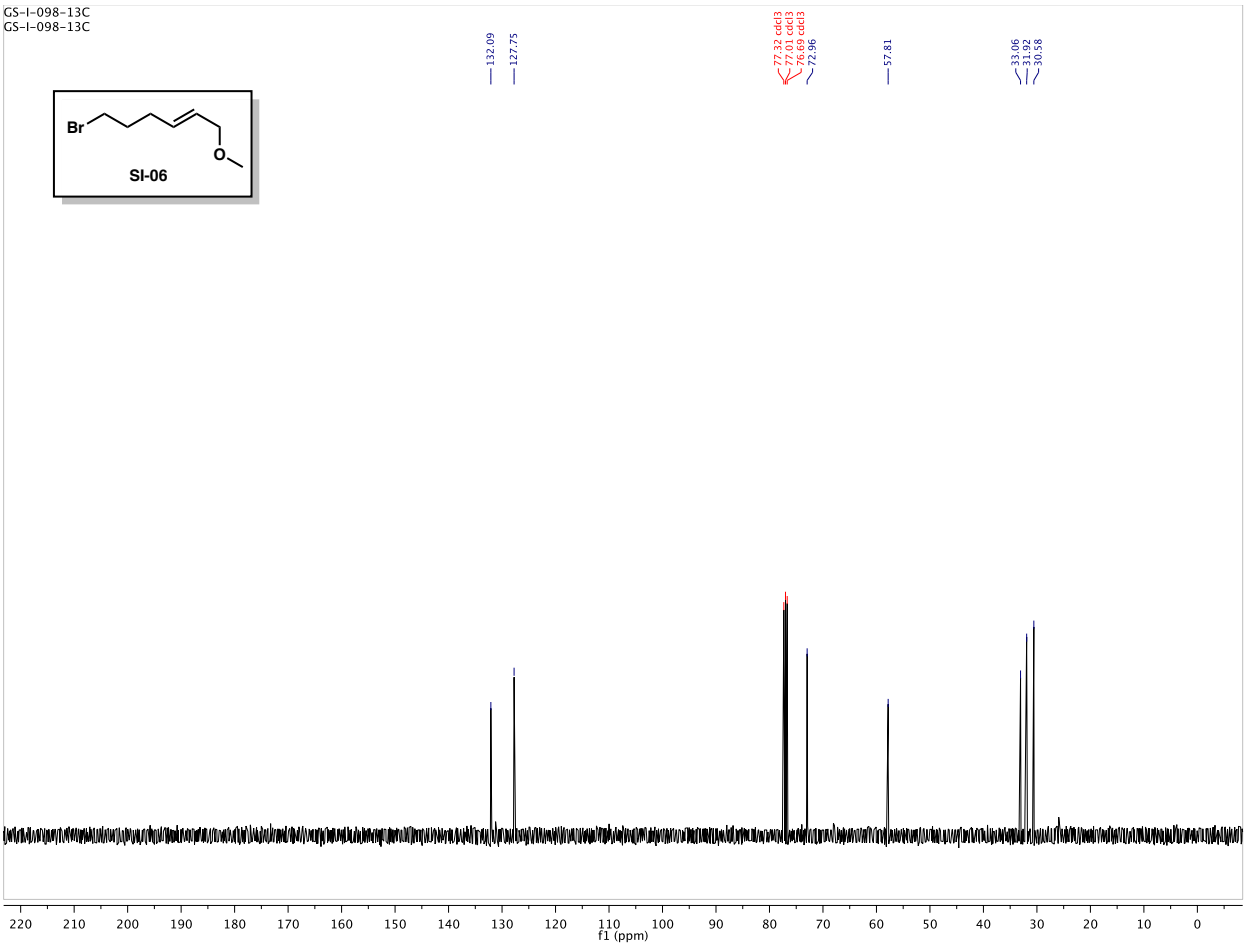

HSS-IV-061_1H_PURE
proton spectrum
Cl
N
3a
B (ddt)
4.98
J(10.06, 2.25, 1.13)
A (dq)
5.04
J(17.13, 1.57)
D (d)
3.82
J(2.38)
E (m)
3.00
G (q)
2.13
J(6.84)
F (t)
2.41
J(2.38)
H (p)
1.74
J(7.36)
C (ddt)
5.81
J(16.91, 10.21, 6.66)
HDO
f1 (ppm)

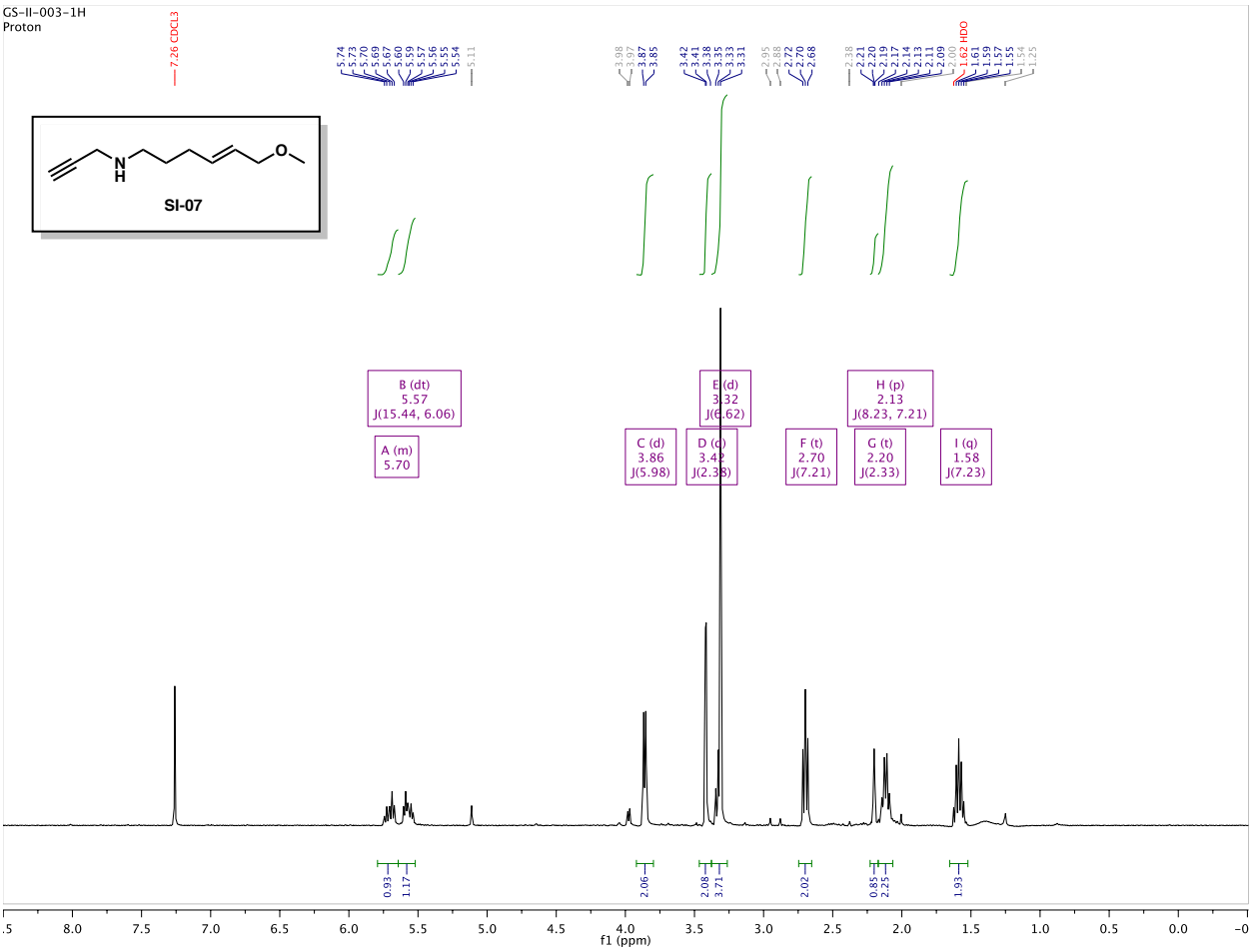

HSS-V-043_13C_PURE
C13-STANDARD
Cl
N
3a
137.84
115.18
77.32 CDCL3
77.00 CDCL3
76.68 CDCL3
74.71
61.30
52.57
30.67
26.99
f1 (ppm)

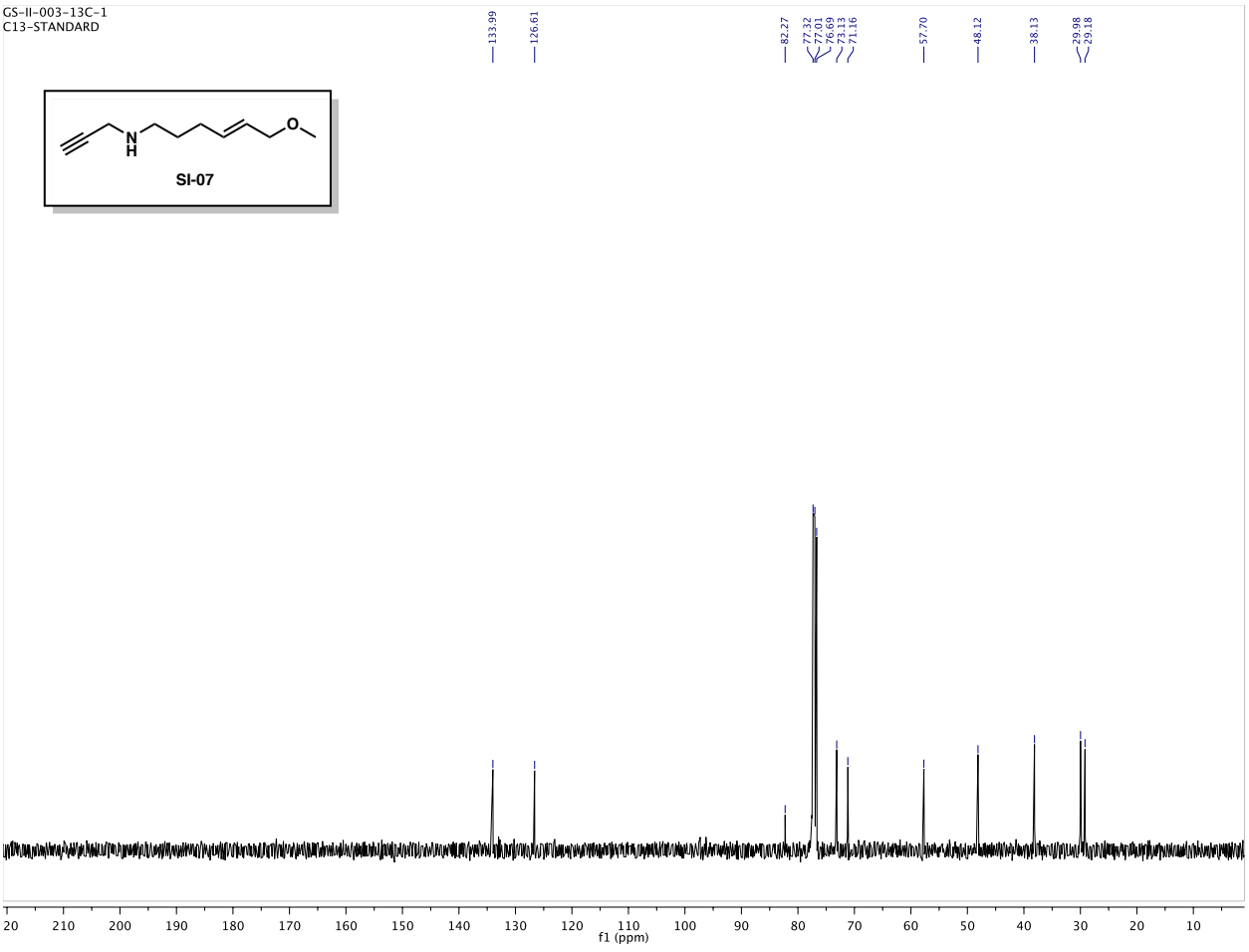

HSS-V-044_F2-1H
Proton
4a
A (h)
5.19
J(2.05)
B (m)
4.36
C (ddd)
4.22
J(14.84, 2.56, 1.34)
D (dt)
3.82
J(11.68, 5.91)
E (m)
3.47
F (dt)
2.83
J(11.49, 7.96)
G (m)
2.93
H (dq)
1.71
J(13.21, 7.75)
I (tt)
2.09
J(7.96, 6.29)
J (dddd)
2.36
J(20.83, 13.12, 6.32, 3.75)
2.00
1.04
1.09
1.05
1.13
1.04
1.07
2.21
2.13
1.01
f1 (ppm)

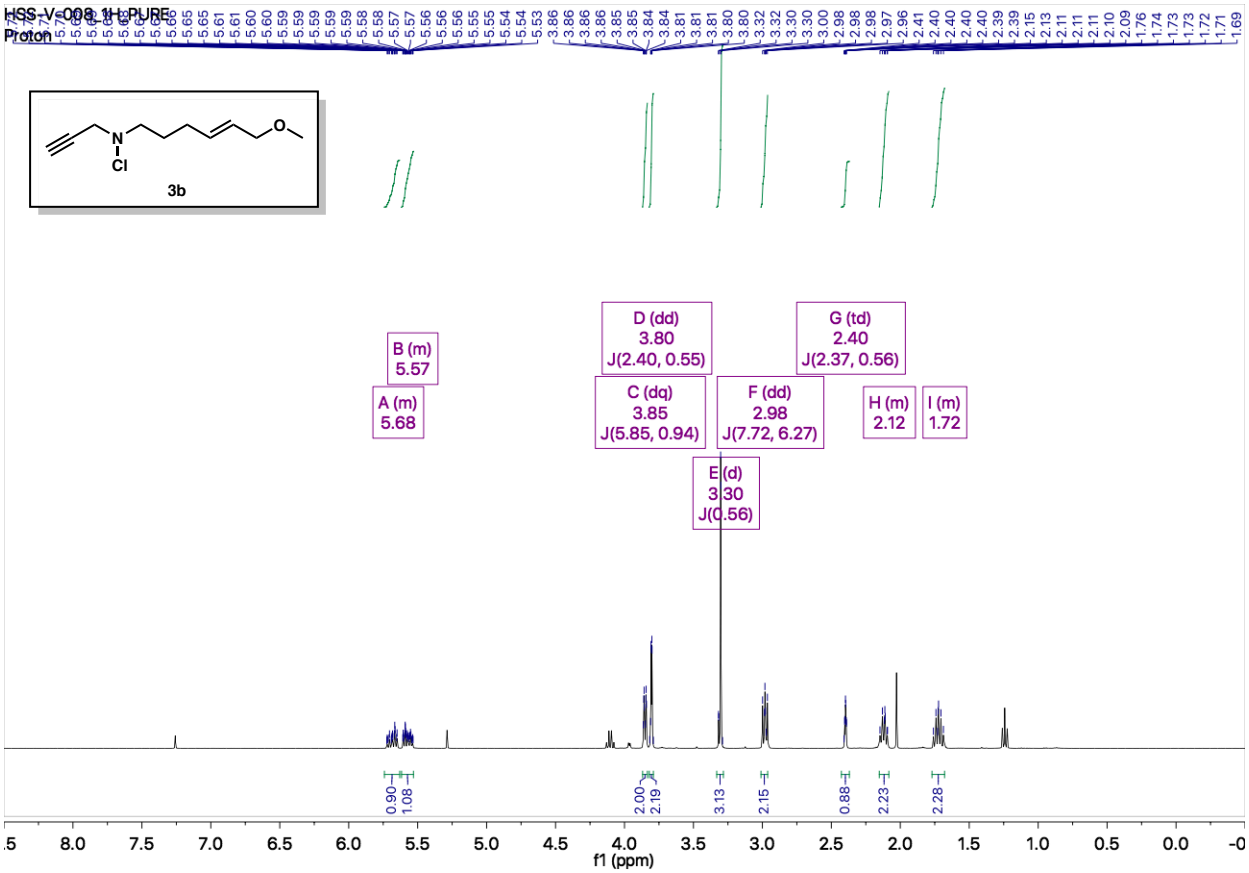

HSS-V-044_F2_13C
C13-STANDARD
4a
139.93
112.59
77.39 CDCL3
77.07 CDCL3
76.75 CDCL3
66.24
57.41
54.92
36.54
31.29
24.99
f1 (ppm)

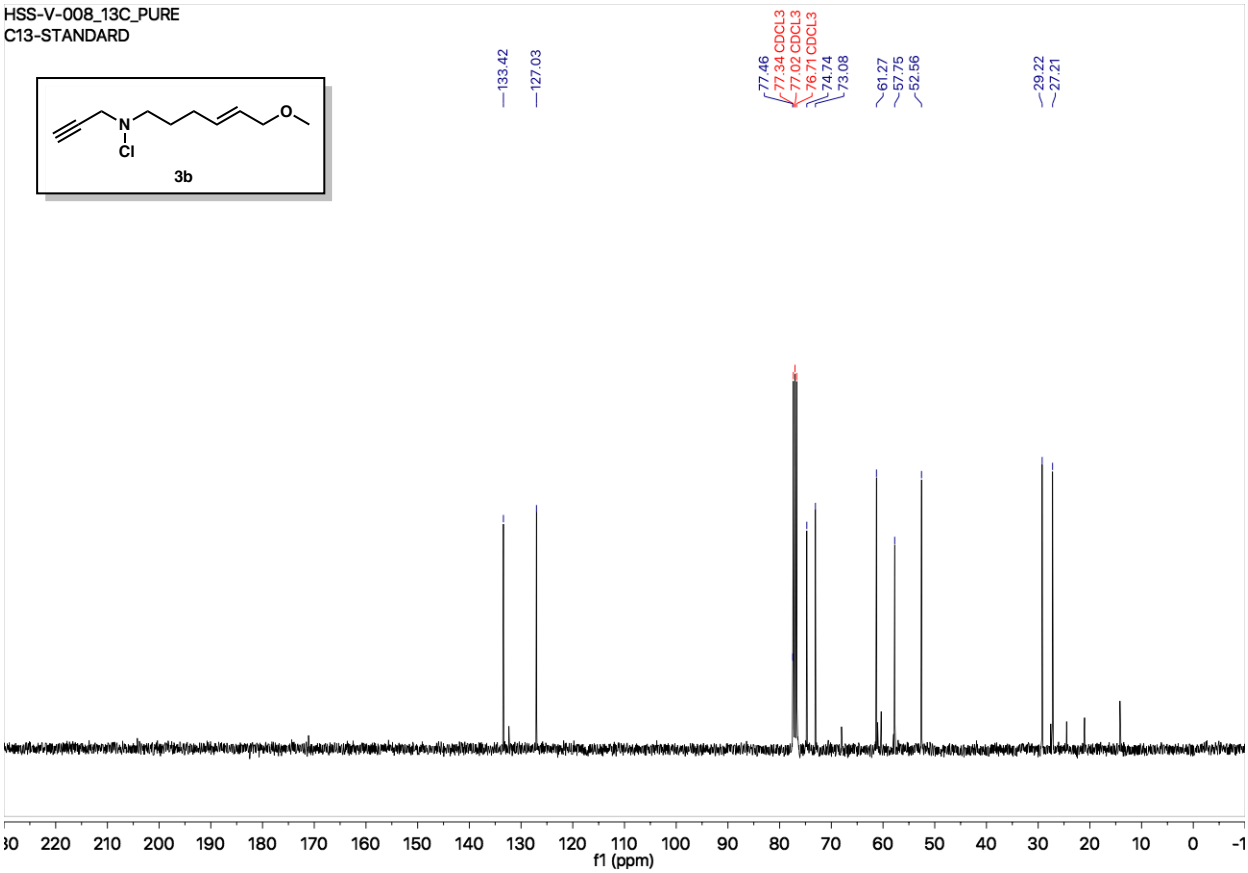

GS-I-098-1H
Br
O
SI-06
A (m)
5.63
B (m)
3.87
E (t)
3.41
J(6.70)
F (d)
3.31
J(7.25)
C (q)
2.21
J(6.57)
D (p)
1.95
J(7.06)
f1 (ppm)


GS-I-098-13C
GS-I-098-13C
132.09
127.75
77.32 cdcl3
77.01 cdcl3
76.69 cdcl3
72.96
57.81
33.06
31.32
30.98
Br
O
SI-06
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


GS-II-003-1H
Proton
7.26 CDCL3
HDO
SI-07
B (dt)
5.57
J(15.44, 6.06)
A (m)
5.70
C (d)
3.86
J(5.98)
E (d)
3.32
J(6.62)
D (d)
3.42
J(2.38)
F (t)
2.70
J(7.21)
H (p)
2.13
J(8.23, 7.21)
G (t)
2.20
J(2.33)
I (q)
1.58
J(7.23)
f1 (ppm)


GS-II-003-13C-1
C13-STANDARD
133.99
126.61
82.27
77.32
77.01
76.69
75.13
71.16
57.70
48.12
38.13
29.98
29.18
N
H
O
SI-07
f1 (ppm)


HSS-V-008-1H-PURE
Proton
N
Cl
O
3b
B (m)
5.57
A (m)
5.68
D (dd)
3.80
J(2.40, 0.55)
C (dq)
3.85
J(5.85, 0.94)
F (dd)
2.98
J(7.72, 6.27)
G (td)
2.40
J(2.37, 0.56)
H (m)
2.12
I (m)
1.72
E (d)
3.30
J(0.56)
0.90
1.08
2.00
2.19
3.13
2.15
0.88
2.23
2.28
f1 (ppm)


HSS-V-008_13C_PURE
C13-STANDARD
133.42
127.03
77.46
77.34 CDCL3
77.02 CDCL3
76.71 CDCL3
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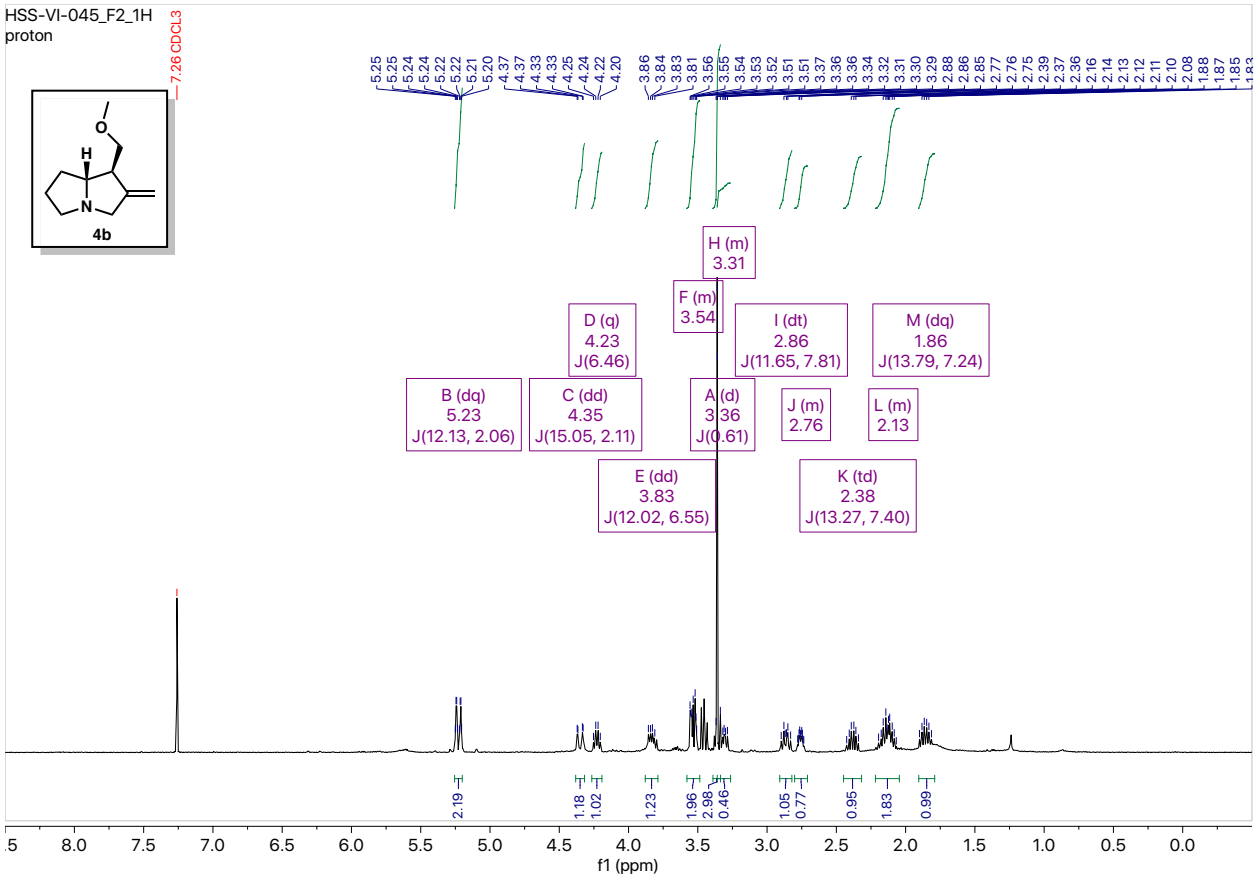
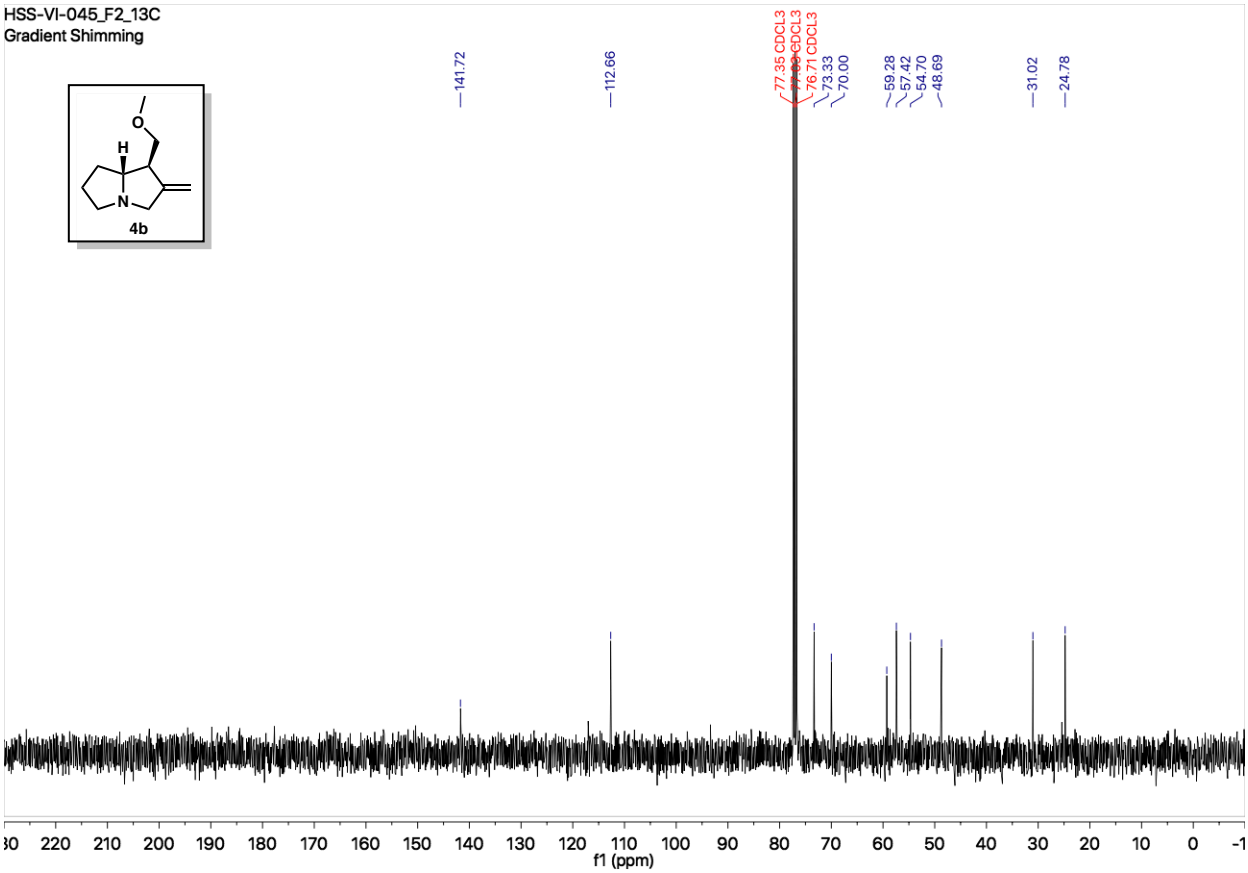
73.08
61.27
57.75
52.56
29.22
27.21
N
Cl
O
3b
f1 (ppm)


HSS-VI-045_F2_1H
proton
7.26 CDCl3
4b
H (m)
3.31
F (m)
3.54
D (q)
4.23
J(6.46)
I (dt)
2.86
J(11.65, 7.81)
M (dq)
1.86
J(13.79, 7.24)
B (dq)
5.23
J(12.13, 2.06)
C (dd)
4.35
J(15.05, 2.11)
A (d)
3.36
J(0.61)
J (m)
2.76
L (m)
2.13
E (dd)
3.83
J(12.02, 6.55)
K (td)
2.38
J(13.27, 7.40)
2.19
1.18
1.02
1.23
1.96
2.98
0.46
1.05
0.77
0.95
1.83
0.99
f1 (ppm)


HSS-VI-045_F2_13C
Gradient Shimming
141.72
112.66
77.35 CDCL3
77.03 CDCL3
76.71 CDCL3
73.33
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59.28
57.42
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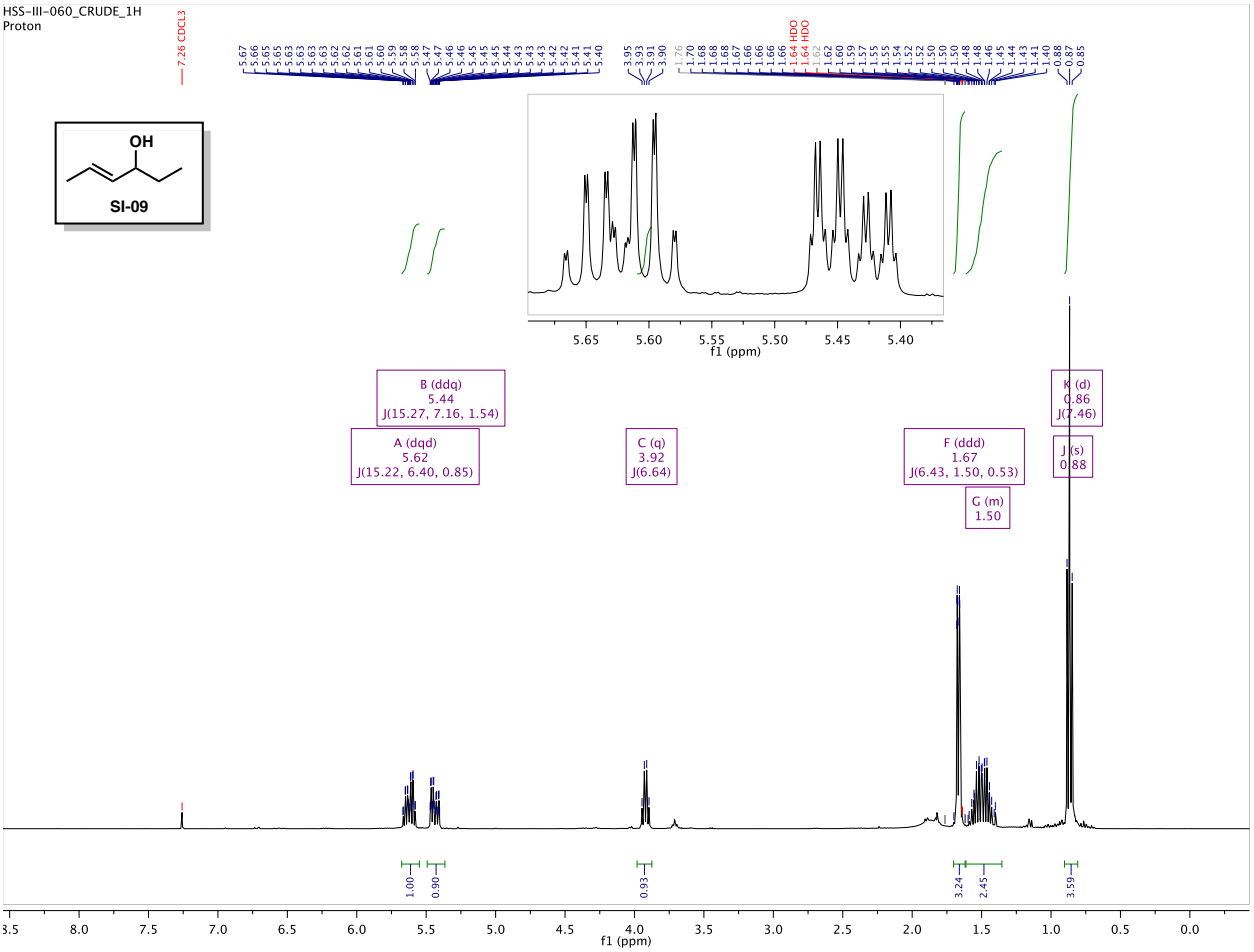
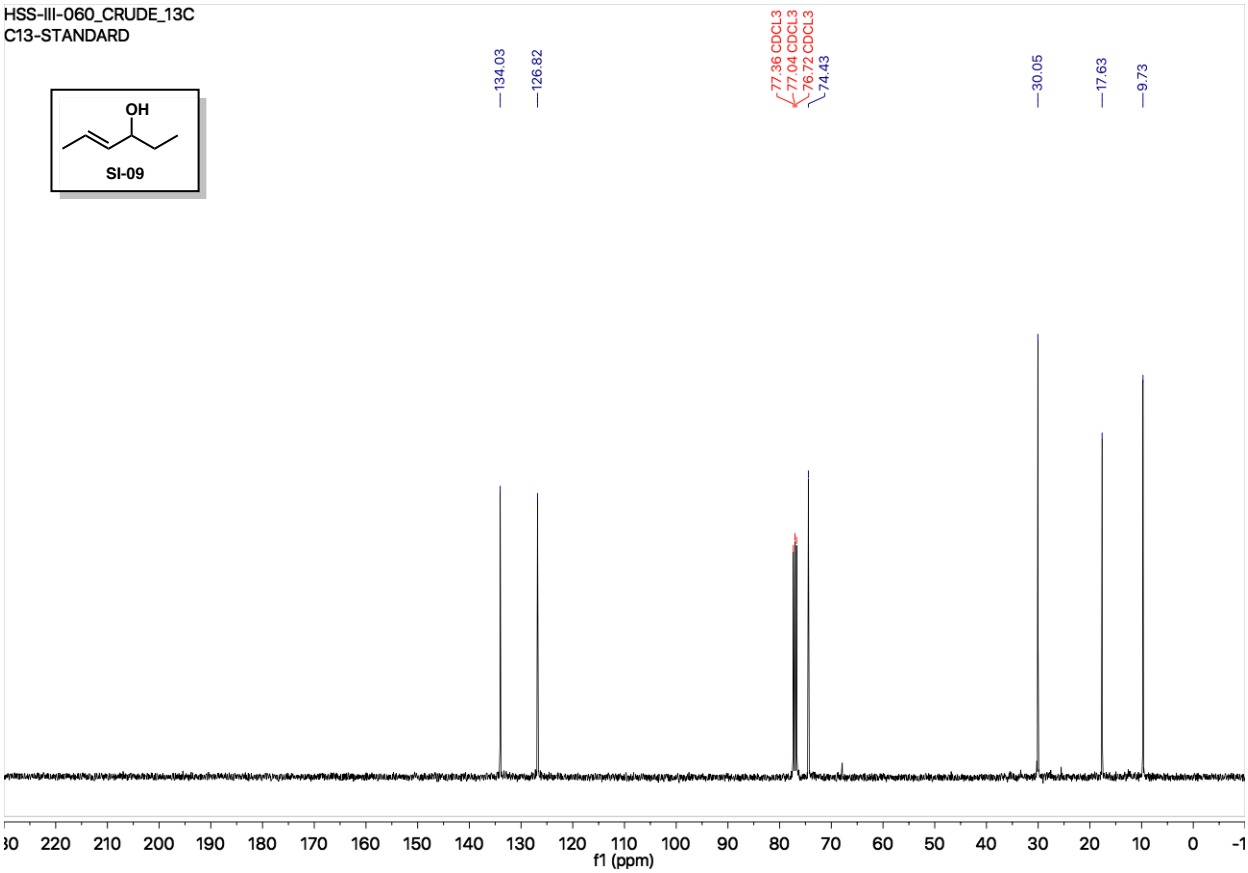
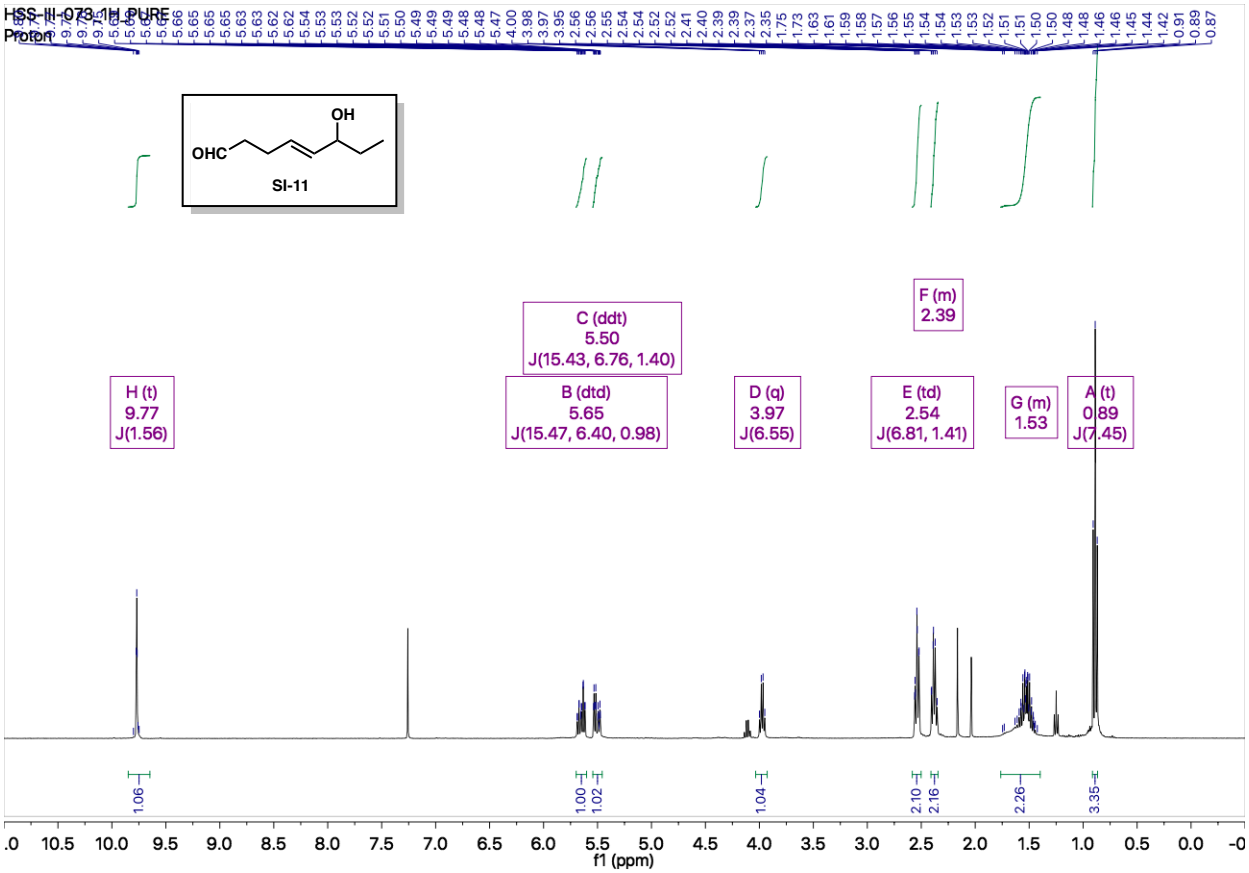
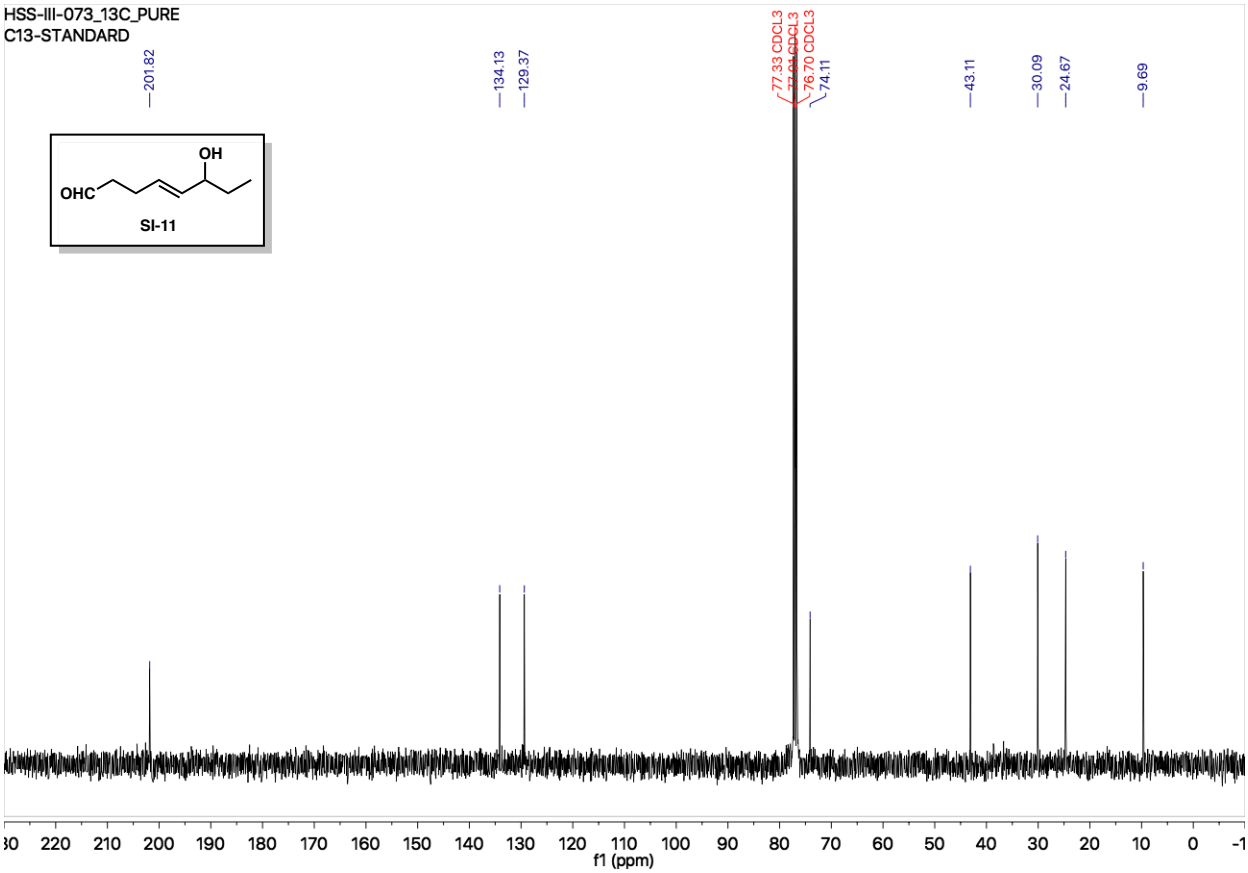
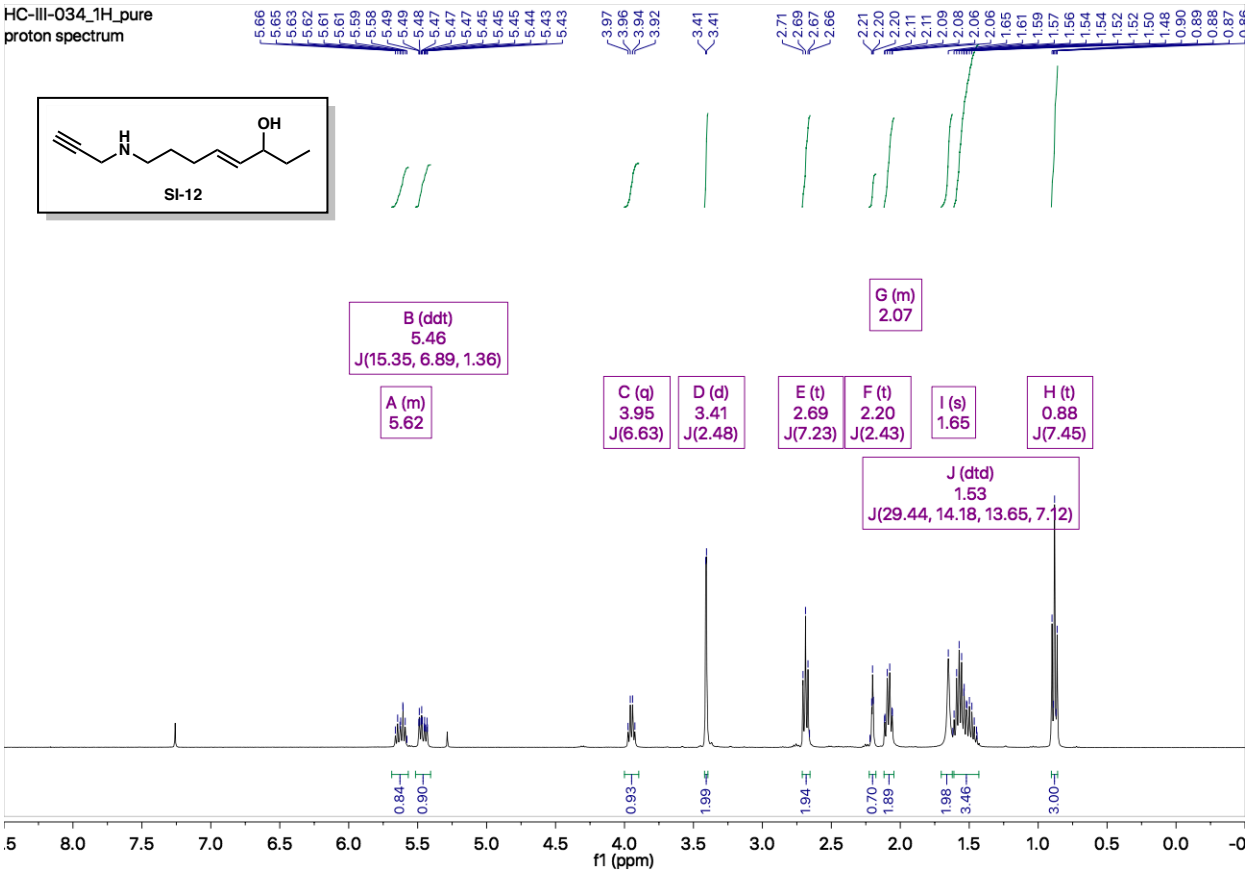
31.02
24.78
O
H
N
4b
f1 (ppm)

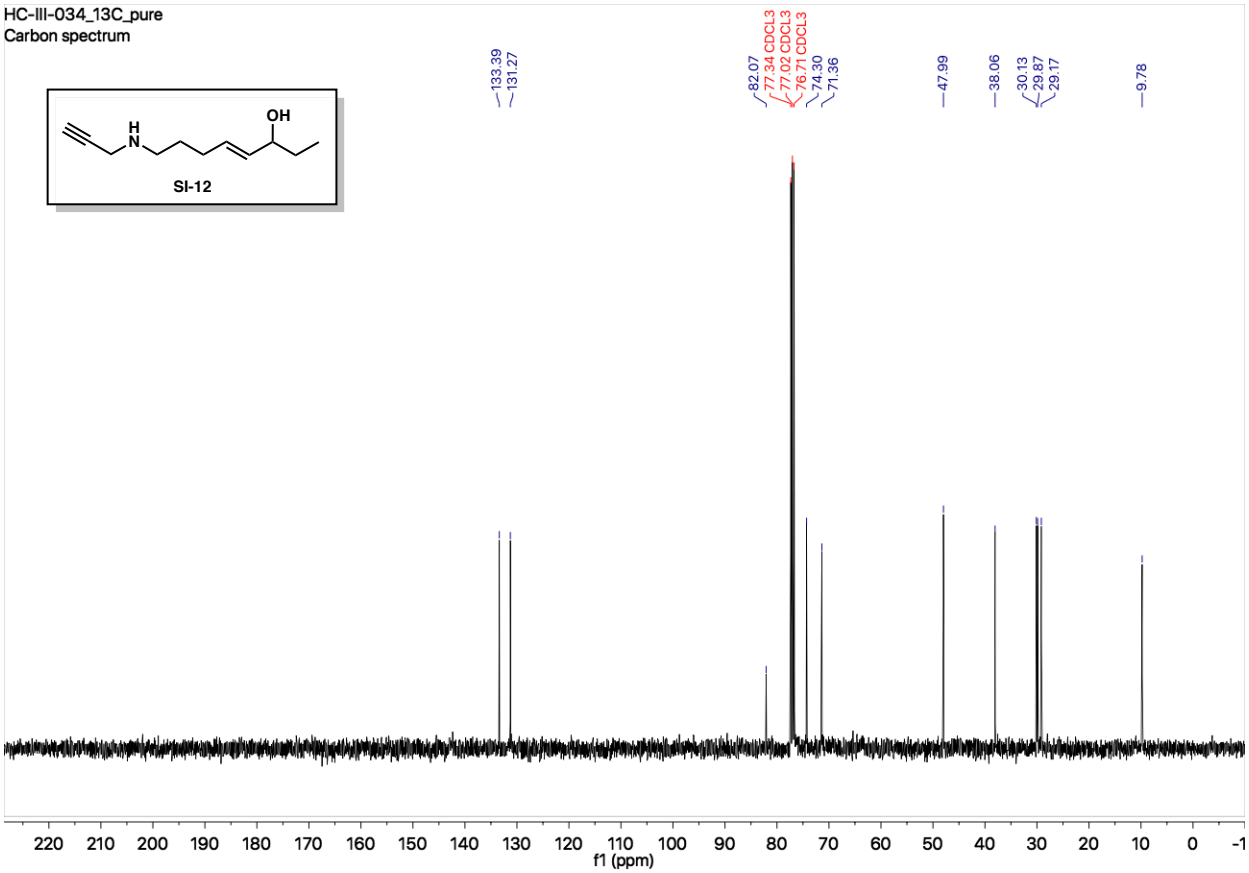

HSS-III-060_CRUDE_1H
Proton
OH
SI-09
B (ddq)
5.44
J(15.27, 7.16, 1.54)
A (dqd)
5.62
J(15.22, 6.40, 0.85)
C (q)
3.92
J(6.64)
F (ddd)
1.67
J(6.43, 1.50, 0.53)
G (m)
1.50
K (d)
0.86
J(7.46)
J (s)
0.88
f1 (ppm)

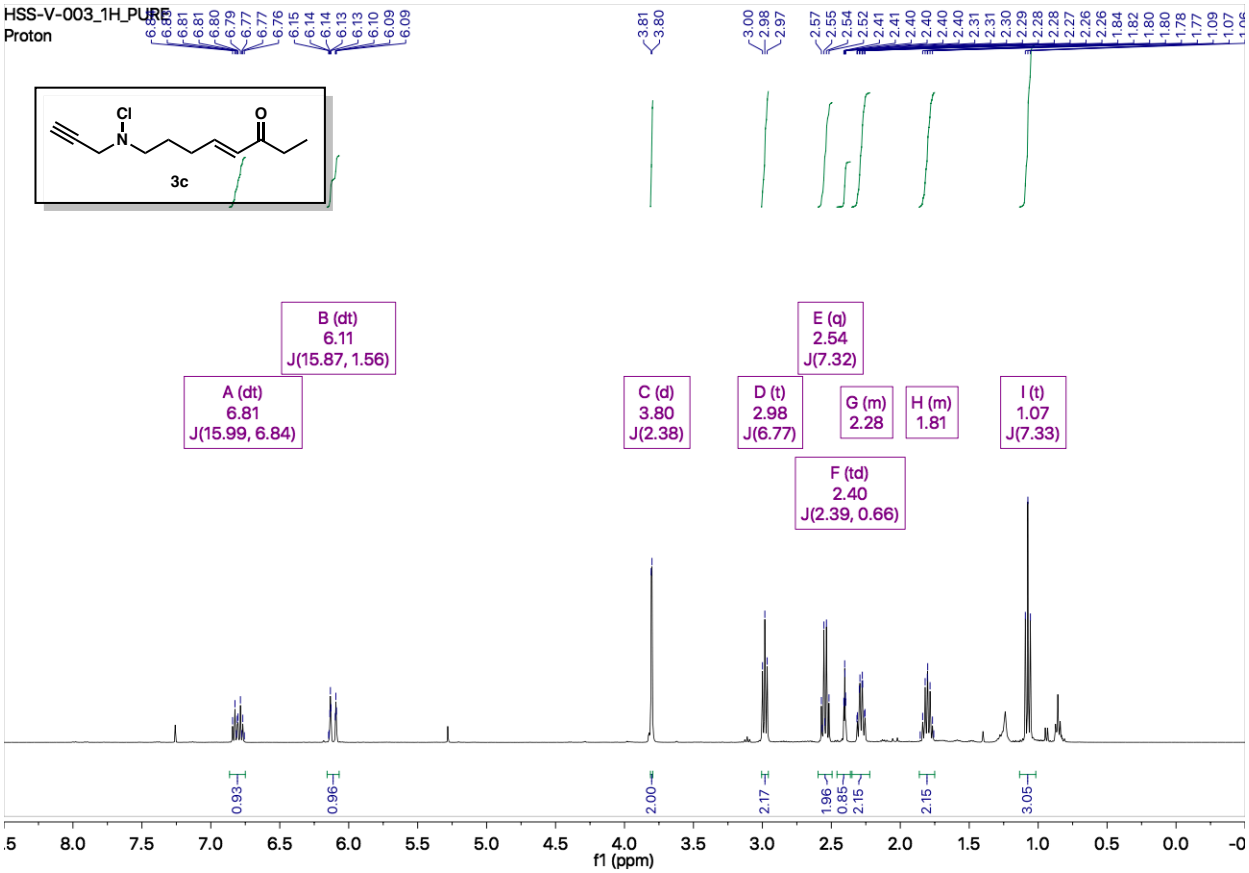

HSS-III-060_CRUDE_13C
C13-STANDARD
OH
SI-09
134.03
126.82
77.36 CDCL3
77.04 CDCL3
76.72 CDCL3
74.43
30.05
17.63
9.73
f1 (ppm)

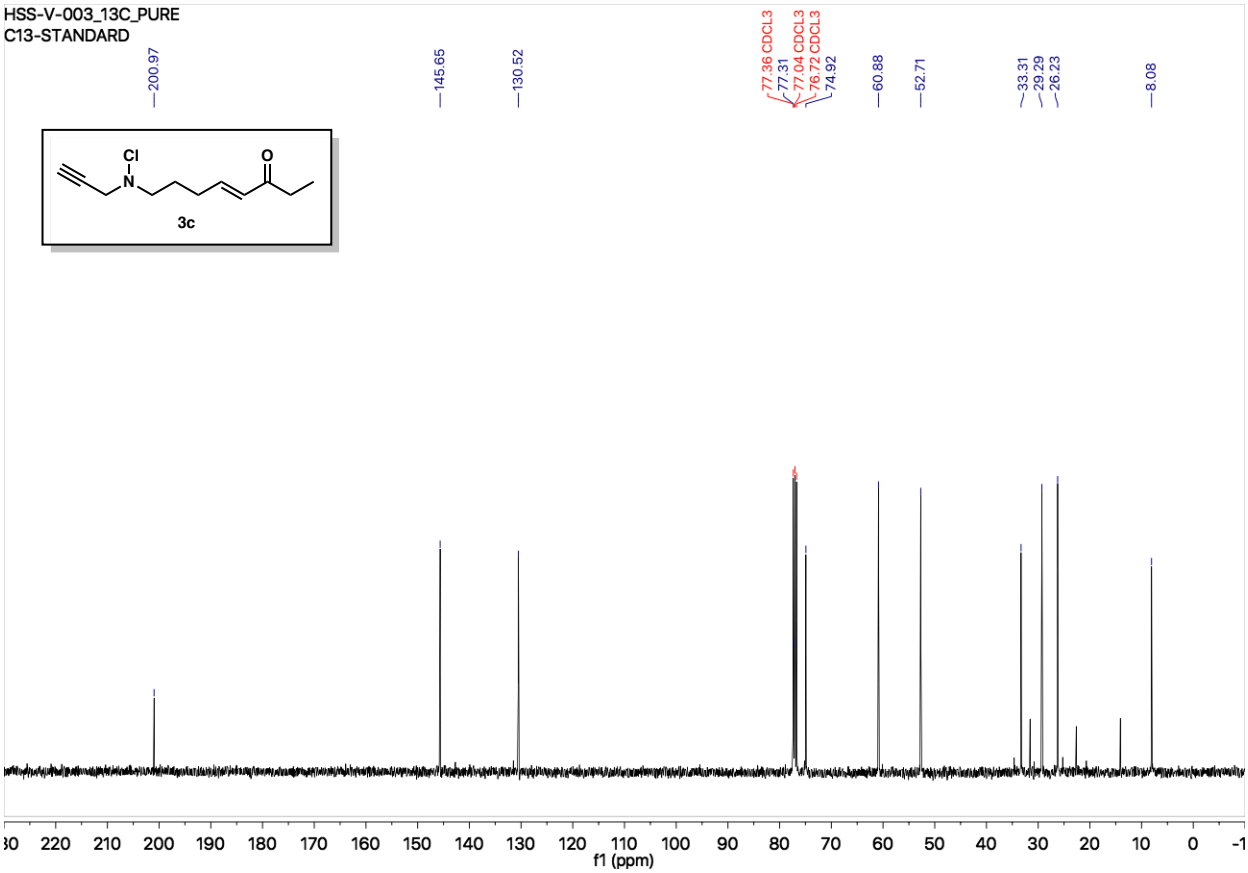

HSS-III-079-1H-PURE
Proton
OH
OHC
SI-11
H (t)
9.77
J(1.56)
C (ddt)
5.50
J(15.43, 6.76, 1.40)
B (dtd)
5.65
J(15.47, 6.40, 0.98)
D (q)
3.97
J(6.55)
F (m)
2.39
E (td)
2.54
J(6.81, 1.41)
G (m)
1.53
A (t)
0.89
J(7.45)
1.06
1.00
1.02
1.04
2.10
2.16
2.26
3.35
f1 (ppm)

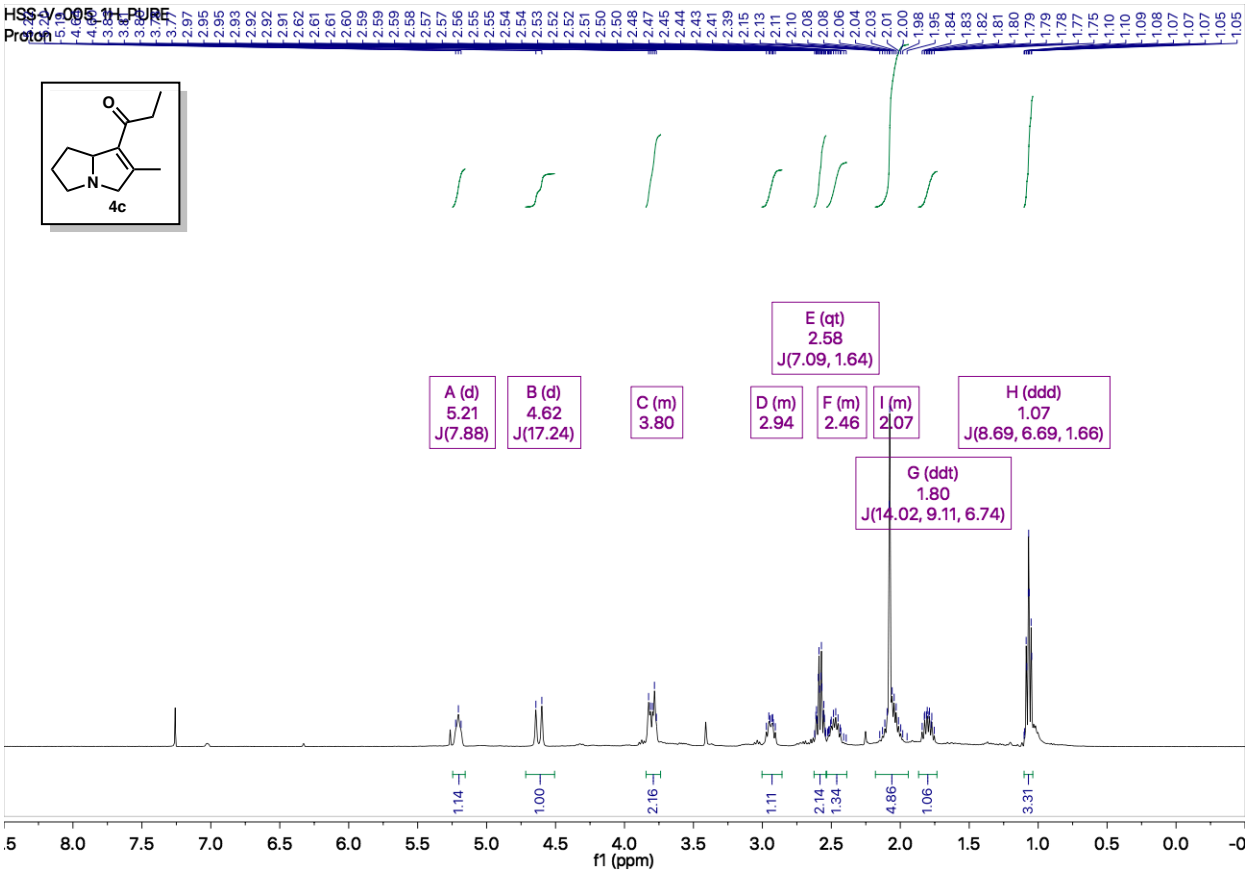

HSS-III-073_13C_PURE
C13-STANDARD
201.82
134.13
129.37
77.33 CDCL3
77.01 CDCL3
76.70 CDCL3
74.11
43.11
30.09
24.67
9.69
OH
OHC
SI-11
f1 (ppm)

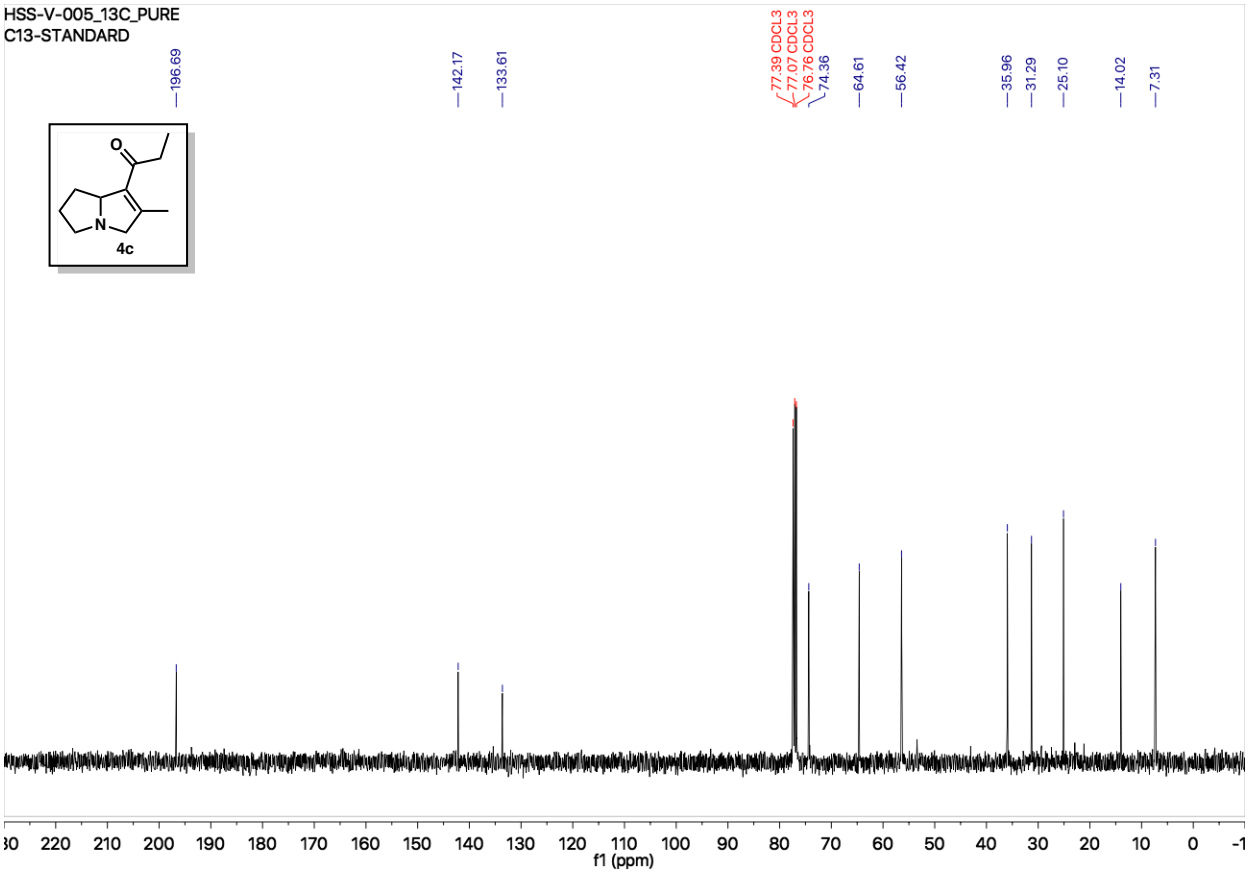

HC-III-034_1H_pure
proton spectrum
SI-12
B (ddt)
5.46
J(15.35, 6.89, 1.36)
A (m)
5.62
C (q)
3.95
J(6.63)
D (d)
3.41
J(2.48)
E (t)
2.69
J(7.23)
F (t)
2.20
J(2.43)
G (m)
2.07
I (s)
1.65
H (t)
0.88
J(7.45)
J (dtd)
1.53
J(29.44, 14.18, 13.65, 7.12)
f1 (ppm)

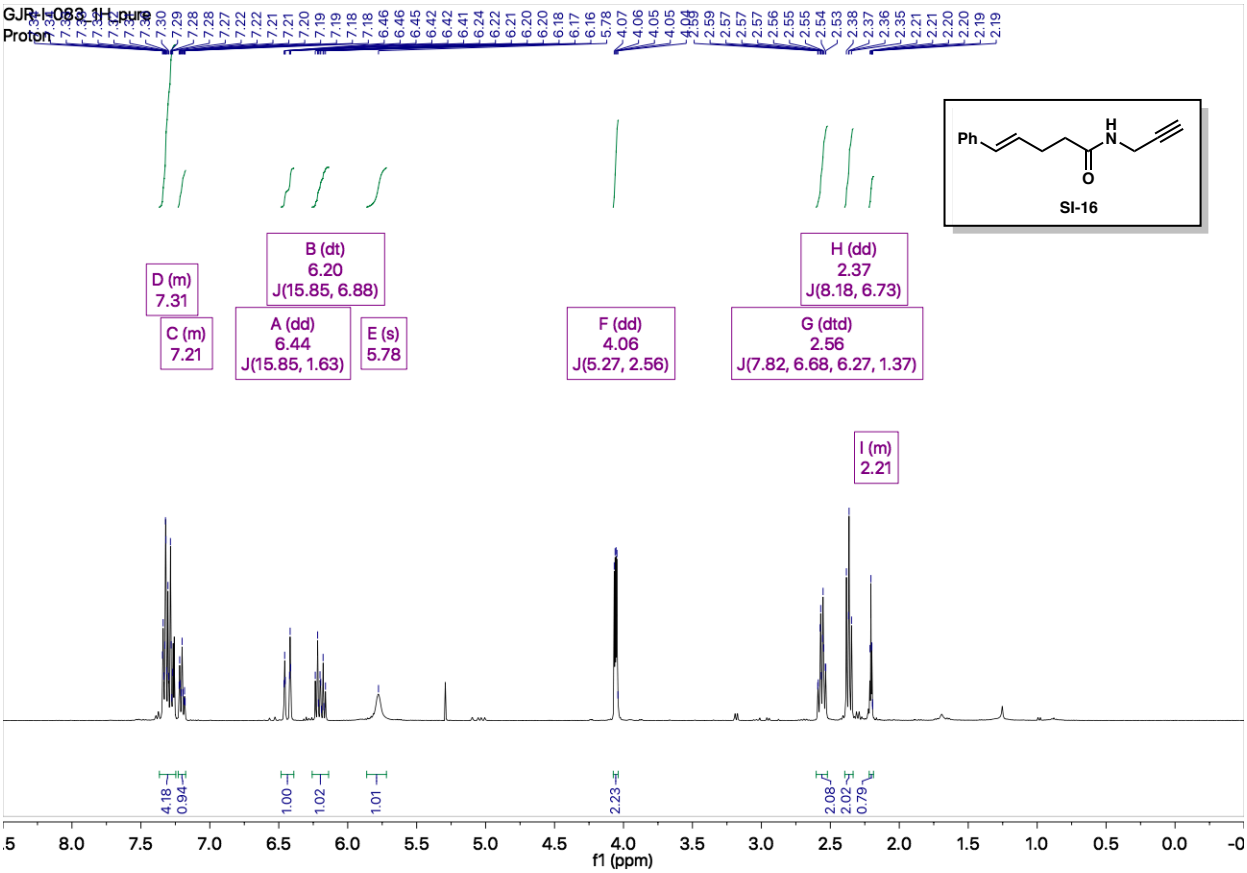

HC-III-034_13C_pure
Carbon spectrum
SI-12
133.39
131.27
82.07
77.34 CDCL3
77.02 CDCL3
76.71 CDCL3
74.30
71.36
47.99
38.06
30.13
29.87
29.17
9.78
f1 (ppm)

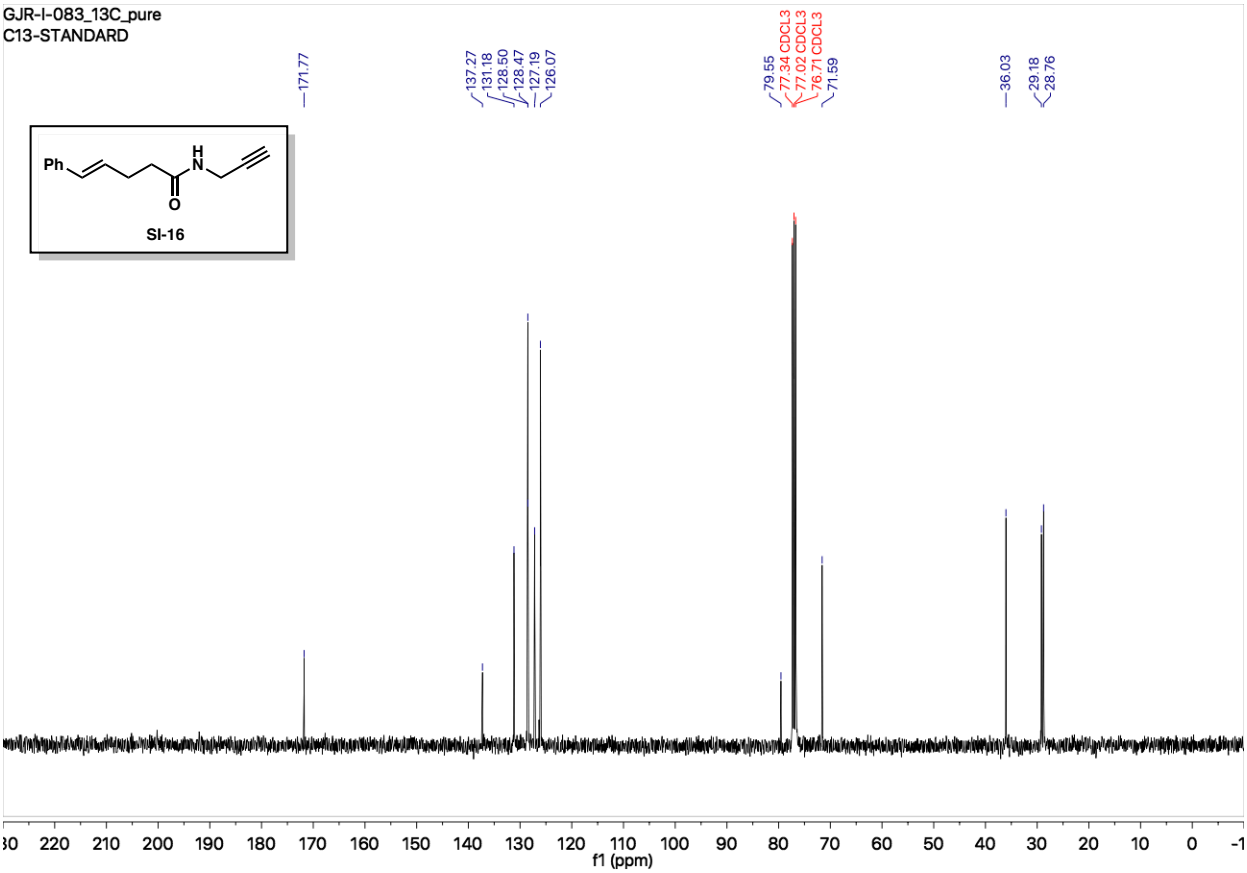

HSS-V-003_1H_PURE
Proton
Cl
N
O
3c
A (dt)
6.81
J(15.99, 6.84)
B (dt)
6.11
J(15.87, 1.56)
C (d)
3.80
J(2.38)
D (t)
2.98
J(6.77)
E (q)
2.54
J(7.32)
F (td)
2.40
J(2.39, 0.66)
G (m)
2.28
H (m)
1.81
I (t)
1.07
J(7.33)
0.93
0.96
2.00
2.17
1.96
0.85
2.15
2.15
3.05
f1 (ppm)

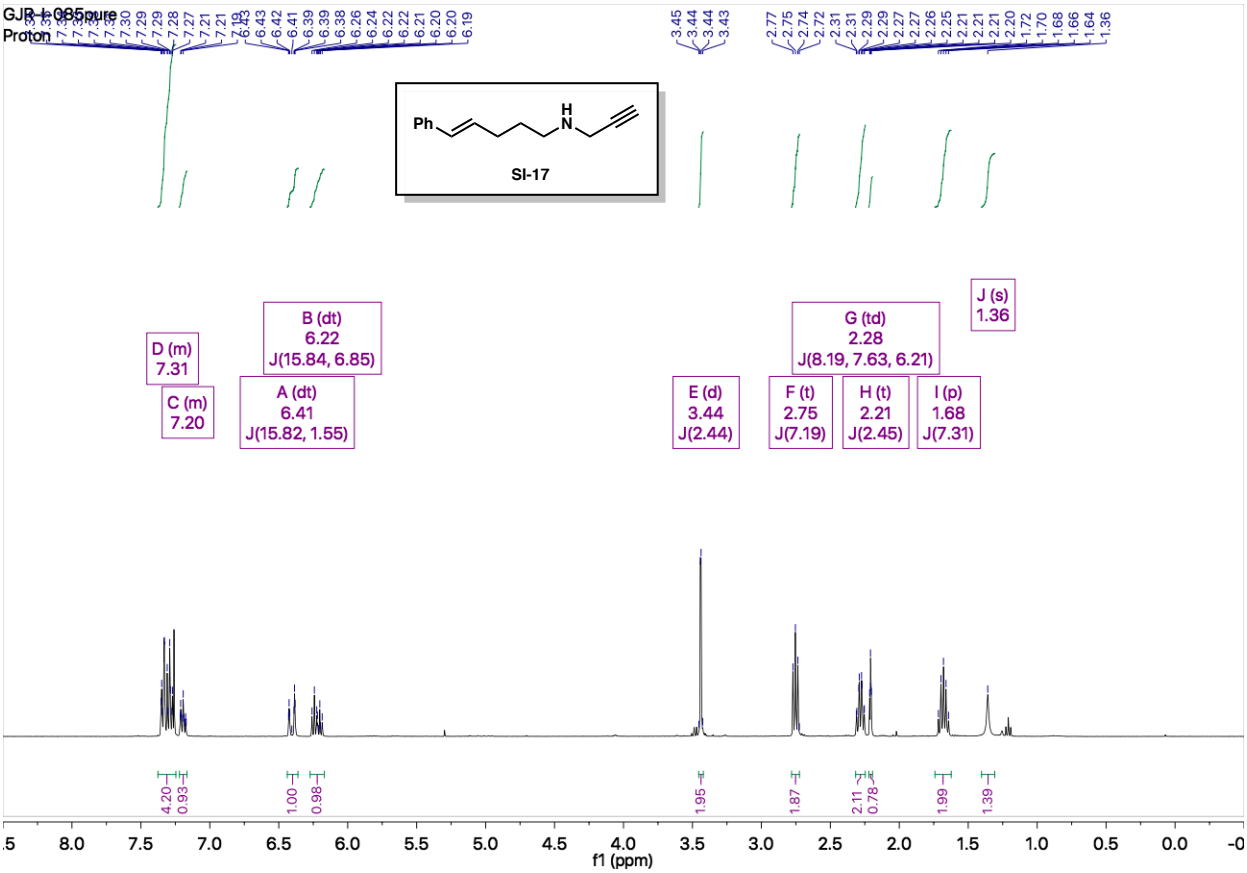

HSS-V-003_13C_PURE
C13-STANDARD
200.97
145.65
130.52
77.36 CDCL3
77.31
77.04 CDCL3
76.72 CDCL3
74.92
60.88
52.71
33.31
29.29
26.23
8.08
Cl
N
O
3c
f1 (ppm)

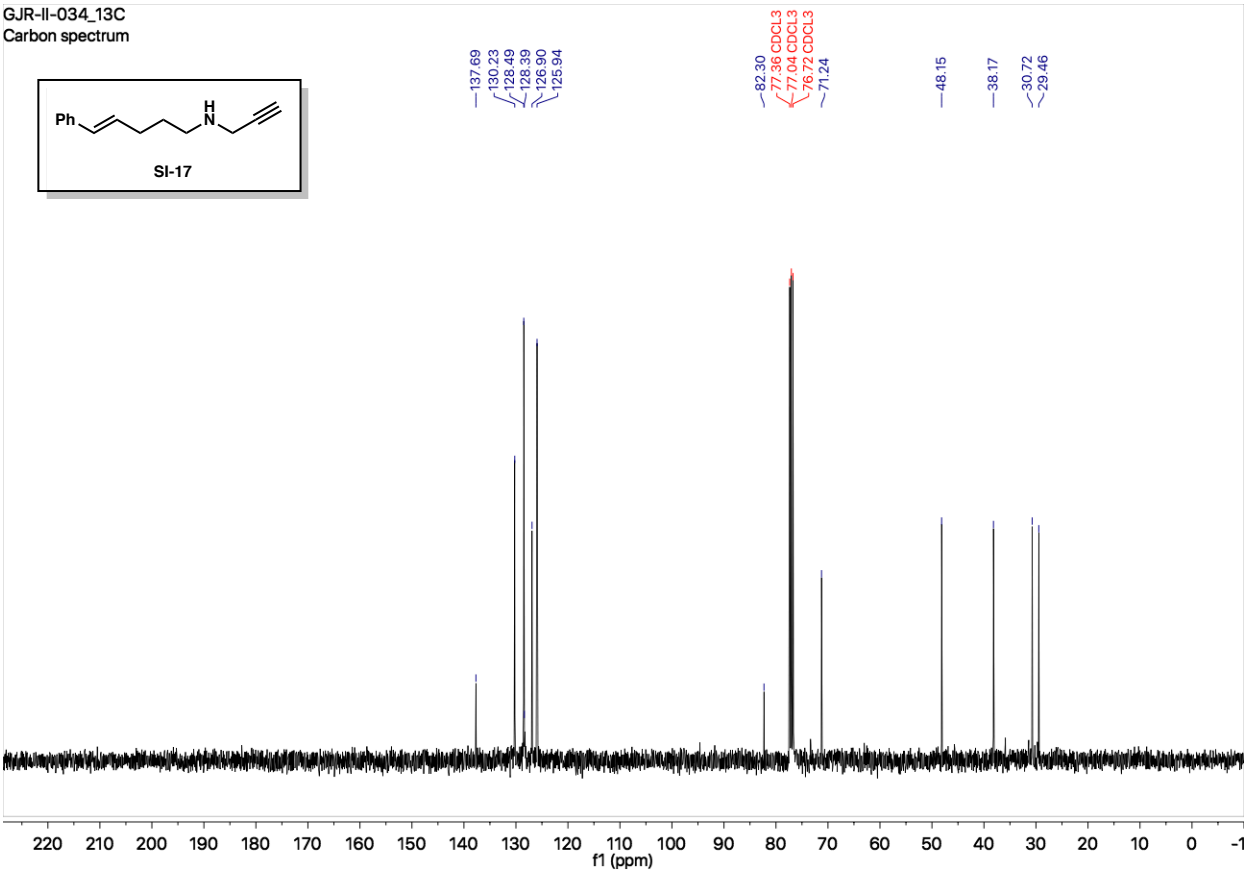

HSS-V-005-1H-PURE
Proton
4c
A (d)
5.21
J(7.88)
B (d)
4.62
J(17.24)
C (m)
3.80
D (m)
2.94
E (qt)
2.58
J(7.09, 1.64)
F (m)
2.46
I (m)
2.07
G (ddt)
1.80
J(14.02, 9.11, 6.74)
H (ddd)
1.07
J(8.69, 6.69, 1.66)
1.14
1.00
2.16
1.11
2.14
1.34
4.86
1.06
3.31
f1 (ppm)

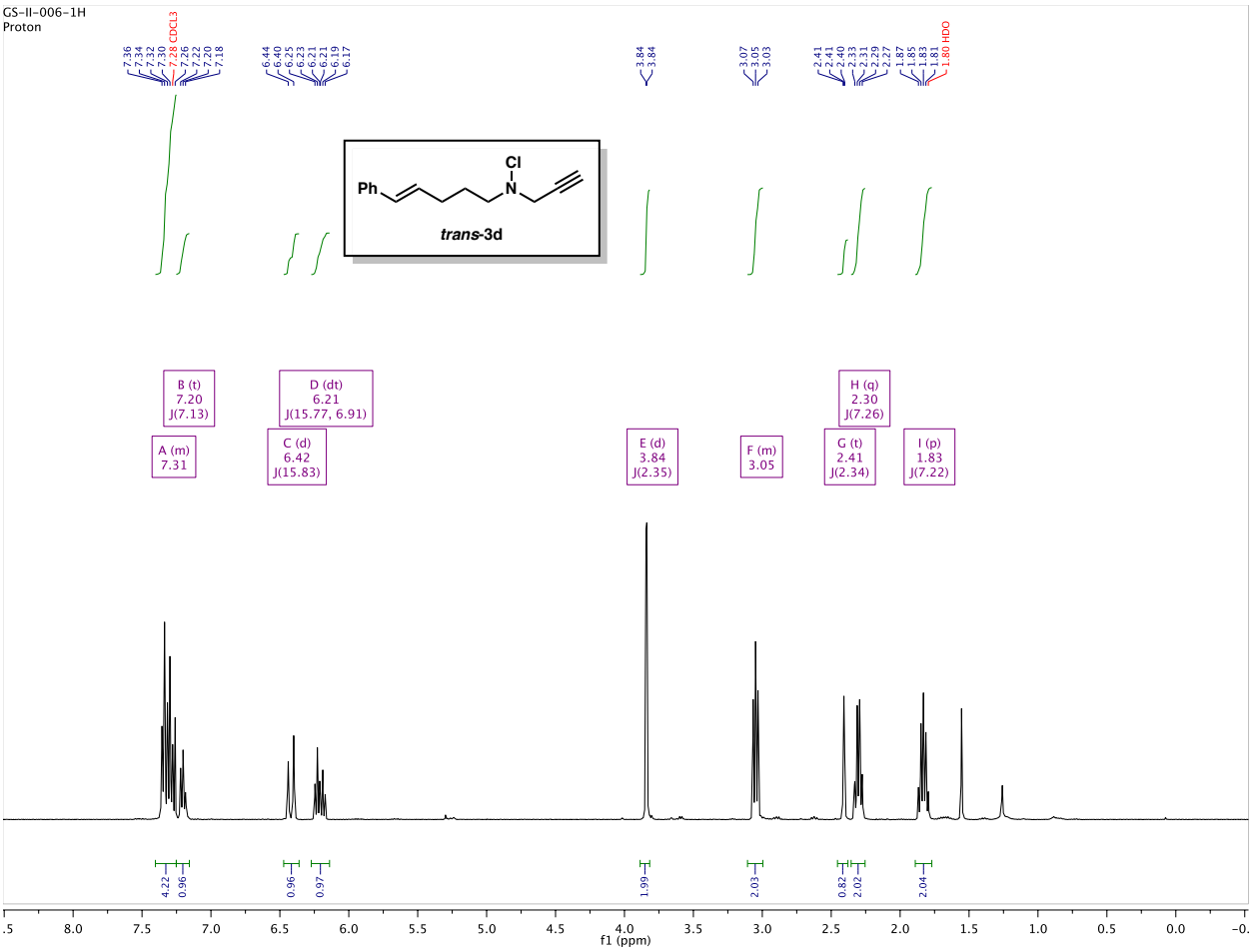

HSS-V-005_13C_PURE
C13-STANDARD
196.69
142.17
133.61
77.39 CDCL3
77.07 CDCL3
76.76 CDCL3
74.36
64.61
56.42
35.96
31.29
25.10
14.02
7.31
O
N
4c
f1 (ppm)

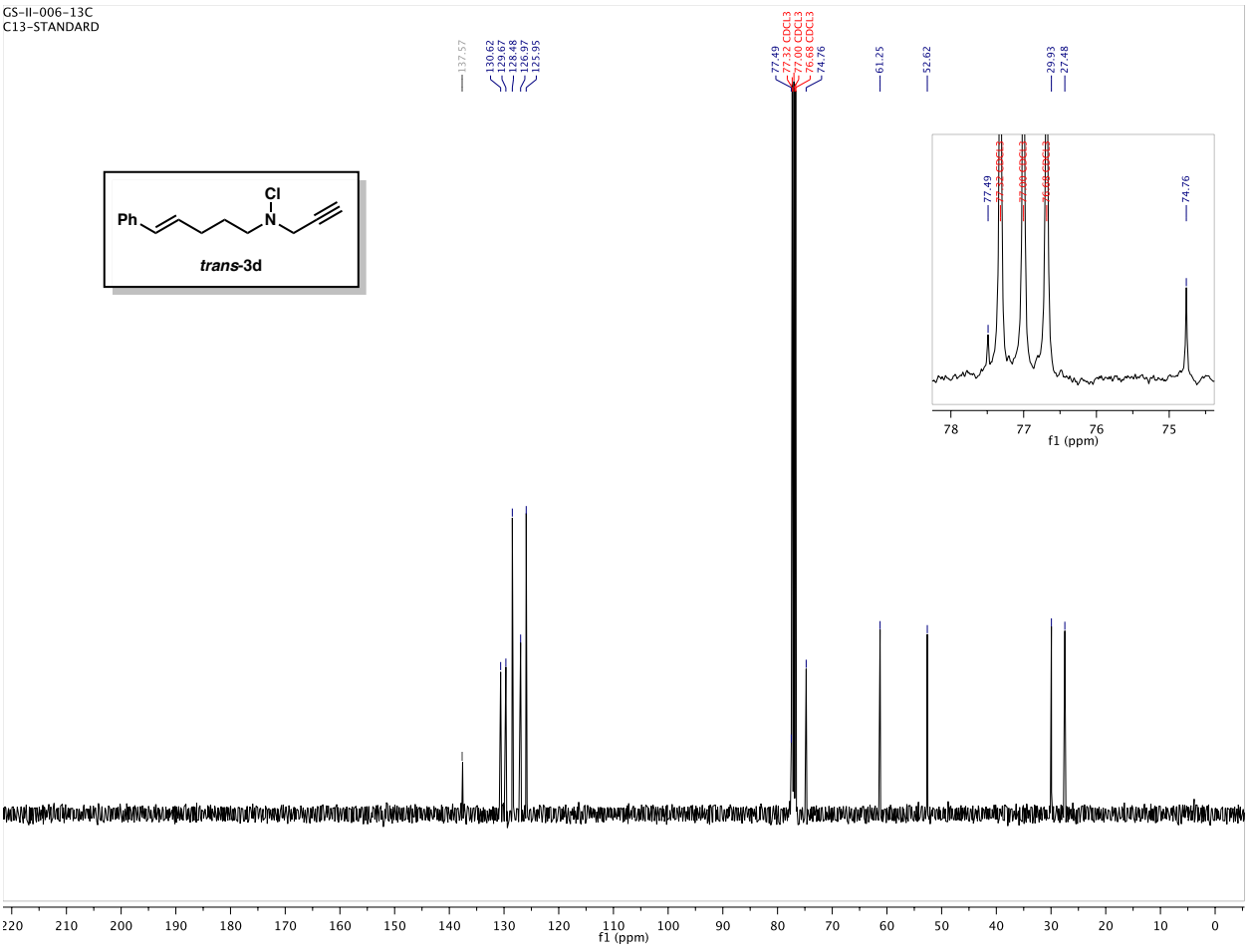

GJR-I-083 1H pure
Proton
Ph
H
N
O
SI-16
D (m)
7.31
C (m)
7.21
B (dt)
6.20
J(15.85, 6.88)
A (dd)
6.44
J(15.85, 1.63)
E (s)
5.78
F (dd)
4.06
J(5.27, 2.56)
H (dd)
2.37
J(8.18, 6.73)
G (dtd)
2.56
J(7.82, 6.68, 6.27, 1.37)
I (m)
2.21
4.18
0.94
1.00
1.02
1.01
2.23
2.08
2.02
0.79
f1 (ppm)

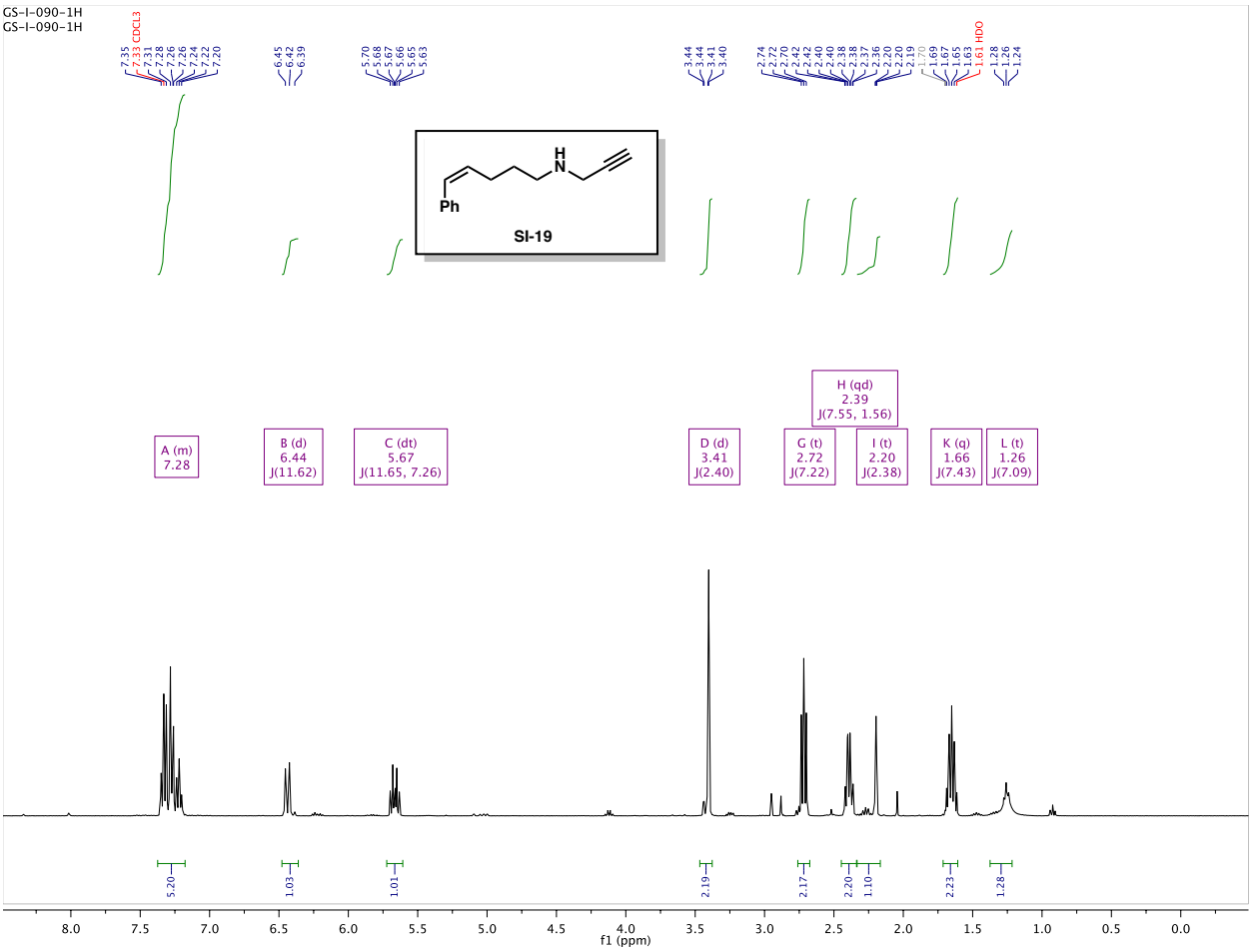

GJR-I-083_13C_pure
C13-STANDARD
171.77
137.27
131.18
128.50
128.47
127.19
126.07
79.55
77.34 CDCL3
77.02 CDCL3
76.71 CDCL3
71.59
36.03
29.18
28.76
Ph
H
N
O
SI-16
f1 (ppm)

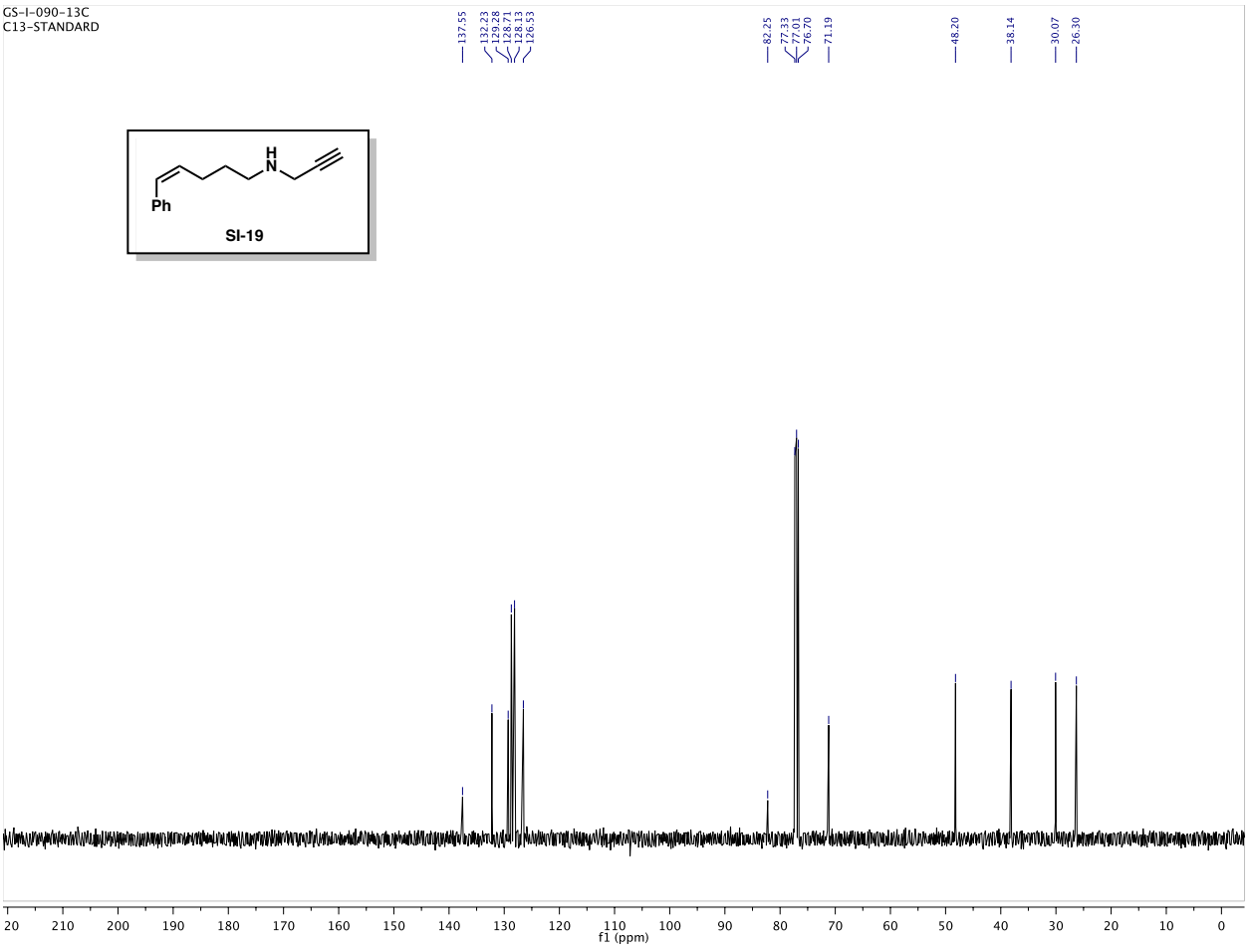

GJR-I-085pure
Proton
Ph
H
N
SI-17
D (m)
7.31
C (m)
7.20
B (dt)
6.22
J(15.84, 6.85)
A (dt)
6.41
J(15.82, 1.55)
E (d)
3.44
J(2.44)
G (td)
2.28
J(8.19, 7.63, 6.21)
F (t)
2.75
J(7.19)
H (t)
2.21
J(2.45)
I (p)
1.68
J(7.31)
J (s)
1.36
4.20
0.93
1.00
0.98
1.95
1.87
2.11
0.78
1.99
1.39
f1 (ppm)

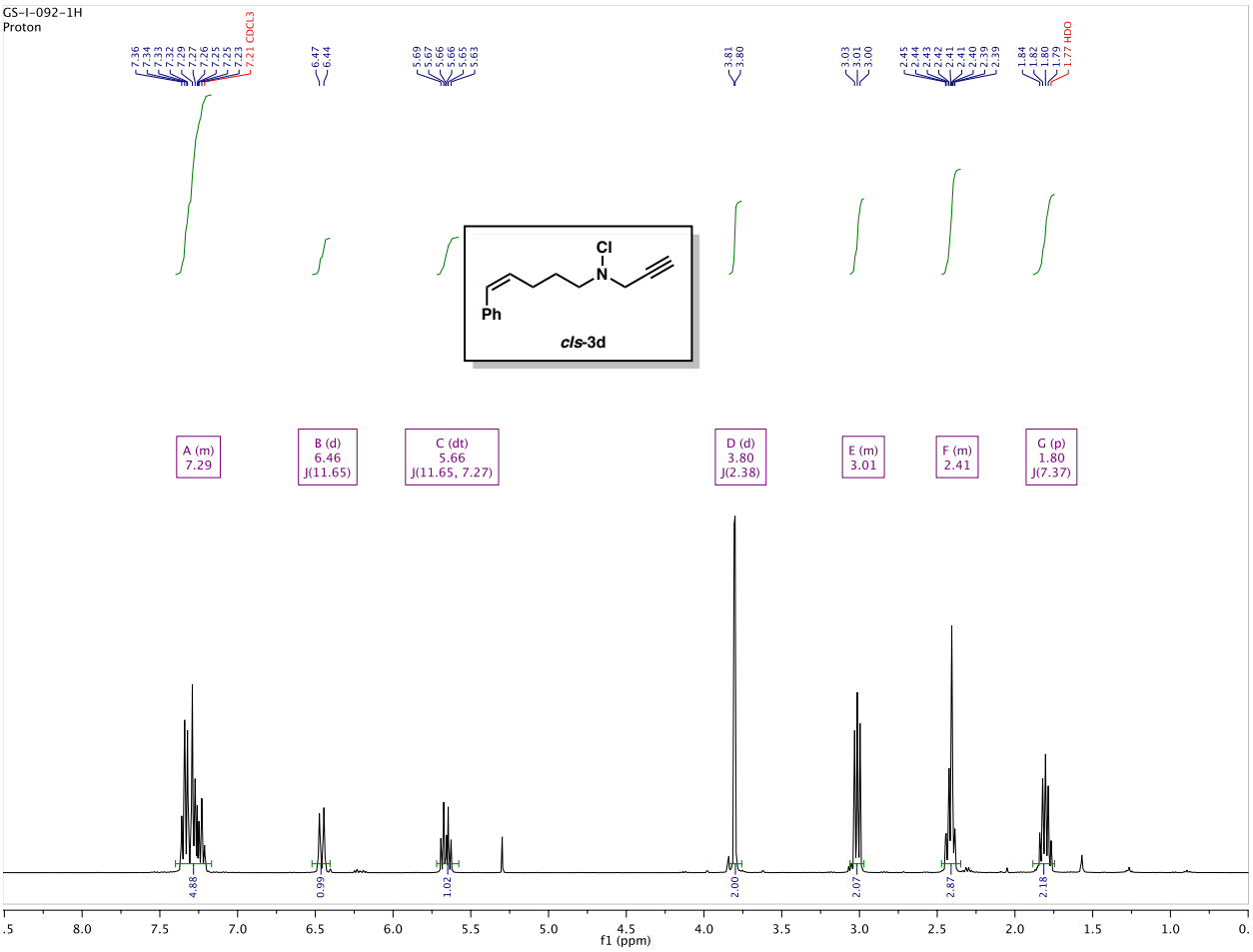

GJR-II-034_13C
Carbon spectrum
137.69
130.23
128.49
128.39
126.90
125.94
82.30
77.36 CDCL3
77.04 CDCL3
76.72 CDCL3
71.24
48.15
38.17
30.72
29.46
Ph
H
N
SI-17
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -1
f1 (ppm)

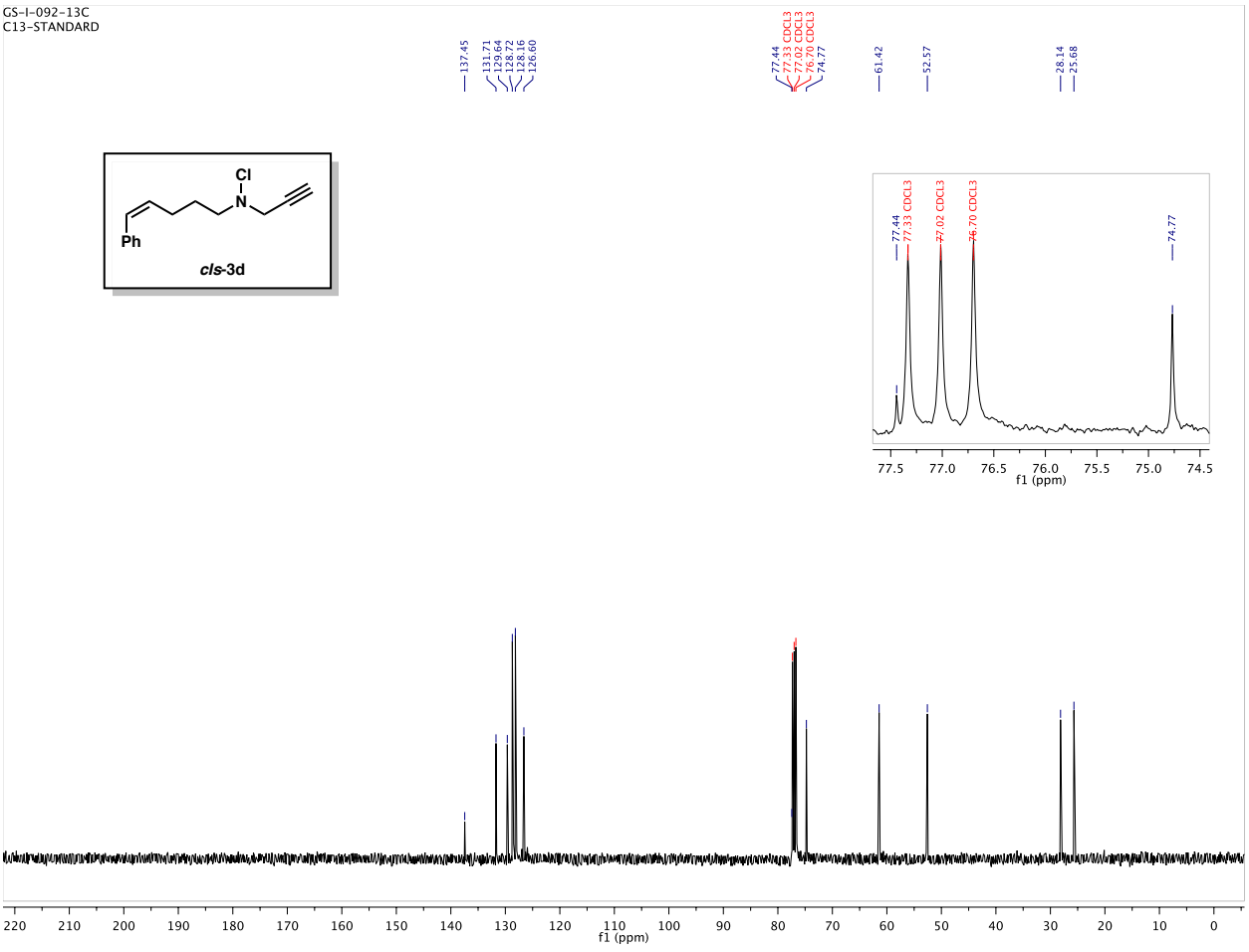

GS-II-006-1H
Proton
CDCL3
HDO
Cl
N
Ph
trans-3d
B (t)
7.20
J(7.13)
D (dt)
6.21
J(15.77, 6.91)
H (q)
2.30
J(7.26)
A (m)
7.31
C (d)
6.42
J(15.83)
E (d)
3.84
J(2.35)
F (m)
3.05
G (t)
2.41
J(2.34)
I (p)
1.83
J(7.22)
4.22
0.96
0.96
0.97
1.99
2.03
0.82
2.02
2.04
f1 (ppm)

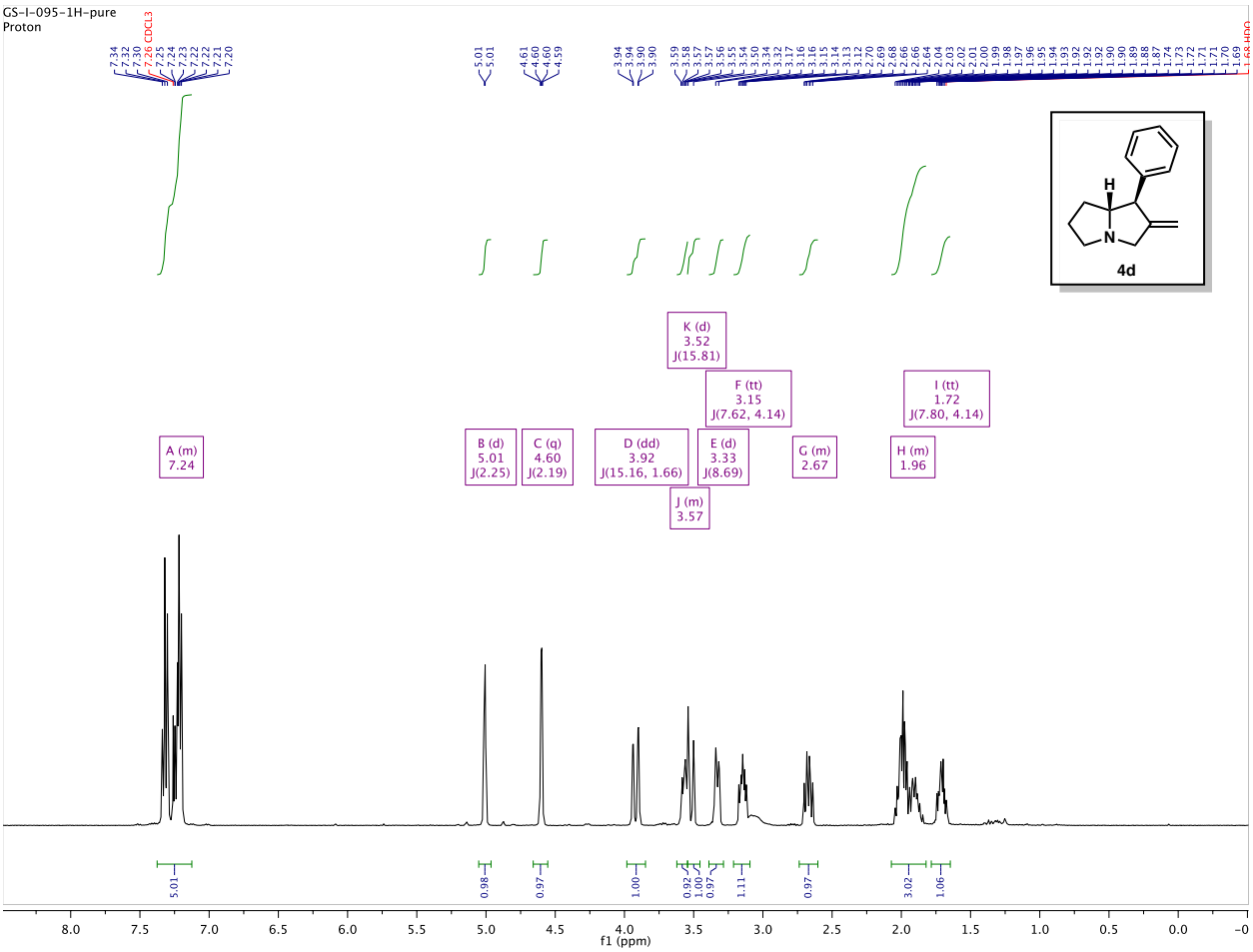

GS-II-006-13C
C13-STANDARD
137.57
130.62
129.67
128.48
126.97
125.95
77.49
77.33 CDCl3
77.00 CDCl3
76.68 CDCl3
74.76
61.25
52.62
29.93
27.48
Cl
Ph
N
trans-3d
f1 (ppm)

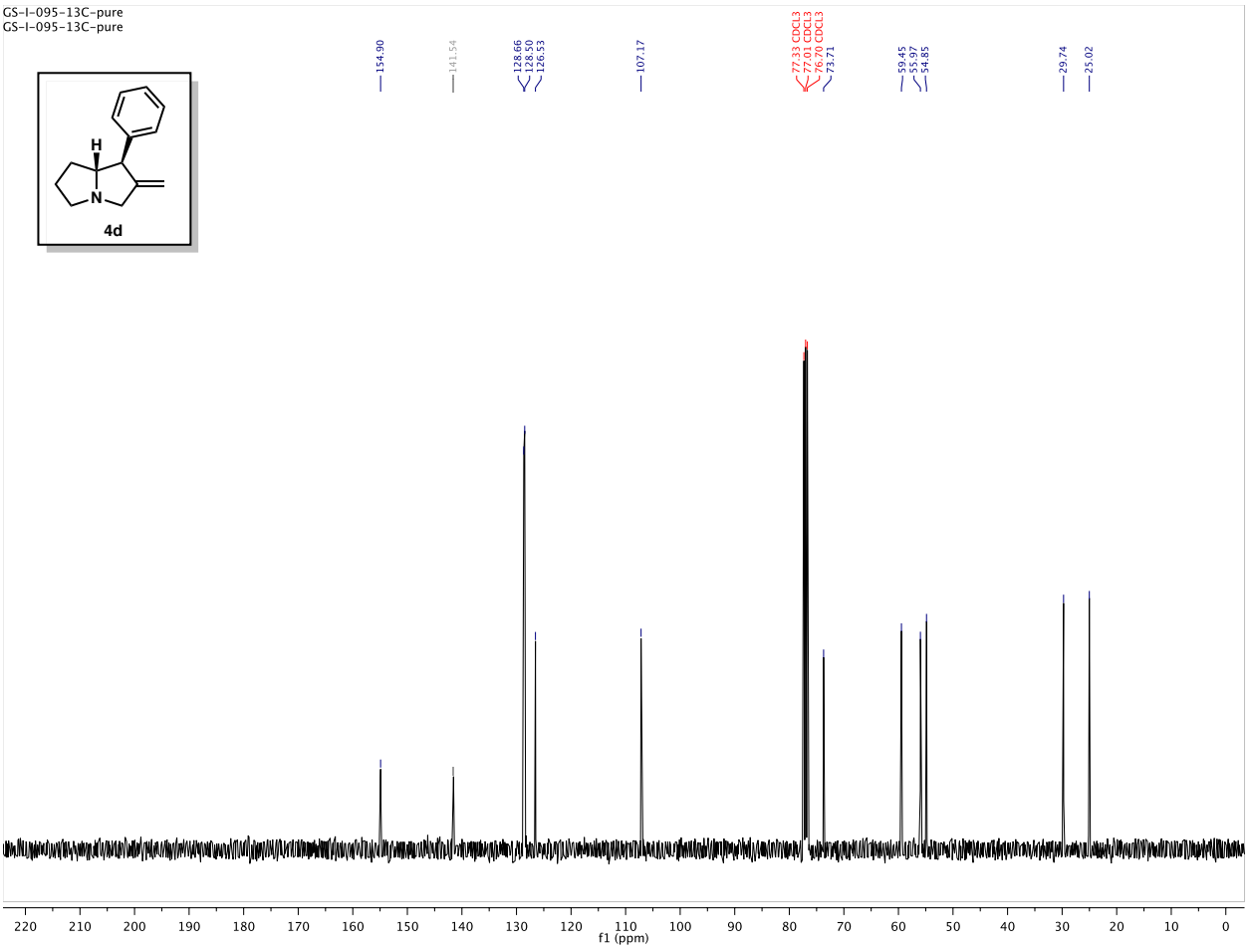

GS-I-090-1H
GS-I-090-1H
SI-19
A (m) 7.28
B (d) 6.44 J(11.62)
C (dt) 5.67 J(11.65, 7.26)
D (d) 3.41 J(2.40)
G (t) 2.72 J(7.22)
H (qd) 2.39 J(7.55, 1.56)
I (t) 2.20 J(2.38)
K (q) 1.66 J(7.43)
L (t) 1.26 J(7.09)
f1 (ppm)

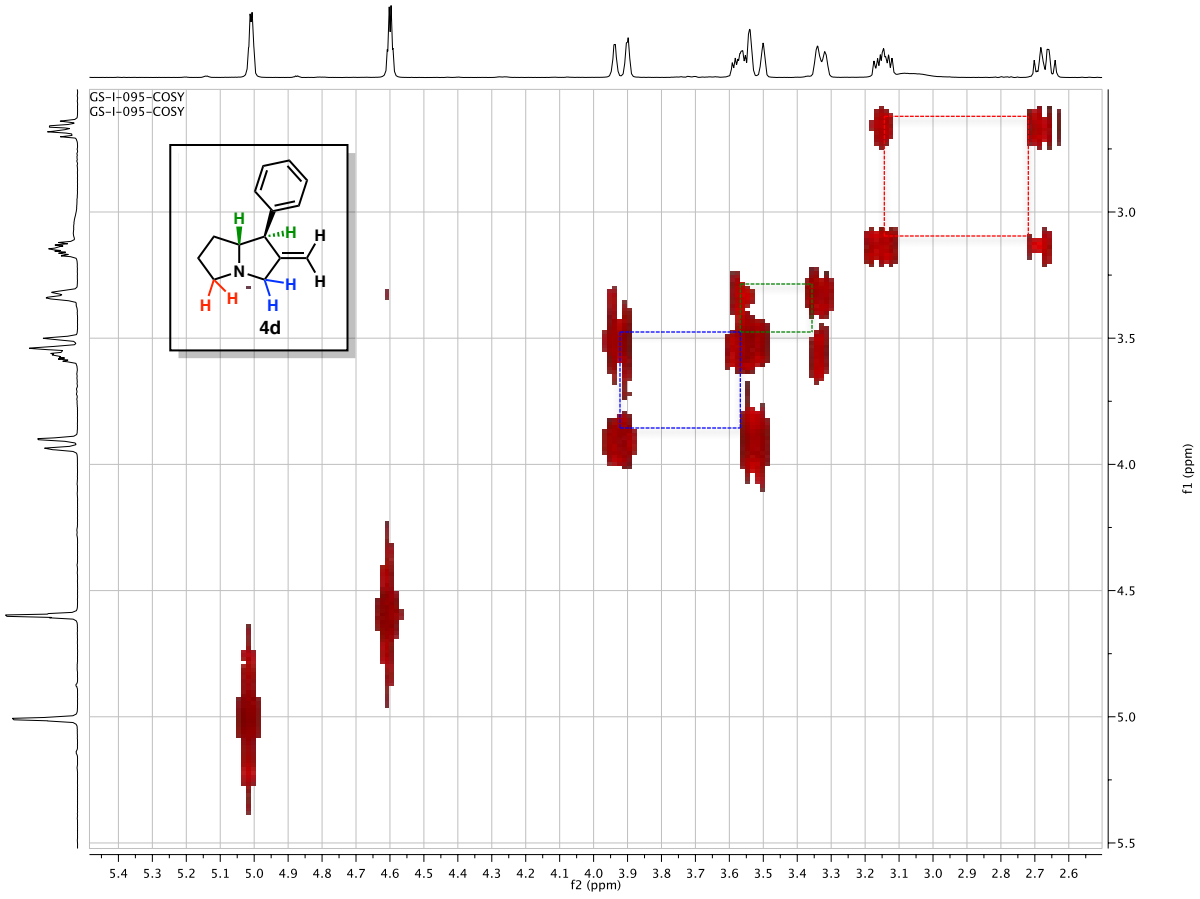

GS-I-090-13C
C13-STANDARD
137.55
132.23
129.28
128.71
128.13
126.53
82.25
77.33
77.01
76.70
71.19
48.20
38.14
30.07
26.30
H
N
Ph
SI-19
f1 (ppm)

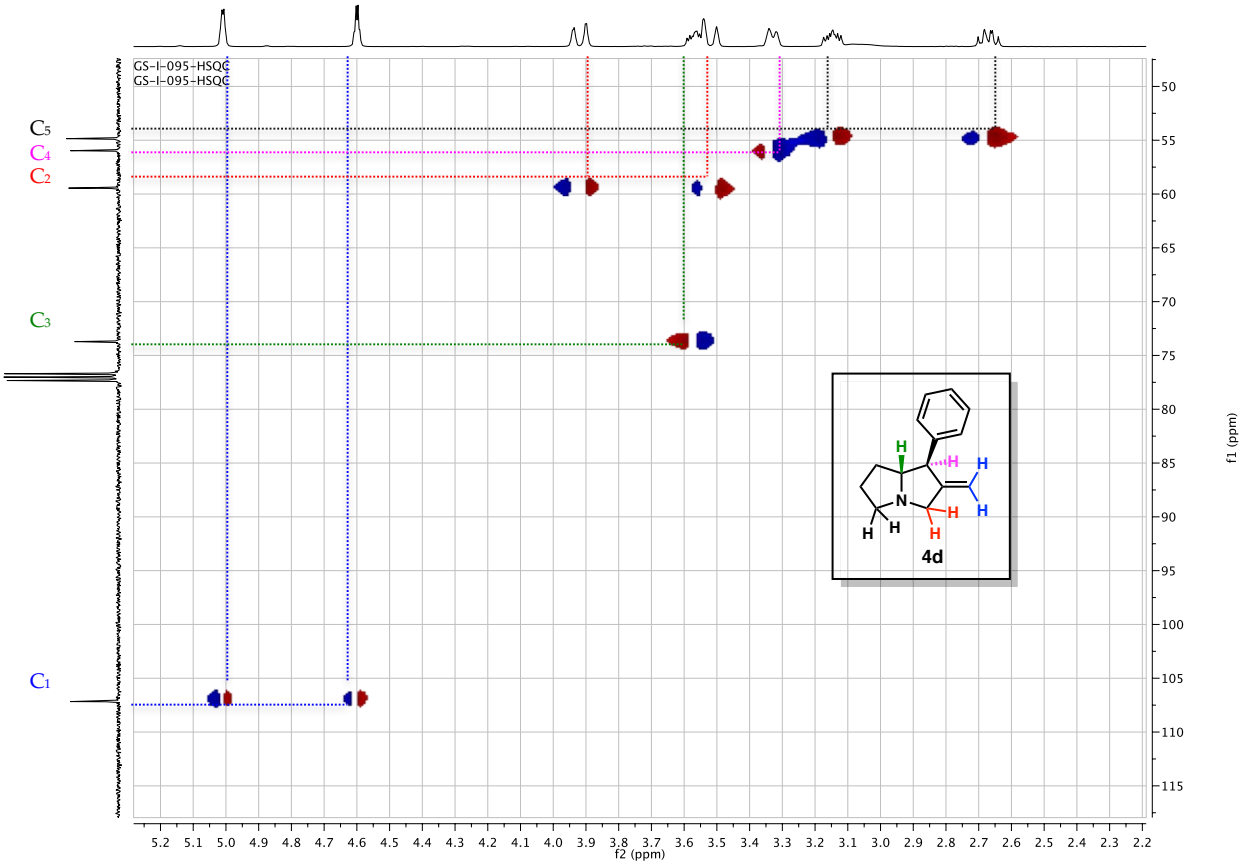

GS-I-092-1H
Proton
Cl
N
Ph
cis-3d
A (m)
7.29
B (d)
6.46
J(11.65)
C (dt)
5.66
J(11.65, 7.27)
D (d)
3.80
J(2.38)
E (m)
3.01
F (m)
2.41
G (p)
1.80
J(7.37)
f1 (ppm)

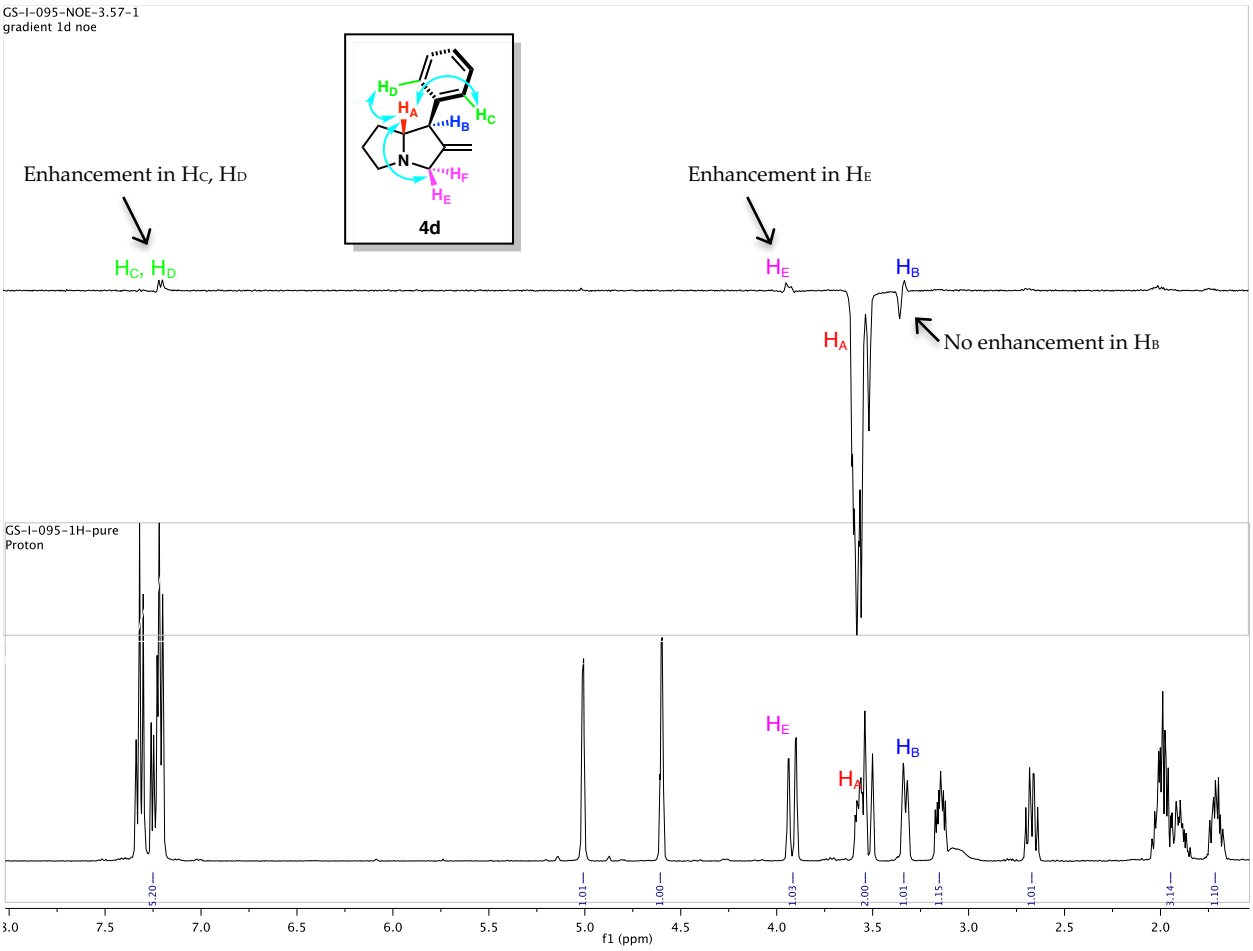

GS-I-092-13C
C13-STANDARD
137.45
131.71
129.64
128.72
128.16
126.60
77.44
77.33 CDCl3
77.02 CDCl3
76.70 CDCl3
74.77
61.42
52.57
28.14
25.68
Cl
N
Ph
cis-3d
f1 (ppm)

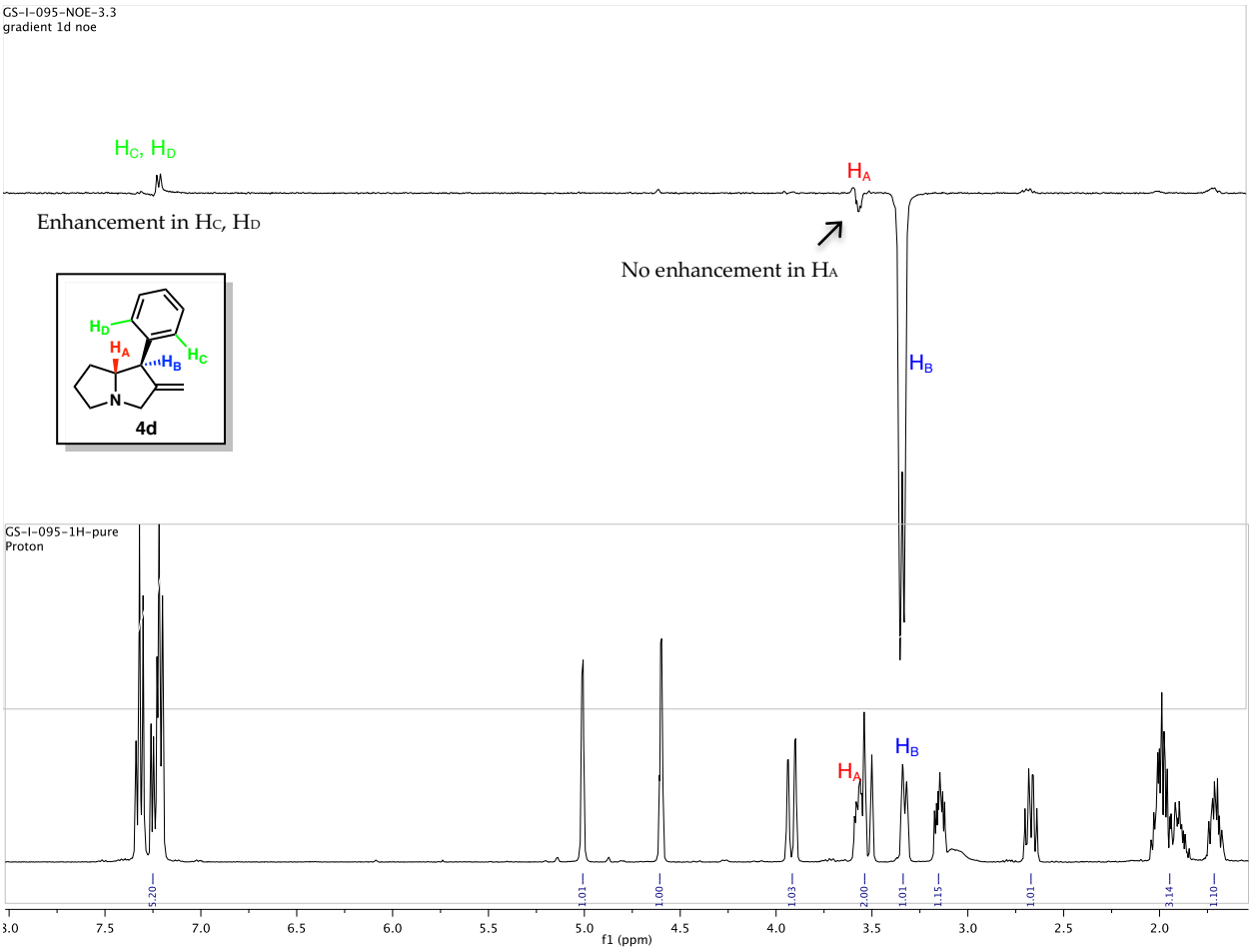

GS-I-095-1H-pure
Proton
4d
A (m)
7.24
B (d)
5.01
J(2.25)
C (q)
4.60
J(2.19)
D (dd)
3.92
J(15.16, 1.66)
E (d)
3.33
J(8.69)
F (tt)
3.15
J(7.62, 4.14)
G (m)
2.67
H (m)
1.96
I (tt)
1.72
J(7.80, 4.14)
J (m)
3.57
K (d)
3.52
J(15.81)
f1 (ppm)

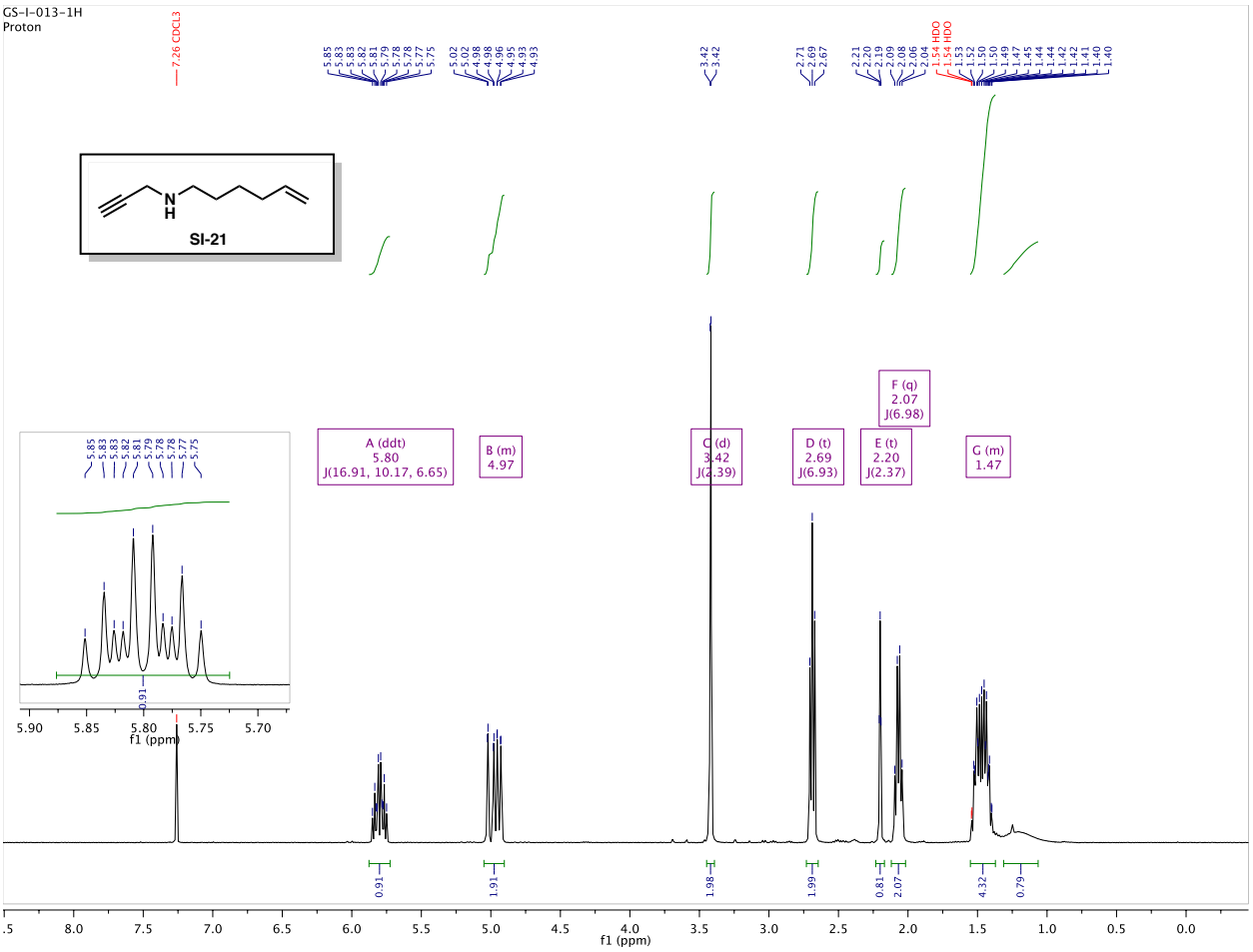

GS-I-095-13C-pure
GS-I-095-13C-pure
154.90
141.54
128.66
128.50
126.53
107.17
77.33 CDCl3
77.01 CDCl3
76.70 CDCl3
73.71
59.45
55.97
54.85
29.74
25.02
H
N
4d
f1 (ppm)

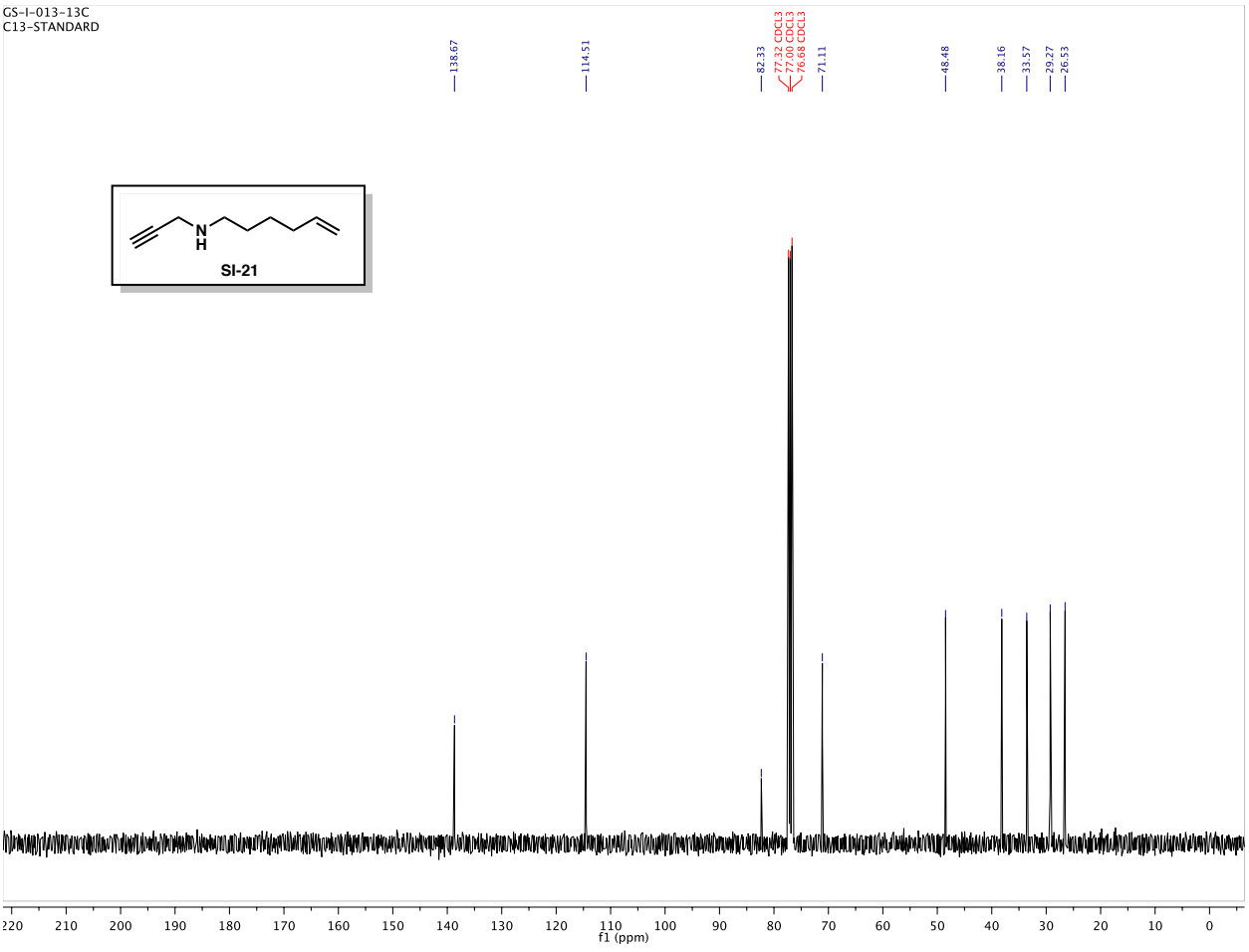

GS-I-095-COSY
GS-I-095-COSY
4d
f2 (ppm)
f1 (ppm)

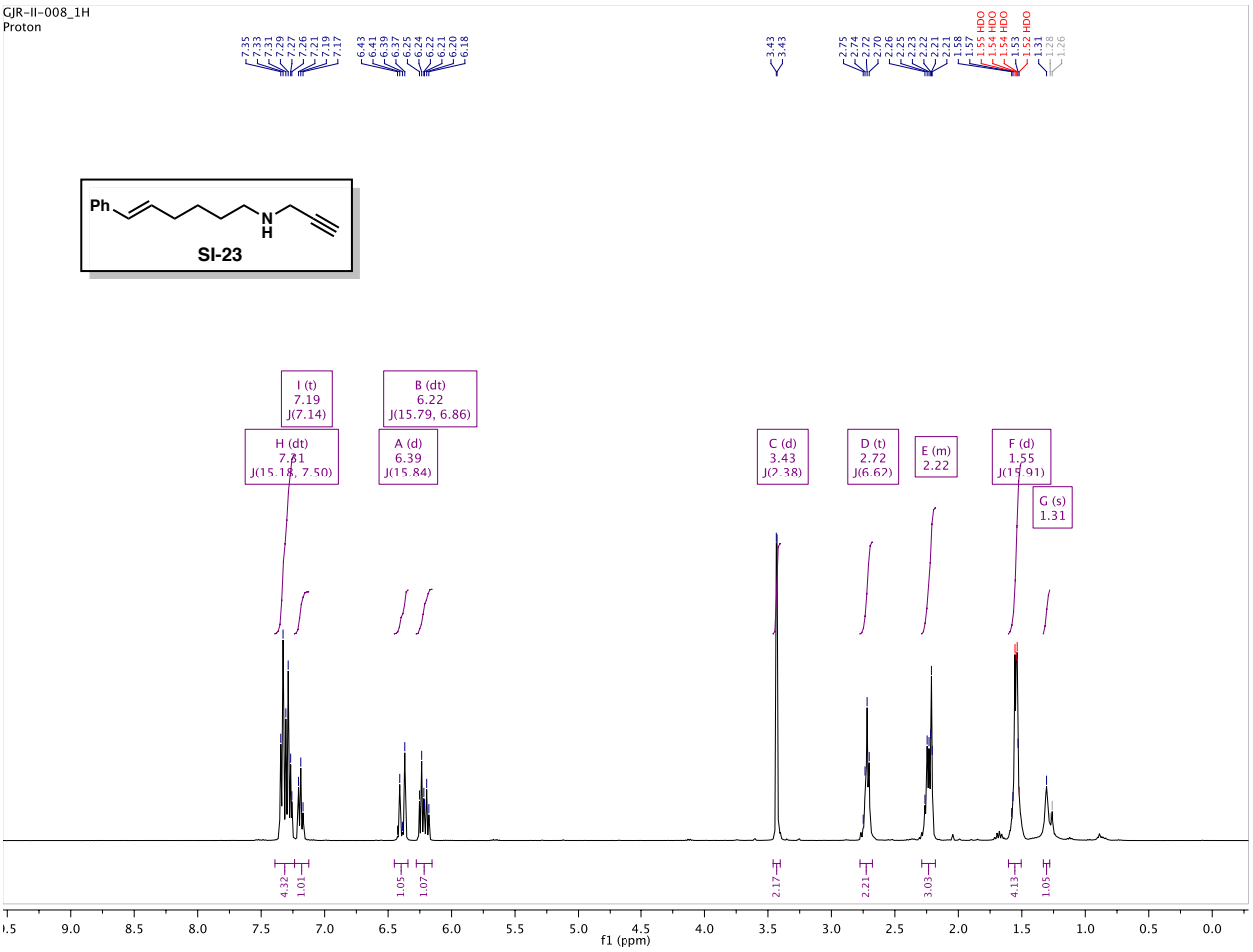

GS-I-095-HSQC
GS-I-095-HSQC
C5
C4
C2
C3
C1
4d
f2 (ppm)
f1 (ppm)

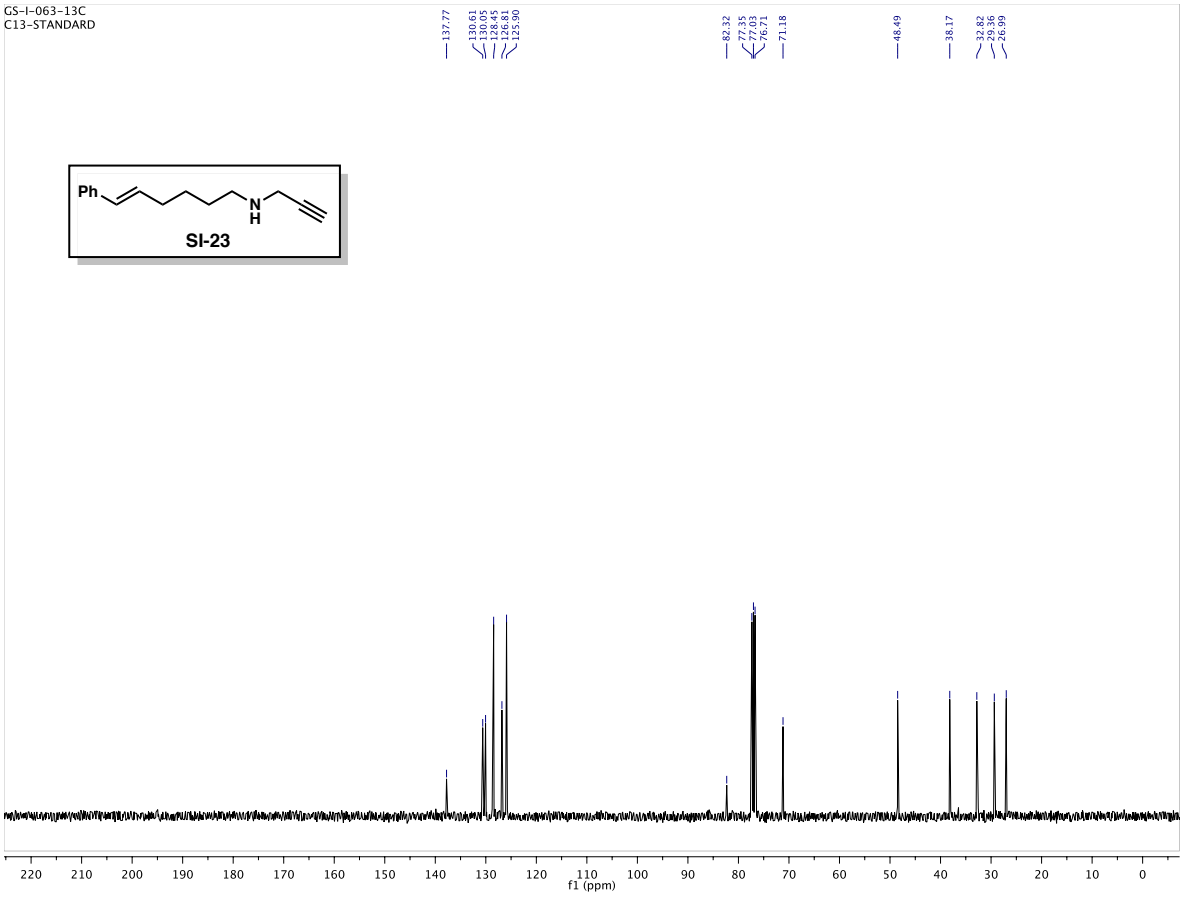

GS-I-095-NOE-3.57-1
gradient 1d noe
4d
Enhancement in HC, HD
Enhancement in HE
HC, HD
HE
HB
HA
No enhancement in HB
GS-I-095-1H-pure
Proton
f1 (ppm)

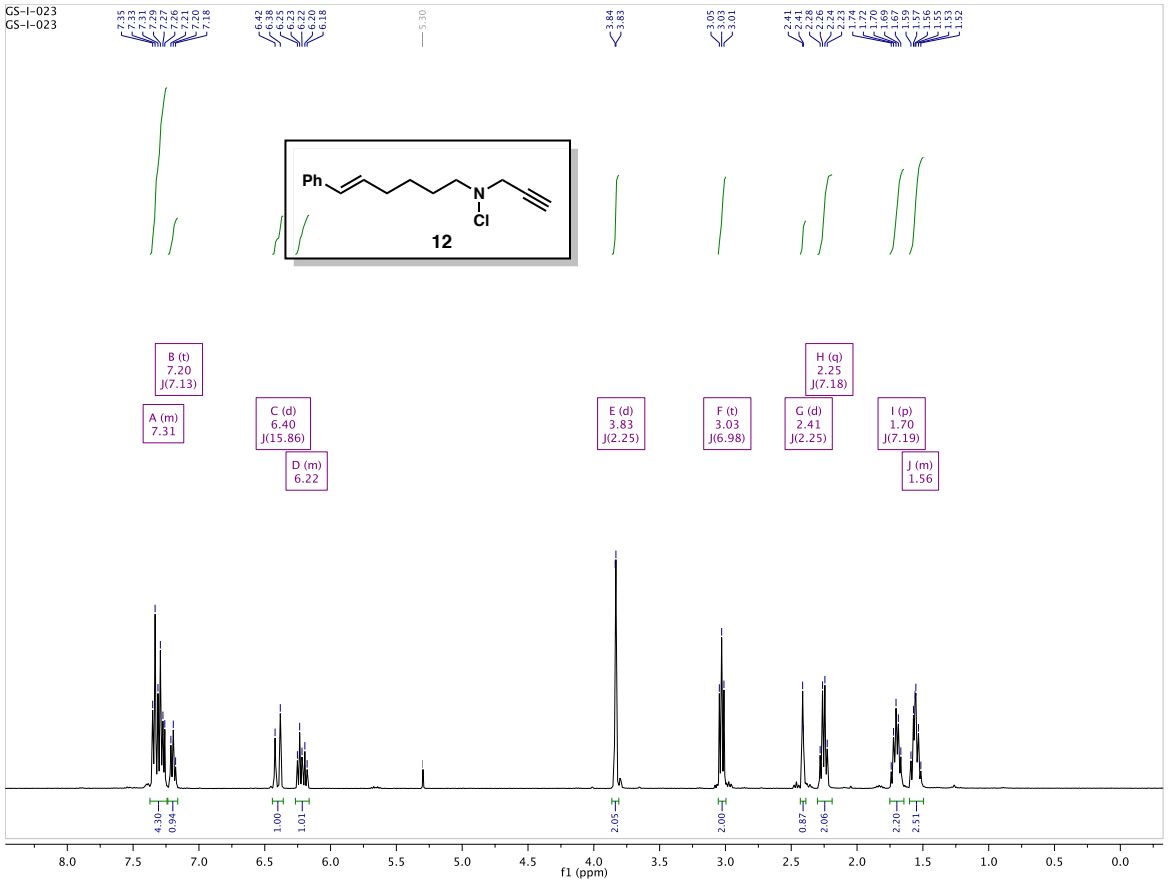

GS-I-095-NOE-3.3
gradient 1d noe
HC, HD
HA
Enhancement in HC, HD
No enhancement in HA
HB
HD
HA
HB
HC
N
4d
GS-I-095-1H-pure
Proton
HB
HA
5.20
1.01
1.00
1.03
2.00
1.01
1.15
1.01
3.14
1.10
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
f1 (ppm)

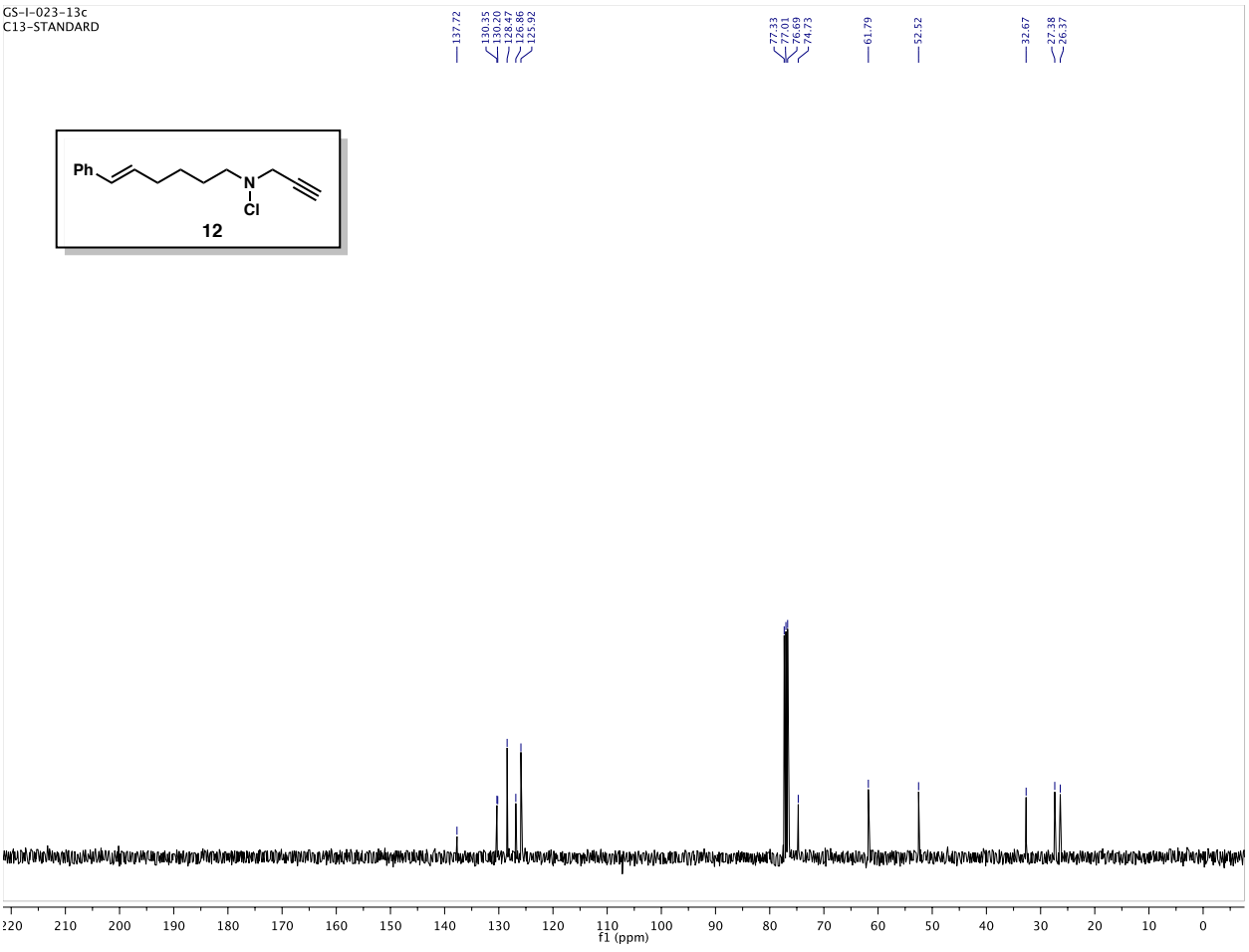

GS-I-013-1H
Proton
7.26 CDCL3
SI-21
A (ddt)
5.80
J(16.91, 10.17, 6.65)
B (m)
4.97
C (d)
3.42
J(2.39)
D (t)
2.69
J(6.93)
E (t)
2.20
J(2.37)
F (q)
2.07
J(6.98)
G (m)
1.47
f1 (ppm)

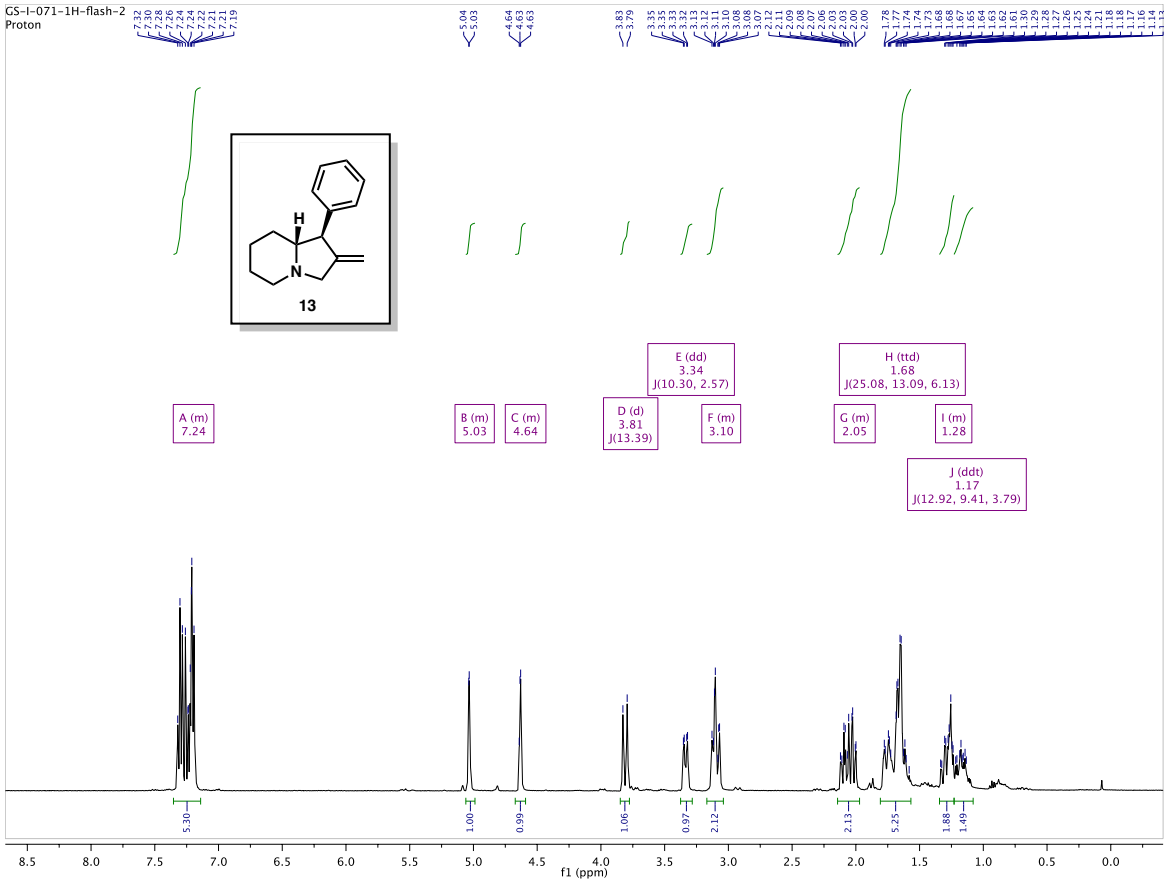

GS-I-013-13C
C13-STANDARD
138.67
114.51
82.33
77.32 CDCL3
77.00 CDCL3
76.68 CDCL3
71.11
48.48
38.16
33.57
29.27
26.53
SI-21
f1 (ppm)

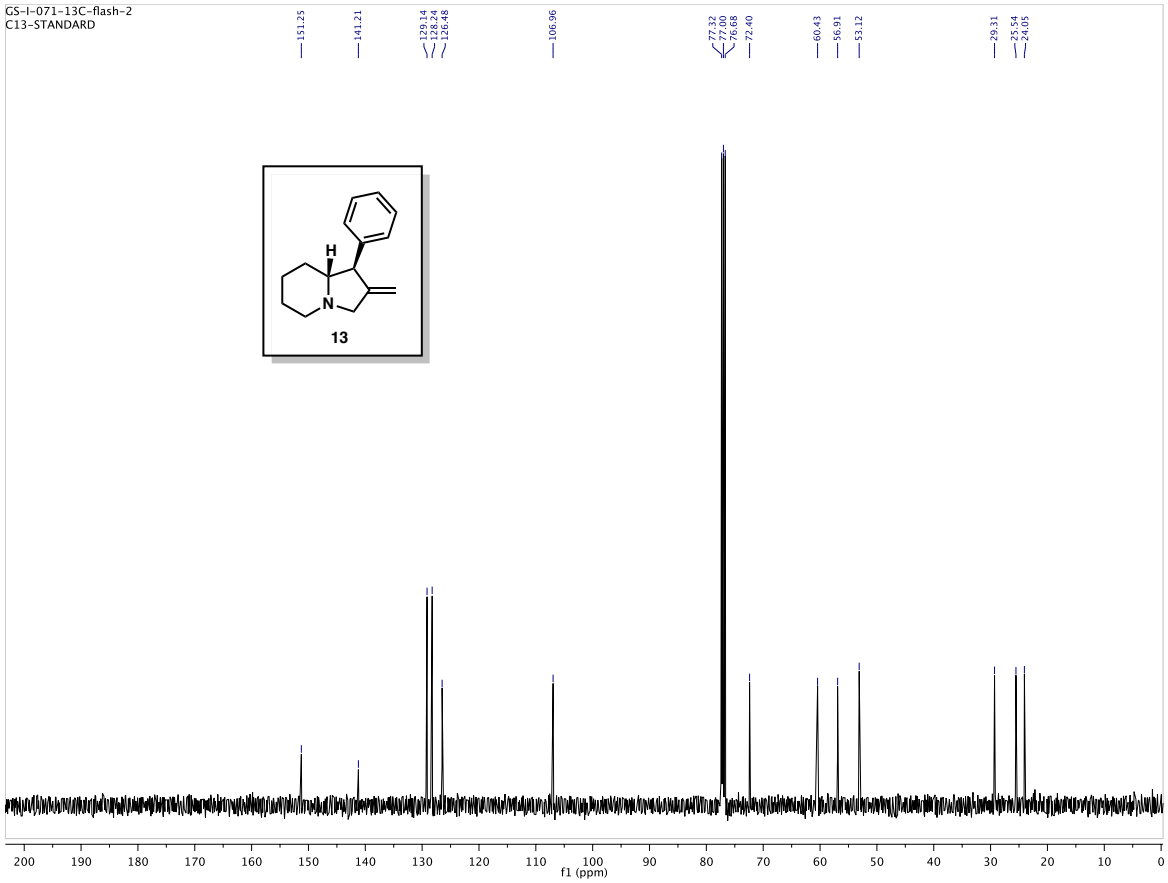

GJR-II-008_1H
Proton
Ph
N
H
SI-23
I (t)
7.19
J(7.14)
B (dt)
6.22
J(15.79, 6.86)
H (dt)
7.81
J(15.18, 7.50)
A (d)
6.39
J(15.84)
C (d)
3.43
J(2.38)
D (t)
2.72
J(6.62)
E (m)
2.22
F (d)
1.55
J(15.91)
G (s)
1.31
4.32
1.01
1.05
1.07
2.17
2.21
3.03
4.13
1.05
f1 (ppm)

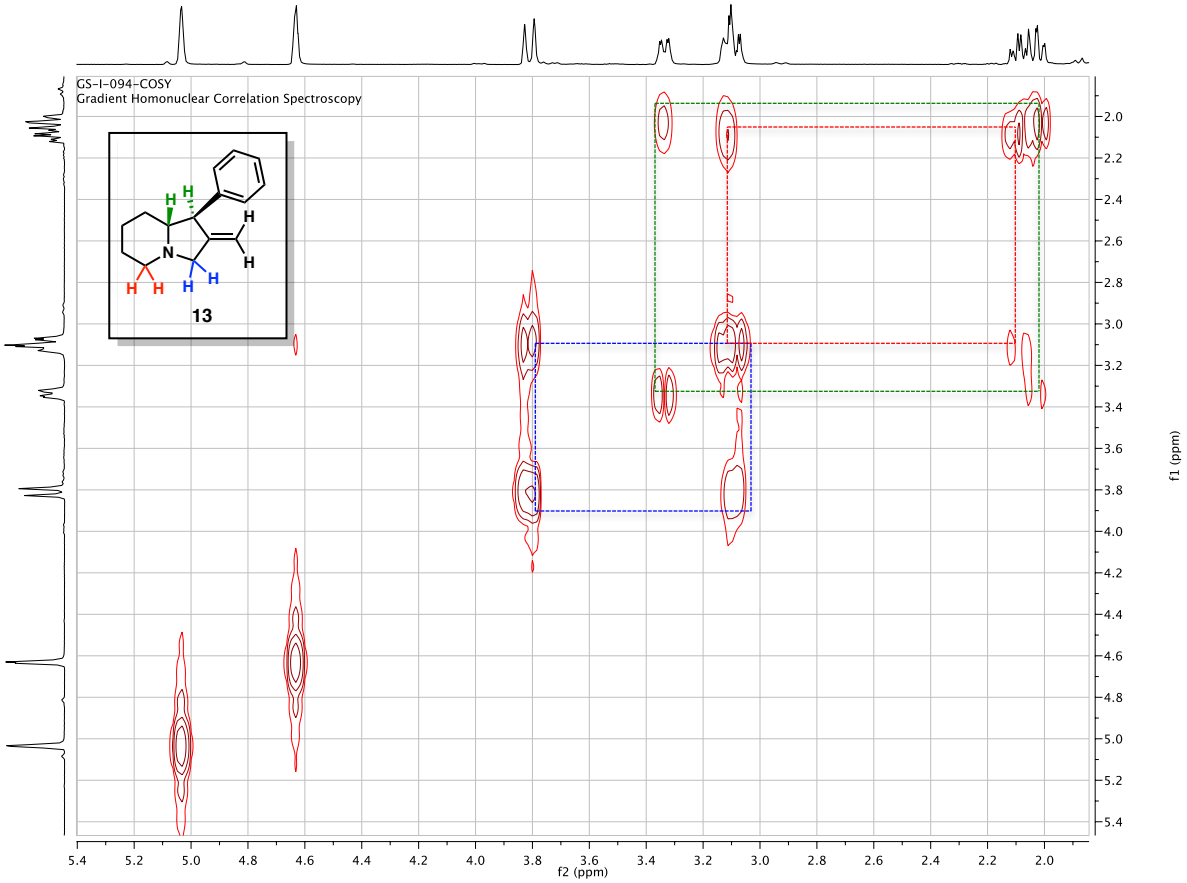

GS-I-063-13C
C13-STANDARD
137.77
130.61
130.05
128.45
126.81
125.90
82.32
77.35
77.03
76.71
71.18
48.49
38.17
32.82
29.36
26.99
Ph
N
H
SI-23
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

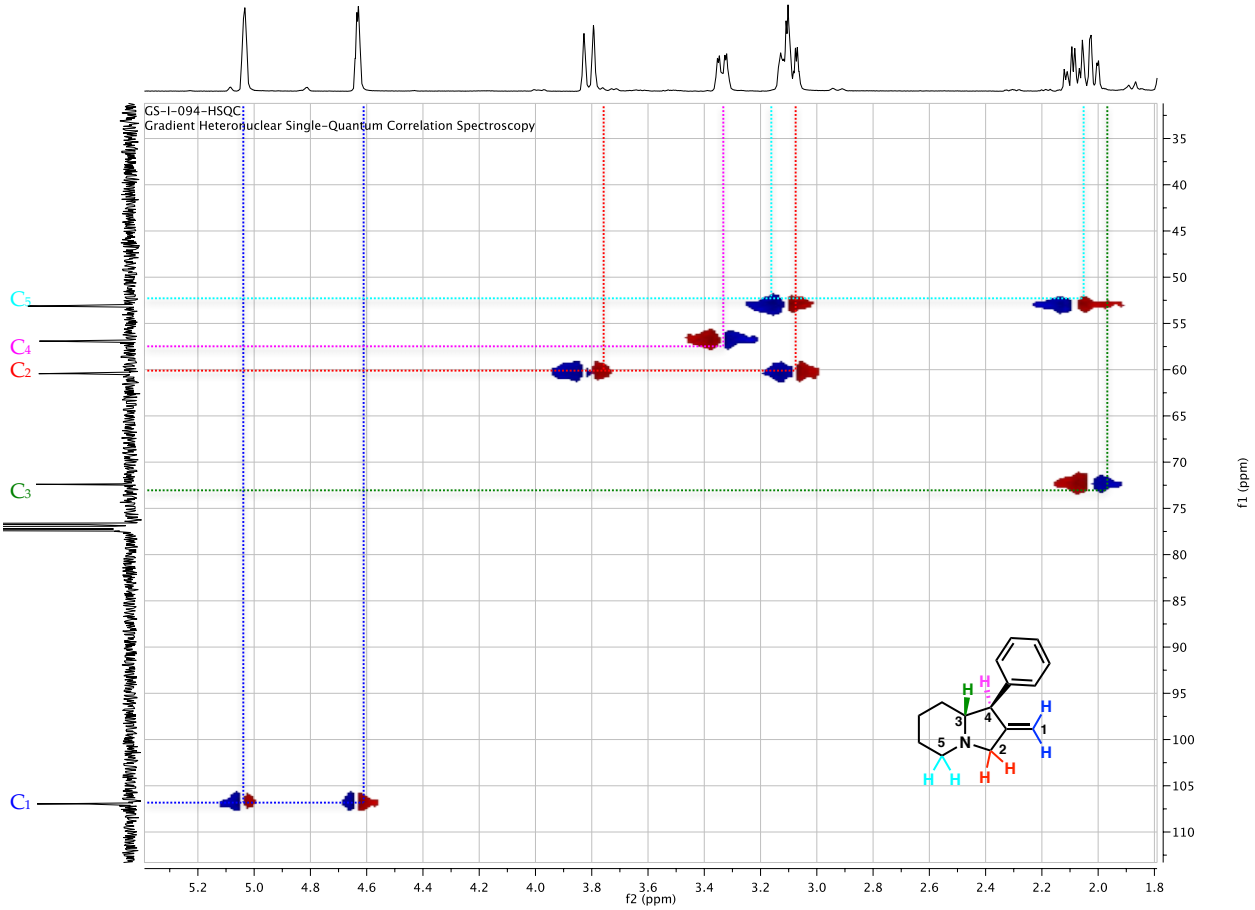

GS-I-023
GS-I-023
Ph
N
Cl
12
B (t)
7.20
J(7.13)
A (m)
7.31
C (d)
6.40
J(15.86)
D (m)
6.22
E (d)
3.83
J(2.25)
F (t)
3.03
J(6.98)
H (q)
2.25
J(7.18)
G (d)
2.41
J(2.25)
I (p)
1.70
J(7.19)
J (m)
1.56
f1 (ppm)

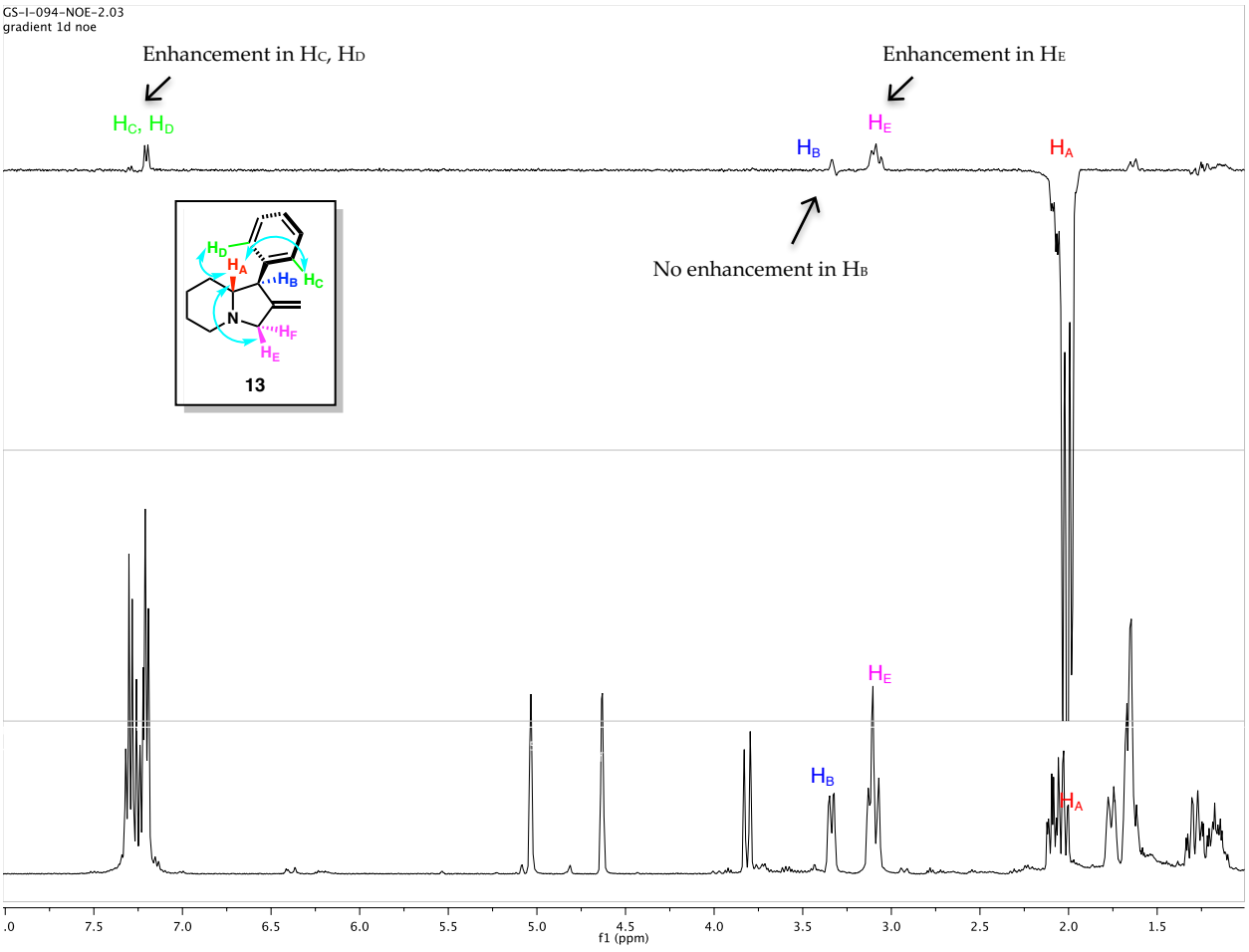

GS-I-023-13c
C13-STANDARD
137.72
130.35
130.20
128.47
126.86
125.92
77.33
77.01
76.69
74.73
61.79
52.52
32.67
27.38
26.37
Ph
N
Cl
12
f1 (ppm)

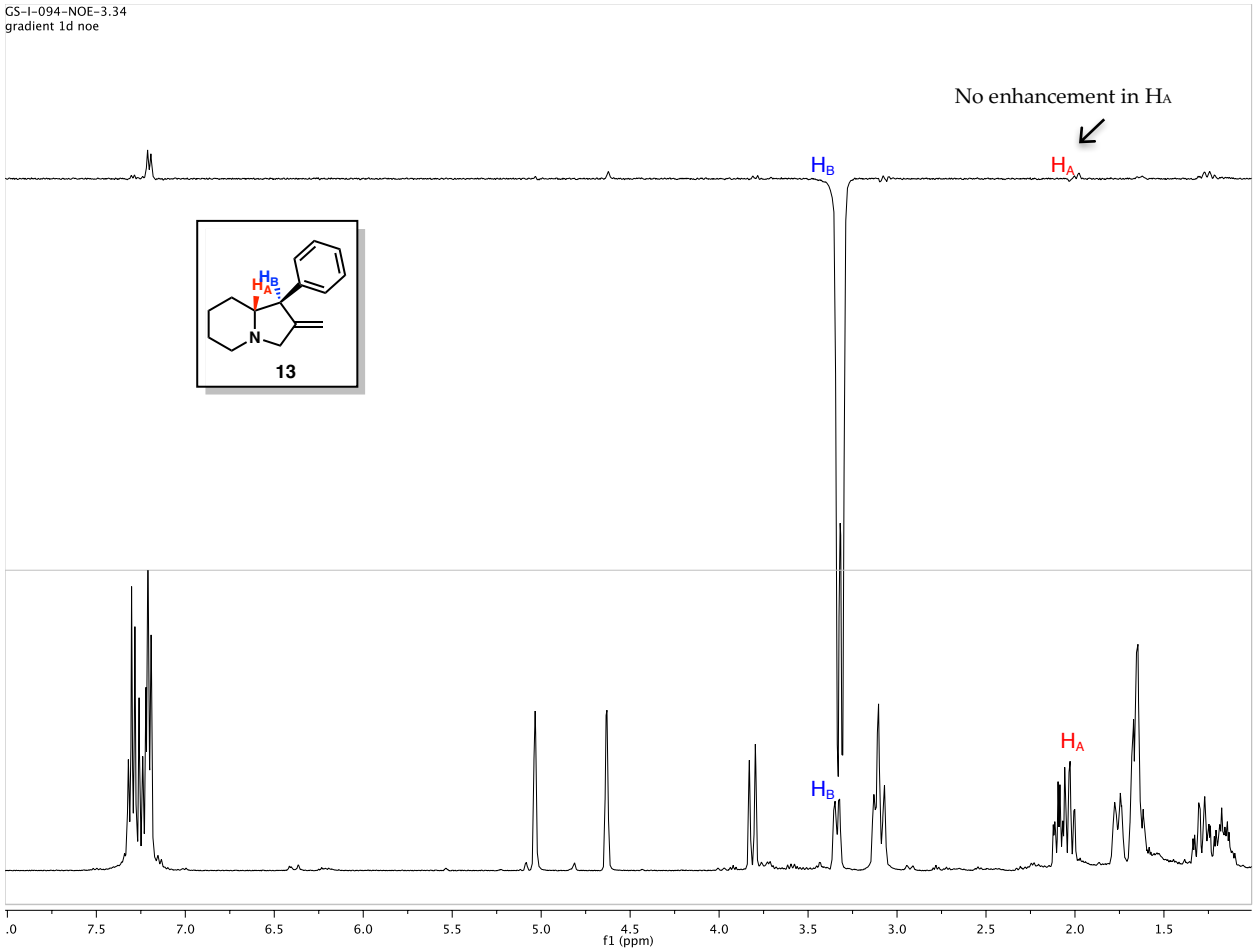

GS-I-071-1H-flash-2
Proton
13
A (m)
7.24
B (m)
5.03
C (m)
4.64
D (d)
3.81
J(13.39)
E (dd)
3.34
J(10.30, 2.57)
F (m)
3.10
G (m)
2.05
H (ttd)
1.68
J(25.08, 13.09, 6.13)
I (m)
1.28
J (ddt)
1.17
J(12.92, 9.41, 3.79)
f1 (ppm)

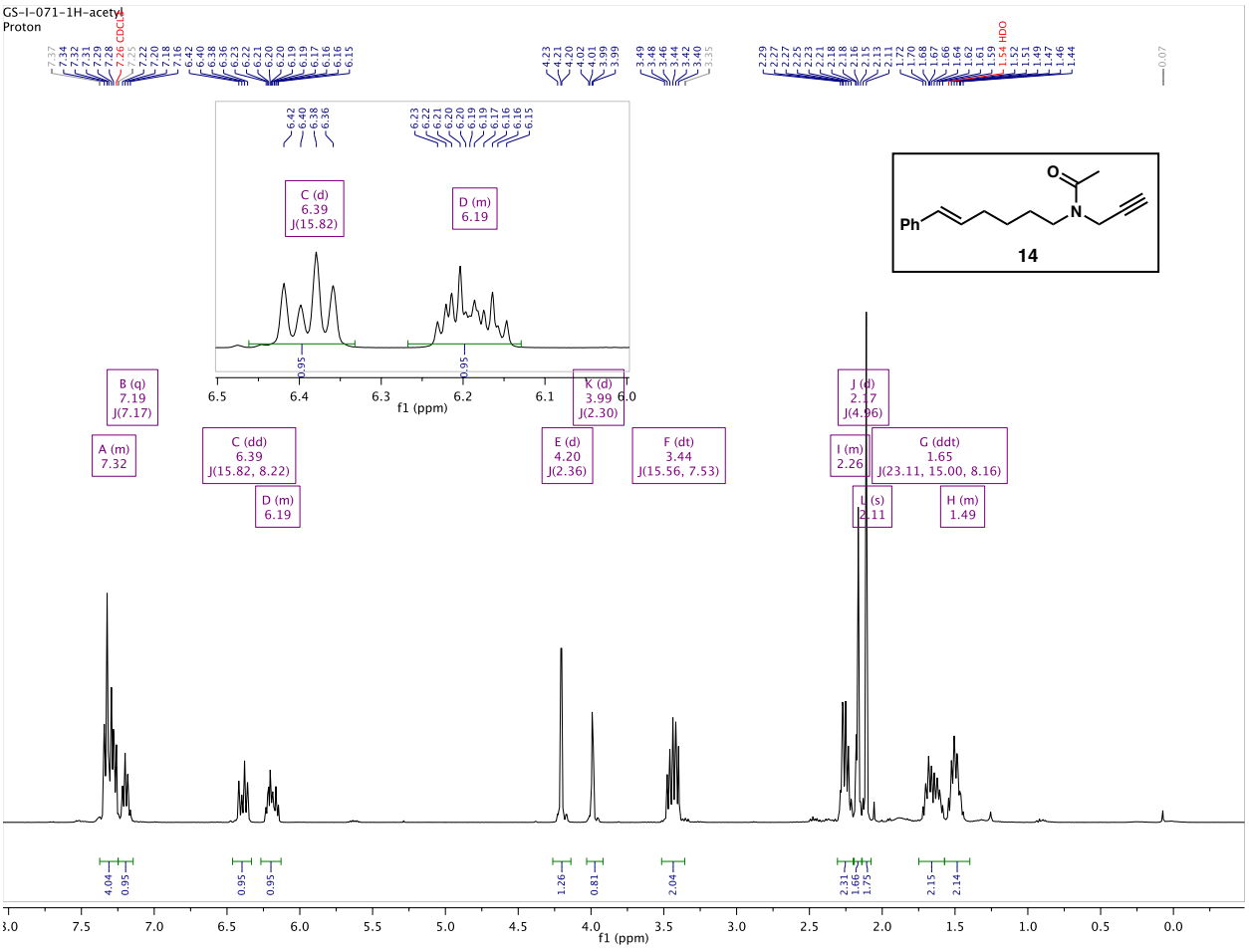

GS-I-071-13C-flash-2
C13-STANDARD
151.25
141.21
129.14
128.24
126.48
106.96
77.32
77.00
76.68
72.40
60.43
56.91
53.12
29.31
25.54
24.05
H
N
13
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

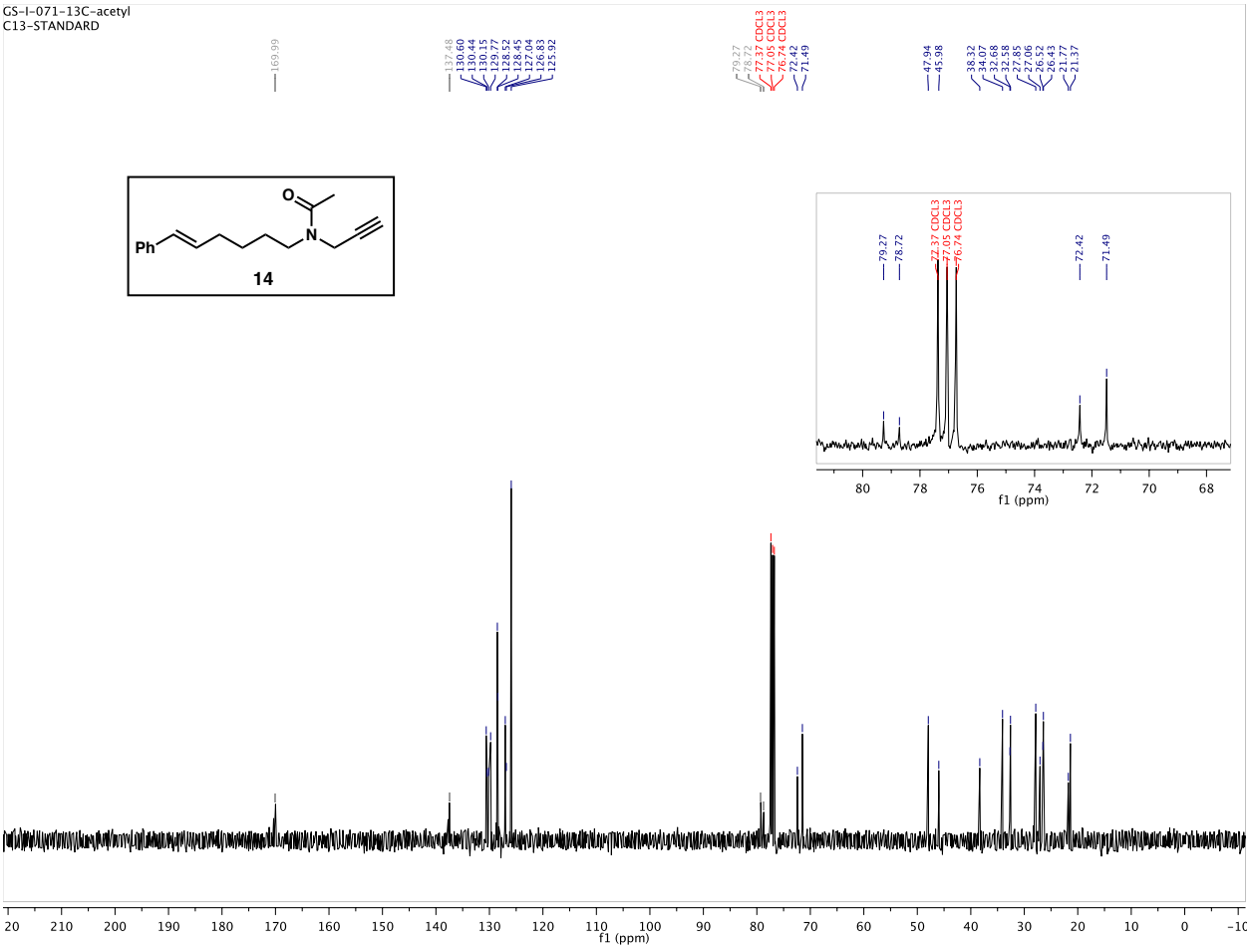

GS-I-094-COSY
Gradient Homonuclear Correlation Spectroscopy
13
f2 (ppm)
f1 (ppm)

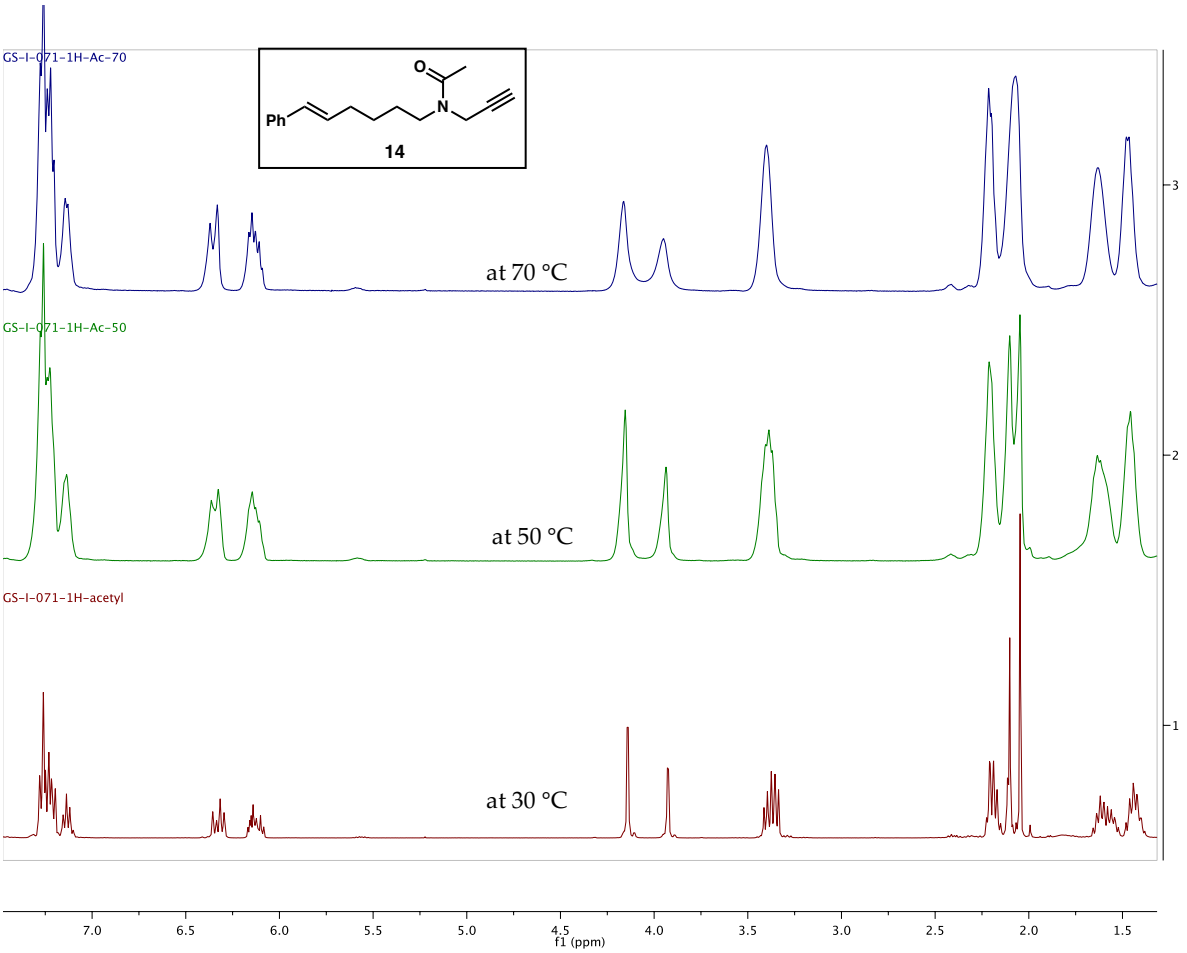

GS-I-094-HSQC
Gradient Heteronuclear Single-Quantum Correlation Spectroscopy
C5
C4
C2
C3
C1
f2 (ppm)
f1 (ppm)


GS-I-094-NOE-2.03
gradient 1d noe
Enhancement in HC, HD
Enhancement in HE
HC, HD
HB
HE
HA
No enhancement in HB
HD
HA
HB HC
N
HF
HE
13
HE
HB
HA
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
f1 (ppm)

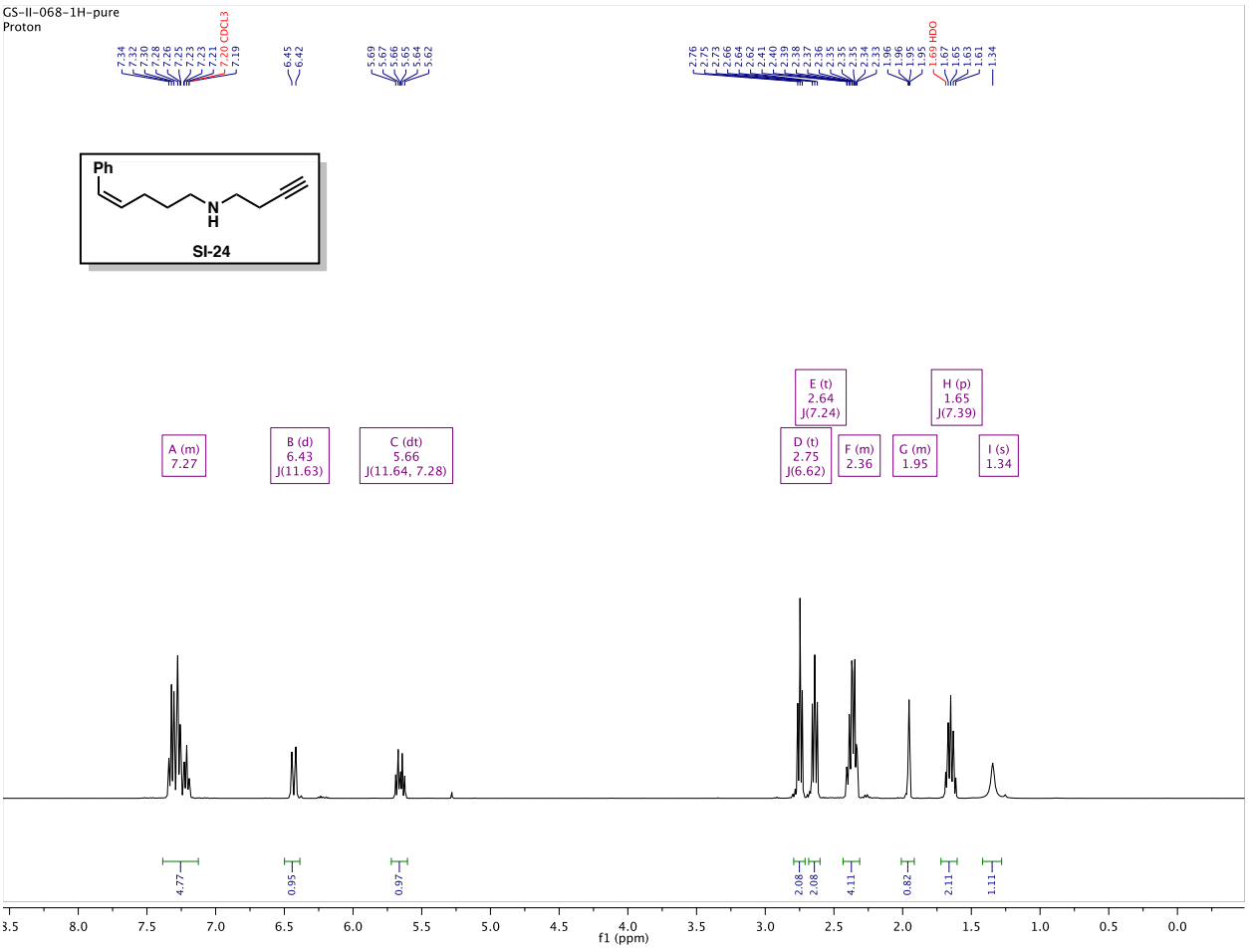

GS-I-094-NOE-3.34
gradient 1d noe
No enhancement in HA
HB
HA
HA
HB
13
.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
f1 (ppm)

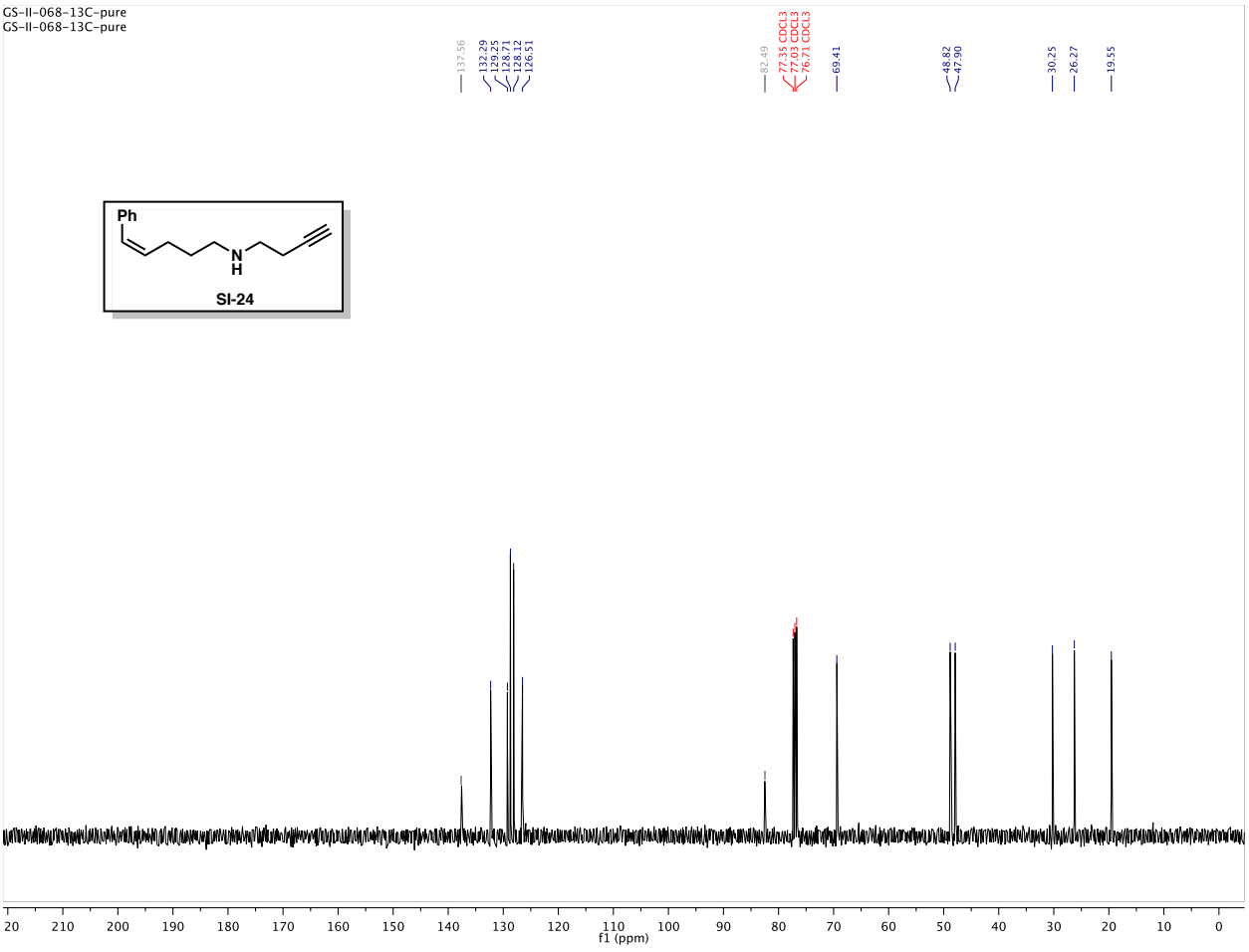

GS-I-071-1H-acetyl
Proton
CDCl3
HDO
C (d)
6.39
J(15.82)
D (m)
6.19
f1 (ppm)
O
N
Ph
14
B (q)
7.19
J(7.17)
A (m)
7.32
C (dd)
6.39
J(15.82, 8.22)
D (m)
6.19
K (d)
3.99
J(2.30)
E (d)
4.20
J(2.36)
F (dt)
3.44
J(15.56, 7.53)
J (d)
2.17
J(4.96)
I (m)
2.26
L (s)
2.11
G (ddt)
1.65
J(23.11, 15.00, 8.16)
H (m)
1.49
f1 (ppm)

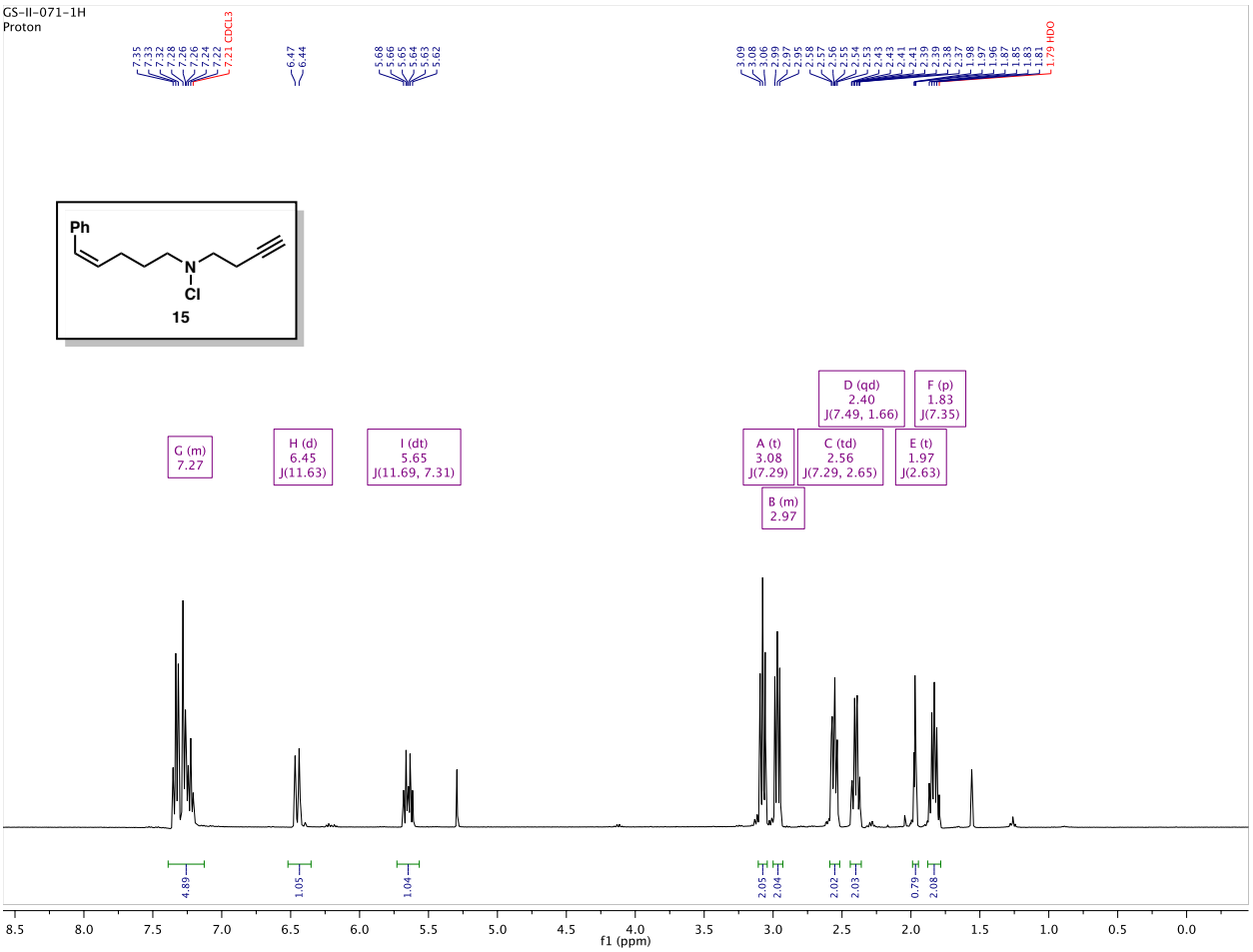

GS-I-071-13C-acetyl
C13-STANDARD
169.99
137.48
130.60
130.44
130.15
129.77
128.52
128.45
127.04
126.83
125.92
79.27
78.72
77.37 CDCl3
77.05 CDCl3
76.74 CDCl3
72.42
71.49
47.94
45.98
38.32
34.07
32.68
32.58
27.85
27.06
26.52
26.43
21.77
21.37
Ph
N
O
14
f1 (ppm)

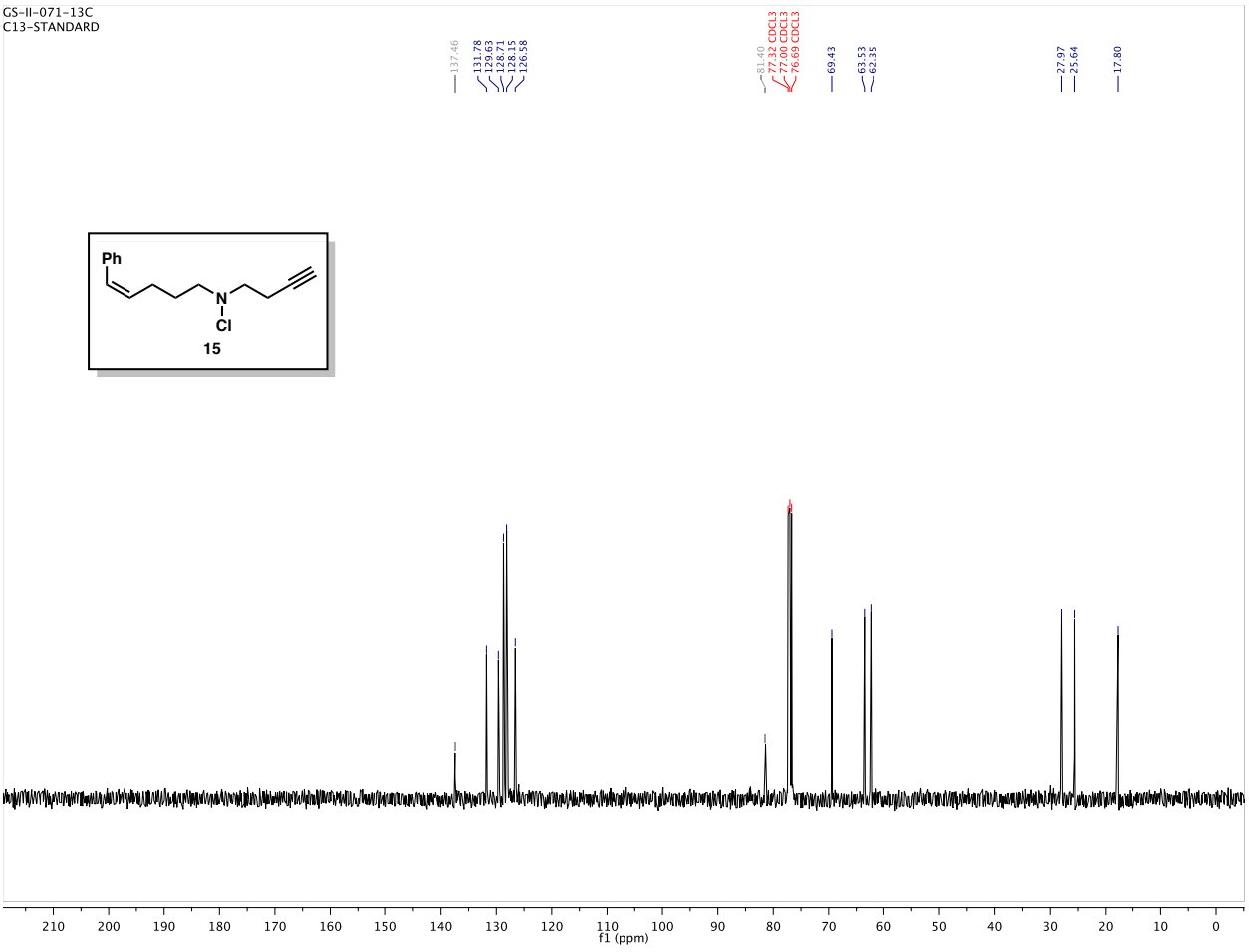


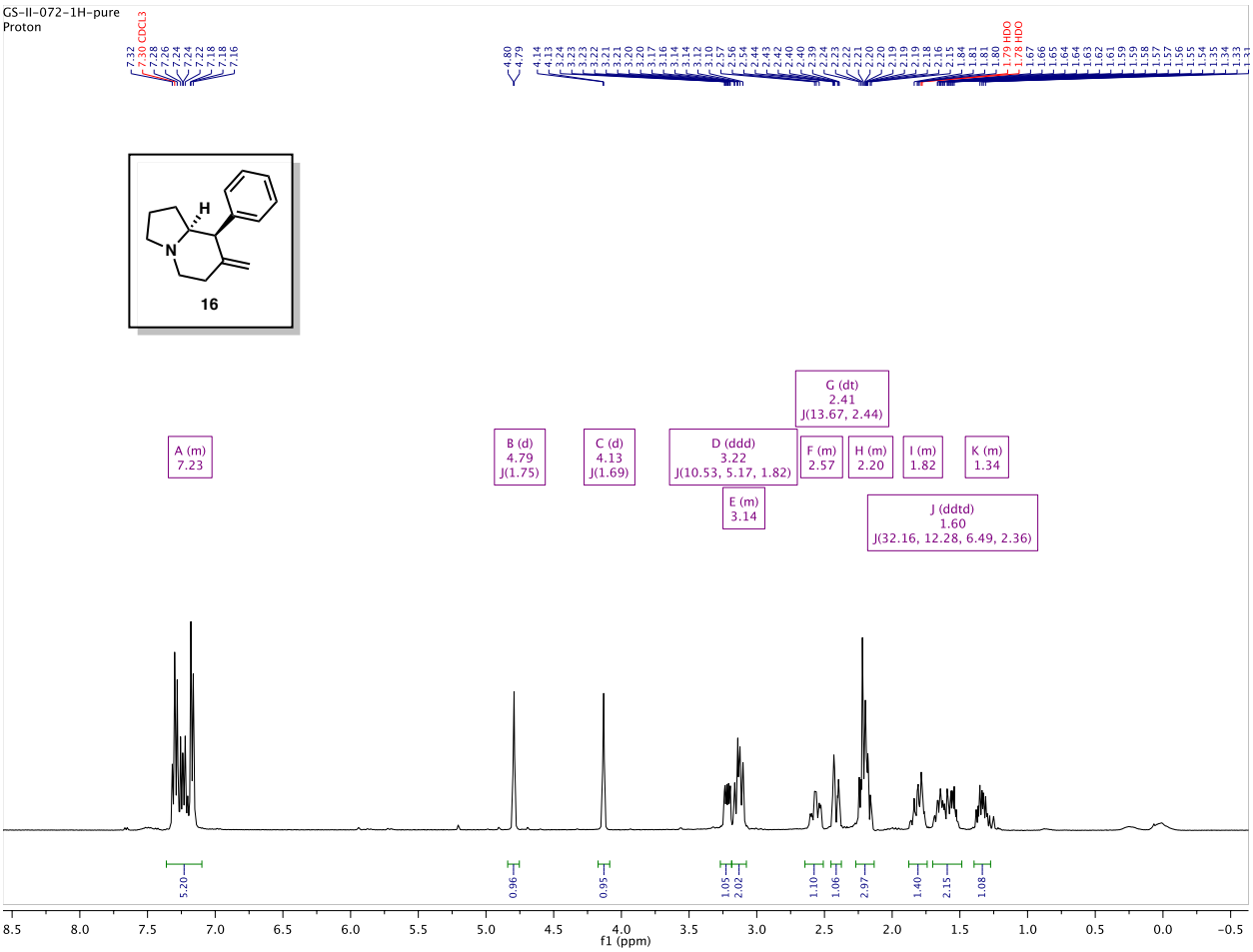
Variable temperature ^{1}H-NMR of compound 14

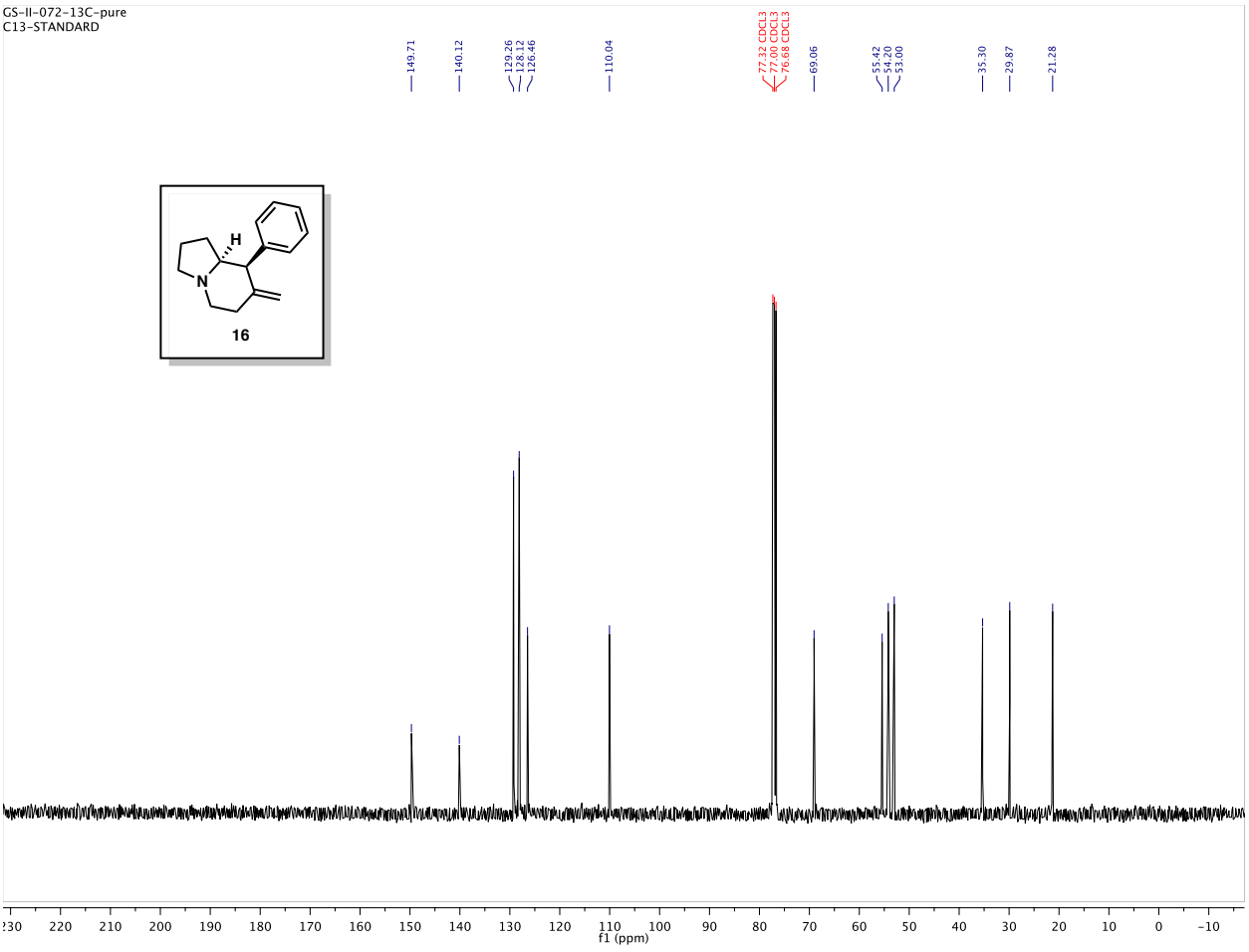

GS-II-068-1H-pure
Proton
Ph
N
H
SI-24
A (m)
7.27
B (d)
6.43
J(11.63)
C (dt)
5.66
J(11.64, 7.28)
D (t)
2.75
J(6.62)
E (t)
2.64
J(7.24)
F (m)
2.36
G (m)
1.95
H (p)
1.65
J(7.39)
I (s)
1.34
f1 (ppm)

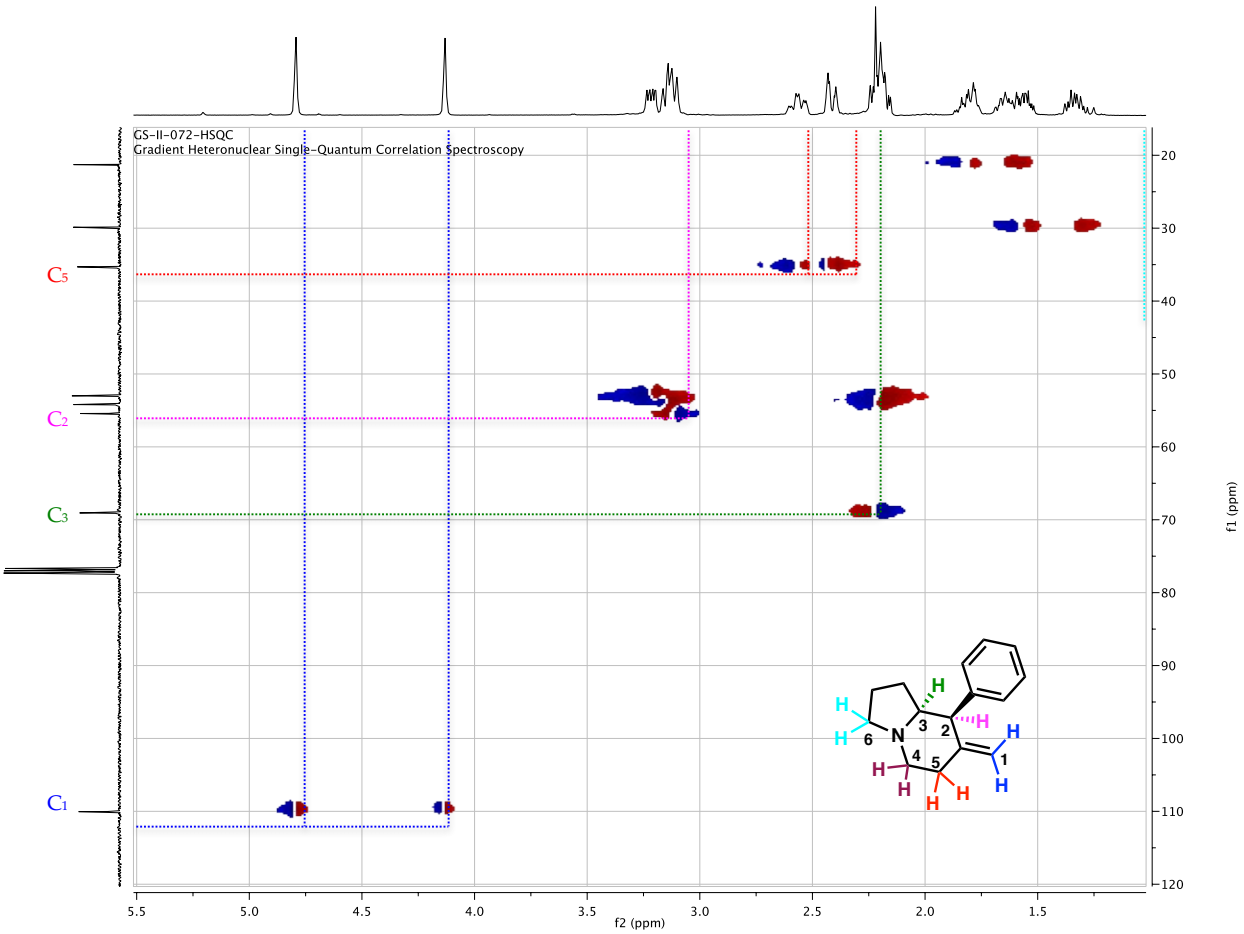

GS-II-068-13C-pure
GS-II-068-13C-pure
137.56
132.29
129.55
128.71
128.12
126.51
82.49
77.35 CDCl3
77.03 CDCl3
76.71 CDCl3
69.41
48.82
47.90
30.25
26.27
19.55
Ph
N
H
SI-24
f1 (ppm)

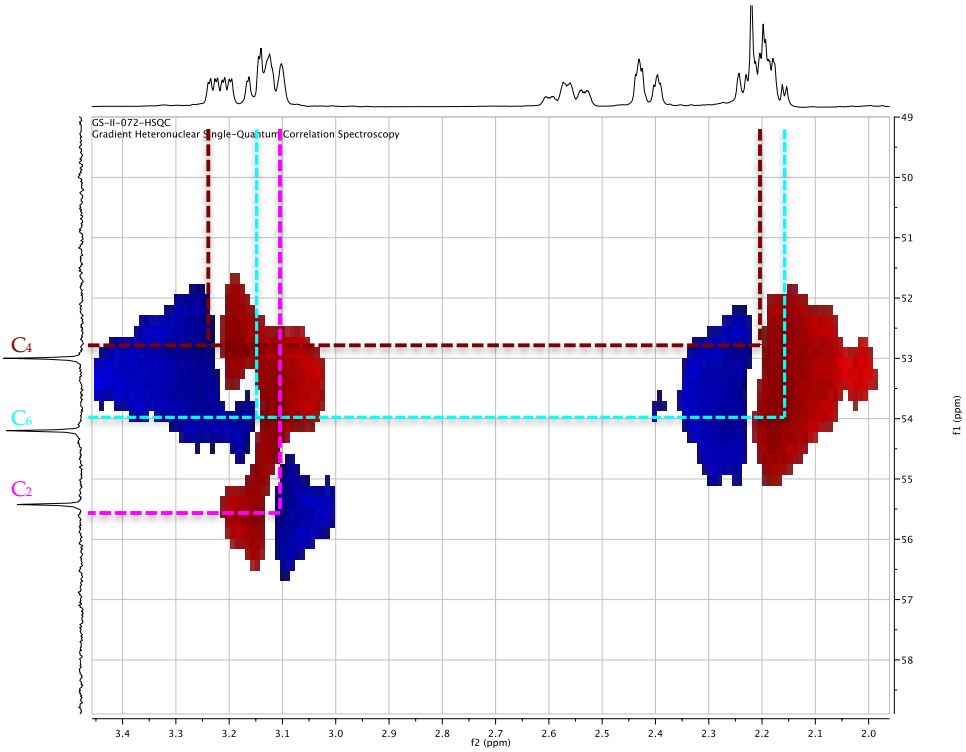

GS-II-071-1H
Proton
Ph
N
Cl
15
G (m)
7.27
H (d)
6.45
J(11.63)
I (dt)
5.65
J(11.69, 7.31)
A (t)
3.08
J(7.29)
B (m)
2.97
C (td)
2.56
J(7.29, 2.65)
D (qd)
2.40
J(7.49, 1.66)
E (t)
1.97
J(2.63)
F (p)
1.83
J(7.35)
f1 (ppm)

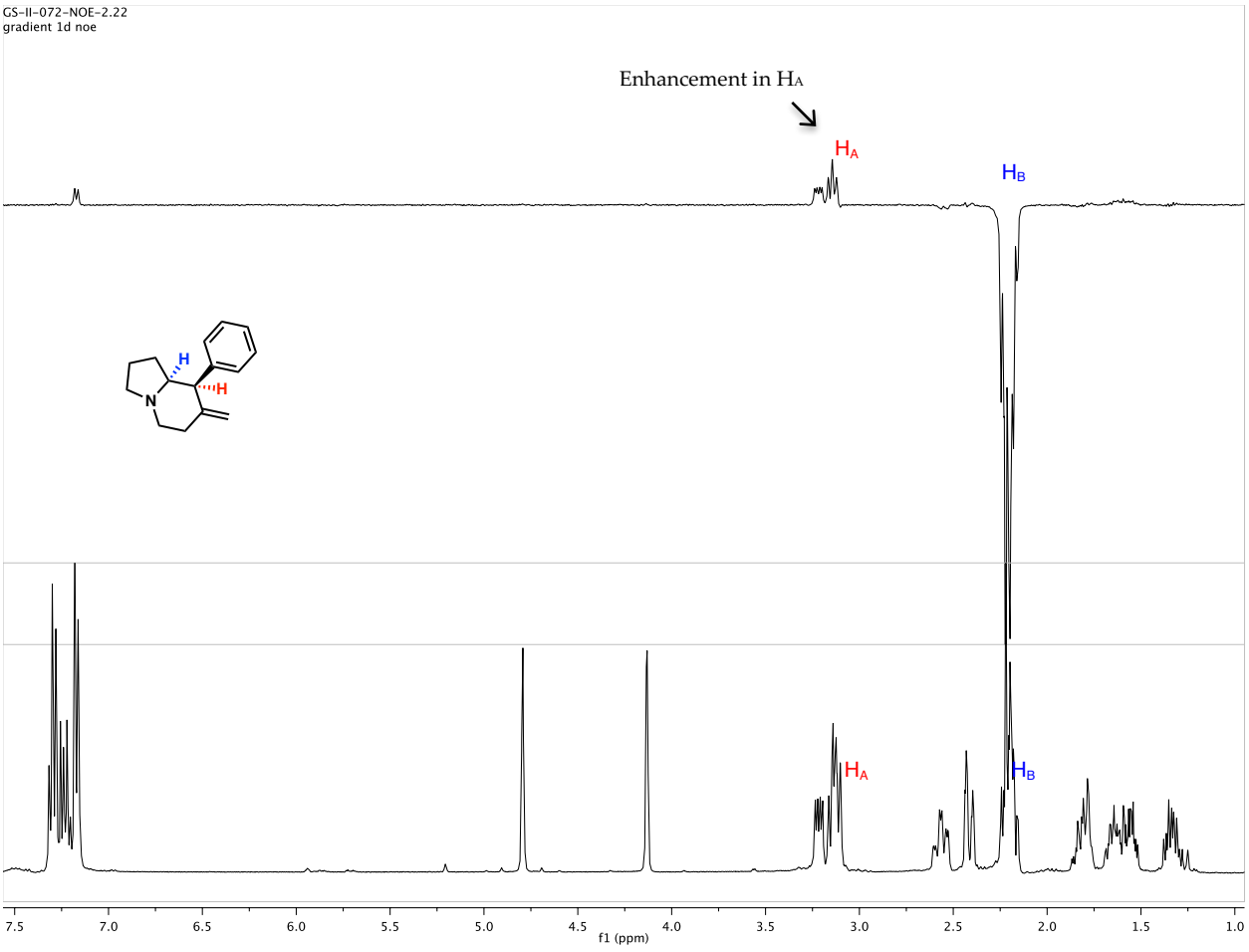

GS-II-071-13C
C13-STANDARD
137.46
131.78
129.63
128.71
128.15
126.58
81.40
77.32 CDCL3
77.06 CDCL3
76.69 CDCL3
69.43
63.53
62.35
27.97
25.64
17.80
Ph
N
Cl
15
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

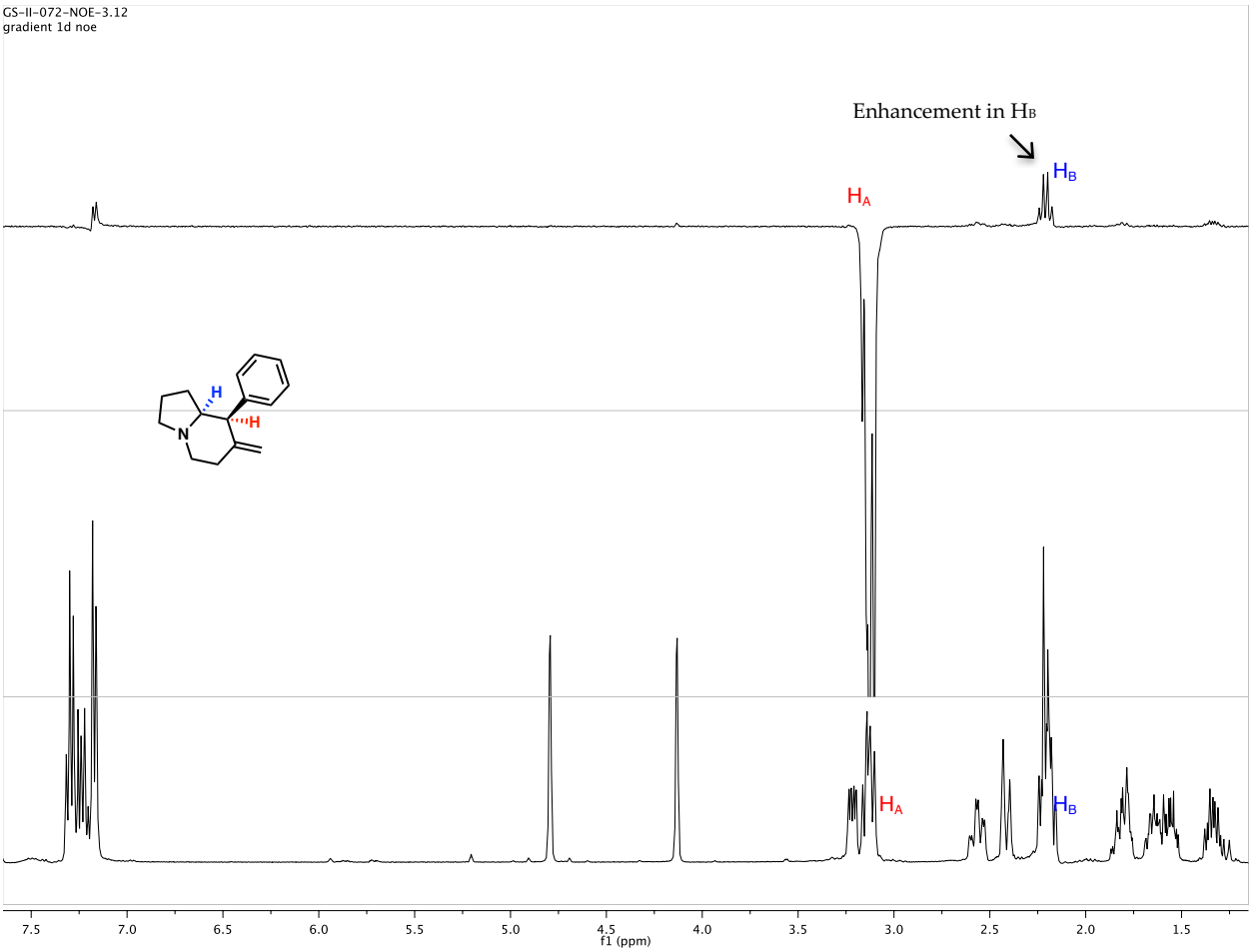

GS-II-072-1H-pure
Proton
16
A (m)
7.23
B (d)
4.79
J(1.75)
C (d)
4.13
J(1.69)
D (ddd)
3.22
J(10.53, 5.17, 1.82)
E (m)
3.14
F (m)
2.57
G (dt)
2.41
J(13.67, 2.44)
H (m)
2.20
I (m)
1.82
J (dddt)
1.60
J(32.16, 12.28, 6.49, 2.36)
K (m)
1.34
f1 (ppm)

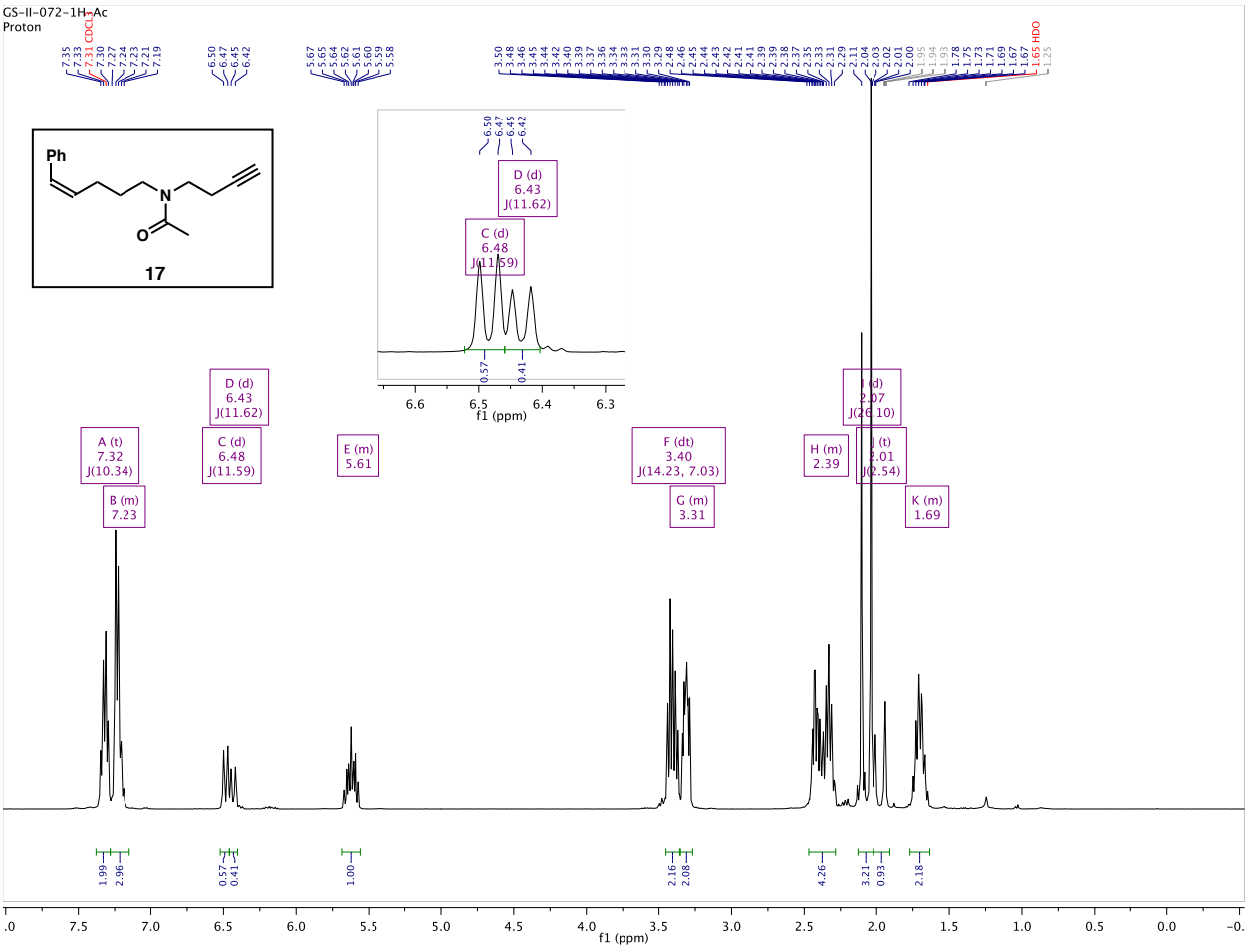

GS-II-072-13C-pure
C13-STANDARD
149.71
140.12
139.26
128.12
126.46
110.04
77.36 CDCL3
77.00 CDCL3
76.65 CDCL3
69.06
55.42
54.20
53.00
35.30
29.87
21.28
H
N
16
f1 (ppm)

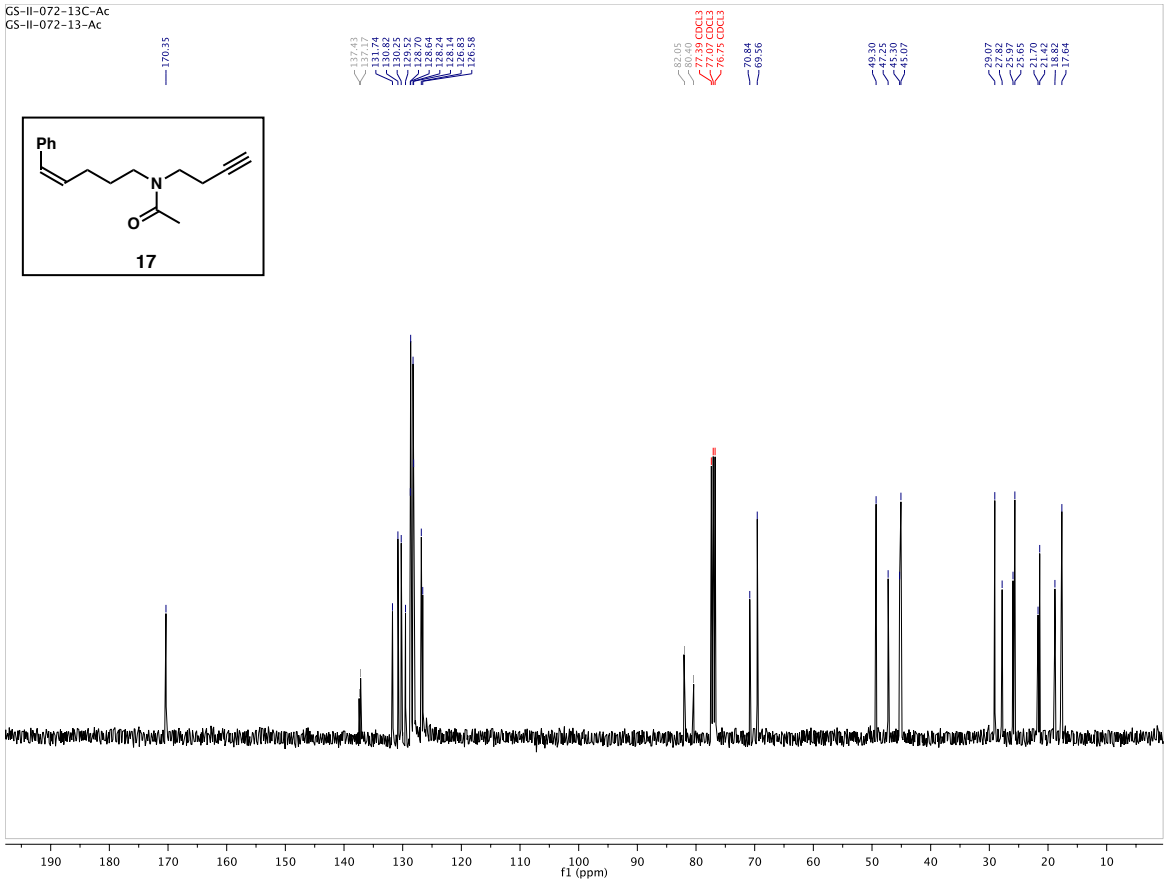

GS-II-072-HSQC
Gradient Heteronuclear Single-Quantum Correlation Spectroscopy
C5
C2
C3
C1
f2 (ppm)
f1 (ppm)

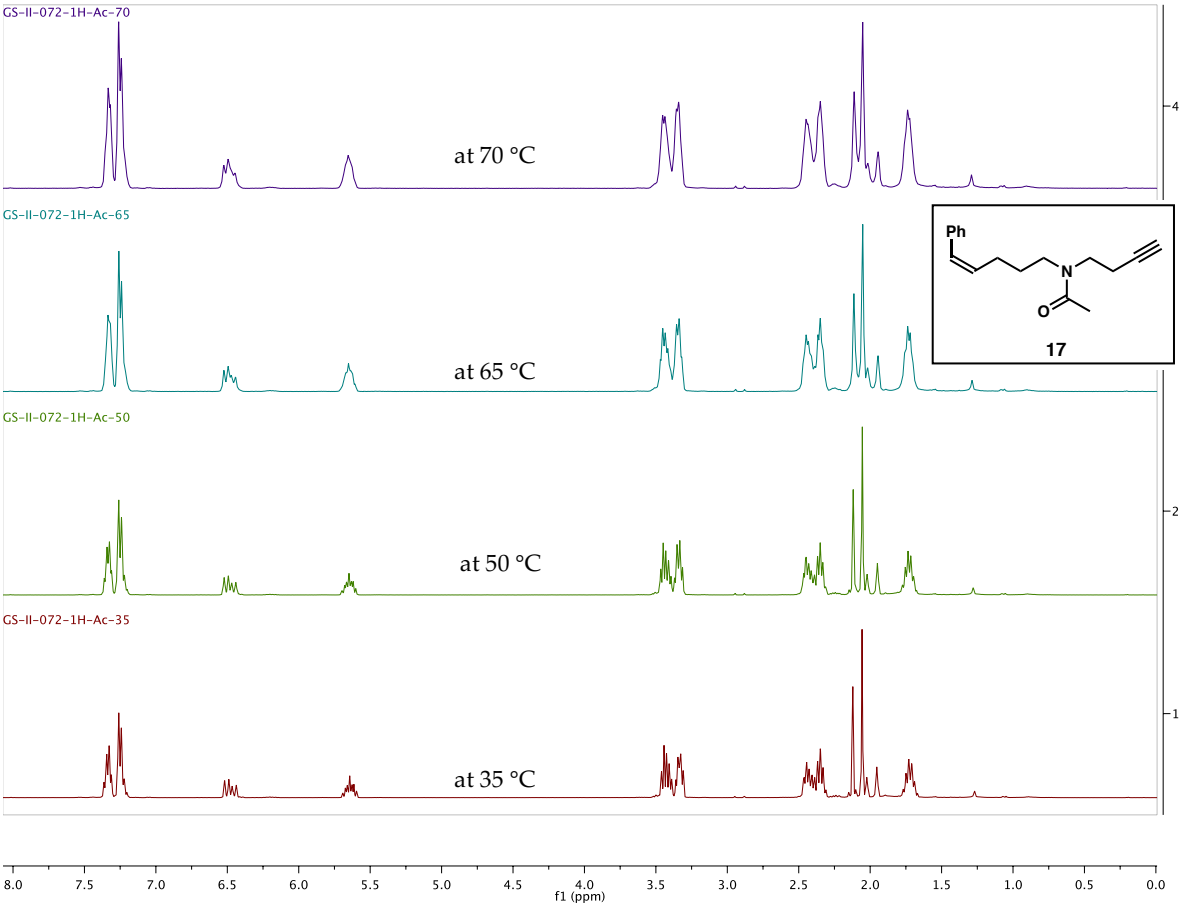

GS-II-072-HSQC
Gradient Heteronuclear Single-Quantum Correlation Spectroscopy
C4
C6
C2
f2 (ppm)
f1 (ppm)


GS-II-072-NOE-2.22
gradient 1d noe
Enhancement in HA
HA
HB
H
H
N
HA
HB
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
f1 (ppm)


GS-II-072-NOE-3.12
gradient 1d noe
Enhancement in HB
HB
HA
H
H
N
HA
HB
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
f1 (ppm)


GS-II-072-1H-Ac
Proton
Ph
N
O
17
A (t)
7.32
J(10.34)
B (m)
7.23
C (d)
6.48
J(11.59)
D (d)
6.43
J(11.62)
E (m)
5.61
F (dt)
3.40
J(14.23, 7.03)
G (m)
3.31
H (m)
2.39
I (t)
2.01
J(2.54)
J (d)
2.07
J(26.10)
K (m)
1.69
f1 (ppm)


GS-II-072-13C-Ac
GS-II-072-13-Ac
170.35
137.43
137.17
131.74
130.82
130.25
129.52
128.70
128.64
128.34
128.14
126.83
126.58
82.05
80.40
77.39 CDCL3
77.07 CDCL3
76.75 CDCL3
70.84
69.56
49.30
47.25
45.30
45.07
29.07
27.82
25.97
25.65
21.70
21.42
14.82
17.64
Ph
N
O
17
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)



Variable temperature ^{1}H-NMR of compound 17