

Supporting Materials

Regioselectivity Control in a Ruthenium-catalyzed Cycloisomerization of Diyne-ols.

Barry M. Trost^{*}, Michael T. Rudd, Moisés Gulías Costa, Philip I. Lee, and
Andrew E. Pomerantz
Department of Chemistry
Stanford University
Stanford, CA 94305-5080

Supporting Materials

General experimental: All reactions were performed under an argon atmosphere unless otherwise noted. Dry acetone was distilled over drierite. Dry tetrahydrofuran (THF) was distilled over sodium benzophenone ketyl or purified on an alumina column purification system. All other solvents were purified on an alumina column purification system. Catalysts **3.1**¹ was prepared according to literature. Flash chromatography was performed with EM Science silica gel. Proton and broad band decoupled ¹³C nuclear magnetic resonance data were acquired on Varian GEM300, Inova Unity 400, or Inova Unity 500 spectrometer as indicated. Chemical shifts are reported in ppm relative to TMS, CDCl₃, or C₆D₆. Infrared (IR) data were recorded on sodium chloride plates on a Perkin Elmer Paragon 500 FT-IR spectrometer. The water used in all reactions was deionized water. All other chemicals were obtained from Aldrich, Acros, or GFS Chemical Companies and distilled prior to use.

Cyclization Procedure A:

To a solution of diyne-ol (0.2 mmol) in distilled acetone (2 mL) was added water (1.5 mmol, 27 μ L) and [CpRu(CH₃CN)₃]PF₆ (**1**) (0.02 mmol, 8.5 mg). The yellow/orange solution was then sealed and heated in a 60 °C oil bath until consumption of starting material was complete as judged by TLC (generally 1-8 hr). The crude reaction mixture was then cooled to room temperature, diluted with petroleum ether (10 mL) and filtered through a plug of celite using ether as the eluent to remove most of the ruthenium components. The solvent was removed in vacuo to yield the crude product, which was purified using silica gel chromatography.

Cyclization Procedure A':

To a solution of diyne-ol (0.2 mmol) in distilled acetone (2 mL) was added water (1.5 mmol, 27 μ L) and [CpRu(CH₃CN)₃]PF₆ (**1**) (0.02 mmol, 8.5 mg). The yellow/orange solution was then sealed and heated in a 50 °C oil bath until consumption of starting material was complete as judged by TLC (2hr). The crude reaction mixture was then cooled to room temperature, diluted with petroleum ether (10 mL) and filtered through a plug of celite using ether as the eluent to remove most of the ruthenium components. The solvent was removed in vacuo to yield the crude product, which was purified using silica gel chromatography.

Cyclization Procedure B:

To a solution of diyne-ol (0.2 mmol) in distilled acetone (1.2 mL) was added water (0.8 mL) and [CpRu(CH₃CN)₃]PF₆ (**1**) (0.02 mmol, 8.5 mg). The yellow/orange solution was then sealed and heated in a 60 °C oil bath until consumption of starting material was complete as judged by TLC (generally 1-8 hr). The crude reaction mixture was then cooled to room temperature, diluted with petroleum ether (10 mL) and filtered through a plug of celite using ether as the eluent to remove most of the ruthenium components. The solvent was removed in vacuo to yield the crude product, which was purified using silica gel chromatography.

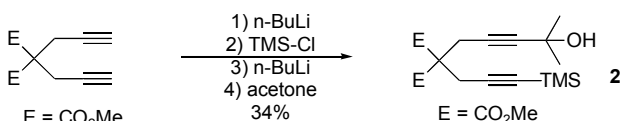
Cyclization Procedure B':

Supporting Materials

To a solution of diyne-ol (0.2 mmol) in distilled acetone (1.2 mL) was added water (0.8 mL) and [CpRu(CH₃CN)₃]PF₆ (**1**) (0.03 mmol, 13 mg). The yellow/orange solution was then sealed and heated in a 60 °C oil bath until consumption of starting material was complete as judged by TLC (generally 1-8 hr). The crude reaction mixture was then cooled to room temperature, diluted with petroleum ether (10 mL) and filtered through a plug of celite using ether as the eluent to remove most of the ruthenium components. The solvent was removed in vacuo to yield the crude product, which was purified using silica gel chromatography.

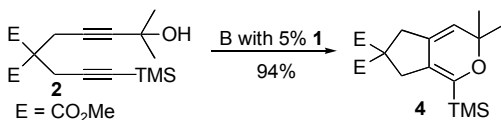
Cyclization Procedure B'':

To a solution of diyne-ol (0.2 mmol) in distilled acetone (2 mL) was added Water (1.5 mmol, 27 μ L) and [CpRu(CH₃CN)₃]PF₆ (**1**) (0.02 mmol, 8.5 mg). The yellow/orange solution was then stirred at room temperature until consumption of starting material was complete as judged by TLC (15 min). The crude reaction mixture was diluted with petroleum ether (10 mL) and filtered through a plug of celite using ether as the eluent to remove most of the ruthenium components. The solvent was removed in vacuo to yield the crude product, which was purified using silica gel chromatography.



To a solution of dimethyl(bis)propargyl malonate (0.5 g, 2.4 mmol) in THF (20 mL) cooled to -78 °C was added n-BuLi (1.5 mL of 1.6 M solution in hexanes, 2.4 mmol). After stirring for 1 hr, TMS-Cl (0.31 mL, 2.4 mmol) was added and stirred for 2 hr. A second aliquot of n-BuLi (1.5 mL of 1.6 M solution in hexanes, 2.4 mmol) was added and stirred 1 hr. Freshly distilled acetone (0.36 mL, 4.8 mmol) was then added and the reaction was stirred 2 hr more. Saturated ammonium chloride was then added to the reaction at -78 °C and the mixture was warmed to room temperature, extracted with ether, dried over MgSO₄, and the solvent removed in vacuo. The crude product was then purified using silica gel chromatography (40% ether/pet. ether) to yield 275 mg of **2** (34%).

Rf (40% Et₂O/PE): 0.3. **IR** (neat): 3495, 2980, 2957, 2931, 2361, 2180, 1745, 1437, 1364, 1324, 1294, 1251, 1211, 1029, 957, 846, 761, 699 cm⁻¹. **¹H NMR** (300 MHz, CDCl₃): 3.72 (s, 6H), 2.92 (s, 2H), 2.91 (s, 2H), 2.27 (bs, 1H), 1.43 (s, 6H), 0.1 (s, 9H). **¹³C NMR** (75 MHz, CDCl₃): 169.3, 100.8, 88.6, 88.5, 76.5, 65.0, 57.2, 53.0, 31.5, 24.1, 22.9, -0.04. **Anal** Cal'c for C₁₇H₂₆O₅Si: C, 60.32; H, 7.74. Found: C, 60.50; H, 7.90.

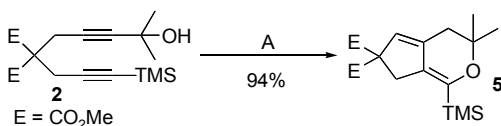


Procedure: B with 5% **1** for 20 hr.

Rf (50% Et₂O/PE): 0.5. **IR** (neat): 2956, 1739, 1434, 1378, 1355, 1249, 1021, 1161, 1076, 901, 840, 754, 696 cm⁻¹. **¹H NMR** (400 MHz, C₆D₆): 4.81 (m, 1H), 3.28 (s, 6H),

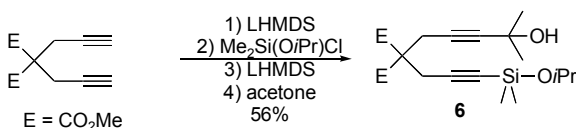
Supporting Materials

3.27 (s, 2H), 3.10, (d, $J = 2$ Hz, 2H), 1.27 (s, 6H), 0.22 (s, 9H). **^{13}C NMR** (100 MHz, C_6D_6): 171.5, 151.8, 133.9, 123.5, 116.7, 73.9, 60.3, 52.3, 37.9, 36.6, 27.5, -1.8. **Anal** Cal'c for $\text{C}_{17}\text{H}_{26}\text{O}_5\text{Si}$: C, 60.32; H, 7.74. Found: C, 60.32; H, 7.87.



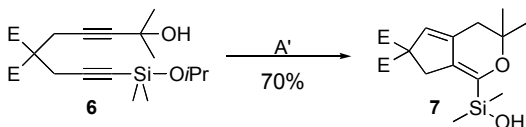
Procedure: A for 2hr.

Rf (50% $\text{Et}_2\text{O}/\text{PE}$): 0.5. **IR** (neat): 2955, 2895, 2840, 1737, 1608, 1434, 1382, 1367, 1321, 1249, 1195, 1171, 1147, 1074, 931, 867, 840, 754 cm^{-1} . **^1H NMR** (300 MHz, C_6D_6): 5.75 (s, 1H), 3.57 (s, 2H), 3.33 (s, 6H), 2.13 (s, 2H), 1.08 (s, 6H), 0.17 (s, 9H). **^{13}C NMR** (75 MHz, C_6D_6): 171.6, 150.9, 140.5, 127.7, 120.6, 72.9, 65.1, 52.7, 36.5, 34.4, 26.4, -2.0. **HRMS** (EI, $[\text{M}]^+$) Cal'c for $\text{C}_{17}\text{H}_{26}\text{O}_5\text{Si}$: 338.1550. Found: 338.1547 (17.4), 279.1402 (92.1), 175.07 (22.1).



To a solution of dimethyl(bis)propargyl malonate (0.5 g, 2.4 mmol) in THF (20 mL) cooled to -78°C was added LHMDS (2.4 mL of 1.0 M solution in THF, 2.4 mmol). After stirring for 30 minutes, $\text{Me}_2\text{Si}(\text{OiPr})\text{Cl}$ (0.33 g, 2.4 mmol) was added and stirred for 1 hr. A second aliquot of LHMDS (2.8 mL of 1.0 M solution in THF, 2.8 mmol) was added and stirred 15 minutes. Freshly distilled acetone (0.36 mL, 4.8 mmol) was then added and the reaction was stirred 1 hr more. Saturated ammonium chloride was then added to the reaction at -78°C and the mixture was warmed to room temperature, extracted with ether, dried over MgSO_4 , and the solvent removed in vacuo. The crude product was then purified using silica gel chromatography (40% ether/pet. ether) to yield 490 mg of **6** (56%).

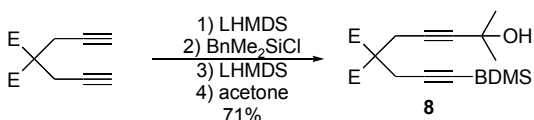
Rf (40% $\text{Et}_2\text{O}/\text{PE}$): 0.35. **IR** (neat): 3490, 2971, 2930, 2179, 1745, 1437, 1368, 1324, 1293, 1257, 1211, 1122, 1081, 1029, 952, 885, 832, 793, 667 cm^{-1} . **^1H NMR** (400 MHz, C_6D_6): 4.15 (sep, $J = 6$ Hz, 1H), 3.37 (s, 6H), 3.30 (s, 2H), 3.28 (s, 2H), 2.57 (bs, 1H), 1.39 (s, 6H), 1.19 (d, $J = 6$ Hz, 6H), 0.23 (s, 6H). **^{13}C NMR** (100 MHz, C_6D_6): 169.3, 101.2, 89.9, 87.6, 76.1, 66.2, 64.7, 57.4, 52.7, 31.6, 25.7, 24.5, 23.4, 0.9. **HRMS** (EI, $[\text{M}-\text{OH}]^+$) Cal'c for $\text{C}_{19}\text{H}_{29}\text{O}_5\text{Si}$: 365.1784. Found: 365.1799 (0.6), 339.1254 (35.1), 307.0992 (49.1).



Procedure: A' for 2hr (some amount of dimer also formed).

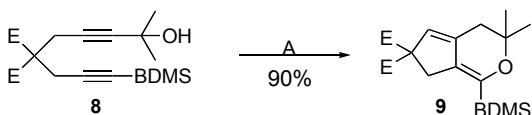
Rf (20% $\text{Et}_2\text{O}/\text{PE}$): 0.40. **IR** (neat): 3530, 2956, 2853, 1736, 1611, 1435, 1382, 1367, 1321, 1252, 1196, 1171, 1148, 1079, 932, 865, 823, 781 cm^{-1} . **^1H NMR** (300 MHz, CDCl_3): 5.52 (bs, 1H), 3.74 (s, 6H), 3.21 (s, 2H), 2.39 (s, 2H), 1.90 (bs, 1H), 1.18 (s, 6H),

0.28 (s, 6H). **¹³C NMR** (75MHz, CDCl₃): 171.5, 149.1, 140.2, 128.5, 121.8, 100.3, 73.3, 65.2, 52.8, 36.5, 26.5, -0.6. **HRMS** (EI, [M]⁺) Cal'c for C₁₆H₂₄O₆Si: 340.1342. Found: 340.1337 (23.1), 281.1225 (100).



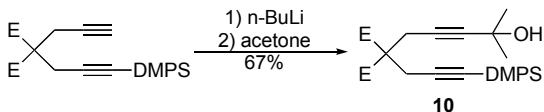
To a solution of dimethyl(bis)propargyl malonate (1.0 g, 4.8 mmol) in THF (35 mL) cooled to -78 °C was added LHMDS (4.8 mL of 1.0 M solution in THF, 4.8 mmol). After stirring for 30 minutes, BnMe₂SiCl (0.87 mL, 4.8 mmol) was added and stirred for 1 hr. A second aliquot of LHMDS (6.2 mL of 1.0 M solution in THF, 6.2 mmol) was added and stirred 30 minutes. Freshly distilled acetone (0.36 mL, 4.8 mmol) was then added and the reaction was stirred 1 hr more. Saturated ammonium chloride was then added to the reaction at -78 °C and the mixture was warmed to room temperature, extracted with ether, dried over MgSO₄, and the solvent removed in vacuo. The crude product was then purified using silica gel chromatography (40% ether/pet. ether) to yield 1.41 g of **8** (71%).

R_f (40% Et₂O/PE): 0.2. **IR** (neat): 3495, 3025, 2958, 2898, 2180, 1744, 1600, 1494, 1452, 1436, 1364, 1324, 1294, 1249, 1209, 1028, 952, 839, 764, 700 cm⁻¹. **¹H NMR** (300 MHz, CDCl₃): 7.20 (m, 2H), 7.05 (m, 3H), 3.71 (s, 6H), 2.97 (s, 2H), 2.92 (s, 2H), 2.37 (s, 1H), 2.15 (s, 2H), 1.46 (s, 6H). **¹³C NMR** (75MHz, CDCl₃): 169.2, 138.8, 128.3, 128.2, 124.3, 102.1, 88.7, 86.9, 76.4, 64.9, 57.0, 52.9, 31.5, 26.1, 24.1, 22.8, -2.1. **HRMS** (EI, [M-CH₃]⁺) Cal'c for C₂₂H₂₇O₅Si: 399.1628. Found: 399.1635 (1.7), 323.1300 (12.3), 263.1099 (90.7). **LRMS** (CI, [M + H]⁺) Cal'c for C₂₃H₃₁O₅Si: 415.2. Found: 415.3, 432.3 [M + NH₃]⁺.



Procedure: A for 2 hr.

R_f (40% Et₂O/PE): 0.4. mp = 59-61 °C. **IR** (neat): 3067, 3021, 2954, 2899, 1737, 1600, 1494, 1434, 1367, 1321, 1250, 1148, 1075, 823, 649 cm⁻¹. **¹H NMR** (300 MHz, C₆D₆): 7.13 (m, 3H), 7.01 (m, 2H), 5.74 (s, 1H), 3.40 (s, 2H), 3.33 (s, 6H), 2.22 (s, 2H), 2.13 (s, 2H), 1.08 (s, 6H). **¹³C NMR** (75MHz, C₆D₆): 171.0, 149.4, 140.0, 139.4, 128.9, 128.4, 128.2, 124.1, 121.8, 72.8, 65.3, 52.0, 36.3, 34.7, 26.2, 24.3, -4.2. **HRMS** (EI, [M]⁺) Cal'c for C₂₃H₃₀O₅Si: 414.1863. Found: 414.1863 (33.3), 355.1717 (100).

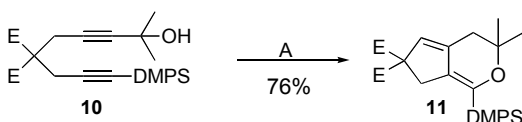


To a solution of mono-dimethylphenylsilyl-protected dimethyl(bis)propargyl malonate (0.83 g, 2.43 mmol) in THF (25 mL) cooled to -78 °C was added n-BuLi (1.88 mL of 1.36 M solution in hexanes, 2.55 mmol). After stirring for 1 hr, acetone (0.2 mL, 2.67 mmol) was added and stirred for 2 hr. Saturated ammonium chloride was then added to

Supporting Materials

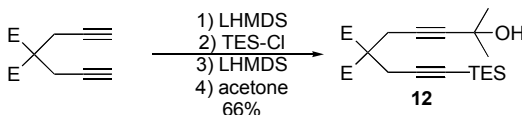
the reaction at $-78\text{ }^{\circ}\text{C}$ and the mixture was warmed to room temperature, extracted with ether, dried over MgSO_4 , and the solvent removed in vacuo. The crude product was then purified using silica gel chromatography (50% ether/pet. ether) to yield 650 mg of **10** (67%).

Rf (30% $\text{Et}_2\text{O}/\text{PE}$): 0.15. **IR** (neat): 3500, 3070, 2958, 2844, 2246, 2180, 1731, 1435, 1265, 1324, 1294, 1208, 1116, 1026, 952, 818, 782, 733, 703, 665 cm^{-1} . **^1H NMR** (400 MHz, CDCl_3): 7.57 (m, 2H), 7.36 (m, 3H), 3.72 (s, 6H), 3.02 (s, 2H), 2.98 (s, 2H), 2.40 (bs 1H), 1.46 (s, 6H), 0.37 (s, 6H). **^{13}C NMR** (100MHz, CDCl_3): 169.4, 137.1, 133.8, 129.6, 128.1, 102.9, 88.9, 86.7, 76.6, 65.2, 57.3, 53.3, 31.7, 24.4, 23.2, -0.6. **HRMS** (EI, $[\text{M}]^+$) Cal'c for $\text{C}_{22}\text{H}_{28}\text{O}_5\text{Si}$: 400.1706. Found: 400.1709 (0.1), 285.1478 (3.4), 135.0672 (100).



Procedure: A for 2.5 hr

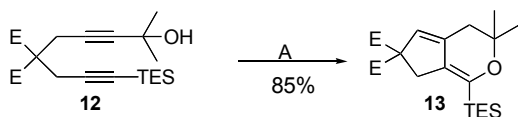
Rf (30% $\text{Et}_2\text{O}/\text{PE}$): 0.4. **IR** (neat): 3070, 2973, 2954, 2901, 1737, 1607, 1430, 1382, 1367, 1321, 1250, 1195, 1171, 1148, 1111, 1076, 865, 812, 780, 701 cm^{-1} . **^1H NMR** (400 MHz, C_6D_6): 7.58 (m, 2H), 7.15 (m, 3H), 5.70 (bs, 1H), 3.34 (s, 2H), 3.26 (s, 6H), 2.05 (d, $J = 1.2\text{ Hz}$, 2H), 1.02 (s, 6H), 0.39 (s, 6H). **^{13}C NMR** (100 MHz, C_6D_6): 171.2, 149.4, 140.4, 137.3, 134.3, 129.7, 129.4, 128.0, 122.3, 73.2, 65.5, 52.2, 36.5, 35.1, 26.4, -3.2. **HRMS** (EI, $[\text{M}]^+$) Cal'c for $\text{C}_{22}\text{H}_{28}\text{O}_5\text{Si}$: 400.1706. Found: 400.1713 (29.7), 342.1613 (23.1), 341.1568 (85.7), 135.0637 (100).



To a solution of dimethyl(bis)propargyl malonate (0.5 g, 2.4 mmol) in THF (20 mL) cooled to $-78\text{ }^{\circ}\text{C}$ was added LHMDS (2.4 mL of 1.0 M solution in THF, 2.4 mmol). After stirring for 30 minutes, TES-Cl (0.36 g, 2.4 mmol) was added and stirred for 1 hr. A second aliquot of LHMDS (2.8 mL of 1.0 M solution in THF, 2.8 mmol) was added and stirred 15 minutes. Freshly distilled acetone (0.36 mL, 4.8 mmol) was then added and the reaction was stirred 1 hr more. Saturated ammonium chloride was then added to the reaction at $-78\text{ }^{\circ}\text{C}$ and the mixture was warmed to room temperature, extracted with ether, dried over MgSO_4 , and the solvent removed in vacuo. The crude product was then purified using silica gel chromatography (40% ether/pet. ether) to yield 627 mg of **12** (66%).

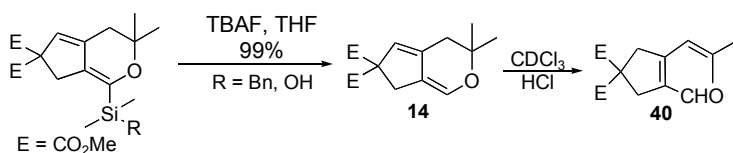
Rf (40% $\text{Et}_2\text{O}/\text{PE}$): 0.4. **IR** (neat): 3494, 2956, 2178, 1745, 1437, 1324, 1294, 1211, 1028, 952, 850, 727 cm^{-1} . **^1H NMR** (500 MHz, CDCl_3): 3.72 (s, 6H), 2.96 (s, 2H), 2.94 (s, 2H), 1.44 (s, 6H), 0.94 (t, $J = 8\text{ Hz}$, 9H), 0.55 (q, $J = 8\text{ Hz}$, 6H). **^{13}C NMR** (125 MHz, CDCl_3): 169.3, 101.8, 88.6, 85.7, 76.7, 65.1, 57.1, 53.0, 31.6, 24.2, 22.9, 7.5, 4.4. **Anal** Cal'c for $\text{C}_{22}\text{H}_{36}\text{O}_5\text{Si}$: C, 64.70; H, 8.88. Found: C, 63.93; H, 8.31.

Supporting Materials



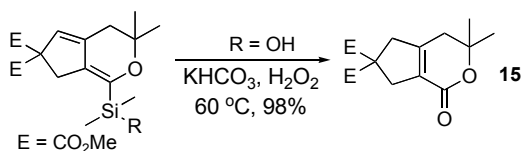
Procedure: A for 2 hr.

R_f (40% Et₂O/PE): 0.55. **IR** (neat): 2954, 2875, 1738, 1434, 1366, 1251, 1073, 1004, 721 cm⁻¹. **¹H NMR** (500 MHz, CDCl₃): 5.42 (s, 1H), 3.71 (s, 6H), 3.12 (s, 2H), 2.34 (s, 2H), 1.14 (s, 6H), 0.93 (t, J = 8Hz, 9H), 0.66 (q, J = 8Hz, 6H). **¹³C NMR** (125 MHz, CDCl₃): 171.9, 150.1, 140.9, 128.6, 73.2, 65.2, 53.0, 36.8, 34.9, 26.8, 7.6, 2.9. **HRMS** Cal'c for C₂₀H₃₂O₅Si: 380.2019. Found: 380.2017 (72.9), 321.0914 (97.1), 87.0631 (100).



To a solution of **7** or **9** (0.15 mmol) in THF (1.6 mL) cooled to 0 °C was added TBAF (0.3 mL of a 1M solution in THF, 0.3 mmol). The solution was then warmed to room temperature, and stirred until starting material was consumed (30 minutes). The crude reaction was filtered through a plug of silica with ether, and the solvent was removed in vacuo. The crude product was then purified on silica (30% ether/pet. ether) to yield **14** (39 mg, 99%).

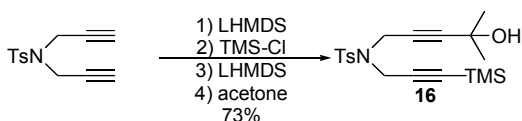
R_f (20% Et₂O/PE):. **IR** (neat): 3072, 2968, 2845, 1732, 1658, 1620, 1434, 1369, 1332, 1248, 1168, 1124, 1091, 1057, 965, 811, 702 cm⁻¹. **¹H NMR** (400 MHz, C₆D₆): 6.06 (bs, 1H), 5.65 (bs, 1H), 3.29 (s, 3H), 3.28 (s, 3H), 3.25 (d, J = 2 Hz, 2H), 2.02 (s, 2H), 1.02 (s, 6H). **¹³C NMR** (100 MHz, C₆D₆): 171.2, 140.2, 135.9, 121.2, 118.7, 74.4, 65.7, 52.2, 36.3, 33.2, 26.2. Compound **14** is highly unstable, and satisfactory elemental analysis or HRMS with EI ionization were unable to be obtained. Additional characterization was obtained upon conversion to the known compound 3-formyl-4-(2-methyl-propenyl)-cyclopent-3-ene-1,1-dicarboxylic acid dimethyl ester (**40**).²



To a solution of **7** (20 mg, 0.058 mmol) in 50/50 THF/MeOH (1 mL total) was added KHCO₃ (12 mg, 0.117 mmol) and H₂O₂ (20 μL of a 30% solution in water, 0.176 mmol). The reaction was then heated to 65 °C for 1 hr, cooled to room temperature, extracted with ether, dried over MgSO₄, and the solvent was removed in vacuo. The crude product was purified on silica (80% ether/pet.ether) to yield **15** (16 mg, 98%).

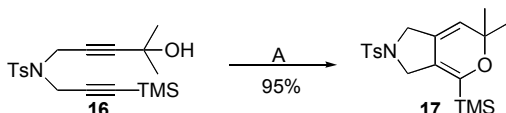
R_f (80% Et₂O/PE): 0.2. **IR** (neat): 2976, 2932, 2849, 1732, 1709, 1433, 1386, 1255, 1193, 1152, 1112, 1070, 1021 cm⁻¹. **¹H NMR** (400 MHz, C₆D₆): 3.50 (app. p, J = 2Hz, 2H), 3.22 (s, 6H), 2.93 (app. t, J = 1.6 Hz, 2H), 1.44 (s, 2H), 0.96 (s, 6H). **¹³C NMR** (100 MHz, C₆D₆): 171.5, 161.6, 152.4, 126.1, 79.8, 57.7, 52.4, 43.9, 38.9, 35.9, 27.6. **HRMS** (EI, [M]⁺) Cal'c for C₁₄H₁₈O₆: 282.1103. Found: 282.1105 (11.9), 223.0944 (61.0), 205.0872 (76.0), 164.0485 (100).

Supporting Materials



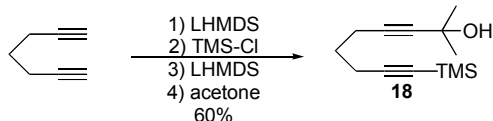
To a solution of bispropargyltosylamine (0.505 g, 2.04 mmol) in THF (8 mL) cooled to -78 °C was added LHMDS (2.9 mL of 0.7 M solution in THF, 2.04 mmol). After stirring for 20 minutes, TMS-Cl (0.26 mL, 2.04 mmol) was added and stirred for 15 minutes. A second aliquot of LHMDS (4.37 mL of 0.7 M solution in THF, 3.06 mmol) was added and stirred 15 minutes. Freshly distilled acetone (0.3 mL, 4.08 mmol) was then added and the reaction was stirred 15 minutes more. Saturated ammonium chloride was then added to the reaction at -78 °C and the mixture was warmed to room temperature, extracted with ether, dried over MgSO₄, and the solvent removed in vacuo. The crude product was then purified using silica gel chromatography (40% ether/pet. ether) to yield 560 mg of **16** (73%).

R_f (50% Et₂O/PE): 0.35. mp = 78-80 °C. **IR** (neat): 3524, 2980, 2179, 1654, 1598, 1495, 1437, 1401, 1352, 1250, 1163, 1095, 1002, 952, 903, 843, 756, 665 cm⁻¹. **¹H NMR** (400 MHz, CDCl₃): 7.70 (d, J = 8.4 Hz, 2H), 7.28 (d, J = 8 Hz, 2H), 4.14 (s, 2H), 4.13 (s, 2H), 2.40 (s, 3H), 1.52 (bs, 1H), 1.35 (s, 6H), 0.04 (s, 9H). **¹³C NMR** (125 MHz, CDCl₃): 143.9, 135.6, 129.7, 128.0, 97.6, 91.1, 90.4, 74.6, 65.0, 37.3, 36.4, 31.1, 21.6, -0.3. **Anal** Cal'c for C₁₉H₂₇NO₃SSi: C, 60.44; H, 7.21; N, 3.71. Found: C, 60.64; H, 7.0; N, 3.57.



Procedure: A for 1 hr.

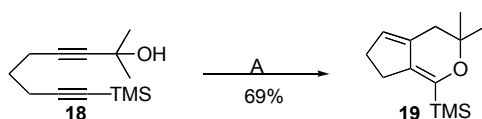
R_f (20% Et₂O/PE): 0.55. mp = 122-124 °C. **IR** (neat): 2964, 2850, 1673, 1597, 1345, 1246, 1162, 1079, 847, 813, 665 cm⁻¹. **¹H NMR** (400 MHz, C₆D₆): 7.75 (d, J = 8.4 Hz, 2H), 6.75 (d, J = 8 Hz, 2H), 4.49 (t, J = 2 Hz, 1H), 4.18 (s, 2H), 3.85 (d, J = 2 Hz, 2H), 1.87 (s, 3H), 1.11 (s, 6H), 0.03 (s, 9H). **¹³C NMR** (100 MHz, C₆D₆): 152.1, 143.1, 134.4, 130.9, 129.7, 128.1, 120.4, 115.3, 73.9, 50.6, 49.6, 27.5, 21.0, -2.6. **Anal** Cal'c for C₁₉H₂₇NO₃SSi: C, 60.44; H, 7.21; N, 3.71. Found: C, 60.51; H, 7.19; N, 3.30.



To a solution of 1,6-heptadiyne (0.530 g, 5.75 mmol) in THF (40 mL) cooled to -78 °C was added LHMDS (11.5 mL of 0.5 M solution in THF, 5.75 mmol). After stirring for 30 minutes, TMS-Cl (0.73 mL, 5.75 mmol) was added and stirred for 30 minutes. A second aliquot of LHMDS (13.8 mL of 0.5 M solution in THF, 6.90 mmol) was added and stirred 30 minutes. Freshly distilled acetone (0.63 mL, 8.63 mmol) was then added and the reaction was stirred 30 minutes more. Saturated ammonium chloride was then added to the reaction at -78 °C and the mixture was warmed to room temperature, extracted with ether, dried over MgSO₄, and the solvent removed in vacuo. The crude product was then purified using silica gel chromatography (30% ether/pet. ether) to yield

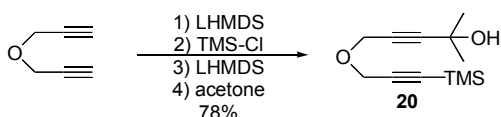
720 mg of **16** (60%). The product still contained some minor impurities which could not be totally eliminated upon distillation, and was used as is after distillation.

Rf (25% Et₂O/PE): 0.3. **IR** (neat): 3374, 2958, 2237, 2175, 1454, 1362, 1249, 1165, 1044, 949, 843, 760, 698, 638 cm⁻¹. **¹H NMR** (300 MHz, CDCl₃): 2.27 (q, J = 7.8 Hz, 4H), 2.1 (bs, 1H), 1.66 (m, 2H), 1.45 (s, 6H), 0.11 (s, 9H). **¹³C NMR** (75 MHz, CDCl₃): 106.4, 85.8, 85.1, 81.5, 65.3, 31.8, 28.8, 19.1, 17.8, 0.2. **Anal** Cal'c for C₁₃H₂₂OSi: C, 70.21; H, 9.97. Found: C, 70.15; H, 10.13.



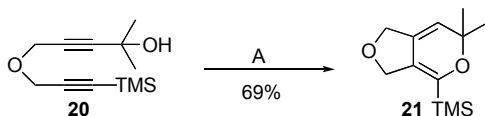
Procedure: A for 15 hr.

Rf (20% Et₂O/PE): 0.9. **IR** (neat): 2926, 2852, 1656, 1446, 1366, 1246, 1066, 836, cm⁻¹. **¹H NMR** (400 MHz, C₆D₆): 5.33 (bs, 1H), 2.52 (m, 2H), 2.38 (m, 2H), 2.20 (q, J = 1.6 Hz, 2H), 1.17 (s, 6H), 0.26 (s, 9H). **¹³C NMR** (100 MHz, C₆D₆): 147.2, 137.1, 132.9, 125.4, 72.2, 37.3, 31.7, 26.7, 25.9, -1.5. **HRMS** (EI, [M]⁺) Cal'c for C₁₃H₂₂OSi: 222.1440. Found: 222.1433 (50.3), 207.1194 (43.0), 73.0474 (100).



To a solution of bispropargylether (0.258 g, 2.72 mmol) in THF (8 mL) cooled to -78 °C was added LHMDS (3.9 mL of 0.7 M solution in THF, 2.72 mmol). After stirring for 20 minutes, TMS-Cl (0.35 mL, 2.72 mmol) was added and stirred for 15 minutes. A second aliquot of LHMDS (5.8 mL of 0.7 M solution in THF, 4.08 mmol) was added and stirred 15 minutes. Freshly distilled acetone (0.40 mL, 5.4 mmol) was then added and the reaction was stirred 30 minutes more. Saturated ammonium chloride was then added to the reaction at -78 °C and the mixture was warmed to room temperature, extracted with ether, dried over MgSO₄, and the solvent removed in vacuo. The crude product was then purified using silica gel chromatography (30% ether/pet. ether) to yield 475 mg of **20** (78%).

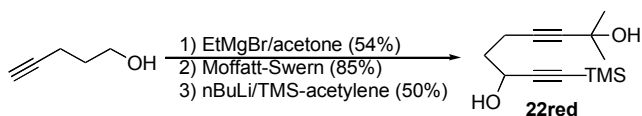
Rf (30% Et₂O/PE): 0.4. **IR** (neat): 3418, 2961, 2855, 2174, 1443, 1363, 1251, 1168, 1088, 1001, 950, 845, 761 cm⁻¹. **¹H NMR** (500 MHz, CDCl₃): 4.22 (s, 2H), 4.19 (s, 2H), 2.1 (bs, 1H), 1.49 (s, 6H), 0.15 (s, 9H). **¹³C NMR** (125 MHz, CDCl₃): 100.6, 92.1, 91.6, 77.2, 65.2, 57.4, 56.9, 31.4, -0.1. **HRMS** (EI, [M-H]⁺) Cal'c for C₁₂H₁₉O₂Si: 223.1154. Found: 223.1158 (12.0), 209.0996 (33.0), 179.0890 (85.0).



Procedure: A for 2hr.

Rf (30% Et₂O/PE): 0.6. **IR** (neat): 2962, 2851, 1460, 1358, 1248, 1164, 1084, 1047, 905, 840, cm⁻¹. **¹H NMR** (400 MHz, C₆D₆): 4.62 (bs, 1H), 4.56 (s, 2H), 4.29 (d, J = 2Hz,

2H), 1.27 (s, 6H), 0.09 (s, 9H). **¹³C NMR** (100 MHz, C₆D₆): 149.8, 134.2, 123.9, 113.0, 73.5, 69.6, 68.9, 27.7, -2.5. **HRMS** (EI, [M]⁺) Cal'c for C₁₂H₂₀O₂Si: 224.1233. Found: 224.1227 (9.8), 149.0238 (29.7), 71.086 (100).

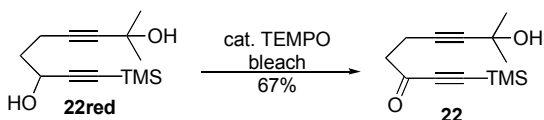


To a solution of 4-pentyn-1-ol (2 mL, 21.4 mmol) in THF (125 mL) cooled to -78 °C was added EtMgBr (42.8 mL of a 1 M solution in THF, 42.8 mmol). The mixture was allowed to warm to room temperature and stir for 3 hours. After cooling back to -78 °C, freshly distilled acetone (4.72 mL, 64.2 mmol) was added slowly. The reaction was warmed to room temperature and stirred an additional 2.5 hr, quenched with saturated ammonium chloride, extracted with ether, dried over MgSO₄, and the solvent was removed in vacuo. The crude product was purified on silica (90% ether/pet. ether) to yield 1.63 g (54%) of the expected tertiary propargyl alcohol.

To a solution of DMSO (1.48 mL, 20 mmol) in DCM (66 mmol) at -78 °C was added oxalyl chloride (0.9 mL, 10 mmol) dropwise and stirred 15 minutes. The tertiary propargyl alcohol product of the first reaction (0.99 g, 6.96 mmol) was then in DCM (15 mL) to the activated DMSO slowly. This solution was then stirred 15 minutes, Et₃N (4.9 mL, 35 mmol) was added, and stirred a further 30 min. The reaction was quenched with water, extracted with ether, dried over MgSO₄, and the solvent was removed in vacuo to yield crude aldehyde (830 mg, 85%) which was used for the following reaction.

To a solution of TMS-acetylene (4 mL, 28 mmol) in THF (50 mL) cooled to -78 °C was added n-BuLi (11 mL of a 2.5 M solution in hexanes, 27.5 mmol), and the mixture was stirred for 1 hr. The aldehyde product from the previous reaction was then added in THF (12 mL), warmed to room temperature and stirred an additional 30 minutes, quenched with saturated ammonium chloride, extracted with ether, dried over MgSO₄, and the solvent was removed in vacuo. The crude product was purified on silica (50% ether/pet. ether) to yield 641 mg (50%) of **22red**.

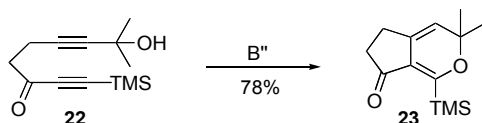
R_f (100% Et₂O): 0.85. **IR** (neat): 3555, 2960, 2934, 2238, 2173, 1423, 1408, 1363, 1333, 1250, 1164, 1069, 1006, 945, 904, 843, 760, 699 cm⁻¹. **¹H NMR** (400 MHz, CDCl₃): 4.46 (m, 1H), 2.42-2.24 (m, 2H), 2.20 (bs, 1H), 1.86 (q, J = 7.2 Hz, 2H), 1.46 (s, 6H), 0.14 (s, 9H). **¹³C NMR** (100 MHz, CDCl₃): 105.9, 89.9, 85.9, 81.3, 65.4, 61.7, 36.4, 31.7, 14.7, -0.08. **Anal** Cal'c for C₁₃H₂₂O₂Si: C, 65.50; H, 9.30. Found: C, 65.52; H, 9.50.



To a solution of **22red** (99 mg, 0.415 mmol) in DCM (2 mL) at 0 °C was added NaHCO₃ (1.0 mL of 5wt% in water), TEMPO (0.65 mg, 0.00415 mmol), KBr (5 mg, 0.04 mmol), and NaOCl (10% in water, 0.62 mmol). The mixture was stirred for 1 hr, extracted with DCM, dried over MgSO₄, and the solvent was removed in vacuo. The crude product was purified on silica (50% ether/pet. ether) to yield 67 mg (67%) of **22**.

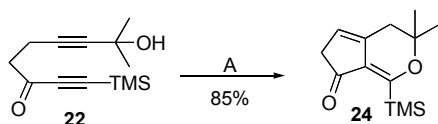
Supporting Materials

R_f (50% Et₂O/PE): 0.35. **IR** (neat): 3416, 2980, 2933, 2151, 1679, 1363, 1253, 1166, 1114, 847, 762 cm⁻¹. **¹H NMR** (400 MHz, C₆D₆): 2.40 (m, 2H), 2.29 (m, 2H), 1.74 (bs, 1H), 1.39 (s, 6H), 0.03 (s, 9H). **¹³C NMR** (100 MHz, C₆D₆): 184.3, 102.5, 97.1, 86.8, 79.9, 64.8, 44.3, 31.7, 13.5, -1.0. **Anal** Cal'c for C₁₃H₂₀O₂Si: C, 66.05; H, 8.53. Found: C, 65.88; H, 8.42.



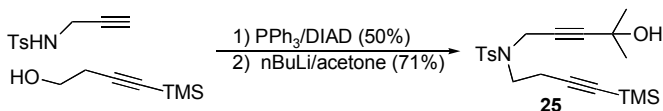
Procedure: B'' for 15 minutes.

R_f (50% Et₂O/PE): 0.6. **IR** (neat): 2972, 2926, 1702, 1654, 1553, 1460, 1412, 1380, 1361, 1287, 1267, 1246, 1175, 1092, 1019, 891, 843, 762, 701 cm⁻¹. **¹H NMR** (400 MHz, C₆D₆): 4.57 (bs, 1H), 2.075 (s, 2H), 2.073 (s, 2H), 1.21 (s, 6H), 0.44 (s, 9H). **¹³C NMR** (100 MHz, C₆D₆): 203.0, 173.5, 135.3, 124.1, 113.6, 78.6, 37.2, 28.4, 23.6, -2.6. **HRMS** (EI, [M]⁺) Cal'c for C₁₃H₂₀O₂Si: 236.1233. Found: 236.1226 (52.3), 221.0998(70.8), 208.1278 (61.5), 73.0484 (100).



Procedure: A for 18 hr.

R_f (50% Et₂O/PE): 0.61. **IR** (neat): 2975, 2933, 2888, 1705, 1568, 1369, 1347, 1246, 1215, 1162, 1128, 1094, 1006, 978, 918, 842, 760, 717. **¹H NMR** (400 MHz, C₆D₆): 5.15 (p, J = 2 Hz, 1H), 2.69 (q, J = 2.4 Hz, 2H), 2.04 (q, J = 1.6 Hz, 2H), 1.01 (s, 6H), 0.47 (s, 9H). **¹³C NMR** (100 MHz, C₆D₆): 202.4, 169.0, 136.6, 127.9, 116.9, 76.2, 43.1, 36.9, 26.5, -2.6. **HRMS** (EI, [M]⁺) Cal'c for C₁₃H₂₀O₂Si: 236.1233. Found: 236.1230 (45.4), 222.1019 (24.4), 221.0992 (66.8), 208.1284 (54.5), 73.0485 (100).

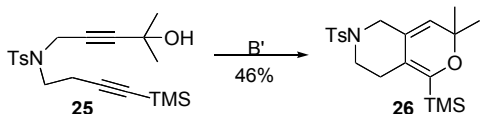


To a solution of tosyl-protected propargyl amine (2 g, 9.56 mmol), 4-trimethylsilanylbut-3-yn-1-ol (1.28 g, 8.93 mmol), and triphenylphosphine (2.46 g, 9.38 mmol) in THF (70 mL) cooled to 0 °C was added DIAD (1.83 mL, 9.29 mmol) dropwise. The mixture was warmed slowly to room temperature and stirred an additional 8 hr. Silica gel was then added to crude reaction mixture, and filtered through silica gel with ether as the eluent. The solvent was removed in vacuo, and the crude product was purified on silica (20% ether/pet. ether) to yield 4-methyl-N-prop-2-ynyl-N-(4-trimethylsilanylbut-3-ynyl)-benzenesulfonamide (1.5 g, 50%) as a white solid (mp = 89-92 °C).

To a solution of the product of the previous reaction (390 mg, 0.89 mmol) in THF (10 mL) at -78 °C was added n-BuLi (0.74 mL of a 1.56 M solution in hexanes, 1.157 mmol). Following 30 minutes stirring, freshly distilled acetone (0.098 mL, 1.34 mmol) was added dropwise, and stirring was continued for 30 minutes more. Saturated ammonium chloride was added, the reaction mixture was warmed to room temperature,

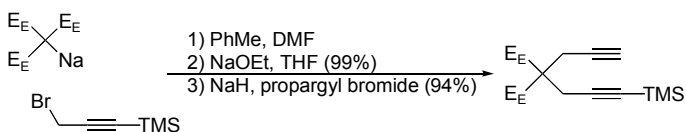
extracted with ether, and the solvent was removed in vacuo to yield the crude product which was purified on silica (50% ether/pet. ether) to give pure **25** (249 mg, 71%).

R_f (50% Et₂O/PE): 0.35. **IR** (neat): 3512, 2980, 2177, 1598, 1493, 1451, 1348, 1250, 1161, 1097, 843 cm⁻¹. **¹H NMR** (500 MHz, CDCl₃): 7.75 (d, J = 8.5 Hz, 2H), 7.33 (d, J = 8 Hz, 2H), 4.2 (s, 2H), 3.36 (t, J = 7 Hz, 2H), 2.56 (t, J = 7 Hz, 2H), 2.43 (s, 3H), 1.30 (s, 6H), 0.16 (s, 9H). **¹³C NMR** (125 MHz, CDCl₃): 143.6, 136.3, 129.6, 127.7, 103.3, 90.3, 86.9, 74.9, 64.8, 45.5, 37.6, 31.0, 21.5, 20.6, 0.01. **Anal** Cal'c for C₂₀H₂₉NO₃SSi: C, 61.34; H, 7.46; N, 3.58. Found: C, 61.18; H, 7.47; N, 3.68.



Procedure: B' for 8 hr (a small amount of a less polar compound, presumably the isomerized compound is formed upon extended heating, but can be easily separated by silica gel chromatography).

R_f (20% Et₂O/PE):. **IR** (neat): 2971, 2926, 2945, 1598, 1461, 1348, 1248, 1165, 1091, 1019, 952, 929, 900, 840, 747, 711, 660. **¹H NMR** (400 MHz, C₆D₆): 7.68 (d, J = 8 Hz, 2H), 6.81 (d, J = 8 Hz, 2H), 4.56 (t, J = 1.6 Hz, 1H), 3.62 (d, J = 1.6 Hz, 2H), 2.94 (t, J = 6 Hz, 2H), 2.16 (t, J = 6 Hz, 2H), 1.93 (s, 3H), 1.15 (s, 6H), 0.12 (s, 9H). **¹³C NMR** (100 MHz, C₆D₆): 153.6, 142.9, 134.6, 129.5, 128.3, 126.1, 121.3, 118.5, 73.3, 48.4, 45.7, 26.6, 25.1, 21.1, -1.3. **HRMS** (EI, [M]⁺) Cal'c for C₂₀H₂₉NO₃SSi: 391.1637. Found: 391.1625 (0.9), 376.1405 (8.2), 308.1136 (7.7), 280.0997 (89.8).



(Procedure based on Brummond, K. M.; Chen, H.; Fisher, K. D.; Kerekes, A. D.; Rickards, B.; Sill, P. C.; and J. Geib, S. J. *Org. Lett.*; **2002**, 4, 1931).

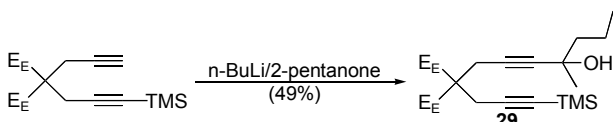
To a solution of triethyl sodiomethanecarboxylate (4.0 g, 15.7 mmol) in toluene:DMF (1:1, 50 mL) was added 3-trimethylsilylpropargyl bromide (3.0 g, 15.7 mmol), and the mixture was stirred and heated at 80 °C overnight. The resulting yellow suspension was cooled to room temperature, diluted with toluene (100 mL), washed with water, saturated Na₂CO₃, and brine. The combined aqueous layers were extracted with toluene and the combined organic layers were dried (MgSO₄), and the solvent was removed in vacuo to afford 2-ethoxycarbonyl-2-(3-trimethylsilyl-2-propynyl)malonic acid diethyl ester as a yellow oil (5.53 g, 99 %).

A solution of this product in THF (20 mL) was added dropwise to a suspension of sodium ethoxide (1.30 g, 1.91 mmol) in THF (30 mL). After stirring at room temperature for 2 h, 1N HCl was added until the solution was acidic. The reaction mixture was then diluted with ether (150 mL), washed with water (30 mL), saturated NaHCO₃ solution, brine, dried (MgSO₄), concentrated in vacuo, and purified on silica (25% ether/pet. ether) to afford 2-(3-trimethylsilyl-2-propynyl)malonic acid diethyl ester (4.15 g, 100 %).

To a suspension of NaH (720 mg, 18 mmol) in THF (20 mL) at 0 °C was added a solution of the product of the previous reaction (4.05 g, 15 mmol) in THF (20 mL).

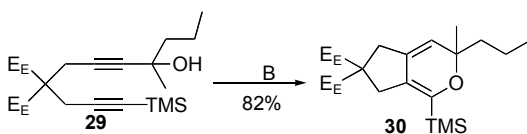
Following stirring for 30 minutes, propargyl bromide (1.67 mL of an 80% solution in toluene, 15 mmol) was added, and the reaction was stirred an additional 3 hours. Water was then added, and extracted with ether, and dried over Na₂SO₄. The solvent removed in vacuo and the crude product was purified on silica (10% ether/pet. ether) to yield 2-prop-2-ynyl-2-(3-trimethylsilanyl-prop-2-ynyl)-malonic acid diethyl ester (4.34 g, 94%).

R_f (40% Et₂O/PE): 0.80. **IR** (neat): 3286, 2962, 2180, 1740, 1427, 1367, 1288, 1207, 1031, 845, 761, 643 cm⁻¹. **¹H NMR** (500 MHz, CDCl₃): 4.19 (m, 4H), 2.96 (s, 2H), 2.93 (d, J = 3 Hz, 2H), 1.99 (t, J = 3 Hz, 1H), 1.23 (t, J = 7.2 Hz, 6H), 0.09 (s, 9H). **¹³C NMR** (125 MHz, CDCl₃): 168.8, 101.0, 88.5, 78.9, 71.7, 62.2, 56.8, 24.1, 22.7, 14.2, 0.1. **Anal** Cal'c for C₁₆H₂₄O₄Si: C, 62.30; H, 7.84. Found: C, 62.48; H, 8.01.



To a solution of 2-prop-2-ynyl-2-(3-trimethylsilanyl-prop-2-ynyl)-malonic acid diethyl ester (308 mg, 1 mmol) in THF (10 mmol) at -78 °C was added n-BuLi (0.4 mL of a 2.5 M solution in hexanes, 1 mmol), and after stirring for 30 minutes, 2-pentanone (103 mg, 1.2 mmol) was added dropwise. The reaction mixture was stirred 30 minutes, quenched with saturated ammonium chloride, extracted with ether, dried over Na₂SO₄, and the solvent was removed in vacuo. The resulting crude product was then purified on silica (20% ether/pet. ether) to yield **29** (193 mg, 49%).

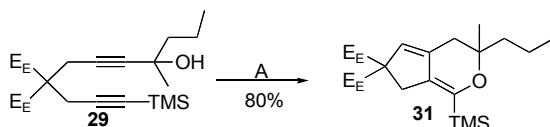
R_f (40% Et₂O/PE): 0.45. **IR** (neat): 3498, 2960, 2180, 1741, 1466, 1367, 1289, 1251, 1192, 1031, 845, 761 cm⁻¹. **¹H NMR** (500 MHz, CDCl₃): 4.17 (m, 4H), 2.93 (s, 2H), 2.92 (s, 2H), 1.90 (bs, 1H), 1.65-1.40 (m, 4H), 1.39 (s, 3H), 1.22 (t, J = 7 Hz, 6H), 0.91 (t, J = 7.2 Hz, 3H), 0.10 (s, 9H). **¹³C NMR** (125 MHz, CDCl₃): 168.9, 101.1, 88.4, 87.6, 78.1, 68.4, 62.1, 57.0, 46.2, 30.1, 24.1, 22.9, 18.2, 14.4, 14.3, 0.1. **Anal** Cal'c for C₂₁H₃₄O₅Si: C, 63.92; H, 8.69. Found: C, 64.12; H, 8.74.



Procedure: B for 1.5 hr.

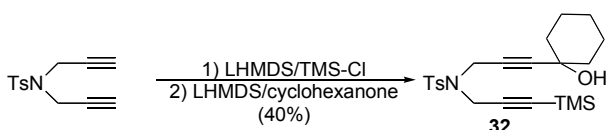
R_f (20% Et₂O/PE):. **IR** (neat): 2960, 1736, 1447, 1366, 1247, 1186, 1155, 1070, 840. **¹H NMR** (500 MHz, C₆D₆): 4.82 (t, J = 2 Hz, 1H), 3.95 (q, J = 7.2 Hz, 4H), 3.31 (d, J = 2 Hz, 2H), 3.15 (t, J = 2.5 Hz, 2H), 1.6-1.3 (m, 4H), 1.26 (s, 3H), 0.90 (t, J = 7.2 Hz, 6H), 0.89 (m, 3H), 0.23 (s, 9H). **¹³C NMR** (125 MHz, C₆D₆): 171.0, 151.5, 134.1, 123.0, 115.8, 76.3, 61.3, 60.0, 43.7, 38.1, 36.5, 25.8, 17.6, 14.7, 13.9, -1.9. **HRMS** (EI, [M]⁺) Cal'c for C₂₁H₃₄O₅Si: 394.2176. Found: 394.2173 (52.1), 379.1931 (57.9), 351.1602 (100)..

Supporting Materials



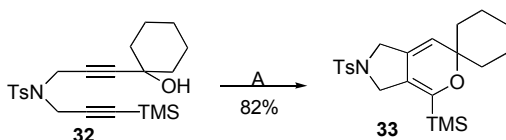
Procedure: A for 2 hr (product still contains a small amount of **30**).

Rf (20% Et₂O/PE):. **IR** (neat): 2959, 1735, 1467, 1446, 1366, 1247, 1186, 1154, 1070, 839. **¹H NMR** (400 MHz, C₆D₆): 5.84 (t, J = 1.6 Hz, 1H), 3.98 (m, 4H), 3.63 (d, J = 16 Hz, 1H), 3.58 (d, J = 16 Hz, 1H), 2.25 (dd, J₁ = 15.6 Hz, J₂ = 1.6 Hz, 2H), 1.30 (m, 4H), 1.06 (s, 3H), 0.93 (t, J = 7 Hz, 6H), 0.82 (t, J = 7 Hz, 3H), 0.20 (s, 9H). **¹³C NMR** (100 MHz, C₆D₆): 170.9, 150.6, 140.3, 128.5, 122.1, 75.0, 65.8, 42.2, 35.3, 35.0, 29.9, 23.2, 17.0, 14.7, 13.9, -1.9. **HRMS** (EI, [M]⁺) Cal'c for C₂₁H₃₄O₅Si: 394.2176. Found: 394.2173 (42.4), 351.1606 (82.6), 73.0474 (100)..



To a solution of bispropargylsilylamine (0.505 g, 2.04 mmol) in THF (8 mL) cooled to -78 °C was added LHMDS (4.08 mL of 0.5 M solution in THF, 2.04 mmol). After stirring for 45 minutes, TMS-Cl (0.26 mL, 2.04 mmol) was added and stirred for 30 minutes. A second aliquot of LHMDS (4.9 mL of 0.5 M solution in THF, 2.45 mmol) was added and stirred 30 minutes. Freshly distilled cyclohexanone (0.317 mL, 3.06 mmol) was then added and the reaction was stirred 1 hour more. Saturated ammonium chloride was then added to the reaction at -78 °C and the mixture was warmed to room temperature, extracted with ether, dried over MgSO₄, and the solvent removed in vacuo. The crude product was then purified using silica gel chromatography (35% ether/pet. ether) to yield 340 mg of **32** (40%).

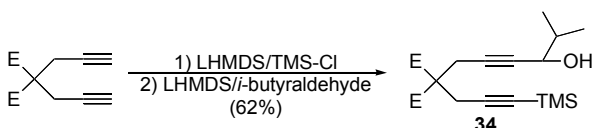
Rf (40% Et₂O/PE):0.3. mp = 85-87 °C. **IR** (neat): 3520, 2934, 2858, 2179, 1597, 1494, 1446, 1353, 1250, 1164, 1094, 1002, 965, 846, 846, 759, 667 cm⁻¹. **¹H NMR** (500 MHz, CDCl₃): 7.69 (d, J = 8.5 Hz, 2H), 7.28 (d, J = 8.5 Hz, 2H), 4.17 (s, 2H), 4.13 (s, 2H), 2.40 (s, 3H), 1.77 (bs, 1H), 1.69-1.56 (m, 5H), 1.45-1.31 (m, 5H), 0.03 (s, 9H). **¹³C NMR** (100 MHz, CDCl₃): 143.9, 135.4, 129.7, 128.1, 97.5, 91.3, 89.5, 76.6, 68.6, 39.7, 37.3, 36.5, 25.1, 23.3, 21.6, -0.3. **Anal** Cal'c for C₂₂H₃₁NO₃SSi: C, 63.27; H, 7.48. Found: C, 63.24; H, 7.46.



Procedure: A for 1 hr.

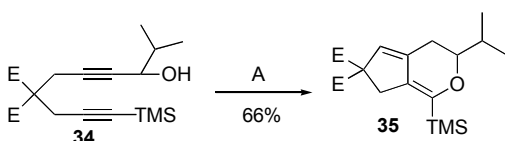
Rf (25% Et₂O/PE): 0.45. **IR** (neat): 2932, 2857, 1597, 1448, 1349, 1248, 1164, 1091, 840, 666. **¹H NMR** (400 MHz, C₆D₆): 7.75 (d, J = 8.4 Hz, 2H), 6.76 (d, J = 8.4 Hz, 2H), 4.56 (bs, 1H), 4.18 (s, 2H), 3.87 (d, J = 2 Hz, 2H), 1.88 (s, 3H), 1.76 (m, 2H), 1.58 (m, 2H), 1.44 (m, 2H), 1.30 (m, 2H), 1.15 (m, 2H), 0.05 (s, 9H). **¹³C NMR** (100 MHz, C₆D₆):

151.9, 143.1, 134.4, 131.2, 129.7, 128.1, 120.9, 114.8, 74.8, 50.7, 49.6, 35.9, 25.7, 21.8, 21.0, -2.2. **Anal** Cal'c for $C_{22}H_{31}NO_3SSi$: C, 63.27; H, 7.48. Found: C, 63.43; H, 7.38.



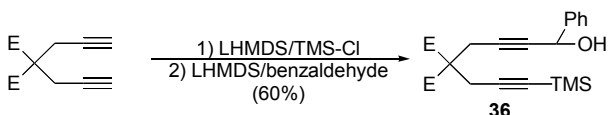
To a solution of dimethyl(bis)propargyl malonate (0.3 g, 1.44 mmol) in THF (10 mL) cooled to $-78\text{ }^{\circ}\text{C}$ was added LHMDS (1.6 mL of 0.9 M solution in THF, 1.44 mmol). After stirring for 30 minutes, TMS-Cl (0.18 mL, 1.44 mmol) was added and stirred for 1.5 hours. A second aliquot of LHMDS (1.9 mL of 0.9 M solution in THF, 1.73 mmol) was added and stirred 30 minutes. Freshly distilled *i*-butylaldehyde (0.2 mL, 2.16 mmol) was then added and the reaction was stirred 1 hour more. Saturated ammonium chloride was then added to the reaction at $-78\text{ }^{\circ}\text{C}$ and the mixture was warmed to room temperature, extracted with ether, dried over $MgSO_4$, and the solvent removed in vacuo. The crude product was then purified using silica gel chromatography (40% ether/pet. ether) to yield 310 mg of **34** (62%).

R_f (40% Et₂O/PE): 0.35. **IR** (neat): 3501, 2958, 2987, 2180, 1744, 1436, 1324, 1293, 1251, 1211, 1029, 844, 761, 644 cm^{-1} . **¹H NMR** (400 MHz, $CDCl_3$): 4.11 (dt, $J_1 = 5.6$ Hz, $J_2 = 2$ Hz, 1H), 3.72 (s, 6H), 2.98 (d, $J = 2$ Hz, 2H), 2.95 (s, 2H), 1.80 (m, 1H), 1.68 (bs, 1H), 0.93 (t, $J = 6.8$ Hz, 6H), 0.10 (s, 9H). **¹³C NMR** (75 MHz, $CDCl_3$): 169.2, 100.6, 88.5, 83.3, 79.8, 67.7, 56.9, 52.9, 34.4, 24.1, 22.9, 18.0, 17.1, -0.1. **HRMS** (EI, $[M-CH_3]^+$) Cal'c for $C_{17}H_{25}O_5Si$: 337.1471. Found: 337.1467 (5.1), 309.1163 (12.5), 277.1225 (13.7), 249.0934 (32.7), 73.0496 (100).



Procedure: A for 2 hr.

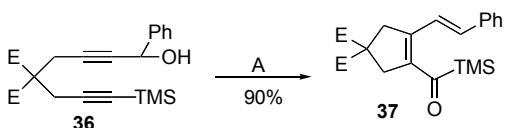
R_f (30% Et₂O/PE): 0.5. **IR** (neat): 2957, 1738, 1606, 1434, 1248, 1196, 1171, 1151, 1082, 841, 756, 697. **¹H NMR** (500 MHz, C_6D_6): 5.70 (d, $J = 1.5$ Hz, 1H), 3.63 (d, $J = 16.5$ Hz, 1H), 3.58 (d, $J = 16.5$ Hz, 1H), 3.36 (s, 3H), 3.35 (s, 3H), 3.13 (ddd, $J_1 = 12.25$ Hz, $J_2 = 6.25$ Hz, $J_3 = 3.0$ Hz, 1H), 2.22 (dd, $J_1 = 16.5$ Hz, $J_2 = 3$ Hz, 1H), 2.09 (ddd, $J_1 = 16.5$ Hz, $J_2 = 12.25$ Hz, $J_3 = 2$ Hz, 1H), 1.61 (oct, $J = 6.5$ Hz, 1H), 0.91 (d, $J = 6.5$ Hz, 3H), 0.76 (d, $J = 6.5$ Hz, 3H), 0.19 (s, 9H). **¹³C NMR** (125 MHz, C_6D_6): 171.5, 171.4, 154.3, 141.5, 129.8, 120.8, 79.5, 65.9, 52.3, 34.9, 32.5, 28.4, 18.5, 18.2, -1.8. **HRMS** (EI, $[M]^+$) Cal'c for $C_{18}H_{28}O_5Si$: 352.1706. Found: 352.1701 (50.7), 293.1572 (84.2), 73.0480 (100).



To a solution of dimethyl(bis)propargyl malonate (0.5 g, 2.4 mmol) in THF (20 mL) cooled to $-78\text{ }^{\circ}\text{C}$ was added LHMDS (2.4 mL of 1 M solution in THF, 2.4 mmol). After

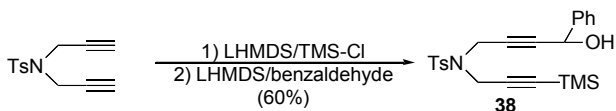
stirring for 30 minutes, TMS-Cl (0.31 mL, 2.4 mmol) was added and stirred for 1.5 hours. A second aliquot of LHMDS (3.6 mL of 1 M solution in THF, 3.6 mmol) was added and stirred 30 minutes. Freshly distilled benzaldehyde (0.37 mL, 3.6 mmol) was then added and the reaction was stirred 1 hour more. Saturated ammonium chloride was then added to the reaction at -78 °C and the mixture was warmed to room temperature, extracted with ether, dried over MgSO₄, and the solvent removed in vacuo. The crude product was then purified using silica gel chromatography (40% ether/pet. ether) to yield 560 mg of **34** (60%).

R_f (50% Et₂O/PE): 0.25. **IR** (neat): 3486, 3021, 2957, 2900, 2180, 1732, 1603, 1494, 1436, 1352, 1294, 1250, 1211, 1139, 1028, 844, 761, 731, 699, 637 cm⁻¹. **¹H NMR** (500 MHz, CDCl₃): 7.5 (m, 2H), 7.3 (m, 3H), 5.41 (bs, 1H), 3.72 (s, 3H), 3.71 (s, 3H), 3.06 (d, J = 2 Hz, 2H), 2.99 (s, 2H), 0.13 (s, 9H). **¹³C NMR** (125 MHz, CDCl₃): 169.4, 140.9, 128.8, 128.6, 126.9, 100.9, 88.9, 83.6, 81.7, 64.9, 57.2, 53.3, 24.5, 23.4, 0.2. **Anal** Cal'c for C₂₁H₂₆O₅Si: C, 65.26; H, 6.78. Found: C, 65.37; H, 6.80.



Procedure: A for 2 hr (product contains a trace amount of impurity (possibly [6H]-pyran).

R_f (20% Et₂O/PE):. **IR** (neat): 2954, 2842, 1737, 1613, 1576, 1535, 1493, 1434, 1252, 1199, 1170, 1075, 969, 843, 823, 752, 692. **¹H NMR** (400 MHz, C₆D₆): 8.15 (d, J = 16.4 Hz, 1H), 7.32 (m, 2H), 7.02 (m, 3H), 6.68 (d, J = 16.4 Hz, 1H), 3.75 (s, 2H), 3.55 (s, 2H), 3.12 (s, 6H), 0.19 (s, 9H). **¹³C NMR** (100 MHz, C₆D₆): 235.3, 171.6, 141.9, 138.8, 136.9, 128.8, 128.6, 128.4, 127.4, 123.8, 58.0, 52.5, 42.1, 41.1, -2.6. **Anal** Cal'c for C₂₁H₂₆O₅Si: C, 65.26; H, 6.78. Found: C, 65.14; H, 6.81.

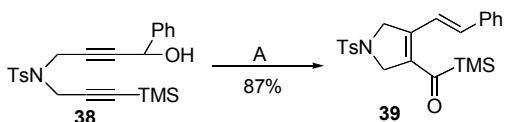


To a solution of bispropargyltosylamine (0.514 g, 2.08 mmol) in THF (25 mL) cooled to -78 °C was added LHMDS (4.16 mL of 0.5 M solution in THF, 2.08 mmol). After stirring for 30 minutes, TMS-Cl (0.26 mL, 2.08 mmol) was added and stirred for 30 minutes. A second aliquot of LHMDS (4.99 mL of 0.5 M solution in THF, 2.49 mmol) was added and stirred 30 minutes. Freshly distilled benzaldehyde (0.317 mL, 3.12 mmol) was then added and the reaction was stirred 1 hour more. Saturated ammonium chloride was then added to the reaction at -78 °C and the mixture was warmed to room temperature, extracted with ether, dried over MgSO₄, and the solvent removed in vacuo. The crude product was then purified using silica gel chromatography (40% ether/pet. ether) to yield 530 mg of **38** (60%).

R_f (20% Et₂O/PE):. **IR** (neat): 3508, 3064, 3032, 2960, 2899, 2280, 2179, 1598, 1494, 1454, 1352, 1250, 1163, 1094, 1002, 905, 846, 814, 757, 699, 665 cm⁻¹. **¹H NMR** (400 MHz, C₆D₆): 7.64 (m, 2H), 7.33 (m, 2H), 7.16-7.04 (m, 3H), 6.75 (m, 2H), 5.07 (app. bd, J = 5.6 Hz, 1H), 4.21 (d, J = 1.6 Hz, 2H), 4.17 (s, 2H), 1.92 (bd, J = 5.6 Hz, 1H), 1.90 (s,

Supporting Materials

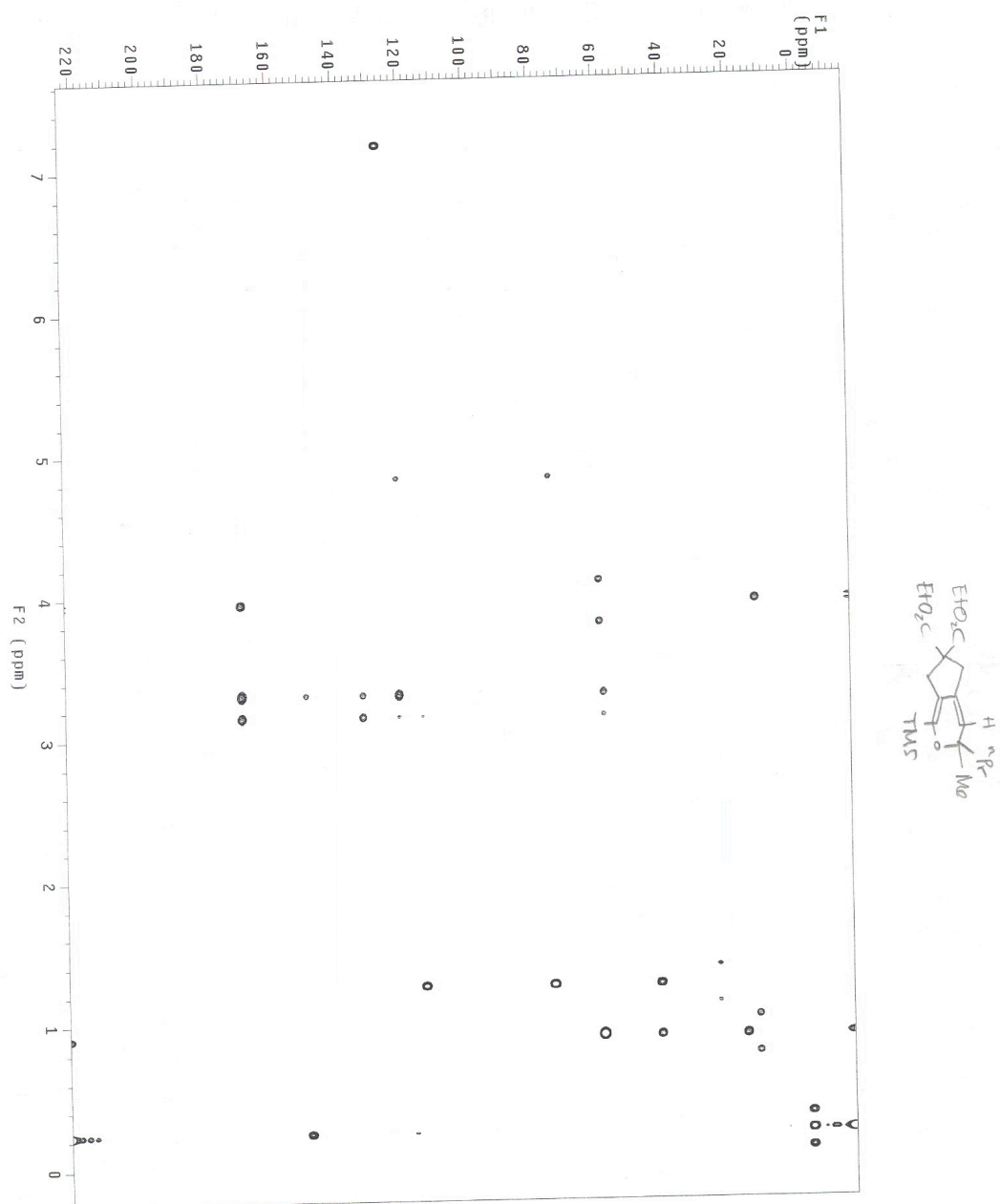
3H), -0.005 (s, 9H). **¹³C NMR** (100 MHz, C₆D₆): 143.4, 141.0, 136.2, 129.6, 128.6, 126.8, 98.6, 90.9, 86.3, 79.2, 64.3, 37.6, 36.9, 21.1. **Anal** Cal'c for C₂₃H₂₇NO₃SSi: C, 64.90; H, 6.39; N, 3.29. Found: C, 64.92; H, 6.46; N, 3.17.



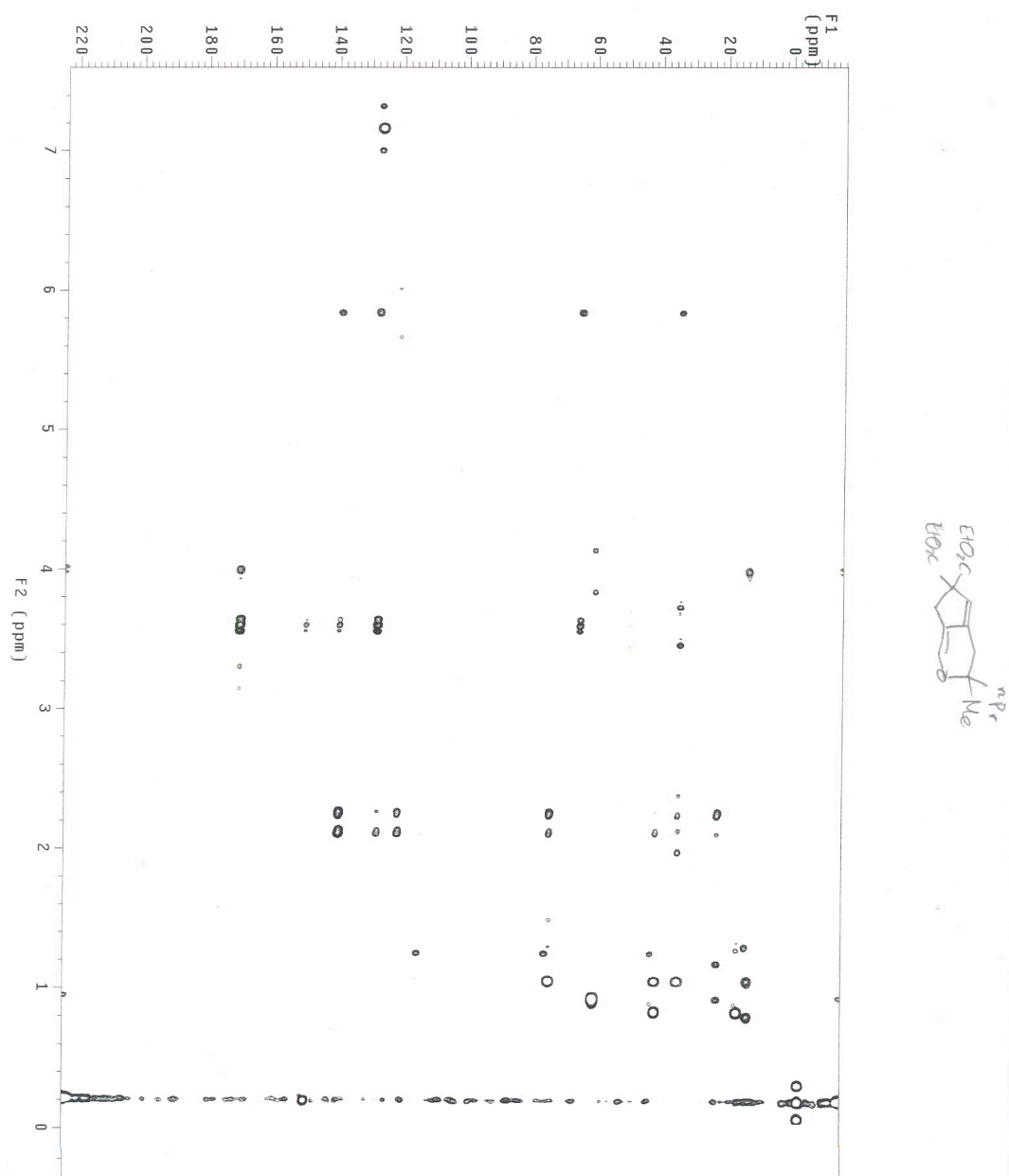
Procedure: A for 1hr.

R_f (20% Et₂O/PE):. reddish crystals mp = 120-122 **IR** (neat): 2923, 2853, 1618, 1597, 1546, 1493, 1448, 1347, 1250, 1165, 1098, 843, 816, 752, 667. **¹H NMR** (400 MHz, C₆D₆): 7.82 (d, J = 8 Hz, 2H), 7.80 (d, J = 16 Hz, 1H), 7.25 (m, 2H), 7.02 (m, 3H), 6.78 (d, J = 8 Hz, 2H), 6.37 (d, J = 16 Hz, 1H), 4.67 (t, J = 3.6 Hz, 2H), 4.48 (dd, J₁ = 4 Hz, J₂ = 3.2 Hz, 2H), 1.85 (s, 3H), 0.04 (s, 9H). **¹³C NMR** (100 MHz, C₆D₆): 233.1, 143.4, 139.5, 137.8, 136.4, 135.4, 134.9, 129.9, 129.2, 129.0, 127.8, 12.5, 121.2, 56.0, 55.2, 21.0, -2.7. **HRMS** (EI, [M]⁺) Cal'c for C₂₃H₂₇NO₃SSi: 425.1481. Found: 425.1488(37.6), 242.1264 (78.5).

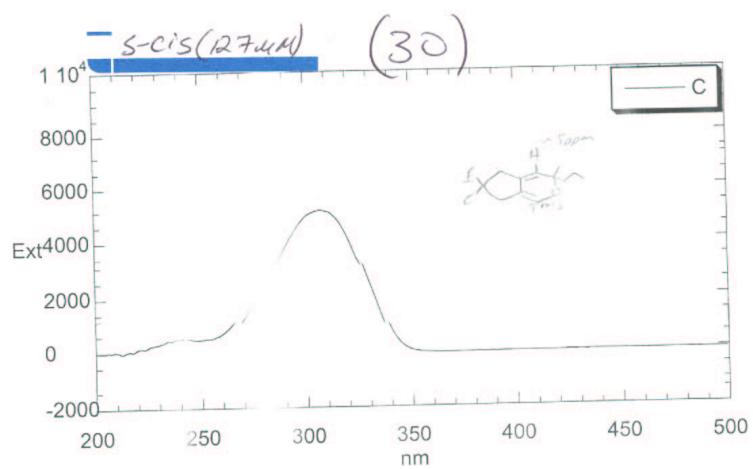
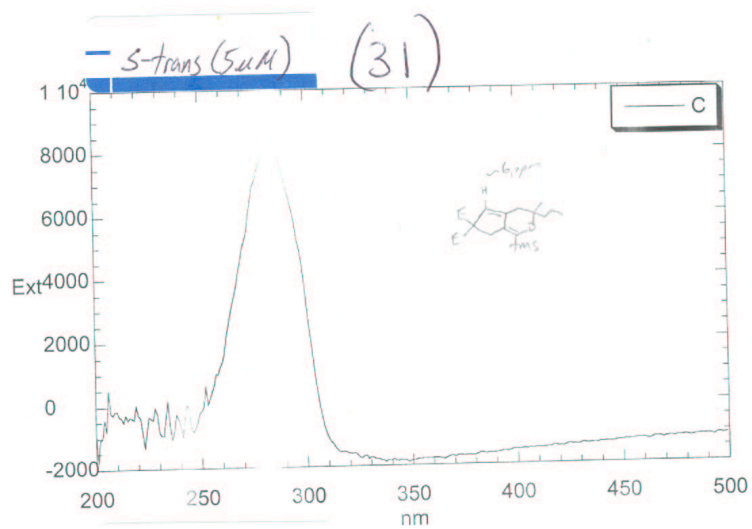
Supporting Materials

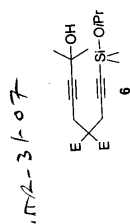


Supporting Materials



Supporting Materials



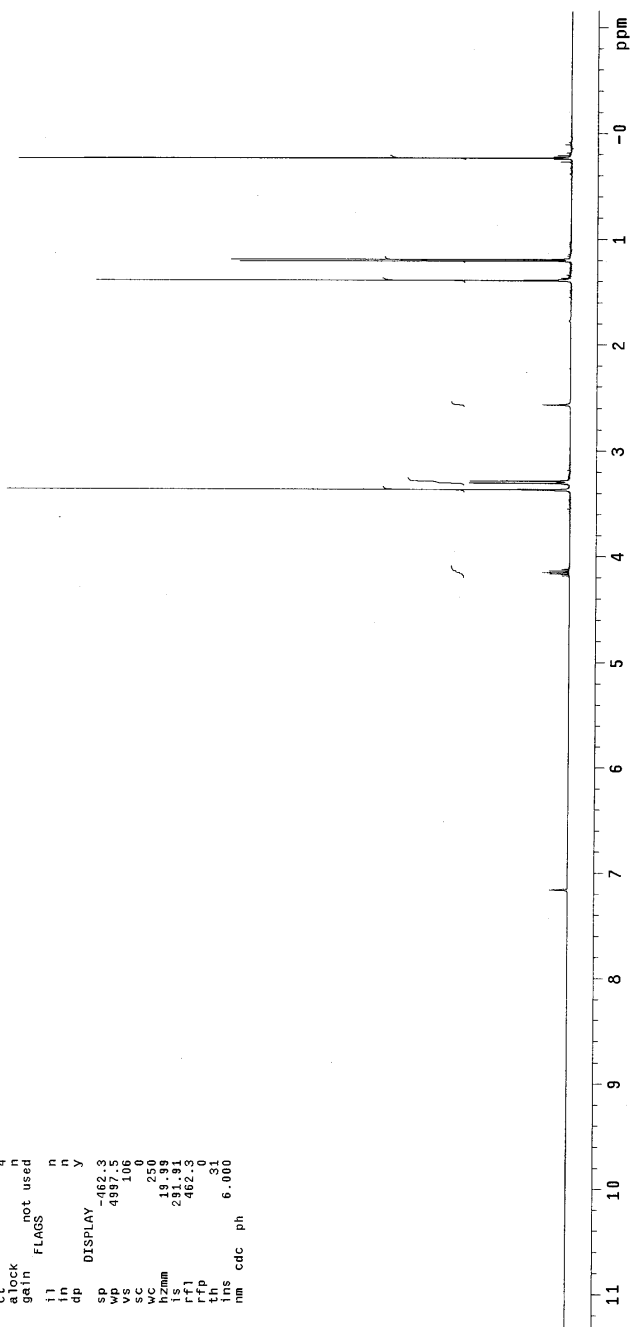


STANDARD IN OBSERVE

```

exp1 stdth
date 19 2004 DEC. & VT
solvent Jul Benzene dn H1
file ACQUISITION exp 30
sfrq 400.114 dm 0
tn 400.114 dm nmC
at 4.002 dmf 200
np 40000 wfile PROCESSING
ad 4997.5 wfile
fb not used proc ft
bs 4 fn not used
tpwr 60
pw 8.0 werr
nt 0.500 wexp
nt 16 wnt
ct 4
adack not used
gath FLAGS
il n
in n
dp n
DISPLAY
sp -462.3
wp 4997.5
sc 100
wc 250
hzmm 19.99
ls 291.91
rfp 462.50
th 31
ins cdc ph
nm 6.000

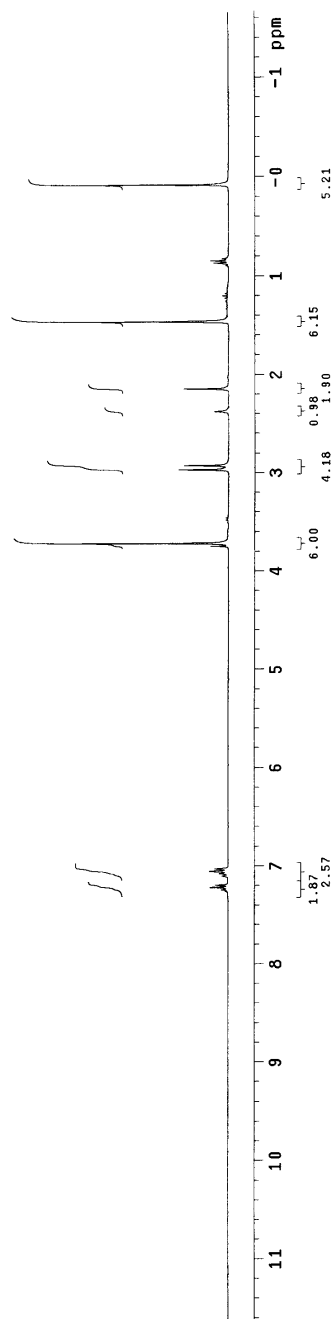
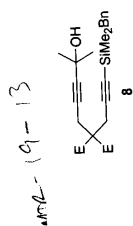
```

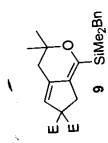


1H SENSITIVITY
0.1%ETHYLBENZENE

exp1 s2pu1

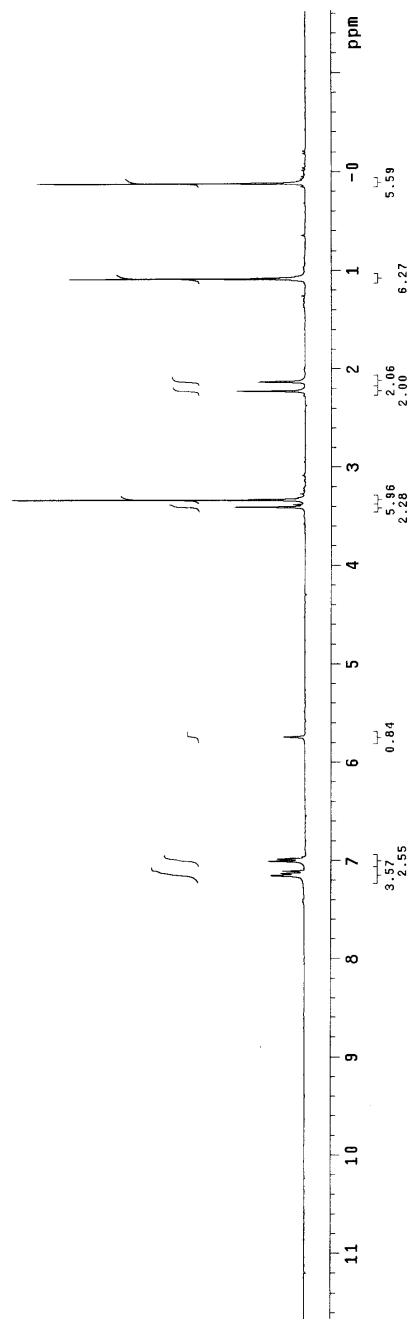
date	Jan 14 2003	dn	DEC. & VT
solvent	CDC13	dof	H1
file	exp	dm	-776.0
nmr	dm	nm	nm
ACQUISITION	exp	dm	C
sfrq	500.049	dm	not used
tr	H1	dip	0.5
at	2.000	dip	1023
np	16000	lb	PROCESSING
pw	4000.0	fr	20
fls	2250	fr	32768
bs	4		
pw	11.5	werrf	
pw	11.5	wexp	
to	0	to	
nt	16	wt	DISPLAY
ct	16	sp	-499.6
alock	n	wp	4000.0
gain	not used	sc	0
il	FLAGS	WC	250
in	n	hzmm	3.24
dp	y	rf1	399.78
		rf2	499.0
		th	4
		ins	6.000
		nm	ph

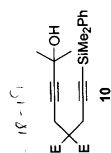




1H SENSITIVITY
0.12ETHYL BENZENE
exp3 szpu1

SAMPLE DEC. & VT
date Jan 14 2003 dn H1
solvent Benzene dof -776.0
file exp dm mn
ACQUISITION 049 dm c
sfrq 500. H1 not used
in dm 0.5
at 2.000 dtp 1023
np 16000 lb PROCESSING
wa 4000.0 f 20
fb 2250 fn 32768
bs 4
pw 11.5 werr
pw 11.5 wexp
pw 0.0000000000
to 0
nt 16 sp
ct 16 sp -489.3
alock n wp 4000.0
gain not used SC 50
flags n wc 250
il n hzmm 16.00
in y 2275.99
dp y rfp 489.3
th 6
nm 2.000
ph



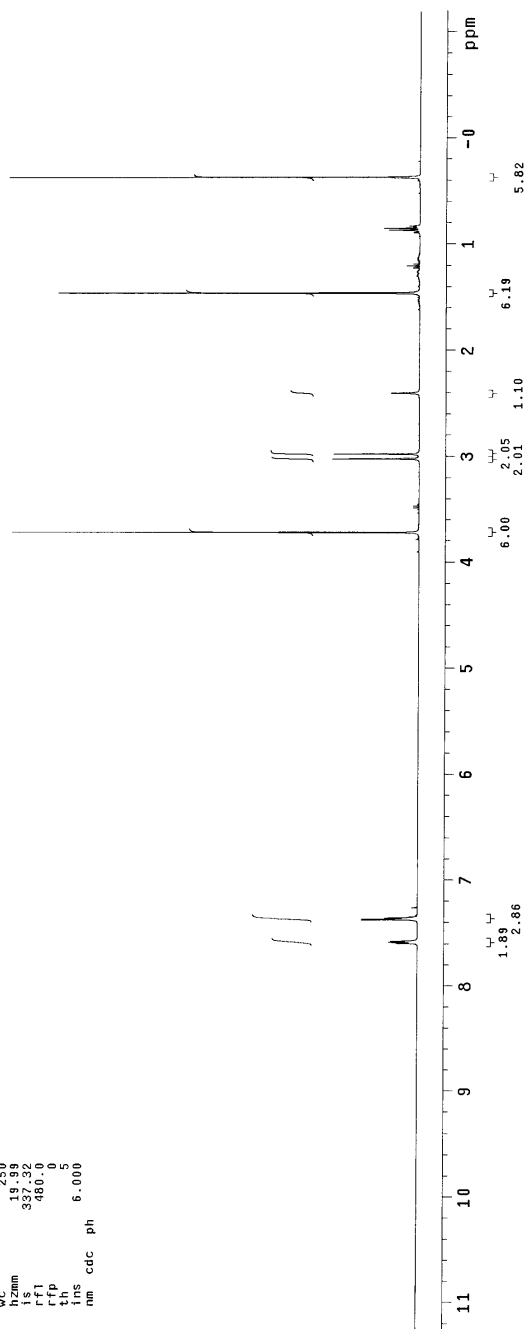


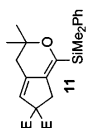
STANDARD IN OBSERVE

```

exp1 stdih
SAMPLE
date Dec 2.2002 dfrq DEC. 400.114
solvent CDC13 dn H1
file ACQUISITION exp 30
sfrq 400.114 dpr 30
tn 4.002 dm nmC
at 4.002 dmf 200
np 40000 wifile
bs not used proc ft
tpwr 60 fn not used
dw 20 werr
tof 0.500 wssp
nt 16 wnt
ct 16
gain not used
flags n
il n
in n
dp y
DISPLAY
sp -480.0
wp 4897.5
sc 70
wc 250
hzmm 19.99
ls 337.32
rfn 480.0
rfp 0
th 5
ins cdc ph
nm 6.000

```



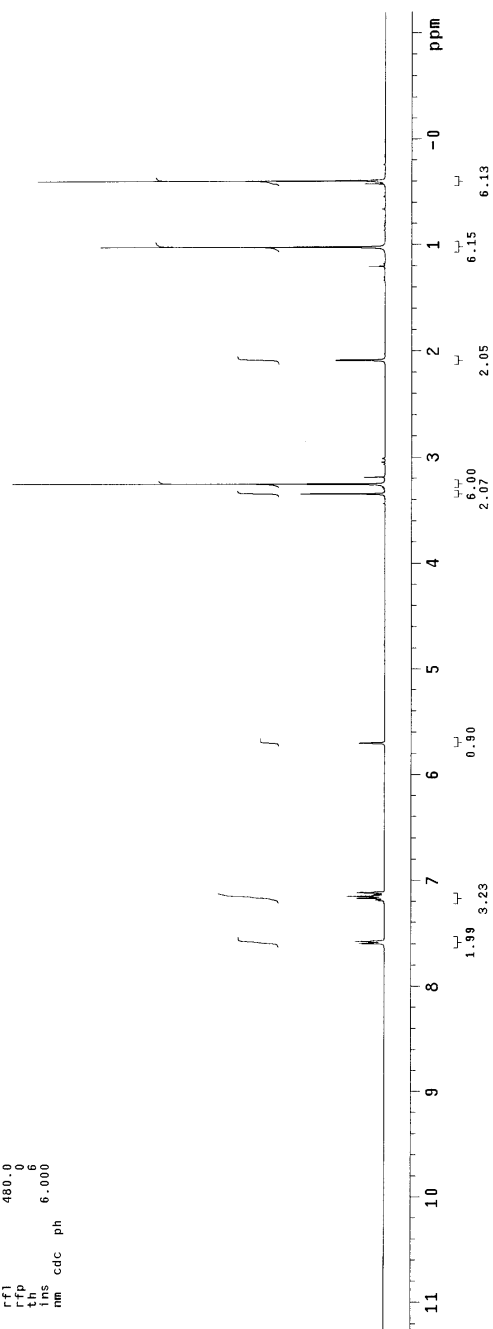


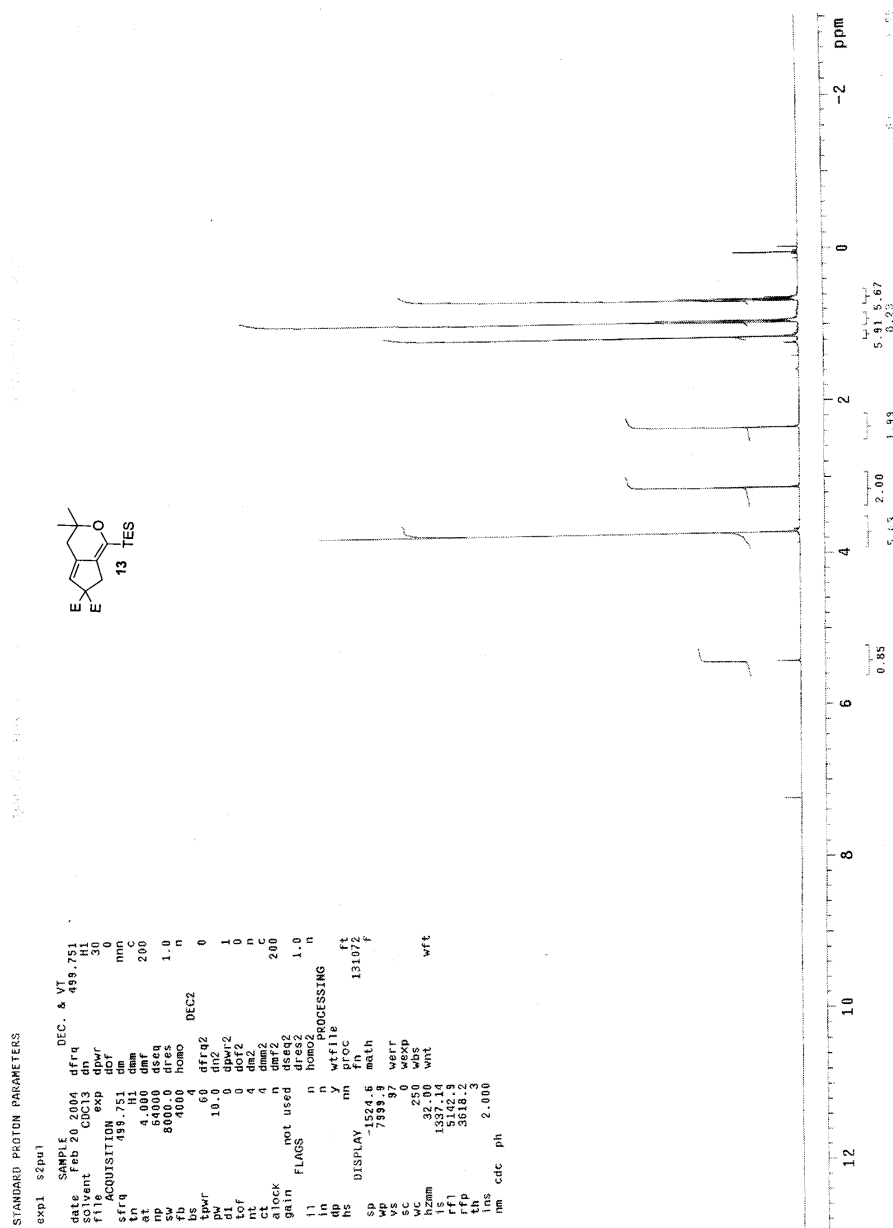
STANDARD 1H OBSERVE

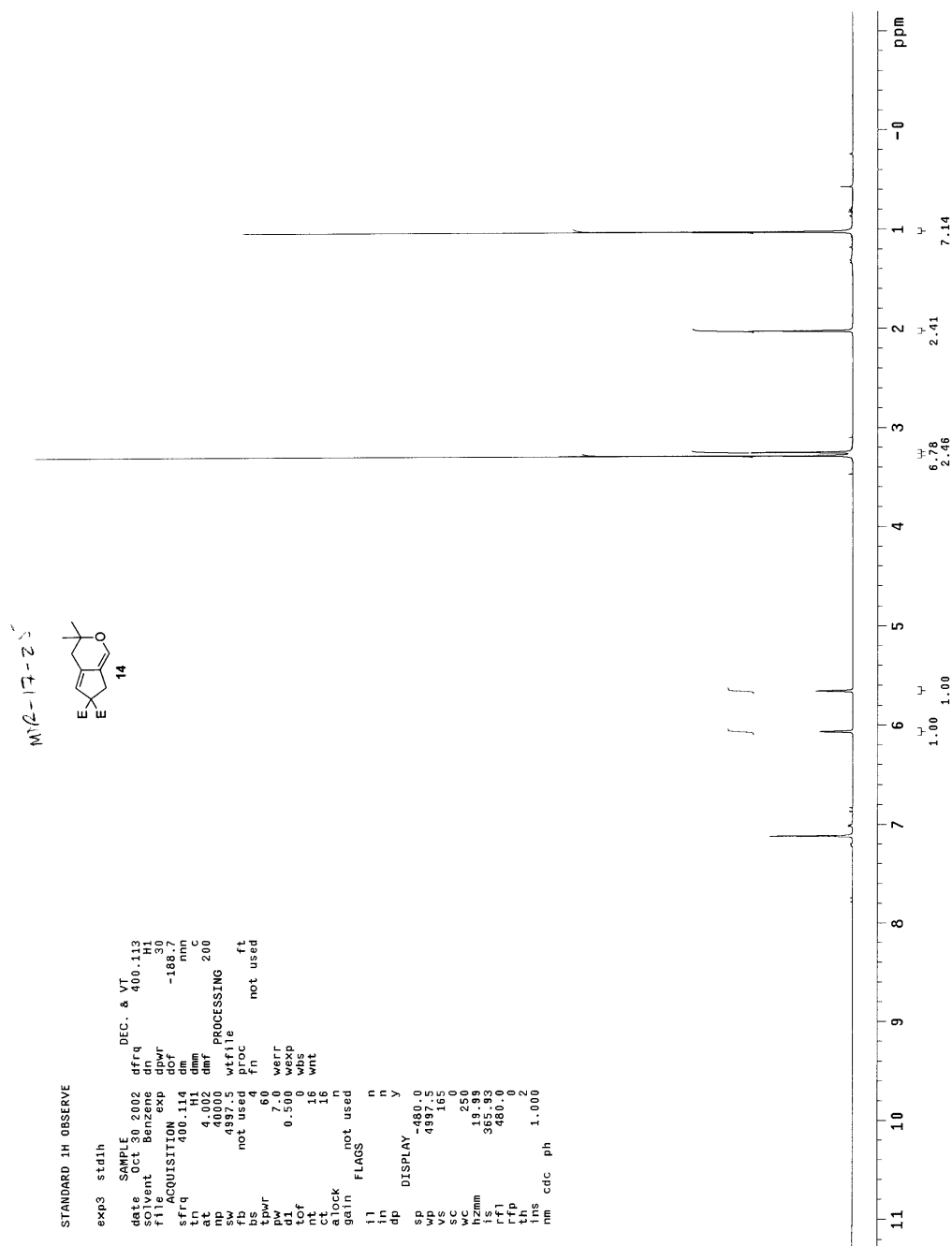
```

exp3 stdih
date Dec 2002 dfrq DEC. & VT
solvent Benzene dn 400.113
file file exp dpwr H1
ACQUISITION exp 30
sfrq 400.114 dof -188.7
dm dm mn
at 4.002 dmf 200
np 40000
sw 4997.5 wfile PROCESSING
bs not used proc ft
ns not used fn not used
tpwr 60
pw 7.0 werr
di 0.500 wexp
ct 16 wnt
nt 16
alock n
gain not used
il n
in n
dp n
DISPLAY y
sp -480.0
wp 4997.5
vs 70
sc 0
h2mm 250
is 19.99
rfl 247.61
rfi 480.0
trp 6
tms cdc
nm 6.000
nm cdc ph

```







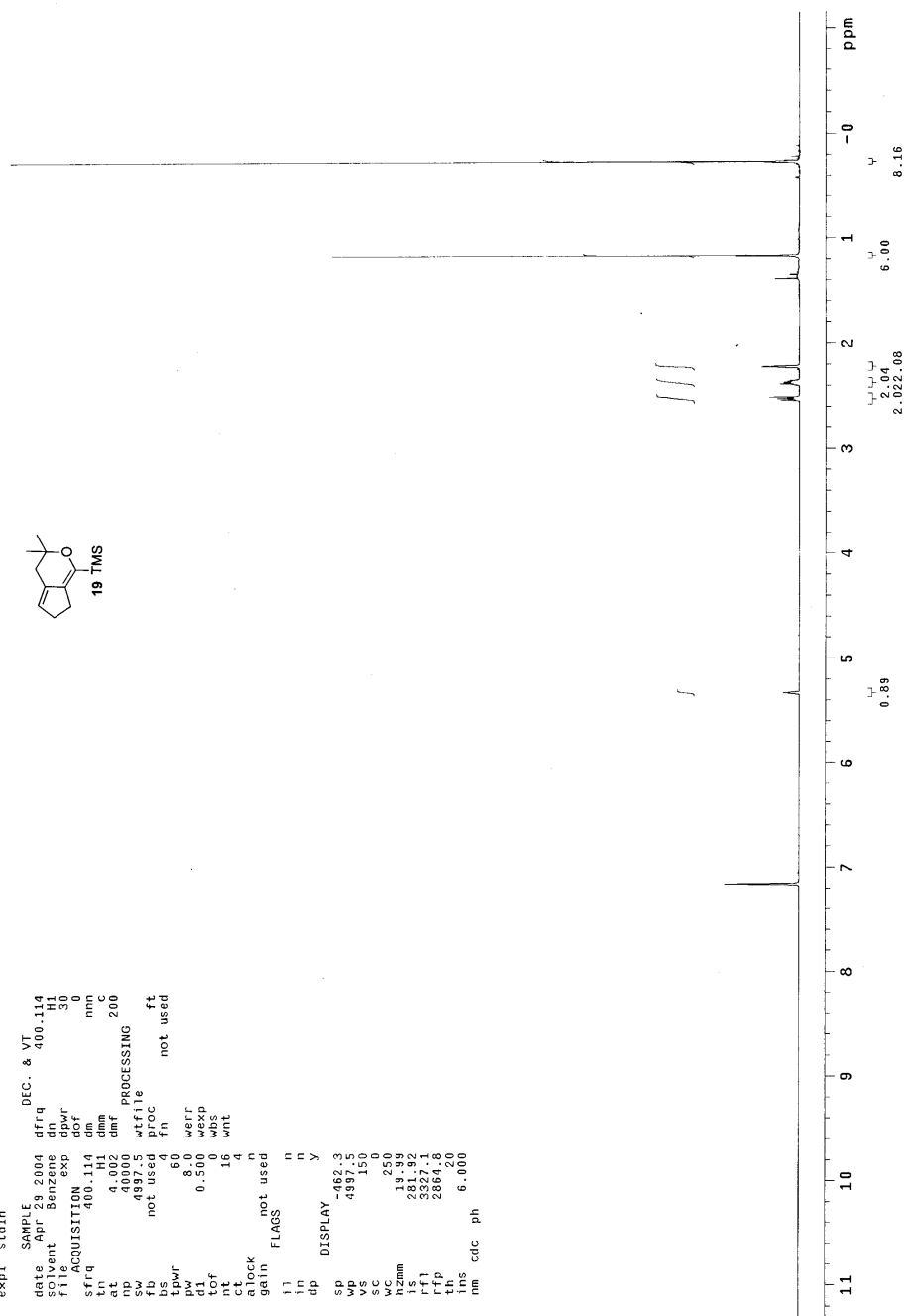
M76-30-12



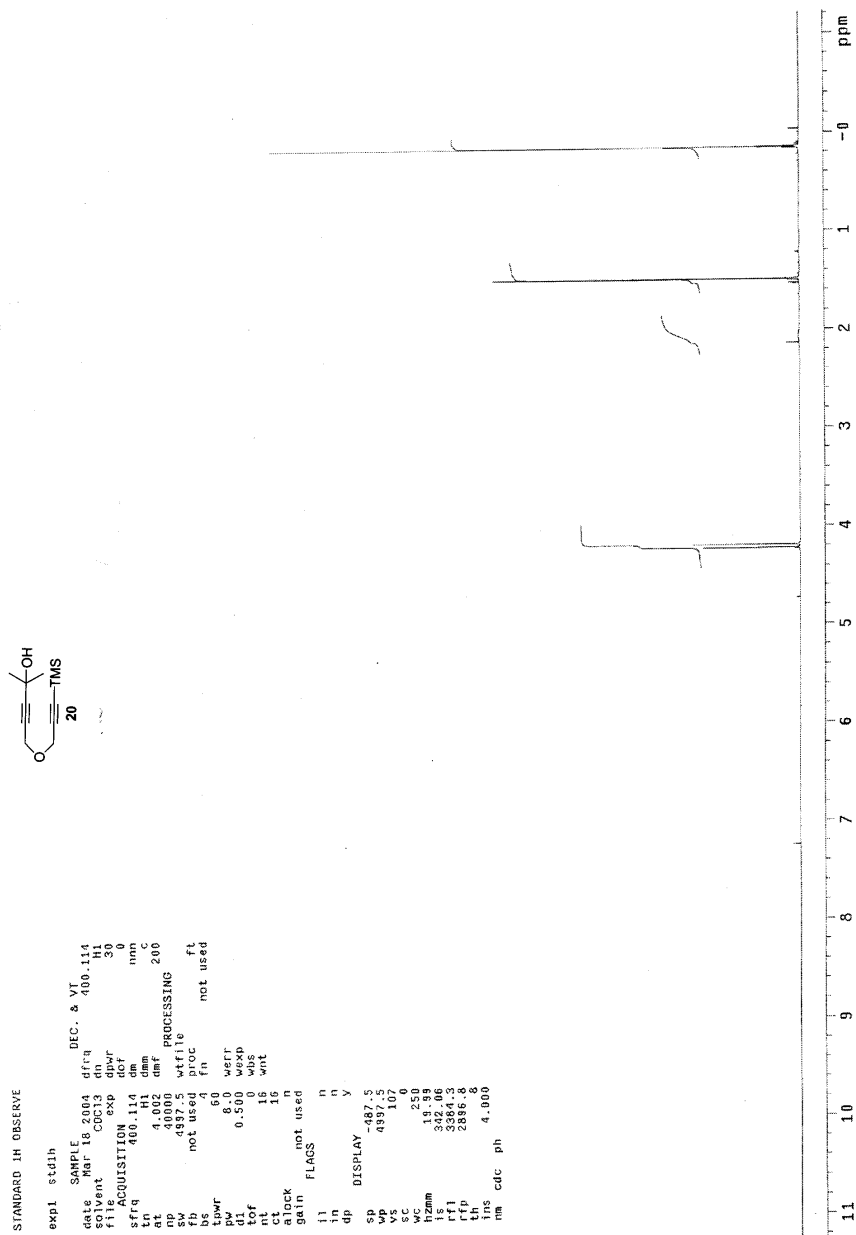
STANDARD 1H OBSERVE

expi stdih

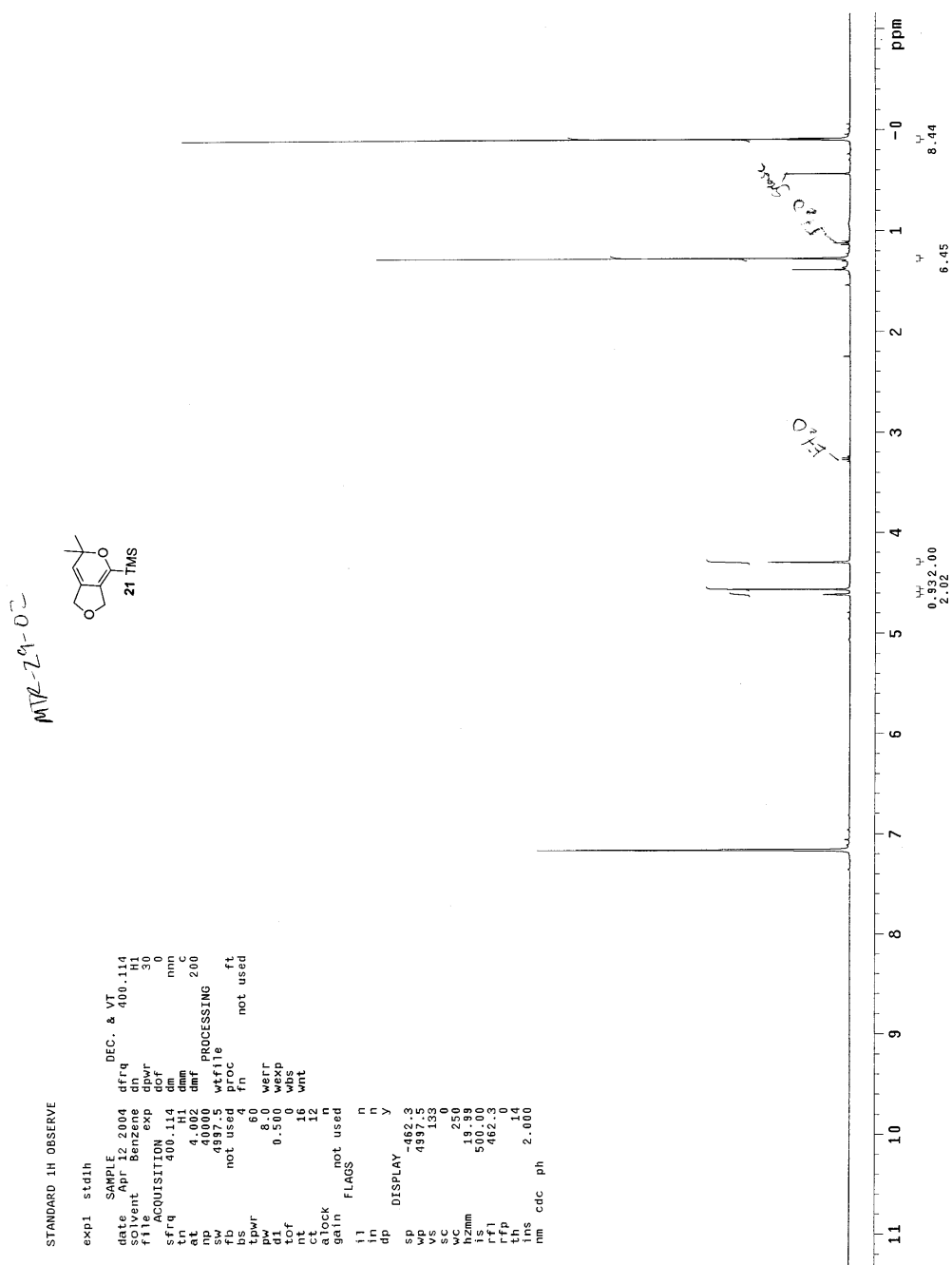
SAMPLE DEC. & VT
 date Apr 29 2004 dfrq 400.114
 solvent Benzene d1
 file exp dpr 30
 ACQUISITION
 sfrq 400.114 dnf 0
 tr 400.114 dnm 200
 at 4.002 dmf
 np 40000
 sw 4937.5 wfile
 bs not used f1 not used
 tpwr 60
 pw 8.0 werr
 pl 0.500 wexp
 rf 16 wnt
 ct 4
 alock n
 gelin not used
 flags
 il n
 in n
 dp y
 DISPLAY
 sp -462.3
 wp 4937.5
 vs 150
 sc 0
 hz 250
 hzmm 19.99
 ls 281.92
 rfl 3227.1
 rfp 2667.0
 th 6.000
 ins
 nm cdc ph



Supporting Materials



Supporting Materials



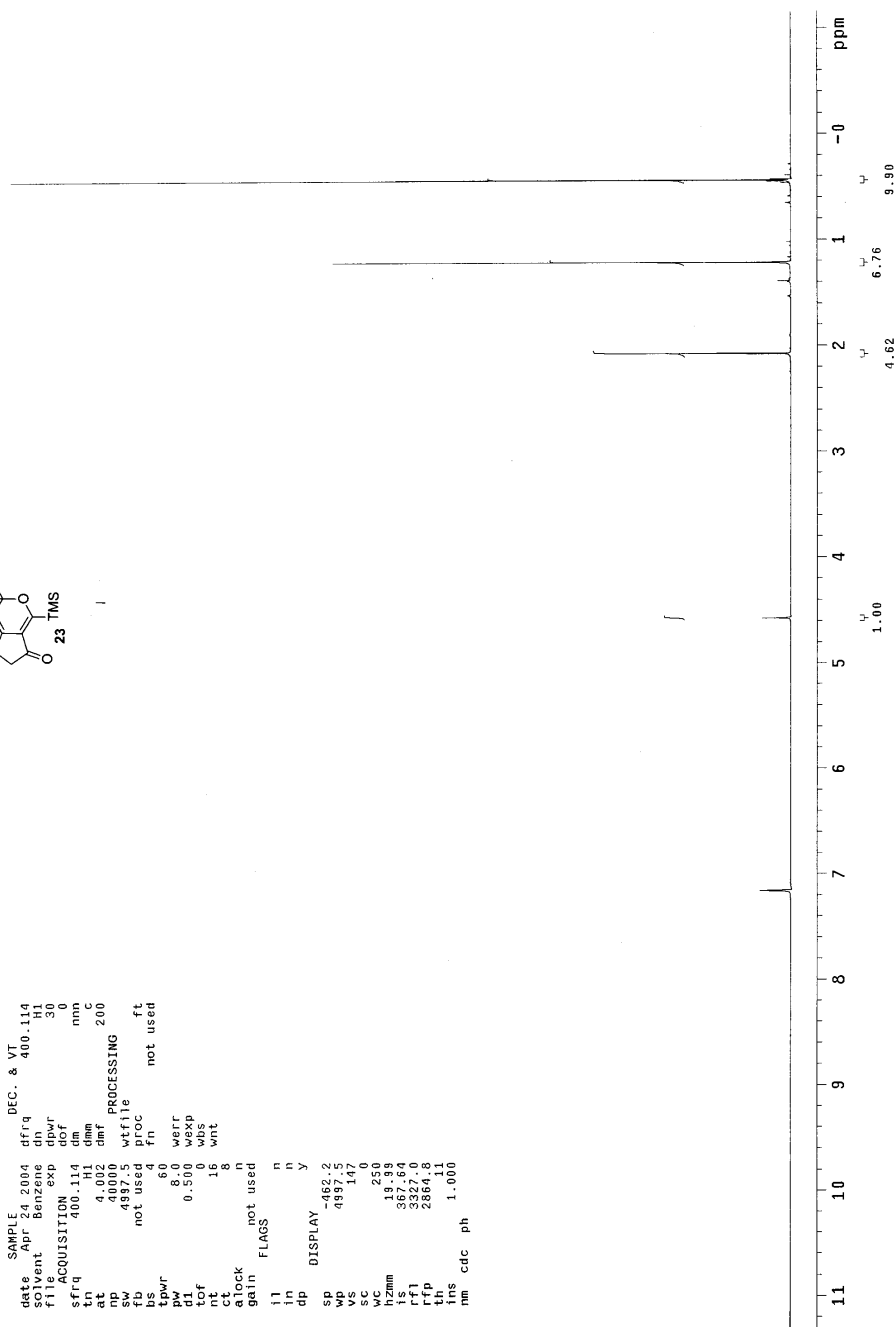
AT12-20-12



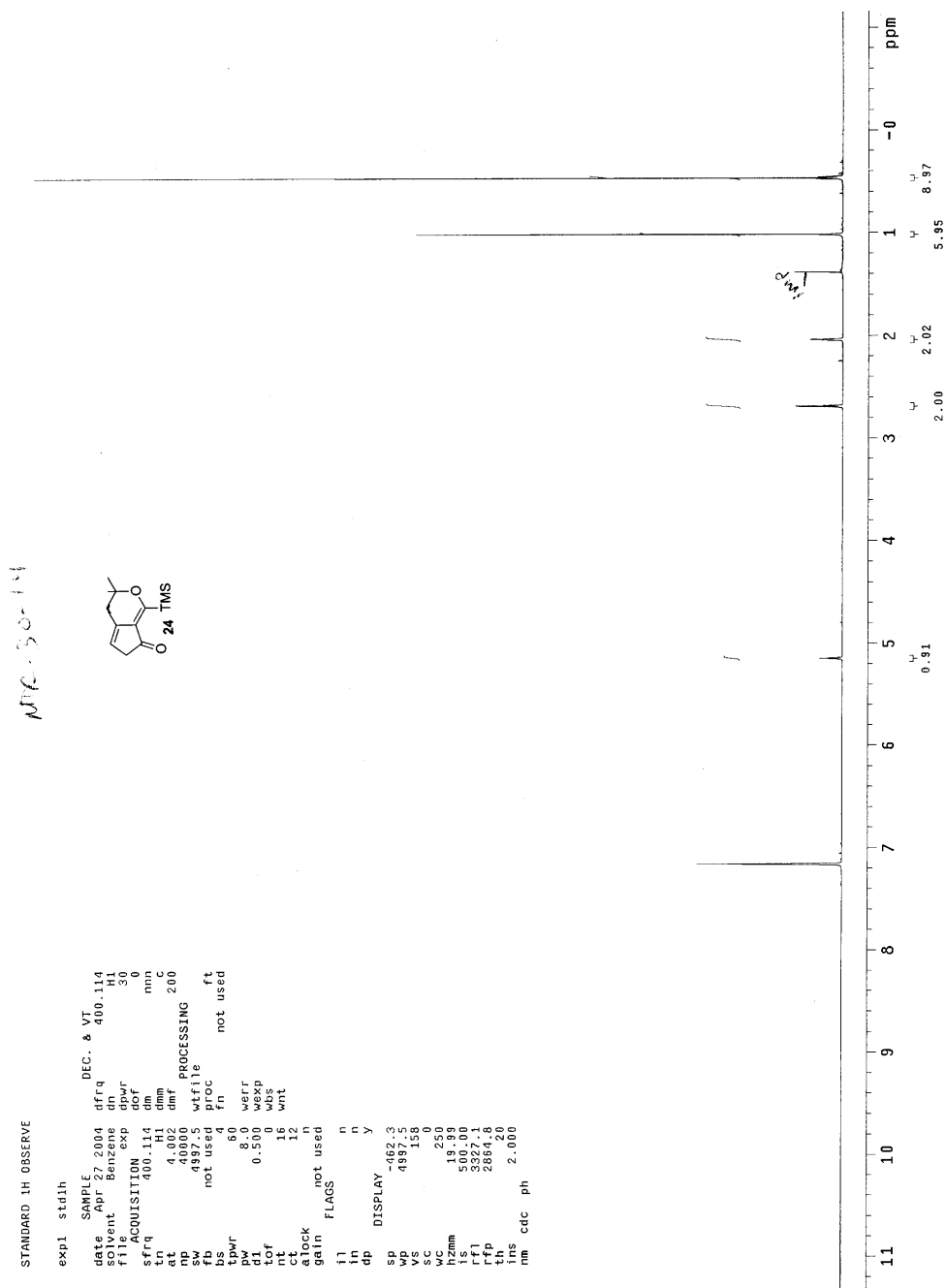
STANDARD 1H OBSERVE

```

expl stdh
SAMPLE
date Apr 24 2004 dfreq DEC. & VT 400.114
solvent Benzene d1 H1
file ACQUISITION exp dpwr 30
sfreq 400.114 dm 0
tn 400.114 dnm nm
at 4.002 dmf 200
np 400000 utfile c
sw 432000 not used
fb not used proc ft
bs 4 fn not used
tpwr 60
pw 80 werr
t1 0.500 wbp
nt 16 wnt
ct 8
alock not used
gain FLAGS n
il n
in n
dp DISPLAY y
sp -462.2
wp 4997.5
vs 147
wc 250
hzmm 19.99
is 367.64
rfi 2864.8
rtp 11
th 11
ins cdc ph
nm 1.000
  
```



Supporting Materials



33606m

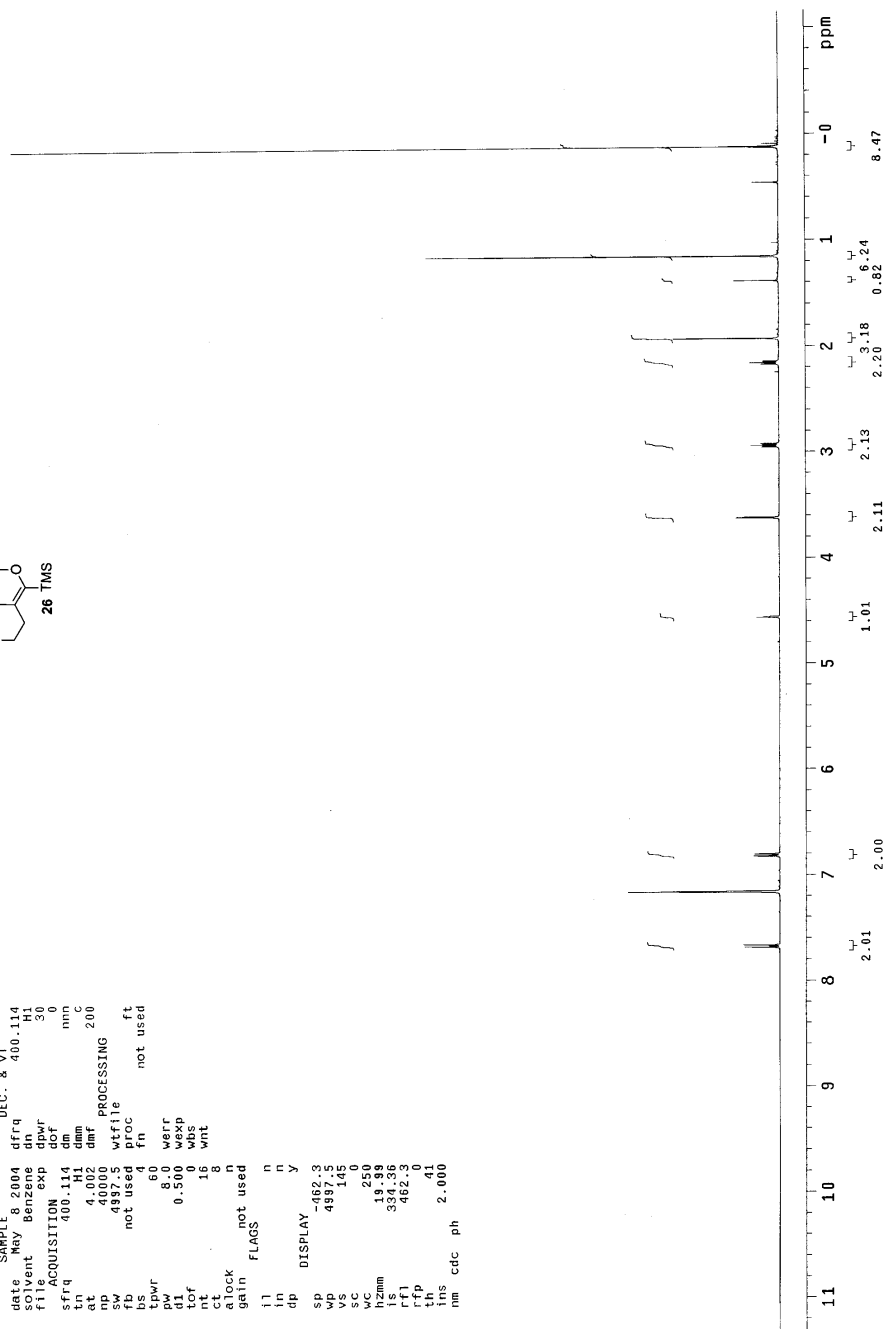
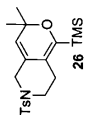
STANDARD 1H OBSERVE

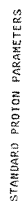
```

expl stdlh
SAMPLE 8 2004 DEC. & VT
date May Benzene dfrq 400.114
solvent file exp dn 30
ACQUISITION 400.114 0
dfrq 400.114 0
at 4.002 dmf 200
np 40000 wfile
sw 4937.5 wproc ft
bs not used 9 fn not used
tpwr 60
pw 8.0 werr
td 0.500 wexp
ct 16 wnt
nt 8
ct 8
alock n
gain not used
il n
in n
dp n
DISPLAY y
sp -462.3
wp 4937.5
vs 145
sc 0
h2mm 250
ls 19.99
rfl 334.36
rfi 462.3
tp 0
ins 40
nm cdc ph 2.000

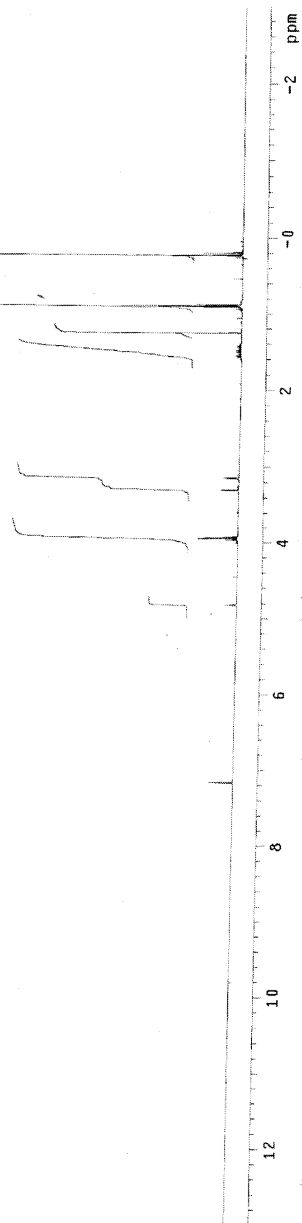
```

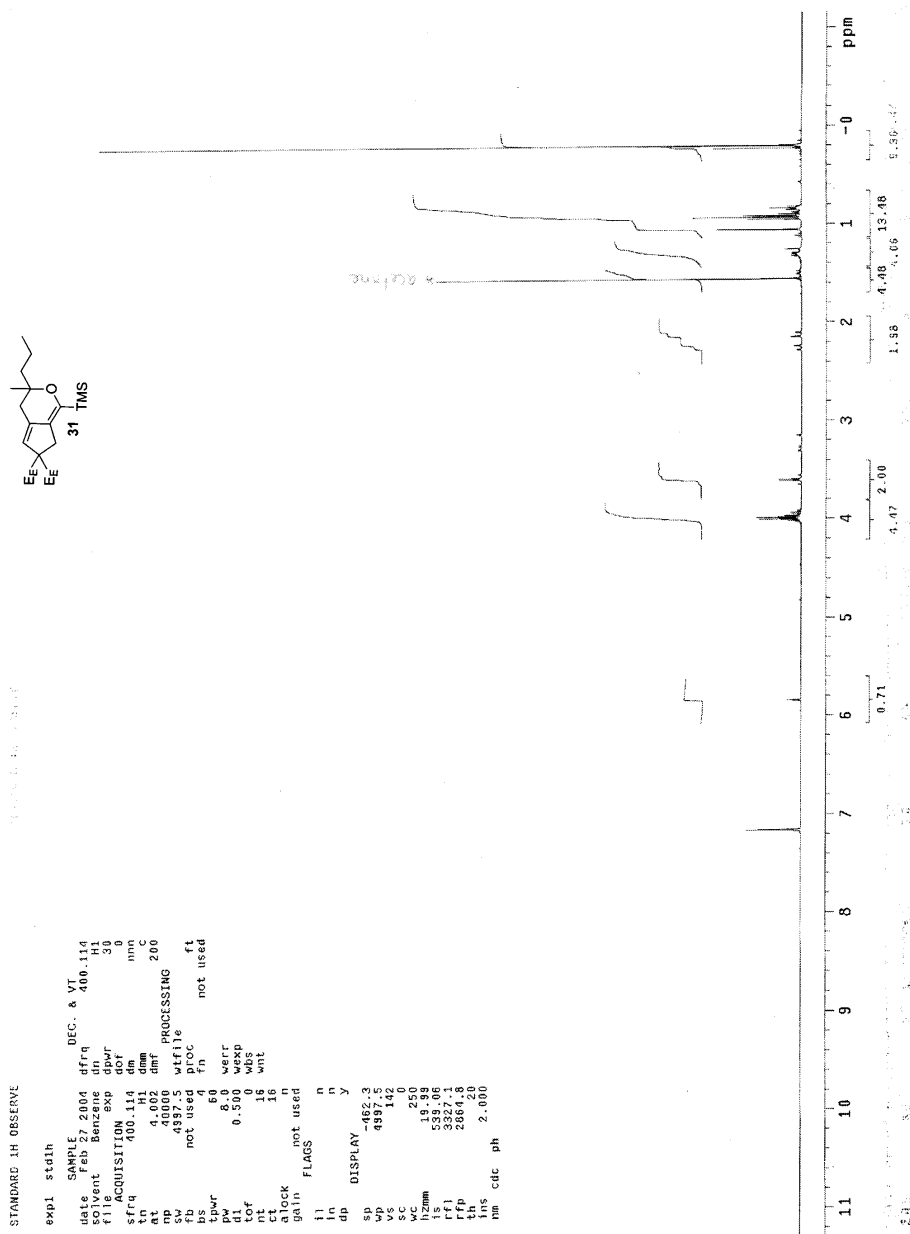
MTR-3D-22

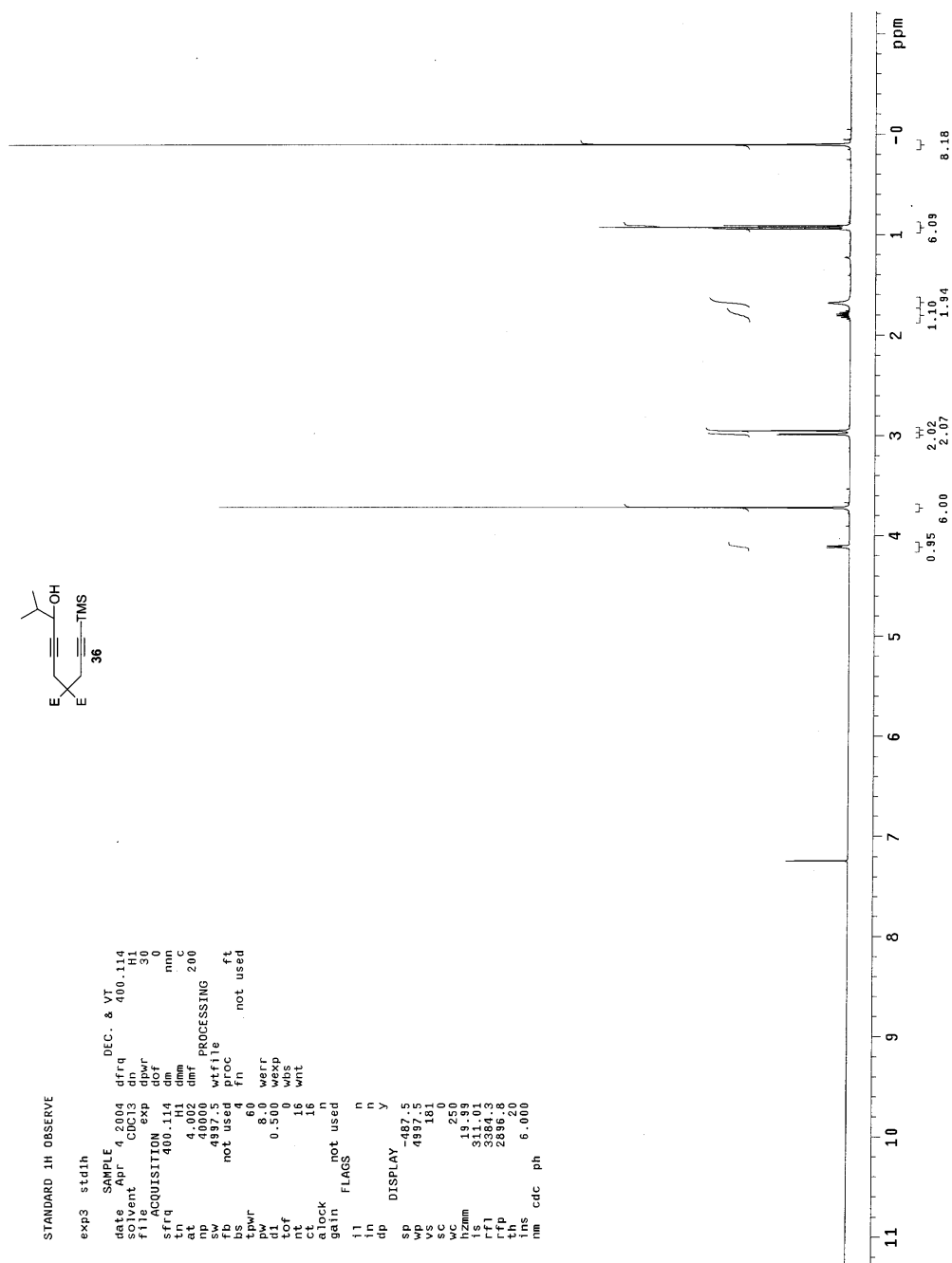


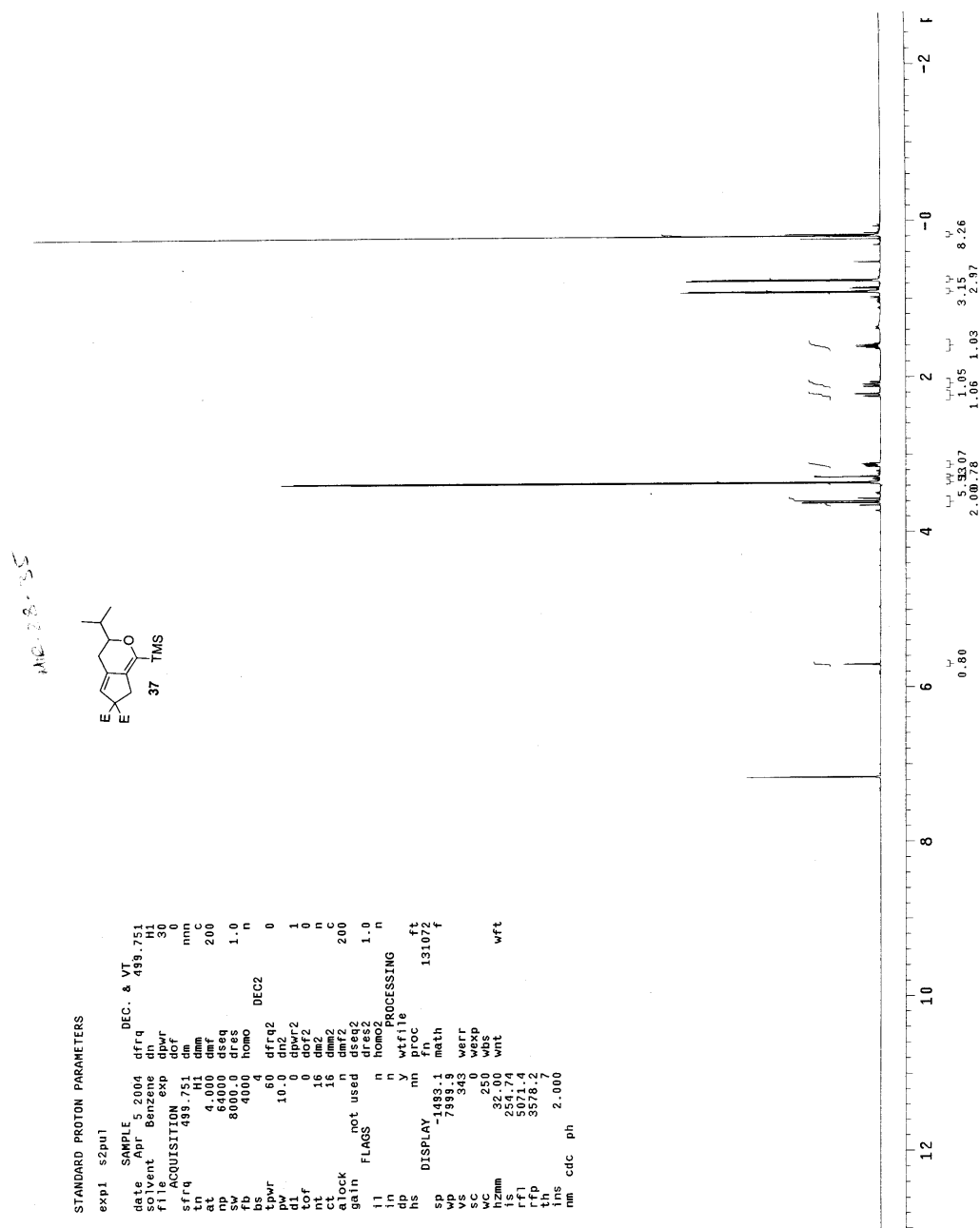


exp1 s2pu1

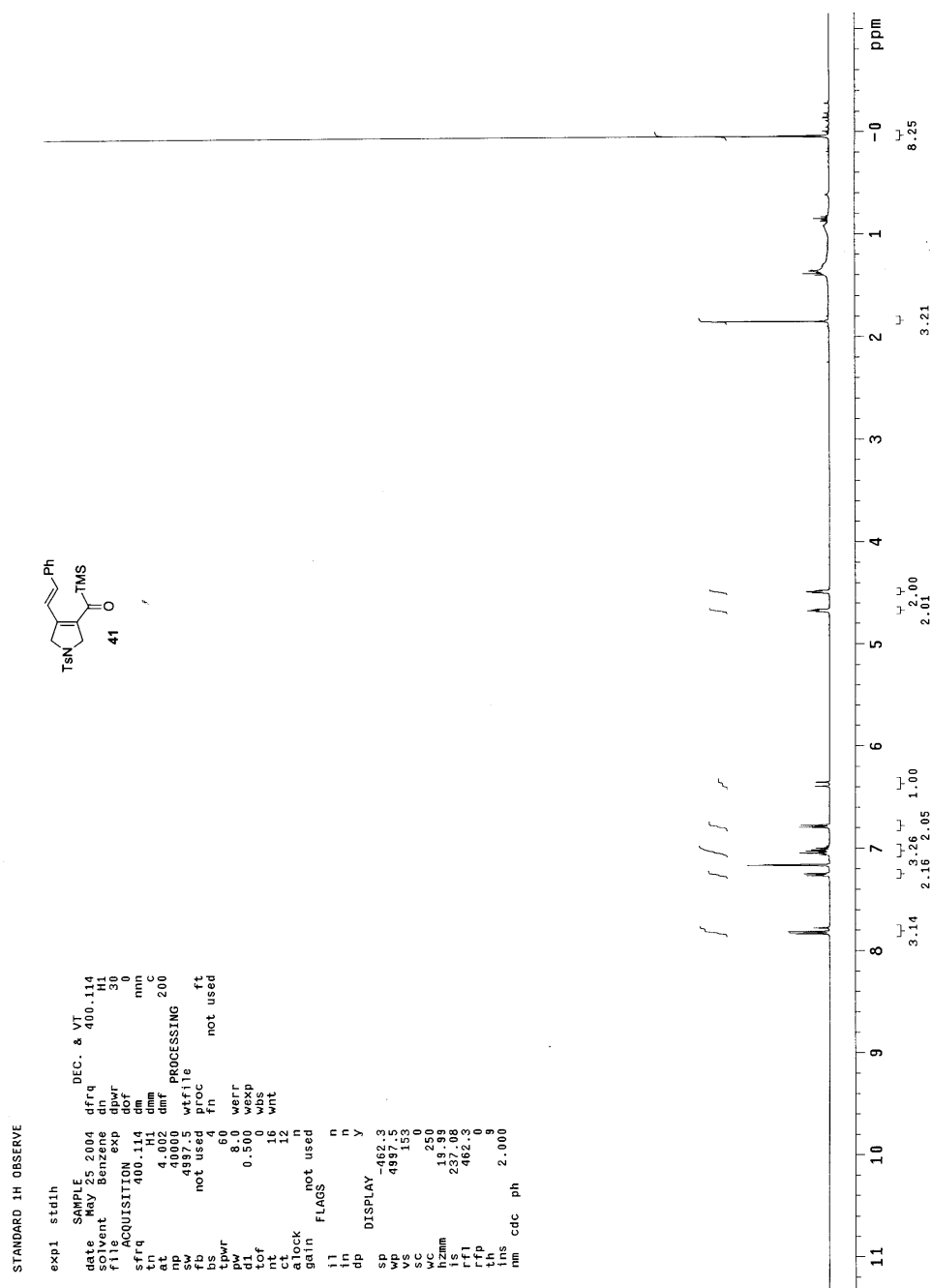
[illegible]







Supporting Materials



Supporting Materials

- [1] Trost, B. M.; Older, C. M. *Organometallics* **2002**, *21*, 2544-2546.
- [2] Trost, B. M.; Rudd, M. T. *J. Am. Chem. Soc.* **2002**, *124*, 4178-4179.