

Tandem Copper-Catalyzed Conjugate Addition-Diastereoselective Protonation of (*E*)- α -Trialkylsilyl- β -Alkyl(Aryl)- α,β -Unsaturated Esters.

*David A. Johnson and Michael P. Jennings**

Department of Chemistry and Biochemistry, The University of Alabama, Tuscaloosa, AL 35487-0336

jenningsm@ua.edu

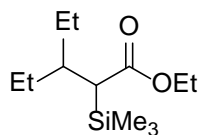
Table of Contents:

General Experimental Section	S2
Experimental Procedures and tabulated ^1H NMR Data of All Compounds Reported	S2-S7
NMR spectra of all reported compounds	S8-S32
1D NOE of Ester 2c	S33
References	S34

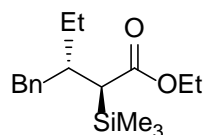
Experimental Section

All of the reactions were performed under Ar in flame-dried glassware. Anhydrous tetrahydrofuran (THF) was obtained from a commercial source and used without purification. Copper(I) iodide (98% purity) and lithium chloride (LiCl, 99%+, ACS) were used without any purification. TMSCl (99%) was purchased from commercial sources and used without further purification. All of the Grignard Reagents (EtMgBr, 3M in Et₂O; PhMgBr, 3M in Et₂O; *i*PrMgCl, 2M in Et₂O; ChxMgCl, 2M in Et₂O) were purchased from commercial courses and used as received. The reaction temperatures described below refer to the cooling bath, not internal reaction temperatures. Cooling bath temperatures were attained as follows: -78 °C, dry ice in acetone; -40 °C, dry ice in MeCN; -20 °C, NaCl in wet ice; -10 °C wet ice in acetone. The preparation of compounds **1a-1g** has been previously reported.¹ The NMR spectra were recorded with either a 360 or 500 MHz Bruker spectrometer. NMR spectra were obtained using CDCl₃ as the solvent with chloroform (CHCl₃: δ = 7.26 ppm; CDCl₃: δ = 77.0 ppm) as the internal standard. Column chromatography was performed using 60-200 μm silica gel. Analytical thin layer chromatography was performed on silica coated glass plates with F-254 indicator. Visualization was accomplished by aq. PMA/CeSO₄.

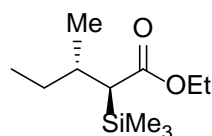
General Experimental Procedure for the Syntheses of 2a, 2b, 2i, and 2j: CuI (0.0050 g, 0.0250 mmol) and LiCl (0.0020 g, 0.050 mmol) were placed into a 10 mL round bottom flask and flame dried under vacuum under Ar. Dry THF (2.00 mL) was then added and the mixture was stirred at rt for 0.5 h until complete dissolution had occurred. The clear, light yellow homogeneous solution was cooled to -40 °C, and the appropriate (*E*)- α -trimethylsilyl- β -alkyl- α,β -unsaturated ester (0.500 mmol) was placed in a dry 1-dram vial and added to the solution dropwise. The vial was washed with dry THF (3 x 0.200 mL) and added to the reaction. TMSCl (1.2 equiv, 0.080 mL, 0.600 mmol) was then added and allowed to stir for 10 min. After this time, EtMgBr (1.2 equiv, 0.220 mL, 0.600 mmol) was added dropwise via syringe, and the solution was stirred at -40 °C for 3 h and the reaction temperature was then lowered to -78 °C. The reaction was quenched with sat. NH₄Cl (0.2 mL) and warmed to rt for 0.5 h. The product was extracted with Et₂O (3 x 10 mL), and the combined organic layers were washed with brine. The organic layer was separated, dried with MgSO₄, and concentrated *in vacuo* to give the crude product, which was then analyzed by ¹H NMR spectroscopy to determine diastereoselectivity. The crude material was then submitted to column chromatography and purified using 2% Et₂O in hexane to provide **2a**, **2b**, **2i**, and **2j** in yields ranging from 78-91%.



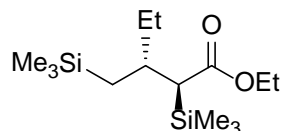
2a: Yield: 0.090 g, 78%: ¹H NMR: (500 MHz, CDCl₃) δ 4.08 (m, 2H), 2.09 (d, *J* = 9.7 Hz, 1H), 1.83 (m, 1H), 1.48 (m, 2H), 1.41 (m, 2H), 1.24 (t, *J* = 7.2 Hz, 3H), 0.84 (t, *J* = 7.2 Hz, 3H), 0.82 (t, *J* = 7.2 Hz, 3H), 0.10 (s, 9H). ¹³C NMR: (125 MHz, CDCl₃) δ 175.4, 59.5, 41.3, 39.5, 24.2, 23.6, 14.4, 10.3, 10.0, -1.3. IR (Et₂O): 2964, 2876, 2360, 1716, 1460, 1366, 1323, 1251, 1207, 1172, 1120, 1039, 982, 844, 691 cm⁻¹. HRMS (EI-EBE Sector) *m/z*: [M]⁺ Calcd for C₁₂H₂₆O₂Si 230.1702; found 230.1743. R_f = 0.7, 10% Et₂O in hexanes.



2b: Yield: 0.120 g, 82%: ^1H NMR: (500 MHz, CDCl_3) δ (Major) 7.27 (m, 2H), 7.18 (m, 3H), 4.10 (m, 2H), 2.66 (m, 2H), 2.23 (d, $J = 8.71$ Hz), 2.17 (m, 1H), 1.42 (m, 2H), 1.27 (t, $J = 7.2$ Hz, 3H), 0.84 (t, $J = 7.4$ Hz, 3H), 0.15 (s, 9H). δ (Minor) 7.27 (m, 2H), 7.18 (m, 3H), 4.10 (m, 2H), 2.66 (m, 2H), 2.17 (m, 1H), 2.11 (d, $J = 7.7$ Hz, 1H), 1.42 (m, 2H), 1.26 (t, $J = 7.2$ Hz, 3H), 0.86 (t, $J = 7.4$ Hz, 3H), 0.13 (s, 9H). ^{13}C NMR: (125 MHz, CDCl_3) δ (Major) 175.1, 141.0, 129.3, 128.1, 125.8, 59.6, 40.7, 38.7, 23.5, 14.5, 10.0, -1.2. δ (Minor) 175.1, 141.0, 129.0, 128.3, 125.8, 59.6, 40.4, 38.7, 23.5, 14.5, 10.0, -1.2. IR (Et_2O): 3027, 2963, 1714, 1603, 1496, 1454, 1367, 1317, 1252, 1129, 1034, 844, 736, 700 cm^{-1} . HRMS (EI-EBE Sector) m/z : $[\text{M}]^+$ Calcd for $\text{C}_{17}\text{H}_{28}\text{O}_2\text{Si}$ 292.1859; found 292.1856. $R_f = 0.7$, 10% Et_2O in hexanes.



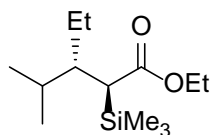
2i: Yield: 0.081 g, 75%: ^1H NMR: (500 MHz, CDCl_3) δ (Major) 4.08 (m, 2H), 1.94 (d, $J = 8.8$ Hz, 1H), 1.88 (m, 1H), 1.55 (m, 1H), 1.24 (t, $J = 7.1$ Hz, 3H), 1.05 (m, 1H), 0.99 (d, $J = 6.5$ Hz, 1H), 0.88 (t, $J = 7.4$ Hz, 3H), 0.10 (s, 9H). δ (Minor) 4.08 (m, 2H), 1.93 (m, 1H), 1.86 (d, $J = 10.3$ Hz, 1H), 1.44 (m, 1H), 1.24 (t, $J = 7.1$ Hz, 3H), 1.05 (m, 1H), 0.95 (d, $J = 6.7$ Hz, 1H), 0.85 (t, $J = 7.4$ Hz, 3H), 0.10 (s, 9H). ^{13}C NMR: (125 MHz, CDCl_3) δ (Major) 175.2, 59.5, 43.9, 34.3, 28.9, 18.8, 14.5, 11.3, -1.3. δ (Minor) 175.5, 59.5, 44.9, 34.2, 29.8, 18.6, 14.5, 10.8, -1.3. IR (Et_2O): 2963, 1716, 1463, 1366, 1316, 1283, 1252, 1217, 1179, 1135, 1118, 1041, 916, 845, 691 cm^{-1} . HRMS (EI-EBE Sector) m/z : $[\text{M}]^+$ Calcd for $\text{C}_{11}\text{H}_{24}\text{O}_2\text{Si}$ 216.1546; found 216.1601. $R_f = 0.7$, 10% Et_2O in hexanes.



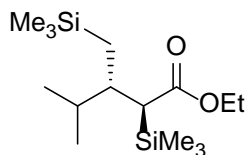
2j: Yield: 0.131 g, 91%: ^1H NMR: (500 MHz, CDCl_3) δ 4.09 (m, 2H), 2.16 (d, $J = 8.1$ Hz, 1H), 2.07 (m, 1H), 1.51 (m, 2H), 1.24 (t, $J = 7.2$ Hz, 3H), 0.86 (dd, $J = 15.0, 10.6$ Hz, 1H), 0.83 (t, $J = 7.2$ Hz, 3H), 0.63 (m, 1H), 0.10 (s, 9H), 0.01 (s, 9H). ^{13}C NMR: (125 MHz, CDCl_3) δ 175.1, 59.4, 43.1, 35.3, 27.0, 20.8, 14.5, 9.9, -0.50, -1.2. IR (Et_2O): 2956, 1716, 1463, 1415, 1366, 1289, 1250, 1183, 1123, 1041, 968, 928, 840, 758, 689, 654 cm^{-1} . HRMS (EI-EBE Sector) m/z : $[\text{M}]^+$ Calcd for $\text{C}_{14}\text{H}_{32}\text{O}_2\text{Si}_2$ 288.1941; found 288.1986. $R_f = 0.7$, 10% Et_2O in hexanes.

General Experimental Procedure for the syntheses of 2d, 2k, and 2l: CuI (0.0050 g, 0.0250 mmol) and LiCl (0.0020 g, 0.0500 mmol) were placed into a 10 mL round bottom flask and flame dried under vacuum under Ar. Dry THF (2.50 mL) was added and the mixture was stirred with at rt for a period of 0.5 h until complete dissolution had occurred. The clear, light yellow homogeneous solution was cooled to -10°C , and the appropriate (*E*)- α -trimethylsilyl- β -alkyl- α,β -unsaturated ester (0.500 mmol) was placed in a dried 1-dram vial and added to the solution dropwise. The vial was washed with dry THF (3 x 0.2 mL) and added to the reaction. TMSCl (1.2 equiv, 0.0800 mL, 0.600 mmol) was then added and allowed

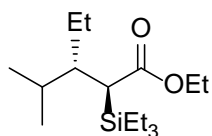
to stir for 10 min. After this time, $i\text{PrMgCl}$ (2.5 equiv, 0.640 mL, 1.25 mmol) was added dropwise via syringe, and the solution was stirred at $-10\text{ }^{\circ}\text{C}$ for 3 h and then lowered to $-78\text{ }^{\circ}\text{C}$. The reaction was quenched with sat. NH_4Cl (0.4 mL) and warmed to rt for 0.5 h. The product was extracted with Et_2O (3 x 10 mL), and the combined organic layers were washed with brine. The organic layer was separated, dried with MgSO_4 , and concentrated *in vacuo* to give the crude product, which was then analyzed by ^1H NMR spectroscopy to determine diastereoselectivity. The crude material was then submitted to column chromatography and purified using 2% Et_2O in hexane to provide **2d**, **2k** and **2l** in yields ranging from 75-85%.



2d: Yield: 0.104 g, 85%: ^1H NMR: (500 MHz, CDCl_3) δ 4.07 (m, 2H), 2.13 (d, $J = 6.7\text{ Hz}$, 1H), 1.87 (m, 1H), 1.60 (m, 1H), 1.56 (m, 1H), 1.47 (m, 1H), 1.24 (t, $J = 7.2\text{ Hz}$, 3H), 0.89 (t, $J = 7.5\text{ Hz}$, 3H), 0.88 (d, $J = 6.82\text{ Hz}$, 3H), 0.84 (d, $J = 6.82\text{ Hz}$, 3H), 0.09 (s, 9H). ^{13}C NMR: (125 MHz, CDCl_3) δ 175.4, 59.4, 45.2, 39.8, 30.6, 23.2, 19.8, 18.9, 14.4, 14.2, -1.6. IR (Et_2O): 2960, 1716, 1466, 1388, 1368, 1320, 1251, 1173, 1125, 1040, 993, 843, 758, 691 cm^{-1} . HRMS (EI-EBE Sector) m/z : $[\text{M}-\text{C}_3\text{H}_7]^+$ Calcd for $\text{C}_{10}\text{H}_{21}\text{O}_2\text{Si}$ $[\text{M}]^+$: 201.1389; found 201.1387. $R_f = 0.7$ 10% Et_2O in hexanes.

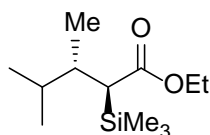


2k: Yield: 0.113 g, 75%: ^1H NMR: (500 MHz, CDCl_3) δ 4.05 (m, 2H), 2.14 (d, $J = 4.9\text{ Hz}$, 1H), 1.96 (m, 1H), 1.77 (m, 1H), 1.23 (t, $J = 7.1\text{ Hz}$, 3H), 0.98 (dd, $J = 15.7, 5.1\text{ Hz}$, 1H), 0.86 (d, $J = 6.8\text{ Hz}$, 3H), 0.80 (d, $J = 6.8\text{ Hz}$, 3H), 0.69 (dd, $J = 15.7, 2.83\text{ Hz}$, 1H), 0.08 (s, 9H), 0.00 (s, 9H). ^{13}C NMR: (125 MHz, CDCl_3) δ 175.2, 59.3, 39.5, 32.7, 19.8, 17.9, 17.9, 14.4, -0.4, -1.7. IR (Et_2O): 2955, 2900, 1716, 1465, 1414, 1387, 1368, 1318, 1250, 1181, 1143, 1120, 1044, 1013, 989, 945, 839, 762, 743, 723, 689, 647, 612, 564, 551, 540, 503 cm^{-1} . HRMS (EI-EBE Sector) m/z : $[\text{M}]^+$ Calcd for $\text{C}_{15}\text{H}_{34}\text{O}_2\text{Si}_2$ 302.2097; found 302.2085. $R_f = 0.8$, 10% Et_2O in hexanes.



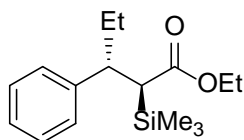
2l: Yield: 0.120 g, 91%: ^1H NMR: (500 MHz, CDCl_3) δ 4.04 (m, 2H), 2.27 (d, $J = 5.2\text{ Hz}$, 1H), 1.86 (m, 1H), 1.57 (m, 3H), 1.23 (t, $J = 7.2\text{ Hz}$, 3H), 0.98 (t, $J = 7.9\text{ Hz}$, 9H), 0.92 (t, $J = 7.2\text{ Hz}$, 3H), 0.88 (d, $J = 6.9\text{ Hz}$, 3H), 0.84 (d, $J = 6.9\text{ Hz}$, 3H), 0.64 (m, 6H). ^{13}C NMR: (125 MHz, CDCl_3) δ 175.5, 59.4, 45.2, 35.7, 30.7, 23.4, 19.8, 19.0, 14.3, 7.4, 3.3. IR (Et_2O): 2957, 2877, 1718, 1465, 1417, 1367, 1319, 1252, 1172, 1124, 1007, 729 cm^{-1} . HRMS (EI-EBE Sector) m/z : $[\text{M}-\text{C}_3\text{H}_7]^+$ Calcd for $\text{C}_{13}\text{H}_{27}\text{O}_2\text{Si}$ 243.1859; found 243.1780. $R_f = 0.8$, 10% Et_2O in hexanes.

Procedure for the Synthesis of 2g @ 2 mmol: CuI (0.0193 g, 0.104 mmol) and LiCl (0.008 g, 0.200 mmol) were placed into a 50 mL round bottom flask and flame dried under vacuum under Ar. Dry THF (8.00 mL) was added and the mixture was stirred with at rt for a period of 0.5 h until complete dissolution had occurred. The clear, light yellow homogeneous solution was cooled to -20 °C, and **1c** (0.371 g, 2.00 mmol) was placed in a dried 1-dram vial and added to the solution dropwise. The vial was washed with dry THF (3 x 0.015 mL) and added to the reaction. TMSCl (1.2 equiv, 0.296 mL, 2.40 mmol) was then added and allowed to stir for 10 min. After this time, ⁱPrMgCl (1.2 equiv, 1.20 mL, 2.40 mmol) was added dropwise via syringe, and the solution was stirred at -20 °C for 3 h and then lowered to -78 °C. The reaction was quenched with sat. NH₄Cl (1.5 mL) and warmed to rt for 0.5 h. The product was extracted with Et₂O (3 x 20 mL), and the combined organic layers were washed with brine. The organic layer was separated, dried with MgSO₄, and concentrated *in vacuo* to give the crude product, which was then analyzed by ¹H NMR spectroscopy to determine diastereoselectivity. The crude material was then submitted to column chromatography and purified using 2% Et₂O in hexane to provide **2g** (0.371 g) in 80% yield.



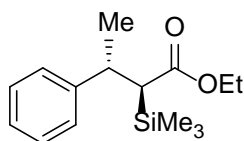
2g: ¹H NMR: (500 MHz, CDCl₃) δ 4.08 (m, 2H), 2.06 (d, *J* = 9.3 Hz, 1H), 1.87 (m, 1H), 1.78 (m, 1H), 1.24 (t, *J* = 7.1 Hz, 3H), 0.92 (d, *J* = 6.8 Hz, 3H), 0.89 (d, *J* = 6.8 Hz, 3H), 0.78 (d, *J* = 6.8 Hz, 3H), 0.09 (s, 9H). ¹³C NMR: (125 MHz, CDCl₃) δ 175.4, 59.5, 42.4, 38.3, 30.9, 21.6, 16.5, 14.4, 13.8, -1.5. IR (Et₂O): 2961, 2874, 1716, 1466, 1389, 1367, 1341, 1319, 1303, 1268, 1251, 1215, 1175, 1134, 1111, 1084, 1039, 924, 891, 844, 759, 736, 692, 659 cm⁻¹. HRMS (EI-EBE Sector) *m/z*: [M-C₃H₇]⁺ Calcd for C₉H₁₉O₂Si 187.1233; found 187.1198. *R*_f = 0.7, 10% Et₂O in hexanes.

Procedure for the synthesis of 2c: CuI (0.0025 g, 0.013 mmol) and LiCl (0.0011 g, 0.025 mmol) were placed into a 10 mL round bottom flask and flame dried under vacuum under Ar. Dry THF (1.00 mL) was added and the mixture was stirred with at rt for a period of 0.5 h until complete dissolution had occurred. The clear, light yellow homogeneous solution was cooled to -20 °C, and **1a** (0.050 g, 0.250 mmol) was placed in a dried 1-dram vial and added to the solution dropwise. The vial was washed with dry THF (3 x 0.2 mL) and added to the reaction. TMSCl (1.2 equiv, 0.040 mL, 0.300 mmol) was then added and allowed to stir for 10 min. After this time, PhMgBr (1.2 equiv, 0.100 mL, 0.300 mmol) was added dropwise via syringe, and the solution was stirred at -20 °C for 3 h and then lowered to -78 °C. The reaction was quenched with sat. NH₄Cl (0.2 mL) and warmed to rt for 0.5 h. The product was extracted with Et₂O (3 x 10 mL), and the combined organic layers were washed with brine. The organic layer was separated, dried with MgSO₄, and concentrated *in vacuo* to give the crude product, which was then analyzed by ¹H NMR spectroscopy to determine diastereoselectivity. The crude material was then submitted to column chromatography and purified using 2% Et₂O in hexane to provide **2c** (0.042 g) in 60% yield.



2c: ^1H NMR: (500 MHz, CDCl_3) δ 7.27 (m, 2H), 7.19 (m, 1H), 7.16 (m, 2H), 4.16 (m, 2H), 2.95 (dt, J = 11.5, 3.4 Hz, 1H), 2.38 (d, J = 11.9 Hz, 1H), 1.74 (m, 1H), 1.53 (m, 1H), 1.29 (t, J = 7.1 Hz, 3H), 0.63 (t, J = 7.4 Hz, 3H), -0.26 (s, 9H). ^{13}C NMR: (125 MHz, CDCl_3) δ 175.2, 143.0, 128.7, 128.3, 126.6, 59.8, 46.7, 45.4, 30.5, 14.5, 11.8, -2.1. IR (Et_2O): 3062, 3028, 2961, 2930, 2873, 1714, 1660, 1603, 1495, 1453, 1366, 1322, 1250, 1197, 1155, 1126, 1078, 1066, 1035, 1012, 961, 897, 845, 760, 734, 702, 621, 601, 580, 554, 538, 510 cm^{-1} . HRMS (EI-EBE Sector) m/z : $[\text{M}]^+$ Calcd for $\text{C}_{16}\text{H}_{26}\text{O}_2\text{Si}$ 278.1702; found 278.1708. R_f = 0.7, 10% Et_2O in hexanes.

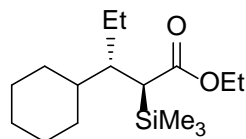
Procedure for the synthesis of 2f: CuI (0.0026 g, 0.0140 mmol) and LiCl (0.0011 g, 0.0270 mmol) were placed into a 10 mL round bottom flask and flame dried under vacuum under Ar. Dry THF (1.00 mL) was added and the mixture was stirred with at rt for a period of 0.5 h until complete dissolution had occurred. The clear, light yellow homogeneous solution was cooled to -20 $^\circ\text{C}$, and **1c** (0.050 g, 0.270 mmol) was placed in a dried 1-dram vial and added to the solution dropwise. The vial was washed with dry THF (3 x 0.2 mL) and added to the reaction. TMSCl (1.2 eq., 0.040 mL, 0.320 mmol) was then added and allowed to stir for 10 min. After this time, PhMgBr (1.2 equiv, 0.110 mL, 0.320 mmol) was added dropwise via syringe, and the solution was stirred at -20 $^\circ\text{C}$ for 3 h and then lowered to -78 $^\circ\text{C}$. The reaction was quenched with sat. NH_4Cl (0.2 mL) and warmed to rt for 0.5 h. The product was extracted with Et_2O (3 x 10 mL), and the combined organic layers were washed with brine. The organic layer was separated, dried with MgSO_4 , and concentrated *in vacuo* to give the crude product, which was then analyzed by ^1H NMR spectroscopy to determine diastereoselectivity. The crude material was then submitted to column chromatography and purified using 2% Et_2O in hexane to provide **2f** (0.060 g) in 84% yield.



2f: ^1H NMR: (500 MHz, CDCl_3) δ (Major) 7.24 (m, 5H), 4.16 (m, 2H), 3.24 (dq, J = 11.7, 6.7 Hz, 1H), 2.34 (d, J = 11.6 Hz, 1H), 1.30 (t, J = 7.2 Hz, 3H), 1.28 (d, J = 6.8 Hz, 3H), -0.23 (s, 9H). ^{13}C NMR: (125 MHz, CDCl_3) δ (Major) 175.0, 145.5, 128.5, 127.7, 126.6, 59.8, 45.9, 39.5, 24.1, 14.5, -2.2. IR (Et_2O): 3062, 3029, 2962, 2900, 1714, 1604, 1495, 1454, 1366, 1350, 1332, 1290, 1261, 1250, 1203, 1161, 1127, 1080, 1040, 913, 844, 766, 738, 702, 571, 539 cm^{-1} . HRMS (EI-EBE Sector) m/z : $[\text{M}]^+$ Calcd for $\text{C}_{15}\text{H}_{24}\text{O}_2\text{Si}$ 264.1546 found 264.1542. R_f = 0.6 10% Et_2O in hexanes.

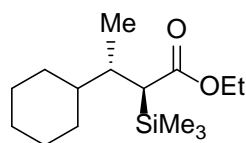
Procedure for the synthesis of 2e: CuI (0.006 g, 0.03 mmol) and LiCl (0.002 g, 0.050 mmol) were placed into a 10 mL round bottom flask and flame dried under vacuum under Ar. Dry THF (2.50 mL) was added and the mixture was stirred with at rt for a period of 0.5 h until complete dissolution had occurred. The clear, light yellow homogeneous solution was cooled to -10 $^\circ\text{C}$, and **1a** (0.100 g, 0.500 mmol) was placed in a dried 1-dram vial and added to the solution dropwise. The vial was washed with dry THF (3 x 0.2 mL) and added to the reaction. TMSCl (1.2 equiv, 0.080 mL, 0.600 mmol) was then added and allowed to stir for 10 min. After this time, ChxMgCl (2.5 equiv, 0.630 mL, 1.25 mmol) was added dropwise via syringe, and the solution was stirred at -10 $^\circ\text{C}$ for 3 h and then lowered to -78 $^\circ\text{C}$.

The reaction was quenched with sat. NH_4Cl (0.4 mL) and warmed to rt for 0.5 h. The product was extracted with Et_2O (3 x 10 mL), and the combined organic layers were washed with brine. The organic layer was separated, dried with MgSO_4 , and concentrated *in vacuo* to give the crude product, which was then analyzed by ^1H NMR spectroscopy to determine diastereoselectivity. The crude material was then submitted to column chromatography and purified using 2% Et_2O in hexane to provide **2e** (0.121 g) in 85% yield.

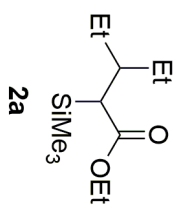


2e: ^1H NMR: (500 MHz, CDCl_3) δ 4.07 (m, 2H), 2.18 (d, 6.7 Hz, 1H), 1.74 (m, 2H), 1.65 (m, 1H), 1.58 (m, 3H), 1.46 (m, 2H), 1.24 (t, J = 7.2 Hz, 3H), 1.15 (m, 6H), 0.89 (t, J = 7.3 Hz, 3H), 0.09 (s, 9H). ^{13}C NMR: (125 MHz, CDCl_3) δ 175.5, 59.4, 45.1, 41.7, 40.0, 30.6, 29.4, 27.2, 26.8, 26.7, 23.6, 14.4, 14.3, -1.5. IR (Et_2O): 2927, 2853, 2360, 1716, 1449, 1365, 1331, 1305, 1251, 1211, 1185, 1170, 1251, 1211, 1185, 1170, 1137, 1114, 1039, 956, 891, 844, 759, 693, 661, 625, 576, 565, 539, 527, 516, 501 cm^{-1} . HRMS (EI-EBE Sector) m/z : $[\text{M}-\text{CH}_3]^+$ Calcd for $\text{C}_{15}\text{H}_{29}\text{O}_2\text{Si}$ 269.1937; found 269.1937. R_f = 0.8, 10% Et_2O in hexanes.

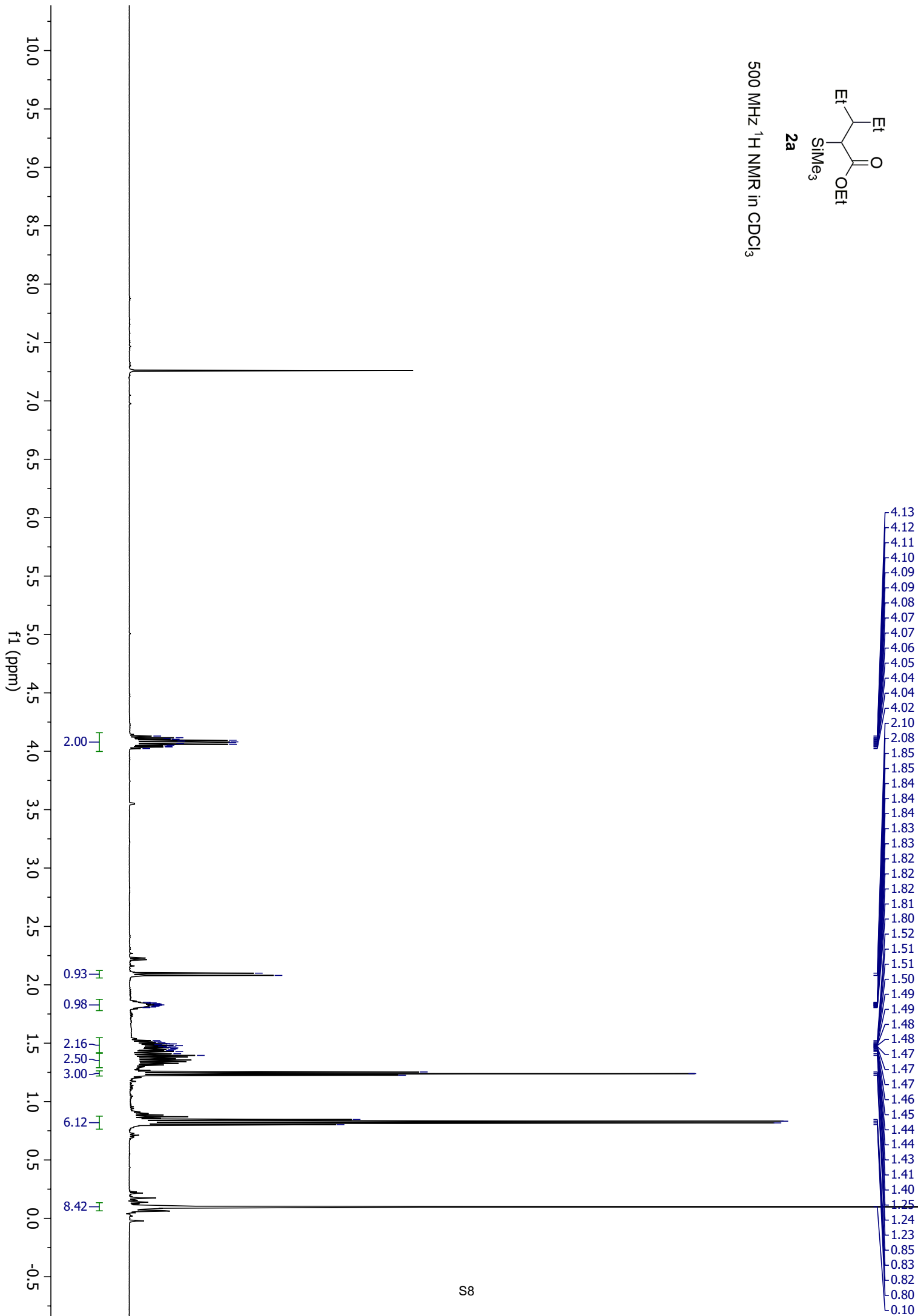
Procedure for the synthesis of 2h: CuI (0.00260 g, 0.0140 mmol) and LiCl (0.00110 g, 0.0270 mmol) were placed into a 10 mL round bottom flask and flame dried under vacuum under Ar. Dry THF (1.0 mL) was added and the mixture was stirred at rt for a period of 0.5 h until complete dissolution had occurred. The clear, light yellow homogeneous solution was cooled to $-20\text{ }^\circ\text{C}$, and **1c** (0.050 g, 0.270 mmol) was placed in a dreid 1-dram vial and added to the solution dropwise. The vial was washed with dry THF (3 x 0.2 mL) and added to the reaction. TMSCl (1.2 equiv, 0.0400 mL, 0.320 mmol) was then added and allowed to stir for 10 min. After this time, ChxMgCl (1.2 equiv, 0.160 mL, 0.320 mmol) was added dropwise via syringe, and the solution was stirred at $-20\text{ }^\circ\text{C}$ for 3 h and then lowered to $-78\text{ }^\circ\text{C}$. The reaction was quenched with sat. NH_4Cl (0.2 mL) and warmed to rt for 0.5 h. The product was extracted with Et_2O (3 x 10 mL), and the combined organic layers were washed with brine. The organic layer was separated, dried with MgSO_4 , and concentrated *in vacuo* to give the crude product, which was then analyzed by ^1H NMR spectroscopy to determine diastereoselectivity. The crude material was then submitted to column chromatography and purified using 2% Et_2O in hexane to provide **2h** (0.052 g) in 71% yield.

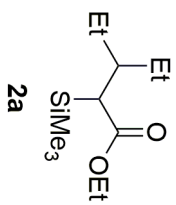


2h: ^1H NMR: (500 MHz, CDCl_3) δ 4.08 (m, 2H), 2.11 (d, J = 9.4 Hz, 1H), 1.86 (m, 1H), 1.73 (m, 2H), 1.65 (m, 1H), 1.54 (m, 2H), 1.38 (m, 1H), 1.24 (t, J = 7.1 Hz, 3H), 1.14 (m, 4H), 0.96 (m, 1H), 0.90 (d, J = 6.9 Hz, 3H), 0.09 (s, 9H). ^{13}C NMR: (125 MHz, CDCl_3) δ 175.4, 59.5, 41.8, 41.5, 38.0, 32.0, 27.1, 27.0, 26.7, 26.4, 15.0, 14.4, -1.5. IR (Et_2O): 2926, 2852, 2360, 1716, 1448, 1365, 1339, 1323, 1303, 1250, 1219, 1190, 1165, 1136, 1111, 1038, 892, 845, 757, 691 cm^{-1} . HRMS (EI-EBE Sector) m/z : $[\text{M}]^+$ Calcd for $\text{C}_{15}\text{H}_{30}\text{O}_2\text{Si}$ 270.2015 found 270.2011. R_f = 0.9, 10% Et_2O in hexanes.

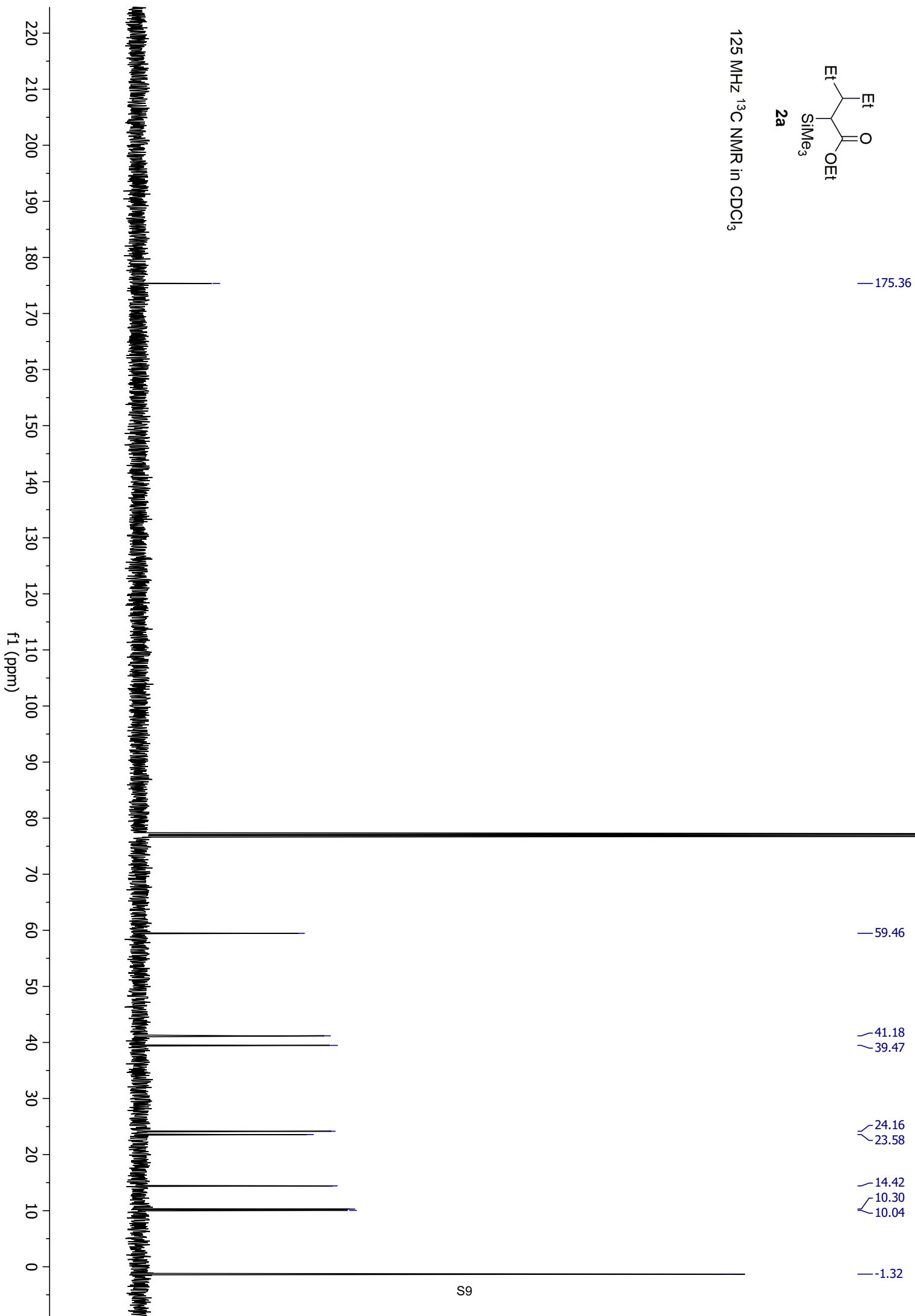


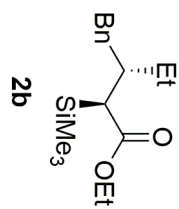
500 MHz ^1H NMR in CDCl_3



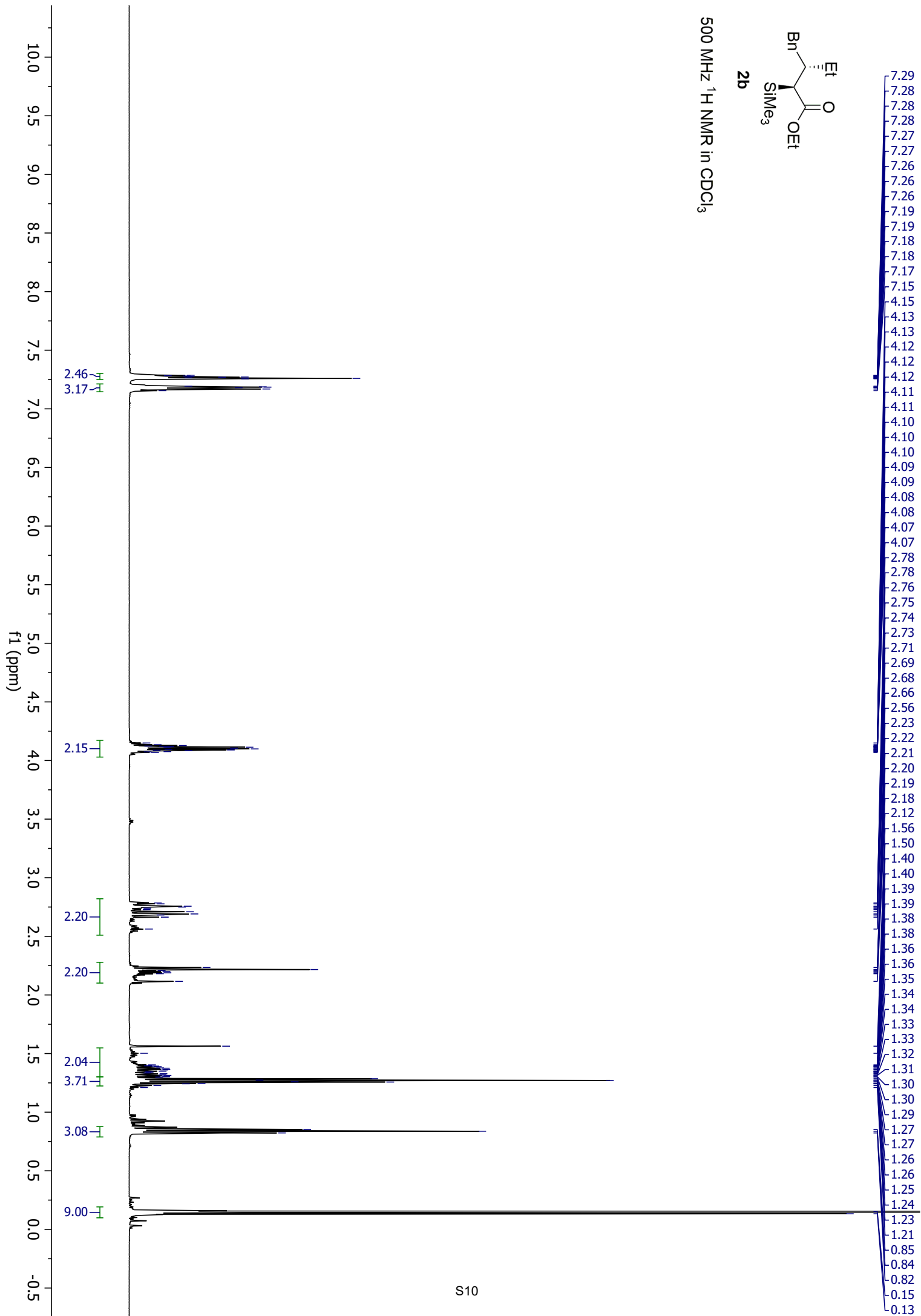


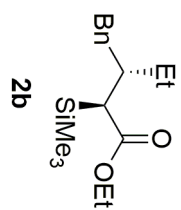
125 MHz ^{13}C NMR in CDCl_3



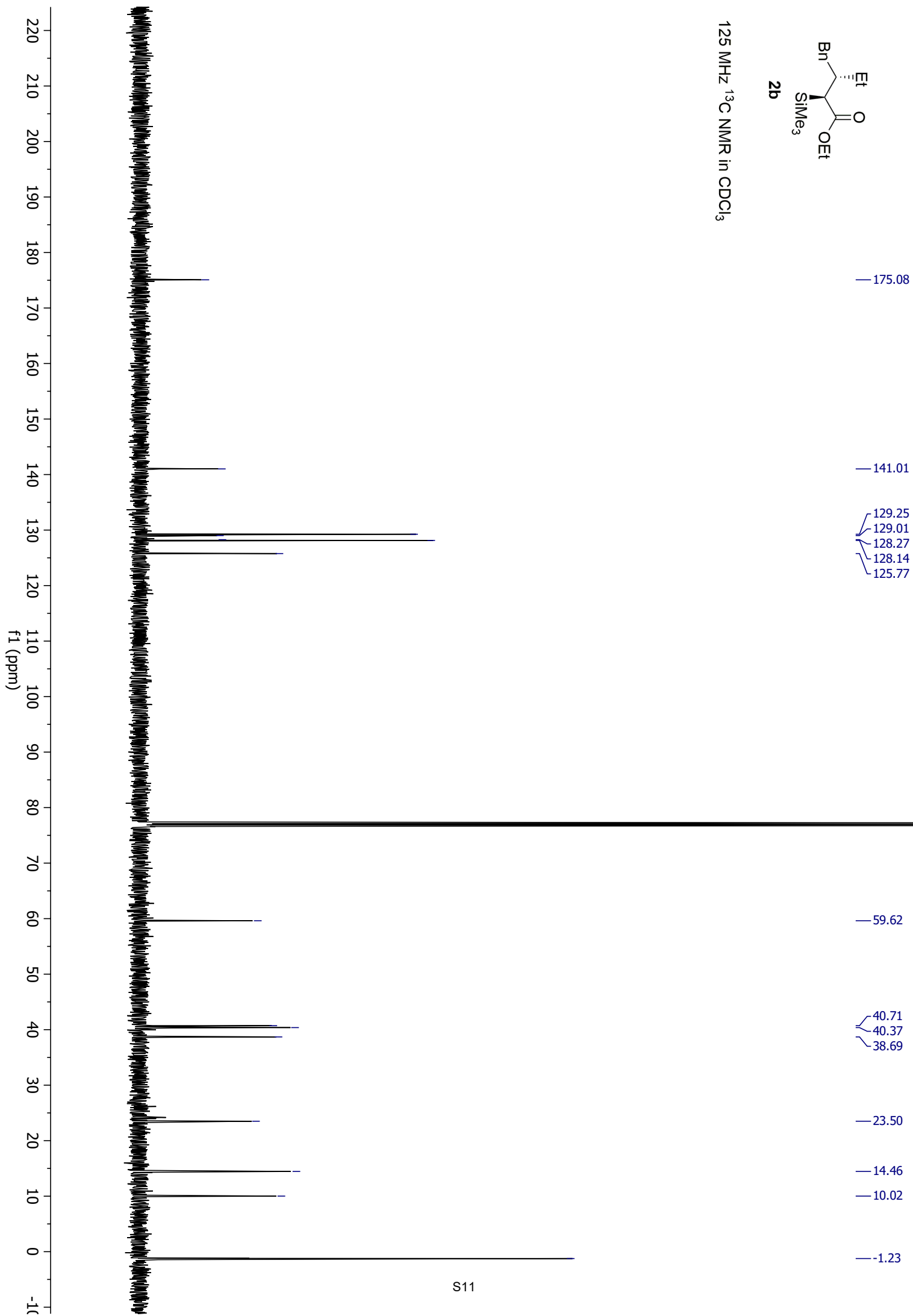


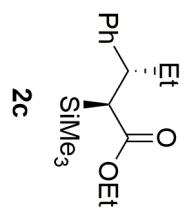
500 MHz ^1H NMR in CDCl_3



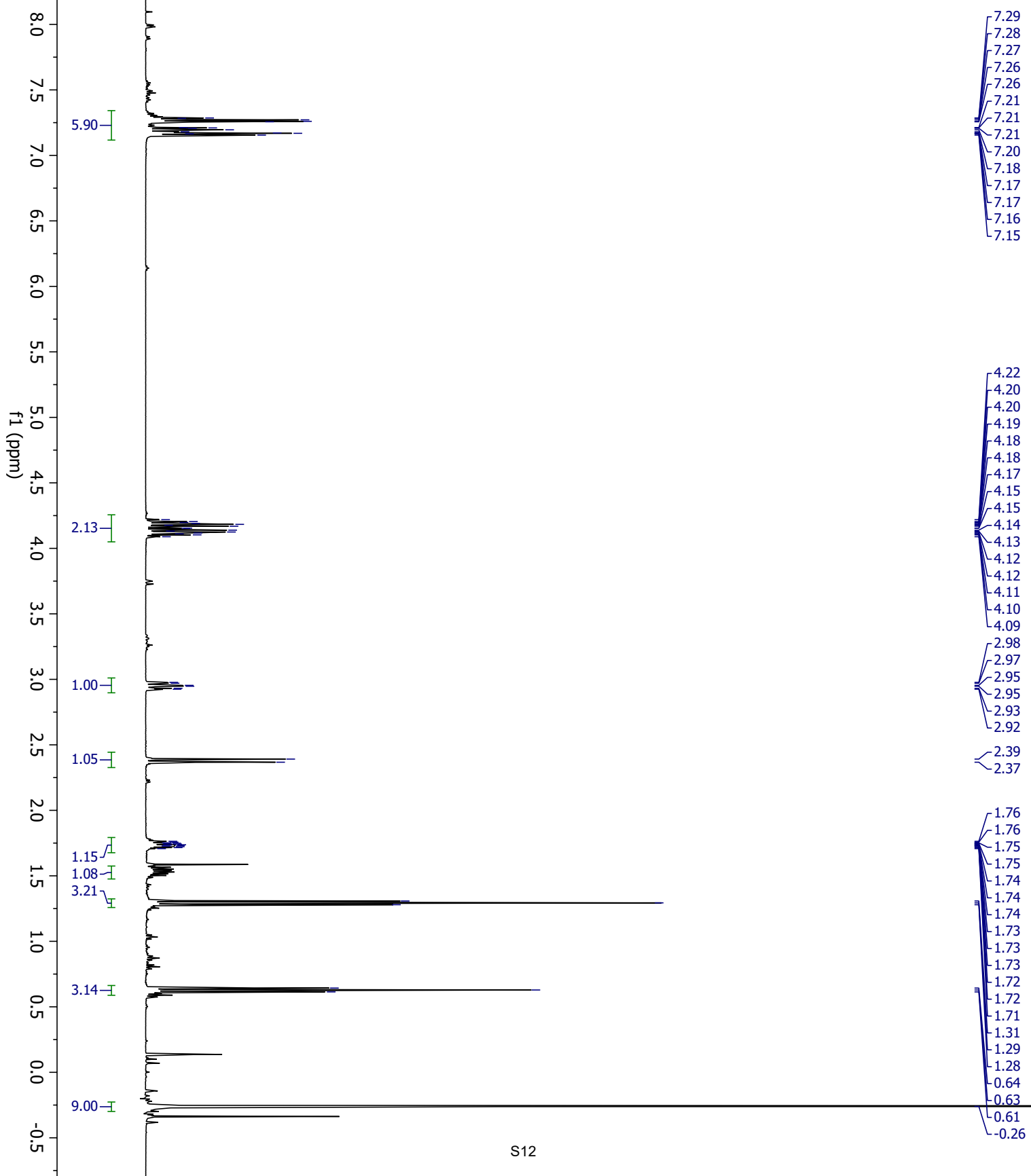


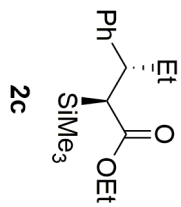
125 MHz ^{13}C NMR in CDCl_3



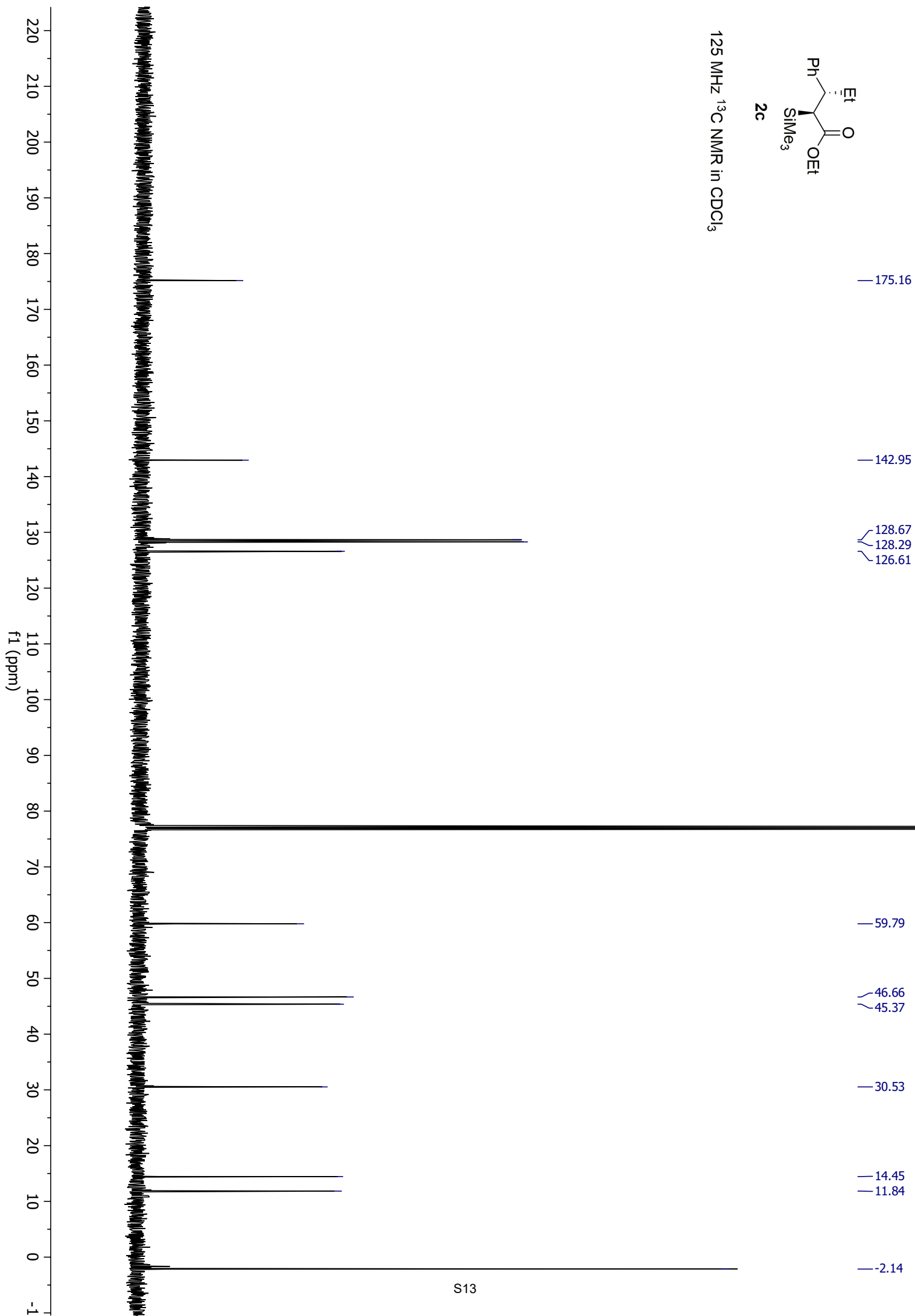


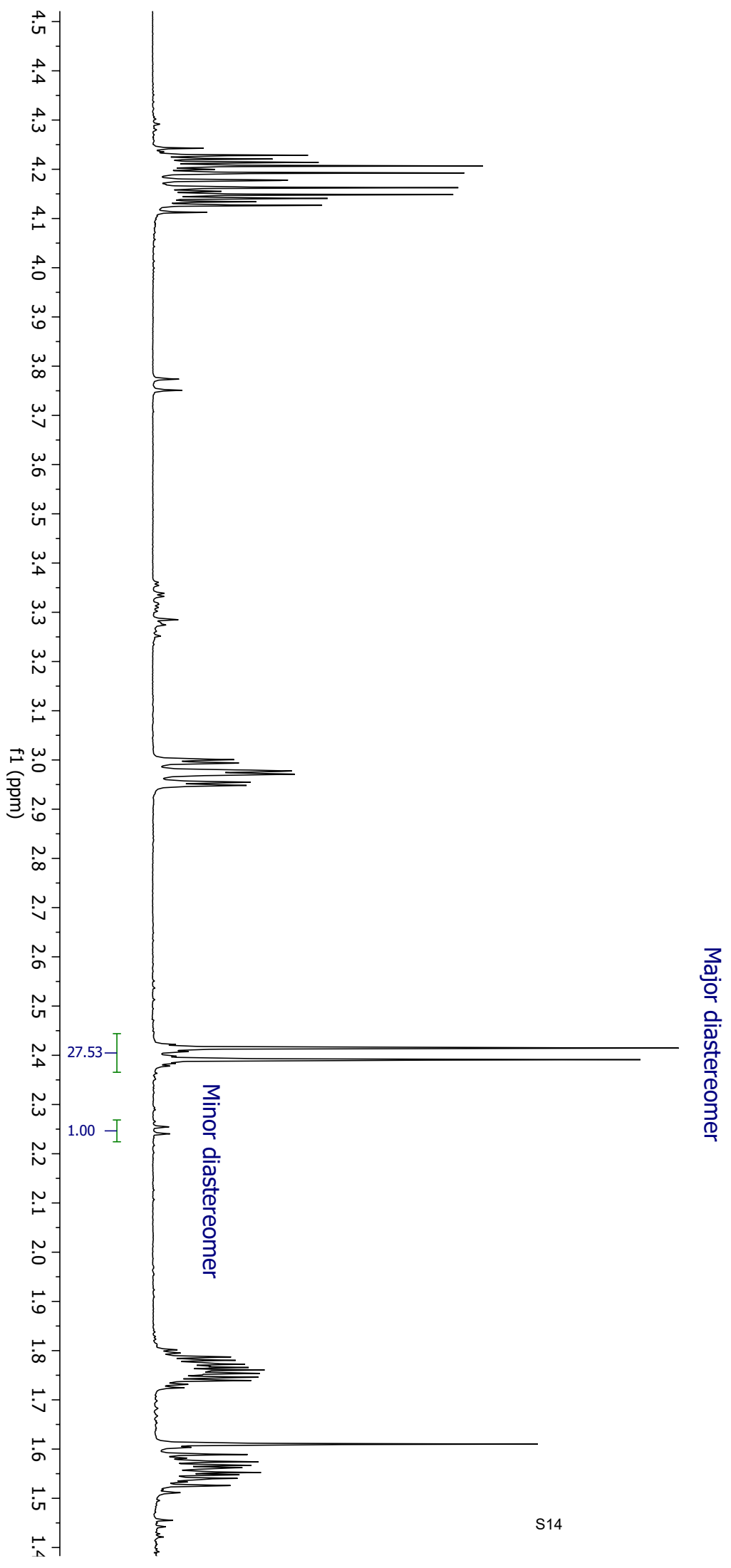
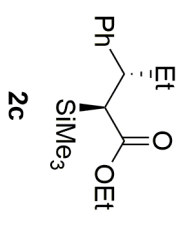
500 MHz ^1H NMR in CDCl_3

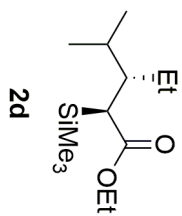




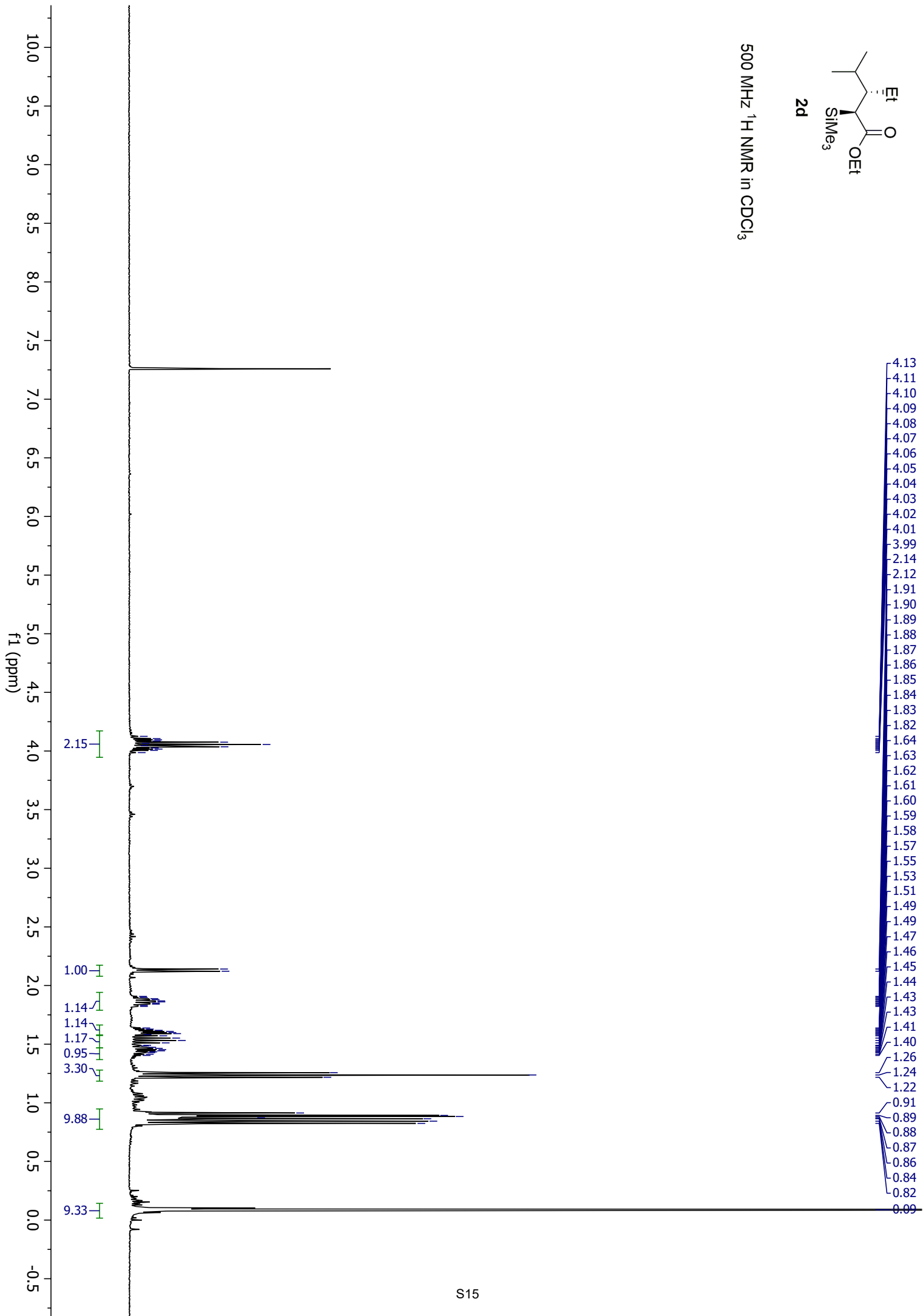
125 MHz ^{13}C NMR in CDCl_3







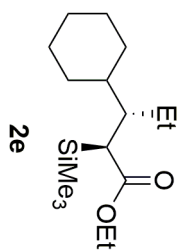
500 MHz ^1H NMR in CDCl_3



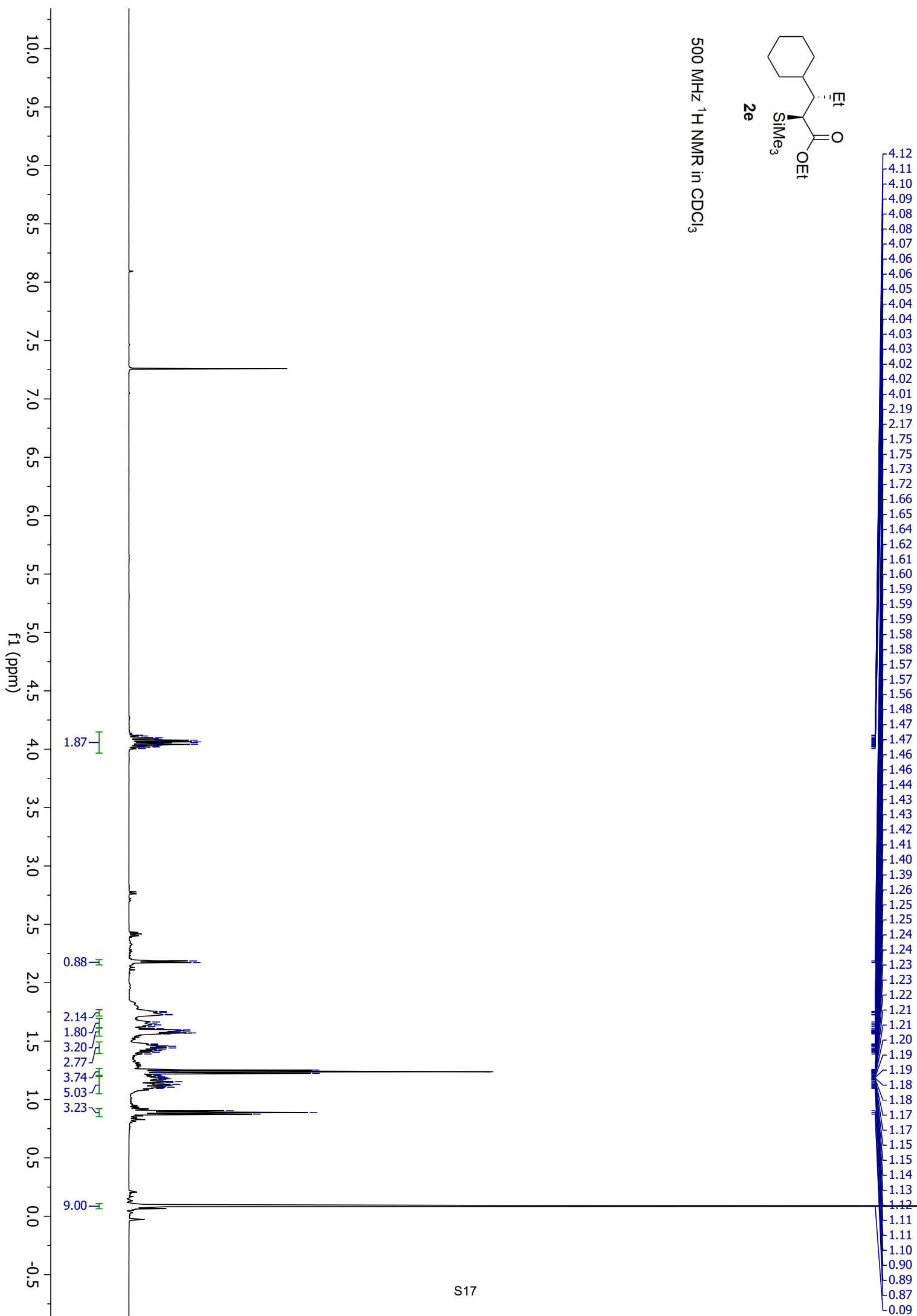


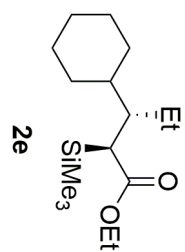
125 MHz ^{13}C NMR in CDCl_3



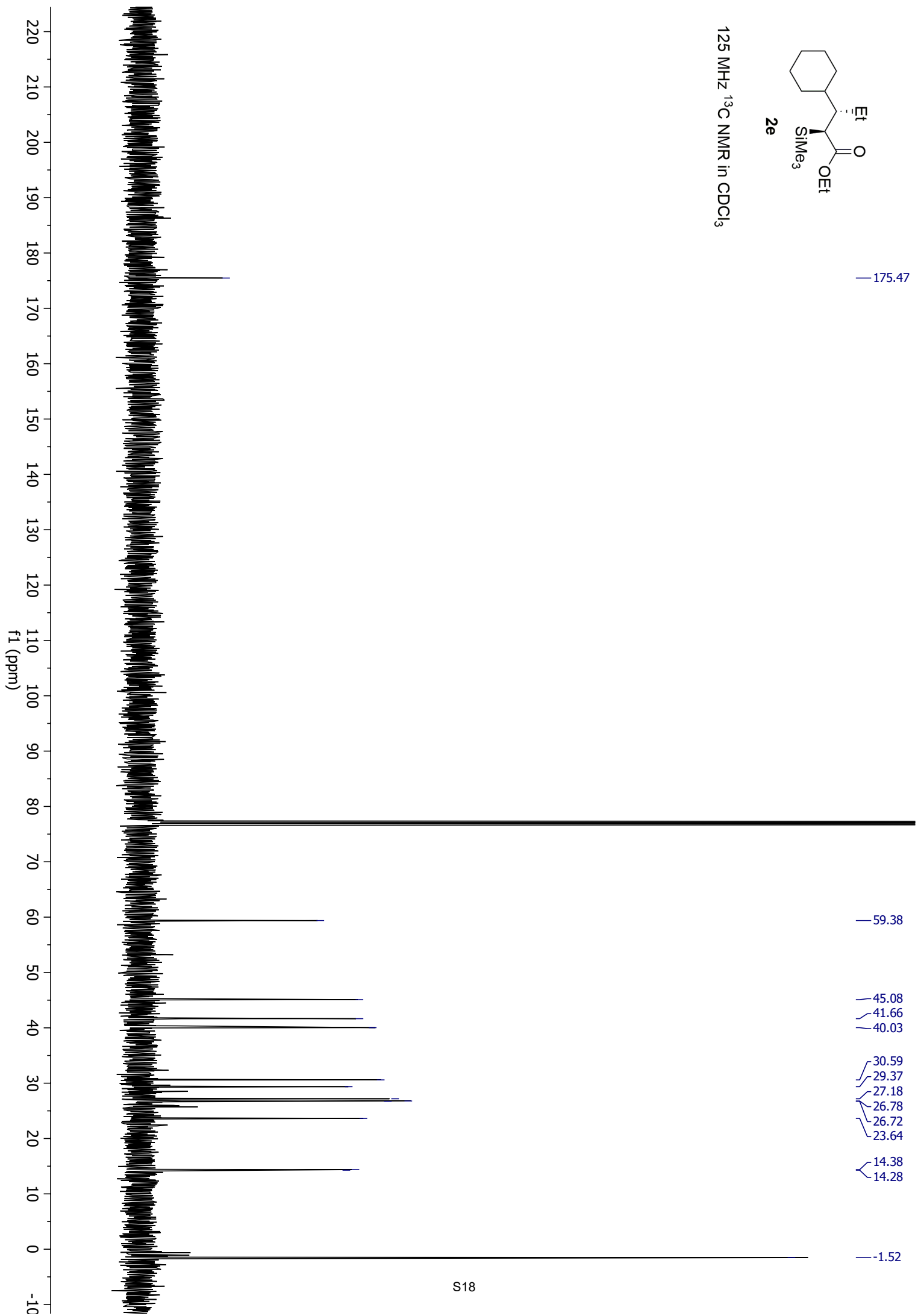


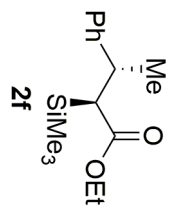
500 MHz ^1H NMR in CDCl_3



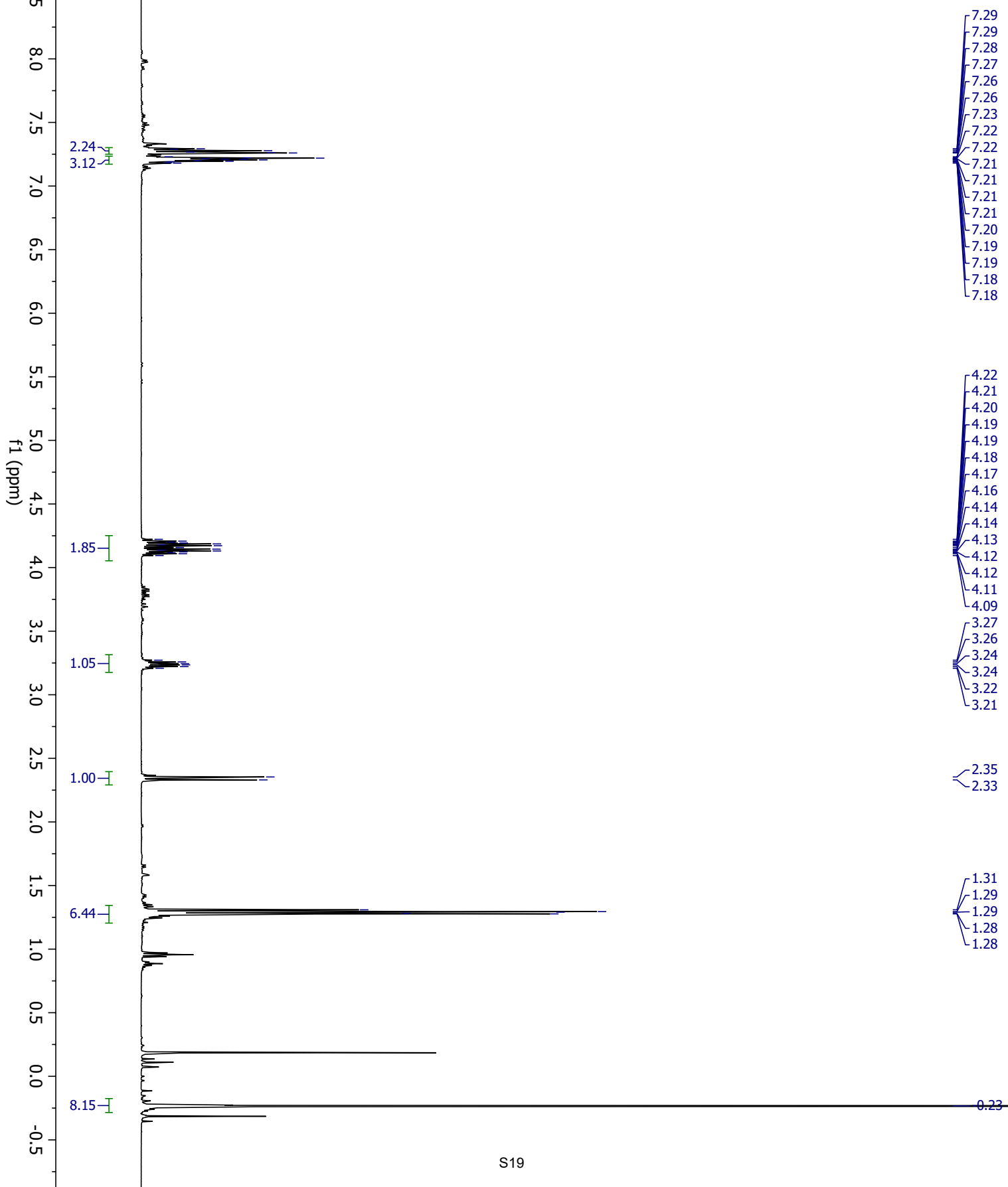


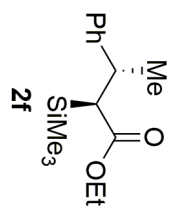
125 MHz ^{13}C NMR in CDCl_3



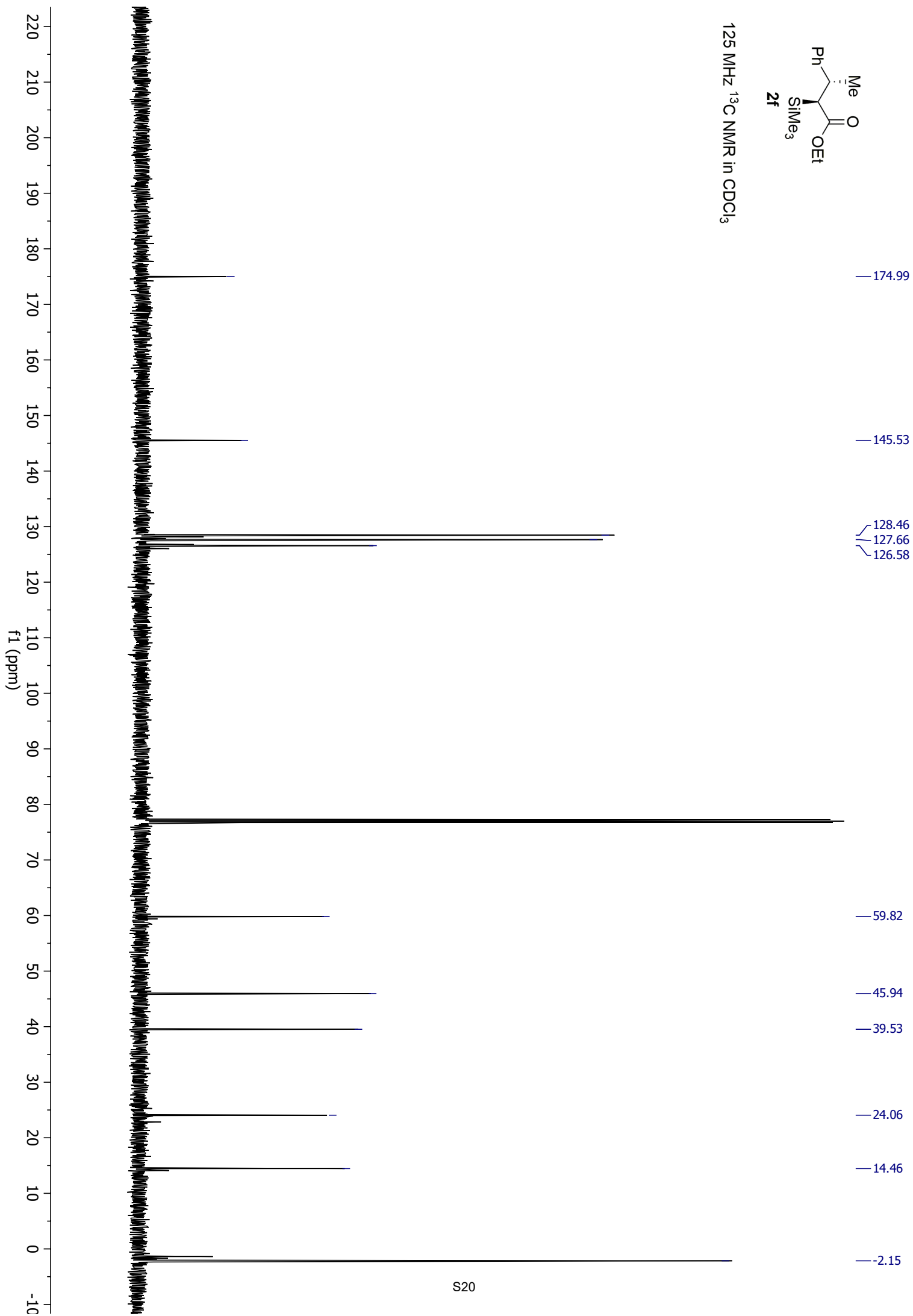


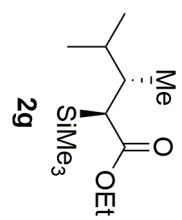
500 MHz ^1H NMR in CDCl_3



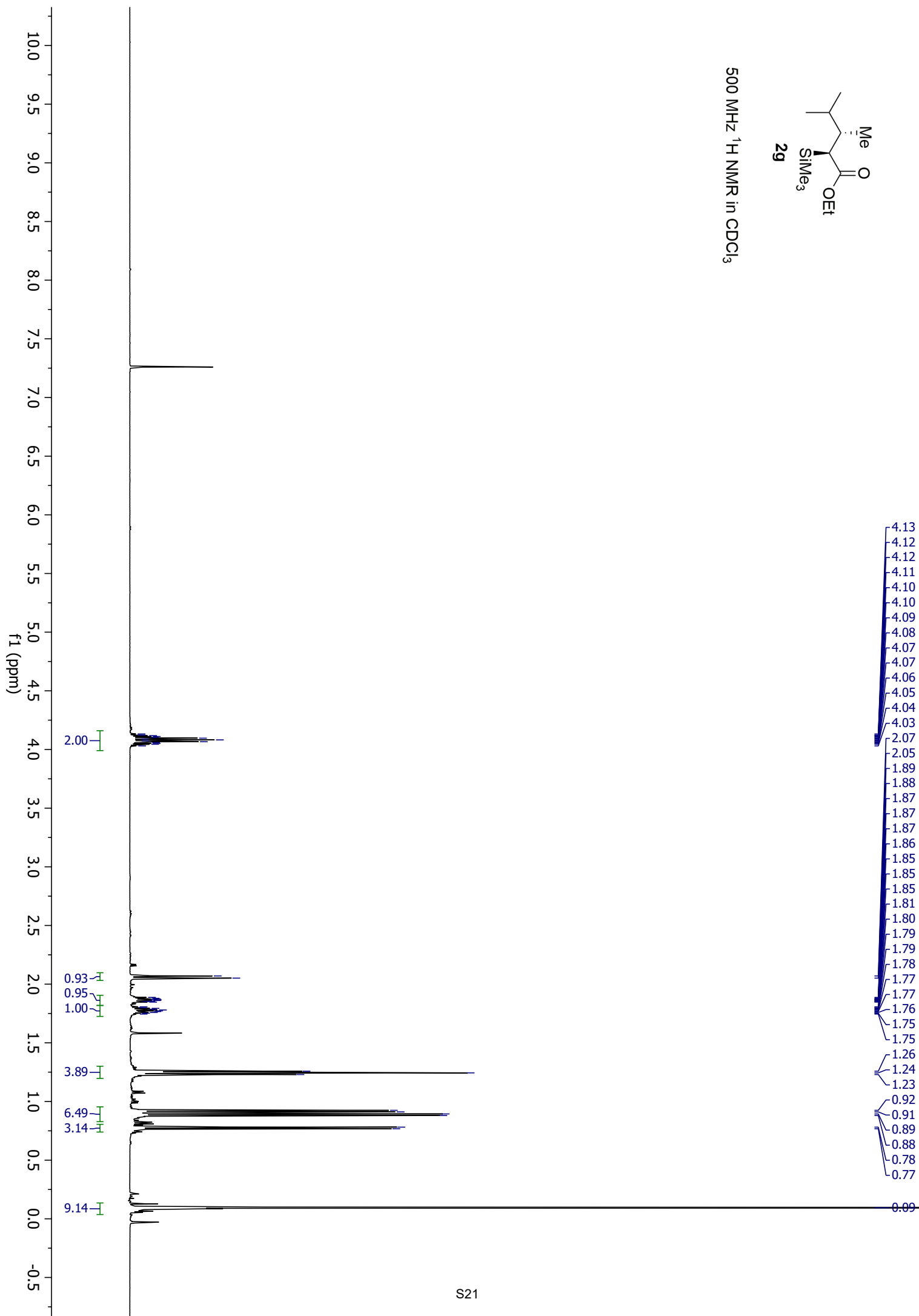


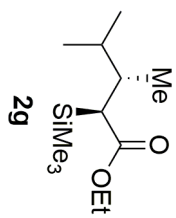
125 MHz ¹³C NMR in CDCl₃



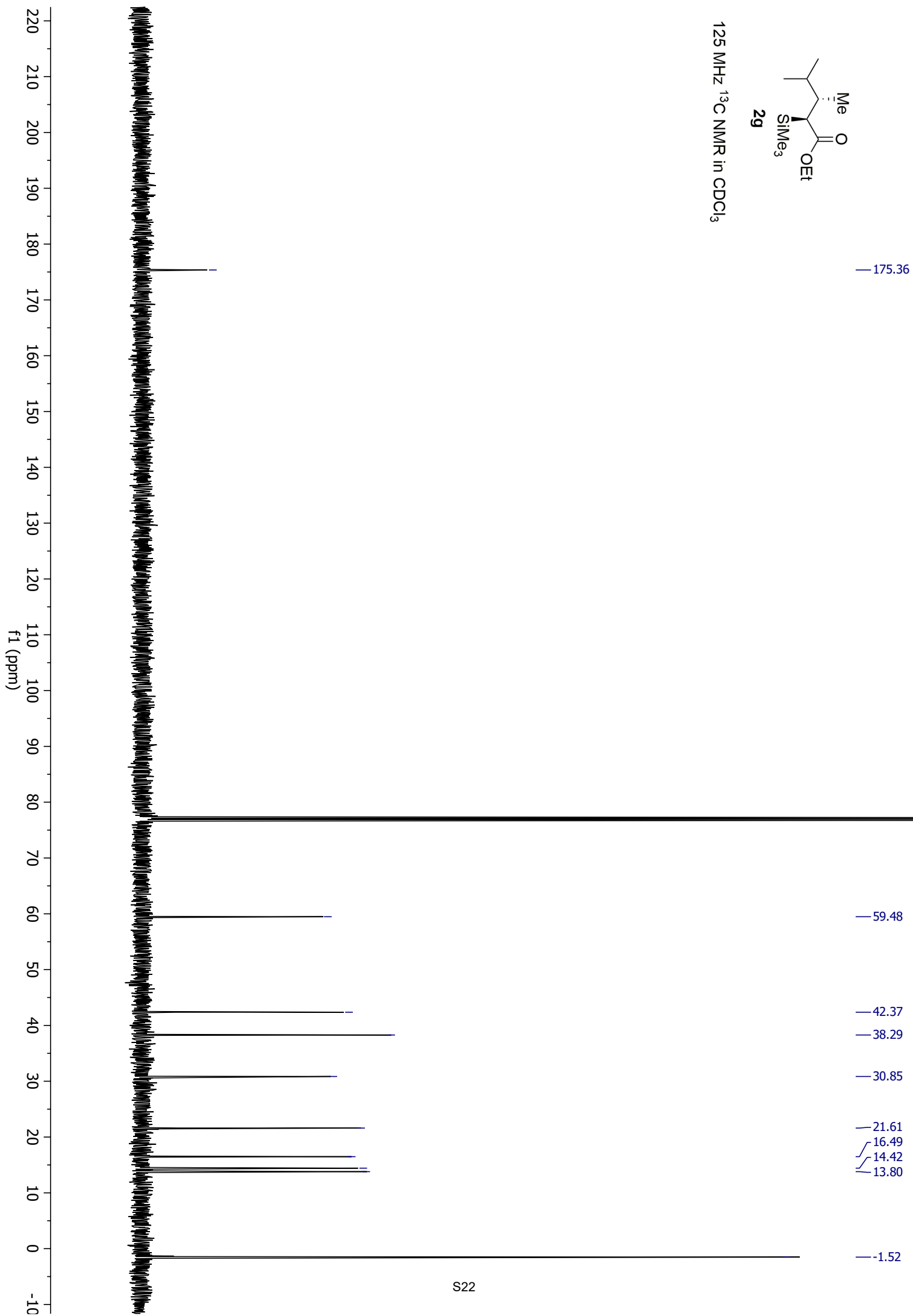


500 MHz ^1H NMR in CDCl_3

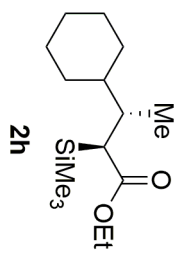




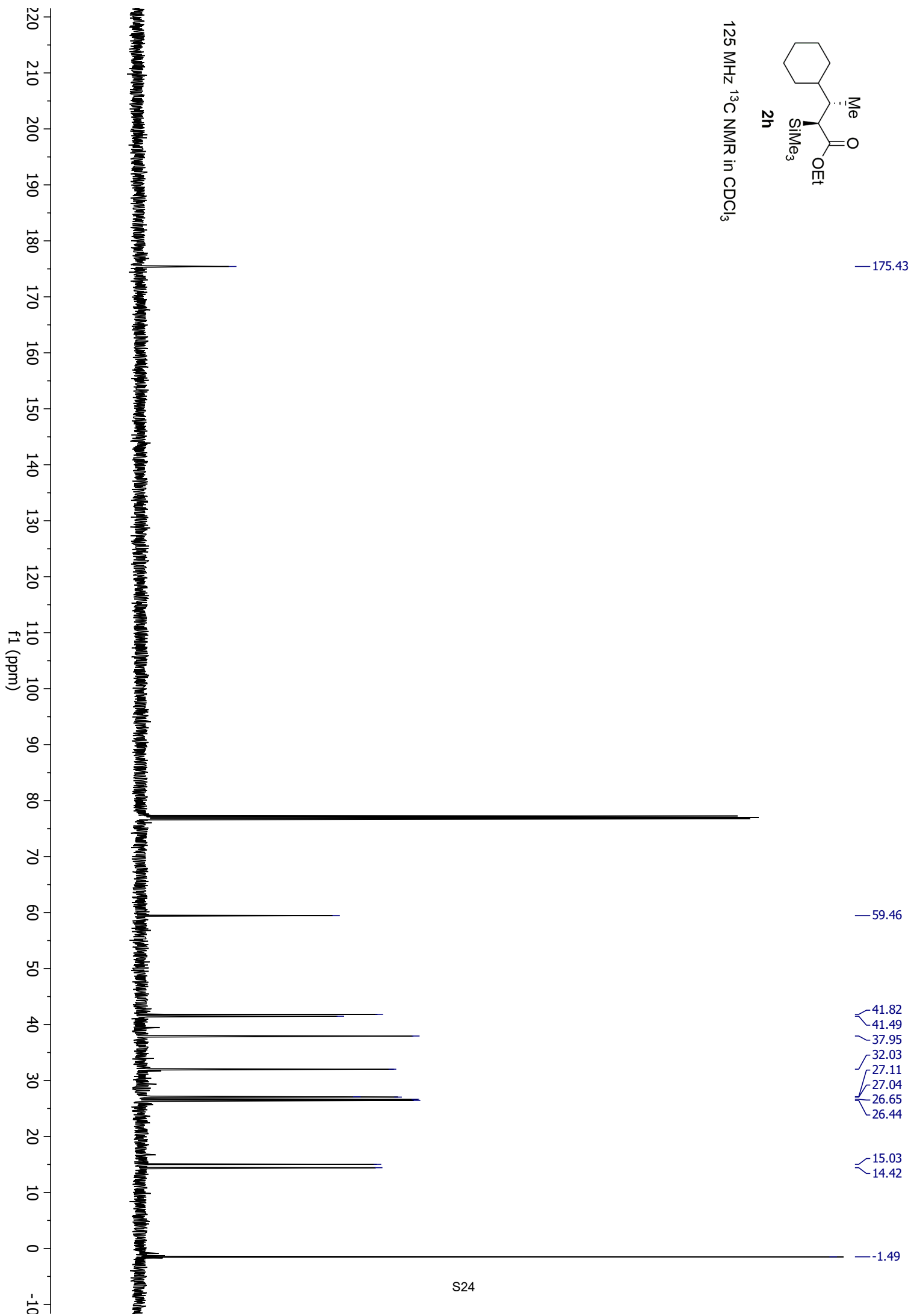
125 MHz ^{13}C NMR in CDCl_3

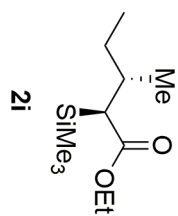


500 MHz ^1H NMR in CDCl_3 

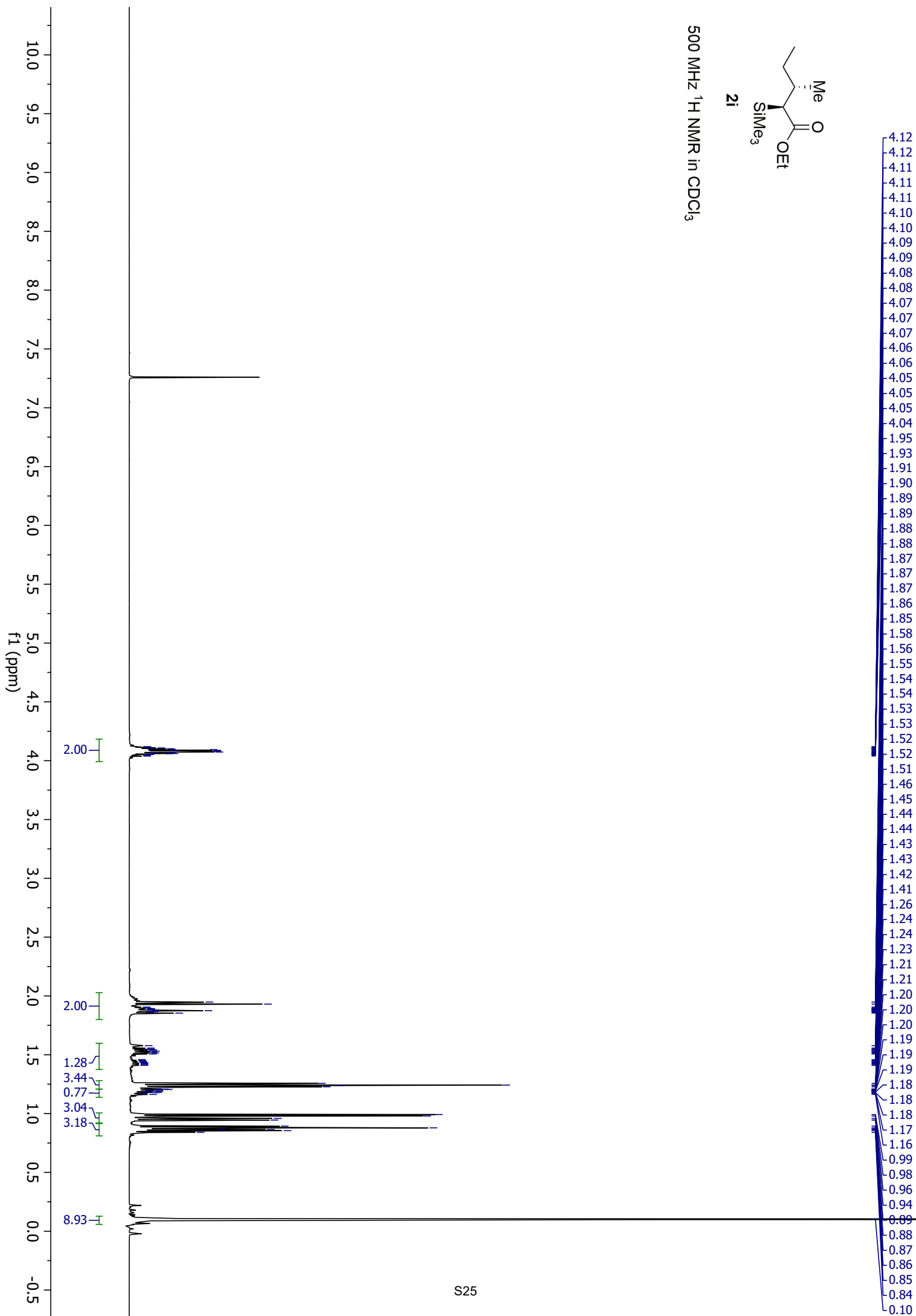


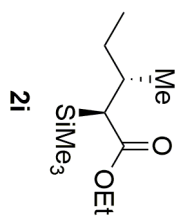
125 MHz ^{13}C NMR in CDCl_3



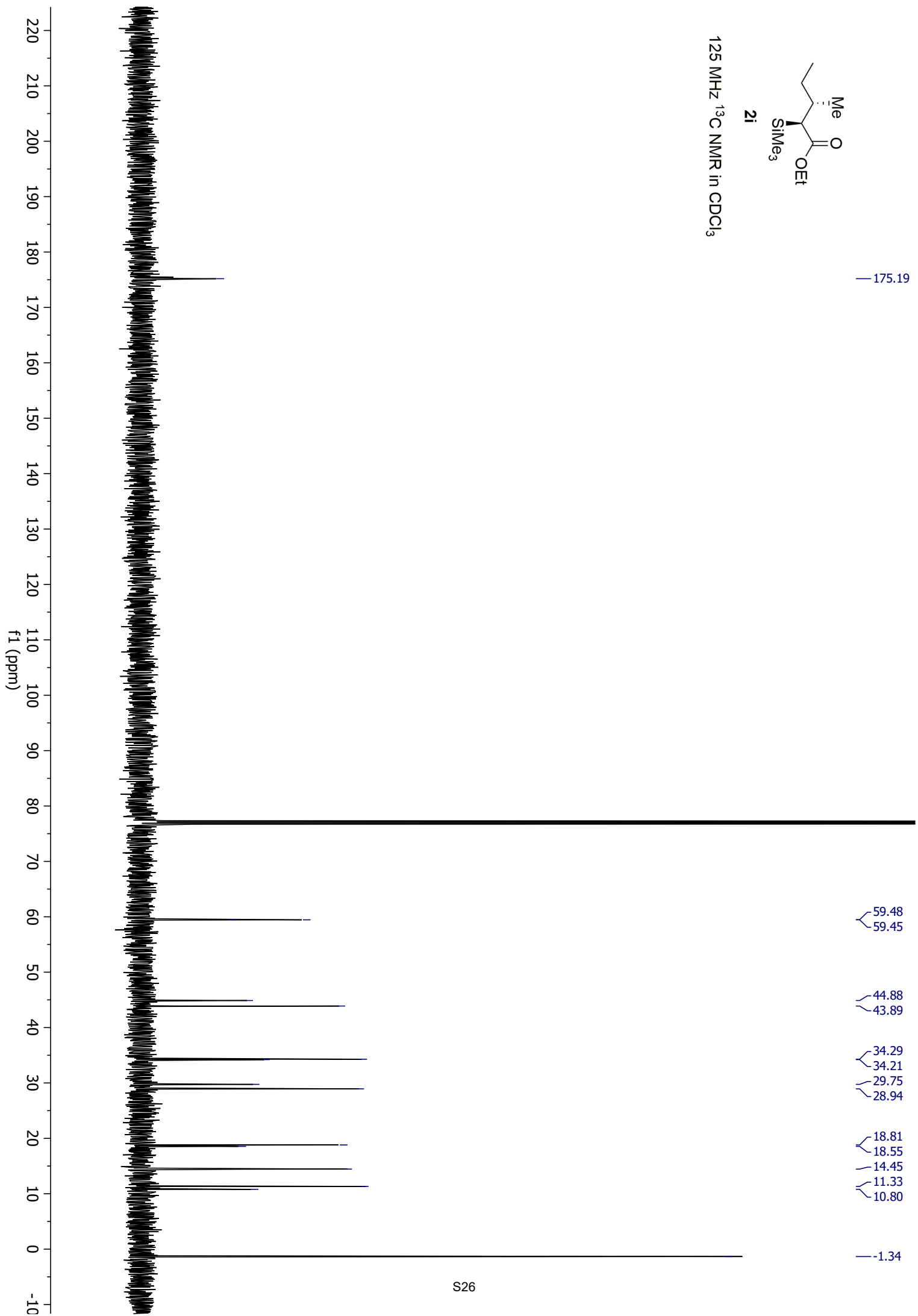


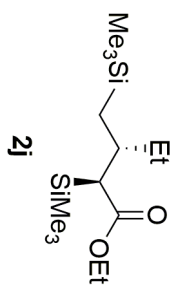
500 MHz ^1H NMR in CDCl_3



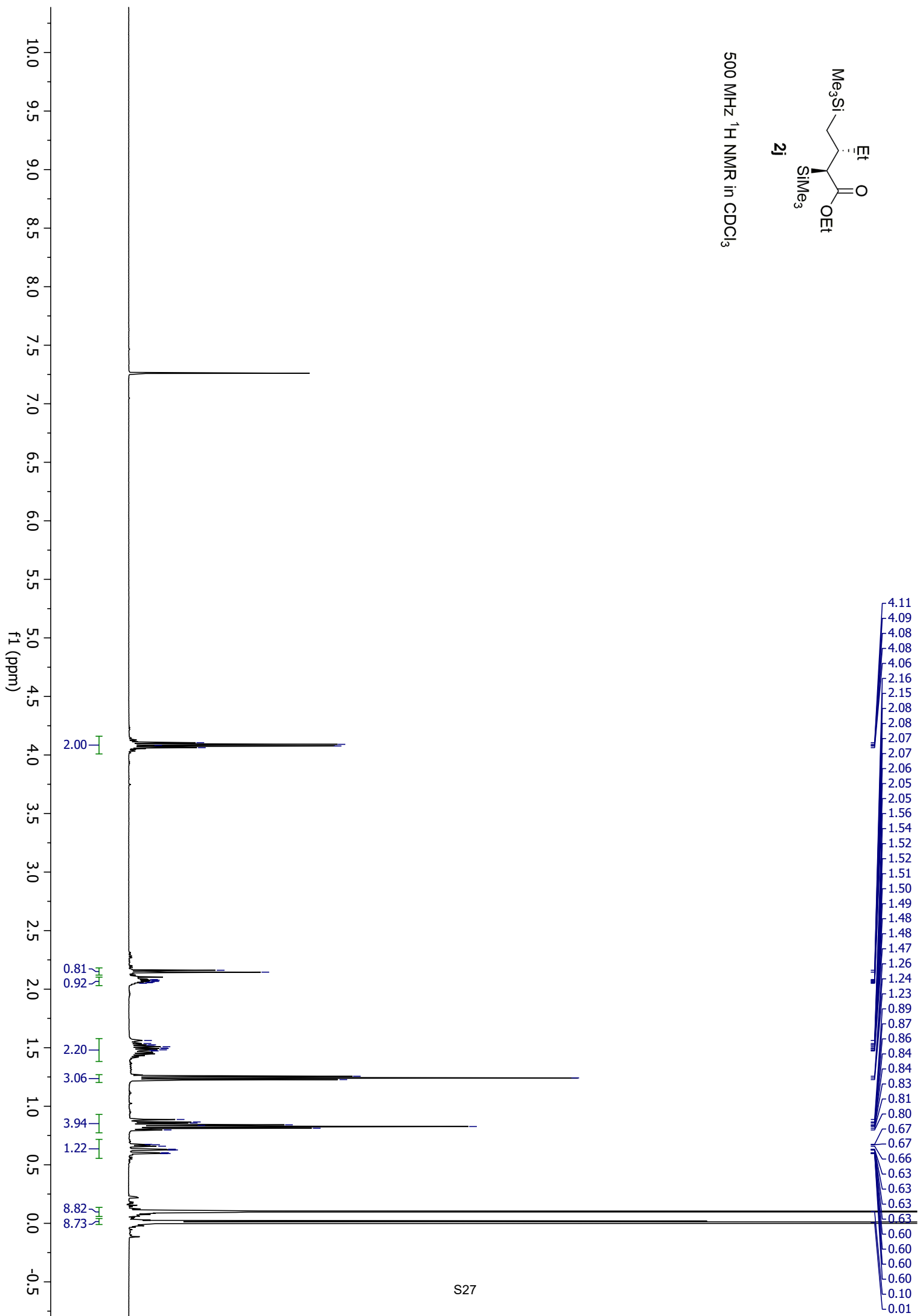


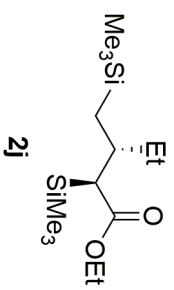
125 MHz ^{13}C NMR in CDCl_3



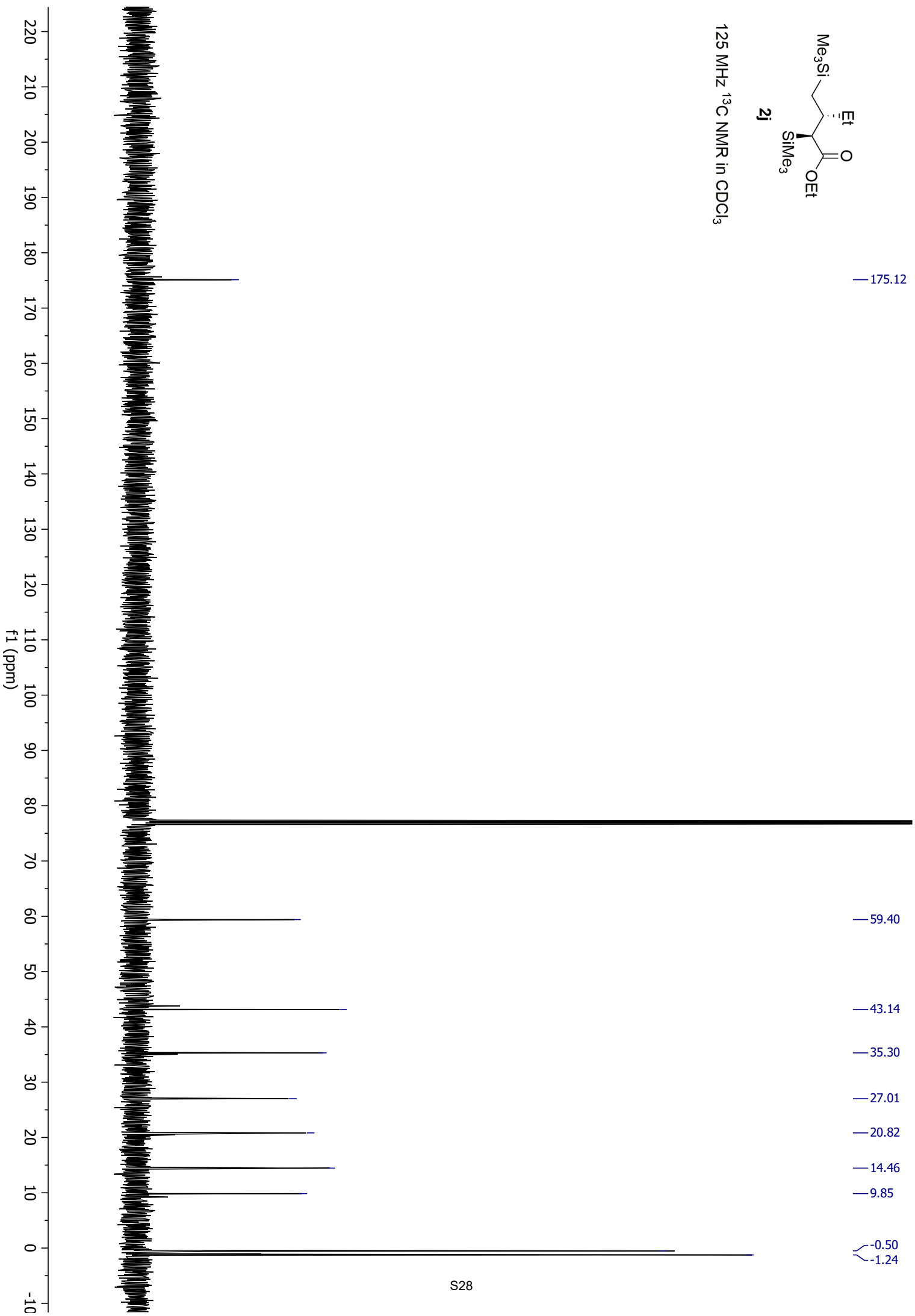


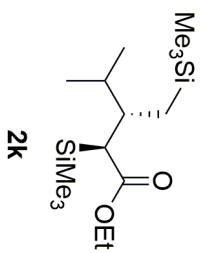
500 MHz ¹H NMR in CDCl₃



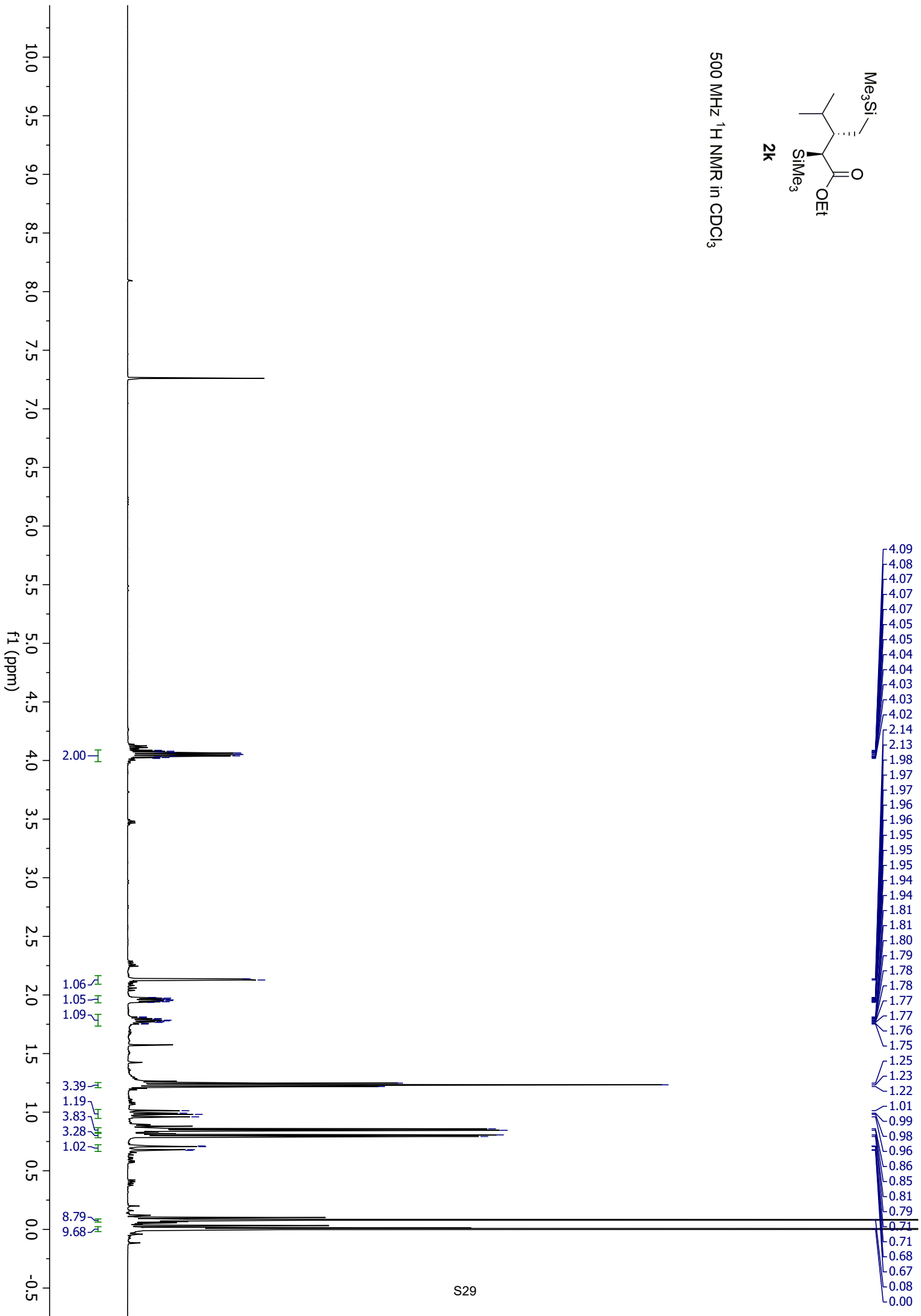


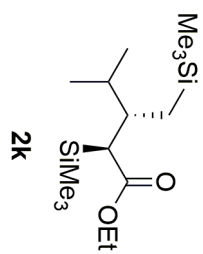
125 MHz ^{13}C NMR in CDCl_3



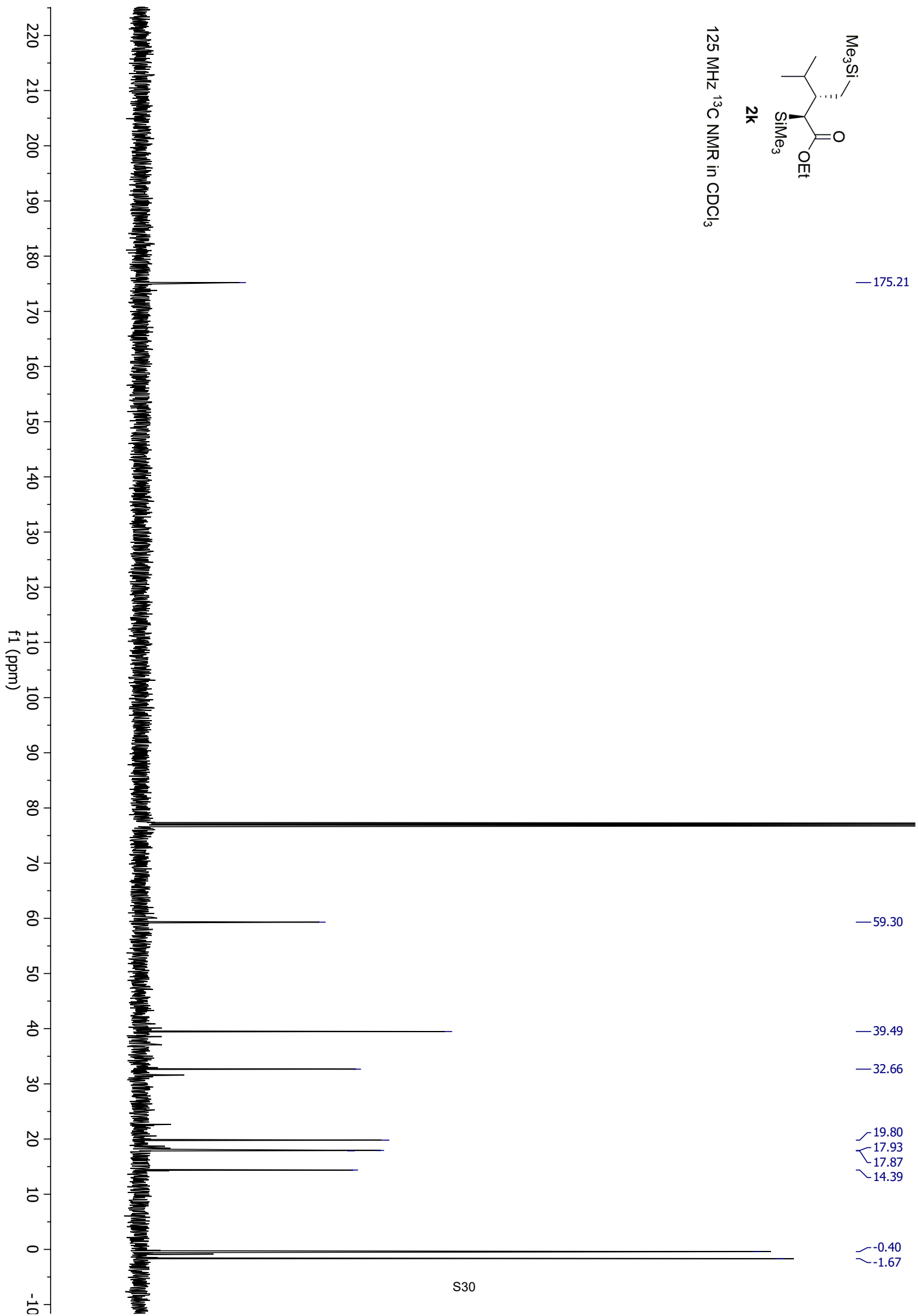


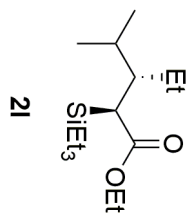
500 MHz ¹H NMR in CDCl₃



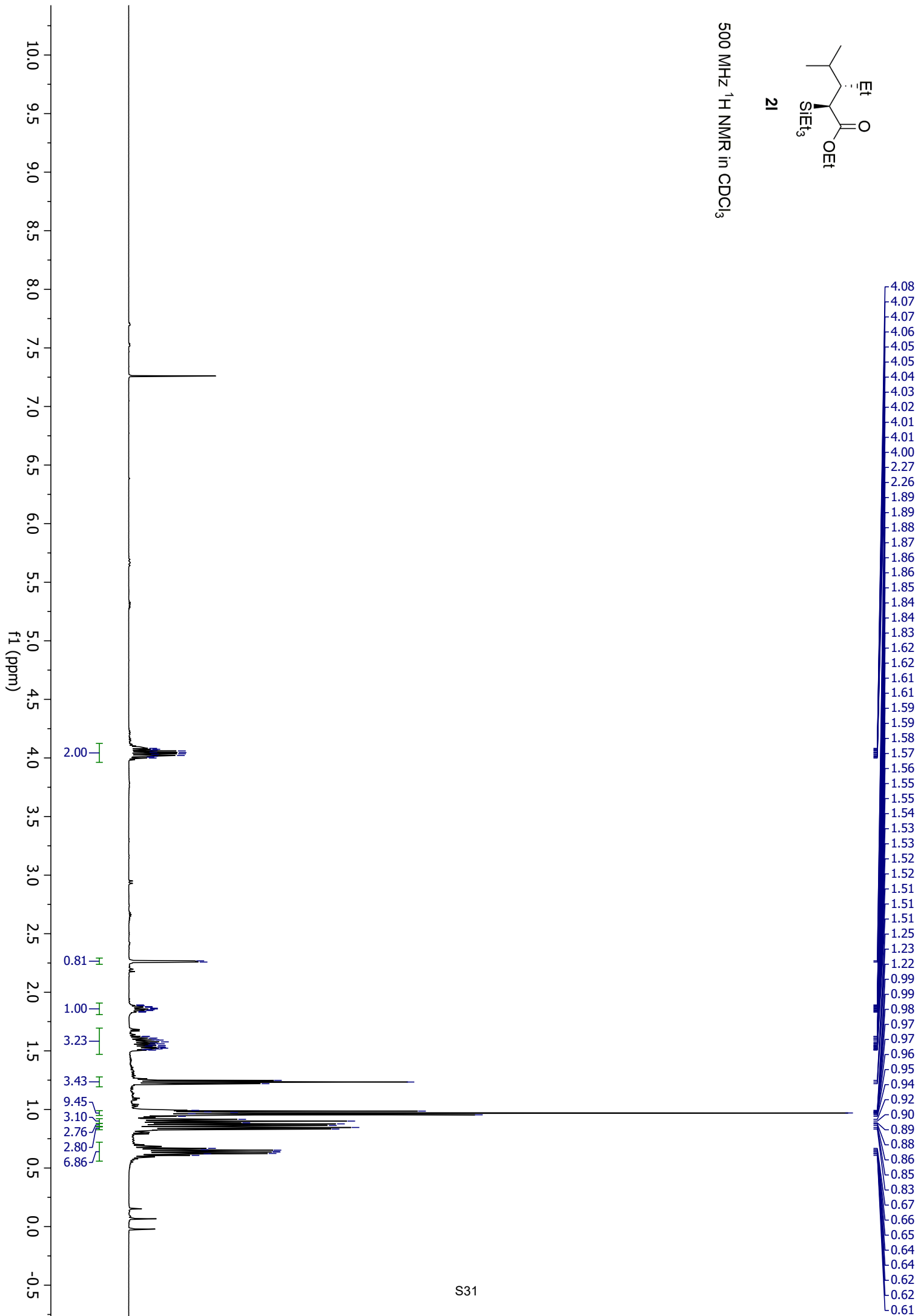


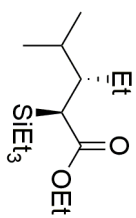
125 MHz ¹³C NMR in CDCl₃





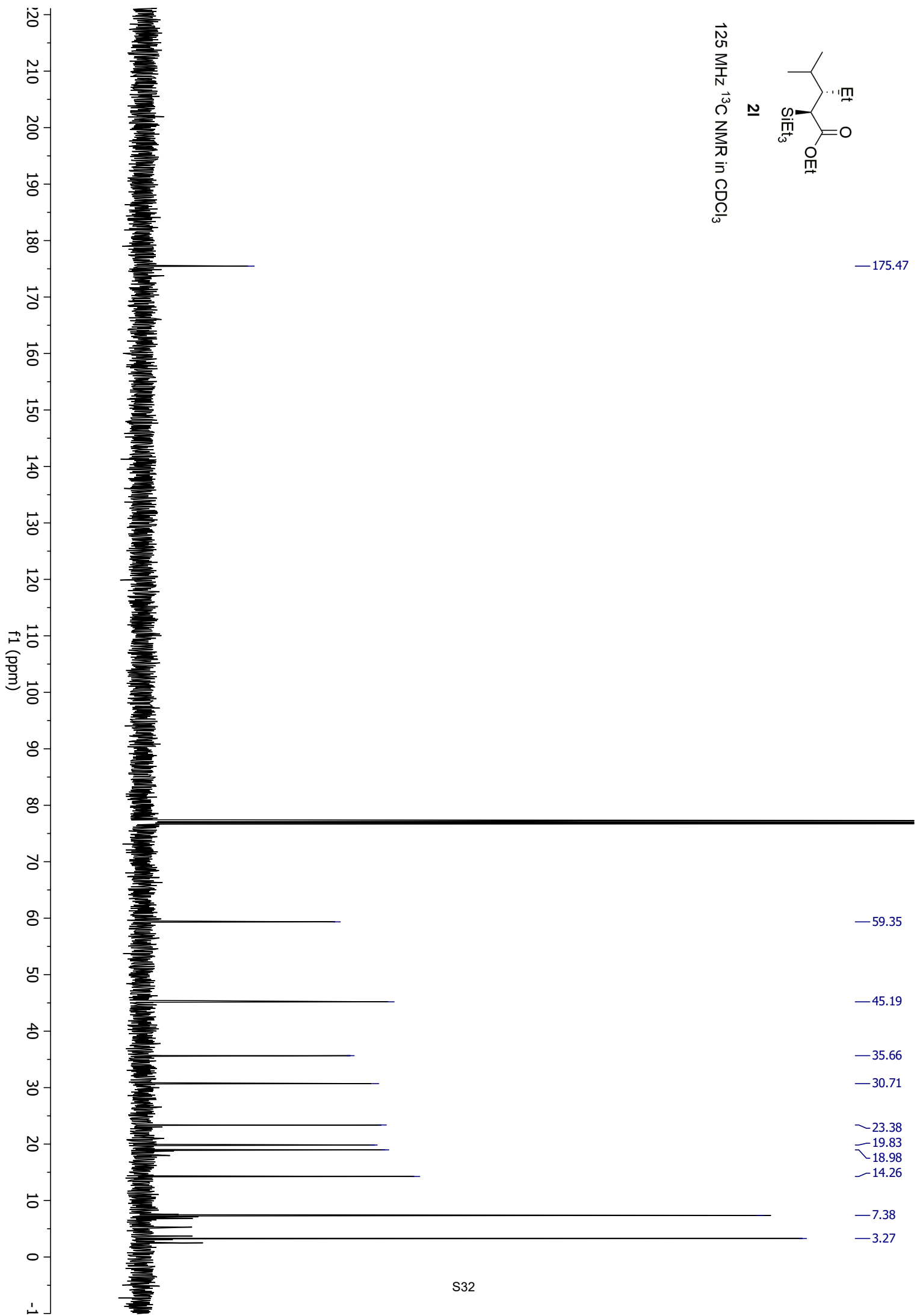
500 MHz ^1H NMR in CDCl_3

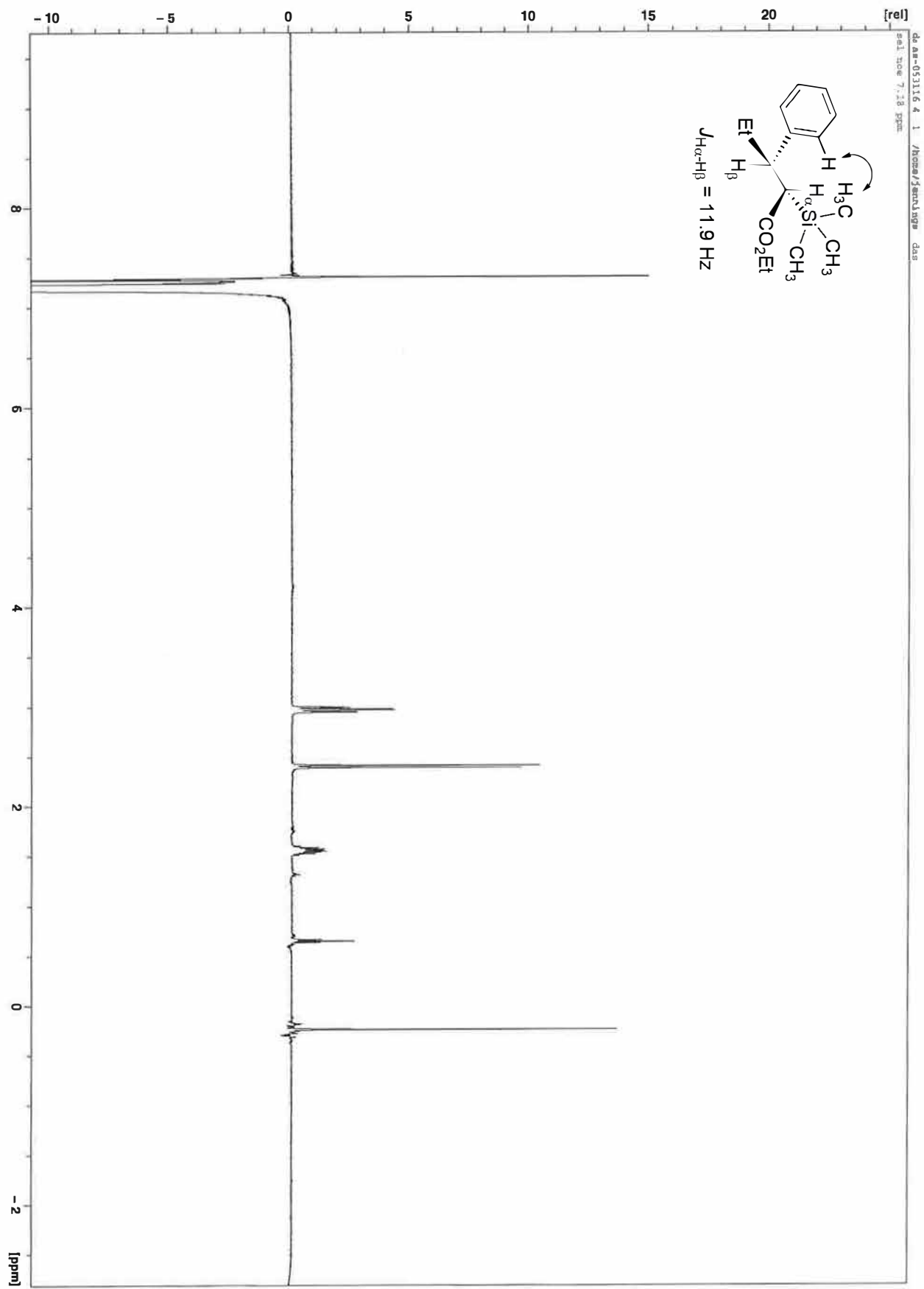




21

125 MHz ^{13}C NMR in CDCl_3





References:

1. Johnson, D. A.; Mueller Hendrix, A. J.; Jennings, M. P. Diastereoselective Syntheses of (*E*)- α -Trialkylsilyl- α,β -Unsaturated Esters, α -Silane Substituted Conjugated Silyl Ketene Acetals, and α,γ -Substituted Allyl Silanes. *J. Org. Chem.* **2018**, 83, 9914-9928.