SUPPLEMENTARY MATERIAL

A Recyclable Polystyrene-Supported Siloxane Transfer Agent for Palladium-Catalyzed Cross-Coupling Reactions

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Experimental procedures and spectral data for all new compounds, including copies of ^{1}H and ^{13}C NMR spectra.

General

All moisture-sensitive reactions were performed using syringe-septum cap techniques under an inert atmosphere of N_2. All glassware was flame dried or dried in an oven (140 °C) for at least 4 h prior to use. Reactions were magnetically stirred unless otherwise stated. Tetrahydrofuran (THF), dichloromethane (CH_2Cl_2) and diethyl ether (Et_2O) were dried by passage through alumina in a Pure Solve™ PS-400 solvent purification system. Unless otherwise stated, solvents and reagents were used as received. Analytical thin layer chromatography was performed on pre-coated silica gel 60 F-254 plates (particle size 40-55 micron, 230-400 mesh) and visualized by a uv lamp or by staining with PMA (2 g phosphomolybdic acid dissolved in 20 mL absolute ethanol), $KMnO_4$ (1.5 g of $KMnO_4$, 10 g of K_2CO_3 and 2.5 mL of 5% aq. NaOH in 150 mL H_2O), or CAM (4.8 g of $(NH_4)_6Mo_7O_{24}\cdot 4H_2O$ and 0.2 g of $Ce(SO_4)_2$ in 100 mL of a 3.5 N H_2SO_4 solution). Column chromatography was performed using silica gel (Silacycle Silaflash®) P60, 40-63 micron particle size, 230-300 mesh) and compressed air pressure with commercial grade solvents. Yields refer to chromatographically and spectroscopically pure compounds, unless otherwise stated. NMR spectra were recorded at 500 MHz/125 MHz (^{1}H NMR/ ^{13}C NMR) on a Bruker Avance III 500 MHz spectrometer at 300 K. Chemical shifts are reported in parts per million with the residual solvent peak as an internal standard. ^{1}H NMR spectra are tabulated as follows: chemical shift, multiplicity (s=singlet, d=doublet, t=triplet, q=quartet, qn=quintet, dd=doublet of doublets, ddd= doublet of doublet of doublets, dddd= doublet of doublet of doublet of doublets, dt= doublet of triplets, m=multiplet, b=broad), coupling constant and integration. ^{13}C NMR spectra are tabulated by observed peak. Melting points were determined using a Thomas-Hoover capillar melting point apparatus and are uncorrected. Infrared spectra were measured on a Jasco FT/IR 480 plus

spectrometer. High-resolution mass spectra (HRMS) were obtained at the University of Pennsylvania on a Waters GCT Premier spectrometer. Elemental analysis of Si was determined by Robertson Microlit Laboratories Inc via inductively coupled plasma optical emission spectrometry (ICP-OES).

Experimental Procedures

Cross-linker **7**,[1] compound **9b**[2] and the corresponding vinyl iodides of **8d**[2] and **8e**[3] were prepared according to previously reported procedures.

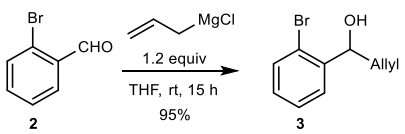
Preparation of Organolithium Reagents 8b, 8c, 8d and 8e:

In a dried flask was added the corresponding aryl or vinyl iodide (2.0 mmol) in 1 ml THF and the solution was cooled down to –78 °C. *t*-BuLi (2.0 equiv) was added dropwise and the obtained solution was stirred at –78 °C for 30 mins and then at room temperature for another 30 mins. The resulting organolithium solution was then titrated with diphenylacetic acid[4] before use.

Preparation of water-washed silica gel for column chromatography (where specified):

Silica gel was suspended in d.i. H_2O and the slurry mixture was then packed into a prepared column. The obtained H_2O-washed silica gel packed column was then rinsed with 2 column volumes of acetone, 1 column volume of EtOAc and 2 column volumes of hexanes, successively. The obtained column is then ready for use.

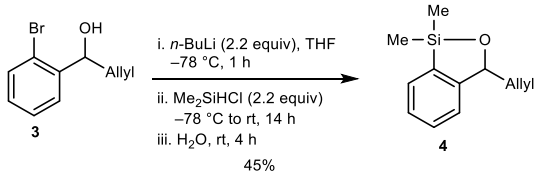
Synthesis of 1-(2-bromophenyl)but-3-en-1-ol (3):



Allylmagnesium chloride (2.0 M in THF, 52.20 mL, 104.47 mmol) was added slowly to a stirred solution of 2-bromobenzaldehyde (16.11 g, 87.05 mmol) in 250 mL THF at room temperature. The obtained solution was stirred for 15 h, and was quenched with saturated aqueous NH_4Cl (50 mL). The organic layer was collected and the aqueous layer was extracted with Et_2O (2 x 50 mL). The combined organic layers were washed with brine, dried with $MgSO_4$, and concentrated *in vacuo*. The crude product was purified by flash chromatography on silica gel (10% EtOAc/Hexanes) to afford the desired alcohol **3** as a pale yellow oil (18.73 g, 82.88 mmol, 95%).

IR (neat, cm^{-1}) 3389 (s), 3073 (m), 2979 (m), 2912 (m), 1639 (m), 1568 (m), 1468 (s), 1439 (s), 1195 (m), 1126 (m), 1023 (s), 917 (s), 754 (s); **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.59-7.55 (m, 1 H), 7.52 (d, *J* = 7.9 Hz, 1 H), 7.34 (t, *J* = 7.5 Hz, 1 H), 7.16-7.11 (m, 1 H), 5.93-5.83 (m, 1 H), 5.24-5.16 (m, 2 H), 5.14-5.09 (m, 1 H), 2.69-2.62 (m, 1 H), 2.40-2.32 (m, 1 H), 2.14 (d, *J* = 3.4 Hz, 1 H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 142.8, 134.4, 132.8, 129.0, 127.8, 127.5, 121.9, 118.9, 72.0, 42.3; **HRMS** (CI^+) *m/z* $(M-C_3H_5)^+$: Calcd for C_7H_6OBr: 184.9602, found: 184.9608.

Synthesis of 3-allyl-1,1-dimethyl-1,3-dihydrobenzo[c][1,2]oxasilole (4):

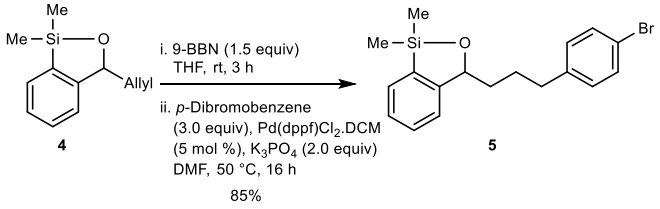


A solution of *n*-BuLi (2.55 M in hexanes, 62.10 mL, 158.30 mmol) was added dropwise to a stirred solution of benzyl alcohol **3** (16.33 g, 71.95 mmol) in 250 mL THF at –78 °C. The obtained solution was stirred for 1 h, followed by addition of Me_2SiHCl (17.20 mL, 158.30 mmol) in one portion at –78 °C. The resulting reaction mixture was allowed to warm to rt and

was stirred overnight. After 14 h, the reaction mixture was quenched by addition of d.i. H_2O (100 mL) and stirred for 4 h. The organic layer was collected and the aqueous layer was extracted with hexanes (2 x 50 mL). The combined organic layers were washed with brine, dried with $MgSO_4$, and concentrated *in vacuo*. Kugelrohr distillation (50 – 140 ^oC, 0.025 mmHg), followed by flash chromatography on water-washed silica gel (1% Et_2O/Hexanes) afforded the desired siloxane **4** as a colorless oil (6.60 g, 32.35 mmol, 45%).

IR (neat, cm^{-1}) 3072 (s), 3001 (s), 2966 (s), 2931 (s), 2899 (s), 2868 (s), 1642 (m), 1595 (m), 1443 (s), 1329 (s), 1251 (s), 1137 (s), 1076 (s), 1049 (s), 988 (s), 897 (s), 825 (s), 790 (s), 744 (s), 653 (s); **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.56 (d, *J* = 7.1 Hz, 1 H), 7.42-7.37 (m, 1 H), 7.31 (t, *J* = 7.1 Hz, 1 H), 7.24 (d, *J* = 7.7 Hz, 1 H), 5.87-5.76 (m, 1 H), 5.30 (dd, *J* = 3.9, 7.0 Hz, 1 H), 5.14-5.04 (m, 2 H), 2.73-2.65 (m, 1 H), 2.47-2.39 (m, 1 H), 0.38 (d, *J* = 15.5 Hz, 6 H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 152.5, 135.9, 134.7, 131.0, 129.7, 127.2, 122.5, 117.7, 81.2, 43.5, 1.5, 0.7; **HRMS** (CI^+) *m/z* $(M\text{-}CH_3)^+$: Calcd for $C_{11}H_{13}OSi$: 189.0736, found: 189.0733.

Synthesis of 3-(3-(4-bromophenyl)propyl)-1,1-dimethyl-1,3-dihydrobenzo[c][1,2]oxasilole (5):

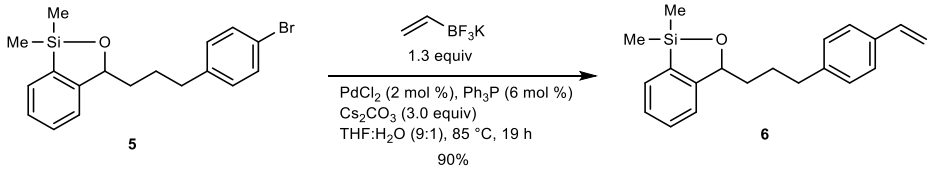


A solution of 9-BBN (0.5 M in THF, 12.15 mL, 6.08 mmol) was added dropwise to a flask containing siloxane **4** (826.3 mg, 4.05 mmol) while stirring at room temperature. The obtained solution was stirred for 3 h, at which time TLC analysis indicated consumption of the starting

material **4**. A screw-cap vial was charged with 1,4-dibromobenzene (2.87 g, 12.15 mmol), Pd(dppf)Cl_2.DCM (165.4 mg, 0.203 mmol), K_3PO_4 (1.72 g, 8.10 mmol), and the mixture was suspended in 10 mL DMF. The obtained mixture was stirred for 15 min at room temperature, followed by addition of the above solution containing siloxane **4**/9-BBN adduct via cannula (rinsed with 0.5 mL DMF). The obtained vial was capped and heated to 50 ^oC for 16 h. The reaction mixture was then cooled to room temperature and quenched with d.i. H_2O (10 mL). The resulting mixture was extracted with Et_2O (2 x 25 mL). The combined organic layers were washed with brine, dried with $MgSO_4$, and concentrated *in vacuo*. The crude oil was then taken up in THF (10 mL), followed by addition of solid $NaBO_3.4H_2O$ (3.12 g, 20.25 mmol), and d.i. H_2O (10 mL) for oxidation of borane byproducts to facilitate purification. The mixture was then stirred vigorously at room temperature, open to air, for 2 h. The aqueous layer was then extracted with hexanes (2 x 25 mL). The combined organic layers were washed with brine, dried with $MgSO_4$, and concentrated *in vacuo*. Kugelrohr distillation (180 ^oC, 0.025 mmHg) afforded the desired aryl bromide **5** as pale yellow oil (1.25 g, 3.46 mmol, 85%).

IR (neat, cm^{-1}) 3058 (m), 2999 (m), 2942 (s), 2860 (s), 1593 (m), 1487 (s), 1442 (m), 1252 (s), 1077 (s), 1012 (m), 949 (m), 876 (s), 818 (s), 790 (s), 749 (s); **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.54 (d, *J* = 7.1 Hz, 1 H), 7.41-7.35 (m, 3 H), 7.29 (t, *J* = 7.1 Hz, 1 H), 7.15 (d, *J* = 7.7 Hz, 1 H), 7.03 (d, *J* = 8.3 Hz, 2 H), 5.25 (dd, *J* = 3.3, 7.4 Hz, 1 H), 2.68-2.53 (m, 2 H), 1.98-1.90 (m, 1 H), 1.82-1.59 (m, 3 H), 0.37 (d, *J* = 4.8 Hz, 6 H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 153.0, 141.5, 135.7, 131.4, 131.0, 130.3, 129.8, 127.1, 122.3, 119.5, 81.5, 38.3, 35.3, 26.5, 1.5, 0.7; **HRMS** (CI^+) *m/z* $(M)^+$: Calcd for $C_{18}H_{21}OBrSi$: 360.0545, found: 360.0529.

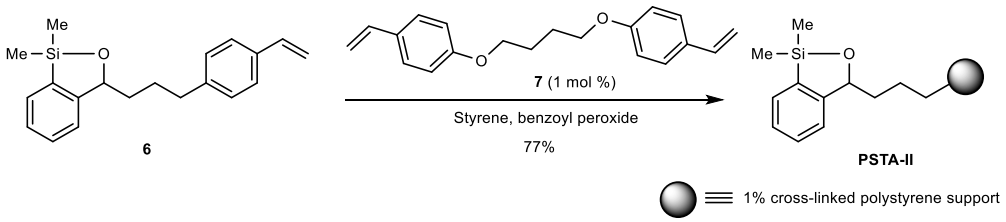
Synthesis of 1,1-dimethyl-3-(3-(4-vinylphenyl)propyl)-1,3-dihydrobenzo[c][1,2]oxasilole (6):



A solution of potassium vinyltrifluoroborate (336.6 mg, 2.51 mmol), $PdCl_2$ (6.9 mg, 0.039 mmol), PPh_3 (30.4 mg, 0.116 mmol), Cs_2CO_3 (1.89 g, 5.80 mmol), and aryl bromide **5** (698.5 mg, 1.93 mmol) in THF/H_2O (9:1, 4.1 mL) was heated at 85 ^oC in a screw-cap vial. The reaction mixture was stirred at 85 ^oC for 19 h, then cooled to room temperature and diluted with H_2O (5 mL), followed by extraction with dichloromethane (2 x 10 mL). The combined organic layers were washed with brine, dried with $MgSO_4$, and concentrated *in vacuo*. Purification via flash chromatography on water-washed silica gel (1% Et_2O/Hexanes) afforded the desired styrene **6** as a colorless oil (536.7 mg, 1.74 mmol, 90%).

IR (neat, cm^{-1}) 3055 (m), 3001 (m), 2941 (s), 2858 (s), 1629 (m), 1511 (m), 1442 (m), 1406 (m), 1330 (m), 1252 (s), 1137 (m), 1085 (s), 1023 (m), 989 (m), 947 (m), 876 (s), 823 (s), 790 (s), 748 (s); **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.54 (d, *J* = 7.1 Hz, 1 H), 7.40-7.35 (m, 1 H), 7.33-7.26 (m, 3 H), 7.16 (d, *J* = 7.7 Hz, 1 H), 7.12 (d, *J* = 7.9 Hz, 2 H), 6.69 (dd, *J* = 10.9, 17.6 Hz, 1 H), 5.70 (d, *J* = 17.6 Hz, 1 H), 5.26 (dd, *J* = 3.2, 7.3 Hz, 1 H), 5.18 (d, *J* = 10.9 Hz, 1 H), 2.72-2.57 (m, 2 H), 2.01-1.90 (m, 1 H), 1.84-1.59 (m, 3 H), 0.38 (d, *J* = 7.1 Hz, 6 H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 153.1, 142.3, 136.9, 135.7, 135.2, 131.0, 129.7, 128.7, 127.0, 126.3, 122.3, 113.0, 81.6, 38.4, 35.6, 26.5, 1.5, 0.7; **HRMS** (CI^+) *m/z* $(M)^+$: Calcd for $C_{20}H_{24}OSi$: 308.1596, found: 308.1581.

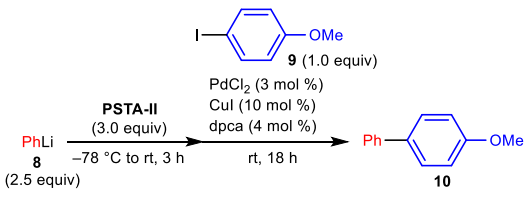
Synthesis of PSTA-II:



A solution of acacia gum (3.2 g) and NaCl (2.0 g) in H_2O (85 mL) was placed in a 100 mL-reaction flask equipped with a mechanical stirrer and deoxygenated by purging with N_2 for 30 min. A solution of monomer **6** (433 mg, 1.40 mmol), styrene (1.20 mL, 10.47 mmol), cross-linker **7** (34.9 mg, 0.119 mmol), and benzoyl peroxide (20.0 mg, 0.083 mmol) in chlorobenzene (2.0 mL) was injected to the rapidly stirred aqueous solution. This mixture was heated at 85 ^oC for 17 h. The crude polymer was collected by filtration and washed sequentially with MeOH/H_2O (3:1, 4 x 50 mL), MeOH (2 x 50 mL), THF (2 x 25 mL), Et_2O (2 x 25 mL), hexanes (2 x 25 mL), followed by drying *in vacuo* to provide the desired polymer **PSTA-II** as white beads (724 mg) and a Si loading of 1.49 mmol/g was determined by inductively coupled plasma optical emission spectrometry (ICP-OES). The yield was 77% based on Si incorporation.

IR (KBr, cm^{-1}) 3026 (s), 2914 (s), 1943 (m), 1872 (m), 1803 (m), 1721 (s), 1492 (s), 1448 (s), 1372 (s), 1329 (s), 1249 (s), 1179 (m), 1082 (s), 1026 (s), 945 (m), 875 (m), 819 (m), 789 (m), 743 (s), 698 (s).

Procedure for Recyclability of PSTA-II Using the Same Nucleophile and Electrophile:

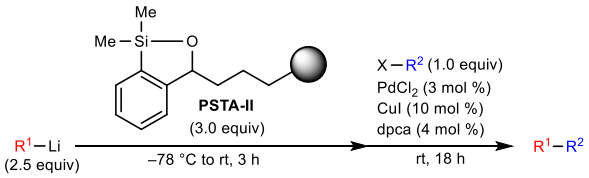


Cycle	Yield
1st	96%
2nd	96%
3rd	95%
4th	97%
5th	96%
6th	97%

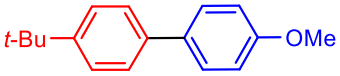
To a cooled suspension of siloxane polymer **PSTA-II** (1.49 mmol/g, 500 mg, 0.745 mmol) swelling in THF (20 mL) at –78 °C was added PhLi in Bu_2O (1.8 M, 345 µL, 0.621 mmol) dropwise. The reaction mixture was allowed to warm to room temperature and was stirred for 3 h. A solid mixture of $PdCl_2$ (1.3 mg, 7.4 µmol), CuI (4.7 mg, 24.8 µmol), and dpca (3.7 mg, 9.9 µmol) was combined and added to the reaction flask, followed by addition of 4-iodoanisole (58.0 mg, 0.248 mmol). The obtained reaction mixture was stirred vigorously at room temperature for 18 h. The reaction mixture was then quenched with sat. aq. NH_4Cl (5 mL), followed by addition of d.i. H_2O (5 mL), and stirred for an hour at room temperature. The obtained mixture was filtered through a fritted filter to remove polymer. The filtered polymer was then washed with Et_2O (4 x 50 mL). The combined filtrate was washed with brine, dried with $MgSO_4$, and concentrated *in vacuo*, followed by purification via flash chromatography (1% Et_2O/ hexanes) to provide the desired cross-coupling product 4-phenylanisole **10** as a white solid (43.8 mg, 0.238 mmol, 96%). Following filtration, the polymer was further washed sequentially with MeOH/H_2O solution (1:1, 2 x 50 mL), MeOH (2 x 25 mL), CH_2Cl_2 (2 x 25 mL), Et_2O (2 x 25 mL), hexanes (2 x 25 mL), and dried *in vacuo* to provide near quantitative recovery of siloxane polymer.

The obtained polymer was re-used 5 more times employing the same procedure above and showed no loss in cross-coupling efficiency.

General Procedure for Recyclability of PSTA-II Using Multiple Nucleophiles and Electrophiles:

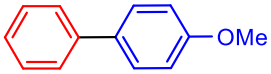


To a cooled suspension of siloxane polymer **PSTA-II** (0.74 mmol/g, 3.0 equiv) swelling in THF (25 mL) at –78 °C was added the organolithium solution (2.5 equiv) dropwise. The reaction mixture was allowed to warm to room temperature and was stirred for 3 h. A solid mixture of $PdCl_2$ (3 mol %), CuI (10 mol %), and dpca (4 mol %) was combined and added to the reaction flask, followed by addition of the aryl or alkenyl halide (1.0 equiv). The obtained reaction mixture was stirred vigorously at room temperature for 18 h. The reaction mixture was then quenched with sat. aq. NH_4Cl (5 mL), followed by addition of d.i. H_2O (5 mL), and stirred for an hour at room temperature. The obtained mixture was filtered through a fritted filter to remove polymer. The filtered polymer was then washed with Et_2O (4 x 50 mL). The combined filtrate was washed with brine, dried with $MgSO_4$, and concentrated *in vacuo*, followed by purification via flash chromatography to provide the desired cross-coupling product. Following filtration, the polymer was further washed sequentially with MeOH/H_2O solution (1:1, 2 x 50 mL), MeOH (2 x 25 mL), CH_2Cl_2 (2 x 25 mL), Et_2O (2 x 25 mL), hexanes (2 x 25 mL), and dried *in vacuo* to provide near quantitative recovery of siloxane polymer, which was employed in the next cross-coupling cycle.



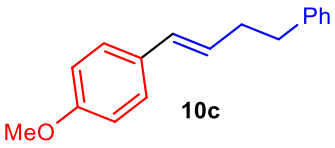
10b

4-(tert-butyl)-4'-methoxy-1,1'-biphenyl: Following general procedure, using PSTA-II (750 mg, 0.555 mmol), **8b** (926 µL, 0.50 M, 0.463 mmol), $PdCl_2$ (1.0 mg, 5.6 µmol), dpca (2.7 mg, 7.4 µmol), CuI (3.5 mg, 18.5 µmol) and **9** (42.0 mg, 0.180 mmol). The product was purified by chromatography on SiO_2 (1% Et_2O/ hexanes) to afford **10b** (41.2 mg, 0.172 mmol, 95%) as a colorless solid. Analytical data matches that which has been previously reported for **10b**:[5] **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.57-7.49 (m, 4 H), 7.48-7.44 (m, 2 H), 6.98 (d, *J* = 8.7 Hz, 2 H), 3.86 (s, 3 H), 1.38 (s, 9 H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 159.1, 149.8, 138.1, 133.8, 128.1, 126.5, 125.8, 114.3, 55.5, 34.6, 31.5.



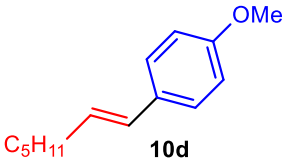
10

4-Phenylanisole: Following general procedure, using PSTA-II (720 mg, 0.533 mmol), **8** (234 µL, 1.9 M, 0.444 mmol), $PdCl_2$ (0.9 mg, 5.3 µmol), dpca (2.6 mg, 7.1 µmol), CuI (3.4 mg, 17.8 µmol) and **9** (41.6 mg, 0.178 mmol). The product was purified by chromatography on SiO_2 (1% Et_2O/ hexanes) to afford **10** (31.8 mg, 0.173 mmol, 97%) as a colorless solid. Analytical data matches that which has been previously reported for **10**:[6] **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.57-7.53 (m, 4 H), 7.42 (t, *J* = 7.6 Hz, 2 H), 7.31 (t, *J* = 7.4 Hz, 1 H), 6.99 (d, *J* = 8.7 Hz, 2 H), 3.86 (s, 3 H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 159.3, 141.0, 133.9, 128.9, 128.3, 126.9, 126.8, 114.3, 55.5.



10c

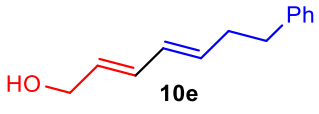
(*E*)-1-methoxy-4-(4-phenylbut-1-en-1-yl)benzene: Following general procedure, using PSTA-II (702 mg, 0.519 mmol), **8c** (1.2 mL, 0.36 M, 0.433 mmol), $PdCl_2$ (0.9 mg, 5.2 µmol), dpca (2.6 mg, 7.0 µmol), CuI (3.3 mg, 17.3 µmol) and **9b** (44.7 mg, 0.173 mmol). The product was purified by chromatography on SiO_2 (0.5 % Et_2O/ hexanes) to afford **10c** (37 mg, 0.155 mmol, 90%) as a colorless solid. Analytical data matches that which has been previously reported for **10c**:[7] **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.34 – 7.18 (m, 7 H), 6.85 (d, *J* = 8.5 Hz, 2 H), 6.38 (d, *J* = 15.9 Hz, 1 H), 6.13 (td, *J* = 6.9, 15.7 Hz, 1 H), 3.82 (s, 3 H), 2.79 (t, *J* = 7.8 Hz, 2 H), 2.52 (q, *J* = 7.2 Hz, 2 H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 158.9, 142.3, 130.7, 129.9, 128.6, 128.5, 127.96, 127.21, 126.0, 114.1, 55.4, 36.2, 35.0.



10d

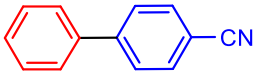
(*E*)-1-(hept-1-en-1-yl)-4-methoxybenzene: Following general procedure, using PSTA-II (686 mg, 0.508 mmol), **8d** (1.14 mL, 0.37 M, 0.423 mmol), $PdCl_2$ (0.9 mg, 5.1 µmol), dpca (2.5 mg, 6.8 µmol), CuI (3.2 mg, 16.9 µmol) and **9** (39.6 mg, 0.169 mmol). The product was purified by chromatography on SiO_2 (0-0.5 % Et_2O/ hexanes) to afford **10d** (25.5 mg, 0.125 mmol, 74%) as a colorless oil. Analytical data matches that which has been previously reported for **10d**:[8] **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.28 (dd, *J* = 2.0, 6.5 Hz, 2 H), 6.84 (dd, *J* = 2.1, 6.6 Hz, 2 H), 6.32 (d, *J* = 15.7 Hz, 1 H), 6.09 (dt, *J* = 7.2, 15.8 Hz, 1 H), 3.80 (s, 3 H), 2.18 (qd, *J* = 1.3, 7.3 Hz, 2 H), 1.46 (qn, *J* = 7.2 Hz, 2 H), 1.40-1.37 (m, 4 H), 0.90 (t, *J* = 7.1 Hz, 3

H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 158.6, 131.2, 129.6, 129.5, 127.1, 114.2, 55.7, 33.5, 31.4, 29.5, 22.7, 14.1.



10e

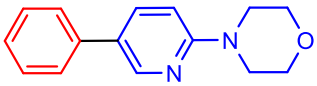
(2*E*, 4*E*)-7-phenylhepta-2,4-dien-1-ol: Following general procedure, using PSTA-II (662 mg, 0.490 mmol), **8e** (1.4 mL, 0.30 M, 0.408 mmol), $PdCl_2$ (0.9 mg, 4.9 µmol), dpca (2.4 mg, 6.5 µmol), CuI (3.1 mg, 16.3 µmol) and **9b** (42.1 mg, 0.163 mmol). The crude was taken up in THF (3 mL) and treated with TBAF (0.65 mmol, 4.0 equiv, 1.0 M in THF). The reaction mixture was stirred at rt for 4 h, quenched with sat. aq. NH_4Cl (5 mL), followed by addition of d.i. H_2O (5 mL). The organic layer was collected and the aqueous layer was extracted with Et_2O (2 x 10 mL). The combined organic layers were washed with brine, dried with $MgSO_4$, and concentrated *in vacuo*. The product was purified by chromatography on SiO_2 (20 % Et_2O/ hexanes) to afford **10e** (22.0 mg, 0.117 mmol, 72%) as a colorless oil. Analytical data matches that which has been previously reported for **10e**:[9] **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.31 - 7.26 (m, 2 H), 7.22 - 7.16 (m, 3 H), 6.22 (dd, *J* = 10.5, 15.1 Hz, 1 H), 6.09 (dd, *J* = 10.5, 15.1 Hz, 1 H), 5.79 - 5.70 (m, 2 H), 4.17 (d, *J* = 3.8 Hz, 2 H), 2.71 (t, *J* = 7.8 Hz, 2 H), 2.42 (q, *J* = 7.4 Hz, 2 H), 1.30 (bs, 1 H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 141.8, 134.6, 132.0, 130.1, 130.0, 128.6, 128.5, 126.0, 63.7, 35.8, 34.6.



10f

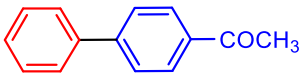
4-Cyanobiphenyl: Following general procedure, using PSTA-II (660 mg, 0.488 mmol), **8** (214 µL, 1.9 M, 0.407 mmol), $PdCl_2$ (0.9 mg, 4.9 µmol), dpca (2.4 mg, 6.5 µmol), CuI (3.1 mg, 16.3 µmol) and **9c** (37.3 mg, 0.163 mmol). The product was purified by chromatography on SiO_2 (2% Et_2O/ hexanes) to afford **10f** (26.8 mg, 0.150 mmol, 92%) as a colorless solid. Analytical data matches that which has been previously reported for **10f**:[10] **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.73 (d, *J* = 8.3 Hz, 2 H), 7.69 (d, *J* = 8.4 Hz, 2 H), 7.59 (d, *J* = 7.4 Hz, 2 H), 7.49 (t, *J* = 7.2 Hz, 2 H), 7.43 (t, *J* = 7.3 Hz, 1 H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 145.8, 139.3, 132.8, 129.3, 128.8, 127.9, 127.4, 119.1, 111.1.

Preparation of **10f** from **9e** was carried out in a similar fashion.



10g

4-(5-phenylpyridin-2-yl)morpholine: Following general procedure, using PSTA-II (650 mg, 0.481 mmol), **8** (211 µL, 1.9 M, 0.401 mmol), $PdCl_2$ (0.9 mg, 4.8 µmol), dpca (2.4 mg, 6.4 µmol), CuI (3.0 mg, 16.0 µmol) and **9d** (46.4 mg, 0.160 mmol). The product was purified by chromatography on SiO_2 (20% Et_2O/ hexanes) to afford **10g** (34.9 mg, 0.145 mmol, 91%) as a colorless solid. Analytical data matches that which has been previously reported for **10g**:[11] **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.47 (d, *J* = 2.2 Hz, 1 H), 7.75 (dd, *J* = 2.5, 8.8 Hz, 1 H), 7.53 (d, *J* = 7.4 Hz, 2 H), 7.43 (t, *J* = 7.5 Hz, 2 H), 7.32 (t, *J* = 7.4 Hz, 1 H), 6.71 (d, *J* = 8.8 Hz, 1 H), 3.85 (app t, *J* = 4.9 Hz, 4 H), 3.56 (app t, *J* = 4.9 Hz, 4 H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 158.9, 146.3, 138.4, 136.3, 129.1, 127.0, 126.9, 126.4, 106.8, 66.9, 45.8.



10h

4-Acetylbiphenyl: Following general procedure, using PSTA-II (620 mg, 0.459 mmol), **8** (201 µL, 1.9 M, 0.382 mmol), $PdCl_2$ (0.8 mg, 4.6 µmol), dpca (2.3 mg, 6.1 µmol), CuI (2.9 mg, 15.3 µmol) and **9f** (36.5 mg, 0.148 mmol). The product was purified by chromatography on SiO_2 (5% Et_2O/ hexanes) to afford **10h** (23.8 mg, 0.121 mmol, 82%) as a colorless solid. Analytical data matches that which has been previously reported for **10h**:[12] **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.04 (d, *J* = 8.3 Hz, 2 H), 7.69 (d, *J* = 8.1 Hz, 2 H), 7.63 (d, *J* = 7.3 Hz, 2 H), 7.48 (t, *J* = 7.5 Hz, 2 H), 7.41 (t, *J* = 7.3 Hz, 1 H), 2.64 (s, 3 H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 197.9, 145.9, 140.0, 136.0, 129.1, 129.0, 128.4, 127.4, 127.4, 26.8.

Preparation of **10h** from **9g** was carried out in a similar fashion.

References

1. Toy, P. H.; Reger, T. S.; Garibay, P.; Garno, J. C.; Malikayil, J. A.; Liu, G.; Janda, K. D. *J. Comb. Chem.* **2001**, *3*, 117.

2. Stille, J. K.; Simpson, J. H. *J. Am. Chem. Soc.* **1987**, *109*, 2138.

3. Huang, Z.; Negishi, E.; *Org. Lett.* **2006**, *8*, 3675.

4.Kofron, W. G.; Baclawski, L. M. J. Org. Chem. **1976**, *41*, 1879.

5. Zhang, L.; Qing, J.; Yang, P.; Wu, J. *Org. Lett.* **2008**, *10*, 4971.

6. Manolikakes, G.; Knochel, P. *Angew. Chem. Int. Ed.* **2009**, *48*, 205.

7. Satoh, T.; Hanaki, N.; Yamada, N.; Asano, T. *Tetrahedron* **2000**, *56*, 6223

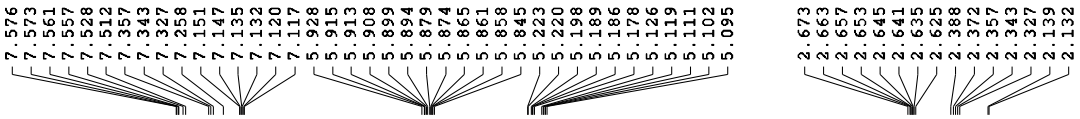
8. Denmark, S. E.; Sweis, R. F. *J. Am. Chem. Soc.* **2001**, *123*, 6439.

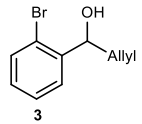
9. Nguyen, M. H., Smith, A. B. III. *Org. Lett*. **2013**, *15*, 4258.

10. Kobayashi, O.; Uraguchi, D.; Yamakawa, T. *Org. Lett*. **2009**, *11*, 2679.

11. Smith, A. B. III; Hoye, A. T.; Martinez-Solorio, D.; Kim, W.-S.; Tong, R. *J. Am. Chem. Soc.* **2012**, *134*, 4533.

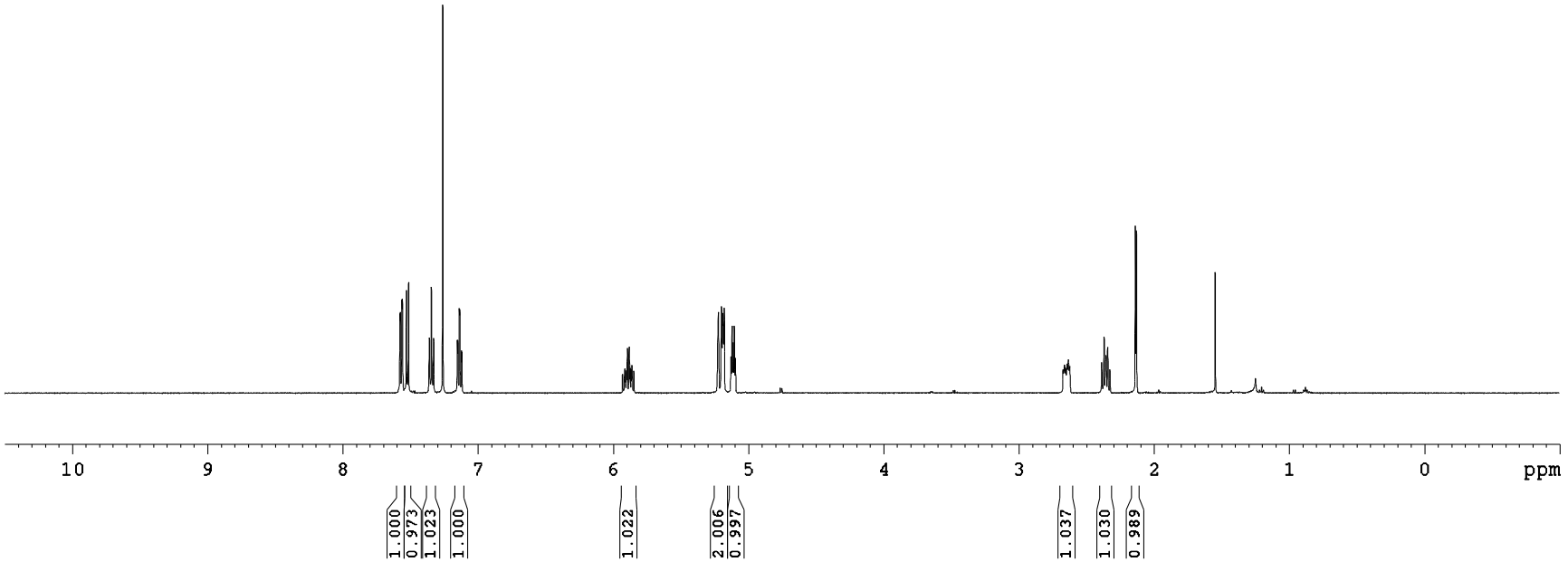
12. Metallinos, C.; Zaifman, J.; Dodge, L. *Org. Lett.* **2008**, *10*, 3527.

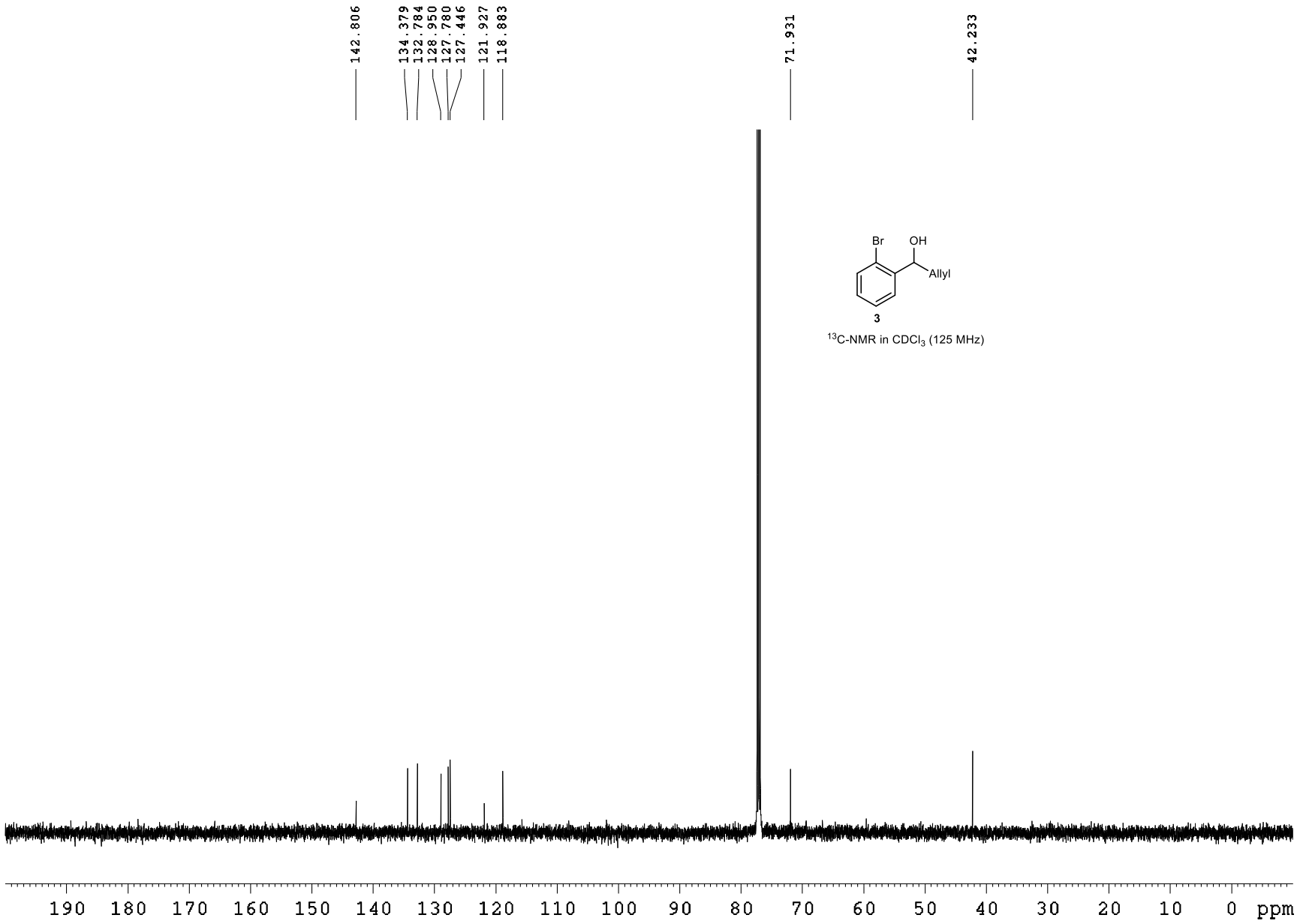


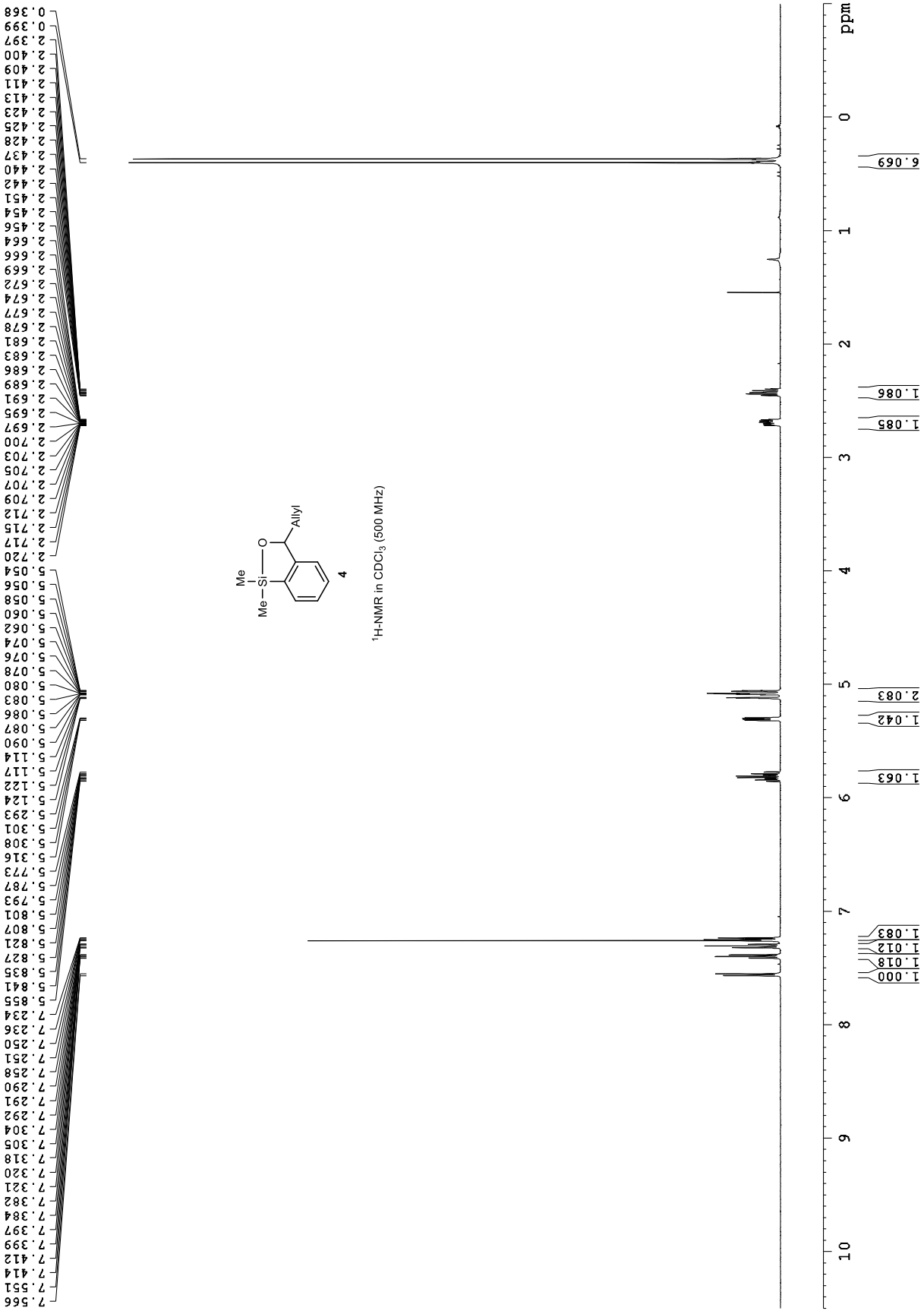


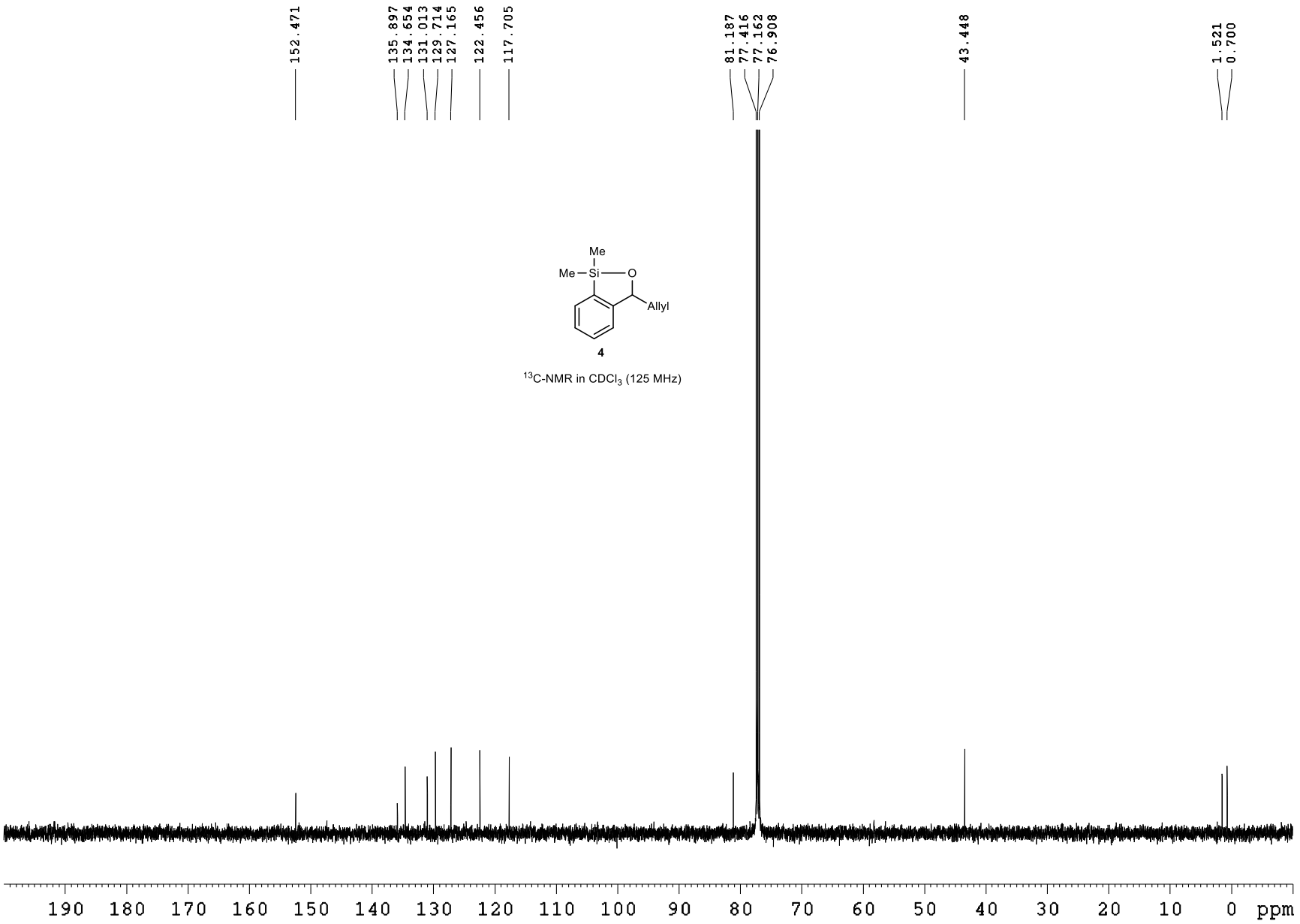
3

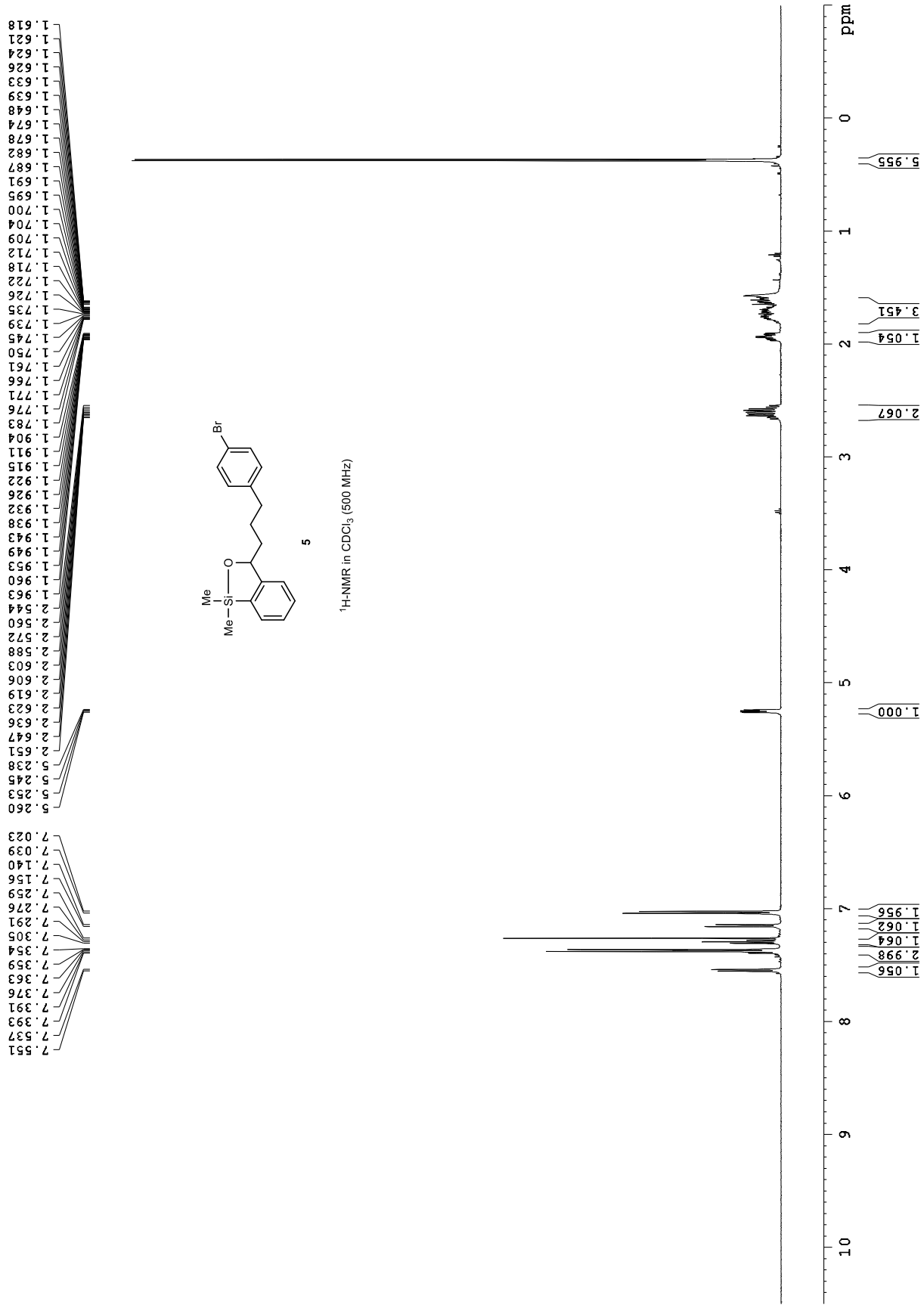
^{1}H-NMR in $CDCl_3$ (500 MHz)

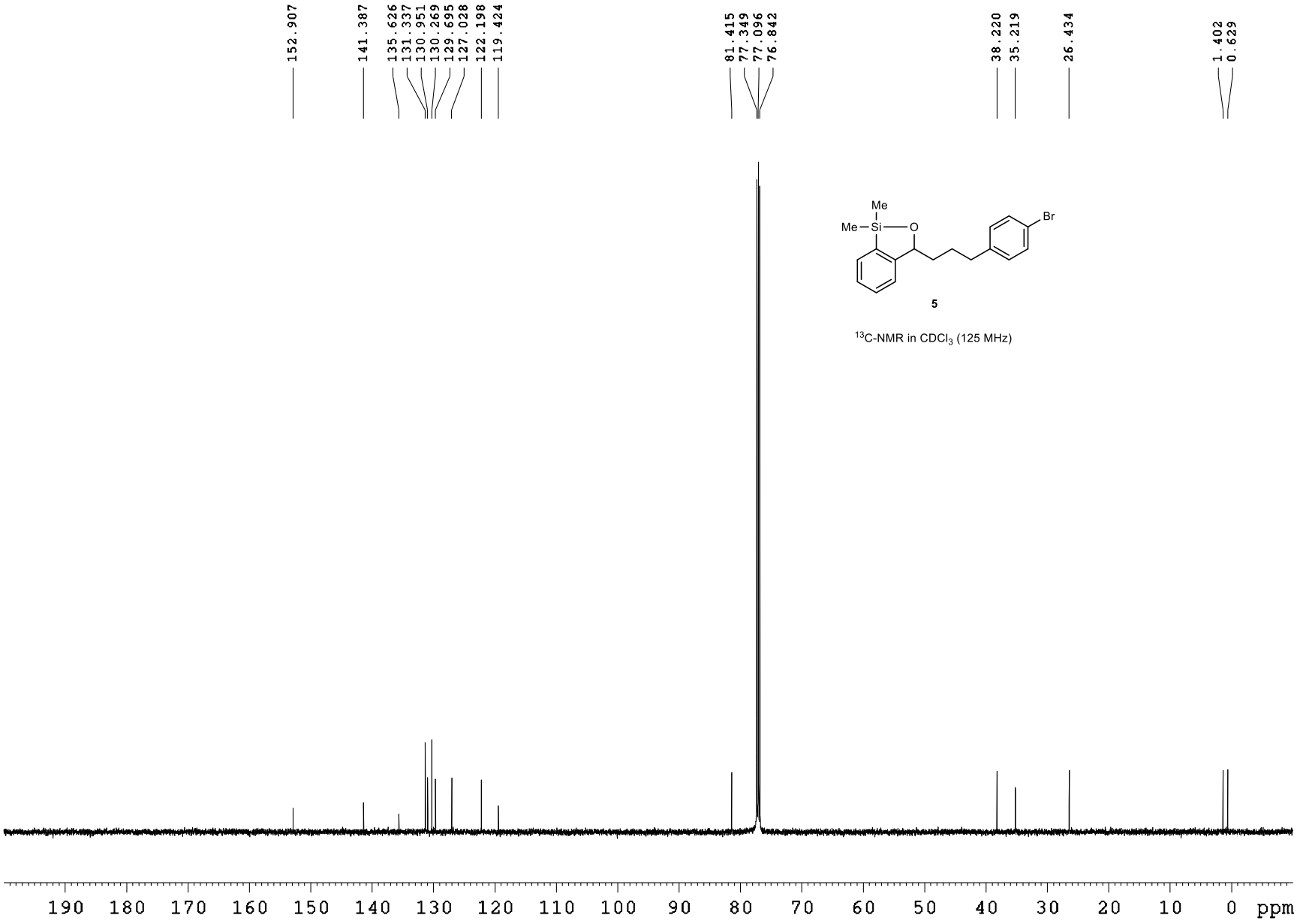


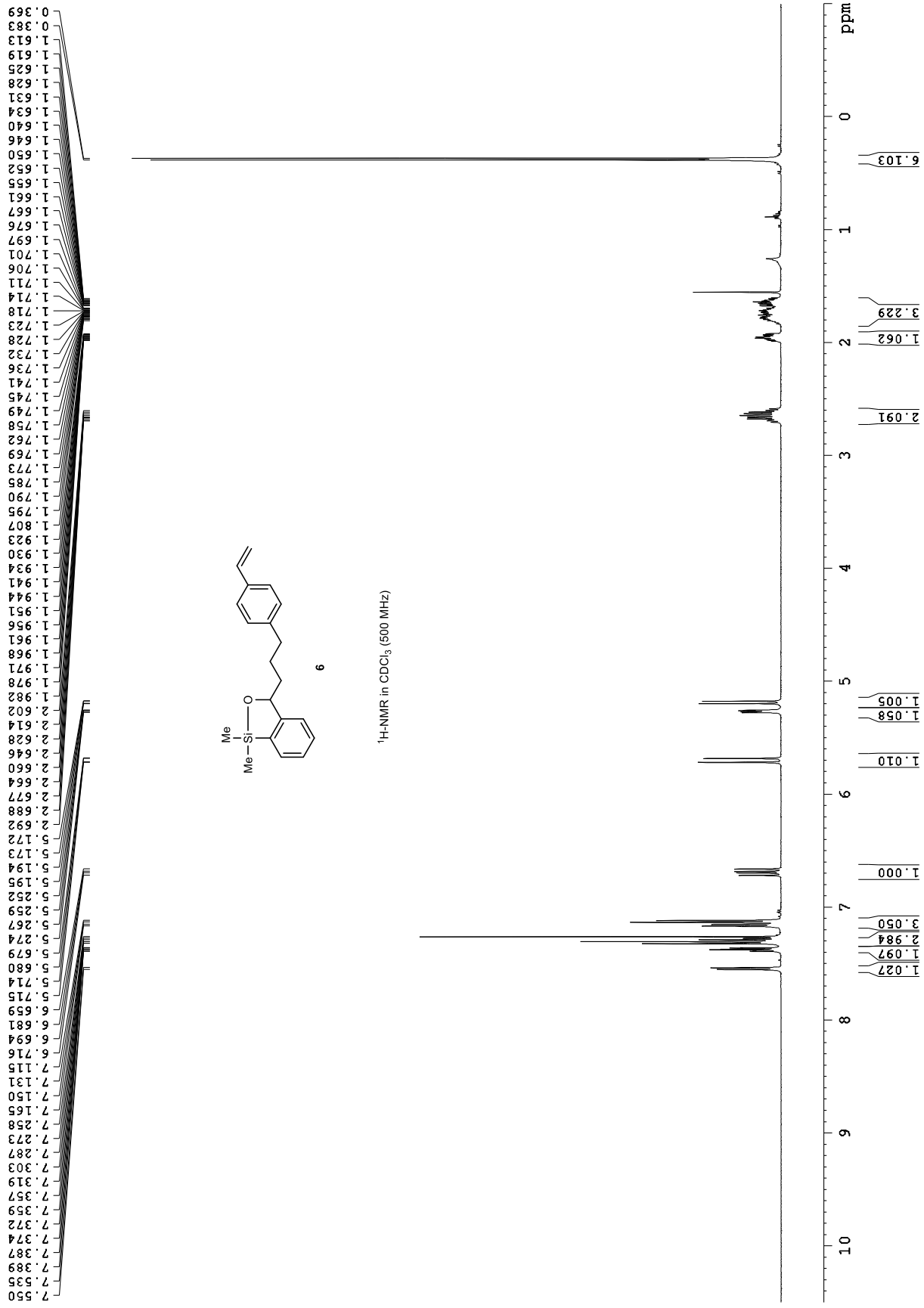

142.806
134.379
132.784
128.950
127.780
127.446
121.927
118.883
71.931
42.233
Br
OH
Allyl
3
13C-NMR in CDCl3 (125 MHz)
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

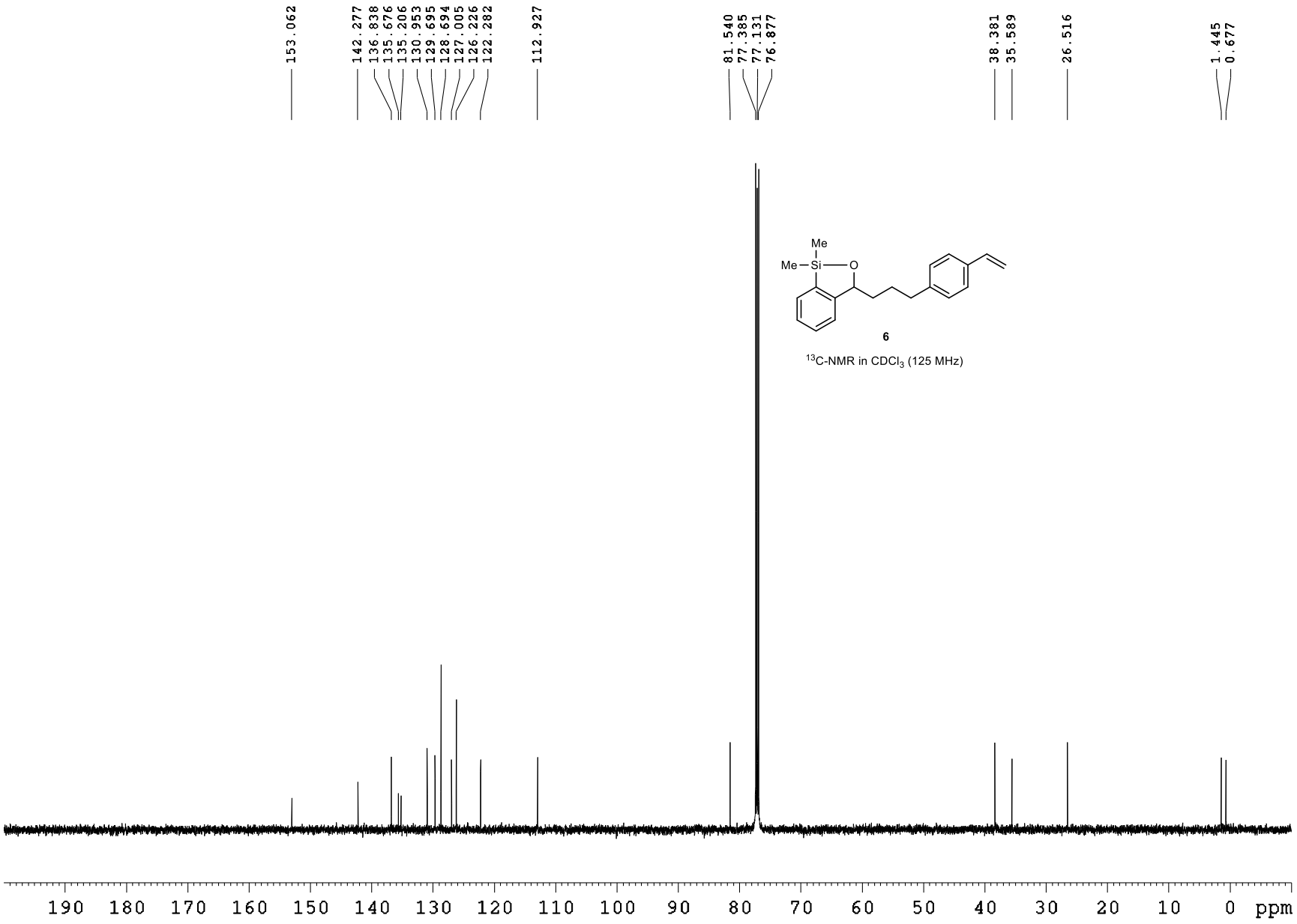

Me
Me—Si—O
Allyl
4
^{1}H-NMR in $CDCl_3$ (500 MHz)
ppm
6.069
1.086
1.085
2.083
1.042
1.063
1.083
1.012
1.018
1.000

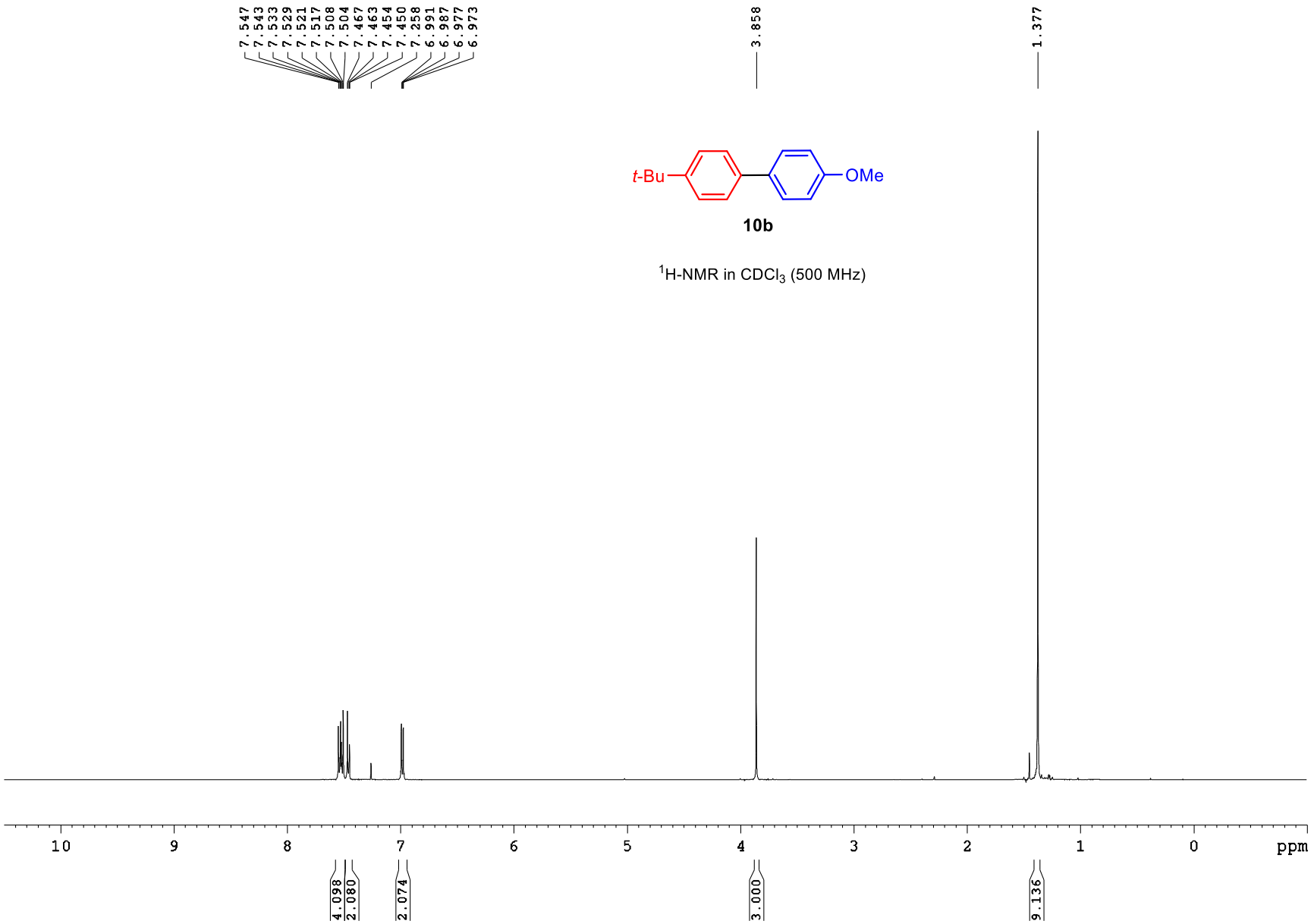

152.471
135.897
134.654
131.013
129.714
127.165
122.456
117.705
81.187
77.416
77.162
76.908
43.448
1.521
0.700
Me
Me
Si
O
Allyl
4
13C-NMR in CDCl3 (125 MHz)
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

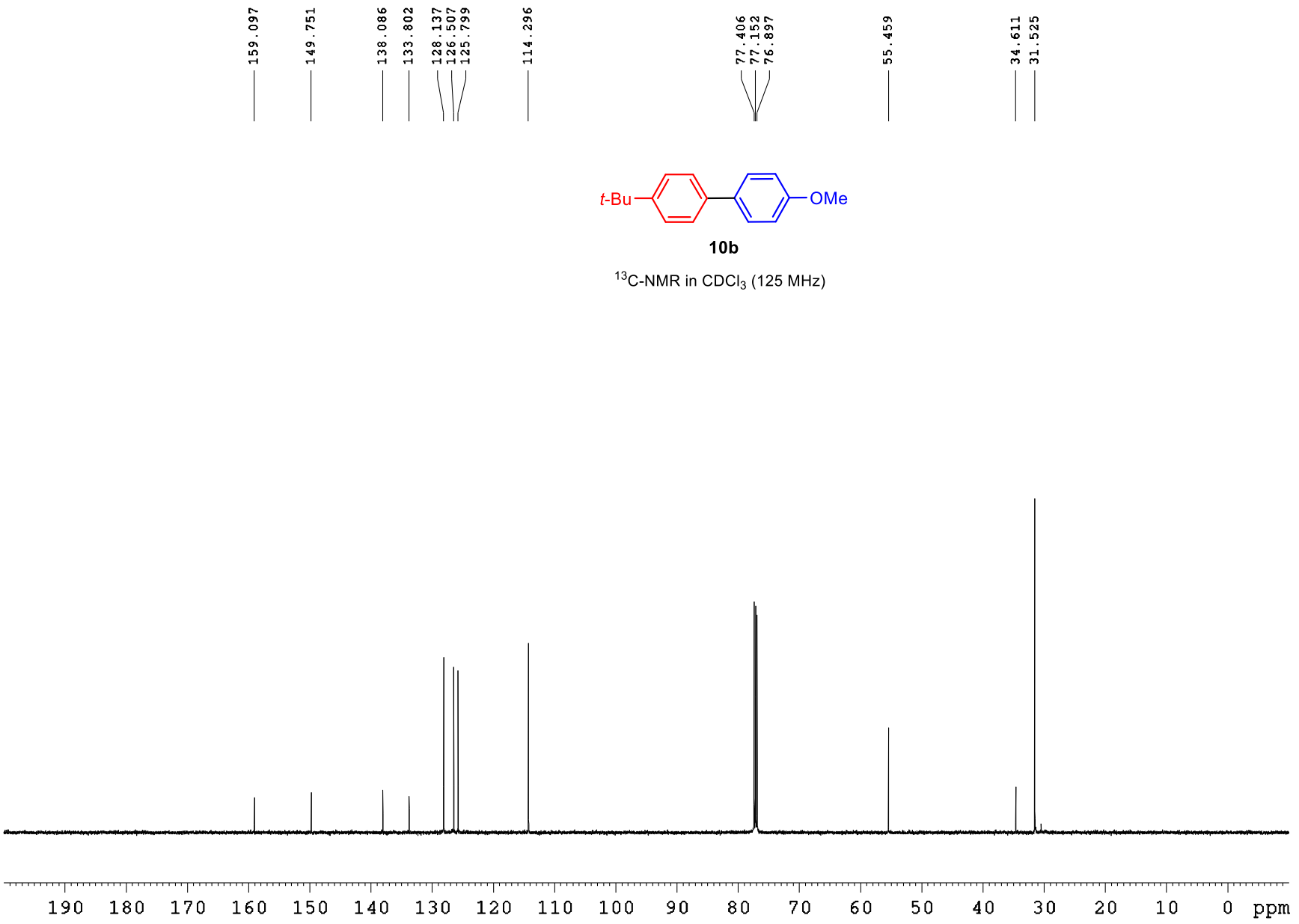

Br
Me
Me—Si—O
5
^{1}H-NMR in $CDCl_3$ (500 MHz)
ppm
0
1
2
3
4
5
6
7
8
9
10
5.955
3.451
1.054
2.067
1.000
1.956
1.062
1.064
2.998
1.056


152.907
141.387
135.626
131.337
130.951
130.269
129.695
127.028
122.198
119.424
81.415
77.349
77.096
76.842
38.220
35.219
26.434
1.402
0.629
Me
Me
Si
O
Br
5
13C-NMR in CDCl3 (125 MHz)
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm


Me
Me—Si—O
6
^{1}H-NMR in $CDCl_3$ (500 MHz)
ppm
0
1
2
3
4
5
6
7
8
9
10
6.103
3.229
1.062
2.091
1.058
1.005
1.010
1.000
3.050
2.984
1.097
1.027

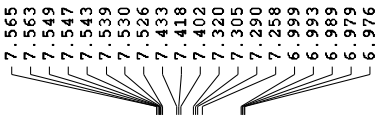

153.062
142.277
136.838
135.676
135.206
130.953
129.695
128.694
127.005
126.226
122.282
112.927
81.540
77.385
77.131
76.877
38.381
35.589
26.516
1.445
0.677
Me
Me–Si–O
6
13C-NMR in CDCl3 (125 MHz)
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

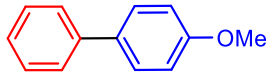

7.547
7.543
7.533
7.529
7.521
7.517
7.508
7.504
7.467
7.463
7.454
7.450
7.258
6.991
6.987
6.977
6.973
3.858
1.377
t-Bu
OMe
10b
1H-NMR in CDCl3 (500 MHz)
10
9
8
7
6
5
4
3
2
1
0
ppm
4.098
2.080
2.074
3.000
9.136



10b

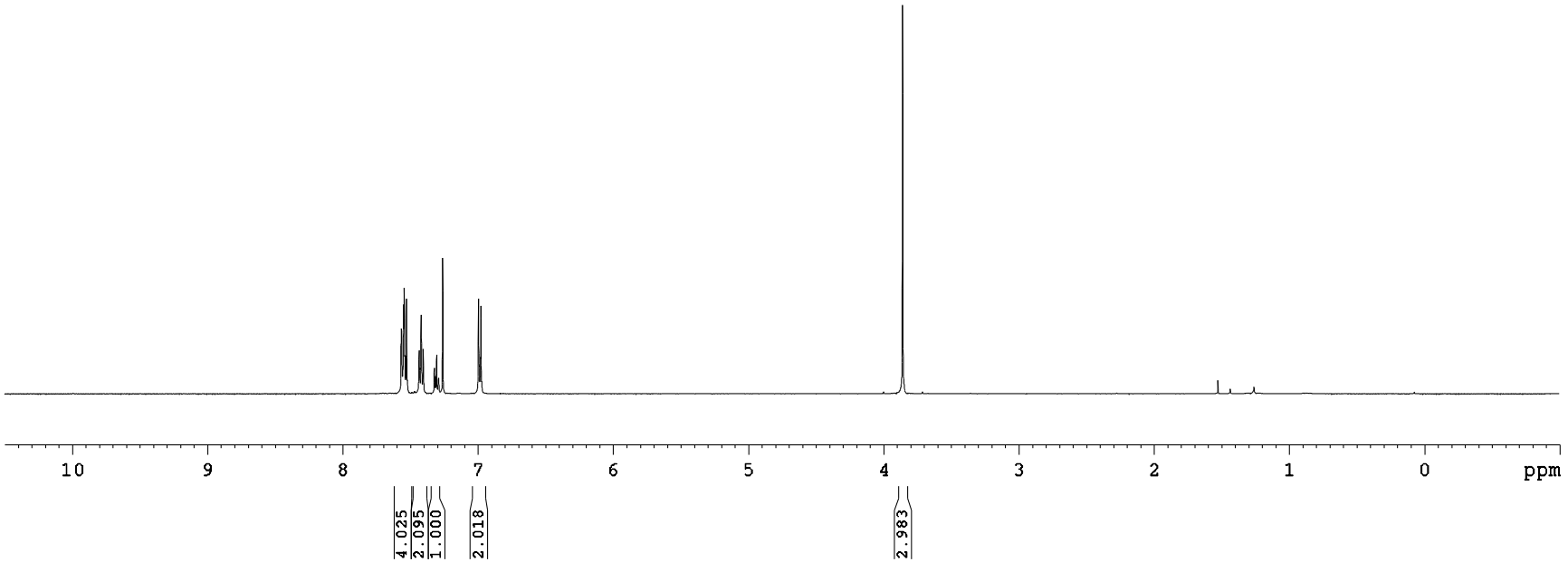
^{13}C-NMR in $CDCl_3$ (125 MHz)

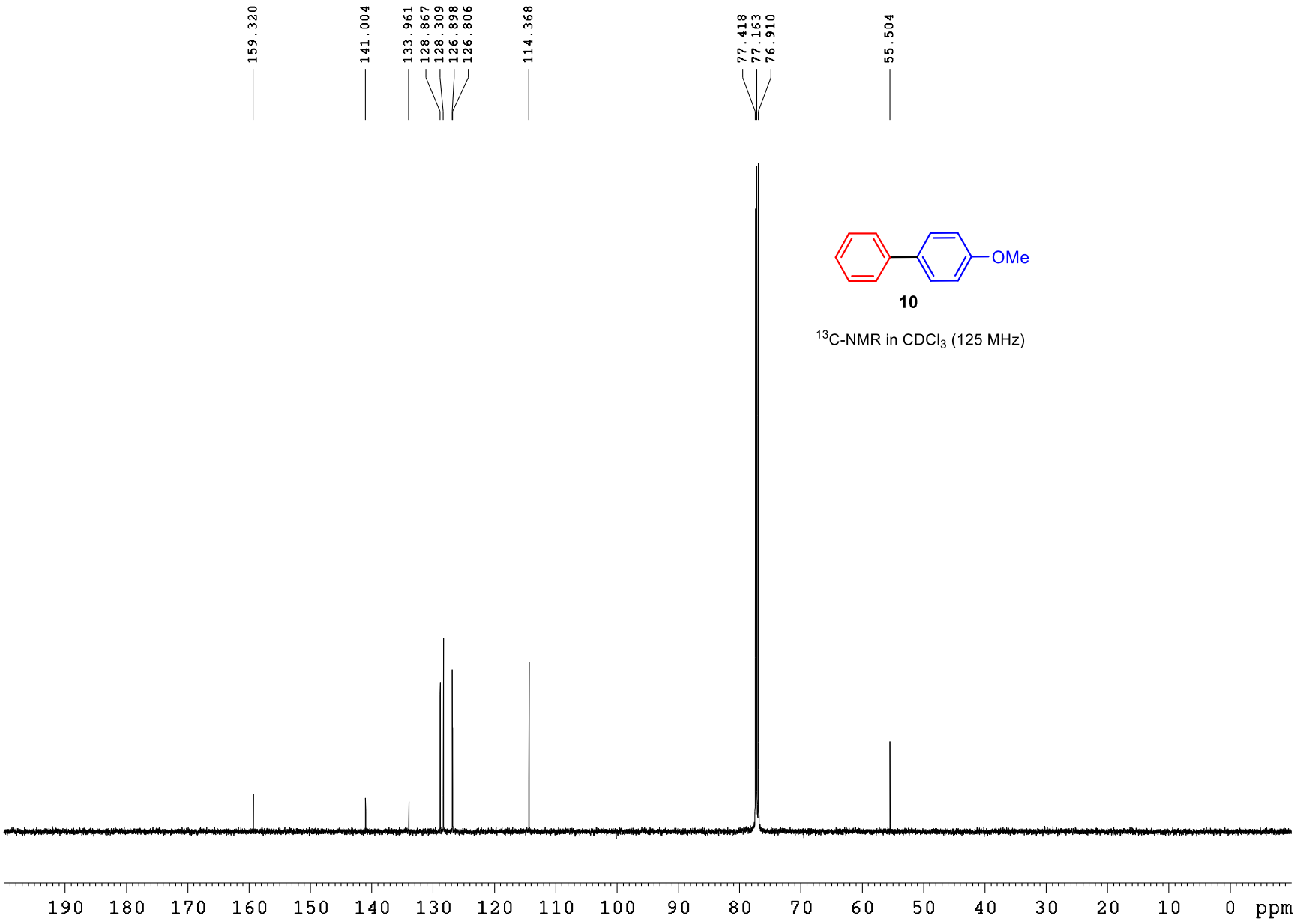


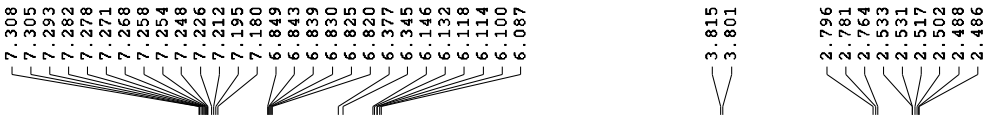


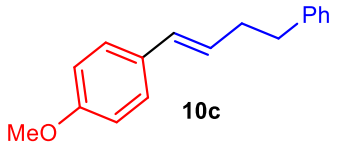
10

^{1}H-NMR in $CDCl_3$ (500 MHz)



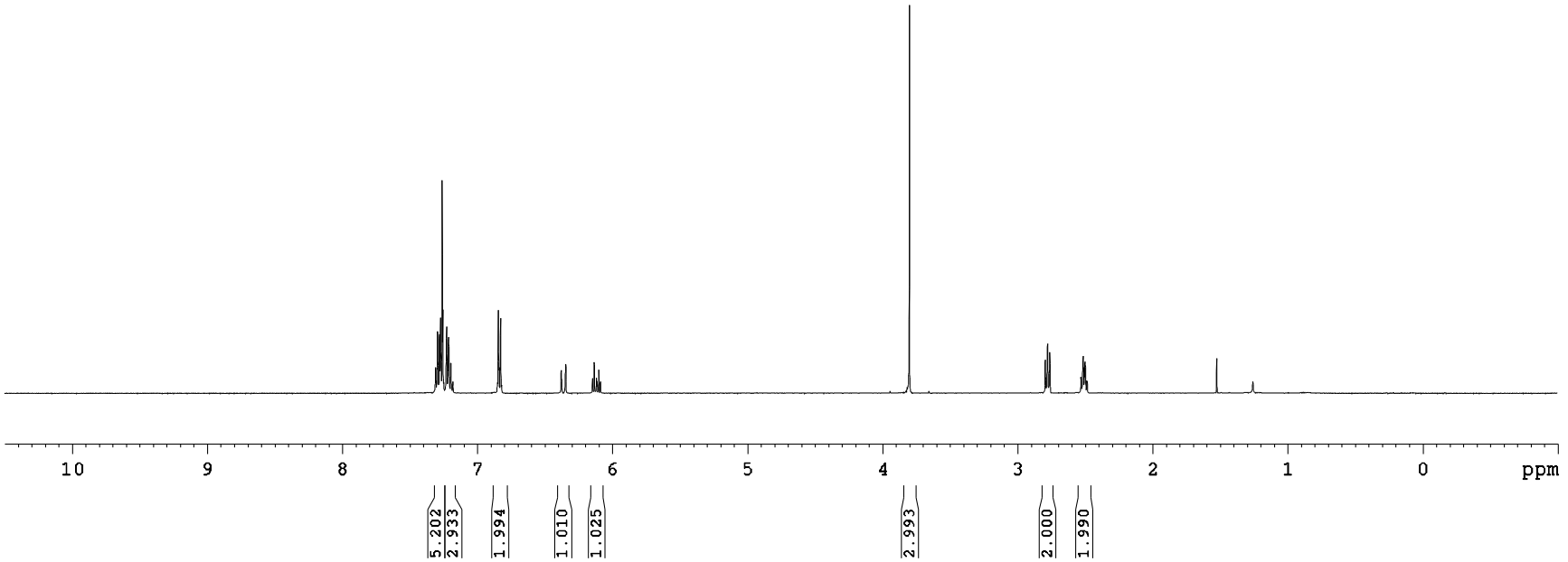

159.320
141.004
133.961
128.867
128.309
126.898
126.806
114.368
77.418
77.163
76.910
55.504
OMe
10
^{13}C-NMR in $CDCl_3$ (125 MHz)
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

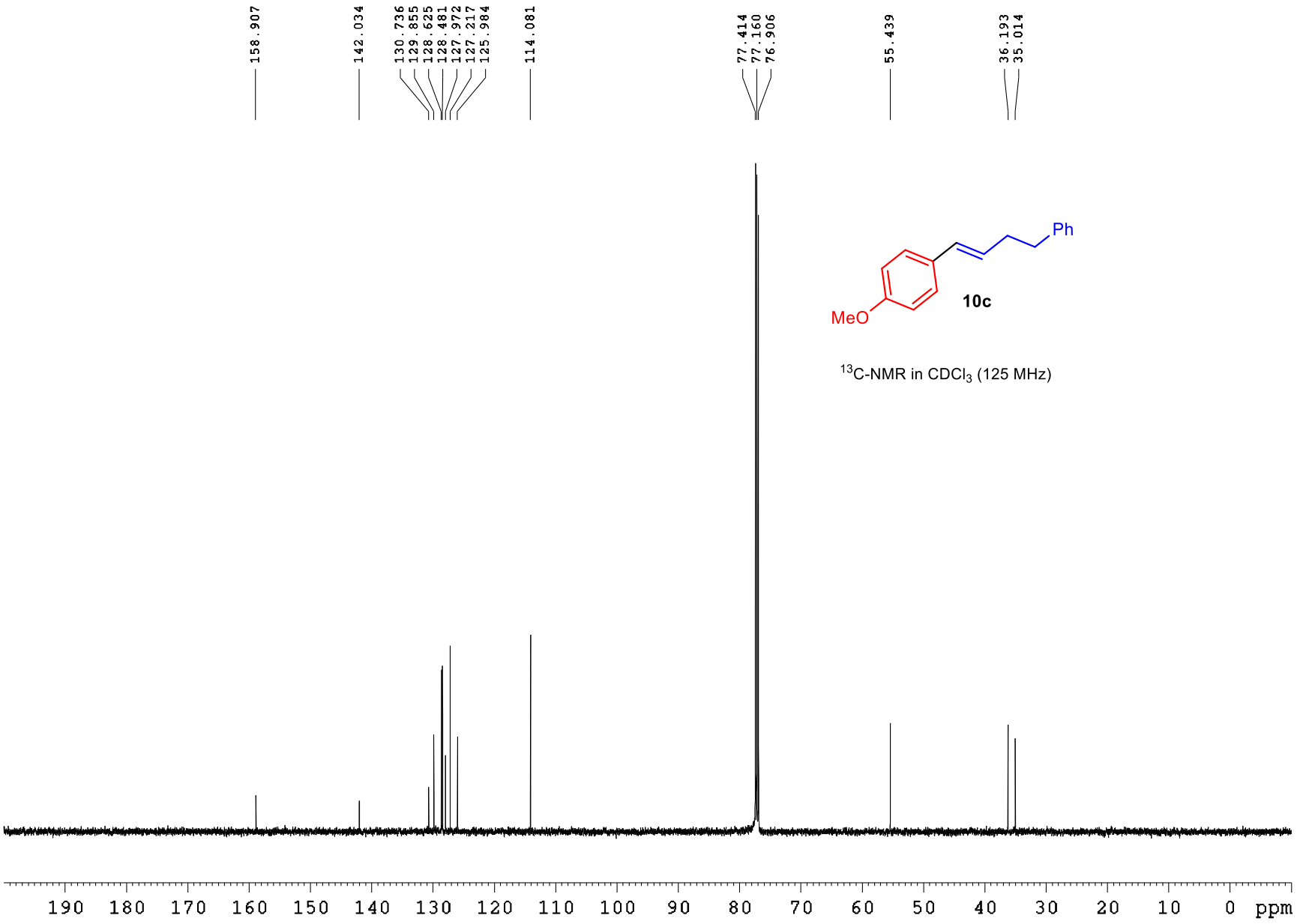




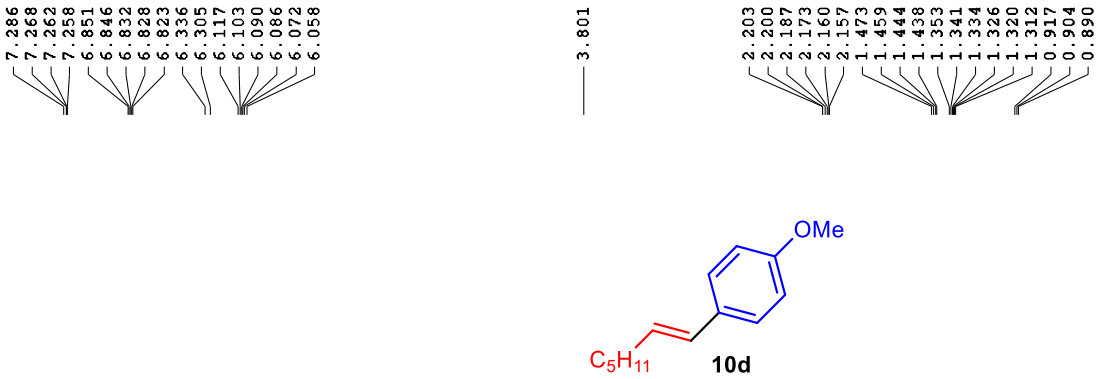
10c

^{1}H-NMR in $CDCl_3$ (500 MHz)

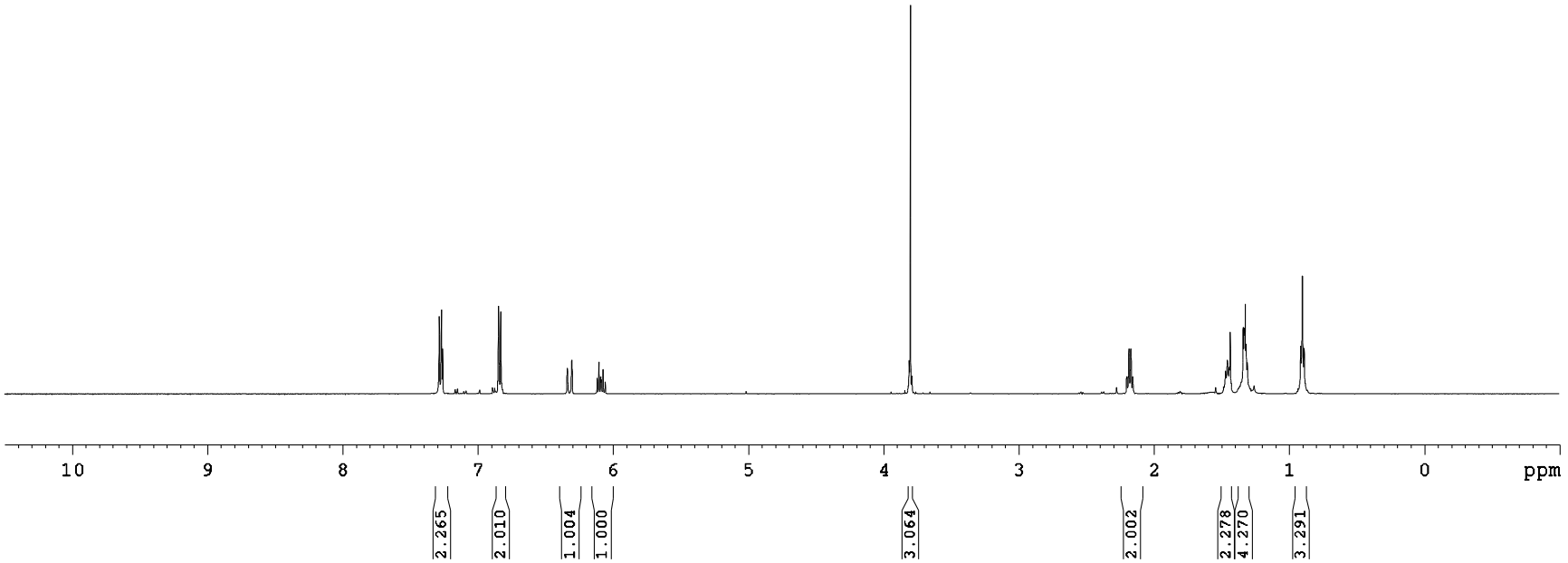


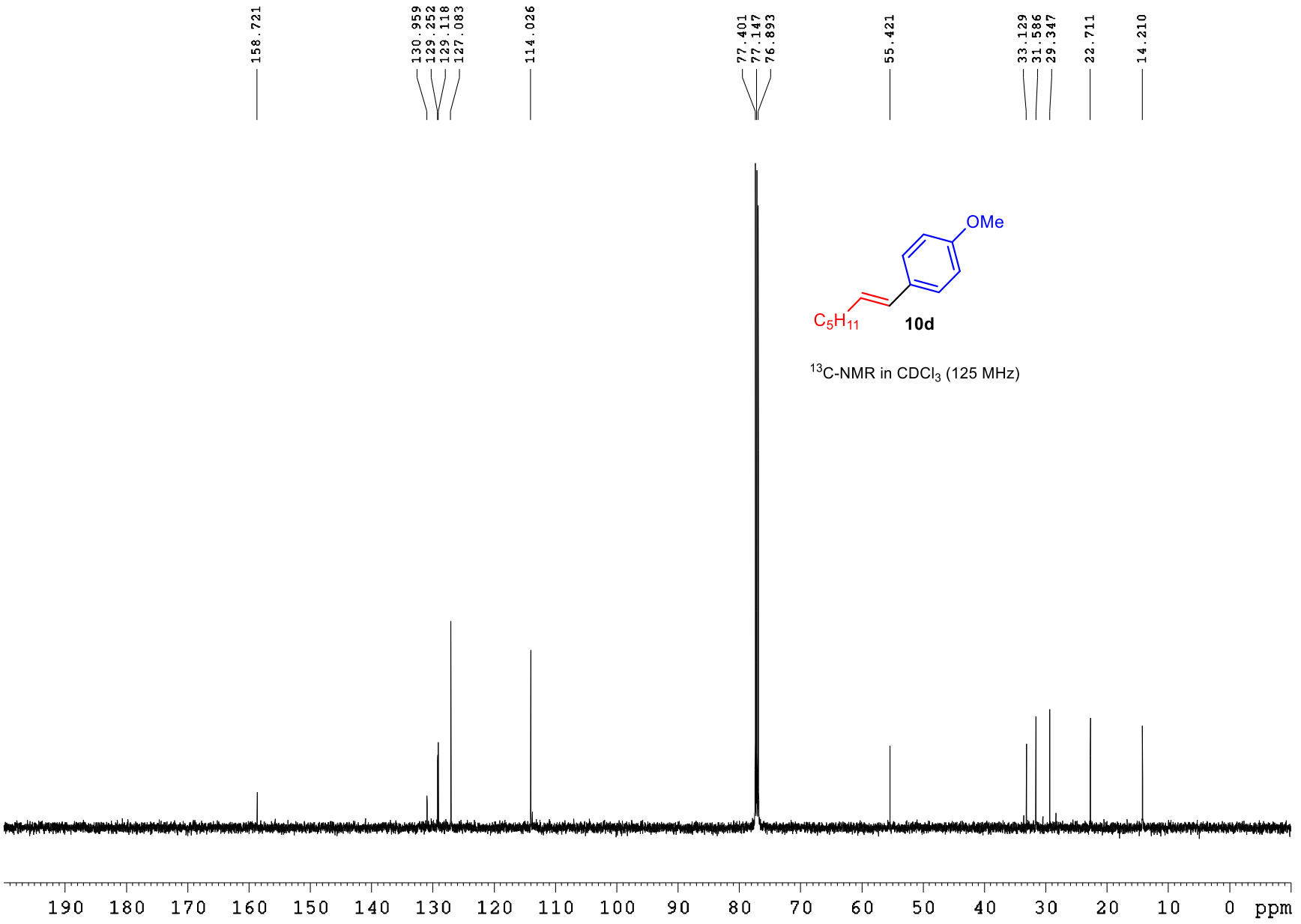


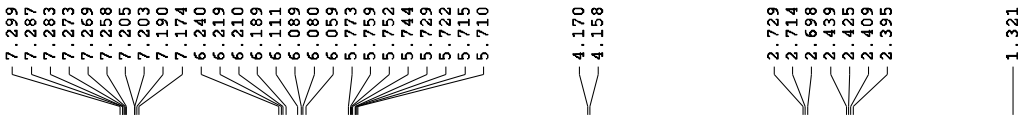
^{13}C-NMR in $CDCl_3$ (125 MHz)

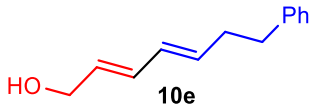


^{1}H-NMR in $CDCl_3$ (500 MHz)



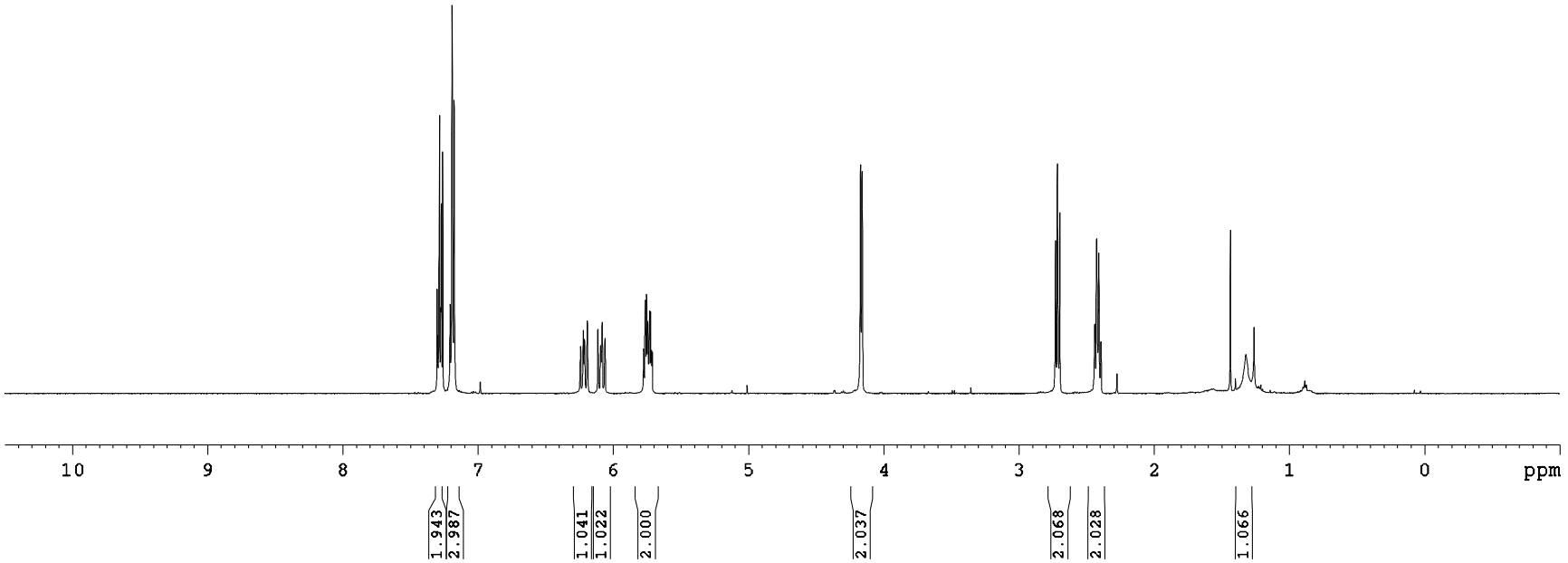

158.721
130.959
129.252
129.118
127.083
114.026
77.401
77.147
76.893
55.421
33.129
31.586
29.347
22.711
14.210
OMe
C5H11
10d
13C-NMR in CDCl3 (125 MHz)
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

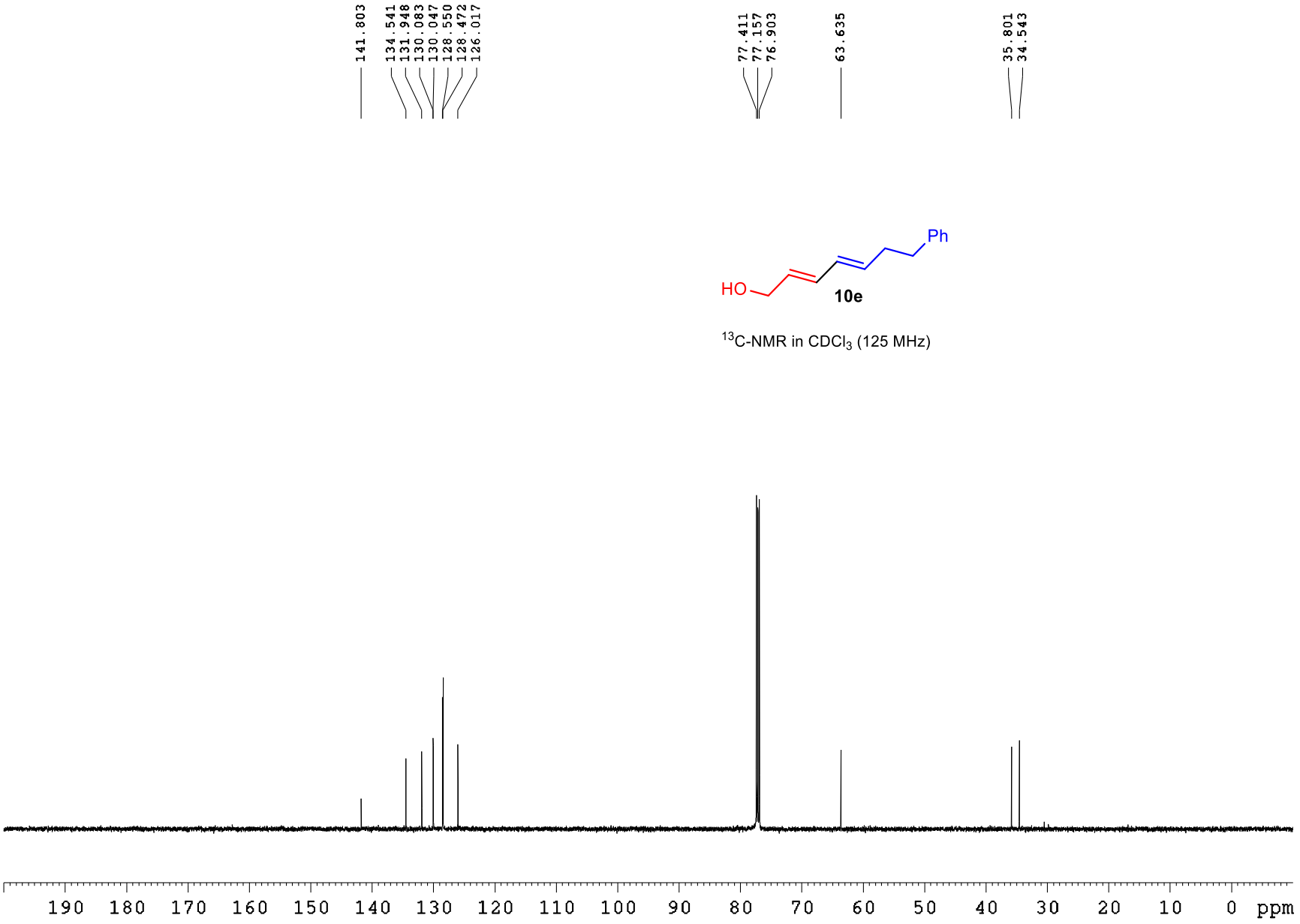




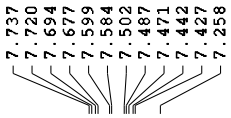
10e

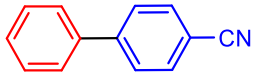
^{1}H-NMR in $CDCl_3$ (500 MHz)





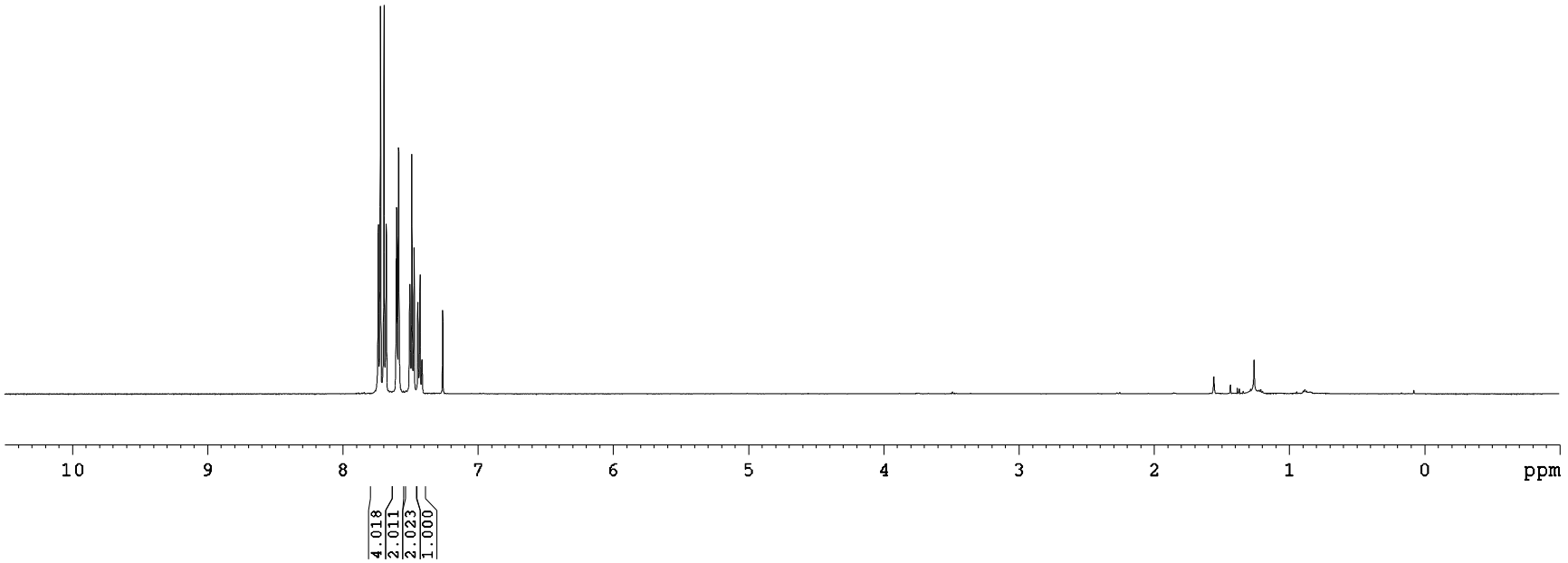
^{13}C-NMR in $CDCl_3$ (125 MHz)

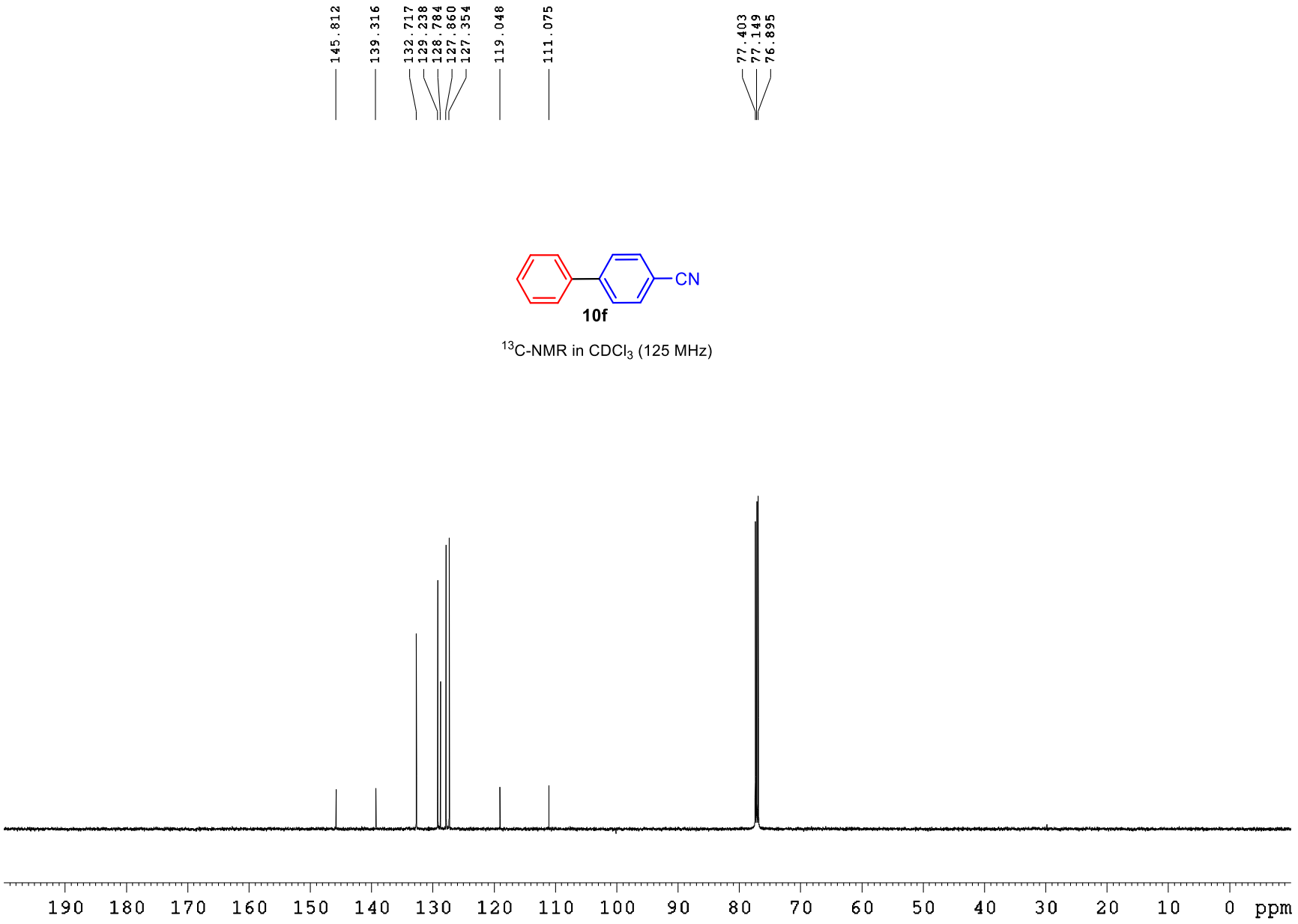




10f

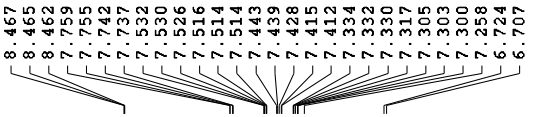
^{1}H-NMR in $CDCl_3$ (500 MHz)

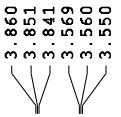


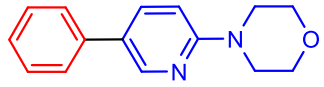


10f

^{13}C-NMR in $CDCl_3$ (125 MHz)

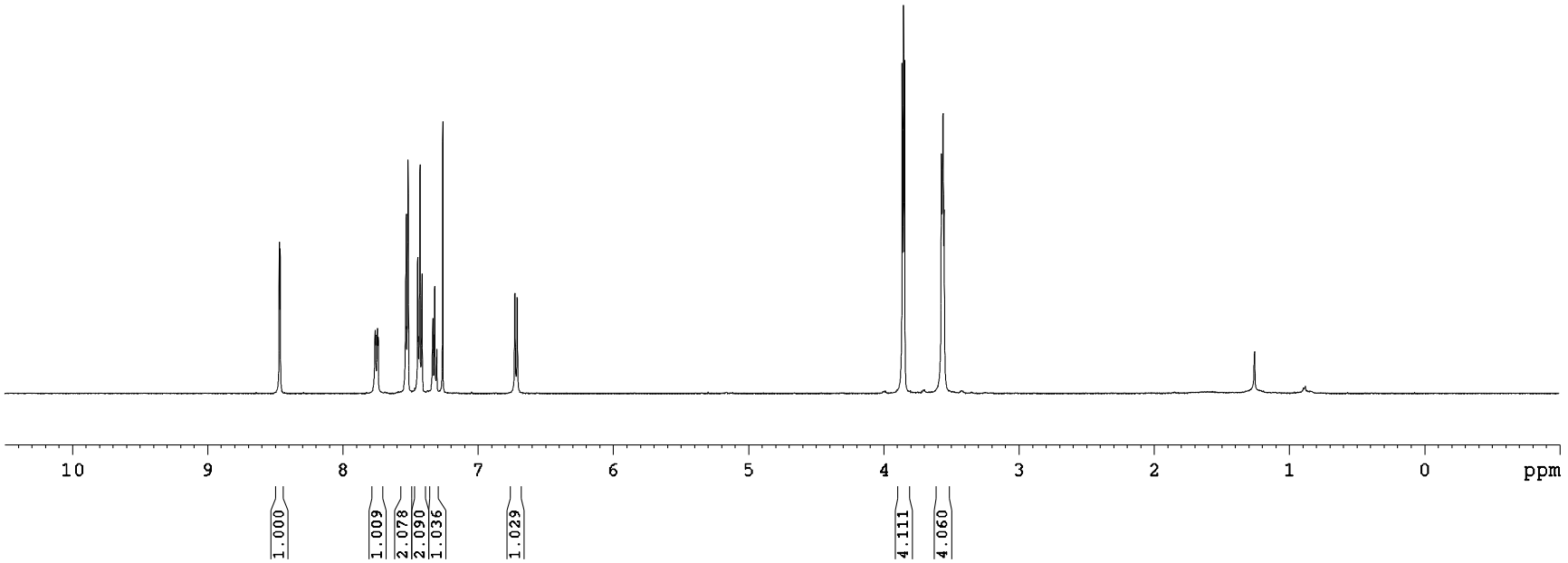


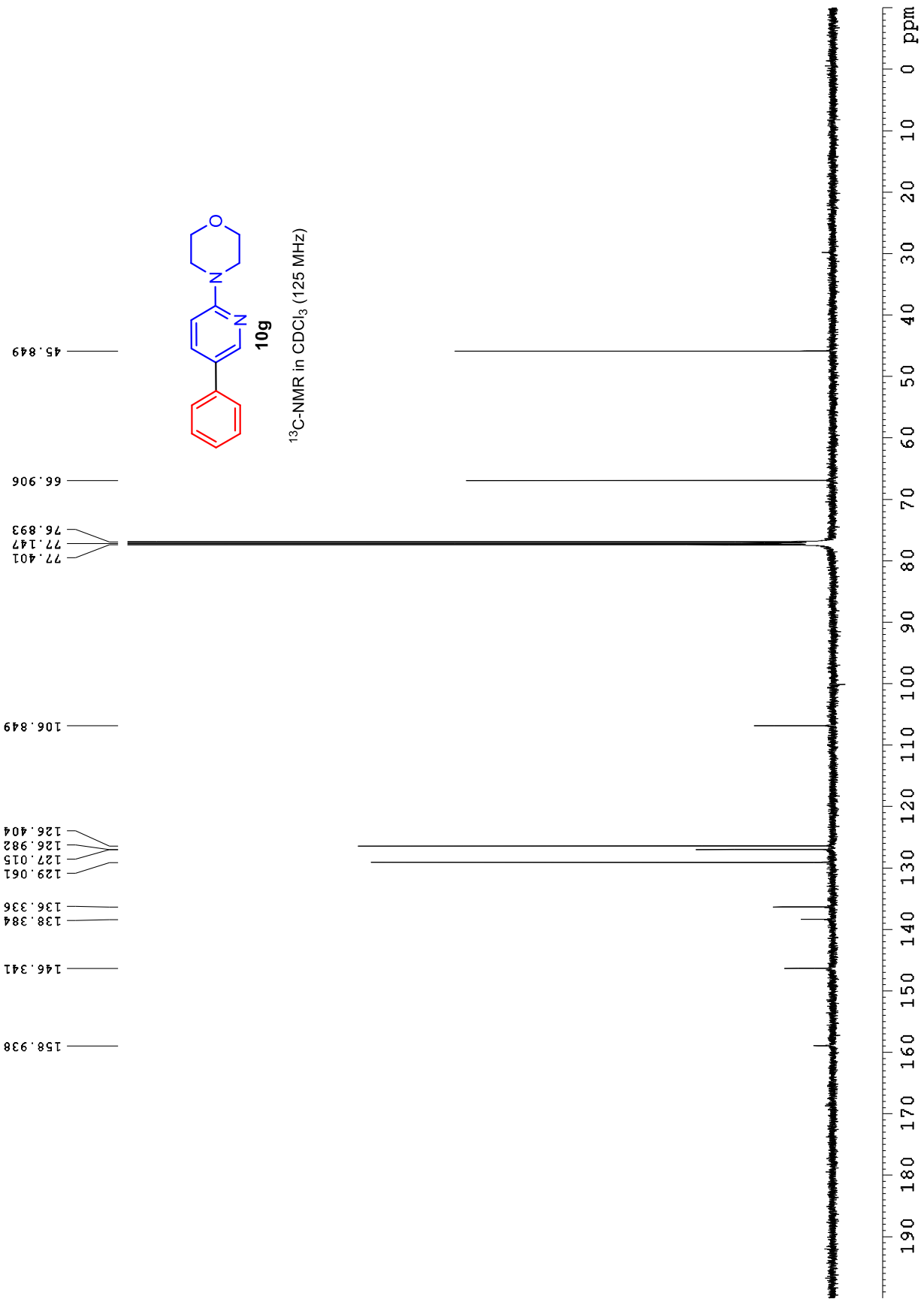


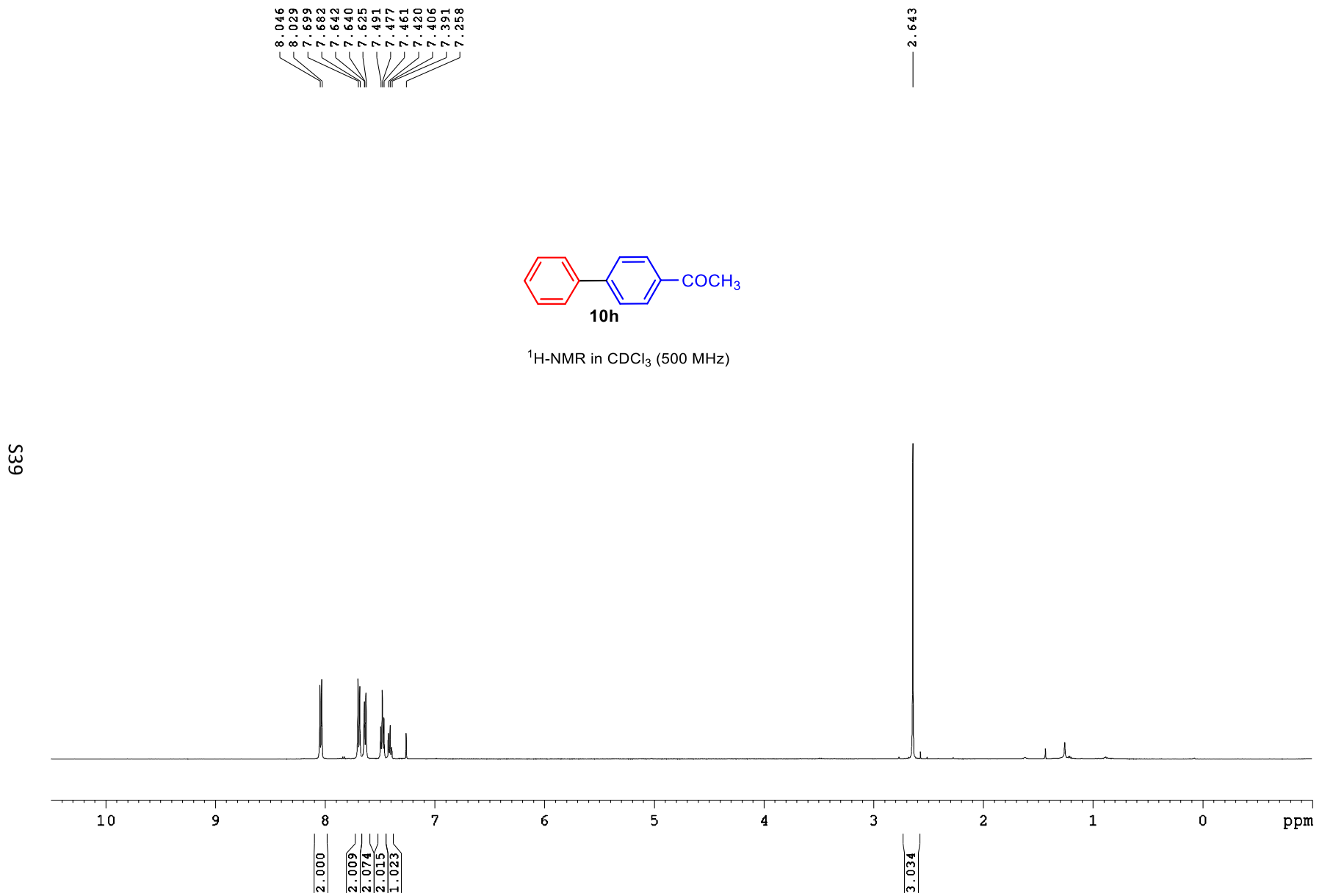


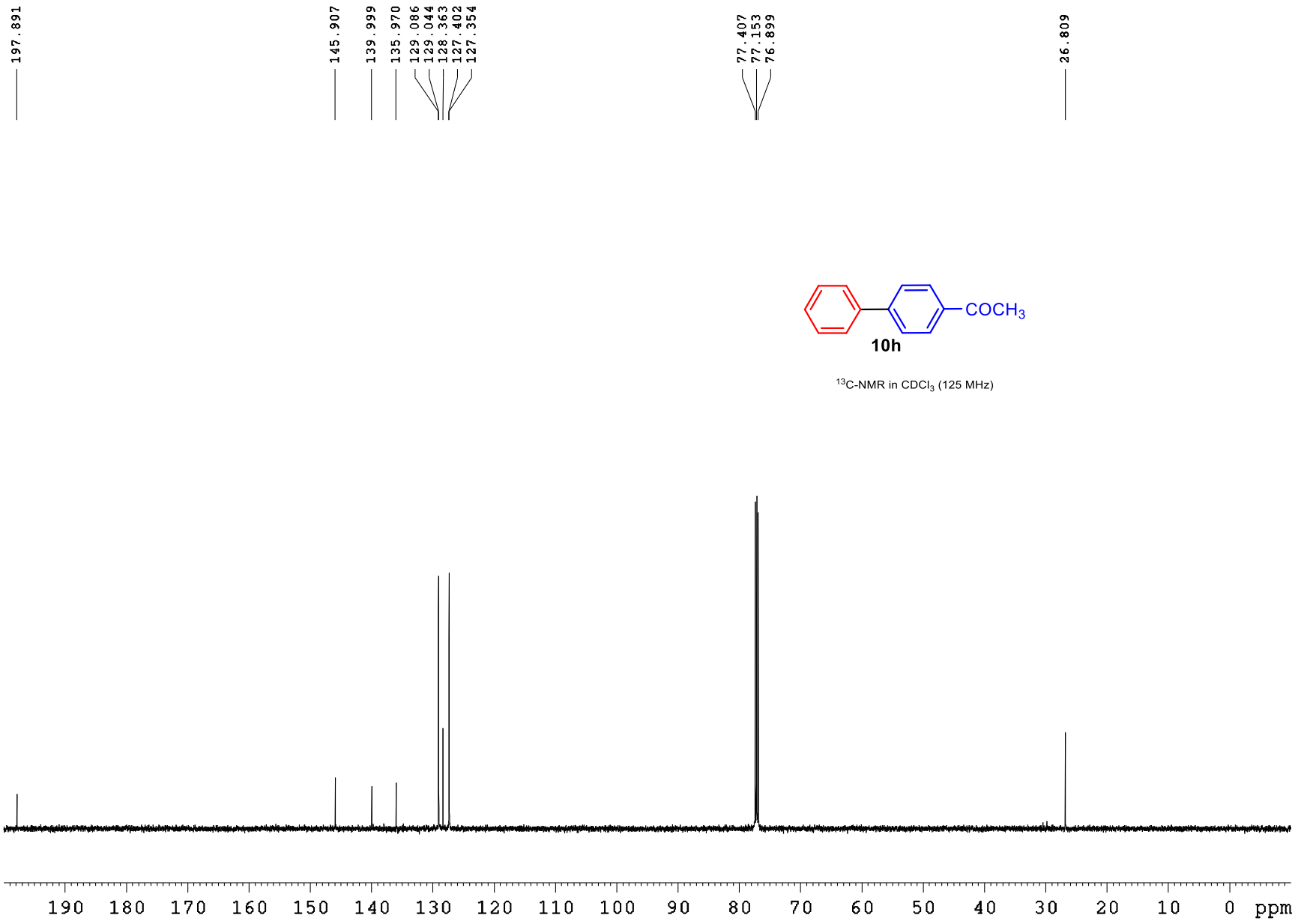
10g

^{1}H-NMR in $CDCl_3$ (500 MHz)




10g
^{13}C-NMR in $CDCl_3$ (125 MHz)
158.938
146.341
138.384
136.336
129.061
127.015
126.982
126.404
106.849
77.401
77.147
76.893
66.906
45.849
ppm


8.046
8.029
7.699
7.682
7.642
7.640
7.625
7.491
7.477
7.461
7.420
7.406
7.391
7.258
2.643
COCH3
10h
1H-NMR in CDCl3 (500 MHz)
10
9
8
7
6
5
4
3
2
1
0
ppm
2.000
2.009
2.074
2.015
1.023
3.034


197.891
145.907
139.999
135.970
129.086
129.044
128.363
127.402
127.354
77.407
77.153
76.899
26.809
COCH3
10h
13C-NMR in CDCl3 (125 MHz)
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm