Electronic Supplementary Material (ESI) for Chemical Science

Experimental Section

Visible-Light-Mediated Photochemistry: Accelerating $Ru(bpy)_3^{2+}$-catalyzed Reactions in Continuous Flow

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1. General Information

All chemicals were reagent grade and used as supplied except where noted. DMF was analysis grade. $Ru(bpy)_3Cl_2•6H_2O$ was obtained from Strem Chemicals or Sigma Aldrich. The term "concentrated under reduced pressure" refers to the removal of solvents and other volatile material using a rotary evaporator while maintaining a water bath temperature under 30 °C. The compounds purified over silica gel were further concentrated by the removal of residual solvent under high vacuum (<0.2 mbar).

^{1}H NMR spectra were recorded on a Varian 400-MR (400 MHz) spectrometer at ambient temperature. The proton signal of residual non-deuterated solvent (δ 7.26 ppm for $CHCl_3$) was used as an internal reference for ^{1}H spectra. Data are reported as follows: chemical shift in parts per million (δ, ppm), multiplicity (s = singlet, bs = broad singlet, d = doublet, t = triplet, q = quartet, qn = quintet and m = multiplet), coupling constants reported in Hertz (Hz) and integration. ^{13}C spectra were recorded on a Varian VXR-300 spectrometer (at 100 MHz) at ambient temperature. Chemical shifts are reported in parts per million (δ, ppm). The carbon signal of deuterated solvent (δ 77.16 ppm for $CDCl_3$) was used as an internal reference for ^{13}C spectra. Infrared (IR) spectra were recorded as thin films on a Perkin-Elmer 1600 FTIR spectrophotometer. High-resolution mass spectra (HRMS) were recorded with an Agilent 6210 ESI-TOF mass spectrometer at the Freie Universität Berlin, Mass Spectrometry Core Facility. The absorption spectrum of $Ru(bpy)_3Cl_2•6H_2O$ was measured with a Shimadzu UVmini-1240 UV-Vis spectrophotometer. The intensity spectrum of the LED lamp was recorded with a photonic multichannel analyzer C10027 (Hamamatsu, Japan). The illuminance of the LED lamps was measured with a VoltCraft MS-1300 luxmeter. Analytical thin layer chromatography (TLC) was performed on Kieselgel 60 F254 glass plates precoated with a 0.25 mm thickness of silica gel. The TLC plates were visualized with UV light and by staining with Hanessian solution (ceric sulfate and ammonium molybdate in aqueous sulfuric acid) or anisaldehyde dip. Column chromatography was perfomed using Kieselgel 60 (230-400 mesh) silica gel.

Continuous Flow Reactor Setup.

The flow reactor setup consisted of two Knauer Smartline® HPLC pumping modules (**1**) equipped with injection loops, [1] an ETFE T-mixer **(2)**, multiple loops of FEP tubing (**3**, fluorinated ethylene polymer from IDEX Health & Science 1520, natural color, outside diameter (OD) 1/16 in and inside diameter (ID) 0.030 in) [2] wrapped tightly around two metal rods, placed between two 17 W PAR 38 cold white LED lamps (**4**, illumination angle 120°, Best-Nr. 574897 - 62 from Conrad), [3] a back-pressure regulator of 6.9 bar (**5**, U-607 from IDEX) [2] and a collection flask **6** (Figure SI-4). The pump system (Knauer) was controlled using ChromGate® software V3.3.2. [4]

FEP tubing was selected for its high transmittance and stability in the UV-vis light range, [5] its flexibility and its high chemical resistance. The temperature in the tube during the reaction is estimated to range from 25 to 30 °C, based on temperature measurements taken between the cooling jacket and the tube. For safety reasons, the experiments were conducted inside a fume hood covered with aluminum foil to partially block the intense irradiation of the lamps.

Figure SI-1.1. Picture of the Flow Reactor Setup

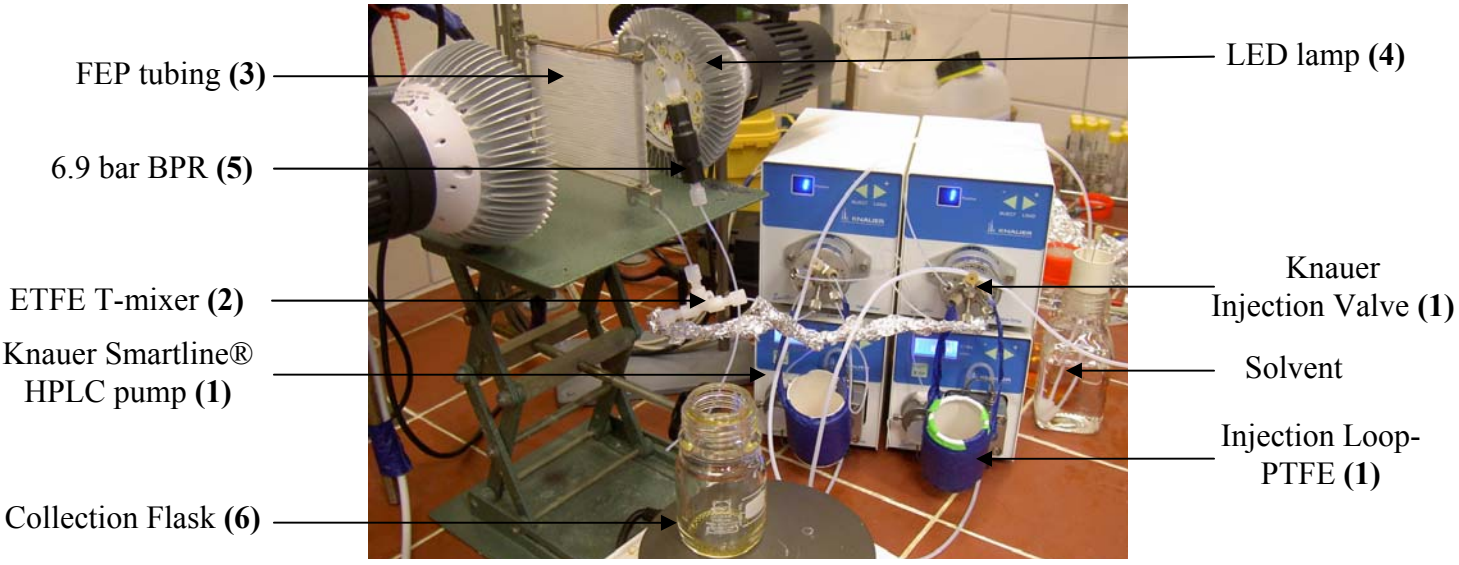


Figure SI-1.2. Picture of the Flow Reactor Setup

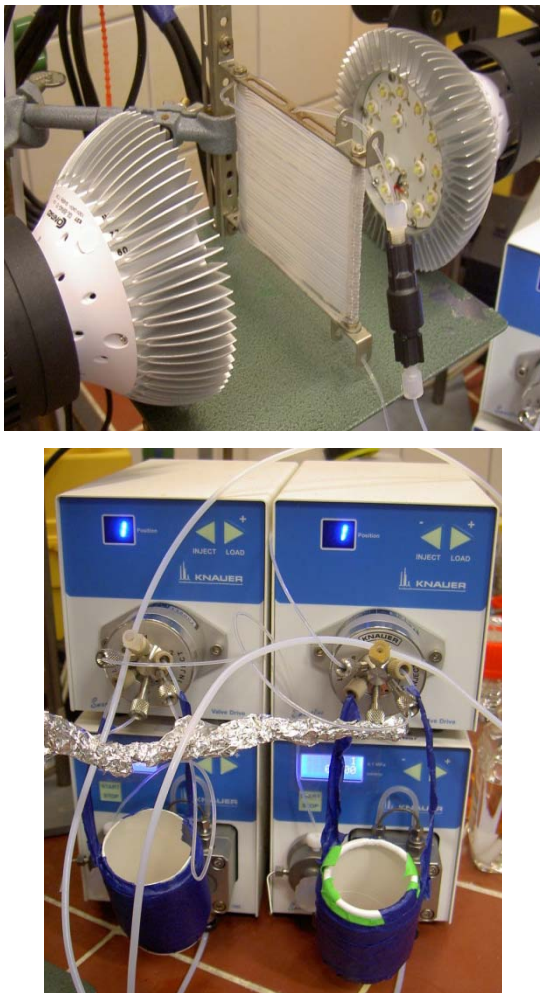


Figure SI-2.1. System Diagram of the Flow Reactor Setup

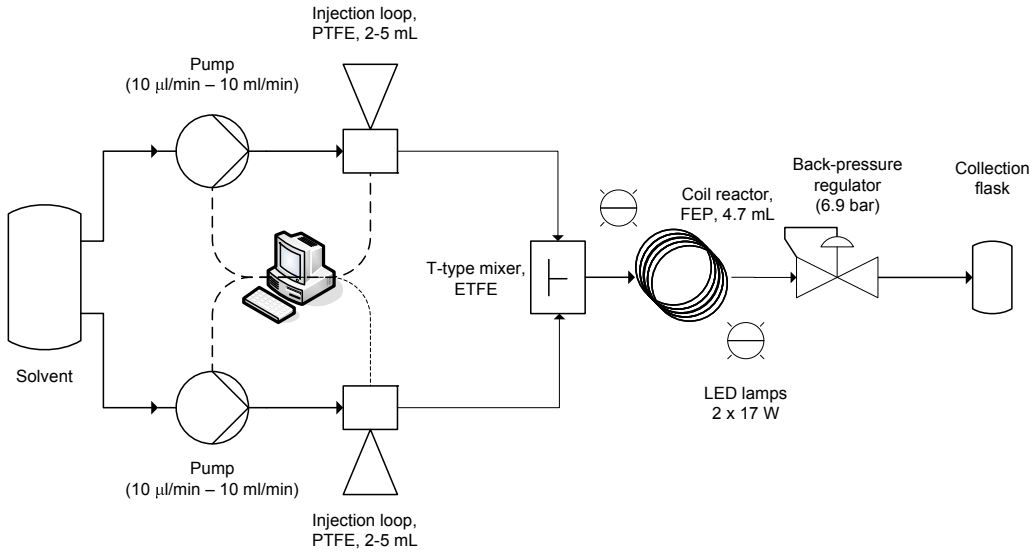
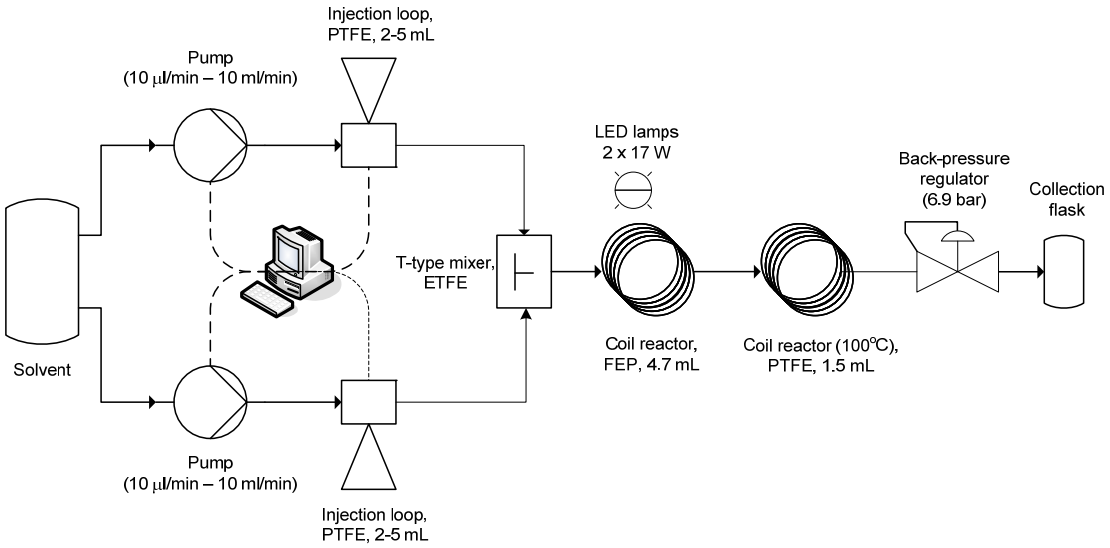


Figure SI-2.2. Modified System Diagram of the Flow Reactor Setup



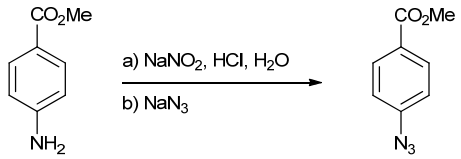
2. Experimental Procedures and Spectroscopic Data

General procedure for the continuous flow photoredox reactions.

The flow reactor system was set up as described in Figure 1. With both pumps set to flow at equal rates, a solution of $Ru(bpy)_3Cl_2 \cdot 6H_2O$ in DMF and another solution of the substrate and reagents in the same solvent were loaded into the reactor *via* the two 2 mL injection loops. The two solutions were then mixed *via* ETFE T-mixer and the middle fraction of the reaction mixture[1] (~1 mL) was collected in a stirred flask containing 1:1 mixture of EtOAc and water or sat. $NaHCO_3$. The organic phase was separated, washed with sat. $NaHCO_3$, brine, dried over Na_2SO_4 and concentrated. Reaction conversion and product ratio were determined by analyzing the ^1H NMR spectrum of the crude product.

To determine the yields of selected reactions, 5 mL loops were used and a specific volume (6 mL) of the middle fraction of the reaction mixture[1] was collected. The organic phase was separated and the aqueous phase extracted with EtOAc (2X). The combined organic phases were washed with sat. $NaHCO_3$, brine, dried over Na_2SO_4 and concentrated. The products were purified by chromatography over silica gel. The yields were then determined based on the theoratical amounts of product in the reaction mixture.[2]

Preparation of Methyl 4-azidobenzoate (1)



2 **1**

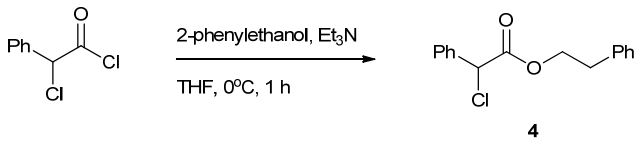
To a solution of methyl 4-aminobenzoate **2** (3.25 g, 21.5 mmol) in aqueous hydrochloric acid (3 M, 120 mL) at 0 °C was added a solution of sodium nitrite (2.82 g, 40.9 mmol, 1.9 eq.) in water (25 mL) dropwise maintaining a temperature below 5 °C. After stirring for 1 h at 0 °C, a solution of sodium azide (2.80 g, 43.0 mmol, 2.0 eq.) in water (50 mL) was added dropwise while maintaining the same low temperature, and the mixture was stirred for an additional 1 h at 0 °C. The resulting suspension was filtered, the residual

[1] Steady state equilibration for systems under continuous flow is generally accepted as being 3-4 times as long as the residence time. However, as this was not practical in our case, we assumed that the middle fraction of a given reaction could be considered as a close approximation to the steady state equilibration.

[2] Theoretical yield (mg) = Substrate conc. (mmol/mL) * Flow rate (mL/min) * Collection time (min) * Mw (mg/mmol)

solid was washed thoroughly with water and dried in the dark under reduced pressure to afford methyl 4-azidobenzoate **1** (3.57 g, 94%) as a light brown solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.03 (d, *J* = 8.5 Hz, 2H), 7.06 (d, *J* = 8.5 Hz, 2H), 3.91 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) □ 166.3, 144.7, 131.4, 126.7, 118.8, 52.1; in agreement with published data. [6]

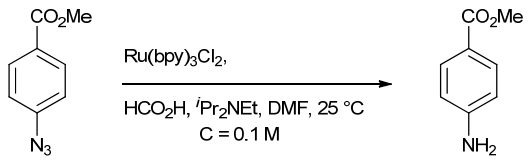
Preparation of 2-phenylethyl-2-chloro-2-phenylacetate (4)



4

To a solution of 2-chloro-2-phenylacetyl chloride (4.0 g, 33.0 mmol, 1.2 equiv.) and Et_3N (3.48 g, 34.4 mmol, 1.25 equiv.) in THF (40 mL) at 0 °C was added 2-chloro-2-phenylacetyl chloride (5.2 g, 27.5 mmol, 1 equiv.) dropwise maintaining a temperature below 5 °C. The reaction mixture was stirred for 1 h at 0 °C then quenched by the addition of water and extracted with EtOAc (3X). The combined organic phases were washed with sat. $NaHCO_3$, brine, dried over Na_2SO_4 and concentrated to afford 2-phenylethyl-2-chloro-2-phenylacetate **4** (7.4 g, 98%) as a light brown solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.47 – 7.41 (m, 2H), 7.38 – 7.33 (m, 3H), 7.28 – 7.20 (m, 3H), 7.12 – 7.08 (m, 2H), 5.33 (s, 1H), 4.39 (dt, *J* = 15.0, 7.0 Hz, 1H), 4.37 (dt, *J* = 15.0, 7.0 Hz, 1H), 2.91 (t, *J* = 7.0 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 168.3, 137.3, 135.8, 129.3, 129.0, 128.9, 128.6, 128.0, 126.7, 66.9, 59.2, 34.9; IR-thin film (ν, cm^{-1}) 3064, 3031, 3004, 3963, 2879, 1750, 1600, 1496, 1454, 1280, 1155, 973, 728, 696; HRMS–ESI: M+Na, calc. 297.0658, meas. 297.0655.

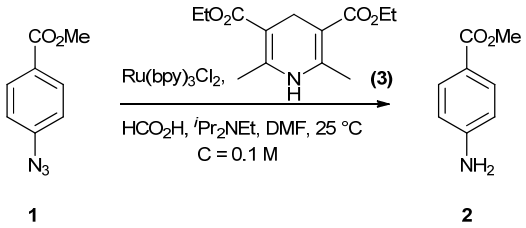
Visible-Light-Mediated Reduction of Methyl 4-azidobenzoate (1)



1 **2**

A solution of methyl 4-azidobenzoate **1** (0.266 g, 1.5 mmol) HCO_2H (0.69 g, 15 mmol, 10 equiv.) and $^{i}Pr_2NEt$ (1.94 g, 15 mmol, 10 equiv.) in 6.5 mL of DMF and another solution of $Ru(bpy)_3Cl_2•6H_2O$ (11.3 mg, 0.015 mmol, 1 mol %) in 7.5 mL of DMF were loaded into the injection loops and the reaction was performed according to the general procedure (Flow rate 0.236 mL/min, residence time 20 min, total concentration after mixing is 0.1 M). The crude product (obtained by collecting 6 mL of the reaction mixture) was purified over silica gel (25% EtOAc/hexanes) to afford methyl 4-aminobenzoate **1** (80 mg, 89%) as a light brown solid.^{1}H NMR (400 MHz, $CDCl_3$) δ 7.84 (d, J = 8.7 Hz, 2H), 6.62 (d, J = 8.7 Hz, 2H), 4.10 (bs, 2H), 3.84 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.3, 151.0, 131.7, 119.7, 113.9, 51.7; IR-thin film (ν, cm^{-1}) 3409, 3339, 3229, 3031, 2988, 2945, 2846, 1683, 1635, 1598, 1515, 1434, 1298, 1175, 1118, 850, 768; HRMS–ESI: M+Na, calc. 174.0531, meas. 174.0531.

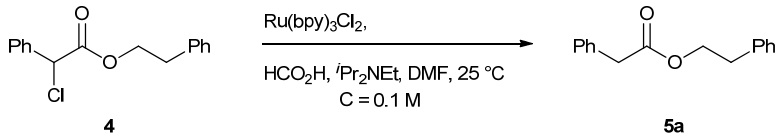
Visible-Light-Mediated Reduction of Methyl 4-azidobenzoate (1)



A solution of methyl 4-azidobenzoate **1** (0.266 g, 1.5 mmol) HCO_2H (0.69 g, 15 mmol, 10 equiv.), $^{i}Pr_2NEt$ (1.94 g, 15 mmol, 10 equiv.) and Hantzsch ester **3** (0.456 g, 1.8 mmol, 1.2 equiv.) in 6.2 mL of DMF and another solution of $Ru(bpy)_3Cl_2•6H_2O$ (11.3 mg, 0.015 mmol, 1 mol %) in 7.5 mL of DMF were loaded into the injection loops and the reaction was performed according to the general procedure (Flow rate 2.36 mL/min, residence time 2 min, total concentration after mixing is 0.1 M). The crude product (obtained by collecting 6 mL of the reaction mixture) was purified over silica gel (25% EtOAc/hexanes) to afford methyl 4-aminobenzoate[3] **1** (80 mg, 89%) as a light brown solid.

Visible-Light-Mediated Reduction of 2-phenylethyl-2-chloro-2-phenylacetate (4)

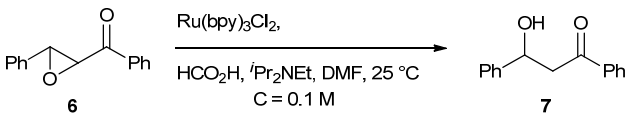
[3] The product was contaminated with around 55 mg of unreacted Hantzsch ester **3**.



4 **5a**

A solution of 2-phenylethyl-2-chloro-2-phenylacetate **4** (0.412 g, 1.5 mmol) HCO_2H (0.69 g, 15 mmol, 10 equiv.) and $^{i}Pr_2NEt$ (1.94 g, 15 mmol, 10 equiv.) in 6.2 mL of DMF and another solution of $Ru(bpy)_3Cl_2$•$6H_2O$ (11.3 mg, 0.015 mmol, 1 mol %) in 7.5 mL of DMF were loaded into the injection loops and the reaction was performed according to the general procedure (Flow rate 0.160 mL/min, residence time 30 min, total concentration after mixing is 0.1 M). The crude product (obtained by collecting 6 mL of the reaction mixture) was purified over silica gel (2% EtOAc/hexanes) to afford 2-phenylethyl-2-chloro-2-phenylacetate **5a** (118 mg, 82%) as a cololess oil.^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35 – 7.19 (m, 8H), 7.18 – 7.13 (m, 2H), 4.31 (t, J = 7.0 Hz, 2H), 3.60 (s, 2H), 2.92 (t, J = 7.0 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.6, 137.8, 134.1, 129.4, 129.0, 128.6, 128.6, 127.2, 126.6, 65.4, 41.5, 35.2; IR-thin film (ν, cm^{-1}) 3087, 3064, 3030, 2957, 1732, 1604, 1585, 1497, 1454, 1245, 1147, 1000, 695; HRMS–ESI: M+Na, calc. 263.1048, meas. 263.1044.

Visible-Light-Mediated Reduction of α,β-epoxychalcone (6)

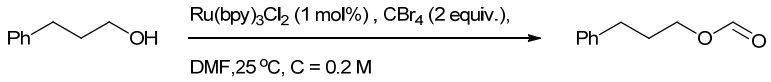


6 **7**

A solution of α,β-epoxychalcone **6** (0.336 g, 1.5 mmol) HCO_2H (0.69 g, 15 mmol, 10 equiv.) and $^{i}Pr_2NEt$ (1.94 g, 15 mmol, 10 equiv.) in 6.2 mL of DMF and another solution of $Ru(bpy)_3Cl_2$•$6H_2O$ (11.3 mg, 0.015 mmol, 1 mol %) in 7.5 mL of DMF were loaded into the injection loops and the reaction was performed according to the general procedure (Flow rate 0.47 mL/min, residence time 10 min, total concentration after mixing is 0.1 M). The crude product (obtained by collecting 6 mL of the reaction mixture) was purified over silica gel (14% EtOAc/hexanes) to afford alcohol **7** (114 mg, 84%) as a cololess oil.^{1}H NMR (400 MHz, $CDCl_3$) δ 7.98 – 7.94 (m, 2H), 7.62 – 7.56 (m, 1H), 7.50 – 7.28 (m, 7H), 5.36 (td, J = 6.0, 3.0 Hz, 1H), 3.59 (dd, J = 3.0, 0.5 Hz, 1H), 3.38 (dd, J = 6.0, 0.5 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 143.1, 136.6, 133.6, 128.7, 128.6, 128.2, 127.7, 125.8, 70.0, 47.5; IR-thin film (ν, cm^{-1}) 3456 (b), 3086,

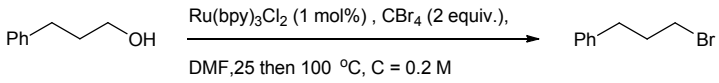
3062, 3031, 2902, 1675, 1597, 1580, 1448, 1357, 1203, 1020, 747, 688; HRMS–ESI: M+Na, calc. 249.0891, meas. 249.0886.

Visible-Light-Mediated Protection of 3-Phenylpropanol



A solution of 3-phenylpropanol (0.410 g, 3.0 mmol) and CBr_4 (2.0 g, 6.0 mmol, 2 equiv.) in 6.8 mL of degassed anhydrous DMF[4] and another solution of $Ru(bpy)_3Cl_2 \cdot 6H_2O$ (22.4 mg, 0.030 mmol, 1 mol %) in 7.5 mL of degassed anhydrous DMF were loaded into the injection loops and the reaction was performed according to the general procedure (Flow rate 0.160 mL/min, residence time 30 min, total concentration after mixing is 0.2 M). The crude product (obtained by collecting 6 mL of the reaction mixture) was purified over silica gel (5-10% EtOAc/hexanes) to afford the corresponding formate ester (160 mg, 81%) as a colorless oil.^{1}H NMR (400 MHz, $CDCl_3$) δ 8.09 (s, 1H), 7.34 – 7.28 (m, 2H), 7.25 – 7.18 (m, 3H), 4.20 (td, J = 6.5, 0.6 Hz, 2H), 2.72 (t, J = 7.5 Hz, 2H), 2.06 – 1.93 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 161.1, 140.9, 128.5, 128.4, 126.1, 63.2, 32.0, 30.1; IR-thin film (ν, cm^{-1}) 3087, 3063, 3028, 2931, 2862, 1720, 1604, 1497, 1454, 1160, 744, 698; HRMS–ESI: M+Na, calc. 187.0735, meas. 187.0735.

Visible-Light-Mediated Bromination of 3-Phenylpropanol

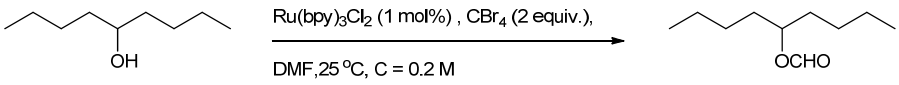


A solution of 3-phenylpropanol (0.410 g, 3.0 mmol) and CBr_4 (2.0 g, 6.0 mmol, 2 equiv.) in 6.8 mL of degassed anhydrous DMF[4] and another solution of $Ru(bpy)_3Cl_2 \cdot 6H_2O$ (22.4 mg, 0.030 mmol, 1 mol %) in 7.5 mL of degassed anhydrous DMF were loaded into the injection loops and the reaction was performed according to the general procedure (Flow rate 0.200 mL/min, residence time 23.5 min at 25°C and 7.5 min at 100°C, total concentration after mixing is 0.2 M). The crude product (obtained by collecting 6 mL of the reaction mixture) was purified over silica gel (5-10% EtOAc/hexanes) to afford the corresponding bromide

[4] DMF was degassed by pumping under vacuum for around 30 min.

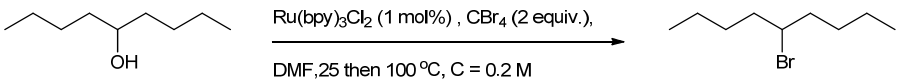
(200 mg, 84%) as a colorless oil.^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35 – 7.29 (m, 2H), 7.25 – 7.20 (m, 3H), 3.41 (t, *J* = 6.5 Hz, 2H), 2.80 (t, *J* = 7.5 Hz, 2H), 2.23 – 2.14 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 140.5, 128.6, 128.5, 126.2, 34.2, 34.0, 33.1; IR-thin film (ν, cm^{-1}) 3085, 3063, 3027, 2939, 2857, 1604, 1496, 1453, 1271, 1241, 743, 698; LRMS–EI: M+, calc. 198.0, meas. 197.9.

Visible-Light-Mediated Protection of 5-Nonanol



A solution of 5-nonanol (0.435 g, 3.0 mmol) and CBr_4 (2.0 g, 6.0 mmol, 2 equiv.) in 6.8 mL of degassed anhydrous DMF[4] and another solution of $Ru(bpy)_3Cl_2$•$6H_2O$ (22.4 mg, 0.030 mmol, 1 mol %) in 7.5 mL of degassed anhydrous DMF were loaded into the injection loops and the reaction was performed according to the general procedure (Flow rate 0.160 mL/min, residence time 30 min, total concentration after mixing is 0.2 M). The crude product (obtained by collecting 6 mL of the reaction mixture) was purified over silica gel (5-10% EtOAc/hexanes) to afford the corresponding formate ester (187 mg, 90%) as a colorless oil.^{1}H NMR (400 MHz, $CDCl_3$) δ 8.08 (s, 1H), 5.00 – 4.95 (q, *J* = 6.5 Hz, 1H), 1.61 – 1.50 (m, 4H), 1.37 – 1.21 (m, 8H), 0.92 – 0.84 (m, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 161.2, 74.6, 33.9, 27.5, 22.7, 14.1; IR-thin film (ν, cm^{-1}) 2958, 2933, 2874, 2963, 1722, 1467, 1379, 1177, 1119, 960, 758; HRMS–ESI: M+Na, calc. 195.1361, meas. 195.1361.

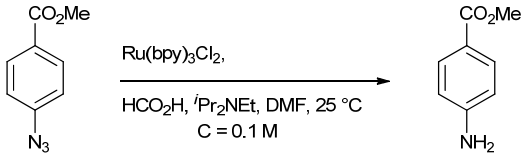
Visible-Light-Mediated Bromination of 5-Nonanol



A solution of 3-phenylpropanol (0.435 g, 3.0 mmol) and CBr_4 (2.0 g, 6.0 mmol, 2 equiv.) in 6.8 mL of degassed anhydrous DMF[4] and another solution of $Ru(bpy)_3Cl_2$•$6H_2O$ (22.4 mg, 0.030 mmol, 1 mol %) in 7.5 mL of degassed anhydrous DMF were loaded into the injection loops and the reaction was performed according to the general procedure (Flow rate 0.200 mL/min, residence time 23.5 min at 25°C and 7.5 min at 100°C, total concentration after mixing is 0.2 M). The crude product (obtained by collecting 6 mL of the

reaction mixture) was purified over silica gel (hexanes) to afford the corresponding bromide[5] (370 mg, estimated yield based on the NMR of the crude reaction mixture >80%) as a colorless oil.^{1}H NMR (400 MHz, $CDCl_3$) δ 4.07 – 3.98 (m, 1H), 1.89 – 1.74 (m, 4H), 1.59 – 1.22 (m, 8H), 0.91 (t, J = 7.0 Hz, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 59.1, 39.0, 29.9, 22.3, 14.1; IR-thin film (ν, cm^{-1}) 2956, 2930, 2872, 2860, 1465, 1432, 1379, 1240, 1182, 936, 731; LRMS–EI: M – Br, calc. 127.1, meas. 127.1.

Visible-Light-Mediated Reduction of Methyl 4-azidobenzoate (1) in a 100 mL Round-Bottom Flask.



1 **2**

To a solution of methyl 4-azidobenzoate **1** (0.532 g, 3.0 mmol) HCO_2H (1.38 g, 30 mmol, 10 equiv.) and $^{i}Pr_2NEt$ (3.92 g, 30 mmol, 10 equiv.) in 25.0 mL of DMF was added $Ru(bpy)_3Cl_2•6H_2O$ (22.4 mg, 0.030 mmol, 1 mol %) and the reaction mixture was irradiated with 2 LED lamps for 4 h. At different time intervals, 1 mL aliquots were taken out of the reaction mixture and quenched in a stirred flask containing 1:1 mixture of EtOAc and sat. $NaHCO_3$. The organic phase was separated, washed with sat. $NaHCO_3$, brine, dried over Na_2SO_4 and concentrated. Reaction conversion and product ratio were determined by analyzing the ^{1}H NMR spectrum of the crude product. The conversion profile is shown in Figure SI.3.

[5] The bromide was contaminated by some inseparable CBr_4.

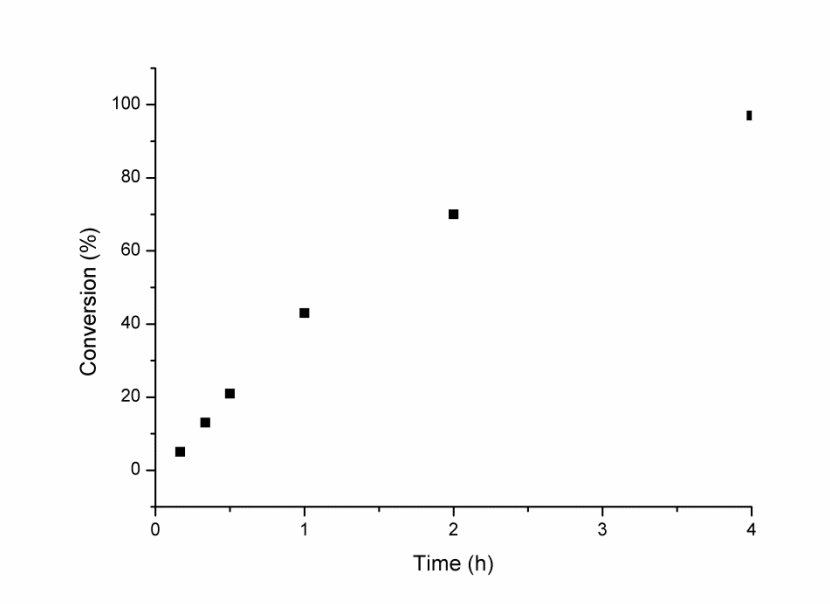
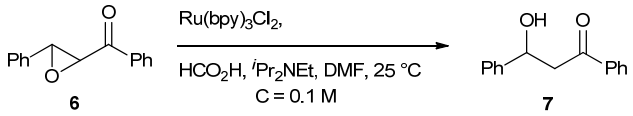


Figure SI.3. Conversion of azide **1** as a function of time.

The remaining reaction mixture (2.4 mmol) was quenched by the addition of sat. $NaHCO_3$ and extracted with EtOAc (3X). The combined organic phases were washed with sat. $NaHCO_3$, brine, dried over Na_2SO_4 and concentrated. The crude product (obtained by collecting 6 mL of the reaction mixture) was purified over silica gel (25% EtOAc/hexanes) to afford methyl 4-aminobenzoate **1** (255 mg, 70%) as a light brown solid.

Visible-Light-Mediated Reduction of α,β-epoxychalcone (6) in a 100 mL Round-Bottom Flask.



To a solution of α,β-epoxychalcone **6** (0.897 g, 4.0 mmol), HCO_2H (1.84 g, 40 mmol, 10 equiv.) and $^{i}Pr_2NEt$ (5.17 g, 40 mmol, 10 equiv.) in 33.0 mL of DMF was added $Ru(bpy)_3Cl_2 \cdot 6H_2O$ (15 mg, 0.020 mmol, 0.5 mol %) and the reaction mixture was irradiated with 2 LED lamps for 4 h. At different time intervals, 1 mL aliquots were taken out of the reaction mixture and quenched in a stirred flask containing 1:1 mixture of EtOAc and sat. $NaHCO_3$. The organic phase was separated, washed with sat. $NaHCO_3$, brine, dried over Na_2SO_4 and concentrated. Reaction conversion was determined by analyzing the ^{1}H NMR spectrum of the crude product. The conversion profile is shown in Figure SI.4.

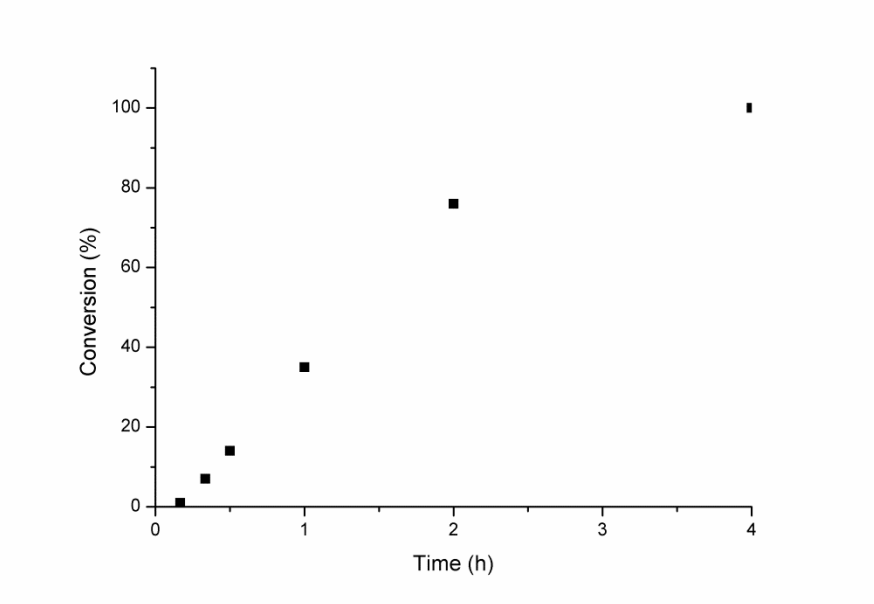
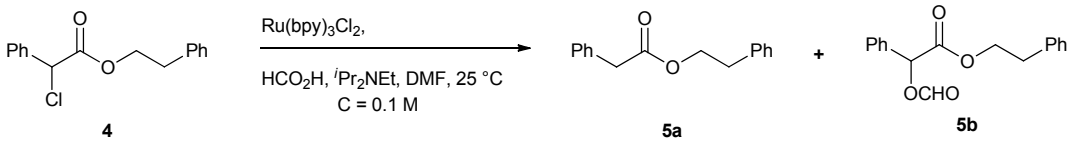


Figure SI.4. Conversion of epoxide **6** as a function of time.

Visible-Light-Mediated Reduction of 2-phenylethyl-2-chloro-2-phenylacetate (4) in a 100 mL Round-Bottom Flask.



To a solution of 2-phenylethyl-2-chloro-2-phenylacetate **4** (1.10 g, 4.0 mmol), HCO_2H (1.84 g, 40 mmol, 10 equiv.) and $^{i}Pr_2NEt$ (5.17 g, 40 mmol, 10 equiv.) in 33.0 mL of DMF was added $Ru(bpy)_3Cl_2 \bullet 6H_2O$ (30 mg, 0.040 mmol, 1 mol %) and the reaction mixture was irradiated with 2 LED lamps for 24 h. At different time intervals, 1 mL aliquots were taken out of the reaction mixture and quenched in a stirred flask containing 1:1 mixture of EtOAc and sat. $NaHCO_3$. The organic phase was separated, washed with sat. $NaHCO_3$, brine, dried over Na_2SO_4 and concentrated. Reaction conversion was determined by analyzing the ^{1}H NMR spectrum of the crude product. The conversion profile is shown in Figure SI.4.

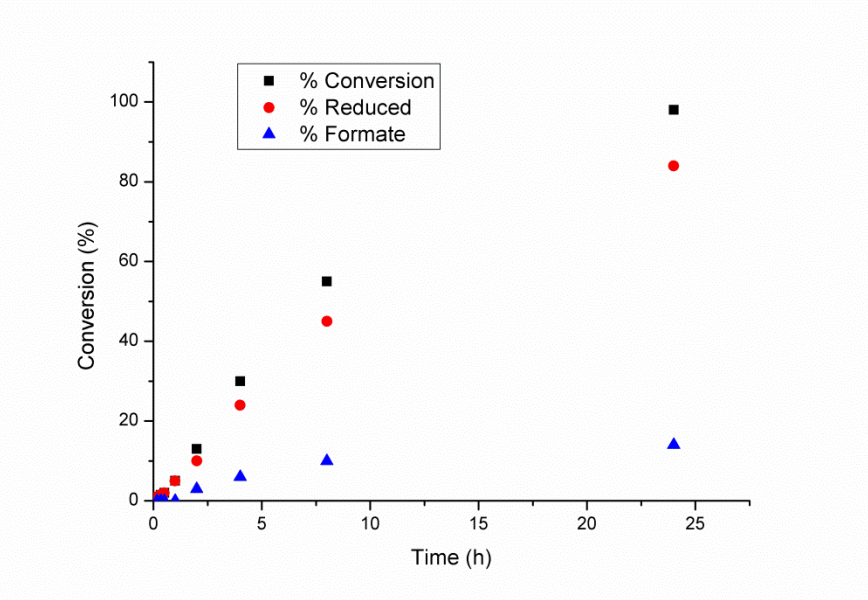
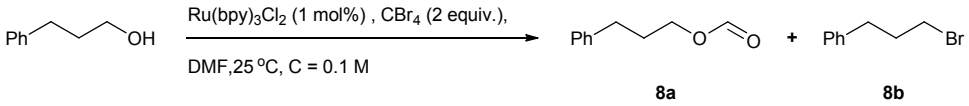


Figure SI.5. Conversion of chloride **4** and the formation of products **5a** and **5b** as a function of time.

Visible-Light-Mediated Bromination of 3-Phenylpropanol in a 100 mL Round-Bottom Flask.



To a solution of 3-phenylpropanol (0.545 g, 4.0 mmol) and CBr_4 (2.65 g, 8.0 mmol, 2 equiv.) in 38.0 mL of degassed anhydrous DMF[4] was added $Ru(bpy)_3Cl_2 \cdot 6H_2O$ (30 mg, 0.040 mmol, 1 mol %) and the reaction mixture was irradiated with 2 LED lamps for 24 h. At different time intervals, 1 mL aliquots were taken out of the reaction mixture and quenched in a stirred flask containing 1:1 mixture of EtOAc and sat. $NaHCO_3$. The organic phase was separated, washed with sat. $NaHCO_3$, brine, dried over Na_2SO_4 and concentrated. Reaction conversion was determined by analyzing the ^1H NMR spectrum of the crude product. The conversion profile is shown in Figure SI.4.

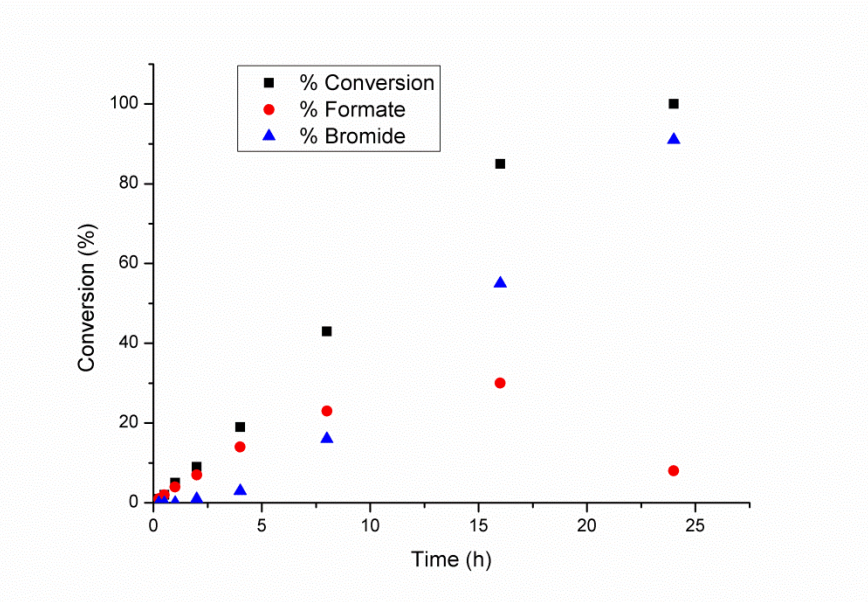
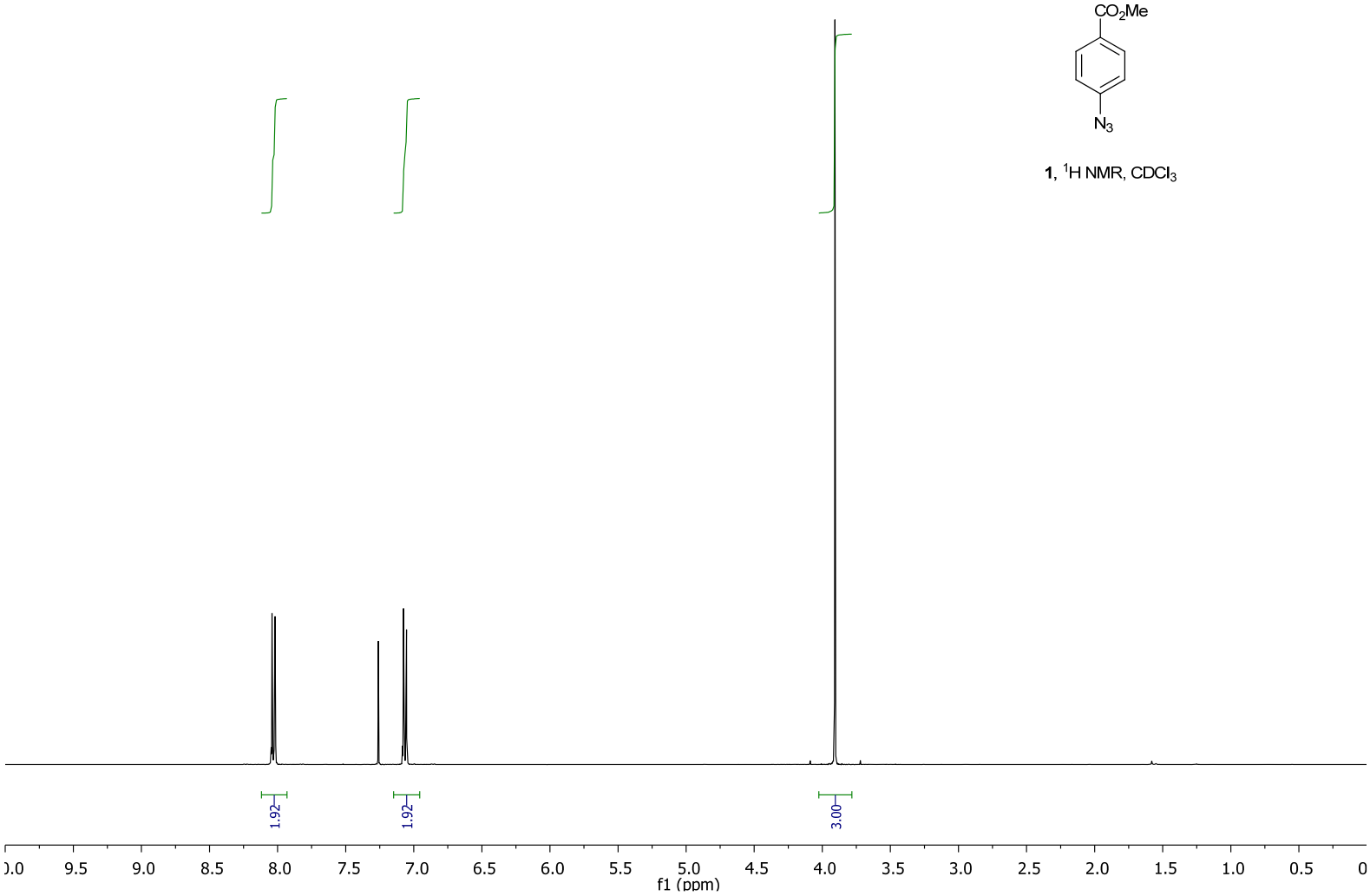
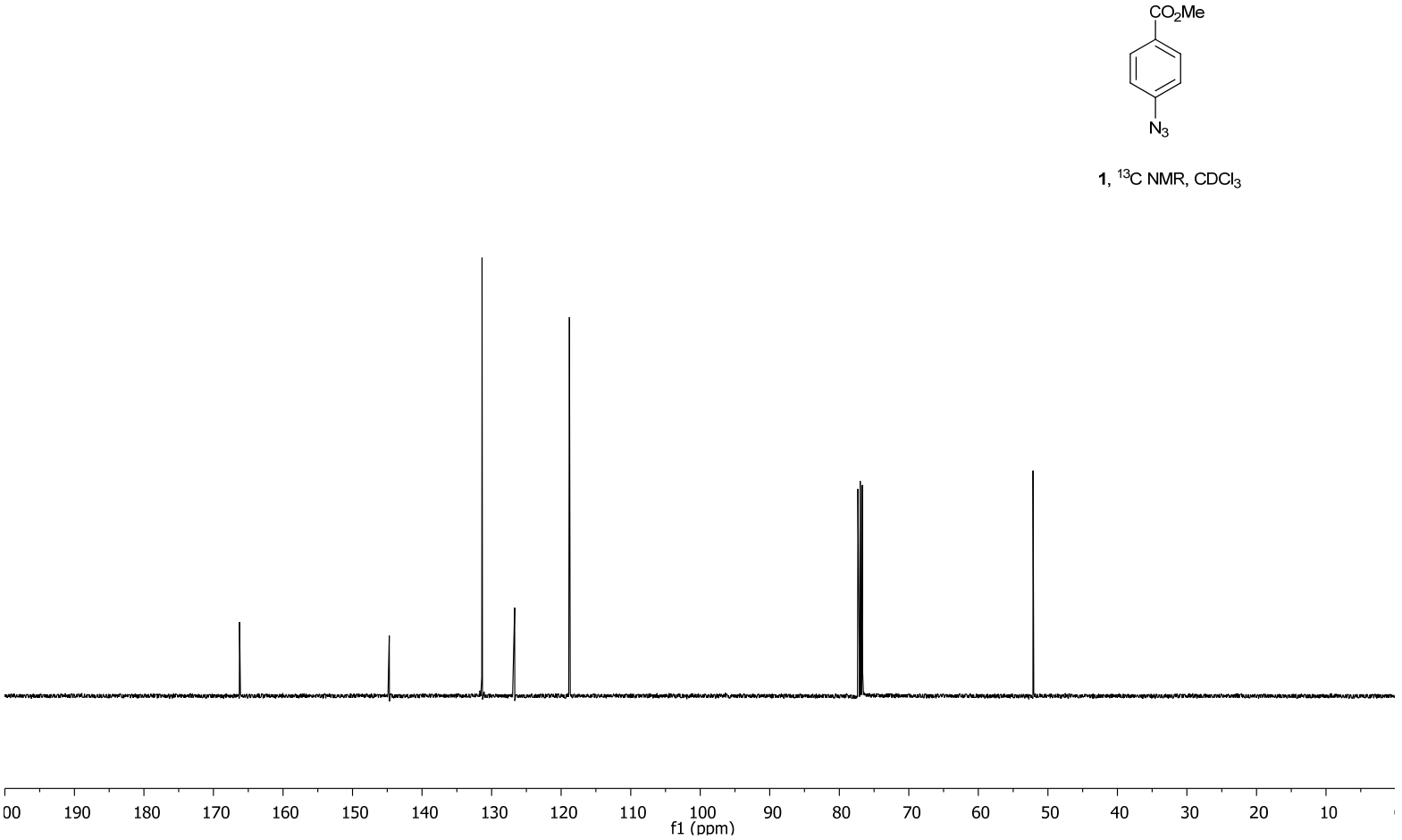
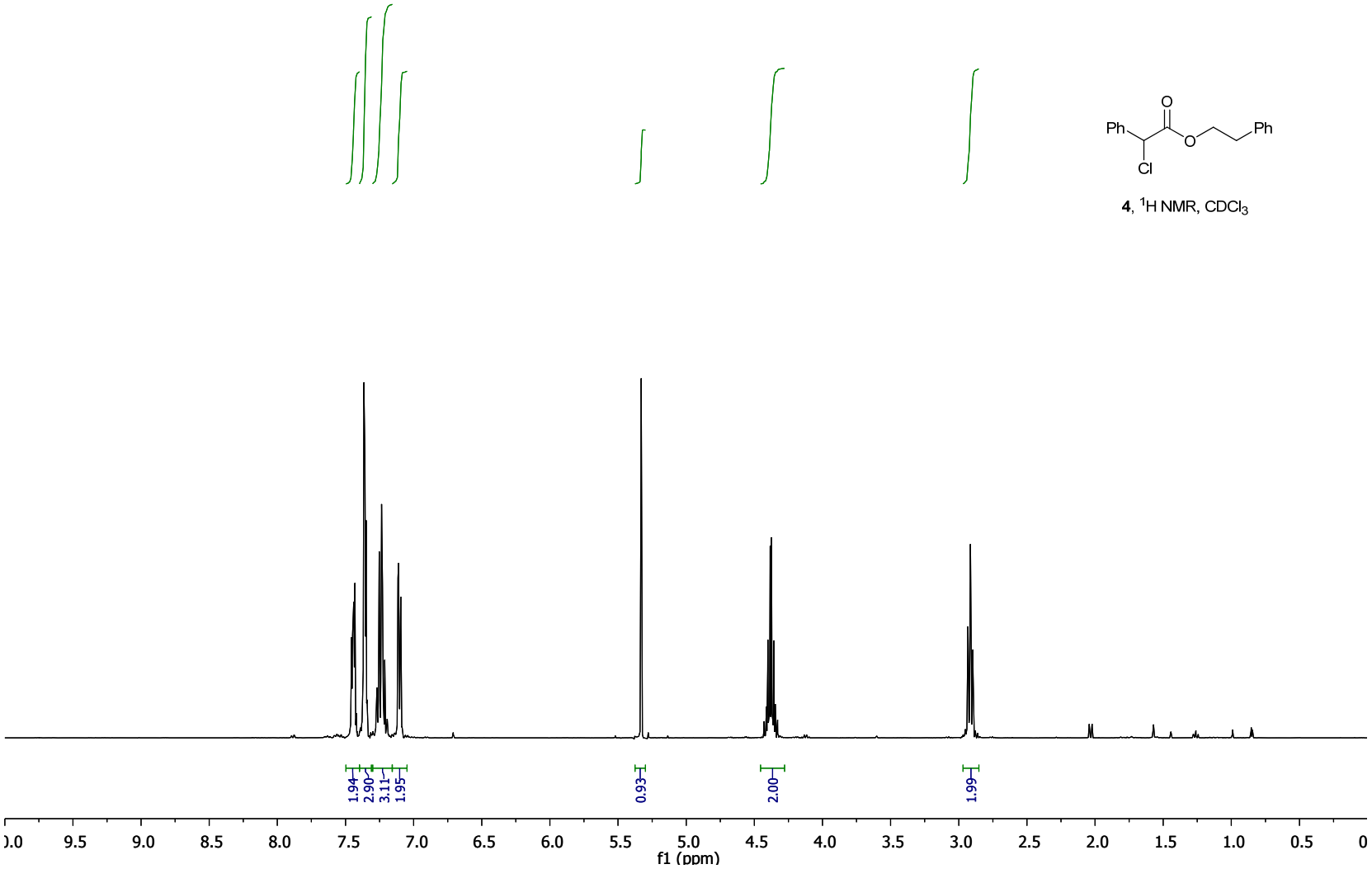


Figure SI.5. Conversion of 3-phenylpropanol and the formation of products **8a** and **8b** as a function of time.

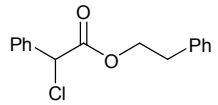
1. ^{1}H and ^{13}C-NMR Data



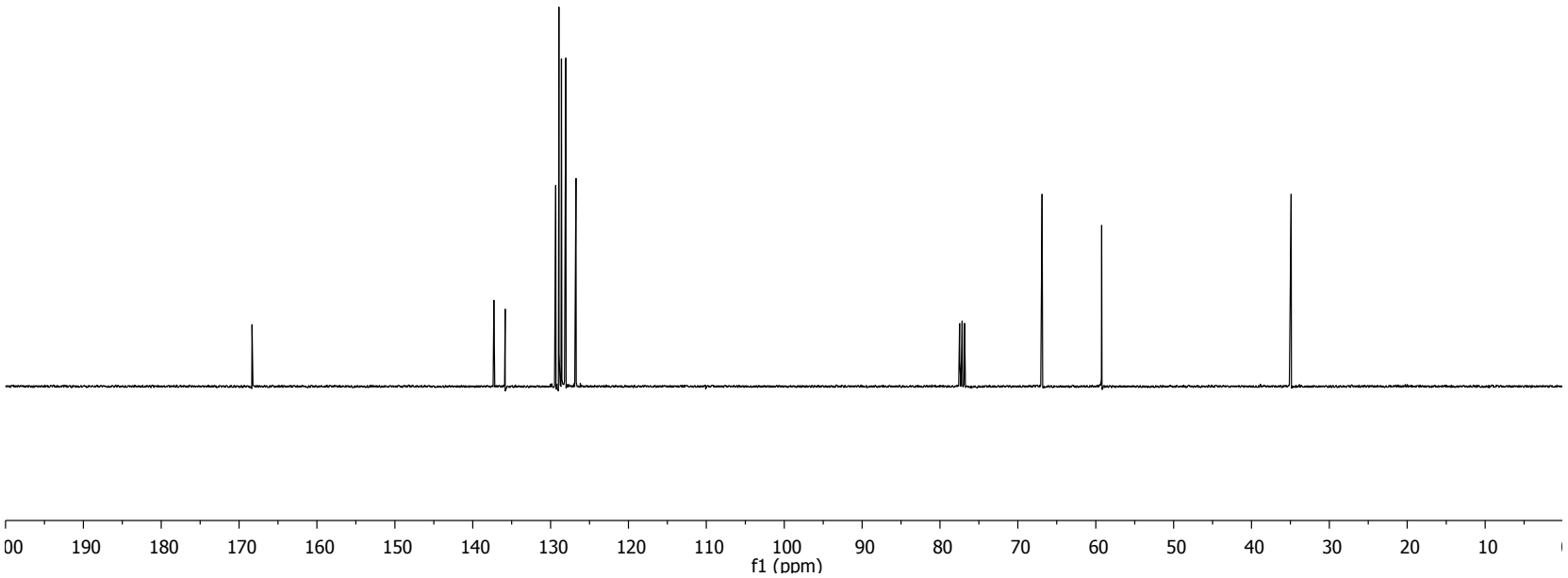


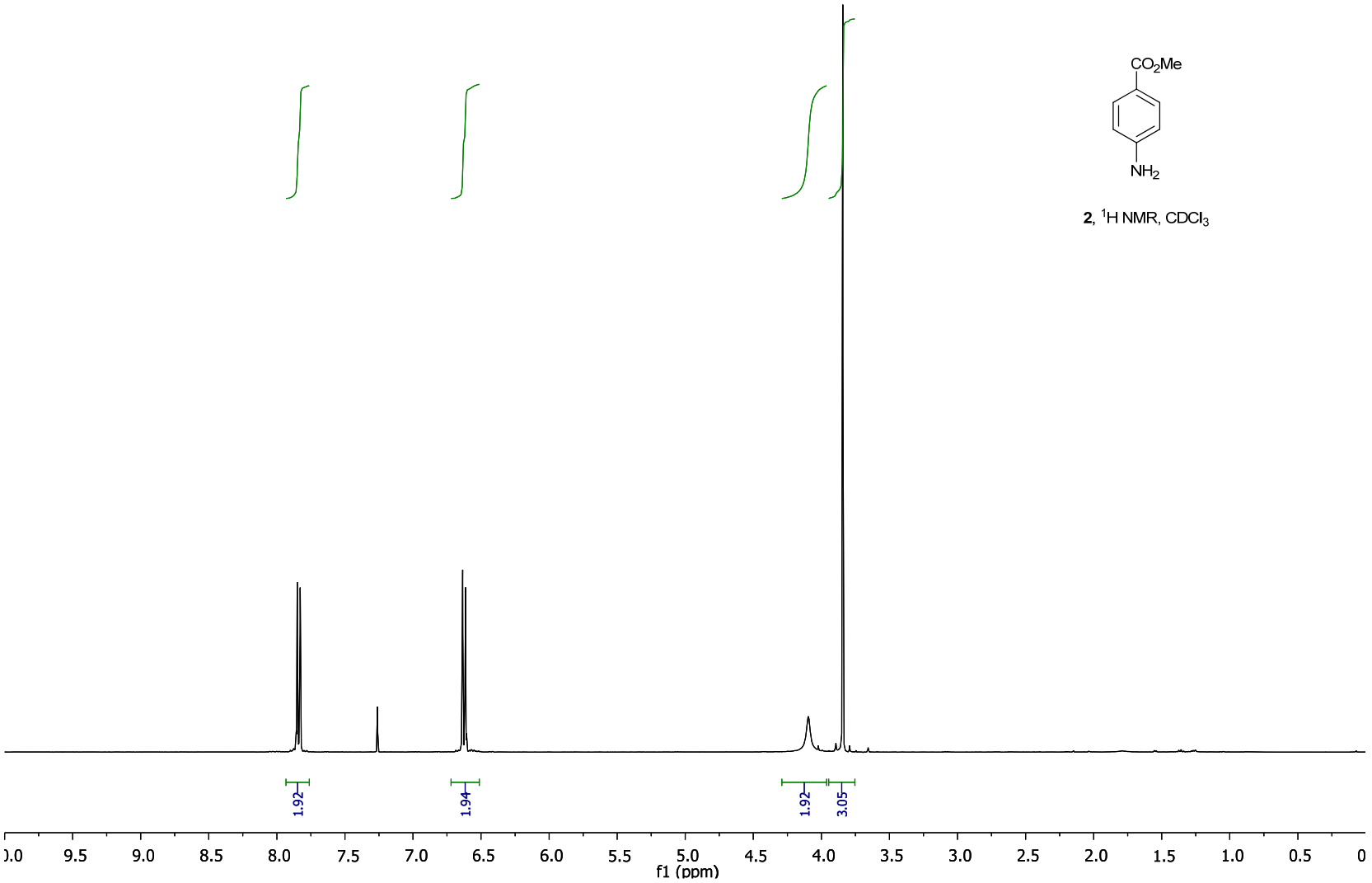


4, ^{1}H NMR, $CDCl_3$

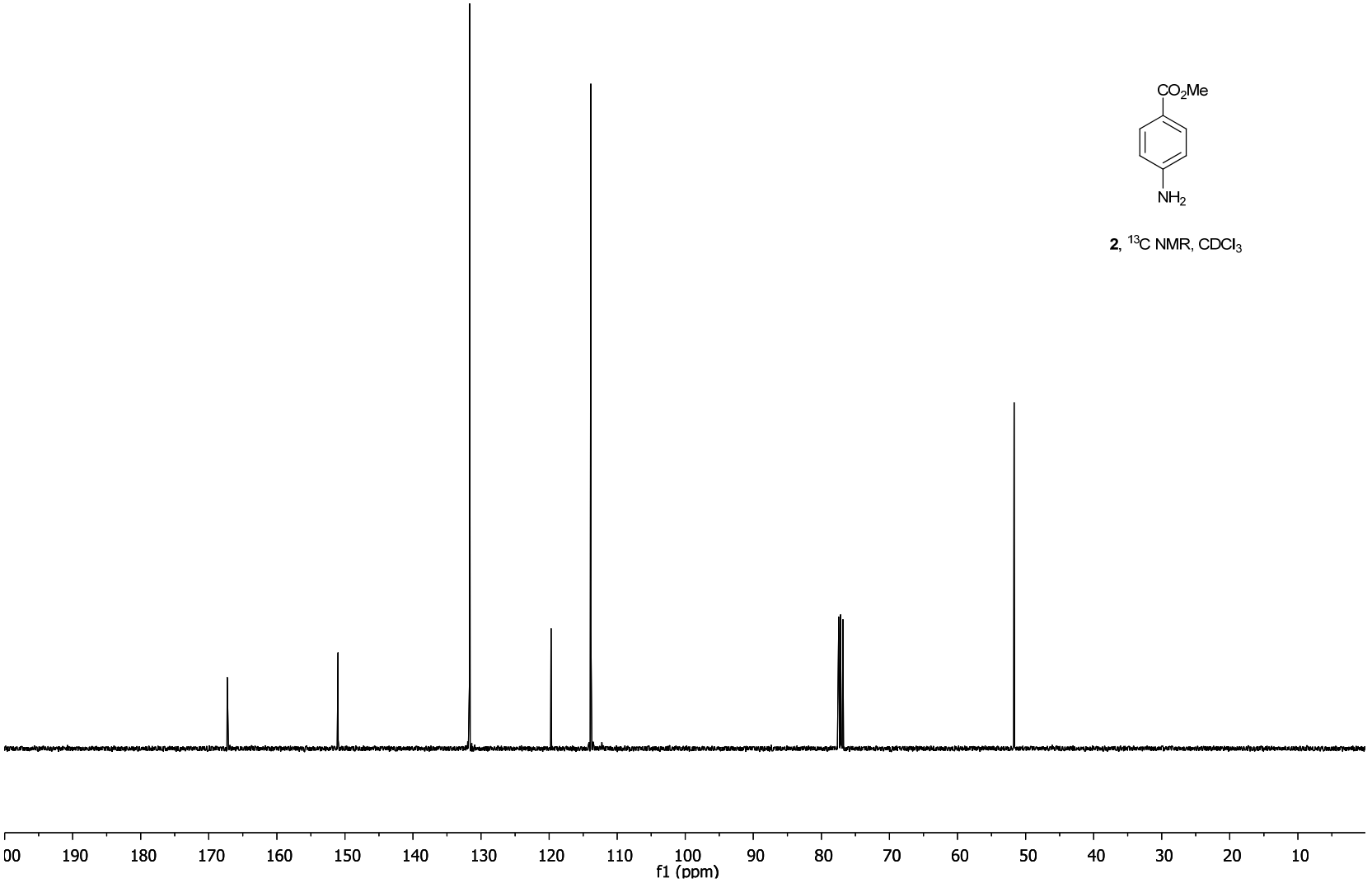


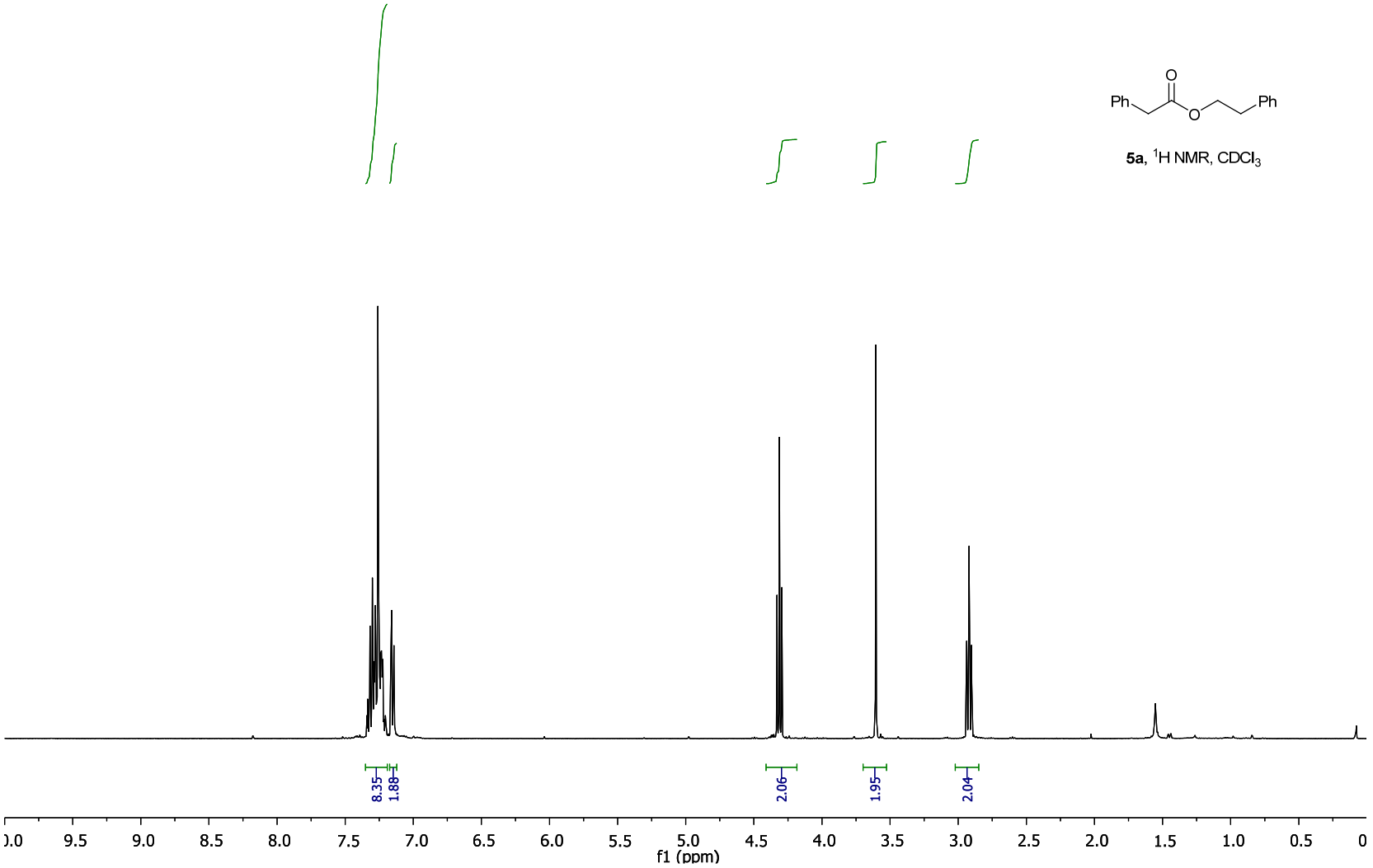
4, ^{13}C NMR, $CDCl_3$

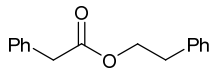




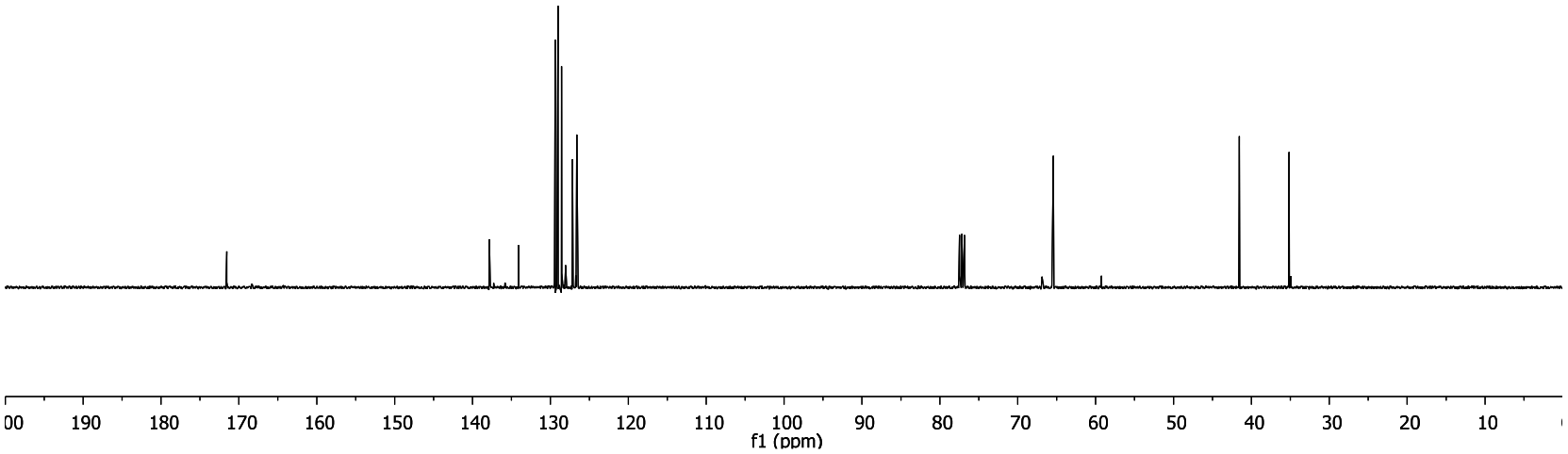
2, ^{1}H NMR, $CDCl_3$

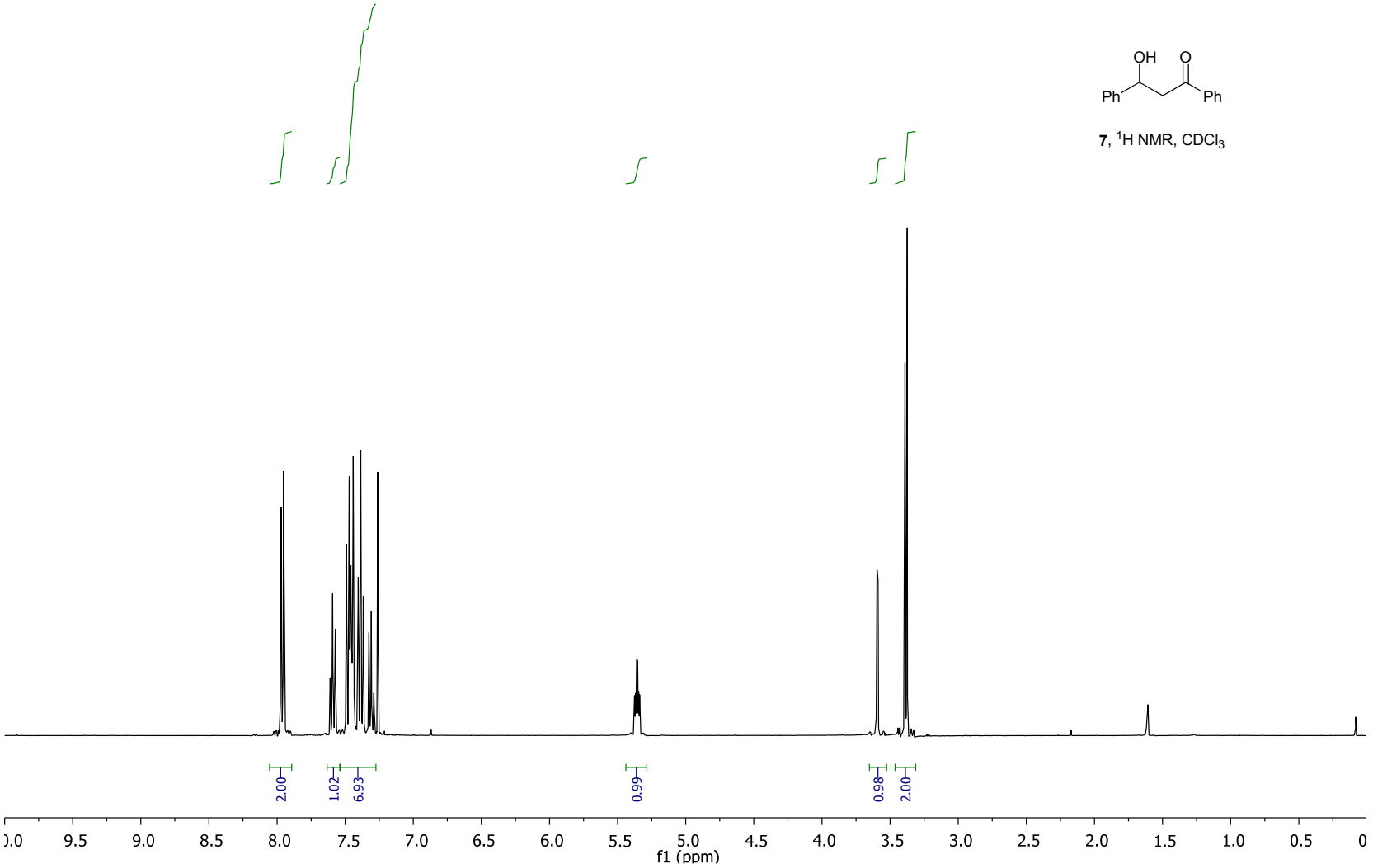


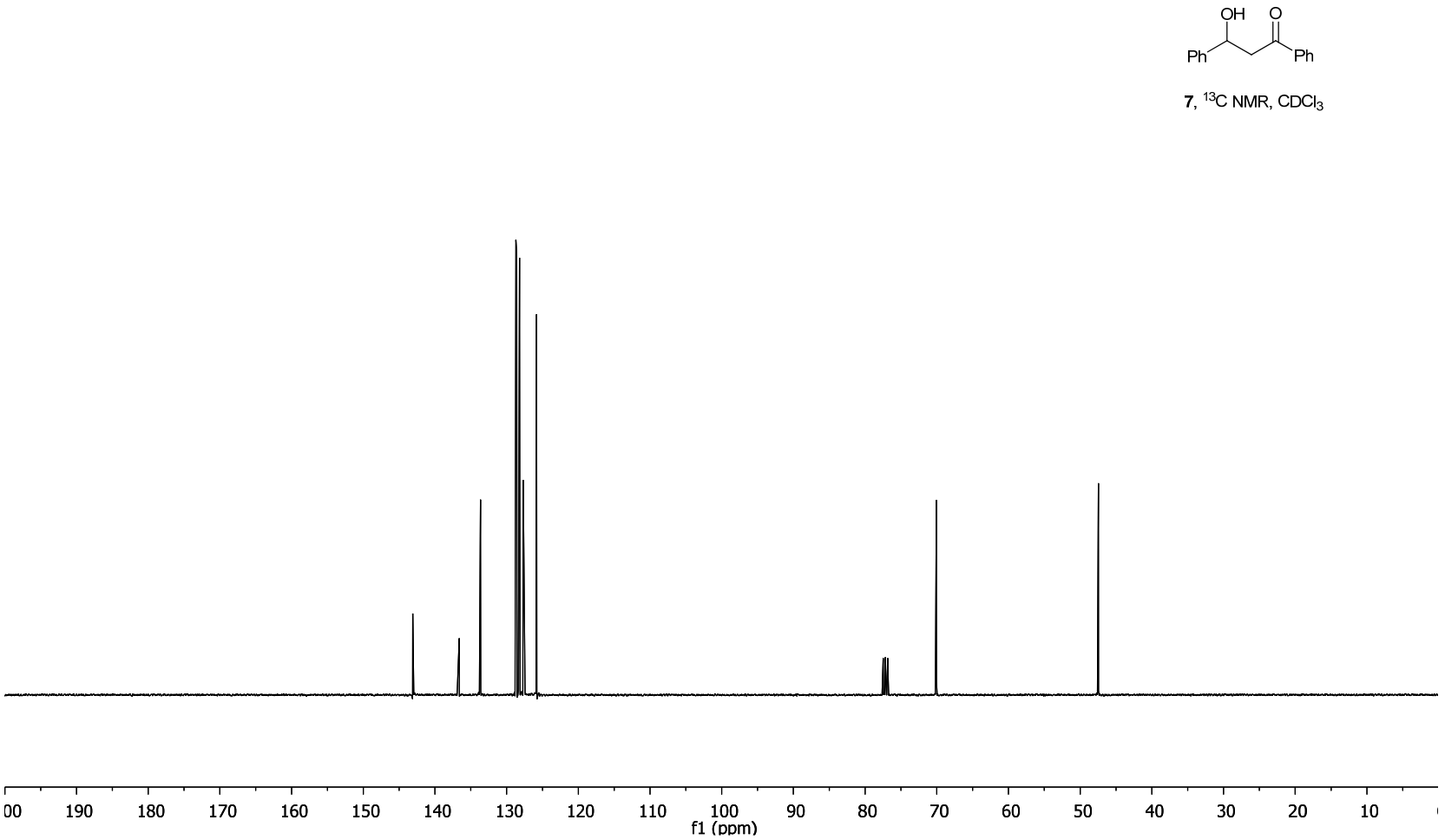


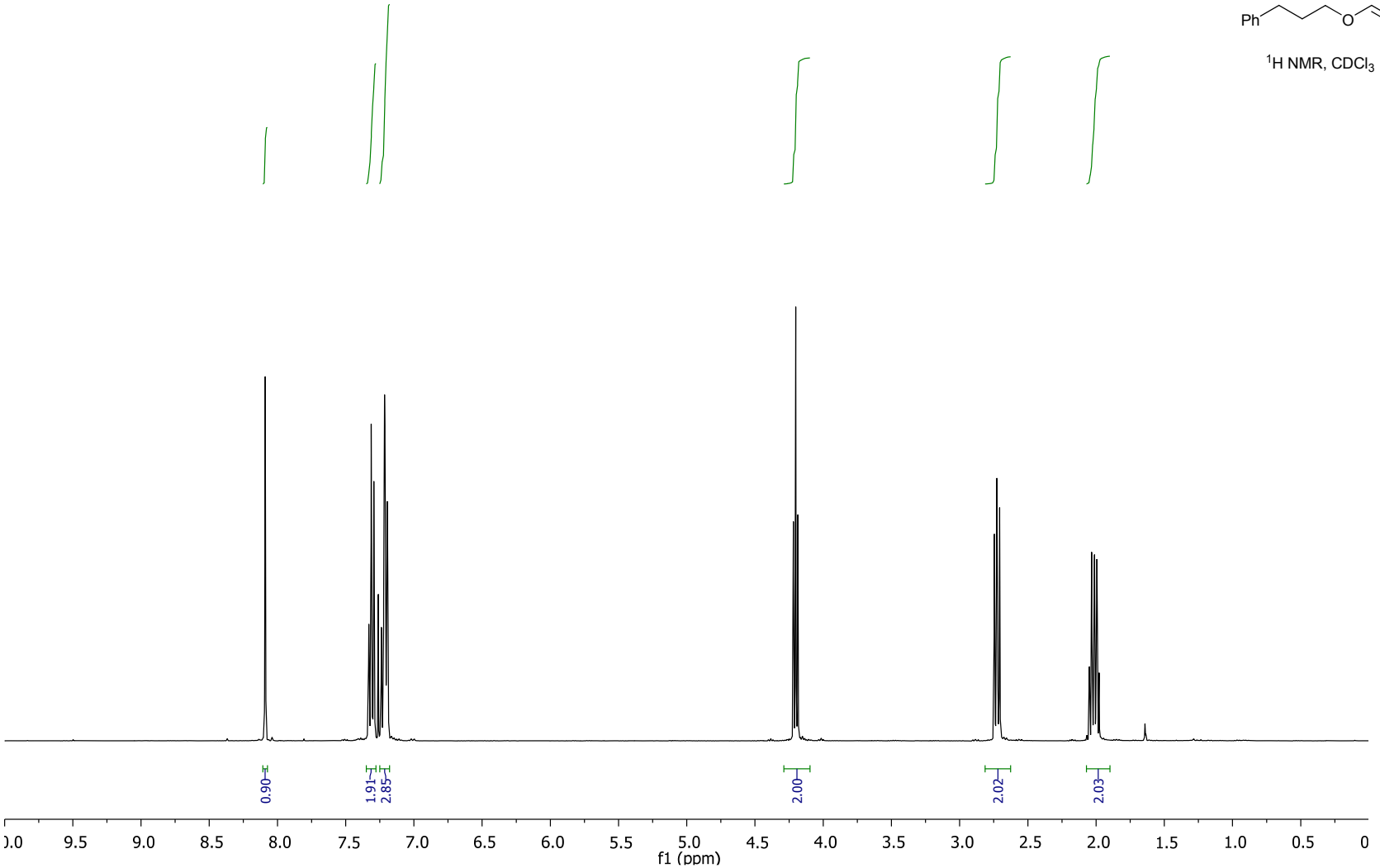


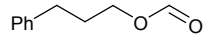
5a, ^{13}C NMR, $CDCl_3$



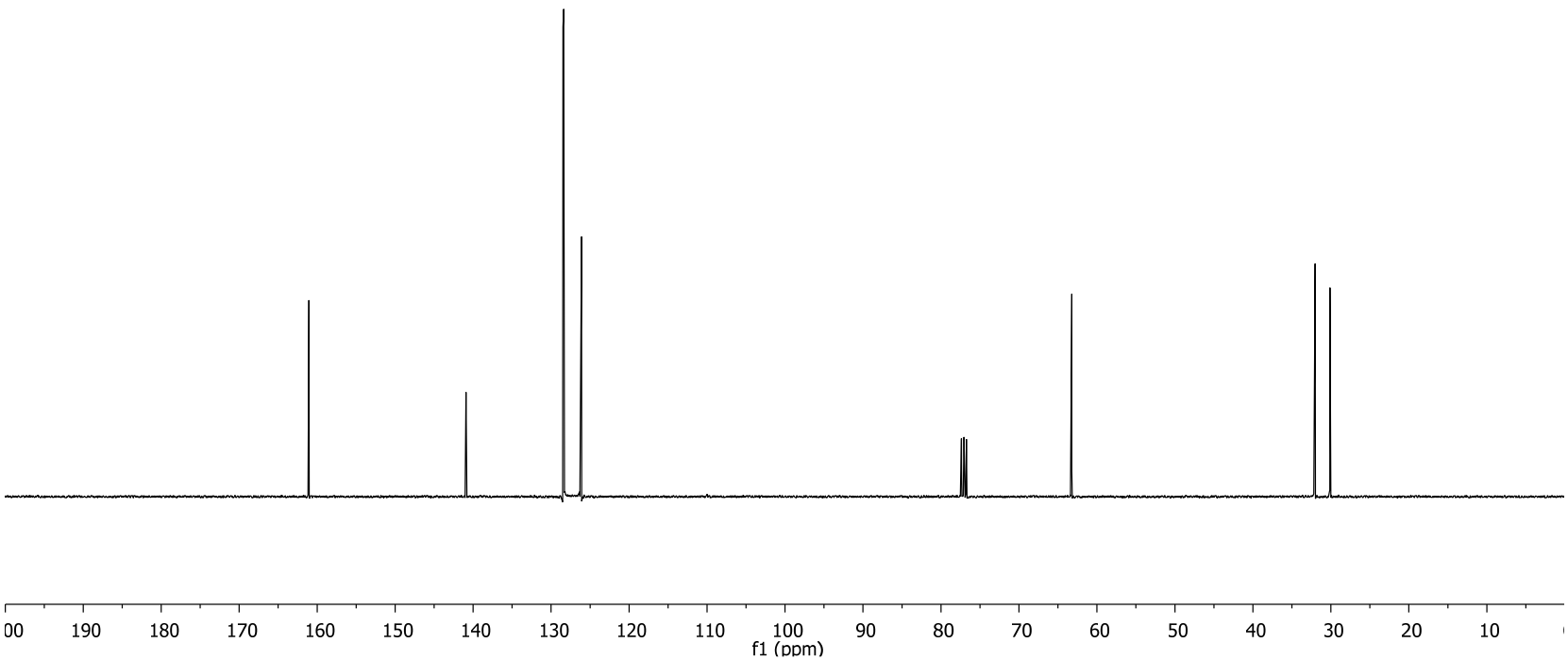


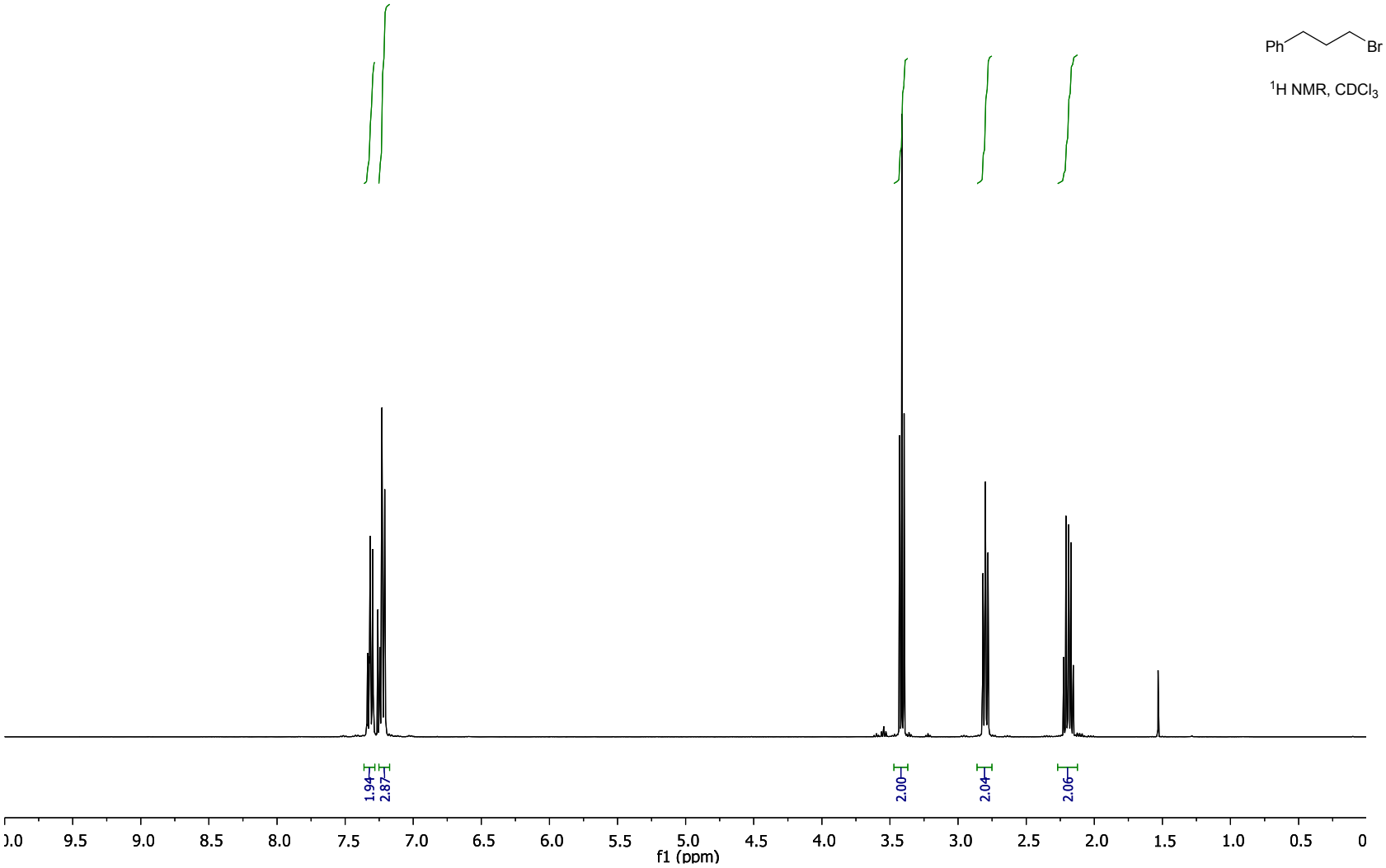


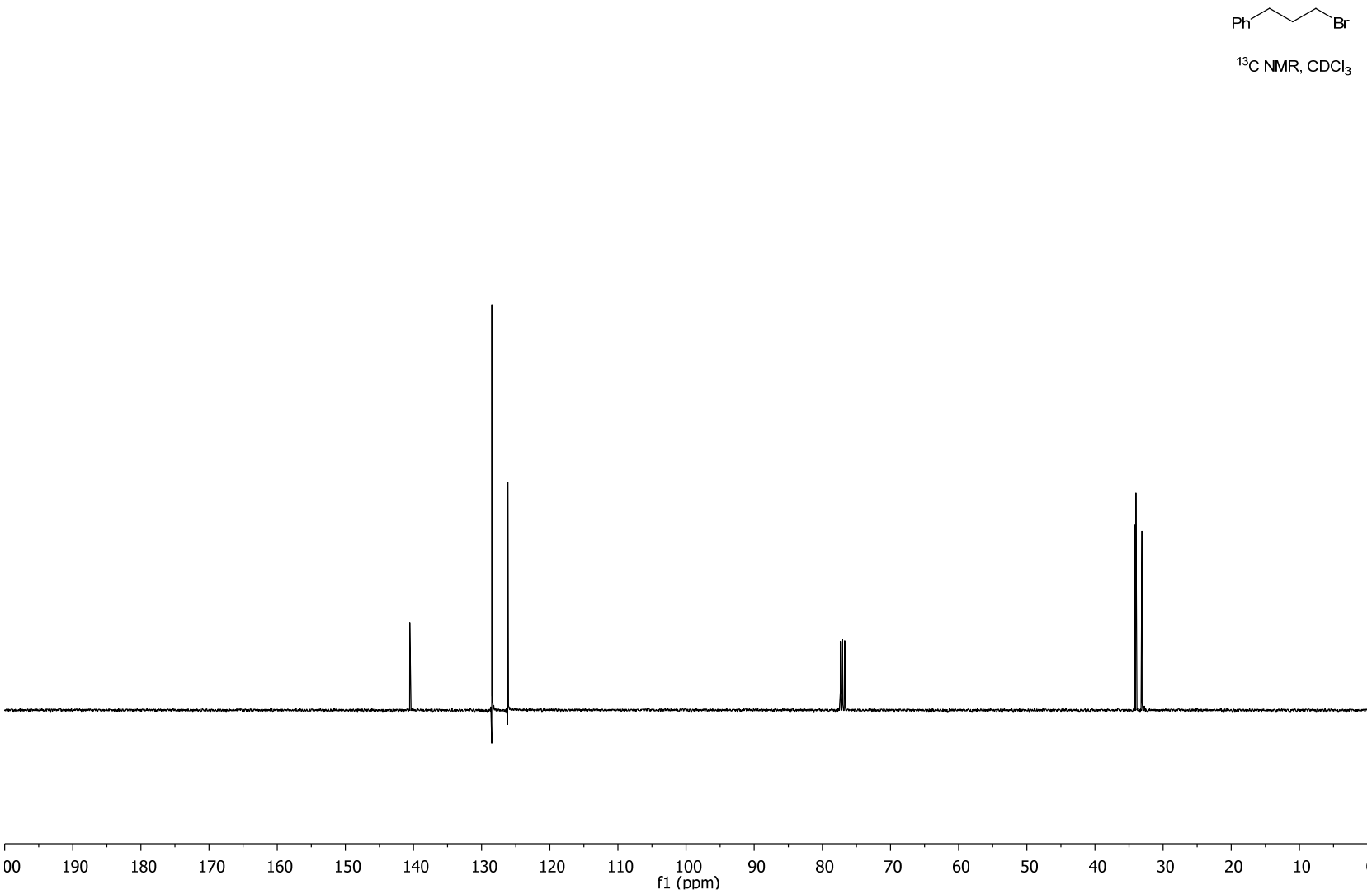


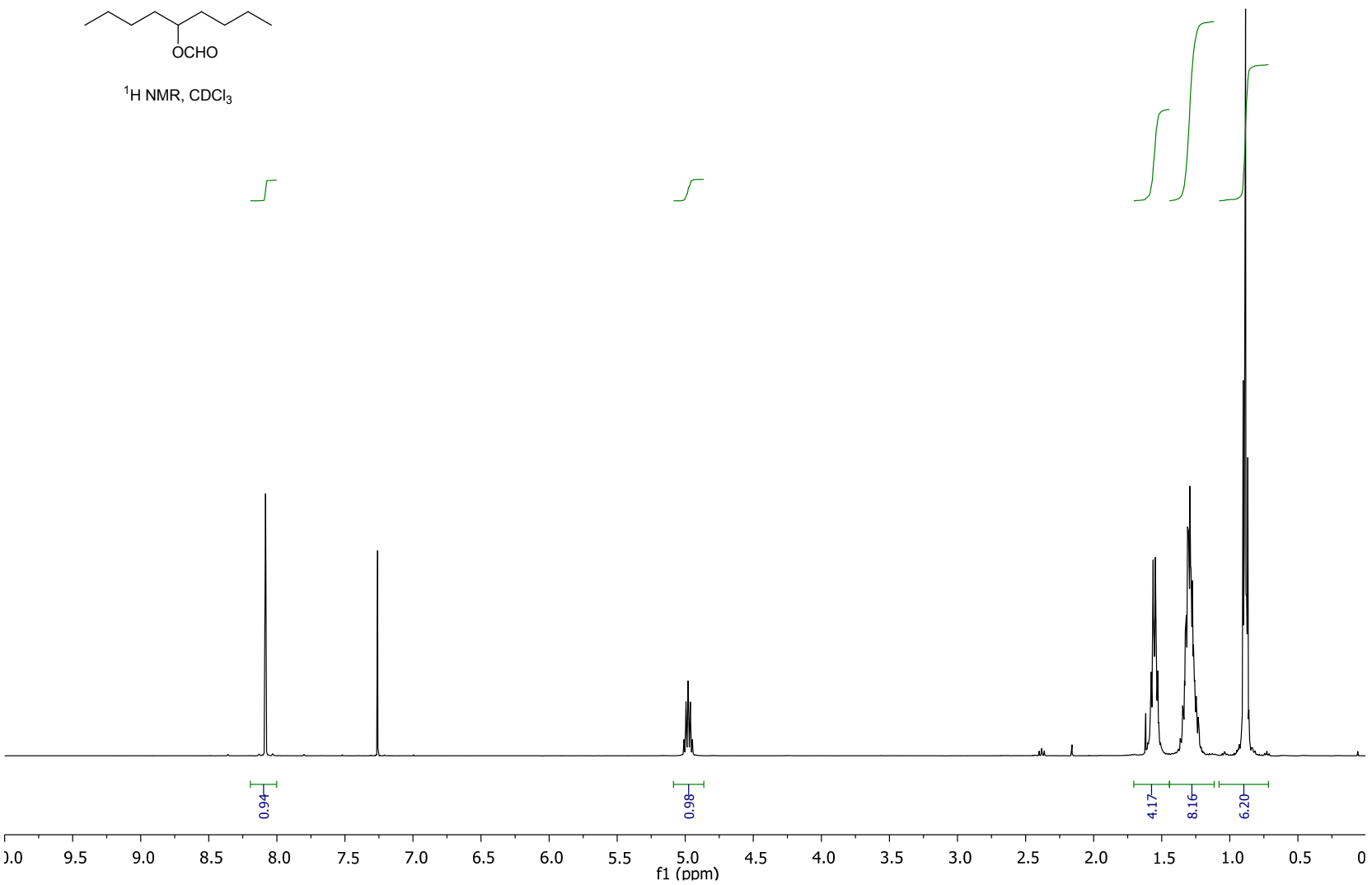


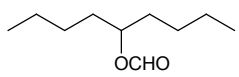
^{13}C NMR, $CDCl_3$



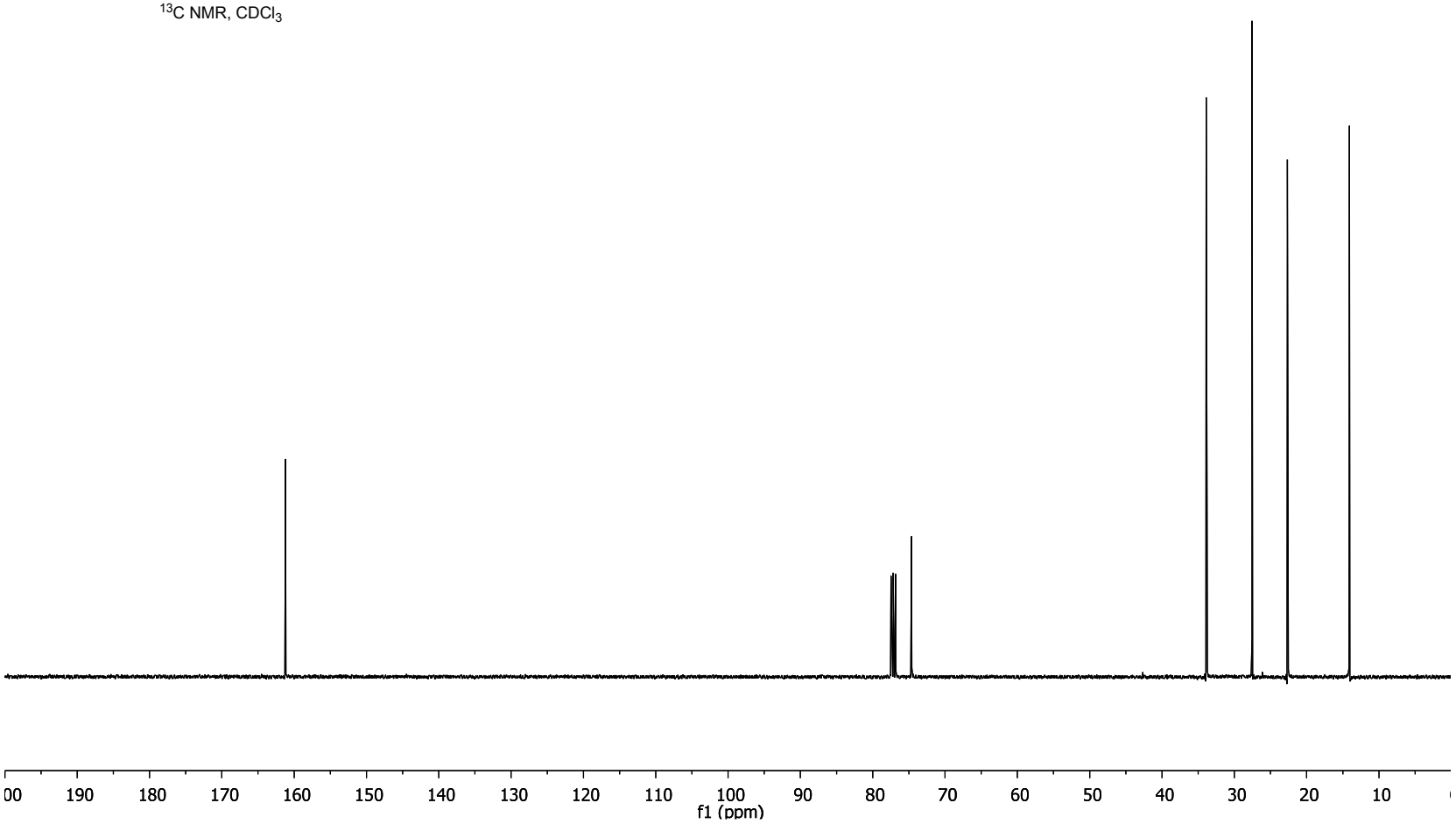


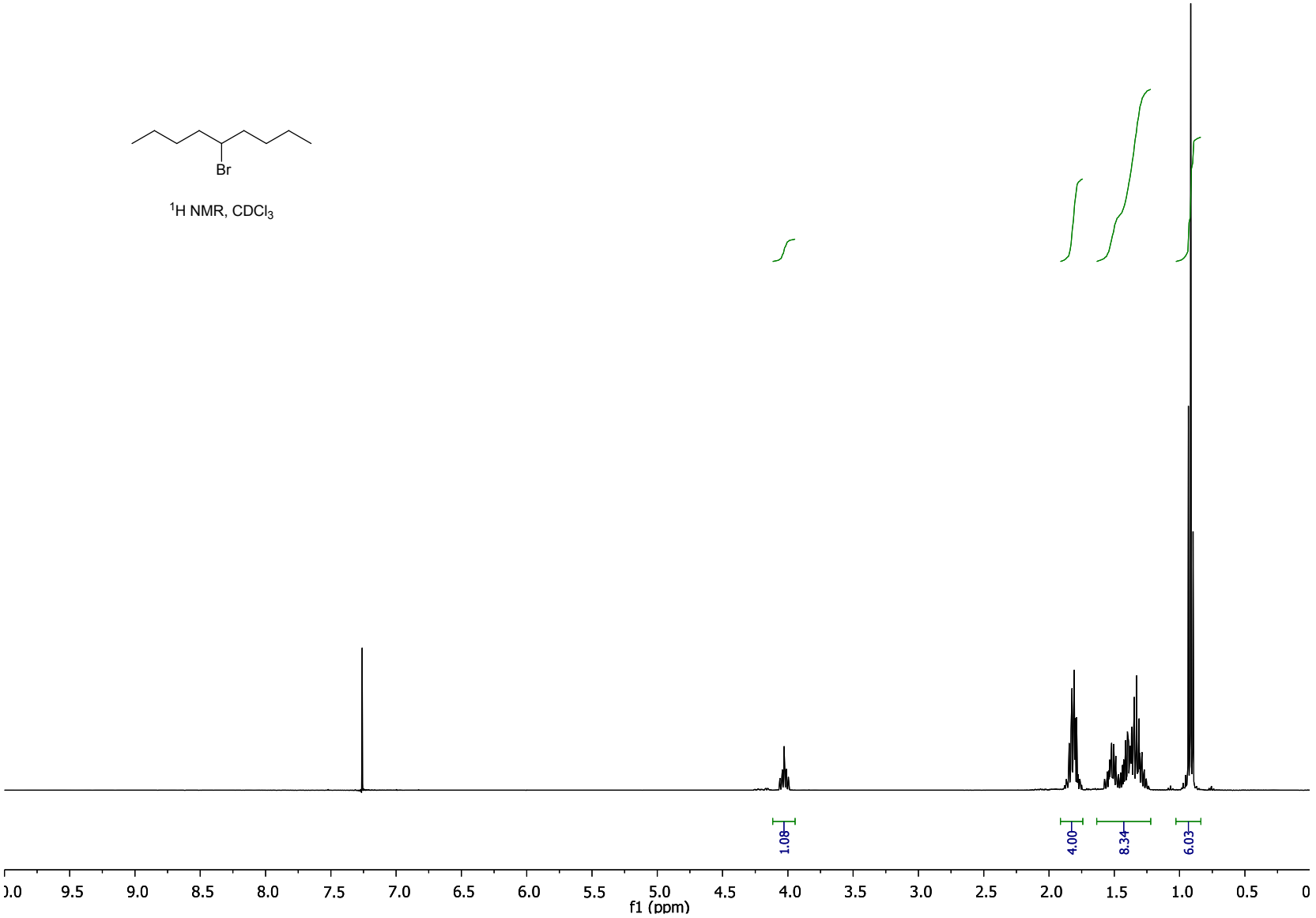


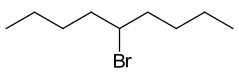




^{13}C NMR, $CDCl_3$







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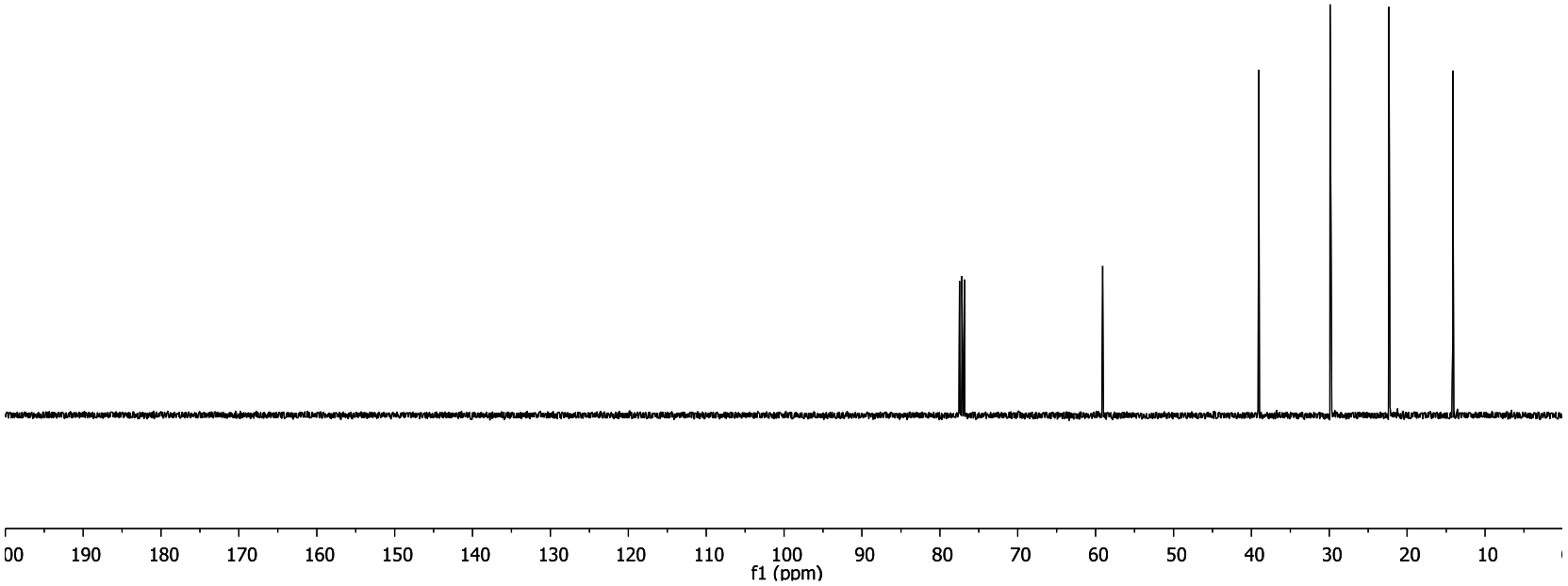

References

[1] http://www.knauer.net

[2] http://www.idex-hs.com

[3] http://www.conrad.de

[4] The Knauer pumps, injection loops and the software were available as a gift from Knauer Inc., Berlin Germany.

[5] (a) A. M. S. Galante, O. L. Galante and L. L. Campos, *Nucl. Instrum. Meth. A*, 2010, **619**, 177; (b) B. D. A. Hook, W. Dohle, P. R. Hirst, M. Pickworth, M. B. Berry and K. I. Booker-Milburn, *J. Org. Chem.*, 2005, **70**, 7558.

[6] Morawietz, J.; Sander, W.; Traeubel, M. *J. Org. Chem.* **1995**, *60*, 6368.