Highly Regioselective Indoline Synthesis under Nickel/Photoredox Dual Catalysis

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Materials and Methods

All reactions were performed under an inert atmosphere of nitrogen with exclusion of moisture from reagents and glassware unless otherwise noted. All Ni-catalyzed coupling reactions were carried out in a glovebox (MBraun Unilab) filled with dry nitrogen. $Ni(cod)_2$ and IPr were purchased from Strem Chemicals (Newburyport, MA) and stored in the glovebox. $Ni(cod)_2$ was stored at –20 °C, and it should be a bright yellow color. IPr was used in the free carbene form, rather than a salt. Acetone was distilled from $CaSO_4$ and freeze/pump/thawed to remove oxygen. Essentially identical yields were obtained using a fresh bottle of >99% purity acetone, sparged for 20 minutes with N_2. Et_3N was distilled from Na and freeze/pump/thawed prior to use, although identical yields were obtained using non-distilled commercial Et_3N stored under atmospheric conditions, if it was sparged for 20 minutes with N_2. 1-octene, vinylcyclohexane, styrene, and allyl benzene were distilled from Na prior to use. Other alkenes were used as purchased, unless significant amounts of peroxides had formed, in which case they were passed through a plug of neutral alumina. All alkenes were sparged with nitrogen prior to use. Commercial $Ru(bpy)_3(PF_6)_2$ gave slightly (~5–15%) lower yield than $Ru(bpy)_3(PF_6)_2$ made by treating $Ru(bpy)_3Cl_2$ with NH_4PF_6 in H_2O, rinsed with Et_2O and dried in a vacuum oven. Alternatively, commercial $Ru(bpy)_3(PF_6)_2$ dried in a vacuum oven at 50 °C for 6 h also gave improved yields. All other reagents were used as received. Commercially available chemicals were purchased from either Sigma-Aldrich Chemical Company (Milwaukee, WI), Alfa Aesar (Ward Hill, MA), Acros Organics (Pittsburgh, PA), or TCI America (Portland, OR). Analytical thin-layer chromatography (TLC) was performed on 0.2 mm coated Science silica gel (EM 60-F254) plates. Visualization was accomplished with UV light (254 nm) and exposure to either ceric ammonium molybdate (CAM), *para*-anisaldehyde, or $KMnO_4$ solution followed by

heating. Column chromatography was carried out on a Biotage Isolera flash chromatography system using SNAP KP-Sil, HP-Sil, or Ultra-Sil columns (silica gel, average particle size 50 μm, 25 μm, and 25 μm spherical respectively).

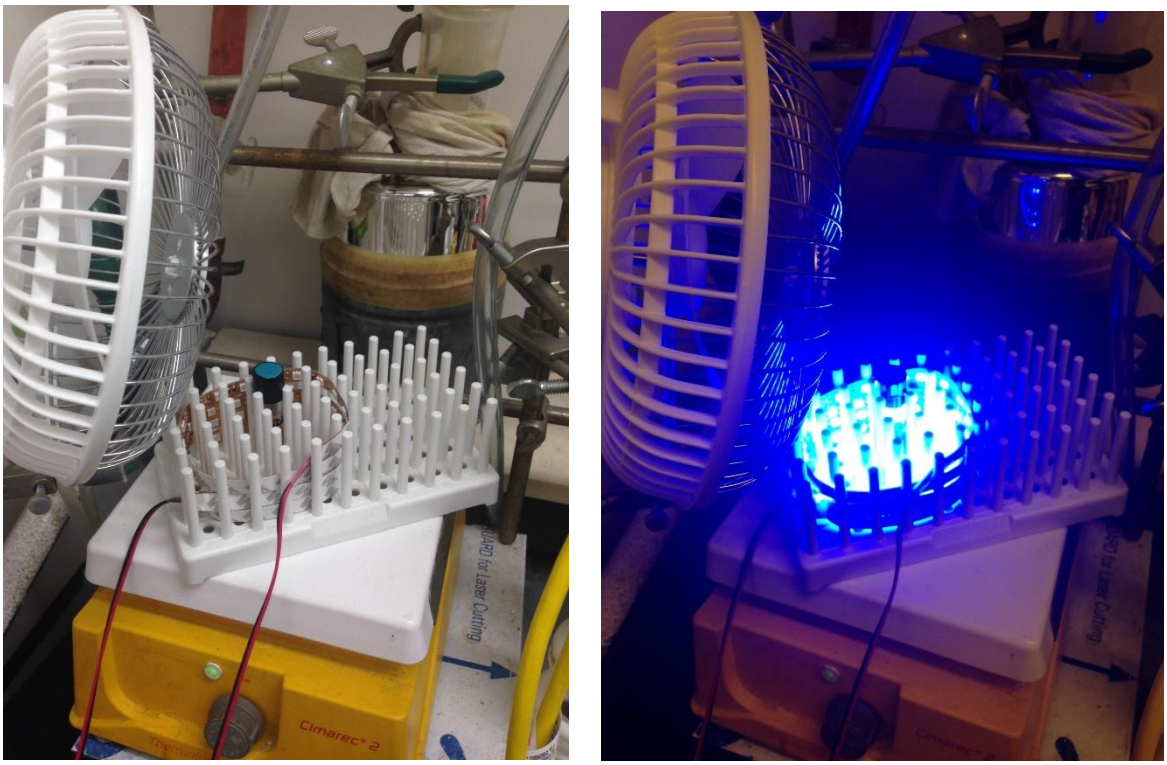
^{1}H NMR Spectra were obtained on either a Bruker 400 MHz, Bruker 600 MHz, or Varian Inova 500 MHz NMR instrument; ^{13}C spectra were recorded on a Bruker 600 MHz (at 151 MHz) NMR instrument. Chemical shifts (^{1}H and ^{13}C) are reported in parts per million and referenced to the residual solvent peak (for $CDCl_3$, δ = 7.27 ppm, 77.0ppm respectively). The following designations are used to describe multiplicities: s (singlet), d (doublet), t (triplet), q (quartet), m (multiplet), br (broad), app (apparent). When rotational isomers are present, the major rotational isomer is reported, as are any clearly differentiated signals arising from the minor rotational isomer for ^{1}H NMR spectra. For ^{13}C NMR spectra, peaks are for major rotational isomer only unless otherwise noted. IR spectra were obtained on an Agilent Cary 630 FT-IR spectrometer equipped with an ATR accessory. High-resolution mass spectrometry data were acquired by the Department of Chemistry Instrumentation Facility, Massachusetts Institute of Technology on a Bruker Daltonics APEXIV 4.7 Tesla FT-ICR Mass Spectrometer. Gas chromatography (GC) was performed on an Agilent 5870 GC (HP-5 column) with a flame ionization detector. GC/MS was performed on an Agilent 5870 GC (HP-5ms column) with an Agilent 5975C MSD. Dodecane (99+%, Alfa Aesar) was used as an internal standard for quantification.

Nickel/Photoredox-Catalyzed Synthesis of Indolines

General Procedures

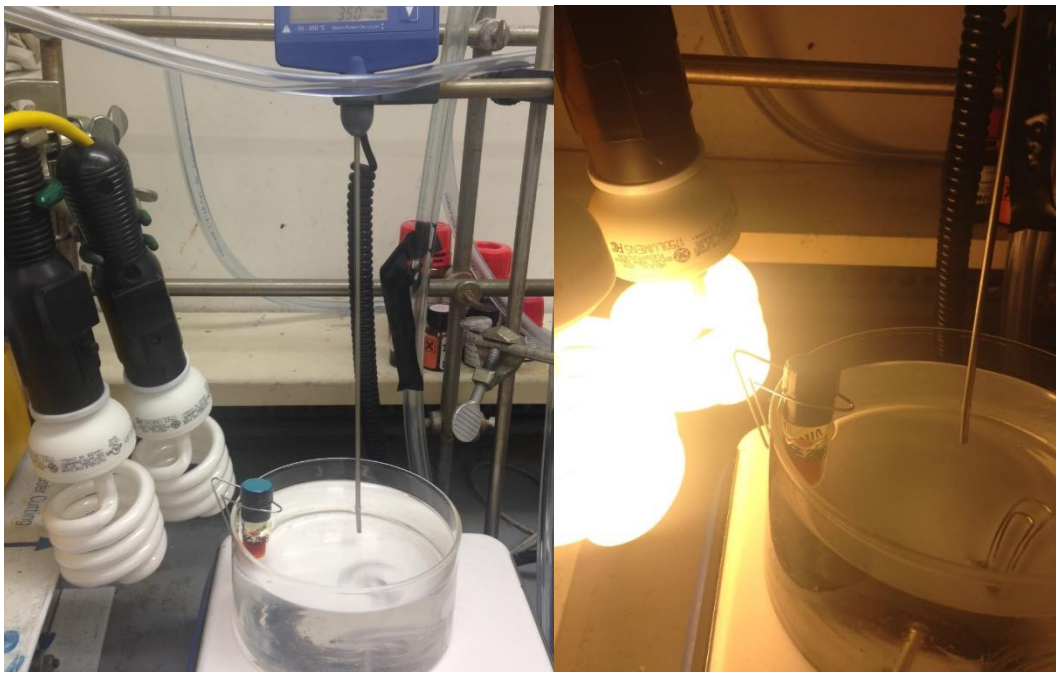
A) Standard Conditions (Room Temperature): In a nitrogen-filled glovebox, $Ni(cod)_2$ (0.075 mmol, 0.15 equiv) and IPr (0.08 mmol, 0.16 equiv) are weighed into a 2 dram (7.4 mL) dry vial. Acetone (0.22 M) is added, solubilizing IPr but not $Ni(cod)_2$, followed by 1-octene (1.0 mmol, 2.0 equiv) to form a homogeneous solution. Et_3N (1.0 mmol, 2.0 equiv), 2'-iodoacetanilide substrate (0.50 mmol 1.0 equiv), and finally $Ru(bpy)_3(PF_6)_2$ (0.005 mmol, 0.01 equiv) are added. The vial cap is then securely fitted and sealed with electrical tape before the vial is removed from the glovebox and placing on a stirplate surrounded by blue LED lights (see Figure S1). Maintaining the reaction mixture at room temperature is key for high selectivity, since more β-hydride elimination occurs at higher temperatures. The heat given off by the LEDs can easily be dispersed by directing a small clip-on desk fan at the reaction mixture (see Figure S1). [A lamp containing a compact fluorescent lightbulb (CFL) can also be used as a light source, again with a fan to disperse heat generated by the lamp, but additional time is needed for reaction completion (~36–48 h).] The reaction is stirred in this manner for 26 h, before being opened to air, and hexanes and EtOAc are added.

Figure S1. Reaction setup using blue LEDs.



B) Elevated Temperature Conditions (35 °C): In a nitrogen-filled glovebox, $Ni(cod)_2$ (0.075 mmol, 0.15 equiv) and IPr (0.08 mmol, 0.16 equiv) are weighed into a 2 dram (7.4 mL) dry vial. Acetone (0.22 M) is added, solubilizing IPr but not $Ni(cod)_2$, followed by 1-octene (1.0 mmol, 2.0 equiv) to form a homogeneous solution. Et_3N (1.0 mmol, 2.0 equiv), 2'-iodoacetanilide substrate (0.50 mmol 1.0 equiv), and finally $Ru(bpy)_3(PF_6)_2$ (0.01 mmol, 0.02 equiv) are added. The vial cap is then securely fitted and sealed with electrical tape before the vial is removed from the glovebox and clamping to the side of an oil bath at 35 °C adjacent to two CFL lamps (see Figure S2). [Unfortunately taping blue LED lights around an oil bath directly heated the oil bath to above 40 °C without any external heating, so could not be used.] The reaction is stirred in this manner for 48 h, before being opened to air, and hexanes and EtOAc are added.

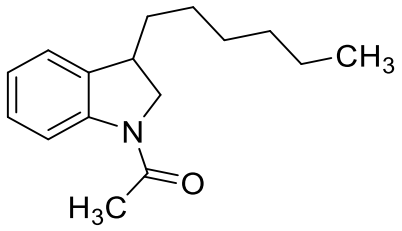
Figure S2. Reaction setup using CFL lamps and oil bath.



Both A) and B): For reactions analyzed by gas chromatography (GC, reactions run at 0.151 mmol), the crude mixture was passed through a short plug of SiO_2, using a small amount of CH_2Cl_2 to solubilize any precipitate, eluting with EtOAc to a total volume of ~20 mL. Dodecane (35.1 μL, 1.0 equiv) was then added, and a sample was submitted to GC analysis using a method which cleanly separated Heck and indoline products (GC conditions: 50 °C for 2 min, ramp 20 °C/min to 250 °C, hold at 250 °C for 10 min). The desired indoline product area was then compared the sum of all small peaks with similar retention times. For **6a**, the main products were the 1,1-disubstituted Heck product, and the isomerized trisubstituted *E*-styrene derivative. Mechanistically, the former arises from β-hydride elimination followed by reinsertion and isomerization of Ni–H to produce the latter. An authentic sample of the 2-hexyl indoline product was synthesized, but this product was not observed using IPr and $Ru(bpy)_3(PF_6)_2$.

For isolated yields (reactions run at 0.50 mmol), the reaction mixture was immediately passed through a short plug of SiO_2, using a small amount of CH_2Cl_2 to solubilize any precipitate, eluting with EtOAc to a total volume of ~50 mL. This mixture was then concentrated and purified by column chromatography (see conditions below). If the first step is not performed and the crude reaction mixture concentrated and placed on the column directly, some over-oxidation to indole is observed. A small amount of the purified product was then used to determine ratio of indoline to all other trace products including Heck and isomerized Heck products, as well as possibly 2-substituted indoline products (not observed for **5a** in GC, nor for other products using ^{1}H NMR) using GC using the same method as above. This selectivity ratio is key, since other products are not separable by standard column chromatography.

Characterization of Products



1-(3-hexylindolin-1-yl)ethan-1-one (6a):

Following general procedure **A**, $Ni(cod)_2$ (20.6 mg, 0.075 mmol, 0.15 equiv), IPr (31.1 mg, 0.08 mmol, 0.16 equiv) acetone (2.3 mL, 0.22 M), Et_3N (139 μL, 1.0 mmol, 2.0 equiv), 1-octene (157 μL, 1.0 mmol, 2.0 equiv), 2'-iodoacetanilide (130.5 mg, 0.50 mmol 1.0 equiv), and $Ru(bpy)_3(PF_6)_2$ (4.3 mg, 0.005 mmol, 0.01 equiv) were added to a 2 dram vial in a nitrogen-filled glovebox. The vial cap was then taped shut, before the vial was removed from the glovebox and placed next to blue LED lights cooled by a fan. After 26 h, the reaction was opened to air,

EtOAc was added, and the reaction mixture was filtered through a short silica plug with EtOAc as the eluent and concentrated. Column chromatography (Biotage 25g HP-sil, 5–40 % EtOAc in hexanes) afforded 108.2 mg (88%) of **6a** as a yellow oil (selectivity ratio of indoline **6a** to [Σ Heck/isomerized Heck/etc.] 22.5:1, determined by GC analysis).

^{1}H NMR (600 MHz, $CDCl_3$): present in a 5:1 ratio of rotational isomers about the amide

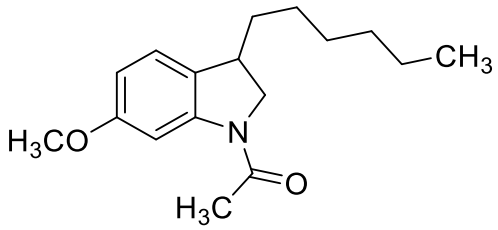
major rotational isomer: δ 8.21 (d, *J* = 8.0 Hz, 1H), 7.21 (t, *J* = 7.8 Hz, 1H), 7.17 (d, *J* = 7.4 Hz, 1H), 7.03 (t, *J* = 7.5 Hz, 1H), 4.15 (app t, *J* = 9.9 Hz, 1H), 3.68 (dd, *J* = 10.2, 6.1 Hz, 1H), 3.39 (tt, *J* = 9.7, 5.4 Hz, 1H), 2.24 (s, 3H), 1.85–1.77 (m, 1H), 1.58–1.52 (m, 1H), 1.43–1.22 (m, 8H), 0.90 (t, *J* = 6.7 Hz, 3H).

minor rotational isomer: δ 4.25 (app t, *J* = 10.6 Hz, 1H), 3.80 (dd, *J* = 12.1, 6.1 Hz, 1H), 3.24 (app p, *J* = 7.1, 6.6 Hz, 1H), 2.44 (s, 3H).

^{13}C {^{1}H} NMR (151 MHz, $CDCl_3$) δ 168.6, 142.6, 135.3, 127.7, 123.8, 123.5, 116.9, 55.2, 40.1, 35.5, 31.8, 29.3, 27.0, 24.3, 22.6, 14.1.

IR (ATR, cm^{-1}) 2925, 2855, 1660, 1598, 1481, 1460, 1398, 1337, 1321, 1273, 1128, 1098, 1022, 921, 752, 730.

HRMS (*m*/*z*) $[M + H]^+$ calcd for $C_{16}H_{23}NO$, 246.1852; found, 246.1855.



1-(3-hexyl-6-methoxyindolin-1-yl)ethan-1-one (6b):

Following general procedure **B**, $Ni(cod)_2$ (20.6 mg, 0.075 mmol, 0.15 equiv), IPr (31.1 mg, 0.08 mmol, 0.16 equiv) acetone (2.3 mL, 0.22 M), Et_3N (139 μL, 1.0 mmol, 2.0 equiv), 1-octene (157 μL, 1.0 mmol, 2.0 equiv), 2'-iodo-5'-methoxyacetanilide (145.5 mg, 0.50 mmol 1.0 equiv), and $Ru(bpy)_3(PF_6)_2$ (8.6 mg, 0.01 mmol, 0.02 equiv) were added to a 2 dram vial in a nitrogen-filled glovebox. The vial cap was then taped shut, before the vial was removed from the glovebox and placed in a 35 °C oil bath next to a compact fluorescent lightbulb. After 48 h, the reaction was opened to air, EtOAc was added, and the reaction mixture was filtered through a short silica plug with EtOAc as the eluent and concentrated. Column chromatography (Biotage 25g HP-sil, 7–60 % EtOAc in hexanes) afforded 56.1 mg (41%) of **6b** as a yellow oil (selectivity ratio of indoline **6b** to [Σ Heck/isomerized Heck/etc.] 7.2:1, determined by GC analysis).

^{1}H NMR (600 MHz, $CDCl_3$) present in ~7:1 ratio of rotational isomers about the amide

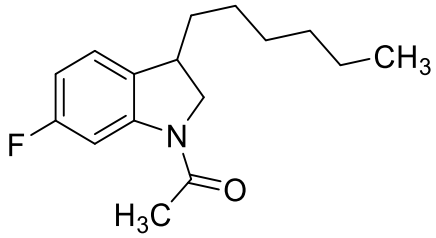
major rotational isomer: δ 7.90 (d, *J* = 2.4 Hz, 1H), 7.04 (d, *J* = 8.2 Hz, 1H), 6.59 (dd, *J* = 8.2, 2.4 Hz, 1H), 4.16 (app t, *J* = 9.8 Hz, 1H), 3.81 (s, 3H), 3.67 (dd, *J* = 10.2, 5.9 Hz, 1H), 3.32 (tt, *J* = 9.5, 5.4 Hz, 1H), 2.23 (s, 3H), 1.79–1.74 (m, 1H), 1.54–1.48 (m, 1H), 1.41–1.23 (m, 8H), 0.90 (t, *J* = 6.8 Hz, 3H).

minor rotational isomer: δ 4.26 (app t, *J* = 11.5 Hz, 1H), 3.17 (app br s, 1H), 2.43 (s, 3H).

^{13}C {^{1}H} NMR (151 MHz, $CDCl_3$) δ 168.8, 159.5 143.7, 127.3, 123.9, 109.9, 102.7, 56.0, 55.6, 39.4, 35.8, 31.8, 29.4, 27.0, 24.3, 22.6, 14.1.

IR (ATR, cm^{-1}) 2924, 2855, 1661, 1596, 1489, 1448, 1398, 1357, 1321, 1281, 1203, 1162, 1116, 1032, 856, 812.

HRMS (*m*/*z*) $[M + H]^+$ calcd for $C_{17}H_{25}NO_2$, 276.1958; found, 276.1952.



1-(6-fluoro-3-hexylindolin-1-yl)ethan-1-one (6c):

Following general procedure **B**, $Ni(cod)_2$ (20.6 mg, 0.075 mmol, 0.15 equiv), IPr (31.1 mg, 0.08 mmol, 0.16 equiv) acetone (2.3 mL, 0.22 M), Et_3N (139 μL, 1.0 mmol, 2.0 equiv), 1-octene (157 μL, 1.0 mmol, 2.0 equiv), 5'-fluoro-2'-iodoacetanilide (139.5 mg, 0.50 mmol 1.0 equiv), and $Ru(bpy)_3(PF_6)_2$ (8.6 mg, 0.01 mmol, 0.02 equiv) were added to a 2 dram vial in a nitrogen-filled glovebox. The vial cap was then taped shut, before the vial was removed from the glovebox and placed in a 35 °C oil bath next to a compact fluorescent lightbulb. After 48 h, the reaction was opened to air, EtOAc was added, and the reaction mixture was filtered through a short silica plug with EtOAc as the eluent and concentrated. Column chromatography (Biotage 25g HP-sil, 5–40 % EtOAc in hexanes) afforded 90.3 mg (69%) of **6c** as a yellow oil (selectivity ratio of indoline **6c** to [Σ Heck/isomerized Heck/etc.] 20.1:1, determined by GC analysis).

^{1}H NMR (600 MHz, $CDCl_3$) present in ~10:1 ratio of rotational isomers about the amide

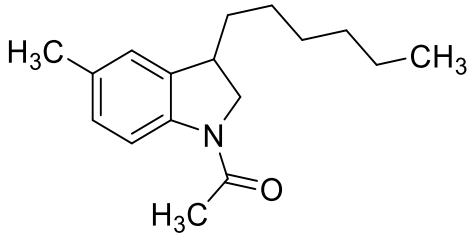
major rotational isomer: δ 7.96 (dd, *J* = 10.6, 2.4 Hz, 1H), 7.07 (dd, *J* = 8.2, 5.6 Hz, 1H), 6.72 (td, *J* = 8.6, 2.3 Hz, 1H), 4.19 (app t, *J* = 9.8 Hz, 1H), 3.71 (dd, *J* = 10.2, 6.0 Hz, 1H), 3.35 (tt, *J* = 9.7, 5.5 Hz, 1H), 2.23 (s, 3H), 1.81–1.75 (m, 1H), 1.56–1.50 (m, 1H), 1.43–1.25 (m, 8H), 0.90 (t, *J* = 6.8 Hz, 3H).

minor rotational isomer: δ 4.26 (t, *J* = 10.9 Hz, 1H), 3.82 (dd, *J* = 12.4, 6.0 Hz, 1H), 3.20 (app br s, 1H), 2.42 (s, 3H).

^{13}C {^{1}H} NMR (151 MHz, $CDCl_3$) δ 168.9, 162.4 (d, *J* = 242.0 Hz), 143.7 (d, *J* = 12.8 Hz), 130.6 (d, *J* = 2.6 Hz), 124.1 (d, *J* = 9.9 Hz), 109.9 (d, *J* = 22.8 Hz), 105.0 (d, *J* = 29.0 Hz), 55.8, 39.5, 35.6, 31.7, 29.3, 26.9, 24.2, 22.6, 14.1.

IR (ATR, cm^{-1}) 2927, 2856, 1665, 1611, 1484, 1438, 1399, 1358, 1318, 1264, 1176, 1160, 1097, 1030, 958, 866, 813.

HRMS (*m*/*z*) $[M + H]^+$ calcd for $C_{16}H_{22}FNO$, 264.1758; found, 264.1740.



1-(3-hexyl-5-methylindolin-1-yl)ethan-1-one (6d):

Following general procedure **A**, $Ni(cod)_2$ (20.6 mg, 0.075 mmol, 0.15 equiv), IPr (31.1 mg, 0.08 mmol, 0.16 equiv) acetone (2.3 mL, 0.22 M), Et_3N (139 μL, 1.0 mmol, 2.0 equiv), 1-octene (157

μL, 1.0 mmol, 2.0 equiv), 2'-iodo-4'-methylacetanilide (137.5 mg, 0.50 mmol 1.0 equiv), and $Ru(bpy)_3(PF_6)_2$ (4.3 mg, 0.005 mmol, 0.01 equiv) were added to a 2 dram vial in a nitrogen-filled glovebox. The vial cap was then taped shut, before the vial was removed from the glovebox and placed next to blue LED lights cooled by a fan. After 26 h, the reaction was opened to air, EtOAc was added, and the reaction mixture was filtered through a short silica plug with EtOAc as the eluent and concentrated. Column chromatography (Biotage 25g HP-sil, 5–40 % EtOAc in hexanes) afforded 95.1 mg (73%) of **6d** as a pale yellow oil (selectivity ratio of indoline **6d** to [Σ Heck/isomerized Heck/etc.] 19.9:1, determined by GC analysis).

^{1}H NMR (600 MHz, $CDCl_3$) present in ~5:1 ratio of rotational isomers about the amide

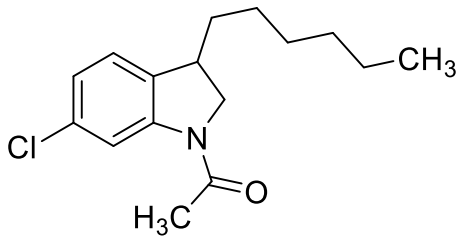
major rotational isomer: δ 8.07 (d, *J* = 8.2 Hz, 1H), 7.01 (m, 2H), 4.14 (app t, *J* = 9.8 Hz, 1H), 3.66 (dd, *J* = 10.2, 6.1 Hz, 1H), 3.35 (tt, *J* = 9.7, 5.4 Hz, 1H), 2.32 (s, 3H), 2.22 (s, 3H), 1.84–1.76 (m, 1H), 1.56–1.50 (m, 1H), 1.42–1.26 (m, 8H), 0.91 (t, *J* = 6.7 Hz, 3H).

minor rotational isomer: δ 4.24 (dd, *J* = 12.1, 9.1 Hz, 1H), 3.78 (dd, *J* = 12.0, 6.2 Hz, 1H), 3.19 (tt, *J* = 9.4, 5.3 Hz, 1H), 2.42 (s, 3H).

^{13}C {^{1}H} NMR (151 MHz, $CDCl_3$) δ 168.3, 140.4, 135.4, 133.1, 128.2, 124.4, 116.6, 55.3, 40.1, 35.5, 31.8, 29.4, 27.0, 24.2, 22.7, 21.1, 14.1.

IR (ATR, cm^{-1}) 2925, 2855, 1656, 1489, 1432, 1394, 1338, 1270, 1138, 1030, 820, 725.

HRMS (*m*/*z*) $[M + H]^+$ calcd for $C_{17}H_{25}NO$, 260.2009; found, 260.2011.



1-(6-chloro-3-hexylindolin-1-yl)ethan-1-one (6e):

Following general procedure **B**, $Ni(cod)_2$ (20.6 mg, 0.075 mmol, 0.15 equiv), IPr (31.1 mg, 0.08 mmol, 0.16 equiv) acetone (2.3 mL, 0.22 M), Et_3N (139 μL, 1.0 mmol, 2.0 equiv), 1-octene (157 μL, 1.0 mmol, 2.0 equiv), 5'-chloro-2'-iodoacetanilide (148 mg, 0.50 mmol 1.0 equiv), and $Ru(bpy)_3(PF_6)_2$ (8.6 mg, 0.01 mmol, 0.02 equiv) were added to a 2 dram vial in a nitrogen-filled glovebox. The vial cap was then taped shut, before the vial was removed from the glovebox and placed in a 35 °C oil bath next to a compact fluorescent lightbulb. After 48 h, the reaction was opened to air, EtOAc was added, and the reaction mixture was filtered through a short silica plug with EtOAc as the eluent and concentrated. Column chromatography (Biotage 50g Ultra-sil, 5–40 % EtOAc in hexanes) afforded 120.5 mg (86%) of **6e** as a yellow oil (selectivity ratio of indoline **6e** to [Σ Heck/isomerized Heck/etc.] 41:1, determined by GC analysis).

^{1}H NMR (500 MHz, $CDCl_3$) present in ~5:1 ratio of rotational isomers about the amide.

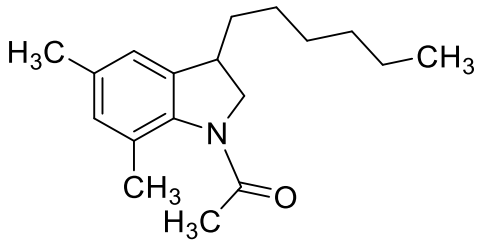
major rotational isomer: δ 8.23 (d, *J* = 1.9 Hz, 1H), 7.06 (d, *J* = 8.0 Hz, 1H), 6.99 (dd, *J* = 8.0, 2.0 Hz, 1H), 4.17 (app t, *J* = 9.9 Hz, 1H), 3.69 (dd, *J* = 10.2, 6.0 Hz, 1H), 3.35 (tt, *J* = 9.6, 5.3 Hz, 1H), 2.23 (s, 3H), 1.83–1.70 (m, 1H), 1.53 (dtd, *J* = 13.8, 8.9, 5.1 Hz, 1H), 1.42–1.22 (m, 8H), 0.90 (t, *J* = 6.6 Hz, 3H).

minor rotational isomer: δ 4.24 (t, *J* = 10.1 Hz, 1H), 3.81 (dd, *J* = 12.4, 6.2 Hz, 1H), 3.20 (app br s, 1H), 2.43 (s, 3H).

^{13}C {^{1}H} NMR (151 MHz, $CDCl_3$) δ 168.8, 143.6, 133.7, 133.2, 124.4, 123.5, 117.1, 55.5, 39.7, 35.4, 31.7, 29.3, 26.8, 24.2, 22.6, 14.1.

IR (ATR, cm^{-1}) 2926, 2854, 1664, 1595, 1475, 1419, 1394, 1313, 1253, 1133, 1070, 1029, 932, 876, 806, 728.

HRMS (*m*/*z*) $[M + H]^+$ calcd for $C_{16}H_{22}ClNO$, 280.1463; found, 280.1461.



1-(3-hexyl-5,7-dimethylindolin-1-yl)ethan-1-one (6g):

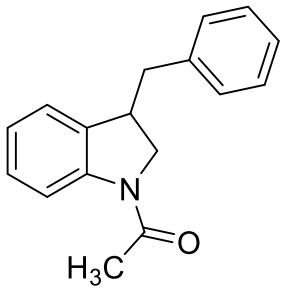
Following general procedure **B**, $Ni(cod)_2$ (20.6 mg, 0.075 mmol, 0.15 equiv), IPr (31.1 mg, 0.08 mmol, 0.16 equiv) acetone (2.3 mL, 0.22 M), Et_3N (139 μL, 1.0 mmol, 2.0 equiv), 1-octene (157 μL, 1.0 mmol, 2.0 equiv), 2'-iodo-4',6'-dimethylacetanilide (145 mg, 0.50 mmol 1.0 equiv), and $Ru(bpy)_3(PF_6)_2$ (8.6 mg, 0.01 mmol, 0.02 equiv) were added to a 2 dram vial in a nitrogen-filled glovebox. The vial cap was then taped shut, before the vial was removed from the glovebox and placed in a 35 °C oil bath next to a compact fluorescent lightbulb. After 48 h, the reaction was opened to air, EtOAc was added, and the reaction mixture was filtered through a short silica plug with EtOAc as the eluent and concentrated. Column chromatography (Biotage 25g Ultra-sil, 5–40 % EtOAc in hexanes) afforded 38.5 mg (28%) of **6g** as a yellow oil (selectivity ratio of indoline **6g** to [Σ Heck/isomerized Heck/etc.] >100:1, determined by GC analysis).

^{1}H NMR (500 MHz, $CDCl_3$) δ 6.86 (br s, 1H), 6.84 (br s, 1H), 4.15 (br s, 1H), 3.68 (br s, 1H), 3.16–3.10 (m, 1H), 2.30 (s, 3H), 2.24 (s, 6H), 1.81–1.70 (m, 1H), 1.49–1.24 (m, 9H), 0.90 (t, *J* = 6.8 Hz, 3H).

^{13}C {^{1}H} NMR (151 MHz, $CDCl_3$) δ 168.3 (br), 139.0 (br), 138.5 (br), 134.8, 130.5, 128.7 (br), 121.7 (br), 57.3, 41.9 (br), 33.5, 31.7, 29.4, 27.2, 23.8 (br), 22.6, 21.0, 20.5 (br), 14.1.

IR (ATR, cm^{-1}) 2924, 2855, 1666, 1475, 1410, 1375, 1245, 1195, 1151, 1033, 970, 853, 725.

HRMS (*m*/*z*) $[M + H]^+$ calcd for $C_{17}H_{25}NO$, 274.2165; found, 274.2160.



1-(3-benzylindolin-1-yl)ethan-1-one (6h):

Following general procedure **A**, $Ni(cod)_2$ (20.6 mg, 0.075 mmol, 0.15 equiv), IPr (31.1 mg, 0.08 mmol, 0.16 equiv) acetone (2.3 mL, 0.22 M), Et_3N (139 μL, 1.0 mmol, 2.0 equiv), allylbenzene (132 μL, 1.0 mmol, 2.0 equiv), 2'-iodoacetanilide (130.5 mg, 0.50 mmol 1.0 equiv), and $Ru(bpy)_3(PF_6)_2$ (4.3 mg, 0.005 mmol, 0.01 equiv) were added to a 2 dram vial in a nitrogen-filled glovebox. The vial cap was then taped shut, before the vial was removed from the glovebox and placed next to blue LED lights cooled by a fan. After 26 h, the reaction was opened to air, EtOAc was added, and the reaction mixture was filtered through a short silica plug with EtOAc

as the eluent and concentrated. Column chromatography (Biotage 25g HP-sil, 6–48 % EtOAc in hexanes) afforded 114.5 mg (91%) of **6h** as a pale yellow solid (selectivity ratio of indoline **6h** to [Σ Heck/isomerized Heck/etc.] 45.6:1, determined by GC analysis).

^{1}H NMR (600 MHz, $CDCl_3$) present in ~5:1 ratio of rotational isomers about the amide.

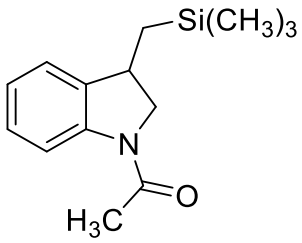
major rotational isomer: δ 8.21 (d, *J* = 8.1 Hz, 1H), 7.34 (t, *J* = 7.5 Hz, 2H), 7.28 (d, *J* = 7.4 Hz, 1H), 7.24 (t, *J* = 7.7 Hz, 1H), 7.20 (d, *J* = 7.5 Hz, 2H), 7.08 (d, *J* = 7.4 Hz, 1H), 7.02 (t, *J* = 7.4 Hz, 1H), 4.02 (app t, *J* = 11.6 Hz, 1H), 3.77–3.71 (m, 2H), 3.15 (dd, *J* = 13.9, 5.2 Hz, 1H), 2.80 (dd, *J* = 14.0, 8.8 Hz, 1H), 2.17 (s, 3H).

minor rotational isomer: δ 4.10 (app t, *J* = 10.6 Hz, 1H), 3.58 (app br s, 1H), 3.07 (dd, *J* = 13.9, 5.8 Hz, 1H), 2.38 (s, 3H).

^{13}C {^{1}H} NMR (151 MHz, $CDCl_3$) δ 168.7, 142.7, 138.8, 134.3, 129.0, 128.7, 128.1, 126.7, 124.0, 123.6, 117.1, 54.5, 41.56, 41.54, 24.3.

IR (ATR, cm^{-1}) 3062, 3027, 2922, 2883, 1656, 1597, 1480, 1459, 1398, 1355, 1337, 1280, 1132, 1085, 1030, 750, 701.

HRMS (*m*/*z*) $[M + H]^+$ calcd for $C_{17}H_{17}NO$, 252.1383; found, 252.1373.



1-(3-((trimethylsilyl)methyl)indolin-1-yl)ethan-1-one (6i):

Following general procedure **B**, $Ni(cod)_2$ (20.6 mg, 0.075 mmol, 0.15 equiv), IPr (31.1 mg, 0.08 mmol, 0.16 equiv) acetone (2.3 mL, 0.22 M), Et_3N (139 μL, 1.0 mmol, 2.0 equiv), allyltrimethylsilane (159 μL, 1.0 mmol, 2.0 equiv), 2'-iodoacetanilide (130.5 mg, 0.50 mmol 1.0 equiv), and $Ru(bpy)_3(PF_6)_2$ (8.6 mg, 0.01 mmol, 0.02 equiv) were added to a 2 dram vial in a nitrogen-filled glovebox. The vial cap was then taped shut, before the vial was removed from the glovebox and placed in a 35 °C oil bath next to a compact fluorescent lightbulb. After 48 h, the reaction was opened to air, EtOAc was added, and the reaction mixture was filtered through a short silica plug with EtOAc as the eluent and concentrated. Column chromatography (Biotage 25g HP-sil, 5–40% EtOAc in hexanes) afforded 85.0 mg (69%) of **6i** as a white solid (selectivity ratio of indoline **6i** to [Σ Heck/isomerized Heck/etc.] 5:1, determined by GC analysis).

^1H NMR (600 MHz, $CDCl_3$) present in ~5:1 ratio of rotational isomers about the amide.

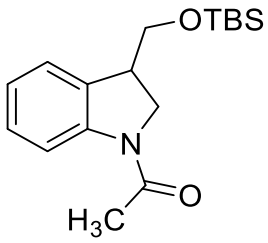
major rotational isomer: δ 8.19 (d, *J* = 8.1 Hz, 1H), 7.20 (t, *J* = 7.8 Hz, 1H), 7.16 (d, *J* = 7.4 Hz, 1H), 7.04 (t, *J* = 7.4 Hz, 1H), 4.18 (t, *J* = 9.5 Hz, 1H), 3.56 (dd, *J* = 9.8, 7.1 Hz, 1H), 3.51 (app q, *J* = 10.5 Hz, 1H), 2.23 (s, 3H), 1.22 (dd, *J* = 14.9, 3.3 Hz, 1H), 0.88 (dd, *J* = 14.9, 10.9 Hz, 1H), 0.09 (d, *J* = 1.2 Hz, 9H).

minor rotational isomer: δ 4.40 (t, *J* = 10.6 Hz, 1H), 3.35 (app q, *J* = 8.4 Hz, 1H), 2.44 (s, 3H).

^{13}C {^{1}H} NMR (151 MHz, $CDCl_3$) δ 168.5, 142.0, 137.6, 127.6, 123.7, 123.3, 116.8, 57.1, 36.5, 24.2, 23.4, -0.8.

IR (ATR, cm^{-1}) 3065, 2952, 2883, 2802, 1660, 1597, 1519, 1478, 1457, 1404, 1353, 1319, 1273, 1247, 1222, 1201, 1160, 1131, 1101, 1032, 960, 837, 742, 692.

HRMS (*m*/*z*) $[M + H]^+$ calcd for $C_{14}H_{21}NOSi$, 248.1465; found, 248.1471.



1-(3-(((tert-butyldimethylsilyl)oxy)methyl)indolin-1-yl)ethan-1-one (6j):

Following general procedure **B**, $Ni(cod)_2$ (20.6 mg, 0.075 mmol, 0.15 equiv), IPr (31.1 mg, 0.08 mmol, 0.16 equiv) acetone (2.3 mL, 0.22 M), Et_3N (139 μL, 1.0 mmol, 2.0 equiv), allyloxy-*tert*-butyldimethylsilane (213 μL, 1.0 mmol, 2.0 equiv), 2'-iodoacetanilide (130.5 mg, 0.50 mmol 1.0 equiv), and $Ru(bpy)_3(PF_6)_2$ (8.6 mg, 0.01 mmol, 0.02 equiv) were added to a 2 dram vial in a nitrogen-filled glovebox. The vial cap was then taped shut, before the vial was removed from the glovebox and placed in a 35 °C oil bath next to a compact fluorescent lightbulb. After 48 h, the reaction was opened to air, EtOAc was added, and the reaction mixture was filtered through a short silica plug with EtOAc as the eluent and concentrated. Column chromatography (Biotage 25g HP-sil, 5–40% EtOAc in hexanes) afforded 113.5 mg (74%) of **6j** as a pale yellow oil (selectivity ratio of indoline **6j** to [Σ Heck/isomerized Heck/etc.] 12.3:1, determined by GC analysis).

^{1}H NMR (600 MHz, $CDCl_3$) present in ~7:1 ratio of rotational isomers about the amide

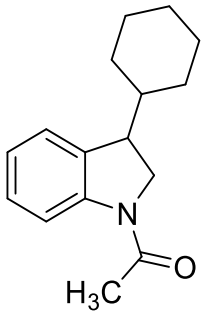
major rotational isomer: δ 8.22 (d, *J* = 8.1 Hz, 1H), 7.23 (t, *J* = 7.8 Hz, 1H), 7.20 (d, *J* = 7.6 Hz, 1H), 7.02 (tt, *J* = 7.5, 1.0 Hz, 1H), 4.10 (dd, *J* = 10.5, 9.1 Hz, 1H), 3.94 (dd, *J* = 10.4, 4.3 Hz, 1H), 3.82 (dd, *J* = 9.7, 5.2 Hz, 1H), 3.60 (dd, *J* = 9.8, 8.3 Hz, 1H), 3.55 (app tt, *J* = 9.0, 4.8 Hz, 1H), 2.25 (s, 3H), 0.89 (s, 9H), 0.06 (s, 3H), 0.02 (s, 3H).

minor rotational isomer: δ 4.15 (app t, *J* = 10.7 Hz, 1H), 4.03 (dd, *J* = 12.1, 4.5 Hz, 1H), 3.77 (app t, *J* = 8.0 Hz, 1H), 3.66 (app t, *J* = 8.6 Hz, 1H), 3.46–3.38 (m, 1H), 2.44 (s, 3H).

^{13}C {^{1}H} NMR (151 MHz, $CDCl_3$) δ 168.7, 143.2, 131.8, 128.3, 124.3, 123.4, 117.0, 66.0, 52.3, 43.1, 25.8, 24.2, 18.3, -5.3, -5.5.

IR (ATR, cm^{-1}) 2953, 2929, 2886, 2857, 1663, 1599, 1482, 1462, 1400, 1359, 1287, 1252, 1114, 1086, 1006, 833, 776, 752, 670.

HRMS (*m*/*z*) $[M + H]^+$ calcd for $C_{17}H_{27}NO_2Si$, 306.1884; found, 306.1883.



1-(3-cyclohexylindolin-1-yl)ethan-1-one (6k):

Following general procedure **B**, $Ni(cod)_2$ (20.6 mg, 0.075 mmol, 0.15 equiv), IPr (31.1 mg, 0.08 mmol, 0.16 equiv) acetone (2.3 mL, 0.22 M), Et_3N (139 μL, 1.0 mmol, 2.0 equiv), vinylcyclohexane (137 μL, 1.0 mmol, 2.0 equiv), 2'-iodoacetanilide (130.5 mg, 0.50 mmol 1.0 equiv), and $Ru(bpy)_3(PF_6)_2$ (8.6 mg, 0.01 mmol, 0.02 equiv) were added to a 2 dram vial in a nitrogen-filled glovebox. The vial cap was then taped shut, before the vial was removed from the glovebox and placed in a 35 °C oil bath next to a compact fluorescent lightbulb. After 48 h, the reaction was opened to air, EtOAc was added, and the reaction mixture was filtered through a short silica plug with EtOAc as the eluent and concentrated. Column chromatography (Biotage 25g HP-sil, 5–46 % EtOAc in hexanes) afforded 114.4 mg (94%) of **6k** as a pale yellow solid (selectivity ratio of indoline **6k** to [Σ Heck/isomerized Heck/etc.] 9.1:1, determined by GC analysis).

^{1}H NMR (600 MHz, $CDCl_3$) present in ~5:1 ratio of rotational isomers about the amide

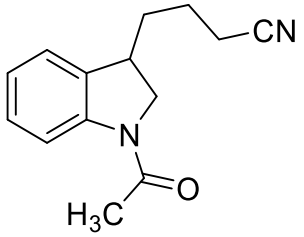
major rotational isomer: δ 8.21 (d, *J* = 8.1 Hz, 1H), 7.21 (t, *J* = 7.8 Hz, 1H), 7.17 (d, *J* = 7.5 Hz, 1H), 7.03 (t, *J* = 7.5 Hz, 1H), 4.01 (t, *J* = 10.1 Hz, 1H), 3.84 (dd, *J* = 10.5, 4.7 Hz, 1H), 3.31 (app dt, *J* = 9.6, 4.7 Hz, 1H), 2.25 (d, *J* = 1.1 Hz, 3H), 1.82–1.62 (m, 5H), 1.44 (d, *J* = 13.4 Hz, 1H), 1.32–1.21 (m, 1H), 1.15 (dddd, *J* = 25.8, 16.2, 9.9, 3.5 Hz, 2H), 1.03 (qdd, *J* = 12.6, 9.5, 3.6 Hz, 2H).

minor rotational isomer: δ 4.12 (dd, *J* = 12.3, 4.6 Hz, 1H), 3.96 (app d, *J* = 11.5 Hz, 1H), 3.16–3.10 (m, 1H), 2.43 (s, 3H).

^{13}C {^{1}H} NMR (151 MHz, $CDCl_3$) δ 168.5, 143.2, 133.5, 127.7, 124.5, 123.4, 116.8, 51.9, 45.6, 42.3, 30.6, 27.9, 26.47, 26.40, 26.3, 24.3.

IR (ATR, cm^{-1}) 2923, 2851, 1660, 1597, 1517, 1481, 1460, 1401, 1356, 1340, 1286, 1223, 1128, 1032, 923, 892, 753.

HRMS (*m*/*z*) $[M + H]^+$ calcd for $C_{16}H_{21}NO$, 244.1696; found, 244.1700.



4-(1-acetylindolin-3-yl)butanenitrile (6l):

Following general procedure **B**, $Ni(cod)_2$ (20.6 mg, 0.075 mmol, 0.15 equiv), IPr (31.1 mg, 0.08 mmol, 0.16 equiv) acetone (2.3 mL, 0.22 M), Et_3N (139 μL, 1.0 mmol, 2.0 equiv), 5-hexenenitrile (114 μL, 1.0 mmol, 2.0 equiv), 2'-iodoacetanilide (130.5 mg, 0.50 mmol 1.0 equiv), and $Ru(bpy)_3(PF_6)_2$ (8.6 mg, 0.01 mmol, 0.02 equiv) were added to a 2 dram vial in a nitrogen-filled glovebox. The vial cap was then taped shut, before the vial was removed from the glovebox and placed in a 35 °C oil bath next to a compact fluorescent lightbulb. After 48 h, the reaction was opened to air, EtOAc was added, and the reaction mixture was filtered through a short silica plug with EtOAc as the eluent and concentrated. Column chromatography (Biotage 25g HP-sil, 17–100 % EtOAc in hexanes) afforded 86.7 mg (76%) of **6l** as a pale orange solid (selectivity ratio of indoline **6l** to [Σ Heck/isomerized Heck/etc.] 61.5:1, determined by GC analysis).

^1H NMR (600 MHz, $CDCl_3$) present in a ~4.5:1 ratio of rotational isomers about the amide

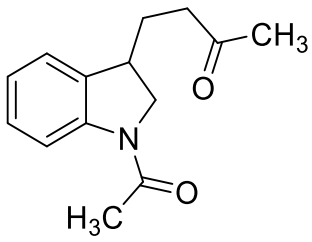
major rotational isomer: δ 8.22 (d, *J* = 8.1 Hz, 1H), 7.24 (t, *J* = 7.8 Hz, 1H), 7.17 (d, *J* = 7.5 Hz, 1H), 7.05 (t, *J* = 7.4 Hz, 1H), 4.20 (app t, *J* = 9.9 Hz, 1H), 3.70 (dd, *J* = 10.3, 5.5 Hz, 1H), 3.49–3.44 (m, 1H), 2.40 (t, *J* = 6.5 Hz, 2H), 2.24 (s, 3H), 1.99–1.89 (m, 1H), 1.81–1.67 (m, 3H).

minor rotational isomer: δ 4.24 (app t, *J* = 10.6 Hz, 1H), 3.84 (dd, *J* = 12.1, 5.6 Hz, 1H), 3.30 (br s, 1H), 2.45 (s, 3H).

^{13}C {^{1}H} NMR (151 MHz, $CDCl_3$) δ 168.6, 142.7, 133.7, 128.3, 123.78, 123.75, 119.2, 117.1, 54.7, 39.4, 34.3, 24.3, 22.6, 17.4.

IR (ATR, cm^{-1}) 2931, 2875, 2246, 1654, 1596, 1480, 1460, 1400, 1349, 1323, 1274, 1131, 1029, 843, 755.

HRMS (*m*/*z*) $[M + H]^+$ calcd for $C_{14}H_{16}N_2O$, 229.1335; found, 229.1344.



4-(1-acetylindolin-3-yl)butan-2-one (6m):

Following general procedure **A**, $Ni(cod)_2$ (20.6 mg, 0.075 mmol, 0.15 equiv), IPr (31.1 mg, 0.08 mmol, 0.16 equiv) acetone (2.3 mL, 0.22 M), Et_3N (139 μL, 1.0 mmol, 2.0 equiv), allylacetone (116 μL, 1.0 mmol, 2.0 equiv), 2'-iodoacetanilide (130.5 mg, 0.50 mmol 1.0 equiv), and $Ru(bpy)_3(PF_6)_2$ (4.3 mg, 0.005 mmol, 0.01 equiv) were added to a 2 dram vial in a nitrogen-filled glovebox. The vial cap was then taped shut, before the vial was removed from the glovebox and

placed next to blue LED lights cooled by a fan. After 26 h, the reaction was opened to air and concentrated. Column chromatography (Biotage 25g HP-sil, 10–100 % EtOAc in hexanes) afforded 99.4 mg (86%) of **6m** as an orange oil (selectivity ratio of indoline **6m** to [Σ Heck/isomerized Heck/etc.] 22:1, determined by GC analysis).

^{1}H NMR (600 MHz, $CDCl_3$) present in ~4.5:1 ratio of rotational isomers about the amide

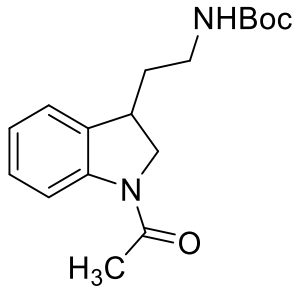
major rotational isomer: δ 8.23 (d, *J* = 8.1 Hz, 1H), 7.25 (t, *J* = 7.8 Hz, 1H), 7.19 (d, *J* = 7.4 Hz, 1H), 7.07 (t, *J* = 7.5 Hz, 1H), 4.17 (app t, *J* = 9.9 Hz, 1H), 3.70 (dd, *J* = 10.3, 5.3 Hz, 1H), 3.47 (app tt, *J* = 8.7, 5.4 Hz, 1H), 2.56–2.44 (m, 2H), 2.25 (s, 3H), 2.17 (s, 3H), 2.09 (tdd, *J* = 13.9, 7.7, 3.6 Hz, 1H), 1.92 (dtd, *J* = 14.2, 8.1, 6.2 Hz, 1H).

minor rotational isomer: δ 4.23 (app t, *J* = 10.7 Hz, 1H), 3.82 (dd, *J* = 12.0, 5.9 Hz, 1H), 3.30 (app q, *J* = 5.5, 5.0 Hz, 1H).

^{13}C {^{1}H} NMR (151 MHz, $CDCl_3$) δ 207.9, 168.7, 142.7, 134.0, 128.1, 123.9, 123.7, 117.0, 54.8, 40.1, 39.1, 30.1, 28.7, 24.3.

IR (ATR, cm^{-1}) 2922, 1711, 1654, 1597, 1480, 1460, 1399, 1354, 1272, 1161, 1130, 1030, 936, 753.

HRMS (*m*/*z*) $[M + H]^+$ calcd for $C_{14}H_{17}NO_2$, 232.1332; found, 232.1340.



tert-butyl (2-(1-acetylindolin-3-yl)ethyl)carbamate (6n):

Following general procedure **A**, $Ni(cod)_2$ (20.6 mg, 0.075 mmol, 0.15 equiv), IPr (31.1 mg, 0.08 mmol, 0.16 equiv) acetone (2.3 mL, 0.22 M), Et_3N (139 μL, 1.0 mmol, 2.0 equiv), 1-(Boc-amino)-3-butene (184 μL, 1.0 mmol, 2.0 equiv), 2'-iodoacetanilide (130.5 mg, 0.50 mmol 1.0 equiv), and $Ru(bpy)_3(PF_6)_2$ (4.3 mg, 0.005 mmol, 0.01 equiv) were added to a 2 dram vial in a nitrogen-filled glovebox. The vial cap was then taped shut, before the vial was removed from the glovebox and placed next to blue LED lights cooled by a fan. After 26 h, the reaction was opened to air and concentrated. Column chromatography (Biotage 25g Ultra-sil, 12–100 % EtOAc in hexanes) afforded 147.2 mg (97%) of **6n** as a yellow solid (selectivity ratio of indoline **6n** to [Σ Heck/isomerized Heck/etc.] 28:1, determined by GC analysis).

^{1}H NMR (500 MHz, $CDCl_3$) present in ~5:1 ratio of rotational isomers about the amide

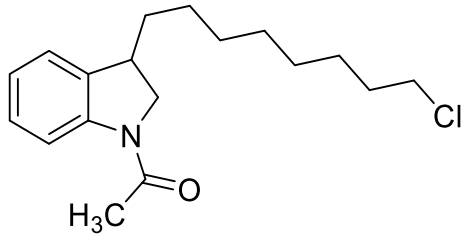
major rotational isomer: δ 8.20 (d, *J* = 8.0 Hz, 1H), 7.21 (t, *J* = 7.8 Hz, 1H), 7.17 (d, *J* = 7.5 Hz, 1H), 7.03 (t, *J* = 7.5 Hz, 1H), 4.66 (br s, 1H), 4.21 (app t, *J* = 9.9 Hz, 1H), 3.75 (dd, *J* = 10.5, 6.0 Hz, 1H), 3.45 (tt, *J* = 9.8, 5.2 Hz, 1H), 3.32–3.19 (m, 2H), 2.23 (s, 3H), 2.00 (dtd, *J* = 12.7, 7.7, 4.6 Hz, 1H), 1.79–1.69 (m, 1H), 1.45 (s, 9H).

minor rotational isomer: δ 4.30–4.23 (m, 1H), 3.83 (dd, *J* = 12.2, 5.8 Hz, 1H), 2.44 (s, 3H).

^{13}C {^{1}H} NMR (151 MHz, $CDCl_3$) δ 168.7, 156.1, 142.6, 134.4, 128.0, 123.7, 117.0, 79.5, 54.9, 38.3, 37.7, 36.0, 29.4, 28.4, 24.3.

IR (ATR, cm^{-1}) 3322, 2972, 2936, 1694, 1651, 1596, 1517, 1481, 1403, 1364, 1272, 1248, 1165, 1031, 911, 846, 728.

HRMS (*m*/*z*) $[M + H]^+$ calcd for $C_{17}H_{24}N_2O_3$, 327.1679; found, 327.1699.



1-(3-(8-chlorooctyl)indolin-1-yl)ethan-1-one (6o):

Following general procedure **A**, $Ni(cod)_2$ (20.6 mg, 0.075 mmol, 0.15 equiv), IPr (31.1 mg, 0.08 mmol, 0.16 equiv) acetone (2.3 mL, 0.22 M), Et_3N (139 μL, 1.0 mmol, 2.0 equiv), 10-chloro-1-decene (199 μL, 1.0 mmol, 2.0 equiv), 2'-iodoacetanilide (130.5 mg, 0.50 mmol 1.0 equiv), and $Ru(bpy)_3(PF_6)_2$ (4.3 mg, 0.005 mmol, 0.01 equiv) were added to a 2 dram vial in a nitrogen-filled glovebox. The vial cap was then taped shut, before the vial was removed from the glovebox and placed next to blue LED lights cooled by a fan. After 26 h, the reaction was opened to air and concentrated. Column chromatography (Biotage 50g Ultra-sil, 5–40 % EtOAc in hexanes) afforded 137.4 mg (89%) of **6o** as a yellow oil (selectivity ratio of indoline **6o** to [Σ Heck/isomerized Heck/etc.] 20.1:1, determined by GC analysis. A significant amount of primary chloride elimination was observed upon GC injection as identified by GCMS, but since no elimination product was observed in the ^{1}H NMR, this peak was disregarded).

^{1}H NMR (500 MHz, $CDCl_3$) present in ~5:1 ratio of rotational isomers about the amide

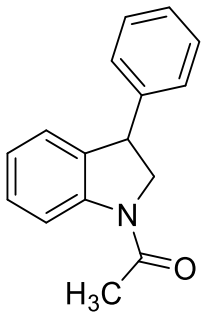
major rotational isomer: δ 8.20 (d, *J* = 8.0 Hz, 1H), 7.21 (t, *J* = 7.8 Hz, 1H), 7.17 (d, *J* = 7.4 Hz, 1H), 7.03 (t, *J* = 7.4 Hz, 1H), 4.15 (app t, *J* = 9.8 Hz, 1H), 3.67 (dd, *J* = 10.2, 6.0 Hz, 1H), 3.54 (t, *J* = 6.7 Hz, 2H), 3.39 (tt, *J* = 9.6, 5.4 Hz, 1H), 2.24 (s, 3H), 1.84–1.73 (m, 3H), 1.59–1.49 (m, 1H), 1.48–1.25 (m, 10H).

minor rotational isomer: δ 4.24 (dd, *J* = 12.0, 9.3 Hz, 1H), 3.80 (dd, *J* = 12.0, 6.1 Hz, 1H), 3.24 (tt, *J* = 7.0, 4.2 Hz, 1H), 2.44 (s, 3H).

^{13}C {^{1}H} NMR (151 MHz, $CDCl_3$) δ 168.6, 142.6, 135.2, 127.7, 123.8, 123.6, 116.9, 55.1, 45.2, 40.1, 35.4, 32.6, 29.5, 29.4, 28.8, 26.9, 26.8, 24.3.

IR (ATR, cm^{-1}) 2926, 2854, 1660, 1598, 1481, 1399, 1338, 1271, 1129, 1095, 1023, 935, 753.

HRMS (*m*/*z*) $[M + H]^+$ calcd for $C_{18}H_{26}ClNO$, 308.1776; found, 308.1765.



1-(3-phenylindolin-1-yl)ethan-1-one (6p):

Following general procedure **A**, $Ni(cod)_2$ (20.6 mg, 0.075 mmol, 0.15 equiv), IPr (31.1 mg, 0.08 mmol, 0.16 equiv) acetone (2.3 mL, 0.22 M), Et_3N (139 μL, 1.0 mmol, 2.0 equiv), styrene (115

μL, 1.0 mmol, 2.0 equiv), 2'-iodoacetanilide (130.5 mg, 0.50 mmol 1.0 equiv), and $Ru(bpy)_3(PF_6)_2$ (4.3 mg, 0.005 mmol, 0.01 equiv) were added to a 2 dram vial in a nitrogen-filled glovebox. The vial cap was then taped shut, before the vial was removed from the glovebox and placed next to blue LED lights cooled by a fan. After 26 h, the reaction was opened to air and concentrated. Column chromatography (Biotage 25g HP-sil, 5–45 % EtOAc in hexanes) afforded 77.1 mg (65%) of **6p** as a yellow oil (selectivity ratio of indoline **6p** to [Σ Heck/isomerized Heck/etc.] 8.2:1, determined by GC analysis).

^{1}H NMR (600 MHz, $CDCl_3$) present in ~6:1 ratio of rotational isomers

major rotational isomer: δ 8.29 (d, *J* = 8.1 Hz, 1H), 7.38–7.30 (m, 2H), 7.32–7.22 (m, 2H), 7.19 (d, *J* = 6.9 Hz, 2H), 7.02 (t, *J* = 7.4 Hz, 1H), 6.98 (d, *J* = 7.5 Hz, 1H), 4.62 (dd, *J* = 10.2, 6.9 Hz, 1H), 4.46 (t, *J* = 10.3 Hz, 1H), 3.95 (dd, *J* = 10.4, 6.8 Hz, 1H), 2.22 (s, 3H).

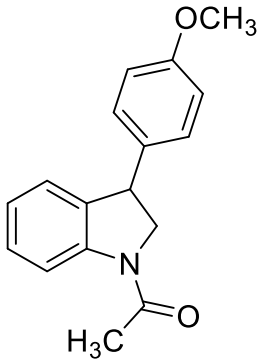
minor rotational isomer: δ 4.06 (dd, *J* = 12.1, 7.1 Hz, 1H), 2.49 (s, 3H).

^{13}C {^{1}H} NMR (151 MHz, $CDCl_3$) δ 168.6, 143.1, 143.0, 134.5, 129.0, 128.2, 127.8, 127.3, 125.0, 124.0, 117.0, 58.1, 46.6, 24.3.

IR (ATR, cm^{-1}) 3029, 2881, 1654, 1594, 1517, 1479, 1396, 1353, 1332, 1286, 1266, 1129, 1094, 1017, 978, 922, 869, 750, 699.

HRMS (*m*/*z*) $[M + H]^+$ calcd for $C_{16}H_{15}NO$, 238.1226; found, 238.1235.

The ^{1}H and ^{13}C NMR spectra are in agreement with those reported in the literature.[1]



1-(3-(4-methoxyphenyl)indolin-1-yl)ethan-1-one (6q):

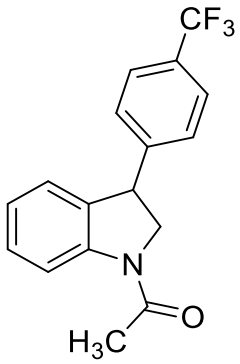
Following general procedure **A**, $Ni(cod)_2$ (20.6 mg, 0.075 mmol, 0.15 equiv), IPr (31.1 mg, 0.08 mmol, 0.16 equiv) acetone (2.3 mL, 0.22 M), Et_3N (139 μL, 1.0 mmol, 2.0 equiv), 4-vinyl anisole (133 μL, 1.0 mmol, 2.0 equiv), 2'-iodoacetanilide (130.5 mg, 0.50 mmol 1.0 equiv), and $Ru(bpy)_3(PF_6)_2$ (4.3 mg, 0.005 mmol, 0.01 equiv) were added to a 2 dram vial in a nitrogen-filled glovebox. The vial cap was then taped shut, before the vial was removed from the glovebox and placed next to blue LED lights cooled by a fan. After 26 h, the reaction was opened to air and concentrated. Column chromatography (Biotage 25g HP-sil, 8–70 % EtOAc in hexanes) afforded 92.4 mg (69%) of **6q** as a viscous orange oil (selectivity ratio of indoline **6q** to [Σ Heck/isomerized Heck/etc.] 11.4:1, determined by GC analysis).

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.28 (d, *J* = 8.1 Hz, 1H), 7.29–7.21 (m, 1H), 7.11 (d, *J* = 8.6 Hz, 2H), 7.02 (t, *J* = 7.4 Hz, 1H), 6.97 (d, *J* = 7.0 Hz, 1H), 6.87 (d, *J* = 8.6 Hz, 2H), 4.59 (dd, *J* = 10.1, 7.0 Hz, 1H), 4.44 (app t, *J* = 10.2 Hz, 1H), 3.91 (dd, *J* = 10.8, 7.2 Hz, 1H), 3.81 (s, 3H), 2.22 (s, 3H).

^{13}C {^{1}H} NMR (151 MHz, $CDCl_3$) δ 168.6, 158.8, 142.9, 135.2, 134.8, 128.9, 128.1, 125.0, 124.0, 116.9, 114.3, 58.3, 55.3, 45.8, 24.3.

IR (ATR, cm^{-1}) 3001, 2932, 2835, 1655, 1596, 1510, 1479, 1396, 1353, 1243, 1177, 1111, 1031, 980, 923, 830, 753.

HRMS (*m*/*z*) $[M + H]^+$ calcd for $C_{17}H_{17}NO_2$, 268.1332; found, 268.1335.



1-(3-(4-(trifluoromethyl)phenyl)indolin-1-yl)ethan-1-one (6r):

Following general procedure **B**, $Ni(cod)_2$ (20.6 mg, 0.075 mmol, 0.15 equiv), IPr (31.1 mg, 0.08 mmol, 0.16 equiv) acetone (2.3 mL, 0.22 M), Et_3N (139 μL, 1.0 mmol, 2.0 equiv), 4-(trifluoromethyl)styrene (98 μL, 0.66 mmol, 1.3 equiv), 2'-iodoacetanilide (130.5 mg, 0.50 mmol 1.0 equiv), and $Ru(bpy)_3(PF_6)_2$ (8.6 mg, 0.01 mmol, 0.02 equiv) were added to a 2 dram vial in a nitrogen-filled glovebox. The vial cap was then taped shut, before the vial was removed from the glovebox and placed in a 35 °C oil bath next to a compact fluorescent lightbulb. After 48 h, the reaction was opened to air, EtOAc was added, and the reaction mixture was filtered through a short silica plug with EtOAc as the eluent and concentrated. Column chromatography (Biotage 50g HP-sil, 5–40 % EtOAc in hexanes) afforded 84.5 mg (55%) of **6r** as a white solid (selectivity ratio of indoline **6r** to [Σ Heck/isomerized Heck/etc.] 8.5:1, determined by GC analysis).

^{1}H NMR (500 MHz, $CDCl_3$) present in ~5:1 ratio of rotational isomers about the amide

major rotational isomer: δ 8.30 (d, *J* = 8.2 Hz, 1H), 7.60 (d, *J* = 8.0 Hz, 2H), 7.34–7.26 (m, 3H), 7.04 (ddd, *J* = 7.3, 6.6, 0.9 Hz, 1H), 6.96 (d, *J* = 7.5 Hz, 1H), 4.70 (dd, *J* = 10.1, 6.6 Hz, 1H), 4.51 (app t, *J* = 10.3 Hz, 1H), 3.95 (dd, *J* = 10.6, 6.6 Hz, 1H), 2.24 (s, 3H).

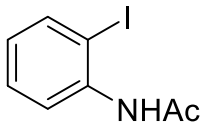
minor rotational isomer: δ 4.65–4.55 (m, 2H), 4.07 (dd, *J* = 11.6, 6.3 Hz, 1H), 2.51 (s, 3H).

^{13}C {^{1}H} NMR (151 MHz, $CDCl_3$) δ 168.6, 147.1, 142.3, 133.5, 129.67 (q, *J* = 32.5 Hz), 128.6, 128.2, 125.96, 125.93, 125.0, 124.2, 117.1, 57.7, 46.4, 24.2.

IR (ATR, cm^{-1}) 1660, 1619, 1597, 1481, 1399, 1358, 1322, 1289, 1163, 1110, 1067, 1018, 980, 839, 754, 725.

HRMS (*m*/*z*) $[M + H]^+$ calcd for $C_{17}H_{14}F_3NO$, 306.1100; found, 306.1089.

Synthesis of Substrates



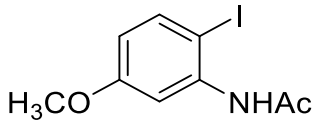
2'-Iodoacetanilide (5a):

In a 25 mL round bottom flask, 2-iodoaniline (2.63 g, 12.0 mmol, 1.0 equiv) was dissolved in EtOAc (12 mL, 1M), acetic anhydride (1.63 mL, 17.2 mmol, 1.4 equiv) was added, and the reaction mixture was stirred at room temperature overnight. Enough additional EtOAc to fully solubilize reaction mixture was added and the mixture was filtered through a plug of SiO_2. Recrystallization from EtOAc/Hexanes yielded 2.52 g (80%) of **5a** as a light tan solid.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.21 (d, *J* = 7.6 Hz, 1H), 7.78 (d, *J* = 7.8 Hz, 1H), 7.43 (br s, 1H), 7.35 (ddd, *J* = 8.4, 7.4, 1.5 Hz, 1H), 6.85 (t, *J* = 7.4 Hz, 1H), 2.25 (s, 3H).

^{13}C {^{1}H} NMR (151 MHz, $CDCl_3$) δ 168.4, 138.8, 138.3, 129.2, 126.3, 122.5, 90.5, 24.8.

The ^{1}H and ^{13}C NMR spectra are in agreement with those reported in the literature.[2]



2'-Iodo-5'-methoxyacetanilide (5b):

In a 500 mL round bottom flask, 4-iodo-3-nitroanisole (1.0 g, 3.6 mmol, 1.0 equiv), Zn powder (18.8 g, 290 mmol, 80 equiv), NH_4Cl (3.08 g, 58 mmol, 16 equiv), MeOH (220 mL, 0.016M) and H_2O (24 mL, 0.15M) were stirred at room temperature overnight. The reaction mixture was

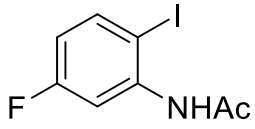
diluted with additional water, and extracted twice with EtOAc. The combined organic layers were washed with brine, dried over $MgSO_4$, filtered, and concentrated. Then, the crude mixture was dissolved in EtOAc (8 mL, 0.45M), acetic anhydride (0.68 mL, 7.2 mmol, 2.0 equiv) was added, and the reaction mixture was stirred at room temperature overnight. Column chromatography (Biotage 25g HP-sil, 11–90 % EtOAc in hexanes) afforded 429 mg (41% over two steps) of **5b** as a light tan solid.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.99 (d, *J* = 3.2 Hz, 1H), 7.61 (d, *J* = 8.8 Hz, 1H), 7.42 (br s, 1H), 6.49 (dd, *J* = 8.7, 3.0 Hz, 1H), 3.81 (s, 3H), 2.25 (s, 3H).

^{13}C {^{1}H} NMR (151 MHz, $CDCl_3$) δ 168.3, 160.6, 139.0, 138.6, 112.8, 107.2, 77.8, 55.5, 25.0.

IR (ATR, cm^{-1}) 3251, 1658, 1579, 1524, 1468, 1408, 1372, 1312, 1287, 1236, 1201, 1172, 1045, 1022, 972, 844, 815, 699.

HRMS (*m*/*z*) $[M + H]^+$ calcd for $C_9H_{10}INO_2$, 291.9829; found, 291.9820.



5'-Fluoro-2'-iodoacetanilide (5c):

In a 25 mL round bottom flask, 5-fluoro-2-iodoaniline (1.90 g, 8.0 mmol, 1.0 equiv) was dissolved in EtOAc (8 mL, 1M), acetic anhydride (0.91 mL, 9.6 mmol, 1.2 equiv) was added,

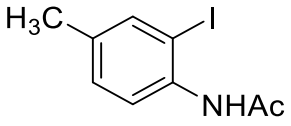
and the reaction mixture was stirred at room temperature overnight. The resulting precipitate was filtered, washing with EtOAc to yield 1.077 g (48%) of **5c** as white filamentous crystals.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.16 (dd, *J* = 11.2, 2.9 Hz, 1H), 7.71 (dd, *J* = 8.8, 6.0 Hz, 1H), 7.48 (br s, 1H), 6.64 (ddd, *J* = 8.6, 7.6, 3.0 Hz, 1H), 2.26 (s, 3H).

^{13}C {^{1}H} NMR (151 MHz, $CDCl_3$) δ 168.3, 163.2 (d, *J* = 246.4 Hz), 139.5 (d, *J* = 11.7 Hz), 139.1 (d, *J* = 9.0 Hz), 113.0 (d, *J* = 22.5 Hz), 109.3 (d, *J* = 28.5 Hz), 82.0, 24.9.

IR (ATR, cm^{-1}) 3249, 1662, 1593, 1526, 1464, 1438, 1414, 1365, 1283, 1234, 1167, 1108, 1026, 973, 875, 805, 774, 677.

HRMS (*m*/*z*) $[M + H]^+$ calcd for C_8H_7FINO, 279.9629; found, 279.9615.



2'-Iodo-4'-methylacetanilide (5d):

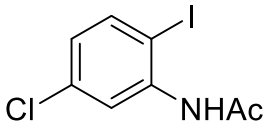
In a 250 mL round bottom flask, 3-iodo-4-nitrotoluene (1.13 mL, 8 mmol, 1.0 equiv), Fe powder (4.48 g, 80 mmol, 10 equiv), NH_4Cl (1.71 g, 32 mmol, 4.0 equiv), MeOH (80 mL, 0.1M) and H_2O (27 mL, 0.3M) were heated to 50 °C for 2 d. Then, the reaction mixture was diluted with additional water, and extracted twice with EtOAc. The combined organic layers were washed with brine, dried over $MgSO_4$, filtered, and concentrated. The resulting orange solid was

dissolved in EtOAc (16 mL, 0.5M), acetic anhydride (1.6 mL, 16 mmol, 2.0 equiv) was added, and the reaction mixture was stirred at room temperature overnight. Column chromatography (30–70 % EtOAc in hexanes) afforded 1.04 g (47% after two steps) of **5d** as a light brown solid.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.03 (d, *J* = 8.3 Hz, 1H), 7.61 (s, 1H), 7.33 (br s, 1H), 7.16 (dd, *J* = 8.3, 1.9 Hz, 1H), 2.29 (s, 3H), 2.24 (s, 3H).

^{13}C {^{1}H} NMR (151 MHz, $CDCl_3$) δ 168.2, 139.0, 136.1, 135.8, 129.9, 122.3, 90.5, 24.7, 20.4.

The ^{1}H and ^{13}C NMR spectra are in agreement with those reported in the literature.[3]



5'-Chloro-2'-iodoacetanilide (5e):

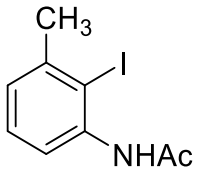
In a 25 mL round bottom flask, 5-chloro-2-iodoaniline (2.02 g, 8.0 mmol, 1.0 equiv) was dissolved in EtOAc (8 mL, 1M), acetic anhydride (1.82 mL, 16 mmol, 2.0 equiv) was added, and the reaction mixture was stirred at room temperature overnight. The resulting precipitate was filtered, washing with EtOAc, to yield 1.91 g (81%) of **5e** as a white powder.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.34 (s, 1H), 7.68 (d, *J* = 8.5 Hz, 1H), 7.43 (br s, 1H), 6.86 (dd, *J* = 8.4, 2.5 Hz, 1H), 2.26 (s, 3H).

^{13}C {^{1}H} NMR (151 MHz, $CDCl_3$) δ 168.2, 139.18, 139.14, 135.4, 125.9, 121.7, 86.4, 24.9.

IR (ATR, cm^{-1}) 3274, 1656, 1568, 1526, 1452, 1398, 1282, 1225, 1090, 1023, 909, 869, 805, 661.

HRMS (*m*/*z*) $[M + H]^+$ calcd for C_8H_7ClINO, 295.9334; found, 295.9342.



2'-Iodo-3'-methylacetanilide (5f):

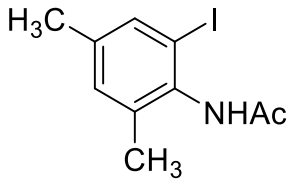
In a 250 mL round bottom flask, 2-iodo-3-nitrotoluene (2.10 g, 8 mmol, 1.0 equiv), Fe powder (4.48 g, 80 mmol, 10 equiv), NH_4Cl (1.71 g, 32 mmol, 4.0 equiv), MeOH (80 mL, 0.1M) and H_2O (27 mL, 0.3M) were heated to 50 °C for 2 d. The reaction mixture was diluted with additional water, and extracted twice with EtOAc. The combined organic layers were washed with brine, dried over $MgSO_4$, filtered, and concentrated. Then, the resulting orange liquid was diluted in EtOAc (13 mL, 0.5M), acetic anhydride (0.94 mL, 9.9 mmol, 1.5 equiv) was added, and the reaction mixture was stirred at room temperature overnight. The resulting precipitate was filtered, washing with EtOAc then hexanes, to yield 516 mg (24% over two steps) of **5f** as a white solid.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.99 (d, *J* = 8.1 Hz, 1H), 7.59 (br s, 1H), 7.23 (t, *J* = 7.8 Hz, 1H), 7.04 (d, *J* = 7.5 Hz, 1H), 2.48 (s, 3H), 2.26 (s, 3H).

^{13}C {^{1}H} NMR (151 MHz, $CDCl_3$) δ 168.3, 142.3, 138.4, 128.5, 125.9, 119.7, 98.0, 29.7, 24.9.

IR (ATR, cm^{-1}) 3255, 1659, 1583, 1528, 1460, 1394, 1367, 1291, 1255, 1167, 1013, 789, 712, 670.

HRMS (*m*/*z*) $[M + H]^+$ calcd for $C_9H_{10}INO$, 275.9880; found, 275.9899.



2'-Iodo-4',6'-dimethylacetanilide (5g):

In a 25 mL round bottom flask, 2-iodo-4,6-dimethylaniline (1.00 g, 4.0 mmol, 1.0 equiv) was dissolved in CH_2Cl_2 (8 mL, 0.5M), acetyl chloride (0.35 mL, 4.8 mmol, 1.2 equiv) and pyridine (0.39 mL, 4.8 mmol, 1.2 equiv) were added, and the reaction mixture was stirred at room temperature overnight, concentrated under reduced pressure, and purified by column chromatography (1–10 % MeOH in CH_2Cl_2) to afford 717 mg (61%) of **5g** as a light tan solid.

^{1}H NMR (500 MHz, $CDCl_3$) present in ~4:1 ratio of rotational isomers about the amide

major rotational isomer: δ 7.52 (dd, *J* = 1.9, 0.9 Hz, 1H), 7.03 (s, 1H), 6.84 (s, 1H), 2.27 (s, 6H), 2.23 (s, 3H).

minor rotational isomer δ 7.61 (s, 1H), 7.08 (s, 1H), 6.68 (s, 1H), 2.32 (s, 3H), 2.31 (s, 3H), 1.77 (s, 3H).

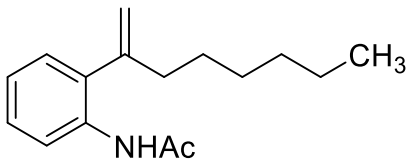
^{13}C {^{1}H} NMR (151 MHz, $CDCl_3$) rotational isomers clearly visible

major rotational isomer: δ 168.9, 139.0, 137.8, 137.0, 134.8, 131.7, 99.6, 23.4, 20.47, 19.6.

minor rotational isomer: δ 173.1, 140.3, 137.7, 137.2, 135.6, 132.0, 102.1, 20.7, 20.51, 19.7.

IR (ATR, cm^{-1}) 3226, 3180, 3021, 2920, 1654, 1597, 1559, 1523, 1470, 1437, 1368, 1293, 1265, 1129, 1036, 1011, 971, 858, 788, 703.

HRMS (*m*/*z*) $[M + H]^+$ calcd for $C_{10}H_{12}INO$, 290.0036; found, 290.0048.



***N*-(2-(oct-1-en-2-yl)phenyl)acetamide (7a):**

In a 20 mL vial in a nitrogen filled glovebox, $Pd(dba)_2$ (86.5 mg, 0.15 mmol, 0.1 equiv) and dppf (100 mg, 0.18 mmol, 0.12 equiv) were mixed in DMA (8.8 mL, 0.17M) for 10 min at room temperature. Then 2-acetamidophenyl trifluoromethanesulfonate **3** (425 mg, 1.5 mmol, 1.0 equiv), 1-octene (470 μL, 3.0 mmol, 2.0 equiv), and urotropine (420 mg, 3.0 mmol, 2.0 equiv) were added. The reaction mixture was then heated to 80 °C for 48 h. After cooling, the reaction

mixture was passed through a plug of SiO_2, eluting with diethyl ether, and concentrated. Column chromatography (Biotage 25g HP-sil, 5–40 % EtOAc in hexanes) afforded 335 mg (91%) **7a** as a colorless oil (rr **7a** to linear product or isomerized Heck 23.4:1, determined by GC analysis).

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.27 (d, *J* = 8.7 Hz, 1H), 7.53 (br s, 1H), 7.31–7.23 (m, 1H), 7.11–7.06 (m, 2H), 5.37 (s, 1H), 5.03 (s, 1H), 2.34 (t, *J* = 7.5 Hz, 2H), 2.15 (s, 3H), 1.44–1.34 (m, 2H), 1.34–1.22 (m, 6H), 0.88 (t, *J* = 6.9 Hz, 3H).

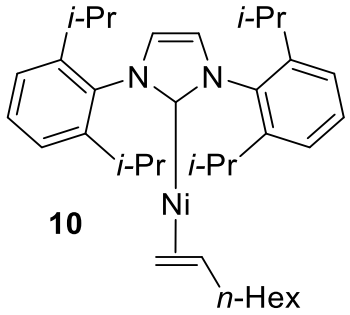
^{13}C {^{1}H} NMR (151 MHz, $CDCl_3$) δ 168.0 147.6, 134.4, 132.8, 128.0, 127.8, 123.6, 120.7, 115.7, 38.1, 31.6, 29.0, 27.8, 24.8, 22.6, 14.1.

IR (ATR, cm^{-1}) 3279, 2927, 2856, 1664, 1579, 1516, 1445, 1368, 1294, 1041, 1006, 905, 755.

HRMS (*m*/*z*) $[M + H]^+$ calcd for $C_{16}H_{23}NO$, 246.1852; found, 246.1845.

Mechanistic Experiments

A) ^{1}H NMR Studies



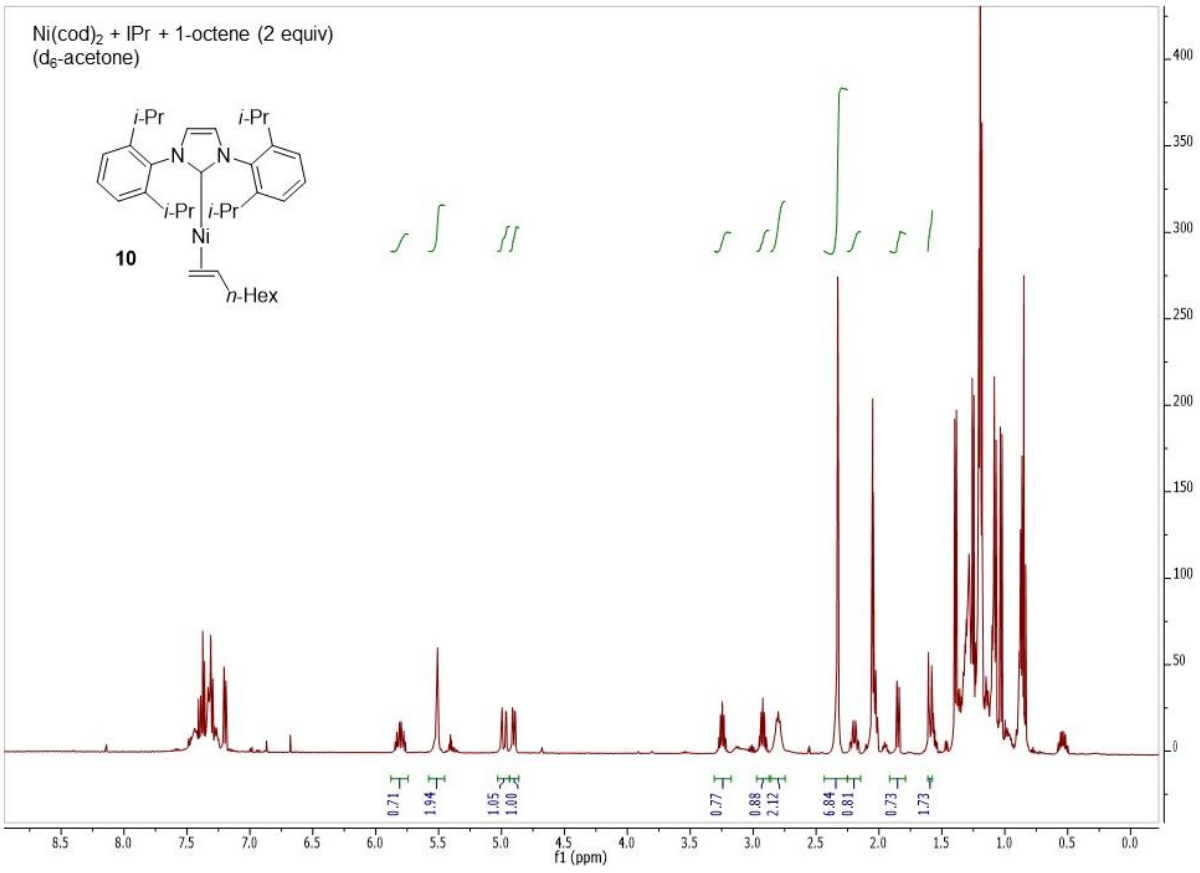
10

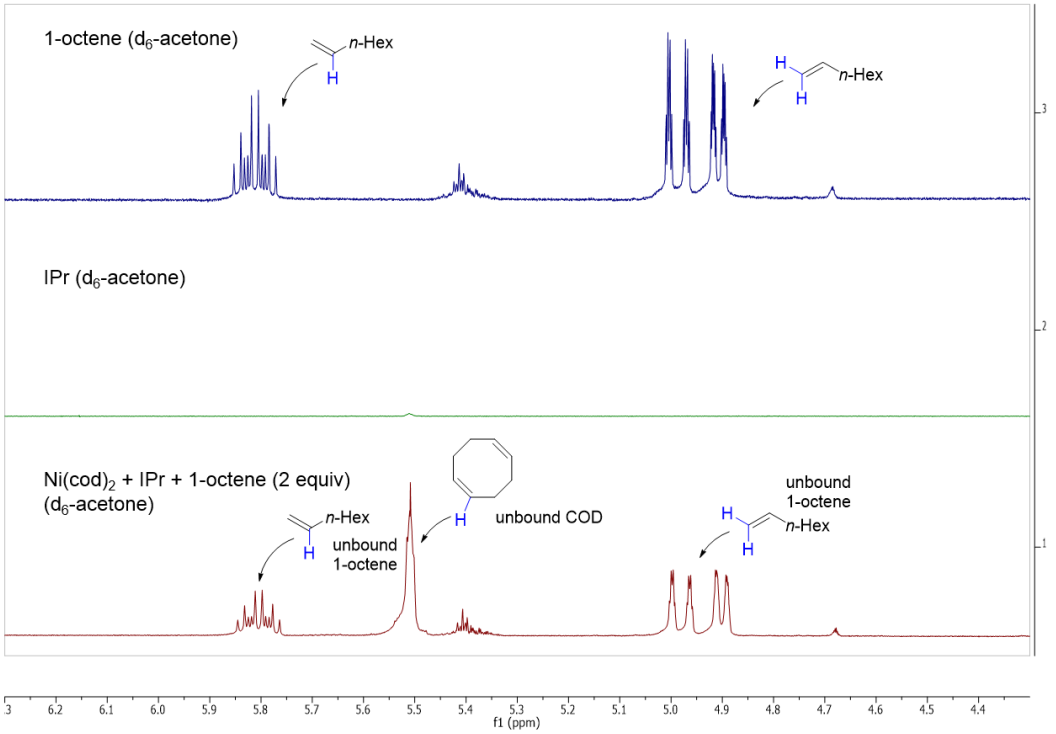
Preparation of 10: $Ni(cod)_2$ (2.1 mg, 0.0076 mmol, 1.0 equiv), IPr (3.0 mg, 0.0077 mmol, 1.0 equiv), 1-octene (2.5 μL, 0.016 mmol, 2.1 equiv), and d_6-acetone (700 μL, 0.01 M) were added to a dry NMR tube in a nitrogen-filled glovebox. The tube was then capped and taped shut, removed from the glovebox, and put on a nutating mixer for 2 h, until all $Ni(cod)_2$ had gone into solution.

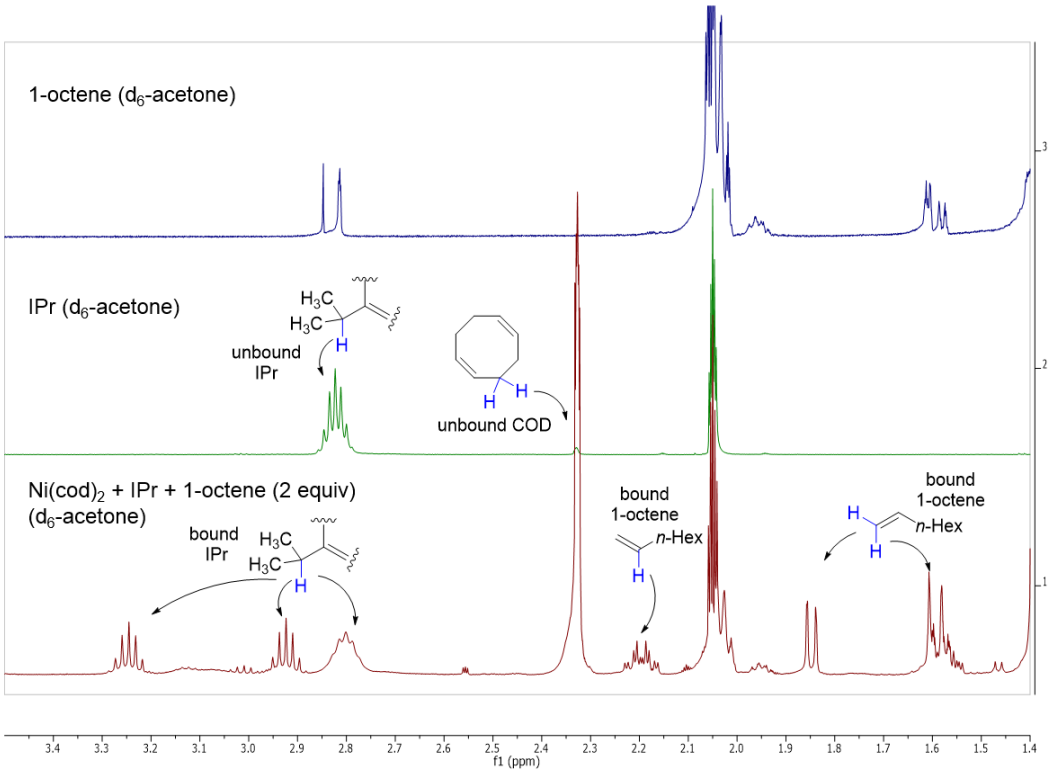
The resulting ^{1}H NMR spectrum (Figure S3) was consistent with the structure **10** with one molecule of 1-octene bound to Ni, and complete displacement of COD as a ligand.

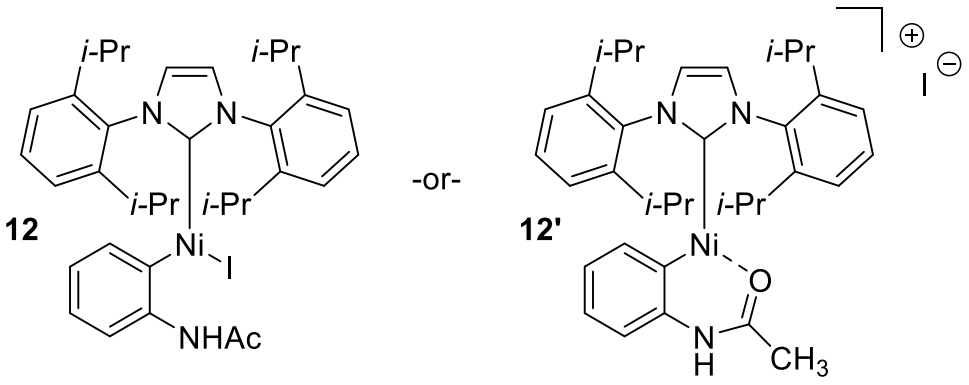
^{1}H NMR (500 MHz, acetone-d_6) δ 7.55–7.23 (m, 7H), 7.20 (dd, *J* = 7.6, 1.5 Hz, 1H), 5.81 (ddt, *J* = 17.0, 10.2, 6.7 Hz, 1H), 5.51 (ddd, *J* = 3.5, 2.4, 1.4 Hz, 2H), 4.99 (dq, *J* = 17.1, 1.8 Hz, 1H), 4.91 (ddt, *J* = 10.2, 2.4, 1.2 Hz, 1H), 3.25 (hept, *J* = 7.2 Hz, 1H), 2.93 (hept, *J* = 6.5 Hz, 1H), 2.88–2.75 (m, *J* = 5.9, 5.4 Hz, 2H), 2.35–2.32 (m, 6H), 2.20 (dtd, *J* = 12.4, 9.0, 3.3 Hz, 1H), 1.85 (dd, *J* = 9.1, 1.0 Hz, 1H), 1.63–1.56 (m, 2H), 1.40 (d, *J* = 6.8 Hz, 3H), 1.26 (d, *J* = 6.8 Hz, 3H), 1.38–1.10 (m, 38H), 1.08 (d, *J* = 6.9 Hz, 3H), 1.03 (d, *J* = 6.9 Hz, 3H), 0.91–0.83 (m, 8H).

Figure S3. ^{1}H NMR spectrum of **10**.




1-octene (d6-acetone)
n-Hex
H
H
H
n-Hex
IPr (d6-acetone)
Ni(cod)2 + IPr + 1-octene (2 equiv)
(d6-acetone)
n-Hex
H
unbound
1-octene
H
unbound COD
unbound
1-octene
H
H
n-Hex
f1 (ppm)


1-octene (d6-acetone)
IPr (d6-acetone)
H3C
H3C
H
unbound
IPr
H
H
unbound COD
Ni(cod)2 + IPr + 1-octene (2 equiv)
(d6-acetone)
bound
IPr
H3C
H3C
H
bound
1-octene
n-Hex
H
H
bound
1-octene
H
H
n-Hex
f1 (ppm)

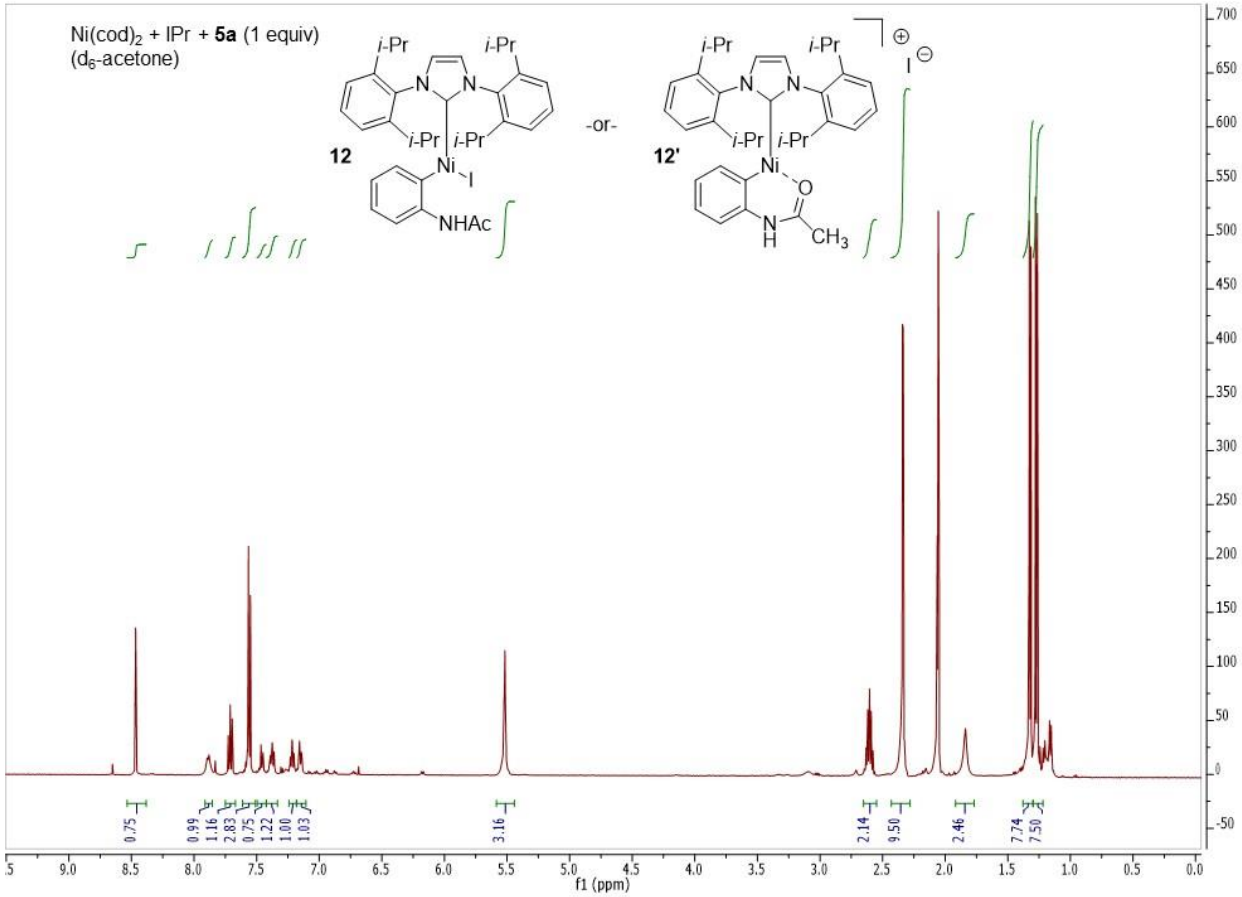


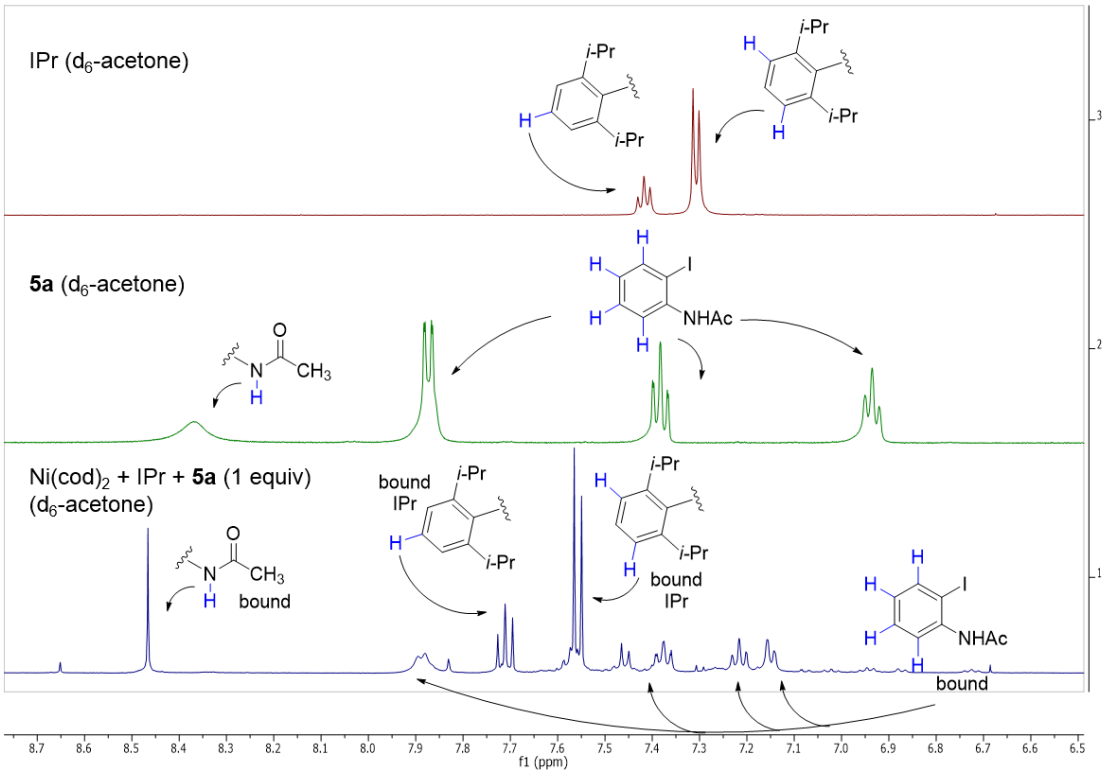
Preparation of 12: $Ni(cod)_2$ (2.1 mg, 0.0076 mmol, 1.0 equiv), IPr (3.0 mg, 0.0077 mmol, 1.0 equiv), **5a** (2.0 mg, 0.0077 mmol, 1.0 equiv), and d_6-acetone (700 μL, 0.01 M) were added to a dry NMR tube in a nitrogen-filled glovebox. The tube was then capped and taped shut, removed from the glovebox, and put on a nutating mixer for 16 h.

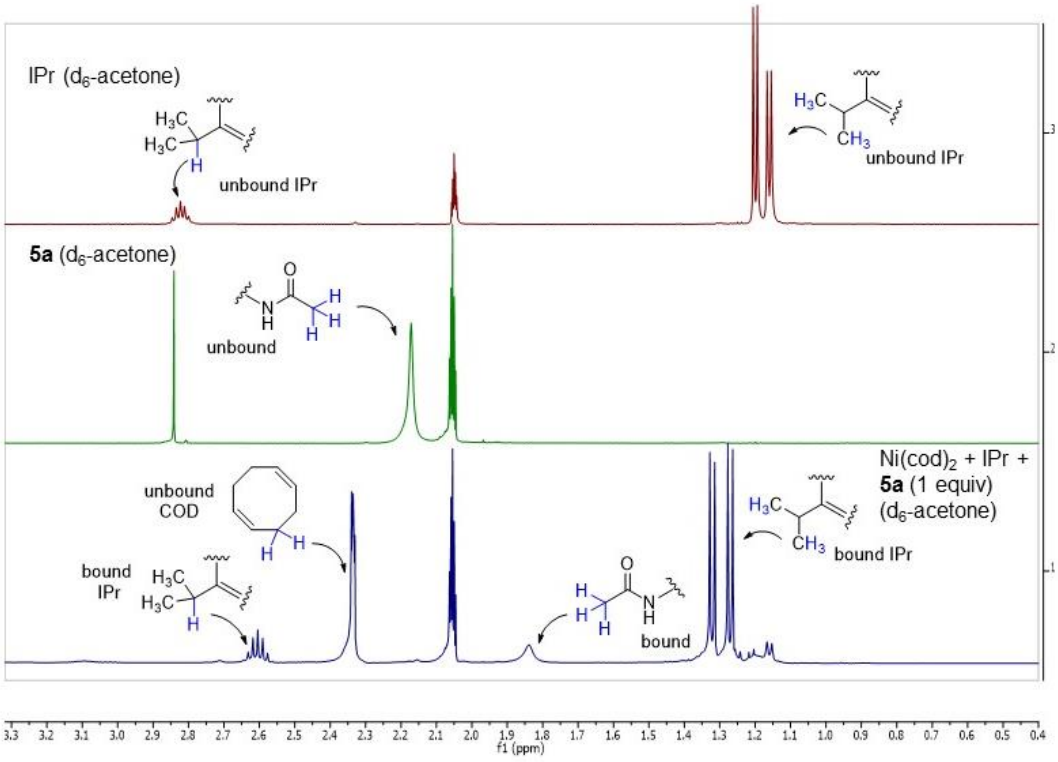
The resulting ^{1}H NMR spectrum (Figure S4) was consistent with the structure **12** or **12'** oxidative addition complex with complete reaction of **5a** as well as crystal structure data of **12'** (Figure S6).

^{1}H NMR (500 MHz, acetone-d_6) δ 8.47 (s, 1H), 7.89 (d, *J* = 8.3 Hz, 1H), 7.71 (ddd, *J* = 8.1, 7.5, 0.5 Hz, 1H), 7.56 (d, *J* = 7.9 Hz, 2H), 7.46 (d, *J* = 7.7 Hz, 1H), 7.42–7.32 (m, 1H), 7.22 (td, *J* = 7.5, 1.2 Hz, 1H), 7.15 (dd, *J* = 7.6, 1.7 Hz, 1H), 5.52 (dddt, *J* = 3.0, 2.4, 1.7, 0.7 Hz, 3H), 2.60 (hept, *J* = 7.1 Hz, 2H), 2.35–2.32 (m, 10H), 1.84 (br s, 2H), 1.32 (d, *J* = 6.8 Hz, 9H), 1.27 (d, *J* = 6.9 Hz, 9H).

Figure S4. ^{1}H NMR spectrum of **12**.



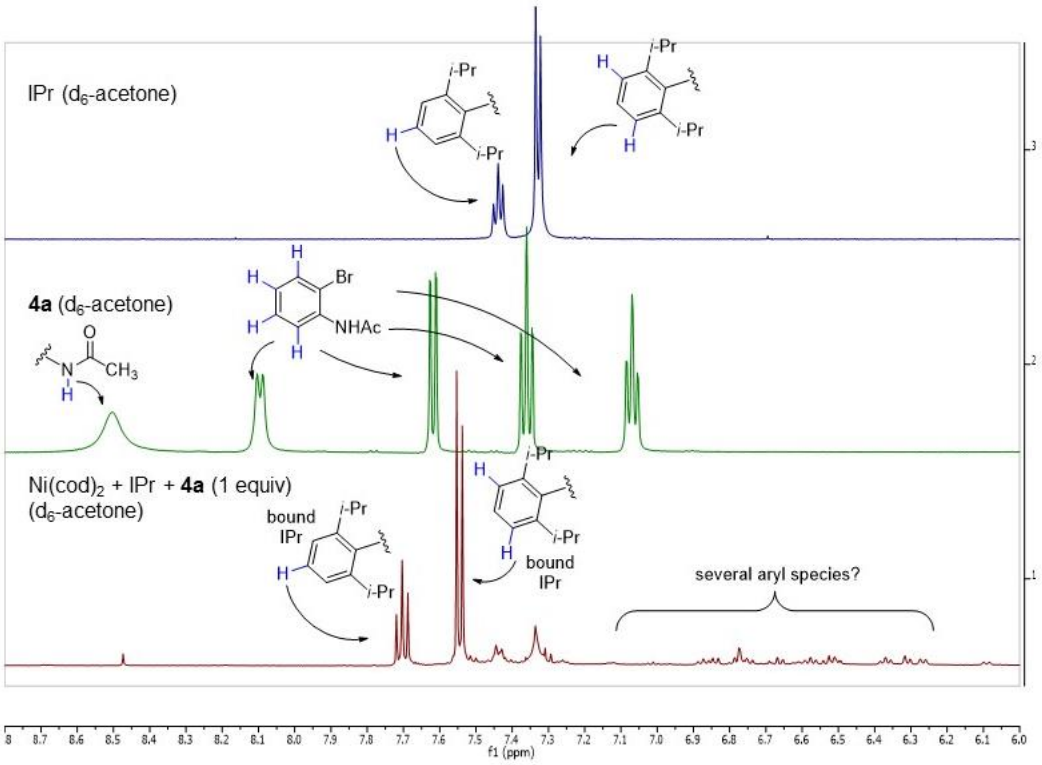

IPr (d6-acetone)
5a (d6-acetone)
Ni(cod)2 + IPr + 5a (1 equiv)
(d6-acetone)
i-Pr
NHAc
CH3
bound
bound IPr
f1 (ppm)


IPr (d6-acetone)
unbound IPr
5a (d6-acetone)
unbound
unbound COD
bound IPr
bound
Ni(cod)2 + IPr +
5a (1 equiv)
(d6-acetone)
f1 (ppm)

Oxidative Addition of ArBr (4a): $Ni(cod)_2$ (2.1 mg, 0.0076 mmol, 1.0 equiv), IPr (3.0 mg, 0.0077 mmol, 1.0 equiv), **4a** (1.6 mg, 0.0077 mmol, 1.0 equiv), and d_6-acetone (700 μL, 0.01 M) were added to a dry NMR tube in a nitrogen-filled glovebox. The tube was then capped and taped shut, removed from the glovebox, and put on a nutating mixer for 16 h.

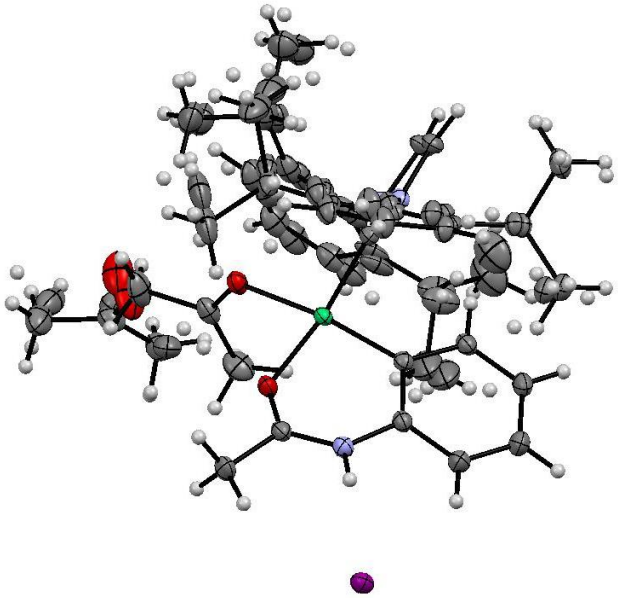
The resulting ^{1}H NMR spectrum (Figure S5), unlike that for the oxidative addition complex of the corresponding ArI (**5a**) (Figure 6) did not show clean formation of one species in solution. Complete consumption of **4a** occurred, but a complex series of small signals in the aromatic region resulted. A similar complex spectrum was observed when 1-octene was added. The presence of multiple species in solution is also corroborated by the complex CV spectrum that also results (Figure S7d).

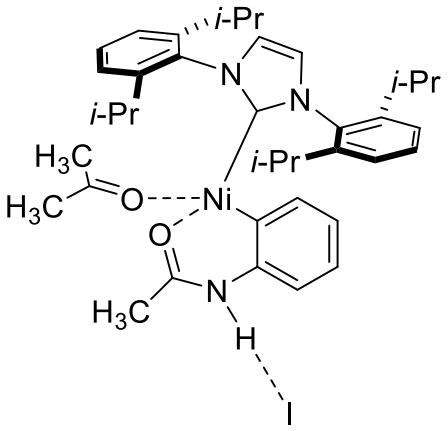
Figure S5. ^{1}H NMR data for oxidative addition of ArBr **4a**.

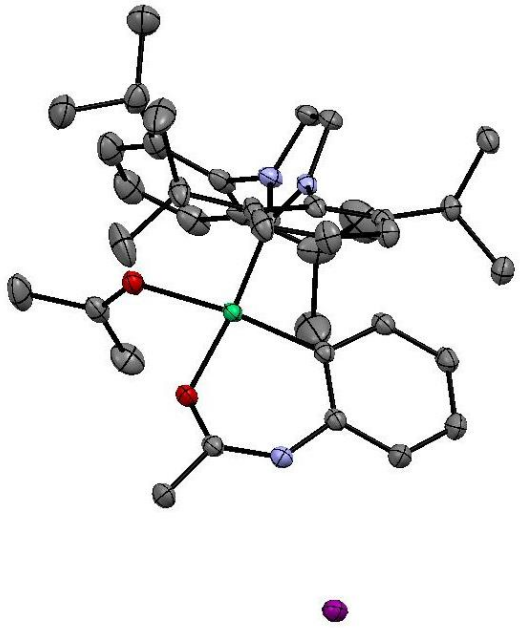


B) Crystal Structures

Figure S5. Thermal ellipsoid depiction of oxidative addition complex **12'**.







(Disorder in IPr ligand and second molecule of acetone removed, and hydrogens omitted for clarity)

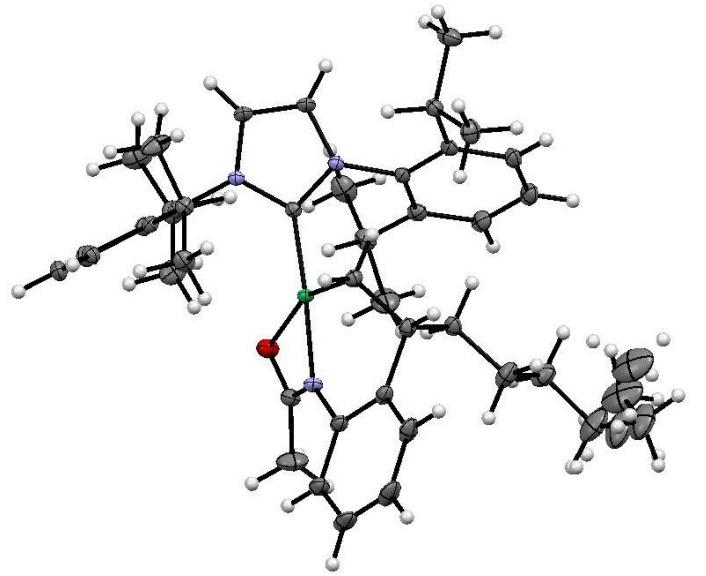
Crystals were grown directly by vapor diffusion with pentane at –20 °C under inert atmosphere from a solution of $Ni(cod)_2$ (25.6 mg, 0.093 mmol, 1.0 equiv), IPr (39.6 mg, 0.10 mmol, 1.1 equiv), 1-octene (34 μL, 0.21 mmol, 2.0 equiv), **5a** (24.2 mg, 0.093 mmol, 1.0 equiv), Et_3N (13 μL, and acetone (1.0 mL).

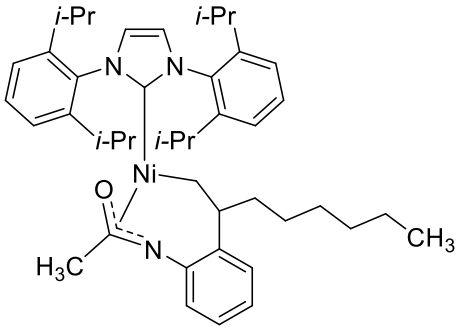
The complete data for this structure are on file with the CCDC under entry 1403188

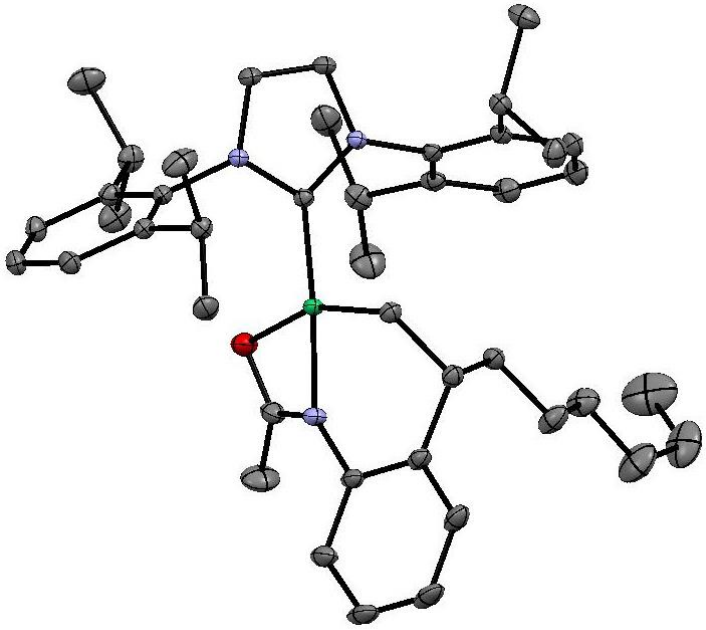
Table S1. Crystal data and structure refinement for compound **12'**.

Identification code	14042	
Empirical formula	$C_{41}H_{56}INiO_3$	
Formula weight	824.49	
Temperature	100(2) K	
Wavelength	0.71073 Å	
Crystal system	Triclinic	
Space group	P-1	
Unit cell dimensions	*a* = 11.9159(2) Å	α= 68.5985(9)°.
	b = 13.6522(3) Å	β= 77.8452(10)°.
	c = 13.8179(3) Å	γ = 82.4777(10)°.
Volume	2042.34(7) Å^3	
Z	2	
Density (calculated)	1.341 Mg/m^3	
Absorption coefficient	1.269 mm^{-1}	
F(000)	856	
Crystal size	0.280 x 0.175 x 0.080 mm^3	
Theta range for data collection	1.605 to 29.574°.	
Index ranges	-16<=*h*<=16, -18<=*k*<=18, -19<=*l*<=19	
Reflections collected	99315	
Independent reflections	11448 [R_{int} = 0.0346]	
Completeness to theta = 25.242°	100.0 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	0.7462 and 0.6859	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	11448 / 2133 / 579	
Goodness-of-fit on F^2	1.038	
Final R indices [I>2σ(I)]	*R*1 = 0.0251, *wR*2 = 0.0593	
R indices (all data)	*R*1 = 0.0311, *wR*2 = 0.0631	
Extinction coefficient	n/a	
Largest diff. peak and hole	1.083 and -0.772 e.Å^{-3}	

Figure S6. Thermal ellipsoid depiction of migratory insertion complex **S16** from aryl bromide **4**.







(Disorder in hexyl sidechain removed, and hydrogens omitted for clarity)

Crystals were grown directly by vapor diffusion with pentane at –20 °C under inert atmosphere from a solution of $Ni(cod)_2$ (25.6 mg, 0.093 mmol, 1.0 equiv), IPr (39.6 mg, 0.10 mmol, 1.1 equiv), 1-octene (34 μL, 0.21 mmol, 2.0 equiv), **4** (20.0 mg, 0.093 mmol, 1.0 equiv), Et_3N (13 μL, and acetone (1.0 mL).

The complete data for this structure are on file with the CCDC under entry 1403189.

Table S2. Crystal data and structure refinement for compound **S16**.

Identification code	X15054	
Empirical formula	C_{43} H_{59} N_3 Ni O	
Formula weight	692.64	
Temperature	100(2) K	
Wavelength	0.71073 Å	
Crystal system	Triclinic	
Space group	P-1	
Unit cell dimensions	*a* = 11.6854(8) Å	α= 91.6260(19)°.
	b = 13.0659(9) Å	β= 109.3194(17)°.
	c = 14.9978(10) Å	γ= 114.9560(18)°.
Volume	1921.0(2) Å^3	
Z	2	
Density (calculated)	1.197 Mg/m^3	
Absorption coefficient	0.541 mm^{-1}	
F(000)	748	
Crystal size	0.390 x 0.300 x 0.290 mm^3	
Theta range for data collection	1.467 to 30.999°.	
Index ranges	-16<=*h*<=16, -18<=*k*<=18, -21<=*l*<=21	
Reflections collected	79302	
Independent reflections	12233 [R_{int} = 0.0364]	
Completeness to theta = 25.242°	100.0 %	
Absorption correction	Semi-empirical from equivalents	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	12233 / 85 / 451	
Goodness-of-fit on F^2	1.037	
Final *R* indices [I>2σ(I)]	*R*1 = 0.0327, *wR*2 = 0.0864	
R indices (all data)	*R*1 = 0.0356, *wR*2 = 0.0881	
Extinction coefficient	n/a	
Largest diff. peak and hole	0.764 and -0.740 e.Å^{-3}	

C) Cyclic Voltammetry Studies

Experimental Procedures:

Complexes **10** and **12** were prepared and studied *in situ* as in section A) above.

For **10**, $Ni(cod)_2$ (27.5 mg, 0.1 mmol, 1.0 equiv), IPr (38.9 mg, 0.1 mmol, 1.0 equiv), 1-octene (16 μL, 0.1 mmol, 1.0 equiv), and acetone (20 mL, 0.005 M) were stirred at room temperature in a nitrogen-filled glovebox. After 2 h, NBu_4PF_6 (38.7 mg, 0.1 mmol, 1.0 equiv) was added, and the mixture was transferred to an electrochemical cell (also in a nitrogen-filled glovebox). Cyclic voltammetry was them performed using a three-electrode cell with a 3 mm glassy carbon working electrode, a Ag/AgCl reference electrode, and a Pt wire counter electrode. Scans were taken at 10 mV/s starting from –1.5V to +0.2V in the positive direction. (Note: adjustment of the scan rate did not produce reversible behavior) (Figure S7a).

For **12**, $Ni(cod)_2$ (27.5 mg, 0.1 mmol, 1.0 equiv), IPr (38.9 mg, 0.1 mmol, 1.0 equiv), **5a** (26.1 mg, 0.1 mmol, 1.0 equiv), and acetone (20 mL, 0.005 M) were stirred at room temperature in a nitrogen-filled glovebox. After 16 h, NBu_4PF_6 (38.7 mg, 0.1 mmol, 1.0 equiv) was added, and the mixture was transferred to an electrochemical cell (also in a nitrogen-filled glovebox). Cyclic voltammetry was them performed using a three-electrode cell with a 3 mm glassy carbon working electrode, a Ag/AgCl reference electrode, and a Pt wire counter electrode. Scans were taken at 10 mV/s starting from –1.0V to +1.5V in the positive direction. (Note: at 100 mV/s, the Ni(III/II) oxidation was irreversible, while the lower scan rate of 10mV/s was needed for **12** to demonstrate reversible behavior) (Figure S7b).

We also obtained a cyclic voltammogram of Et_3N in acetone given the possibility of it acting as a single electron oxidation transfer relay between the photocatalyst and the Ni(II) intermediate.

Et_3N (14 μL, 0.1 mmol, 1.0 equiv), NBu_4PF_6 (38.7 mg, 0.1 mmol, 1.0 equiv), and acetone (20 mL, 0.005 M) mixed and the solution was transferred to an electrochemical cell in a nitrogen-filled glovebox. Cyclic voltammetry was them performed using a three-electrode cell with a 3 mm glassy carbon working electrode, a Ag/AgCl reference electrode, and a Pt wire counter electrode. Scans were taken at 100 mV/s starting from –1.0V to +2.0V in the positive direction (Figure S7c).

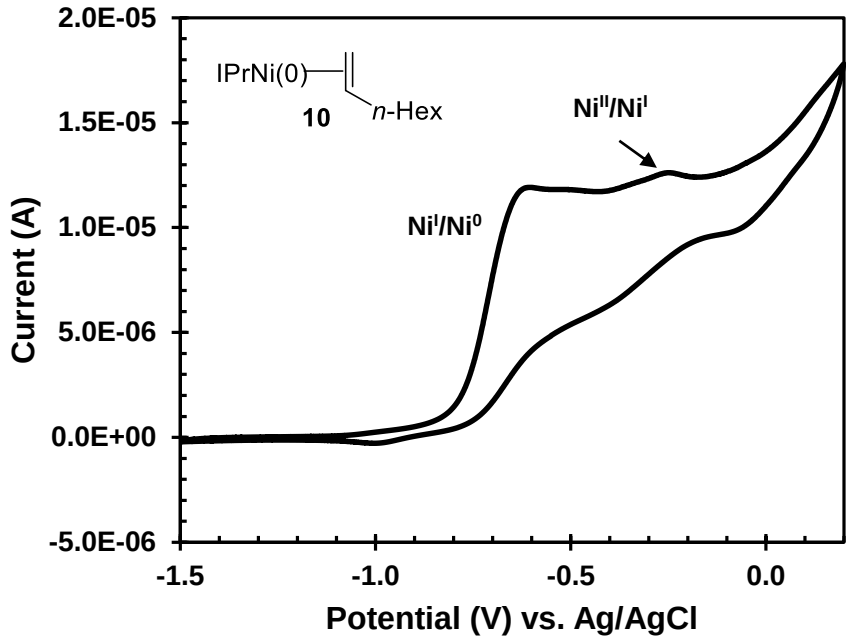
The spectra were then referenced against Fc/Fc^+. Significant overlap occurred between this redox couple and **10** and **12**, while Et_3N did not have significant overlap, the $E_{1/2}$ of the Fc/Fc^+ couple was measured and referenced internally for Et_3N (Fc/Fc^+ = +0.52V vs. Ag/AgCl, see below) and the spectra of **10** and **12** were referenced to ferrocene externally. These values can then be converted to values vs. the standard calomel electrode (SCE) to compare with the literature values for the relevant oxidation states of $Ru(bpy)_3$ by adding 0.38V.[4]

Since both single electron oxidations of **12** were reversible, $E_{1/2}$ was calculated by the standard method: $E_{1/2} = (E_p – E_c)/2$. [5] The other potentials of interest were irreversible, so $E_{1/2}$ could not be directly measured since by definition, a half cell reduction potential requires a reversible process. Alongside the measurement of E_p, or oxidation peak potential, for purposes of estimation of redox feasibility, I have shown $E_{p/2}$, or the voltage at half the current peak height (E_p). In an ideal reversible cyclic voltammogram, $E_{1/2} = E_{p/2} \pm 0.028V/n$ where n is the number of moles of electrons transferred. For an irreversible process, this measurement is not ideal, since the location of E_p will also vary with voltage sweep rate, by about 0.03V per order of magnitude change in sweep rate. Therefore, using this estimation must be used with caution, and a large error should be expected.

Finally, the oxidative addition of aryl bromide **4a** was also studied. $Ni(cod)_2$ (27.5 mg, 0.1 mmol, 1.0 equiv), IPr (38.9 mg, 0.1 mmol, 1.0 equiv), **4a** (21.4 mg, 0.1 mmol, 1.0 equiv), and acetone (20 mL, 0.005 M) were stirred at room temperature in a nitrogen-filled glovebox. After 16 h, NBu_4PF_6 (38.7 mg, 0.1 mmol, 1.0 equiv) was added, and the mixture was transferred to an electrochemical cell (also in a nitrogen-filled glovebox). Cyclic voltammetry was them performed using a three-electrode cell with a 3 mm glassy carbon working electrode, a Ag/AgCl reference electrode, and a Pt wire counter electrode. Scans were taken at 10 mV/s starting from +0.2V to +1.5V in the positive direction (Figure S7d). Consistent with the ^{1}H NMR studies (Figure S5), a complex cyclic voltammogram was observed, suggesting the presence of multiple redox-active species in solution.

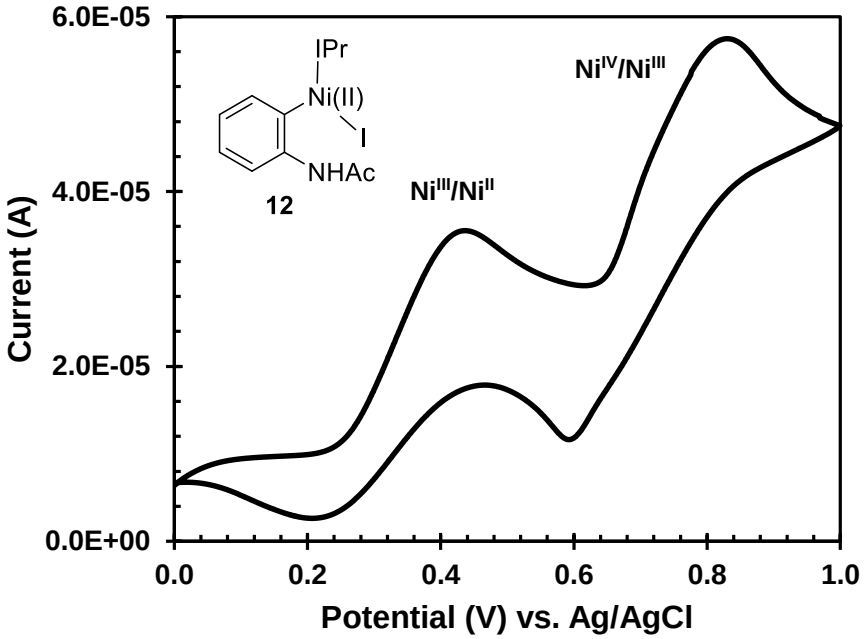
Figure S7. Cyclic voltammograms and calculated reduction potentials.

a)



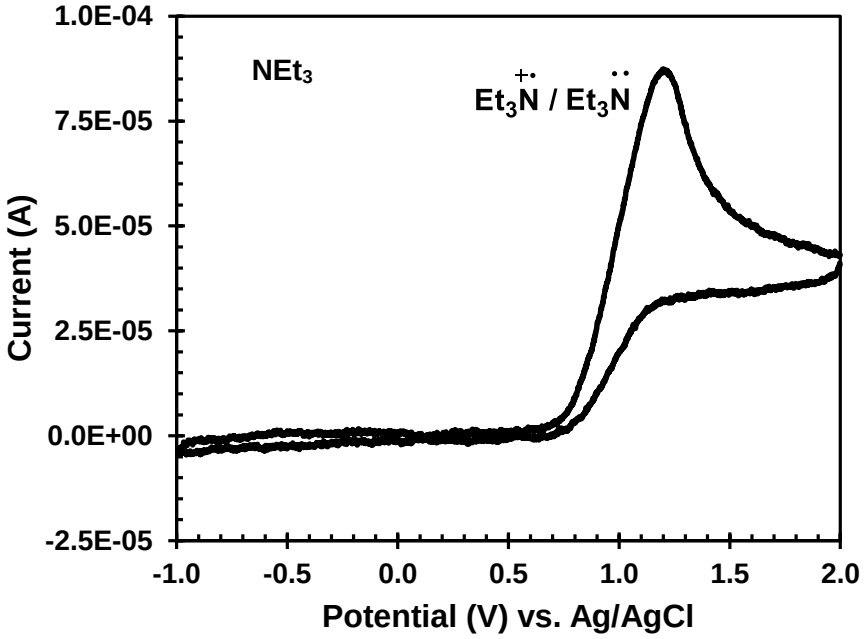
10: $E_p^{I/0}$ = –0.60V vs. Ag/AgCl; –1.12 V vs. Fc/Fc^+; ~ –0.74V vs. SCE
$E_{p/2}^{I/0}$ = –0.72V vs. Ag/AgCl; –1.24V vs. Fc/Fc^+; ~ –0.86V vs. SCE

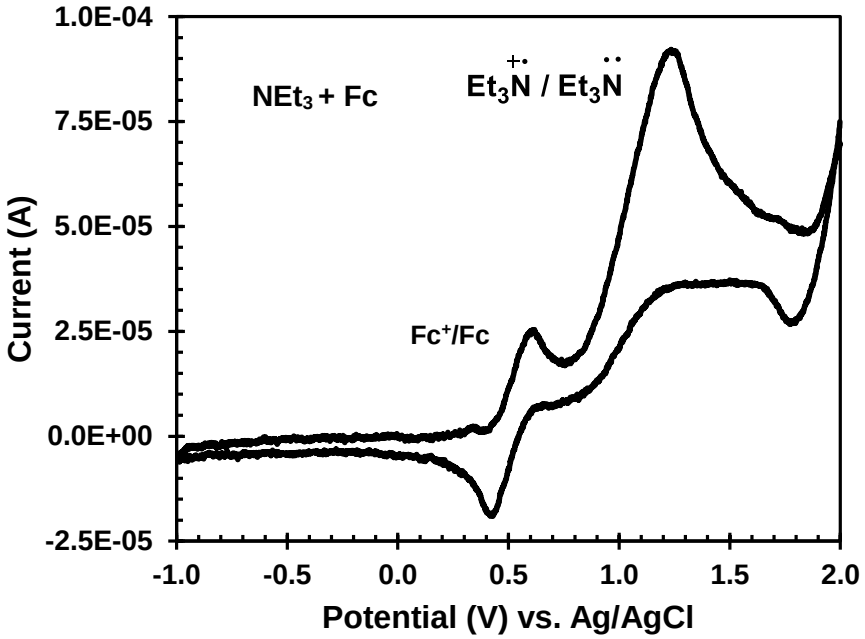
b)



12: $E_{1/2}^{III/II}$ = +0.32V vs. Ag/AgCl; –0.20V vs. Fc/Fc^+; ~ +0.18 V vs. SCE
Additionally, $E_{1/2}^{IV/III}$ = +0.71V vs. Ag/AgCl; +0.19V vs. Fc/Fc^+; ~ +0.57V vs. SCE

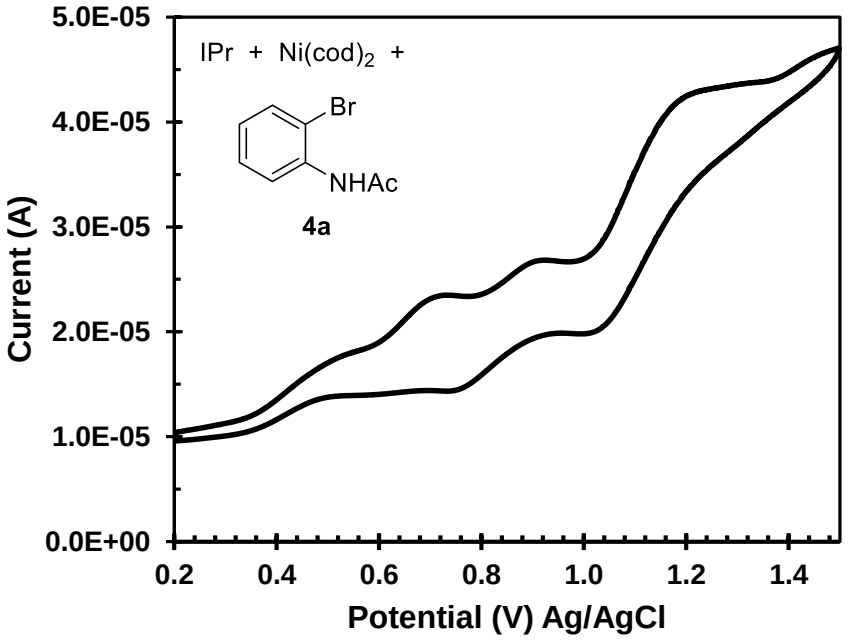
c)





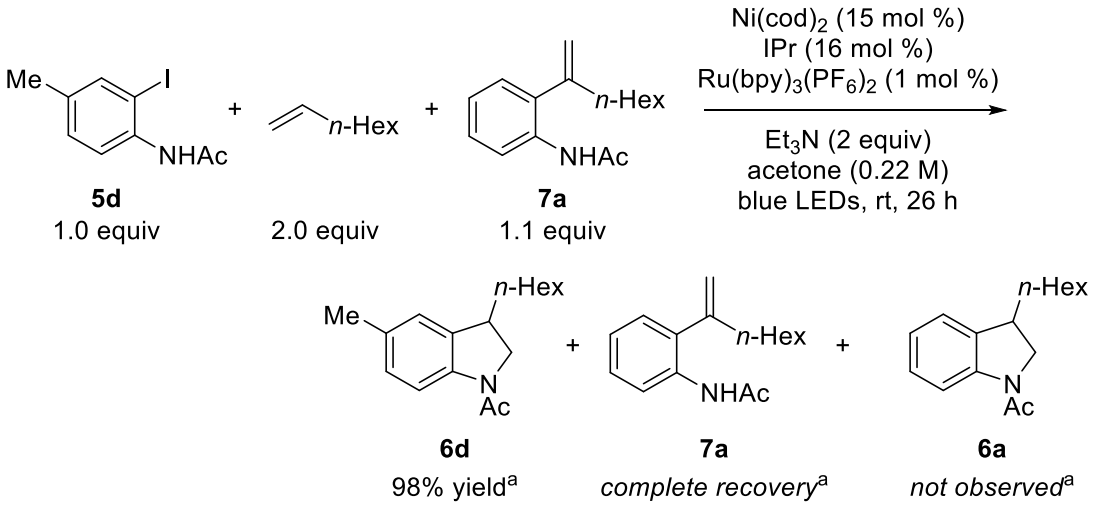
Et3N: E_p^{red} = +1.21V vs. Ag/AgCl; +0.69V vs. Fc/Fc^+; ~ 1.07 V vs. SCE
$E_{p/2}^{red}$= +0.97V vs. Ag/AgCl; +0.45V vs. Fc/Fc^+; ~ +0.83V vs. SCE

d)

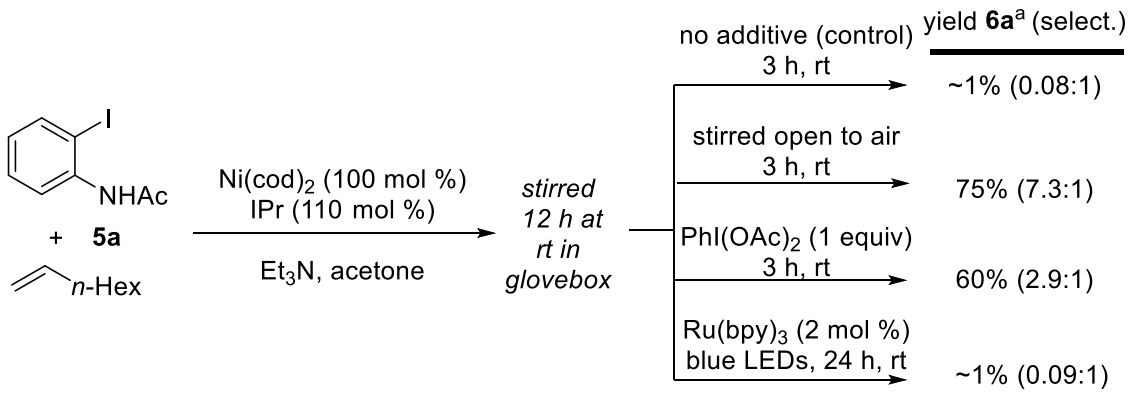


[Complex mixture of compounds formed.]

D) Other Mechanistic Studies



$Ni(cod)_2$ (6.4 mg, 0.023 mmol, 0.15 equiv), IPr (9.9 mg, 0.025 mmol, 0.16 equiv) acetone (0.7 mL, 0.22 M), Et_3N (43 μL, 0.31 mmol, 2.0 equiv), 1-octene (49 μL, 0.31 mmol, 2.0 equiv), 2'-iodo-4'-methylacetanilide **5d** (42.5 mg, 0.15 mmol 1.0 equiv), **7a** (37.7 μL, 0.17 mmol, 1.1 equiv), and $Ru(bpy)_3(PF_6)_2$ (1.4 mg, 0.0016 mmol, 0.01 equiv) were added to a 2 dram vial in a nitrogen-filled glovebox. The vial cap was then taped shut, before the vial was removed from the glovebox and placed next to blue LED lights cooled by a fan. After 26 h, the reaction was opened to air, EtOAc was added, and the reaction mixture was filtered through a silica plug using ~20 mL EtOAc as the eluent. Dodecane (35 μL, 0.15 mmol, 1.0 equiv) was then added, and the reaction mixture was analyzed by gas chromatography. Calibration curves for 2'-iodo-4'-methylacetanilide **5d**, **7a**, **6d**, and **6a** had been generated using dodecane as an internal standard, and each product had a cleanly differentiated retention time. Using these results, 100% conversion of **5d** and 98% yield of **6d** were observed. Additionally, 111 mol % of **7a** was recovered (complete recovery), and **6a** was not observed at the GC limit of detection.



$Ni(cod)_2$ (137 mg, 0.5 mmol, 1.0 equiv), IPr (194 mg, 0.5 mmol, 1.0 equiv) acetone (4.6 mL, 0.11 M), Et_3N (139 μL, 1.0 mmol, 2.0 equiv), 1-octene (157 μL, 1.0 mmol, 2.0 equiv), 2'-iodoacetanilide **5a** (130.5 mg, 0.50 mmol 1.0 equiv), and dodecane (114 μL, 0.50 mmol, 1.0 equiv) were added to a 2 dram vial in a nitrogen-filled glovebox. The vial cap was then taped shut, and stirred at room temperature for 12 h. Then, the reaction was split into five portions of ~1.04 mL each labeled A–E.

A: Control, no additive. After 3 h, half of the reaction mixture was filtered through a plug of neutral alumina in the glovebox to remove metals, eluting with Et_2O. Analysis by gas chromatography revealed ~1% **6a**, with trace amounts also of approximately four other products, including known Heck products (overall selectivity ratio of indoline **6a** to [Σ Heck/isomerized Heck/etc.]: 0.08). After 24 h, the remainder of the mixture was worked up in the same way to again yield ~1% **6a** and other products in trace amounts.

B: Open to air. The vial was removed from the glovebox, the cap was removed, and it was stirred at room temperature for 3 h. The reaction mixture was then filtered through a plug of neutral alumina using Et_2O as the eluent and analyzed by gas chromatography to yield 75% **6a** and selectivity ratio of indoline **6a** to [Σ Heck/isomerized Heck/etc.]: 7.3:1.

C: $PhI(OAc)_2$. $PhI(OAc)_2$ (39 mg, 0.12 mmol, 1.2 equiv) was added in the glovebox, and the vial was stirred at room temperature. After 3 h, the reaction mixture was filtered through a plug of neutral alumina in the glovebox to remove metals, eluting with Et_2O. Analysis by gas chromatography revealed 60% **6a**, selectivity ratio of indoline **6a** to [Σ Heck/isomerized Heck/etc.] 2.9:1.

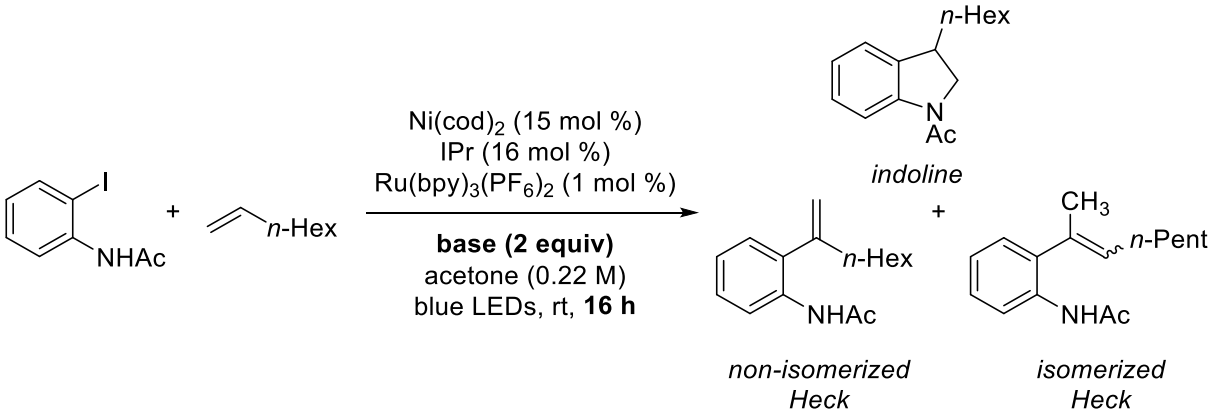
D: $Ru(bpy)_3(PF_6)_2$, blue LEDs: $Ru(bpy)_3(PF_6)_2$ (1.7 mg, 0.0020 mmol, 0.02 equiv) was added in the glovebox. The vial cap was then taped shut, before the vial was removed from the glovebox and placed next to blue LED lights cooled by a fan. After 24 h, the reaction vial was again brought inside the glovebox to be worked up under inert atmosphere. The reaction mixture was filtered through a plug of neutral alumina in the glovebox to remove metals, eluting with Et_2O. Analysis by gas chromatography revealed ~1% **6a**, selectivity ratio of indoline **6a** to [Σ Heck/isomerized Heck/etc.] 0.09:1 with a variety of trace products.

E: $Ru(bpy)_3(PF_6)_2$, dark: $Ru(bpy)_3(PF_6)_2$ (1.7 mg, 0.0020 mmol, 0.02 equiv) was added in the glovebox to a vial tightly wrapped in foil. The vial cap was then taped shut and stirred at room temperature in the glovebox. After 24 h, the reaction mixture was filtered through a plug of neutral alumina in the glovebox to remove metals, eluting with Et_2O. Analysis by gas chromatography revealed ~1% **6a**, selectivity ratio of indoline **6a** to [Σ Heck/isomerized Heck/etc.]: 0.03:1 with a variety of trace products.

Poor mass recovery was observed for A, D, and E, suggesting that the arene remained ligated to the intermediate nickel complex, which was filtered out by the plug of alumina.

Additional Reaction Optimization Tables

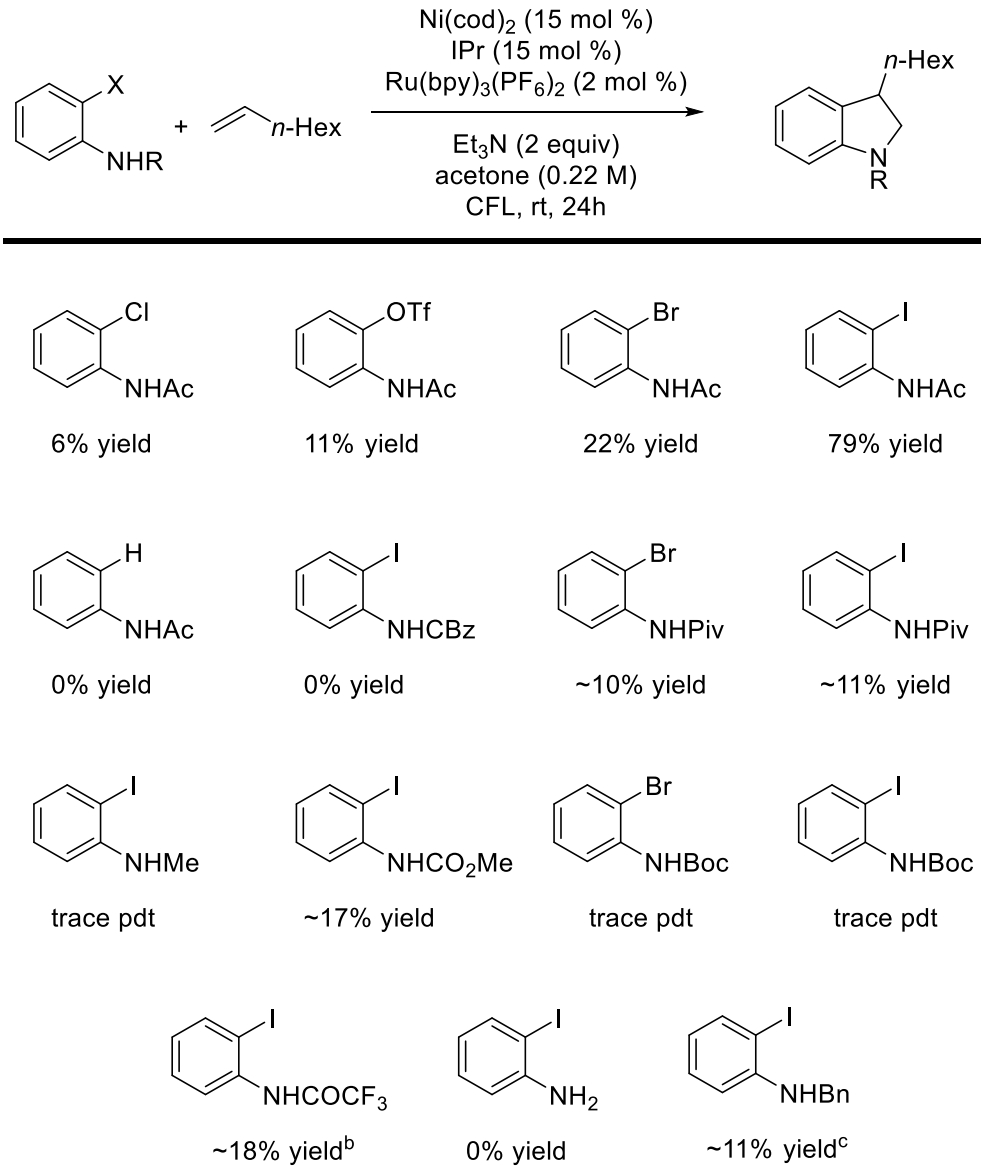
Table S3. Evaluation of nitrogen bases.[a]



Entry	Base	Conversion ArI (%)	Yield Indoline (%)	Ratio Indoline/Total Heck	Ratio Isomerized Heck/Non-Isomerized Heck
1	none	25	10	0.5:1	8:1
2	Et_3N	94	88	35:1	7:1
3	DABCO	90	18	10:1	0:1
4	quinuclidine	74	17	5:1	0:1
5	Et_2NH	46	28	96:1	0:1
6	*i*-Pr_2EtN	83	73	14:1	8:1
7	DBU	29	3	0.4:1	0:1
8	Ph_2MeN	–[b]	11	0.5:1	9:1
9	$PhMe_2N$	23	13	0.7:1	9:1

[a] Conversions and yields determined by GC with dodecane as internal standard [b] ArI overlapped with base in chromatogram

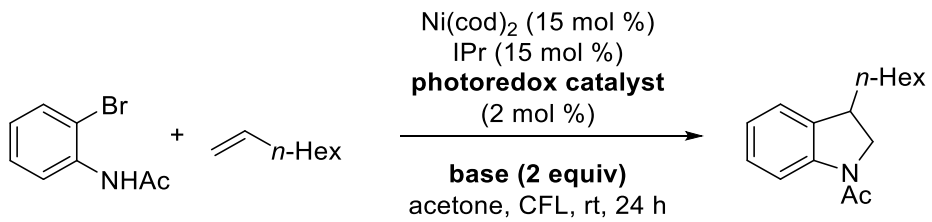
Table S4. Substrate optimization table[a]



[a] Conversions and yields determined by GC with dodecane as internal standard [b] large amounts of arene homocoupling. [c] 30 °C, 48 h.

Note: The rationale regarding why *N*-acetyl aryl iodide substrates are ideal is unclear. However, given the delicate balance between the redox potentials and rates of the desired reaction pathway vs. off cycle reactions, it is possible that these groups tune the electronic properties of key nickel species to encourage productive reaction pathways. Alternatively, the aniline protecting group alters the pK_a of the amide proton, impacting the rate and/or order of deprotonation. Steric bulk of the aniline protecting group also seems to have a detrimental effect (e.g, Boc vs. CO_2Me or Piv vs. Ac), consistent with decreased reactivity of sterically bulky **6f** and **6g**.

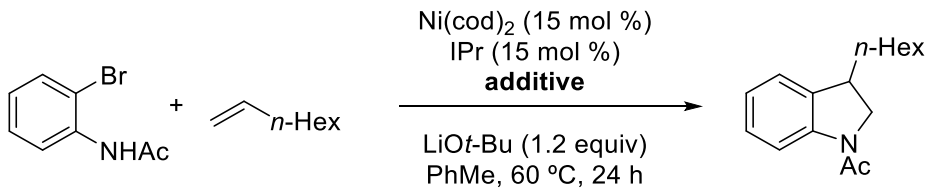
Table S5. Optimization of bromides with photoredox catalysts and additives.[a]



Entry	Photoredox Catalyst	Base	Additive	Conversion (%)	Yield (%)
1	none	2,6-lutidine	–	12	5
2	$Ru(bpy)_3(PF_6)_2$	2,6-lutidine	–	28	14
3	$Ir(dtbbpy)(ppy)_2(PF_6)$	2,6-lutidine	–	13	9
4	9-mesityl-10-methylacridinium ClO_4	2,6-lutidine	–	13	7
5	$Ir[dF(CF_3)ppy_2](dtbbpy)(PF_6)$	2,6-lutidine	–	39	11
6	$Cu(dap)_2Cl$	2,6-lutidine	–	11	7
7	$Ru(bpz)_3\ 2PF_6$	2,6-lutidine	–	21	9
8	$Ru(bpy)_3(PF_6)_2$	Et_3N	–	33	22
9[b]	$Ru(bpy)_3(PF_6)_2$	Et_3N	–	61	33
10	none	Et_3N	–	8	10
11	$Ru(bpy)_3(PF_6)_2$	Et_3N	LiI (30 mol %)	22	15
12	$Ru(bpy)_3(PF_6)_2$	Et_3N	I_2 (50 mol %)	12	10
13	$Ir(dtbbpy)(ppy)_2(PF_6)$	Et_3N	–	98[c]	18

[a] Conversions and yields determined by GC with dodecane as internal standard [b] 66 h. [c] large amounts of aryl bromide reduction (i.e., ArBr → ArH)

Table S6. Initial evaluation of additives to induce catalyst turnover.[a]



Entry	Additive	Amount	Conversion (%)	Yield (%)
1	none	–	7	10
2	*p*-fluorostyrene	50 mol %	12	6
3[b]	Zn(0)	200 mol %	79	13
4	ceric ammonium nitrate	50 mol %	22	6
5	sodium formate	50 mol %	48	8
6	$(Me_3Si)_3SiH$	50 mol %	16	6
7	Et_2MeSiH	50 mol %	36	7
8	Hantzsch Ester	50 mol %	30	9
9	TEMPO	50 mol %	20	5
10	SiO_2	50 mol %	29	9
11	Mn(0)	200 mol %	17	9
12	*p*-benzoquinone	50 mol %	27	5
13[b,c]	$Ru(bpy)_3(PF_6)_2$	3 mol %	6	8

[a] Conversions and yields determined by GC with dodecane as internal standard [b] no LiO*t*-Bu [c] *i*-Pr_2EtNH (2.0 equiv), MeCN, CFL

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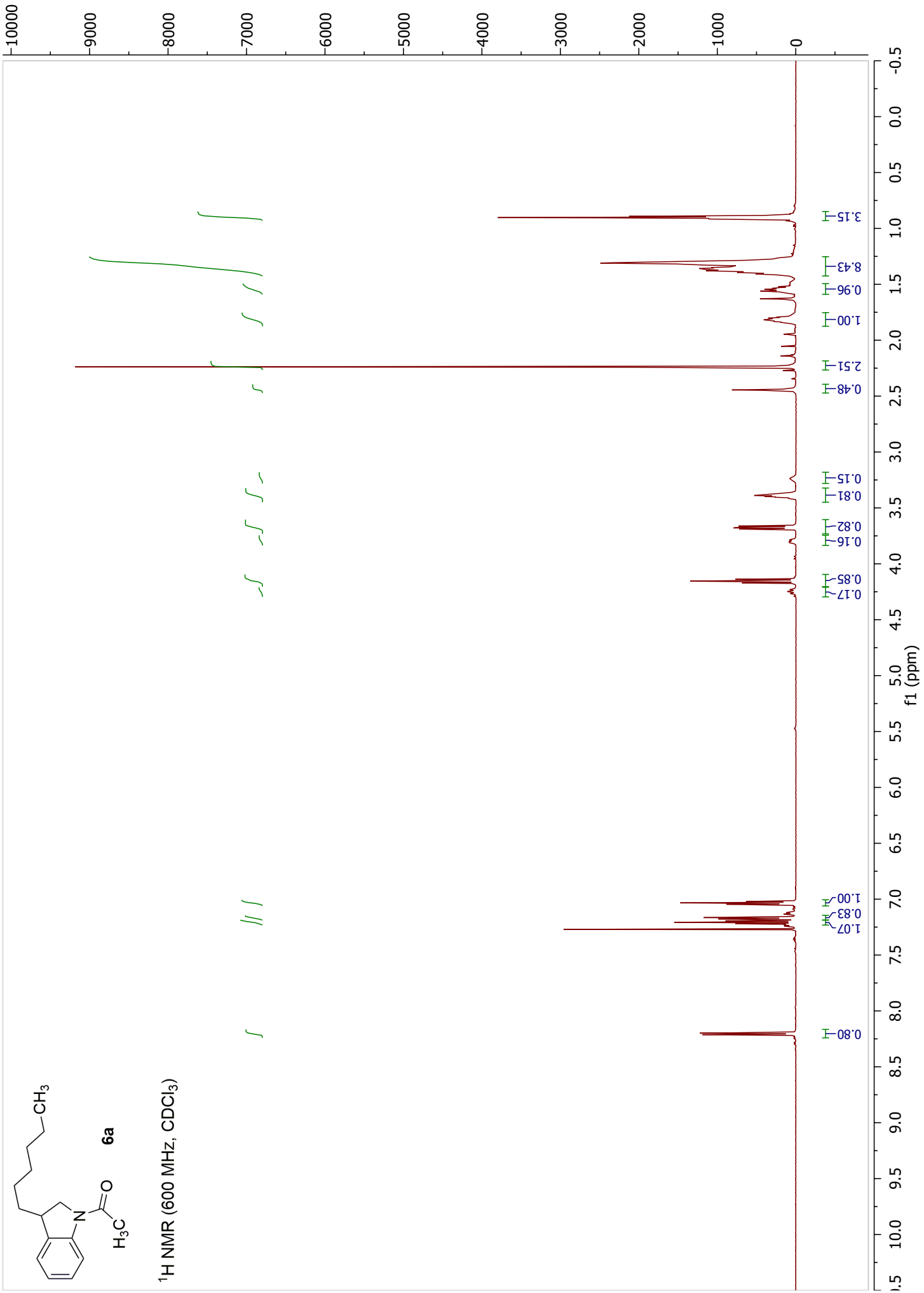
(2) Gimbert, C.; Vallribera, A. *Org. Lett.* **2009**, *11*, 269.

(3) Bruch, A.; Fröhlich, R.; Grimme, S.; Studer, A.; Curran, D. P. *J. Am. Chem. Soc.* **2011**, *133*, 16270.

(4) Pavlishchuk, V. V.; Addison, A. W. *Inorg. Chim. Acta* **2000**, *298*, 97.

(5) a) Pletcher, D.; Greef, R.; Peat, R.; Peter, L. M.; Robinson, J. *Instrumental Methods in Electrochemistry*, Horwood: Chichester, 2001. b) Scholz, F. (Ed.) *Electroanalytical Methods*, Springer: Berlin, 2002. c) Mabbot, G. A. *J. Chem. Ed.* **1983**, *60*, 697. d) Evans, D. H.; O'Connell, K. M.; Petersen, R. A.; Kelly, M. J. *J. Chem. Ed.* **1983**, *60*, 290.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2000
1000
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2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
f1 (ppm)
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8.43
0.96
1.00
2.51
0.48
0.15
0.81
0.82
0.16
0.85
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0.83
1.07
0.80
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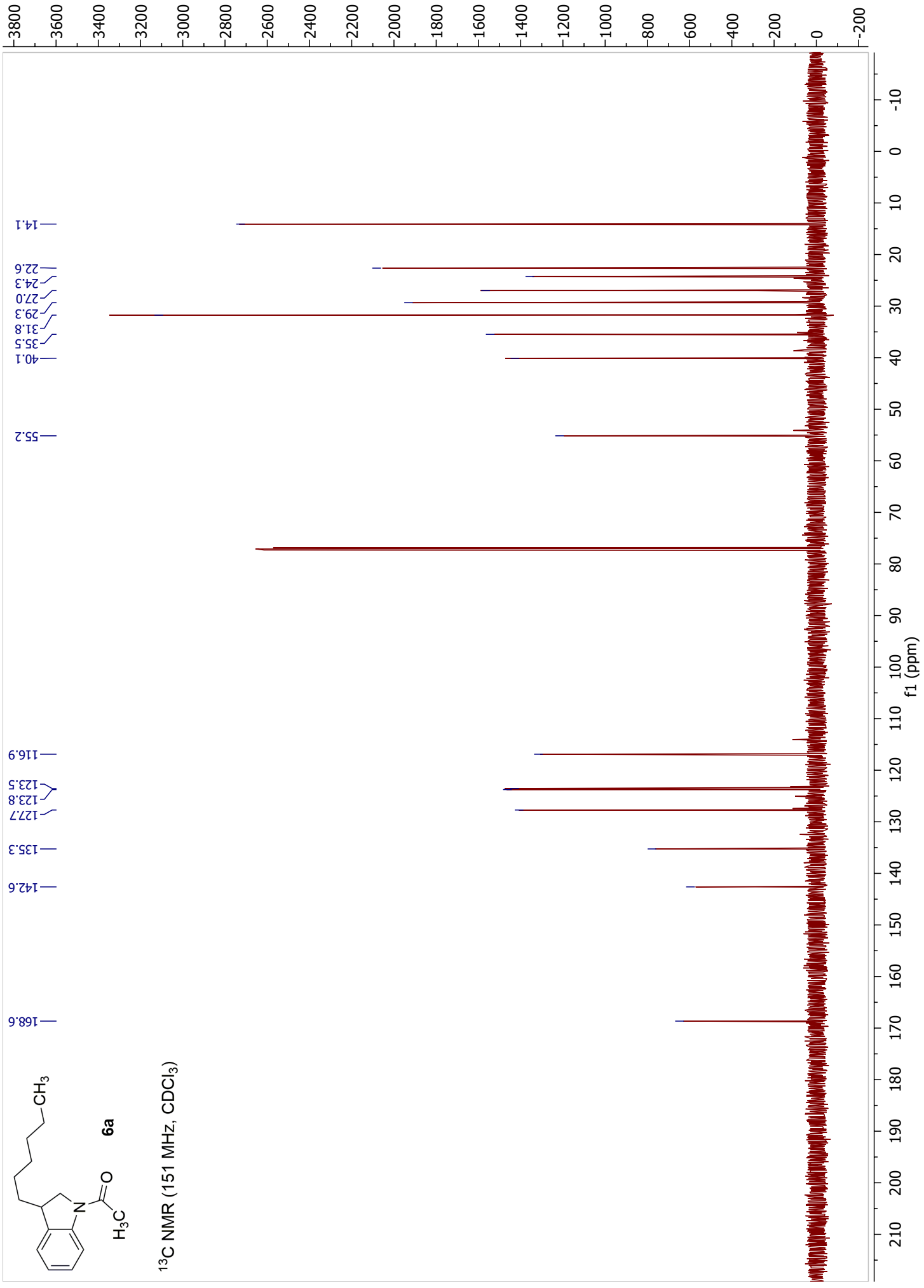
O
H3C
6a
1H NMR (600 MHz, CDCl3)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142.6
168.6
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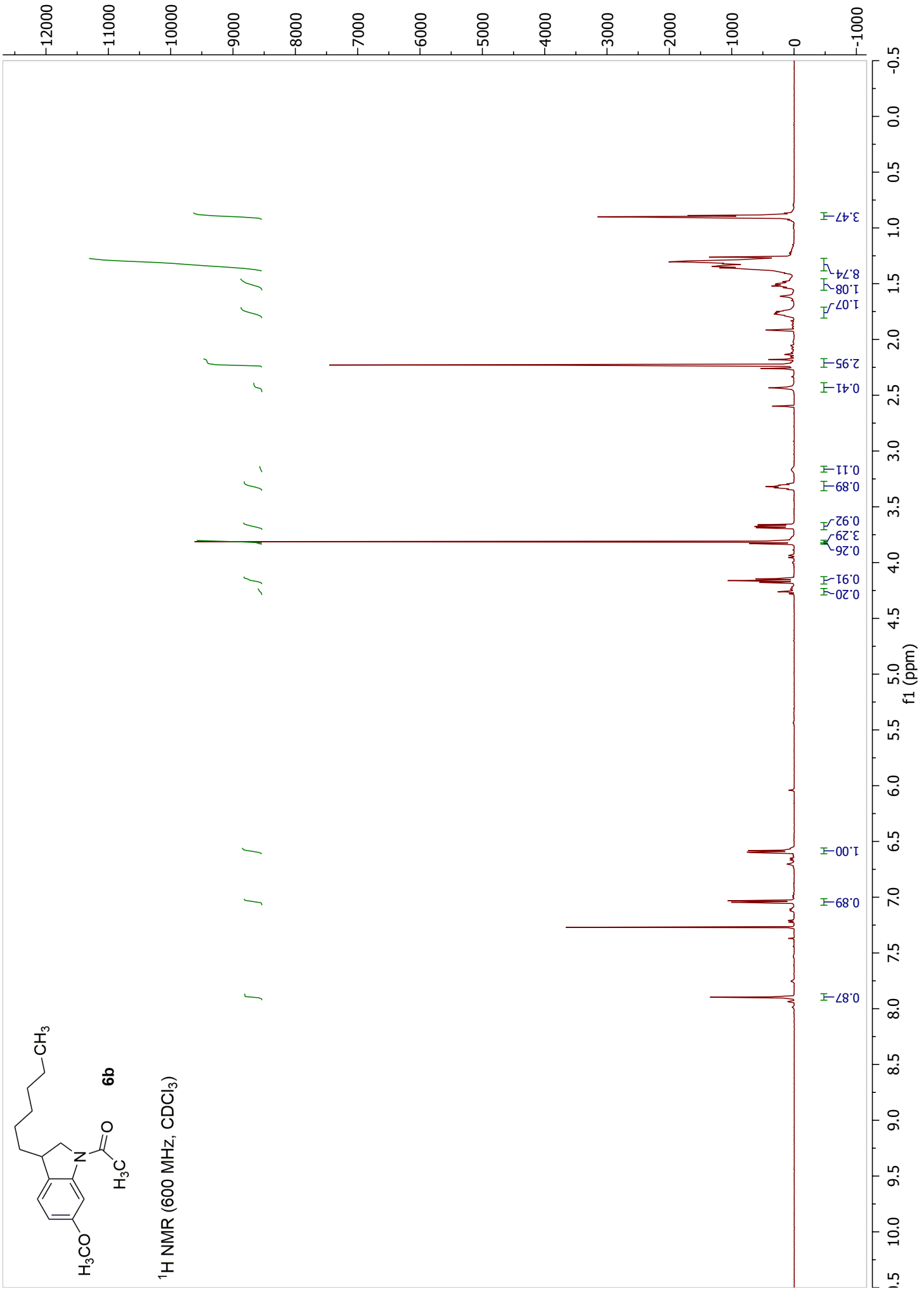
N
O
H3C
6a
13C NMR (151 MHz, CDCl3)
f1 (ppm)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4.0
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6.0
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8.5
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9.5
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1.07
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0.92
3.29
0.26
0.91
0.20
1.00
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O
N
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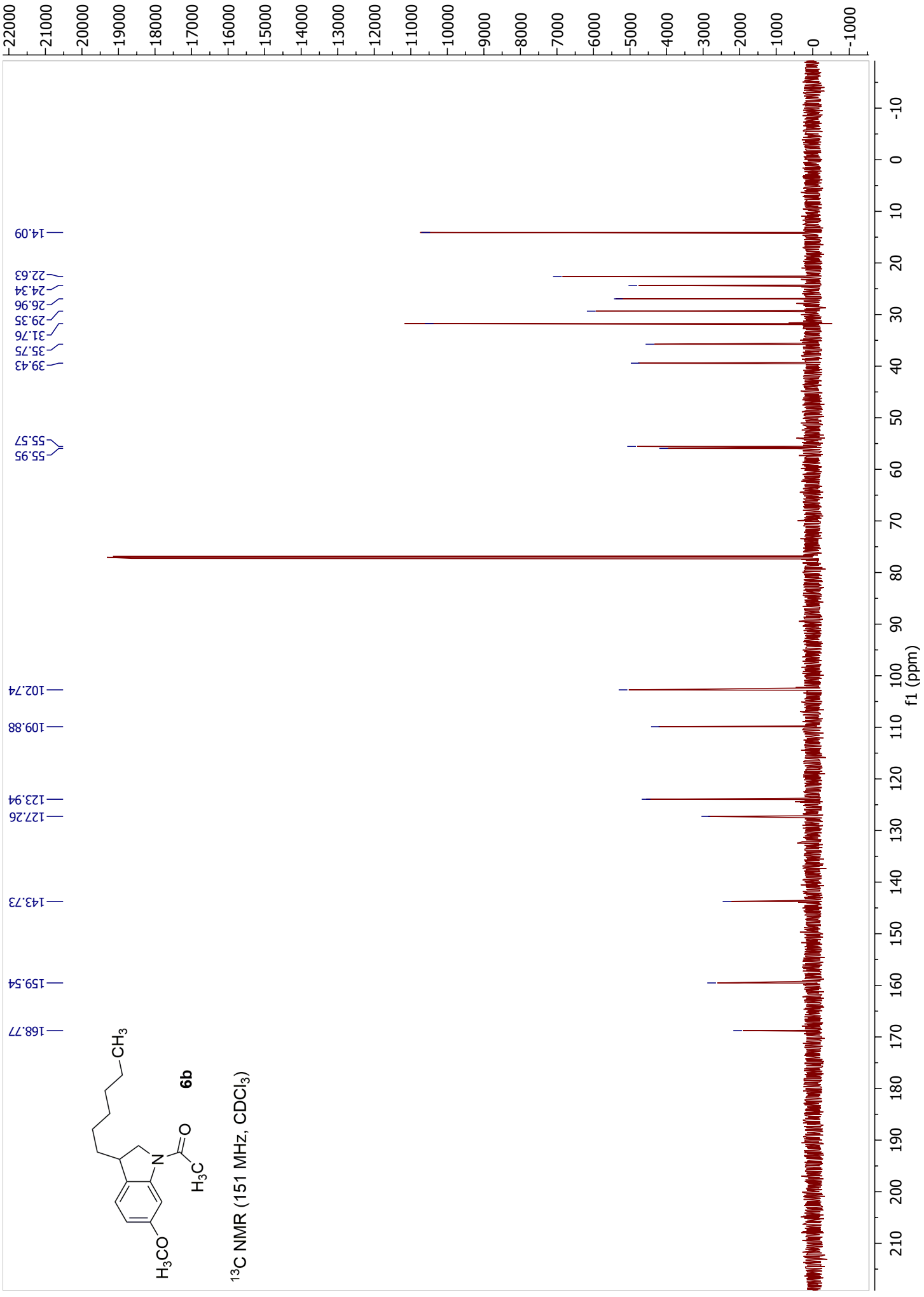
H_3CO
6b
^{1}H NMR (600 MHz, $CDCl_3$)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143.73
127.26
123.94
109.88
102.74
55.95
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39.43
35.75
31.76
29.35
26.96
24.34
22.63
14.09
f1 (ppm)
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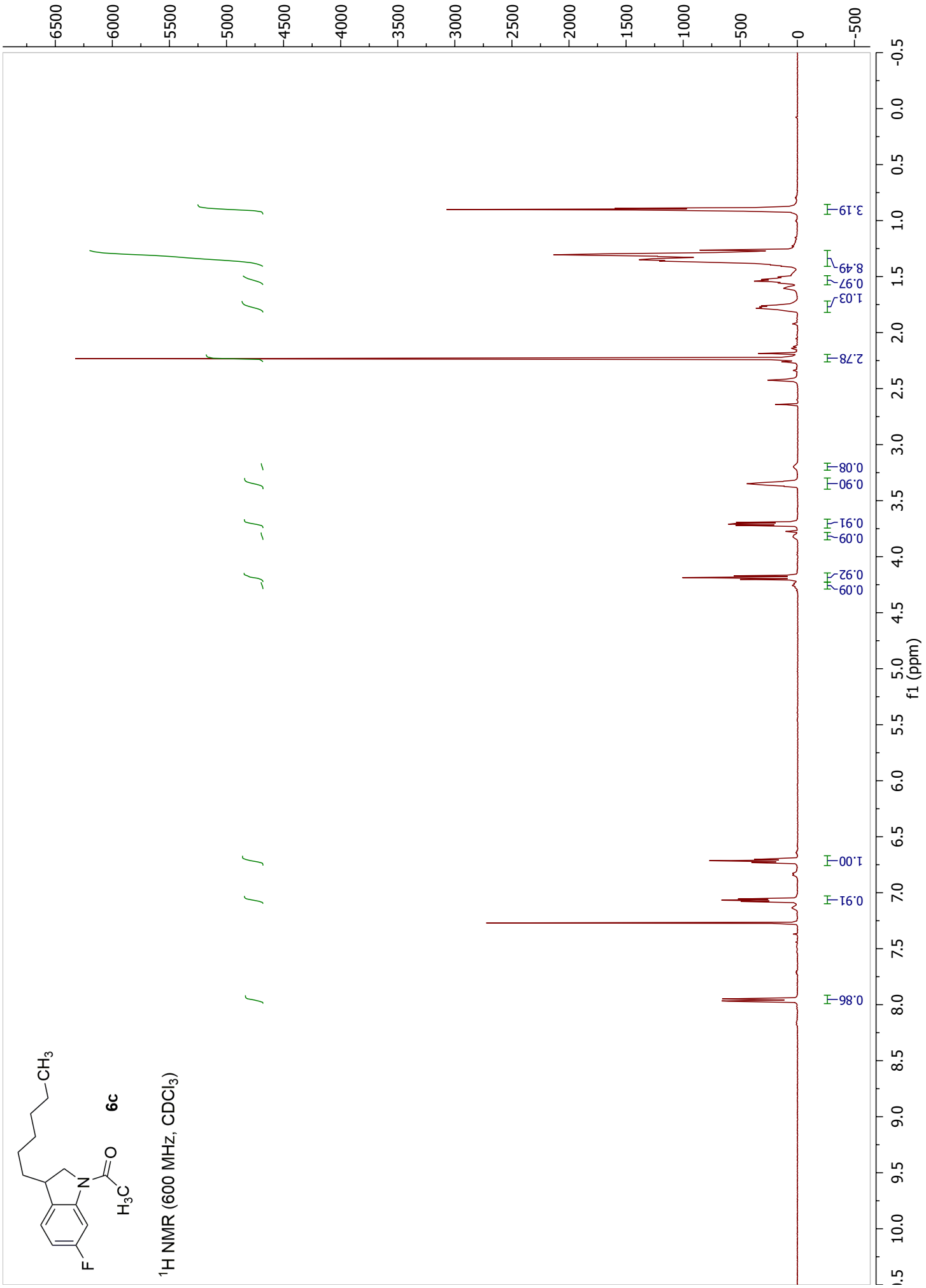
H_3C
O
N
CH_3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0.92
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1.00
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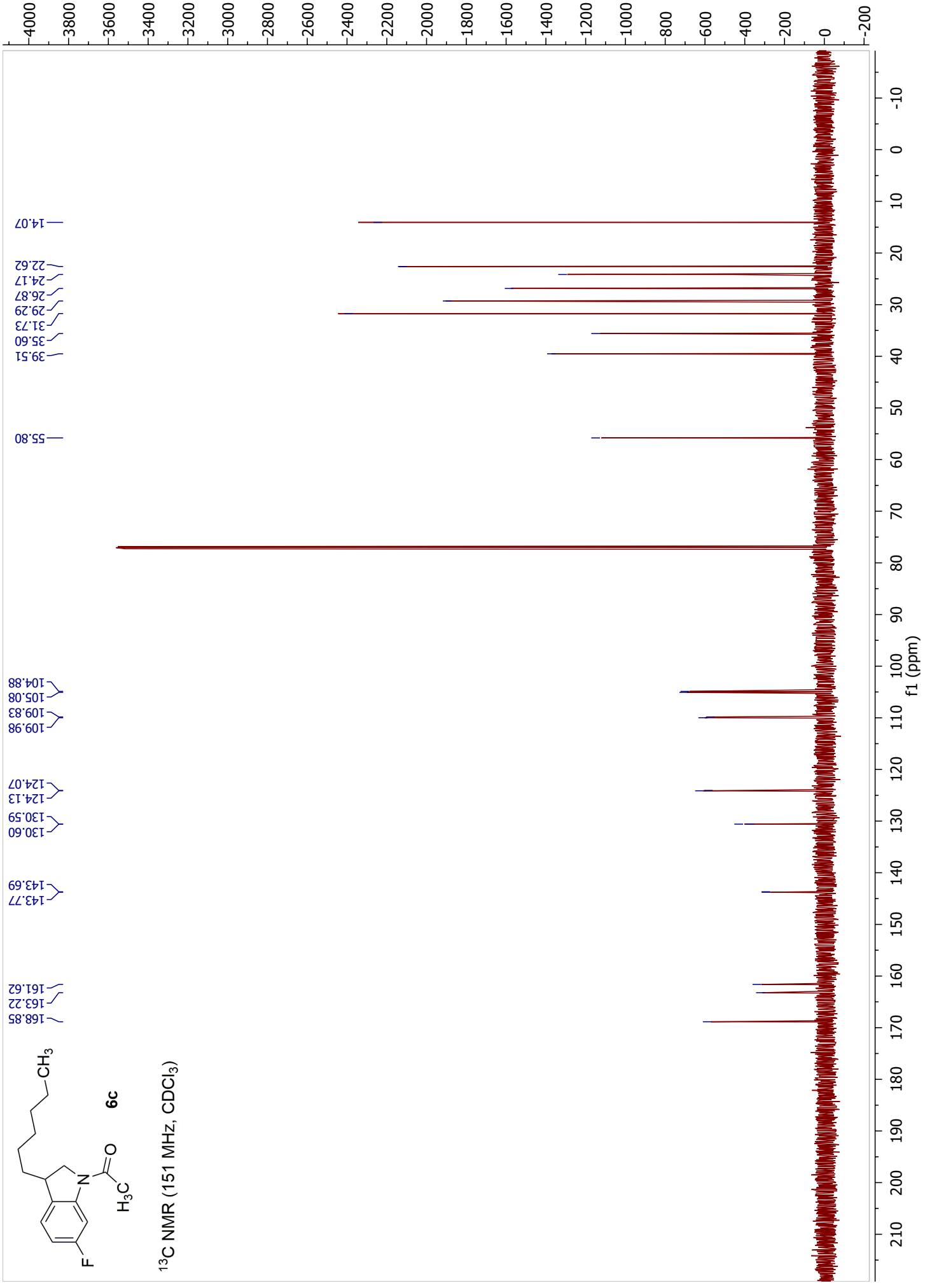
0.86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109.98
124.07
124.13
130.59
130.60
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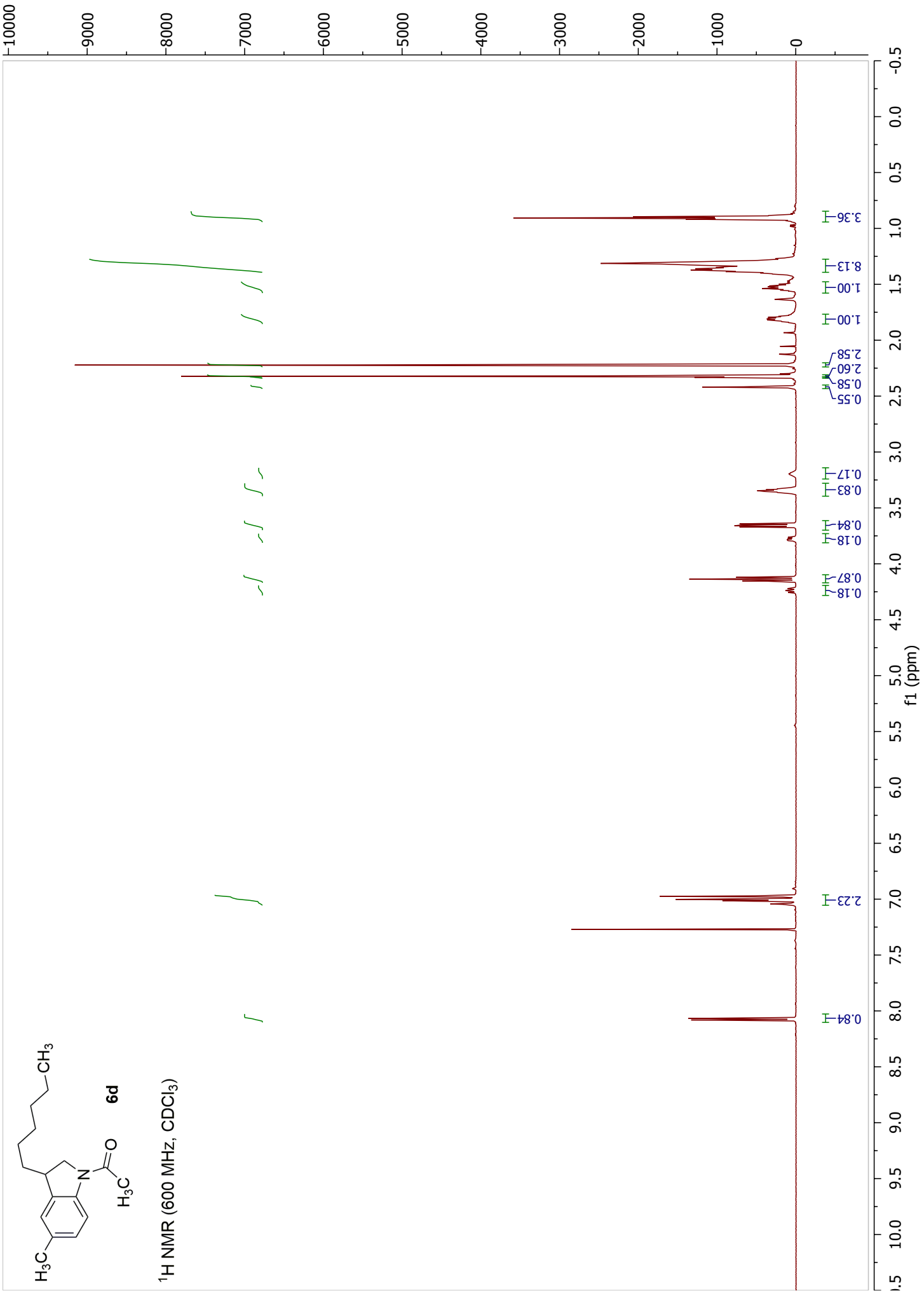
161.62
163.22
168.85
6c
^{13}C NMR (151 MHz, $CDCl_3$)
f1 (ppm)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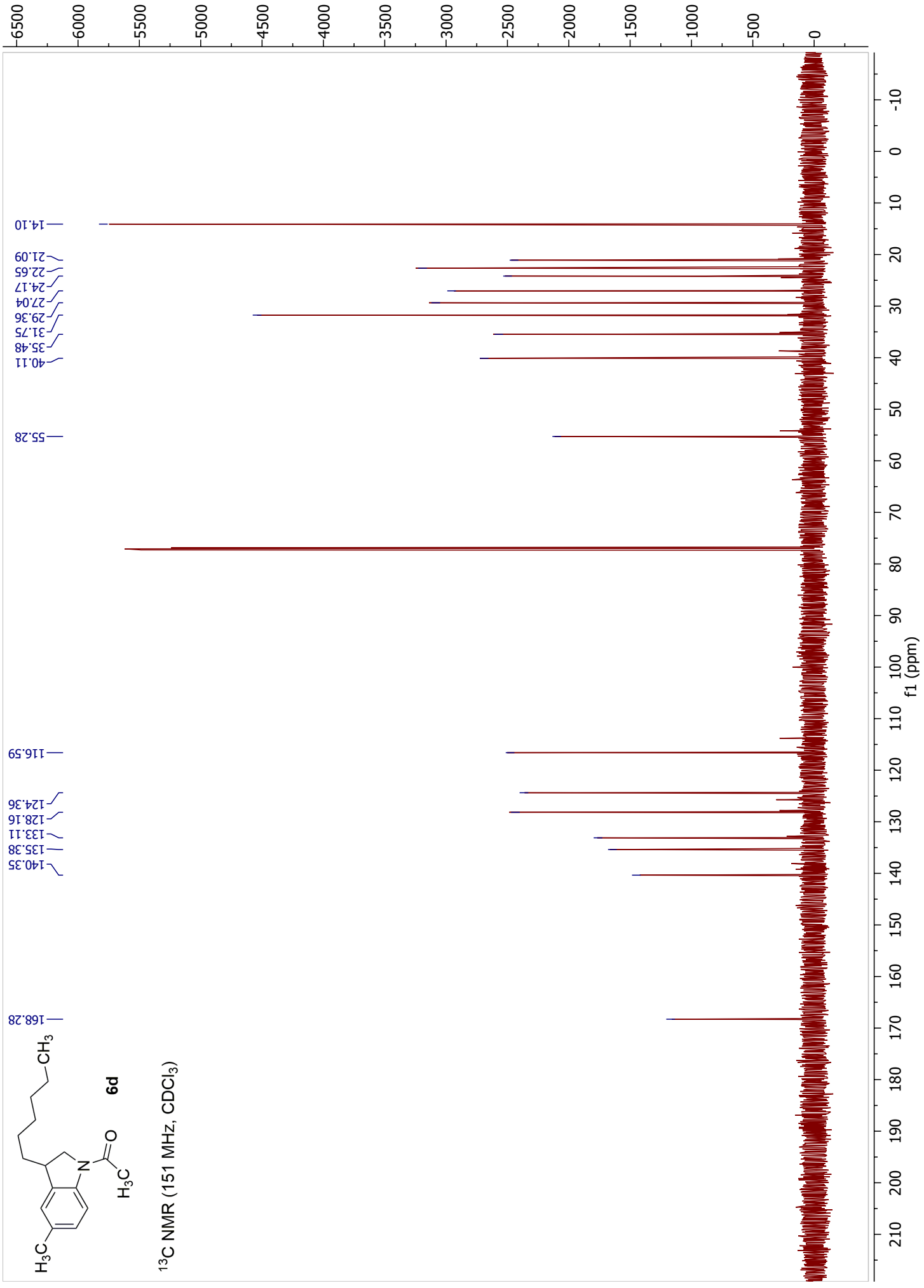
0.84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27.04
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135.38
140.35
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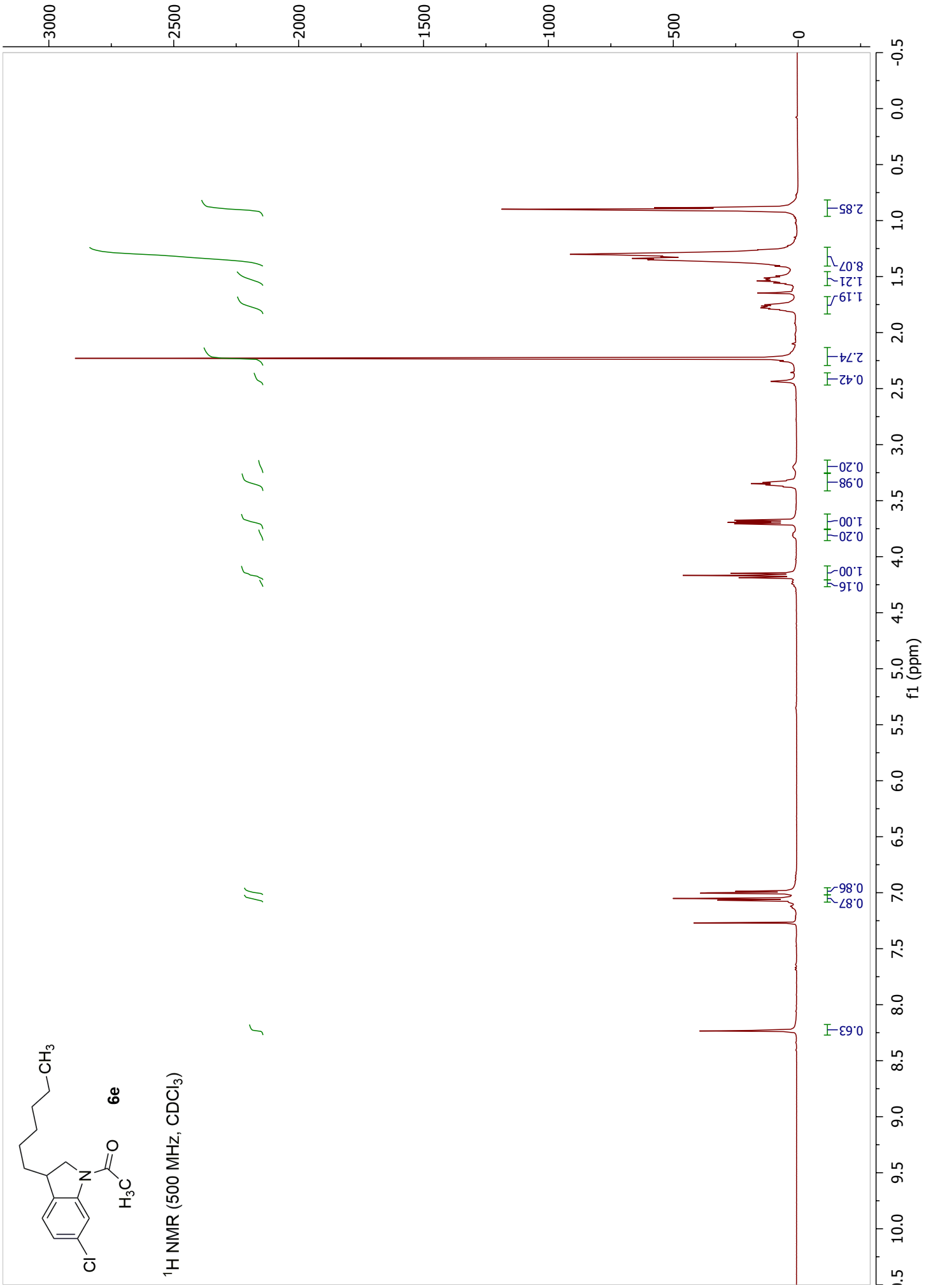
6d
f1 (ppm)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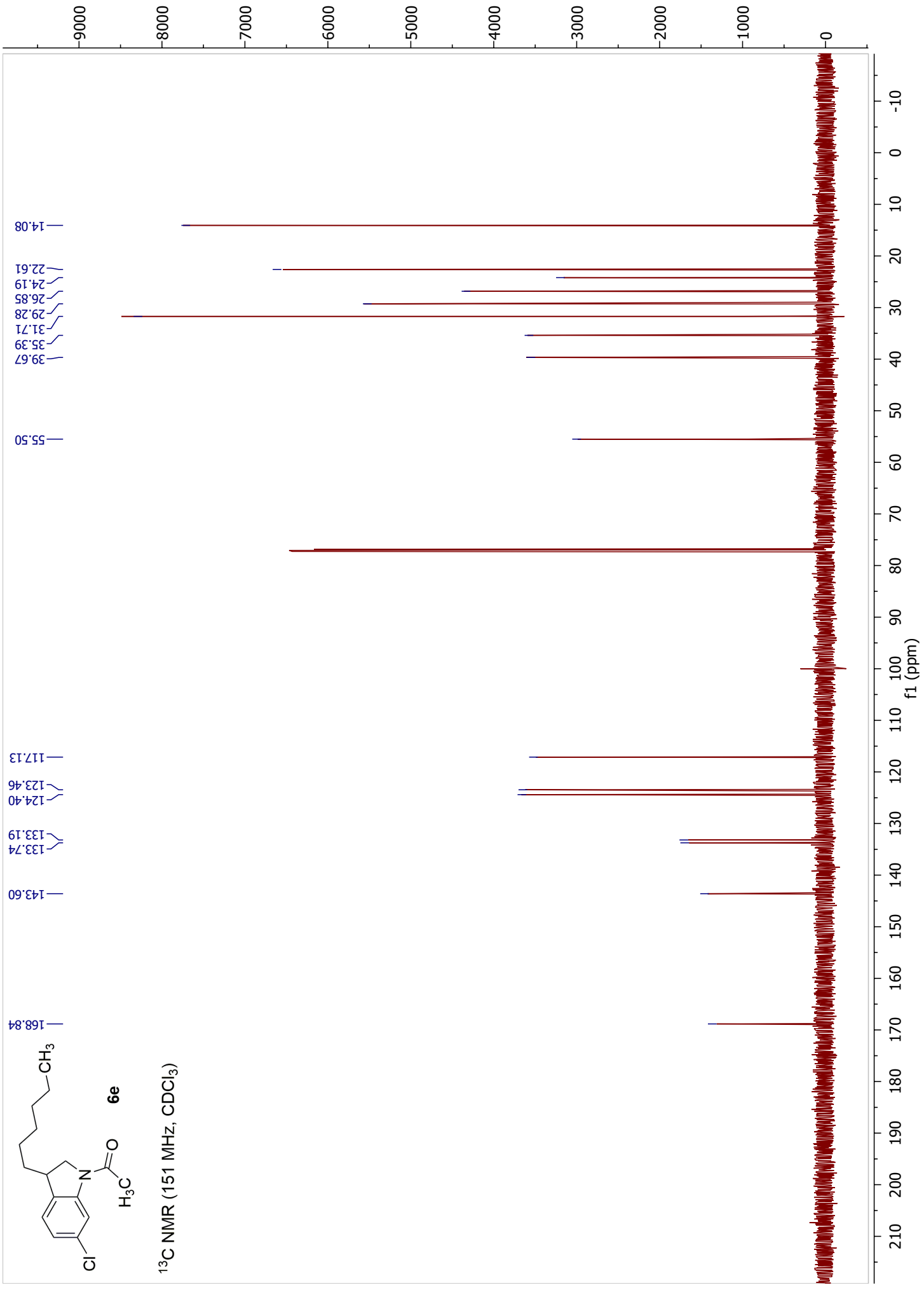
0.87
0.63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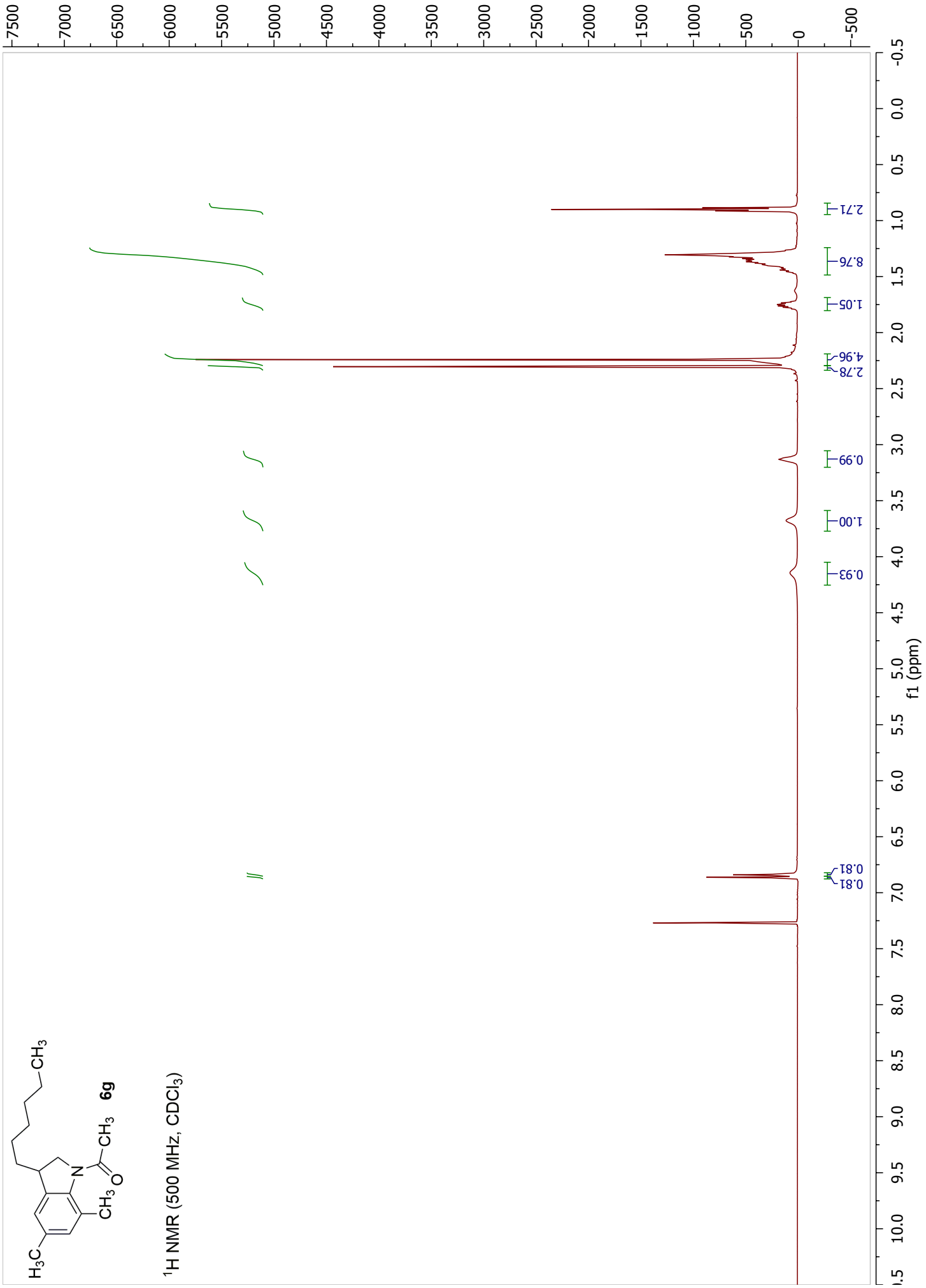
O
N
H_3C
Cl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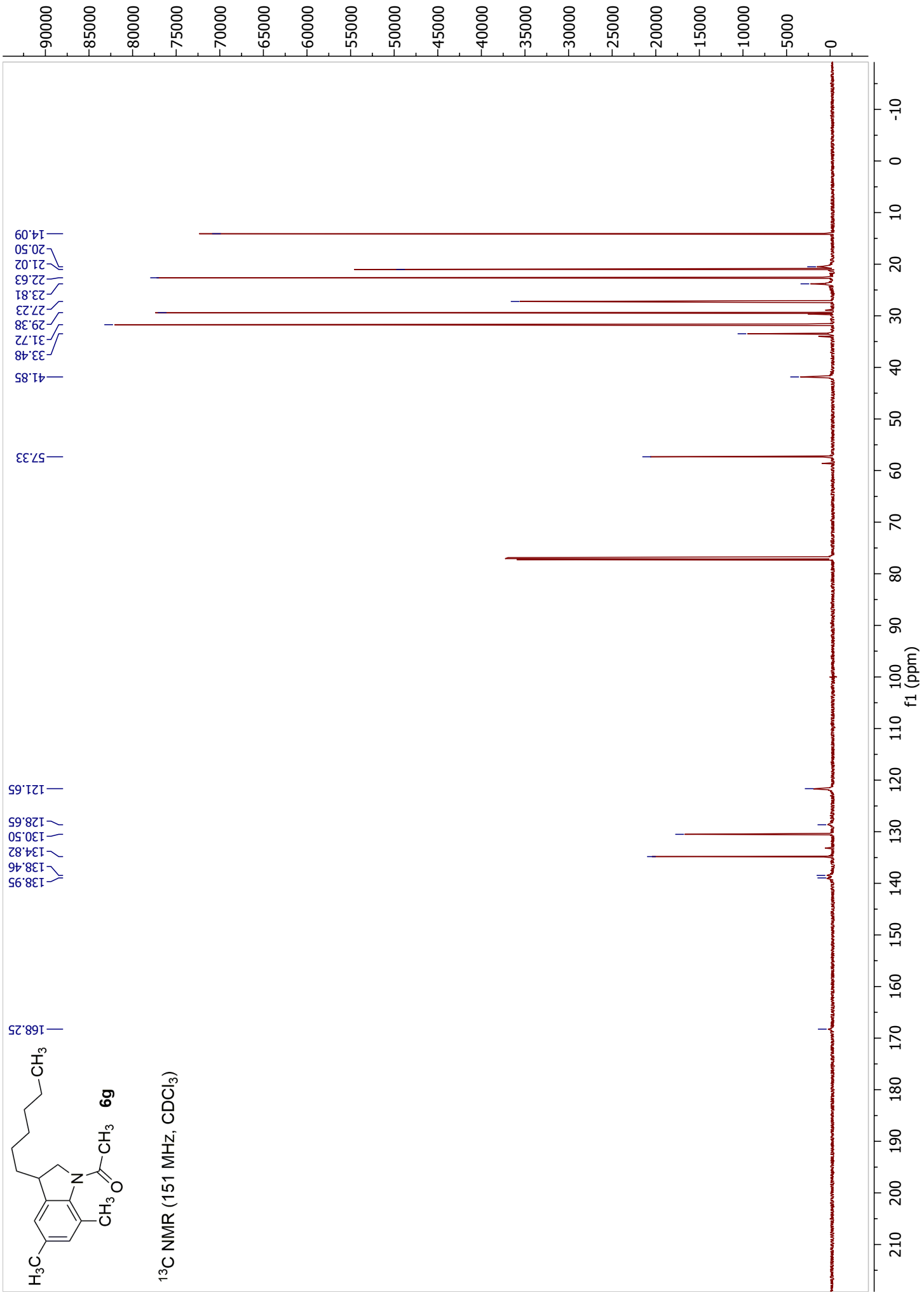
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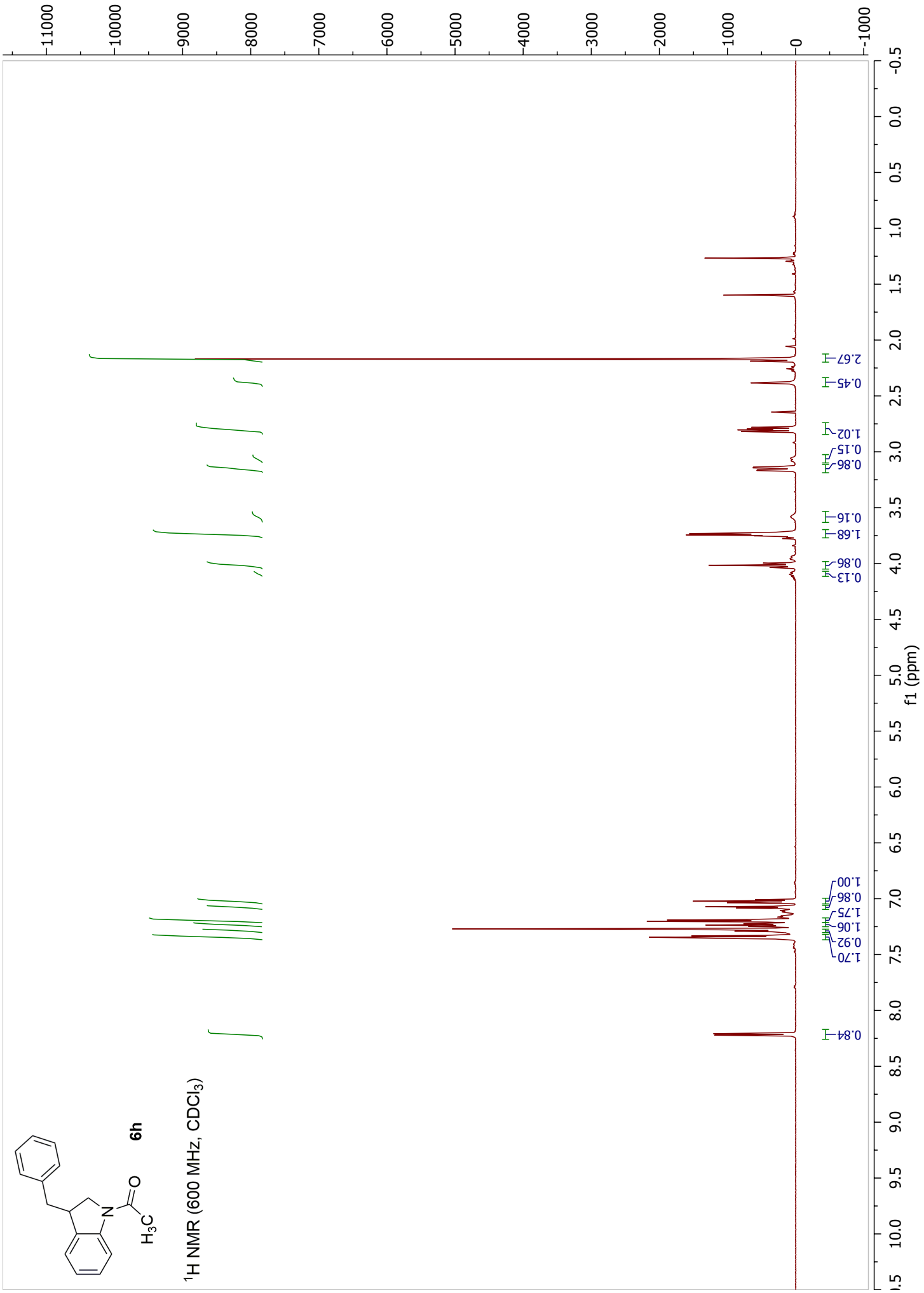
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2.0
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3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
f1 (ppm)
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0.15
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1.68
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0.13
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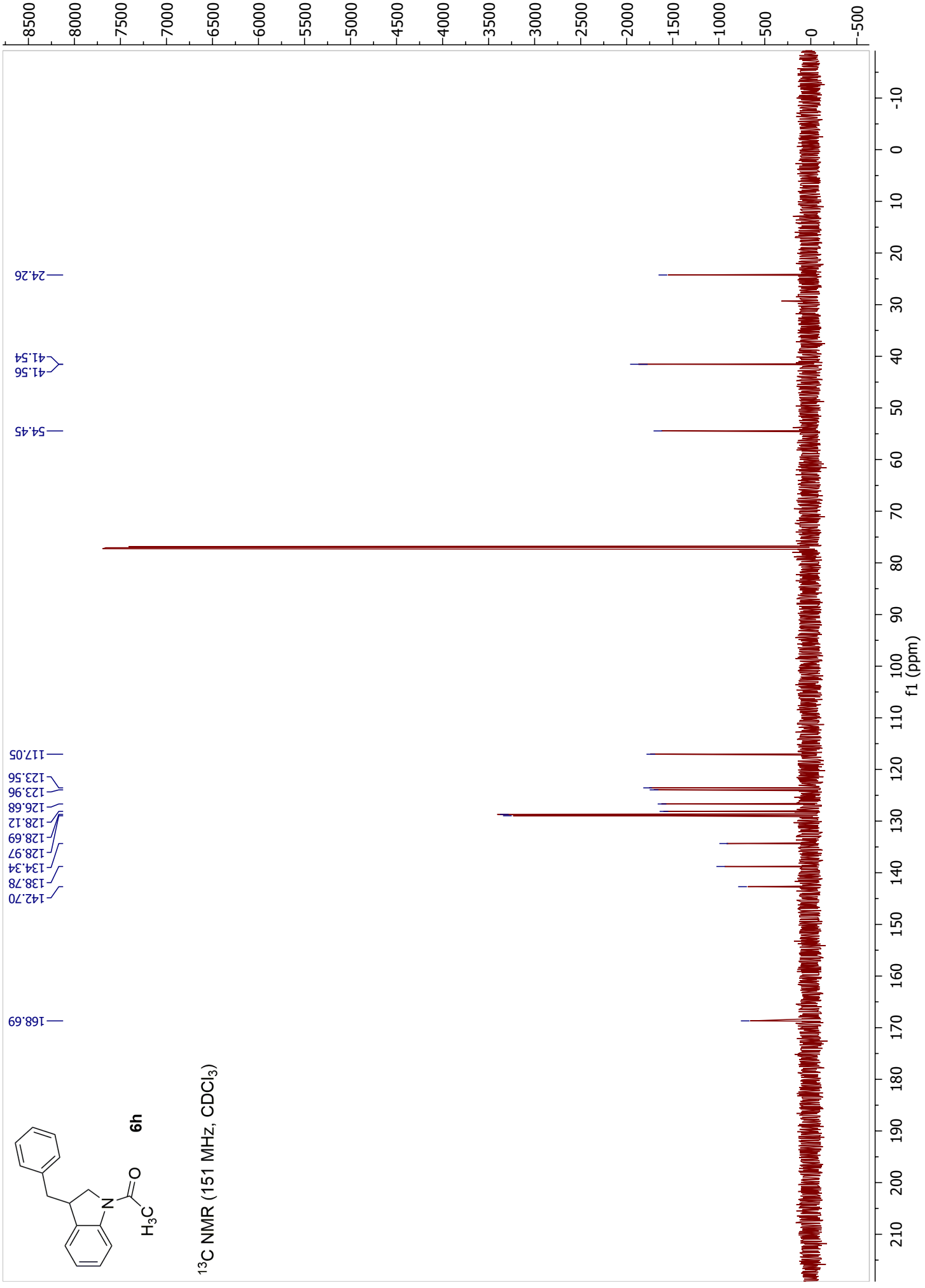
6h
1H NMR (600 MHz, CDCl3)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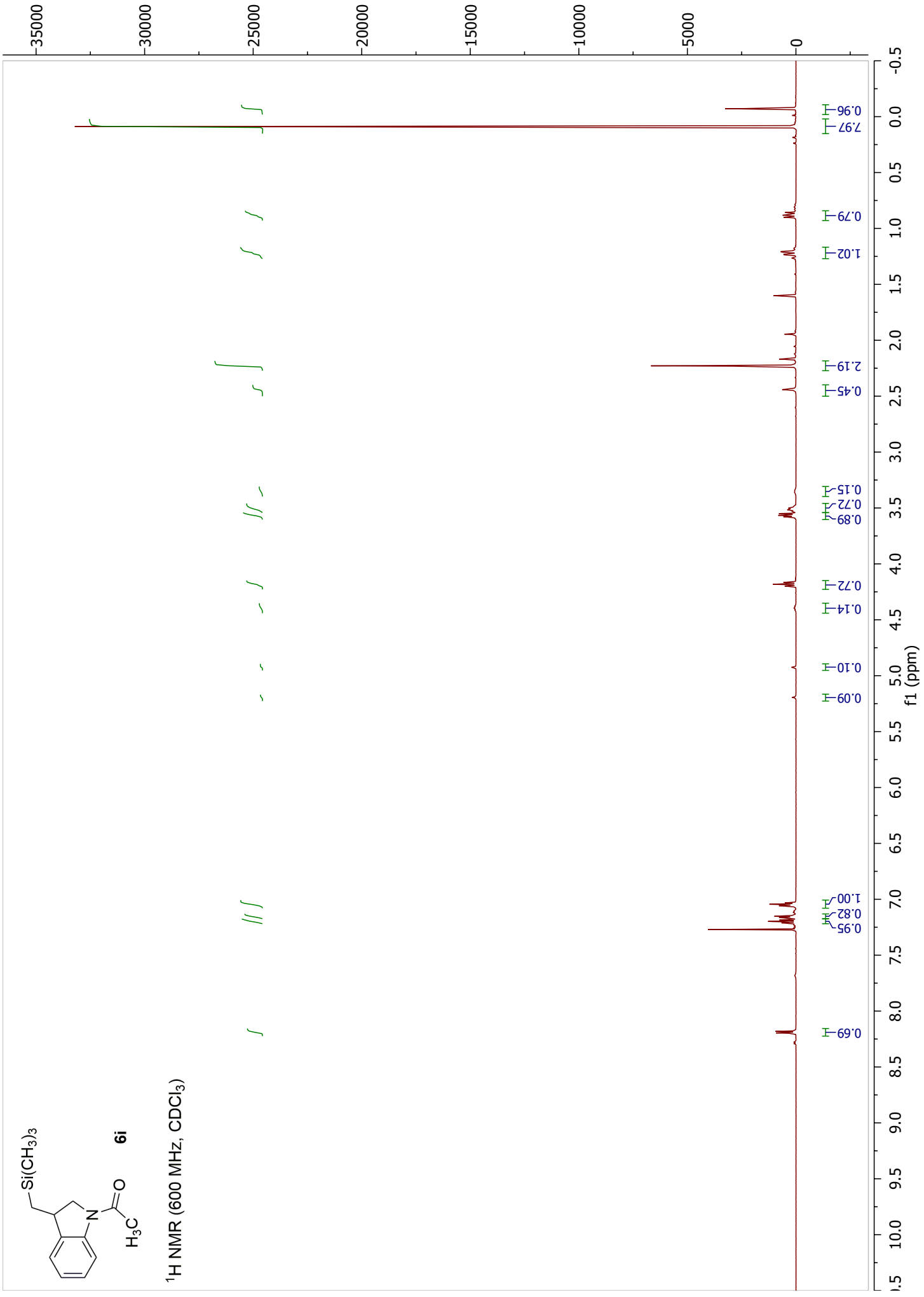
^{13}C NMR (151 MHz, CDCl$_3$)
6h
f1 (ppm)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0.72
0.89
0.72
0.14
0.10
0.09
1.00
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0.95
0.69
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0.0
0.5
1.0
1.5
2.0
2.5
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4.0
4.5
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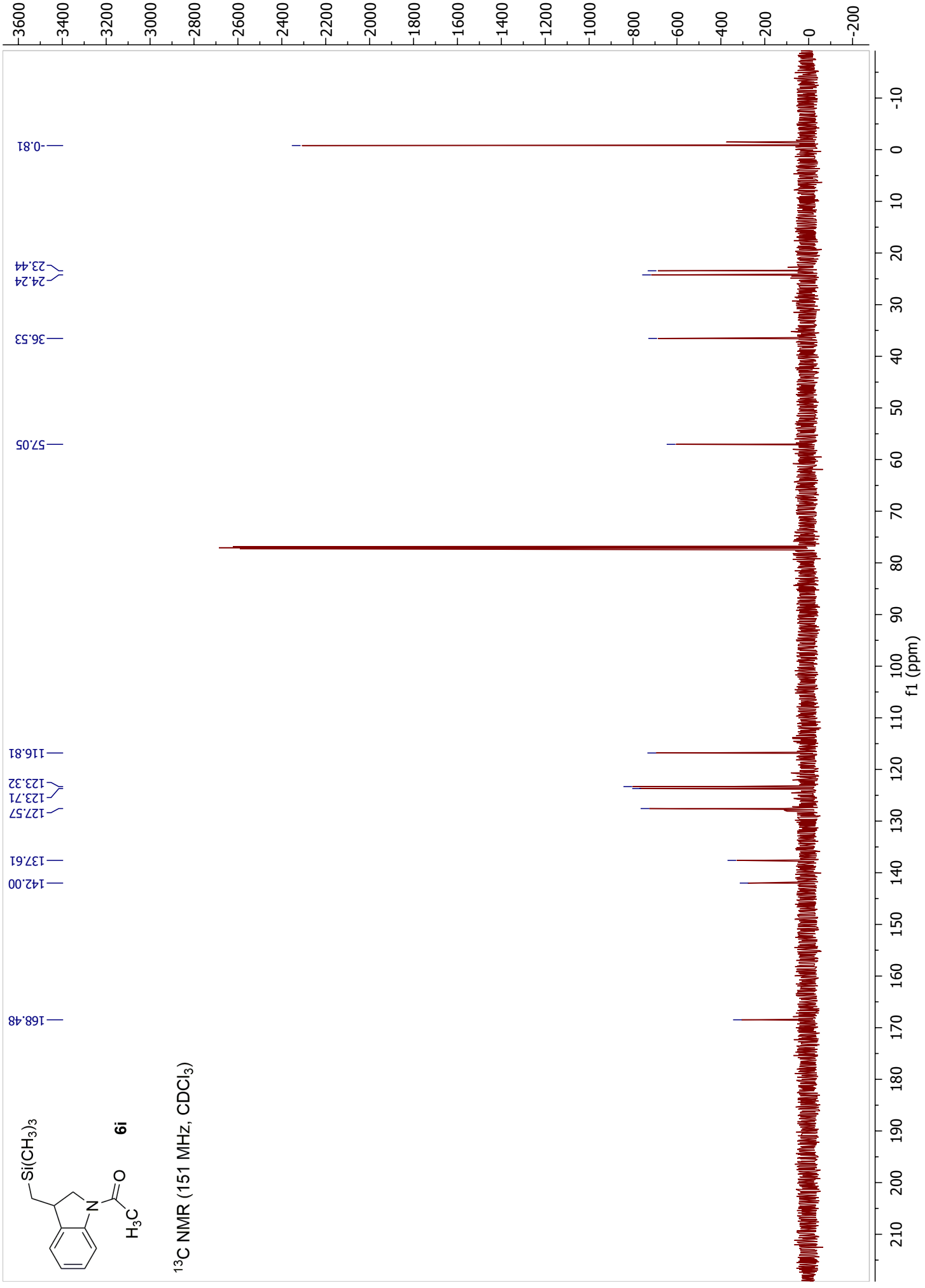
1H NMR (600 MHz, CDCl3)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168.48
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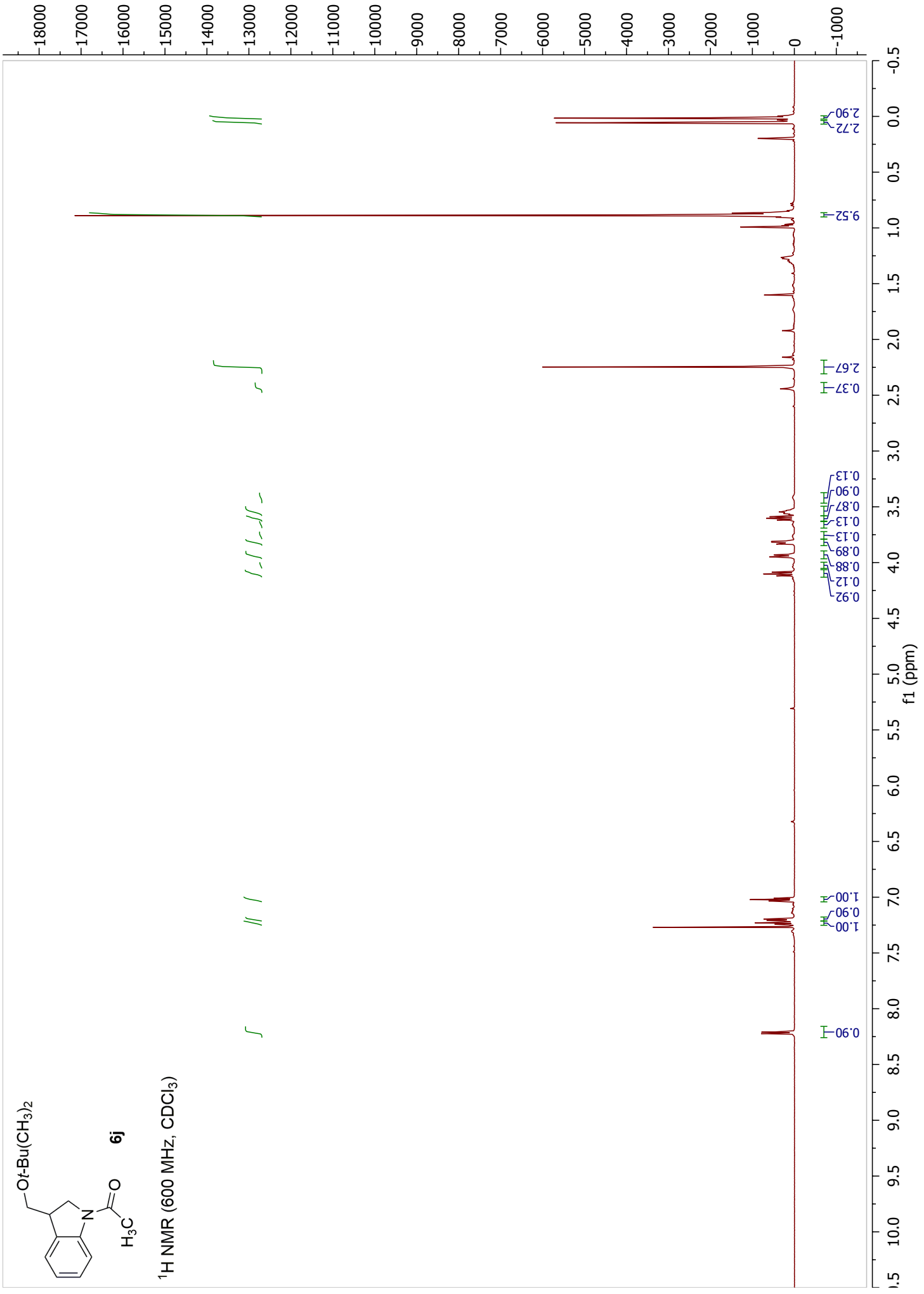
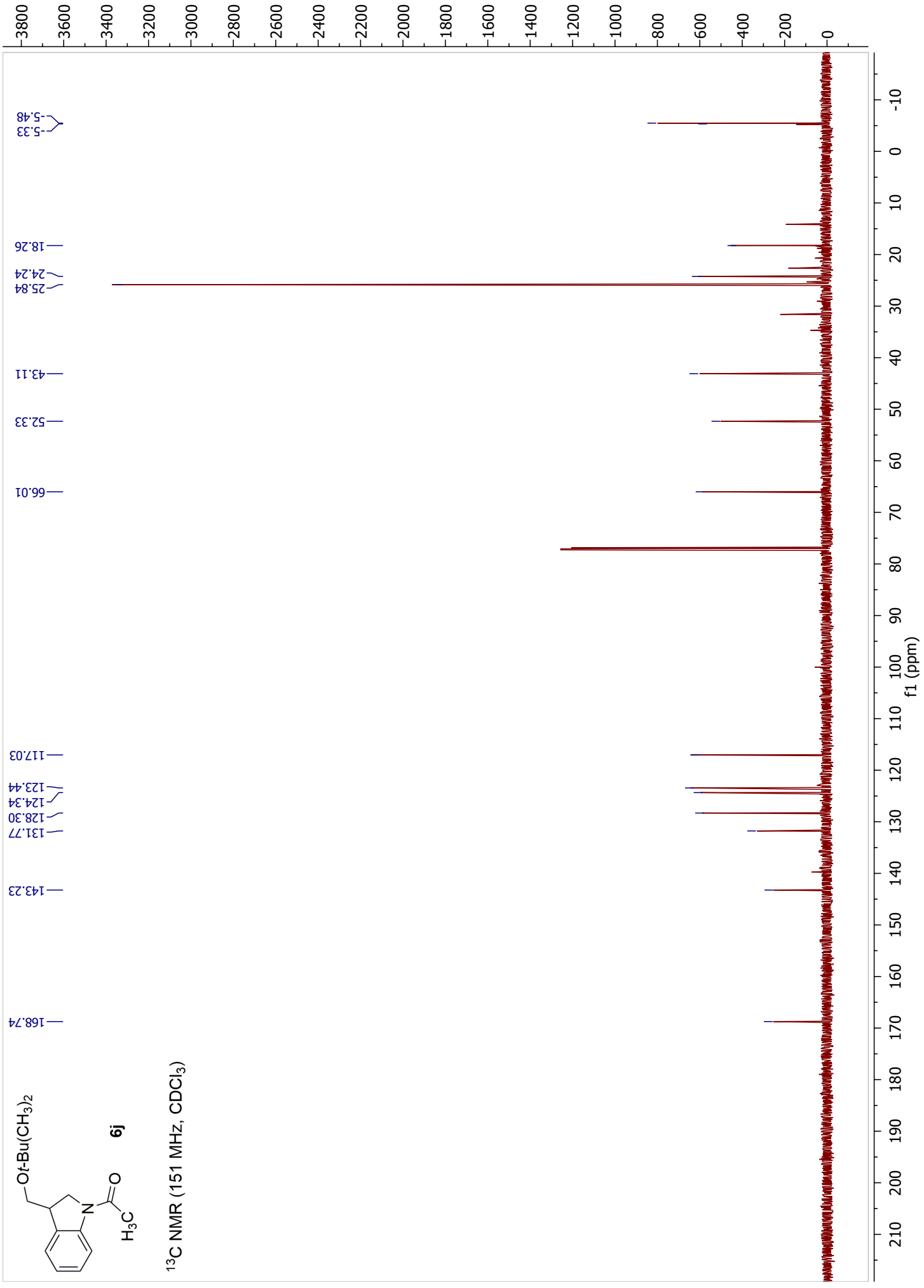
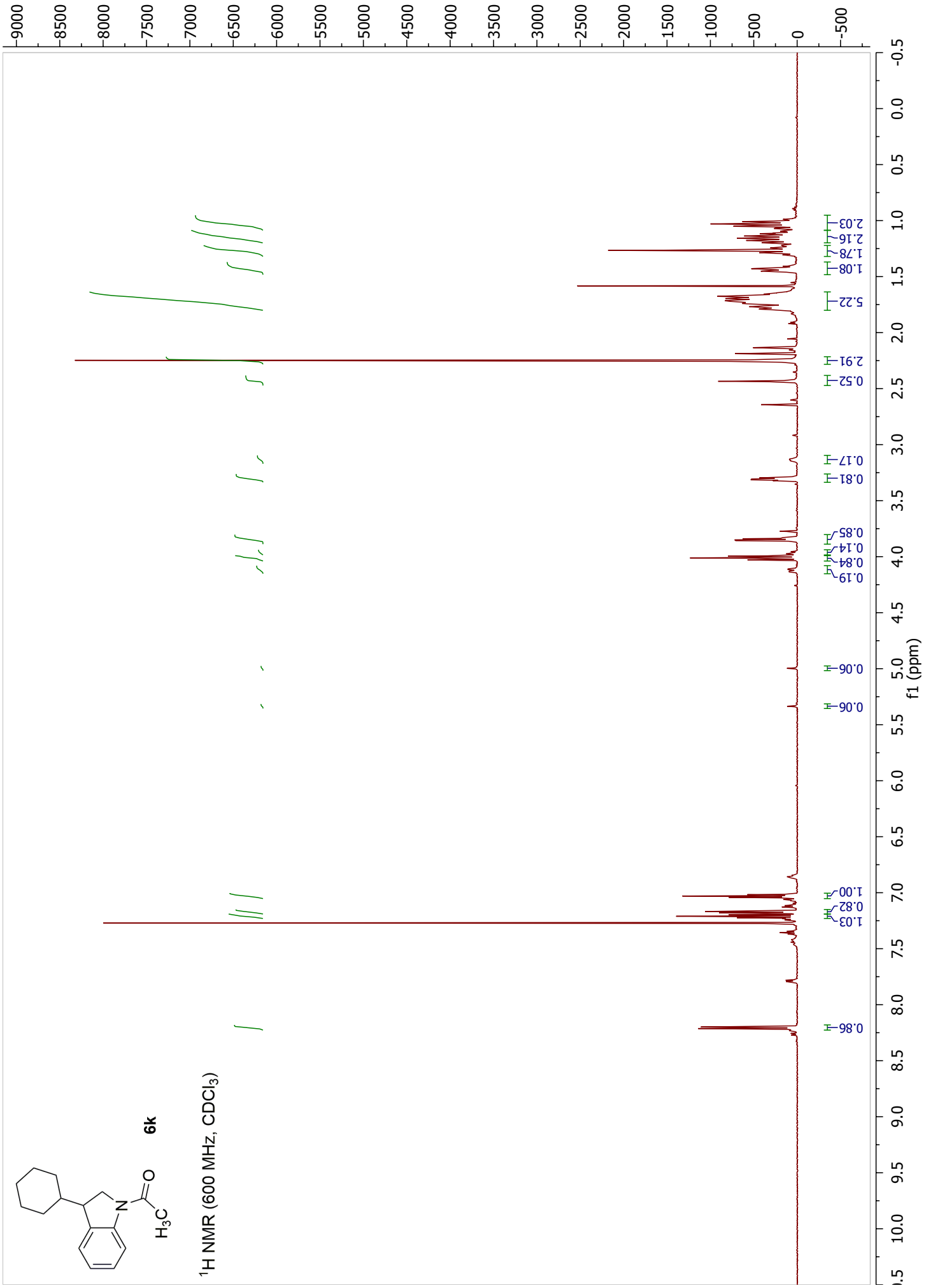
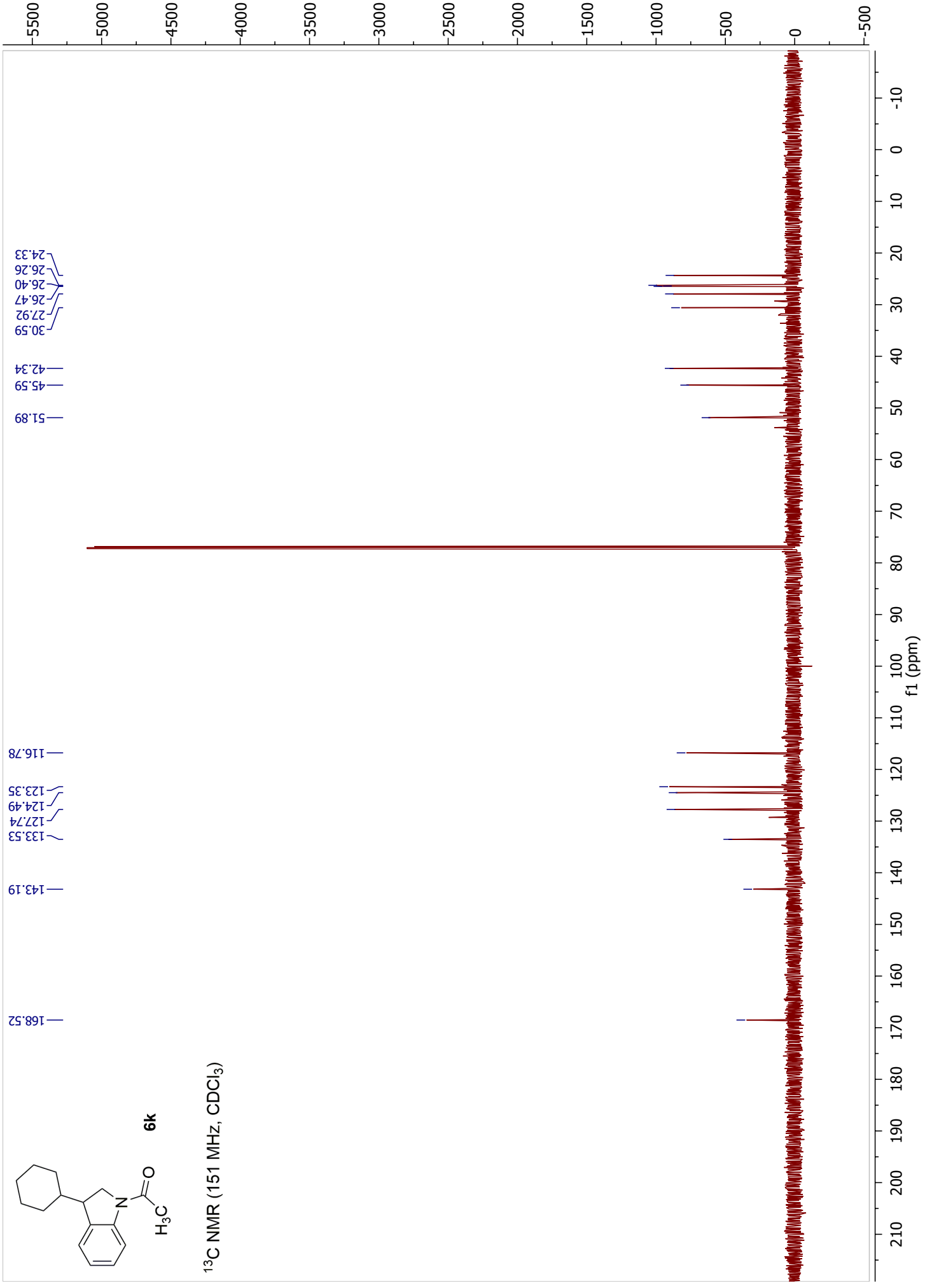
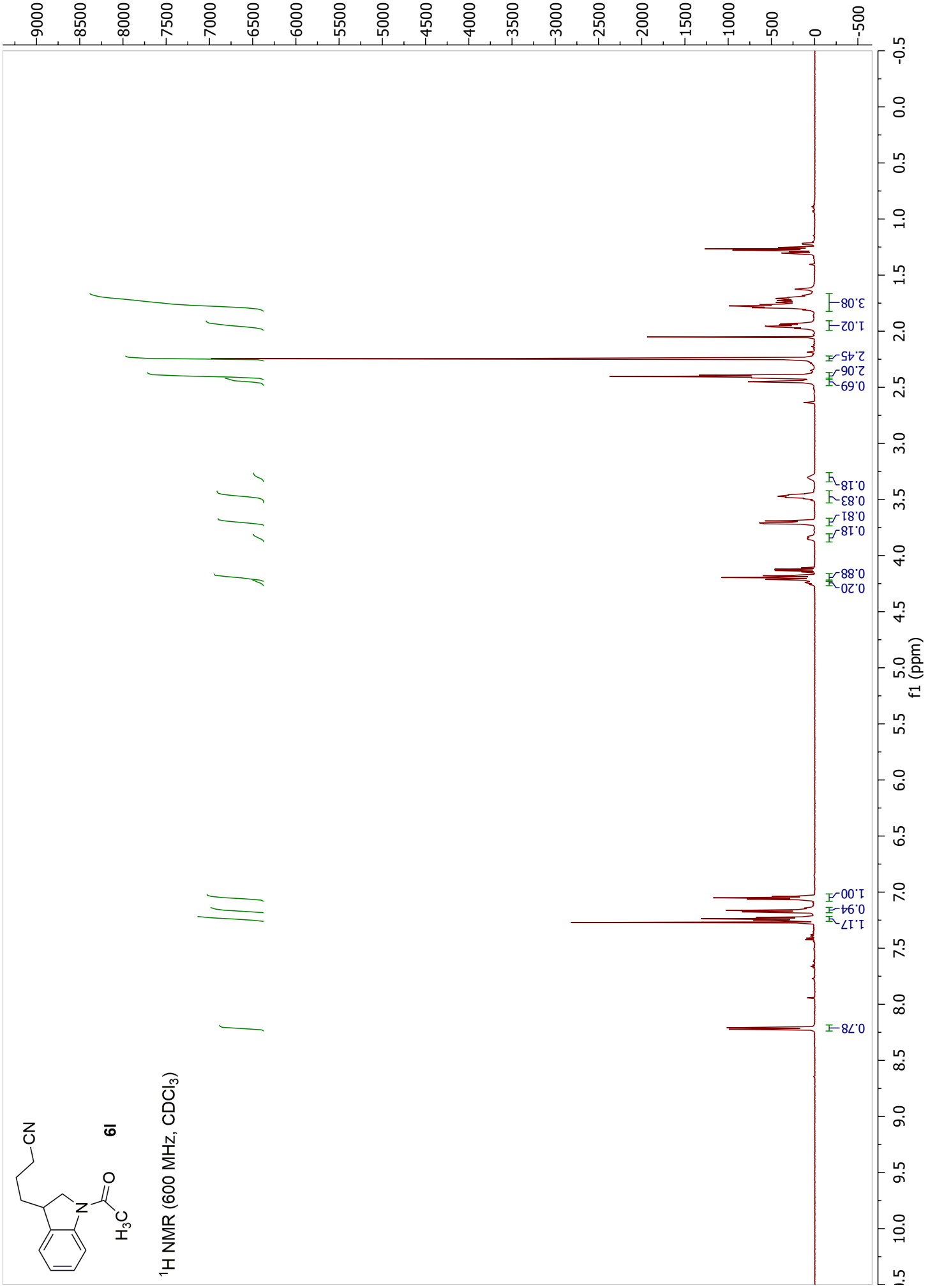
$Si(CH_3)_3$
N
O
H_3C
6i
f1 (ppm)

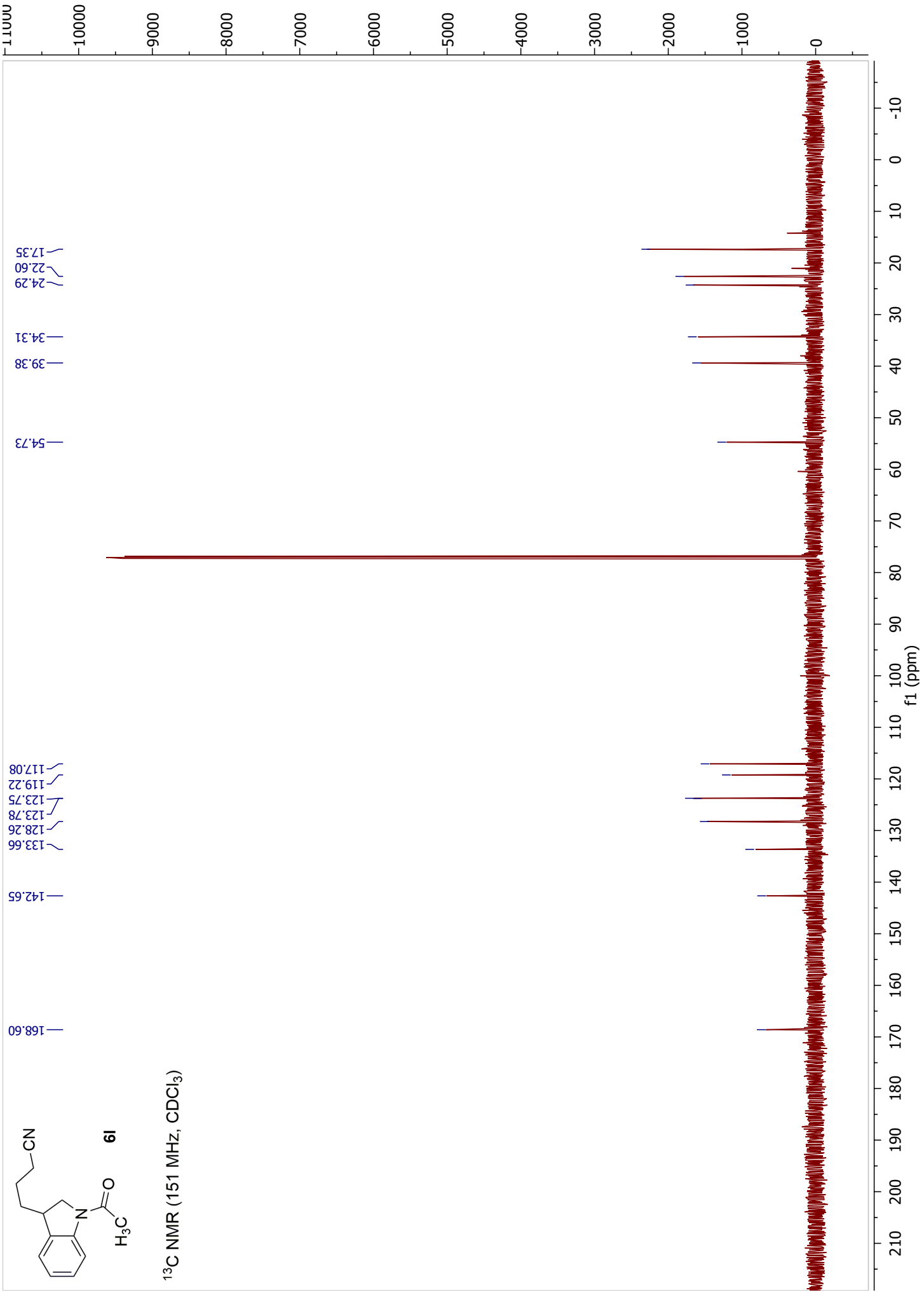

Ot-Bu(CH3)2
6j
H3C
O
N
1H NMR (600 MHz, CDCl3)
2.90
2.72
9.52
2.67
0.37
0.13
0.90
0.87
0.13
0.13
0.89
0.88
0.12
0.92
1.00
0.90
1.00
0.90
f1 (ppm)

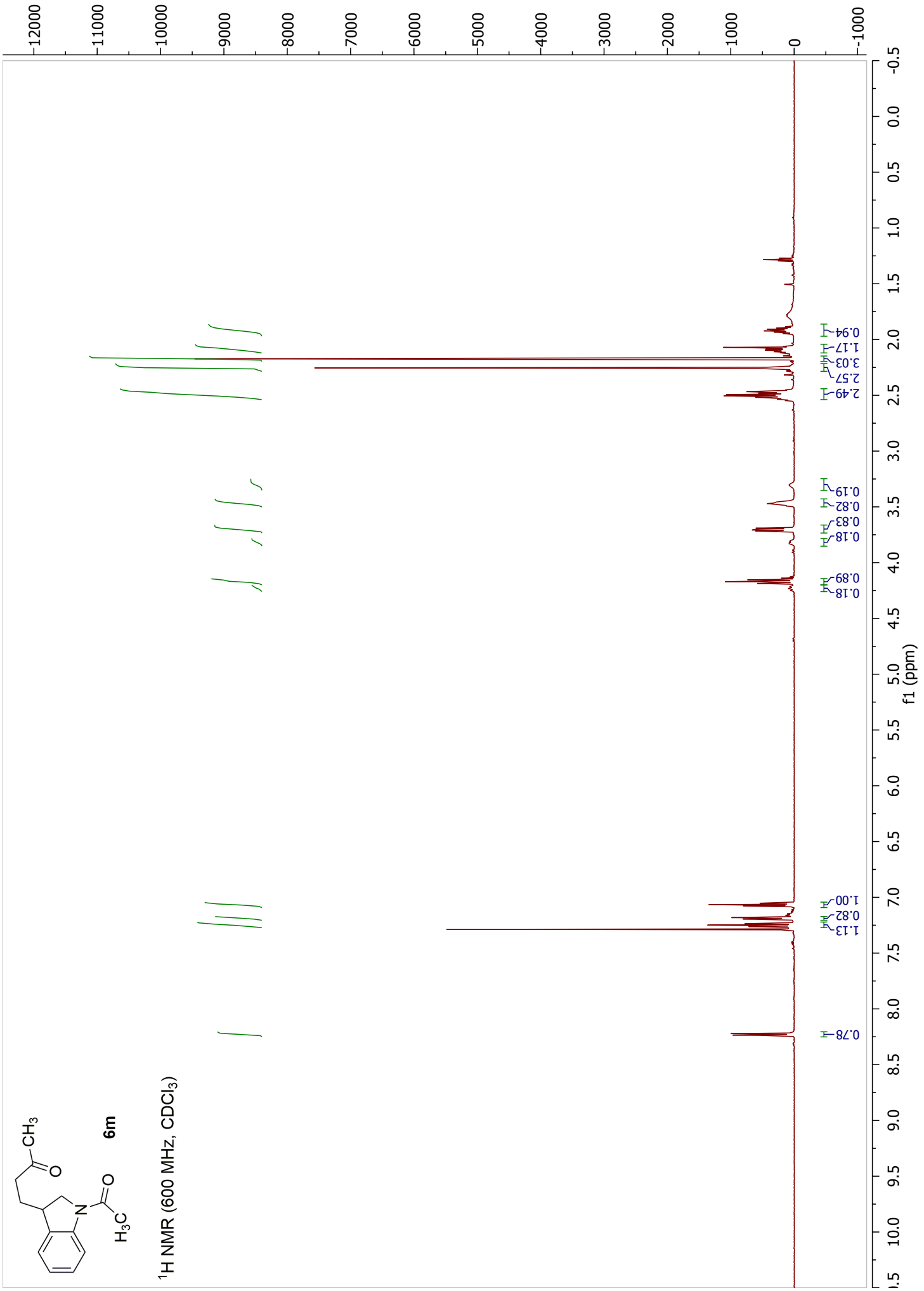

-5.48
-5.33
18.26
24.24
25.84
43.11
52.33
66.01
117.03
123.44
124.34
128.30
131.77
143.23
168.74
Ot-Bu(CH3)2
O
N
H3C
6j
13C NMR (151 MHz, CDCl3)
f1 (ppm)

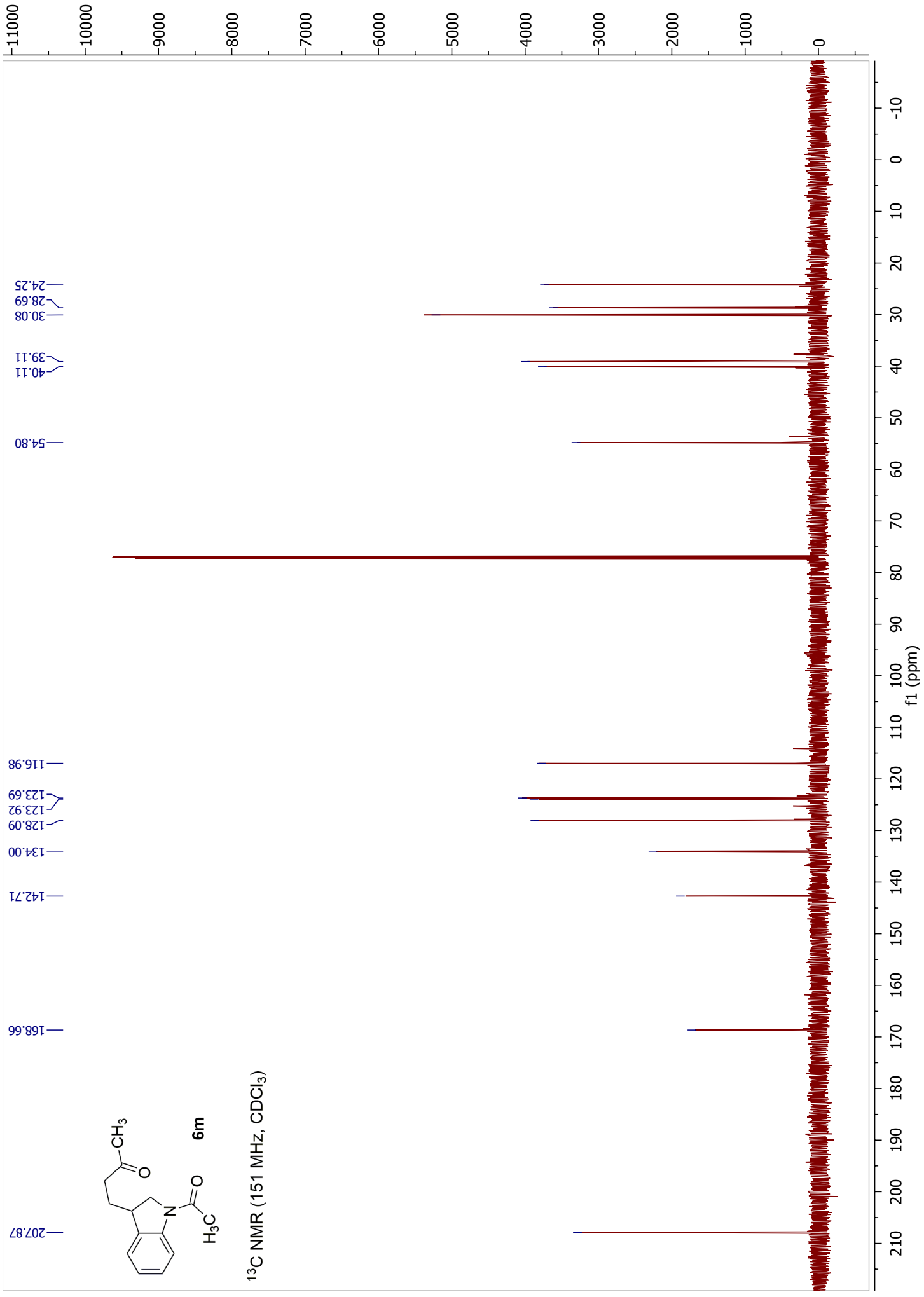

6k
^{1}H NMR (600 MHz, $CDCl_3$)
f1 (ppm)
2.03
2.16
1.78
1.08
5.22
2.91
0.52
0.17
0.81
0.85
0.14
0.84
0.19
0.06
0.06
1.00
0.82
1.03
0.86

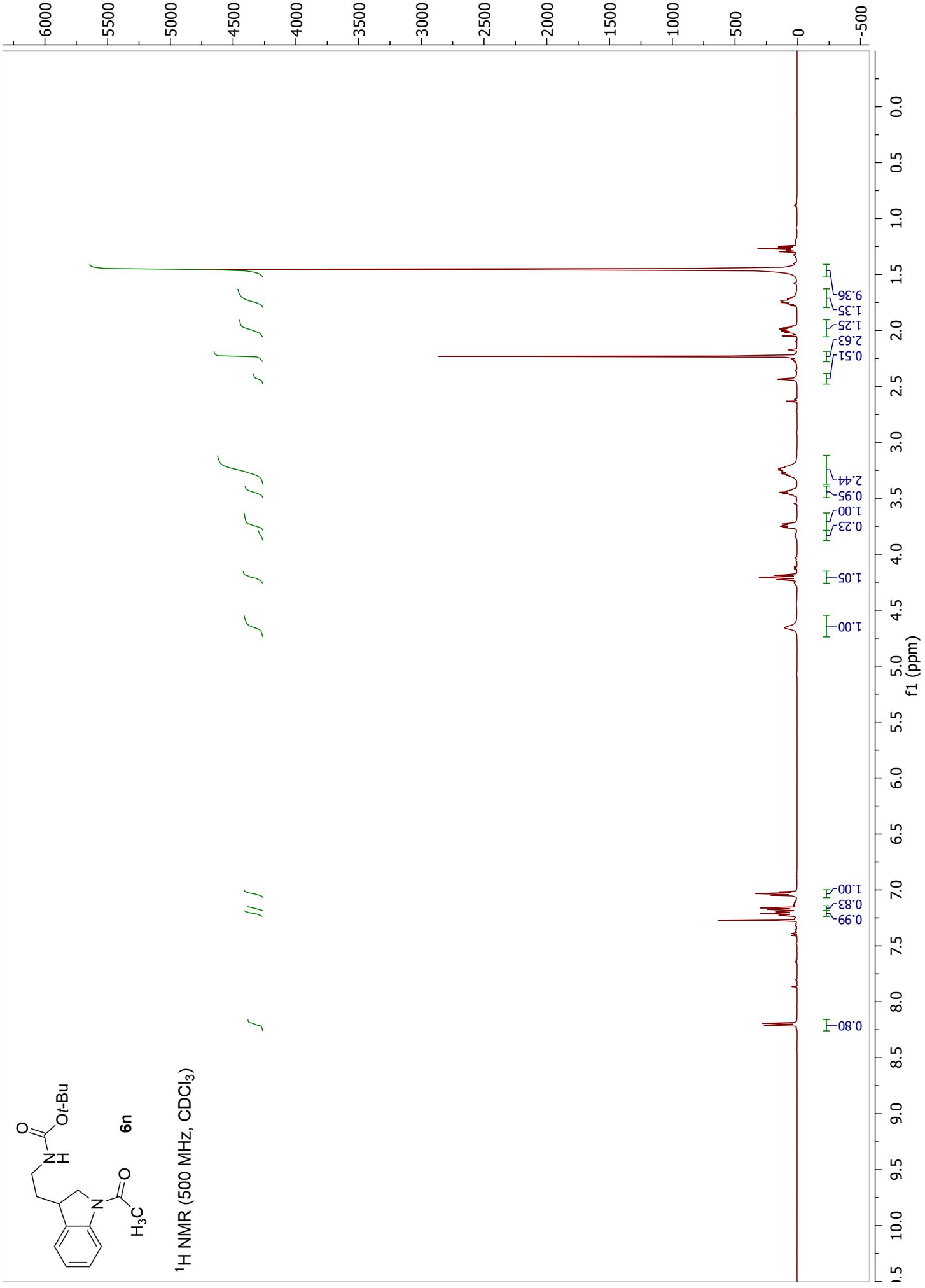

168.52
143.19
133.53
127.74
124.49
123.35
116.78
51.89
45.59
42.34
30.59
27.92
26.47
26.40
26.26
24.33
f1 (ppm)
^{13}C NMR (151 MHz, $CDCl_3$)
6k
N
O
H_3C

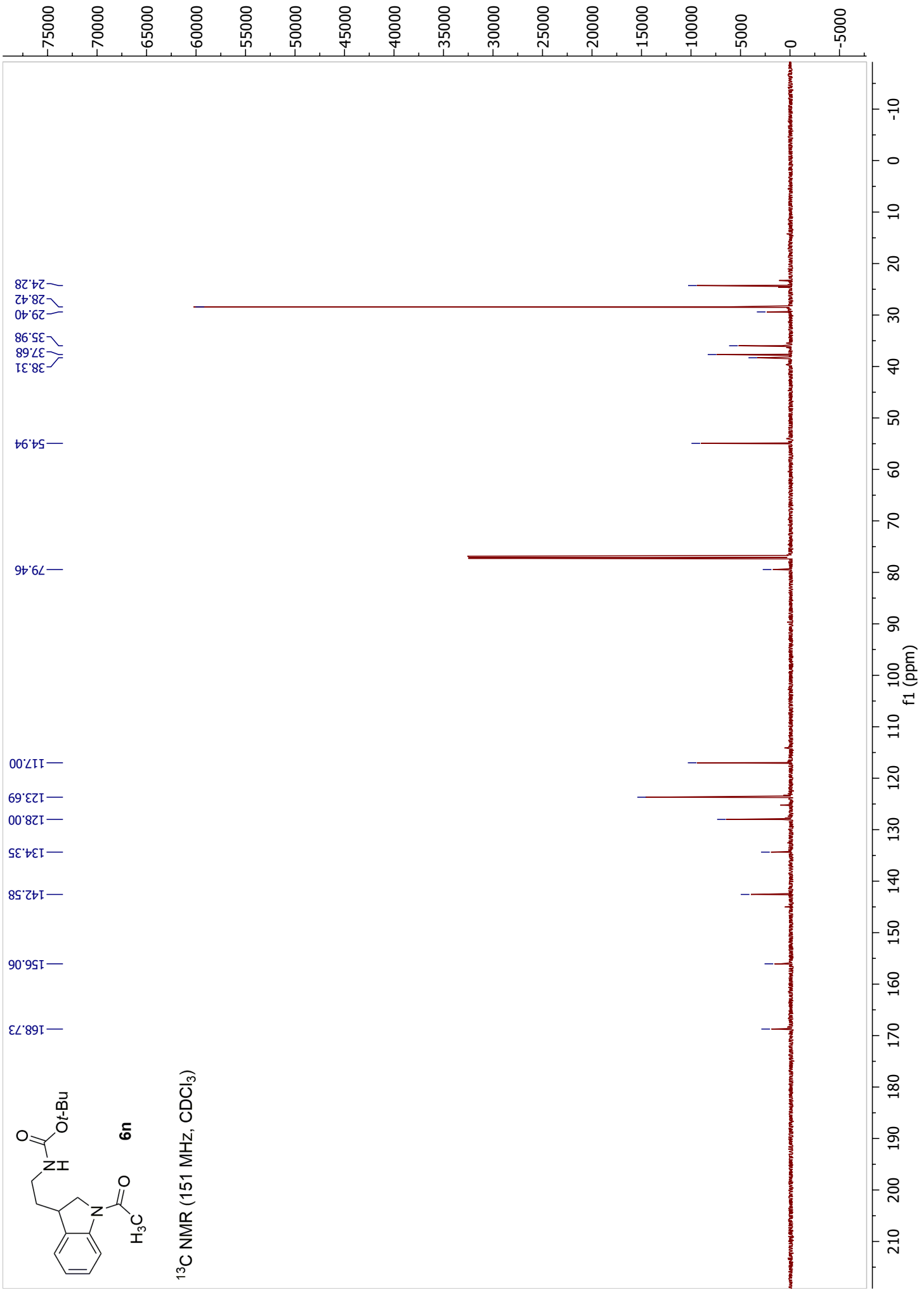

f1 (ppm)
3.08
1.02
2.45
2.06
0.69
0.18
0.83
0.81
0.18
0.88
0.20
1.00
0.94
1.17
0.78
CN
O
N
H3C
6l
1H NMR (600 MHz, CDCl3)

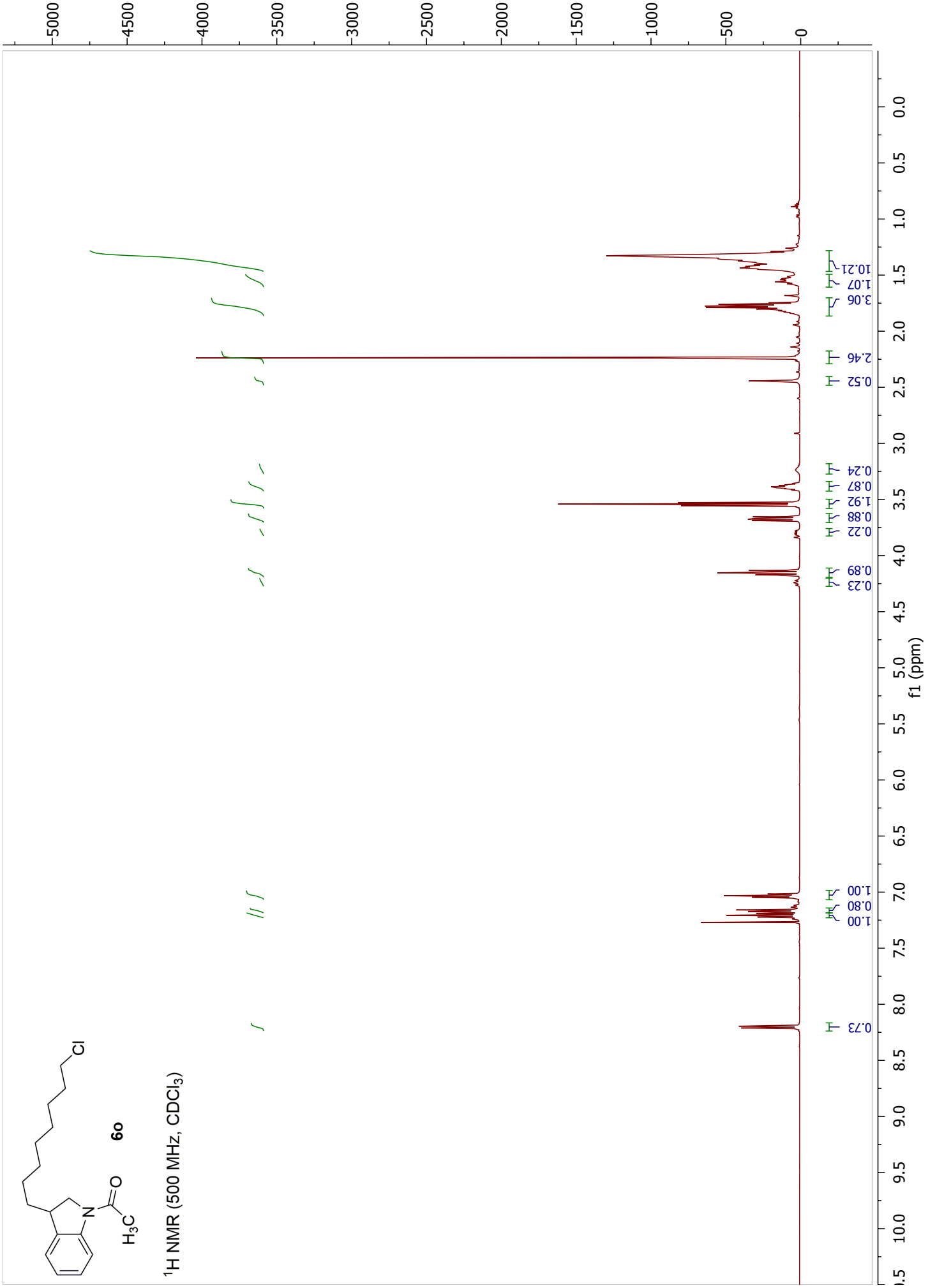

168.60
142.65
133.66
128.26
123.78
123.75
119.22
117.08
54.73
39.38
34.31
24.29
22.60
17.35
f1 (ppm)
^{13}C NMR (151 MHz, $CDCl_3$)
6l
CN
O
N
H_3C

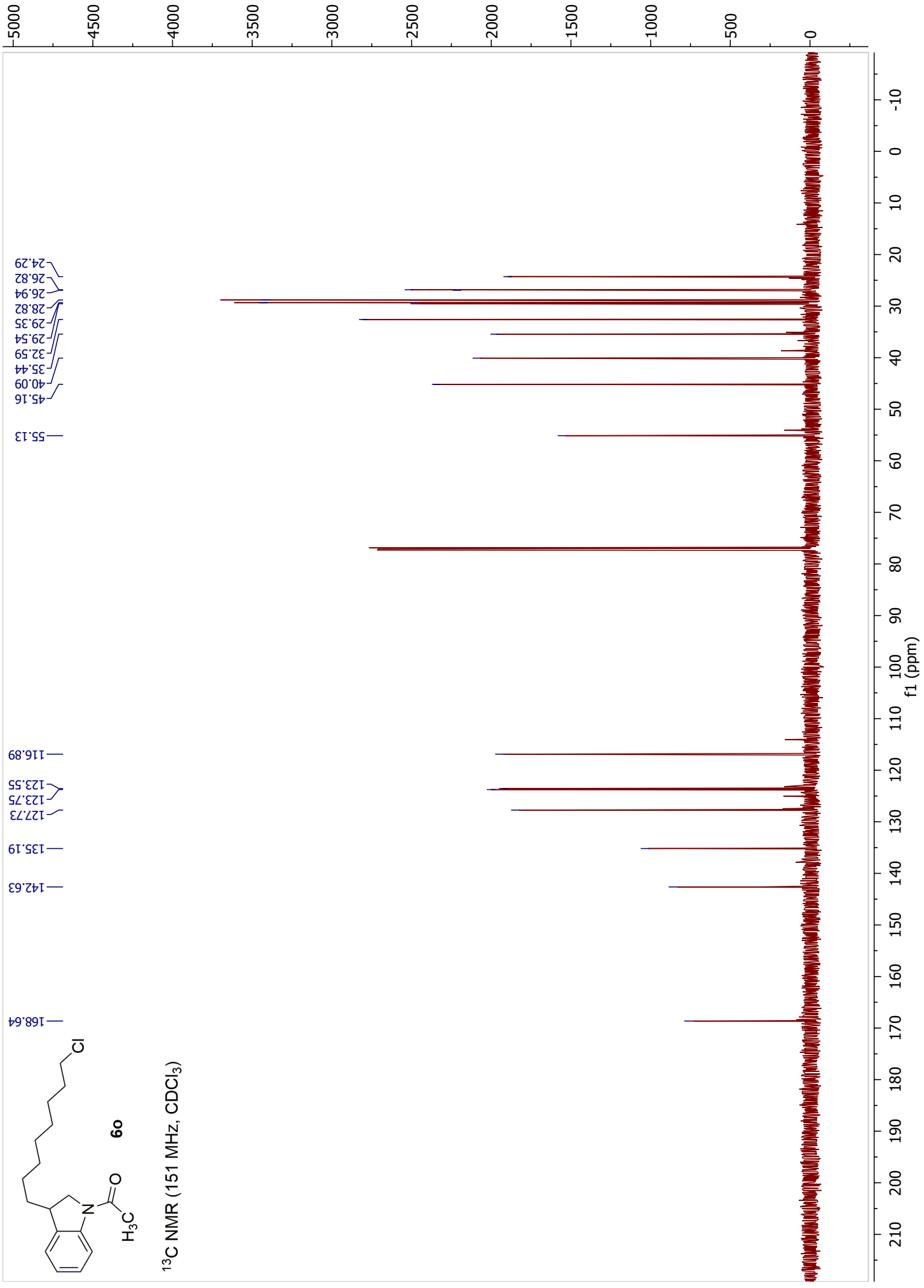

6m
^{1}H NMR (600 MHz, $CDCl_3$)
f1 (ppm)
0.94
1.17
3.03
2.57
2.49
0.19
0.82
0.83
0.18
0.89
0.18
1.00
0.82
1.13
0.78

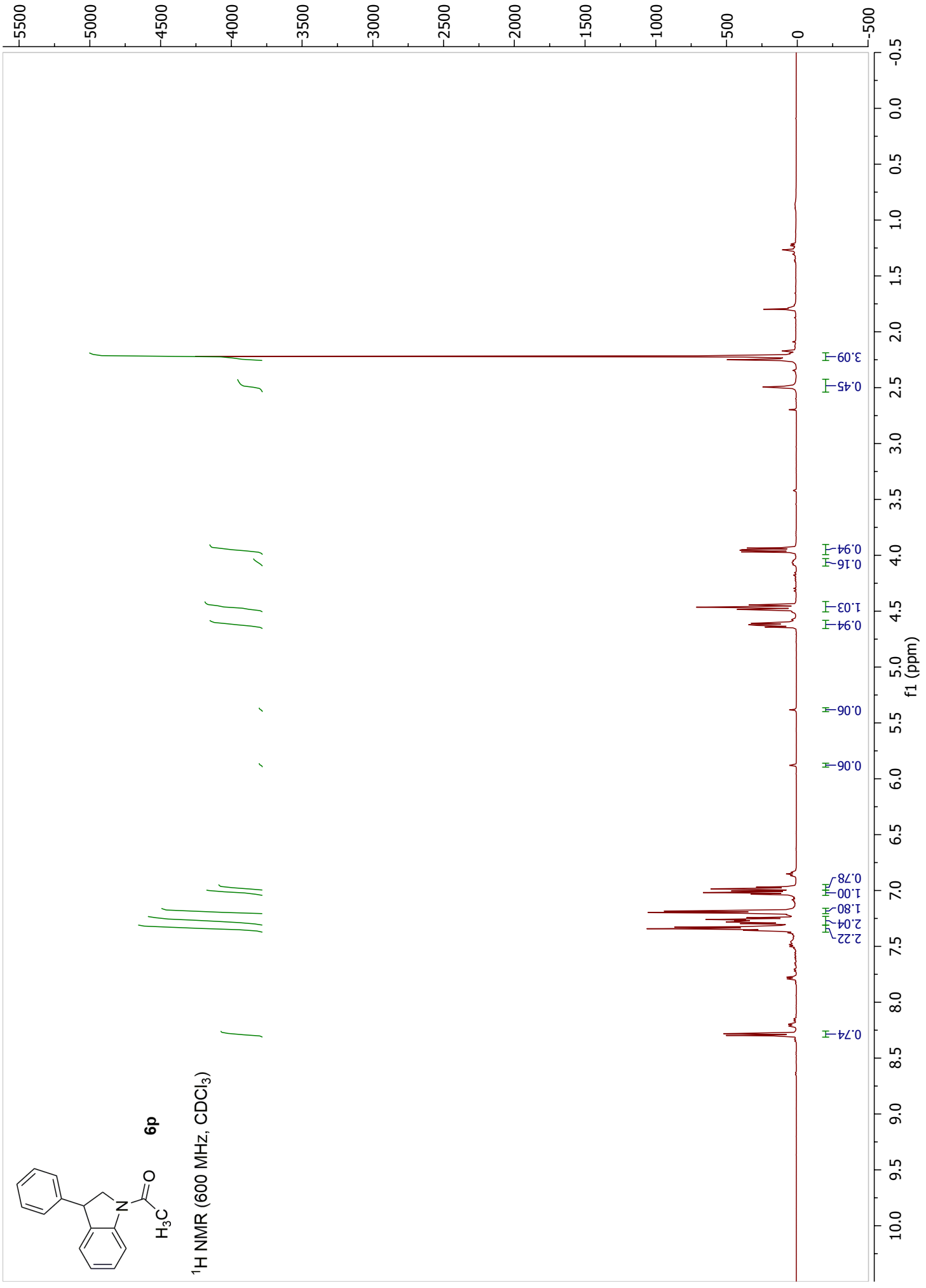

24.25
28.69
30.08
39.11
40.11
54.80
116.98
123.69
123.92
128.09
134.00
142.71
168.66
207.87
^{13}C NMR (151 MHz, $CDCl_3$)
6m
f1 (ppm)

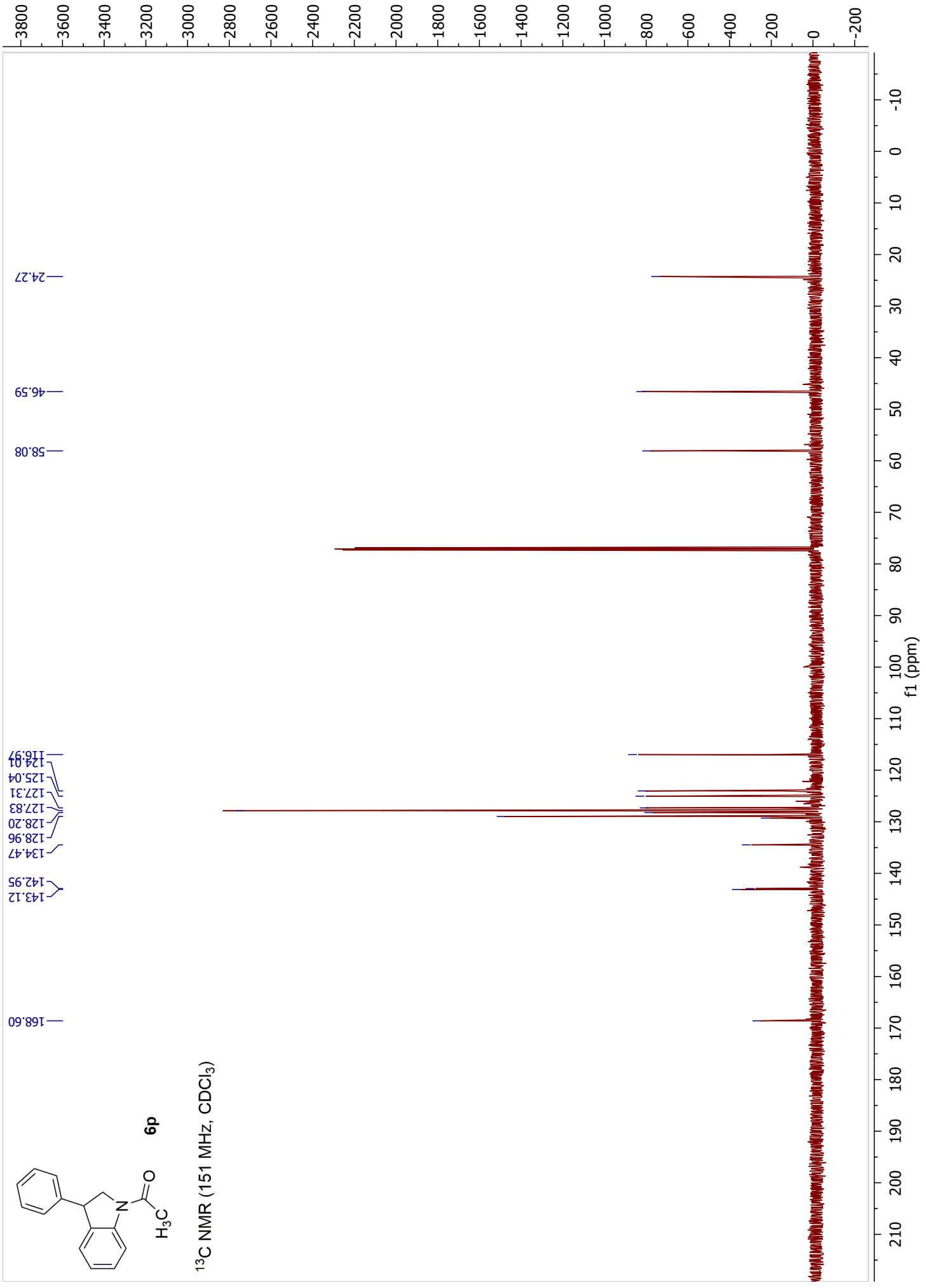

6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-500
9.36
1.35
1.25
2.63
0.51
2.44
0.95
1.00
0.23
1.05
1.00
1.00
0.83
0.99
0.80
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
f1 (ppm)
O
Ot-Bu
N
H
N
O
H3C
6n
1H NMR (500 MHz, CDCl3)

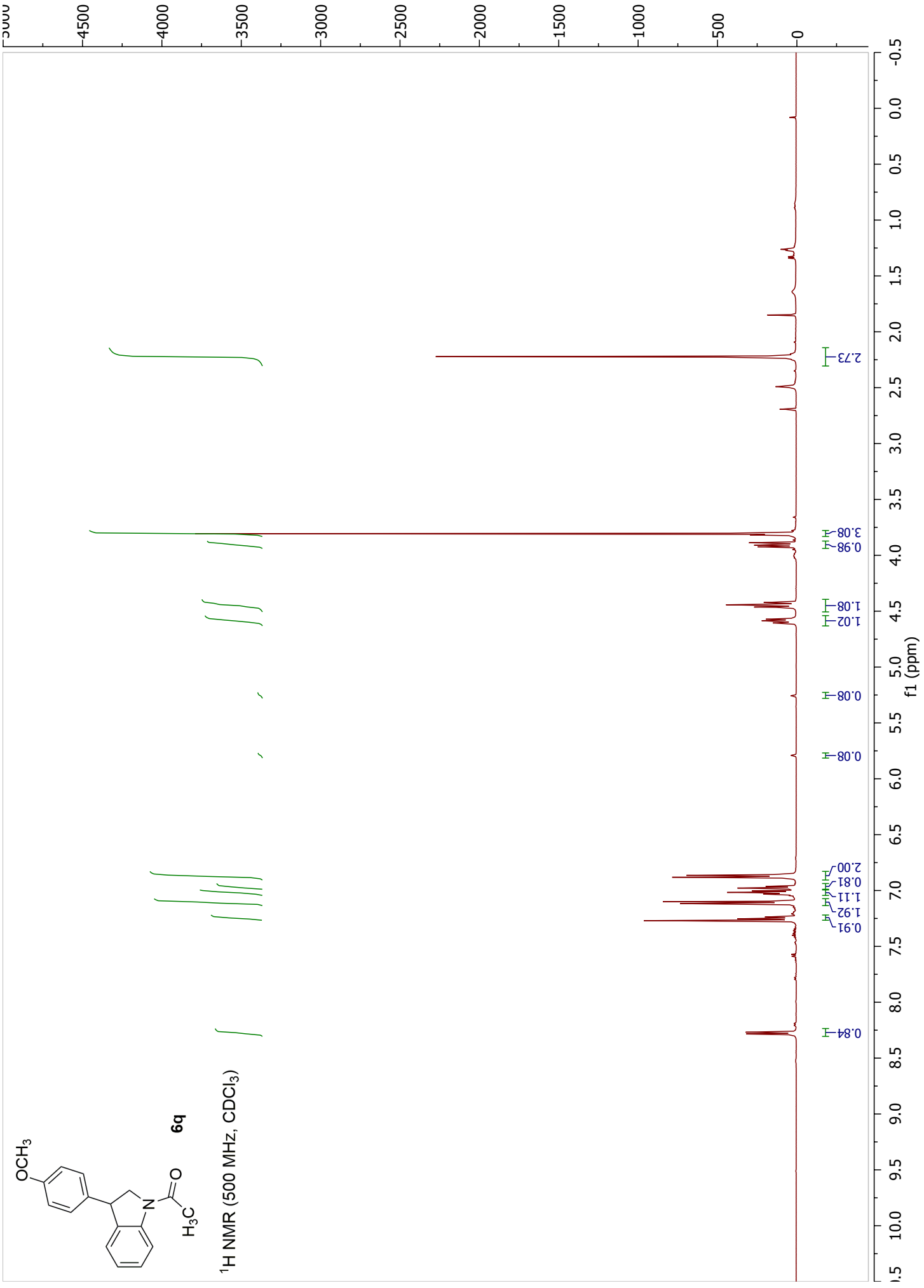

168.73
156.06
142.58
134.35
128.00
123.69
117.00
79.46
54.94
38.31
37.68
35.98
29.40
28.42
24.28
f1 (ppm)
^{13}C NMR (151 MHz, $CDCl_3$)
6n
O
Ot-Bu
N
H
N
O
H_3C

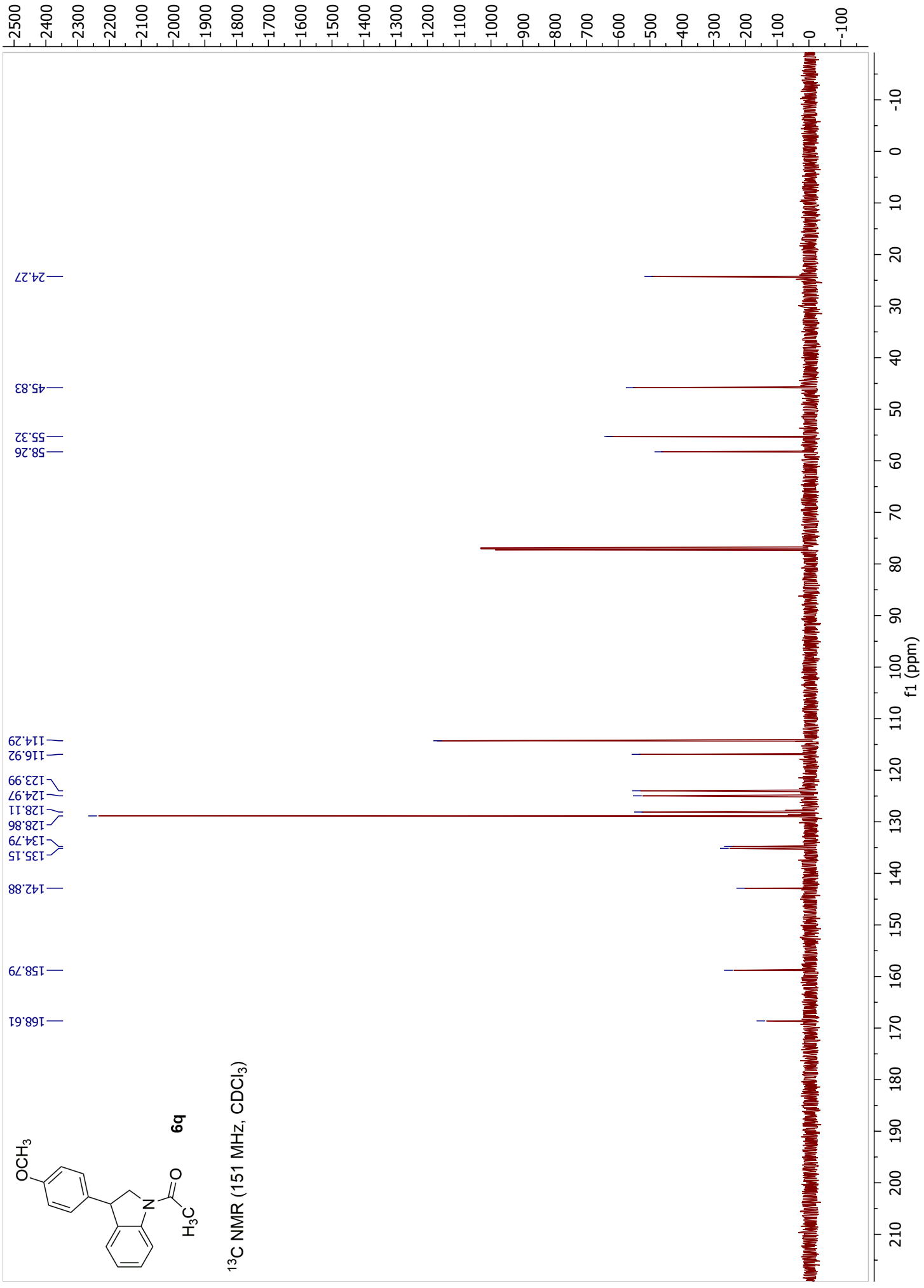

Cl
N
O
H3C
6o
1H NMR (500 MHz, CDCl3)
10.21
1.07
3.06
2.46
0.52
0.24
0.87
1.92
0.88
0.22
0.89
0.23
1.00
0.80
1.00
0.73
f1 (ppm)

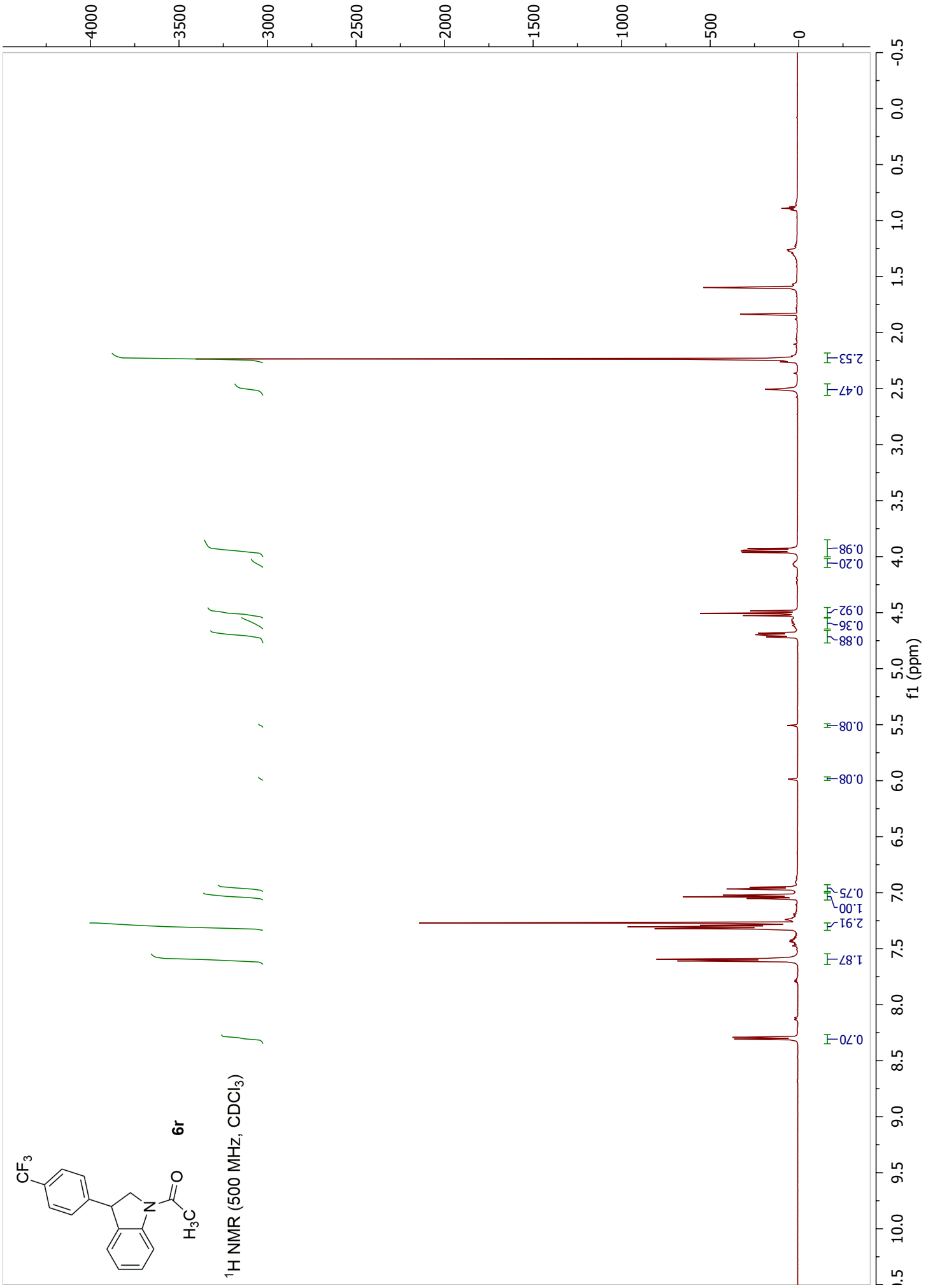

168.64
142.63
135.19
127.73
123.75
123.55
116.89
55.13
45.16
40.09
35.44
32.59
29.54
29.35
28.82
26.94
26.82
24.29
f1 (ppm)
^{13}C NMR (151 MHz, $CDCl_3$)
6o
Cl
O
N
H_3C

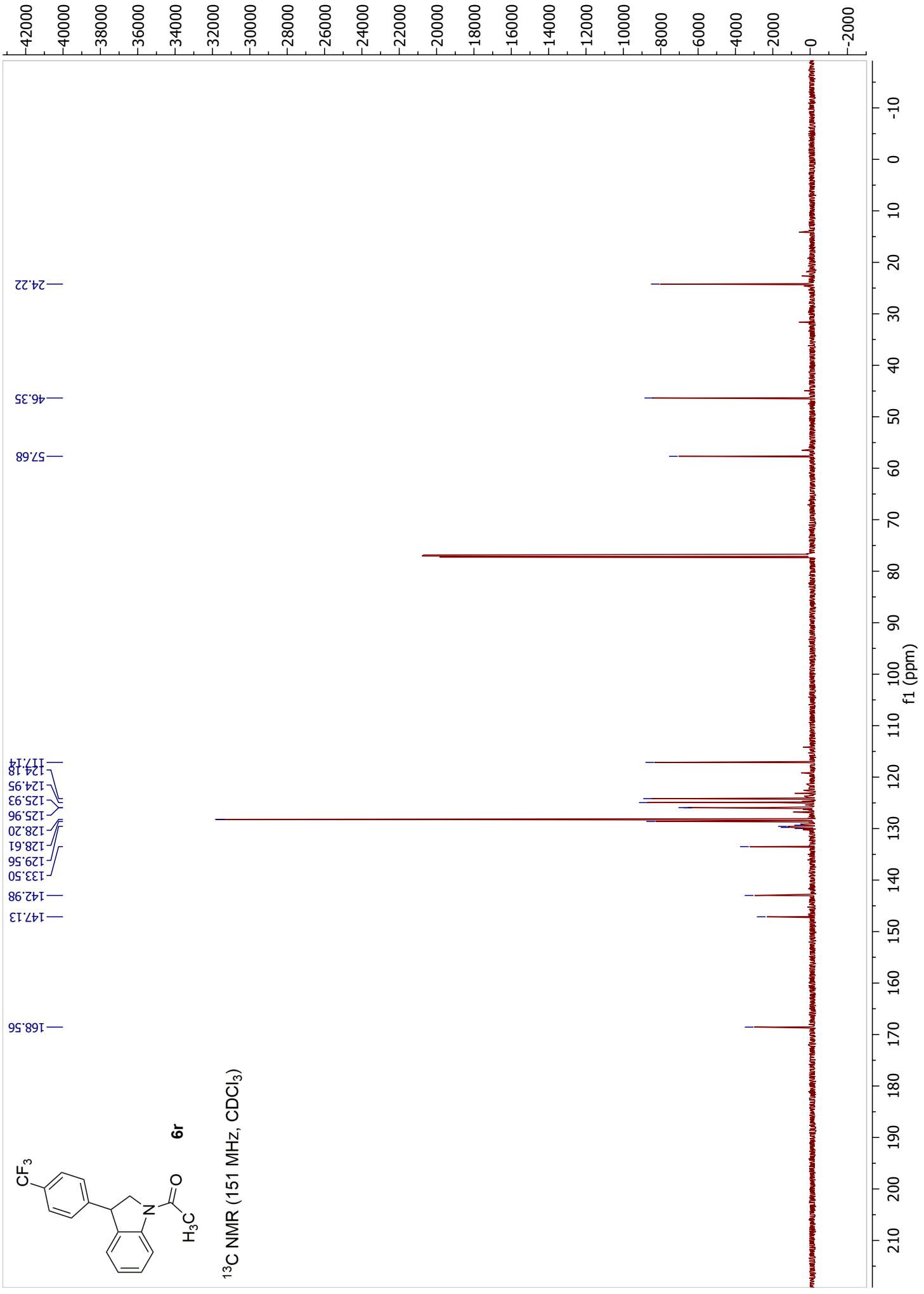

6p
^{1}H NMR (600 MHz, $CDCl_3$)
f1 (ppm)
3.09
0.45
0.94
0.16
1.03
0.94
0.06
0.06
0.78
1.00
1.80
2.04
2.22
0.74

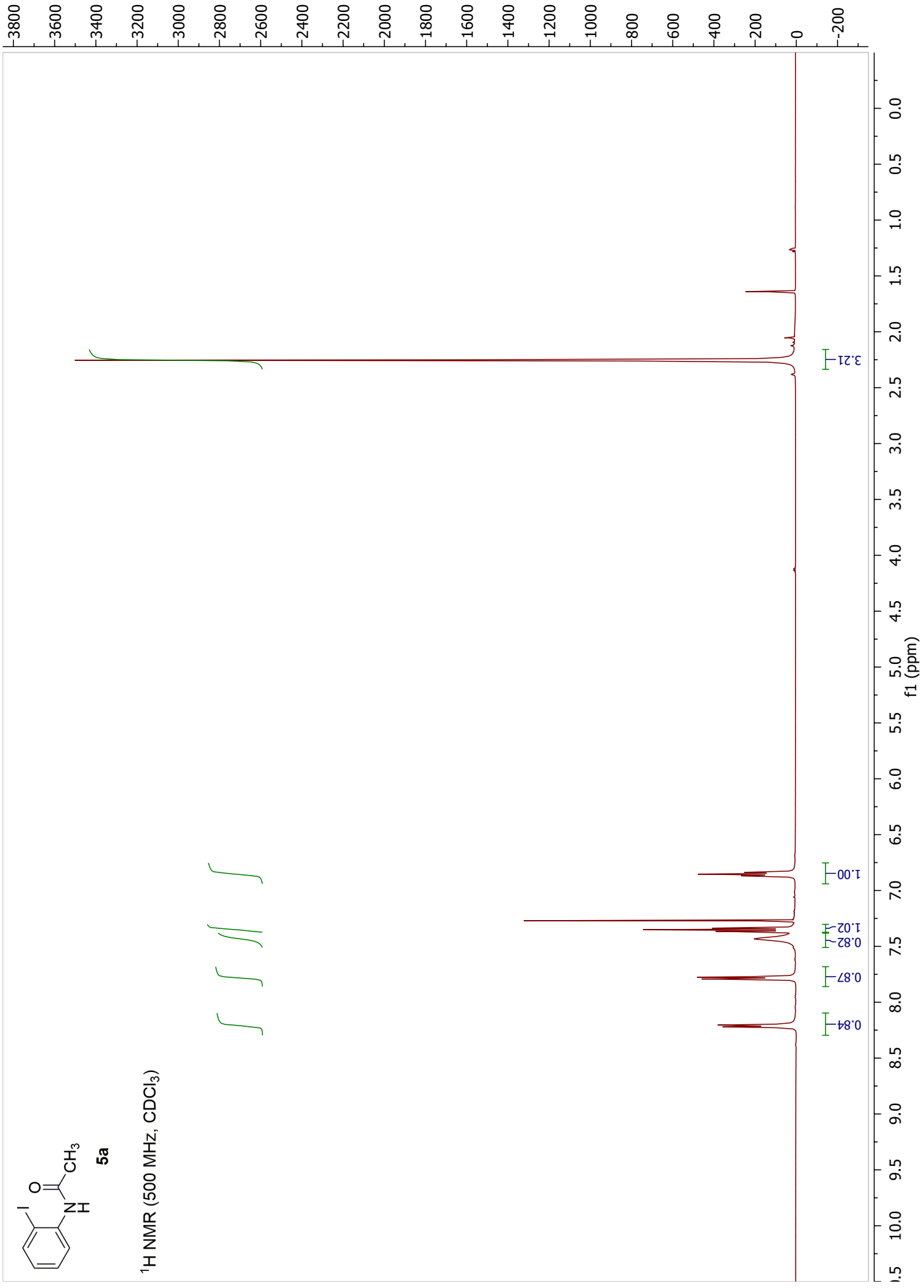

24.27
46.59
58.08
116.97
124.01
125.04
127.31
127.83
128.20
128.96
134.47
142.95
143.12
168.60
6p
^{13}C NMR (151 MHz, $CDCl_3$)
f1 (ppm)


OCH3
N
O
H3C
6q
1H NMR (500 MHz, CDCl3)
2.73
3.08
0.98
1.08
1.02
0.08
0.08
2.00
0.81
1.11
1.92
0.91
0.84
f1 (ppm)


24.27
45.83
55.32
58.26
114.29
116.92
123.99
124.97
128.11
128.86
134.79
135.15
142.88
158.79
168.61
f1 (ppm)
OCH3
O
N
H3C
6q
13C NMR (151 MHz, CDCl3)

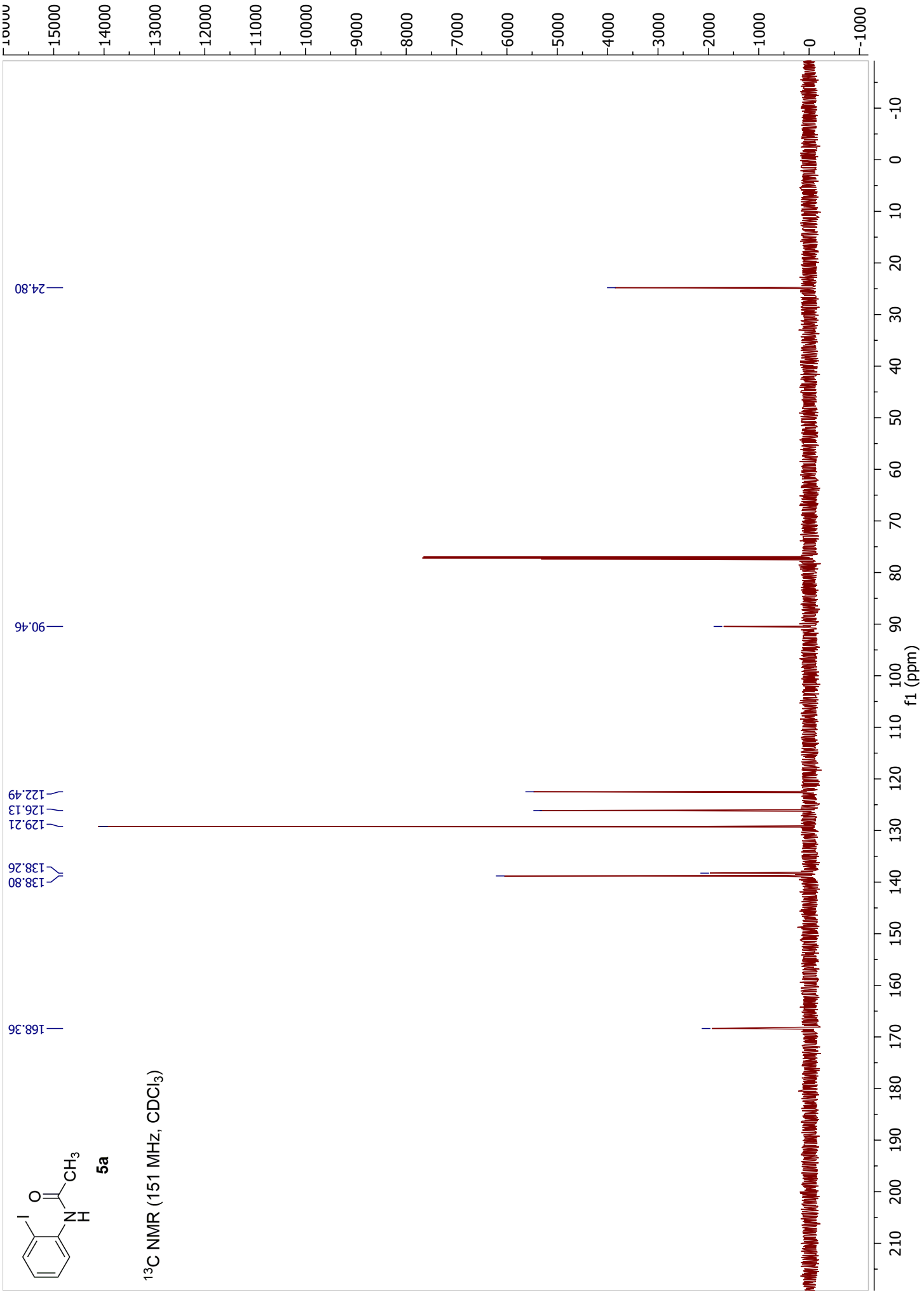

^{1}H NMR (500 MHz, $CDCl_3$)
6r
CF_3
O
N
H_3C
2.53
0.47
0.98
0.20
0.92
0.36
0.88
0.08
0.08
0.75
1.00
2.91
1.87
0.70
f1 (ppm)

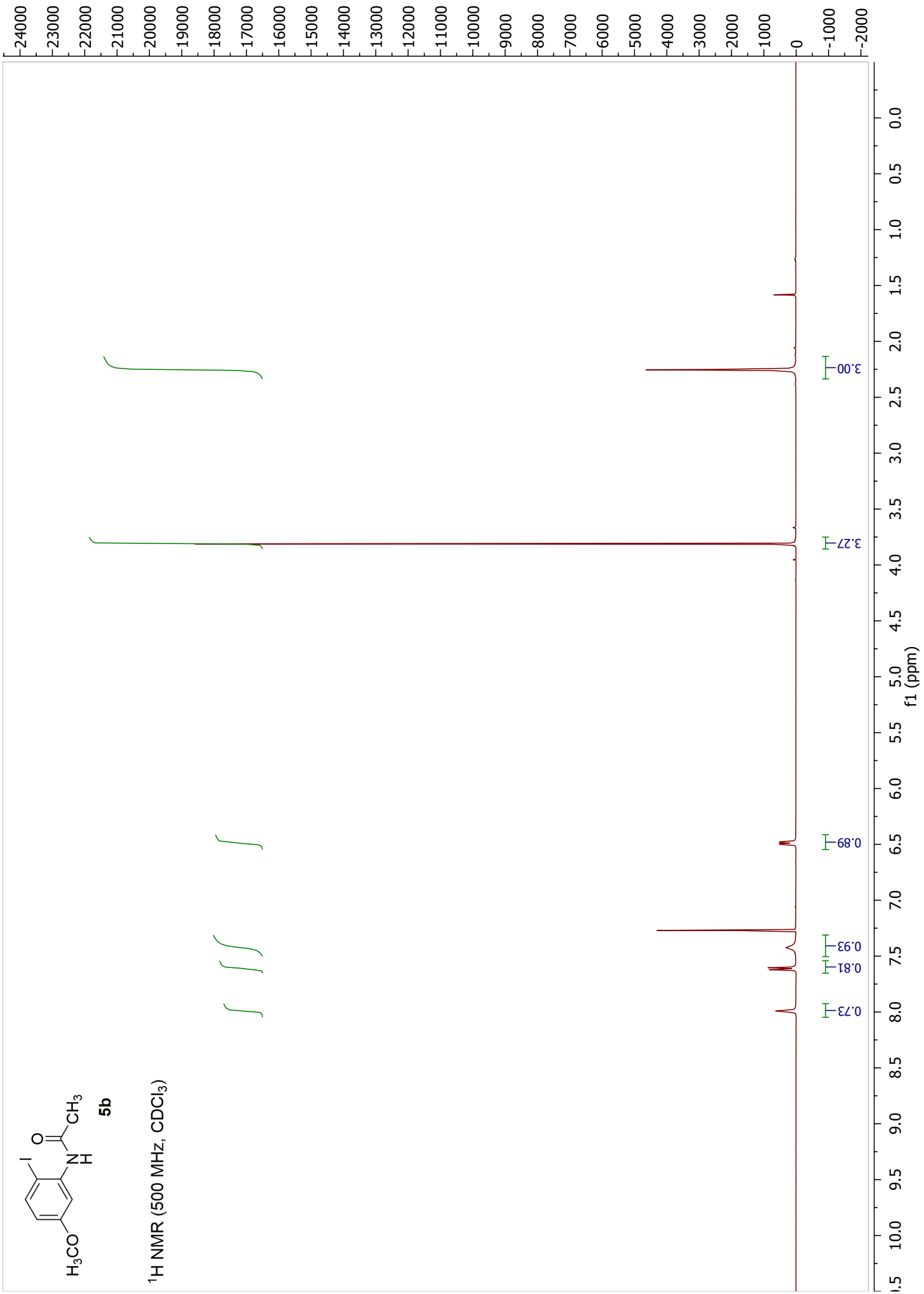

168.56
147.13
142.98
133.50
129.56
128.61
128.20
125.96
125.93
124.95
124.18
117.14
57.68
46.35
24.22
f1 (ppm)
^{13}C NMR (151 MHz, $CDCl_3$)
6r
CF_3
N
O
H_3C

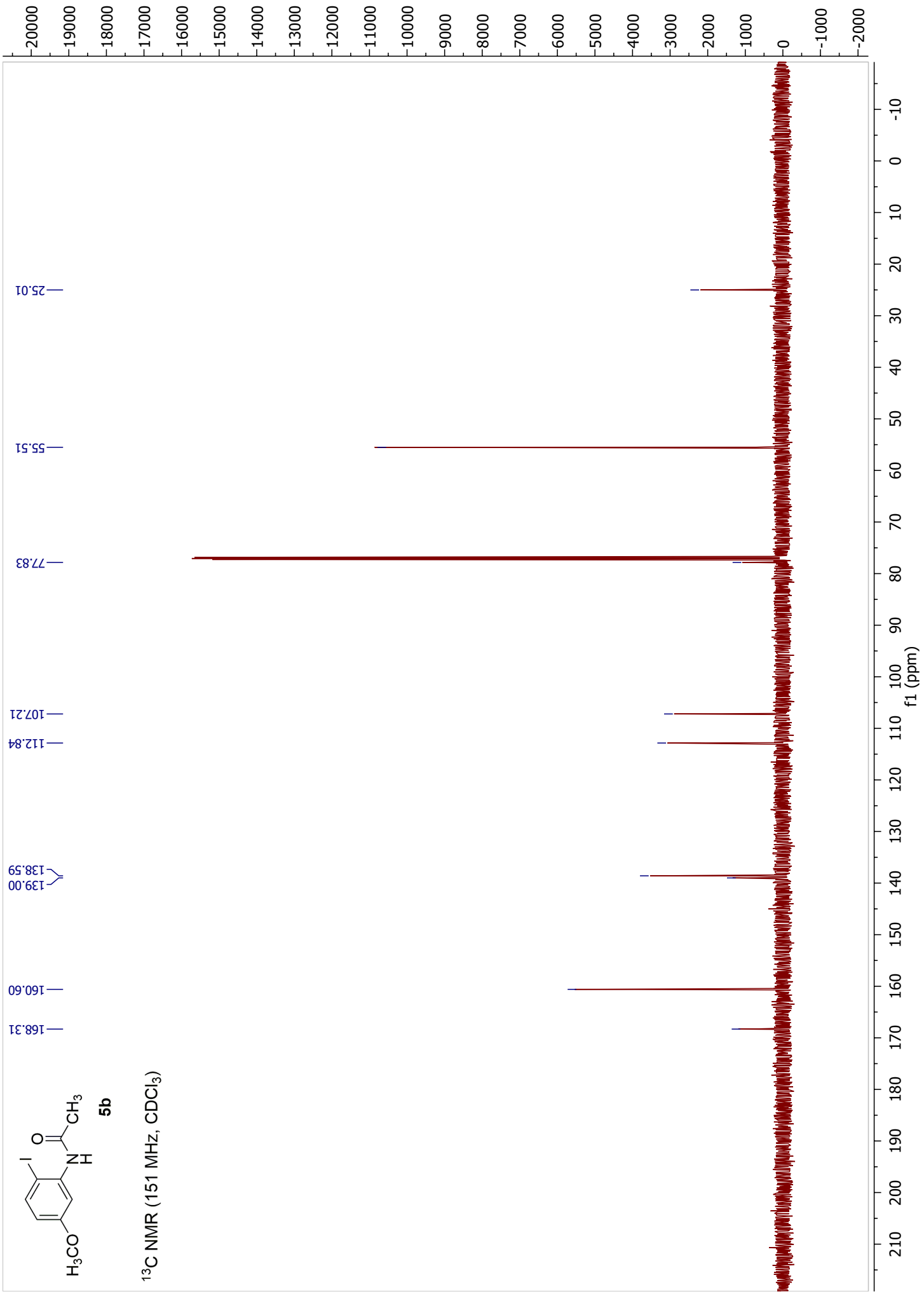


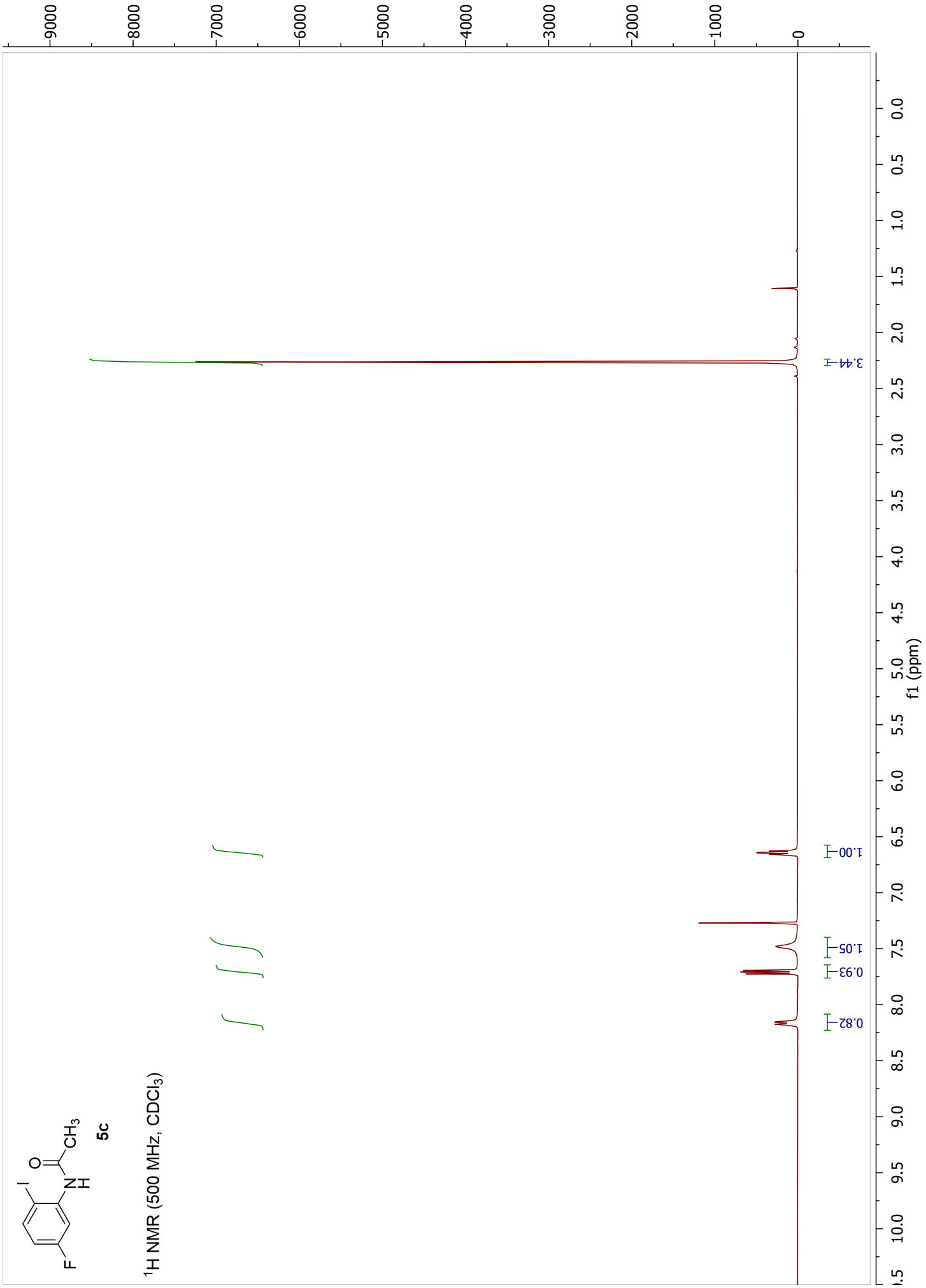
^{1}H NMR (500 MHz, $CDCl_3$)

5a


168.36
138.80
138.26
129.21
126.13
122.49
90.46
24.80
f1 (ppm)
^{13}C NMR (151 MHz, $CDCl_3$)
5a

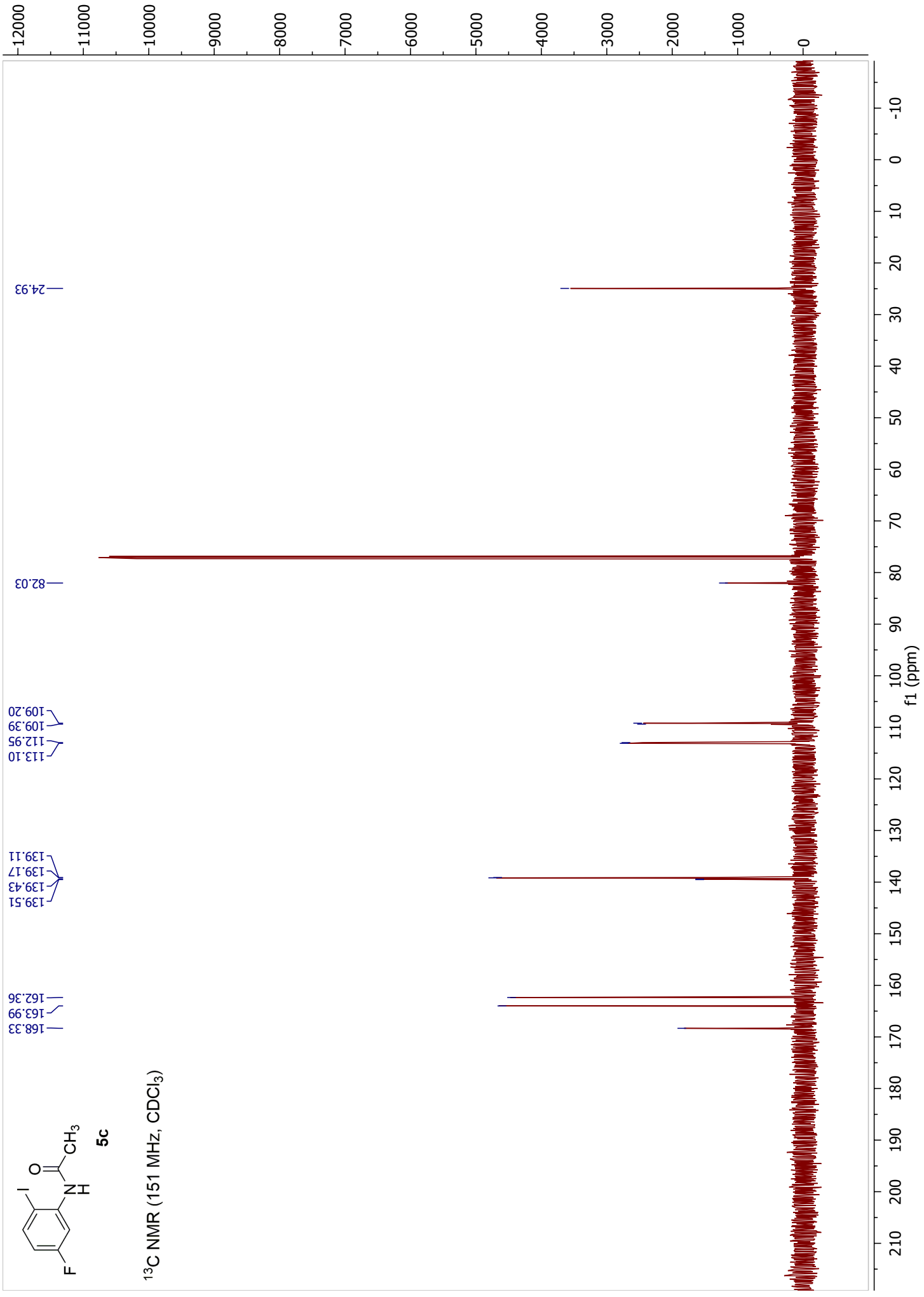

5b
^{1}H NMR (500 MHz, $CDCl_3$)
f1 (ppm)
3.00
3.27
0.89
0.93
0.81
0.73

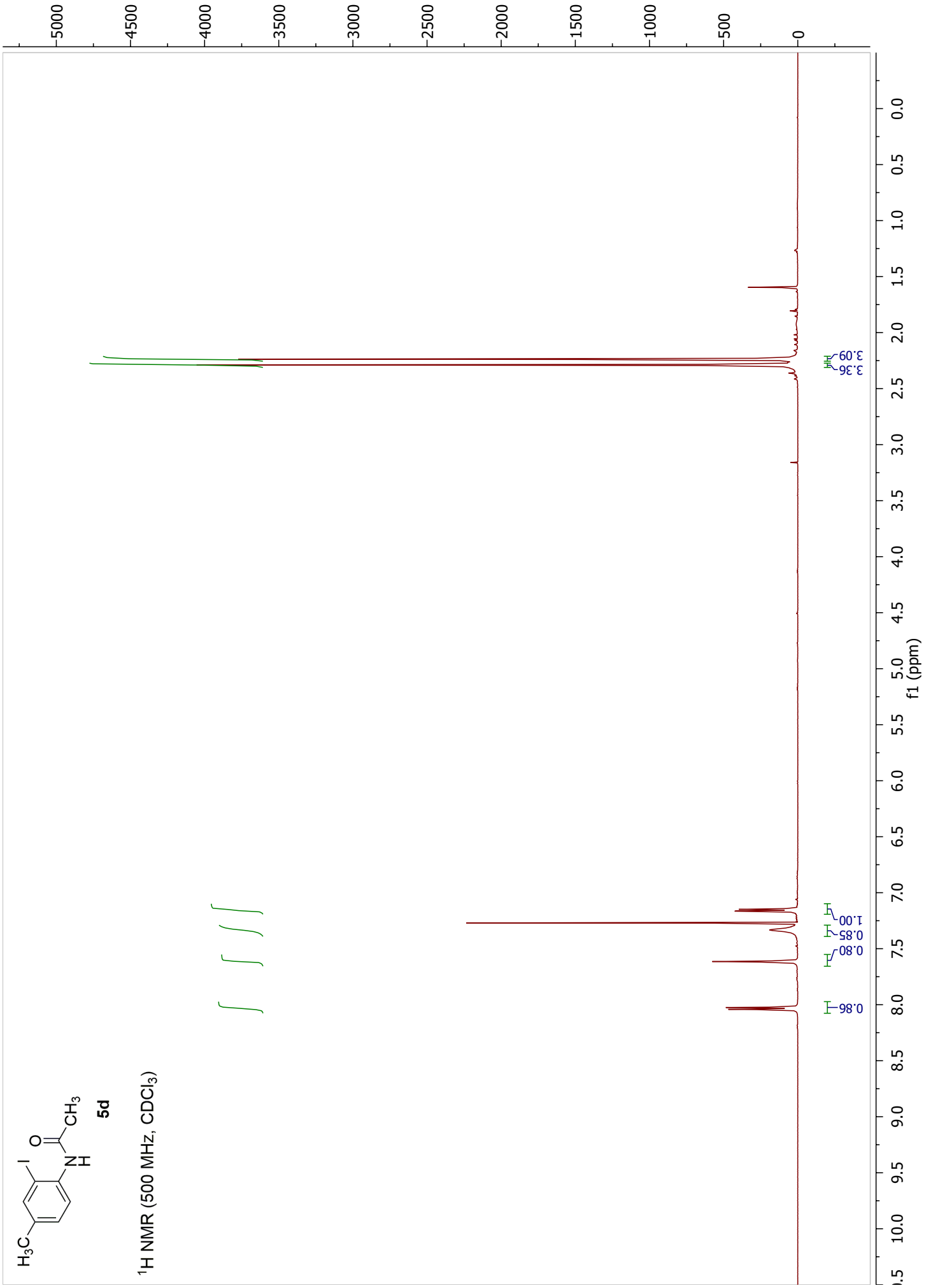

25.01
55.51
77.83
107.21
112.84
138.59
139.00
160.60
168.31
f1 (ppm)
^{13}C NMR (151 MHz, $CDCl_3$)
5b
H_3CO
I
O
N
H
CH_3

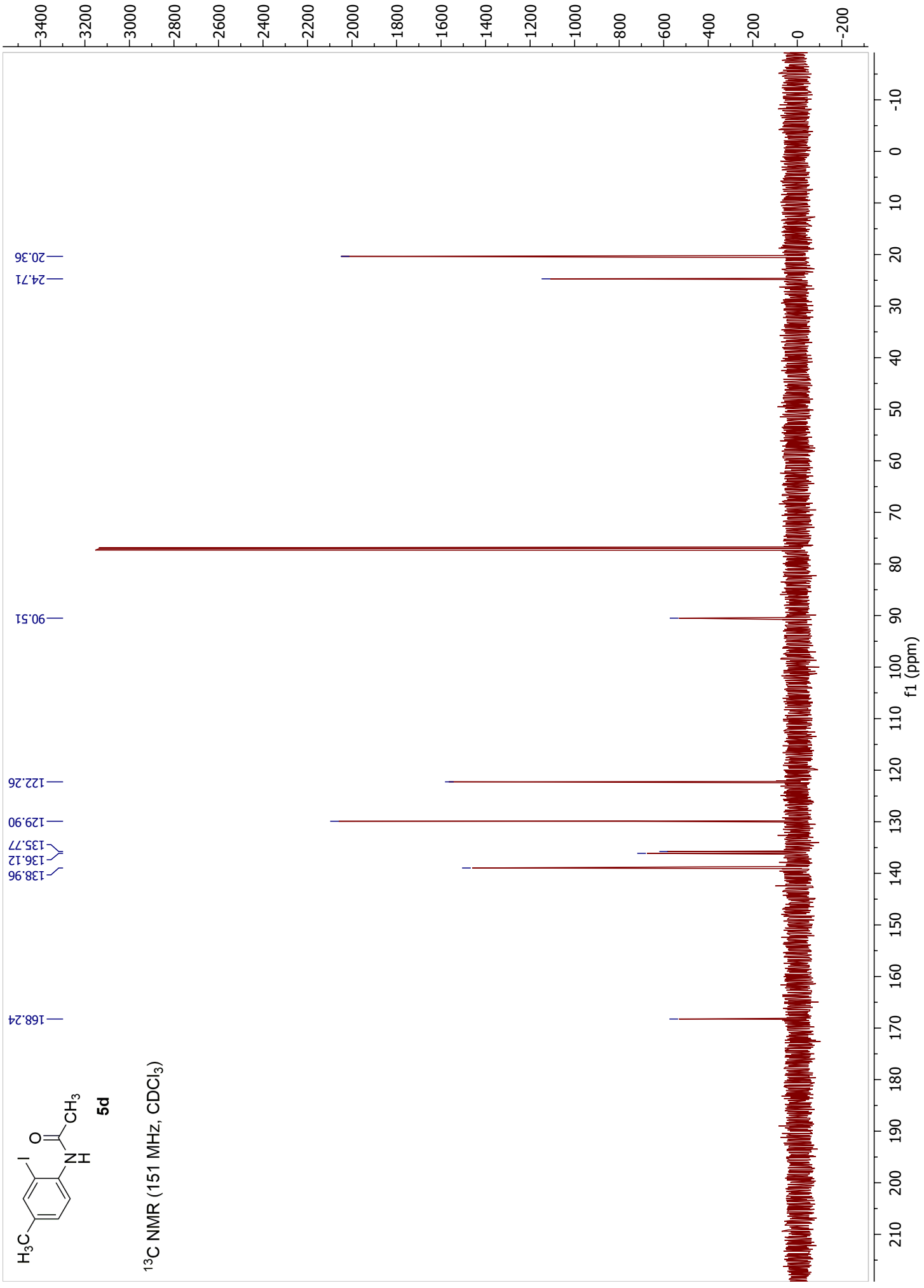


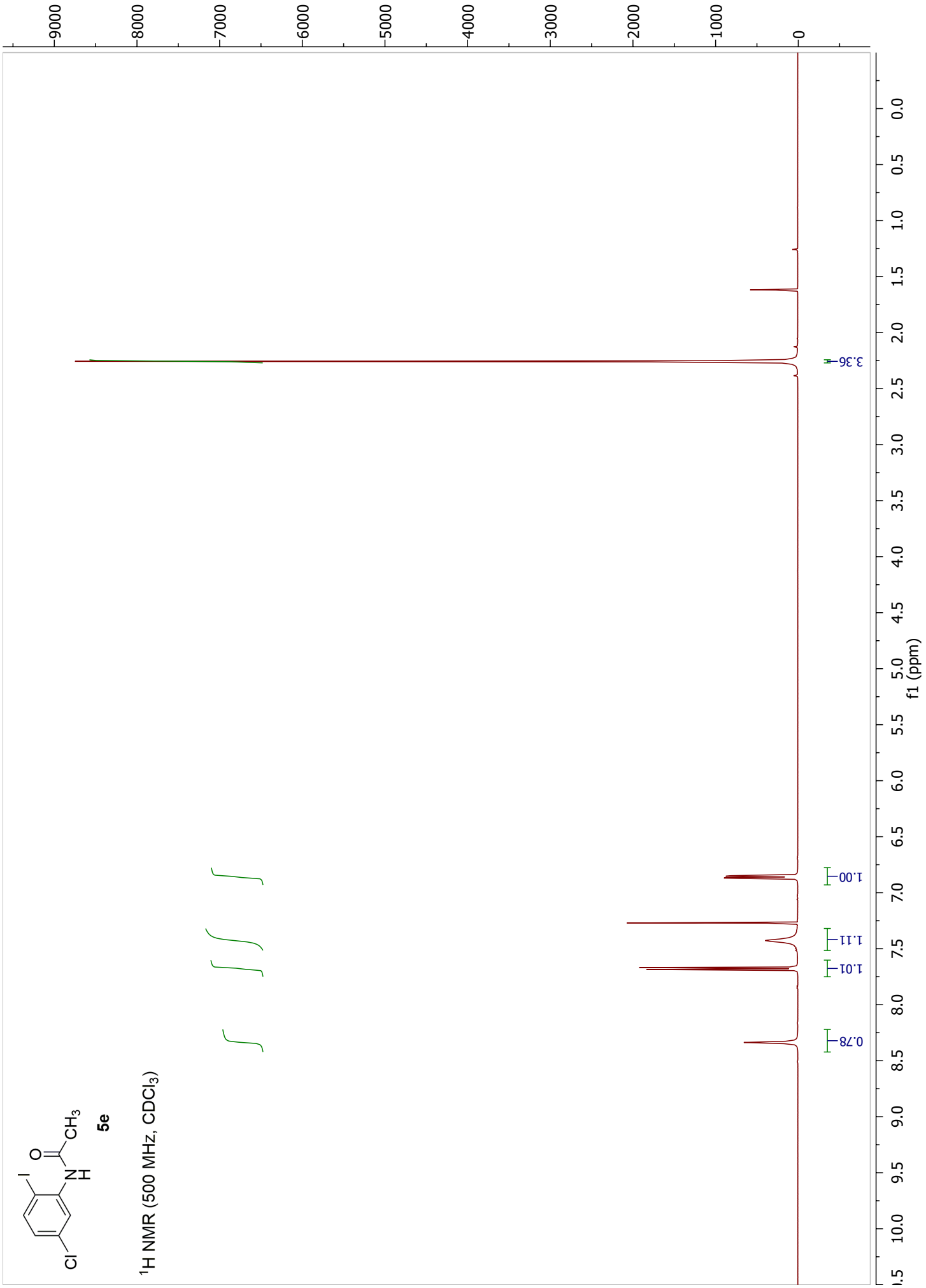
5c

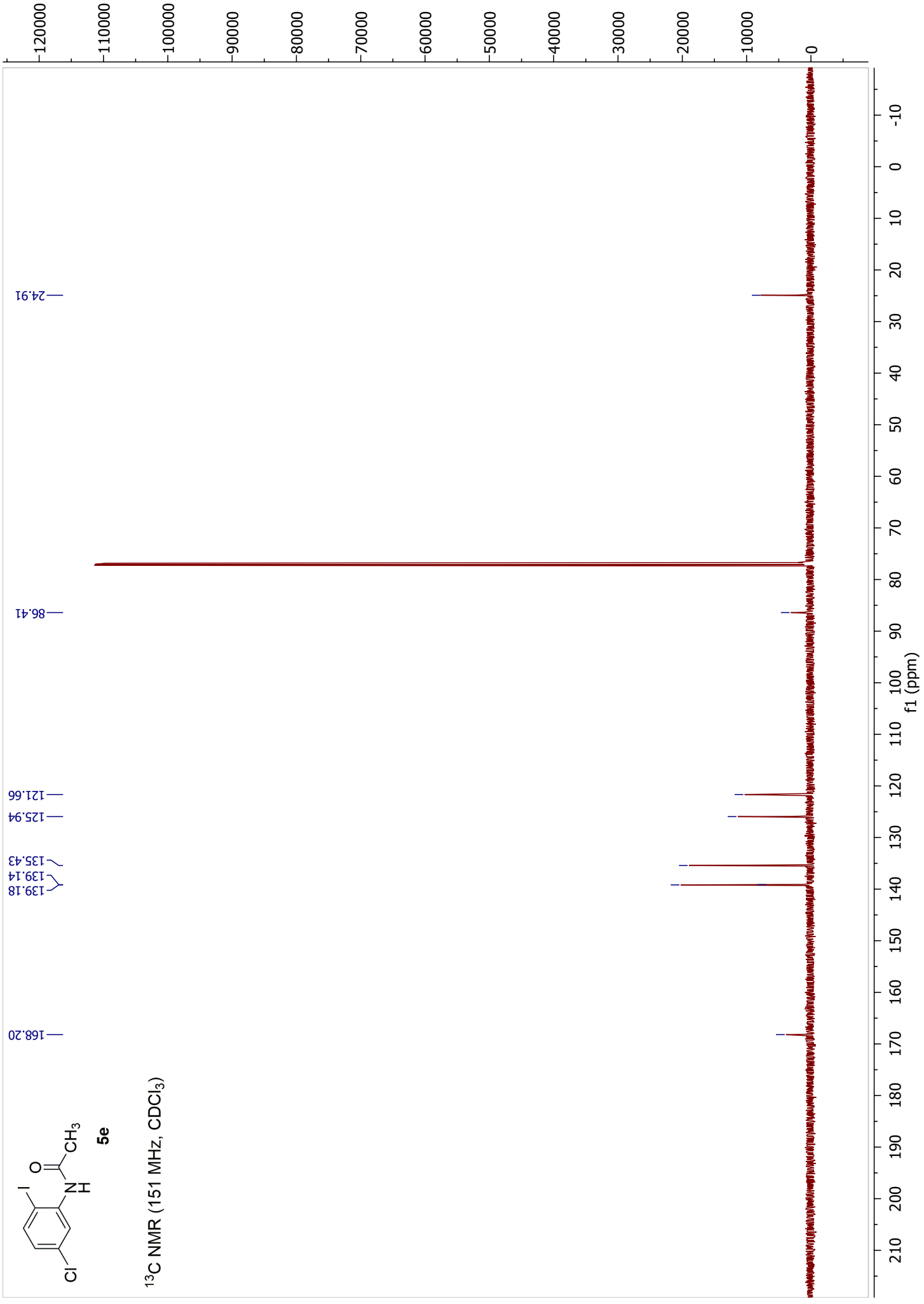
^{1}H NMR (500 MHz, $CDCl_3$)

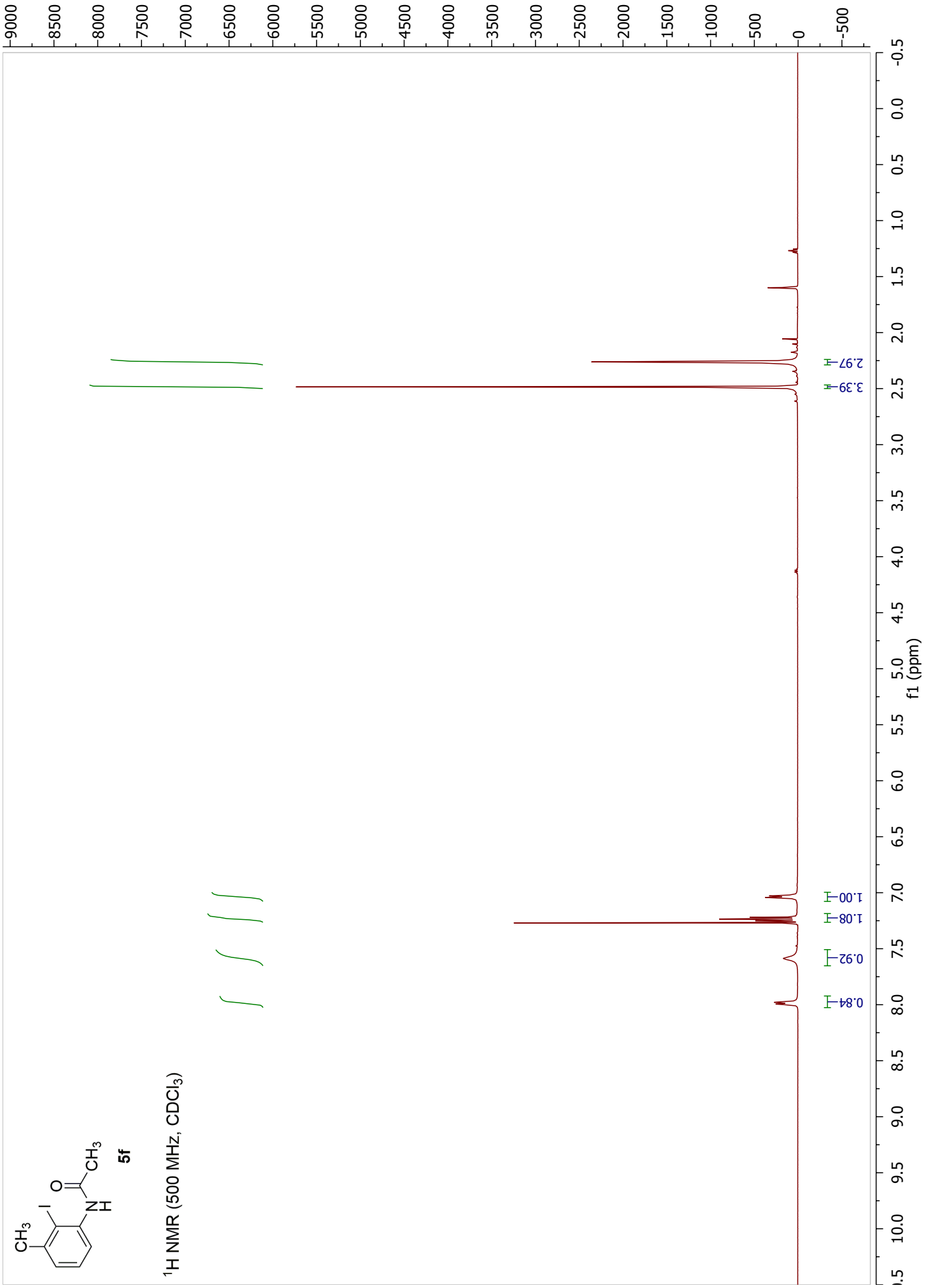

^{13}C NMR (151 MHz, CDCl$_3$)
5c
168.33
163.99
162.36
139.51
139.43
139.17
139.11
113.10
112.95
109.39
109.20
82.03
24.93
f1 (ppm)

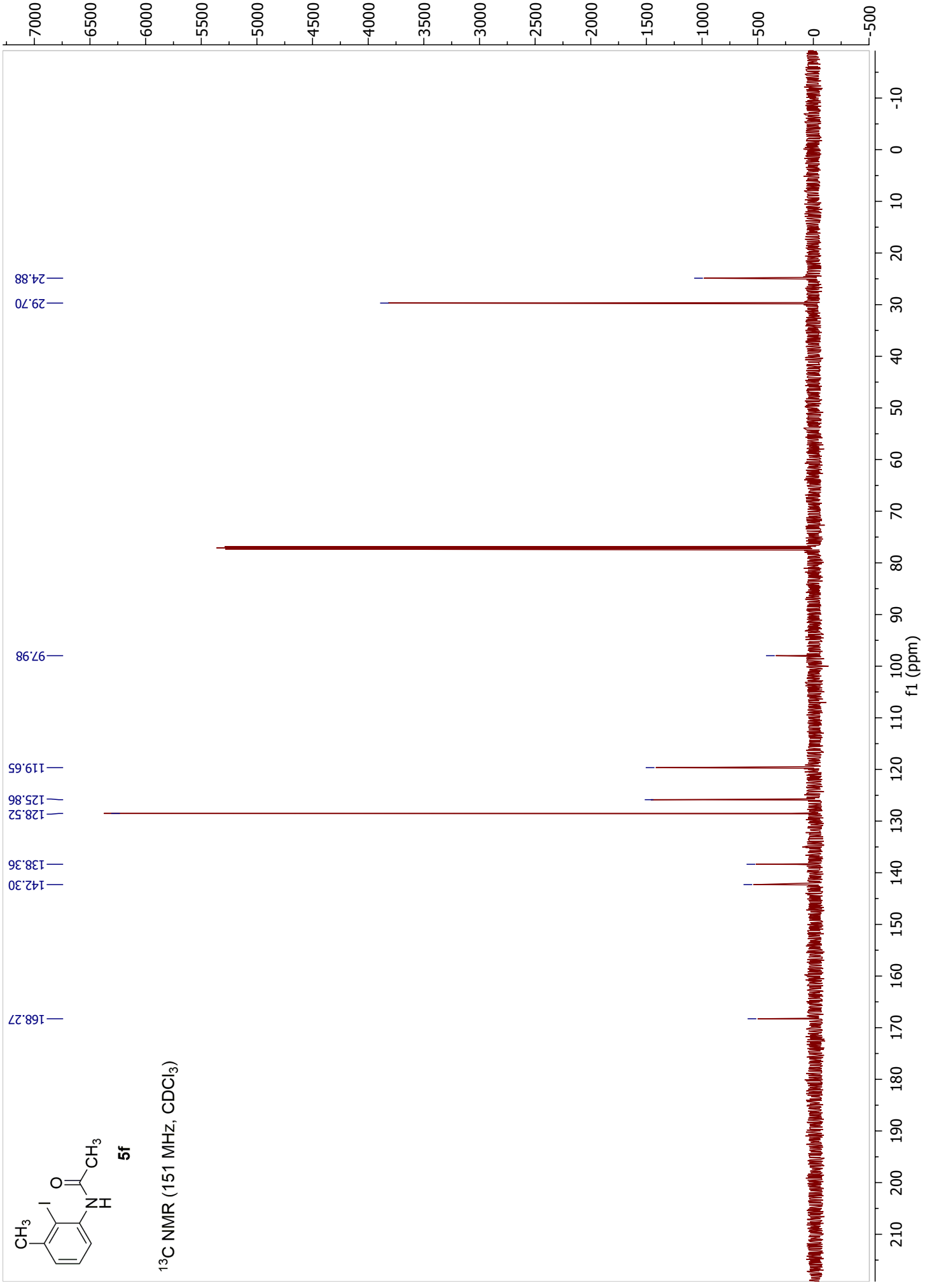

5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
3.36
3.09
1.00
0.85
0.80
0.86
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
f1 (ppm)
H_3C
I
O
CH_3
N
H
5d
^{1}H NMR (500 MHz, $CDCl_3$)

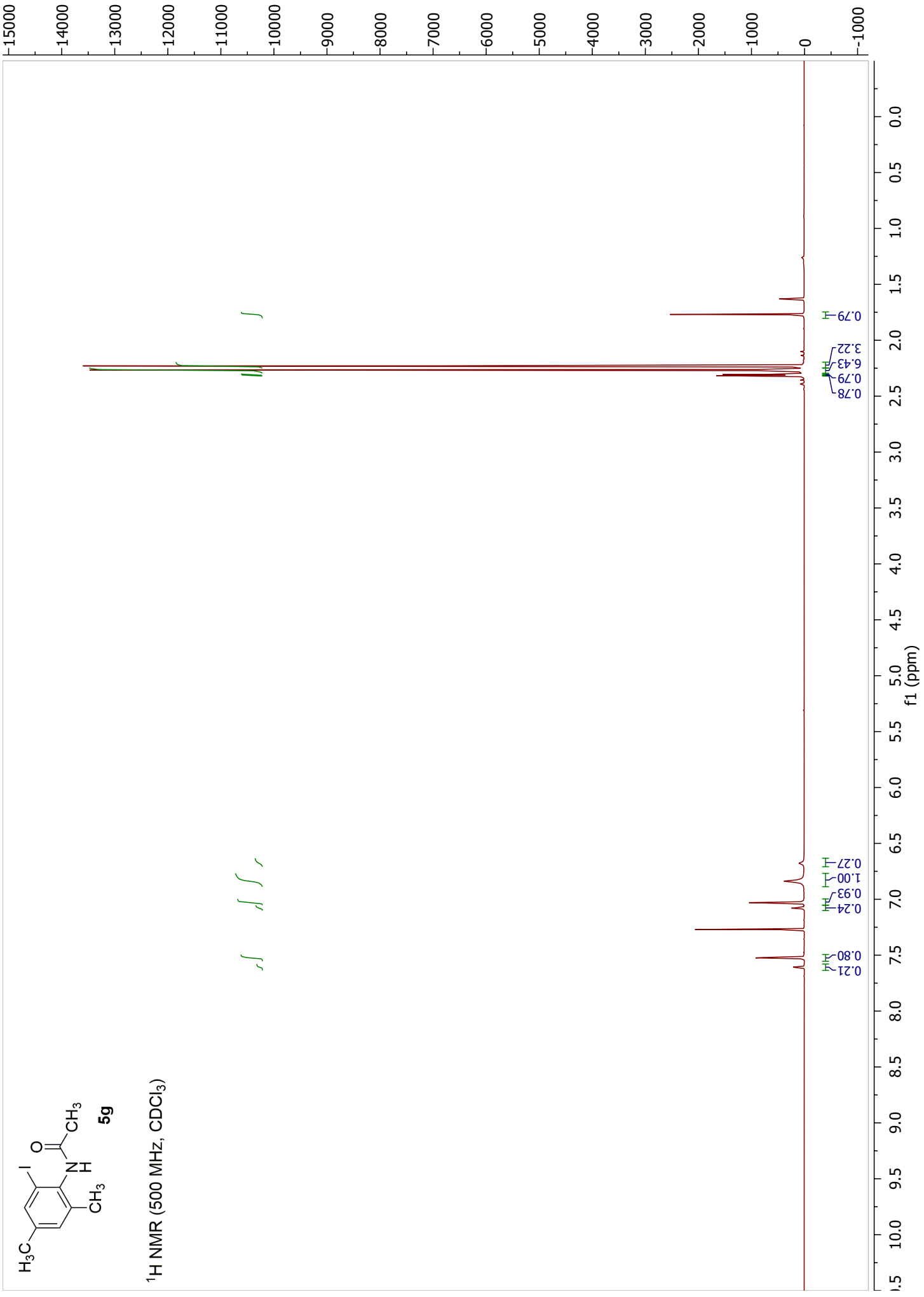

168.24
138.96
136.12
135.77
129.90
122.26
90.51
24.71
20.36
f1 (ppm)
^{13}C NMR (151 MHz, $CDCl_3$)
5d

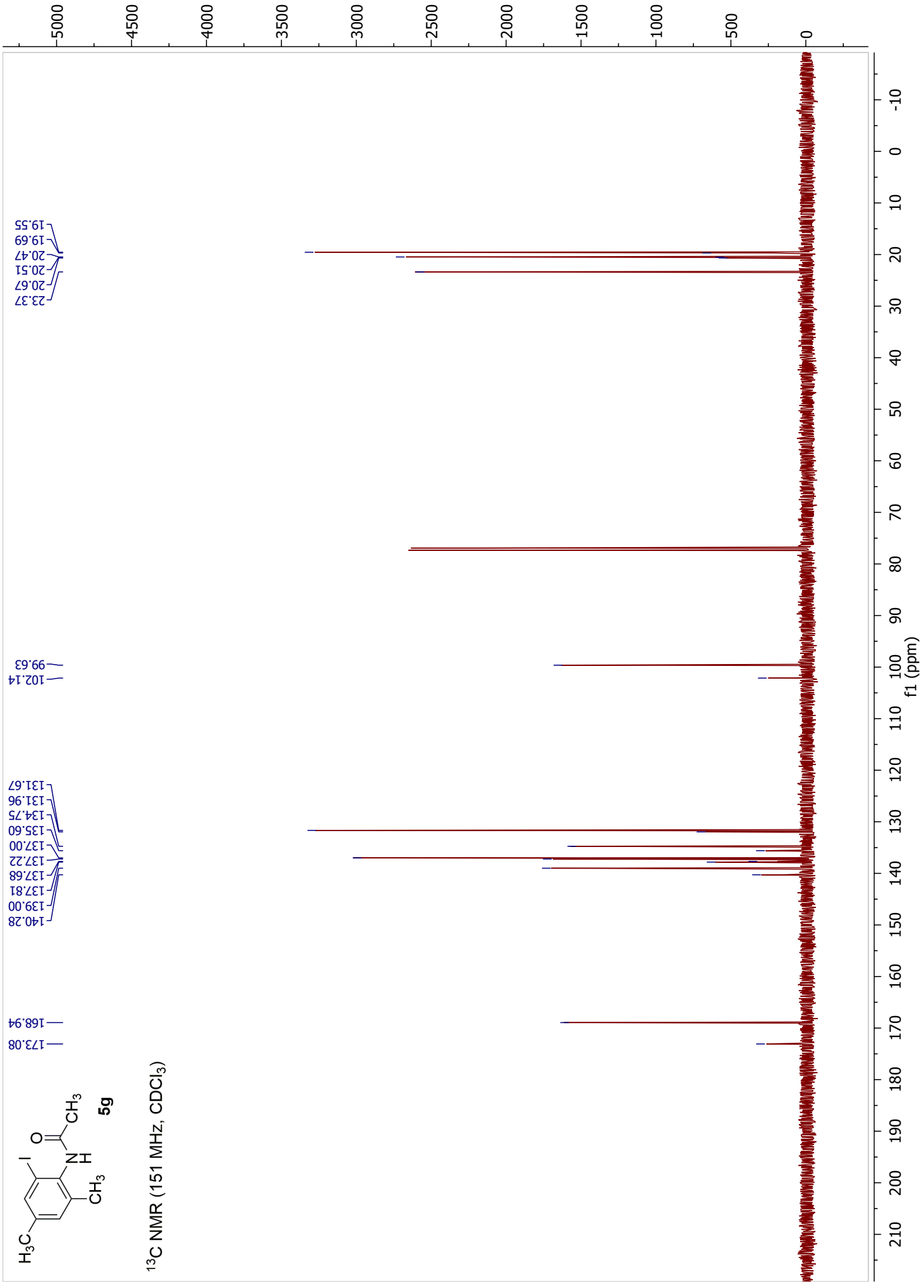

9000
8000
7000
6000
5000
4000
3000
2000
1000
0
3.36
1.00
1.11
1.01
0.78
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
f1 (ppm)
O
CH3
N
H
I
Cl
5e
1H NMR (500 MHz, CDCl3)

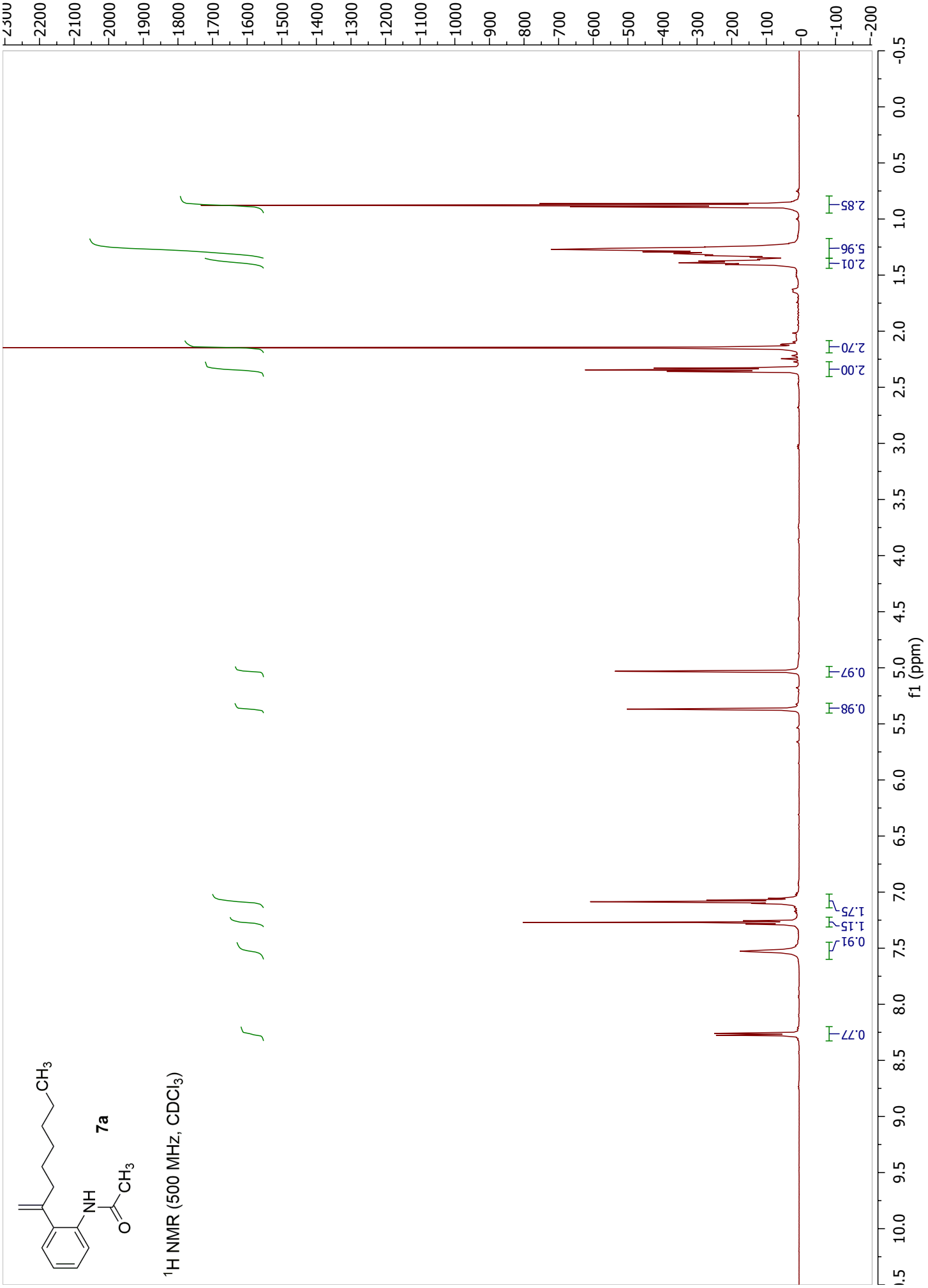

168.20
139.18
139.14
135.43
125.94
121.66
86.41
24.91
f1 (ppm)
^{13}C NMR (151 MHz, $CDCl_3$)
5e

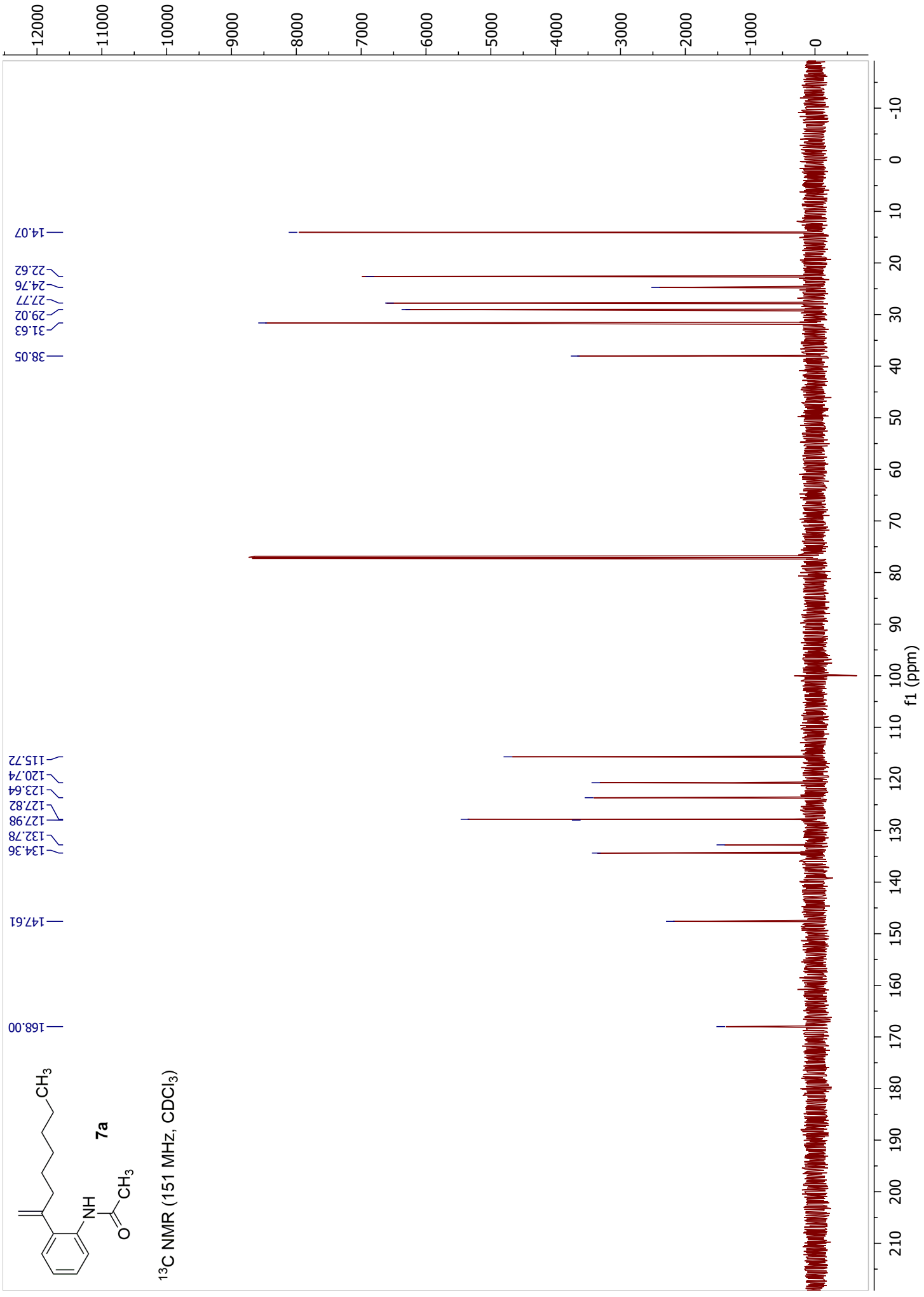

5f
^{1}H NMR (500 MHz, $CDCl_3$)
2.97
3.39
1.00
1.08
0.92
0.84
f1 (ppm)


24.88
29.70
97.98
119.65
125.86
128.52
138.36
142.30
168.27
f1 (ppm)
^{13}C NMR (151 MHz, $CDCl_3$)
5f


5g
^{1}H NMR (500 MHz, CDCl$_3$)
f1 (ppm)
0.79
3.22
6.43
0.79
0.78
0.27
1.00
0.93
0.24
0.80
0.21


5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
f1 (ppm)
19.55
19.69
20.47
20.51
20.67
23.37
99.63
102.14
131.67
131.96
134.75
135.60
137.00
137.22
137.68
137.81
139.00
140.28
168.94
173.08
^{13}C NMR (151 MHz, $CDCl_3$)
5g
H_3C
I
O
N
H
CH_3
CH_3


2.85
5.96
2.01
2.70
2.00
0.97
0.98
1.75
1.15
0.91
0.77
f1 (ppm)
7a
NH
O
CH3
CH3
1H NMR (500 MHz, CDCl3)


14.07
22.62
24.76
27.77
29.02
31.63
38.05
115.72
120.74
123.64
127.82
127.98
132.78
134.36
147.61
168.00
f1 (ppm)
^{13}C NMR (151 MHz, $CDCl_3$)
7a
NH
O
CH_3
CH_3