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Supplementary Materials for

Modular Terpene Synthesis Enabled by Mild Electrocatalytic Couplings

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Experimental Procedures

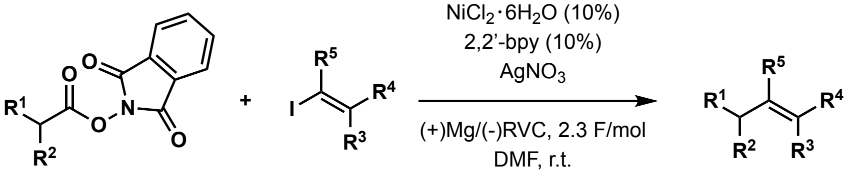
General Remarks

All reactions were carried out under an inert argon atmosphere with dry solvents under anhydrous conditions unless otherwise stated. All electrochemical experiments were conducted with commercially available ElectraSyn 2.0 and standard equipment unless otherwise stated. The RVC electrodes were purchased from commercial RVC block (purchased from ULTRAMET, 100 ppi, 14.40” x 13.86” x 8”). Large-scale electrochemical batch reactions were performed using a customized ElectraSyn 2.0 capable of delivering 200 mA at 30V. Cyclic voltammetry was carried out in a glass cell with Pine WaveNow potentiostat. A commercial glassy carbon disk electrode supplied by IKA (diameter is 3.0 mm, PCTFE shroud) was used as a working electrode. Platinum was used as a counter electrode. Ag/AgCl electrode was used as a reference electrode. Tetrabutylammonium hexafluorophosphate ($TBAPF_6$) (98%, Acros) was recrystallization three times from ethanol and dried at room temperature under reduced pressure for greater than 24 hours. Dimethyl formamide (DMF) (Spectroscopic Grade) was purchased from Fisher Chemical and dried over activated 4 Å molecular sieves (Mallinckrodt Chemicals) for at least two days before use. Microcloth PSA (polishing paper), diamond paste, and MetaDi Fluid were purchased from Buehler. SEM imaging was done using an FEI Quanta 600F scanning electron microscope with a field emission electron source. Higher resolution imaging was done using scanning transmission electron microscopy (S/TEM) on thin sections cut out of the electrodes. The samples were prepared using an FEI Helios Nanolab 650 focused ion beam and scanning electron microscope. A JEOL 2800 scanning transmission electron microscope with twin Gatan Si drift detectors was used. A beam energy of 200kV was used for both transmission and scanning imaging modes. Ozonolysis was performed using a 110V, Fischer Model 502 Ozone-Generator. Melting points were recorded on a Fisher-Johns 12-144 melting point apparatus and are uncorrected. Optical rotations were recorded using an Anton Paar MCP100 polarimeter. Anhydrous acetonitrile (MeCN), dichloromethane (DCM) stabilizer-free, diethyl ether (Et_2O) inhibitor-free, tetrahydrofuran (THF) inhibitor-free, toluene (PhMe), dimethylformamide (DMF), benzene, and triethylamine (TEA) were obtained by passing the previously argon sparged solvents through activated alumina columns. Reagents were purchased at the highest commercial quality and used without further purification, unless otherwise stated. Yields refer to chromatographically and spectroscopically (1H NMR or LCMS) homogeneous material, unless otherwise stated. Reactions were monitored by thin layer chromatography (TLC) carried out on 0.25 mm E. Merck silica plates (60F254), using UV light as the visualizing agent and/or p-anisaldehyde or $KMNO_4$ and heat as a developing agent. Flash silica gel chromatography was performed using E. Merck silica gel (60, particle size 0.043 – 0.063 mm). 15 wt% $AgNO_3$ impregnated silica gel was prepared from E. Merck silica gel (60, particle size 0.043 – 0.063 mm) using a procedure adapted from the literature (*51*). Preparation was as follows: To a suspension of 340g of silica gel in 800 mL of deionized water was added 60g $AgNO_3$ dissolved in 100 mL of DI water. This slurry was concentrated via rotary evaporation, shielded from light, in a water bath at 70 °C to dryness. The solid was suspended twice in toluene (2L) and evaporated to azeotrope any remaining water and then dried under vacuum overnight to provide 400g of 15 wt% $AgNO_3$ impregnated silica as an off-white, free-flowing solid. This solid was stored in an opaque container to shield it from light. NMR spectra were recorded on Bruker DRX600, DRX-500 and AMX-400 instruments and were calibrated using residual undeuterated solvents as an internal reference (chloroform-d: 1H NMR $\delta = 7.26$ ppm, 13C NMR $\delta = 77.16$ ppm, benezene-d: 1H NMR $\delta = 7.15$ ppm, 13C NMR $\delta = 128.6$ ppm). The following abbreviations are used to explain NMR peak multiplicities: s = singlet, d = doublet, t = triplet, q = quartet, m =

multiplet, br = broad. High-resolution mass spectra (HRMS) were recorded on an Agilent LC/MSD TOF mass spectrometer by electrospray ionization time-of-flight (ESI-TOF) reflection experiments.

Electrochemical Cross-Coupling (procedures)

Fig S1 —Scaling protocols for electrochemical alkenylation



Recommened Benchtop Set Up By Scale

scale	cathode dimensions	Ag loading (mmol/m$^2_{cathode}$)*	[M]	current density (A/m^2)	current
0.2 mmol	3mm X 7 mm X 51 mm	27	0.067 M	2.7	6 mA
0.6 mmol	3mm X 7 mm X 51 mm	38	0.200 M	3.8	18 mA
1.0 mmol	3mm X 7 mm X 51 mm	64	0.200 M	6.4	30 mA
5.0 mmol	9 mm dia. X 40 mm length	106	0.250 M	7.0 - 10.6	100 - 150 mA†
n x 5.0 mmol‡	9 mm dia. X 40 mm lenght	106	0.250 M	7.0 - 10.6	100 - 150 mA per vial§

* caluclated using volume of submerged cathode.

† 150 mA of current is needed on larger scale for vinyl iodides bearing carboxylic acids. If not, then a lower current of 100 mA may be used. See syntheses for several examples.

‡ *n* = 1 through 6

§ if the potential is high (> 5V per vial), LiCl (0.3 eq) may be used as a supporting electrolyte.

A tabulated summary of scaling protocols for preparative electrolysis of the electrochemical decarboxylative alkenylation.

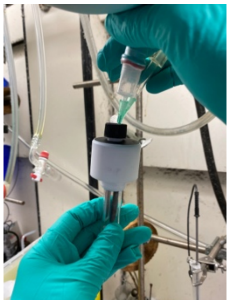
<u>General Procedure A: 0.2 mmol scale:</u>

To an oven dried 5 mL ElectraSyn 2.0 vial, redox active ester (RAE) (0.2 mmol, 1 equiv.), vinyl iodide (0.3 mmol, 1.5 equiv.), $AgNO_3$ (10.2 mg, 0.06 mmol, 27 mmol$_{Ag}$/m$^2_{(cathode)}$, 0.3 equiv.), $NiCl_2$•$6H_2O$ (4.75 mg, 0.02 mmol, 0.1 equiv.), and 2,2′-bypridine (3.12 mg, 0.02 mmol, 0.1 equiv.) were all directly added as solids/oils. The vial was sealed with a 5 mL ElectraSyn 2.0 vial cap fitted with a magnesium sacrificial anode and a 100 ppi RVC cathode (3 mm x 7 mm x 51 mm). The sealed vial was then evacuated and backfilled with argon three times. Anhydrous DMF was then added (3 mL) via syringe. The vial was then placed on an IKA ElectraSyn 2.0 stir plate and electrolysis was set to 6 mA, 0.2 mmol substrate, and 2.3 F/mol, providing 2.7 A/m^2 current density. The reaction underwent the programmed electrolysis. After completion of the reaction, the reaction was transferred to a separatory funnel, the electrodes were rinsed with diethyl ether (5 mL) and 1N HCl (10 mL) was *slowly* added. The aqueous layer was extracted with diethyl ether (3 X 10 mL). The combined organics were washed successively with distilled water (2 X 10 mL) then brine (1 X 10 mL), then dried over magnesium sulfate before being filtered and concentrated via rotary evaporation. The crude oily solid was purified silica gel chromatography.

Note: Quenching and dissolution of DMF in water is exothermic and extraction of the warm reaction solution with diethyl ether can lead to boiling of the solvent.

Fig S2 —Visual guide for pre-formed RAE procedure


1.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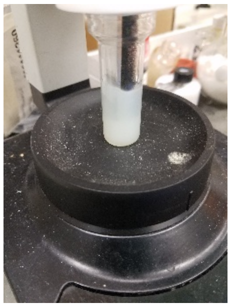
3.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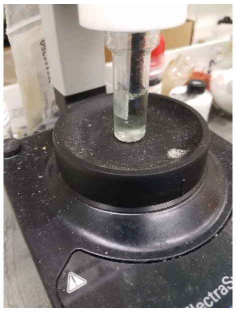
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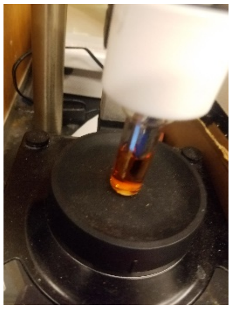

6.

1. ElectraSyn 2.0 vial with threads wrapped in Teflon tape containing $AgNO_3$, $NiCl_2$•$6H_2O$, 2,2'-bipyridine, RAE and vinyl iodide next to a vial cap fitted with commercial Mg anode supplied by IKA and 100ppi RVC cathode (3 mm x 7 mm x 51 mm).
2. Sealed vial is evacuated and backfilled three times with argon.
3. Vial is placed on ElectraSyn 2.0 with the following settings: constant current, 6 mA, 2.3 F/mol, 0.2 mmol, no reference electrode, no alternating polarity. Anhydrous DMF is added to the vial under argon.
4. Electrolysis and stirring is started, a white suspension form.
5. After ~0.3 F/mol the white suspension becomes a homogenous solution.
6. The reaction goes from pale green to red. After electrolysis is complete the reaction is worked up and purified as written.

General Procedure B: in-situ redox active ester synthesis and coupling: 0.2 mmol scale

An oven-dried culture tube equipped with stir bar was charged with carboxylic acid (0.2 mmol, 1 equiv.) and *N*-hydroxyphthalimide (NHPI) (40.8 mg, 0.25 mmol, 1.25 equiv.). The tube was sealed and purged with argon. The contents of the flask were diluted in anhydrous inhibitor-free THF (0.50 mL). To this solution, DIC (34 µL, 0.22 mmol, 1.1 equiv.) was added and the reaction was allowed to stir at room temperature until complete formation of redox active ester (1-3 hours, by TLC) and a white solid was observed.

To a separate culture tube containing a stir bar was added $NiCl_2•6H_2O$ (4.75 mg, 0.02 mmol, 0.1 equiv.), and 2,2'-bipyridine (3.12 mg, 0.02 mmol, 0.10 equiv.). This flask was evacuated and backfilled three times with argon before the addition of anhydrous DMF (2.5 mL). This solution was allowed to stir for 20 minutes and a homogeneous, dark green solution developed. This green solution was transferred via syringe into the flask containing the *in situ* activated ester (white suspension) and the vinyl iodide (0.3 mmol, 1.5 equiv.) was added.

This green suspension (~ 3.5 mL) was added to a 5 mL ElectraSyn 2.0 vial under argon containing a magnesium anode, 100 ppi RVC cathode (3 mm x 7 mm x 51 mm), $AgNO_3$ (10.2 mg, 0.06 mmol, 27 $mmol_{Ag}/m^2{}_{(cathode)}$, 0.30 equiv.) and stir bar. After addition electrolysis was immediately started. The electrochemical reaction was performed using an ElectraSyn 2.0 constant current conditions with the settings as follows: 6 mA, 0.2 mmol, 2.3 F/mol providing 2.7 A/m^2 current density. After completion of the reaction, the reaction was transferred to a separatory funnel, the electrodes were rinsed with diethyl ether (5 mL) and 1N HCl (10 mL) was *slowly* added. The aqueous layer was extracted with diethyl ether (3 X 10 mL). The combined organics were washed successively with distilled water (2 X 10 mL) then brine (1 X 10 mL), then dried over magnesium sulfate before being filtered and concentrated via rotary evaporation. The crude oily solid was purified silica gel chromatography.

Note: Quenching and dissolution of DMF in water is exothermic and extraction of the warm reaction solution with diethyl ether can lead to boiling of the solvent.

In-situ redox active ester synthesis and coupling: 5 mmol scale

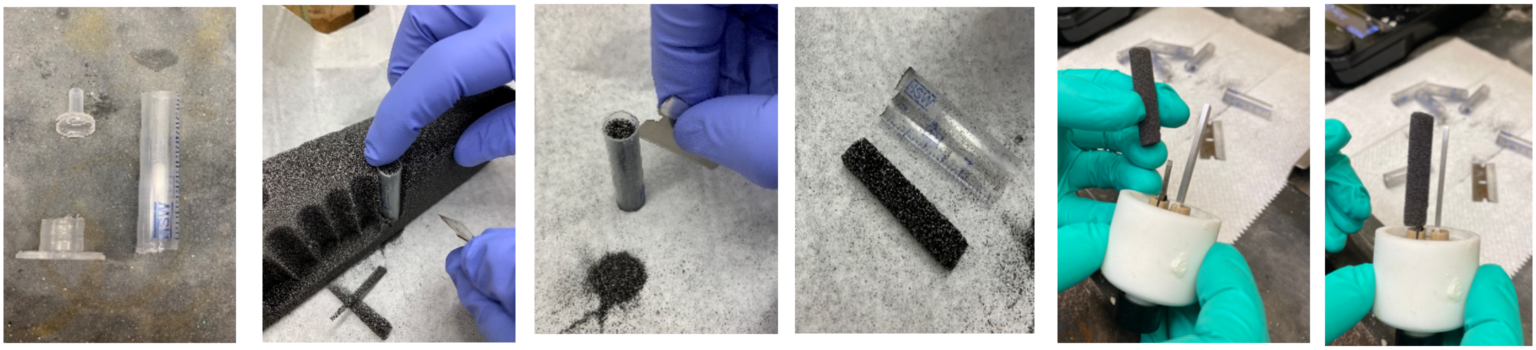
To a flame dried flask was added a stir bar, carboxylic acid (5 mmol, 1 equiv.) and NHPI (6.25 mmol, 1.25 equiv.). The flask was sealed with a septum, evacuated and backfilled three times with argon before the addition of anhydrous, inhibitor-free THF (3 mL). The flask was placed in a water bath at room temperature (19 °C) and DIC (5.5 mmol, 1.1 equiv.) was added. The activation was allowed to stir for two hours and a white suspension formed.

To a separate flask containing a stir bar was added $NiCl_2•6H_2O$ (0.5 mmol, 0.10 equiv.), and 2,2'-bipyridine (0.5 mmol, 0.10 equiv.). This flask was evacuated and backfilled three times with argon before the addition of anhydrous DMF (12 mL). This solution was allowed to stir for 20 minutes and a homogeneous, dark green solution developed. This green solution was transferred via syringe into the flask containing the *in situ* activated ester (white suspension) and the vinyl iodide (7.5 mmol, 1.5 equiv.) was added.

This green suspension (~18 mL) was added to a 20 mL ElectraSyn 2.0 vial under argon containing a magnesium anode, 100 ppi RVC cathode (9 mm diameter, 40 mm length), $AgNO_3$ (255 mg, 1.5 mmol, 106 mmol$_{Ag}$/m$^2_{(cathode)}$, 0.3 equiv.) and stir bar. After addition electrolysis was immediately started. The electrochemical reaction was performed using an ElectraSyn 2.0 constant current conditions with the settings as follows: 150 mA, 5 mmol, 2.5 F/mol providing 10.6 A/m^2 current density. After completion of the reaction, the vial was *slowly* quenched with 1N HCl (50 mL) and extracted with diethyl ether (3 X 50 mL). The combined organics were washed successively with distilled water (2 X 50 mL) then brine (1 X 50 mL), then dried over magnesium sulfate before being filtered and concentrated via rotary evaporation. The crude oily solid was purified silica gel chromatography.

Note: Quenching and dissolution of DMF in water is exothermic and extraction of the warm reaction solution with diethyl ether can lead to boiling of the solvent.

Fig S3 — Electrode Cutting Visual Guide



1. 1. 3. 4. 5. 6.

1. The ends of a 3mL syringe body are cut with a razor to provide a plastic cylinder ~9mm in internal diameter.
2. This cylinder is pressed into a block of 100 ppi RVC and the syringe body and RVC inside are removed from the block.
3. The plastic cylinder is cut open with a razor carefully to not damage the cylinder of RVC inside.
4. The plastic cylinder is peeled away to remove the cylinder of RVC that is 9mm in diameter and ~40 mm long.
5. This cylinder of RVC is placed onto an RVC fork supplied commercially by IKA that has been fit onto the cathode terminal of an IKA ElectraSyn 2.0 cap. (a paperclip can be cut and bent to serve as the connector between the RVC cylinder and terminal on the cap)
6. The RVC electrode is checked for a secure connection to the terminal and to ensure that it will not contact the other electrode once placed into the ElectraSyn 2.0 vial.

Notes: It is advisable to work inside a well-ventilated area like a fume hood and on top of a disposable surface (like a paper towel) when working with RVC. The microparticulate carbon *dust generated is carcinogenic if breathed into the lungs. After working with RVC discard any waste and dust being careful to avoid aerosolizing and breathing in the carbon dust.*

Considerations when using the ElectraSyn 2.0 carousel on scale and representative procedure

The ElectraSyn 2.0 is factory limited at 100 mA and 30 V. This creates some challenges when using the device to prepare larger quantities of material. As reaction scale increases, so too should current in this reaction. Thus, there is an upper bound on the scale that can be accomplished at 100 mA (6 mA/ 0.2 mmol material yields 3.33 mmol of material at 100mA). This can be ameliorated through the use of an ElectraSyn 2.0 carousel which allows for current delivery, in series, for up to 6 cells (3.33 mmol in 6 vials yields 20 mmol).

However, in series, the potentials of each vial are summed. Thus, each vial can only have a 5 V potential on average to stay below the total 30 V limit of the ElectraSyn 2.0. To accomplish this in our system LiCl (0.3 equiv.) was added as a supporting electrolyte to lower the resistance of each cell to lower the required potential to below the 30 V limit. This electrolyte was chosen based on evidence for the need of a halide source, low cost, and data demonstrating its innocuous effects on reaction performance.

Carousel procedure

To a flame dried flask was added a stir bar, carboxylic acid (30 mmol, 1 equiv.) and NHPI (6.12 g, 37.5 mmol, 1.25 equiv.). Next, the flask was sealed with a septum, evacuated and backfilled three times with argon before the addition of anhydrous, inhibitor-free THF (18 mL). The flask was placed in a water bath at room temperature (19 °C) and DIC (5.17 mL, 33 mmol, 1.1 equiv.) was added. The activation was allowed to stir for two hours and a white suspension formed.

To a separate flask containing a stir bar was added $NiCl_2 \cdot 6H_2O$ (711 mg, 3 mmol, 0.10 equiv.), 2,2'-bipyridine (468 mg, 3 mmol, 0.10 equiv.) and lithium chloride (381 mg, 9 mmol, 0.3 equiv.). This flask was evacuated and backfilled 3 times with argon before the addition of anhydrous DMF (72 mL). This solution was allowed to stir for 20 minutes and a homogeneous, dark green solution developed. This green solution was transferred via cannula into the flask containing the *in situ* activated ester (white suspension) and the vinyl iodide (45 mmol, 1.5 equiv.) was added. This green suspension was split into 6 equal portions (18 mL each) via syringe and added to 6, 20 mL ElectraSyn 2.0 vials under argon each containing a magnesium anode, 100 ppi RVC cathode (9mm diameter, 40 mm length), $AgNO_3$ (255 mg, 1.5 mmol, 106 $mmol_{Ag}/m^2_{(cathode)}$, 0.3 equiv.) and stir bar. After complete addition electrolysis was immediately started. The electrochemical reaction was performed using an ElectraSyn 2.0 and carousel under constant current conditions with the settings as follows: 150 mA, 5 mmols, 2.5 F/mol providing 10.6 A/m^2 current density. After completion of the reaction, the vials were combined into a single flask along and *slowly* quenched with 1N HCl (150 mL) and extracted with diethyl ether (3 X 100 mL). The combined organics were washed successively with distilled water (2 X 100 mL) then brine (1 X 100 mL), then dried over magnesium sulfate before being filtered and concentrated via rotary evaporation. The oily solid was purified via silica gel chromatography.

Notes: Quenching and dissolution of DMF in water is exothermic and extraction of the warm reaction solution with diethyl ether can lead to boiling of the solvent.

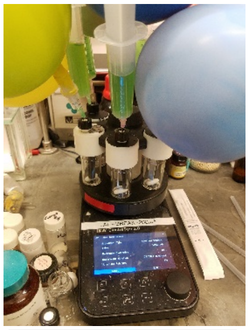
Fig S4 —Visual guide for carousel procedure


2.


2.


3.


4.


5.


6.

1. Commercial 20mL ElectraSyn 2.0 vials and caps. Vial threads are wrapped with Teflon tape and vials contain silver nitrate salt and stir bar. Caps are fitted with Mg anode supplied commercially from IKA and 100 ppi RVC cathode (9 mm diameter, 40 mm length). These electrodes were cut using a 3 mL syringe body (see electrode cutting guide above). These vials were sealed, evacuated and backfilled with argon 3 times, then placed on the ElectraSyn 2.0.
2. To a solution of NHPI, carboxylic acid and anhydrous, inhibitor- free THF under argon is added DIC.
3. After ~2h activation is complete and a white precipitate is observed.
4. To a flask under argon charged with $NiCl_2{\bullet}6H_2O$, 2,2'-bipyridine, and LiCl is added anhydrous DMF and stirred until homogeneous.
5. The contents of the flask in image 4 is transferred into the flask in image 3 via cannula and vinyl iodide is added. The reaction volume is split into 6 equal portions via syringe (~18 mL) and added to the sealed vials under argon. The ElectraSyn 2.0 was programmed with the following settings: constant current, 150 mA, 5 mmols, 2.5 F/mol, no reference electrode, no alternating polarity.
6. The reaction was started and the resulting light-green cloudy suspension eventually became homogeneous and turned red. (balloons removed for photo) After completion of electrolysis, the reaction was worked up and purified as written.

FAQ

Q: What is the observed potential usually for this reaction?
A: On the ElectraSyn 2.0, the terminal potential usually falls between 0.5V and 3V on smaller scales. Typically, the potential may be higher at the outset of the Ag-NP plating process but will quickly fall as silver is getting reduced and plated on the electrodes. For reactions at higher currents (100-150 mV) on larger scale, with LiCl potentials remained below 6V. The measured potential of the working electrode (RVC) is – 1.15V vs Ag/AgCl.

Q: Error message: "Vial not connected; Resistance too high"
A: This usually means that the device is having a very difficult time passing current through your reaction mixture. Often, this is the result of electrode connectivity issues. Check to ensure both electrodes have a clean connection to the cap terminals and that the vial is properly attached to the ElectraSyn 2.0. Additionally, it was found that simply resetting the device by turning the ElectraSyn 2.0 off and on again can help.

Q: How long can the lithium chloride and silver nitrate sit in solution before electrolysis?
A: It is best to start the electrolysis immediately after LiCl and AgNO3 are diluted in anhydrous degassed DMF as AgCl is rapidly formed. If it sits for a minute or two, the reactions are generally fine. Control studies have shown that allowing the two reagents to sit for five minutes is permissible, but it is generally best to immediately begin electrolysis once DMF is added to the two solids.

Q: How do I monitor the reaction?
A: TLC is appropriate and the products tend to be active in *p*-anisaldehyde stain.

Q: How do you clean the RVC electrode?
A: The RVC electrode can be washed with acetone, water, HCl or HNO_3, water, then acetone. Since the material is highly porous, the electrodes are best dried in an oven or under vacuum for an extended period of time (usually overnight).

Q: How do you clean the Magnesium electrode?
A: The magnesium anode can be cleaned by successively dipping in 1M HCl, washing with water and acetone, followed by polishing with sand paper.

Q: What are the byproducts of this reaction?
A: Occasionally RAE can be recovered after 2.3 F/mol. Prolong electrolysis to convert this into product. Carboxylic acid can be recovered and recycled. Proto-decarboxylated product is also observed. Excess Vinyl iodide can be recovered, some vinyl chloride formation is observed (~5-10%), proto-dehalogenation (~10-20%) is observed (more nickel leads to more proto-dehalogenation).

Q: Is the reaction air sensitive?
A: Yes. Solvents should be sparged with argon and the flasks/vials used should be evacuated and backfilled with argon. However, if an electrode has a poor connection to the cap or the reaction

needs to be unsealed for other some reason, the reaction will still work. In these cases, a small but appreciable (~5-10%) of product might be lost.

Q: Is the reaction water sensitive?
A: A hexahydrate nickel salt is used as the catalyst so the reaction can tolerate some amount of water, however, excess water will lead to lower yields. Glassware does not need to be flame dried, although, this practice is recommended.

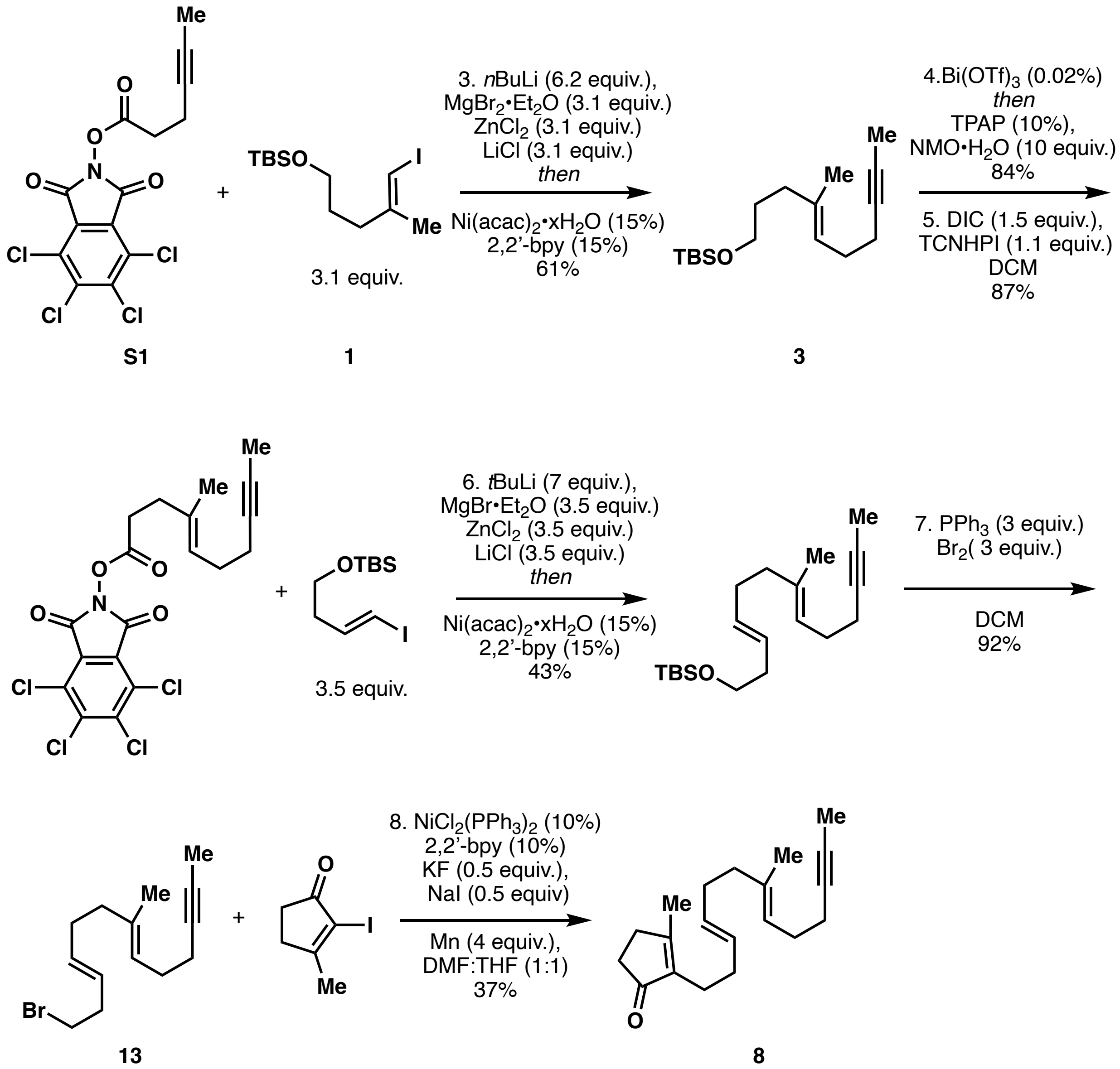
Q: Is stirring crucial for the reaction?
A: RPM's were between 800 and 1200 RPM in 5mL vials. In 20 mL vials, larger stir bars were used and RPM's were 400-700. No substantial change in yield was observed to correlate to stir rate, although stirring is needed since this is a heterogeneous reaction.

Q: What considerations are there for scaling this chemistry?
A: Scale current and electrode surface area linearly with reaction scale for best results. The reaction is not terribly sensitive to current density so electrode surface area does not need to be exactly the same, but if you deviate too far from the optimized current density yield will go down. Reaction concentration can be increased most of the time, one substrate did not tolerate increased reaction concentration (preparation of **12**). This seems to be a particular issue to this one substrate. We have provided a guide above for various scales this reaction has been performed on using the ElectraSyn 2.0, and there is information on how this reaction can be accomplished in recirculating flow in the nerolidols section. For largest scale applications recirculating flow is the recommended procedure.

Q: For reactions without added Ag, why does the reaction require potentials well below -2 V for such a long initial period? Is it possible that the Ag assists in the formation of an easily-reduced (bpy)Ni cation by halide abstraction or that it aids in the complexation process altogether?
A: The high potential reading at the outset of the reaction without silver could be the result of incomplete Ni(bpy) complex formation. Another explanation is that the potential starts high and drops to a more positive value due to the dissolution of Mg cation from the sacrificial anode acting as an electrolyte. In the reaction with silver, there is an additional nitrate anion that helps serve as an electrolyte and the reduction of Ag(I) to Ag(0) is very feasible resulting in a lower observed potential at the cathode.

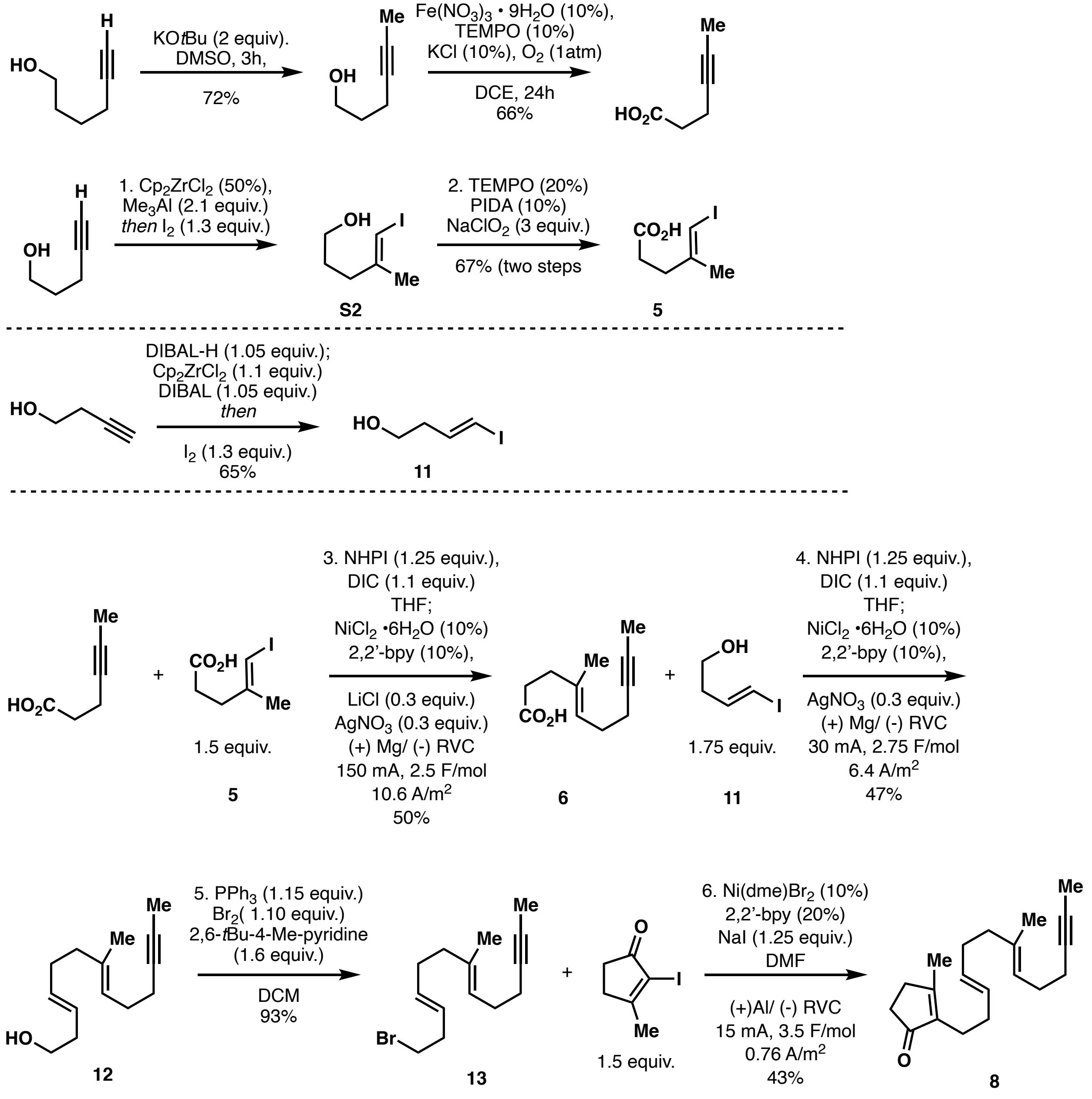
Progesterone (Procedures)

Fig S5 —1st generation formal synthesis of progesterone

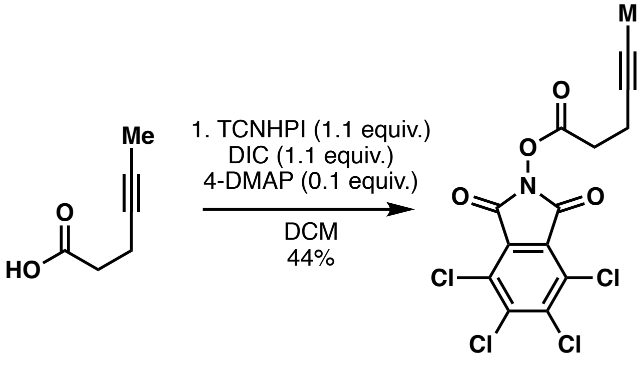


Although achievable, this route left a lot to be desired regarding its efficiency and ideality. Multiple equivalents of vinyl iodide and alkyl lithiums were needed for each coupling, protecting groups needed to be installed and removed, and redox-reactions were needed in the synthesis choreography.

Fig S6 — Complete formal synthesis of progesterone



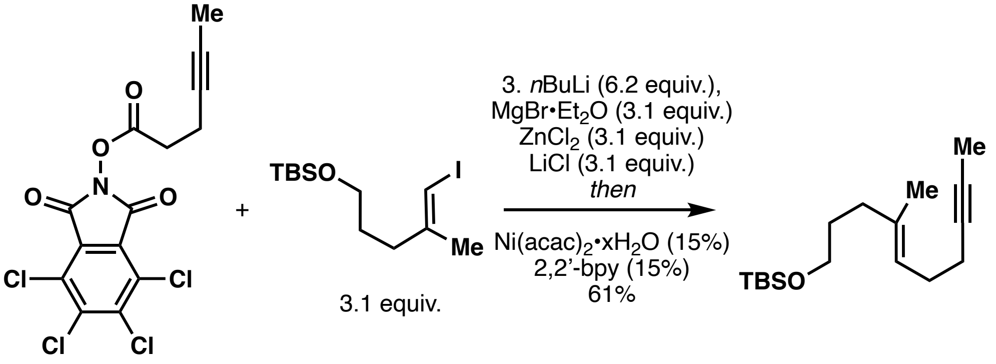
Progesterone Compound Experimental



S1

To a flame dried flask and stir bar was added 4-hexynoic acid (500 mg, 4.46 mmol, 1 equiv.), *N*-hydroxytetrachlorophthalimide (1.47 g, 4.91 mmol, 1.1 equiv.), 4-DMAP (49 mg, 0.44 mmol, 0.1 equiv.) and anhydrous DCM (30 mL). Next, DIC (0.77 mL, 4.91 mmol, 1.1 equiv.) was added to the stirring solution. A mild exotherm was observed and the solution briefly became homogeneous before a precipitate was observed. The reaction was monitored by TLC and upon completion the reaction was concentrated via rotary evaporation, suspended in ethyl acetate, filtered through silica, concentrated and recrystallized from DCM/MeOH to provide TCNHPI-RAE **S1** as a tan solid (768 mg, 1.94 mmol, 44%).

Physical State: Pale yellow solid.
^{1} H NMR (400 MHz, CDCl3): δ 2.93 – 2.82 (m, 2H), 2.66 – 2.55 (m, 2H), 1.80 (t, *J* = 2.5 Hz, 3H).
^{13}C NMR (150 MHz, CDCl3): δ 168.0, 157.5, 141.2, 130.6, 124.8, 77.9, 75.7, 31.1, 14.7, 3.6
Melting point: 178 – 180°C
HRMS (ESI-TOF) calculated for $C_{14}H_7Cl_4NO_4$ $[M+H]^+$: 393.9207, found: *not found. Decomposition under MS conditions.*
TLC: $R_f = 0.53$ (4:1 hexanes / ethyl acetate)



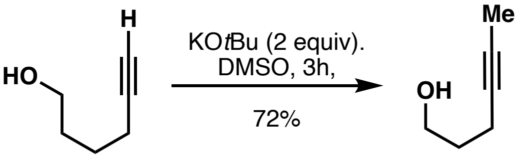
S1 **1** **3**

Procedure was slightly modified literature precedents. (*52*)

To a flame dried flask and stir bar under argon was added anhydrous, inhibitor-free THF (300 mL) and vinyl iodide **1** (52 g, 152.8 mmol, 3.1 equiv.). This mixture was cooled to -78 °C and *n*BuLi (2.5M in Hexanes, 122.24 mL, 305.6 mmol, 6.2 equiv.) was added dropwise. The reaction was stirred for 1h at this temperature, then allowed to warm to 0 °C and stirred an additional 30 minutes. Next, the solution was transferred via cannula to a separate flask and stir bar under argon containing $MgBr_2•Et_2O$ (39.45 g, 152.8 mmol, 3.1 equiv.) in an ice bath. The solution was stirred until homogeneous and then transferred via cannula to at third flask under argon containing freshly dried (via torch under vacuum) $ZnCl_2$ (20.83 g, 152.8 mmol, 3.1 equiv.) and LiCl (6.477 g, 152.8 mmol, 3.1 equiv.). Again, this solution was allowed to stir until homogeneous, then the organozinc was titrated with iodine and found to be 0.15M.

To a separate flame dried flask and stir bar was added $Ni(acac)_2•xH_2O$ (2.161 g, 7.4 mmol, 0.15 equiv.) and 2,2'-bypridine (1.148 g, 7.4 mmol, 0.15 equiv.). This flask was evacuated and backfilled three times with argon then anhydrous DMF (300 mL) was added and the solution was stirred until homogeneous (~20 minutes). The redox-active ester **S1** (19.36 g, 49 mmol, 1 equiv.) was added as a solid in a single portion and the solution was cooled to 0 °C. The organozinc solution was transferred via cannula to the mixture of RAE and catalyst and a dark-red solution developed. After the addition, the flask was warmed to ambient temperature and stirred 12 hours. The reaction was carefully quenched with 1N HCl (300 mL) and the organics were extracted with hexanes (3 X 200 mL). The combined organics were washed with water (2 X 100 mL), then brine (100 mL) and dried over $MgSO_4$ before being concentrated via rotary evaporation. The product was purified via fractional distillation to provide silyl ether **3** (8.4 g, 29.9 mmol, 61%) as a colorless oil.

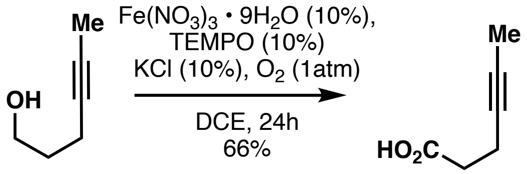
Physical State: Clear colorless oil.
^{1}H NMR (600 MHz, CDCl3): δ 5.20 – 5.15 (m, 1H), 3.59 (t, *J* = 6.6 Hz, 2H), 2.20 – 2.15 (m, 2H), 2.15 – 2.10 (m, 2H), 2.05 – 2.00 (m, 2H), 1.78 (t, *J* = 2.4 Hz, 3H), 1.65 – 1.58 (m, 2H), 1.61 (d, *J* = 0.9 Hz, 3H), 0.89 (s, 9H), 0.05 (s, 6H).
^{13}C NMR (150 MHz, CDCl3): δ 136.2, 123.2, 79.3, 75.6, 63.0, 35.9, 31.2, 27.9, 26.1, 19.4, 18.5, 16.2, 3.6, -5.1
HRMS (ESI-TOF) calculated for $C_{17}H_{32}OSi$ $[M+H]^+$: 281.2295, found: 281.2297
TLC: $R_f = 0.48$ (5% ethyl acetate / hexanes)



5-hexyn-1-ol (50g, 509.5 mmmol, 1 equiv.) was isomerized to 4-hexyn-1-ol according to a literature procedure.(*53*) (35.93 g, 72%).

Spectral data matched previous reports; the ^{1}H NMR data is provided here for convenience.(*53*)

^{1}H NMR (400 MHz, CDCl3): δ 3.75 (t, *J* = 6.1 Hz, 2H), 2.26 (tq, *J* = 7.0, .2.5 Hz, 2H), 1.84 (br s, 1H), 1.78 (t, *J* = 2.7 Hz, 3H), 1.73 (quin, *J* = 6.5 Hz, 2H).

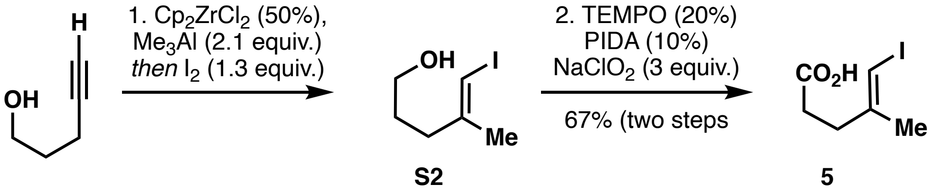


Procedure adapted from a literature procedure.(*54*)

To a flask and stir bar was consecutively added with iron nitrate nonahydrate (6.87 g, 17 mmol, 0.10 equiv.), TEMPO (2.66 g, 17 mmol, 0.10 equiv.), and potassium chloride (1.27 g, 17 mmol, 0.10 equiv.). Then, a solution of DCE (250 mL) and 4-hexyn-1-ol (16.7 g, 170 mmol, 1equiv.) was added. The reaction was placed under an atmosphere of oxygen and allowed to stir for ~24 h. Upon completion of the reaction monitored by TLC, the stir bar was removed, and the reaction was concentrated to a thick red oil which was loaded onto silica and filtered with ether. After concentration a yellow solid was obtained. This yellow solid was recrystallized from diethyl ether to provide 4-hexynoic acid as a white, crystalline solid (12.56 g, 66%).
Procedure adapted from: *J. Am. Chem. Soc.* **2016**, *138*, 27, 8344-8347

Spectral data matched previous reports; the ^{1}H NMR data is provided here for convenience.(*55*)

^{1}H NMR (400 MHz, CDCl3): δ 11.97 (br s, 1H), 2.47 – 2.51 (m, 2H), 2.35 – 2.40 (m, 2H), 1.69 (t, *J* = 2.5 Hz, 3H).



This procedure is adapted from a literature procedure.(*56*)

A flame dried flask containing a stir bar and zirconocene dichloride (23.39 g, 80 mmol, 0.40 equiv.) was evacuated and backfilled three times with argon. Anhydrous 1,2-dichloroethane (500 mL) was added followed by trimethyl aluminum (40.26 mL, 420 mmol, 2.1 equiv.) as two 20.13

mL syringe additions and stirred 15 minutes. After addition of trimethyl aluminum, the flask was placed in an ice bath and allowed to cool before the addition of 4-pentyn-1-ol (16.82 g, 18.61 mL, 200 mmol) dropwise. The reaction was allowed to warm to room temperature and was stirred for 15h. Next, the reaction was placed in an ice bath and allowed to cool before a solution of iodine (66 g, 260 mmol, 1.3 equiv.) in THF (200 mL) was transferred via cannula. The reaction was stirred at 0 °C for 30 minutes where it turned a bright yellow color, then the septum was removed, DCM (200 mL) was added, and water (approximately 30 mL) was added **dropwise very slowly!** The yellow heterogeneous solution became white and heterogeneous and the bubbling stopped at complete quenching. More DCM was added and the slurry was filtered. The solution was washed with 2N HCl (100 mL), then saturated aqueous sodium bicarbonate (100 mL) and saturated aqueous sodium thiosulfate (100 mL) before being washed with brine (100 mL) and dried over magnesium sulfate. The organic layer was then concentrated via rotary evaporation in a fume hood. **The reaction was not evaporated above 30 °C and was shielded from light. After concentration, the crude material was stored in a -20 °C freezer to prevent slow decomposition.** The resulting vinyl iodide (**S2**) was carried into the oxidation step without further purification (47.11 g crude red oil.)

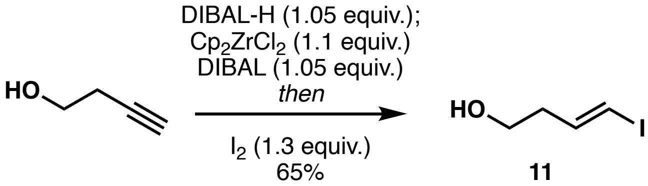
Notes: Trimethyl Aluminum is extremely pyrophoric, propter Schlenk technique should be used when handling. Addition of pentynol results in gas evolution, ensure that any vent needles do not become clogged throughout addition to prevent flask over-pressurization. Quenching the reaction with iodine and water is exothermic. Water should be added very slowly dropwise and gas evolution is observed to avoid vigorous bubbling. The reaction should be evaporated in a space with good ventilation, such as a fume hood, to prevent exposure to any methyl iodide that may have inadvertently been generated upon quenching.

Oxidation procedure adapted from a literature procedure. (*57*)

To a flask containing a stir bar and a 1:1 solution (500 mL total volume) of MeCN and 1M pH 7 sodium phosphate buffer cooled to 0 °C was added sequentially TEMPO (6.25 g, 40 mmol, 0.20 equiv.), PIDA (6.44 g, 20 mmol, 0.10 equiv.) and alcohol **S2** (47.11 g crude oil). Next, sodium chlorite (54.25 g, 600 mmol, 3 equiv.) was added as a solid slowly portion-wise into the reaction. After complete addition of the sodium chlorite, the reaction turned a deep purple and was allowed to slowly warm to room temperature and stirred 12h. After completion of the reaction, the flask was cooled 0 °C again and diluted with distilled water (100 mL) and excess solid sodium sulfite was added portion-wise (*Note: exothermic)* until the reaction became colorless. The reaction was acidified with conc. Hydrochloric acid to pH 1. The aqueous layer was extracted with diethyl ether (4 X 200 mL) and the combined organics were washed with 1N HCl (1 X 100 mL). The organic layer was back extracted into the aqueous phase using 1N NaOH (5 X 100 mL). The collected basic phase was washed with hexanes (1 X 100 mL), then acidified with concentrated HCl to pH 1 at which point the aqueous phase became a cloudy suspension. This suspension was extracted with hexanes (5 X 200 mL) and these combined organic fractions were successively washed with water (1 X 200mL), brine (1 X 100 mL), dried over magnesium sulfate, filtered and concentrated to provide vinyl iodide **5** as a clear colorless, oil (32.1 g, 67% over two steps) that was stored in at -20 °C.

Notes: the addition of sodium chlorite results in a large exotherm if not added portion-wise, slowly.

Physical State: Pale yellow oil
^{1}H NMR (600 MHz, CDCl3): δ 6.01 (q, *J* = 1.1 Hz, 1H), 2.56 – 2.48 (m, 4H), 1.86 (d, *J* = 1.1 Hz, 3H).
^{13}C NMR (151 MHz, CDCl3): δ 179.0, 145.8, 76.4, 34.1, 32.5, 24.0
HRMS: calculated for $C_6H_9IO_2$ $[M+H]^+$: 240.9725, found: 240.9724
TLC: R_f = 0.50 (1:1 hexanes / EtOAc)

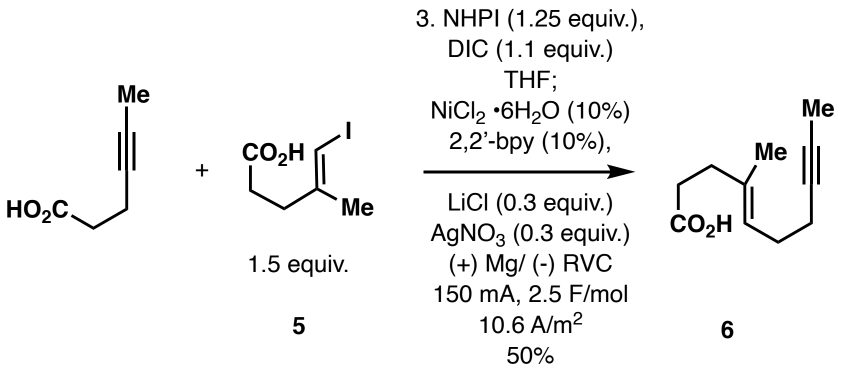


A flame dried flask containing a stir bar and zirconocene dichloride (23.4 g, 80 mmol, 1.1 equiv.) was evacuated and backfilled three times with argon before the addition of anhydrous, inhibitor-free THF (180 mL). This flask was wrapped in aluminum foil to shield its contents from light and was placed in an ice bath and cooled to 0 °C. Next, neat diisobutylaluminum hydride (13.5 mL, 76 mmol, 1.05 equiv.) was added dropwise via syringe and the reaction was allowed to stir for 1.5h.

To a separate flame dried flask and stir bar under argon was added 3-butyn-1-ol (5.1 g, 72 mmol, 1 equiv.) and anhydrous, inhibitor-free THF (60 mL). After cooling to 0 °C neat diisobutylaluminum hydride (13.5 mL, 76 mmol, 1.05 equiv.) was added dropwise via syringe and the reaction was allowed to stir for 30 minutes. The contents of this flask were transferred via cannula to the white suspension above at the allotted time at 0 °C and this reaction was allowed to stir at 0 °C for 2h before being allowed to slowly warm to room temperature and stir for an additional 1 hour. A color change was observed from a white suspension to a green suspension to ultimately a homogenous dark red solution. At this time, the flask was cooled to -78 °C and iodine (23.75 g, 93.6 mmol, 1.3 equiv.) was added as a solution in THF (100 mL). The reaction was stirred for 15 minutes at this temperature before being warmed to 0 °C, stirred an additional 15 minutes and then *slowly* quenched dropwise with distilled water. The reaction was diluted with diethyl ether (200 mL) and washed successively with 1N HCl (2 X 100 mL), saturated sodium bicarbonate (100 mL), saturated sodium thiosulfate (100 mL), brine (100 mL) before being dried over magnesium sulfate and concentrated via rotary evaporation in a fume hood. The compound was purified via silica gel chromatography (0 to 30% EtOAc in hexanes) to provide vinyl iodide **11** (9.31 g, 65%) as a yellow oil that darkened over time. This compound was stored at - 20 °C and shielded from light.

Spectral data matched previous reports; the ^{1}H NMR data is provided here for convenience.(*58*)

^{1} H NMR (400 MHz, CDCl3): δ = 6.54 (dt, 1H, J = 14.5 Hz, J = 7.3 Hz), 6.16 (dt, 1 H, J = 14.4 Hz, J = 1.4 Hz), 3.68 (dt, 2H, J = 6.1 Hz, J = 6.0 Hz), 2.32 (dtd, 2H, J = 7.3 Hz, J = 6.2 Hz, J = 1.2 Hz), 1.54 (bd, 1H).



5 **6**

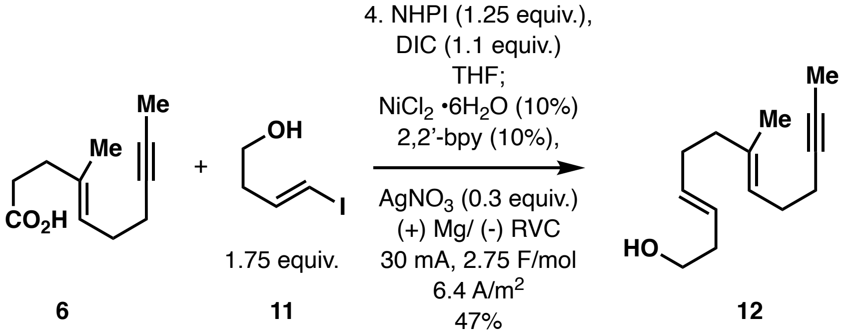
To a flame dried flask was added a stir bar, 4-hexynoic acid (3.36 g, 30 mmol, 1 equiv.) and NHPI (6.12 g, 37.5 mmol, 1.25 equiv.). Next, the flask was sealed with a septum, evacuated and backfilled three times with argon before the addition of anhydrous, inhibitor-free THF (18 mL). The flask was placed in a water bath at room temperature (19 °C) and DIC (5.17 mL, 33 mmol, 1.1 equiv.) was added. The activation was allowed to stir for two hours and a white suspension formed.

To a separate flask containing a stir bar was added $NiCl_2 \bullet 6H_2O$ (711 mg, 3 mmol, 0.10 equiv.), 2,2'-bipyridine (468 mg, 3 mmol, 0.10 equiv.) and lithium chloride (381 mg, 9 mmol, 0.3 equiv.). This flask was evacuated and backfilled 3 times with argon before the addition of anhydrous DMF (72 mL). This solution was allowed to stir for 20 minutes and a homogeneous, dark green solution developed. This green solution was transferred via cannula into the flask containing the *in situ* activated ester (white suspension) and the vinyl iodide **5** (10.8 g, 45 mmol, 1.5 equiv.) was added. This green suspension was split into 6 equal portions (18 mL each) via syringe and added to 6, 20 mL ElectraSyn 2.0 vial under argon each containing a magnesium anode, 100 ppi RVC cathode (9mm diameter, 40 mm length), $AgNO_3$ (255 mg, 1.5 mmol, 106 $mmol_{Ag}/m^2_{(cathode)}$, 0.3 equiv.) and stir bar. After complete addition electrolysis was immediately started. The electrochemical reaction was performed using an ElectraSyn 2.0 and carousel under constant current conditions with the settings as follows: 150 mA, 5 mmols, 2.5 F/mol providing 10.6 A/m^2 current density. After completion of the reaction, the vials were combined into a single flask along with the contents of 12 other vials' contents (a total of 18 vials, 90 mmol of 4-hexynoic acid) and *slowly* quenched with 1N HCl (300 mL) and extracted with diethyl ether (3 X 200 mL). The combined organics were washed successively with distilled water (2 X 100 mL) then brine (1 X 100 mL), then dried over magnesium sulfate before being filtered and concentrated via rotary evaporation. The oily solid was purified via 15wt% $AgNO_3$ silica gel chromatography (0% to 30% Et_2O in toluene containing 0.20% AcOH). Product fractions were collected, concentrated, and the white solid was suspended in iced toluene and filtered. The mother liquor was concentrated to provide pure enyne **6** (8.125 g, 50 %) as a white solid.

Note: Quenching and dissolution of DMF in water is exothermic and extraction of the warm reaction solution with diethyl ether can lead to boiling of the solvent.

Physical State: White solid
m.p. 44 – 46 °C

^{1}H NMR (600 MHz, CDCl3): δ 5.23 (ddt, *J* = 7.0, 5.6, 1.4 Hz, 1H), 2.49 – 2.44 (m, 2H), 2.33 (t, *J* = 7.8 Hz, 2H), 2.21 – 2.15 (m, 2H), 2.15 – 2.10 (m, 2H), 1.77 (t, *J* = 2.5 Hz, 3H), 1.64 (d, *J* = 1.3 Hz, 3H).
^{13}C NMR (151 MHz, CDCl3): δ 178.6, 134.4, 124.2, 79.1, 75.7, 34.4, 32.8, 27.8, 19.2, 16.2, 3.6
HRMS (ESI-TOF): calculated for $C_{11}H_{16}O_2$ [M-H]$^-$ 179.1072, found: 179.1077
Rf = 0.15 (3:1 hexanes / ethyl acetate)



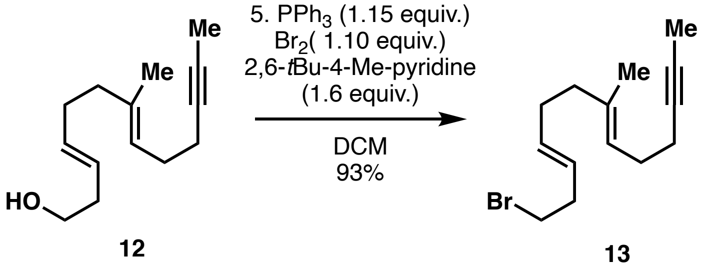
To a flame dried culture tube was added a stir bar, acid **6** (180 mg, 1 mmol, 1 equiv.) and NHPI (204 mg, 1.25 mmol, 1.25 equiv.). Next, the tube was evacuated and backfilled three times with argon before the addition of anhydrous, inhibitor-free THF (2.5 mL). Next, DIC (0.17 mL, 1.1 mmol, 1.1 equiv.) was added. The activation was allowed to stir for two hours and a white suspension formed.

To a separate flask containing a stir bar was added $NiCl_2•6H_2O$ (23.7 mg, 0.10 mmol, 0.10 equiv.) and 2,2'-bipyridine (15.6 mg, 0.10 mmol, 0.10 equiv.). This flask was evacuated and backfilled 3 times with argon before the addition of anhydrous DMF (12.5 mL). This solution was allowed to stir for 20 minutes and a homogeneous, dark green solution developed. This green solution was transferred via syringe into the tube containing the *in situ* activated ester (white suspension) and the vinyl iodide **11** (347 mg, 1.75 mmol, 1.75 equiv.). The reaction contents were then transferred via syringe to a 20mL ElectraSyn 2.0 vial under argon containing a magnesium anode, 100 ppi RVC cathode (3 mm x 7 mm x 51 mm), $AgNO_3$ (51 mg, 0.30 mmol, 64 $mmol_{Ag}/m^2_{(cathode)}$, 0.30 equiv.) and stir bar. After complete addition electrolysis was immediately started. The electrochemical reaction was performed using an ElectraSyn 2.0 under constant current conditions with the settings as follows: 30 mA, 1 mmol, 2.75 F/mol providing 6.4 A/m^2 current density. After completion of the reaction the vial was poured into a flask, quenched with 1N HCl (50 mL) and extracted with diethyl ether (3 X 50 mL). The combined organics were washed successively with distilled water (2 X 50 mL), saturated sodium bicarbonate solution (2 X 50 mL) then brine (1 X 50 mL), then dried over magnesium sulfate before being filtered and concentrated via rotary evaporation. The oily solid was purified via silica gel chromatography (0% to 40% EtOAc in hexanes). Product fractions were collected, concentrated, and the white solid was suspended in iced toluene and filtered and concentrated to provide pure polyene **12** (97 mg, 47%) as a pale-yellow oil.

Note: Quenching and dissolution of DMF in water is exothermic and extraction of the warm reaction solution with diethyl ether can lead to boiling of the solvent.

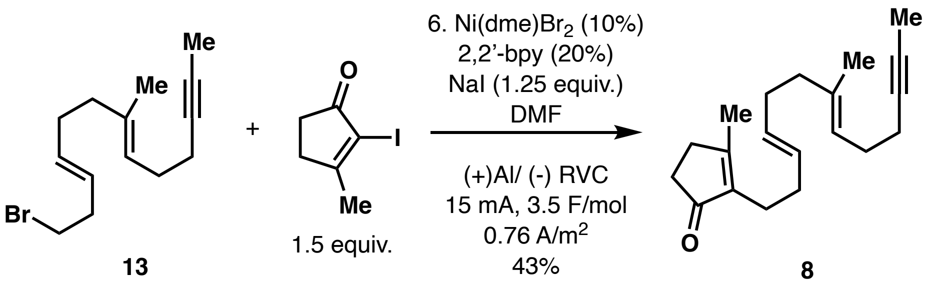
Physical State: pale-yellow oil

^{1}H NMR (600 MHz, CDCl3): δ 5.59 – 5.48 (m, 1H), 5.44 – 5.32 (m, 1H), 5.17 (t, *J* = 6.5 Hz, 1H), 3.61 (t, *J* = 6.2 Hz, 2H), 2.25 (q, *J* = 7.3 Hz, 2H), 2.21 – 2.09 (m, 6H), 2.09 – 2.00 (m, 2H), 1.78 (t, *J* = 2.4 Hz, 3H), 1.60 (d, *J* = 1.4 Hz, 3H), 1.40 (s, 1H).
^{13}C NMR (151 MHz, CDCl3): δ 136.0, 134.0, 126.1, 123.6, 79.3, 75.6, 62.0, 39.6, 36.1, 31.2, 27.8, 19.3, 16.1, 3.6
HRMS (ESI-TOF): calculated for $C_{14}H_{22}O$, $[M+H]^+$: 207.1749, found: 207.1747
TLC: R_f = 0.43 (4:1 hexanes / ethyl acetate)



A flame dried flask containing a stir bar and triphenylphosphine (2.85 g, 10.9 mmol, 1.15 equiv.) was evacuated and backfilled three times with argon before the addition of anhydrous DCM (40 mL). After dissolution, this flask was placed in an ice bath and bromine (1.66 g, 10.4 mmol, 1.10 equiv.) was added dropwise. The reaction was allowed to stir for 15 minutes at 0 °C and a white suspension was observed. In a separate flask, alcohol **12** (1.95 g, 9.45 mmol, 1 equiv.) and 2,6-ditertbutyl-4-methyl-pyridine (3.1 g, 15.1 mmol, 1.6 equiv.) were dissolved in anhydrous DCM (10 mL) and transferred via dropwise addition to the white suspension at 0 °C. After 15 minutes at 0 °C, the flask was removed from the ice bath and stirred at room temperature for 1 hour. Full conversion was observed by TLC before the addition of pentane (200 mL) and silica gel. The reaction was filtered through a plug of silica and the plug was rinsed with pentane (3 X 200 mL). The combined organics were washed with HCl (3 X 100 mL), then brine (100 mL) and dried over magnesium sulfate before concentration via rotary evaporation. The crude product was purified via silica gel chromatography (0% to 3% Et_2O in pentane). The product fractions were collected and concentrated to provide bromide **13** (2.37 g, 93%) as a pale-yellow oil.

Physical State: Clear colorless to pale yellow oil
^{1}H NMR (600 MHz, CDCl3): δ 5.53 (dtt, *J* = 14.5, 6.6, 1.4 Hz, 1H), 5.40 (dtt, *J* = 14.9, 6.7, 1.4 Hz, 1H), 5.17 (tq, *J* = 7.0, 1.4 Hz, 1H), 3.36 (t, *J* = 7.1 Hz, 2H), 2.54 (qd, *J* = 7.0, 1.2 Hz, 2H), 2.20 – 2.08 (m, 6H), 2.05 (dd, *J* = 8.9, 6.2 Hz, 2H), 1.78 (t, *J* = 2.5 Hz, 3H), 1.60 (d, *J* = 1.4 Hz, 3H).
^{13}C NMR (151 MHz, CDCl3): δ 135.8, 133.6, 126.7, 123.5, 79.3, 75.6, 39.5, 36.2, 33.0, 31.1, 27.9, 19.4, 16.2, 3.6
HRMS: Calculated for $C_{14}H_{21}Br$ $[M+H]^+$ 269.0905,; found, 269.0913.
TLC: R_f = 0.25 (hexanes)



13

1.5 equiv.

8

1.2 mmol scale

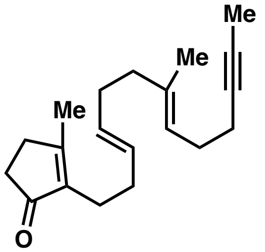
To an oven dried 20 mL ElectraSyn 2.0 vial was added 2-iodo-3-methyl-cyclopentenone (399.7 mg, 1.8 mmol, 1.5 equiv.), alkyl bromide **13** (323.1 mg, 1.2 mmol, 1.0 equiv.), 2,2'-bypyridine (37.5 mg, 0.24 mmol, 0.2 equiv.), NiCl$_2$(dme) (26.4 mg, 0.12 mmol, 0.1 equiv.) and sodium iodide (224.8 mg, 1.5 mmol, 1.25 equiv.). The vial was sealed with a 20 mL ElectraSyn 2.0 vial cap fitted with an aluminum sacrificial anode and a 100 ppi RVC cathode (9 mm diameter, 40 mm length). The sealed vial was then evacuated and backfilled three times with argon. Next, anhydrous DMF was added (18 mL) and the sealed vial was allowed to briefly stir until homogeneous. The vial was then placed on an IKA ElectraSyn 2.0 and electrolysis was set to 15 mA (0.76 A/m^2), 1.2 mmol substrate, and 3.5 F/mol. The reaction was allowed to undergo the programmed electrolysis under argon with rigorous stirring (~1000 rpm). Upon completion of electrolysis, the reaction mixture was diluted in diethyl ether (20 mL) and the electrodes were washed with diethyl ether (10 mL). The reaction mixture was partitioned between 1M HCl (30 mL) and the organics were extracted with diethyl ether (3 X 100 mL). The combined organics were washed with brine, dried over MgSO$_4$, and concentrated via rotary evaporation to afford a yellow oil. The crude material was purified via silica gel chromatography (0-30% ethyl acetate/hexanes) to provide enone **8** as a clear colorless oil (146.0 mg, 43% yield).

0.2 mmol scale

To an oven dried 5 mL ElectraSyn 2.0 vial was added 2-iodo-3-methyl-cyclopentenone (66.6 mg, 0.3 mmol, 1.5 equiv.), alkyl bromide **13** (53.9 mg, 0.2 mmol, 1.0 equiv.), 2,2'-bypyridine (6.25 mg, 0.04 mmol, 0.2 equiv.), NiCl$_2$(dme) (4.39 mg, 0.02 mmol, 0.1 equiv.) and sodium iodide (37.5 mg, 0.25 mmol, 1.25 equiv.). The vial was sealed with a 5 mL ElectraSyn 2.0 vial cap fitted with an aluminum sacrificial anode and a 100 ppi RVC cathode (3 mm X 7 mm X 51 mm). The sealed vial was then evacuated and backfilled three times with argon. Next, anhydrous DMF was added (3 mL) and the sealed vial was allowed to briefly stir until homogeneous. The vial was then placed on an IKA ElectraSyn 2.0 and electrolysis was set to 2.5 mA (0.72 A/m^2), 0.2 mmol substrate, and 3.5 F/mol. The reaction was allowed to undergo the programmed electrolysis under argon with rigorous stirring (~1000 rpm). Upon completion of electrolysis, the reaction mixture was diluted in diethyl ether (10 mL) and the electrodes were washed with diethyl ether (10 mL). The reaction mixture was partitioned between 1M HCl (10 mL) and the organics were extracted with diethyl ether (3 X 10 mL). The combined organics were washed with brine, dried over MgSO$_4$, and concentrated via rotary evaporation to afford a yellow oil. The crude material was purified via silica gel chromatography (0-30% ethyl acetate/hexanes) to provide enone **8** as a clear colorless oil (27.0 mg, 48% yield).

Physical State: Clear colorless oil
^{1}H NMR (600 MHz, CDCl3): δ 5.41 – 5.35 (m, 2H), 5.19 – 5.13 (m, 1H), 2.51 – 2.46 (m, 2H), 2.38 – 2.32 (m, 2H), 2.22 (t, *J* = 7.7 Hz, 2H), 2.17 (q, *J* = 7.5 Hz, 2H), 2.15 – 2.10 (m, 2H), 2.09 – 2.02 (m, 4H), 2.04 (s, 3H), 2.00 (dd, *J* = 9.1, 6.0 Hz, 2H), 1.78 (dt, *J* = 3.0, 1.4 Hz, 3H), 1.59 (d, *J* = 1.4 Hz, 3H).
^{13}C NMR (151 MHz, CDCl3): δ 209.7, 170.5, 140.1, 136.2, 130.8, 129.5, 123.2, 79.3, 75.6, 39.8, 34.5, 31.7, 31.4, 31.3, 27.9, 23.4, 19.4, 17.5, 16.2, 3.6
HRMS: Calculated for $C_{20}H_{28}O$ $[M+H]^+$, 285.2218; found, 285.2223.
TLC: R_f = 0.38 (4:1 hexanes / ethyl acetate)

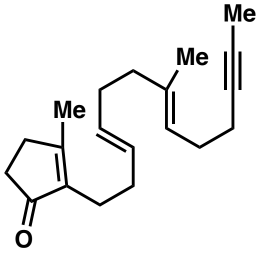
Table S1— Progesterone's Polyene ^{1}H Shifts Comparison



Tabulated data for Synthetic **8**
^{1}H-NMR ($CDCl_3$)

Synthetic **8** (600 MHz)	Synthetic **8** (Dudley, 400 MHz) (*59*)	Δppm
5.41 – 5.35 (m, 2H)	5.47 – 5.30 (m, 2H)	0.00
5.19 – 5.13 (m, 1H)	5.16 (t, *J* = 6.1 Hz, 1H)	0.00
2.51 – 2.46 (m, 2H)	2.48 (d, *J* = 4.2 Hz, 2H)	0.00
2.38 – 2.32 (m, 2H)	2.36 (t, *J* = 4.2 Hz, 2H)	0.00
2.22 (t, *J* = 7.7 Hz, 2H) 2.17 (q, *J* = 7.5 Hz, 2H) 2.15 – 2.10 (m, 2H) 2.09 – 2.02 (m, 4H) 2.04 (s, 3H) 2.00 (dd, *J* = 9.1, 6.0 Hz, 2H)	2.32 – 1.92 (m, 15H)	N/A
1.78 (dt, *J* = 3.0, 1.4 Hz, 3H)	1.78 (t, *J* = 2.3 Hz, 3H)	0.00
1.59 (d, *J* = 1.4 Hz, 3H)	1.60 (s, 3H)	0.01

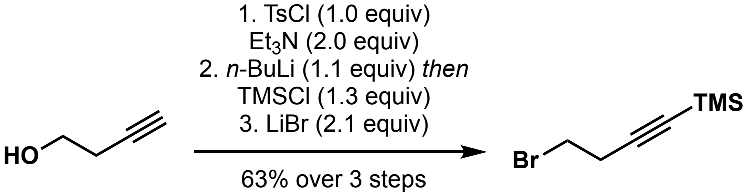
Table S2 —Progesterone's Polyene ^{13}C Shifts Comparison



Tabulated data for Synthetic **8**
^{13}C-NMR ($CDCl_3$)

Synthetic **8** (151 MHz)	Precedent **8** (Dudley, 100 MHz) (*59*)	Δppm
209.7	209.6	0.1
170.5	170.6	0.1
140.1	140.0	0.1
136.2	136.0	0.2
130.8	130.7	0.1
129.5	129.4	0.1
123.2	123.1	0.1
79.3	79.2	0.1
75.6	75.4	0.2
39.8	39.6	0.2
34.5	34.3	0.2
31.7	31.5	0.2
31.3	31.2	0.1
27.9	27.7	0.2
23.4	23.2	0.2
19.4	19.2	0.2
17.5	17.3	0.2
16.2	16.1	0.1
3.6	3.5	0.1

Iodoeneone Coupling Reaction Development



(4-bromobut-1-yn-1-yl)trimethylsilane was prepared according to literature precedent with minor modifications.(*60*)

To a stirring solution of but-3-yn-1-ol (5.00 g, 71.3 mmol, 1.0 equiv.), triethylamine (20 mL, 142.6 mmol, 2.0 equiv.) in DCM (120 mL) was added *p*-toluenesulfonyl chloride (13.75 g, 71.3 mmol, 1.0 equiv.) as a solid at 0 ºC. The reaction mixture was allowed to warm to room temperature and stir overnight. Upon completion (monitored by TLC), the reaction mixture was quenched with saturated aqueous ammonium chloride (150 mL). The organic material was extracted with DCM (3 x 100 mL). The combined organics were washed with saturated aqueous sodium bicarbonate (50 mL) followed by brine (50 mL) dried over magnesium sulfate and concentrated to afford the crude product as a yellow oil (16.56 g crude mass). The crude product was carried forward without any additional purification.

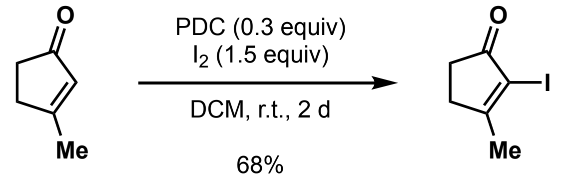
The crude material was added to an oven-dried, round bottom flask equipped with stir bar. The flask was sealed and purged with argon then THF (120 mL) was added. The stirring solution was allowed to cool to -78 ºC under an inert atmosphere then *n*-butyllithium (31.4 mL, 78.4 mmol, 1.1 equiv.). was added slowly as a solution in hexanes (2.5 M). The reaction mixture was then allowed to stir for 1 hour at -78 ºC. Trimethylsilyl chloride (11.8 mL, 92.7 mmol, 1.3 equiv.) was added slowly to the stirring mixture. After addition, the reaction mixture was allowed to warm to room temp and stir overnight. Upon completion, the reaction mixture was cooled to 0 ºC and quenched with saturated aqueous ammonium chloride (100 mL) and the organic material was extracted with diethyl ether (3 X 100 mL). The combined organics were dried over magnesium sulfate and concentrated to afford an orange oil (19.66 g crude mass). The crude material was carried forward without any additional purification.

The crude material (19.66 g) from the previous step was dissolved in acetone (130 mL). Lithium bromide (12.09 g, 139.3 mmol, 2.1 equiv.) was added in portions. The reaction vessel was shielded from light and allowed to stir at room temperature overnight. Upon completion, water was added (300 mL) and the organics were extracted with hexanes (3 X 200 mL). The combined organics were washed with saturated aqueous $NaHCO_3$, then with brine, then dried over magnesium sulfate and concentrated to afford a clear oil. The crude material was purified via distillation (10 mbar, 80 ºC) to afford a clear colorless oil (9.20 g, 63% yield over 3 steps).

Note: exotherm upon addition of LiBr.

Spectral data matched previous reports; the ^{1}H NMR data is provided here for convenience.(*60*)

^{1} H NMR (400 MHz, CDCl3): δ 3.42 (t, *J* = 7.5 Hz, 2H), 2.77 (t, *J* = 7.5 Hz, 2H), 0.16 (s, 9H).



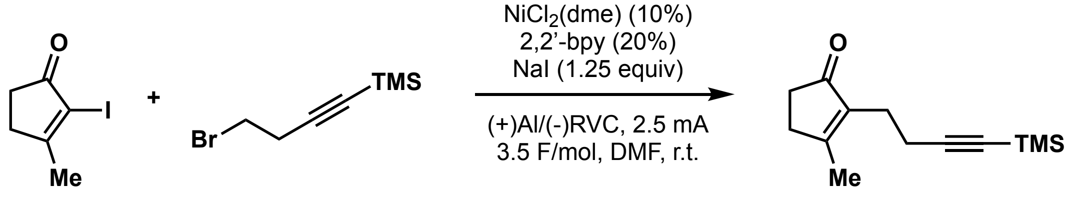
2-iodo-3-methylcyclopent-2-en-1-one was prepared according to literature precedents with minor modifications.(*61*)

To a flame dried 1 L round bottom flask was added anhydrous DCM (670 mL) under argon. 3-methylcyclopent-2-en-1-one (9.613 g, 100 mmol, 1.0 equiv.) was added to the flask *via* syringe. Iodine (38.07 g, 150 mmol, 1.5 equiv.) and pyridinium dichromate (11.29 g, 30 mmol, 0.3 equiv.) were added directly to the flask portion-wise as solids. The reaction mixture was allowed to stir at ambient temperature under argon for 2 days. The reaction mixture was then filtered through a pad of celite and the filtrate was carefully washed with DCM (300 mL). The organic material was washed with 1M HCl (2 X 200 mL) followed by saturated aqueous $NaHCO_3$ (200 mL), saturated aqueous sodium thiosulfate (200 mL) and brine (200 mL). The organic phase was dried over $MgSO_4$ and concentrated to afford an orange paste. The crude material was purified through recrystallization in diethyl ether to afford 2-iodo-3-methylcyclopent-2-en-1-one as a pale yellow crystalline solid (15.03 g, 68% yield).

Spectral data matched previous reports; the ^{1}H NMR data is provided here for convenience. (*61*)

^{1} H NMR (400 MHz, CDCl3): δ 2.75 (m, 2H), 2.58 (m, 2H), 2.22 (m, 3H).

General Procedure 1: 0.2 mmol



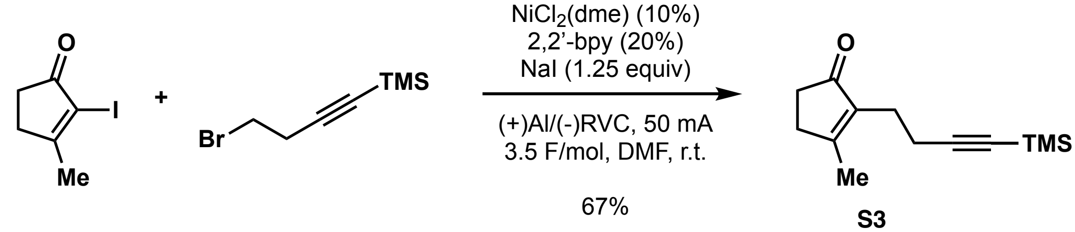
S3

To an oven dried 5 mL ElectraSyn 2.0 vial, 2-iodo-3-methylcyclopent-2-en-1-one (66.6 mg, 0.3 mmol, 1.5 equiv.), (4-bromobut-1-yn-1-yl)trimethylsilane (41.0 mg, 0.2 mmol, 1.0 equiv.), 2,2'-bypyridine (6.2 mg, 0.04 mmol, 0.2 equiv.), $NiCl_2$(dme) (4.39 mg, 0.02 mmol, 0.1 equiv.) and sodium iodide (37.4 mg, 0.25 mmol, 1.25 equiv.) were all directly added as solids/oils. The vial was sealed with a cap fitted with an aluminum sacrificial anode and a RVC cathode (3 mm X 7 mm X 51 mm). The sealed vial was evacuated and backfilled five times with argon. Anhydrous DMF was then added (3 mL) and the sealed vial was allowed to stir until homogeneous. The vial was then placed on an IKA ElectraSyn 2.0 and electrolysis was set to 2.5 mA (0.72 A/m^2), 0.2 mmol substrate, and 3.5 F/mol. The reaction was allowed to undergo the programmed electrolysis. Upon completion of electrolysis, the reaction mixture was diluted in Et_2O (10 mL) and the electrodes were washed with diethyl ether (5 mL). The reaction mixture was partitioned between

1M HCl (20 mL) and the organics were extracted with diethyl ether (3 X 10 mL). The combined organics were then washed with brine (30 mL), dried over $MgSO_4$, and concentrated to afford a yellow oil. The crude material was purified via silica gel chromatography (0-25% ethyl acetate/hexanes) to afford the silyl alkyne **S3** as a clear colorless oil (27.8 mg, 63% yield).

Physical State: Clear Colorless Oil
^{1}H NMR (600 MHz, CDCl3): δ 2.52 (dtd, *J* = 7.1, 2.1, 1.0 Hz, 2H), 2.41 (ddd, *J* = 7.8, 6.5, 1.3 Hz, 2H), 2.39 – 2.33 (m, 4H), 2.11 (s, 3H), 0.12 (s, 9H).
^{13}C NMR (151 MHz, CDCl3): δ 209.4, 172.0, 138.8, 107.0, 84.8, 34.4, 31.9, 22.5, 18.9, 17.8, 0.2
HRMS (ESI-TOF) calculated for $C_{13}H_{20}OSi$, $[M+H]^+$: 221.1362, found: 221.1355
TLC: R_f = 0.20 (9:1 Hexanes / Ethyl Acetate)

General Procedure 2: 4.0 mmol

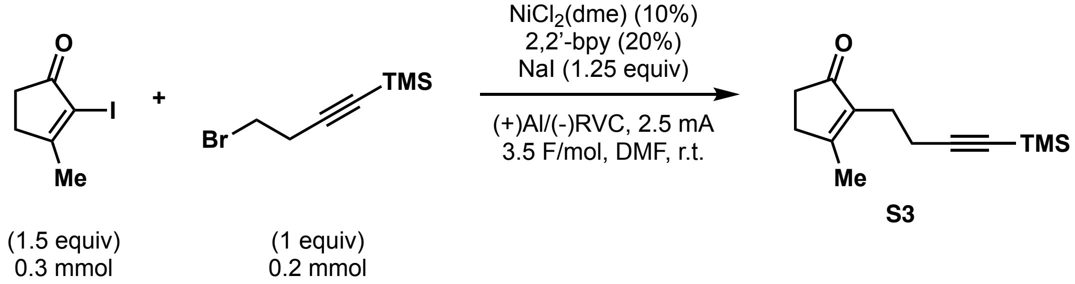


S3

To an oven dried 20 mL ElectraSyn 2.0 vial, 2-iodo-3-methylcyclopent-2-en-1-one (1.332 g, 6.0 mmol, 1.5 equiv.), (4-bromobut-1-yn-1-yl)trimethylsilane (820.0 mg, 4.0 mmol, 1.0 equiv.), 2,2'-bypyridyl (125 mg, 0.8 mmol, 0.2 equiv.), $NiCl_2$(dme) (87.8 mg, 0.40 mmol, 0.1 equiv.) and sodium iodide (750 mg, 5 mmol, 1.25 equiv.) were all directly added as solids/oils. The vial was sealed with a cap fitted with an aluminum sacrificial anode and a 100 ppi RVC cathode (3 mm X 7 mm X 51 mm). The sealed vial was then fitted with an argon balloon and the headspace was flushed 5 times with a 20 mL syringe. DMF was then added (18 mL) and the sealed vial was allowed to stir until homogeneous. The vial was then placed on an IKA ElectraSyn 2.0 and electrolysis was set to 50 mA (14.38 A/m^2), 4.0 mmol substrate, and 3.5 F/mol. The reaction was allowed to undergo the programmed electrolysis with rigorous stirring (~1000 rpm). Upon completion of electrolysis, the reaction mixture was diluted in diethyl ether (60 mL) and the electrodes were washed with diethyl ether (20 mL). The reaction mixture was partitioned between 1M HCl (100 mL) and the organics were extracted with diethyl ether (3 X 100 mL). Combined organics were then washed with brine, dried over $MgSO_4$, and concentrated to afford a yellow oil. The crude material was purified via silica gel chromatography (0-25% ethyl acetate/hexanes) to afford the silyl alkyne **S3** as a clear colorless to yellow oil (594.5 mg, 67% yield).

Table S3—α-iodoenone coupling control reactions

Electrochemical Controls

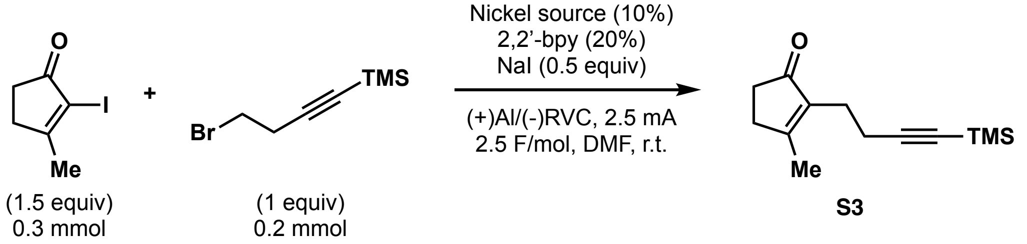


entry	Modification	%yield (^{1}H-NMR)
1	none	63
2	No Ni	0
3	No 2,2'-bpy	0
4	No electricity*	0

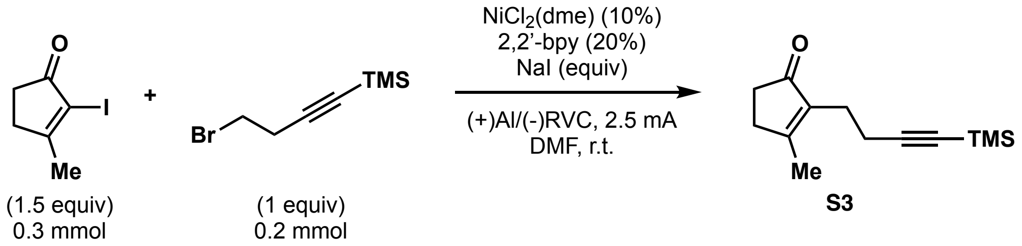
* stirred in the presence of both electrodes

Table S4–S5 —Optimization of α-iodoenone coupling

Nickel source screen

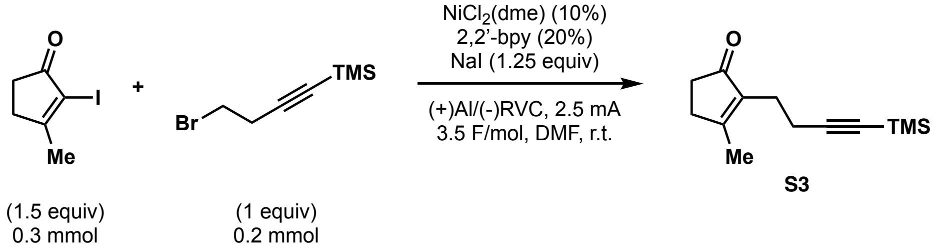


entry	nickel source	PDT	SM-Br	SM-I	dimer	elimination	dehalogenation
1	$NiCl_2(dme)$	38	22	3	9	trace	15
2	$NiBr_2(dme)$	38	18	9	20	N.D.	12
3	$NiCl_2 \cdot 6H_2O$	35	22	2	8	trace	19
4	$NiCl_2(PPh_3)_2$	27	25	trace	2	trace	23



entry	iodoenone equiv	NaI equiv	F/mol	PDT	SM-Br	SM-I	dimer	elimination	dehalogenation
1	1.0	0.5	2.5	38	22	3	9	trace	15
2	1.5	0.5	2.5	38	33	21	0	0	16
3	1.0	1.0	2.5	47	17	4	4	0	12
4	1.0	0.25	2.5	29	41	10	2	trace	17
5	1.0	2.0	2.5	39	11	8	5	0	8
6	1.5	1.0	2.5	54	30	37	2	0	15
7	1.5	1.0	3.5	60	19	3	1	0	8
8	1.5	0.75	3.5	47	25	20	1	0	17
9	1.5	1.25	3.5	63	14	9	3	0	18
10	1.5	1.5	3.5	62	15	2	2	0	16
11	1.5	1.75	3.5	58	9	6	2	0	18

Table S6 —Effects of concentration and current density



entry	scale (mmol)	concentration (M)	current (mA)	RVC dimmensions	current density (A/m^2)	isolated yield
1	0.2	0.067	2.5	3 mm X 7 mm X 51 mm	0.72	63%
2	0.6	0.200	7.5	3 mm X 7 mm X 51 mm	2.16	70%
3	2.0	0.200	25	9 mm diameter X 40 mm length	1.27	61%
4	2.0	0.200	25	3 mm X 7 mm X 51 mm	7.19	68%
5	1.2	0.400	15	3 mm X 7 mm X 51 mm	4.32	36%
6	4.0	0.200	50	3 mm X 7 mm X 51 mm	14.38	53%
7	4.0	0.200	50	9 mm diameter X 40 mm length	2.54	57%
8	4.0	0.200	50	9 mm diameter X 40 mm length	2.54	61%*
9	4.0	0.200	50	3 mm X 7 mm X 51 mm	14.38	67%*

* 1000 rpm stir rate

FAQ's

Q: What is the potential reading supposed to read during the reaction?

A: The potential is generally observed to be <2V on the Electrasyn's voltage reading. On larger scale where a greater current is applied, the terminal potential could be as high as 4V.

Q: How do I scale the reaction's electrochemical parameters?

A: The reaction can be scaled by a factor of 12.5 mA/mmol and keeping the reaction concentration constant at 0.2M DMF. For instance, a 2 mmol scale reaction will be run at 25 mA in a 10 mL ElectraSyn 2.0 vial.

Q: Are there characteristic colors that the reaction turns to?

A: When electrolysis commences, the reaction mixture turns a deep red.

Q: Is the reaction air sensitive?

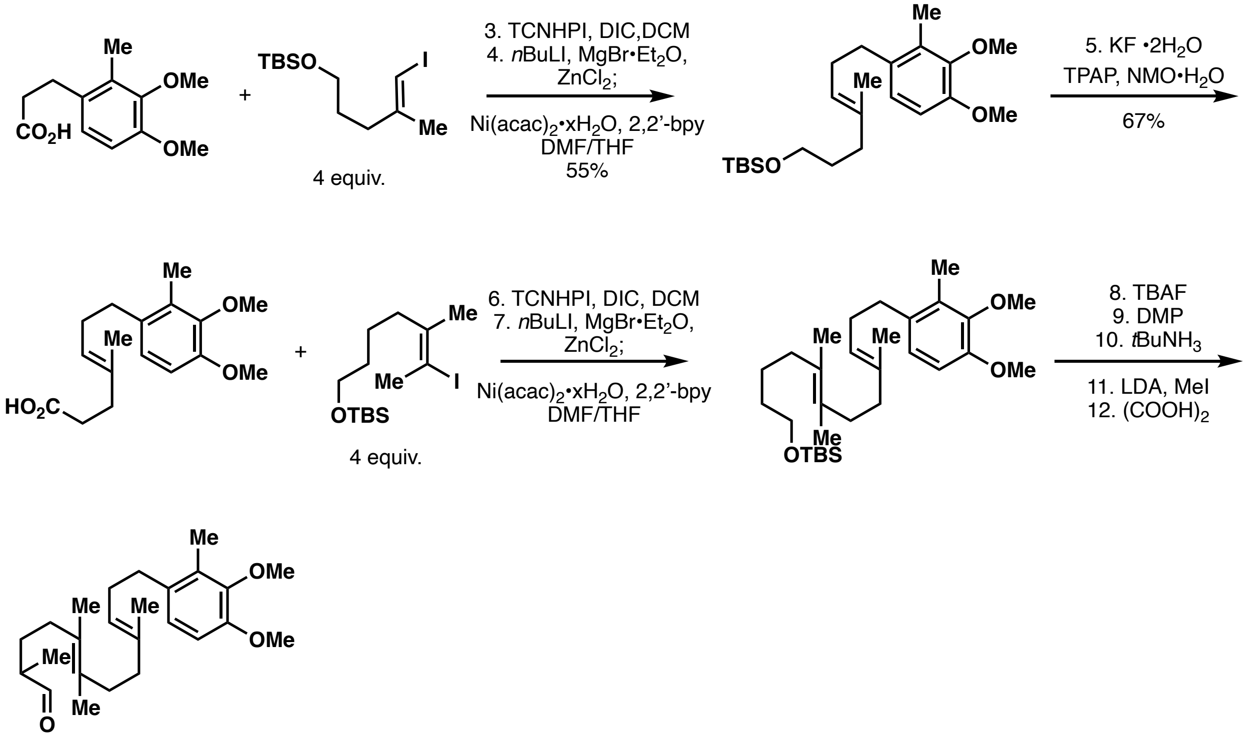
A: On small scale, there is a negative effect on the reaction if a balloon is omitted or leaking. On larger scale, the headspace of the vial is significantly diminished and the current is sufficiently high that adventitious oxygen and moisture do not seem to hurt the reaction. Nevertheless, an argon balloon is still used on large scale.

Q: How important is stir rate on scale?

A: The reaction appears to be affected by mass transfer processes. Consequently, a high stir rate is needed on scale to maintain optimal reaction performance.

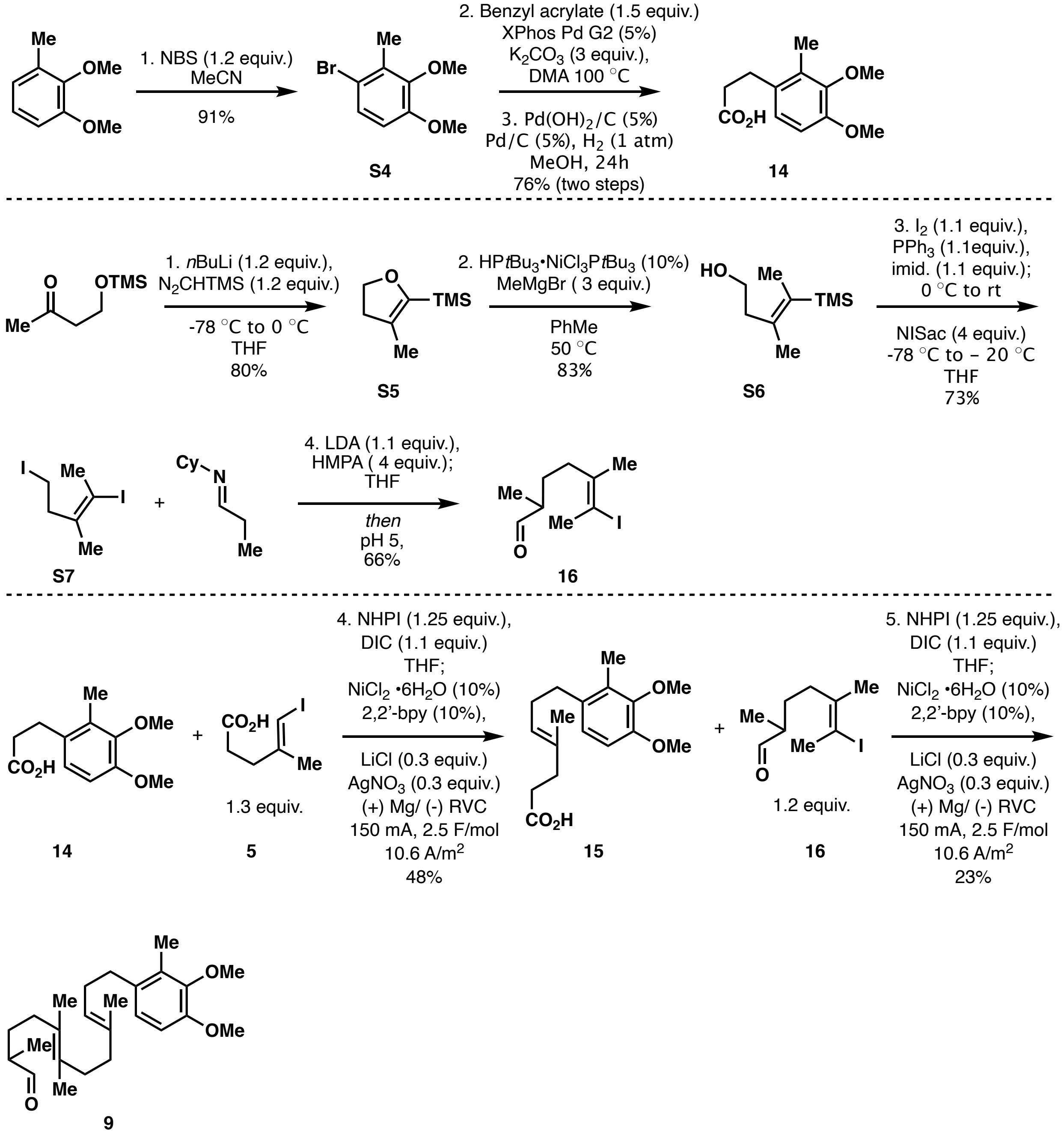
Celastrol (procedures)

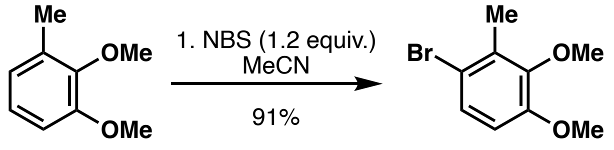
Fig S7 — 1st generation approach to celastrol



This first generation route displays many of the same drawbacks of the first generation of the progesterone synthesis pursued. Particularly, the last 5 steps are glaringly indirect and non-ideal.

Fig S8 —Complete celastrol formal synthesis



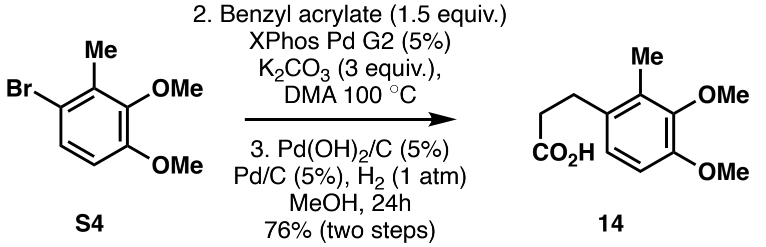


S4

A stirring solution of 2,3-dimethoxy toluene (15.22 g, 100 mmol, 1 equiv.) in anhydrous acetonitrile was cooled to 0 °C before NBS (21.36 g, 120 mmol, 1.2 equiv.) was added in one portion. The reaction was allowed to warm to room temperature and stirred for 24h. After completion of the reaction, a solution of 1:1 saturated bicarbonate and saturated thiosulfate was added to quench the reaction and the reaction was extracted with diethyl ether (3 X 200 mL). The combined organics were washed with water (3 X 100 mL) then with brine (100 mL). The organic layer was dried over magnesium sulfate, filtered and concentrated. The product was recrystallized from methanol to provide aryl bromide **S4** as a crystalline white solid (21.1 g, 91%).

Spectral data matched previous reports; the ^{1}H NMR data is provided here for convenience.(*62*)

^{1}H NMR (400 MHz, CDCl3): δ = 7.22 (d, *J* = 8.8 Hz, 1H), 6.64 (d, *J* = 8.8 Hz, 1H), 3.82 (s, 3H), 3.76 (s, 3H), 2.32 (s, 3H).

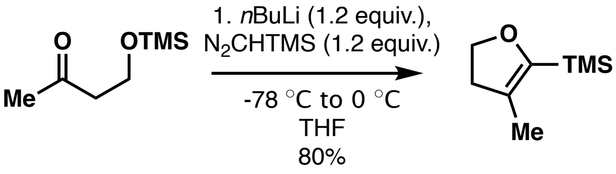


A flame dried flask was charged with a large stir bar, 2-bromo-5,6-dimethoxytoluene (25.87 g, 112 mmol, 1 equiv.), potassium carbonate (45.43 g, 336 mmol, 3 equiv.) and XPhos Pd G2 (4.4 g, 5.6 mmol, 0.05 equiv.) and fitted with a septum. The reaction flask was evacuated and backfilled three times with argon. Next, under an atmosphere of argon, anhydrous and degassed DMA (225 mL) was added and the reaction was stirred to dissolve the solids (except for the potassium carbonate). After stirring 5 minutes, benzyl acrylate (21.203 g, 20.4 mL, 168 mmol, 1.5 equiv.) was added and the flask was placed in an oil bath pre-heated to 100 °C and stirred for 12 h at this temperature. Upon completion of the reaction, the flask was removed from the bath and allowed to cool. After cooling, the reaction was diluted with water and the solids dissolved. The reaction solution was extracted with diethyl ether (3 X 200 mL) and the combined organics were washed with 1N HCl (3 X 100 mL) then brine (100 mL) and then dried over magnesium sulfate. Next, the organics were filtered over a pad of celite and concentrated to provide the product as a crude red solid that was carried into the next step without further purification.

To the flask containing the red solid was added a stir bar before being sparged with argon and capped with a septum. Next, Pearlman's catalyst (20 wt. %) (3.93 g, 20 mmol, 0.25 equiv.) and palladium on carbon (10 wt. %) (5.96 g, 56 mmol, 0.5 equiv.) was added to the flask. The flask was evacuated three times and backfilled with argon before a solution of methanol (250 mL) (freshly sparged with argon) was added via cannula and the reaction was stirred. A hydrogen balloon was placed on the reaction and the headspace was purged of argon (5 minutes). The reaction was allowed to stir for 24 hours, and monitored for completion by NMR. After full conversion, the hydrogen balloon was removed and the reaction was sparged with argon to completely remove any remaining hydrogen. The reaction was filtered over a pad of celite which was rinsed with ethyl acetate (3 X 100 mL) and care was taken to prevent the solids from drying during filtration (to prevent fire risk). The orange filtrate was concentrated to provide a tan solid which was triturated with iced diethyl ether to provide **14** (19 g, 76% over two steps) as a white solid.

Notes: Both Pearlman's catalyst and palladium on carbon were chosen after experimentation to improve reliability. Individually, either will achieve the hydrogenation, but often full conversion was never achieved. Additionally, the alkyl benzyl ester (hydrogenation but no hydrogenolysis) product was never observed while the debenzylated styrenyl acid was observed. Thus, it appears that hydrogenolysis must occur first before hydrogenation can occur. This combination was found to be highly reliable. Palladium on carbon catalysts are highly pyrophoric and great care should be taken to dispose of any waste properly. Only use degassed solvents and keep the catalysts under oxygen free atmospheres.

Physical State: crystalline white solid
m.p. 111 – 113 °C
^{1}H NMR (600 MHz, CDCl3): δ 6.87 (d, J = 8.4 Hz, 1H), 6.71 (d, J = 8.4 Hz, 1H), 3.84 (s, 3H), 3.78 (s, 3H), 2.94 – 2.86 (m, 2H), 2.61 (td, J = 7.8, 1.0 Hz, 2H), 2.24 (s, 3H).
^{13}C NMR (151 MHz, CDCl3): δ 178.9, 151.4, 147.5, 131.7, 130.4, 123.9, 109.7, 60.4, 55.8, 34.8, 28.1, 11.8
HRMS (ESI-TOF): calculated for $C_{12}H_{16}O_4$ $[M+H]^+$: 223.0970, found: 223.0964
TLC: R_f = 0.30 (1:1 ethyl acetate / hexanes)



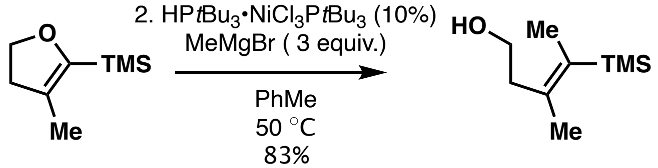
S5

Silane (**S5**) was prepared according to literature precedent with minor modifications.(*63*)

To a flame dried, 2L three neck flask fitted with an addition funnel and stir bar under argon was added anhydrous, inhibitor-free THF (700 mL). After cooling to -78 °C, a 2M solution of (Trimethylsilyl)diazomethane in hexanes (53.6 mL, 107.2 mmol, 1.2 equiv.) was transferred via cannula, followed by a dropwise addition of a 2.5M solution of *n*BuLi in hexanes (42.8 mL, 107.2 mmol, 1.2 equiv.) via cannula over 30 minutes. Next, a solution of 4-((trimethylsilyl)oxy)butan-2-one (14.33 g, 89.4 mmol, 1 equiv.) in THF (170 mL) added dropwise via addition funnel over 30 minutes. After complete addition, the reaction was allowed to warm to 0 °C over 5h. At 0 °C, the reaction was slowly quenched and diluted with distilled, ice water (300 mL) and diethyl ether (300 mL) was added. The aqueous layer was extracted with diethyl ether (3 X 200 mL). The combined organics were washed successively with 1N HCL (100 mL) and brine (200 mL) then dried over magnesium sulfate, filtered and concentrated via rotary evaporation inside a fume hood.

The product was purified via silica gel chromatography (0% to 30% Et_2O in pentanes) to provide **S5** as a pale-yellow oil (11.17 g, 80% yield).

Physical State: Clear colorless to yellow oil
^{1}H NMR (500 MHz, CDCl3): δ 4.18 (t, *J* = 9.6 Hz, 2H), 2.55 (tq, *J* = 9.5, 1.3 Hz, 2H), 1.74 (t, *J* = 1.3 Hz, 3H), 0.18 (s, 9H).
^{13}C NMR (125 MHz, CDCl3): δ 152.9, 121.5, 69.3, 37.4, 12.4, -1.2.
HRMS (ESI-TOF): calculated for $C_8H_{16}OSi$ $[M+H]^+$: 157.1049, found: 157.1042
TLC: R_f = 0.61 (9:1 Hexanes / ethyl acetate)



S5 **S6**

Preparation of nickelate precatalyst:

A flask containing a stir bar was evacuated and backfilled three times with argon before the addition of degassed, 200 proof ethanol (50 mL) followed by a 2M solution of tri-tert-butylphosphine in toluene (20 mL, 40 mmol, 2 equiv.). Next, a degassed, green solution of nickel(II)chloride hexahydrate (5.07 g, 20 mmol, 1 equiv.) and aqueous 37% HCl (1.56 mL, 20 mmol, 1 equiv.) in 200 proof ethanol (50 mL) was added dropwise. Initially, a pale blue solution developed, as the addition continued, a blue solid began to form. After addition, the reaction was allowed to stir for 2h at room temperature (19 °C). At that time, the stir bar was removed and the contents of the flask were concentrated via rotary evaporation to a blue solid. This solid was dissolved in benzene and concentrated to dryness three times. Then, the solid was dissolved in DCM and filtered to remove any green nickel hydroxide solid. Lastly, the product was recrystallized from DCM/toluene to provide cyan blue crystals (11.59 g, 100%) which were dried under vacuum and found to be bench stable for many months.

Reaction procedure:

A flame dried flask containing $HP\textit{t}Bu_3{\bullet}NiCl_3(P\textit{t}Bu_3)$ (2.1 g, 3.68 mmol, 0.075 equiv.) and stir bar was evacuated and backfilled with argon three times. Next, anhydrous degassed toluene (150 mL) was added. Subsequently, a 3M solution methylmagnesium bromide in Et_2O was added dropwise (49.2 mL, 148 mmol, 3 equiv.) and the blue solution became black. After 15 minutes of stirring, 2-TMS-3-Me-dihydrofuran **S5** (7.73 g, 49.2 mmol, 1 equiv.) was added dropwise and the flask was heated to 50 °C for 24 hours. After complete consumption of starting material as monitored by TLC, the reaction was allowed to cool and slowly poured into a flask containing a saturated ammonium chloride solution and crushed ice. The aqueous layer was extracted three times with diethyl ether (3 X 100 mL) to provide a pale-yellow organic layer which was washed with brine (1 X 100 mL) before being dried over magnesium sulfate, filtered and concentrated via rotary evaporation to provide a yellow oil. The product was purified via silica gel chromatography (0% to 40 % Et_2O in pentanes) to provide **S6** as a pale-yellow oil (7.06 g, 83%).

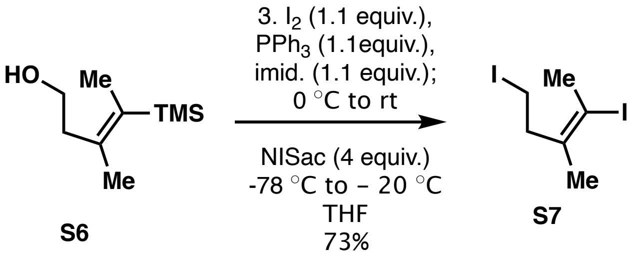
Physical State: Clear colorless oil

^{1}H NMR (500 MHz, CDCl3): δ 3.68 (t, *J* = 7.0 Hz, 2H), 2.44 (t, *J* = 7.0 Hz, 2H), 1.83 (q, *J* = 1.5 Hz, 3H), 1.70 (q, *J* = 1.5 Hz, 3H), 1.28 (s, 1H), 0.14 (s, 9H).

^{13}C NMR (151 MHz, CDCl3): δ 141.6, 131.5, 60.9, 38.3, 23.4, 18.0, 0.6

HRMS (ESI-TOF): calculated for $C_9H_{20}OSi$ $[M+Na]^+$, 195.1175; found, 195.1171.

Rf = 0.40 (4:1 hexanes / ethyl acetate)



To a flame dried flask containing a stir bar was added triphenylphosphine (11.97 g, 45.2 mmol, 1.1 equiv.) and imidazole (3.11 g, 45.2 mmol, 1.1 equiv.) as solids. The flask was then evacuated and backfilled three times with argon before the addition of anhydrous, inhibitor-free THF (420 mL). This solution was cooled to 0 °C with an ice bath before the addition of solid iodine (11.46 g, 45.2 mmol, 1.1 equiv.) in one portion. After dissolution, the flask was removed from the ice bath and allowed to stir at room temperature for 30 minutes before being cooled back down to 0 °C for the dropwise addition of alcohol **S6** (7.06 g, 41 mmol, 1 equiv.). After addition, the ice bath was removed and the reaction was allowed to stir until complete consumption of starting material as monitored by TLC (ca. 1h). Next, the flask was cooled to - 78°C and NISac (50.86 g, 164.2 mmol, 4 equiv.) was added as a solid in one portion. The reaction was allowed to warm to -20 °C over 3.5h and monitored by TLC for disappearance of the intermediate vinyl silane. Once complete, the reaction was diluted with pentane and filtered through a plug of silica. The solids were washed with pentane (3 X 100 mL) and the organic layer was washed successively with saturated sodium bicarbonate, a 1:1 solution of saturated sodium bicarbonate: saturated sodium thiosulfate, and brine. The organic layer was dried over magnesium sulfate and concentrated (at 20 °C) to an oily solid which was shielded from light and purified via silica gel chromatography (100% pentanes). The diiodie **S7** (9.96 g, 73%) was isolated as a clear to pale-pink oil which was shielded from light and used immediately in the next step.

Physical State: clear to pale-pink oil

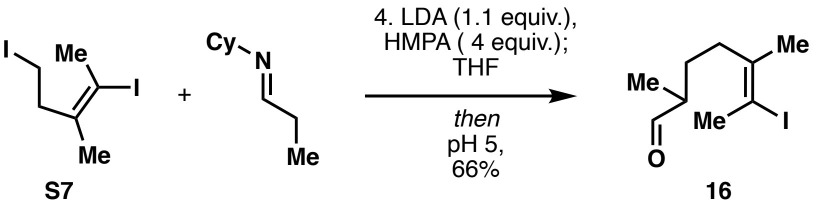
^{1}H NMR (500 MHz, CDCl3): δ 3.17 (dd, *J* = 8.5, 7.3 Hz, 2H), 2.82 – 2.75 (m, 2H), 2.53 (qd, *J* = 1.5, 0.7 Hz, 3H), 1.95 (q, *J* = 1.5 Hz, 3H).

^{13}C NMR (125 MHz, CDCl3): δ 138.7, 98.3, 37.3, 30.5, 29.0, 1.7

MS (GCMS): calculated for $C_6H_{10}I_2$ $[M]^{+\bullet}$: 335.8872, found: 335.9

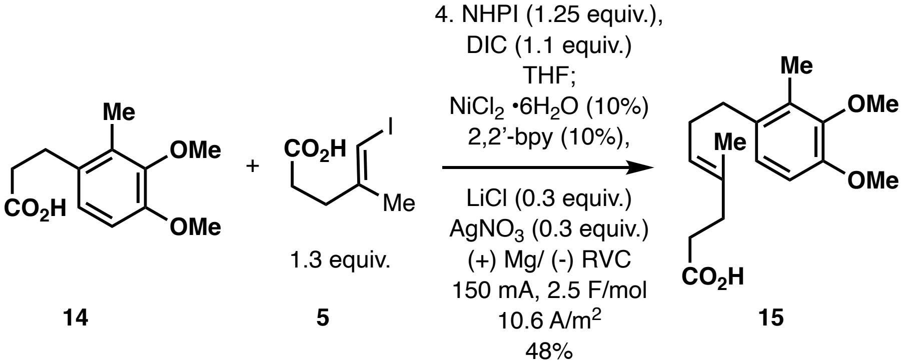
Note: HRMS with ESI-TOF unable to detect desired mass

Rf = 0.82 (9: 1 hexanes / ethyl acetate)



To a flame dried flask under argon and containing a stir bar was added diisopropyl amine (4.6 mL, 37.6 mmol, 1.1 equiv.) and anhydrous, inhibitor-free THF (80 mL). The flask was placed in an ice bath and cooled to 0 °C before the dropwise addition of 2.5M *n*BuLi in hexanes (13 mL, 37.6 mmol, 1.1 equiv.). After addition, the reaction was allowed to stir at 0 °C for 30 minutes before the addition of absolute HMPA (25.75 mL, 148 mmol, 5 equiv.). At this point the reaction was cooled to -78 °C and a solution of N-cyclohexylpropan-1-imine (4.4 g, 31.7 mmol, 1.07 equiv.) in THF (20 mL) was added dropwise. The reaction was allowed to stir an additional hour at this temperature before the dropwise addition of a solution of the diiodide **S7** (9.96 g, 29.6 mmol, 1 equiv.) in THF (25 mL). Over the course of the addition a series of color changes were observed from yellow to dark red to violet to dark blue to pale blue to colorless upon completion of the addition. After the addition, the reaction was allowed to gradually warm from -78 °C to 0 °C over the course of 4 hours. Once the reaction was complete as monitored by TLC, a 1M, pH 5 acetic acid/ sodium acetate buffer (125 mL) was added to quench the reaction. Concentrated HCL was added to return the reaction to pH 5 and the reaction was vigorously stirred for 15 minutes. Complete hydrolysis of the imine was confirmed by NMR aliquot. The reaction was diluted with diethyl ether (100 mL) and the layers were separated. The aqueous layer was extracted with diethyl ether (3 X 100 mL). The organics were combined and washed successively with 0.5N HCl (2X 150 mL), saturated sodium bicarbonate (3 X 50 mL) and brine (1 X 100 mL) before being dried over magnesium sulfate, filtered and concentrated via rotary evaporation (at 20 °C). The crude yellow oil was purified via silica gel chromatography (0% to 15% Et_2O in pentanes) to provide aldehyde **16** (5.20 g, 66%) as a light-yellow oil.

Physical State: light yellow oil
^{1}H NMR (600 MHz, CDCl3): δ 9.62 (d, *J* = 1.7 Hz, 1H), 2.54 – 2.46 (m, 3H), 2.32 (hd, *J* = 7.0, 1.7 Hz, 1H), 2.27 – 2.20 (m, 2H), 1.93 (q, *J* = 1.5 Hz, 3H), 1.87 – 1.77 (m, 1H), 1.50 – 1.40 (m, 1H), 1.13 (d, *J* = 7.1 Hz, 3H).
^{13}C NMR (151 MHz, CDCl3): δ 204.5, 139.3, 95.6, 46.0, 30.6, 30.3, 29.6, 28.7, 13.7
HRMS (ESI-TOF): Calculated for $C_9H_{15}IO$, $[M+H]^+$, 267.0241 ; found, 267.0241.
Rf = 0.65 (9:1 hexanes / ethyl acetate)



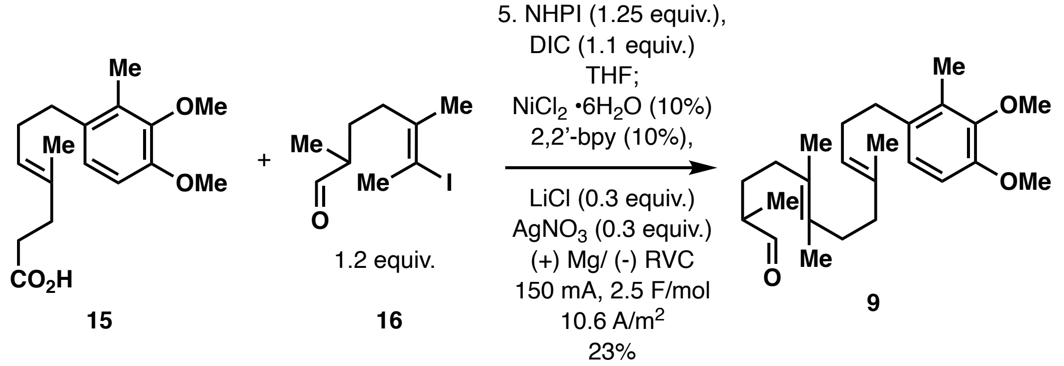
To a flask containing a stir bar and carboxylic acid **14** (6.73 g, 30 mmol, 1 equiv.) was added NHPI (6.12 g, 37.5 mmol, 1.25 equiv.) and anhydrous, inhibitor-free THF (18 mL) and allowed to stir until dissolved. This flask was placed in a water bath a room temperature (19 °C). Next, DIC (5.17 mL, 33 mmol, 1.1 equiv.) was added and the reaction was allowed to stir 2h and a white suspension formed.

To a separate flask containing a stir bar was added $NiCl_2•6H_2O$ (711 mg, 3 mmol, 0.10 equiv.), 2,2'-bipyridine (468 mg, 3 mmol, 0.10 equiv.) and lithium chloride (381 mg, 9 mmol, 0.3 equiv.). This flask was evacuated and backfilled 3 times with argon before the addition of anhydrous DMF (72 mL). This solution was allowed to stir for 20 minutes and a homogeneous, dark green solution developed. This green solution was transferred via cannula into the flask containing the *in situ* activated ester (white suspension) and the vinyl iodide **5** (9.36 g, 39 mmol, 1.3 equiv.) was added. This green suspension was split into 6 equal portions (18 mL each) via syringe and added to 6, 20mL ElectraSyn 2.0 vial under argon each containing a magnesium anode, 100 ppi RVC cathode (9 mm diameter, 40 mm length), $AgNO_3$ (255 mg, 1.5 mmol, 106 $mmol_{Ag}/m^2{}_{(cathode)}$, 0.3equiv.) and stir bar. After complete addition electrolysis was immediately started. The electrochemical reaction was performed using an ElectraSyn 2.0 and carousel under constant current conditions with the settings as follows: 150 mA, 5 mmols, 2.5 F/mol providing 10.6 A/m^2 current density. After completion of the reaction the vials were combined into a single container and quenched with 1N HCl (100 mL) and extracted with diethyl ether (3 X 100 mL). The combined organics were washed successively with distilled water (2 X 100 mL) then brine (1 X 100 mL), then dried over magnesium sulfate before being filtered and concentrated via rotary evaporation. The oily solid was purified via 15 wt% $AgNO_3$ silica gel chromatography (0% to 40% Et_2O in toluene containing 0.25% AcOH). Product fractions were collected, concentrated, and the white solid was suspended in iced toluene and filtered. The mother liquor was concentrated and this solid was further purified via silica gel chromatography (20% Et_2O in hexanes containing 0.50% AcOH) to provide carboxylic acid **15** as a white solid (4.21 g, 48% yield).

Note: Quenching and dissolution of DMF in water is exothermic and extraction of the warm reaction solution with diethyl ether can lead to boiling of the solvent.

Physical State: White Crystalline Solid
m.p. 82 – 84 ^{o}C
^{1}H NMR (500 MHz, CDCl3): δ 6.83 (d, *J* = 8.4 Hz, 1H), 6.70 (d, *J* = 8.3 Hz, 1H), 5.27 – 5.21 (m, 1H), 3.83 (s, 3H), 3.78 (s, 3H), 2.59 – 2.51 (m, 2H), 2.48 – 2.41 (m, 2H), 2.32 (t, *J* = 7.8 Hz, 2H), 2.25 – 2.19 (m, 2H), 2.23 (s, 3H), 1.57 (d, *J* = 1.3 Hz, 3H).

^{13}C NMR (151 MHz, CDCl3): δ 178.9, 151.0, 147.4, 133.8, 133.7, 130.4, 124.9, 124.3, 109.5, 60.3, 55.8, 34.4, 33.2, 32.9, 29.0, 16.0, 11.9
HRMS (ESI-TOF): calculated for $C_{17}H_{24}O_4$ $[M+H]^+$: 291.1596, found: 291.1599
Rf = 0.35 (1:1 ethyl acetate / hexanes)

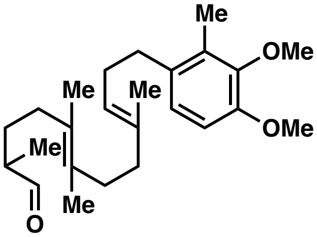


To a flask containing a stir bar and carboxylic acid **15** (1.46 g, 5 mmol, 1equiv.) was added NHPI (1.02 g, 6.25 mmol, 1.25 equiv.) and anhydrous, inhibitor-free THF (3 mL) and allowed to stir until dissolved. This flask was placed in a water bath a room temperature (19 °C). Next, DIC (0.86 mL, 5.5 mmol, 1.1 equiv.) was added and the reaction was allowed to stir 2h and a white suspension formed. To a separate flask containing a stir bar was added $NiCl_2$•$6H_2O$ (119 mg, 0.5 mmol, 0.10 equiv.), 2,2'-bipyridine (78 mg, 0.5 mmol, 0.10 equiv.) and lithium chloride (63 mg, 1.5 mmol, 0.3 equiv.). This flask was evacuated and backfilled 3 times with argon before the addition of anhydrous DMF (12 mL). This solution was allowed to stir for 20 minutes and a homogeneous, dark green solution developed. This green solution was transferred via syringe into the flask containing the *in situ* activated ester (white suspension) and the vinyl iodide **16** (1.59 g, 6 mmol, 1.2 equiv.) was added. This green suspension was added to a 20mL ElectraSyn 2.0 vial under argon containing a magnesium anode, 100 ppi RVC cathode (9 mm diameter, 40 mm length), $AgNO_3$ (255 mg, 1.5 mmol, 106 $mmol_{Ag}/m^2_{(cathode)}$, 0.3equiv.) and stir bar. After complete addition electrolysis was immediately started. The electrochemical reaction was performed using an ElectraSyn 2.0 and carousel under constant current conditions with the settings as follows: 150 mA, 5 mmols, 2.5 F/mol providing 10.6 A/m^2 current density. After completion of the reaction the vials were combined into a single container and quenched with 1N HCl (100 mL) and extracted with diethyl ether (3 X 100 mL). The combined organics were washed successively with distilled water (2 X 100 mL) then a solution of saturated sodium bicarbonate (3 X 50 mL), then brine then dried over magnesium sulfate before being filtered and concentrated via rotary evaporation. The crude residue was dissolved in ethanol (25 mL) and a saturated solution of sodium bisulfite was added. The mixture was stirred vigorously for 30 minutes and then filtered. The solid was rinsed with hexanes (2 X 20 mL) then collected and dissolved with 1N NaOH. This basic solution was extracted with diethyl ether (5 X 50 mL). The combined organics were washed with brine (1 X 50 mL), dried over magnesium sulfate and concentrated via rotary evaporation. The resulting oil was purified via silica gel chromatography (0% to 30% diethyl ether in hexanes) to provide aldehyde **9** (437 mg, 23%)

Note: Quenching and dissolution of DMF in water is exothermic and extraction of the warm reaction solution with diethyl ether can lead to boiling of the solvent

Physical State: Clear colorless oil
^{1}H NMR (600 MHz, CDCl3): δ 9.62 (d, *J* = 1.9 Hz, 1H), 6.85 (d, *J* = 8.4 Hz, 1H), 6.70 (d, *J* = 8.4 Hz, 1H), 5.20 (tq, *J* = 7.1, 1.3 Hz, 1H), 3.83 (s, 3H), 3.78 (s, 3H), 2.59 – 2.50 (m, 2H), 2.36 – 2.27 (m, 1H), 2.26 – 2.17 (m, 2H), 2.23 (s, 3H), 2.11 – 1.94 (m, 6H), 1.83 – 1.74 (m, 1H), 1.64 (dt, *J* = 4.7, 1.5 Hz, 6H), 1.59 (d, *J* = 1.3 Hz, 3H), 1.45 – 1.36 (m, 1H), 1.11 (d, *J* = 7.0 Hz, 3H).
^{13}C NMR (151 MHz, CDCl3): δ 205.3, 150.9, 147.4, 136.1, 134.0, 130.4, 129.4, 127.5, 124.2, 123.8, 109.5, 60.3, 55.9, 46.3, 38.2, 33.8, 33.4, 32.0, 29.2, 29.1, 18.3, 18.0, 16.2, 13.6, 11.9.
HRMS: Calculated for $C_{25}H_{38}O_3$, $[M+H]^+$, 387.2894; found, 387.2884.
Rf = 0.63 (4:1 hexanes / ethyl acetate)

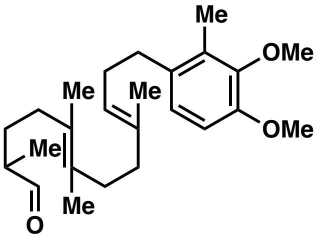
Table S7 — Celastrol’s Polyene ^{1}H Shifts Comparison



Tabulated data for Synthetic **9**
^{1}H-NMR ($CDCl_3$)

Synthetic **9** (600 MHz)	Synthetic **9** (Siegel, 600 MHz)(*64*)	Δppm
9.62 (d, *J* = 1.9 Hz, 1H)	9.62 (d, *J* = 2.1 Hz, 1H)	0.00
6.85 (d, *J* = 8.4 Hz, 1H)	6.85 (d, *J* = 8.2 Hz, 1 H)	0.00
6.70 (d, *J* = 8.4 Hz, 1H)	6.70 (d, *J* = 8.2, 1H)	0.00
5.20 (tq, *J* = 7.1, 1.3 Hz, 1H)	5.20 (dd, *J* = 7.2, 6.8 Hz, 1H)	0.00
3.83 (s, 3H)	3.84 (s, 3H)	0.01
3.78 (s, 3H)	3.78 (s, 3H)	0.00
2.59 – 2.50 (m, 2H)	2.55 (dd, *J* = 7.9, 5.8 Hz, 2H)	0.00
2.36 – 2.27 (m, 1H)	2.31 (ddd, *J* = 1.7 Hz, 1H)	0.00
2.23 (s, 3H)	2.23 (s, 3H)	0.00
2.26 – 2.17 (m, 2H)	2.24 – 2.18 (m, 2H)	0.02
2.11 – 1.94 (m, 6H)	2.10 – 1.96 (m, 6H)	0.02
1.83 – 1.74 (m, 1H)	1.78 (m, 1H)	0.00
1.64 (dt, *J* = 4.7, 1.5 Hz, 6H)	1.64 (s, 6H)	0.00
1.59 (d, *J* = 1.3 Hz, 3H)	1.59 (s, 3H)	0.00
1.45 – 1.36 (m, 1H)	1.40 (m, 1H)	0.00
1.11 (d, *J* = 7.0 Hz, 3H)	1.11 (d, *J* = 7.2 Hz, 3H)	0.00

Table S8 —Celastrol’s Polyene ^{13}C Shifts Comparison

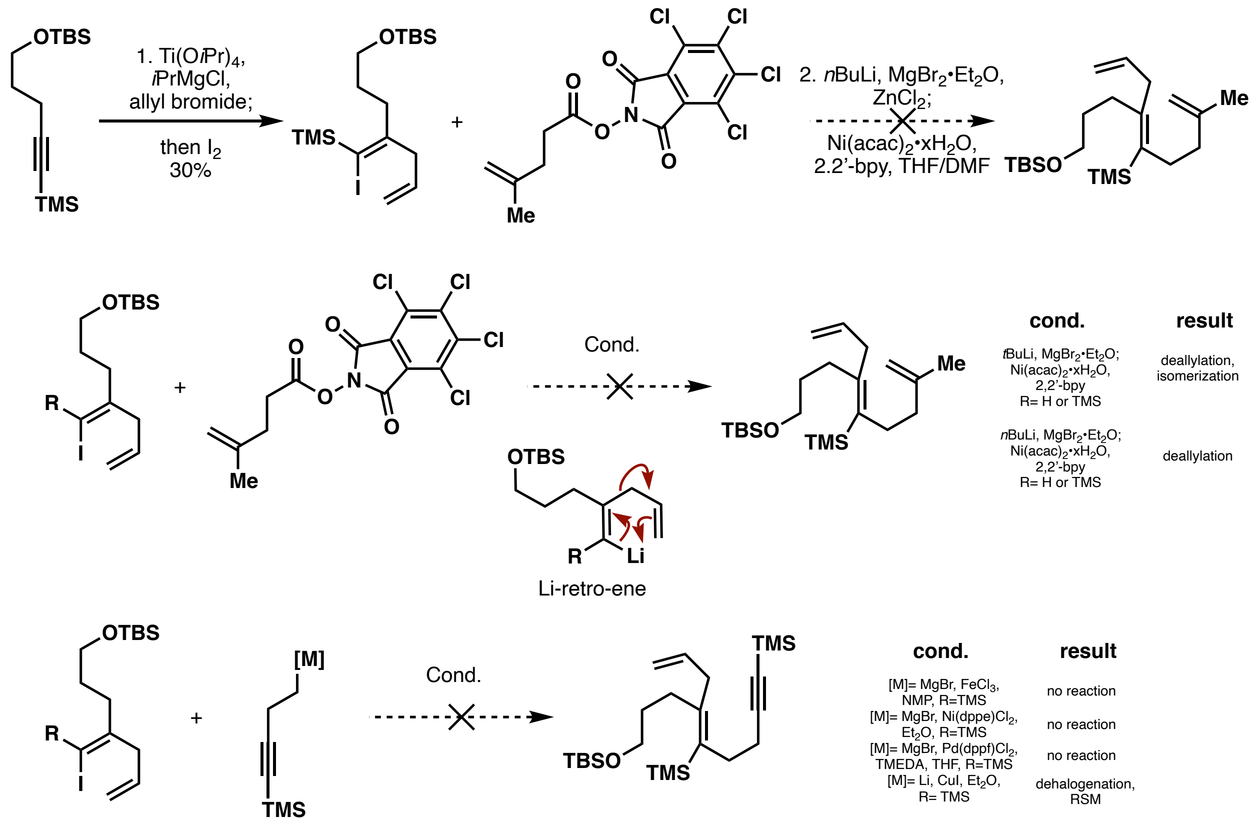


Tabulated data for Synthetic **9**
^{13}C-NMR (CDCl$_3$)

Synthetic **9** (151 MHz)	Synthetic **9** (Siegel, 100 MHz)(*64*)	Δppm
205.3	205.3	0.0
150.9	151.0	0.1
147.4	147.5	0.1
136.1	136.1	0.0
134.0	134.1	0.1
130.4	130.4	0.0
129.4	129.5	0.1
127.5	127.6	0.1
124.2	124.3	0.1
123.8	123.9	0.1
109.5	109.5	0.0
60.3	60.4	0.1
55.9	55.9	0.0
46.3	46.4	0.1
38.2	38.3	0.1
33.8	33.9	0.1
32.0	32.1	0.1
29.2	29.3	0.1
29.1	29.2	0.1
18.3	18.4	0.1
18.0	18.1	0.1
16.2	16.3	0.1
13.6	13.7	0.1
11.9	12.0	0.1

Isosteviol (procedures)

Fig S9 —Failed approach to isosteviol

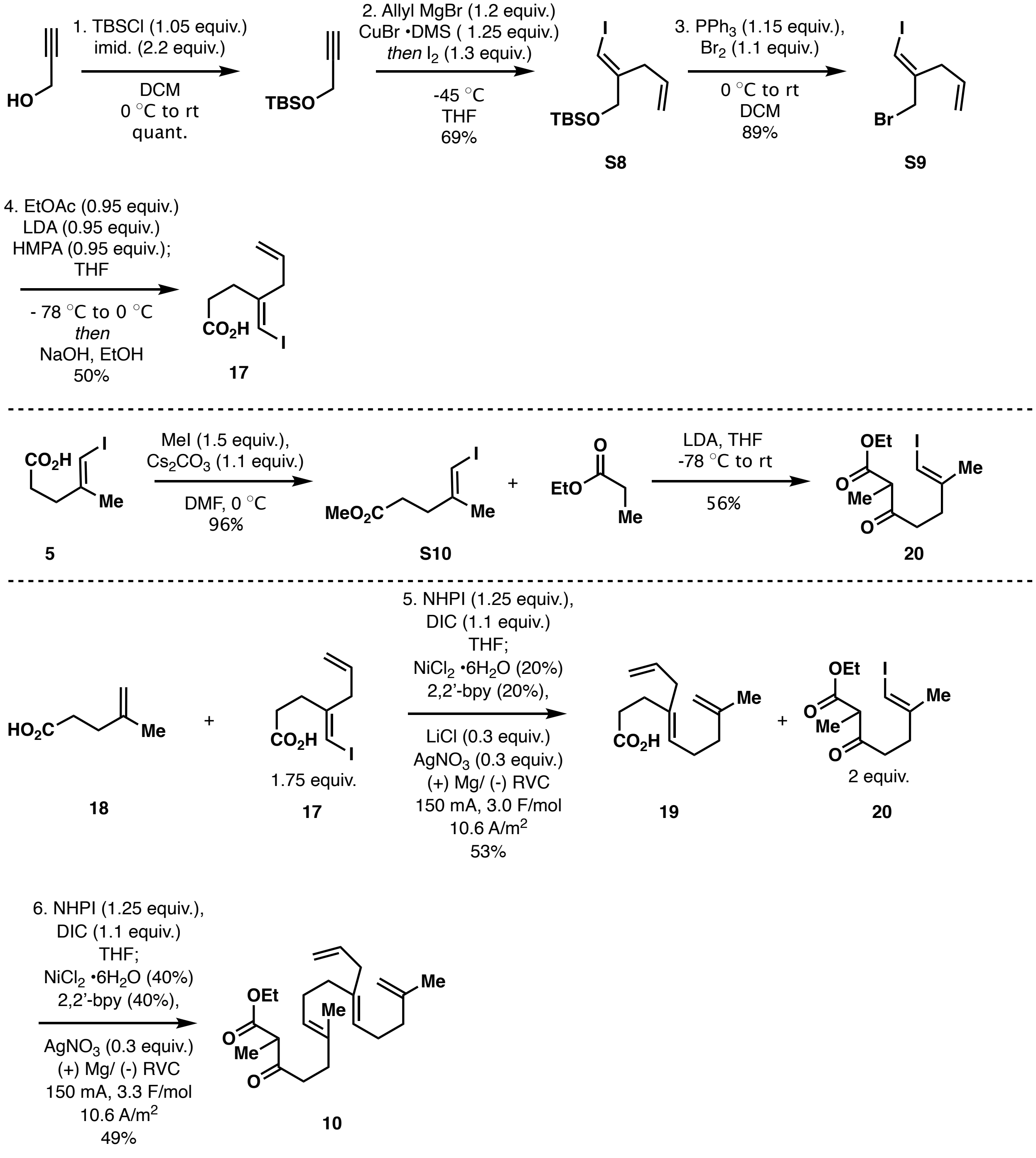


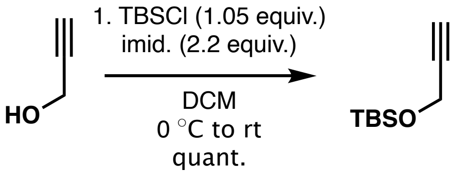
cond.	result
*t*BuLi, $MgBr_2$•Et_2O; Ni(acac)$_2$•xH_2O, 2,2'-bpy R= H or TMS	deallylation, isomerization
*n*BuLi, $MgBr_2$•Et_2O; Ni(acac)$_2$•xH_2O, 2,2'-bpy R= H or TMS	deallylation

cond.	result
[M]= MgBr, $FeCl_3$, NMP, R=TMS	no reaction
[M]= MgBr, Ni(dppe)Cl_2, Et_2O, R=TMS	no reaction
[M]= MgBr, Pd(dppf)Cl_2, TMEDA, THF, R=TMS	no reaction
[M]= Li, CuI, Et_2O, R= TMS	dehalogenation, RSM

Ultimately, the first-generation approach was abandoned after the inability to construct isosteviol. At this point, using traditional organometallic reagents for cross-coupling was recognized as an untenable strategy for a broadly-useful platform. Several attempts were made to forge this bond thorough alternative methodologies with no success. The reductive coupling approach offered a solution by avoiding unstable organometallic intermediates and gave a broader functional group tolerance than the previous methodology.

Fig S10 —Complete formal synthesis of isosteviol

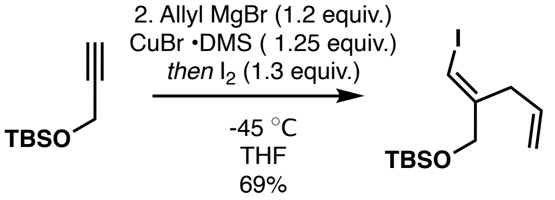




A flame dried flask was charged with stir bar, imidazole (37.84 g, 550 mmol, 2.2 equiv.), propargyl alcohol (14 g, 250 mmol, 1 equiv.), and anhydrous DCM (250 mL). Next, this flask was placed in an ice bath and allowed to cool prior to the portion-wise addition of TBSCl (38.62 g, 256 mmol, 1.05 equiv.). The reaction was allowed to warm to room temperature and monitored by TLC, where a white suspension was observed. After complete conversion (2 h), the stir bar was removed and the reaction was concentrated via rotary evaporation to remove the DCM and provide an oily white residue. The residue was diluted with pentanes (250 mL) and vacuum filtered through a silica gel plug. After rinsing the plug with pentanes (4 X 100 mL) the combined organics were concentrated via rotary evaporation to provide tert-butyldimethyl(prop-2-yn-1-yloxy)silane (42.67 g, quant.) as a clear, colorless oil.

Spectral data matched previous reports; the ^{1}H NMR data is provided here for convenience.(*65*)

^{1}H NMR (300 MHz, CDCl3): δ = 4.31 (d, J = 2.4 Hz, 2H), 2.39 (t, J = 2.4 Hz, 1H), 0.91 (s, 9H), 0.13 (s, 6H).

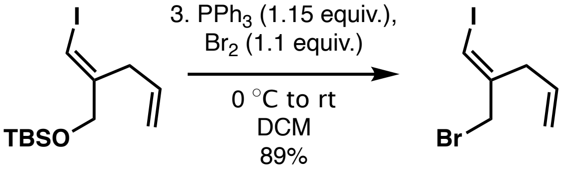


S8

Procedure adapted from a literature procedure. (*66*)

To a flame dried flask and stir bar was added freshly prepared copper bromide dimethylsulfide complex (13.58 g, 66.03mmol, 1.25 equiv.) (prepared via House procedure (*67*)). The flask was evacuated and backfilled three times with argon prior to the addition of anhydrous, inhibitor-free THF (260 mL). This suspension was cooled to –45 °C and allyl magnesium chloride (2 M in THF, 31.7 mL, 63.4 mmol, 1.2 equiv.) was added dropwise. The reaction turned a dark red and was stirred for 1.5 h at this temperature. Next, a solution of *tert*-butyl-dimethyl-prop-2-ynyloxy-silane (9 g, 52.8 mmol, 1 equiv.) in THF (75 mL) was added dropwise at –45 °C and the reaction was allowed to stir for 10.5 h at this temperature. To this black reaction, A solution of iodine (17.44 g, 68.7 mmol, 1.3 equiv.) in THF (50 mL) was transferred via cannula at –45 °C and the reaction was stirred an additional 1.5 h. Over this time a red suspension developed. The reaction was quenched with a solution of saturated ammonium chloride (100 mL) at –45 °C. The reaction was removed from the cryogenic bath and further diluted with a 9:1 solution of saturated ammonium chloride: ammonium hydroxide (400 mL). The quenched reaction was stirred vigorously while air was bubbled through it until a dark blue biphasic solution formed. The reaction was diluted with hexane and the aqueous layer was extracted with hexanes (2 X 200 mL). The combined organics were vigorously mixed and washed with the 9:1 ammonium: ammonia hydroxide solution (4 X 100mL) until no trace of a blue or green color in the aqueous layer was observed. The combined organics were washed next with a 1:1 solution of saturated sodium bicarbonate: saturated sodium thiosulfate followed by brine before being dried over magnesium sulfate. Purification was achieved via silica gel chromatography (4% DCM in hexanes) to provide vinyl iodide **S8** (12.4 g, 69%) as a pale-yellow oil.

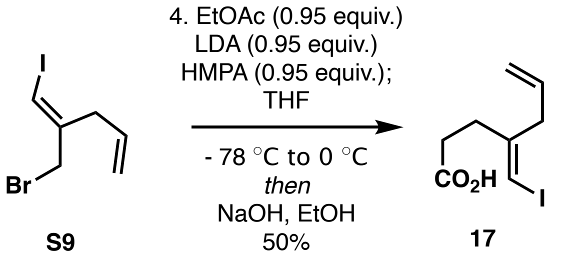
Physical State: pale-yellow oil
^{1}H NMR (500 MHz, CDCl3): δ 6.30 (t, *J* = 1.7 Hz, 1H), 5.74 (ddt, *J* = 17.1, 10.0, 6.6 Hz, 1H), 5.13 (dq, *J* = 17.1, 1.6 Hz, 1H), 5.07 (dq, *J* = 10.0, 1.4 Hz, 1H), 4.12 (d, *J* = 1.6 Hz, 2H), 2.94 (dt, *J* = 6.7, 1.6 Hz, 2H), 0.90 (s, 9H), 0.06 (s, 6H).
^{13}C NMR (151 MHz, CDCl3): δ 148.1, 133.5, 116.8, 77.2, 65.8, 39.3, 26.0, 18.5, -5.3
HRMS (ESI-TOF): calculated for $C_{12}H_{23}IOSi$ $[M+H]^+$: 339.0641, found: 339.0643
TLC: R_f = 0.68 (9:1 Hexanes / EtOAc)



S8 **S9**

To a flame dried flask and stir bar was added triphenylphospine (66.07 g, 251.9 mmol, 1.15 equiv.). This flask was evacuated and backfilled with argon three times prior to the addition of anhydrous DCM (1 L) and cooling to 0 °C. After dissolution, bromine (39.37 g, 246.4 mmol, 1.13 equiv.) was added dropwise and the reaction was stirred 20 minutes at this temperature. A white precipitate was observed. Next, a solution of ether **S8** (74.09 g, 219 mmol, 1.0 equiv.) in DCM (100 mL) was transferred via cannula at 0°C. After addition, the reaction was allowed to warm to room temperature and monitored by TLC for complete consumption of starting material. After 5.5h the reaction was diluted with pentane and silica gel was added to the reaction. The reaction was filtered through a plug of silica gel, and this plug was rinsed with pentane (3 X 200 mL). The combined organics were concentrated via rotary evaporation and the crude reaction mixture was purified via silica gel chromatography (100% pentane) to provide allylic bromide **S9** (56.13 g, 89%) as a pale-yellow oil.

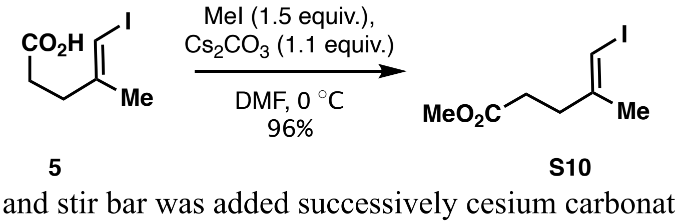
Physical State: pale-yellow oil
^{1}H NMR (500 MHz, CDCl3): δ 6.75 – 6.53 (m, 1H), 5.74 (ddt, *J* = 16.9, 10.0, 6.7 Hz, 1H), 5.20 (dq, *J* = 17.1, 1.6 Hz, 1H), 5.15 (dq, *J* = 10.0, 1.3 Hz, 1H), 4.05 (d, *J* = 0.8 Hz, 2H), 3.17 (dt, *J* = 6.8, 1.4 Hz, 2H).
^{13}C NMR (151 MHz, CDCl3): δ 145.1, 132.8, 118.0, 83.6, 39.5, 34.5
MS (GCMS): calculated for C_4H_6BrI $[M]^{+\bullet}$: 259.8698, found: 259.9
Note: HRMS with ESI-TOF unable to detect desired mass
TLC: R_f = 0.91 (9:1 Hexanes / EtOAc)



S9 **17**

A flame dried flask and stir bar under argon charged with diisopropyl amine (26.2 mL, 186 mmol, 0.95 equiv.) and anhydrous THF (500 mL) was cooled to 0 °C prior to the dropwise addition of *n*BuLi (74.3 mL, 186 mmol, 0.95 equiv., 2.5 M in hexane.). This reaction was allowed to stir for 30 minutes. Next, absolute HMPA (32.3 mL, 186 mmol, 0.95 equiv.) was added and the reaction was cooled to –78 °C. After reaching –78 °C, anhydrous ethyl acetate (18.11 mL, 186 mmol, 0.95 equiv.) in anhydrous THF (500 mL) was transferred via cannula over 30 minutes. The reaction was allowed to stir at this temperature for 1h before the addition of a solution of allylic bromide **S9** (56.13 g, 196 mmol, 1 equiv.) in anhydrous THF (500 mL) via cannula over 30 minutes. The reaction was stirred at –78 °C for 2.5 h and monitored by TLC. The reaction was quenched with the addition of 1 L of absolute ethanol then water (500 mL). The reaction was removed from the cryogenic bath and sodium hydroxide was added as a solid (39.12 g, 978 mmol, 5 equiv.). The reaction was allowed to stir at room temperature and monitored by TLC for full consumption of the ester (ca. 3 h). After complete consumption, the aqueous layer was extracted with hexanes (3 X 200 mL), acidified to pH 1 with conc. HCl, and extracted again with diethyl ether (4 X 200 mL). The combined ether extractions were washed with water (3 X 200 mL) then brine (1 X 200 mL) before being dried over magnesium sulfate and concentrated via rotary evaporation. The product was purified via silica gel chromatography (0% to 30% ethyl acetate in hexanes) to provide acid **17** as a pale-yellow oil (26.0g, 50%).

Physical State: pale-yellow oil
^{1}H NMR (500 MHz, CDCl3): δ 6.09 (d, *J* = 1.3 Hz, 1H), 5.73 (ddt, *J* = 16.7, 10.0, 6.6 Hz, 1H), 5.15 (dq, *J* = 17.1, 1.6 Hz, 1H), 5.11 (dq, *J* = 10.0, 1.4 Hz, 1H), 3.01 (dt, *J* = 6.6, 1.5 Hz, 2H), 2.55 – 2.48 (m, 4H).
^{13}C NMR (151 MHz, CDCl3): δ 178.6, 147.2, 133.5, 117.3, 77.3, 42.0, 32.4, 31.8
HRMS (ESI-TOF): calculated for $C_8H_{11}IO_2$ $[M+H]^+$: 266.9882, found: 266.9886
TLC: R_f = 0.45 (1:1 Hexanes / EtOAc)

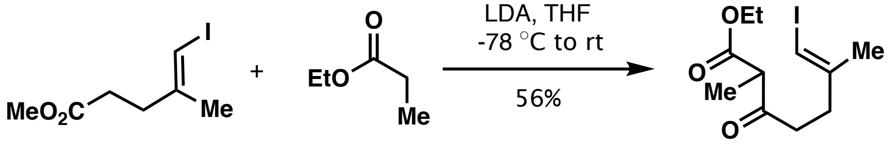


5 **S10**

To a flame dried flask and stir bar was added successively cesium carbonate (47.88 g, 147 mmol, 1.1 equiv.), anhydrous DMF (250 mL), acid **5** (32.06 g, 134 mmol, 1 equiv.), then methyl iodide (12.4 mL, 200 mmol, 1.5 equiv.) dropwise. The reaction was allowed to stir overnight before being diluted with hexanes (300 mL) and water (300 mL). The aqueous layer was extracted with hexanes (2X 100 mL). The combined organics were washed with water (2 X 200 mL) then brine (1 X 100 mL) before being dried over magnesium sulfate and concentrated via rotary evaporation to provide ester **S10** (32.52 g, 96%). The product was used in the next step without further purification.

Physical State: Clear colorless oil
^{1}H NMR (600 MHz, CDCl3): 5.97 (q, *J* = 1.2 Hz, 1H), 3.67 (s, 3H), 2.53 (ddt, *J* = 8.1, 6.5, 1.2 Hz, 2H), 2.45 (ddd, *J* = 8.2, 6.8, 1.1 Hz, 2H), 1.85 (d, *J* = 1.2 Hz, 3H).
^{13}C NMR (151 MHz, CDCl3): 173.1, 146.2, 76.1, 51.9, 34.5, 32.6, 24.0
MS (GCMS): calculated for $C_7H_{11}IO_2$ $[M]^{+\bullet}$: 253.9804, found: 254.0
Note: HRMS with ESI-TOF unable to detect desired mass

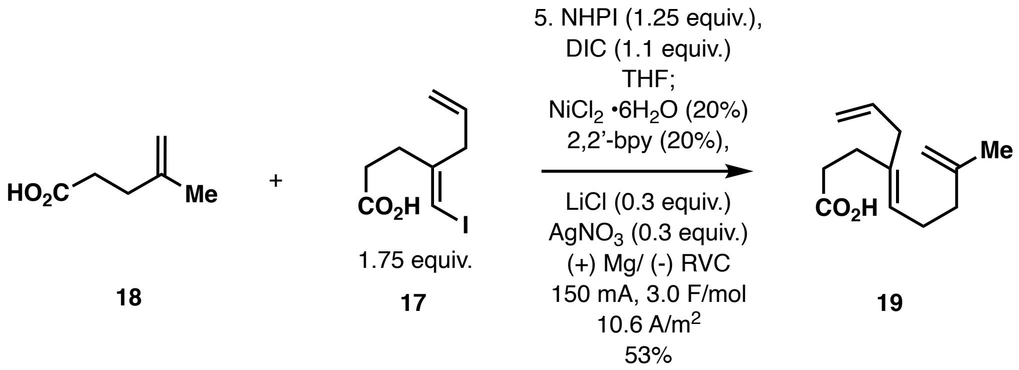
TLC: R_f = 0.62 (3:1 hexanes / ethyl acetate)



S10 **20**

A flame dried three-neck flask with two addition funnels and stir bar under argon charged with diisopropyl amine (55.1 mL, 390 mmol, 3.05 equiv.) and anhydrous THF (500 mL) was cooled to 0 °C prior to the dropwise addition of *n*BuLi (156 mL, 390 mmol, 3.05 equiv., 2.5 M in hexane). The solution was cooled to -78 °C and ethyl propionate (44 mL, 384 mmol, 3 equiv.) was added over 30 minutes. The reaction was stirred an additional 45 minutes at this temperature then methyl ester **S10** (32.52 g, 128 mmol, 1 equiv.) was added dropwise as a solution in THF (150 mL) via addition funnel over 20 minutes. The reaction was stirred 1 h at this temperature before being allowed to warm to room temperature and stirred overnight. The reaction was quenched with saturated ammonium chloride and diluted with diethyl ether (200 mL). The aqueous layer was extracted with diethyl ether (3 X 200 mL) and the combined organics were washed with brine (1X 200 mL), dried over magnesium sulfate, and concentrated via rotary evaporation. The crude yellow oil was purified via vacuum distillation (9 torr, 160 °C bath temp, 139 °C boiling point) followed by silica gel chromatography (0% to 40% ethyl acetate in hexanes) to provide β-keto ester **20** (23.34 g, 72 mmol, 56%) as a pale-yellow oil.

Physical State: Clear colorless oil
^{1}H NMR (600 MHz, CDCl3): 5.95 (h, *J* = 1.2 Hz, 1H), 4.19 (qd, *J* = 7.1, 0.6 Hz, 2H), 3.50 (q, *J* = 7.1 Hz, 1H), 2.74 (ddd, *J* = 17.6, 8.5, 6.7 Hz, 1H), 2.66 – 2.59 (m, 1H), 2.52 – 2.47 (m, 2H), 1.84 (d, *J* = 1.1 Hz, 3H), 1.33 (d, *J* = 7.2 Hz, 3H), 1.27 (t, *J* = 7.1 Hz, 3H).
^{13}C NMR (151 MHz, CDCl3): 204.6, 170.5, 146.3, 75.9, 61.6, 53.1, 39.5, 33.0, 24.1, 14.3, 12.9
HRMS (ESI-TOF): Calculated for $C_{11}H_{17}IO_3$, $[M+H]^+$, 325.0295; found, 325.0299.
TLC: R_f = 0.54 (3:1 hexanes / ethyl acetate)



18 **17** **19**

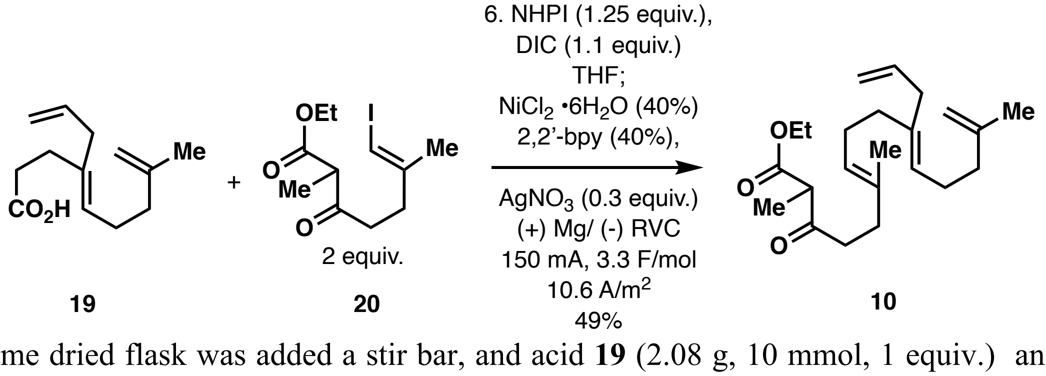
To a flame dried flask was added a stir bar, and 4-methylpent-4-enoic acid (**18**) (2.28 g, 20 mmol, 1 equiv.) and NHPI (4.08 g, 25 mmol, 1.25 equiv.). Next, the flask was sealed with a septum, evacuated and backfilled three times with argon before the addition of THF (12 mL). The flask was placed in a water bath at room temperature (19 °C) and DIC (3.44 mL, 22 mmol, 1.1 equiv.) was added. The activation was allowed to stir for two hours and a white suspension formed.

To a separate flask containing a stir bar was added NiCl$_2$•6H$_2$O (948 mg, 4 mmol, 0.20 equiv.), 2,2'-bipyridine (624 mg, 4 mmol, 0.20 equiv.) and lithium chloride (252 mg, 6 mmol, 0.3 equiv.). This flask was evacuated and backfilled 3 times with argon before the addition of anhydrous, inhibitor-free DMF (48 mL). This solution was allowed to stir for 20 minutes and a homogeneous, dark green solution developed. This green solution was transferred via cannula into the flask containing the *in situ* activated ester (white suspension) and the vinyl iodide **17** (9.31 g, 35 mmol, 1.75 equiv.) was added. This green suspension was split into four equal portions (18 mL each) via syringe and added to 4, 20 mL ElectraSyn 2.0 vial under argon each containing a magnesium anode, 100 ppi RVC cathode (9 mm diameter, 40 mm length), AgNO$_3$ (255 mg, 1.5 mmol, 106 mmol$_{Ag}$/m$^2{}_{(cathode)}$, 0.3 equiv.) and stir bar. After complete addition electrolysis was immediately started. The electrochemical reaction was performed using an ElectraSyn 2.0 and carousel under constant current conditions with the settings as follows: 150 mA, 5 mmols, 3.0 F/mol providing 10.6 A/m^2 current density. After completion of the reaction, the four vials were combined into a single flask and quenched with 1N HCl (100 mL) and extracted with diethyl ether (3 X 100 mL). The combined organics were washed successively with distilled water (2 X 50 mL) then brine (1X 50 mL), then dried over magnesium sulfate before being filtered and concentrated via rotary evaporation. The oily solid was purified via silica gel chromatography (12.5% ethyl acetate in hexanes). Product fractions were collected and concentrated to provide acid **19** as a pale-yellow oil was obtained (2.22 g, 53%).

Note: Quenching and dissolution of DMF in water is exothermic and extraction of still the warm reaction solution with diethyl ether can lead to boiling of the solvent. An additional 10% of catalyst was found to dramatically improve the yield with this substrate, possibly a result of some catalyst becoming coordinated with the substrates or products of the reaction.

Physical State: pale yellow oil
^{1}H NMR (500 MHz, CDCl3): δ 5.73 (ddt, *J* = 16.7, 10.0, 6.4 Hz, 1H), 5.25 (t, *J* = 7.0 Hz, 1H), 5.05 (dq, *J* = 17.1, 1.8 Hz, 1H), 5.01 (dq, *J* = 10.1, 1.6 Hz, 1H), 4.73 – 4.64 (m, 2H), 2.80 (dt, *J* = 6.1, 1.7 Hz, 2H), 2.49 – 2.42 (m, 2H), 2.32 (ddt, *J* = 8.7, 6.5, 1.1 Hz, 2H), 2.19 – 2.11 (m, 2H), 2.04 (dd, *J* = 9.0, 6.3 Hz, 2H), 1.71 (s, 3H).

^{13}C NMR (125 MHz, CDCl3): δ 179.4, 145.6, 136.0, 135.1, 126.5, 115.7, 110.2, 37.9, 35.0, 33.0, 31.7, 26.1, 22.6.
HRMS (ESI-TOF): Calculated for $C_{13}H_{20}O_2$, $[M+H]^+$, 209.1536; found, 209.1536.
Rf = 0.58 (1:1 ethyl acetate / hexanes)



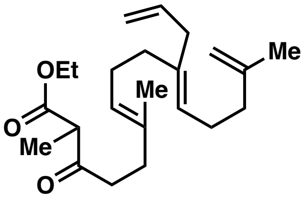
To a flame dried flask was added a stir bar, and acid **19** (2.08 g, 10 mmol, 1 equiv.) and NHPI (2.04 g, 12.5 mmol, 1.25 equiv.). Next, the flask was sealed with a septum, evacuated and backfilled three times with argon before the addition of THF (6 mL). The flask was placed in a water bath at room temperature (19 °C) and DIC (1.72 mL, 11 mmol, 1.1 equiv.) was added. The activation was allowed to stir for two hours and a white suspension formed.

To a separate flask containing a stir bar was added $NiCl_2•6H_2O$ (948 mg, 4 mmol, 0.40 equiv.) and 2,2'-bipyridine (624 mg, 4 mmol, 0.40 equiv.). This flask was evacuated and backfilled 3 times with argon before the addition of anhydrous, inhibitor-free DMF (24 mL). This solution was allowed to stir for 20 minutes and a green suspension developed. This green suspension was transferred via cannula into the flask containing the *in situ* activated ester (white suspension) and the vinyl iodide **20** (6.48 g, 20 mmol, 2 equiv.) was added. This green suspension was split into two equal portions (18 mL each) via syringe and added to 2, 20 mL ElectraSyn 2.0 vial under argon each containing a magnesium anode, 100 ppi RVC cathode (9 mm diameter, 40 mm length), $AgNO_3$ (255 mg, 1.5 mmol, 106 $mmol_{Ag}/m^2_{(cathode)}$, 0.3 equiv.) and stir bar. After complete addition electrolysis was immediately started. The electrochemical reaction was performed using an ElectraSyn 2.0 and carousel under constant current conditions with the settings as follows: 150 mA, 5 mmols, 3.3 F/mol providing 10.6 A/m^2 current density. After completion of the reaction, the four vials were combined into a single flask and quenched with 1N HCl (100 mL) and extracted with diethyl ether (3 X 100 mL). The combined organics were washed successively with distilled water (2 X 50 mL), saturated sodium bicarbonate solution (3 X 50 mL), then brine (1 X 50 mL), then dried over magnesium sulfate before being filtered and concentrated via rotary evaporation. The oily solid was purified via silica gel chromatography (2% diethyl ether, 38% benzene, 60% hexanes). Product fractions were collected and concentrated to provide polyene **10** as a pale-yellow oil was obtained (1.77g, 49%).

Notes: Quenching and dissolution of DMF in water is exothermic and extraction of still the warm reaction solution with diethyl ether can lead to boiling of the solvent. Additional catalyst was used to remove the cyclization isomer generated through the 5-exo-trig cyclization of the primary radical generated after decarboxylation reacting with the pendant allyl group and subsequent cross-coupling with the vinyl iodide. Should less nickel be required, the two isomers can be *separated through silica gel chromatography using 15% $AgNO_3$ impregnated silica gel (0- 30% Et_2O in hexanes).*

Physical State: pale-yellow oil
^{1}H NMR (600 MHz, CDCl3): δ 5.73 (ddt, *J* = 16.6, 10.0, 6.5 Hz, 1H), 5.23 – 5.17 (m, 1H), 5.11 (tq, *J* = 7.0, 1.3 Hz, 1H), 5.03 (dq, *J* = 17.0, 1.7 Hz, 1H), 4.98 (dq, *J* = 10.0, 1.5 Hz, 1H), 4.71 (ddh, *J* = 2.1, 1.5, 0.7 Hz, 1H), 4.67 (dq, *J* = 2.2, 1.2 Hz, 1H), 4.19 (qd, *J* = 7.2, 1.4 Hz, 2H), 3.51 (q, *J* = 7.2 Hz, 1H), 2.78 (dt, *J* = 6.5, 1.8 Hz, 2H), 2.70 – 2.54 (m, 2H), 2.29 – 2.22 (m, 2H), 2.19 – 2.11 (m, 2H), 2.09 – 2.01 (m, 4H), 1.98 (ddt, *J* = 9.5, 7.2, 1.1 Hz, 2H), 1.72 (t, *J* = 1.1 Hz, 3H), 1.59 (d, *J* = 1.3 Hz, 3H), 1.33 (d, *J* = 7.1 Hz, 3H), 1.27 (t, *J* = 7.1 Hz, 3H).
^{13}C NMR (151 MHz, CDCl3): δ 205.7, 170.7, 145.8, 136.8, 136.5, 133.5, 125.7, 125.2, 115.2, 110.1, 61.5, 53.0, 40.3, 38.1, 36.9, 35.1, 33.4, 26.8, 26.2, 22.6, 16.2, 14.2, 12.9
HRMS (ESI-TOF): Calculated for $C_{23}H_{36}O_3$, $[M+H]^+$, 361.2737; found, 361.2739.
Rf = 0.65 (3:1 hexanes / ethyl acetate)

Table S9 —Isosteviol's Polyene ^{1}H Shifts Comparison

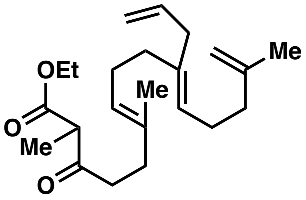


Tabulated data for Synthetic **10**
^{1}H-NMR ($CDCl_3$)

Synthetic **10** (600 MHz)	Synthetic **10** (Snider, 400 MHz)(*68*)	Δppm
5.73 (ddt, *J* = 16.6, 10.0, 6.5 Hz, 1H)	5.73 (ddt, *J* = 16.6, 10.0, 6.4 Hz, 1H)	0.00
5.23 – 5.17 (m, 1H)	5.20 (br t, *J* = 6.8 Hz, 1H)	0.00
5.11 (tq, *J* = 7.0, 1.3 Hz, 1H)	5.11 (dt, *J* = 6.8, 1.4 Hz, 1H)	0.00
5.03 (dq, *J* = 17.0, 1.7 Hz, 1H)	5.03 (br d, *J* = 16.6 Hz, 1H)	0.00
4.98 (dq, *J* = 10.0, 1.5 Hz, 1H)	4.98 (br d, *J* = 10.0 Hz, 1H)	0.00
4.71 (ddh, *J* = 2.1, 1.5, 0.7 Hz, 1H)	4.71 (br s, 1H)	0.00
4.67 (dq, *J* = 2.2, 1.2 Hz, 1H)	4.68 (br s, 1H)	0.01
4.19 (qd, *J* = 7.2, 1.4 Hz, 2H)	4.19 (q, *J* = 7.1 Hz, 2H)	0.00
3.51 (q, *J* = 7.2 Hz, 1H)	3.52 (q, *J* = 7.1 Hz, 1H)	0.01
2.78 (dt, *J* = 6.5, 1.8 Hz, 2H)	2.78 (br d, *J* = 6.4 Hz, 2H)	0.00
2.70 – 2.54 (m, 2H)	2.67 (dt, *J* = 17.1, 7.8 Hz, 1H) 2.58 (dt, *J* = 17.1, 7.4 Hz, 1H)	N/A
2.29 – 2.22 (m, 2H)	2.25 (br t, *J* = 7.8 Hz, 2H)	0.00
2.19 – 2.11 (m, 2H) 2.09 – 2.01 (m, 4H) 1.98 (ddt, *J* = 9.5, 7.2, 1.1 Hz, 2H)	2.20 – 1.98 (m, 8H)	N/A

1.72 (t, *J* = 1.1 Hz, 3H)	1.72 (s, 3H)	0.00
1.59 (d, *J* = 1.3 Hz, 3H)	1.59 (s, 3H)	0.00
1.33 (d, *J* = 7.1 Hz, 3H)	1.33 (d, *J* = 7.1 Hz, 3H)	0.00
1.27 (t, *J* = 7.1 Hz, 3H)	1.27 (t, *J* = 7.1 Hz, 3H)	0.00

Table S10 —Isosteviol's Polyene ^{1}H Shifts Comparison

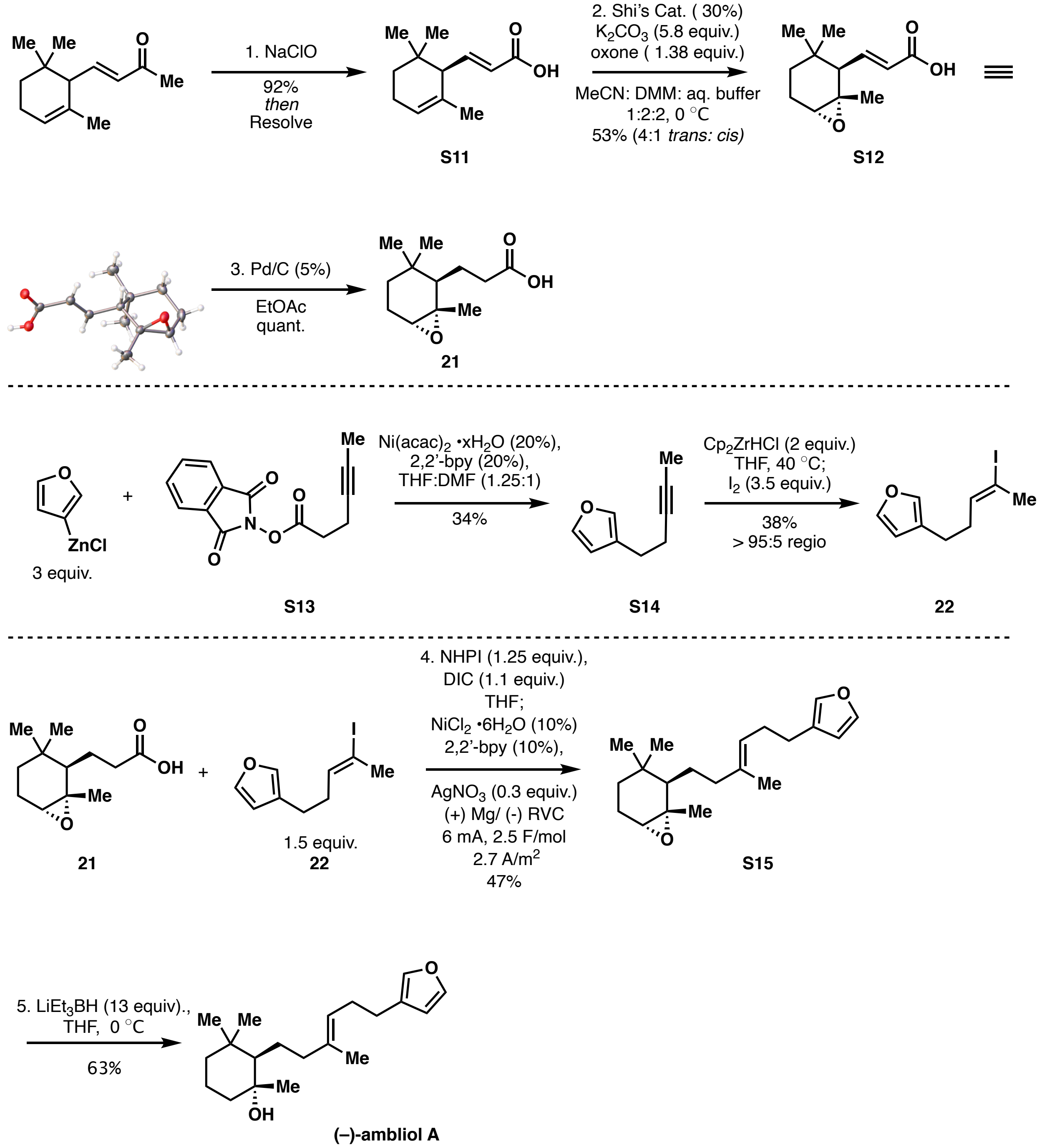


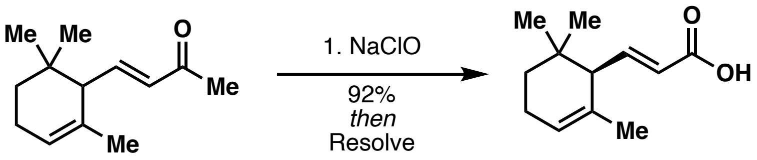
Tabulated data for Synthetic **10**
^{13}C-NMR ($CDCl_3$)

Synthetic **10** (151 MHz)	Synthetic **10** (Snider, 100 MHz)(*68*)	Δppm
205.7	205.5	0.2
170.7	170.5	0.2
145.8	145.6	0.2
136.8	136.6	0.2
136.5	136.3	0.2
133.5	133.3	0.2
125.7	125.5	0.2
125.2	125.0	0.2
115.2	115.0	0.2
110.1	109.9	0.2
61.5	61.2	0.3
53.0	52.9	0.1
40.3	40.1	0.2
38.1	37.9	0.2
36.9	36.8	0.1
35.1	34.9	0.2
33.4	33.2	0.2
26.8	26.6	0.2
26.2	26.0	0.2
22.6	22.4	0.2
16.2	16.0	0.2
14.2	14.1	0.1
12.9	12.7	0.2

(–)-Ambliol A (procedures)

Fig S11 — (–)-ambliol A complete total synthesis





S11

Haloform Reaction and resolution procedure was adapted from a literature procedure. (*69*)

α-ionone (20 mL, 97 mmol) was reacted using the known procedure to provide product acid **rac-S11** (17.254 g, 92%). This crude product resolved through the reported crystallization using R-phenethylamine. Nine rounds of crystallization were conducted to provide the product acid **S11** with a final enantiomeric excess of 94%.

Spectral data matched previous reports; the ^{1}H NMR data is provided here for convenience. (*69*)

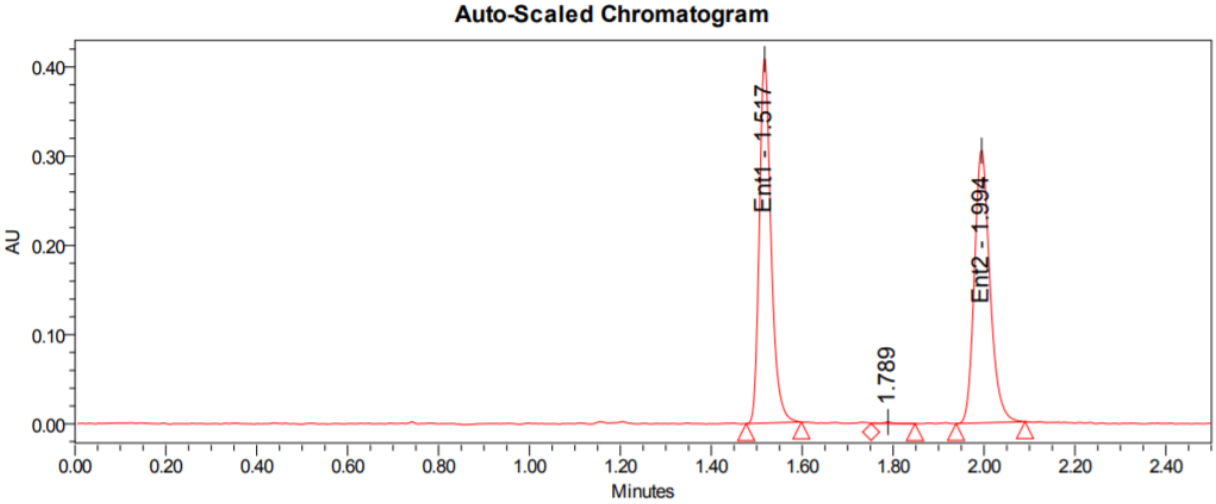
^{1}H NMR (400 MHz, CDCl$_3$): δ 6.92 (dd, *J* = 15.4, 9.9 Hz, 1H), 5.81 (d, *J* = 15.4 Hz, 1H), 5.50 (br s, 1H), 2.31 (d, *J* = 9.9 Hz, 1H), 2.04 (br s, 2H), 1.57 (d, *J* = 1.5 Hz, 3H), 1.47 (m, 1H), 1.20 (m, 1H), 0.93 (s, 3H), 0.86 (s, 3H).

Racemic sample LC standard

SJH-F-015-rac	49.98	50.02	-0.05	727100	727795

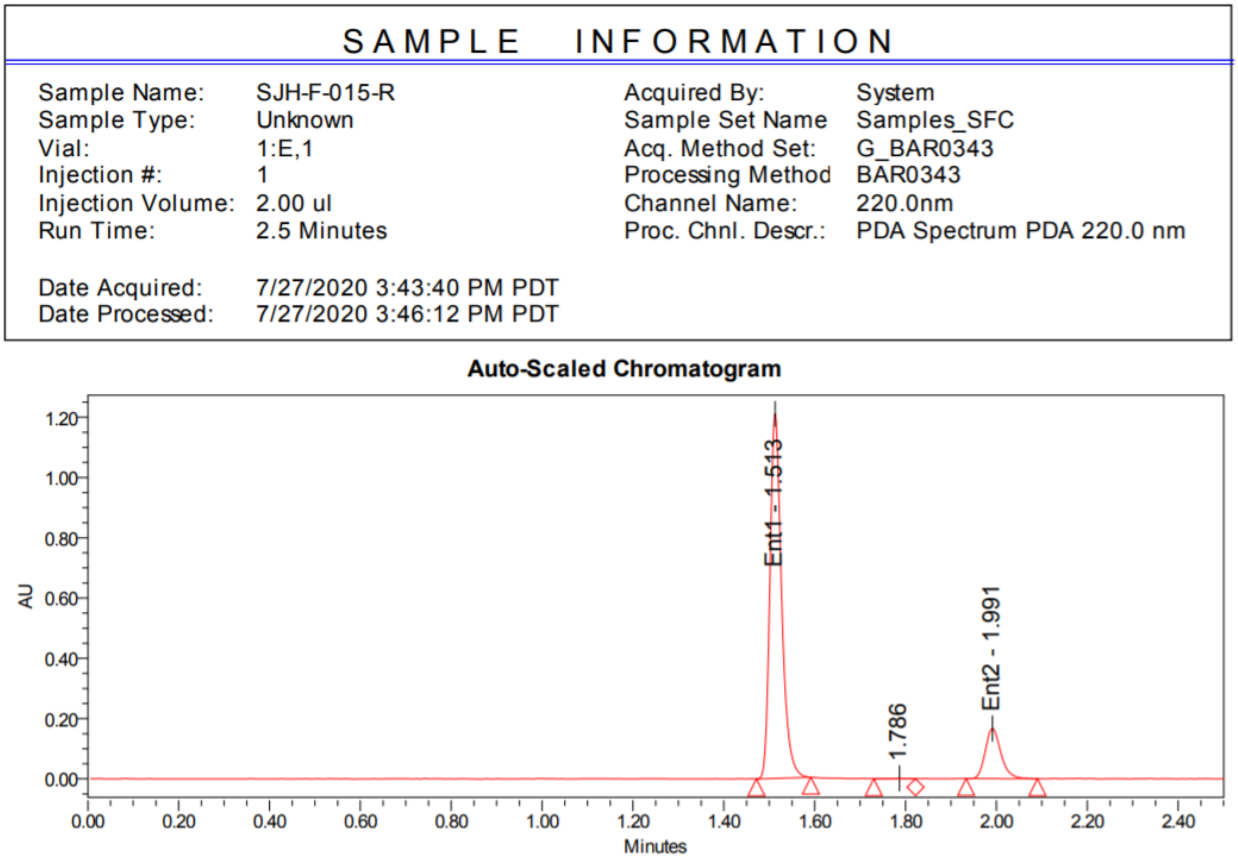
SAMPLE INFORMATION

Sample Name:	SJH-F-015-rac	Acquired By:	System
Sample Type:	Unknown	Sample Set Name	Samples_SFC
Vial:	1:C,5	Acq. Method Set:	G_BAR0343
Injection #:	1	Processing Method	BAR0343
Injection Volume:	2.00 ul	Channel Name:	220.0nm
Run Time:	2.5 Minutes	Proc. Chnl. Descr.:	PDA Spectrum PDA 220.0 nm
Date Acquired:	7/27/2020 3:38:01 PM PDT		
Date Processed:	7/27/2020 3:40:34 PM PDT		



3 Rounds of crystallization 69% ee

SJH-F-015-R	84.33	15.67	68.66	2145723	398691



SAMPLE INFORMATION

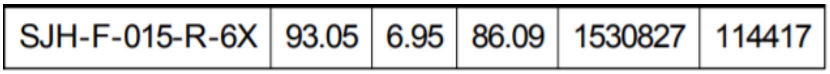
Sample Name: SJH-F-015-R
Sample Type: Unknown
Vial: 1:E,1
Injection #: 1
Injection Volume: 2.00 ul
Run Time: 2.5 Minutes

Acquired By: System
Sample Set Name Samples_SFC
Acq. Method Set: G_BAR0343
Processing Method BAR0343
Channel Name: 220.0nm
Proc. Chnl. Descr.: PDA Spectrum PDA 220.0 nm

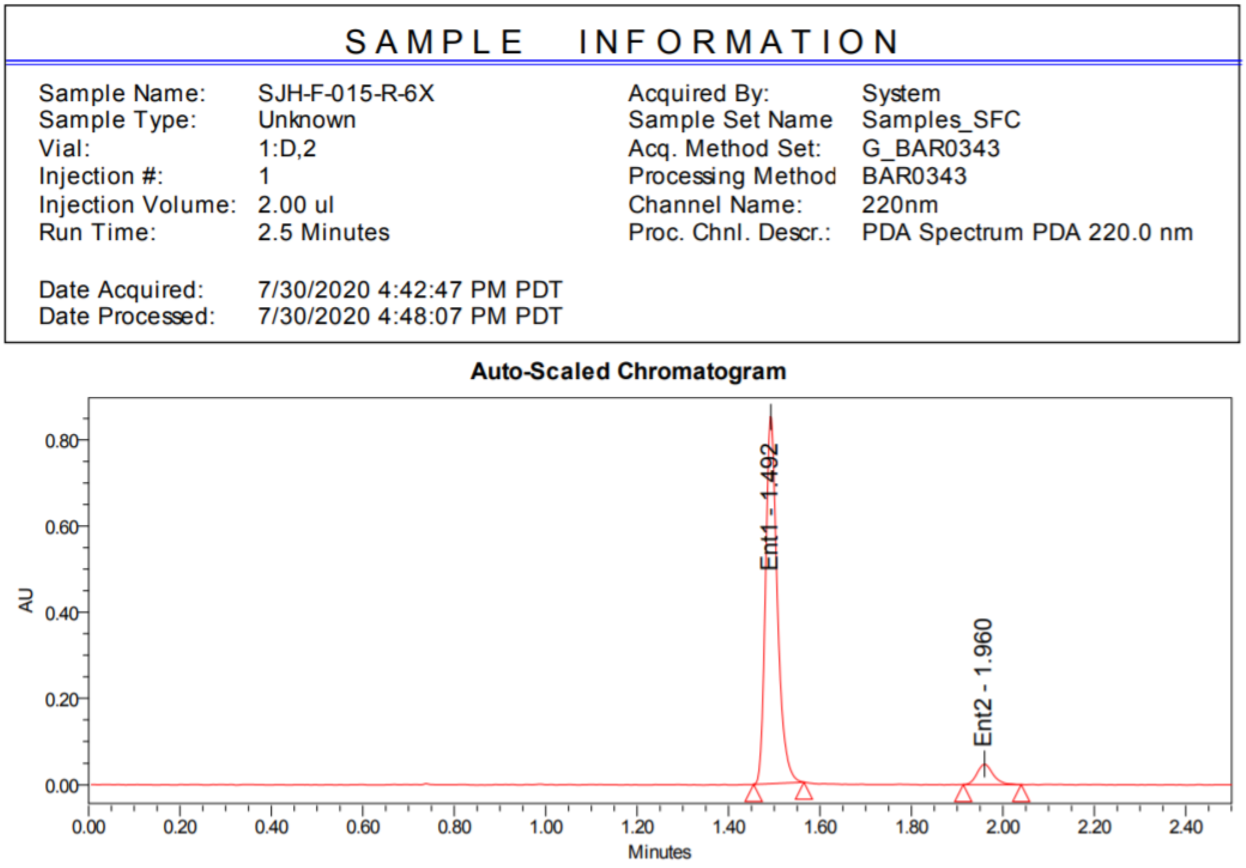
Date Acquired: 7/27/2020 3:43:40 PM PDT
Date Processed: 7/27/2020 3:46:12 PM PDT

Auto-Scaled Chromatogram

6 Rounds of crystallization 86% ee



SJH-F-015-R-6X	93.05	6.95	86.09	1530827	114417



SAMPLE INFORMATION

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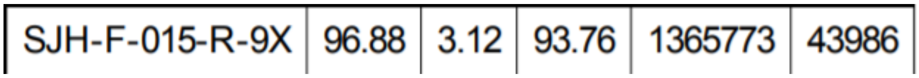
Injection #:	1	Processing Method	BAR0343
Injection Volume:	2.00 ul	Channel Name:	220nm
Run Time:	2.5 Minutes	Proc. Chnl. Descr.:	PDA Spectrum PDA 220.0 nm
Date Acquired:	7/30/2020 4:42:47 PM PDT		
Date Processed:	7/30/2020 4:48:07 PM PDT		

Auto-Scaled Chromatogram

9 rounds of crystallization 94% ee



SJH-F-015-R-9X	96.88	3.12	93.76	1365773	43986

SAMPLE INFORMATION

Sample Name:	SJH-F-015-R-9X	Acquired By:	System
Sample Type:	Unknown	Sample Set Name	Samples_SFC
Vial:	1:A,2	Acq. Method Set:	G_BAR0343
Injection #:	1	Processing Method	BAR0343
Injection Volume:	2.00 ul	Channel Name:	220nm
Run Time:	2.5 Minutes	Proc. Chnl. Descr.:	PDA Spectrum PDA 220.0 nm
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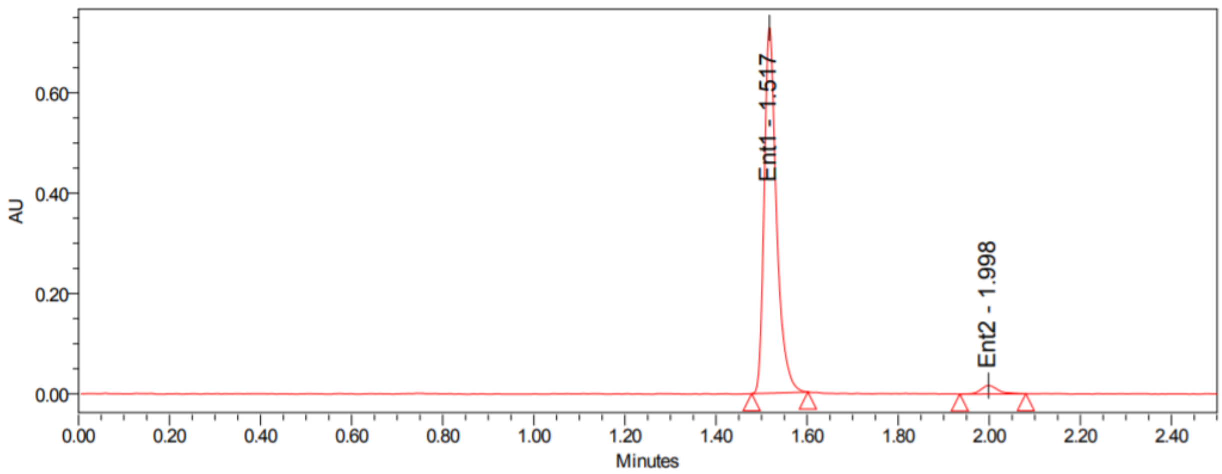
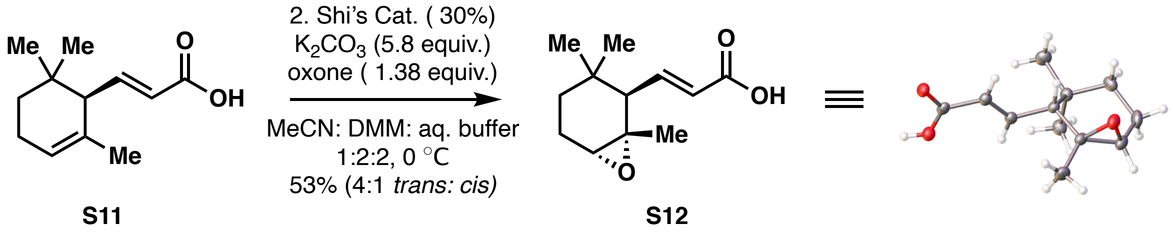
Date Processed:	8/6/2020 1:02:39 PM PDT		

Auto-Scaled Chromatogram



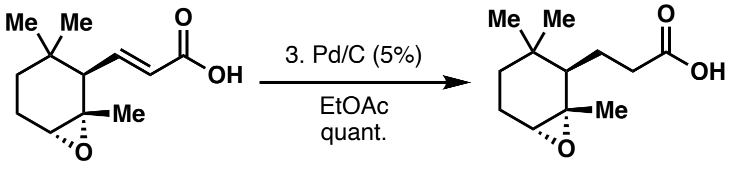


Shi epoxidation procedure was adapted from a literature procedure. (*70*)

Enoate **S11** (971 mg, 5 mmol) was epoxidized using the standard method B reported by Shi and coworkers using 30 mol% catalyst. A mixture of diastereomers in a 4:1 ratio was obtained favoring the desired *trans*-relationship stereochemistry. The isomers were separated on a Waters Prep SFC 150 AP using a Phenomenex i-AMY-3 column (5 µm, 21 x 250 mm). The purification was run under isocratic conditions (5% MeOH / CO2, 100 mL/min, 1600 psi backpressure) at 40 °C. Fractionation was triggered by UV light (220 nm). Product fractions were collected and concentrated to provide epoxy-enoate **S12** (444 mg, 42% yield) as a white solid.

Physical State: White crystalline solid
m.p. 102 – 104 °C
^{1}H NMR (600 MHz, $CDCl_3$): δ 6.95 (dd, *J* = 15.4, 11.6 Hz, 1H), 5.91 (d, *J* = 15.4 Hz, 1H), 3.03 – 2.99 (m, 1H), 2.38 (d, *J* = 11.6 Hz, 1H), 2.03 (ddt, *J* = 15.5, 5.5, 2.2 Hz, 1H), 1.95 – 1.86 (m,

1H), 1.39 (td, J = 12.9, 5.4 Hz, 1H), 1.21 (s, 3H), 1.14 (ddd, J = 13.4, 5.8, 2.3 Hz, 1H), 0.87 (s, 3H), 0.82 (s, 3H).
^{13}C NMR (151 MHz, $CDCl_3$): δ 170.5, 149.7, 124.1, 60.0, 58.0, 54.1, 32.6, 31.9, 29.6, 23.6, 21.6, 21.5.
HRMS (ESI-TOF): calculated for $C_{12}H_{18}O_3$ $[M+H]^+$: 211.1334, found: 211.1334
TLC: R_f = 0.22 (40% EtOAc / hexanes)
$[\alpha]_D^{20}$ = - 4.200° (c = 0.500 $CHCl_3$)

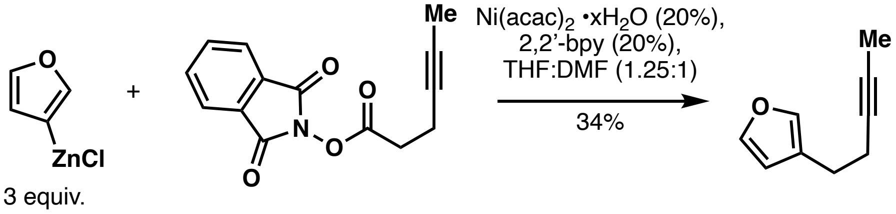


S12 **21**

A culture tube containing a stir bar, 10 wt% Pd/C (26.6 mg, 0.25 mmol, 5 mol%) and epoxide **S12** (105 mg, 0.5 mmol, 1 equiv.) was backfilled three times with argon before the addition of ethyl acetate (2.5 mL) freshly sparged with argon. Next, the reaction headspace was purged with hydrogen and the reaction was fitted with a hydrogen balloon (1 atm). The reaction was allowed to stir until complete consumption of starting material was observed by TLC (1h). Upon completion, the reaction was purged with argon before being filtered through a plug of celite which was rinsed with ethyl acetate (3 X 2 mL). The combined organics were concentrated via rotary evaporation at 24 °C and the product acid **21** (107 mg, quant.) was used immediately in the next step without further purification.

Note: product decomposition was observed over time.

Physical State: Clear colorless oil
^{1}H NMR (600 MHz, $CDCl_3$): δ 2.91 (t, J = 2.3 Hz, 1H), 2.63 (ddd, J = 16.4, 10.2, 4.9 Hz, 1H), 2.44 (ddd, J = 16.5, 9.5, 7.1 Hz, 1H), 1.96 (ddt, J = 15.5, 5.7, 1.8 Hz, 1H), 1.91 – 1.81 (m, 2H), 1.63 (ddt, J = 14.5, 9.6, 4.8 Hz, 1H), 1.41 (dd, J = 10.0, 1.8 Hz, 1H), 1.36 – 1.30 (m, 1H) 1.35 (s, 3H), 1.09 – 1.04 (m, 1H), 0.91 (s, 3H), 0.76 (s, 3H).
^{13}C NMR (151 MHz, $CDCl_3$): δ 178.9, 61.3, 58.7, 49.5, 35.9, 33.9, 32.1, 29.6, 22.7, 22.7, 21.7, 19.9
HRMS (ESI-TOF): calculated for $C_{12}H_{20}O_3$ $[M+H]^+$: 213.1491, found: 213.1490
TLC: R_f = 0.17 (40% EtOAc / hexanes)
$[\alpha]_D^{20}$ = + 22.0 ° (c = 0.500 $CHCl_3$)



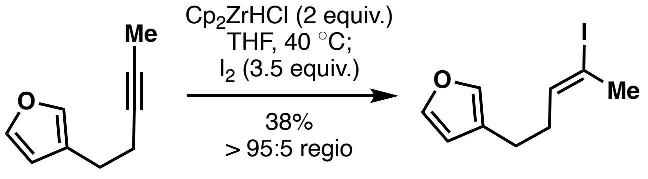
S13 **S14**

Procedure adapted a literature procedure. (*52*)

A flask containing stir bar, magnesium turnings (10.33 g, 425 mmol, 2.5 equiv.) and lithium chloride (8.93 g, 212.5 mmol, 1.25 equiv.) was flame dried under vacuum and backfilled with argon. Next anhydrous, inhibitor-free THF (300 mL) was added and the flask was placed in an ice bath. After cooling to 0 °C, dibromoethane (0.50 mL, 5.8 mmol, 0.34 equiv.) was added and bubbling was observed. After the bubbling had stopped, a solution of 3-bromofuran (25g, 170 mmol, 1 equiv.) in THF (50 mL) was added dropwise. After addition, the reaction was stirred 30 minutes at 0 °C. Next, a freshly prepared solution of anhydrous 1M, $ZnCl_2$ (23.12 g, 170 mmol, 1 equiv.) in THF (170 mL) was transferred via cannula and the solution was removed from the ice bath. The reaction was stirred another 30 minutes and an allequout of the reaction was titrated with iodine to afford 3-*furan-ZnCl* at a concentration of 0.25M in THF.

A separate flame dried flask and stir bar was charged with redox active ester **S13** (10.71 g, 41.63 mmol, 1 equiv.), $Ni(acac)_2 \bullet XH_2O$ (2.142 g, 8.34 mmol, 0.20 equiv.) and 2,2'-bipyridine (1.30 g, 8.34 mmol, 0.20 equiv.) before being evacuated and backfilled three times with argon. Anydrous DMF (400 mL) was added and the mixture was stirred 20 minutes before being placed in an ice bath to cool. Next, 500 mL of the freshly prepared organozinc (0.25 M, 125 mmol, 3 equiv.) was poured into the reaction and the reaction was allowed to stir overnight. The reaction was quenched with 0.5M HCl (500 mL) and extracted with pentane (3 X 400 mL). The combined organics were washed successively with distilled water (2 X 200 mL), a saturated solution of sodium bicarbonate (1 X 200 mL), then brine (1 X 200 mL) before being dried over magnesium sulfate and concentrated via rotary evaporation. The crude reaction mixture was purified via silica gel chromatography (100% pentane) followed by a crystallization from pentane at -20 °C to remove 3,3'-bifuran as a white solid to provide alkyne **S14** (1.88 g, 34%) as a clear colorless oil.

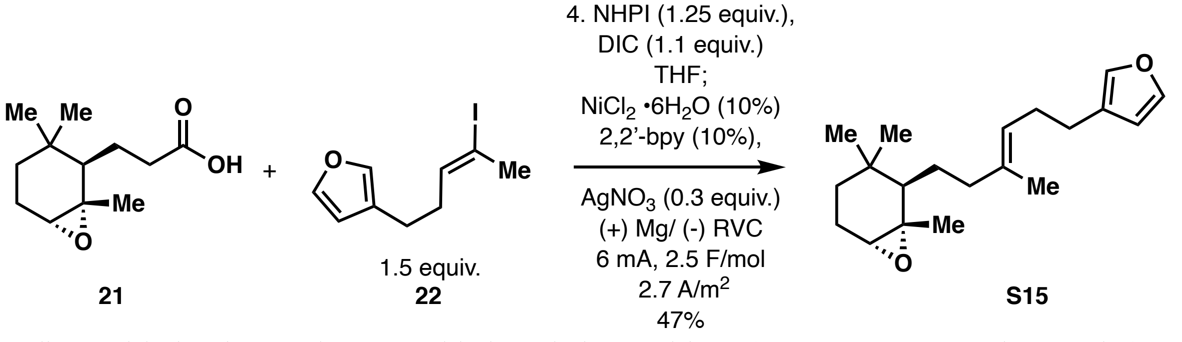
Physical State: Clear colorless oil
^{1}H NMR (600 MHz, $CDCl_3$): δ 7.35 (t, *J* = 1.7 Hz, 1H), 7.28 (dq, *J* = 2.0, 1.0 Hz, 1H), 6.32 (dt, *J* = 2.1, 0.6 Hz, 1H), 2.64 – 2.57 (m, 2H), 2.36 (tq, *J* = 7.5, 2.5 Hz, 2H), 1.78 (t, *J* = 2.6 Hz, 3H).
^{13}C NMR (151 MHz, $CDCl_3$): δ 142.8, 139.2, 124.1, 111.0, 78.7, 76.3, 24.9, 20.0, 3.6
MS (GCMS): calculated for $C_9H_{10}O$ $[M]^{+\bullet}$: 134.0732, found: 134.1
Note: HRMS with ESI-TOF unable to detect desired mass
TLC: R_f = 0.78 (9:1 hexanes / ethyl acetate)



S14 **22**

To a flame dried flask wrapped in aluminum foil to shield its contents from light was added a stir bar and Schwartz's reagent (1.031 g, 4 mmol, 2 equiv.). After evacuating and backfilling three times with argon a solution of alkyne **S14** (268 mg, 2 mmol, 1 equiv.) in THF (20 mL) was added and the reaction was heated to 40 °C for 6 hours. Next, the reaction was cooled to -78 °C and a solution of iodine (888 mg, 3.5 mmol, 3.5 equiv.) in THF (5 mL) was added dropwise. The reaction was allowed to stir for 15 minutes and then warmed to 0 °C, diluted with pentane (20 mL) and quenched with a 1:1 solution of saturated sodium thiosulfate and saturated sodium bicarbonate (50 mL). The aqueous layer was extracted with pentane (2 X 20 mL) and the combined organics washed with brine, dried over magnesium sulfate and concentrated via rotary evaporation. The crude product was purified via silica gel chromatography (2% Et_2O in pentanes) to provide vinyl iodide **22** (200 mg, 38%) as a clear colorless oil with >95:5 regioselectivity.

Physical State: Clear colorless oil
^{1}H NMR (600 MHz, $CDCl_3$): δ 7.35 (t, *J* = 1.7 Hz, 1H), 7.22 (dq, *J* = 1.9, 1.0 Hz, 1H), 6.26 (dd, *J* = 1.9, 0.9 Hz, 1H), 6.18 (tq, *J* = 7.4, 1.5 Hz, 1H), 2.51 – 2.47 (m, 2H), 2.33 (dt, *J* = 1.7, 0.9 Hz, 3H), 2.30 – 2.25 (m, 2H).
^{13}C NMR (151 MHz, $CDCl_3$): δ 143.0, 140.4, 139.1, 111.0, 94.6, 31.3, 27.2, 24.2
MS (GCMS): calculated for $C_9H_{11}IO$ $[M]^{+\bullet}$: 261.9855, found: 261.9
Note: HRMS with ESI-TOF unable to detect desired mass
TLC: R_f = 0.43 (Hexanes)



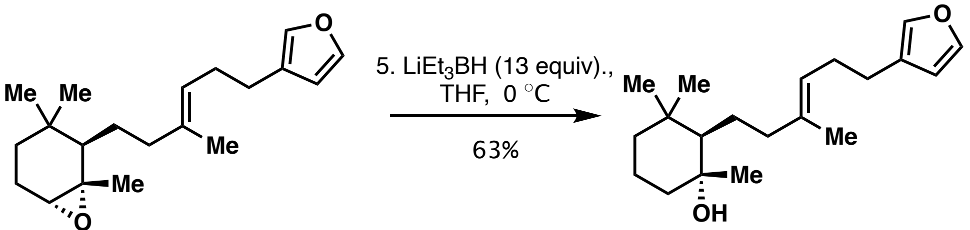
21 **22** **S15**

To a flame dried culture tube was added a stir bar, acid **21** (42.5 mg, 0.2 mmol, 1 equiv.) and NHPI (40.8 mg, 0.25 mmol, 1.25 equiv.). The tube was evacuated and backfilled three times with argon before the addition of anhydrous, inhibitor-free THF (0.5 mL). Next, DIC (0.034 mL, 0.22 mmol, 1.1 equiv.) was added. The activation was allowed to stir for two hours and a white suspension formed.

To a separate flask containing a stir bar was added $NiCl_2 \cdot 6H_2O$ (4.74 mg, 0.02 mmol, 0.10 equiv.) and 2,2'-bipyridine (3.12 mg, 0.02 mmol, 0.10 equiv.). This flask was evacuated and backfilled 3 times with argon before the addition of anhydrous DMF (2.5 mL). This solution was allowed to stir for 20 minutes and a homogeneous, dark green solution developed. This green solution was transferred via syringe into the tube containing the *in situ* activated ester (white suspension) and the vinyl iodide **22** (78.6 mg, 0.3 mmol, 1.5 equiv.). The reaction contents were then transferred via syringe to a 5mL ElectrasSyn vial under argon containing a magnesium anode, 100 ppi RVC cathode (3 mm x 7 mm x 51 mm), $AgNO_3$ (10.2 mg, 0.06 mmol, 27 $mmol_{Ag}/m^2_{(cathode)}$, 0.30 equiv.) and stir bar. After complete addition electrolysis was immediately started. The electrochemical reaction was performed using an ElectraSyn 2.0 under constant current conditions with the settings as follows: 6 mA, 0.20 mmol, 2.5 F/mol providing 2.7 A/m^2 current density. After completion of the reaction the vial was quenched with 0.5 M HCl (10 mL) and extracted with diethyl ether (3 X 5 mL). The combined organics were washed successively with distilled water (2 X 3 mL), saturated sodium bicarbonate solution (2 X 3 mL) then brine (1 X 3 mL), then dried over magnesium sulfate before being filtered and concentrated via rotary evaporation. The oily solid was purified via silica gel chromatography (2.5% EtOAc in hexanes). Product fractions were collected and concentrated to provide epoxy-furan **S15** (28.5 mg, 47%) as a colorless oil.

Note: Quenching and dissolution of DMF in water is exothermic and extraction of the warm reaction solution with diethyl ether can lead to boiling of the solvent.

Physical State: Clear colorless oil
^{1}H NMR (500 MHz, $CDCl_3$): δ 7.34 (t, J = 1.7 Hz, 1H), 7.22 (dq, J = 1.9, 1.0 Hz, 1H), 6.28 (dd, J = 1.8, 0.9 Hz, 1H), 5.21 (tq, J = 7.0, 1.3 Hz, 1H), 2.89 (t, J = 2.2 Hz, 1H), 2.46 (td, J = 7.5, 1.0 Hz, 2H), 2.30 – 2.20 (m, 3H), 2.05 – 1.91 (m, 2H), 1.84 (dddd, J = 15.3, 12.7, 6.2, 2.4 Hz, 1H), 1.61 (d, J = 1.3 Hz, 3H), 1.51 (ddd, J = 13.2, 10.8, 7.2 Hz, 1H), 1.41 – 1.28 (m, 4H), 1.35 (s, 3H), 1.05 (dddd, J = 13.4, 6.1, 2.0, 0.8 Hz, 1H), 0.85 (s, 3H), 0.73 (s, 3H).
^{13}C NMR (125 MHz, $CDCl_3$): δ 142.7, 139.0, 135.9, 125.1, 124.4, 111.2, 61.1, 59.1, 49.3, 42.0, 34.1, 32.0, 29.6, 28.7, 26.2, 25.2, 22.9, 21.8, 20.0, 16.3.
HRMS (ESI-TOF): calculated for $C_{20}H_{30}O_2$ $[M+H]^+$: 303.2324 , found: 303.2334
TLC: R_f = 0.71 (20% EtOAc/ hexanes)
$[\alpha]_D^{20}$ = + 21.802° (c = 0.688 $CHCl_3$)



S15

(–)-ambliol A

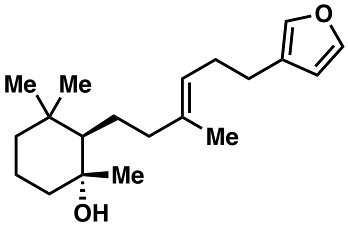
This reaction was performed according to literature precedents with modifications.(*71*)

To a flame dried culture tube containing a stir bar and epoxy-furan **S15** (11.4 mg, 0.038 mmol, 1 equiv.) under argon in an ice bath was added a 1M solution of $LiEt_3BH$ in THF (0.50 mL, 0.50 mmol, 13 equiv.). The reaction was allowed to warm to room temperature and stir overnight before being quenched with a 5% NaOH aqueous solution. The reaction was extracted with diethyl ether

(3 X 2 mL) and the combined organics were washed with brine (2 mL), dried, concentrated and purified via preparative TLC (20% Ethyl acetate in hexanes) to provide (–)-ambliol A as a clear colorless oil (7.5 mg, 63%).

Physical State: Clear colorless oil
^{1}H NMR (500 MHz, C_6D_6): δ 7.14 (t, *J* = 1.7 Hz, 1H), 7.09 (p, *J* = 1.0 Hz, 1H), 6.11 (dd, *J* = 1.8, 0.9 Hz, 1H), 5.32 (tq, *J* = 7.0, 1.3 Hz, 1H), 2.40 – 2.27 (m, 3H), 2.27 – 2.12 (m, 3H), 1.74 – 1.58 (m, 2H), 1.63 (s, 3H), 1.46 – 1.03 (m, 7H), 1.07 (s, 3H), 0.92 (s, 3H), 0.75 (s, 3H), 0.62 (br s, 1H).
^{13}C NMR (125 MHz, C_6D_6): δ 142.9, 139.3, 137.1, 125.3, 124.2, 111.4, 73.6, 56.7, 44.0, 43.3, 41.8, 35.6, 33.0, 28.9, 25.4, 25.3, 23.5, 21.6, 20.9, 16.3
HRMS (ESI-TOF): calculated for $C_{20}H_{32}O_2$ $[M+H]^+$: 305.2481, found: 305.2469
TLC: $R_f = 0.27$ (10% EtOAc/ hexanes)
$[\alpha]_D^{20}$ = - 4.842° (c = 0.470 $CHCl_3$)

Table S11 — (–)- ambliol A ^{1}H Shifts Comparison

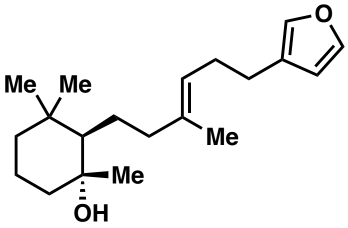


Tabulated data for Synthetic (–)- ambliol A
^{1}H-NMR

Synthetic (–)- ambliol A (500 MHz, C_6D_6)	Synthetic (–)- ambliol A (Serra, 400 MHz C_6D_6) (*71*)	Natural (–)- ambliol A (Faulkner, 400 MHz, CCl_4)* (*72*)	Δppm from Synthetic (–)- ambliol A
7.14 (t, *J* = 1.7 Hz, 1H)	7.13 (t, *J* = 1.5 Hz, 1H)	7.25 (br s, 1H)	0.01
7.09 (p, *J* = 1.0 Hz, 1H)	7.09 (s, 1H)	7.14 (br s, 1H)	0.00
6.11 (dd, *J* = 1.8, 0.9 Hz, 1H)	6.11 (s, 1H)	6.18 (br s, 1H)	0.00
5.32 (tq, *J* = 7.0, 1.3 Hz, 1H)	5.29 (t, *J* = 7.0 Hz, 1H)	5.13 (br t, *J* = 7 Hz, 1H)	0.03
2.40 – 2.27 (m, 3H) 2.27 – 2.12 (m, 3H)	2.45 – 2.09 (m, 6H)	2.43 (t, *J* = 7 Hz, 2H)	N/A
1.74 – 1.58 (m, 2H)	1.73 – 1.52 (m, 2H)	2.21 (q, *J* = 7 Hz, 2H)	0.06
1.63 (s, 3H)	1.62 (s, 3H)	1.60 (s, 3H)	0.01
1.46 – 1.03 (m, 7H)	1.45 – 1.03 (m, 7H)	1.10 (s, 3H)	0.01
1.07 (s, 3H)	1.07 (3H)	0.93 (s, 3H)	0.00
0.92 (s, 3H)	0.91 (s, 3H)	0.80 (s, 3H)	0.01
0.75 (s, 3H)	0.74 (s, 3H)		0.01
0.62 (br s, 1H)	0.66 (br s, 1H)		0.04

* Not all protons accounted for in isolation report.

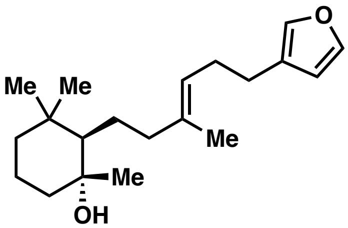
Table S12— (–)- ambliol A ^{13}C Shifts Comparison



Tabulated data for Synthetic (–)- ambliol A
^{13}C-NMR

Synthetic (–)- ambliol A (125 MHz, C_6D_6)	Synthetic (–)- ambliol A (Serra, 100 MHz C_6D_6)(*71*)	Natural (–)- ambliol A (Faulkner, 100 MHz, CCl_4) (*72*)	Δppm from Synthetic (–)- ambliol A
142.9	142.8	142.8	0.1
139.3	139.2	139.2	0.1
137.1	137.1	137.0	0.0
125.2	125.2	125.2	0.0
124.2	124.2	124.1	0.0
111.4	111.3	111.3	0.1
73.6	73.6	73.7	0.0
56.7	56.8	56.7	0.1
44.0	44.0	43.9	0.0
43.3	43.2	43.2	0.1
41.8	41.9	41.8	0.1
35.6	35.6	35.6	0.0
33.0	33.0	33.0	0.0
28.9	28.9	28.8	0.0
25.4	25.4	25.3	0.0
25.3	25.3	25.3	0.0
23.5	23.6	23.5	0.1
21.6	21.6	21.6	0.0
20.9	20.9	20.8	0.0
16.2	16.2	16.2	0.0

Table S13 — (–)- ambliol A Optical Rotation Comparison

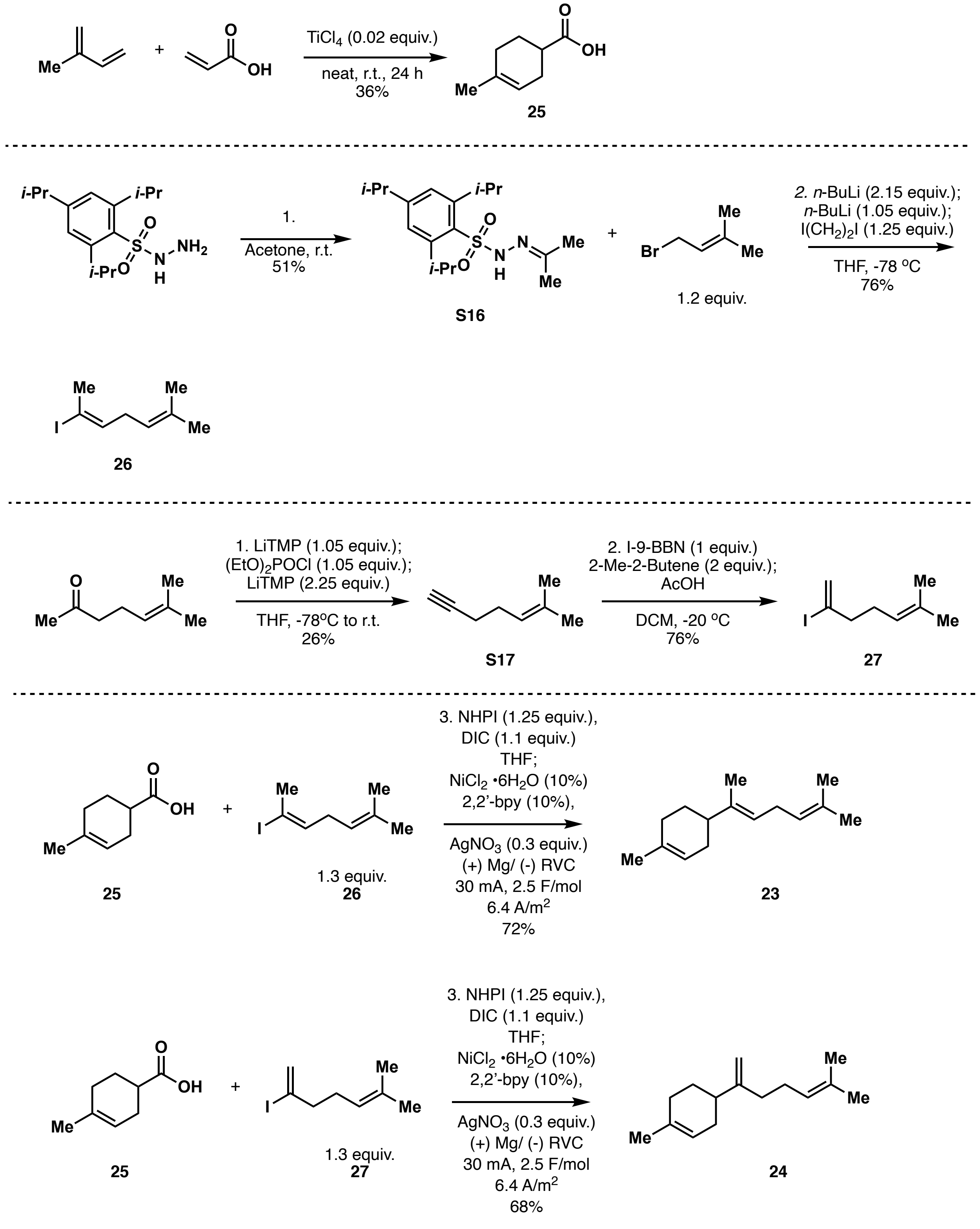


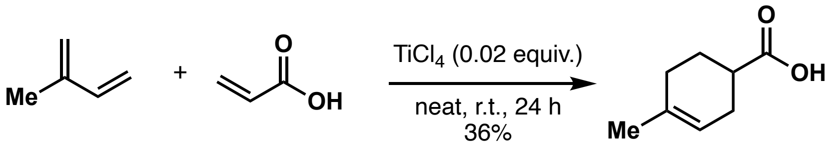
Tabulated data for Synthetic (–)- ambliol A
Optical Rotation ($[\alpha]_D^{20}$)

Synthetic (–)- ambliol A	Synthetic (–)- ambliol A (Serra) (*71*)	Natural (–)- ambliol A (Faulkner) (*72*)
-4.842º (c = 0.470, $CHCl_3$)	+4.0º (c = 1.8, $CHCl_3$)	-3.9º (c = 2.5, $CHCl_3$)

Bisabolenes (procedures)

Fig S12 —Synthesis of α- & β- bisabolenes





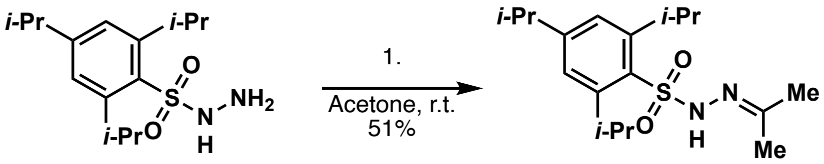
25

Procedure was adapted from a literature procedure.(*73*)

A large culture tube and stir bar was sparged with argon and a septum was placed over the opening. Next, titanium tetrachloride (0.110 mL, 1 mmol, 0.02 equiv.) was added followed by acrylic acid (3.43 mL, 50 mmol, 1 equiv.). Then the vessel was cooled to 0 °C and isoprene (5.00 mL, 50 mmol, 1 equiv.) was added. The septum was replaced with a screwcap and allowed to warm to room temperature after stirring for 2 hours at 0 °C. Solids precipitated after 8h and the reaction was complete after 24h. The reaction was transferred *via* spatula to a flask where heptane (37.5 mL) and isopropanol (5 mL) were added and the contents were heated to 80 °C for 1 hour. The organic layer was subsequently extracted with 10 % sulfuric acid, water (twice) then brine and dried over magnesium sulfate. The organic layer was evaporated using rotary evaporation and the product was recrystallized from hot hexanes to afford acid **25** as a white crystalline solid (2.49 g, 36%).

Spectral data matched previous reports; the ^{1}H NMR data is provided here for convenience.(*73*)

^{1}H NMR (500 MHz, CDCl3): δ = 5.40 (s, 1H), 2.50 (m, 1H), 2.28 – 2.16 (m, 2H), 2.26 – 1.92 (m, 3H), 1.70 (m, 1H), 1.63 (s, 3H).



S16

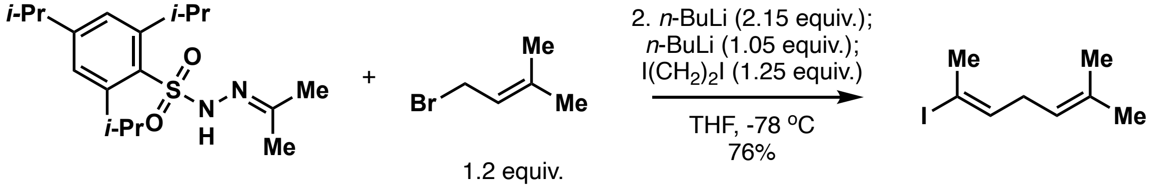
Procedure adapted from a literature procedure. (*74*)

2,4,6-triisopropylbenzenesulfonohydrazide (TPSH) (8.00 g, 26.81 mmol, 1 equiv.) was added directly to a round bottom flask equipped with stir bar. Acetone (107 mL) was added, and the contents were allowed to stir for 30 minutes. Upon completion, the reaction mixture was concentrated under reduced pressure to afford a white crystalline solid. Recrystallization from methanol afforded hyrazone **S16** as a white crystalline solid (4.58 g, 51% yield).

Spectral data matched previous reports; the ^{1}H NMR data is provided here for convenience.(*74*)

^{1}H NMR (100 MHz, CDCl3): τ = 8.84 (d, J = 7 Hz, 18H), 8.23 (s, 3H), 8.12 (s, 3H), 7.13 (m, 1H), 5.77 (m, 2H), 2.90 (s, 2H).

Converted to δ = 1.16 (d, J = 7 Hz, 18H), 1.77 (s, 3H), 1.88 (s, 3H), 2.87 (m, 1H), 4.23 (s, 2H), 7.10 (s, 2H).



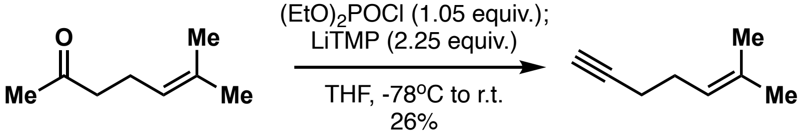
S16 **26**

Procedure adapted from a literature procedure. (*75*)

To a flame dried flask under argon was added hydrazone **S16** (4.00 g, 11.8 mmol, 1 equiv.) and anhydrous THF (60 mL). After cooling to -78 °C, *n*Buli (2.5 M in hexanes, 10.2 mL, 25.4 mmol, 2.15 equiv.) was added dropwise and the reaction was stirred 1h at -78 °C. The solution turned orange and then prenyl bromide (1.64 mL, 14.2 mmol, 1.2 equiv.) was added as a solution in THF (6 mL) dropwise at -78 °C. The reaction was allowed warm to -60 °C over 1h and the reaction turned yellow. The reaction was again cooled to -78 °C and *n*-BuLi (2.5 M in hexanes, 5.0 mL, 12.4 mmol, 1.05 equiv.) was added dropwise and stirred for 15 minutes at this temperature. The reaction was allowed to warm to 0 °C over 15 minutes and stirred for 30 minutes at 0 °C. Gas evolution was observed. Next, the reaction was cooled to -78 °C a third time before solid diiodoethane (4.16 g, 14.8 mmol, 1.25 equiv.) was added in one portion. The reaction was allowed warm to room temperature and stirred 30 minutes before being quenched slowly with a saturated sodium bicarbonate solution (50 mL) followed by a saturated sodium thiosulfate solution (50 mL). The organics were extracted with pentane (3 X 200 mL), washed with a saturated sodium bicarbonate solution (2 X 200 mL), brine (200 mL), and then dried with magnesium sulfate. The product was purified via silica gel chromatography (100% pentane) to afford vinyl iodide **26** (2.13 g, 76%) as a clear oil which discolors quickly. **26** was stored in a -20 °C freezer away from direct light.

Spectral data matched previous reports; the ^{1}H NMR data is provided here for convenience.(*75*)

^{1} H NMR (400 MHz, CDCl3): δ = 6.11 (m, 1H), 5.07 (m, 1H), 2.70 (*t*, J = 7.5 Hz, 2H), 2.39 (s, 3H), 1.69 (s, 3H), 1.61 (s, 3H).



S17

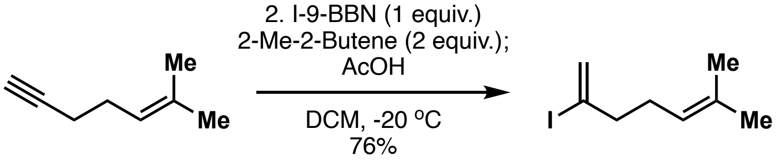
Procedure adapted from a literature procedure. (*76*)

To a flame dried flask and stir bar under argon was added THF (60 mL) and freshly distilled 2,2,6,6-tetramethylpiperidine (10.72 ml, 63 mmol, 1.05 equiv.) before being cooled to 0 °C. Next, *n*-BuLi (2.5M in hexanes, 25.2 mL, 63 mmol, 1.05 equiv.) was added dropwise. The reaction was allowed to stir 30 minutes at 0 °C and then cooled to -78 °C before the dropwise addition of sulcatone (8.89 mL, 60 mmol, 1 equiv.). The reaction was stirred for 1h at this temperature before diethyl chlorophosphate (9.13 mL, 63 mmol, 1.05 equiv.) was added dropwise and stirred 3h at -78 °C.

To a separate flame dried flask and stir bar under argon, LiTMP was prepared at 0 °C as prepared above. To a solution of THF (120 mL) and 2,2,6,6-tetramethylpiperidine (22.97 g, 135 mmol, 2.25 equiv.) at 0 °C was added *n*-BuLi (2.5M in hexanes, 54 mL, 135 mmol, 2.25 equiv.) dropwise and stirred 30 minutes. The contents of the first flask were added via cannula dropwise over 45 minutes at 0 °C. The reaction was stirred and allowed to warm to room temperature over 3 hours, then quenched with water at 0 °C (20 mL). The reaction was diluted with pentane, then washed successively with ice cold 1N HCl (100 mL), water (100 mL), bicarbonate (100 mL) and dried over magnesium sulfate. The organic layer was carefully concentrated under rotary evaporation and the product was distilled at 115-120 °C and ambient pressure to afford alkyne **S17** as a clear oil (1.67 g, 26% yield).

Spectral data matched previous reports; the ^{1}H NMR data is provided here for convenience.(*77*)

^{1} H NMR (400 MHz, CDCl3): δ = = 5.18-5.15 (m, 1H), 2.23-2.17 (m, 4H), 1.94-1.93 (t, *J* = 2.5 Hz, 1H), 1.70 (s, 3H), 1.62 (s, 3H).



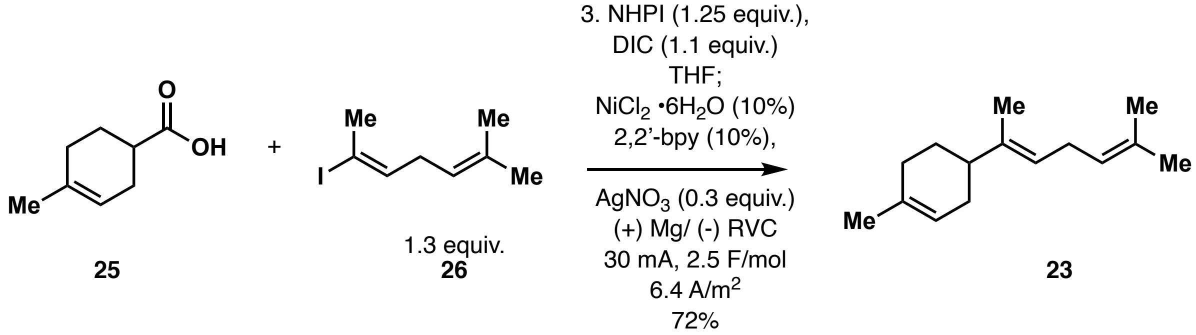
S17 **27**

Procedure adapted from a literature procedure. (*78*)

To a flame dried flask and stir bar under argon was added dichloromethane (40 mL). Next B-Iodo-9-BBN (1M in hexanes, 10 mL, 10 mmol, 1 equiv.) was added and the solution was cooled to -20 °C before the dropwise addition of alkyne **S17** (1.08 g, 10 mmol, 1 equiv.) followed successively by 2-methlyl-2-butene (1.4 g, 20 mmol, 2 equiv.). The reaction was stirred at this temperature until full conversion of the starting material was observed by TLC. Next, acetic acid (7 mL) was added at -20 °C dropwise. The reaction was allowed to warm to 0 °C and stirred 1h. Pentane was added and the reaction was quenched with a saturated solution of sodium bicarbonate. The organic layer was washed with saturated sodium bicarbonate (2 X 50 mL), then brine (50 mL) and dried over magnesium sulfate before being filtered through a silica gel plug and carefully concentrated via rotary evaporation at 20 °C to provide vinyl iodide **27** (1.79 g, 7.58 mmol, 76% yield) which was used without further purification and stored in a -20 °C freezer away from direct light to avoid decomposition.

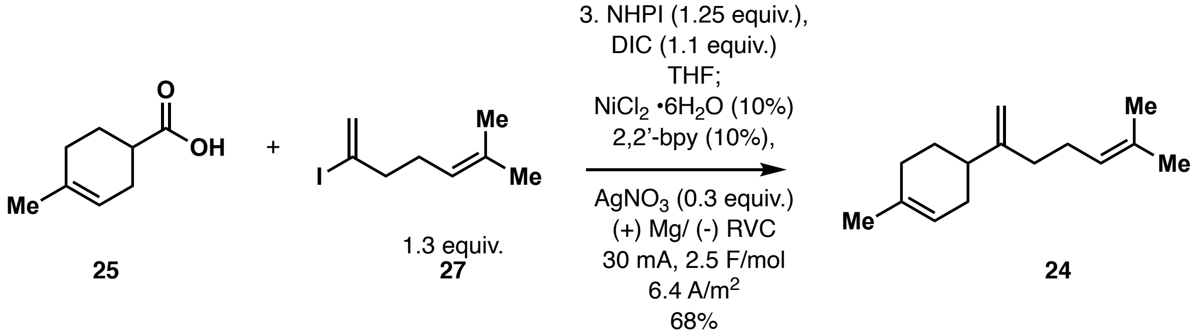
Physical State: Clear colorless oil
^{1}H NMR (399 MHz, CDCl3): δ 6.01 (q, *J* = 1.4 Hz, 1H), 5.69 (dt, *J* = 1.4, 0.6 Hz, 1H), 5.08 (dddd, *J* = 7.1, 5.6, 2.9, 1.5 Hz, 1H), 2.44 – 2.36 (m, 2H), 2.19 (m, 2H), 1.69 (d, *J* = 1.4 Hz, 3H), 1.64 (s, 3H).
^{13}C NMR (151 MHz, CDCl3): δ 133.1, 125.5, 122.2, 112.2, 45.7, 28.0, 25.8, 18.1

HRMS (ESI-TOF): calculated for $C_8H_{13}I$ $[M+H]^+$: 237.0140, found: 237.0138
TLC: R_f = 0.75 (100% Pentane)



To a flask containing a stir bar and carboxylic acid **25** (140.2 mg, 1 mmol, 1 equiv.) was added NHPI (204 mg, 1.25 mmol, 1.25 equiv.) and anhydrous, inhibitor-free THF (0.75 mL) and allowed to stir until dissolved. Next, DIC (172 µL, 1.1 mmol, 1.1 equiv.) was added and the reaction was allowed to stir 2h and a white suspension formed. To a separate flask containing a stir bar was added $NiCl_2 \cdot 6H_2O$ (23.8 mg, 0.10 mmol, 0.10 equiv.), 2,2'-bipyridine (15.6 mg, 0.10 mmol, 0.10 equiv.) and vinyl iodide **26** (307 mg, 1.3 mmol, 1.3 equiv.) was added. This flask was evacuated and backfilled 3 times with argon before the addition of anhydrous DMF (4.2 mL). This solution was allowed to stir for 20 minutes and a homogeneous, dark green solution developed. This green solution was transferred via cannula into the flask containing the *in situ* activated ester (white suspension). This green suspension was added to a 5 mL ElectraSyn 2.0 vial under argon containing a magnesium anode, 100 ppi RVC cathode (3 mm X 7 mm X 51 mm), $AgNO_3$ (50.9 mg, 0.3 mmol, 64 $mmol_{Ag}/m^2_{(cathode)}$, 0.3 equiv.) and stir bar. After complete addition electrolysis was immediately started. The electrochemical reaction was performed using an ElectraSyn 2.0 under constant current conditions with the settings as follows: 30 mA, 1 mmols, 2.5 F/mol providing 6.4 A/m^2 current density. After completion of the reaction the vial was transferred to a separatory funnel and quenched with 1N HCl (20 mL) and extracted with diethyl ether (3 X 20 mL). The combined organics were washed successively with distilled water (2 X 20 mL) then brine (1 X 20 mL), then dried over magnesium sulfate before being filtered and concentrated via rotary evaporation. The oily solid was purified via silica gel chromatography (pentanes) to provide α-bisabolene **23** as a clear colorless oil (146.8 mg, 72% yield).

Physical State: Clear colorless oil
^{1}H NMR (399 MHz, CDCl3): δ 5.39 (dq, *J* = 3.7, 1.3 Hz, 1H), 5.12 (m, 2H), 2.69 (t, *J* = 7.2 Hz, 2H), 2.12 – 1.83 (m, 5H), 1.75 – 1.68 (m, 1H), 1.69 (d, *J* = 1.4 Hz, 3H), 1.65 (s, 3H), 1.63 (d, *J* = 1.2 Hz, 3H), 1.61 (d, *J* = 1.2 Hz, 3H), 1.47 (dtd, *J* = 12.6, 11.5, 5.6 Hz, 1H).
^{13}C NMR (151 MHz, CDCl3): δ 139.4, 133.8, 131.4, 123.7, 121.9, 121.1, 43.0, 30.9, 30.9, 28.1, 27.1, 25.9, 23.7, 17.9, 14.3
HRMS (ESI-TOF): calculated for $C_{15}H_{24}$ $[M+H]^+$: 205.1956, found: 205.1958
TLC: R_f = 0.65 (100% Pentane)



25

1.3 equiv.
27

3. NHPI (1.25 equiv.),
DIC (1.1 equiv.)
THF;
$NiCl_2 \cdot 6H_2O$ (10%)
2,2'-bpy (10%),

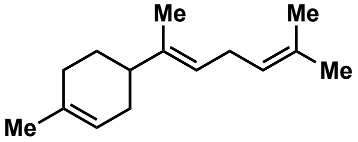
$AgNO_3$ (0.3 equiv.)
(+) Mg/ (-) RVC
30 mA, 2.5 F/mol
6.4 A/m^2
68%

24

The procedure is identical to the preparation of α-bisabolene (**23**) except iodide **27** (306.9 mg, 1.3 mmol., 1.3 equiv.) was used. β-bisabolene (**24**) was isolated after silica gel chromatography in pentane as a clear colorless oil (138 mg, 68%).

Physical State: Clear colorless oil
^{1}H NMR (399 MHz, CDCl3): δ 5.41 (t, *J* = 3.6 Hz, 1H), 5.12 (tdt, *J* = 5.8, 3.0, 1.5 Hz, 1H), 4.79 – 4.70 (m, 2H), 2.16 – 1.95 (m, 8H), 1.95 – 1.85 (m, 1H), 1.85 – 1.77 (m, 1H), 1.69 (d, *J* = 1.3 Hz, 3H), 1.66 (d, *J* = 1.1 Hz, 3H), 1.61 (d, *J* = 1.4 Hz, 3H), 1.47 (dtd, *J* = 12.7, 11.3, 5.7 Hz, 1H).
^{13}C NMR (151 MHz, CDCl3): δ 154.5, 133.9, 131.7, 124.5, 121.0, 107.2, 39.9, 35.0, 31.6, 30.9, 28.5, 27.0, 25.8, 23.6, 17.9
HRMS (ESI-TOF): calculated for $C_{15}H_{24}$ $[M+H]^+$: 205.1956, found: 205.1951
TLC: R_f = 0.62 (100% Pentane)

Table S14 —α-bisabolene ^{1}H Shifts Comparison

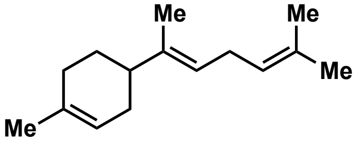


23

Tabulated data for Synthetic **23**
^{1}H-NMR

Synthetic **23** (399 MHz, CDCl$_3$)	Synthetic **23** (Delay, 360 MHz CDCl$_3$) (*79*)	Δppm from Synthetic **23**
5.39 (dq, *J* = 3.7, 1.3 Hz, 1H)	5.41 (br, s, 1H)	0.02
5.12 (m, 2H),	5.14 – 5.12 (t, *J* = 7.0 Hz, 2H)	0.00
2.69 (t, *J* = 7.2 Hz, 2H)	2.70 (t, *J* = 7.0 Hz, 2H)	0.01
2.12 – 1.83 (m, 5H)	2.12 – 1.82 (br m, 5H)	0.01
1.75 – 1.68 (m, 1H)	1.66 (m, 1H)	0.02
1.69 (d, *J* = 1.4 Hz, 3H)	1.69 (s, 3H)	0.00
1.65 (s, 3H)	1.64 (s, 3H)	0.01
1.63 (d, *J* = 1.2 Hz, 3H)	1,63 (s, 3H)	0.00
1.61 (d, *J* = 1.2 Hz, 3H)	1.61 (s, 3H)	0.00
1.47 (dtd, *J* = 12.6, 11.5, 5.6 Hz, 1H)	1.46 (br m, 1H)	0.01

Table S15 —α-bisabolene ^{13}C Shifts Comparison

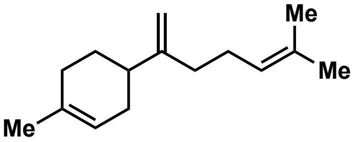


23

Tabulated data for Synthetic **23**
^{13}C-NMR

Synthetic **23** (100 MHz, $CDCl_3$)	Synthetic **23** (Delay, 90 MHz $CDCl_3$)(*79*)	Δppm from Synthetic **23**
139.4	139.2	0.2
133.8	133.5	0.3
131.4	131.1	0.3
123.7	123.7	0.0
121.9	121.9	0.0
43.0	42.9	0.1
30.9	30.9	0.0
28.1	28.1	0.0
27.1	27.0	0.1
25.9	25.7	0.2
23.7	23.5	0.2
17.9	17.7	0.2
14.3	14.2	0.1

Table S16 —β-bisabolene ^{1}H Shifts Comparison

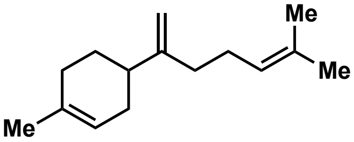


24

Tabulated data for Synthetic **24**
^{1}H-NMR

Synthetic **24** (399 MHz, CDCl$_3$)	Synthetic **24** (Ito, 400 MHz CDCl$_3$) (*80*)	Natural **24** (Scheffrahn, 125 MHz, CCl$_4$ + 10% CDCl$_3$)(*81*)	Δppm from Synthetic **24**
5.41 (t, *J* = 3.6 Hz, 1H)	5.42–5.40 (m, 1 H)	5.33 (br s, 1H)	0.00
5.12 (tdt, *J* = 5.8, 3.0, 1.5 Hz, 1H)	5.13 (tt, J = 6.8, 1.4 Hz, 1 H)	5.06 (t, *J* = 7.0 Hz, 1H)	0.01
4.79 – 4.70 (m, 2H)	4.76–4.74 (m, 2 H)	4.69 (s, 1H)	0.00
		4.67 (s, 1H)	
2.16 – 1.95 (m, 8H)	2.15–1.78 (m, 10 H)	2.04 (m, 7H)	0.01
1.95 – 1.85 (m, 1H)		1.97 – 1.72 (m, 3H)	0.00
1.85 – 1.77 (m, 1H)			0.00
1.69 (d, *J* = 1.3 Hz, 3H)	1.69 (d, J = 1.2 Hz, 3 H)	1.67 (s, 3H)	0.00
1.66 (d, *J* = 1.1 Hz, 3H)	1.66 (t, J = 1.4 Hz, 3 H)	1.63 (s, 3H)	0.00
1.61 (d, *J* = 1.4 Hz, 3H)	1.61 (s, 3 H)	1.60 (s, 3H)	0.00
1.47 (dtd, *J* = 12.7, 11.3, 5.7 Hz, 1H)	1.54–1.41 (m, 1 H)		0.00

Table S17 —β-bisabolene ^{13}C Shifts Comparison



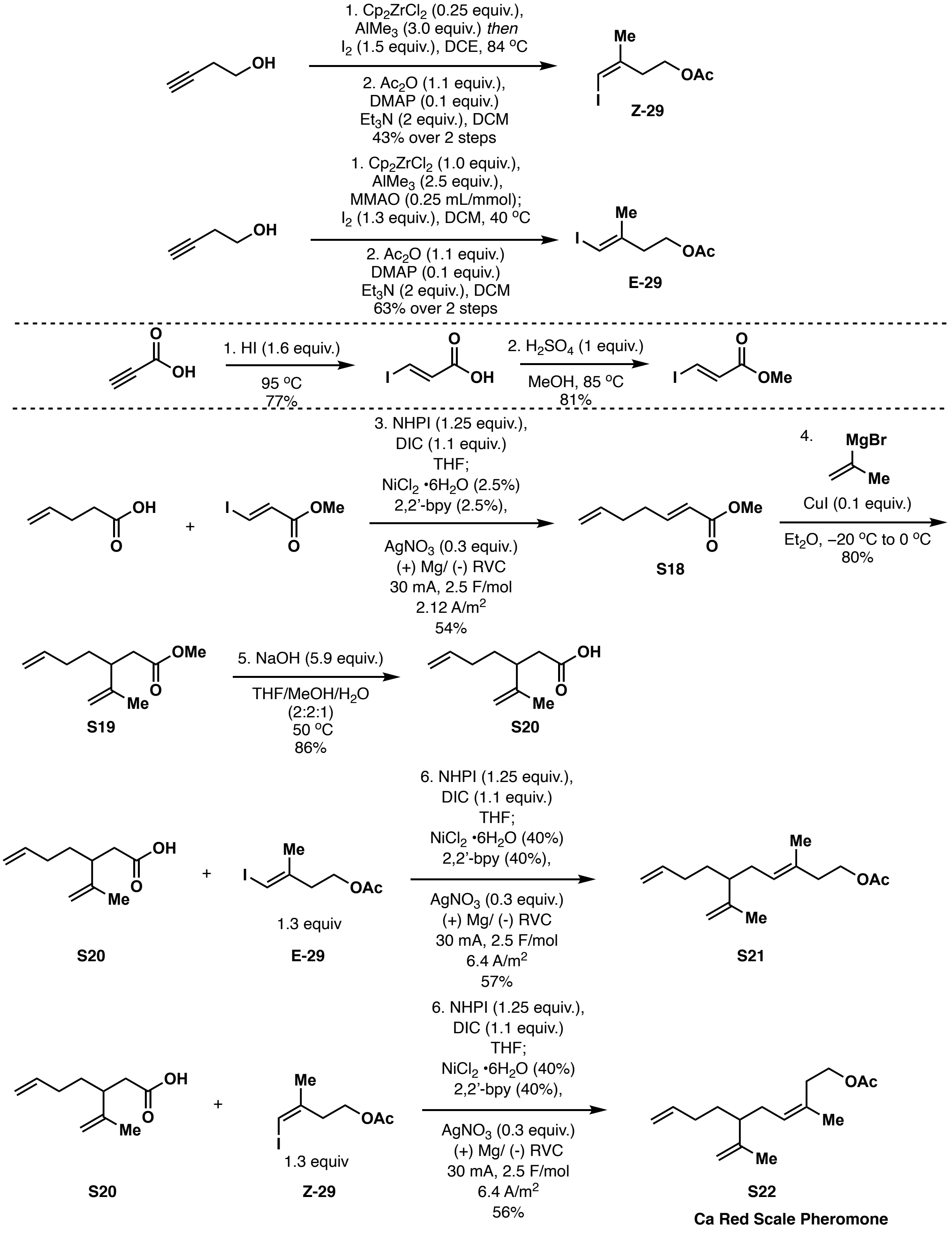
24

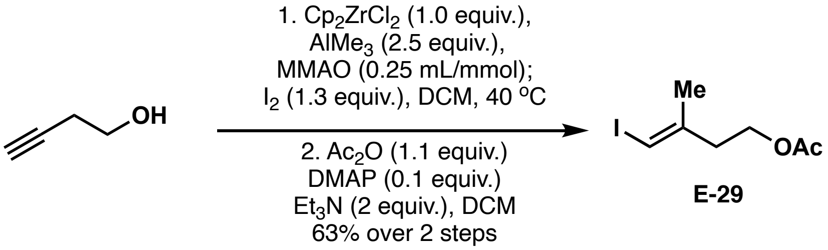
Tabulated data for Synthetic **24**
^{13}C-NMR

Synthetic **24** (100 MHz, $CDCl_3$)	Synthetic **24** (Ito, 100 MHz $CDCl_3$) (*80*)	Natural **24** (Scheffrahn, 500 MHz, CCl_4 + 10% $CDCl_3$) (*81*)	Δppm from Synthetic **24**
154.5	154.3	153.5	0.2
133.9	133.7	133.1	0.2
131.7	131.5	130.4	0.2
124.5	124.3	124.3	0.2
121.0	120.8	120.6	0.2
107.2	107.1	107.3	0.1
39.9	39.8	39.6	0.1
35.0	34.9	34.8	0.1
31.6	31.4	31.1	0.2
30.9	30.8	30.5	0.1
28.5	28.3	28.0	0.2
27.0	26.8	26.5	0.2
25.8	25.7	25.4	0.1
23.6	23.4	23.0	0.2
17.9	17.7	17.6	0.2

California Red Scale Pheromone (procedures)

Fig S13 — Complete synthesis of California Red Scale Pheromone





E-29

A three-neck flask fitted with a reflux condenser and charged with zirconocene dichloride (5.85 g, 20 mmol, 1 equiv.) was evacuated and backfilled with argon three times before DCM (25 mL) was added followed by trimethyl aluminum (25 mL, 50 mmol, 2.5 equiv.) as a solution in hexanes (2M). Then, a 7% solution of MMAO-12 (5 mL, 0.25mL/mmol substrate) in toluene obtained from Sigma Aldrich was added. The reaction was stirred 15 minutes, then cooled to 0 °C before the addition of 3-butyn-1-ol (1.51 mL, 20 mmol, 1 equiv.) dropwise. The reaction was allowed to warm to room temperature before being warmed to 40 °C for 12h. Then the reaction was cooled to 0 °C and a solution of iodine (6.60 g, 26 mmol, 1.3 equiv.) in THF (20 mL) was added *via* syringe. The reaction was stirred at 0 °C for 30 minutes where it turned a bright yellow color, then the septum was removed, diethyl ether (200 mL) was added, and water (approximately 30 mL) was added **dropwise very slowly!** The yellow heterogeneous solution became white and heterogeneous and the bubbling stopped at complete quenching. More diethyl ether was added, and the slurry was filtered through a pad of Celite. The solution was washed with 2N HCl (100 mL), then sodium bicarbonate (100 mL) and thiosulfate (100 mL) before being washed with brine (100mL) and dried over magnesium sulfate. The organic layer was then concentrated via rotary evaporation in a fume hood to afford an orange oil (3.49 g). The crude alcohol was carried forward without further purification.

Note: reaction times longer than 12 hours resulted in isomerization of the resultant vinyl iodide.

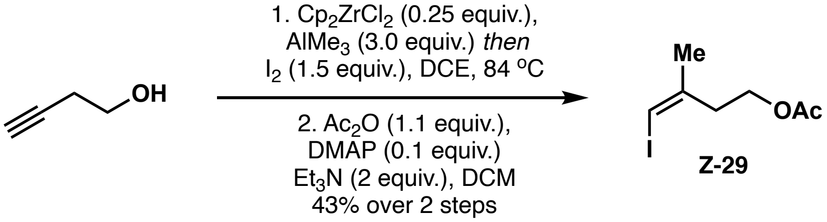
Spectral data matched previous reports; the ^{1}H NMR data is provided here for convenience.(*82*)

^{1} H NMR (500 MHz, CDCl3): δ 6.02 (s, 1H), 3.72 (t, *J* = 6.1 Hz, 2H), 2.48 (t, *J* = 6.2 Hz, 2H), 1.87 (s, 3H), 1.42 (s, 1H).

Procedure adapted from a literature procedure. (*83*)

To a round bottom flask and stir bar was added crude alcohol (3.49 g, 16.45 mmol, 1 equiv.), DCM (80 mL), DMAP (201 mg, 1.65 mmol, 0.1 equiv.) then triethyl amine (4.59 mL, 32.90 mmol, 2 equiv.), then acetic anhydride (1.71 mL, 18.10 mmol, 1.1 equiv.). The reaction was stirred for 1h at room temperature and full conversion was confirmed by TLC. Water was added and the layers were separated. The aqueous layer was extracted with DCM (2 X 100 mL). The organic layer was then washed with water, then brine, then dried over magnesium sulfate. The crude material was concentrated and purified via silica gel chromatography (0-10% ethyl acetate / hexanes) to afford **E-29** as a clear yellow oil (3.21 g, 63% over 2 steps).
Physical State: Clear yellow oil
^{1} H NMR (500 MHz, CDCl3): δ 6.00 (q, *J* = 1.1 Hz, 1H), 4.15 (t, *J* = 6.7 Hz, 2H), 2.52 (td, *J* = 6.7, 1.1 Hz, 2H), 2.04 (s, 3H), 1.87 (d, *J* = 1.2 Hz, 3H).
^{13}C NMR (151 MHz, CDCl3): δ 171.0, 144.0, 77.2, 62.0, 38.4, 24.0, 21.1
HRMS (ESI-TOF): calculated for $C_7H_{11}IO_2$ $[M+H]^+$: 254.9882, found: 254.9876

TLC: R_f = 0.67 (4:1 hexanes/ethyl acetate)



The anti-carbometalation procedure is adapted from a literature procedure. (*84*)

A flame dried round bottom flask was charged with zirconocene dichloride (1.83 g, 6.25 mmol, 0.25 equiv.). The flask was evacuated and backfilled with argon three times before DCE (50 mL) was added followed by trimethyl aluminum (7.2 mL, 75 mmol, 3.0 equiv.). The reaction was stirred for 15 minutes, then cooled to 0 °C before the addition of 3-butyn-1-ol (1.89 mL, 25 mmol, 1 equiv.) dropwise. The reaction was allowed to stir at room temperature for 19 hrs. The reaction was then allowed to warm to 84 °C and stir for 3 days. Then the reaction was cooled to 0 °C and a solution of iodine (9.52 g, 37.5 mmol, 1.5 equiv.) in THF (10 mL) was added *via* syringe. The reaction was stirred at 0 °C for 30 minutes where it turned a bright yellow color, then the septum was removed, diethyl ether (200 mL) was added, and water (approximately 10 mL) was added **dropwise very slowly!** The yellow heterogeneous solution became white and heterogeneous and the bubbling stopped at complete quenching. More diethyl ether was added, and the slurry was filtered through a pad of Celite. The solution was washed with 2N HCl (100 mL), then sodium bicarbonate (100 mL) and thiosulfate (100mL) before being washed with brine (100mL) and dried over magnesium sulfate. The organic layer was then concentrated via rotary evaporation in a fume hood to afford an orange oil (5.305 g crude mass). The crude alcohol was carried forward without further purification.

Spectral data matched previous reports; the ^{1}H NMR data is provided here for convenience.(*84*)

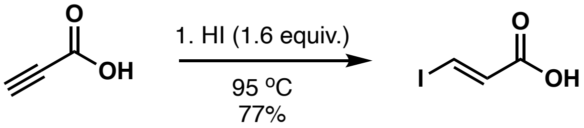
^{1}H NMR (500 MHz, CDCl3): δ 6.00 (q, *J* = 1.0 Hz, 1H), 3.78 (t, *J* = 6.8 Hz, 2H), 2.52 (t, *J* = 6.8 Hz, 2H), 1.96 (d, *J* = 1.0 Hz, 3H), 1.85 (br s, 1H).

Procedure adapted from a literature procedure. (*83*)

To a round bottom flask and stir bar was added crude alcohol (5.305 g crude mass, 25 mmol, 1 equiv.), DCM (125 mL), DMAP (305 mg, 2.5 mmol, 0.1 equiv.) then triethylamine (6.97 mL, 50 mmol, 2 equiv.), then acetic anhydride (2.62 mL, 27.5 mmol, 1.1 equiv.). The reaction was stirred for 1h at room temperature and full conversion was confirmed by TLC. Water was added and the layers were separated. The aqueous layer was extracted with DCM (2 X 100 mL). The organic layer was then washed with water, then brine, then dried over magnesium sulfate. The crude material was concentrated and purified via silica gel chromatography (0-10% ethyl acetate / hexanes) to afford **Z-29** as a clear yellow oil (2.73 g, 43% over two steps).

Physical State: Clear yellow oil
^{1}H NMR (600 MHz, CDCl3): δ 6.01 (q, *J* = 1.5 Hz, 1H), 4.18 (t, *J* = 6.8 Hz, 2H), 2.56 (t, *J* = 6.8 Hz, 2H), 2.06 (d, *J* = 0.8 Hz, 3H), 1.93 (d, *J* = 1.5 Hz, 3H).

^{13}C NMR (151 MHz, CDCl3): δ 171.1, 143.9, 76.9, 61.7, 38.0, 23.9, 21.2
HRMS (ESI-TOF): calculated for $C_7H_{11}IO_2$ $[M+H]^+$: 254.9882, found: 254.9867
TLC: R_f = 0.68 (4:1 hexanes/ethyl acetate)

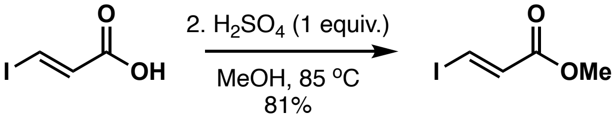


Procedure adapted from a literature procedure. (*85*)

To a pressure vessel containing a stir bar was added hydroiodic acid (47%) (20 mL, 114 mmol, 1.6 equiv.) followed by propiolic acid (5.00 g, 71.4 mmol, 1 equiv.). The vessel was then fitted with a cap and submerged in an oil bath heated to 95 °C for 20h. The vessel was then removed from the bath and allowed to cool to room temperature before being placed in an ice bath. The resulting crystals were filtered and rinsed with ice water. The white needle crystals of (E)-3-iodoacrylic acid (10.894 g, 77%) were thoroughly dried and used without further purification.

Spectral data matched previous reports; the ^{1}H NMR data is provided here for convenience.(*86*)

^{1}H NMR (300 MHz, CDCl3): δ = 10.54 – 8.66 (br s, 1H), 8.08 (d, *J* = 14.7 Hz, 1H), 6.89 (d, *J* = 14.7 Hz, 1H).

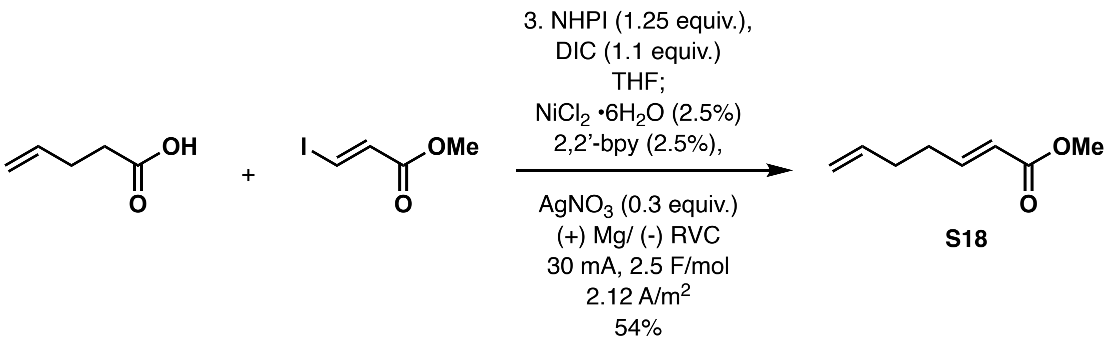


To a round bottom flask equipped with stir bar and reflux condenser was added methanol (70 mL) and (E)-3-iodoacrylic acid (7.00 g, 35.36 mmol, 1 equiv.). Then, carefully, concentrated sulfuric acid (1.89 mL, 35.36 mmol, 1 equiv.) was added dropwise. After complete addition of the acid, the flask was heated to 85 °C and monitored for full conversion by TLC. Once complete, the reaction was cooled to room temperature, diluted with diethyl ether (200 mL) and quenched with a saturated solution of sodium bicarbonate (15 mL). The organic layer was washed with brine (100 mL), dried over magnesium sulfate, then concentrated under reduced pressure to afford methyl (E)-3-iodoacrylate as a pale white solid (6.077 g, 81%). The crude material was used without further purification.

Note: The dissolution of H_2SO_4 in MeOH results in an exotherm capable of boiling the solvent. The acid should be added slowly.

Spectral data matched previous reports; the ^{1}H NMR data is provided here for convenience.(*87*)

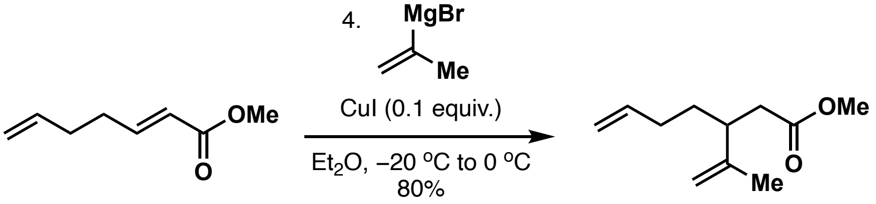
^{1}H NMR (400 MHz, CDCl3): δ = 7.89 (d, *J* = 14.8 Hz, 1H), 6.88 (d, *J* = 14.8 Hz, 1H), 3.75 (s, 3H).



To a flask containing a stir bar and pent-4-enoic acid (0.51 mL, 5 mmol, 1 equiv.) was added NHPI (1.02 g, 6.25 mmol, 1.25 equiv.) and anhydrous, inhibitor-free THF (3.75 mL) and allowed to stir until dissolved. Next, DIC (0.861 mL, 5.5 mmol, 1.1 equiv.) was added and the reaction was allowed to stir 2h and a white suspension formed. To a separate flask containing a stir bar was added $NiCl_2$•$6H_2O$ (29.7 mg, 0.125 mmol, 0.025 equiv.), 2,2'-bipyridine (15.6 mg, 0.125 mmol, 0.025 equiv.) and methyl (E)-3-iodoacrylate (1.378 g, 6.5 mmol, 1.3 equiv.) was added. This flask was evacuated and backfilled 3 times with argon before the addition of anhydrous DMF (15 mL). This solution was allowed to stir for 20 minutes and a homogeneous, dark green solution developed. This green solution was transferred via cannula into the flask containing the *in situ* activated ester (white suspension). This green suspension was added to a 20 mL ElectraSyn 2.0 vial under argon containing a magnesium anode, 100 ppi RVC cathode (9 mm dia. X 40 mm length), $AgNO_3$ (254.8 mg, 1.5 mmol, 106 $mmol_{Ag}/m^2_{(cathode)}$, 0.3 equiv.) and stir bar. After complete addition electrolysis was immediately started. The electrochemical reaction was performed using an ElectraSyn 2.0 under constant current conditions with the settings as follows: 30 mA, 5 mmols, 2.5 F/mol providing 2.12 A/m^2 current density. After completion of the reaction the vial was transferred to a separatory funnel and quenched with 1N HCl (50 mL) and extracted with diethyl ether (3 X 100 mL). The combined organics were washed successively with distilled water (2 X 100 mL) then brine (1 X 100 mL), then dried over magnesium sulfate before being filtered and concentrated via rotary evaporation. The oily solid was purified via silica gel chromatography (0-25% ethyl acetate/ hexanes) to provide **S18** as a clear colorless oil (380.8 mg, 54%).

Notes: The addition of HCl is exothermic. Be sure to wait until the contents reach ambient temperature before continuing the work up.

Physical State: Clear colorless to yellow oil
^{1}H NMR (600 MHz, CDCl3): δ 6.97 (dt, *J* = 15.7, 6.7 Hz, 1H), 5.88 – 5.73 (m, 2H), 5.13 – 4.99 (m, 2H), 3.73 (s, 3H), 2.31 (dtt, *J* = 7.9, 6.4, 1.5 Hz, 2H), 2.28 – 2.17 (m, 2H).
^{13}C NMR (151 MHz, CDCl3): δ 167.2, 148.7, 137.2, 121.4, 115.7, 51.6, 32.2, 31.6,
HRMS (ESI-TOF): calculated for $C_8H_{12}O_2$ $[M+H]^+$: 141.0916, found: 141.0918
TLC: R_f = 0.67 (4:1 hexanes/ethyl acetate)

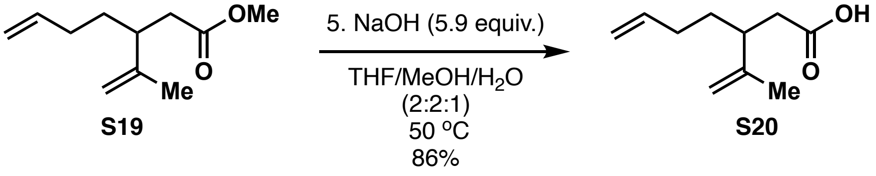


S18 **S19**

To a flame dried flask containing a stir bar and magnesium turnings (984 mg, 40.5 mmol, 2.5 equiv.) under argon was added anhydrous, inhibitor-free THF (32.4 mL). The turnings were activated with a small amount of 1,2-dibromoethane (0.05 mL) and bubbling was observed. Next, 2-bromopropene (1.546 mL, 16.2 mmol, 1 equiv.) was added dropwise at a rate sufficient to maintain a gentle reflux. The Grignard formation was allowed to stir for 1 hour after returning to room temperature and was subsequently titrated with iodine and found to be 0.36 M in concentration.

To a separate flame dried round bottom flask was added copper iodide (62 mg, 0.324 mmol, 0.1 equiv.). This flask was evacuated and backfilled with argon three times before the addition anhydrous, inhibitor-free diethyl ether (7 mL). The tube was cooled to -20 °C and the Grignard solution in THF (18 mL, 6.48 mmol, 2 equiv.) was added dropwise. This was allowed to stir for 15 minutes before the dropwise addition of a solution of the enoate ester **S18** (434 mg, 3.24 mmol, 1 equiv.) in diethyl ether (3.5 mL). The reaction was allowed to slowly warm to 0 °C and was quenched with a 9:1 ammonium chloride: ammonium hydroxide solution (30 mL) and diluted with ether (100 mL). The organic layer was successively washed with the 9:1 ammonium chloride: ammonium hydroxide solution (5 X 30 mL) until colorless. The organic phase was washed with brine (200 mL), dried over magnesium sulfate and concentrated to afford a yellow oil. The product was purified thorough silica gel chromatography (0-6% Ethyl acetate / hexanes) to provide diene **S19** as a clear oil (469.7 mg, 80%).

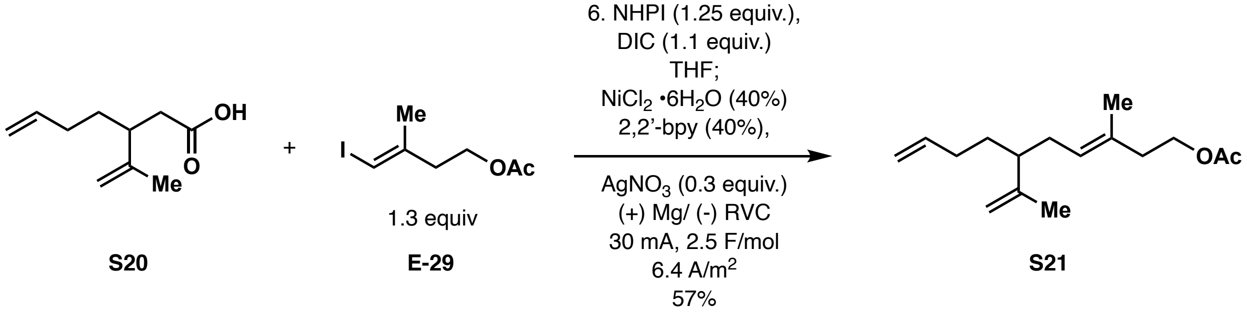
Physical State: Clear colorless oil
^{1} H NMR (399 MHz, CDCl3): δ 5.79 (ddt, *J* = 16.9, 10.2, 6.6 Hz, 1H), 5.00 (ddt, *J* = 17.1, 2.1, 1.6 Hz, 1H), 4.97 – 4.92 (m, 1H), 4.80 – 4.73 (m, 2H), 3.65 (s, 3H), 2.66 – 2.54 (m, 1H), 2.37 (dd, *J* = 7.6, 1.3 Hz, 2H), 2.10 – 1.87 (m, 2H), 1.66 (dd, *J* = 1.5, 0.8 Hz, 3H), 1.53 – 1.41 (m, 2H).
^{13}C NMR (151 MHz, CDCl3): δ 173.2, 146.0, 138.5, 114.8, 112.5, 51.6, 43.3, 39.2, 32.2, 31.4, 18.7
HRMS (ESI-TOF): calculated for $C_{11}H_{18}O_2$ $[M+H]^+$: 183.1385, found: 183.1385
TLC: R_f = 0.36 (20:1 hexanes/ethyl acetate)



S19 **S20**

To a stirring solution of ester **S19** (1.7865 g, 9.80 mmol, 1 equiv.) in THF (10 mL), MeOH (10 mL) and water (5 mL) was added sodium hydroxide (1.567 g, 39.20 mmol, 4 equiv.). The mixture was allowed to warm to 50 °C and monitored by TLC. After 4h, another portion of sodium hydroxide (750 mg, 18.75 mmol, 1.9 equiv.) and water (5 mL) was added. Upon completion, the reaction was allowed to cool to room temperature and was concentrated under reduced pressure to afford an orange suspension. The crude material was dissolved in water (100 mL) and extracted with diethyl ether (3 X 100 mL). The aqueous layer was acidified to pH 1 with 1M aqueous HCl. The now acidic aqueous layer was extracted again with diethyl ether (3 X 100 mL). These combined organics were dried over $MgSO_4$ and concentrated to afford acid **S20** as a clear yellow oil (1.413 g, 86%). This material was used in the subsequent step without any further purification.

Physical State: Clear yellow oil
^{1}H NMR (600 MHz, CDCl3): δ 5.79 (ddt, *J* = 16.9, 10.2, 6.6 Hz, 1H), 5.01 (dq, *J* = 17.1, 1.7 Hz, 1H), 4.96 (ddt, *J* = 10.2, 2.2, 1.3 Hz, 1H), 4.81 (q, *J* = 1.6 Hz, 1H), 4.78 (dt, *J* = 1.9, 0.9 Hz, 1H), 2.61 (p, *J* = 7.4 Hz, 1H), 2.41 (dd, *J* = 7.5, 1.0 Hz, 2H), 2.07 – 1.92 (m, 2H), 1.67 (dd, *J* = 1.5, 0.8 Hz, 3H), 1.54 – 1.45 (m, 2H).
^{13}C NMR (151 MHz, CDCl3): δ 178.4, 145.7, 138.4, 114.9, 112.7, 43.0, 39.0, 32.2, 31.4, 18.8
HRMS (ESI-TOF): calculated for $C_{10}H_{16}O_2$ $[M+H]^+$: 169.1229, found: 169.1228
TLC: R_f = 0.21 (3:1 hexanes/ethyl acetate)

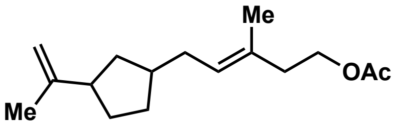


To a flask containing a stir bar and carboxylic acid **S20** (168.2 mg, 1 mmol, 1 equiv.) was added NHPI (204 mg, 1.25 mmol, 1.25 equiv.) and anhydrous, inhibitor-free THF (0.75 mL) and allowed to stir until dissolved. Next, DIC (0.172 mL, 1.1 mmol, 1.1 equiv.) was added and the reaction was allowed to stir 2h and a white suspension formed. To a separate flask containing a stir bar was added $NiCl_2•6H_2O$ (95.1 mg, 0.4 mmol, 0.4 equiv.), 2,2'-bipyridine (62.5 mg, 0.4 mmol, 0.4 equiv.) and vinyl iodide **E-29** (330.3 mg, 1.3 mmol, 1.3 equiv.) was added. This flask was evacuated and backfilled 3 times with argon before the addition of anhydrous DMF (4.2 mL). This solution was allowed to stir for 20 minutes and a homogeneous, dark green solution developed. This green solution was transferred via cannula into the flask containing the *in situ* activated ester (white suspension). This green suspension was added to a 5 mL ElectraSyn 2.0 vial under argon containing a magnesium anode, 100 ppi RVC cathode (3 mm X 7 mm X 51 mm), $AgNO_3$ (50.9 mg, 0.3 mmol, 64 $mmol_{Ag}/m^2_{(cathode)}$, 0.3 equiv.) and stir bar. After complete addition electrolysis was immediately started. The electrochemical reaction was performed using an ElectraSyn 2.0 under constant current conditions with the settings as follows: 30 mA, 1 mmols, 2.5 F/mol providing 6.4 A/m^2 current density. After completion of the reaction the vial was transferred to a separatory funnel and quenched with 1N HCl (20 mL) and extracted with diethyl ether (3 X 50 mL). The combined organics were washed successively with distilled water (2 X 50 mL) then brine (1 X 50 mL), then dried over magnesium sulfate before being filtered and concentrated via rotary evaporation. The oily solid was purified via silica gel chromatography (pentane) to provide

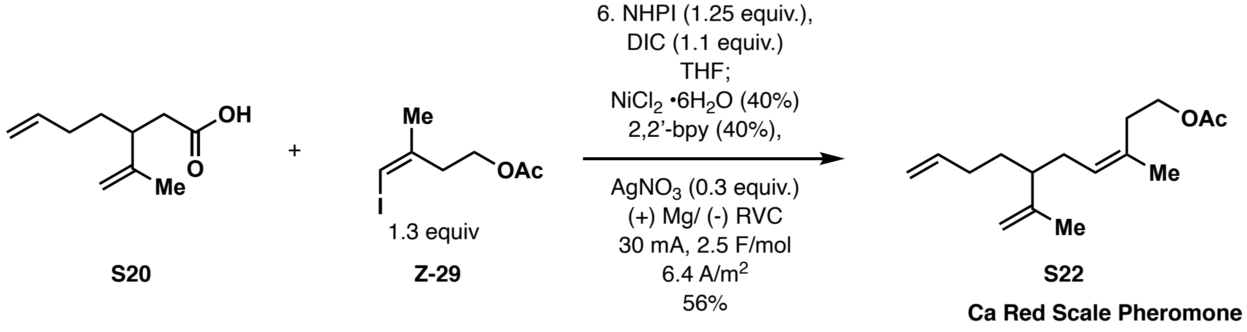
S21 and **S23** as a clear colorless oil (162 mg as an 88:12 mixture of desired linear to undesired cyclized product, 57% desired, 8% undesired). **S21** was further purified via 15 wt% $AgNO_3$ silica gel chromatography (0-10% Et_2O / Hexanes).

Notes: The addition of HCl is exothermic. Be sure to wait until the contents reach ambient temperature before continuing the work up.

Physical State: Clear colorless to pale yellow oil
^{1}H NMR (600 MHz, CDCl3): δ 5.79 (ddt, *J* = 16.9, 10.2, 6.6 Hz, 1H), 5.17 – 5.10 (m, 1H), 4.98 (dq, *J* = 17.1, 1.7 Hz, 1H), 4.93 (ddt, *J* = 10.2, 2.3, 1.3 Hz, 1H), 4.75 (dt, *J* = 2.9, 1.5 Hz, 1H), 4.67 (d, *J* = 2.4 Hz, 1H), 4.11 (t, *J* = 6.9 Hz, 2H), 2.31 – 2.26 (m, 2H), 2.13 – 1.98 (m, 4H), 2.02 (s, 3H), 2.00 – 1.88 (m, 1H), 1.63 (d, *J* = 1.2 Hz, 3H), 1.61 (t, *J* = 1.2 Hz, 3H), 1.52 – 1.35 (m, 2H).
^{13}C NMR (151 MHz, CDCl3): δ 171.3, 147.4, 139.1, 131.4, 125.9, 114.4, 111.7, 63.2, 47.0, 38.8, 32.3, 32.1, 31.8, 21.2, 18.6, 16.4
HRMS (ESI-TOF): calculated for $C_{16}H_{26}O_2$ $[M+H]^+$: 251.2011, found: 251.2011
TLC: R_f = 0.45 (20:1 hexanes/diethyl ether)



*Cyclized Product (**S23**)*
Isolated as an inseparable ~10:1 mixture of diastereomers
Physical State: Clear colorless to pale yellow oil
^{1}H NMR (500 MHz, CDCl3): δ 5.20 (td, *J* = 6.9, 1.3 Hz, 1H), 4.70 – 4.66 (m, 1H), 4.65 (ddt, *J* = 2.2, 1.4, 0.7 Hz, 1H), 4.13 (td, *J* = 7.0, 1.3 Hz, 2H), 2.58 – 2.39 (m, 1H), 2.33 – 2.26 (m, 2H), 2.07 – 1.96 (m, 3H), 2.03 (s, 3 H), 1.91 – 1.74 (m, 2H), 1.71 (dd, *J* = 1.4, 0.7 Hz, 3H), 1.66 – 1.58 (m, 1H), 1.63 (s, 3H), 1.49 – 1.36 (m, 2H), 1.31 – 1.12 (m, 1H).
^{13}C NMR (151 MHz, CDCl3):
Major diastereomer: δ 171.3, 149.4, 131.2, 126.7, 108.0, 63.2, 45.9, 39.2, 38.9, 36.7, 34.8, 32.7, 31.6, 21.3, 21.2, 16.4
Minor diastereomer: δ 171.3, 149.3, 131.2, 126.7, 108.0, 63.2, 47.3, 40.3, 38.8, 38.5, 34.6, 31.3, 30.2, 21.3, 21.2, 16.3
HRMS (ESI-TOF): calculated for $C_{16}H_{26}O_2$ $[M+H]^+$: 251.2011, found: 251.2014
TLC: R_f = 0.45 (20:1 hexanes/diethyl ether)

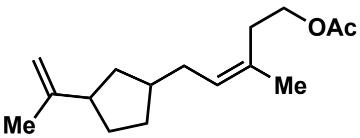


To a flask containing a stir bar and carboxylic acid **S20** (168.2 mg, 1 mmol, 1 equiv.) was added NHPI (204 mg, 1.25 mmol, 1.25 equiv.) and anhydrous, inhibitor-free THF (0.75 mL) and allowed to stir until dissolved. Next, DIC (0.172 mL, 1.1 mmol, 1.1 equiv.) was added and the reaction was allowed to stir 2h and a white suspension formed. To a separate flask containing a stir bar was added $NiCl_2$•$6H_2O$ (95.1 mg, 0.4 mmol, 0.4 equiv.), 2,2'-bipyridine (62.5 mg, 0.4 mmol, 0.4 equiv.) and vinyl iodide **Z-29** (330.3 mg, 1.3 mmol, 1.3 equiv.) was added. This flask was evacuated and backfilled 3 times with argon before the addition of anhydrous DMF (4.2 mL). This solution was allowed to stir for 20 minutes and a homogeneous, dark green solution developed. This green solution was transferred via cannula into the flask containing the *in situ* activated ester (white suspension). This green suspension was added to a 5 mL ElectraSyn 2.0 vial under argon containing a magnesium anode, 100 ppi RVC cathode (3 mm X 7 mm X 51 mm), $AgNO_3$ (50.9 mg, 0.3 mmol, 64 $mmol_{Ag}/m^2_{(cathode)}$, 0.3 equiv.) and stir bar. After complete addition electrolysis was immediately started. The electrochemical reaction was performed using an ElectraSyn 2.0 under constant current conditions with the settings as follows: 30 mA, 1 mmols, 2.5 F/mol providing 6.4 A/m^2 current density. After completion of the reaction the vial was transferred to a separatory funnel and quenched with 1N HCl (20 mL) and extracted with diethyl ether (3 X 50 mL). The combined organics were washed successively with distilled water (2 X 50 mL) then brine (1 X 50 mL), then dried over magnesium sulfate before being filtered and concentrated via rotary evaporation. The oily solid was purified via silica gel chromatography (pentane)to provide **S22** and **S24** as a clear colorless oil (163 mg as an 84:16 mixture of desired linear to undesired cyclized product). The residue was further purified via 15 wt% $AgNO_3$ silica gel chromatography (0-10% Et_2O / Hexanes) to afford California Red Scale pheromone **S22** as a clear colorless oil (139.8 mg, 56% yield)

Notes: The addition of HCl is exothermic. Be sure to wait until the contents reach ambient temperature before continuing the work up.

Physical State: Clear colorless to pale yellow oil
^{1} H NMR (500 MHz, CDCl3): δ 5.79 (ddt, J = 17.0, 10.2, 6.6 Hz, 1H), 5.23 – 5.17 (m, 1H), 4.99 (dq, J = 17.1, 1.7 Hz, 1H), 4.93 (ddt, J = 10.2, 2.3, 1.3 Hz, 1H), 4.76 (dq, J = 2.8, 1.5 Hz, 1H), 4.70 – 4.66 (m, 1H), 4.09 (t, J = 7.2 Hz, 2H), 2.35 (t, J = 7.2 Hz, 2H), 2.11 – 1.96 (m, 4H), 2.05 (s, 3H), 1.96 – 1.86 (m, 1H), 1.71 (q, J = 1.3 Hz, 3H), 1.61 (dd, J = 1.5, 0.8 Hz, 3H), 1.51 – 1.34 (m, 2H).
^{13}C NMR (151 MHz, CDCl3): δ 171.2, 147.3, 139.1, 131.3, 126.6, 114.4, 111.8, 62.9, 47.2, 32.1, 31.8, 31.4, 23.7, 21.2, 18.6
HRMS (ESI-TOF): calculated for $C_{16}H_{26}O_2$ $[M+H]^+$: 251.2011, found: 251.2010
TLC: R_f = 0.41 (20:1 hexanes/diethyl ether)

*Cyclized Product (**S24**)*



Isolated as an inseparable ~10:1 mixture of diastereomers
Physical State: Clear colorless to pale yellow oil

^{1} H NMR (399 MHz, CDCl3): δ 5.26 (t, *J* = 6.7 Hz, 1H), 4.72 – 4.62 (m, 2H), 4.10 (t, *J* = 7.2 Hz, 2H), 2.52 (p, *J* = 8.4 Hz, 1H), 2.40 – 2.32 (m, 2H), 2.09 – 1.74 (m, 5H), 2.04 (s, 3H), 1.73 (q, *J* = 1.2 Hz, 3H), 1.71 (dt, *J* = 1.2, 0.6 Hz, 3H), 1.67 – 1.58 (m, 1H), 1.51 – 1.35 (m, 1H), 1.34 – 1.11 (m, 1H).

^{13}C NMR (151 MHz, CDCl3):

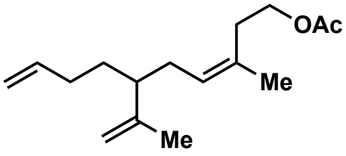
Major diastereomer: δ 171.3, 149.4, 131.0, 127.5, 108.1, 62.9, 45.9, 39.3, 36.7, 34.7, 32.8, 31.6, 31.4, 23.8, 21.3, 21.2

Minor diastereomer: δ 171.3, 149.2, 130.9, 127.5, 108.0, 62.9, 47.3, 40.4, 38.6, 36.7, 34.5, 31.4, 31.3, 30.1, 23.8, 21.3

HRMS (ESI-TOF): calculated for $C_{16}H_{26}O_2$ $[M+H]^+$: 251.2011, found: 251.2008

TLC: $R_f = 0.41$ (20:1 hexanes/diethyl ether)

Table S18—California Red Scale Pheromone ^{1}H Shifts Comparison



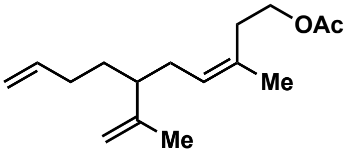
S22

Tabulated data for Synthetic **S22**
^{1}H-NMR ($CDCl_3$)

Synthetic **S22** (500 MHz, $CDCl_3$)	Synthetic **S22** (Aggarwal, 400 MHz $CDCl_3$) (*88*)	Natural **S22** (Anderson, 300MHz, CS_2) (*89*)	Δppm from Synthetic **S22**
5.79 (ddt, *J* = 17.0, 10.2, 6.6 Hz, 1H)	5.79 (ddt, *J* = 17.0, 10.2, 6.6 Hz, 1H)	5.71 (ddt, *J* = 16, 10, 7 Hz, 1H)	0.00
5.23 – 5.17 (m, 1H)	5.20 (t, *J* = 6.4 Hz, 1H)	5.12 (t, *J* = 6 Hz, 1H)	0.00
4.99 (dq, *J* = 17.1, 1.7 Hz, 1H)	4.98 (dq, *J* = 17.0, 1.8 Hz, 1H)	4.92 (d, *J* = 16 Hz, 1H)	0.01
4.93 (ddt, *J* = 10.2, 2.3, 1.3 Hz, 1H)	4.92 (ddt, *J* = 10.2, 2.2, 1.2 Hz, 1H)	4.87 (d, *J* = 10 Hz, 1H)	0.01
4.76 (dq, *J* = 2.8, 1.5 Hz, 1H)	4.76 (dq, *J* = 2.4, 1.4 Hz, 1H)	4.70 (s, 1H)	0.00
4.70 – 4.66 (m, 1H)	4.68 (d, *J* = 2.4 Hz, 1H)	4.64 (s, 1H)	0.00
4.09 (t, *J* = 7.2 Hz, 2H)	4.10* (m, 2H)	3.95 (t, *J* = 7 Hz, 2H)	0.01
2.35 (t, *J* = 7.2 Hz, 2H)	2.35 (t, 2H)	2.27 (t, *J* = 7 Hz, 2H)	0.00
2.11 – 1.96 (m, 4H)	2.09 – 1.90 (m, 5H)	2.10 – 1.90 (m, 5H)	0.06
2.05 (s, 3H)	2.04 (s, 3H)	1.92 (s, 3H)	0.01
1.96 – 1.86 (m, 1H)			0.04 (part of previous peak)
1.71 (q, *J* = 1.3 Hz, 3H)	1.71 (d, *J* = 1.3 Hz, 3H)	1.69 (s, 3H)	0.00
1.61 (dd, *J* = 1.5, 0.8 Hz, 3H)	1.61 (m, 3H)	1.60 (s, 3H)	0.00
1.51 – 1.34 (m, 2H)	1.50 – 1.36 (m, 2H)	1.39 (m, 2H)	0.02

* Peak not accounted for in tabulation but present in reported spectra.

Table S19—California Red Scale Pheromone ^{13}C Shifts Comparison

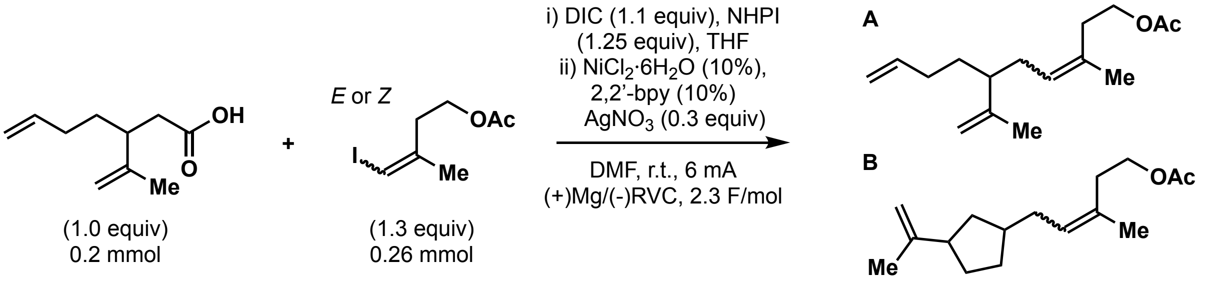


S22

Tabulated data for Synthetic **S22**
^{13}C-NMR ($CDCl_3$)

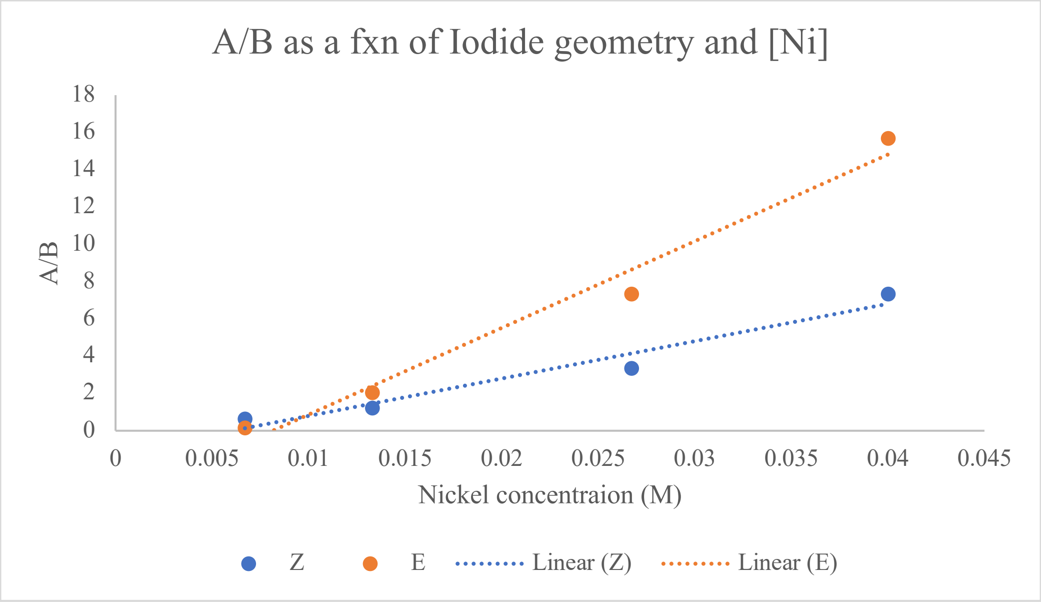
Synthetic **S22** (151 MHz, $CDCl_3$)	Synthetic **S22** (Aggarwal, 101 MHz $CDCl_3$) (*88*)	Δppm from Synthetic **S22**
171.2	171.2	0.0
147.3	147.2	0.1
139.1	139.1	0.0
131.3	131.3	0.0
126.6	126.6	0.0
114.4	114.4	0.0
111.8	111.8	0.0
62.9	62.9	0.0
47.2	47.2	0.0
32.1	32.1	0.0
31.8	31.8	0.0
31.4	31.4	0.0
23.7	23.7	0.0
21.2	21.3	0.1
18.6	18.6	0.0

Table S20 —Radical Cyclization Experiments



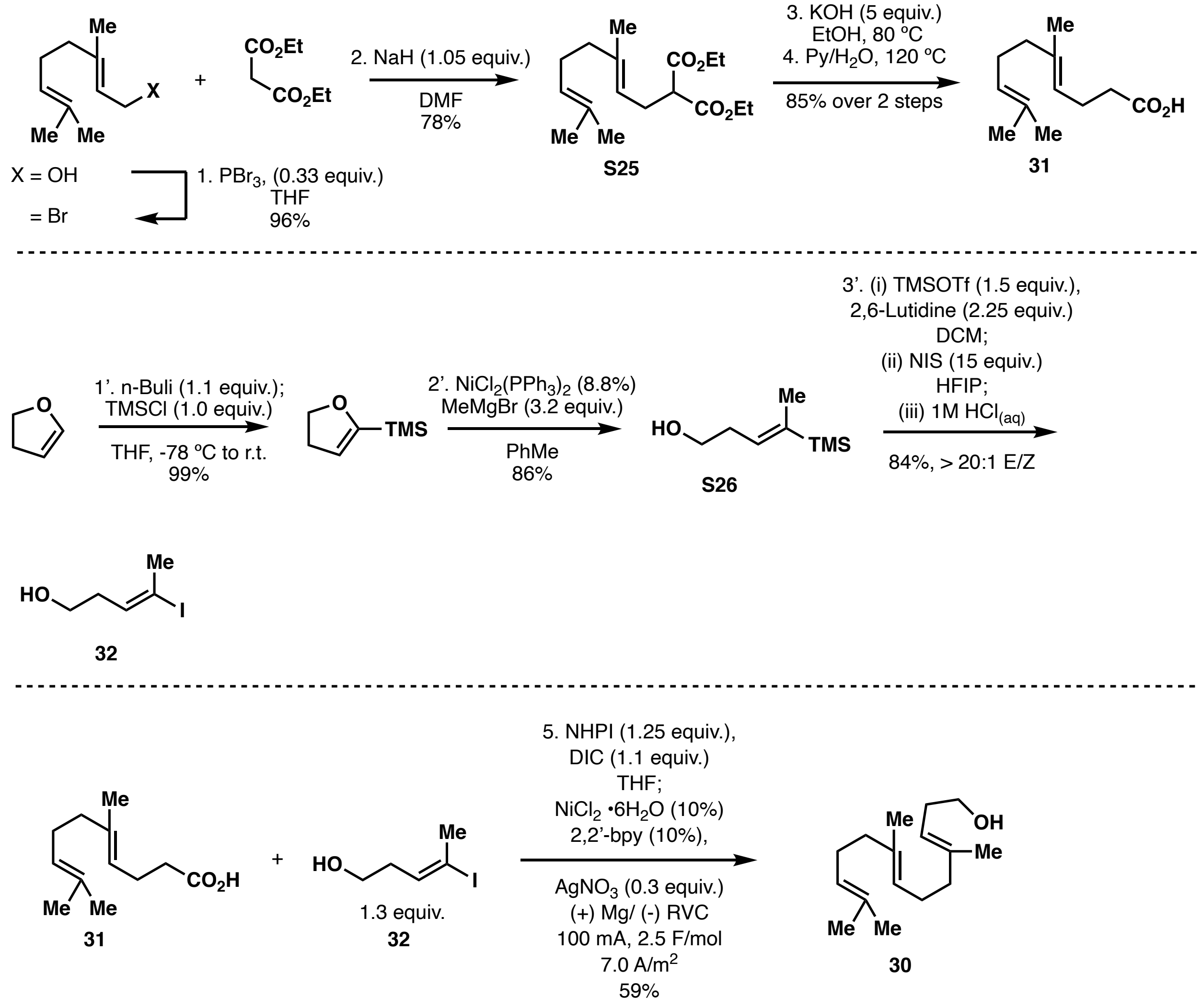
entry	iodide geometry	Ni/bpy (%)	Ni concentration (M)	total yield (A+B)	A:B	A/B
1	Z	10	0.0067	54%	39:61	0.64
2	Z	20	0.0133	45%	55:45	1.22
3	Z	40	0.0267	49%	77:23	3.35
4	Z	60	0.0400	45%	88:12	7.33
5	E	10	0.0067	43%	13:87	0.15
6	E	20	0.0133	47%	67:33	2.03
7	E	40	0.0267	45%	88:12	7.33
8	E	60	0.0400	47%	94:6	15.67

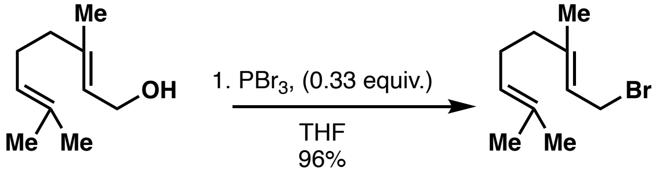
Fig. S14 — Radical Cyclization Graph



Homofarnesol (procedures)

Fig S15 — Complete homofarnesol synthesis

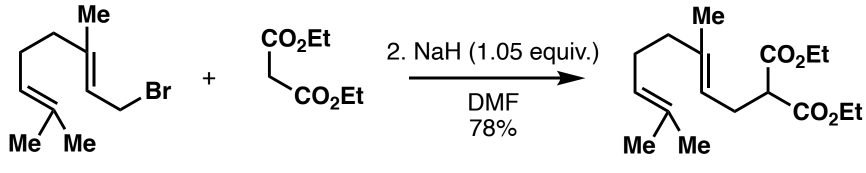




To a stirring solution of geraniol (20.82 mL, 120 mmol, 1 equiv.) in anhydrous diethyl ether (480 mL) under argon was added dropwise phosphorus tribromide (3.80 mL, 40 mmol, 0.33 equiv.) at 0 °C. The reaction mixture was allowed to stir and slowly warm to room temperature. Reaction progress was monitored by TLC. Upon completion, the reaction was quenched with brine (200 mL). The organics were extracted with diethyl ether (3 x 200 mL). The combined organics were washed with brine (200 mL), dried over $MgSO_4$, and concentrated to afford geranyl bromide as a pale-yellow oil which was used in the next step without further purification (25.39 g, 96%).

Spectral data matched previous reports; the ^{1}H NMR data is provided here for convenience.(*90*)

^{1} H NMR (400 MHz, CDCl3): δ = 5.53 (m, 1H), 5.07 (m, 1H), 4.02 (d, *J* = 8.4 Hz, 2H), 2.11 – 2.06 (m, 4H), 1.73 (s, 3H), 1.68 (s, 3H), 1.60 (s, 3H).



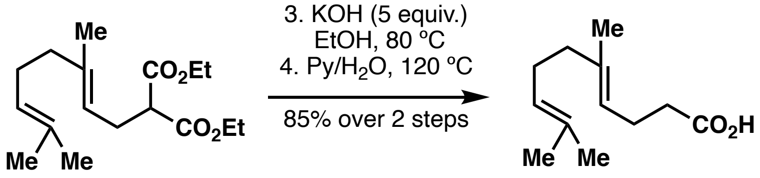
S25

A flame dried 1L round bottom flask equipped with stir bar was charged with sodium hydride (4.19 g, 105 mmol, 1.05 equiv.) as an oil dispersion (60% w/w). The flask was sealed, evacuated and backfilled three times with argon. The contents of the flask were dissolved in anhydrous THF (200 mL) and cooled to 0 °C. Diethyl malonate (15.25 mL, 100 mmol, 1 equiv.) was added to the suspension of sodium hydride dropwise. The mixture was allowed to stir at 0 °C until homogenous (~1 hr). Next, geranyl bromide (25.39 g, 117 mmol, 1.17 equiv.) was slowly added. The reaction mixture was allowed to slowly warm to room temperature and was monitored by TLC. Upon completion, the reaction mixture was quenched with a saturated solution of NH_4Cl (aq.) (50 mL). Organics were extracted with diethyl ether (3 x 100 mL). The combined organics were washed with brine (200 mL), dried over $MgSO_4$, and concentrated to afford an orange oil. The crude material was purified via silica gel chromatography (0-5% Ethyl acetate/ Hexanes) to afford diester **S25** as a clear pale-yellow oil (23.14 g, 78%).

Note: addition of malonate will generate H_2 gas. Periodically ensure pressure is venting from the vessel to avoid inadvertent over-pressurization.

Spectral data matched previous reports; the ^{1}H NMR data is provided here for convenience.(*91*)

^{1} H NMR (200 MHz, CDCl3): δ = 5.12 – 4.96 (m, 2H), 4.16 (q, *J* = 7.0 Hz, 4H), 3.31 (t, *J* = 7.7 Hz, 1H), 2.57 (t, *J* = 7.5 Hz, 2H) 2.09 – 1.86 (m, 4H), 1.64 (s, 3H), 1.60 (s, 3H), 1.56 (s, 3H), 1.23 (t, *J* = 7.0 Hz, 6H).

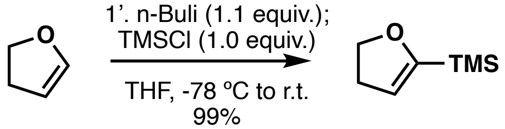


S25 **31**

To a stirring solution of potassium hydroxide (17.52 g, 312.3 mmol, 5 equiv.) in ethanol (125 mL) was added diester **S25** (18.513 g, 62.5 mmol, 1 equiv.) in one portion. The flask containing the reaction mixture was equipped with a reflux condenser and was heated to 80 °C. The reaction was monitored by TLC and allowed to stir until complete. Upon completion, the reaction was cooled to room temperature and concentrated under reduced pressure to afford a white paste. The crude material was dissolved in water (400 mL) and extracted with diethyl ether (2 x 200 mL). The aqueous layer was acidified to pH 1 with 1M aqueous HCl and back-extracted with diethyl ether (3 x 300 mL). These combined organics were dried over $MgSO_4$ and concentrated to afford a clear yellow oil. The crude material was transferred to a 250 mL round bottom flask equipped with stir bar and reflux condenser. Pyridine (25 mL) and water (2.5 mL) were added to the flask. The mixture was heated to reflux and stirred until complete consumption of diacid starting material as monitored by TLC. Upon completion, the reaction was cooled to room temperature, partitioned between diethyl ether (200 mL) and 1M HCl (400 mL), and the organic material was extracted with diethyl ether (3 X 150 mL). The combined organics were successively washed with 1M HCl (150 mL) and brine (300 mL), then dried over $MgSO_4$ and concentrated in a fume hood to afford acid **31** as an orange oil (10.422 g, 85%) which was used in the next step without further purification.

Spectral data matched previous reports; the ^{1}H NMR data is provided here for convenience.(*92*)

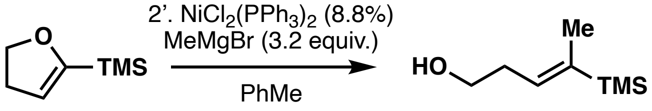
^{1} H NMR (300 MHz, CDCl3): δ = 11.64 – 11.25 (br s, 1H), 5.17 – 5.03 (m, 2H), 2.43 – 2.27 (m, 4H), 2.11 – 1.94 (m, 4H), 1.67 (d, *J* = 0.9 Hz, 3H), 1.62 (d, *J* = 1.2 Hz, 3H), 1.59 (d, *J* = 0.3 Hz, 3H).



To a flame dried 500 mL round bottom flask equipped with stir bar under argon was added 2,3-dihydrofuran (9.07 mL, 120 mmol, 1.2 equiv.) and anhydrous THF (200 mL) before cooling to -78 °C. *n*BuLi (44 mL, 110 mmol, 1.1 equiv.) was added dropwise as a solution in hexanes (2.5 M). The reaction was allowed to warm to 0 °C and stir for 15 minutes. The reaction was then cooled to -78 °C and trimethylsilyl chloride (12.69 mL, 100 mmol, 1.0 equiv.) was added dropwise. The reaction mixture was allowed to warm to room temperature and stir for 1 hr. Upon completion, the reaction was quenched with a saturated solution of NH_4Cl (aq.) (30 mL). The crude material was partitioned between water (50 mL) and diethyl ether (100 mL). The organic material was extracted with diethyl ether (3 X 200 mL). The combined organics were washed with brine, dried over $MgSO_4$ and concentrated to 2-(trimethylsilyl)-2,3-dihydrofuran as a pale-yellow oil (14.2 g, 99%). The crude material was used in the next step without further purification.

Spectral data matched previous reports; the ^{1}H NMR data is provided here for convenience.(*93*)

^{1} H NMR (270 MHz, CDCl3): δ 5.19 (t, *J* = 2.5 Hz, 1H), 4.27 (t, *J* = 9.6 Hz, 2H), 2.58 (dt, *J* = 9.7, 2.5 Hz, 2H), 0.15 (s, 9H).



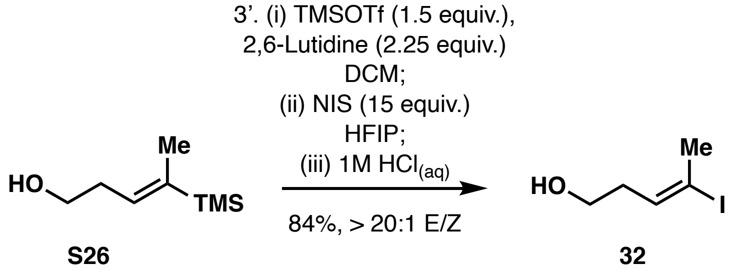
S26

The following reaction was performed following a previously reported procedure with minor modifications.(*93*) To a flame dried 1L three-neck round bottom flask equipped with a reflux condenser was added $NiCl_2(PPh_3)_2$ (3.51 g, 5.36 mmol, 0.088 equiv.). The flask was evacuated and backfilled with argon three times. Anhydrous toluene (265 mL) methylmagnesium bromide in Et_2O (3M) (65.1 mL, 195.2 mmol, 3.2 equiv.) and were added to the flask at room temperature successively and stirred 15 minutes. Next, 2-(trimethylsilyl)-2,3-dihydrofuran (8.678 g, 61 mmol, 1.0 equiv.) was added and the reaction mixture was warmed to 80 °C and stirred for 2 hr. The reaction mixture was then cooled to 0 °C and quenched slowly with a 9:1 solution of NH_4Cl: NH_4OH (500 mL) and stirred until the deep black color of the reaction faded. The organic material was extracted with diethyl ether (3 X 500 mL). The combined organics were washed with brine (500 mL), dried over $MgSO_4$, and concentrated to afford an orange oil. The alcohol **(S26)** was obtained via short path distillation (100 °C at 8 mbar) as a clear colorless oil (8.33 g, 86%).

Note: Significant gas evolution when quenching.

Spectral data matched previous reports; the ^{1}H NMR data is provided here for convenience.(*93*)

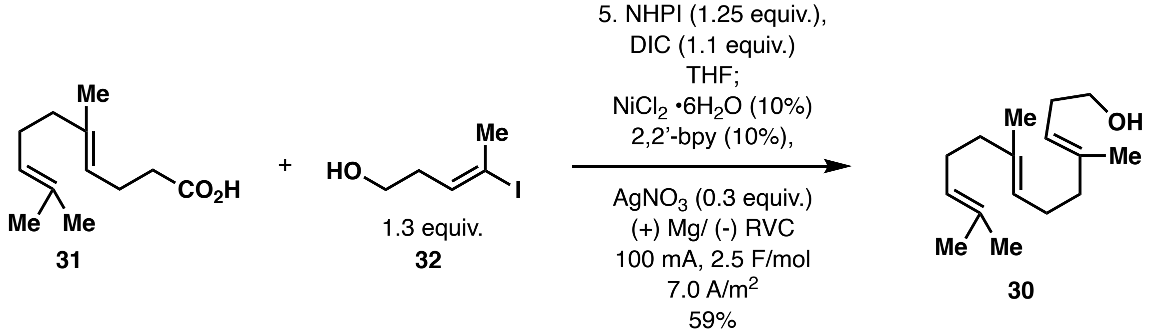
^{1} H NMR (260 MHz, CDCl3): δ 5.70 (m, 1H), 3.65 (t, *J* = 6.7 Hz, 2H), 2.37 (dt, *J* = 6.9, 6.7 Hz, 2H), 1.98 (br s, 1H), 1.69 (d, *J* = 0.8 Hz, 3H), 0.04 (s, 9H).



The following reaction was performed following a previously reported procedure with minor modifications.(*94*) To a flame dried 1 L round bottom flask equipped with stir bar charged with vinyl silane **S26** (8.33 g, 52.61 mmol, 1 equiv.) was added DCM (35 mL) and 2,6-lutidine (13.77 mL, 118.37 mmol, 2.25 equiv.) under an inert atmosphere. Trimethylsilyl trifluoromethanesulfonate (14.28 mL, 78.91 mmol, 1.5 equiv.) was added slowly at 0 °C. The reaction mixture was allowed to warm to room temperature and stir until full consumption of alcohol starting material (monitored by TLC). The reaction was cooled to 0 °C then HFIP (210 mL) and 2,6-lutidine (3.05 mL, 26.31 mmol, 0.75 equiv.) were added. Next, *N*-iodosuccinimide (17.75 g, 78.91 mmol, 1.5 equiv.) was added portion-wise as a solid. The reaction mixture turned a deep purple and was allowed to stir at 0 °C for 5 minutes. The reaction was quenched with a saturated solution of sodium sulfite (aq.) (300 mL) was added and stirred until a colorless solution was obtained. The mixture was diluted in diethyl ether (200 mL) and 1M HCl (400 mL) was added directly to the flask. The reaction was allowed to warm to room temperature and stir for 1.5 hr. The organic material was extracted with diethyl ether (3 X 250 mL). The combined organics were washed with brine, dried over $MgSO_4$ and concentrated to afford a dark red oil. The vinyl iodide **32** was obtained by silica gel chromatography (0-40% ethyl acetate / hexanes) as a clear yellow oil (9.34 g, 84%, 35:1 *E/Z*).

Spectral data matched previous reports; the ^{1}H NMR data is provided here for convenience.(*95*)

^{1} H NMR (400 MHz, CDCl3): δ 6.18 (td, *J* = 8.0, 2.0 Hz, 1H), 3.65 (t, *J* = 8.4 Hz, 2H), 2.40 (t, *J* = 0.8 Hz, 3H), 2.29 (m, 2H).



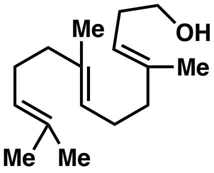
To a flame dried flask was added a stir bar, acid **31** (5.89 g, 30 mmol, 1 equiv.) and NHPI (6.12 g, 37.5 mmol, 1.25 equiv.). Next, the flask was sealed with a septum, evacuated and backfilled three times with argon before the addition of anhydrous, inhibitor-free THF (22.5 mL). The flask was placed in a water bath at room temperature (19 °C) and DIC (5.17 mL, 33 mmol, 1.1 equiv.) was added. The activation was allowed to stir for two hours and a white suspension formed.

To a separate flask containing a stir bar was added $NiCl_2•6H_2O$ (713 mg, 3 mmol, 0.10 equiv.) and 2,2'-bipyridine (468 mg, 3 mmol, 0.10 equiv.). This flask was evacuated and backfilled 3 times with argon before the addition of anhydrous DMF (87 mL). This solution was allowed to stir for 20 minutes and a homogeneous, dark green solution developed. This green solution was transferred via cannula into the flask containing the *in situ* activated ester (white suspension) and the vinyl iodide **32** (8.27 g, 39 mmol, 1.3 equiv.) was added. This green suspension was split into 6 equal portions (~18 mL each) via syringe and added to 6, 20 mL ElectraSyn 2.0 vial under argon each containing a magnesium anode, 100 ppi RVC cathode (9mm diameter, 40 mm length), $AgNO_3$ (255 mg, 1.5 mmol, 106 $mmol_{Ag}/m^2{}_{(cathode)}$, 0.3 equiv.) and stir bar. After complete addition electrolysis was immediately started. The electrochemical reaction was performed using an ElectraSyn 2.0 and carousel under constant current conditions with the settings as follows: 100 mA, 5 mmols, 2.5 F/mol providing 7.0 A/m^2 current density. After completion of the reaction, the vials were combined into a single flask and *slowly* quenched with 1N HCl (300 mL) and extracted with diethyl ether (3 X 200 mL). The combined organics were washed successively with distilled water (2 X 200 mL) then brine (1 X 200 mL), then dried over magnesium sulfate before being filtered and concentrated via rotary evaporation. The oily solid was purified via silica gel chromatography (0-25% ethyl acetate / hexanes) as a clear colorless to yellow oil. If acid impurity present, material was dissolved in ether and washed with 1M aq NaOH, the organics were dried over $MgSO_4$ and concentrated to afford *E,E*-homofarnesol (**30**) as a clear yellow oil (4.173 g, 59%).

Note: Quenching and dissolution of DMF in water is exothermic and extraction of the warm reaction solution with diethyl ether can lead to boiling of the solvent

Physical State: Clear colorless to yellow oil
^{1}H NMR (400 MHz, CDCl3): δ 5.21 – 5.03 (m, 3H), 3.61 (t, *J* = 6.5 Hz, 2H), 2.28 (dtd, *J* = 7.4, 6.5, 0.9 Hz, 2H), 2.17 – 2.01 (m, 6H), 1.97 (dd, *J* = 9.2, 6.0 Hz, 2H), 1.68 (d, *J* = 1.4 Hz, 3H), 1.64 (d, *J* = 1.3 Hz, 3H), 1.60 (s, 6H), 1.46 (s, 1H).
^{13}C NMR (151 MHz, CDCl3): δ 139.0, 135.4, 131.4, 124.5, 124.1, 120.0, 62.5, 39.9, 39.8, 31.6, 26.9, 26.6, 25.8, 17.8, 16.3, 16.1
HRMS (ESI-TOF): calculated for $C_{16}H_{29}O$ $[M+H]^+$: 237.2218, found: 237.2221
TLC: R_f = 0.40 (4:1 Hexanes / ethyl acetate)

Table S21 —Homofarnesol ^{1}H Shifts Comparison



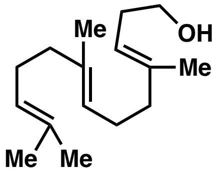
30

Tabulated data for Synthetic **30**
^{1}H-NMR ($CDCl_3$)

Synthetic **30** (400 MHz)	Synthetic **30** (Kocienski, 270 MHz) (*96*)	Δppm
5.21 – 5.03 (m, 3H)	5.09 (m, 3H)	0.00
3.61 (t, *J* = 6.5 Hz, 2H)	3.60 (t, *J* = 6.5 Hz, 2H)	0.01
2.28 (dtd, *J* = 7.4, 6.5, 0.9 Hz, 2H)	2.28 (dt, *J* = 7.3, 6.5 Hz, 2H)	0.00
2.17 – 2.01 (m, 6H) 1.97 (dd, *J* = 9.2, 6.0 Hz, 2H)	2.16 – 1.91 (m, 8H)	N/A
1.68 (d, *J* = 1.4 Hz, 3H)	1.68 (s, 3H)	0.00
1.64 (d, *J* = 1.3 Hz, 3H)	1.64 (s, 3H)	0.00
1.60 (s, 6H)	1.60 (s, 6H)	0.00
1.46 (br s, 1H) *OH**	-	N/A

*OH confirmed with D_2O wash.

Table S22 —Homofarnesol ^{13}C Shifts Comparison



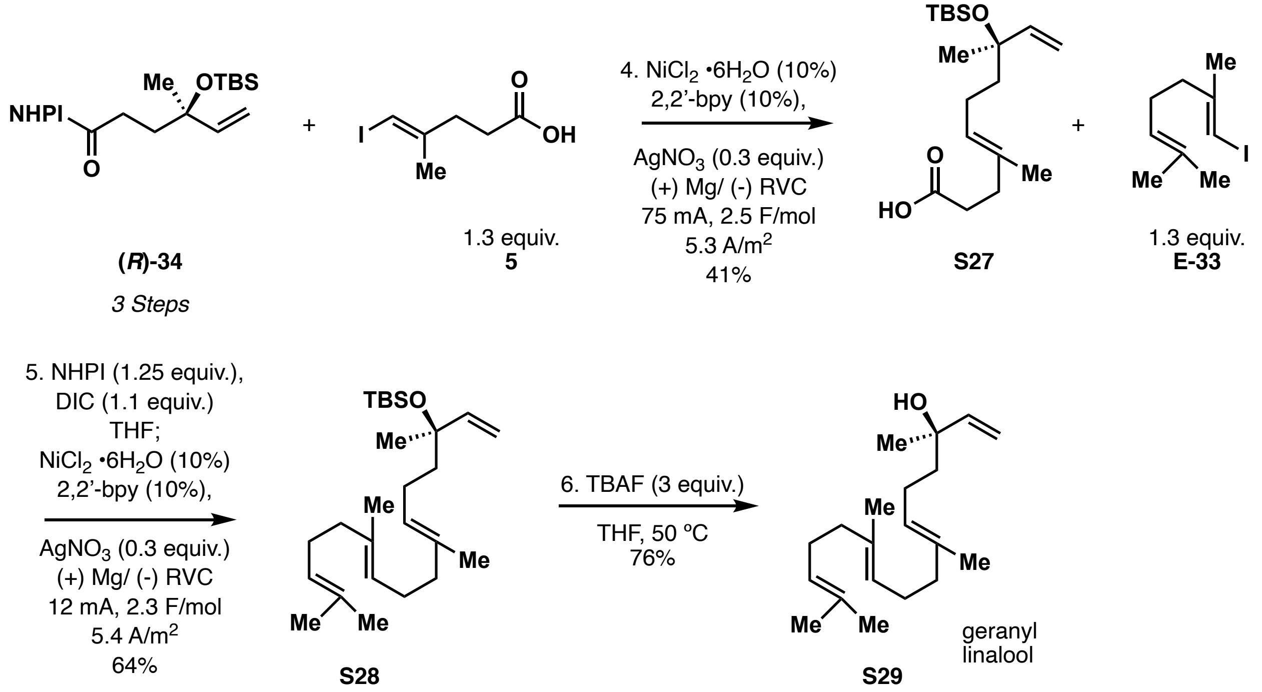
30

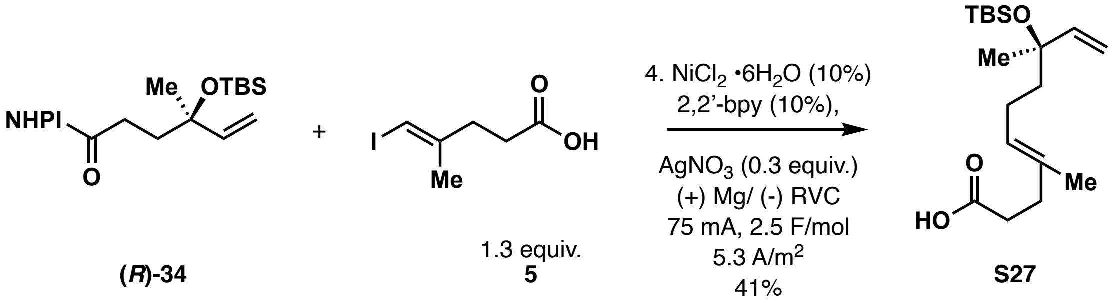
Tabulated data for Synthetic **30**
^{1}H-NMR (CDCl$_3$)

Synthetic **30** (151 MHz)	Synthetic **30** (Kocienski, 67.5 MHz) (*96*)	Δppm
139.0	138.9	0.1
135.4	135.3	0.1
131.4	131.3	0.1
124.5	124.4	0.1
124.1	124.0	0.1
120.0	119.0	0.1
62.5	62.4	0.1
39.9	39.8	0.1
39.8	39.4	0.4
31.6	31.5	0.1
26.9	26.8	0.1
26.6	26.5	0.1
25.8	25.7	0.1
17.8	17.7	0.1
16.3	16.2	0.1
16.1	16.1	0.0

Geranyl linalool (procedures)

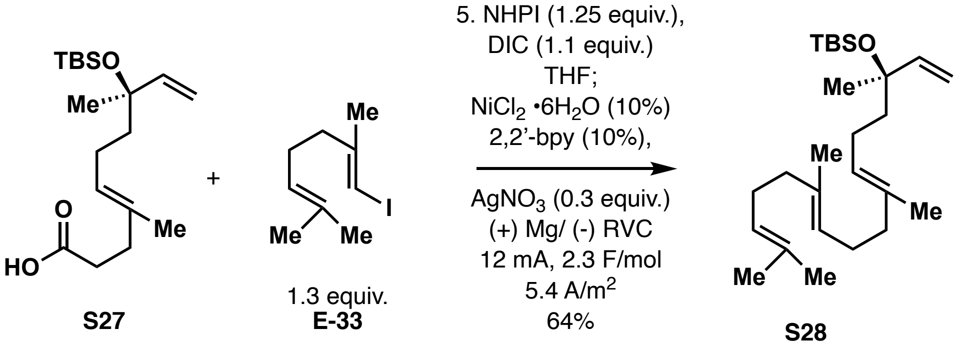
Fig S16. — Synthesis of (*E, E*)-Geranyl Linalool





To an oven dried 10 mL ElectraSyn 2.0 vial was added a stir bar, redox active ester **(*R*)-34** (1.01 g, 2.5 mmol, 1 equiv.), vinyl iodide **5** (781.4 mg, 3.25 mmol, 1.3 equiv.), $NiCl_2{\bullet}6H_2O$ (59.4 mg, 0.25 mmol, 0.10 equiv.) and 2,2'-bipyridine (39.0 mg, 0.25 mmol, 0.10 equiv.) and $AgNO_3$ (127.4 mg, 0.75 mmol, 53 $mmol_{Ag}/m^2_{(cathode)}$, 0.3 equiv.). The vial was sealed with a cap containing a magnesium anode, 100 ppi RVC cathode (9 mm diameter, 40 mm length). The vial was evacuated and backfilled 3 times with argon before the addition of anhydrous DMF (10 mL). After complete addition of solvent, electrolysis was immediately started. The electrochemical reaction was performed using an ElectraSyn 2.0 under constant current conditions with the settings as follows: 75 mA, 2.5 mmols, 2.5 F/mol providing 5.3 A/m^2 current density. After completion of the reaction, the vial was transferred to a flask and *slowly* quenched with 1N HCl (50 mL) and extracted with diethyl ether (3 X 50 mL). The combined organics were washed successively with distilled water (2 X 100 mL) then brine (1 X 100 mL), then dried over magnesium sulfate before being filtered and concentrated via rotary evaporation. The oily solid was purified via 15wt% $AgNO_3$ silica gel chromatography (0-30% Et_2O / Hexanes with 0.25%v/v AcOH) to afford acid **S27** as a clear colorless oil (336.3 mg, 41%)

Physical State: Clear colorless oil
^{1}H NMR (600 MHz, CDCl3): δ 5.84 (dd, *J* = 17.3, 10.7 Hz, 1H), 5.22 – 5.11 (m, 2H), 4.98 (dd, *J* = 10.7, 1.6 Hz, 1H), 2.44 (dd, *J* = 8.7, 6.8 Hz, 2H), 2.29 (t, *J* = 7.8 Hz, 2H), 2.09 – 1.93 (m, 2H), 1.60 (d, *J* = 1.3 Hz, 3H), 1.52 – 1.38 (m, 2H), 1.29 (s, 3H), 0.89 (s, 9H), 0.07 (s, 3H), 0.06 (s, 3H).
^{13}C NMR (151 MHz, CDCl3): δ 178.8, 145.7, 132.8, 125.9, 111.8, 75.6, 43.7, 34.5, 32.9, 27.6, 26.1, 22.8, 18.5, 16.0, -1.9, -1.9
HRMS (ESI-TOF): calculated for $C_{18}H_{34}O_3Si$ [M-OTBS]$^+$: 195.1382, found: 195.1389
TLC: R_f = 0.70 (40% Ethyl acetate, 0.25% acetic acid, hexanes)
$[\alpha]_D^{20}$= -9.200 (c = 0.5 EtOH)



To a flask containing a stir bar and carboxylic acid **27** (130.6 mg, 0.4 mmol, 1 equiv.) was added NHPI (81.6 mg, 0.50 mmol, 1.25 equiv.) and anhydrous, inhibitor-free THF (0.50 mL) and allowed to stir until dissolved. Next, DIC (69 µL, 0.44 mmol, 1.1 equiv.) was added and the reaction was allowed to stir 2h and a white suspension formed. To a separate flask containing a stir bar was added $NiCl_2$•$6H_2O$ (9.5 mg, 0.04 mmol, 0.1 equiv.), 2,2'-bipyridine (6.3 mg, 0.04 mmol, 0.1 equiv.) and vinyl iodide ***E*-33** (130.0 mg, 0.52 mmol, 1.3 equiv.) was added. This flask was evacuated and backfilled 3 times with argon before the addition of anhydrous DMF (2.5 mL). This solution was allowed to stir for 20 minutes and a homogeneous, dark green solution developed. This green solution was transferred via cannula into the flask containing the *in situ* activated ester (white suspension). This green suspension was added to a 5 mL ElectraSyn 2.0 vial under argon containing a magnesium anode, 100 ppi RVC cathode (3 mm X 7 mm X 51 mm), $AgNO_3$ (20.4 mg, 0.6 mmol, 54 $mmol_{Ag}/m^2_{(cathode)}$, 0.3 equiv.) and stir bar. After complete addition electrolysis was immediately started. The electrochemical reaction was performed using an ElectraSyn 2.0 under constant current conditions with the settings as follows: 12 mA, 0.4 mmols, 2.5 F/mol providing 5.4 A/m^2 current density. After completion of the reaction the vial was transferred to a separatory funnel and quenched with 1N HCl (20 mL) and extracted with diethyl ether (3 X 20 mL). The combined organics were washed successively with distilled water (2 X 20 mL) then brine (1 X 20 mL), then dried over magnesium sulfate before being filtered and concentrated via rotary evaporation. The oily solid was purified via silica gel chromatography (pentanes) to provide partially purified **S28** as a clear colorless oil (132.3 mg total mass with 21% yield of vinyl iodide impurity, 11% yield of vinyl chloride impurity and 64% yield of desired compound by ^{1}H-NMR, purity: 78% wt/wt). This material was used in the subsequent step without any further purification.

Physical State: Clear colorless oil

^{1}H NMR (600 MHz, CDCl3): δ 5.89 – 5.81 (m, 1H), 5.14 (dd, *J* = 17.3, 1.7 Hz, 1H), 5.12 – 5.08 (m, 3H), 4.98 (dd, *J* = 10.7, 1.6 Hz, 1H), 2.12 – 1.91 (m, 10H), 1.68 (q, *J* = 1.3 Hz, 3H), 1.62 – 1.58 (m, 9H), 1.52 – 1.44 (m, 2H), 1.30 (s, 3H), 0.89 (s, 9H), 0.08 (s, 3H), 0.06 (s, 3H).

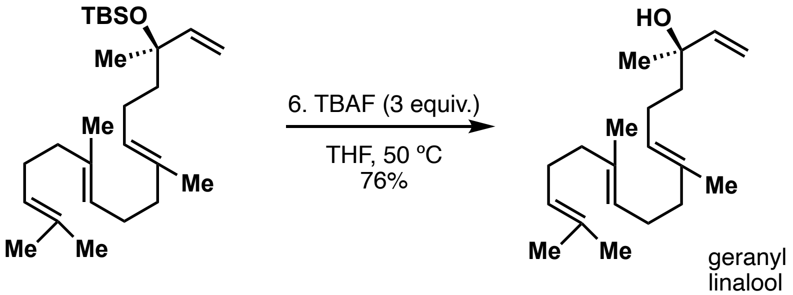
^{13}C NMR (125 MHz, CDCl3): δ 145.9, 135.0, 134.9, 131.4, 124.8, 124.6, 124.4, 111.7, 75.7, 44.0, 39.9, 27.6, 26.9, 26.8, 26.1, 25.9, 22.8, 18.5, 17.8, 16.2, 16.1, -1.9

MS (GC): calculated for $C_{26}H_{48}OSi$ $[M]^{+\bullet}$: 404.3474, found: 404.3

Note: HRMS with ESI-TOF unable to detect desired mass

TLC: R_f = 0.81 (pentanes)

$[\alpha]_D^{20}$= -4.000 (c = 0.1 $CDCl_3$)



S28 **S29**

To a flask charged with silyl ether **S28** (100 mg, 0.192 mmol, 78% wt/wt, 1.0 equiv.) in anhydrous THF (0.3 mL) at 0 °C was added a 1M solution of tetrabutylammonium fluoride (385 µL, 0.385 mmol, 2.0 equiv.) in THF. The reaction was then heated to 50 °C for 24h. Additional TBAF (0.192 mL, 0.192 mmol, 1 equiv.) was added and the reaction was allowed to continue stirring at 50 °C until complete as monitored by TLC. The reaction mixture was concentrated via rotary evaporation and loaded directly onto a silica gel column for purification (0-15% Ethyl Acetate / Hexanes) to afford geranyl linalool (**S29**) as a clear colorless oil (42.5 mg, 76%).

Physical State: Clear colorless oil

^{1}H NMR (600 MHz, CDCl3): δ 5.92 (ddd, *J* = 17.3, 10.8, 1.0 Hz, 1H), 5.21 (dd, *J* = 17.3, 1.4 Hz, 1H), 5.14 (t, *J* = 7.2 Hz, 1H), 5.12 – 5.04 (m, 3H), 2.11 – 1.94 (m, 10H), 1.68 (s, 3H), 1.63 – 1.56 (m, 11H), 1.28 (s, 3H).

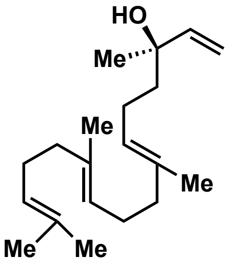
^{13}C NMR (150 MHz, CDCl3): δ 145.2, 135.8, 135.2, 131.4, 124.5, 124.3, 124.3, 111.8, 73.7, 42.2, 39.9, 39.8, 28.1, 26.9, 26.7, 25.9, 22.9, 17.8, 16.2, 16.2

HRMS (ESI-TOF): calculated for $C_{20}H_{34}O$ $[M+H]^+$: 291.2688, found: 291.2694

TLC: $R_f = 0.41$ (10% ethyl acetate / hexanes)

$[\alpha]_D^{20}$ = -16.000 (c = 0.1 EtOH)

Table S23 — (*E, E*)- geranyl linalool ^{1}H Shifts Comparison

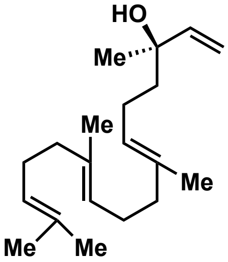


S29

Tabulated data for Synthetic **S29**
^{1}H-NMR (CDCl$_3$)

Synthetic **S29** (600 MHz)	Synthetic **S29** (Svatos, 500 MHz) (*97*)	Δppm
5.92 (ddd, *J* = 17.3, 10.8, 1.0 Hz, 1H)	5.92 (dd, *J* = 17.3, 10.7 Hz, 1H)	0.00
5.21 (dd, *J* = 17.3, 1.4 Hz, 1H)	5.21 (br d, *J* = 17.3 Hz, 1H)	0.00
5.14 (t, *J* = 7.2 Hz, 1H)	5.17 (t, *J* = 6.6 Hz, 1H)	0.03
5.12 – 5.04 (m, 3H)	5.10 (br t, *J* = 6.6 Hz, 2H) 5.07 (br d, *J* = 10.7 Hz, 1H)	0.00
2.11 – 1.94 (m, 10H)	2.06 – 1.60 (m, 12 H)	N/A
1.68 (s, 3H)	1.68 (3H, s)	0.00
1.63 – 1.56 (m, 11H)	1.60 (s, 3H) 1.59 (s, 3H) 1.56 (s, 3H)	N/A
1.28 (s, 3H)	1.28 (s, 3H)	0.00

Table S24 — (*E, E*)- geranyl linalool ^{13}C Shifts Comparison



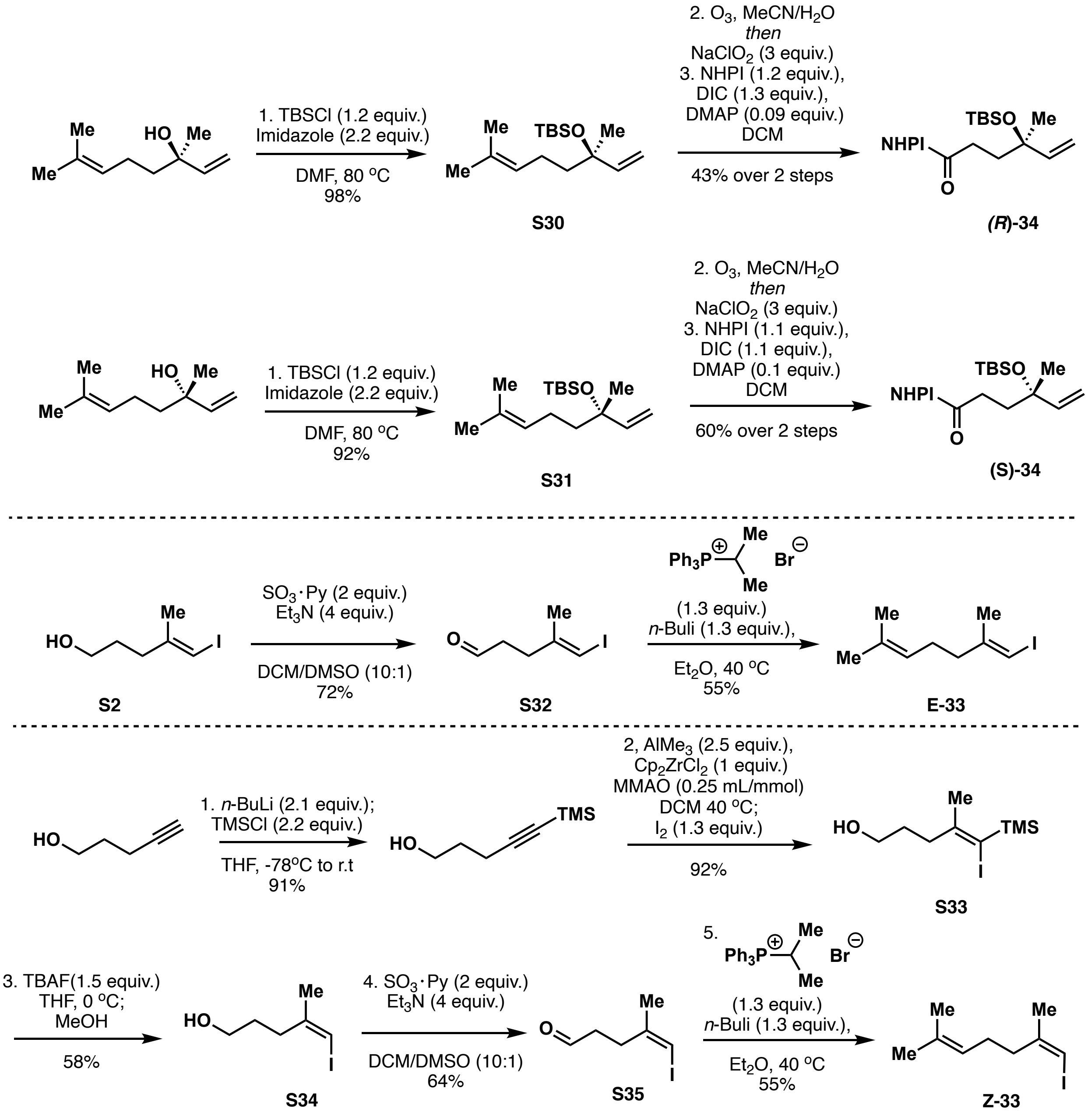
S29

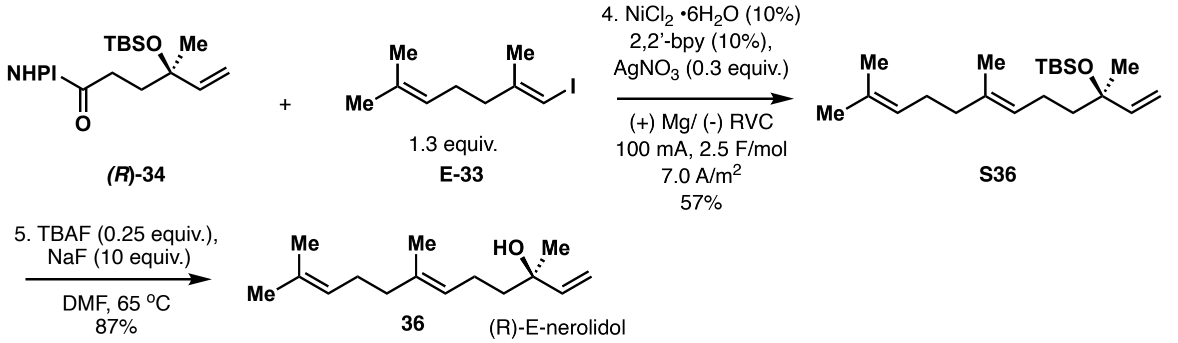
Tabulated data for Synthetic **S29**
^{13}C-NMR ($CDCl_3$)

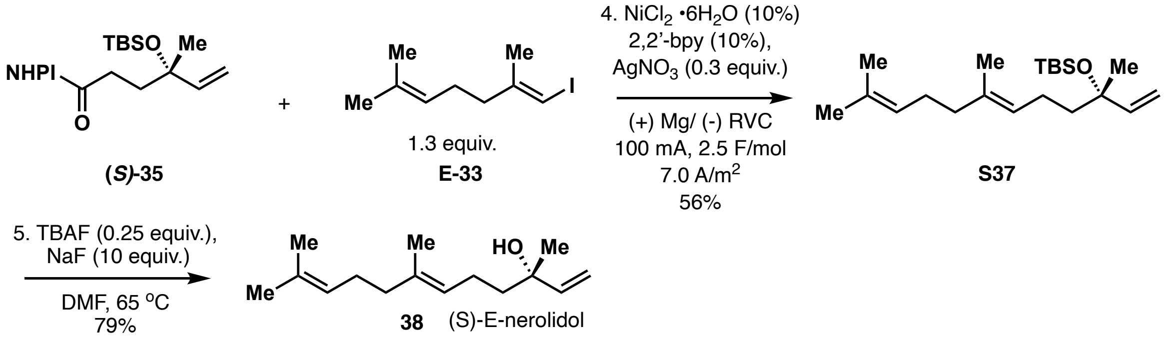
Synthetic **S29** (150 MHz)	Synthetic **S29** (Svatos, 128 MHz)(*97*)	Δppm
145.2	145.1	0.1
135.8	135.7	0.1
135.2	135.6	0.4
131.4	131.2	0.2
124.5	124.4	0.1
124.3	124.3	0.0
124.3	124.2	0.1
111.8	111.7	0.1
73.7	73.5	0.2
42.2	42.1	0.1
39.9	39.7	0.2
39.8	39.7	0.1
28.1	27.9	0.2
26.9	26.8	0.1
26.7	26.6	0.1
25.9	25.7	0.2
22.9	22.7	0.2
17.8	17.7	0.1
16.2	16.0	0.2
16.2	16.0	0.2

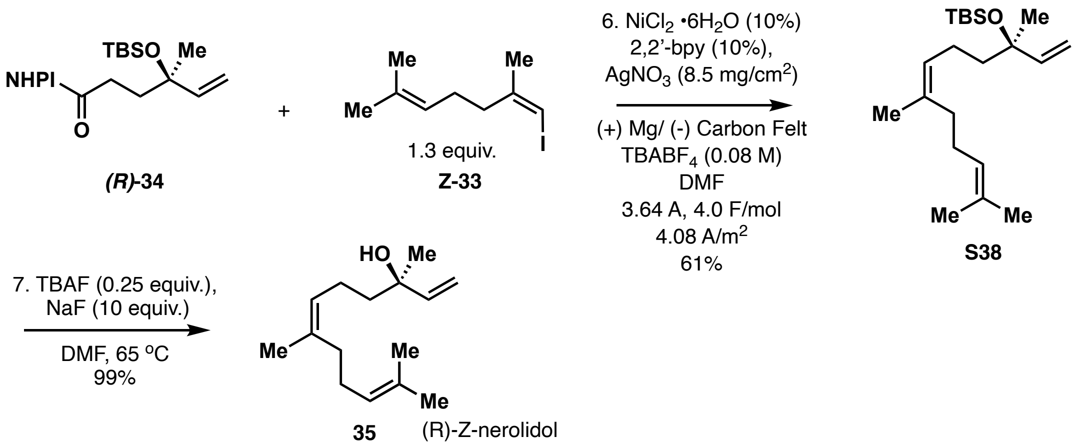
Nerolidols (procedures)

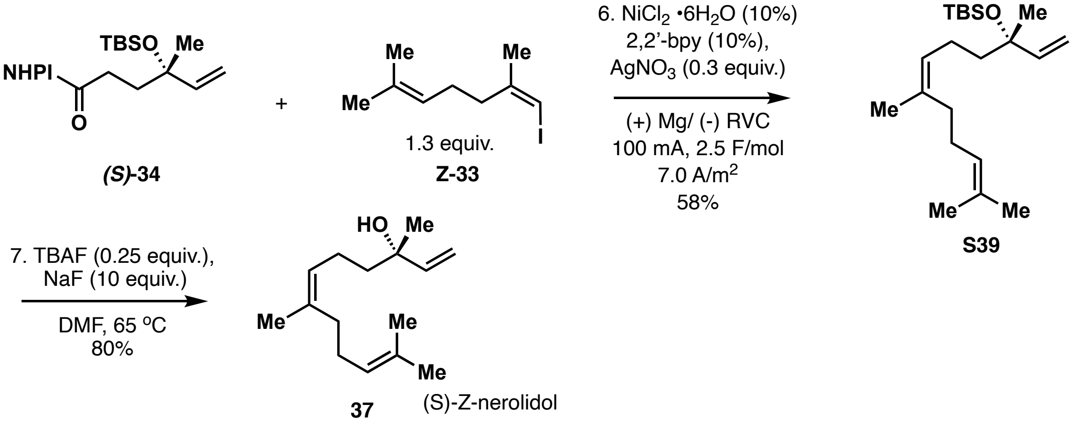
Fig S17— Nerolidol Syntheses

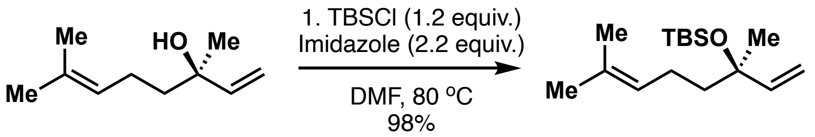



NHPI
TBSO
Me
O
(R)-34
+
Me
Me
Me
I
1.3 equiv.
E-33
4. $NiCl_2$ •$6H_2O$ (10%)
2,2'-bpy (10%),
$AgNO_3$ (0.3 equiv.)
(+) Mg/ (-) RVC
100 mA, 2.5 F/mol
7.0 A/m^2
57%
Me
Me
TBSO
Me
Me
S36
5. TBAF (0.25 equiv.),
NaF (10 equiv.)
DMF, 65 °C
87%
Me
Me
HO
Me
Me
36
(R)-E-nerolidol


NHPI
TBSO
Me
O
(S)-35
+
Me
Me
Me
I
1.3 equiv.
E-33
4. $NiCl_2$ •$6H_2O$ (10%)
2,2'-bpy (10%),
$AgNO_3$ (0.3 equiv.)
(+) Mg/ (-) RVC
100 mA, 2.5 F/mol
7.0 A/m^2
56%
Me
Me
TBSO
Me
Me
S37
5. TBAF (0.25 equiv.),
NaF (10 equiv.)
DMF, 65 °C
79%
Me
Me
HO
Me
Me
38
(S)-E-nerolidol


NHPI
TBSO
Me
O
(R)-34
+
Me
Me
Me
I
1.3 equiv.
Z-33
6. $NiCl_2$ •$6H_2O$ (10%)
2,2'-bpy (10%),
$AgNO_3$ (8.5 mg/cm^2)
(+) Mg/ (-) Carbon Felt
$TBABF_4$ (0.08 M)
DMF
3.64 A, 4.0 F/mol
4.08 A/m^2
61%
TBSO
Me
Me
Me
Me
S38
7. TBAF (0.25 equiv.),
NaF (10 equiv.)
DMF, 65 °C
99%
HO
Me
Me
Me
Me
35
(R)-Z-nerolidol


NHPI
TBSO
Me
O
(S)-34
+
Me
Me
Me
I
1.3 equiv.
Z-33
6. $NiCl_2$ •$6H_2O$ (10%)
2,2'-bpy (10%),
$AgNO_3$ (0.3 equiv.)
(+) Mg/ (-) RVC
100 mA, 2.5 F/mol
7.0 A/m^2
58%
TBSO
Me
Me
Me
Me
S39
7. TBAF (0.25 equiv.),
NaF (10 equiv.)
DMF, 65 °C
80%
HO
Me
Me
Me
Me
37
(S)-Z-nerolidol

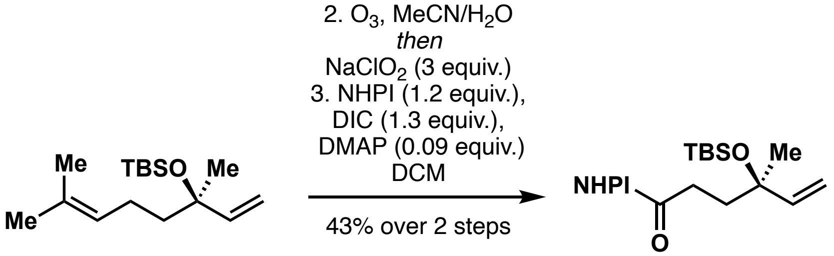


S30

To a flame dried flask containing a stir bar and (–)-linalool (177 mL, 1 mol, 1 equiv.) was added 200 mL of anhydrous DMF, Imidazole (151.36 g, 2.2 mol, 2.2 equiv.), and TBSCl (180.924 g, 1.2 mol, 1.2 equiv.). The flask was fitted with a reflux condenser and heated to 80 °C for 2.5 days. The reaction was allowed to cool to room temperature before being diluted with 400mL water and the organics were extracted with pentane (3 X 200mL). The organic layer was washed with water (2 X 200mL), washed with brine (200mL) and dried over magnesium sulfate. Then the organic layer was filtered through a short plug of silica and the plug was rinsed with pentane (3 X 100 mL). After evaporation, the silyl ether **S30** (263.5g, 98%) was obtained and used without further purification.

Spectral data matched previous reports; the ^{1}H NMR data is provided here for convenience.(*98*)

^{1} H NMR (CDCl3): δ 5.84 (dd, *J* = 17, 10.7 Hz, 1H), 5.38 (m, 1H), 5.14 (dd, *J* = 17.3, 1.6 Hz, 1H), 4.99 (dd, *J* = 10.7, 1.6 Hz, 1H), 3.98 (m, 2H), 2.05 (m, 2H), 1.65 (s, 3H), 1.47 – 1.52 (m, 2H), 1.30 (s, 3H), 0.90 – 0.87 (m, 9H), 0.08 – 0.05 (m, 6H).



S30 **(*R*)-34**

This ozonolysis procedure is adapted from a literature procedure.(*99*)

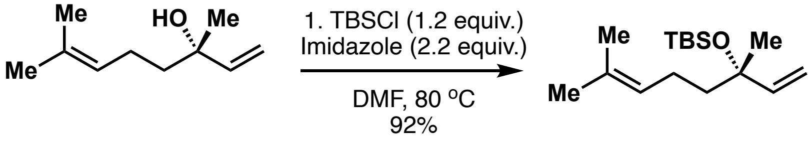
A three-neck flask charged with silyl ether **S30** (134.26 g, 500 mmol, 1equiv.) in MeCN (1.185 L, 2.37 ml/mmol substrate) and water (118.5 mL, 0.237 mL/mmol substrate) was fitted with a mechanical stirrer and internal temperature probe. The reaction mixture was cooled to 4 °C by being placed in an ice bath. Ozone was bubbled through the reaction mixture until complete consumption of the starting material to the intermediate aldehyde (ca. 3h). The reaction turns from cloudy to clear as all the starting material dissolves into the reaction mixture and is consumed. This indicator was used to gauge reaction progress, and complete consumption was verified via TLC.

After complete consumption of the starting material, a 2M aqueous solution of sodium chlorite (135.663 g, 1.5 mol, 3 equiv. in 750 mL H_2O), was added dropwise to maintain an internal temperature below 20 °C. The reaction turned from colorless to orange as the oxidant was added and an exotherm was observed. After complete addition of oxidant, the ice bath was removed, and the reaction was placed in a water bath for 12h. The reaction was next cooled to 4 ^{0}C by being placed in an ice bath and was quenched with 200 mL of saturated sodium bicarbonate followed by a saturated solution of sodium thiosulfate (400 mL) added slowly to maintain an internal temperature below 20 °C**.** Then, diethyl ether was used to extract the reaction (4 X 300 mL). The organics were washed with sodium bicarbonate (1 X 200 mL), brine (1 X 200 mL) and the reaction was dried over magnesium sulfate. The organic layer was concentrated via rotary evaporation with a bath temperature below 30 °C to a thick clear oil and used crude in the next step.

A flask containing the carboxylic acid, N-hydroxypthalimide (97.866 g, 600 mmol, 1.2 equiv.), and DMAP (5 g, 40 mmol, 0.09 equiv.), stir bar, and anhydrous DCM (1.25 L) was placed in a water bath at 20 °C. The reaction was stirred into a slurry and then DIC (100.5 mL, 650 mmol, 1.3 equiv.) was added. The reaction was monitored for disappearance of starting material by TLC. Then, the reaction was filtered over Celite and concentrated to a thick red oil. Diethyl Ether was added to the oil and the suspension was filtered through a short plug of silica gel. The silica gel was washed several times with diethyl ether (4 X 100 mL) and the clear organic layer was concentrated until a pale-yellow solid was formed. This solid was recrystallized from methanol to yield colorless crystals of RAE **(*R*)-34** (86g, 43% yield) (two steps).

Notes: With sodium chlorite puriss 80% from Sigma Aldrich, no color change or exotherm was observed after addition indicating the oxidation did not initiate. This can lead to a potentially dangerous exotherm when the reaction does initiative. To induce initiation, a small amount of 2N HCl was added dropwise until a persistent color change from clear to straw-yellow was observed as the oxidant was added portion-wise. The acid product after ozonolysis is not thermally stable so care should be taken to concentrate the organic layer at a temperature below 30 °C. The acid should be used immediately to prevent lactonization, which occurs even at room temperature over time. The RAE was found to be bench stable for > 1 year. An improved procedure for the work-up and purification was developed from (S)-linalool, we recommend using that protocol over the methanol recrystallization which led to some RAE degradation.

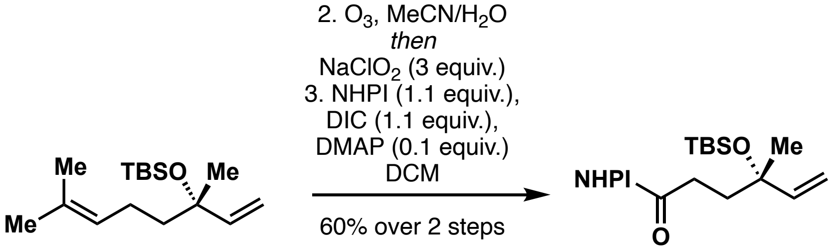
Physical State: Pale-yellow crystalline solid
m.p. 70 – 72 °C
^{1}H NMR (500 MHz, CDCl3): δ 7.88 (dd, *J* = 5.4, 3.1 Hz, 2H), 7.79 (dd, *J* = 5.5, 3.1 Hz, 2H), 5.82 (dd, *J* = 17.3, 10.7 Hz, 1H), 5.24 (dd, *J* = 17.3, 1.4 Hz, 1H), 5.10 (dd, *J* = 10.7, 1.4 Hz, 1H), 2.81 – 2.63 (m, 2H), 1.96 (ddd, *J* = 10.2, 7.2, 5.9 Hz, 2H), 1.38 (s, 3H), 0.92 (s, 9H), 0.12 (s, 3H), 0.10 (s, 3H).
^{13}C NMR (151 MHz, CDCl3): δ 170.4, 162.1, 144.2, 134.9, 129.1, 124.1, 113.5, 74.9, 38.1, 27.9, 26.4, 26.1, 18.5, -1.9, -2.0
HRMS (ESI-TOF): calculated for $C_{21}H_{29}NO_5Si$ [M+H]$^{+}$: 404.1893, found: 404.1898
TLC: R_f = 0.44 (20:80 EtOAc/Hexanes)
[α]$_D^{20}$ = -8.200 (c = 1.00 Acetone)



S31

To a flame dried flask containing a stir bar and (+)-linalool (27.34 g, 177 mmol, 1 equiv.) was added anhydrous DMF (40 mL), Imidazole (26.83 g, 389.9 mol, 2.2 equiv.), and TBSCl (29.39 g, 195 mmol, 1.1 equiv.). The flask was fitted with a reflux condenser and heated to 80 °C for 2.5 days. The reaction was allowed to cool to room temperature before being diluted with 100 mL water and the organics were extracted with pentane (3 X 50 mL). The organic layer was washed with water (2 X 50 mL), washed with brine (50 mL) and dried over magnesium sulfate. Then the organic layer was filtered through a short plug of silica and the plug was washed with pentane (3 X 100 mL). After evaporation, the silyl ether **S31** (43.5 g, 92%) was obtained and used without further purification.

Physical State: Clear Colorless Oil
^{1}H NMR (399 MHz, CDCl3): δ ^{1}H NMR (400 MHz, CDCl$_3$) δ 5.85 (dd, *J* = 17.3, 10.7 Hz, 1H), 5.14 (dd, *J* = 17.3, 1.7 Hz, 1H), 5.09 (tp, *J* = 7.3, 1.4 Hz, 1H), 4.98 (dd, *J* = 10.7, 1.7 Hz, 1H), 2.10 – 1.89 (m, 2H), 1.67 (q, *J* = 1.3 Hz, 3H), 1.59 (d, *J* = 1.3 Hz, 3H), 1.47 (tt, *J* = 10.1, 6.8 Hz, 2H), 1.29 (s, 3H), 0.89 (s, 9H), 0.08 (s, 3H), 0.06 (s, 3H).
^{13}C NMR (151 MHz, CDCl3): δ 145.8, 131.3, 124.9, 111.7, 75.7, 43.9, 27.6, 26.1, 25.9, 22.9, 18.5, 17.7, -1.9
HRMS (ESI-TOF): calculated for $C_{16}H_{32}OSi$ $[M+H]^+$: 269.2301, found: 269.2299
TLC: R_f = 0.79 (100% pentane)
$[\alpha]_D^{20}$ = +10.100 (c = 1.00 Ethanol)



S31 **(S)-34**

This ozonolysis procedure is adapted from a literature procedure.(*99*)

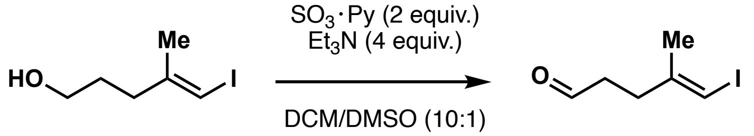
A 1-L flask charged with a stir bar and silyl ether **S31** (43.5 g, 162 mmol, 1 equiv.) in MeCN (400 mL, 2.37ml/mmol substrate) and water (40 mL, 0.237 mL/mmol substrate) was cooled to 4 °C by being placed in an ice bath. Ozone was bubbled through the reaction mixture until complete consumption of the starting material to the intermediate aldehyde (ca. 2h 35m). The reaction turns from cloudy to clear as all the starting material is consumed. This indicator was used to gauge reaction progress, and complete consumption was verified via TLC.

After complete consumption of the starting material, a 2M aqueous solution of sodium chlorite (43.95 g, 486 mmol, 3 equiv. in 243 mL H_2O), was added dropwise to maintain an internal temperature below 20 °C. The reaction turned from colorless to yellow/orange as the oxidant was added and an exotherm was observed. After complete addition of oxidant, the ice bath was removed, and the reaction was placed in a water bath for 12 h. The reaction was next cooled to 4 ^{0}C by being placed in an ice bath and was quenched with saturated sodium bicarbonate followed by a saturated solution of sodium thiosulfate added slowly to maintain an internal temperature below 20 °C. Then, diethyl ether was used to extract the reaction (4 X 300 mL). The organics were washed with sodium bicarbonate (1 X 200mL), brine (1 X 200mL) and the reaction was dried over magnesium sulfate. The organic layer was concentrated to a thick clear oil (40.22 g) and used crude in the next step.

A flask containing the carboxylic acid, N-hydroxypthalimide (27.9 g, 171.2 mmol, 1.1 equiv.), and DMAP (1.89 g, 15.6 mmol, 0.1 equiv.), stir bar, and 400 mL of DCM was placed in a water bath at room temperature. The reaction was stirred into a slurry and then DIC (26.8 mL, 171.2 mmol, 1.1 equiv.) was added. The reaction was monitored for disappearance of starting material by TLC (ca. 5h). Then, the reaction was concentrated to a thick red oil. Diethyl Ether was added to the oil and the suspension was filtered through a short plug of silica gel. The silica gel was washed several times with diethyl ether (4 X 100 mL) and the clear organic layer was concentrated until a yellow solid was formed. This solid was triturated with iced methanol to yield the RAE (***S*-34**) as a white solid (39.4 g, 97.5 mmol, 60 % yield over two steps).

Notes: With sodium chlorite puriss 80% from Sigma Aldrich, no color change or exotherm was observed after addition indicating the oxidation did not initiate. This can lead to a potentially dangerous exotherm when the reaction does initiative. To induce initiation, a small amount of 2N HCl was added dropwise until a persistent color change from clear to straw-yellow was observed as the oxidant was added portion-wise. The acid is not thermally stable so care should be taken to concentrate the organic layer at a temperature below 30 ^{o}C. The acid should be used immediately to prevent lactonization, which occurs even at room temperature over time. The RAE was found to be bench stable for > 1 year. This purification differs from the R-Linalool derived RAE procedure. Recrystallization from methanol led to a significant amount of methyl ester formation. Trituration, however, improved the overall yield and increased the ease of purification of the compound. It is recommended that the work-up for the S-linalool derived RAE be followed for both enantiomers.

Physical State: Crystalline White solid
m.p. 70 – 72 ^{o}C
^{1}H NMR (600 MHz, CDCl3): δ 7.88 (ddd, *J* = 5.3, 3.2, 1.1 Hz, 1H), 7.78 (ddd, *J* = 5.4, 3.0, 1.1 Hz, 1H), 5.82 (dd, *J* = 16.6, 11.3 Hz, 0H), 5.24 (d, *J* = 17.2 Hz, 0H), 5.10 (d, *J* = 10.7 Hz, 0H), 2.80 – 2.65 (m, 1H), 2.02 – 1.91 (m, 1H), 1.38 (s, 1H), 0.91 (s, 3H), 0.12 (s, 1H), 0.10 (s, 1H).
^{13}C NMR (151 MHz, CDCl3): δ 170.4, 162.1, 144.2, 134.9, 129.1, 124.1, 113.5, 74.8, 38.1, 27.9, 26.3, 26.1, 18.5, -1.9, -2.0
HRMS (ESI-TOF): calculated for $C_{21}H_{29}NO_5Si$ [M+H]$^+$: 404.1893, found: 404.1880
TLC: R_f = 0.44 (20:80 EtOAc/Hexanes)
$[\alpha]_D^{20}$ = +8.600 (c = 1.00 Acetone)

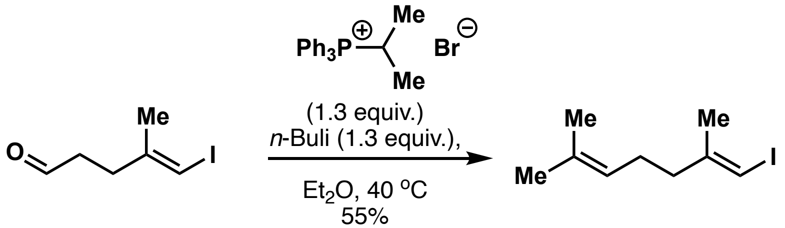


S2 **S32**

A flask charged with alcohol **S2** (15.80 g, 69.9 mmol, 1 equiv.), anhydrous DCM (300 mL), anhydrous DMSO (30 mL) and triethylamine (39 mL, 279.7 mmol, 4 equiv.) was cooled to 0 ^{o}C before the addition of the sulfur trioxide pyridine complex (21.84 g, 139.9 mmol, 2 equiv.). The reaction was monitored by TLC for conversion to the aldehyde (**S32**). The reaction was diluted with diethyl ether (400 mL), washed with water (2 X 300 mL) and brine (300 mL) then concentrated and purified *via* silica gel chromatography (0-40% Et$_2$O / hexanes) to provide aldehyde **S32** as a clear yellow oil (11.31 g, 72%).

Note: The vinyl iodide is volatile so the reaction should be concentrated at room temperature and at a pressure not below 100 torr. The product was stored in the freezer at -20 °C to prevent slow decomposition.

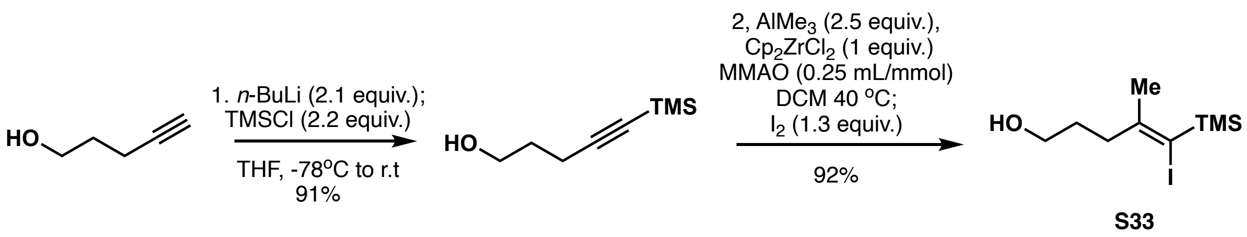
Physical State: Clear yellow oil
^{1}H NMR (600 MHz, CDCl3): δ 9.77 (t, *J* = 1.4 Hz, 1H), 5.98 (q, J = 1.2 Hz, 1H), 2.59 (ddt, J = 8.0, 6.7, 1.4 Hz, 2H), 2.53 (ddt, J = 8.3, 6.8, 1.4 Hz, 2H), 1.85 (d, J = 1.1 Hz, 3H).
^{13}C NMR (151 MHz, CDCl3): δ 201.0, 145.9, 76.1, 41.9, 31.6, 24.1
HRMS (ESI-TOF): calculated for C$_6$H$_9$IO [M+H]$^+$: 224.9776, found: 224.9769
TLC: R$_f$ = 0.57 (40% Et$_2$O in hexanes)



S32 **E-33**

An oven-dried two-neck flask equipped with stir bar was charged with isopropyl triphenylphosphonium bromide (4.613 g, 11.97 mmol, 1.3 equiv.). The flask was fitted with a reflux condenser, sealed, evacuated and backfilled three times with argon. Anhydrous diethyl ether (25 mL) was added to the flask and the resulting white suspension was cooled to 0 °C. *n*-BuLi (4.78 mL, 11.97 mmol, 1.3 equiv.) dropwise as a solution in hexanes (2.5 M). The solution turned dark red and heated to 40 °C. The mixture was stirred until homogeneous (ca. 30 minutes) then aldehyde **S32** (2.06 g, 9.21 mmol, 1 equiv.) was added dropwise. The reaction was allowed to stir overnight. Upon completion, the reaction mixture was cooled to room temperature and subsequently diluted in diethyl ether (100 mL) and partitioned between 1M aqueous HCl (100 mL). The organic material was extracted with diethyl ether (3 x 50 mL). The combined organics were washed with brine, dried over MgSO$_4$ and concentrated to afford a yellow paste. The crude material was purified by column chromatography (hexanes) to afford vinyl iodide **E-33** as a clear colorless oil (1.27 g, 55%).

Physical State: Clear colorless oil
^{1}H NMR (600 MHz, CDCl3): δ 5.87 (d, J = 1.2 Hz, 1H), 5.06 (tt, J = 6.9, 1.5 Hz, 1H), 2.24 – 2.18 (m, 2H), 2.11 (q, J = 7.2 Hz, 2H), 1.84 (d, J = 1.2 Hz, 3H), 1.69 (d, J = 1.5 Hz, 3H), 1.60 (s, 3H).
^{13}C NMR (151 MHz, CDCl3): δ 148.0, 132.6, 123.2, 74.9, 39.7, 26.6, 25.8, 24.1, 17.8
HRMS (ESI-TOF): calculated for C$_9$H$_{15}$I [M+H]$^+$: 251.0.297, found: 251.0.298
TLC: R$_f$ = 0.72 (100% hexanes)



To a flask charged with 4-pentyn-1-ol (10 g, 11.06 mL, 119 mmol, 1 equiv.) in THF (200 mL) at -78 °C was added dropwise a solution of *n*-BuLi (100 mL, 250 mmol, 2.1 equiv.) dropwise. The reaction was allowed to stir at this temperature for 1h before the addition of freshly distilled trimethylsilyl chloride (28.45 g, 33.23 mL, 262 mmol, 2.2 equiv.) dropwise. The reaction was allowed to warm to room temperature and was stirred at this temperature for 1h before being quenched with a 2N HCl solution (200 mL) and stirred vigorously for 2h. The aqueous layer was washed with diethyl ether (3 X 100mL). The combined organics were washed with brine (100mL), dried over magnesium sulfate, and concentrated to a pale-yellow oil. Flash chromatography (5% EtOAc/Hexanes; 40% EtOAc/Hexanes) provided the 5-(trimethylsilyl)-4-pentyn-1-ol (15.45 g, 91%).

Spectral data matched previous reports; the ^{1}H NMR data is provided here for convenience.(*100*)

^{1} H NMR (400 MHz, CDCl3): δ 3.62 (t, *J* = 6.3Hz, 2H) 2.29 (t, *J* = 7.1Hz, 2H) 1.69 (p, *J* = 6.7Hz, 2H) 0.10 (s, 9H).

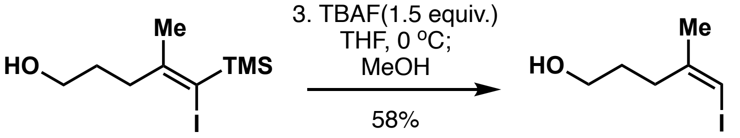
The anti-carbometalation procedure is adapted from a literature procedure.(*84*)

A two-neck flask fitted with a reflux condenser and charged with zirconocene dichloride (23.37 g, 94.4 mmol, 1 equiv.) was evacuated and backfilled with argon three times before DCM (120 mL) was added followed by a 2.0 M trimethyl aluminum in hexanes (100 mL, 200 mmol, 2.5 equiv.). Then, a 7% solution of MMAO-12 (20 mL, 0.25mL/mmol substrate) in toluene obtained from Sigma Aldrich was added. The reaction was stirred 15 minutes, then cooled to 0 °C before the addition of 5-TMS-4-pentyn-1-ol (11.38g, 80 mmol, 1 equiv.) dropwise. The reaction was allowed to warm to room temperature before being heated to 40 °C for 12h. Then the reaction was cooled to 0 °C and a solution of iodine (26.4 g, 104 mmol, 1.3 equiv.) in THF (60mL) was added *via* cannula. The reaction was stirred at 0 °C for 30 minutes where it turned a bright yellow color, then the septum was removed, diethyl ether (200 mL) was added, and water (approximately 30 mL) was added **dropwise very slowly!** The yellow heterogeneous solution became white and heterogeneous and the bubbling stopped at complete quenching. More diethyl ether (200 mL) was added and the slurry was filtered through a pad of Celite. The solution was washed with 2N HCl (100 mL), then sodium bicarbonate (100 mL) and thiosulfate (100mL) before being washed with brine (100mL) and dried over magnesium sulfate. The organic layer was then concentrated via rotary evaporation in a fume hood to afford **S34** as an orange oil (22.0 g, 92%). **After concentration, the crude material was stored in a -20 °C freezer to prevent slow decomposition.** The vinyl iodide **S33** was carried forward without further purification.

Spectral data matched previous reports; the ^{1}H NMR data is provided here for convenience.(*84*)

^{1}H NMR (400 MHz, CDCl3): δ 3.70 (t, *J* = 8.1 Hz, 2H), 2.52 (t, *J* = 8.2 Hz, 2H), 1.97 (s, 3H), 1.80 – 1.70 (m, 2H), 1.45 (br s, 1H), 0.25 (s, 9H).

Notes: Trimethyl aluminum is extremely pyrophoric and great care should be taken to avoid its exposure to air and moisture. The addition of pentynol results in evolution of a large amount of methane gas. Ensure that the argon balloon is fitted with a thick gauge needle and the needle is unobstructed to avoid a potential over-pressurization of the flask that could lead to failure of the flask or ejection of the septum. The excess organometallic reagent's reaction with water is very exothermic and care should be taken to avoid adding water too quickly or else the reaction solution can vigorously bubble out of the flask. Quenching the reaction with I_2 may produce methyl iodide.

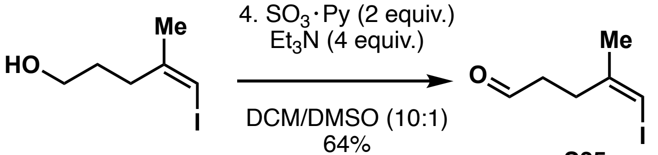


S33 **S34**

To a solution of vinyl iodide **S33** (1.19 g, 4.0 mmol, 1 equiv.) in THF (1.5 mL) was added a 1M solution of tetrabutylammonium fluoride (6 mL, 1 M in THF, 6 mmol, 1.5 equiv.) in THF at 0 °C. The reaction turned a dark purple and was allowed to stir 15 minutes before the addition of a saturated solution of NH_4Cl (aq.) (10 mL). The crude reaction mixture was then washed with a saturated solution of NH_4Cl (20 mL). The organics were dried over MgSO4, filtered and concentrated to afford an orange oil. The crude material was purified *via* silica gel chromatography (0-50% Ethyl Acetate/ Hexanes) to afford **S34** (526 mg, 58% yield).

Spectral data matched previous reports; the ^{1}H NMR data is provided here for convenience.(*101*)

^{1}H NMR (400 MHz, CDCl3): δ 5.87 (q, *J* = 1.3 Hz, 1H), 3.67 (t, *J* = 6.4 Hz, 2H), 2.33 – 2.29 (m, 2H), 1.91 (d, *J* = 1.5 Hz, 3H), 1.75 – 1.68 (m, 2H).

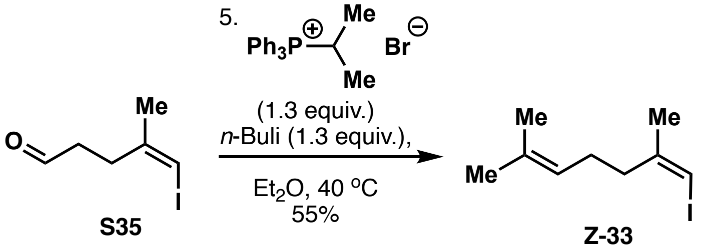


S34 **S35**

A flask charged with alcohol **S34** (10.33 g, 45.70 mmol, 1 equiv.), DCM (200 mL), DMSO (20 mL) and triethylamine (25.48 mL, 182.80 mmol, 4equiv.) was cooled to 0 °C before the addition of the sulfur trioxide pyridine complex (14.27 g, 91.40, 2 equiv.). The reaction was monitored by TLC for conversion to the aldehyde. The reaction was diluted with diethyl ether (500 mL), washed with water (2 X 250 mL) then brine (250 mL), concentrated and purified *via* silica gel chromatography (0-40% Et_2O / hexanes) to provide aldehyde **S35** as a clear oil (6.502 g, 64%, 1:13 *E/Z*).

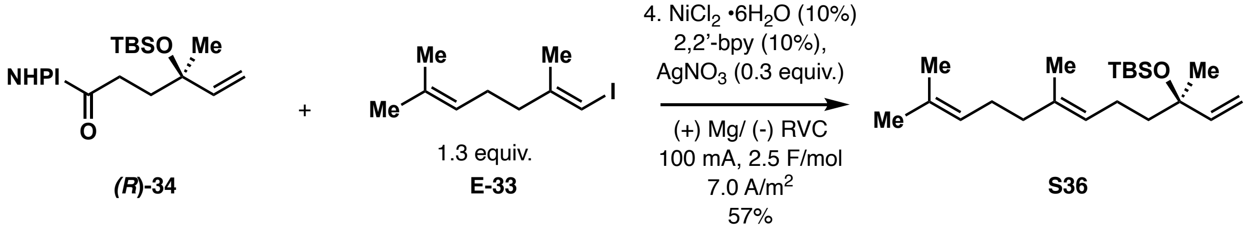
Note: The vinyl iodide is volatile so the reaction should not be concentrated at high temperature and low pressure. The product was stored in the freezer at -20 °C to prevent slow decomposition.

Physical State: Clear colorless oil
^{1}H NMR (600 MHz, CDCl3): δ 9.82 (t, *J* = 1.4 Hz, 1H), 5.93 (q, *J* = 1.5 Hz, 1H), 2.71 – 2.39 (m, 4H), 1.89 (d, *J* = 1.4 Hz, 1H).
^{13}C NMR (151 MHz, CDCl3): δ 201.2, 145.7, 75.8, 41.2, 31.5, 23.5
HRMS (ESI-TOF): calculated for C_6H_9IO $[M+H]^+$: 224.9776, found: 224.9772
TLC: R_f = 0.56 (40:60 Et_2O/ hexanes)



To solution of isopropyl triphenylphoshonium bromide (14.54 g, 37.73 mmol, 1.3 equiv.) in diethyl ether (75 mL) at 0 °C was added *n*-BuLi (15.1 mL, 37.73 mmol, 1.3 equiv.) dropwise. The solution turned dark red and was allowed heated to 40 °C. The mixture was stirred until homogeneous (ca. 30 minutes) then aldehyde **S35** (6.502 g, 29.02 mmol, 1 equiv.) was added dropwise. The reaction was allowed to stir overnight. Upon completion, the reaction mixture was allowed to cool to room temperature and was subsequently diluted in diethyl ether (300 mL) and partitioned between 1M aqueous HCl (300 mL). The organic material was extracted with diethyl ether (3 X 200 mL). The combined organics were washed with brine, dried over $MgSO_4$ and concentrated to afford a yellow paste. The crude material was purified by column chromatography (hexanes) to afford vinyl iodide **Z-33** as a clear colorless oil (3.9890 g, 55%).

Physical State: Clear colorless oil
^{1}H NMR (399 MHz, CDCl3): δ 5.84 (q, *J* = 1.4 Hz, 1H), 5.14 (dddd, *J* = 6.9, 5.5, 2.8, 1.4 Hz, 1H), 2.26 – 2.19 (m, 2H), 2.14 – 2.07 (m, 2H), 1.89 (d, *J* = 1.4 Hz, 3H), 1.70 (d, *J* = 1.3 Hz, 3H), 1.64 (s, 3H).
^{13}C NMR (151 MHz, CDCl3): δ 147.6, 132.6, 123.4, 74.3, 39.0, 25.9, 25.8, 23.6, 17.9
HRMS (ESI-TOF): calculated for $C_9H_{15}I$ $[M+H]^+$: 251.0297, found: 251.0286
TLC: R_f = 0.67 (hexanes)

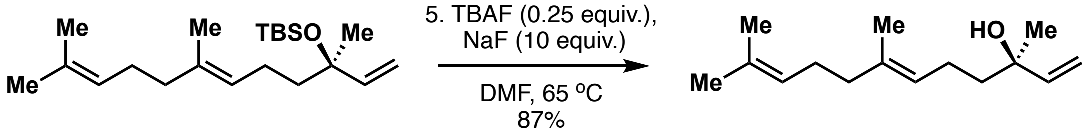


To a flame dried flask was added a stir bar, redox active ester **(*R*)-34** (6.05 g, 15 mmol, 1 equiv.), vinyl iodide ***E*-33** (4.57 g, 18.3 mmol, 1.22 equiv.), $NiCl_2 \cdot 6H_2O$ (356.5 mg, 1.5 mmol, 0.1 equiv.) and 2,2'-bipyridine (234.3 mg, 1.5 mmol, 0.1 equiv.). Next, the flask was sealed with a septum, evacuated, and backfilled three times with argon before the addition of anhydrous DMF (45 mL).

This solution was allowed to stir for 20 minutes and a homogeneous, dark green solution developed. This green suspension was split into 3 equal portions (~18 mL each) via syringe and added to 3, 20 mL ElectraSyn 2.0 vial under argon each containing a magnesium anode, 100 ppi RVC cathode (9 mm diameter, 40 mm length), $AgNO_3$ (255 mg, 1.5 mmol, 106 $mmol_{Ag}/m^2_{(cathode)}$, 0.3 equiv.) and stir bar. After complete addition electrolysis was immediately started. The electrochemical reaction was performed using an ElectraSyn 2.0 and carousel under constant current conditions with the settings as follows: 100 mA, 5 mmols, 2.5 F/mol providing 7.0 A/m^2 current density. After completion of the reaction, the vials were combined into a single flask and *slowly* quenched with 1N HCl (300 mL) and extracted with diethyl ether (3 X 200 mL). The combined organics were washed successively with distilled water (2 X 200 mL) then brine (1 X 200 mL), then dried over magnesium sulfate before being filtered and concentrated via rotary evaporation. The oily solid was purified via silica gel chromatography (pentane) to afford a mixture of **S36** and residual vinyl iodide (3.498 g total mass with 29% vinyl iodide impurity, 57% yield of desired compound by ^{1}H-NMR, purity: 82.3% wt/wt). This material was used in the subsequent step without any further purification.

Notes: The addition of HCl is exothermic. Be sure to wait until the contents reach ambient temperature before continuing the work up.

Physical State: Clear colorless oil
^{1}H NMR (600 MHz, CDCl3): δ 5.85 (dd, *J* = 17.3, 10.7 Hz, 1H), 5.15 (dd, *J* = 17.3, 1.7 Hz, 1H), 5.09 (m, 2H), 4.98 (dd, *J* = 10.7, 1.7 Hz, 1H), 2.08 – 1.94 (m, 6H), 1.68 (d, *J* = 1.3 Hz, 3H), 1.60 (d, *J* = 1.3 Hz, 3H), 1.58 (d, *J* = 0.6 Hz, 3H), 1.30 (s, 3H), 0.89 (s, 9H), 0.08 (s, 3H), 0.06 (s, 3H).
^{13}C NMR (151 MHz, CDCl3): δ 145.9, 134.9, 131.4, 124.8, 124.6, 111.7, 75.7, 43.9, 39.9, 27.6, 26.9, 26.1, 25.8, 22.8, 18.5, 17.8, 16.0, -1.9.
HRMS (ESI-TOF): calculated for $C_{21}H_{40}OSi$ $[M-OTBS]^+$: 219.2113, found: 219.2112
TLC: R_f = 0.74 (15:85 DCM/Hexanes)
$[\alpha]_D^{20}$ = -8.600° (c = 1.00 MeOH)



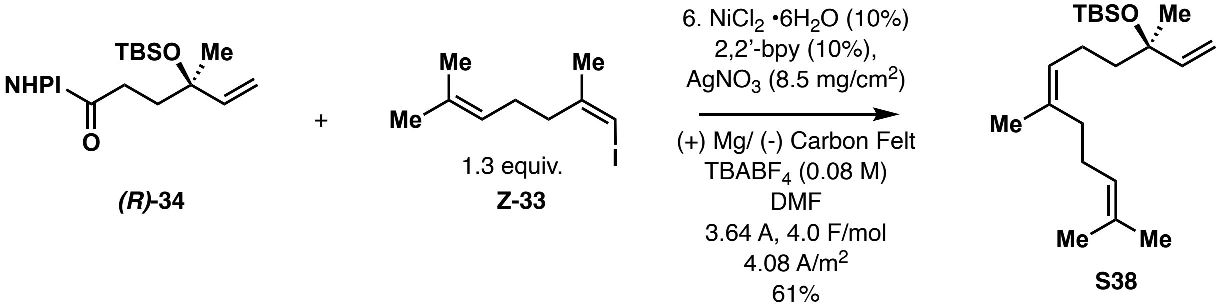
S36 **36** (R)-E-nerolidol

To a flame dried 100 mL round bottom flask was added silyl ether **S36** from previous step (3.498 g, 82.3% wt/wt, 8.55 mmol, 1 equiv.) and sodium fluoride (3.59 g, 85.5 mmol, 10 equiv.). The flask was sealed and purged with argon three times before the addition of dry anhydrous DMF (23 mL). The mixture was allowed to cool to 0 °C and TBAF (2.14 mL, 2.14 mmol, 0.25 equiv.) was added slowly as a solution in THF (1M). The flask was removed from the ice bath and was allowed to warm to 65 °C. The reaction mixture was allowed to stir at this temperature for 36 hours. Upon completion (monitored by NMR), the flask was allowed to cool to room temperature before the being diluted in diethyl ether (150 mL) and partitioned between aqueous LiCl (5% wt/wt). The aqueous material was extracted with diethyl ether (3 X 100 mL). The combined organics were washed with brine (200 mL), dried over $MgSO_4$, and concentrated to afford an orange oil. The crude material was purified via silica gel column chromatography (0-10% EtOAc/ hexanes) to afford (*R*)-E-nerolidol (**36**) as a pale-yellow to colorless oil (1.645 g, 87%).

Physical State: Clear colorless to pale-yellow oil
^{1}H NMR (600 MHz, CDCl3): δ 5.92 (dd, J = 17.3, 10.8 Hz, 1H), 5.22 (dd, J = 17.3, 1.3 Hz, 1H), 5.14 (ddt, J = 8.5, 7.1, 1.4 Hz, 1H), 5.10 – 5.04 (m, 2H), 2.11 – 1.95 (m, 6H), 1.68 (d, J = 1.4 Hz, 3H), 1.63 – 1.55 (m, 2H), 1.60 (d, J = 1.3 Hz, 6H), 1.28 (s, 3H).
^{13}C NMR (151 MHz, CDCl3): δ 145.2, 135.8, 131.6, 124.4, 124.4, 111.8, 73.7, 42.2, 39.9, 28.1, 26.8, 25.8, 22.9, 17.8, 16.2
HRMS (ESI-TOF): calculated for $C_{15}H_{26}O$ $[M+H]^+$: 223.2062, found: 223.2058
TLC: R_f = 0.39 (10:90 EtOAc/Hexanes)
$[\alpha]_D^{20}$ = -19.143° (c = 1.05 EtOH)

Flow-Reactor Scale Up

(Z)-R-nerolidol: 100-gram flow reactor set-up



Frame Cell Setup:

Four Teflon frame blocks (length: 18.0 cm, width: 12.0 cm, thickness: 2.0 cm) were packed in a row. Two carbon felt sheets embedded on stainless steel gaskets (length: 25.0 cm, width: 12.0 cm, thickness: 2.0 mm) as cathode and 3 magnesium plates (length: 20.5 cm, width: 12.0 cm, thickness: 3.0 mm) as anodes which have two silica pads (length: 18.0 cm, width: 12.0 cm, thickness: 2.0 mm) attached on their both sides were inserted between each frame. The two ends of frame cell were attached by two Teflon plates (length: 18.0 cm, width: 12.0 cm, thickness: 2.0 cm) and all components were then threaded through 8 stainless steel screws (length: 25.0 cm, diameter: 5.0 mm) and locked by screw nuts above stainless steel gasket. The side of each frame was screwed to a Teflon joint with which a rubber tube was connected (8 mm in diameter). The immersion surface area of each electrode in frame cell was 7.0 cm×13.0 cm.

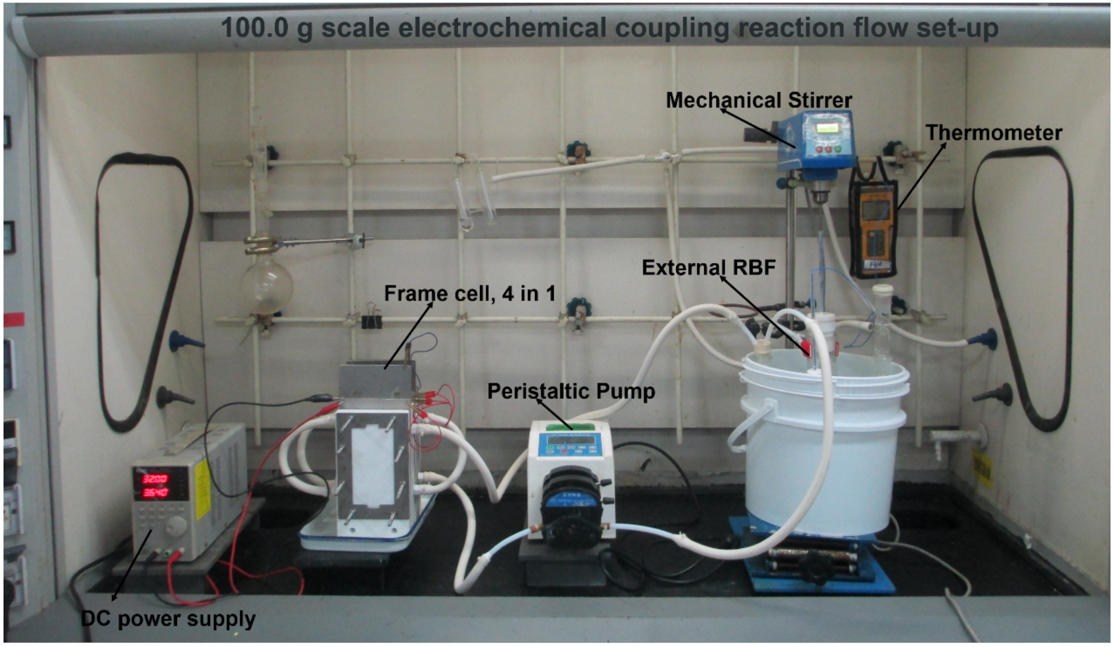
Experimental procedure:

A 5.0 L 4-necked round bottom flask as an external container with mechanical stirrer was charged with $NiCl_2 \cdot 6H_2O$ (5.9 g, 24.8 mmol, 0.1 equiv.), 2,2’-bipyridine (3.9 g, 24.8 mmol, 0.1 equiv.) and $TBABF_4$ solution (0.08 M, 4.0 L in DMF). Then redox active ester ***(R)*-34** (100g, 247.8 mmol, 1.0 equiv.) and alkenyl iodide **Z-33** (S2, 297.4 mmol, 74.4g, 1.2 equiv.) were added into the solution. The mixture was stirred vigorously under N_2 protection until a clear, green solution was obtained. A peristaltic pump was connected with frame cell and external round bottom flask by rubber tubes (diameter: 8.0 mm) and teflon tubes (diameter: 6.0 mm) respectively to form a circulatory system. The loop system was then purged by nitrogen for 10 minutes followed by bubbling the reaction mixture with nitrogen for 20 minutes. Then $AgNO_3$ (3.1 g, 8.5 mg/cm^2 of electrode area) was added to the solution and white precipitate appeared. The mixture was then pumped into frame cell with a speed of 200ml/min in the loop by a peristaltic pump. Electrolysis was then conducted under a constant current of 3.64 A with a current density of 4.08 A/m^2 (determined using specific surface area of carbon felt from literature precedents ((*102*)) from DC power for 7.5 h until the complete consumption of redox active ester as judged by TLC and GC within the frame cell with a distance of 2.0 cm between each electrode. After the reaction, the reaction was driven into a 10 L container from frame cell and external round bottom by peristaltic pump and *n*-Hexanes (1 L×4) was added and circulated for 60 min to wash frame cell and connecting tube four times.

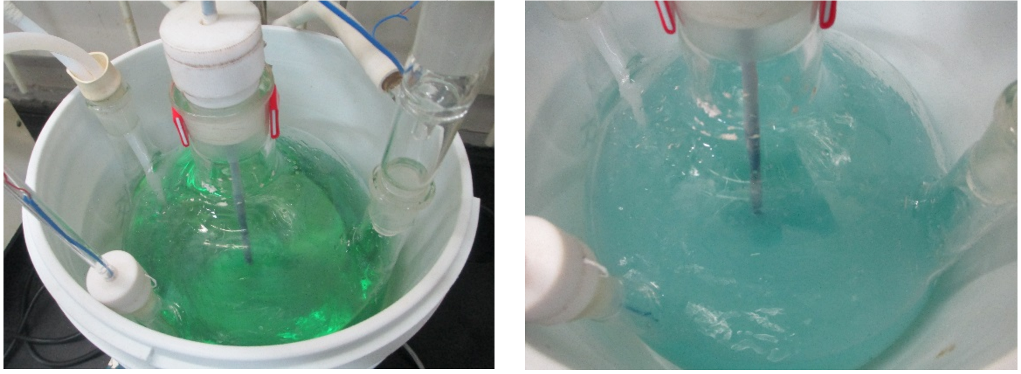
The reaction mixture was cooled with an ice-water bath and 1M HCl (4L) was added into the reaction mixture and stirred vigorously. The mixture was extracted with n-hexanes (1 L×3) three times. The combined organic phases were dried over sodium sulfate and concentrated via rotary evaporation (>120 mbar, 35 ^{o}C water bath). The crude material was purified by column chromatography (*n*-hexane) on silica gel to afford **S38** as a pale-yellow oil (78.53 g total mass with 61% yield of desired compound by ^{1}H-NMR, purity: 64.2% wt/wt). This material was used in the subsequent step without any further purification.

Physical State: pale-yellow oil
^{1}H NMR (600 MHz, CDCl3): δ 5.84 (dd, *J* = 17.3, 10.7 Hz, 1H), 5.14 (dd, *J* = 17.3, 1.6 Hz, 1H), 5.12 – 5.05 (m, 2H), 4.98 (dd, *J* = 10.7, 1.6 Hz, 1H), 2.06 – 1.95 (m, 6H), 1.68 (d, *J* = 1.5 Hz, 3H), 1.67 (d, *J* = 1.3 Hz, 3H), 1.61 (d, *J* = 1.4 Hz, 3H), 1.52 – 1.42 (m, 2H), 1.29 (s, 3H), 0.89 (s, 9H), 0.07 (s, 3H), 0.06 (s, 3H).
^{13}C NMR (151 MHz, CDCl3): δ 145.8, 135.1, 131.6, 125.6, 124.5, 111.7, 75.7, 44.2, 32.0, 27.6, 26.8, 26.1, 25.9, 23.5, 22.7, 18.5, 17.8, -1.9, -1.9
HRMS (ESI-TOF): calculated for $C_{21}H_{40}OSi$ $[M+H]^+$: 219.2113, found: 219.2109
TLC: R_f = 0.78 (100% pentane)
$[\alpha]_D^{20}$ = - 5.200 ^{o} (c = 1.00 MeOH)

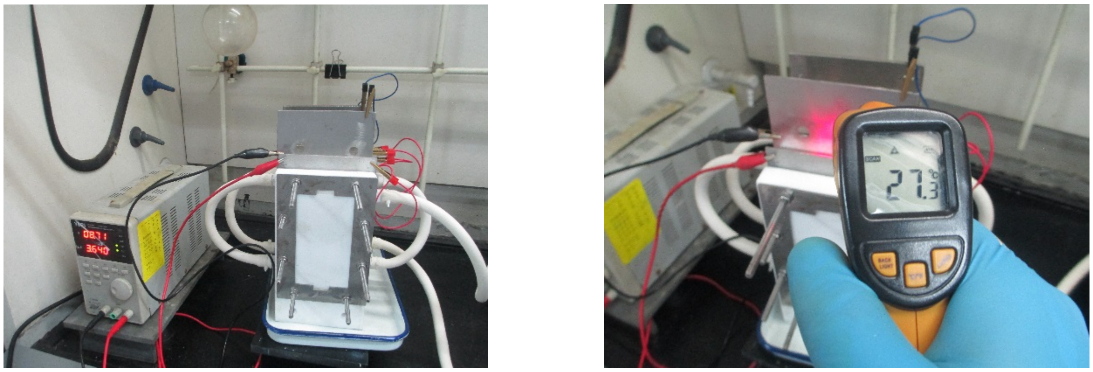
Frame Cell set up: left, front, right views.



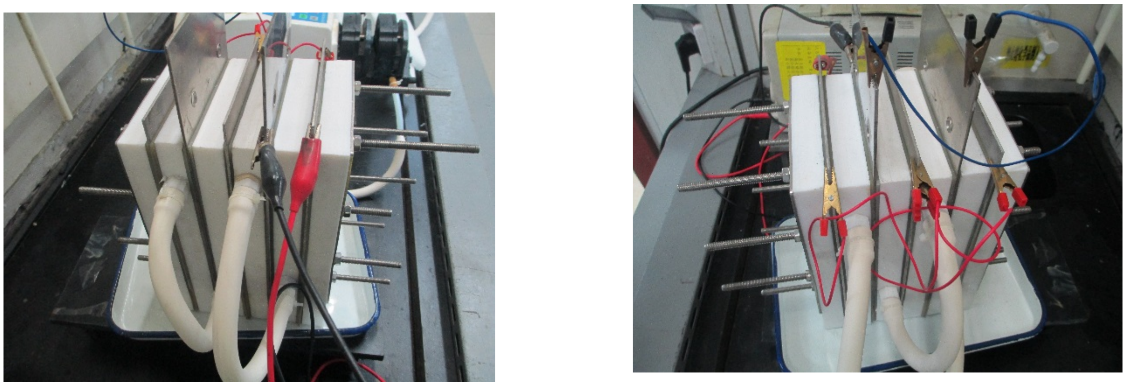
Electrolysis set up in flow



(***Left***) Before adding $AgNO_3$ (***Right***) After adding $AgNO_3$



(***Left***) Frame cell and DC power during electrolysis. (***Right***) Temperature monitor of frame cell.

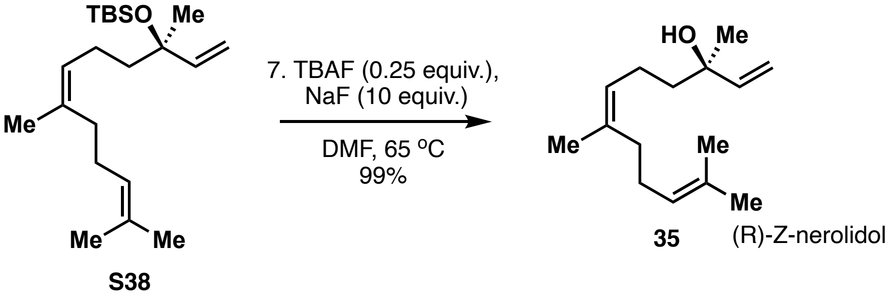


(***Left***) Left side view of frame cell in electrolysis. (***Right***) Right side view of frame cell in electrolysis.

(***Left***) Peristaltic pump and fluororubber tube. (***Right***) External round bottom flask after electrolysis.

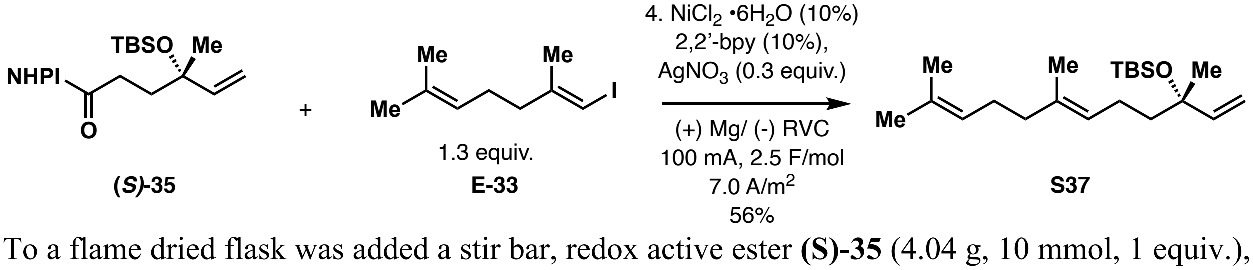
(***Left***) Extraction of quenched reaction mixture with *n*-hexanes (***Right***) Crude product after concentration

(***Left***) Purification of product via column chromatography (***Right***) Product after column chromatography



To a flame dried 100 mL round bottom flask was added crude silyl ether **S38** (5.24 g, 64.2% wt/wt, 10 mmol, 1 equiv.) and sodium fluoride (4.20 g, 100 mmol, 10 equiv.). The flask was sealed and evacuated and backfilled with argon three times before the addition of anhydrous DMF (27 mL). The mixture was cooled to 0 °C and TBAF (2.5 mL, 2.5 mmol, 0.25 equiv.) was added dropwise as a solution in THF (1M). The flask was removed from the ice bath and was allowed to warm to 65 °C. The reaction mixture was stirred at this temperature for 2 days. Upon completion (monitored by NMR), the flask was allowed to cool to room temperature, diluted in diethyl ether (150 mL) and partitioned between aqueous LiCl (5% wt/wt) (200 mL). The aqueous layer was extracted with diethyl ether (3 X 100 mL). The combined organics were washed with brine (200 mL), dried over $MgSO_4$, and concentrated via rotary evaporation to afford an orange oil. The crude material was purified via silica gel column chromatography (0-10% EtOAc/ hexanes) to afford (R)-Z-nerolidol **35** as a pale-yellow to colorless oil (2.198 g, 99%).

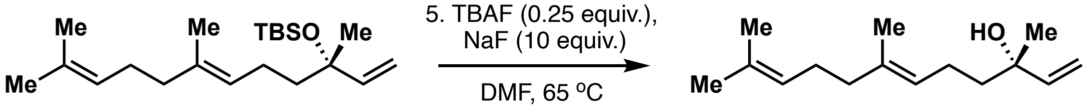
Physical State: Clear colorless oil
^{1}H NMR (500 MHz, CDCl3): δ 5.93 (dd, J = 17.4, 10.8 Hz, 1H), 5.24 (dd, J = 17.4, 1.3 Hz, 1H), 5.15 (q, J = 7.7 Hz, 2H), 5.08 (dd, J = 10.7, 1.3 Hz, 1H), 2.14 – 1.98 (m, 6H), 1.74 – 1.68 (m, 6H), 1.63 (d, J = 1.4 Hz, 3H), 1.62 – 1.54 (m, 2H), 1.50 (s, 1H), 1.30 (s, 3H).
^{13}C NMR (151 MHz, CDCl3): δ 145.2, 135.8, 131.8, 125.1, 124.4, 111.9, 73.6, 42.5, 32.1, 28.0, 26.7, 25.9, 23.5, 22.7, 17.8
HRMS (ESI-TOF): calculated for $C_{15}H_{26}O$ $[M+H]^+$: 223.2062, found: 223.2063
TLC: R_f = 0.39 (10:90 EtOAc/Hexanes)
$[\alpha]_D^{20}$ = -19.600° (c = 5.00 MeOH)



To a flame dried flask was added a stir bar, redox active ester **(S)-35** (4.04 g, 10 mmol, 1 equiv.), vinyl iodide **E-33** (3.252 g, 13 mmol, 1.3 equiv.), $NiCl_2 \bullet 6H_2O$ (237.7 mg, 1.0 mmol, 0.1 equiv.) and 2,2'-bipyridine (156.2 mg, 1.0 mmol, 0.1 equiv.). Next, the flask was sealed with a septum, evacuated, and backfilled three times with argon before the addition of anhydrous DMF (30 mL). This solution was allowed to stir for 20 minutes and a homogeneous, dark green solution developed. This green suspension was split into 2 equal portions (~18 mL each) via syringe and added to 3, 20 mL ElectraSyn 2.0 vial under argon each containing a magnesium anode, 100 ppi RVC cathode (9mm diameter, 40 mm length), $AgNO_3$ (255 mg, 1.5 mmol, 106 $mmol_{Ag}/m^2_{(cathode)}$, 0.3 equiv.) and stir bar. After complete addition electrolysis was immediately started. The electrochemical reaction was performed using an ElectraSyn 2.0 and carousel under constant current conditions with the settings as follows: 100 mA, 5 mmols, 2.5 F/mol providing 7.0 A/m^2 current density. After completion of the reaction, the vials were combined into a single flask and *slowly* quenched with 1N HCl (300 mL) and extracted with diethyl ether (3 X 200 mL). The combined organics were washed successively with distilled water (2 X 200 mL) then brine (1 X 200 mL), then dried over magnesium sulfate before being filtered and concentrated via rotary evaporation. The oily solid was purified via silica gel chromatography (pentane) to afford a mixture of **S37** and residual vinyl iodide (2.427 g total mass with 41% vinyl iodide impurity and 3% homocoupled alkyl product, 56% yield of desired compound by ^{1}H-NMR, purity: 77% wt/wt). This material was used in the subsequent step without any further purification.

Notes: The addition of HCl is exothermic. Be sure to wait until the contents reach ambient temperature before continuing the work up.

Physical State: Clear colorless oil
^{1}H NMR (600 MHz, CDCl3): δ 5.85 (dd, J = 17.3, 10.7 Hz, 1H), 5.15 (dd, J = 17.3, 1.7 Hz, 1H), 5.10 (m, 2H), 4.98 (dd, J = 10.7, 1.7 Hz, 1H), 2.11 – 1.92 (m, 6H), 1.68 (d, J = 1.4 Hz, 3H), 1.60 (d, J = 1.1 Hz, 3H), 1.59 (d, J = 1.3 Hz, 3H), 1.53 – 1.43 (m, 3H), 1.30 (s, 3H), 0.89 (s, 9H), 0.08 (s, 3H), 0.06 (s, 3H).
^{13}C NMR (151 MHz, CDCl3): δ 145.9, 134.9, 131.4, 124.8, 124.6, 111.7, 75.7, 44.0, 39.9, 27.6, 26.9, 26.1, 25.8, 22.8, 18.5, 17.8, 16.1, -1.9
HRMS (ESI-TOF): calculated for $C_{21}H_{40}OSi$ [M-OTBS]$^+$: 219.2113, found: 219.2112
TLC: R$_f$ = 0.68 (100% pentane)
$[\alpha]_D^{20}$ = +2.900^o (c = 1.00 MeOH)

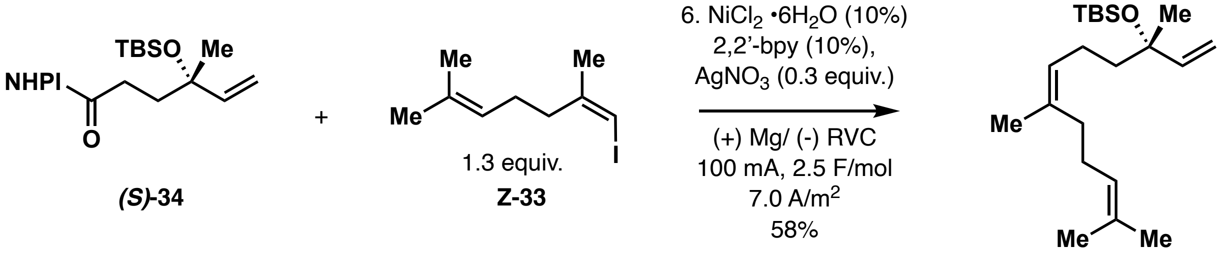


S37 **38** (S)-E-nerolidol

To a flame dried 100 mL round bottom flask was added silyl ether **S37** from previous step (2.427 g, 77% wt/wt, 5.60 mmol, 1 equiv.) and sodium fluoride (2.35 g, 56 mmol, 10 equiv.). The flask was sealed, evacuated and backfilled three times with argon before the addition of anhydrous DMF (15 mL). The mixture was cooled to 0 ^{o}C and TBAF (1.40 mL, 1.4 mmol, 0.25 equiv.) was added dropwise as a solution in THF (1M). The flask was removed from the ice bath and was heated to 65 ^{o}C. The reaction mixture was allowed to stir at this temperature for 16 hours. Upon completion (monitored by NMR), the flask was cooled to room temperature before the being diluted in diethyl ether (150 mL) and partitioned with aqueous LiCl (5% wt/wt) (100 mL). The aqueous layer was extracted with diethyl ether (3 X 100 mL). The combined organics were washed with brine (100 mL), dried over MgSO$_4$, and concentrated to afford an orange oil. The crude material was purified via silica gel column chromatography (0-10% EtOAc/ hexanes) to afford (S)-E-nerolidol (**38**) as a pale-yellow to colorless oil (984.4 mg, 79%).

Physical State: Clear colorless to pale-yellow oil

^{1}H NMR (399 MHz, CDCl3): δ 5.91 (dd, *J* = 17.3, 10.7 Hz, 1H), 5.21 (dd, *J* = 17.3, 1.3 Hz, 1H), 5.14 (ddt, *J* = 7.2, 5.8, 1.4 Hz, 1H), 5.10 – 5.05 (m, 1H), 5.06 (dd, *J* = 10.8, 1.3 Hz, 1H), 2.18 – 1.89 (m, 6H), 1.68 (d, *J* = 1.3 Hz, 3H), 1.59 (s, 6H), 1.61 – 1.52 (m, 2H), 1.28 (s, 3H).
^{13}C NMR (151 MHz, CDCl3): δ 145.2, 135.8, 131.6, 124.4, 124.4, 111.8, 73.7, 42.2, 39.8, 28.1, 26.8, 25.8, 22.9, 17.8, 16.2
HRMS (ESI-TOF): calculated for $C_{15}H_{26}O$ $[M+H]^+$: 223.2062, found: 223.2060
TLC: R_f = 0.39 (10:90 EtOAc/Hexanes)
$[\alpha]_D^{20}$ = +18.100° (c = 1.00 EtOH)



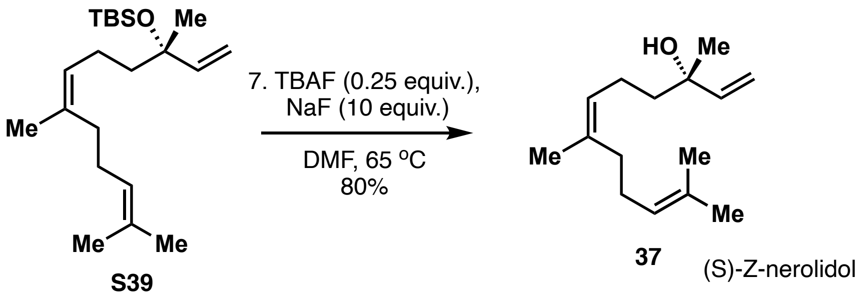
S39

To a flame dried flask was added a stir bar, redox active ester **(S)-34** (4.04 g, 10 mmol, 1 equiv.), vinyl iodide **Z-33** (3.252 g, 13 mmol, 1.3 equiv.), $NiCl_2$•$6H_2O$ (237.7 mg, 1.0 mmol, 0.1 equiv.) and 2,2'-bipyridine (156.2 mg, 1.0 mmol, 0.1 equiv.). Next, the flask was sealed with a septum, evacuated, and backfilled three times with argon before the addition of anhydrous DMF (30 mL). This solution was allowed to stir for 20 minutes and a homogeneous, dark green solution developed. This green suspension was split into 2 equal portions (~18 mL each) via syringe and added to 3, 20 mL ElectraSyn 2.0 vial under argon each containing a magnesium anode, 100 ppi RVC cathode (9 mm diameter, 40 mm length), $AgNO_3$ (255 mg, 1.5 mmol, 106 $mmol_{Ag}/m^2_{(cathode)}$, 0.3 equiv.) and stir bar. After complete addition electrolysis was immediately started. The electrochemical reaction was performed using an ElectraSyn 2.0 and carousel under constant current conditions with the settings as follows: 100 mA, 5 mmols, 2.5 F/mol providing 7.0 A/m^2 current density. After completion of the reaction, the vials were combined into a single flask and *slowly* quenched with 1N HCl (300 mL) and extracted with diethyl ether (3 X 200 mL). The combined organics were washed successively with distilled water (2 X 200 mL) then brine (1 X 200 mL), then dried over magnesium sulfate before being filtered and concentrated via rotary evaporation. The oily solid was purified via silica gel chromatography (pentane) to afford a mixture of **S39** and residual vinyl iodide (2.949 g total mass with 55% vinyl iodide impurity and 8% homocoupled alkyl product, 58% yield of desired compound by ^{1}H-NMR, purity: 66% wt/wt). This material was used in the subsequent step without any further purification.

Notes: The addition of HCl is exothermic. Be sure to wait until the contents reach ambient temperature before continuing the work up.

Physical State: Clear colorless oil
^{1}H NMR (600 MHz, CDCl3): δ 5.84 (dd, *J* = 17.3, 10.7 Hz, 1H), 5.14 (dd, *J* = 17.3, 1.6 Hz, 1H), 5.12 – 5.08 (m, 2H), 4.98 (dd, *J* = 10.7, 1.6 Hz, 1H), 2.07 – 1.95 (m, 6H), 1.68 (d, *J* = 1.3 Hz, 3H), 1.67 (d, *J* = 1.4 Hz, 3H), 1.60 (d, *J* = 1.4 Hz, 3H), 1.52 – 1.42 (m, 2H), 1.29 (s, 3H), 0.89 (s, 9H), 0.07 (s, 3H), 0.06 (s, 3H).

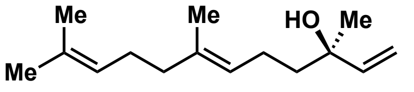
^{13}C NMR (151 MHz, CDCl3): δ 145.8, 135.1, 131.6, 125.6, 124.5, 111.7, 75.7, 44.2, 32.0, 27.6, 26.8, 26.1, 25.9, 23.5, 22.7, 18.5, 17.8, -1.9, -1.9
HRMS (ESI-TOF): calculated for $C_{21}H_{40}OSi$ $[M\text{-}OTBS]^+$: 219.2113, found: 219.2111
TLC: $R_f = 0.78$ (100% pentane)
$[\alpha]_D^{20}$ = +6.600° (c = 1.00 MeOH)



To a flame dried 100 mL round bottom flask was added crude silyl ether **S39** (2.949 g, 66% wt/wt, 5.80 mmol, 1 equiv.) and sodium fluoride (2.44 g, 58 mmol, 10 equiv.). The flask was sealed, evacuated and backfilled three times with argon before the addition of anhydrous DMF (16 mL). The mixture was cooled to 0 °C and TBAF (1.45 mL, 1.45 mmol, 0.25 equiv.) was added dropwise as a solution in THF (1M). The flask was removed from the ice bath and was heated to 65 °C. The reaction mixture was stirred at this temperature for 16 hours. Upon completion (monitored by NMR), the flask was cooled to room temperature before the being diluted in diethyl ether (150 mL) and partitioned between aqueous LiCl (5% wt/wt) (100 mL). The aqueous layer was extracted with diethyl ether (3 X 100 mL). The combined organics were washed with brine (100 mL), dried over $MgSO_4$, and concentrated to afford an orange oil. The crude material was purified via silica gel column chromatography (0-10% EtOAc/ hexanes) to afford (*S*)-Z-nerolidol (**37**) as a pale-yellow to colorless oil (1.029 g, 80%).

Physical State: Clear colorless to pale-yellow oil
^{1}H NMR (399 MHz, CDCl3): δ 5.91 (dd, *J* = 17.3, 10.8 Hz, 1H), 5.21 (dd, *J* = 17.3, 1.3 Hz, 1H), 5.12 (m, 2H), 5.06 (dd, *J* = 10.8, 1.3 Hz, 1H), 2.12 – 1.95 (m, 6H), 1.68 (m, 6H), 1.61 (d, *J* = 1.4 Hz, 3H), 1.59 – 1.52 (m, 2H), 1.28 (s, 3H).
^{13}C NMR (151 MHz, CDCl3): δ 145.2, 135.8, 131.8, 125.1, 124.4, 111.9, 73.6, 42.5, 32.1, 28.0, 26.7, 25.9, 23.5, 22.7, 17.8
HRMS (ESI-TOF): calculated for $C_{15}H_{26}O$ $[M+H]^+$: 223.2062, found: 223.2064
TLC: $R_f = 0.40$ (10:90 EtOAc/Hexanes)
$[\alpha]_D^{20}$ = +20.100° (c = 1.00 EtOH)

Table S25 — 36 ^{1}H Shifts Comparison



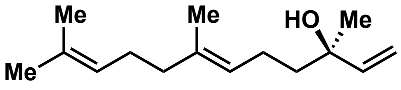
36 (R)-E-nerolidol

Tabulated data for Synthetic **36**
^{1}H-NMR ($CDCl_3$)

Synthetic **36** (600 MHz, $CDCl_3$)	Synthetic **36** (Kigoshi, 400 MHz $CDCl_3$) (*103*)	Natural **36** (Schubert, 300MHz, $CDCl_3$) (*104*)	Δppm from natural **36**
5.92 (dd, J = 17.3, 10.8 Hz, 1H)	5.93 (dd, *J* = 17, 10 Hz, 1H)	5.92 (dd, 1H)	0.00
5.22 (dd, J = 17.3, 1.3 Hz, 1H)	5.20 (dd, *J* = 17, 1 Hz, 1H)	5.22 (dd, 1H)	0.00
5.14 (ddt, J = 8.5, 7.1, 1.4 Hz, 1H) 5.10 – 5.04 (m, 2H)	5.10 (m, 2H) 5.05 (dd, *J* = 10, 1 Hz, 1H)	5.16 – 5.05 (m, 2H) 5.06 (dd, 1H)	0.01
2.11 – 1.95 (m, 6H)	2.20 – 1.90 (m, 6H)	2.10 – 1.95 (m, 6H)	0.01
1.68 (d, J = 1.4 Hz, 3H)	1.68 (br s, 3H)	1.68 (s, 3H)	0.00
1.63 – 1.55 (m, 2H)	Not accounted for.	1.67 – 1.50 (m, 3H)*	0.05
1.60 (2x br s, 6H)	1.60 (2x br s, 6H)	1.60 (s, 6H)	0.00
1.28 (s, 3H)	1.28 (s, 3H)	1.28 (s, 3H)	0.00

*OH Proton observed in natural spectra but not in synthetic.

Table S26 — 36 ^{13}C Shifts Comparison

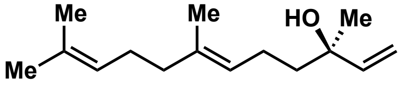


36 (R)-E-nerolidol

Tabulated data for Synthetic **36**
^{13}C-NMR ($CDCl_3$)

Synthetic **36** (151 MHz, $CDCl_3$)	Synthetic **36** (Cane, 15 MHz $CDCl_3$)(*105*)	Δppm from Synthetic **36**
145.2	145.3	0.1
135.8	135.5	0.3
131.6	131.4	0.2
124.4	124.5	0.1
124.4	124.5	0.1
111.8	111.8	0.0
73.7	73.5	0.2
42.2	42.2	0.0
39.9	39.8	0.1
28.1	27.9	0.2
26.8	26.8	0.0
25.8	25.8	0.0
22.9	22.8	0.1
17.8	17.7	0.1
16.2	16.1	0.1

Table S27 — 36 Optical Rotation Comparison

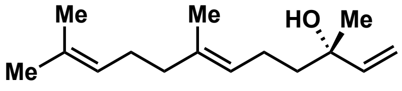


36 (R)-E-nerolidol

Tabulated data for Synthetic **36**
Optical rotation ($[\alpha]_D^{20}$)

Synthetic **36** (c = 1.05 EtOH)	Synthetic **36** (Kigoshi, c = 1.15 EtOH)(*103*)
- 19.143°	- 17.9°

Table S28 — 38 Optical Rotation Comparison

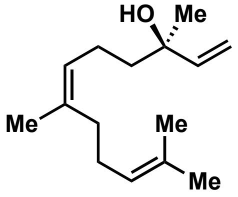


38 (S)-E-nerolidol

Tabulated data for Synthetic **38**
Optical rotation ($[\alpha]_D^{20}$)

Synthetic **38** (c = 1.00 EtOH)	Synthetic **38** (Campbell, c = 1.48, EtOH)(*106*)
+ 18.000°	+ 18°

Table S29— 35 ^{1}H Shifts Comparison



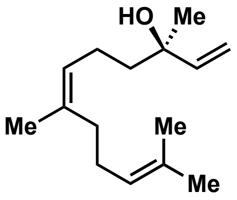
35 (R)-Z-nerolidol

Tabulated data for Synthetic **35**
^{1}H-NMR ($CDCl_3$)

Synthetic **35** (500 MHz, $CDCl_3$)	Natural **35** (Schubert, 300MHz, $CDCl_3$)(*104*)	Δppm from natural **35**
5.93 (dd, *J* = 17.4, 10.8 Hz, 1H)	5.91 (dd, 1H)	0.02
5.24 (dd, *J* = 17.4, 1.3 Hz, 1H)	5.21 (dd, 1H)	0.03
5.15 (q, *J* = 7.7 Hz, 2H)	5.16 – 5.09 (m, 2H)	0.01
5.08 (dd, *J* = 10.7, 1.3 Hz, 1H)	5.06 (dd, 1H)	0.02
2.14 – 1.98 (m, 6H)	2.07 – 1.95 (m, 6H)	0.07
1.74 – 1.68 (m, 6H)	1.69 (s, 3H) 1.68 (s, 3H)	0.00

1.63 (d, *J* = 1.4 Hz, 3H)	1.61 (s, 3H)	0.02
1.62 – 1.54 (m, 2H) 1.50 (s, 1H)	1.67 – 1.50 (m, 3H)	0.05
1.30 (s, 3H)	1.28 (s, 3H)	0.02

Table S30 — Optical Rotation Comparison of 35



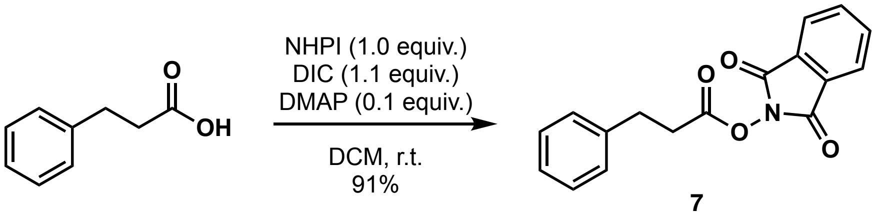
35 (R)-Z-nerolidol

Tabulated data for Synthetic **35**
Optical rotation ($[\alpha]_D^{20}$)

Synthetic **35** (c = 5.00 MeOH)	Natural **35** (Schubert, c = 6.28 MeOH)(*104*)
- 19.600°	- 13.2 °

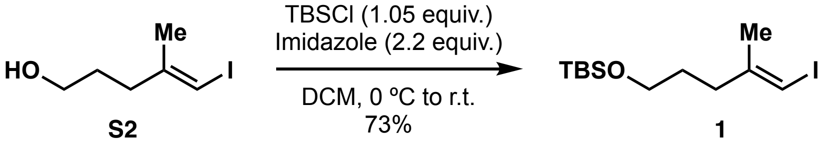
Electrochemical cross-coupling (optimization, controls, surface & mechanistic studies)

Preparation of Model Substrates



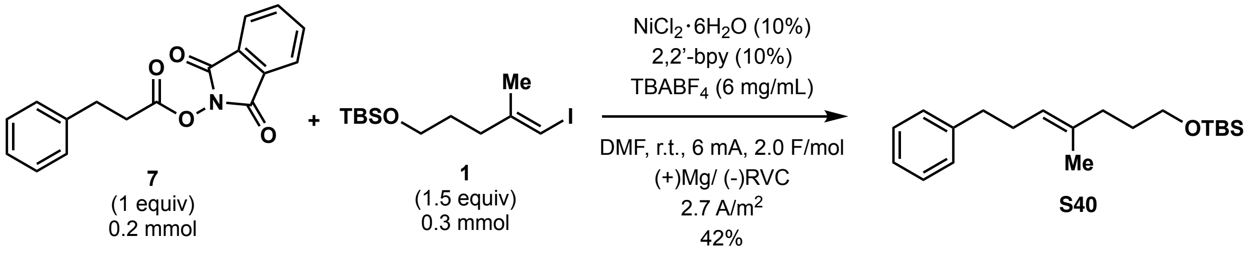
To a stirring solution of hydrocinnamic acid (10.0 g, 66.6 mmol, 1.0 equiv.), *N*-hydroxyphthalimide (10.9 g, 66.6 mmol, 1.0 equiv.), and 4-dimethylaminopyridine (814 mg, 6.66 mmol, 0.1 equiv.) in anhydrous DCM (333 mL) under argon, DIC (11.5 mL, 73.3 mmol, 1.1 equiv.) was added via syringe. The reaction mixture was vigorously stirred until complete (monitored by TLC). Upon completion, the mixture was concentrated, suspended in diethyl ether, then filtered through a pad of silica gel and the pad was subsequently rinsed with additional diethyl ether (3 X 200 mL). The filtrate was concentrated under reduced pressure to afford RAE **7** as a white crystalline solid (18.18 g, 91%).

Physical State: White crystalline solid
^{1} H NMR (500 MHz, CDCl3): δ 7.92 – 7.86 (m, 2H), 7.82 – 7.77 (m, 2H), 7.36 – 7.31 (m, 2H), 7.28 – 7.23 (m, 4H), 3.11 (dd, *J* = 8.8, 6.9 Hz, 2H), 3.02 – 2.96 (m, 2H).
^{13}C NMR (125 MHz, CDCl3): δ 169.0, 162.0, 139.3, 134.9, 129.1, 128.9, 128.5, 126.9, 124.1, 32.9, 30.7.
Melting point: 76 – 78 °C
HRMS (ESI-TOF) calculated for $C_{17}H_{13}NO_4$ $[M+H]^+$: 296.0918, found: 296.0917
TLC: $R_f = 0.28$ (4:1 Hexanes / ethyl acetate)



To a stirring solution of vinyl iodide **S2** (2.74 g, 12.1 mmol, 1.0 equiv.) and imidazole (1.82 g, 26.68 mmol, 2.2 equiv.) in anhydrous DCM (60 mL), tert-butyldimethylsilyl chloride (1.92 g, 12.7 mmol, 1.05 equiv.) was added in portions at 0 °C. The reaction mixture was allowed to warm to room temperature and stir until complete (monitored by TLC). Upon completion, the stir bar was removed and the solvent was removed under reduced pressure to afford an oily white paste. The paste was suspended in hexanes (300 mL) and passed through a pad of silica. The filtrate was concentrated to afford the silyl ether **1** as a clear colorless oil (3.0 g, 73%).

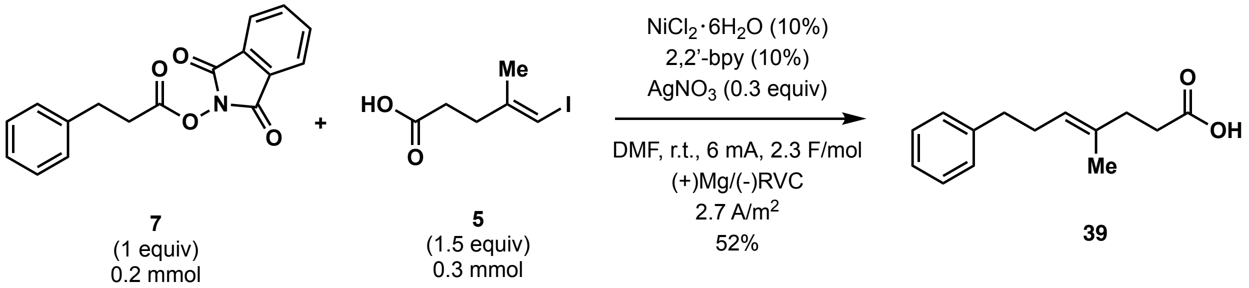
Physical State: Colorless Oil
^{1} H NMR (600 MHz, CDCl3): δ 5.88 (h, *J* = 1.2 Hz, 1H), 3.58 (t, *J* = 6.3 Hz, 2H), 2.32 – 2.23 (m, 2H), 1.84 (d, *J* = 1.1 Hz, 3H), 1.68 – 1.60 (m, 2H), 0.89 (s, 9H), 0.04 (s, 6H).
^{13}C NMR (151 MHz, CDCl3): δ 147.9, 74.8, 62.3, 36.0, 30.9, 26.1, 24.0, 18.5, -5.2
HRMS (ESI-TOF) calculated for $C_{12}H_{25}IOSi$ $[M+H]^+$: 341.0798, found: 341.0804
TLC: $R_f = 0.52$ (15:85 DCM/ Hexane)



To an oven dried 5 mL ElectraSyn 2.0 vial, redox active ester **7** (59.1 0.2 mmol, 1 equiv.), vinyl iodide **1** (102 mg, 0.3 mmol, 1.5 equiv.), $TBABF_4$ (18 mg, 6 mg/mL), $NiCl_2$•$6H_2O$ (4.75 mg, 0.02 mmol, 0.1 equiv.), and 2,2′-bypridine (3.12 mg, 0.02 mmol, 0.1 equiv.) were all directly added as solids/oils. The vial was sealed with a 5 mL ElectraSyn 2.0 vial cap fitted with a magnesium sacrificial anode and a 100 ppi RVC cathode (3 mm x 7 mm x 51 mm). The sealed vial was then evacuated and backfilled with argon three times. Anhydrous DMF was then added (3 mL) via syringe. The vial was then placed on an IKA ElectraSyn 2.0 and electrolysis was set to 6 mA, 0.2 mmol substrate, and 2.0 F/mol, providing 2.7 A/m^2 current density. The reaction was allowed to undergo the programmed electrolysis. After completion of the reaction, the reaction was transferred to a separatory funnel, the electrodes were rinsed with diethyl ether (5 mL) and 1N HCl (10 mL) was *slowly* added. The aqueous layer was extracted with diethyl ether (3 X 10 mL). The combined organics were washed successively with distilled water (2 X 10 mL) then brine (1 X 10 mL), then dried over magnesium sulfate before being filtered and concentrated via rotary evaporation. The crude oily solid was purified via silica gel chromatography (0-15% DCM/Hexanes) to afford **S40** (26.7 mg, 42% yield).

Alternatively, **S40** was prepared according to general procedure A. Isolated 33.5 mg, 53% yield.

Physical State: Clear Colorless Oil
^{1}H NMR (600 MHz, CDCl3): δ 7.29 – 7.25 (m, 2H), 7.21 – 7.16 (m, 3H), 5.19 (tq, *J* = 7.1, 1.3 Hz, 1H), 3.58 (t, *J* = 6.6 Hz, 2H), 2.67 – 2.59 (m, 2H), 2.30 (dddd, *J* = 8.6, 7.0, 6.0, 0.9 Hz, 2H), 2.04 – 1.97 (m, 2H), 1.63 – 1.57 (m, 2H), 1.55 (t, *J* = 0.7 Hz, 3H), 0.90 (s, 9H), 0.05 (s, 6H).
^{13}C NMR (151 MHz, CDCl3): δ 142.5, 135.7, 128.6, 128.4, 125.8, 123.8, 63.1, 36.3, 35.9, 31.3, 30.1, 26.1, 18.5, 16.1, -5.1.
HRMS (ESI-TOF): calculated for $C_{20}H_{34}OSi$ $[M+Na]^+$: 341.2271, found: 341.2267
TLC: R_f = 0.32 (15:85 DCM/Hexanes).

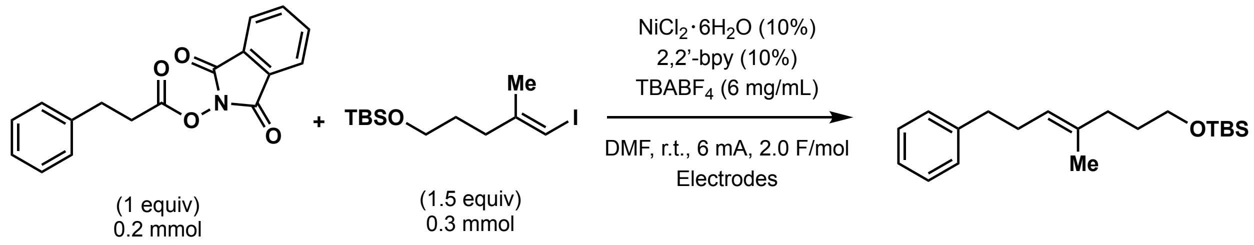


39 was prepared according to general procedure A with minor modifications.
To an oven dried 5 mL ElectraSyn 2.0 vial, redox active ester (59.1 mg, 0.2 mmol, 1 equiv.), vinyl iodide (72.0 mg, 0.3 mmol, 1.5 equiv.), $AgNO_3$ (10.2 mg, 0.06 mmol, 27 mmol$_{ag}$/m$^2_{(cathode)}$, 0.3

equiv.), $NiCl_2•6H_2O$ (4.75 mg, 0.02 mmol, 0.1 equiv.), and 2,2′-bypridine (3.12 mg, 0.02 mmol, 0.1 equiv.) were all directly added as solids/oils. The vial was sealed with a 5 mL ElectraSyn 2.0 vial cap fitted with a magnesium sacrificial anode and a 100 ppi RVC cathode (3 mm x 7 mm x 51 mm). The sealed vial was then evacuated and backfilled with argon three times. Anhydrous DMF was then added (3 mL) via syringe. The vial was then placed on an IKA ElectraSyn 2.0 and electrolysis was set to 6 mA, 0.2 mmol substrate, and 2.3 F/mol, providing 2.7 A/m^2 current density. The reaction was allowed to undergo the programmed electrolysis. After completion of the reaction, the reaction was transferred to a separatory funnel, the electrodes were rinsed with diethyl ether (5 mL) and 1N HCl (10 mL) was *slowly* added. The aqueous layer was extracted with diethyl ether (3 X 10 mL). The combined organics were washed successively with distilled water (2 X 10 mL) then brine (1 X 10 mL), then dried over magnesium sulfate before being filtered and concentrated via rotary evaporation. ^{1}H-NMR yield of **39** was determined to be 52% using 1,3,5-trimethyoxybenzne as an internal standard.

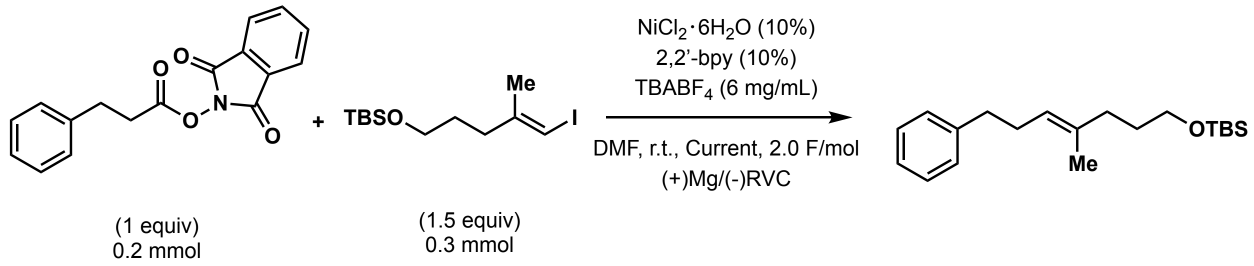
Physical State: Clear Colorless Oil
^{1} H NMR (400 MHz, CDCl3): δ 7.31 – 7.24 (m, 2H), 7.18 (t, *J* = 6.7 Hz, 3H), 5.23 (t, *J* = 7.1 Hz, 1H), 2.68 – 2.59 (m, 2H), 2.46 – 2.41 (m, 2H), 2.34 – 2.26 (m, 2H), 1.55 (s, 3H).
^{13}C NMR (151 MHz, CDCl3): δ 178.1, 142.3, 133.9, 128.6, 128.4, 125.9, 124.8, 36.1, 34.4, 32.7, 30.0, 16.0.
HRMS (ESI-TOF) calculated for $C_{14}H_{18}O_2$ $[M+H]^+$: 219.1385, found: 219.1388
TLC: $R_f = 0.48$ (1:1 hexanes / ethyl acetate)

Table S31 — Effect of Electrode Material



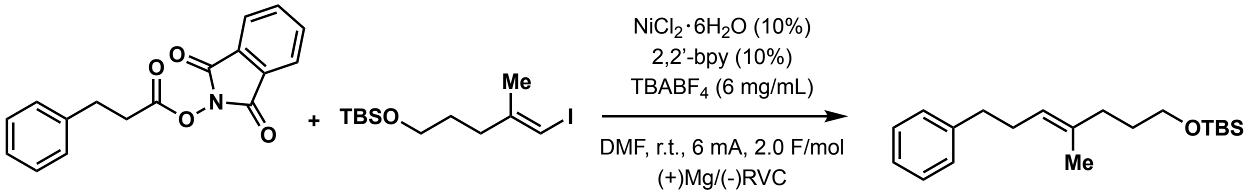
entry	cathode material	anode material$^-$	%yield (^{1}H-NMR)
1	RVC	Mg	42
2	RVC	Al	20
3	RVC	Cu Wire	3
4	RVC	Zn	11
5	RVC	Fe	12
6	RVC	Co	24
7	Glassy Carbon	Mg	15
8	Graphite	Mg	13

Table S32—Effect of Current



entry	current	%yield (^{1}H-NMR)
1	3 mA	43
2	6 mA	42
3	10 mA	44

Table S33 — Starting material stoichiometry

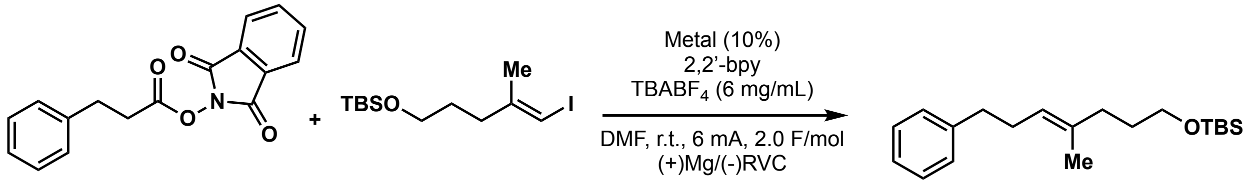


entry	RAE equivalents*	iodide equivalents*	%yield (^{1}H-NMR)
1	1	1	35
2	1	1.5	44
3	1	2	51
4	1	2.5	57
5	2.5	1	26

* 0.2 mmol of limiting reagent used.

Note: As the equivalents of the vinyl iodide increased, the reaction yield was improved however separation of the product and the unreacted vinyl iodide could be challenging.

Table S34 — Effect of Metal Source



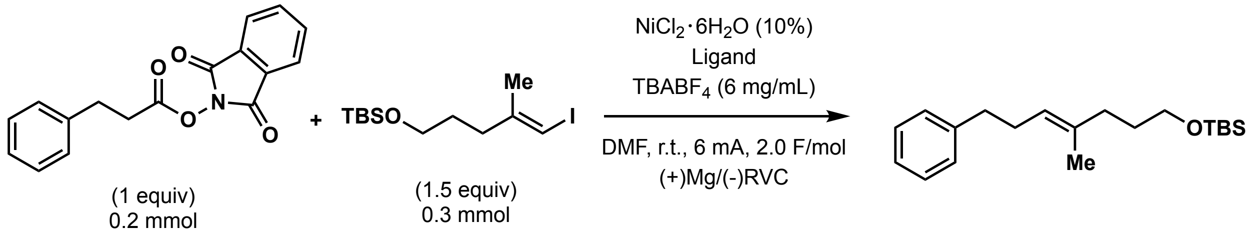
(1 equiv)
0.2 mmol

(1.5 equiv)
0.3 mmol

entry	metal source	%yield (^{1}H-NMR)
1	$NiCl_2·6H_2O$	42
2	$CoCl_2·6H_2O$	Trace
3	$NiCl_2(dme)$	40
4	$Ni(acac)_2·xH_2O$	N/A*
5	$NiCl_2(PPh_3)_2$	30
6	$Ni(NO_3)_2·6H_2O$	14

* Unable to pass current due to high resistance/potential

Table S35 — Effect of Ligand



entry	ligand	%yield (^{1}H-NMR)
1	L1 (10%)	42
2	L2 (10%)	41
3	L3 (10%)	40
4	L4 (10%)	36
5	L5 (10%)	39
6	L6 (10%)	38
7	L7 (10%)	0
8	L1 (10%) + Pyridine (90%)	41
9	L1 (10%) + Pyridine (90%)	44
10	Pyridine (90%)	trace

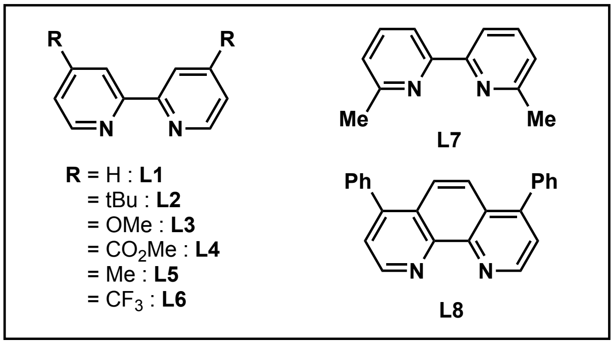
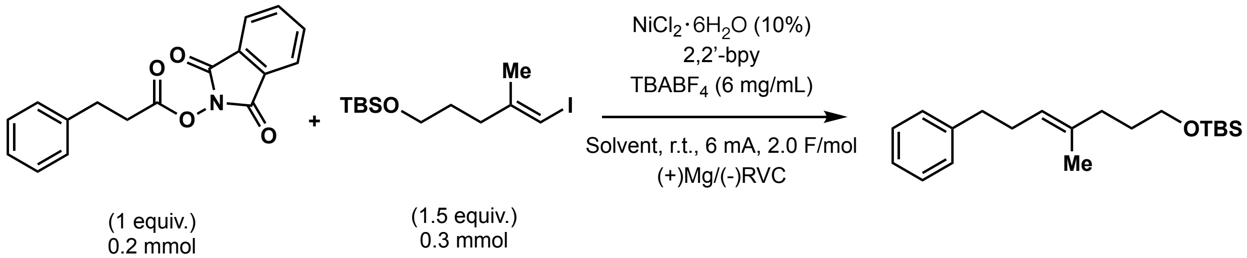


Table S36 — Effect of Solvent

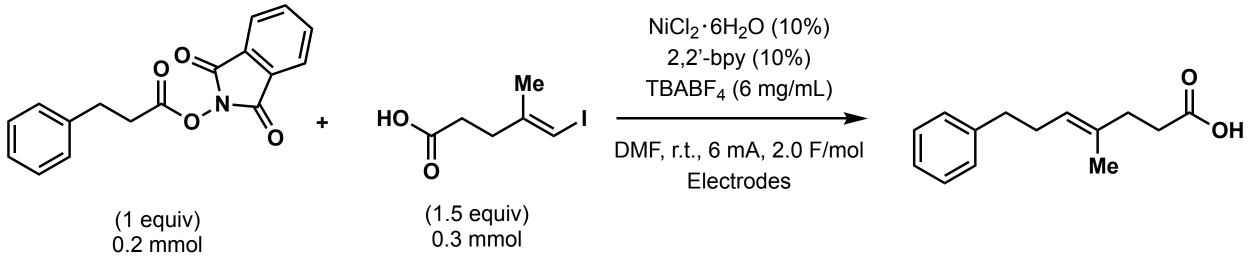


entry	solvent	%yield (^{1}H-NMR)
1	DMF	42
2	DMA	31
3	MeCN	Trace
4	DMF/THF (1:1)	10
5	Acetone	0
6	THF	N/A*

* Voltage overload on the Electrasyn

Reoptimization of the Electrochemical Alkenylation Using Halo-Acid Modules

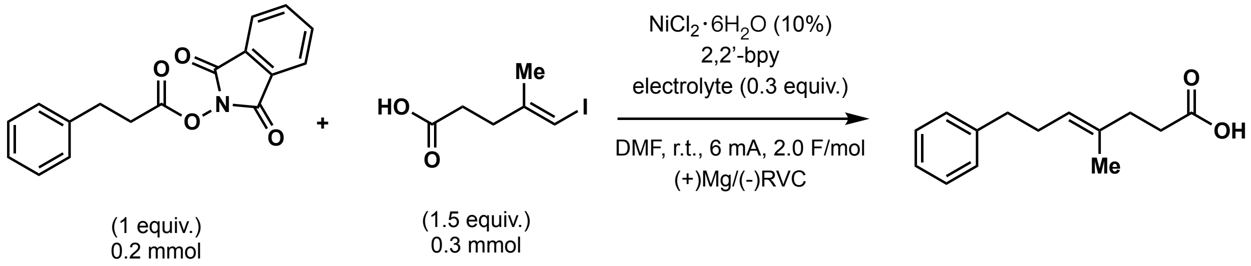
Table S37—Effect of Electrode Material on Coupling of Acid-Bearing Vinyl Iodide



entry	cathode material	anode material	%yield (^{1}H-NMR)
1	RVC	Mg	18
2	Pt	Mg	4
3	Ag	Mg	20
4	Ni Foam	Mg	0
5	Glassy Carbon	Mg	8
6	Graphite	Mg	5
7	RVC	Fe	5
8	RVC	Zn	2
9	RVC	Al	34*

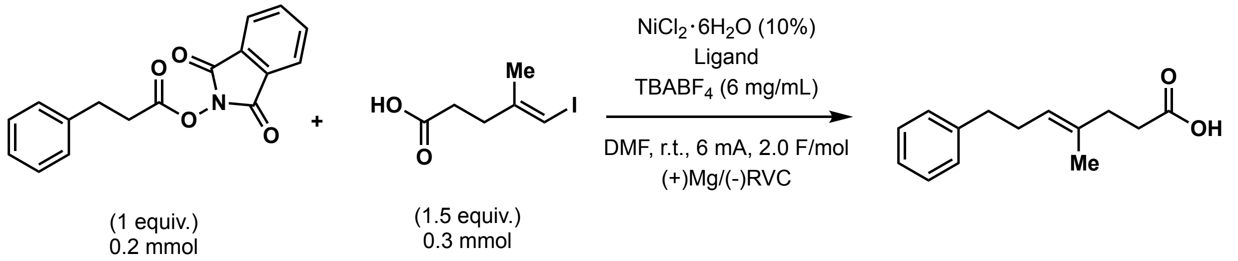
* high voltage and not ammenable to scale up beyond 0.2 mmol

Table S38—Effect of Electrolyte on Coupling of Acid-Bearing Vinyl Iodide



entry	electrolyte	%yield (^{1}H-NMR)
1	$TBABF_4$	18
2	LiCl	27
3	$LiNO_3$	18
4	$TBAPF_6$	18
5	$MgBr_2(OEt_2)$	24
6	$LiBF_4$	21
7	TBAI	19

Table S39—Effect of Ligand on Coupling of Acid-Bearing Vinyl Iodide



entry	ligand	%yield (^{1}H-NMR)
1	L1 (10%)	19
2	L1 (20%)	0
3	L2 (10%)	9
4	L3 (10%)	9
5	L4 (10%)	10
6	L5 (10%)	9
7	L6 (10%)	0
8	L7 (10%)	0
9	L8 (10%)	11

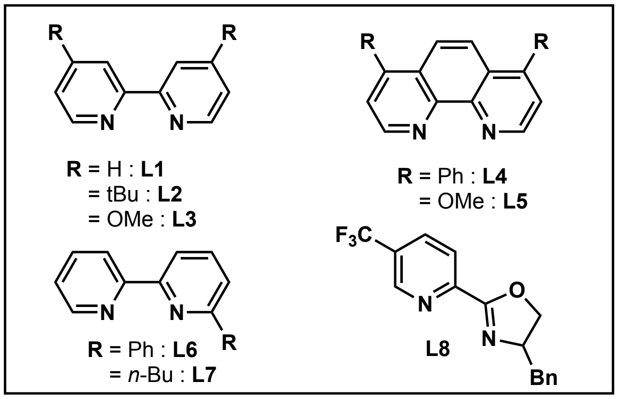
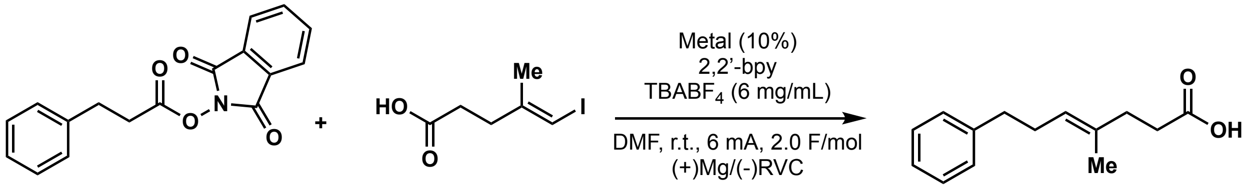


Table S40—Effect of Metal Source on Coupling of Acid-Bearing Vinyl Iodide

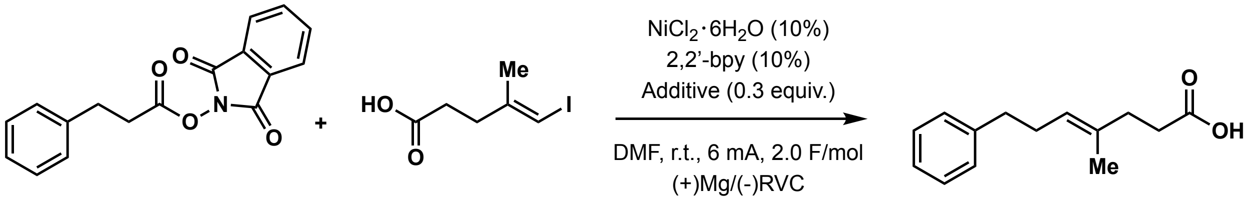


(1 equiv.)
0.2 mmol

(1.5 equiv.)
0.3 mmol

entry	metal source	%yield (^{1}H-NMR)
1	$NiCl_2 \cdot 6H_2O$	18
2	$NiCl_2$(dme)	17
3	$Ni(acac)_2$	trace
4	$Ni(NO_3)_2 \cdot 6H_2O$	1
5	$NiI_2 \cdot 6H_2O$	2
6	$NiBr_2$(diglyme)	2
7	$NiCl_2(PPh_3)_2$	14
8	$CoCl_2 \cdot 6H_2O$	0
9	$Fe(acac)_3$	0

Table S41—Effect of Electrode Plating Additives on Coupling of Acid-Bearing Vinyl Iodide



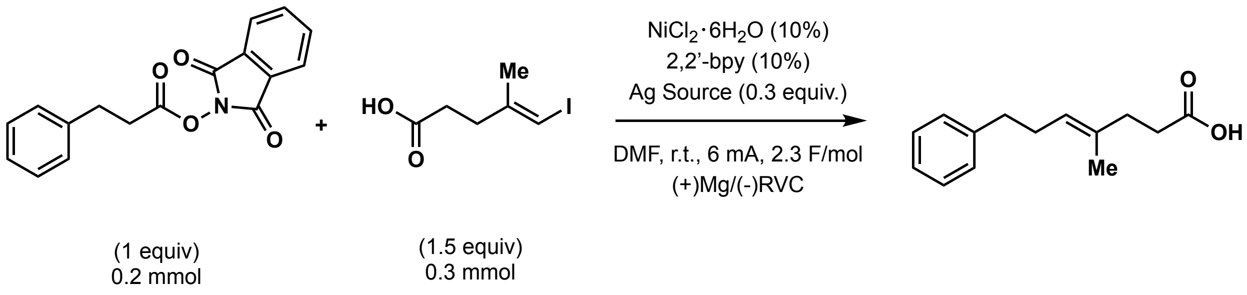
(1 equiv.)
0.2 mmol

(1.5 equiv.)
0.3 mmol

entry	additive	%yield (^{1}H-NMR)
1	$CuCl_2$	14
2	$AgNO_3$*	52

* 2.3 F/mol passed

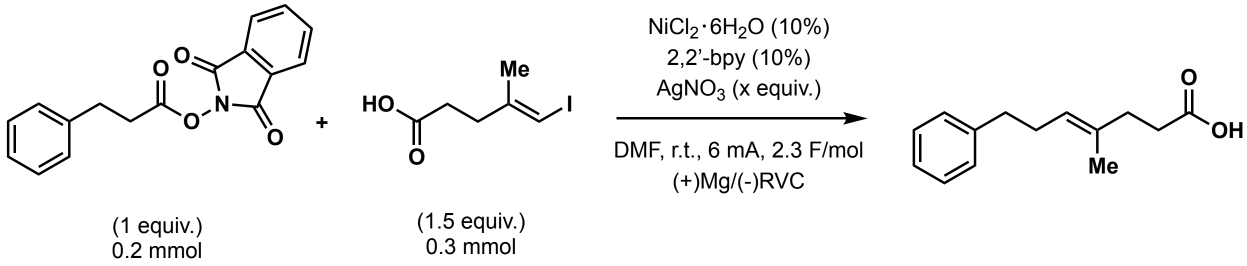
Table S42 — Effect of Silver Salt



entry	Ag Source	%yield (^{1}H-NMR)
1	$AgNO_3$	52
2	$Ag(CF_3CO_2)$	36
3	Ag(OAc)	20
4	AgOTf	27
5	Ag_2SO_4*	22
6	Ag_2CO_3*	11

* 0.15 equivalents used.

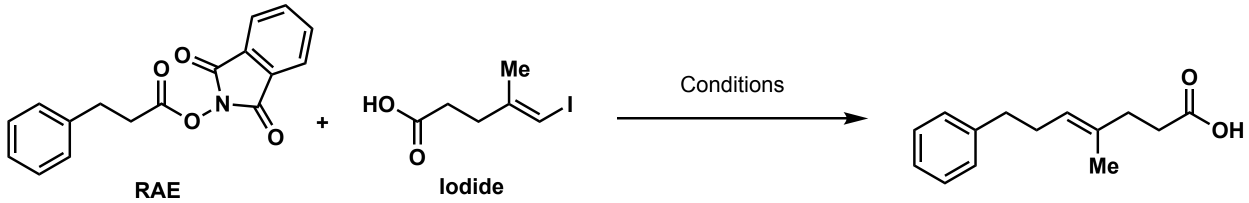
Table S43 — Silver Salt Equivalencies



entry	$AgNO_3$ equivalents	%yield (^{1}H-NMR)
1	0.5*	45
2	0.5*,†	45
3	0.3	52
4	0.1‡	34

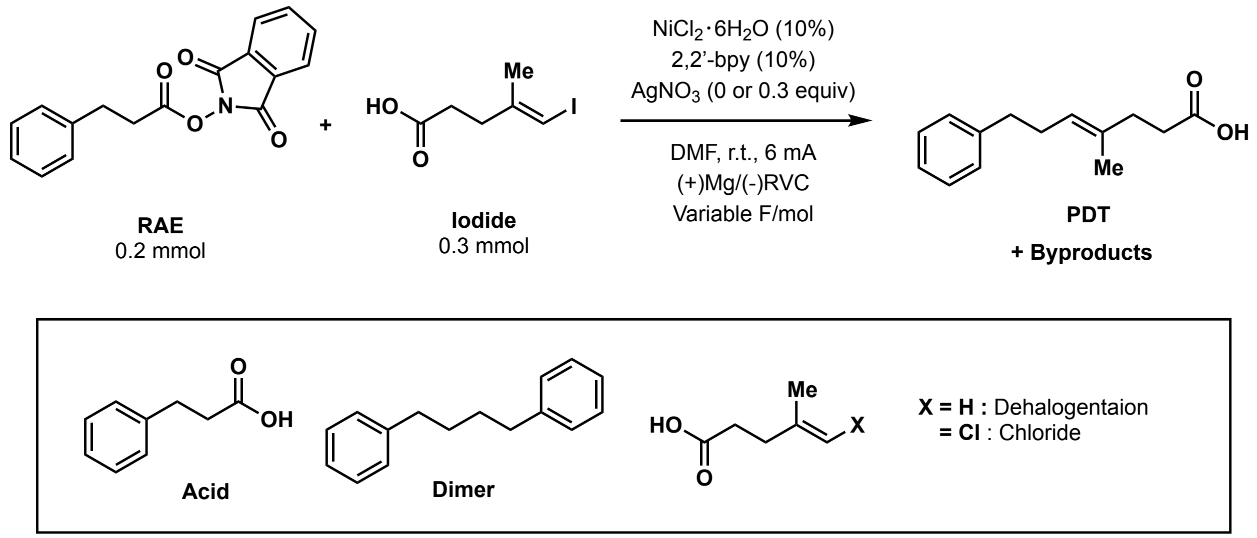
* 2.5 F/mol passed. † LiCl (0.3 equiv.) used as additive. ‡ 2.1 F/mol passed

Table S44 – Comparison to exisiting C(sp^3)-C(sp^2) couplings utilizing redox active esters



entry	Equiv. RAE	Equiv. Iodide	Conditions	Reference	%yield (^{1}H-NMR)
1	1.5	1.0	$NiCl_2$(dme) (10%) dtbbpy (10%) NaI (0.2 M) DMA (+)Zn/(-)RVC 3 mA, 2.0 F/mol	*Preformed RAE* Loren, et. al. *Org Lett*, **2019** *21,* 816 - 820	0
2	1.5	1.0	i) NaOH, MeOH ii) PITU iii)$NiCl_2$(dme) (10%) dtbbpy (10%) NaI (0.2 M) DMA (+)Zn/(-)RVC 3 mA, 2.0 F/mol	*In-situ activation* Loren, et. al. *Org Lett*, **2019** *21,* 816 - 820	0
3	1.0	2.0	$NiBr_2$(dme) (30%) dtbbpy (30%) Et_3N (6 equiv.) $TBAPF_6$ (2 equiv.) DMA (+)RVC/(+)RVC Divided cell, 20 mA	Jamison, et. al. *Org. Lett.* **2018***, 20* 1338 - 1341	8
4	1.5	1.0	$NiBr_2$(diglyme) (7%) dtbbpy (7%) Zn (2 equiv.) DMA, r.t., o/n	Weix, et. al. *J. Am. Chem. Soc.* **2016**, *138*, 5016 - 5019	0
5	1.0	1.5	$NiCl_2 \cdot 6H_2O$ (10%) 2,2'–bpy (10%) $AgNO_3$ (0.3 equiv.) DMF, r.t., 6 mA (+)Mg/(–)RVC 2.3 F/mol	this work	52

Fig S18 — Byproduct Analysis and Reaction Progress Monitoring Experiments



Notes: The above reaction was set up following the general optimization procedure with a small modification: The reaction was stopped after a predetermined amount of electricity had passed (0, 0.3, 0.8, 1.3, 1.8, and 2.3 F/mol) and subjected to a full workup. Reaction progress was evaluated by ^{1}*H-NMR using trimethoxybenzene as an internal standard.*

Fig S19 — Byproduct distribution over time without silver additive.

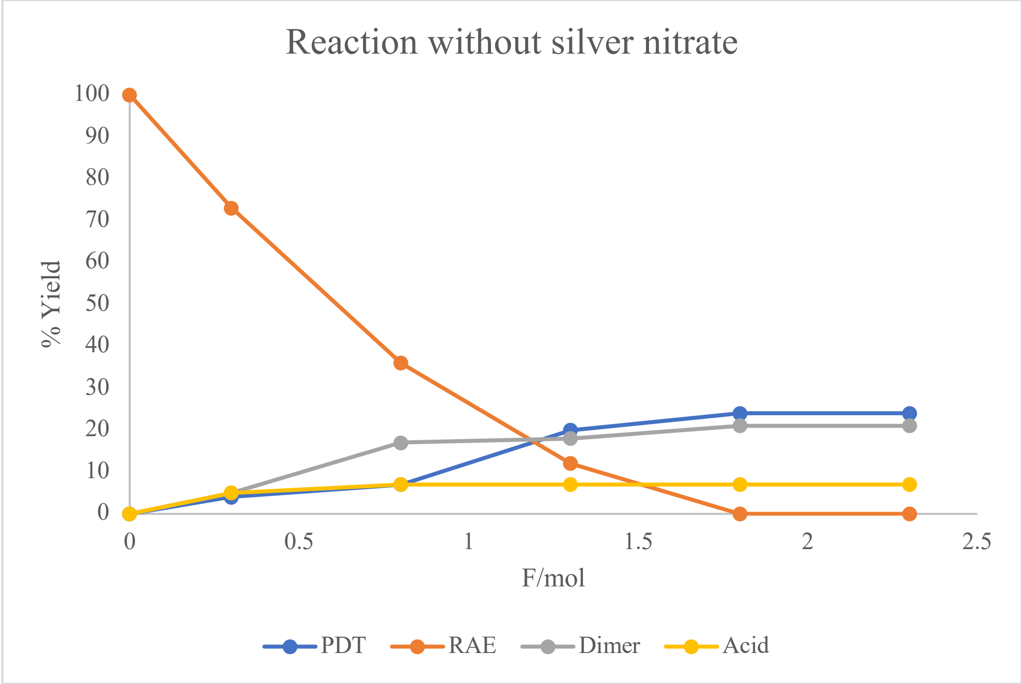
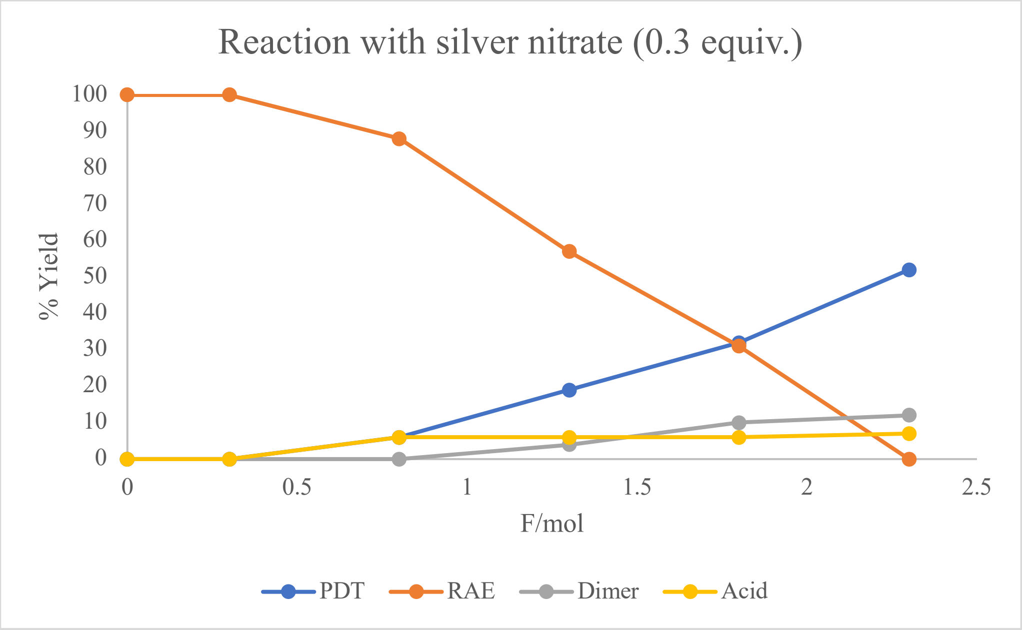


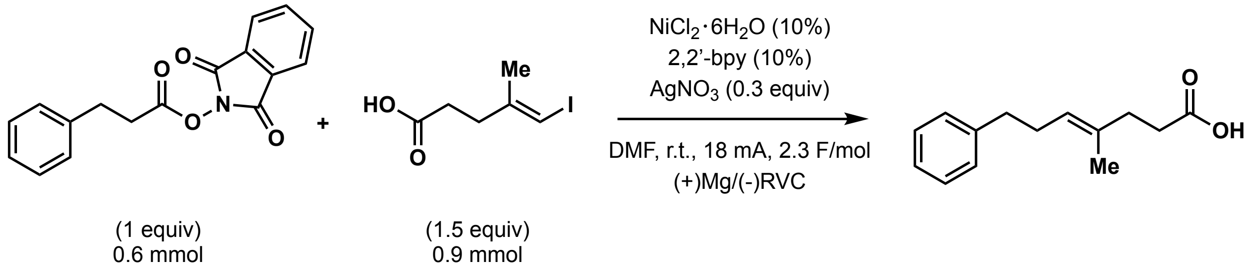
Fig S20 — Byproduct distribution over time with silver additive.



Slower consumption of RAE starting material is observed. Additionally, with silver. a 0.3F/mol induction period where no product is formed nor is any starting material consumed. We attribute this induction period to the reduction and deposition of the $AgNO_3$ *(0.3 equiv.) prior to reduction events relevant to the cross-coupling reaction. During the first 0.3 F/mol of the reaction the cloudy white suspension observed in the reaction eventually disappears to provide a homogeneous solution. We propose that this is the result of a salt metathesis reaction involving* $AgNO_3$ *and* $NiCl_2{\bullet}6H_2O$ *to produce AgCl which is electrochemically reduced.*

Electrochemical Alkenylation Control Studies

Fig S21 — Recycling of Ag-Deposited Electrode

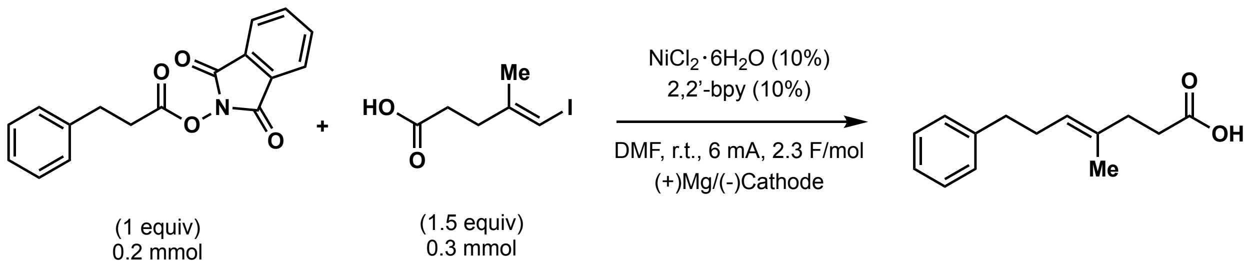


entry	modification	%yield (^{1}H-NMR)
1	none	52
2	Recycled RVC. No added AgNO$_3$	53

Notes: To recycle the electrode, the RVC electrode was removed and gently placed on a Kimwipe to allow the solvent to drain. Once all the trapped solvent had been removed from the coated RVC electrode, this electrode was used directly in a second reaction (entry 2) with a clean magnesium anode following general optimization procedure, but without the addition of AgNO$_3$. The yield was determined by ^{1}H-NMR using 1,3,5-trimethoxybenzene as an internal standard (53%). When reusing an AgNP-plated electrode, it is important that the electrode is not thoroughly rinsed with a solvent. If the electrode was washed with diethyl ether prior to reuse, the positive effect of the deposited silver on the reaction outcome was diminished. Allowing the electrode to airdry on a Kimwipe preserved the function of the deposited AgNP's.

This result was interpreted to suggest that the impact of the addition of AgNO$_3$ on reaction performance was dependent on a cathode-localized surface change.

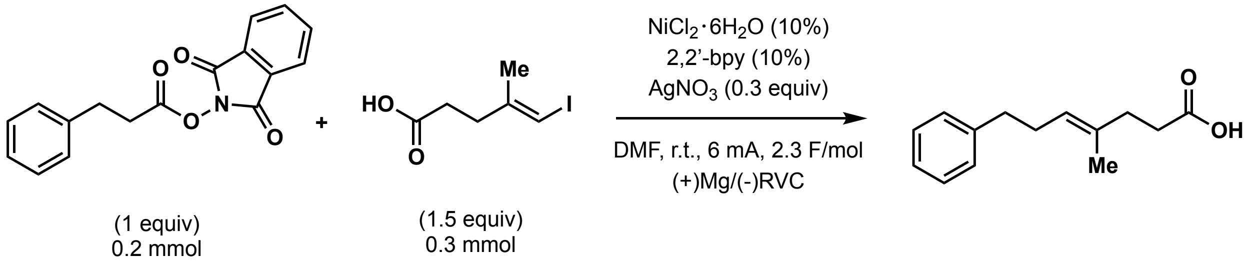
Table S45 — Cathode Material Control Experiments



entry	cathode	additive	%yield (^{1}H-NMR)
1	RVC	AgNO$_3$ (0.3 eq)	52
2	RVC	none	20
3	Silver-coated RVC	TBABF$_4$*	1
4	Silver	none	18

* high potential observed.

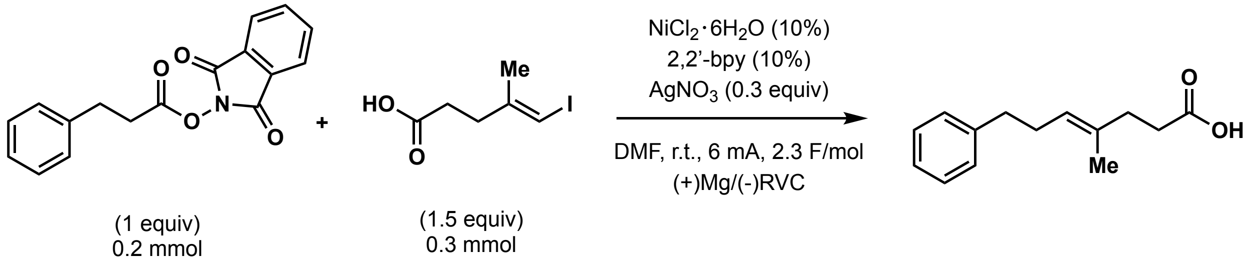
Table S46 —Active Catalyst Control Experiments



entry	modification	%yield (^{1}H-NMR)
1	-	52
2	no $NiCl_2 \cdot 6H_2O^*$	0
3	no $NiCl_2 \cdot 6H_2O$, no bpy*	0
4	no bpy	0
5	$Ni(NO_3)_2 \cdot 6H_2O$ instead of $NiCl_2 \cdot 6H_2O$	9
6	same as entry 5 + LiCl (0.3 equiv.)	40

* LiCl (0.3 equiv.) used as electrolyte to mitigate voltage spike.

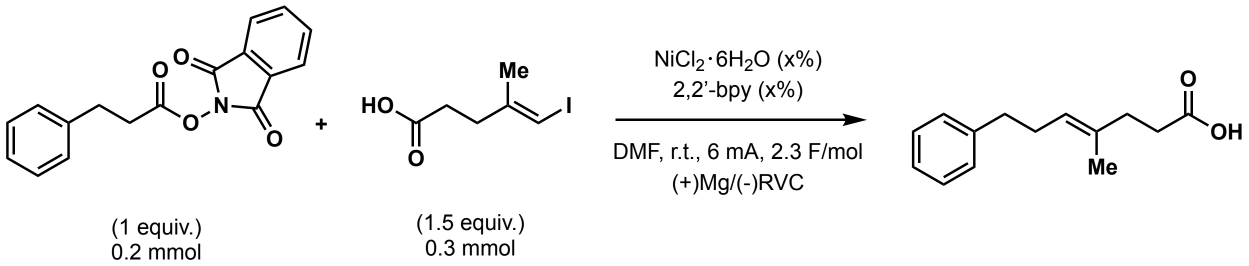
Table S47 —Electricity Control Experiments



entry	modification	%yield (^{1}H-NMR)
1	none	52
2	no electricity*	28
3	no electricity*, no $AgNO_3$	2
4	no electricity*, I_2 (cat.) instead of $AgNO_3$	0

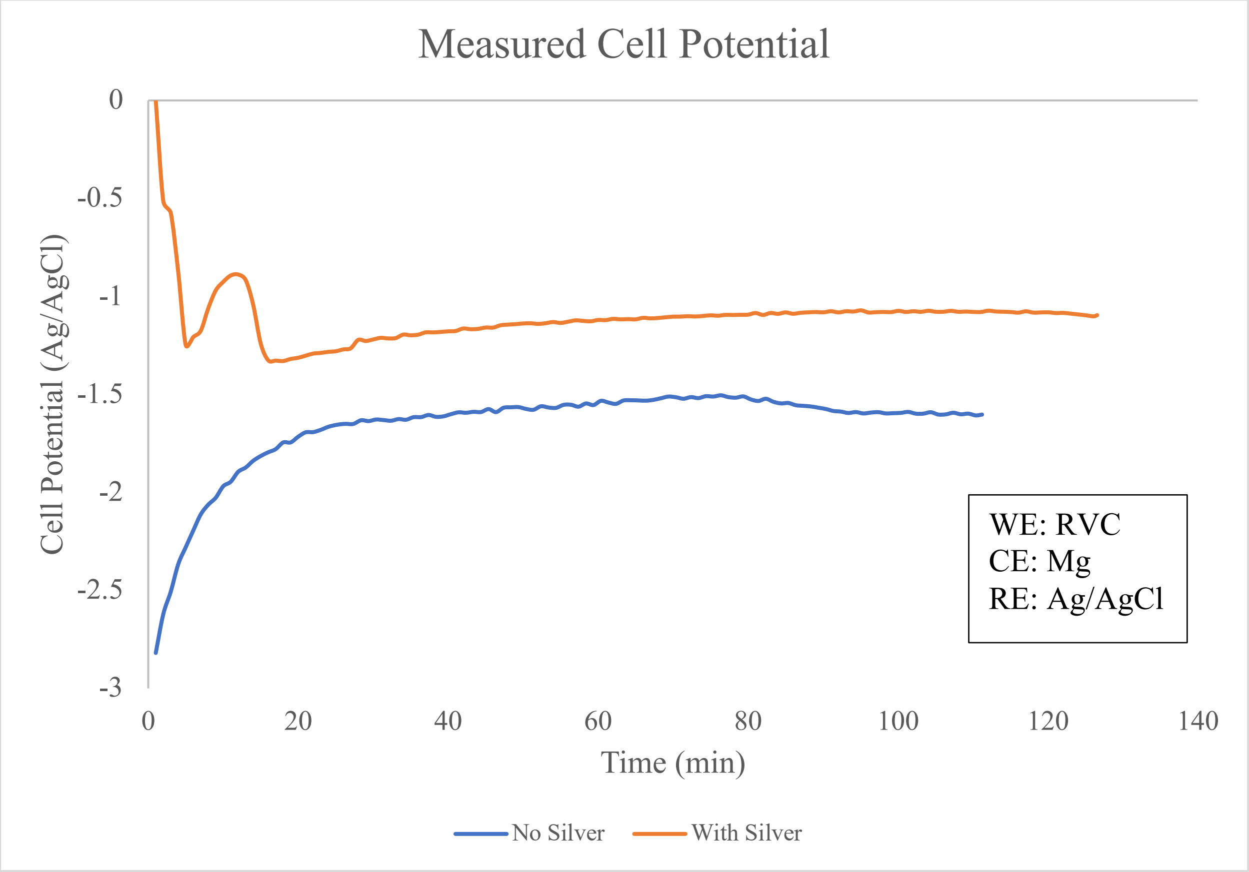
* stirred in the presence of both electrodes.

Table S48 — Catalyst Loading Control Experiments



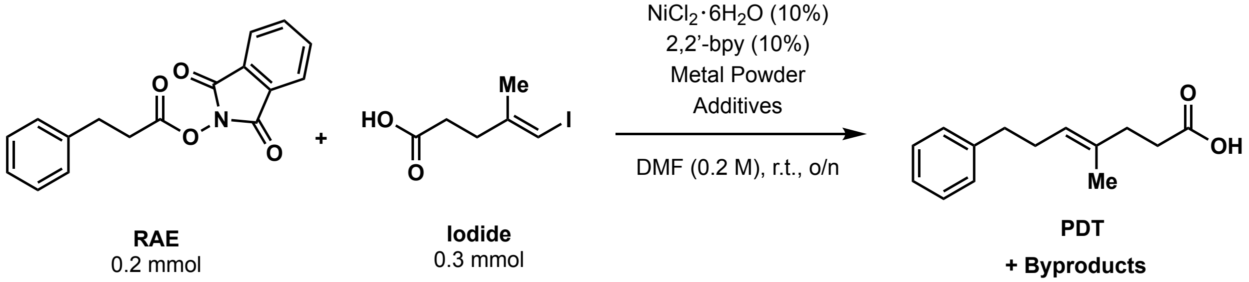
entry	Ni and Li loading	%yield (^{1}H-NMR)
1	10%	18
2	20%	33

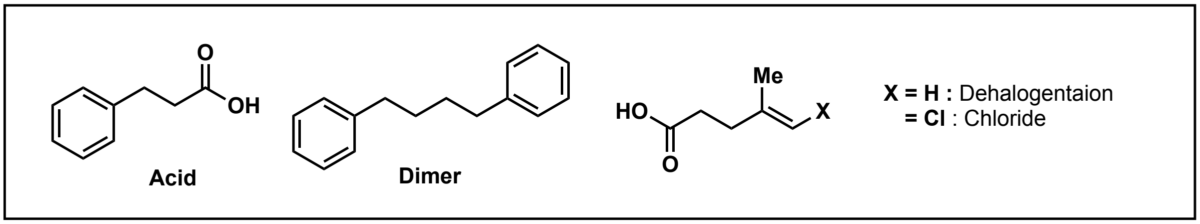
Fig. S22 — Referenced Cell Potentials during reaction



Notes: Measured cell potential during the reaction with and without $AgNO_3$ *(0.3 equiv.). All potentials measured against a Ag/AgCl reference electrode with 3M* $KCl_{(aq)}$ *in reference chamber.*

Table S49 — Comparison with metal powder reductants

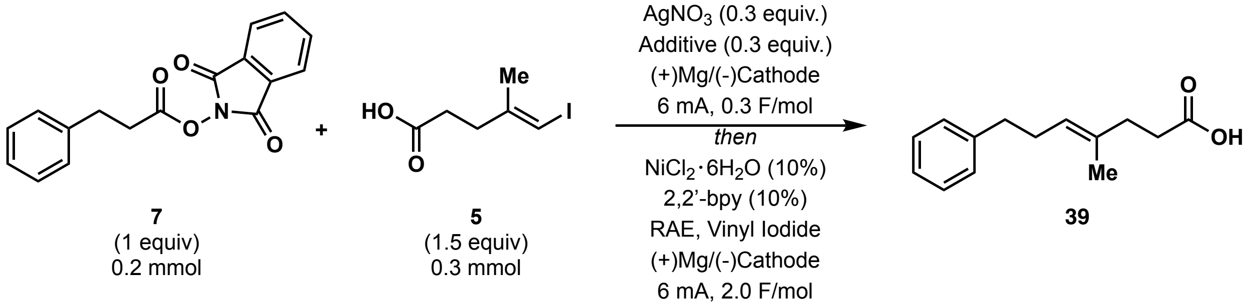




entry	reductant	additive(s)	PDT	RAE	iodide	acid	dimer	dehalogenation	chloride
1	Zn (2 eq)	-	2	0	51	7	15	46	1
2	Zn (2 eq)	LiCl (2 eq)	16	0	9	12	20	57	13
3	Zn (2 eq)	$AgNO_3$ (0.3 eq)	0	0	87	11	5	5	0
4	Zn (2 eq)	LiCl (2 eq), $AgNO_3$ (0.3 eq)	11	0	88	30	8	3	5
5	Zn-Ag (2 eq)	-	2	2	45	8	17	54	0
6	Zn-Ag (2 eq)	LiCl (2 eq)	13	0	7	0	18	65	9
7	Zn-Ag (2 eq)	$AgNO_3$ (0.3 eq)	2	4	81	8	7	16	0
8	Zn-Ag (2 eq)	LiCl (2 eq), $AgNO_3$ (0.3 eq)	5	trace	76	14	6	6	4
9	Mn (3 eq)	-	5	0	47	0	16	48	0
10	Mn (3 eq)	LiBr (1 eq)	7	0	0	26	0	92	0
11	Mn (3 eq)	$AgNO_3$ (0.3 eq)	5	0	92	0	8	1	0
12	Mn (3 eq)	LiBr (1 eq), $AgNO_3$ (0.3 eq)	29	0	66	27	7	7	0
13	Mg (2 eq)	-	4	56	94	11	3	0	3
14	Mg (2 eq)	$AgNO_3$ (0.3 eq)	14	0	74	17	14	7	8

Note: Zinc-Silver couple was prepared according to a literature procedure. (107)

Table S50 — Electrode Pre-Plating Control Experiments



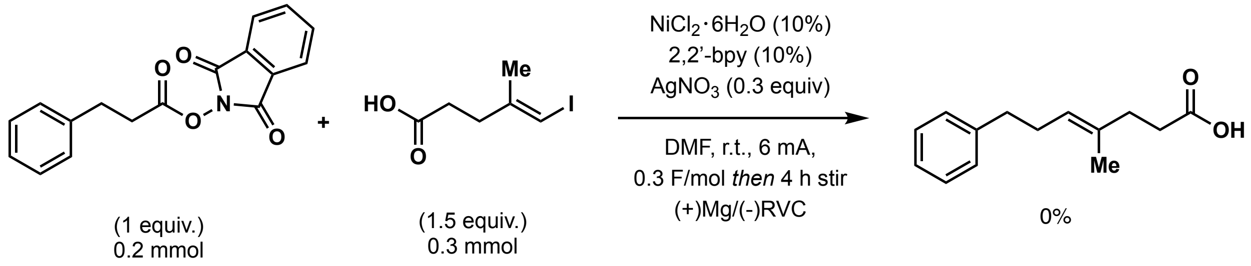
entry	cathode material	additive	%yield (^{1}H-NMR)
1	RVC	-	24
2	Graphite	-	24
3	RVC	LiCl	41
4	Graphite	LiCl	46
5	Graphite	$LiNO_3$	26
6	Graphite	LiCl*	17

* prolonged stirring until visible decompostion of $AgNO_3$/LiCl solution prior towards the first 0.3 F/mol electrolysis period.

The experiments in the above table were carried out following the general 0.2 mmol scale procedure with some modifications:

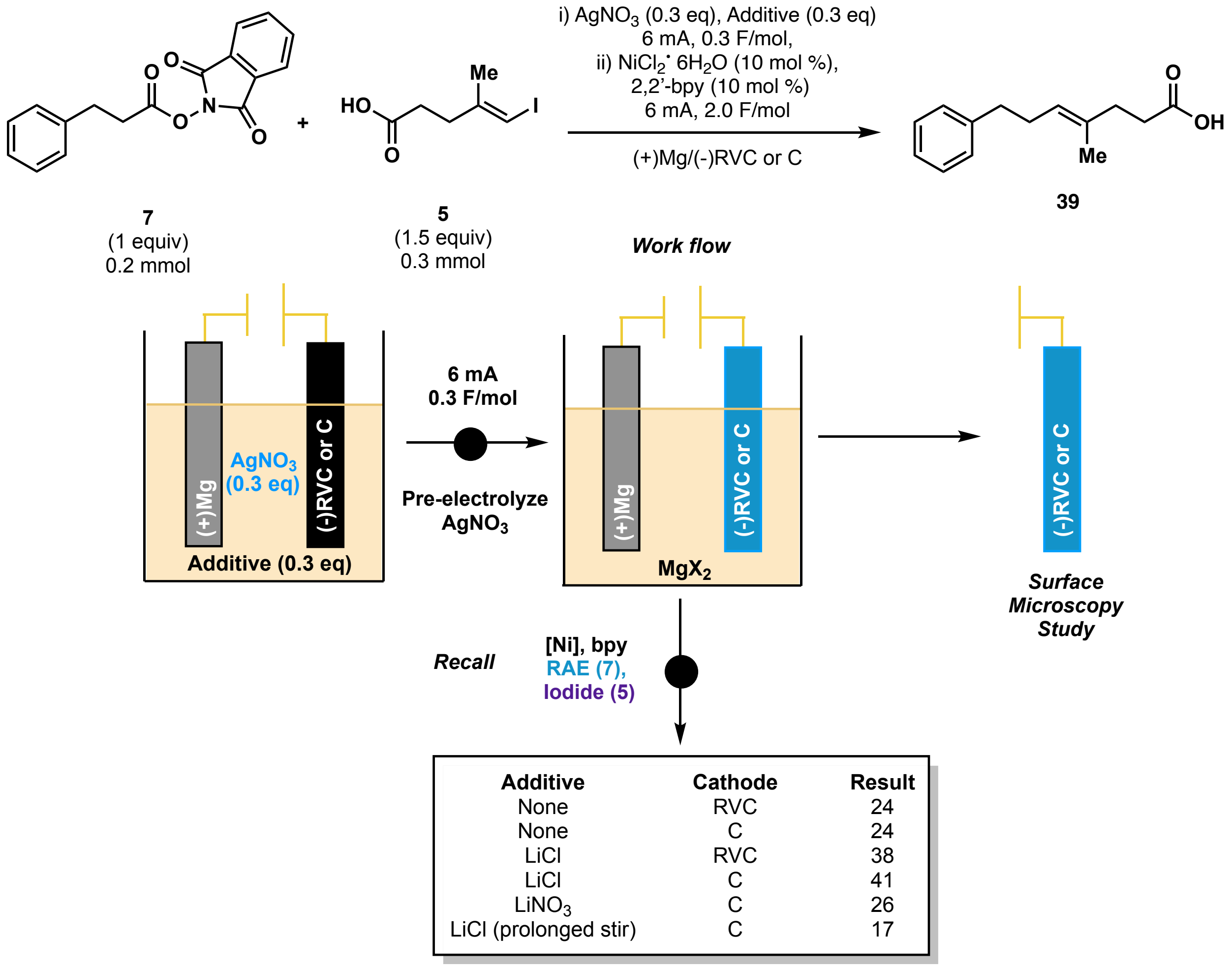
An oven dried 5 mL ElectraSyn 2.0 vial was added $AgNO_3$ (10.2 mg, 0.06 mmol, 0.3 equiv.) and additive (0.06 mmol, 0.3 equiv.). The vial was sealed with a 5 mL IKA ElectraSyn 2.0 cap equipped with a sacrificial magnesium anode and a 100 ppi RVC (3 mm X 7 mm X 51 mm) or graphite cathode (3 mm X 7 mm X 51 mm). The vial was evacuated and backfilled with argon three times. Anhydrous DMF (2.5 mL) was added to the vial *via* syringe. The vial was then placed on an IKA ElectraSyn 2.0 stir plate and electrolysis was set to 6 mA, 0.2 mmol substrate, and 0.3 F/mol to deliver a current density of 2.7 A/m^2. The reaction underwent the programmed electrolysis under a positive pressure of argon. Upon completion, a solution containing $NiCl_2$•$6H_2O$ (4.75 mg, 0.02 mmol, 0.1 equiv.), 2.2'-bipyridine (3.12 mg, 0.02 mmol, 0.1 equiv.), RAE **7** (59.1 mg, 0.2 mmol, 1 equiv.) and vinyl iodide **5** (72.0 mg, 0.3 mmol, 1.5 equiv.) in anhydrous DMF (0.5 mL) was added directly to the ElectraSyn 2.0 vial. Electrolysis was set to 6 mA, 0.2 mmol substrate, and 2.0 F/mol to deliver a current density of 2.7 A/m^2. The reaction underwent the programmed electrolysis under a positive pressure of argon. After completion of the reaction, the reaction was transferred to a separatory funnel, the electrodes were rinsed with diethyl ether (5 mL) and 1N HCl (10 mL) was *slowly* added. The aqueous layer was extracted with diethyl ether (3 X 10 mL). The combined organics were washed successively with distilled water (2 X 10 mL) then brine (1 X 10 mL), then dried over magnesium sulfate before being filtered and concentrated via rotary evaporation. The yield of **39** was determined by ^{1}H-NMR using 1,3,5-trimethoxybenzene as an internal standard.

Fig. S23 — Evaluation of the promotion of the reaction through the Ag-deposited cathode by the sacrificial anode.



The reduction potential of Mg(0) should be quite negative (<-2.5 V) and should make the E(cell) of the reaction favorable without e-chem. While it was demonstrated that the reaction does not generate significant amounts of product without electrolysis even when the Mg anode is included, this may be the result of the potentiostat serving as an infinite resistor between the two electrodes or that the Mg has an inactive oxide layer that is otherwise stripped during electrolysis. This experiment tried to electrogenerate the AgRVC and then remove the power supply to see if the Mg anode can directly promote reduction at the Ag-deposited-cathode. Unfortunately, there was no product formation even after prolonged stirring once the Ag-deposited cathode had been generated. This result suggests that Mg alone cannot promote reduction at the Ag-deposited cathode and that an applied potential is indeed needed for the reaction.

Fig. S24— General workflow of the pre-plating and surface studies with relevant results.



Additive	Cathode	Result
None	RVC	24
None	C	24
LiCl	RVC	38
LiCl	C	41
$LiNO_3$	C	26
LiCl (prolonged stir)	C	17

The following microscopy study follows the above graphic wherein the electrodes are functionalized in the presence of $AgNO_3$ and a supporting additive under a constant 6 mA current for 0.3 F/mol relative to a standard 0.2 mmol scale coupling reaction. After functionalization, the electrode was removed for analysis.

Electrode SEM, TEM and EDS Analysis

Electrode Preparation

To an oven dried 5 mL ElectraSyn 2.0 vial was added silver nitrate (10.2 mg, 0.06 mmol, 1 equiv.) and supporting additive (0.06 mmol, 1 equiv. equiv.). The vial was sealed with a 5 mL IKA ElectraSyn 2.0 cap equipped with a sacrificial magnesium anode and a 100 ppi RVC (3mm X 7mm X 51mm) or graphite cathode (3 mm X 7 mm X 51mm). The vial was evacuated and backfilled with argon three times. Anhydrous DMF (2.5 mL) was added to the vial *via* syringe. The vial was then placed on an IKA ElectraSyn 2.0 stir plate and electrolysis was set to 6 mA, 0.2 mmol substrate, and 0.3 F/mol to deliver a current density of 2.7 A/m^2. The reaction underwent the programmed electrolysis under a positive pressure of argon. Upon completion, the electrodes were carefully removed from the vial and allowed to air dry before being stored under argon prior to surface microscopy studies.

Note: The RVC is very porous and traps a significant volume of solvent. Efficient draining of this residual solvent can be accomplished by lightly placing a corner of the electrode against a Kimwipe.

SEM Imaging

SEM imaging was done using an FEI Quanta 600F scanning electron microscope with a field emission electron source. Carbon electrode samples were mounted on aluminum stubs using double sided carbon tape. The microscope was run under high vacuum mode (~10-6 Torr). Samples were imaged as received without the need for coating. EDS elemental analysis for particles/features larger than 1 micron was done on the same SEM with the use of an EDAX Octane Elect x-ray detector. Beam energy and current settings were optimized to achieve the best possible resolution when imaging and high intensity X-ray counts during EDS analysis.

FIB sample Preparation, S/TEM Imaging and EDS analysis

Higher resolution imaging was done using scanning transmission electron microscopy (S/TEM) on thin sections cut out of the electrodes. Prior to S/TEM imaging of the AgNP-coated electrode, the sample was prepared using an FEI Helios Nanolab 650 focused ion beam and scanning electron microscope. A piece of the surface was cut and thinned to increase electron transparency for TEM imaging. A JEOL 2800 scanning transmission electron microscope with twin Gatan Si drift detectors was used. A beam energy of 200kV was used for both transmission and scanning imaging modes.

Fig. S25—SEM images of a bare 100 ppi RVC electrode.

Notes: Electrode material: RVC.
Additional information: Uncoated, commercial electrode

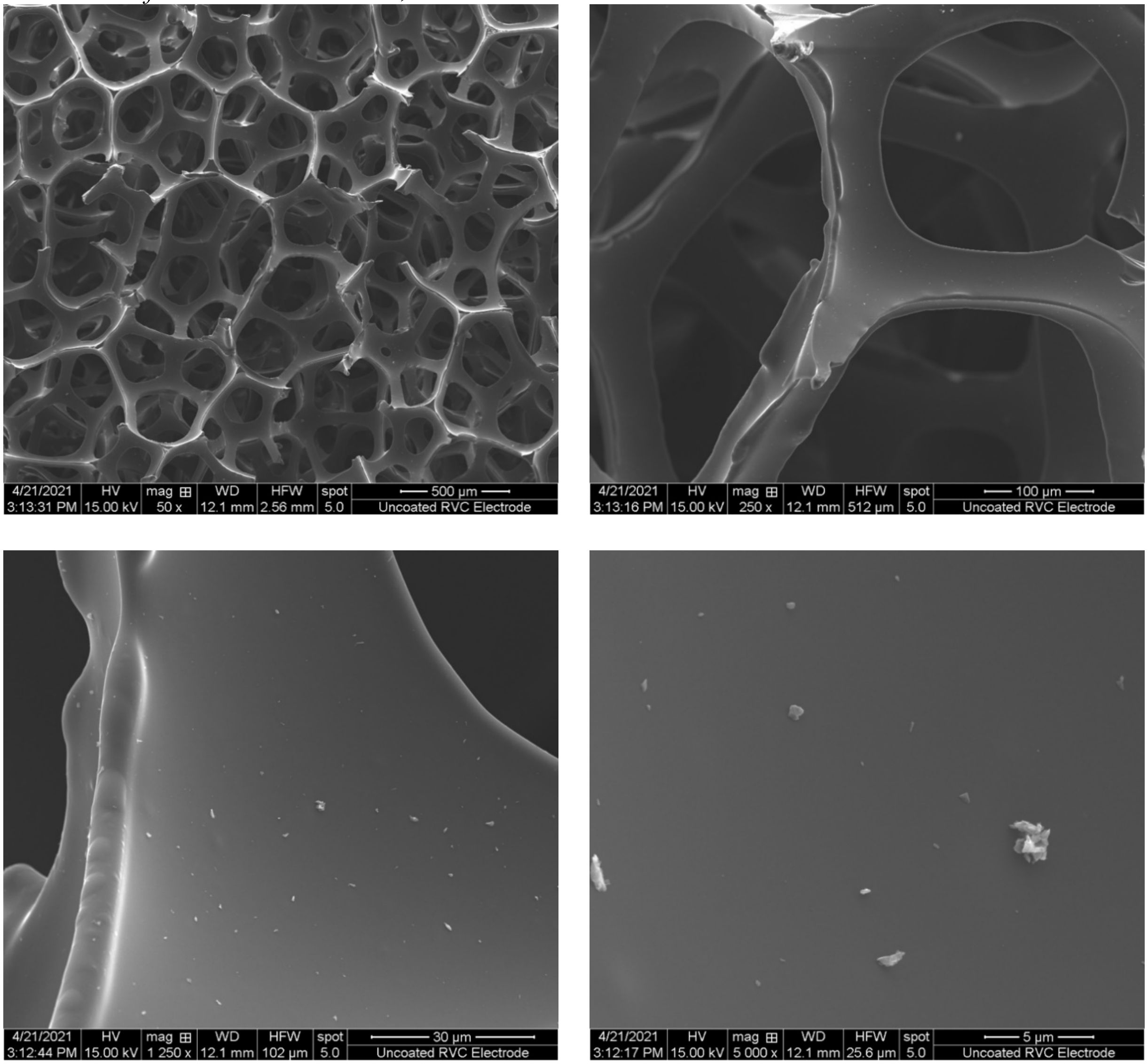


Fig. S26 — EDS analysis of a bare 100 ppi RVC electrode

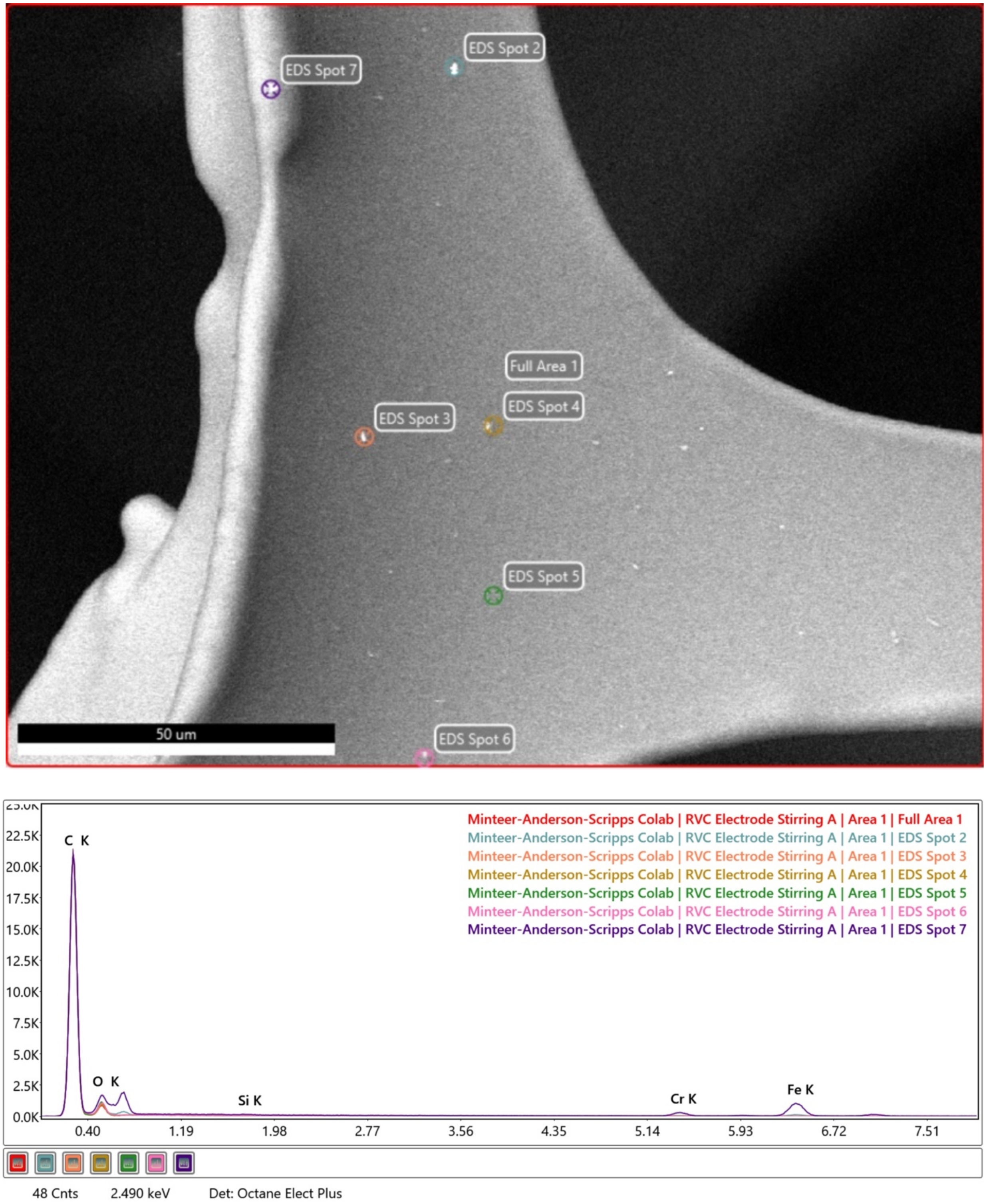


Fig. S27 — SEM images of a bare commercial graphite electrode.

Notes: Electrode material: Graphite.
Additional information: Uncoated, commercial electrode supplied by IKA

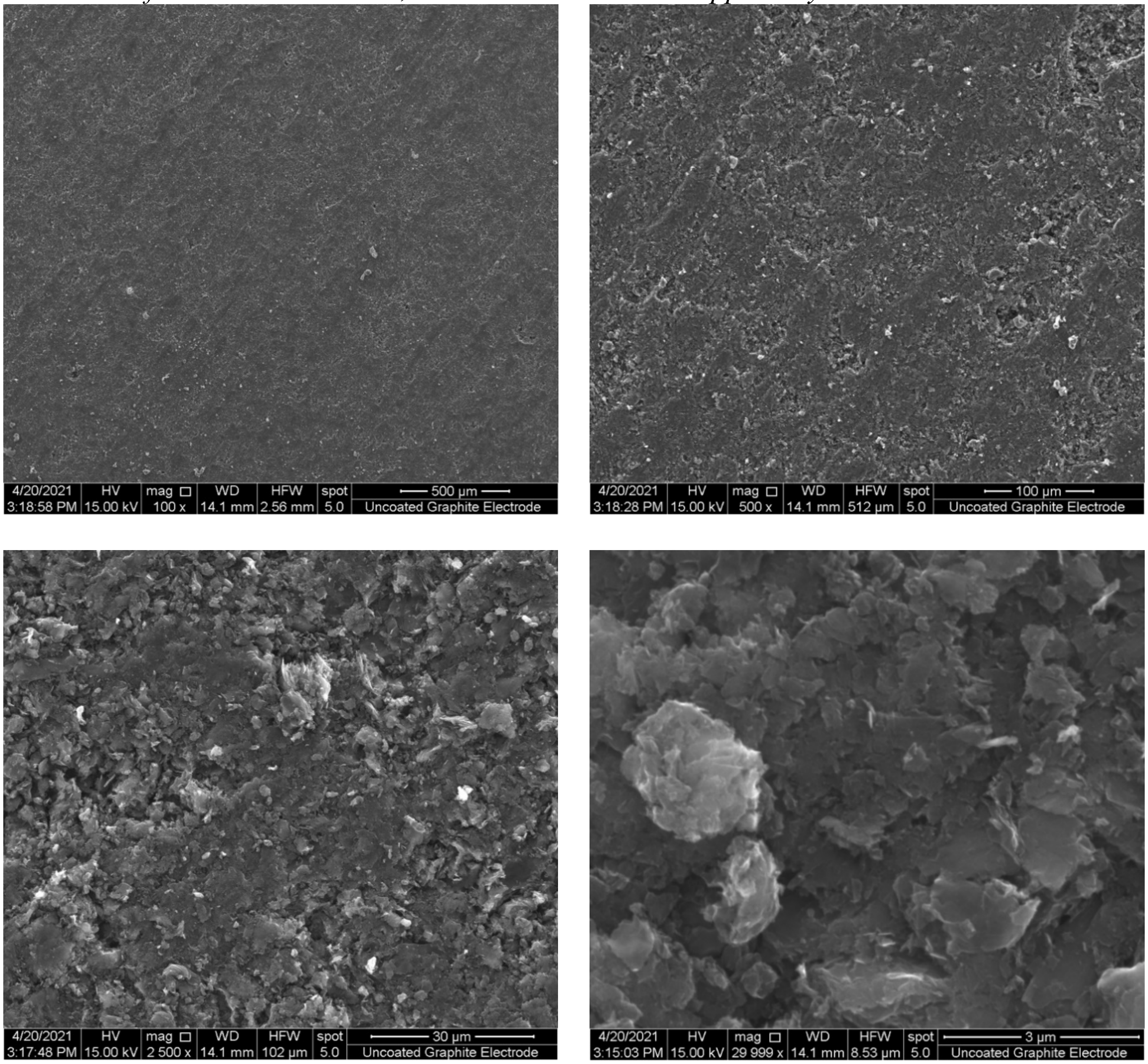


Fig. S28 — EDS analysis of a bare commercial graphite electrode.

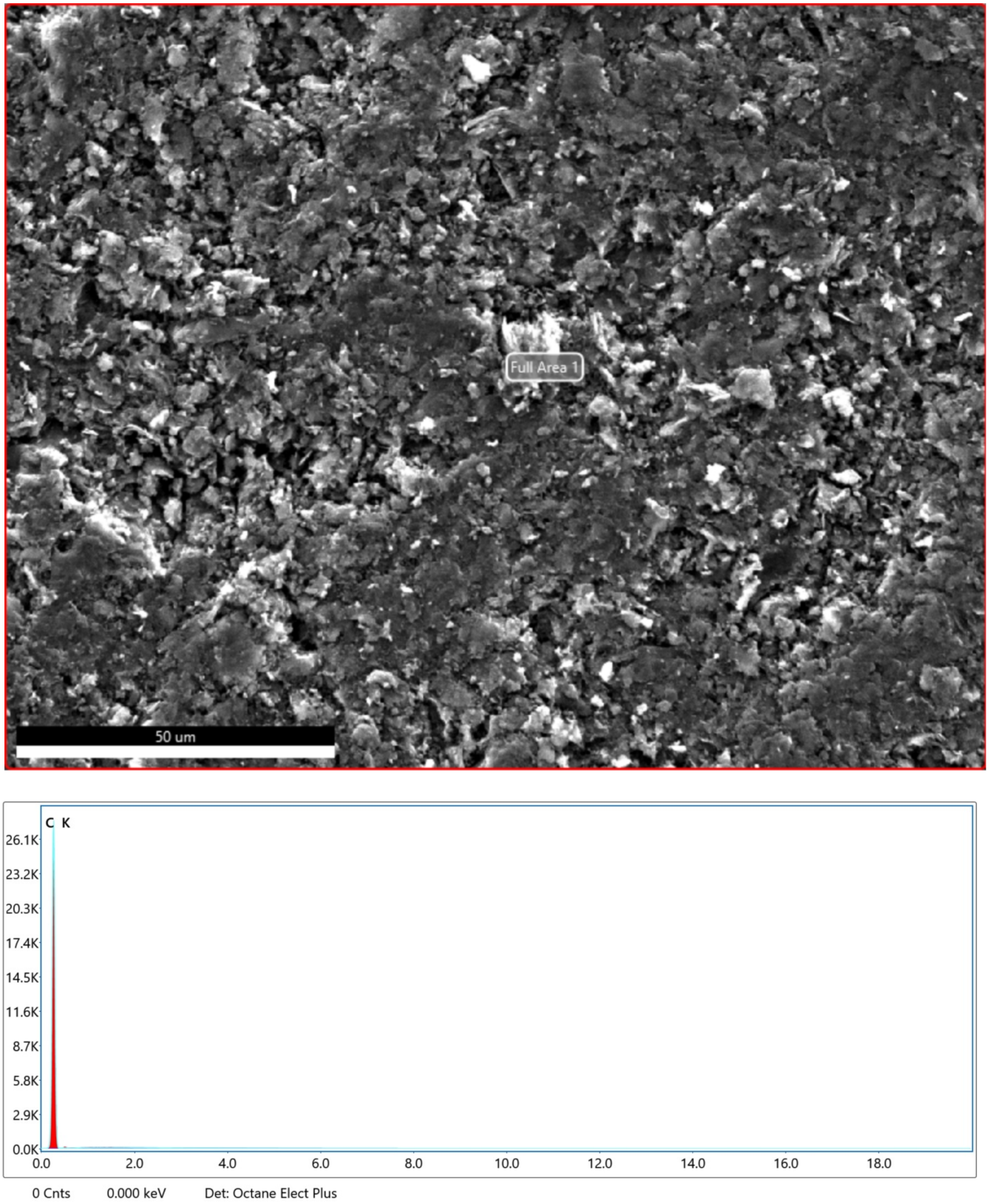


Fig. S29 —SEM images of RVC electrode post-reaction w/ $AgNO_3$

Notes: Electrode material: RVC. SEM images of the RVC electrode after its use coupling ***7*** *and* ***5*** *with $NiCl_2•6H_2O$ (0.1 equiv.), 2,2'-bpy (0.1 equiv.) and $AgNO_3$ (0.3 equiv.) affording* ***39*** *in 52% yield. Post-reaction RVC electrode. The electrode was allowed to gently dry on a kimwipe after removal from the reaction.*

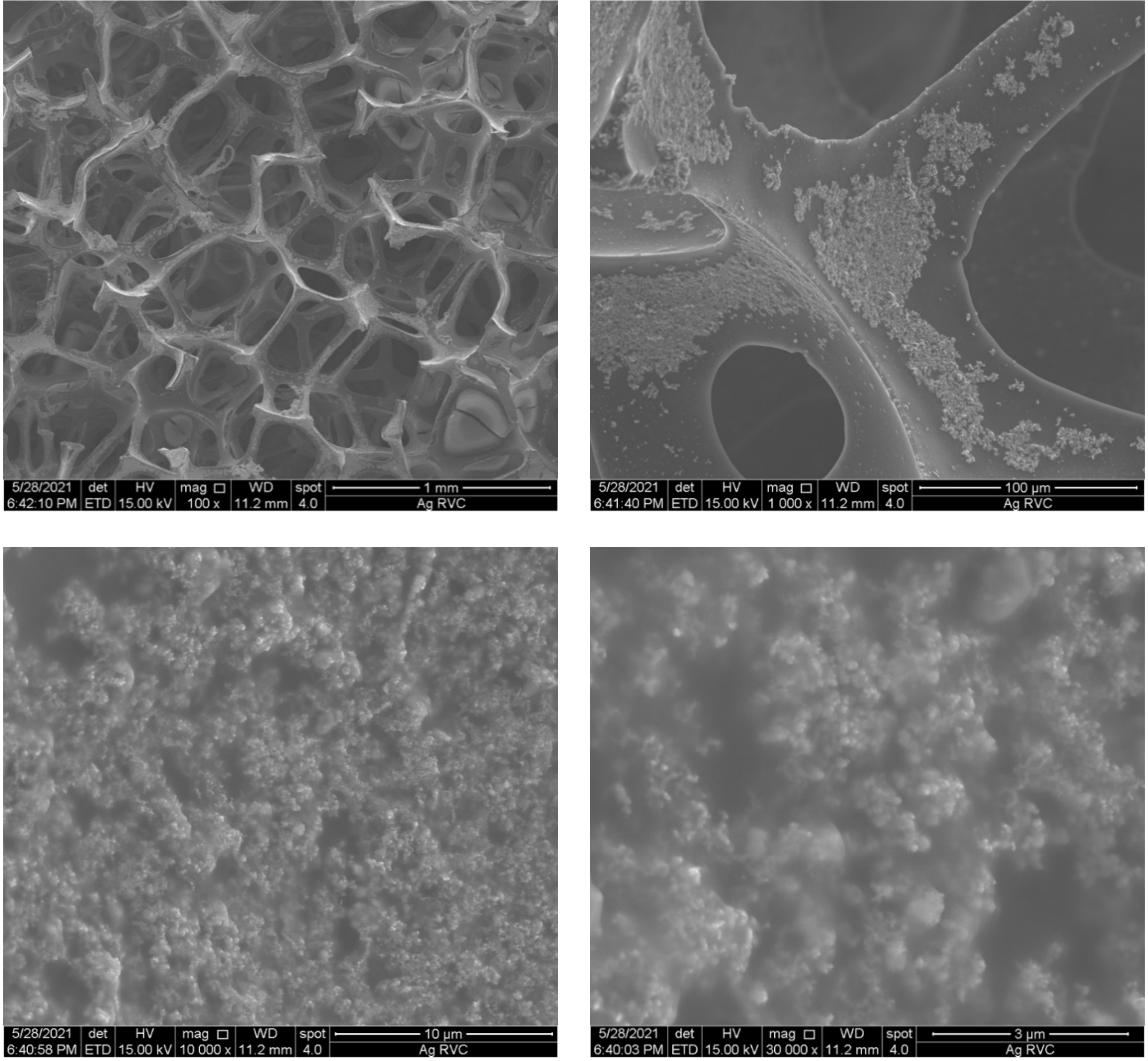


Fig. S30 — EDS analysis of RVC electrode post-reaction w/ AgNO$_3$

EDS analysis of the post reaction RVC electrode in figure ***S29***

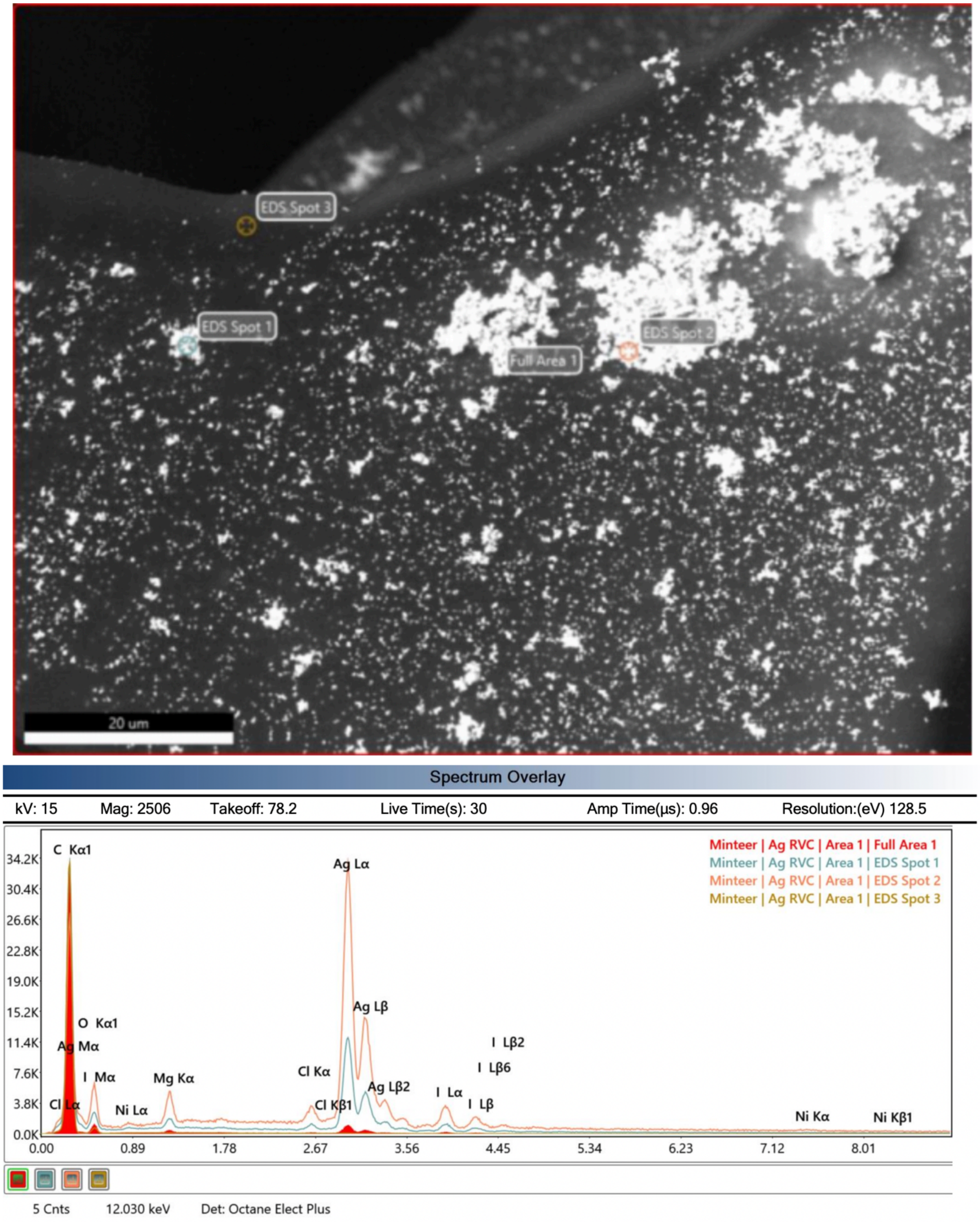


Fig. S31—SEM images of Graphite electrode post-reaction w/ $AgNO_3$

Notes: Electrode material: Graphite. SEM images of the Graphite (C) electrode after its use coupling ***7*** *and* ***5*** *with $NiCl_2•6H_2O$ (0.1 equiv.), 2,2'-bpy (0.1 equiv.) and $AgNO_3$ (0.3 equiv.) affording* ***39*** *in 46% yield. Post-reaction graphite electrode. The electrode was allowed to gently air dry after removal from the completed reaction.*

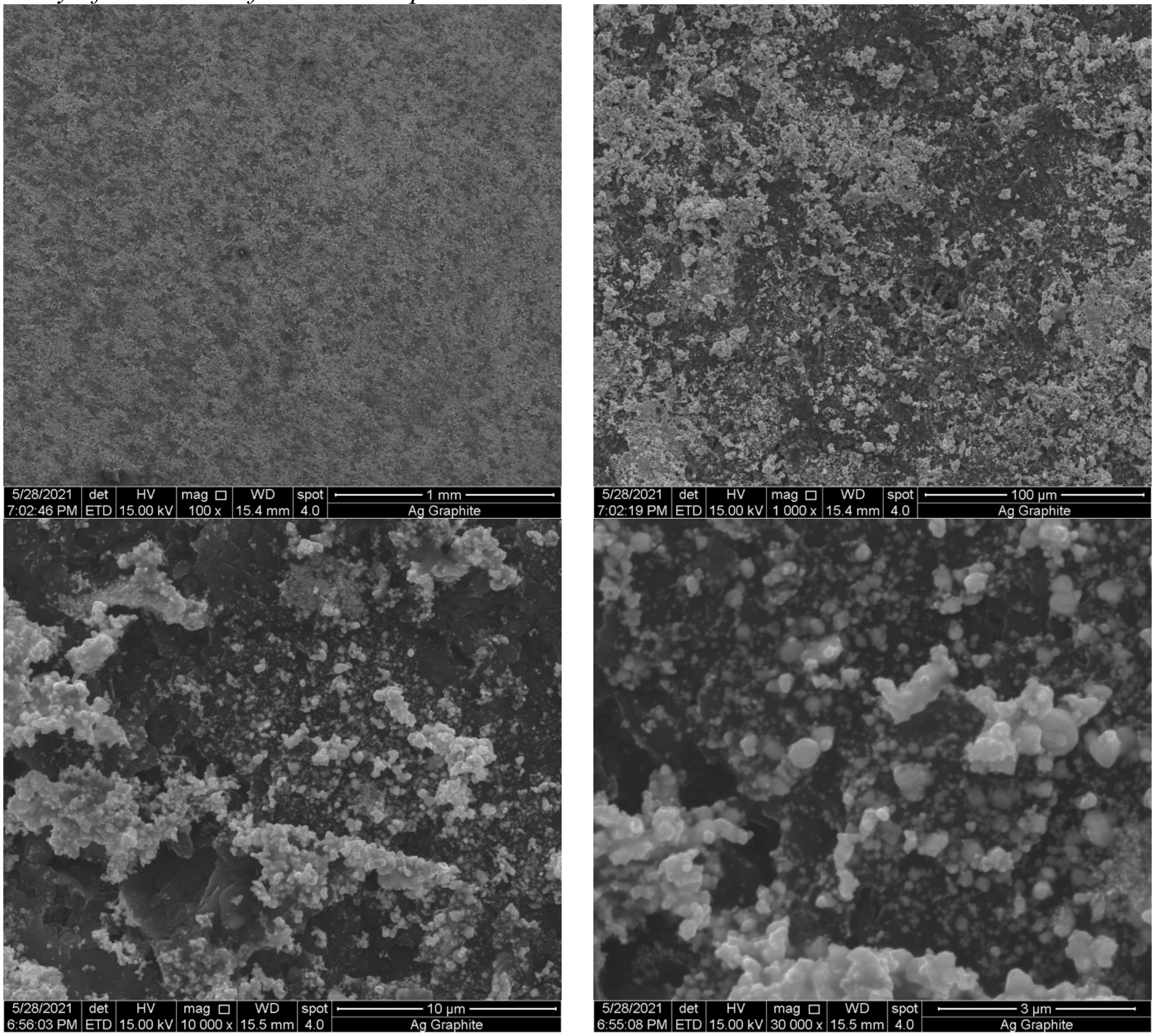
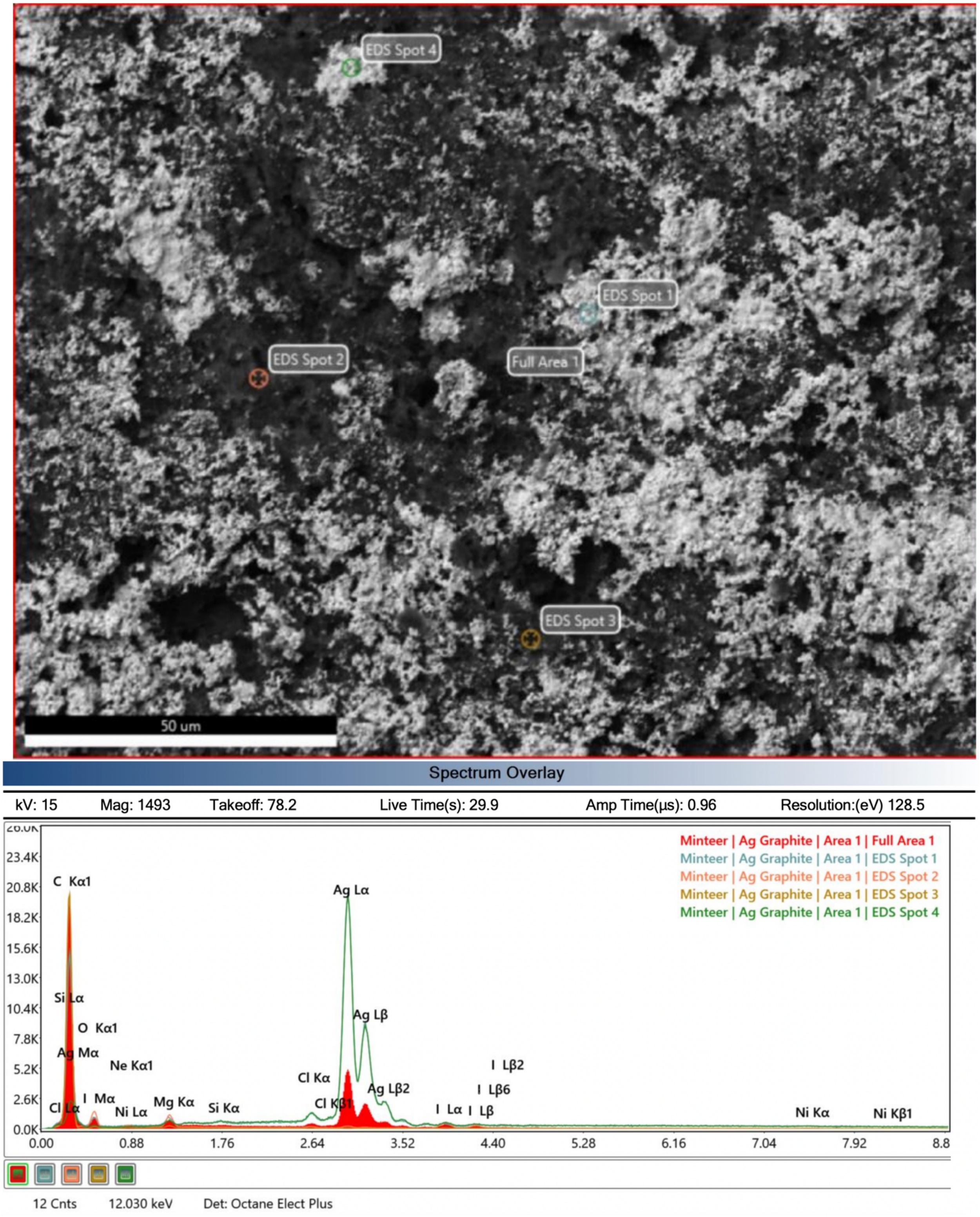


Fig. S32— EDS analysis of graphite electrode post-reaction w/ AgNO3

*EDS analysis of the post reaction graphite electrode in figure **S31**.*



Spectrum Overlay

kV: 15 Mag: 1493 Takeoff: 78.2 Live Time(s): 29.9 Amp Time(µs): 0.96 Resolution:(eV) 128.5

12 Cnts 12.030 keV Det: Octane Elect Plus

Fig. S33 — SEM images of RVC electrode post-reaction

Notes: Electrode material: RVC. SEM images of the RVC electrode after its use coupling ***7*** *and* ***5*** *with* $NiCl_2 \cdot 6H_2O$ *(0.1 equiv.), 2,2'-bpy (0.1 equiv.) affording* ***39*** *in 20% yield. Post-reaction RVC electrode without* $AgNO_3$

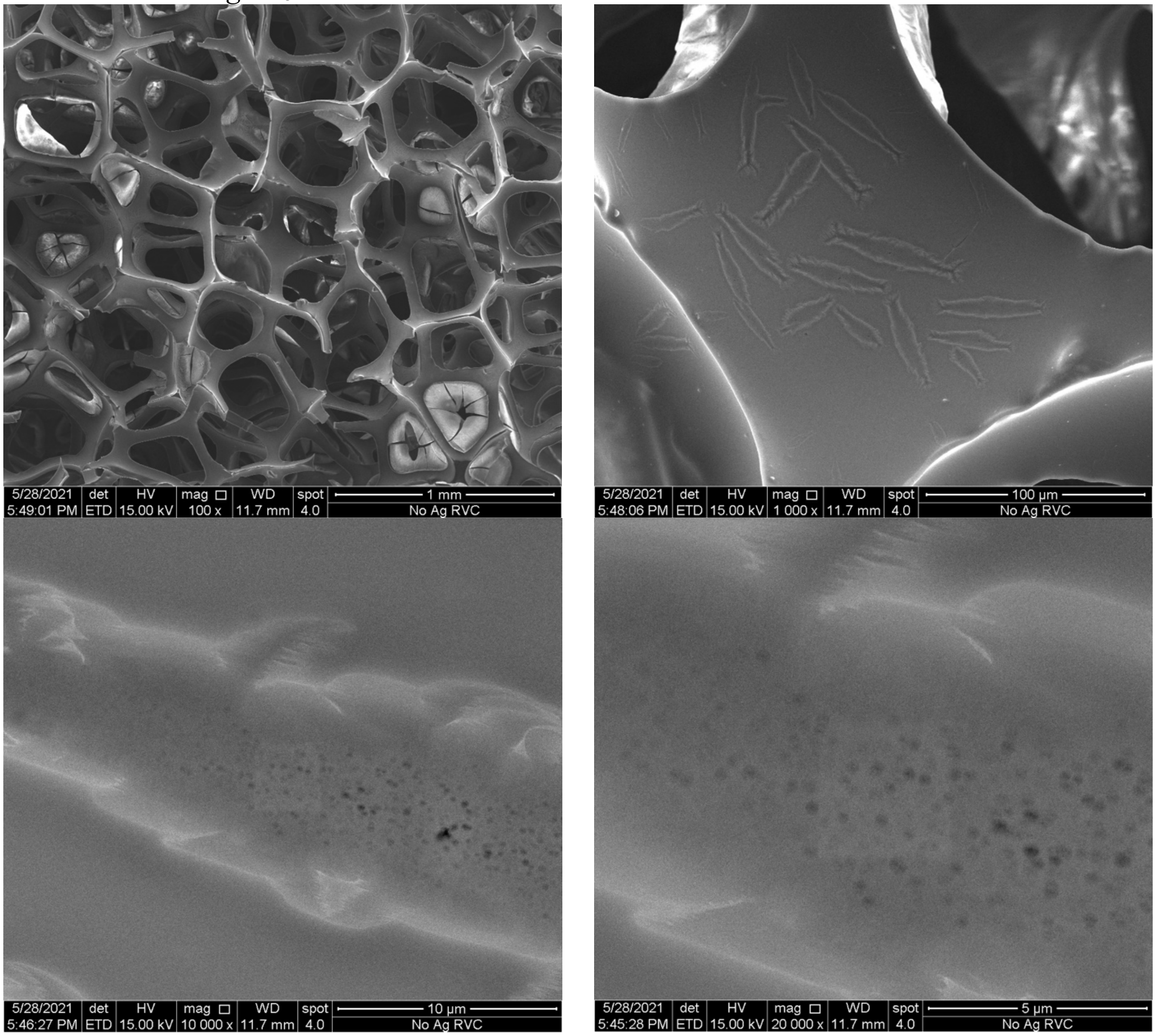


Fig. S34 —EDS analysis of RVC electrode post-reaction

EDS analysis of the post reaction RVC electrode without $AgNO_3$ shown in figure ***S33***.

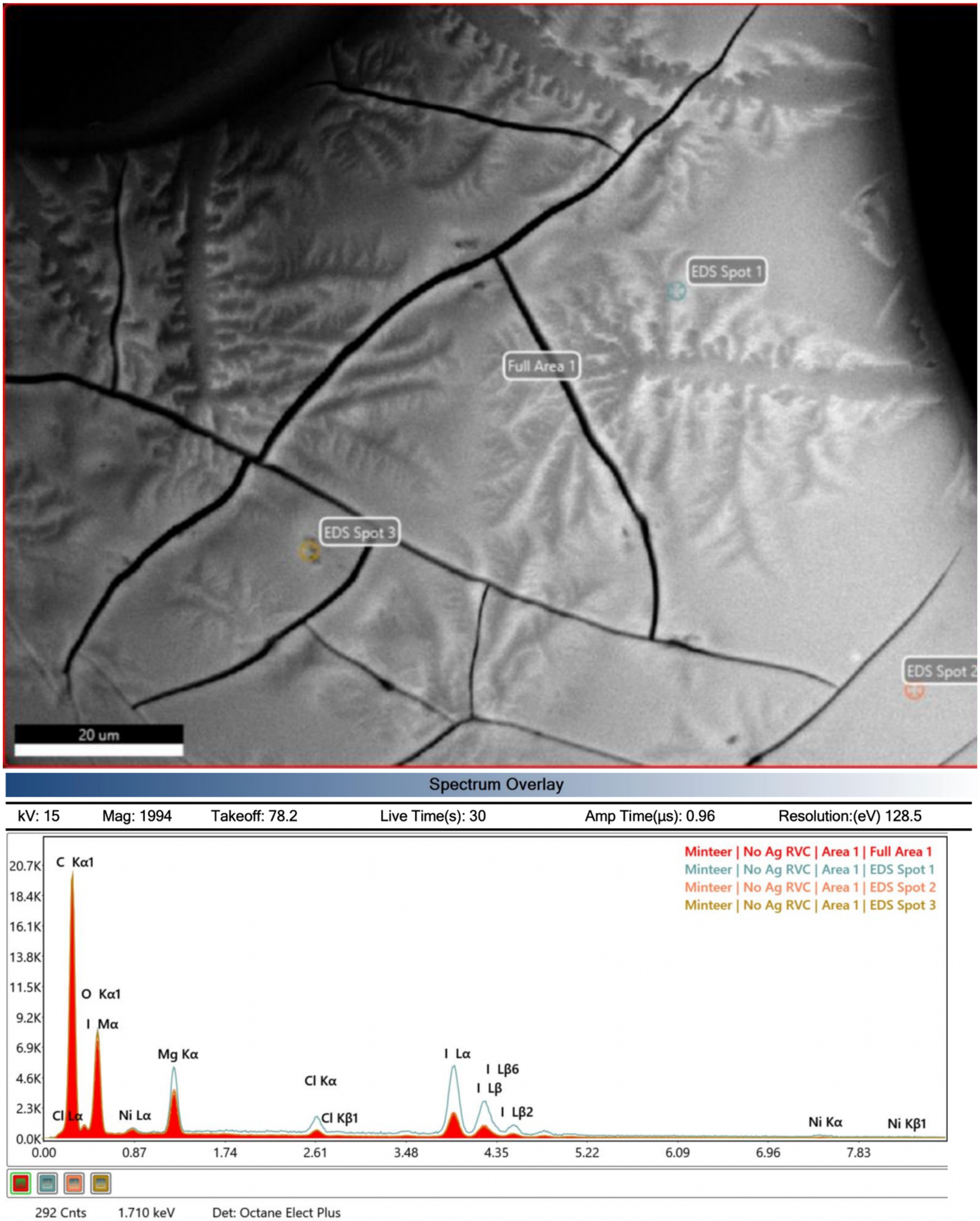


Fig. S35—SEM images of graphite electrode post-reaction

Notes: Electrode material: graphite. SEM images of the graphite electrode after its use coupling 7 and ***5*** *with* $NiCl_2 \cdot 6H_2O$ *(0.1 equiv.), and 2,2'-bpy (0.1 equiv.) affording* ***39*** *in 5% yield. Post-reaction graphite electrode without* $AgNO_3$*.*

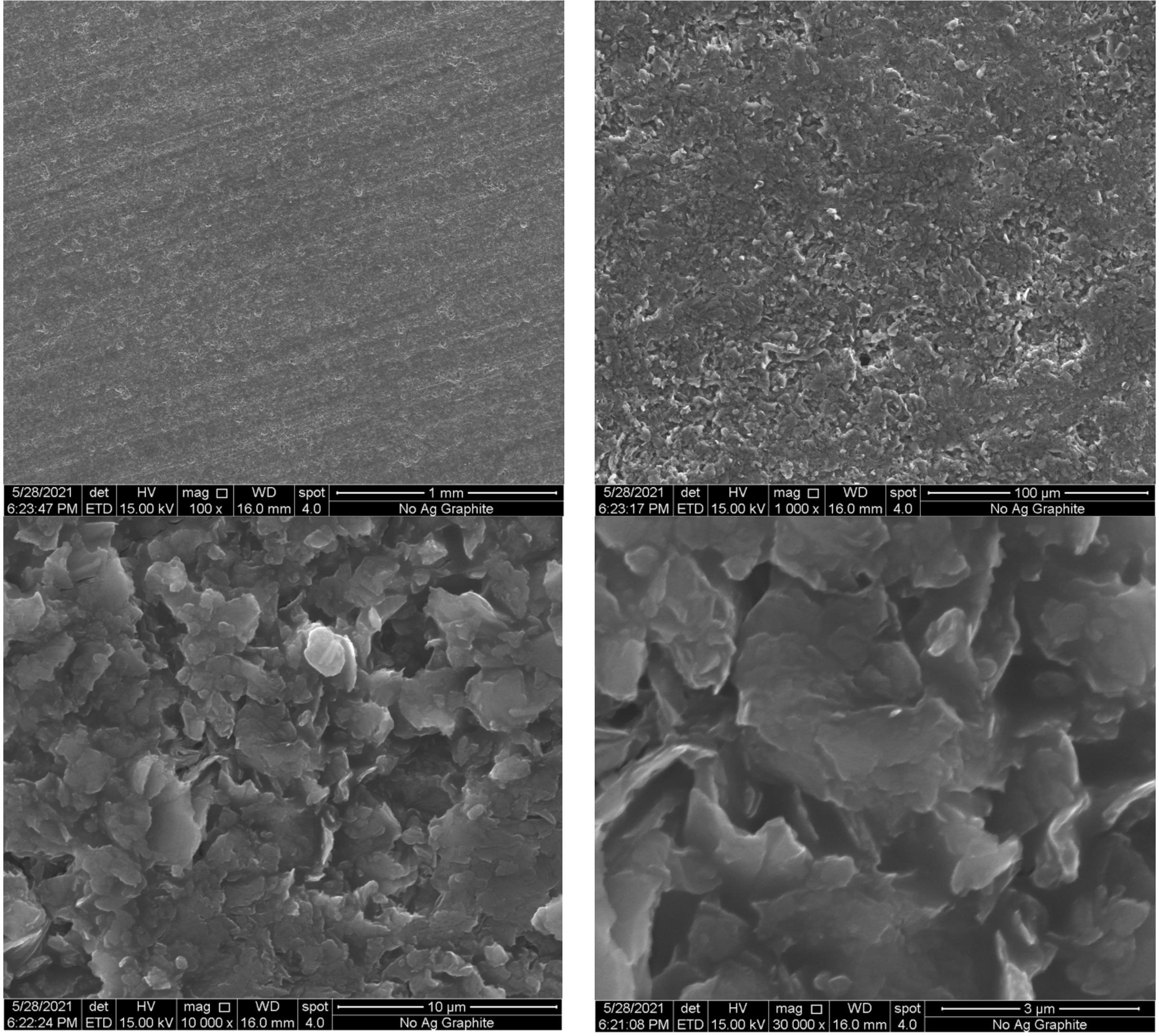


Fig. S36 —EDS analysis of the post reaction graphite electrode

EDS analysis of the post reaction graphite electrode without $AgNO_3$ shown in figure ***S35***.

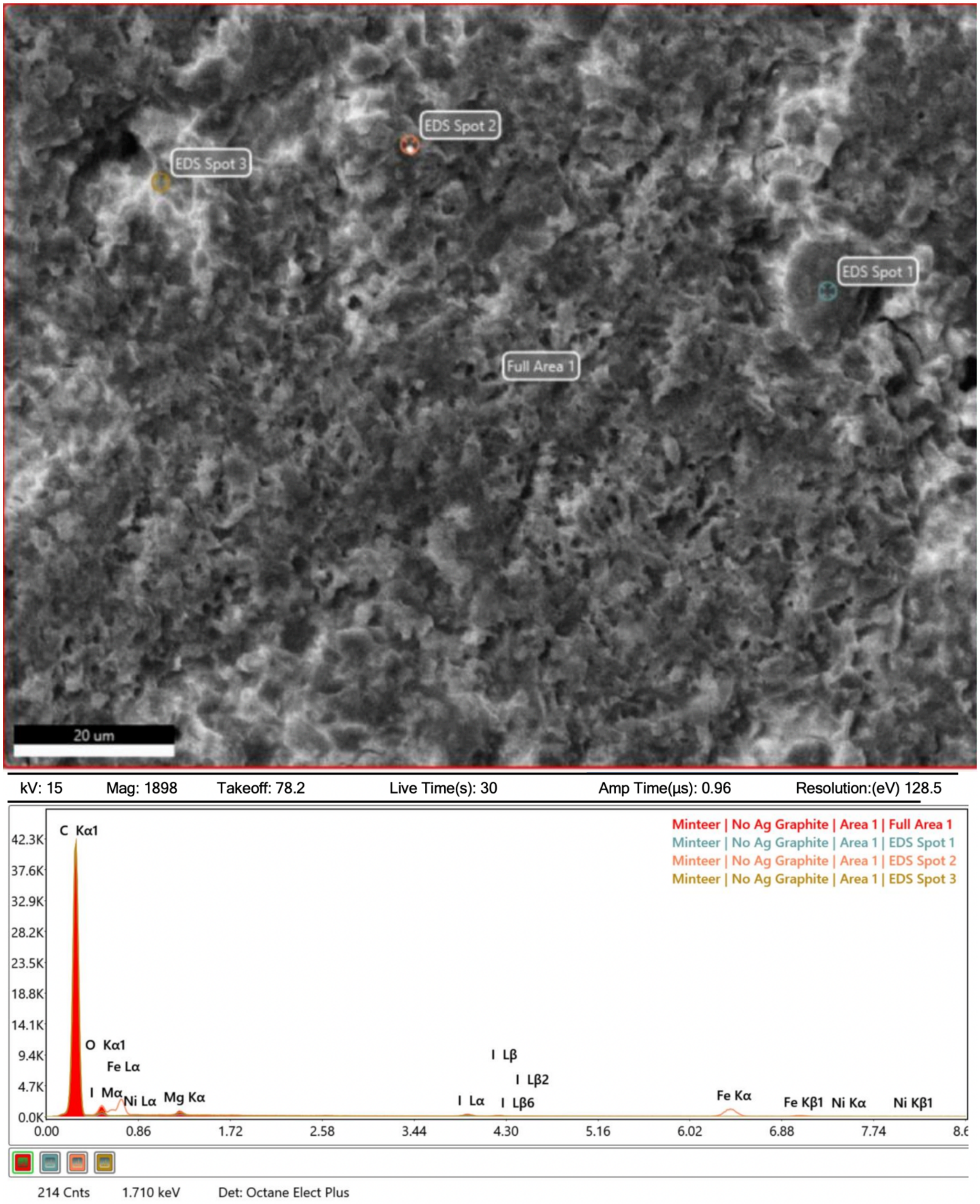


Fig S37— *SEM images of the RVC electrode plated in presence of AgNO₃ and LiCl*

*SEM images of the RVC electrode plated in presence of AgNO₃ (0.3 equiv.) and LiCl (0.3 equiv.) at 6 mA for 0.3 F/mol (relative to 0.2 mmol scale). When these deposition conditions were followed by a cross coupling of 7 and **5**, the yield of **39** was 38%.*

Additional information: RVC electrode plated in presence of AgNO₃ and LiCl

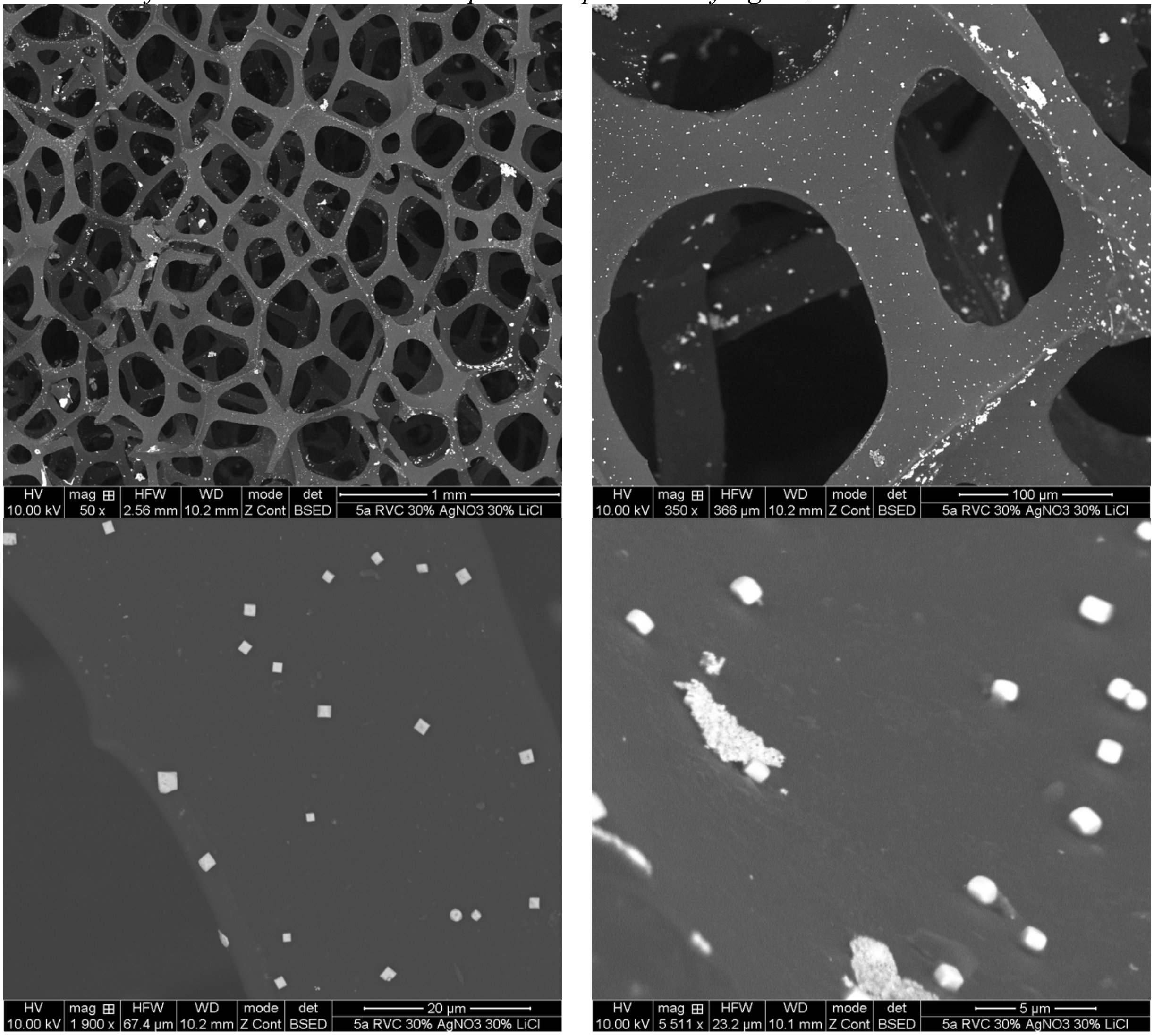
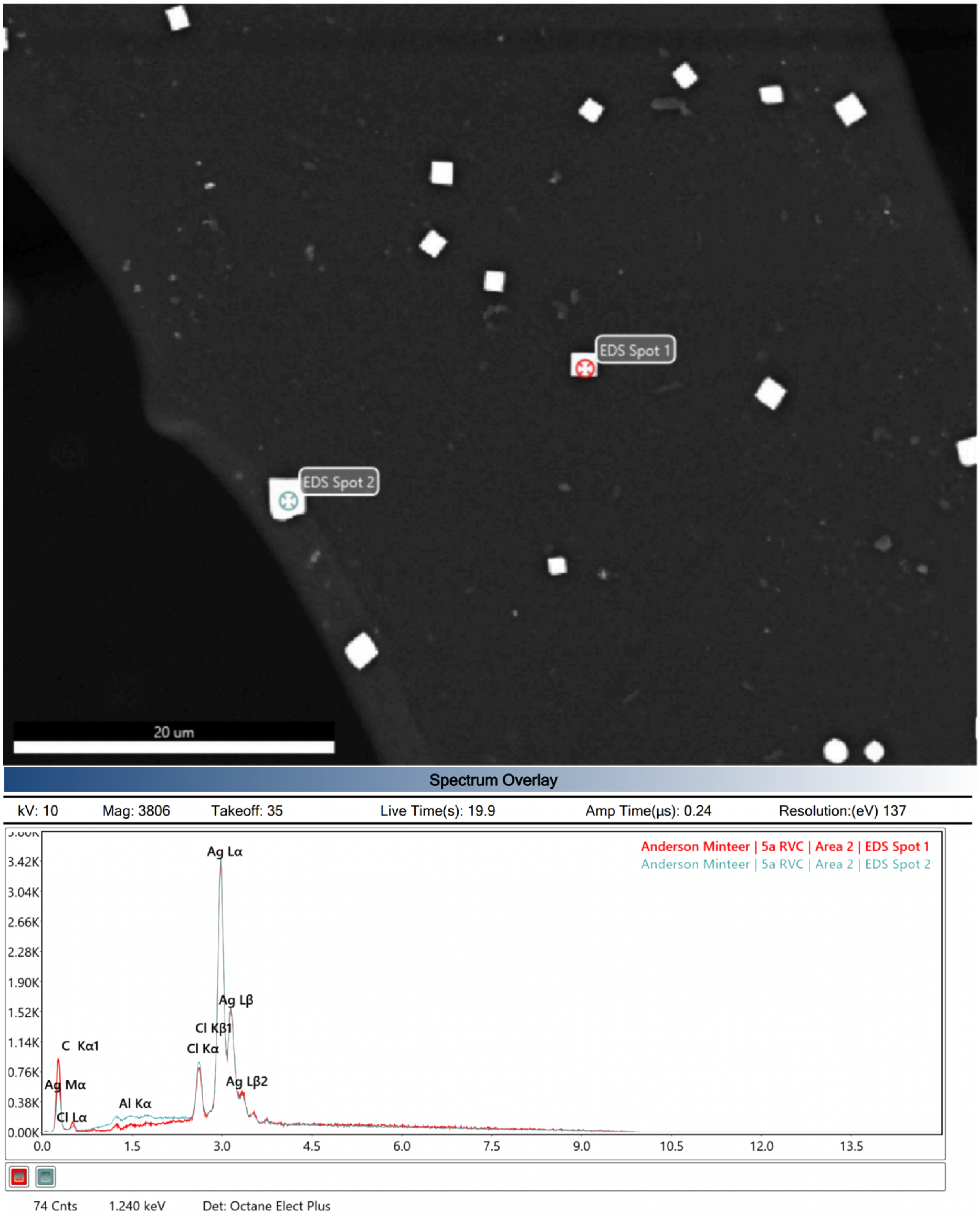


Fig S38 —EDS analysis of the RVC electrode plated in presence of $AgNO_3$ and LiCl

EDS analysis of the RVC electrode plated in presence of $AgNO_3$ and LiCl shown in figure **S37**.



Spectrum Overlay

kV: 10 Mag: 3806 Takeoff: 35 Live Time(s): 19.9 Amp Time(µs): 0.24 Resolution:(eV) 137

Anderson Minteer | 5a RVC | Area 2 | EDS Spot 1

Anderson Minteer | 5a RVC | Area 2 | EDS Spot 2

74 Cnts 1.240 keV Det: Octane Elect Plus

Fig. S39 — *SEM images of the graphite electrode plated in presence of $AgNO_3$ and LiCl*

SEM images of the graphite electrode plated in presence of $AgNO_3$ (0.3 equiv.) and LiCl (0.3 equiv.) at 6 mA for 0.3 F/mol (relative to 0.2 mmol scale). When these deposition conditions were followed by a cross coupling of 7 and ***5****, the yield of* ***39*** *was 41%.*

Additional information: graphite electrode plated in presence of $AgNO_3$ and LiCl.

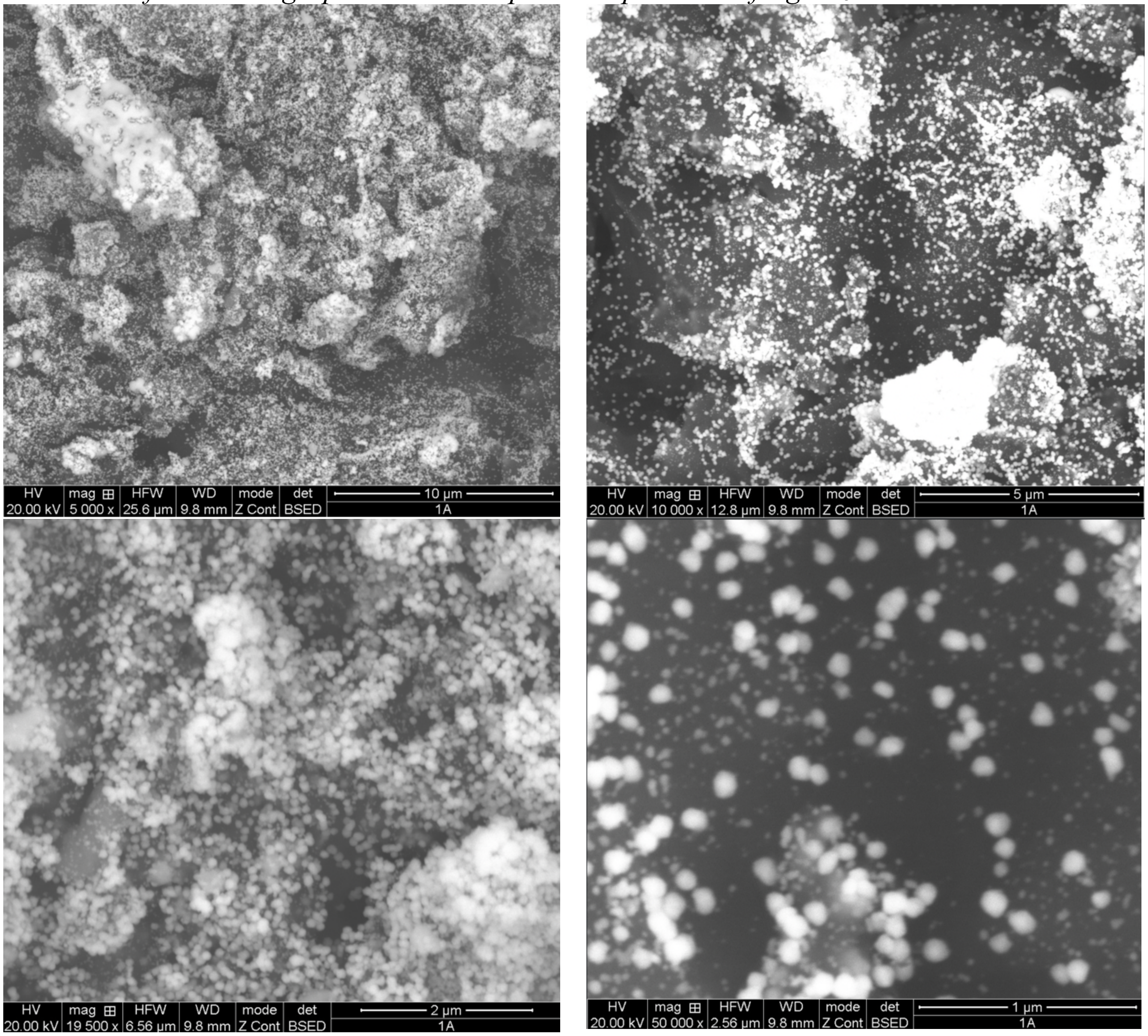


Fig. S40— ***EDS analysis of the graphite electrode plated in presence of AgNO$_3$ and LiCl***
EDS analysis of the graphite electrode plated in presence of AgNO$_3$ and LiCl shown in figure ***S39***.

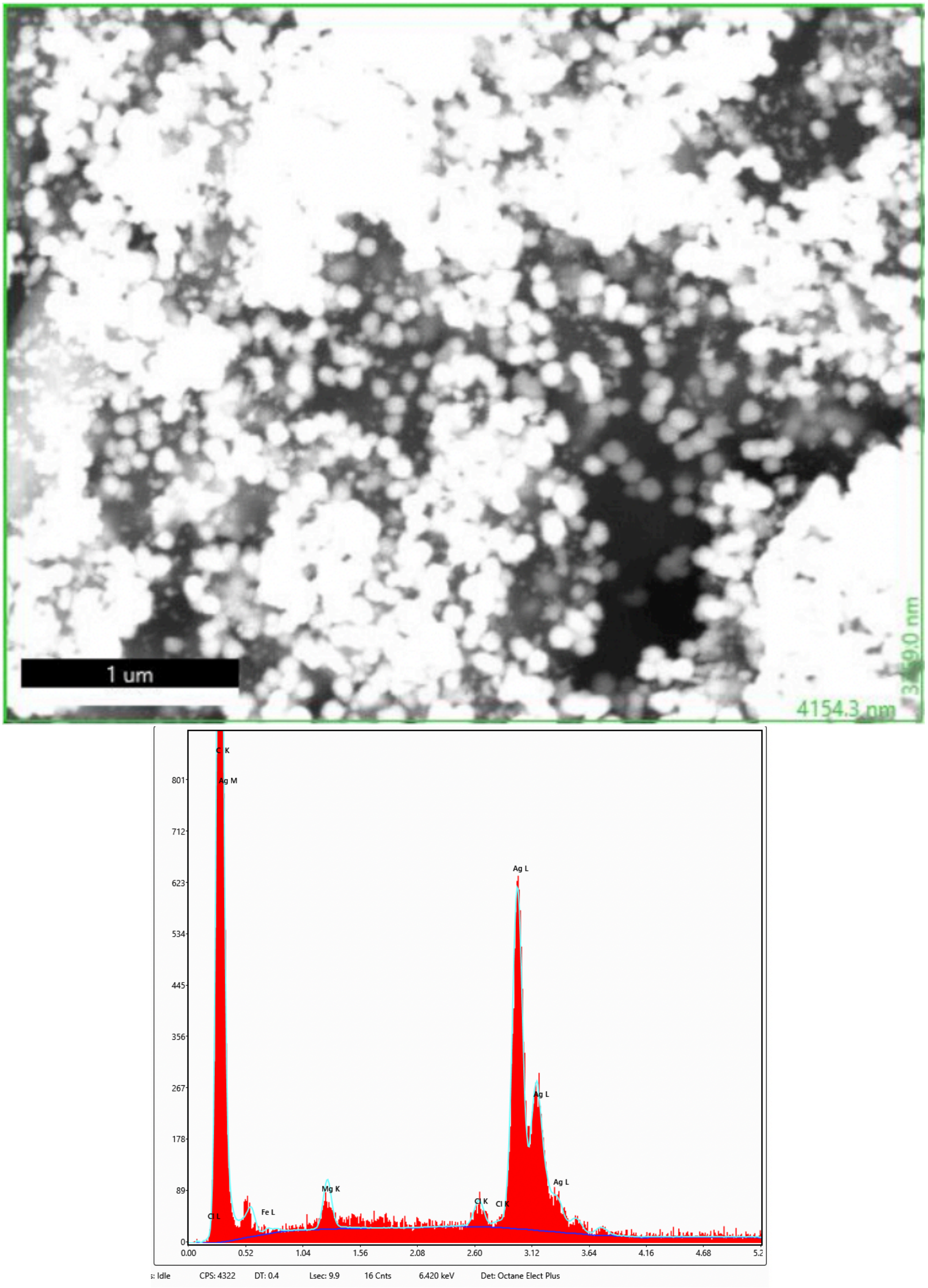


Fig. S41 —TEM images of graphite electrode plated in presence of AgNO3 and LiCl

TEM images of the graphite electrode plated in presence of $AgNO_3$ *(0.3 equiv.) and LiCl (0.3 equiv.) at 6 mA for 0.3 F/mol (relative to 0.2 mmol scale).*

Additional information: TEM images of graphite electrode plated in presence of $AgNO_3$ *and LiCl.*

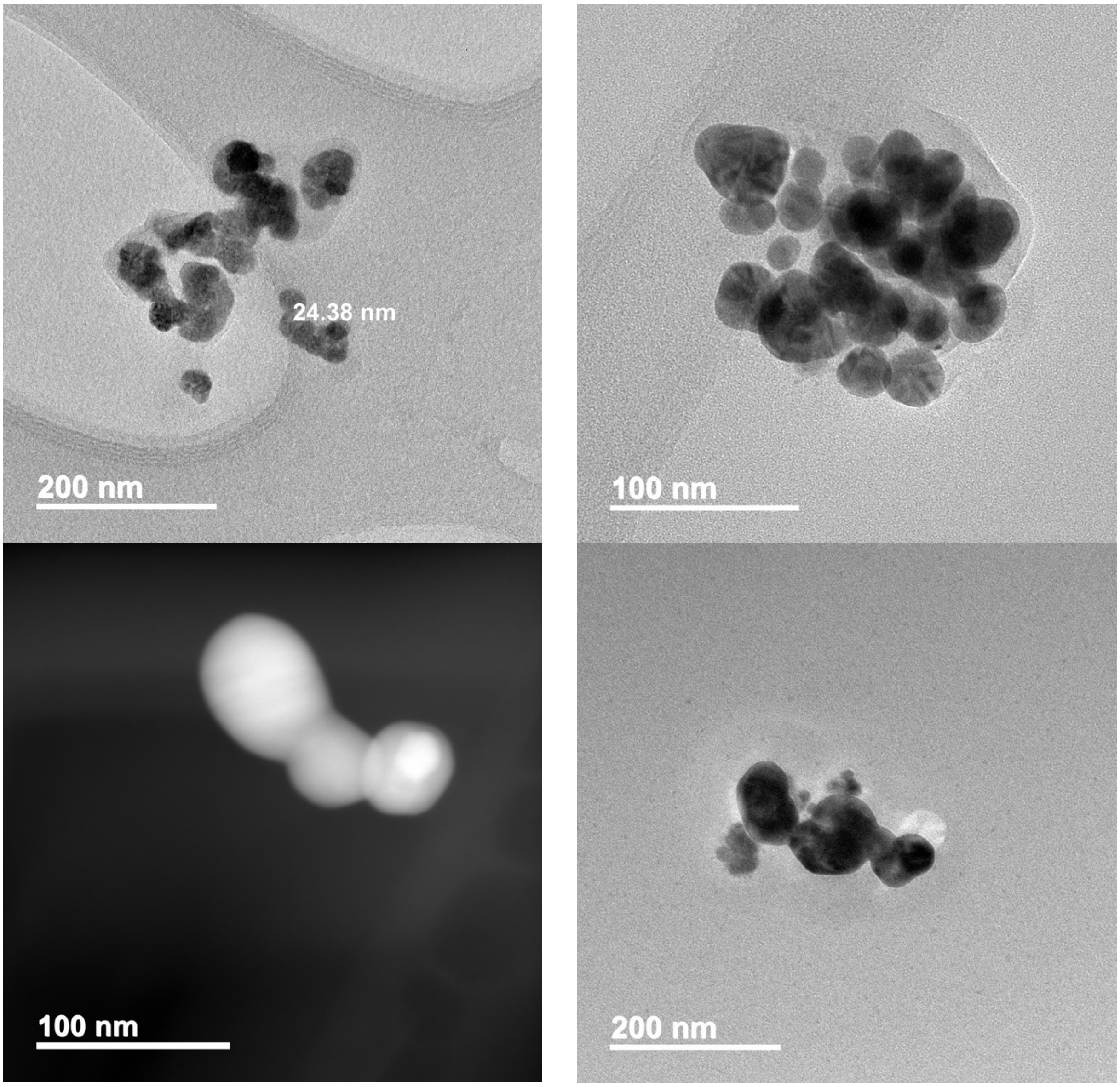


Fig S42 — *EDS maps images of the nanoparticles from graphite electrode plated in presence of AgNO$_3$ and LiCl*

*EDS maps images of the nanoparticles from graphite electrode plated in presence of AgNO$_3$ and LiCl shown in figure **S41**.*

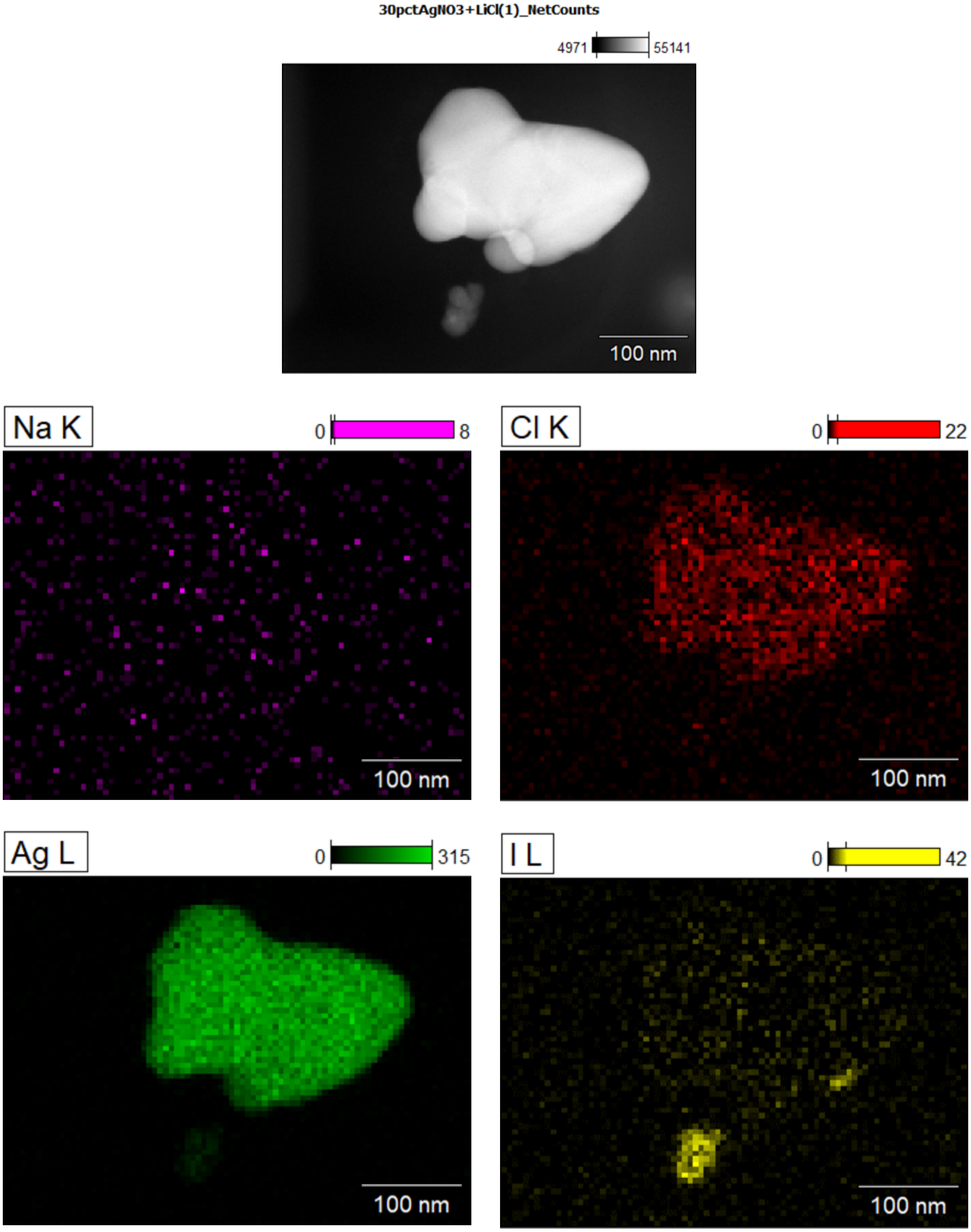


Fig S43 —SEM images of the graphite electrode plated in presence of AgNO3

SEM images of the graphite electrode plated in presence of $AgNO_3$ *(0.3 equiv.) at 6 mA for 0.3 F/mol (relative to 0.2 mmol scale). When these deposition conditions were followed by a cross coupling of 7 and* ***5****, the yield of* ***39*** *was 24%.*

Additional information: graphite electrode plated in presence of $AgNO_3$

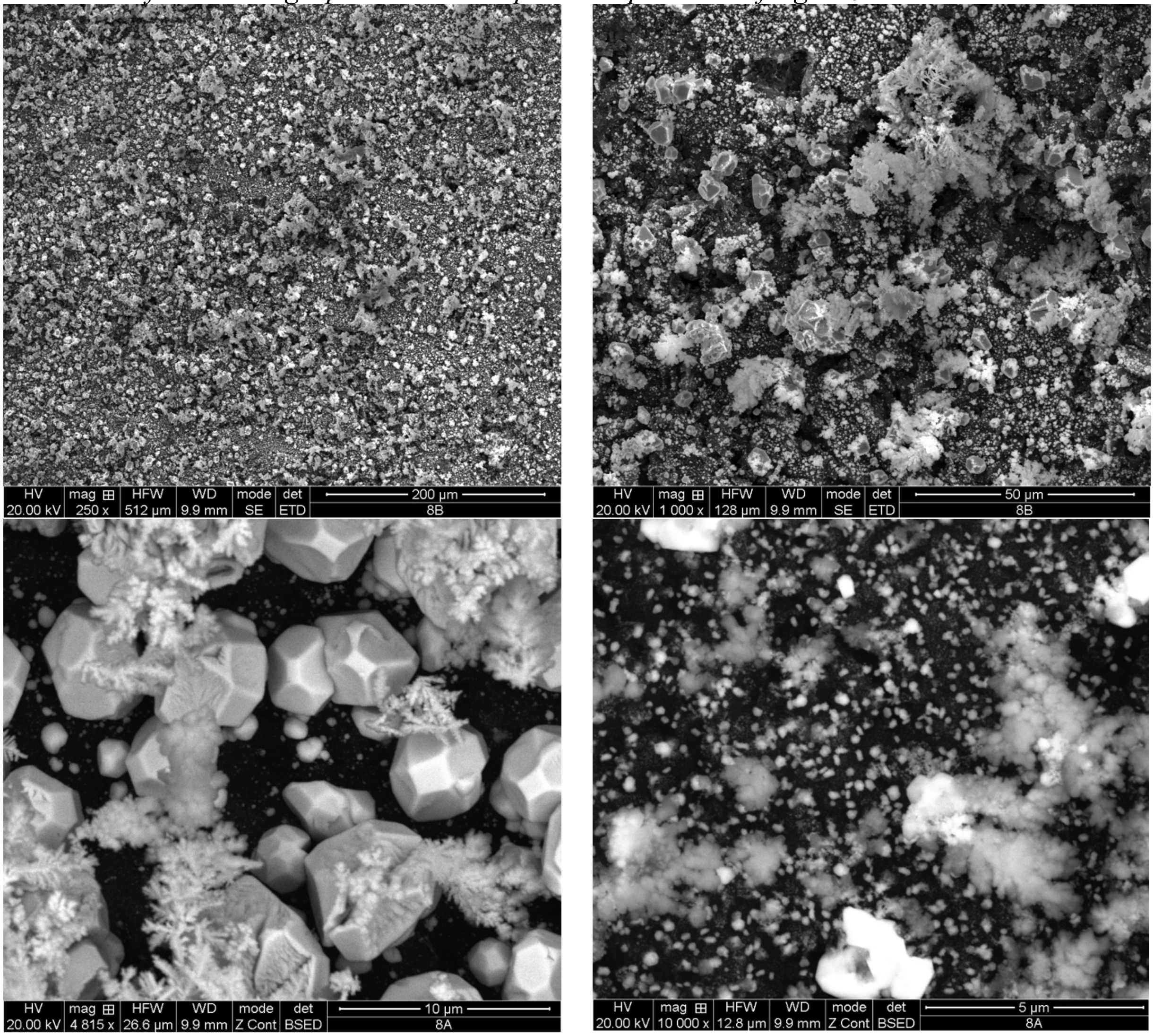


Fig S44 —*EDS analysis of the graphite electrode plated in presence of AgNO₃*

EDS analysis of the graphite electrode plated in presence of AgNO₃ shown in figure ***S43***.

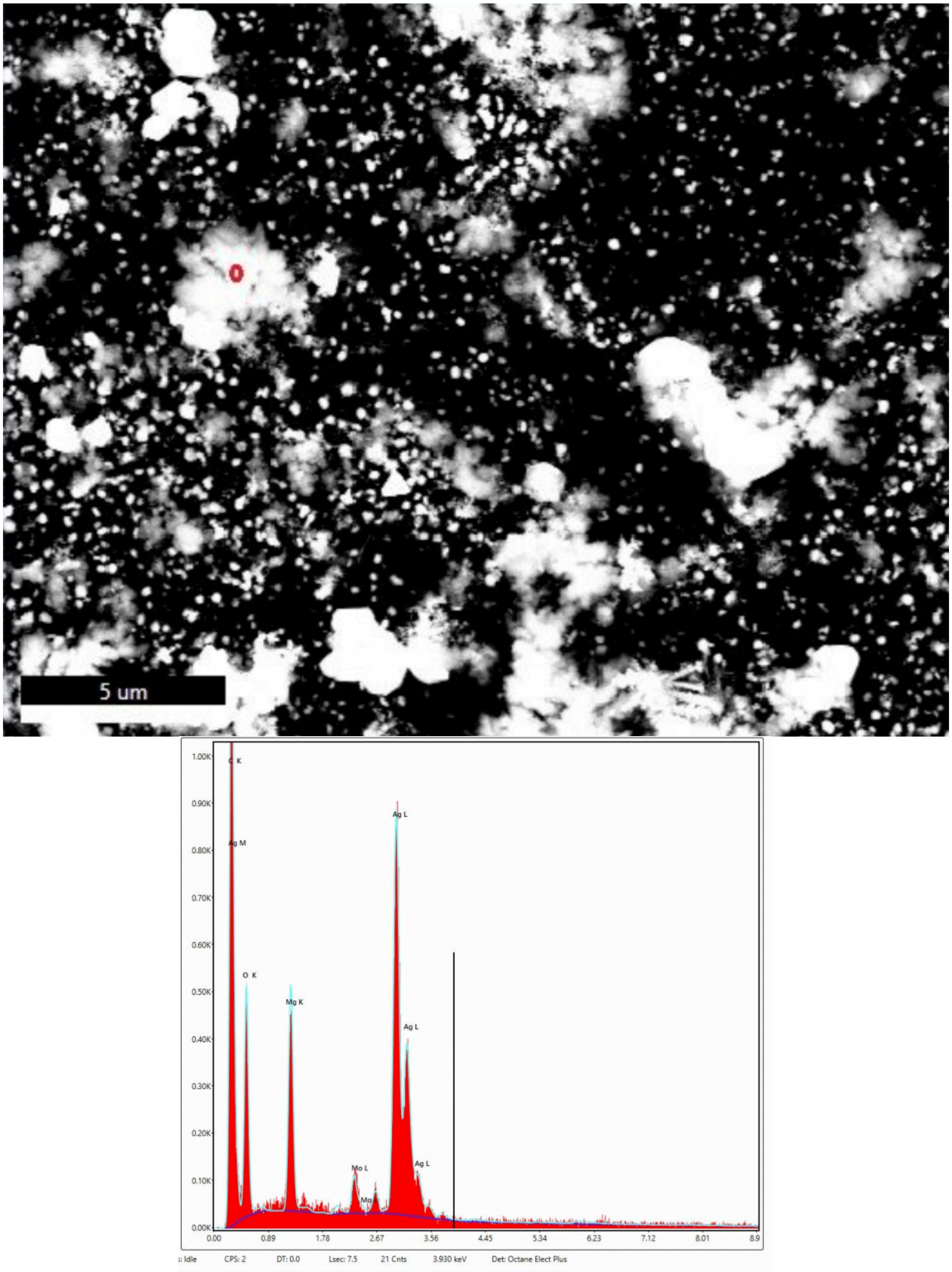


Fig S45 —*SEM images of graphite electrode plated in presence of $AgNO_3$ and LiCl, prolonged stirring.*

*SEM images of graphite electrode plated in presence of $AgNO_3$ (0.3 equiv.) and LiCl (0.3 equiv.) solution that was allowed to stir in the presence of light until visual decomposition the white suspension to a purple suspension (presumed decomposed AgCl). The electrode was then plated in the presence of this solution at 6 mA for 0.3 F/mol (relative to 0.2 mmol scale). When these deposition conditions were followed by a cross coupling of **7** and **5**, the yield of **39** was 17%.*

Additional information: graphite electrode plated in presence of $AgNO_3$ and LiCl after solution decomposition.

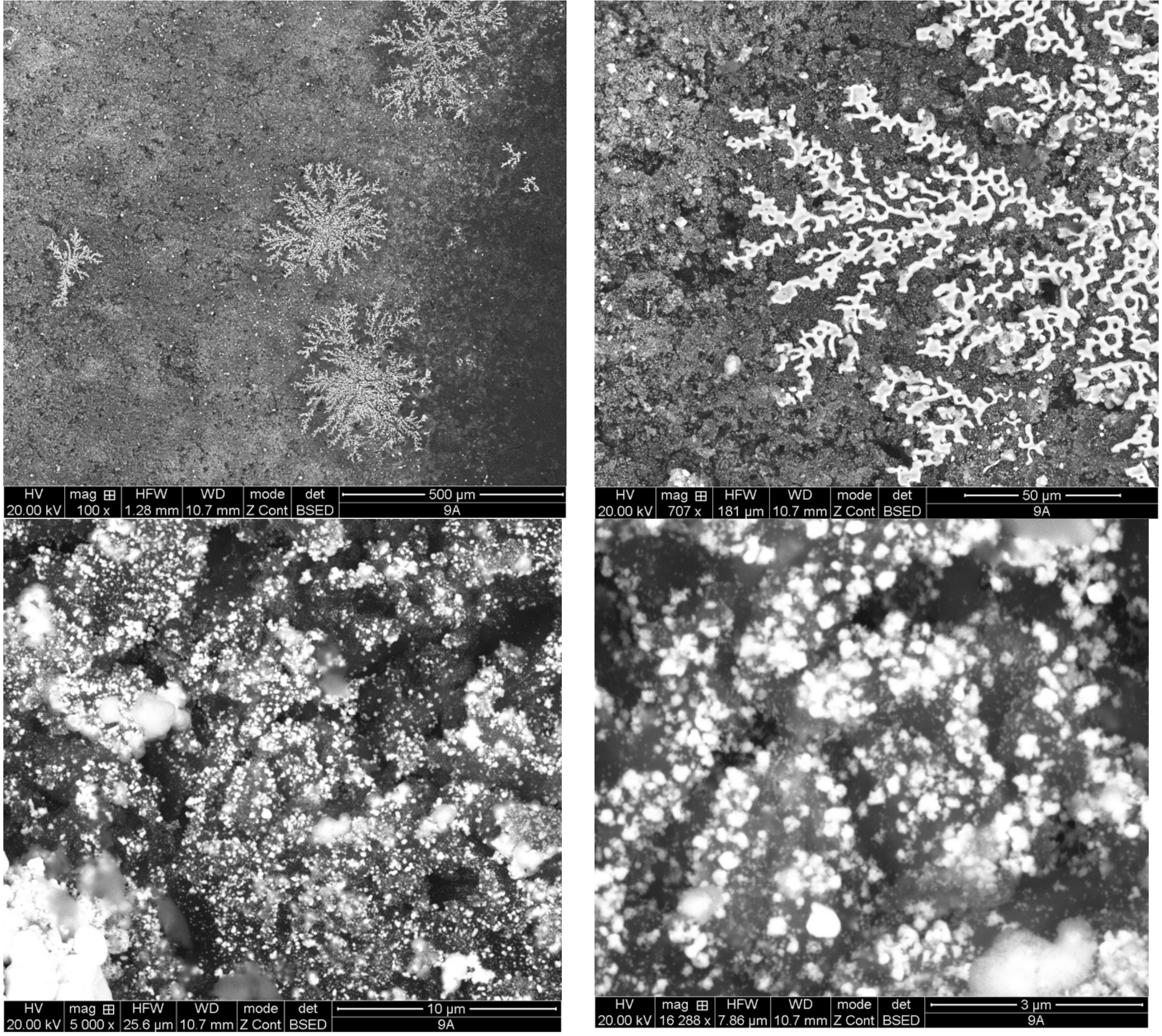


Fig. S46 —*EDS analysis of graphite electrode plated in presence of $AgNO_3$ and LiCl, prolonged stirring.*

*EDS analysis of graphite electrode plated in presence of decomposed $AgNO_3$/LiCl solution shown in figure **S45**.*

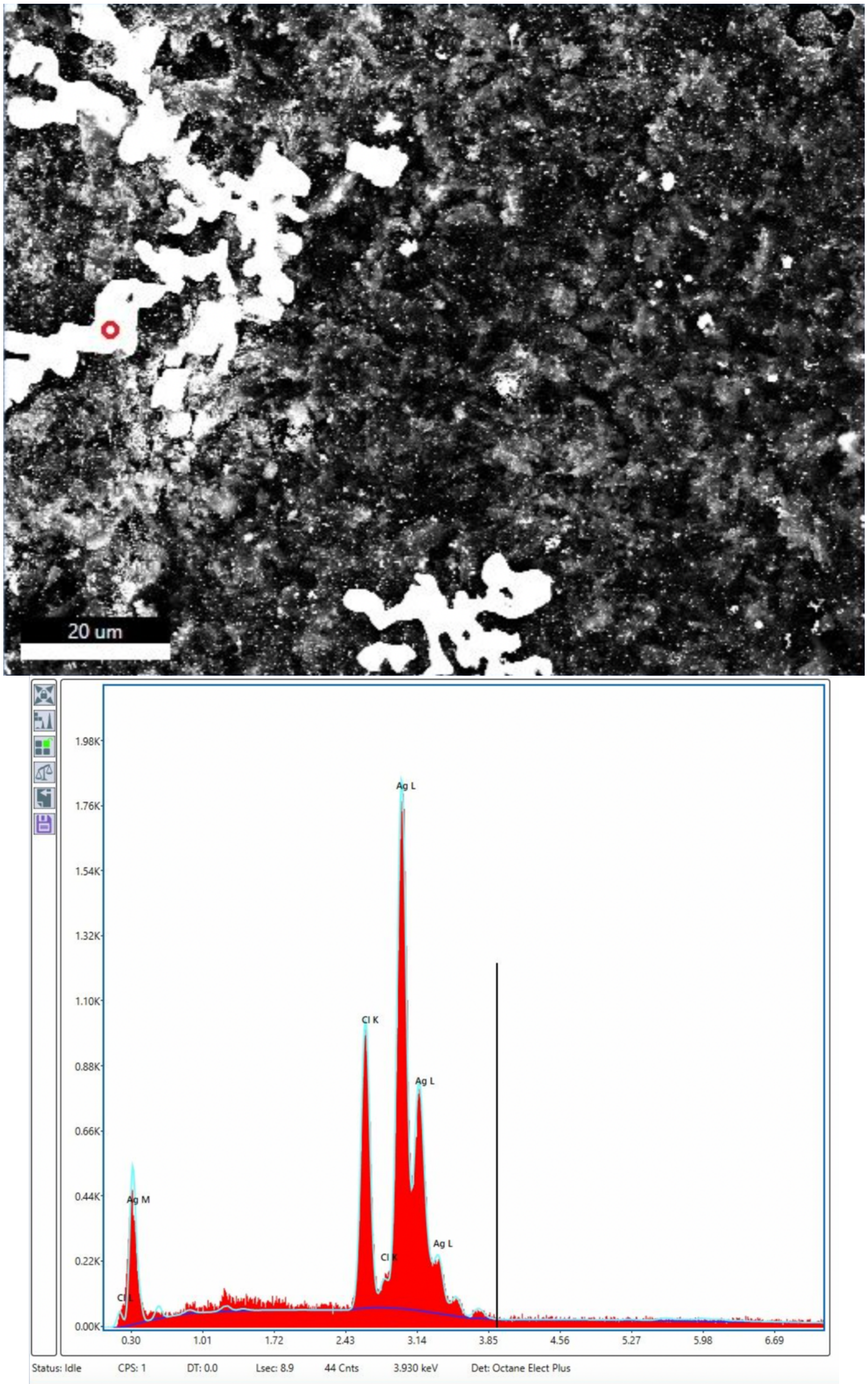


Fig S47 — SEM images of commercial carbon felt electrode.

Additional information: carbon felt electrode used in flow-cell reactor scale up of ***S38*** *before the reaction.*

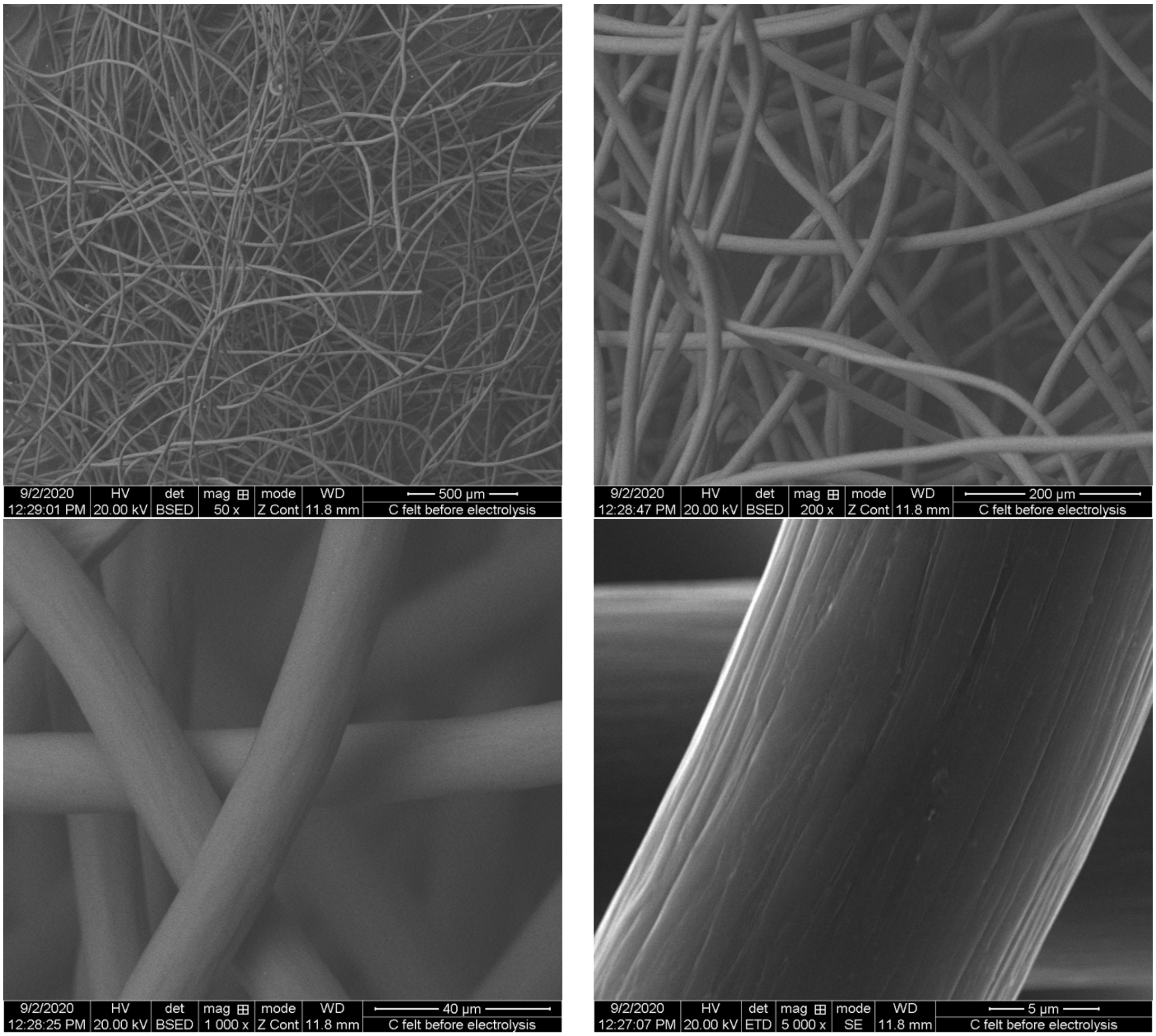


Fig S48— ***SEM images of carbon felt electrode after flow reaction with $AgNO_3$***

SEM images of carbon felt electrode after flow reaction where ***(R)-34*** *and* ***Z-33*** *were coupled using $NiCl_2$•$6H_2O$ (0.1 eqiuv.), 2,2'-bpy (0.1 equiv.), $AgNO_3$ (8.5 mg/cm^2) and $TBABF_4$ (0.08M) in DMF at 3.64 A for 4.0 F/mol to afford* ***S38*** *in 61% yield.*

Additional information: carbon felt from Flow-Cell reactor scale up after reaction

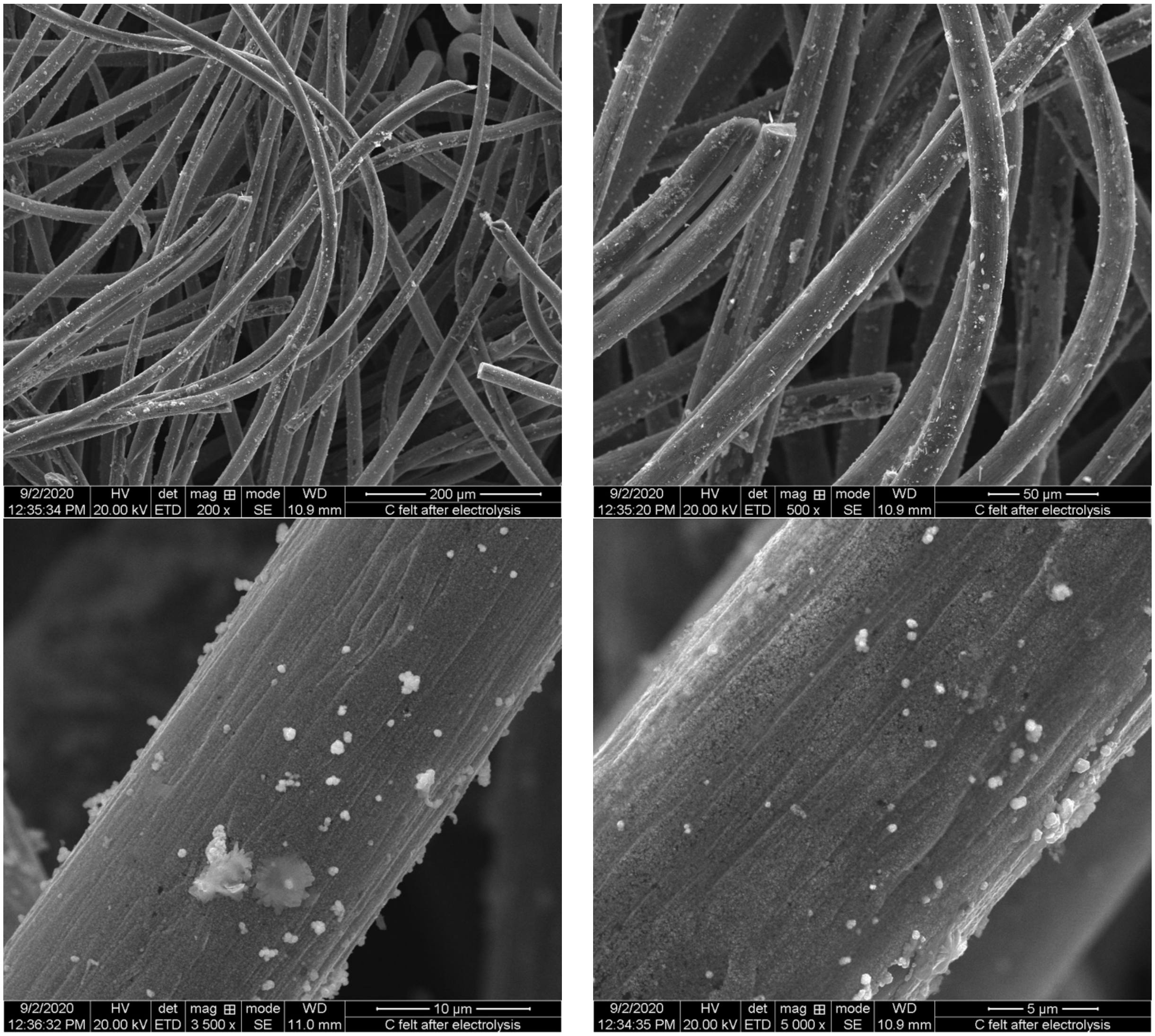
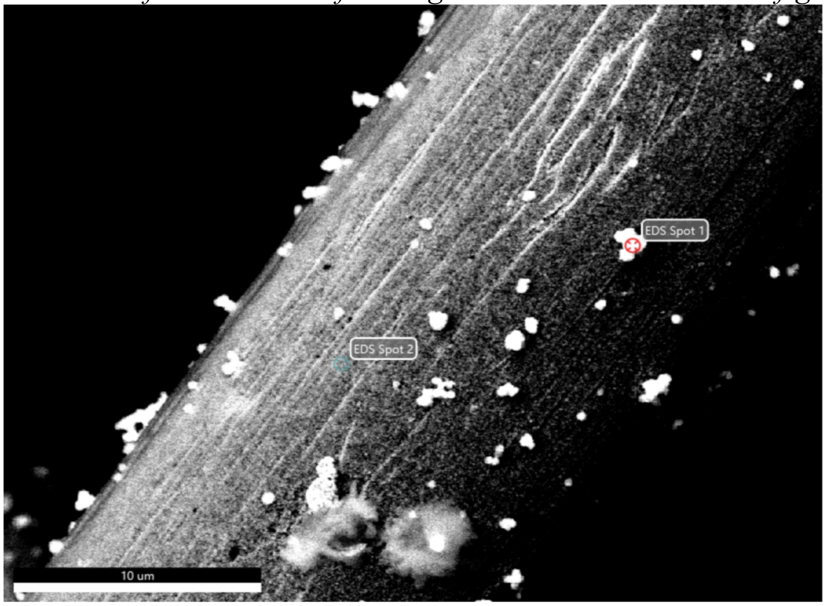
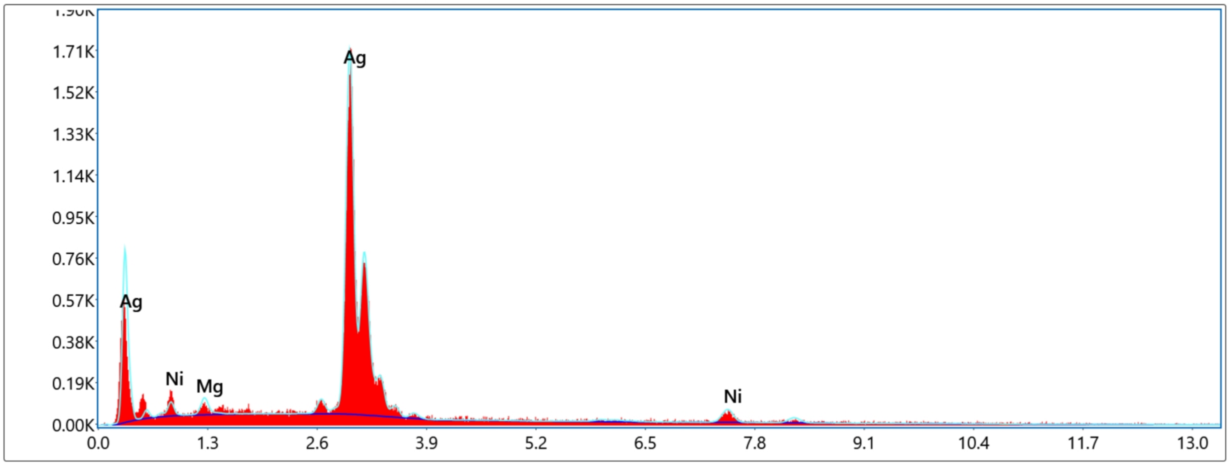


Fig S49— EDS analysis of the carbon felt electrode after flow reaction with $AgNO_3$

EDS analysis of the carbon felt electrode after large scale reaction shown in figure ***S48***.

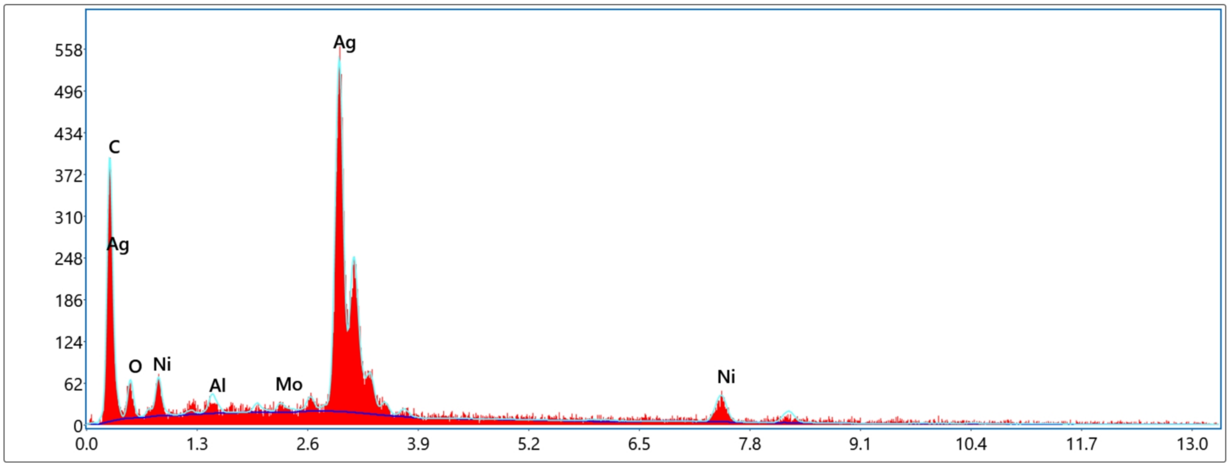


Anderson-Minteer (08-2020) | C Felt After electrolysis | Area 1 | EDS Spot 1



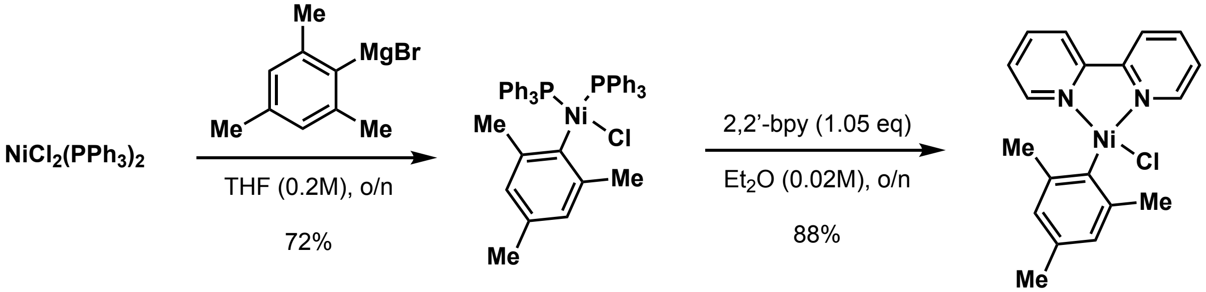
64 Cnts 1.690 keV Det: Octane Elect Plus Lock Map/Line Elements

Anderson-Minteer (08-2020) | C Felt After electrolysis | Area 1 | EDS Spot 2



27 Cnts 1.690 keV Det: Octane Elect Plus Lock Map/Line Elements

Synthesis of Nickel Complexes for CV Analysis



The procedure for the transmetallation was adapted from a literature procedure. (*108*)

A flame dried three-neck round bottom flask equipped with stir bar was charged with magnesium turnings (1.82 g, 75 mmol, 5 equiv.) and fitted with a reflux condenser, evacuated and back filled with argon. Next, 1,2-dibromoethane (65 µL, 0.075 mmol, 0.05 equiv.) was added to the turnings. An exotherm was observed upon gentle stirring. Anhydrous, inhibitor-free THF (30 mL) was added to the turnings followed by slow addition of mesityl bromide (2.3 mL, 15 mmol, 1 equiv.) at a rate sufficient to maintain a gentle reflux. The reaction was refluxed and stirred for 1 hour. The Grignard solution was titrated with I_2 and was found to be 0.39M.

A separate flame dried round bottom flask was charged with $NiCl_2(PPh_3)_2$ (5.23 g, 8 mmol, 1.0 equiv.). The flask was evacuated and backfilled with argon and anhydrous, inhibitor-free THF (30 mL) was added. The green suspension was cooled to 0 °C. The 0.39M Grignard solution (20.5 mL, 8 mmol, 1 equiv.) was added dropwise via syringe to the stirring suspension. The suspension quickly turned yellow and was allowed to warm to room temperature and stir for 30 minutes. The reaction was quenched with saturated aqueous ammonium chloride (20 mL) and filtered to afford a yellow solid. The precipitate was washed with ethanol and allowed to dry under vacuum to afford $(PPh_3)_2NiClMes$ as a yellow solid (4.23 g, 72%).

The procedure for the ligand exchange was adapted from a literature procedure. (*109*)

To an oven dried round bottom flask equipped with stir bar was added 2,2'-bipyridine (110.9 mg, 0.71 mmol, 1.05 equiv.) and $(PPh_3)_2NiClMes$ (500 mg, 0.68 mmol, 1 equiv.). The flask was then sealed and purged with argon. Anhydrous, inhibitor-free diethyl ether (34 mL) was added and the reaction mixture was allowed to stir at room temperature overnight. The diethyl ether was carefully decanted. The red solid material was washed with hexanes several times and dried under a vacuum to afford (bpy)NiClMes (220 mg, 88%).

Spectral data matched previous reports; the ^{1}H NMR data is provided here for convenience.(*109*)

^{1}H NMR (CD_3COCD_3): δ 9.43 (m, 1H), 8.36 (m, 1H), 8.33 (m, 1H), 8.21 (m, 1H), 8.15 (m, 1H), 7.71 (m, 1H), 7.35 (m, 1H), 7.22 (m, 1H), 6.45 (m, 1H), 3.05 (s, 6H), 2.20 (s, 3H).

Cyclic Voltammetry Experiments

Determination of Silver Coverage on RVC Electrode Surface

$$Volume\ of\ Submerged\ RVC = (0.8\ cm)(0.2\ cm)(1.2\ cm) = 0.192\ cm^3 = 1.92\ x\ 10^{-7} m^3$$

$$RVC\ Surface\ Area\ to\ Volume\ Ratio = 6560 \frac{m^2}{m^3} = 6560\ m^{-1}$$

$$Submerged\ Surface\ Area = (1.92\ x\ 10^{-7} m^3)(6560\ m^{-1}) = 1.26\ x\ 10^{-3} m^2 = 12.6\ cm^2$$

$$\frac{Ag}{cm^2} = \frac{10.2\ mg}{12.6\ cm^2} = 0.81 \frac{mg}{cm^2} \approx 1 \frac{mg}{cm^2} = 0.006\ mmol\ Ag/cm^2$$

Determination of $AgNO_3$ Needed to Coat Analytical Electrode

$$GC\ Disk\ Electrode\ Area = \pi r^2 = \pi(0.0015\ m)^2 = 7.1\ x\ 10^{-6}\ m^2 = 0.071\ cm^2$$

$$Ag\ needed = 0.071\ cm^2 \left(1 \frac{mg}{cm^2}\right) = 0.071\ mg\ AgNO_3 = 4.2\ x\ 10^{-7} mol$$

Determination of Deposition Time at Constant Current (-70 μA)

$$t = \frac{nF}{I} = \frac{4.2\ x\ 10^{-7} mol\ (96{,}485 \frac{C}{mol})}{0.070\ A} = 579\ s\ \approx 10\ min$$

Deposition of Ag-NP's on Analytical Glassy Carbon Disk Electrode

To an oven dried 5 mL ElectraSyn 2.0 vial equipped with a circular 3 mm glassy carbon working electrode, platinum counter electrode and Ag/AgCl reference electrode in a 3.0 M aqueous potassium chloride compartment was added lithium chloride solution (1.5 mL, 0.47 mM in anhydrous DMF freshly sparged with argon) and was allowed to thoroughly sparged using an argon balloon. A separate solution of silver nitrate (0.28 mM in anhydrous DMF sparged with argon) was freshly prepared and shieled from light. Immediately upon dissolution of silver nitrate in DMF, 1.5 mL of this solution was added to the sparging ElectraSyn 2.0 vial. The vial was sparged for an additional three minutes. The vial was connected to a potentiostat and a constant current of -70 μA was applied for 10 minutes while stirring under argon. Upon completion, the ElectraSyn 2.0 cap containing the electrodes was carefully removed from the reaction mixture and the electrodes were allowed to briefly airdry. The ElectraSyn 2.0 cap was equipped with a new 5 mL vial and a dry anhydrous DMF analyte solution with 5 mM analyte and 0.1 M $TBABF_4$ electrolyte was added. The analyte solution was allowed to gently sparge with argon prior to voltammetry measurements with the functionalized electrode. Deviations from this procedure to plate more silver were performed according to the table below.

Table S51 — Conditions for plating silver at various loadings.

Procedure changes

entry	silver multiplier	stock Ag	stock LiCl	plating time/current	silver coverage
1	1x	0.28 mM	0.47 mM	10 min/ -70 uA	0.006 mmol/cm^2
2	2x	0.56 mM	0.94 mM	20 min/ -70 uA	0.012 mmol/cm^2
3	3x	0.84 mM	1.41 mM	30 min/ -70 uA	0.018 mmol/cm^2
4	4x	1.12 mM	1.88 mM	40 min/ -70 uA	0.024 mmol/cm^2

Confirmation of Successful Plating through Anodic Stripping

Following the above procedure, the Ag-NP coated analytical glassy carbon disk electrode was prepared. After completion, the cap containing the newly functionalized electrode was removed from the plating solution, allowed to briefly airdry. A new oven dried 5 mL vial was equipped and an aqueous solution of lithium nitrate (0.1M, 3 mL) was added carefully via syringe. The vial was then equipped with an argon balloon and was sparged for 10 minutes. The vial was connected to a potentiostat and cyclic voltammetry was performed with the following parameters:

Segments: 2
Initial potential: 0.0 V
Vertex potential: 1.0 V
Final potential: 0.0 V
Scan rate: 50 mV/s

An irreversible oxidation of the surface bound particulate silver (0) was observed between 350 mV and 500 mV vs Ag/AgCl (shown below).

Fig S50 — Anodic stripping experiment with irreversible silver (0) oxidation

Anodic stripping experiment with irreversible silver (0) oxidation on the electrode surface in 0.1 M $LiNO_{3(aq)}$.

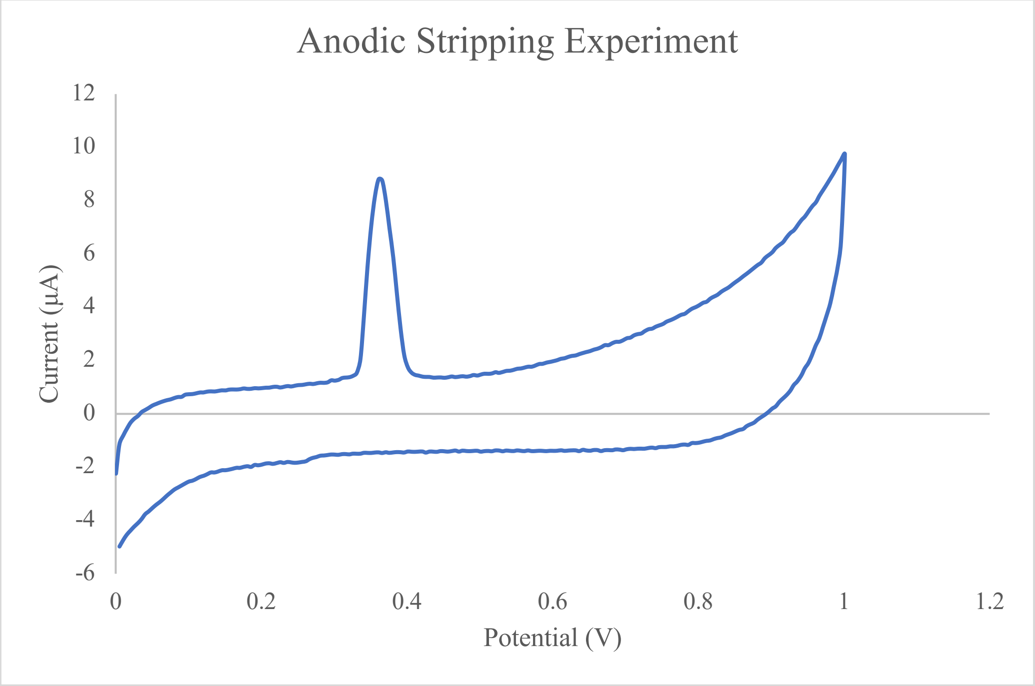


Fig S51— Dark Field S/TEM images of surface lift out of a 3mm carbon disk electrode with $AgNO_3$ and LiCl

Dark Field S/TEM images of surface lift out of a 3mm carbon disk electrode after plating with to achieve a theoretical 0.006 mmol/cm^2 $AgNO_3$ *loading described in table* ***S49***.

Notes: Electrode material: 3mm glassy carbon disk. Additive(s): LiCl, $AgNO_3$
Additional information: Analytical electrode coated with 0.006 mmol/cm^2 $AgNO_3$ *loading*
Confirmation of Successful Plating through SEM and EDS and FIB lift out.

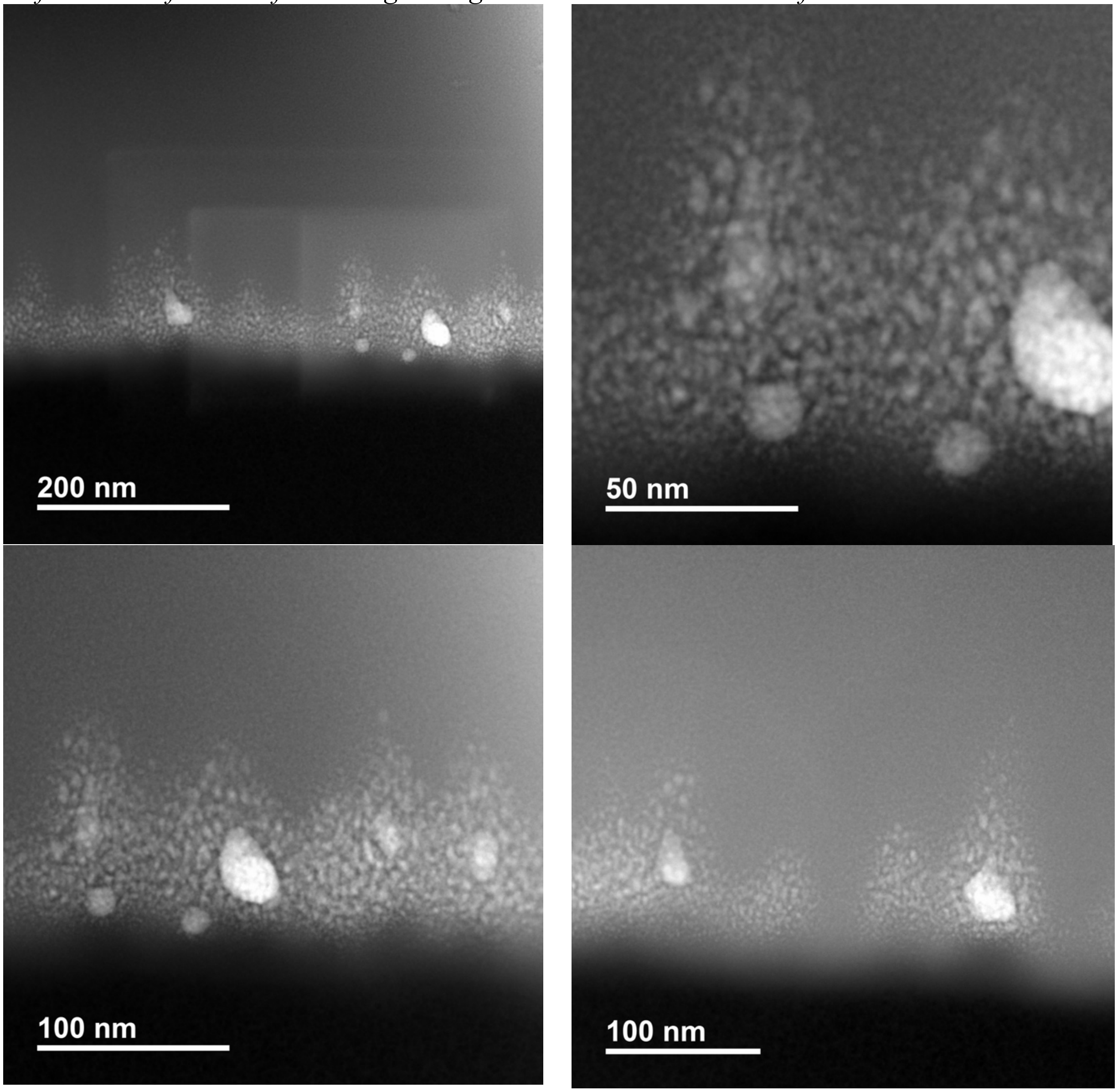
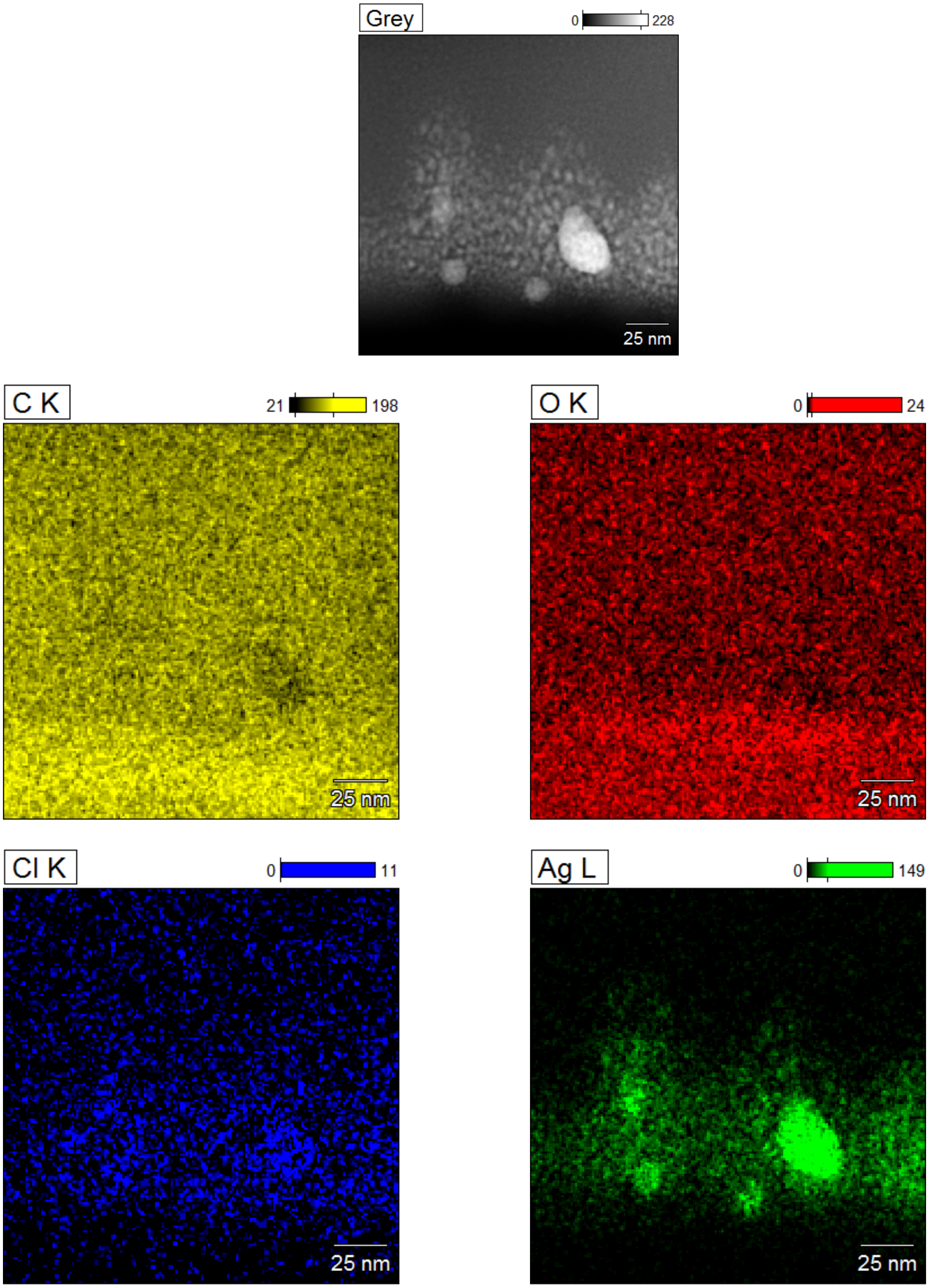


Fig S52— *EDS maps from glassy carbon disk electrode plated with $AgNO_3$ and LiCl*

*EDS elemental maps of the nanoparticles from glassy carbon disk electrode plated with 0.006 mmol/cm^2 $AgNO_3$ loading shown in table **S49**.*



Cleaning/ Removal of the Surface Bound Particulate Silver

The electrodes were carefully removed from the cap of the ElectraSyn 2.0. The working electrode and counter electrode were sonicated in ethanol for 15 minutes. The glassy carbon disk electrode was then gently polished on wet fine sandpaper (3000 grit). The cleaned electrodes were then dried under reduced pressure for 30 minutes. To confirm that the electrodes were clean, a cyclic voltammogram was collected in 0.1M aqueous lithium nitrate using identical parameters as the anodic stripping experiment and no irreversible silver (0) oxidation peak was observed.

Note: If an oxidation peak is observed, constant potential electrolysis can be applied for 5 minutes at the peak potential of the anodic stripping voltammogram to remove any particulate silver still present.

Fig S52 — *Anodic stripping experiment of cleaned glassy carbon disk electrode*

Anodic stripping experiment of cleaned glassy carbon disk electrode in 0.1 M $LiNO_{3(aq)}$

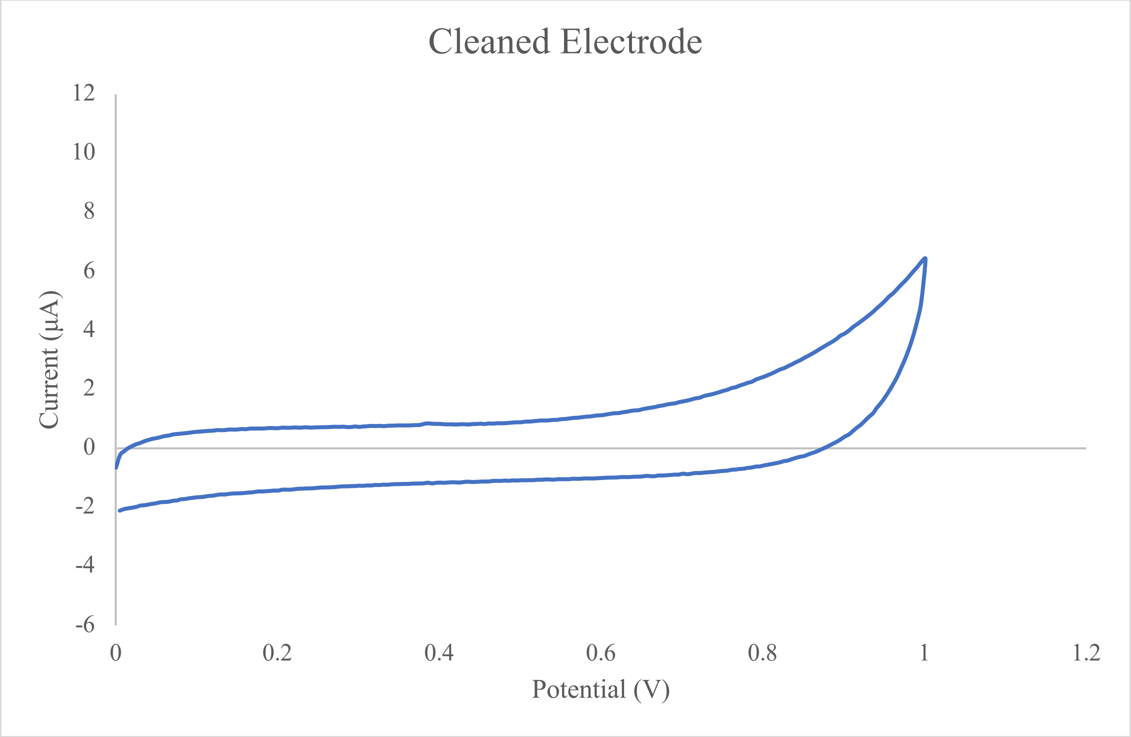


Table S52 —General Parameters for Cyclic Voltammetry of Various Analytes

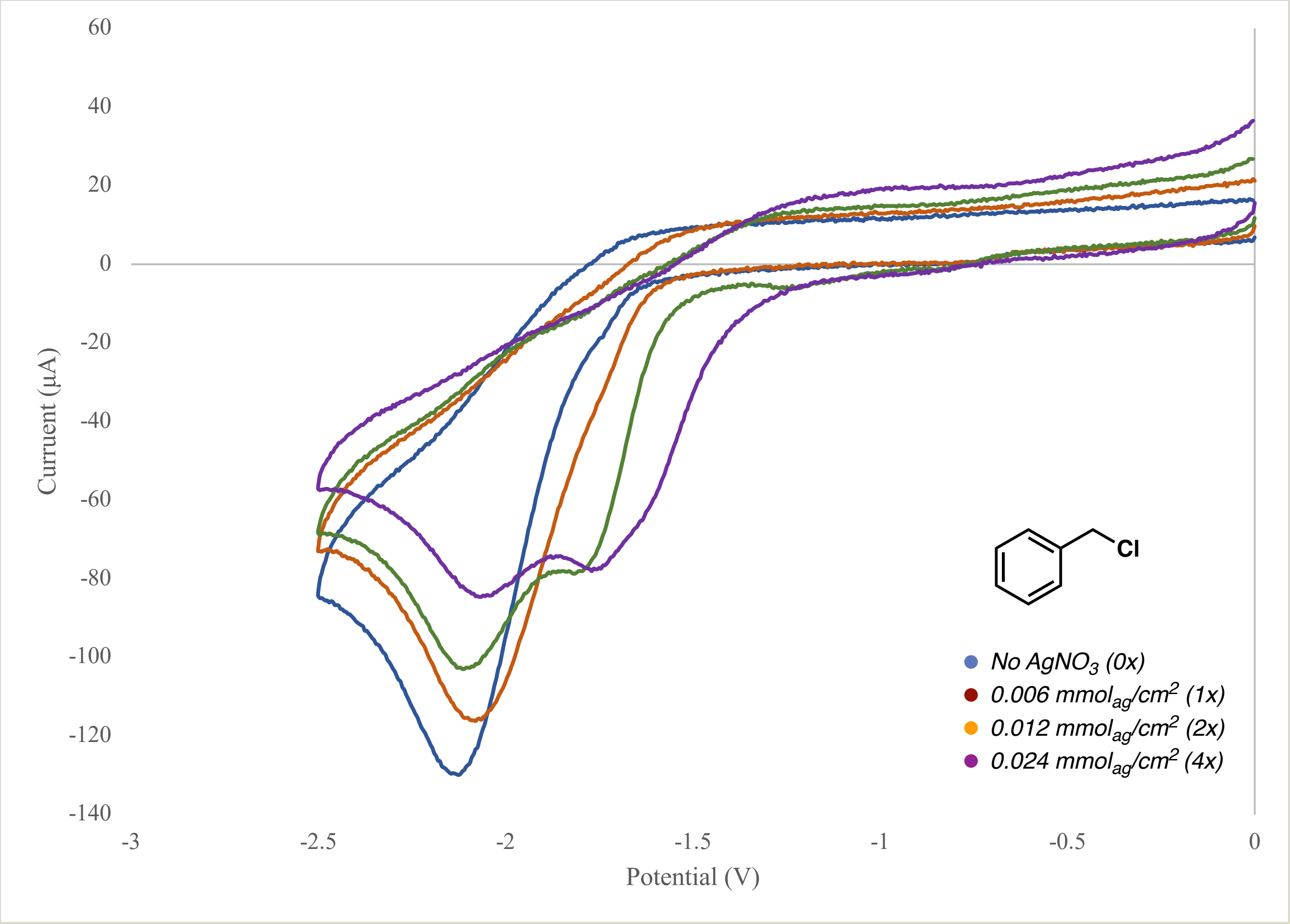
All voltammograms were measured using the following parameters:

Working electrode	3 mm Glassy Carbon Disk (with and without silver deposition)
Counter electrode	Platinum
Reference Electrode	Ag/AgCl with 3.0M aqueous KCl in reference electrode chamber
Segments	2
Initial Potential	0 V
Vertex Potential	-2.5 V
Final Potential	0 V
Solvent	DMF
Electrolyte	0.1 M $TBABF_4$
Analyte Concentration	5 mM
Scan rate (mV/s)	25, 50, 100, 200, 400, 600, 800

Fig S54 —Cyclic voltammograms of benzyl chloride with Ag-NP deposition

Cyclic voltammograms of 5 mM benzyl chloride with silver loadings 0x-4x that of the reaction (0.006 – 0.024 mmol Ag/cm^2*).*

Notes: Analyte: 5 mM BnCl. Scan rate: 100 mV/s. Control Study with Benzyl Chloride Reduction. A positive shift in reduction onset is observed consistent with the Ag-NP functionalized electrochemical sensor literature.(110) This is consistent with the deposition of silver nanoparticles on the analytical electrode.



Cyclic Voltammograms

All voltammograms were run in triplicate with anodic stripping and thorough cleaning in between each set of measurements. Datapoints represent an average of the three runs. The error bars depicted in the data sets are the standard deviation of I_p extracted from the voltammograms.

Fig S55 — CV of vinyl iodide 5 on bare glassy carbon.

Cyclic voltammograms of 5 mM vinyl iodide on bare glassy carbon.

*Notes: Analyte: 5 mM vinyl iodide (**5**).*

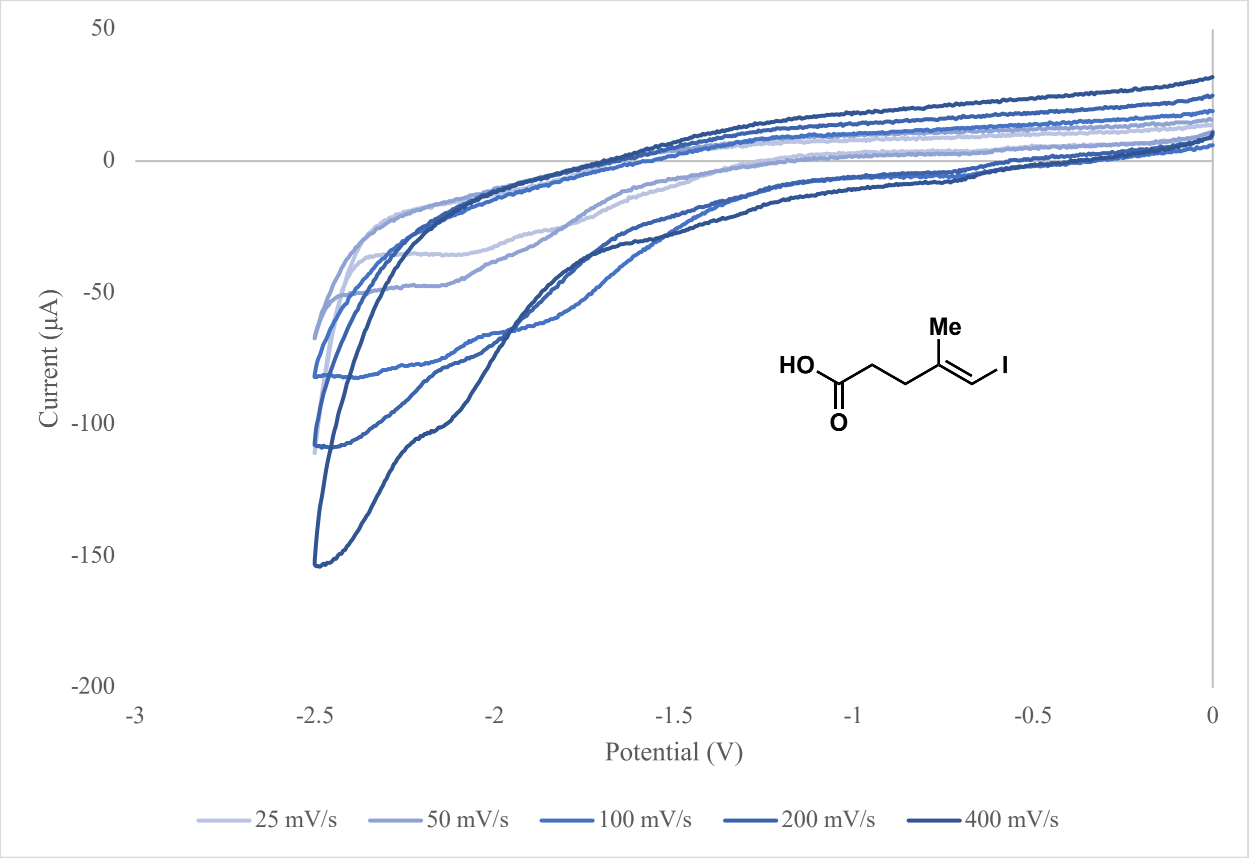


Fig S56 — CV of vinyl iodide 5 on glassy carbon with ~0.006 $\text{mmol}_{\text{Ag}}/\text{cm}^2$ Ag

Cyclic voltammograms of 5 mM vinyl iodide on glassy carbon with 1x silver loading (0.006 $\text{mmol}_{Ag}/\text{cm}^2$ *Ag).*

*Notes: Analyte: 5 mM vinyl iodide (**5**). 0.006* $\text{mmol}_{Ag}/\text{cm}^2$ *Ag coverage*

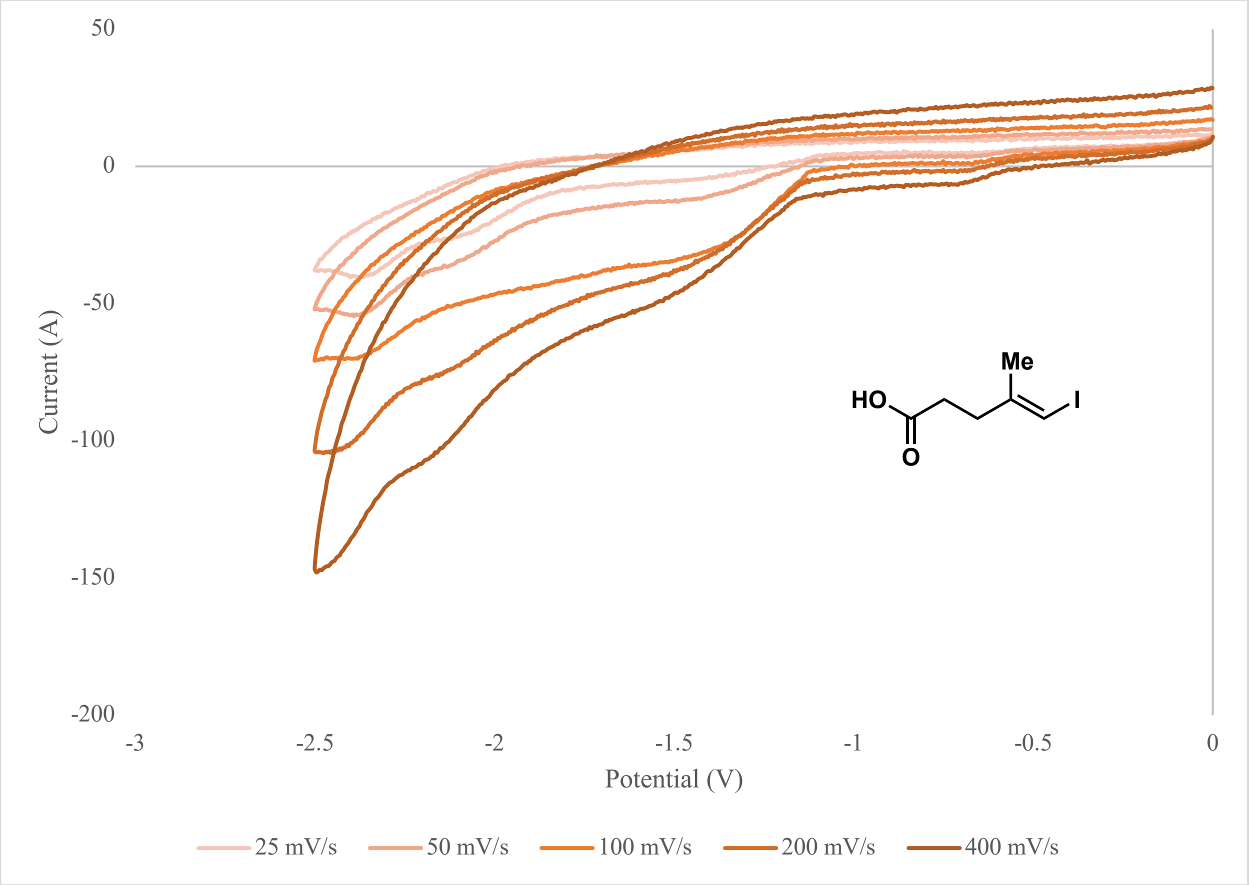


Fig S57 — CV's of $NiCl_2{\cdot}6H_2O$ + 2,2'-bpy varying Ag-NP coverage

Cyclic voltammograms of 5 mM $NiCl_2{\cdot}6H_2O$ + 5 mM 2,2'-bpy on bare glassy carbon (blue), 0.006 $mmol_{Ag}/cm^2$ (red), and 0.018 $mmol_{Ag}/cm^2$ (green) at 100 mV/s.

Notes: Analyte: 5 mM $NiCl_2{\cdot}6H_2O$ + 5 mM 2,2'-bpy.

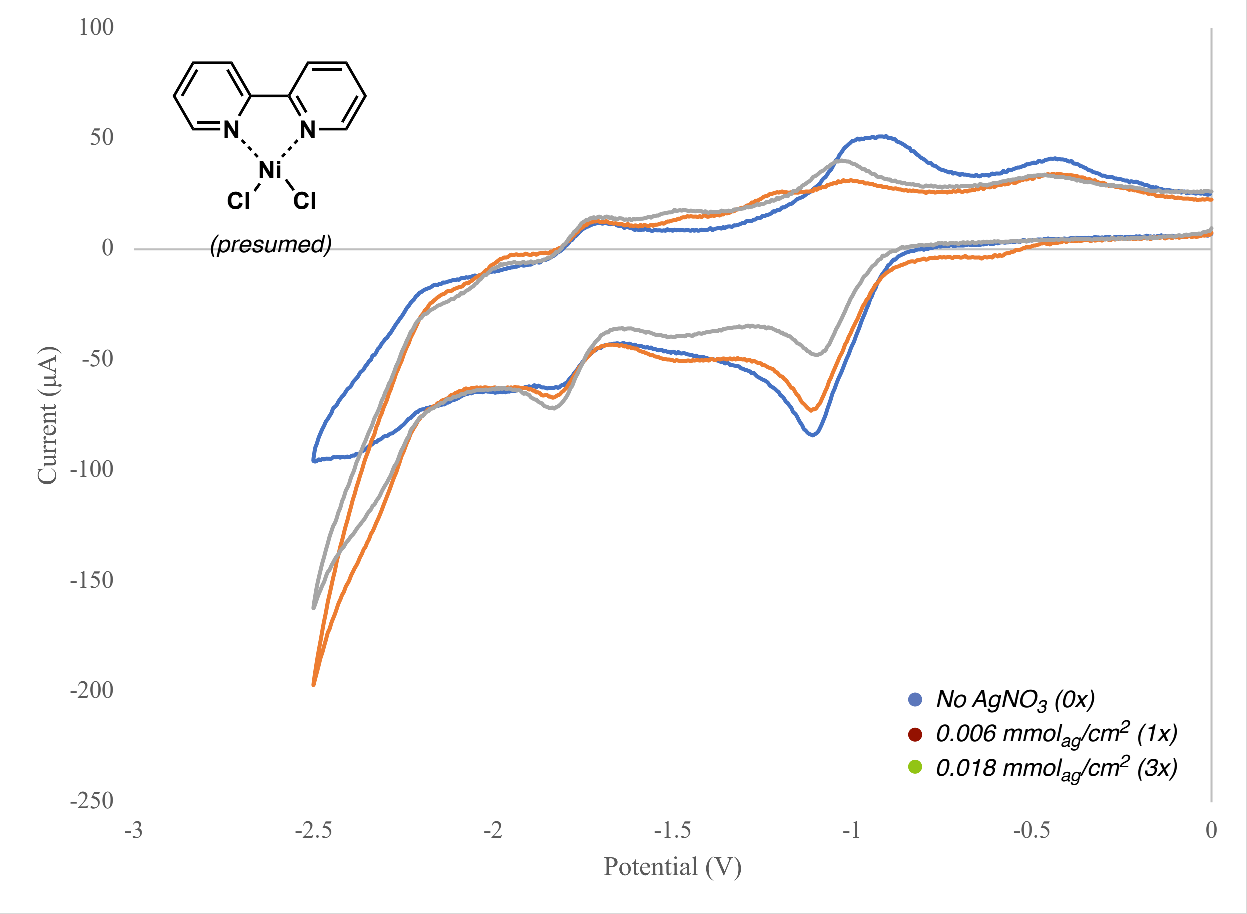


Fig S58 — CV's of $NiCl_2{\cdot}6H_2O$ + 2,2'-bpy on bare glassy carbon

Cyclic voltammograms of 5 mM $NiCl_2{\cdot}6H_2O$ + 5 mM 2,2'-bpy on bare glassy carbon.

Notes: Analyte: 5 mM $NiCl_2{\cdot}6H_2O$ + 5 mM 2,2'-bpy. Unfunctionalized glassy carbon disk electrode.

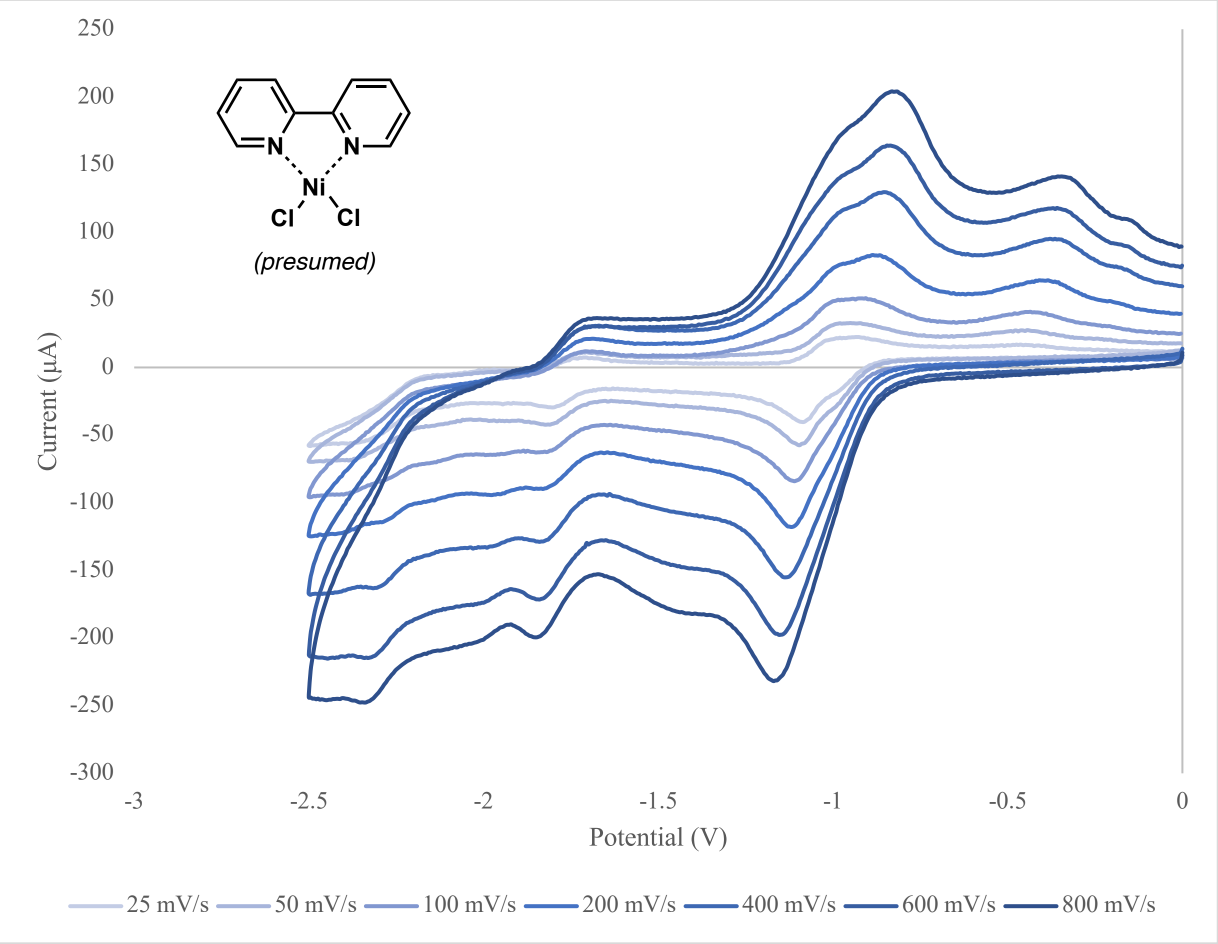


Fig S59 — CV's of $NiCl_2{\cdot}6H2O$ + 2,2'-bpy on glassy carbon with 0.006 $mmol_{Ag}/cm^2$ Ag

Cyclic voltammograms of 5 mM $NiCl_2{\cdot}6H_2O$ + 5 mM 2,2'-bpy on glassy carbon with 1x silver loading (0.006 $mmol_{Ag}/cm^2$ Ag).

Notes: Analyte: 5 mM $NiCl_2{\cdot}6H_2O$ + 5 mM 2,2'-bpy. 0.006 $mmol_{Ag}/cm^2$ Ag coverage

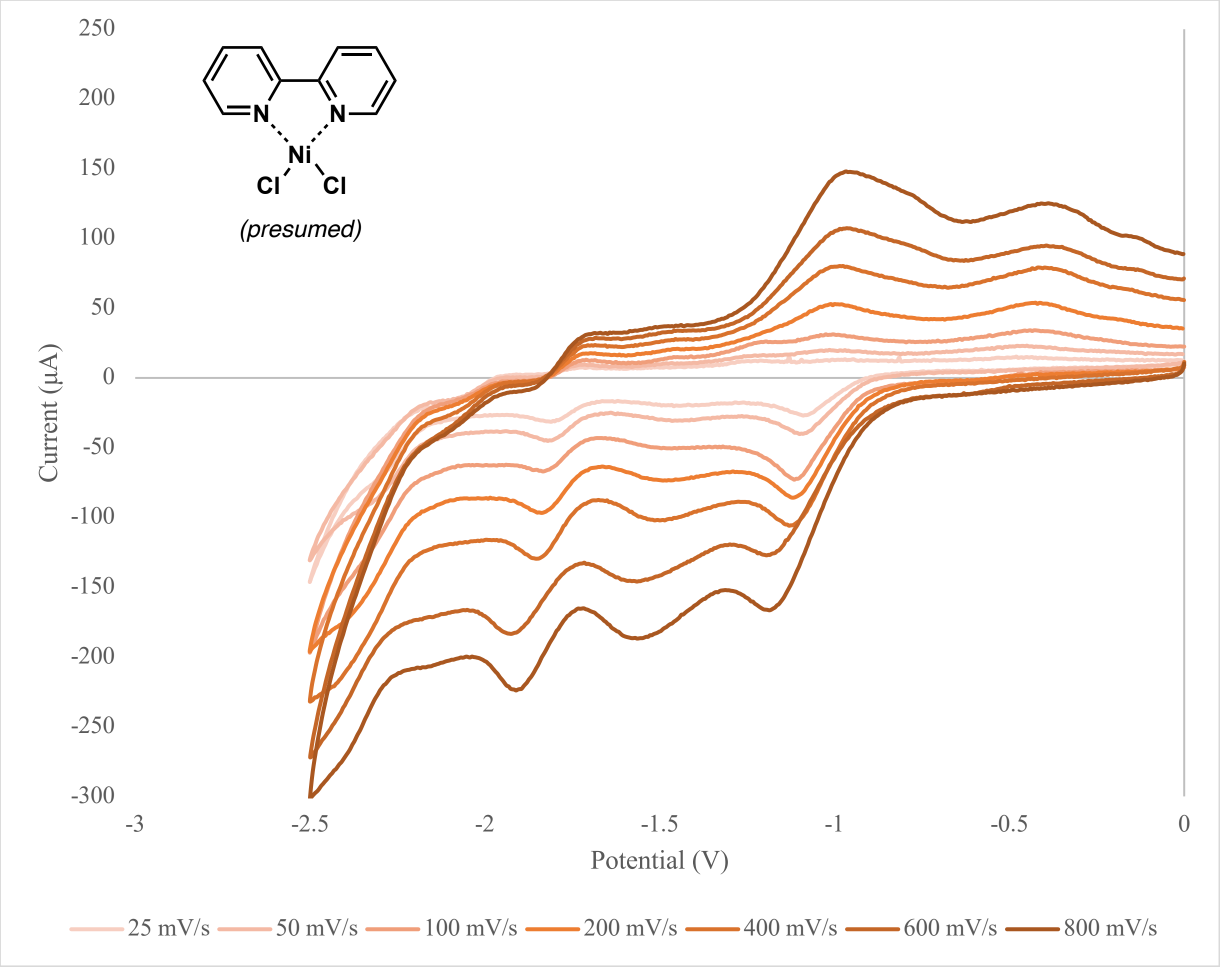


Fig S60 — CV’s of NiCl₂·6H2O + 2,2’-bpy on glassy carbon with 0.018 mmol$_{Ag}$/cm^2 Ag

Cyclic voltammograms of 5 mM $NiCl_2 \cdot 6H_2O$ *+ 5 mM 2,2’-bpy on glassy carbon with 3x silver loading (0.018 mmol$_{Ag}$/cm^2).*

Notes: Analyte: 5 mM $NiCl_2 \cdot 6H_2O$ *+ 5 mM 2,2’-bpy. 0.018 mmol$_{Ag}$/m^2 Ag coverage*

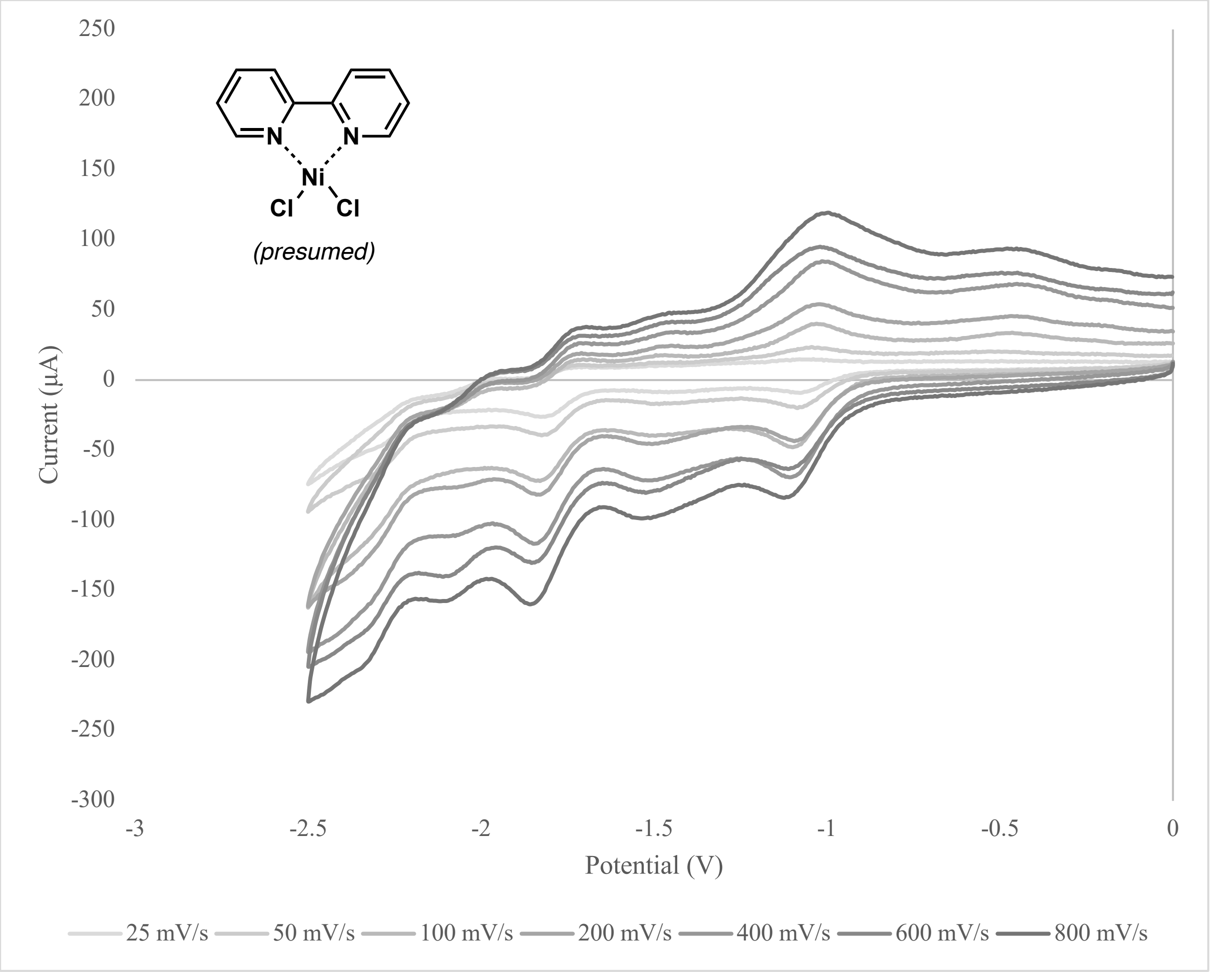


Fig S61 — CV's of RAE 7 on glassy carbon varying the Ag-NP coverage

Cyclic voltammograms of 5mM 7 on bare glassy carbon (blue), 0.006 mmol$_{Ag}$/cm^2 (red), and 0.018 mmol$_{Ag}$/cm^2 (green) at 100 mV/s.

Notes: Analyte: 5 mM Redox Active Ester ***(7)***

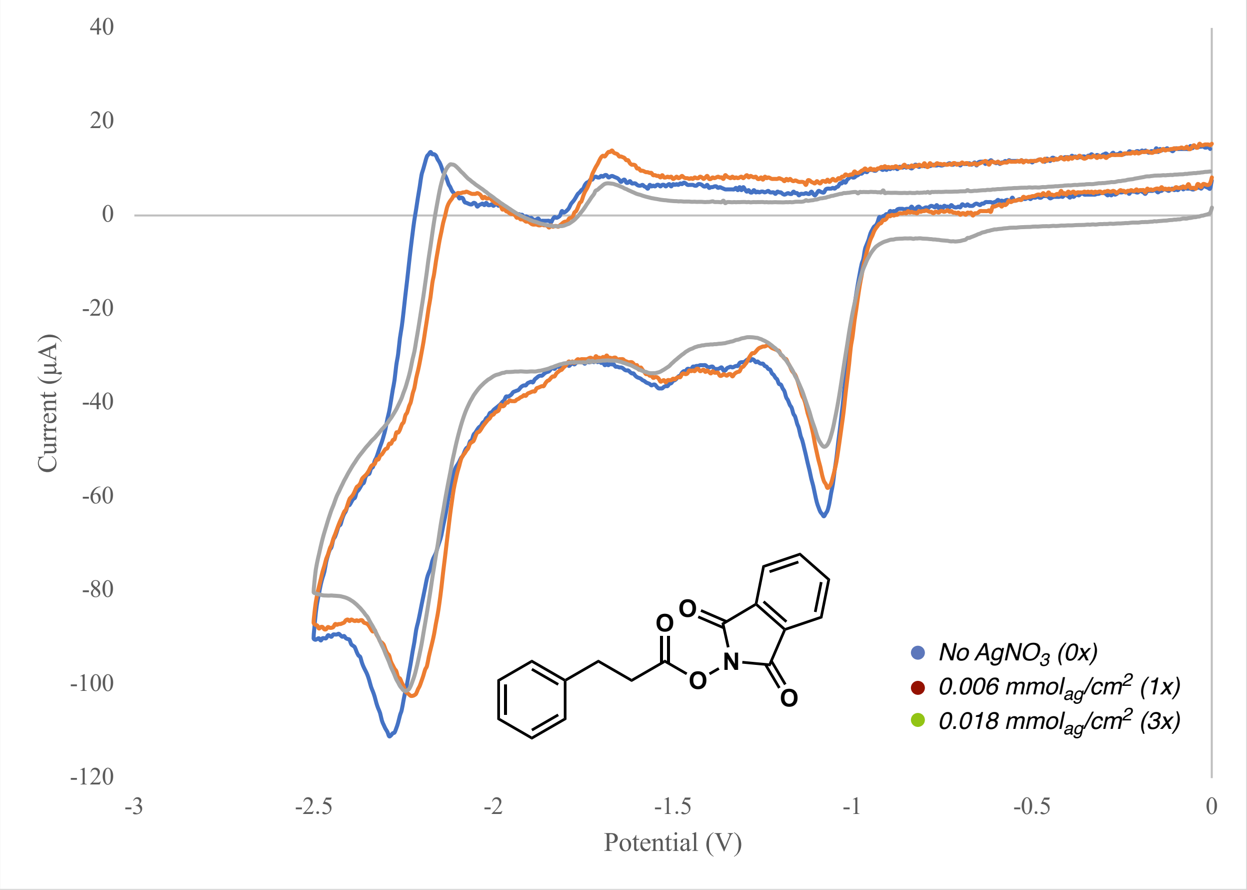


Fig S62 — CV's of RAE 7 on bare glassy carbon

Cyclic voltammograms of 5mM 7 on bare glassy carbon.

*Notes: Analyte: 5 mM Redox Active Ester **(7)**, bare glassy carbon disk electrode.*

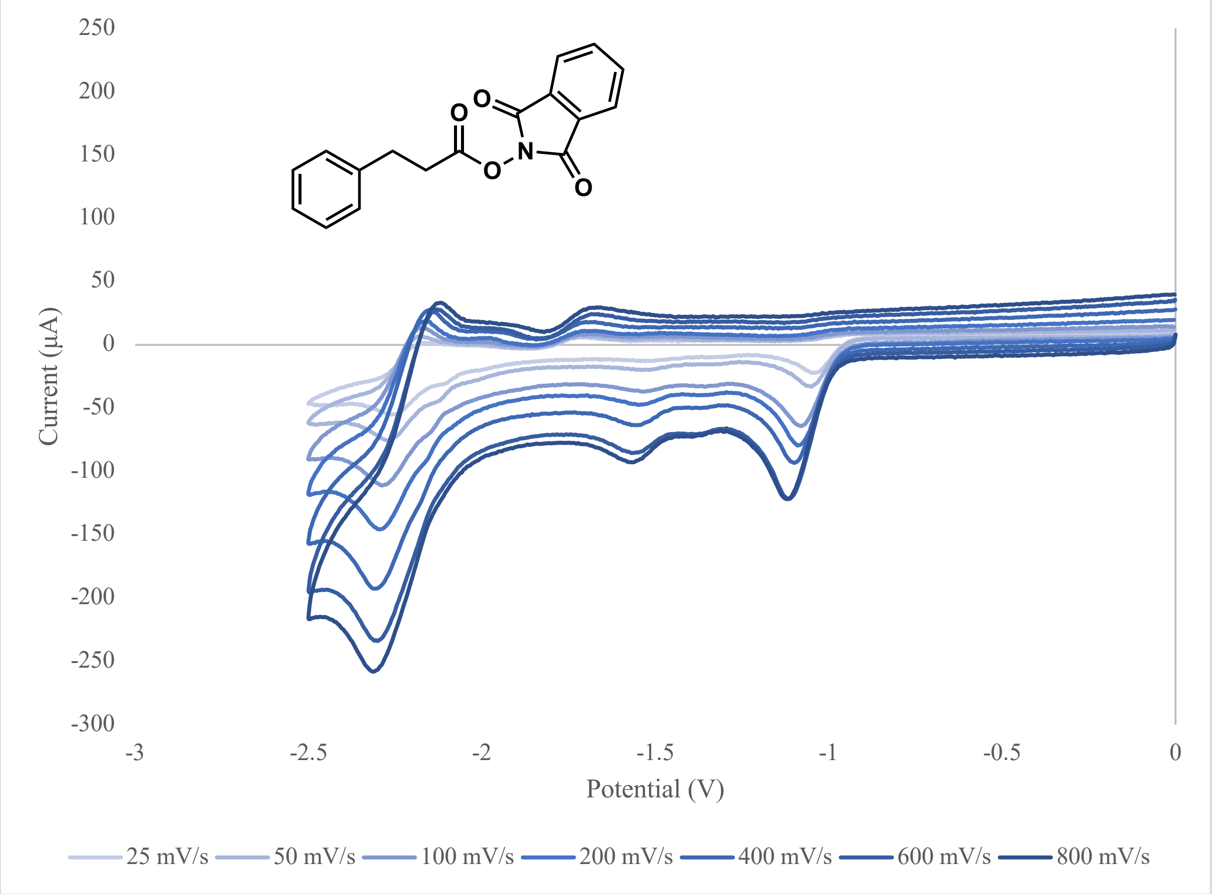


Fig S63 — CV's of RAE 7 on glassy carbon with 0.006 $mmol_{Ag}/cm^2$ Ag

Cyclic voltammograms of 5 mM 7 on glassy carbon with 1x silver loading (0.006 $mmol_{Ag}/cm^2$*).*

Notes: Analyte: 5 mM Redox Active Ester ***(7)****. 0.006* $mmol_{Ag}/cm^2$ *Ag coverage.*

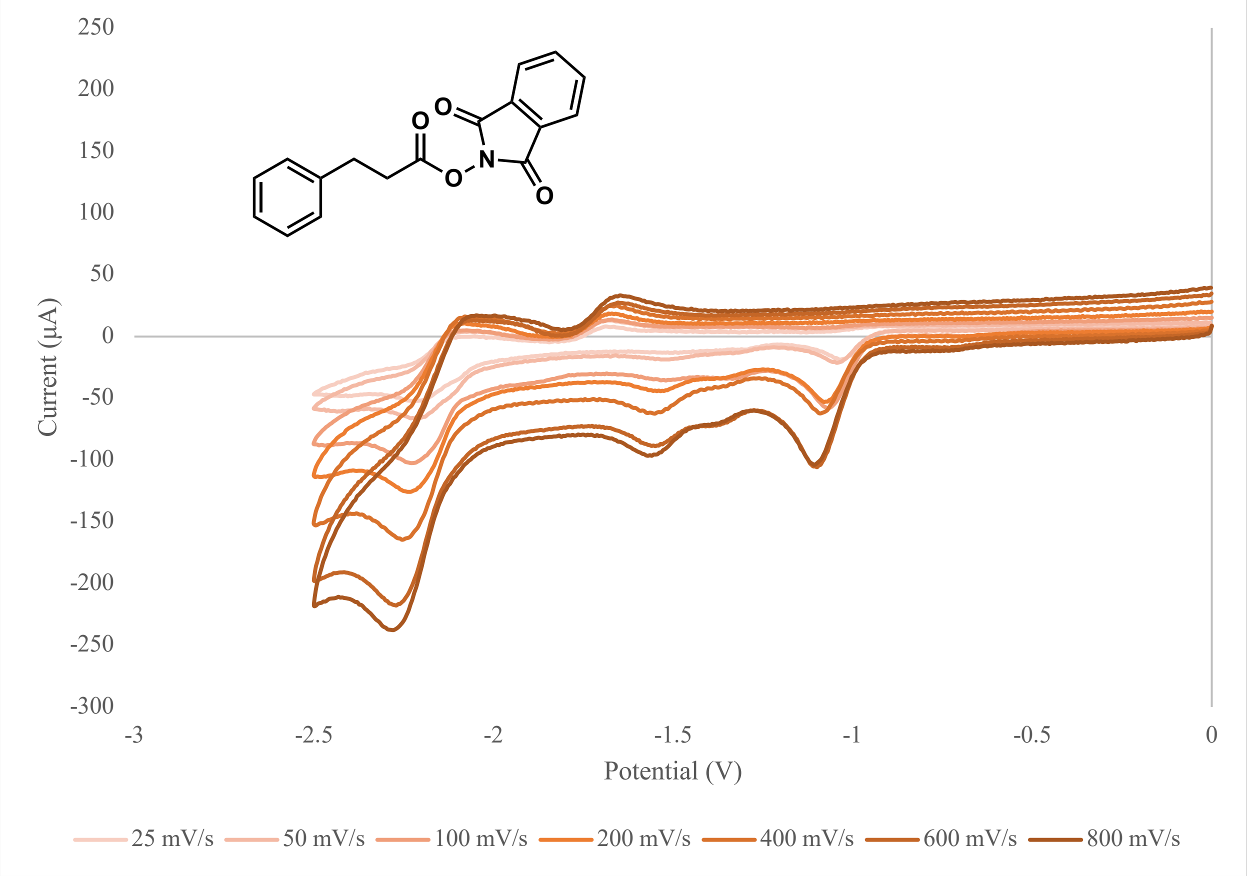


Fig S64 — CV's of RAE 7 on glassy carbon with 0.018 mmol$_{Ag}$/cm^2 Ag

Cyclic voltammograms of 7 on bare glassy carbon with 3x silver loading (0.018 mmol$_{Ag}$/m^2).

*Notes: Analyte: 5 mM Redox Active Ester **(7)**. 0.018 mmol$_{Ag}$/m^2 Ag coverage.*

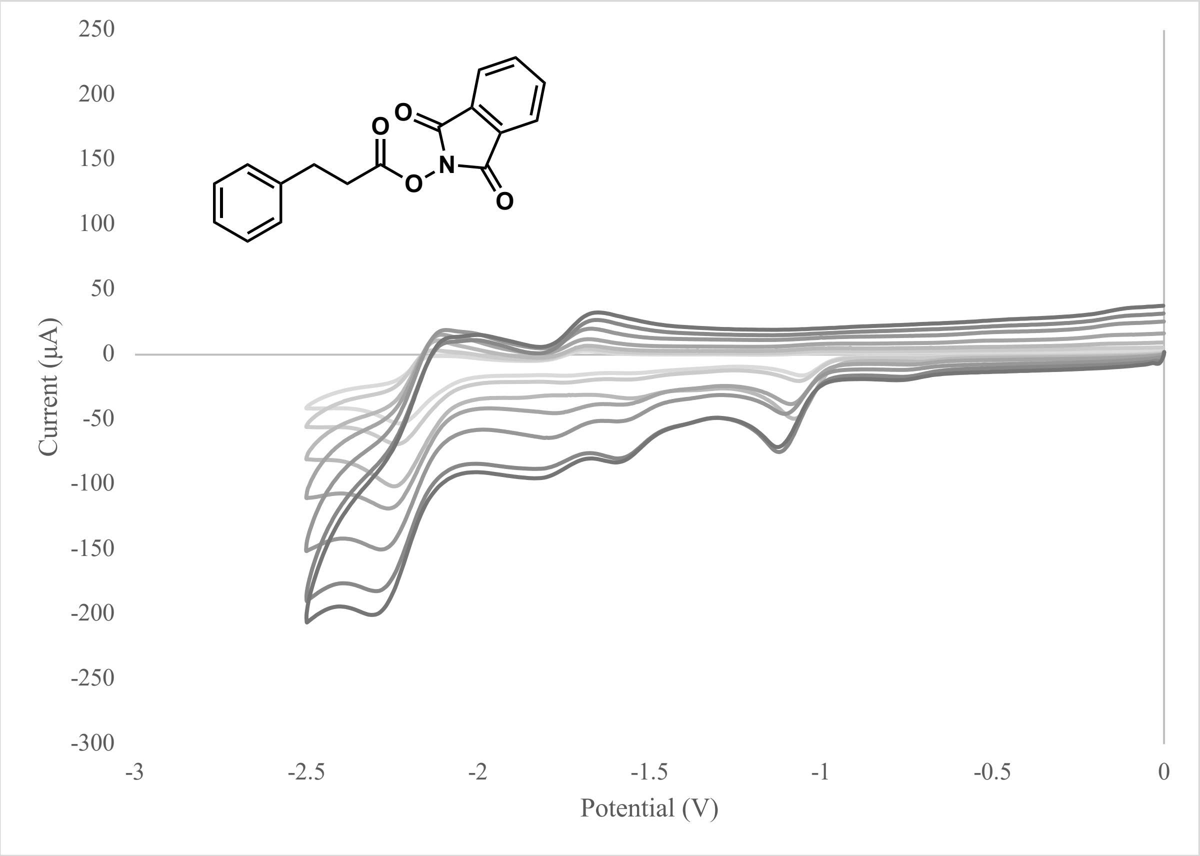


Fig S65 — CV's of (bpy)NiCl(Mes) on glassy carbon with various Ag-NP coverage

Cyclic voltammograms of 5mM (bpy)NiCl(Mes) *on bare glassy carbon (blue), 0.006 mmol*$_{Ag}$*/cm*^{2} *(red), and 0.018 mmol*$_{Ag}$*/cm*^{2} *(green) at 100 mV/s.*

Notes: Analyte: 5 mM (bpy)NiCl(Mes).

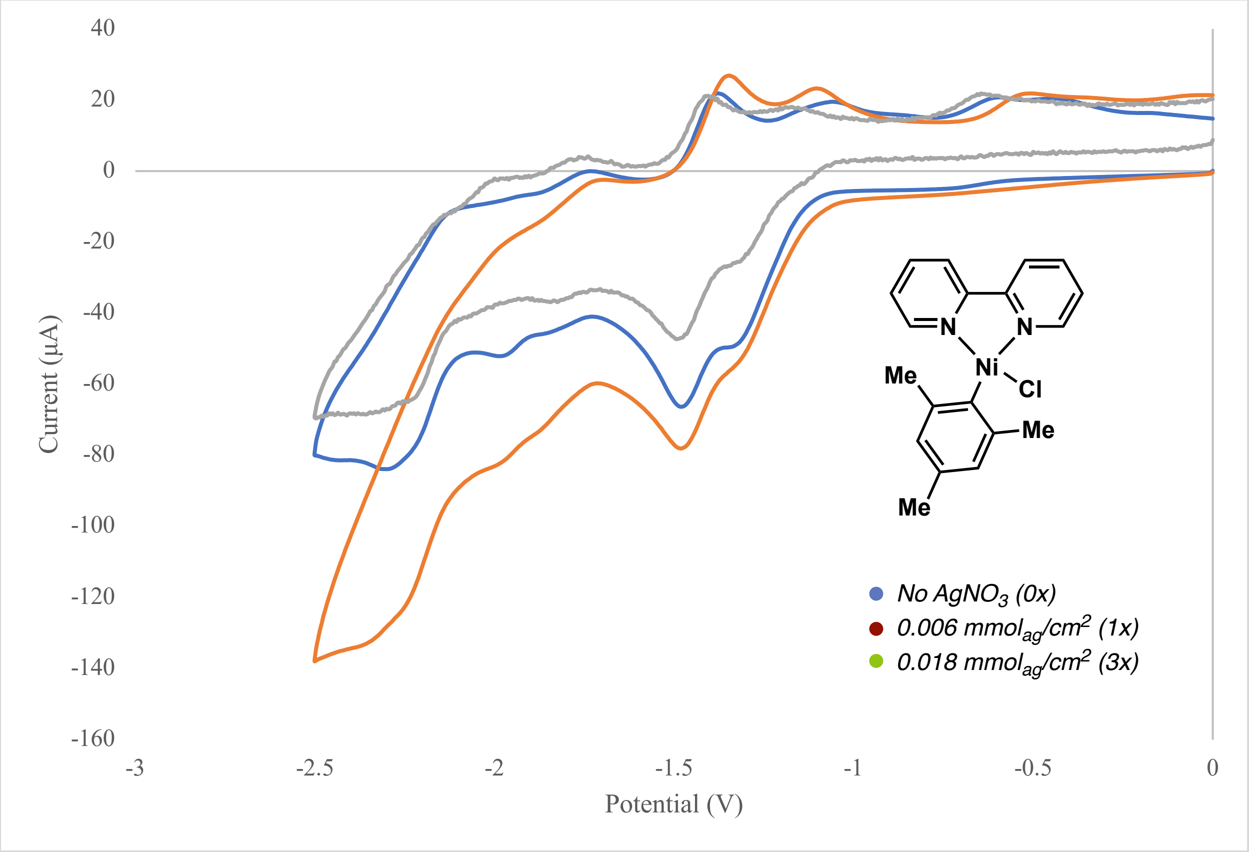


Fig S66 — CV's of nickel complex (bpy)NiCl(Mes) on bare glassy carbon

Cyclic voltammograms of 5mM (bpy)NiCl(Mes) *on bare glassy carbon.*

Notes: Analyte: 5 mM (bpy)NiCl(Mes). *Bare glassy carbon disk electrode.*

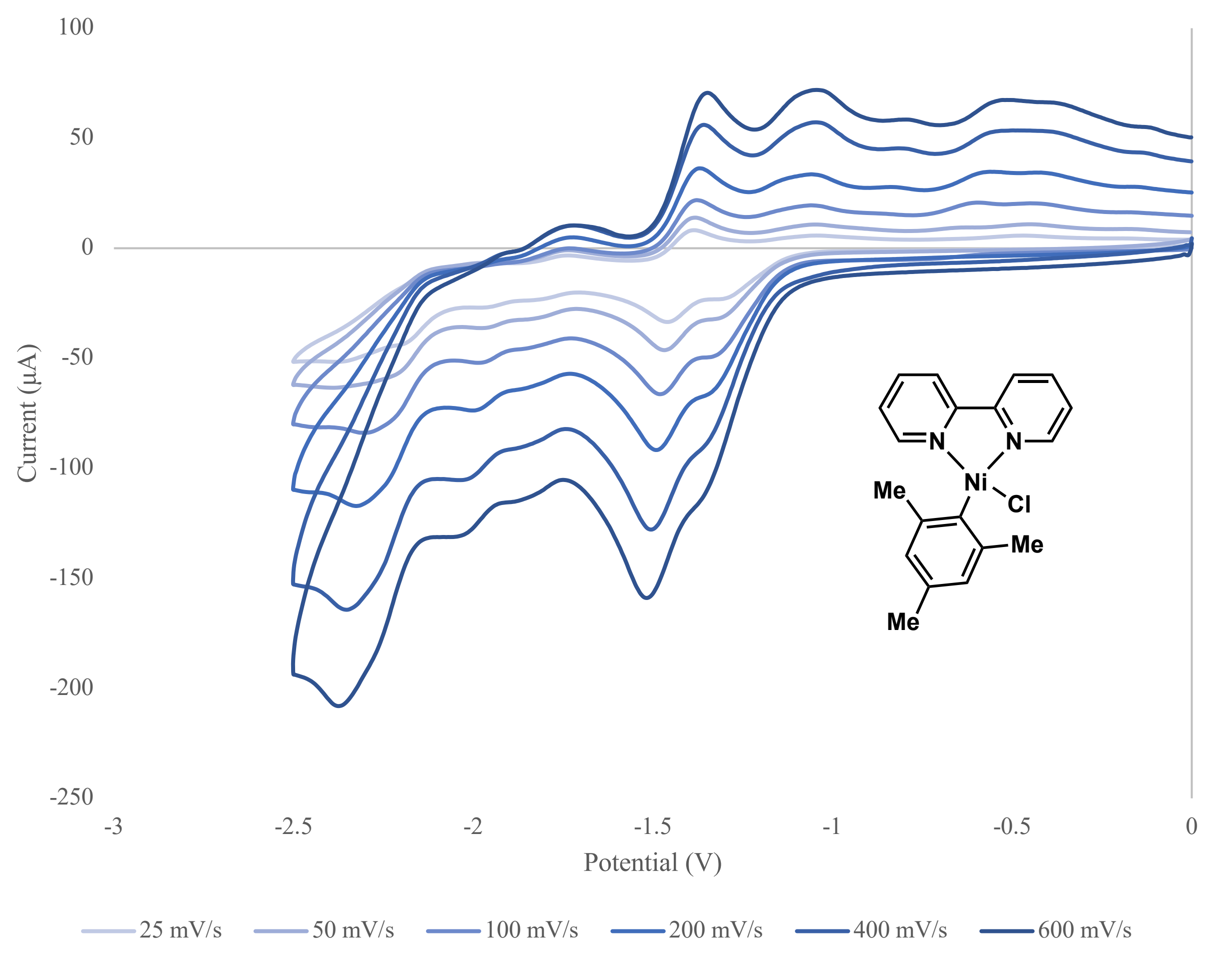


Fig S67 — CV's of nickel complex (bpy)NiCl(Mes) on glassy carbon with 0.006 mmol$_{Ag}$/cm^2 Ag

Cyclic voltammograms of 5mM (bpy)NiCl(Mes) *on glassy carbon with 1x silver loading (0.006 mmol$_{Ag}$/cm^2).*

Notes: Analyte: 5 mM (bpy)NiCl(Mes). *0.006 mmol$_{Ag}$/cm^2 Ag coverage.*

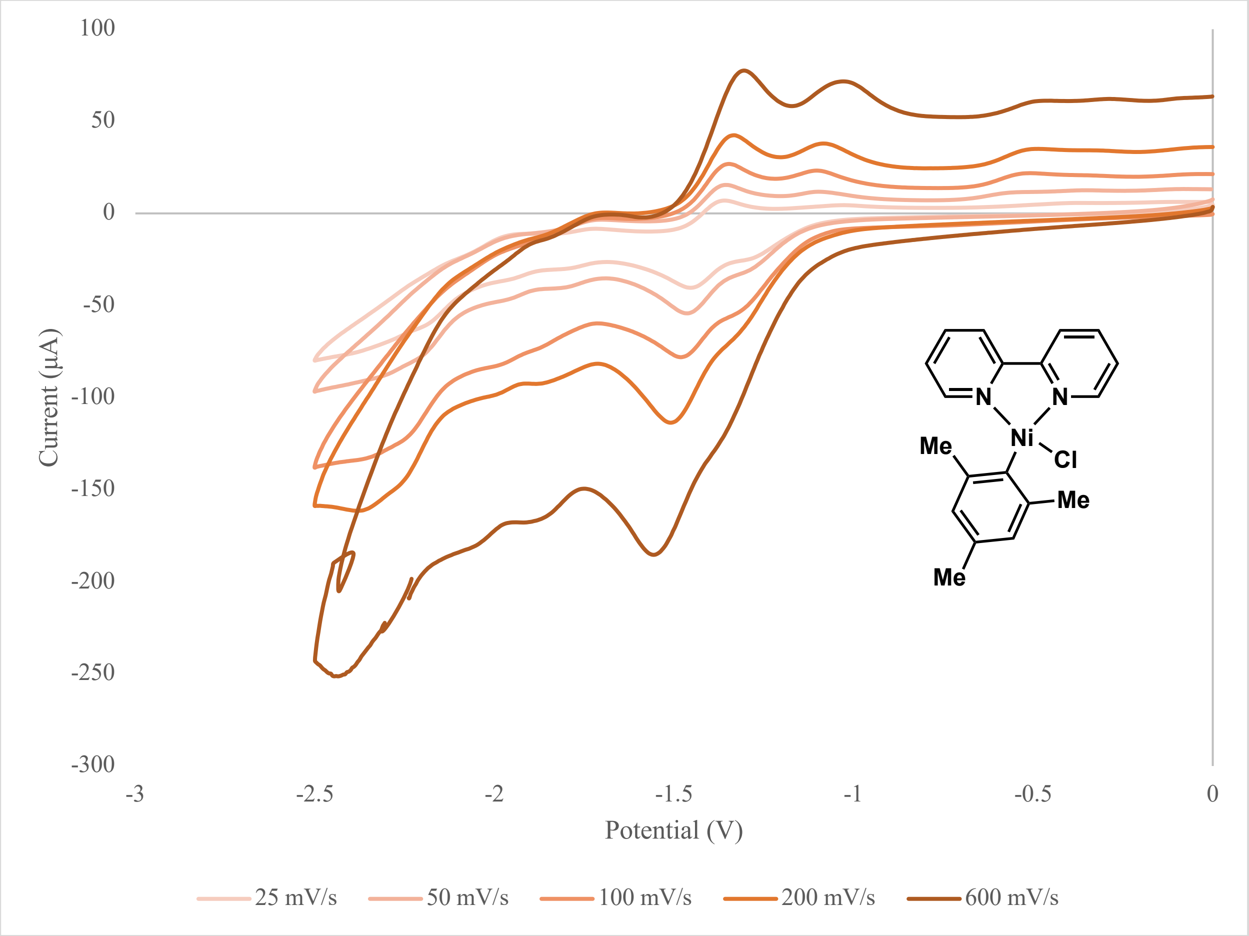
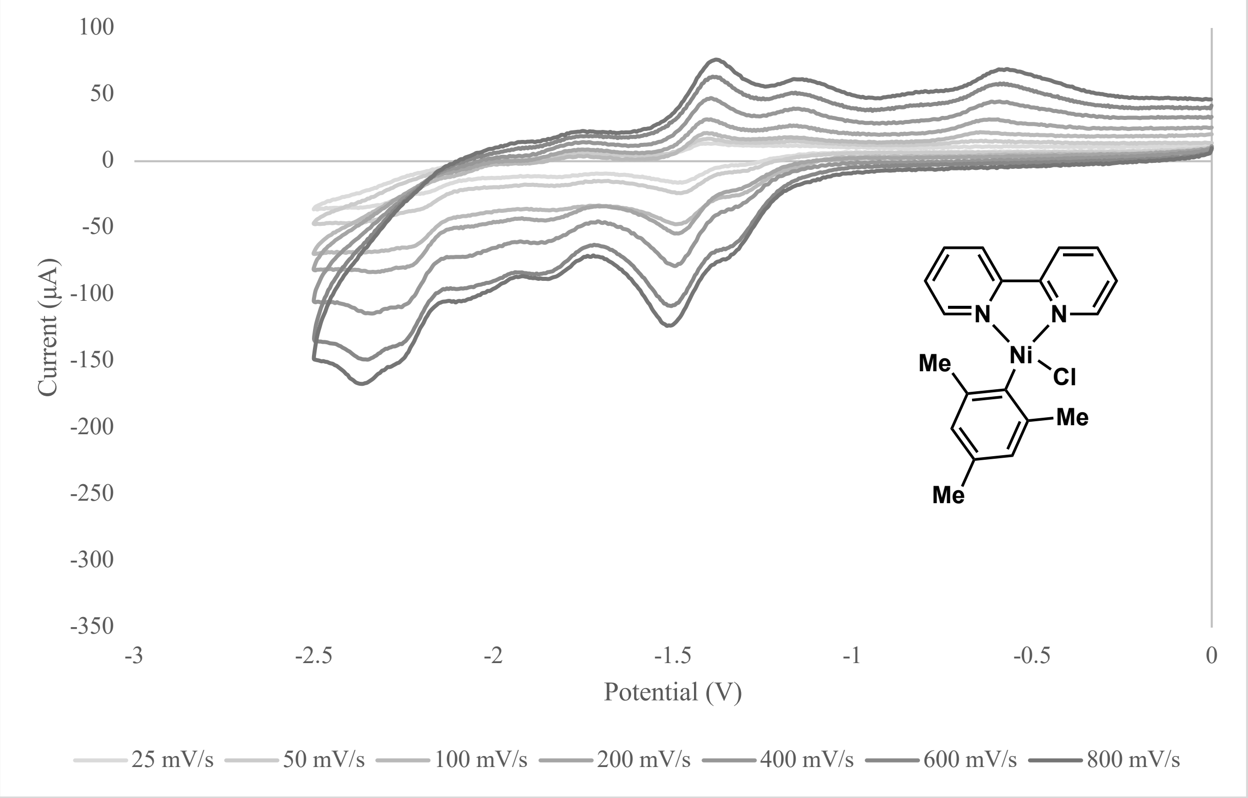


Fig S68 — CV's of nickel complex (bpy)NiCl(Mes) on glassy carbon with 0.018 mmol$_{Ag}$/cm^2 Ag

Cyclic voltammograms of 5mM (bpy)NiCl(Mes) *on glassy carbon with 3x silver loading (0.018 mmol$_{Ag}$/cm^2).*

Notes: Analyte: 5 mM (bpy)NiCl(Mes). *0.018 mmol$_{Ag}$/cm^2 Ag coverage.*



Combination Voltammograms

Fig S69 — CV of $NiCl_2·6H_2O$, 2,2’-bpy and RAE 7 on bare glassy carbon

Cyclic voltammograms of 5 mM $NiCl_2·6H_2O$ + 5 mM 2,2’-bpy and 5 mM RAE (7) on bare glassy carbon.

Notes: Analyte Combination: 5 mM $NiCl_2·6H_2O$ + 5 mM 2,2’-bpy + 5 mM RAE (7)

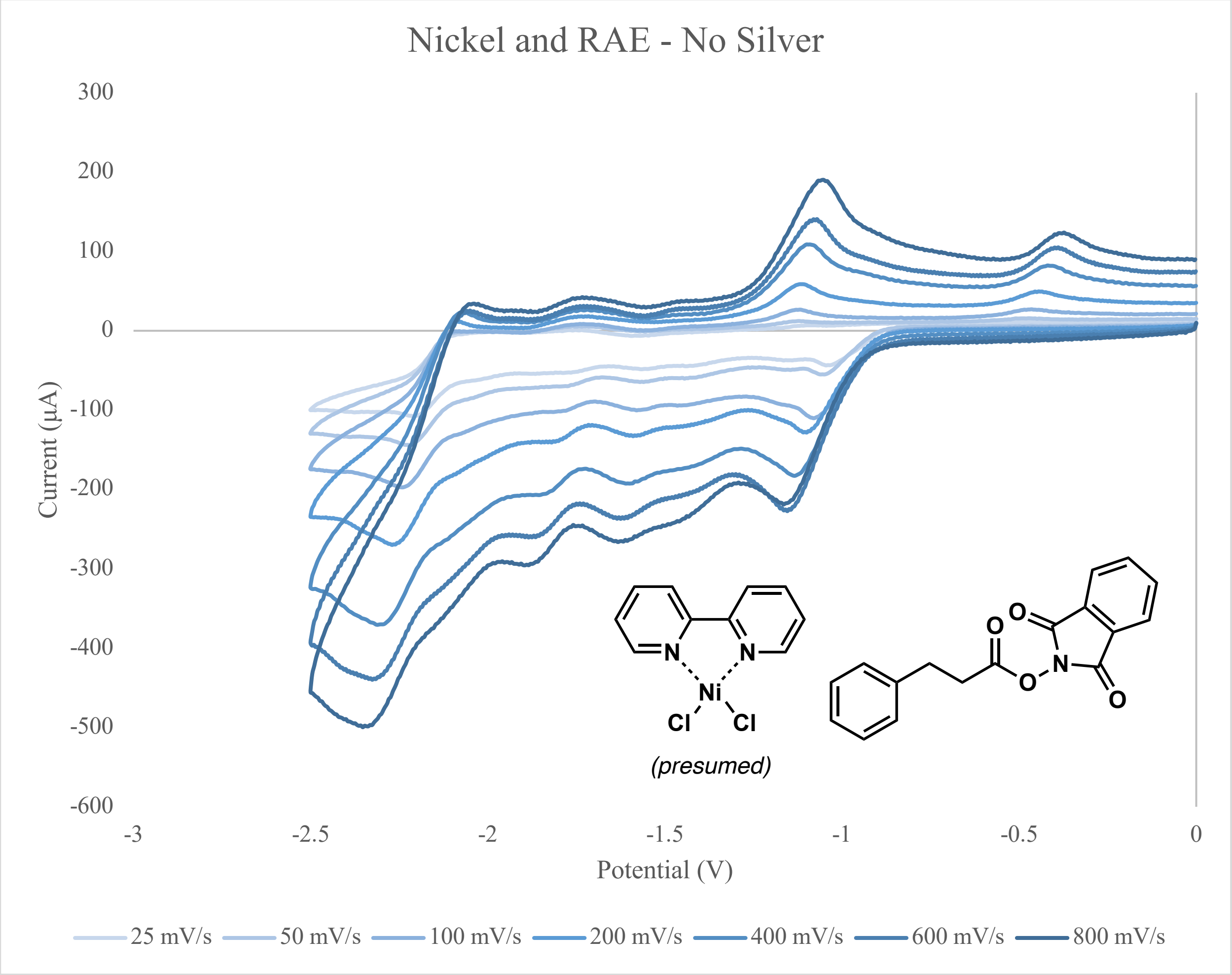


Fig S70 — CV of $NiCl_2 \cdot 6H_2O$, 2,2’-bpy and RAE 7 on glassy carbon with 0.006 $mmol_{Ag}/cm^2$ Ag

Cyclic voltammograms of 5 mM $NiCl_2 \cdot 6H_2O$ + 5 mM 2,2’-bpy and 5 mM RAE (7) on glassy carbon with 1x silver loading (0.006 $mmol_{Ag}/cm^2$).

Notes: 5 mM $NiCl_2 \cdot 6H_2O$ + 5 mM 2,2’-bpy and 5 mM RAE (7)). 0.006 $mmol_{Ag}/cm^2$ Ag coverage

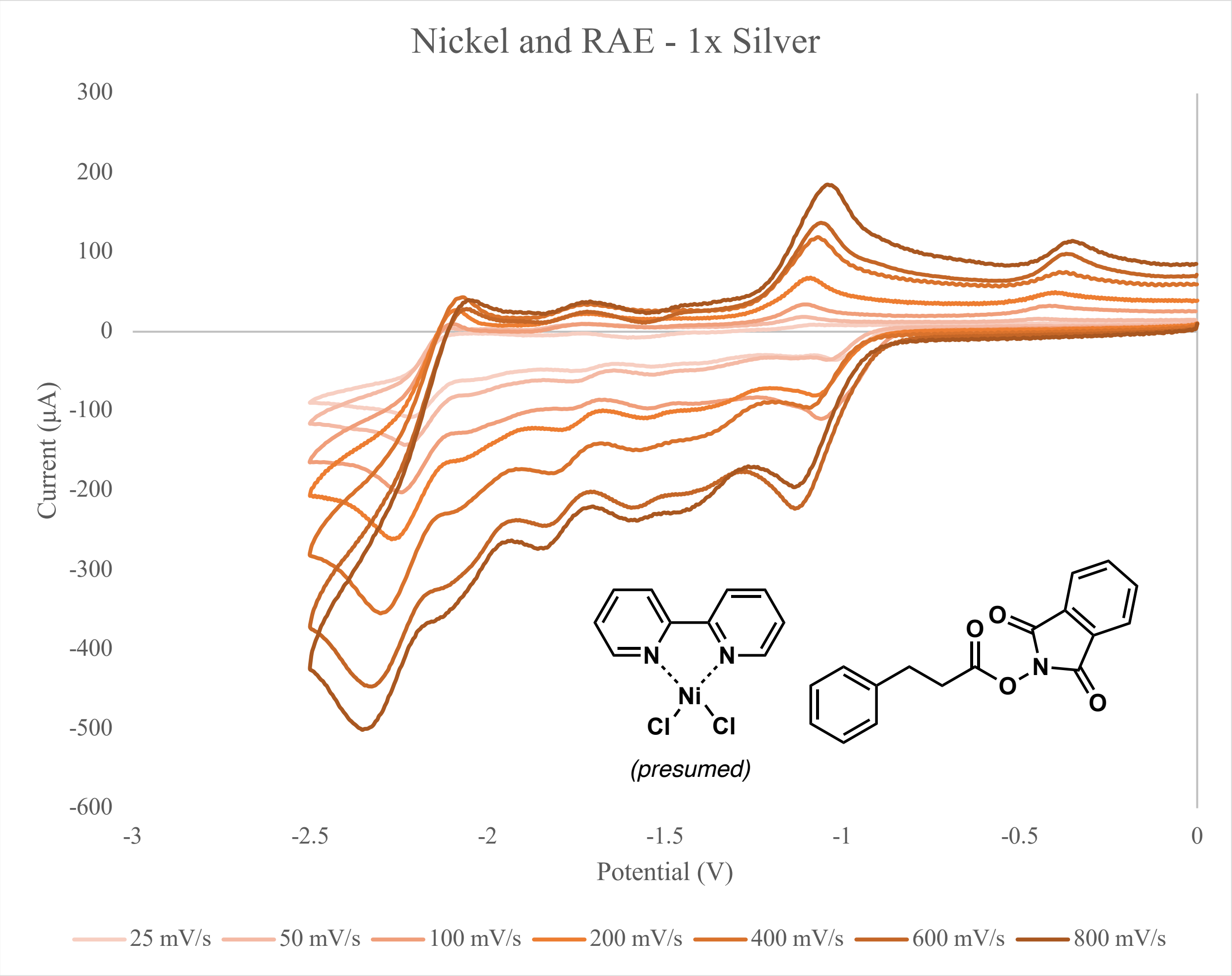


Fig S71 — CV of $NiCl_2·6H_2O$, 2,2’-bpy and RAE 7 on glassy carbon with 0.018 $mmol_{Ag}/cm^2$ Ag

Cyclic voltammograms 5 mM $NiCl_2·6H_2O$ + 5 mM 2,2’-bpy and 5 mM RAE (7) on glassy carbon with 3x silver loading (0.018 $mmol_{Ag}/cm^2$).

Notes: 5 mM $NiCl_2·6H_2O$ + 5 mM 2,2’-bpy and 5 mM RAE (7). 0.018 $mmol_{Ag}/cm^2$ Ag coverage

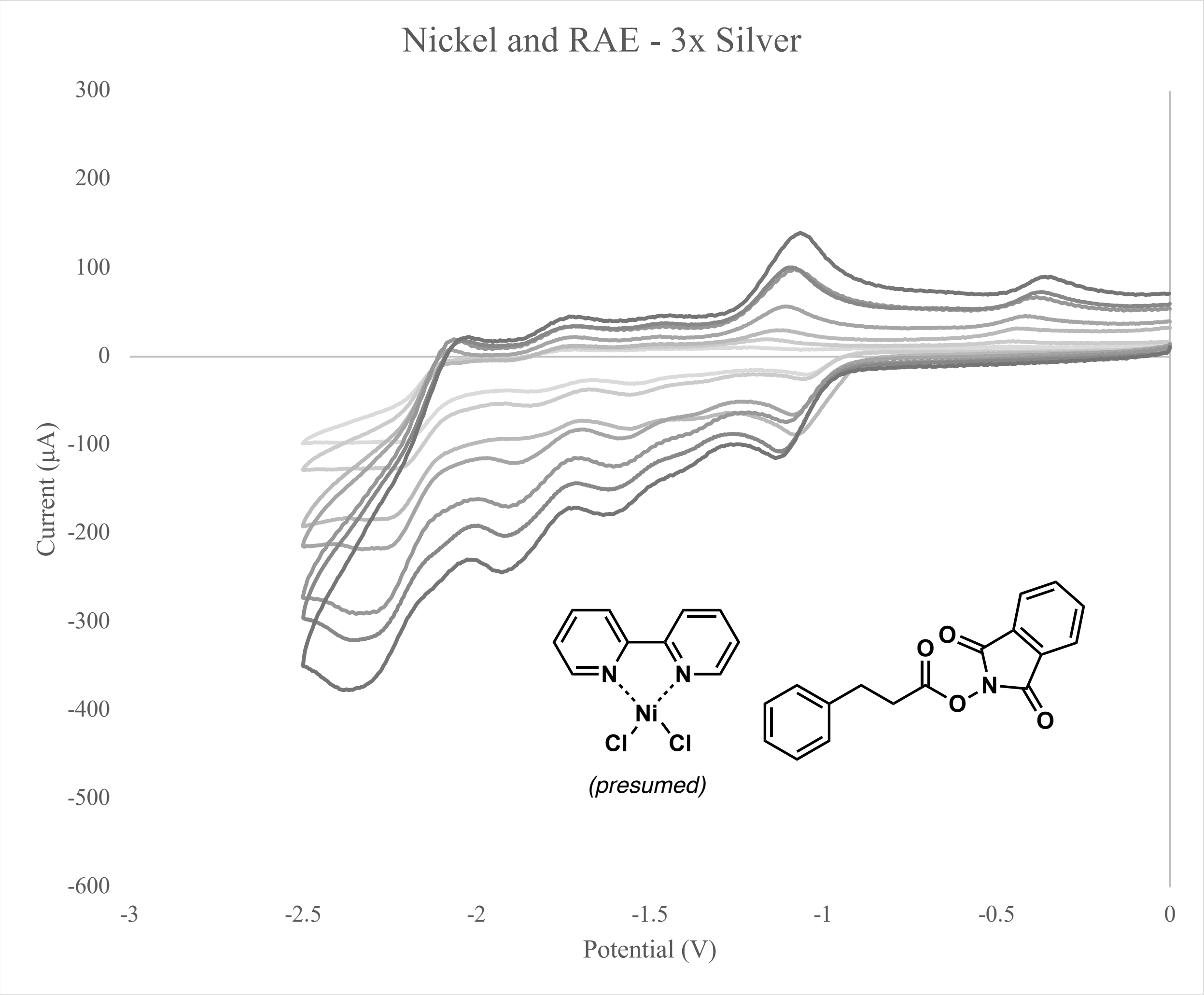


Fig S72 — CV of $NiCl_2 \cdot 6H_2O$, 2,2’-bpy and iodide 5 on bare glassy carbon

Cyclic voltammograms of 5 mM $NiCl_2 \cdot 6H_2O$ + 5 mM 2,2’-bpy + 5 mM vinyl iodide ***5*** *on bare glassy carbon.*

Notes: Analyte Combination: 5 mM $NiCl_2 \cdot 6H_2O$ + 5 mM 2,2’-bpy + 5 mM vinyl iodide ***5****. Bare glassy carbon electrode.*

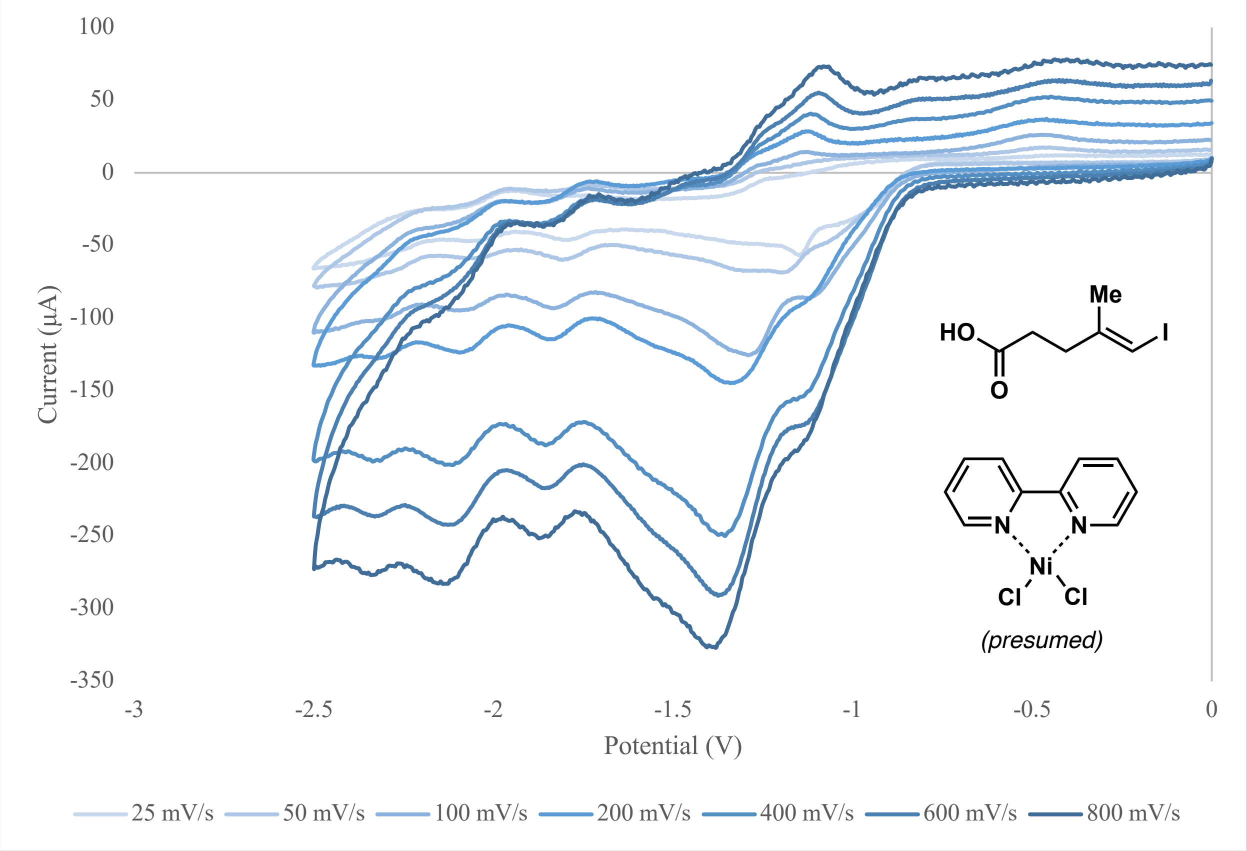


Fig S73 — CV of $NiCl_2 \cdot 6H_2O$, 2,2'-bpy and iodide 5 on glassy carbon with 0.006 $mmol_{Ag}/cm^2$ Ag

Cyclic voltammograms of 5 mM $NiCl_2 \cdot 6H_2O$ *+ 5 mM 2,2'-bpy + 5 mM vinyl iodide* ***5*** *on glassy carbon with 1x silver loading (0.006* $mmol_{Ag}/m^2$*).*

Notes: 5 mM $NiCl_2 \cdot 6H_2O$ *+ 5 mM 2,2'-bpy + 5 mM vinyl iodide* ***5****. 0.006* $mmol_{Ag}/m^2$ *Ag coverage*

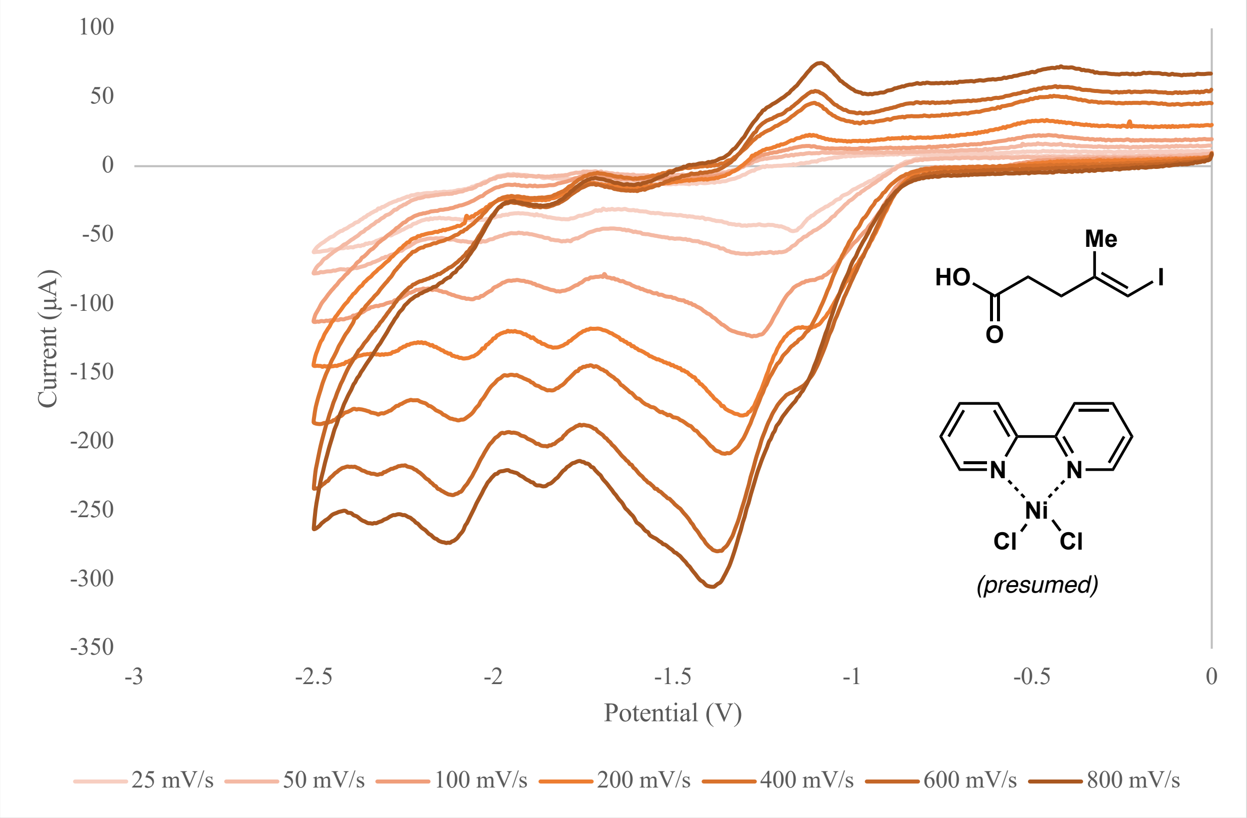


Fig S74 — CV of $NiCl_2\cdot 6H_2O$, 2,2’-bpy and iodide 5 on glassy carbon with 0.018 $mmol_{Ag}/cm^2$ Ag

*Cyclic voltammograms of 5 mM $NiCl_2\cdot 6H_2O$ + 5 mM 2,2’-bpy + 5 mM vinyl iodide (**5**) on glassy carbon with 3x silver loading (0.018 $mmol_{Ag}/m^2$).*

*Notes5 mM $NiCl_2\cdot 6H_2O$ + 5 mM 2,2’-bpy + 5 mM vinyl iodide (**5**). 0.018 $mmol_{Ag}/m^2$ Ag coverage*

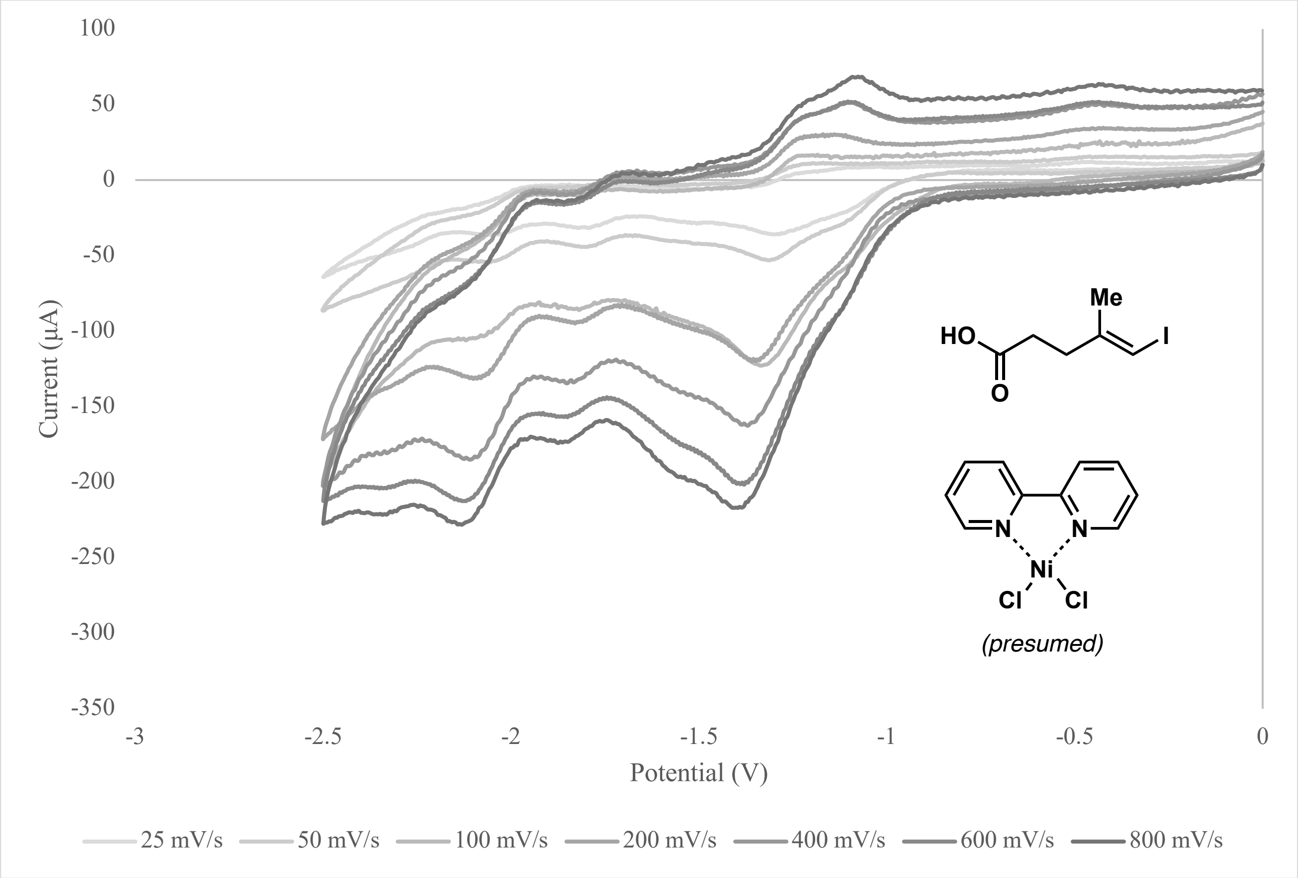


Fig S75 — CV of (bpy)NiCl(Mes) and RAE 7 on bare glassy carbon

Cyclic voltammograms 5 mM (bpy)NiCl(Mes) + 5 mM RAE (7) on bare glassy carbon.

Notes: Analyte Combination: 5 mM (bpy)NiCl(Mes) + 5 mM RAE (7). Bare Glassy carbon disk electrode.

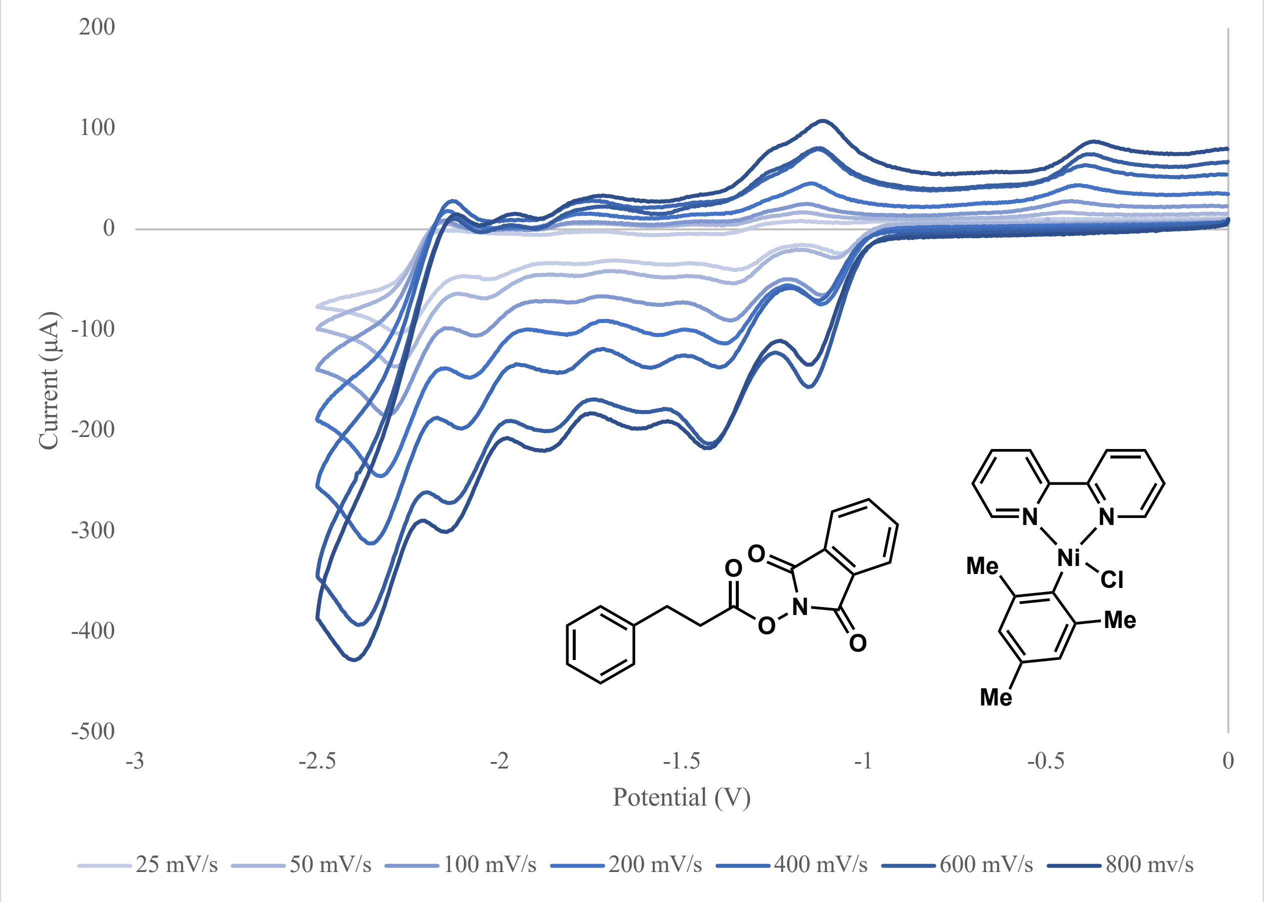


Fig S76 — CV of (bpy)NiCl(Mes) and RAE 7 on glassy carbon with 0.006 mmol$_{Ag}$/cm^2 Ag

Cyclic voltammograms 5 mM (bpy)NiCl(Mes) + 5 mM RAE (7) on glassy carbon with 1x silver loading (0.006 mmol$_{Ag}$/m^2).

Notes: 5 mM (bpy)NiCl(Mes) + 5 mM RAE (7). 0.006 mmol$_{Ag}$/m^2 Ag coverage

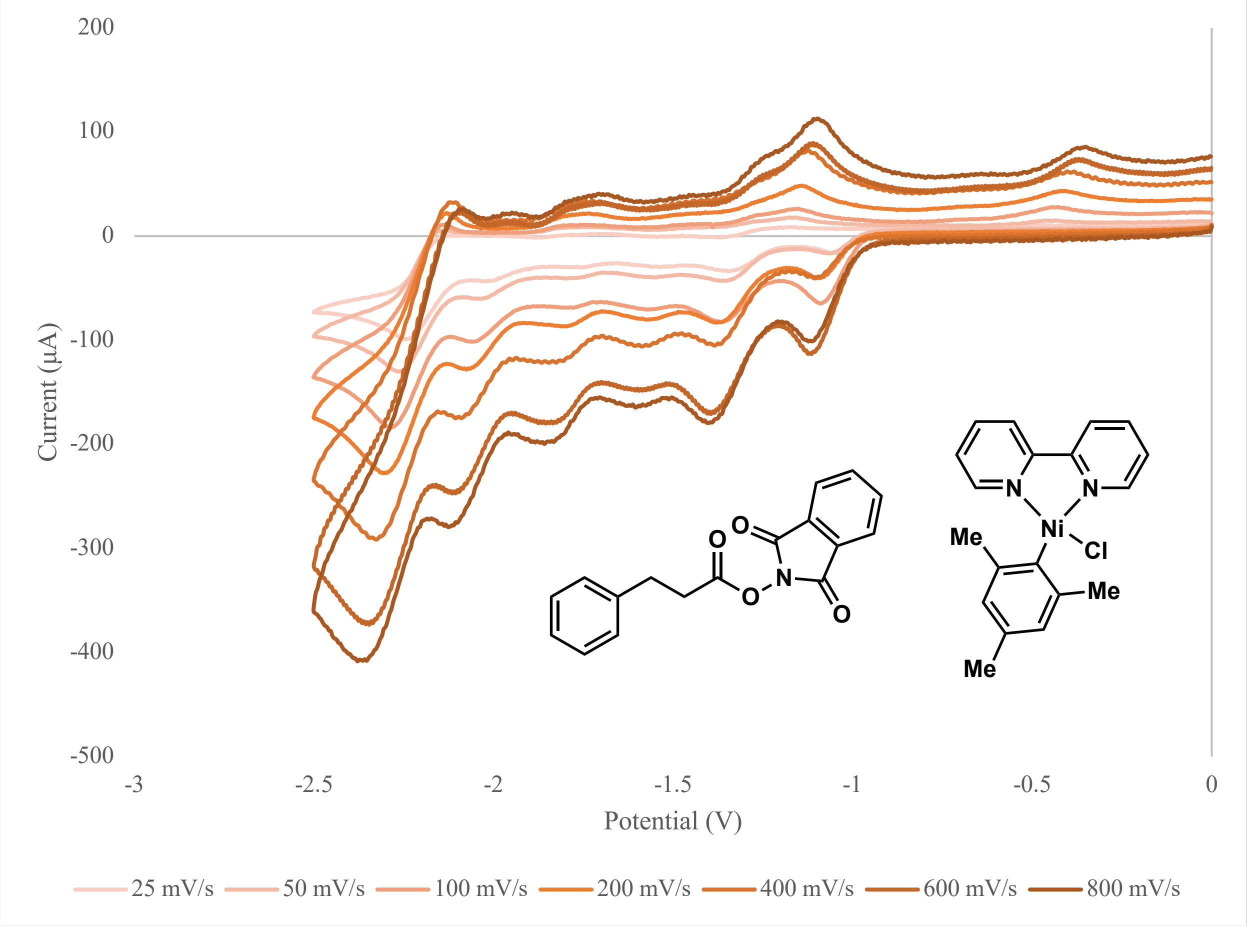
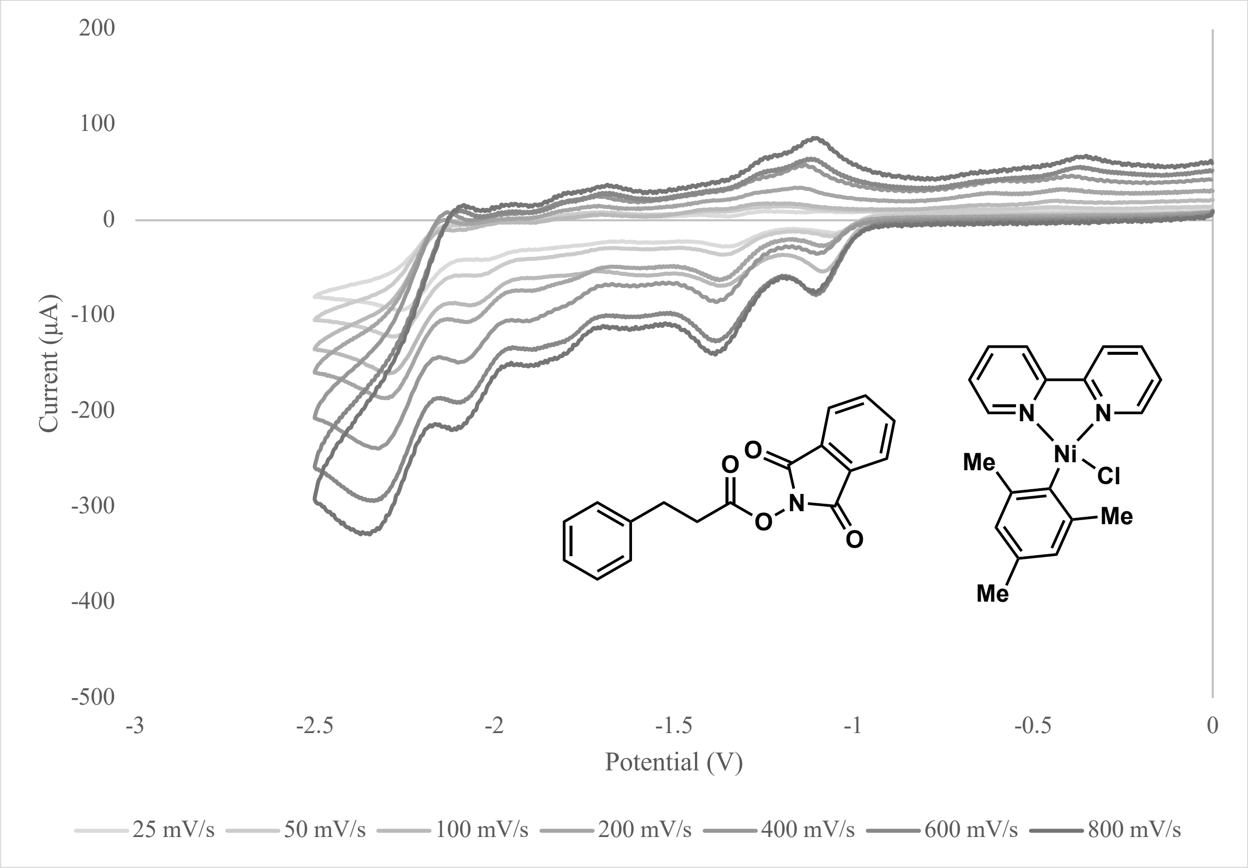


Fig S77 — CV of (bpy)NiCl(Mes) and RAE 7 on glassy carbon with 0.018 mmol$_{Ag}$/cm^2 Ag

Cyclic voltammograms of 5 mM (bpy)NiCl(Mes) + 5 mM RAE (7) on glassy carbon with 3x silver loading (0.018 mmol$_{Ag}$/m^2).

Notes: 5 mM (bpy)NiCl(Mes) + 5 mM RAE (7). 0.018 mmol$_{Ag}$/m^2 Ag coverage



Rotating Disk Electrode Voltammetry

Cyclic voltammetry and rotating disk electrode (RDE) experiments were performed using a three electrode configuration in a glass three-compartment cell with medium porosity glass frits. A homemade 2 mm glassy carbon electrode was used as the working electrode, a homemade Ag/AgCl electrode served as the reference electrode (E = –0.53 V vs. Fc/Fc$^+$), and a coiled Pt wire served as the counter electrode. Before beginning electrochemical measurements, the glassy carbon electrode was polished with diamond paste and MetaDi Fluid, unless otherwise noted. The electrolyte solution for all experiments was 0.1 M TBAPF$_6$ in DMF. Prior to experimentation, the solution was thoroughly purged with Ar gas to remove all dissolved oxygen. Electrochemical measurements were performed with a Biologic SP150 potentiostat. RDE experiments were run with using a Pine Instruments rotator. For electrochemical measurements involving the Ag nanoparticle modified electrode, the coating procedure (Table **S49**) was used to produce a 0.012 mmol$_{Ag}$/cm^2 film.

Fig S78—RDE voltammograms of NiCl$_2$·6H2O + 2,2'-bpy on bare glassy carbon

RDE voltammograms 5 mM NiCl$_2$·6H$_2$O + 5 mM 2,2'-bpy on bare glassy carbon taken over 5 cycles in DMF with 0.1 M TBAPF$_6$ supporting electrolyte at a rotation rate of 1600 rpm and a scan rate of 10 mV/s

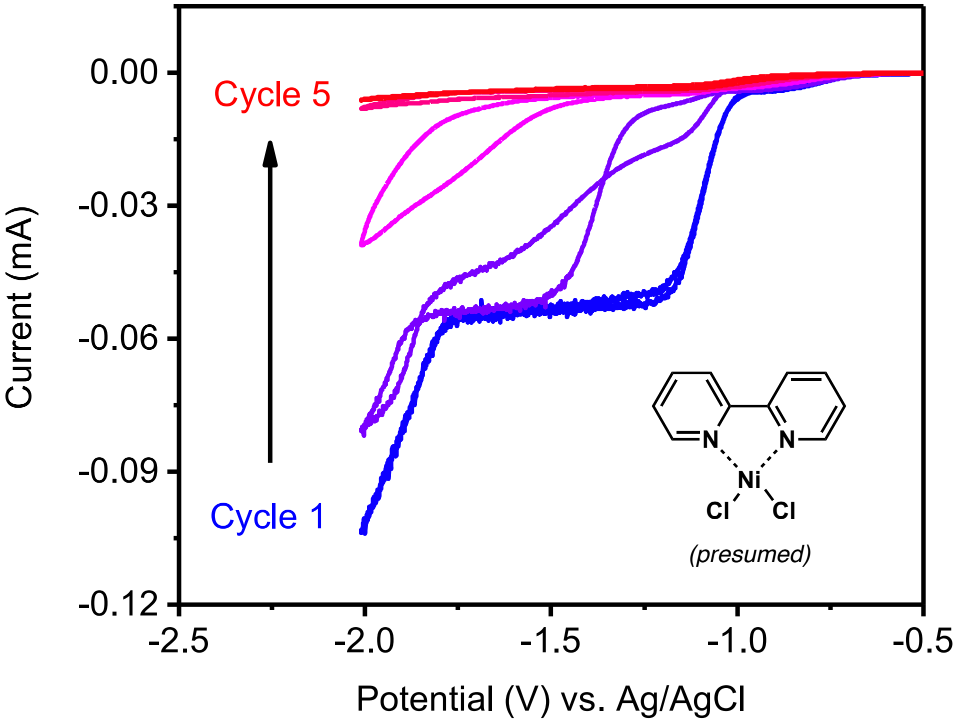


Fig S79—RDE voltammograms of $NiCl_2·6H2O$ on bare glassy carbon

RDE voltammograms 5 mM $NiCl_2·6H_2O$ on bare glassy carbon taken over 5 cycles in DMF with 0.1 M $TBAPF_6$ supporting electrolyte at a rotation rate of 1600 rpm and a scan rate of 10 mV/s.

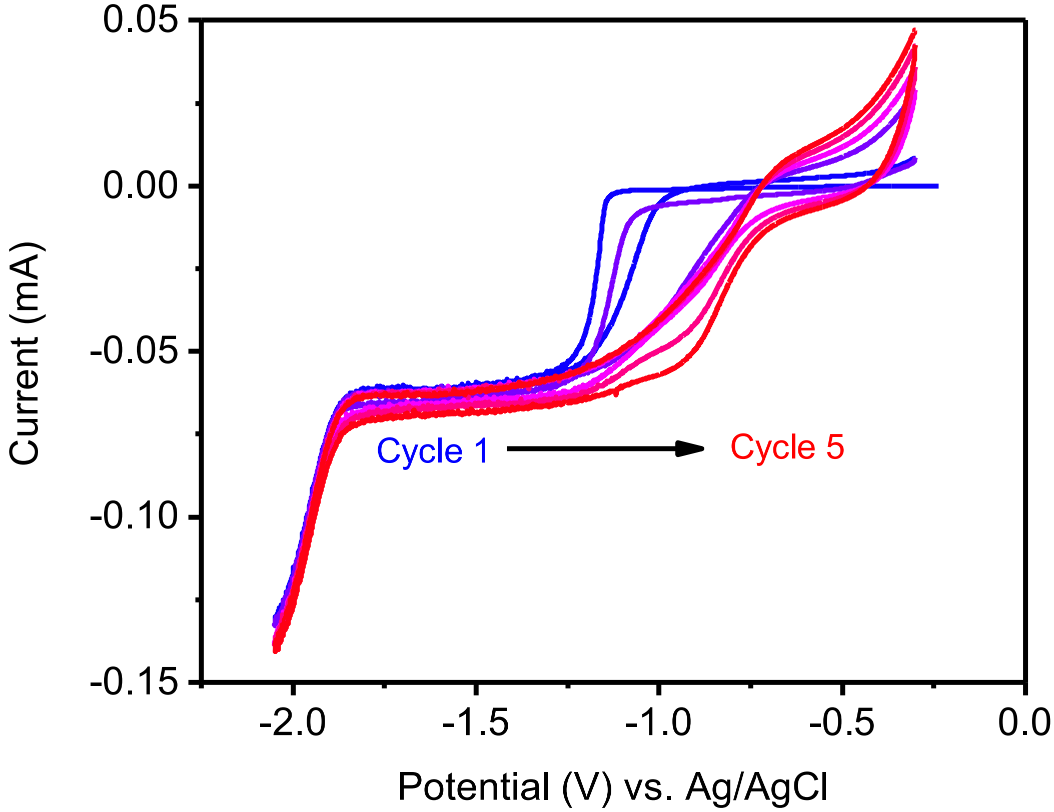


Fig S80—RDE voltammograms of 2,2'-bypridine on bare glassy carbon

RDE voltammograms 5 mM 2,2'-bpy on bare glassy carbon taken over 5 cycles in DMF with 0.1 M $TBAPF_6$ supporting electrolyte at a rotation rate of 1600 rpm and a scan rate of 10 mV/s.

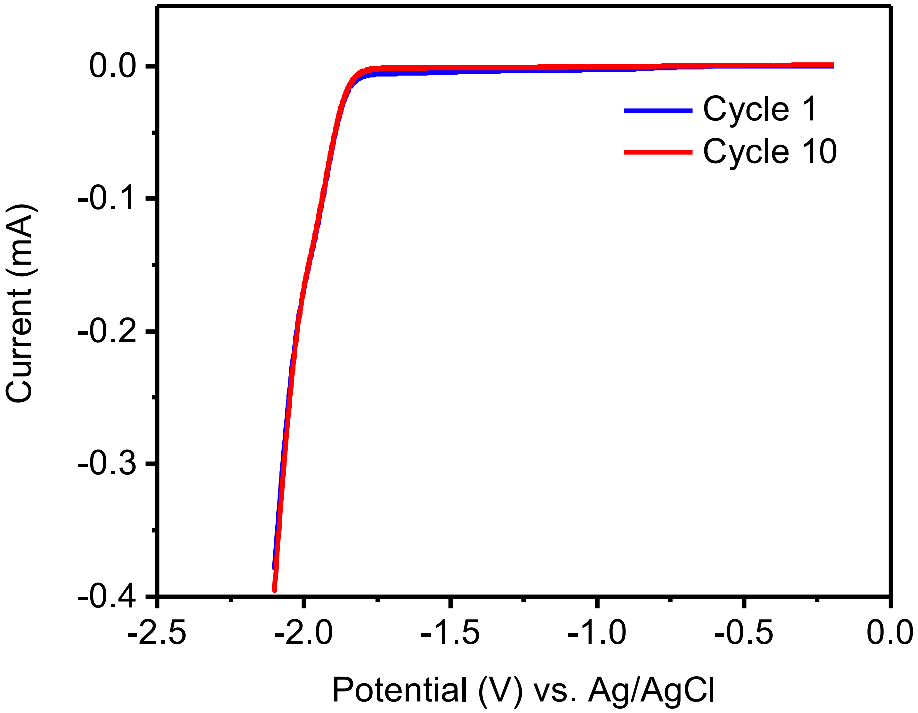


Fig S81—RDE voltammograms of $NiCl_2{\cdot}6H2O$ + 2,2’-bpy on glassy carbon with 0.012 $mmol_{Ag}/cm^2$ Ag

RDE voltammograms 5 mM $NiCl_2{\cdot}6H_2O$ + 5 mM 2,2’-bpy on glassy carbon with with 0.012 $mmol_{Ag}/cm^2$ Ag taken over 5 cycles in DMF with 0.1 M $TBAPF_6$ supporting electrolyte at a rotation rate of 1600 rpm and a scan rate of 10 mV/s

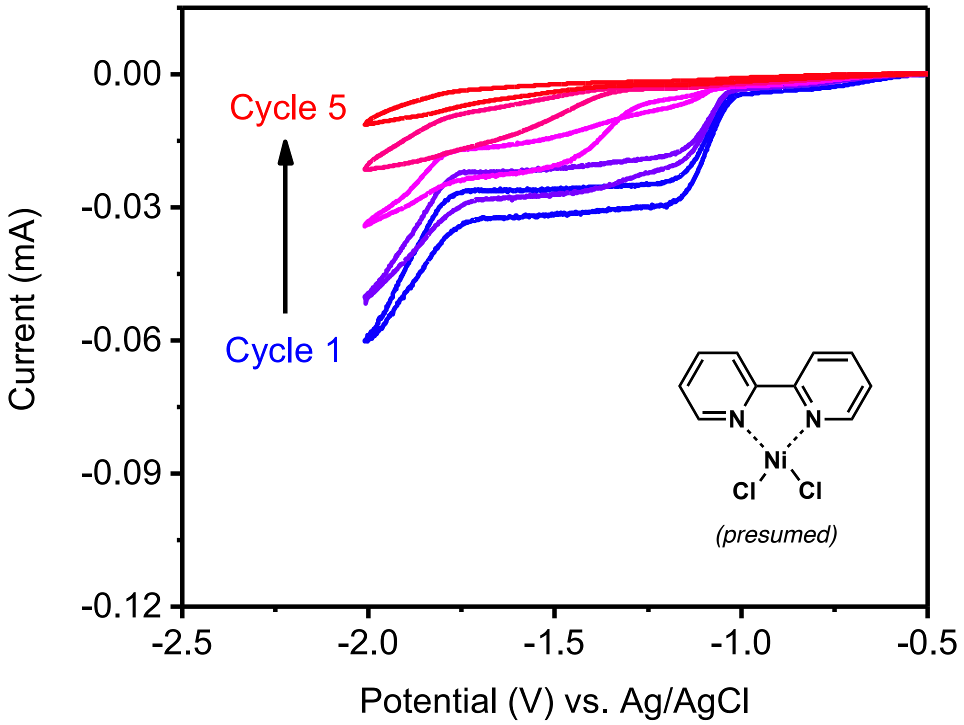


Fig S82—RDE voltammograms of $NiCl_2 \cdot 6H2O$ + 2,2'-bpy on glassy carbon with reactivation by anodic stripping.

RDE voltammograms 5 mM $NiCl_2 \cdot 6H_2O$ + 5 mM 2,2'-bpy on glassy carbon taken over 8 cycles in DMF with 0.1 M $TBAPF_6$ supporting electrolyte at a rotation rate of 1600 rpm and a scan rate of 10 mV/s

After the 5th cycle, a +1.5V potential was run for 3 minutes. The electrode was then run through 3 cycles as described above.

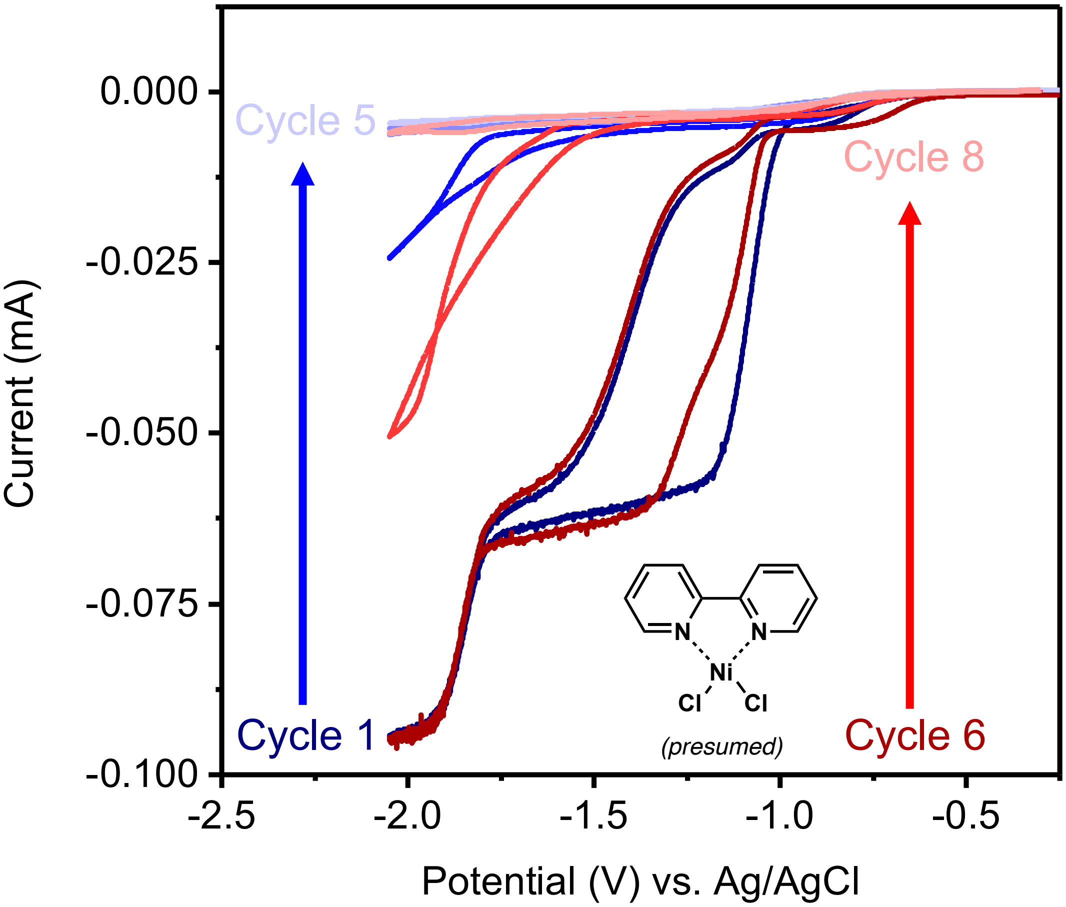
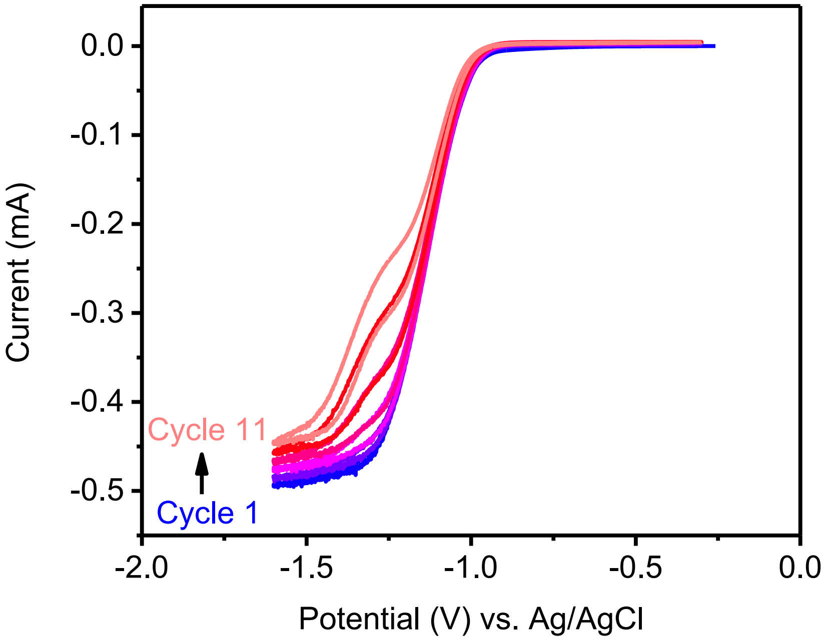


Fig S83—RDE voltammetry of a bare glassy carbon electrode in the presence of 5 mM $NiCl_2$ and 5 mM bpy in 0.1 M $TBAPF_6$ in DMF cycling at 10 mV/s and 1600 rpm wherein the lower potential cutoff is limited to -1.6 V vs. Ag/AgCl.



The electrode is passivated with continuous cycling, but the passivation occurs at a slower rate, relative to cycling the electrode to -2 V vs. Ag/AgCl. Upon cycling, the initial reductive wave becomes two discrete waves. This is likely due to a change in the concentration of Ni(II) centers in the solution. During the reductive cycles, Ni(0) is produced and likely undergoes disproportionation reactions with Ni(II) in the bulk solution, yielding an increased concentration of Ni(I). Ni(I) is likely reduced at a slightly lower (more negative) potential than Ni(II), and we believe results in the observed wave at ~ -1.35 V vs. Ag/AgCl. This change in the voltametric profile is accompanied by a change in the color of the solution from a blue-green to a green-grey color.

Fig S84—RDE voltammograms of RAE 7 on bare glassy carbon at various rotation rates. RDE voltammograms 1 mM RAE 7 on glassy carbon taken in DMF with 0.1 M TBAPF$_6$ supporting electrolyte at a rotation rates ranging from 200-1600 RPM and a scan rate of 10 mV/s.

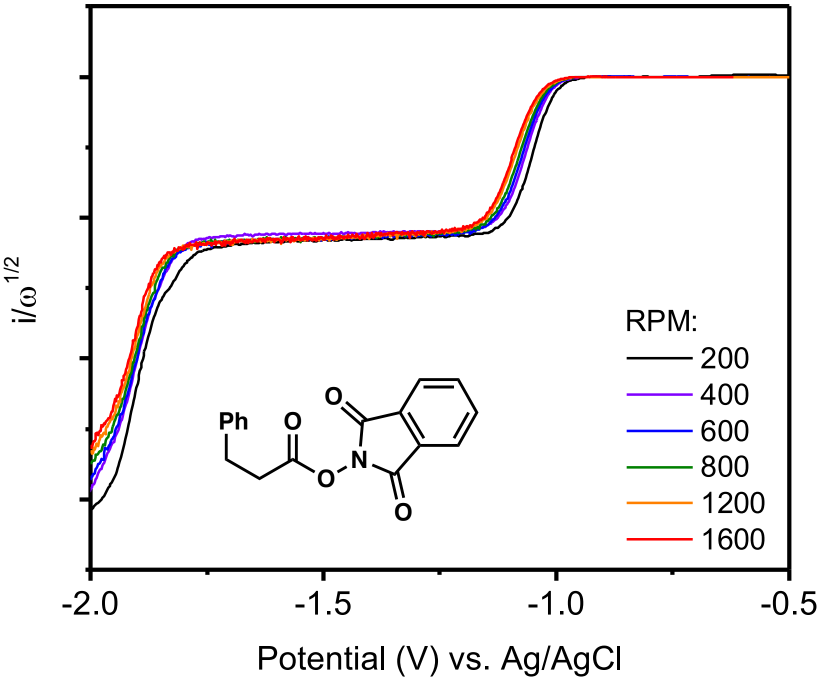


Fig S85—RDE voltammograms of RAE 7 on glassy carbon with 0.012 $\text{mmol}_{\text{Ag}}/\text{cm}^2$ Ag at various rotation rates.

RDE voltammograms 1 mM RAE 7 on glassy carbon with 0.012 $\text{mmol}_{\text{Ag}}/\text{cm}^2$ Ag taken in DMF with 0.1 M TBAPF_6 supporting electrolyte at a rotation rates ranging from 200-1600 RPM and a scan rate of 10 mV/s.

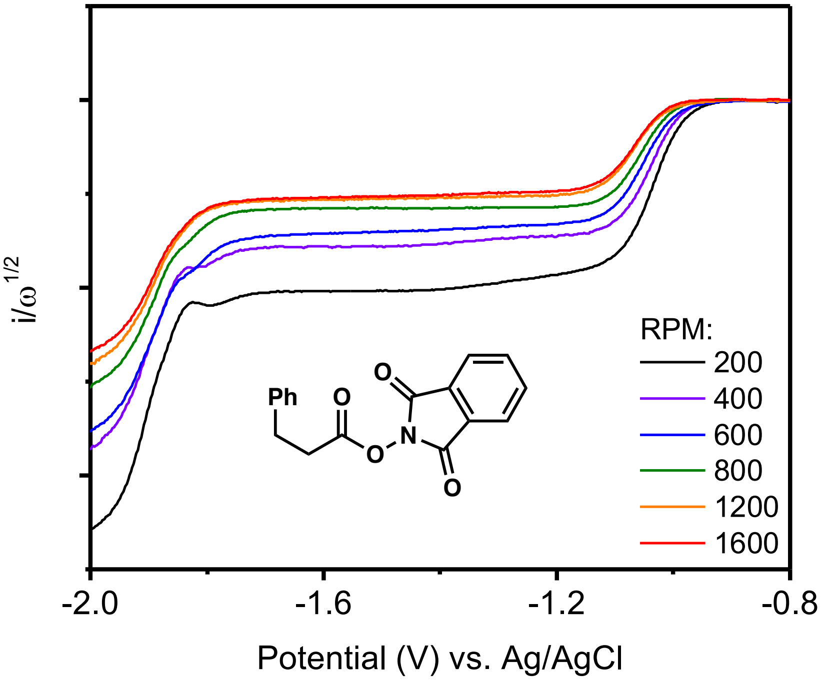


Fig S86— Comparison of RDE voltammograms of RAE 7 on glassy carbon with and without 0.012 mmol$_{Ag}$/cm^2 Ag at various rotation rates.

RDE voltammograms 1 mM RAE 7 on glassy carbon with 0.012 mmol$_{Ag}$/cm^2 Ag taken in DMF with 0.1 M TBAPF$_6$ supporting electrolyte at a rotation rates 200 (top) or 1600 (bottom) RPM and a scan rate of 10 mV/s.

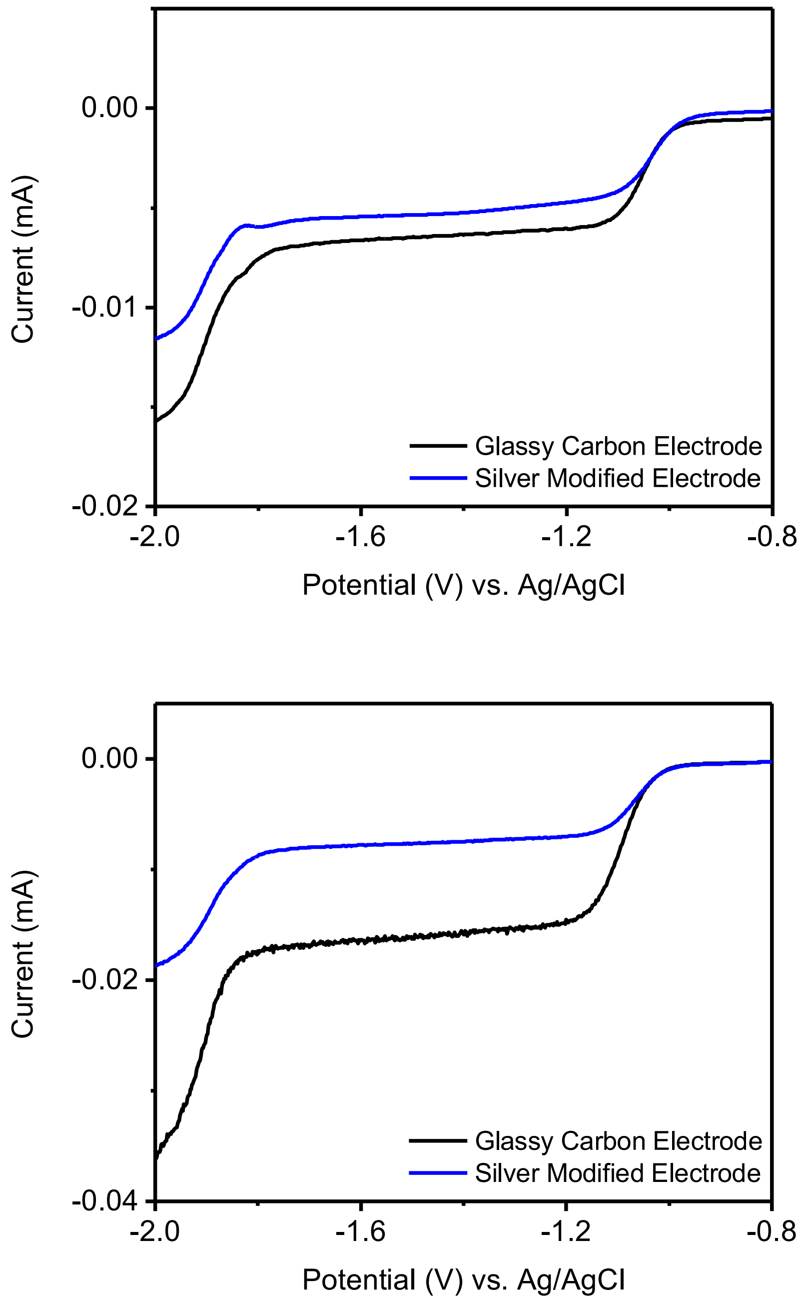


Fig S87—RDE voltammograms of NiCl₂·6H2O + 2,2'-bpy, and RAE 7 on glassy carbon.
RDE voltammograms 1 mM $NiCl_2 \cdot 6H_2O$ + 1 mM 2,2'-bpy with 10mM RAE **7** on glassy carbon taken over 3 cycles in DMF with 0.1 M $TBAPF_6$ supporting electrolyte at a rotation rate of 600 rpm and a scan rate of 10 mV/s

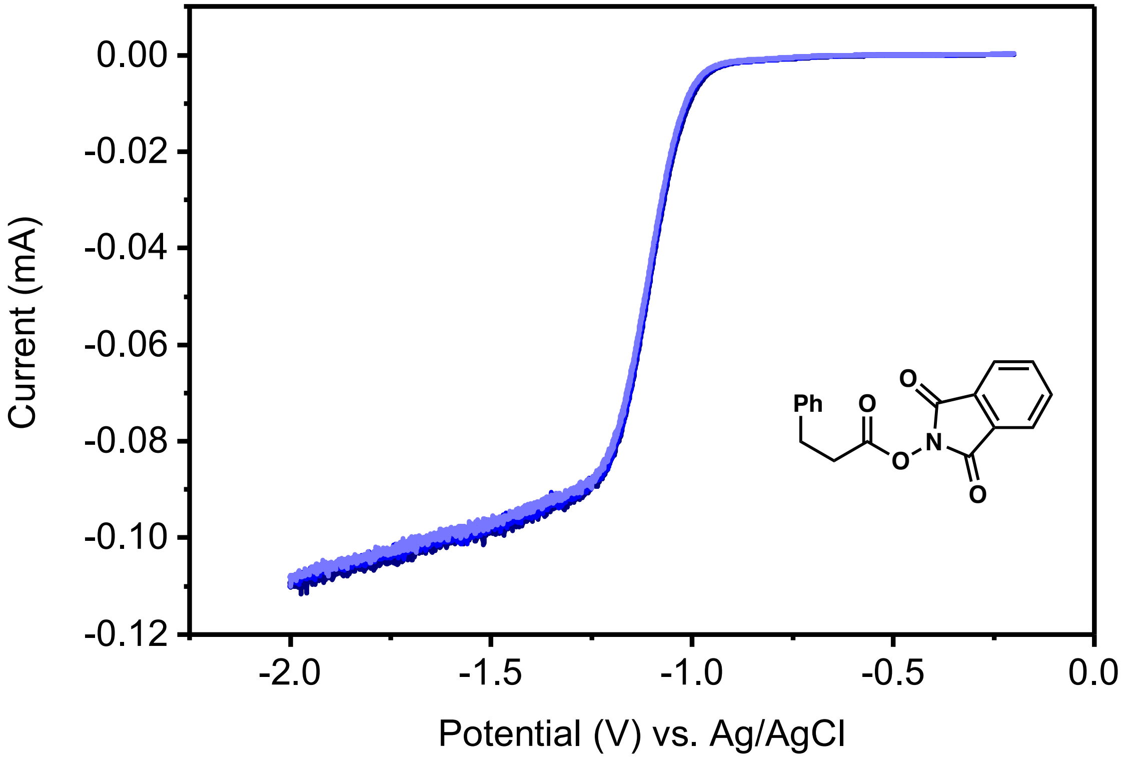


Fig S88—RDE voltammograms of $NiCl_2$·6H2O + 2,2'-bpy, and RAE 7 on Ag modified (0.012 $mmol_{Ag}/cm^2$ coverage) glassy carbon electrode.

RDE voltammograms 1 mM $NiCl_2 \cdot 6H_2O$ + 1 mM 2,2'-bpy and 10mM RAE **7** on glassy carbon taken over 3 cycles in DMF with 0.1 M $TBAPF_6$ supporting electrolyte at a rotation rate of 600 rpm and a scan rate of 10 mV/s. *Note: Increasing current response could be due to delamination of Ag-NP layer.*

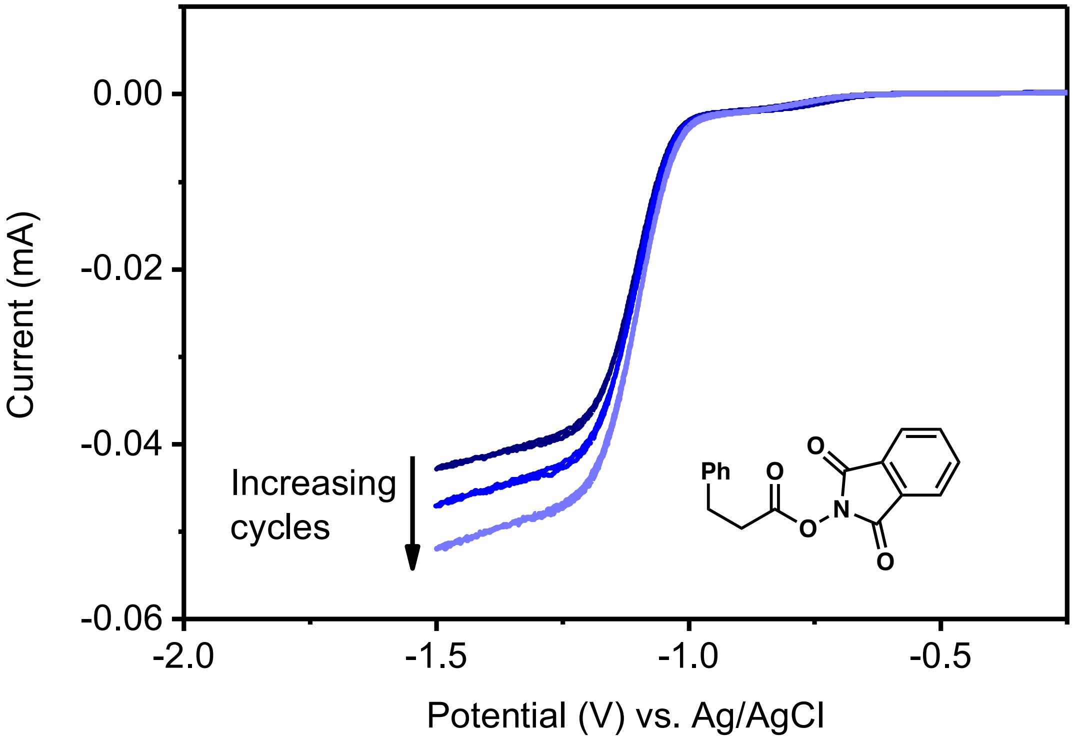


Fig S89—RDE voltammograms of redox active ester 7, and nickel catalyst on a glassy carbon electrode at 1600 RPM.

RDE voltammograms of 10mM RAE **7** + 1 mM $NiCl_2 \cdot 6H_2O$ + 1 mM 2,2'-bpy, on glassy carbon taken in DMF with 0.1 M $TBAPF_6$ supporting electrolyte at a rotation rate of 1600 rpm and a scan rate of 10 mV/s. *Note: slight passivation observed upon cycling.*

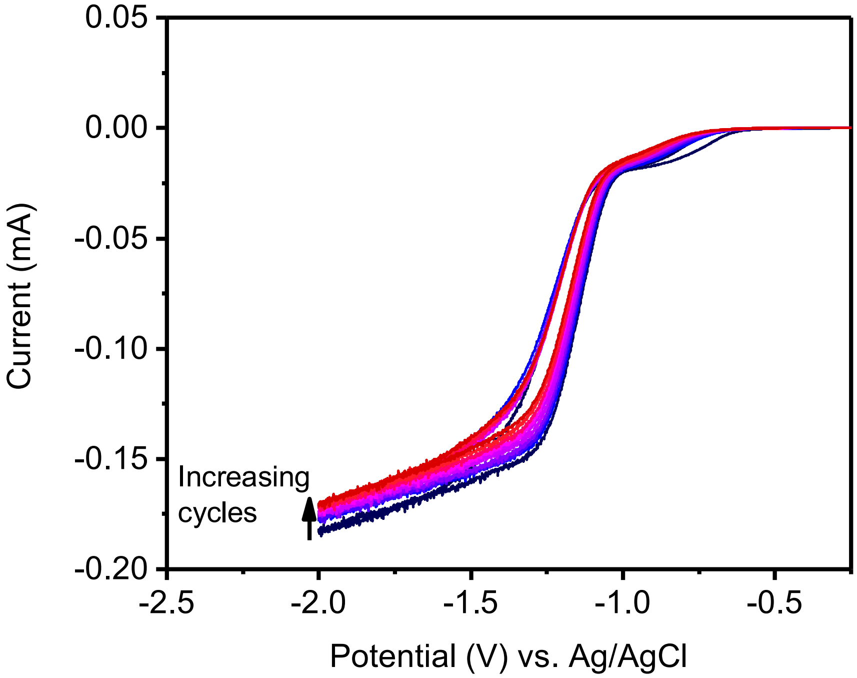


Fig S90—RDE voltammograms of redox active ester 7, and nickel catalyst on Ag modified ($0.012\ \mathrm{mmol_{Ag}/cm^2}$ coverage) glassy carbon electrode at 1600 RPM.

RDE voltammograms of 10mM RAE **7** + 1 mM $NiCl_2{\cdot}6H_2O$ + 1 mM 2,2'-bpy on glassy carbon with $0.012\ \mathrm{mmol_{Ag}/cm^2}$ Ag taken in DMF with 0.1 M $TBAPF_6$ supporting electrolyte at a rotation rate of 1600 rpm and a scan rate of 10 mV/s. *Note: Increase current response with cycling could be a result of Ag-NP layer delamination.*

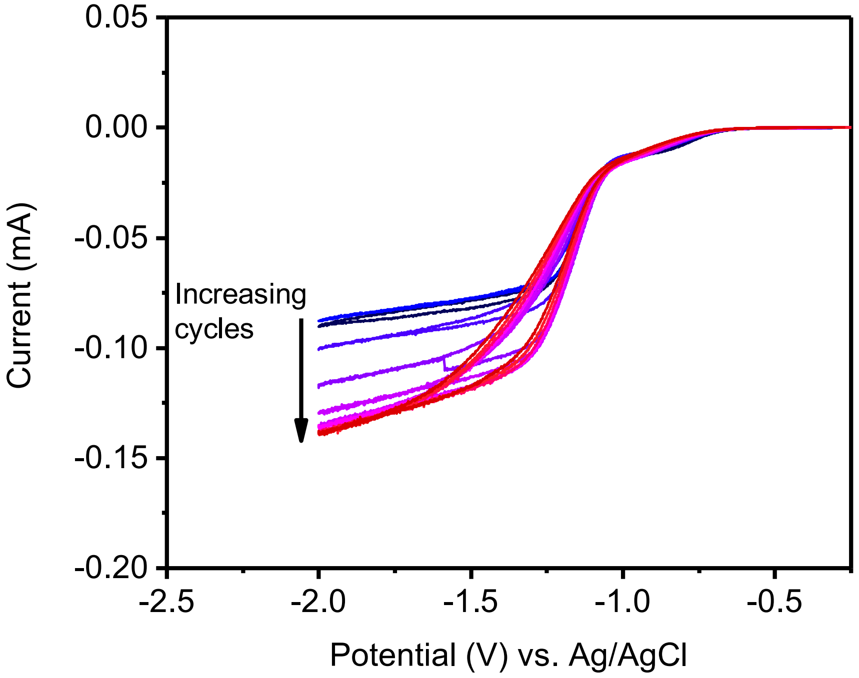


Fig S91—Levich analysis of NiCl₂·6H2O + 2,2'-bpy on Ag modified (0.012 mmol$_{Ag}$/cm^2 coverage) and unmodified glassy carbon electrode.

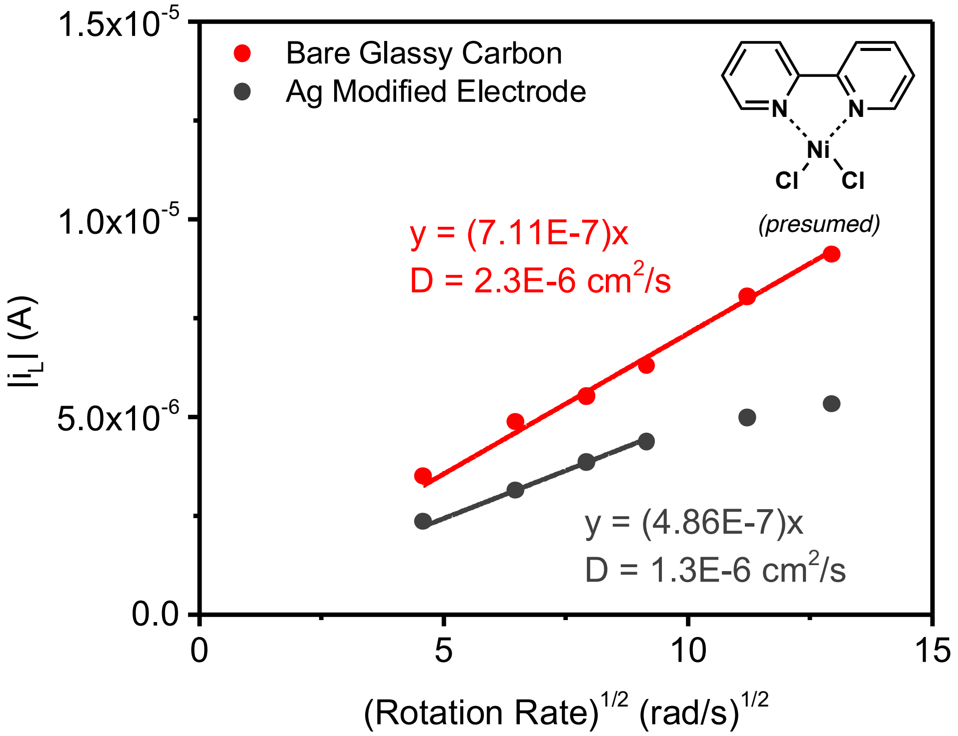


Fig S92—Levich Analysis of 7 on Ag modified (0.012 $\text{mmol}_{\text{Ag}}/\text{cm}^2$ coverage) and unmodified glassy carbon electrode.

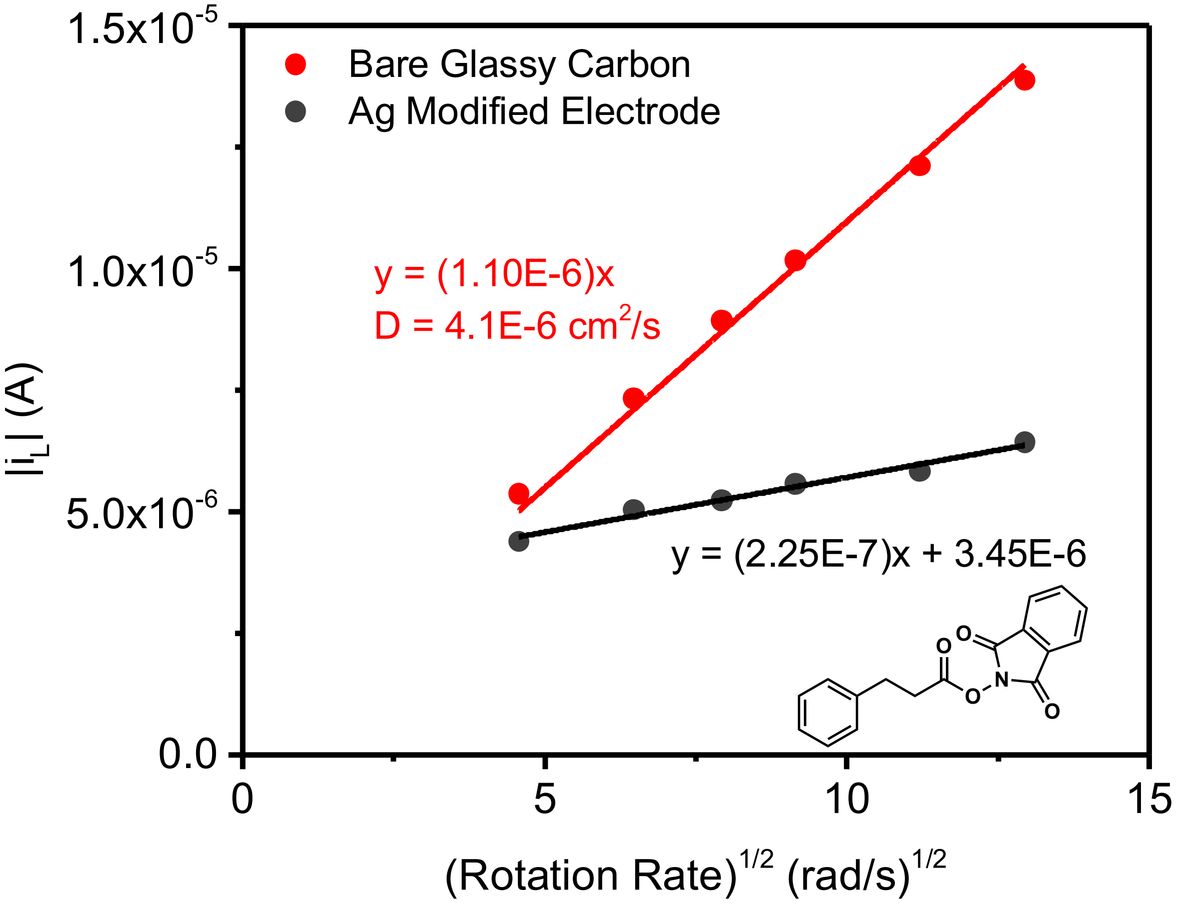
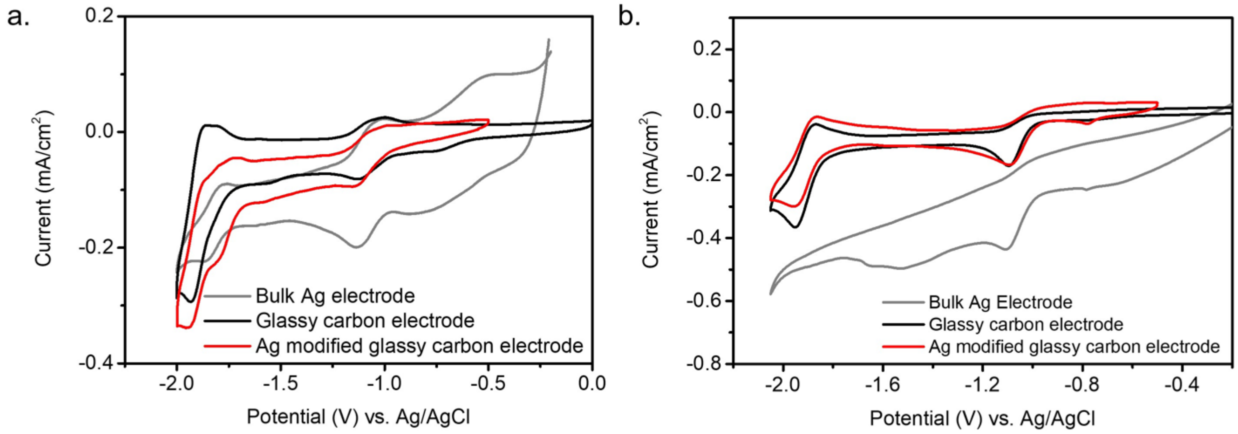


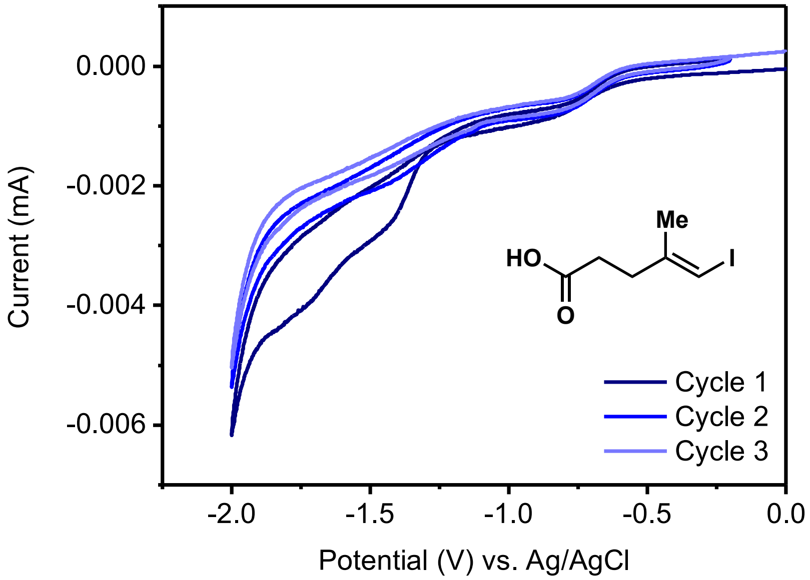
Fig S93—Cyclic voltammograms at 50 mV/s of (a.) 1 mM $NiCl_2$ and 1 mM bpy, and (b.) 1 mM RAE in 0.1M $TBAPF_6$ in DMF at a Ag, glassy carbon, and Ag nanoparticle modified glassy carbon electrode.



The current is normalized to the geometric area of each electrode. The voltametric profile of the Ag electrode has distinct features not observed in the voltammograms of the glassy carbon nor the Ag nanoparticle modified glassy carbon electrode, indicating that the majority of the reductive events likely occur at the glassy carbon surface and not the Ag nanoparticles.

Fig S94—RDE voltammograms of vinyl iodide 5 on Ag modified (0.012 mmol$_{Ag}$/cm^2 coverage) and unmodified glassy carbon electrode

CV voltammograms 1 mM vinyl iodide **5** on glassy carbon taken over 3 cycles on Ag-modified glass carbon with 0.012 mmol$_{Ag}$/cm^2 coverage (bottom) or unmodified glassy carbon (top) in DMF with 0.1 M TBAPF$_6$ supporting electrolyte at a rotation rate of 600 rpm and a scan rate of 10 mV/s. *Note: the vinyl iodide displays non-passivating adsorptive behavior on both electrodes*



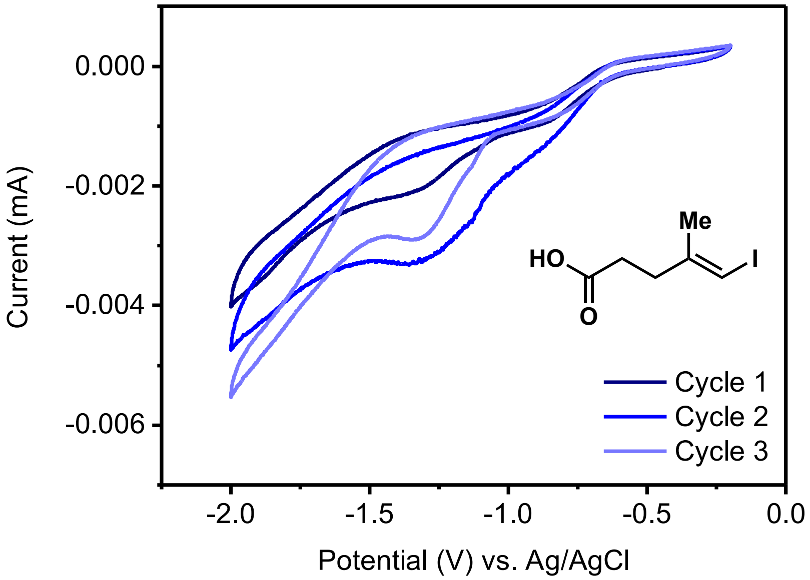


Fig S95—RDE voltammograms of vinyl iodide 5 on glassy carbon with and without $NiCl_2$·6H2O + 2,2’-bpy.

RDE voltammograms of 1 mM vinyl iodide 5 on glassy carbon taken in DMF with 0.1 M $TBAPF_6$ supporting electrolyte at a rotation rate of 600 rpm and a scan rate of 10 mV/s. The measurement was repeated with added 1mM $NiCl_2$·6H2O + 1 mM 2,2’-bpy.

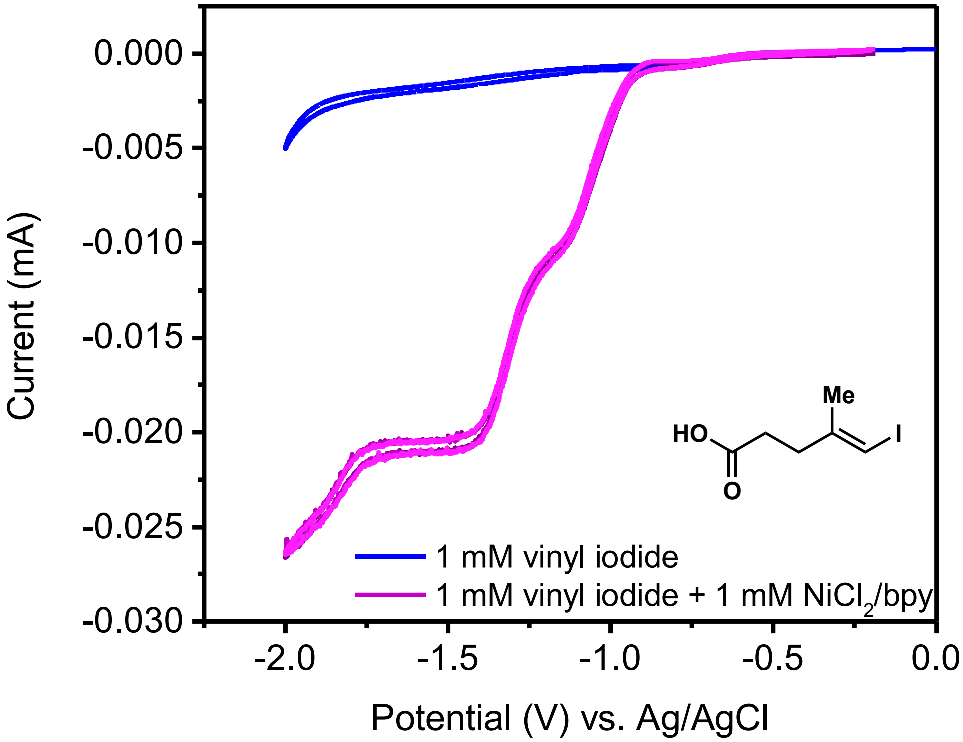


Fig S96—RDE voltammograms of vinyl iodide 5 on glassy carbon with 0.012 mmol$_{Ag}$/cm^2 Ag with and without NiCl$_2$·6H2O + 2,2'-bpy.

RDE voltammograms of 1 mM vinyl iodide 5 on glassy carbon with 0.012 mmol$_{Ag}$/cm^2 Ag taken in DMF with 0.1 M TBAPF$_6$ supporting electrolyte at a rotation rate of 600 rpm and a scan rate of 10 mV/s. The measurement was repeated with added 1mM NiCl$_2$·6H2O + 1 mM 2,2'-bpy. *Note: Increasing current response could be due to delamination of Ag-NP layer.*

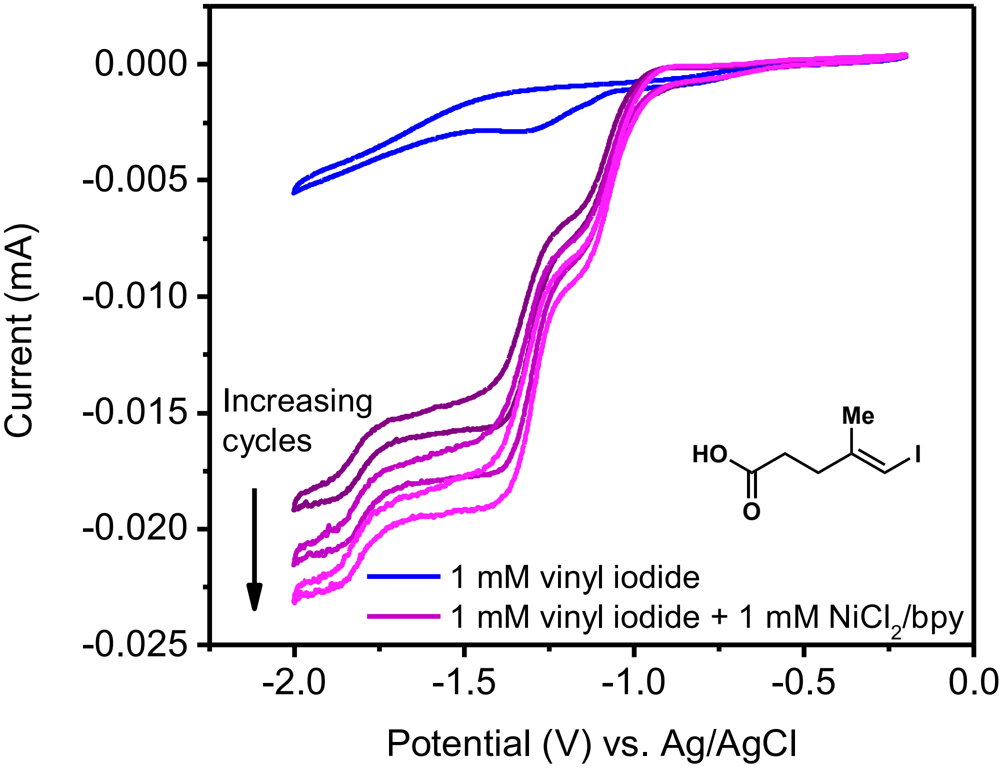


Fig S97—RDE voltammograms of vinyl iodide 40 on glassy carbon with NiCl₂·6H2O + 2,2'-bpy.

RDE voltammograms of 1 mM vinyl iodide **40** in the presence of added 1mM NiCl₂·6H2O + 1 mM 2,2'-bpy on glassy carbon taken in DMF with 0.1 M TBAPF₆ supporting electrolyte at a rotation rate of 600 rpm and a scan rate of 10 mV/s.

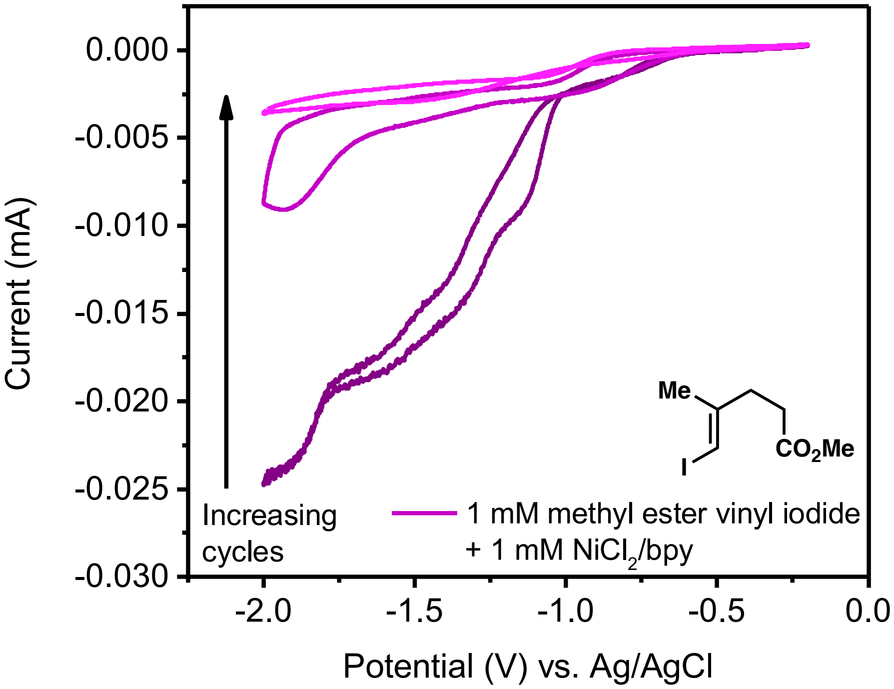


Fig S98—RDE voltammograms of vinyl iodide 5 on glassy carbon with 0.012 mmol$_{Ag}$/cm^2 Ag with and without NiCl$_2$·6H2O + 2,2'-bpy.

RDE voltammograms of 1 mM vinyl iodide **40** in the presence of added 1mM NiCl$_2$·6H2O + 1 mM 2,2'-bpy on glassy carbon with 0.012 mmol$_{Ag}$/cm^2 Ag taken in DMF with 0.1 M TBAPF$_6$ supporting electrolyte at a rotation rate of 600 rpm and a scan rate of 10 mV/s. The measurement was repeated without added 1mM NiCl$_2$·6H2O + 1 mM 2,2'-bpy.

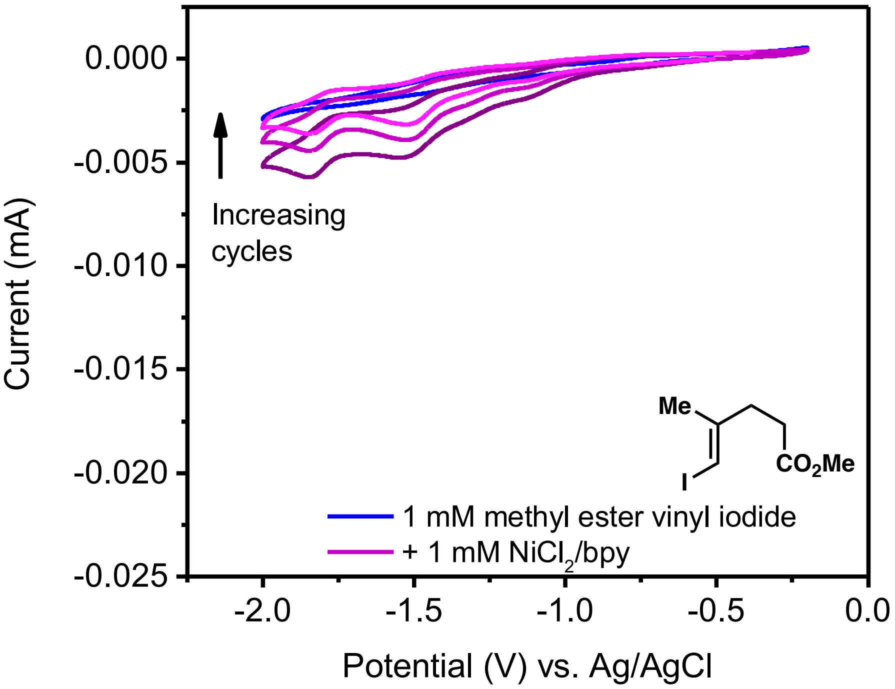


Fig S99—RDE voltammograms of vinyl iodide 5, redox active ester 7, and nickel catalyst on Ag modified (0.012 mmol$_{Ag}$/cm^2 coverage) glassy carbon electrode and unmodified glassy carbon electrode.

RDE voltammograms of 15 mM vinyl iodide 5 + 10 mM redox active ester 7 + 1 mM $NiCl_2 \cdot 6H_2O$ + 1 mM 2,2'-bpy on glassy carbon with 0.012 mmol$_{Ag}$/cm^2 Ag or unmodified glassy carbon taken in DMF with 0.1 M $TBAPF_6$ supporting electrolyte at a rotation rate of 600 rpm and a scan rate of 10 mV/s.

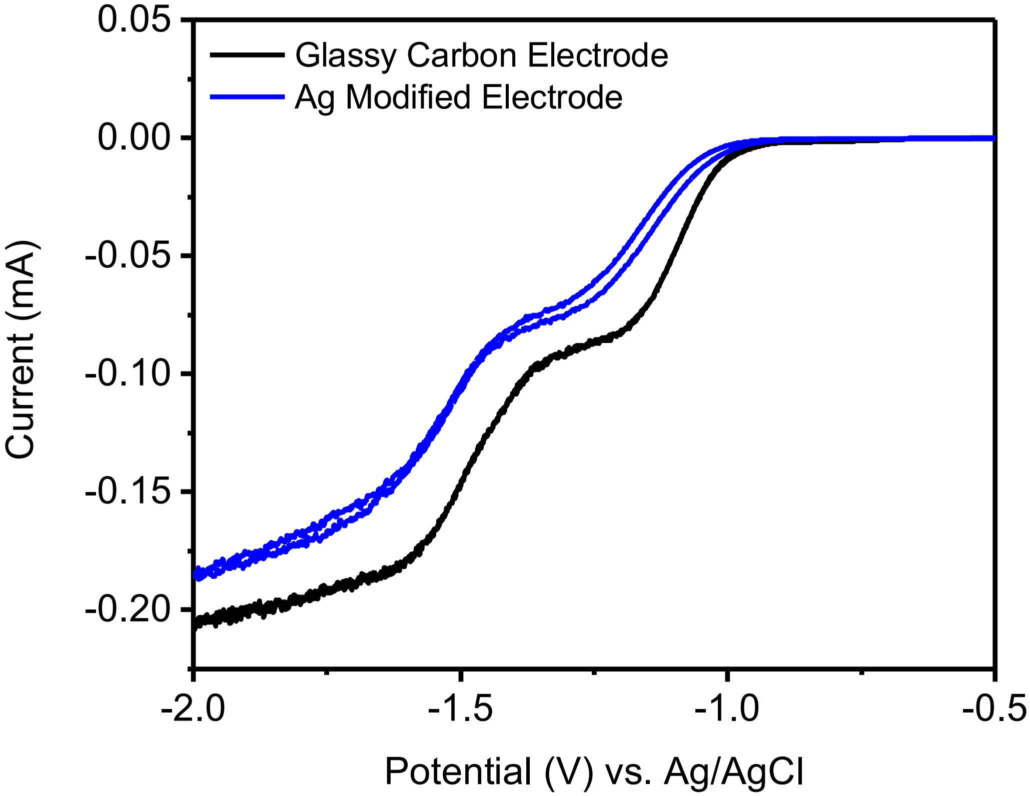


Fig S100—RDE voltammograms of vinyl iodide 5, redox active ester 7, and nickel catalyst on Ag modified (0.012 mmol$_{Ag}$/cm^2 coverage) glassy carbon electrode in different combinations.

RDE voltammograms of combination of reaction components (15 mM vinyl iodide **5** + 1 mM $NiCl_2 \cdot 6H_2O$ + 1 mM 2,2'-bpy, blue trace) (15 mM vinyl iodide **40** + 10 mM redox active ester 7 + 1 mM $NiCl_2 \cdot 6H_2O$ + 1 mM 2,2'-bpy, red trace) on glassy carbon with 0.012 mmol$_{Ag}$/cm^2 Ag taken in DMF with 0.1 M $TBAPF_6$ supporting electrolyte at a rotation rate of 600 rpm and a scan rate of 10 mV/s.

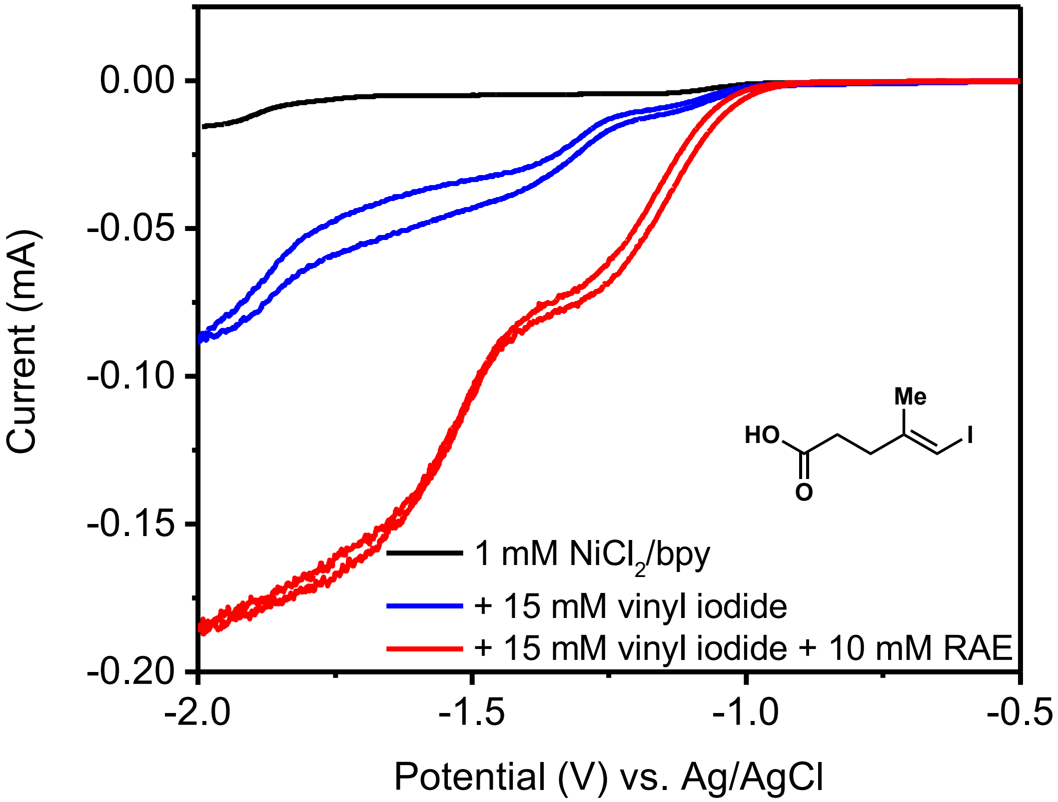


Fig S101—RDE voltammograms of vinyl iodide 5, redox active ester 7, and nickel catalyst on a glassy carbon electrode at 1600 RPM.

RDE voltammograms of combination of reaction components (15 mM vinyl iodide **5** + 10mM RAE **7** + 1 mM $NiCl_2 \cdot 6H_2O$ + 1 mM 2,2'-bpy,) on glassy carbon taken in DMF with 0.1 M $TBAPF_6$ supporting electrolyte at a rotation rate of 1600 rpm and a scan rate of 10 mV/s. *Note: slight passivation observed.*

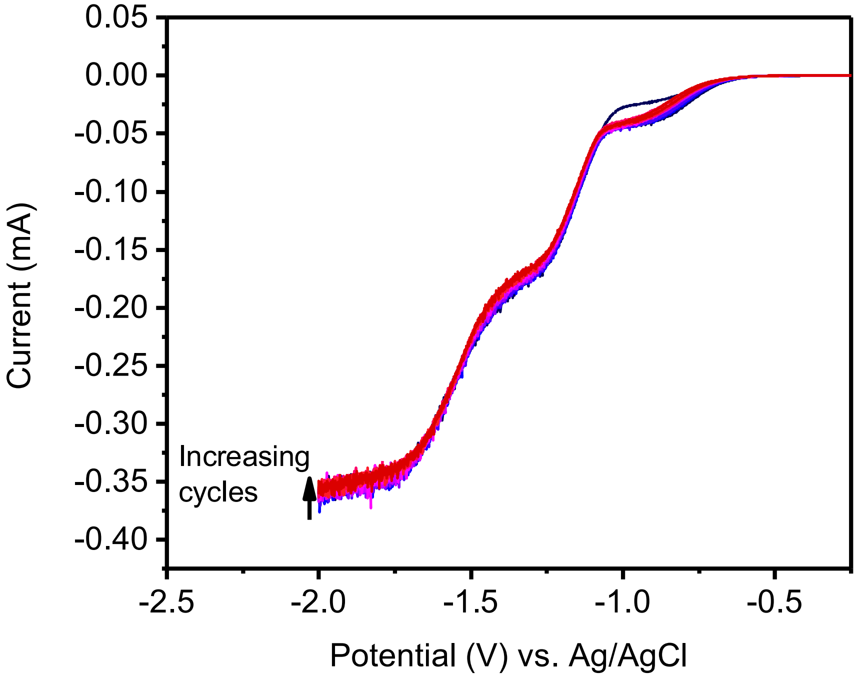


Fig S102—RDE voltammograms of vinyl iodide 5, redox active ester 7, and nickel catalyst on Ag modified (0.012 mmol$_{Ag}$/cm^2 coverage) glassy carbon electrode at 1600 RPM.

RDE voltammograms of combination of reaction components (15 mM vinyl iodide **5** + 10mM RAE **7** + 1 mM $NiCl_2 \cdot 6H_2O$ + 1 mM 2,2'-bpy) on glassy carbon with 0.012 mmol$_{Ag}$/cm^2 Ag taken in DMF with 0.1 M $TBAPF_6$ supporting electrolyte at a rotation rate of 600 rpm and a scan rate of 10 mV/s. *Note: Initial increase current response with cycling could be a result of Ag-NP layer delamination and resulting slight passivation at later cycles could be occurring on a bare glassy carbon surface.*

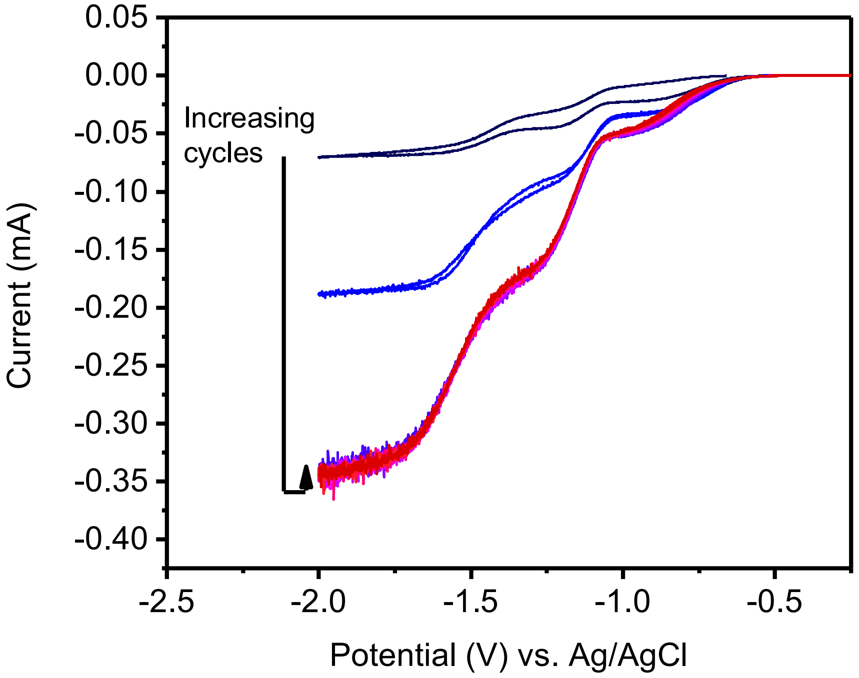


Fig S103—RDE voltammograms of vinyl iodide 40, redox active ester 7, and nickel catalyst on Ag modified (0.012 mmol$_{Ag}$/cm^2 coverage) glassy carbon electrode in different combinations.

RDE voltammograms of combination of reaction components (15 mM vinyl iodide **40** + 1 mM $NiCl_2 \cdot 6H_2O$ + 1 mM 2,2'-bpy, blue trace) (15 mM vinyl iodide **40** + 10 mM redox active ester 7 + 1 mM $NiCl_2 \cdot 6H_2O$ + 1 mM 2,2'-bpy, red trace) on glassy carbon with 0.012 mmol$_{Ag}$/cm^2 Ag taken in DMF with 0.1 M $TBAPF_6$ supporting electrolyte at a rotation rate of 600 rpm and a scan rate of 10 mV/s.

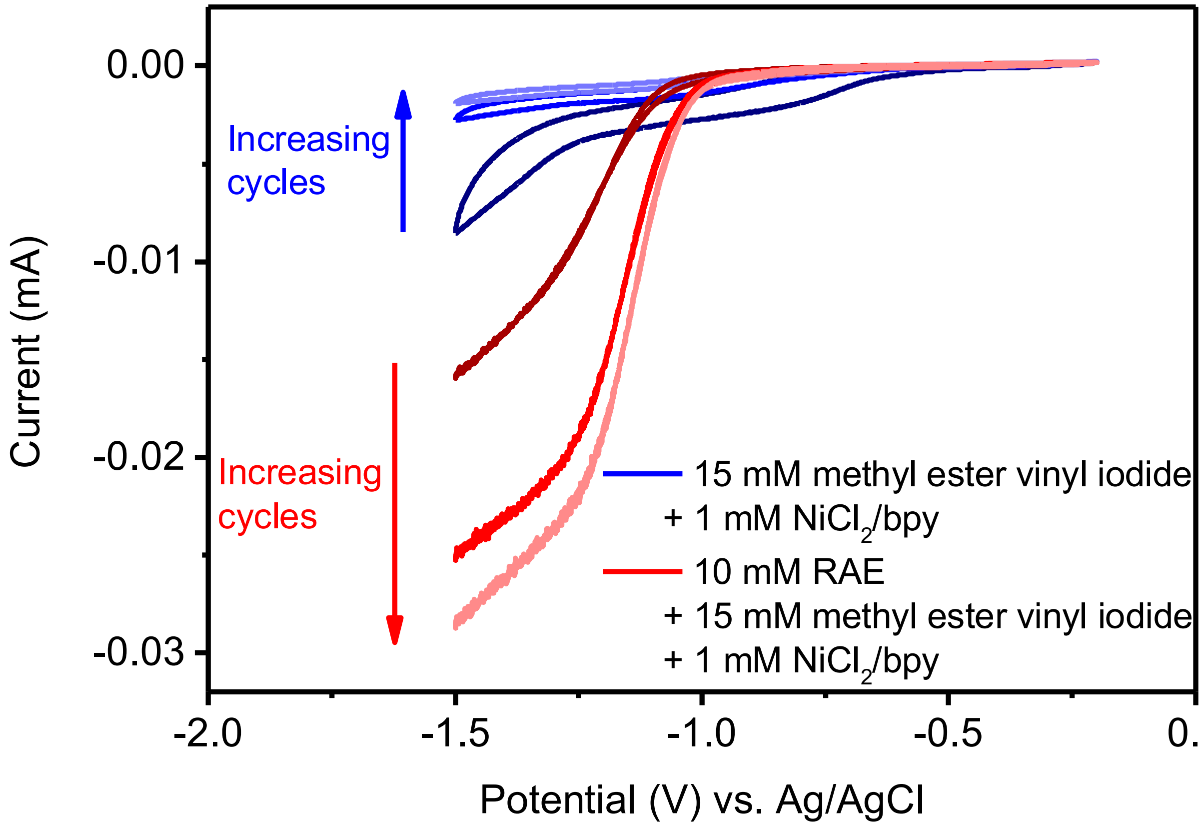


Fig S104—RDE voltammograms of vinyl iodide 40 or 5, redox active ester 7, and nickel catalyst on glassy carbon electrode in different combinations.

RDE voltammograms of combination of reaction components (15 mM vinyl iodide **40** + 10 mM redox active ester **7** + 1 mM $NiCl_2 \cdot 6H_2O$ + 1 mM 2,2'-bpy, red trace), (15 mM vinyl iodide **5** + 10 mM redox active ester **7** + 1 mM $NiCl_2 \cdot 6H_2O$ + 1 mM 2,2'-bpy, blue trace) on glassy carbon taken in DMF with 0.1 M $TBAPF_6$ supporting electrolyte at a rotation rate of 600 rpm and a scan rate of 10 mV/s.

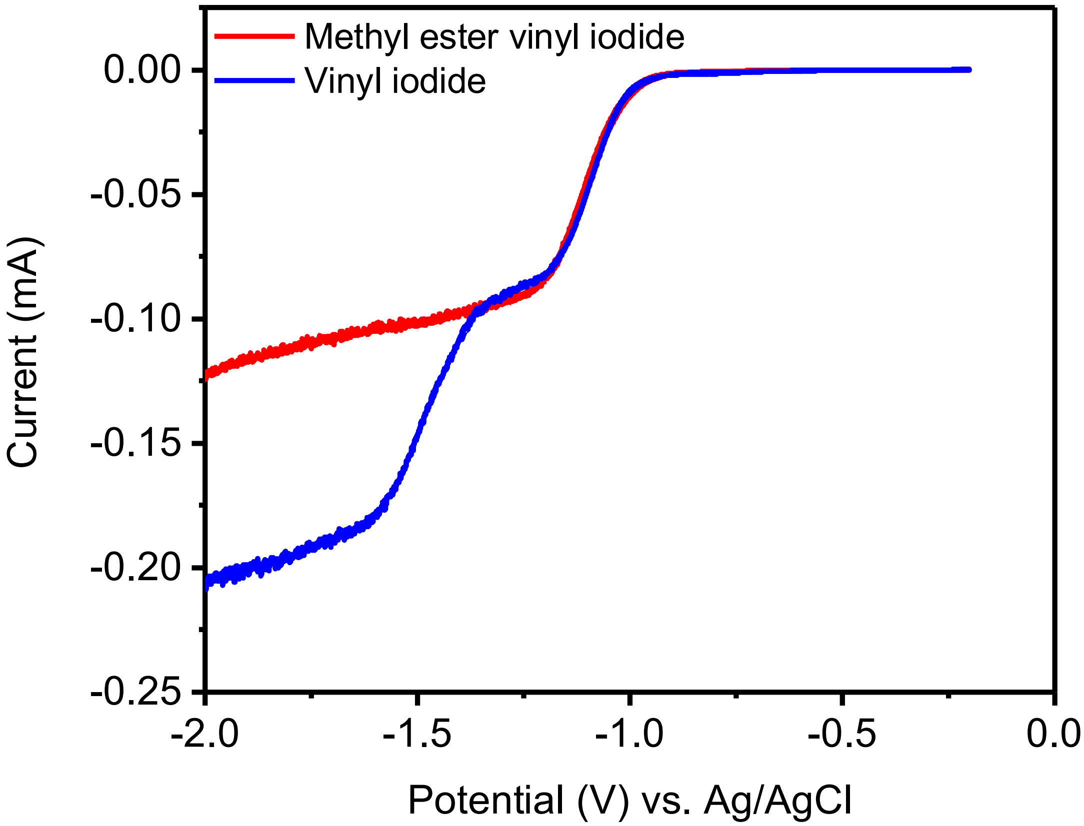


Fig S105—RDE voltammograms of vinyl iodide 5, redox active ester 7, and nickel catalyst on glassy carbon electrode in different combinations.

RDE voltammograms of combination of reaction components: 15 mM vinyl iodide **5** + 10 mM redox active ester **7** + 1 mM $NiCl_2 \cdot 6H_2O$ + 1 mM 2,2'-bpy on glassy carbon taken in DMF with 0.1 M $TBAPF_6$ supporting electrolyte at a rotation rate of 600 rpm and a scan rate of 10 mV/s.

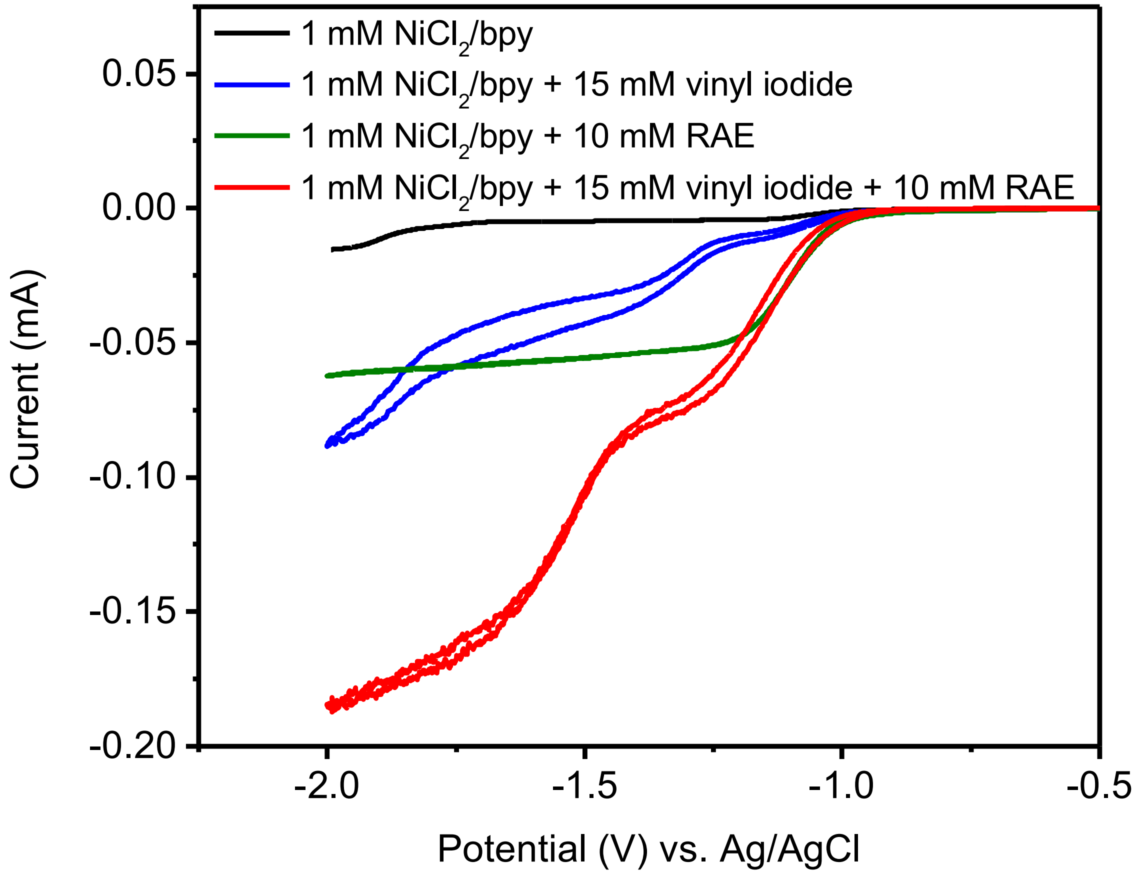


Fig S106—RDE voltammogram profiles exhibiting EC$_{cat}$ behavior of redox active ester 7, and nickel catalyst on glassy carbon electrode at different rotation rates.

RDE voltammograms of 10 mM redox active ester **7** + 1 mM $NiCl_2·6H_2O$ + 1 mM 2,2'-bpy on glassy carbon taken in DMF with 0.1 M $TBAPF_6$ supporting electrolyte at a rotation rates ranging from 200–1600 rpm and a scan rate of 10 mV/s.

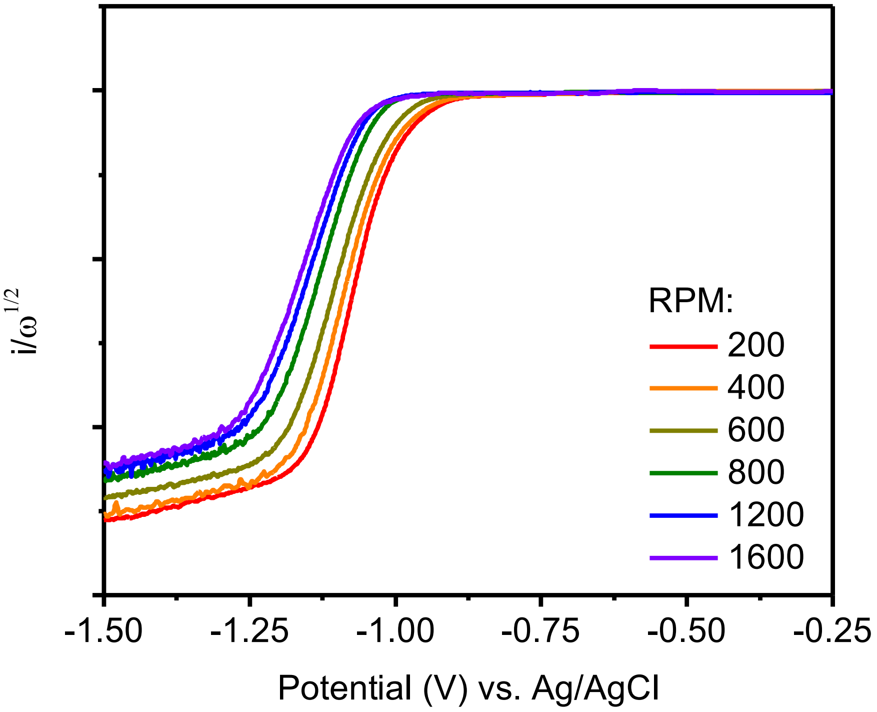


Fig.S107—RDE voltammograms of Ni(Mes)(bpy)Cl on bare glassy carbon

RDE voltammograms 1 mM Ni(Mes)(bpy)Cl on bare glassy carbon taken over 5 cycles in DMF with 0.1 M $TBAPF_6$ supporting electrolyte at a rotation rate of 1600 rpm and a scan rate of 10 mV/s

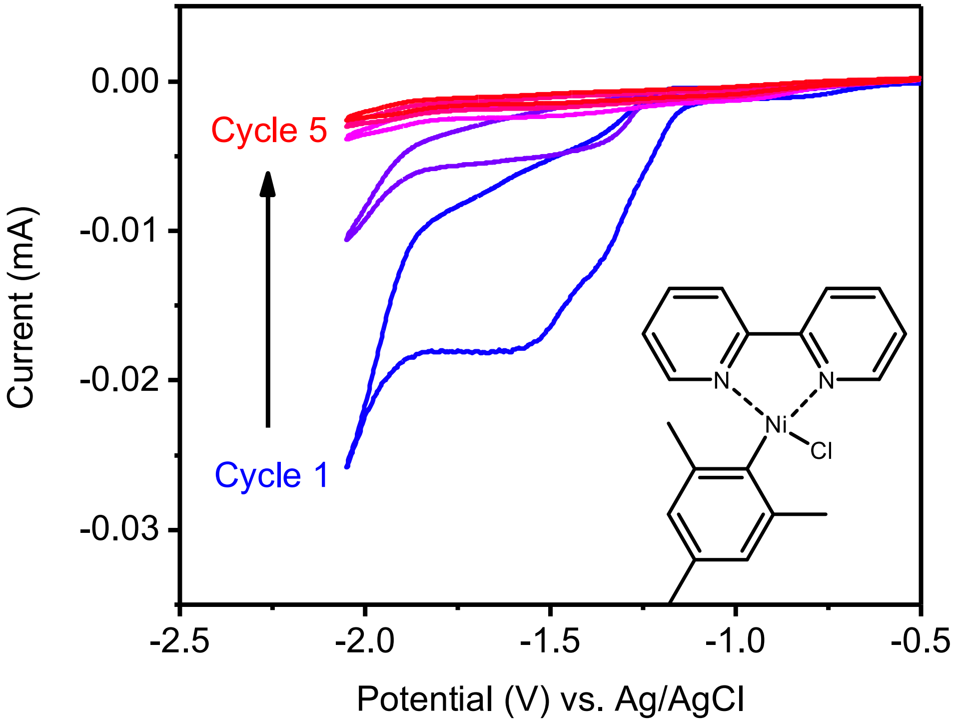


Fig S108—RDE voltammograms of Ni(Mes)(bpy)Cl on glassy carbon with 0.012 mmol$_{Ag}$/cm^2 Ag

RDE voltammograms 1 mM Ni(Mes)(bpy)Cl on glassy carbon with with 0.012 mmol$_{Ag}$/cm^2 Ag taken over 5 cycles in DMF with 0.1 M TBAPF$_6$ supporting electrolyte at a rotation rate of 1600 rpm and a scan rate of 10 mV/s

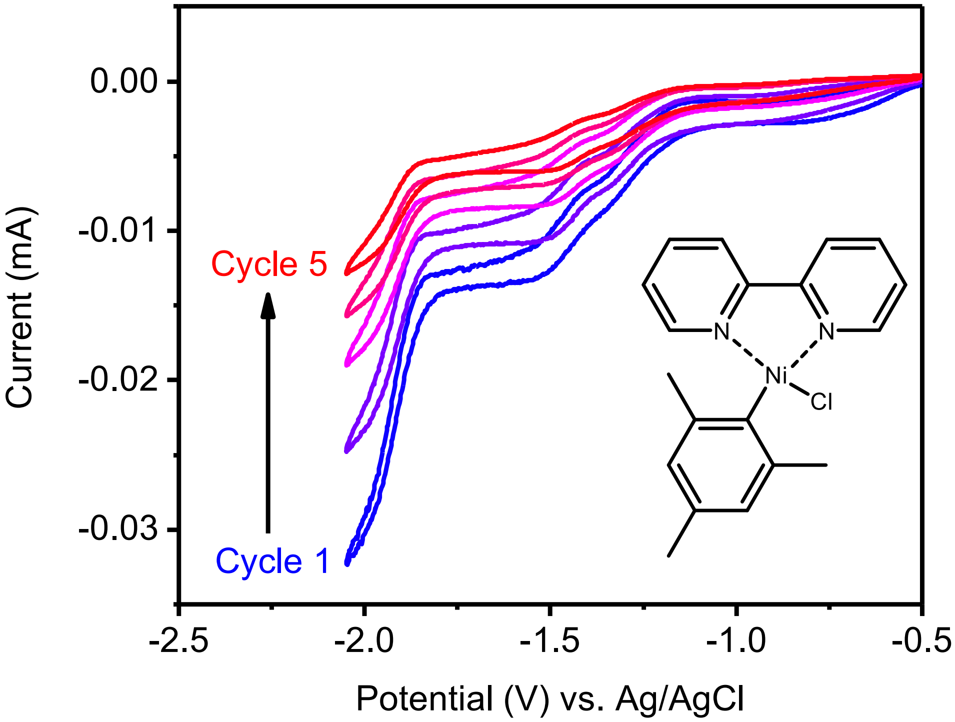


Fig S109—RDE voltammograms of redox active ester 7, and Ni(Mes)(bpy)Cl on a glassy carbon electrode at 1600 RPM.

RDE voltammograms of 10mM RAE **7** + 1 mM Ni(Mes)(bpy)Cl, on glassy carbon taken in DMF with 0.1 M $TBAPF_6$ supporting electrolyte at a rotation rate of 1600 rpm and a scan rate of 10 mV/s. *Note:passivation observed upon cycling.*

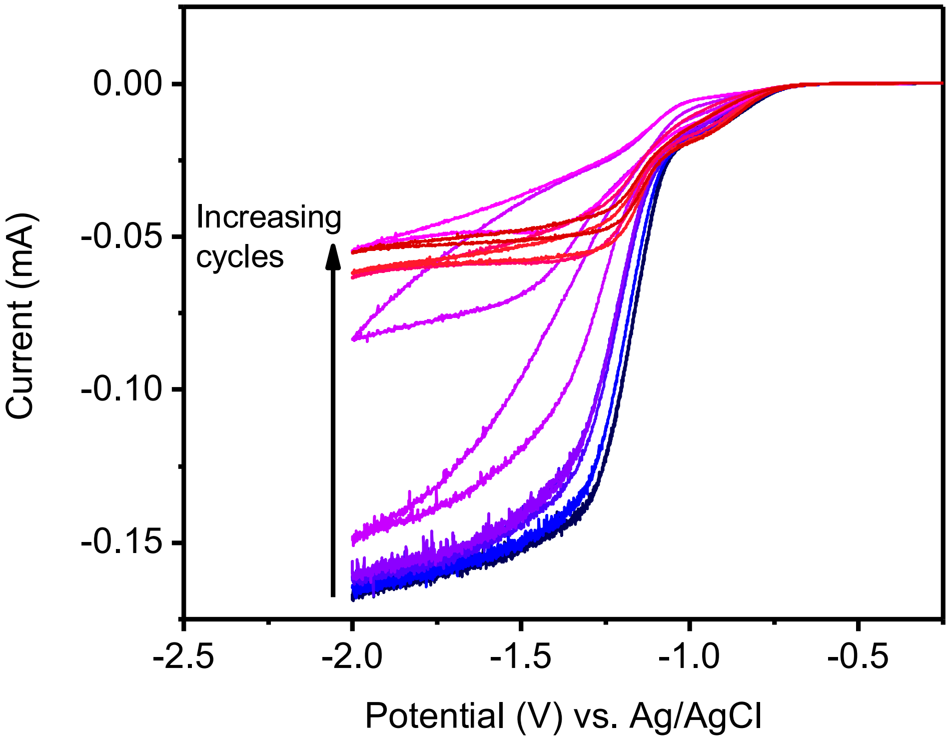


Fig S110—RDE voltammograms of redox active ester 7, and Ni(Mes)(bpy)Cl on Ag modified (0.012 mmol$_{Ag}$/cm^2 coverage) glassy carbon electrode at 1600 RPM.

RDE voltammograms of 10mM RAE **7** + 1 mM Ni(Mes)(bpy)Cl on glassy carbon with 0.012 mmol$_{Ag}$/cm^2 Ag taken in DMF with 0.1 M TBAPF$_6$ supporting electrolyte at a rotation rate of 1600 rpm and a scan rate of 10 mV/s.

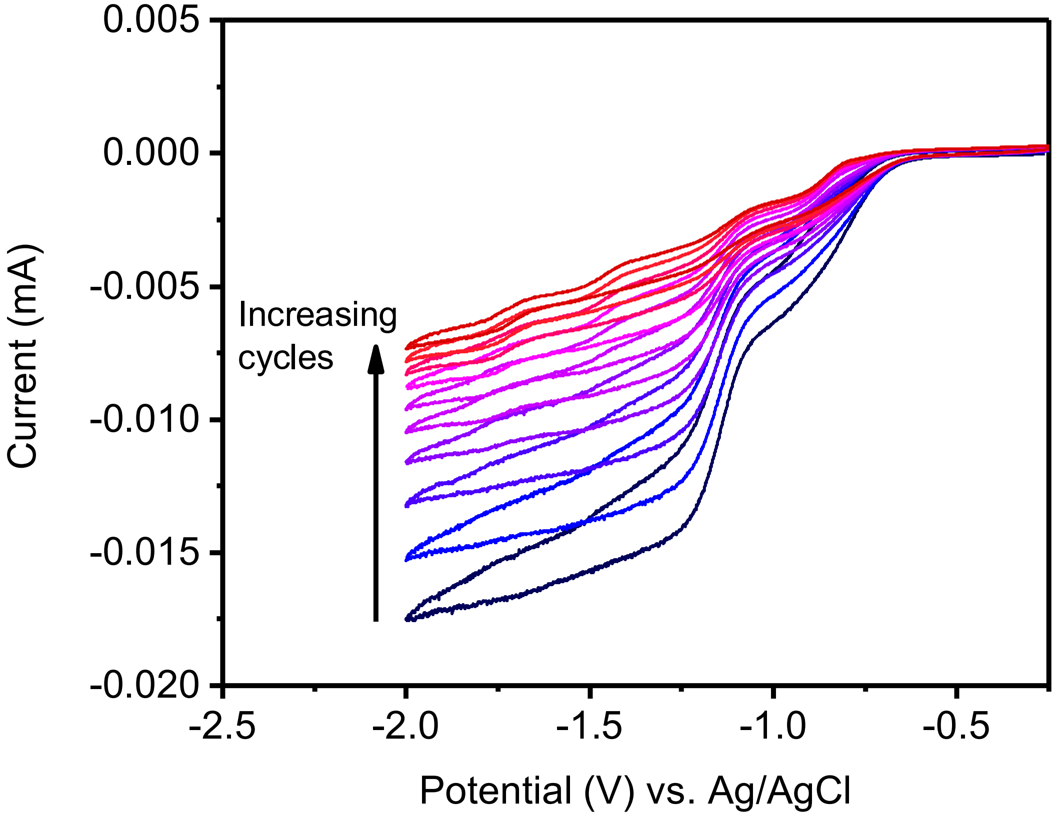


Fig S111—Cyclic voltammograms of $NiCl_2 \cdot 6H2O$ + 2,2'-bpy on Ag modified (0.012 $mmol_{Ag}/cm^2$ coverage) glassy carbon electrode, solid Ag electrode and unmodified glassy carbon electrode

CV voltammograms 1 mM $NiCl_2 \cdot 6H2O$ + 1mM 2,2'-bpy on glassy carbon taken or Ag-modified glass carbon with 0.012 $mmol_{Ag}/cm^2$ coverage, pure Ag electrode or unmodified glassy carbon in DMF with 0.1 M $TBAPF_6$ supporting electrolyte at a 50 mV/s scan rate.

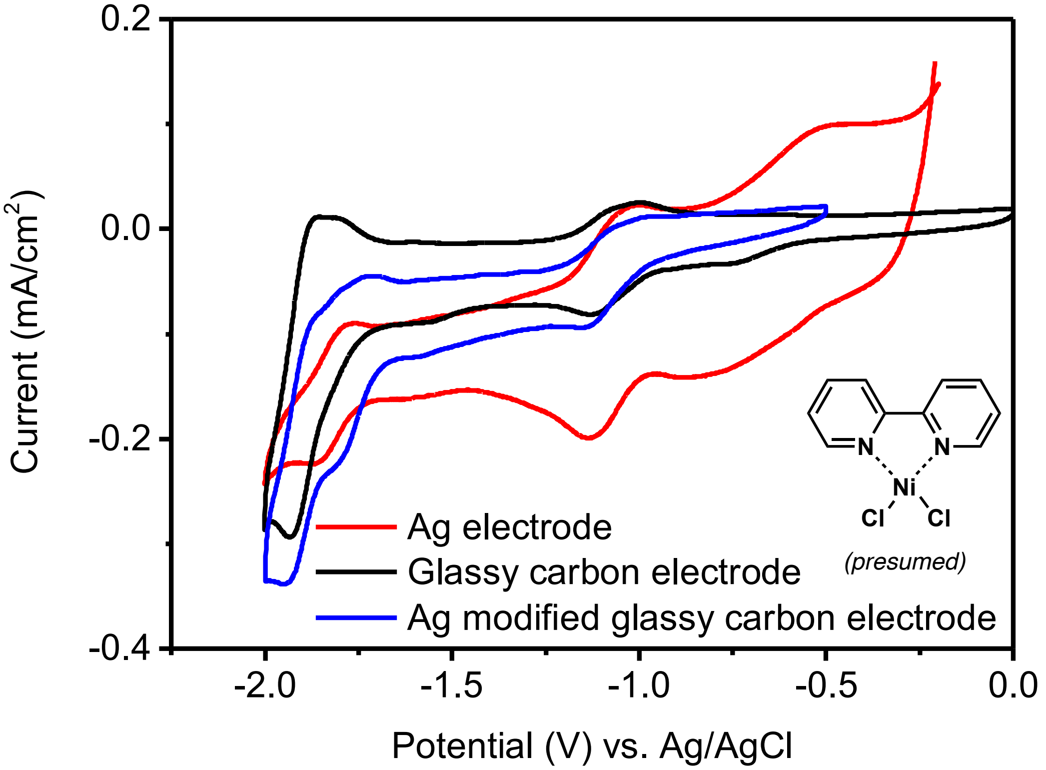
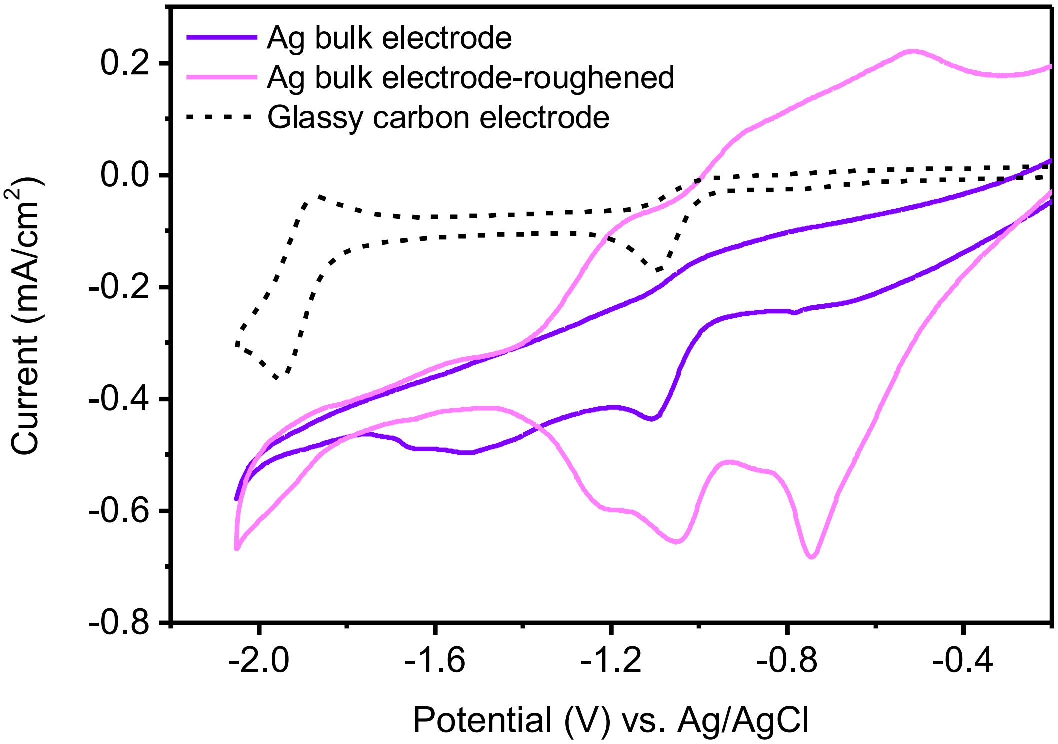
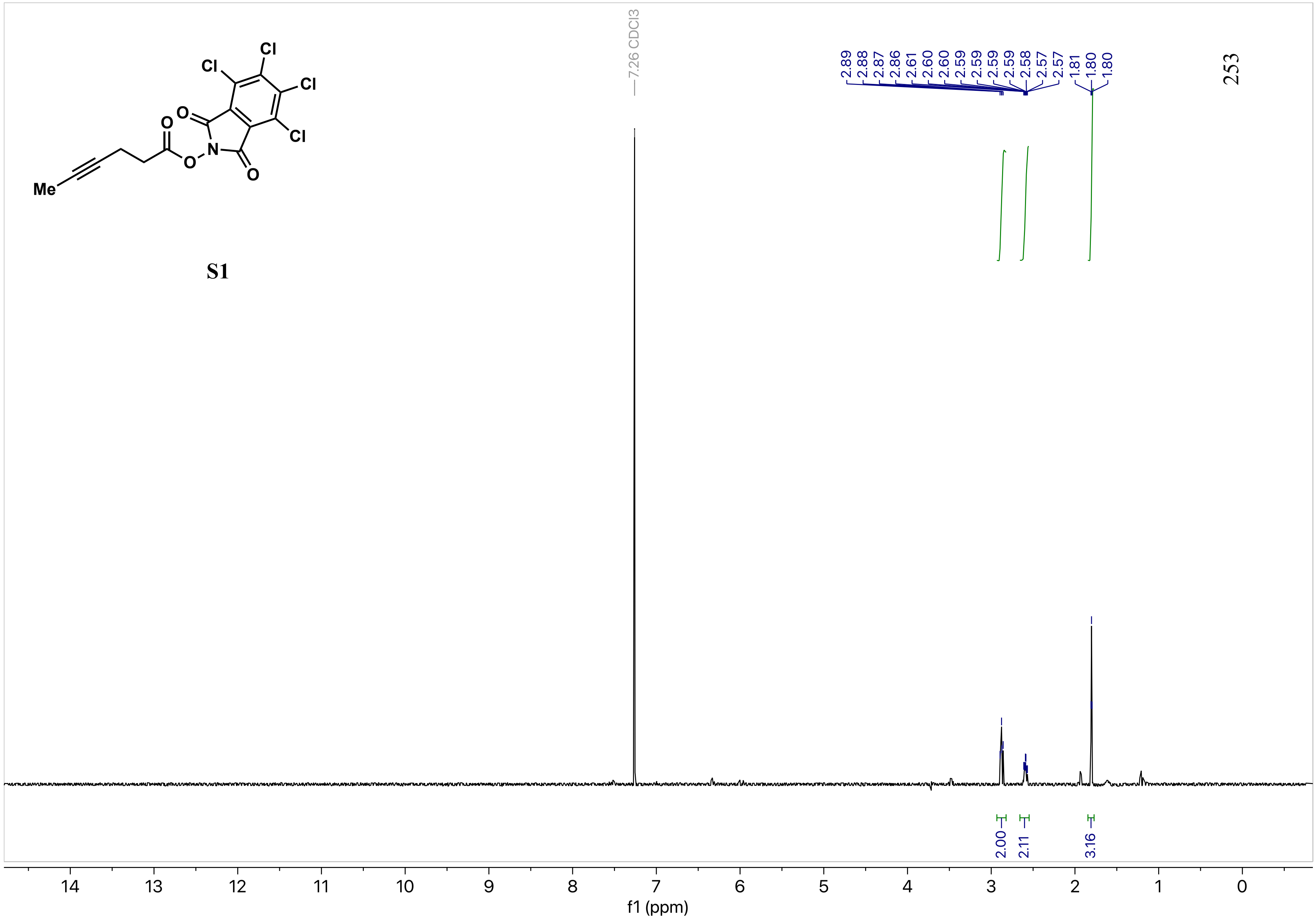


Fig S112—Cyclic voltammograms of redox active ester 7 on Ag modified (0.012 $mmol_{Ag}/cm^2$ coverage), roughened Ag electrode and unmodified glassy carbon electrode

CV voltammograms 1 mM 7 on glassy carbon taken or Ag-modified glass carbon with 0.012 $mmol_{Ag}/cm^2$ coverage, roughened Ag electrode or unmodified glassy carbon in DMF with 0.1 M $TBAPF_6$ supporting electrolyte at a 50 mV/s scan rate.

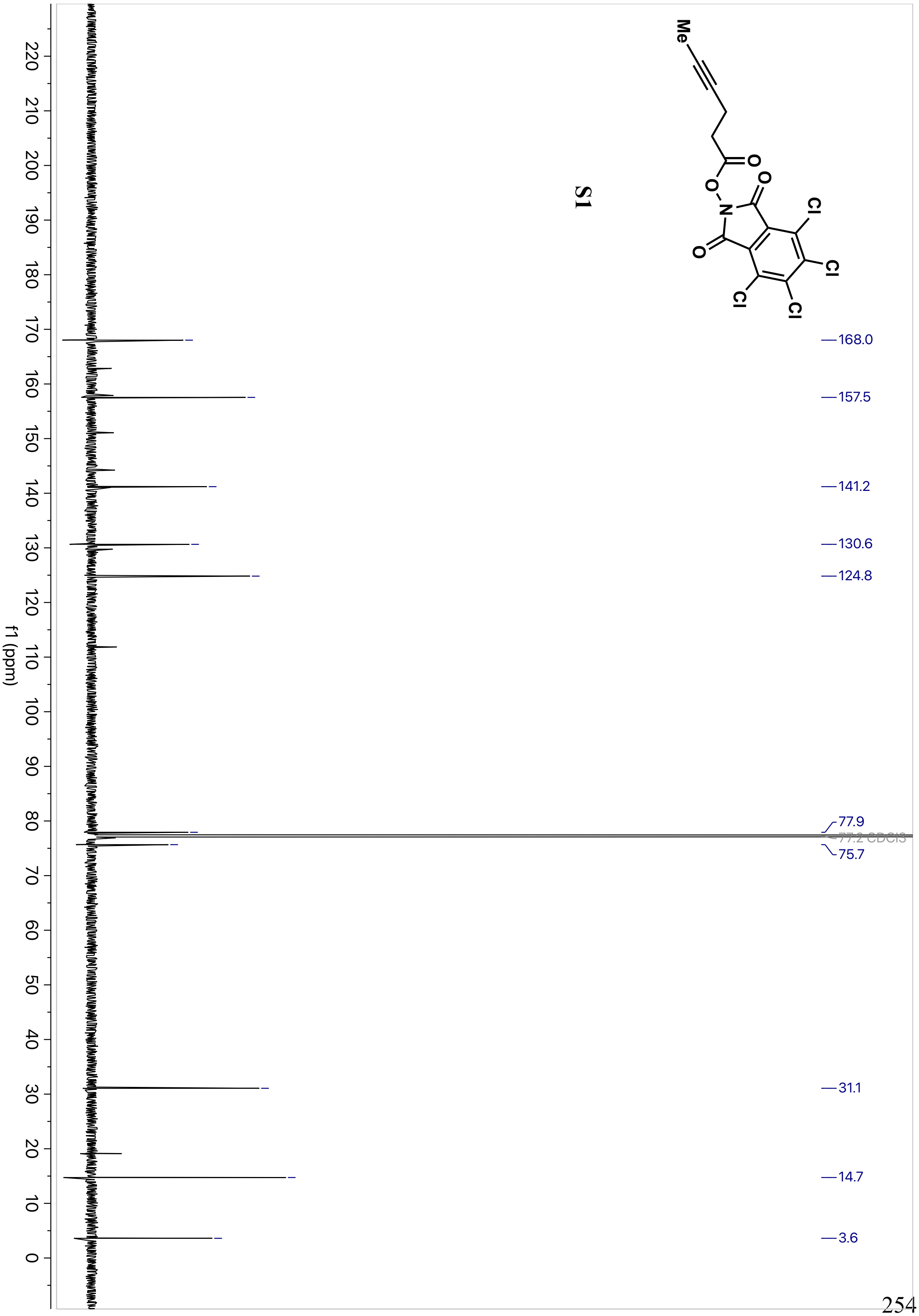


NMR Spectra

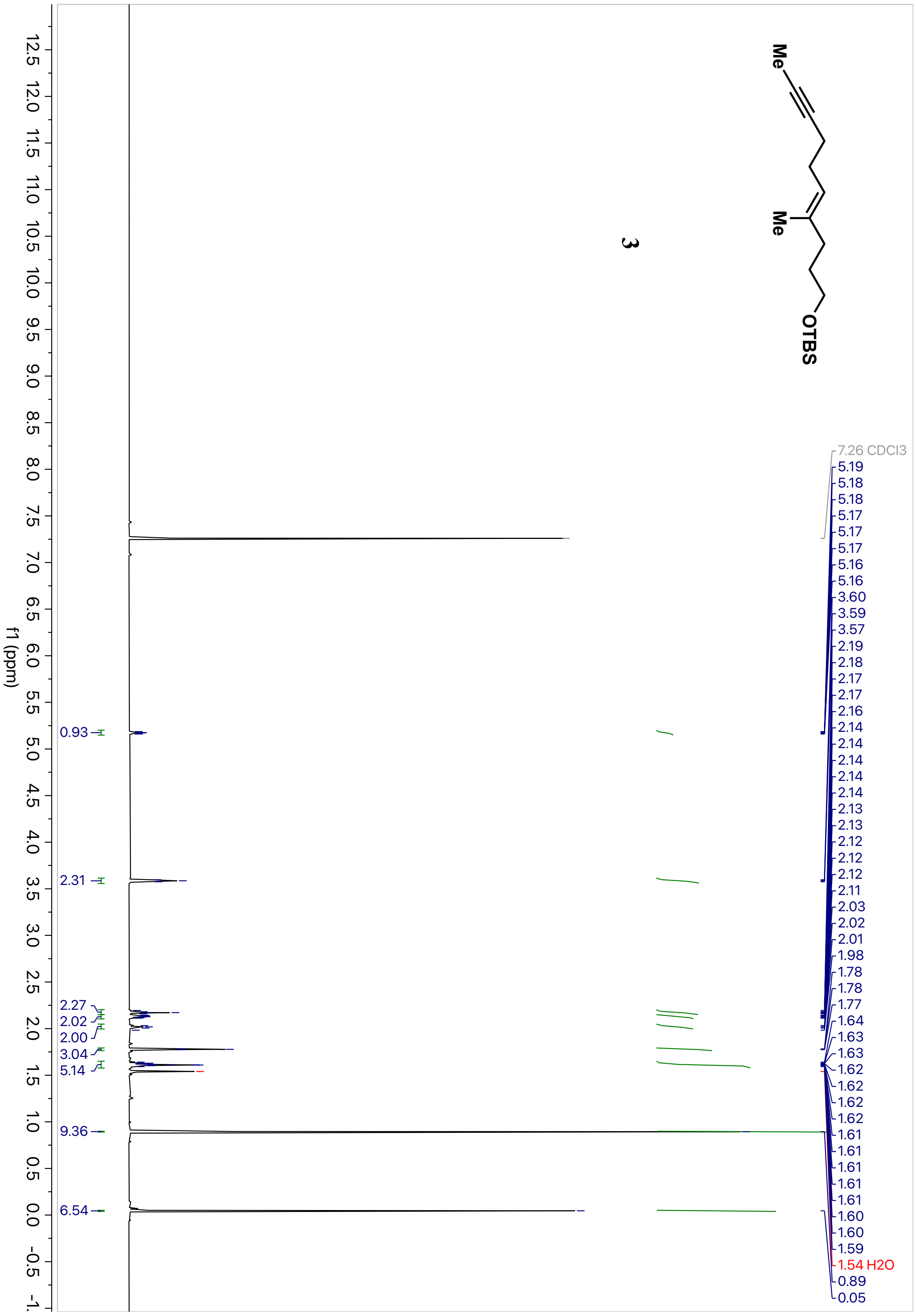


S1

Me
O
O
N
O
O
Cl
Cl
Cl
Cl
7.26 CDCl3
2.89
2.88
2.87
2.86
2.61
2.60
2.60
2.59
2.59
2.59
2.59
2.58
2.57
2.57
1.81
1.80
1.80
2.00
2.11
3.16
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)


Me
O
O
N
O
O
Cl
Cl
Cl
Cl
168.0
157.5
141.2
130.6
124.8
77.9
77.2 CDCl3
75.7
31.1
14.7
3.6
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

S1



3

Me
Me
OTBS
7.26 CDCl3
5.19
5.18
5.18
5.17
5.17
5.17
5.16
5.16
3.60
3.59
3.57
2.19
2.18
2.17
2.17
2.16
2.14
2.14
2.14
2.14
2.14
2.13
2.13
2.12
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1.98
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1.63
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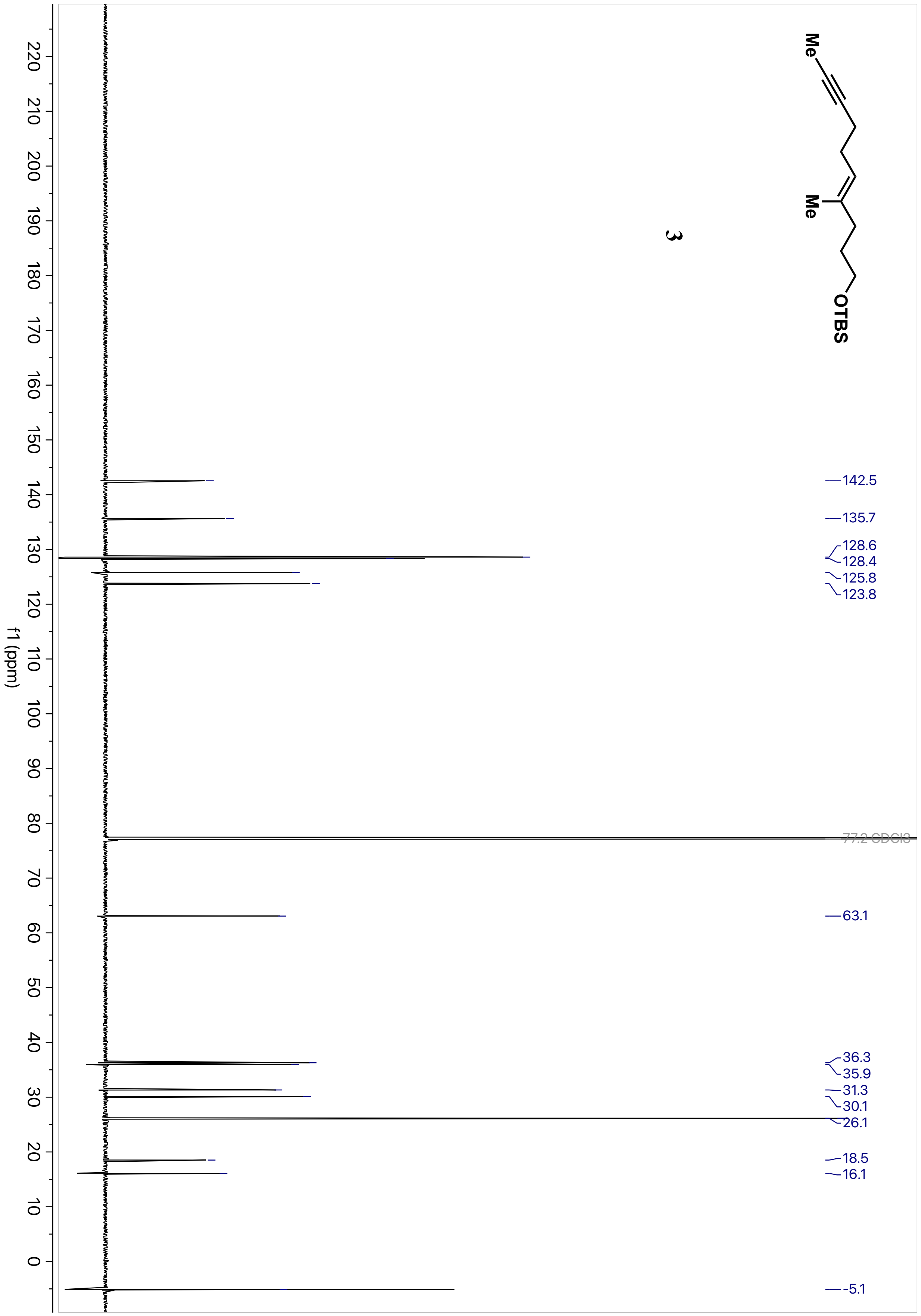
1.62
1.62
1.62
1.62
1.61
1.61
1.61
1.61
1.61
1.60
1.60
1.59
1.54 H2O
0.89
0.05
0.93
2.31
2.27
2.02
2.00
3.04
5.14
9.36
6.54
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.
f1 (ppm)



Me
Me
OTBS
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135.7
128.6
128.4
125.8
123.8
77.2 CDCl3
63.1
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35.9
31.3
30.1
26.1
18.5
16.1
-5.1
220
210
200
190
180
170
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90
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70
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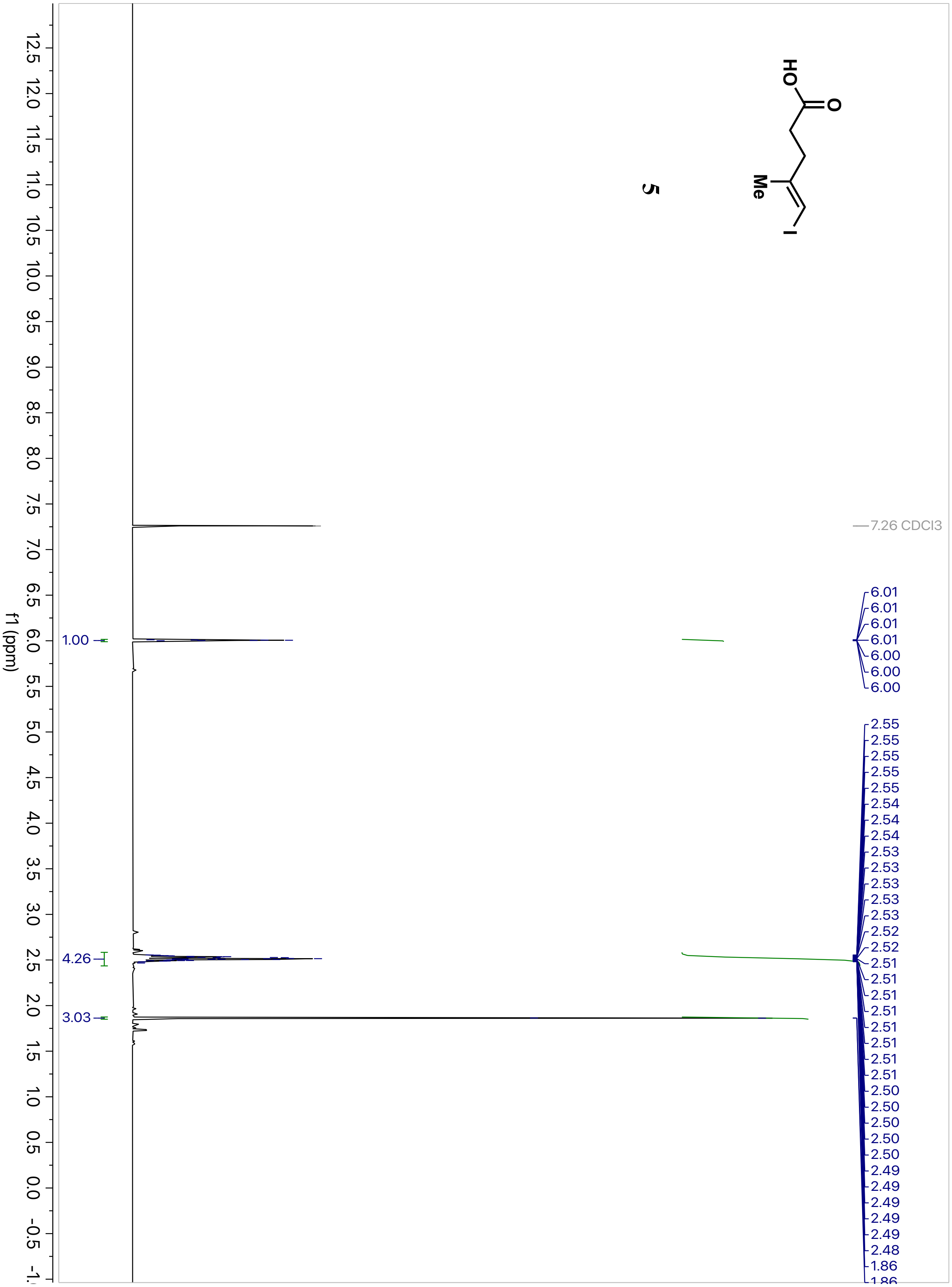
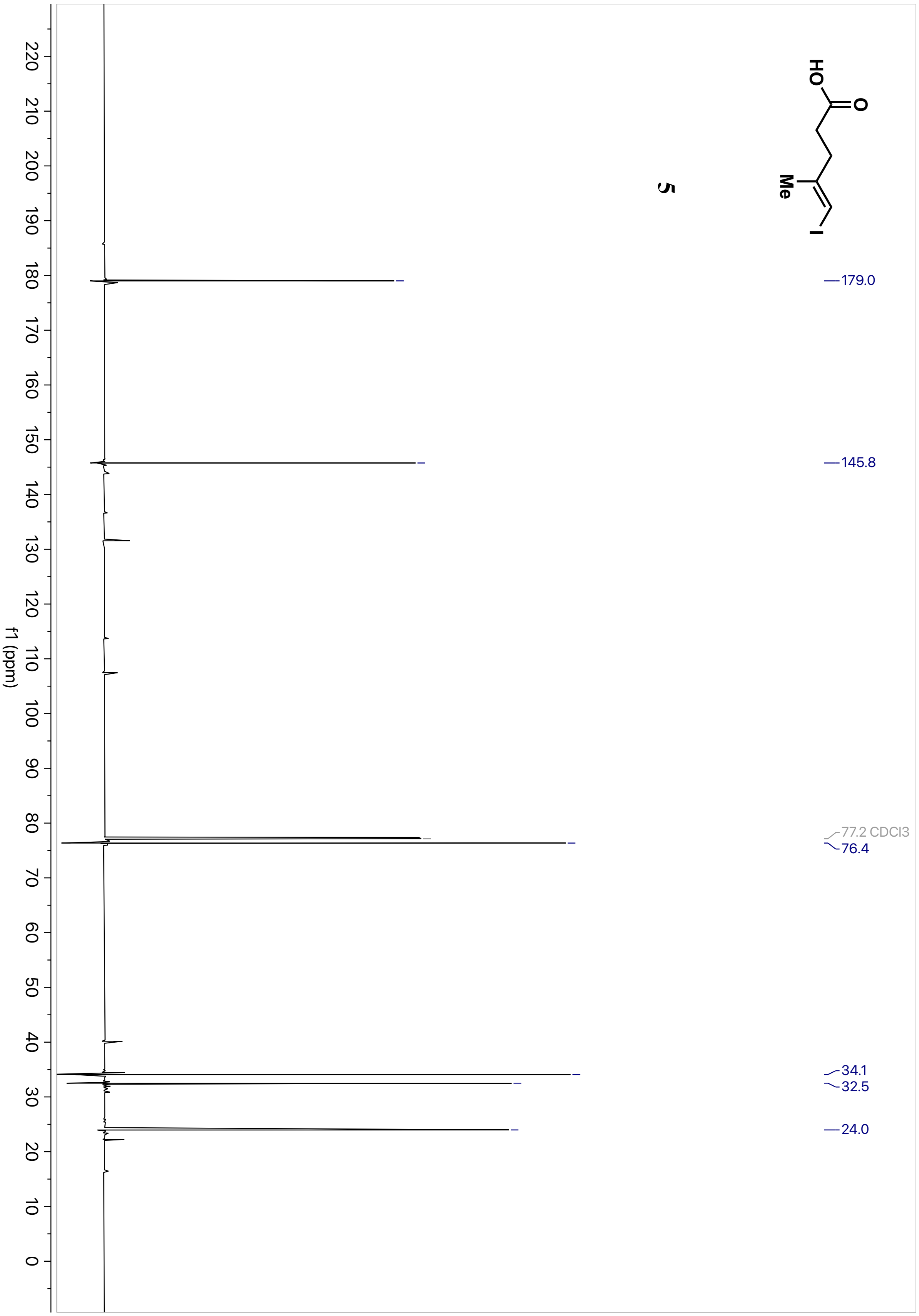
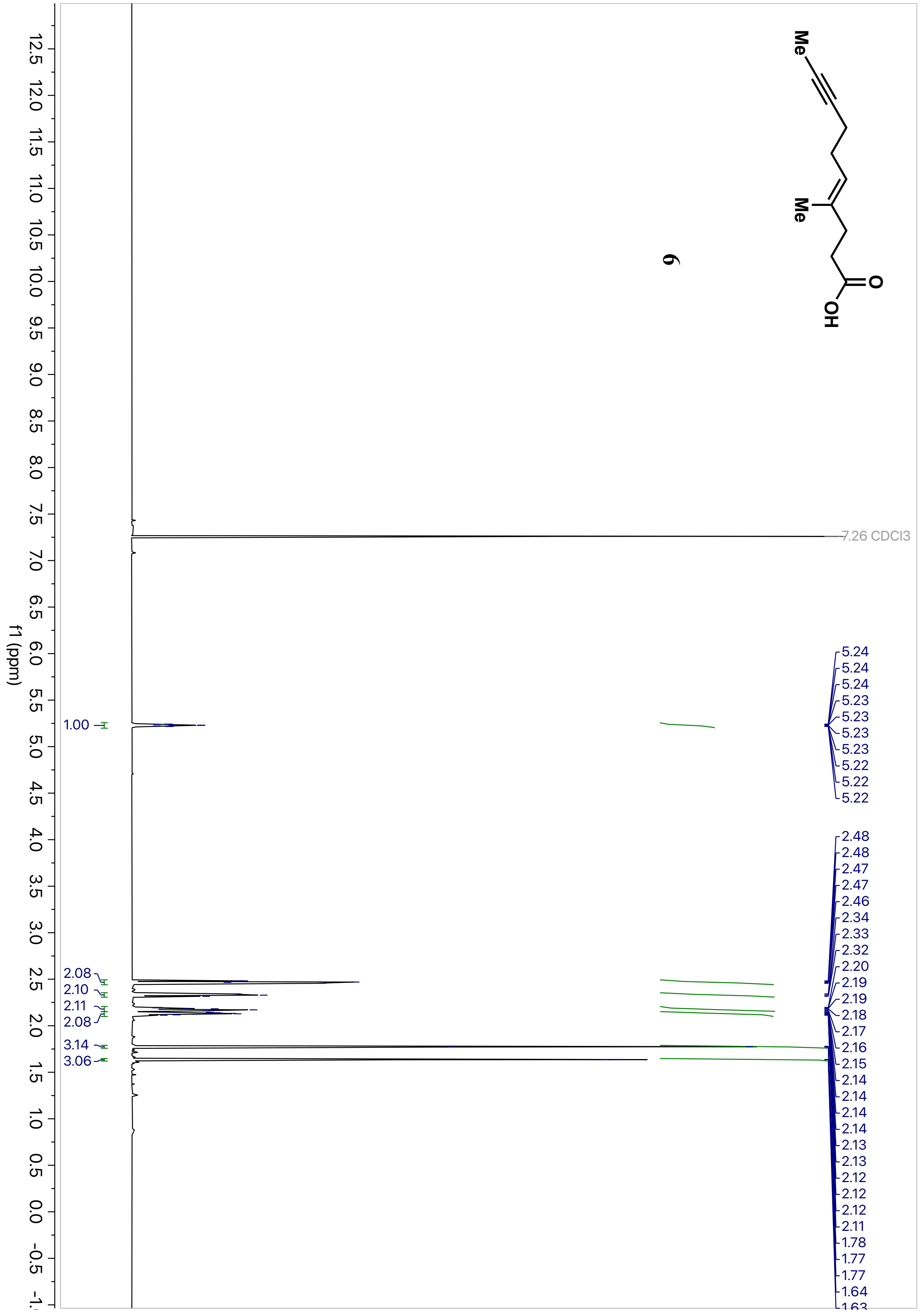
50
40
30
20
10
0
f1 (ppm)

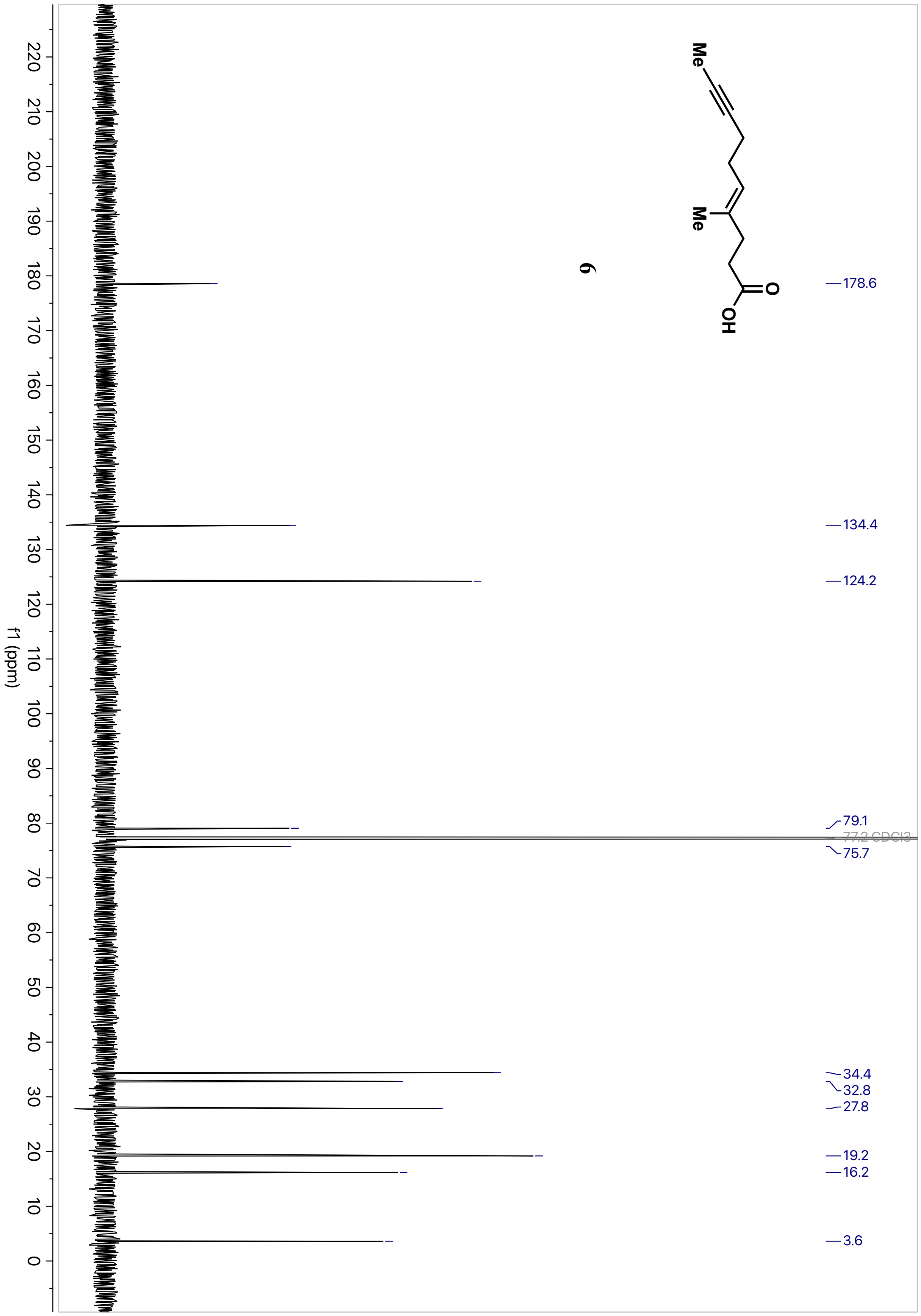

5
HO
O
Me
I
—7.26 CDCl3
6.01
6.01
6.01
6.01
6.00
6.00
6.00
2.55
2.55
2.55
2.55
2.55
2.54
2.54
2.54
2.53
2.53
2.53
2.53
2.53
2.52
2.52
2.51
2.51
2.51
2.51
2.51
2.51
2.51
2.51
2.50
2.50
2.50
2.50
2.50
2.49
2.49
2.49
2.49
2.49
2.48
1.86
1.00
4.26
3.03
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)



5

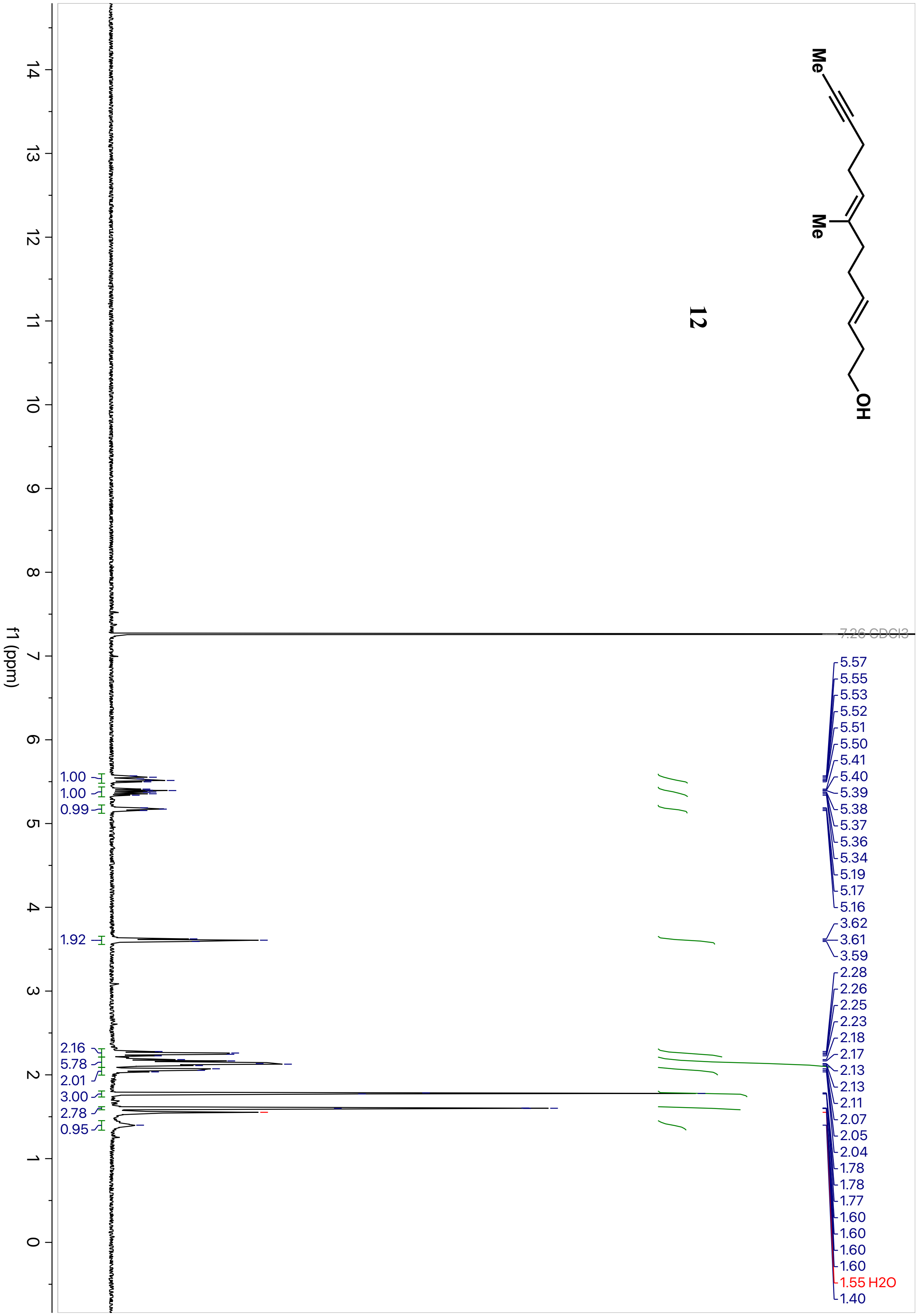
HO
O
Me
I
179.0
145.8
77.2 CDCl3
76.4
34.1
32.5
24.0
f1 (ppm)
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0

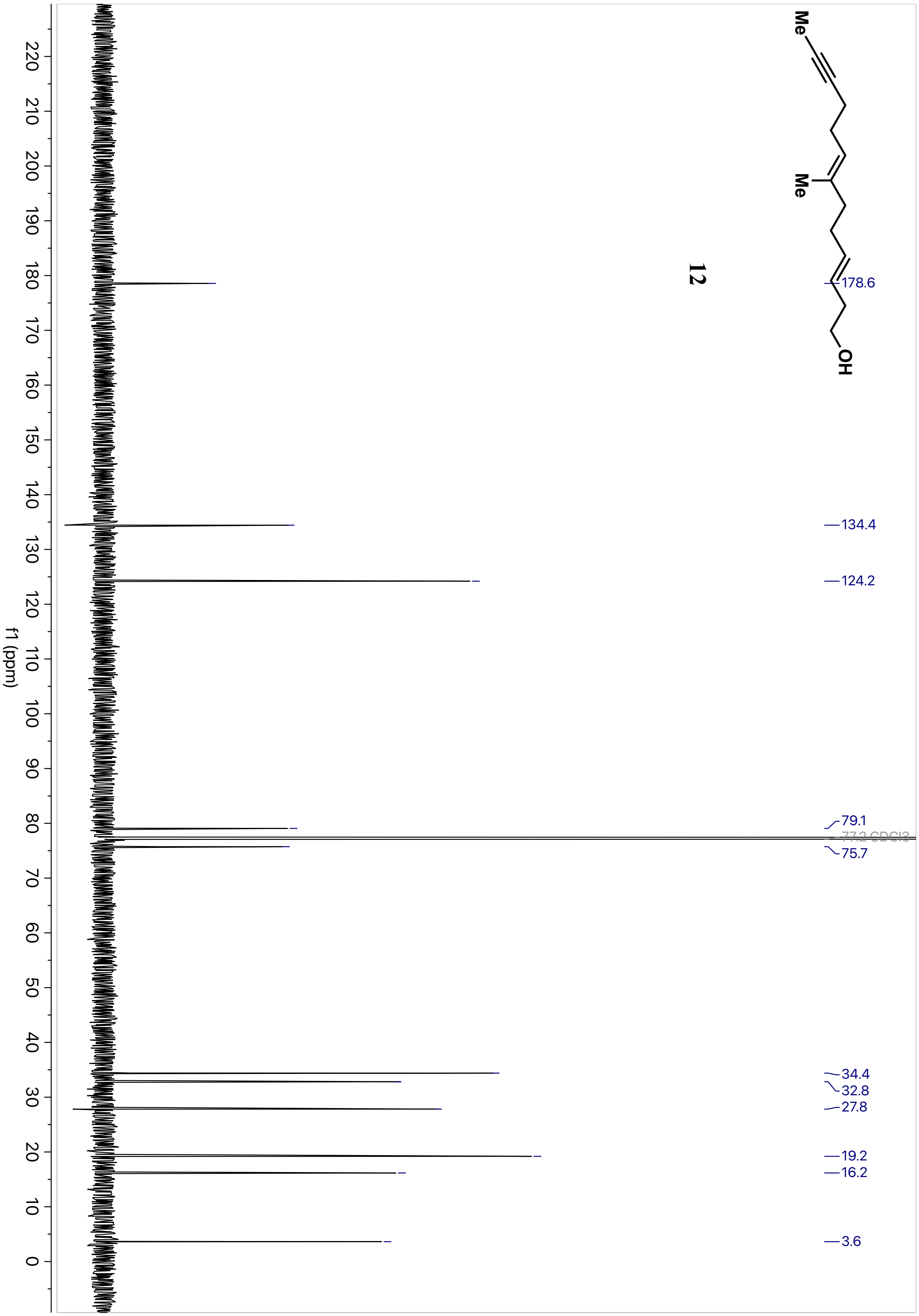

6
Me
Me
O
OH
7.26 CDCl3
5.24
5.24
5.24
5.23
5.23
5.23
5.23
5.22
5.22
5.22
2.48
2.48
2.47
2.47
2.46
2.34
2.33
2.32
2.20
2.19
2.19
2.18
2.17
2.16
2.15
2.14
2.14
2.14
2.14
2.13
2.13
2.12
2.12
2.12
2.11
1.78
1.77
1.77
1.64
1.63
1.00
2.08
2.10
2.11
2.08
3.14
3.06
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)



Me
Me
O
OH
178.6
134.4
124.2
79.1
77.2 CDCl3
75.7
34.4
32.8
27.8
19.2
16.2
3.6
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

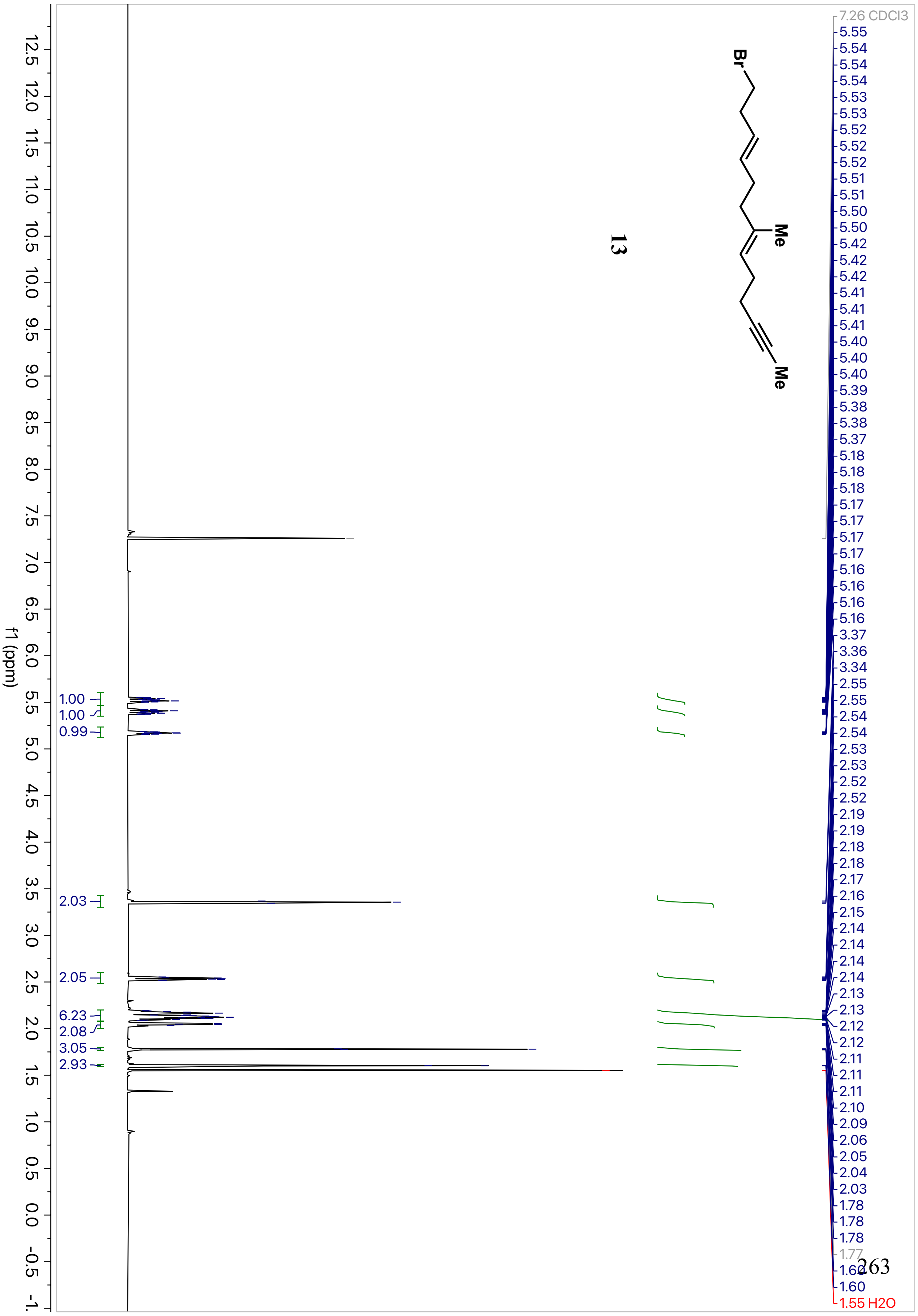
6


12
Me
Me
OH
7.26 CDCl3
5.57
5.55
5.53
5.52
5.51
5.50
5.41
5.40
5.39
5.38
5.37
5.36
5.34
5.19
5.17
5.16
3.62
3.61
3.59
2.28
2.26
2.25
2.23
2.18
2.17
2.13
2.13
2.11
2.07
2.05
2.04
1.78
1.78
1.77
1.60
1.60
1.60
1.60
1.55 H2O
1.40
1.00
1.00
0.99
1.92
2.16
5.78
2.01
3.00
2.78
0.95
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

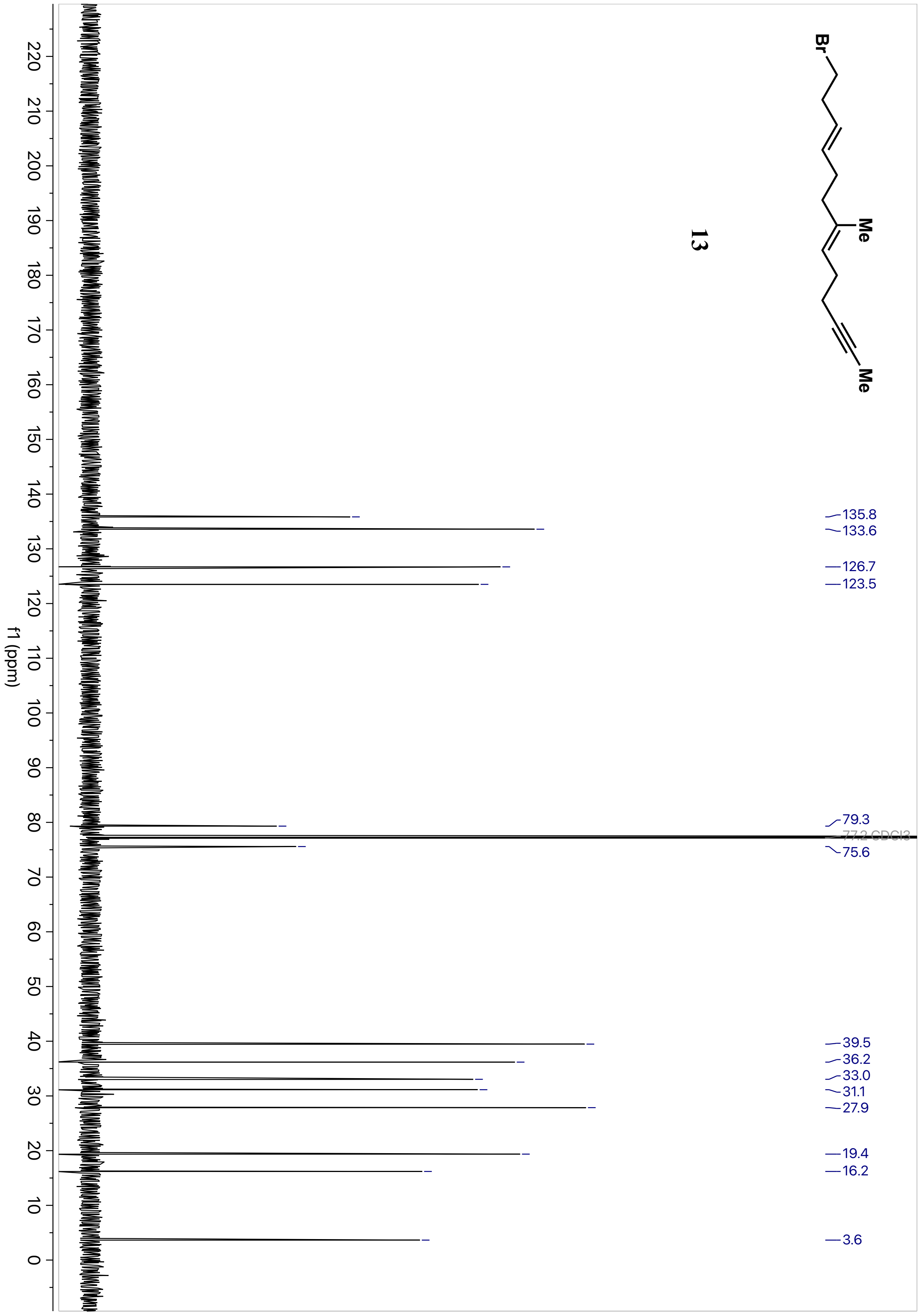


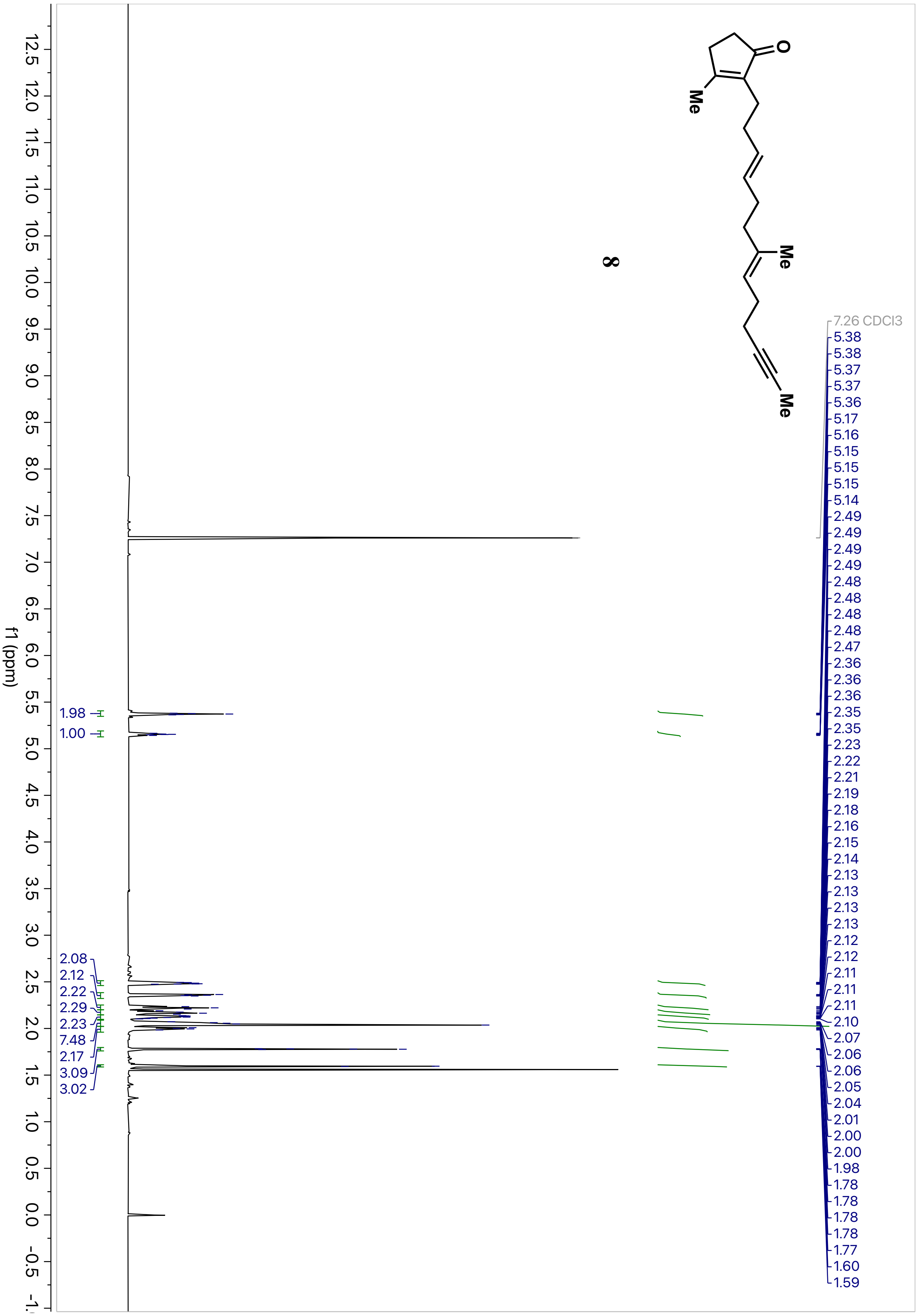
12

Me
Me
OH
178.6
134.4
124.2
79.1
77.2 CDCl3
75.7
34.4
32.8
27.8
19.2
16.2
3.6
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

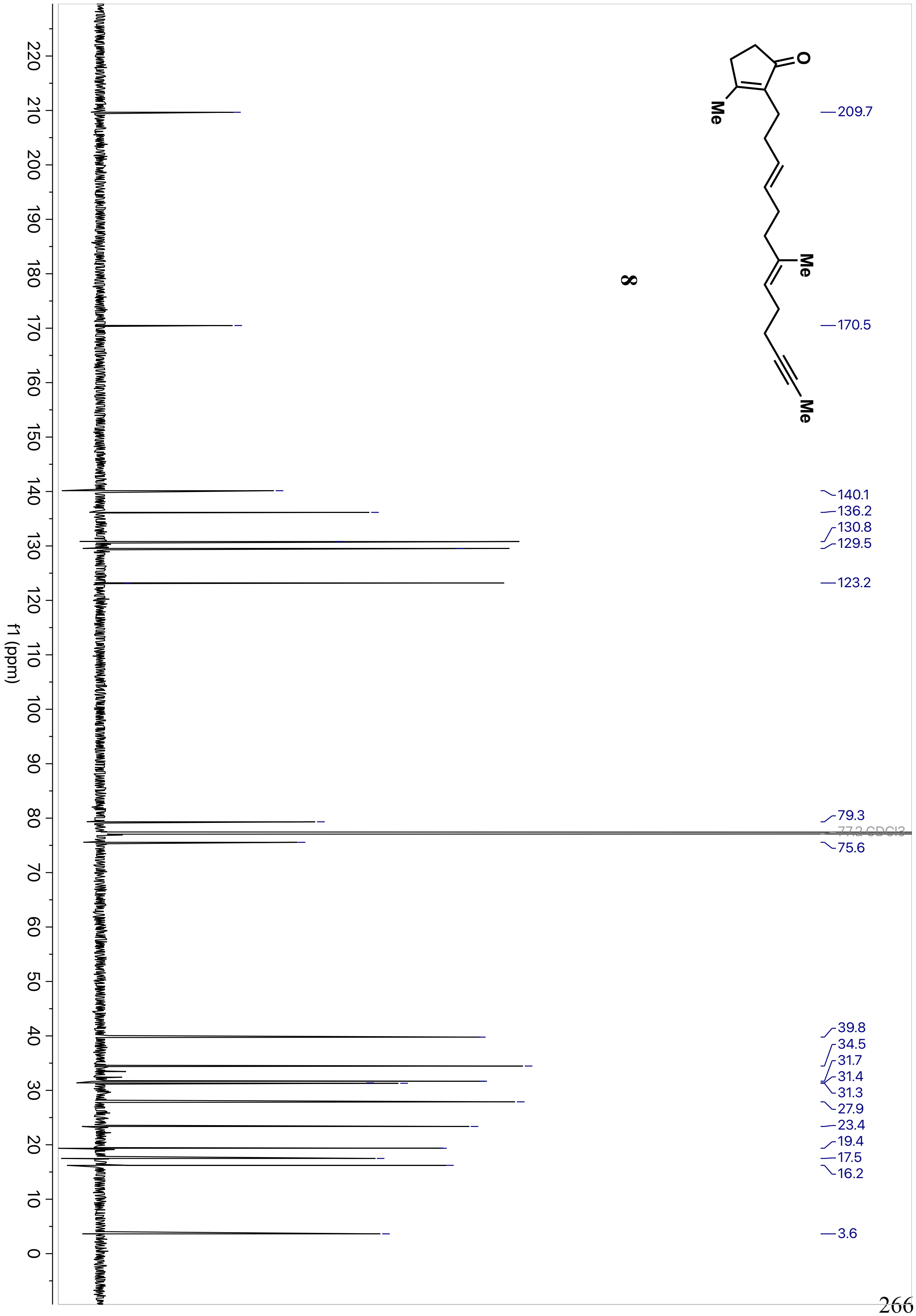

13

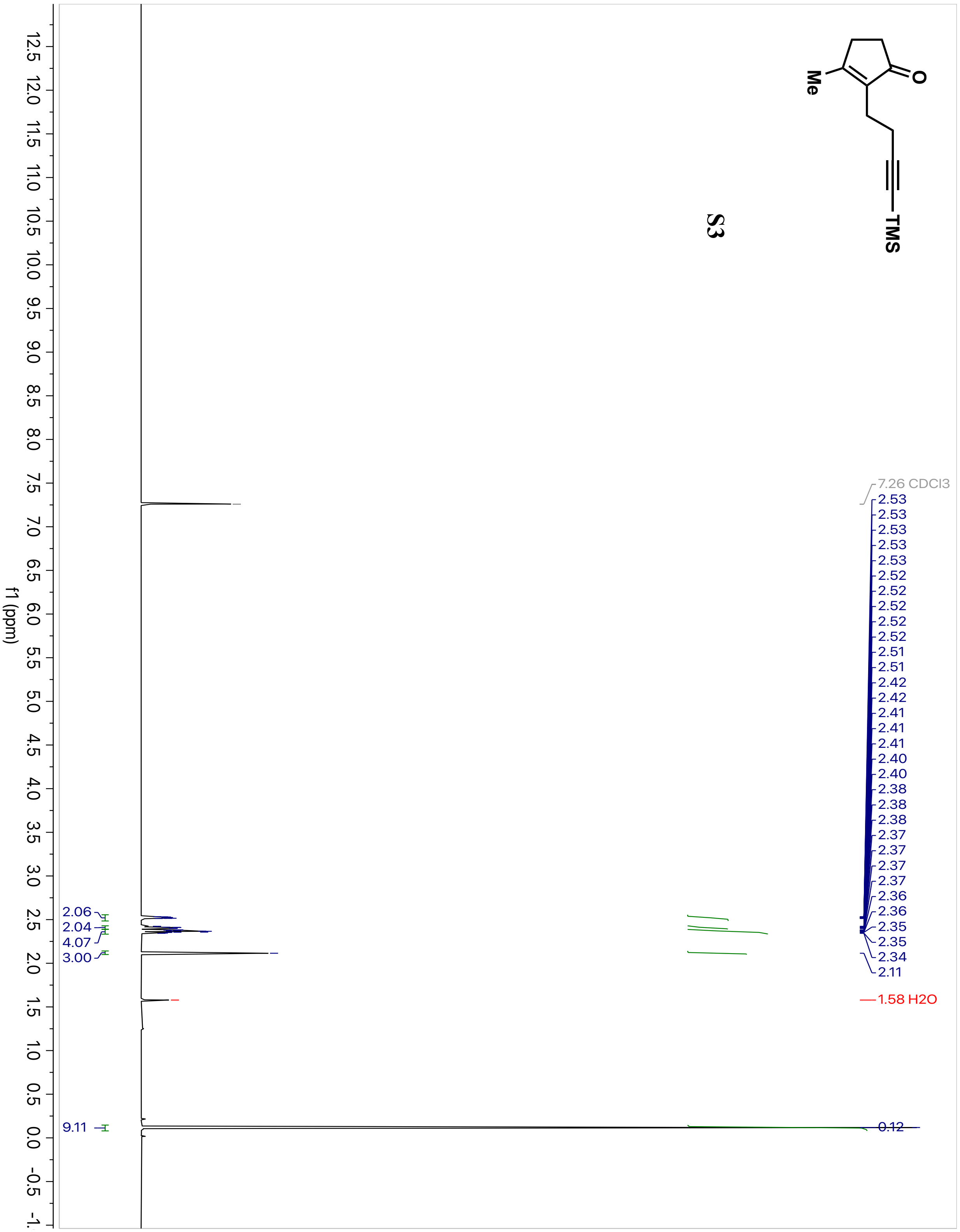
Br
Me
Me
7.26 CDCl3
5.55
5.54
5.54
5.54
5.53
5.53
5.52
5.52
5.52
5.51
5.51
5.50
5.50
5.42
5.42
5.42
5.41
5.41
5.41
5.40
5.40
5.40
5.39
5.38
5.38
5.37
5.18
5.18
5.18
5.17
5.17
5.17
5.17
5.16
5.16
5.16
5.16
3.37
3.36
3.34
2.55
2.55
2.54
2.54
2.53
2.53
2.52
2.52
2.19
2.19
2.18
2.18
2.17
2.16
2.15
2.14
2.14
2.14
2.14
2.13
2.13
2.12
2.12
2.11
2.11
2.11
2.10
2.09
2.06
2.05
2.04
2.03
1.78
1.78
1.78
1.77
1.60
1.60
1.55 H2O
1.00
1.00
0.99
2.03
2.05
6.23
2.08
3.05
2.93
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

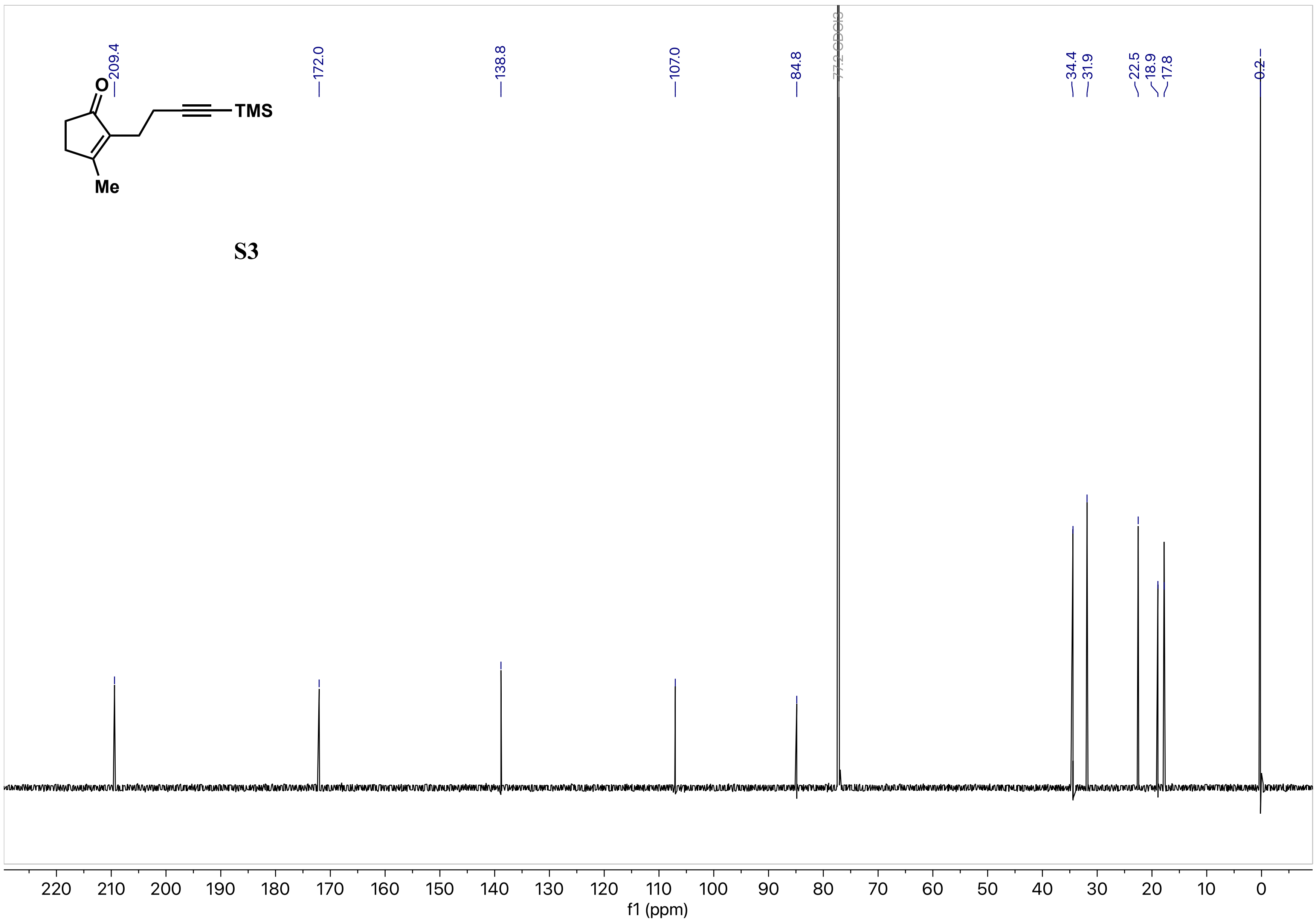

13
Br
Me
Me
135.8
133.6
126.7
123.5
79.3
77.2 CDCl3
75.6
39.5
36.2
33.0
31.1
27.9
19.4
16.2
3.6
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


O
Me
Me
Me
7.26 CDCl3
5.38
5.38
5.37
5.37
5.36
5.17
5.16
5.15
5.15
5.15
5.14
2.49
2.49
2.49
2.49
2.48
2.48
2.48
2.48
2.47
2.36
2.36
2.36
2.35
2.35
2.23
2.22
2.21
2.19
2.18
2.16
2.15
2.14
2.13
2.13
2.13
2.13
2.12
2.12
2.11
2.11
2.11
2.10
2.07
2.06
2.06
2.05
2.04
2.01
2.00
2.00
1.98
1.78
1.78
1.78
1.78
1.77
1.60
1.59
1.98
1.00
2.08
2.12
2.22
2.29
2.23
7.48
2.17
3.09
3.02
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.
f1 (ppm)

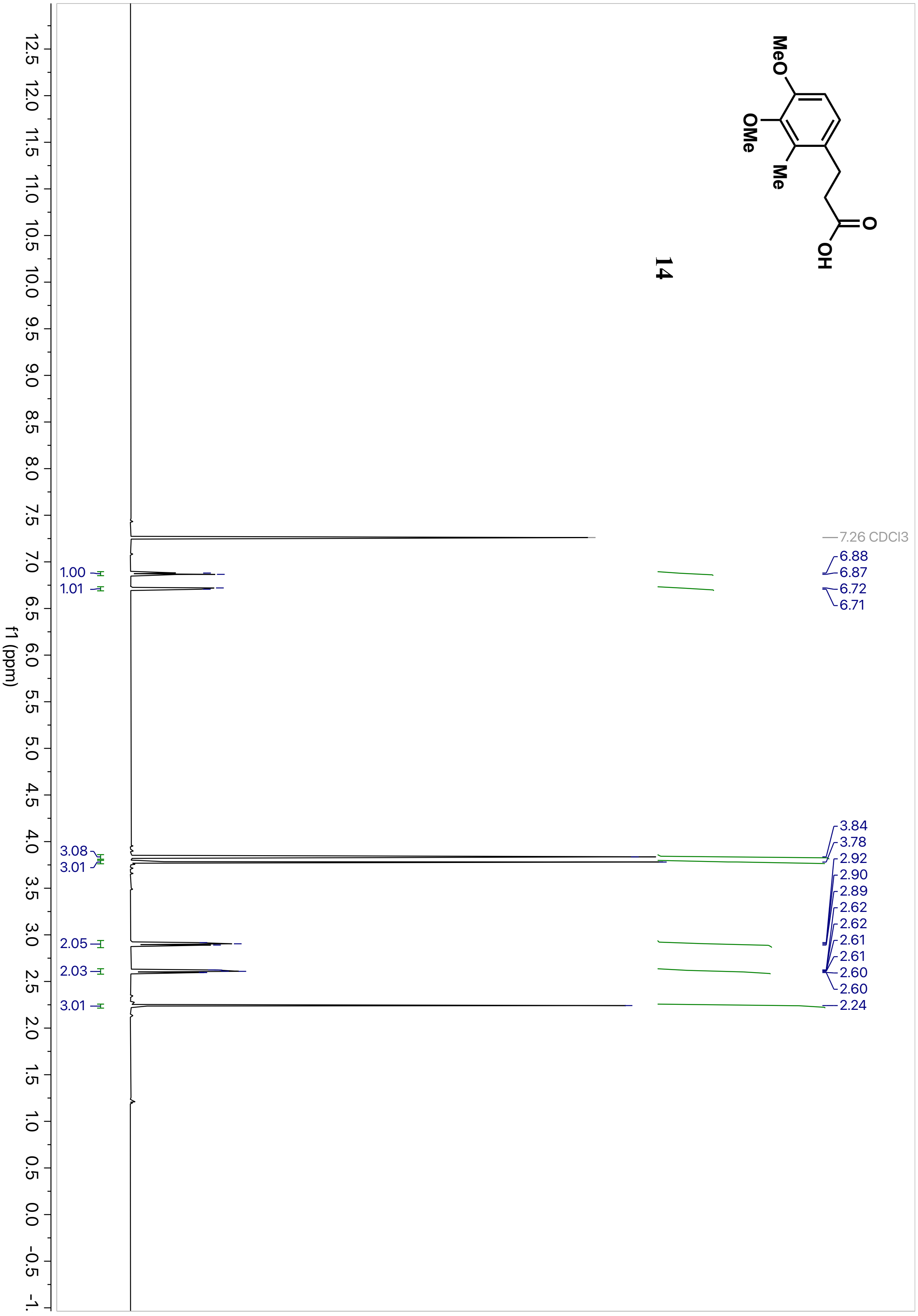
8


8
O
Me
Me
Me
209.7
170.5
140.1
136.2
130.8
129.5
123.2
79.3
77.2 CDCl3
75.6
39.8
34.5
31.7
31.4
31.3
27.9
23.4
19.4
17.5
16.2
3.6
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

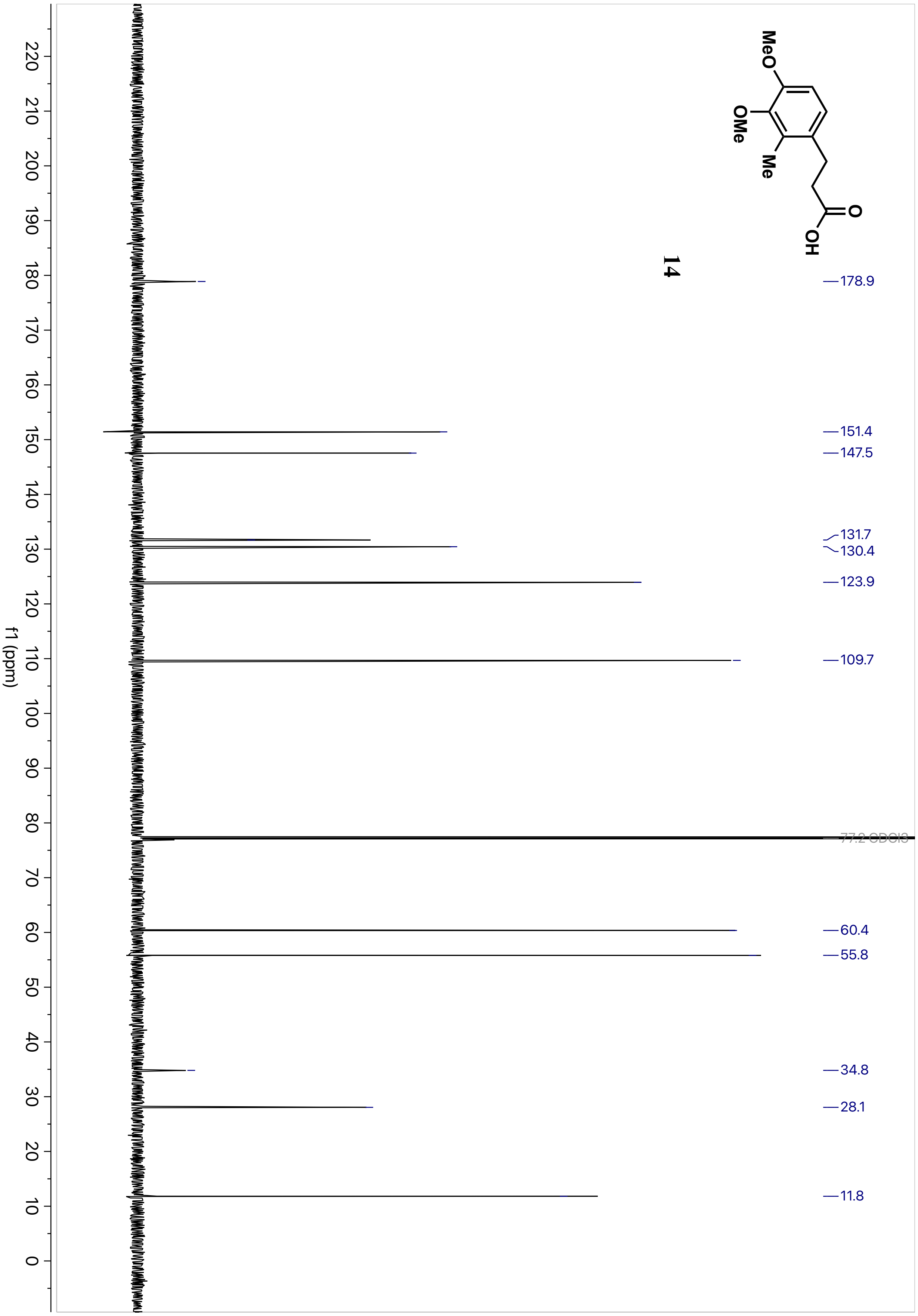

S3
O
Me
TMS
7.26 CDCl3
2.53
2.53
2.53
2.53
2.53
2.52
2.52
2.52
2.52
2.52
2.51
2.51
2.42
2.42
2.41
2.41
2.41
2.40
2.40
2.38
2.38
2.38
2.37
2.37
2.37
2.37
2.36
2.36
2.35
2.35
2.34
2.11
1.58 H2O
0.12
2.06
2.04
4.07
3.00
9.11
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.
f1 (ppm)

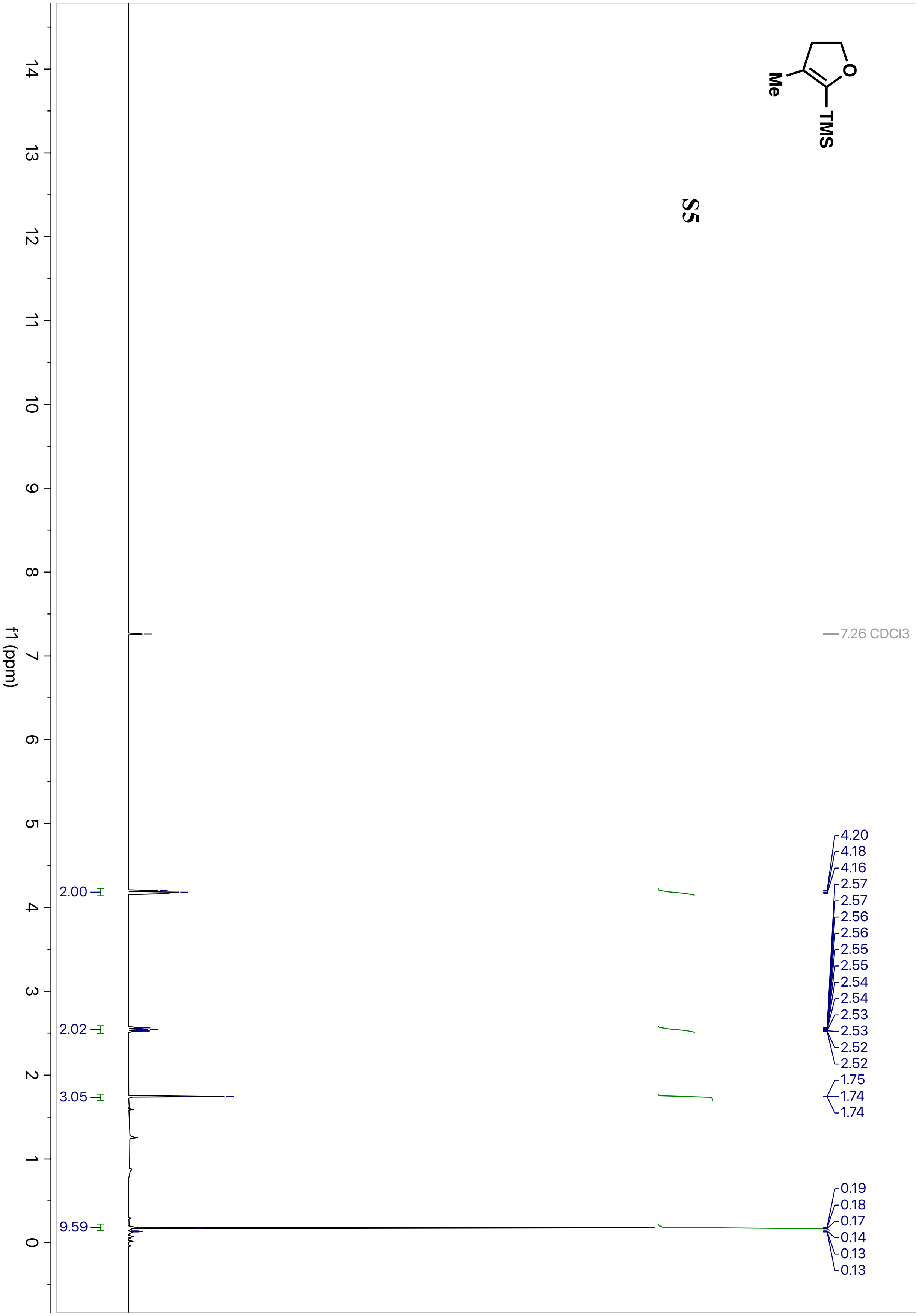

S3

O
TMS
Me
209.4
172.0
138.8
107.0
84.8
77.2 CDCl3
34.4
31.9
22.5
18.9
17.8
0.2
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


14

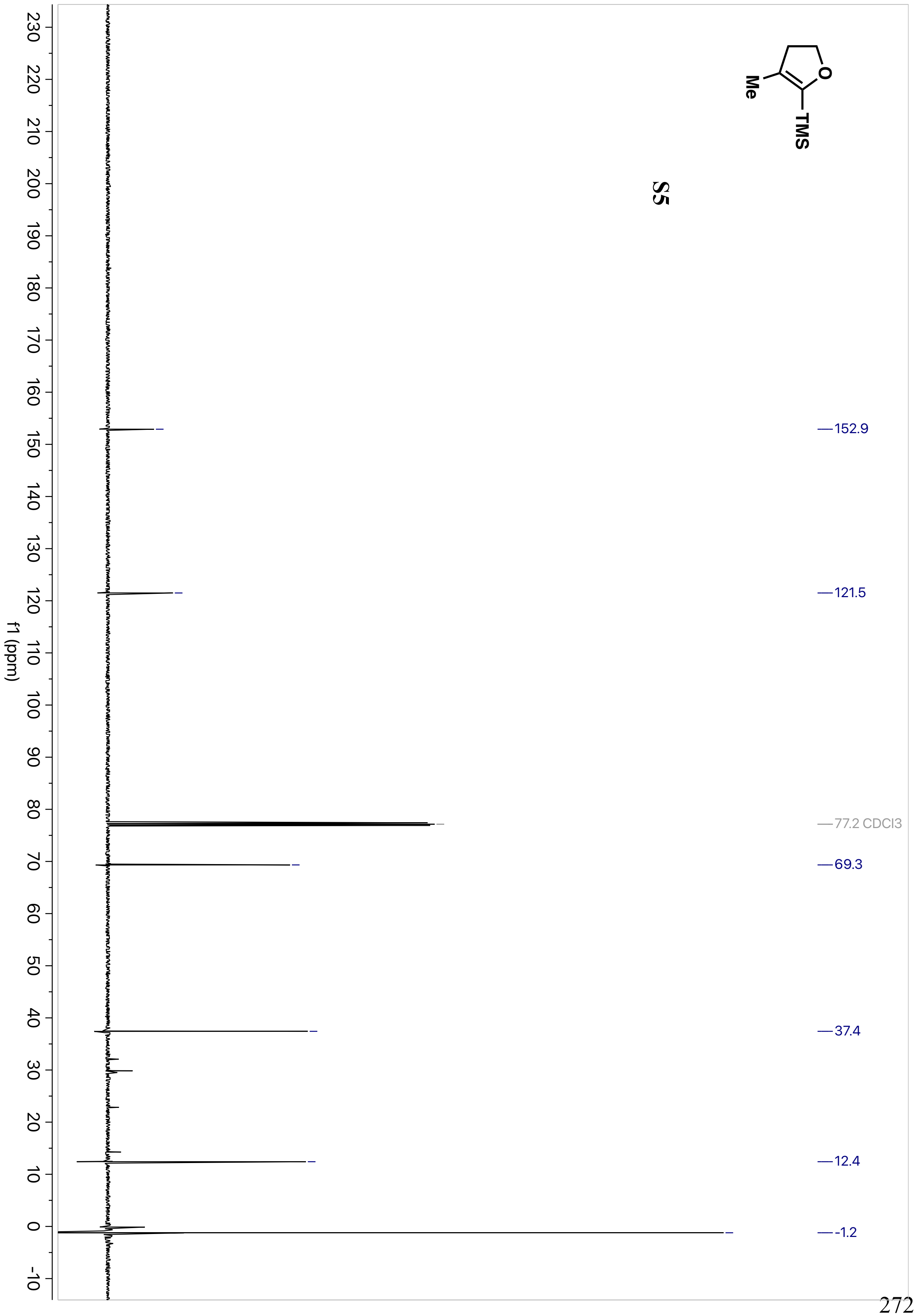
MeO
OMe
Me
O
OH
7.26 CDCl3
6.88
6.87
6.72
6.71
3.84
3.78
2.92
2.90
2.89
2.62
2.62
2.61
2.61
2.60
2.60
2.24
1.00
1.01
3.08
3.01
2.05
2.03
3.01
12.5 12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.
f1 (ppm)


MeO
OMe
Me
O
OH
14
178.9
151.4
147.5
131.7
130.4
123.9
109.7
77.2 CDCl3
60.4
55.8
34.8
28.1
11.8
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)



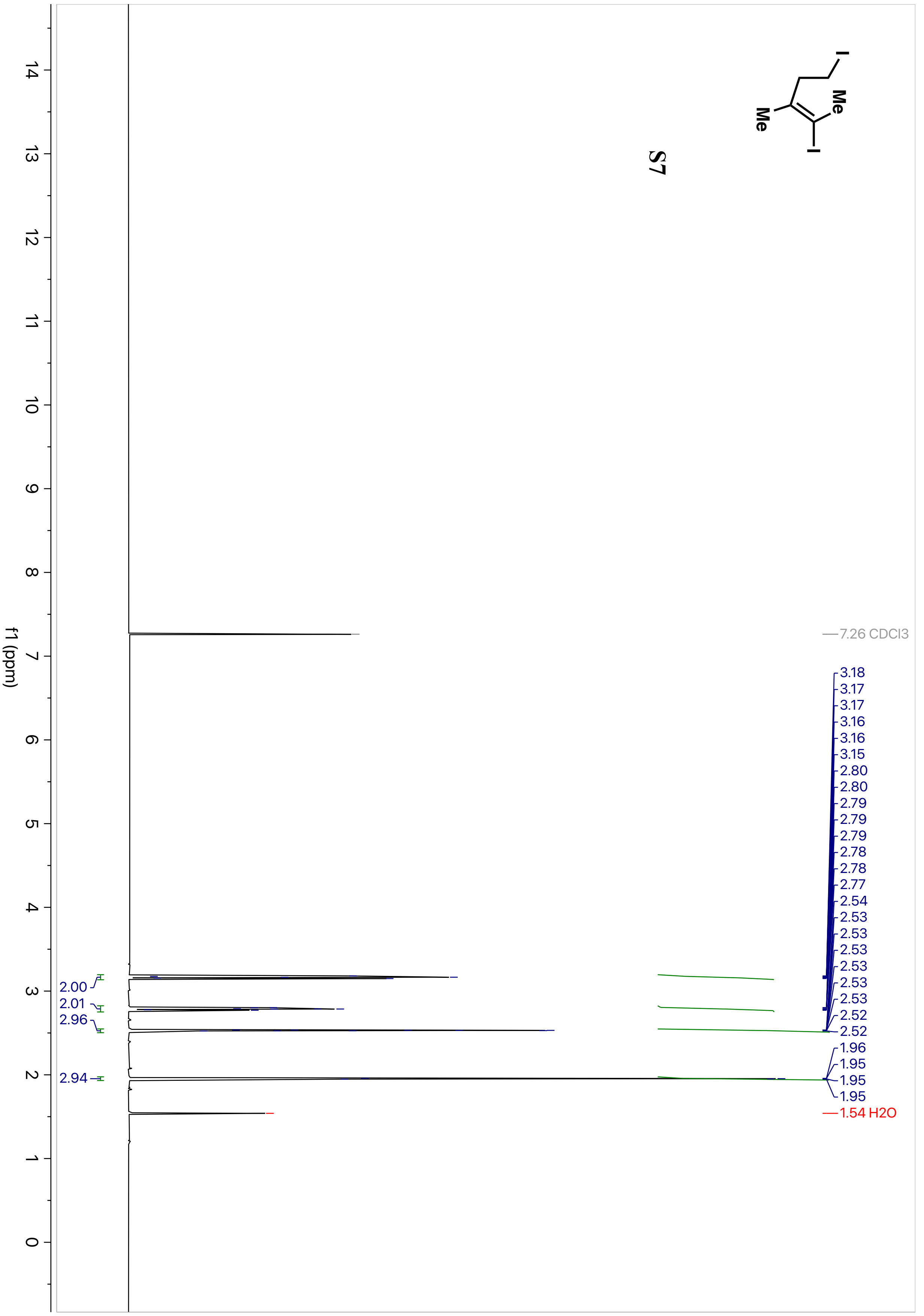
S5

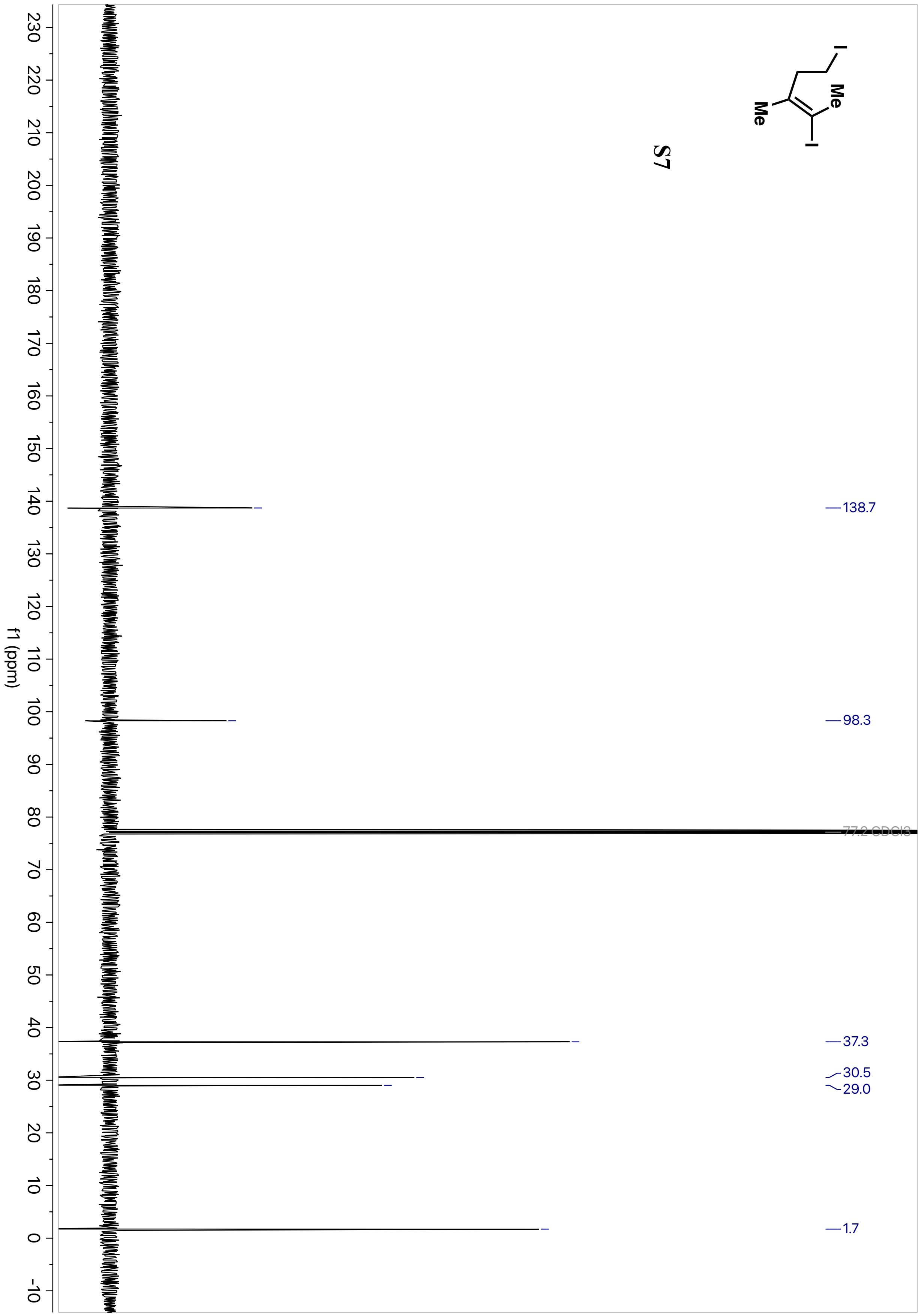
Me
TMS
O
7.26 CDCl3
4.20
4.18
4.16
2.57
2.57
2.56
2.56
2.55
2.55
2.54
2.54
2.53
2.53
2.52
2.52
1.75
1.74
1.74
0.19
0.18
0.17
0.14
0.13
0.13
2.00
2.02
3.05
9.59
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

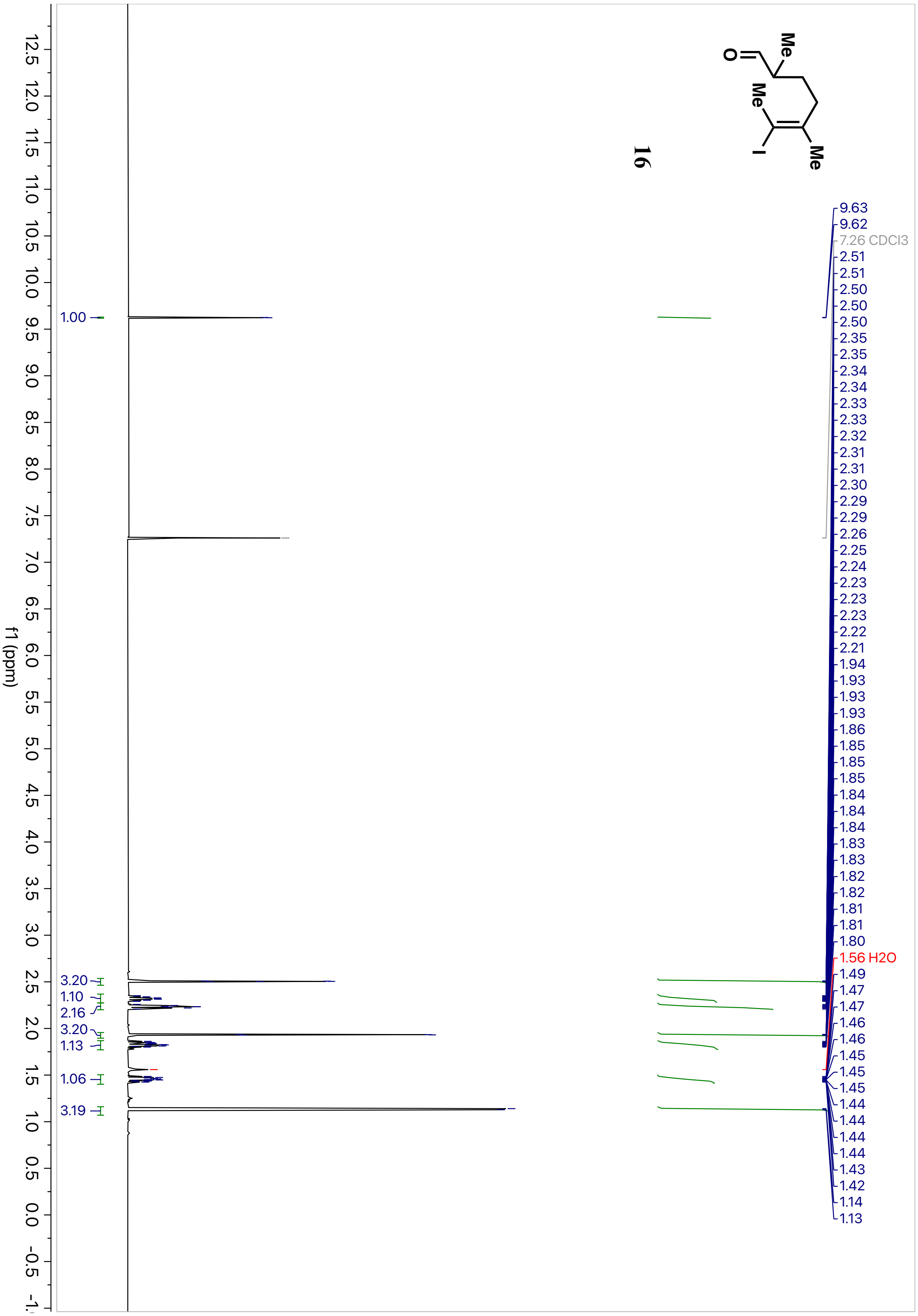


S5

TMS
Me
O
—152.9
—121.5
—77.2 CDCl3
—69.3
—37.4
—12.4
—-1.2
f1 (ppm)
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10

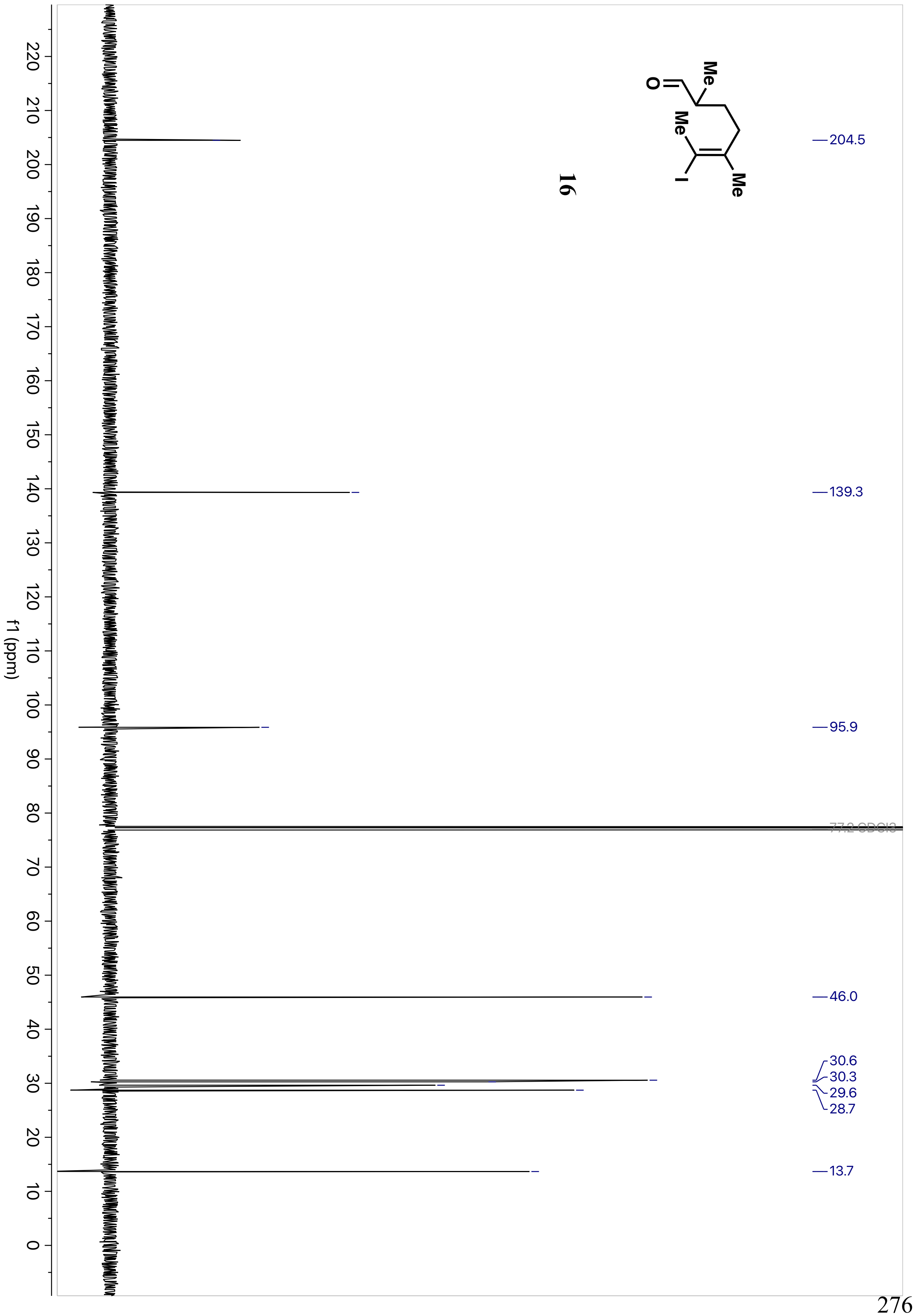

S7
Me
Me
I
I
7.26 CDCl3
3.18
3.17
3.17
3.16
3.16
3.15
2.80
2.80
2.79
2.79
2.79
2.78
2.78
2.77
2.54
2.53
2.53
2.53
2.53
2.53
2.53
2.52
2.52
1.96
1.95
1.95
1.95
1.54 H2O
2.00
2.01
2.96
2.94
f1 (ppm)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0


S7
Me
Me
I
I
138.7
98.3
77.2 CDCl3
37.3
30.5
29.0
1.7
f1 (ppm)
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10



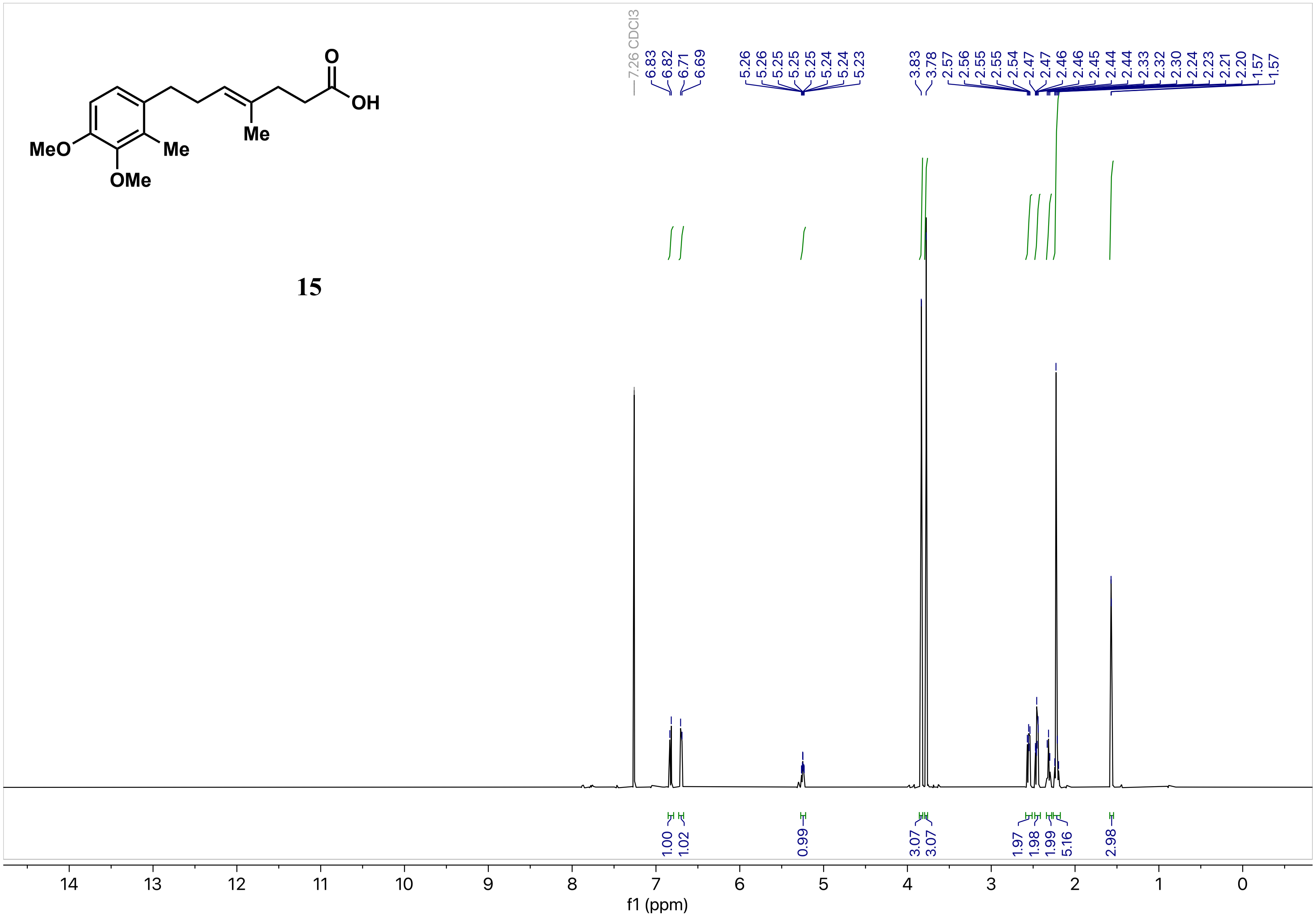
16

Me
O
Me
I
Me
9.63
9.62
7.26 CDCl3
2.51
2.51
2.50
2.50
2.50
2.35
2.35
2.34
2.34
2.33
2.33
2.32
2.31
2.31
2.30
2.29
2.29
2.26
2.25
2.24
2.23
2.23
2.23
2.22
2.21
1.94
1.93
1.93
1.93
1.86
1.85
1.85
1.85
1.84
1.84
1.84
1.83
1.83
1.82
1.82
1.81
1.81
1.80
1.56 H2O
1.49
1.47
1.47
1.46
1.46
1.45
1.45
1.45
1.44
1.44
1.44
1.44
1.43
1.42
1.14
1.13
1.00
3.20
1.10
2.16
3.20
1.13
1.06
3.19
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)



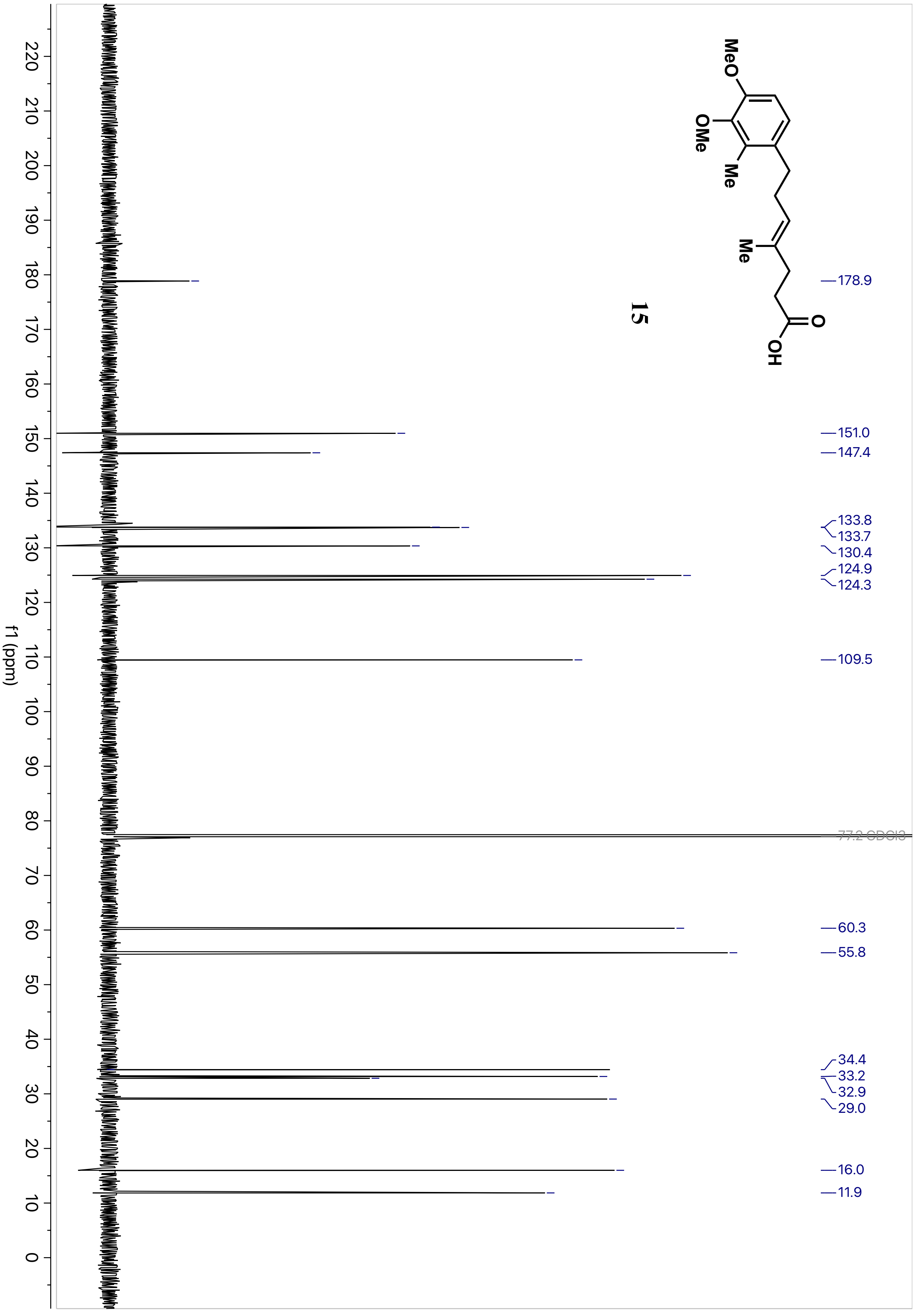
16

204.5
139.3
95.9
77.2 CDCl3
46.0
30.6
30.3
29.6
28.7
13.7
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)
Me
Me
Me
O
I

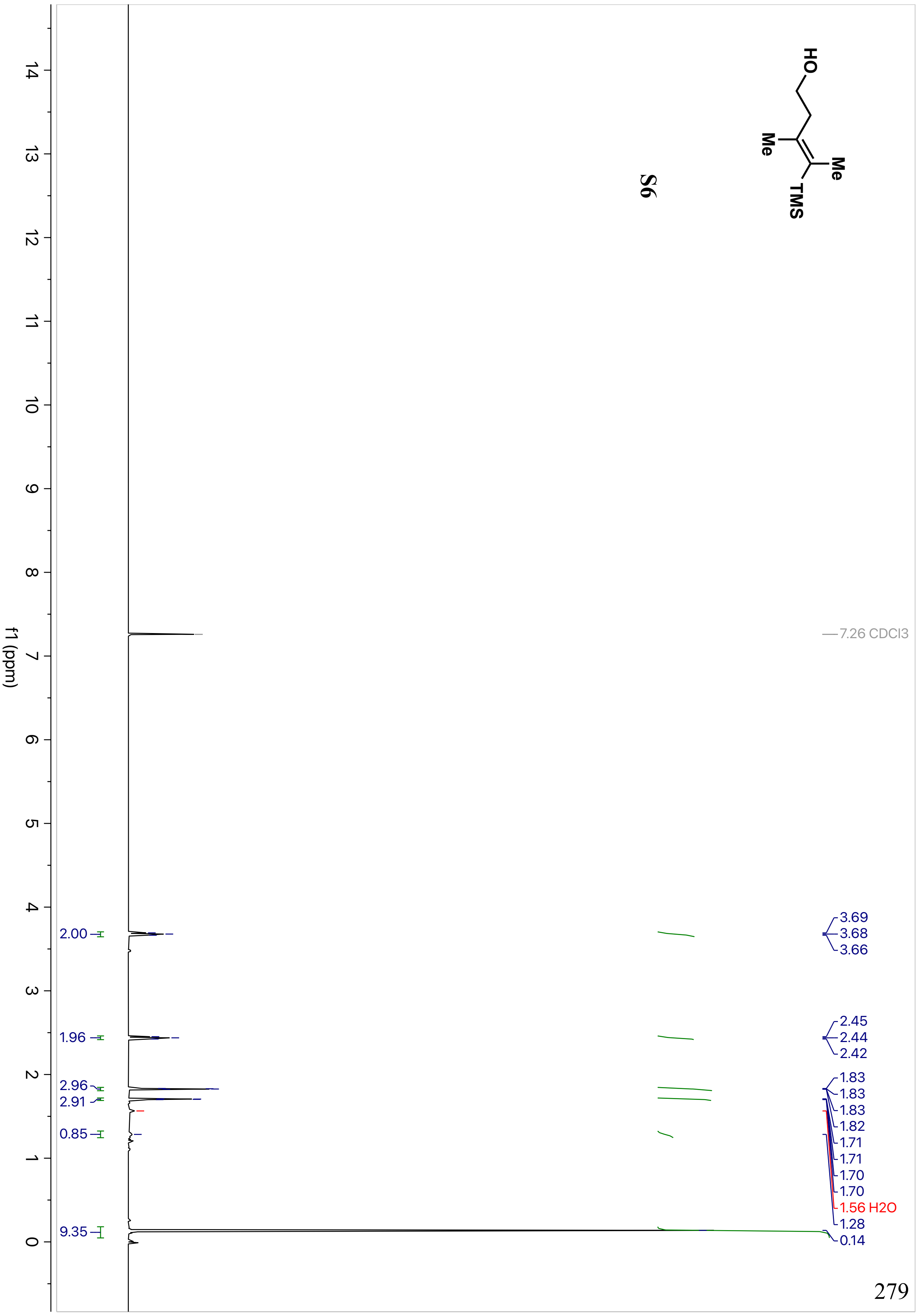


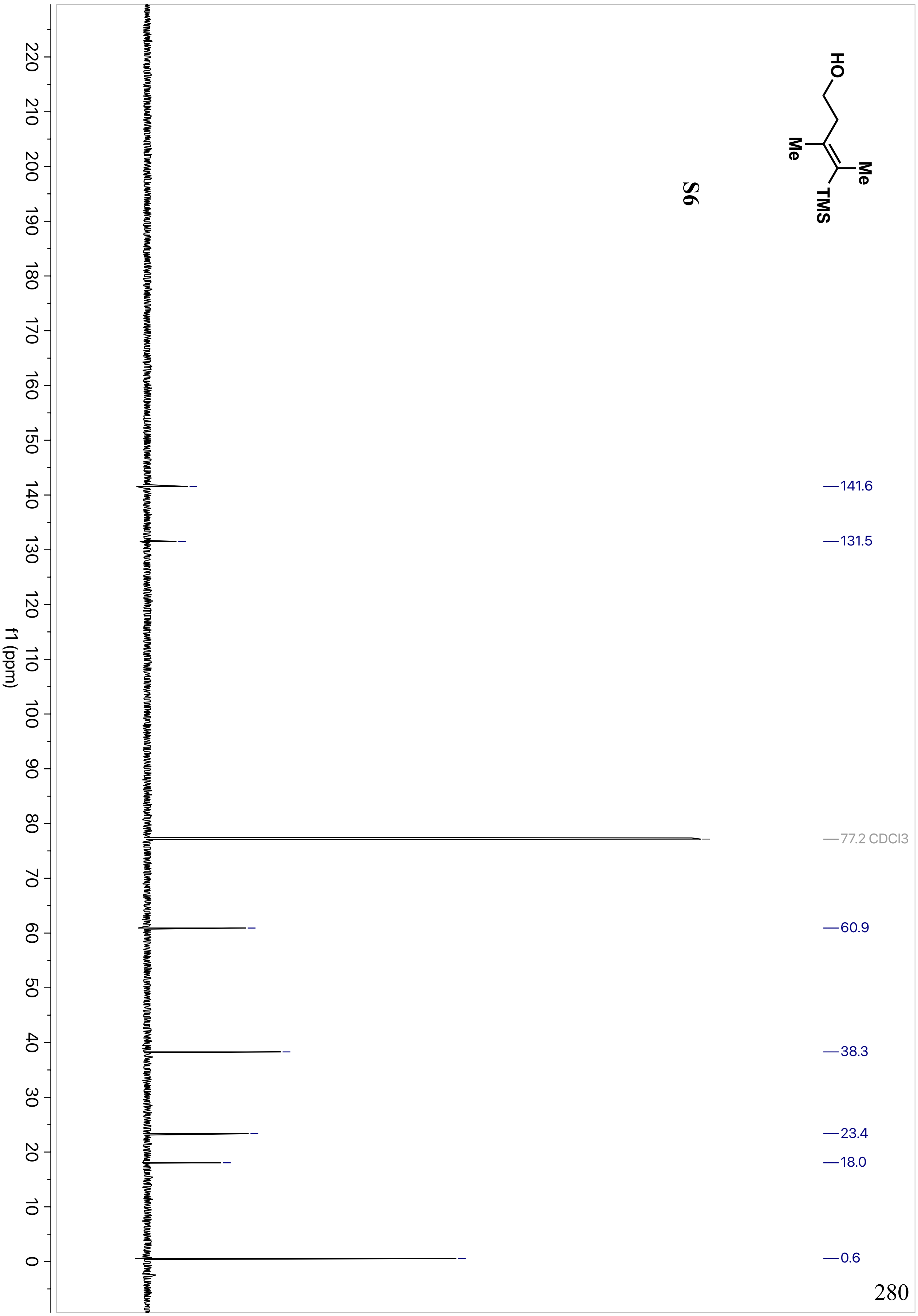
15

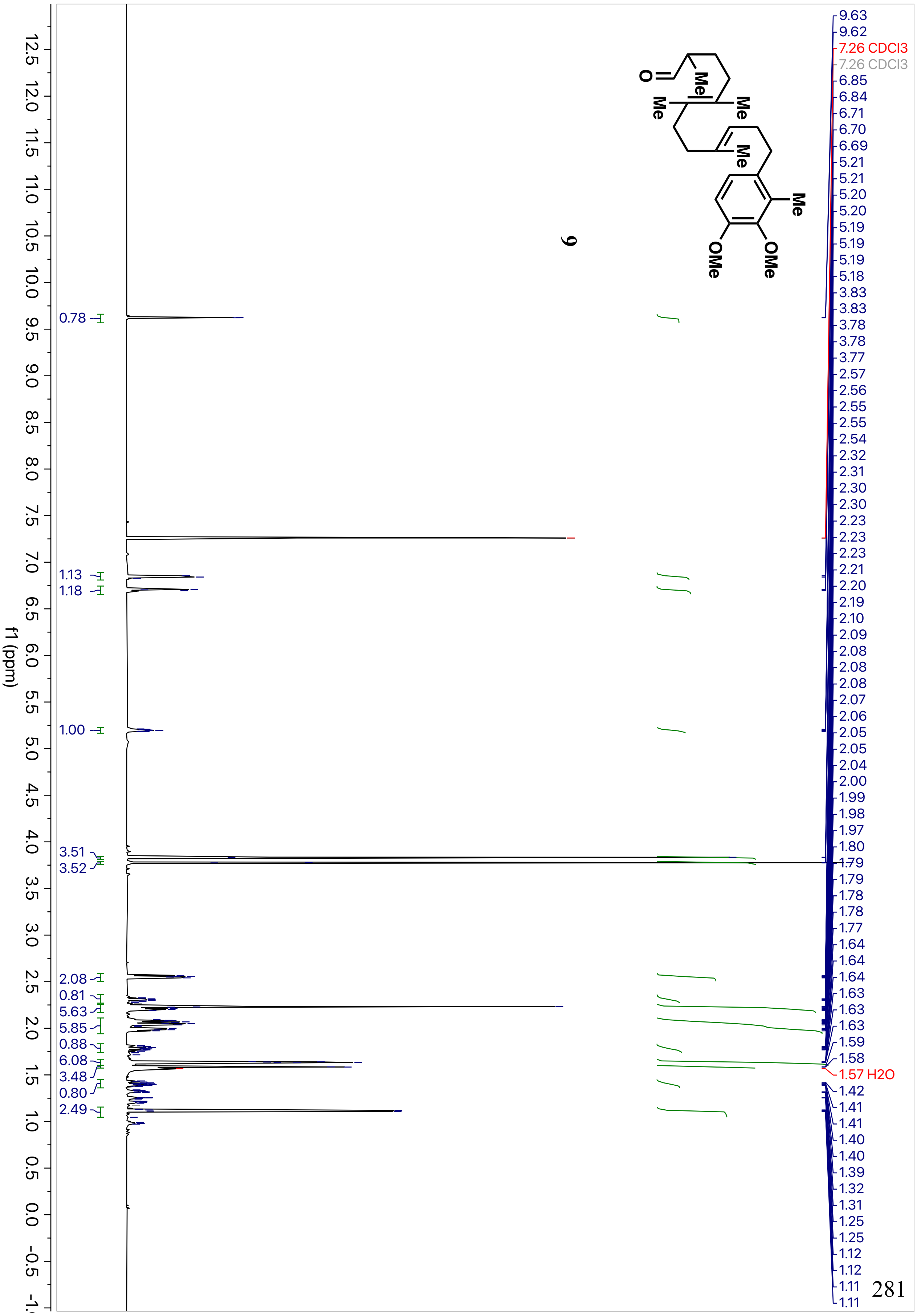
MeO
OMe
Me
Me
O
OH
7.26 CDCl3
6.83
6.82
6.71
6.69
5.26
5.26
5.25
5.25
5.25
5.24
5.24
5.23
3.83
3.78
2.57
2.56
2.55
2.55
2.54
2.47
2.47
2.46
2.46
2.45
2.44
2.44
2.33
2.32
2.30
2.24
2.23
2.21
2.20
1.57
1.57
1.00
1.02
0.99
3.07
3.07
1.97
1.98
1.99
5.16
2.98
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)


MeO
OMe
Me
Me
O
OH
178.9
151.0
147.4
133.8
133.7
130.4
124.9
124.3
109.5
77.2 CDCl3
60.3
55.8
34.4
33.2
32.9
29.0
16.0
11.9
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

15

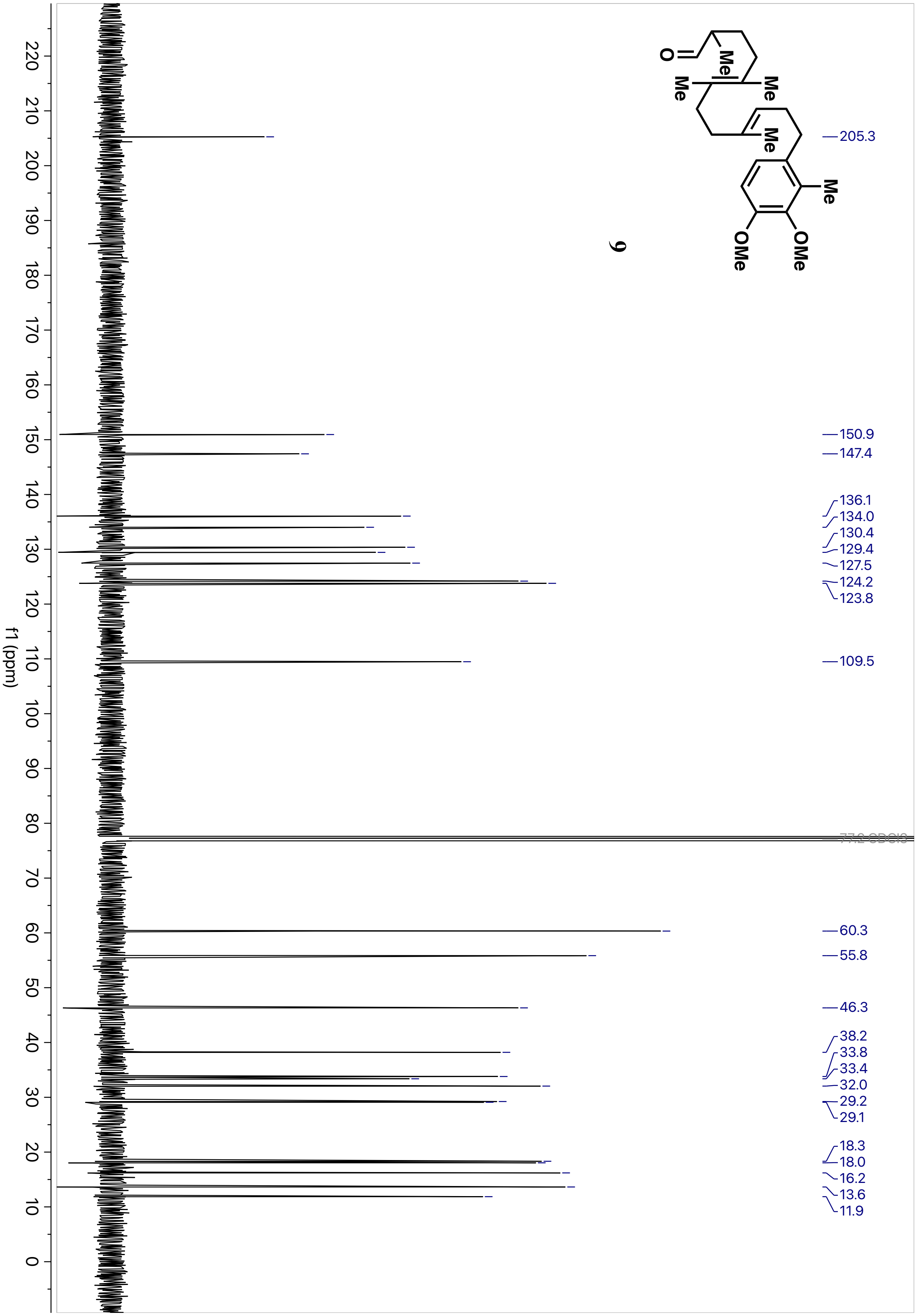

S6
HO
Me
Me
TMS
—7.26 CDCl3
3.69
3.68
3.66
2.45
2.44
2.42
1.83
1.83
1.83
1.82
1.71
1.71
1.70
1.70
1.56 H2O
1.28
0.14
2.00
1.96
2.96
2.91
0.85
9.35
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

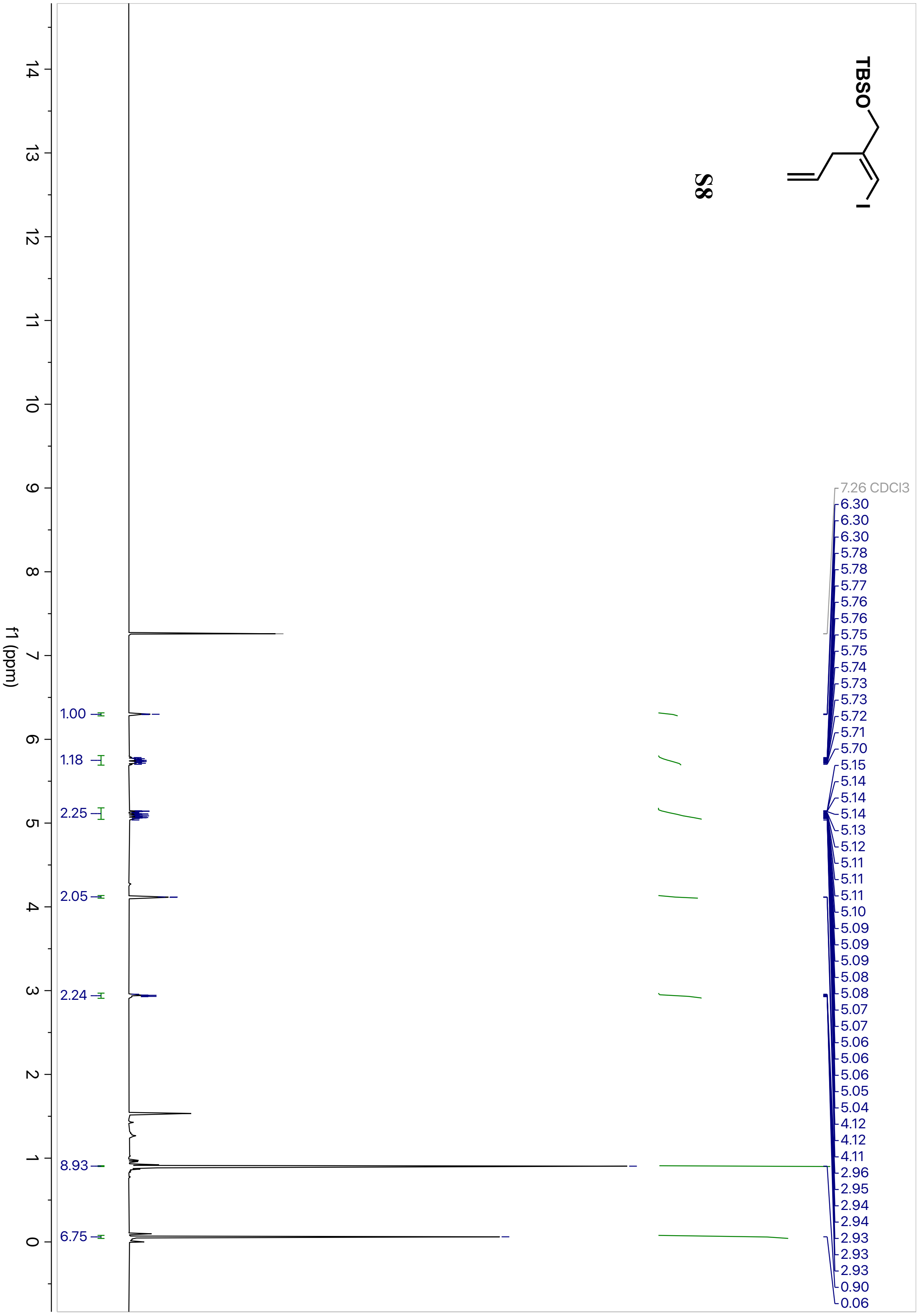

S6
HO
Me
Me
TMS
141.6
131.5
77.2 CDCl3
60.9
38.3
23.4
18.0
0.6
f1 (ppm)
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0



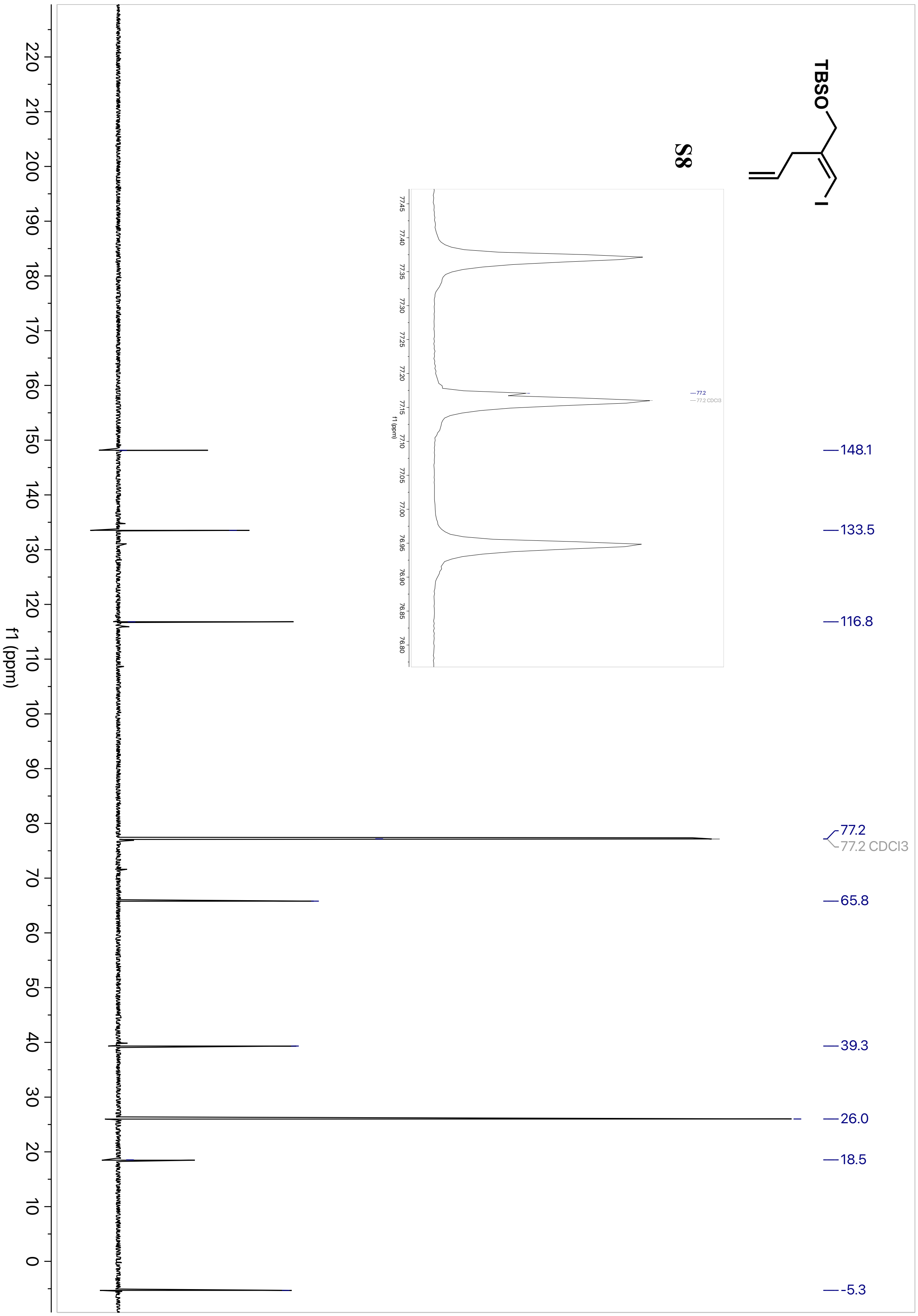
9.63
9.62
7.26 CDCl3
7.26 CDCl3
6.85
6.84
6.71
6.70
6.69
5.21
5.21
5.20
5.20
5.19
5.19
5.19
5.18
3.83
3.83
3.78
3.78
3.77
2.57
2.56
2.55
2.55
2.54
2.32
2.31
2.30
2.30
2.23
2.23
2.23
2.21
2.20
2.19
2.10
2.09
2.08
2.08
2.08
2.07
2.06
2.05
2.05
2.04
2.00
1.99
1.98
1.97
1.80
1.79
1.79
1.78
1.78
1.77
1.64
1.64
1.64
1.63
1.63
1.63
1.59
1.58
1.57 H2O
1.42
1.41
1.41
1.40
1.40
1.39
1.32
1.31
1.25
1.25
1.12
1.12
1.11
1.11
OMe
OMe
Me
Me
Me
Me
Me
O
0.78
1.13
1.18
1.00
3.51
3.52
2.08
0.81
5.63
5.85
0.88
6.08
3.48
0.80
2.49
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

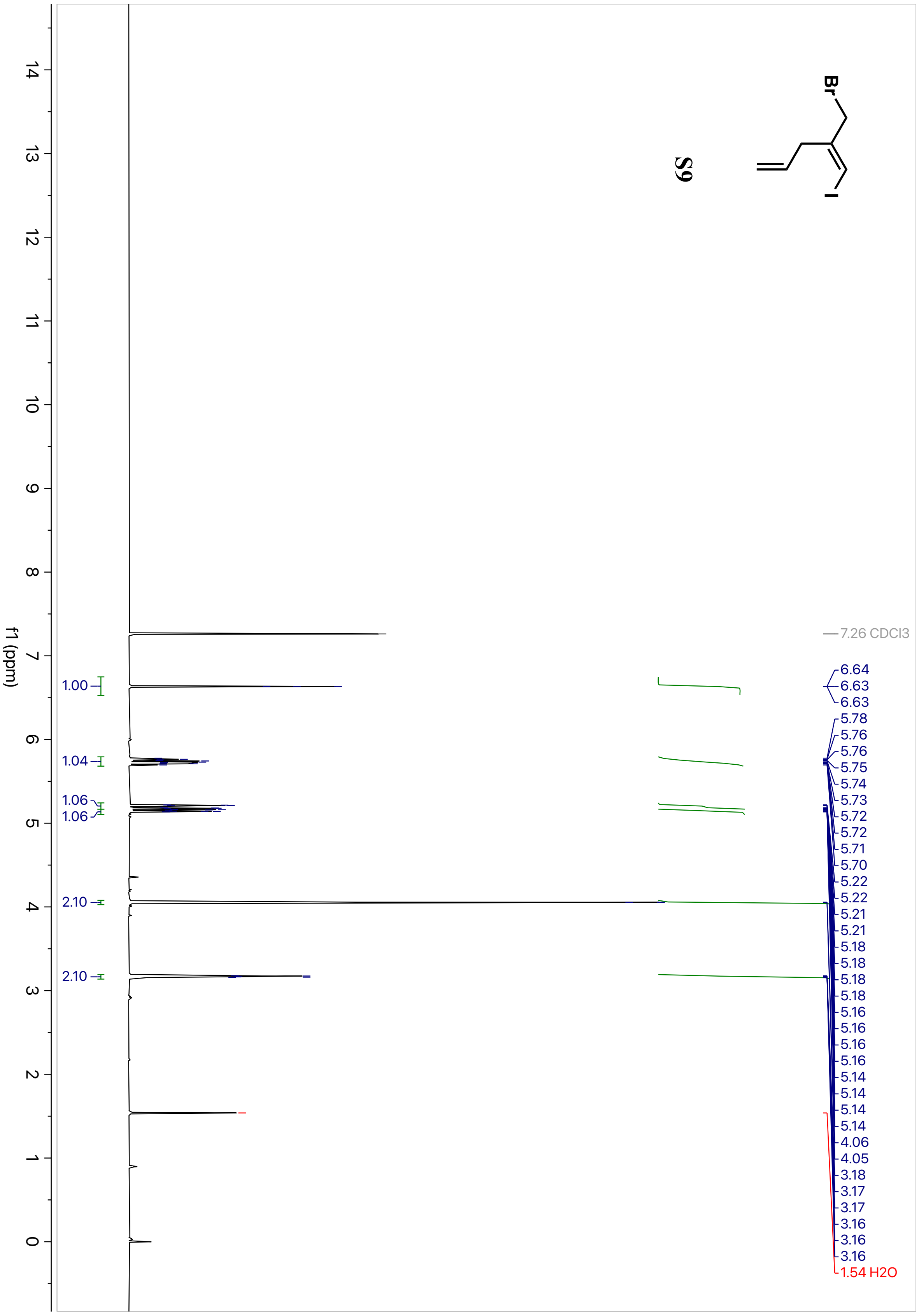
9

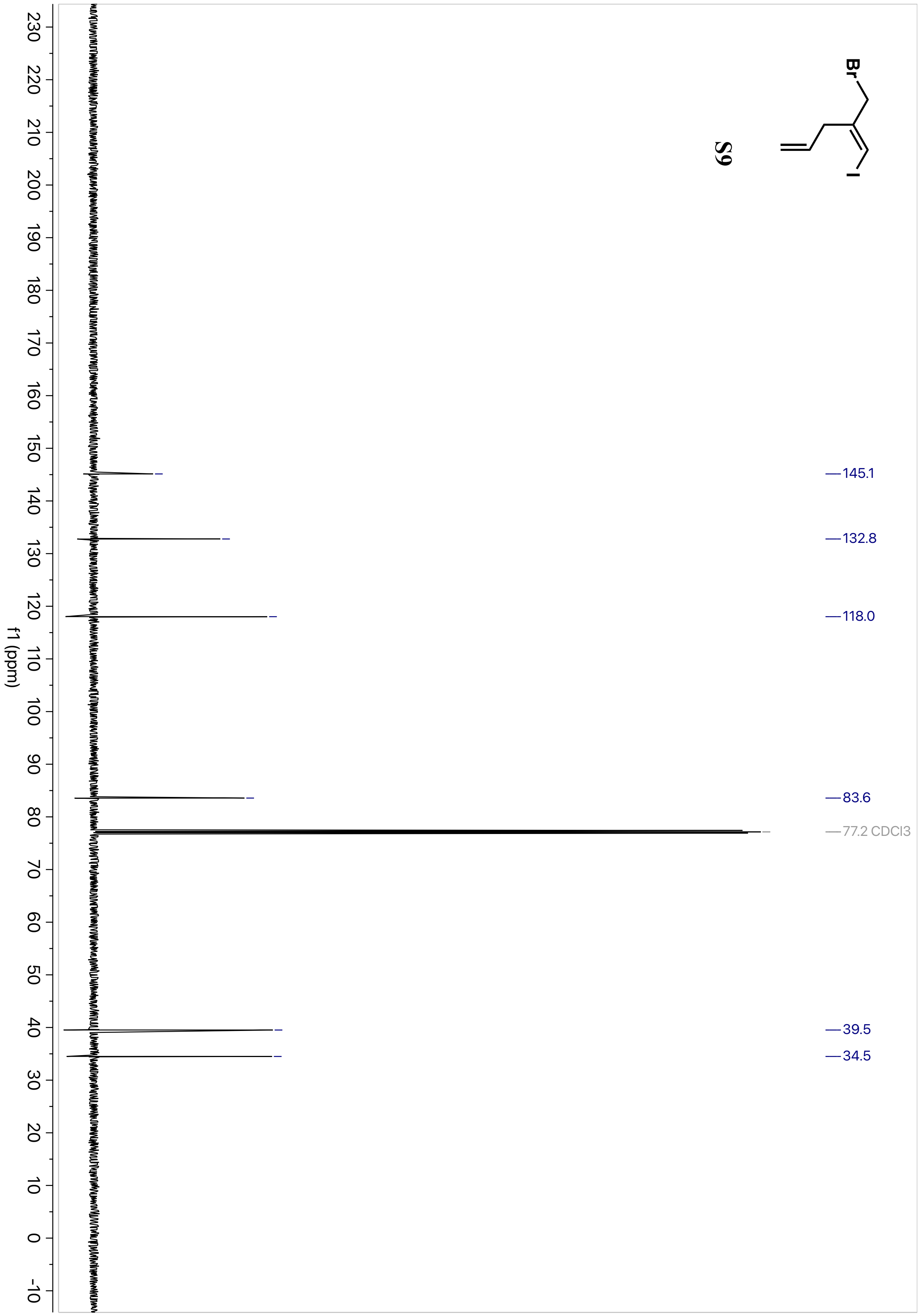

9
O
Me
Me
Me
Me
Me
OMe
OMe
205.3
150.9
147.4
136.1
134.0
130.4
129.4
127.5
124.2
123.8
109.5
77.0 CDCl3
60.3
55.8
46.3
38.2
33.8
33.4
32.0
29.2
29.1
18.3
18.0
16.2
13.6
11.9
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


S8

TBSO
I
7.26 CDCl3
6.30
6.30
6.30
5.78
5.78
5.77
5.76
5.76
5.75
5.75
5.74
5.73
5.73
5.72
5.71
5.70
5.15
5.14
5.14
5.14
5.13
5.12
5.11
5.11
5.11
5.10
5.09
5.09
5.09
5.08
5.08
5.07
5.07
5.06
5.06
5.06
5.05
5.04
4.12
4.12
4.11
2.96
2.95
2.94
2.94
2.93
2.93
2.93
0.90
0.06
1.00
1.18
2.25
2.05
2.24
8.93
6.75
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

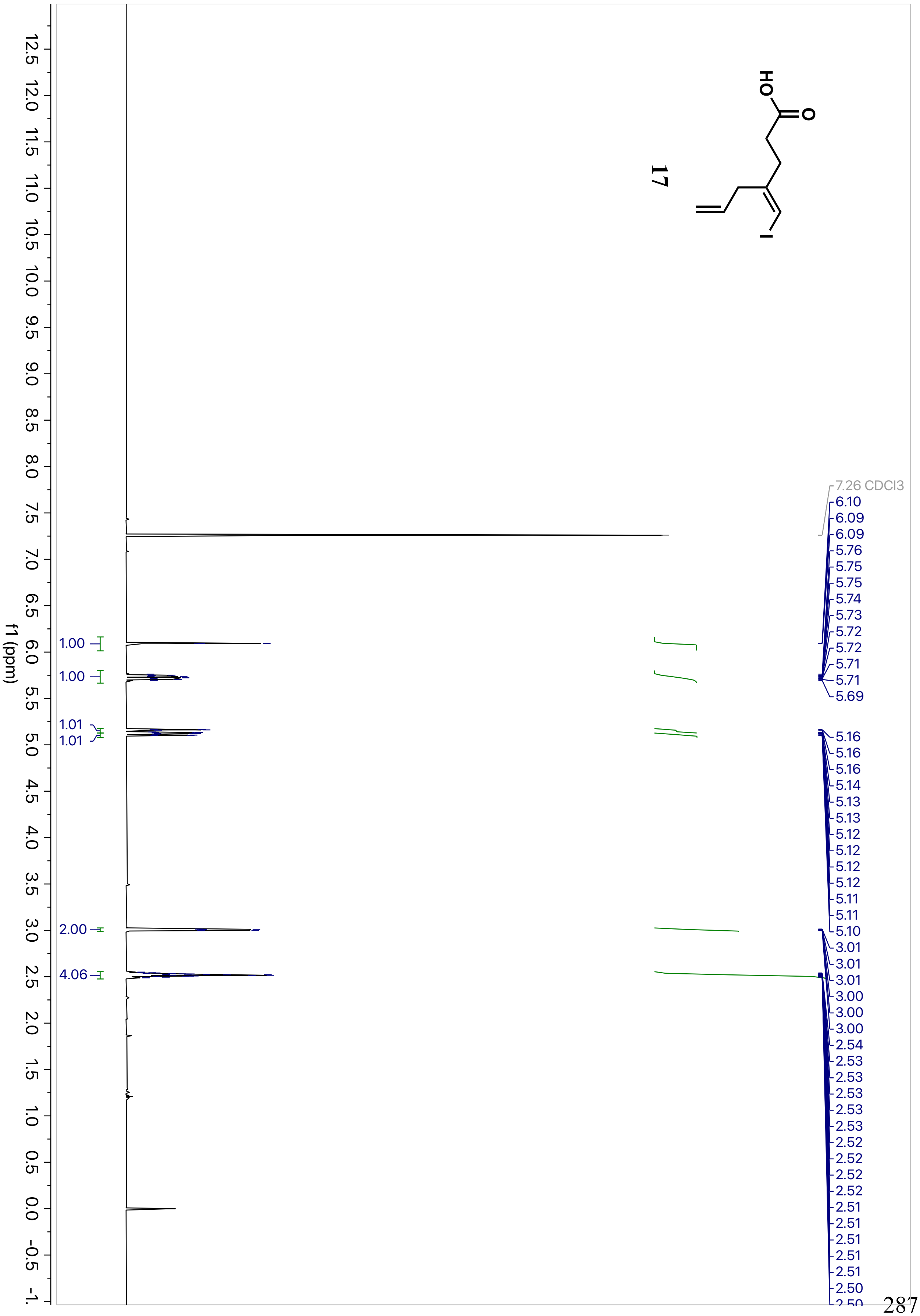

S8
TBSO
I
148.1
133.5
116.8
77.2
77.2 CDCl3
65.8
39.3
26.0
18.5
-5.3
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)
77.45
77.40
77.35
77.30
77.25
77.20
77.15
77.10
77.05
77.00
76.95
76.90
76.85
76.80
f1 (ppm)

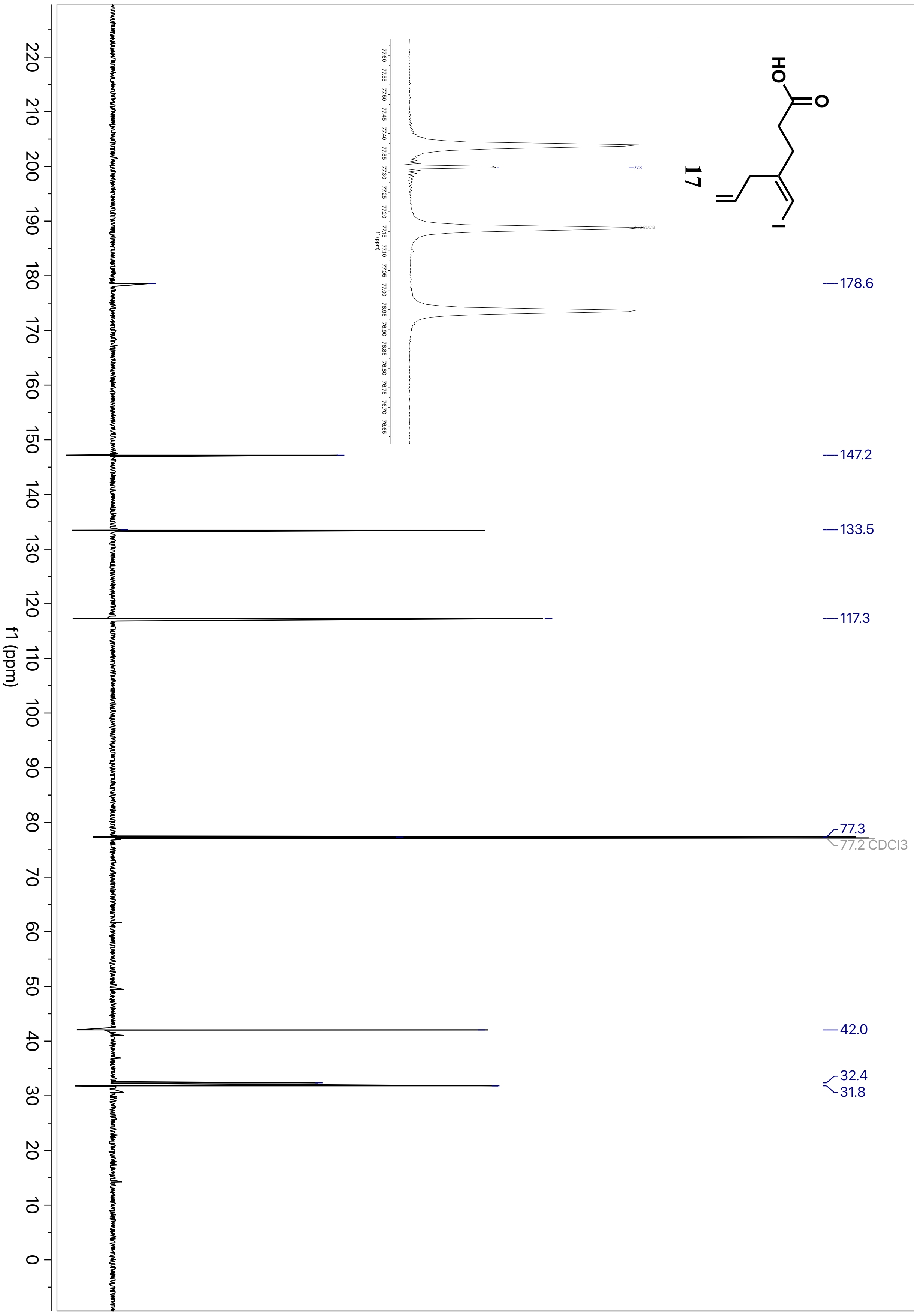

S9
Br
I
7.26 CDCl3
6.64
6.63
6.63
5.78
5.76
5.76
5.75
5.74
5.73
5.72
5.72
5.71
5.70
5.22
5.22
5.21
5.21
5.18
5.18
5.18
5.18
5.16
5.16
5.16
5.16
5.14
5.14
5.14
5.14
4.06
4.05
3.18
3.17
3.17
3.16
3.16
3.16
1.54 H2O
1.00
1.04
1.06
1.06
2.10
2.10
f1 (ppm)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0



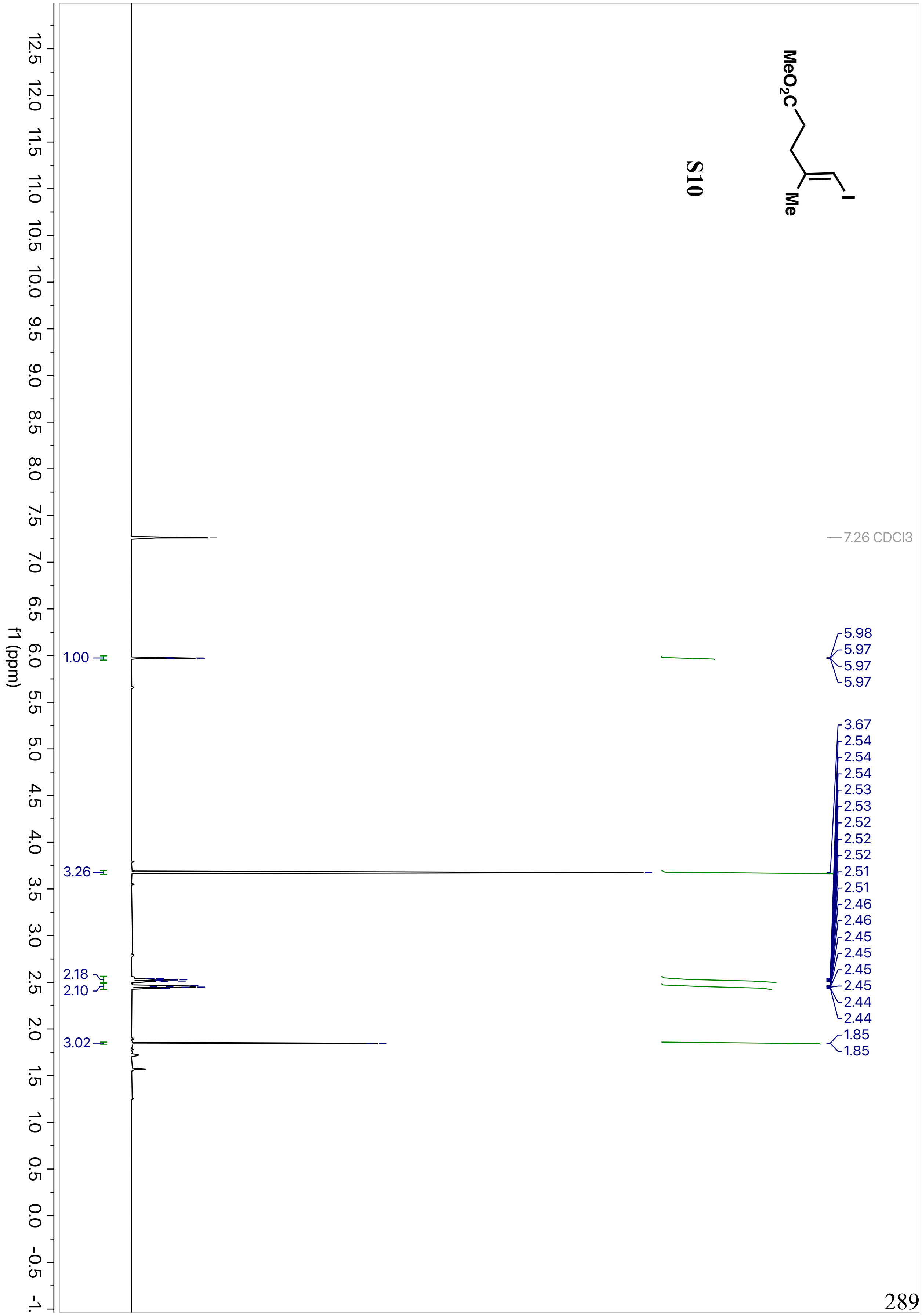
S9

Br
I
145.1
132.8
118.0
83.6
77.2 CDCl3
39.5
34.5
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

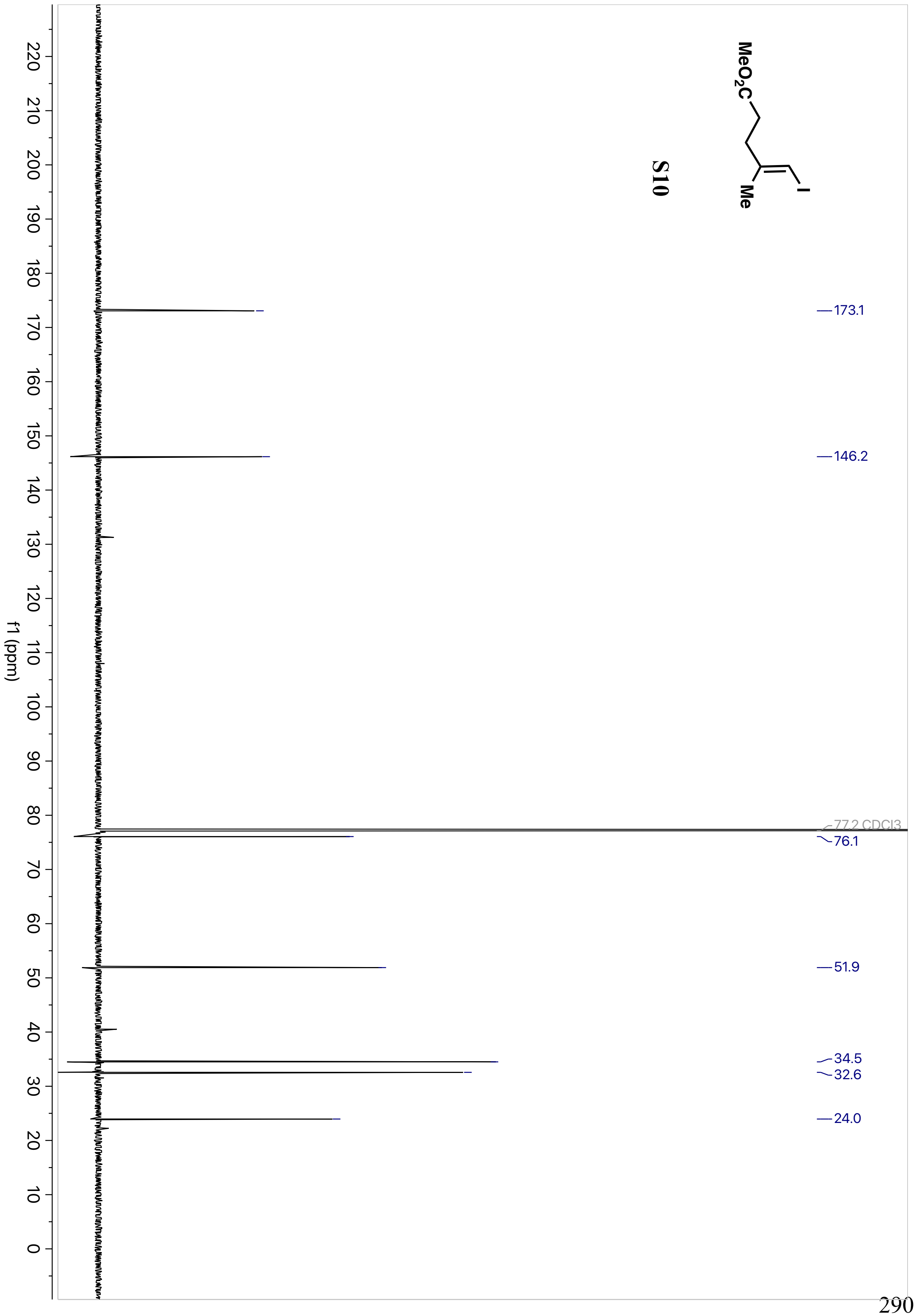

17
HO
O
I
7.26 CDCl3
6.10
6.09
6.09
5.76
5.75
5.75
5.74
5.73
5.72
5.72
5.71
5.71
5.69
5.16
5.16
5.16
5.14
5.13
5.13
5.12
5.12
5.12
5.12
5.11
5.11
5.10
3.01
3.01
3.01
3.00
3.00
3.00
2.54
2.53
2.53
2.53
2.53
2.53
2.52
2.52
2.52
2.52
2.51
2.51
2.51
2.51
2.51
2.50
1.00
1.00
1.01
1.01
2.00
4.06
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)


HO
O
I
—178.6
—147.2
—133.5
—117.3
77.3
77.2 CDCl3
—42.0
32.4
31.8
—77.3
f1 (ppm)
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0

17

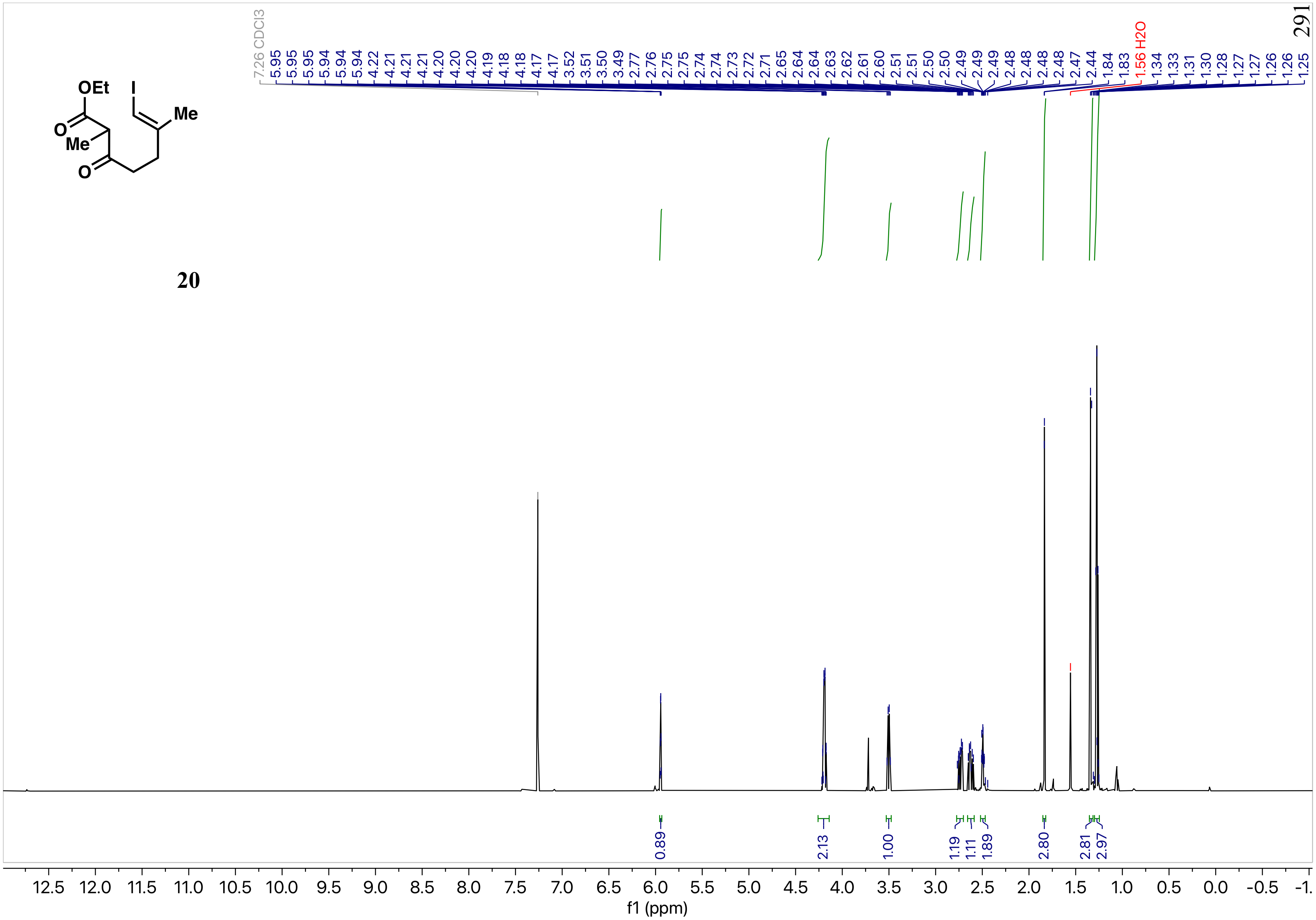

MeO2C
Me
I
—7.26 CDCl3
5.98
5.97
5.97
5.97
3.67
2.54
2.54
2.54
2.53
2.53
2.52
2.52
2.52
2.51
2.51
2.46
2.46
2.45
2.45
2.45
2.45
2.44
2.44
1.85
1.85
1.00
3.26
2.18
2.10
3.02
12.5 12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.
f1 (ppm)

S10

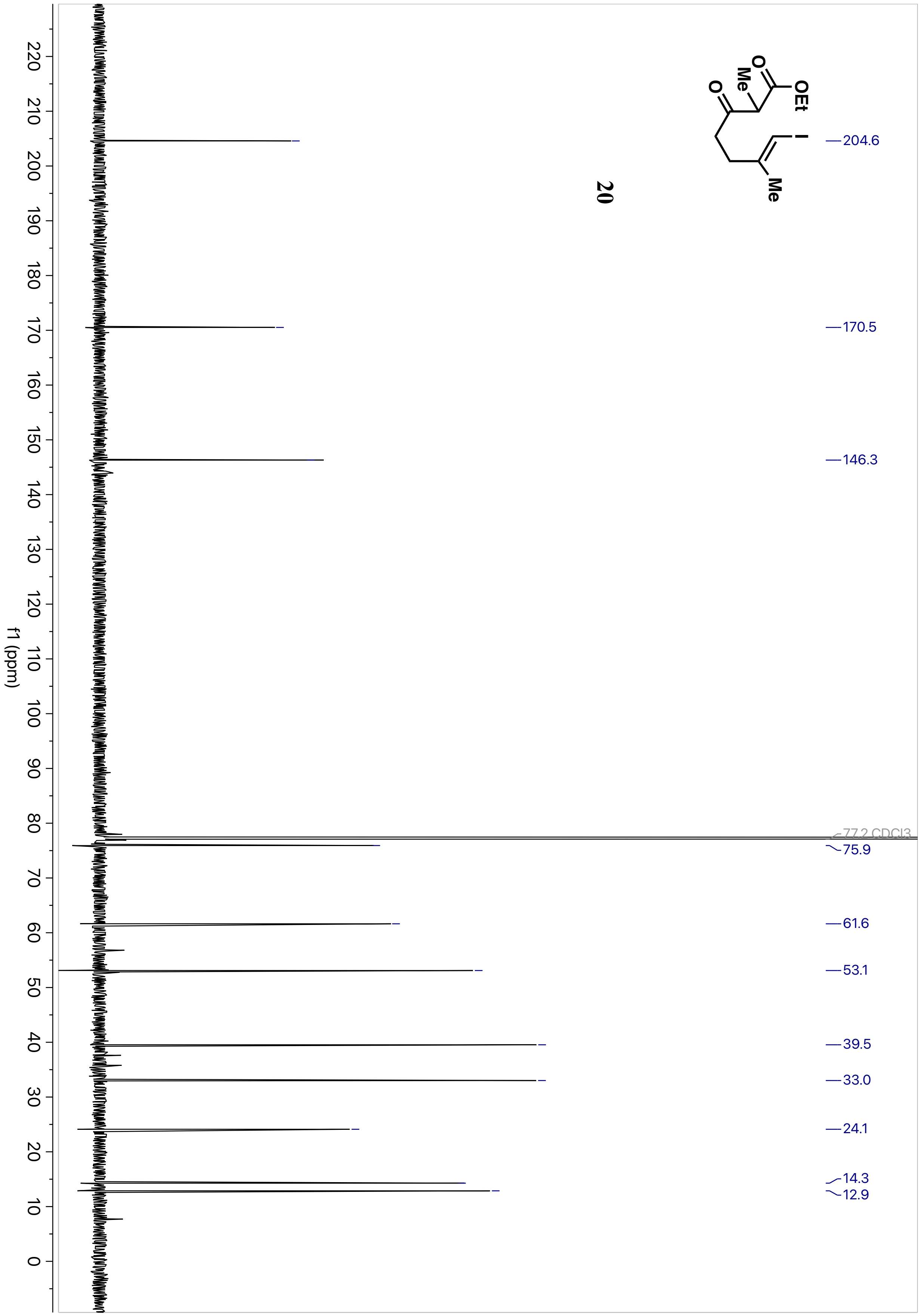


MeO2C
Me
I
173.1
146.2
77.2 CDCl3
76.1
51.9
34.5
32.6
24.0
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

S10

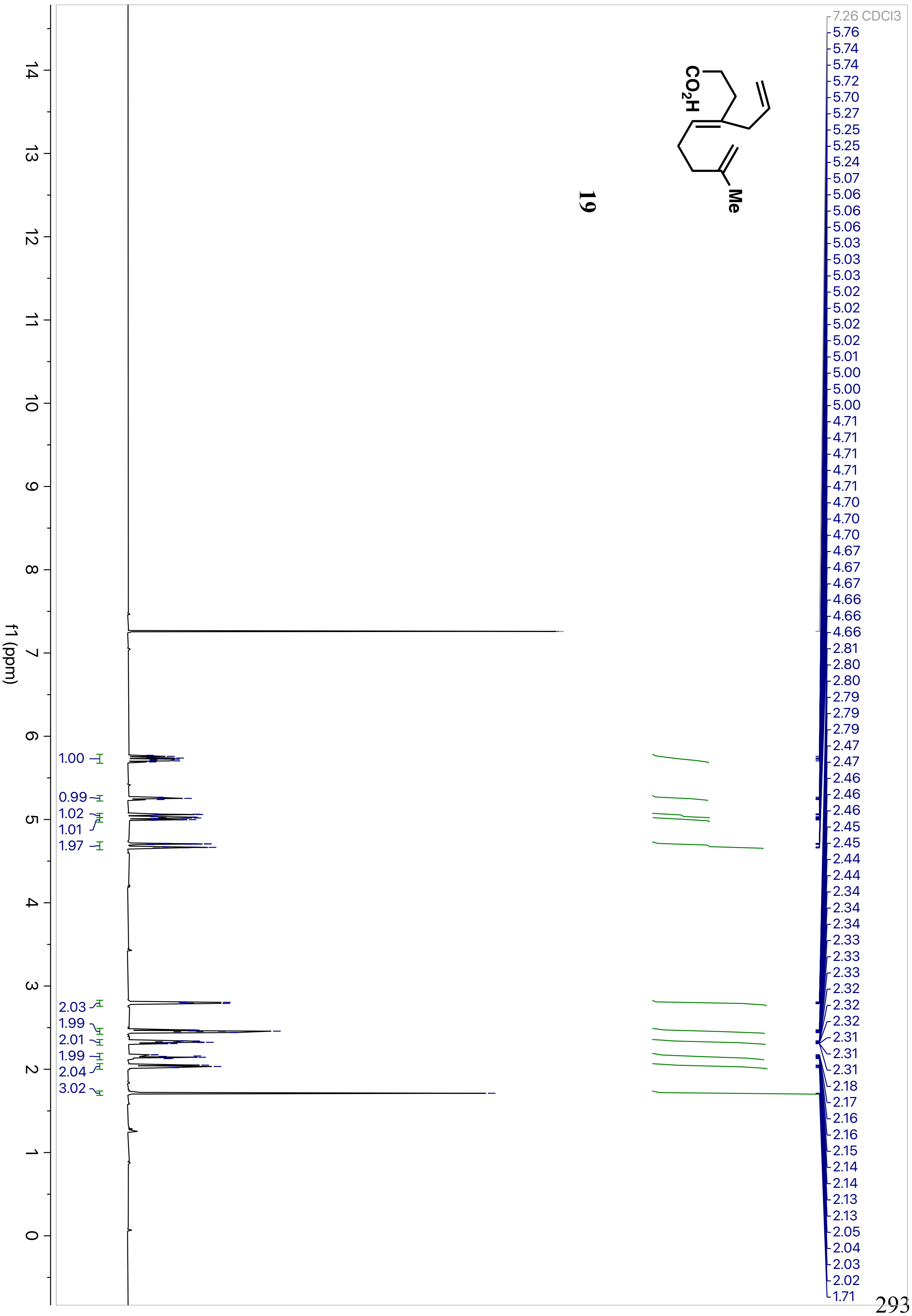

OEt
I
Me
O
Me
O
7.26 CDCl3
5.95
5.95
5.95
5.94
5.94
5.94
4.22
4.21
4.21
4.21
4.20
4.20
4.20
4.19
4.18
4.18
4.17
4.17
3.52
3.51
3.50
3.49
2.77
2.76
2.75
2.75
2.74
2.74
2.73
2.72
2.71
2.65
2.64
2.64
2.63
2.62
2.61
2.60
2.51
2.51
2.50
2.50
2.49
2.49
2.49
2.48
2.48
2.48
2.48
2.47
2.44
1.84
1.83
1.56 H2O
1.34
1.33
1.31
1.30
1.28
1.27
1.27
1.26
1.26
1.25
0.89
2.13
1.00
1.19
1.11
1.89
2.80
2.81
2.97
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.
f1 (ppm)

20

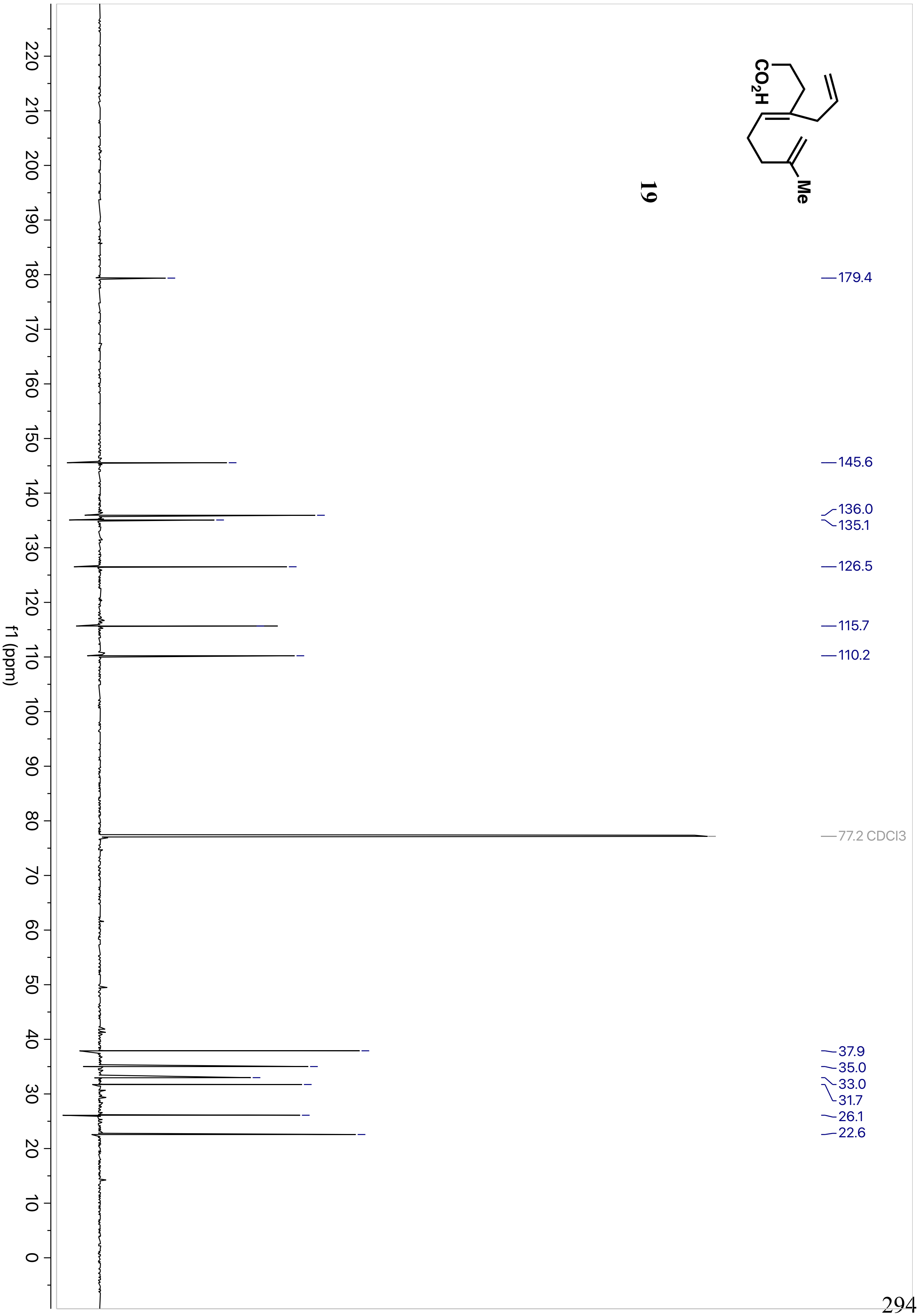


20

OEt
O
Me
O
I
Me
204.6
170.5
146.3
77.2 CDCl3
75.9
61.6
53.1
39.5
33.0
24.1
14.3
12.9
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

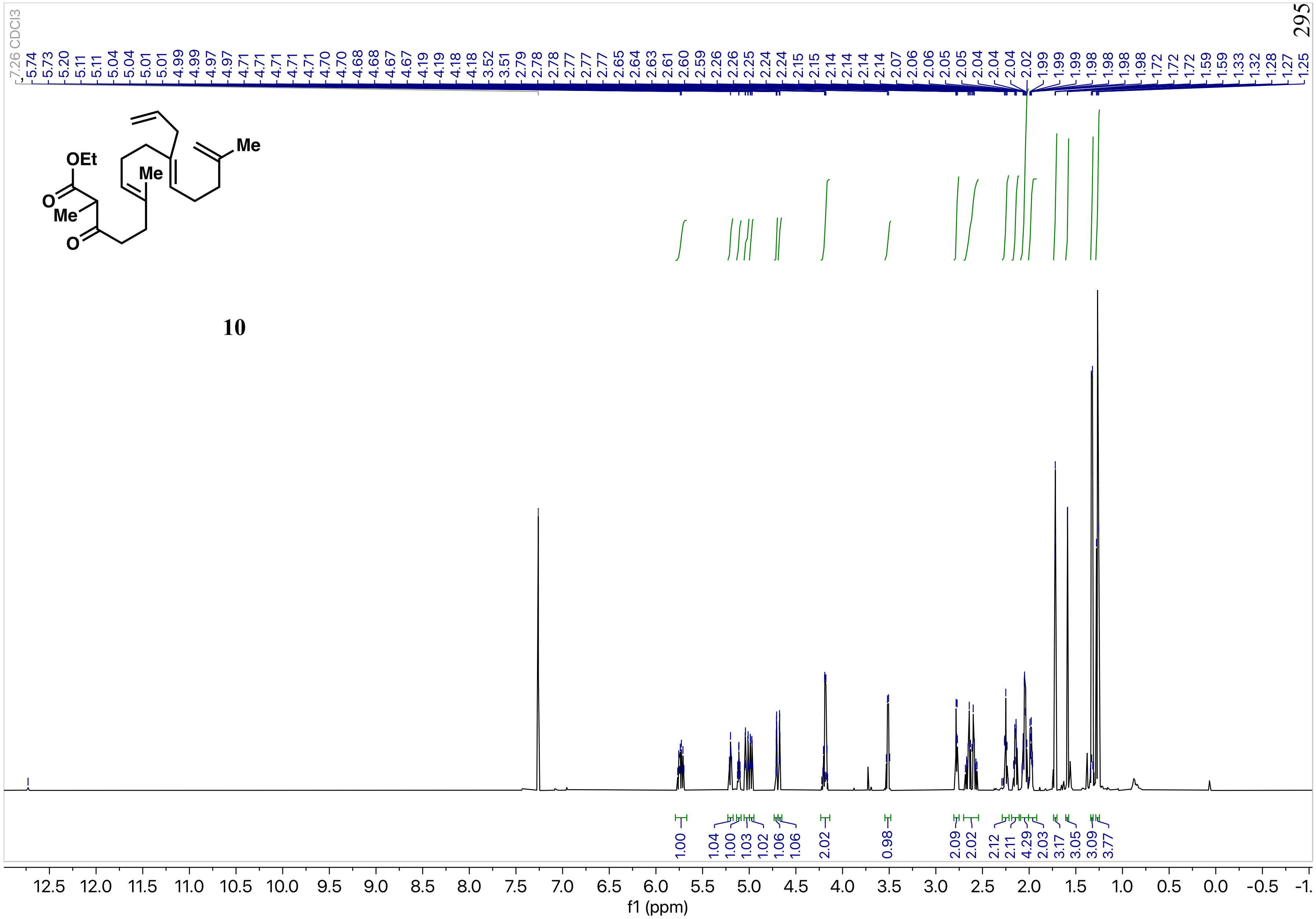

7.26 CDCl3
5.76
5.74
5.74
5.72
5.70
5.27
5.25
5.25
5.24
5.07
5.06
5.06
5.06
5.03
5.03
5.03
5.02
5.02
5.02
5.02
5.01
5.00
5.00
5.00
4.71
4.71
4.71
4.71
4.71
4.70
4.70
4.70
4.67
4.67
4.67
4.66
4.66
4.66
2.81
2.80
2.80
2.79
2.79
2.79
2.47
2.47
2.46
2.46
2.46
2.45
2.45
2.44
2.44
2.34
2.34
2.34
2.33
2.33
2.33
2.32
2.32
2.32
2.31
2.31
2.31
2.18
2.17
2.16
2.16
2.15
2.14
2.14
2.13
2.13
2.05
2.04
2.03
2.02
1.71
Me
CO2H
1.00
0.99
1.02
1.01
1.97
2.03
1.99
2.01
1.99
2.04
3.02
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

19



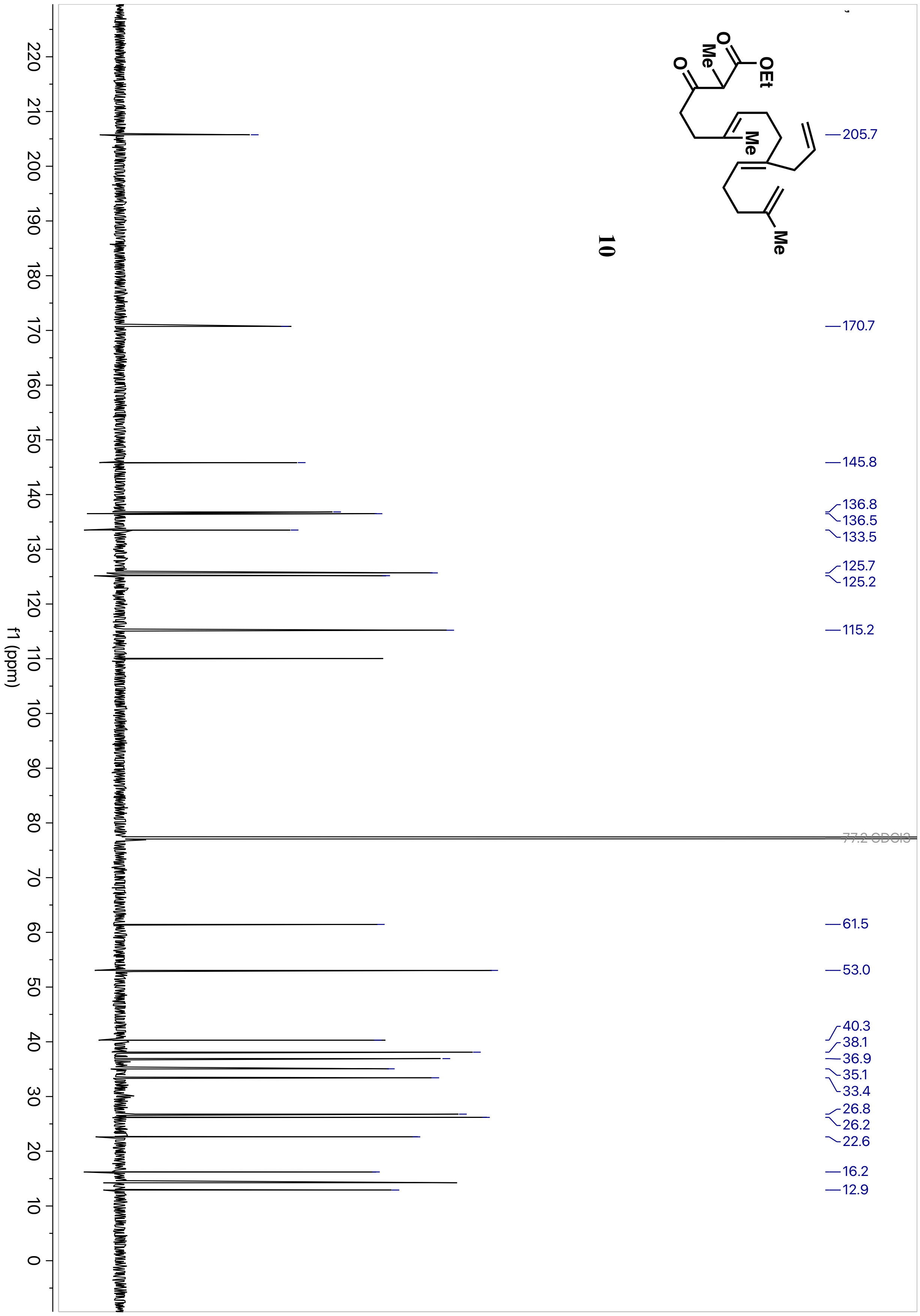
19

CO2H
Me
179.4
145.6
136.0
135.1
126.5
115.7
110.2
77.2 CDCl3
37.9
35.0
33.0
31.7
26.1
22.6
f1 (ppm)
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0



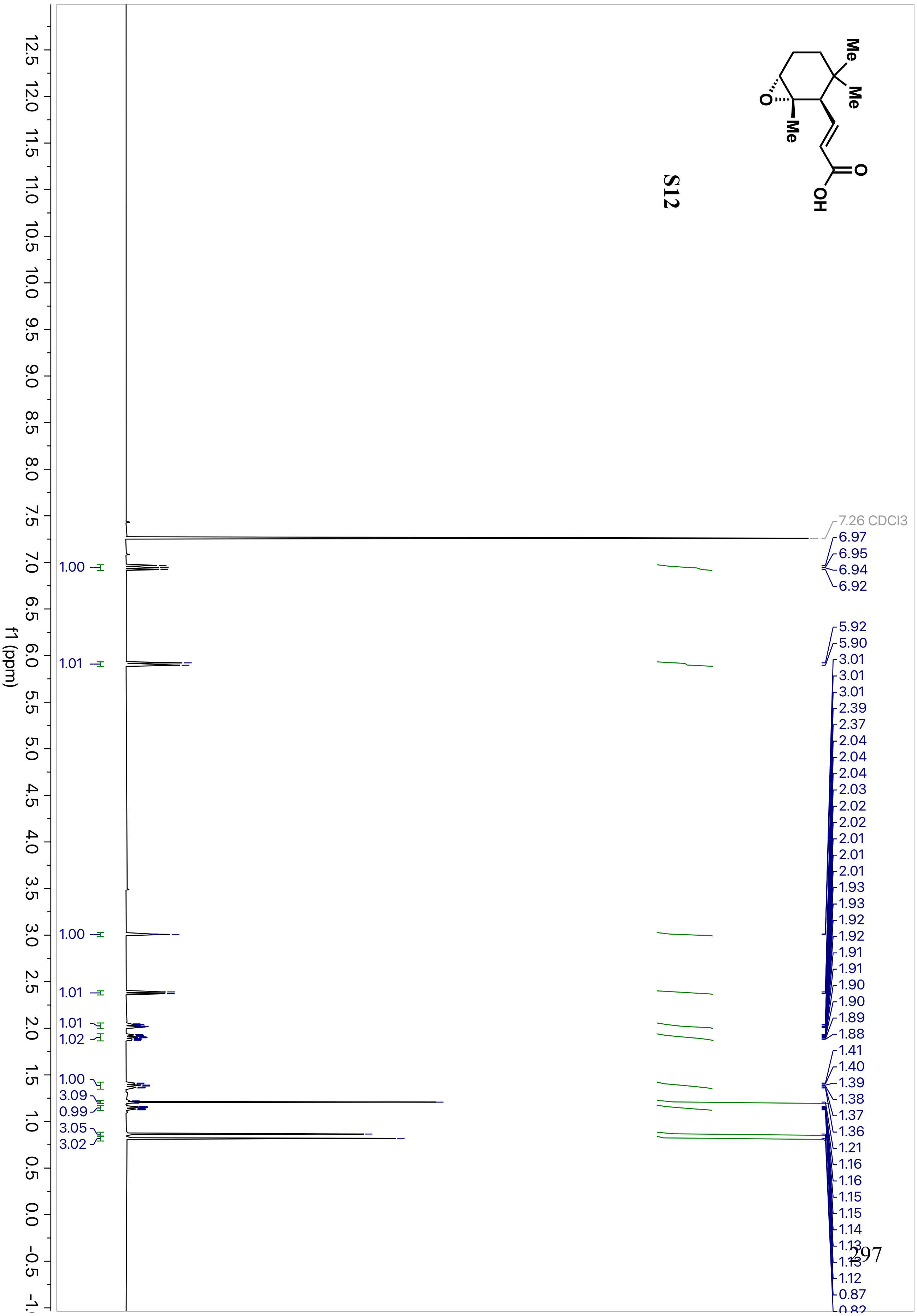
10

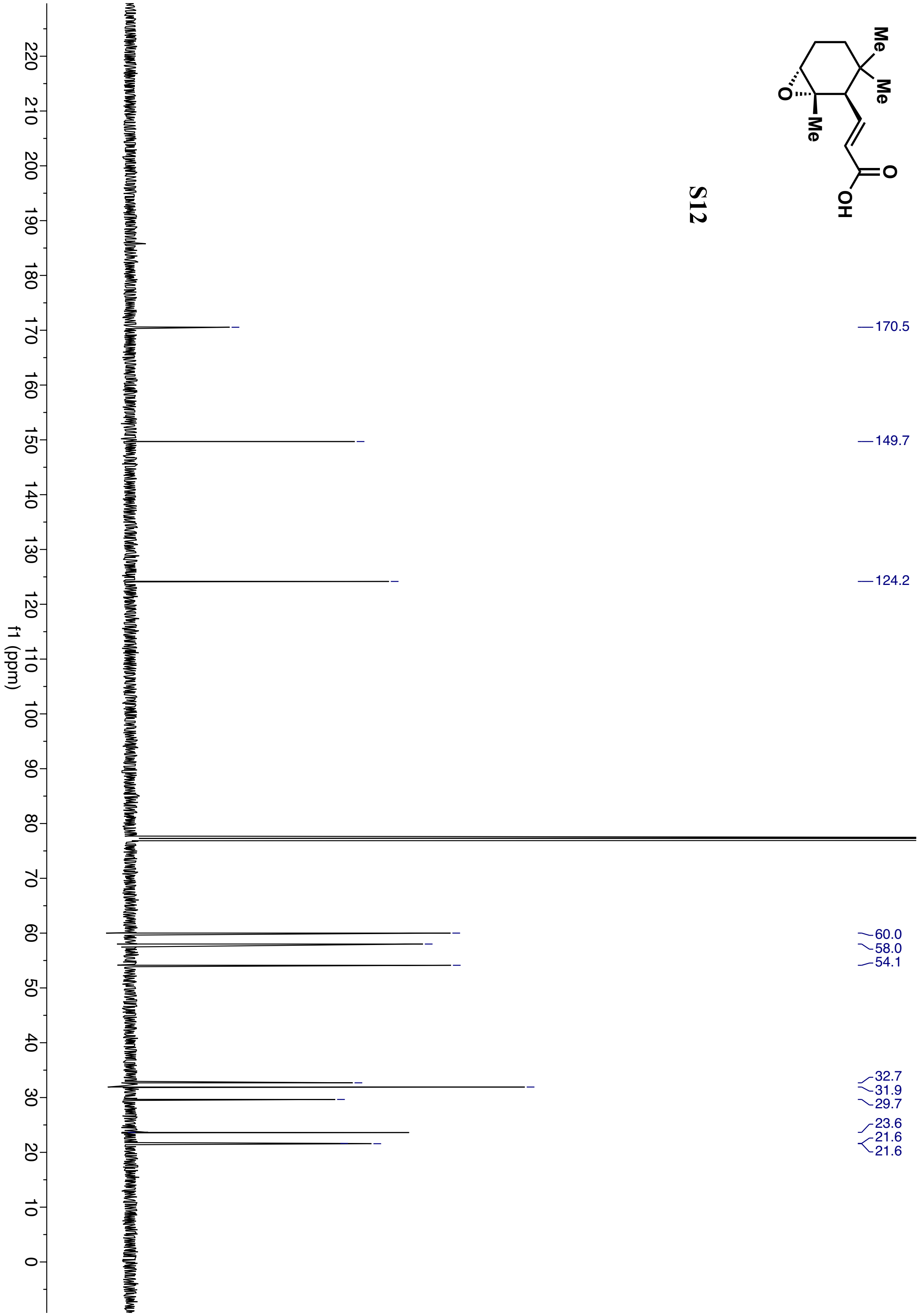
7.26 CDCl3
5.74
5.73
5.20
5.11
5.11
5.04
5.04
5.01
5.01
4.99
4.99
4.97
4.97
4.71
4.71
4.71
4.71
4.71
4.70
4.70
4.68
4.68
4.67
4.67
4.19
4.19
4.18
4.18
3.52
3.51
2.79
2.78
2.78
2.77
2.77
2.77
2.65
2.64
2.63
2.61
2.60
2.59
2.26
2.26
2.25
2.24
2.24
2.15
2.15
2.14
2.14
2.14
2.14
2.07
2.06
2.06
2.05
2.05
2.04
2.04
2.04
2.02
1.99
1.99
1.99
1.98
1.98
1.98
1.98
1.72
1.72
1.72
1.59
1.59
1.33
1.32
1.28
1.27
1.25
OEt
O
Me
O
Me
Me
1.00
1.04
1.00
1.03
1.02
1.06
1.06
2.02
0.98
2.09
2.02
2.12
2.11
4.29
2.03
3.17
3.05
3.09
3.77
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.
f1 (ppm)



OEt
O
Me
O
Me
Me
—205.7
—170.7
—145.8
136.8
136.5
133.5
125.7
125.2
—115.2
77.2 CDCl3
—61.5
—53.0
40.3
38.1
36.9
35.1
33.4
26.8
26.2
22.6
—16.2
—12.9
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

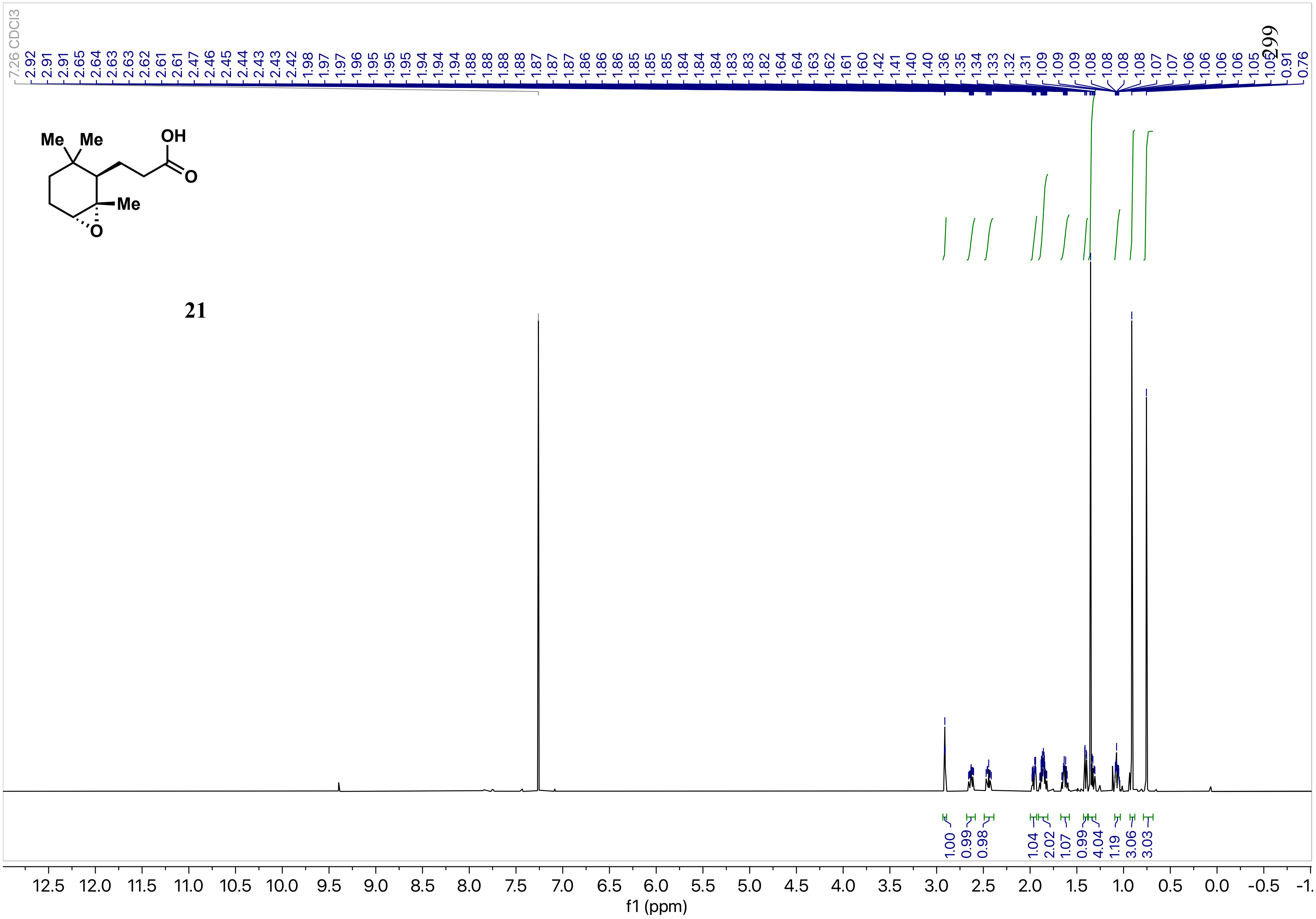
10

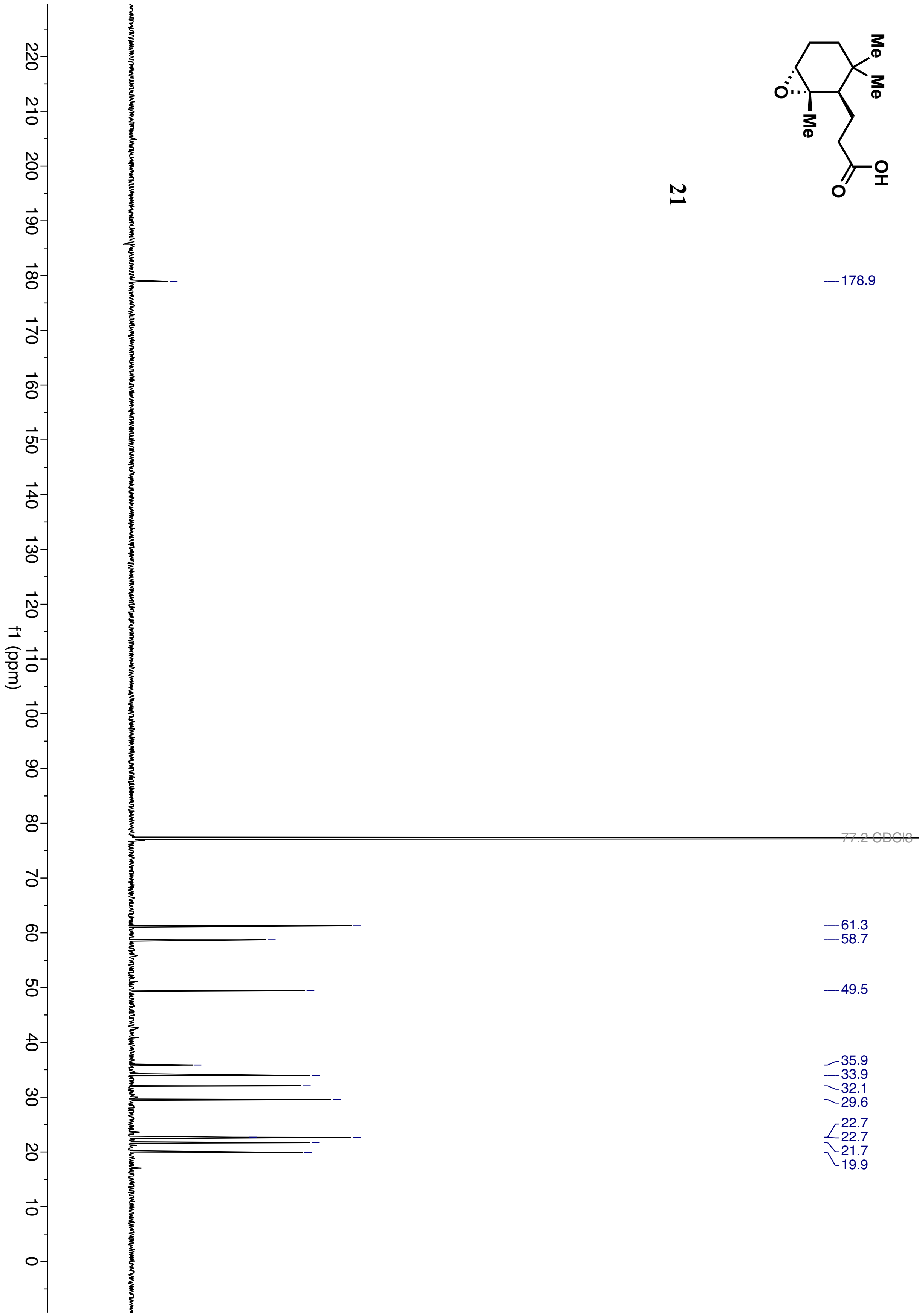

S12
Me
Me
Me
O
O
OH
7.26 CDCl3
6.97
6.95
6.94
6.92
5.92
5.90
3.01
3.01
3.01
2.39
2.37
2.04
2.04
2.04
2.03
2.02
2.02
2.01
2.01
2.01
1.93
1.93
1.92
1.92
1.91
1.91
1.90
1.90
1.89
1.88
1.41
1.40
1.39
1.38
1.37
1.36
1.21
1.16
1.16
1.15
1.15
1.14
1.13
1.13
1.12
0.87
0.82
1.00
1.01
1.00
1.01
1.01
1.02
1.00
3.09
0.99
3.05
3.02
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)



Me
Me
Me
O
O
OH
170.5
149.7
124.2
60.0
58.0
54.1
32.7
31.9
29.7
23.6
21.6
21.6
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

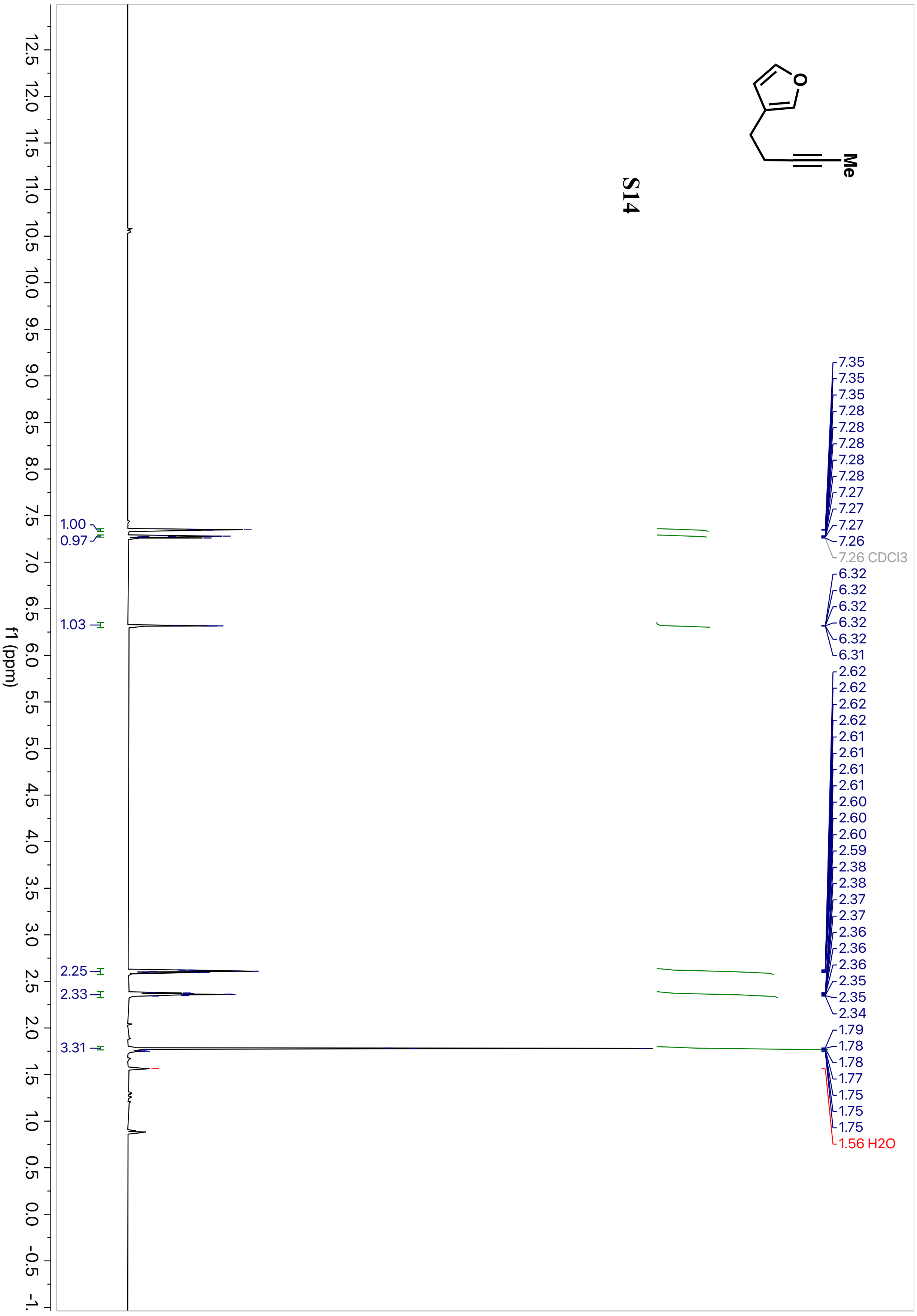
S12


7.26 CDCl3
2.92
2.91
2.91
2.65
2.64
2.63
2.63
2.62
2.61
2.61
2.47
2.46
2.45
2.44
2.43
2.43
2.42
1.98
1.97
1.97
1.96
1.95
1.95
1.95
1.94
1.94
1.94
1.88
1.88
1.88
1.88
1.87
1.87
1.87
1.86
1.86
1.86
1.85
1.85
1.85
1.84
1.84
1.84
1.83
1.83
1.82
1.64
1.64
1.63
1.62
1.61
1.60
1.42
1.41
1.40
1.40
1.36
1.35
1.34
1.33
1.32
1.31
1.09
1.09
1.09
1.08
1.08
1.08
1.08
1.07
1.07
1.06
1.06
1.06
1.06
1.05
1.0
0.91
0.76
Me
Me
OH
O
Me
O
21
1.00
0.99
0.98
1.04
2.02
1.07
0.99
4.04
1.19
3.06
3.03
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.
f1 (ppm)

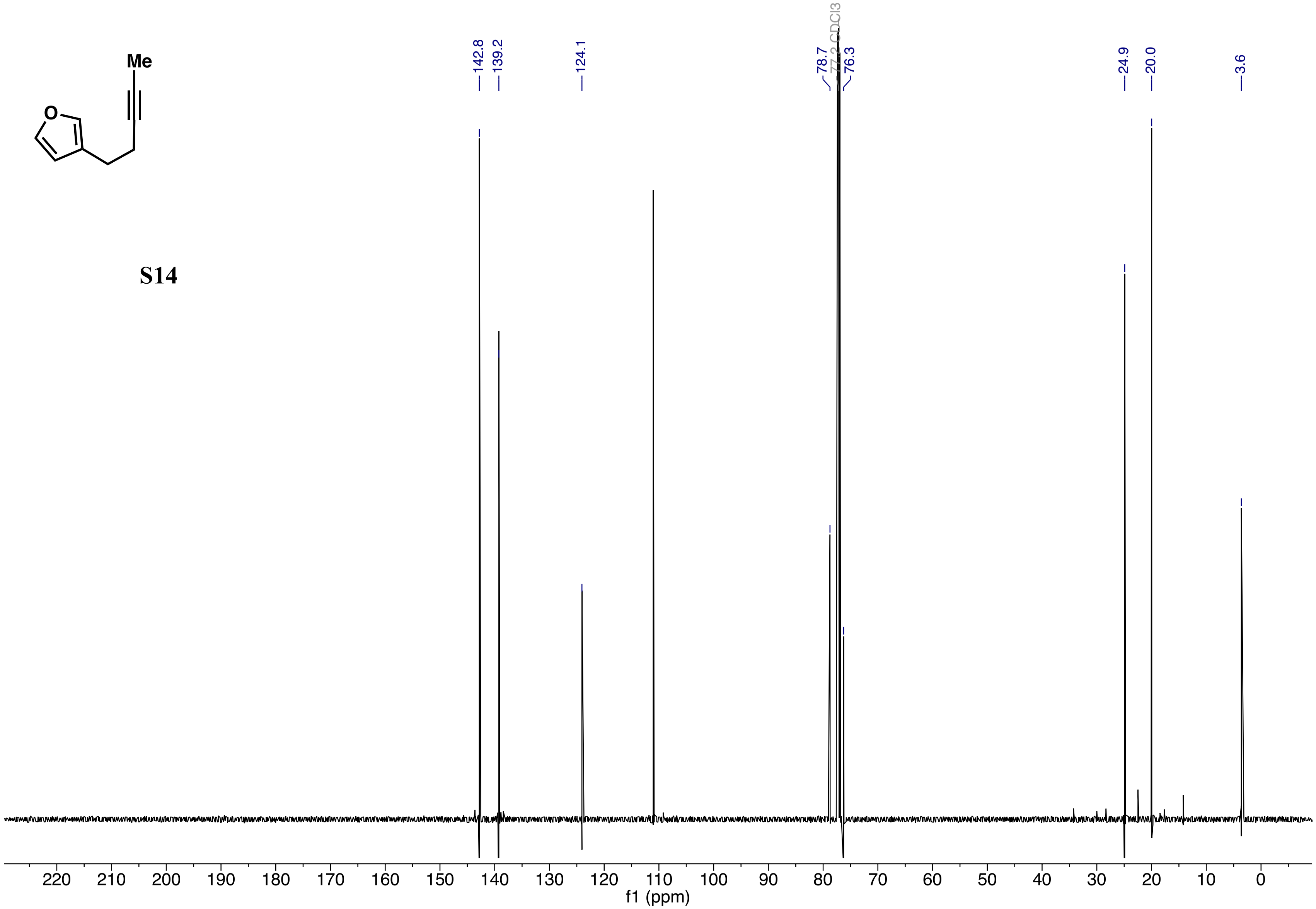


Me
Me
Me
O
OH
O
178.9
77.2 CDCl3
61.3
58.7
49.5
35.9
33.9
32.1
29.6
22.7
22.7
21.7
19.9
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

21

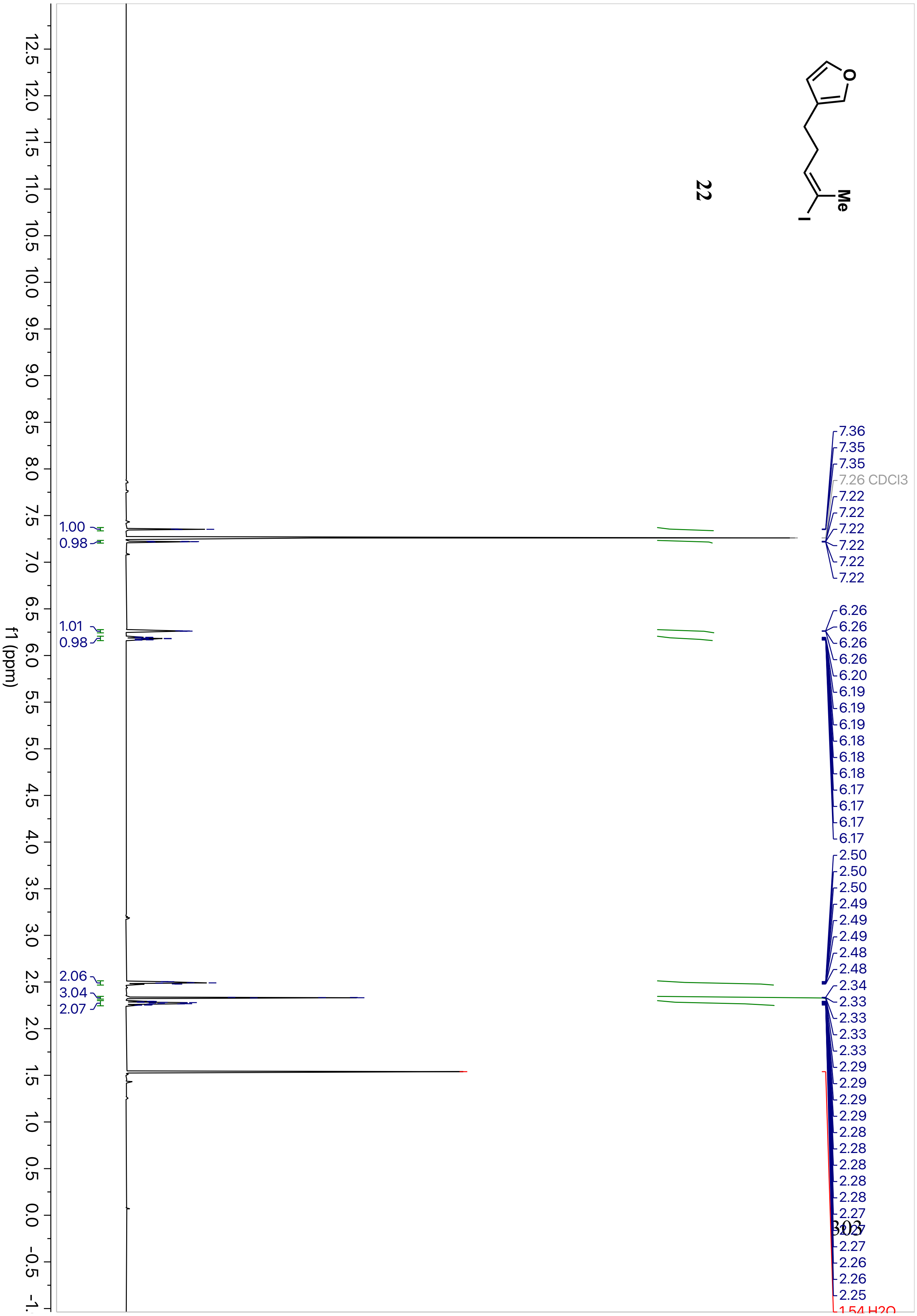

S14

Me
O
7.35
7.35
7.35
7.28
7.28
7.28
7.28
7.28
7.27
7.27
7.27
7.26
7.26 CDCl3
6.32
6.32
6.32
6.32
6.32
6.31
2.62
2.62
2.62
2.62
2.61
2.61
2.61
2.61
2.60
2.60
2.60
2.59
2.38
2.38
2.37
2.37
2.36
2.36
2.36
2.35
2.35
2.34
1.79
1.78
1.78
1.77
1.75
1.75
1.75
1.56 H2O
1.00
0.97
1.03
2.25
2.33
3.31
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)



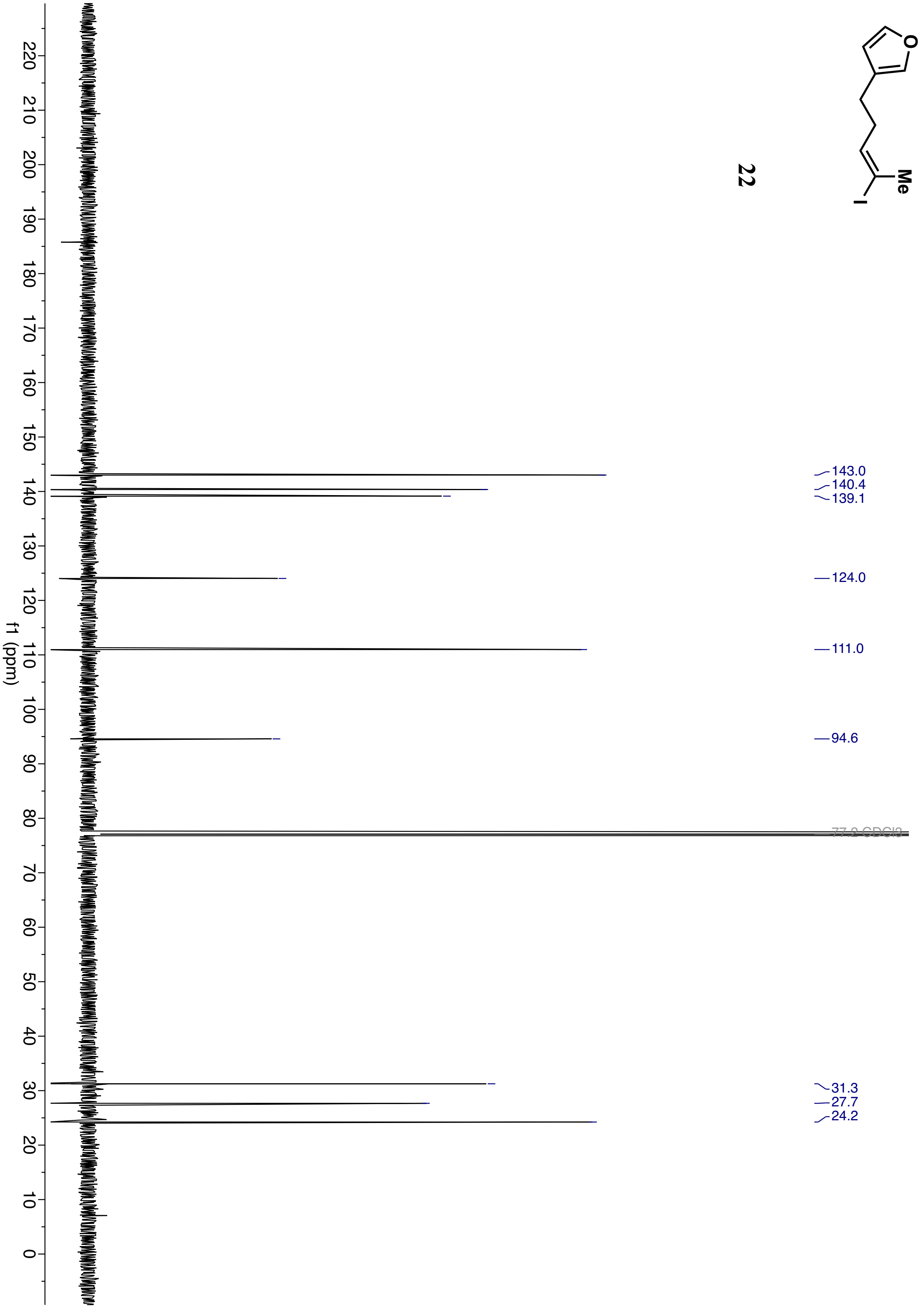
S14

Me
O
142.8
139.2
124.1
78.7
77.2 CDCl3
76.3
24.9
20.0
3.6
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)



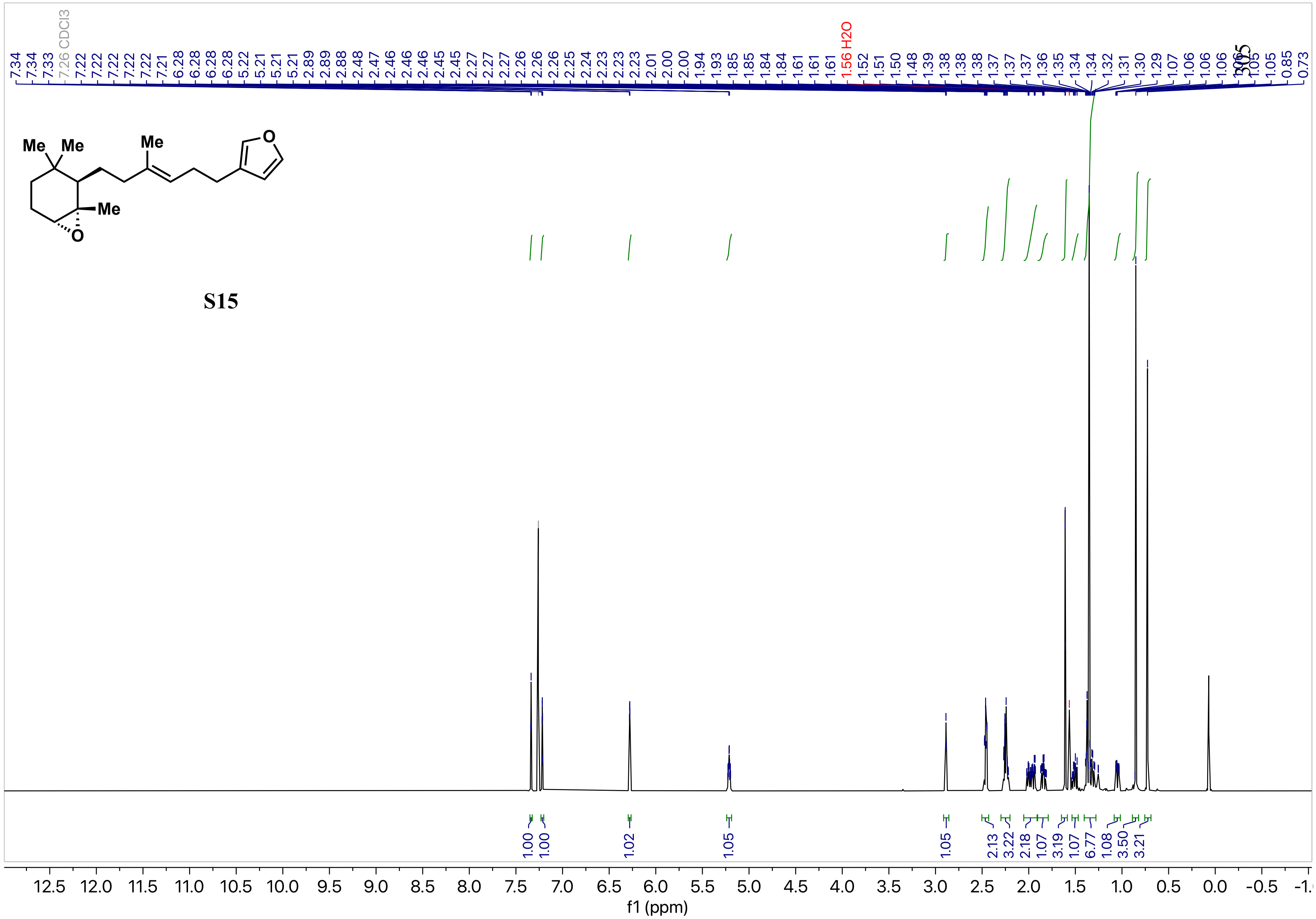
22

Me
I
O
7.36
7.35
7.35
7.26 CDCl3
7.22
7.22
7.22
7.22
7.22
7.22
6.26
6.26
6.26
6.26
6.20
6.19
6.19
6.19
6.18
6.18
6.18
6.17
6.17
6.17
6.17
2.50
2.50
2.50
2.49
2.49
2.49
2.48
2.48
2.34
2.33
2.33
2.33
2.33
2.29
2.29
2.29
2.29
2.28
2.28
2.28
2.28
2.28
2.27
2.27
2.27
2.26
2.26
2.25
1.54 H2O
1.00
0.98
1.01
0.98
2.06
3.04
2.07
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

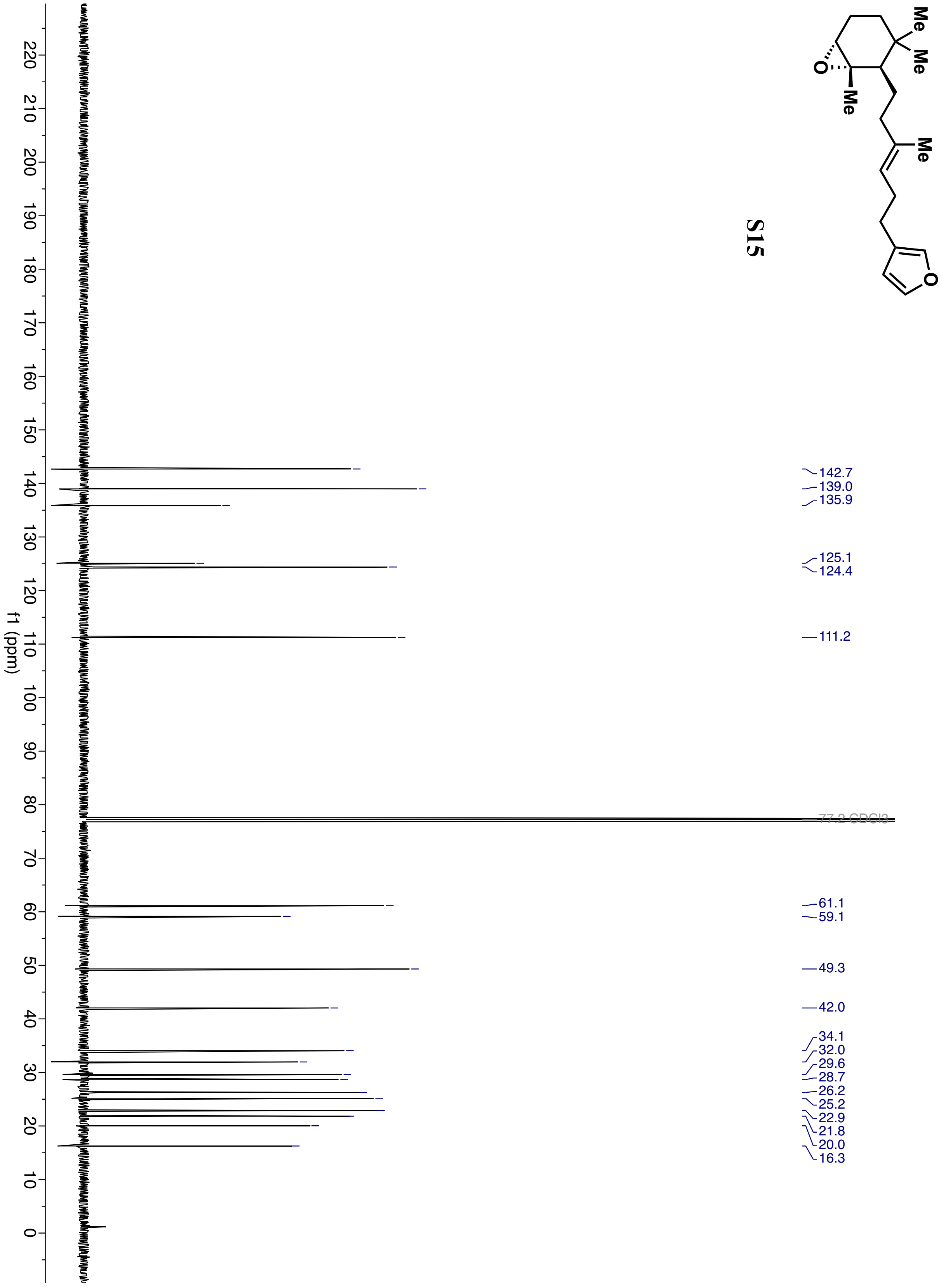


22

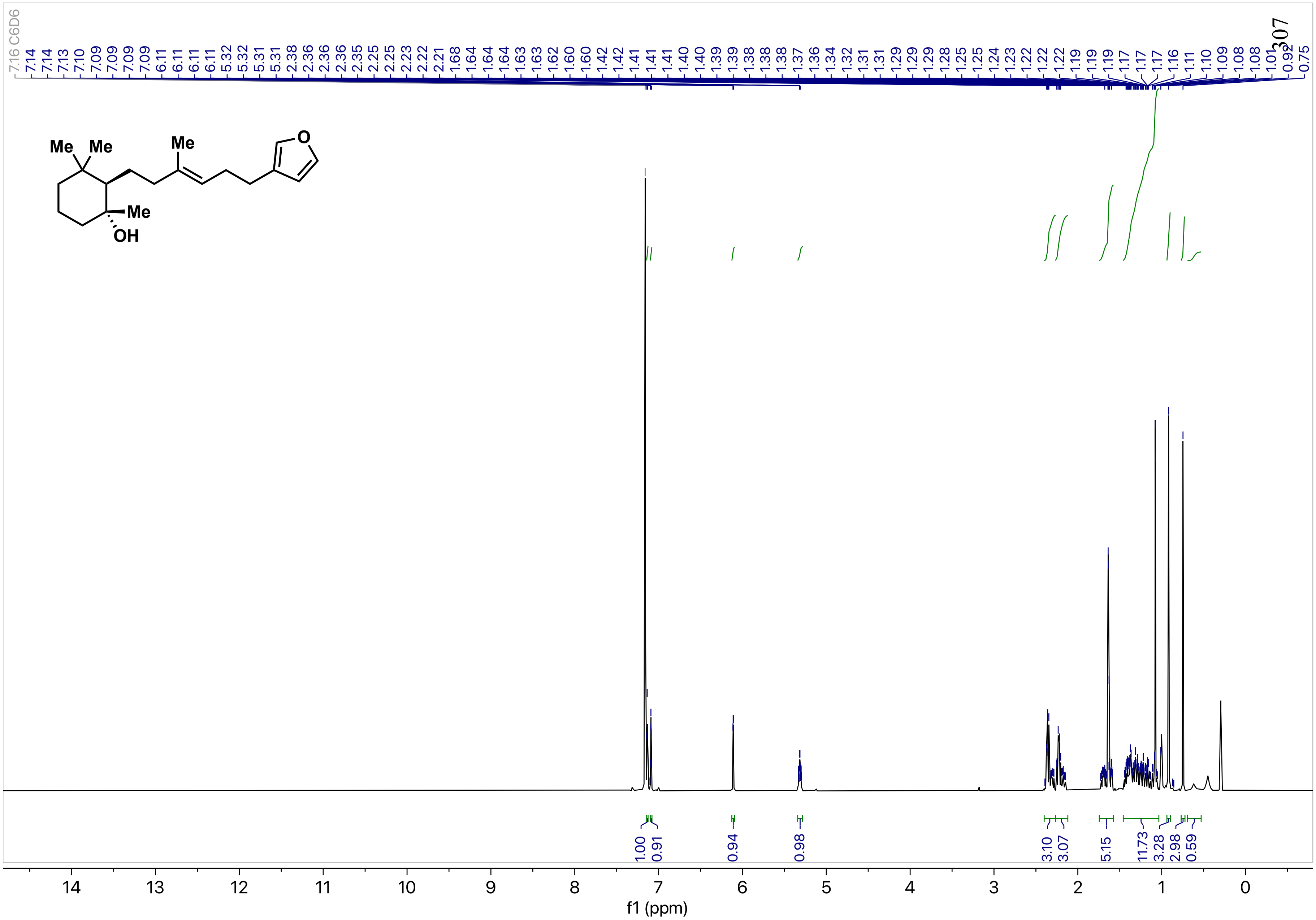
O
Me
I
143.0
140.4
139.1
124.0
111.0
94.6
77.2 CDCl3
31.3
27.7
24.2
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

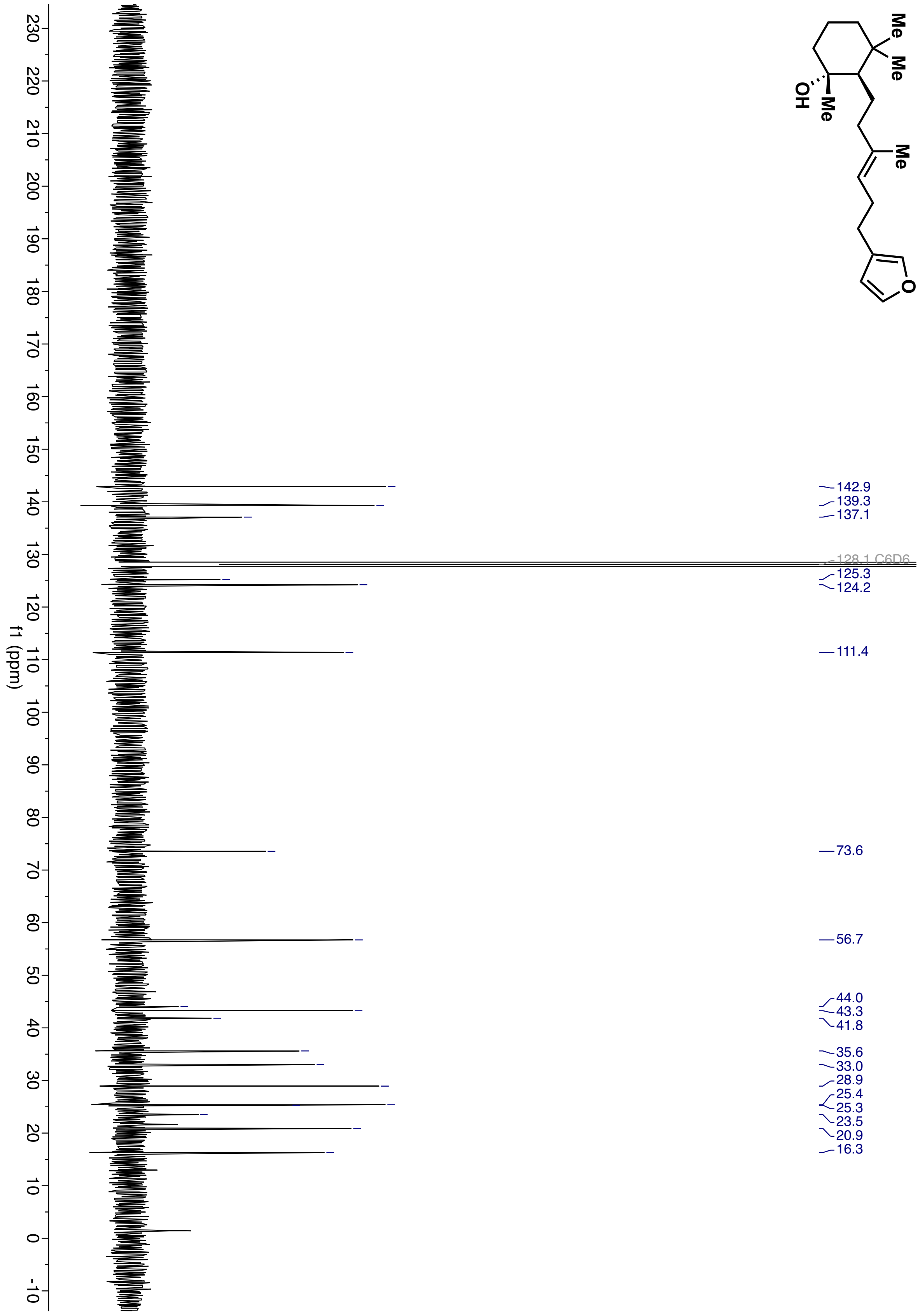

S15

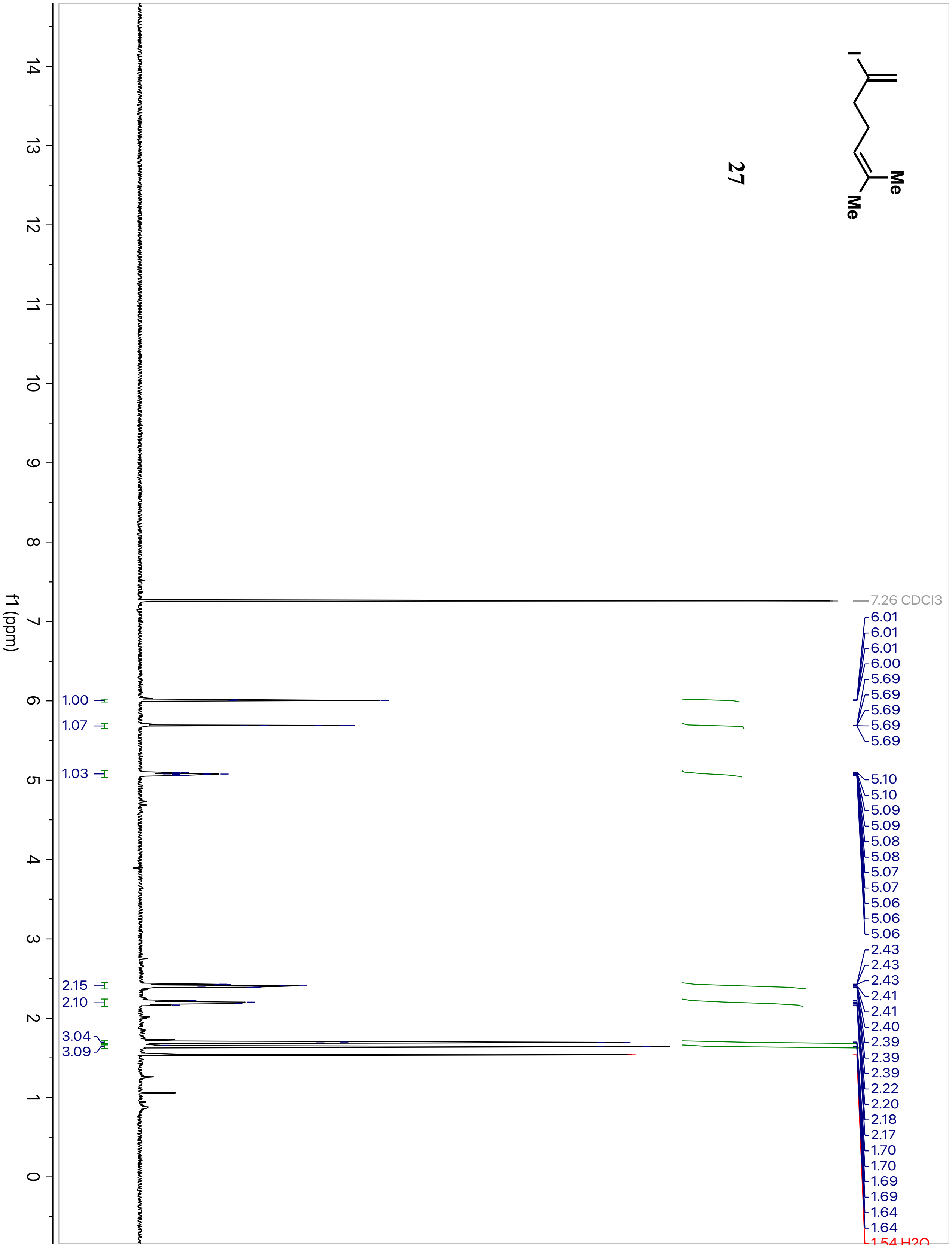
Me
Me
Me
Me
O
O
7.34
7.34
7.33
7.26 CDCl3
7.22
7.22
7.22
7.22
7.22
7.21
6.28
6.28
6.28
6.28
5.22
5.21
5.21
5.21
2.89
2.89
2.88
2.48
2.47
2.46
2.46
2.46
2.45
2.45
2.27
2.27
2.27
2.26
2.26
2.26
2.25
2.24
2.23
2.23
2.23
2.01
2.00
2.00
1.94
1.93
1.85
1.85
1.84
1.84
1.61
1.61
1.61
1.56 H2O
1.52
1.51
1.50
1.48
1.39
1.38
1.38
1.38
1.37
1.37
1.37
1.36
1.35
1.34
1.34
1.32
1.31
1.30
1.29
1.07
1.06
1.06
1.06
1.06
1.05
1.05
0.85
0.73
1.00
1.00
1.02
1.05
1.05
2.13
3.22
2.18
1.07
3.19
1.07
6.77
1.08
3.50
3.21
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.
f1 (ppm)


Me
Me
Me
Me
O
O
142.7
139.0
135.9
125.1
124.4
111.2
77.2 CDCl3
61.1
59.1
49.3
42.0
34.1
32.0
29.6
28.7
26.2
25.2
22.9
21.8
20.0
16.3
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

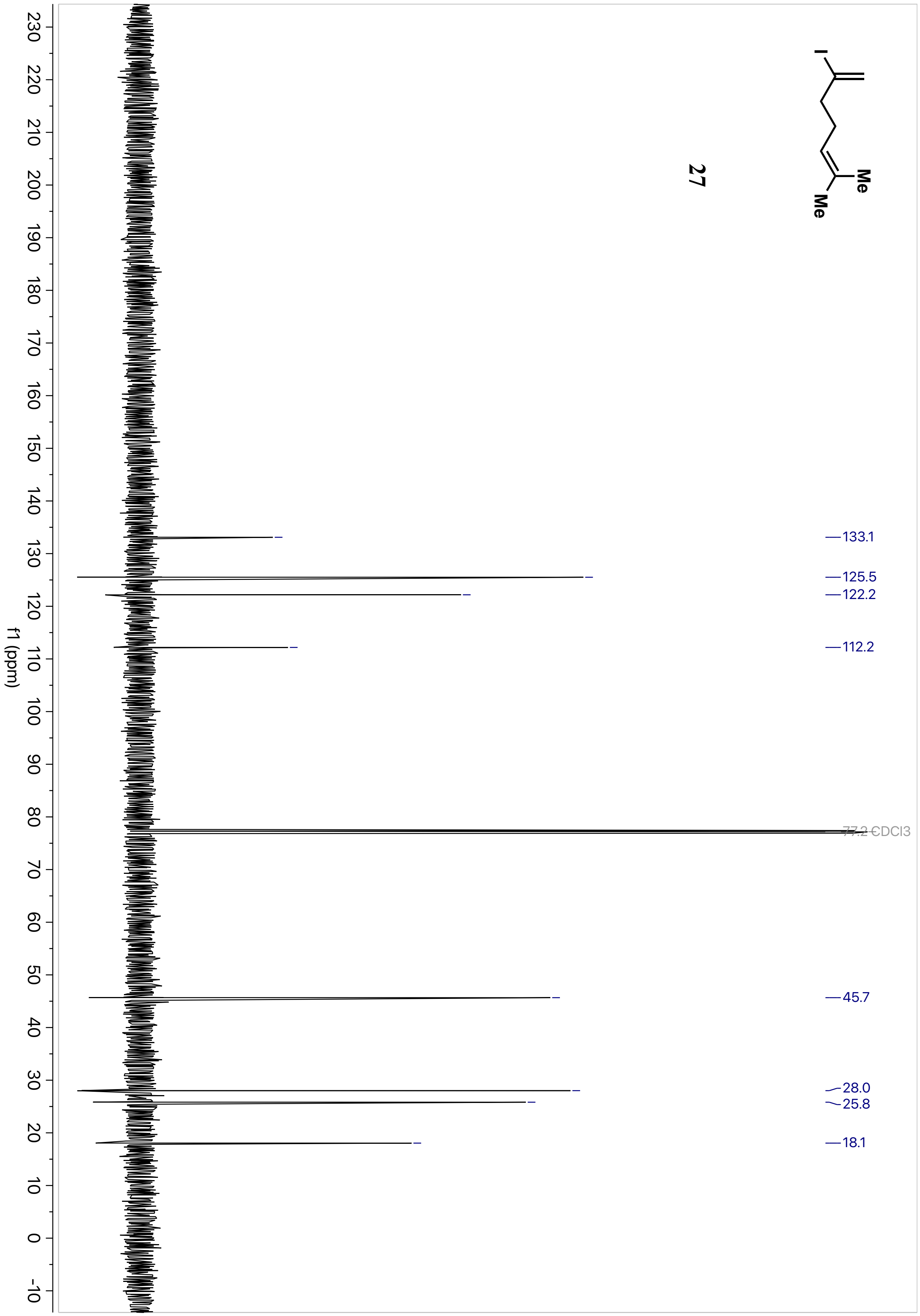
S15


7.16 C6D6
7.14
7.14
7.13
7.10
7.09
7.09
7.09
7.09
6.11
6.11
6.11
6.11
5.32
5.32
5.31
5.31
2.38
2.36
2.36
2.36
2.35
2.25
2.25
2.23
2.22
2.21
1.68
1.64
1.64
1.64
1.63
1.63
1.62
1.60
1.60
1.42
1.42
1.41
1.41
1.41
1.40
1.40
1.39
1.39
1.38
1.38
1.38
1.37
1.36
1.34
1.32
1.31
1.31
1.29
1.29
1.29
1.28
1.25
1.25
1.24
1.23
1.22
1.22
1.22
1.19
1.19
1.19
1.17
1.17
1.17
1.16
1.11
1.10
1.09
1.08
1.08
1.01
0.92
0.75
Me
Me
Me
Me
OH
O
1.00
0.91
0.94
0.98
3.10
3.07
5.15
11.73
3.28
2.98
0.59
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

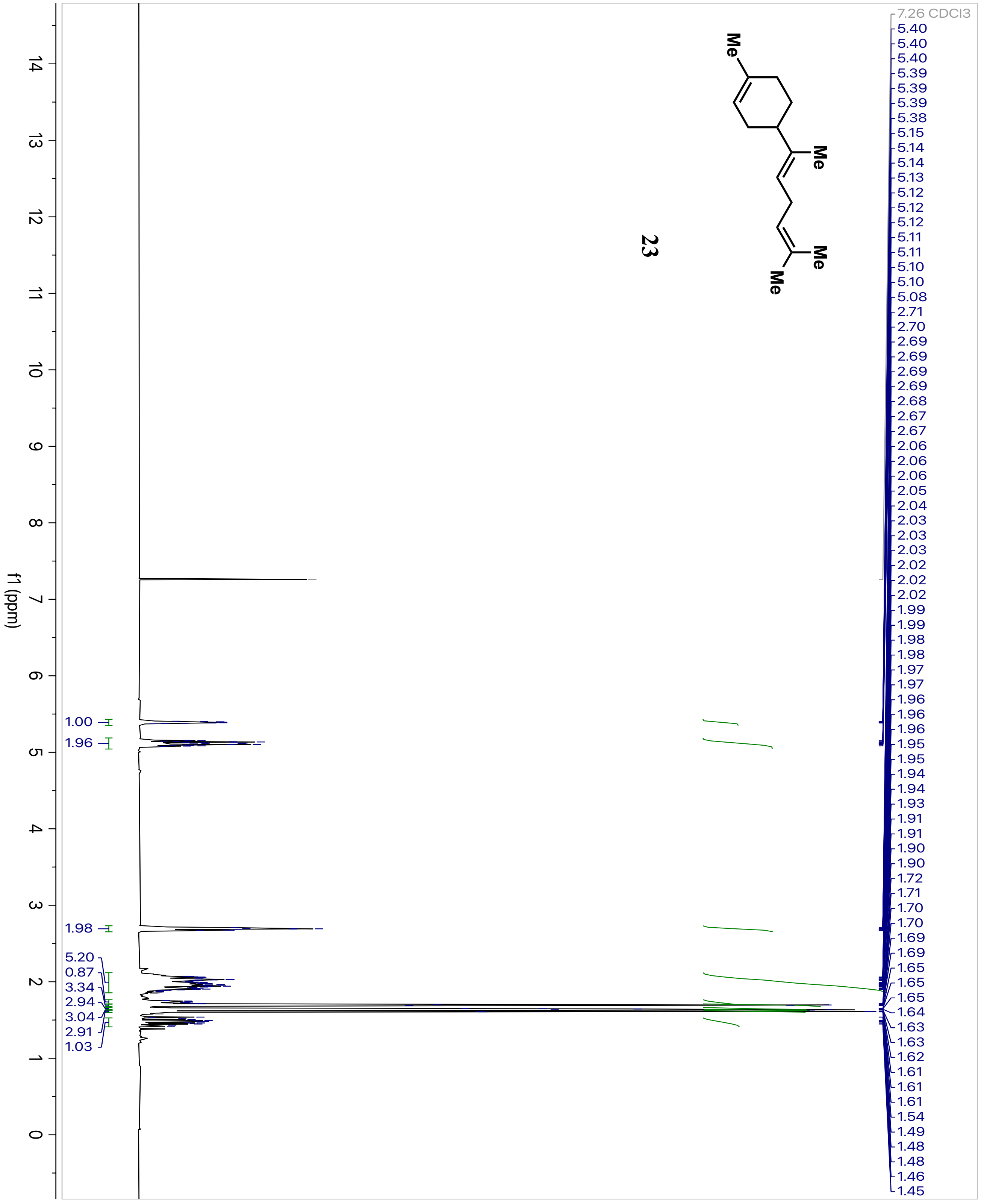

Me
Me
Me
OH
Me
O
142.9
139.3
137.1
128.1 C6D6
125.3
124.2
111.4
73.6
56.7
44.0
43.3
41.8
35.6
33.0
28.9
25.4
25.3
23.5
20.9
16.3
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)


27

I
Me
Me
7.26 CDCl3
6.01
6.01
6.01
6.00
5.69
5.69
5.69
5.69
5.69
5.10
5.10
5.09
5.09
5.08
5.08
5.07
5.07
5.06
5.06
5.06
2.43
2.43
2.43
2.41
2.41
2.40
2.39
2.39
2.39
2.22
2.20
2.18
2.17
1.70
1.70
1.69
1.69
1.64
1.64
1.54 H2O
1.00
1.07
1.03
2.15
2.10
3.04
3.09
f1 (ppm)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0

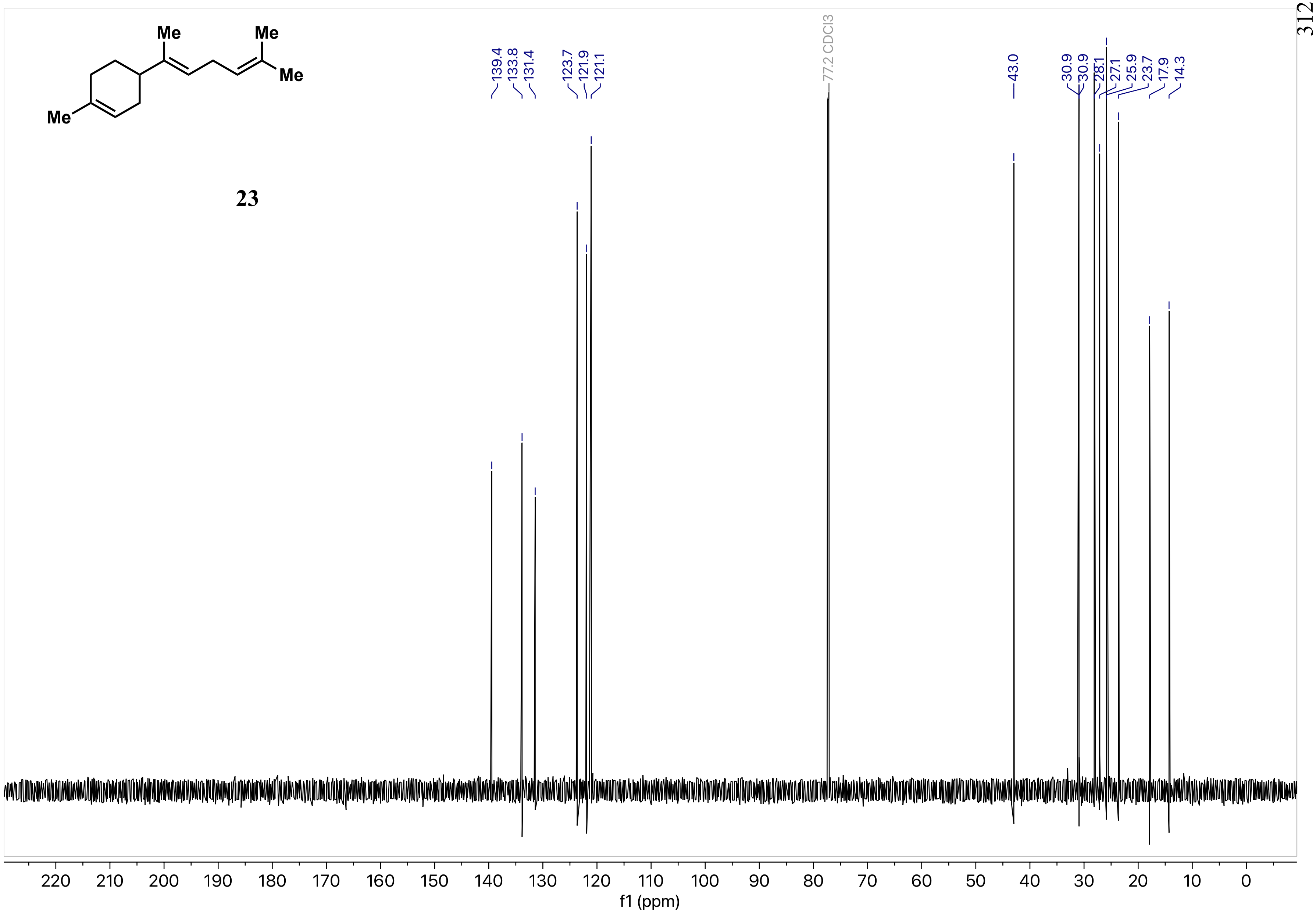

I
Me
Me
133.1
125.5
122.2
112.2
77.2 CDCl3
45.7
28.0
25.8
18.1
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

27



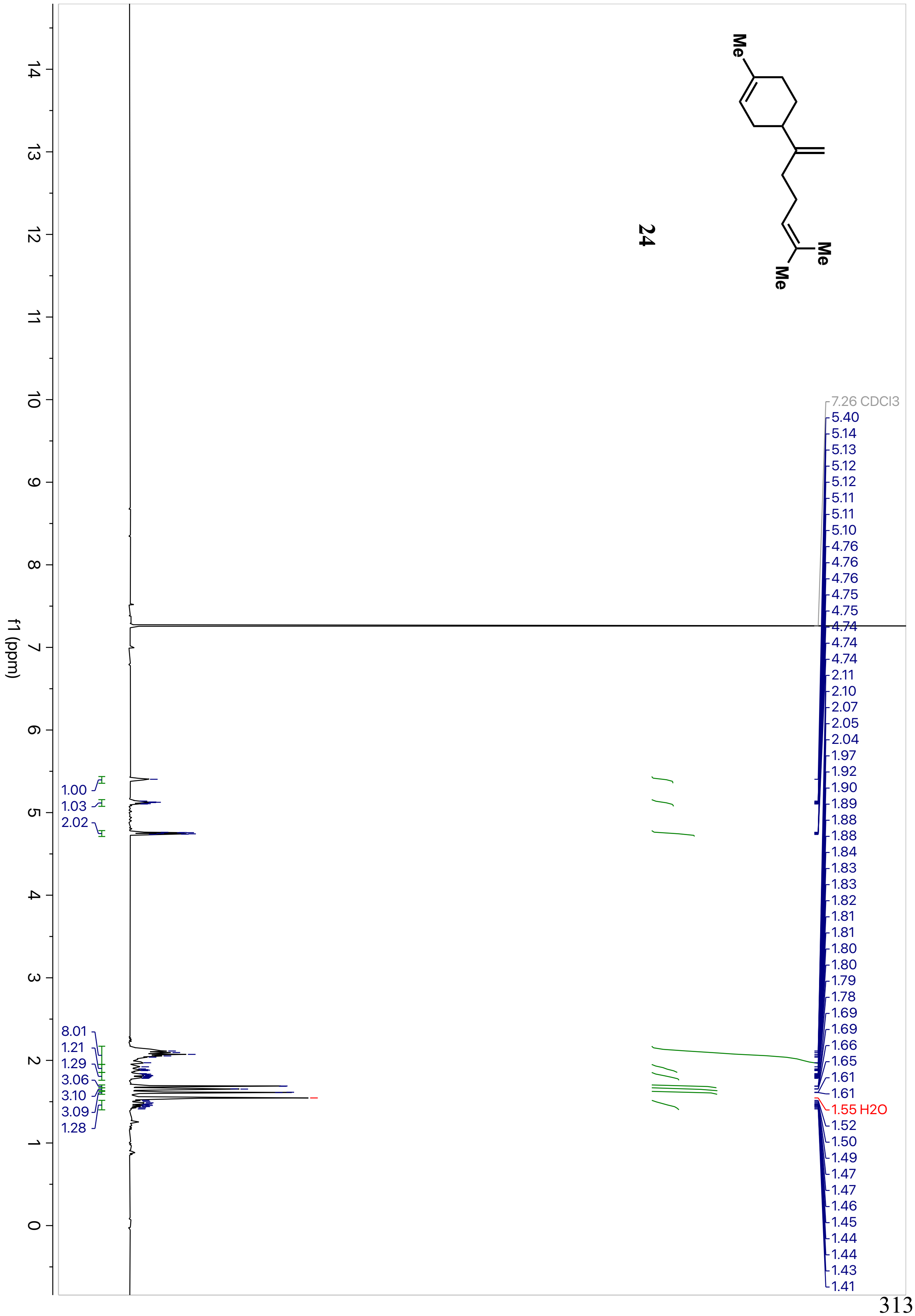
7.26 CDCl3
5.40
5.40
5.40
5.39
5.39
5.39
5.38
5.15
5.14
5.14
5.13
5.12
5.12
5.12
5.11
5.11
5.10
5.10
5.08
2.71
2.70
2.69
2.69
2.69
2.69
2.68
2.67
2.67
2.06
2.06
2.06
2.05
2.04
2.03
2.03
2.03
2.02
2.02
2.02
1.99
1.99
1.98
1.98
1.97
1.97
1.96
1.96
1.96
1.95
1.95
1.94
1.94
1.93
1.91
1.91
1.90
1.90
1.72
1.71
1.70
1.70
1.69
1.69
1.65
1.65
1.65
1.64
1.63
1.63
1.62
1.61
1.61
1.61
1.54
1.49
1.48
1.48
1.46
1.45
Me
Me
Me
Me
1.00
1.96
1.98
5.20
0.87
3.34
2.94
3.04
2.91
1.03
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

23



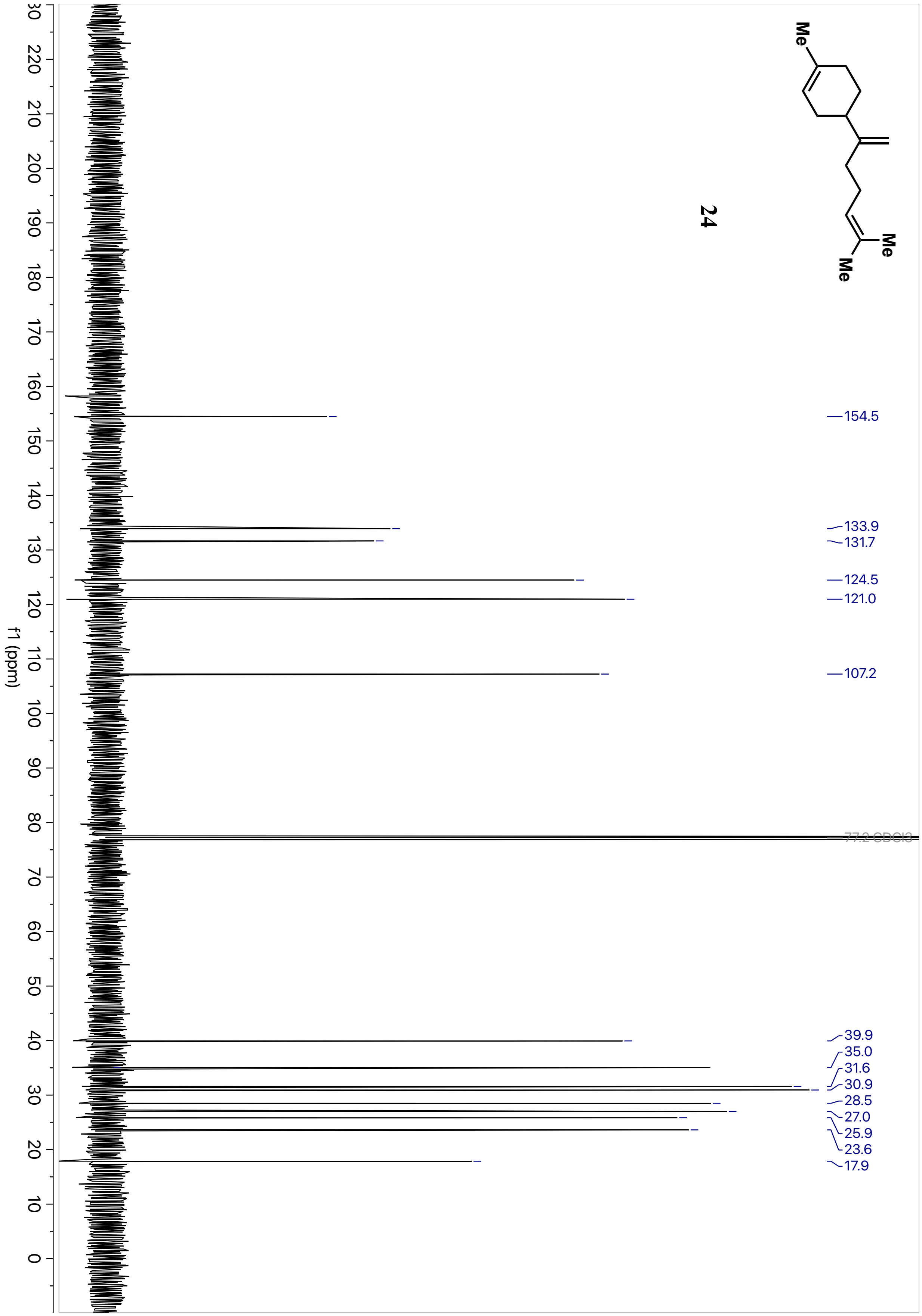
23

Me
Me
Me
Me
139.4
133.8
131.4
123.7
121.9
121.1
77.2 CDCl3
43.0
30.9
30.9
28.1
27.1
25.9
23.7
17.9
14.3
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)



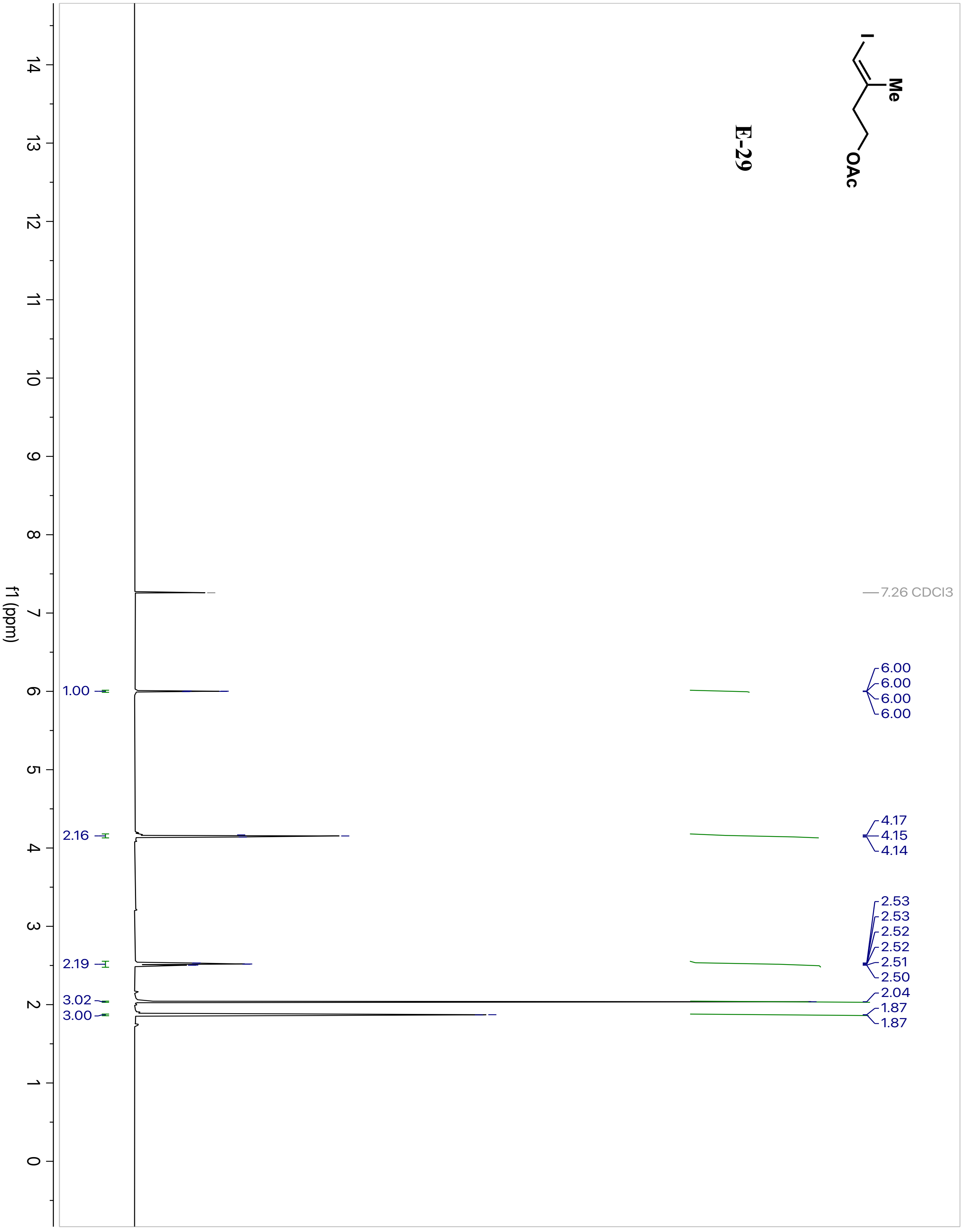
24

Me
Me
Me
7.26 CDCl3
5.40
5.14
5.13
5.12
5.12
5.11
5.11
5.10
4.76
4.76
4.76
4.75
4.75
4.74
4.74
4.74
2.11
2.10
2.07
2.05
2.04
1.97
1.92
1.90
1.89
1.88
1.88
1.84
1.83
1.83
1.82
1.81
1.81
1.80
1.80
1.79
1.78
1.69
1.69
1.66
1.65
1.61
1.61
1.55 H2O
1.52
1.50
1.49
1.47
1.47
1.46
1.45
1.44
1.44
1.43
1.41
1.00
1.03
2.02
8.01
1.21
1.29
3.06
3.10
3.09
1.28
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)



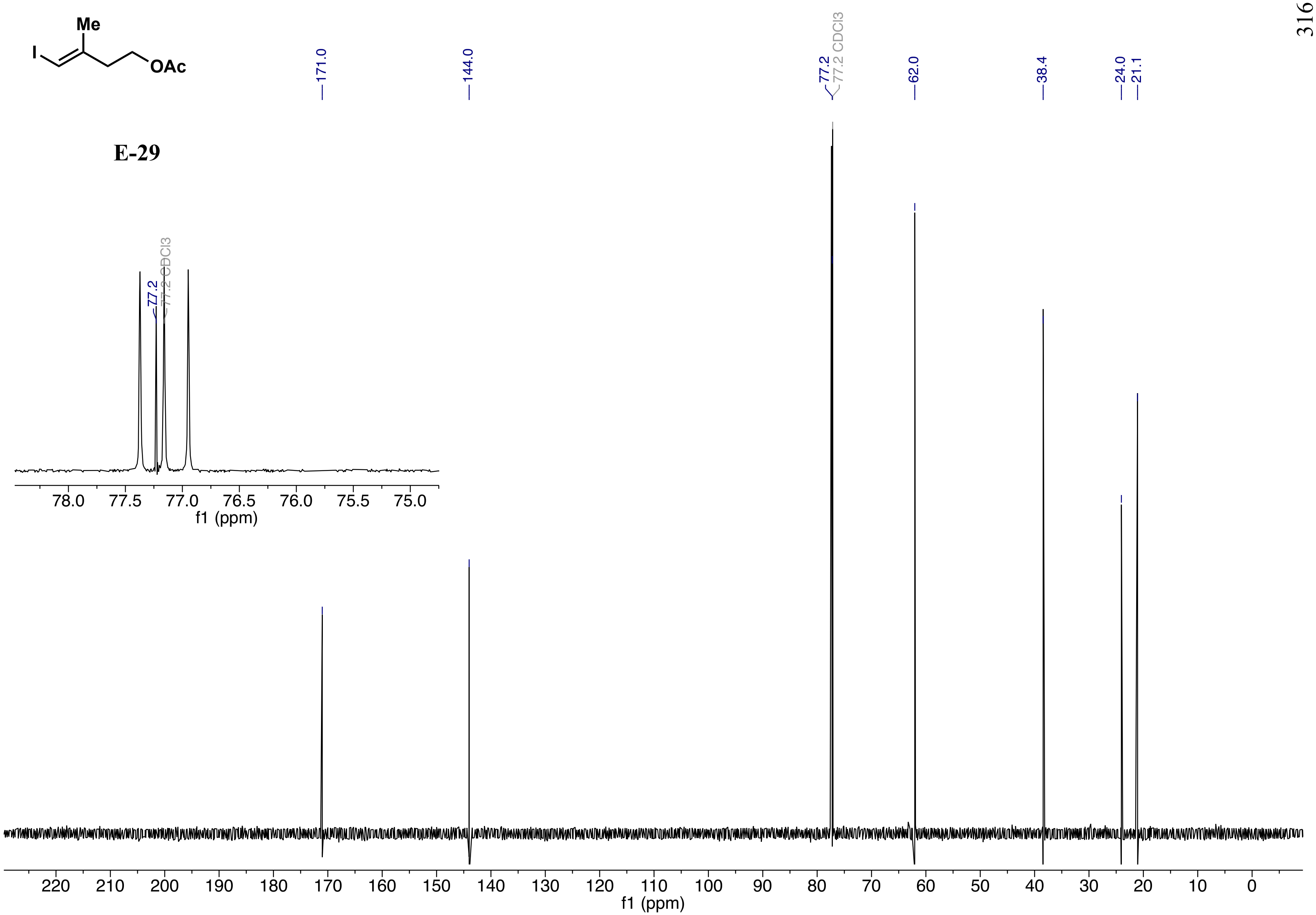
Me
Me
Me
154.5
133.9
131.7
124.5
121.0
107.2
77.2 CDCl3
39.9
35.0
31.6
30.9
28.5
27.0
25.9
23.6
17.9
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

24

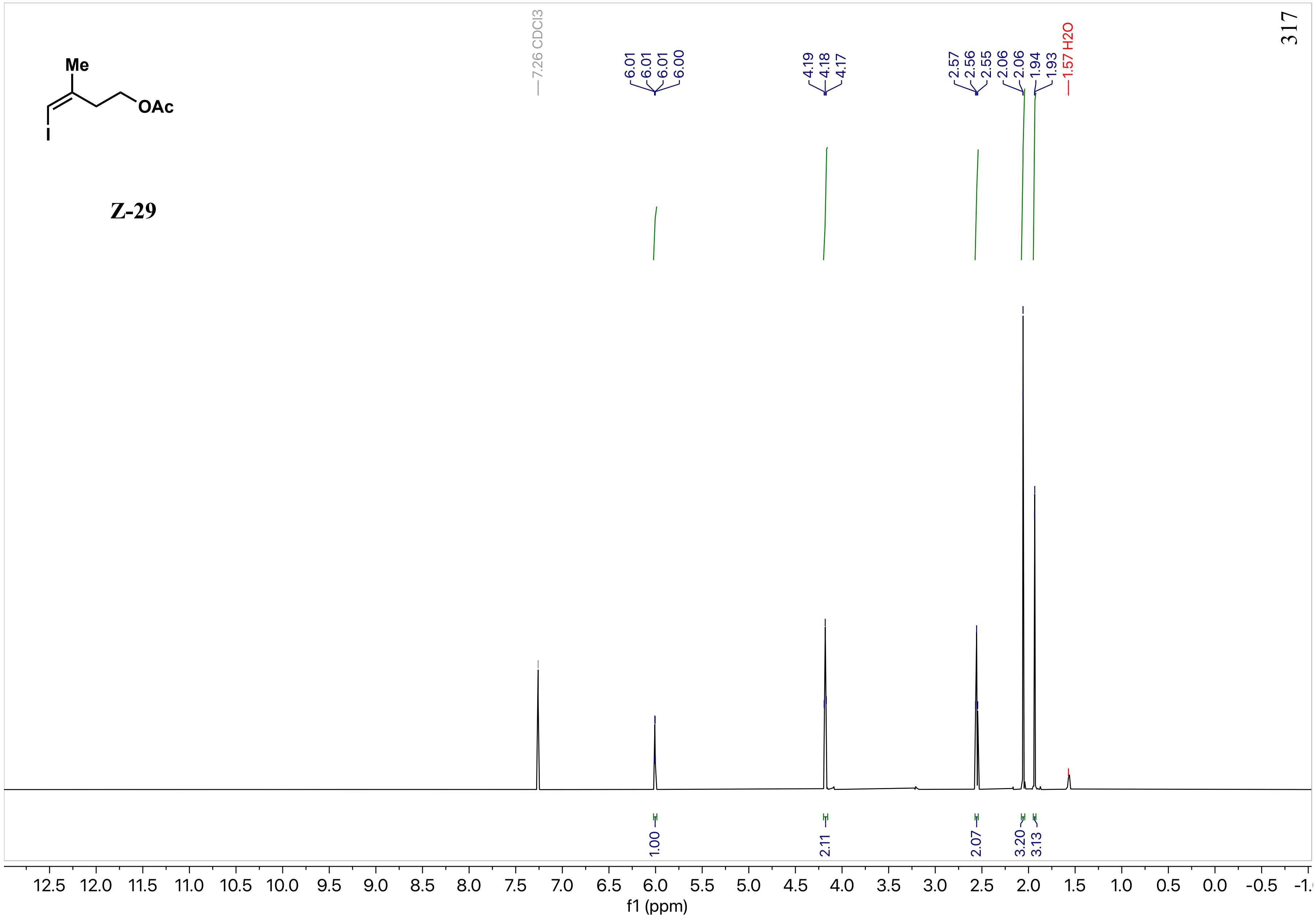


E-29

I
Me
OAc
7.26 CDCl3
6.00
6.00
6.00
6.00
4.17
4.15
4.14
2.53
2.53
2.52
2.52
2.51
2.50
2.04
1.87
1.87
1.00
2.16
2.19
3.02
3.00
f1 (ppm)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0

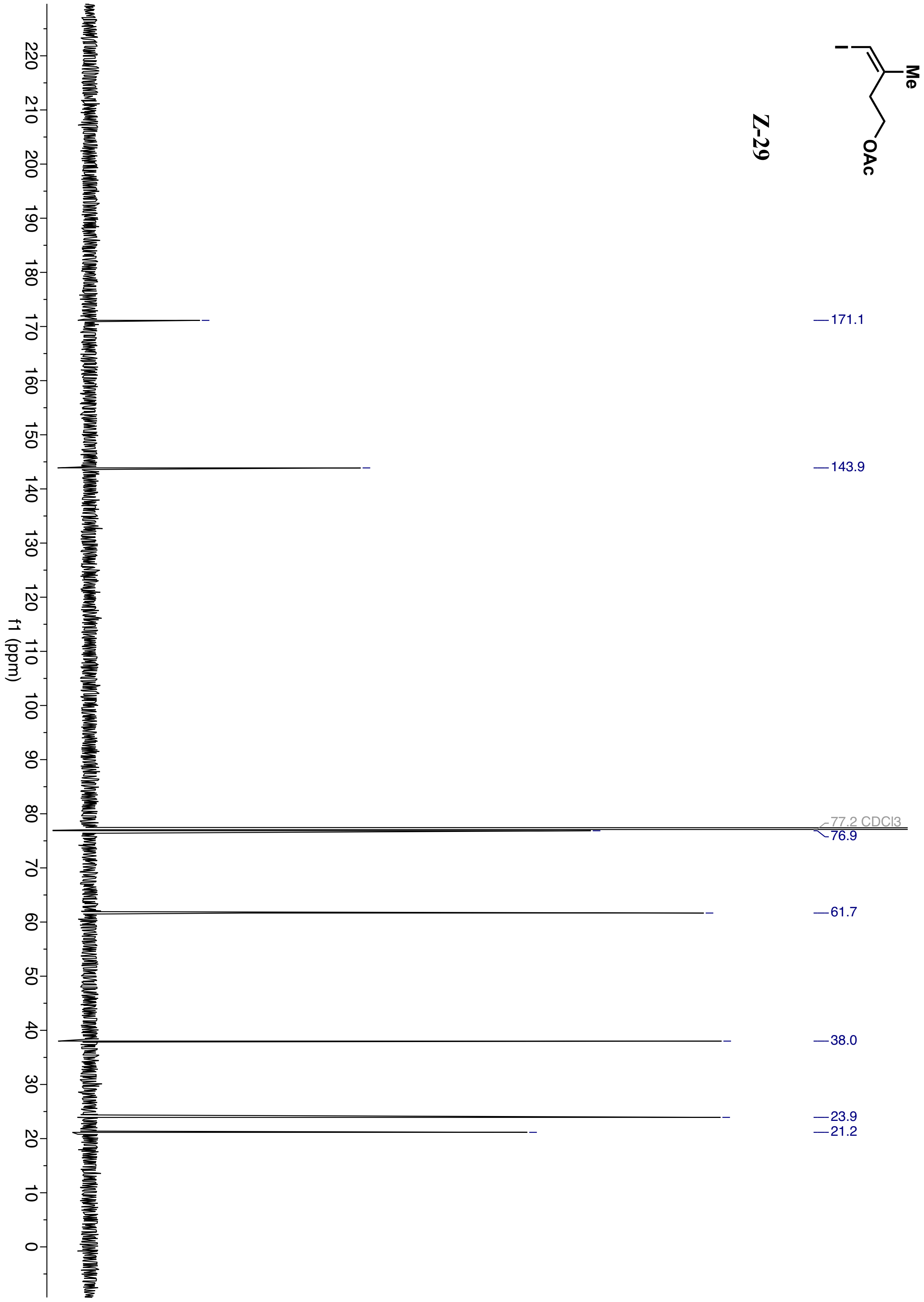

E-29

Me
I
OAc
171.0
144.0
77.2
77.2 CDCl3
62.0
38.4
24.0
21.1
77.2
77.2 CDCl3
78.0
77.5
77.0
76.5
76.0
75.5
75.0
f1 (ppm)
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

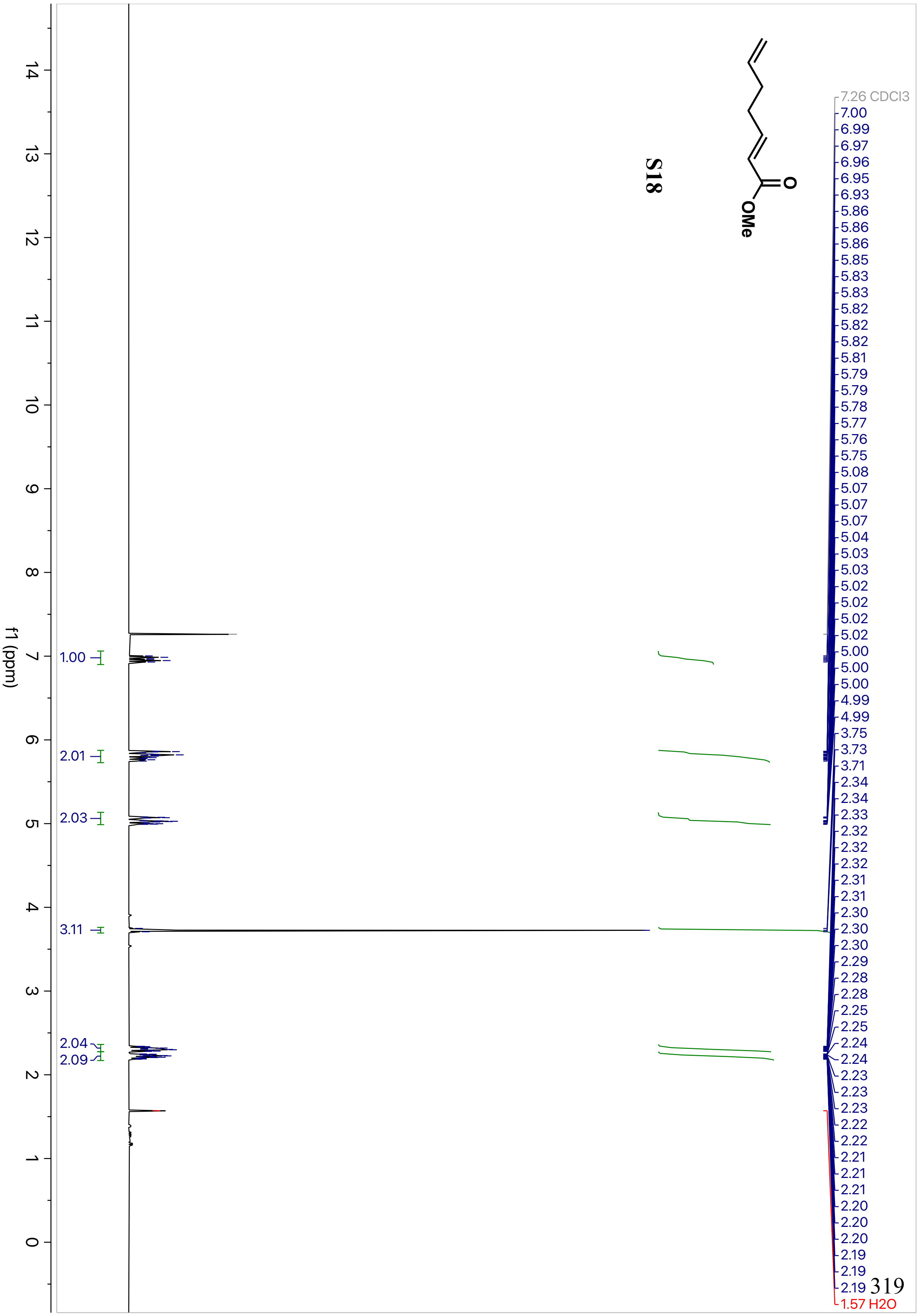


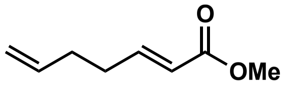
Z-29

Me
OAc
I
7.26 CDCl3
6.01
6.01
6.01
6.00
4.19
4.18
4.17
2.57
2.56
2.55
2.06
2.06
1.94
1.93
1.57 H2O
1.00
2.11
2.07
3.20
3.13
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

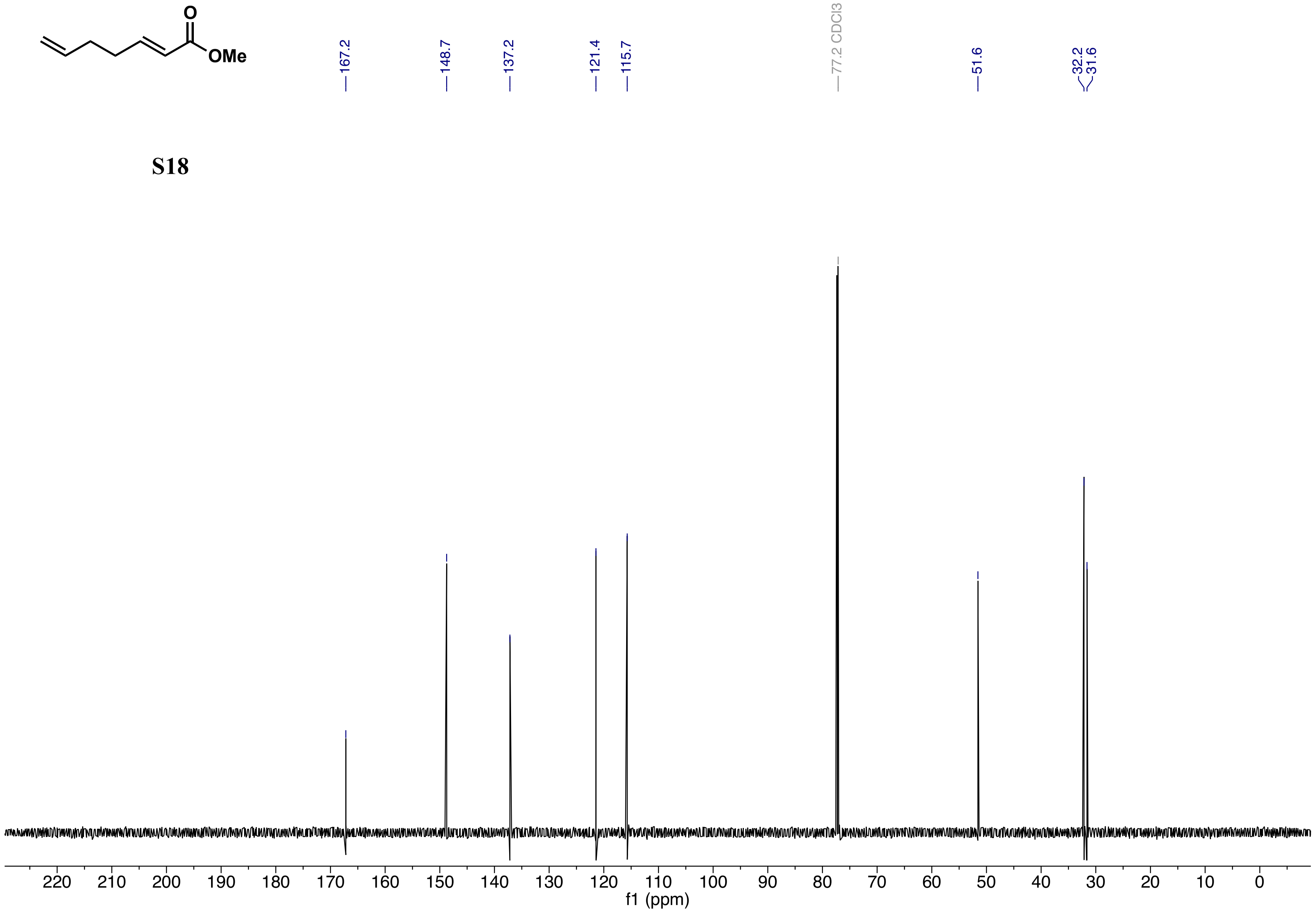

Me
OAc
I
171.1
143.9
77.2 CDCl3
76.9
61.7
38.0
23.9
21.2
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Z-29

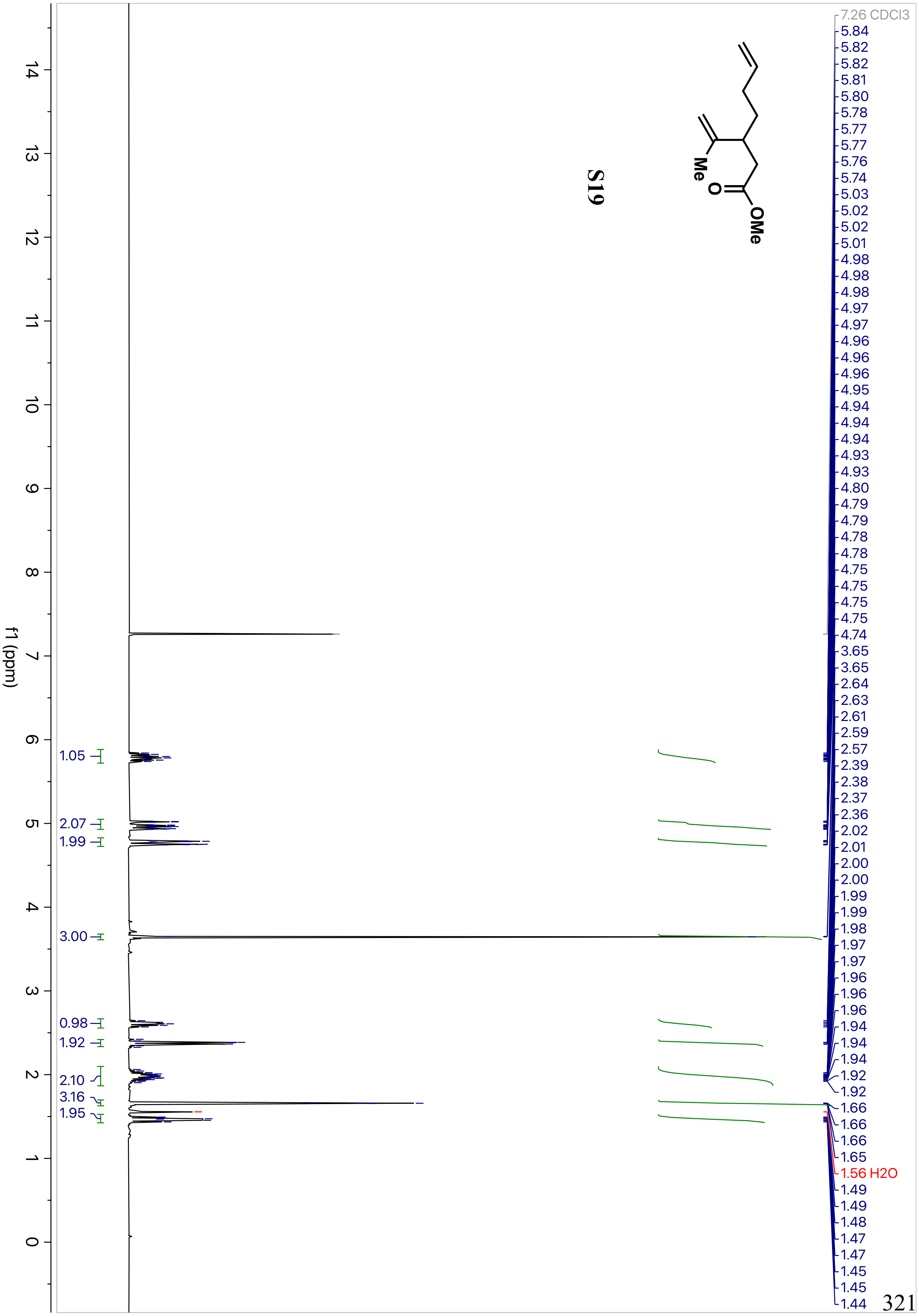

S18
OMe
O
7.26 CDCl3
7.00
6.99
6.97
6.96
6.95
6.93
5.86
5.86
5.86
5.85
5.83
5.83
5.82
5.82
5.82
5.81
5.79
5.79
5.78
5.77
5.76
5.75
5.08
5.07
5.07
5.07
5.04
5.03
5.03
5.02
5.02
5.02
5.02
5.00
5.00
5.00
4.99
4.99
3.75
3.73
3.71
2.34
2.34
2.33
2.32
2.32
2.32
2.31
2.31
2.30
2.30
2.30
2.29
2.28
2.28
2.25
2.25
2.24
2.24
2.23
2.23
2.23
2.22
2.22
2.21
2.21
2.21
2.20
2.20
2.20
2.19
2.19
2.19
1.57 H2O
1.00
2.01
2.03
3.11
2.04
2.09
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

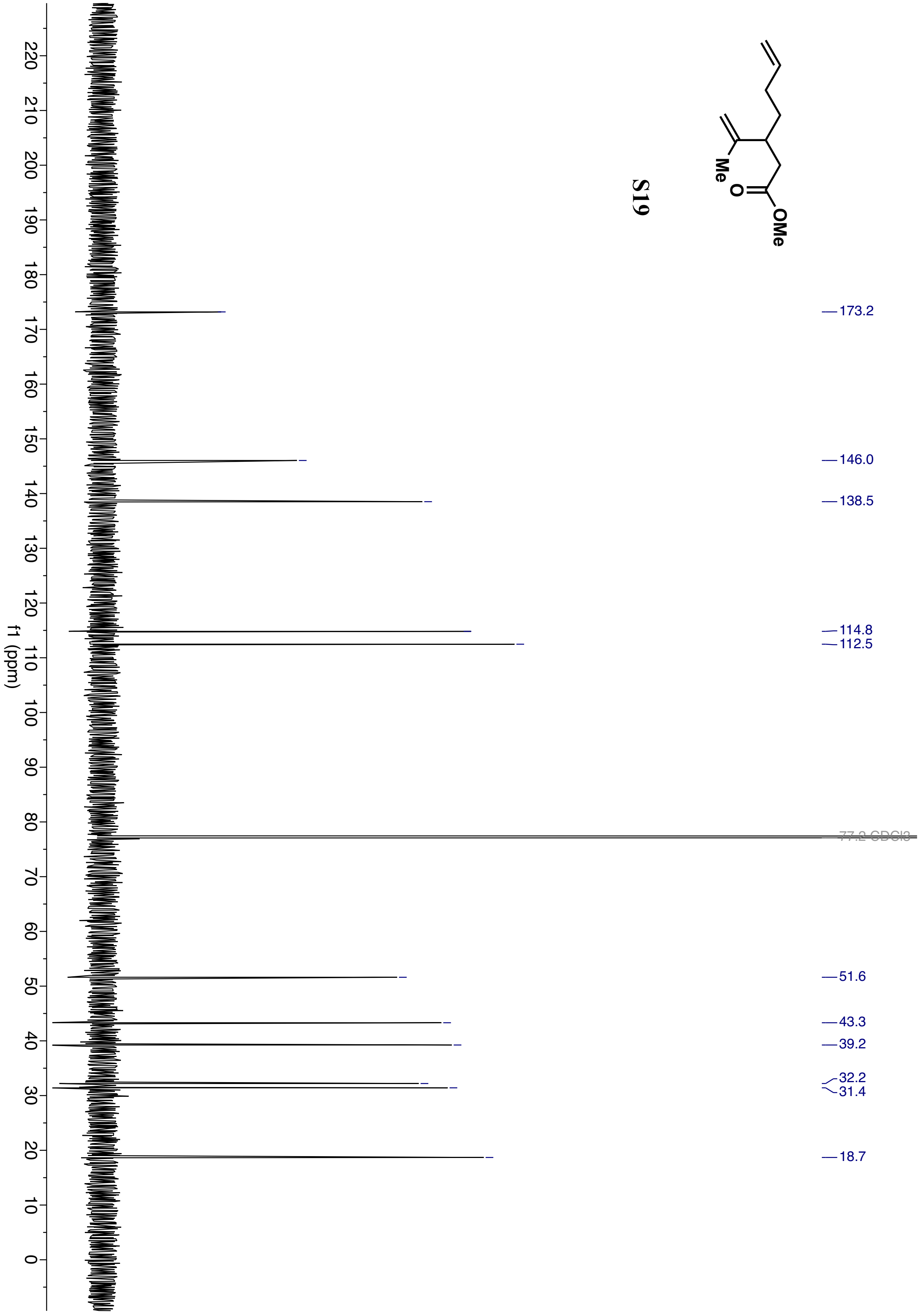


S18

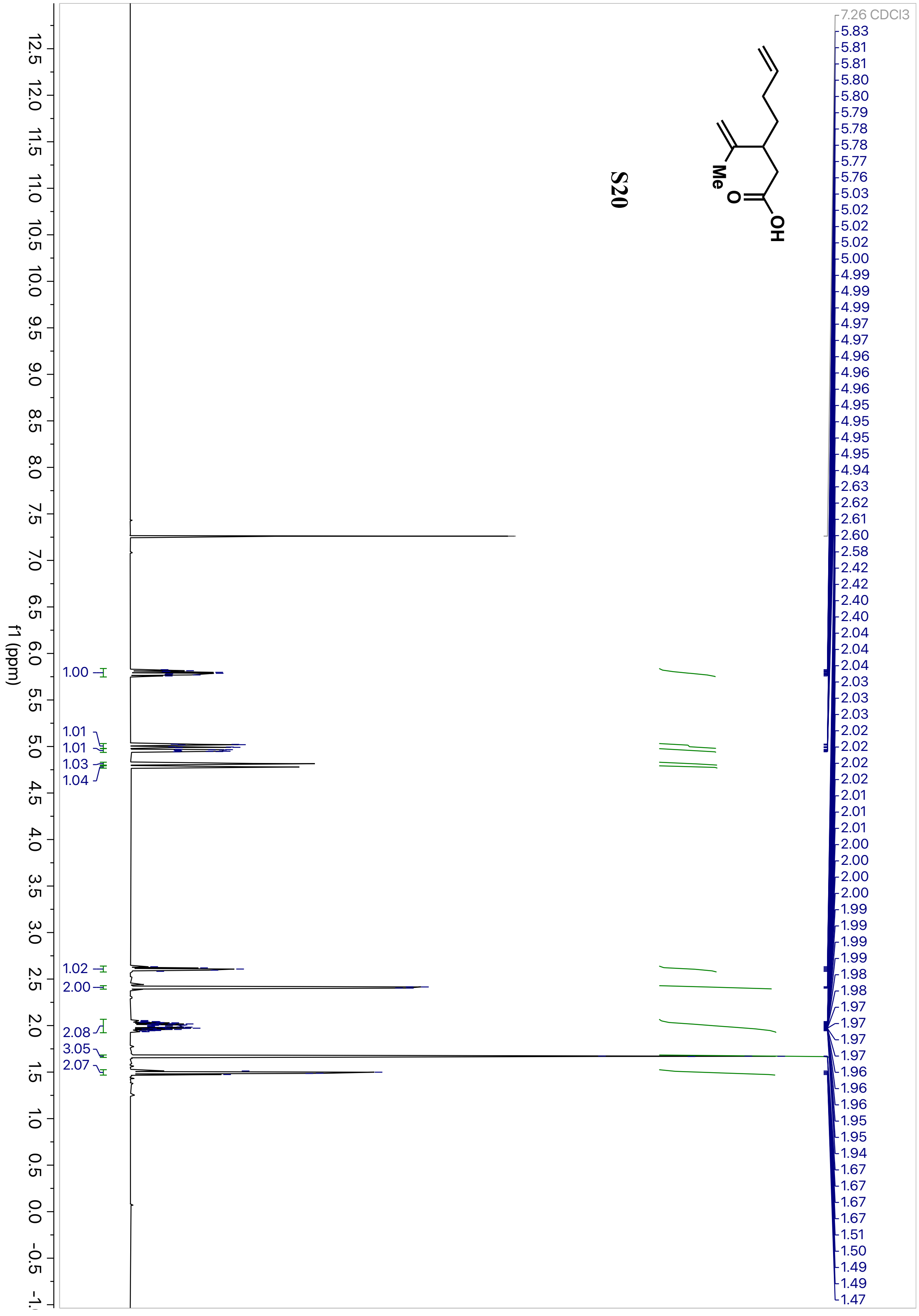


167.2
148.7
137.2
121.4
115.7
77.2 CDCl3
51.6
32.2
31.6
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

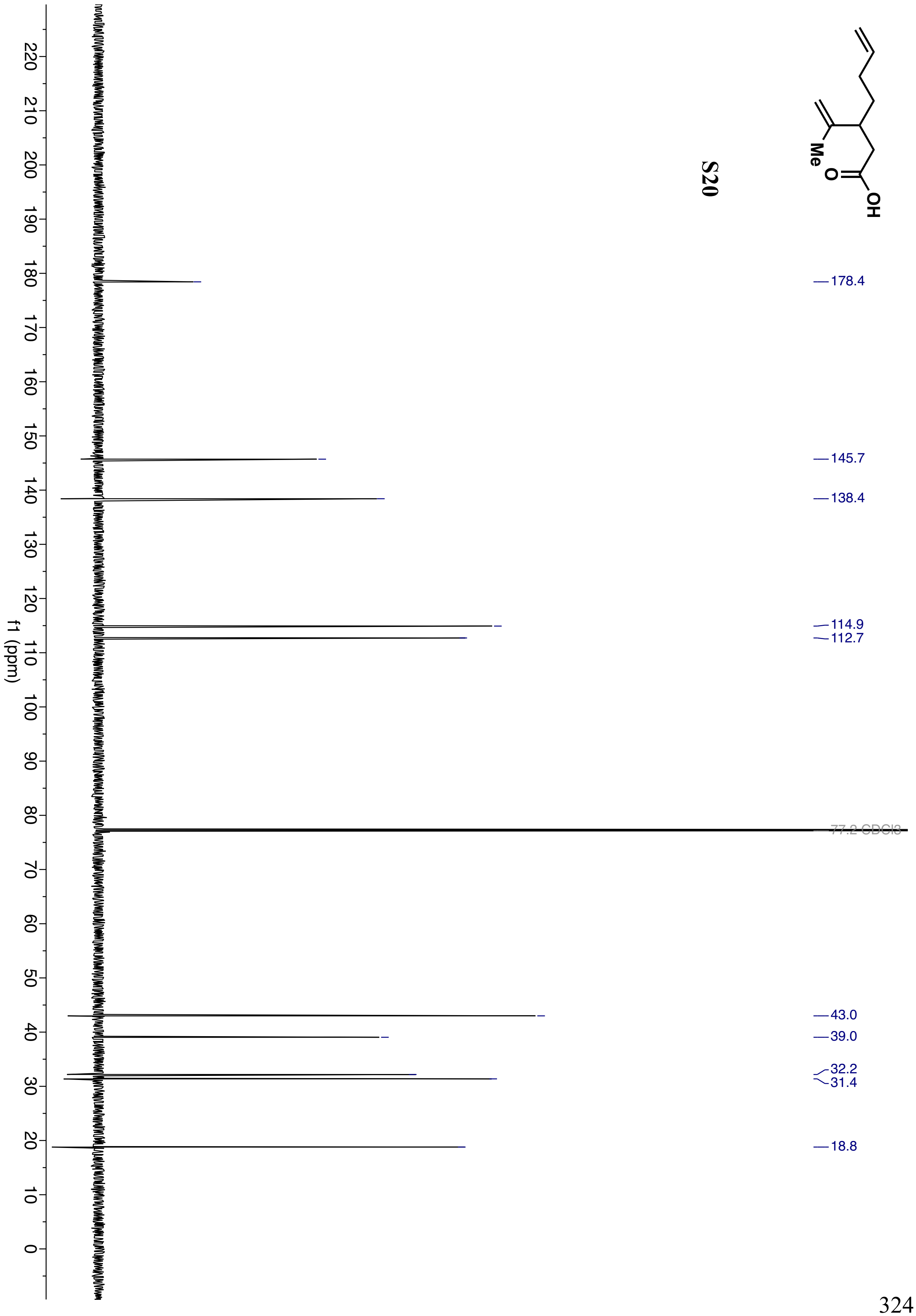

S19
OMe
O
Me
7.26 CDCl3
5.84
5.82
5.82
5.81
5.80
5.78
5.77
5.77
5.76
5.74
5.03
5.02
5.02
5.01
4.98
4.98
4.98
4.97
4.97
4.96
4.96
4.96
4.95
4.94
4.94
4.94
4.93
4.93
4.80
4.79
4.79
4.78
4.78
4.75
4.75
4.75
4.75
4.74
3.65
3.65
2.64
2.63
2.61
2.59
2.57
2.39
2.38
2.37
2.36
2.02
2.01
2.00
2.00
1.99
1.99
1.98
1.97
1.97
1.96
1.96
1.96
1.94
1.94
1.94
1.92
1.92
1.66
1.66
1.66
1.65
1.56 H2O
1.49
1.49
1.48
1.47
1.47
1.45
1.45
1.44
1.05
2.07
1.99
3.00
0.98
1.92
2.10
3.16
1.95
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)


OMe
O
Me
O
173.2
146.0
138.5
114.8
112.5
77.2 CDCl3
51.6
43.3
39.2
32.2
31.4
18.7
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

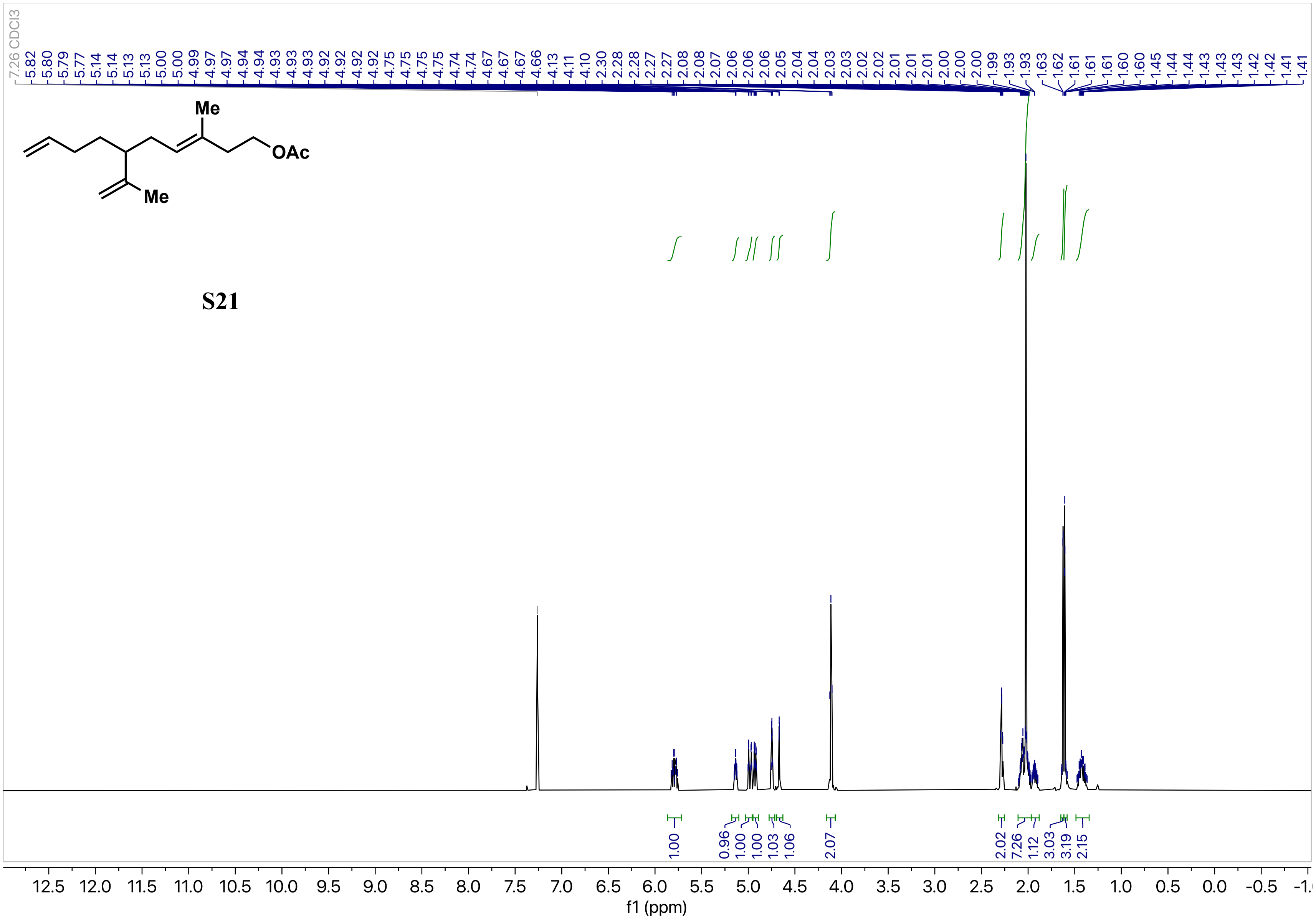
S19


S20

7.26 CDCl3
5.83
5.81
5.81
5.80
5.80
5.79
5.78
5.78
5.77
5.76
5.03
5.02
5.02
5.02
5.00
4.99
4.99
4.99
4.97
4.97
4.96
4.96
4.96
4.95
4.95
4.95
4.95
4.94
2.63
2.62
2.61
2.60
2.58
2.42
2.42
2.40
2.40
2.04
2.04
2.04
2.03
2.03
2.03
2.02
2.02
2.02
2.02
2.01
2.01
2.01
2.00
2.00
2.00
2.00
1.99
1.99
1.99
1.99
1.98
1.98
1.97
1.97
1.97
1.97
1.96
1.96
1.96
1.95
1.95
1.94
1.67
1.67
1.67
1.67
1.51
1.50
1.49
1.49
1.47
OH
O
Me
1.00
1.01
1.01
1.03
1.04
1.02
2.00
2.08
3.05
2.07
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.
f1 (ppm)

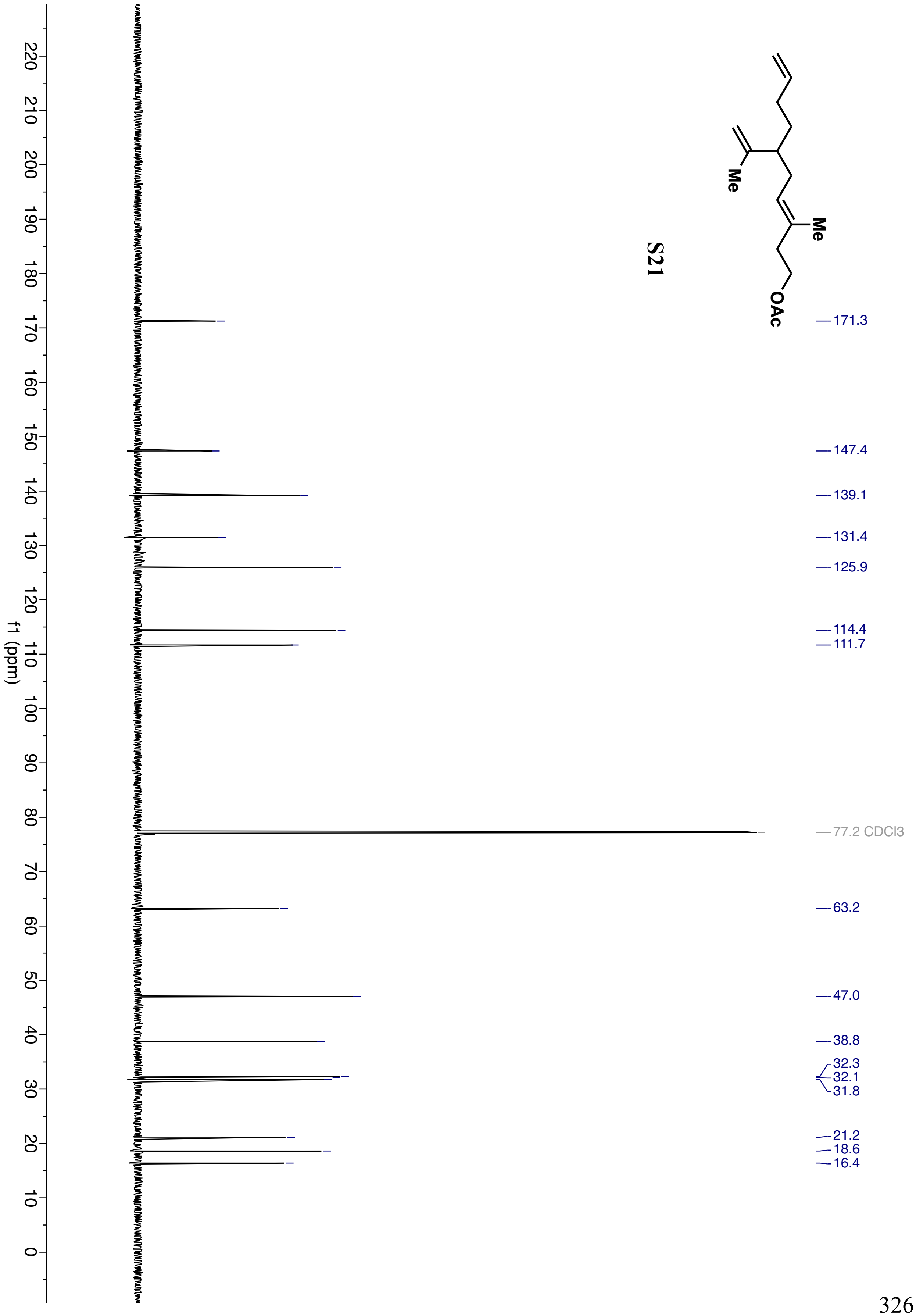

Me
O
OH
178.4
145.7
138.4
114.9
112.7
77.2 CDCl3
43.0
39.0
32.2
31.4
18.8
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

S20



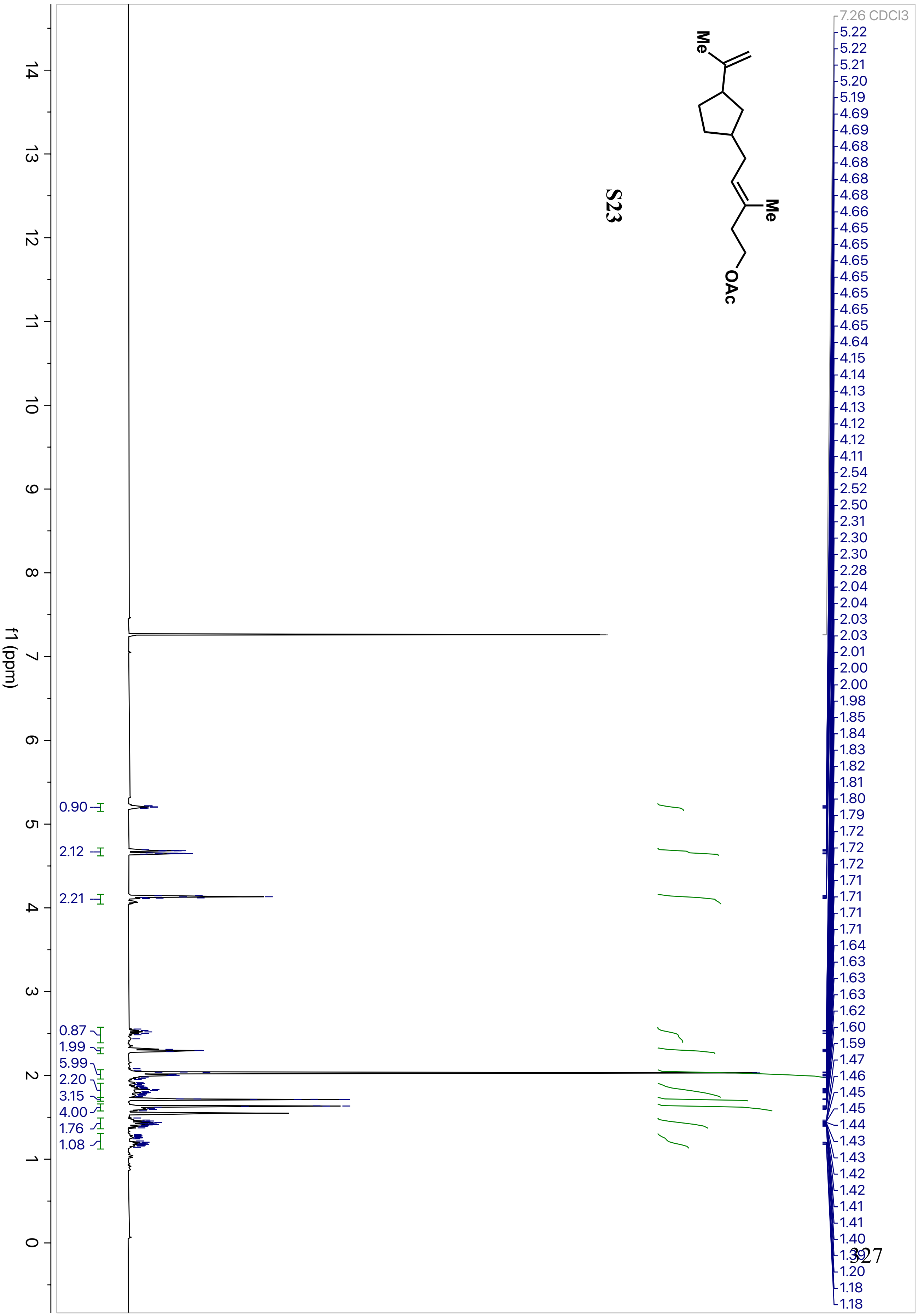
S21

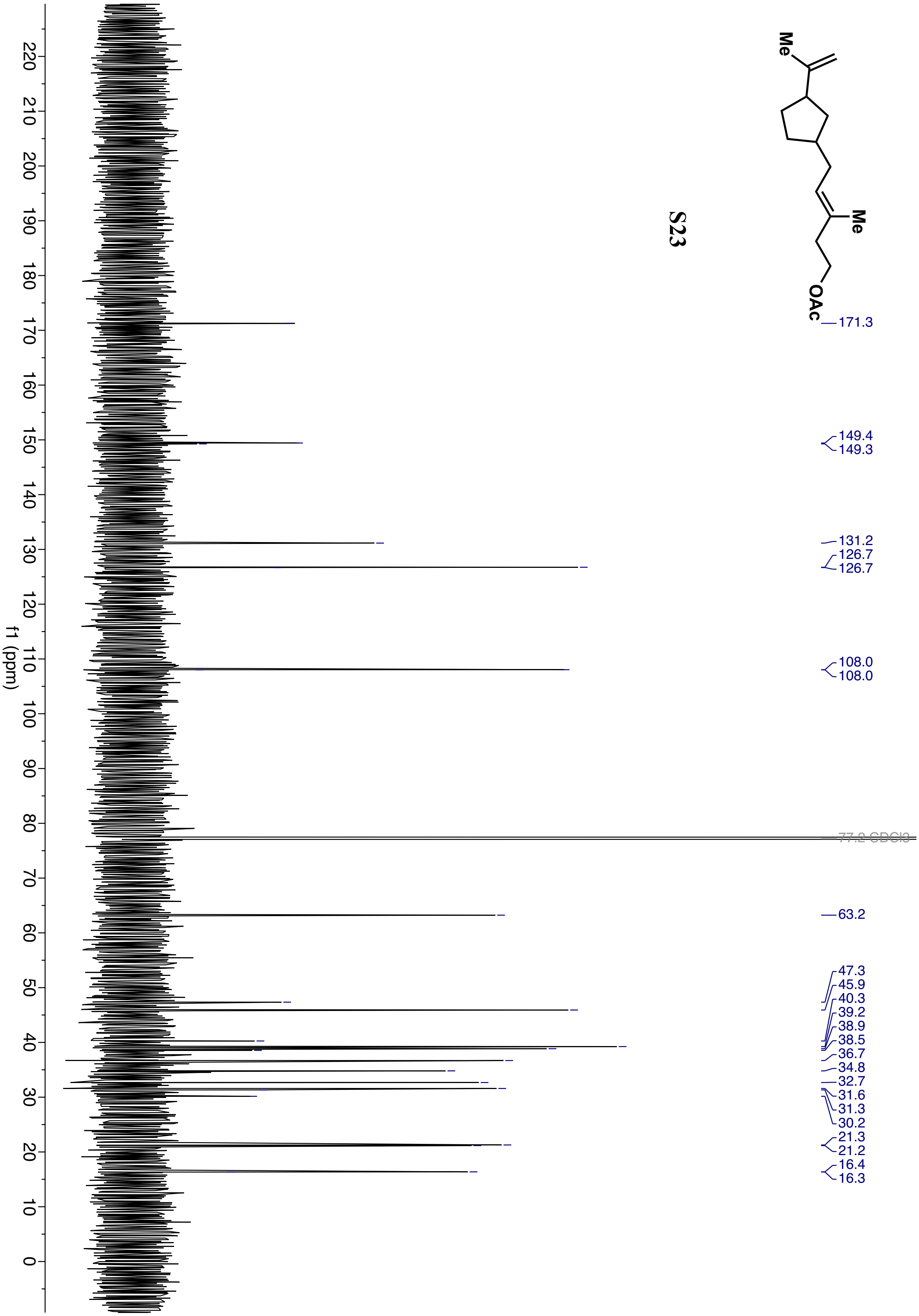
7.26 CDCl3
5.82
5.80
5.79
5.77
5.14
5.14
5.13
5.13
5.00
5.00
4.99
4.97
4.97
4.94
4.94
4.93
4.93
4.93
4.92
4.92
4.92
4.92
4.75
4.75
4.75
4.75
4.74
4.74
4.67
4.67
4.67
4.66
4.13
4.11
4.10
2.30
2.28
2.28
2.27
2.27
2.08
2.08
2.07
2.06
2.06
2.06
2.05
2.04
2.04
2.03
2.03
2.02
2.02
2.01
2.01
2.01
2.00
2.00
2.00
1.99
1.93
1.93
1.63
1.62
1.61
1.61
1.61
1.60
1.60
1.45
1.44
1.44
1.43
1.43
1.43
1.42
1.42
1.41
1.41
Me
OAc
Me
1.00
0.96
1.00
1.00
1.03
1.06
2.07
2.02
7.26
1.12
3.03
3.19
2.15
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.
f1 (ppm)



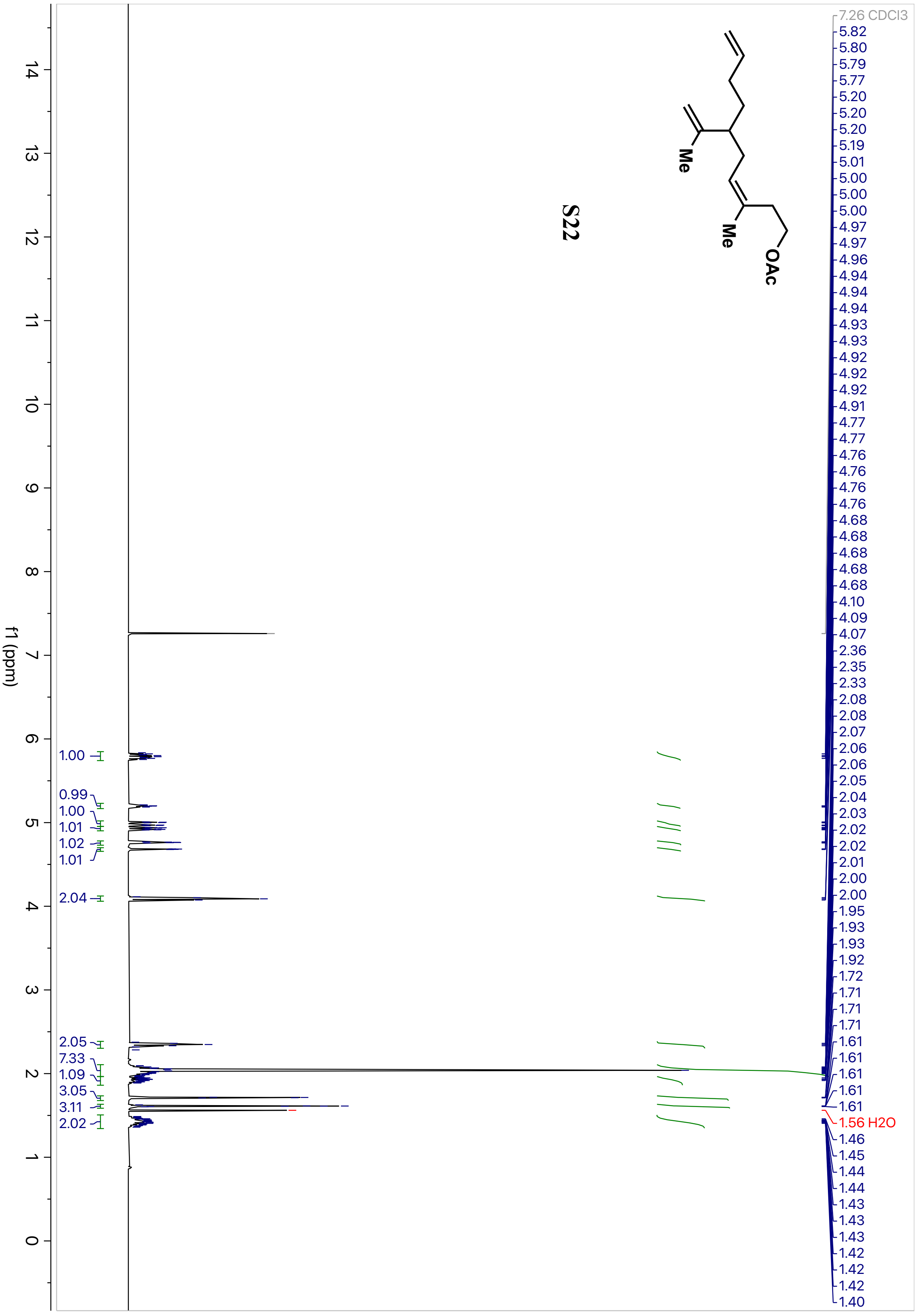
S21

OAc
Me
Me
171.3
147.4
139.1
131.4
125.9
114.4
111.7
77.2 CDCl3
63.2
47.0
38.8
32.3
32.1
31.8
21.2
18.6
16.4
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


S23
Me
Me
OAc
7.26 CDCl3
5.22
5.22
5.21
5.20
5.19
4.69
4.69
4.68
4.68
4.68
4.68
4.66
4.65
4.65
4.65
4.65
4.65
4.65
4.65
4.64
4.15
4.14
4.13
4.13
4.12
4.12
4.11
2.54
2.52
2.50
2.31
2.30
2.30
2.28
2.04
2.04
2.03
2.03
2.01
2.00
2.00
1.98
1.85
1.84
1.83
1.82
1.81
1.80
1.79
1.72
1.72
1.72
1.71
1.71
1.71
1.71
1.64
1.63
1.63
1.63
1.62
1.60
1.59
1.47
1.46
1.45
1.45
1.44
1.43
1.43
1.42
1.42
1.41
1.41
1.40
1.39
1.20
1.18
1.18
0.90
2.12
2.21
0.87
1.99
5.99
2.20
3.15
4.00
1.76
1.08
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

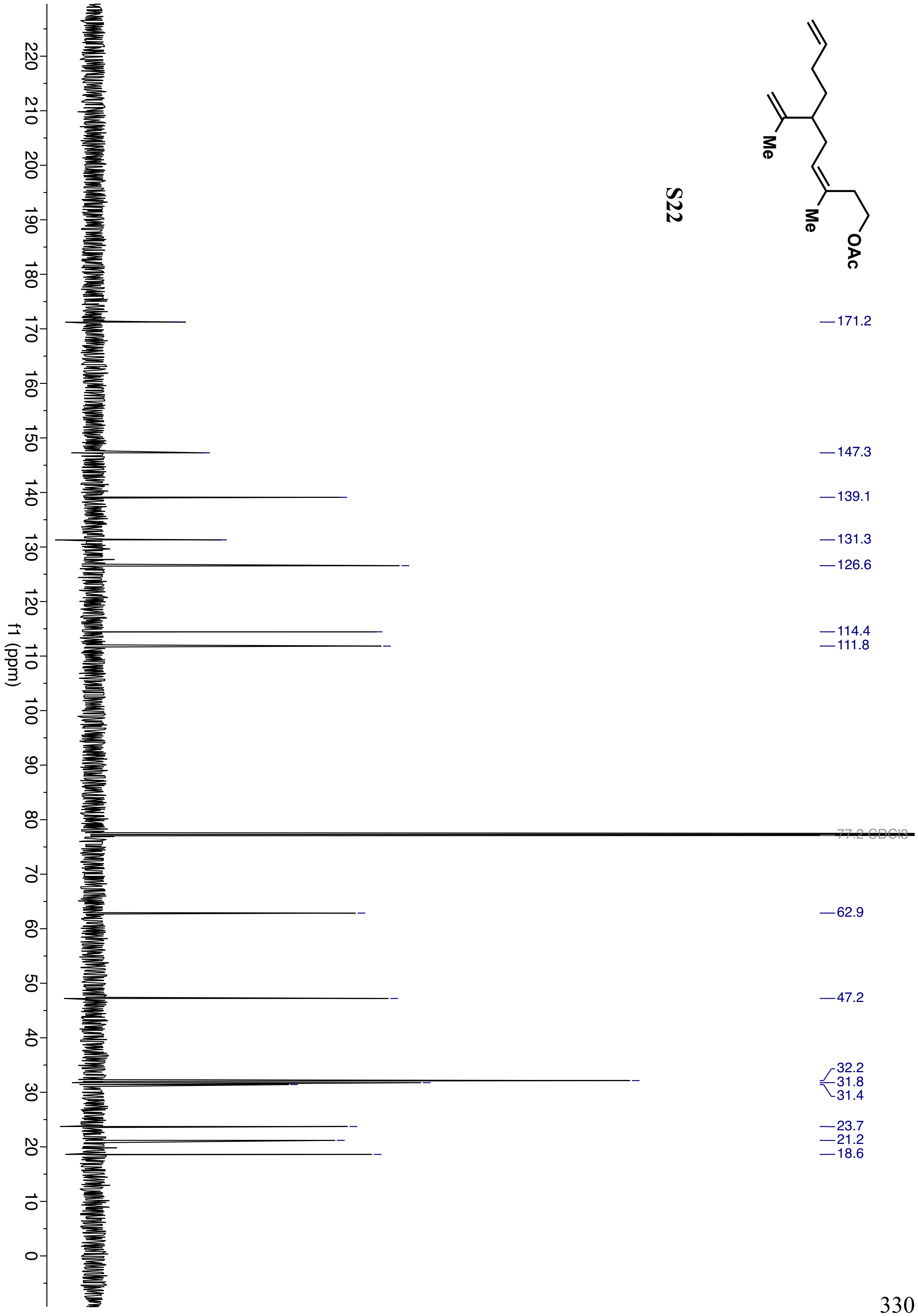

Me
Me
OAc
171.3
149.4
149.3
131.2
126.7
126.7
108.0
108.0
77.2 CDCl3
63.2
47.3
45.9
40.3
39.2
38.9
38.5
36.7
34.8
32.7
31.6
31.3
30.2
21.3
21.2
16.4
16.3
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

S23

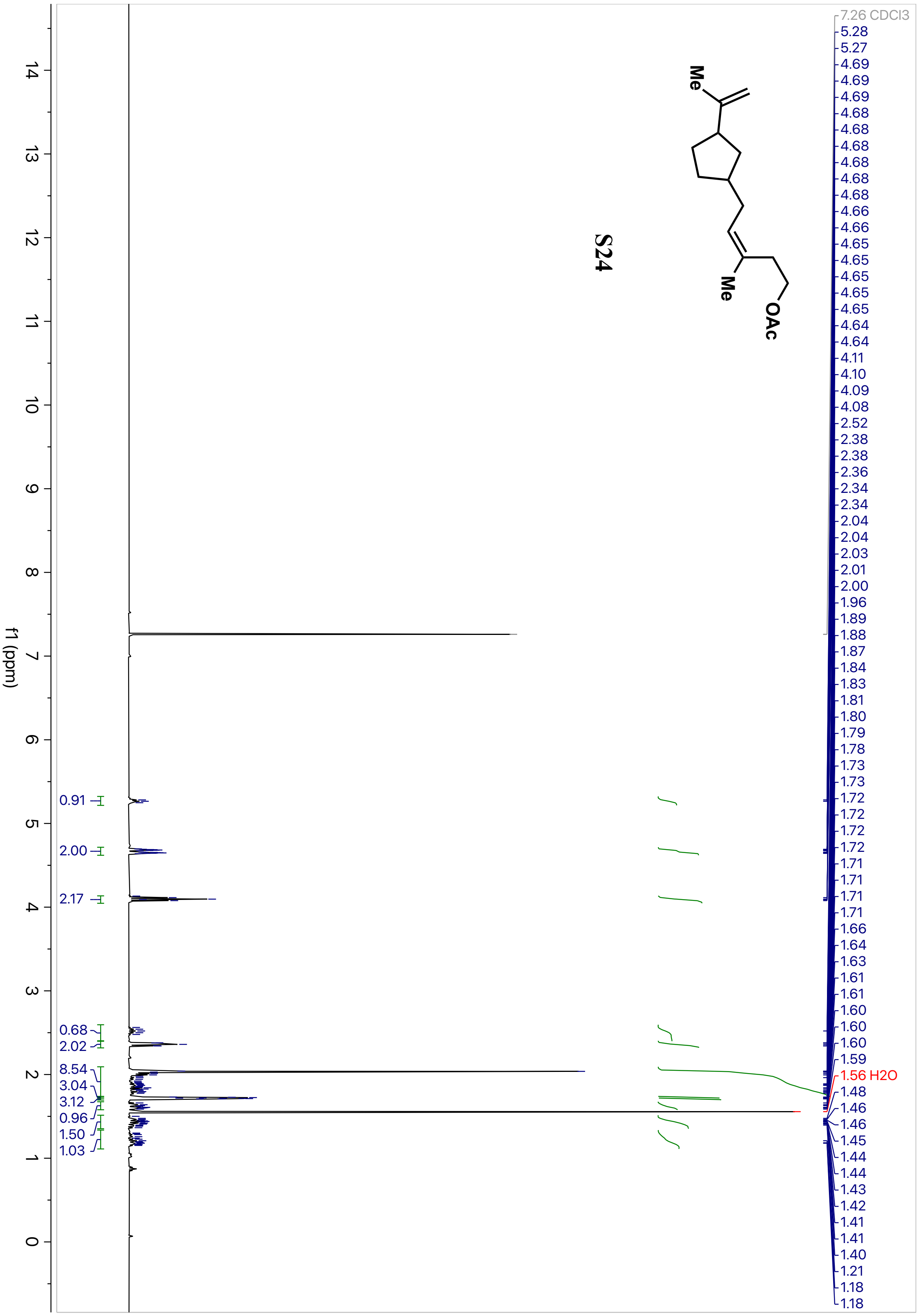


S22

OAc
Me
Me
f1 (ppm)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
1.00
0.99
1.00
1.01
1.02
1.01
2.04
2.05
7.33
1.09
3.05
3.11
2.02
7.26 CDCl3
5.82
5.80
5.79
5.77
5.20
5.20
5.20
5.19
5.01
5.00
5.00
5.00
4.97
4.97
4.96
4.94
4.94
4.94
4.93
4.93
4.92
4.92
4.92
4.91
4.77
4.77
4.76
4.76
4.76
4.76
4.68
4.68
4.68
4.68
4.68
4.10
4.09
4.07
2.36
2.35
2.33
2.08
2.08
2.07
2.06
2.06
2.05
2.04
2.03
2.02
2.02
2.01
2.00
2.00
1.95
1.93
1.93
1.92
1.72
1.71
1.71
1.71
1.61
1.61
1.61
1.61
1.61
1.56 H2O
1.46
1.45
1.44
1.44
1.43
1.43
1.43
1.42
1.42
1.42
1.40

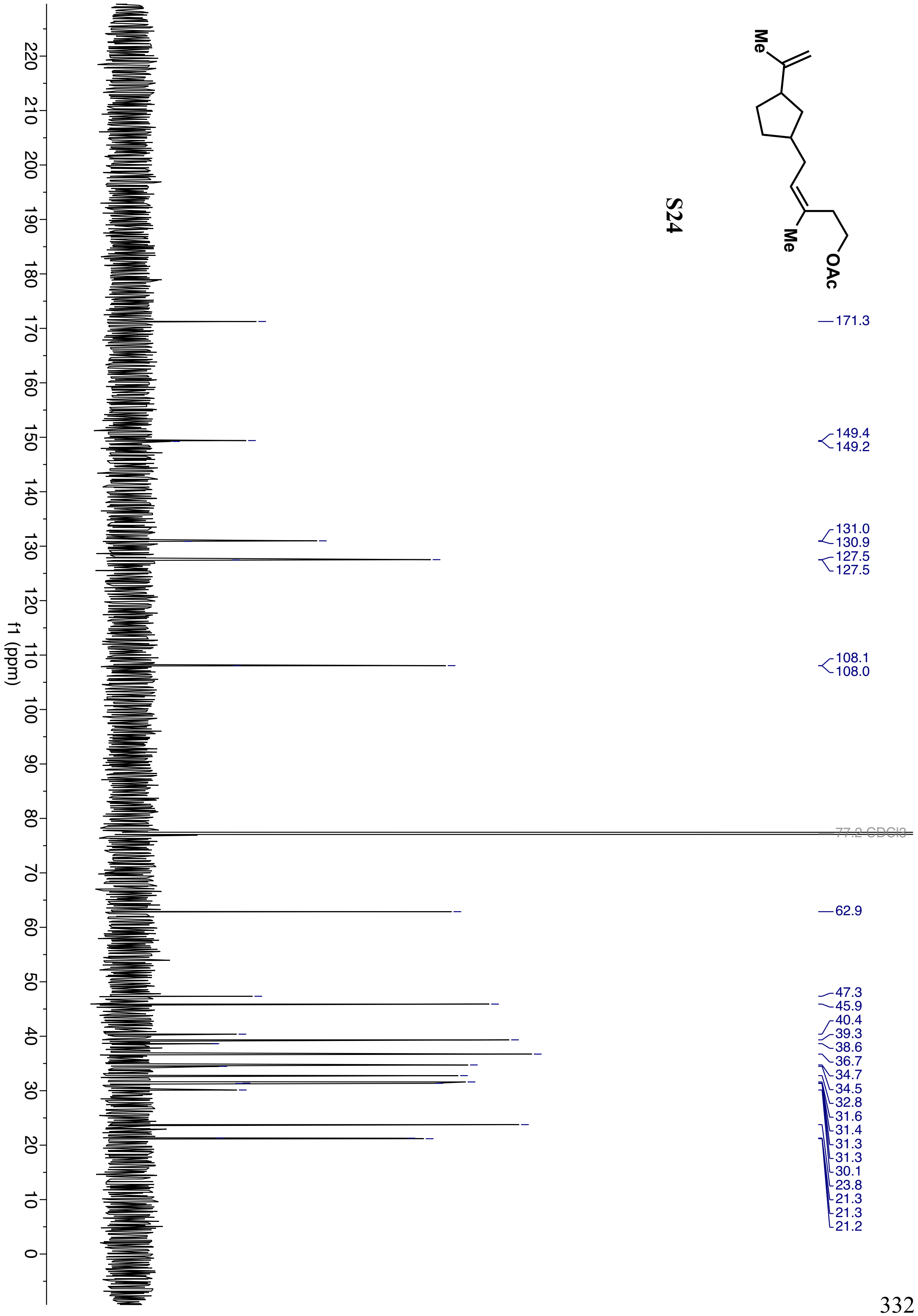

OAc
Me
Me
171.2
147.3
139.1
131.3
126.6
114.4
111.8
77.2 CDCl3
62.9
47.2
32.2
31.8
31.4
23.7
21.2
18.6
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

S22

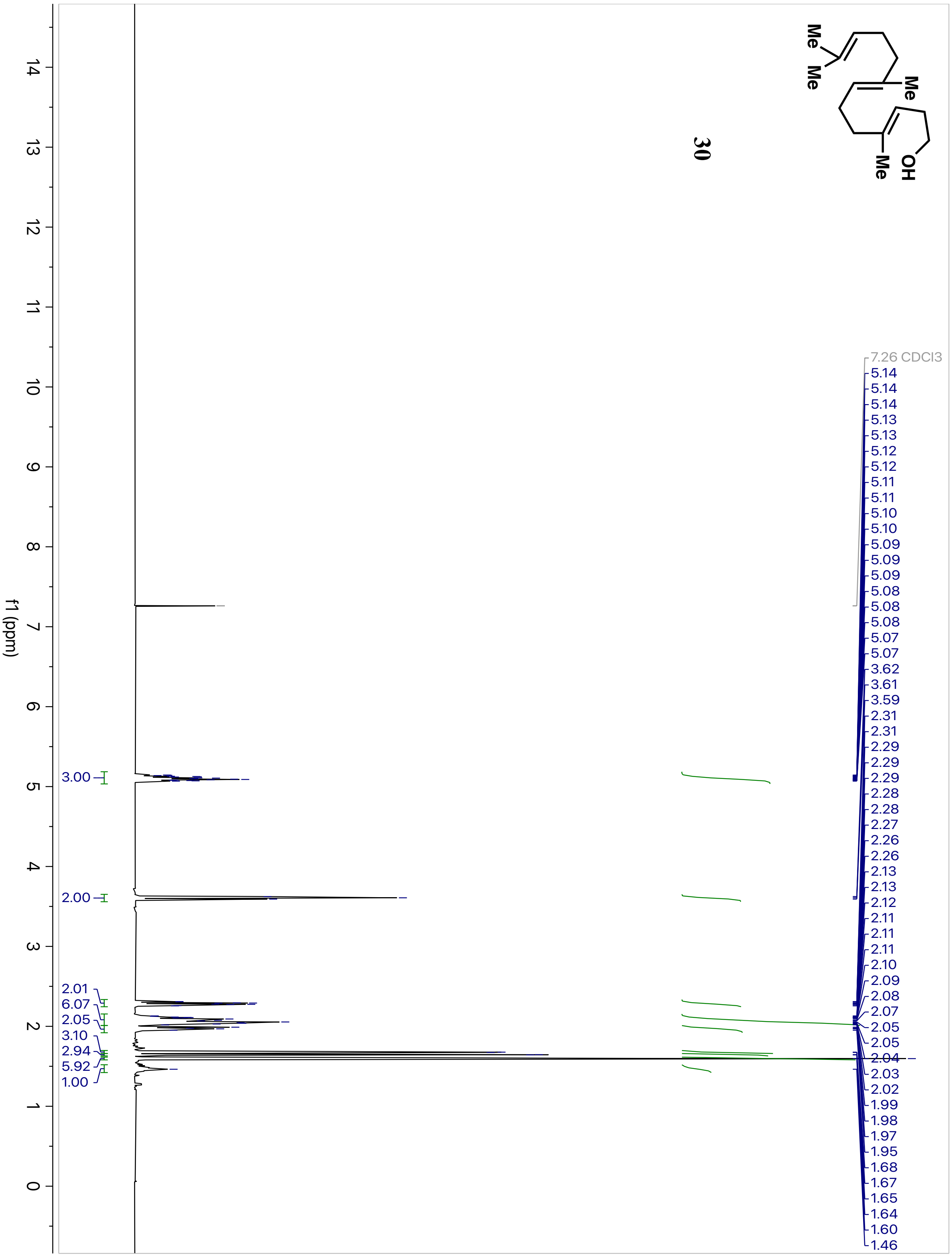


S24

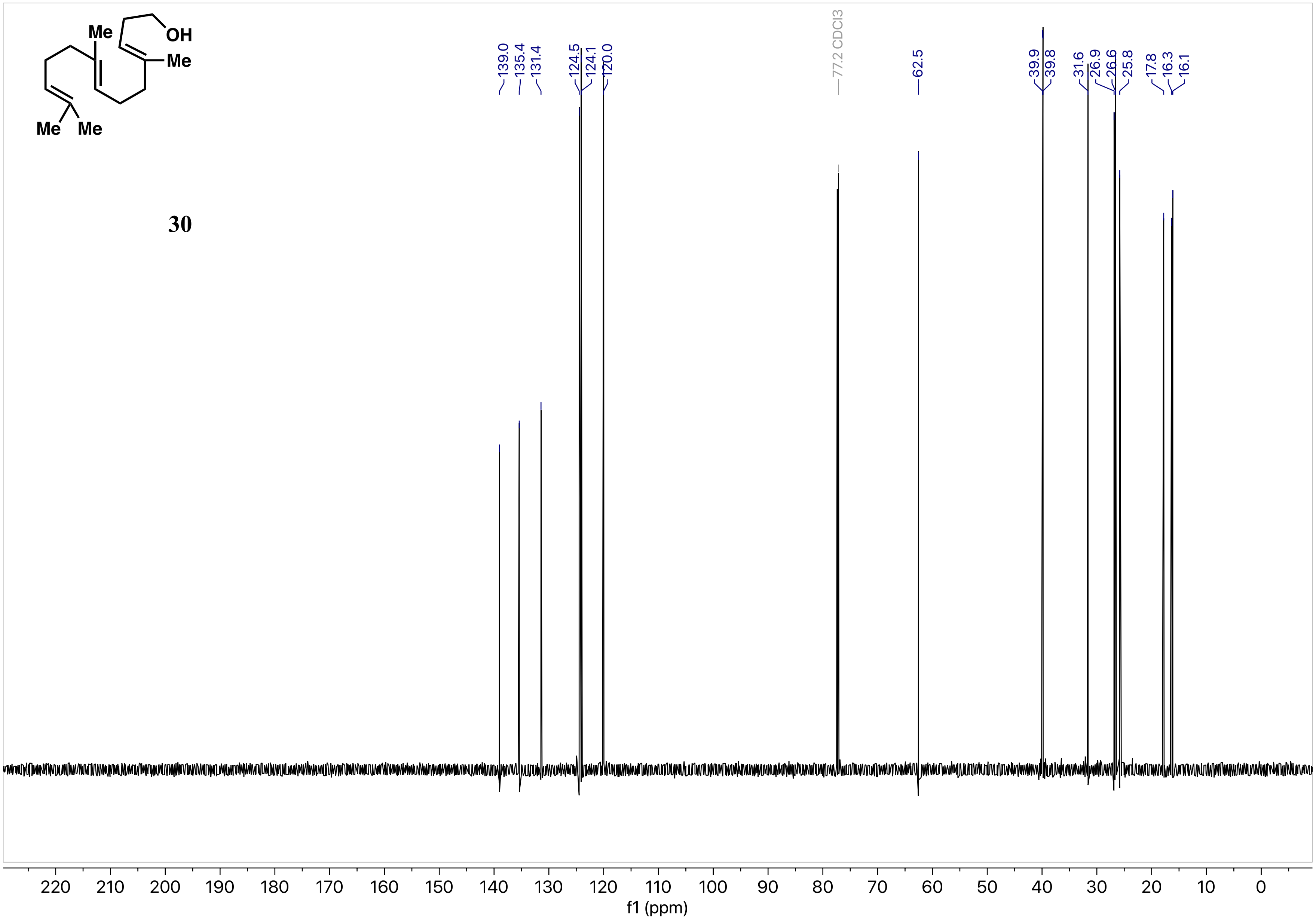
Me
Me
OAc
f1 (ppm)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0.91
2.00
2.17
0.68
2.02
8.54
3.04
3.12
0.96
1.50
1.03
7.26 CDCl3
5.28
5.27
4.69
4.69
4.69
4.68
4.68
4.68
4.68
4.68
4.68
4.66
4.66
4.65
4.65
4.65
4.65
4.65
4.64
4.64
4.11
4.10
4.09
4.08
2.52
2.38
2.38
2.36
2.34
2.34
2.04
2.04
2.03
2.01
2.00
1.96
1.89
1.88
1.87
1.84
1.83
1.81
1.80
1.79
1.78
1.73
1.73
1.72
1.72
1.72
1.72
1.71
1.71
1.71
1.71
1.66
1.64
1.63
1.61
1.61
1.60
1.60
1.60
1.59
1.56 H2O
1.48
1.46
1.46
1.45
1.44
1.44
1.43
1.42
1.41
1.41
1.40
1.21
1.18
1.18

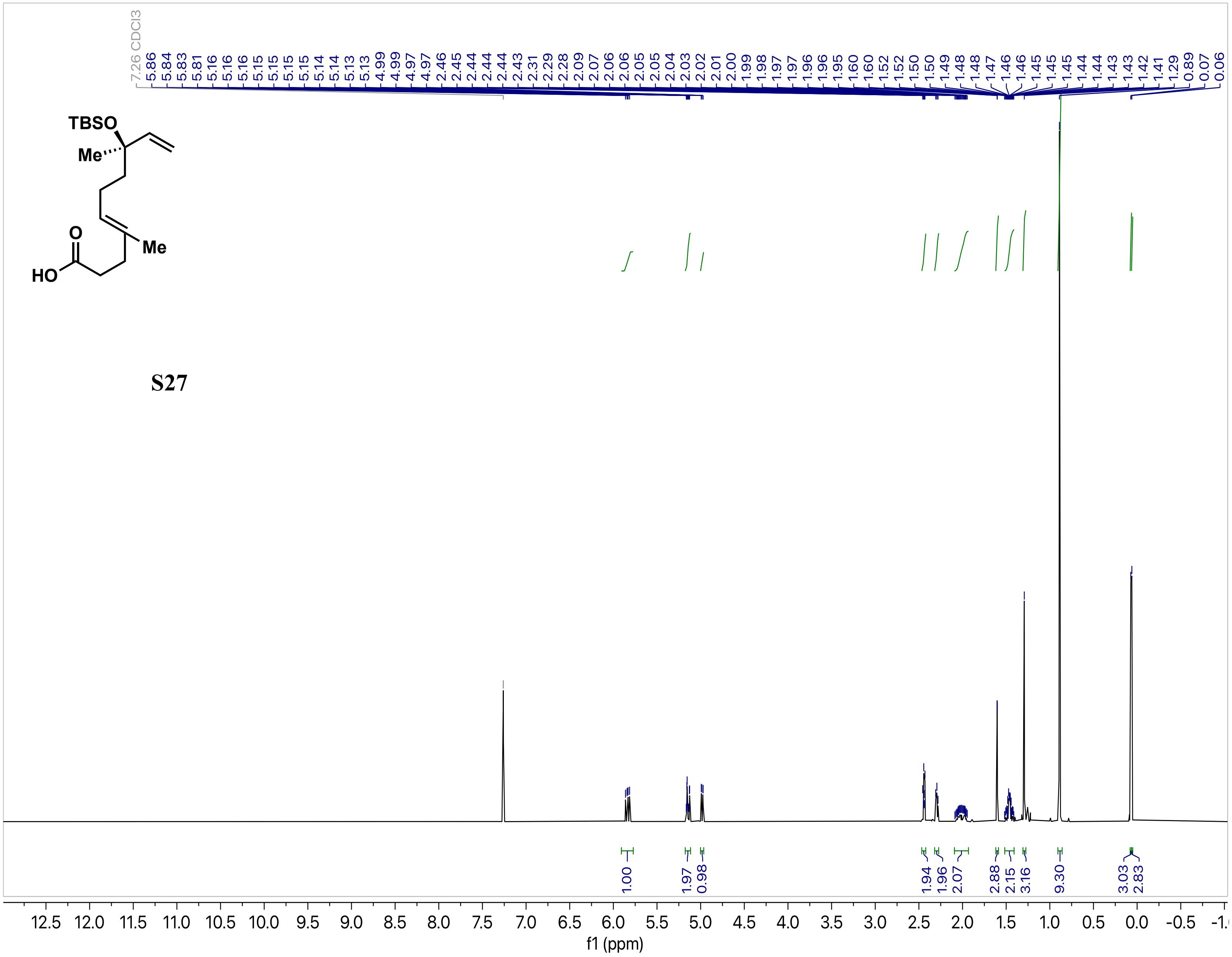

S24

Me
Me
OAc
171.3
149.4
149.2
131.0
130.9
127.5
127.5
108.1
108.0
77.2 CDCl3
62.9
47.3
45.9
40.4
39.3
38.6
36.7
34.7
34.5
32.8
31.6
31.4
31.3
31.3
30.1
23.8
21.3
21.3
21.2
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

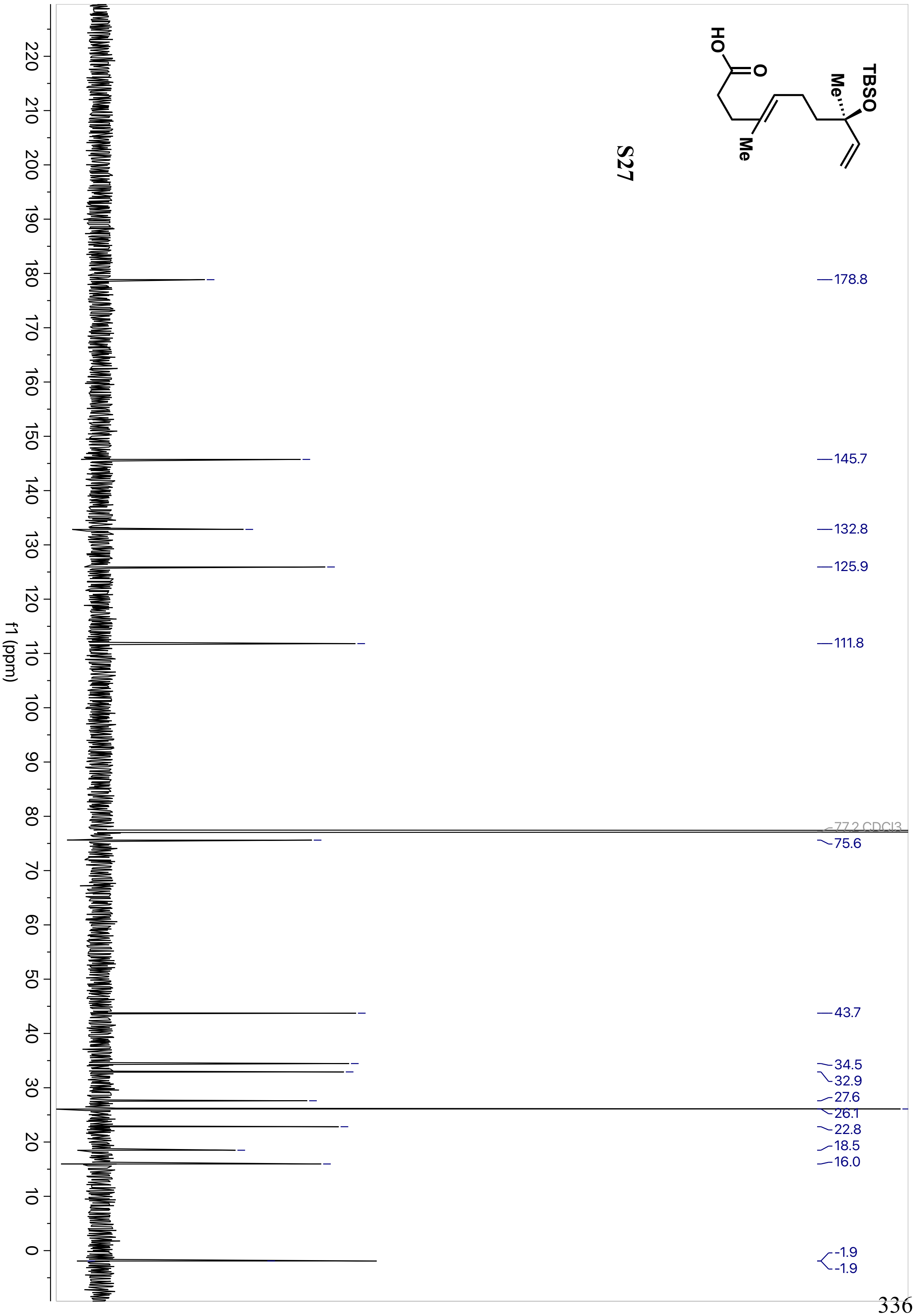

30

OH
Me
Me
Me
Me
7.26 CDCl3
5.14
5.14
5.14
5.13
5.13
5.12
5.12
5.11
5.11
5.10
5.10
5.09
5.09
5.09
5.08
5.08
5.08
5.07
5.07
3.62
3.61
3.59
2.31
2.31
2.29
2.29
2.29
2.28
2.28
2.27
2.26
2.26
2.13
2.13
2.12
2.11
2.11
2.11
2.10
2.09
2.08
2.07
2.05
2.05
2.04
2.03
2.02
1.99
1.98
1.97
1.95
1.68
1.67
1.65
1.64
1.60
1.46
3.00
2.00
2.01
6.07
2.05
3.10
2.94
5.92
1.00
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

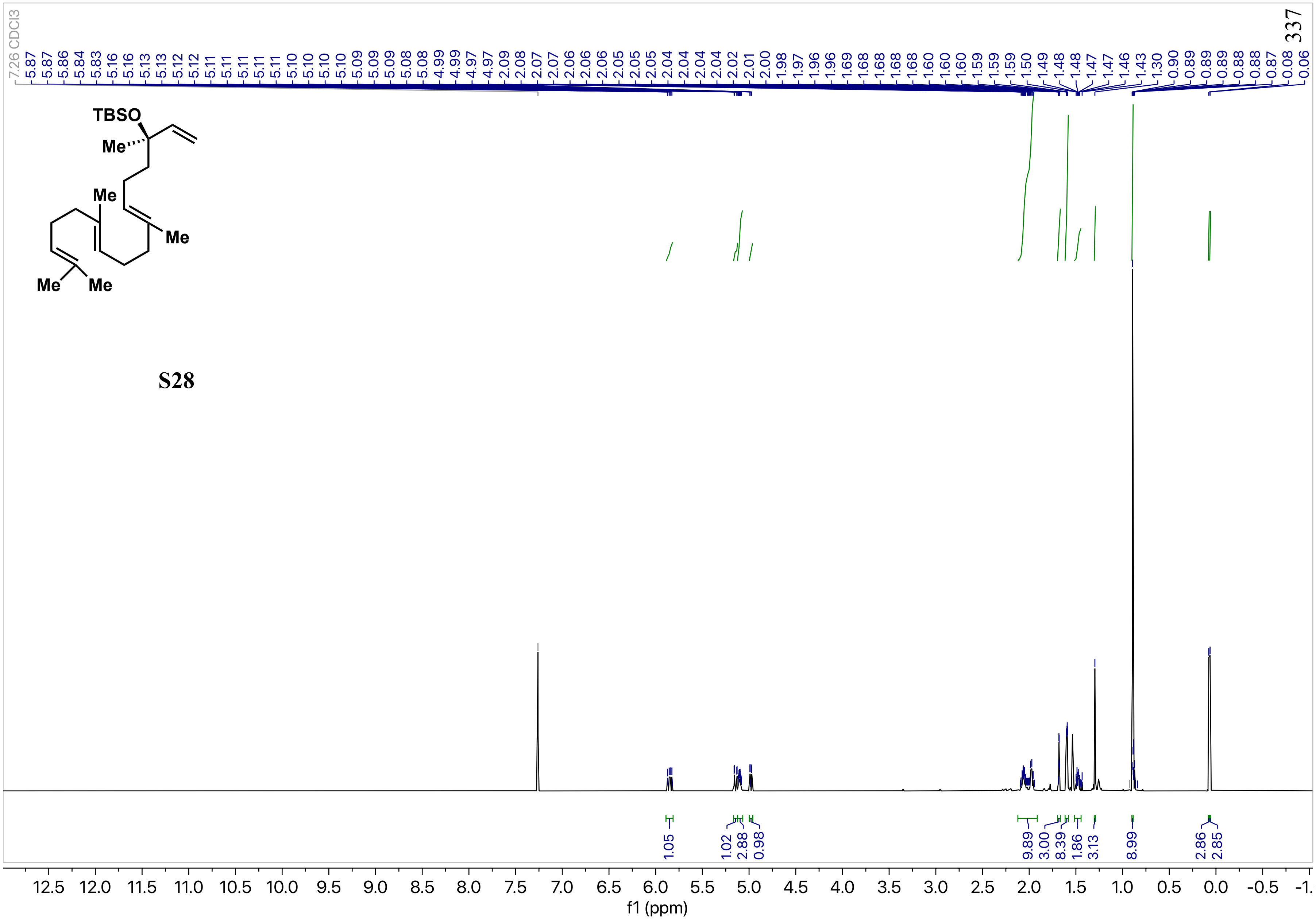

Me
OH
Me
Me
Me
30
139.0
135.4
131.4
124.5
124.1
120.0
77.2 CDCl3
62.5
39.9
39.8
31.6
26.9
26.6
25.8
17.8
16.3
16.1
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


TBSO
Me
Me
O
HO
7.26 CDCl3
5.86
5.84
5.83
5.81
5.16
5.16
5.16
5.15
5.15
5.15
5.15
5.14
5.14
5.13
5.13
4.99
4.99
4.97
4.97
2.46
2.45
2.44
2.44
2.44
2.43
2.31
2.29
2.28
2.09
2.07
2.06
2.06
2.05
2.05
2.04
2.03
2.02
2.01
2.00
1.99
1.98
1.97
1.97
1.96
1.96
1.95
1.60
1.60
1.52
1.52
1.50
1.50
1.49
1.48
1.48
1.47
1.46
1.46
1.45
1.45
1.45
1.44
1.44
1.43
1.43
1.42
1.41
1.29
0.89
0.07
0.06
1.00
1.97
0.98
1.94
1.96
2.07
2.88
2.15
3.16
9.30
3.03
2.83
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.
f1 (ppm)

S27

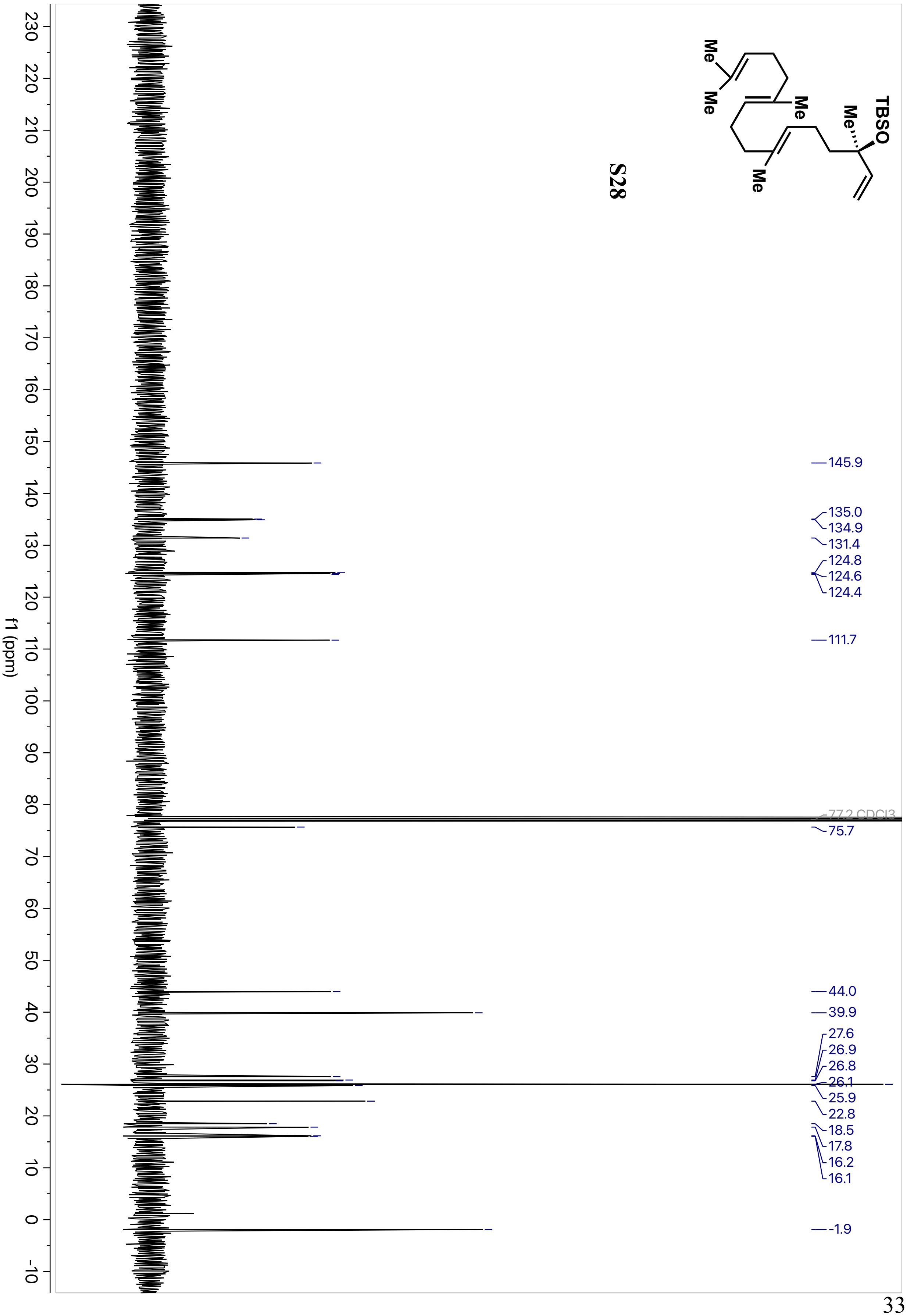

TBSO
Me
Me
HO
O
178.8
145.7
132.8
125.9
111.8
77.2 CDCl3
75.6
43.7
34.5
32.9
27.6
26.1
22.8
18.5
16.0
-1.9
-1.9
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

S27



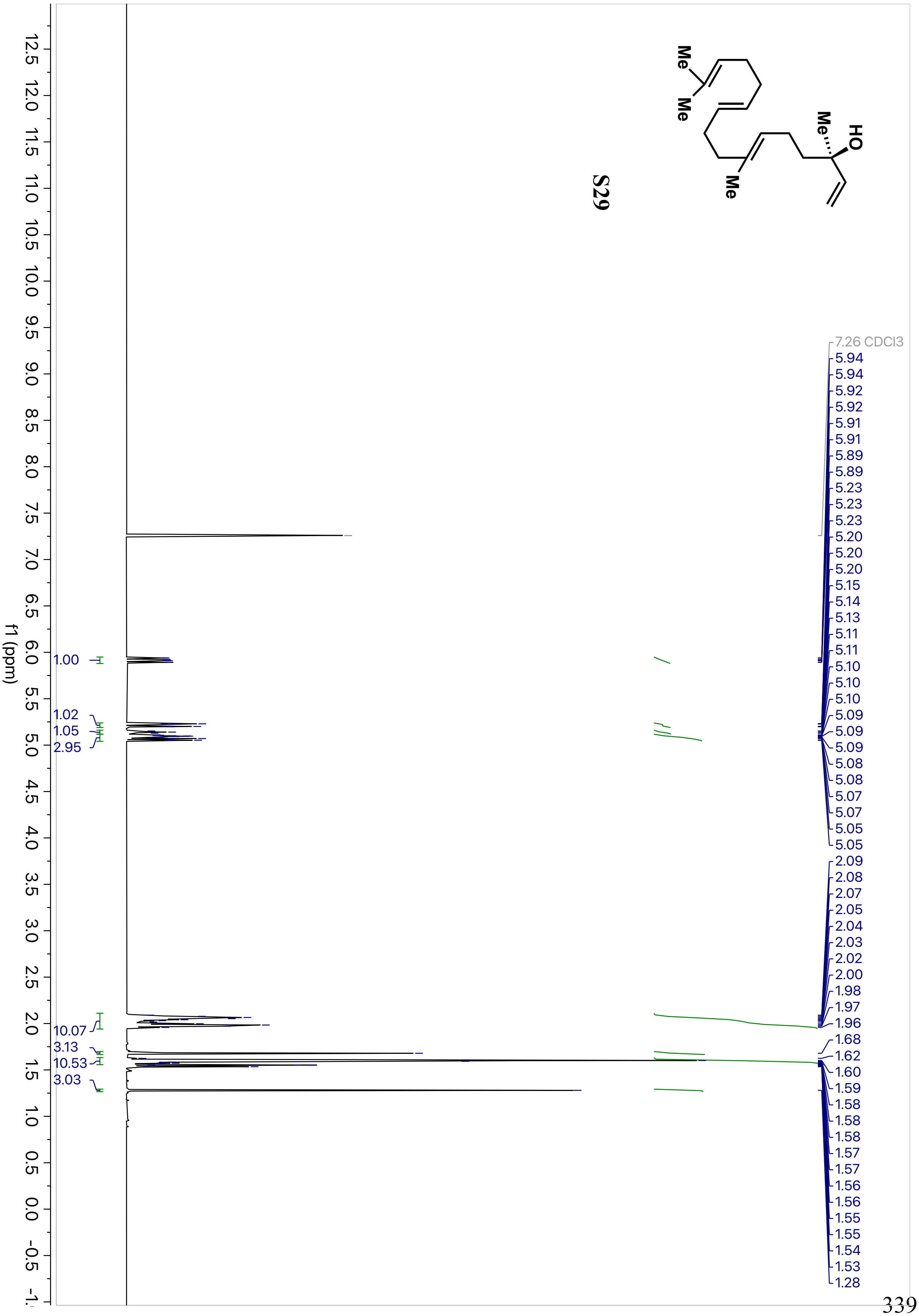
S28

TBSO
Me
Me
Me
Me
Me
7.26 CDCl3
5.87
5.87
5.86
5.84
5.83
5.16
5.16
5.13
5.13
5.12
5.12
5.11
5.11
5.11
5.11
5.11
5.10
5.10
5.10
5.10
5.09
5.09
5.09
5.08
5.08
4.99
4.99
4.97
4.97
2.09
2.08
2.07
2.07
2.06
2.06
2.06
2.05
2.05
2.05
2.04
2.04
2.04
2.04
2.02
2.01
2.00
1.98
1.97
1.96
1.96
1.69
1.68
1.68
1.68
1.68
1.60
1.60
1.60
1.59
1.59
1.59
1.50
1.49
1.48
1.48
1.47
1.47
1.46
1.43
1.30
0.90
0.89
0.89
0.89
0.88
0.88
0.87
0.08
0.06
1.05
1.02
2.88
0.98
9.89
3.00
8.39
1.86
3.13
8.99
2.86
2.85
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)



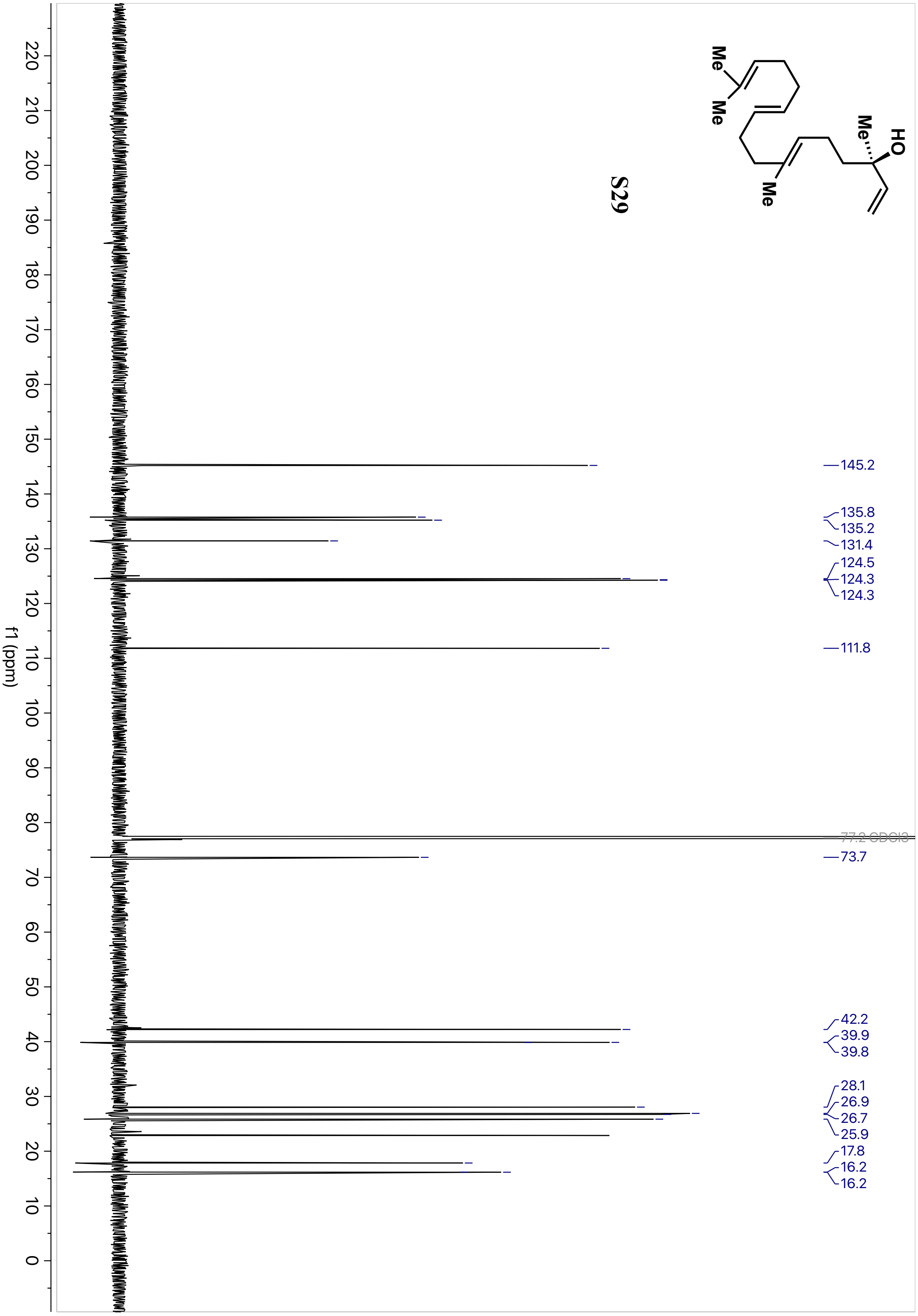
S28

TBSO
Me
Me
Me
Me
Me
145.9
135.0
134.9
131.4
124.8
124.6
124.4
111.7
77.2 CDCl3
75.7
44.0
39.9
27.6
26.9
26.8
26.1
25.9
22.8
18.5
17.8
16.2
16.1
-1.9
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

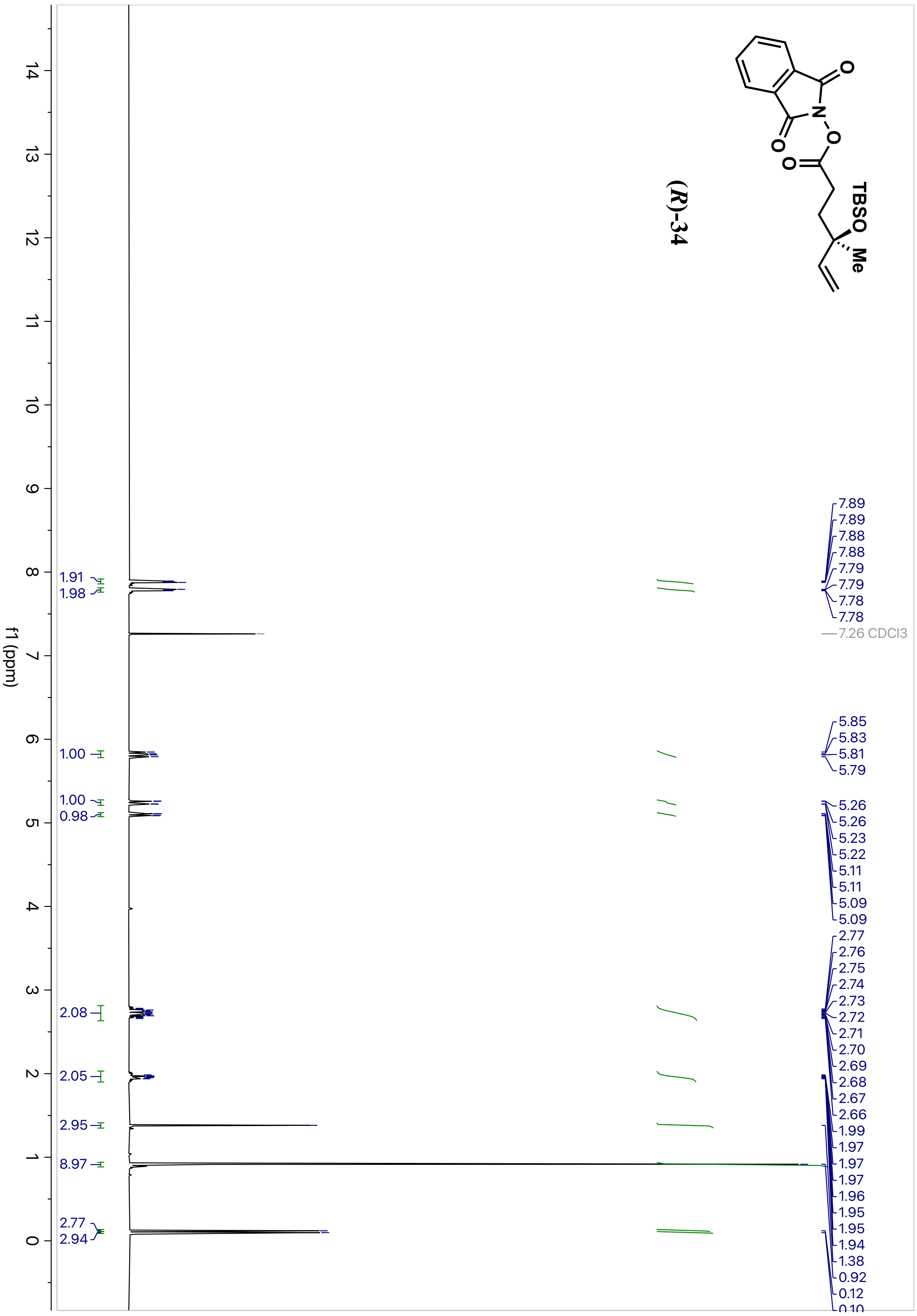


S29

HO
Me
Me
Me
Me
7.26 CDCl3
5.94
5.94
5.92
5.92
5.91
5.91
5.89
5.89
5.23
5.23
5.23
5.20
5.20
5.20
5.15
5.14
5.13
5.11
5.11
5.10
5.10
5.10
5.09
5.09
5.09
5.08
5.08
5.07
5.07
5.05
5.05
2.09
2.08
2.07
2.05
2.04
2.03
2.02
2.00
1.98
1.97
1.96
1.68
1.62
1.60
1.59
1.58
1.58
1.58
1.57
1.57
1.56
1.56
1.55
1.55
1.54
1.53
1.28
1.00
1.02
1.05
2.95
10.07
3.13
10.53
3.03
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.
f1 (ppm)

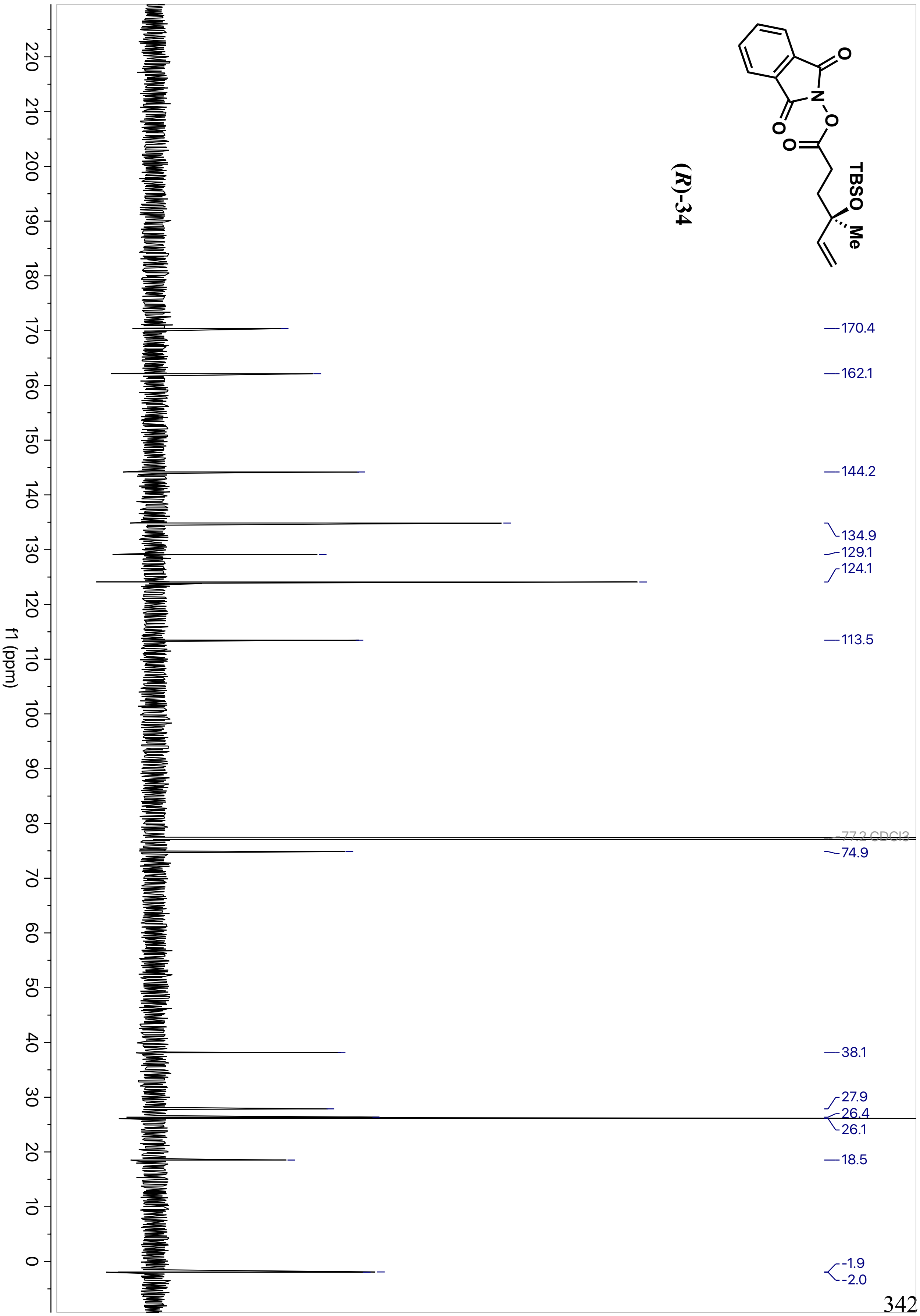

S29

HO
Me
Me
Me
Me
145.2
135.8
135.2
131.4
124.5
124.3
124.3
111.8
77.2 CDCl3
73.7
42.2
39.9
39.8
28.1
26.9
26.7
25.9
17.8
16.2
16.2
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)



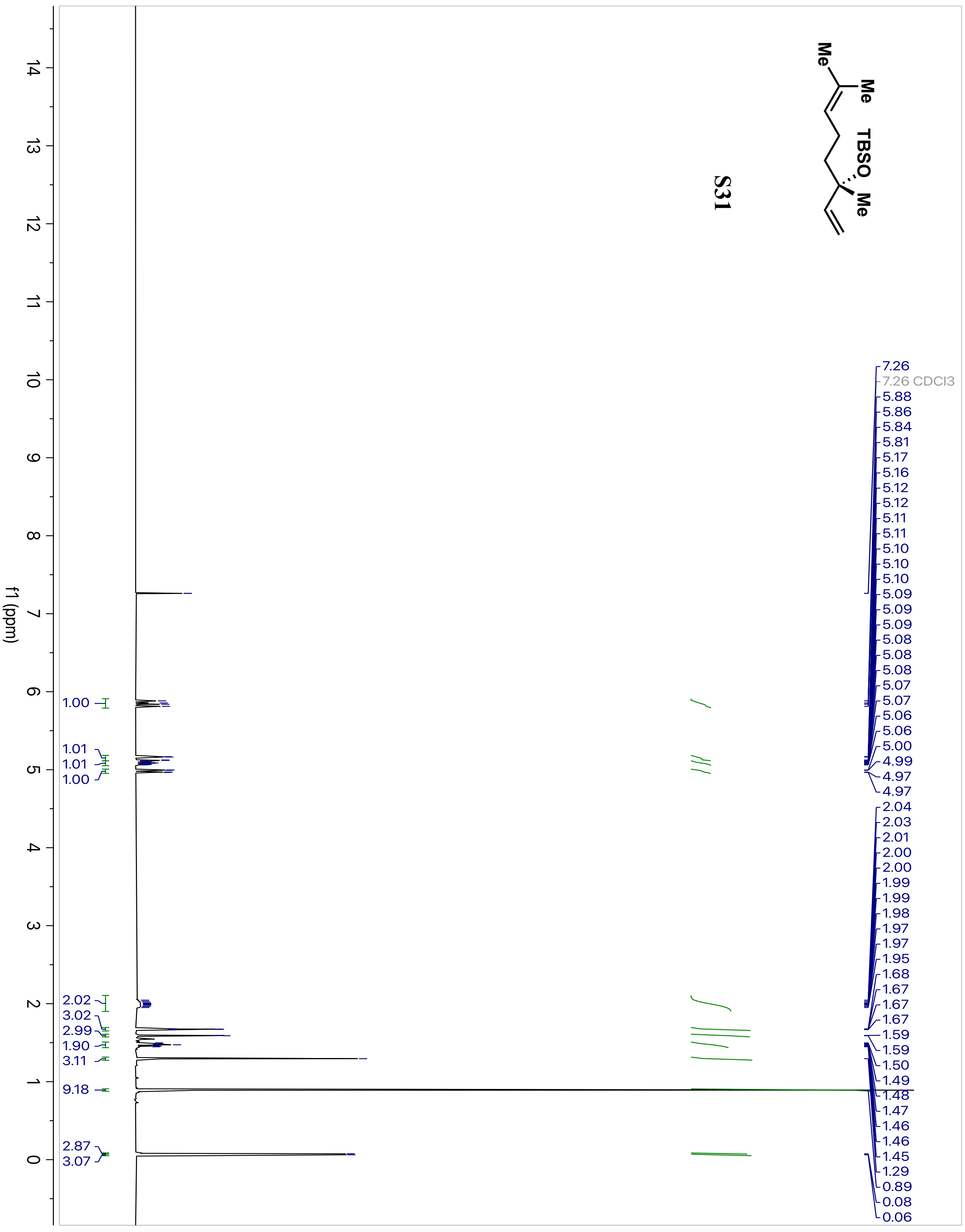
(*R*)-34

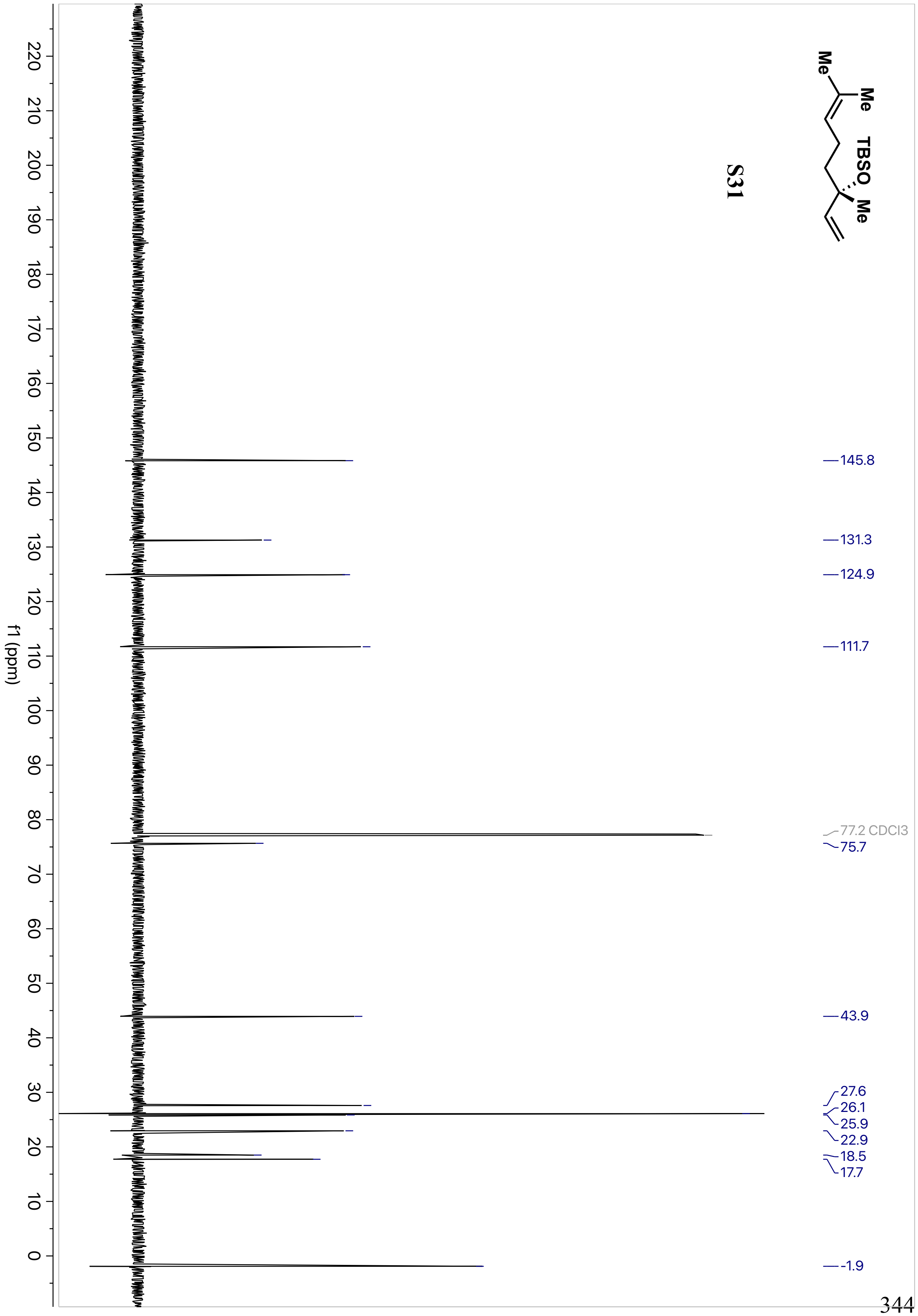
TBSO
Me
O
N
O
O
O
7.89
7.89
7.88
7.88
7.79
7.79
7.78
7.78
7.26 CDCl3
5.85
5.83
5.81
5.79
5.26
5.26
5.23
5.22
5.11
5.11
5.09
5.09
2.77
2.76
2.75
2.74
2.73
2.72
2.71
2.70
2.69
2.68
2.67
2.66
1.99
1.97
1.97
1.97
1.96
1.95
1.95
1.94
1.38
0.92
0.12
0.10
1.91
1.98
1.00
1.00
0.98
2.08
2.05
2.95
8.97
2.77
2.94
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)



(R)-34

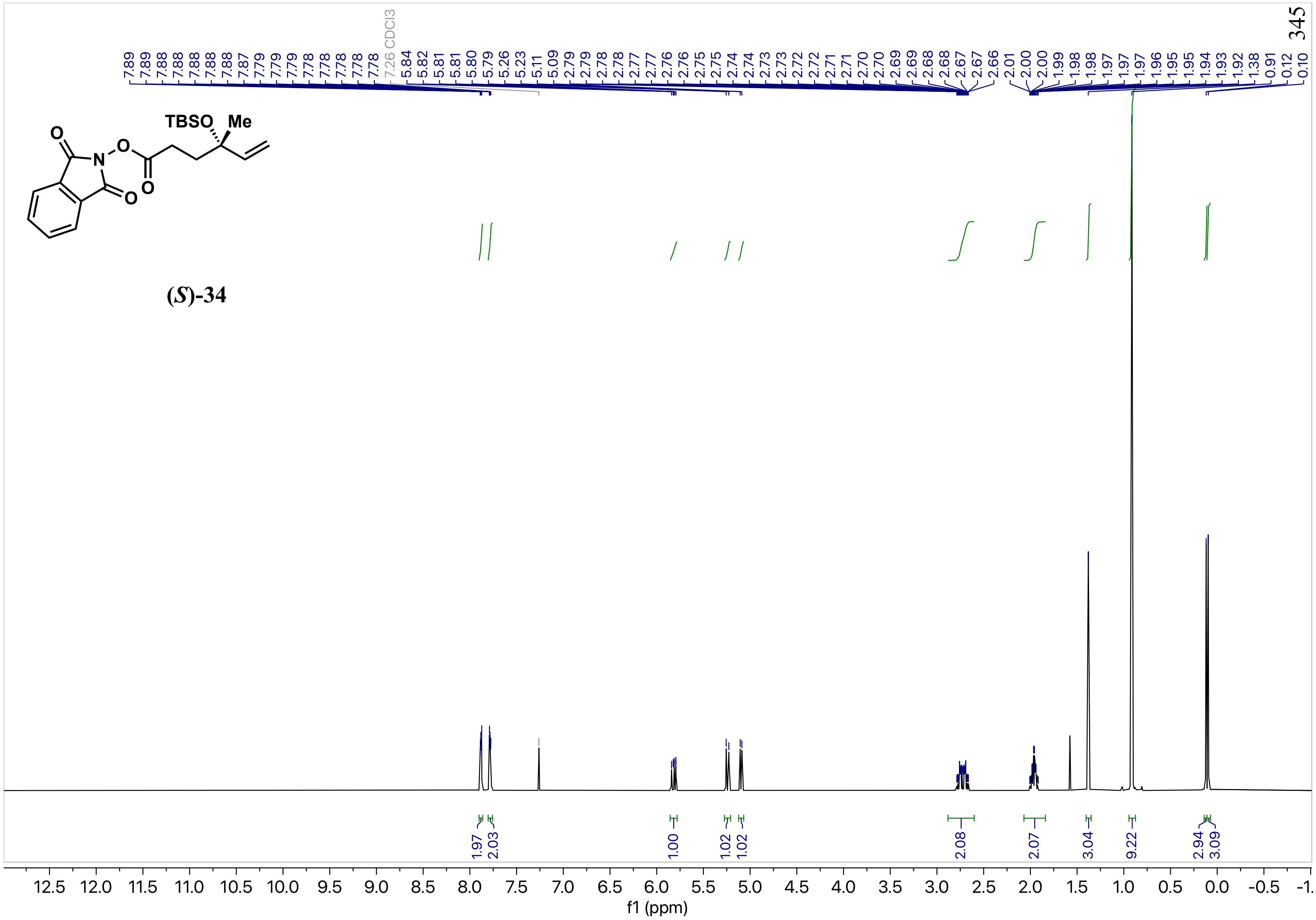
TBSO
Me
O
N
O
O
O
170.4
162.1
144.2
134.9
129.1
124.1
113.5
77.2 CDCl3
74.9
38.1
27.9
26.4
26.1
18.5
-1.9
-2.0
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


S31
Me
Me
TBSO
Me
7.26
7.26 CDCl3
5.88
5.86
5.84
5.81
5.17
5.16
5.12
5.12
5.11
5.11
5.10
5.10
5.10
5.09
5.09
5.09
5.08
5.08
5.08
5.07
5.07
5.06
5.06
5.00
4.99
4.97
4.97
2.04
2.03
2.01
2.00
2.00
1.99
1.99
1.98
1.97
1.97
1.95
1.68
1.67
1.67
1.67
1.59
1.59
1.50
1.49
1.48
1.47
1.46
1.46
1.45
1.29
0.89
0.08
0.06
1.00
1.01
1.01
1.00
2.02
3.02
2.99
1.90
3.11
9.18
2.87
3.07
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)



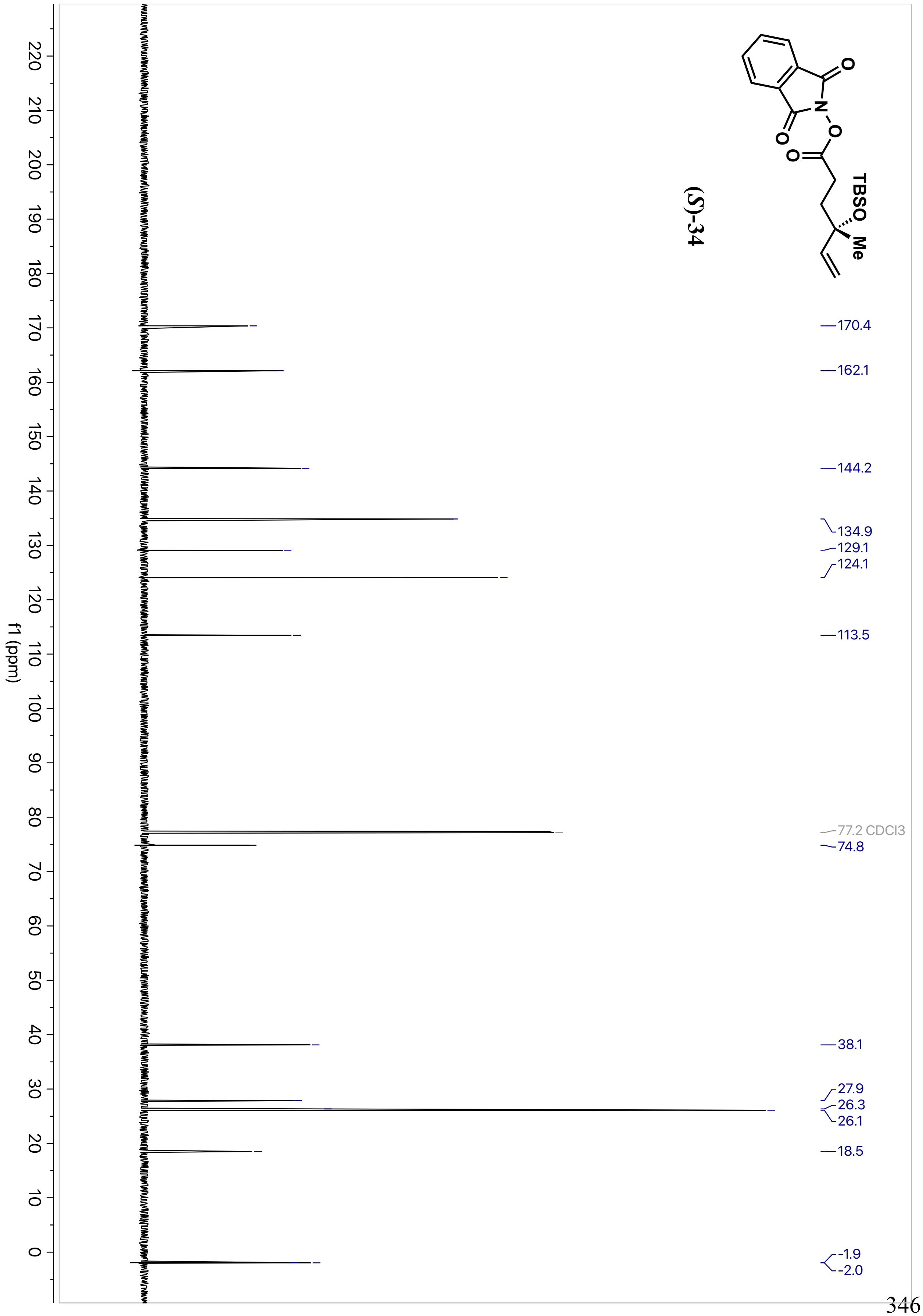
S31

Me
Me
TBSO
Me
145.8
131.3
124.9
111.7
77.2 CDCl3
75.7
43.9
27.6
26.1
25.9
22.9
18.5
17.7
-1.9
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

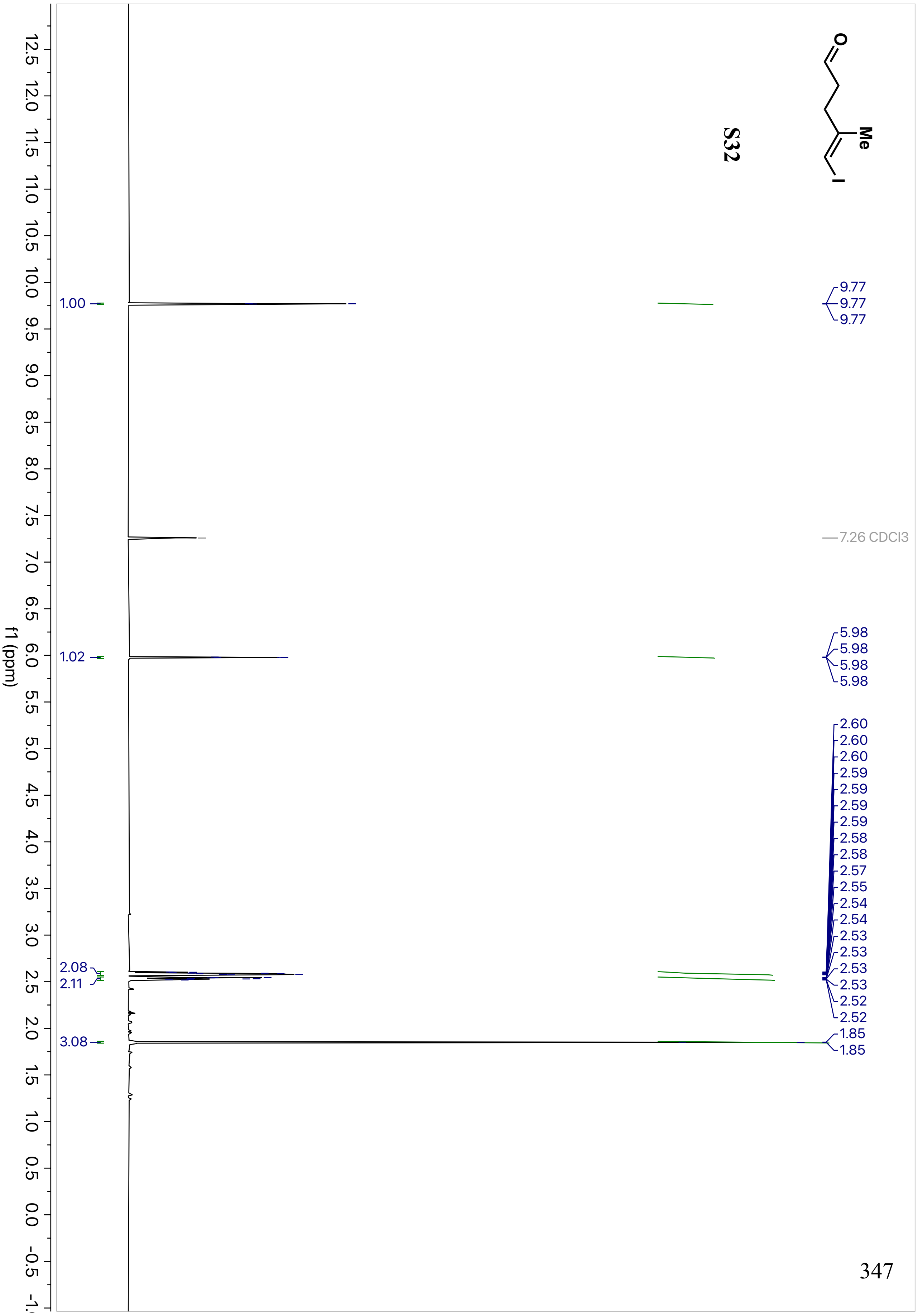


(*S*)-34

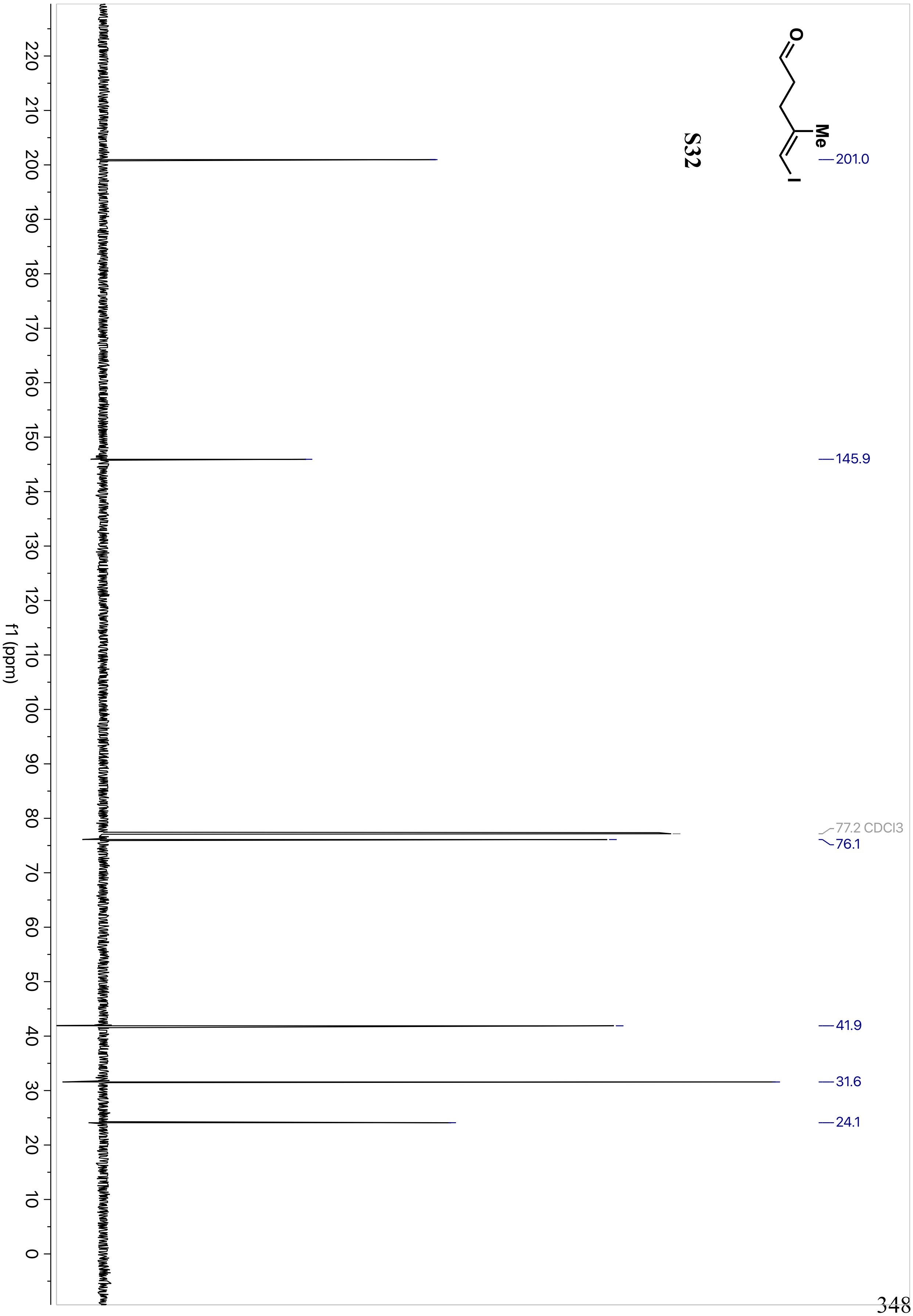
TBSO
Me
O
N
O
O
O
O
7.89 7.89 7.88 7.88 7.88 7.88 7.88 7.87 7.79 7.79 7.79 7.78 7.78 7.78 7.78 7.78
7.26 CDCl3
5.84 5.82 5.81 5.81 5.80 5.79 5.26 5.23 5.11 5.09
2.79 2.79 2.78 2.78 2.77 2.77 2.76 2.76 2.75 2.75 2.74 2.74 2.73 2.73 2.72 2.72 2.71 2.71 2.70 2.70 2.69 2.69 2.68 2.68 2.67 2.67 2.66
2.01 2.00 2.00 1.99 1.98 1.98 1.97 1.97 1.97 1.96 1.95 1.95 1.94 1.93 1.92
1.38 0.91 0.12 0.10
1.97
2.03
1.00
1.02
1.02
2.08
2.07
3.04
9.22
2.94
3.09
12.5 12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.
f1 (ppm)

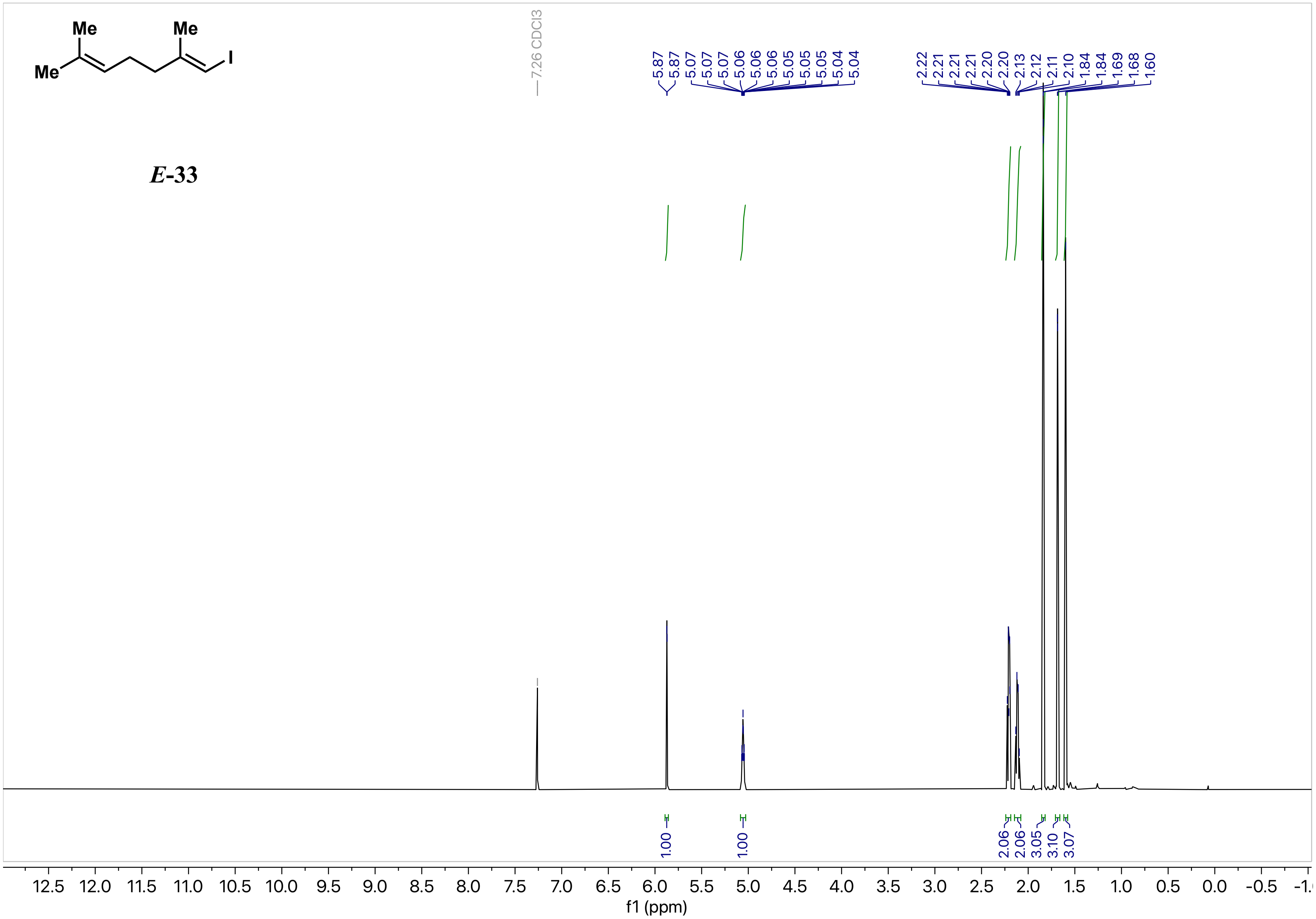

TBSO
Me
O
N
O
O
O
170.4
162.1
144.2
134.9
129.1
124.1
113.5
77.2 CDCl3
74.8
38.1
27.9
26.3
26.1
18.5
-1.9
-2.0
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

(*S*)-34


S32

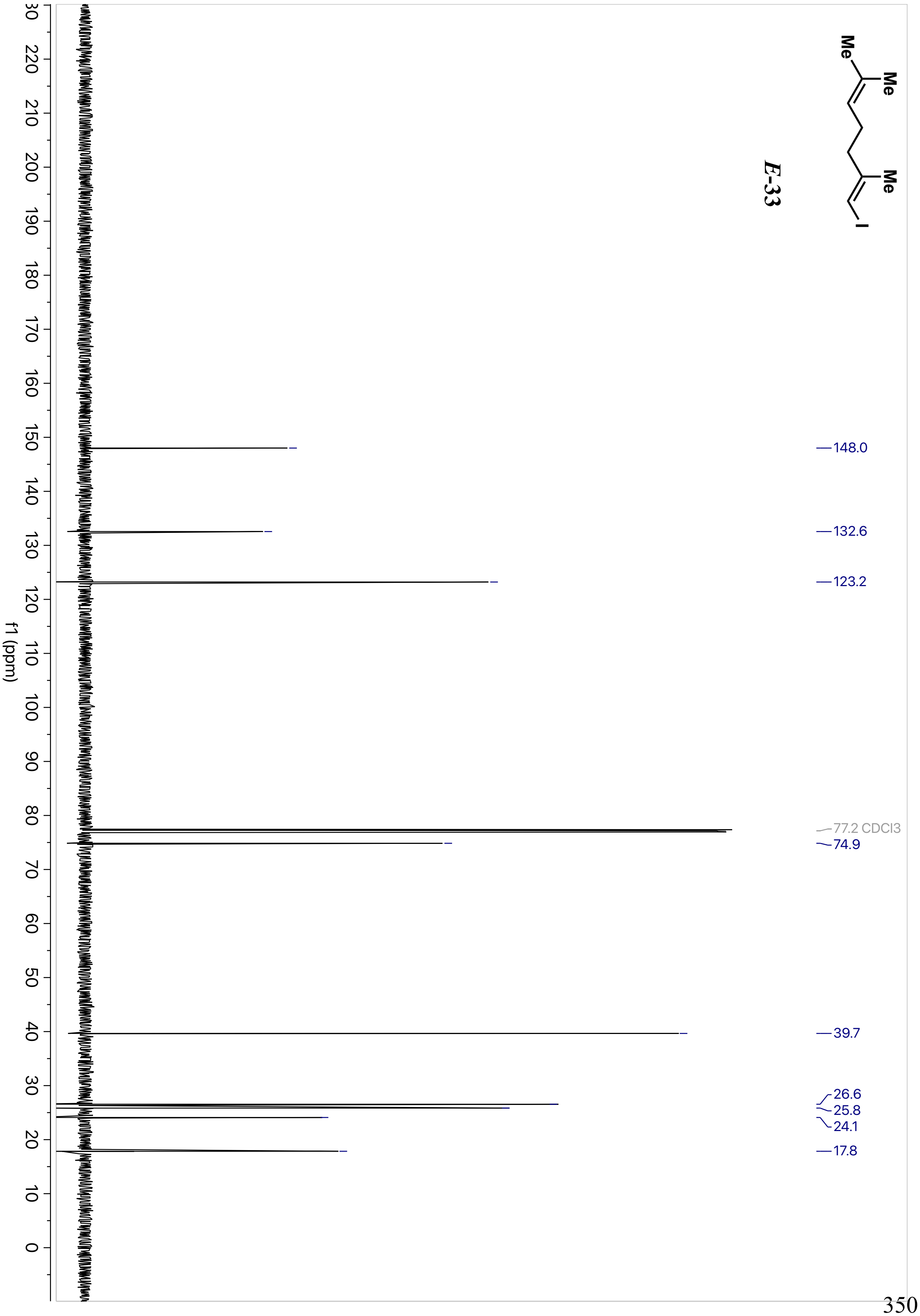
Me
I
O
9.77
9.77
9.77
7.26 CDCl3
5.98
5.98
5.98
5.98
2.60
2.60
2.60
2.59
2.59
2.59
2.59
2.58
2.58
2.57
2.55
2.54
2.54
2.53
2.53
2.53
2.53
2.52
2.52
1.85
1.85
1.00
1.02
2.08
2.11
3.08
12.5 12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.
f1 (ppm)


S32
O
Me
I
201.0
145.9
77.2 CDCl3
76.1
41.9
31.6
24.1
f1 (ppm)
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0

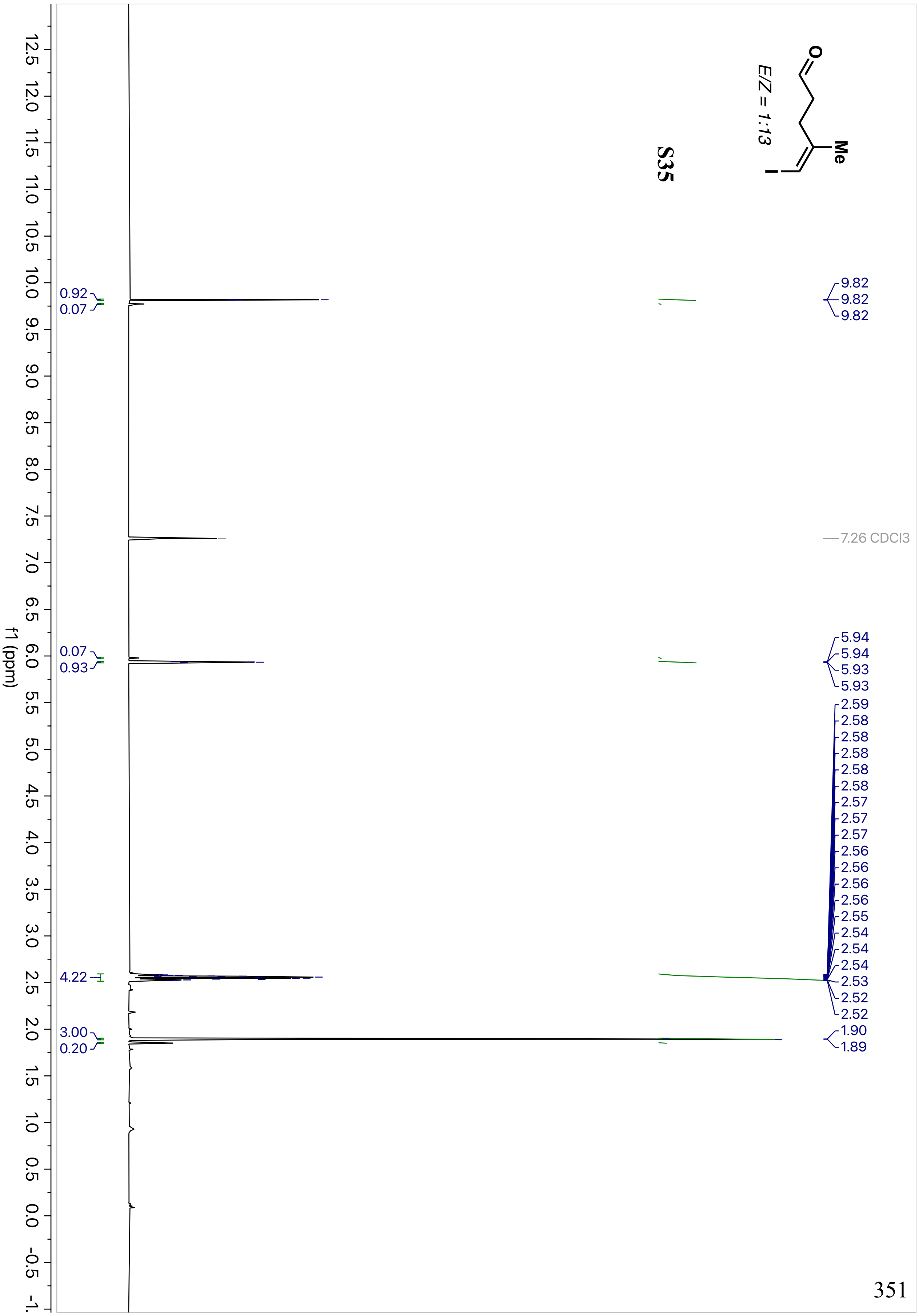


E-33

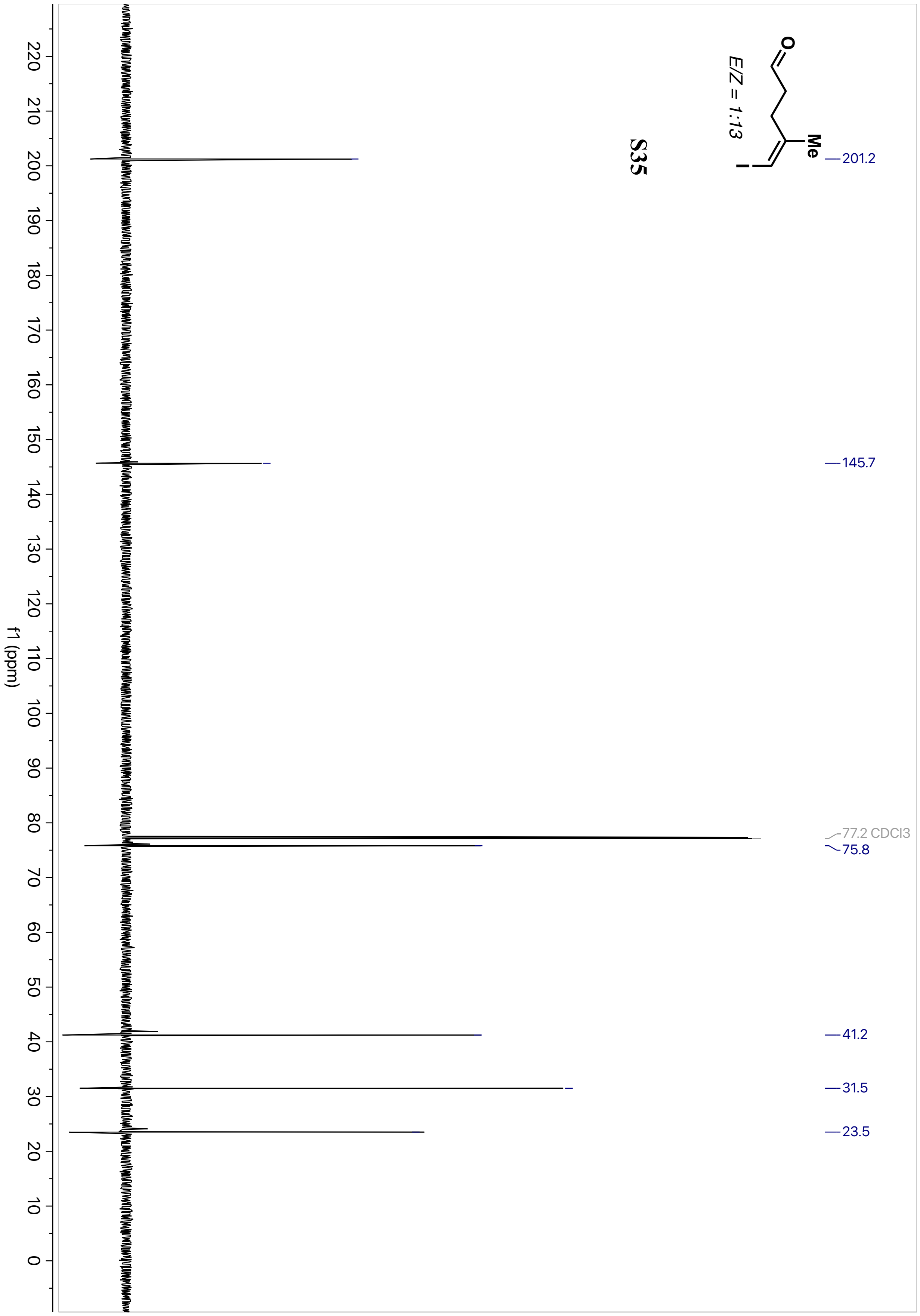
Me
Me
Me
I
7.26 CDCl3
5.87
5.87
5.07
5.07
5.07
5.06
5.06
5.06
5.05
5.05
5.05
5.04
5.04
2.22
2.21
2.21
2.21
2.20
2.20
2.13
2.12
2.11
2.10
1.84
1.84
1.69
1.68
1.60
1.00
1.00
2.06
2.06
3.05
3.10
3.07
12.5 12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.
f1 (ppm)


E-33

Me
Me
Me
I
148.0
132.6
123.2
77.2 CDCl3
74.9
39.7
26.6
25.8
24.1
17.8
f1 (ppm)
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0

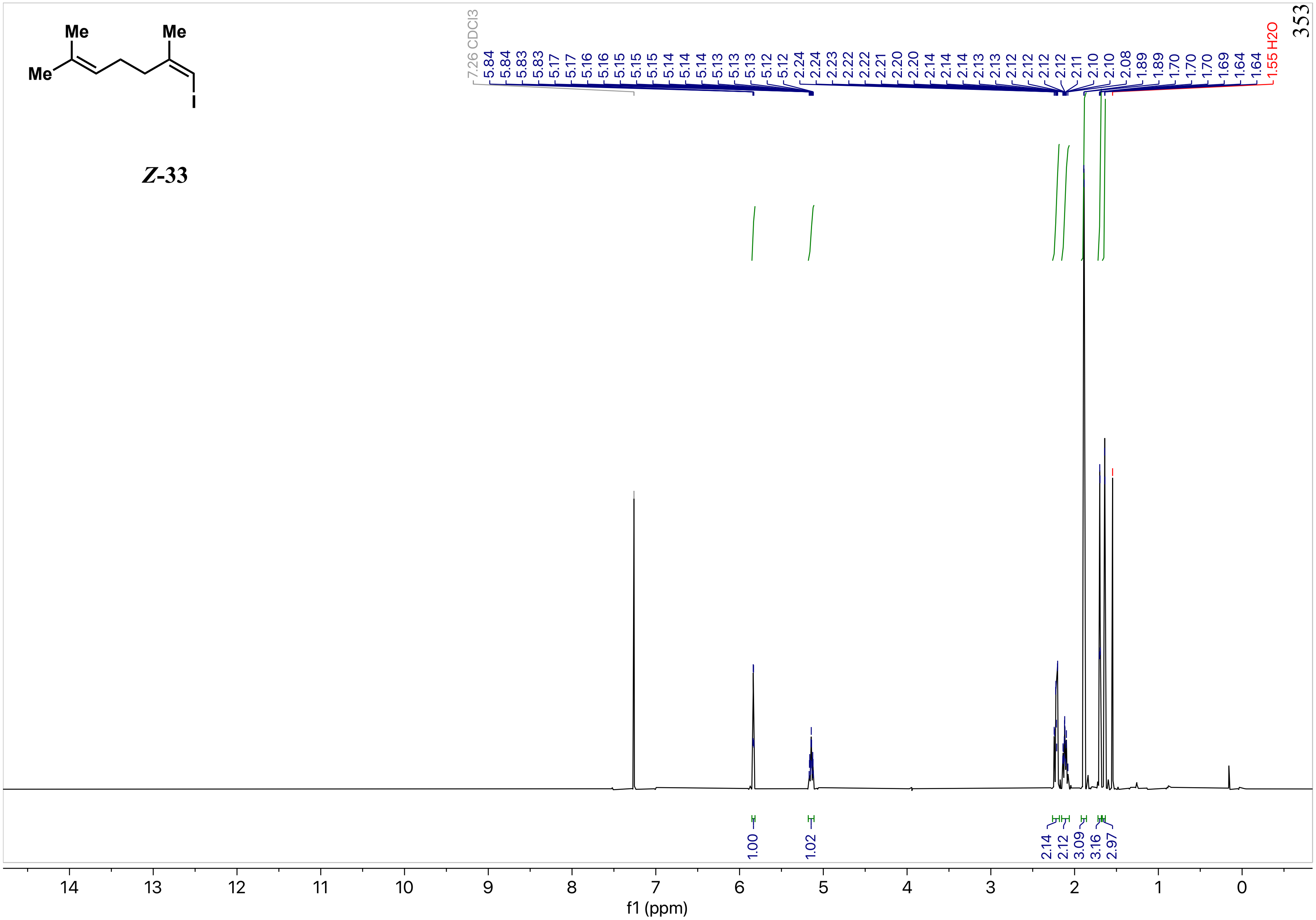

Me
O
I
E/Z = 1:13
9.82
9.82
9.82
7.26 CDCl3
5.94
5.94
5.93
5.93
2.59
2.58
2.58
2.58
2.58
2.58
2.57
2.57
2.57
2.56
2.56
2.56
2.56
2.55
2.54
2.54
2.54
2.53
2.52
2.52
1.90
1.89
0.92
0.07
0.07
0.93
4.22
3.00
0.20
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.
f1 (ppm)

S35



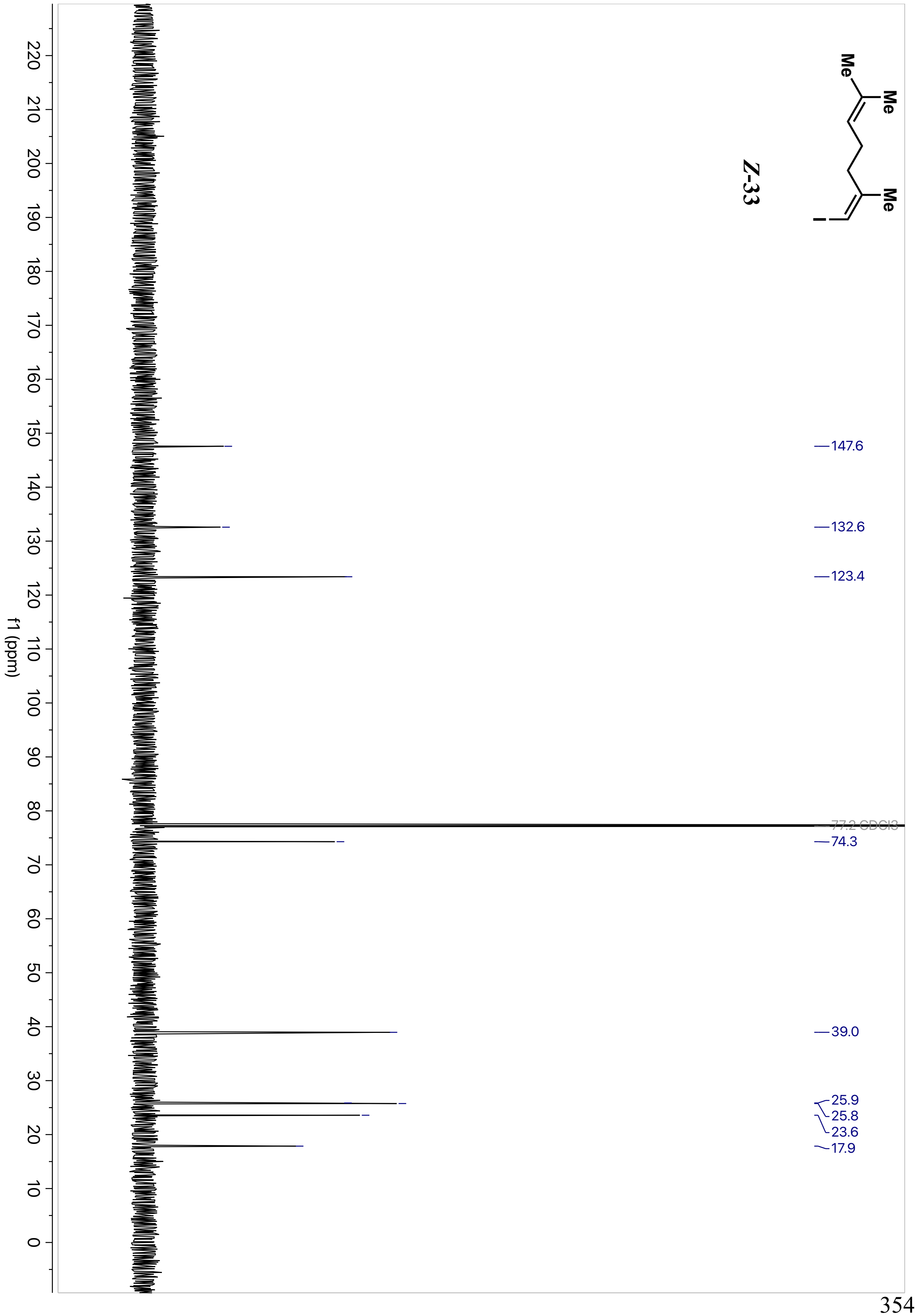
O
Me
I
E/Z = 1:13
201.2
145.7
77.2 CDCl3
75.8
41.2
31.5
23.5
f1 (ppm)
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0

S35

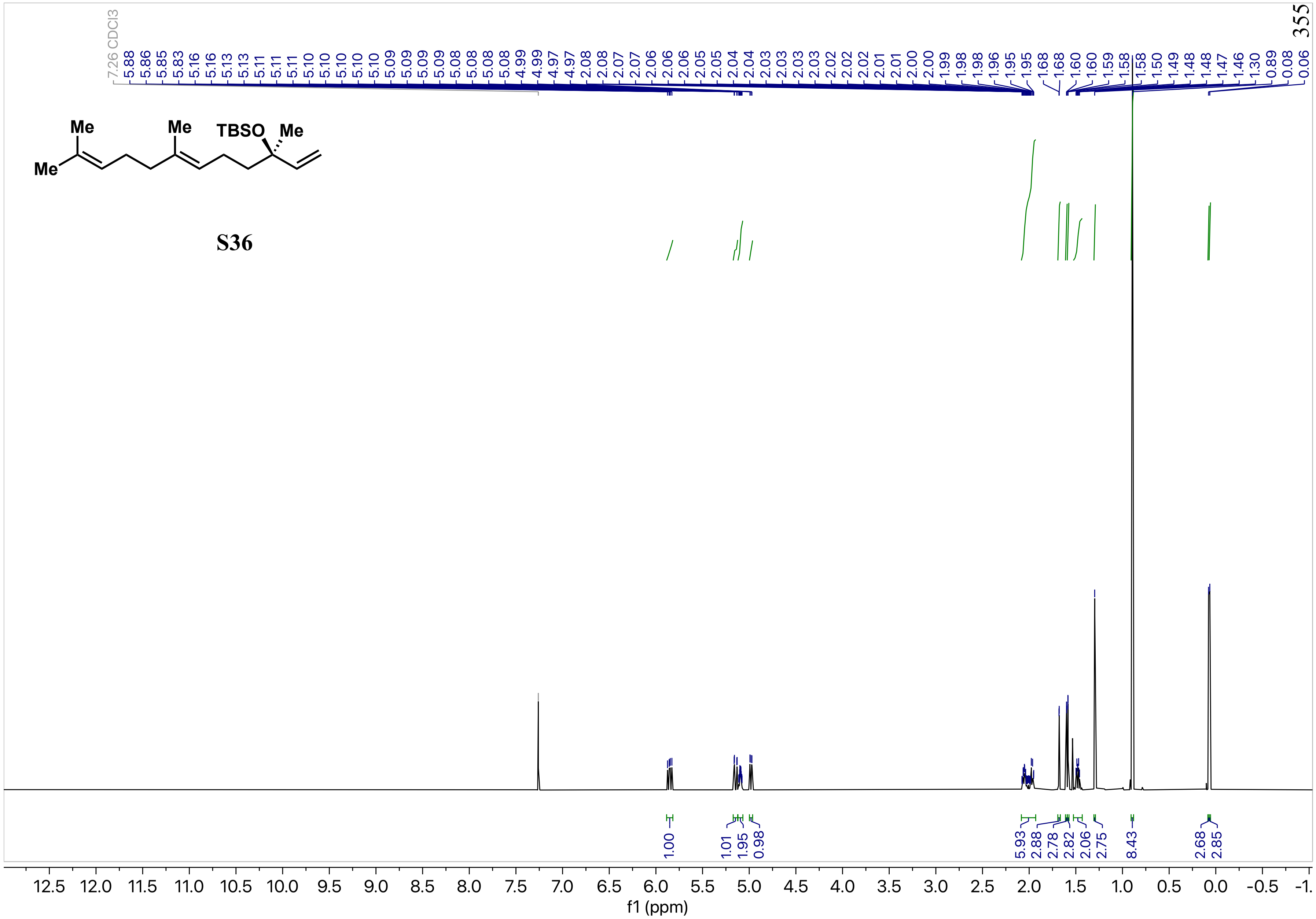


Z-33

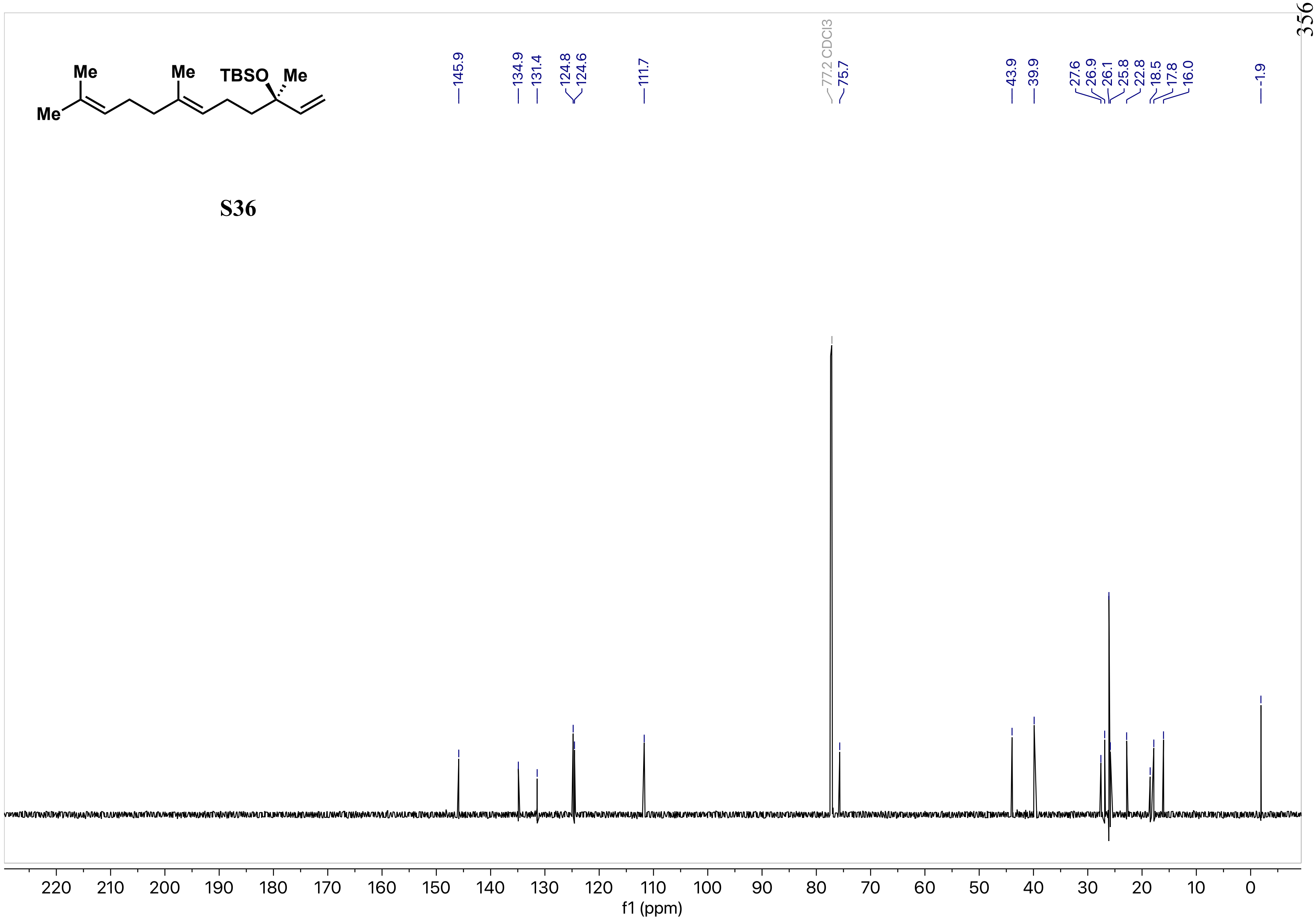
Me
Me
Me
I
7.26 CDCl3
5.84
5.84
5.83
5.83
5.17
5.17
5.16
5.16
5.15
5.15
5.15
5.14
5.14
5.14
5.13
5.13
5.13
5.12
5.12
2.24
2.24
2.23
2.22
2.22
2.21
2.20
2.20
2.14
2.14
2.14
2.13
2.13
2.12
2.12
2.12
2.12
2.11
2.10
2.10
2.08
1.89
1.89
1.70
1.70
1.70
1.69
1.64
1.64
1.55 H2O
1.00
1.02
2.14
2.12
3.09
3.16
2.97
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

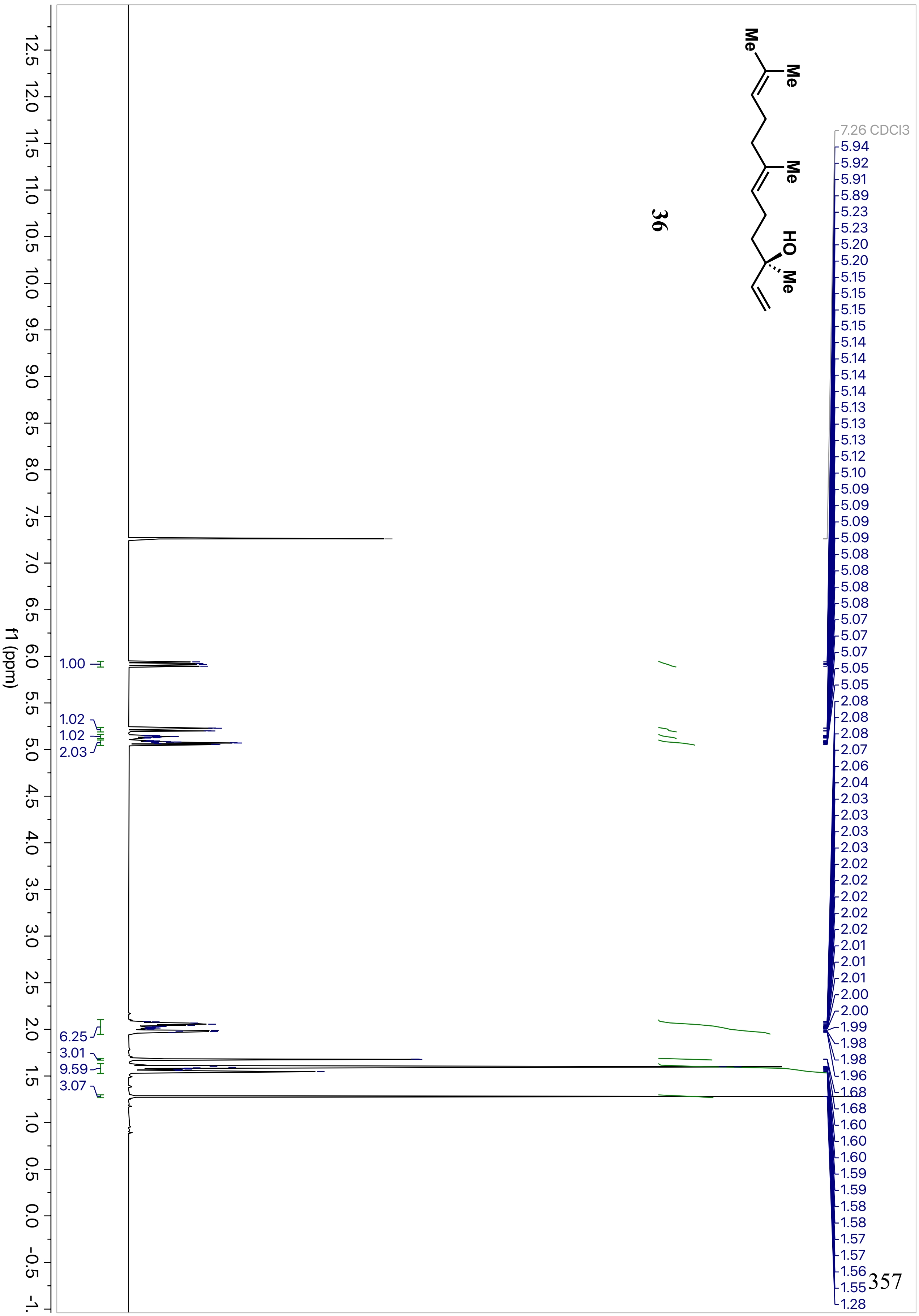

Me
Me
Me
I
147.6
132.6
123.4
77.2 CDCl3
74.3
39.0
25.9
25.8
23.6
17.9
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

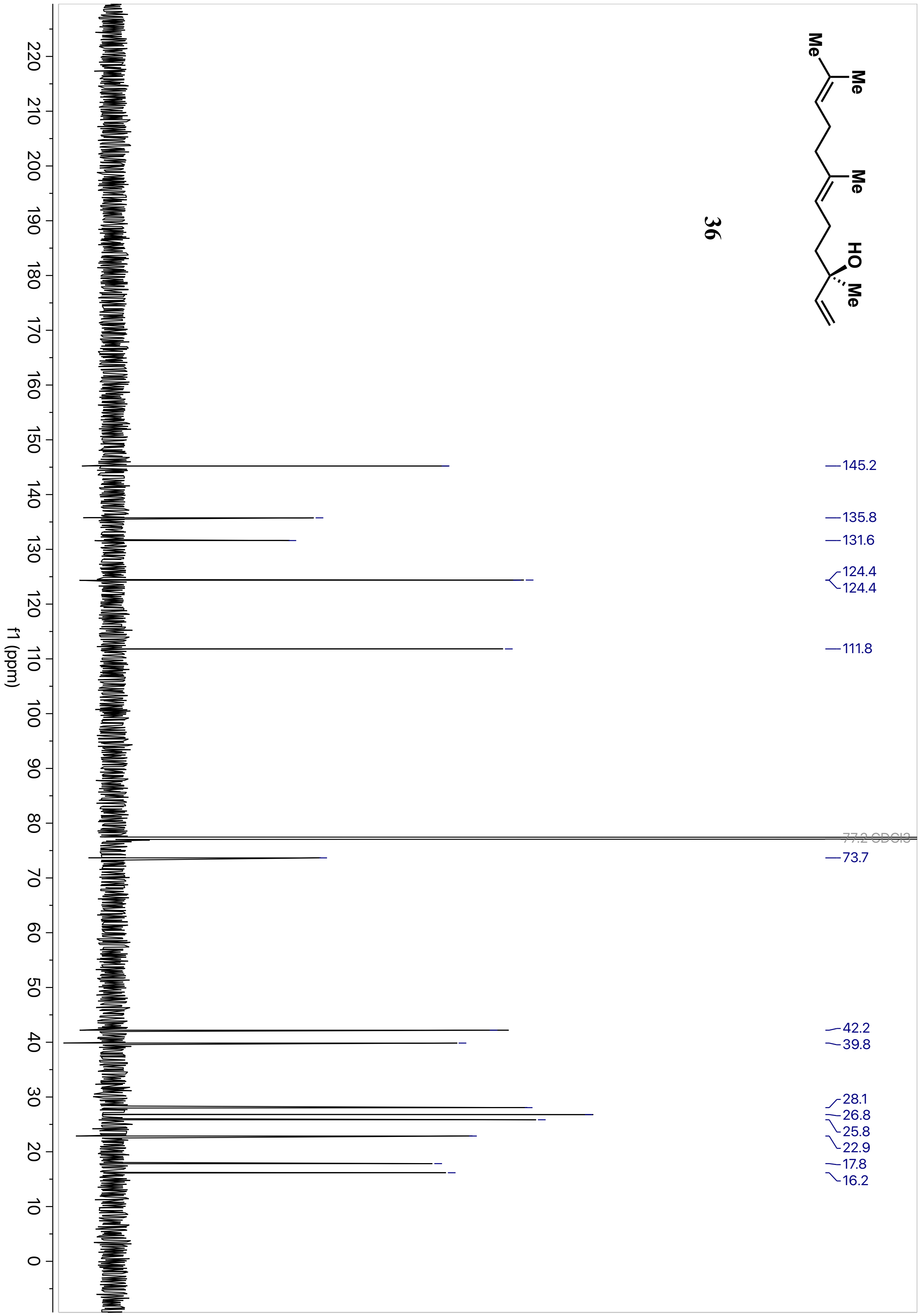
Z-33


7.26 CDCl3
5.88
5.86
5.85
5.83
5.16
5.16
5.13
5.13
5.11
5.11
5.11
5.10
5.10
5.10
5.10
5.10
5.09
5.09
5.09
5.09
5.08
5.08
5.08
5.08
4.99
4.99
4.97
4.97
2.08
2.08
2.07
2.07
2.06
2.06
2.06
2.05
2.05
2.04
2.04
2.03
2.03
2.03
2.03
2.02
2.02
2.02
2.01
2.01
2.00
2.00
1.99
1.98
1.98
1.96
1.95
1.95
1.68
1.68
1.60
1.60
1.59
1.58
1.58
1.50
1.49
1.48
1.48
1.47
1.46
1.30
0.89
0.08
0.06
Me
Me
Me
TBSO
Me
1.00
1.01
1.95
0.98
5.93
2.88
2.78
2.82
2.06
2.75
8.43
2.68
2.85
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.
f1 (ppm)

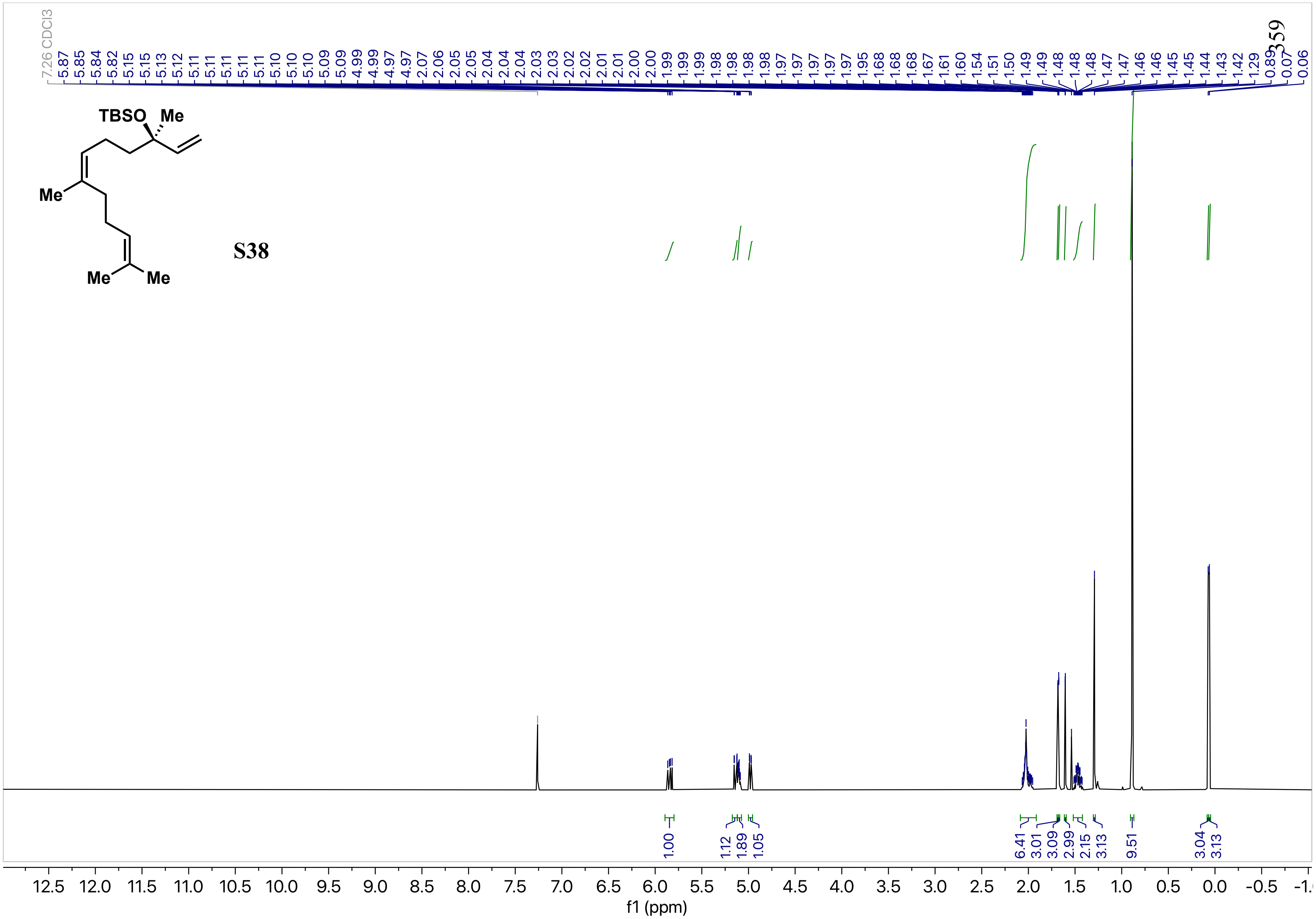
S36

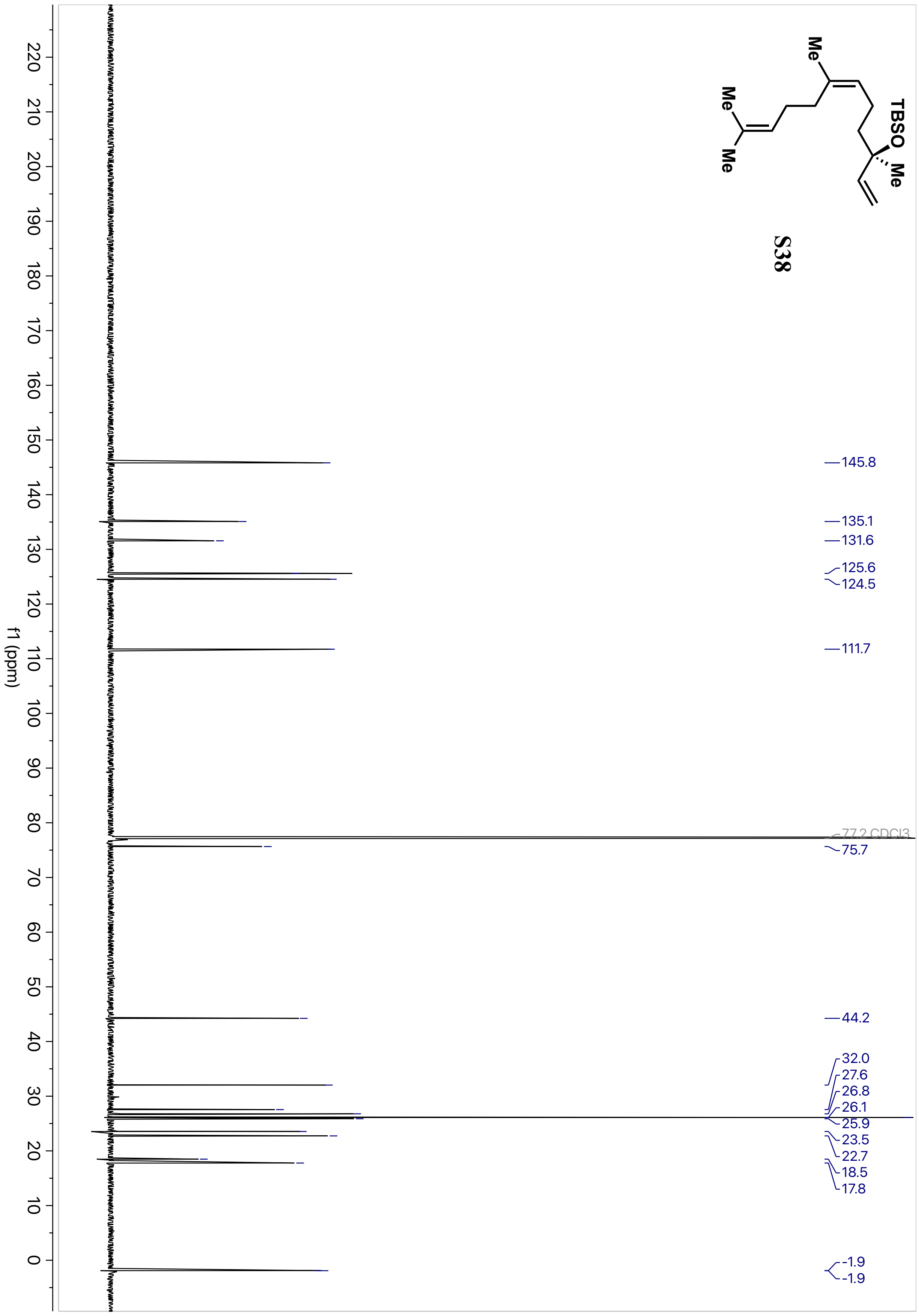

Me
Me
Me
TBSO
Me
S36
145.9
134.9
131.4
124.8
124.6
111.7
77.2 CDCl3
75.7
43.9
39.9
27.6
26.9
26.1
25.8
22.8
18.5
17.8
16.0
-1.9
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


Me
Me
Me
Me
HO
Me
36
7.26 CDCl3
5.94
5.92
5.91
5.89
5.23
5.23
5.20
5.20
5.15
5.15
5.15
5.15
5.14
5.14
5.14
5.14
5.13
5.13
5.13
5.12
5.10
5.09
5.09
5.09
5.09
5.08
5.08
5.08
5.08
5.07
5.07
5.07
5.05
5.05
2.08
2.08
2.08
2.07
2.06
2.04
2.03
2.03
2.03
2.03
2.02
2.02
2.02
2.02
2.02
2.01
2.01
2.01
2.00
2.00
1.99
1.98
1.98
1.96
1.68
1.68
1.60
1.60
1.60
1.59
1.59
1.58
1.58
1.57
1.57
1.56
1.55
1.28
1.00
1.02
1.02
2.03
6.25
3.01
9.59
3.07
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.
f1 (ppm)


Me
Me
Me
HO
Me
145.2
135.8
131.6
124.4
124.4
111.8
77.2 CDCl3
73.7
42.2
39.8
28.1
26.8
25.8
22.9
17.8
16.2
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

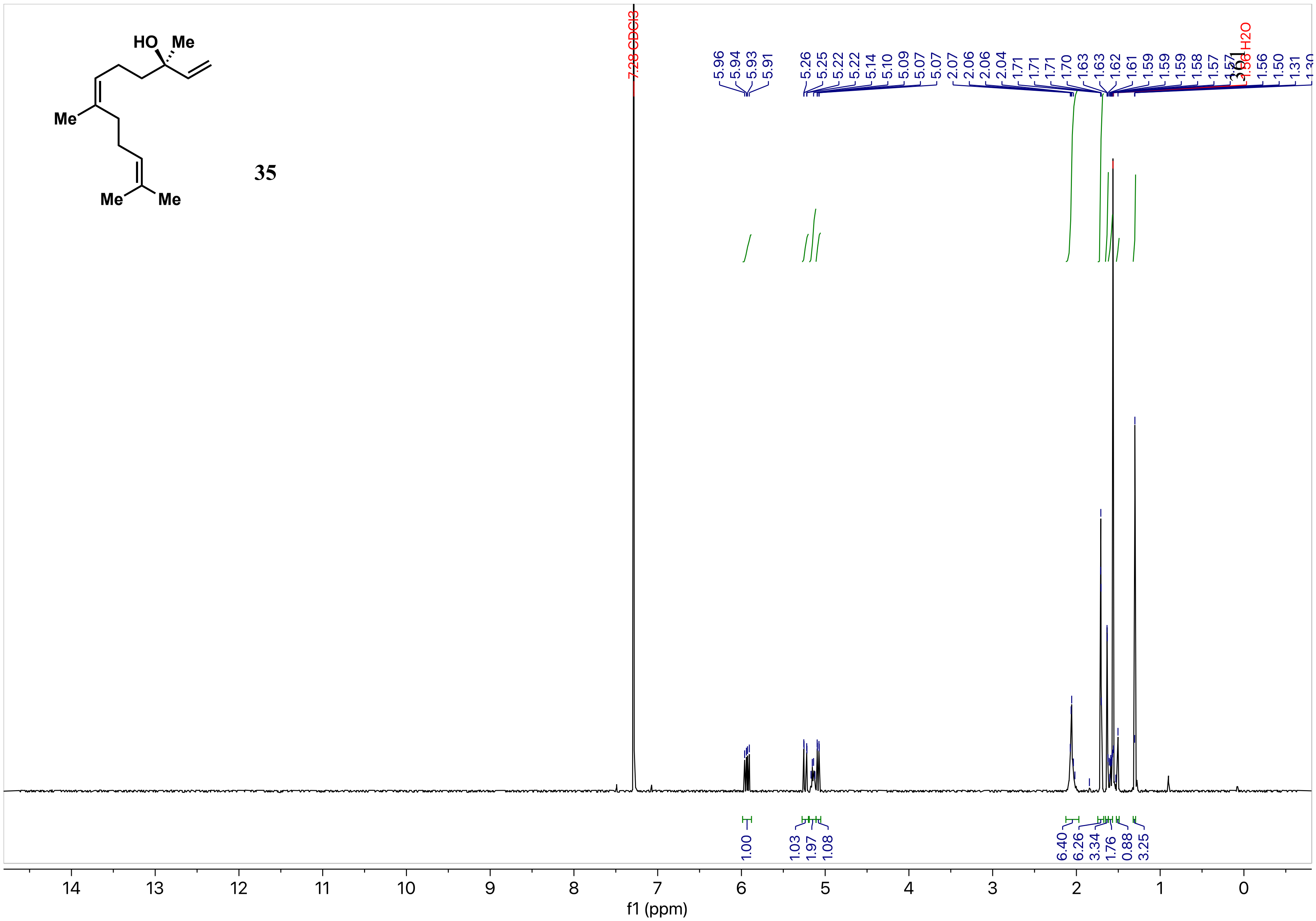
36


TBSO
Me
Me
Me
Me
S38
7.26 CDCl3
5.87
5.85
5.84
5.82
5.15
5.15
5.13
5.12
5.11
5.11
5.11
5.11
5.11
5.10
5.10
5.10
5.09
5.09
4.99
4.99
4.97
4.97
2.07
2.06
2.05
2.05
2.04
2.04
2.04
2.03
2.03
2.02
2.02
2.01
2.01
2.00
2.00
1.99
1.99
1.99
1.98
1.98
1.98
1.98
1.97
1.97
1.97
1.97
1.97
1.95
1.68
1.68
1.68
1.67
1.61
1.60
1.54
1.51
1.50
1.49
1.49
1.48
1.48
1.48
1.47
1.47
1.46
1.46
1.45
1.45
1.44
1.43
1.42
1.29
0.89
0.07
0.06
1.00
1.12
1.89
1.05
6.41
3.01
3.09
2.99
2.15
3.13
9.51
3.04
3.13
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

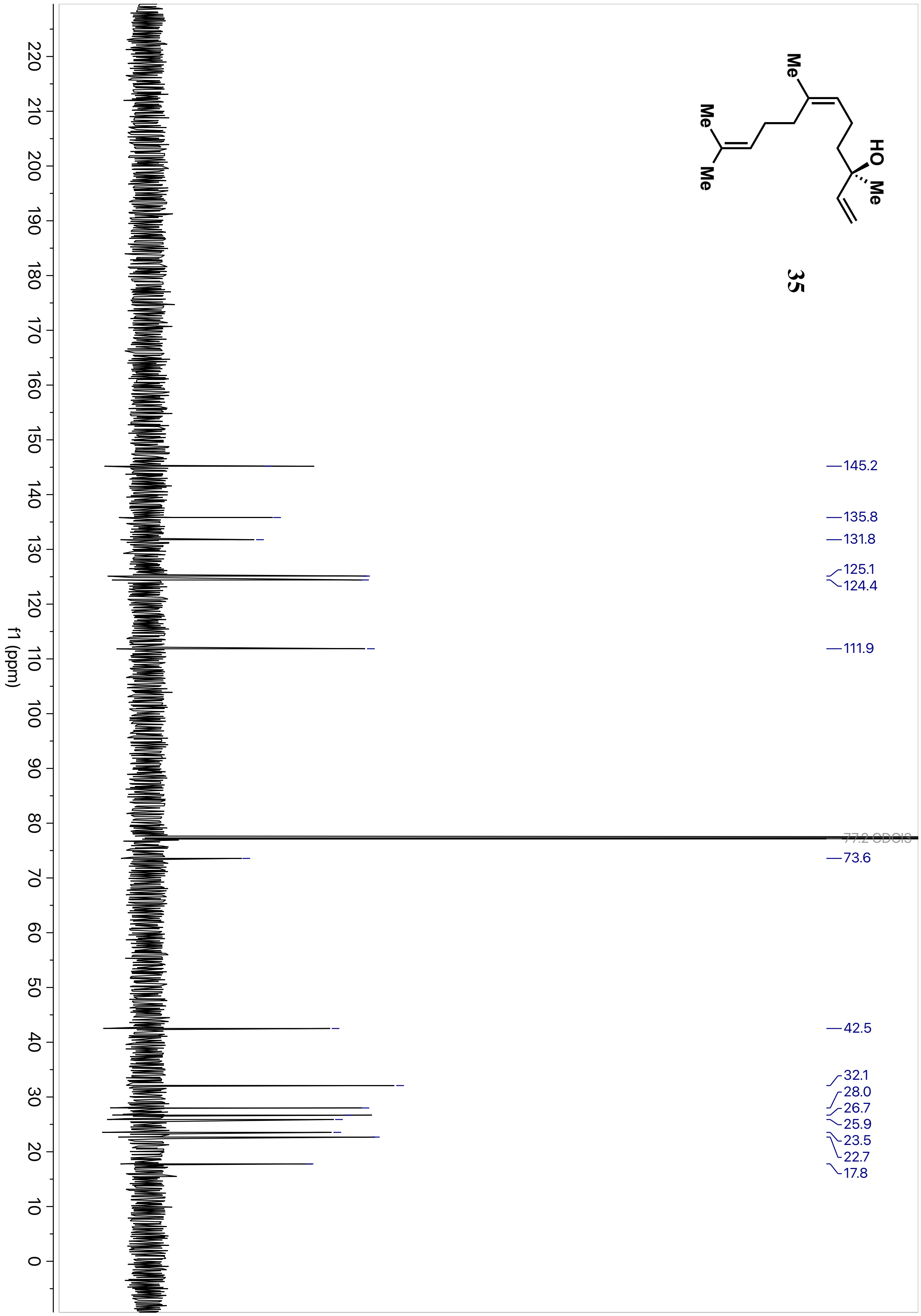


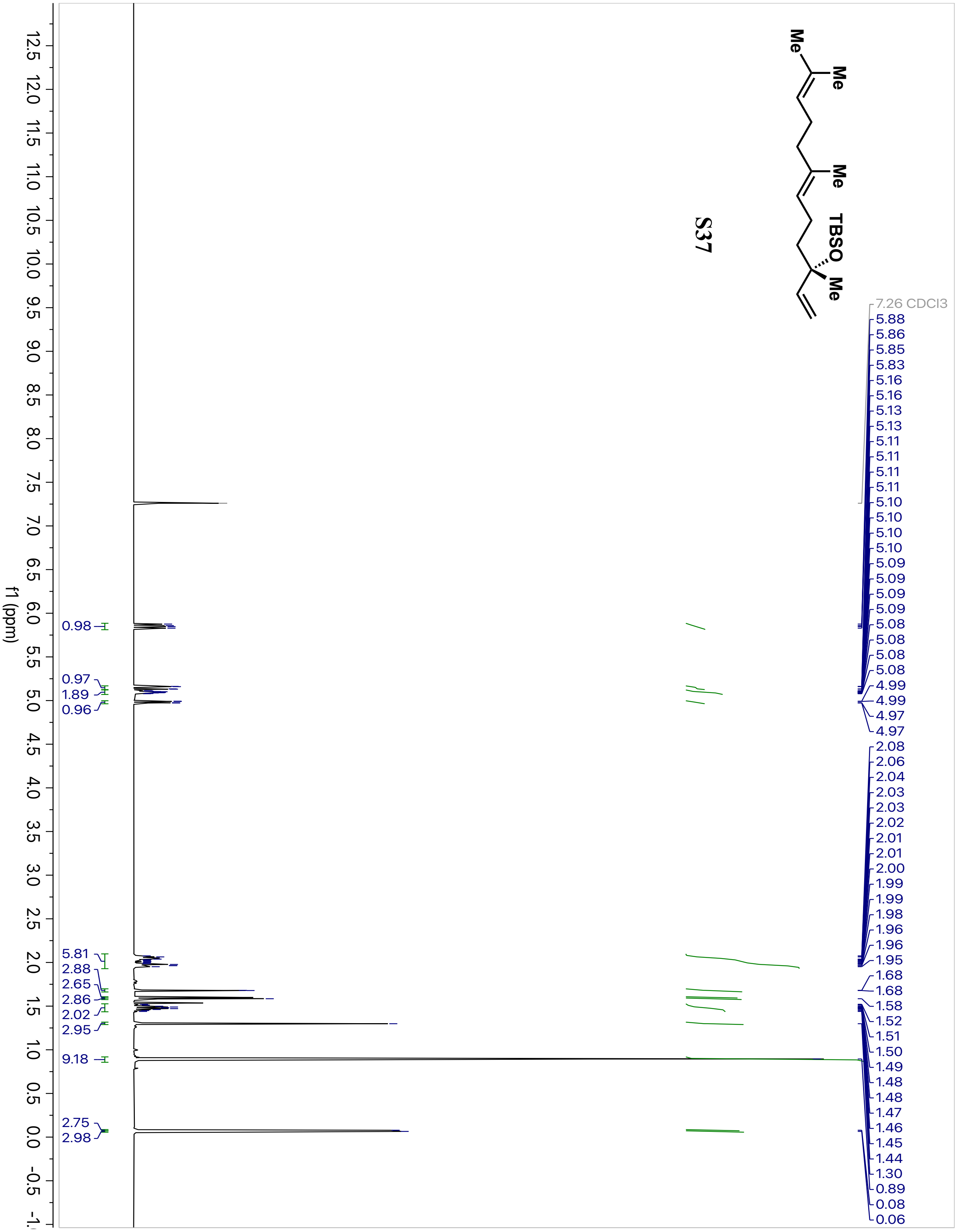
S38

TBSO
Me
Me
Me
Me
145.8
135.1
131.6
125.6
124.5
111.7
77.2 CDCl3
75.7
44.2
32.0
27.6
26.8
26.1
25.9
23.5
22.7
18.5
17.8
-1.9
-1.9
f1 (ppm)
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0

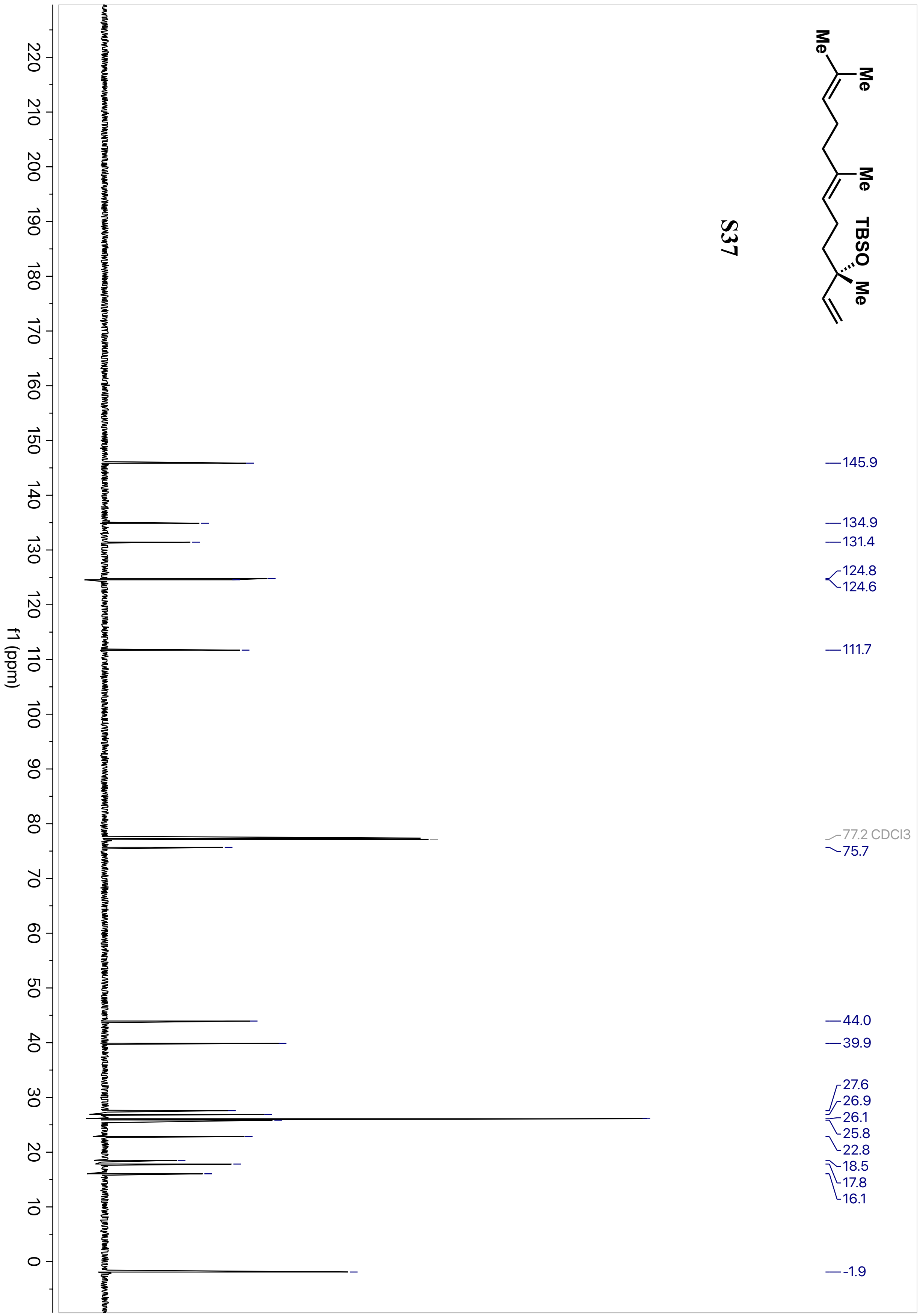

HO
Me
Me
Me
Me
7.28 CDCl3
5.96
5.94
5.93
5.91
5.26
5.25
5.22
5.22
5.14
5.10
5.09
5.07
5.07
2.07
2.06
2.06
2.04
1.71
1.71
1.71
1.70
1.63
1.63
1.62
1.61
1.59
1.59
1.59
1.58
1.57
1.57
1.56 H2O
1.56
1.50
1.31
1.30
1.00
1.03
1.97
1.08
6.40
6.26
3.34
1.76
0.88
3.25
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

35


35
Me
Me
Me
HO
Me
145.2
135.8
131.8
125.1
124.4
111.9
77.2 CDCl3
73.6
42.5
32.1
28.0
26.7
25.9
23.5
22.7
17.8
f1 (ppm)
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0

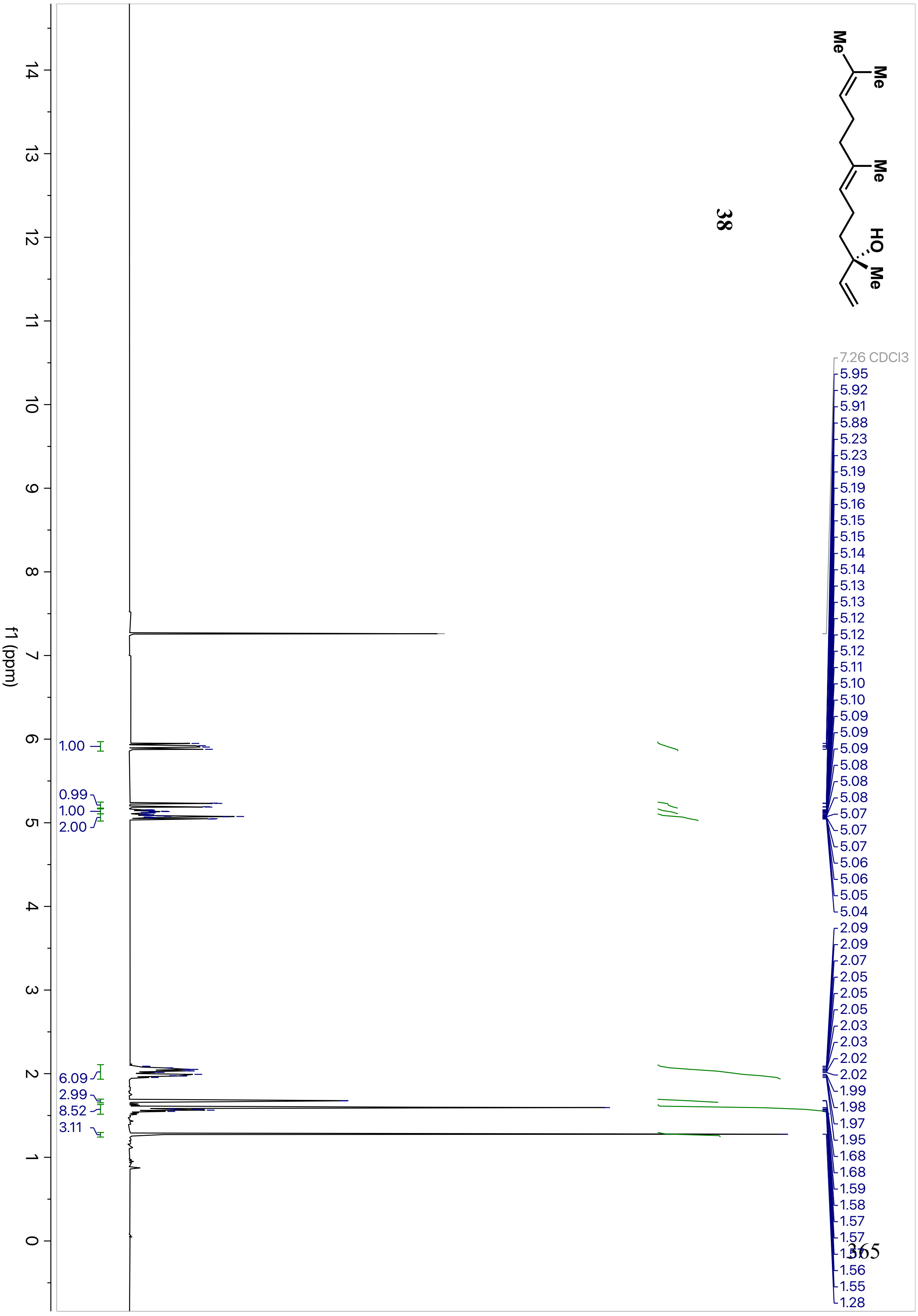

S37

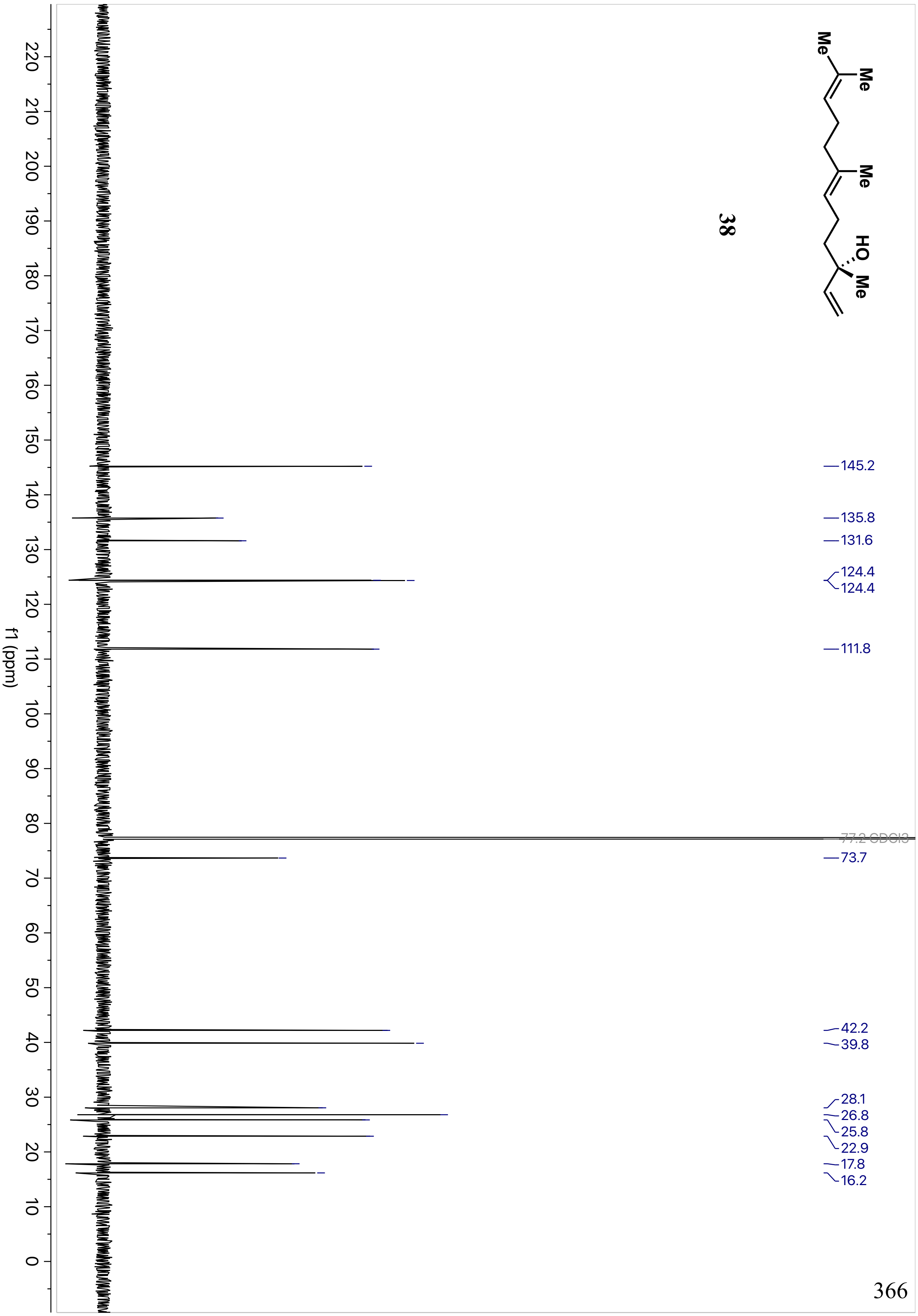
Me
Me
Me
TBSO
Me
7.26 CDCl3
5.88
5.86
5.85
5.83
5.16
5.16
5.13
5.13
5.11
5.11
5.11
5.11
5.10
5.10
5.10
5.10
5.09
5.09
5.09
5.09
5.08
5.08
5.08
5.08
4.99
4.99
4.97
4.97
2.08
2.06
2.04
2.03
2.03
2.02
2.01
2.01
2.00
1.99
1.99
1.98
1.96
1.96
1.95
1.68
1.68
1.58
1.52
1.51
1.50
1.49
1.48
1.48
1.47
1.46
1.45
1.44
1.30
0.89
0.08
0.06
0.98
0.97
1.89
0.96
5.81
2.88
2.65
2.86
2.02
2.95
9.18
2.75
2.98
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

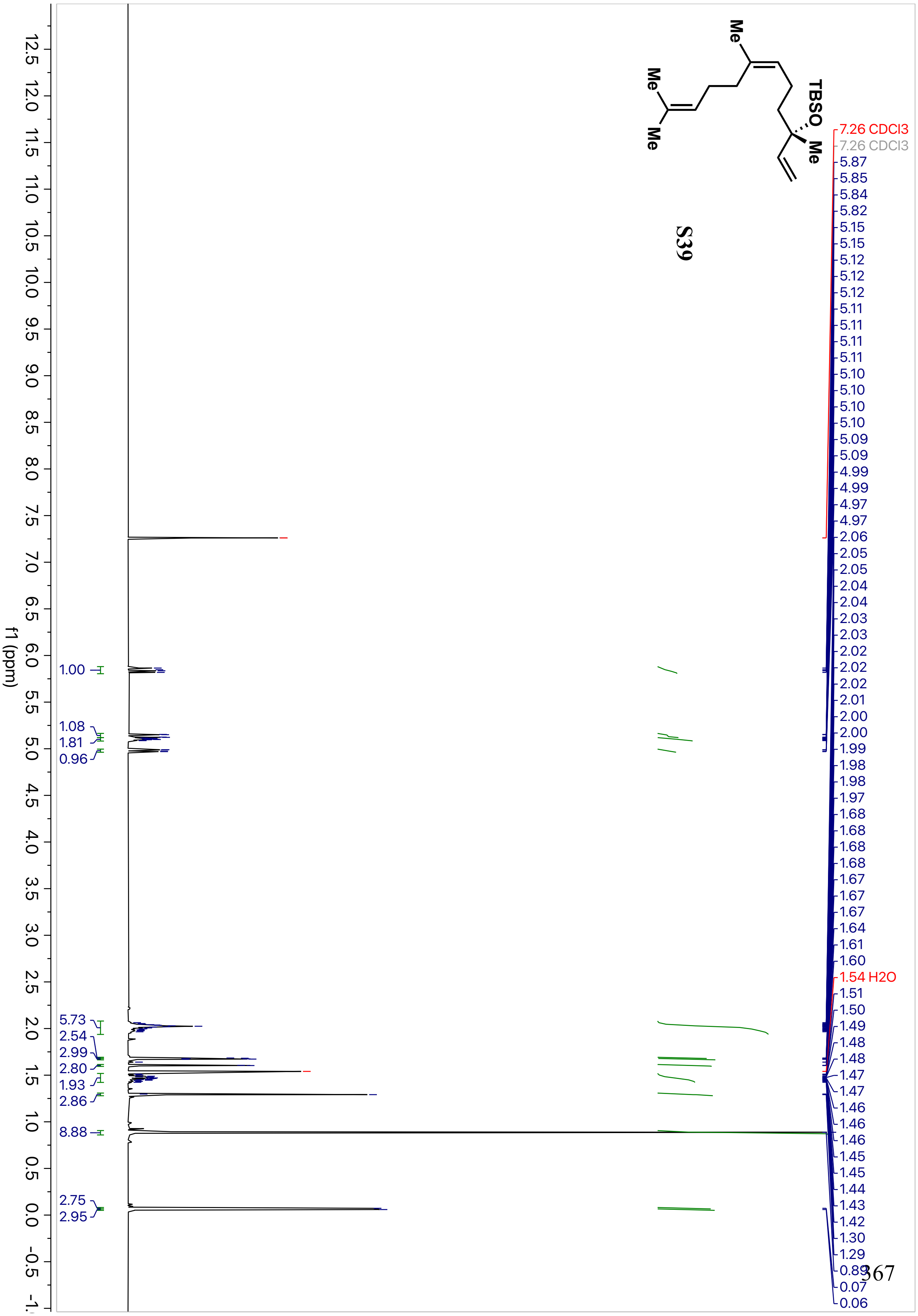


Me
Me
Me
TBSO
Me
—145.9
—134.9
—131.4
124.8
124.6
—111.7
77.2 CDCl3
75.7
—44.0
—39.9
27.6
26.9
26.1
25.8
22.8
18.5
17.8
16.1
—-1.9
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

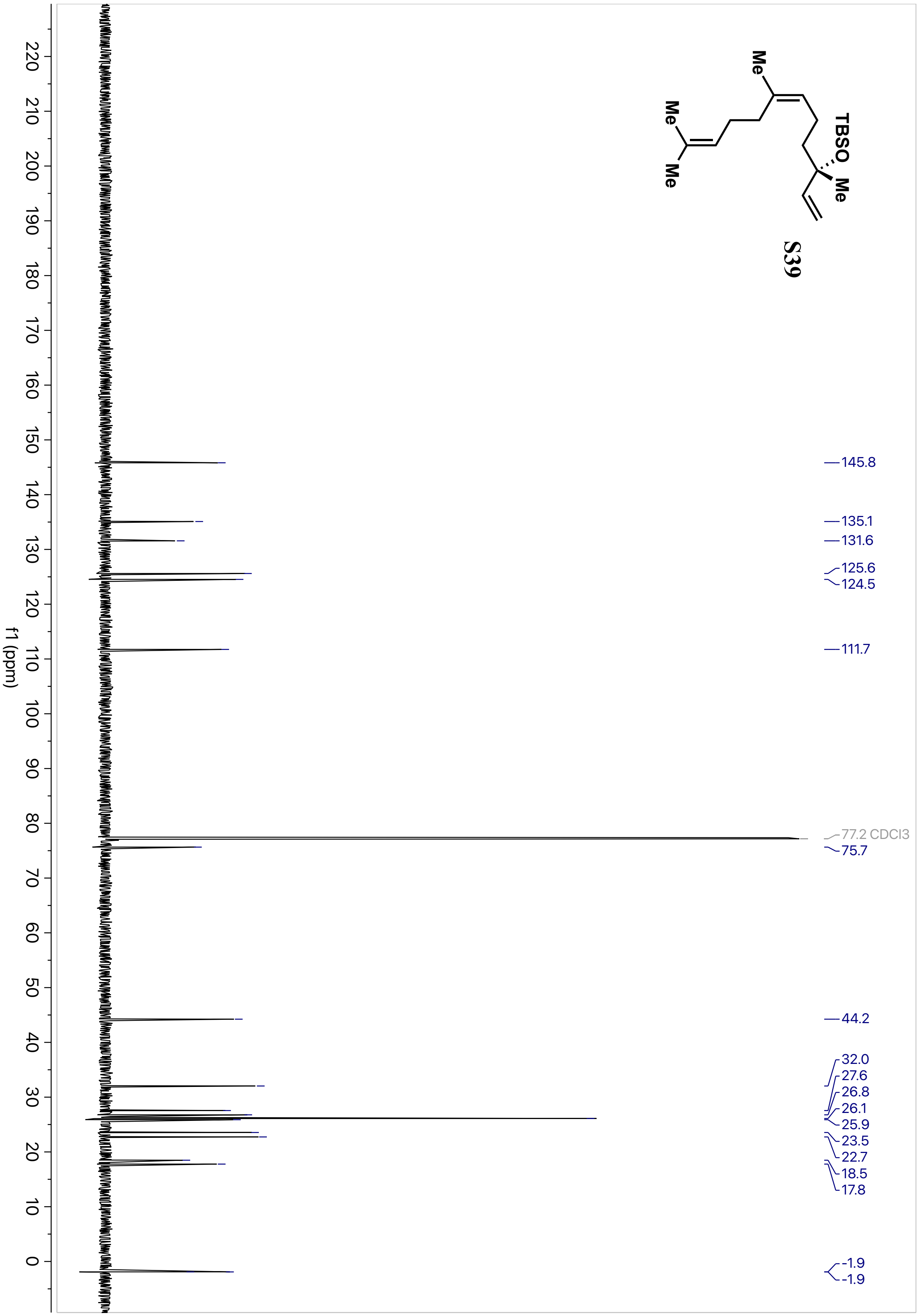
S37


Me
Me
Me
HO
Me
38
7.26 CDCl3
5.95
5.92
5.91
5.88
5.23
5.23
5.19
5.19
5.16
5.15
5.15
5.14
5.14
5.13
5.13
5.12
5.12
5.12
5.11
5.10
5.10
5.09
5.09
5.09
5.08
5.08
5.08
5.07
5.07
5.07
5.06
5.06
5.05
5.04
2.09
2.09
2.07
2.05
2.05
2.05
2.03
2.03
2.02
2.02
1.99
1.98
1.97
1.95
1.68
1.68
1.59
1.58
1.57
1.57
1.56
1.55
1.28
1.00
0.99
1.00
2.00
6.09
2.99
8.52
3.11
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

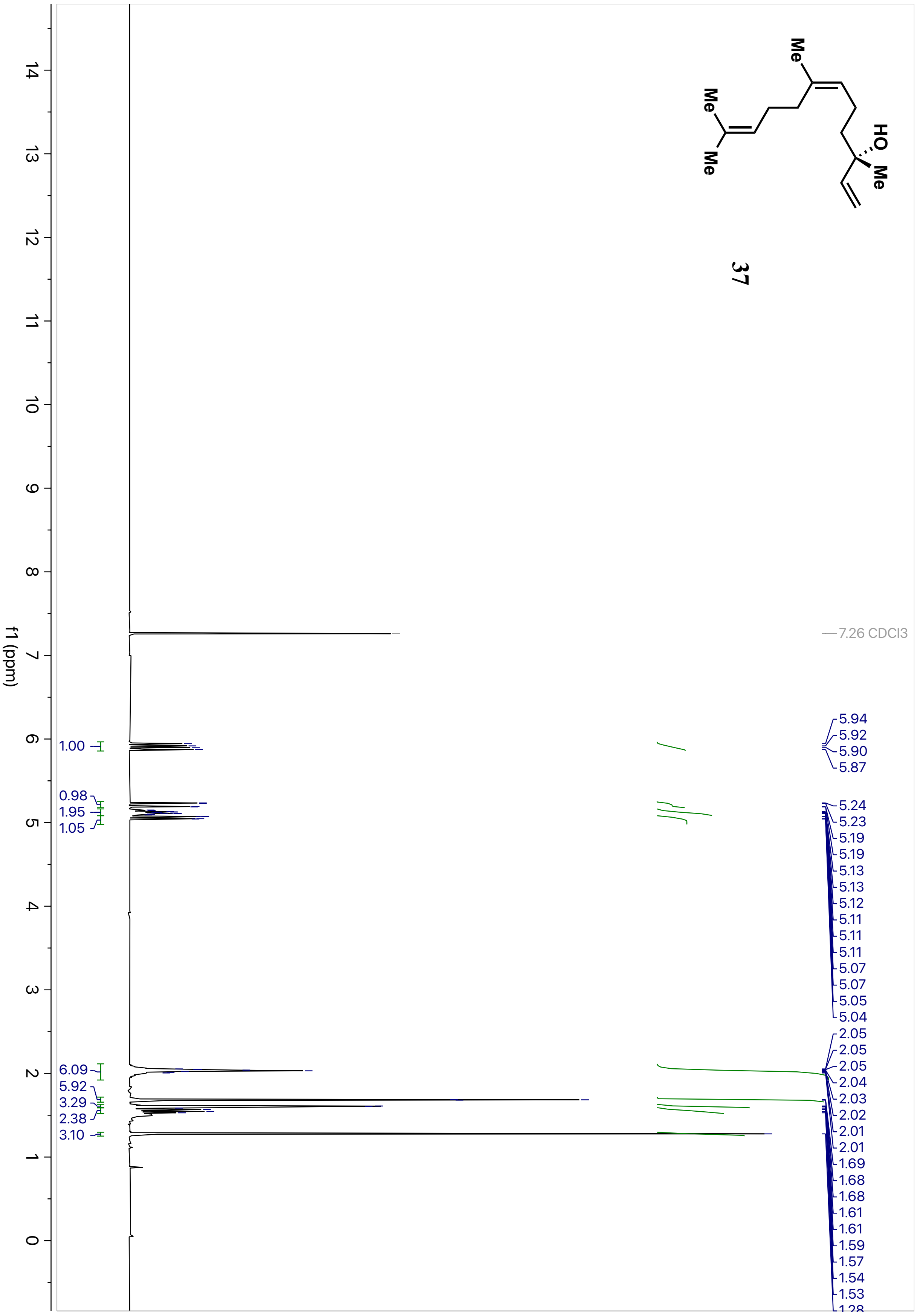

38
Me
Me
Me
HO
Me
145.2
135.8
131.6
124.4
124.4
111.8
77.2 CDCl3
73.7
42.2
39.8
28.1
26.8
25.8
22.9
17.8
16.2
f1 (ppm)
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0


TBSO
Me
Me
Me
Me
7.26 CDCl3
7.26 CDCl3
5.87
5.85
5.84
5.82
5.15
5.15
5.12
5.12
5.12
5.11
5.11
5.11
5.11
5.10
5.10
5.10
5.10
5.09
5.09
4.99
4.99
4.97
4.97
2.06
2.05
2.05
2.04
2.04
2.03
2.03
2.02
2.02
2.02
2.01
2.00
2.00
1.99
1.98
1.98
1.97
1.68
1.68
1.68
1.68
1.67
1.67
1.67
1.64
1.61
1.60
1.54 H2O
1.51
1.50
1.49
1.48
1.48
1.47
1.47
1.46
1.46
1.46
1.45
1.45
1.44
1.43
1.42
1.30
1.29
0.89
0.07
0.06
1.00
1.08
1.81
0.96
5.73
2.54
2.99
2.80
1.93
2.86
8.88
2.75
2.95
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.
f1 (ppm)

S39

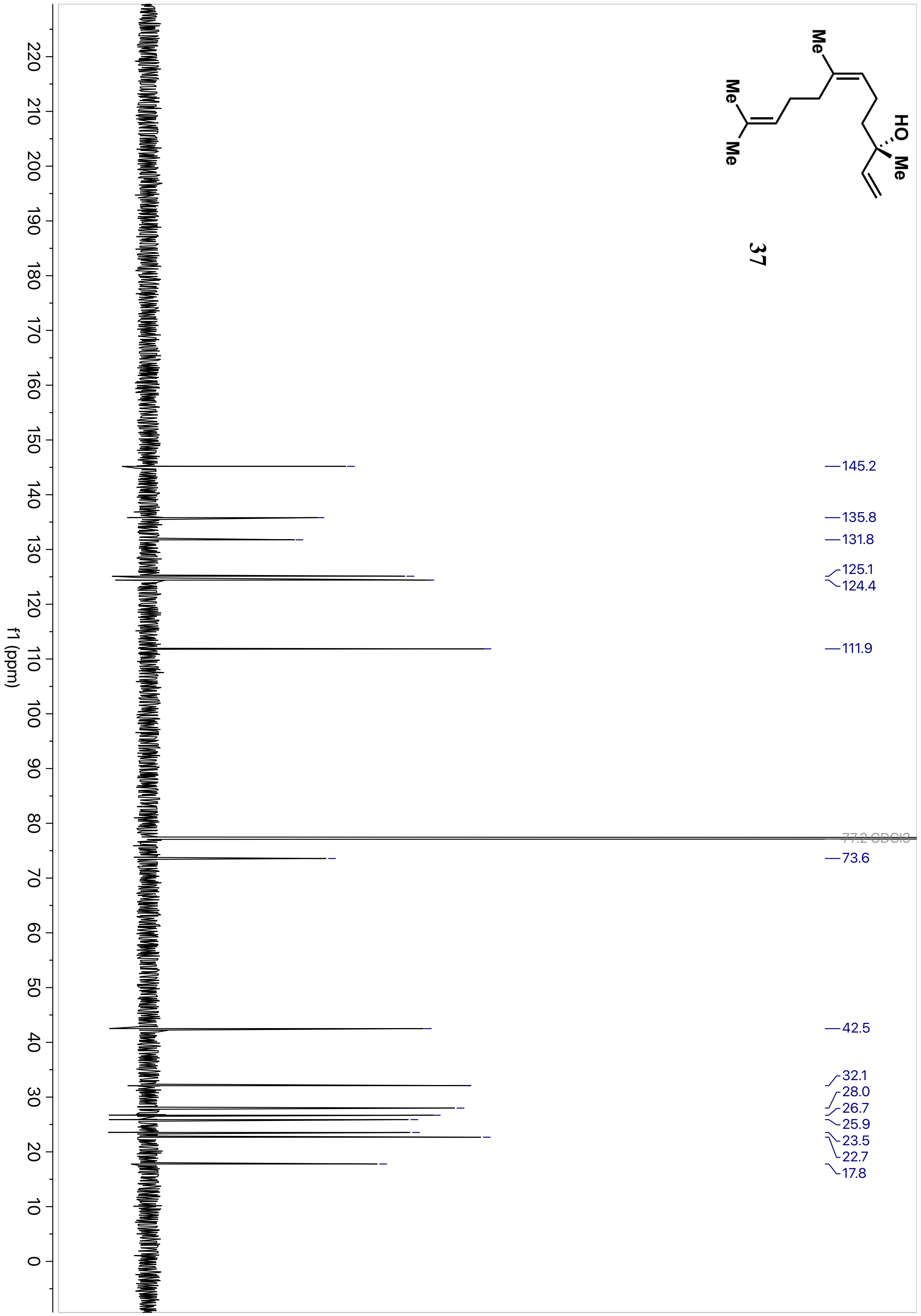

S39

TBSO
Me
Me
Me
Me
145.8
135.1
131.6
125.6
124.5
111.7
77.2 CDCl3
75.7
44.2
32.0
27.6
26.8
26.1
25.9
23.5
22.7
18.5
17.8
-1.9
-1.9
f1 (ppm)
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0

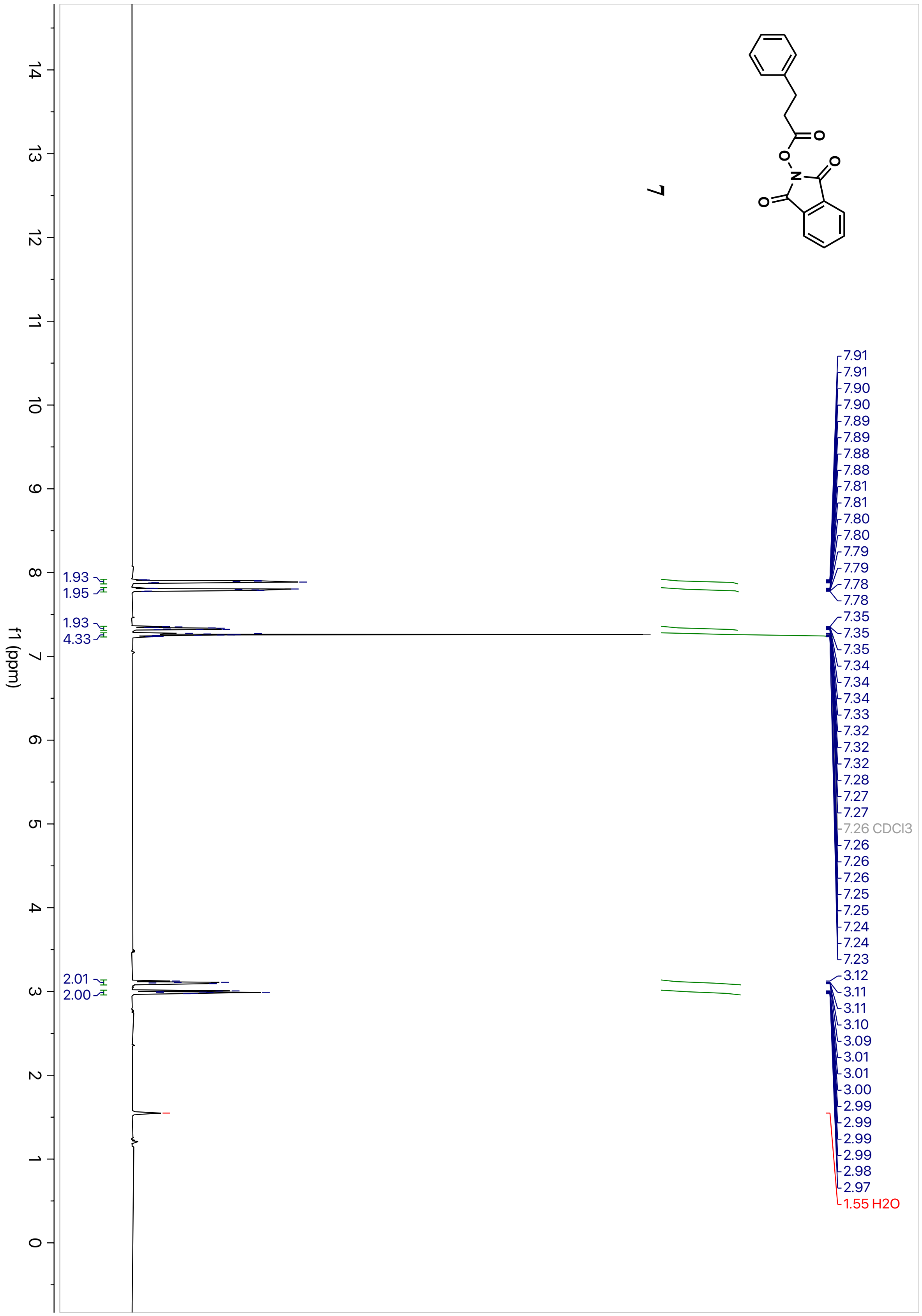


37

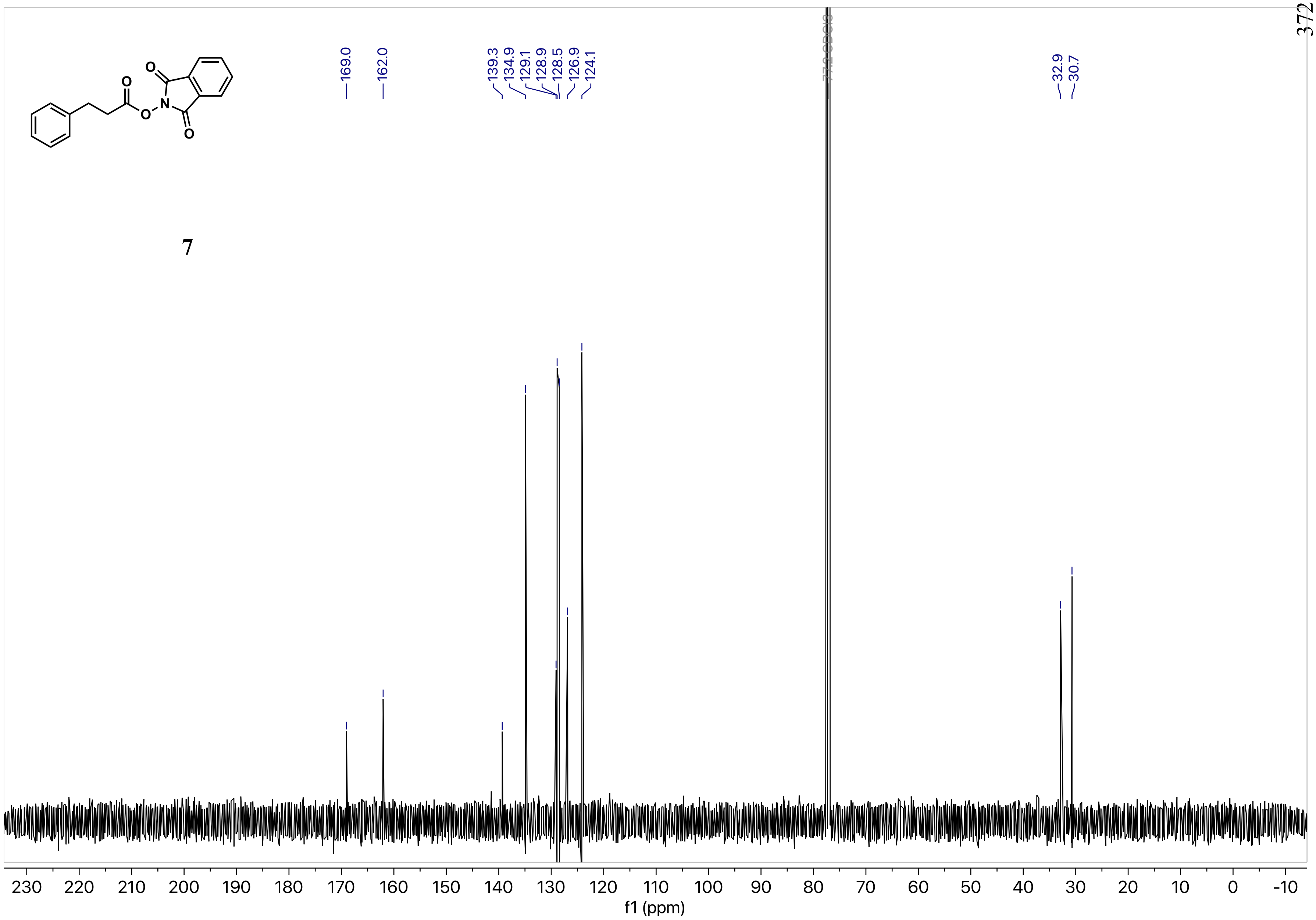
—7.26 CDCl3
5.94
5.92
5.90
5.87
5.24
5.23
5.19
5.19
5.13
5.13
5.12
5.11
5.11
5.11
5.07
5.07
5.05
5.04
2.05
2.05
2.05
2.04
2.03
2.02
2.01
2.01
1.69
1.68
1.68
1.61
1.61
1.59
1.57
1.54
1.53
1.00
0.98
1.95
1.05
6.09
5.92
3.29
2.38
3.10
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)
HO
Me
Me
Me
Me


37

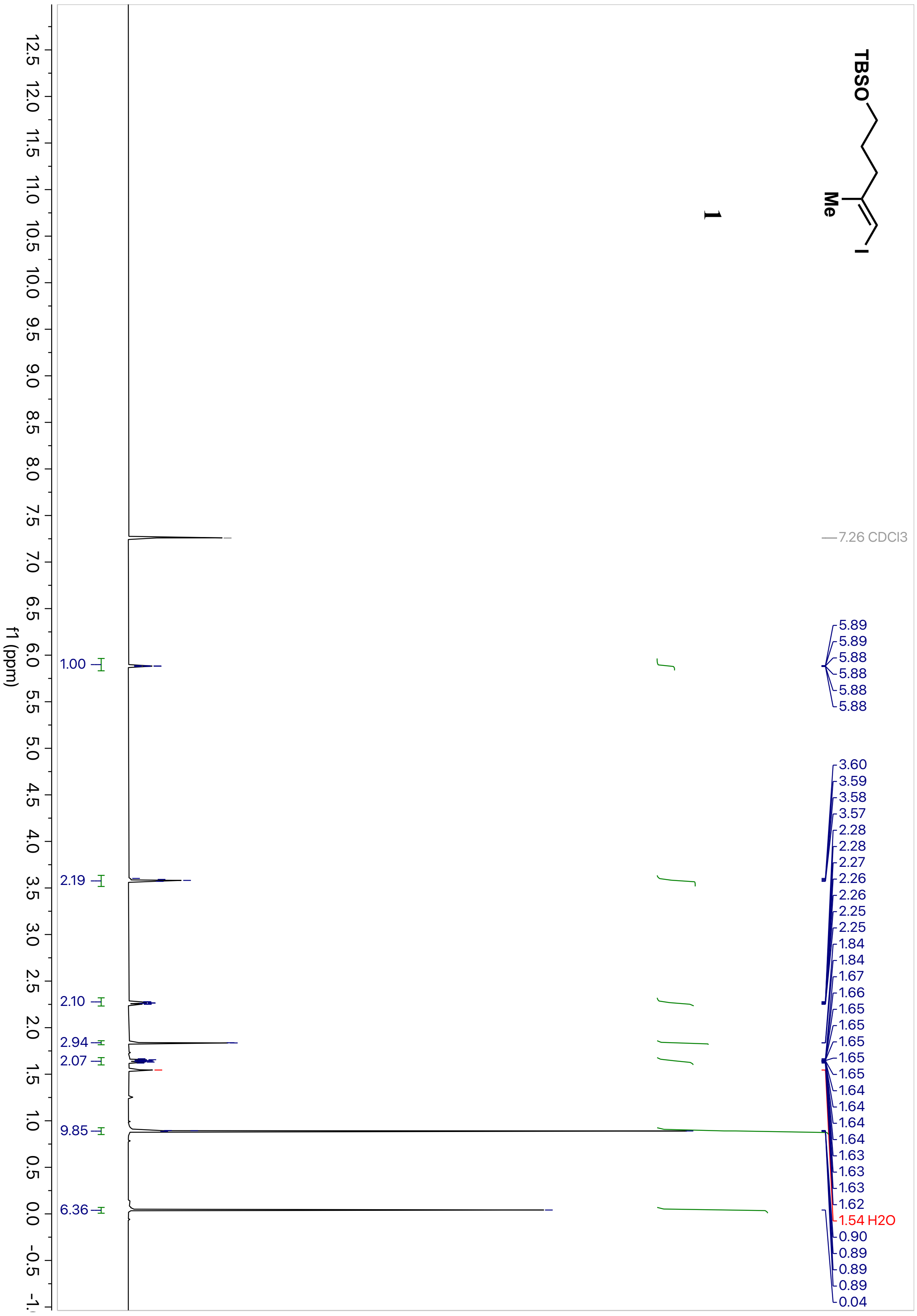
145.2
135.8
131.8
125.1
124.4
111.9
77.2 CDCl3
73.6
42.5
32.1
28.0
26.7
25.9
23.5
22.7
17.8
f1 (ppm)
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
HO
Me
Me
Me
Me

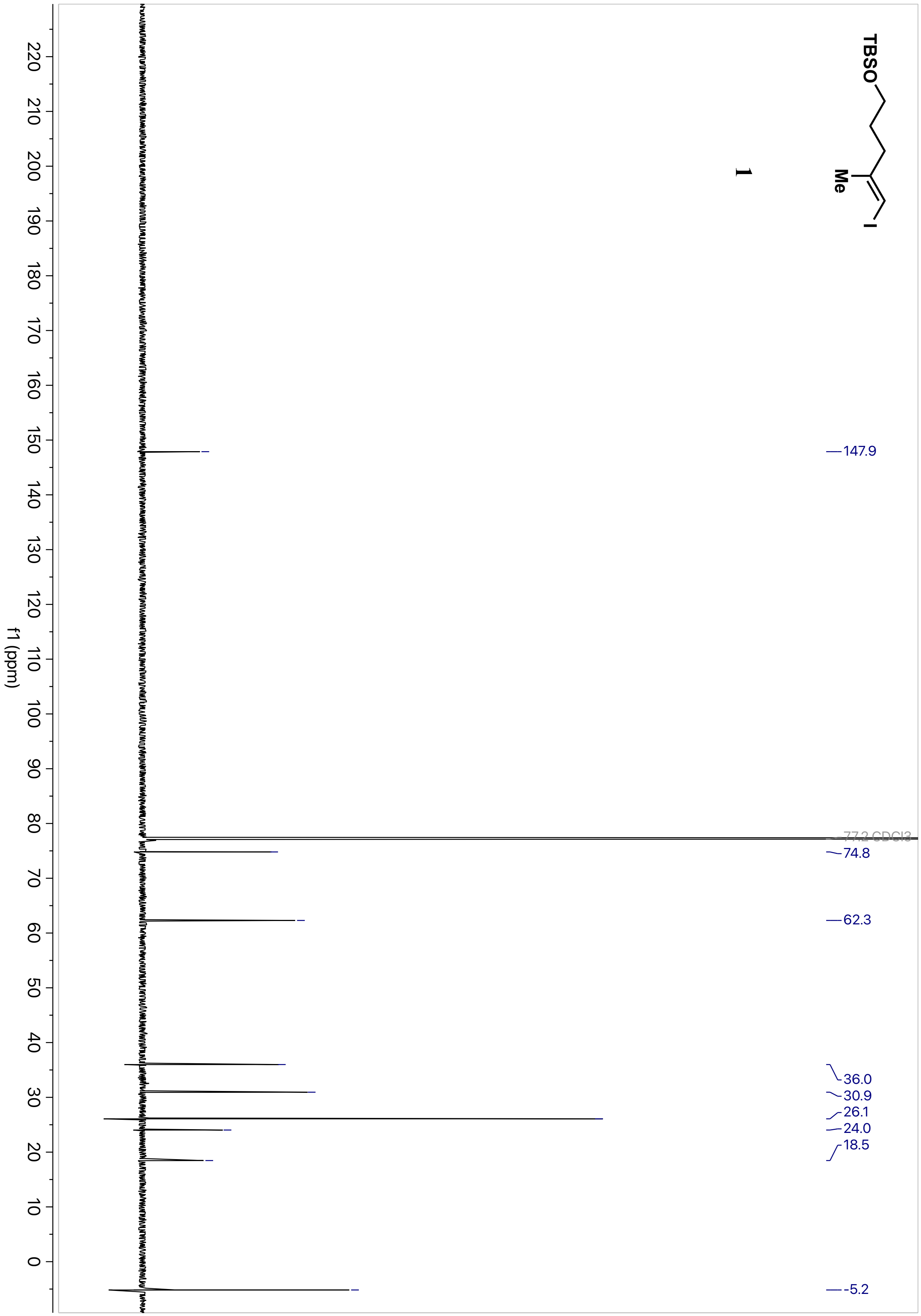

14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)
1.93
1.95
1.93
4.33
2.01
2.00
7.91
7.91
7.90
7.90
7.89
7.89
7.88
7.88
7.81
7.81
7.80
7.80
7.79
7.79
7.78
7.78
7.35
7.35
7.35
7.34
7.34
7.34
7.33
7.32
7.32
7.32
7.28
7.27
7.27
7.26 CDCl3
7.26
7.26
7.26
7.25
7.25
7.24
7.24
7.23
3.12
3.11
3.11
3.10
3.09
3.01
3.01
3.00
2.99
2.99
2.99
2.99
2.98
2.97
1.55 H2O
N
O
O
O
O

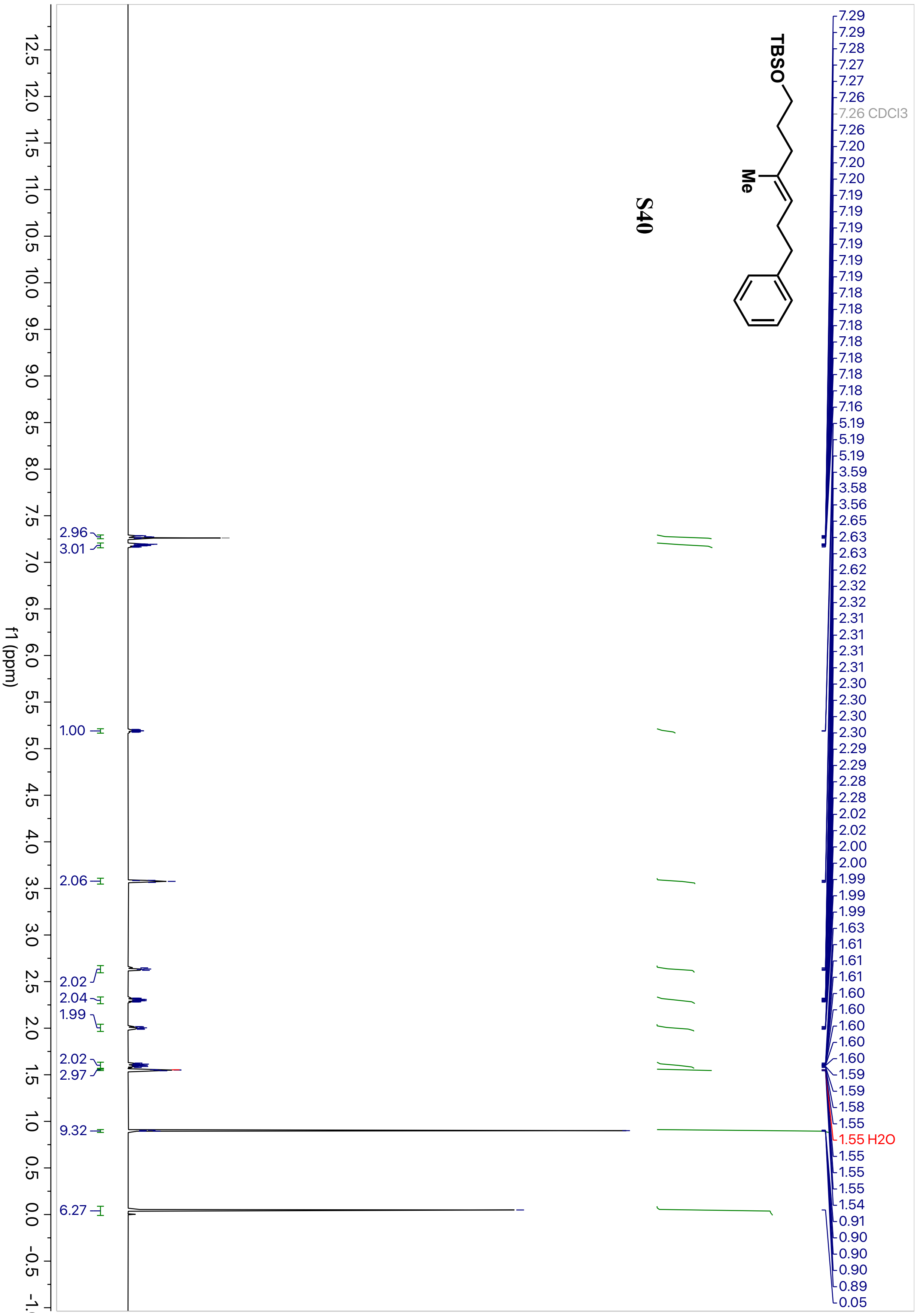
7


169.0
162.0
139.3
134.9
129.1
128.9
128.5
126.9
124.1
77.2 CDCl3
32.9
30.7
O
N
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

7


TBSO
Me
I
1
7.26 CDCl3
5.89
5.89
5.88
5.88
5.88
5.88
3.60
3.59
3.58
3.57
2.28
2.28
2.27
2.26
2.26
2.25
2.25
1.84
1.84
1.67
1.66
1.65
1.65
1.65
1.65
1.65
1.64
1.64
1.64
1.64
1.63
1.63
1.63
1.62
1.54 H2O
0.90
0.89
0.89
0.89
0.04
1.00
2.19
2.10
2.94
2.07
9.85
6.36
f1 (ppm)
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.


TBSO
Me
I
1
147.9
77.2 CDCl3
74.8
62.3
36.0
30.9
26.1
24.0
18.5
-5.2
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)



S40

TBSO
Me
7.29
7.29
7.28
7.27
7.27
7.26
7.26 CDCl3
7.26
7.20
7.20
7.20
7.19
7.19
7.19
7.19
7.19
7.19
7.18
7.18
7.18
7.18
7.18
7.18
7.18
7.16
5.19
5.19
5.19
3.59
3.58
3.56
2.65
2.63
2.63
2.62
2.32
2.32
2.31
2.31
2.31
2.31
2.30
2.30
2.30
2.30
2.29
2.29
2.28
2.28
2.02
2.02
2.00
2.00
1.99
1.99
1.99
1.63
1.61
1.61
1.61
1.60
1.60
1.60
1.60
1.60
1.59
1.59
1.58
1.55
1.55 H2O
1.55
1.55
1.55
1.54
0.91
0.90
0.90
0.90
0.89
0.05
2.96
3.01
1.00
2.06
2.02
2.04
1.99
2.02
2.97
9.32
6.27
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
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-1.
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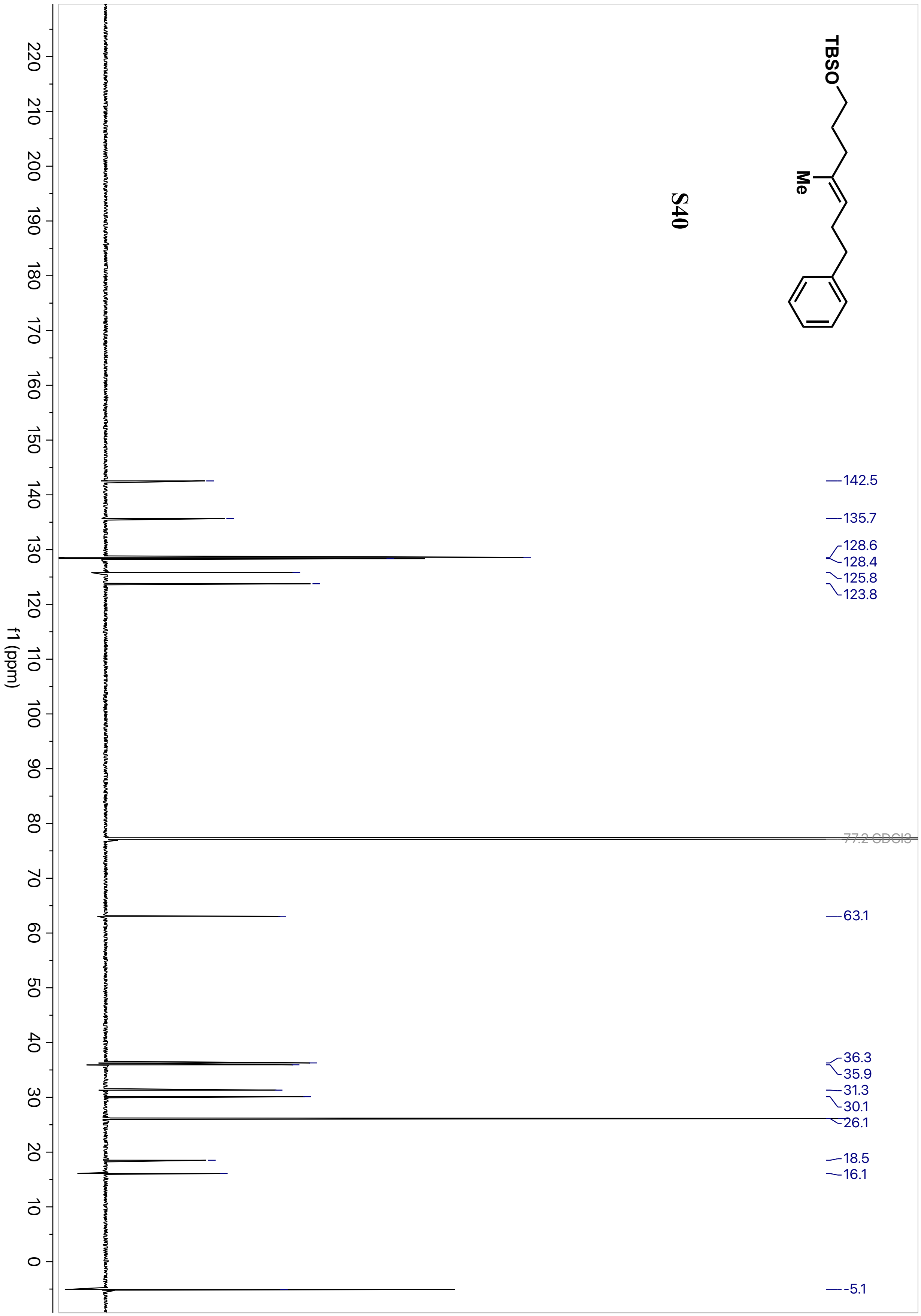
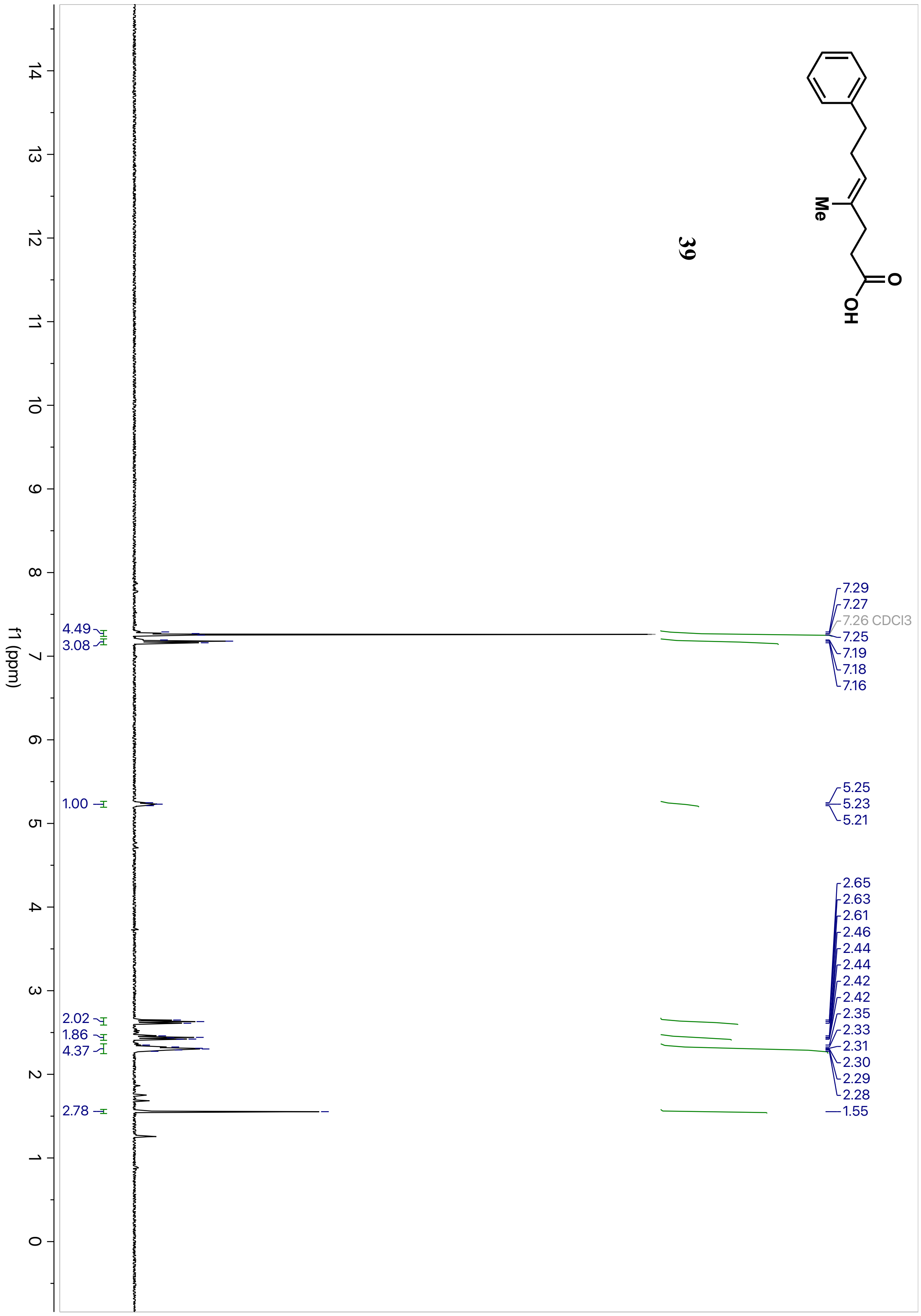
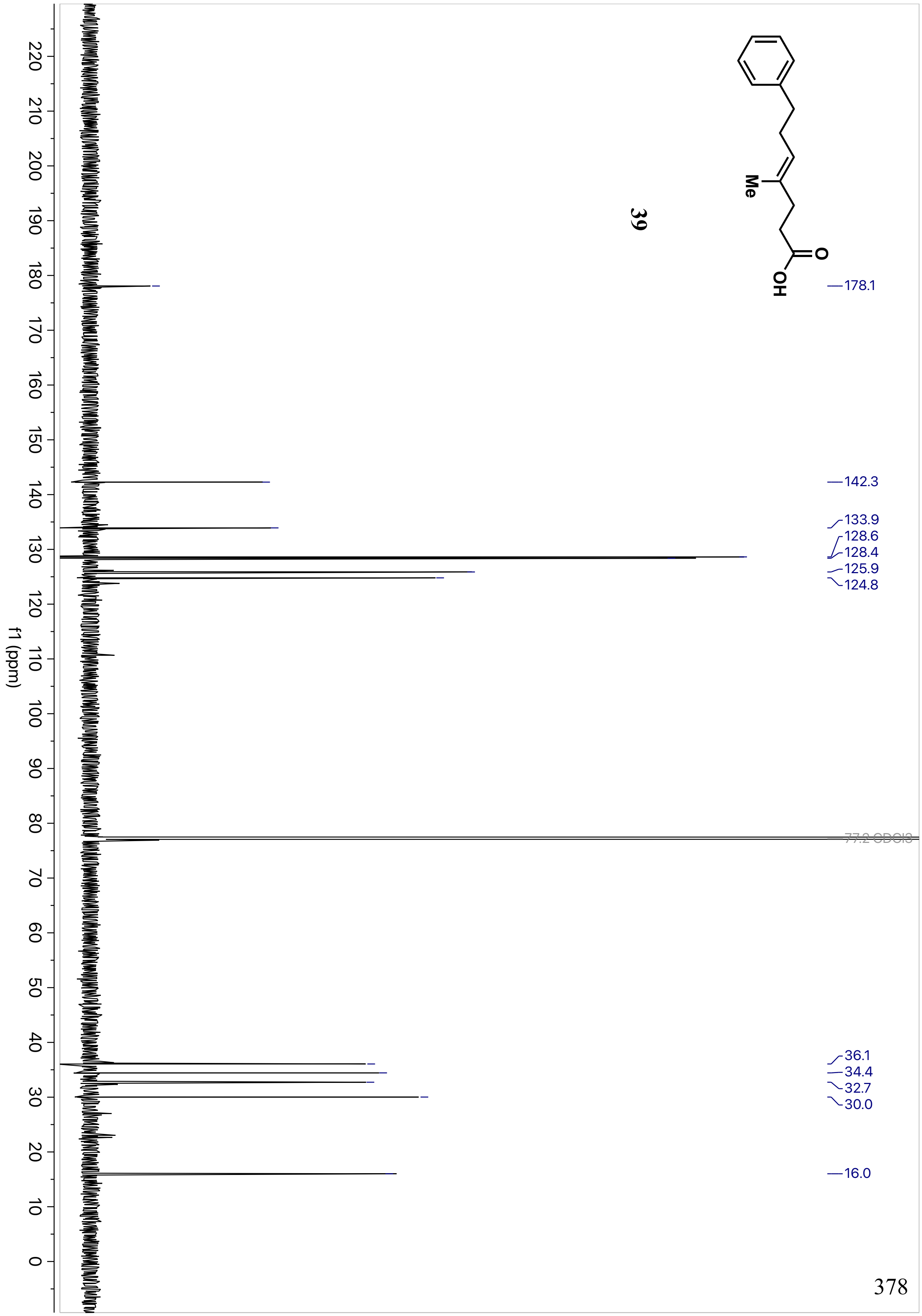

S40

TBSO
Me
142.5
135.7
128.6
128.4
125.8
123.8
77.2 CDCl3
63.1
36.3
35.9
31.3
30.1
26.1
18.5
16.1
-5.1
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


Me
O
OH
7.29
7.27
7.26 CDCl3
7.25
7.19
7.18
7.16
5.25
5.23
5.21
2.65
2.63
2.61
2.46
2.44
2.44
2.42
2.42
2.35
2.33
2.31
2.30
2.29
2.28
1.55
4.49
3.08
1.00
2.02
1.86
4.37
2.78
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

39



—178.1
—142.3
133.9
128.6
128.4
125.9
124.8
77.2 CDCl3
36.1
34.4
32.7
30.0
—16.0
O
OH
Me
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

39

Crystallographic Information

Fig S112— X-ray crystal Structure for (–)- S12

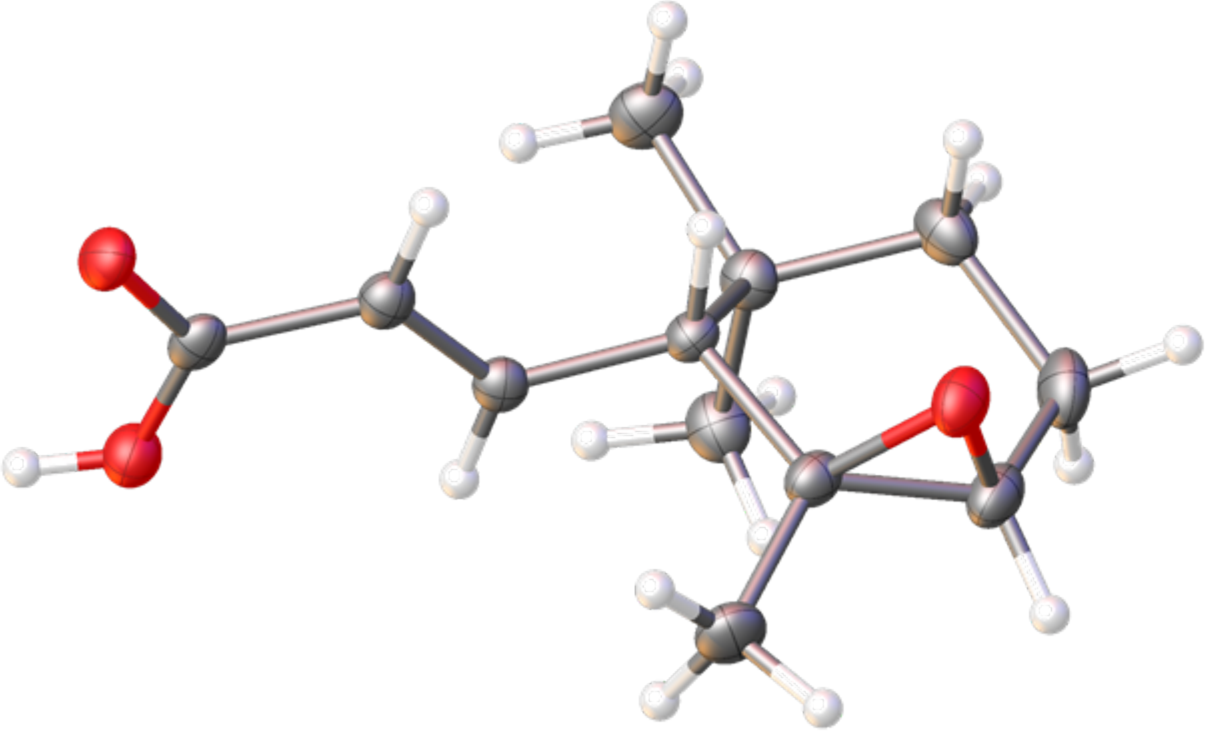
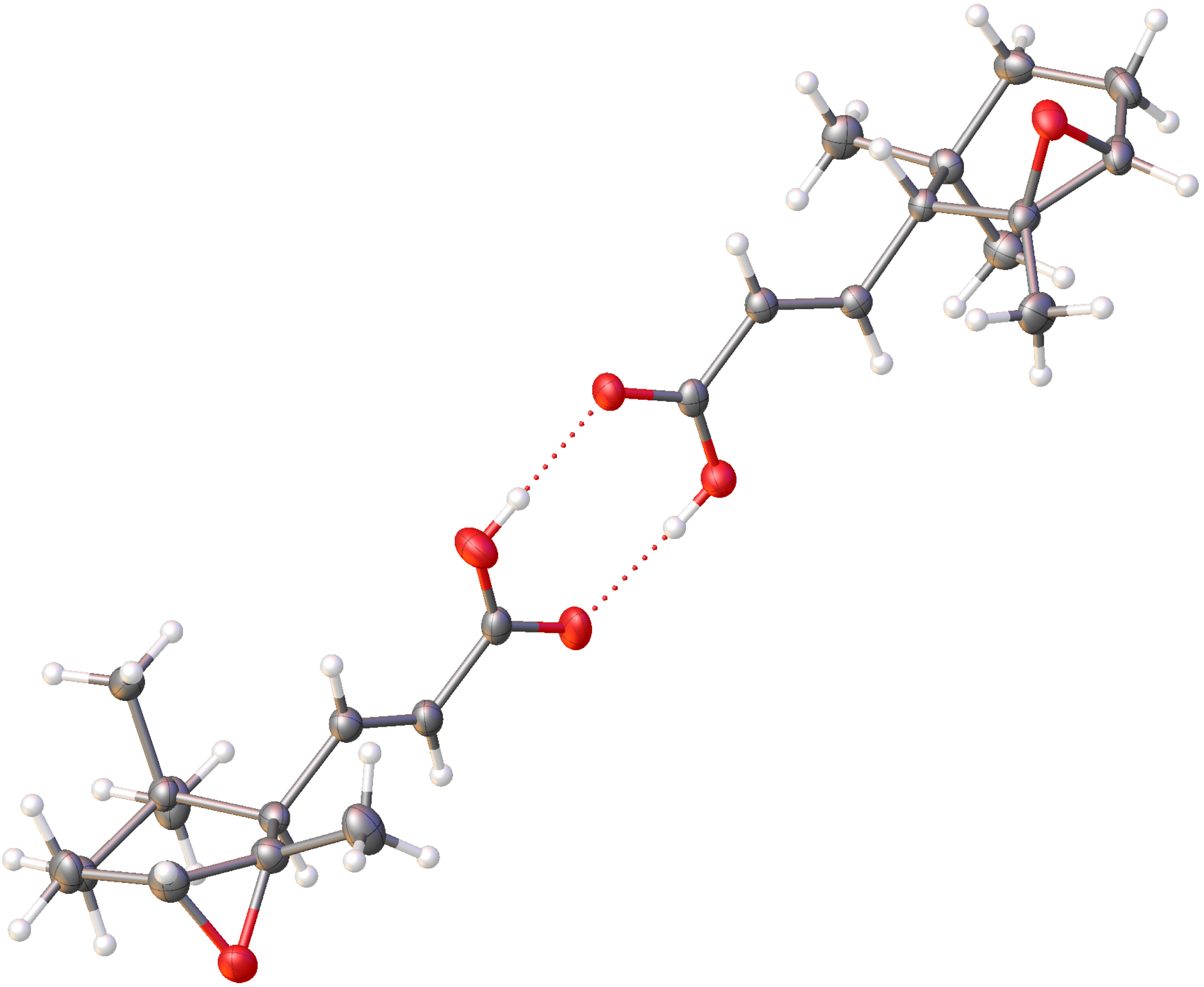


Fig S113 — X-ray crystal Structures for (–)-S12 (dimer)



Experimental Summary

The single crystal X-ray diffraction studies were carried out on a Bruker Pt135 diffractometer equipped with Cu K$_{\square}$ radiation (□=1.54178 Å).

Crystals of the subject compound were used as received (grow from Et2O/Pentane).

A 0.185 x 0.160 x 0.150 mm colorless crystal was mounted on a Cryoloop with Paratone oil. Data were collected in a nitrogen gas stream at 100(2) K using □ and □ scans. Crystal-to-detector distance was 45 mm and exposure time was 4.0, 6.0 and 8.0 seconds (depending on the 2□□ range) per frame using a scan width of 1.50°. Data collection was 99.6 % complete to 67.500° in □. A total of 17538 reflections were collected covering the indices, -7<=h<=7, -18<=k<=17, -30<=l<=30. 4500 reflections were found to be symmetry independent, with a R_{int} of 0.0335. Indexing and unit cell refinement indicated a **P**rimitive, **Orthorhombic** lattice. The space group was found to be $\boldsymbol{P2_12_12_1}$. The data were integrated using the Bruker SAINT Software program and scaled using the SADABS software program. Solution by direct methods (SHELXT) produced a complete phasing model consistent with the proposed structure.

All nonhydrogen atoms were refined anisotropically by full-matrix least-squares (SHELXL-2014). All carbon bonded hydrogen atoms were placed using a riding model. Their positions were constrained relative to their parent atom using the appropriate HFIX command in SHELXL-2014. . Crystallographic data are summarized in Table 1.

Notes: Excellent data and refinement,

Structure as proposed, Absolute structure parameter 0.00(5) conclusive

"acid dimer" with disorder hydrogen positions. (not displayed on pics 2)

Table S53 —Crystal data and structure refinement for (–)-S12

Crystal data and structure refinement for Baran770.

Report date	2020-09-21	
Identification code	baran770	
Empirical formula	C12 H18 O3	
Molecular formula	C12 H18 O3	
Formula weight	210.26	
Temperature	100.15 K	
Wavelength	1.54178 Å	
Crystal system	Orthorhombic	
Space group	$P2_12_12_1$	
Unit cell dimensions	a = 6.0707(3) Å	□= 90°.
	b = 15.3036(7) Å	□= 90°.
	c = 25.4900(12) Å	□ = 90°.
Volume	2368.11(19) Å^3	
Z	8	
Density (calculated)	1.180 Mg/m^3	
Absorption coefficient	0.677 mm^{-1}	
F(000)	912	
Crystal size	0.185 x 0.16 x 0.15 mm^3	
Crystal color, habit	colorless block	
Theta range for data collection	3.368 to 71.250°.	
Index ranges	-7<=h<=7, -18<=k<=17, -30<=l<=30	
Reflections collected	17538	
Independent reflections	4500 [R(int) = 0.0335]	
Completeness to theta = 67.500°	99.6 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	0.7534 and 0.6777	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	4500 / 4 / 289	
Goodness-of-fit on F^2	1.035	
Final R indices [I>2sigma(I)]	R1 = 0.0288, wR2 = 0.0766	
R indices (all data)	R1 = 0.0297, wR2 = 0.0776	
Absolute structure parameter	0.00(5)	
Largest diff. peak and hole	0.202 and -0.143 e.Å^{-3}	

Table S54 — Atomic coordinates and equivalent isotropic displacement parameters for (–)-S12

Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters (Å^{2}x 10^3) for Baran770. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
O(1)	-1883(2)	3636(1)	5040(1)	26(1)
O(2)	5572(2)	6368(1)	4322(1)	25(1)
O(3)	3431(2)	6544(1)	3612(1)	24(1)
C(1)	2125(3)	3618(1)	4856(1)	30(1)
C(2)	229(3)	4068(1)	5124(1)	21(1)
C(3)	-912(3)	3618(1)	5558(1)	26(1)
C(4)	-2123(3)	4098(1)	5979(1)	30(1)
C(5)	-2558(3)	5050(1)	5836(1)	26(1)
C(6)	-526(3)	5518(1)	5609(1)	21(1)
C(7)	31(2)	5071(1)	5076(1)	18(1)
C(8)	1409(3)	5470(1)	5996(1)	26(1)
C(9)	-1123(3)	6477(1)	5509(1)	29(1)
C(10)	1988(3)	5481(1)	4812(1)	19(1)
C(11)	1874(3)	5853(1)	4342(1)	21(1)
C(12)	3751(3)	6279(1)	4081(1)	20(1)
O(1')	14751(2)	8062(1)	1596(1)	30(1)
O(2')	6578(2)	7365(1)	3119(1)	34(1)
O(3')	8600(2)	7342(1)	3855(1)	33(1)
C(1')	11941(4)	6982(1)	1840(1)	37(1)
C(2')	12536(3)	7939(1)	1799(1)	25(1)
C(3')	12888(3)	8327(1)	1278(1)	29(1)
C(4')	12703(3)	9289(1)	1188(1)	30(1)
C(5')	13004(3)	9805(1)	1694(1)	24(1)
C(6')	11489(3)	9494(1)	2139(1)	20(1)
C(7')	11998(3)	8515(1)	2277(1)	20(1)
C(8')	9074(3)	9616(1)	1976(1)	29(1)
C(9')	11934(4)	10060(1)	2622(1)	33(1)
C(10')	10127(3)	8125(1)	2588(1)	22(1)
C(11')	10205(3)	7940(1)	3097(1)	23(1)
C(12')	8340(3)	7526(1)	3372(1)	22(1)

Table S55 —Bond lengths [Å] and angles [°] for (–)-S12

Bond lengths [Å] and angles [°] for Baran770.

O(1)-C(2)	1.4584(19)
O(1)-C(3)	1.4468(19)
O(2)-C(12)	1.271(2)
O(3)-C(12)	1.2774(19)
C(1)-C(2)	1.506(2)
C(2)-C(3)	1.476(2)
C(2)-C(7)	1.545(2)
C(3)-C(4)	1.495(3)
C(4)-C(5)	1.524(3)
C(5)-C(6)	1.539(2)
C(6)-C(7)	1.558(2)
C(6)-C(8)	1.535(2)
C(6)-C(9)	1.532(2)
C(7)-C(10)	1.503(2)
C(10)-C(11)	1.330(2)
C(11)-C(12)	1.471(2)
O(1')-C(2')	1.4533(19)
O(1')-C(3')	1.450(2)
O(2')-C(12')	1.273(2)
O(3')-C(12')	1.273(2)
C(1')-C(2')	1.511(2)
C(2')-C(3')	1.471(2)
C(2')-C(7')	1.539(2)
C(3')-C(4')	1.494(2)
C(4')-C(5')	1.524(2)
C(5')-C(6')	1.535(2)
C(6')-C(7')	1.570(2)
C(6')-C(8')	1.535(2)
C(6')-C(9')	1.531(2)
C(7')-C(10')	1.507(2)
C(10')-C(11')	1.330(2)
C(11')-C(12')	1.474(2)
C(3)-O(1)-C(2)	61.05(10)
O(1)-C(2)-C(1)	113.45(13)
O(1)-C(2)-C(3)	59.09(10)
O(1)-C(2)-C(7)	111.76(12)
C(1)-C(2)-C(7)	118.54(13)
C(3)-C(2)-C(1)	119.04(14)
C(3)-C(2)-C(7)	119.16(14)
O(1)-C(3)-C(2)	59.86(10)
O(1)-C(3)-C(4)	116.47(14)
C(2)-C(3)-C(4)	122.63(14)
C(3)-C(4)-C(5)	112.53(14)
C(4)-C(5)-C(6)	113.33(14)
C(5)-C(6)-C(7)	107.27(13)
C(8)-C(6)-C(5)	110.46(13)
C(8)-C(6)-C(7)	111.84(13)
C(9)-C(6)-C(5)	108.59(13)
C(9)-C(6)-C(7)	109.11(12)
C(9)-C(6)-C(8)	109.49(14)
C(2)-C(7)-C(6)	112.59(12)
C(10)-C(7)-C(2)	112.92(12)
C(10)-C(7)-C(6)	112.23(12)
C(11)-C(10)-C(7)	122.79(14)
C(10)-C(11)-C(12)	123.80(15)
O(2)-C(12)-O(3)	123.35(14)
O(2)-C(12)-C(11)	120.24(14)
O(3)-C(12)-C(11)	116.41(14)
C(3')-O(1')-C(2')	60.90(11)
O(1')-C(2')-C(1')	111.76(14)
O(1')-C(2')-C(3')	59.42(11)
O(1')-C(2')-C(7')	113.88(13)
C(1')-C(2')-C(7')	116.74(14)
C(3')-C(2')-C(1')	119.23(15)
C(3')-C(2')-C(7')	120.93(14)
O(1')-C(3')-C(2')	59.68(10)
O(1')-C(3')-C(4')	114.92(15)
C(2')-C(3')-C(4')	121.73(15)
C(3')-C(4')-C(5')	111.80(14)
C(4')-C(5')-C(6')	113.12(14)
C(5')-C(6')-C(7')	110.14(12)
C(5')-C(6')-C(8')	109.58(13)
C(8')-C(6')-C(7')	111.36(13)
C(9')-C(6')-C(5')	108.26(14)
C(9')-C(6')-C(7')	108.89(12)
C(9')-C(6')-C(8')	108.54(15)
C(2')-C(7')-C(6')	114.24(12)
C(10')-C(7')-C(2')	110.39(13)
C(10')-C(7')-C(6')	110.35(12)
C(11')-C(10')-C(7')	124.75(15)
C(10')-C(11')-C(12')	121.89(16)
O(2')-C(12')-O(3')	123.42(15)
O(2')-C(12')-C(11')	119.19(14)
O(3')-C(12')-C(11')	117.39(15)

Table S56 — Anisotropic displacement parameters for (–)-S12

Anisotropic displacement parameters (Å^{2}x 10^3) for Baran770. The anisotropic displacement factor exponent takes the form: $-2\pi^2[\, h^2\, a^{*2}U^{11} + \ldots + 2\, h\, k\, a^*\, b^*\, U^{12}\,]$

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
O(1)	28(1)	23(1)	27(1)	3(1)	-4(1)	-8(1)
O(2)	25(1)	24(1)	26(1)	3(1)	-1(1)	-2(1)
O(3)	26(1)	26(1)	20(1)	5(1)	3(1)	1(1)
C(1)	33(1)	19(1)	38(1)	-1(1)	2(1)	5(1)
C(2)	23(1)	16(1)	23(1)	1(1)	-4(1)	-1(1)
C(3)	28(1)	21(1)	29(1)	7(1)	-5(1)	-5(1)
C(4)	31(1)	36(1)	24(1)	8(1)	3(1)	-10(1)
C(5)	22(1)	35(1)	19(1)	-1(1)	4(1)	1(1)
C(6)	23(1)	22(1)	17(1)	-1(1)	2(1)	0(1)
C(7)	20(1)	17(1)	17(1)	1(1)	-1(1)	1(1)
C(8)	28(1)	31(1)	20(1)	-2(1)	0(1)	-2(1)
C(9)	36(1)	24(1)	26(1)	-6(1)	3(1)	5(1)
C(10)	21(1)	16(1)	19(1)	-2(1)	1(1)	1(1)
C(11)	24(1)	18(1)	20(1)	-1(1)	1(1)	1(1)
C(12)	27(1)	14(1)	19(1)	-2(1)	3(1)	3(1)
O(1')	27(1)	29(1)	34(1)	4(1)	9(1)	4(1)
O(2')	31(1)	38(1)	33(1)	4(1)	6(1)	-9(1)
O(3')	36(1)	36(1)	26(1)	12(1)	11(1)	9(1)
C(1')	48(1)	25(1)	38(1)	-3(1)	10(1)	-4(1)
C(2')	24(1)	24(1)	26(1)	-1(1)	4(1)	0(1)
C(3')	32(1)	30(1)	23(1)	-2(1)	7(1)	2(1)
C(4')	36(1)	32(1)	22(1)	6(1)	8(1)	4(1)
C(5')	24(1)	22(1)	27(1)	6(1)	4(1)	-1(1)
C(6')	22(1)	21(1)	18(1)	3(1)	0(1)	1(1)
C(7')	20(1)	22(1)	18(1)	3(1)	-1(1)	-1(1)
C(8')	24(1)	35(1)	28(1)	9(1)	4(1)	5(1)
C(9')	51(1)	25(1)	23(1)	-1(1)	-2(1)	0(1)
C(10')	23(1)	20(1)	24(1)	1(1)	1(1)	0(1)
C(11')	25(1)	19(1)	24(1)	4(1)	3(1)	2(1)
C(12')	28(1)	18(1)	22(1)	3(1)	4(1)	4(1)

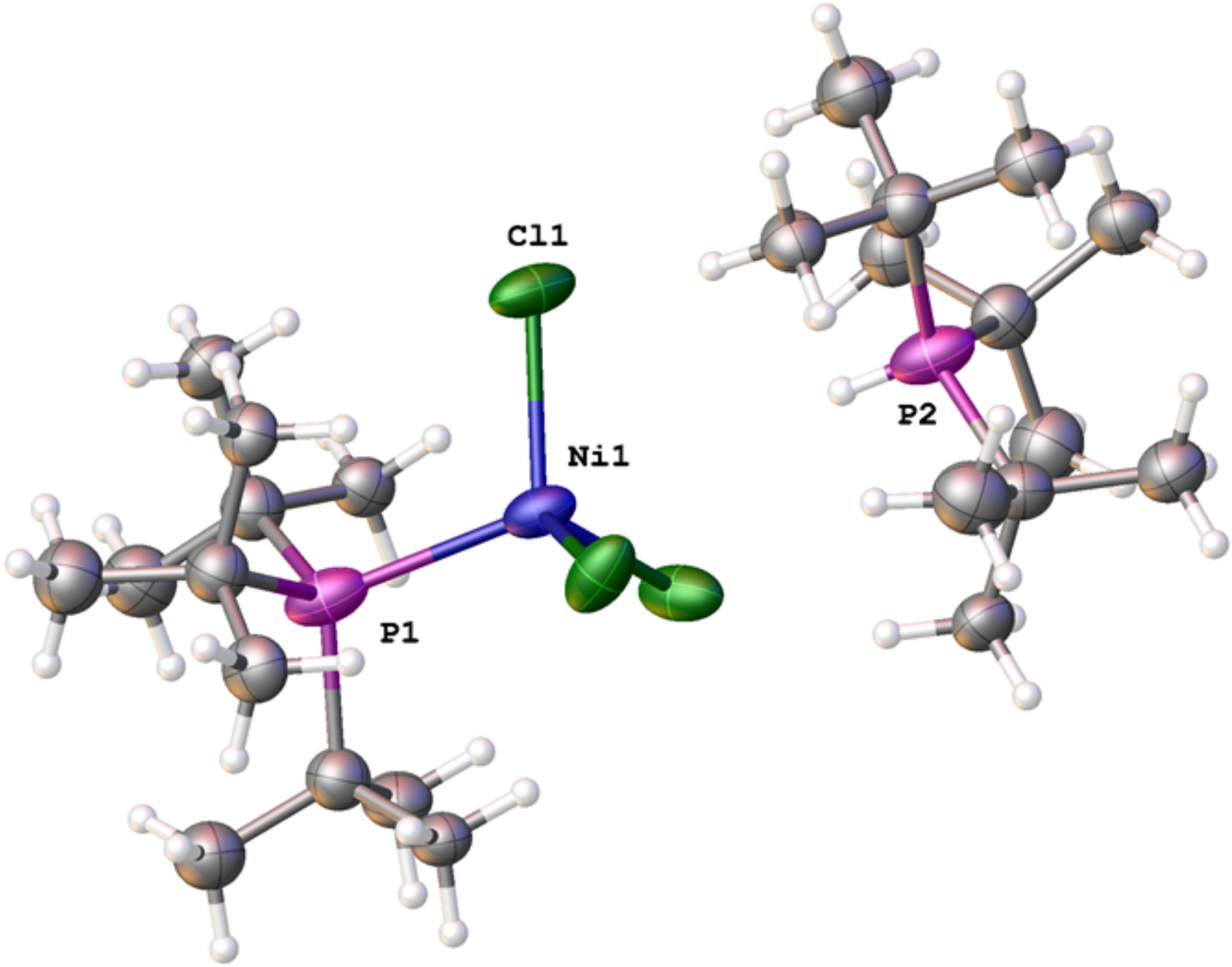
Table S57 — Hydrogen coordinates and isotropic displacement parameters (–)-S12

Hydrogen coordinates (x 10^4) and isotropic displacement parameters ($Å^2$x 10^3)

for Baran770.

	x	y	z	U(eq)
H(2)	6560(60)	6660(30)	4173(17)	38
H(3)	4530(60)	6810(30)	3494(17)	36
H(1A)	1988	2984	4902	45
H(1B)	3515	3817	5011	45
H(1C)	2107	3759	4481	45
H(3A)	-260	3045	5666	31
H(4A)	-1251	4077	6307	36
H(4B)	-3546	3802	6046	36
H(5A)	-3056	5366	6153	31
H(5B)	-3765	5073	5575	31
H(7)	-1256	5183	4841	21
H(8A)	1962	4868	6011	39
H(8B)	911	5650	6345	39
H(8C)	2590	5859	5878	39
H(9A)	141	6778	5353	43
H(9B)	-1509	6758	5842	43
H(9C)	-2381	6507	5269	43
H(10)	3365	5474	4989	22
H(11)	501	5843	4163	25
H(2')	5590(70)	7100(30)	3275(19)	51
H(3')	7550(60)	7090(30)	4013(19)	49
H(1'A)	12449	6675	1525	56
H(1'B)	10339	6923	1871	56
H(1'C)	12649	6729	2150	56
H(3'A)	12537	7945	971	34
H(4'A)	11238	9422	1037	36
H(4'B)	13834	9474	931	36
H(5'A)	12707	10430	1624	29
H(5'B)	14555	9753	1810	29
H(7')	13326	8513	2509	24
H(8'A)	8702	9193	1701	43
H(8'B)	8860	10210	1842	43
H(8'C)	8119	9522	2280	43
H(9'A)	10966	9876	2909	49
H(9'B)	11648	10674	2538	49
H(9'C)	13475	9992	2730	49
H(10')	8795	8003	2406	27
H(11')	11500	8077	3289	27

Fig S114 — X-ray Crystal Structure of $NiCl_3(PtBu_3) \cdot HPtBu_3$



Experimental summary

The single crystal X-ray diffraction studies were carried out on a Bruker D8-Venture 3-circle diffractometer equipped with a Photon3 detector and Mo K_α radiation (λ =0.7107 Å).

Crystals of the subject compound were used as received. A 0.15 x 0.15 x 0.16 mm piece of a blue crystal was mounted on a Cryoloop with Paratone oil. Data were collected in a nitrogen gas stream at 100(2) K using ϕ and ϖ scans. Crystal-to-detector distance was 50 mm and exposure time was 4, 6, 8 seconds per frame using a scan width of 0.70°. Data collection was 99.7 % complete to 25.242° in θ. A total of 24665 reflections were collected covering the indices, -16<=h<=16, -16<=k<=16, -35<=l<=35. 2000 reflections were found to be symmetry independent, with a R_{int} of 0.0485. Indexing and unit cell refinement indicated a **Rhombohedral**, **Trigonal** lattice. The space group was found to be ***R*3*c***. The data were integrated using the Bruker SAINT Software program and scaled using the SADABS software program. Solution by direct methods (SHELXT) produced a complete phasing model consistent with the proposed structure.

All nonhydrogen atoms were refined anisotropically by full-matrix least-squares (SHELXL-2014). All carbon bonded hydrogen atoms were placed using a riding model. Their positions were constrained relative to their parent atom using the appropriate HFIX command in SHELXL-2014. Crystallographic data are summarized in Table 1.

Notes: Good data and refinement. Absolute stereochemistry determination was not applicable (Flack = -0.58(6)). The structure is disordered due to symmetry.

Table S58— Crystal data and structure refinement for NiCl$_3$(PtBu$_3$) • HPtBu$_3$

Crystal data and structure refinement for Baran791_01_b_1st.

Identification code	baran791_01_b_1st	
Empirical formula	C24 H55 Cl3 Ni P2	
Formula weight	570.68	
Temperature	100 K	
Wavelength	0.71073 Å	
Crystal system	Trigonal	
Space group	R 3 c	
Unit cell dimensions	a = 13.5923(9) Å	α= 90°.
	b = 13.5923(9) Å	β= 90°.
	c = 28.142(3) Å	γ = 120°.
Volume	4502.6(8) Å^3	
Z	6	
Density (calculated)	1.263 Mg/m^3	
Absorption coefficient	1.031 mm^{-1}	
F(000)	1848	
Crystal size	0.16 x 0.15 x 0.15 mm^3	
Theta range for data collection	3.374 to 26.414°.	
Index ranges	-16<=h<=16, -16<=k<=16, -35<=l<=31	
Reflections collected	24665	
Independent reflections	2000 [R(int) = 0.0483]	
Completeness to theta = 25.242°	99.7 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	0.6465 and 0.5903	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	2000 / 163 / 182	
Goodness-of-fit on F^2	1.067	
Final R indices [I>2sigma(I)]	R1 = 0.0376, wR2 = 0.0840	
R indices (all data)	R1 = 0.0517, wR2 = 0.0948	
Absolute structure parameter	0.58(6)	
Extinction coefficient	n/a	
Largest diff. peak and hole	0.389 and -0.227 e.Å^{-3}	

Table S59— Atomic coordinates and equivalent isotropic displacement parameters for $NiCl_3(PtBu_3)$ • $HPtBu_3$

Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters ($Å^2$x 10^3)

for Baran791_01_b_1st. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
Cl(1)	5105(1)	3340(3)	4958(1)	53(1)
Ni(1)	6667	3333	4702(1)	39(1)
P(1)	6667	3333	3861(3)	50(2)
P(2)	6667	3333	6252(3)	50(2)
C(1)	6252(11)	4385(12)	3636(5)	46(4)
C(2)	6822(12)	5440(12)	3959(4)	40(3)
C(3)	4970(11)	3910(14)	3708(5)	47(4)
C(4)	6596(16)	4771(16)	3123(6)	58(4)
C(5)	7183(11)	4841(12)	6425(5)	45(4)
C(6)	8476(13)	5545(17)	6351(7)	62(5)
C(7)	6894(17)	4942(16)	6946(6)	50(4)
C(8)	6611(14)	5301(14)	6083(5)	44(4)
Ni(2)	6667	3333	5191(2)	41(2)
P(1A)	6667	3333	3653(6)	50(2)
P(2A)	6667	3333	6055(6)	50(2)
C(1A)	6171(15)	4323(16)	3467(7)	35(5)
C(2A)	6720(20)	5382(19)	3778(8)	43(6)
C(3A)	4874(15)	3791(19)	3522(8)	36(5)
C(4A)	6400(20)	4670(20)	2952(8)	48(6)
C(5A)	7038(16)	4840(20)	6260(8)	44(6)
C(6A)	8338(17)	5640(20)	6222(9)	40(6)
C(7A)	6870(30)	4940(30)	6785(10)	67(10)
C(8A)	6360(20)	5190(20)	5925(9)	61(7)

Table S60 — Bond lengths and angles for NiCl3(PtBu3) • HPtBu3

Bond lengths [Å] and angles [°] for Baran791_01_b_1st.

Cl(1)-Ni(1)	2.2459(16)	C(8)-H(8C)	0.9800
Cl(1)-Ni(2)	2.2257(19)	Ni(2)-P(2A)	2.43(2)
Ni(1)-P(1)	2.367(10)	P(1A)-H(1A)	1.0000
P(1)-C(1)#1	1.889(16)	P(1A)-C(1A)#1	1.86(2)
P(1)-C(1)#2	1.889(16)	P(1A)-C(1A)#2	1.86(2)
P(1)-C(1)	1.889(16)	P(1A)-C(1A)	1.86(2)
P(2)-H(2)	1.0000	P(2A)-C(5A)#1	1.94(2)
P(2)-C(5)#2	1.869(15)	P(2A)-C(5A)#2	1.94(3)
P(2)-C(5)	1.869(15)	P(2A)-C(5A)	1.94(2)
P(2)-C(5)#1	1.869(15)	C(1A)-C(2A)	1.524(17)
C(1)-C(2)	1.539(14)	C(1A)-C(3A)	1.543(16)
C(1)-C(3)	1.539(13)	C(1A)-C(4A)	1.508(18)
C(1)-C(4)	1.528(14)	C(2A)-H(2AA)	0.9800
C(2)-H(2A)	0.9800	C(2A)-H(2AB)	0.9800
C(2)-H(2B)	0.9800	C(2A)-H(2AC)	0.9800
C(2)-H(2C)	0.9800	C(3A)-H(3AA)	0.9800
C(3)-H(3A)	0.9800	C(3A)-H(3AB)	0.9800
C(3)-H(3B)	0.9800	C(3A)-H(3AC)	0.9800
C(3)-H(3C)	0.9800	C(4A)-H(4AA)	0.9800
C(4)-H(4A)	0.9800	C(4A)-H(4AB)	0.9800
C(4)-H(4B)	0.9800	C(4A)-H(4AC)	0.9800
C(4)-H(4C)	0.9800	C(5A)-C(6A)	1.546(17)
C(5)-C(6)	1.538(15)	C(5A)-C(7A)	1.513(19)
C(5)-C(7)	1.540(15)	C(5A)-C(8A)	1.548(18)
C(5)-C(8)	1.553(14)	C(6A)-H(6AA)	0.9800
C(6)-H(6A)	0.9800	C(6A)-H(6AB)	0.9800
C(6)-H(6B)	0.9800	C(6A)-H(6AC)	0.9800
C(6)-H(6C)	0.9800	C(7A)-H(7AA)	0.9800
C(7)-H(7A)	0.9800	C(7A)-H(7AB)	0.9800
C(7)-H(7B)	0.9800	C(7A)-H(7AC)	0.9800
C(7)-H(7C)	0.9800	C(8A)-H(8AA)	0.9800
C(8)-H(8A)	0.9800	C(8A)-H(8AB)	0.9800
C(8)-H(8B)	0.9800	C(8A)-H(8AC)	0.9800

Cl(1)#2-Ni(1)-Cl(1)#1	110.22(10)
Cl(1)#2-Ni(1)-Cl(1)	110.22(10)
Cl(1)#1-Ni(1)-Cl(1)	110.22(10)
Cl(1)#1-Ni(1)-P(1)	108.71(10)
Cl(1)-Ni(1)-P(1)	108.71(10)
Cl(1)#2-Ni(1)-P(1)	108.71(10)
C(1)-P(1)-Ni(1)	109.6(5)
C(1)#2-P(1)-Ni(1)	109.6(5)
C(1)#1-P(1)-Ni(1)	109.6(5)
C(1)#2-P(1)-C(1)	109.3(5)
C(1)#1-P(1)-C(1)	109.3(5)
C(1)#1-P(1)-C(1)#2	109.3(5)
C(5)-P(2)-H(2)	105.1
C(5)#2-P(2)-H(2)	105.1
C(5)#1-P(2)-H(2)	105.1
C(5)#2-P(2)-C(5)	113.4(4)
C(5)#1-P(2)-C(5)	113.4(4)
C(5)#1-P(2)-C(5)#2	113.4(4)
C(2)-C(1)-P(1)	107.7(10)
C(3)-C(1)-P(1)	110.0(10)
C(3)-C(1)-C(2)	104.5(12)
C(4)-C(1)-P(1)	114.9(11)
C(4)-C(1)-C(2)	108.2(12)
C(4)-C(1)-C(3)	110.9(13)
C(1)-C(2)-H(2A)	109.5
C(1)-C(2)-H(2B)	109.5
C(1)-C(2)-H(2C)	109.5
H(2A)-C(2)-H(2B)	109.5
H(2A)-C(2)-H(2C)	109.5
H(2B)-C(2)-H(2C)	109.5
C(1)-C(3)-H(3A)	109.5
C(1)-C(3)-H(3B)	109.5
C(1)-C(3)-H(3C)	109.5
H(3A)-C(3)-H(3B)	109.5
H(3A)-C(3)-H(3C)	109.5
H(3B)-C(3)-H(3C)	109.5
C(1)-C(4)-H(4A)	109.5
C(1)-C(4)-H(4B)	109.5
C(1)-C(4)-H(4C)	109.5
H(4A)-C(4)-H(4B)	109.5
H(4A)-C(4)-H(4C)	109.5
H(4B)-C(4)-H(4C)	109.5
C(6)-C(5)-P(2)	109.4(11)
C(6)-C(5)-C(7)	109.7(14)
C(6)-C(5)-C(8)	108.1(12)
C(7)-C(5)-P(2)	111.9(10)
C(7)-C(5)-C(8)	110.7(12)
C(8)-C(5)-P(2)	106.9(10)
C(5)-C(6)-H(6A)	109.5
C(5)-C(6)-H(6B)	109.5
C(5)-C(6)-H(6C)	109.5
H(6A)-C(6)-H(6B)	109.5
H(6A)-C(6)-H(6C)	109.5
H(6B)-C(6)-H(6C)	109.5
C(5)-C(7)-H(7A)	109.5
C(5)-C(7)-H(7B)	109.5
C(5)-C(7)-H(7C)	109.5
H(7A)-C(7)-H(7B)	109.5
H(7A)-C(7)-H(7C)	109.5
H(7B)-C(7)-H(7C)	109.5
C(5)-C(8)-H(8A)	109.5
C(5)-C(8)-H(8B)	109.5
C(5)-C(8)-H(8C)	109.5
H(8A)-C(8)-H(8B)	109.5
H(8A)-C(8)-H(8C)	109.5
H(8B)-C(8)-H(8C)	109.5
Cl(1)#2-Ni(2)-Cl(1)#1	111.73(13)
Cl(1)#2-Ni(2)-Cl(1)	111.73(13)
Cl(1)#1-Ni(2)-Cl(1)	111.73(13)
Cl(1)#1-Ni(2)-P(2A)	107.11(14)
Cl(1)-Ni(2)-P(2A)	107.11(14)
Cl(1)#2-Ni(2)-P(2A)	107.11(14)

C(1A)-P(1A)-H(1A)	106.4
C(1A)#2-P(1A)-H(1A)	106.4
C(1A)#1-P(1A)-H(1A)	106.4
C(1A)#2-P(1A)-C(1A)	112.4(6)
C(1A)#1-P(1A)-C(1A)	112.4(6)
C(1A)#1-P(1A)-C(1A)#2	112.4(6)
C(5A)-P(2A)-Ni(2)	107.3(8)
C(5A)#2-P(2A)-Ni(2)	107.3(8)
C(5A)#1-P(2A)-Ni(2)	107.3(8)
C(5A)#2-P(2A)-C(5A)	111.6(7)
C(5A)#1-P(2A)-C(5A)	111.6(7)
C(5A)#1-P(2A)-C(5A)#2	111.6(7)
C(2A)-C(1A)-P(1A)	109.9(15)
C(2A)-C(1A)-C(3A)	106.7(17)
C(3A)-C(1A)-P(1A)	112.0(13)
C(4A)-C(1A)-P(1A)	113.9(16)
C(4A)-C(1A)-C(2A)	109.2(18)
C(4A)-C(1A)-C(3A)	104.8(18)
C(1A)-C(2A)-H(2AA)	109.5
C(1A)-C(2A)-H(2AB)	109.5
C(1A)-C(2A)-H(2AC)	109.5
H(2AA)-C(2A)-H(2AB)	109.5
H(2AA)-C(2A)-H(2AC)	109.5
H(2AB)-C(2A)-H(2AC)	109.5
C(1A)-C(3A)-H(3AA)	109.5
C(1A)-C(3A)-H(3AB)	109.5
C(1A)-C(3A)-H(3AC)	109.5
H(3AA)-C(3A)-H(3AB)	109.5
H(3AA)-C(3A)-H(3AC)	109.5
H(3AB)-C(3A)-H(3AC)	109.5
C(1A)-C(4A)-H(4AA)	109.5
C(1A)-C(4A)-H(4AB)	109.5
C(1A)-C(4A)-H(4AC)	109.5
H(4AA)-C(4A)-H(4AB)	109.5
H(4AA)-C(4A)-H(4AC)	109.5
H(4AB)-C(4A)-H(4AC)	109.5
C(6A)-C(5A)-P(2A)	108.7(15)
C(6A)-C(5A)-C(8A)	112.9(19)
C(7A)-C(5A)-P(2A)	114.3(18)
C(7A)-C(5A)-C(6A)	100(2)
C(7A)-C(5A)-C(8A)	115(2)
C(8A)-C(5A)-P(2A)	105.4(16)
C(5A)-C(6A)-H(6AA)	109.5
C(5A)-C(6A)-H(6AB)	109.5
C(5A)-C(6A)-H(6AC)	109.5
H(6AA)-C(6A)-H(6AB)	109.5
H(6AA)-C(6A)-H(6AC)	109.5
H(6AB)-C(6A)-H(6AC)	109.5
C(5A)-C(7A)-H(7AA)	109.5
C(5A)-C(7A)-H(7AB)	109.5
C(5A)-C(7A)-H(7AC)	109.5
H(7AA)-C(7A)-H(7AB)	109.5
H(7AA)-C(7A)-H(7AC)	109.5
H(7AB)-C(7A)-H(7AC)	109.5
C(5A)-C(8A)-H(8AA)	109.5
C(5A)-C(8A)-H(8AB)	109.5
C(5A)-C(8A)-H(8AC)	109.5
H(8AA)-C(8A)-H(8AB)	109.5
H(8AA)-C(8A)-H(8AC)	109.5
H(8AB)-C(8A)-H(8AC)	109.5

Symmetry transformations used to generate equivalent atoms:

#1 -x+y+1,-x+1,z #2 -y+1,x-y,z

Table S61 — Anisotropic displacement parameters for NiCl3(PtBu3) • HPtBu3

Anisotropic displacement parameters (Å^{2}x 10^3) for Baran791_01_b_1st. The anisotropic displacement factor exponent takes the form: $-2\pi^2[h^2 a^{*2}U^{11} + ... + 2 h k a^* b^* U^{12}]$

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
Cl(1)	34(1)	52(1)	78(1)	26(1)	14(1)	26(1)
Ni(1)	26(1)	26(1)	65(2)	0	0	13(1)
P(1)	32(1)	32(1)	86(6)	0	0	16(1)
P(2)	31(1)	31(1)	89(7)	0	0	16(1)
C(1)	47(4)	45(5)	46(4)	1(3)	0(3)	23(3)
C(2)	45(4)	39(4)	43(5)	3(3)	1(3)	25(3)
C(3)	48(5)	48(5)	52(5)	4(4)	-4(3)	30(4)
C(4)	63(6)	56(5)	59(6)	3(4)	3(4)	32(4)
C(5)	47(5)	42(5)	49(5)	2(3)	-1(3)	24(3)
C(6)	60(6)	57(6)	65(7)	2(4)	-3(4)	26(4)
C(7)	49(5)	48(5)	57(5)	0(4)	1(4)	27(4)
C(8)	50(5)	38(5)	47(5)	-3(4)	-1(4)	24(3)
Ni(2)	24(1)	24(1)	77(4)	0	0	12(1)
P(1A)	32(1)	32(1)	86(6)	0	0	16(1)
P(2A)	31(1)	31(1)	89(7)	0	0	16(1)
C(1A)	36(6)	34(6)	39(6)	1(3)	0(3)	20(4)
C(2A)	45(7)	39(7)	49(7)	-1(4)	-1(4)	25(4)
C(3A)	33(6)	37(6)	45(6)	0(4)	2(4)	24(4)
C(4A)	49(7)	46(7)	53(8)	1(4)	0(4)	26(5)
C(5A)	45(6)	43(6)	43(6)	-3(3)	2(3)	22(4)
C(6A)	41(7)	36(7)	41(7)	-2(4)	-1(4)	19(4)
C(7A)	68(10)	67(10)	66(10)	0(4)	0(4)	33(6)
C(8A)	63(8)	59(8)	68(8)	1(4)	-1(4)	36(5)

Table S62 — Hydrogen coordinates and isotropic displacement parameters for NiCl3(PtBu3) • HPtBu3

Hydrogen coordinates (x 10^4) and isotropic displacement parameters ($Å^2$x 10^3)

for Baran791_01_b_1st.

	x	y	z	U(eq)
H(2)	6667	3333	5896	60
H(2A)	6601	5212	4290	61
H(2B)	6580	5980	3863	61
H(2C)	7650	5800	3929	61
H(3A)	4543	3248	3502	70
H(3B)	4778	4496	3627	70
H(3C)	4772	3685	4041	70
H(4A)	6238	4110	2911	87
H(4B)	7423	5139	3093	87
H(4C)	6347	5310	3035	87
H(6A)	8858	5310	6582	93
H(6B)	8731	6353	6394	93
H(6C)	8663	5420	6028	93
H(7A)	6070	4498	6991	75
H(7B)	7164	5741	7021	75
H(7C)	7265	4651	7156	75
H(8A)	6821	5249	5754	66
H(8B)	6866	6096	6160	66
H(8C)	5784	4848	6117	66
H(1A)	6667	3333	4008	60
H(2AA)	6567	5158	4113	64
H(2AB)	6394	5865	3700	64
H(2AC)	7538	5802	3722	64
H(3AA)	4486	3167	3295	54
H(3AB)	4660	4369	3461	54
H(3AC)	4651	3498	3846	54
H(4AA)	7224	5107	2898	72
H(4AB)	6068	5145	2872	72
H(4AC)	6065	3994	2750	72
H(6AA)	8710	5504	6493	60
H(6AB)	8514	6428	6223	60
H(6AC)	8613	5477	5926	60
H(7AA)	6054	4528	6858	101
H(7AB)	7194	5739	6871	101
H(7AC)	7247	4606	6967	101
H(8AA)	5565	4810	6023	92

H(8AB)	6416	4975	5598	92
H(8AC)	6682	6018	5941	92

Manuscript References

1. K. C. Nicolaou, E. J. Sorenson, *Classics in Total Synthesis: Targets, Strategies, Methods*. (1997), pp. xxii - 798.
2. D. Cox-Georgian, N. Ramadoss, C. Dona, C. Basu, Therapeutic and Medicinal Uses of Terpenes. *Medicinal Plants*, 333 - 359 (2019).
3. D. J. Jansen, R. A. Shenvi, Synthesis of medicinally relevant terpenes: reducing the cost and time of drug discovery. *Future Med. Chem.* **6**, 1127-1148 (2014).
4. S. Serra, in *Studies in Natural Products Chemistry,* R. Atta ur, Ed. (Elsevier, 2015), vol. 46, pp. 201-226.
5. W. S. Johnson, M. B. Gravestock, B. E. McCarry, Acetylenic bond participation in biogenetic-like olefinic cyclizations. II. Synthesis of dl-progesterone. *J. Am. Chem. Soc.* **93**, 4332-4334 (1971).
6. R. A. Yoder, J. N. Johnston, A Case Study in Biomimetic Total Synthesis: Polyolefin Carbocyclizations to Terpenes and Steroids. *Chem. Rev.* **105**, 4730-4756 (2005).
7. C. N. Ungarean, E. H. Southgate, D. Sarlah, Enantioselective polyene cyclizations. *Org. Biomol. Chem.* **14**, 5454-5467 (2016).
8. C. Thirsk, A. Whiting, Polyene natural products. *J. Chen. Soc. Perkin Trans. I*, 999-1023 (2002).
9. E.-i. Negishi, G. Wang, H. Rao, Z. Xu, Alkyne Elementometalation−Pd-Catalyzed Cross-Coupling. Toward Synthesis of All Conceivable Types of Acyclic Alkenes in High Yields, Efficiently, Selectively, Economically, and Safely: “Green” Way. *J. Org. Chem.* **75**, 3151-3182 (2010).
10. J. Li, A. S. Grillo, M. D. Burke, From Synthesis to Function via Iterative Assembly of N-Methyliminodiacetic Acid Boronate Building Blocks. *Acc. Chem. Res.* **48**, 2297-2307 (2015).
11. P. M. Dewick, The mevalonate and methylerythritol phosphate pathways: Terpenoids and steroids. *Medicinal Natural Products; A biosynthetic approach* **2**, 167-289 (2002).
12. J. M. Smith, S. J. Harwood, P. S. Baran, Radical Retrosynthesis. *Acc. Chem. Res.* **51**, 1807-1817 (2018).
13. D. S. Peters, C. R. Pitts, K. S. McClymont, T. P. Stratton, C. Bi, P. S. Baran, Ideality in Context: Motivations for Total Synthesis. *Acc. Chem. Res.* **54**, 605-617 (2021).
14. J. T. Edwards, R. R. Merchant, K. S. McClymont, K. W. Knouse, T. Qin, L. R. Malins, B. Vokits, S. A. Shaw, D.-H. Bao, F.-L. Wei, T. Zhou, M. D. Eastgate, P. S. Baran, Decarboxylative alkenylation. *Nature* **545**, 213-218 (2017).
15. C. Cannes, S. Condon, M. Durandetti, J. Périchon, J. Y. Nédélec, Nickel-Catalyzed Electrochemical Couplings of Vinyl Halides: Synthetic and Stereochemical Aspects. *J. Org. Chem.* **65**, 4575-4583 (2000).
16. L. F. T. Novaes, J. Liu, Y. Shen, L. Lu, J. M. Meinhardt, S. Lin, Electrocatalysis as an enabling technology for organic synthesis. *Chem. Soc. Rev.* **50**, 7941-8002 (2021).
17. T. Wirtanen, T. Prenzel, J.-P. Tessonnier, S. R. Waldvogel, Cathodic Corrosion of Metal Electrodes—How to Prevent It in Electroorganic Synthesis. *Chem. Rev.* **121**, 10241-10270 (2021).

18. J. M. Campelo, D. Luna, R. Luque, J. M. Marinas, A. A. Romero, Sustainable Preparation of Supported Metal Nanoparticles and Their Applications in Catalysis. *ChemSusChem* **2**, 18-45 (2009).
19. K. M. M. Huihui, J. A. Caputo, Z. Melchor, A. M. Olivares, A. M. Spiewak, K. A. Johnson, T. A. DiBenedetto, S. Kim, L. K. G. Ackerman, D. J. Weix, Decarboxylative Cross-Electrophile Coupling of N-Hydroxyphthalimide Esters with Aryl Iodides. *J. Am. Chem. Soc.* **138**, 5016-5019 (2016).
20. T. Koyanagi, A. Herath, A. Chong, M. Ratnikov, A. Valiere, J. Chang, V. Molteni, J. Loren, One-Pot Electrochemical Nickel-Catalyzed Decarboxylative Sp2–Sp3 Cross-Coupling. *Org. Lett.* **21**, 816-820 (2019).
21. H. Li, C. P. Breen, H. Seo, T. F. Jamison, Y.-Q. Fang, M. M. Bio, Ni-Catalyzed Electrochemical Decarboxylative C–C Couplings in Batch and Continuous Flow. *Org. Lett.* **20**, 1338-1341 (2018).
22. R. J. Perkins, D. J. Pedro, E. C. Hansen, Electrochemical Nickel Catalysis for Sp2-Sp3 Cross-Electrophile Coupling Reactions of Unactivated Alkyl Halides. *Org. Lett.* **19**, 3755-3758 (2017).
23. R. Slegeris, G. B. Dudley, Alternative synthetic approaches to rac-progesterone by way of the classic Johnson cationic polycyclization strategy. *Tetrahedron* **72**, 3666-3672 (2016).
24. A. M. Camelio, T. C. Johnson, D. Siegel, Total Synthesis of Celastrol, Development of a Platform to Access Celastroid Natural Products. *J. Am. Chem. Soc.* **137**, 11864-11867 (2015).
25. B. B. Snider, J. Y. Kiselgof, B. M. Foxman, Total Syntheses of (±)-Isosteviol and (±)-Beyer-15-ene-3β,19-diol by Manganese(III)-Based Oxidative Quadruple Free-Radical Cyclization. *J. Org. Chem.* **63**, 7945-7952 (1998).
26. R. P. Walker, D. J. Faulkner, Diterpenes from the sponge Dysidea amblia. *J. Org. Chem.* **46**, 1098-1102 (1981).
27. J. E. Thompson, R. P. Walker, D. J. Faulkner, Screening and bioassays for biologically-active substances from forty marine sponge species from San Diego, California, USA. *Mar. Biol.* **88**, 11-21 (1985).
28. S. Serra, V. Lissoni, First Enantioselective Synthesis of Marine Diterpene Ambliol-A. *Eur. J. Org. Chem.* **2015**, 2226-2234 (2015).
29. R. H. Scheffrahn, L. K. Gaston, J. J. Sims, M. K. Rust, Identification of the defensive secretion from soldiers of the North American termite,Amitermes wheeleri (Desneux) (Isoptera: Termitidae). *J. Chem. Ecol.* **9**, 1293-1305 (1983).
30. W. L. Roelofs, M. J. Gieselmann, A. M. CardÉ, H. Tashiro, D. S. Moreno, C. A. Henrick, R. J. Anderson, Sex pheromone of the California red scale, Aonidiella aurantii. *Nature* **267**, 698-699 (1977).
31. D. J. Weix, Methods and Mechanisms for Cross-Electrophile Coupling of Csp2 Halides with Alkyl Electrophiles. *Acc. Chem. Res.* **48**, 1767-1775 (2015).
32. C. Brito, V. L. Jordão, G. J. Pierce, Ambergris as an overlooked historical marine resource: its biology and role as a global economic commodity. *J. Mar. Biol. Assoc. U. K.* **96**, 585-596 (2016).
33. A. F. Barrero, J. Altarejos, E. J. Alvarez-Manzaneda, J. M. Ramos, S. Salido, Synthesis of (±)-Ambrox from (E)-Nerolidol and β-Ionone via Allylic Alcohol [2,3] Sigmatropic Rearrangement. *J. Org. Chem.* **61**, 2215-2218 (1996).

34. V. Schubert, A. Dietrich, T. Ulrich, A. Mosandl, The Stereoisomers of Nerolidol: Separation, Analysis and Olfactoric Properties. *Zeitschrift für Naturforschung C* **47**, 304-307 (1992).
35. G. Ben Salha, M. Abderrabba, J. Labidi, A status review of terpenes and their separation methods. *Rev. Chem. Eng.* **37**, 433-447 (2021).
36. W.-K. Chan, L. T. Tan, K.-G. Chan, L.-H. Lee, B.-H. Goh, Nerolidol: A Sesquiterpene Alcohol with Multi-Faceted Pharmacological and Biological Activities. *Molecules* **21**, 529 (2016).
37. D. McGinty, C. S. Letizia, A. M. Api, Addendum to Fragrance material review on Nerolidol (isomer unspecified). *Food and Chemical Toxicology* **48**, S43-S45 (2010).
38. X.-Y. Dong, Z.-W. Gao, K.-F. Yang, W.-Q. Zhang, L.-W. Xu, Nanosilver as a new generation of silver catalysts in organic transformations for efficient synthesis of fine chemicals. *Catalysis Science & Technology* **5**, 2554-2574 (2015).
39. R. R. Chillawar, K. K. Tadi, R. V. Motghare, Voltammetric techniques at chemically modified electrodes. *J. Anal. Chem.* **70**, 399-418 (2015).
40. J.-M. Zen, A. Senthil Kumar, D.-M. Tsai, Recent Updates of Chemically Modified Electrodes in Analytical Chemistry. *Electroanalysis* **15**, 1073-1087 (2003).
41. J. E. Nutting, J. B. Gerken, A. G. Stamoulis, D. L. Bruns, S. S. Stahl, "How Should I Think about Voltage? What Is Overpotential?": Establishing an Organic Chemistry Intuition for Electrochemistry. *J. Org. Chem.*, (2021).
42. X. Luo, A. Morrin, A. J. Killard, M. R. Smyth, Application of Nanoparticles in Electrochemical Sensors and Biosensors. *Electroanalysis* **18**, 319-326 (2006).
43. C. M. Welch, C. E. Banks, A. O. Simm, R. G. Compton, Silver nanoparticle assemblies supported on glassy-carbon electrodes for the electro-analytical detection of hydrogen peroxide. *Analytical and Bioanalytical Chemistry* **382**, 12-21 (2005).
44. C. M. Fox, C. B. Breslin, Electrochemical formation of silver nanoparticles and their applications in the reduction and detection of nitrates at neutral pH. *J. Appl. Electrochem.* **50**, 125-138 (2020).
45. C. Karuppiah, K. Muthupandi, S.-M. Chen, M. A. Ali, S. Palanisamy, A. Rajan, P. Prakash, F. M. A. Al-Hemaid, B.-S. Lou, Green synthesized silver nanoparticles decorated on reduced graphene oxide for enhanced electrochemical sensing of nitrobenzene in waste water samples. *RSC Adv.* **5**, 31139-31146 (2015).
46. A. A. Isse, S. Gottardello, C. Maccato, A. Gennaro, Silver nanoparticles deposited on glassy carbon. Electrocatalytic activity for reduction of benzyl chloride. *Electrochem. Commun.* **8**, 1707-1712 (2006).
47. X. Ren, X. Meng, D. Chen, F. Tang, J. Jiao, Using silver nanoparticle to enhance current response of biosensor. *Biosens. Bioelectron.* **21**, 433-437 (2005).
48. A. B. Manohar, M. B. Bhalchandra, Silver Nanoparticles: Synthesis, Characterization and their Application as a Sustainable Catalyst for Organic Transformations. *Current Organic Chemistry* **19**, 708-727 (2015).
49. R. G. Compton, M. E. Laing, D. Mason, R. J. Northing, P. R. Unwin, J. S. Rowlinson, Rotating disc electrodes: the theory of chronoamperometry and its use in mechanistic investigations. *Proc. Math. Phys. Eng. Sci.* **418**, 113-154 (1988).
50. J. Gu, K. X. Rodriguez, Y. Kanda, S. Yang, M. Oceipa, H. Wilke, A. V. Abrishami, L. Jørgensen, T. Skak-Nielsen, J. S. Chen, P. S. Baran, Convergent Total Synthesis of (+)-

Calcipotriol: A Scalable Modular Approach to Vitamin D Analogs. *ChemRxiv. Cambridge: Cambridge Open Engage,* doi:10.26434/chemrxiv-2021-kn6tl (2021)

SM References

51. M. Royzen, G. P. A. Yap, J. M. Fox, A Photochemical Synthesis of Functionalized trans-Cyclooctenes Driven by Metal Complexation. *J. Am. Chem. Soc.* **130**, 3760-3761 (2008).
52. J. T. Edwards, R. R. Merchant, K. S. McClymont, K. W. Knouse, T. Qin, L. R. Malins, B. Vokits, S. A. Shaw, D.-H. Bao, F.-L. Wei, T. Zhou, M. D. Eastgate, P. S. Baran, Decarboxylative alkenylation. *Nature* **545**, 213-218 (2017).
53. S. Hötling, B. Haberlag, M. Tamm, J. Collatz, P. Mack, J. L. M. Steidle, M. Vences, S. Schulz, Identification and Synthesis of Macrolide Pheromones of the Grain Beetle Oryzaephilus Surinamensis and the Frog Spinomantis Aglavei. *Chem. Eur. J.* **20**, 3183-3191 (2014).
54. X. Jiang, J. Zhang, S. Ma, Iron Catalysis for Room-Temperature Aerobic Oxidation of Alcohols to Carboxylic Acids. *J. Am. Chem. Soc.* **138**, 8344-8347 (2016).
55. A. Fürstner, S. Flügge, O. Larionov, Y. Takahashi, T. Kubota, J. i. Kobayashi, Total Synthesis and Biological Evaluation of Amphidinolide V and Analogues. *Chem. Eur. J.* **15**, 4011-4029 (2009).
56. D. E. Van Horn, E. Negishi, Selective carbon-carbon bond formation via transition metal catalysts. 8. Controlled carbometalation. Reaction of acetylenes with organoalane-zirconocene dichloride complexes as a route to stereo- and regio-defined trisubstituted olefins. *J. Am. Chem. Soc.* **100**, 2252-2254 (1978).
57. Q. Liu, P. Hu, Y. He, Asymmetric Total Synthesis of Nannocystin A. *J. Org. Chem.* **82**, 9217-9222 (2017).
58. R. Schrof, K.-H. Altmann, Studies toward the Total Synthesis of the Marine Macrolide Salarin C. *Org. Lett.* **20**, 7679-7683 (2018).
59. R. Slegeris, G. B. Dudley, Alternative synthetic approaches to rac-progesterone by way of the classic Johnson cationic polycyclization strategy. *Tetrahedron* **72**, 3666-3672 (2016).
60. J. A. Davies, F. M. Bull, P. D. Walker, A. N. M. Weir, R. Lavigne, J. Masschelein, T. J. Simpson, P. R. Race, M. P. Crump, C. L. Willis, Total Synthesis of Kalimantacin A. *Org. Lett.* **22**, 6349-6353 (2020).
61. A. Richter, C. Hedberg, H. Waldmann, Enantioselective Synthesis of the C10–C20 Fragment of Fusicoccin A. *J. Org. Chem.* **76**, 6694-6702 (2011).
62. R. Malhotra, C. Rarhi, K. V. Diveshkumar, R. Barik, R. D'cunha, P. Dhar, M. Kundu, S. Chattopadhyay, S. Roy, S. Basu, P. I. Pradeepkumar, S. Hajra, Dihydrochelerythrine and its derivatives: Synthesis and their application as potential G-quadruplex DNA stabilizing agents. *Bioorg. Med. Chem.* **24**, 2887-2896 (2016).
63. K. Miwa, T. Aoyama, T. Shiori, A New Synthesis of 5-Trimethylsilyl-2,3-dihydrofurans from β-Trimethylsiloxyketones Utilizing Trimethylsilyldiazomethan. *Synlett* **1994**, 461-462 (1994).
64. A. M. Camelio, T. C. Johnson, D. Siegel, Total Synthesis of Celastrol, Development of a Platform to Access Celastroid Natural Products. *J. Am. Chem. Soc.* **137**, 11864-11867 (2015).

65. O. K. Karjalainen, M. Passiniemi, A. M. P. Koskinen, Short and Straightforward Synthesis of (−)-1-Deoxygalactonojirimycin. *Org. Lett.* **12**, 1145-1147 (2010).
66. M. E. Layton, C. A. Morales, M. D. Shair, Biomimetic Synthesis of (−)-Longithorone A. *J. Am. Chem. Soc.* **124**, 773-775 (2002).
67. H. O. House, C.-Y. Chu, J. M. Wilkins, M. J. Umen, Chemistry of carbanions. XXVII. Convenient precursor for the generation of lithium organocuprates. *J. Org. Chem.* **40**, 1460-1469 (1975).
68. B. B. Snider, J. Y. Kiselgof, B. M. Foxman, Total Syntheses of (±)-Isosteviol and (±)-Beyer-15-ene-3β,19-diol by Manganese(III)-Based Oxidative Quadruple Free-Radical Cyclization. *J. Org. Chem.* **63**, 7945-7952 (1998).
69. H.-J. Fang, X.-A. Shou, Q. Liu, C.-C. Gan, H.-Q. Duan, N. Qin, Synthesis and anti-metastatic effects of novel chiral ionone alkaloid derivatives. *Eur. J. Med. Chem.* **101**, 245-253 (2015).
70. Z.-X. Wang, Y. Tu, M. Frohn, J.-R. Zhang, Y. Shi, An Efficient Catalytic Asymmetric Epoxidation Method. *J. Am. Chem. Soc.* **119**, 11224-11235 (1997).
71. S. Serra, V. Lissoni, First Enantioselective Synthesis of Marine Diterpene Ambliol-A. *Eur. J. Org. Chem.* **2015**, 2226-2234 (2015).
72. R. P. Walker, D. J. Faulkner, Diterpenes from the sponge Dysidea amblia. *J. Org. Chem.* **46**, 1098-1102 (1981).
73. K. K. Miller, P. Zhang, Y. Nishizawa-Brennen, J. W. Frost, Synthesis of Biobased Terephthalic Acid from Cycloaddition of Isoprene with Acrylic Acid. *ACS Sustain. Chem. Eng.* **2**, 2053-2056 (2014).
74. N. J. Cusack, C. B. Reese, A. C. Risius, B. Roozepeikar, 2,4,6-Tri-isopropylbenzenesulphonyl hydrazide: A convenient source of di-imide. *Tetrahedron* **32**, 2157-2162 (1976).
75. J. Mikusek, J. Nugent, P. Lan, M. G. Banwell, Chemical Synthesis Study Establishes the Correct Structure of the Potent Anti-Inflammatory Agent Myrsinoic Acid F. *J. Nat. Prod.* **82**, 96-100 (2019).
76. E.-i. Negishi, A. O. King, J. M. Tour, Conversion of Methyl Ketones into Terminal Alkynes: (E)-buten-3-ynyl-2,6,6-trimethyl-1-cyclohexene. *Org. Synth.* **64**, 44-49 (1986).
77. F. Salvaggio, J. T. Hodgkinson, L. Carro, S. M. Geddis, W. R. J. D. Galloway, M. Welch, D. R. Spring, The Synthesis of Quinolone Natural Products from Pseudonocardia sp. *Eur. J. Org. Chem.* **2016**, 434-437 (2016).
78. J.-X. Wang, Total Synthesis of plakortones A, B, and E; Synthesis of cyclic peroxides by ring closing metathesis and synthesis and stereochemistry of (+)-Zerumin B & beyond., Université Laval., (2007).
79. F. Delay, G. Ohloff, Syntheses and Absolute Configuration of (E)- and (Z)-α-Bisabolenes. *Helv. Chim. Acta.* **62**, 369-377 (1979).
80. F. Ito, Y. Ohbatake, S. Aoyama, T. Ikeda, S. Arima, Y. Yamada, H. Ikeda, T. Nagamitsu, Total Synthesis of (+)-Clavulatriene A. *Synthesis* **47**, 1348-1355 (2015).
81. R. H. Scheffrahn, L. K. Gaston, J. J. Sims, M. K. Rust, Identification of the defensive secretion from soldiers of the North American termite,Amitermes wheeleri (Desneux) (Isoptera: Termitidae). *J. Chem. Ecol.* **9**, 1293-1305 (1983).
82. C. Cook, X. Guinchard, F. Liron, E. Roulland, Total Synthesis of (−)-Exiguolide. *Org. Lett.* **12**, 744-747 (2010).

83. S. Raghavan, V. Sudheer Babu, Total Synthesis of (+)-(2′S,3′R)-Zoapatanol Exploiting the B-Alkyl Suzuki Reaction and the Nucleophilic Potential of the Sulfinyl Group. *Chem. Eur. J.* **17**, 8487-8494 (2011).
84. S. Ma, E.-i. Negishi, Anti-Carbometalation of Homopropargyl Alcohols and Their Higher Homologues via Non-Chelation-Controlled Syn-Carbometalation and Chelation-Controlled Isomerization. *J. Org. Chem.* **62**, 784-785 (1997).
85. B. Wang, C. Lu, S.-Y. Zhang, G. He, W. A. Nack, G. Chen, Palladium-Catalyzed Stereoretentive Olefination of Unactivated C(sp3)–H Bonds with Vinyl Iodides at Room Temperature: Synthesis of β-Vinyl α-Amino Acids. *Org. Lett.* **16**, 6260-6263 (2014).
86. L. R. Cox, G. A. DeBoos, J. J. Fullbrook, J. M. Percy, N. S. Spencer, M. Tolley, Catalytic Asymmetric Synthesis of a 1-Deoxy-1,1-difluoro-d-xylulose. *Org. Lett.* **5**, 337-339 (2003).
87. K. S. Madden, H. R. E. Jokhoo, F. D. Conradi, J. P. Knowles, C. W. Mullineaux, A. Whiting, Using Nature's polyenes as templates: studies of synthetic xanthomonadin analogues and realising their potential as antioxidants. *Org. Biomol. Chem.* **17**, 3752-3759 (2019).
88. M. J. Hesse, C. P. Butts, C. L. Willis, V. K. Aggarwal, Diastereodivergent Synthesis of Trisubstituted Alkenes through Protodeboronation of Allylic Boronic Esters: Application to the Synthesis of the Californian Red Scale Beetle Pheromone. *Angew. Chem. Int. Ed.* **51**, 12444-12448 (2012).
89. W. Roelofs, M. Gieselmann, A. Cardé, H. Tashiro, D. S. Moreno, C. A. Henrick, R. J. Anderson, Identification of the California red scale sex pheromone. *J. Chem. Ecol.* **4**, 211-224 (1978).
90. S. Kobayashi, A. Ando, H. Kuroda, S. Ejima, A. Masuyama, I. Ryu, Rapid access to 6-bromo-5,7-dihydroxyphthalide 5-methyl ether by a CuBr2-mediated multi-step reaction: concise total syntheses of hericenone J and 5′-deoxohericenone C (hericene A). *Tetrahedron* **67**, 9087-9092 (2011).
91. J. Godeau, F. Fontaine-Vive, S. Antoniotti, E. Duñach, Experimental and Theoretical Studies on the Bismuth-Triflate-Catalysed Cycloisomerisation of 1,6,10-Trienes and Aryl Polyenes. *Chem. Eur. J.* **18**, 16815-16822 (2012).
92. D. M. Cermak, D. F. Wiemer, K. Lewis, R. J. Hohl, 2-(Acyloxy)ethylphosphonate analogues of prenyl pyrophosphates: synthesis and biological characterization. *Bioorg. Med. Chem.* **8**, 2729-2737 (2000).
93. P. J. Kocieński, M. Pritchard, S. N. Wadman, R. J. Whitby, C. L. Yeates, A stereoselective synthesis of trisubstituted alkenes. Part 1. Nickel-catalysed coupling of Grignard reagents with 5-alkyl-2,3-dihydrofurans. *J. Chen. Soc. Perkin Trans. I*, 3419-3429 (1992).
94. E. A. Ilardi, C. E. Stivala, A. Zakarian, Hexafluoroisopropanol as a Unique Solvent for Stereoselective Iododesilylation of Vinylsilanes. *Org. Lett.* **10**, 1727-1730 (2008).
95. A. T. Radosevich, V. S. Chan, H.-W. Shih, F. D. Toste, Synthesis of (−)-Octalactin A by a Strategic Vanadium-Catalyzed Oxidative Kinetic Resolution. *Angew. Chem. Int. Ed.* **47**, 3755-3758 (2008).
96. P. Kocienski, S. Wadman, K. Cooper, A highly stereoselective and iterative approach to isoprenoid chains: synthesis of homogeraniol, homofarnesol, and homogeranylgeraniol. *J. Org. Chem.* **54**, 1215-1217 (1989).

97. A. Svatoš, K. Urbanová, I. Valterová, The First Synthesis of Geranyllinalool Enantiomers. *Collect. Czech. Chem. Commun.* **67**, 83-90 (2002).
98. D. E. Cane, H.-J. Ha, D. B. McIlwaine, K. O. Pascoe, The synthesis of (3R)-nerolidol. *Tetrahedron Lett.* **31**, 7553-7554 (1990).
99. B. M. Cochran, One-Pot Oxidative Cleavage of Olefins to Synthesize Carboxylic Acids by a Telescoped Ozonolysis–Oxidation Process. *Synlett* **27**, 245-248 (2016).
100. L. Díaz, J. Bujons, J. Casas, A. Llebaria, A. Delgado, Click Chemistry Approach to New N-Substituted Aminocyclitols as Potential Pharmacological Chaperones for Gaucher Disease. *J. Med. Chem.* **53**, 5248-5255 (2010).
101. J.-N. Schäckermann, T. Lindel, Synthesis and Photooxidation of the Trisubstituted Oxazole Fragment of the Marine Natural Product Salarin C. *Org. Lett.* **19**, 2306-2309 (2017).
102. J. González-García, P. Bonete, E. Expósito, V. Montiel, A. Aldaz, R. Torregrosa-Maciá, Characterization of a carbon felt electrode: structural and physical properties. *J. Mater. Chem.* **9**, 419-426 (1999).
103. H. Kigoshi, M. Ojika, Y. Shizuri, H. Niwa, K. Yamada, Isolation of (10R,11R)-(+)-squalene-10,11-epoxide from the red alga laurencia okamurai and its enantioselective synthesis. *Tetrahedron* **42**, 3789-3792 (1986).
104. V. Schubert, A. Dietrich, T. Ulrich, A. Mosandl, The Stereoisomers of Nerolidol: Separation, Analysis and Olfactoric Properties. *Zeitschrift für Naturforschung C* **47**, 304-307 (1992).
105. D. E. Cane, R. Iyengar, M.-S. Shiao, Cyclonerodiol biosynthesis and the enzymic conversion of farnesyl to nerolidyl pyrophosphate. *J. Am. Chem. Soc.* **103**, 914-931 (1981).
106. J. B. del Castillo, C. J. W. Brooks, M. M. Campbell, Caparrapidiol and caparrapitriol: Two new acyclic sesquiterpene alcohols. *Tetrahedron Lett.* **7**, 3731-3736 (1966).
107. R. D. Clark, C. H. Heathcock, Reduction of .beta.-halo-.alpha.,.beta.-unsaturated ketones. *J. Org. Chem.* **38**, 3658-3658 (1973).
108. A. Klein, Synthesis, Spectroscopic Properties, and Crystal Structure of 2,2′-Bipyridyldimesitylnickel(II). *Zeitschrift für anorganische und allgemeine Chemie* **627**, 645-650 (2001).
109. A. Klein, A. Kaiser, W. Wielandt, F. Belaj, E. Wendel, H. Bertagnolli, S. Záliš, Halide Ligands—More Than Just σ-Donors? A Structural and Spectroscopic Study of Homologous Organonickel Complexes. *Inorg. Chem.* **47**, 11324-11333 (2008).
110. Z.-X. Zhang, S. Wang, S.-M. Li, S.-L. Shan, H. Wang, J.-X. Lu, Synthesis of Ag nanoparticles/ordered mesoporous carbon as a highly efficient catalyst for the electroreduction of benzyl bromide. *RSC Adv.* **10**, 756-762 (2020).