Electronic Supplementary Information for

Thiocyanopalladation/Carbocyclization Transformation identified Through Enzymatic Screening: Stereocontrolled Tandem C-SCN and C-C Bond Construction

Guillaume Malik,† Robert A. Swyka,† Virendra. K. Tiwari, Xiang Fei, Gregory A. Applegate, David B. Berkowitz*

Department of Chemistry, University of Nebraska, Lincoln, NE 68588-0304, United States

**Corresponding Author-E-mail: dberkowitz1@unl.edu*
†These authors contributed equally

Table of Contents

I. General Experimental 3

II. Enzyme-Assisted Catalyst Screening 3

III. General Synthetic Procedures 9

IV. Substrate Synthesis 11

A. Nitrogen-Bridged Substrates 11

B. Malonate-Bridged Substrates 14

C. Sulfur-Bridged Substrates 17

D. Propargyl-Substituted Substrates 20

E. Allyl-Substituted Substrates 47

F. Asymmetric Route into Bridged Bicyclic Oxabicyclo[3.2.1]oct-2-enyl Systems 60

V. Thiocyanopalladation/Carbocyclization 63

VI. Tailoring Chemistry 82

VII. X-Ray Crystallography Studies for Compound 4t 86

VIII. X-Ray Crystallography Studies for Compound 60. 96

IX ^{1}H, ^{13}C and ^{19}F NMR Spectra 112

a. Bridging Variation 112

b. Propargyl- Substituted Substrates 147

c. Allyl- Substituted Substrates 254

d. Massarilactone/ Annuionone Core – Leading Intermediates 312

e. Thiocyanopalladation products 320

f. Massarilactione/ Annuionone Core Series and Tailoring Chemistry 413

X. Chiral HPLC Traces 431

XI. References 439

I. General Experimental

Unless otherwise specified, reactions were conducted under inert atmosphere (N_2 or Ar) using oven-dried glassware. THF and ether were distilled from sodium benzophenone ketyl. Methanol was distilled over magnesium metal. Dichloromethane was distilled over CaH_2. Reaction progress was monitored by TLC. Flash chromatography was performed using Silicycle Silica gel 60 (230-400 Mesh). ^{1}H NMR spectra were aquired on a Bruker-DRX-Avance 300, 400, 500 or 700 MHz instrument, with chemical shifts reported relative to residual $CHCl_3$ (7.25 ppm), residual methanol (3.35 ppm) or residual acetone (2.05 ppm). Proton-decoupled ^{13}C-NMR spectra were acquired on Bruker-DRX-Avance-300, 400 and 700 MHz instruments, with chemical shifts reported relative to $CDCl_3$ (77.0 ppm) or CD_3OD (50.0 ppm). ^{19}F NMR spectra were acquired on the Brucker-DRX-Avance-400 MHz instrument with chemical shifts reported relative to TFA in $CDCl_3$ (-77.0 ppm, externally referenced). High resolution mass spectra were acquired at the Nebraska Center for Mass Spectroscopy (NCMS; University of Nebraska). Optical rotations @ 589 nm were measured in an Autopol polarimeter. For asymmetric allylation, enantiomeric excesses were determined by chiral HPLC analysis, as described.

II. Enzyme-Assisted Catalyst Screening

Described here are the general procedures used for optimizing the thiocyanopalladation/carbocyclization reaction employing enzymatic screening. Alcohol oxidase [EC 1.1.3.13; from *Hansenula sp.*, lyophilized powder, 3 nominal units/mg protein (Bradford) (1.6 nominal units/ mg)], peroxidase (EC 1.11.1.7; from horseradish, Type VI, lyophilized powder, 250-330 nominal units/mg solid) and 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) diammonium salt (ABTS) were purchased from Sigma.

Initial Enzymatic Screening: Temperature Dependence and Catalyst Loading

An initial enzymatic screen was performed expanding upon the colorimetric ISES conditions for the initial hit for this new transformation.[1] The title transformation was screened at temperatures ranging from 35 °C to 70 °C in 5° C intervals, with the catalyst loading varying from 2.5 to 5, to 10 mol% of $Pd(PhCN)_2Cl_2$.

Reporting Layer Stock Solutions:

- 1.5 mL of 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) diammonium salt (ABTS) 3.6 mM in 100 mM potassium phosphate buffer (pH 7.5)
- 1.5 mg of Alcohol oxidase (AO; from *Hansenula* sp.) in 0.5 mL 100 mM potassium phosphate buffer (pH 7.5) [4.8 nominal U/ mL]
- 1 mg of peroxidase from horseradish (HRP) in 1 mL 100 mM potassium phosphate buffer (pH 7.5; 500 pyrogallol U/ mL)
- Reporting layer is made by combining 100 μL AO soln., 100 μL HRP soln., and all 1.5 mL of the ABTS soln.

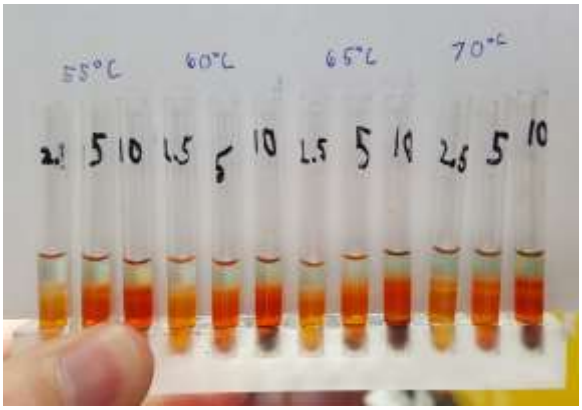
All enzymatic solutions were stored on ice and only mixed prior to layering on the reaction screen (100 μL per tube)

Organic Layer Stock Solutions:

- 0.75 mL of 1.2 M substrate in 1,1,2-trichloroethane (TCE)
- 0.75 mL of 12 M LiSCN in THF
- Catalyst loading solutions in TCE:
    - 1.5 mL 60 mM $Pd(PhCN)_2Cl_2$
    - 1.5 mL 30 mM $Pd(PhCN)_2Cl_2$
    - 1.5 mL 15 mM $Pd(PhCN)_2Cl_2$

Enzymatic Screening Procedure:

The organic test reactions were loaded into Fisher disposable culture tubes (6 x 50 mm) to a 200 μL total volume (50 μL of substrate and LiSCN stock solutions, 100 μL of metal solutions). Consistent results were obtained by loading the SCN nucleophile solution for each tube first, followed by the substrate solution (300 mM final conc of (Z)-methyl (4-(prop-2-yn-1-yloxy)but-2-en-1-yl) carbonate **1**) and concluding by adding the desired Pd catalyst solution. The tubes were then placed in an oil bath at the proper temperature for 15 min. Following this, they were allowed to cool and layered with 100 μL of the aqueous reporting layer. The results are shown below.



Assay Figure S1. Initial colorimetric, enzymatic screening results. Temperature increases from left to right in 5 °C intervals, from 35 °C to 70 °C, with $Pd(NCPh)_2Cl_2$ catalyst loading varied (2.5, 5, 10 mol%) at each temperature.

As can be seen from the array of temperatures/catalyst loadings screened, the new Pd(II)-mediated thiocyanopalladation/carbocyclization is favored at elevated temperatures, with the colorimetric, enzymatic signal really emerging in the 60-70 °C window, with 2.5 mol% catalyst being sufficient to promote this chemistry. Note that for these initial screens, the enzymatic reporting signal is muted due to the presence of 10 equivalents of LiSCN pseudohalide. As revealed in the subsequent higher throughput screens (see 96 well plate screening results below and in Figure 1 of the manuscript), LiSCN levels even in the 5-7 equivalent range inhibit the reaction relative to the 1.5 equivalents that now appear to be optimal. Suffice it to say that based upon these initial rapid T/Pd loading screens, we elected to move forward @ 2.5 mol % Pd(II) loading and 60 °C reaction temperatures for the development of the new elevated temperature, plate-based enzymatic screening assay to further optimize this transformation.

Elevated Temperature 96 Well Plate Screen

(Probing Pd (II) Source, Nucleophile Loading Levels, and Ligand Effects)

An aluminum 96 well plate fabricated at University of Nebraska Machine Shop was used to hold an 8 x 12 array of disposable Fisher culture tubes (6 x 50 mm). The organic reaction layers (200 μL each) were loaded into the array of tubes and the plate was then placed into a

sand bath (80 °C sand temperature ~ 60 °C internal reaction temperature as measured with a platinum temperature thermoprobe) and removed after the desired reaction time. Upon cooling to ambient temperature, the reporting layer (100 μL) is added, and the ABTS signal allowed to develop for 10 min, followed by scoring based on color intensity (see Figure 1 in the manuscript and below).

Reporting Layer Stock Solutions:

- 15 mL of 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) diammonium salt (ABTS) 3.6 mM in 100 mM potassium phosphate buffer (pH 7.5)
- 3 mg of Alcohol oxidase (AO; from *Hansenula* sp.) in 1 mL 100 mM potassium phosphate buffer (pH 7.5) [4.8 nominal U/ mL]
- 2 mg of peroxidase from horseradish (HRP) in 1 mL 100 mM potassium phosphate buffer (pH 7.5) [500 pyrogallol U/ mL)

All enzymatic solutions were stored on ice and only mixed prior to layering on the reaction screen (100 μL per tube)

Organic Layer Stock Solutions:

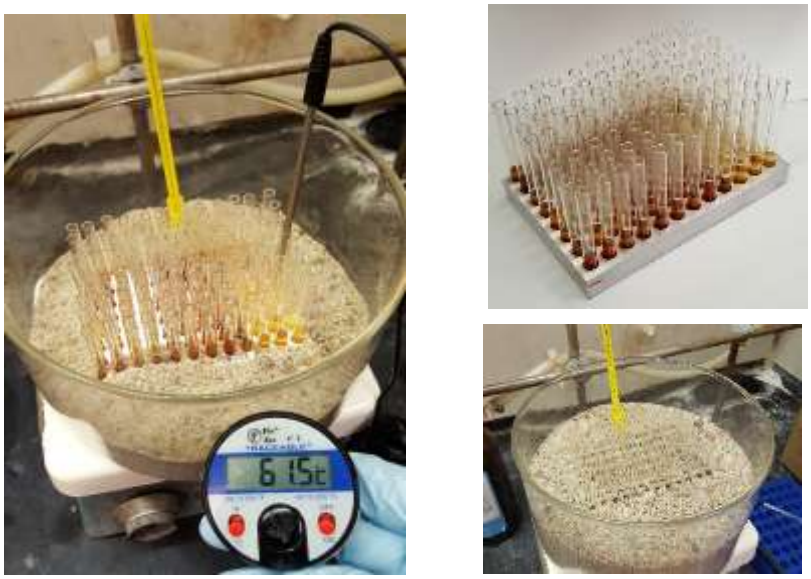
- 5 mL of 1.2 M substrate in 1,1,2-trichloroethane (TCE)
- LiSCN solutions:
    - 2 mL of 1.8 M LiSCN in THF—1.5 eq.
    - 2 mL of 6.0 M LiSCN in THF—5 eq.
    - 2 mL of 8.4 M LiSCN in THF— 7 eq.
- 1.5 mL of 60 mM for $Pd(PhCN)_2Cl_2$, $Pd(acac)_2$, $Pd(OAc)_2$, and $PdCl_2$ in TCE (4 solutions total)
- 0.75 mL of 120 mM solutions in TCE for all monodentate ligands (PPh_3, $P(2\text{-fur})_3$, $P(p\text{-}CF_3Ph)_3$, $P(o\text{-tol})_3$ $AsPh_3$)
- 0.75 mL of 60mM for each bidentate ligand (dppf, $PhS(O)CH_2CH_2S(O)Ph$)

Thermal Plate-Based Enzymatic Screening Procedure:

An aluminum 96 well plate was loaded with Fisher disposable culture tubes (6 x 50 mm). The organic test reactions were then loaded to a final volume of 200 μL (50 μL of each stock

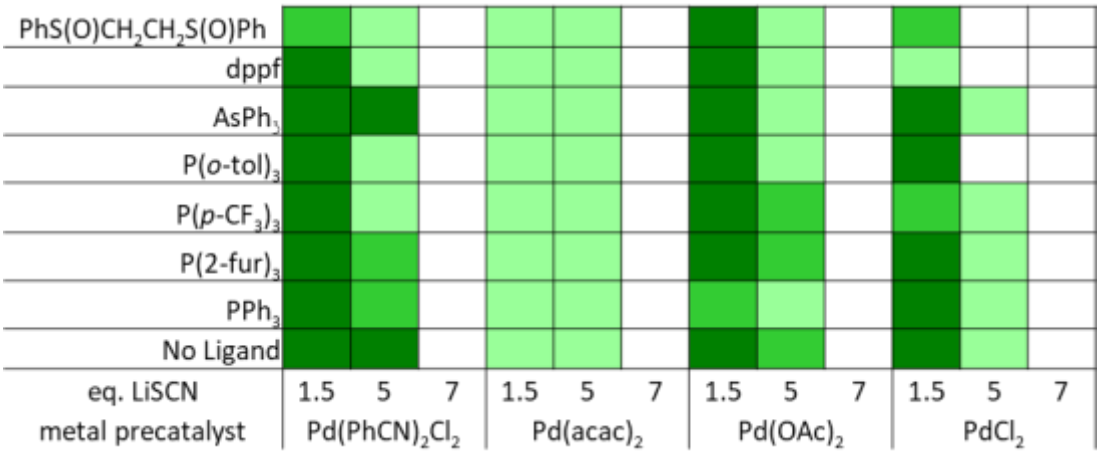
solution). Consistent results were obtained by loading the proper SCN nucleophile solution (1.5, 5, or 7 eq) for each tube first, followed by the substrate solution (300 mM final conc). Subsequently charging the tubes with the desired ligand solutions (5 mol% for bidentate, 10 mol % for monodentate) [50 μL pure TCE was used for the unligated case] and concluding by adding the desired Pd catalyst (5 mol%).

This plate charged with the desired reaction conditions to screen was then placed in a 80°C sand bath and the tubes were surrounded with sand up to the solvent level. The plate was allowed to sit until temperature monitoring via a thermoprobe indicated the solution temperature was at ~ 60 °C for 15 min. The plate was then removed and allowed to cool to ambient temperature. At this time the three reporting layer stock solutions were combined (17 mL total) and a Matrix Impact 1250 mL multi-channel pipetter was used to layer the enzymatic layer (100 μL per tube) onto the reactions of interest. This pipetter has 8 arms/pipet tips, allowing the experimentalist to layer an entire 8-well row at once. The appearance of the green dye occurred nearly instantly for the more effective reaction conditions, after 10 min of incubation time all hits were visible and the reactions were then ranked based on color intensity and photographed.

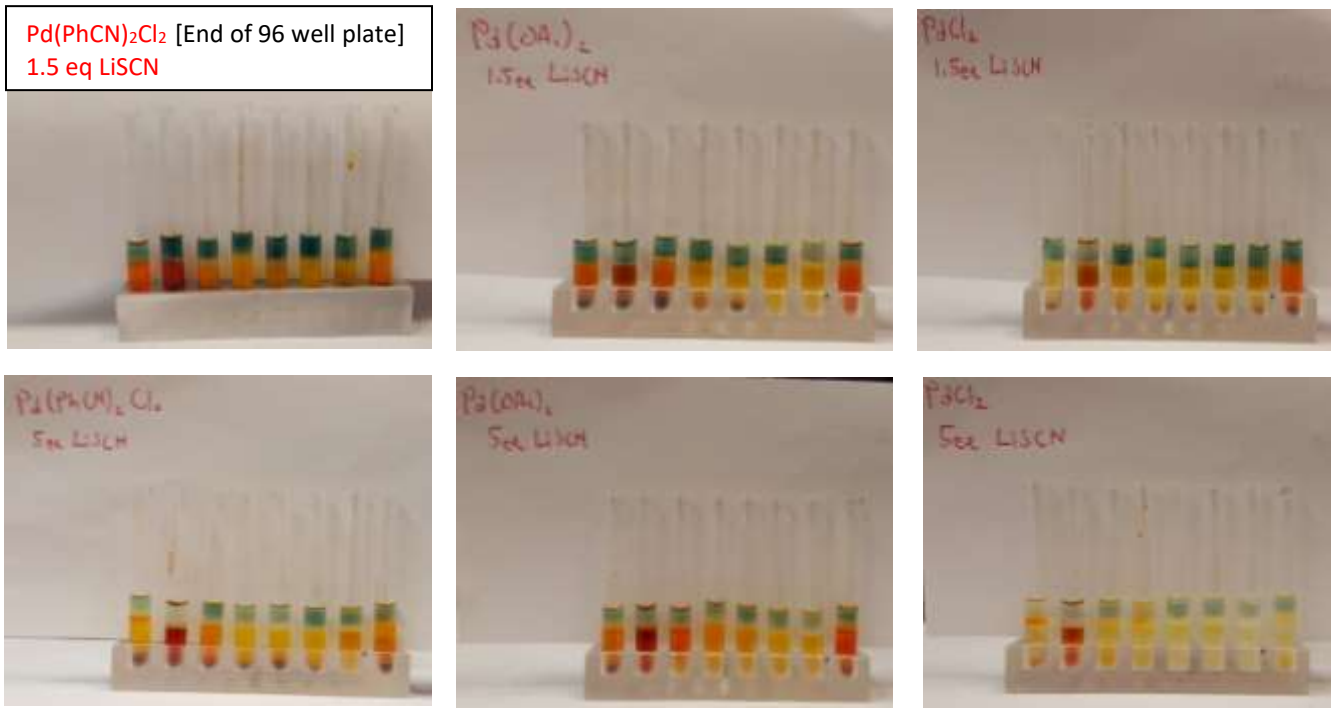


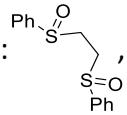
Assay Figure S2. **Left:** thermoprobe analyzing reaction temperature; **Upper Right:** 96 well plate prior to addition of reporting layer; **Lower Right:** Placement of 96 well plate in sand bath.

Enzymatic Screen Results Summary



Assay Table S 1. Graphical summary of screening results from 96 well tray, three shades of green color represent observed ABTS dye intensity in the screen.



Ligand array from Left to right:  , dppf, $AsPh_3$, P(*o*-tol)$_3$, P(*p*-CF_3Ph), P(2-fur)$_3$, PPh_3, no ligand

Assay Figure S3. Cross-sectional images taken from the six effective conditions highlighting portions of the plate masked in full plate end-on images shown in the manuscript. For visualization/illustration purposes, rows of interest have been placed in the front row of a 96 well tray and highlighted with white paper backing for clarity.

III. General Synthetic Procedures

General Procedure A: Preparation of Secondary Alcohols

To a solution of trimethylsilylacetylene (1.1 eq.) in THF (0.2 M) at -78 °C was added slowly, via syringe, *n*-butyllithium (1.1 eq., 1.6 M in hexanes). After stirring for 30 min, neat aldehyde (1.0 eq.) was added via syringe and the solution was allowed to warm up to 0 °C. After completion of the reaction based upon TLC (1 to 2 h), the reaction was quenched via addition of saturated aqueous ammonium chloride. The aqueous layer was extracted twice with ethyl acetate and the combined organic extracts were dried (Na_2SO_4) and concentrated *in vacuo*. The crude alcohols were purified by flash chromatography on silica gel.

General Procedure B: Allylic Ether Installation and O-THP Deprotection

To a solution of secondary propargylic alcohol (1 eq.) in THF (0.1 M) at 0 °C was added NaH (60% in oil, 1.2 eq.), under N_2-stream, and the resulting solution was stirred for 30 min. Then a solution of 4-bromo-2*Z*-butenol-*O*-THP ether[6] **57** (1.2 eq.) in THF (1-2 mL) was added, via cannula, and the mixture was heated to reflux. Upon completion (TLC), the reaction mixture was quenched with a saturated solution of NH_4Cl (saturated aqueous solution). Following extraction of the aqueous layer with ethyl acetate twice, the combined organics were dried (Na_2SO_4), filtered and concentrated on a rotary evaporator. The crude product was taken up in MeOH to a 100 mM concentration and PTSA (0.1 eq.) was added. After TLC indicated complete O-THP deprotection, the reaction mixture was concentrated, taken up in ethyl acetate, washed with brine, dried over Na_2SO_4 and concentrated. Purification by flash chromatography with hexanes:ethyl acetate afforded homogeneous allylic alcohol.

General Procedure C: Preparation of Methyl Carbonates

To a solution of allylic alcohol (1 eq.) in CH_2Cl_2 (0.2 M) and pyridine (1.3 eq.) at 0 °C was added methyl chloroformate (1.3 eq.) via syringe. The reaction mixture was allowed to warm to RT and left to stir until complete, where upon the reaction was quenched by addition of saturated aqueous ammonium chloride. Following extraction of the aqueous layer with CH_2Cl_2 (twice), the organic extracts were combined, dried (Na_2SO_4), filtered and concentrated. Purification of the crude product via SiO_2 flash chromatography (hexanes:ethyl acetate) then afforded the desired carbonate esters.

General Procedure D: Semi-hydrogenation to the Z-Alkene

To a suspension of Pd on $CaCO_3$ (5 mol% in palladium) in a MeOH:Pyridine (2:1, 60 mM) that had been previously stirred at room temperature for 15-20 min was added a solution alkyne in MeOH (1-2 mL) via syringe. After addition of the alkyne, the flask was flushed with nitrogen and placed under H_2 atmosphere (balloon pressure). After 1 h, no starting material remained (TLC) and so the reaction mixture was filtered through a pad of Celite™, concentrated and the crude product purified by flash chromatography (hexanes:ethyl acetate) to afford the homogeneous *Z*-alkene.

General Procedure E: Propargyl Bromide Displacement

To a solution of allylic alcohol (1 eq.) in THF (0.2 M) at 0 °C was added NaH (2 eq.). After 30 min, propargyl bromide (2 eq.) was added via syringe and the reaction was stirred at reflux until complete. The reaction was quenched with an aqueous, saturated ammonium chloride, followed by extraction with ethyl acetate (thrice). The combined organic extracts were dried over Na_2SO_4 and concentrated. Flash SiO_2 chromatography (hexanes:ethyl acetate) afforded the targeted propargyl ethers.

General Procedure F: Silyl Ether Deprotection

Propargylic ethers obtained as described in General Procedure E were taken up in TBAF solution (1M in THF, 3 eq.) at RT and stirred for 3-4 h. Upon completion (TLC), the reaction mixture was diluted with ethyl acetate and quenched with a saturated, aqueous ammonium chloride. The aqueous layer was extracted with ethyl acetate (thrice). The combined organics were dried (Na_2SO_4), filtered and concentrated in vacuo. The crude product was subjected to flash chromatography on silica gel (hexanes:ethyl acetate) to provide homogeneous alcohol.

General Procedure G : Thiocyanopalladation/Carbocyclization

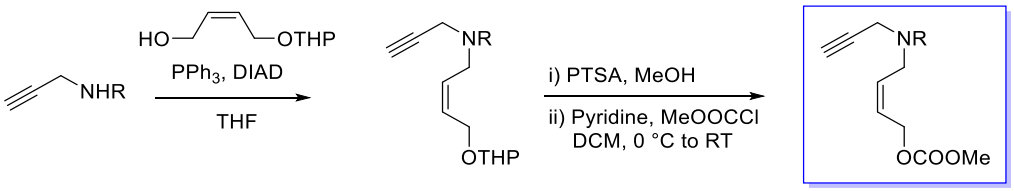
LiSCN (1.5 eq.) and $PdCl_2(PhCN)_2$ (0.025 eq.) were placed in a flamed dry flask and the appropriate carbonate (1 eq.) was dissolved in THF (25 mM) and added to the reaction vessel. The reaction mixture was heated to 60 °C, with stirring, until TLC indicated that the title

transformation had gone to completion. Purification by SiO_2 flash chromatography yielded analytically pure thiocyanopalladation/carbocyclization products.

IV. Substrate Synthesis

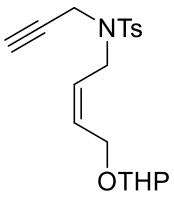
The synthesis of the 5-exo-trigester **1** was performed following previously described method.[1]

A. <u>Nitrogen-Bridged Substrates</u>



The N-tosyl-[2] and N-trifluoroactyl-bridged[3] systems were prepared from mono-*O*-THP-protected 2*Z*-buten-1,4-diol, according to established procedures for the N-Mitsunobu reaction. Thereafter, THP deprotection and carbonate installation gave the desired nitrogen-bridged substrates **3** and **5**.

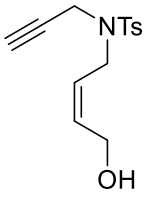
4-(N-Propargyl-N-*p*-toluenesulfonamide)but-2*Z*-en-1-ol-O-THP ether (S1).



To a solution of N-*p*-toluenesulfonylpropargylamine (591 mg, 2.83 mmol), mono-*O*-THP-protected 2*Z*-buten-1,4-diol (730 mg, 4.24 mmol, 1.5 eq.) and triphenyl phosphine (1.11 g, 4.24 mmol, 1.5 eq.) at 0 °C in THF (28 mL) was slowly added DIAD (843 µL, 4.24 mmol, 1.5 eq.). The resulting orange solution was stirred at RT until TLC indicated that the substitution was complete, over approximately 2 h. At this time, the reaction mixture was concentrated, and the. residue taken up in hexanes and filtered. The filtrate was concentrated in vacuo and subjected to SiO_2 flash chromatography [hexanes/ethyl acetate (90:10)] to yield the title compound (700 mg, 70%) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.69 (d, *J* = 7.9 Hz, 2H), 7.25 (d, *J* = 7.9 Hz, 2H), 5.76 (dt, *J* = 11.2, 6.3 Hz, 1H), 5.51-5.42 (m, 1H), 4.56 (t, *J* = 3.3 Hz, 1H), 4.23 (dd, *J* = 12.8, 6.0 Hz, 1H), 4.08-4.01 (m, 3H), 3.86 (d, *J* = 7.2 Hz, 2H), 3.82-3.73 (m, 1H), 3.43 (dt, *J* = 10.8, 5.0 Hz, 1H), 2.38

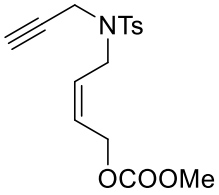
(s, 3H), 1.98 (t, *J* = 2.4 Hz, 1H), 1.81-1.40 (m, 6H) .^{13}C NMR (100 MHz, $CDCl_3$) δ.143.51 , 135.78 , 131.86 , 129.39 (2 CH), 127.67 (2 CH), 126.06 , 98.04 , 76.61 , 73.70 , 62.43 , 62.07 , 43.22 , 35.83 , 30.46 , 25.29 ; 21.44 , 19.25 . HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{19}H_{25}NO_4SNa$ $(M+Na)^+$ 386.1402, obsd 386.1418.

4-(N-Propargyl-N-*p*-toluenesulfonamide)but-2*Z*-en-1-ol. **(S2)**



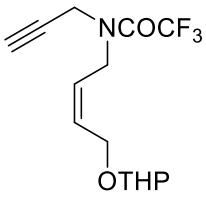
To a solution of **S1** (546 mg, 1.5 mmol) in MeOH (15 mL) was added PTSA (57 mg, 0.3 mmol, 0.2 eq.) and the resulting mixture was stirred for 2 h until the THP deprotection was complete by TLC. After concentrating the reaction in vacuo, the residue was taken up in ethyl acetate, washed with brine, dried (Na_2SO_4), filtered, and evaporated. Purification by flash chromatography [hexanes/ethyl acetate (80:20)] yielded the title compound (376 mg, 90%) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72 (d, *J* = 8.2 Hz, 2H), 7.29 (d, *J* = 8.1 Hz, 2H), 5.86 (dt, *J* = 11.1, 6.8 Hz, 1H), 5.55-5.45 (m, 1H), 4.21 (d, *J* = 6.5 Hz, 2H), 4.09 (d, *J* = 2.3 Hz, 2H), 3.89 (d, *J* = 7.3 Hz, 2H), 2.41 (s, 3H), 2.04 (t, *J* = 2.4 Hz, 1H), 1.59 (br s, 1H).^{13}C NMR (100 MHz, $CDCl_3$) δ.143.73 , 135.68 , 134.20 , 129.55 (2 CH), 127.74 (2 CH), 125.59 , 73.88 , 58.02 , 42.92 , 36.00 ; 21.55 . (alkyne masked by chloroform signal). HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{14}H_{17}NO_3SNa$ $(M+Na)^+$ 302.0827, obsd 302.0831.

Methyl 4-(N-Propargyl-N-*p*-toluenesulfonamide)but-2*Z*-en-1-yl Carbonate (3).



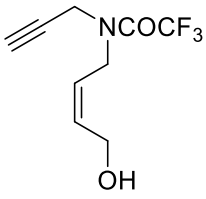
Carbonate **3** was prepared following General Procedure C from alcohol **S2** (122 mg, 0.437 mmol), pyridine (30 µL, 0.57 mmol, 1.3 eq.) and methyl chloroformate (47 µL, 0.57 mmol, 1.3 eq.) in CH_2Cl_2 (F4 mL) to afford the desired substrate (132 mg, 90%) as a colorless oil after chromatography [hexanes/ethyl acetate (90:10)]. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72 (d, *J* = 8.0 Hz, 2H), 7.29 (d, *J* = 8.0 Hz, 2H), 5.80 (dt, *J* = 10.8, 6.9 Hz, 1H), 5.66-5.57 (m, 1H), 4.70 (d, *J* = 6.8 Hz, 2H), 4.08 (d, *J* = 1.9 Hz, 2H), 3.91 (d, *J* = 7.4 Hz, 2H), 3.76 (s, 3H), 2.42 (s, 3H), 2.01 (t, *J* = 2.4 Hz, 1H).^{13}C NMR (100 MHz, $CDCl_3$) δ.155.54 , 143.74 , 135.65 , 129.57 (2 CH), 128.57 (2 CH), 127.76 (2 CH), 76.40 , 74.00 , 62.92 , 54.86 , 43.08 , 36.06 ; 21.54 . HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{16}H_{19}NO_5SNa$ $(M+Na)^+$ 360.0882, obsd 360.0881.

4-(N-Propargyl-N-trifluoroacetamide)but-2*Z*-en-1-ol-O-THP ether (S3).



To a solution of N-trifluoroacetylpropargylamine (300 mg, 1.98 mmol), triphenylphosphine (780 mg, 2.97 mmol, 1.5 eq.) and mono-*O*-THP-protected 2*Z*-buten-1,4-diol (511 mg, 2.97 mmol, 1.5 eq.) in THF (10 mL) was slowly added diisopropyl azodicarboxylate (DIAD; 580 μL, 2.97 mmol, 1.5 eq.) at 0 °C. Following addition, the reaction mixture was allowed to warm up to room temperature, and stirred overnight, after which time the reaction mixture was concentrated in vacuo. Purification by SiO_2 flash chromatography [hexanes/ethyl acetate (90:10→80:20)] yielded the desired N-Mitsunobu product **S3** (300 mg, 50%) as a colorless oil. ^{1}H NMR (700 MHz, $CDCl_3$) δ 5.86 (apt m, 1H, *J* = 5.8 Hz), 5.53-5.44 (m, 1H), 4.63 (apt q, *J* = 3.6 Hz, 1H), 4.31 (dt, *J* = 12.8, 5.8 Hz, 1H), 4.24 (d, *J* = 7.3 Hz, 2H), 4.19 (s, 1H), 4.14 (s, 1H), 4.1 (apt m, *J* = 6.6 Hz, 1H), 3.85-3.79 (m, 1H), 3.52-3.47 (m, 1H), 2.32 and 2.26 (t, *J* =1.9 Hz, 1H), 1.83-1.74 (m, 1H), 1.73-1.64 (m, 1H), 1.83-1.45 (m, 4H).^{13}C NMR (175 MHz, $CDCl_3$) δ.158.38 and 156.23 (q, *J* = 36.7 Hz,), 132.13 and 132.07 , 125.55 and 125.02 , 116.23 and 116.13 (q, *J* = 289 Hz,), 98.16 and 98.07 , 76.96 and 76.73 , 73.25 and 72.93 , 62.38 and 62.35 , 62.14 and 62.12 , 43.73 and 36.19 (q, *J* = 3.3 and 4.2 Hz, respectively, CH_2), 43.05 and 34.82 , 30.45 and 30.41 , 25.29 and 25.26 , 19.29 and 19.23 . ^{19}F NMR (377 MHz, $CDCl_3$) δ. -70.27 and -70.47. HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{14}H_{18}F_3NO_3Na$ $(M+Na)^+$ 328.1136, obsd 328.1150.

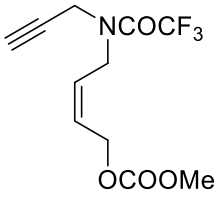
4-(N-Propargyl-N-trifluoroacetamide)but-2*Z*-en-1-ol.(S4)



To a solution of THP-protected alcohol (300 mg, 1 mmol) in methanol (5 mL) was added PTSA (20 mg, 0.1 mmol, 0.1 eq.) and the resulting reaction mixture was allowed to stir for 3 h before being concentrated, taken up in ethyl acetate and washed with brine. The organic layer was dried over Na_2SO_4 and the crude product was purified by chromatography [hexanes/ethyl acetate (70:30)] to yield XX (170 mg, 76%) as a colorless oil. ^{1}H NMR (700 MHz, $CDCl_3$) δ 5.91 (apt m, *J* = 6.2 Hz), 5.51 and 5.55 (apt dt, *J* = 11.3 and 7.4 Hz, 1H), 4.27 (d, *J* = 18.4, 8.1 Hz, 2H), 4.21 (d, *J* = 14.8, 7.7 Hz, 2H), 4.22 (dd, *J* = 1.9 Hz, 1H), 4.19 (dd, *J* = 1.9 Hz, 1H), 2.37 and 2.30 (t, *J* = 2.4 Hz, 1H), 1.94 and 1.81 (br s, 1H).^{13}C NMR (175 MHz, $CDCl_3$) δ.156.46 and 156.37 (q, *J* = 36.6 Hz,), 134.48 , 124.76 and 123.82 , 116.24 a,d 116.08 (q, *J* = 287.6 Hz,), 76.88 and 76.48 , 73.78 and 73.24 , 58.17 and 58.01 , 43.54 and 34.73 , 43.46 and 36.96 (q, *J* = 3.4 and 4.4 Hz, respectively, CH_2).

^{19}F NMR (377 MHz, $CDCl_3$) δ.-70.28 and –70.52. HRMS (TOF MS ESI$^+$) m/z Calcd for $C_9H_{10}F_3NO_2Na$ $(M+Na)^+$ 244.0561, obsd 244.0563.

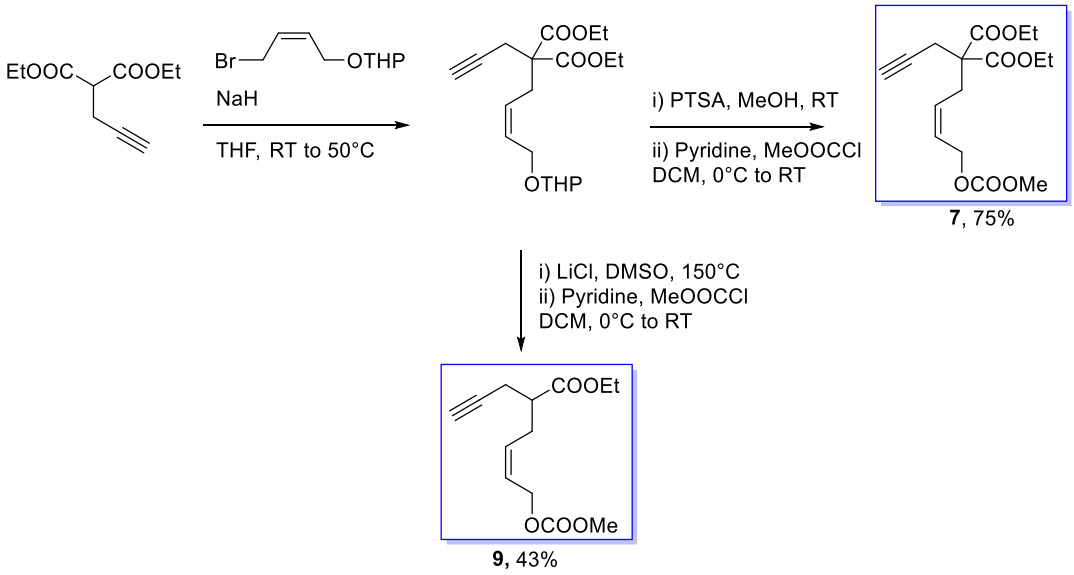
Methyl 4-(N-Propargyl-N-trifluoroacetamido)but-2*Z*-en-1-yl Carbonate (5).



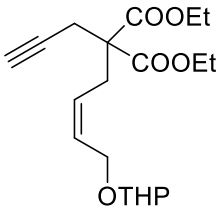
Carbonate **5** was prepared following General Procedure C from alcohol **S4** (150 mg, 0.68 mmol), pyridine (72 µL, 0.88 mmol, 1.3 eq.) and methyl chloroformate (68 µL, 0.88 mmol, 1.3 eq.) in CH_2Cl_2 (5 mL) to afford **5** (177 mg, 93%) as a colorless oil after SiO_2 chromatography [hexanes/ethyl acetate (85:15)]. ^{1}H NMR (400 MHz, $CDCl_3$) 5.92-5.81 (m, 1H), 5.69-5.54 (m, 1H), 4.78 and 4.74 (dd, *J* = 6.8, 1.0 Hz, 2H), 4.28 (apt dd, *J* = 6.9, 4.2 Hz, 2H), 4.23 and 4.18 (d, *J* = 2.3 and 2.4 Hz, repectively, 2H), 3.79 and 3.78 (s, 3H), 2.35 and 2.30 (t, *J* = 2.5 Hz, 1H).^{13}C NMR (100 MHz, $CDCl_3$) δ.156.45 and 156.37 (d, *J* = 36.3 Hz,), 155.57 and 155.54 , 128.87 and 128.83 , 128.01 and 127.32 , 116.24 and 116.12 (q, *J* = 286.6 Hz,), 77.20 and 76.53 , 73.71 and 73.39 , 62.83 and 62.56 , 54.98 and 54.92 , 43.53 and 36.61 (d, *J* = 3.4 and 4.4 Hz, CH_2), 43.18 and 34.99 . ^{19}F NMR (377 MHz, $CDCl_3$) δ -70.27 and -70.50.HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{11}H_{12}F_3NO_4Na$ $(M+Na)^+$ 302.0616, obsd 302.0620.

B. <u>Malonate-Bridged Substrates</u>

Diethyl malonate enolate alkylation with propargyl bromide followed standard procedure, as previously reported.[4] Subsequent enolate alkylation with 4-bromo-2*Z*-butenol-*O*-THP ether[6] **57** furnished the desired α,α-disubstitued malonate derivative. Deprotection of the THP group with PTSA and carbonate installation gave the desired malonate-bridged substrate **7**. Krapcho decarboxylation of **S5**, followed by carbonate installation furnished the mono-carboxylate-bridged substrate **9**.

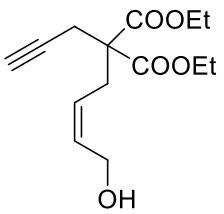


Diethyl 2-(Propargyl)-2-(4'-(tetrahydro-2''H-pyran-2''-yloxy)but-2'*Z*-en-1-yl) malonate (S5)



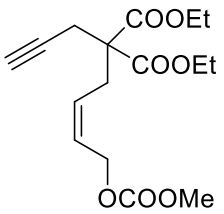
To a suspension of NaH (68 mg, 1.70 mmol, 1.2 eq.) in THF (1 mL) was added a solution of ethylmalonate propargyl derivative (280 mg, 1.42 mmol) in THF (1 mL). After stirring for 30 min at RT, 4-bromo-2*Z*-butenol-*O*-THP ether (400 mg, 1.70 mmol, 1.2 eq.) in THF (2 mL) was added and the reaction was stirred at 50 °C for 4 h. The reaction was quenched with a solution of ammonium chloride and the aqueous layer was extracted thrice with ethyl acetate. The combined organics were dried over Na_2SO_4 and concentrated. Purification by flash chromatography [hexanes/ethyl acetate (100:0→80:20)] gave **S5** (400 mg, 80%) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.74-5.62 (m, 1H), 5.31 (apt q, *J* = 8.5 Hz, 1H), 4.57 (br s, 1H), 4.25 (dd, *J* = 11.7, 4.7 Hz, 1H), 4.20-4.10 (m, 4H), 4.10-4.02 (m, 1H), 3.85-3.77 (m, 1H), 3.49-3.41 (m, 1H), 2.81 (d, *J* = 7.3 Hz, 2H), 2.73 (d, *J* = 2.1 Hz, 2H), 1.97 (t, *J* = 2.1 Hz, 1H), 1.83-1.41 (m, 6H), 1.25-1.13 (m, 6H).^{13}C NMR (100 MHz, $CDCl_3$) δ 169.51 (2), 131.05 , 125.18 , 98.06 , 78.80 , 71.38 , 62.74 , 62.06 , 61.6 (2 CH_2), 56.46 , 30.53 , 30.03 , 25.34 , 22.45 , 19.35 , 13.91 (2 CH_3). HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{19}H_{28}O_6Na$ $(M+Na)^+$ 375.1784, obsd 375.1773.

Diethyl -2-(4'-Hydroxybut-2'*Z*-en-1-yl)-2-(propargyl)malonate (S6)



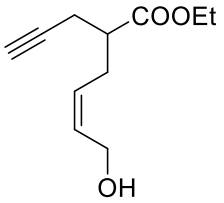
To a solution of THP-protected alcohol **S5** (200 mg, 0.56 mmol) in MeOH (2 mL) was added PTSA (21 mg, 0.11 mmol, 0.2 eq.) and the resulting mixture was stirred for 2 h at RT whereupon TLC indicated complete deprotection. The reaction mixture was concentrated and the resulting residue was taken up in ethyl acetate, washed with brine, dried over Na_2SO_4 and concentrated. The crude product was purified via SiO_2 flash chromatography [hexanes/ethyl acetate (80:20)] to yield the title alcohol (140 mg, 93%) as a colorless oil. ^{1}H NMR (300 MHz, $CDCl_3$) δ 5.78 (dtt, *J* = 11.2, 6.8, 1.4 Hz, 1H), 5.32 (dtt, *J* = 11.0, 8.1, 1.4 Hz, 1H), 4.22 (m, 6H), 2.83 (dd, *J* = 8.1, 1.0 Hz, 2H), 2.79 (d, *J* = 2.7 Hz, 2H), 2.02 (t, *J* = 2.7 Hz, 1H), 1.76 (br s, 1H), 1.23 (t, *J* = 7.1 Hz, 6H).^{13}C NMR (75 MHz, $CDCl_3$) δ 169.61 (2), 133.33 , 125.00 , 78.85 , 71.55 , 61.79 (2 CH_2), 58.14 , 56.55 , 29.90 , 22.62 , 13.96 (2 CH_3). HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{14}H_{20}O_5Na$ $(M+Na)^+$ 291.1208, obsd 291.1206.

Diethyl-2-(4'-(Methoxycarbonyloxy)but-2'*Z*-en-1'-yl)-2-(propargyl)malonate (7)



Carbonate **7** was prepared following General Procedure C from the corresponding alcohol **S6** (137 mg, 0.51 mmol), pyridine (54 µL, 0.67 mmol, 1.3 eq.) and methyl chloroformate (52 µL, 0.67 mmol, 1.3 eq.) in CH_2Cl_2 (3 mL) to afford **7** (132 mg, 80%) as a colorless oil after chromatography [hexanes/ethyl acetate (90:10)]. ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.72 (dt, *J* = 11.2, 6.6 Hz, 1H), 5.51-5.41 (m,1H), 4.72 (d, *J* = 6.6 Hz, 2H), 4.24-4.13 (m, 4H), 3.75 (s, 3H), 2.86 (d, *J* = 8.0 Hz, 2H), 2.76 (d, *J* = 2.5 Hz, 2H), 2.01 (t, *J* = 2.5 Hz, 1H), 1.23 (t, *J* = 7.1 Hz, 6H).^{13}C NMR (100 MHz, $CDCl_3$) δ 169.42 (2), 155.62 , 127.85 , 127.68 , 78.63 , 71.66 , 63.45 , 61.81 , 56.42 , 54.72 , 30.07 , 22.60 , 13.96. HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{16}H_{22}O_7Na$ $(M+Na)^+$ 349.1263, obsd 349.1262.

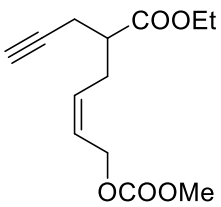
Ethyl -6-Hydroxy-2-(propargyl)-hex-4*Z*-enoate (S7)



To a solution of **S6** (200 mg, 0.57 mmol) in DMSO (2 mL) was added LiCl (240 mg, 5.57 mmol, 10 eq.) and the resulting reaction mixture was heated to 150 °C for 4 h. After being allowed to cool to RT, the reaction mixture was quenched with water. The reaction mixture was extracted with ether (5x) and

the combined extracts were dried (Na_2SO_4), filtered and concentrated. The crude product was purified via silica gel chromatography [hexanes/ethyl acetate (90:10→70:30) to yield the desired alcohol (55 mg, 50%) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.71 (dtt, *J* = 10.9, 7.0, 1.4 Hz, 1H), 5.42 (ddt, *J* = 11.2, 7.6, 1.4 Hz, 1H), 4.19 (dd, *J* = 12.5, 7.3 Hz, 1H), 4.13 (q, *J* = 7.1 Hz, 2H), 4.11 (dd, *J* = 12.5, 7.3 Hz, 1H), 2.64-2.35 (m, 5H), 2.0 (t, *J* = 2.6 Hz, 2H), 1.23 (t, *J* = 7.1 Hz, 3H).^{13}C NMR (100 MHz, $CDCl_3$) δ 173.72 , 131.45 , 128.03 , 80.94 , 70.28 , 60.84 , 58.07 , 43.87 , 28.38 , 20.48 , 14.15 . HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{11}H_{16}O_3Na$ $(M+Na)^+$ 219.0997, obsd 219.0991.

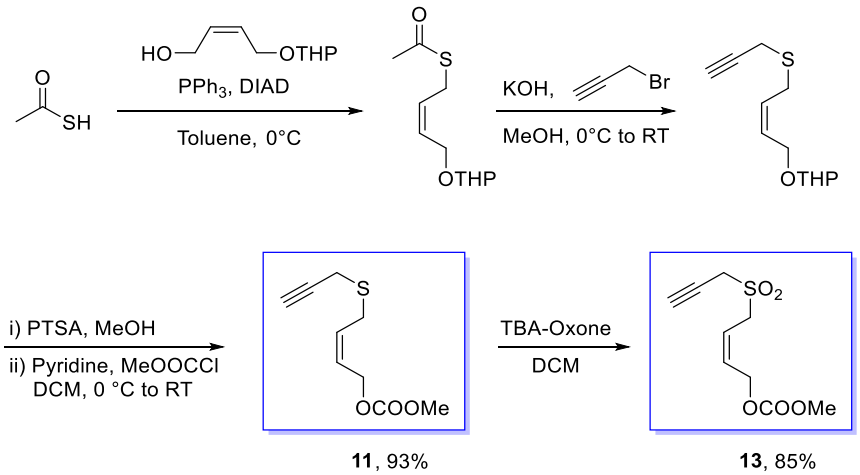
Ethyl-6-(Methoxycarbonyloxy)-2-(prop-2'-yn-1'-yl)hex-4*Z*-enoate (9)



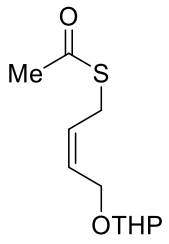
Carbonate **9** was prepared following General Procedure C from the corresponding alcohol (55 mg, 0.28 mmol), pyridine (30 µL, 0.36 mmol, 1.3 eq.) and methyl chloroformate (28 µL, 0.36 mmol, 1.3 eq.) in CH_2Cl_2 (1.5 mL) to afford **9** (60 mg, 83%) as a colorless oil after chromatography on silica gel [hexanes/ethyl acetate (90:10)]. ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.70-5.52 (m, 2H), 4.7 (dd, *J* = 12.3, 6.5 Hz, 1H), 4.65 (dd, *J* = 12.3, 6.5 Hz, 1H), 4.13 (q, *J* = 7.1 Hz, 2H), 3.74 (s, 3H), 2.6 (m, *J* = 6.7 Hz, 1H), 2.65-2.35 (m, 4H), 1.98 (*J* = 2.6 Hz, 1H), 1.23 (t, *J* = 7.1 Hz, 3H).^{13}C NMR (100 MHz, $CDCl_3$) δ 173.19 , 155.62 , 130.97 , 125.76 , 80.87 , 70.26 , 63.36 , 60.76 , 54.68 , 43.74 , 28.60 , 20.35 , 14.14 . HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{13}H_{18}O_5Na$ $(M+Na)^+$ 277.1052, obsd 277.1051.

C. <u>*Sulfur-Bridged Substrates*</u>

The key step in this series involved a Mitsunobu reaction between thioacetate and mono-THP-protected *Z*-but-2-en-1,4-diol. Sequential S-propargylation, *O*-THP deprotection and carbonate installation then provided the desired thioether substrate. This thioether could be oxidized with tetrabutylammonium oxone[5] to provide the corresponding sulfone-bridged substrate.

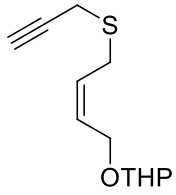


S-(4'-(Tetrahydro-2''H-pyran-2''-yloxy)but-2'*Z*-en-1'-yl)ethanethioate (S8)



To a solution of triphenylphosphine (0.78g, 3 mmol, 1 eq.) in toluene (30 mL) at 0 °C was added diisopropyl azodicarboxylate (0.6 mL, 3 mmol, 1 eq.) and the resulting mixture stirred for 15 min at 0 °C. A solution of mono-*O*-THP-protected 2*Z*-buten-1,4-diol (0.5 g, 3 mmol) and thioacetic acid (0.21 mL, 3 mmol, 1 eq.) in toluene (15 mL) was cooled to 0 °C and added, via canula, to the DIAD-PPh_3 solution. The resulting reaction mixture was stirred at 0 °C until TLC indicated completion. Following concentration on a rotary evaporator, purification by flash chromatography [hexanes/ethyl acetate (90:10)] afforded the title thioacetate (470 mg, 68%) as a pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.65-5.45 (m, 2H), 4.57 (dd, *J* = 3.7, 3.0 Hz, 1H), 4.25 (dd, *J* = 12.8, 5.6 Hz, 1H), 4.08 (dd, *J* = 12.8, 7.0 Hz, 1H), 3.8 (ddd, *J* = 11.3, 8.1, 3.0 Hz, 1H), 3.52 (d, *J* = 7.5 Hz, 2H), 3.49-3.41 (m, 1H), 2.25 (s, 3H), 1.83-1.41 (m, 6 H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 194.91 , 129.13 , 127.22 , 97.73 , 62.18 , 61.99 , 30.40 , 30.17 , 26.13 , 25.26 , 19.24 . HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{11}H_{18}O_3SNa$ $(M+Na)^+$ 253.0874, obsd 253.0870.

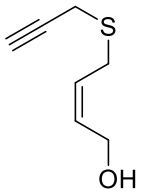
4-(S-Propargyl)thio-but-2*Z*-en-1-ol-O-THP ether (S9)



To a solution of thioacetate **S8** (0.4 g, 1.7 mmol) and potassium hydroxide (480 mg, 8.5 mmol, 5 eq.) in methanol (10 mL) under inert atmosphere, was added propargyl bromide (280 µL of a 80% wt solution in toluene, 2.6 mmol, 1.5 eq.) dropwise, via syringe. The reaction mixture was stirred at RT until completion before being concentrated, taken up in ethyl acetate and washed with brine. The aqueous layer

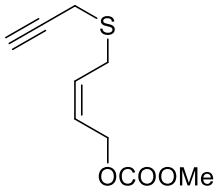
was extracted twice with ethyl acetate and the organic layers were combined, dried over Na_2SO_4 and concentrated. Purification by SiO_2 chromatography [hexanes/ethyl acetate (90:10→80:20)] afforded the desired S-propargyl thioether (300 mg, 79%) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.76 (dddt, *J* = 10.8, 5.9, 7.3, 1.3 Hz, 1H), 5.61 (dddt, *J* = 10.8, 8.0, 7.9, 1.3 Hz, 1H), 4.64 (dd, *J* = 3.9, 3.1 Hz, 1H), 4.3 (ddd, *J* = 12.6, 6.0, 1.3 Hz, 1H), 4.13 (ddd, *J* = 12.6, 7.4, 1.3 Hz, 1H), 3.86 (ddd, *J* = 11.1, 8.0, 3.2 Hz, 1H), 3.55-3.47 (m, 1H), 3.36 (d, *J* = 7.9 Hz, 2H), 3.19 (d, *J* = 2.5 Hz, 2H), 2.22 (t, *J* = 2.5 Hz, 1H), 1.89-1.43 (m, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 129.65 , 127.82 , 98.04 , 80.17 , 70.88 , 62.32 , 62.21 , 30.59 , 27.97 , 25.40 , 19.41 , 18.18 . HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{12}H_{18}O_2SNa$ $(M+Na)^+$ 249.0925, obsd 249.0935.

4-(S-Propargyl)thio-but-2*Z*-en-1-ol (S10)



To a solution of protected alcohol (300 mg, 1.3 mmol) in methanol (10 mL) was added PTSA (25 mg, 0.13 mmol, 0.1 eq.). The resulting reaction mixture was allowed to stir at RT until THP-deprotection reached completion, whereupon the mixture was concentrated, taken up in ethyl acetate and washed with brine. The organic layer was dried (Na_2SO_4), filtered and concentrated. The crude was product was purified by flash chromatography on silica gel to afford the targeted allylic alcohol (175 mg, 95% yield) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.84-5.74 (m, 1H), 5.60-5.50 (m, 1H), 4.23 (d, *J* = 7.1 Hz, 2H), 3.35 (d, *J* = 8.1 Hz, 2H), 3.18 (d, *J* = 2.5 Hz, 2H), 2.26 (t, *J* = 2.5 Hz, 1H), 1.83 (br s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 132.18 , 126.98 , 80.04 , 71.06 , 57.95 , 27.48 , 17.94 . HRMS (TOF MS ESI$^+$) m/z Calcd for $C_7H_{10}OSNa$ $(M+Na)^+$ 165.0350, obsd 165.0355.

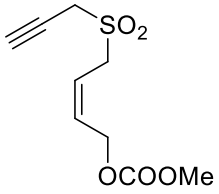
Methyl 4-(S-Propargyl)thio-but-2*Z*-en-1-yl Carbonate (11)



Carbonate **11** was prepared following General Procedure C from the corresponding alcohol (220 mg, 1.54 mmol), pyridine (163 µL, 2 mmol, 1.3 eq.) and methyl chloroformate (153 µL, 2 mmol, 1.3 eq.) in CH_2Cl_2 (10 mL) to afford **11** as colorless oil the title compound (295 mg, 98%) after chromatography [hexanes/ethyl acetate (85:15)]. ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.80-5.63 (m, 2H), 4.74 (d, *J* = 6.2 Hz, 2H), 3.77 (s, 3H), 3.38 (d, *J* = 7.2 Hz, 2H), 3.18 (d, *J* = 2.6 Hz, 2H), 2.24 (t, *J* = 2.6 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.60 , 130.08 , 126.28 , 79.78 , 71.17 ,

63.01 , 54.81 , 27.61 , 18.10 . HRMS (TOF MS ESI$^+$) m/z Calcd for $C_9H_{12}O_3SNa$ $(M+Na)^+$ 223.0405, obsd 223.0407.

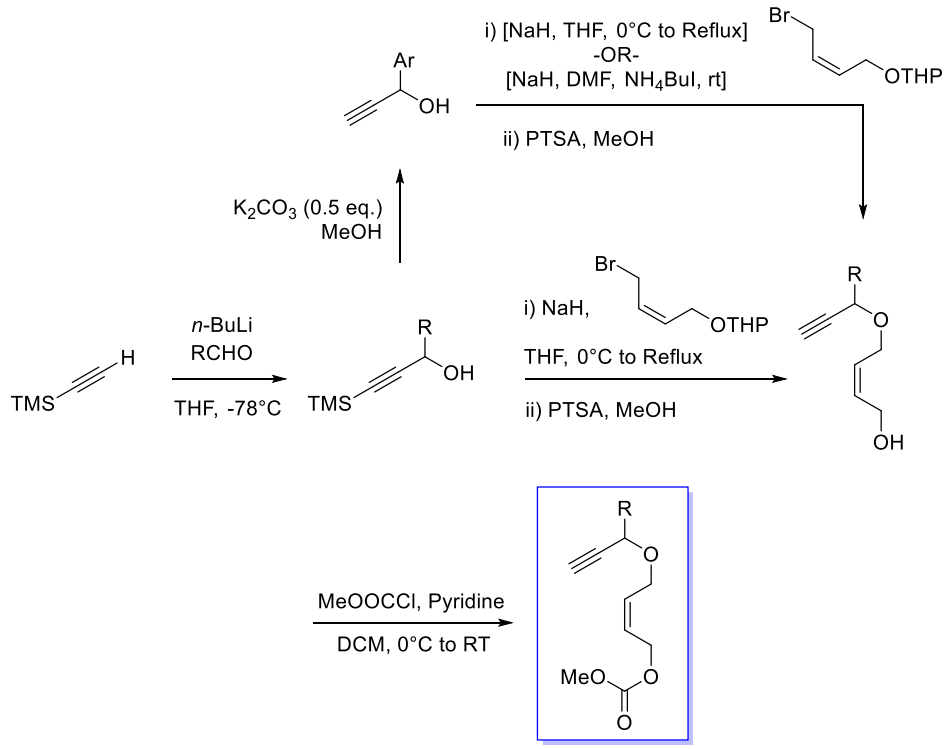
Methyl 4-(S-Propargylsulfonyl)thio-but-2*Z*-en-1-yl carbonate (13)



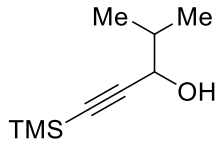
A mixture of carbonate **11** (130 mg, 0.65 mmol) and tetrabutylammonium oxone (20% wt, 3.4 g, 1.95 mmol, 3 eq.) in CH_2Cl_2 at room temperature was stirred overnight. The reaction mixture was then concentrated and the resulting crude product subjected to silica gel chromatography [CH_2Cl_2/MeOH (100:0→95:5) to yield the desired sulfone-bridged product (128 mg, 85%) as an amorphous solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.08 (dt, *J* = 10.8, 6.8 Hz, 1H), 5.83 (dt, *J* = 10.8, 8.1 Hz, 1H), 4.78 (d, *J* = 6.8 Hz, 2H), 4.07 (d, *J* = 8.1 Hz, 2H), 3.84 (d, *J* = 2.6 Hz, 2H), 3.78 (s, 3H), 2.54 (t, *J* = 2.6 Hz, 1H). ^{13}C NMR (75 MHz, $CDCl_3$) δ 155.47 , 133.10 , 119.74 , 76.68 , 71.31 , 62.80 , 54.97 , 50.29 , 43.97 . HRMS (TOF MS ESI+) m/z Calcd for $C_9H_{12}O_5SNa$ $(M+Na)^+$ 355.0303, obsd 355.0301.

D. *Propargyl-Substituted Substrates*

Substrates were prepared according to the general scheme presented below. Condensation of lithiated trimethylsilylacetylene with the appropriate aldehyde furnished the desired alcohol . Displacement of 4-bromo-2*Z*-butenol-*O*-THP ether **57**, prepared as previously described,[6] was followed by THP deprotection. This gave led to the penultimate alcohol which was then converted to the carbonate. For R = Ar, TMS deprotection was carried out prior to allyl ether formation.

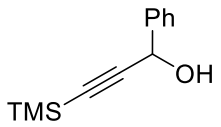


4-Methyl-1-(trimethylsilyl)pent-1-yn-3-ol (S12)



Alcohol **S12** was prepared following General Procedure A from trimethylsilylacetylene (0.5 mL, 3.5 mmol, 1.2 eq.), isobutyraldehyde (290 µL, 3.18 mmol) and *n*-butyllithium (2.2 mL of a 1.6 M solution in hexanes, 3.5 mmol, 1.2 eq.). Following purification by SiO_2 flash chromatography [hexanes/ethyl acetate (90:10)], **S12** (600 mg, 99%) was obtained as a clear pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 4.12 (d, *J* = 5.7 Hz, 1H), 2.20-2.03 (br s, 1H), 1.83 (apt m, *J* = 6.6 Hz, 1H), 0.99 (apt t, *J* = 6.6 Hz, 6H), 0.14 (s, 9H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 105.61 , 90.00 , 68.19 , 34.36 , 18.02 , 17.38 (3 CH_3), -015 (3 CH_3). HRMS (TOF MS CI^-) m/z Calcd for $C_9H_{17}OSi$ $(M-H)^-$ 169.1049, obsd 169.1048.

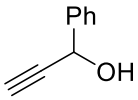
1-Phenyl-3-(trimethylsilyl)prop-2-yn-1-ol (S13)



Alcohol **S13** was prepared following General Procedure A from trimethylsilylacetylene (0.5 mL, 3.5 mmol, 1.2 eq.), benzaldehyde (324 µL, 3.18 mmol) and *n*-butyllithium (2.2 mL of a 1.6 M solution in hexanes, 3.5 mmol, 1.2 eq.). Purification via silica gel chromatography [hexanes/ethyl acetate (90:10)] gave

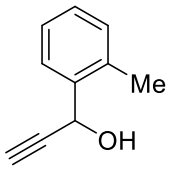
the desired product (570 mg, 90%) as a clear yellow oil. ^{1}H NMR (700 MHz, $CDCl_3$) δ 7.54 (d, *J* = 7.6 Hz, 2H), 7.38 (t, *J* = 7.6 Hz, 2H), 7.33 (t, *J* = 7.6 Hz, 1H), 5.45 (d, *J* = 3.3 Hz, 1H), 2.23 (br s, 1H), 0.21 (s, 9H).^{13}C NMR (175 MHz, $CDCl_3$) δ 140.29 , 128.58 (2 CH), 128.37 , 126.72 (2 CH), 104.89 , 91.60 , 64.99 , -0.19 (3 CH_3). HRMS (TOF MS EI^+) m/z Calcd for $C_{12}H_{16}OSi$ ($m^{+\cdot}$) 204.0970, obsd 204.0979.

1-Phenylprop-2-yn-1-ol (S14)



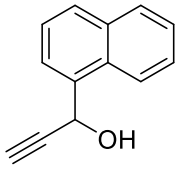
To a solution of TMS-protected alkyne **S13** (420 mg, 2.05 mmol) in MeOH (10 mL) was added solid K_2CO_3 (140 mg, 1.02 mmol, 0.5 eq.) and the resulting reaction mixture was allowed to stir at RT. When TLC indicated complete silyl deprotection, the reaction mixture was diluted with diethyl ether and washed with NH_4Cl (aq., saturated). The aqueous layer was extracted with diethyl ether (twice) and the combined organic extracts were dried (Na_2SO_4), filtered and concentrated. Purification via silica gel chromatography (hexanes/ethyl acetate 90:10→80:20) afforded the title compound (230 mg, 85%) as a colorless oil. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.54 (dd, *J* = 7.8, 1.8 Hz, 2H), 7.43-7.31 (m, 3H), 5.42 (dd, *J* = 5.2, 2.2 Hz, 1H), 3.29 (br s, 1H), 2.67 (d, *J* = 2.2 Hz, 1H). ^{13}C NMR (75 MHz, $CDCl_3$) δ 139.88 , 128.42 (2 CH), 128.25 , 126.49 (2 CH), 83.45 , 74.69 , 63.98 . HRMS (TOF MS EI^+) m/z Calcd for C_9H_8O $(M)^{+\cdot}$ 132.0565, obsd 132.0578.

1-(2'-Methoxyphenyl)prop-2-yn-1-ol (S15)



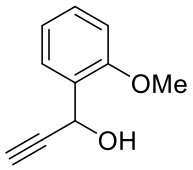
Alcohol **S15** was prepared following General Procedure A from trimethylsilylacetylene (1.34 mL, 9.15 mmol, 1.1 eq.), o-tolualdehyde (1g, 8.33 mmol) and n-butyllithium (7.1 mL of a 1.6 M solution in hexanes, 11.4 mmol, 1.4 eq.) **S15** (976 mg, 92%) was obtained following TMS deprotection (see **S14)** purification by SiO_2 flash chromatography (hexanes/ethyl acetate 90:10) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 – 7.62 (m, 1H), 7.35 – 7.26 (m, 2H), 7.26 – 7.18 (m, 1H), 5.61 (dd, *J* = 5.6, 2.2 Hz, 1H), 2.93 (d, *J* = 5.7 Hz, 1H), 2.67 (d, *J* = 2.3 Hz, 1H), 2.47 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 138.08 , 136.04 , 130.91 , 128.66 , 126.49 , 83.56 , 77.63 , 77.31 , 62.20 , 19.06 .

1-(Naphthalen-1'-yl)prop-2-yn-1-ol (S16)



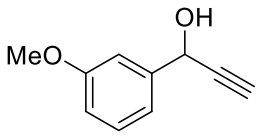
Alcohol **S16** was prepared following General Procedure A from trimethylsilylacetylene (1.04 mL, 7.05 mmol, 1.1 eq.), 1-Naphthaldehyde (1g, 6.41 mmol) and n-butyllithium (5.6 mL of a 1.6 M solution in hexanes, 8.97 mmol, 1.4 eq.) **S16** (1.05 g, 90%) was obtained following TMS deprotection (see **S14)** purification by SiO_2 flash chromatography (hexanes/ethyl acetate 90:10) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.29 (d, *J* = 7.9 Hz, 1H), 7.93 (d, *J* = 7.4 Hz, 1H), 7.88 (d, *J* = 7.6 Hz, 2H), 7.66 – 7.54 (m, 2H), 7.50 (t, *J* = 7.6 Hz, 1H), 6.10 (s, 1H), 3.38 (d, *J* = 5.0 Hz, 1H), 2.77 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 135.33 , 134.17 , 130.64 , 129.63 , 128.98 , 126.69 , 126.15 , 125.48 , 124.85 , 124.11 , 83.63 , 75.74 , 62.66 .

1-(2'-Methoxyphenyl)prop-2-yn-1-ol (S17):



Alcohol **S17** was prepared following General Procedure A from trimethylsilylacetylene (1.25 mL, 8.84 mmol, 1.1 eq.), 2-Methoxybenzaldehyde (1g, 7.35 mmol) and n-butyllithium (6.4 mL of a 1.6 M solution in hexanes, 10.24 mol, 1.4 eq.) **S17** (1.12 g, 94%) was obtained following TMS deprotection (see **S14)** as a yellow oil after purification by SiO_2 flash chromatography (hexanes/ethyl acetate 90:20) as a yellow solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.59 (dd, *J* = 7.5, 1.7 Hz, 1H), 7.45 – 7.31 (m, 1H), 7.01 (td, *J* = 7.5, 0.9 Hz, 1H), 6.94 (d, *J* = 8.2 Hz, 1H), 5.72 (d, *J* = 3.6 Hz, 1H), 3.91 (s, 3H), 3.15 (d, *J* = 6.1 Hz, 1H), 2.64 (d, *J* = 2.3 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 156.88 , 129.96 , 128.37 , 127.97 (2CH), 121.04 , 111.01 , 83.27 , 74.23 , 61.12 , 55.71 .

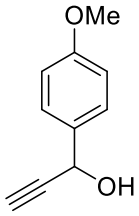
1-(3'-Methoxyphenyl)prop-2-yn-1-ol (S18)



Alcohol **S18** was prepared following General Procedure A from trimethylsilylacetylene (0.68 mL, 5.0 mmol, 1.2 eq.), 3-methoxybenzaldehyde (0.5ML, 4.0 mmol) and *n*-butyllithium (3.2 mL of a 1.6 M solution in hexanes, 4.0 mmol, 1.2 eq.)., **S18** (0.65 g , quant) was obtained as a clear pale yellow oil obtained following TMS deprotection (see **S14)** without need for further purification. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.32 (dd, *J* = 14.4, 6.6 Hz, 2H), 7.17 (s, 1H), 6.91 (d, *J* = 8.4 Hz,

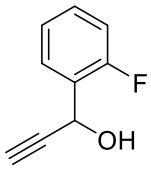
1H), 5.47 (d, *J* = 6.1 Hz, 1H), 3.85 (s, 3H), 2.69 (s, 1H). ^{13}C NMR (75 MHz, $CDCl_3$) δ 159.86, 141.59, 129.76, 118.85, 114.26, 112.01, 83.42, 74.82, 64.36, 55.32.

1-(4'-Methoxyphenyl)prop-2-yn-1-ol (S19):



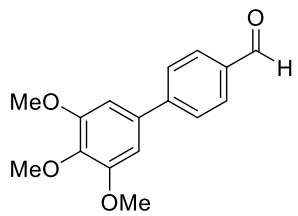
Alcohol **S19** was prepared following General Procedure A from trimethylsilylacetylene (1.09 mL, 8.08 mmol, 1.1 eq.), 4-methoxybenzaldehyde (1g, 7.35 mmol) and n-butyllithium (6.4 mL of a 1.6 M solution in hexanes, 10.29 mmol, 1.4 eq.) 1 (1.02g, 86%) was obtained as a yellow oil following TMS deprotection (see **S14)** and purification by SiO_2 flash chromatography (hexanes/ethyl acetate 80:20). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.46 (d, *J* = 8.5 Hz, 2H), 6.90 (d, *J* = 8.8 Hz, 2H), 5.39 (d, *J* = 2.0 Hz, 1H), 3.80 (s, 3H), 3.04 (s, 1H), 2.67 (d, *J* = 2.2 Hz, 1H). 13C NMR (100 MHz, CDCl3) δ 159.79 , 132.68 , 128.21 (2CH), 114.13 (2CH), 84.03 , 74.66 , 63.99 , 55.43 .

1-(2'-Fluorophenyl)prop-2-yn-1-ol (S20):



Alcohol **S20** was prepared following General Procedure A from trimethylsilylacetylene (1.36 mL, 9.67 mmol, 1.1 eq.), 2-fluorobenzaldehyde (1g, 8.06 mmol) and n-butyllithium (7.05 mL of a 1.6 M solution in hexanes, 11.28 mmol, 1.4 eq.) 1 (1.16g, 96%) was obtained following TMS deprotection (see **S14)** as a colorless oil after purification by SiO_2 flash chromatography (hexanes/ethyl acetate 90:10). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.68 (td, *J* = 7.6, 1.8 Hz, 1H), 7.39 – 7.26 (m, 1H), 7.18 (td, *J* = 7.5, 1.1 Hz, 1H), 7.07 (ddd, *J* = 10.2, 8.2, 1.1 Hz, 1H), 5.75 (d, *J* = 2.2 Hz, 1H), 2.65 (d, *J* = 2.3 Hz, 2H). ^{13}C NMR (100 MHz, CDCl3) δ 160.25 (d, *J* = 248.25 Hz) (CF), 130.50 (d, *J* = 8.3 Hz)(C_{quet}), 128.42 (d, *J* = 3.4 Hz), 127.44 (d, *J* = 13.2 Hz), 124.55 (d, *J* = 3.6 Hz), 115.24 (D, J =21.24 Hz), 82.54 , 74.88 , 58.87 (d, *J* = 5.0 Hz). ^{19}F NMR (376 MHz, $CDCl_3$) δ -119.21 (ddd, *J* = 10.4, 7.5, 5.4 Hz).

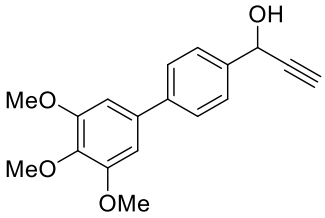
3',4',5'-Trimethoxy-[1,1'-biphenyl]-4-carbaldehyde (S21)



A solution containing 4-formylphenylboronic acid (150 mg, 1 mmol, 1.5eq), 3,4,5-trimethoxybromobenzne (164 mg, 0.67 mmol, 1.0 eq), $Pd(OAc)_2$ (15 mg, 0.067 mmol, 0.1 eq), $P(o\text{-}tol)_3$ (41 mg, 0.134 mmol,

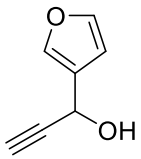
0.2 eq), K_2CO_3 (370 mg, 2.68, 4 eq) in DMF (3 mL) and water (0.1 mL) was heated to 80 °C **S21** (200 mg , 97%) was obtained as a clear pale yellow oil following column chromatography Hexane/EtoAc (85/15). ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.02 (s, 1H), 7.91 (d, *J* = 8.3 Hz, 2H), 7.70 (d, *J* = 8.2 Hz, 2H), 6.82 (s, 2H), 3.92 (s, 5H), 3.90 (s, 3H).). ^{13}C NMR (75 MHz, $CDCl_3$) δ 191.86, 153.67, 147.28, 138.65, 134.20, 130.26, 128.05, 127.62, 104.72, 61.02, 56.30.

1-(3',4',5'-Trimethoxy-[1,1'-biphenyl]-4''-yl)prop-2-yn-1-ol (S22)



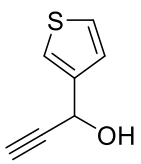
Alcohol **S22** was prepared following General Procedure A from trimethylsilylacetylene (122 μL, 0.88 mmol, 1.2 eq.), aldehyde **S21** (200 mg, 0.74 mmol) and *n*-butyllithium (0.55 mL of a 1.6 M solution in hexanes, 0.88 mmol, 1.2 eq.)., **S21** (160 mg , 72%) was obtained as a clear pale yellow oil without need for further purification following TMS deprotection (see **S14)** ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.68 – 7.49 (m, 4H), 6.80 (d, *J* = 12.8 Hz, 2H), 5.53 (s, 1H), 3.92 (s, 6H), 3.90 (s, 3H), 2.97 (s, 1H), 2.70 (s, 1H).

1-(Furan-3'-yl)prop-2-yn-1-ol (S23):



Alcohol **S23** was prepared following General Procedure A from trimethylsilylacetylene (1.81 mL, 12.5 mmol, 1.1 eq.), 3-furancarboxaldehyde (1g, 10.41 mmol) and n-butyllithium (9.1 mL of a 1.6 M solution in hexanes, 14.7 mmol, 1.4 eq.) **S23** (1.18 g, 93%) was obtained as a light yellow oil following TMS deprotection (see **S14)** and purification by SiO_2 flash chromatography (hexanes/ethyl acetate 90:20 ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.52 (s, 1H), 7.39 (s, 1H), 6.50 (d, *J* = 0.8 Hz, 1H), 5.37 (s, 1H), 3.25 (s, 1H), 2.60 (d, *J* = 2.2 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 143.76 , 140.41 , 126.05 , 109.29 , 83.24 , 73.48 , 56.97 .

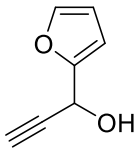
1-(Thiophen-3'-yl)prop-2-yn-1-ol (S24):



Alcohol **S24** was prepared following General Procedure A from trimethylsilylacetylene (1.39 mL, 9.81 mmol, 1.1 eq.), 3-thiophenecarboxaldehyde (1g, 8.92 mmol) and n-butyllithium (7.81 mL of a 1.6 M solution in hexanes, 12.47 mmol, 1.4 eq.) 1 (1.20 g, 98%) was obtained following TMS deprotection (see **S14)** purification by SiO_2 flash chromatography (hexanes/ethyl acetate 80:20) as a yellow solid. ^{1}H NMR (400

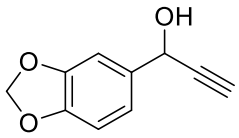
MHz, $CDCl_3$) δ 7.42 (d, *J* = 2.4 Hz, 1H), 7.33 (dd, *J* = 4.9, 3.1 Hz, 1H), 7.21 (d, *J* = 4.8 Hz, 1H), 5.49 (d, *J* = 1.3 Hz, 1H), 3.10 (s, 1H), 2.66 (d, *J* = 2.1 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 141.61 , 126.73 , 126.48 , 122.98 , 83.63 , 74.20 , 60.33 .

1-(Furan-2'-yl)prop-2-yn-1-ol (S25):



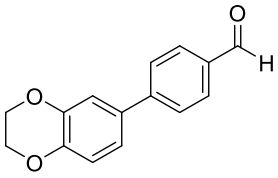
Alcohol **S25** was prepared following General Procedure A from trimethylsilylacetylene (1.62 mL, 11.45 mmol, 1.1 eq.), furfural (1g, 10.41 mmol) and n-butyllithium (9.14 mL of a 1.6 M solution in hexanes, 14.63 mmol, 1.4 eq**.) S25** (1.11 g, 88%) was obtained as a yellow oil TMS deprotection (see **S14)** SiO_2 flash chromatography (hexanes/ethyl acetate 90:10) as a yellow solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49 – 7.37 (m, 1H), 6.53 – 6.42 (m, 1H), 6.35 (dd, *J* = 3.1, 1.8 Hz, 1H), 5.45 (s, 1H), 3.35 (d, *J* = 8.4 Hz, 1H), 2.63 (d, *J* = 2.3 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 152.57 (s), 143.70 (s), 143.20 (s), 110.57 (s), 108.10 (s), 81.26 (s), 77.61 (s), 77.29 (s), 76.97 (s), 74.22 (s), 57.87 (s). ^{13}C NMR (100 MHz, $CDCl_3$) δ 152.57 , 143.20 , 110.61 , 108.10 , 81.26 , 74.22 , 57.87 .

1-(Benzo[d][1',3']dioxol-5'-yl)prop-2-yn-1-ol (S26)



Alcohol **S26** was prepared following General Procedure A from trimethylsilylacetylene (1,1 mL, 8.0 mmol, 1.2 eq.), piperonal (1g, 6.7 mmol) and *n*-butyllithium (5 mL of a 1.6 M solution in hexanes, 8.0 mmol, 1.2 eq.)., **S26** (1.15g , 98%) was obtained as a clear pale yellow oil without need for further purification following TMS deprotection (see **S14)**. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.09 (s, 1H), 7.04 (d, *J* = 8.0 Hz, 1H), 6.83 (d, *J* = 7.9 Hz, 1H), 6.00 (s, 2H), 5.41 (s, 1H), 2.69 (d, *J* = 1.8 Hz, 1H). ^{13}C NMR (75 MHz, $CDCl_3$) δ 147.93, 147.82, 134.13, 120.37, 108.20, 107.35, 101.27, 83.51, 74.76, 64.22

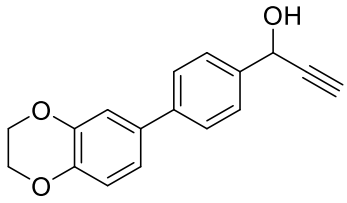
4-(2',3'-Dihydrobenzo[b][1,4]dioxin-6-yl)benzaldehyde (S27)



A solution containing 4-formylphenylboronic acid (300 mg, 2 mmol, 1.5eq), ethylenedioxybromobenzne (0.18 mL, 1,33 mmol, 1.0 eq), $Pd(OAc)_2$ (30 mg, 0.133 mmol, 0.1 eq), $P(o\text{-}tol)_3$ (80 mg, 0.266 mmol, 0.2 eq), K_2CO_3 (734 mg, 5.4, 4 eq) in DMF (5 mL) and water (0.2 mL) was heated to 80 °C **S27** (310 mg , 97%) was obtained as a clear pale yellow oil was obtained as

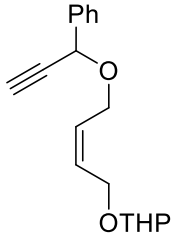
a clear pale yellow oil following column chromatography Hexane/EtoAc (85/15). ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.03 (s, 1H), 7.92 (d, *J* = 7.5 Hz, 2H), 7.69 (d, *J* = 7.5 Hz, 2H), 7.21 – 7.08 (m, 2H), 6.97 (d, *J* = 8.1 Hz, 1H), 4.31 (s, 4H).

1-(4-(2',3'-dihydrobenzo[b][1',4']dioxin-6'-yl)phenyl)prop-2-yn-1-ol (S28)



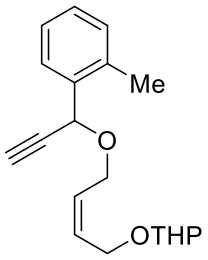
Alcohol **S28** was prepared following General Procedure A from trimethylsilylacetylene (210 μL, 1.5 mmol, 1.2 eq.), aldehyde **S27** (300 mg, 1.2 mmol) and *n*-butyllithium (1 mL of a 1.6 M solution in hexanes, 1.5 mmol, 1.2 eq.)., **S27** (160 mg , 51%) was obtained as a clear pale yellow oil without need for further purification following TMS deprotection (see **S14)**. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65 – 7.54 (m, 4H), 7.21 – 7.05 (m, 2H), 6.95 (d, *J* = 8.3 Hz, 1H), 5.51 (d, *J* = 3.4 Hz, 1H), 4.31 (s, 4H), 2.71 (d, *J* = 2.2 Hz, 1H), 2.59 (d, *J* = 5.7 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 143.82 , 143.46 , 140.99 , 138.75 , 134.26 , 127.15 (d, *J* = 5.1 Hz), 120.31 , 117.75 , 115.99 , 83.69 , 77.51 , 77.20 , 76.88 , 75.01 , 64.57 (d, *J* = 3.7 Hz), 64.29

4-((1''-Phenylprop-2'-yn-1'-yl)oxy)but-2*Z*-en-1-ol (S29)



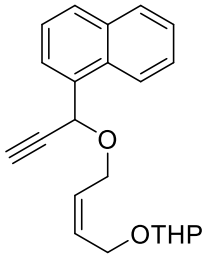
Allylic ether was prepared following General Procedure B from **S14** (230 mg, 1.74 mmol), NaH (70 mg, 1.74 mmol, 1 eq.), 4-bromo-2*Z*-butenol-*O*-THP ether (449 mg, 1.91 mmol, 1.1 eq.) in THF (17 mL). Homogenous product (348 mg, 70%) was obtained as a colorless oil following purification by SiO_2 flash chromatography (hexanes/ethyl acetate 100:0→90:10). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.51 (dd, *J* = 7.7, 1.4 Hz, 2H), 7.40-7.30 (m, 3H), 5.80 (apt dd, *J* = 10.7, 4.4 Hz, 1H), 5.74 (apt dd, *J* = 10.7, 4.4 Hz, 1H), 5.2 (apt d, *J* = 2.1 Hz, 1H), 4.61 (s, 1H), 4.33-4.21 (m, 3H), 4.15-4.02 (m, 1H), 3.89-3.79 (m, 1H), 3.53-3.43 (m, 1H), 2.65 (apt d, *J* = 2.1 Hz, 1H), 1.89-1.43 (m, 6H). ^{13}C NMR (75 MHz, $CDCl_3$) δ 137.94 , 129.95 , 129.93 , 128.46 , 128.38 (2 CH), 127.26 (2 CH), 97.89 , 97.82 , 81.4 , 75.65 ; 70.35 , 63.72 , 62.76 , 62.69 , 62.00 , 30.46 , 25.31 , 19.27 (some carbon signals are doubled due to the presence of THP-diastereomers). HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{18}H_{22}O_3Na$ $(M+Na)^+$ 309.1467, obsd 309.1476.

(Z)-2-((4'-((1'-(o-Tolyl)prop-2'-yn-1'-yl)oxy)but-2-en-1-yl)oxy)tetrahydro-2H-pyran (S30):



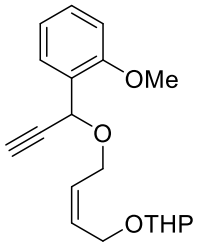
A solution containing alcohol **S15** (730 mg 5 mmol, 1eq), tetrabutylammonium iodide (811 mg, 2 mmol, 0.4eq) and, 4-bromo-2Z-butenol-O-THP ether 1.28 g, 5.5 mmol, 1.1 eq.) in DMF (5 mL) was cooled to 0 °C. To this 230 mg (9 mmol, 1.8 eq) of NaH is added. The solution was allowed to warm to ambient temperature after 15min. Either product **S30** (1.2 g, 80%) was obtained as a colorless oil following purification by SiO_2 flash chromatography (hexanes/ethyl acetate 90:10). 1H NMR (400 MHz, CDCl3) δ 7.65 (dd, J = 5.5, 3.4 Hz, 1H), 7.26 – 7.22 (m, 2H), 7.21 – 7.15 (m, 1H), 5.80 (d, J = 4.6 Hz, 2H), 5.35 (t, J = 1.7 Hz, 1H), 4.64 (d, J = 3.5 Hz, 1H), 4.33 – 4.27 (m, 2H), 4.20 – 4.05 (m, 1H), 3.91 – 3.83 (m, 1H), 3.56 – 3.48 (m, 1H), 2.68 (d, J = 2.2 Hz, 1H), 2.43 (s, 3H), 1.85 (dd, J = 9.7, 3.1 Hz, 1H), 1.77 – 1.70 (m, 1H), 1.63 – 1.52 (m, 4H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 136.42 , 136.04 , 130.81 , 130.18 , 128.67 , 127.73 , 126.18 , 98.07 , 81.41 , 62.94 , 76.69 , 62.18 , 30.70 , 28.36 , 25.57 , 22.82 , 19.10 .

(Z)-2-((4-((1-(Naphthalen-1''-yl)prop-2'-yn-1'-yl)oxy)but-2-en-1-yl)oxy)tetrahydro-2H-pyran (S31):



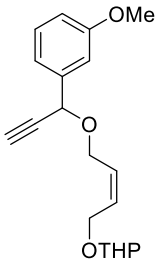
A solution containing alcohol **S16** (911 mg 5 mmol, 1eq), tetrabutylammonium iodide (811 mg, 2 mmol, 0.4eq) and, 4-bromo-2Z-butenol-O-THP ether 1.28 g, 5.5 mmol, 1.1 eq.) in DMF (5 mL) was cooled to 0 °C. To this 230 mg (9 mmol, 1.8 eq) of NaH is added. The solution was allowed to warm to ambient temperature after 15min. Either product **S31** (1.3 g, 77%) was obtained as a colorless oil following purification by SiO_2 flash chromatography (hexanes/ethyl acetate 90:10). 1H NMR (400 MHz, CDCl3) δ 8.37 (d, *J* = 8.5 Hz, 1H), 7.97 – 7.81 (m, 3H), 7.59 (d, *J* = 7.5 Hz, 1H), 7.57 – 7.44 (m, 2H), 5.89 (dt, *J* = 8.0, 2.9 Hz, 3H), 4.64 (dt, *J* = 9.5, 3.5 Hz, 1H), 4.46 – 4.27 (m, 3H), 4.24 – 4.03 (m, 1H), 3.97 – 3.78 (m, 1H), 3.62 – 3.41 (m, 1H), 2.82 (t, *J* = 4.2 Hz, 1H), 1.84 (qd, *J* = 10.5, 6.6 Hz, 1H), 1.80 – 1.69 (m, 1H), 1.70 – 1.48 (m, 4H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 134.21 , 133.45 , 131.00 , 130.41 , 129.70 , 128.95 , 126.52 , 126.10 , 125.29 , 124.34 , 98.09 , 81.65 , 77.85 , 77.53 , 77.21 , 76.74 , 69.29 , 64.01 , 63.01 , 30.76 , 25.63 , 19.56 .

(Z)-2-((4-((1'-(2''-Methoxyphenyl)prop-2'-yn-1'-yl)oxy)but-2-en-1-yl)oxy)tetrahydro-2H-pyran (S32):



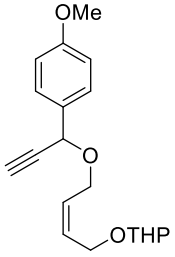
A solution containing alcohol **S17** (1.0 g 6.16 mmol, 1eq), tetrabutylammonium iodide (911 mg, 2.46 mmol, 0.4eq) and, 4-bromo-2Z-butenol-O-THP ether 1.58 g, 6.78 mmol, 1.1 eq.) in DMF (21 mL) was cooled to 0 °C. To this 342 mg (15.84 mmol, 1.8 eq) of NaH was added. The solution was allowed to warm to ambient temperature after 15min. Either product **S32** (1.5 g, 76%) was obtained as a colorless oil following purification by SiO_2 flash chromatography (hexanes/ethyl acetate 90:10). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.67 (dd, *J* = 7.6, 1.7 Hz, 1H), 7.40 – 7.23 (m, 1H), 7.00 (td, *J* = 7.5, 0.9 Hz, 1H), 6.89 (d, *J* = 8.3 Hz, 1H), 5.86 – 5.71 (m, 2H), 5.59 (s, 1H), 4.67 – 4.58 (m, 1H), 4.38 – 4.18 (m, 3H), 4.18 – 4.04 (m, 1H), 3.90 – 3.84 (m, 4H), 3.50 (ddd, *J* = 6.1, 5.1, 3.0 Hz, 1H), 2.58 (d, *J* = 2.2 Hz, 1H), 2.10 – 2.02 (m, 1H), 1.82 (s, 1H), 1.78 – 1.66 (m, 1H), 1.61 – 1.50 (m, 4H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 156.68 , 130.03 , 129.03 , 128.58 (2CH), 126.66 , 120.85 , 110.84 , 98.11 , 82.14 , 76.97 , 74.60 , 64.70 , 64.41 , 63.02 , 55.69 , 30.73 , 25.57 , 19.66 .

(Z)-2-((4-((1'-(3''-Methoxyphenyl)prop-2'-yn-1'-yl)oxy)but-2-en-1-yl)oxy)tetrahydro-2H-pyran (S33)



A solution containing alcohol **S18** (700 mg 4 mmol, 1eq), tetrabutylammonium iodide (320 mg, 0.86 mmol, 0.2eq) and, 4-bromo-2*Z*-butenol-*O*-THP ether 1 g, 4.4 mmol, 1.1 eq.) in DMF (10 mL) was cooled to 0 °C. To this 192 mg (4.7 mmol, 1.2eq) of NaH is added. The solution was allowed to warm to ambient temperature after 15min. Either product **S33** (1g, 75%) was obtained as a colorless oil following purification by SiO_2 flash chromatography (hexanes/ethyl acetate 100:0→90:10). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.41 – 7.22 (m, 2H), 7.12 (s, 1H), 6.90 (dd, J = 8.8, 1.9 Hz, 2H), 5.79 (dt, J = 16.0, 7.9 Hz, 4H), 5.20 (s, 2H), 4.66 (d, J = 9.7 Hz, 2H), 4.42 – 4.22 (m, 4H), 4.18 – 4.05 (m, 3H), 3.85 (s, 3H), 3.52 (dd, J = 11.0, 4.4 Hz, 1H), 2.67 (d, J = 2.1 Hz, 1H), 1.97 – 1.79 (m, 2H), 1.79 – 1.67 (m, 2H), 1.60 – 1.39 (m, 4H). ^{13}C NMR (75 MHz, $CDCl_3$) δ 159.77, 139.55, 130.07, 129.50, 122.59, 119.74, 114.30, 112.74 , 98.09 , 81.46 , 75.74, 70.40 , 63.85, 62.21, 55.29 , 30.57 , 25.41 , 19.37.

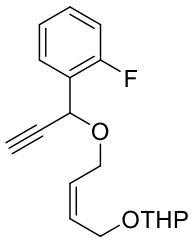
(Z)-2-((4-((1'-(4''-Methoxyphenyl)prop-2'-yn-1'-yl)oxy)but-2-en-1-yl)oxy)tetrahydro-2H-pyran (S34):



A solution containing alcohol **S19** (500 mg 3.08 mmol, 1eq), tetrabutylammonium iodide (227 mg, 0.61 mmol, 0.2eq) and, 4-bromo-2Z-butenol-O-THP ether 794 mg, 3.39 mmol, 1.1 eq.) in DMF (8 mL) was cooled to 0 °C. To this 131 mg (3.95 mmol, 1.8 eq) of NaH is added. The solution was allowed to warm to ambient temperature after 15min. Either product **S34** (551 mg, 56%) was obtained as a colorless oil following purification by SiO_2 flash chromatography (hexanes/ethyl acetate 90:10). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.46 (d, *J* = 8.7 Hz, 2H), 6.91 (d, *J* = 8.7 Hz, 2H), 5.85 – 5.70 (m, 2H), 5.17 (d, *J* = 1.5 Hz, 1H), 4.64 (t, *J* = 3.2 Hz, 1H), 4.37 – 4.26 (m, 1H), 4.27 – 4.18 (m, 2H), 4.17 – 4.05 (m, 1H), 3.82 (s, 3H), 3.57 – 3.47 (m, 1H), 2.70 – 2.65 (m, 1H), 1.94 – 1.79 (m, 1H), 1.79 – 1.68 (m, 1H), 1.67 – 1.46 (m, 4H). 13C NMR (100 MHz, CDCl3) δ 159.91 , 131.16 , 130.41 , 130.07 , 128.62 (2CH), 114.00 (2CH), 98.14 , 81.87 , 75.68 , 70.20 , 63.75 , 63.01 , 62.30 , 55.41 , 30.71 , 25.55 , 19.53 .

.

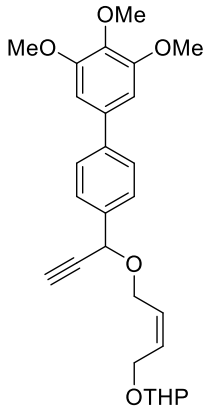
(Z)-2-((4-((1'-(2''-Fluorophenyl)prop-2'-yn-1'-yl)oxy)but-2-en-1-yl)oxy)tetrahydro-2H-pyran (S35):



A solution containing alcohol **S20** (330 mg 2.19 mmol, 1eq), tetrabutylammonium iodide (356 mg, 0.87mmol, 0.4eq) and, 4-bromo-2Z-butenol-O-THP ether 566 mg, 2.41 mmol, 1.1 eq.) in DMF (6 mL) was cooled to 0 °C. To this 96 mg (3.95 mmol, 1.8eq) of NaH was added. The solution was allowed to warm to ambient temperature after 15min. Either product **xx** (230 mg, 35%) was obtained as a dark blue oil following purification by SiO2 flash chromatography (hexanes/ethyl acetate 90:10). ^{1}H NMR (700 MHz, $CDCl_3$) δ 7.70 (t, *J* = 7.4 Hz, 1H), 7.34 (dd, *J* = 13.0, 7.2 Hz, 1H), 7.19 (t, *J* = 7.4 Hz, 1H), 7.07 (t, *J* = 9.1 Hz, 1H), 5.80 (ddd, *J* = 16.7, 10.5, 4.6 Hz, 2H), 5.50 (s, 1H), 4.65 (s, 1H), 4.38 – 4.30 (m, 2H), 4.27 (dd, *J* = 17.1, 9.9 Hz, 2H), 4.19 – 4.07 (m, 1H), 3.87 (t, *J* = 9.9 Hz, 1H), 3.60 – 3.44 (m, 1H), 1.84 (d, *J* = 9.0 Hz, 1H), 1.73 (t, *J* = 11.2 Hz, 1H), 1.63 – 1.58 (m, 2H), 1.54 (d, *J* = 4.1 Hz, 2H). ^{13}C NMR (175 MHz, $CDCl_3$) δ 160.90 (d *J* = 249.05 Hz) (CF), 130.52 – 130.21 (m) , 129.15 (d, *J* = 3.2 Hz) , 128.36 (d, *J* = 10.2 Hz), 125.48 (d, *J* = 13.3 Hz), 124.33 (d, *J* = 3.6 Hz), 115.53 , 98.03 (d, *J* = 6.2 Hz), 80.71 , 77.23 , 77.05 , 76.87 , 75.44 , 64.41 (d, *J* = 4.5 Hz), 64.15 (dd, *J* = 4.6, 1.9 Hz), 62.17 (d, *J* = 5.2 Hz),

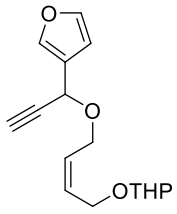
30.59 (d, *J* = 2.3 Hz),, 25.43 (s) ,, 19.40 (d, *J* = 4.5 Hz) . ^{19}F NMR (376 MHz, $CDCl_3$) δ -118.96 – -119.16 (m).

(Z)-2-((4-((1-(3',4'',5''-Trimethoxy-[1,1''-biphenyl]-4-yl)prop-2'-yn-1-yl)oxy)but-2-en-1-yl)oxy)tetrahydro-2H-pyran (S35)



A solution containing alcohol **S22** (150 mg 0.5 mmol, 1eq), tetrabutylammonium iodide (37 mg, 0.1 mmol, 0.2eq) and, 4-bromo-2*Z*-butenol-*O*-THP ether 130 mg, 0.55 mmol, 1.1 eq.) in DMF (2 mL) was cooled to 0 °C. To this 24 mg (0.6 mmol, 1.2eq) of NaH is added. The solution was allowed to warm to ambient temperature after 15min. Either product **S35** (100 mg, 44%) was obtained as a colorless oil following purification by SiO_2 flash chromatography (hexanes/ethyl acetate 100:0→80:20). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.67 – 7.41 (m, 4H), 6.85 – 6.71 (m, 2H), 5.88 – 5.64 (m, 2H), 5.26 (s, 1H), 4.65 (s, 1H), 4.31 (dt, *J* = 9.6, 5.1 Hz, 3H), 4.17 – 4.04 (m, 2H), 4.00 – 3.91 (m, 8H), 3.89 (d, *J* = 13.8 Hz, 3H), 3.56 – 3.45 (m, 1H), 2.70 (d, *J* = 2.0 Hz, 1H). ^{13}C NMR (75 MHz, $CDCl_3$) δ 153.59 , 141.77 , 137.90 , 137.30 , 136.81 , 130.27 , 128.64 (d, *J* = 7.1 Hz), 127.92 , 127.38 , 104.60 , 98.18 (d, *J* = 7.4 Hz), 81.60 , 77.52 , 77.21 , 76.89 , 75.98 , 70.33 , 64.04 , 63.03 (d, *J* = 7.3 Hz), 62.32 , 61.07 , 56.32 , 30.72 , 25.55 , 19.53 (some carbon signals are doubled due to the presence of THP-diastereomers).

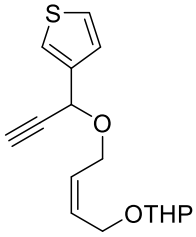
(Z)-2-((4-((1'-(Furan-3''-yl)prop-2'-yn-1'-yl)oxy)but-2-en-1-yl)oxy)tetrahydro-2H-pyran (S36):



A solution containing alcohol **S23** (244 mg 2 mmol, 1eq), tetrabutylammonium iodide (148 mg, 0.4 mmol, 0.2eq) and, 4-bromo-2Z-butenol-O-THP ether 514 mg, 2.2 mmol, 1.1 eq.) in DMF (5 mL) was cooled to 0 °C. To this 86 mg (3.6 mmol, 1.8 eq) of NaH was added. The solution was allowed to warm to ambient temperature after 15 min. Either product **S36** (314 mg, 57%) was obtained as a yellow oil following purification by SiO_2 flash chromatography (hexanes/ethyl acetate 90:10). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.53 (s, 1H), 7.40 (d, *J* = 1.5 Hz, 1H), 6.49 (d, *J* = 1.4 Hz, 1H), 5.18 (d, *J* = 1.9 Hz, 1H), 4.63 (s, 1H), 4.35 – 4.24 (m, 1H), 4.22 (d, *J* = 5.5 Hz, 2H), 4.16 – 4.01 (m,

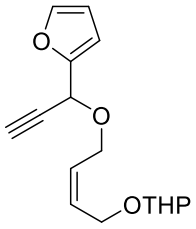
1H), 3.85 (ddd, *J* = 11.2, 8.1, 3.2 Hz, 1H), 3.51 (dd, *J* = 10.6, 5.6 Hz, 1H), 2.59 (d, *J* = 2.1 Hz, 1H), 1.81 (ddd, *J* = 11.4, 9.0, 4.7 Hz, 1H), 1.71 (tt, *J* = 8.8, 3.1 Hz, 1H), 1.64 – 1.49 (m, 4H).

(Z)-2-((4-((1'-(Thiophen-3''-yl)prop-2'-yn-1'-yl)oxy)but-2-en-1-yl)oxy)tetrahydro-2H-pyran (S37):



A solution containing alcohol **S24** (276 mg 2 mmol, 1eq), tetrabutylammonium iodide (148 mg, 0.4 mmol, 0.2eq) and, 4-bromo-2Z-butenol-O-THP ether 514 mg, 2.2 mmol, 1.1 eq.) in DMF (5 mL) was cooled to 0 °C. To this 86 mg (3.6 mmol, 1.8 eq) of NaH was added. The solution was allowed to warm to ambient temperature after 15min. Either product **xx** (303 mg, 54%) was obtained as a dark blue oil following purification by SiO_2 flash chromatography (hexanes/ethyl acetate 90:10). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.43 (s, 1H), 7.33 (dd, *J* = 5.0, 3.0 Hz, 1H), 7.19 (dd, *J* = 5.0, 0.9 Hz, 1H), 5.78 (qd, *J* = 11.5, 5.7 Hz, 2H), 5.38 – 5.22 (m, 1H), 4.72 – 4.60 (m, 1H), 4.45 – 4.26 (m, 1H), 4.24 (dd, *J* = 6.6, 3.6 Hz, 2H), 4.11 (ddd, *J* = 13.4, 8.2, 6.1 Hz, 1H), 3.96 – 3.79 (m, 1H), 3.53 (dd, *J* = 10.7, 5.5 Hz, 1H), 2.65 (d, *J* = 2.2 Hz, 1H), 1.83 (s, 1H), 1.72 (s, 1H), 1.66 – 1.51 (m, 4H).

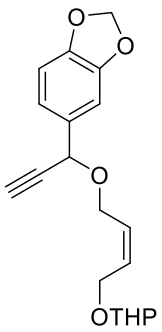
(Z)-2-((4-((1'-(Furan-2''-yl)prop-2'-yn-1'-yl)oxy)but-2-en-1-yl)oxy)tetrahydro-2H-pyran (S38):



A solution containing alcohol **S25** (640 mg 5.24 mmol, 1eq), tetrabutylammonium iodide (773 mg, 2.06 mmol, 0.4eq) and, 4-bromo-2Z-butenol-O-THP ether 1.35 g, 5.76 mmol, 1.1 eq.) in DMF (13 mL) was cooled to 0 °C. To this 226 mg (9.4 mmol, 1.8 eq) of NaH is added. The solution was allowed to warm to ambient temperature after 15min. Either product **S38** (737 mg, 51%) was obtained as a yellow oil following purification by SiO_2 flash chromatography (hexanes/ethyl acetate 90:10). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 (d, *J* = 0.9 Hz, 1H), 6.48 (d, *J* = 3.2 Hz, 1H), 6.33 (dd, *J* = 3.1, 1.8 Hz, 1H), 5.83 – 5.63 (m, 2H), 5.26 (d, *J* = 1.8 Hz, 1H), 4.61 (dd, *J* = 9.1, 5.9 Hz, 1H), 4.31 – 4.13 (m, 3H), 4.15 – 3.99 (m, 1H), 3.90 – 3.73 (m, 1H), 3.47 (dd, *J* = 10.5, 4.9 Hz, 1H), 2.62 (d, *J* = 2.2 Hz, 1H), 1.87 – 1.73 (m, 1H), 1.68 (tt, *J* = 17.0, 7.2 Hz, 1H), 1.53 (ddd, *J* = 22.2, 10.8, 4.6 Hz, 4H). ^{13}C NMR (100 MHz, CDCl3) δ 150.79 , 143.41 ,

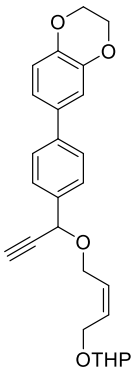
130.33 , 128.41 , 110.50 , 109.61 , 98.15 , 79.17 , 76.07 , 75.09 , 63.79 , 63.51 , 62.96 , 62.31 , 30.70 , 25.54 , 19.51 .

(Z)-5-(1-((4;-((Tetrahydro-2''H-pyran-2''-yl)oxy)but-2'-en-'1-yl)oxy)prop-2-yn-1-yl)benzo[d][1,3]dioxole (S39)



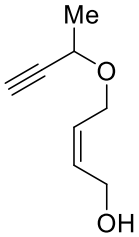
A solution containing alcohol **S26** (350 mg 2 mmol, 1eq), tetrabutylammonium iodide (150 mg, 0.385mmol, 0.2eq) and, 4-bromo-2*Z*-butenol-*O*-THP ether 514 mg, 2.2 mmol, 1.1 eq.) in DMF (4 mL) was cooled to 0 °C. To this 100 mg (2.4 mmol, 1.2eq) of NaH is added. The solution was allowed to warm to ambient temperature after 15min. Either product **S39** (600 mg, 60%) was obtained as a colorless oil following purification by SiO_2 flash chromatography (hexanes/ethyl acetate 100:0→90:10). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.05 (s, 1H), 7.00 (dd, *J* = 8.0, 1.4 Hz, 1H), 6.81 (d, *J* = 8.0 Hz, 1H), 5.99 (s, 2H), 5.88 – 5.70 (m, 2H), 5.13 (d, *J* = 1.8 Hz, 1H), 4.65 (s, 1H), 4.38 – 4.25 (m, 1H), 4.22 (dd, *J* = 12.0, 5.6 Hz, 2H), 4.18 – 4.04 (m, 1H), 3.94 – 3.80 (m, 1H), 3.58 – 3.43 (m, 1H), 2.67 (dd, *J* = 4.7, 1.6 Hz, 1H), 1.85 (dd, *J* = 9.3, 3.1 Hz, 1H), 1.79 – 1.70 (m, 1H), 1.59 (ddd, *J* = 16.2, 10.7, 5.0 Hz, 5H) ^{13}C NMR (75 MHz, $CDCl_3$) δ 147.87, 132.03, 130.07, 129.31, 128.59, 121.22, 108.03, 101.21, 98.06, 81.55, 75.68, 70.26, 63.68, 62.84, 62.18, 30.58, 25.42, 19.39 (some peaks doubled due to OTHP).

(Z)-6-(4-(1-((4'-((Tetrahydro-2''H-pyran-2''-yl)oxy)but-2'-en-1'-yl)oxy)prop-2-yn-1-yl)phenyl)-2,3-dihydrobenzo[b][1,4]dioxine (S40)



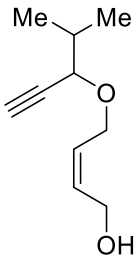
A solution containing alcohol **S28** (150 mg 0.625 mmol, 1eq), Tetrabutylammonium Iodide (46 mg, 0.125 mmol, 0.2eq) and, 4-bromo-2*Z*-butenol-*O*-THP ether 161 mg, 0.68 mmol, 1.1 eq.) in DMF (2 mL) was cooled to 0 °C. To this 30 mg (0.75 mmol, 1.2eq) of NaH is added. The solution was allowed to warm to ambient temperature after 15min. Either product **S40** (170 mg, 65%) was obtained as a colorless oil following purification by SiO_2 flash chromatography (hexanes/ethyl acetate 100:0→80:20). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.11 (m, 1H), 7.5-7.6 (m 4H), 6.93-7.17 (m 3H), 5.82 (m 2H), 4.6 (m 2H), 4.33 (s 6H), 3.87 (m 1H), 3.54 (m 1H), 2.71 (s 1H), 1.4-2 (m 6H).

4-(But-3'-yn-2'-yloxy)but-2*Z*-en-1-ol (S41)



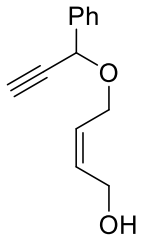
Alcohol **S41** was prepared following General Procedure B from the corresponding alcohol (250 mg, 1.75 mmol), NaH (84 mg, 2.1 mmol, 1.2 eq.), and 4-bromo-2*Z*-butenol-*O*-THP ether (493 mg, 2.1 mmol, 1.2 eq.) in THF (17 mL). The intermediate THP-ether was deprotected with PTSA (33 mg, 0.175 mmol, 0.1 eq.) in MeOH (17 mL). Following SiO_2 chromatography [hexanes:ethyl acetate (85:15→ 70:30)] the title compound was obtained (130 mg, 52% yield over 2 steps) in analytically pure form as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.79 (ddt, *J* = 11.2, 6.5, 1.3 Hz, 1H), 5.71-5.59 (m, 1H), 4.26 (dd, *J* = 12.6, 6.3 Hz, 1H), 4.21-4.13 (m, 3H), 4.04 (dd, *J* = 12.1, 6.9 Hz, 1H), 2.43 (d, *J* = 2.0 Hz, 1H), 2.26 (br s, 1H), 1.42 (d, *J* = 6.7 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 132.75 , 127.58 , 83.33 , 73.30 , 64.44 , 63.96 , 58.45 , 21.93 . HRMS (TOF MS EI$^+$) m/z Calcd for $C_8H_{10}O$ $(M-H_2O)^{+\cdot}$ 122.0732, obsd 122.0736.

4-((4''-Methylpent-1'-yn-3'-yl)oxy)but-2*Z*-en-1-ol (S42)



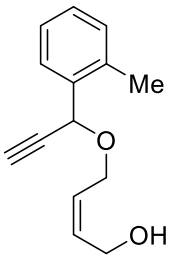
Alcohol **S42** was prepared following General Procedure B from **S12** (440 mg, 2.34 mmol), NaH (112 mg, 2.81 mmol, 1.2 eq.), allylic bromide (662 mg, 2.81 mmol, 1.2 eq.) in THF (20 mL). THP deprotection was performed with PTSA (45 mg, 0.28 mmol, 0.1 eq.) in MeOH (15 mL). After the two step procedure, purification by flash chromatography [hexanes:EtOAc (85:15→70:30)] provided homogeneous **S42** (220 mg, 56% yield over 2 steps) as a colorless oil. ^{1}H NMR (700 MHz, $CDCl_3$) δ 5.82 (ddt, *J* = 11.3, 6.5, 1.4 Hz, 1H), 5.70-5.65 (m, 1H), 4.3 (dd, *J* = 12.2, 5.8 Hz, 1H), 4.24 (dd, *J* = 13.2, 6.0 Hz, 1H), 4.2 (dd, *J* = 13.2, 6.0 Hz, 1H), 4.07 (dd, *J* = 12.4, 6.8 Hz, 1H), 3.83 (dd, *J* = 5.8, 2.0 Hz, 1H), 2.43 (d, *J* = 2.1 Hz, 1H), 1.92 (apt m, *J* = 6.5 Hz, 1H), 1.84 (br s, 1H), 1.0 (d, *J* = 6.8 Hz, 3H), 0.97 (d, *J* = 6.8 Hz, 3H). ^{13}C NMR (175 MHz, $CDCl_3$) δ 132.61 , 127.99 , 81.38 , 74.60 , 74.42 , 64.36 , 58.69 , 32.85 , 18.39 , 17.66 . HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{10}H_{16}O_2Na$ $(M+Na)^+$ 191.1048, obsd 191.1043.

4-((1''-Phenylprop-2'-yn-1'-yl)oxy)but-2*Z*-en-1-ol (S43)



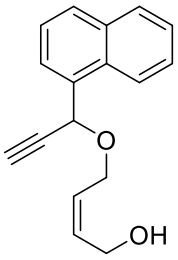
To a solution of THP-protected alcohol (175 mg, 0.62 mmol) in methanol (5 mL). was added PTSA (23 mg, 0.12 mmol, 0.2 eq.). The resulting reaction mixture was stirred at room temperature until complete removal of the THP protecting group was indicated by TLC. Following concentration, the crude residue was taken up in ethyl acetate, washed with brine, then dried (Na_2SO_4), filtered and concentrated. Silica gel flash chromatography [hexanes:ethyl acetate (70:30)] then afforded **S43** (100 mg, 80%) as a colorless oil. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.51 (dd, *J* = 7.8, 1.7 Hz, 2H), 7.41-7.30 (m, 3H), 5.81 (dddt, *J* = 11.3, 6.3, 6.2, 1.1 Hz, 1H), 5.7 (dddt, *J* = 11.3, 6.3, 6.2, 1.1 Hz, 1H), 5.19 (d, *J* = 2.2 Hz, 1H), 4.23 (dd, *J* = 12.3, 5.8 Hz, 1H), 4.19-4.12 (m, 3H), 2.67 (d, *J* = 2.2 Hz, 1H), 2.20 (br s, 1H). ^{13}C NMR (75 MHz, $CDCl_3$) δ 137.73 , 133.00 , 128.57 , 128.50 (2 CH), 127.35 , 127.32 (2 CH), 81.21 , 75.97 , 70.57 , 63.51 , 58.43 . HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{13}H_{14}O_2Na$ $(M+Na)^+$ 225.0891, obsd 225.0883.

(Z)-4-((1''-(o-Tolyl)prop-2'-yn-1'-yl)oxy)but-2-en-1-ol (S44):



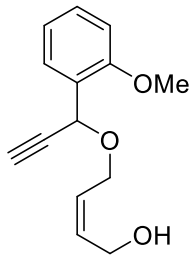
To a solution of THP-protected alcohol (1.19 g, 3.96 mmol) in methanol (40 mL). was added PTSA (68 mg, 0.396mmol, 0.1 eq.). The resulting reaction mixture was stirred at room temperature until complete removal of the THP protecting group was indicated by TLC. Following concentration, the crude residue was taken up in ethyl acetate, washed with brine, then dried (Na_2SO_4), filtered and concentrated. It gave afforded **S44** (630 mg, 88%) and crude was used for next step without purification.

(Z)-4-((1'-(Naphthalen-1''-yl)prop-2'-yn-1'-yl)oxy)but-2-en-1-ol (S45):



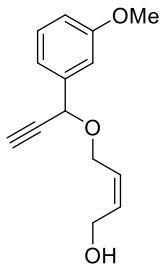
To a solution of THP-protected alcohol (1.28 g, 3.80 mmol) in methanol (38 mL). was added PTSA (65 mg, 0.38 mmol, 0.1 eq.). The resulting reaction mixture was stirred at room temperature until complete removal of the THP protecting group was indicated by TLC. Following concentration, the crude residue was taken up in ethyl acetate, washed with brine, then dried (Na_2SO_4), filtered and concentrated. It gave afforded **S45** (823 mg, 86%) and crude was used for next step without purification.

(Z)-4-((1'-(2''-Methoxyphenyl)prop-2'-yn-1'-yl)oxy)but-2-en-1-ol (S46):



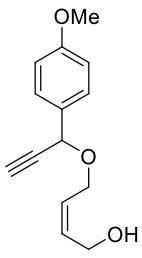
To a solution of THP-protected alcohol (1 g, 3.16 mmol) in methanol (28 mL). was added PTSA (53 mg, 0.31 mmol, 0.1 eq.). The resulting reaction mixture was stirred at 0 °C temperature next 2 hours and it showed 50% staring material was consumed indicated by TLC and then reaction had stopped to avoid the decomposition at the benzylic center. Following concentration, the crude residue was taken up in ethyl acetate, washed with brine, then dried (Na_2SO_4), filtered and concentrated. Silica gel flash chromatography (hexanes:ethyl acetate 60:40) then afforded **S46** (220 mg, 59% on the brsm) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.68 (dd, *J* = 7.6, 1.7 Hz, 1H), 7.34 (ddd, *J* = 8.2, 7.5, 1.7 Hz, 1H), 7.02 (td, *J* = 7.5, 0.9 Hz, 1H), 6.94 – 6.86 (m, 1H), 5.88 – 5.79 (m, 1H), 5.78 – 5.69 (m, 1H), 5.61 (d, *J* = 2.2 Hz, 1H), 4.34 – 4.24 (m, 1H), 4.25 – 4.13 (m, 3H), 3.86 (s, 3H), 2.63 (d, *J* = 2.2 Hz, 1H), 2.51 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 156.73 , 133.23 , 130.17 , 128.71 , 127.73 , 126.33 , 120.92 , 110.96 , 81.85 , 75.07 , 64.92 , 64.10 , 58.63 , 55.77 .

Z)-4-((1'-(3''-Methoxyphenyl)prop-2'-yn-1'-yl)oxy)but-2-en-1-ol (S47)



To a solution of THP-protected alcohol (1 g, 3.2 mmol) in methanol (20 mL). was added PTSA (54 mg, 0.32 mmol, 0.1 eq.). The resulting reaction mixture was stirred at room temperature until complete removal of the THP protecting group was indicated by TLC. Following concentration, the crude residue was taken up in ethyl acetate, washed with brine, then dried (Na_2SO_4), filtered and concentrated. Silica gel flash chromatography [hexanes:ethyl acetate (70:30)] then afforded **S47** (700 mg, 94%) as a colorless oil.). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.29 (1H), 7.09 (2H), 6.89 (1H), 5.75-5.87 (2H), 5.20 (1H), 4.24 (4H), 3.82 (2H), 3.84 (3H), 2.7 (1H)

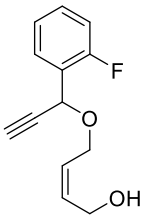
(Z)-4-((1'-(4''-Methoxyphenyl)prop-2'-yn-1'-yl)oxy)but-2-en-1-ol (S48):



To a solution of THP-protected alcohol (551 mg, 1.52 mmol) in methanol (15 mL). was added PTSA (27 mg, 0.15 mmol, 0.1 eq.). The resulting reaction mixture was stirred at room temperature until complete removal of the THP group was indicated by TLC. Following concentration, the crude residue was taken up in ethyl acetate, washed with brine, then dried (Na_2SO_4), filtered and

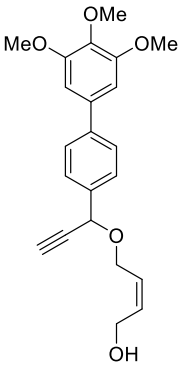
concentrated. Silica gel flash chromatography (hexanes:ethyl acetate 50:50) then afforded **S48** (161 mg, 66%) as a yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.44 (d, *J* = 8.7 Hz, 2H), 6.90 (d, *J* = 8.7 Hz, 2H), 5.87 – 5.77 (m, 1H), 5.70 (dt, *J* = 11.1, 6.3 Hz, 1H), 5.16 (d, *J* = 2.1 Hz, 1H), 4.19 (p, *J* = 5.3 Hz, 4H), 3.80 (s, 3H), 2.69 (d, *J* = 2.2 Hz, 1H), 2.48 (s, 1H).

(Z)-4-((1'-(2''-Fluorophenyl)prop-2'-yn-1'-yl)oxy)but-2-en-1-ol (S49):



To a solution of THP-protected alcohol (130 mg, 0.42 mmol) in methanol (5 mL). was added PTSA (8 mg, 0.042 mmol, 0.1 eq.). The resulting reaction mixture was stirred at room temperature until complete removal of the THP protecting group was indicated by TLC. Following concentration, the crude residue was taken up in ethyl acetate, washed with brine, then dried (Na_2SO_4), filtered and concentrated. Silica gel flash chromatography (hexanes:ethyl acetate 80:20) then afforded **S49** (80 mg, 87%) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.69 (td, *J* = 7.5, 1.6 Hz, 1H), 7.41 – 7.29 (m, 1H), 7.19 (t, *J* = 7.2 Hz, 1H), 7.13 – 7.02 (m, 1H), 5.91 – 5.80 (m, 1H), 5.81 – 5.67 (m, 1H), 5.51 (d, *J* = 2.1 Hz, 1H), 4.32 (dd, *J* = 12.0, 6.2 Hz, 1H), 4.24 (t, *J* = 7.3 Hz, 3H), 2.65 (d, *J* = 2.2 Hz, 1H), 1.84 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 161.60, 159.12 , 133.33 , 130.54 (d, *J* = 8.3 Hz), 129.27 (d, *J* = 3.2 Hz), 127.52 , 125.53 (d, *J* = 13.3 Hz), 124.41 (d, *J* = 3.7 Hz), 115.66 , 115.45 , 80.74 , 77.42 , 77.11 , 76.79 , 75.66 , 64.66 – 64.20 (m), 58.76 . ^{19}F NMR (376 MHz, $CDCl_3$) δ -119.08.

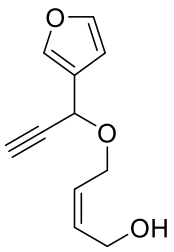
(Z)-4-((1'-(3''',4''',5'''-Trimethoxy-[1'',1'''-biphenyl]-4''-yl)prop-2'-yn-1'-yl)oxy)but-2-en-1-ol (S50)



To a solution of THP-protected alcohol (90 mg, 0.19 mmol) in methanol (2 mL). was added PTSA (2 mg, 0.009 mmol, 0.05 eq.). The resulting reaction mixture was stirred at room temperature until complete removal of the THP protecting group was indicated by TLC. Following concentration, the crude residue was taken up in ethyl acetate, washed with brine, then dried (Na_2SO_4), filteredand concentrated. Silica gel flash chromatography [hexanes:ethyl acetate (70:30)] then afforded **S50** (45 mg, 61%) as a yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.59 (s, 4H), 6.79 (s, 2H), 5.87 (s, 1H), 5.78 (s, 1H), 5.27 (s, 1H), 4.26 (s, 4H), 3.94 (s, 6H), 3.91 (s, 3H), 2.73 (s, 1H).. ^{13}C NMR (100 MHz, $CDCl_3$) δ 153.60 , 141.89 , 137.92 , 137.05 , 136.74 ,

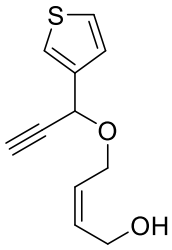
133.22 , 127.85 (d, *J* = 18.4 Hz), 127.44 , 104.62 , 81.39 , 77.50 , 77.18 , 76.87 , 76.24 , 70.51 , 63.84 , 61.08 , 58.83 , 56.33.

(Z)-4-((1'-(Furan-2''-yl)prop-2'-yn-1'-yl)oxy)but-2-en-1-ol (S51):



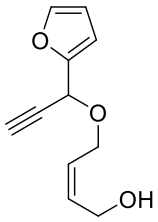
To a solution of THP-protected alcohol (182 mg, 0.69 mmol) in methanol (7 mL). was added PTSA (12 mg, 0.069 mmol, 0.1 eq.). The resulting reaction mixture was stirred at room temperature until complete removal of the THP protecting group was indicated by TLC. Following concentration, the crude residue was taken up in ethyl acetate, washed with brine, then dried (Na_2SO_4), filtered and concentrated. Silica gel flash chromatography (hexanes:ethyl acetate 50:50) then afforded **S51** (120 mg, 91%) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.56 (s, 1H), 7.42 (s, 1H), 6.51 (d, *J* = 0.9 Hz, 1H), 5.93 – 5.78 (m, 1H), 5.81 – 5.63 (m, 1H), 5.20 (d, *J* = 1.7 Hz, 1H), 4.21 (t, *J* = 5.8 Hz, 4H), 2.62 (d, *J* = 2.1 Hz, 1H), 2.07 (s, 1H) ^{13}C NMR (100 MHz, $CDCl_3$) δ 142.83, 141.22, 133.05, 127.87, 109.05, 74.69, 63.21, 58.58.

(Z)-4-((1'-(Thiophen-3''-yl)prop-2'-yn-1'-yl)oxy)but-2-en-1-ol (S52):



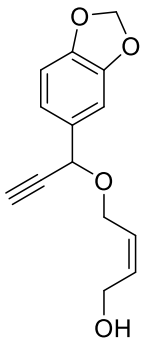
To a solution of THP-protected alcohol (280 mg, 1.00 mmol) in methanol (10 mL). was added PTSA (17.2 mg, 0.1 mmol, 0.1 eq.). The resulting reaction mixture was stirred at room temperature until complete removal of the THP protecting group was indicated by TLC. Following concentration, the crude residue was taken up in ethyl acetate, washed with brine, then dried (Na_2SO_4), filtered and concentrated. Silica gel flash chromatography (hexanes:ethyl acetate 50:50) then afforded **S52** (140 mg, 67%) as a yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.44 (d, *J* = 2.8 Hz, 1H), 7.33 (dd, *J* = 5.0, 3.0 Hz, 1H), 7.19 (dd, *J* = 5.0, 0.9 Hz, 1H), 5.84 (dt, *J* = 11.7, 6.5 Hz, 1H), 5.72 (dt, *J* = 11.3, 6.5 Hz, 1H), 5.31 (d, *J* = 2.0 Hz, 1H), 4.22 (d, *J* = 7.0 Hz, 4H), 2.68 (d, *J* = 2.2 Hz, 1H), 2.17 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 139.21, 130.12, 129.59, 127.48, 126.75, 126.90, 109.09, 81.71, 66.60, 63.35, 60.40.

(Z)-4-((1'-(Furan-2''-yl)prop-2'-yn-1'-yl)oxy)but-2-en-1-ol (S53):



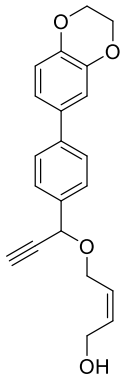
To a solution of THP-protected alcohol (500 mg, 1.81 mmol) in methanol (18 mL). was added PTSA (31 mg, 0.1 mmol, 0.1 eq.). The resulting reaction mixture was stirred at room temperature until complete removal of the THP protecting group was indicated by TLC. Following concentration, the crude residue was taken up in ethyl acetate, washed with brine, then dried (Na_2SO_4), filtered and concentrated. Silica gel flash chromatography (hexanes:ethyl acetate 8:20) then afforded **S53** (205 mg, 93%) as a colorless gel. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.43 (dd, *J* = 1.7, 0.8 Hz, 1H), 6.52 (d, *J* = 3.3 Hz, 1H), 6.37 (dd, *J* = 3.2, 1.8 Hz, 1H), 5.90 – 5.76 (m, 1H), 5.77 – 5.62 (m, 1H), 5.29 (d, *J* = 2.2 Hz, 1H), 4.20 (d, *J* = 5.5 Hz, 4H), 3.43 (dd, *J* = 9.2, 6.4 Hz, 1H), 2.65 (d, *J* = 2.3 Hz, 1H), 2.22 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 150.60 , 143.49 , 133.42 , 127.28 , 110.54 , 109.75 , 76.90 , 75.36 , 63.86 , 63.19 , 58.63 .

(Z)-4-((1'-(Benzo[d][1'',3'']dioxol-5''-yl)prop-2'-yn-1'-yl)oxy)but-2-en-1-ol (S54)



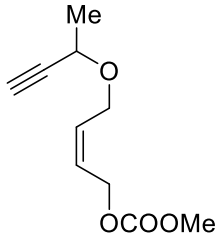
To a solution of THP-protected alcohol (600 mg, 1.3 mmol) in methanol (7 mL). was added PTSA (20 mg, 0.13 mmol, 0.1 eq.). The resulting reaction mixture was stirred at room temperature until complete removal of the THP protecting group was indicated by TLC. Following concentration, the crude residue was taken up in ethyl acetate, washed with brine, then dried (Na_2SO_4), filtered and concentrated. Silica gel flash chromatography [hexanes:ethyl acetate (70:30)] then afforded **S54** (320 mg, 65%) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.03 (d, *J* = 1.5 Hz, 1H), 6.99 (dd, *J* = 8.0, 1.4 Hz, 1H), 6.81 (d, *J* = 8.0 Hz, 1H), 5.99 (d, *J* = 9.0 Hz, 2H), 5.86 (dt, *J* = 12.8, 6.5 Hz, 1H), 5.73 (dt, *J* = 11.3, 6.5 Hz, 1H), 5.12 (d, *J* = 2.0 Hz, 1H), 4.32 – 4.18 (m, 4H), 2.68 (d, *J* = 2.1 Hz, 1H). . ^{13}C NMR (100 MHz, $CDCl_3$) δ 148.05 , 133.11 , 131.93 , 127.81 , 121.38 , 108.15 (d, *J* = 12.0 Hz), 101.37 , 75.98 , 70.54 , 63.59 , 58.82.

(Z)-4-((1'-(4''-(2''';,3''')-Dihydrobenzo[b][1,4]dioxin-6''-yl)phenyl)prop-2'-yn-1'-yl)oxy)but-2-en-1-ol (S55)



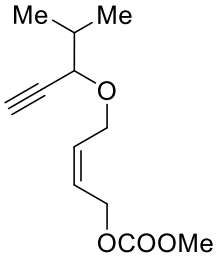
To a solution of THP-protected alcohol (170 mg, 0.5 mmol) in methanol (10 mL). was added PTSA (10 mg, 0.05 mmol, 0.05 eq.). The resulting reaction mixture was stirred at room temperature until complete removal of the THP protecting group was indicated by TLC. Following concentration, the crude residue was taken up in ethyl acetate, washed with brine, then dried (Na_2SO_4), filtered and concentrated. Silica gel flash chromatography [hexanes:ethyl acetate (70:30)] then afforded **xx** (90 mg, 53%) as a yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.56 (s, 4H), 7.15 – 7.05 (m, 2H), 6.95 (d, *J* = 8.2 Hz, 1H), 5.90 – 5.72 (m, 2H), 5.25 (d, *J* = 2.2 Hz, 1H), 4.32 (d, *J* = 3.1 Hz, 4H), 4.28 (dd, *J* = 10.3, 4.0 Hz, 6H), 3.45 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 143.72 , 143.36 , 141.03 , 136.39 , 134.18 , 133.04 , 128.92 , 127.79 (d, *J* = 7.6 Hz), 126.85 (d, *J* = 17.4 Hz), 120.20 , 117.72 (d, *J* = 14.6 Hz), 115.97 (d, *J* = 12.9 Hz), 81.34 , 77.48 , 77.06 , 76.63 , 76.06 , 70.45 , 64.44 , 63.67 , 58.74 , 54.23.

Methyl 4-(But-3'-yn-2'-yloxy)but-2*Z*-en-1-yl Carbonate (25)



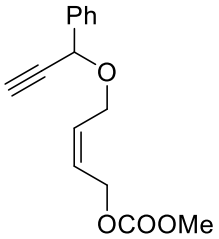
Carbonate **25** was prepared following General Procedure C from alcohol **S41** (130 mg, 0.93 mmol), pyridine (106 µL, 1.3 mmol, 1.3 eq.) and methyl chloroformate (100 µL, 1.3 mmol, 1.3 eq.) in CH_2Cl_2 (5 mL). The title compound was obtained as a colorless oil (170 mg, 93%) after chromatography [hexanes/ethyl acetate (90:10)]. ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.80-5.65 (m, 2H), 4.73 (dd, *J* = 16.7, 6.1 Hz, 1H), 4.69 (dd, *J* = 16.7, 6.1 Hz, 1H), 4.28 (dd, *J* = 12.5, 5.5 Hz, 1H), 4.15 (ddd, *J* = 13.3, 6.6, 1.9 Hz, 1H), 4.08 (dd, *J* = 12.5, 6.6 Hz, 1H), 3.74 (s, 3H), 2.42 (d, *J* = 1.9 Hz, 1H), 1.40 (d, *J* = 6.6 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.54 , 130.66 , 126.39 , 83.27 , 73.24 , 64.48 , 63.95 , 63.52 , 54.70 , 21.90 . HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{12}H_{14}O_4Na$ $(M+Na)^+$ 221.0790, obsd 221.0791.

Methyl 4-(4''-Methylpent-1'-yn-3'-yloxy)but-2*Z*-en-1-yl Carbonate (27)



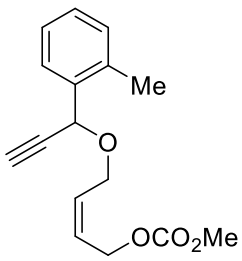
Carbonate **27** was prepared following General Procedure C from alcohol **S42** (148 mg, 0.89 mmol), pyridine (92 µL, 1.13 mmol, 1.3 eq.) and methyl chloroformate (92 µL, 1.13 mmol, 1.3 eq.) in CH_2Cl_2 (5 mL). Purification via silica gel chromatography [hexanes/ethyl acetate (90:10)], yielded the desired carbonate ester (165 mg, 83%) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.81-5.65 (m, 2H), 4.75 (dd, *J* = 13.1, 5.7 Hz, 1H), 4.71 (dd, *J* = 13.1, 5.7 Hz, 1H), 4.31 (dd, *J* = 13.8, 4.7 Hz, 1H), 4.09 (dd, *J* = 12.8, 6.4 Hz, 1H), 3.81 (dd, *J* = 5.9, 2.1 Hz, 1H), 3.75 (s, 3H), 2.41 (d, *J* = 2.1 Hz, 1H), 1.90 (apt m, *J* = 6.6 Hz; 1H), 0.98 (d, *J* = 6.6 Hz, 3H), 0.96 (d, *J* = 6.6 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.60 , 130.82 , 126.31 , 81.32 , 74.55 , 74.46 , 64.35 , 63.72 , 54.73 , 32.82 , 18.31 , 17.63 . HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{12}H_{18}O_4Na$ $(M+Na)^+$ 249.1103, obsd 249.1098.

Methyl 4-((1''-phenylprop-2'-yn-1'-yl)oxy)but-2*Z*-en-1-yl Carbonate (29)



Following General Procedure C, carbonate **29** was prepared from alcohol **S43** (90 mg, 0.44 mmol), pyridine (50 µL, 0.65 mmol, 1.3 eq.), and methyl chloroformate (50 µL, 0.65 mmol, 1.3 eq.) in CH_2Cl_2 (5 mL). Purification via SiO_2 chromatography [hexanes/ethyl acetate (90:10)] yielded **29** (100 mg, 87%) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.51 (dd, *J* = 7.5, 1.5 Hz, 2H), 7.40-7.30 (m, 3H), 5.88-5.80 (m, 1H), 5.79-5.70 (m, 1H), 5.2 (d, *J* = 2.0 Hz, 1H), 4.74 (dd, *J* = 13.2, 6.1 Hz, 1H), 4.70 (dd, *J* = 13.2, 6.1 Hz, 1H), 4.28 (dd, *J* = 12.2, 5.7 Hz, 1H), 4.28 (dd, *J* = 12.4, 7.1 Hz, 1H), 3.77 (s, 3H), 2.67 (d, *J* = 2.0 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.49 , 137.74 , 130.47 , 128.49 , 128.44 (2 CH), 127.26 (2 CH), 126.67 , 81.15 , 75.94 , 70.61 ; 63.49 (2 CH_2), 54.69 . HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{15}H_{16}O_4Na$ $(M+Na)^+$ 283.0946, obsd 283.0945.

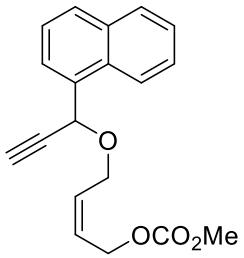
(Z)-Methyl (4-((1'-(o-tolyl)prop-2'-yn-1'-yl)oxy)but-2-en-1-yl) Carbonate (31):



Carbonate was prepared following General Procedure C from the corresponding alcohol **S44** 680 mg, 3.14 mmol), pyridine (330 µL, 4.09 mmol, 1.3 eq.) and methyl chloroformate (316 µL, 4.09 mmol, 1.3 eq.) in

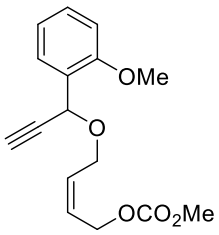
CH_2Cl_2 (16 mL). Silica gel flash chromatography (hexanes:ethyl acetate 90:10) then afforded **31** (717 mg, 71%) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65 (d, *J* = 5.2 Hz, 1H), 7.27 (t, *J* = 6.5 Hz, 2H), 7.21 (s, 1H), 5.97 – 5.83 (m, 1H), 5.83 – 5.69 (m, 1H), 5.36 (s, 1H), 4.76 (p, *J* = 13.1 Hz, 2H), 4.43 – 4.21 (m, 2H), 3.81 (s, 3H), 2.69 (d, *J* = 0.7 Hz, 1H), 2.44 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.75 , 136.42 , 135.82 , 130.80 , 128.78 , 127.70 (2CH), 126.90 , 126.23 (CH, 81.16 , 77.59 , 68.87 , 63.76 , 54.93 , 19.07 .

(Z)-Methyl (4-((1'-(naphthalen-1''-yl)prop-2'-yn-1'-yl)oxy)but-2-en-1-yl) carbonate (33):



Carbonate **33** was prepared following General Procedure C from the corresponding alcohol **S45** (832 mg, 3.26 mmol), pyridine (342 µL, 4.24 mmol, 1.3 eq.) and methyl chloroformate (329 µL, 4.24 mmol, 1.3 eq.) in CH_2Cl_2 (21 mL). Silica gel flash chromatography (hexanes:ethyl acetate 90:10) then afforded **33**(717 mg, 71%) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.30 (d, *J* = 8.4 Hz, 1H), 7.90 (t, *J* = 8.5 Hz, 2H), 7.84 (d, *J* = 7.0 Hz, 1H), 7.60 (ddd, *J* = 8.5, 6.9, 1.5 Hz, 1H), 7.55 (dd, *J* = 8.0, 1.2 Hz, 1H), 7.50 (dd, *J* = 8.1, 7.3 Hz, 1H), 5.97 – 5.84 (m, 2H), 5.85 – 5.72 (m, 1H), 4.74 (dd, *J* = 16.3, 9.8 Hz, 2H), 4.36 (d, *J* = 6.3 Hz, 2H), 3.81 (s, 3H), 2.78 (d, *J* = 2.2 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.75 , 134.16 , 133.10 , 130.80 C_{quat}), 129.79 , 128.85 , 127.02 , 126.55 , 126.10 , 125.25 , 124.16 , 81.29 , 77.56 , 77.25 , 76.86 , 69.45 , 54.96 .

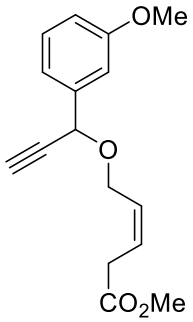
(Z)-4-((1'-(2''-Methoxyphenyl)prop-2'-yn-1'-yl)oxy)but-2-en-1-yl methyl carbonate (35):



Carbonate **35** was prepared following General Procedure C from the corresponding alcohol **S46** (220 mg, 0.98 mmol), pyridine (100 µL, 1.23 mmol, 1.3 eq.) and methyl chloroformate (95 µL, 01.23 mmol, 1.3 eq.) in CH_2Cl_2 (5 mL). Silica gel flash chromatography (hexanes:ethyl acetate 80:20) then afforded **35** (264 mg, 93%) as a dark yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.66 (d, *J* = 7.3 Hz, 1H), 7.30 (d, *J* = 7.7 Hz, 1H), 7.01 (d, *J* = 7.0 Hz, 1H), 6.89 (d, *J* = 8.1 Hz, 1H), 5.86 (d, *J* = 6.7 Hz, 1H), 5.81 – 5.67 (m, 1H), 5.59 (s, 1H), 4.75 (s, 2H), 4.32 (d, *J* = 11.8 Hz, 1H), 4.29 –

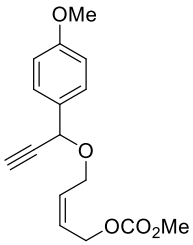
4.16 (m, 1H), 3.85 (s, 3H), 3.77 (s, 3H), 2.61 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 156.70, 155.74 , 130.94 , 130.05 , 128.61 , 126.75 , 126.42 , 120.85 , 110.86 , 81.87 , 74.93 , 64.91 , 64.13 , 63.81 , 55.68 , 54.88 .

Z)-5-((1'-(3''-Methoxyphenyl)prop-2'-yn-1'-yl)oxy)pent-3-enoate (37)



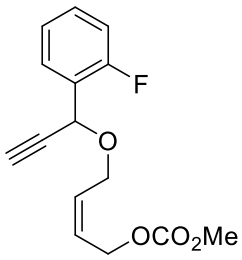
Carbonate **37** was prepared following General Procedure C from alcohol **S47** (700 mg, 3.2 mmol), pyridine (500 µL, 6 mmol, 2 eq.) and methyl chloroformate (470 µL, 6 mmol, 2 eq.) in CH_2Cl_2 (20 mL). The title compound was obtained as a colorless oil (800 mg, 92%) after chromatography [hexanes/ethyl acetate (90:10)]. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.28 (s 1H), 7.10 (d, 2H), 6.90 (dd *J* = 2.4, 8.1 Hz, 1H), 5.82 (m 2H), 5.19 (s 1H), 4.750 (t *J* = 6.3Hz, 4H), 4.285 (d *J* =3 Hz, 2H), 3.84 (s 3H), 3.80 (s 3H), 2.69 (d *J* = 2.1 Hz, 1H) ^{13}C NMR (75 MHz, $CDCl_3$) δ 159.80, 155.66 , 139.32 , 130.58 , 129.62 , 126.81 , 119.72 , 114.40 , 112.75 , 81.18 , 76.01, 70.64, 63.64 , 55.45 , 55.30, 54.87.

(Z)-4-((1'-(4''-Methoxyphenyl)prop-2'-yn-1'-yl)oxy)but-2-en-1-yl methyl carbonate (39):



Carbonate **39** was prepared following General Procedure C from the corresponding alcohol **S48** (161 mg, 0.68 mmol), pyridine (72 µL, 0.85 mmol, 1.3 eq.) and methyl chloroformate (66 µL, 0.85 mmol, 1.3 eq.) in CH2Cl2 (2.5 mL) to provide **39** (160 mg, 81%) as a yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.44 (d, *J* = 8.6 Hz, 2H), 7.00 – 6.84 (m, 2H), 5.88 – 5.79 (m, 1H), 5.74 (dt, *J* = 11.3, 6.5 Hz, 1H), 5.16 (d, *J* = 2.1 Hz, 1H), 4.79 – 4.68 (m, 2H), 4.23 (t, *J* = 6.0 Hz, 2H), 3.80 (s, 3H), 3.78 (s, 3H), 2.68 (d, *J* = 2.2 Hz, 1H)). ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.98 , 155.74 , 130.82 , 128.95 (2CH), 114.04 (2CH), 81.59 , 75.92 , 70.45 , 63.75 , 63.50 , 55.42 .

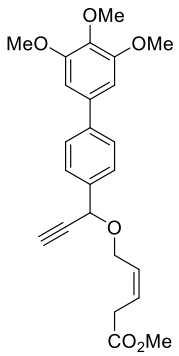
(Z)-4-((1'-(2''-Fluorophenyl)prop-2'-yn-1'-yl)oxy)but-2-en-1-yl methyl carbonate (41):



Carbonate **41** was prepared following General Procedure C from the corresponding alcohol **S49** (72 mg, 0.32 mmol), pyridine (34 µL, 0.42 mmol, 1.3 eq.) and methyl chloroformate (33 µL, 0.42 mmol, 1.3 eq.) in CH2Cl2 (1.6 mL) to provide **41** (78 mg, 88%) as a yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.70 (td, *J* = 7.5, 1.7 Hz, 1H), 7.35 (tdd, *J* = 7.3, 5.3,

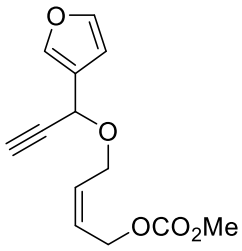
1.7 Hz, 1H), 7.20 (td, *J* = 7.6, 0.8 Hz, 1H), 7.16 – 7.00 (m, 1H), 5.91 – 5.83 (m, 1H), 5.79 (dt, *J* = 11.3, 6.5 Hz, 1H), 5.51 (d, *J* = 2.1 Hz, 1H), 4.76 (d, *J* = 6.1 Hz, 2H), 4.36 (dd, *J* = 12.6, 5.6 Hz, 1H), 4.28 (dd, *J* = 12.5, 6.5 Hz, 1H), 3.81 (s, 3H), 2.67 (d, *J* = 2.2 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.54 (d, *J* = 245.45 Hz), 155.75 , 130.79 , 129.26 (d, *J* = 3.2 Hz) , 127.19 , 125.34 (d, *J* = 13.3 Hz), 124.48 (d, *J* = 3.6 Hz) , 115.74 , 80.52 , 77.48 , 77.16 , 75.87 , 64.50 (d, *J* = 4.8 Hz)(CH_2), 54.96 . ^{19}F NMR (376 MHz, $CDCl_3$) δ -119.08.

Methyl (Z)-5-((1'-(benzo[d][1,3]dioxol-5''-yl)prop-2'-yn-1'-yl)oxy)pent-3-enoate (43)



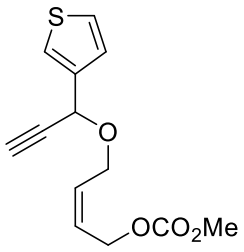
Carbonate **43** was prepared following General Procedure C from alcohol **S50** (40 mg, 0,10 mmol), pyridine (20 µL, 0.21 mmol, 2 eq.) and methyl chloroformate (20 µL, 0.21 mmol, 2 eq.) in CH_2Cl_2 (6 mL). The title compound was obtained as a yellow oil (40 mg, 97%) after chromatography [hexanes/ethyl acetate (90:10)]. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.59 (s, 4H), 6.79 (s, 2H), 5.98 – 5.70 (m, 2H), 5.27 (d, *J* = 2.2 Hz, 1H), 4.83 – 4.69 (m, 2H), 4.31 (t, *J* = 5.7 Hz, 2H), 3.95 (d, *J* = 4.7 Hz, 6H), 3.91 (s, 3H), 3.81 (s, 3H), 2.72 (d, *J* = 2.2 Hz, 1H).. ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.66 , 153.49 , 141.78 , 137.79 , 136.81 (d, *J* = 19.7 Hz), 130.90 , 130.56 , 128.81 , 127.81 , 127.33 , 126.87 , 104.50 , 81.21 , 77.47 , 77.04 , 76.62 , 76.14 , 70.48 , 68.17 , 63.66 , 60.98 , 56.22 , 54.87 , 38.74 , 30.37 , 28.93 , 23.75 , 22.99 , 14.06 , 10.97.

(Z)-4-((1'-(Furan-3''-yl)prop-2'-yn-1'-yl)oxy)but-2-en-1-yl methyl carbonate (45):



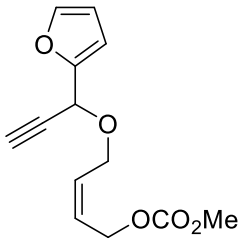
Carbonate **45** was prepared following General Procedure C from the corresponding alcohol **S51** (108 mg, 0.56 mmol), pyridine (59 µL, 0.73 mmol, 1.3 eq.) and methyl chloroformate (56 µL, 0.73 mmol, 1.3 eq.) in CH_2Cl_2 (3 mL). Silica gel flash chromatography (hexanes:ethyl acetate 80:20) then afforded **45** (124 mg, 89%) as a dark yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.56 (d, *J* = 0.6 Hz, 1H), 7.42 (t, *J* = 1.5 Hz, 1H), 6.51 (d, *J* = 0.9 Hz, 1H), 5.80 (tdd, *J* = 17.7, 11.3, 6.4 Hz, 2H), 5.21 (d, *J* = 1.9 Hz, 1H), 4.75 (d, *J* = 6.1 Hz, 2H), 4.31 – 4.19 (m, 2H), 3.80 (s, 3H), 2.62 (d, *J* = 2.1 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.77 , 143.80 , 141.23 , 130.62 , 126.89 , 123.57 , 109.53 , 80.73 , 76.09 , 74.73 , 63.73 , 63.22 , 54.97 .

(Z)-Methyl (4-((1-(thiophen-3''-yl)prop-2'-yn-1'-yl)oxy)but-2-en-1-yl) carbonate (47):



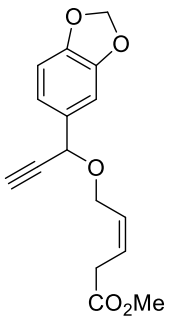
Carbonate **47** was prepared following General Procedure C from the corresponding alcohol **S52** (115 mg, 0.55 mmol), pyridine (57 µL, 0.71 mmol, 1.3 eq.) and methyl chloroformate (55 µL, 0.71 mmol, 1.3 eq.) in CH2Cl2 (16 mL). Silica gel flash chromatography (hexanes:ethyl acetate 50:50) then afforded **47** (100 mg, 74%) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.51 – 7.40 (m, 1H), 7.33 (dd, *J* = 5.0, 3.0 Hz, 1H), 7.19 (dd, *J* = 5.0, 1.1 Hz, 1H), 5.89 – 5.71 (m, 2H), 5.31 (d, *J* = 2.0 Hz, 1H), 4.74 (d, *J* = 6.3 Hz, 2H), 4.26 (d, *J* = 6.1 Hz, 2H), 3.80 (s, 3H), 2.67 (d, *J* = 2.2 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.75 , 139.09 , 130.66 (2CH), 126.99 , 126.48 , 123.91 , 81.11 , 75.41 , 66.54 , 63.73 , 63.35 , 54.96 .

Z)-4-((1'-(Furan-2''-yl)prop-2'-yn-1'-yl)oxy)but-2-en-1-yl methyl carbonate (49):



Carbonate **49** was prepared following General Procedure C from ol the corresponding alcohol **S53** (80 mg, 0.41 mmol), pyridine (44 µL, 0.54 mmol, 1.3 eq.) and methyl chloroformate (41 µL, 0.54 mmol, 1.3 eq.) in CH_2Cl_2 (2 mL). Silica gel flash chromatography (hexanes:ethyl acetate 80:20) then afforded **49** (85 mg, 83%) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.43 (d, *J* = 0.8 Hz, 1H), 6.52 (d, *J* = 3.2 Hz, 1H), 6.36 (dd, *J* = 3.1, 1.9 Hz, 1H), 5.77 (dt, *J* = 15.3, 6.1 Hz, 2H), 5.29 (d, *J* = 2.2 Hz, 1H), 4.72 (d, *J* = 6.0 Hz, 2H), 4.23 (t, *J* = 6.7 Hz, 2H), 3.78 (s, 3H), 2.64 (d, *J* = 2.2 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.72 , 150.59 , 143.48 , 130.39 , 127.02 , 110.50 , 109.75 , 78.90 , 76.89 , 75.35 , 63.95 , 63.67 , 54.91 .

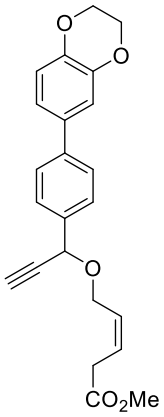
Methyl (Z)-5-((1'-(benzo[d][1,3]dioxol-5''-yl)prop-2'-yn-1'-yl)oxy)pent-3-enoate (51)



Carbonate **51** was prepared following General Procedure C from alcohol **S54** (320 mg, 1.3 mmol), pyridine (210 µL, 2.6 mmol, 2 eq.) and methyl chloroformate (200 µL, 2.6 mmol, 2 eq.) in CH_2Cl_2 (6 mL). The title compound was obtained as a colorless oil (280 mg, 76%) after chromatography [hexanes/ethyl acetate (90:10)]. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.04 (s, 1H), 6.99 (d, *J* = 8.0 Hz, 1H), 6.81 (d, *J* = 8.0 Hz, 1H), 5.99 (s, 2H), 5.92 – 5.66 (m, 2H), 5.12 (d, *J* = 1.9 Hz, 1H), 4.73 (dd, *J* = 5.8, 2.8 Hz, 2H), 4.24 (t, *J* = 6.9 Hz, 2H), 3.80 (s, 3H),

2.68 (d, *J* = 2.1 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.74 , 148.04 , 131.93 , 130.72 , 126.88 , 121.36 , 108.13 (d, *J* = 10.6 Hz), 101.35 , 81.39 , 75.99 , 70.62 , 63.63 (d, *J* = 16.0 Hz), 54.95.

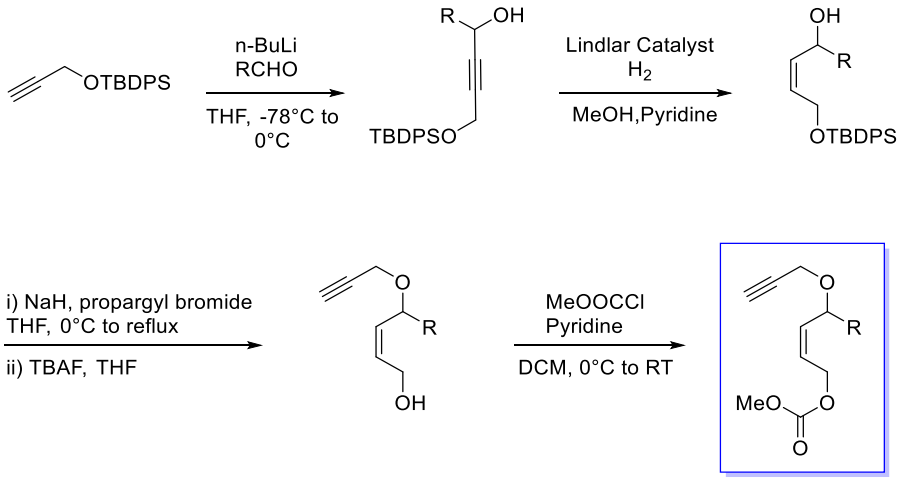
methyl (Z)-5-((1'-(4''-(2''',3'''-dihydrobenzo[b][1,4]dioxin-6''-yl)phenyl)prop-2'-yn-1'-yl)oxy)pent-3-enoate (53)



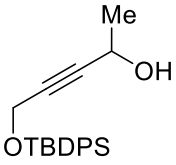
Carbonate **53** was prepared following General Procedure C from alcohol **S55** (90 mg, 0,10 mmol), pyridine (40 µL, 0.53 mmol, 2 eq.) and methyl chloroformate (240 µL, 0.53 mmol, 2 eq.) in CH_2Cl_2 (6 mL). The title compound was obtained as a yellow oil (80 mg, 81%) after chromatography [hexanes/ethyl acetate (90:10)]. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.57 (s, 4H), 7.16 – 7.01 (m, 3H), 6.95 (d, *J* = 8.3 Hz, 2H), 5.88 (dt, *J* = 11.4, 6.3 Hz, 2H), 5.79 (dt, *J* = 11.3, 6.5 Hz, 2H), 5.25 (d, *J* = 2.2 Hz, 2H), 4.76 (dd, *J* = 5.9, 3.7 Hz, 2H), 4.33 (s, 2H), 4.32 (s, 4H), 3.82 (d, *J* = 5.4 Hz, 3H), 3.45 (s, 1H), 2.71 (d, *J* = 2.1 Hz, 1H).. ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.76 , 143.82 , 143.45 , 141.12 , 136.51 , 134.35 , 130.76 , 127.92 , 127.00 (d, *J* = 14.5 Hz), 120.32 , 117.71 , 116.01 , 81.38 , 77.46 , 77.14 , 76.83 , 76.17 , 70.63 , 64.57 (d, *J* = 3.9 Hz), 63.76 , 54.97 , 54.32.

E. *Allyl-Substituted Substrates*

Allyl-substituted substrates were prepared as depicted in the synthetic scheme. Condensation of lithiated *O*-TBDPS-protected propargyl alcohol with the appropriate aldehyde furnished the desired secondary alcohol. Semi-hydrogenation (Lindlar catalyst) then provided the desired *Z*-alkene. Subsequent propargyl ether formation and installation of the methyl carbonate ester then furnished the requisite thiocyanopalladation substrates

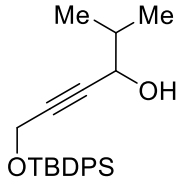


5-((*tert*-Butyldiphenylsilyl)oxy)pent-3-yn-2-ol (S56)



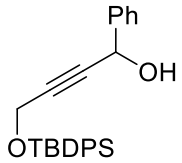
Alcohol **S56** was prepared following General Procedure A from *tert*-butyldiphenyl-(prop-2-yn-1-yloxy)-silane (600 mg, 2.00 mmol), acetaldehyde (235 µL, 2.40 mmol, 1.2 eq.) and *n*-butyllithium (1.5 mL of a 1.6 M solution in hexanes, 1.2 eq.). Following purification via SiO_2 chromatography [hexanes/ethyl acetate (90:10)], the desired alcohol was obtained (600 mg, 90% yield) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.73-7.71 (m, 2H), 7.71-7.69 (m, 2H), 7.48-7.35 (m, 6H), 4.47-4.39 (m, 1H), 4.35 (d, *J* = 1.6 Hz, 2H), 1.53 (d, *J* = 5.3 Hz, 1H), 1.34 (d, *J* = 6.6 Hz, 3H), 1.05 (s, 9H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 135.71, 133.26 , 133.22 , 129.81 (2 CH), 127.67 (4 CH), 81.12 , 82.46 , 58.35 , 52.66 , 28.73 (3 CH_3), 24.02 , 19.15 . HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{21}H_{26}O_2SiNa$ $(M+Na)^+$ 361.1600, obsd 361.1607.

6-(*tert*-Butyldiphenylsilyloxy)-2-methylhex-4-yn-3-ol (S57)



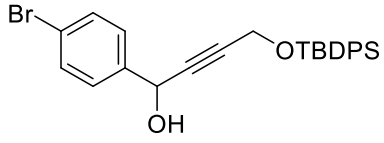
Following General Procedure A, alcohol **S57** was prepared from *tert*-butyldiphenyl(prop-2-yn-1-yloxy)silane (833 mg, 2.83 mmol), isobutyraldehyde (310 µL, 3.4 mmol, 1.2 eq.) and *n*-butyllithium (2.1 mL of a 1.6 M solution in hexanes,, 3.4 mmol, 1.2 eq.). The crude product was purified via flash chromatography on silica gel [hexanes/ethyl acetate (90:10)] to give **S57** (900 mg, 87% yield) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.71 (dd, *J* = 7.8, 1.4 Hz, 4H), 7.46-7.34 (m, 6H), 4.37 (d, *J* = 1.7 Hz, 2H), 4.09 (dt, *J* = 5.5, 1.4 Hz, 1H), 1.91 (d, *J* = 6.3 Hz, 1H), 1.79 (apt m, *J* = 6.5 Hz, 1H), 1.05 (s, 9H), 0.94 (d, *J* = 6.8 Hz, 3H), 0.93 (d, *J* = 6.8 Hz, 3H).^{13}C NMR (100 MHz, $CDCl_3$) δ 135.65 (4 CH), 133.23 , 133.20 , 129.78 (2 CH), 127.66 (4 CH), 84.91 , 83.97 , 67.87 , 52.68 , 34.32 , 26.67 (3 CH_3), 19.13 , 17.98 , 17.38 . HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{23}H_{30}O_2SiNa$ $(M+Na)^+$ 389.1913, obsd 389.1920.

4-(*tert*-Butyldiphenylsilyloxy)-1-phenylbut-2-yn-1-ol (S58)



Following General Procedure A, alcohol **S58** was obtained from *tert*-butyldiphenyl(prop-2-yn-1-yloxy)silane (860 mg, 2.93 mmol), benzaldehyde (359 µL, 3.52 mmol, 1.2 eq.) and *n*-butyllithium (2.2 mL of a 1.6 M solution in hexanes, 1.2 eq.). Final purification was carried out by SiO_2 chromatography [hexanes/ethyl acetate (90:10)] to provide **S58** (840 mg, 72% yield) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.71 (apt dd, *J* = 7.8, 1.3 Hz, 4H), 7.47-7.30 (m, 11H), 5.38 (d, *J* = 5.8 Hz, 1H), 4.42 (d, *J* = 1.8 Hz, 2H), 1.94 (d, *J* = 6.2 Hz, 1H), 1.06 (s, 9H).^{13}C NMR (100 MHz, $CDCl_3$) δ 140.36 , 135.66 (4 CH), 135.58 , 130.05 , 129.79 (2 CH), 129.60 , 128.50 (2 CH), 128.26 , 127.88 , 127.66 (2 CH), 126.59 (2 CH), 85.12 , 84.87 , 64.51 , 52.72 , 26.67 (3 CH_3), 19.13 . HRMS (TOF MS EI$^+$) m/z Calcd for $C_{26}H_{28}O_2SiNa$ $(M+Na)^+$ 423.1756, obsd 423.1740.

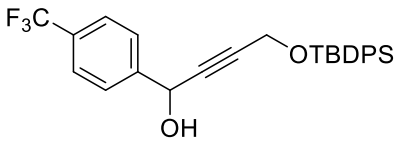
1-(4'-bromophenyl)-4-((tert-Butyldiphenylsilyl)oxy)but-2-yn-1-ol (S59)



Following General Procedure A, alcohol **S59** was obtained from *tert*-butyldiphenyl(prop-2-yn-1-yloxy)silane (4 g, 13 mmol), bromobenzaldehyde (3 g, 16 mmol, 1.2 eq.) and *n*-butyllithium

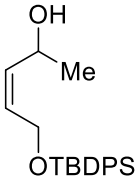
(10 mL of a 1.6 M solution in hexanes, 1.2 eq.). Final purification was carried out by SiO_2 chromatography [hexanes/ethyl acetate (90:10)] to provide **S59** (4.8 mg, 77% yield) as a colorless oil.). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.79 (m 5H), 7,15-7.64 (m 10H), 5.39 (s 1H), 4.48 (s 2H), 1.11 (s 9H) ^{13}C NMR (100 MHz, $CDCl_3$) δ 135.80, 134.91, 133,23, 133.19, 131.70, 129.98, 128.43, 127.82, 85.62, 84.54, 63.95, 52.79, 26.78, 19.25

4-((tert-Butyldiphenylsilyl)oxy)-1-(4'-(trifluoromethyl)phenyl)but-2-yn-1-ol (S60)



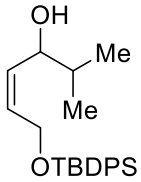
Following General Procedure A, alcohol **S60** was obtained from *tert*-butyldiphenyl(prop-2-yn-1-yloxy)silane (1 g, 3 mmol), trifluoromethylbenzaldehyde (0.45 mL g, 3 mmol, 1 eq.) and *n*-butyllithium (1.9 mL of a 1.6 M solution in hexanes, 1.2 eq.). Final purification was carried out by SiO_2 chromatography [hexanes/ethyl acetate (90:10)] to provide **S60** (0.65 g, 50% yield) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$)) δ 7.80 – 7.70 (m, 5H), 7.67 – 7.54 (m, 5H), 7.49 – 7.36 (m, 8H), 5.43 (d, *J* = 4.7 Hz, 1H), 4.46 (d, *J* = 1.7 Hz, 2H), 1.08 (s, 8H). ^{13}C NMR (100 MHz, $CDCl_3$)) δ 144.20 , 135.80 , 134.92 , 133.20 (d, *J* = 5.2 Hz), 130.19 – 130.03 (m), 129.89 (d, *J* = 22.6 Hz), 127.83 , 126.93 , 125.57 (d, *J* = 3.8 Hz), 85.89 , 84.39 , 77.39 (d, *J* = 11.6 Hz), 77.13 , 76.82 , 63.91 , 52.77 , 41.69 , 26.73 (d, *J* = 10.5 Hz), 23.42 , 19.25 , 14.23 . ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.56

5-(*tert*-Butyldiphenylsilyloxy)pent-3*Z*-en-2-ol (S61)



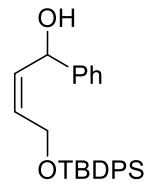
Z-Alkene (**S61**) was prepared following General Procedure D from **S56** (600 mg, 1.77 mmol) and Pd on $CaCO_3$ (200 mg, 5% wt in Pd, 0.05 eq.) in pyridine (10 mL)/MeOH (20 mL). The desired *Z*-alkene product **S61** (600 mg, quantitative) was obtained in homogeneous colorless oil form following SiO_2 chromatography [hexanes/ethyl acetate (90:10)]. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.70-7.65 (m, 4H), 7.46-7.36 (m, 6H), 5.65-5.68 (m, 1H), 5.46 (ddt, *J* = 8.1, 11.1, 1.5 Hz, 1H), 4.39 (apt quint, *J* = 7.0 Hz, 1H), 4.31 (ddd, *J* = 13.2, 6.7, 1.5 Hz, 1H), 4.22 (ddd, *J* = 13.2 Hz, 5.5 Hz, 1.5 Hz, 1H), 1.62 (br s, 1H), 1.14 (d, *J* = 6.4 Hz, 3H), 1.04 (s, 9H).^{13}C NMR (100 MHz, $CDCl_3$) δ 135.64 (2 CH), 135.57 (2 CH), 135.21 , 133.44 , 133.38 , 129.77 , 129.75 , 129.50 , 127.72 (2 CH), 127.68 (2 CH), 63.85 , 60.19 , 26.75 (3 CH_3), 23.17 , 19.07 . HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{21}H_{28}O_2SiNa$ $(M+Na)^+$ 363.1756, obsd 363.1749.

6-(*tert*-Butyldiphenylsilyloxy)-2-methylhex-4*Z*-en-3-ol (S62)



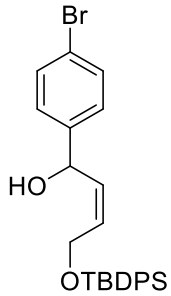
Following General Procedure D, *Z*-alkene **S62** was obtained from **S57** (900 mg, 2.46 mmol) and Pd on $CaCO_3$ (300 mg, 5% wt in Pd, 0.05 eq.) in pyridine (15 mL)/MeOH (30 mL). Purification via SiO_2 flash chromatography [hexanes/ethyl acetate (90:10)] provided the title compound (850 mg, 93%) as colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.71-7.65 (m, 4H), 7.46-7.35 (m, 6H), 5.73 (qdd, *J* = 5.6, 6.7, 1.1 Hz, 1H), 5.43 (ddt, *J* = 11.3, 8.9, 1.5 Hz, 1H), 4.33 (ddd, *J* = 13.3, 7.1, 1.5 Hz, 1H), 4.21 (ddd, *J* = 13.2, 5.4, 1.5 Hz, 1H), 3.86 (ddd, *J* = 8.5, 6.8, 0.8 Hz, 1H), 1.60 (apt m, J = 6.7 Hz, 1H), 1.60 (br s, 1H), 1.04 (s, 9H), 0.85 (d, *J* = 6.7 Hz, 3H), 0.78 (d, *J* = 6.7 Hz, 3H).^{13}C NMR (100 MHz, $CDCl_3$) δ 135.64 (2 CH), 135.56 (2 CH), 133.53 , 133.48 , 132.12 CH), 131.31 , 129.73 , 129.71 , 127.69 (2 CH), 127.65 (2 CH), 72.59 , 60.28 , 33.79 , 26.76 (3 CH_3), 19.08 , 18.02 , 17.98 . HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{23}H_{32}O_2SiNa$ $(M+Na)^+$ 391.2069, obsd 391.2076.

5-(*tert*-Butyldiphenylsilyloxy)pent-3*Z*-en-2-ol (S63)



Z-Alkene **S63** was prepared following General Procedure D from **S58** (337 mg, 0.84 mmol) and Pd on $CaCO_3$ (100 mg, 5% wt in Pd, 0.05 eq.) in pyridine (5 mL)/MeOH (10 mL). Purification via SiO_2 chromatography [hexanes/ethyl acetate (90:10)] gave the title compound (330 mg, 98%) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.68 (d, *J* = 7.7 Hz, 2H), 7.66 (d, *J* = 7.7 Hz, 2H), 7.44-7.32 (m, 6H), 7.30-7.19 (m, 5H), 5.85 (apt m, *J* = 5.9 Hz, 1H), 5.55 (ddt, *J* = 10.8, 9.4, 1.5 Hz, 1H), 5.16 (d, *J* = 8.9 Hz, 1H), 4.45 (ddd, *J* = 13.5, 6.3, 1.2 Hz, 1H), 4.36 (ddd, *J* = 13.5, 6.3, 1.2 Hz, 1H), 2.09 (br s, 1H), 1.03 (s, 9H).^{13}C NMR (100 MHz, $CDCl_3$) δ 142.90 , 135.65 (2 CH), 135.55 (2 CH), 133.42 , 133.35 , 133.20 , 130.41 , 129.78 , 129.75 ; 128.42 (2 CH), 127.74 (2 CH), 127.71 (2 CH), 127.41 , 125.87 (2 CH), 69.73 , 60.29 , 26.76 (3 CH_3), 19.09 . HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{26}H_{30}O_2SiNa$ $(M+Na)^+$ 425.1913, obsd 425.1895.

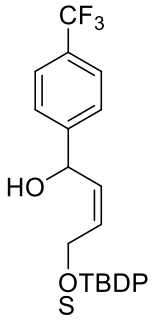
(Z)-(1-(4'-bromophenyl)-4-(*tert*-Butyldiphenylsilyloxy)but-2*Z*-en-1-ol (S64)



Z-Alkene **S64** was prepared by making a solution of **S59** (2 g, 4.1 mmol) and Pd on $BaSO_4$ (300 mg, 5% wt in Pd.) in pyridine (50 mL pyridine) and subjecting it to 50 PSI H_2 for 2 hrs.. Purification via SiO_2 chromatography [hexanes/ethyl

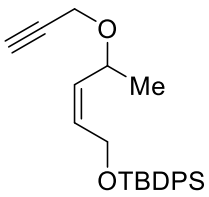
acetate (90:10)] gave the title compound (1.7 g, 85%) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72 (t, *J* = 6.3 Hz, 5H), 7.54 – 7.37 (m, 10H), 7.17 (d, *J* = 8.4 Hz, 2H), 5.86 – 5.71 (m, 1H), 5.67 – 5.56 (m, 1H), 5.30 (d, *J* = 8.3 Hz, 1H), 4.40 (ddd, *J* = 18.9, 13.3, 6.1 Hz, 2H), 2.13 (d, *J* = 3.2 Hz, 1H), 1.09 (s, 10H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 141.91 , 135.65 (d, *J* = 7.8 Hz), 133.29 (d, *J* = 7.1 Hz), 132.95 , 131.50 , 130.78 , 129.89 (d, *J* = 2.1 Hz), 128.10 – 127.56 (m), 121.27 , 77.47 , 77.05 , 76.62 , 69.14 , 60.30 , 26.79 , 19.12 .

(Z)-4-((*t*ert-Butyldiphenylsilyl)oxy)-1-(4'-(trifluoromethyl)phenyl)but-2-en-1-ol (S65)



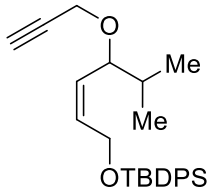
Z-Alkene **S65** was prepared by making a solution of **S60** (0.5 g, 4.1 mmol) and Pd on $BaSO_4$ (75 mg, 5% wt in Pd.) in pyridine (20 mL) and subjecting it to 50 PSI H_2 for 2 hrs.. Purification via SiO_2 chromatography [hexanes/ethyl acetate (90:10)] gave the title compound (0.36 g, 90% BRSM) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83 – 7.68 (m, 5H), 7.57 (d, *J* = 8.0 Hz, 3H), 7.52 – 7.35 (m, 5H), 5.89 – 5.76 (m, 1H), 5.67 – 5.59 (m, 1H), 5.41 (d, *J* = 8.4 Hz, 1H), 4.47 (dd, *J* = 12.8, 6.3 Hz, 2H), 4.36 (dd, *J* = 13.1, 5.0 Hz, 1H), 1.09 (s, 9H) ^{13}C NMR (75 MHz, $CDCl_3$) δ 135.70, 135.59, 134.82, 132.78, 131.11, 129.94, 127.84, 127.74, 126.20, 125.38, 89.00, 69.17, 60.32, 26.78, 19.12.

5-(*tert*-Butyldiphenylsilyloxy)-2-(prop-2'-yn-1'yloxy)pent-3*Z*-ene (S66)



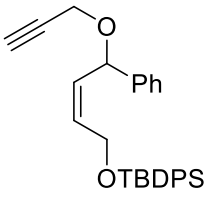
Following General Procedure E, propargyl ether was prepared from alcohol **S61** (585 mg, 1.72 mmol), NaH (140 mg, 60% in oil, 3.44 mmol, 2 eq.) and propargyl bromide (243 μL of a 80% wt solution in toluene, 3.44 mmol, 2 eq.). Following SiO_2 chromatography [hexanes/ethyl acetate (95:5)] the title compound (450 mg, 70%) was obtained as pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.70-7.65 (m, 4H), 7.45-7.35 (m, 6H), 5.79 (dtd, *J* = 11.1 Hz, 6.2 Hz, 1.5 Hz, 1H), 5.28 (ddt, *J* = 10.2, 10.2, 1.7 Hz, 1H), 4.38-4.21 (m, 3H), 4.03 (dd, *J* = 15.6 Hz, 2.4 Hz, 1H), 3.87 (dd, *J* = 15.6, 2.4 Hz, 1H), 2.22 (t, *J* = 2.4 Hz, 1H), 1.15 (d, *J* = 6.3 Hz, 3H), 1.05 (s, 9H).^{13}C NMR (100 MHz, $CDCl_3$) δ 135.56 (4 CH), 133.56 (2), 132.56 , 131.51 , 129.68 , 127.68 (4 CH), 129.50 , 80.14 , 73.77 , 69.77 , 60.16 , 55.00 , 26.77 (3 CH_3), 21.20 , 19.13 . HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{24}H_{30}O_2SiNa$ $(M+Na)^+$ 401.1913, obsd 401.1907.

6-(*tert*-Butyldiphenylsilyloxy)-3-(prop-2'-yn-1'yloxy)-2-methylpent-3*Z*-ene (S67)



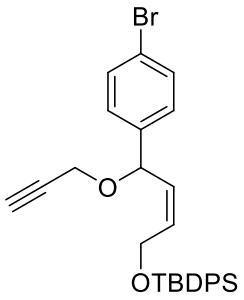
Propargyl ether was prepared following General Procedure E from alcohol **S62** (440 mg, 1.19 mmol), NaH (95 mg, 60% in oil, 2.39 mmol, 2 eq.) and propargyl bromide (266 µL of a 80% wt solution in toluene, 2.39 mmol, 2 eq.). Following purification by SiO_2 chromatography [hexanes:ethyl acetate (95:5)], the title compound was obtained (300 mg, 63%) as a pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.81-7.70 (m, 4H) 7.50-7.37 (m, 6H), 5.97 (apt m, *J* = 5.8 Hz, 1H), 5.30 (ddt, *J* = 11.3, 9.7, 1.5 Hz, 1H), 4.44 (ddd, *J* = 13.3, 6.9, 1.6 Hz, 1H), 4.31 (ddd, *J* = 13.3, 5.4, 1.8 Hz, 1H), 4.1 (dd, *J* = 15.7, 2.4 Hz, 1H), 3.9 (dd, *J* = 15.7, 2.4 Hz, 1H), 3.82 (dd, *J* = 9.7, 6.9 Hz, 1H), 2.25 (t, *J* = 2.3 Hz, 1H), 1.73 (apt m, *J* = 6.8 Hz, 1H), 1.11 (s, 9H), 0.93 (d, *J* = 6.8 Hz, 3H), 0.84 (d, *J* = 6.8 Hz, 3H).^{13}C NMR (100 MHz, $CDCl_3$) δ 135.54 (2 CH), 135.52 (2 CH), 134.58 , 133.54 , 129.64 , ,129.62 , 128.63 , 127.69 , 127.66 (4 CH), 80.35 , 78.61 , 73.55 , 60.24 , 55.11 , 32.54 , 26.76 (3 CH_3), 19.10 , 18.51 , 18.04 . HRMS (TOF MS ESI$^+$) m/z Calcd $C_{26}H_{34}O_2SiNa$ $(M+Na)^+$ 429.2226, obsd 429.2239.

4-(*tert*-Butyldiphenylsilyloxy)-1-(prop-2'-yn-1'yloxy)-1-phenylbut-2*Z*-ene (S68)



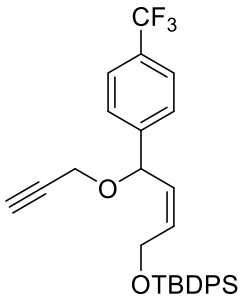
Propargyl ether was prepared following General Procedure E from alcohol **S63** (278 mg, 0.69 mmol), NaH (55 mg, 60% in oil, 1.38 mmol, 2 eq.) and propargyl bromide (105 µL of a 80% wt solution in toluene, 1.38 mmol, 2 eq.). In this case, purification with silica gel chromatography with hexanes/ethyl acetate (95:5) yielded the titled compound as a pale yellow oil (210 mg, 70%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.71 (dd, *J* = 7.7, 1.6 Hz, 2H), 7.69 (dd, *J* = 7.7, 1.6 Hz, 2H), 7.47-7.34 (m, 6H), 7.32-7.21 (m, 5H), 5.88 (m, 1H), 5.57 (ddt, *J* = 9.5, 10.6, 1.2 Hz, 1H), 5.19 (d, *J* = 9.0 Hz, 1H), 4.48 (ddd, *J* = 13.4, 6.3, 1.3 Hz, 1H), 4.38 (ddd, *J* = 13.4, 5.9, 1.5 Hz, 1H), 4.05 (dd, *J* = 15.7, 2.3 Hz, 1H), 3.99 (dd, *J* = 15.7, 2.3 Hz, 1H), 2.24 (t, *J* = 2.3 Hz, 1H), 1.06 (s, 9H).^{13}C NMR (100 MHz, $CDCl_3$) δ 140.38 , 135.60 (2 CH), 135.57 (2 CH), 133.55 (2), 133.04 (2 CH), 129.93 , 129.68 , 129.65 , 128.47 (2 CH), 127.70 (4 CH), 128.74 (2 CH), 79.74 , 75.48 , 74.29 , 60.38 , 55.08 , 26.79 (3 CH_3), 19.15 . HRMS (TOF MS ESI$^+$) m/z Calcd $C_{29}H_{32}O_2SiNa$ $(M+Na)^+$ 463.2069, obsd 463.2068.

(Z)-((4-(4''-Bromophenyl)-4-(prop-2'-yn-1'-yloxy)but-2-en-1-yl)oxy)(tert-butyl)diphenylsilaneene (S69)



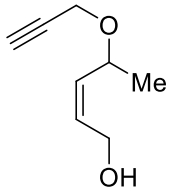
Propargyl ether was prepared following General Procedure E from alcohol **S64** (1.7 mg, 3.5 mmol), NaH (220 mg, 60% in oil, 1.38 mmol, 1.5 eq.) and propargyl bromide (450 µL of a 80% wt solution in toluene, 1.38 mmol, 1.5 eq.). In this case, purification with silica gel chromatography with hexanes/ethyl acetate (95:5) yielded the titled compound as a pale yellow oil (1.1 g, 61%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.74 – 7.59 (m, 5H), 7.50 – 7.37 (m, 10H), 7.15 (d, *J* = 8.3 Hz, 2H), 5.96 – 5.88 (m, 1H), 5.52 (dd, *J* = 10.9, 9.1 Hz, 1H), 5.19 (d, *J* = 8.9 Hz, 1H), 4.48 – 4.32 (m, 2H), 4.04 (t, *J* = 2.3 Hz, 2H), 2.26 (d, *J* = 2.4 Hz, 1H), 1.08 (s, 9H) ^{13}C NMR (100 MHz, $CDCl_3$) δ 135.71, 135.69, 134.62, 133.57, 131.67, 129.85, 129.61, 128.57, 127.86, 79.62, 74.87, 74.65, 60.45, 55.26, 26.90, 19.27.

(Z)-*tert*-Butyldiphenyl((4-(prop-2'-yn-1'-yloxy)-4-(4''-(trifluoromethyl)phenyl)but-2-en-1-yl)oxy)silane (S70)



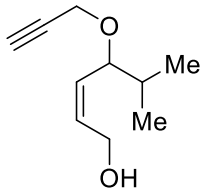
Propargyl ether was prepared following General Procedure E from alcohol **S65** (320 mg, 6.8 mmol), NaH (60 mg, 60% in oil, 1.4 mmol, 2 eq.) and propargyl bromide (160 µL of a 80% wt solution in toluene, 1.4 mmol, 2 eq.). In this case, purification with silica gel chromatography with hexanes/ethyl acetate (95:5) yielded the titled compound as a pale yellow oil (220 mg, 63%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.71 (dd, *J* = 10.4, 3.8 Hz, 5H), 7.56 (d, *J* = 8.1 Hz, 5H), 7.52 – 7.32 (m, 10H), 6.05 – 5.86 (m, 1H), 5.52 (t, *J* = 10.0 Hz, 1H), 5.38 – 5.25 (m, 1H), 4.45 (ddd, *J* = 26.4, 13.5, 6.0 Hz, 1H), 4.08 (d, *J* = 2.3 Hz, 1H), 1.08 (s, 9H). ^{13}C NMR (100 MHz, $CDCl_3$)) δ 135.72 , 134.05 , 129.90 , 129.38 , 127.88 , 127.07 , 125.52 , 77.50 , 77.44 , 76.97 (d, *J* = 31.9 Hz), 74.83 , 60.45 , 55.40 , 26.89 , 19.27 .

4-(Prop-2'-yn-1'-yloxy)pent-2*Z*-en-1-ol (S71)



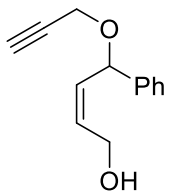
Alcohol **S71** was prepared following General Procedure F from the corresponding propargyl ether **S66** (435 mg, 1.15 mmol) and TBAF (4.45 mL of a 1M solution in THF, 3 eq.). Chromatography with hexanes/ethyl acetate (70:30) provided the title alcohol (140 mg, 87%) as a colorless oil. ^{1}H NMR (300 MHz, $CDCl_3$) 5.84-5.72 (m, 1H), 5.36 (ddt, *J* = 10.7, 9.4, 1.5 Hz, 1H), 4.56-4.42 (m, 1H), 4.31 (ddd, *J* = 13.0, 7.2, 1.5 Hz, 1H), 4.17 (ddd, *J* = 10.0 Hz, 3.0 Hz, 1.2 Hz, 1H), 4.14 (dd, *J* = 15.8 Hz, 2.4 Hz, 1H), 4.02 (dd, *J* = 15.6, 2.4 Hz, 1H), 2.41 (t, *J* = 2.4 Hz, 1H), 1.95 (br s, 1H), 1.23 (d, *J* = 6.4 Hz, 3H).^{13}C NMR (75 MHz, $CDCl_3$) δ 132.89 , 132.03 , 80.00 , 74.18 , 69.25 , 58.41 , 54.91 , 21.14 . HRMS (TOF MS CI$^+$) m/z Calcd for $C_8H_{12}O_2$ $(M)^+$ 140.0847, obsd 140.0844.

5-Methyl-4-(prop-2'-yn-1'-yloxy)hex-2*Z*-en-1-ol (S72)



Following General Procedure F, alcohol **S72** was prepared from the corresponding propargyl ether **S67** (230 mg, 0.56 mmol,) and TBAF (1.68 mL of a 1M solution in THF, 1.68 mmol, 3 eq.). Purification by SiO_2 chromatography [hexanes:ethyl acetate (70:30)] gave the desired alcohol (100 mg, 87%) in homogeneous form. ^{1}H NMR (400 MHz, $CDCl_3$) 5.9-5.82 (m, 1H), 5.29 (ddt, *J* = 11.2, 9.8, 1.5 Hz, 1H), 4.30 (ddd, *J* = 13.1, 7.6, 1.4 Hz, 1H), 4.14 (dd, *J* = 15.9, 2.5 Hz, 1H), 4.10 (ddd, *J* = 13.2, 5.7, 1.5 Hz, 1H), 4.00-3.93 (m, 2H), 2.38 (t, *J* = 2.4 Hz, 1H), 2.21 (br s, 1H), 1.72 (m, *J* = 6.8 Hz, 1H), 0.9 (d, *J* = 6.8 Hz, 3H); 0.81 (d, *J* = 6.8 Hz, 3H).^{13}C NMR (100 MHz, $CDCl_3$) δ 133.86 , 129.84 , 80.23 , 78.21 , 73.94 , 58.47 , 55.03 , 32.38 ; 18.53 , 17.95 . HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{10}H_{16}O_2Na$ $(M+Na)^+$ 191.1048, obsd 191.1054.

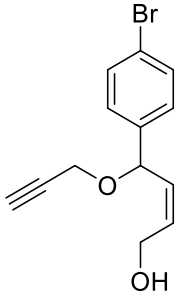
4-Phenyl-4-(prop-2'-yn-1'-yloxy)but-2*Z*-en-1-ol (S73)



Following General Procedure F, alcohol **S73** was prepared from the corresponding propargyl ether **S68** (410 mg, 0.93 mmol) and TBAF (2.79 mL of a 1M solution in THF, 2.79 mmol, 3 eq.). The crude product was purified via silica gel chromatography (hexanes/ethyl acetate 75:25) to give **S73** (150 mg 80%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35 (apt d, *J* = 4.3 Hz, 4H), 7.37-7.33 (m, 4H), 7.30-7.27 (m, 1H), 5.84 (apt dtd, *J* = 11.2, 6.4, 1.1 Hz, 1H), 5.67 (ddt, *J* = 9.3, 10.3, 1.3 Hz, 1H), 5.41 (d, *J* = 8.9 Hz, 1H), 4.42 (ddd, *J* = 13.2, 7.3, 1.4 Hz, 1H), 4.24 (ddd, *J* = 13.3, 6.0, 1.2 Hz, 1H), 4.15

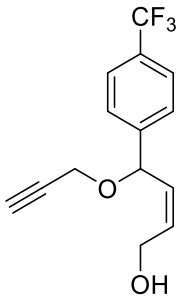
(dd, *J* = 16.0, 2.7 Hz, 1H), 4.07 (dd, *J* = 16.0, 2.7 Hz, 1H), 2.47 (t, *J* = 2.3 Hz, 1H), 2.19 (br, 1H).^{13}C NMR (100 MHz, $CDCl_3$) δ 140.06 , 132.12 , 131.42 , 128.58 (2 CH), 127.93 , 126.80 (2 CH), 79.56, , 75.34 , 74.69 , 58.60 , 54.96 . HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{13}H_{14}O_2Na$ $(M+Na)^+$ 225.0891, obsd 225.0881.

(Z)-4-(4'-Bromophenyl)-4-(prop-2''-yn-1''-yloxy)but-2-en-1-ol (S74)



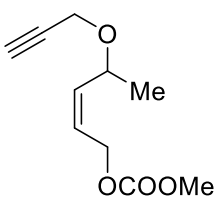
Following General Procedure F, alcohol **xx** was prepared from the corresponding propargyl ether **S69** (1 g, 1.9 mmol) and TBAF (5.7 mL of a 1M solution in THF, 5.7 mmol, 3 eq.). The crude product was purified via silica gel chromatography (hexanes/ethyl acetate 75:25) to give **S74** (350 mg 66%). %). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50 (d, *J* = 8.4 Hz, 2H), 7.27 (t, *J* = 6.5 Hz, 2H), 5.90 (ddd, *J* = 11.3, 8.5, 6.6 Hz, 1H), 5.70 – 5.54 (m, 1H), 5.43 (d, *J* = 8.7 Hz, 1H), 4.45 (dd, *J* = 13.3, 7.1 Hz, 1H), 4.29 (dd, *J* = 13.2, 6.0 Hz, 1H), 4.16 (qd, *J* = 15.9, 2.3 Hz, 2H), 2.50 (t, *J* = 2.4 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 139.42 , 132.72 , 131.90 , 131.36 , 128.69 , 122.03 , 79.54 , 77.46 , 77.14 , 76.83 , 75.07 , 74.77 , 58.89 , 55.26 .

(Z)-4-(Prop-2'-yn-1'-yloxy)-4-(4''-(trifluoromethyl)phenyl)but-2-en-1-ol (S75)



Following General Procedure F, alcohol **S74** was prepared from the corresponding propargyl ether **S70** (200 mg, 0.4 mmol) and TBAF (1.2 mL of a 1M solution in THF, 1.2 mmol, 3 eq.). The crude product was purified via silica gel chromatography (hexanes/ethyl acetate 75:25) to give (80 mg 74%). ^{1}H NMR (300 MHz, $CDCl_3$) 7.65 (d *J* = 7.8 Hz, 2H), 7.52 (d *J* = 7.8 Hz, 2H), 5.95 (m 1H), 5.66 (dd (d *J* = 9, 19 Hz, 2H), 4.53 (dd *J* = 6, 12.6 Hz, 1H), 4.37 (dd *J* = 5.1, 12.9 Hz, 1H) 4.35 (m 2H), 2.51 (d *J* = 7.8 Hz, 2.4H) ^{13}C NMR (75 MHz, $CDCl_3$) δ 133.02, 130.97, 127.08, 125.62 (2 C), 75.07, 74.58, 58.82, 55.29

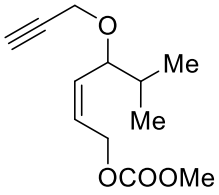
Methyl 4-(Prop-2'-yn-1'-yloxy)pent-2*Z*-en-1-yl Carbonate (15)



Following General Procedure C, carbonate **15** was prepared from alcohol **S71** (120 mg, 0.85 mmol), pyridine (85 µL, 1.1 mmol, 1.3 eq.) and methyl chloroformate (90 µL, 1.1 mmol, 1.3 eq.) in CH_2Cl_2 (5 mL). Flash chromatography on silica gel [hexanes/ethyl acetate (90:10)] provided **15**(140

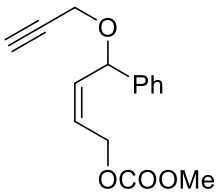
mg, 83%) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) 5.75-5.66 (m, 1H), 5.50 (apt t, *J* = 10.0 Hz, 1H), 4.79-4.66 (m, 2H), 4.48 (apt quint, *J* = 7.0 Hz, 1H), 4.12 (dd, *J* = 15.7 Hz, 1.3 Hz, 1H), 4.00 (dd, *J* = 15.7 Hz, 1.3 Hz, 1H), 3.76 (s, 3H), 2.39 (t, *J* = 1.3 Hz, 1H), 1.24 (d, *J* = 6.2 Hz, 3H).^{13}C NMR (100 MHz, $CDCl_3$) δ 155.55 , 135.82 , 126.14 , 79.84 , 74.14 , 69.43 , 63.30 , 55.17 , 54.78 , 21.06 . HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{10}H_{14}O_4Na$ $(M+Na)^+$ 221.0790, obsd 221.0798.

Methyl 5-Methyl-4-(prop-2'-yn-1'-yloxy)hex-2*Z*-en-1-yl Carbonate (17)



Carbonate **17** was prepared, following General Procedure C, from alcohol **S72** (100 mg, 0.59 mmol), pyridine (63 µL, 0.77 mmol, 1.3 eq.), and methyl chloroformate (60 µL, 0.77 mmol, 1.3 eq.) in CH_2Cl_2 (3 mL). Purification via SiO_2 chromatography [hexanes/ethyl acetate (90:10)] provided carbonate **17** (108 mg, 81%) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.83 (dddd, *J* = 11.2, 6.2, 7.1, 0.8 Hz, 1H), 5.45 (ddt, *J* = 9.6, 11.2, 1.5 Hz, 1H), 4.80 (ddd, *J* = 12.9, 7.6, 1.4 Hz, 1H), 4.66 (ddd, *J* = 12.9, 5.9, 1.6 Hz, 1H), 4.15 (dd, *J* = 15.9, 2.4 Hz, 1H), 3.98 (dd, *J* = 15.8, 2.4 Hz, 1H), 3.96 (dd, *J* = 9.0, 7.2 Hz, 1H), 3.76 (s, 3H), 2.37 (t, *J* = 2.4 Hz, 1H), 1.75 (m, *J* = 6.7 Hz, 1H), 0.93 (d, *J* = 6.7 Hz, 3H), 0.84 (d, *J* = 6.7 Hz, 3H).^{13}C NMR (100 MHz, $CDCl_3$) δ 155.58 , 132.99 , 128.01 , 128.09 , 80.07 , 78.41 , 73.94 , 63.58 , 55.38 , 54.78 , 32.50, 18.47 , 18.00 . HRMS (TOF MS ESI+) m/z Calcd for $C_{12}H_{18}O_4Na$ $(M+Na^+)$ 249.1103, obsd 249.1101.

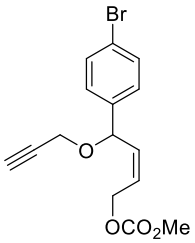
Methyl 4-Phenyl-4-(prop-2'-yn-1'-yloxy)but-2*Z*-en-1-yl Carbonate (19)



Following General Procedure C, carbonate **19** was prepared from alcohol **S73** (72 mg, 0.36 mmol), pyridine (38 µL, 0.46 mmol, 1.3 eq.), and methyl chloroformate (35 µl, 0.46 mmol, 1.3 eq.) in CH_2Cl_2 (5 mL). Flash chromatography [hexanes/ethyl acetate (90:10)] afforded **19** (85 mg, 92%) as a white amorphous solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35 (apt d, *J* = 4.4 Hz, 4H), 7.33-7.26 (m, 1H), 5.80-5.76 (m, 2H), 5.42-5.37 (m, 1H), 4.90 (dd, *J* = 13.1, 5.6 Hz, 1H), 4.82 (dd, *J* = 13.1, 5.6, 1H), 4.16 (dd, *J* = 15.8, 2.3 Hz, 1H), 4.08 (dd, *J* = 15.8, 2.4 Hz, 1H), 3.79 (s, 3H), 2.45 (t, *J* = 2.4 Hz, 1H).^{13}C NMR (100 MHz, $CDCl_3$) δ 155.54 , 139.72 , 133.93 , 128.60 (2 CH),

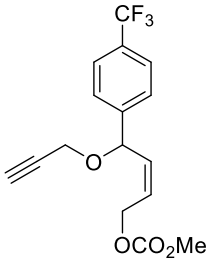
128.00 , 126.82 (2 CH), 126.29 , 79.46 , 75.40 , 74.67 , 63.61 , 55.13 , 54.78 . HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{15}H_{16}O_4Na$ $(M+Na)^+$ 283.0946, obsd 283.0935.

(Z)-4-(4''-Bromophenyl)-4-(prop-2'-yn-1'-yloxy)but-2-en-1-yl methyl carbonate (21)

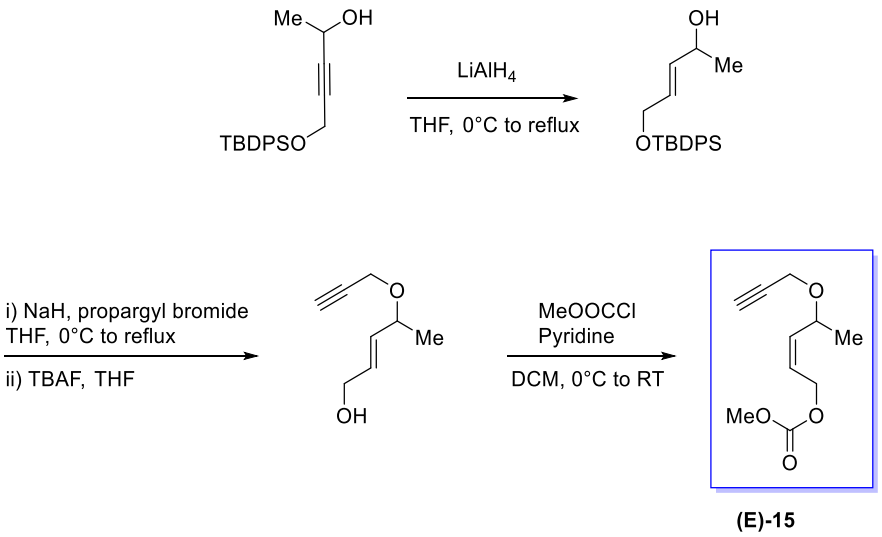


Following General Procedure C, carbonate **21** was prepared from alcohol **S74** (350 mg, 1.2 mmol), pyridine (160 µL, 1.9 mmol, 153 eq.), and methyl chloroformate (186 µl, 2 mmol, 2 eq.) in CH_2Cl_2 (6 mL). Flash chromatography [hexanes/ethyl acetate (90:10)] afforded **21** (340 mg, 95%) as a colorless oil. %). ^{1}H NMR (400 MHz, $CDCl_3$ δ 7.51 (d, *J* = 8.4 Hz, 2H), 7.27 (d, *J* = 8.5 Hz, 2H), 5.96 – 5.62 (m, 2H), 5.41 (d, *J* = 8.5 Hz, 1H), 4.95 – 4.72 (m, 2H), 4.15 (qd, *J* = 15.9, 2.4 Hz, 2H), 3.81 (d, *J* = 6.0 Hz, 3H), 2.49 (t, *J* = 2.4 Hz, 1H).. ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.73 , 139.04 , 133.67 , 131.91 , 128.70 , 127.05 , 122.13 , 79.40 , 77.46 , 77.14 , 76.82 , 75.09 , 74.83 , 63.64 , 55.41 , 55.05 .

(Z)-Methyl (4-(prop-2'-yn-1'-yloxy)-4-(4''-(trifluoromethyl)phenyl)but-2-en-1-yl) carbonate (23)

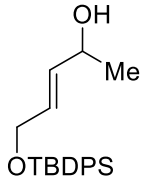


Following General Procedure C, carbonate **23** was prepared from alcohol **S75** (50 mg, 1.2 mmol), pyridine (30 µL, 0.37 mmol, 2 eq.), and methyl chloroformate (30 µl, 0.37 mmol, 2 eq.) in CH_2Cl_2 (6 mL). Flash chromatography [hexanes/ethyl acetate (90:10)] afforded **23** (60 mg, 99%) as a colorless oil. %). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.64 (d, *J* = 8.2 Hz, 2H), 7.52 (d, *J* = 8.1 Hz, 2H), 5.99 – 5.83 (m, 1H), 5.79 – 5.68 (m, 1H), 5.52 (d, *J* = 8.8 Hz, 1H), 4.98 – 4.76 (m, 2H), 4.19 (qd, *J* = 15.9, 2.3 Hz, 2H), 3.83 (s, 3H), 2.50 (t, *J* = 2.3 Hz, 1H).. ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.73 , 144.05 , 134.91 , 133.41 , 127.83 , 127.54 , 127.22 , 125.73 (d, *J* = 3.7 Hz), 79.27 , 77.45 , 77.29 (d, *J* = 32.0 Hz), 76.81 , 75.23 , 74.76 , 63.56 , 55.56 , 55.07 . ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.59 .



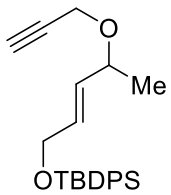
(E)-15

5-(*tert*-Butyldiphenylsilyloxy)pent-3*E*-en-2-ol ((E)-61)



To a suspension of $LiAlH_4$ (270 mg, 7.08 mmol, 4 eq.) in THF (3 mL) at 0 °C under N_2 atmosphere was added alkyne **S56** (600 mg, 1.77 mmol) in THF (1 mL) via syringe. The reaction was brought to reflux and stirring continued until all starting alkyne had been consumed (TLC with mini-quench). Ethyl acetate was added and the reaction was carefully quenched with a 1M solution of sodium hydroxide. The aqueous layer was extracted twice with CH_2Cl_2. and the combined organic extracts were dried (Na_2SO_4), filtered and concentrated. The crude product was purified by flash chromatography [hexanes/ethyl acetate (90:10)] to afford **(E)-61** (300 mg, 50%) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.70 (apt d, *J* = 1.5 Hz, 2H), 7.68 (dd, *J* = 1.9 Hz, 2H), 7.46-7.36 (m, 6H), 5.79 (ddt *J* = 15.5, 5.7, 1.2 Hz, 1H), 5.73 (dt, *J* = 15.6, 4.0 Hz, 1H), 4.31 (Apt quint, *J* = 6.2 Hz, 1H), 4.22 (d, *J* = 4.0 Hz, 2H), 1.53 (br s, 1H), 1.26 (d, *J* = 6.3 Hz, 3H), 1.08 (s, 9H).^{13}C NMR (100 MHz, $CDCl_3$) δ 135.52 (4 CH), 134.01 (2 CH), 133.65 , 133.63 , 129.62 , 128.75 , 127.61 (4 CH), 68.28 , 63.79 , 26.81 (3 CH_3), 23.20 , 19.19 . HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{21}H_{28}O_2SiNa$ $(M+Na)^+$ 363.1756, obsd 363.1762.

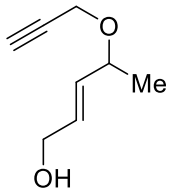
5-(*tert*-Butyldiphenylsilyloxy)-2-(prop-2'-yn-1'yloxy)pent-3*E*-ene ((E)-S66)



Propargyl ether was prepared following General Procedure E from alcohol **(E)-61** (460 mg, 1.35 mmol), NaH (108 mg, 60% in oil, 2.70 mmol, 2 eq.) and propargyl bromide (300 µL of a 80% wt solution in toluene, 2.70 mmol, 2 eq.). Following

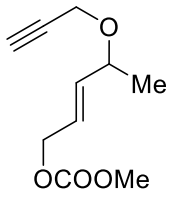
gradient flash chromatography [hexanes/ethyl acetate (95:5→90:10)], the title compound was obtained (400 mg, 70%) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) 7.69 (apt d, *J* = 7.1 Hz, 4H), 7.48-7.35 (m, 6H), 5.81-5.74 (m, 1H), 5.61 (ddt, *J* = 15.5, 7.9, 1.6 Hz, 1H), 4.24 (dd, *J* = 4.2, 1.6 Hz, 2H), 4.13 (dd, *J* = 15.8, 2.3 Hz, 1H), 4.09 (m, *J* = 6.9 Hz, 1H), 3.99 (dd, *J* = 15.8, 2.3 Hz, 1H), 2.39 (t, *J* = 2.3 Hz, 1H), 1.28 (d, *J* = 6.3 Hz, 3H), 1.08 (s, 9H).^{13}C NMR (100 MHz, $CDCl_3$) δ 135.50 (4 CH), 133.59 (2), 132.14 , 130.51 , 129.65 (2 CH), 127.64 (4 CH), 80.26 , 74.93 , 73.72 , 63.58 , 54.96 , 26.80 (3 CH_3), 21.41 , 19.21 . HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{24}H_{30}O_2SiNa$ $(M+Na)^+$ 401.1913, obsd 401.1898.

4-(Prop-2'-yn-1'-yloxy)pent-2*E*-en-1-ol ((E)-71)



Following General Procedure F, from the corresponding propargyl ether (400 mg, 1.05 mmol) and TBAF (3.15 mL of a 1M solution in THF, 3 eq.) was obtained alcohol **(E)-71** (95 mg, 65%) as a colorless oil after chromatography [hexanes/ethyl acetate (70:30)]. ^{1}H NMR (400 MHz, $CDCl_3$) 5.77 (dt, *J* = 15.7, 5.2 Hz, 1H), 5.5 (ddt, *J* = 15.8, 7.5, 1.8 Hz, 1H), 4.11-4.02 (m, 4H), 3.97 (dd, *J* = 15.6, 2.3 Hz, 1H), 2.64 (br s, 1H), 2.36 (t, *J* = 2.2 Hz, 1H), 1.20 (d, *J* = 6.4 Hz, 3H).^{13}C NMR (100 MHz, $CDCl_3$) δ 132.13 , 131.51 , 79.92 , 74.62 , 73.92 , 62.28 , 54.89 , 21.01 . HRMS (TOF MS CI$^-$) m/z Calcd for $C_8H_{11}O_2$ $(M-H)^-$ 139.0759, obsd 139.0738.

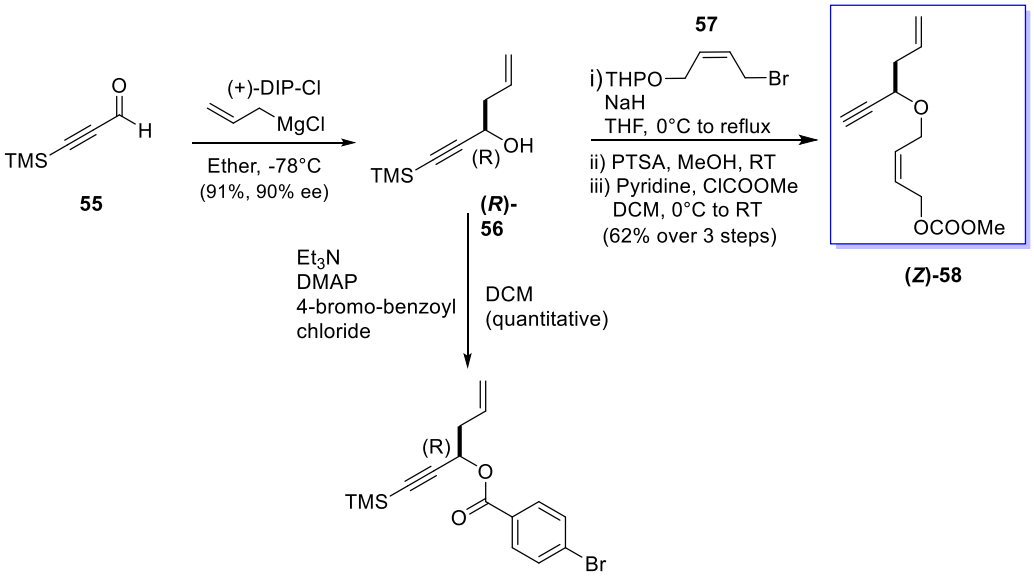
Methyl 4-(Prop-2'-yn-1'-yloxy)pent-2*E*-en-1-yl Carbonate ((E)-15)



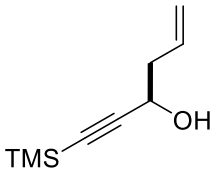
Following General Procedure A, the desired carbonate ester was prepared from alcohol **(E)-71** (95 mg, 0.67 mmol), pyridine (70 µL, 0.90 mmol, 1.3 eq.) and methyl chloroformate (73 µL, 0.90 mmol, 1.3 eq.). Purification via SiO_2 chromatography [hexanes/ethyl acetate (90:10)] provided carbonate **(E)-15** (120 mg, 90%) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) 5.80 (dt, *J* = 15.7, 5.8 Hz, 1H), 5.66 (ddt, *J* = 15.6, 7.4, 1.0 Hz, 1H), 4.63 (dd, *J* = 5.8, 0.8 Hz, 2H), 4.14 (dd, *J* = 15.8, 2.4 Hz, 1H), 4.1 (m, *J* = 6.7 Hz, 1H), 4.02 (dd, *J* = 15.8, 2.4 Hz, 1H), 3.79 (s, 3H), 2.39 (t, *J* = 2.4 Hz, 1H), 1.26 (t, *J* = 6.4 Hz, 3H).^{13}C NMR (100 MHz, $CDCl_3$) δ 155.54 , 135.83 , 125.98 , 79.94 , 74.38 , 74.03 , 67.45 , 55.29 , 54.85 , 21.04 . HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{10}H_{14}O_4Na$ $(M+Na)^+$ 221.0790, obsd 221.0794.

F. Asymmetric Route into Bridged Bicyclic Oxabicyclo[3.2.1]oct-2-enyl Systems

Starting aldehyde was prepared according literature procedures with similar yields to those reported.[7]



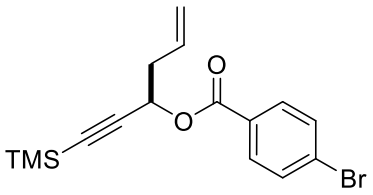
(+)-(3*R*)-1-(Trimethylsilyl)hex-5-en-1-yn-3-ol (56)



To a solution of (+)-DIP-chloride (5.30 g, 16.56 mmol, 1.45 eq.) in ether (90 mL) at 0 °C under N_2 atmosphere as added allyl magnesium chloride (8.7 mL of a 1.7M solution in ether, 14.8 mmol, 1.3 eq.), via syringe, and the resulting reaction mixture was left to stir at RT for 30 min before behind cooled to -78 °C. Then a solution of TMS-propynal (1.40 g, 11.4 mmol) in ether (90 mL) at -78 °C wa added, dropwise, via cannula, and the reaction mixture allowed to stir until the allylation had proceeded to completion (~3 h). The reaction was then quenched by addition of methanol and 1M HCl. Following basification with 2M NaOH (~pH 12), the layers were separated and aqueous layer extracted thrice with CH_2Cl_2. The combined organic layers were dried (Na_2SO_4), filtered and concentrated in vacuo. Ensuing column chromatography [hexanes/ethyl acetate (95:5 →90;10)] to afforded an analytically pure sample of the title compound (1.7 g, 91%) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.94-5-80 (m, 1H), 5.20 (d, *J* = 4.7 Hz, 1H), 5.16 (s, 1H), 4.40 (app q, *J* = 6.0, 1H), 2.46 (app t, *J* = 6.6 Hz, 2H), 1.90-1.85 (m, 1H), 0.16 (s, 9H) . ^{13}C NMR (100 MHz, $CDCl_3$) δ 132.94 , 119.01 , 105.89 , 89.84 , 61.95 , 42.08 , -0.16 (3 CH_3). HRMS (TOF

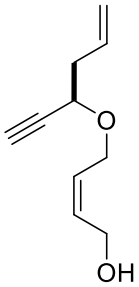
MS ESI$^+$) m/z Calcd for $C_9H_{16}OSiNa$ $(M+Na)^+$ 191.0868, obsd 191.0871.$[\alpha]^{20}_D$ = +36 (c = 1; $CHCl_3$). The ee was determined to be 90.2%, following derivatization (see next procedure).

(3*R*)-1-(Trimethylsilyl)hex-5-en-1-yn-3-yl 4-bromobenzoate (S76)



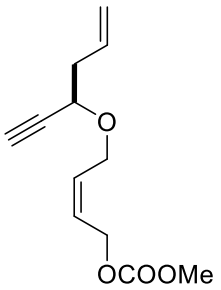
To a solution of alcohol **56** (10 mg, 0.065 mmol) in CH_2Cl_2 (1 mL) were added Et_3N (18 µL, 0.130 mmol, 2 eq.), *p*-bromobenzoyl chloride (28 mg, 0.130 mmol, 2 eq.) and DMAP (catalytic, one crystal). The resulting reaction mixture was stirred at RT until acylation was complete via TLC (~ 2 h). Concentration and purification via silica gel chromatography [hexanes/ethyl acetate (95:5)] afforded the targeted *p*-bromobenzoate ester in quantitative yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.9 (apt dt, *J* = 8.6, 1.9 Hz, 2H), 7.57 (apt dt, *J* = 8.6, 1.9 Hz, 2H), 5.86 (ddt, *J* = 10.4, 17.1, 6.8 Hz, 1H), 5.64 (t, *J* = 6.3, 1H), 5.17 (apt dq, *J* = 17.1, 1.9 Hz, 1H), 5.14 (apt dq, J = 10.4, 1.4 Hz, 1H), 2.63 (dt, *J* = 6.7, 1.3 Hz, 2H), 0.16 (s, 9H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.62 , 132.12 , 131.70 (2 CH), 131.31 (2 CH), 128.82 , 128.28 , 118.86 , 101.74 , 91.33 , 64.34 , 39.46 , -0.25 (3 CH_3). HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{16}H_{19}O_2SiBr^{79}Na$ $(M+Na)^+$ 373.0235, obsd 373.0244; m/z Calcd for $C_{16}H_{19}O_2SiBr^{81}Na$ $(M+Na)^+$ 375.0215, obsd 375.0224. Enantiopurity: 90.2% ee (Pirkle covalent, (S,S) Whelk-O 1 10/100, Eluent: hexanes/iPrOH (99.5:0.5), 1 mL/min, R_T1 = 5.31 min (major), R_T2 = 5.82 min (minor)).

(+)-(3'*R*)4-(Hex-5'-en-1'-yn-3'-yloxy)but-2*Z*-en-1-ol (S77)



Alcohol was prepared following General Procedure B from **56** (1.7 g, 10.2 mmol), NaH (546 mg, 13.65 mmol, 1.2 eq.) and 4-bromo-2*Z*-butenol-*O*-THP ether (3.2 g, 13.65 mmol, 1.2 eq.) in THF (100 mL). THP deprotection was then carried out with PTSA (260 mg, 1.37 mmol, 0.1 eq.) in MeOH (50 mL) to give the title compound as a colorless oil (1.1 g, 68% yield over 2 steps) after chromatography [hexanes/ethyl acetate (70:30)]. ^{1}H NMR (300 MHz, $CDCl_3$) δ 5.90-5.70 (m, 2H), 5.67-5.56 (m, 1H), 5.17-5.03 (m, 2H), 4.26 (dd, *J* = 12.5, 5.9 Hz, 1H), 4.17 (br d, *J* = 6.0 Hz, 2H), 4.11-4.04 (m, 2H), 2.52-2.40 (m, 3H), 2.33 (br s, 1H). ^{13}C NMR (75 MHz, $CDCl_3$) δ 133.00 , 132.87 , 127.41 , 117.94 , 81.94 , 74.42 , 68.21 , 64.04 , 58.40 , 39.84 . HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{10}H_{14}O_2Na$ $(M+Na)^+$ 189.0891, obsd 189.0882. $[\alpha]^{20}_D$ = +67 (c = 1; $CHCl_3$).

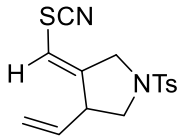
(+)-(3'*R*) Methyl4-(Hex-5'-en-1'-yn-3'-yloxy)but-2*Z*-en-1-yl Carbonate (58)



Carbonate **58** was prepared following General Procedure C from the alcohol **S77** (1.1 g, 6.62 mmol), pyridine (661 µL, 8.6 mmol, 1.3 eq.) and methyl chloroformate (701 µL, 8.6 mmol, 1.3 eq.) in CH_2Cl_2 (75 mL) to provide **58** (1.35 g, 91%) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.95-5.66 (m, 3H), 5.20-5.05 (m, 2H), 4.73-4.68 (m, 2H), 4.38-4.26 (m, 1H), 4.16-4.04 (m, 2H), 3.74 (s, 3H), 2.52-2.42 (m, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.51 , 133.04 , 130.48 , 126.50 , 117.84 , 81.87 , 74.41 , 68.31 , 64.05 , 63.56 , 54.67 , 39.82 . HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{12}H_{16}O_4Na$ $(M+Na)^+$ 247.0946, obsd 247.0951. $[\alpha]^{20}_D$ = +48 (c = 1; $CHCl_3$)

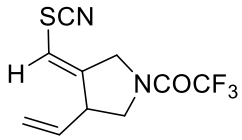
V. Thiocyanopalladation/Carbocyclization

(±)3*Z*-(Thiocyanatomethylene)-1-*p*-toluenesulfonyl-4-vinylpyrrolidine (4)



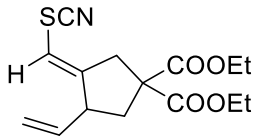
Thiocyanato-exomethylene tetrahydropyrrolidine derivative **4** was prepared following General Procedure G from carbonate **3** (38 mg, 0.113 mmol), LiSCN 14 mg, 0.17 mmol, 1.5 eq.) and $PdCl_2(PhCN)_2$ (1.1 mg, 0.003 mmol, 0.025 eq.) in THF (5 mL) to afford the *Z*-product (transoid) (30 mg, 85%) after column chromatography with hexanes/diethyl ether (95:5), from which product was recrystallized from hexanes:ether. ^{1}H NMR (700 MHz, $CDCl_3$) δ 7.72 (d, *J* = 8.3 Hz, 2H), 7.37 (d, *J* = 8.3 Hz, 2H), 5.80 (apt q, *J* = 2.4 Hz, 1H), 5.45 (ddd, *J* = 16.9, 9.9, 8.5 Hz, 1H), 5.23 (d, *J* = 10.1 Hz, 1H), 5.19 (d, *J* = 17.1 Hz, 1H), 4.08 (dd, *J* = 15.8, 2.2 Hz, 1H), 3.77 (dt, *J* = 15.8, 2.2 Hz, 1H), 3.70 (dd, *J* = 9.4, 8.0 Hz, 1H), 3.38 (apt q, *J* = 8.3 Hz, 1H), 2.85 (apt t, *J* = 9.4 Hz, 1H).^{13}C NMR (100 MHz, $CDCl_3$) δ 151.88 , 144.34 , 133.28 , 132.12 , 130.00 (2 CH), 127.82 (2 CH), 120.33 , 109.17 , 105.44 , 52.90 , 50.59 , 49.13 , 21.58 . m.p. 75-77°C. HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{15}H_{16}N_2O_2S_2Na$ $(M+Na)^+$ 343.0551, obsd 343.0549.

(±)-3*Z*-(Thiocyanatomethylene)-1-trifluoroacetamide-4-vinylpyrrolidine (6)



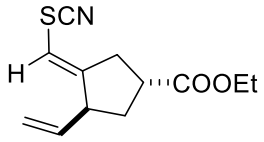
Thiocyanato-exomethylene tetrahydropyrrolidine derivative **6** was prepared following General Procedure G from carbonate **5** (56 mg, 0.2 mmol), LiSCN 24 mg, 0.3 mmol, 1.5 eq.) and $PdCl_2(PhCN)_2$ (1.9 mg, 0.005 mmol, 0.025 eq.) in THF (8 mL) to afford the *Z*-product (transoid) (45 mg, 87%) after purification on SiO_2 chromatography [hexanes/diethyl ether (80:20) →(70:30)]. ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.0 (apt m, *J* = 2.4 Hz, 1H), 5.61 (apt ddd, *J* = 17.2, 9.5, 8.4 Hz, 1H), 5.36 and 5.35 (d, *J* = 10.3 Hz, 1H), 5.29 and 5.28 (d, *J* = 16.9 Hz, 1H), 4.44 (dd, *J* = 24.1, 17.7 Hz) and 4.33 (dd, *J* = 20.4, 20.0, 2H), 4.18-4.05 (m, 1H), 3.64-3.35 (m, 2H).^{13}C NMR (100 MHz, $CDCl_3$) δ 155.38 and 155.3 (q, *J* = 37.6 Hz,), 150.63 and 148.32 , 132.93 and 132.45 , 121.9 and 120.81 , 115.94 (q, *J* = 286.6 Hz,), 108.96 and 108.71 , 106.88 and 106.40 , 51.47 and 49.14 , 51.08 and 48.7 (q, *J* = 3.4 and 4.0 Hz, respectively, CH_2), 49.74 and 46.76 . ^{19}F NMR (377 MHz, $CDCl_3$) δ.-73.39 and -73.79. HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{10}H_9F_3N_2OSNa$ $(M+Na)^+$ 285.0285, obsd 285.0292.

(±)-Diethyl -3*E*-(Thiocyanatomethylene)-4-vinylcyclopentane-1,1-dicarboxylate (8)

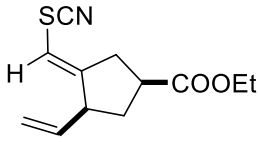


The title cyclic vinyl thiocyanate **8** was prepared, following General Procedure G, from carbonate **7** (32 mg, 0.1 mmol), LiSCN (12 mg, 0.15 mmol, 1.5 eq.) and $PdCl_2(PhCN)_2$ (1 mg, 0.0025 mmol, 0.025 eq.) in THF (4 mL) to afford the-product **8** (7 mg, 60% based on recovered starting material) after chromatography [hexanes/EtOAc (95:5)]. ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.76 (apt q, *J* = 2.5 Hz, 1H), 5.57 (ddd, *J* = 17.3, 8.8, 9.0 Hz, 1H), 5.18 (d, *J* = 10.6 Hz, 1H), 5.14 (d, *J* = 17.5 Hz, 1H), 4.22 (q, *J* = 7.2 Hz, 2H), 4.21 (q, *J* = 7.2 Hz, 2H), 3.28 (apt q, *J* = 9.4 Hz, 1H), 3.15 (d, *J* = 18.1 Hz, 1H), 3.01 (dt, *J* = 18.4, 2.3 Hz, 1H), 2.63 (dd, *J* = 13.3, 7.3 Hz, 1H), 2.04 (t, *J* = 12.4 Hz, 1H), 1.26 (apt t, *J* = 6.7 Hz, 6H).^{13}C NMR (100 MHz, $CDCl_3$) δ 170.93 , 170.56 , 155.67 , 136.53 , 118.56 , 110.37 , 104.74 , 62.07 , 62.02 , 58.44 , 49.50 , 40.17 , 38.42 , 14.03 , 14.01 . HRMS (TOF MS EI$^+$) m/z Calcd for $C_{15}H_{19}NO_4S$ ($M^{+\cdot}$) 309.1035, obsd 309.1034.

(±)-Ethyl (1*R,4*S**)-3*E*-(Thiocyanatomethylene)-4-vinylcyclopentane-1-carboxylate and (±)-Ethyl (1*S**,4*S**)-3*E*-(Thiocyanatomethylene)-4-vinylcyclopentane-1-carboxylate (10)**



(1R, 4S*) isomer*



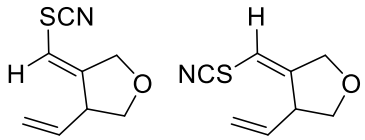
(1S, 4S*) isomer*

The title cyclopentanoid vinyl thiocyanates **10** were prepared, following General Procedure G, from carbonate **7** (50 mg, 0.2 mmol), LiSCN (24 mg, 0.3 mmol, 1.5 eq.) and $PdCl_2(PhCN)_2$ (2 mg, 0.005 mmol, 0.025 eq.) in THF (8 mL). Preparative HPLC [eluent: hexanes/EtOAc (97:3), flow rate: 20 mL/min] on silica gel afforded the title diastereoisomers in equal amounts (19 mg each, 80% total yield):

(1*R, 4*S**)-isomer** ^{1}H NMR (700 MHz, $CDCl_3$) δ 5.78 (apt q, *J* = 2.3 Hz, 1H), 5.59 (ddd, *J* = 10.1, 16.9, 7.4 Hz, 1H), 5.14 (apt d, *J* = 10.1 Hz, 1H), 5.10 (dt, *J* = 16.9, 1.2 Hz, 1H), 4.15 (q, *J* = 7.0 Hz, 2H), 3.31 (apt q, *J* = 8.0 Hz, 1H), 3.05 (m, 1H), 2.79 (br d, *J* = 18 Hz, 1H), 2.71 (ddt, *J* = 18.0, 8.8, 2.1 Hz, 1H), 2.26 (ddd, *J* = 13.0, 7.1, 5.0 Hz, 1H), 1.85 (apt dt, *J* = 13.0, 8.5 Hz, 1H), 1.26 (t, *J* = 7.0 Hz, 3H).^{13}C NMR (175 MHz, $CDCl_3$) δ 174.62 , 157.69 , 137.37 , 117.41 , 110.61 , 103.94 , 60.95 , 49.33 , 41.45 , 36.43 , 34.02 , 14.18 . HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{12}H_{15}NO_2SNa$ $(M+Na)^+$ 260.0721, obsd 260.0724.

(1*S, 4*S**)-isomer** ^{1}H NMR (700 MHz, $CDCl_3$) δ 5.75 (apt q, *J* = 2.5 Hz, 1H), 5.60 (ddd, *J* = 16.9, 10.0, 8.5 Hz, 1H), 5.17 (apt dd, *J* = 10.0, 1.3 Hz, 1H), 5.13 (apt d, *J* = 16.9 Hz, 1H), 4.16 (q, *J* = 7.0 Hz, 2H), 3.16 (apt q, *J* = 9.2 Hz, 1H), 2.94-2.88 (m, 1H), 2.79 (br dd, *J* = 18.2, 8.5 Hz, 1H), 2.70 (ddt, *J* = 18.2, 9.9, 2.6 Hz, 1H), 2.30 (m, *J* = 6.4 Hz, 1H), 1.75 (q, *J* = 12.0 Hz, 1H), 1.27 (t, *J* = 7.1 Hz, 3H).^{13}C NMR (175 MHz, $CDCl_3$) δ 173.86 , 157.25 , 136.95 , 118.14 , 110.57 , 104.12 , 60.92 , 51.20 , 42.40 , 37.21 , 34.30 , 14.20 . HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{12}H_{15}NO_2SNa$ $(M+Na)^+$ 260.0721, obsd 260.0710.

(±)-(*Z*) and (±)-(*E*)-3-(Thiocyanatomethylene)-4-vinyltetrahydrofuran (2t, 2c)

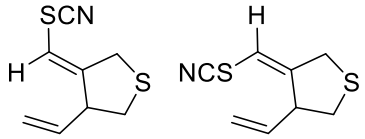


Thiocyanato-exomethylene tetrahydrofuran geometric isomers (*Z*)-**2e** and (*E*)-**3e** were prepared following General Procedure G from carbonate **1e** (260 mg, 1.42 mmol), LiSCN (172 mg, 2.13 mmol, 1.5 eq.) and $PdCl_2(PhCN)_2$ (54 mg, 0.028 mmol, 0.025 eq.) in THF (56 mL). The title thiocyanopalladation/carbocyclization transformation afforded a 1:4 mixture of *E:Z* geometric isomers (193 mg, 81%) that could be separated with chromatography [hexanes/ethyl acetate (95:5)].

Z-Isomer (transoid): (major) ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.84 (apt q, *J* = 2.4 Hz, 1H), 5.60 (ddd, *J* = 17.6, 8.5, 9.3 Hz, 1H), 5.25 (d, *J* = 4.5 Hz, 1H), 5.22 (d, *J* = 11.9 Hz, 1H), 4.54 (dd, *J* = 15.2, 1.3 Hz, 1H), 4.43 (dt, *J* = 15.2, 1.3 Hz, 1H), 4.16 (apt t, *J* = 8.0 Hz, 1H), 3.59 (apt t, *J* = 8.8 Hz, 1H), 3.44 (apt q, *J* = 8.2 Hz, 1H).^{13}C NMR (100 MHz, $CDCl_3$) δ 156.88 , 133.83 , 119.52 , 109.71 , 102.36 , 73.46 , 70.13 , 50.77 . HRMS (TOF MS EI$^+$) m/z Calcd for C_8H_9NOS $(M)^{+\cdot}$ 167.0405, obsd 167.0410.

E-Isomer (cisoid): (minor) ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.30 (br s, 1H), 5.70 (ddd, *J* = 16.9, 10.3, 7.6 Hz, 1H), 5.20-5.10 (m, 2H), 4.25 (br s, 2H), 3.89 (dd, *J* = 11.4, 4.9 Hz, 1H), 3.51 (dd, *J* = 11.4, 6.3 Hz, 1H), 3.09 (br s, 1H).^{13}C NMR (100 MHz, $CDCl_3$) δ 136.06 , 135.35 , 122.03 , 117.86 , 108.86 , 68.05 , 67.16 , 41.16 . HRMS (TOF MS CI$^+$) m/z Calcd for $C_8H_{10}NOS$ $(M+H)^+$ 168.0483, obsd 168.0486.

(±)-(*Z*) and (±)-(*E*)-3-(Thiocyanatomethylene)-4-vinyltetrahydrothiophene (12c, 12t)

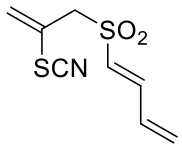


Thiocyanato-exomethylene tetrahydrothiophene derivatives (*Z*)-**12t** and (*E*)-**12c** were prepared following General procedure G from carbonate **11**(150 mg, 0.77 mmol), LiSCN (94 mg, 1.15 mmol, 1.5 eq.) and $PdCl_2(PhCN)_2$ (7.3 mg, 0.020 mmol, 0.025 eq.) in THF (8 mL). The key thiocyanocarbocyclization transformation afforded a 1.5:1 mixture of *E:Z* isomers (120 mg, 85%). The geometric isomers were separated by preparative HPLC on silica gel [hexanes/ethyl acetate (90:10), 20 mL/min flow rate]:

E-Isomer (cisoid): (major) ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.24 (dt, *J* = 3.7, 1.7 Hz, 1H), 5.79 (ddd, *J* = 17.2, 7.6, 10.2 Hz, 1H), 5.20-5.10 (m, 2H), 3.41 (dt, *J* = 17.5, 1.8 Hz, 1H), 3.35 (dt, *J* = 17.5, 1.8 Hz, 1H), 3.26-3.19 (m, 1H), 2.82 (dd, *J* = 13.6, 4.6 Hz, 1H), 2.54 (dd, *J* = 13.6, 6.9 Hz, 1H).^{13}C NMR (100 MHz, $CDCl_3$) δ 138.34 , 137.50 , 121.59 , 117.24 , 109.63 , 42.41 , 29.15 , 29.07 . HRMS (TOF MS CI$^+$) m/z Calcd for $C_8H_{10}NS_2$ $(M+H)^+$ 184.0255, obsd 184.0268.

Z-Isomer (transoid): (minor) ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.88 (q, *J* = 2.1 Hz, 1H), 5.66 (ddd, *J* = 17.1, 10.0, 8.1 Hz, 1H), 5.26 (d, *J* = 13.7 Hz, 1H), 5.23 (d, *J* = 21.1 Hz, 1H), 3.64 (dt, *J* = 15.9, 1.9 Hz, 1H), 3.57 (dt, *J* = 15.9, 1.9 Hz, 1H), 3.47 (apt q, *J* = 8.1 Hz, 1H), 3.02 (dd, *J* = 11.1, 6.8 Hz, 1H), 2.76 (dd, *J* = 11.1, 9.2 Hz, 1H).^{13}C NMR (100 MHz, $CDCl_3$) δ 154.80 , 135.61 , 119.17 , 109.91 , 105.70 , 54.45 , 36.29 , 33.36 . HRMS (TOF MS CI$^+$) m/z Calcd for $C_8H_{10}NS_2$ $(M+H)^+$ 184.0255, obsd 184.0271.

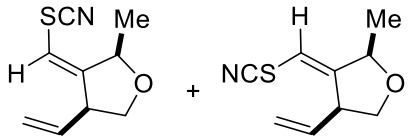
(1-(2-Thiocyanatoallylsulfonyl)buta-1*E*,3-diene (14)



Butadiene derivative 1**4** was obtained following General Procedure G from carbonate **13** (24 mg, 0.1 mmol), LiSCN (12 mg, 0.15 mmol, 1.5 eq.) and $PdCl_2(PhCN)_2$ (1 mg, 0.0025 mmol, 0.025 eq.) in THF (4 mL). Flash chromatography [CH_2Cl_2/MeOH (100:0)→(95:5)] provided the side product shown above (18 mg, 83%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.24 (dd, *J* = 14.9, 10.9 Hz, 1H), 6.47 (dt, *J* = 16.9, 10.5 Hz, 1H), 6.4 (d, *J* = 14.9 Hz, 1H), 5.99 (d, *J* = 1.9 Hz, 1H), 5.9 (d, *J* = 1.9 Hz, 1H), 5.81 (d, *J* = 16.9 Hz, 1H), 5.73 (d, *J* = 10.0 Hz, 1H), 3.99 (s, 2H).^{13}C NMR (100 MHz,

$CDCl_3$) δ 146.90 , 131.91 , 130.28 , 128.12 , 126.55 , 122.97 , 108.88 , 60.70 . HRMS (TOF MS CI^+) m/z Calcd for $C_8H_{10}NO_2S_2$ $(M+H)^+$ 216.0153, obsd 216.0162.

(±)-(2*R,4*S**,*Z*) and (±)-(2*R**,4*S**,*E*)-2-Methyl-3-(thiocyanatomethylene)-4-vinyltetrahydrofuran (26t, 26c)**

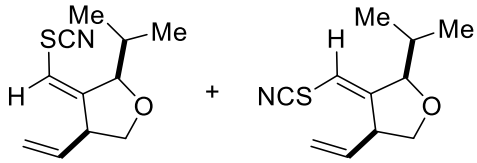


The tetrahydrofuranoid vinyl thiocyanate **26** was prepared, following General Procedure G, from carbonate **25** (20 mg, 0.1 mmol), LiSCN (12 mg, 0.15 mmol, 1.5 eq.) and $PdCl_2(PhCN)_2$ (2 mg, 0.005 mmol, 0.05 eq.) in THF (6 mL) to afford a *E:Z* mixture (1:1.6) after chromatography column [hexane/EtOAc (95:5)] to yield both the *E*-isomer (6 mg, 34%) and the *Z*-isomer (10 mg, 56%).

Z-Isomer (transoid): ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.88 (apt t, *J* = 1.9 Hz, 1H), 5.67 (ddd, *J* = 17.8, 9.4, 8.2 Hz, 1H), 5.19 (br s, 1H), 5.16 (apt d, *J* = 4.6 Hz, 1H), 4.77 (qd, *J* = 6.5, 2.0 Hz, 1H), 4.04 (dd, *J* = 9.0, 7.3 Hz, 1H), 3.76 (dd, *J* = 9.1, 1.4 Hz, 1H), 3.44 (apt q, *J* = 7.5 Hz, 1H), 1.36 (d, *J* = 6.6 Hz, 3H).^{13}C NMR (100 MHz, $CDCl_3$) δ 159.42 , 135.42 , 118.40 , 109.97 , 103.28 , 76.20 , 70.90 , 51.39 , 18.79 . HRMS (TOF MS CI^+) m/z Calcd for $C_9H_{12}NOS$ $(M+H)^+$ 182.0640, obsd 182.0633.

E-Isomer (cisoid): ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.35 (apt d, *J* = 3.7 Hz, 1H), 5.77 (ddd, *J* = 17.3, 10.1, 7.3 Hz, 1H), 5.16 (d, *J* = 10.2 Hz, 1H), 5.11 (d, *J* = 17.1 Hz, 1H), 4.36 (qt, *J* = 6.6, 1.4 Hz, 1H), 3.79 (dd, *J* = 11.4, 4.4 Hz, 1H), 3.70 (dd, *J* = 11.4, 4.4 Hz, 1H), 3.04-2.96 (m, 1H), 1.44 (d, *J* = 6.7 Hz, 3H).^{13}C NMR (100 MHz, $CDCl_3$) δ 136.46 , 136.01 , 126.98 , 117.49 , 109.57 , 71.83 , 65.57 , 41.60 , 18.93 . HRMS (TOF MS CI^+) m/z Calcd for $C_9H_{12}NOS$ $(M+H)^+$ 182.0640, obsd 182.0646.

(±)-(2*R,4*S**,*Z*) and (±)-(2*R**,4*S**,*E*)-2-Isopropyl-3-(thiocyanatomethylene)-4-vinyltetrahydrofuran (28t, 28c)**

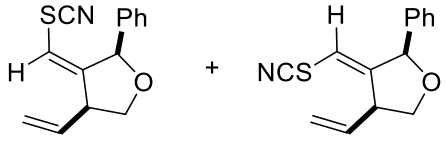


The title thiocyanopalladation/carbocyclization products were prepared following General Procedure G from carbonate **27** (22 mg, 0.1 mmol), LiSCN (12 mg, 0.15 mmol, 1.5 eq.) and $PdCl_2(PhCN)_2$ (2 mg, 0.005 mmol, 0.05 eq.) in THF (4 mL). The geometric isomers were obtained in a 1:2.2 *E:Z* mixture. Chromatography [hexanes:EtOAc (95:5)] delivered homogeneous *E*-isomer (5 mg, 24%) and *Z*-isomer (11 mg, 53%).

Z-Isomer (transoid): ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.97 (t, *J* = 2.2 Hz, 1H); 5.68 (ddd, *J* = 17.0, 9.7, 8.5 Hz, 1H), 5.20-5.13 (m, 2H), 4.42 (dd, *J* = 4.1, 2.2 Hz, 1H), 4.05 (dd, *J* = 8.8, 7.8 Hz, 1H), 3.74 (dd, *J* = 8.8, 6.8 Hz, 1H), 3.49 (apt q, *J* = 7.5 Hz, 1H), 2.13 (md, *J* = 6.8, 2.7 Hz, 1H), 1.05 (d, *J* = 6.8, 3H), 0.89 (d, *J* = 6.8, 3H).^{13}C NMR (100 MHz, $CDCl_3$) δ 156.43 , 135.60 , 117.90 , 110.08 , 104.40 , 84.97 , 72.09 , 51.55 , 31.65 , 19.95 , 17.03 . HRMS (TOF MS EI$^+$) m/z Calcd for $C_{11}H_{15}NOS$ $(M)^{+\cdot}$ 209.0874, obsd 209.0871.

E-Isomer (cisoid): ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.45 (dt, *J* = 6.1, 1.6 Hz, 1H), 5.85 (ddd, *J* = 17.4, 7.4, 10.2 Hz, 1H), 5.11 (apt q, *J* = 1.3 Hz, 1H), 5.10 (dt, *J* = 28.8, 1.2 Hz, 1H), 4.09 (qpt q, J = 2.2 Hz, 1H), 3.87 (dt, *J* = 11.4, 1.2 Hz, 1H), 3.72 (dd, *J* = 11.2, 3.5 Hz, 1H), 2.91-2.83 (m, 1H), 2.11 (md, *J* = 6.8, 2.4 Hz, 1H), 1.09 (d, *J* = 6.8 Hz, 3H), 0.83 (d, *J* = 6.8 Hz, 3H).^{13}C NMR (100 MHz, $CDCl_3$) δ 137.11 , 136.33 , 126.20 , 116.90 , 109.74 , 79.70 , 67.49 , 41.73 , 30.06 , 19.39 , 14.79 . HRMS (TOF MS EI$^+$) m/z Calcd for $C_{11}H_{15}NOS$ $(M)^{+\cdot}$ 209.0874, obsd 209.0873.

(±)-(2*R,4*S**,*Z*) and (±)-(2*R**,4*S**,*E*)-2-Phenyl-3-(thiocyanatomethylene)-4-vinyltetrahydrofuran (30t, 30c)**



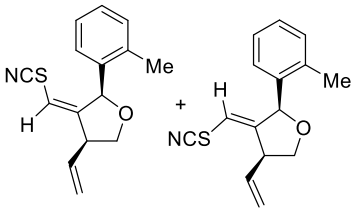
The title phenyl-substituted tetrahydrofuran-type cyclization products **30** were obtained following General Procedure G from carbonate **29** (52 mg, 0.2 mmol), LiSCN (24 mg, 0.3 mmol, 1.5 eq.) and $PdCl_2(PhCN)_2$ (4 mg, 0.01 mmol, 0.05 eq.) in THF (8 mL). Analysis of the crude product revealed a 1:2.1 mixture of *E:Z*-cyclization

products. Flash. chromatography column [hexanes/EtOAc (95:5)] allowed for the isolation of the individual *E*-(10 mg, 21%) and *Z*-isomers (21 mg, 43%).

Z-Isomer (transoid): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.41-7.35 (m, 3H), 7.31-7.26 (m, 2H), 6.07 (t, *J* = 2.2 Hz, 1H), 5.83 (ddd, *J* = 17.0, 8.4, 9.7 Hz, 1H), 5.47 (dd, *J* = 2.2, 1H), 5.28 (br d, *J* = 7.9, 1H), 5.25 (br s, 1H), 4.12 (dd, *J* = 9.0, 7.3 Hz, 1H), 3.86 (dd, *J* = 9.0, 6.7 Hz, 1H), 3.64 (apt q, *J* = 7.6 Hz, 1H).^{13}C NMR (100 MHz, $CDCl_3$) δ 159.41 , 137.52 , 135.14 , 129.06 , 129.02 (2 CH), 128.52 (2 CH), 118.47 , 110.12 , 107.27 , 82.88 , 71.68 , 51.40 . HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{14}H_{13}NOSNa$ $(M+Na)^+$ 266.0616, obsd 266.0615.

E-Isomer (cisoid): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.42-7.33 (m, 5H), 6.53 (dd, *J* = 4.8, 1.5 Hz, 1H), 6.0-5.89 (m, 1H), 5.25 (br s, 1H), 5.22 (apt d, *J* = 6.7 Hz, 1H), 5.17 (t, *J* = 2.0 Hz, 1H), 3.89 (dd, *J* = 11.5, 4.2 Hz, 1H), 3.83 (dd, *J* = 11.5, 3.6 Hz, 1H), 3.15-3.08 (m, 1H).^{13}C NMR (100 MHz, $CDCl_3$) δ 136.54 , 136.29 , 134.96 , 129.53 , 128.87 (2 CH), 128.68 (2 CH), 125.83 , 117.53 , 109.45 , 78.67 , 66.25 , 41.30 . HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{14}H_{13}NOSNa$ $(M+Na)^+$ 266.0616, obsd 266.0612.

(±)(2R*,4S*,Z) and (±)-(2*R,4*S**,*E*)-3-(Thiocyanatomethylene)-2-(o-tolyl)-4-vinyltetrahydrofuran (32t, 32c):**



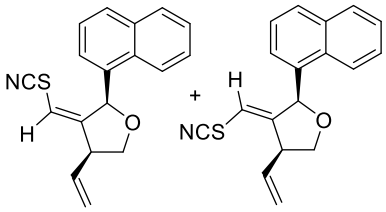
The tetrahydrofuranoid vinyl thiocyanate **32** was prepared, following General Procedure G, from carbonate **31** (50 mg, 0.18 mmol), LiSCN (18 mg, 0.27 mmol, 1.5 eq.) and $PdCl_2(PhCN)2$ (3.44 mg, 0.009 mmol, 0.05 eq.) in THF (8 mL) to afford a *E:Z* mixture (1:2.7) after chromatography column (hexane/EtOAc 90:10) to yield both the *E*-isomer (9.71 mg 21%) and the *Z*-isomer (34 mg, 75%).

Z-Isomer (transoid): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.28 (dd, *J* = 4.5, 3.0 Hz, 2H), 7.20 (dd, *J* = 10.9, 4.6 Hz, 1H), 7.07 (dd, *J* = 22.2, 7.6 Hz, 1H), 6.11 (t, *J* = 2.2 Hz, 1H), 5.89 (ddd, *J* = 17.1, 10.0, 8.5 Hz, 1H), 5.77 (d, *J* = 1.7 Hz, 1H), 5.37 – 5.27 (m, 2H), 4.13 (dd, *J* = 8.8, 7.3 Hz, 1H), 3.82 (dd, *J* = 8.7, 7.3 Hz, 1H), 3.73 – 3.65 (m, 1H), 2.52 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 154.91 , 138.03 , 135.03 , 131.44 , 129.22 , 127.85 (2CH), 126.44 (2CH), 118.80 , 110.37 ,

106.91 , 79.84 , 71.46 , 51.71 , 19.59 . HRMS (TOF MS EI$^+$) m/z Calcd $C_{15}H_{15}NOS$ $(M)^{+\cdot}$ 257.0874 obsd 257.0911.

E-Isomer (cisoid): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35 – 7.20 (m, 4H), 6.57 (d, *J* = 3.7 Hz, 1H), 5.49 (s, 1H), 5.28 (d, *J* = 7.2 Hz, 1H), 5.24 (s, 1H), 3.88 (dd, *J* = 11.6, 4.7 Hz, 1H), 3.76 (d, *J* = 7.5 Hz, 1H), 3.19 (s, 1H), 2.51 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 138.29 , 136.25 , 133.87 , 131.40 , 129.50 , 126.87 (C_{quat}), 126.21 (2CH), 125.82 , 117.69 , 109.55 , 41.63 , 19.37 . HRMS (TOF MS EI$^+$) m/ Calcd $C_{15}H_{15}NOS$ $(M)^{+\cdot}$ 257.0874 obsd 257.0872.

(±) ((2R*,4S*,Z) and (±)-(2*R,4*S**,*E*)-2-(Naphthalen-1'-yl)-3-(thiocyanatomethylene)-4-vinyltetrahydrofuran (34t, 34c):**



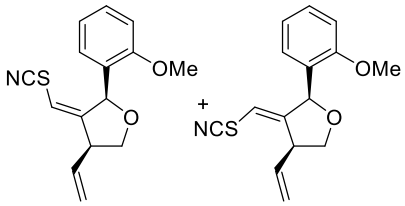
The tetrahydrofuranoid vinyl thiocyanate **34** was prepared, following general procedure G, from carbonate **33**(50 mg, 0.16 mmol), LiSCN (15 mg, 0.24 mmol, 1.5 eq.) and $PdCl_2$(PhCN)2 (3.44 mg, 0.008 mmol, 0.05 eq.) in THF (6 mL) to afford a *E:Z* mixture (1:3) after chromatography column (hexane/EtOAc 90:10) to yield both the *E*-isomer (5.1 mg 11%) and the *Z*-isomer (37 mg, 80%).

Z-Isomer (transoid): ^{1}H NMR (400 MHz, CDCl3) δ 8.31 (d, *J* = 8.4 Hz, 1H), 7.91 (d, *J* = 8.8 Hz, 2H), 7.66 – 7.62 (m, 1H), 7.62 – 7.57 (m, 1H), 7.46 (dd, *J* = 8.1, 7.1 Hz, 1H), 7.23 (d, *J* = 7.1 Hz, 1H), 6.39 (d, *J* = 2.1 Hz, 1H), 6.28 (t, *J* = 2.1 Hz, 1H), 6.01 – 5.85 (m, 1H), 5.39 (s, 1H), 5.35 (d, *J* = 0.7 Hz, 1H), 4.20 (d, *J* = 1.5 Hz, 1H), 3.76 (dd, *J* = 9.8, 7.6 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 154.59 , 134.84 , 134.58 , 131.67 , 130.11 , 128.99 , 127.03 , 126.39 , 125.26 , 124.97 , 124.07 , 119.14 , 110.15 , 107.68 , 79.51 , 51.81 . HRMS (TOF MS EI$^+$) m/z Calcd $C_{18}H_{15}NOS$ $(M)^+$ 293.0874 obsd 293.0869.

E-Isomer (cisoid): ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.32 (d, *J* = 7.6 Hz, 1H), 7.93 (d, *J* = 7.9 Hz, 2H), 7.58 (dt, *J* = 14.9, 7.6 Hz, 2H), 7.51 (d, *J* = 7.2 Hz, 1H), 7.48 – 7.35 (m, 1H), 6.68 (d, *J* = 2.6 Hz, 1H), 5.89 (dd, *J* = 19.0, 10.5 Hz, 2H), 5.38 – 5.20 (m, 2H), 3.92 (s, 1H), 3.83 – 3.59 (m, 1H), 3.32 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 134.35 , 131.22 , 130.47 , 128.98 (2CH),

126.97 (2CH), 126.93 (C_{quat}), 126.32 , 124.84 , 117.98 , 109.52 , 77.46 , 77.14 , 76.82 , 41.73 . HRMS (TOF MS EI^+) m/z Calcd $C_{18}H_{15}NOS$ $(M)^+$ 293.0874 obsd 293.0879.

(±)-(2R*,4S*,Z) and (±)-(2*R,4*S**,*E*)-2-(2'-Methoxyphenyl)-3-(thiocyanatomethylene)-4-vinyltetrahydrofuran (36t, 36c):**

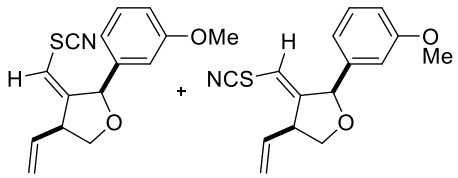


The tetrahydrofuranoid vinyl thiocyanate **36** was prepared, following General Procedure G, from carbonate **35** (50 mg, 0.18 mmol), LiSCN (18mg, 0.27 mmol, 1.5 eq.) and $PdCl_2(PhCN)2$ (3.5 mg, 0.009 mmol, 0.05 eq.) in THF (8 mL) to afford a *E:Z* mixture (1:3.5) after chromatography column (hexane/EtOAc 80:20) to yield both the *E*-isomer (9.8 mg 20%) and the *Z*-isomer (36 mg, 74%).

Z-Isomer (transoid): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37 (td, *J* = 7.9, 1.7 Hz, 1H), 7.12 (dd, *J* = 7.7, 1.6 Hz, 1H), 6.97 (t, *J* = 7.5 Hz, 2H), 6.00 (t, *J* = 2.4 Hz, 1H), 5.92 – 5.88 (m, 1H), 5.89 – 5.79 (m, 1H), 5.32 (d, *J* = 5.6 Hz, 1H), 5.28 (s, 1H), 4.16 (dd, *J* = 8.6, 7.6 Hz, 1H), 3.93 – 3.89 (m, 4H), 3.68 (d, *J* = 8.9 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 157.83 , 154.83 , 135.15 , 130.77 , 129.71 (2CH), 125.54 , 120.90 , 118.84 , 111.41 , 110.68 , 105.76 , 77.99 , 74.46 , 55.72 , 51.84 . HRMS (TOF MS EI^+) m/z Calcd $C_{15}H_{15}NO_2S$ $(M)^{+\cdot}$ 273.0823 obsd 273.0818.

E-Isomer (cisoid): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.44 – 7.35 (m, 1H), 7.25 (dd, *J* = 7.5, 1.7 Hz, 1H), 7.05 – 6.90 (m, 2H), 6.55 (dd, *J* = 4.6, 1.8 Hz, 1H), 5.93 (ddd, *J* = 17.4, 9.9, 7.5 Hz, 1H), 5.75 (t, *J* = 2.1 Hz, 1H), 3.96 – 3.84 (m, 4H), 3.84 – 3.69 (m, 1H), 3.23 – 3.08 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 136.58 , 135.75 , 135.12 , 130.87 , 129.79 , 129.52 , 128.78 , 126.78 (C_{quat}), 125.85 , 124.21 , 120.71 , 117.92 , 111.27 , 72.06 , 65.90 , 55.79 , 41.58 . HRMS (TOF MS EI^+) m/z Calcd $C_{15}H_{15}NO_2S$ $(M)^{+\cdot}$ 273.0823 obsd 273.0828.

(±)-1-Methoxy-3-((1R*,3S*,Z) and (±)-(2*R,4*S**,*E*)- -2-(3-Methoxyphenyl)-3-(thiocyanatomethylene)-4-vinyltetrahydrofuran (38t, 38c)**

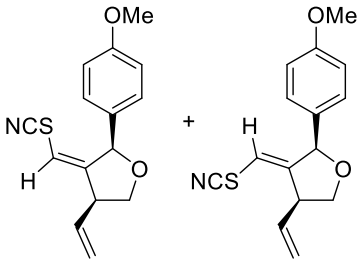


The tetrahydrofuranoid vinyl thiocyanate **38** was prepared, following General Procedure G, from carbonate **37** (50 mg, 0.17 mmol), LiSCN (21 mg, 0.26 mmol, 1.5 eq.) and $PdCl_2(PhCN)_2$ (1.7 mg, 0.00025 mmol, 0.025 eq.) in THF (7 mL) to afford a *E:Z* mixture (1:3) after chromatography column [hexane/EtOAc (95:5)] to yield both the *E*-isomer (9 mg, 20%) and the *Z*-isomer (27 mg, 61%).

Z-Isomer (transoid): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.33 (t, *J* = 7.9 Hz, 1H), 6.90 (ddd, *J* = 16.8, 8.6, 2.1 Hz, 3H), 6.11 (t, *J* = 2.1 Hz, 1H), 5.92 – 5.74 (m, 1H), 5.48 (d, *J* = 2.1 Hz, 1H), 5.35 – 5.18 (m, 2H), 4.15 (dd, *J* = 8.9, 7.3 Hz, 1H), 3.95 – 3.76 (m, 4H), 3.67 (dd, *J* = 13.7, 6.8 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.17 , 154.37 , 139.08 , 135.27 , 130.21 , 120.78 , 118.65 , 114.58 , 114.28 , 107.55 , 82.87 , 77.45 , 77.14 , 76.82 , 71.83 , 55.41 , 51.47 . HRMS (TOF MS EI$^+$) m/z Calcd for $C_{15}H_{15}NO_2S$ $(M)^{+\cdot}$ 273.0824, obsd 273.0828.

E-Isomer (cisoid): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.34 (t, *J* = 6.3 Hz, 3H), 6.97 (d, *J* = 7.0 Hz, 4H), 6.56 (d, *J* = 4.9 Hz, 2H), 6.04 – 5.88 (m, 2H), 5.29 (t, *J* = 12.9 Hz, 4H), 5.17 (s, 2H), 4.04 – 3.80 (m, 11H), 3.15 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 136.72 , 135.03 , 130.02 , 125.94 , 121.07 , 117.65 , 115.19 , 114.27 , 78.67 , 77.63 , 77.29 (d, *J* = 32.0 Hz), 76.81 , 66.35 , 55.40 , 41.39 . HRMS (TOF MS EI$^+$) m/z Calcd for $C_{15}H_{15}NO_2S$ $(M)^{+\cdot}$ 273.0824 obsd 273.0817.

(±) -(2R*,4S*,Z) and (±)-(2*R,4*S**,*E*)-2-(4'-Methoxyphenyl)-3 (thiocyanatomethylene)-4-vinyltetrahydrofuran(40t, 40c):**

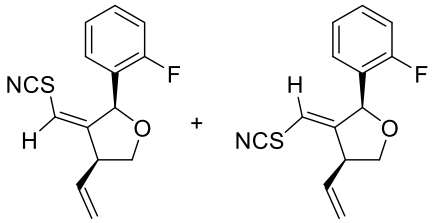


The tetrahydrofuranoid vinyl thiocyanate **40** was prepared, following General Procedure G, from carbonate **39** (50 mg, 0.17 mmol), LiSCN (17 mg, 0.26 mmol, 1.5 eq.) and PdCl2(PhCN)2 (3 mg, 0.00425 mmol, 0.025 eq.) in THF (7.2 mL) to afford a *E:Z* mixture (1:3) after chromatography column (hexane/EtOAc 80:20) to yield both the *E*-isomer (12.99 mg, 28%) and the *Z*-isomer (28.77 mg, 62%).

Z-Isomer (transoid): ^{1}H NMR (700 MHz, CDCl3) δ 7.23 (d, *J* = 7.7 Hz, 2H), 6.92 (d, *J* = 7.6 Hz, 2H), 6.07 (s, 1H), 5.91 – 5.81 (m, 1H), 5.44 (s, 1H), 5.29 (dd, *J* = 13.5, 8.0 Hz, 2H), 4.75 (d, *J* = 6.4 Hz, 1H), 4.42 – 4.18 (m, 1H), 4.11 (t, *J* = 8.0 Hz, 1H), 3.97 (dd, *J* = 17.6, 15.3 Hz, 1H), 3.87 (t, *J* = 7.7 Hz, 1H), 3.85 (d, *J* = 18.2 Hz, 3H), 3.65 (d, *J* = 7.2 Hz, 1H). ^{13}C NMR (175 MHz, $CDCl_3$) δ 160.19 , 154.23, 135.34 , 129.99 (2CH), 126.65 , 118.33 , 114.41 (2CH), 110.38 , 107.31 , 82.55 , 71.54 , 55.31 , 51.38 . HRMS (TOF MS EI^{+}) m/z Calcd for $C_{15}H_{15}NO_2S$ $(M)^{+\cdot}$ 273.0823 obsd 273.0822.

E-Isomer (cisoid): ^{1}H NMR (700 MHz, $CDCl_3$) δ 7.30 (d, *J* = 7.2 Hz, 2H), 6.94 (d, *J* = 7.2 Hz, 2H), 6.60 – 6.44 (m, 1H), 5.96 (dt, *J* = 17.6, 8.7 Hz, 1H), 5.34 – 5.18 (m, 2H), 5.15 (s, 1H), 3.90 (dt, *J* = 23.4, 11.7 Hz, 1H), 3.89 – 3.74 (m, 5H), 3.13 (s, 1H). ^{13}C NMR (176 MHz, $CDCl_3$) δ 136.68 , 134.17 , 130.06 (2CH), 128.28 , 126.98, 126.28 , 117.44 (2CH), 114.26 , 109.60 , 78.15 , 66.23 , 55.33 , 41.30 . HRMS (TOF MS EI^{+}) m/z Calcd for $C_{15}H_{15}NO_2S$ $(M)^{+\cdot}$ 273.0823 obsd 273.0830.

(±) -(2R*,4S*,*Z*) and (±)-(2*R,4*S**,*E*)-2-(2'-Fluorophenyl)-3-(thiocyanatomethylene)-4-vinyltetrahydrofuran (42t, 42c)**



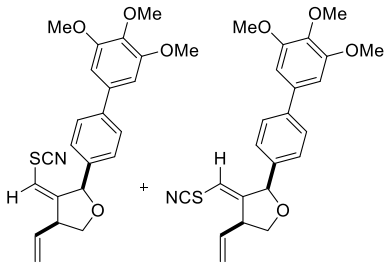
The tetrahydrofuranoid vinyl thiocyanate **42** was prepared, following General Procedure G, from carbonate **41** (50 mg, 0.18 mmol), LiSCN (18 mg, 0.27 mmol, 1.5 eq.) and PdCl2(PhCN)2 (3 mg, 0.0072 mmol, 0.04 eq.) in THF (9 mL) to afford a *E:Z* mixture (1:5) after chromatography column (hexane/EtOAc 90:10) to yield both the *E*-isomer (6.75 mg, 12%) and the *Z*-isomer (32 mg, 70%).

Z-Isomer (transoid): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 (tdd, *J* = 7.2, 5.3, 2.0 Hz, 1H), 7.23 (td, *J* = 7.4, 1.9 Hz, 1H), 7.21 – 7.09 (m, 2H), 6.06 (t, *J* = 2.3 Hz, 1H), 5.88 (dd, *J* = 18.0, 8.9 Hz, 1H), 5.78 (d, *J* = 2.3 Hz, 1H), 5.34 (d, *J* = 3.0 Hz, 1H), 5.30 (d, *J* = 2.7 Hz, 1H), 4.25 – 4.15 (m, 1H), 3.93 (t, *J* = 8.2 Hz, 1H), 3.70 (d, *J* = 7.4 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 161.19 (*J* = 249.19 Hz) (CF), 159.89 , 134.84 , 131.29 (d, *J* = 8.5 Hz), 130.30 (d, *J* = 3.5 Hz), 125.12 (d, *J* = 13.4 Hz), 124.68 (d, *J* = 3.7 Hz), 119.22 , 116.48 , 116.26 , 110.01 , 106.63 , 72.28 (d, *J* = 1.3

Hz), 51.73 . ^{19}F NMR (376 MHz, $CDCl_3$) δ -114.86 – -114.99 (m). HRMS (TOF MS EI$^+$) m/z Calcd $C_{14}H_{12}FNOS$ $(M)^{+\cdot}$ 261.0624 obsd 261.0860.

E-Isomer (cisoid): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 – 7.37 (m, 1H), 7.34 (td, *J* = 7.5, 1.7 Hz, 1H), 7.21 (t, *J* = 7.5 Hz, 1H), 7.18 – 7.09 (m, 1H), 6.62 (dd, *J* = 4.8, 1.8 Hz, 1H), 6.02 – 5.87 (m, 1H), 5.59 (t, *J* = 2.1 Hz, 1H), 5.28 (d, *J* = 0.6 Hz, 1H), 5.25 (d, *J* = 7.2 Hz, 1H), 3.93 (dd, *J* = 11.6, 4.5 Hz, 1H), 3.82 (dd, *J* = 11.3, 4.3 Hz, 1H), 3.17 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.2 (*J* = 249.19 Hz) (CF), 154 , 134.84 , 131.29 (d, *J* = 8.5 Hz), 130.30 (d, *J* = 3.5 Hz), 124.68 (d, *J* = 3.6 Hz), 119.22 , 116.48 , 116.26 , 110.16 , 106.63, 72.27 , 51.17 .^{19}F NMR (376 MHz, $CDCl_3$) δ -116.68 – -116.86 (m). HRMS (TOF MS EI$^+$) m/z Calcd for $C_{14}H_{12}FNOS$ $(M)^{+\cdot}$ 261.0624 obsd 261.0860.

(±)-1R*,3S*,Z) and (±)-(2*R,4*S**,*E*)- 3-(Thiocyanatomethylene)-2-(3'',4'',5''-trimethoxy-[1',1''-biphenyl]-4'-yl)-4-vinyltetrahydrofuran (44t, 44c)**



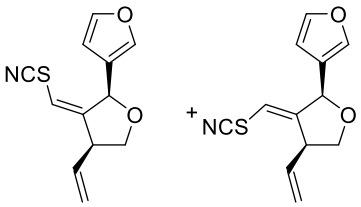
The tetrahydrofuranoid vinyl thiocyanate **44** was prepared, following General Procedure G, from carbonate **43** (30 mg, 0.07 mmol), LiSCN (9 mg, 0.105 mmol, 1.5 eq.) and $PdCl_2(PhCN)_2$ (2 mg, 0.0035 mmol, 0.05 eq.) in THF (3 mL) to afford a *E:Z* mixture (1:3) totaling 25 mg (89%) after chromatography column [hexane/EtOAc (90:10)] Analytically pure samples prepared using a 2:2:1 (Hexane: toluene: ethyl acetate) mobile phase.

Z-Isomer (transoid): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60 (d, *J* = 8.2 Hz, 2H), 7.38 (d, *J* = 8.2 Hz, 2H), 7.01 – 6.74 (m, 2H), 6.14 (t, *J* = 2.2 Hz, 1H), 5.92 – 5.82 (m, 1H), 5.56 (d, *J* = 2.2 Hz, 1H), 5.34 (d, *J* = 9.0 Hz, 1H), 5.30 (s, 1H), 4.16 (dt, *J* = 12.7, 6.4 Hz, 1H), 3.96 (d, *J* = 6.8 Hz, 6H), 3.94 – 3.90 (m, 4H), 3.74 – 3.66 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$ δ 153.64, 136.55, 135.23, 129.04, 127.81, 118.72, 107.46, 104.60, 82.66, 71.82, 65.78, 61.10, 56.35, 51.55, 29.82, 14.24. HRMS (TOF MS EI$^+$) m/z Calcd for $C_{23}H_{23}NO_4S$ $(M)^{+\cdot}$ 409.1348, obsd 409.1335.

E-Isomer (cisoid): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 (d, *J* = 8.2 Hz, 2H), 7.45 (d, *J* = 8.2 Hz, 2H), 6.81 (d, *J* = 9.1 Hz, 2H), 6.60 (d, *J* = 5.0 Hz, 2H), 6.06 – 5.90 (m, 2H), 5.30 (s, 2H), 5.26 (s,

2H), 3.95 (s, 6H), 3.92 (s, 3H), 3.18 (s, 1H).. HRMS (TOF MS EI$^+$) m/z Calcd for $C_{23}H_{23}NO_4S$ $(M)^{+\cdot}$409.1348, obsd 409.1365.

(±)-3-((2R*,4S*,Z) and (±)-(2*R,4*S**,*E*)-3-(Thiocyanatomethylene)-4-vinyltetrahydrofuran-2'-yl)furan (46t, 46c):**

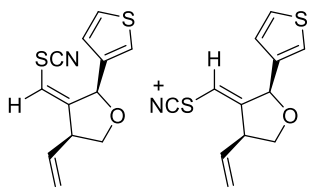


The tetrahydrofuranoid vinyl thiocyanate **46** was prepared, following General Procedure G, from carbonate **45** (50 mg, 0.21 mmol), LiSCN (21mg, 0.32 mmol, 1.5 eq.) and $PdCl_2(PhCN)2$ (2 mg, 0.00525 mmol, 0.025 eq.) in THF (8 mL) to afford a *E:Z* mixture (1:2.8) after chromatography column (hexane/EtOAc 80:20) to yield both the *E*-isomer (7.8 mg 16%) and the *Z*-isomer (29 mg, 59%).

Z-Isomer (transoid): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.46 (t, *J* = 1.6 Hz, 1H), 7.38 (d, *J* = 0.6 Hz, 1H), 6.36 (dt, *J* = 4.4, 2.2 Hz, 1H), 6.04 (t, *J* = 2.2 Hz, 1H), 5.74 (ddd, *J* = 17.0, 10.1, 8.3 Hz, 1H), 5.56 (d, *J* = 2.1 Hz, 1H), 5.33 – 5.27 (m, 1H), 5.26 (d, *J* = 0.5 Hz, 1H), 4.13 (dd, *J* = 8.9, 7.3 Hz, 1H), 3.77 (dd, *J* = 16.3, 8.4 Hz, 1H), 3.60 (d, *J* = 8.3 Hz, 1H). ^{13}C NMR (175 MHz, $CDCl_3$) δ 154.47 , 144.39 , 141.55 , 134.81 , 122.59 , 118.86 , 110.09 , 109.55 , 106.62 , 74.44 , 51.06 . HRMS (TOF MS EI$^+$) m/z Calcd for $C_{12}H_{11}NO_2S$ $(M)^{+\cdot}$ 233.0510 obsd 233.0546.

E-Isomer (cisoid): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.46 (s, 1H), 7.38 (s, 1H), 6.37 (s, 1H), 6.05 (t, *J* = 2.1 Hz, 1H), 5.82 – 5.68 (m, 1H), 5.57 (d, *J* = 1.7 Hz, 1H), 5.33 – 5.22 (m, 2H), 4.14 (dd, *J* = 8.7, 7.5 Hz, 1H), 3.80 – 3.71 (m, 1H), 3.62 (t, *J* = 7.2 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.12 , 142.46 , 135.89 , 135.60 , 125.09 , 121.84 , 117.90 , 109.56 , 70.27 , 65.21 , 41.36 . HRMS (TOF MS EI$^+$) m/z Calcd for $C_{12}H_{11}NO_2S$ $(M)^{+\cdot}$ 233.0510 obsd 233.0546.

(±)-(2S',4S',Z) and (±)-(2*R,4*S**,*E*)-3-(Thiocyanatomethylene)-2-(thiophen-3'-yl)-4-vinyltetrahydrofuran (48t, 48c):**



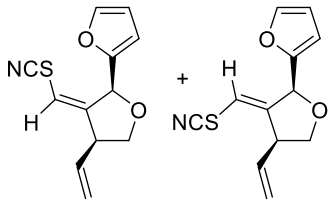
The tetrahydrofuranoid vinyl thiocyanate **48** was prepared, following General Procedure G, from carbonate **47** (50 mg, 0.18 mmol), LiSCN (18mg, 0.28 mmol, 1.5 eq.) and $PdCl_2(PhCN)2$ (2 mg, 0.0045 mmol, 0.025 eq.) in THF (8 mL) to afford a *E:Z* mixture (1:3) after

chromatography column (hexane/EtOAc 80:20) to yield both the *E*-isomer (8 mg, 18%) and the *Z*-isomer (27 mg, 61%).

Z-Isomer (transoid): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.39 (dd, *J* = 5.0, 3.0 Hz, 1H), 7.27 – 7.21 (m, 1H), 7.04 (dd, *J* = 5.0, 1.2 Hz, 1H), 6.08 (t, *J* = 2.2 Hz, 1H), 5.79 (ddd, *J* = 17.1, 10.1, 8.3 Hz, 1H), 5.64 (d, *J* = 2.1 Hz, 1H), 5.30 (d, *J* = 8.6 Hz, 1H), 5.27 (s, 1H), 4.15 (dd, *J* = 8.9, 7.3 Hz, 1H), 3.81 (t, *J* = 8.2 Hz, 1H), 3.71 – 3.58 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 154.66 , 138.71 , 135.09 , 127.53 , 125.17 , 124.96 , 118.88 , 110.31 , 107.22 , 76.84 , 71.62 , 51.28 . HRMS (TOF MS EI$^+$) m/z Calcd $C_{12}H_{11}NOS_2$ $(M)^{+\cdot}$ 249.0282 obsd 249.0313.

E-Isomer (cisoid): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.44 – 7.34 (m, 2H), 7.11 (dd, *J* = 4.8, 1.5 Hz, 1H), 6.52 (dd, *J* = 4.5, 1.6 Hz, 1H), 5.95 – 5.81 (m, 1H), 5.34 (t, *J* = 1.9 Hz, 1H), 5.26 (dd, *J* = 1.9, 1.0 Hz, 1H), 5.23 (d, *J* = 9.7 Hz, 1H), 4.29 – 4.13 (m, 1H), 3.89 (dd, *J* = 11.6, 4.7 Hz, 1H), 3.77 (dd, *J* = 11.6, 4.8 Hz, 1H), 3.17 (dd, *J* = 4.8, 2.3 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 137.61 , 136.16 , 135.19 , 127.08 , 126.03 , 117.82 , 109.46 , 106.37 , 73.56 , 65.66 , 41.39 . HRMS (TOF MS EI$^+$) m/z Calcd for $C_{12}H_{11}NOS_2$ $(M)^{+\cdot}$ 249.0282 obsd 249.0313.

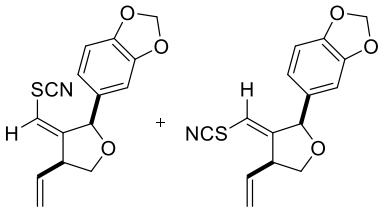
(±)-2-((2S*,4S*,Z) and (±)-(2*R,4*S**,*E*)-3-(Thiocyanatomethylene)-4-vinyltetrahydrofuran-2'-yl)furan (50t, 50c):**



The tetrahydrofuranoid vinyl thiocyanate **50** was prepared, following General Procedure G, from carbonate **49** (50 mg, 0.2 mmol), LiSCN (20mg, 0.30 mmol, 1.5 eq.) and $PdCl_2$(PhCN)2 (3 mg, 0.008 mmol, 0.04 eq.) in THF (8 mL) to afford a E:Z mixture (9:1) after chromatography column (hexane/EtOAc 90:10) to yield *Z*-isomer (34 mg, 73%).

Z-Isomer (transoid): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 – 7.45 (m, 1H), 6.39 (dd, *J* = 3.3, 1.9 Hz, 1H), 6.34 (d, *J* = 3.3 Hz, 1H), 6.06 (t, *J* = 2.2 Hz, 1H), 5.78 (ddd, *J* = 17.2, 9.9, 8.7 Hz, 1H), 5.63 (d, *J* = 2.1 Hz, 1H), 5.33 – 5.28 (m, 1H), 5.27 (s, 1H), 4.23 – 4.15 (m, 1H), 3.83 (t, *J* = 8.7 Hz, 1H), 3.71 – 3.57 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 153.15 , 150.65 , 143.99 , 138.69 , 134.60 , 119.38 , 110.51 , 110.14 , 107.65 , 75.22 , 72.11 , 51.21 . HRMS (TOF MS EI$^+$) m/z Calcd for $C_{12}H_{11}NO_2S$ $(M)^{+\cdot}$ 233.0510 obsd 233.0521.

(±)-5-((1R*,3S*,Z) and (±)-(2*R,4*S**,*E*)-3-(Thiocyanatomethylene)-4-vinyltetrahydrofuran-2'-yl)benzo[d][1',3']dioxole (52t, 52c)**

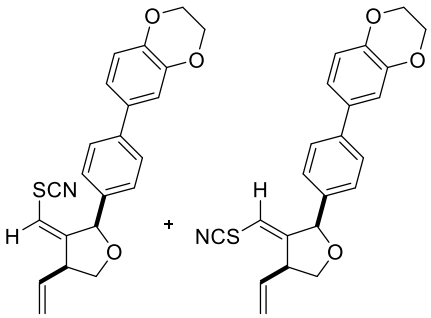


The tetrahydrofuranoid vinyl thiocyanate **52** was prepared, following General Procedure G, from carbonate **51** (50 mg, 0.16 mmol), LiSCN (20 mg, 0.25 mmol, 1.5 eq.) and $PdCl_2(PhCN)_2$ (3 mg, 0.005 mmol, 0.05 eq.) in THF (7 mL) to afford a *E:Z* mixture (1:4) after chromatography column [hexane/EtOAc (95:5)] to yield both the *E*-isomer (7.2 mg, 16%) and the *Z*-isomer (32 mg, 70%).

Z-Isomer (transoid): ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.85 – 6.71 (m, 3H), 6.07 (dd, *J* = 6.5, 4.3 Hz, 1H), 6.01 (d, *J* = 1.0 Hz, 2H), 5.92 – 5.74 (m, 1H), 5.39 (d, *J* = 1.7 Hz, 1H), 5.31 (d, *J* = 5.6 Hz, 1H), 5.27 (s, 1H), 4.11 (dd, *J* = 8.9, 7.2 Hz, 1H), 3.88 (dd, *J* = 8.7, 6.6 Hz, 1H), 3.64 (d, *J* = 7.3 Hz, 1H).. ^{13}C NMR (100 MHz, $CDCl_3$ δ 154.04 , 148.45 , 135.33 , 131.47 , 122.77 , 118.58 , 110.40 , 108.65 (d, *J* = 10.9 Hz), 107.72 , 101.53 , 82.84 , 71.69 , 51.40 .. HRMS (TOF MS EI$^+$) m/z Calcd for $C_{15}H_{13}NO_3S$ $(M)^{+\cdot}$ 287.0616, obsd 287.0625.

E-Isomer (cisoid): ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.94 – 6.80 (m, 3H), 6.53 (dd, *J* = 5.0, 1.7 Hz, 1H), 6.01 (dd, *J* = 3.2, 1.3 Hz, 2H), 5.99 – 5.85 (m, 1H), 5.32 – 5.20 (m, 2H), 5.14 – 5.05 (m, 1H), 3.97 – 3.84 (m, 2H), 3.12 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 148.67 , 136.63 , 134.42 , 130.03 , 122.91 , 117.54 , 108.42 (d, *J* = 11.9 Hz), 101.42 , 78.43 , 77.45 , 77.03 , 76.60 , 66.42 , 41.23 . HRMS (TOF MS EI$^+$) m/z Calcd for $C_{15}H_{13}NO_3S$ $(M)^{+\cdot}$ 287.0616, obsd 287.0628.

(±)-6-(4-((1R*,3.*S,Z) and (±)-(2*R,4*S**,*E*)-3-(thiocyanatomethylene)-4-vinyltetrahydrofuran-2-yl)phenyl)-2',3'-dihydrobenzo[b][1,4]dioxine (54t, 54c)**

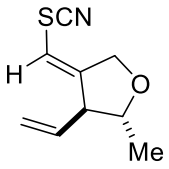


The tetrahydrofuranoid vinyl thiocyanate **54** was prepared, following General Procedure G, from carbonate **53** (20 mg, 0.05 mmol), LiSCN (6 mg, 0.076 mmol, 1.5 eq.) and $PdCl_2(PhCN)_2$ (1 mg, 0.0015 mmol, 0.05 eq.) in THF (3 mL) to afford a *E:Z* mixture (1:3) Column chromatography [hexane/EtOAc (95:5)] provided 8mg (44%) of the Z isomer and 2 mg (11%) of the E isomer.

Z-Isomer (transoid): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.57 (d, *J* = 8.2 Hz, 2H), 7.34 (d, *J* = 8.2 Hz, 2H), 7.17 – 7.10 (m, 2H), 6.96 (d, *J* = 8.3 Hz, 1H), 6.13 (d, *J* = 2.0 Hz, 1H), 5.88 (dd, *J* = 17.6, 9.3 Hz, 1H), 5.54 (s, 1H), 5.33 (d, *J* = 6.4 Hz, 2H), 5.30 (s, 1H), 4.33 (s, 3H), 4.16 (dd, *J* = 8.9, 7.3 Hz, 1H), 3.93 – 3.87 (m, 1H), 3.69 (d, *J* = 7.5 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$ δ 154.43, 143.87, 143.60, 141.48, 136.05, 135.28, 133.96, 129.02, 127.42, 120.29, 127.42, 120.29, 127.42, 120.29, 118.66, 117.76, 116.00, 110.31, 107.49, 82.72, 71.81, 64.60, 64.55, 51.57, 29.81 HRMS (TOF MS EI$^+$) m/z Calcd for $C_{22}H_{21}NO_3S$ $(M)^{+\cdot}$ 377.1086, obsd 377.1082.

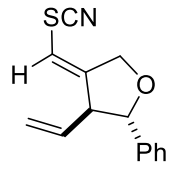
E-Isomer (cisoid): ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.58 (d, *J* = 4.8 Hz, 2H), 6.02 – 5.93 (m, 3H), 5.33 (s, 1H), 5.29 – 5.23 (m, 2H), 4.33 (s, 4H), 3.95 – 3.84 (m, 2H), 3.17 (s, 1H).. HRMS (TOF MS EI$^+$) m/z Calcd for $C_{22}H_{21}NO_3S$ 377.1086 $(M)^{+\cdot}$, obsd 377.1082.

(±)-(2*R, 3*S**)-2-Methyl-4*Z*-(thiocyanatomethylene)-3-vinyltetrahydrofuran (16t)**



Following General Procedure G, the title compound **16t** (21 mg, 85%) was stereoselectively obtained from carbonate **(Z)-15** (30 mg, 0.15 mmol), LiSCN (18 mg, 0.225 mmol, 1.5 eq.) and $PdCl_2(PhCN)_2$ (1.5, 0.00375 mmol, 0.025 eq.) in THF (6 mL). ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.76 (apt q, *J* = 2.5 Hz, 1H), 5.53 (ddd, *J* = 17.0, 10.0, 8.9 Hz, 1H), 5.29 (dd, *J* = 10.0, 1.4 Hz, 1H), 5.23 (dd, *J* = 16.9, 1.0 Hz, 1H), 4.61 (dd, *J* = 15.2, 2.1 Hz, 1H), 4.40 (dt, *J* = 15.2, 2.4 Hz, 1H), 3.69 (dq, *J* = 9.8, 6.0 Hz, 1H), 2.88 (tt, *J* = 9.2, 2.4 Hz, 1H), 1.30 (d, *J* = 6.0 Hz, 3H).^{13}C NMR (100 MHz, $CDCl_3$) δ 157.96 , 133.28 , 120.69 , 109.80 , 101.86 , 80.54 , 69.61 , 58.34 , 18.08 . HRMS (TOF MS CI$^-$) m/z Calcd for $C_9H_{11}NOS$ $(M)^-$ 181.0561, obsd 181.0569.

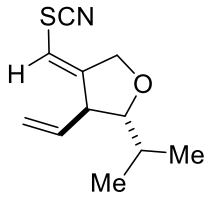
(±)-(2*S,3*S**)-2-Phenyl-4*Z*-(thiocyanatomethylene)-3-vinyltetrahydrofuran (20t)**



Thiocyanopalladation/carbocyclization product **20** (39 mg, 85%). was selectively prepared following General Procedure G from carbonate **19** (52 mg, 0.2 mmol), LiSCN (24 mg, 0.3 mmol, 1.5 eq.) and $PdCl_2(PhCN)_2$ (2 mg, 0.005 mmol, 0.025 eq.) in THF (8 mL). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.41-7.27 (m, 5H), 5.84 (apt q, *J* = 2.4 Hz, 1H), 5.65 (ddd, *J* = 16.9, 9.8, 9.2 Hz, 1H), 5.26 (d, *J* = 10.1 Hz, 1H), 5.04 (d, *J* = 17.1 Hz, 1H), 4.83 (dd, *J* = 15.1, 2.0 Hz, 1H), 4.60 (d, *J* = 9.7 Hz, 1H), 4.59 (dt, *J* = 15.3, 2.2 Hz,

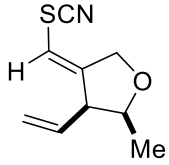
1H), 3.25 (tt, *J* = 9.1, 2.1 Hz, 1H).^{13}C NMR (100 MHz, $CDCl_3$) δ 157.04 , 138.48 , 132.63 , 128.43 (2 CH), 128.30 , 126.18 (2 CH), 121.20 , 109.68 , 102.51 , 86.00 , 69.79 , 59.03 . HRMS (TOF MS ESI+) m/z Calcd for $C_{14}H_{13}NOSNa$ $(M+Na)^+$ 266.0616, obsd 266.0615.

(±)-(2*S, 3*S**)-2-Isopropyl-4*Z*-(thiocyanatomethylene)-3-vinyltetrahydrofuran (18t)**



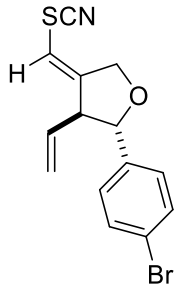
Following General Procedure G, from carbonate **17** (45 mg, 0.2 mmol), LiSCN (24 mg, 0.3 mmol, 1.5 eq.) and $PdCl_2(PhCN)_2$ (2 mg, 0.005 mmol, 0.025 eq.) in THF (8 mL) was obtained **18** (31 mg, 75%), selectively as the *Z*-1,2 *anti*-product. ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.75 (apt q, *J* = 2.1 Hz, 1H), 5.56 (ddd, *J* = 17.2, 8.7, 9.9 Hz, 1H), 5.24 (dd, *J* = 10.1, 1.3 Hz, 1H), 5.18 (d, *J* = 17.2 Hz, 1H), 4.57 (dd, *J* = 15.2, 2.4 Hz, 1H); 4.38 (dt, *J* = 15.2, 2.3 Hz, 1H), 3.46 (dd, *J* = 9.2, 5.2 Hz, 1H), 3.13 (tt, *J* = 9.0, 1.9 Hz, 1H), 1.85 (md, *J* = 6.6, 1.4 Hz, 1H), 0.97 (d, *J* = 4.3 Hz, 3H), 0.95 (d, *J* = 4.3 Hz, 3H).^{13}C NMR (100 MHz, $CDCl_3$) δ 158.17 , 135.01 , 119.49 , 109.87 , 101.98 , 88.99 , 69.23 , 53.87 , 30.95 , 19.14 , 17.66 . HRMS (TOF MS ESI+) m/z Calcd for $C_{11}H_{15}NOSNa$ $(M+Na)^+$ 232.0772, obsd 232.0780.

(±)-(2*S, 3*S**)-2-Methyl-4*Z*-(thiocyanatomethylene)-3-vinyltetrahydrofuran (16-syn)**



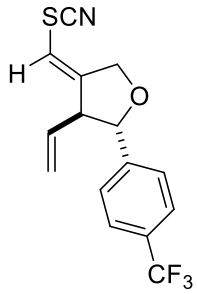
Following General Procedure G, the thiocyanopalladation/carbocyclization from carbonate **(E)-15** (40 mg, 0.2 mmol), LiSCN (24 mg, 0.3 mmol, 1.5 eq.) and $PdCl_2(PhCN)_2$ (2 mg, 0.005 mmol, 0.025 eq.) in THF (8 mL) gave the Z-1,2-*anti*-product **16-syn** (10 mg, 27%) and the *Z*-1,2-*syn*-product **7** (12 mg, 33%) which is characterized here: ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.85 (apt q, *J* = 2.0 Hz, 1H), 5.60 (ddd, *J* = 17.3, 9.5, 9.5 Hz, 1H), 5.23 (d, *J* = 10.0 Hz, 1H), 5.16 (d, *J* = 16.9 Hz, 1H), 4.56 (dt, *J* = 15.2, 2.0 Hz, 1H), 4.41 (dd, *J* = 15.2, 1.9 Hz, 1H), 4.24 (m, *J* = 6.4 Hz, 1H), 3.39 (apt t, *J* = 7.8 Hz, 1H), 1.14 (d, *J* = 6.6 Hz, 3H).^{13}C NMR (100 MHz, $CDCl_3$) δ 157.52 , 133.14 , 119.27 , 109.79 , 102.58 , 78.75 , 68.48 , 54.40 , 15.84 . HRMS (TOF MS CI^+) m/z Calcd for $C_9H_{12}NOS$ $(M+H)^+$ 182.0640, obsd 182.0634.

(±)-(2S*,3S*,Z)-2-(4'-Bromophenyl)-4-(thiocyanatomethylene)-3-vinyltetrahydrofuran (22t)



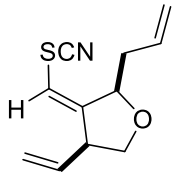
Thiocyanopalladation/carbocyclization product **22** (40 mg, 85%). was selectively prepared following General Procedure G from carbonate **21** (50 mg, 0.147 mmol), LiSCN (18 mg, 0.22 mmol, 1.5 eq.) and $PdCl_2(PhCN)_2$ (1,4 mg, 0.0036 mmol, 0.025 eq.) in THF (6 mL%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.54 – 7.47 (m, 2H), 7.26 (t, *J* = 9.5 Hz, 2H), 5.87 (dd, *J* = 5.0, 2.5 Hz, 1H), 5.66 (ddd, *J* = 17.0, 10.0, 8.8 Hz, 1H), 5.31 (dd, *J* = 10.1, 1.1 Hz, 1H), 5.07 (d, *J* = 17.0 Hz, 1H), 4.85 (dd, *J* = 15.2, 2.2 Hz, 1H), 4.60 (ddd, *J* = 9.8, 6.3, 3.8 Hz, 2H), 3.20 (t, *J* = 9.1 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 156.63 , 137.77 , 132.44 , 131.71 , 127.95 , 122.31 , 121.76 , 109.70 , 102.99 , 85.38 , 77.49 , 77.17 , 76.85 , 69.95 , 59.30 . HRMS (EI MS) m/z Calcd for $C_{14}H_{12}BrNOS$ 320.9823, 322.9803 , $(M)^{+\cdot}$ obsd 320.9836, 322.9809.

(±)-(2S*,3S*,Z)-4-(Thiocyanatomethylene)-2-(4'-(trifluoromethyl)phenyl)-3-vinyltetrahydrofuran (24t)



Thiocyanopalladation/carbocyclization product **24** (13 mg, 62%). was selectively prepared following General Procedure G from carbonate **23** (23 mg, 0.147 mmol), LiSCN (10 mg, 0.11 mmol, 1.5 eq.) and $PdCl_2(PhCN)_2$ (1 mg, 0.002 mmol, 0.025 eq.) in THF (4 mL%). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.64 (d, *J* = 8.1 Hz, 2H), 7.49 (d, *J* = 8.0 Hz, 2H), 5.89 (d, *J* = 2.4 Hz, 1H), 5.80 – 5.61 (m, 1H), 5.34 (d, *J* = 10.1 Hz, 1H), 5.08 (d, *J* = 17.0 Hz, 1H), 4.89 (d, *J* = 14.9 Hz, 1H), 4.66 (t, *J* = 12.6 Hz, 2H), 3.22 (t, *J* = 9.2 Hz, 1H). ^{13}C NMR (75 MHz, $CDCl_3$) δ 126.36 , 125.46 , 85.11 , 77.46 , 77.04 , 76.62 , 59.28 ^{19}F NMR (282 MHz, $CDCl_3$) δ -62.55

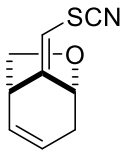
(+)-(2*R*,4*S*)-2-Allyl-3*Z*-(thiocyanatomethylene)-4-vinyltetrahydrofuran (59)



The carbonate **58** derived from enantiomerically enriched allylation previously described was treated under thiocyanopalladation/carbocyclization conditions, following General Procedure G. Thus, from carbonate **58** (1.35 g, 6.02 mmol), LiSCN (731 mg, 9.03 mmol, 1.5 eq.) and $PdCl_2(PhCN)_2$ (114 mg, 0.3 mmol, 0.05 eq.) in THF (240 mL) was obtained the *Z*-1,3-*syn*-product **59** (670 mg, 55%). ^{1}H NMR (400

MHz, $CDCl_3$) δ 5.92 (apt t, *J* = 2.1 Hz, 1H), 5.88-5.77 (m, 1H), 5.66 (ddd, *J* = 17.7, 9.3, 8.2 Hz, 1H), 5.22-5-11 (m, 4H), 4.72 (ddd, *J* = 8.1, 4.2, 2.3 Hz, 1H), 4.07 (dd, *J* = 8.9, 7.6 Hz, 1H), 3.75 (apt t, *J* = 8.6 Hz, 1H), 3.46 (q, *J* = 7.5 Hz, 1H), 2.51-2.35 (m, 2H).^{13}C NMR (100 MHz, $CDCl_3$) δ 157.46 , 135.17 , 133.36 , 118.50 , 118.35 , 109.89 , 104.01 , 79.71 , 71.21 , 51.19 , 37.21 . HRMS (TOF MS EI$^+$) m/z Calcd for $C_{11}H_{13}NOS$ $(M)^+$ 230.0616, obsd 230.0621. $[\alpha]^{20}_D$ = +232 (c = 0.9; $CHCl_3$).

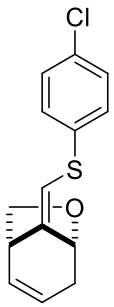
(+)-(1*S*,5*R*)-8*Z*-(Thiocyanatomethylene)-6-oxabicyclo[3.2.1]oct-2-ene (60)



The aforementioned thiocyanocarbocyclization product **59** (630 mg, 3.04 mmol) was dissolved in degassed CH_2Cl_2 (150 mL) and Grubbs II catalyst (193 mg, 0.228 mmol, 0.075 eq) was added. The resulting reaction mixture was heated to reflux for 2 h, then cooled to room temperature and concentrated. Purification by SiO2 flash chromatography [hexanes/ethyl acetate (90:10)] to yield the desired oxabicyclo[3.2.1]octene cross-metathesis product **60** as a pale green oil (408 mg, 75%) which could be crystalized from a hexanes/isopropanol (95:5) mixture at -20°C (crystals happen to melt at room temperature). ^{1}H NMR (700 MHz, $CDCl_3$) δ 5.97 (ddt, *J* = 9.2, 6.7, 1.8 Hz, 1H), 5.95 (s, 1H), 5.62-5.58 (m, 1H), 4.94 (br s, 1H), 4.09 (d, *J* = 6.9 Hz, 1H), 3.88 (d, *J* = 6.9, 3.5 Hz, 1H), 3.12 (dd, *J* = 6.5, 3.7 Hz, 1H), 2.55 (apt dt, *J* = 18.0, 2.2 Hz, 1H), 2.51 (apt dm, *J* = 2.2 Hz, 1H).^{13}C NMR (175 MHz, $CDCl_3$) δ 155.84 , 130.66 , 126.24 , 110.51 , 97.05 , 76.99 (CH_2, masked by the chloroform signal, determined by HMBC experiment), 73.55 , 43.22 , 39.40 . HRMS (TOF MS CI$^-$) m/z Calcd for C_9H_9NOS $(M)^-$ 179.0405, obsd 179.0401. $[\alpha]^{20}_D$ = +28.7 (c = 0.715; $CHCl_3$).

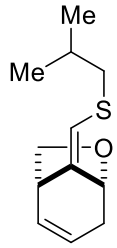
VI. Tailoring Chemistry

(+)-(1*S*,5*R*)-8*Z*-((4'-Chlorophenyl)thiomethylene)-6-oxabicyclo[3.2.1]oct-2-ene (61)



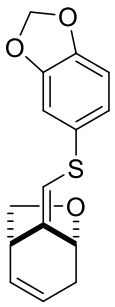
p-chlorophenylmagnesium bromide (0.22 mL of a 1M solution in ether, 0.22 mmol, 2 eq.) was added to a solution of oxabicylic vinyl thiocyanate **60** (20 mg, 0.11 mmol) in ether (2 mL) at 0 °C. The resulting reaction mixture was allowed to warm to room temperature, and stirred for 2 h, whereupon TLC analysis indicated that the reaction was complete. Following quenching [saturated NH4Cl (aq)], and extraction (EtOAc, 2 x), the crude product was dried (Na_2SO_4), filtered and evaporation. Purification by flash chromatography [hexanes/ethyl acetate (95:5)→(90:10)] provided the desired thioether product as a colorless oil (24 mg, 81%). ^{1}H NMR (700 MHz, $CDCl_3$) δ 7.27 (d, *J* = 7.2 Hz, 2H), 7.24 (d, *J* = 7.2 Hz, 2H), 6.04 (s, 1H), 6.03 (apt dd, *J* = 14.7, 9.2 Hz, 1H), 5.59 (d, *J* = 9.2 Hz, 1H), 4.99 (s, 1H), 4.09 (d, *J* = 7.0 Hz, 1H), 3.90 (dd, *J* = 5.7, 3.9 Hz, 1H), 3.11 (dd, *J* = 5.7, 3.9 Hz, 1H), 2.52 (d, *J* = 18.2 Hz, 1H), 2.46 (d, *J* = 18.2 Hz, 1H).^{13}C NMR (175 MHz, $CDCl_3$) δ 148.34 , 135.01 , 132.12 , 131.57 , 129.41 (2 CH), 129.09 (2 CH), 126.00 , 106.98 , 76.80 , 73.58 , 42.89 , 39.41 . HRMS (TOF MS EI$^+$) m/z Calcd for $C_{14}H_{13}OSCl^{35}$ $(M)^{+\cdot}$ 266.0376, obsd 266.0367. $[\alpha]^{20}_D$ = +189 (c = 0.65; $CDCl_3$).

(+)-(1*S*,5*R*)-8*Z*-((Isobutylthio)methylene)-6-oxabicyclo[3.2.1]oct-2-ene (62)



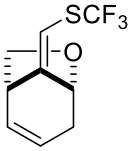
To a solution of oxabicylic thiocyanate **60** (20 mg, 0.11 mmol) in ether (2 mL) at 0 °C was added isobutylmagnesium bromide (0.11 ml of a 2M solution in ether, 0.22 mmol, 2 eq.), dropwise, via syringe. The reaction was allowed to warm to RT, stirred for 1-2 h, at that temperature, and was then quenched (saturated aq. ammonium chloride), extracted (EtOAc, 2x) and dried (Na_2SO_4). Flash chromatography over silica gel [hexanes/EtOAc (95:5)→(90:10)] then yielded the desired isobutyl thioether product **62** as a colorless oil (21 mg, 91%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.97 (ddt, *J* = 8.9, 6.8, 2.0 Hz, 1H), 5.80 (s, 1H), 5.52 (dt, *J* = 8.9, 3.0 Hz, 1H), 4.89 (s, 1H), 3.99 (d, *J* = 6.8 Hz, 1H), 3.77 (dd, *J* = 6.4, 3.7 Hz, 1H), 2.95 (dd, *J* = 6.4, 3.8 Hz, 1H), 2.56 (dd, *J* = 13.2, 6.4 Hz, 1H), 2.49 (dd, *J* = 12.9, 7.1, 1H), 2.47 (s, 2H), 1.81 (m, *J* = 6.6 Hz, 1H), 0.98 (d, *J* = 6.8 Hz, 6H).^{13}C NMR (175 MHz, $CDCl_3$) δ 141.81 , 131.85 , 125.86 , 110.91 , 76.69 , 73.42 , 43.46 , 42.76 , 38.81 , 29.04 , 21.86 , 21.65 . HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{12}H_{18}OSNa$ $(M+Na)^+$ 233.0976, obsd 233.0973. $[\alpha]^{20}_D$ = +176 (c = 0.25; $CDCl_3$)

(+)-(1*S*,5*R*)-8*Z*-((benzo[d][1',3']dioxole)methylene)-6-oxabicyclo[3.2.1]oct-2-ene (63)



In a flame-dried two neck flask was placed magnesium (30 mg, 1.24 mmol) in THF (3 mL) and the resulting suspension heated to reflux. A solution of 1-bromo-3,4-(methylenedioxy)benzene (250 mg, 1.24 mmol) in THF (1 mL) was slowly added, via syringe, and the resulting reaction mixture was stirred for 30 min to insure Grignard reagent formation. To a solution of oxabicylic vinyl thiocyanate **60** (20 mg, 0.11 mmol) in THF (2 mL) at 0 °C was added the aforementioned Grignard solution (1 mL, 0.31 mmol, 2.81 eq.). The resulting reaction mixture was allowed to warm to room temp, stirred for 2 h at RT, and then quenched (saturated aq. NH_4Cl), extracted (EtOAc, 2x) and dried (Na_2SO_4). Purification by flash chromatography [hexanes:ethyl acetate (95:5) $\rightarrow$(90:10)] yielded the desired product as a light brown oil (30 mg, quantitative). ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.83 (dd, *J* = 5.0, 3.4, Hz, 1H), 6.83 (d, *J* = 8.4 Hz, 1H), 6.74 (d, *J* = 8.4 Hz, 1H), 6.00 (s, 2H), 5.99 (ddt, *J* = 6.8, 8.9, 1.8 Hz, 1H), 5.94 (s, 2H), 5.56 (dtd, *J* = 8.9, 3.1, 1.2 Hz, 1H), 4.97 (s, 1H), 4.04 (d, *J* = 6.8 Hz, 1H), 3.85 (dd, *J* = 6.8, 3.6 Hz, 1H), 3.04 (dd, *J* = 3.6, 6.3 Hz, 1H), 2.47 (br s, 2H).^{13}C NMR (100 MHz, $CDCl_3$) δ 148.12 , 146.95 , 145.53 , 131.67 , 128.27 , 125.95 , 123.33 , 110.43 , 109.32 , 108.78 , 101.31 , 76.73 , 73.42 , 42.80 , 39.29 . HRMS (TOF MS ESI$^+$) m/z Calcd for $C_{15}H_{14}O_3SNa$ $(M+Na)^+$ 297.0561, obsd 299.0572. $[\alpha]^{20}_D$ = +200 (c = 0.45; $CDCl_3$).

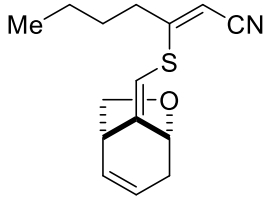
(+)-(1*S*,5*R*)-8*Z*-((Trifluoromethylthio)methylene)-6-oxabicyclo[3.2.1]oct-2-ene (64).



To a solution of oxabicyclic vinyl thiocyanate **60** (30 mg, 0.17 mmol) and $TMSCF_3$ (50 µL, 0.34 mmol, 2 eq.) in THF (5 mL) at -40 °C was added a solution of TBAF (34 µL of 1M solution in THF, 0.034 mmol, 0.2 eq.). The resulting reaction mixture was stirred for 3 h, quenched (saturated NH_4Cl (aq.)) chloride,. and extracted (EtOAc, 2 x). The combined organic extracts were dried over Na_2SO_4, vacuum-filtered and evaporated. Flash chromatography on silica gel [hexanes/EtOAc (100:0)$\rightarrow$(80:20) to yield the title compound as a pale yellow oil (30 mg, 81%). ^{1}H NMR (700 MHz, $CDCl_3$) δ 6.00 (s, 1H), 5.96 (ddt, *J* = 6.8, 9.1, 1.8, 1H), 5.57 (dt, *J* = 9.6, 2.7 Hz, 1H), 4.93 (s, 1H), 4.08 (d, *J* = 6.8 Hz, 1H), 3.88, (*J* = 6.8, 3.8 Hz, 1H), 3.1 (dd, *J* = 6.4, 3.8 Hz, 1H), 2.52 (dt, *J* = 18.1, 3.8 Hz, 1H), 2.45 (dm, *J* = 18.4, 2.0 Hz, 1H). ^{13}C NMR (175 MHz, $CDCl_3$) δ 155.84 , 130.92 , 129.42 (q, *J* =

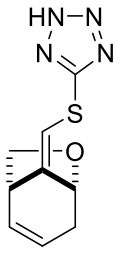
308.7 Hz,), 126.07 ; 98.21 (q, *J* = 2.9 Hz, CH), 76.91 , 73.64 , 43.07 , 39.58 . ^{19}F NMR (377 MHz, $CDCl_3$) δ -42.8. HRMS (TOF MS ESI$^+$) m/z Calcd for $C_9H_9F_3OS$ $(M)^{+\cdot}$ 222.0326, obsd 222.0329. $[\alpha]^{20}_D$ = +31.8 (c = 0.8; $CDCl_3$).

(+)-(1*S*,5*R*)-8*Z*-((Hept-2'*Z*-enenitrile-3'-ylthio)methylene)-6-oxabicyclo[3.2.1]oct-2-ene (65).



Pd_2dba_3 (2.7 mg 0.003 mmol) and PPh_3 (6.2 mg 0.024 mmol) were added to a flame-dried Schlenk tube and evacuated then backfilled with N_2. This was stirred at rt for 1 h. To this a solution enantioenriched oxabicyclic vinyl thiocyanate **60** (10 mg, 0.06 mmol). and 1-hexyne (20 µL, 0.18 mmol, 3 eq.) dissolved in 0.5 mL of toluene were added. The reaction vessel was sealed, heated to 120 °C under inert atmosphere and stirred overnight before allowed to cool and then being concentrated, in vacuo. Purification via flash chromatography [hexanes/CH_2Cl_2/EtOAc (70:25:5)] yielded the title compound as a brown oil (8 mg, 55%). ^{1}H NMR (700 MHz, $CDCl_3$) δ 6.10 (s, 1H), 5.97 (ddt, *J* = 6.7, 8.9, 1.9 Hz, 1H), 5.57 (dt, *J* = 9.0, 3.1 Hz, 1H), 5.23 (s, 1H), 4.96 (s, 1H), 4.06 (d, *J* = 6.9 Hz, 1H), 3.87 (dd, *J* = 6.9, 3.5 Hz, 1H), 3.1 (dd, *J* = 6.4, 3.1 Hz, 1H), 2.51 (dt, *J* = 18.2, 3.5 Hz, 1H), 2.45 (dm, *J* = 18.2, 2.1 Hz, 1H), 2.37 (td, *J* = 7.6, 2.9 Hz, 2H), 1.49 (m, *J* = 7.6 Hz, 2H), 1.33 (md, *J* = 7.3, 2.1 Hz, 2H), 0.90 (t, *J* = 7.4 Hz, 3H). ^{13}C NMR (175 MHz, $CDCl_3$) δ 164.63 , 152.64 , 131.11 , 126.07 , 116.18 , 102.32 , 91.89 , 76.74 , 73.42 , 43.02 , 39.43 , 36.56 , 30.36 , 21.94 , 13.70 . .HRMS (TOF MS EI$^+$) m/z Calcd for $C_{15}H_{19}NOS$ $(M)^+$ 261.1187, obsd 261.1189. $[\alpha]^{20}_D$ = +226.5 (c = 0.2; $CHCl_3$).

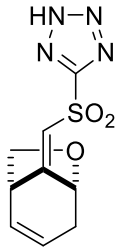
(+)-(1*S*,5*R*)-8*Z*-((2'H-tetrazolethio)methylene)-6-oxabicyclo[3.2.1]oct-2-ene (66).



Bicyclic vinyl thiocyanate **60** (150 mg, 0.84 mmol), $ZnBr_2$ (189 mg, 0.84 mmol, 1 eq.) and NaN_3 (136 mg, 2.1 mmol, 2.5 eq.) were combined in a mixed solvent [H_2O/iPrOH (1:1, 30 mL)] and refluxed for 3 h, whereupon the desired cycloadditon reaction appeared to be complete. The reaction mixture was acidified (1M HCl), and partitioned in a separatory funnel (EtOAc, 3x). The organic extracts were combined, washed with water and brine, then dried (Na_2SO_4), filtered, and concentrated to afford a the title cycloaddition product (168 mg, 91%) as a pale brown amorphous solid. ^{1}H NMR (300 MHz, CD_3OD) δ 6.36 (d, *J* = 0.8 Hz, 1H), 6.0 (ddt, *J* = 9.0, 6.6, 1.8 Hz, 1H), 5.54 (dtd, *J* = 9.2, 3.0, 1.2 Hz, 1H), 5.27 (br s, 1H), 4.92 (s, 1H), 4.02 (d, *J* = 7.0, 1H), 3.84 (dd, *J* = 7.0, 3.6 Hz, 1H), 3.22

(dd, *J* = 6.5, 3.8 Hz, 1H), 2.43 (br s, 2H).^{13}C NMR (75 MHz, CD_3OD) δ 155.53 , 152.05 , 132.64 , 126.58 , 102.35 , 77.82 , 74.67 , 44.01 , 40.27 . HRMS (TOF MS EI^+) m/z Calcd for $C_9H_{10}N_4OS$ $(M)^{+\cdot}$ 222.0575, obsd 222.0586. $[\alpha]^{20}_D$ = +199 (c = 2.1; EtOH).

(+)-(1*S*,5*R*)-8*Z*-((2'H-tetrazolesulfonyl)methylene)-6-oxabicyclo[3.2.1]oct-2-ene (67)



Thiotetrazole 14 (70 mg, 0.31 mmol) was treated with a solution of dimethyl dioxyrane (6 mL of a 0.1 M solution in acetone, 0.66 mmol, 2.1 eq.) and stirred till completion was observed on TLC (1 to 2 h). Solvent removal afforded the crude sulfonyl tetrazole as an amorphous white solid (78 mg, 98%). ^{1}H NMR (700 MHz, Acetone d6) δ 9.54 (br s, 1H), 6.74 (s, 1H), 6.01 (ddt, *J* = 7.1, 8.9, 1.7 Hz, 1H), 5.62 (dt, *J* = 8.9, 2.7 Hz, 1H), 5.57 (br s, 1H), 4.05 (d, *J* = 7.1 Hz, 1H), 3.81 (dd, *J* = 6.8, 3.3 Hz, 1H), 3.36 (dd, *J* = 6.4, 3.3 Hz, 1H), 2.73 (d, *J* = 18.3 Hz, 1H), 2.55 (d, *J* = 18.3 Hz, 1H). ^{13}C NMR (175 MHz, Acetone d6) δ 165.67 , 130.90 , 126.19 , 120.24 , 115.38 , 75.12 , 72.49 , 43.60 , 40.90 . HRMS (TOF MS ESI^+) m/z Calcd for $C_9H_9N_4O_3SNa_2$ $(M\text{-}H+2\ Na)^+$ 299.0191, obsd 299.0200. $[\alpha]^{20}_D$ = +72 (c = 0.65; EtOH).

VII. X-Ray Crystallography Studies for Compound 4t

Comment

One side-arm of the molecule was disordered. The occupancies of atoms C14 and C15 refined to 0.804(7) and 0.196(7) for the unprimed and primed atoms. Restraints on the positional and displacement parameters of the disordered atoms were required. The displacement ellipsoids were drawn at the 50% probability level.

Experimental

A colorless needle-shaped crystal of dimensions 0.540 x 0.050 x 0.020 mm was selected for structural analysis. Intensity data for this compound were collected using a diffractometer with a Bruker APEX ccd area detector (1) and graphite-monochromated Mo Kα radiation (λ = 0.71073 Å). The sample was cooled to 100(2) K. Cell parameters were determined from a non-linear least squares fit of 1133 peaks in the range $2.28 < \theta < 24.51°$. A total of 28257 data were measured in the range $1.649 < \theta < 28.462°$ using ϕ and ω oscillation frames. The data were corrected for absorption by the empirical method (2) giving minimum and maximum transmission factors of 0.836 and 0.993. The data were merged to form a set of 3925 independent data with R(int) = 0.0821 and a coverage of 100.0 %.

The monoclinic space group *P*21/*n* was determined by systematic absences and statistical tests and verified by subsequent refinement. The structure was solved by direct methods and refined by full-matrix least-squares methods on F^2 (3). The positions of hydrogens were initially determined by geometry and were refined using a riding model. Non-hydrogen atoms were refined with anisotropic displacement parameters. Hydrogen atom displacement parameters were set to 1.2 (1.5 for methyl) times the isotropic equivalent displacement parameters of the bonded atoms. A total of 209 parameters were refined against 15 restraints and 3925 data to give $wR(F^2) = 0.1608$ and S = 0.998 for weights of $w = 1/[\sigma^2 (F^2) + (0.0650\ P)^2 + 2.5000\ P]$, where $P = [Fo^2 + 2Fc^2] / 3$. The final R(*F*) was 0.0616 for the 2650 observed, [$F > 4\sigma(F)$], data. The largest shift/s.u. was 0.000 in the final refinement cycle. The final difference map had maxima and minima of 0.513 and -0.588 e/Å^3, respectively.

Figure S4: Thermal Ellipsoid Plot of Orientation for 4t

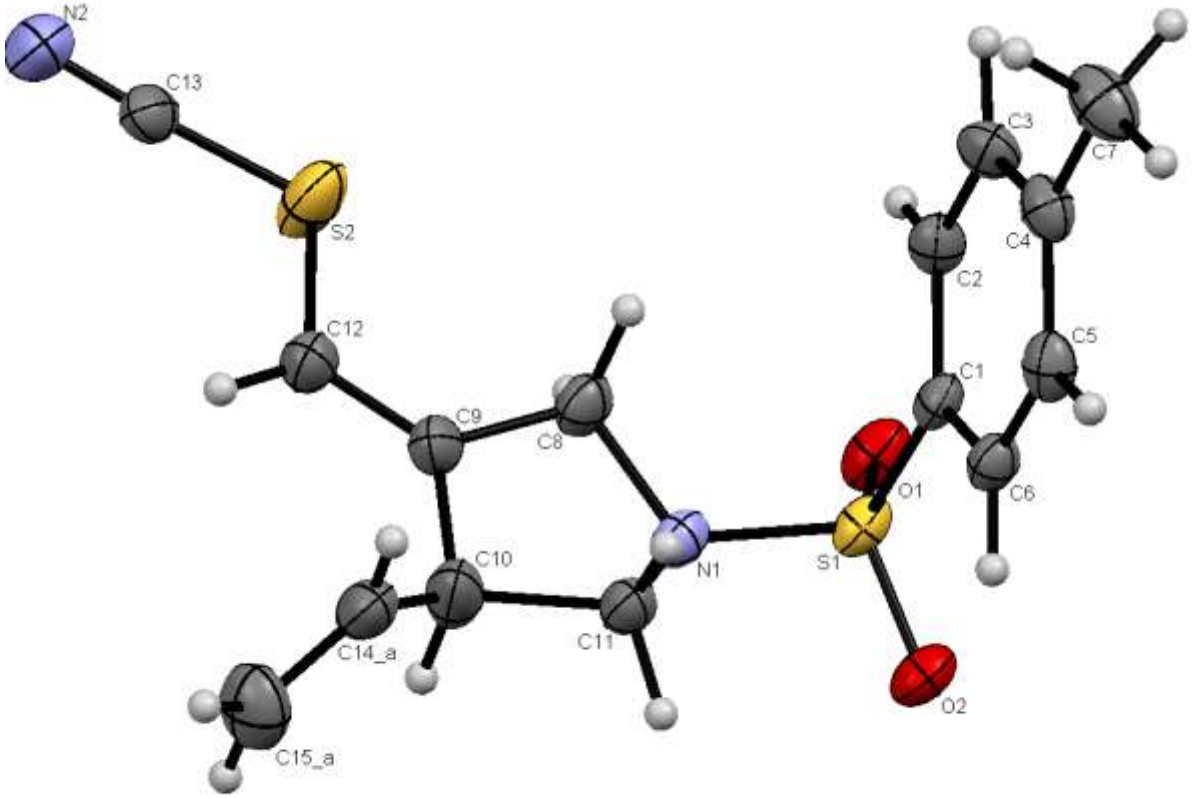


Table S2. Crystal data and structure refinement for 4t

Empirical formula	C15 H16 N2 O2 S2	
Formula weight	320.42	
Crystal system	monoclinic	
Space group	*P*21/*n*	
Unit cell dimensions	*a* = 16.354(6) Å	α = 90°
	b = 5.370(2) Å	β = 92.655(8)°
	c = 17.896(7) Å	γ = 90°
Volume	1570.0(10) Å3	
Z, Z'	4, 1	
Density (calculated)	1.356 Mg/m3	
Wavelength	0.71073 Å	
Temperature	100(2) K	
F(000)	672	
Absorption coefficient	0.344 mm-1	
Absorption correction	semi-empirical from equivalents	
Max. and min. transmission	0.993 and 0.836	
Theta range for data collection	1.649 to 28.462°	
Reflections collected	28257	
Independent reflections	3925 [R(int) = 0.0821]	
Data / restraints / parameters	3925 / 15 / 209	
wR(*F*2 all data)	*wR*2 = 0.1608	
R(*F* obsd data)	*R*1 = 0.0616	
Goodness-of-fit on *F*2	0.998	
Observed data	[I > 2σ(I)] 2650	
Largest and mean shift / s.u.	0.000 and 0.000	
Largest diff. peak and hole	0.513 and -0.588 e/Å3	

$wR2 = \{ \Sigma [w(Fo^2 - F_c^2)^2] / \Sigma [w(F_o{}^2)^2] \}^{1/2}$

$R1 = \Sigma ||F_o| - |F_c|| / \Sigma |F_o|$

Table S3. Atomic coordinates and equivalent isotropic displacement parameters for 4t. U(eq) is defined as one third of the trace of the orthogonalized U_{ij} tensor.

	x	y	z	U(eq)
S(1)	0.42050(5)	1.09598(14)	0.30331(4)	0.02657(19)
S(2)	0.38761(6)	0.4167(2)	0.06538(6)	0.0520(3)
O(1)	0.35084(14)	1.1913(4)	0.26107(12)	0.0349(5)
O(2)	0.47732(13)	1.2622(4)	0.34092(12)	0.0328(5)
N(1)	0.47345(15)	0.9384(5)	0.24494(13)	0.0278(6)
N(2)	0.3992(2)	-0.0097(7)	-0.0237(2)	0.0563(9)
C(1)	0.38617(17)	0.8820(5)	0.36935(15)	0.0238(6)
C(2)	0.31420(17)	0.7482(6)	0.35541(16)	0.0275(6)
C(3)	0.29192(18)	0.5704(6)	0.40640(18)	0.0323(7)
C(4)	0.33816(18)	0.5274(6)	0.47242(17)	0.0300(7)
C(5)	0.40954(18)	0.6655(6)	0.48584(17)	0.0296(7)
C(6)	0.43397(18)	0.8390(6)	0.43407(16)	0.0263(6)
C(7)	0.3125(2)	0.3328(7)	0.5273(2)	0.0417(8)
C(8)	0.42911(19)	0.7693(6)	0.19251(17)	0.0315(7)
C(9)	0.49696(19)	0.6187(6)	0.16140(17)	0.0326(7)
C(10)	0.5774(2)	0.6889(8)	0.2011(2)	0.0463(9)
C(11)	0.54928(18)	0.8129(6)	0.27214(17)	0.0307(7)
C(12)	0.48691(19)	0.4506(6)	0.10727(18)	0.0341(7)
C(13)	0.3977(2)	0.1626(6)	0.01395(17)	0.0335(7)
C14a	0.6369(2)	0.4940(8)	0.2098(2)	0.0398(12)
C15a	0.7083(3)	0.4809(12)	0.1792(3)	0.0509(15)
C14'b	0.6530(5)	0.736(3)	0.1678(8)	0.035(4)
C15'b	0.7153(8)	0.588(4)	0.1583(12)	0.039(4)

Table S4. Bond lengths [Å] and angles [°] for 4t.

S(1)-O(1)	1.432(2)	C(7)-H(7C)	0.9800
S(1)-O(2)	1.434(2)	C(8)-C(9)	1.501(4)
S(1)-N(1)	1.625(3)	C(8)-H(8A)	0.9900
S(1)-C(1)	1.759(3)	C(8)-H(8B)	0.9900
S(2)-C(13)	1.659(4)	C(9)-C(12)	1.329(4)
S(2)-C(12)	1.766(3)	C(9)-C(10)	1.513(4)
N(1)-C(8)	1.472(4)	C(10)-C14'b	1.420(6)
N(1)-C(11)	1.474(4)	C(10)-C14a	1.432(5)
N(2)-C(13)	1.145(4)	C(10)-C(11)	1.524(4)
C(1)-C(6)	1.386(4)	C(10)-H10a	1.0012
C(1)-C(2)	1.391(4)	C(10)-H10'b	1.0015
C(2)-C(3)	1.381(4)	C(11)-H(11A)	0.9900
C(2)-H(2)	0.9500	C(11)-H(11B)	0.9900
C(3)-C(4)	1.392(4)	C(12)-H(12)	0.9500
C(3)-H(3)	0.9500	C14a-C15a	1.315(6)
C(4)-C(5)	1.395(4)	C14a-H14a	0.9500
C(4)-C(7)	1.507(5)	C15a-H15Aa	0.9500
C(5)-C(6)	1.386(4)	C15a-H15Ba	0.9500
C(5)-H(5)	0.9500	C14'b-C15'b	1.310(7)
C(6)-H(6)	0.9500	C14'b-H14'b	0.9500
C(7)-H(7A)	0.9800	C15'b-H15Cb	0.9500
C(7)-H(7B)	0.9800	C15'b-H15Db	0.9500
O(1)-S(1)-O(2)	120.51(14)	C(8)-N(1)-C(11)	108.1(2)
O(1)-S(1)-N(1)	106.34(13)	C(8)-N(1)-S(1)	118.0(2)
O(2)-S(1)-N(1)	105.83(13)	C(11)-N(1)-S(1)	119.41(19)
O(1)-S(1)-C(1)	108.49(14)	C(6)-C(1)-C(2)	120.2(3)
O(2)-S(1)-C(1)	108.15(13)	C(6)-C(1)-S(1)	119.0(2)
N(1)-S(1)-C(1)	106.74(13)	C(2)-C(1)-S(1)	120.7(2)
C(13)-S(2)-C(12)	101.94(16)	C(3)-C(2)-C(1)	119.0(3)

C(3)-C(2)-H(2)	120.5	C14'b-C(10)-C(11)	125.0(7)
C(1)-C(2)-H(2)	120.5	C14a-C(10)-C(11)	117.3(3)
C(2)-C(3)-C(4)	121.7(3)	C(9)-C(10)-C(11)	102.2(3)
C(2)-C(3)-H(3)	119.1	C14a-C(10)-H10a	106.7
C(4)-C(3)-H(3)	119.1	C(9)-C(10)-H10a	106.9
C(3)-C(4)-C(5)	118.4(3)	C(11)-C(10)-H10a	107.0
C(3)-C(4)-C(7)	120.8(3)	C14'b-C(10)-H10'b	100.2
C(5)-C(4)-C(7)	120.8(3)	C(9)-C(10)-H10'b	96.6
C(6)-C(5)-C(4)	120.5(3)	C(11)-C(10)-H10'b	96.4
C(6)-C(5)-H(5)	119.7	N(1)-C(11)-C(10)	101.9(2)
C(4)-C(5)-H(5)	119.8	N(1)-C(11)-H(11A)	111.4
C(5)-C(6)-C(1)	120.1(3)	C(10)-C(11)-H(11A)	111.4
C(5)-C(6)-H(6)	120.0	N(1)-C(11)-H(11B)	111.4
C(1)-C(6)-H(6)	120.0	C(10)-C(11)-H(11B)	111.4
C(4)-C(7)-H(7A)	109.5	H(11A)-C(11)-H(11B)	109.3
C(4)-C(7)-H(7B)	109.5	C(9)-C(12)-S(2)	117.4(3)
H(7A)-C(7)-H(7B)	109.5	C(9)-C(12)-H(12)	121.3
C(4)-C(7)-H(7C)	109.5	S(2)-C(12)-H(12)	121.3
H(7A)-C(7)-H(7C)	109.5	N(2)-C(13)-S(2)	175.1(3)
H(7B)-C(7)-H(7C)	109.5	C15a-C14a-C(10)	127.3(5)
N(1)-C(8)-C(9)	102.6(2)	C15a-C14a-H14a	116.3
N(1)-C(8)-H(8A)	111.2	C(10)-C14a-H14a	116.3
C(9)-C(8)-H(8A)	111.2	C14a-C15a-H15Aa	120.0
N(1)-C(8)-H(8B)	111.2	C14a-C15a-H15Ba	120.0
C(9)-C(8)-H(8B)	111.2	H15Aa-C15a-H15Ba	120.0
H(8A)-C(8)-H(8B)	109.2	C15'b-C14'b-C(10)	130.1(9)
C(12)-C(9)-C(8)	124.6(3)	C15'b-C14'b-H14'b	115.0
C(12)-C(9)-C(10)	126.0(3)	C(10)-C14'b-H14'b	115.0
C(8)-C(9)-C(10)	109.4(3)	C14'b-C15'b-H15Cb	120.0
C14'b-C(10)-C(9)	127.0(7)	C14'b-C15'b-H15Db	120.0
C14a-C(10)-C(9)	116.1(3)	H15Cb-C15'b-H15Db	120.0

Table S5. Anisotropic displacement parameters ($Å^2 x\ 10^3$) for 4t. The anisotropic displacement factor exponent takes the form: $-2\ \pi 2[\ h^2\ a^{*2}\ U_{11} + ... + 2\ h\ k\ a^*\ b^*\ U_{12}\ ]$

	U11	U22	U33	U23	U13	U12
S(1)	33(1)	21(1)	25(1)	-3(1)	-6(1)	2(1)
S(2)	42(1)	54(1)	58(1)	-30(1)	-14(1)	7(1)
O(1)	42(1)	28(1)	33(1)	-3(1)	-11(1)	6(1)
O(2)	41(1)	23(1)	34(1)	-5(1)	-4(1)	-3(1)
N(1)	34(1)	27(1)	22(1)	-3(1)	-2(1)	-2(1)
N(2)	47(2)	59(2)	63(2)	-29(2)	11(2)	-15(2)
C(1)	26(1)	22(1)	23(1)	-7(1)	-3(1)	4(1)
C(2)	22(1)	35(2)	25(2)	-3(1)	-4(1)	6(1)
C(3)	21(1)	39(2)	37(2)	-3(1)	2(1)	1(1)
C(4)	29(2)	31(2)	31(2)	1(1)	6(1)	8(1)
C(5)	29(2)	34(2)	26(2)	-2(1)	-2(1)	11(1)
C(6)	26(1)	29(2)	24(1)	-6(1)	-3(1)	2(1)
C(7)	38(2)	42(2)	47(2)	11(2)	11(2)	9(2)
C(8)	34(2)	35(2)	26(2)	-7(1)	-4(1)	-1(1)
C(9)	30(2)	40(2)	28(2)	-7(1)	6(1)	-4(1)
C(10)	30(2)	64(2)	45(2)	-26(2)	3(2)	-2(2)
C(11)	27(2)	34(2)	32(2)	-9(1)	0(1)	-2(1)
C(12)	31(2)	40(2)	32(2)	-10(1)	2(1)	-2(1)
C(13)	34(2)	41(2)	26(2)	-2(1)	5(1)	-10(1)
C14a	34(2)	39(2)	46(3)	-17(2)	1(2)	-4(2)
C15a	40(2)	60(4)	53(4)	-6(3)	3(2)	15(2)
C14'b	29(6)	45(10)	31(9)	0(7)	-5(6)	5(5)
C15'b	36(5)	44(8)	39(8)	-8(6)	13(6)	2(5)

Table S6. Hydrogen coordinates and isotropic displacement parameters for 4t.

	x	y	z	U(eq)
H(2)	0.2809	0.7788	0.3115	0.033
H(3)	0.2438	0.4750	0.3962	0.039
H(5)	0.4417	0.6405	0.5308	0.035
H(6)	0.4836	0.9287	0.4429	0.032
H(7A)	0.2541	0.3516	0.5359	0.063
H(7B)	0.3442	0.3536	0.5747	0.063
H(7C)	0.3226	0.1667	0.5070	0.063
H(8A)	0.3987	0.8632	0.1526	0.038
H(8B)	0.3904	0.6621	0.2188	0.038
H10a	0.6025	0.8220	0.1705	0.056
H10'b	0.5892	0.5217	0.2240	0.056
H(11A)	0.5383	0.6883	0.3112	0.037
H(11B)	0.5903	0.9340	0.2922	0.037
H(12)	0.5314	0.3525	0.0917	0.041
H14a	0.6232	0.3591	0.2412	0.048
H15Aa	0.7252	0.6105	0.1473	0.061
H15Ba	0.7430	0.3417	0.1890	0.061
H14'b	0.6594	0.9008	0.1496	0.042
H15Cb	0.7136	0.4202	0.1750	0.047
H15Db	0.7622	0.6483	0.1347	0.047

Table S7. Torsion angles [°] for 4t.

O(1)-S(1)-N(1)-C(8)	-44.5(3)	S(1)-N(1)-C(8)-C(9)	-167.7(2)
O(2)-S(1)-N(1)-C(8)	-173.8(2)	N(1)-C(8)-C(9)-C(12)	-175.2(3)
C(1)-S(1)-N(1)-C(8)	71.2(2)	N(1)-C(8)-C(9)-C(10)	4.8(4)
O(1)-S(1)-N(1)-C(11)	-179.2(2)	C(12)-C(9)-C(10)-C14'b	45.0(9)
O(2)-S(1)-N(1)-C(11)	51.5(3)	C(8)-C(9)-C(10)-C14'b	-135.0(8)
C(1)-S(1)-N(1)-C(11)	-63.5(2)	C(12)-C(9)-C(10)-C14a	-32.2(6)
O(1)-S(1)-C(1)-C(6)	-154.8(2)	C(8)-C(9)-C(10)-C14a	147.9(3)
O(2)-S(1)-C(1)-C(6)	-22.5(3)	C(12)-C(9)-C(10)-C(11)	-161.1(3)
N(1)-S(1)-C(1)-C(6)	91.0(2)	C(8)-C(9)-C(10)-C(11)	19.0(4)
O(1)-S(1)-C(1)-C(2)	28.4(3)	C(8)-N(1)-C(11)-C(10)	40.6(3)
O(2)-S(1)-C(1)-C(2)	160.7(2)	S(1)-N(1)-C(11)-C(10)	179.3(2)
N(1)-S(1)-C(1)-C(2)	-85.9(3)	C14'b-C(10)-C(11)-N(1)	119.7(7)
C(6)-C(1)-C(2)-C(3)	-0.9(4)	C14a-C(10)-C(11)-N(1)	-163.1(3)
S(1)-C(1)-C(2)-C(3)	175.9(2)	C(9)-C(10)-C(11)-N(1)	-34.9(3)
C(1)-C(2)-C(3)-C(4)	2.1(5)	C(8)-C(9)-C(12)-S(2)	4.0(5)
C(2)-C(3)-C(4)-C(5)	-1.3(5)	C(10)-C(9)-C(12)-S(2)	-175.9(3)
C(2)-C(3)-C(4)-C(7)	179.9(3)	C(13)-S(2)-C(12)-C(9)	-170.2(3)
C(3)-C(4)-C(5)-C(6)	-0.7(4)	C14'b-C(10)-C14a-C15a	-6.4(9)
C(7)-C(4)-C(5)-C(6)	178.1(3)	C(9)-C(10)-C14a-C15a	114.3(5)
C(4)-C(5)-C(6)-C(1)	1.9(4)	C(11)-C(10)-C14a-C15a	-124.6(5)
C(2)-C(1)-C(6)-C(5)	-1.1(4)	C14a-C(10)-C14'b-C15'b	8.8(18)
S(1)-C(1)-C(6)-C(5)	-177.9(2)	C(9)-C(10)-C14'b-C15'b	-96(2)
C(11)-N(1)-C(8)-C(9)	-28.3(3)	C(11)-C(10)-C14’b-C15’b	116(2)

Table S8. Hydrogen bonds for 4t [Å and °].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
C(2)-H(2) O(1)#1	0.95	2.51	3.347(4)	147.4
C(11)-H(11A) O(2)#2	0.99	2.56	3.432(4)	146.7
C(12)-H(12) N(2)#3	0.95	2.51	3.401(5)	156.8

Symmetry transformations used to generate equivalent atoms:

#1 -x+1/2, y-1/2, -z+1/2 #2 x, y-1, z #3 -x+1, -y, -z

VIII. X-Ray Crystallography Studies for Compound 60.

Large well-shaped single crystals of **60** were grown at -20 °C in an ether:hexanes mixture using the vapor diffusion method and melt as soon as they're taken out of the freezer. Since the crystals were too large for a single crystal x-ray structure determination, they had to be cut. It was therefore necessary to devise a way of cutting the large crystals and mounting them on the diffractometer before they melted. This was accomplished by keeping the crystallization flask in dry ice next to a microscope temporarily installed inside the diffractometer enclosure. The crystals were removed from the crystallization flask and placed in a petri dish on the microscope stage while constantly blowing cold (100K) nitrogen from an Oxford Low Temperature cold head over them. The crystals were then examined under the microscope and a piece of more appropriate size was cut from one of them with a razor blade. This crystal was mounted with Paratone oil on a nylon cryoloop and rapidly transferred to a second 100K coldstream on the goniometer head.

A set of unique diffraction data [1923 0.5^0-wide ω- or φ-scan frames with scan times of 3-5 seconds] was collected [S1] at 100(2)K using monochromated CuKα radiation (λ= 1.54178 Å) on a dual-detector Bruker Proteum Single Crystal Diffraction System with a Bruker MicroStar microfocus Cu rotating anode x-ray source operating at 45kV and 60mA. Data was collected using a Platinum 135 CCD detector equipped with high-brilliance Helios multilayer optics. The integrated data[S2] were corrected empirically for variable absorption effects using equivalent reflections. The Bruker software package SHELXTL was used to solve the structure using "direct methods" techniques. All stages of weighted full-matrix least-squares refinement were conducted using F_o^2 data with the SHELXTL XL program in the Bruker APEX2 v2014.11-0 software package[S3]. Final crystallographic details are summarized in Table S9.

The asymmetric unit contains two crystallographically-independent chiral molecules that have virtually identical conformations. In fact, their nonhydrogen atoms superimpose to within 0.046 Å. Since the unit cell is metrically pseudo hexagonal, the absence of pseudomerohedral hexagonal twinning was confirmed. This crystal of **60** does, however, contain 16.5% of the enantiomer and is therefore a racemic twin. The absolute structure was determined experimentally using anomalous dispersion of the Cu x-rays and the enantiomer shown in the plot is the predominant species.

The final structural model incorporated anisotropic thermal parameters for all nonhydrogen atoms and isotropic thermal parameters for all hydrogen atoms. All hydrogen atoms were located from a difference Fourier and initially refined as independent isotropic atoms. However, when the isotropic thermal parameters for six of the eighteen hydrogen atoms (H1, H2, H5, H15, H17A and H18) refined to small or slightly negative values, they were fixed at values 1.2 times the equivalent isotropic thermal parameter of the carbon atoms to which they are covalently bonded. The isotropic thermal parameters of the remaining hydrogen atoms were allowed to vary in refinement cycles, as were the positional parameters of all hydrogen atoms.

[S1] Data Collection: SMART Software in APEX2 v2014.11-0 Suite. Bruker-AXS, 5465 E. Cheryl Parkway, Madison, WI 53711-5373 USA.

[S2] Data Reduction: SAINT Software in APEX2 v2014.11-0 Suite. Bruker-AXS, 5465 E. Cheryl Parkway, Madison, WI 53711-5373 USA.

[S3] Refinement: SHELXTL Software in APEX2 v2014.11-0 Suite. Bruker-AXS, 5465 E. Cheryl Parkway, Madison, WI 53711-5373 USA.

Figure S5: Thermal Ellipsoid Plot of Orientation 1

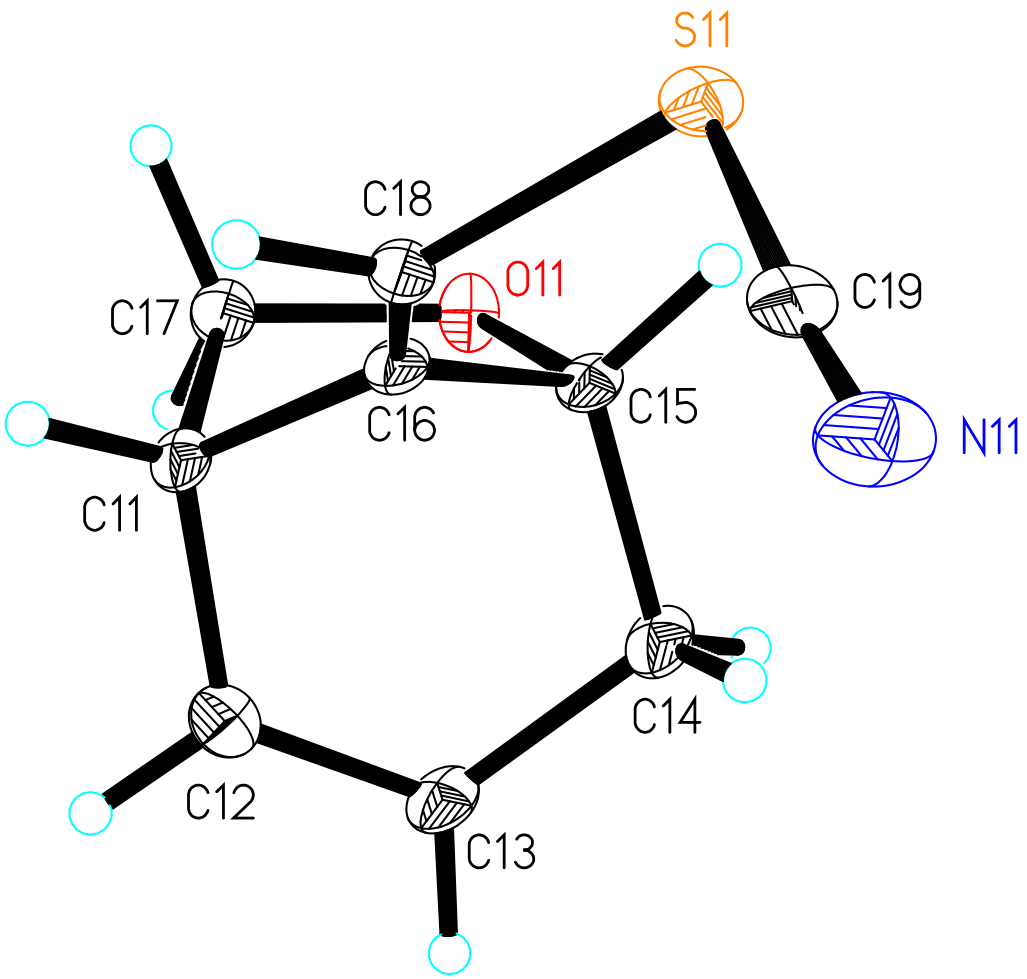


Table S9. Crystallographic data collection and structure refinement for 60.

Compound	**10**
Formula	C_9H_9NOS
Formula weight	179.23
Crystal system	Monoclinic
Space group	$P2_1$ (No. 4)
a (Å)	5.8614(10)
b (Å)	27.535(5)
c (Å)	5.9676(10)
α (°)	90.00
β (°)	119.351(2)
γ (°)	90.00
V (Å3)	839.5(2)
Z	4
ρcalcd (g cm^{-3})	1.418
λ (Å)	1.54178
T (K)	100(2)
F(000)	376
Crystal size (mm^3)	0.500 x 0.450 x 0.420
μ (mm^{-1})	2.98
Abs corr	Multi-scan
Max, min trans	1.000, 0.654
θ range (°)	6.43 to 67.65
Completeness to theta = 66.00°	96.6%

Reflns collected	4298
(Indep reflns)	1923
Rint	0.039
Data/restr/param	1923 / 1 / 285
R_1; wR_2 [$I>2\sigma(I)$]	0.050; 0.128
R_1; wR_2 (all data)	0.050; 0.128
GOF (F^2)	1.085
Largest diff. peak and hole ($e^- Å^{-3}$)	0.57, -0.53

Table S10. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters ($Å^2$x 10^3)

for 60. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
S(1)	649(2)	101(1)	-157(2)	15(1)
O(1)	6216(7)	1272(2)	1257(6)	16(1)
N(1)	-4250(9)	68(3)	-231(9)	23(1)
C(1)	5869(10)	1112(2)	4973(10)	14(1)
C(2)	4793(10)	1605(2)	5112(10)	15(1)
C(3)	3044(10)	1825(2)	2962(11)	18(1)
C(4)	2014(10)	1603(2)	360(10)	18(1)
C(5)	3561(9)	1139(2)	495(10)	16(1)
C(6)	3792(9)	845(2)	2708(9)	13(1)
C(7)	7832(10)	1174(2)	3953(10)	17(1)
C(8)	2626(9)	432(2)	2728(9)	13(1)
C(9)	-2223(11)	92(2)	-104(9)	17(1)
S(11)	8311(2)	4254(1)	5021(2)	14(1)
O(11)	12300(7)	3091(1)	3378(6)	15(1)
N(11)	3425(9)	4296(3)	4959(9)	23(1)
C(11)	8276(9)	3274(2)	-300(9)	13(1)
C(12)	6980(10)	2786(2)	-494(11)	17(1)

C(13)	7347(11)	2556(2)	1611(11)	16(1)
C(14)	9006(12)	2772(2)	4283(11)	18(1)
C(15)	10420(10)	3228(2)	4172(9)	13(1)
C(16)	8493(9)	3539(2)	2015(9)	13(1)
C(17)	11221(10)	3202(2)	663(10)	16(1)
C(18)	7355(10)	3953(2)	2041(9)	13(1)
C(19)	5352(11)	4268(2)	4909(9)	16(1)

Table S11. Bond lengths [Å] and angles [°] for 60.

S(1)-C(9)	1.699(6)	C(8)-H(8)	0.97(10)
S(1)-C(8)	1.785(5)	S(11)-C(19)	1.703(6)
O(1)-C(7)	1.437(6)	S(11)-C(18)	1.785(5)
O(1)-C(5)	1.439(6)	O(11)-C(15)	1.447(6)
N(1)-C(9)	1.155(8)	O(11)-C(17)	1.454(6)
C(1)-C(6)	1.495(7)	N(11)-C(19)	1.147(8)
C(1)-C(2)	1.516(8)	C(11)-C(16)	1.512(7)
C(1)-C(7)	1.553(7)	C(11)-C(12)	1.519(7)
C(1)-H(1)	0.77(7)	C(11)-C(17)	1.542(7)
C(2)-C(3)	1.332(8)	C(11)-H(11)	0.95(7)
C(2)-H(2)	0.98(6)	C(12)-C(13)	1.327(8)
C(3)-C(4)	1.494(8)	C(12)-H(12)	0.92(7)
C(3)-H(3)	0.99(7)	C(13)-C(14)	1.524(8)
C(4)-C(5)	1.546(8)	C(13)-H(13)	0.95(11)
C(4)-H(4A)	0.87(7)	C(14)-C(15)	1.523(7)
C(4)-H(4B)	1.08(8)	C(14)-H(14A)	0.96(8)
C(5)-C(6)	1.497(7)	C(14)-H(14B)	0.83(7)
C(5)-H(5)	0.99(6)	C(15)-C(16)	1.498(7)
C(6)-C(8)	1.329(7)	C(15)-H(15)	0.98(6)
C(7)-H(7A)	0.92(7)	C(16)-C(18)	1.324(8)
C(7)-H(7B)	1.08(9)	C(17)-H(17A)	1.05(8)

C(17)-H(17B)	1.06(8)	O(1)-C(5)-C(4)	108.8(4)
C(18)-H(18)	0.97(7)	C(6)-C(5)-C(4)	106.9(4)
C(9)-S(1)-C(8)	99.8(2)	O(1)-C(5)-H(5)	106(4)
C(7)-O(1)-C(5)	108.8(4)	C(6)-C(5)-H(5)	122(4)
C(6)-C(1)-C(2)	108.2(4)	C(4)-C(5)-H(5)	108(4)
C(6)-C(1)-C(7)	97.5(4)	C(8)-C(6)-C(1)	127.3(5)
C(2)-C(1)-C(7)	109.3(4)	C(8)-C(6)-C(5)	130.2(5)
C(6)-C(1)-H(1)	110(5)	C(1)-C(6)-C(5)	102.3(4)
C(2)-C(1)-H(1)	113(5)	O(1)-C(7)-C(1)	104.5(4)
C(7)-C(1)-H(1)	117(5)	O(1)-C(7)-H(7A)	105(4)
C(3)-C(2)-C(1)	120.0(5)	C(1)-C(7)-H(7A)	117(4)
C(3)-C(2)-H(2)	122(4)	O(1)-C(7)-H(7B)	109(4)
C(1)-C(2)-H(2)	118(4)	C(1)-C(7)-H(7B)	105(4)
C(2)-C(3)-C(4)	122.9(5)	H(7A)-C(7)-H(7B)	116(5)
C(2)-C(3)-H(3)	121(3)	C(6)-C(8)-S(1)	121.5(4)
C(4)-C(3)-H(3)	116(3)	C(6)-C(8)-H(8)	137(6)
C(3)-C(4)-C(5)	110.9(4)	S(1)-C(8)-H(8)	101(5)
C(3)-C(4)-H(4A)	116(4)	N(1)-C(9)-S(1)	175.2(5)
C(5)-C(4)-H(4A)	102(4)	C(19)-S(11)-C(18)	98.9(2)
C(3)-C(4)-H(4B)	107(4)	C(15)-O(11)-C(17)	109.0(4)
C(5)-C(4)-H(4B)	114(5)	C(16)-C(11)-C(12)	108.2(4)
H(4A)-C(4)-H(4B)	107(6)	C(16)-C(11)-C(17)	98.3(4)
O(1)-C(5)-C(6)	104.0(4)	C(12)-C(11)-C(17)	110.0(4)

C(16)-C(11)-H(11)	111(4)	C(16)-C(15)-C(14)	108.2(4)
C(12)-C(11)-H(11)	116(4)	O(11)-C(15)-H(15)	107(3)
C(17)-C(11)-H(11)	112(4)	C(16)-C(15)-H(15)	111(4)
C(13)-C(12)-C(11)	120.5(5)	C(14)-C(15)-H(15)	117(4)
C(13)-C(12)-H(12)	124(4)	C(18)-C(16)-C(15)	130.9(5)
C(11)-C(12)-H(12)	116(4)	C(18)-C(16)-C(11)	127.6(5)
C(12)-C(13)-C(14)	121.8(5)	C(15)-C(16)-C(11)	101.4(4)
C(12)-C(13)-H(13)	115(6)	O(11)-C(17)-C(11)	103.8(4)
C(14)-C(13)-H(13)	123(6)	O(11)-C(17)-H(17A)	102(4)
C(15)-C(14)-C(13)	111.0(4)	C(11)-C(17)-H(17A)	108(3)
C(15)-C(14)-H(14A)	108(4)	O(11)-C(17)-H(17B)	113(4)
C(13)-C(14)-H(14A)	113(4)	C(11)-C(17)-H(17B)	114(4)
C(15)-C(14)-H(14B)	105(5)	H(17A)-C(17)-H(17B)	115(5)
C(13)-C(14)-H(14B)	110(4)	C(16)-C(18)-S(11)	119.8(4)
H(14A)-C(14)-H(14B)	110(6)	C(16)-C(18)-H(18)	122(4)
O(11)-C(15)-C(16)	104.0(4)	S(11)-C(18)-H(18)	117(4)
O(11)-C(15)-C(14)	108.5(4)	N(11)-C(19)-S(11)	175.9(5)

Symmetry transformations used to generate equivalent atoms:

Table S12. Anisotropic displacement parameters ($Å^2 x\ 10^3$) for 10. 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}
S(1)	16(1)	10(1)	21(1)	-4(1)	10(1)	-3(1)
O(1)	17(2)	17(2)	17(2)	-2(2)	9(1)	-4(2)
N(1)	21(2)	21(3)	29(2)	-8(2)	13(2)	-4(2)
C(1)	19(2)	11(3)	12(2)	1(2)	7(2)	-3(2)
C(2)	18(2)	9(3)	19(3)	-1(2)	11(2)	-3(2)
C(3)	15(2)	16(3)	24(3)	1(2)	10(2)	2(2)
C(4)	17(2)	12(3)	20(3)	3(2)	5(2)	0(2)
C(5)	15(2)	16(3)	13(2)	1(2)	6(2)	-2(2)
C(6)	14(2)	9(3)	17(2)	0(2)	9(2)	3(2)
C(7)	18(2)	9(3)	23(3)	-3(2)	9(2)	-2(2)
C(8)	16(2)	5(2)	17(2)	-1(2)	7(2)	-4(2)
C(9)	22(3)	9(2)	19(2)	-3(2)	9(2)	-3(2)
S(11)	18(1)	9(1)	19(1)	-3(1)	11(1)	0(1)
O(11)	17(2)	17(2)	14(2)	2(1)	8(1)	6(1)
N(11)	21(2)	23(3)	33(3)	-7(2)	18(2)	-4(2)
C(11)	18(2)	8(3)	13(2)	1(2)	8(2)	1(2)
C(12)	15(2)	17(3)	16(3)	-2(2)	7(2)	1(2)
C(13)	25(3)	7(3)	21(3)	1(2)	14(2)	0(2)

C(14)	30(3)	9(3)	19(3)	2(2)	14(2)	-1(2)
C(15)	20(2)	6(2)	17(2)	-1(2)	12(2)	-1(2)
C(16)	19(2)	7(2)	14(2)	-1(2)	9(2)	-2(2)
C(17)	21(2)	13(3)	16(2)	-1(2)	10(2)	0(2)
C(18)	18(2)	9(3)	13(2)	-2(2)	8(2)	-1(2)
C(19)	26(3)	3(2)	17(2)	0(2)	8(2)	-1(2)

Table S13. Hydrogen coordinates (x 10^4) and isotropic displacement parameters ($Å^2$x 10^3) for 60.

	x	y	z	U(eq)
H(1)	6320(120)	960(30)	6200(130)	17
H(2)	5550(120)	1760(20)	6800(120)	18
H(3)	2420(110)	2160(20)	3020(110)	12(14)
H(4A)	2180(130)	1780(30)	-760(120)	18(16)
H(4B)	-40(160)	1540(30)	-380(130)	40(20)
H(5)	2820(120)	1000(20)	-1260(120)	19
H(7A)	8950(120)	1430(30)	4570(110)	12(14)
H(7B)	8740(150)	820(30)	4200(140)	40(20)
H(8)	2640(180)	210(40)	4000(170)	60(30)
H(11)	7470(120)	3470(30)	-1790(130)	21(16)
H(12)	5970(130)	2670(30)	-2140(140)	20(16)
H(13)	6600(200)	2240(40)	1320(190)	70(30)
H(14A)	10290(140)	2550(30)	5460(130)	22(17)
H(14B)	8040(130)	2870(30)	4860(120)	17(17)
H(15)	11390(110)	3420(20)	5770(120)	16
H(17A)	11470(120)	2870(30)	-70(120)	19
H(17B)	12120(140)	3500(30)	320(130)	27(18)
H(18)	6340(120)	4140(30)	490(120)	16

Table S14. Torsion angles [°] for 60.

C(6)-C(1)-C(2)-C(3)	-31.1(6)	C(9)-S(1)-C(8)-C(6)	-121.8(5)
C(7)-C(1)-C(2)-C(3)	74.1(6)	C(16)-C(11)-C(12)-C(13)	-32.1(6)
C(1)-C(2)-C(3)-C(4)	1.4(8)	C(17)-C(11)-C(12)-C(13)	74.3(6)
C(2)-C(3)-C(4)-C(5)	-9.2(8)	C(11)-C(12)-C(13)-C(14)	1.5(8)
C(7)-O(1)-C(5)-C(6)	-13.4(5)	C(12)-C(13)-C(14)-C(15)	-8.3(8)
C(7)-O(1)-C(5)-C(4)	100.2(5)	C(17)-O(11)-C(15)-C(16)	-14.1(5)
C(3)-C(4)-C(5)-O(1)	-65.2(5)	C(17)-O(11)-C(15)-C(14)	100.9(5)
C(3)-C(4)-C(5)-C(6)	46.6(6)	C(13)-C(14)-C(15)-O(11)	-65.9(6)
C(2)-C(1)-C(6)-C(8)	-117.3(6)	C(13)-C(14)-C(15)-C(16)	46.3(6)
C(7)-C(1)-C(6)-C(8)	129.5(5)	O(11)-C(15)-C(16)-C(18)	-137.3(5)
C(2)-C(1)-C(6)-C(5)	67.0(5)	C(14)-C(15)-C(16)-C(18)	107.5(6)
C(7)-C(1)-C(6)-C(5)	-46.3(5)	O(11)-C(15)-C(16)-C(11)	39.2(5)
O(1)-C(5)-C(6)-C(8)	-136.8(5)	C(14)-C(15)-C(16)-C(11)	-76.0(5)
C(4)-C(5)-C(6)-C(8)	108.3(6)	C(12)-C(11)-C(16)-C(18)	-116.4(6)
O(1)-C(5)-C(6)-C(1)	38.8(5)	C(17)-C(11)-C(16)-C(18)	129.2(5)
C(4)-C(5)-C(6)-C(1)	-76.1(5)	C(12)-C(11)-C(16)-C(15)	67.0(5)
C(5)-O(1)-C(7)-C(1)	-16.1(5)	C(17)-C(11)-C(16)-C(15)	-47.4(5)
C(6)-C(1)-C(7)-O(1)	38.6(5)	C(15)-O(11)-C(17)-C(11)	-16.2(5)
C(2)-C(1)-C(7)-O(1)	-73.8(5)	C(16)-C(11)-C(17)-O(11)	39.1(5)
C(1)-C(6)-C(8)-S(1)	-167.8(4)	C(12)-C(11)-C(17)-O(11)	-73.8(5)
C(5)-C(6)-C(8)-S(1)	6.8(8)	C(15)-C(16)-C(18)-S(11)	6.1(8)

C(11)-C(16)-C(18)-S(11)	-169.5(4)	C(19)-S(11)-C(18)-C(16)	-121.8(4)

Symmetry transformations used to generate equivalent atoms:

Table S15. Hydrogen bonds for 60 [Å and °].

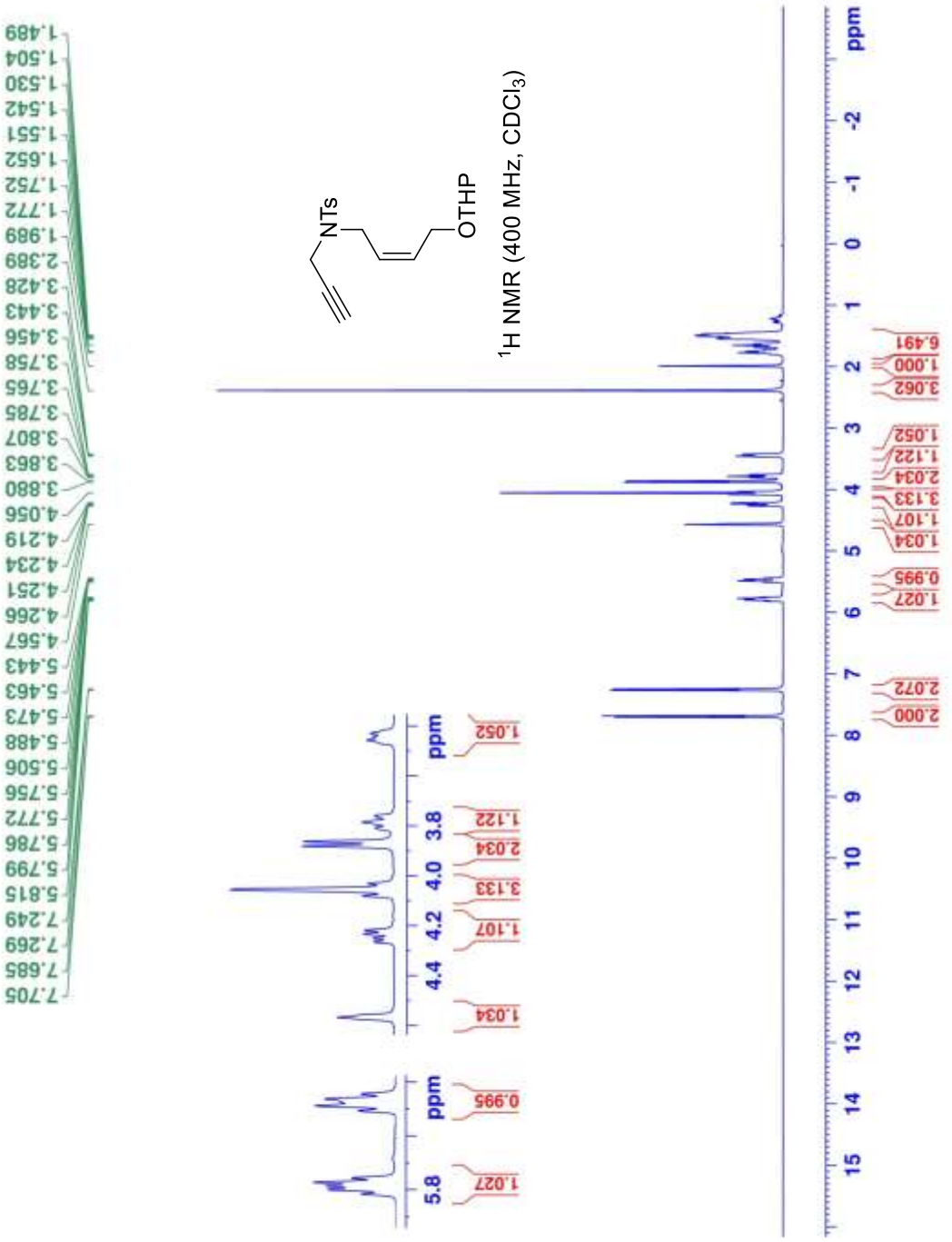
D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
C(8)-H(8)...S(11)#1	0.97(10)	2.82(10)	3.656(5)	145(7)

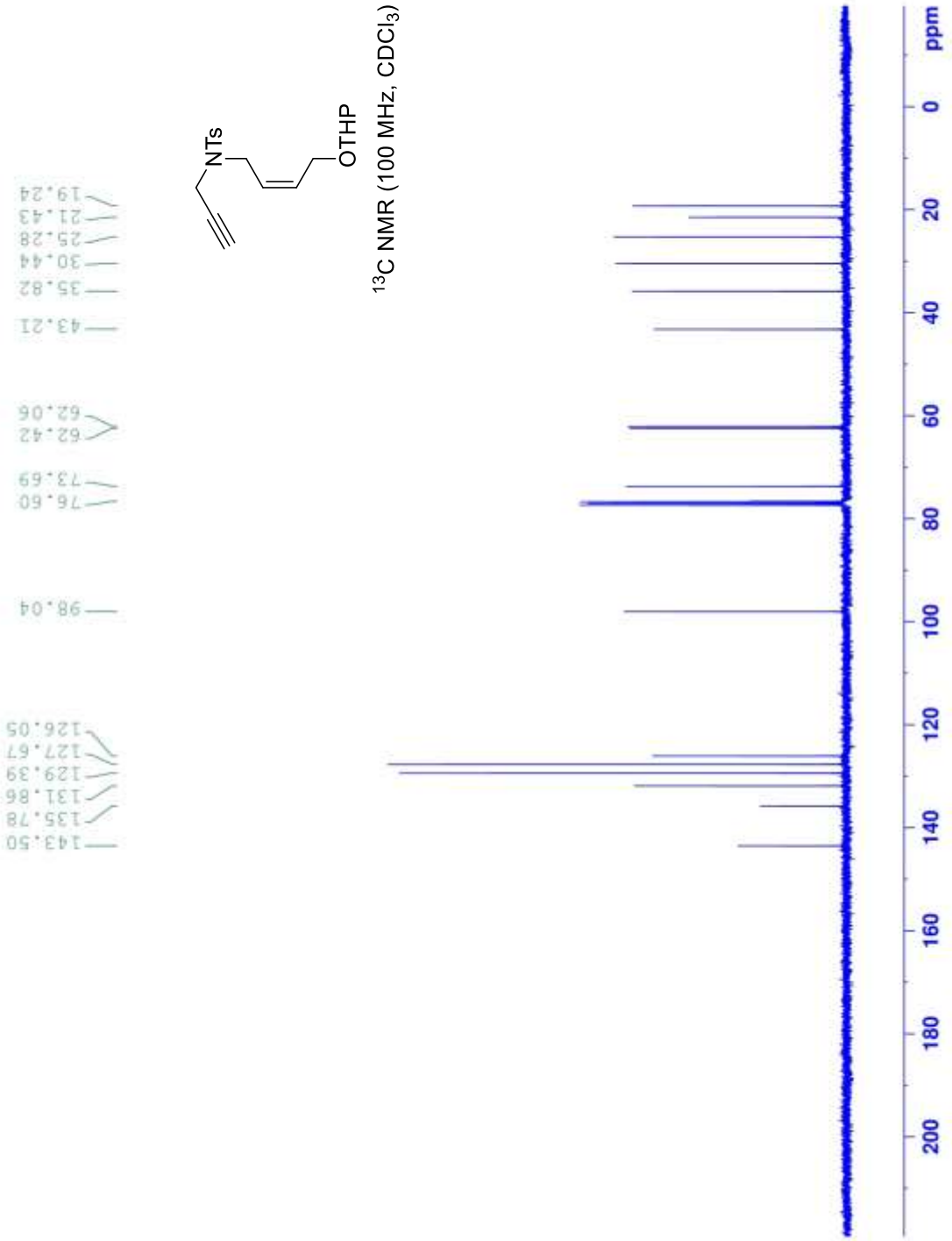
Symmetry transformations used to generate equivalent atoms:

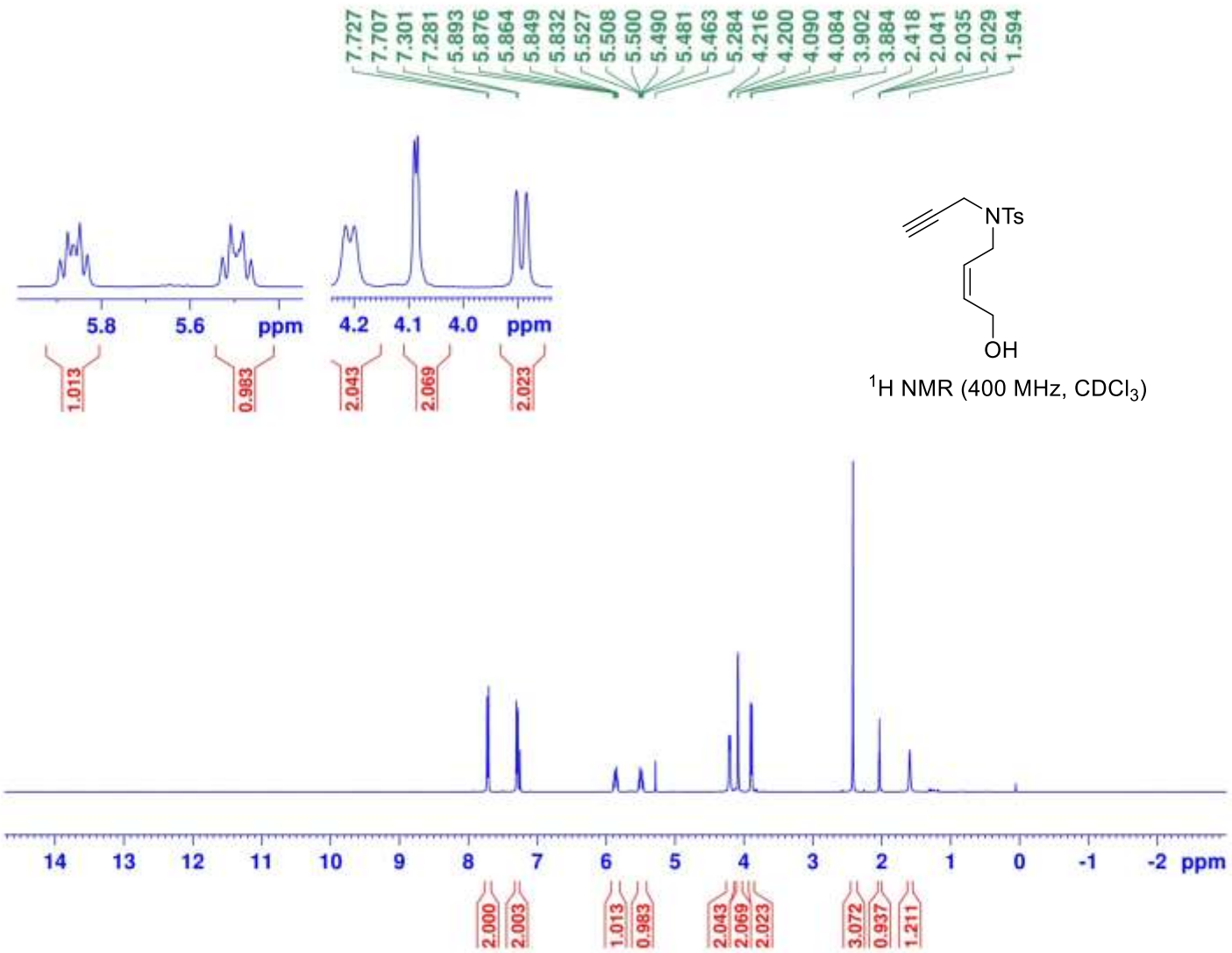
#1 -x+1,y-1/2,-z+1

IX ^{1}H, ^{13}C and ^{19}F NMR Spectra

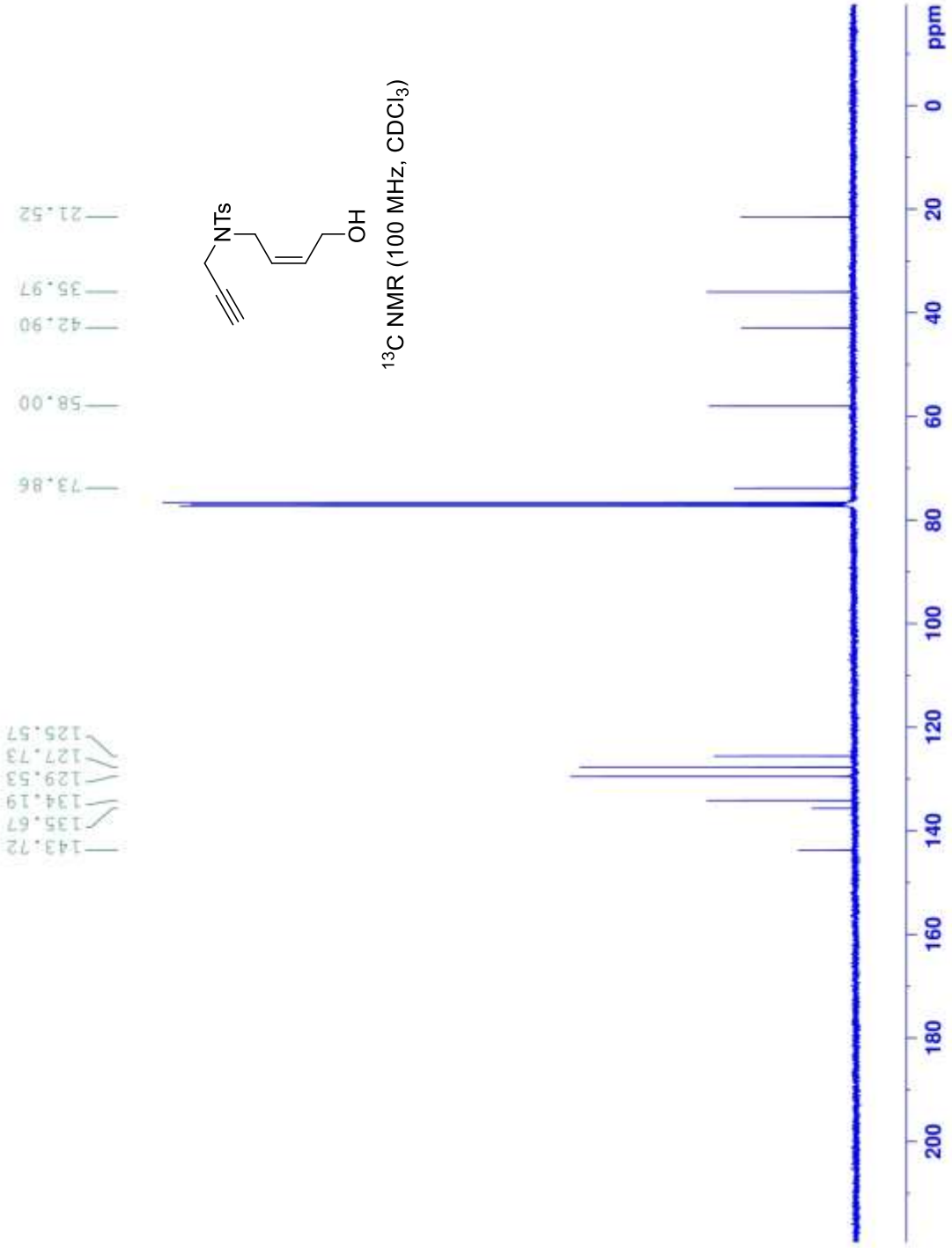
a. *Bridging Variation*

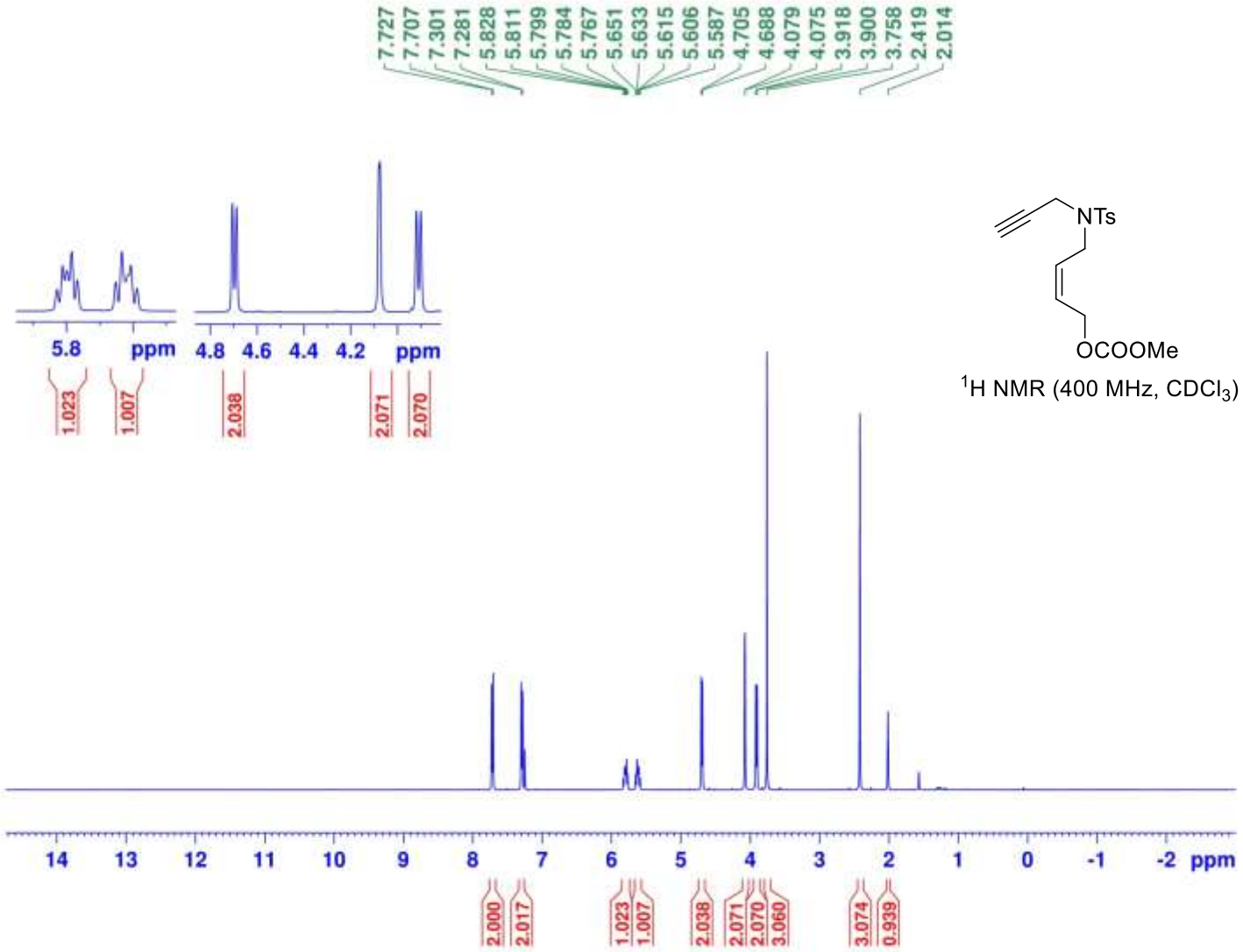



NTs
OTHP
^{13}C NMR (100 MHz, $CDCl_3$)
19.24
21.43
25.28
30.44
35.82
43.21
62.06
62.42
73.69
76.60
98.04
126.05
127.67
129.39
131.86
135.78
143.50
ppm
0
20
40
60
80
100
120
140
160
180
200

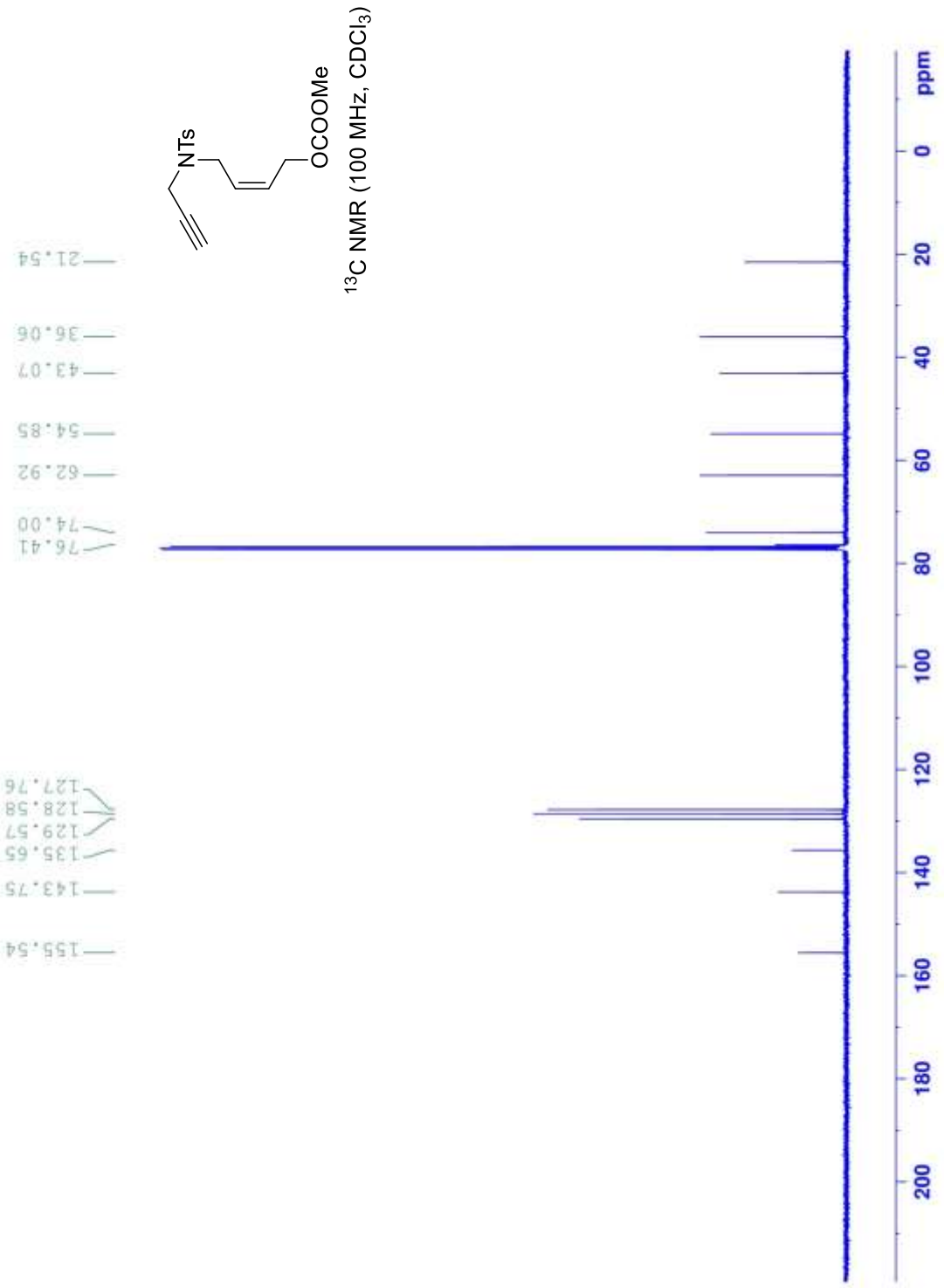


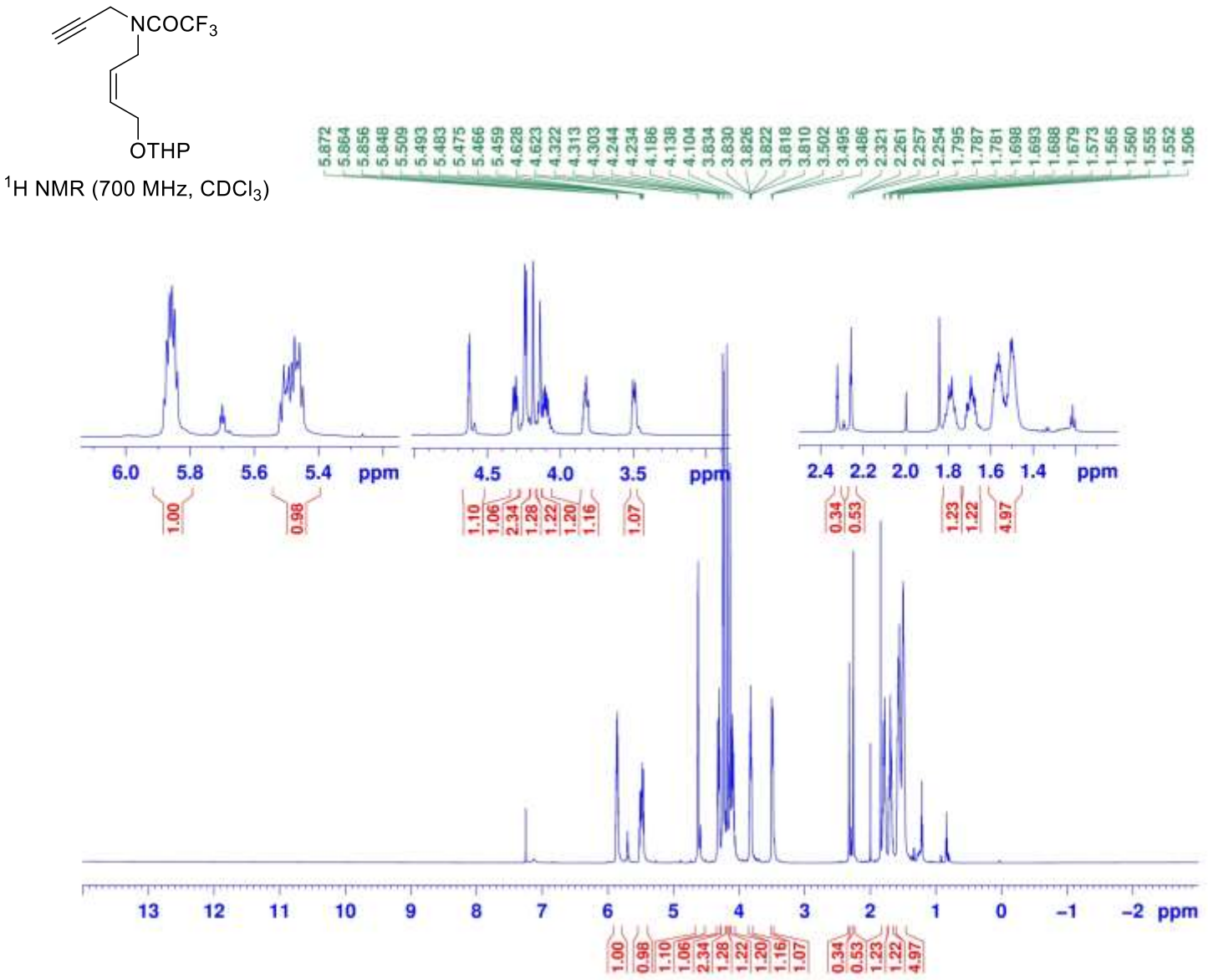
^{1}H NMR (400 MHz, $CDCl_3$)

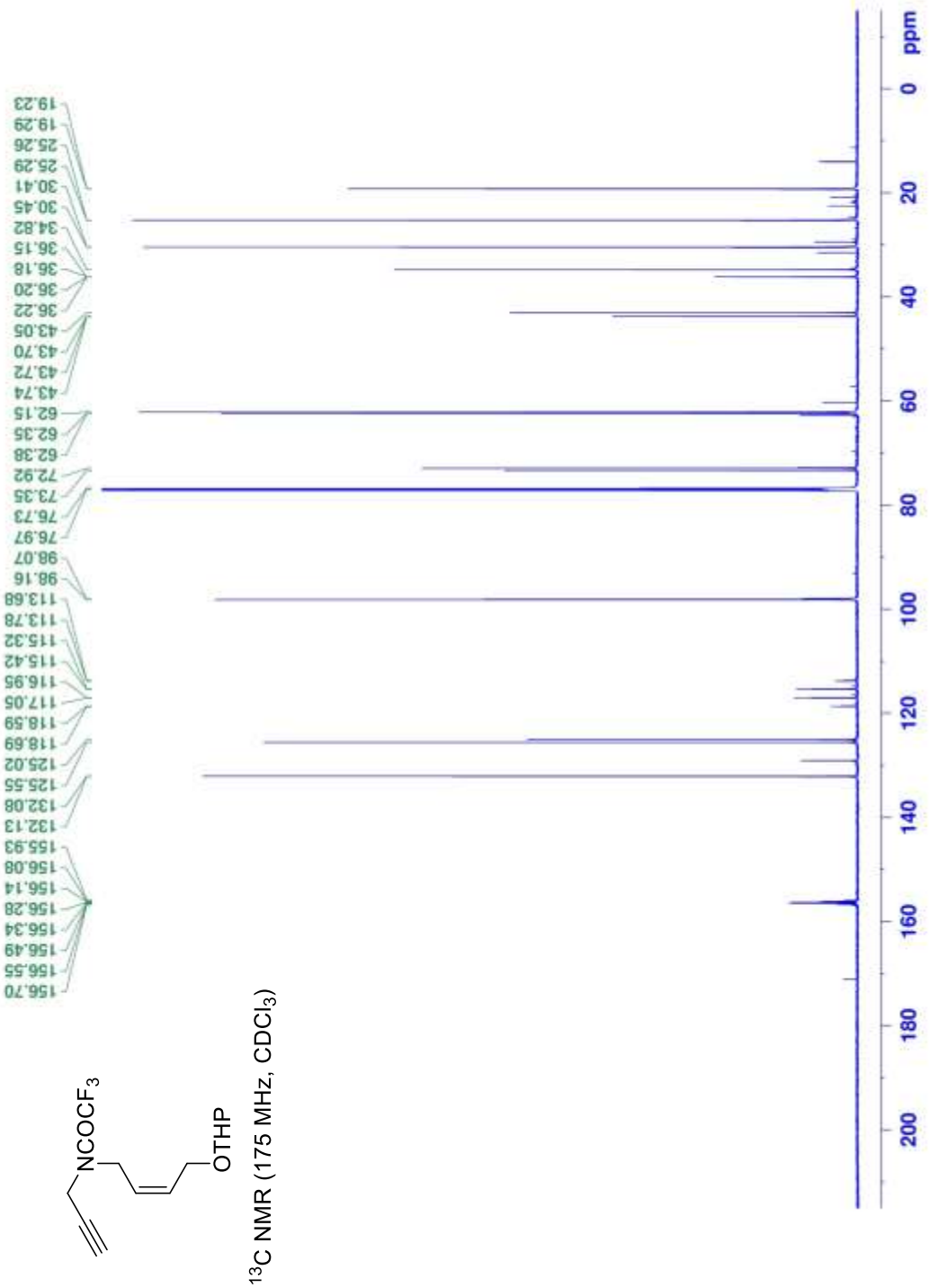

^{13}C NMR (100 MHz, $CDCl_3$)
NTs
OH
21.52
35.97
42.90
58.00
73.86
125.57
127.73
129.53
134.19
135.67
143.72
ppm
0
20
40
60
80
100
120
140
160
180
200



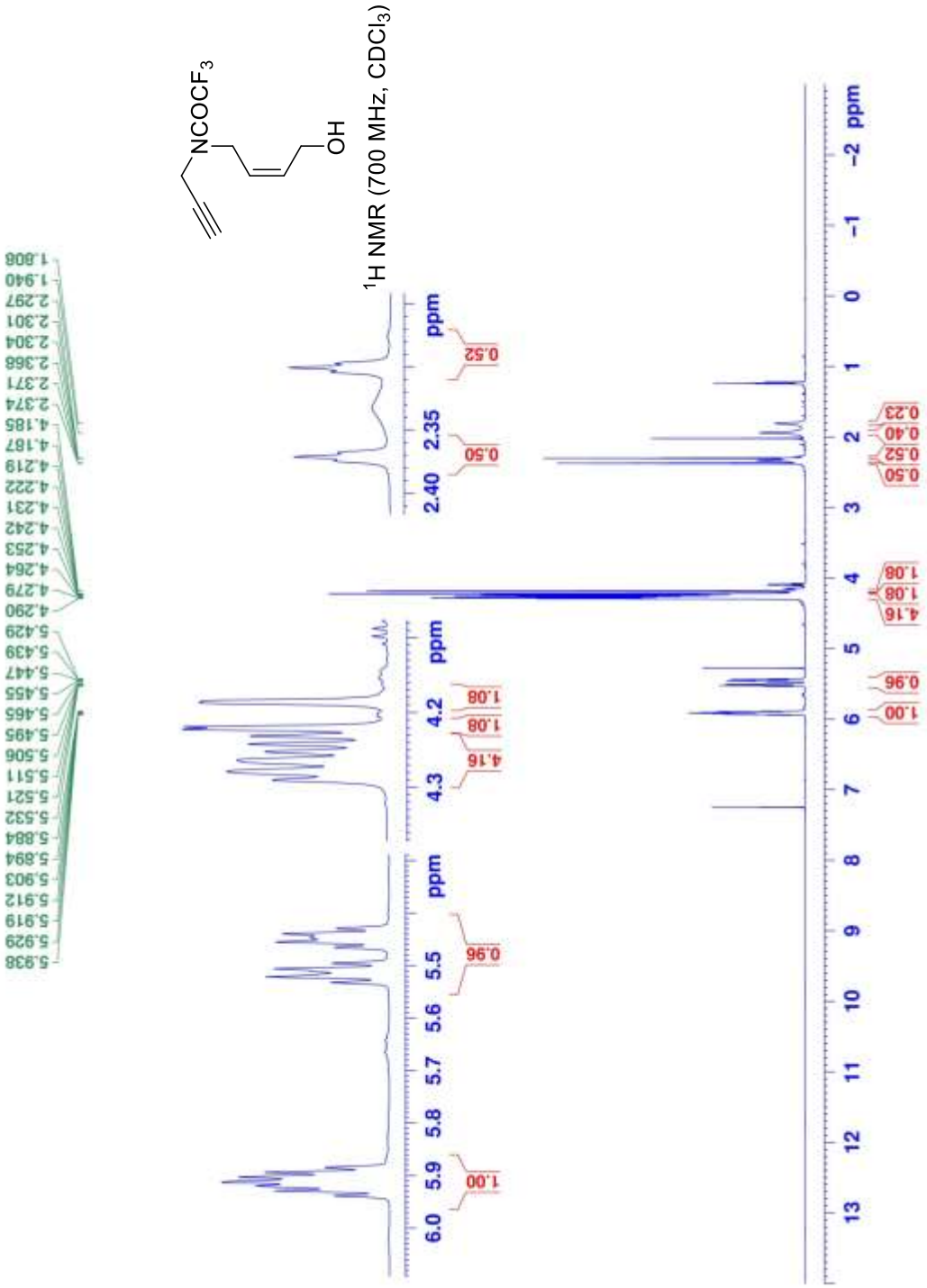
^{1}H NMR (400 MHz, $CDCl_3$)

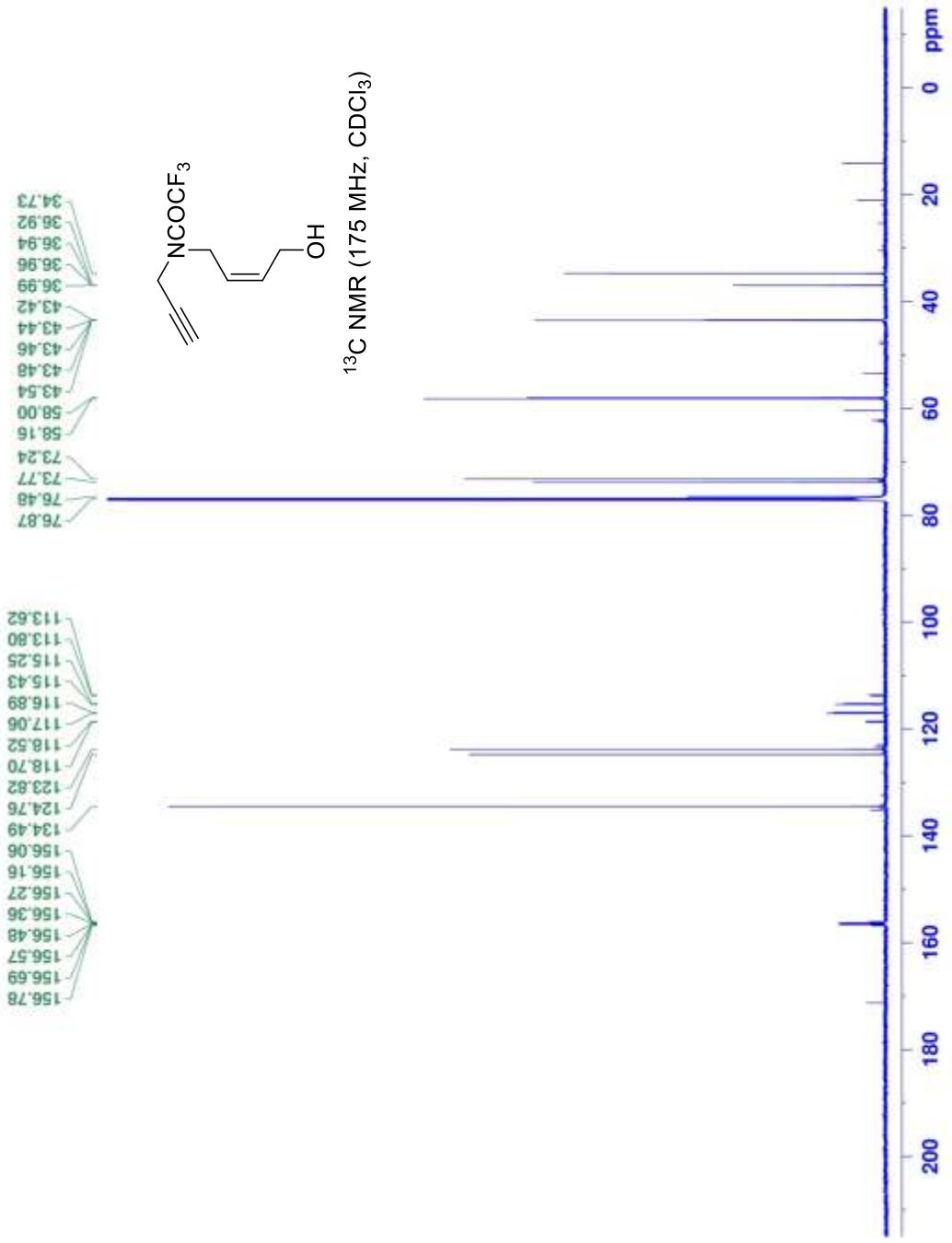

NTs
OCOOMe
^{13}C NMR (100 MHz, $CDCl_3$)
21.54
36.06
43.07
54.85
62.92
74.00
76.41
127.76
128.58
129.57
135.65
143.75
155.54
ppm
0
20
40
60
80
100
120
140
160
180
200

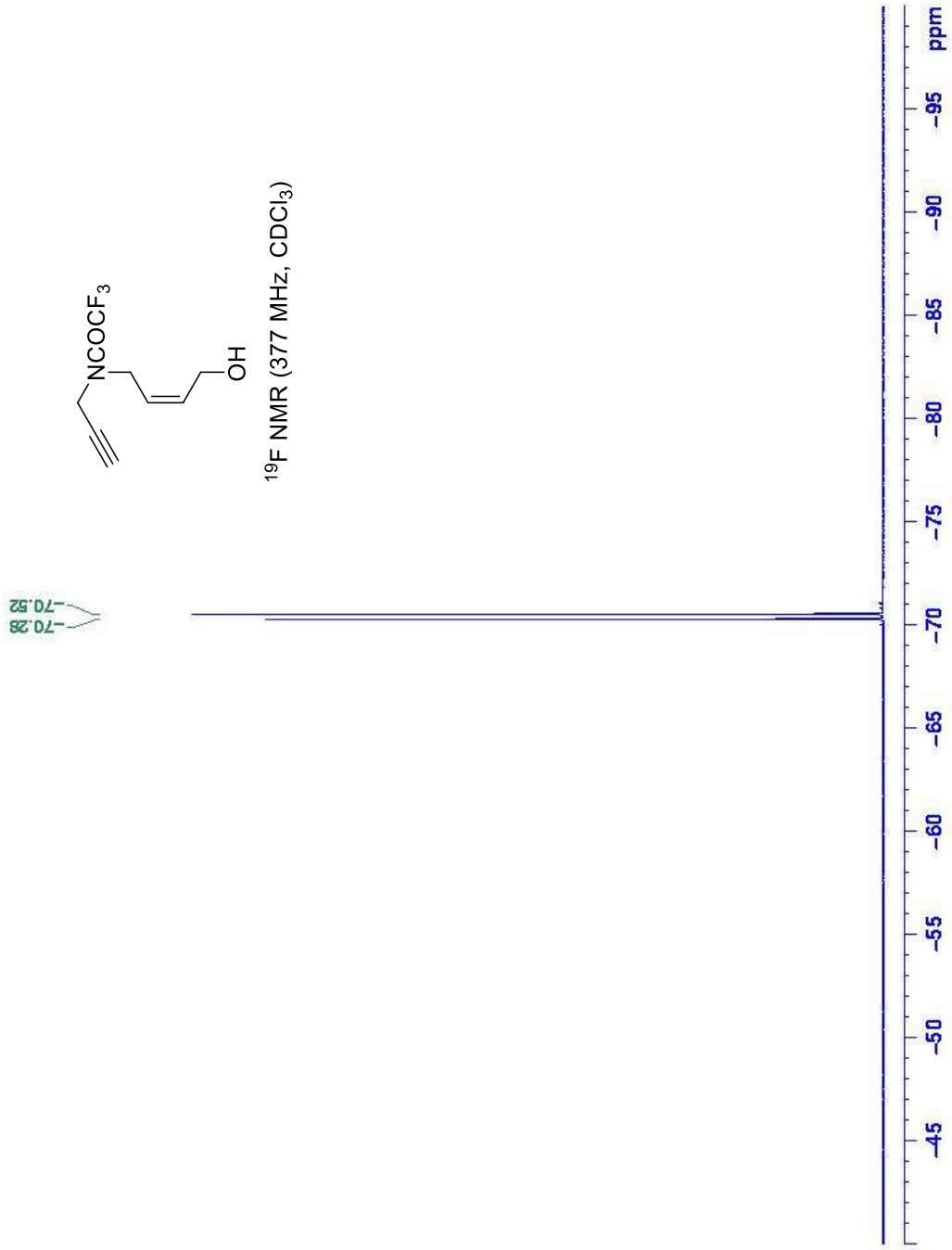

NCOCF3
OTHP
1H NMR (700 MHz, CDCl3)
5.872 5.864 5.856 5.848 5.509 5.493 5.483 5.475 5.466 5.459 4.628 4.623 4.322 4.313 4.303 4.244 4.234 4.186 4.138 4.104 3.834 3.830 3.826 3.822 3.818 3.810 3.502 3.495 3.486 2.321 2.261 2.257 2.254 1.795 1.787 1.781 1.698 1.693 1.688 1.679 1.573 1.565 1.560 1.555 1.552 1.506
6.0 5.8 5.6 5.4 ppm
4.5 4.0 3.5 ppm
2.4 2.2 2.0 1.8 1.6 1.4 ppm
1.00 0.98 1.10 1.06 2.34 1.28 1.22 1.20 1.16 1.07 0.34 0.53 1.23 1.22 4.97
13 12 11 10 9 8 7 6 5 4 3 2 1 0 −1 −2 ppm

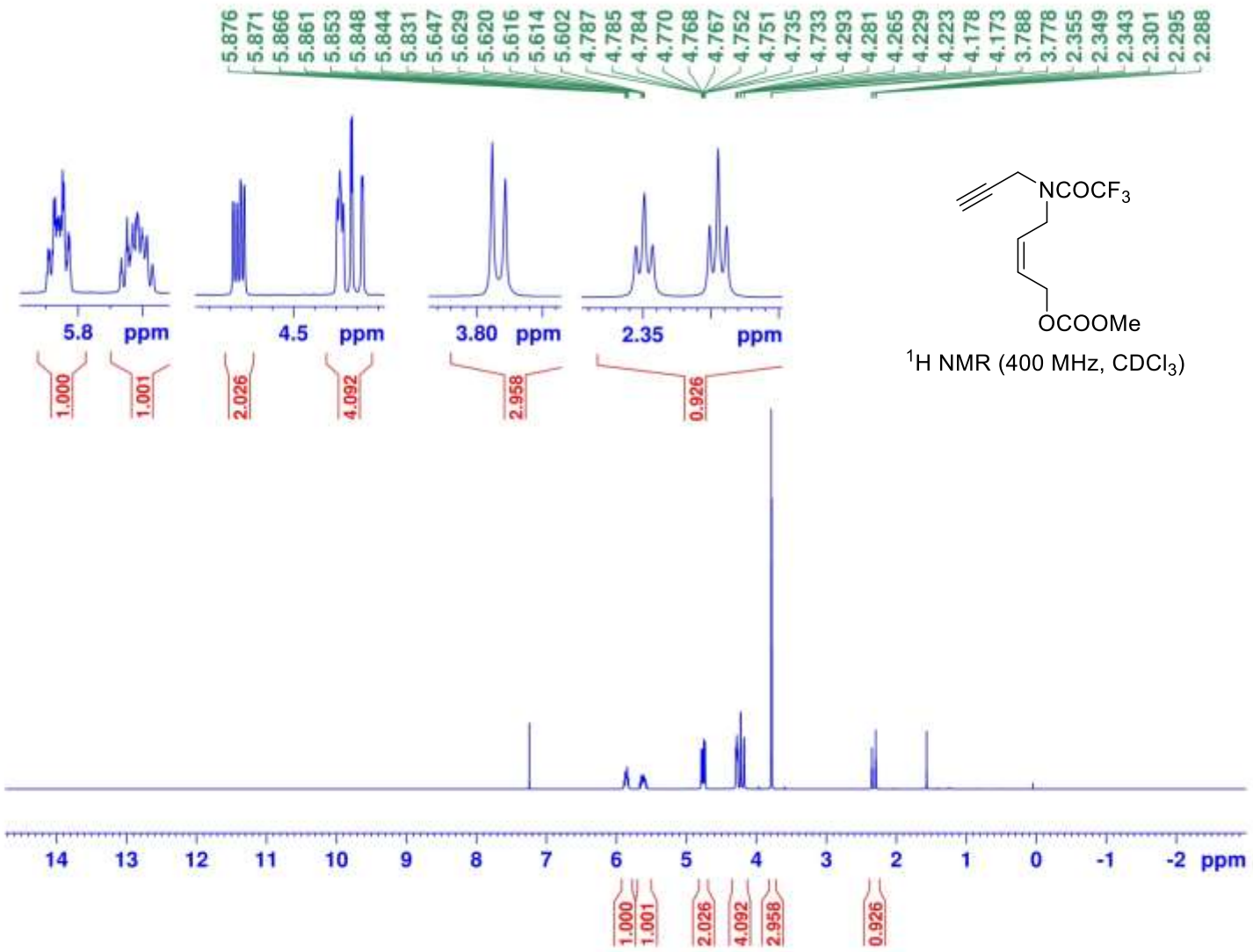

NCOCF3
OTHP
13C NMR (175 MHz, CDCl3)
19.23
19.29
25.26
25.29
30.41
30.45
34.82
36.15
36.18
36.20
36.22
43.05
43.70
43.72
43.74
62.15
62.35
62.38
72.92
73.35
76.73
76.97
98.07
98.16
113.68
113.78
115.32
115.42
116.95
117.05
118.59
118.69
125.02
125.55
132.08
132.13
155.93
156.08
156.14
156.28
156.34
156.49
156.55
156.70
ppm
0
20
40
60
80
100
120
140
160
180
200

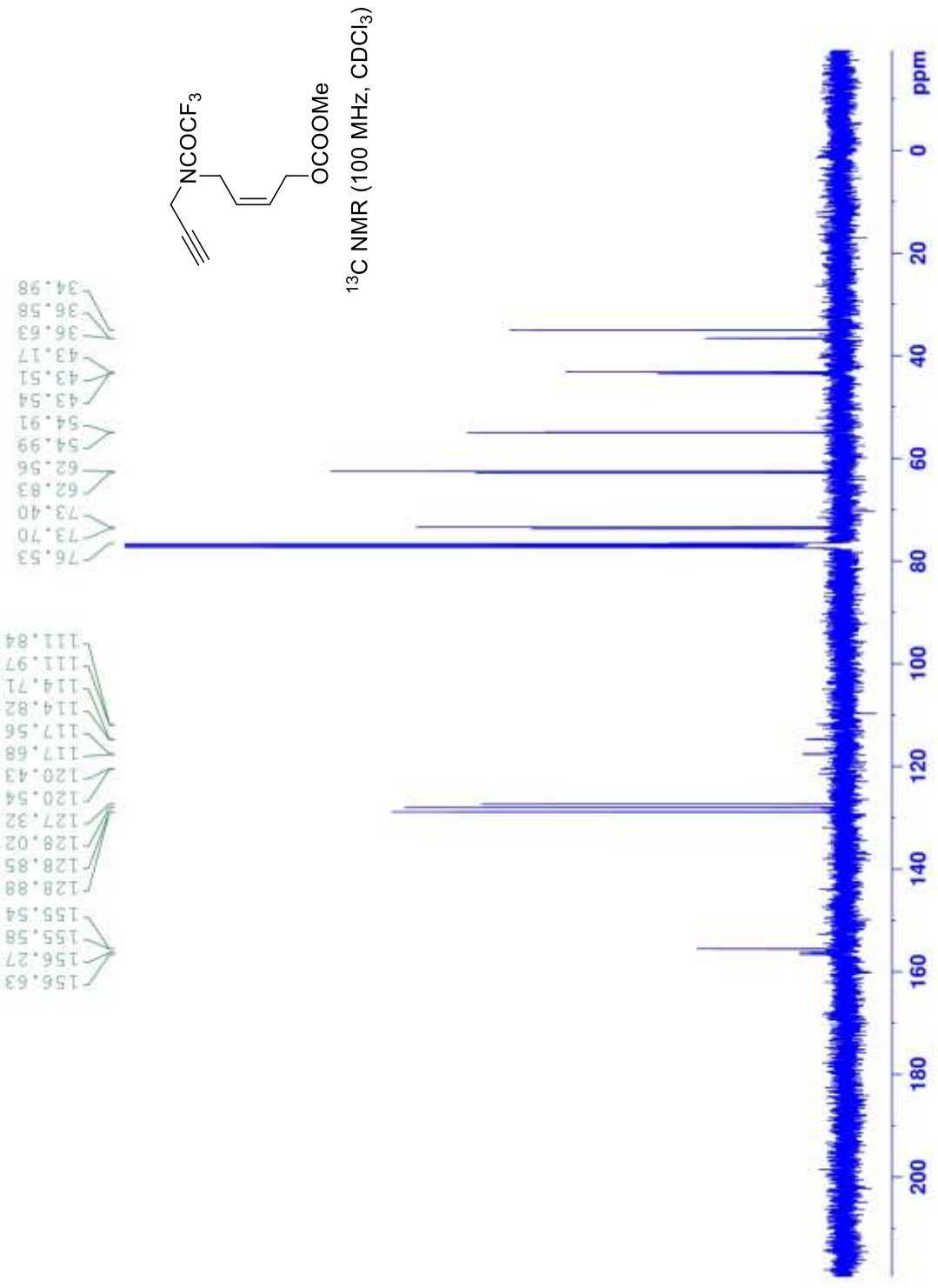
NCOCF3
OTHP
19F NMR (377 MHz, CDCl3)
-70.27
-70.45
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
-95
ppm


NCOCF3
OH
1H NMR (700 MHz, CDCl3)

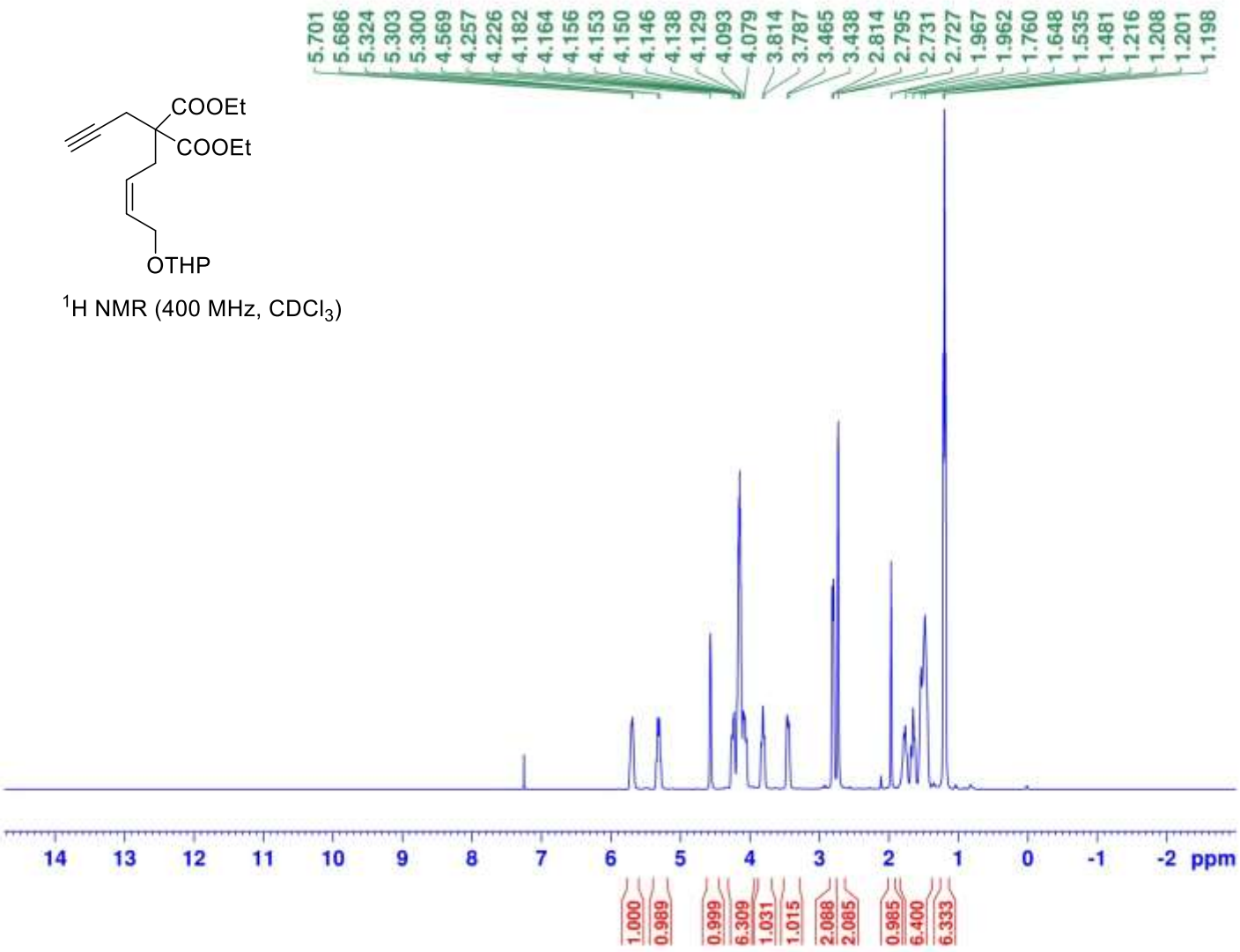

^{13}C NMR (175 MHz, CDCl$_3$)
NCOCF$_3$
OH
ppm
0
20
40
60
80
100
120
140
160
180
200
34.73
36.92
36.94
36.96
36.99
43.42
43.44
43.46
43.48
43.54
58.00
58.16
73.24
73.77
76.48
76.87
113.62
113.80
115.25
115.43
116.89
117.06
118.52
118.70
123.82
124.76
134.49
156.06
156.16
156.27
156.36
156.48
156.57
156.69
156.78


NCOCF3
OH
19F NMR (377 MHz, CDCl3)
-70.28
-70.52
ppm
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
-95

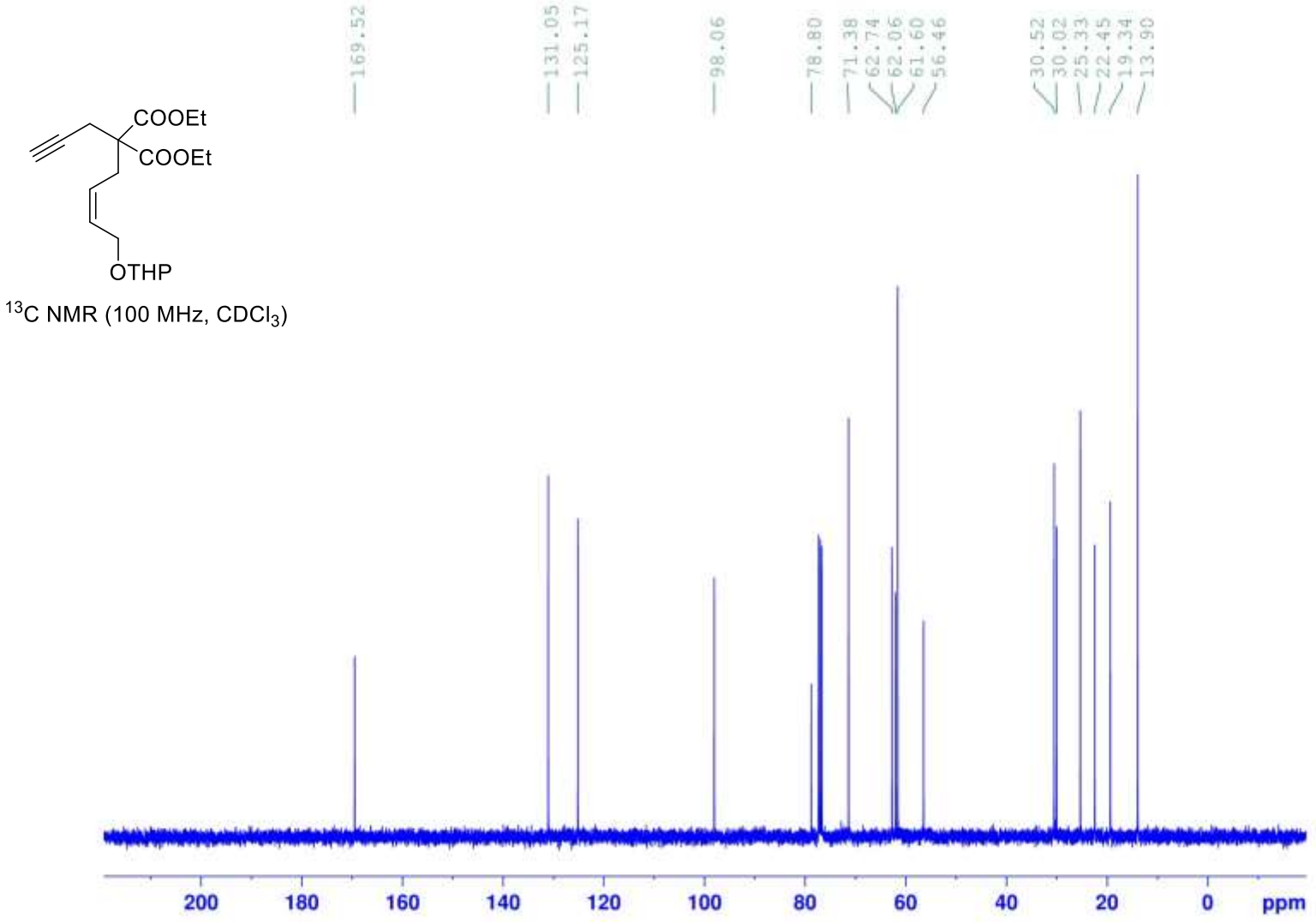

5.876
5.871
5.866
5.861
5.853
5.848
5.844
5.831
5.647
5.629
5.620
5.616
5.614
5.602
4.787
4.785
4.784
4.770
4.768
4.767
4.752
4.751
4.735
4.733
4.293
4.281
4.265
4.229
4.223
4.178
4.173
3.788
3.778
2.355
2.349
2.343
2.301
2.295
2.288
5.8 ppm
4.5 ppm
3.80 ppm
2.35 ppm
1.000
1.001
2.026
4.092
2.958
0.926
NCOCF3
OCOOMe
1H NMR (400 MHz, CDCl3)
14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 -1 -2 ppm
1.000
1.001
2.026
4.092
2.958
0.926


NCOCF3
OCOOMe
13C NMR (100 MHz, CDCl3)
ppm
0
20
40
60
80
100
120
140
160
180
200
34.98
36.58
36.63
43.17
43.51
43.54
54.91
54.99
62.56
62.83
73.40
73.70
76.53
111.84
111.97
114.71
114.82
117.56
117.68
120.43
120.54
127.32
128.02
128.85
128.88
155.54
155.58
156.27
156.63

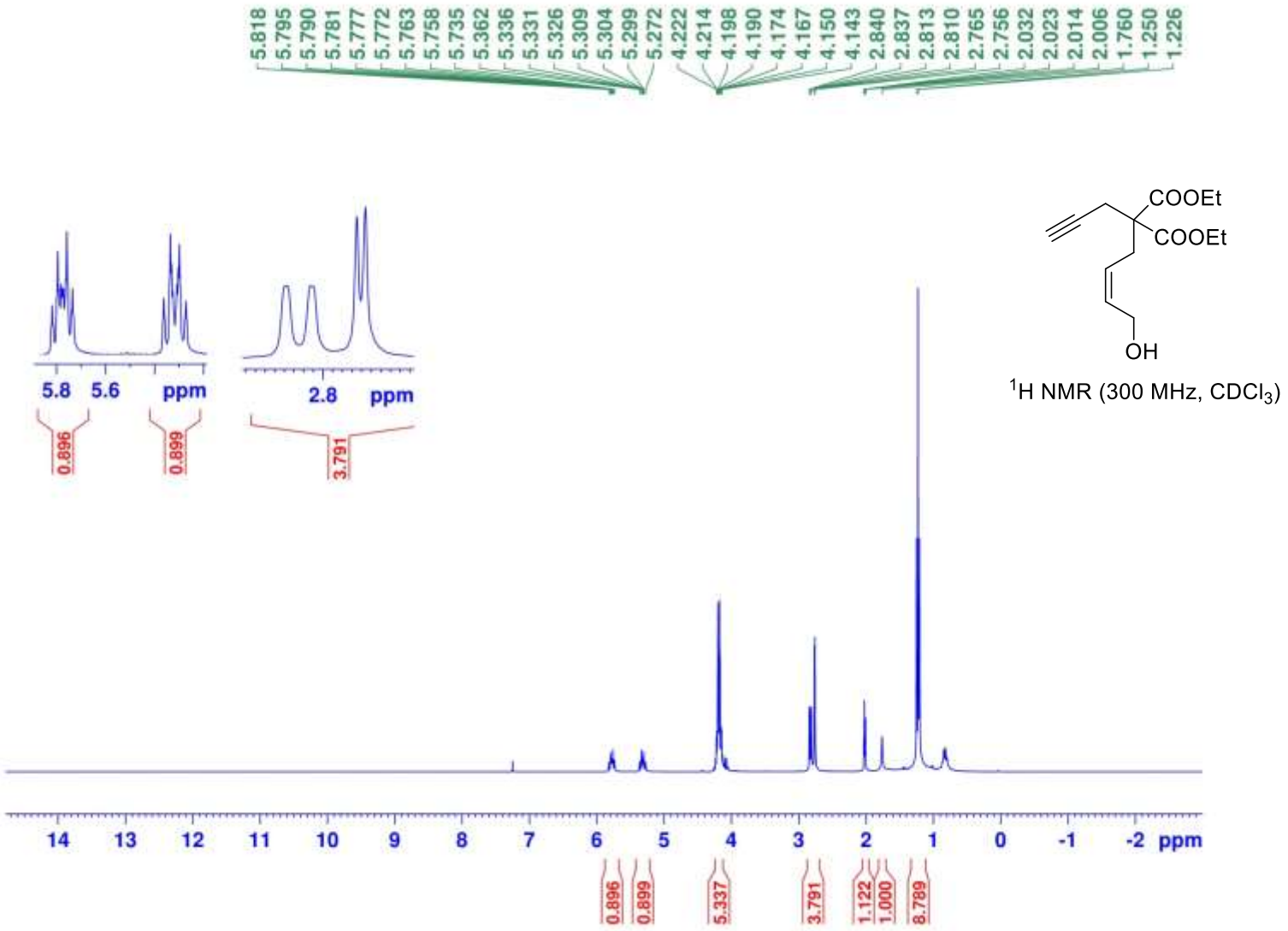
NCOCF3
OCOOMe
19F NMR (377 MHz, CDCl3)
-70.27
-70.50
ppm
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
-95



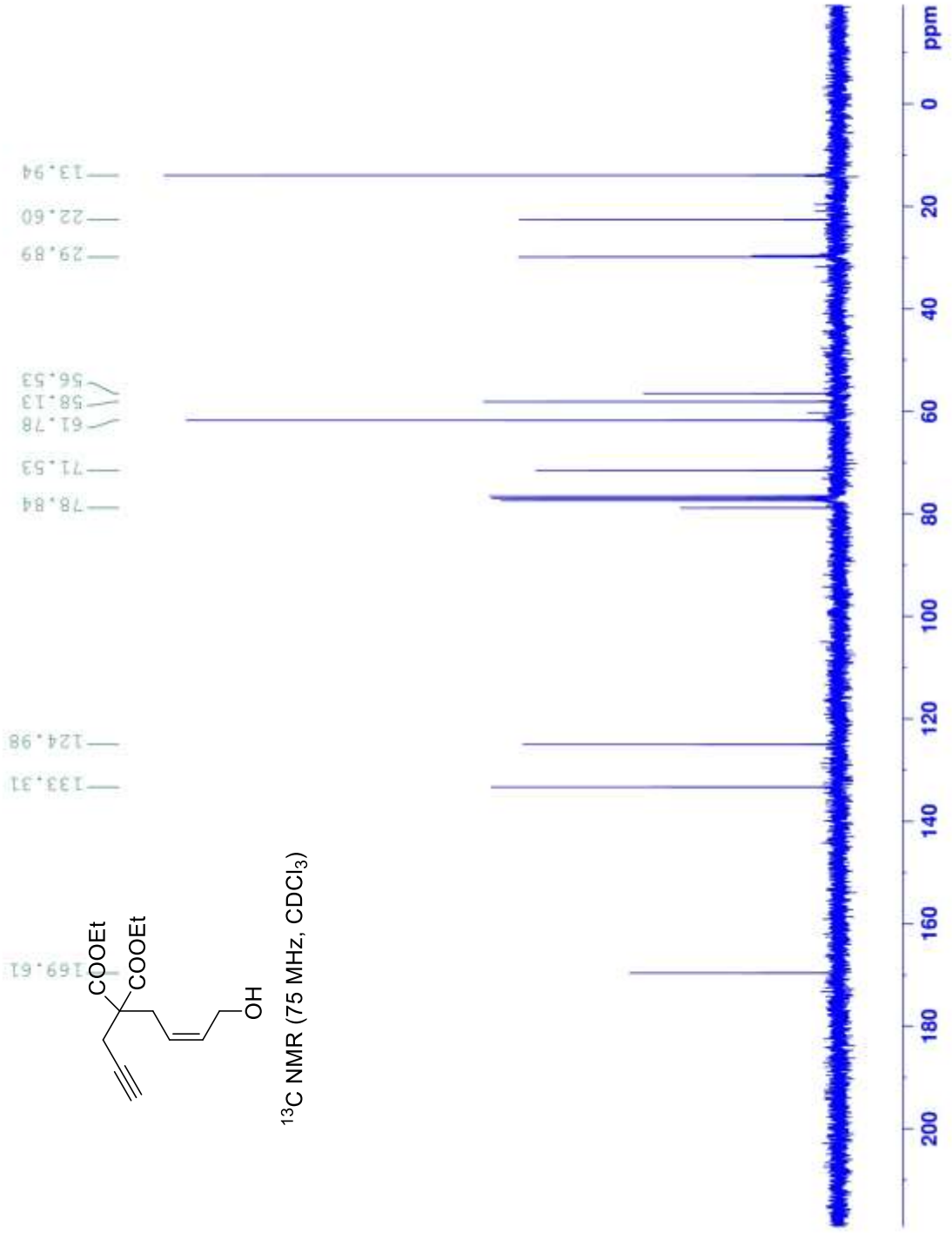
^{1}H NMR (400 MHz, $CDCl_3$)

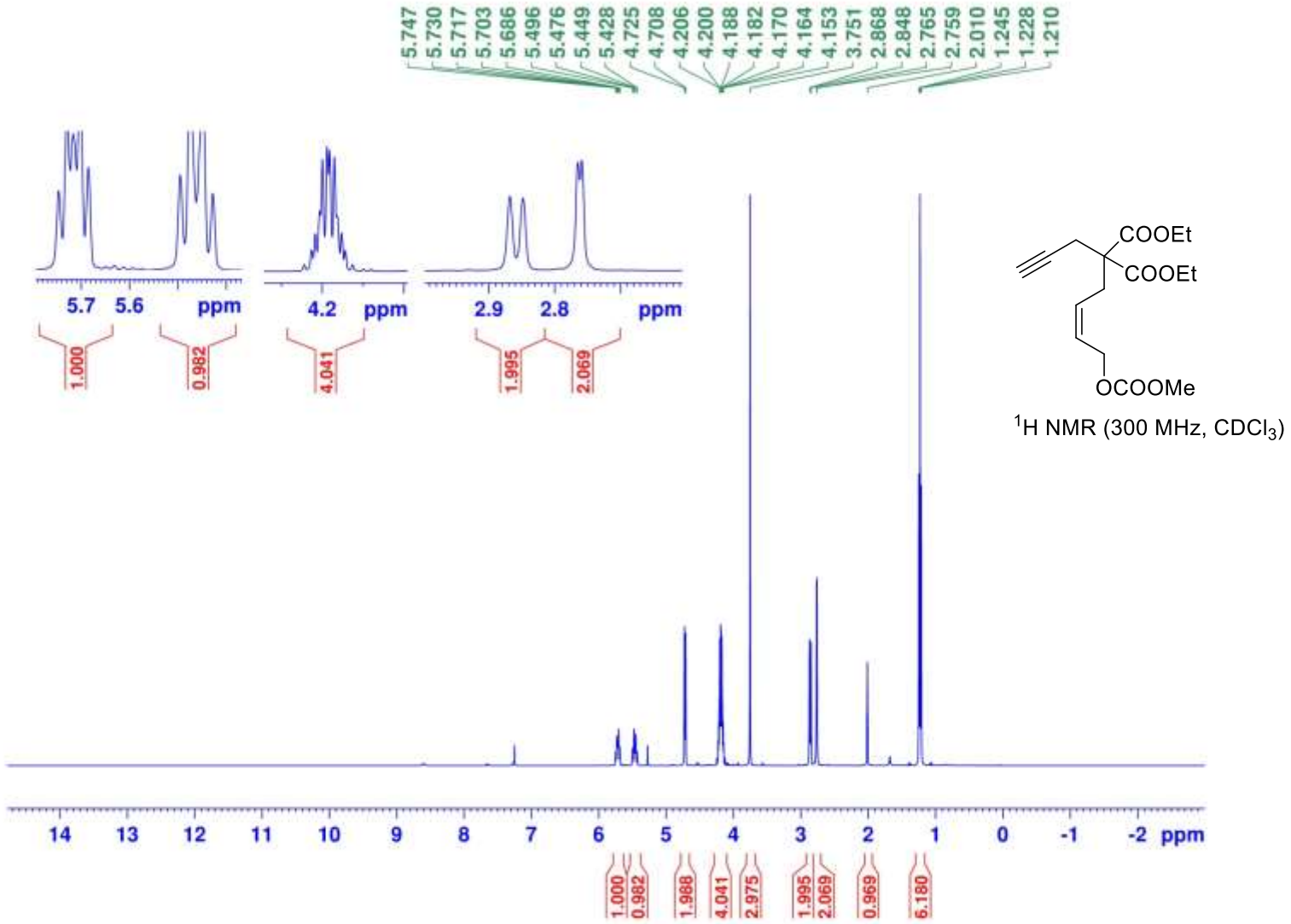


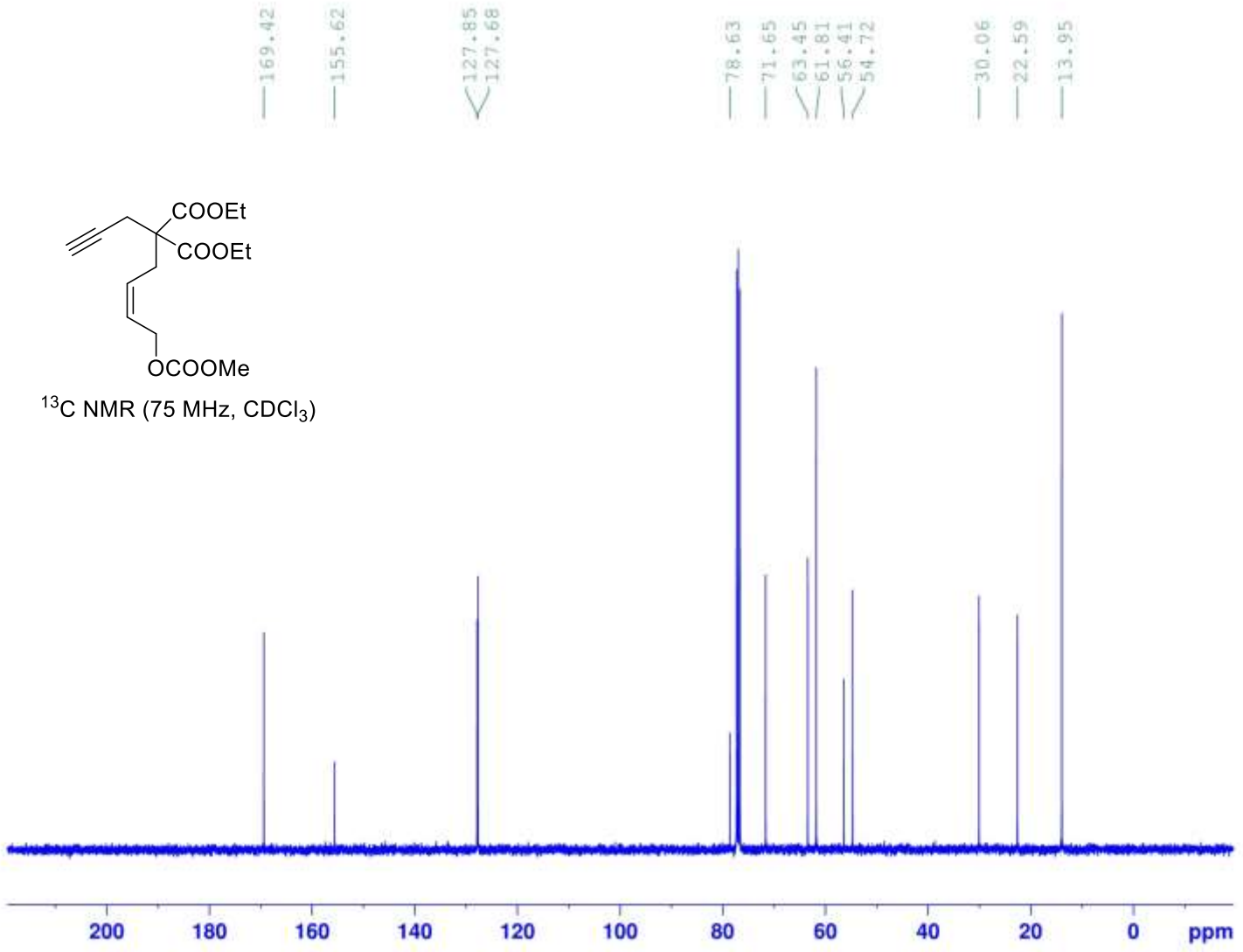
^{13}C NMR (100 MHz, $CDCl_3$)



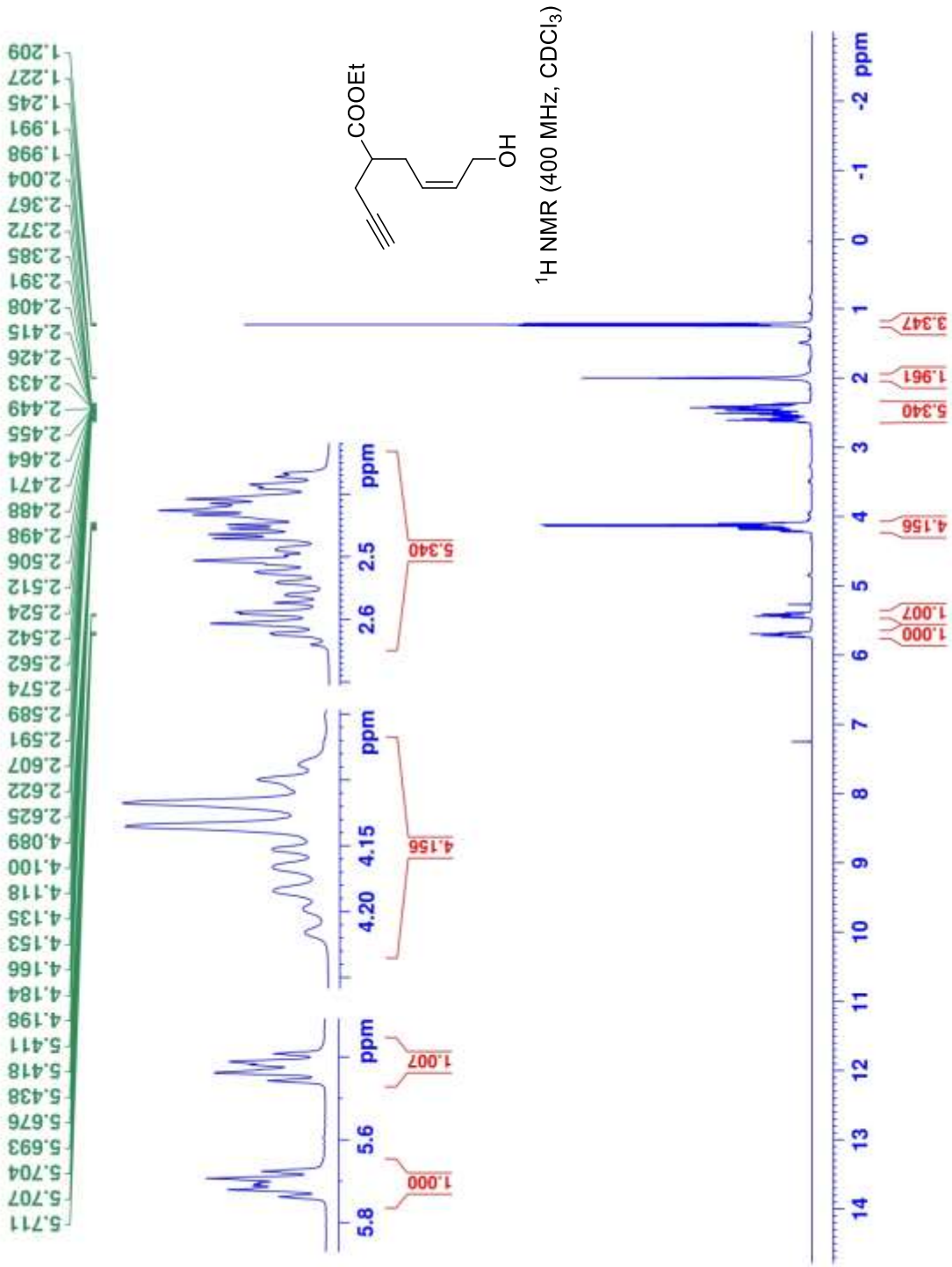
^{1}H NMR (300 MHz, $CDCl_3$)

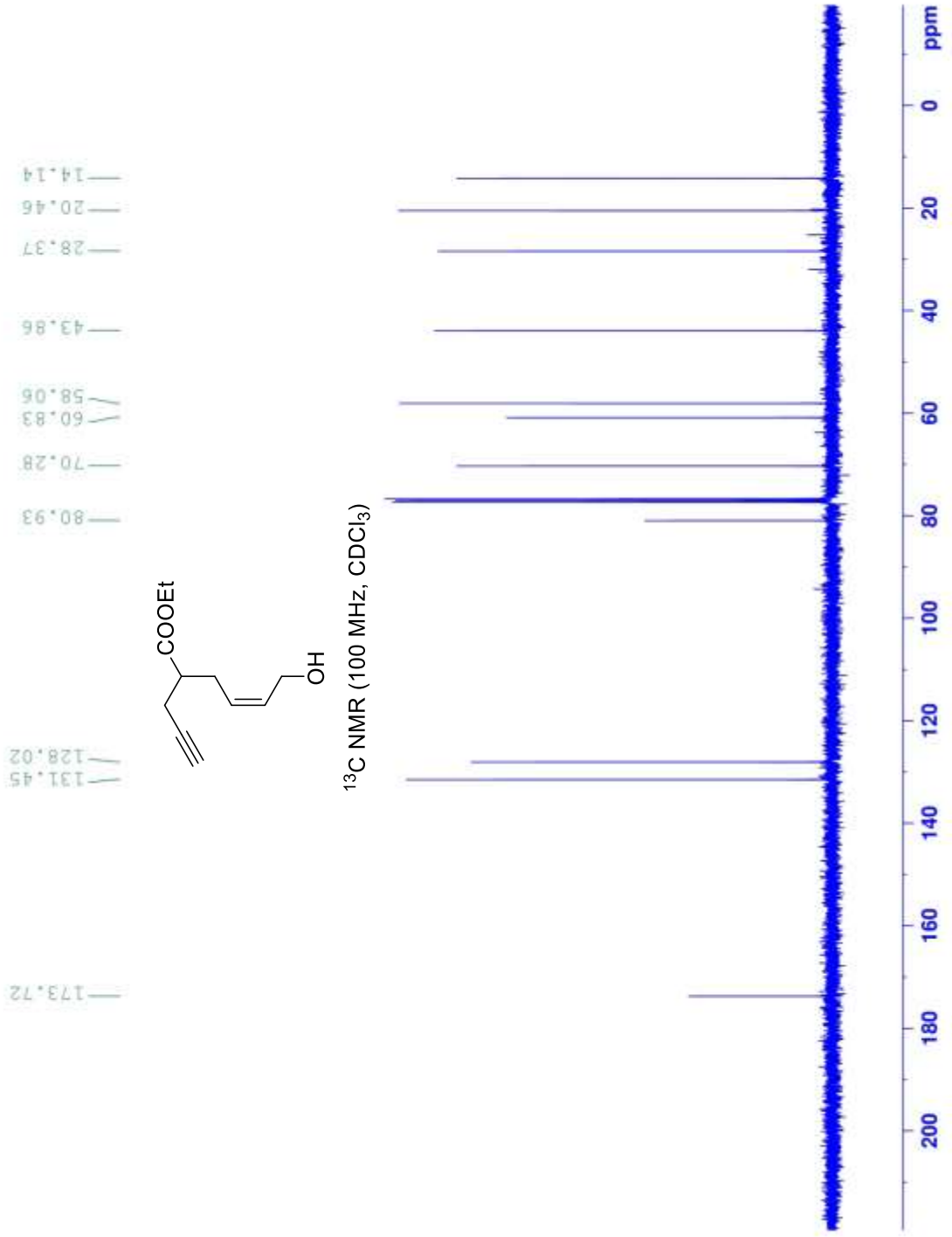

13.94
22.60
29.89
56.53
58.13
61.78
71.53
78.84
124.98
133.31
169.61
COOEt
COOEt
OH
^{13}C NMR (75 MHz, $CDCl_3$)
ppm
0
20
40
60
80
100
120
140
160
180
200

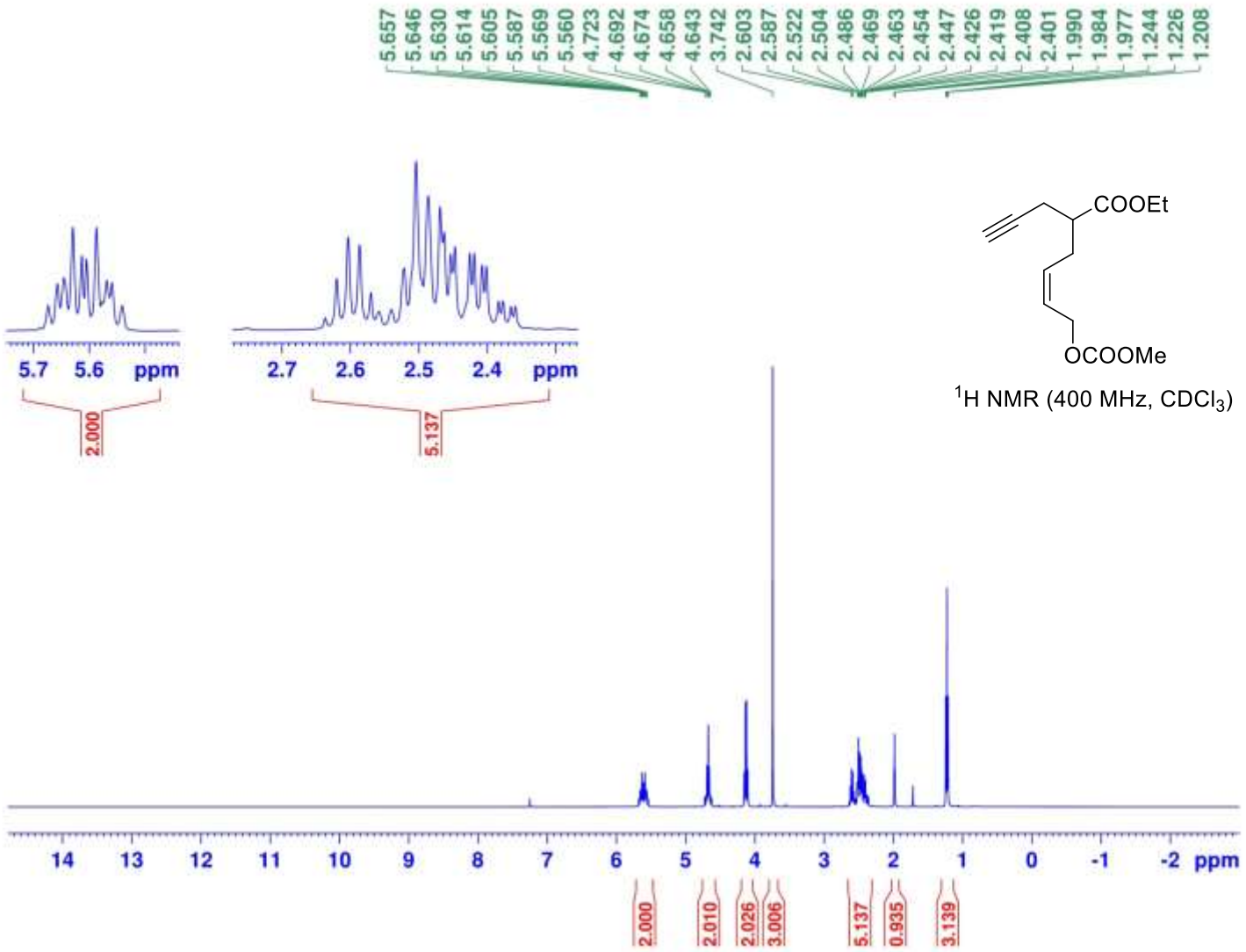

5.747
5.730
5.717
5.703
5.686
5.496
5.476
5.449
5.428
4.725
4.708
4.206
4.200
4.188
4.182
4.170
4.164
4.153
3.751
2.868
2.848
2.765
2.759
2.010
1.245
1.228
1.210
5.7
5.6
ppm
4.2
ppm
2.9
2.8
ppm
1.000
0.982
4.041
1.995
2.069
COOEt
COOEt
OCOOMe
1H NMR (300 MHz, CDCl3)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
ppm
1.000
0.982
1.988
4.041
2.975
1.995
2.069
0.969
6.180



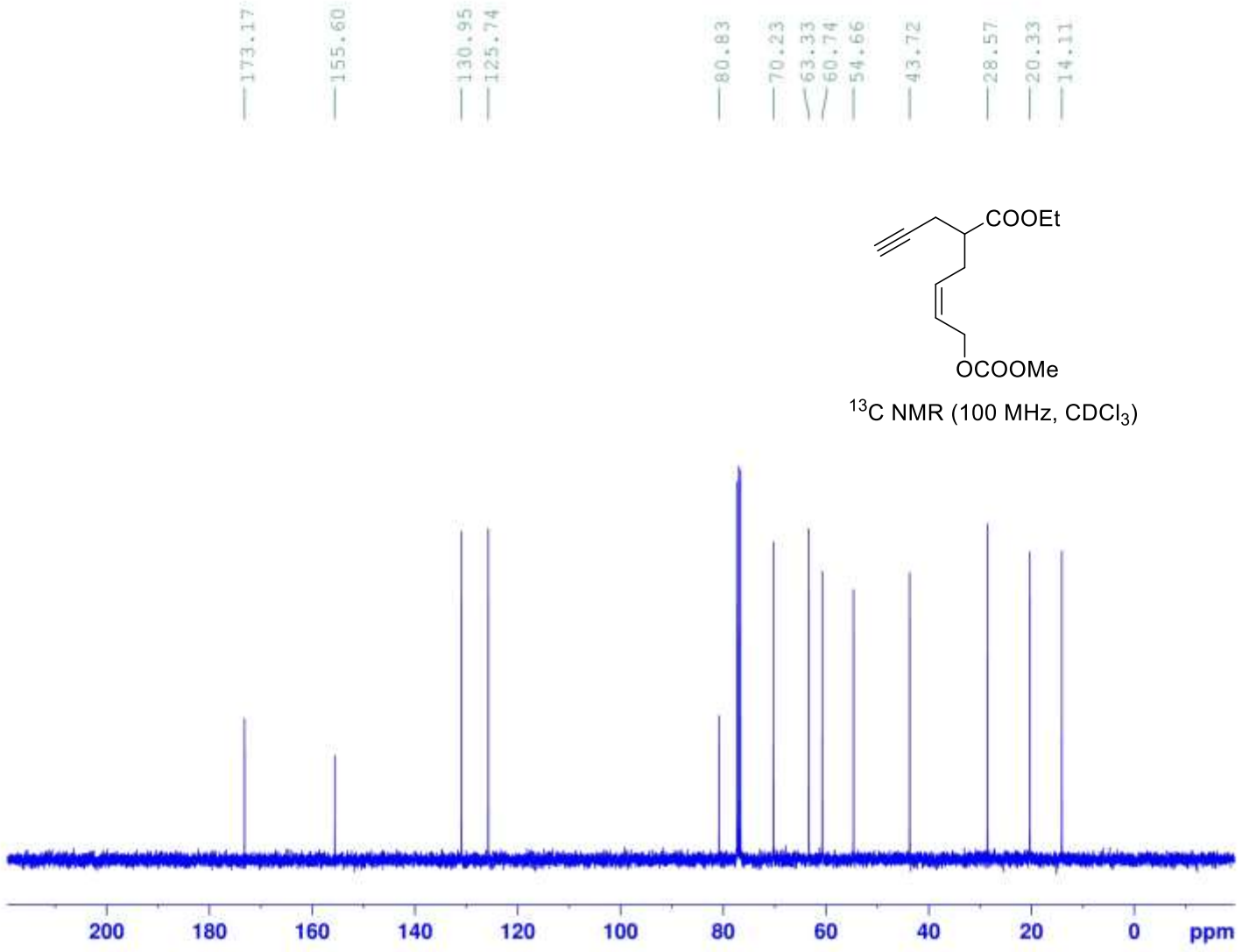
^{13}C NMR (75 MHz, $CDCl_3$)


^{1}H NMR (400 MHz, CDCl$_3$)
COOEt
OH
ppm
3.347
1.961
5.340
4.156
1.007
1.000

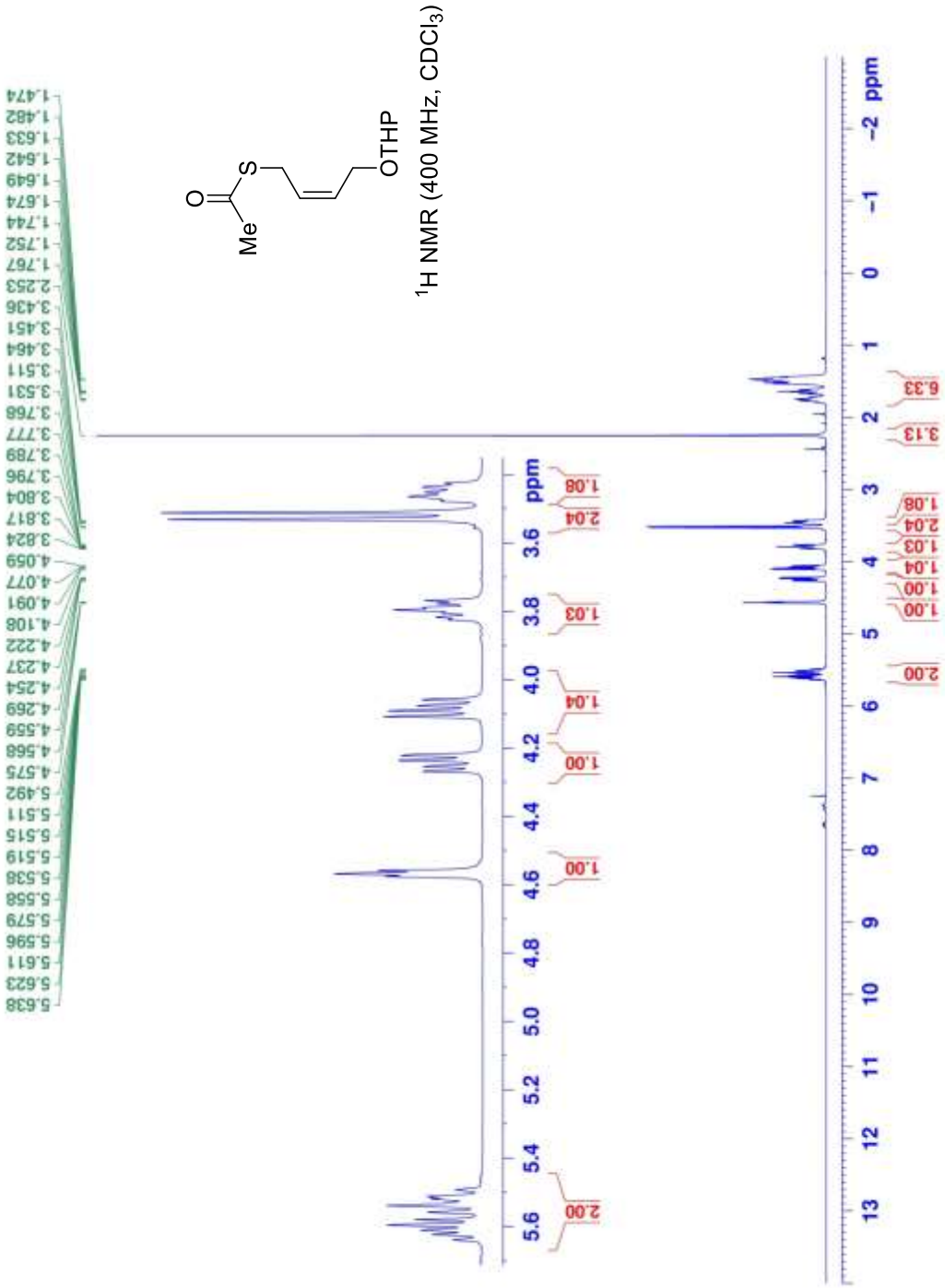

14.14
20.46
28.37
43.86
58.06
60.83
70.28
80.93
128.02
131.45
173.72
COOEt
OH
^{13}C NMR (100 MHz, $CDCl_3$)
ppm
0
20
40
60
80
100
120
140
160
180
200

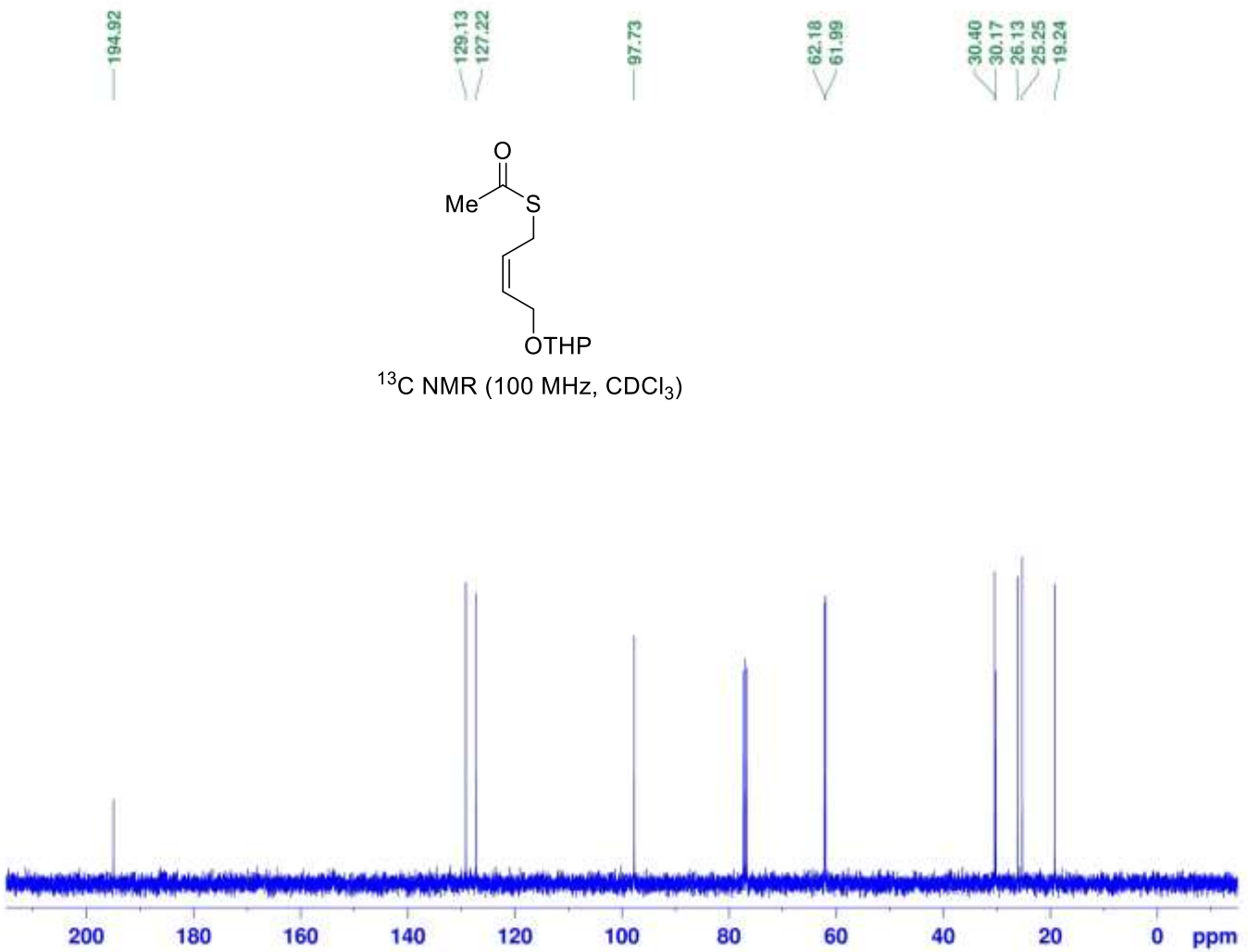


^{1}H NMR (400 MHz, $CDCl_3$)

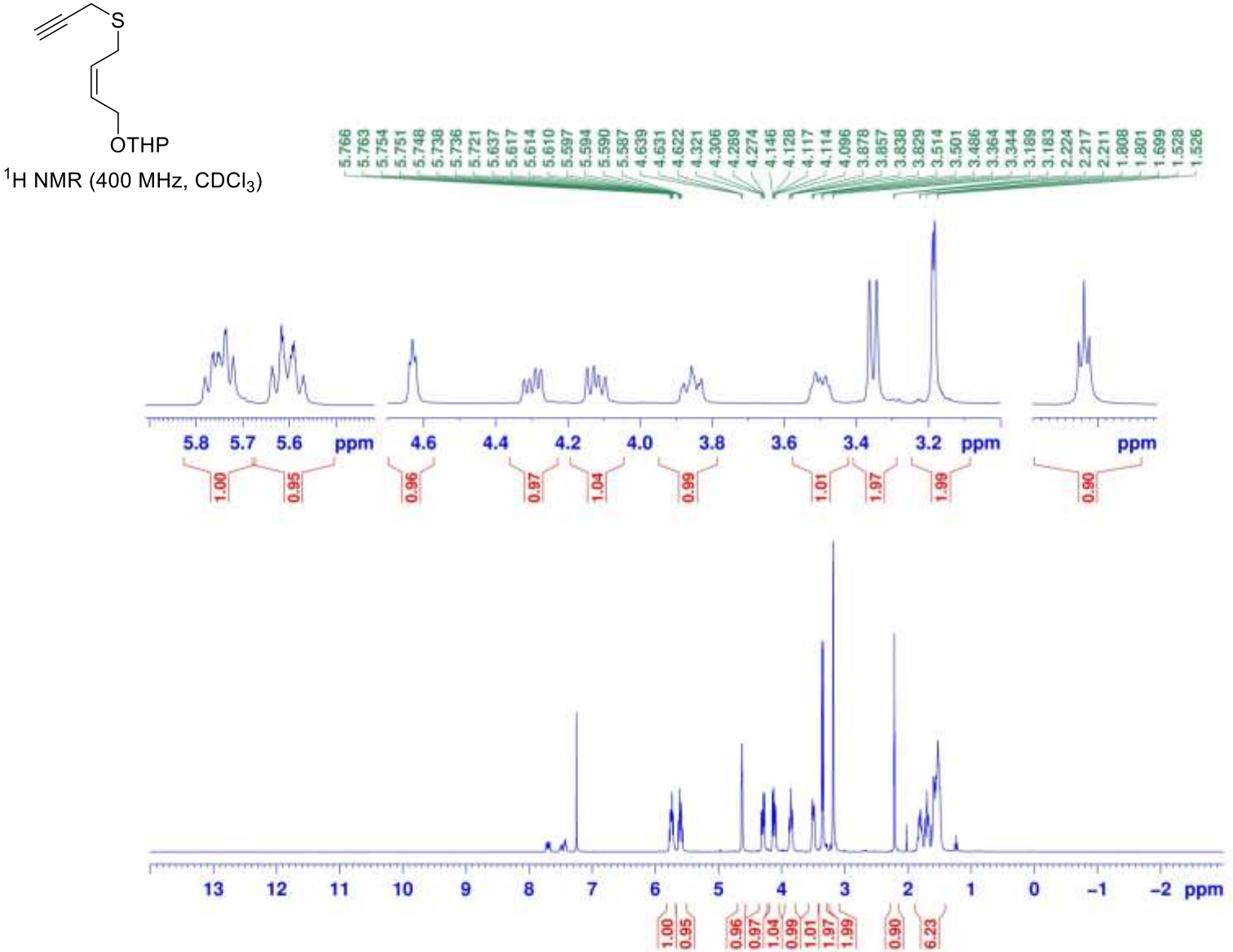


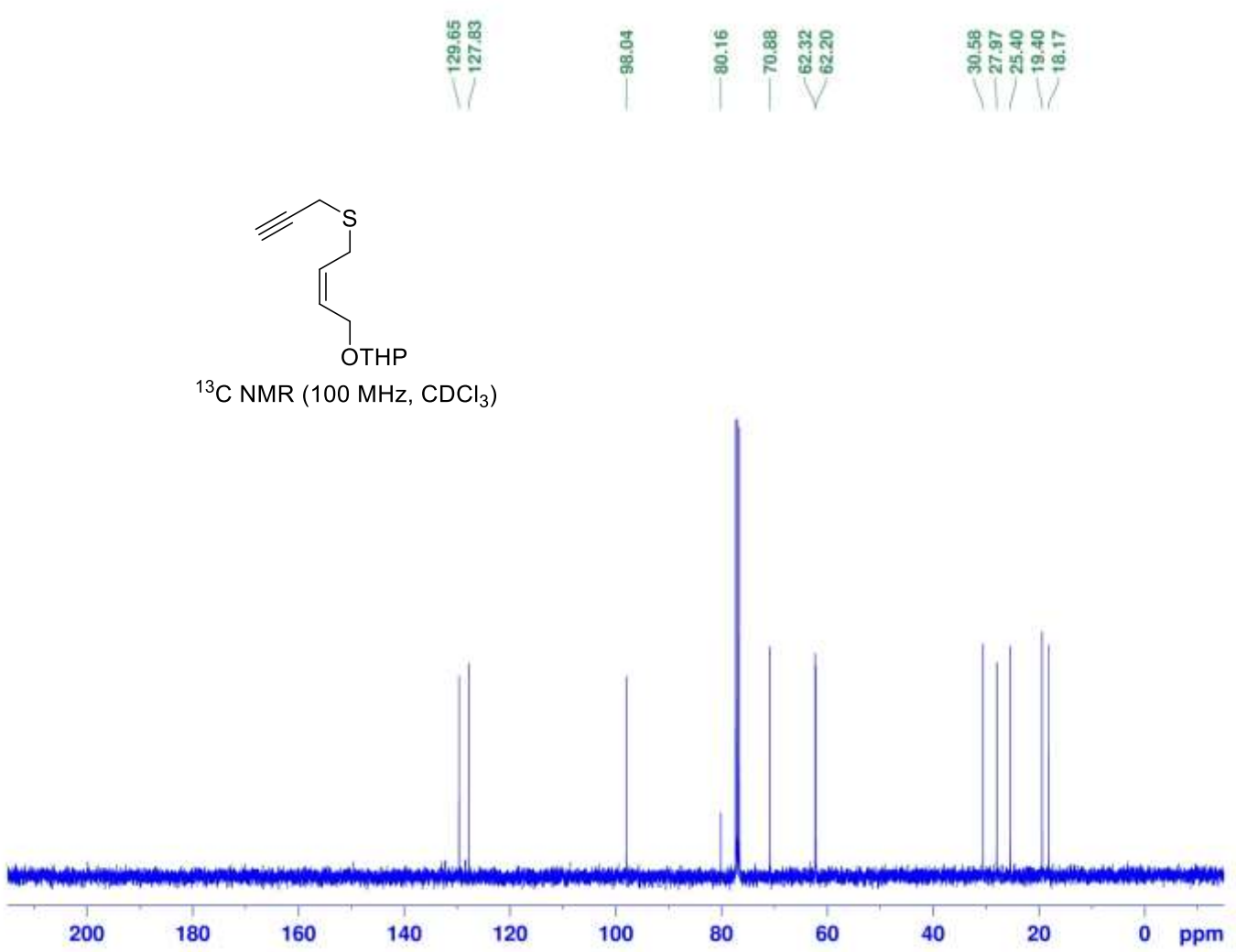
^{13}C NMR (100 MHz, $CDCl_3$)


^{1}H NMR (400 MHz, $CDCl_3$)
O
S
Me
OTHP
ppm

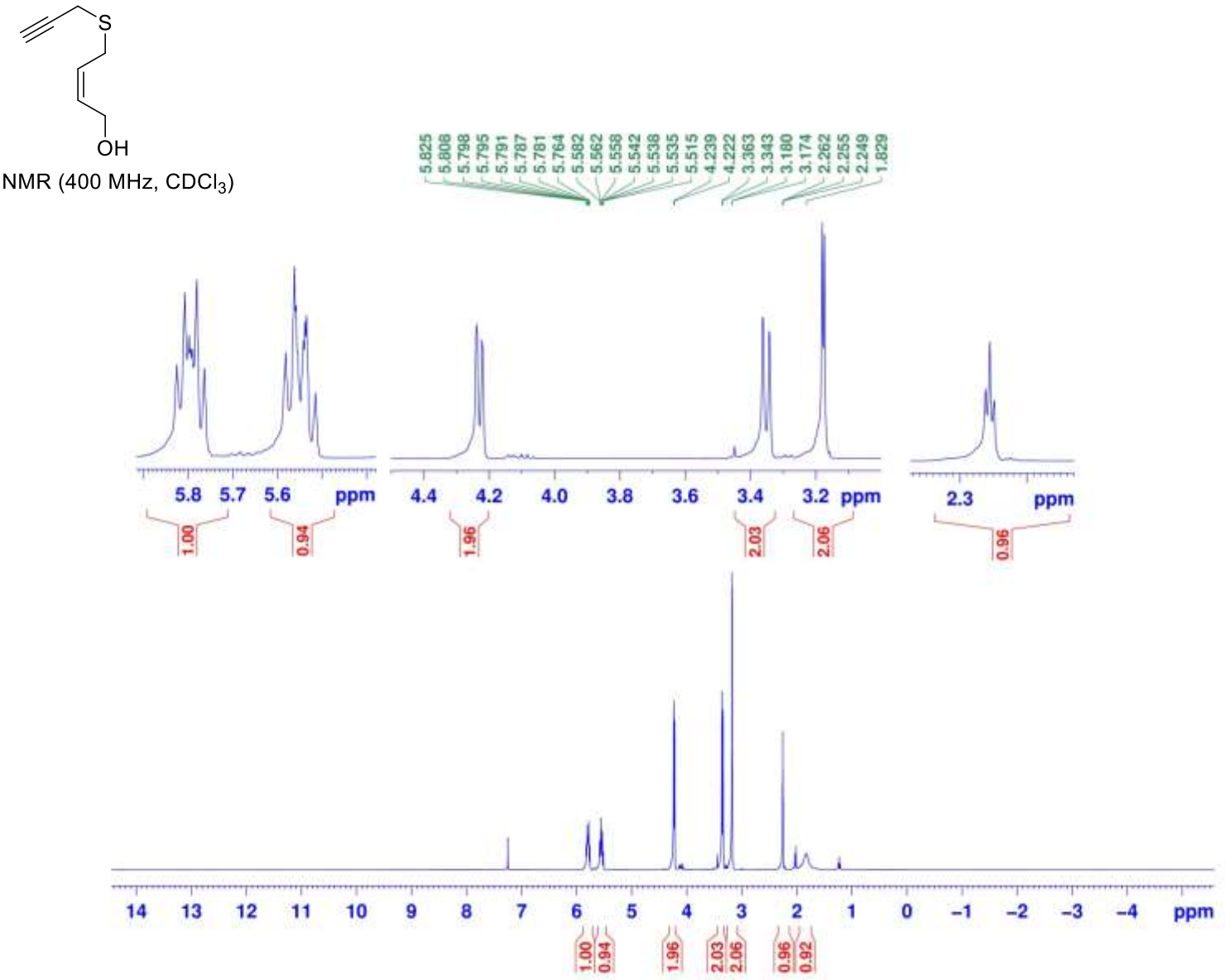


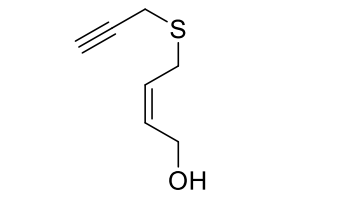
^{13}C NMR (100 MHz, $CDCl_3$)


S
OTHP
1H NMR (400 MHz, CDCl3)
5.766 5.763 5.754 5.751 5.748 5.738 5.736 5.721 5.637 5.617 5.614 5.610 5.597 5.594 5.590 5.587 4.639 4.631 4.622 4.321 4.306 4.289 4.274 4.146 4.128 4.117 4.114 4.096 3.878 3.857 3.838 3.829 3.514 3.501 3.486 3.364 3.344 3.189 3.183 2.224 2.217 2.211 1.808 1.801 1.699 1.528 1.526
5.8 5.7 5.6 ppm 4.6 4.4 4.2 4.0 3.8 3.6 3.4 3.2 ppm ppm
1.00 0.95 0.96 0.97 1.04 0.99 1.01 1.97 1.99 0.90
13 12 11 10 9 8 7 6 5 4 3 2 1 0 −1 −2 ppm
1.00 0.95 0.96 0.97 1.04 0.99 1.01 1.97 1.99 0.90 6.23

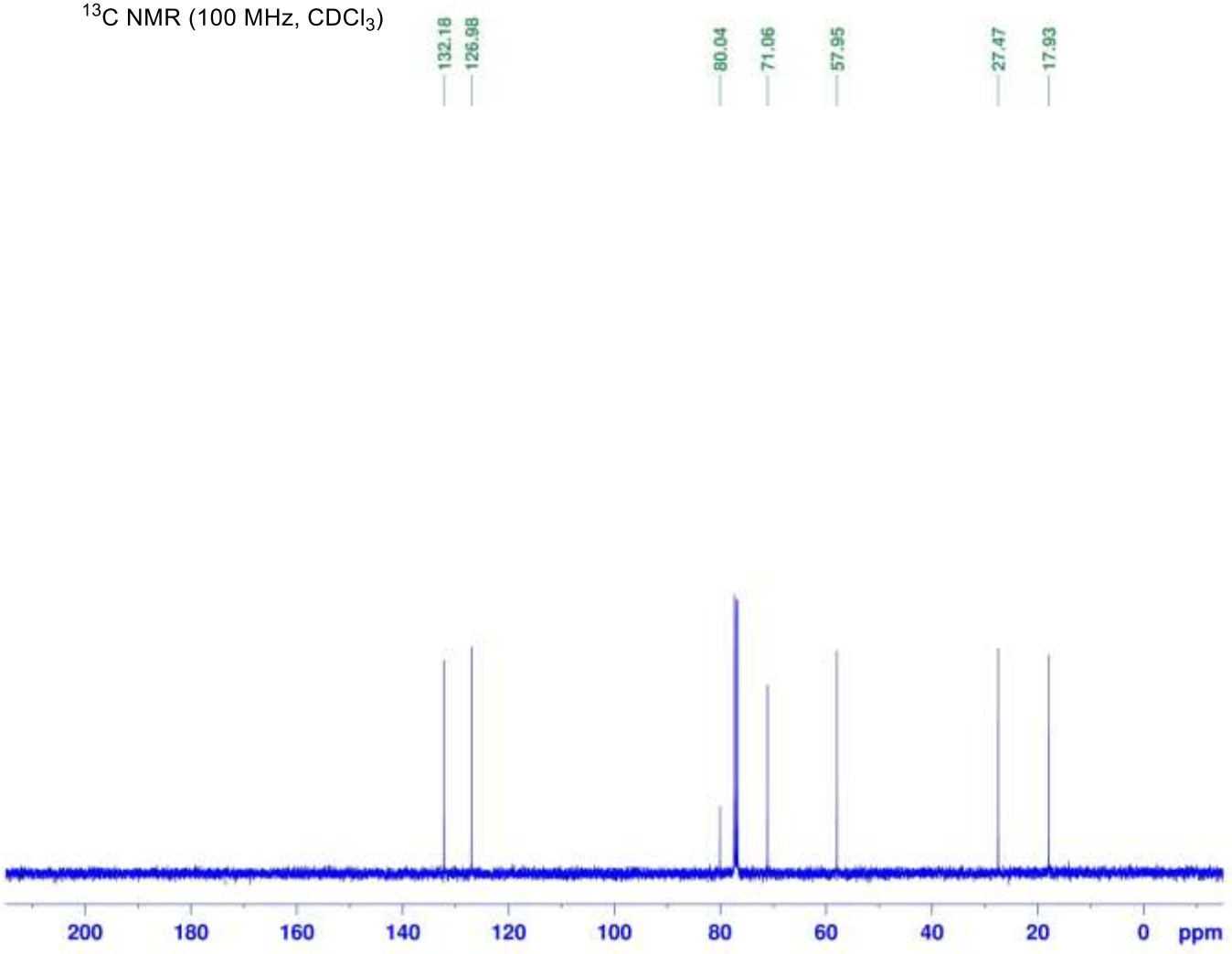


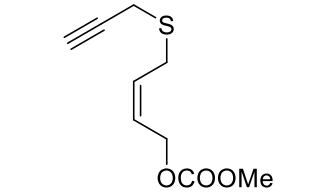
^{13}C NMR (100 MHz, $CDCl_3$)


S
OH
1H NMR (400 MHz, CDCl3)
5.825
5.808
5.798
5.795
5.791
5.787
5.781
5.764
5.582
5.562
5.558
5.542
5.538
5.535
5.515
4.239
4.222
3.363
3.343
3.180
3.174
2.262
2.255
2.249
1.829
5.8 5.7 5.6 ppm
4.4 4.2 4.0 3.8 3.6 3.4 3.2 ppm
2.3 ppm
1.00
0.94
1.96
2.03
2.06
0.96
14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 −1 −2 −3 −4 ppm
1.00
0.94
1.96
2.03
2.06
0.96
0.92

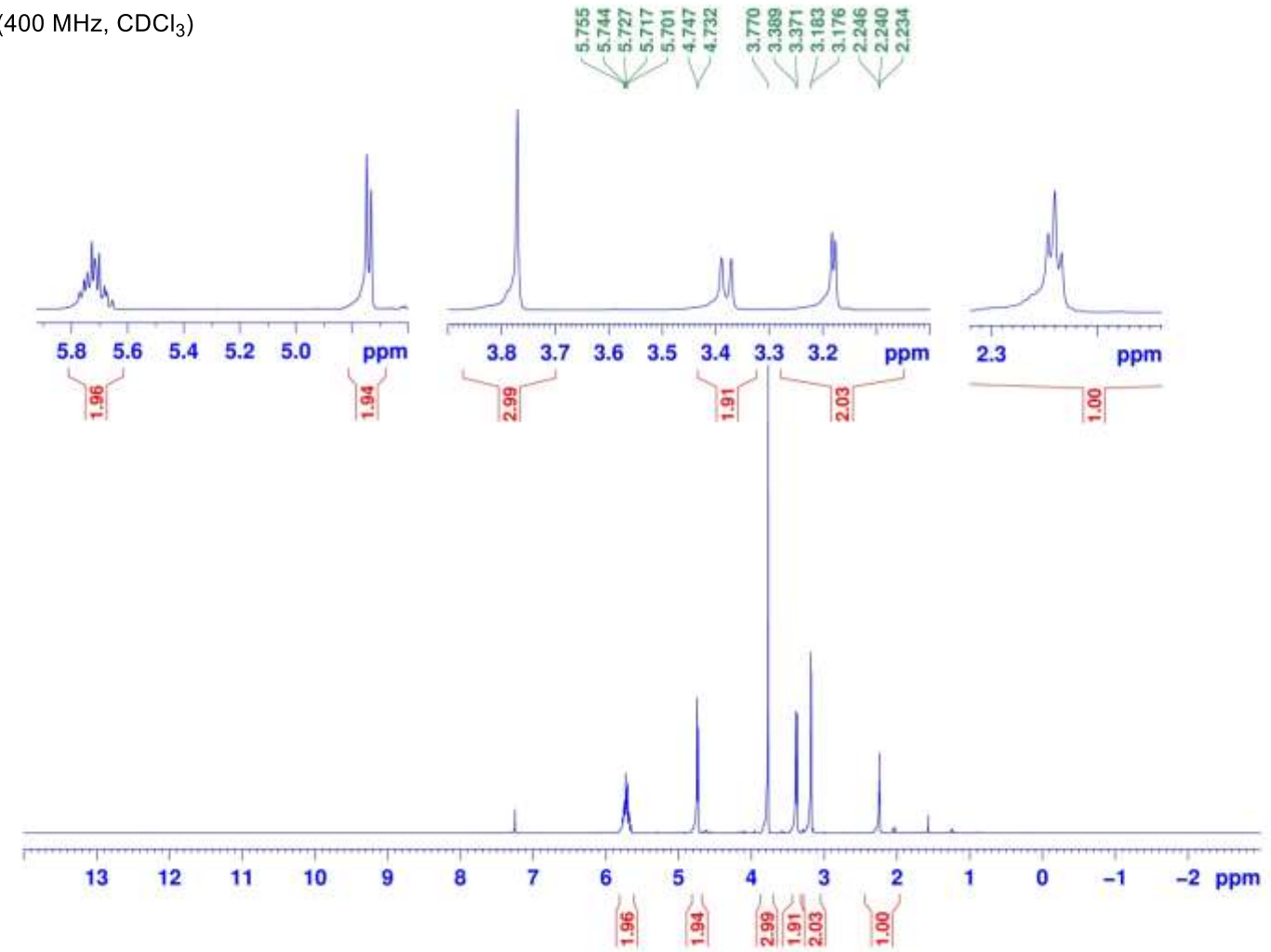


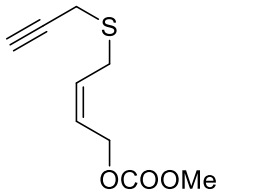
^{13}C NMR (100 MHz, $CDCl_3$)



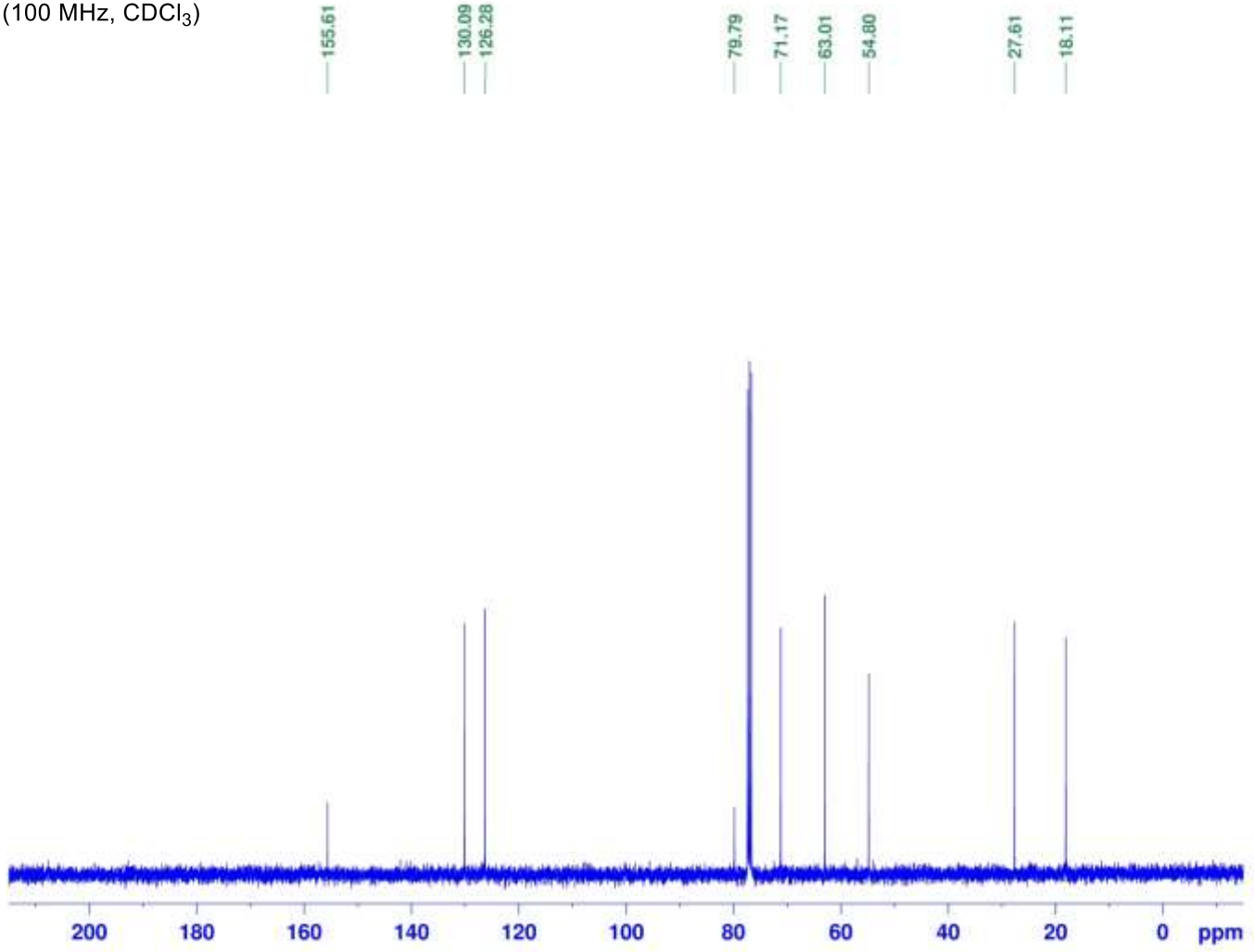


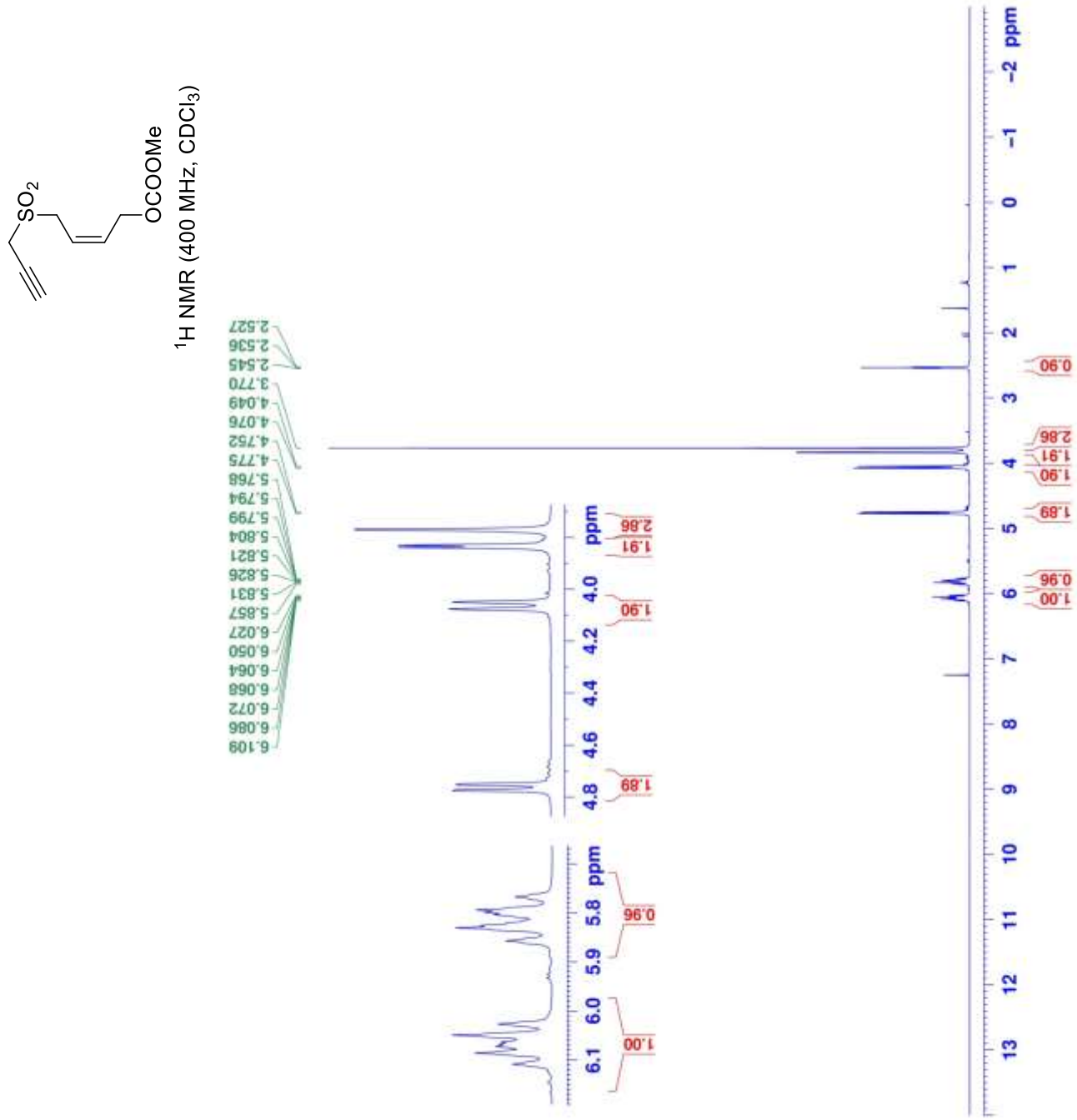
^{1}H NMR (400 MHz, $CDCl_3$)

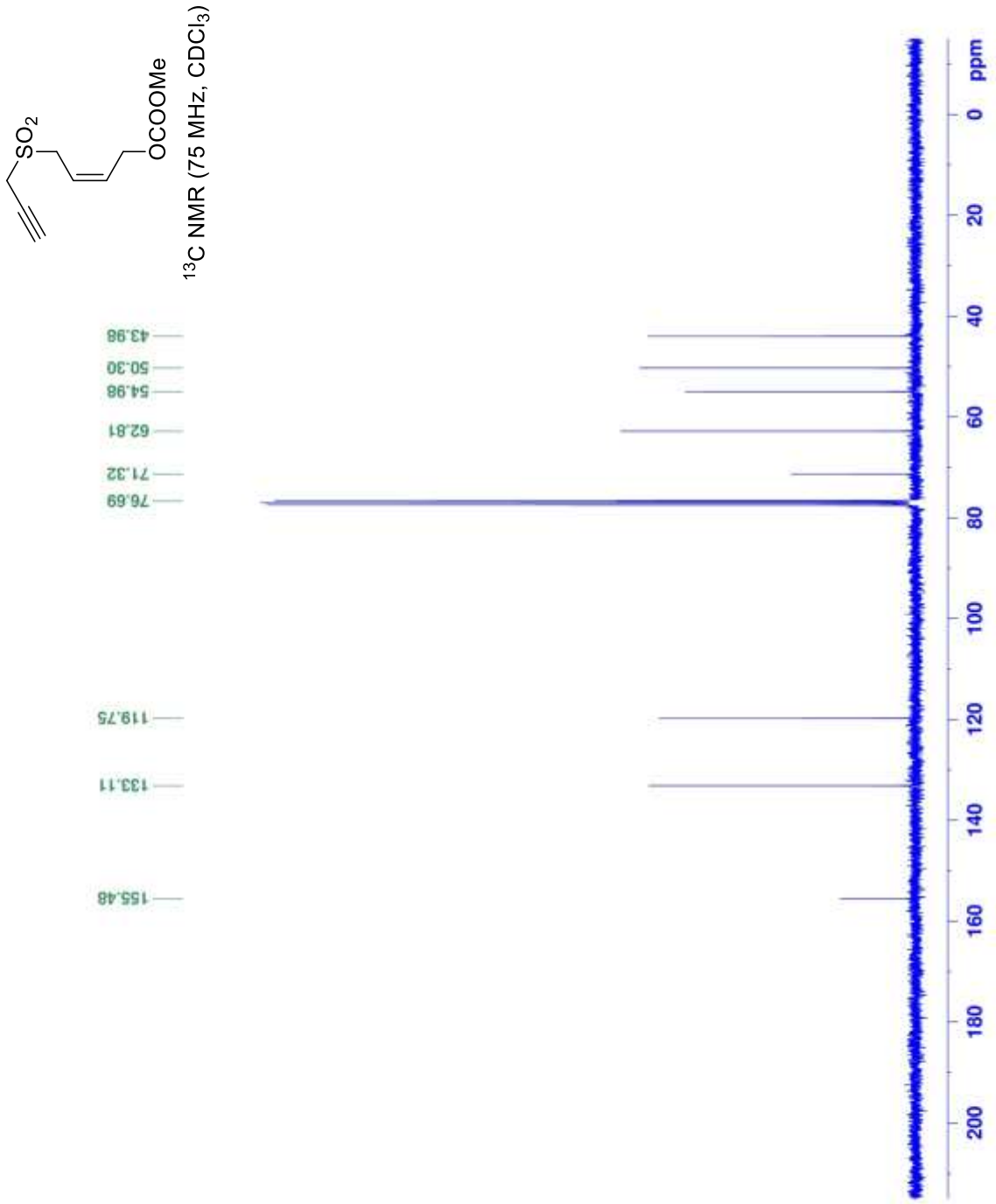




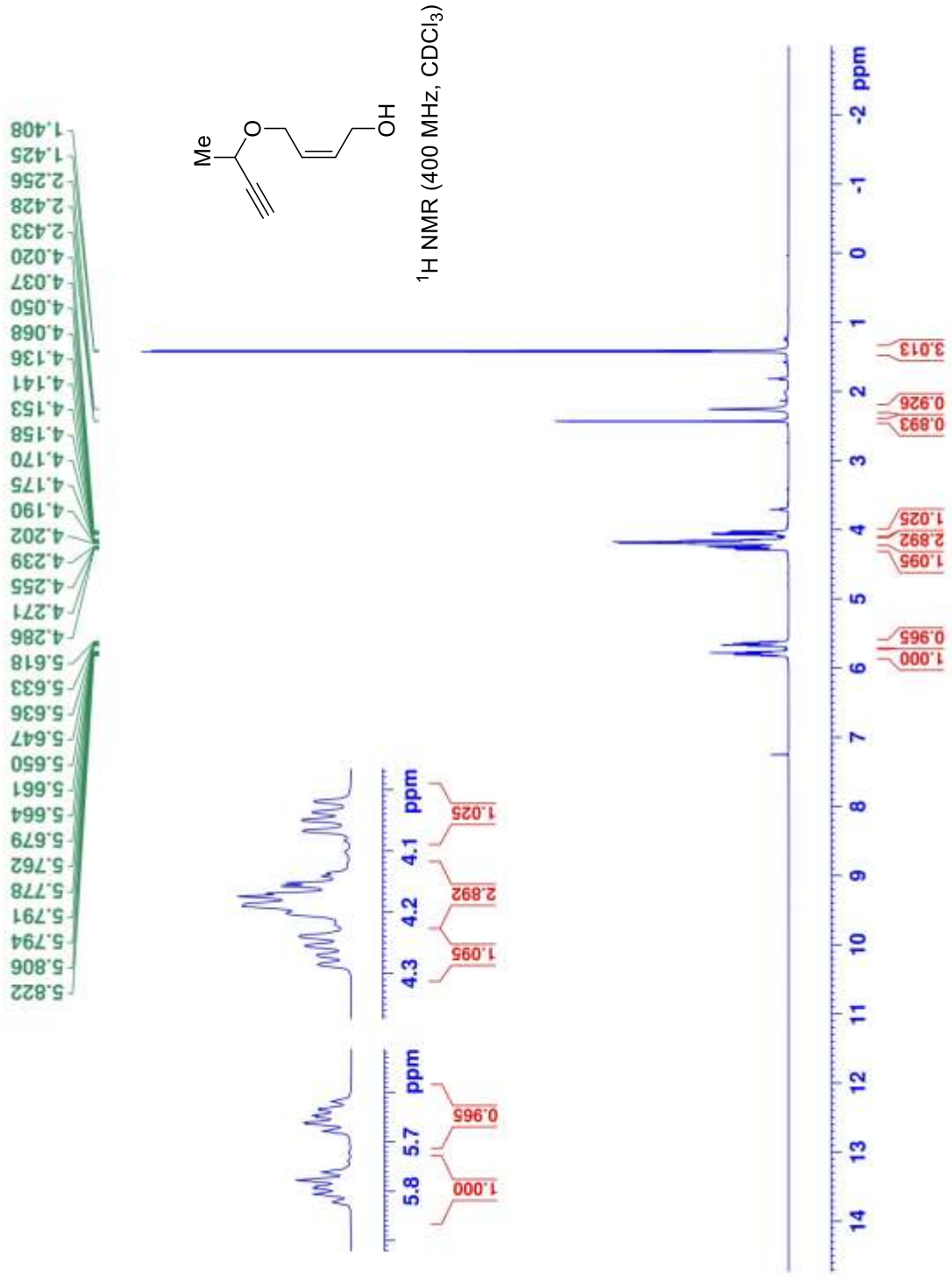
^{13}C NMR (100 MHz, $CDCl_3$)

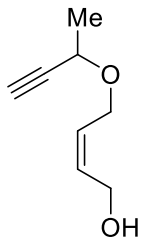



SO2
OCOOMe
1H NMR (400 MHz, CDCl3)
2.527
2.536
2.545
3.770
4.049
4.076
4.752
4.775
5.768
5.794
5.799
5.804
5.821
5.826
5.831
5.857
6.027
6.050
6.064
6.068
6.072
6.086
6.109
ppm
0.90
2.86
1.91
1.90
1.89
0.96
1.00

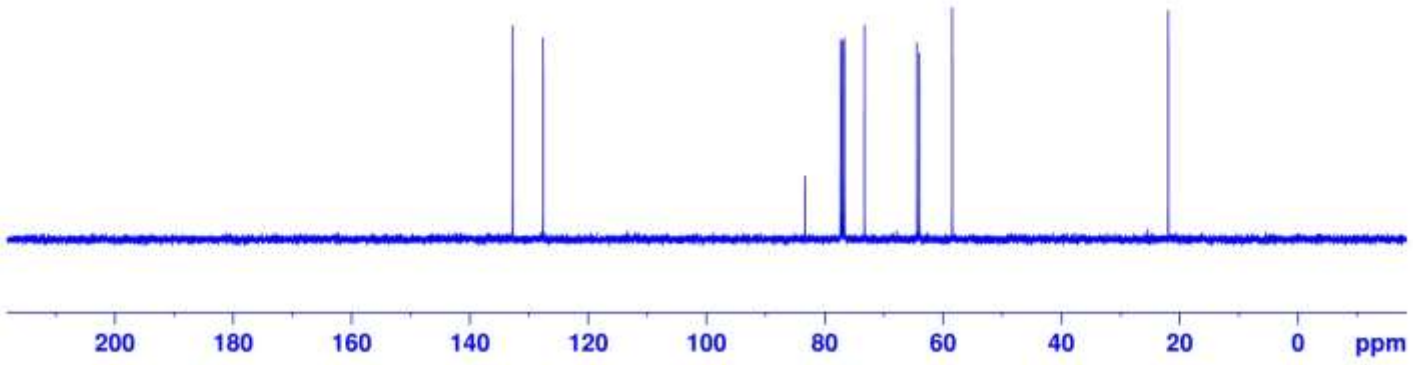

SO2
OCOOMe
13C NMR (75 MHz, CDCl3)
43.98
50.30
54.98
62.81
71.32
76.69
119.75
133.11
155.48
0
20
40
60
80
100
120
140
160
180
200
ppm

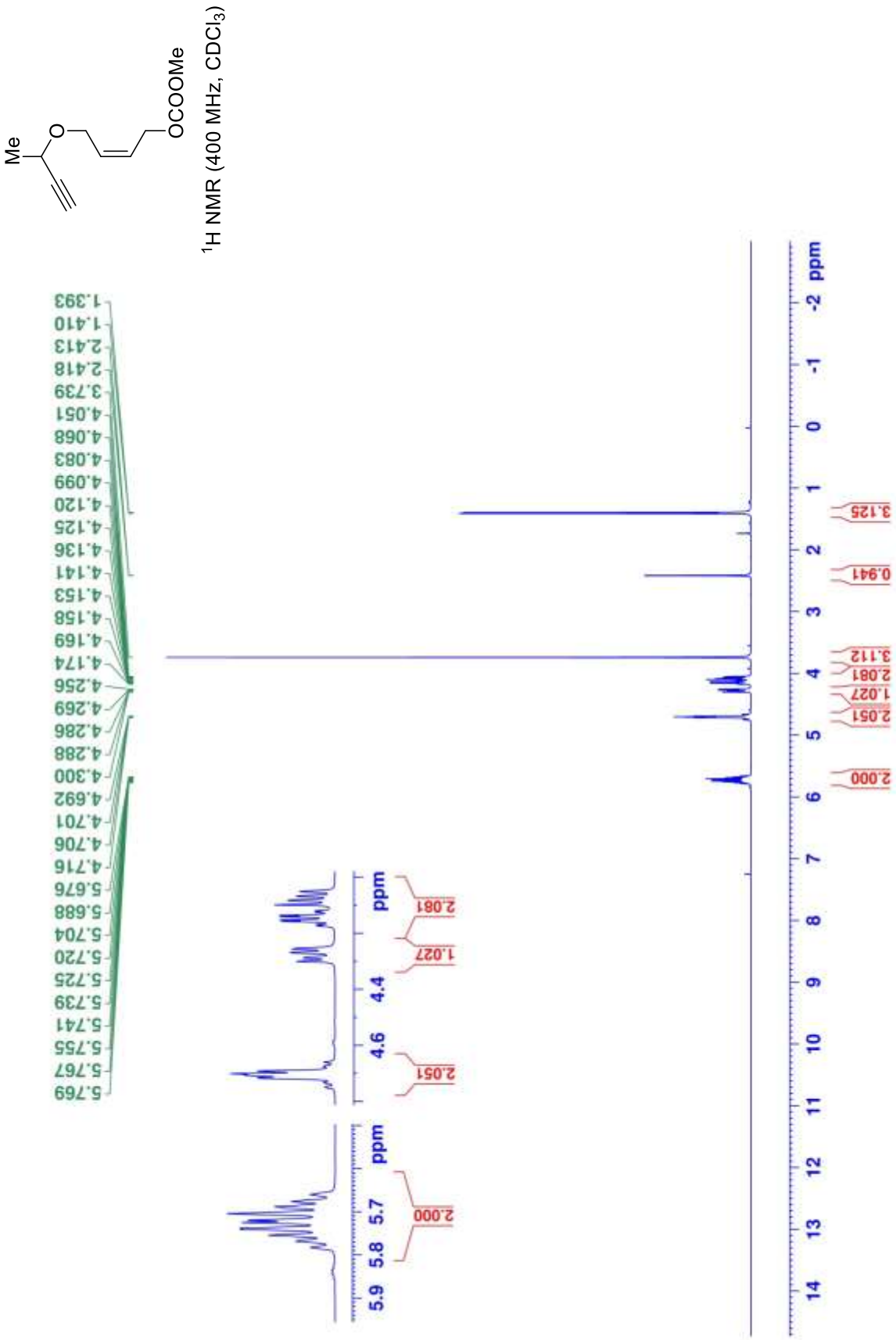
b. *Propargyl- Substituted Substrates*

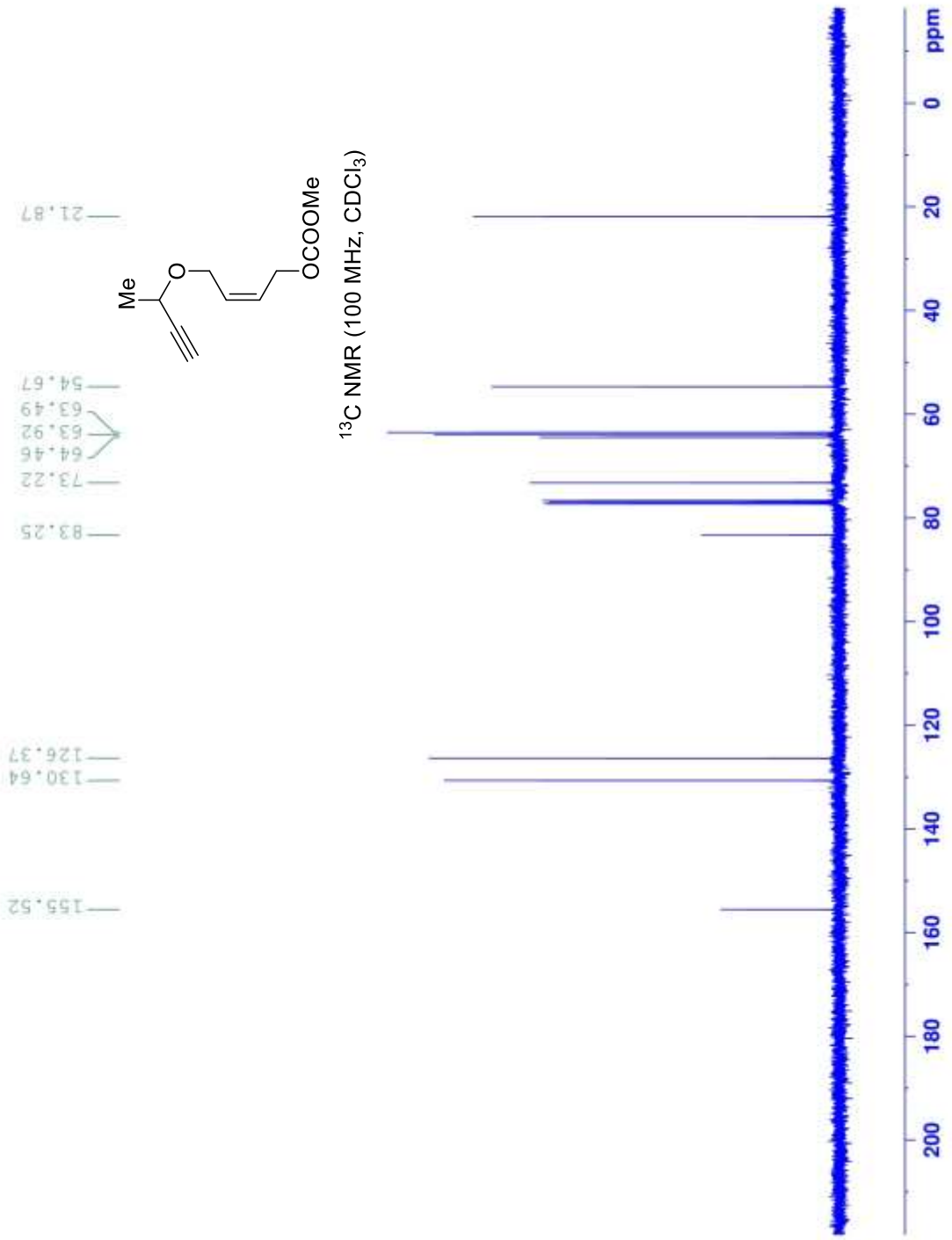


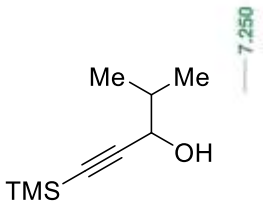


^{13}C NMR (100 MHz, $CDCl_3$)

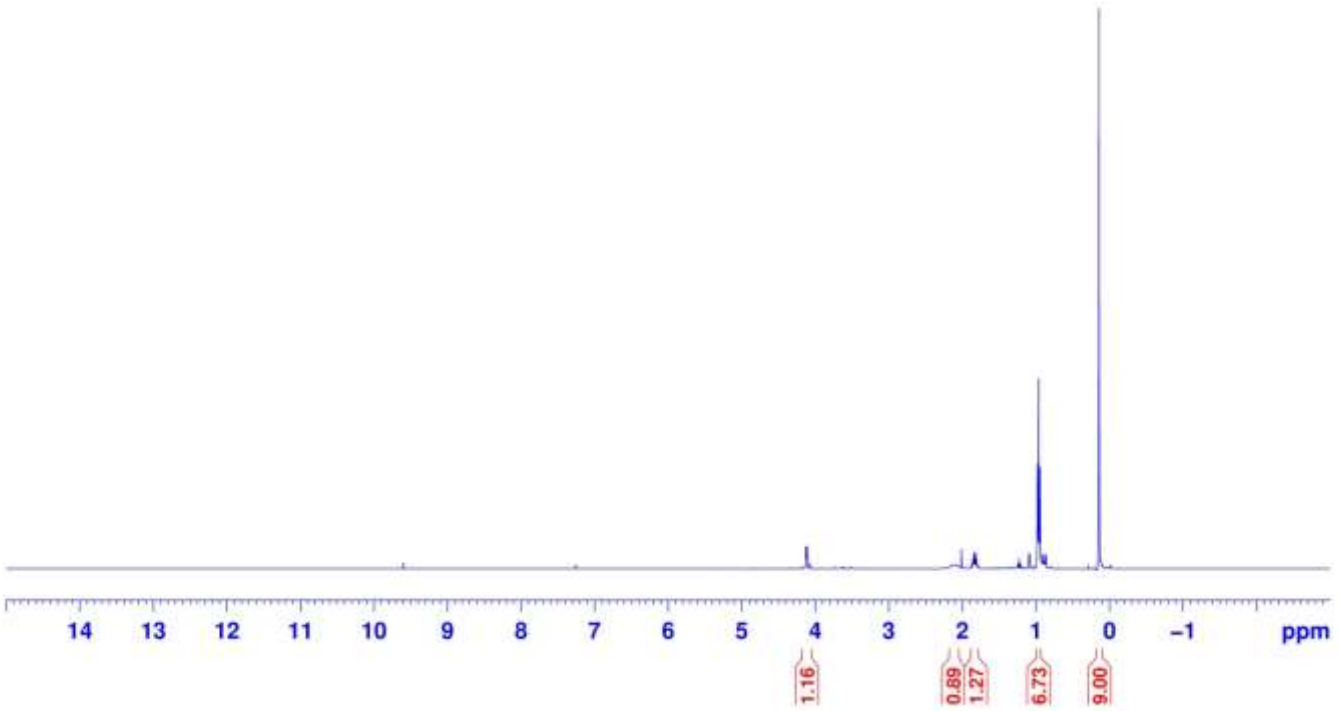


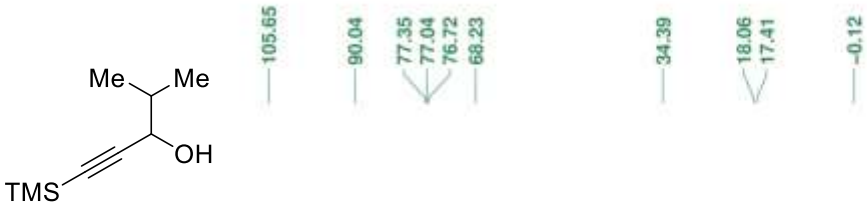

Me
O
OCOOMe
^{1}H NMR (400 MHz, CDCl$_3$)
1.393
1.410
2.413
2.418
3.739
4.051
4.068
4.083
4.099
4.120
4.125
4.136
4.141
4.153
4.158
4.169
4.174
4.256
4.269
4.286
4.288
4.300
4.692
4.701
4.706
4.716
5.676
5.688
5.704
5.720
5.725
5.739
5.741
5.755
5.767
5.769
ppm
2.081
1.027
2.051
2.000
3.125
0.941
3.112
2.081
1.027
2.051
2.000


^{13}C NMR (100 MHz, CDCl$_3$)
Me
O
OCOOMe
21.87
54.67
63.49
63.92
64.46
73.22
83.25
126.37
130.64
155.52
ppm
0
20
40
60
80
100
120
140
160
180
200

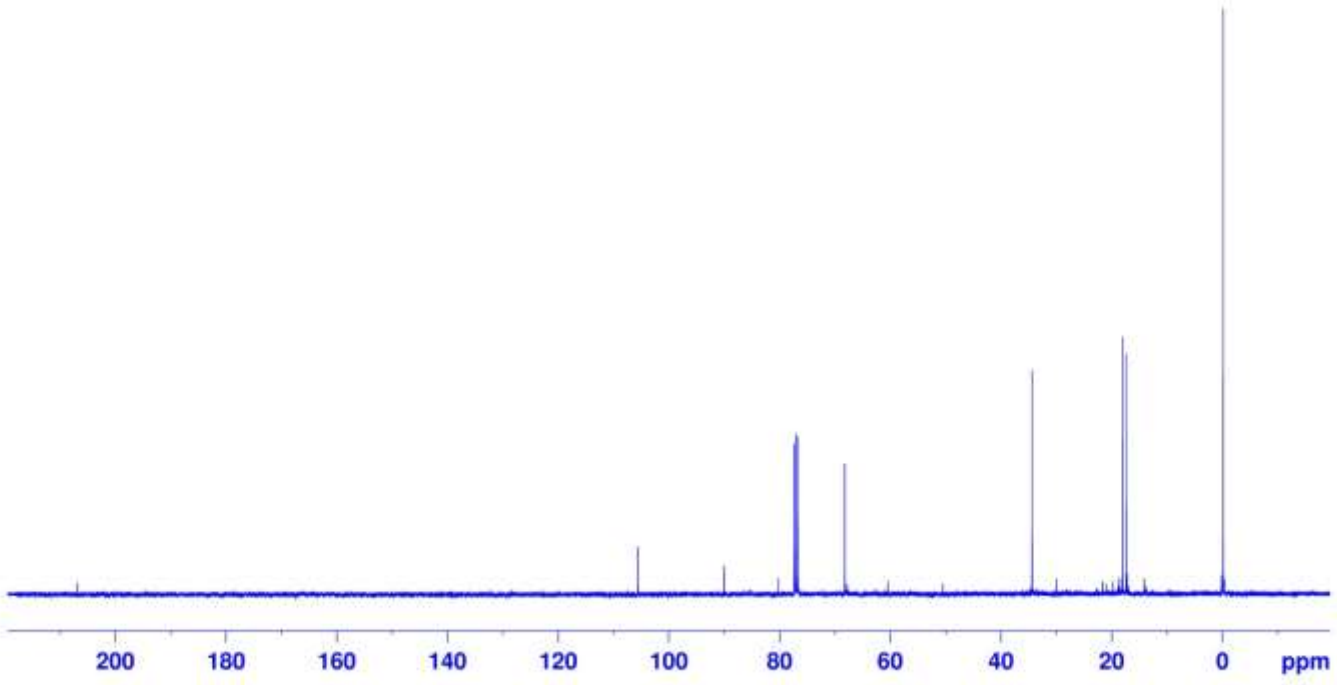


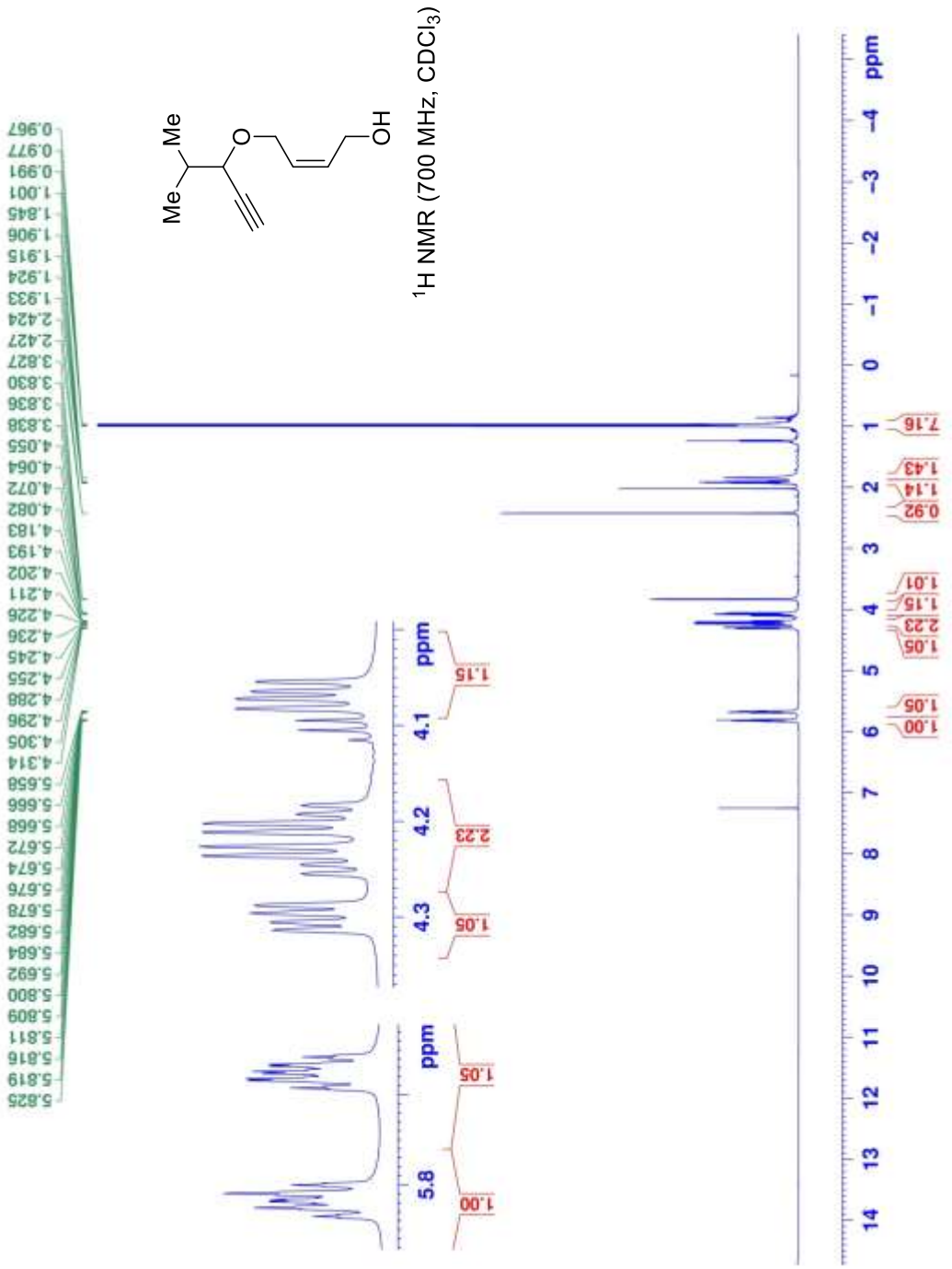
^{1}H NMR (400 MHz, $CDCl_3$)

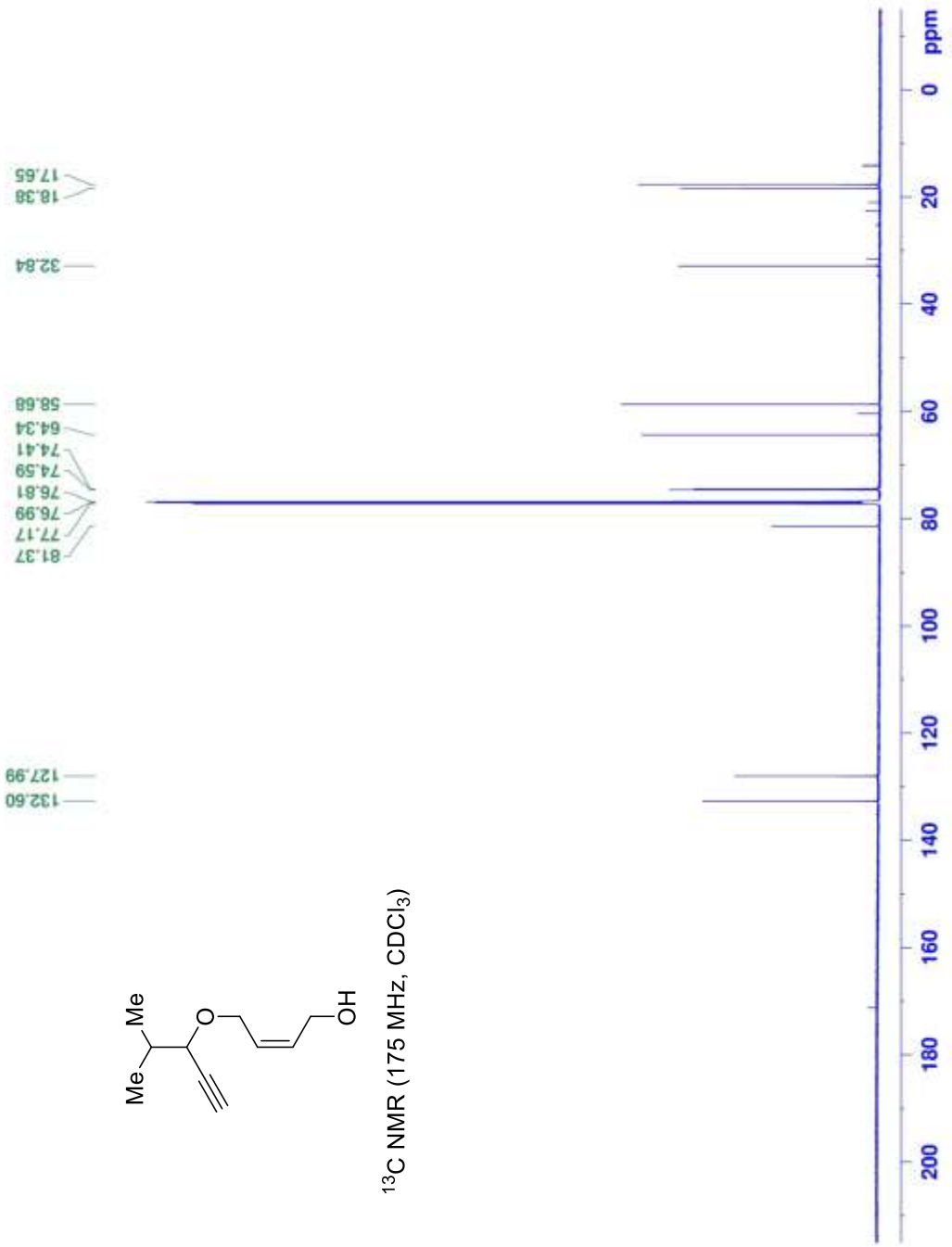


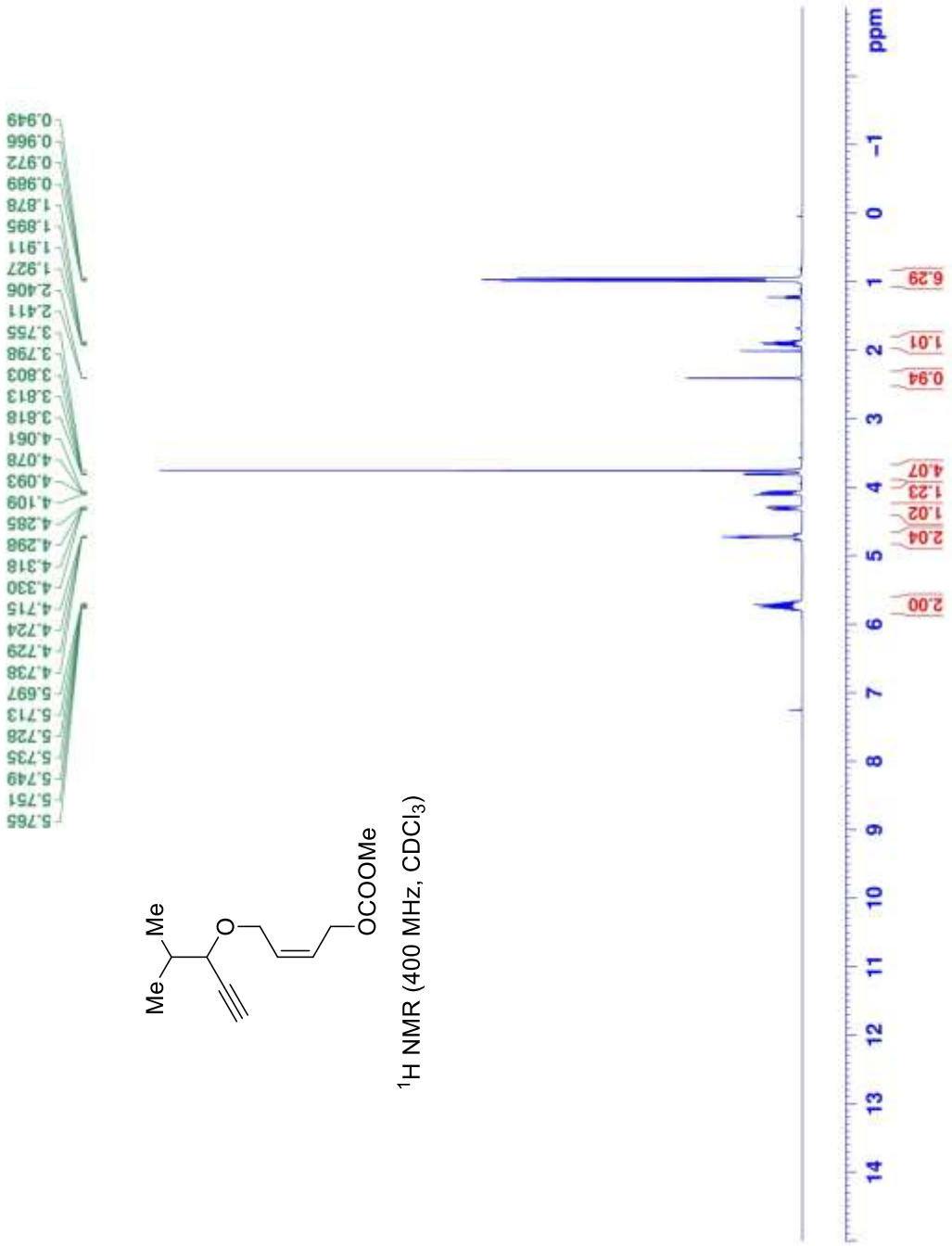


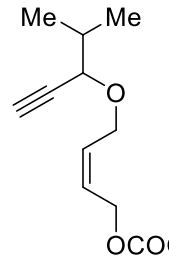
^{13}C NMR (100 MHz, $CDCl_3$)



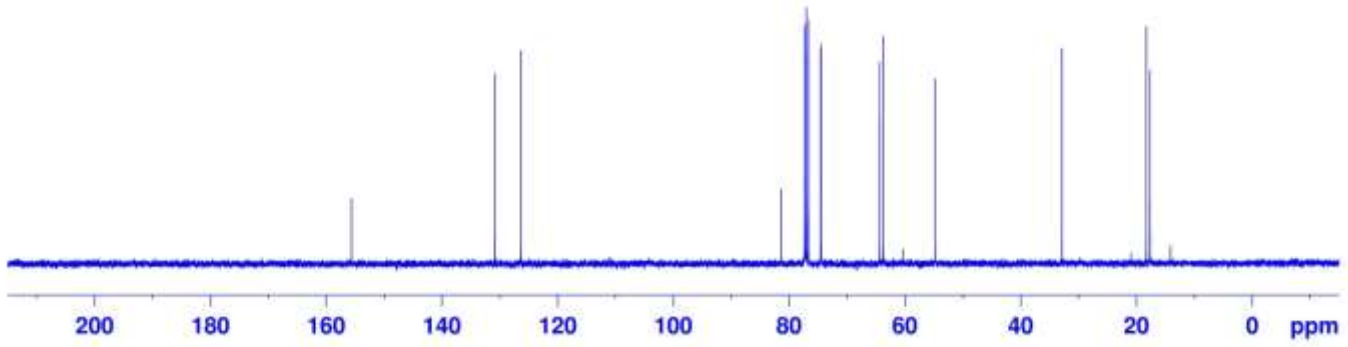

^{1}H NMR (700 MHz, $CDCl_3$)
Me
Me
O
OH
ppm
7.16
1.43
1.14
0.92
1.01
1.15
2.23
1.05
1.00
1.05
1.15
2.23
1.05
1.00

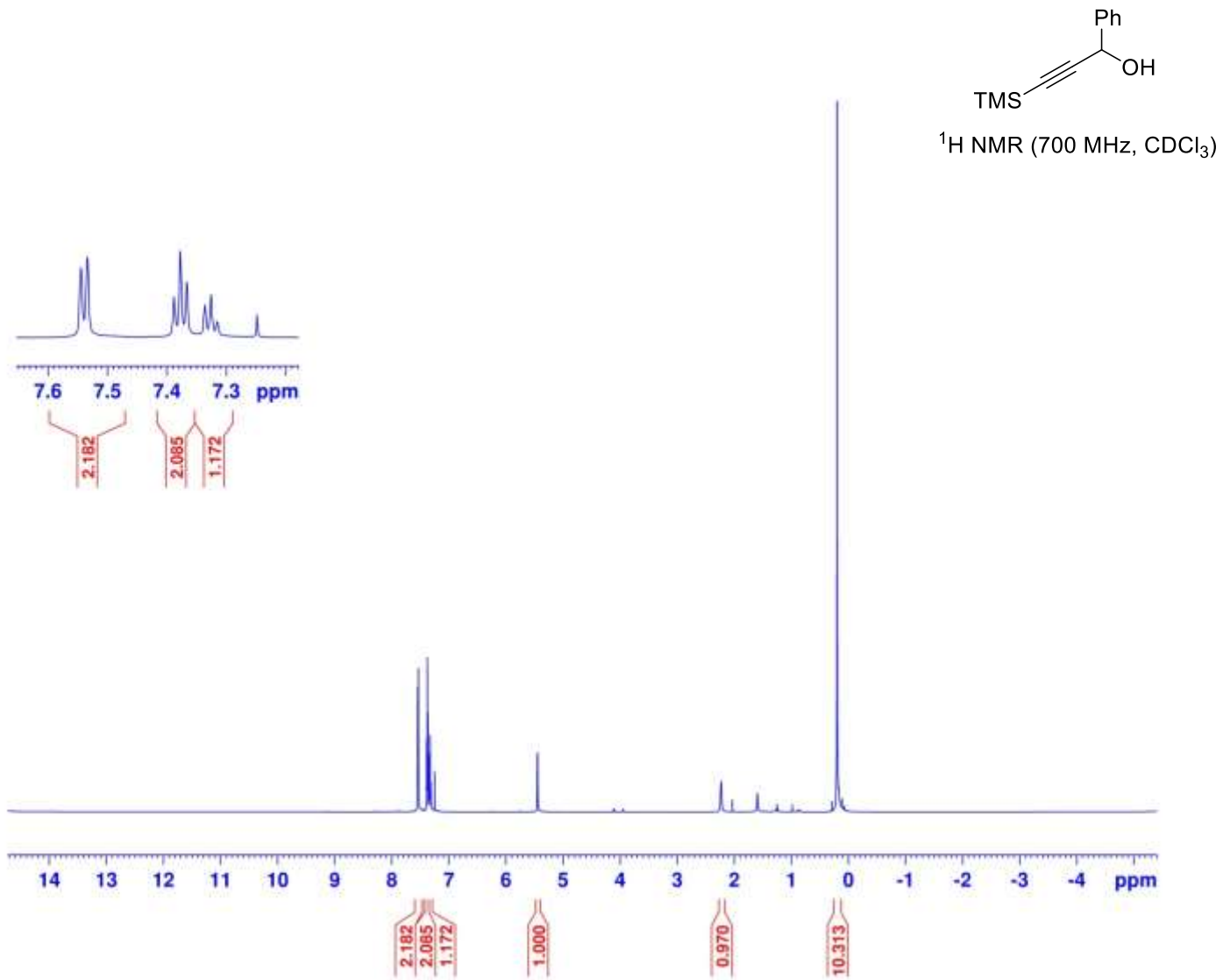

17.65
18.38
32.84
58.68
64.34
74.41
74.59
76.81
76.99
77.17
81.37
127.99
132.60
Me
Me
O
OH
^{13}C NMR (175 MHz, $CDCl_3$)
0
20
40
60
80
100
120
140
160
180
200
ppm

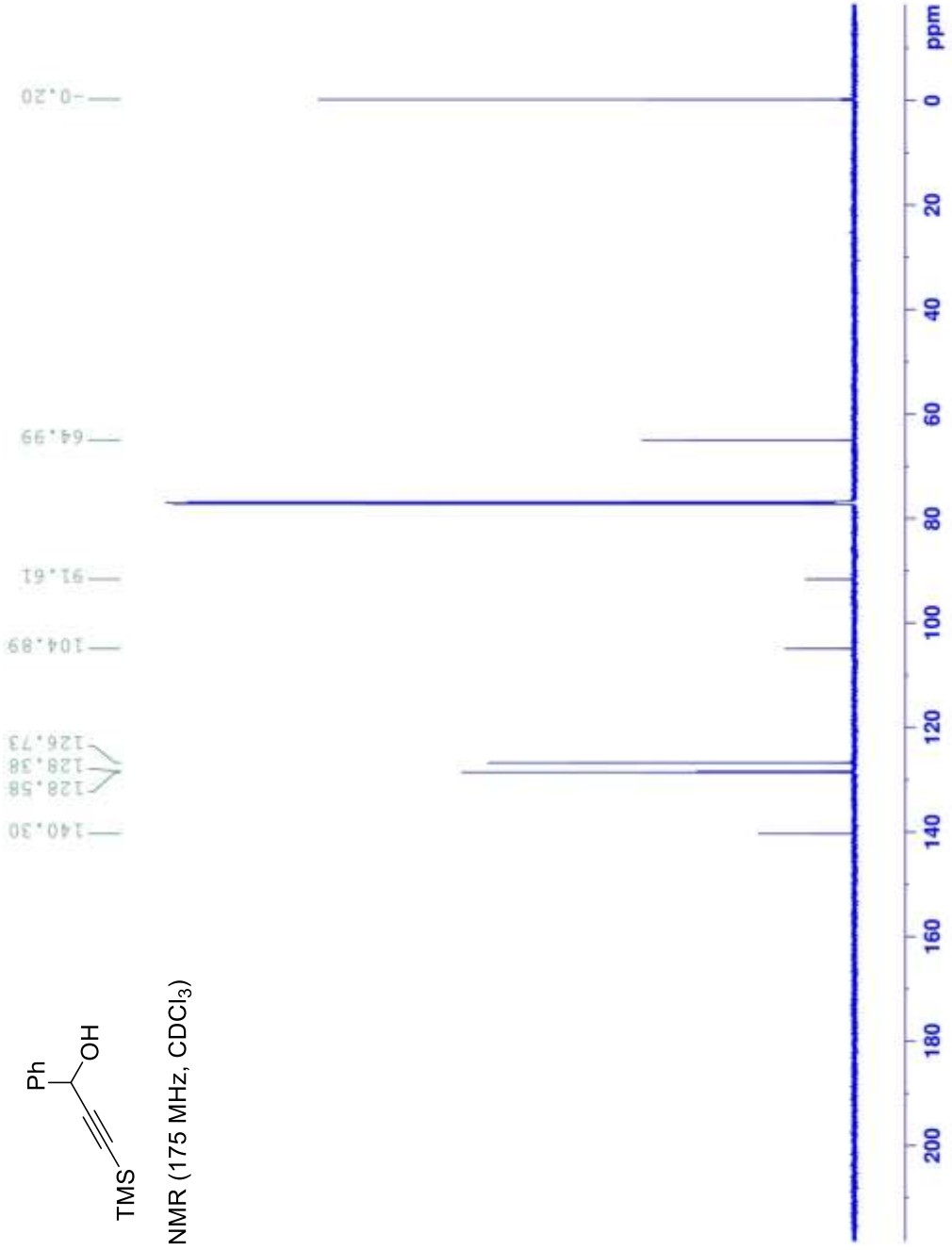

0.949
0.966
0.972
0.989
1.878
1.895
1.911
1.927
2.406
2.411
3.755
3.798
3.803
3.813
3.818
4.061
4.078
4.093
4.109
4.285
4.298
4.318
4.330
4.715
4.724
4.729
4.738
5.697
5.713
5.728
5.735
5.749
5.751
5.765
Me
Me
O
OCOOMe
^{1}H NMR (400 MHz, $CDCl_3$)
6.29
1.01
0.94
4.07
1.23
1.02
2.04
2.00
ppm



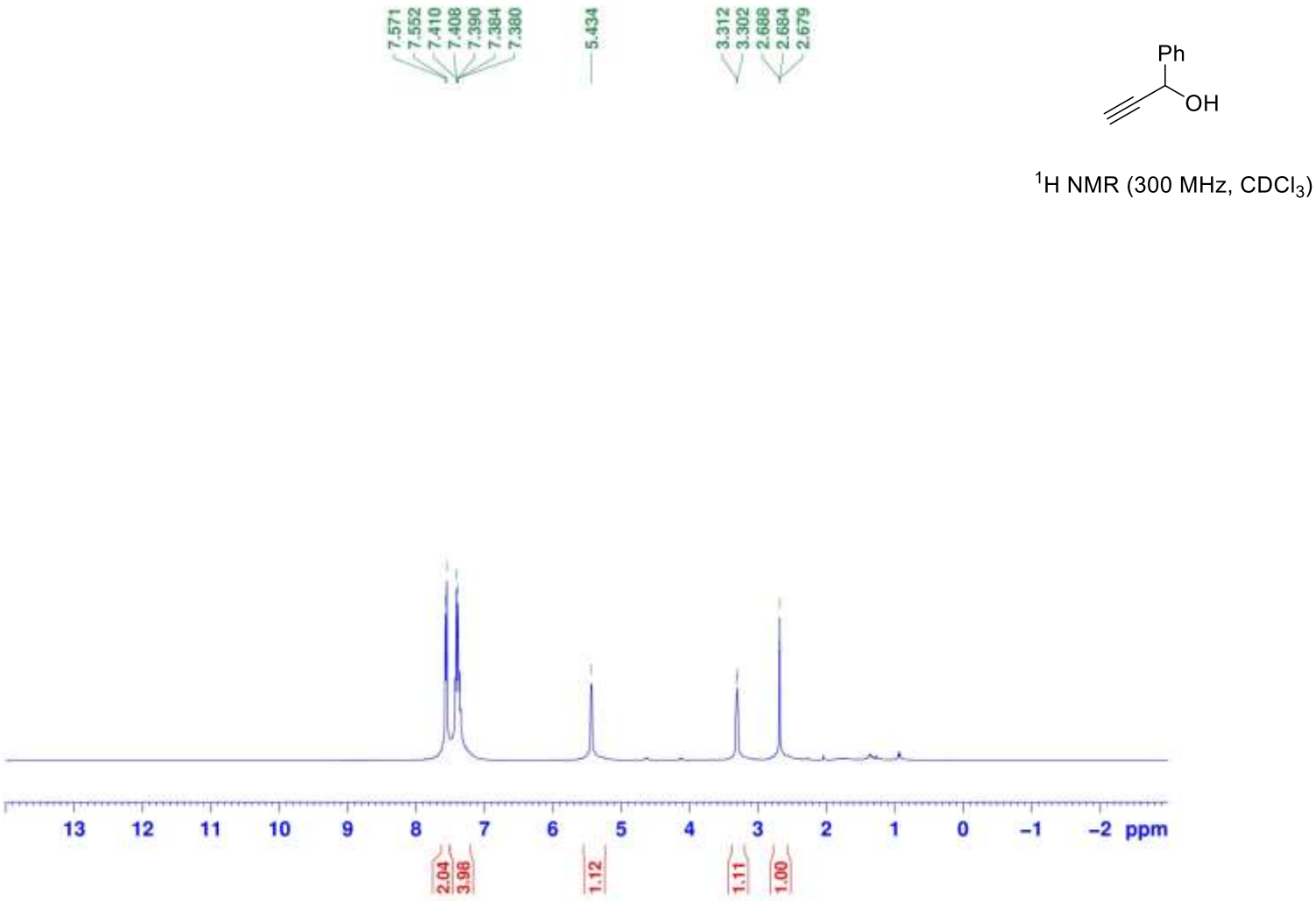
^{13}C NMR (100 MHz, $CDCl_3$)




Ph
OH
TMS
^{1}H NMR (700 MHz, $CDCl_3$)
7.6
7.5
7.4
7.3
ppm
2.182
2.085
1.172
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
-4
ppm
2.182
2.085
1.172
1.000
0.970
10.313

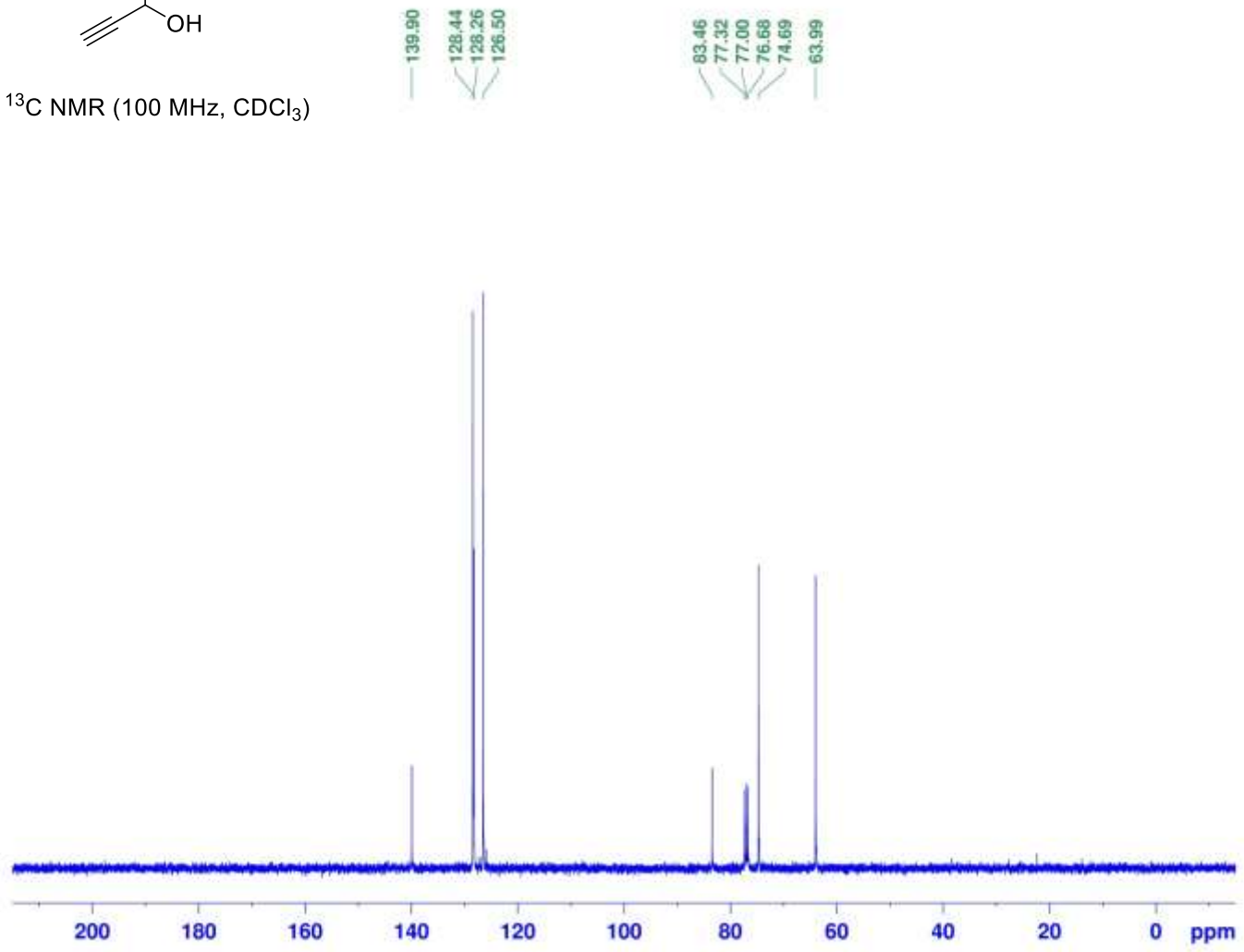


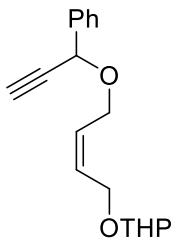
^{13}C NMR (175 MHz, $CDCl_3$)



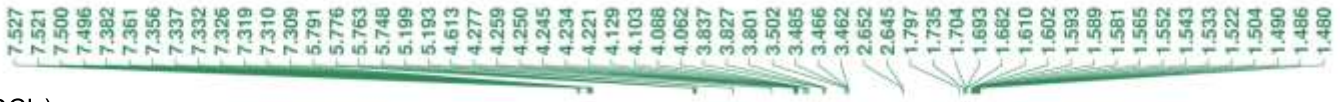
^{1}H NMR (300 MHz, $CDCl_3$)

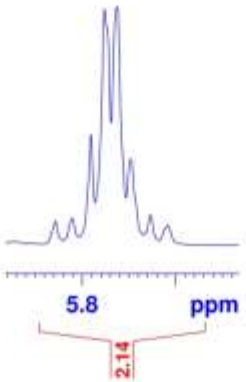
^{13}C NMR (100 MHz, $CDCl_3$)

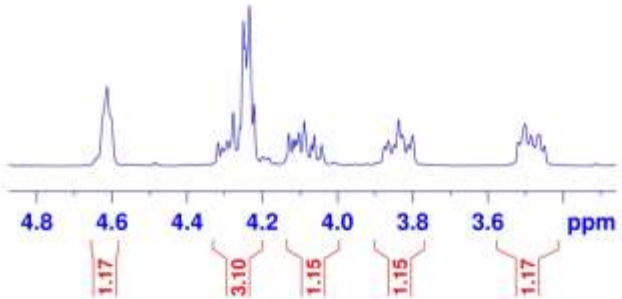


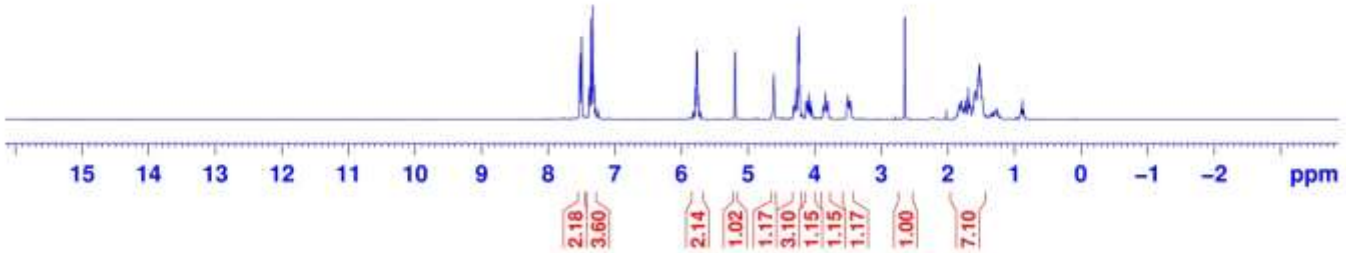


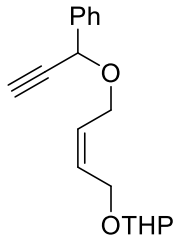
^{1}H NMR (300 MHz, $CDCl_3$)



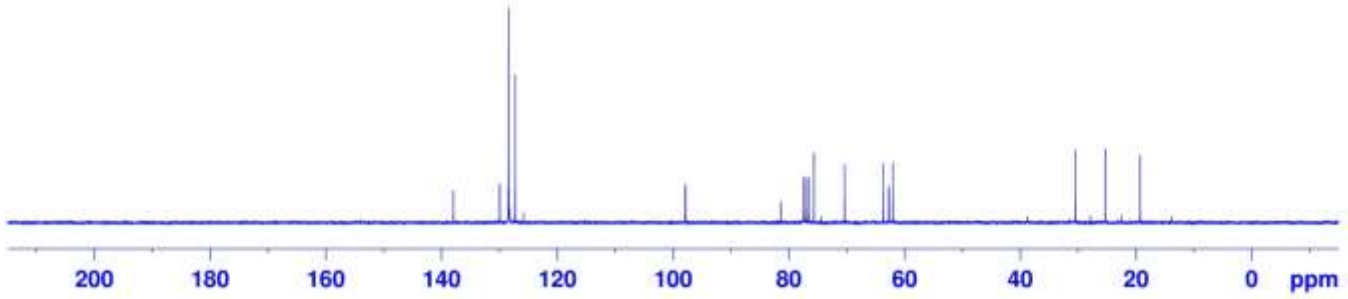


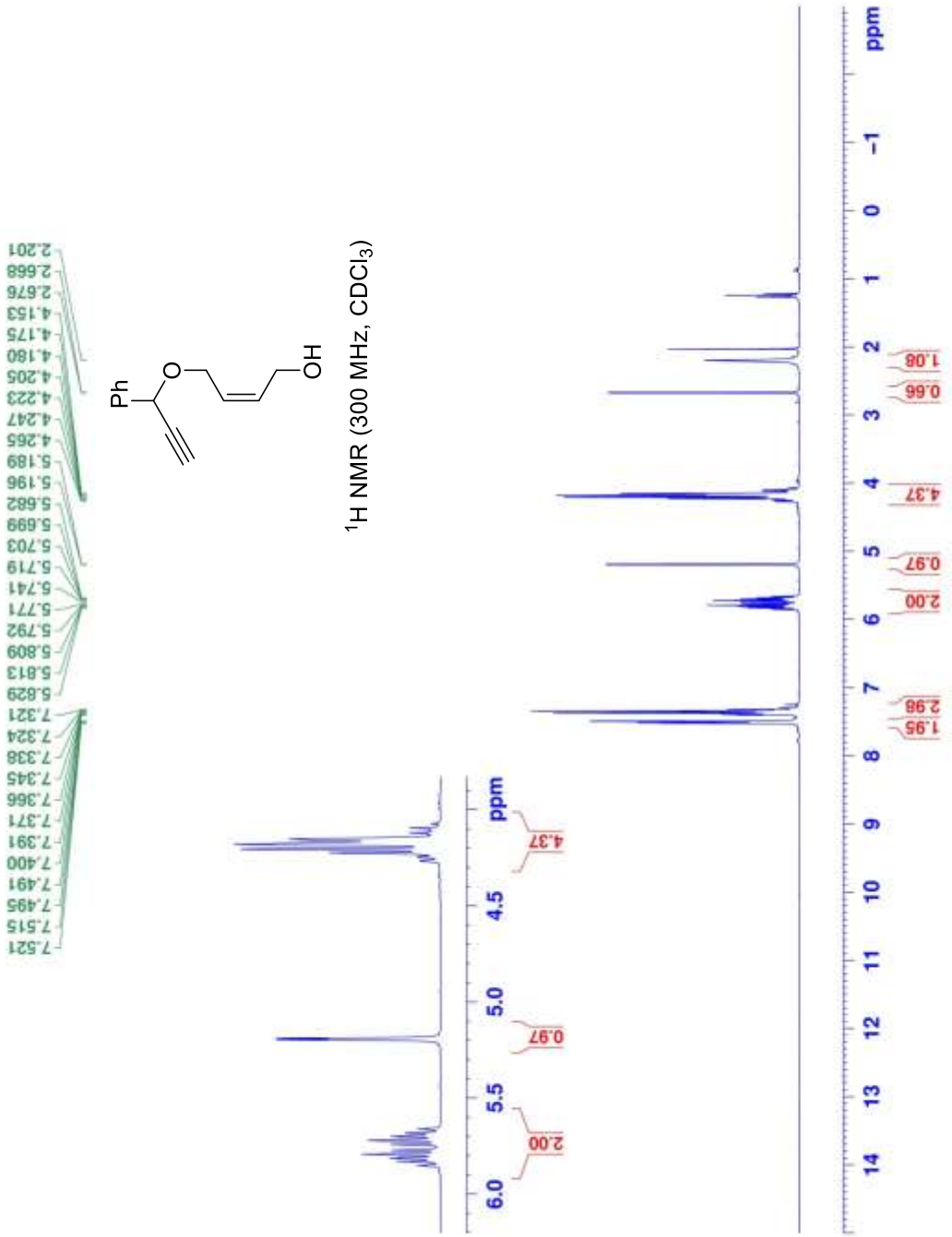


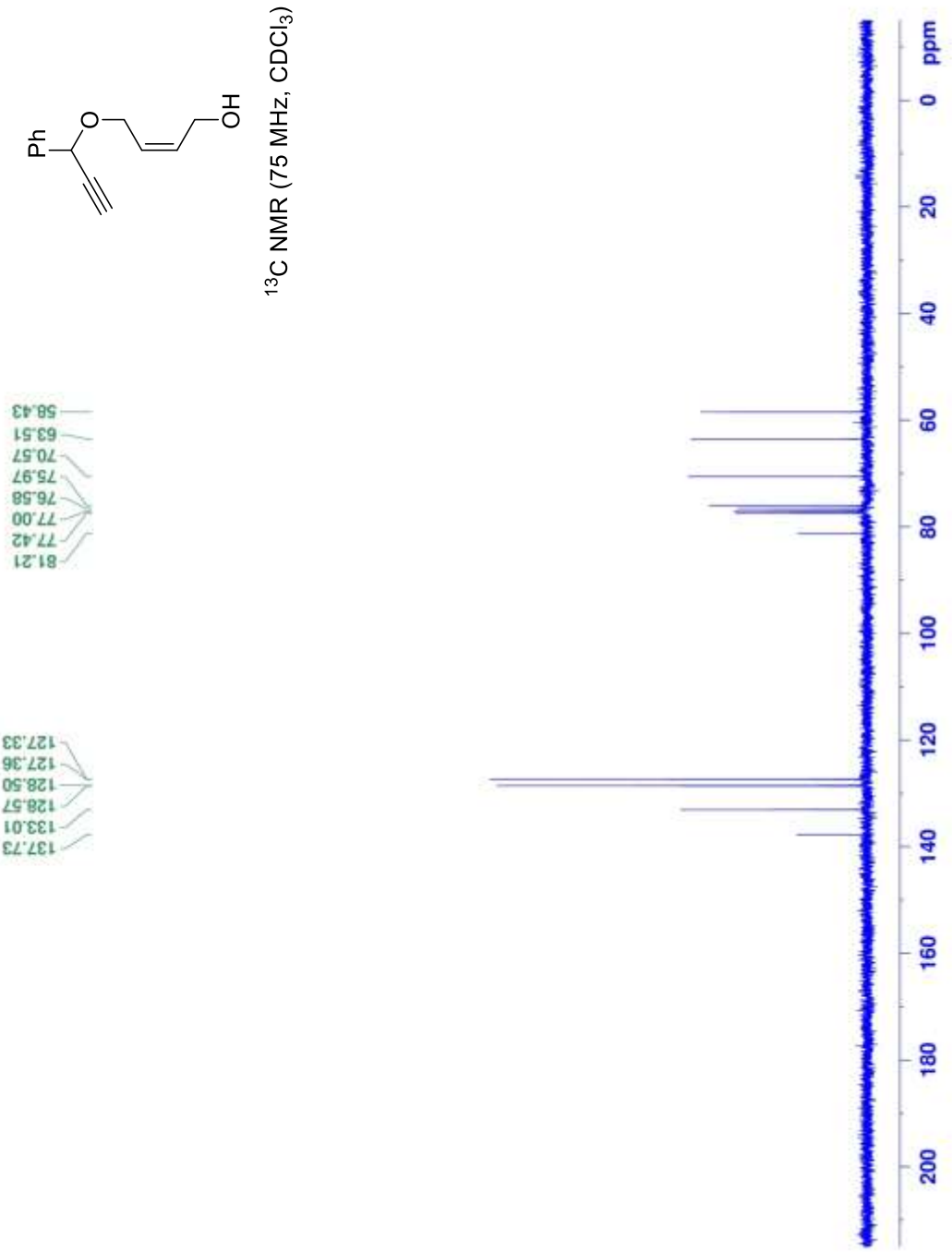


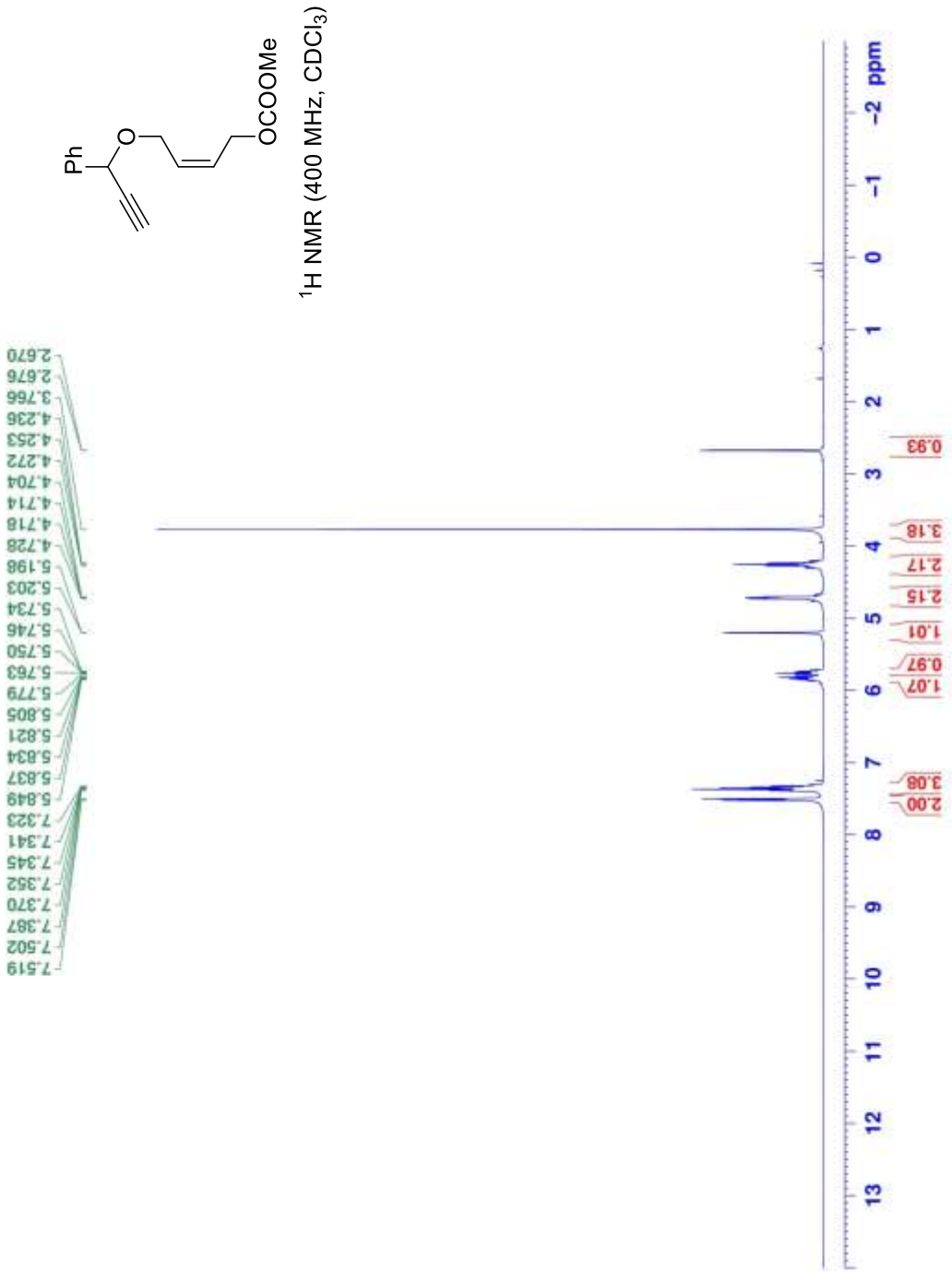


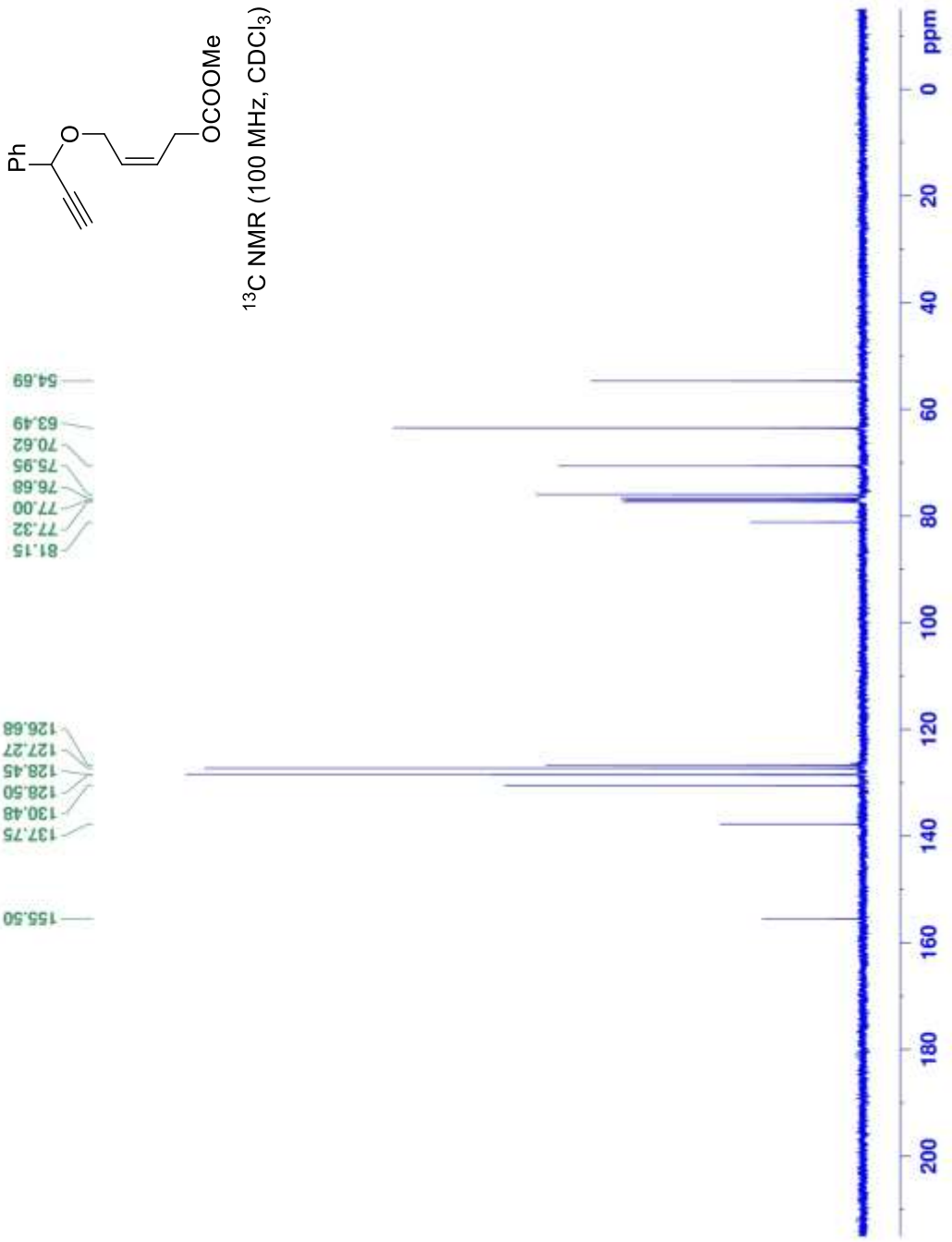
^{13}C NMR (75 MHz, $CDCl_3$)

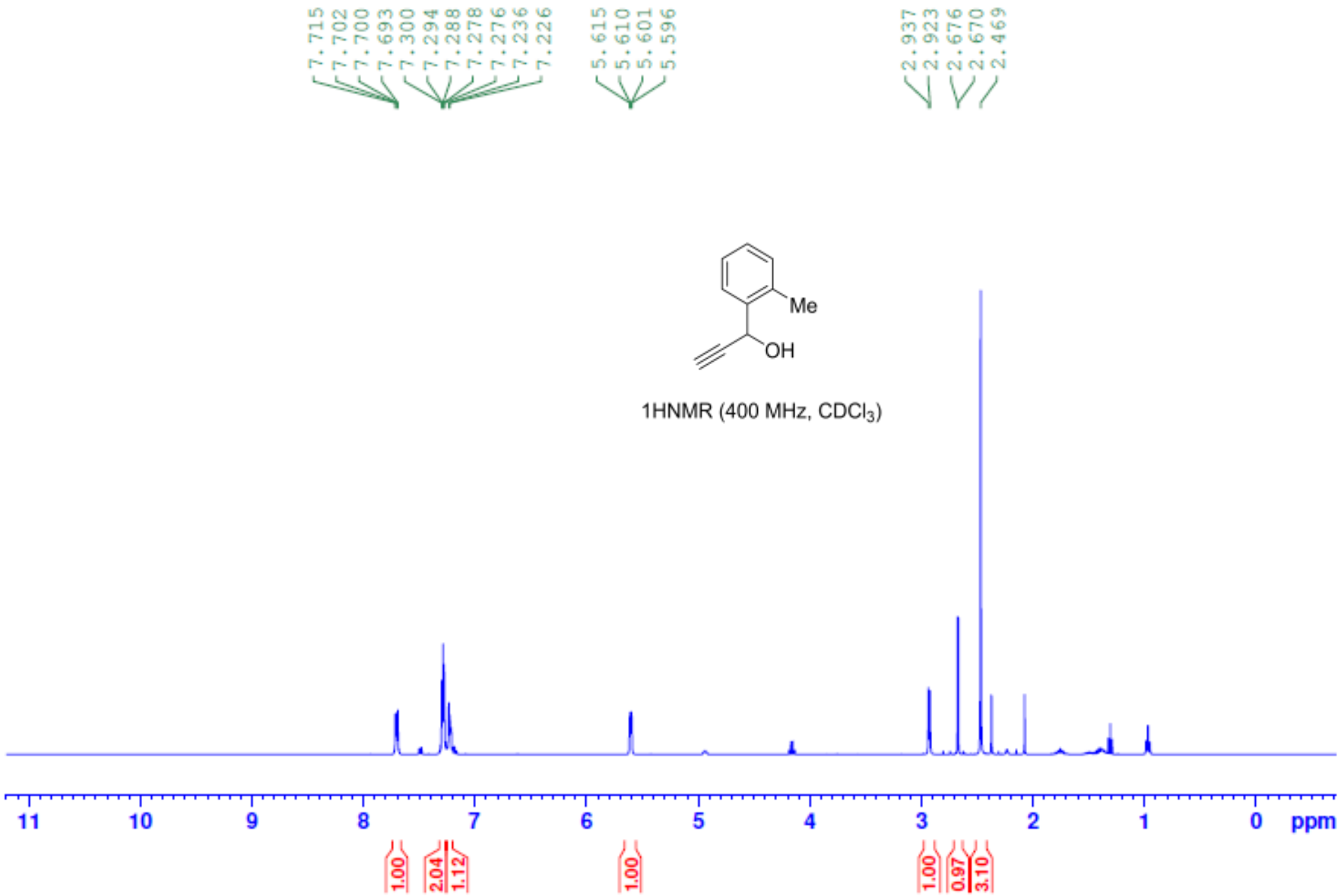


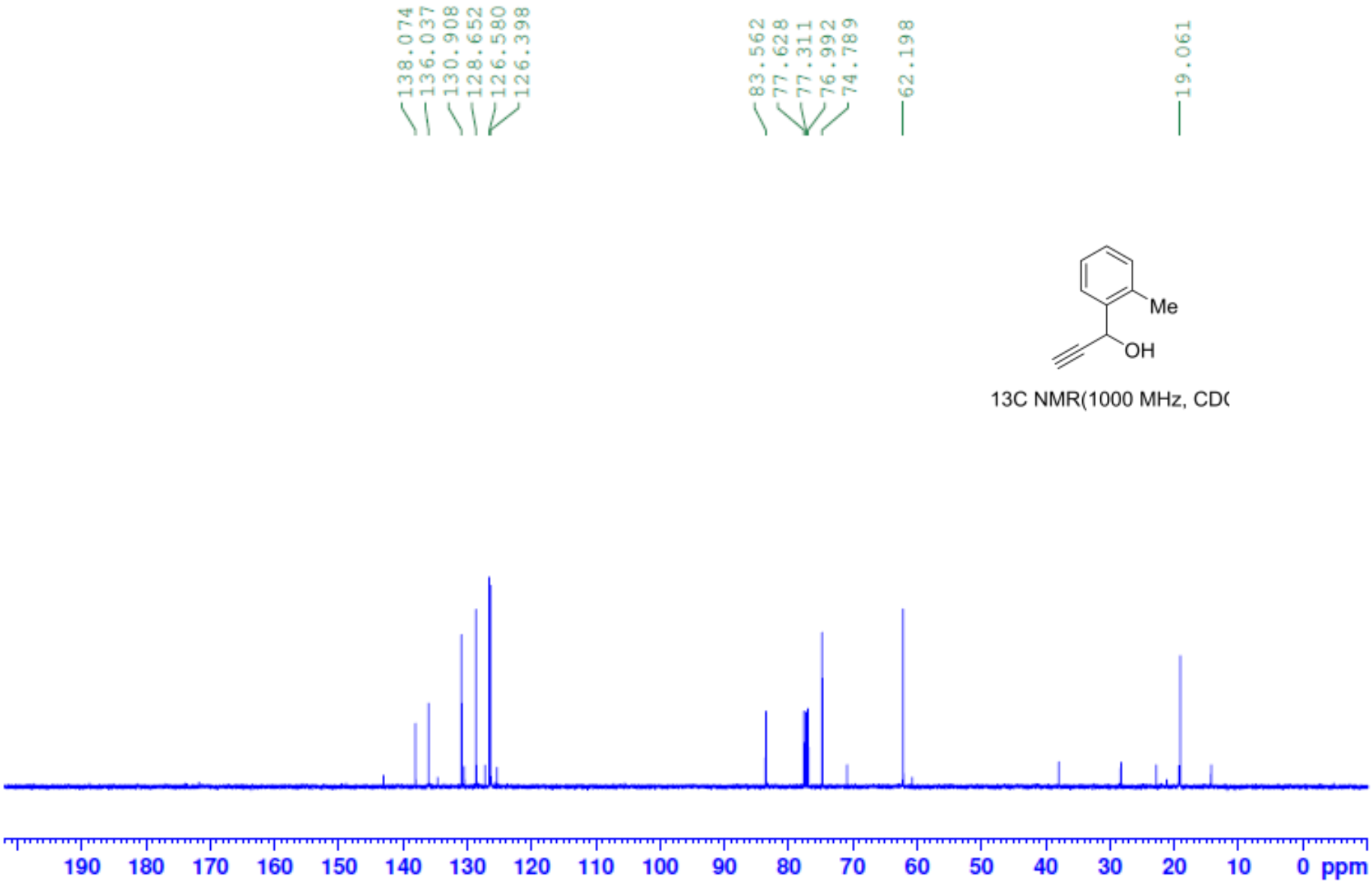

Ph
O
OH
^{1}H NMR (300 MHz, CDCl$_3$)
2.201
2.668
2.676
4.153
4.175
4.180
4.205
4.223
4.247
4.265
5.189
5.196
5.682
5.699
5.703
5.719
5.741
5.771
5.792
5.809
5.813
5.829
7.321
7.324
7.338
7.345
7.366
7.371
7.391
7.400
7.491
7.495
7.515
7.521
ppm
1.08
0.66
4.37
0.97
2.00
2.98
1.95
4.37
0.97
2.00

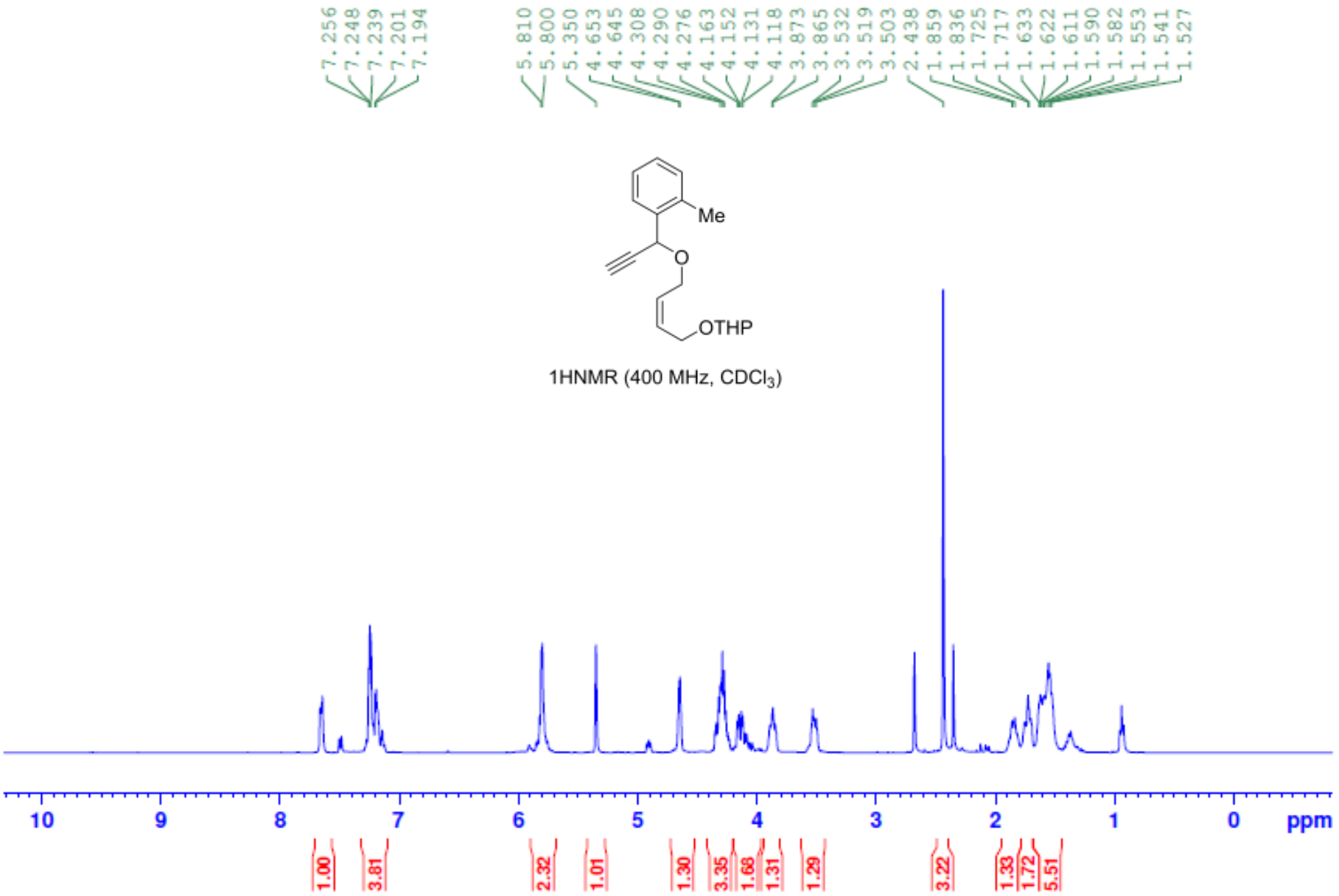

Ph
O
OH
^{13}C NMR (75 MHz, CDCl$_3$)
58.43
63.51
70.57
75.97
76.58
77.00
77.42
81.21
127.33
127.36
128.50
128.57
133.01
137.73
ppm
0
20
40
60
80
100
120
140
160
180
200

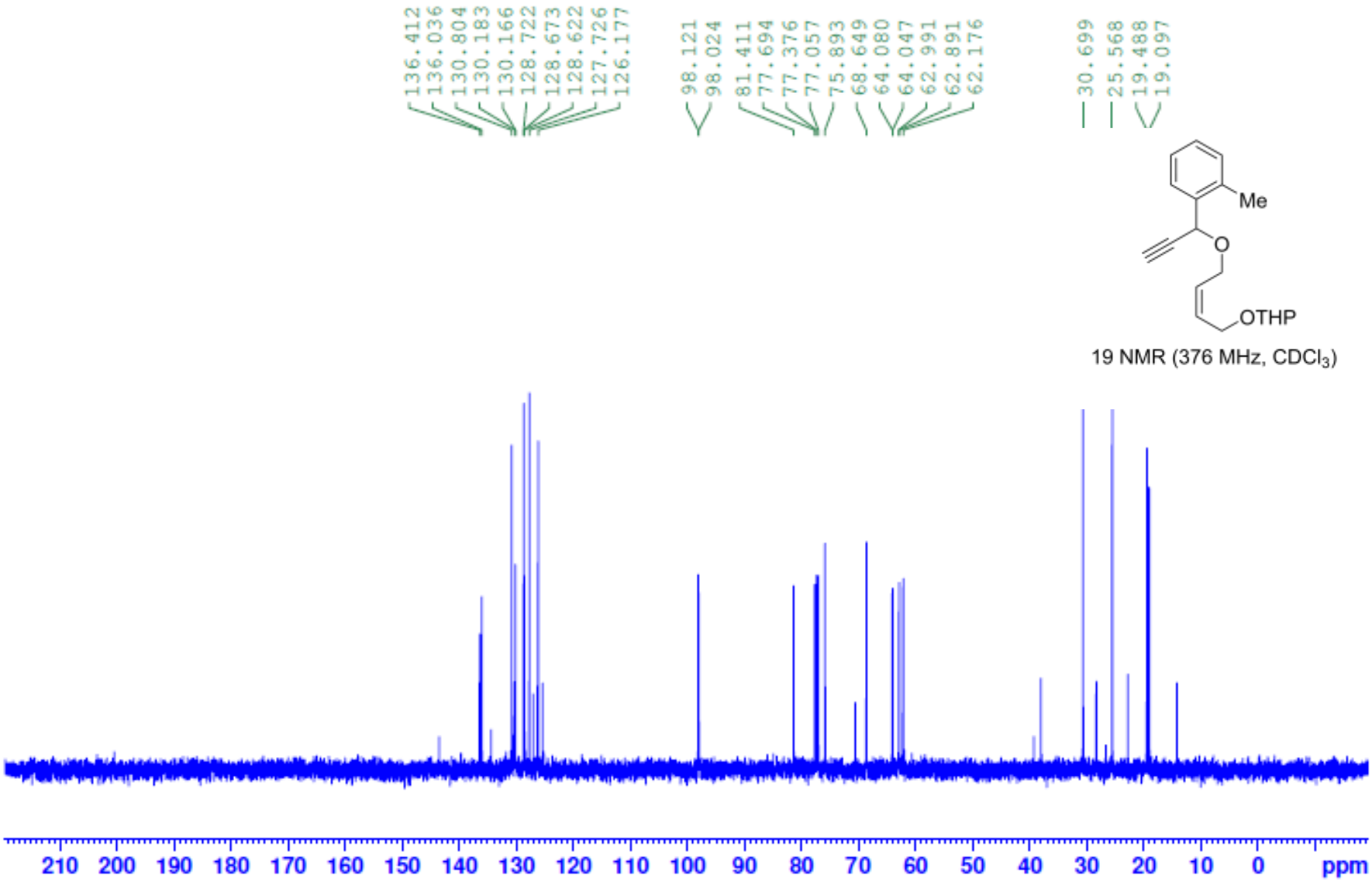

Ph
O
OCOOMe
^{1}H NMR (400 MHz, CDCl$_3$)
2.670
2.676
3.766
4.236
4.253
4.272
4.704
4.714
4.718
4.728
5.198
5.203
5.734
5.746
5.750
5.763
5.779
5.805
5.821
5.834
5.837
5.849
7.323
7.341
7.345
7.352
7.370
7.387
7.502
7.519
0.93
3.18
2.17
2.15
1.01
0.97
1.07
3.08
2.00
ppm


Ph
O
OCOOMe
^{13}C NMR (100 MHz, $CDCl_3$)
54.69
63.49
70.62
75.95
76.68
77.00
77.32
81.15
126.68
127.27
128.45
128.50
130.48
137.75
155.50
ppm
0
20
40
60
80
100
120
140
160
180
200

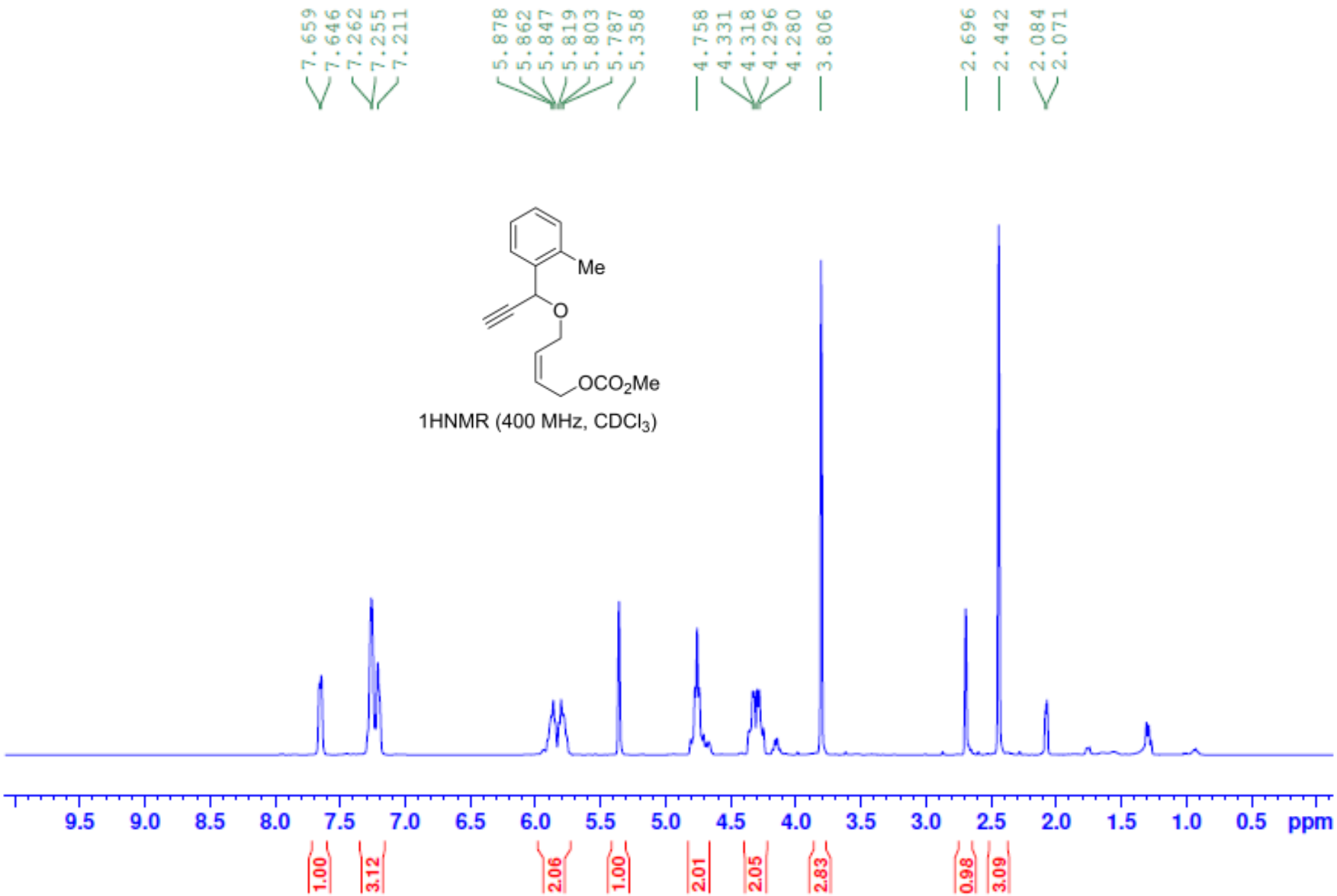

7.715
7.702
7.700
7.693
7.300
7.294
7.288
7.278
7.276
7.236
7.226
5.615
5.610
5.601
5.596
2.937
2.923
2.676
2.670
2.469
Me
OH
1HNMR (400 MHz, CDCl3)
11
10
9
8
7
6
5
4
3
2
1
0
ppm
1.00
2.04
1.12
1.00
1.00
0.97
3.10

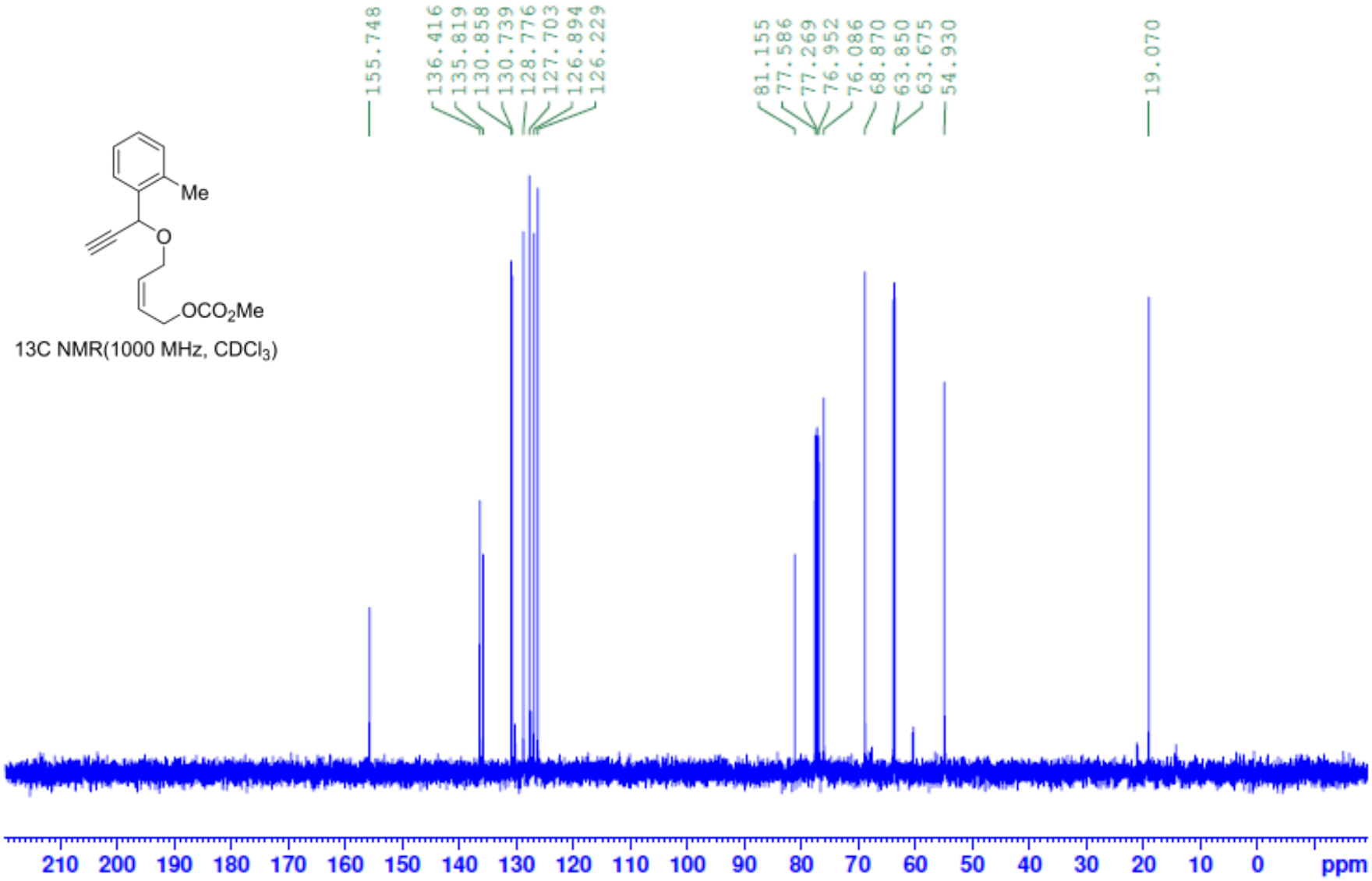

138.074
136.037
130.908
128.652
126.580
126.398
83.562
77.628
77.311
76.992
74.789
62.198
19.061
Me
OH
13C NMR(1000 MHz, CDC
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0 ppm

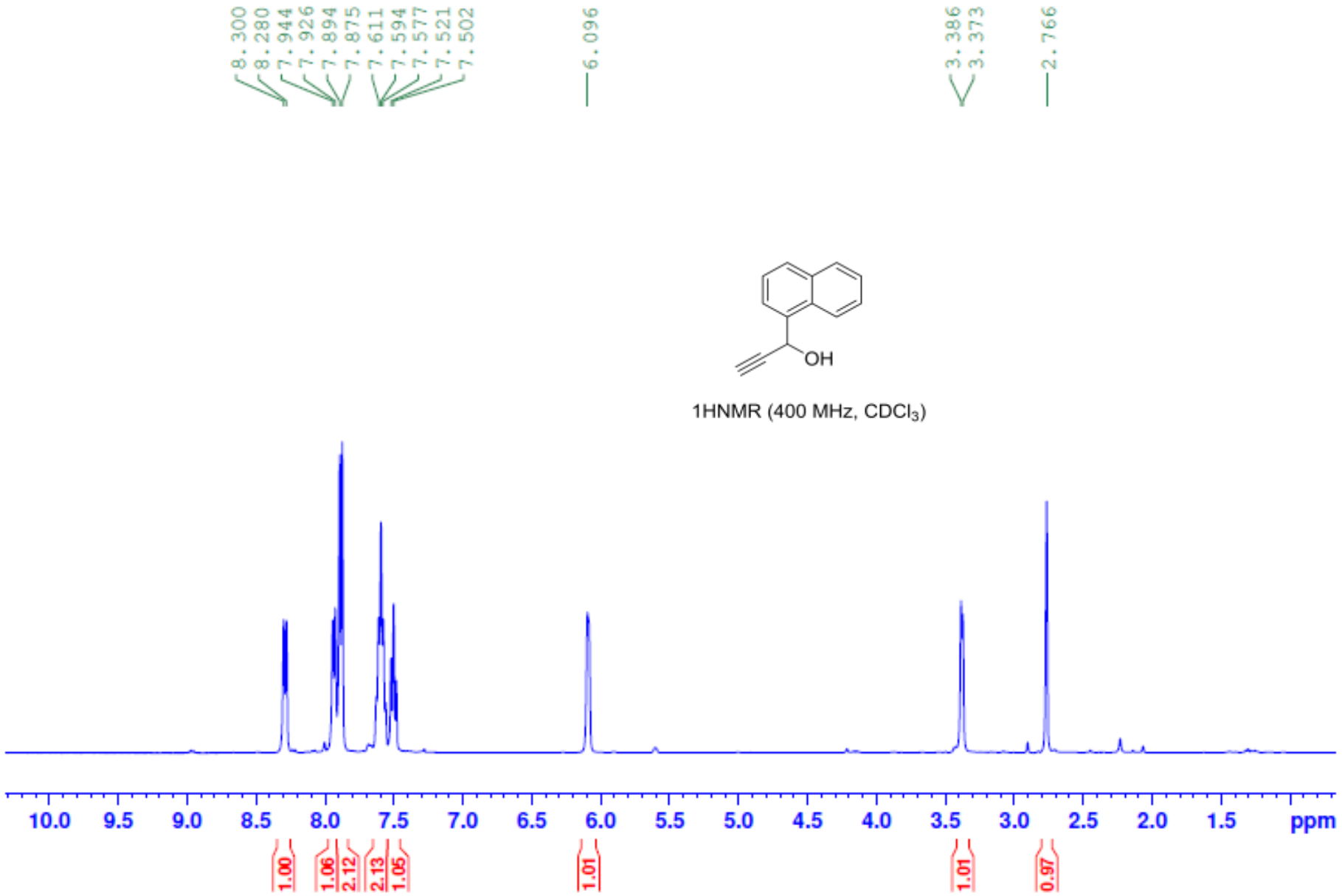

7.256
7.248
7.239
7.201
7.194
5.810
5.800
5.350
4.653
4.645
4.308
4.290
4.276
4.163
4.152
4.131
4.118
3.873
3.865
3.532
3.519
3.503
2.438
1.859
1.836
1.725
1.717
1.633
1.622
1.611
1.590
1.582
1.553
1.541
1.527
Me
O
OTHP
1HNMR (400 MHz, CDCl3)
10
9
8
7
6
5
4
3
2
1
0
ppm
1.00
3.81
2.32
1.01
1.30
3.35
1.68
1.31
1.29
3.22
1.33
1.72
5.51

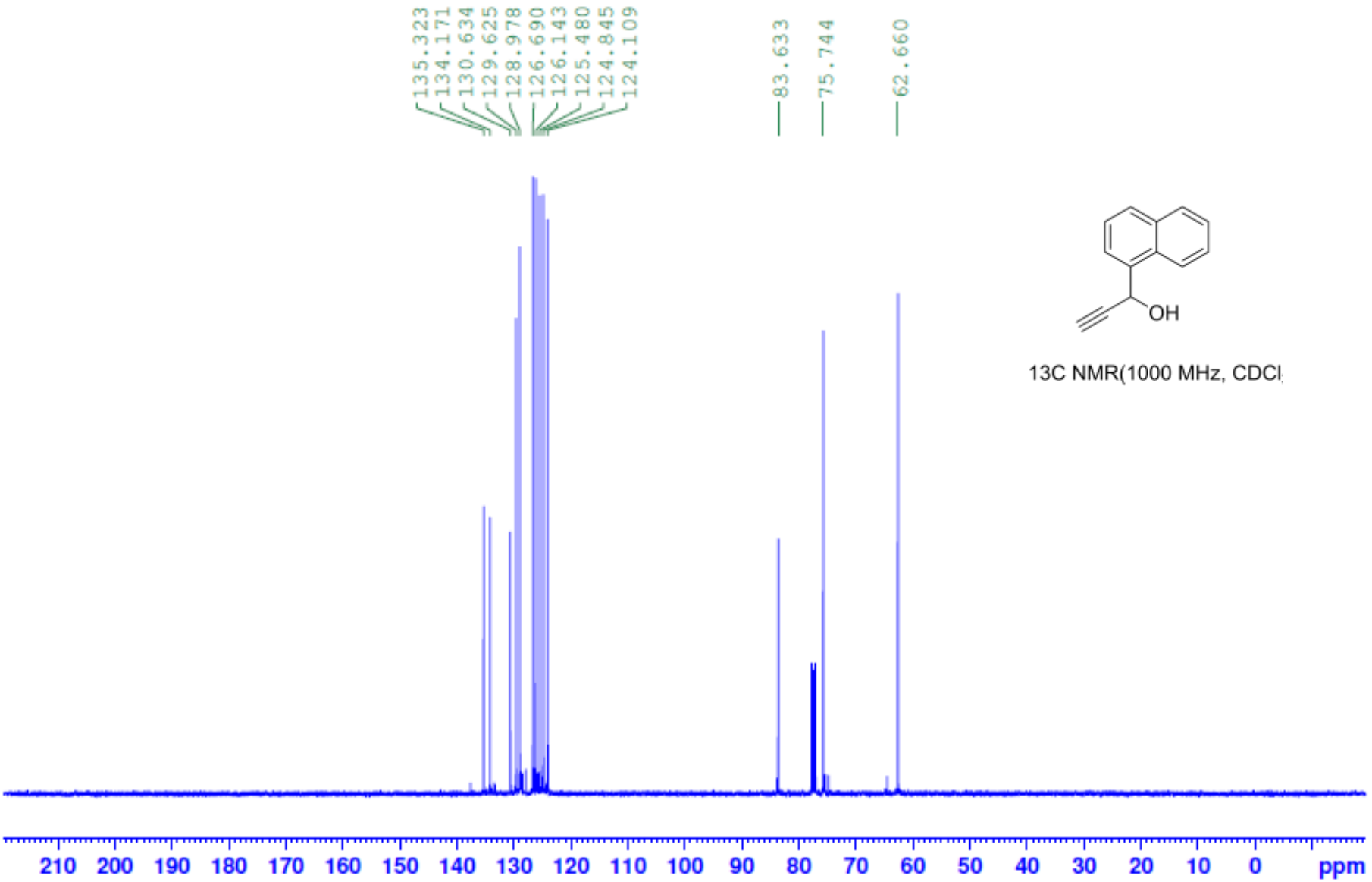


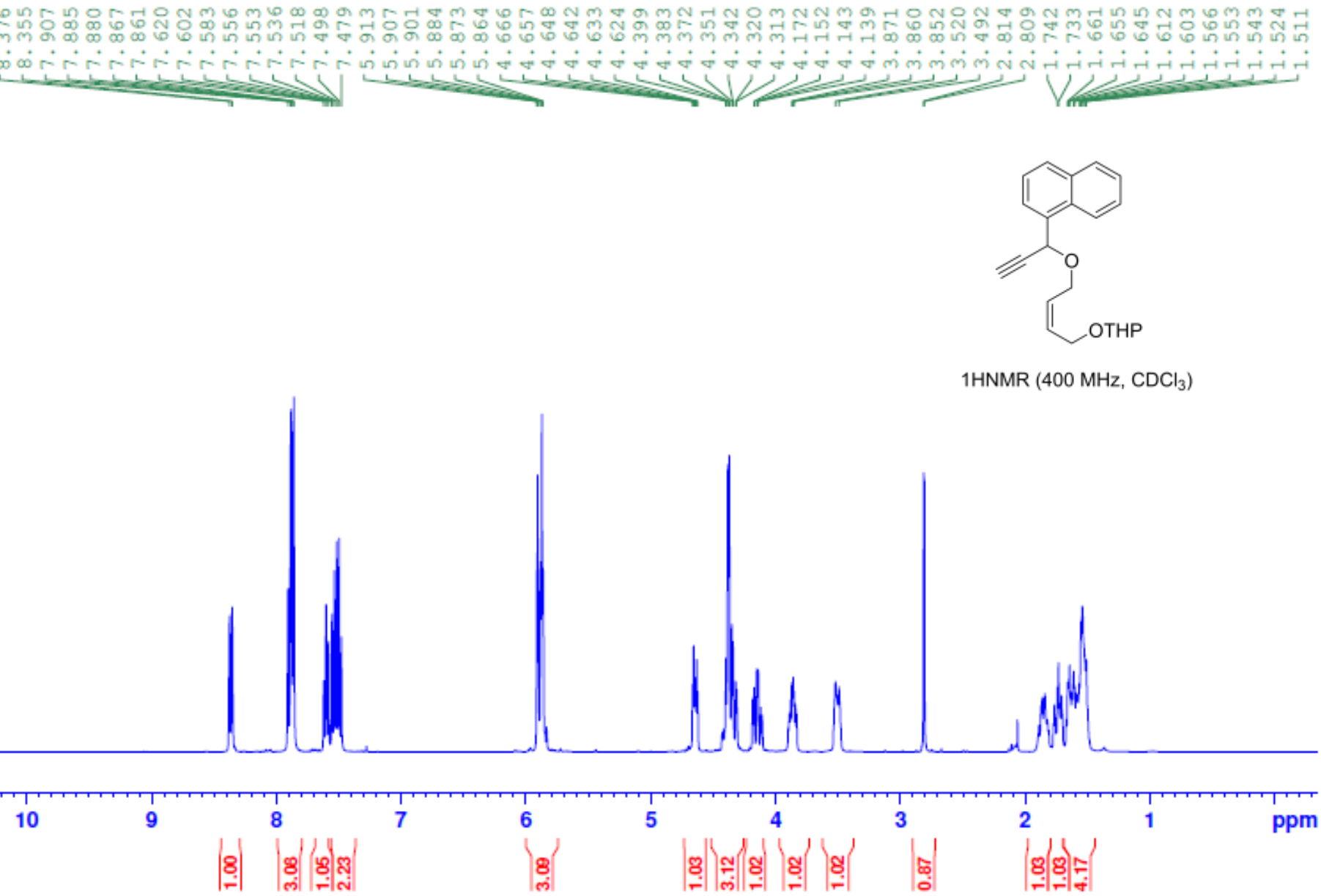
19 NMR (376 MHz, $CDCl_3$)

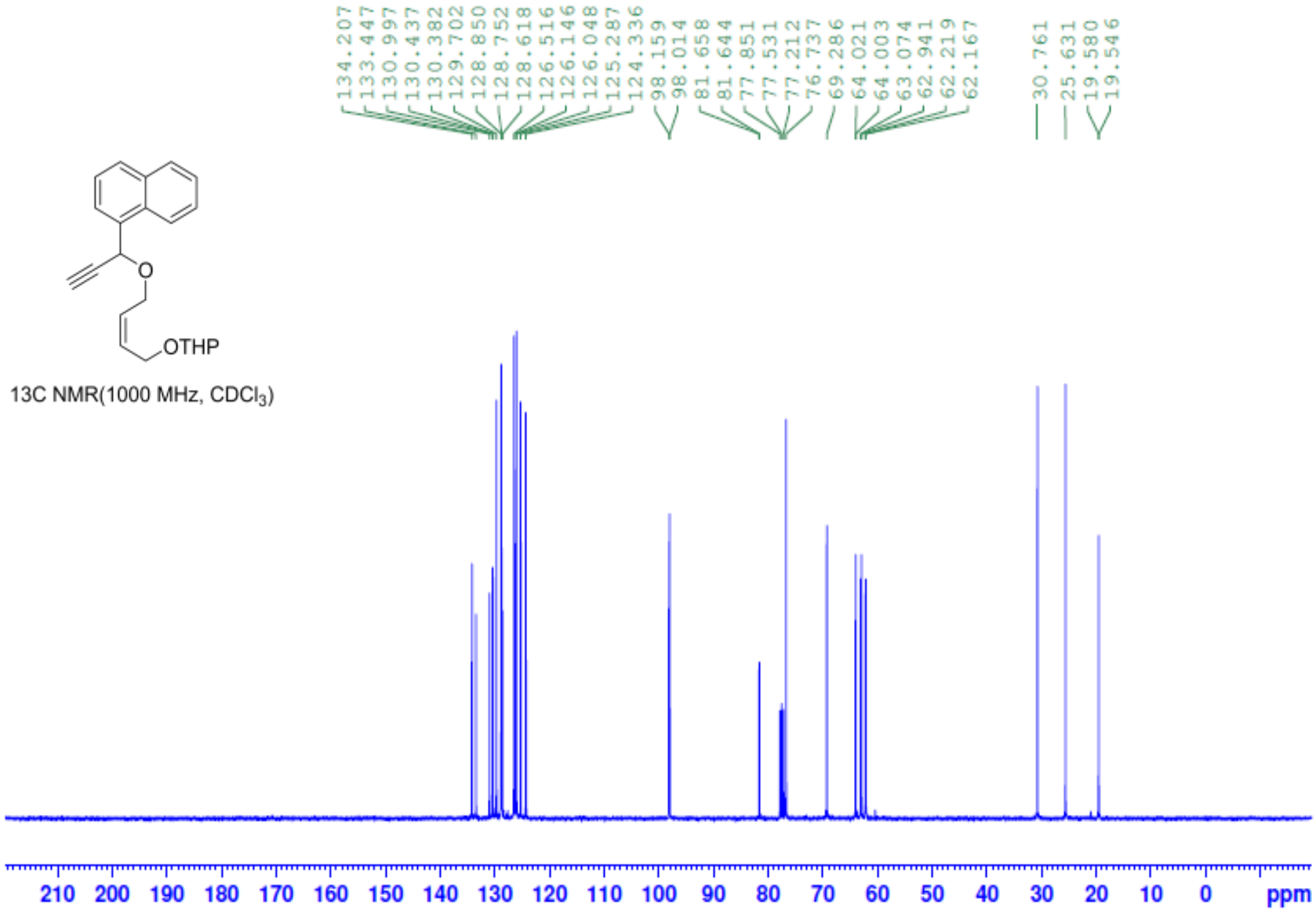

7.659
7.646
7.262
7.255
7.211
5.878
5.862
5.847
5.819
5.803
5.787
5.358
4.758
4.331
4.318
4.296
4.280
3.806
2.696
2.442
2.084
2.071
Me
O
OCO2Me
1HNMR (400 MHz, CDCl3)
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm
1.00
3.12
2.06
1.00
2.01
2.05
2.83
0.98
3.09

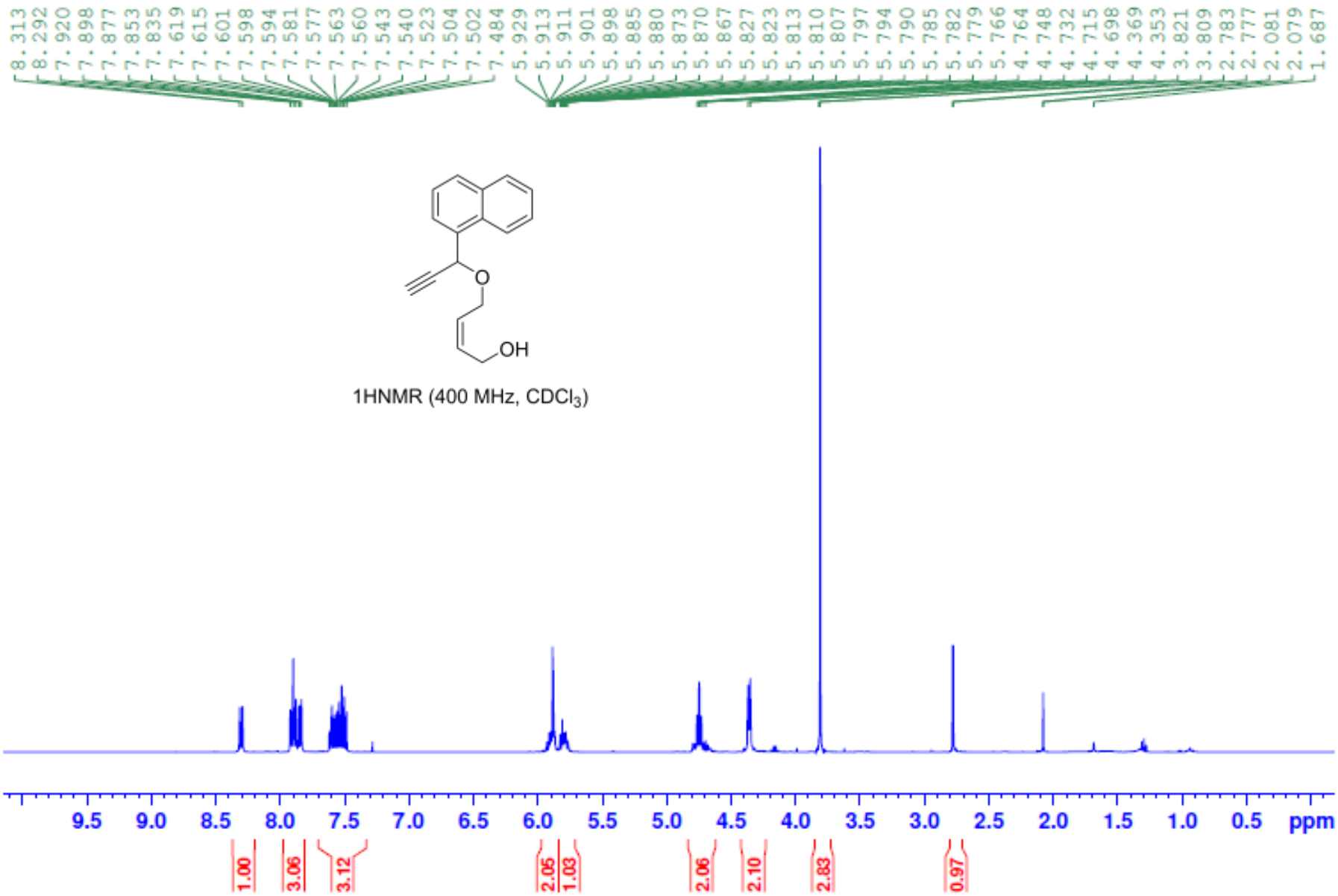

155.748
136.416
135.819
130.858
130.739
128.776
127.703
126.894
126.229
81.155
77.586
77.269
76.952
76.086
68.870
63.850
63.675
54.930
19.070
Me
O
OCO2Me
13C NMR(1000 MHz, CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

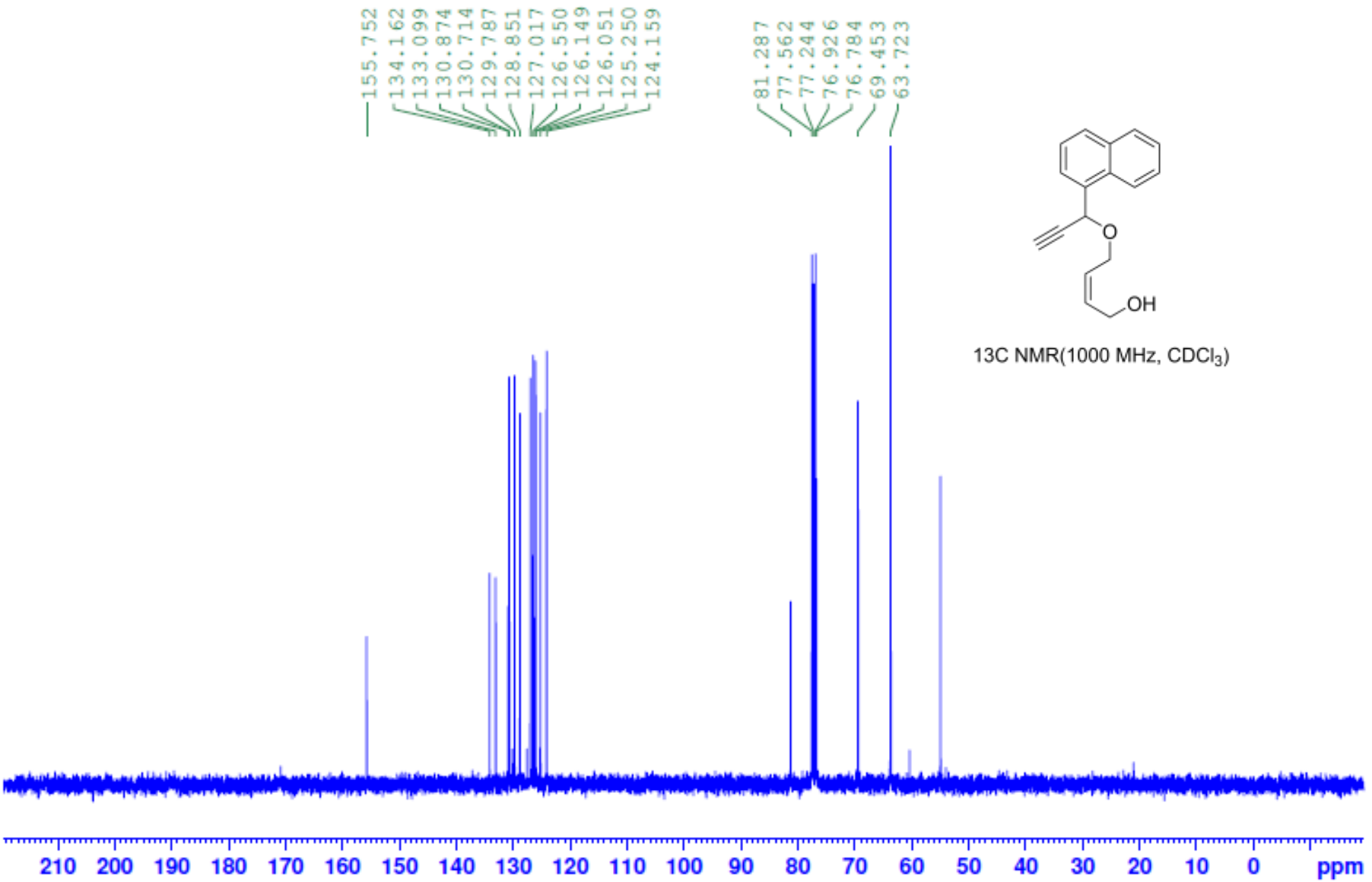

8.300
8.280
7.944
7.926
7.894
7.875
7.611
7.594
7.577
7.521
7.502
6.096
3.386
3.373
2.766
OH
1HNMR (400 MHz, CDCl3)
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
ppm
1.00
1.06
2.12
2.13
1.05
1.01
1.01
0.97

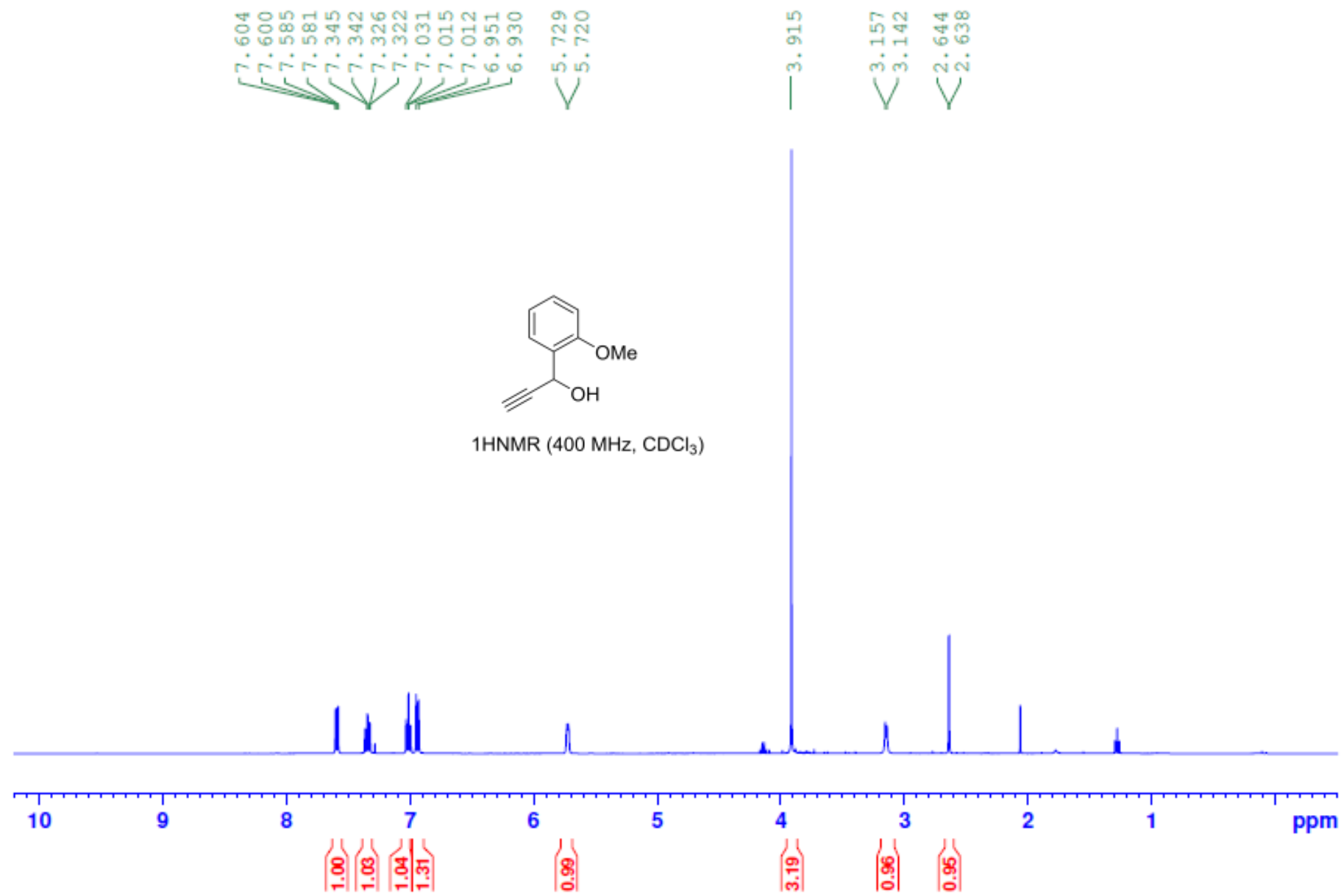

135.323
134.171
130.634
129.625
128.978
126.690
126.143
125.480
124.845
124.109
83.633
75.744
62.660
OH
13C NMR(1000 MHz, CDCl
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

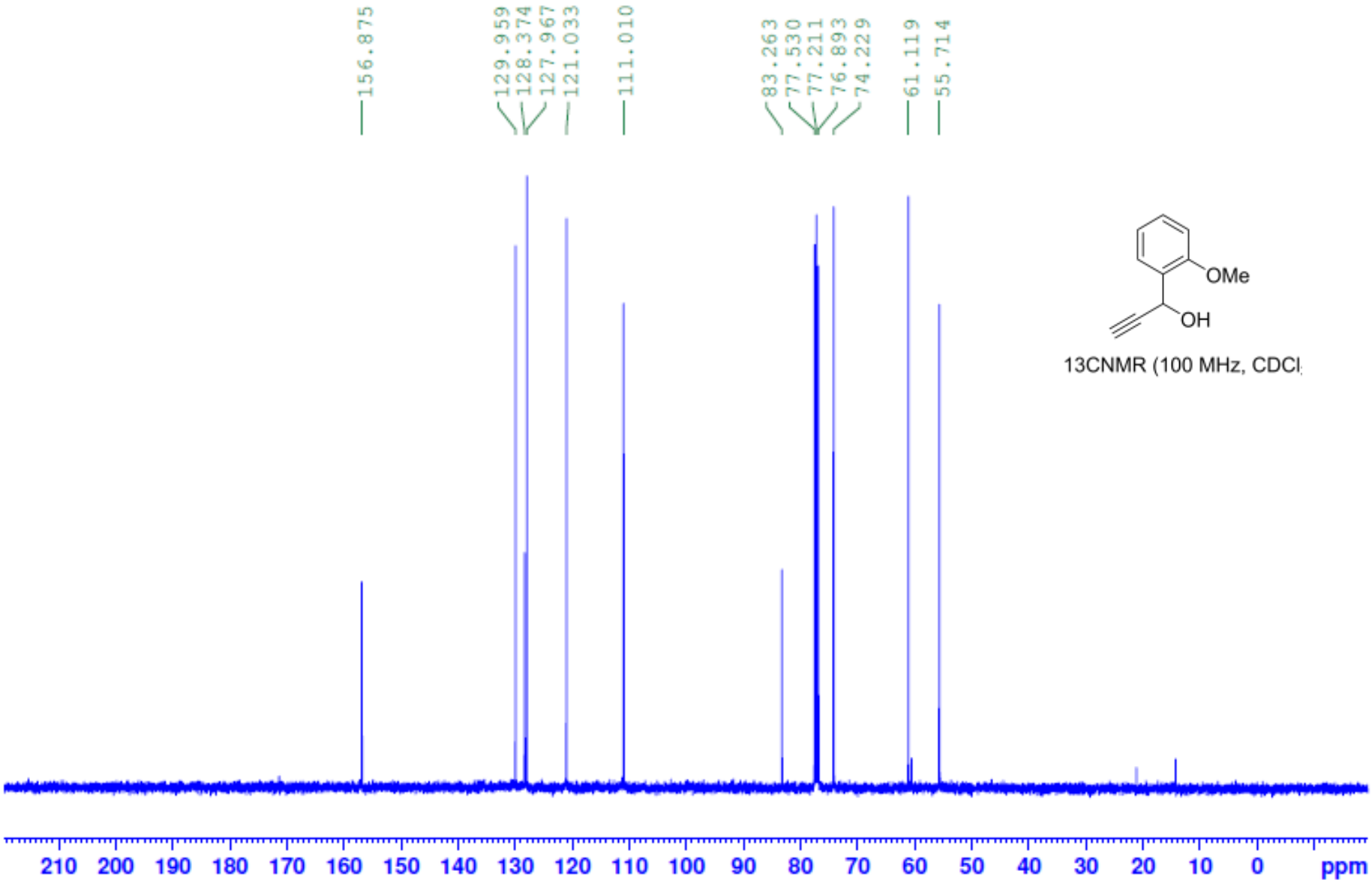

8.376
8.355
7.907
7.885
7.880
7.867
7.861
7.620
7.602
7.583
7.556
7.553
7.536
7.518
7.498
7.479
5.913
5.907
5.901
5.884
5.873
5.864
4.666
4.657
4.648
4.642
4.633
4.624
4.399
4.383
4.372
4.351
4.342
4.320
4.313
4.172
4.152
4.143
4.139
3.871
3.860
3.852
3.520
3.492
2.814
2.809
1.742
1.733
1.661
1.655
1.645
1.612
1.603
1.566
1.553
1.543
1.524
1.511
O
OTHP
1HNMR (400 MHz, CDCl3)
10
9
8
7
6
5
4
3
2
1
ppm
1.00
3.06
1.05
2.23
3.09
1.03
3.12
1.02
1.02
1.02
0.87
1.03
1.03
4.17

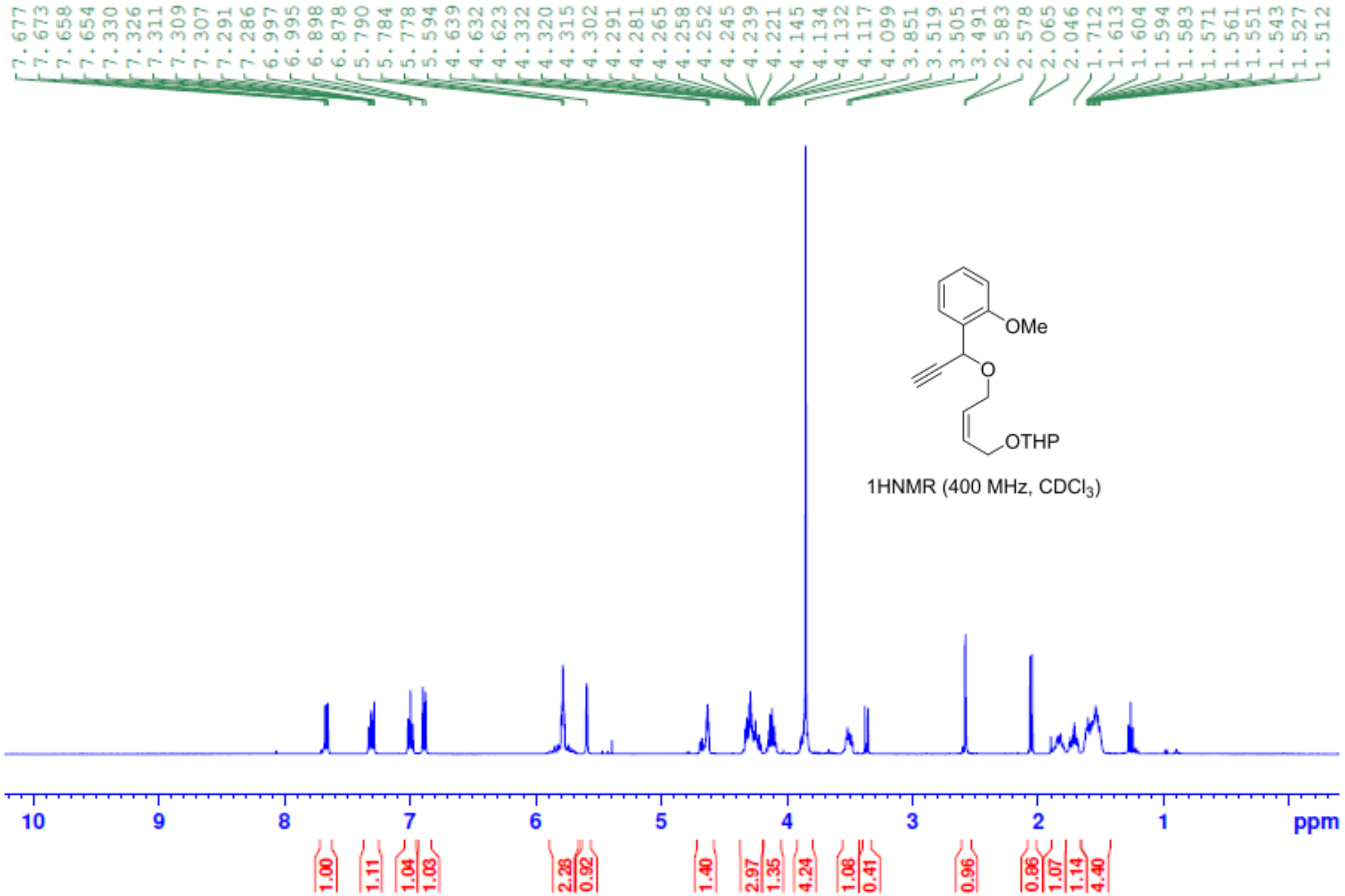

134.207
133.447
130.997
130.437
130.382
129.702
128.850
128.752
128.618
126.516
126.146
126.048
125.287
124.336
98.159
98.014
81.658
81.644
77.851
77.531
77.212
76.737
69.286
64.021
64.003
63.074
62.941
62.219
62.167
30.761
25.631
19.580
19.546
O
OTHP
13C NMR(1000 MHz, CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

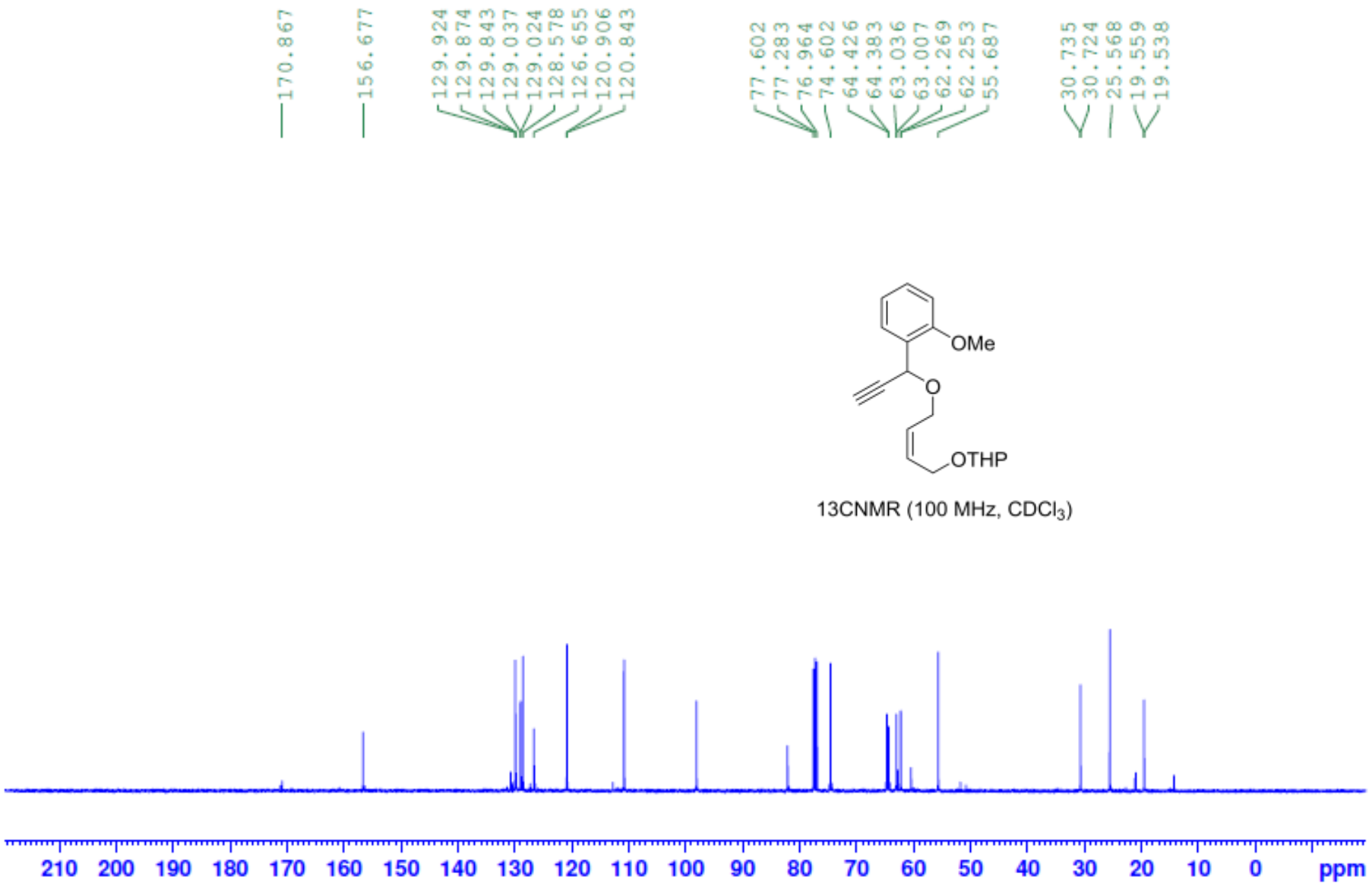

8.313
8.292
7.920
7.898
7.877
7.853
7.835
7.619
7.615
7.601
7.598
7.594
7.581
7.577
7.563
7.560
7.543
7.540
7.523
7.504
7.502
7.484
5.929
5.913
5.911
5.901
5.898
5.885
5.880
5.873
5.870
5.867
5.827
5.823
5.813
5.810
5.807
5.797
5.794
5.790
5.785
5.782
5.779
5.766
5.764
4.748
4.732
4.715
4.698
4.369
4.353
3.821
3.809
2.783
2.777
2.081
2.079
1.687
O
OH
1HNMR (400 MHz, CDCl3)
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
ppm
1.00
3.06
3.12
2.05
1.03
2.06
2.10
2.83
0.97


155.752
134.162
133.099
130.874
130.714
129.787
128.851
127.017
126.550
126.149
126.051
125.250
124.159
81.287
77.562
77.244
76.926
76.784
69.453
63.723
O
OH
13C NMR(1000 MHz, CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

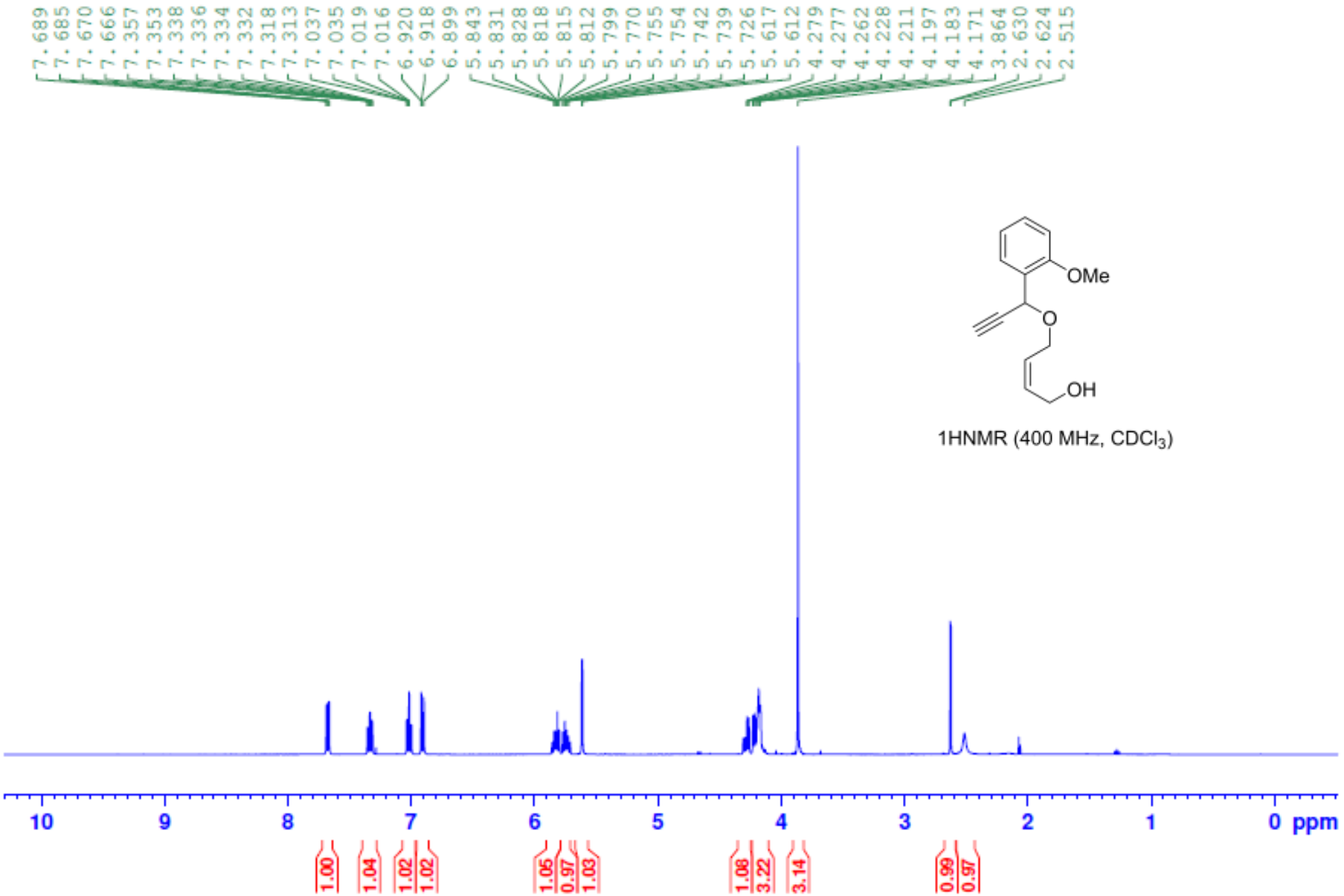

7.604
7.600
7.585
7.581
7.345
7.342
7.326
7.322
7.031
7.015
7.012
6.951
6.930
5.729
5.720
3.915
3.157
3.142
2.644
2.638
OMe
OH
1HNMR (400 MHz, CDCl3)
10
9
8
7
6
5
4
3
2
1
ppm
1.00
1.03
1.04
1.31
0.99
3.19
0.96
0.95


156.875
129.959
128.374
127.967
121.033
111.010
83.263
77.530
77.211
76.893
74.229
61.119
55.714
OMe
OH
13CNMR (100 MHz, CDCl
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

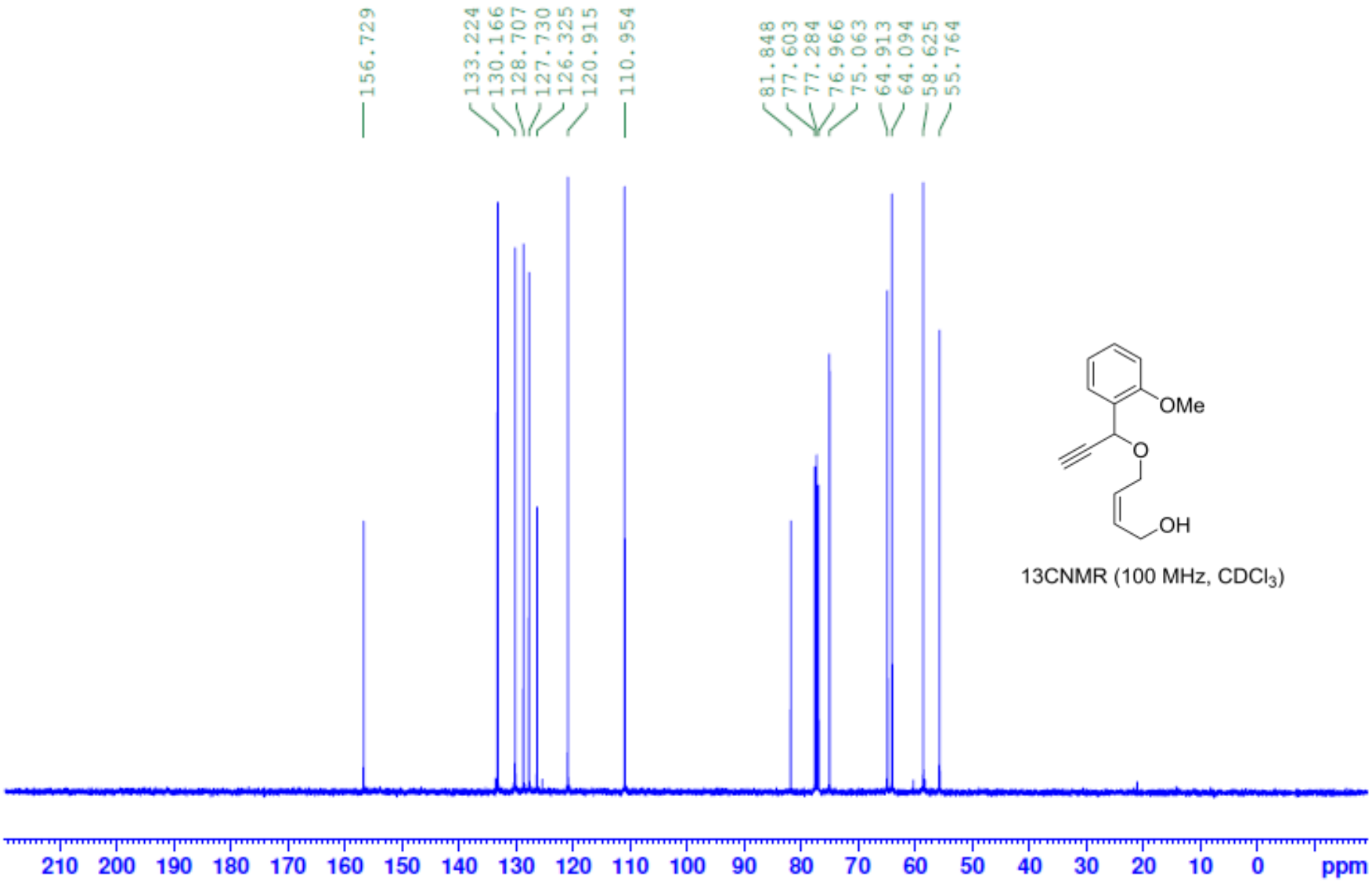

7.677
7.673
7.658
7.654
7.330
7.326
7.311
7.309
7.307
7.291
7.286
6.997
6.995
6.898
6.878
5.790
5.784
5.778
5.594
4.639
4.632
4.623
4.332
4.320
4.315
4.302
4.291
4.281
4.265
4.258
4.252
4.245
4.239
4.221
4.145
4.134
4.132
4.117
4.099
3.851
3.519
3.505
3.491
2.583
2.578
2.065
2.046
1.712
1.613
1.604
1.594
1.583
1.571
1.561
1.551
1.543
1.527
1.512
OMe
O
OTHP
1HNMR (400 MHz, CDCl3)
10
9
8
7
6
5
4
3
2
1
ppm
1.00
1.11
1.04
1.03
2.28
0.92
1.40
2.97
1.35
4.24
1.08
0.41
0.96
0.86
1.07
1.14
4.40

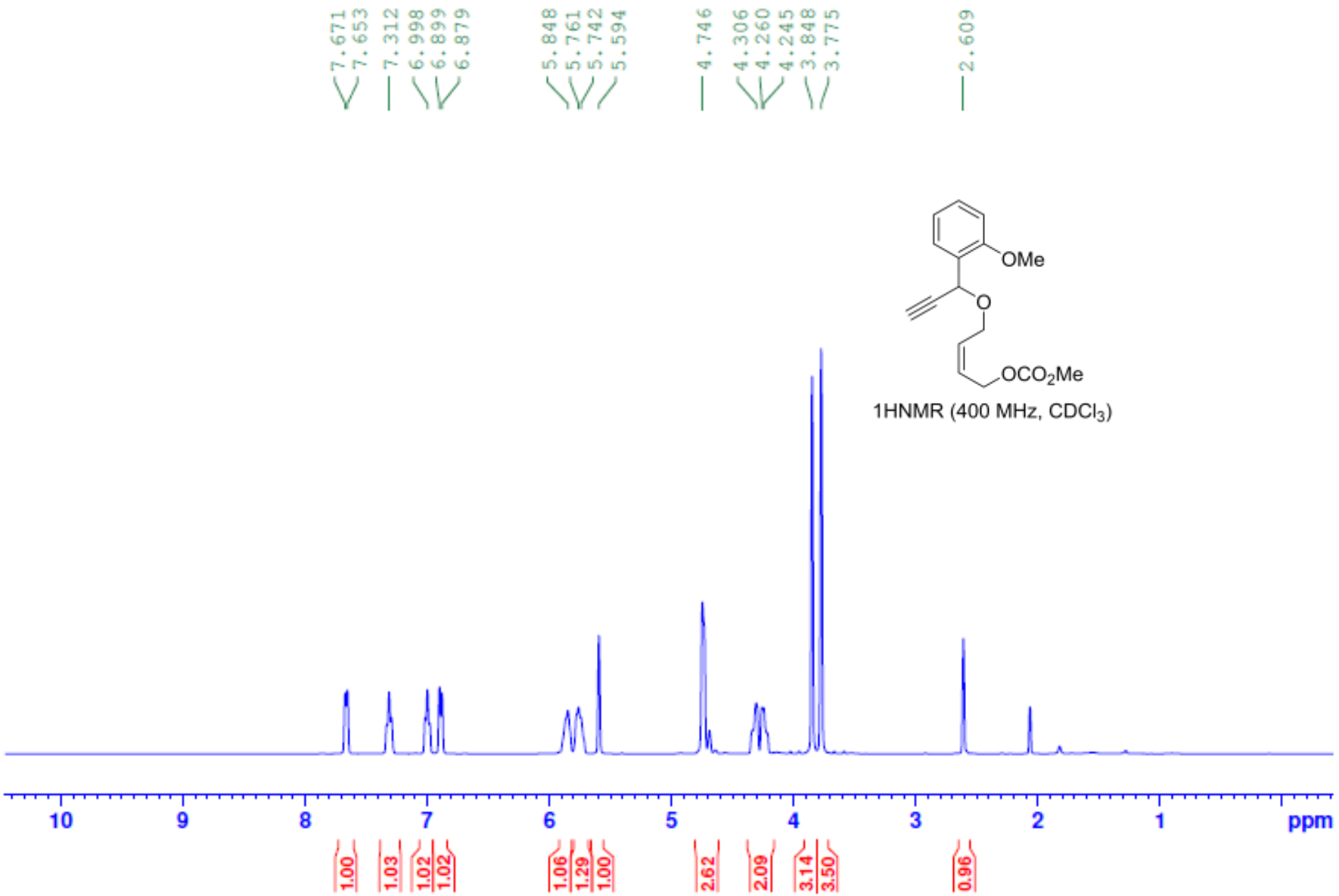


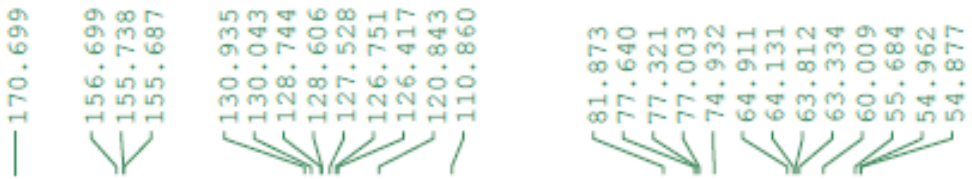
13CNMR (100 MHz, $CDCl_3$)

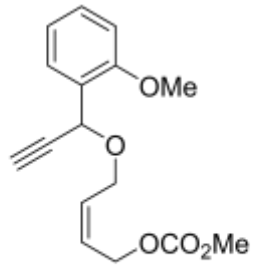


1HNMR (400 MHz, $CDCl_3$)

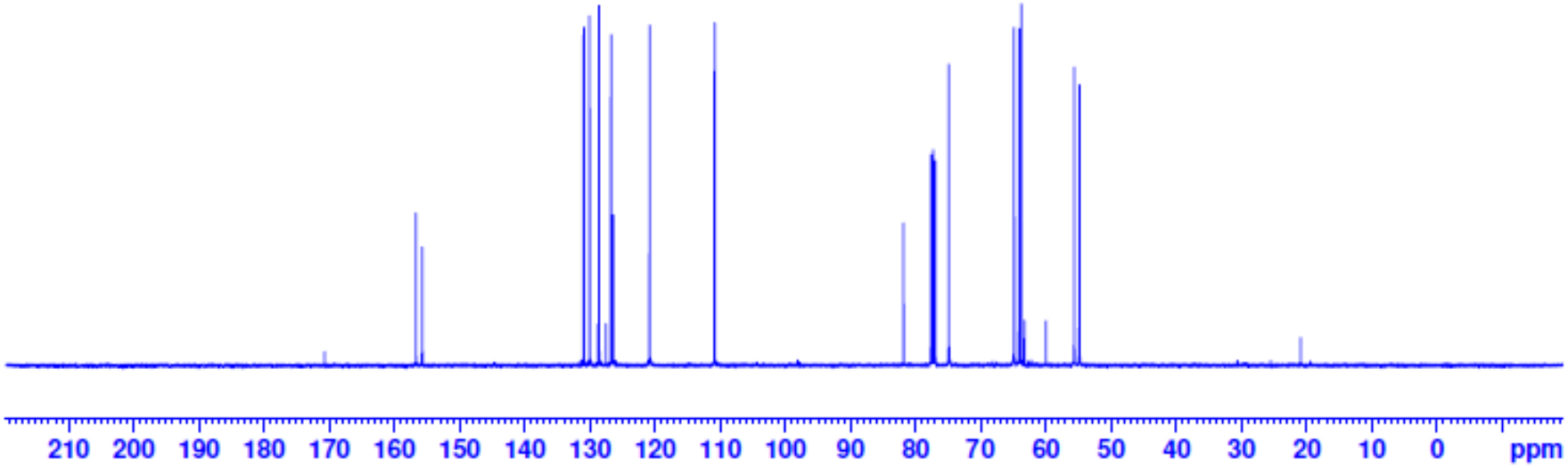

156.729
133.224
130.166
128.707
127.730
126.325
120.915
110.954
81.848
77.603
77.284
76.966
75.063
64.913
64.094
58.625
55.764
OMe
O
OH
13CNMR (100 MHz, CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

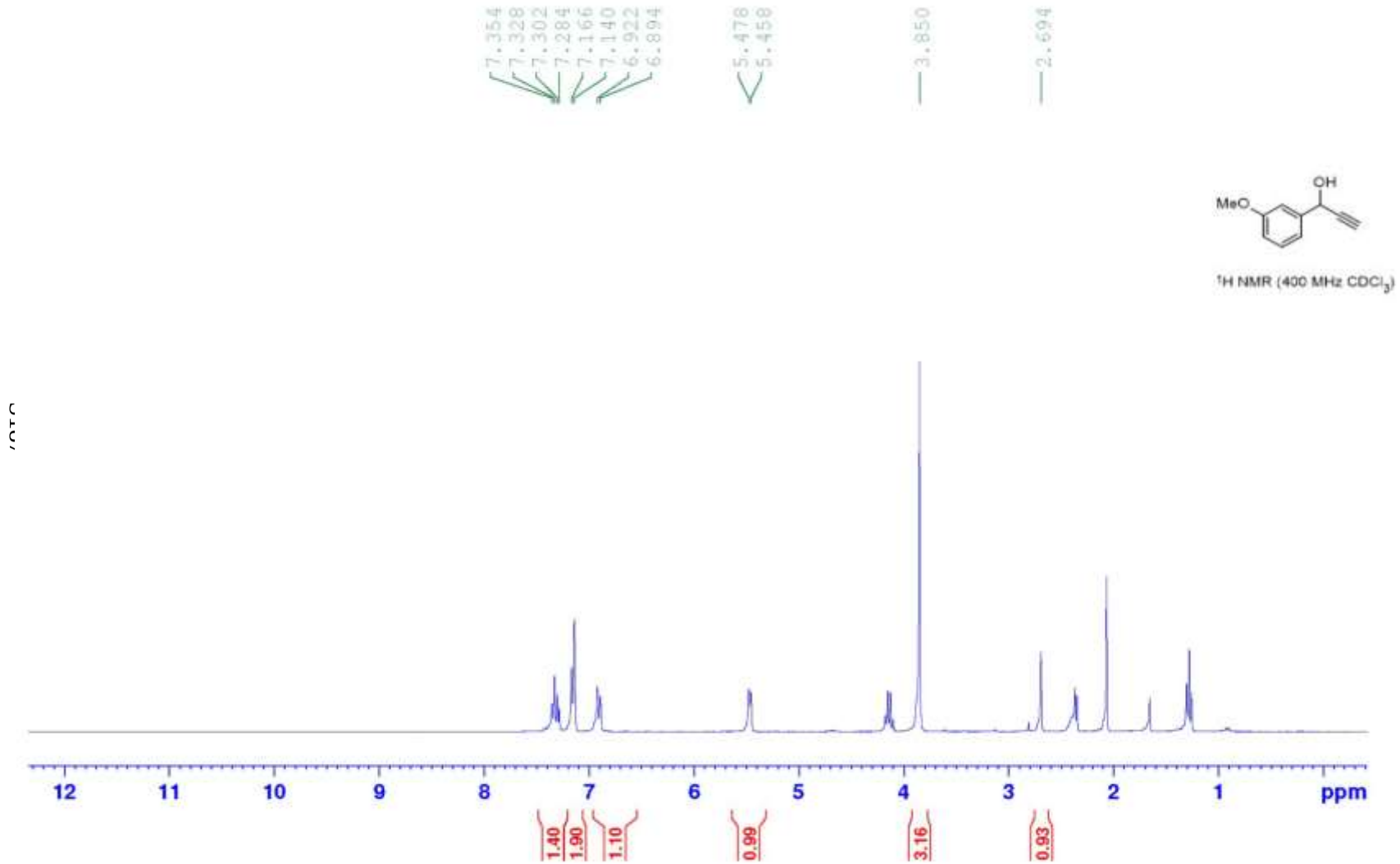

7.671
7.653
7.312
6.998
6.899
6.879
5.848
5.761
5.742
5.594
4.746
4.306
4.260
4.245
3.848
3.775
2.609
OMe
O
OCO2Me
1HNMR (400 MHz, CDCl3)
10
9
8
7
6
5
4
3
2
1
ppm
1.00
1.03
1.02
1.02
1.06
1.29
1.00
2.62
2.09
3.14
3.50
0.96

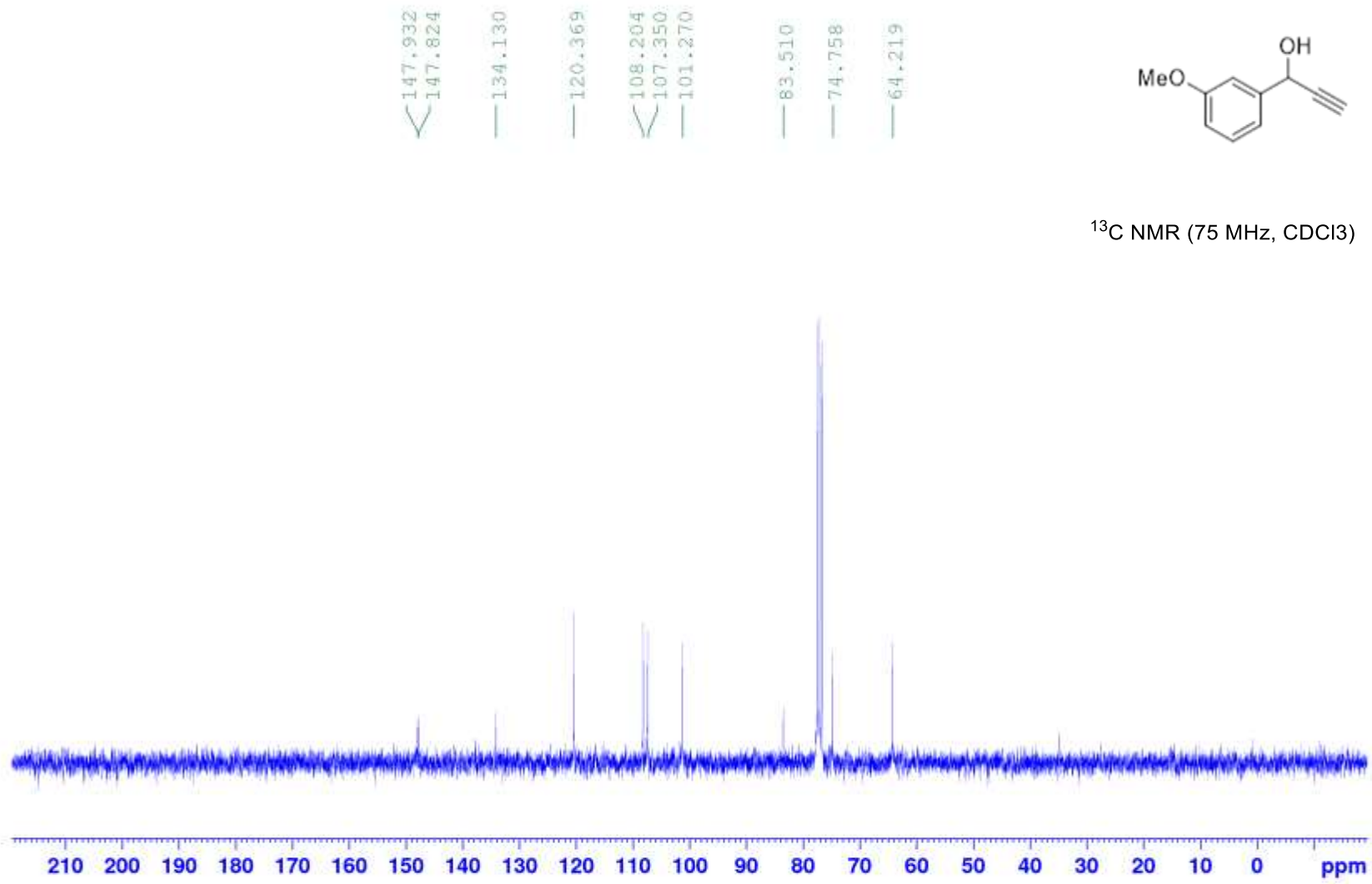




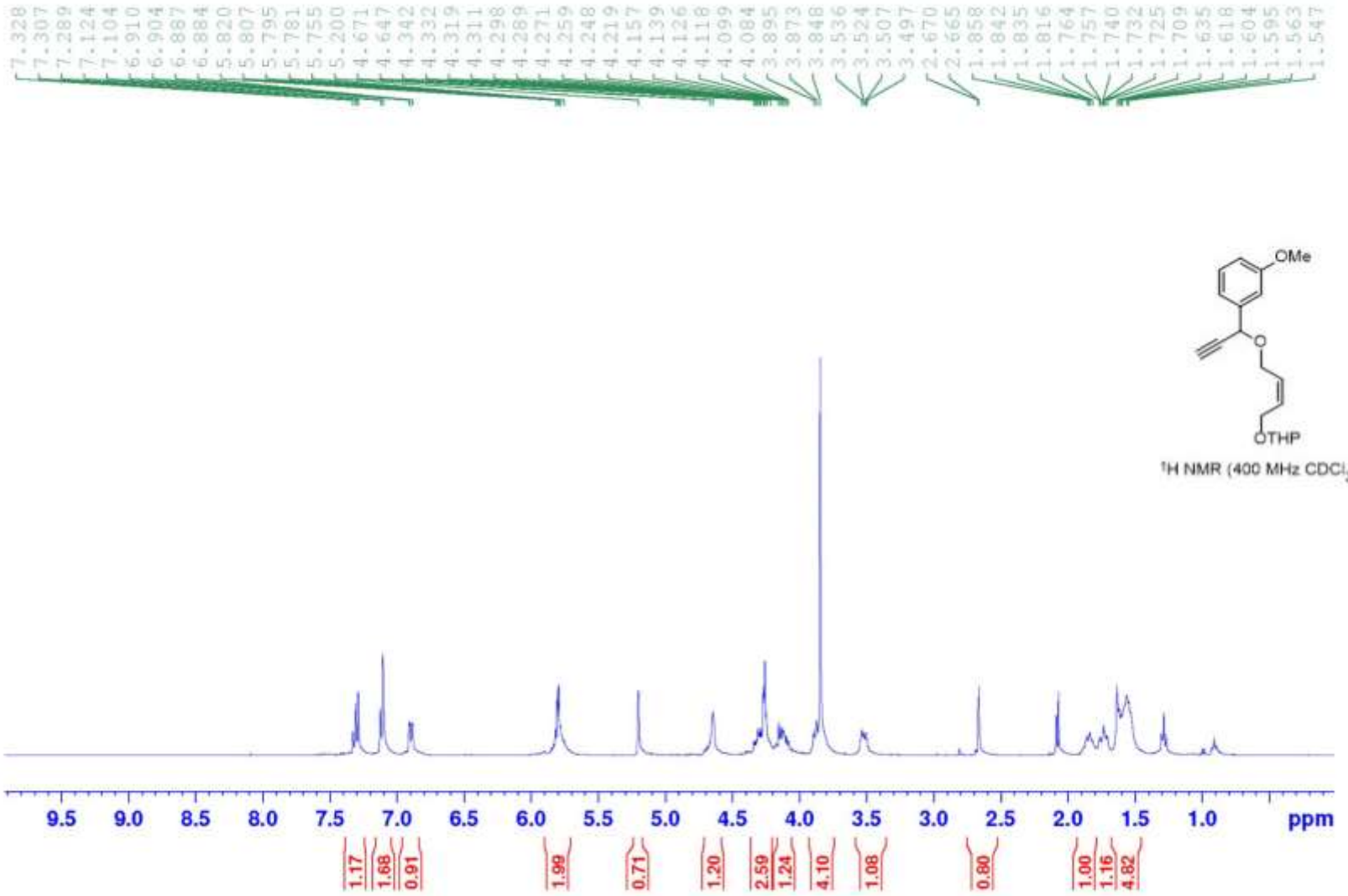
13CNMR (100 MHz, $CDCl_3$)

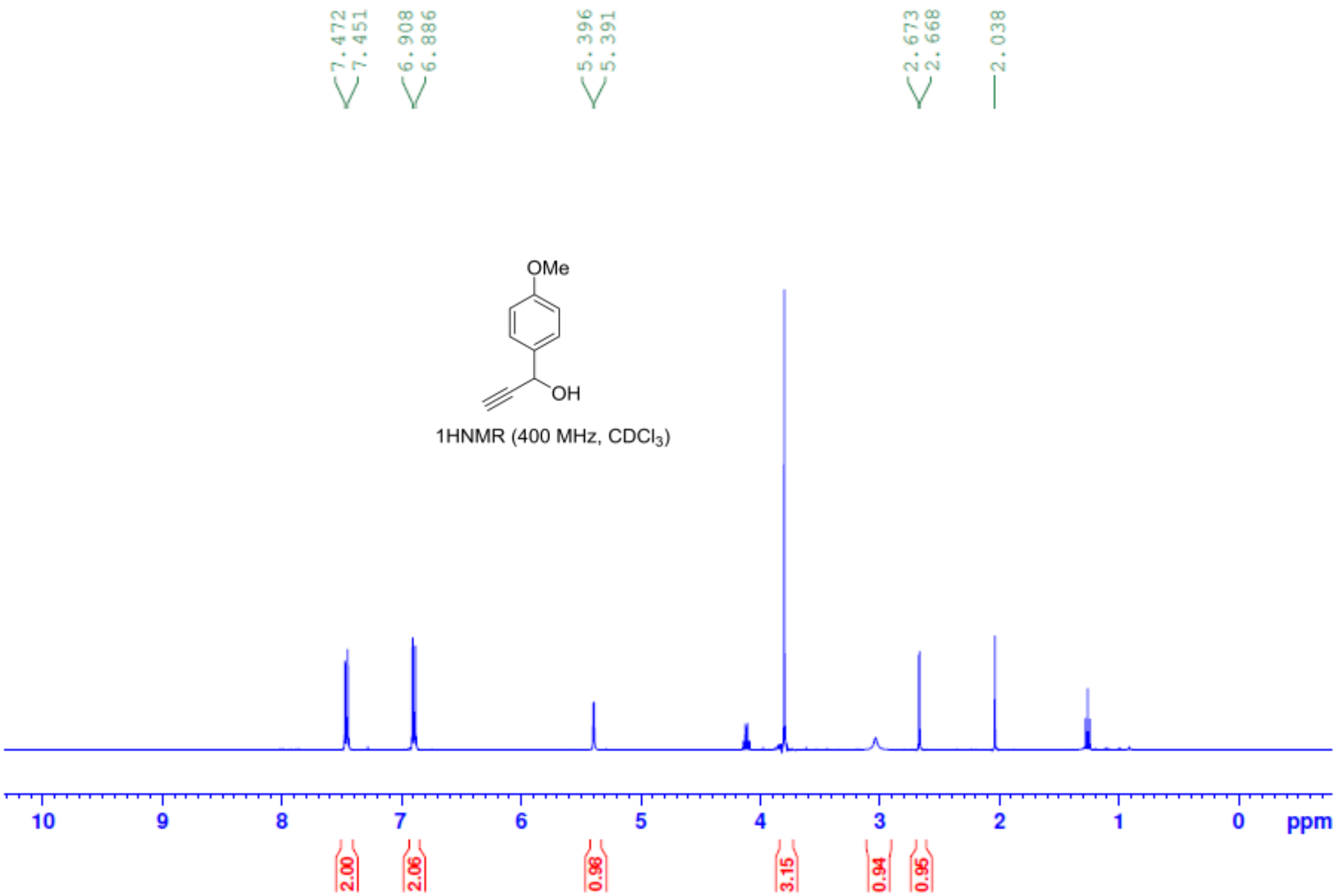


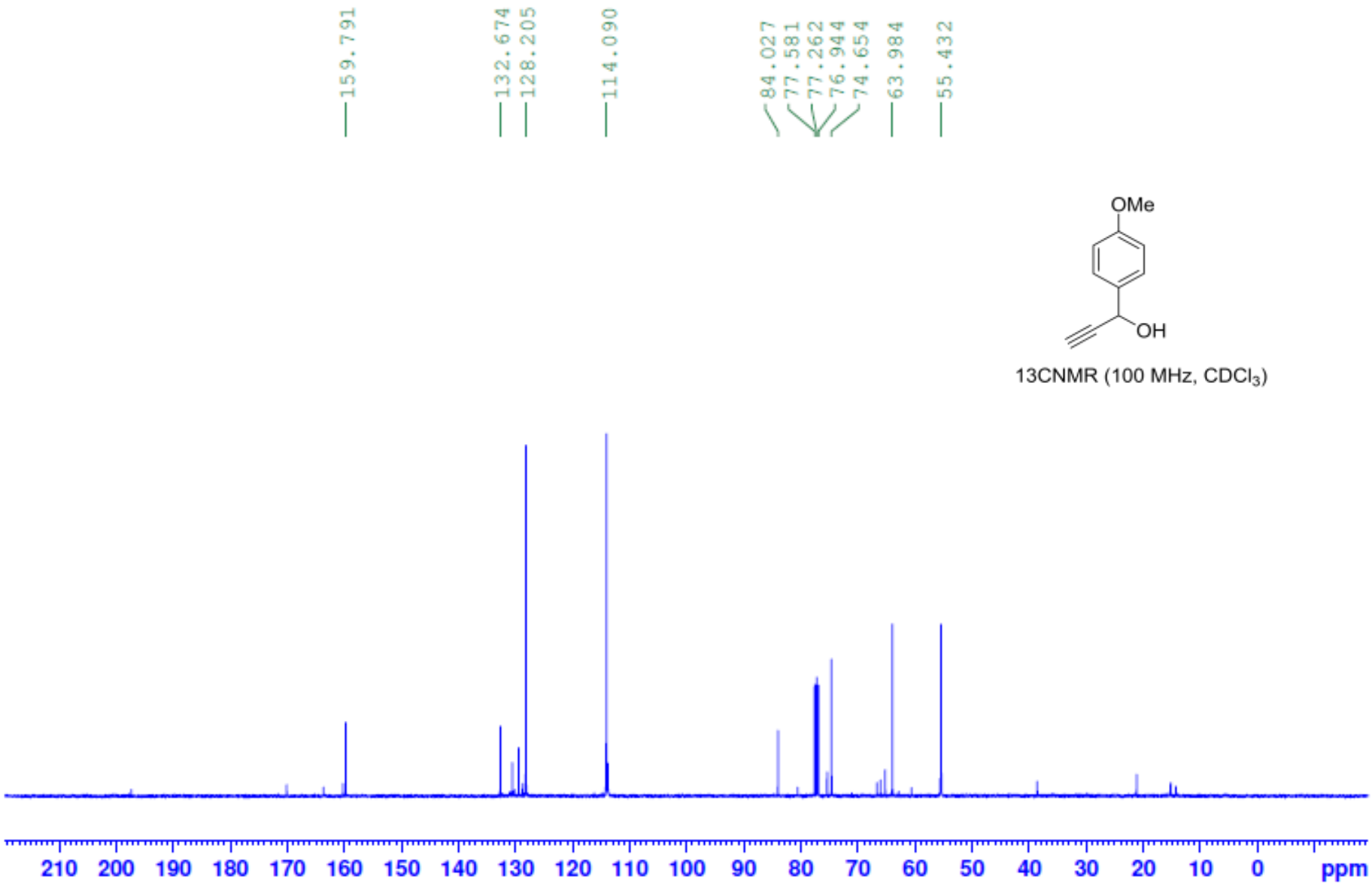

7.354
7.328
7.302
7.284
7.166
7.140
6.922
6.894
5.478
5.458
3.850
2.694
MeO
OH
^{1}H NMR (400 MHz $CDCl_3$)
12
11
10
9
8
7
6
5
4
3
2
1
ppm
1.40
1.90
1.10
0.99
3.16
0.93



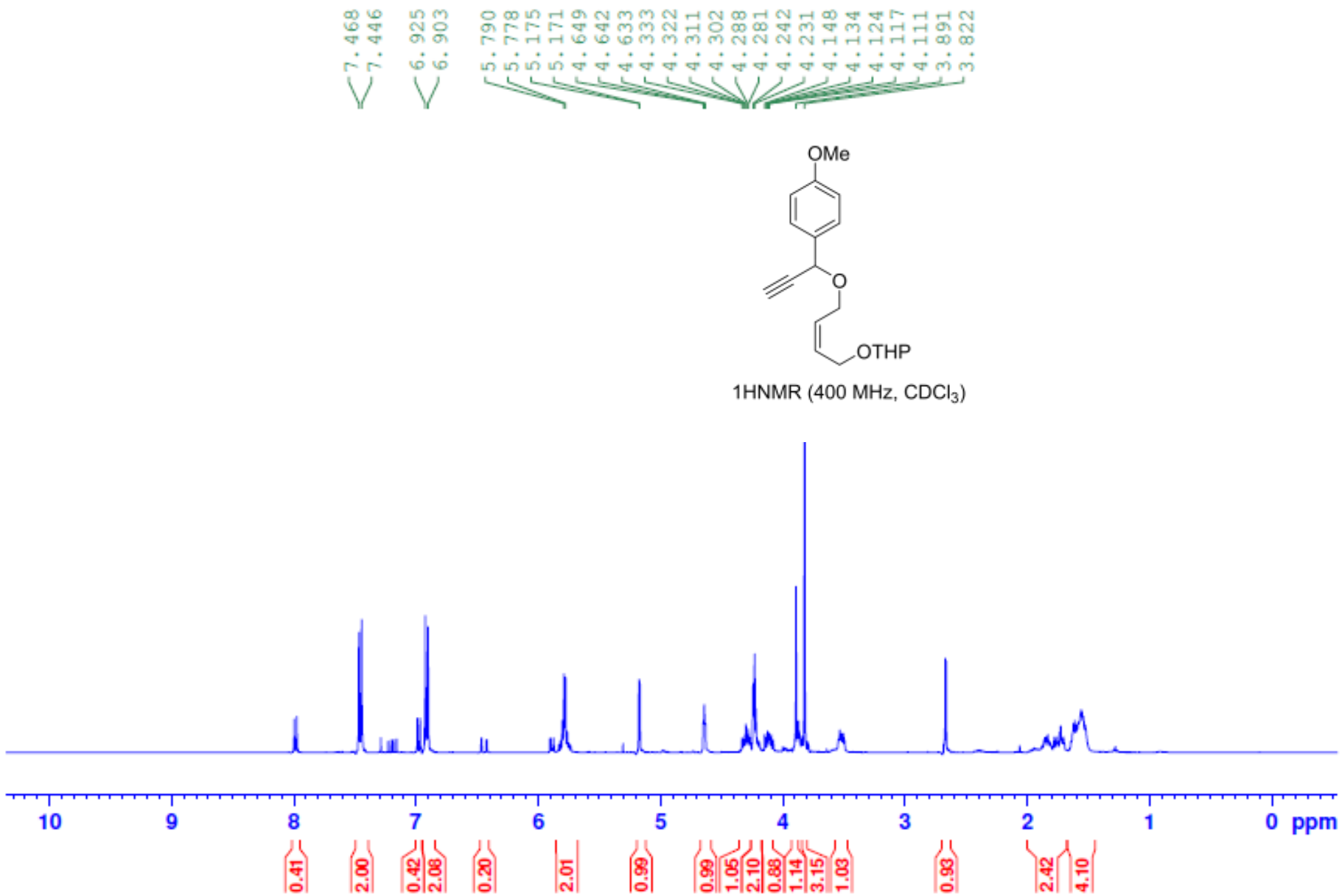
^{13}C NMR (75 MHz, CDCl3)

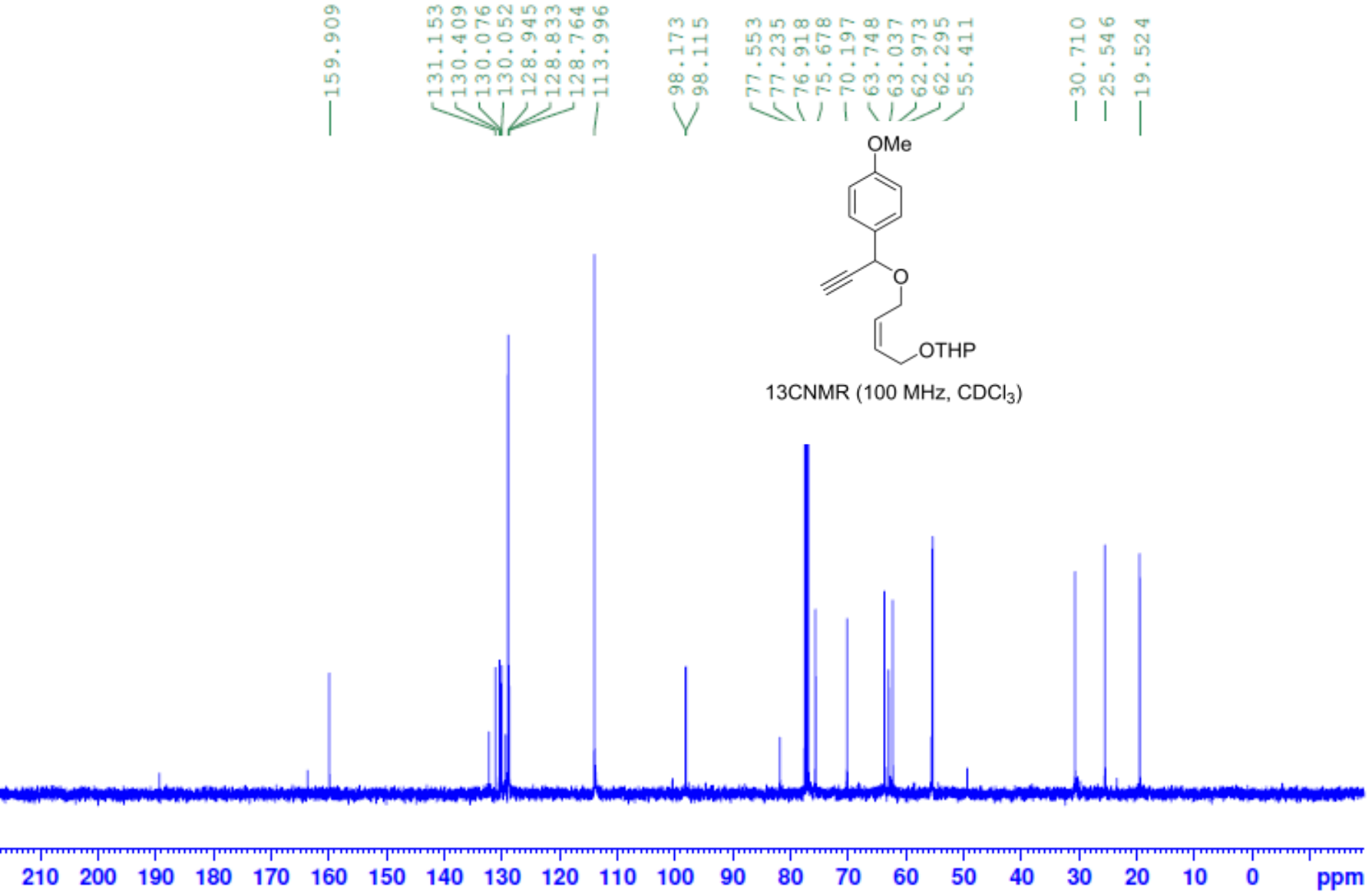

7.328
7.307
7.289
7.124
7.104
6.910
6.904
6.887
6.884
5.820
5.807
5.795
5.781
5.755
5.200
4.671
4.647
4.342
4.332
4.319
4.311
4.298
4.289
4.271
4.259
4.248
4.219
4.157
4.139
4.126
4.118
4.099
4.084
3.895
3.873
3.848
3.536
3.524
3.507
3.497
2.670
2.665
1.858
1.842
1.835
1.816
1.764
1.757
1.740
1.732
1.725
1.709
1.635
1.618
1.604
1.595
1.563
1.547
OMe
O
OTHP
^{1}H NMR (400 MHz $CDCl_3$)
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
ppm
1.17
1.68
0.91
1.99
0.71
1.20
2.59
1.24
4.10
1.08
0.80
1.00
1.16
4.82

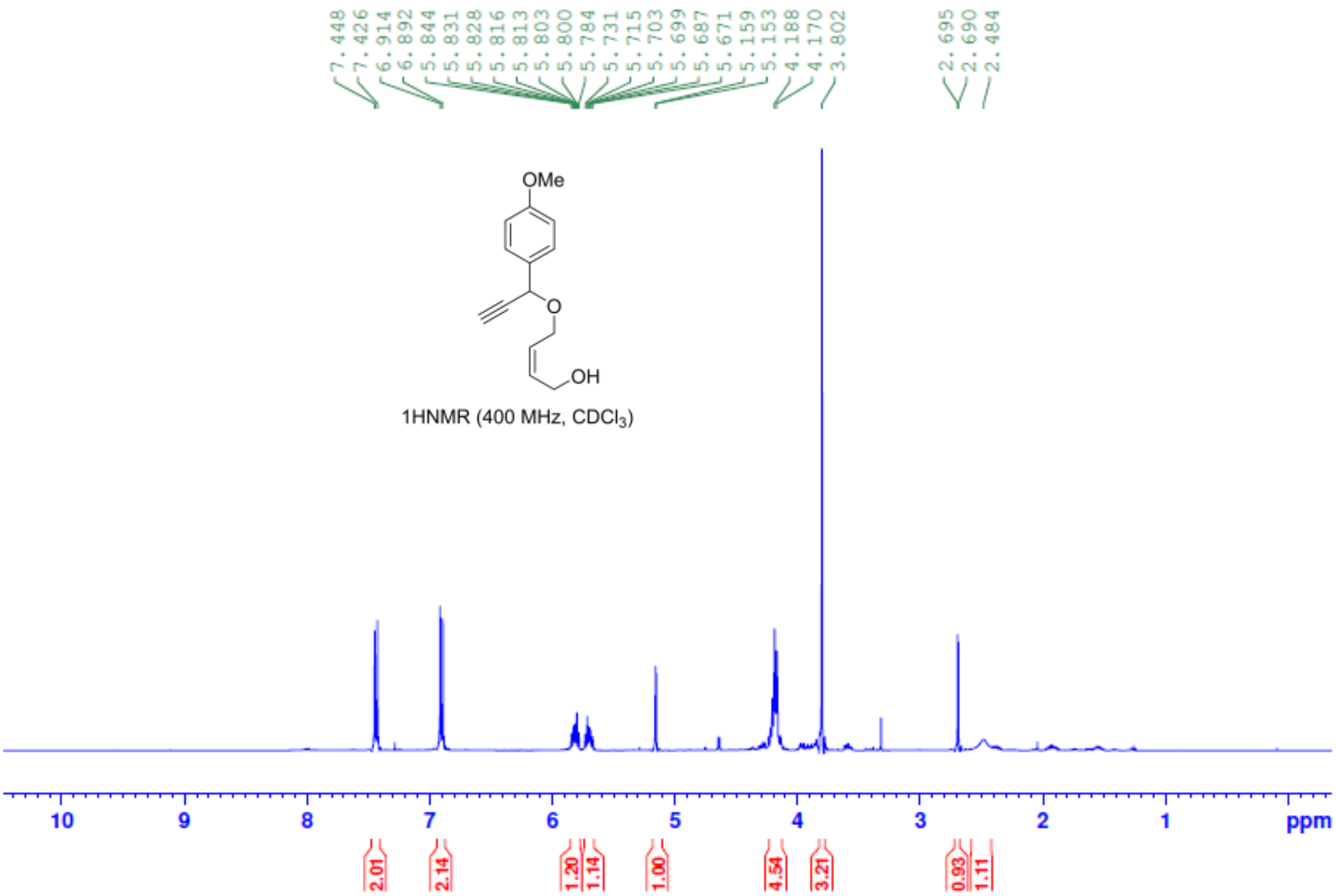

7.472
7.451
6.908
6.886
5.396
5.391
2.673
2.668
2.038
OMe
OH
1HNMR (400 MHz, CDCl3)
10
9
8
7
6
5
4
3
2
1
0
ppm
2.00
2.06
0.98
3.15
0.94
0.95

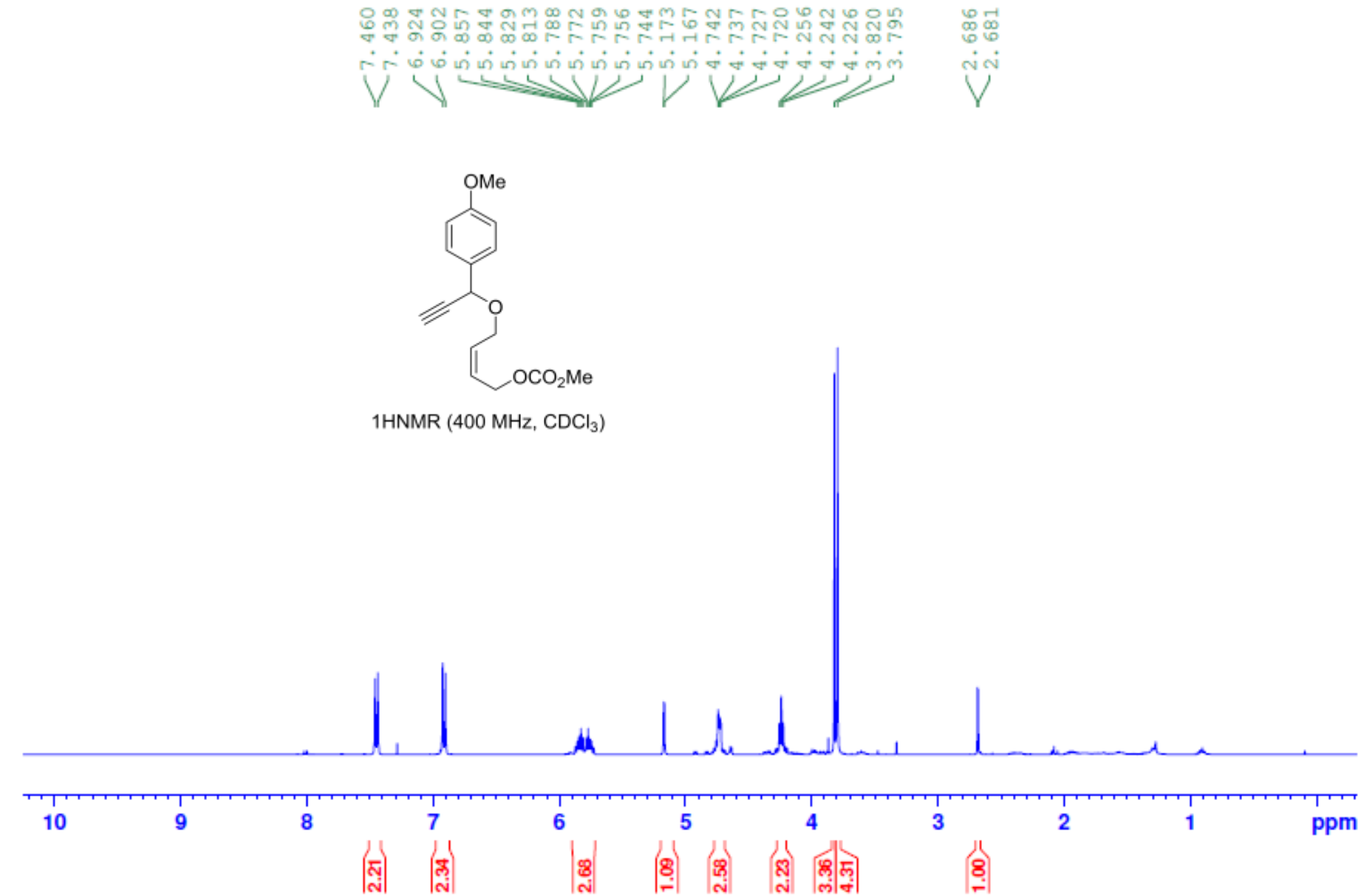


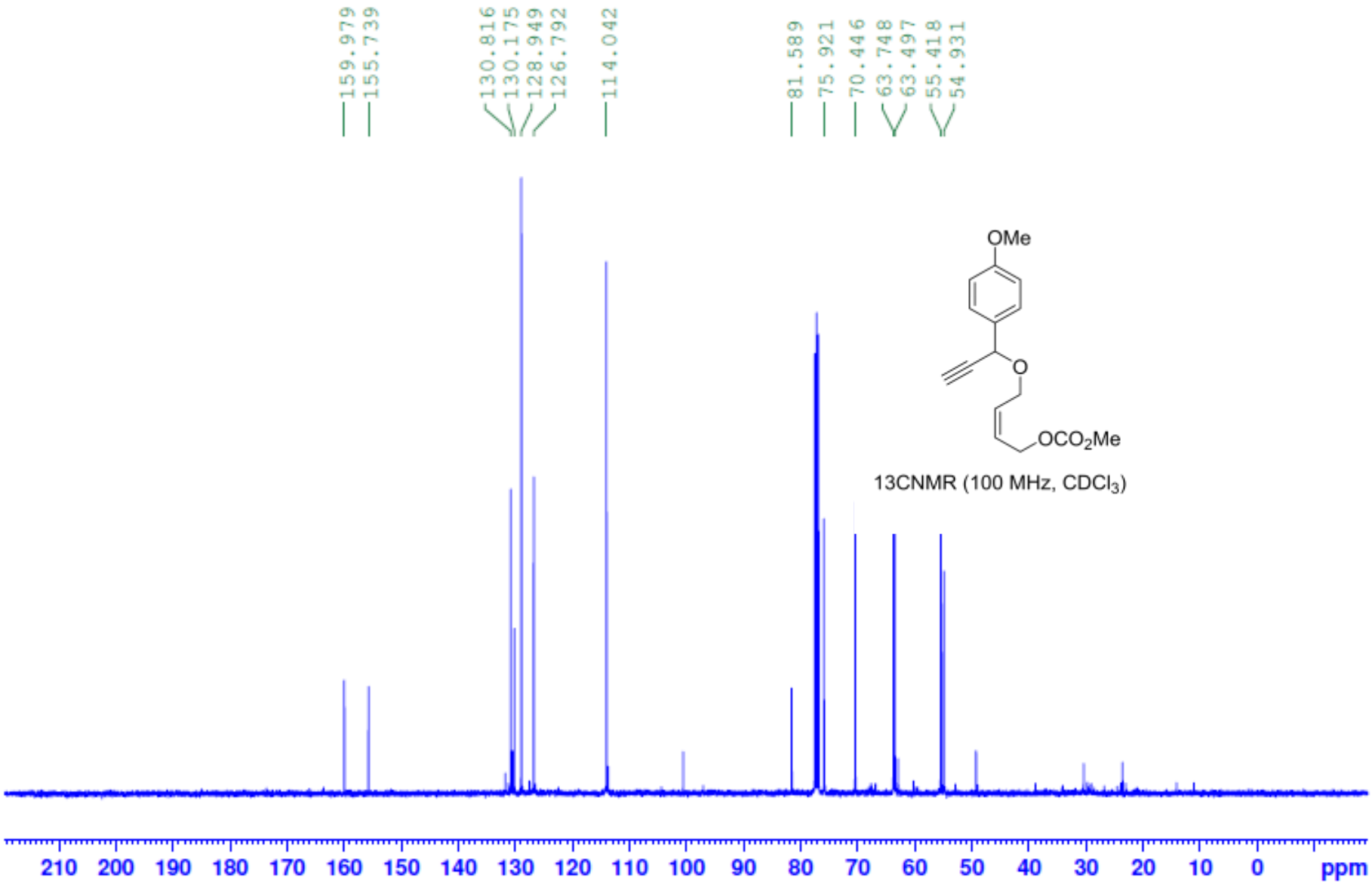
13CNMR (100 MHz, $CDCl_3$)

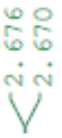

7.468
7.446
6.925
6.903
5.790
5.778
5.175
5.171
4.649
4.642
4.633
4.333
4.322
4.311
4.302
4.288
4.281
4.242
4.231
4.148
4.134
4.124
4.117
4.111
3.891
3.822
OMe
O
OTHP
1HNMR (400 MHz, CDCl3)
10
9
8
7
6
5
4
3
2
1
0 ppm
0.41
2.00
0.42
2.08
0.20
2.01
0.99
0.99
1.05
2.10
0.88
1.14
3.15
1.03
0.93
2.42
4.10

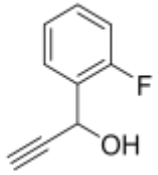

159.909
131.153
130.409
130.076
130.052
128.945
128.833
128.764
113.996
98.173
98.115
77.553
77.235
76.918
75.678
70.197
63.748
63.037
62.973
62.295
55.411
30.710
25.546
19.524
OMe
O
OTHP
13CNMR (100 MHz, CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm


7.448
7.426
6.914
6.892
5.844
5.831
5.828
5.816
5.813
5.803
5.800
5.784
5.731
5.715
5.703
5.699
5.687
5.671
5.159
5.153
4.188
4.170
3.802
2.695
2.690
2.484
OMe
O
OH
1HNMR (400 MHz, CDCl3)
10
9
8
7
6
5
4
3
2
1
ppm
2.01
2.14
1.20
1.14
1.00
4.54
3.21
0.93
1.11

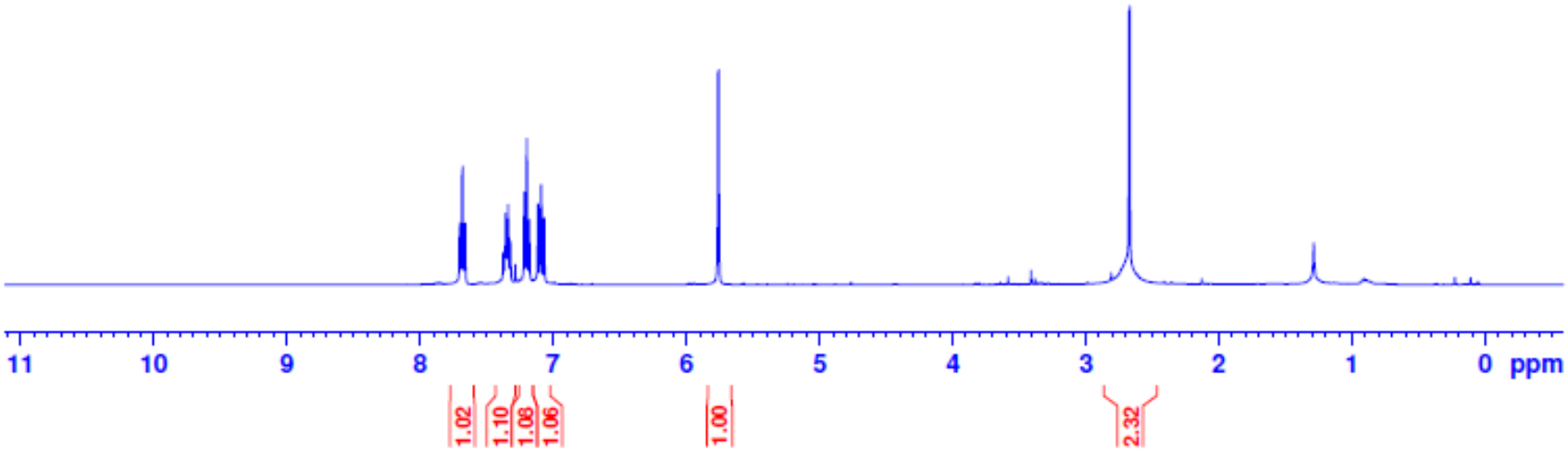

7.460
7.438
6.924
6.902
5.857
5.844
5.829
5.813
5.788
5.772
5.759
5.756
5.744
5.173
5.167
4.742
4.737
4.727
4.720
4.256
4.242
4.226
3.820
3.795
2.686
2.681
OMe
O
OCO2Me
1HNMR (400 MHz, CDCl3)
10
9
8
7
6
5
4
3
2
1
ppm
2.21
2.34
2.68
1.09
2.58
2.23
3.36
4.31
1.00

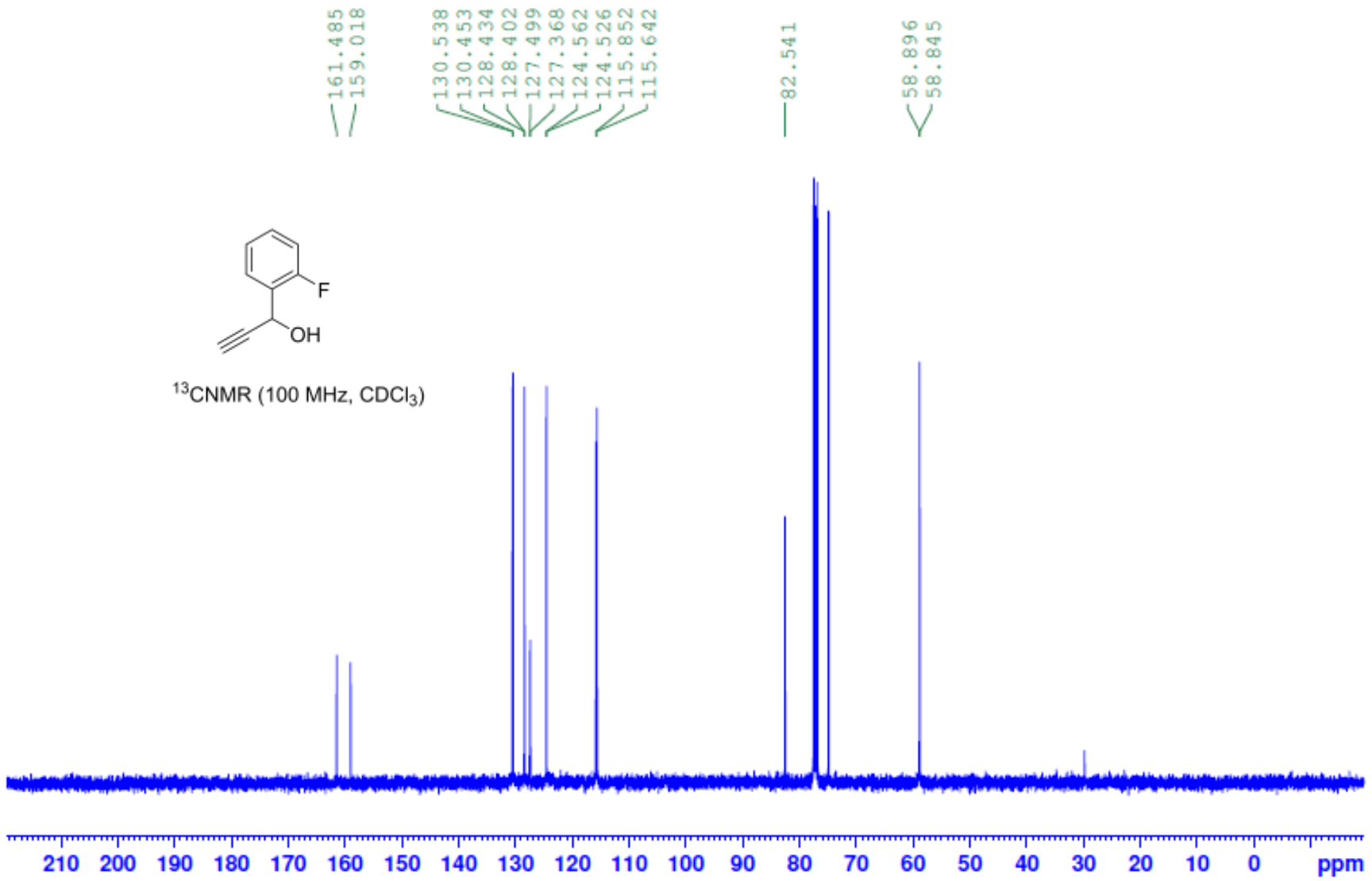

159.979
155.739
130.816
130.175
128.949
126.792
114.042
81.589
75.921
70.446
63.748
63.497
55.418
54.931
OMe
O
OCO2Me
13CNMR (100 MHz, CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

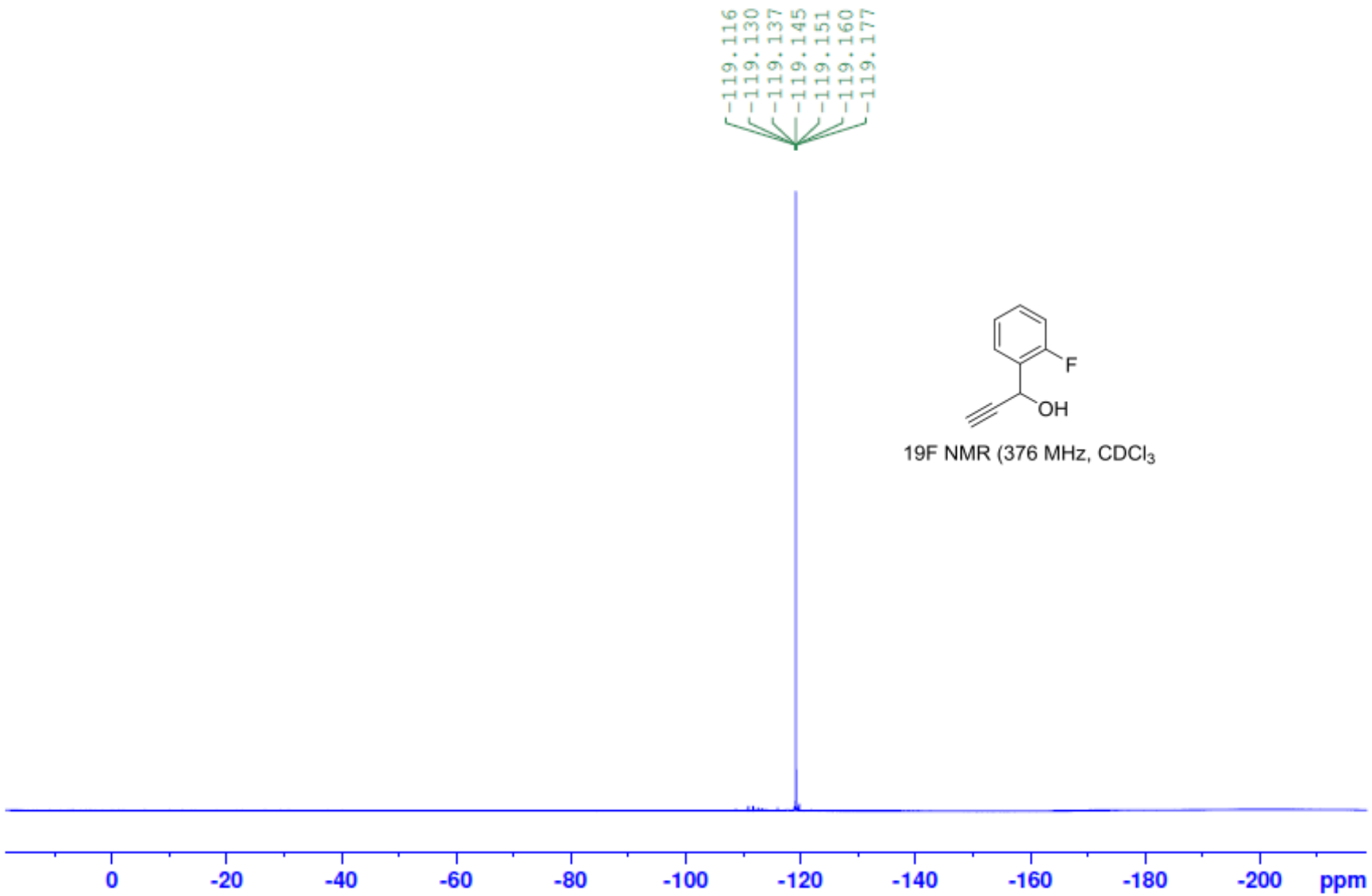




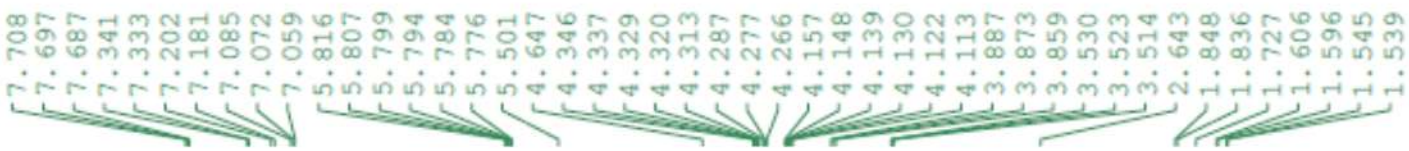
1HNMR (400 MHz, $CDCl_3$)

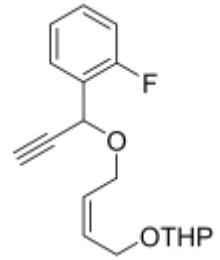



161.485
159.018
130.538
130.453
128.434
128.402
127.499
127.368
124.562
124.526
115.852
115.642
82.541
58.896
58.845
F
OH
^{13}CNMR (100 MHz, $CDCl_3$)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

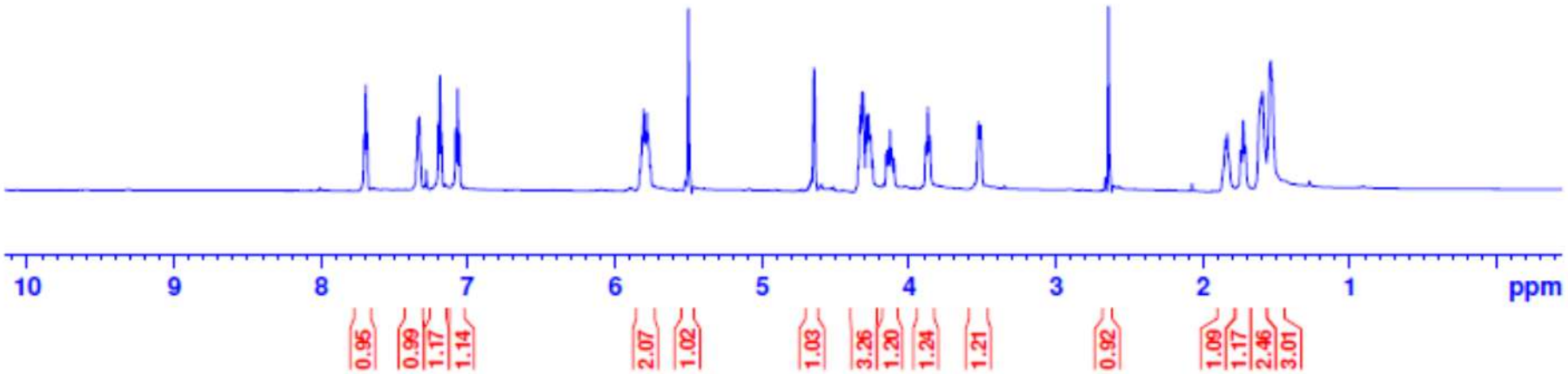


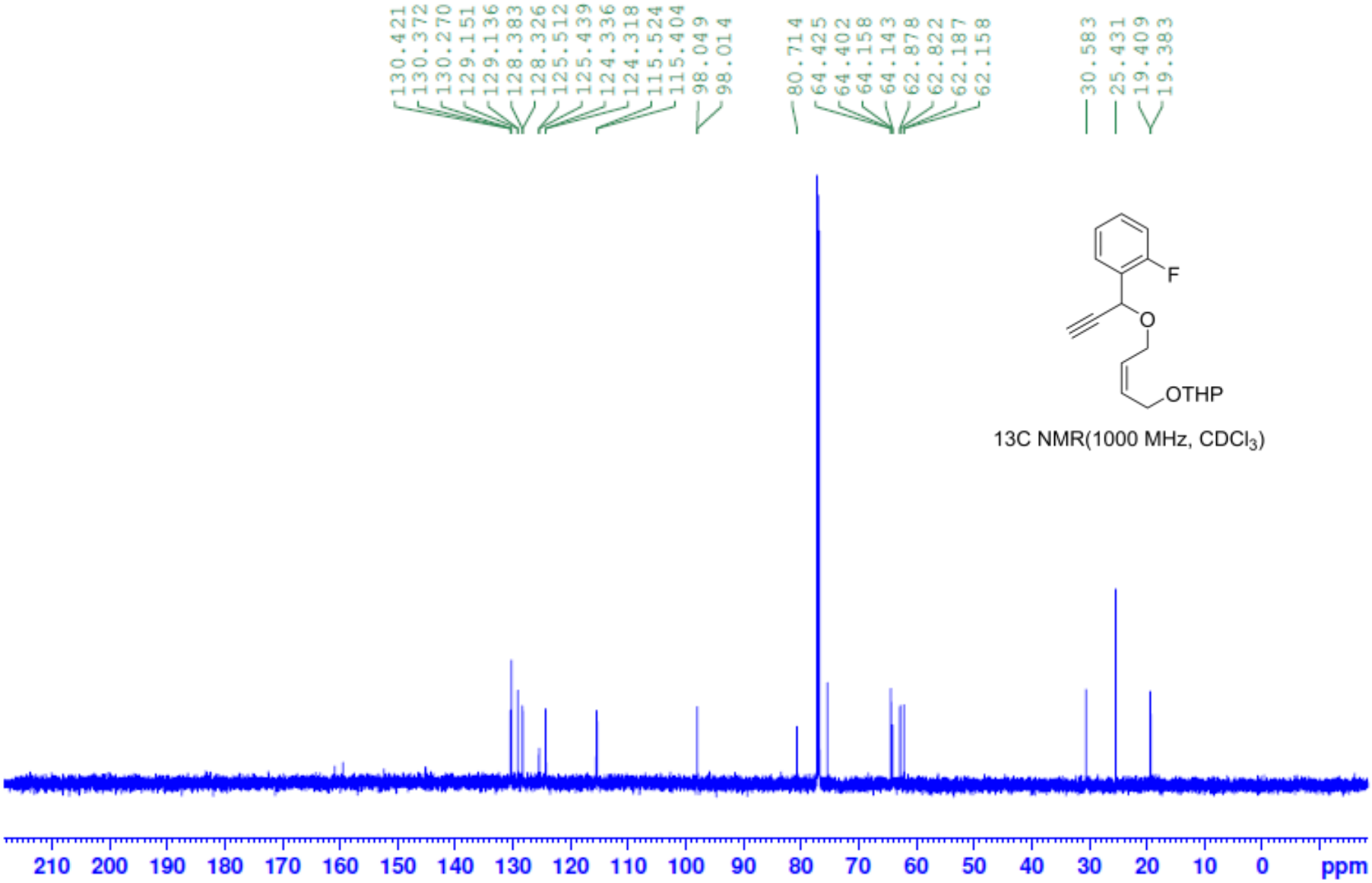
19F NMR (376 MHz, $CDCl_3$)

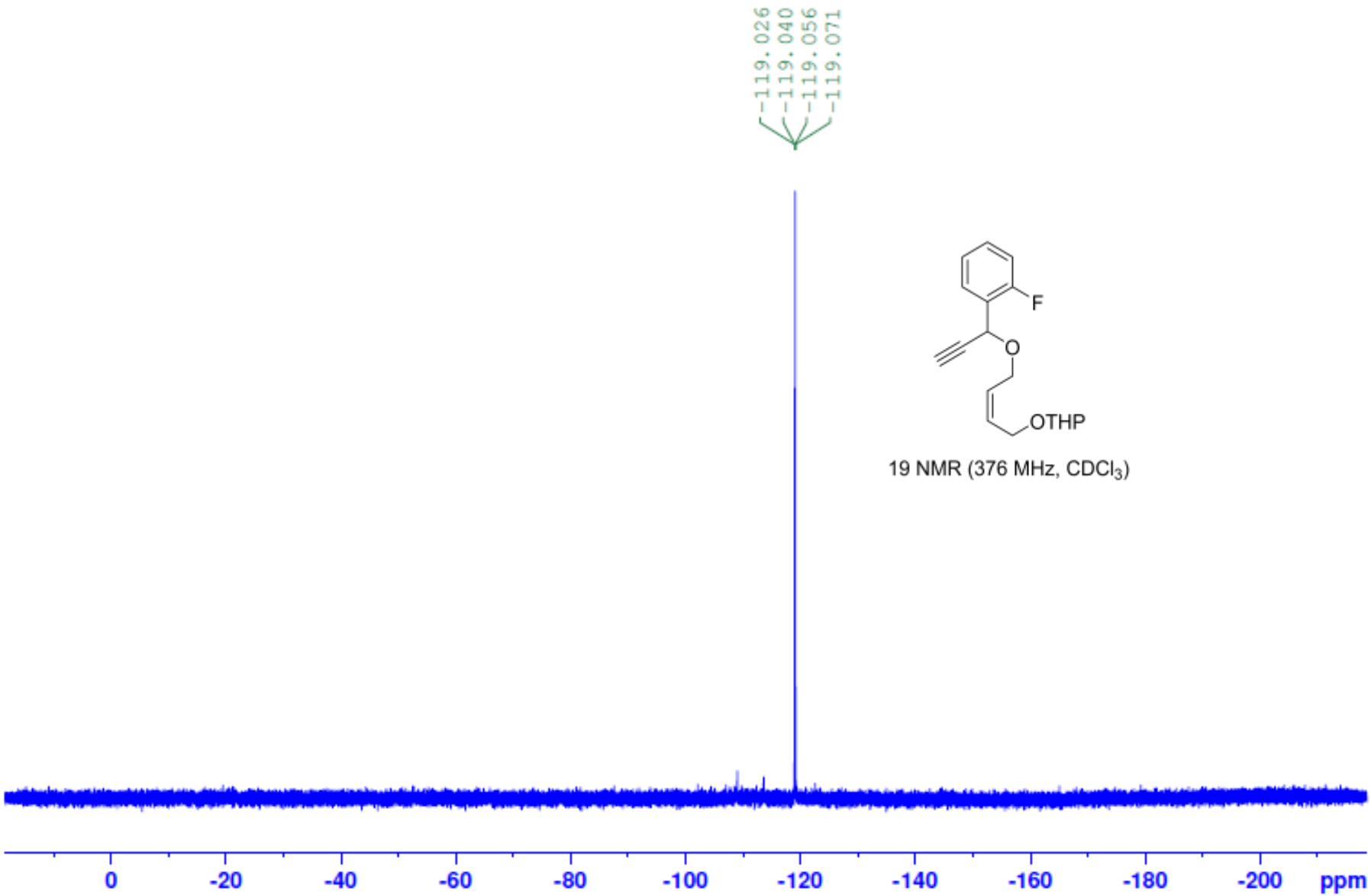




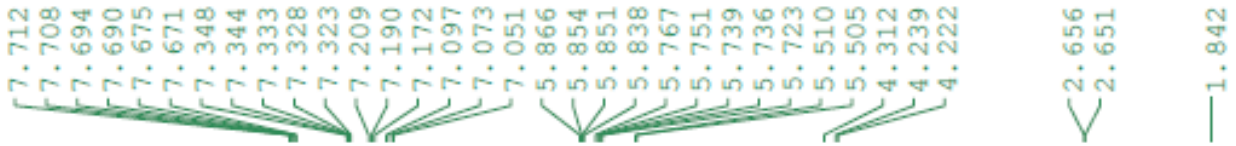
1HNMR (400 MHz, $CDCl_3$)

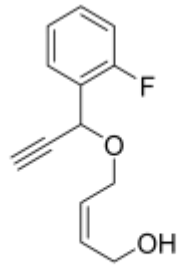



130.421
130.372
130.270
129.151
129.136
128.383
128.326
125.512
125.439
124.336
124.318
115.524
115.404
98.049
98.014
80.714
64.425
64.402
64.158
64.143
62.878
62.822
62.187
62.158
30.583
25.431
19.409
19.383
F
O
OTHP
13C NMR(1000 MHz, CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

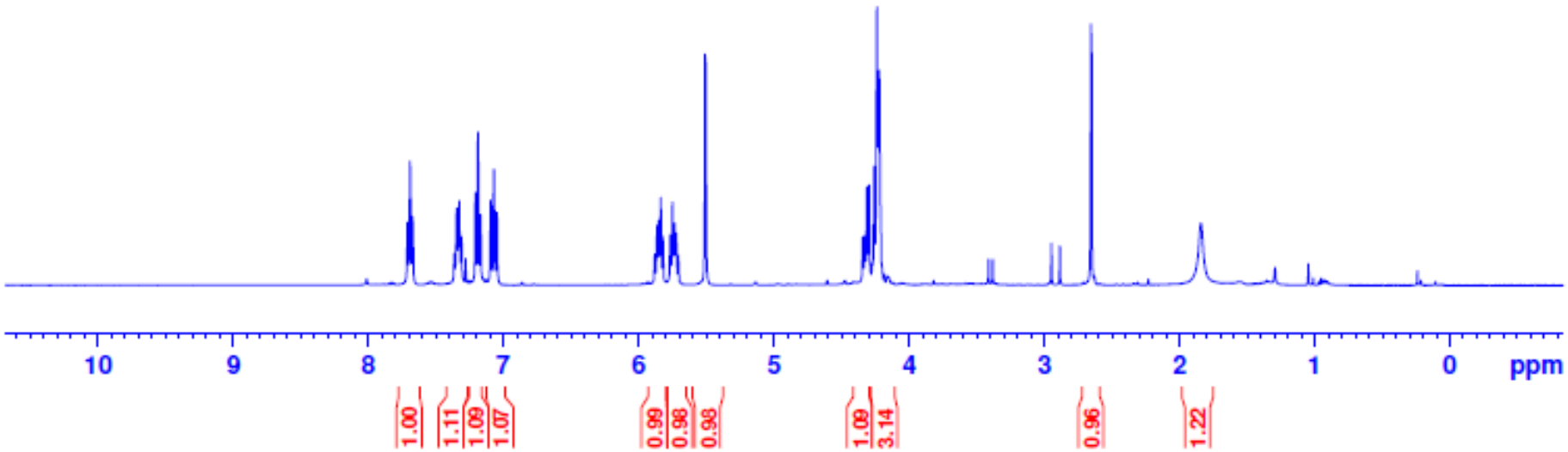


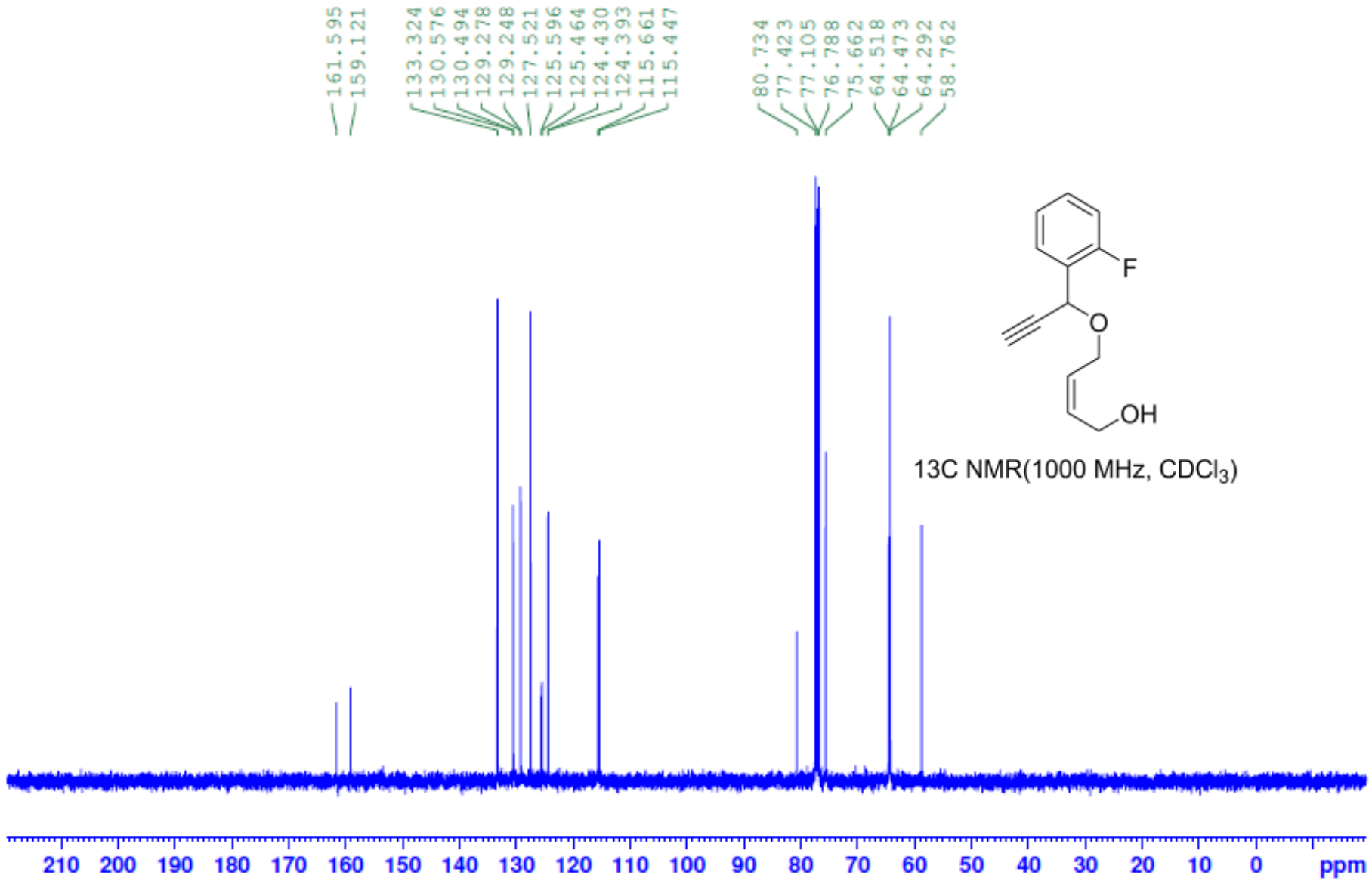
19 NMR (376 MHz, $CDCl_3$)

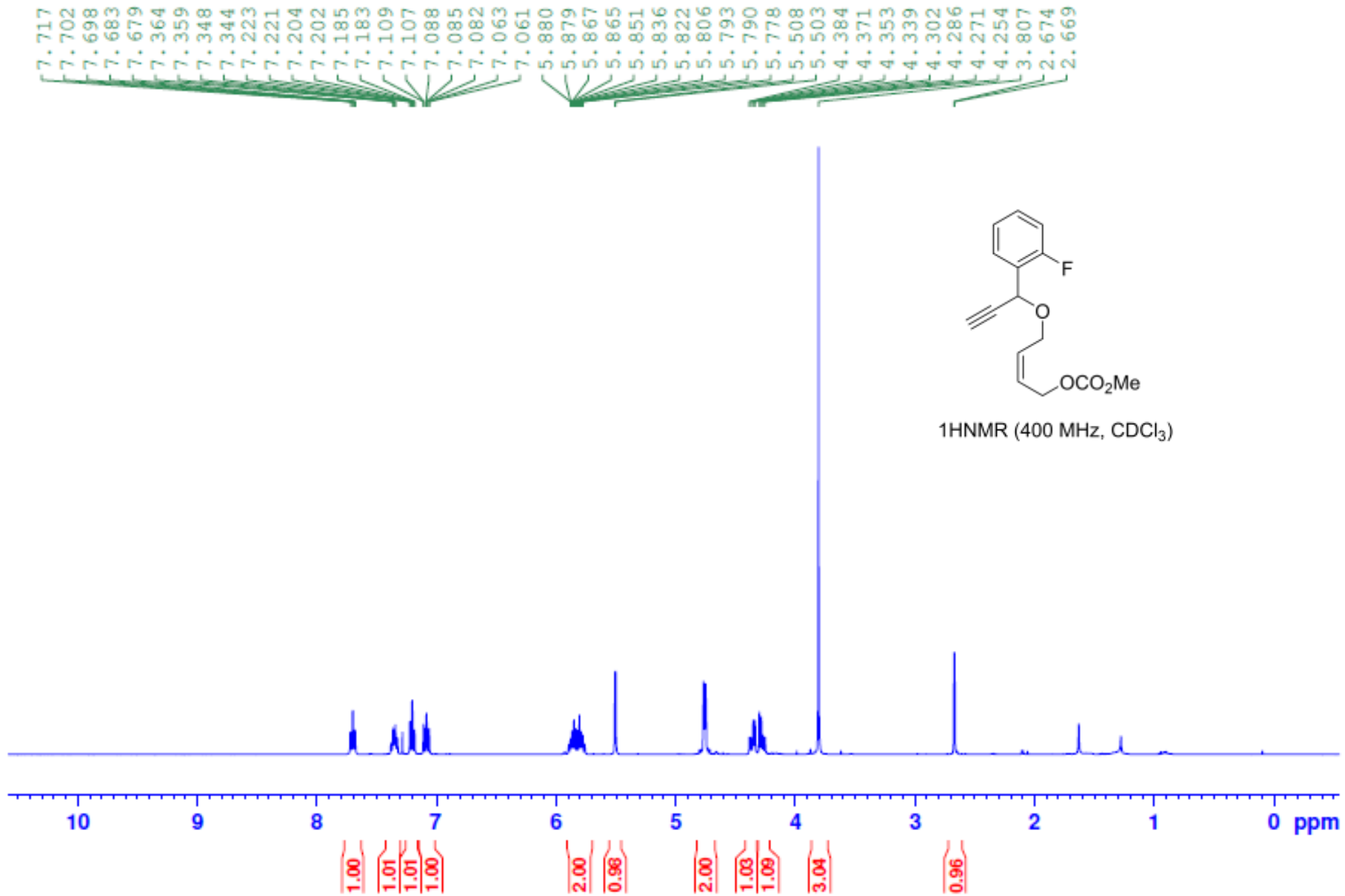


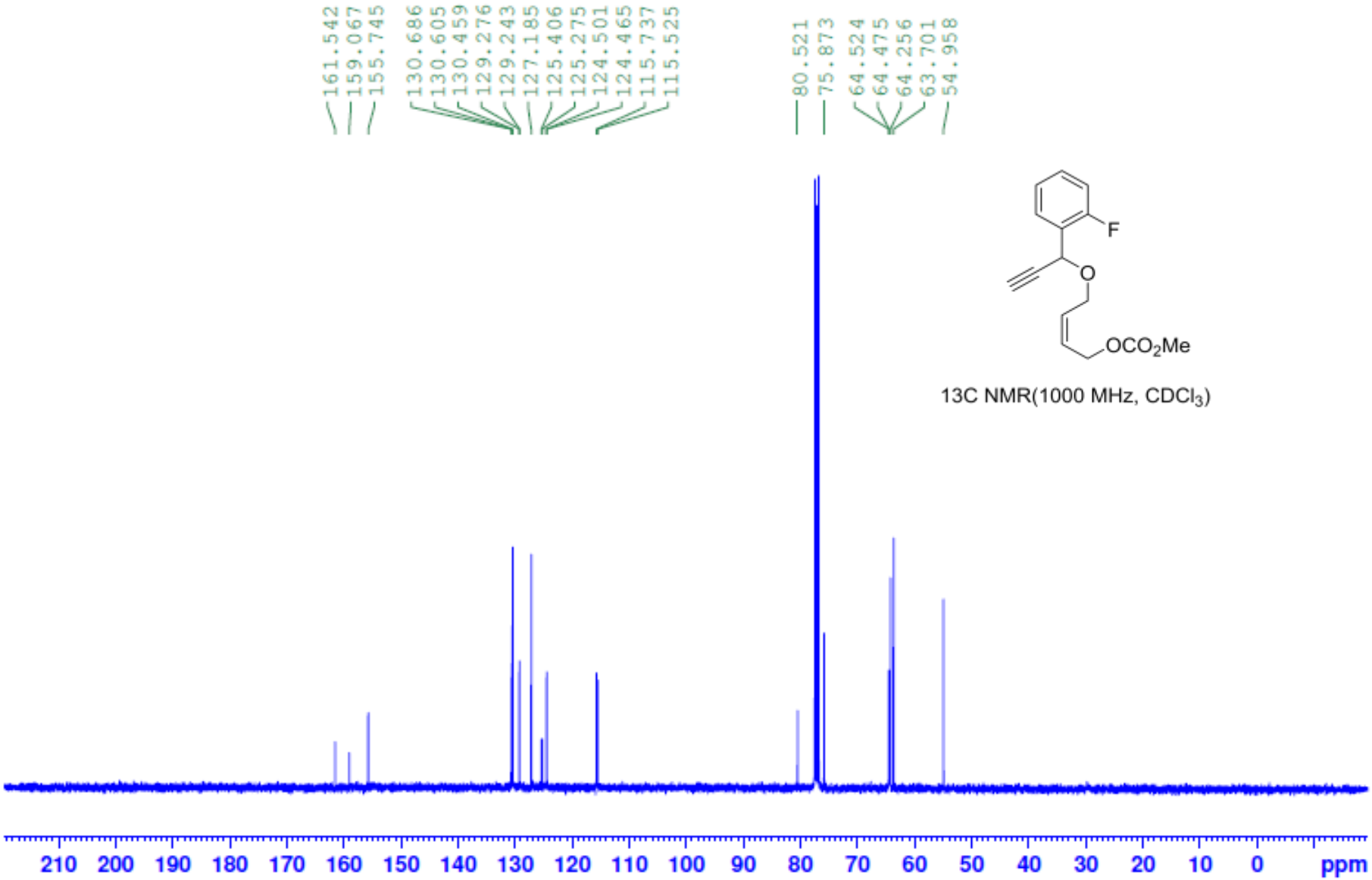


1HNMR (400 MHz, $CDCl_3$)

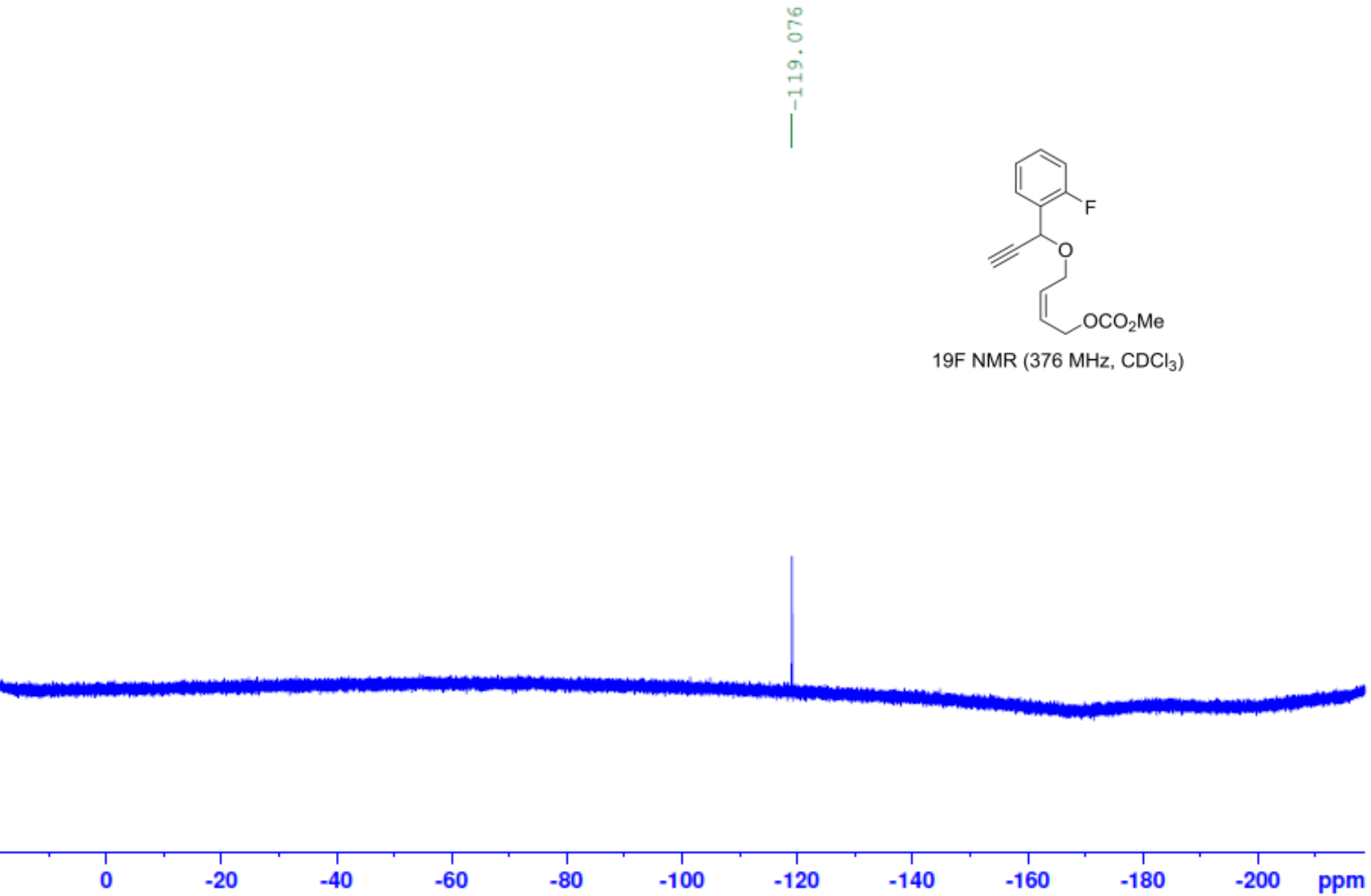



161.595
159.121
133.324
130.576
130.494
129.278
129.248
127.521
125.596
125.464
124.430
124.393
115.661
115.447
80.734
77.423
77.105
76.788
75.662
64.518
64.473
64.292
58.762
F
O
OH
13C NMR(1000 MHz, CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

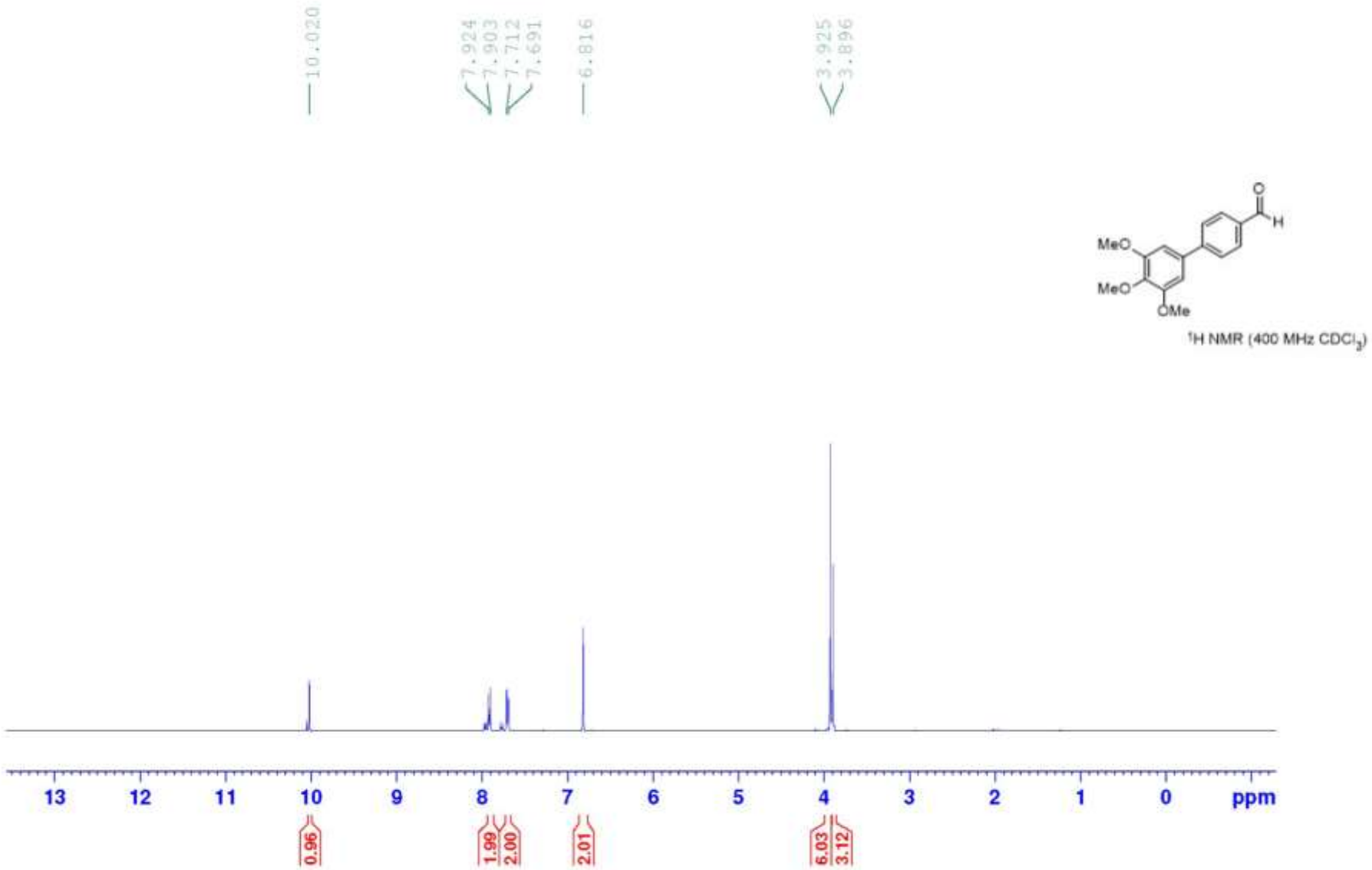

7.717
7.702
7.698
7.683
7.679
7.364
7.359
7.348
7.344
7.223
7.221
7.204
7.202
7.185
7.183
7.109
7.107
7.088
7.085
7.082
7.063
7.061
5.880
5.879
5.867
5.865
5.851
5.836
5.822
5.806
5.793
5.790
5.778
5.508
5.503
4.384
4.371
4.353
4.339
4.302
4.286
4.271
4.254
3.807
2.674
2.669
F
O
OCO2Me
1HNMR (400 MHz, CDCl3)
10
9
8
7
6
5
4
3
2
1
0 ppm
1.00
1.01
1.01
1.00
2.00
0.98
2.00
1.03
1.09
3.04
0.96



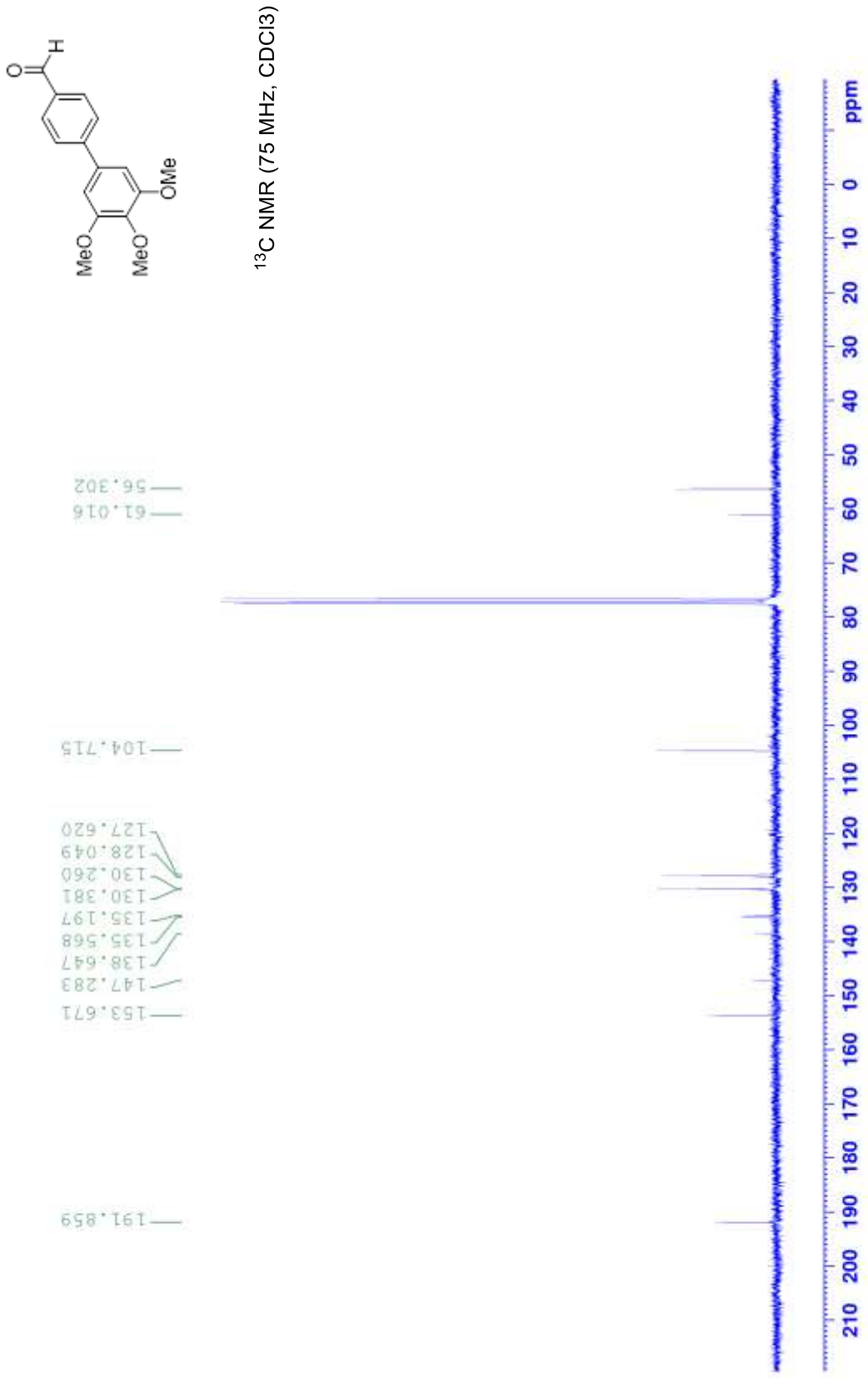
13C NMR(1000 MHz, $CDCl_3$)

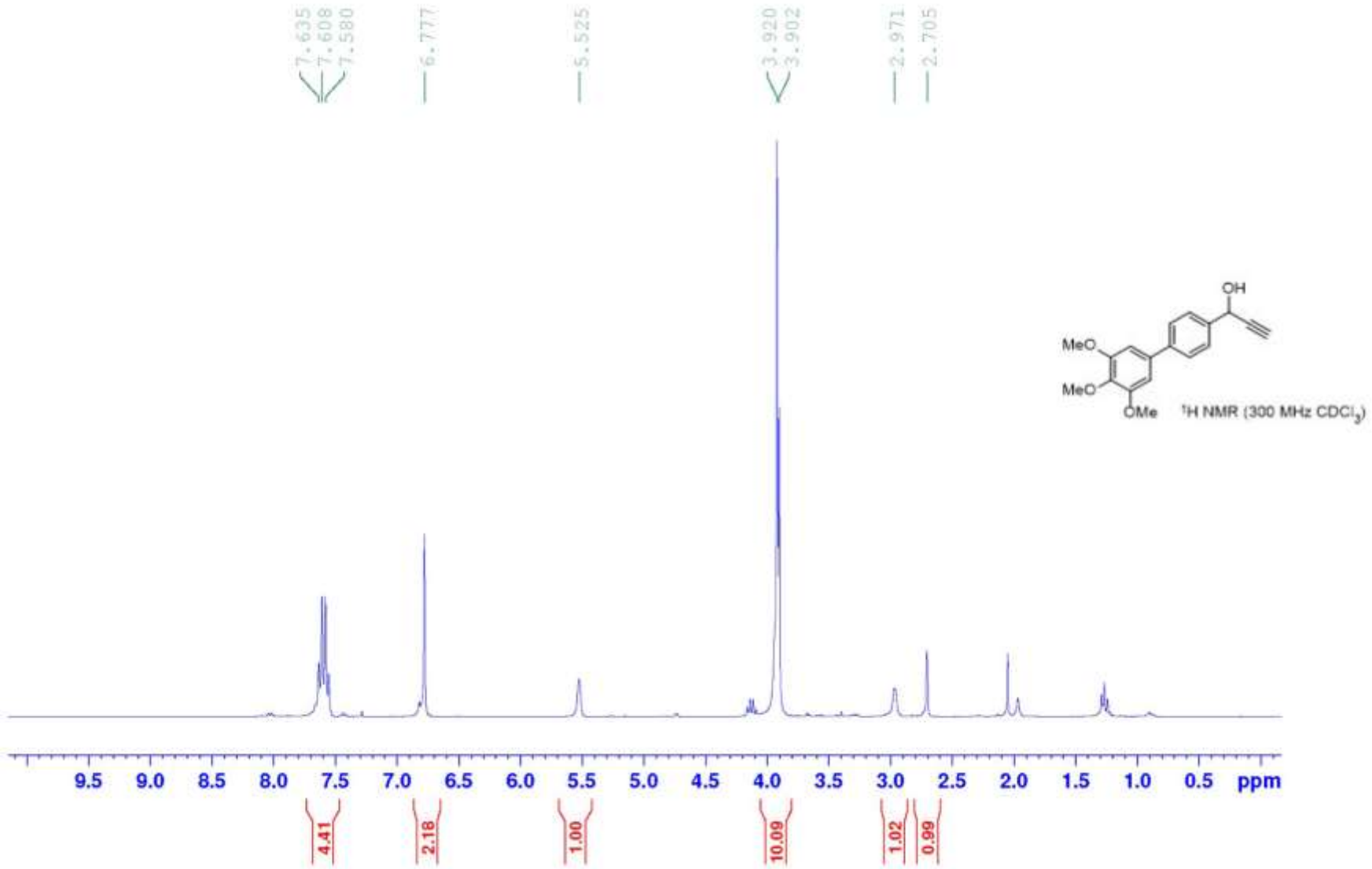


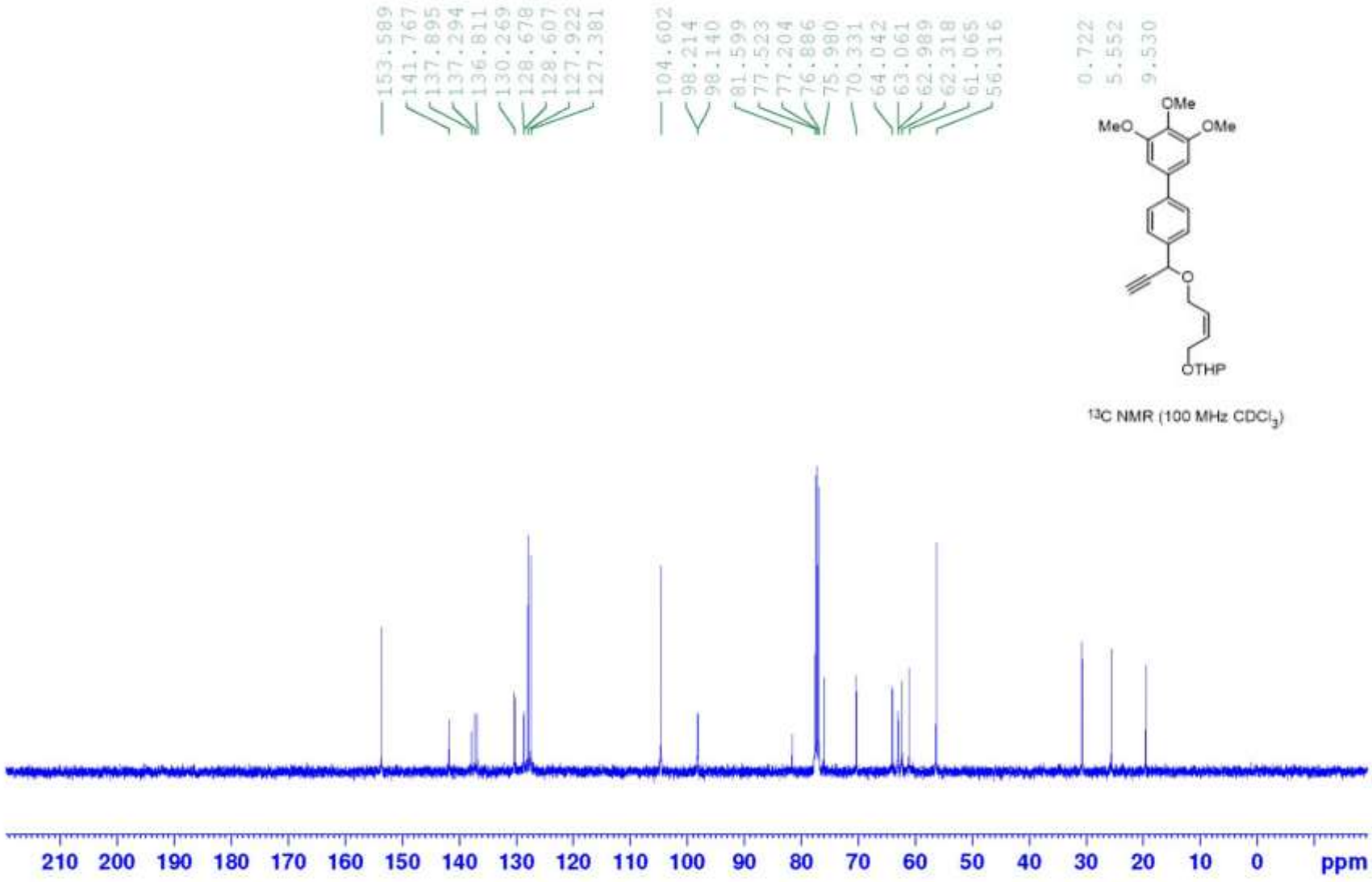
19F NMR (376 MHz, $CDCl_3$)



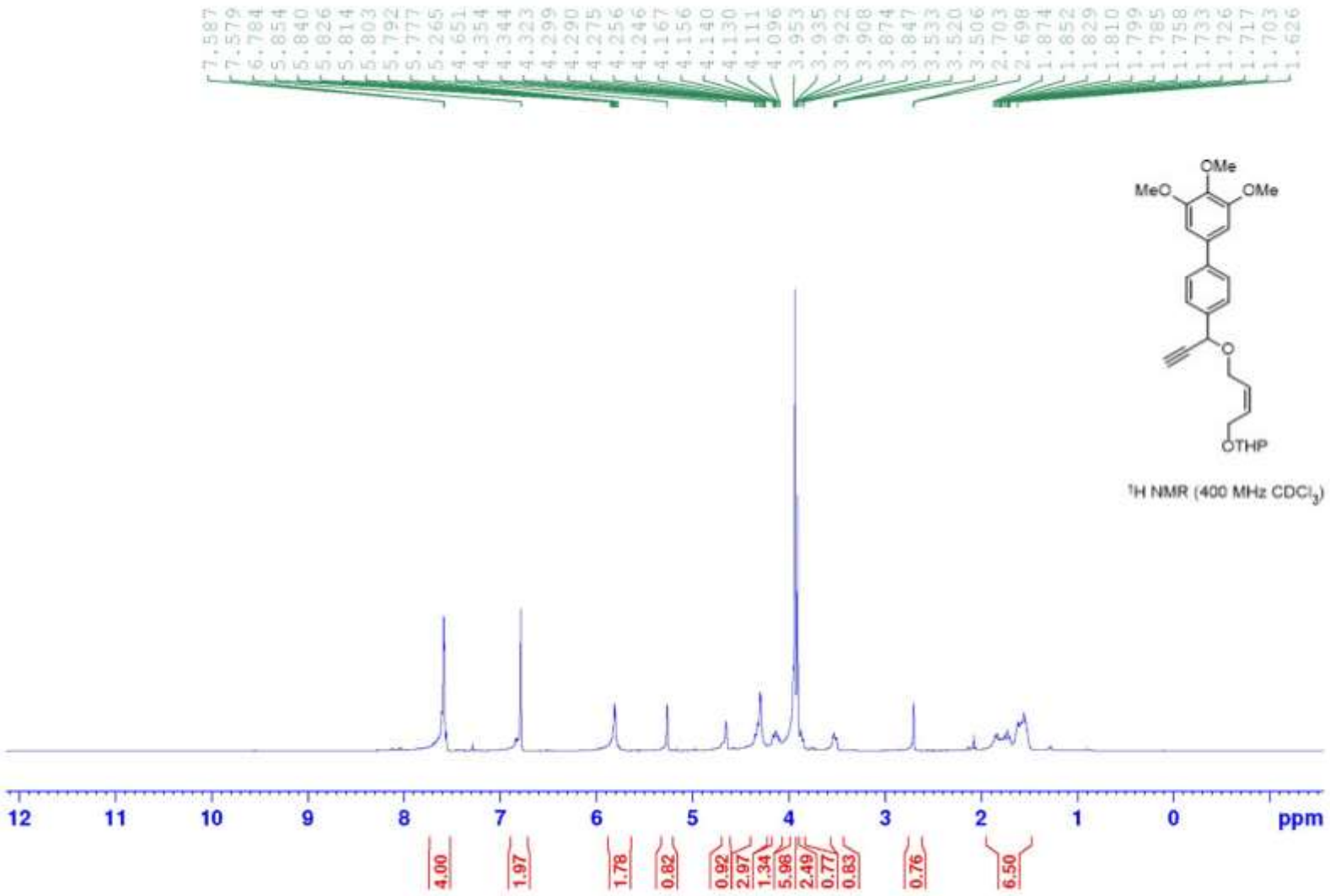
^{1}H NMR (400 MHz $CDCl_3$)


O
H
MeO
MeO
OMe
^{13}C NMR (75 MHz, CDCl3)
56.302
61.016
104.715
127.620
128.049
130.260
130.381
135.197
135.568
138.647
147.283
153.671
191.859
ppm
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

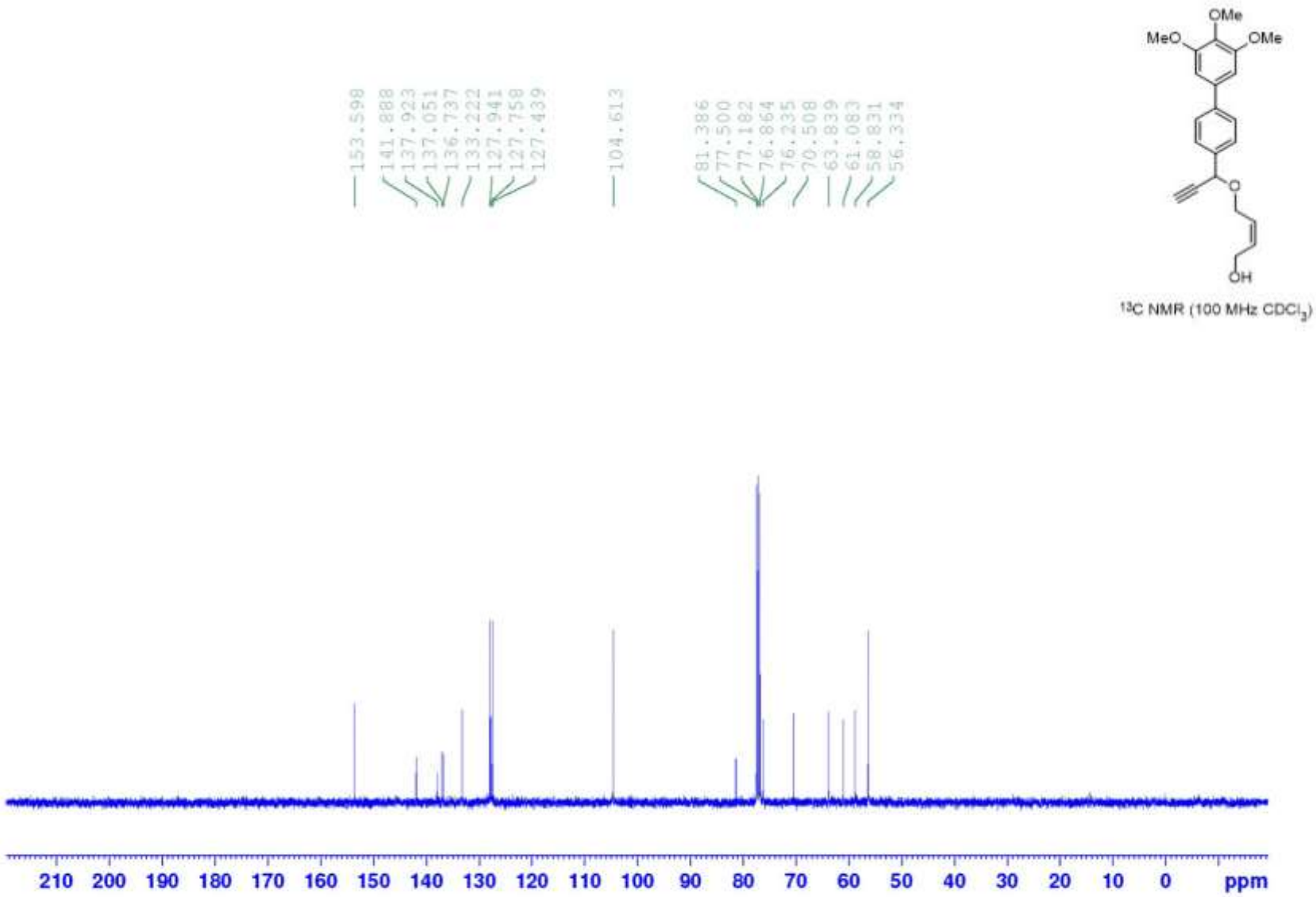

7.635
7.608
7.580
6.777
5.525
3.920
3.902
2.971
2.705
OH
MeO
MeO
OMe
^{1}H NMR (300 MHz CDCl$_3$)
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm
4.41
2.16
1.00
10.09
1.02
0.99



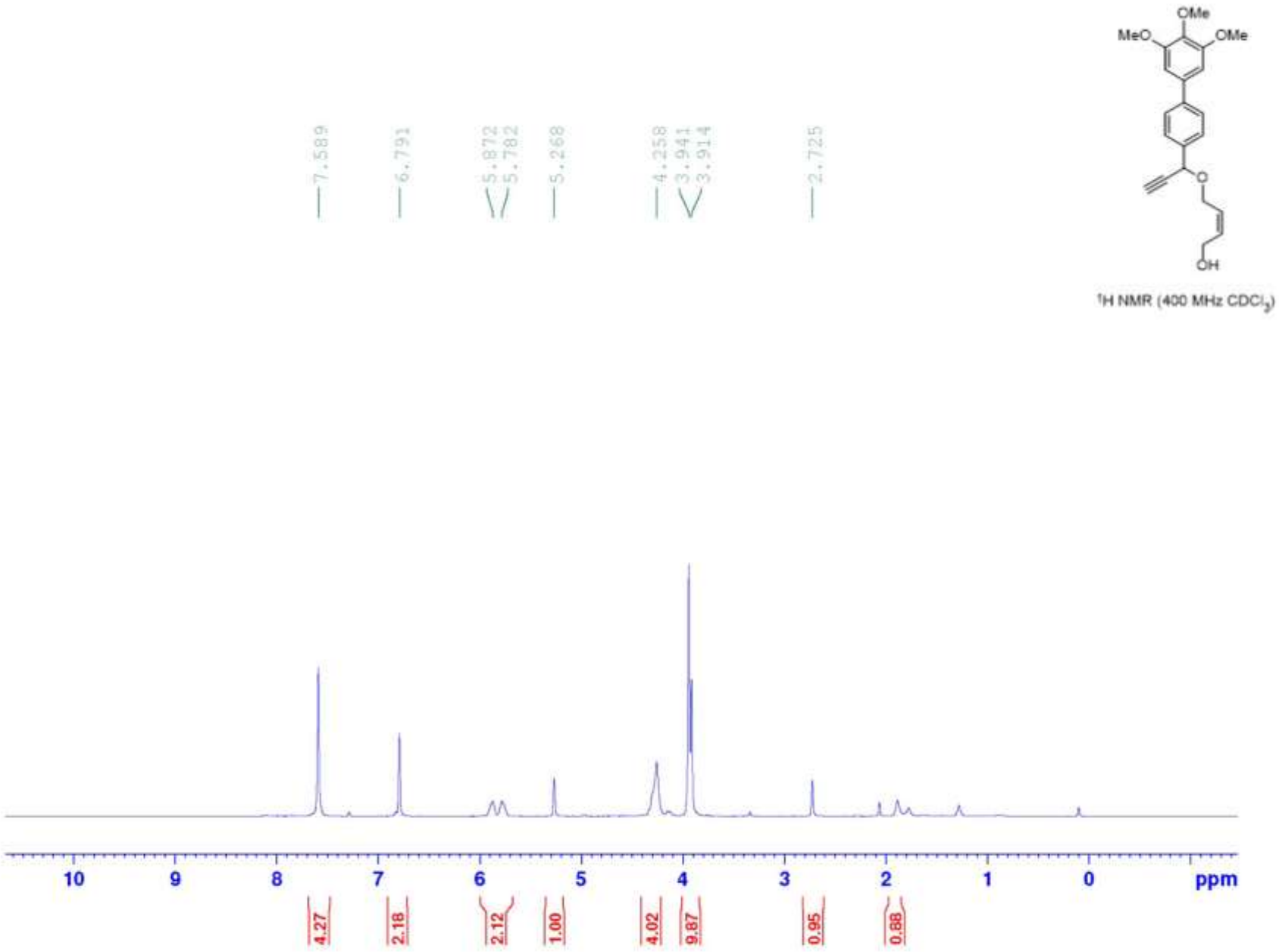
^{13}C NMR (100 MHz $CDCl_3$)

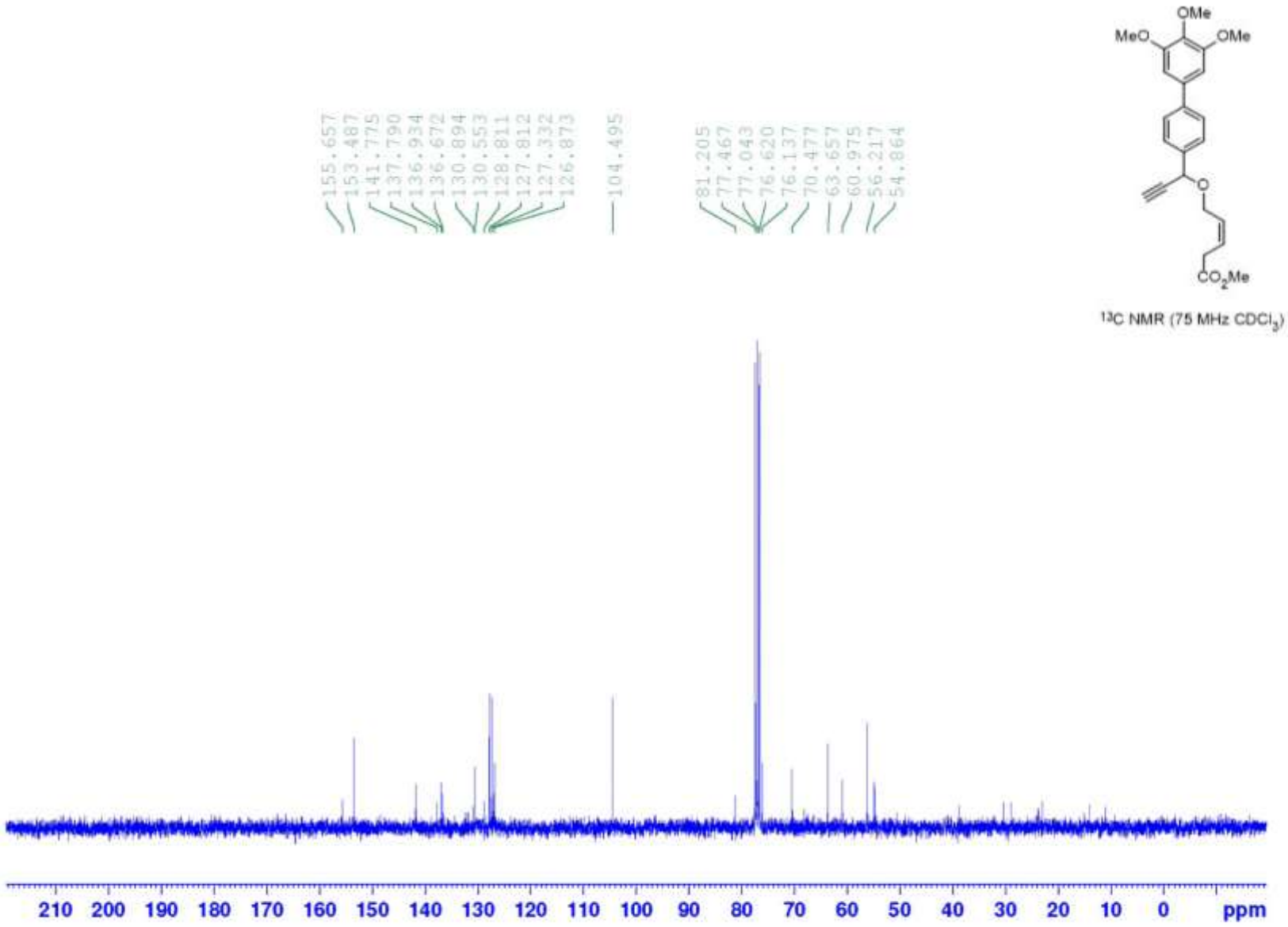


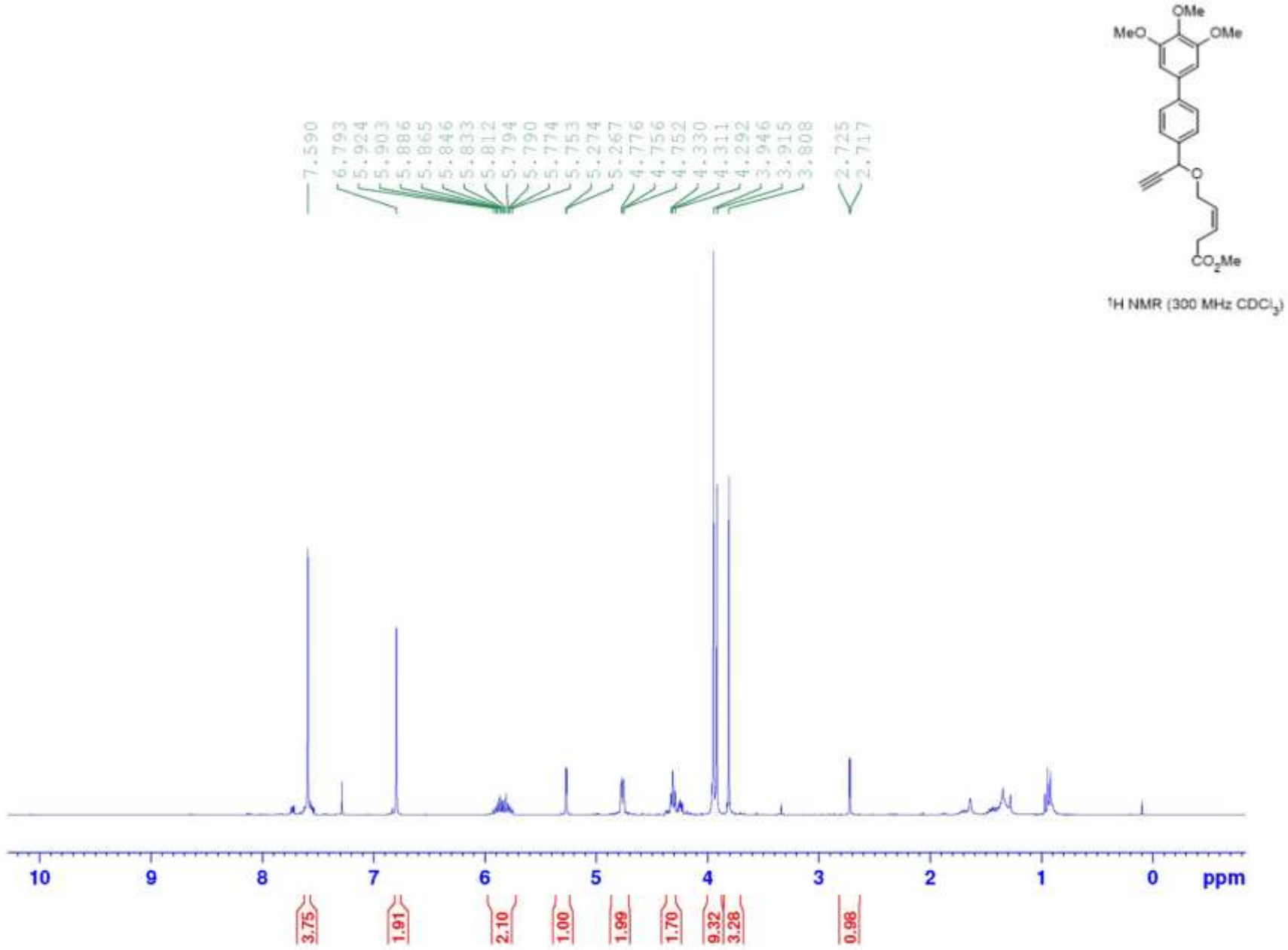
^{1}H NMR (400 MHz $CDCl_3$)

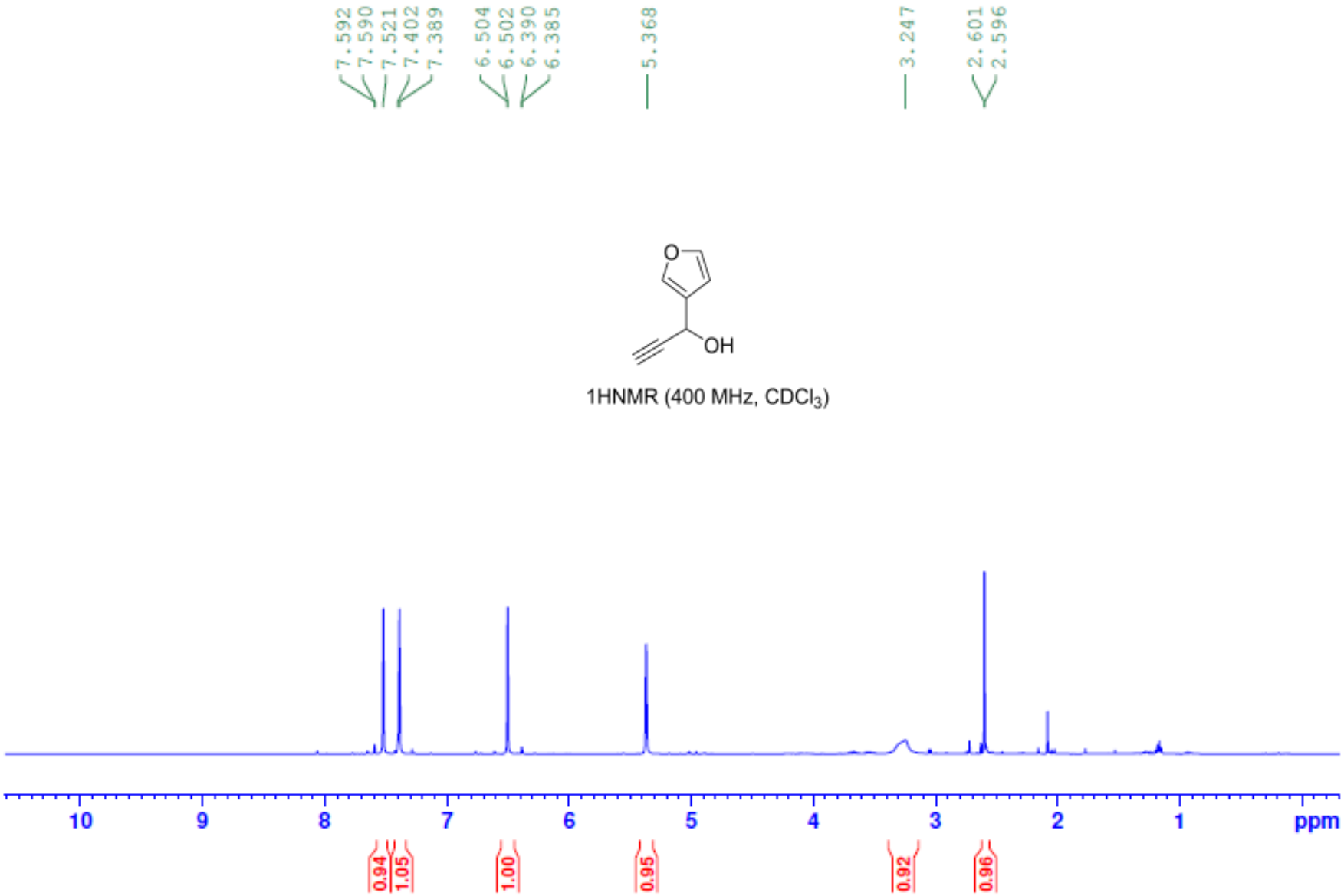


^{13}C NMR (100 MHz $CDCl_3$)

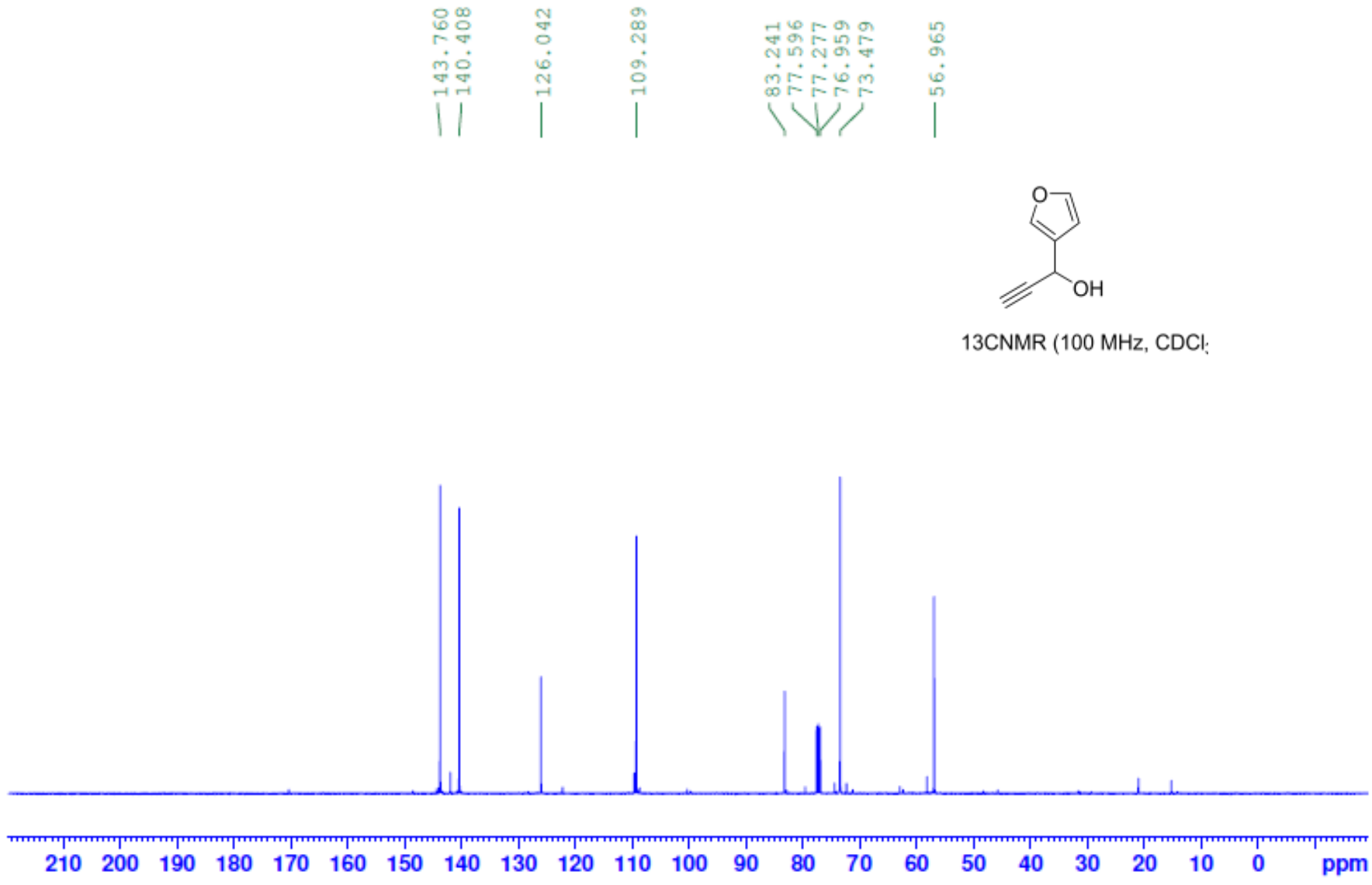

7.589
6.791
5.872
5.782
5.268
4.258
3.941
3.914
2.725
OMe
MeO
OMe
O
OH
^{1}H NMR (400 MHz $CDCl_3$)
10
9
8
7
6
5
4
3
2
1
0
ppm
4.27
2.18
2.12
1.00
4.02
9.87
0.95
0.88


155.657
153.487
141.775
137.790
136.934
136.672
130.894
130.553
128.811
127.812
127.332
126.873
104.495
81.205
77.467
77.043
76.620
76.137
70.477
63.657
60.975
56.217
54.864
OMe
MeO
OMe
O
CO2Me
13C NMR (75 MHz CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

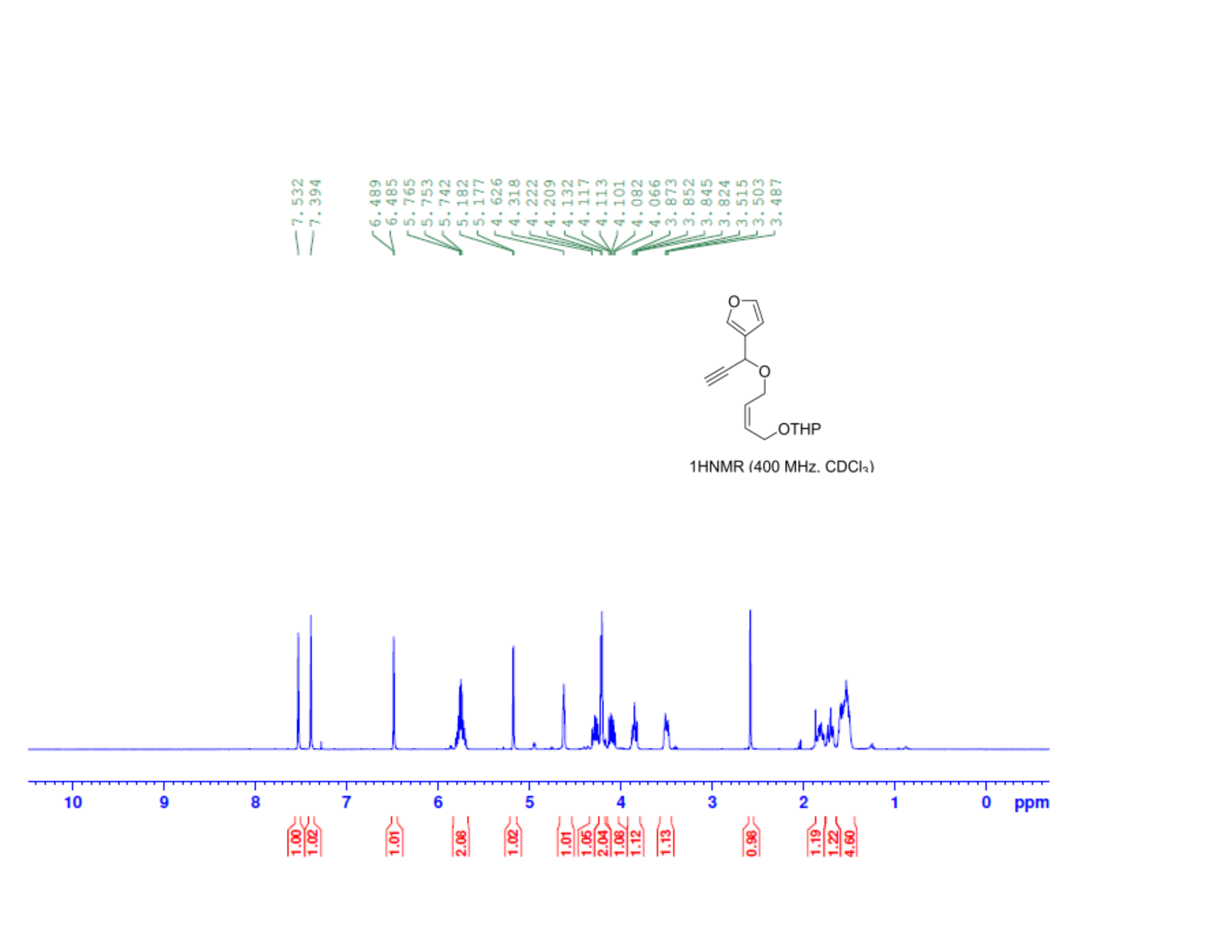

7.590
6.793
5.924
5.903
5.886
5.865
5.846
5.833
5.812
5.794
5.790
5.774
5.753
5.274
5.267
4.776
4.756
4.752
4.330
4.311
4.292
3.946
3.915
3.808
2.725
2.717
OMe
MeO
OMe
O
CO2Me
1H NMR (300 MHz CDCl3)
10
9
8
7
6
5
4
3
2
1
0
ppm
3.75
1.91
2.10
1.00
1.99
1.70
9.32
3.28
0.98



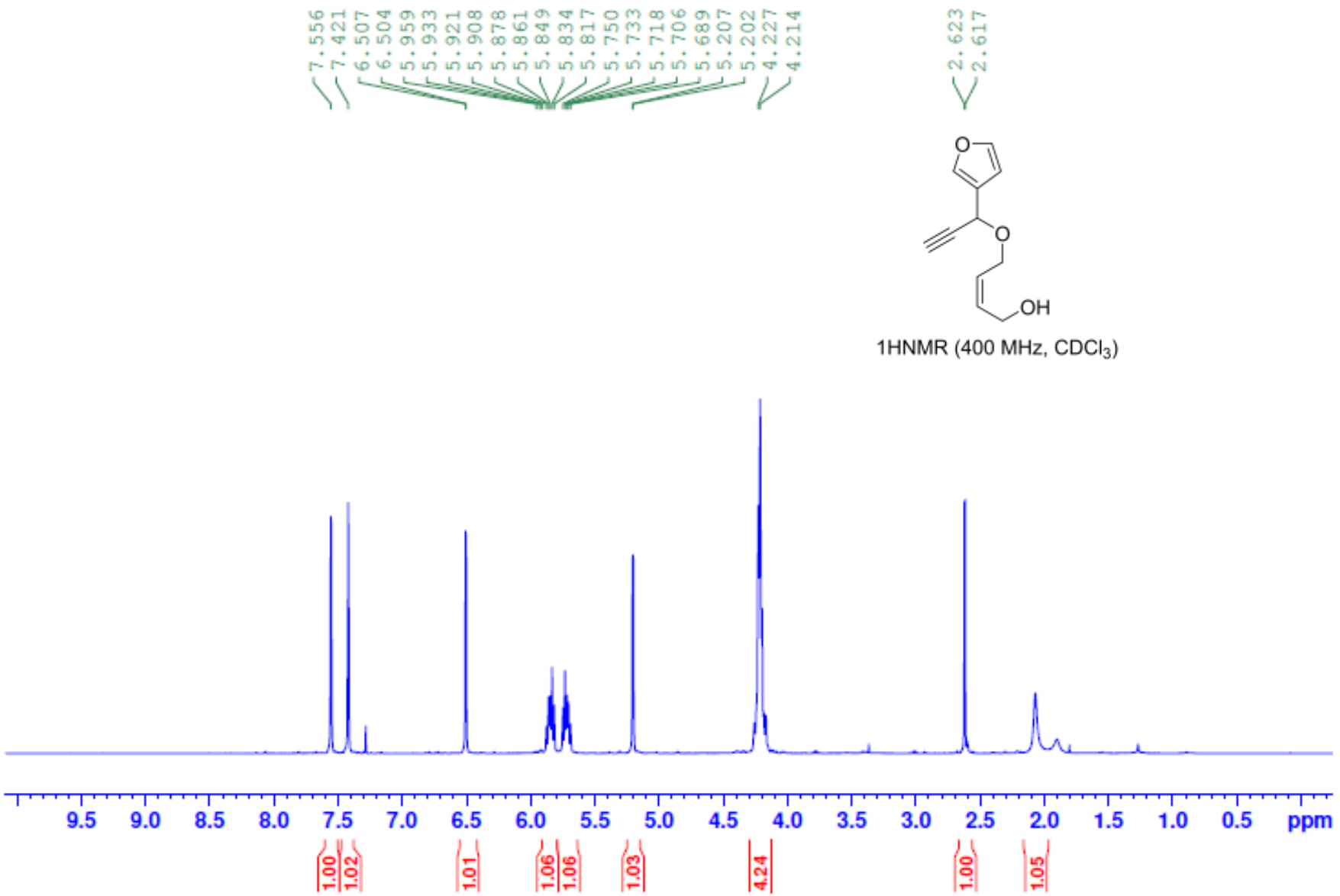
1HNMR (400 MHz, $CDCl_3$)



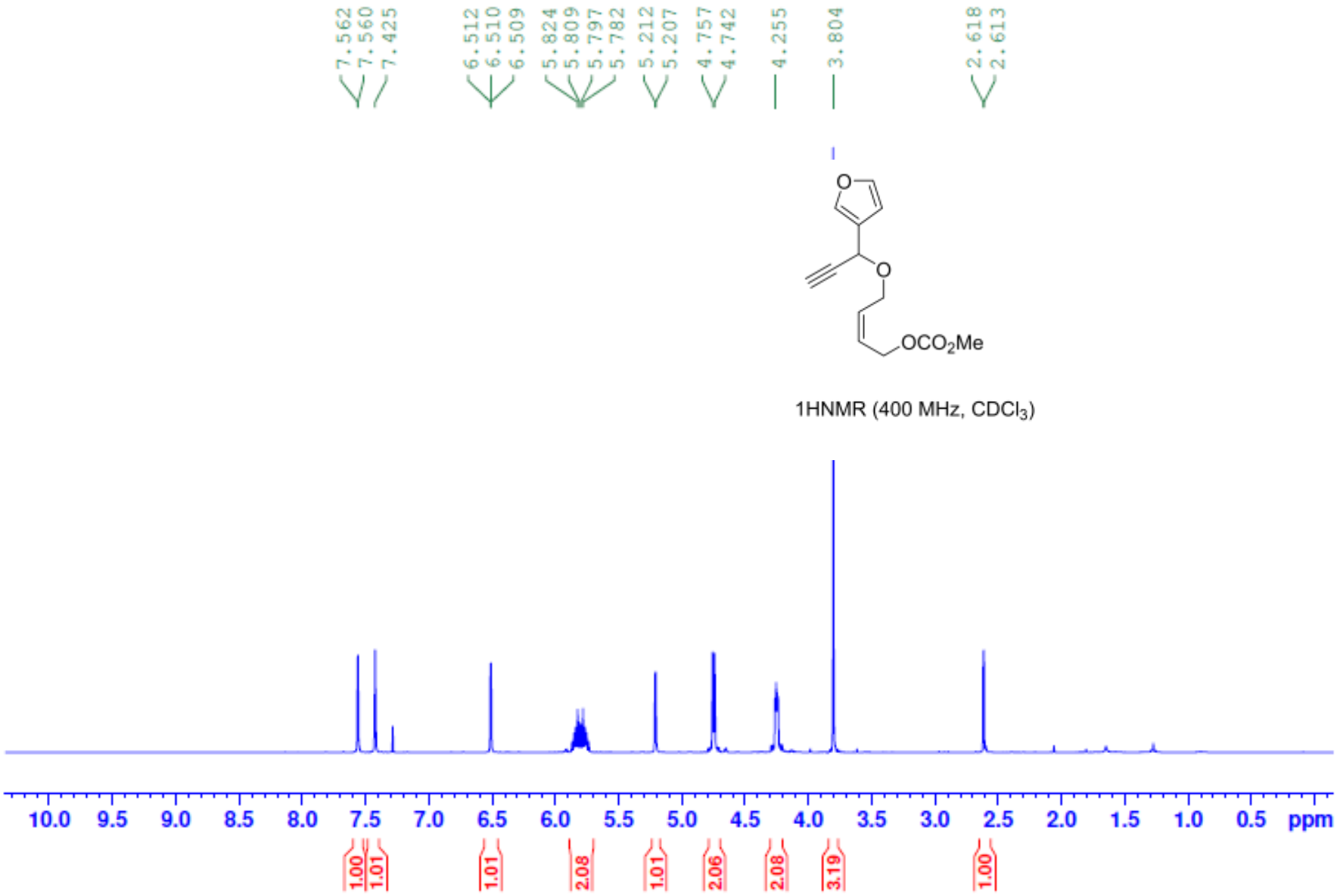
13CNMR (100 MHz, CDCl



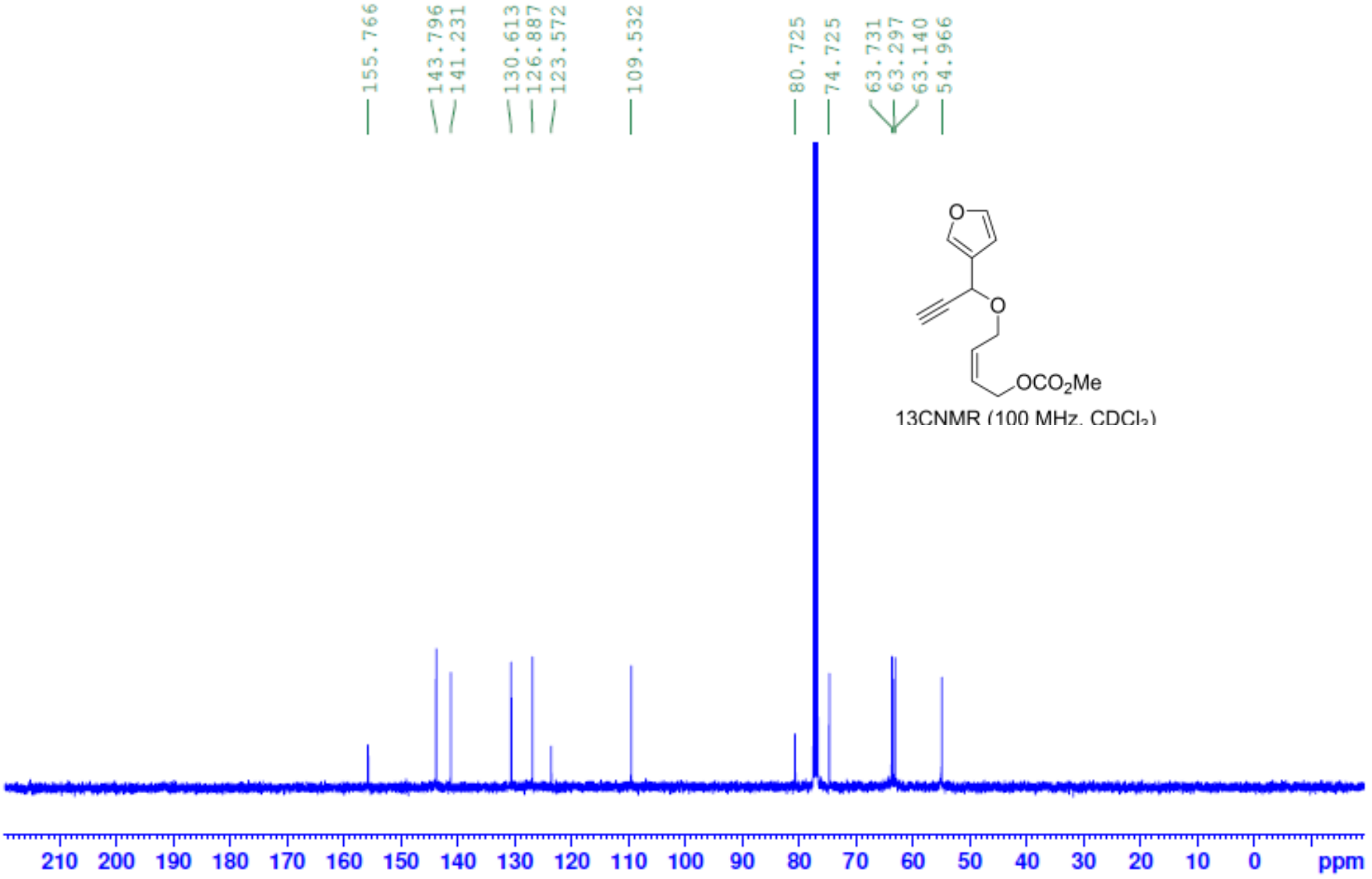
1HNMR (400 MHz. $CDCl_3$)

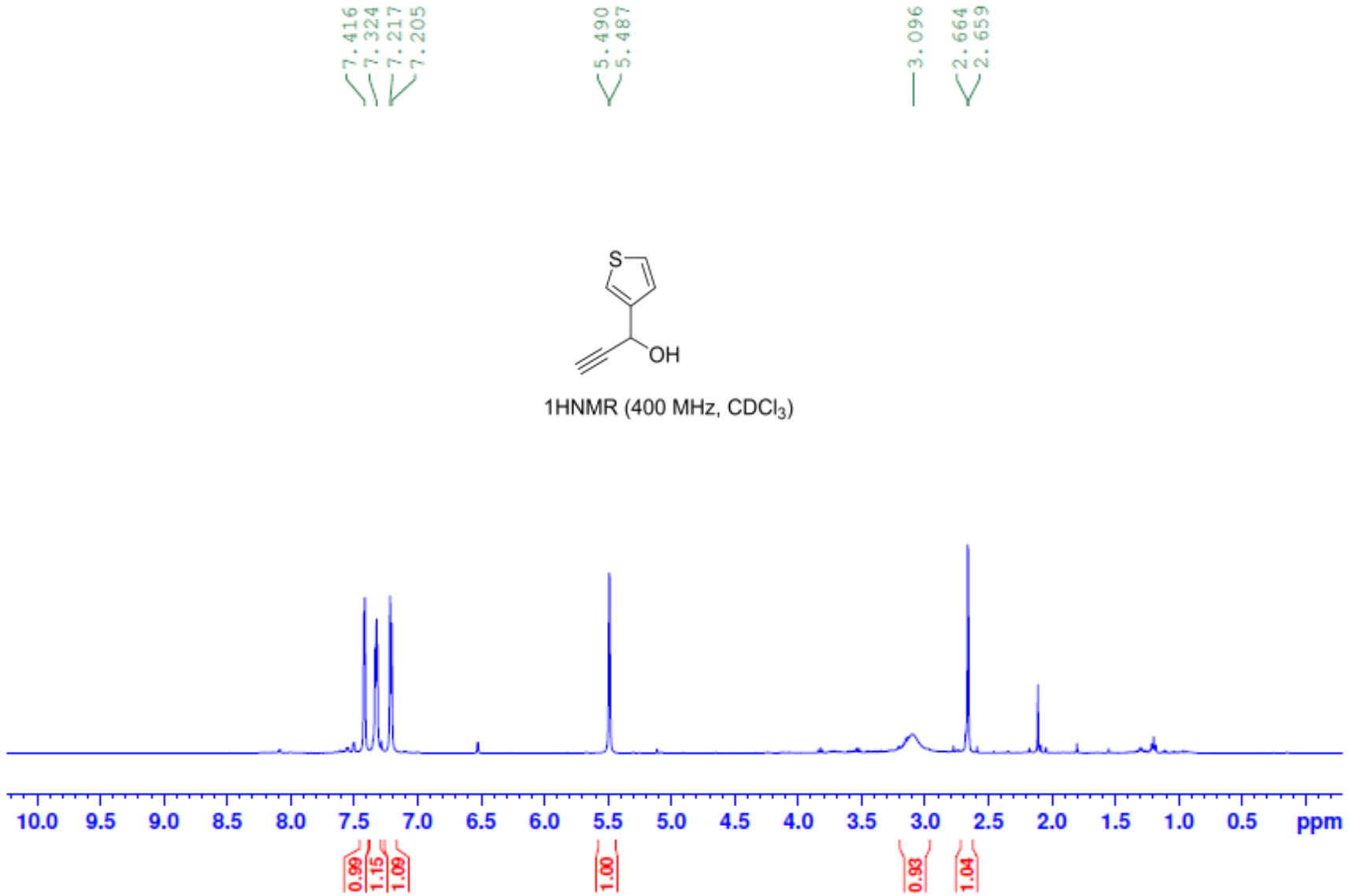


1HNMR (400 MHz, $CDCl_3$)

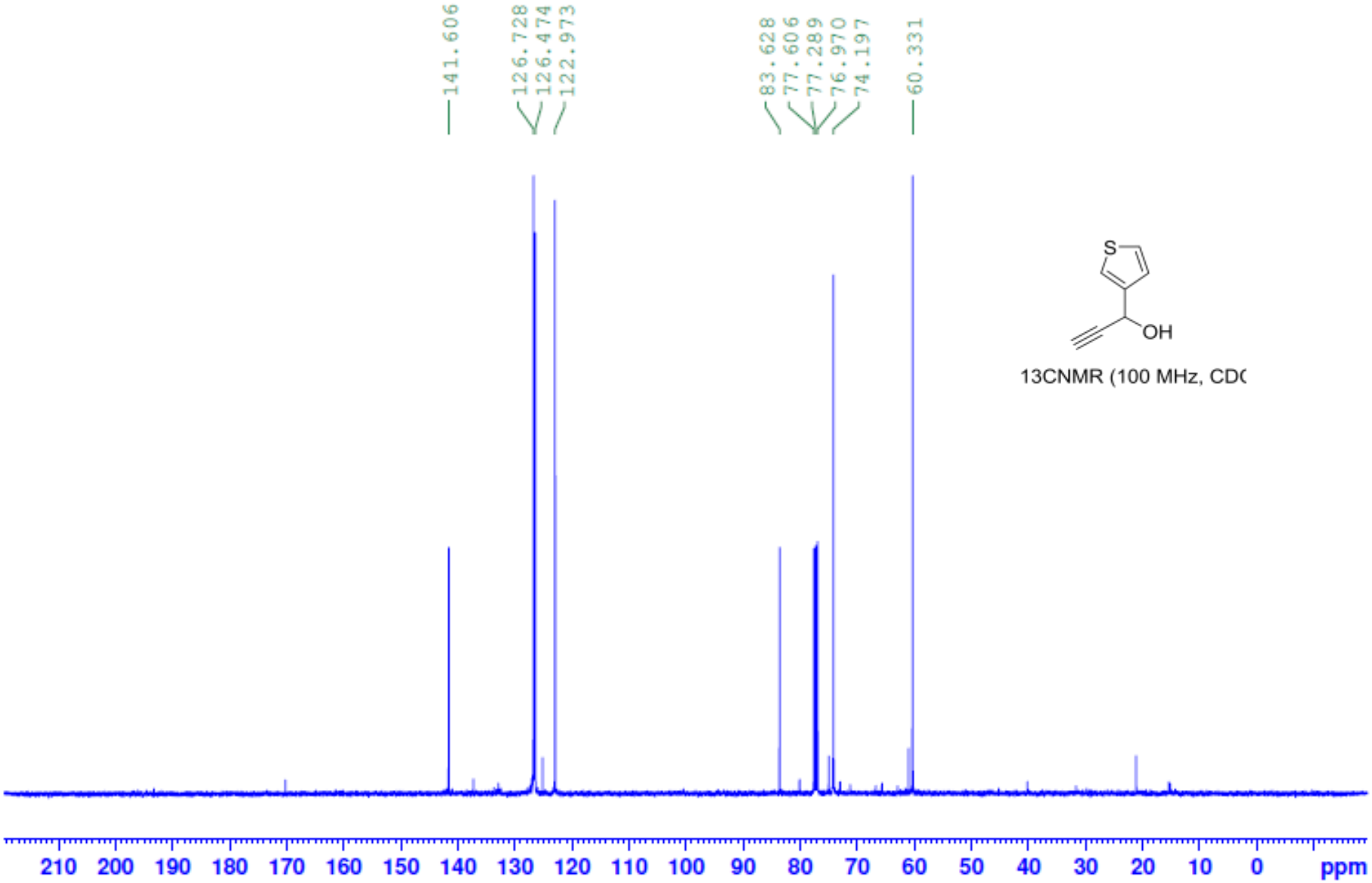


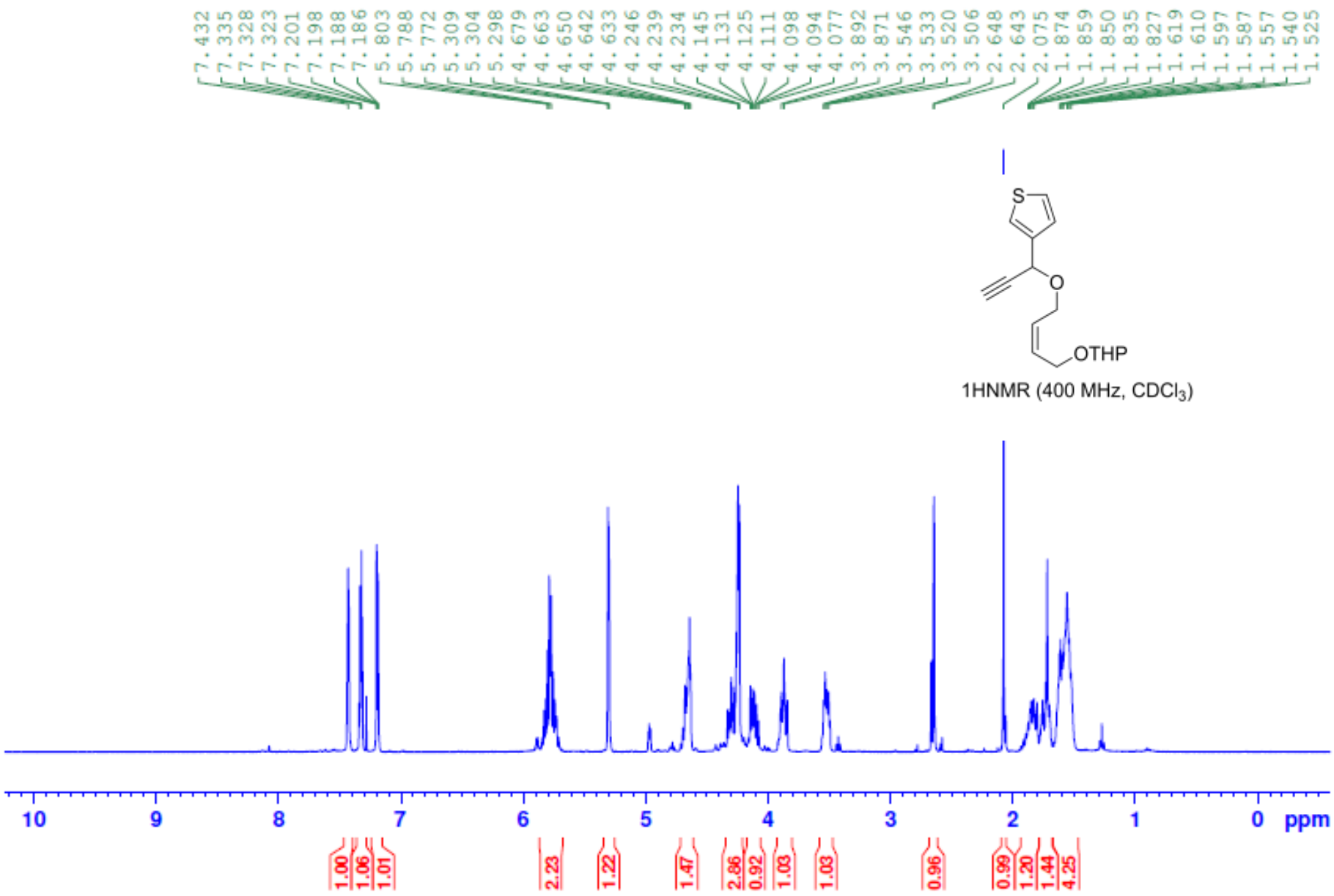
1HNMR (400 MHz, $CDCl_3$)

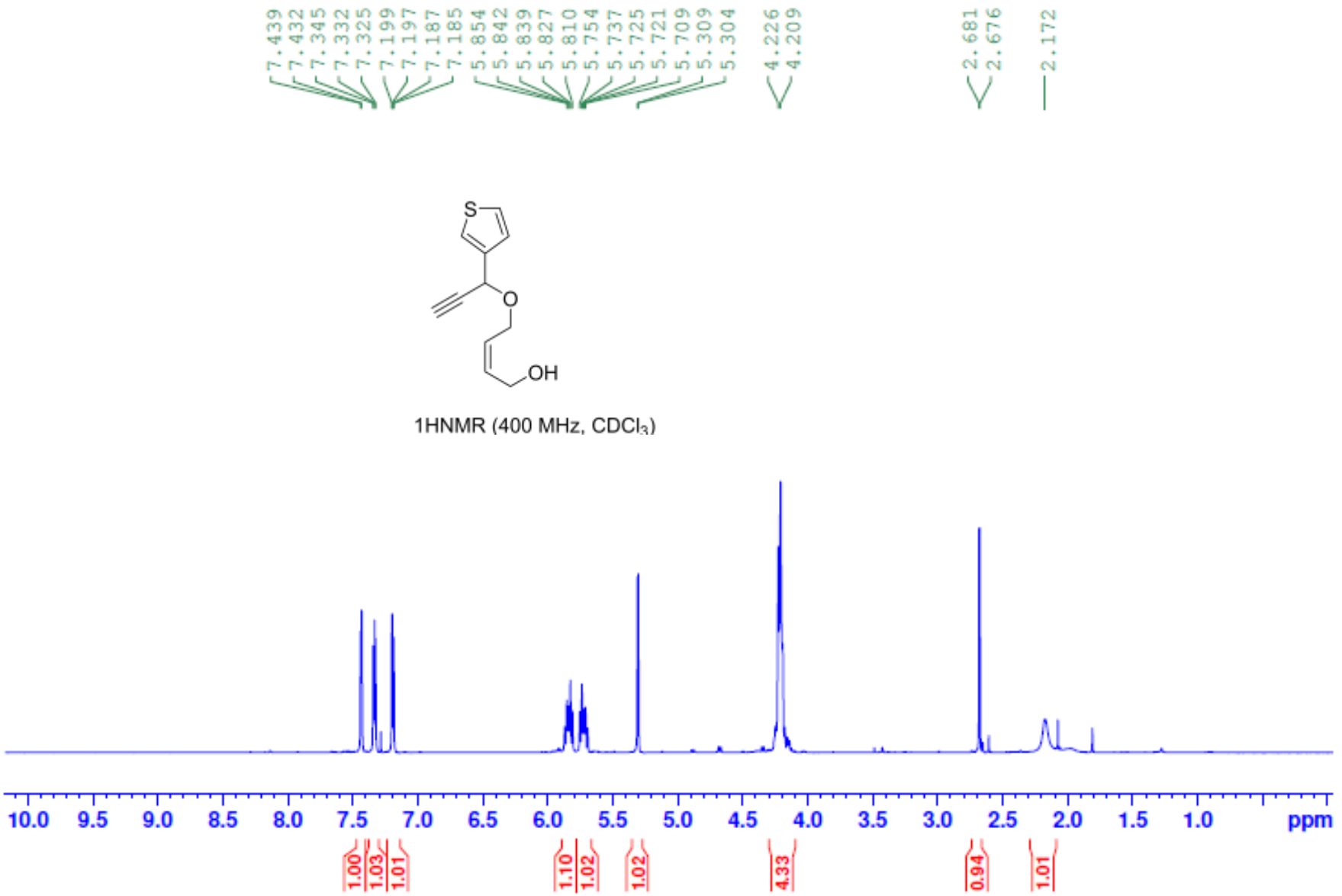

155.766
143.796
141.231
130.613
126.887
123.572
109.532
80.725
74.725
63.731
63.297
63.140
54.966
O
O
OCO2Me
13CNMR (100 MHz, CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

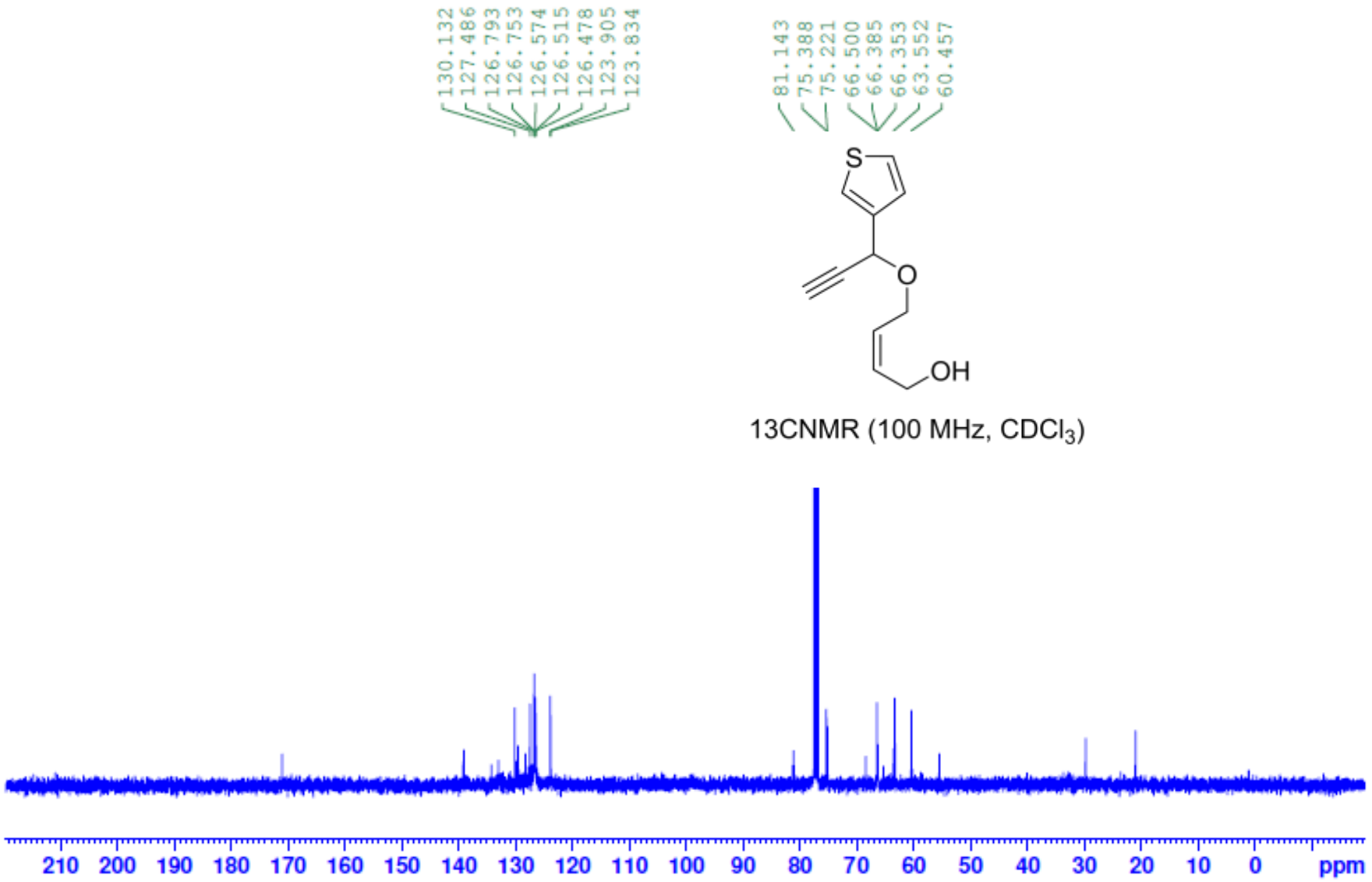


1HNMR (400 MHz, $CDCl_3$)

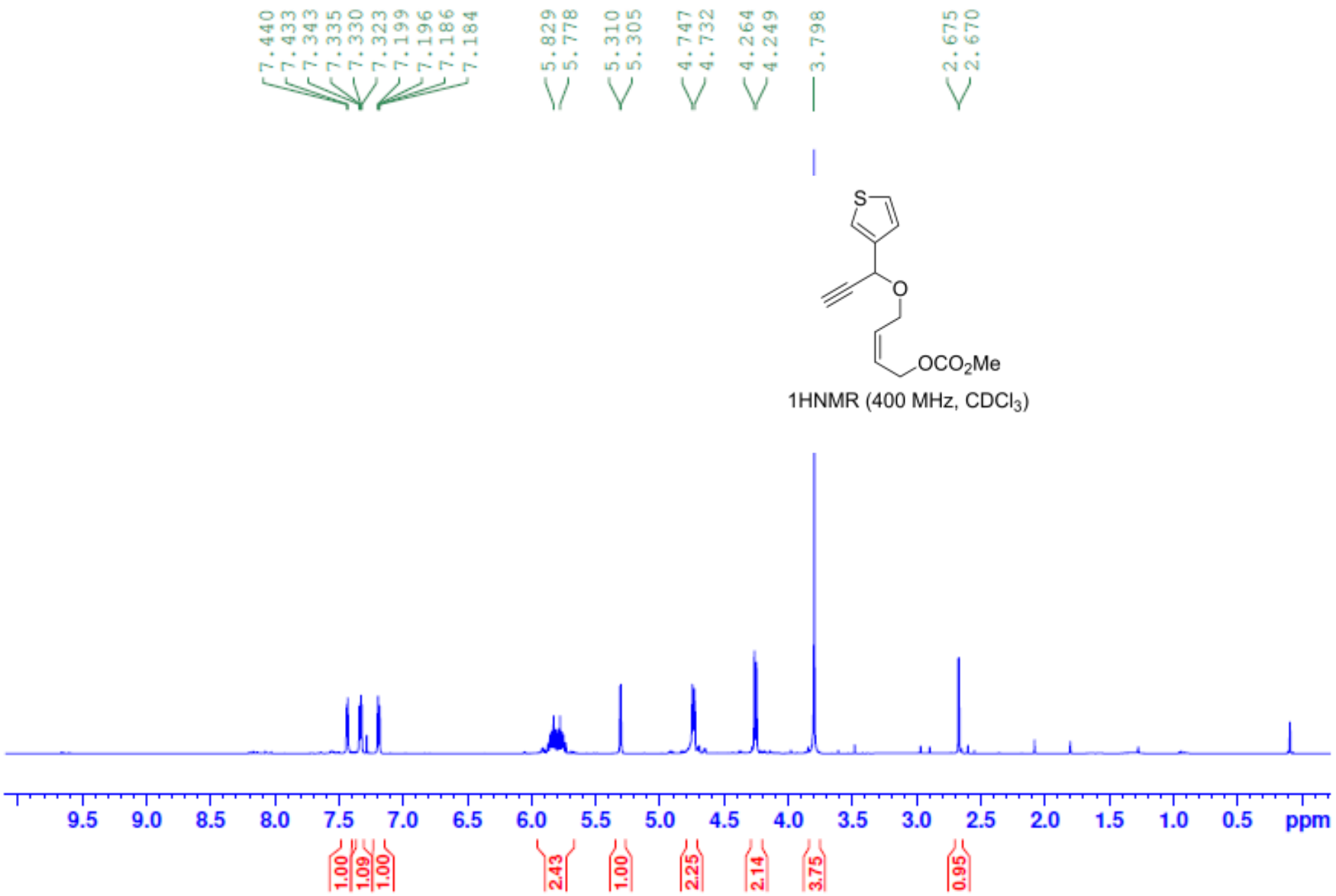

141.606
126.728
126.474
122.973
83.628
77.606
77.289
76.970
74.197
60.331
S
OH
13CNMR (100 MHz, CDC
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

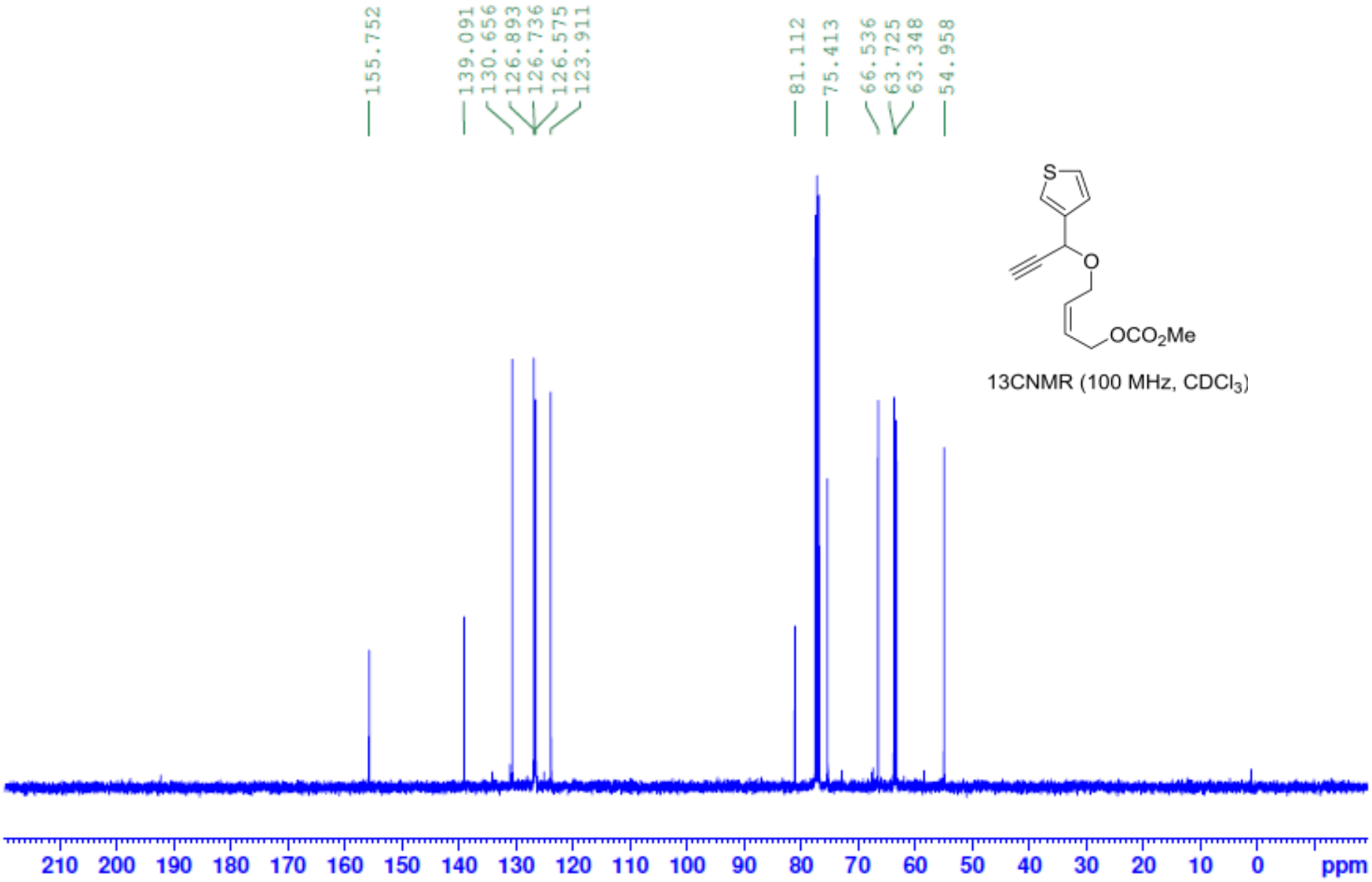

7.432
7.335
7.328
7.323
7.201
7.198
7.188
7.186
5.803
5.788
5.772
5.309
5.304
5.298
4.679
4.663
4.650
4.642
4.633
4.246
4.239
4.234
4.145
4.131
4.125
4.111
4.098
4.094
4.077
3.892
3.871
3.546
3.533
3.520
3.506
2.648
2.643
2.075
1.874
1.859
1.850
1.835
1.827
1.619
1.610
1.597
1.587
1.557
1.540
1.525
S
O
OTHP
1HNMR (400 MHz, CDCl3)
10
9
8
7
6
5
4
3
2
1
0
ppm
1.00
1.06
1.01
2.23
1.22
1.47
2.86
0.92
1.03
1.03
0.96
0.99
1.20
1.44
4.25

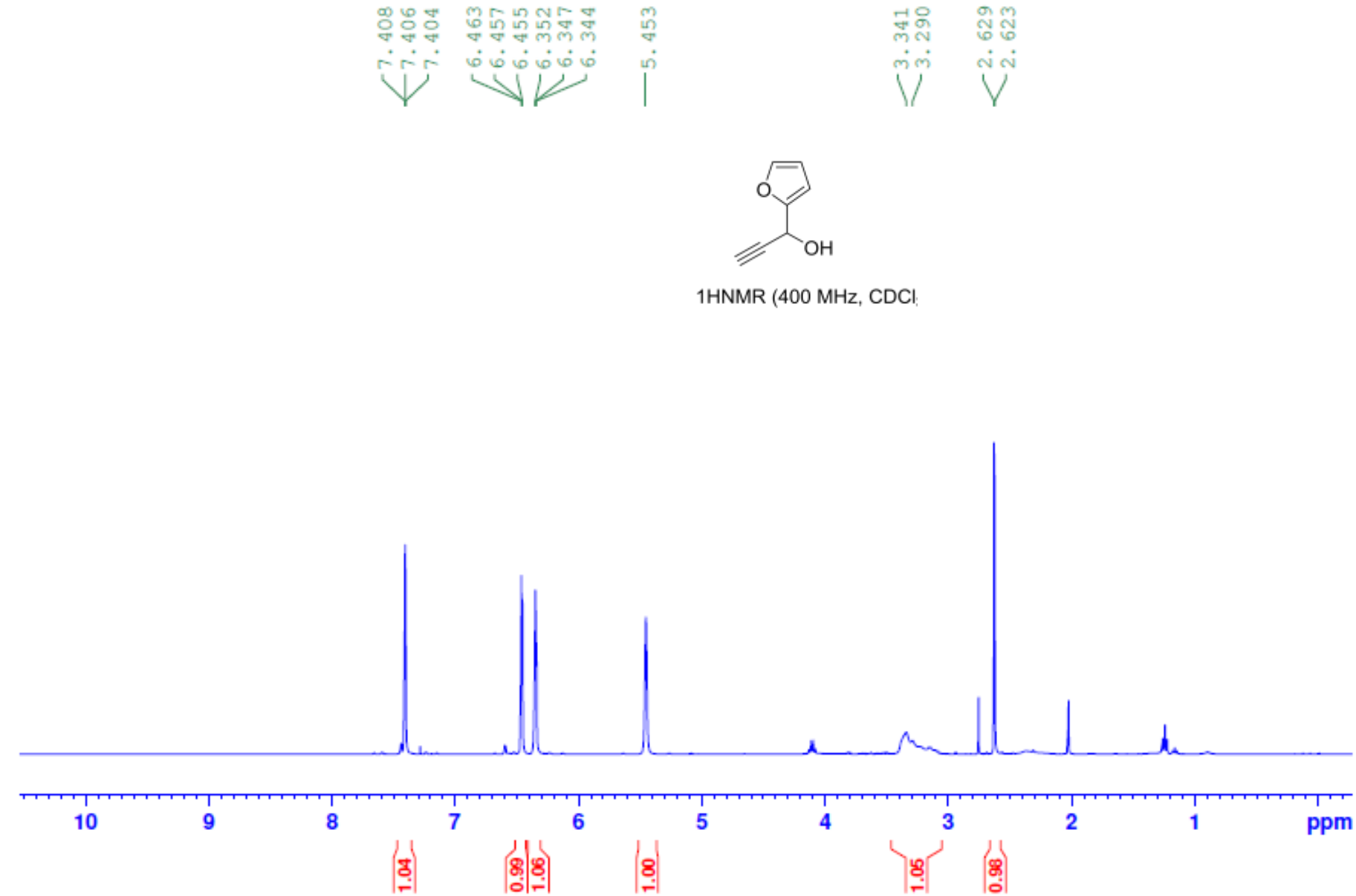

7.439
7.432
7.345
7.332
7.325
7.199
7.197
7.187
7.185
5.854
5.842
5.839
5.827
5.810
5.754
5.737
5.725
5.721
5.709
5.309
5.304
4.226
4.209
2.681
2.676
2.172
S
O
OH
1HNMR (400 MHz, CDCl3)
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
ppm
1.00
1.03
1.01
1.10
1.02
1.02
4.33
0.94
1.01



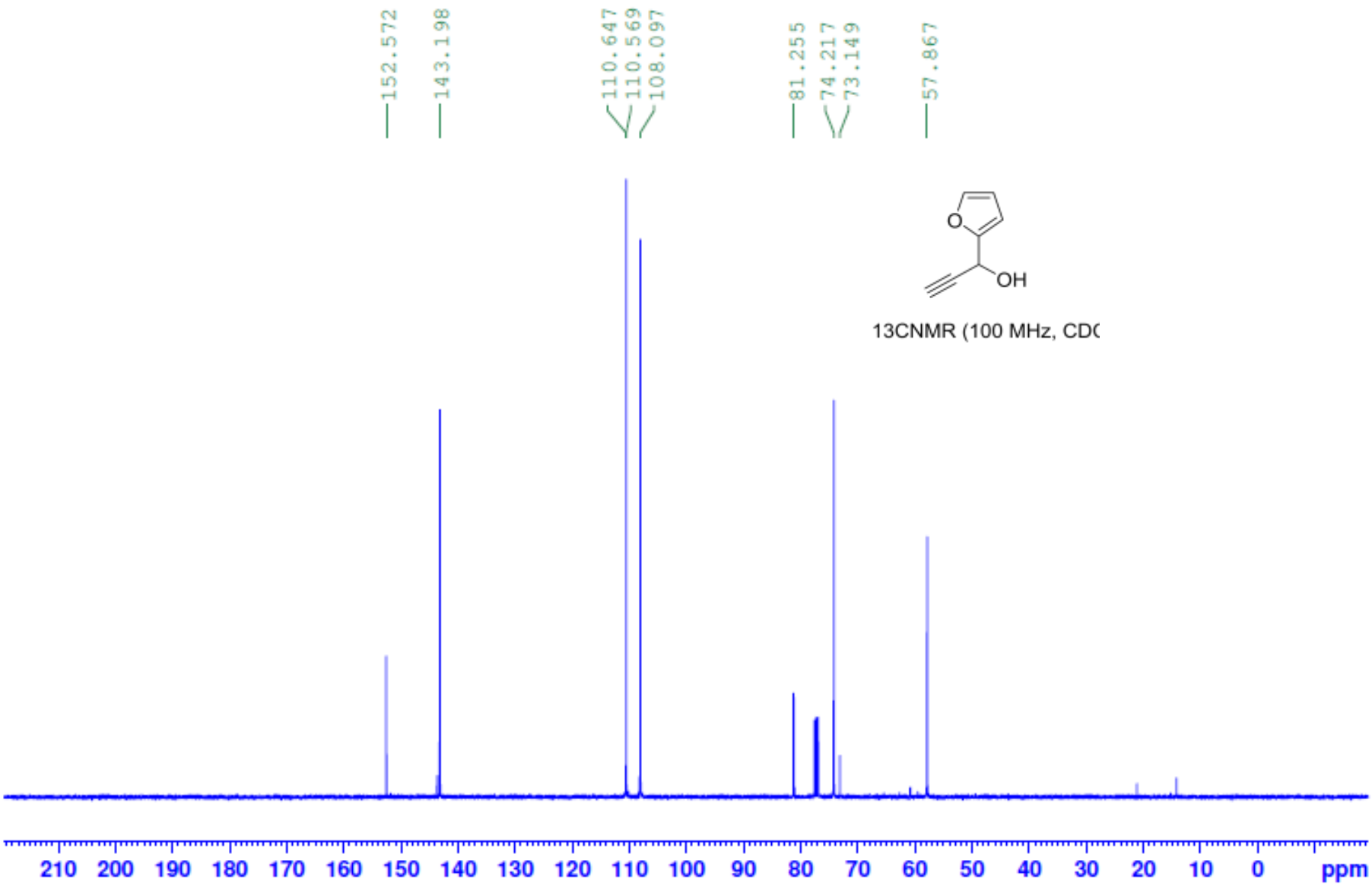
13CNMR (100 MHz, $CDCl_3$)

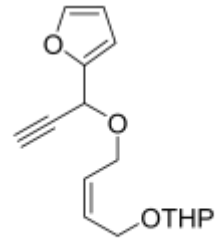

7.440
7.433
7.343
7.335
7.330
7.323
7.199
7.196
7.186
7.184
5.829
5.778
5.310
5.305
4.747
4.732
4.264
4.249
3.798
2.675
2.670
S
O
OCO2Me
1HNMR (400 MHz, CDCl3)
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm
1.00
1.09
1.00
2.43
1.00
2.25
2.14
3.75
0.95


155.752
139.091
130.656
126.893
126.736
126.575
123.911
81.112
75.413
66.536
63.725
63.348
54.958
S
O
OCO2Me
13CNMR (100 MHz, CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

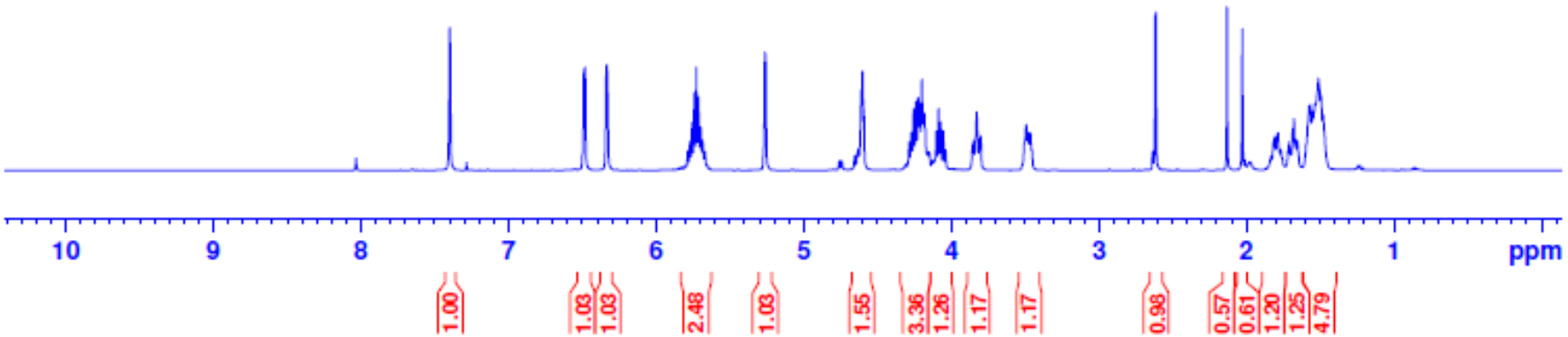


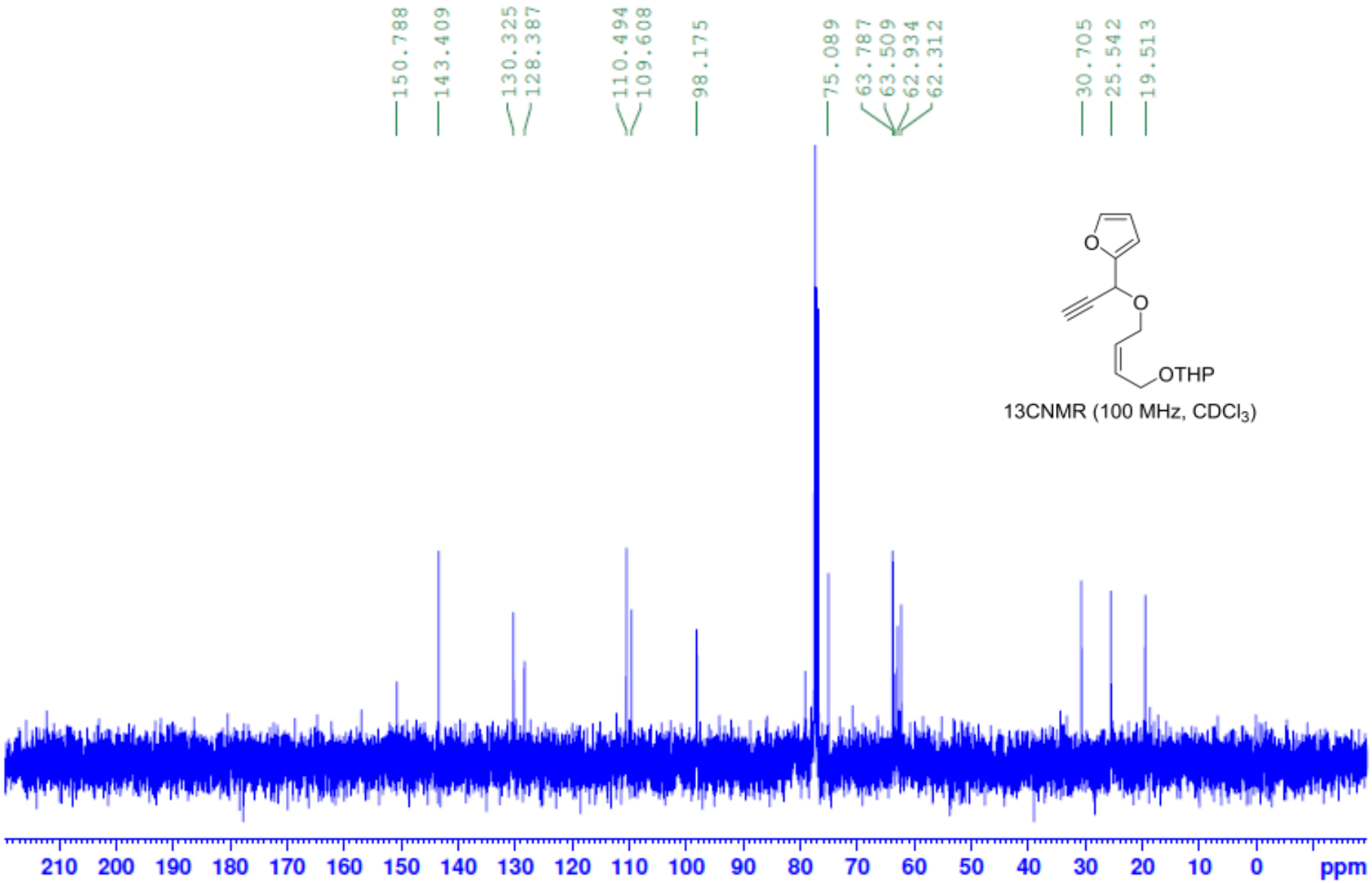
1HNMR (400 MHz, CDCl

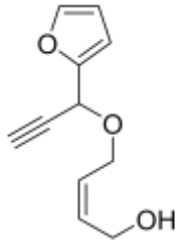

152.572
143.198
110.647
110.569
108.097
81.255
74.217
73.149
57.867
O
OH
13CNMR (100 MHz, CDC
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm



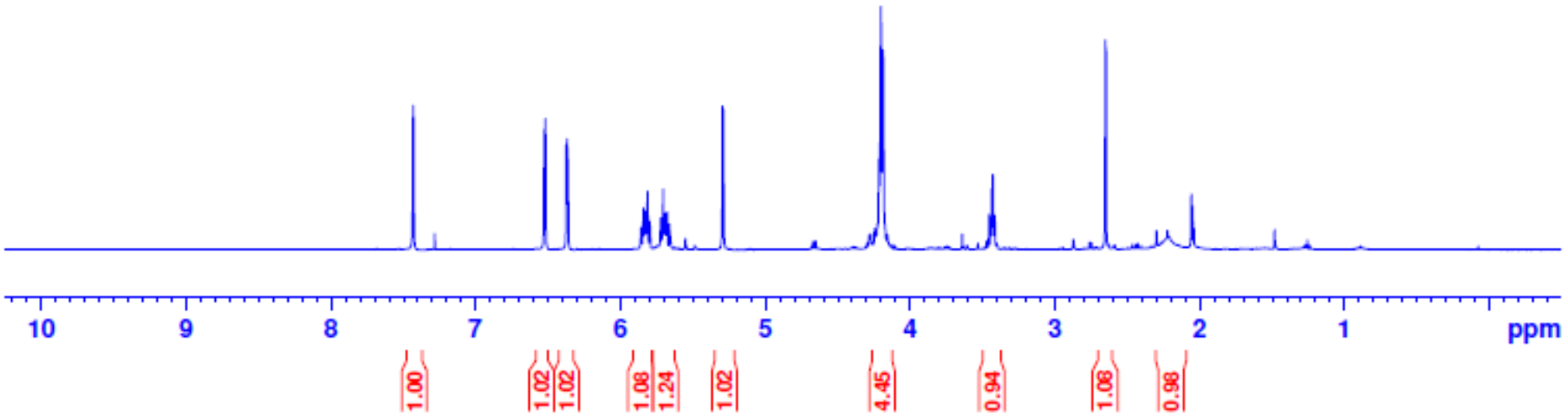
1HNMR (400 MHz, $CDCl_3$)

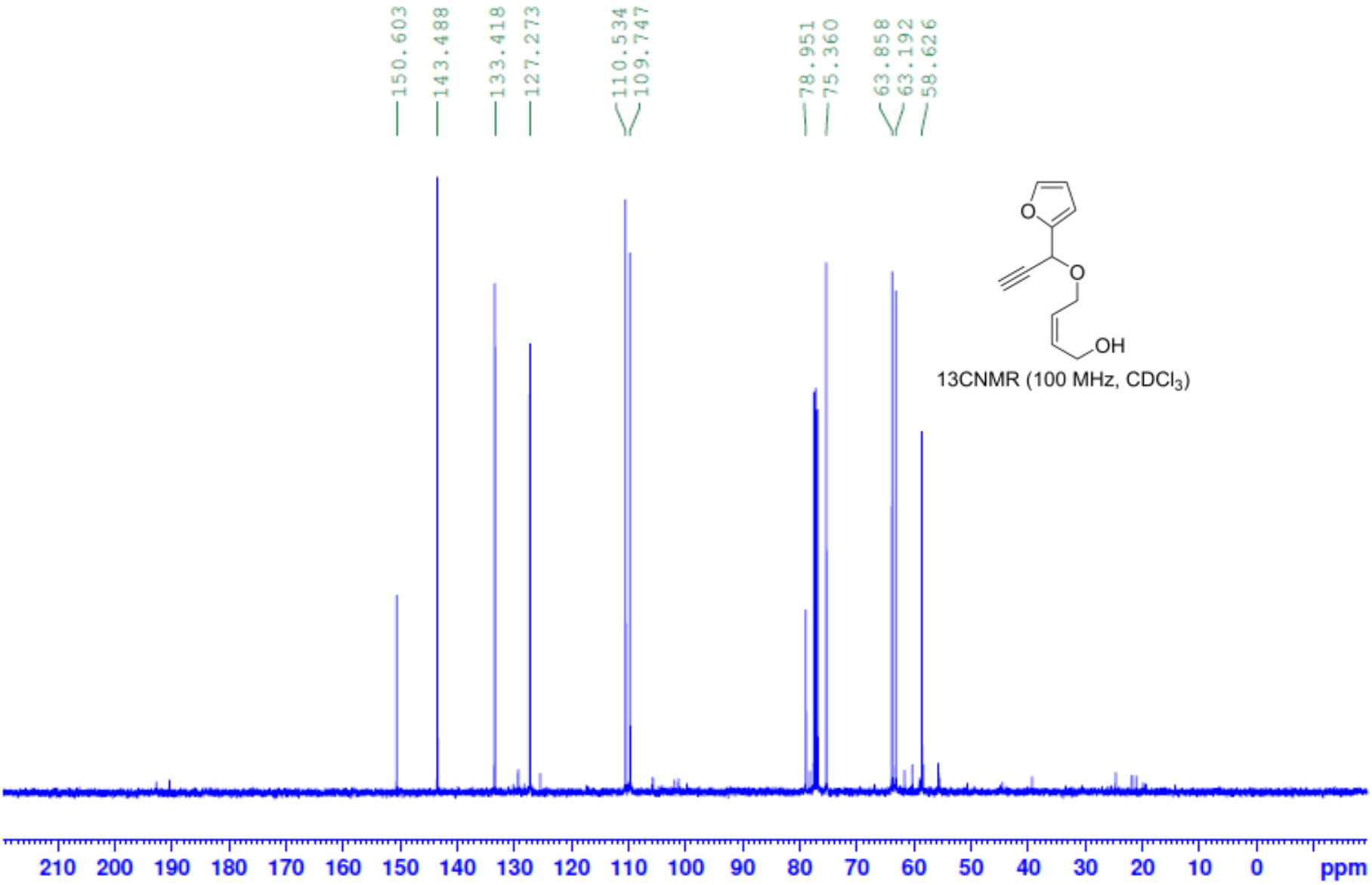


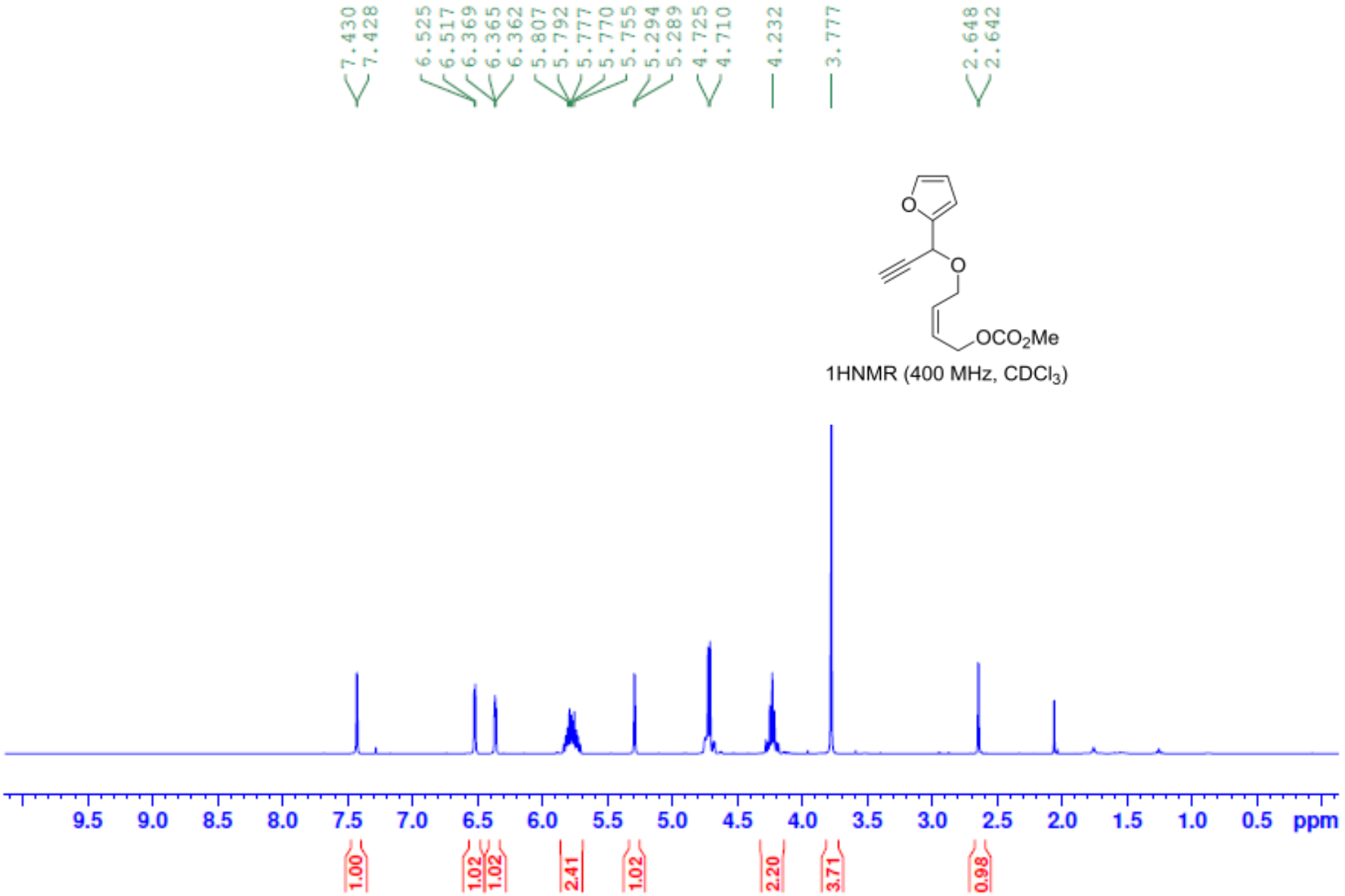

150.788
143.409
130.325
128.387
110.494
109.608
98.175
75.089
63.787
63.509
62.934
62.312
30.705
25.542
19.513
O
O
OTHP
13CNMR (100 MHz, CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm



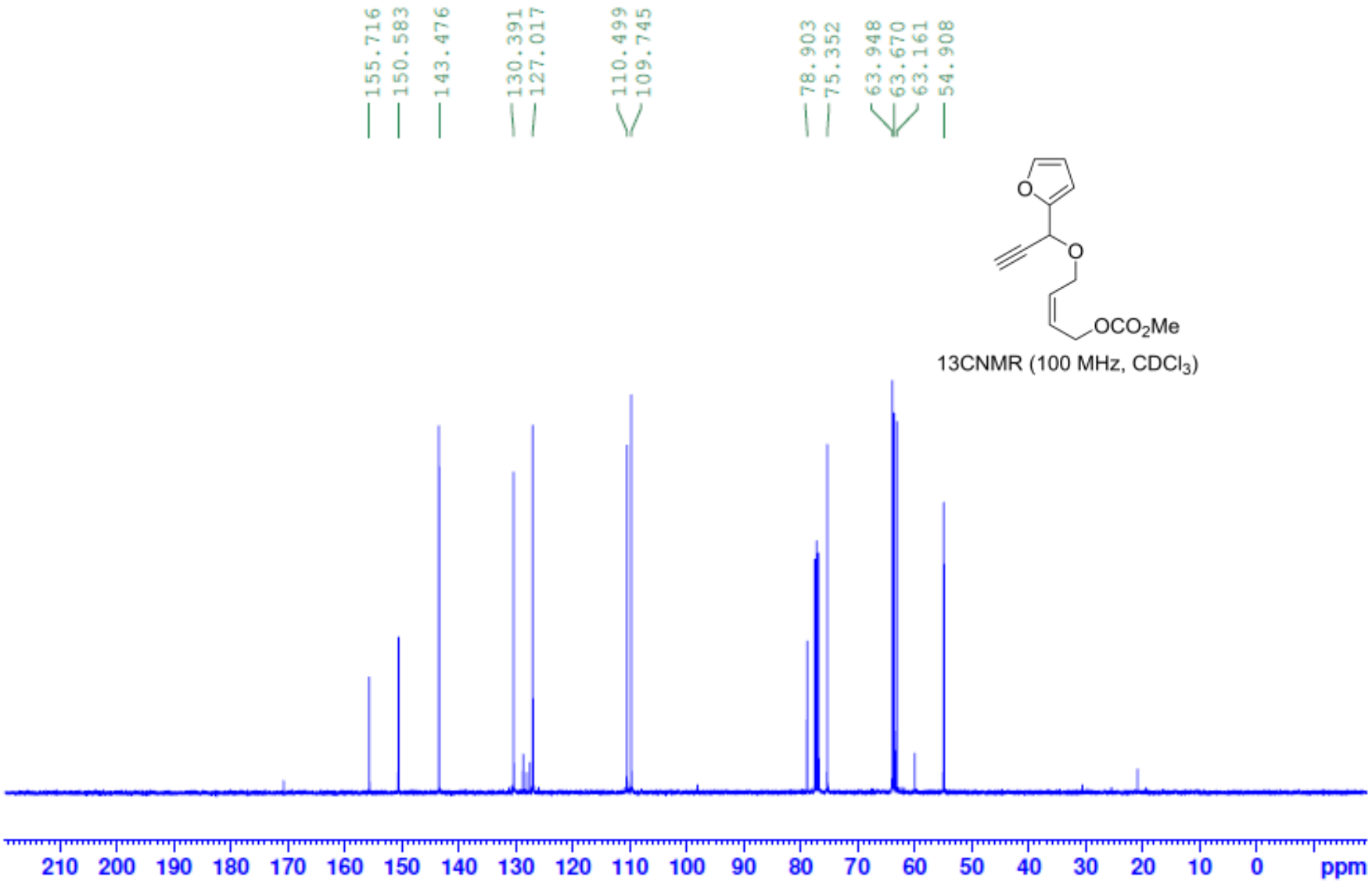
1HNMR (400 MHz, $CDCl_3$)

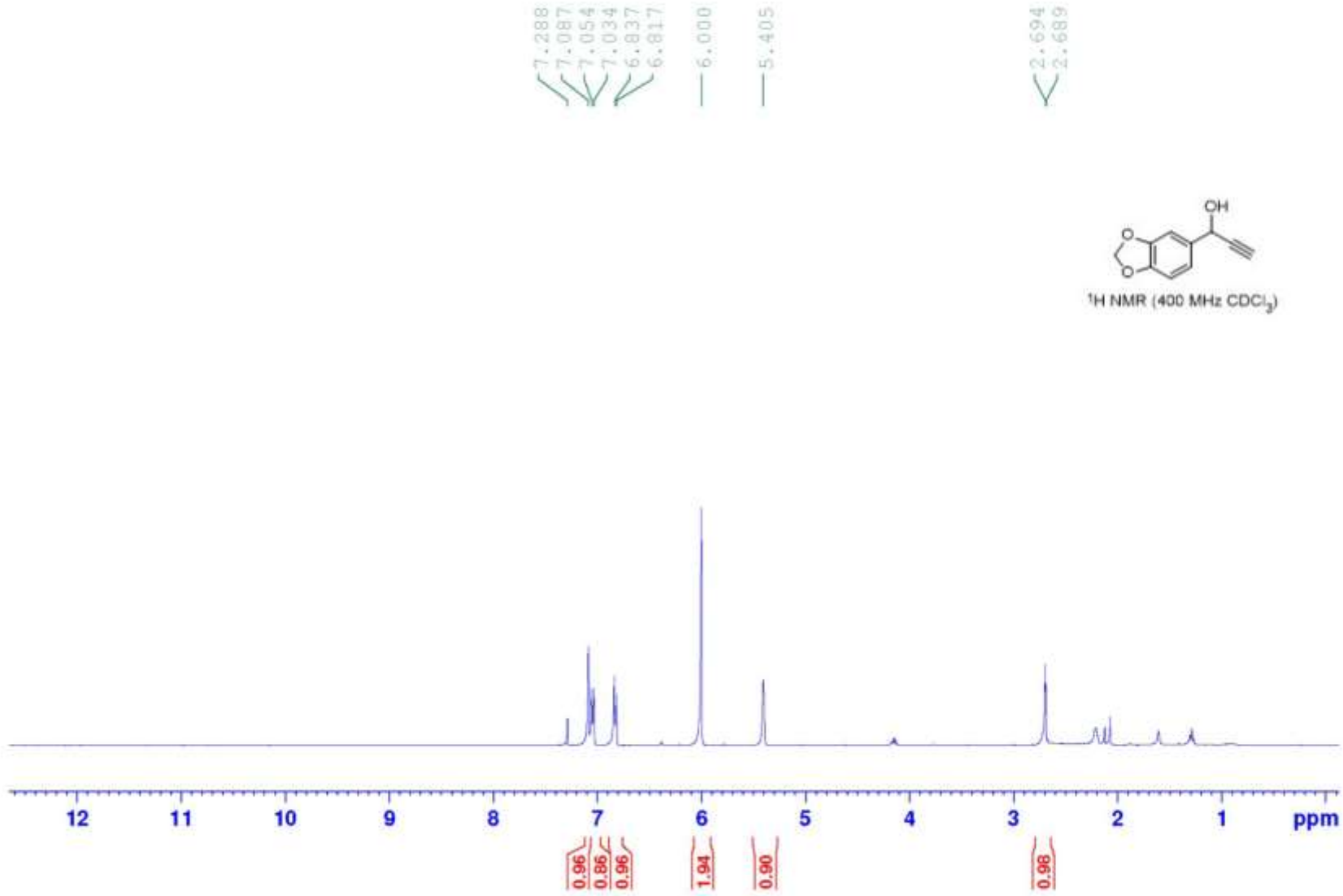


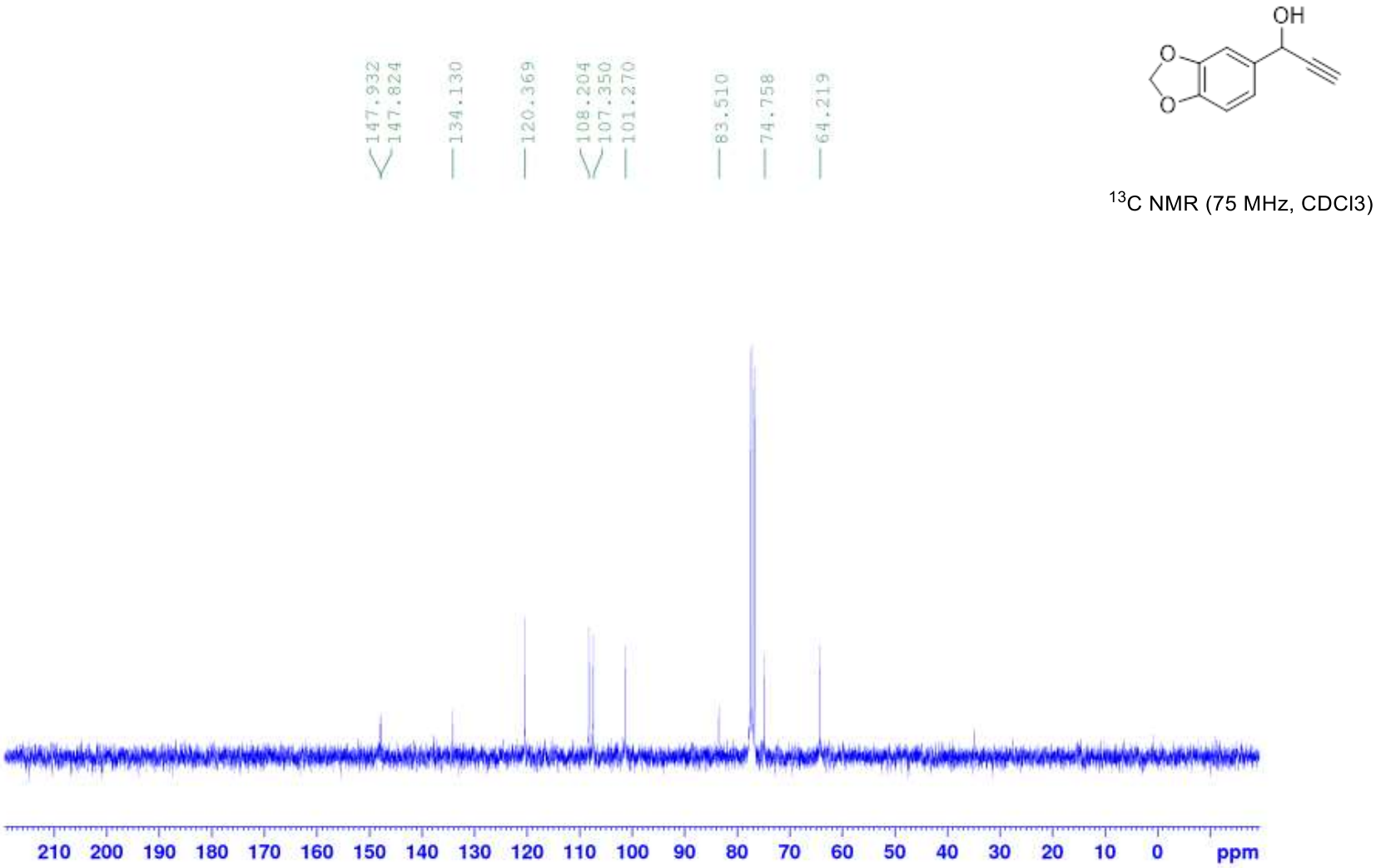

150.603
143.488
133.418
127.273
110.534
109.747
78.951
75.360
63.858
63.192
58.626
O
O
OH
13CNMR (100 MHz, CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm



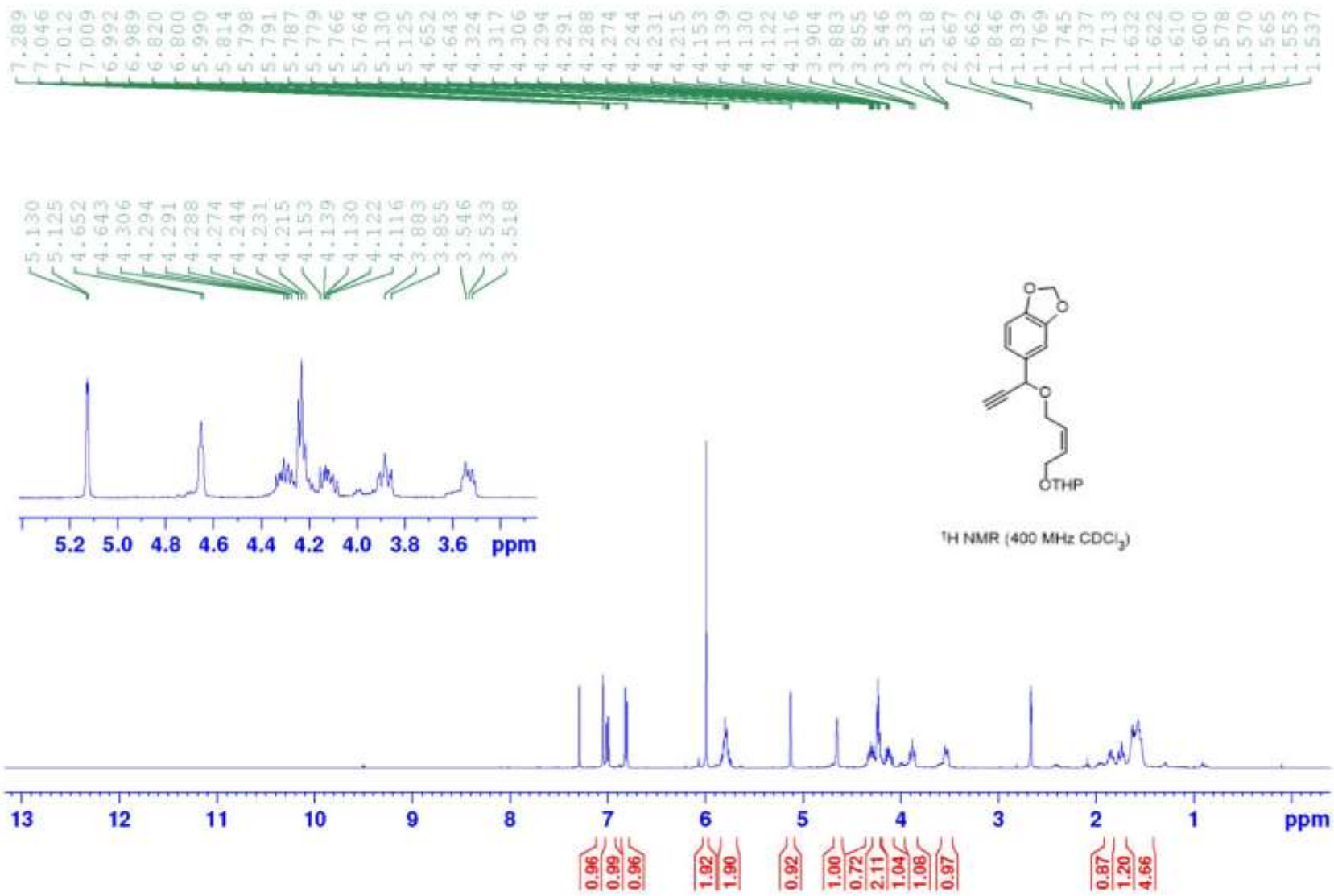
1HNMR (400 MHz, $CDCl_3$)

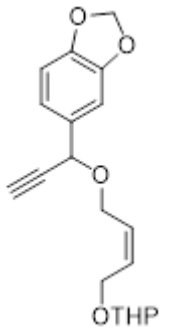

155.716
150.583
143.476
130.391
127.017
110.499
109.745
78.903
75.352
63.948
63.670
63.161
54.908
O
O
OCO2Me
13CNMR (100 MHz, CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm


7.288
7.087
7.054
7.034
6.837
6.817
6.000
5.405
2.694
2.689
OH
^{1}H NMR (400 MHz $CDCl_3$)
12
11
10
9
8
7
6
5
4
3
2
1
ppm
0.96
0.86
0.96
1.94
0.90
0.98

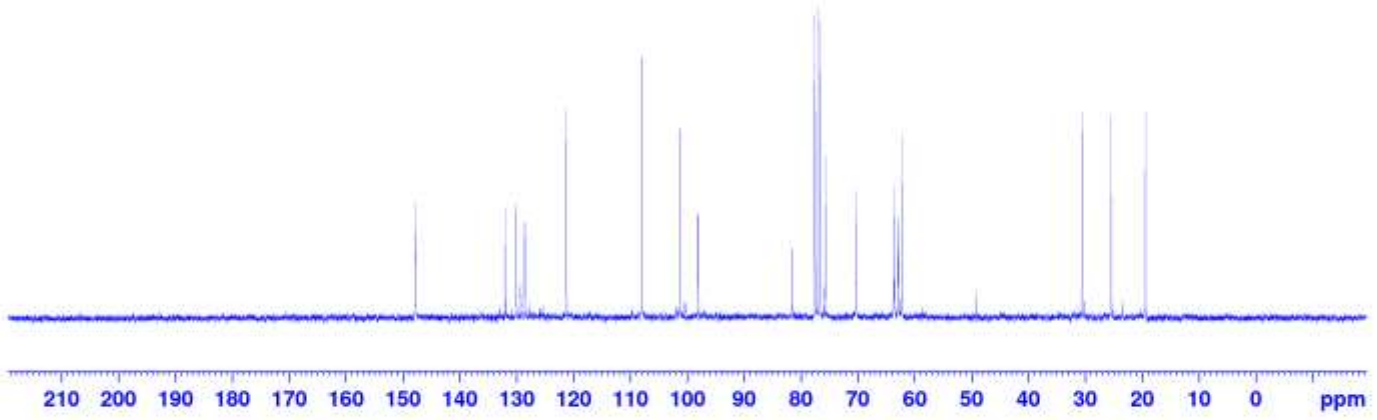


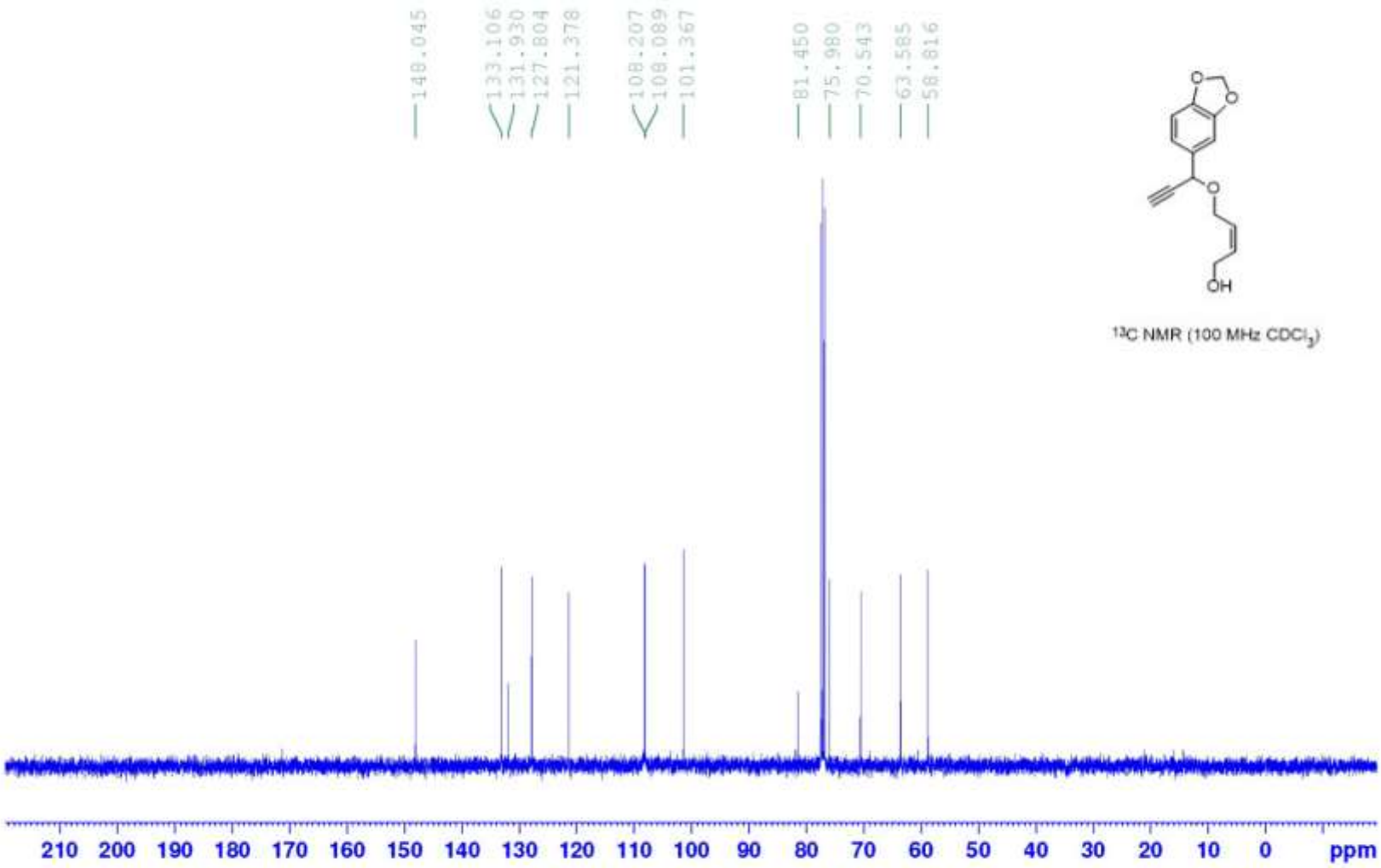
^{13}C NMR (75 MHz, CDCl3)

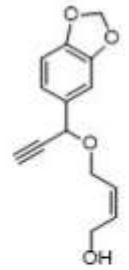

7.289
7.046
7.012
7.009
6.992
6.989
6.820
6.800
5.990
5.814
5.798
5.791
5.787
5.779
5.766
5.764
5.130
5.125
4.652
4.643
4.324
4.317
4.306
4.294
4.291
4.288
4.274
4.244
4.231
4.215
4.153
4.139
4.130
4.122
4.116
3.904
3.883
3.855
3.546
3.533
3.518
2.667
2.662
1.846
1.839
1.769
1.745
1.737
1.713
1.632
1.622
1.610
1.600
1.578
1.570
1.565
1.553
1.537
5.2 5.0 4.8 4.6 4.4 4.2 4.0 3.8 3.6 ppm
THP
^{1}H NMR (400 MHz $CDCl_3$)
13 12 11 10 9 8 7 6 5 4 3 2 1 ppm
0.96 0.99 0.96 1.92 1.90 0.92 1.00 0.72 2.11 1.04 1.08 0.97 0.87 1.20 4.66



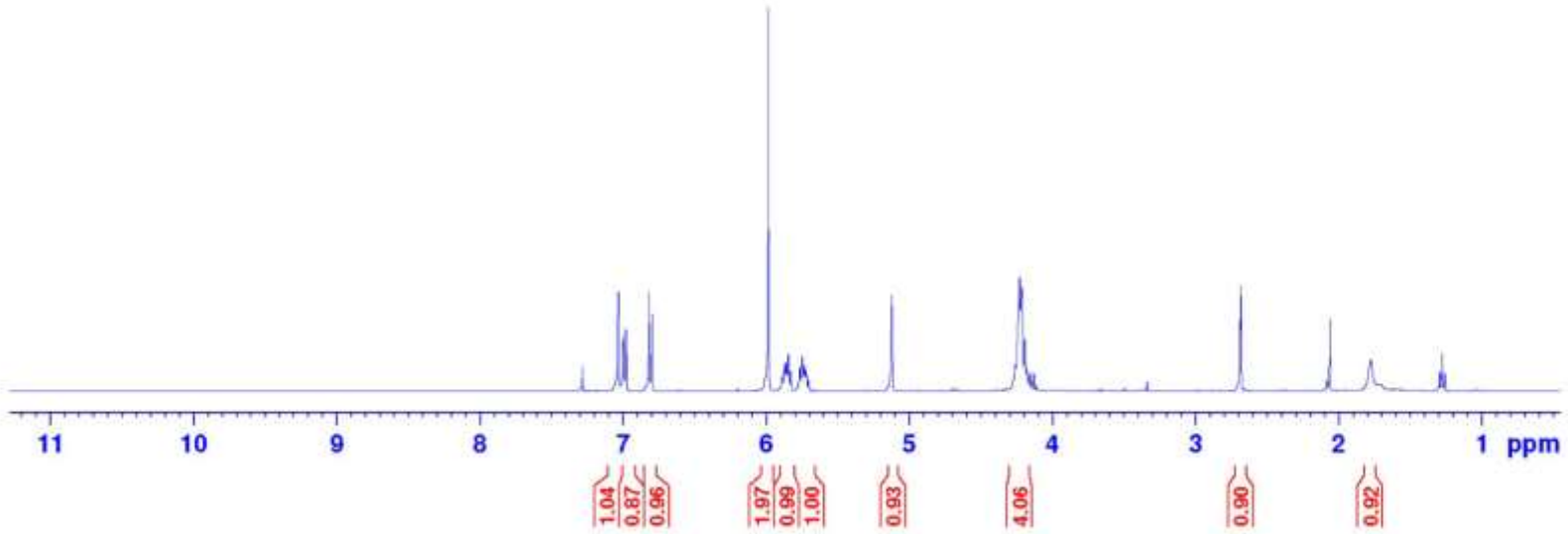
^{13}C NMR (75 MHz, CDCl3)

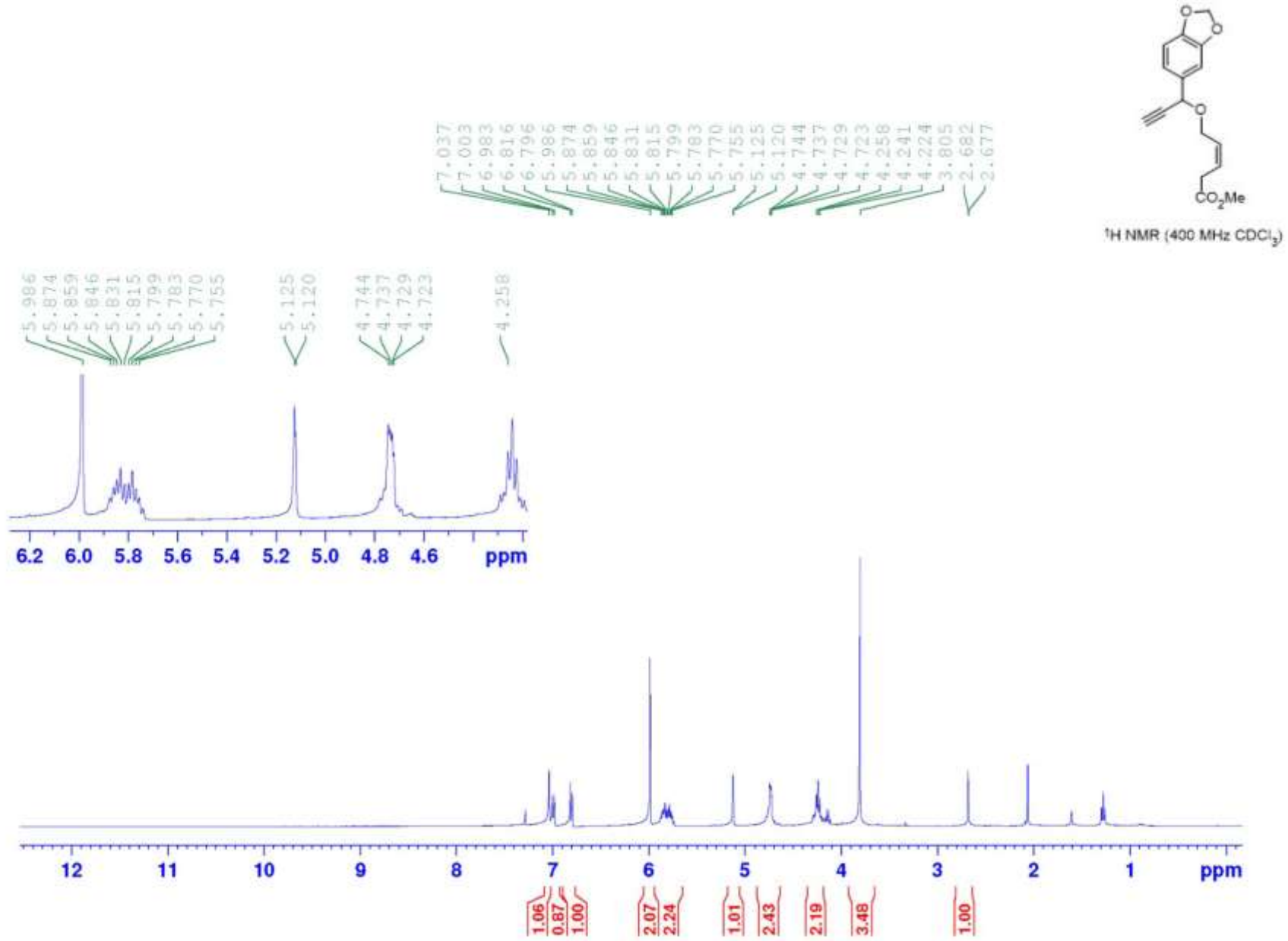


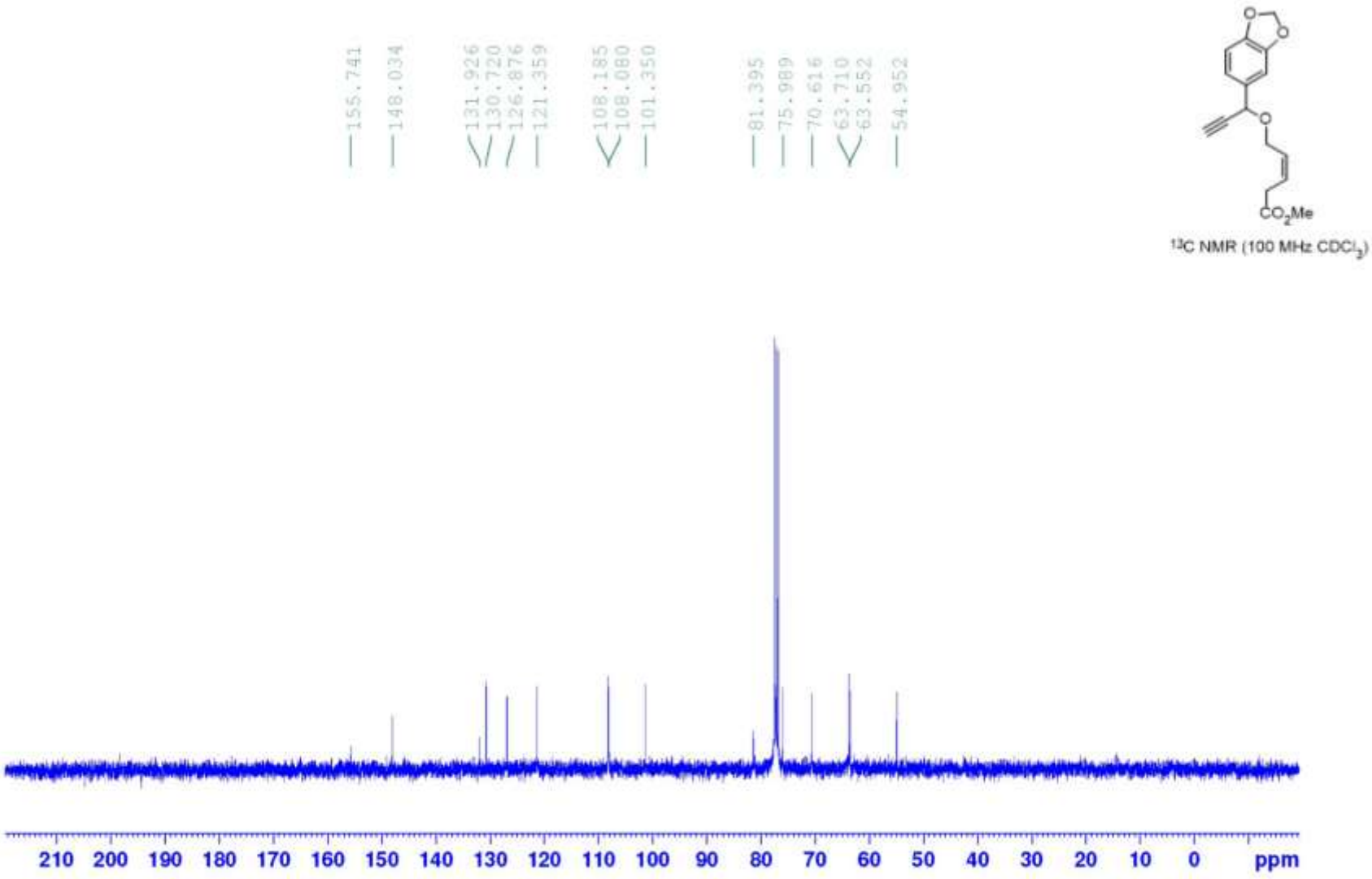

148.045
133.106
131.930
127.804
121.378
108.207
108.089
101.367
81.450
75.980
70.543
63.585
58.816
OH
^{13}C NMR (100 MHz $CDCl_3$)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm



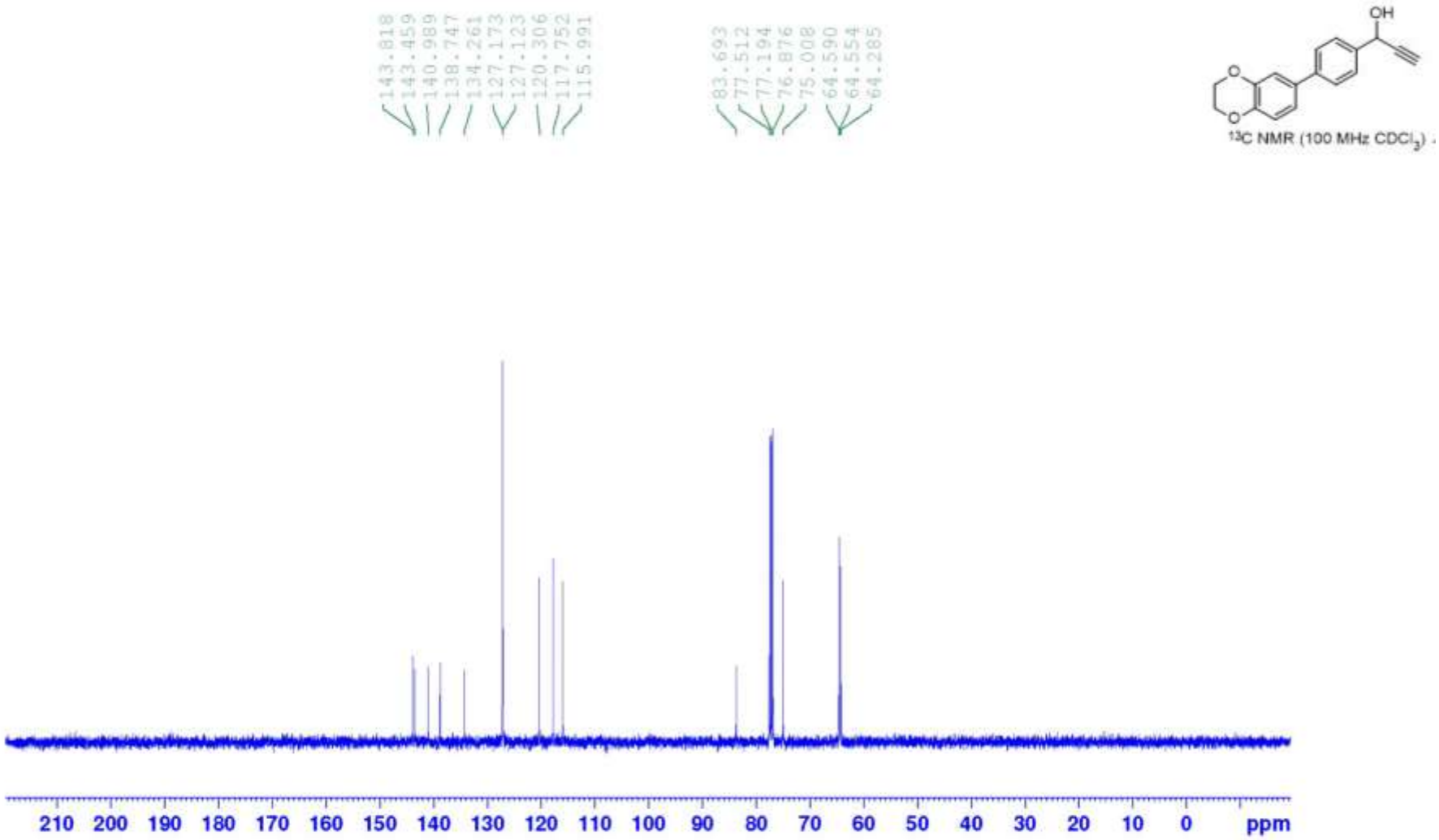
^{1}H NMR (400 MHz $CDCl_3$)



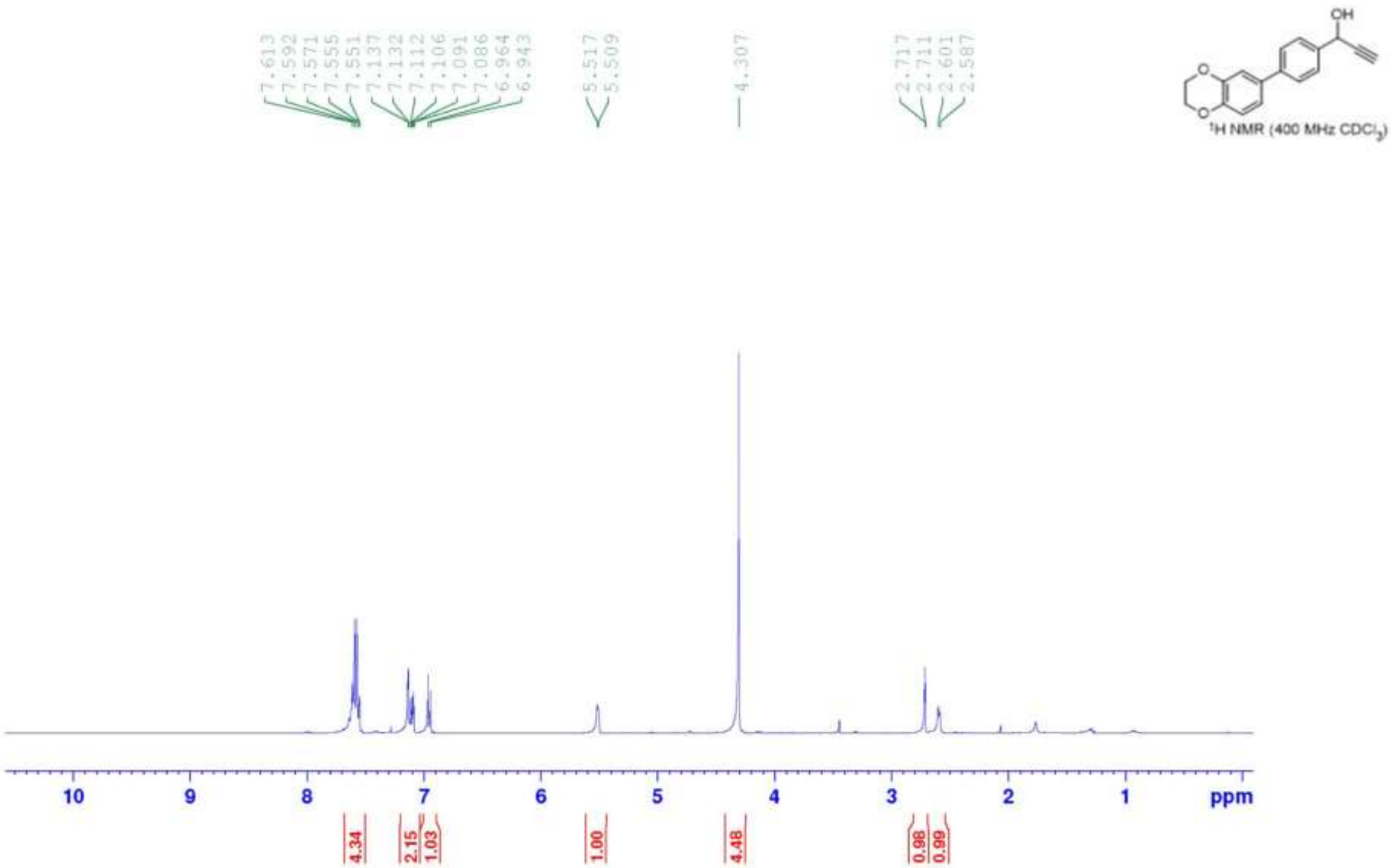

7.037
7.003
6.983
6.816
6.796
5.986
5.874
5.859
5.846
5.831
5.815
5.799
5.783
5.770
5.755
5.125
5.120
4.744
4.737
4.729
4.723
4.258
4.241
4.224
3.805
2.682
2.677
CO2Me
1H NMR (400 MHz CDCl3)
6.2 6.0 5.8 5.6 5.4 5.2 5.0 4.8 4.6 ppm
12 11 10 9 8 7 6 5 4 3 2 1 ppm
1.06
0.87
1.00
2.07
2.24
1.01
2.43
2.19
3.48
1.00

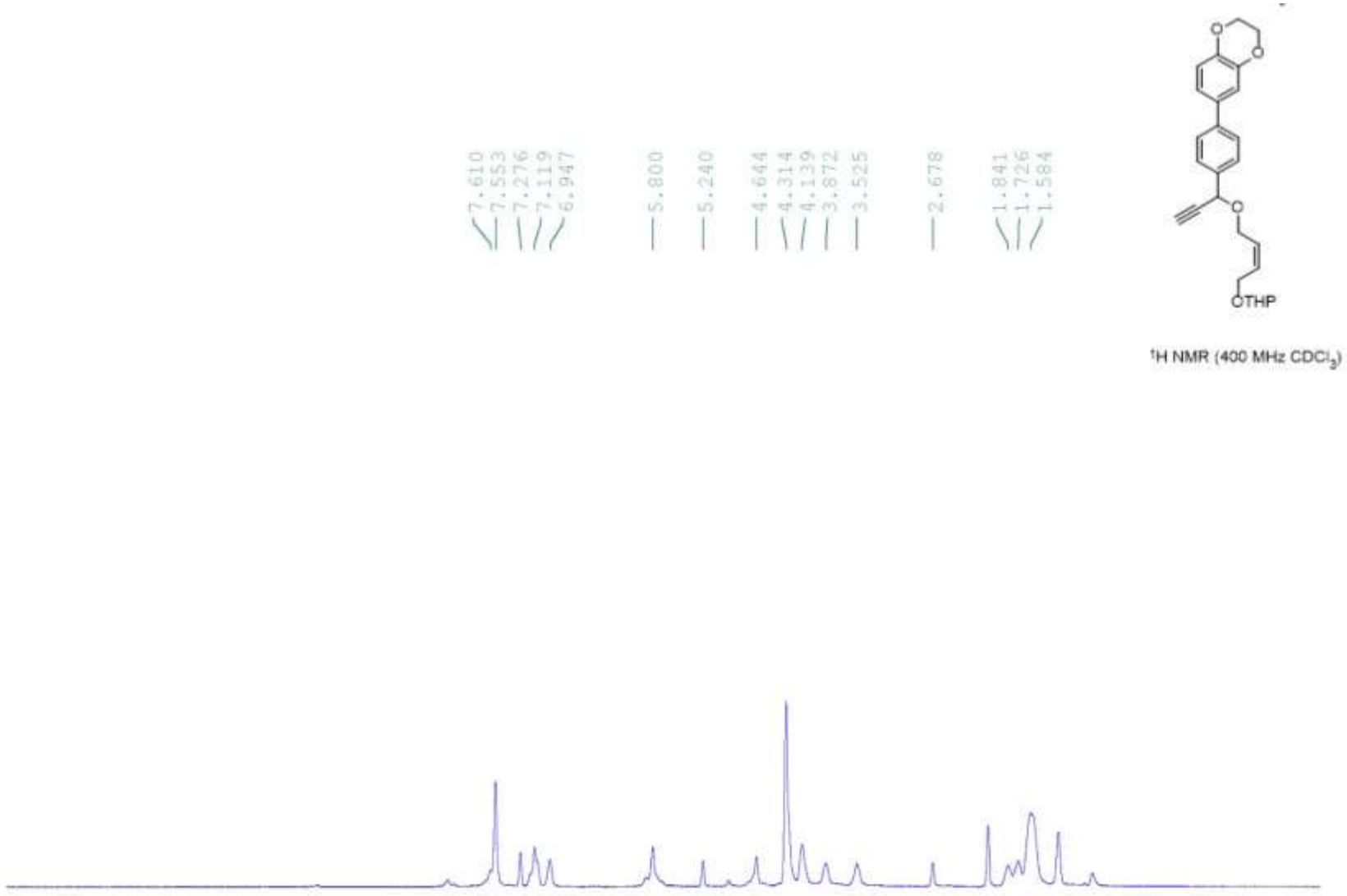

155.741
148.034
131.926
130.720
126.876
121.359
108.185
108.080
101.350
81.395
75.989
70.616
63.710
63.552
54.952
CO2Me
13C NMR (100 MHz CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

^{1}H NMR (400 MHz $CDCl_3$)
10.034
7.925
7.906
7.702
7.684
7.180
7.162
7.140
6.984
6.964
4.315
4.03
1.07
1.55
2.09
1.80
1.17
ppm

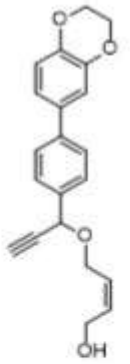


^{13}C NMR (100 MHz $CDCl_3$)

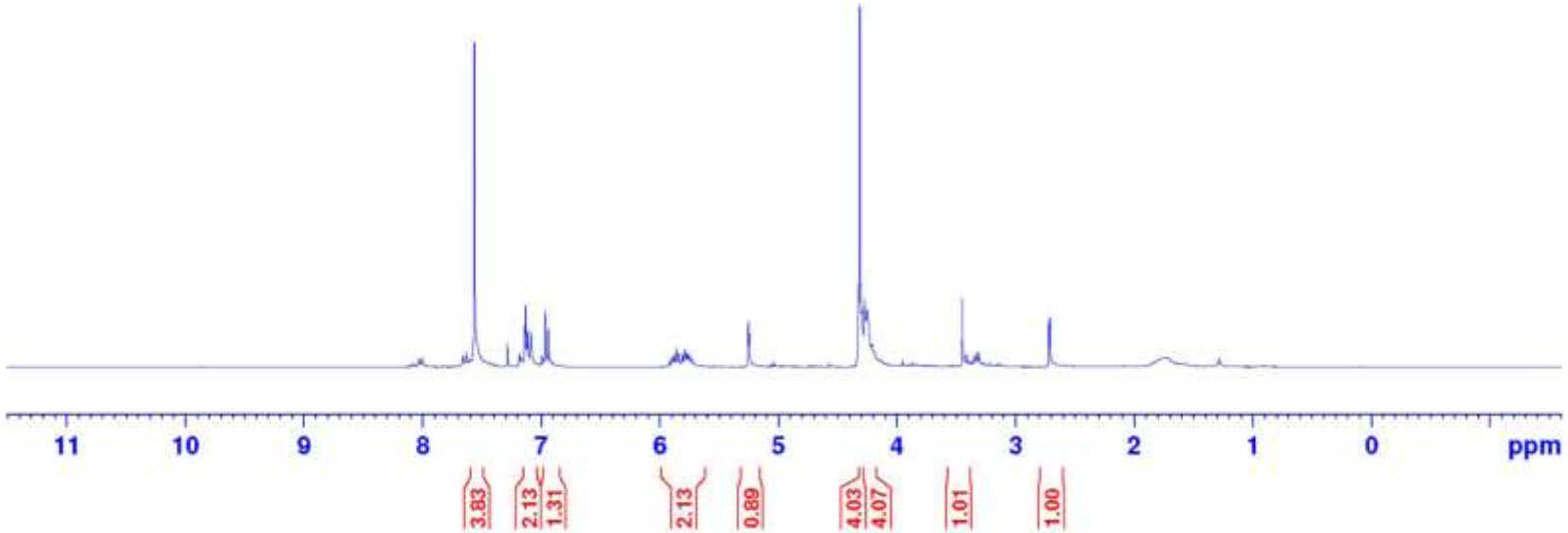

7.613
7.592
7.571
7.555
7.551
7.137
7.132
7.112
7.106
7.091
7.086
6.964
6.943
5.517
5.509
4.307
2.717
2.711
2.601
2.587
OH
^{1}H NMR (400 MHz CDCl$_3$)
10
9
8
7
6
5
4
3
2
1
ppm
4.34
2.15
1.03
1.00
4.48
0.98
0.99

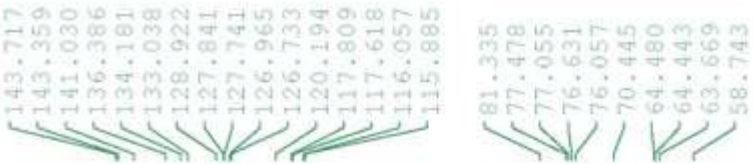


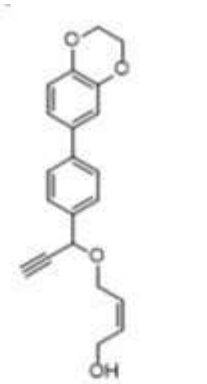
^{1}H NMR (400 MHz $CDCl_3$)



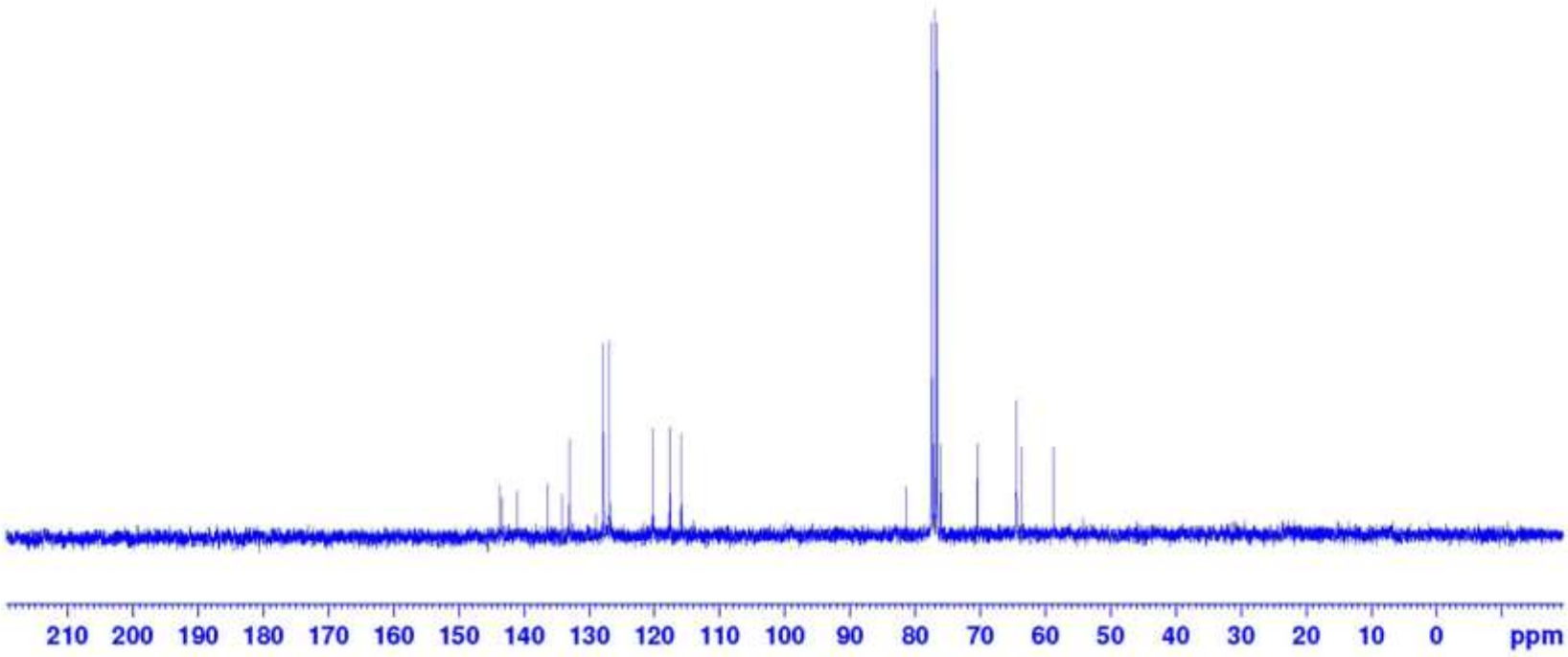
^{1}H NMR (300 MHz $CDCl_3$)

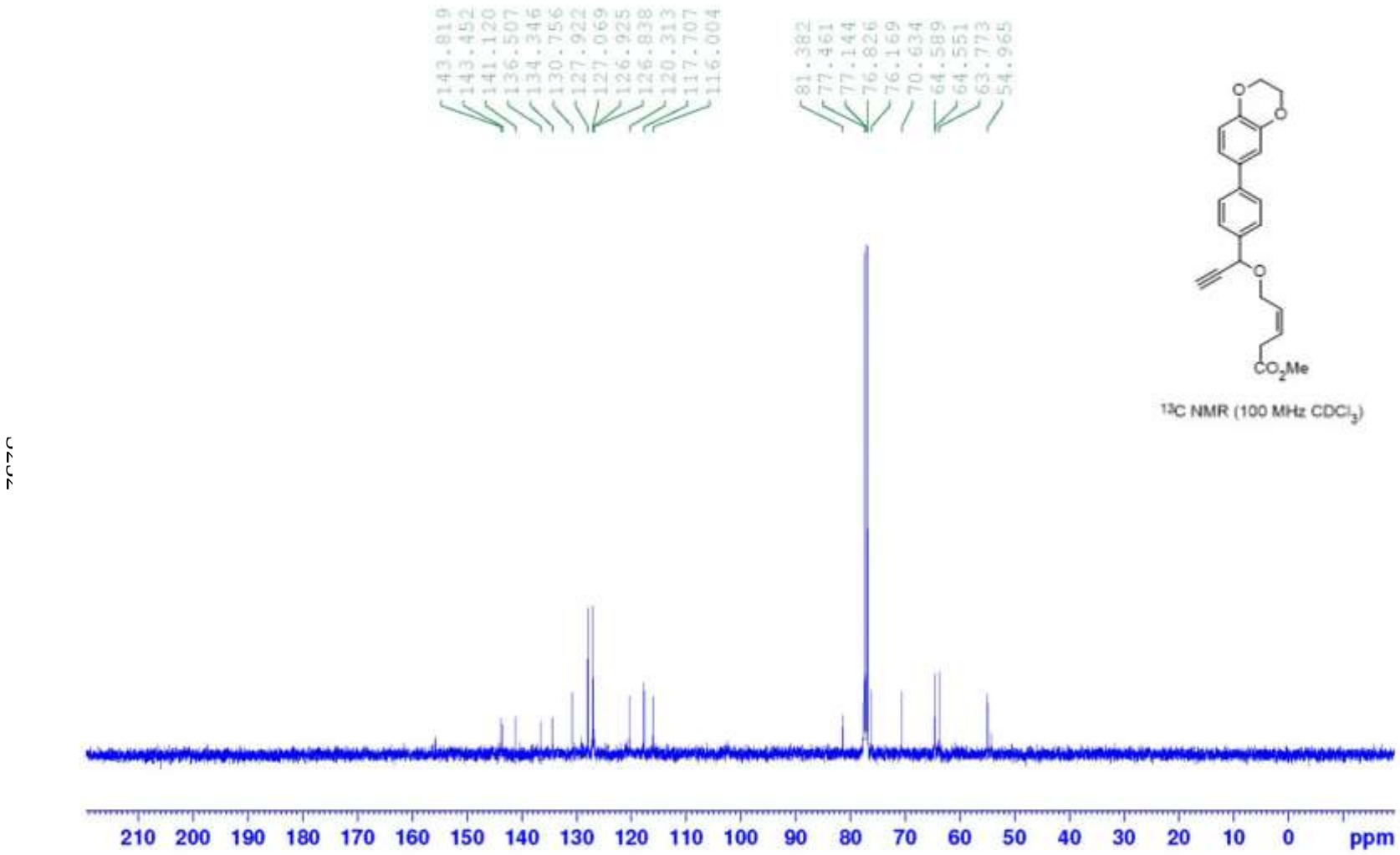


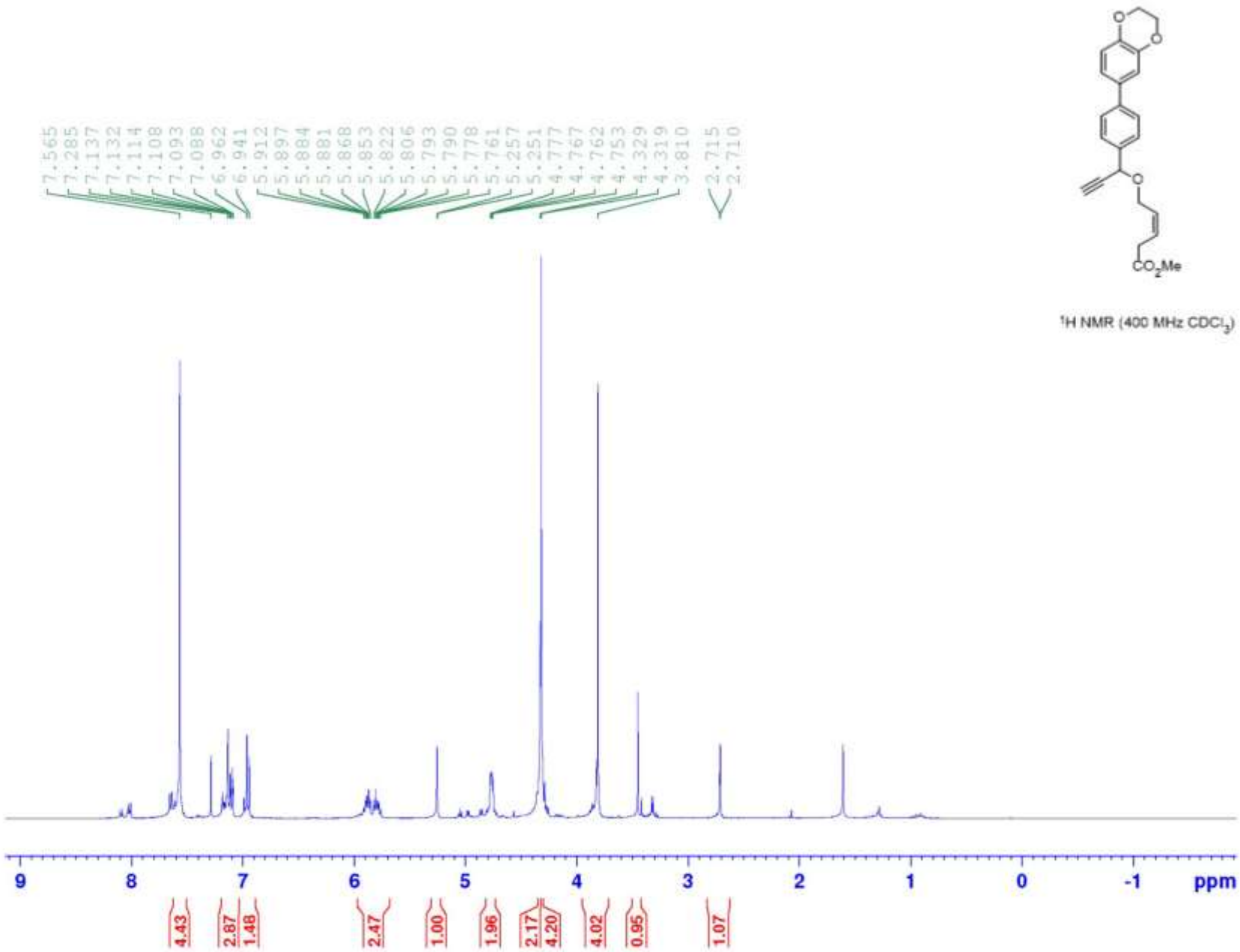




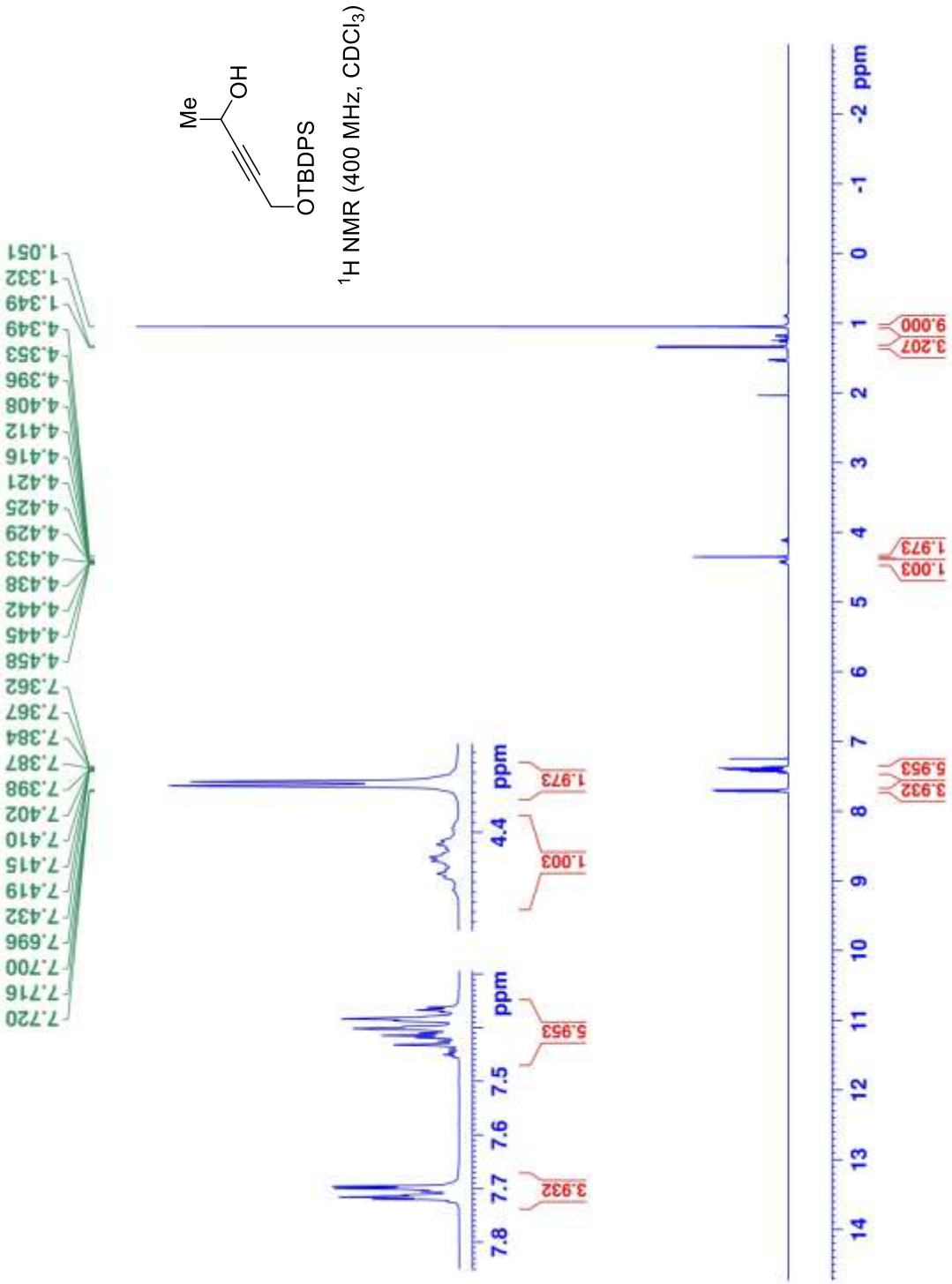
^{13}C NMR (75 MHz $CDCl_3$)

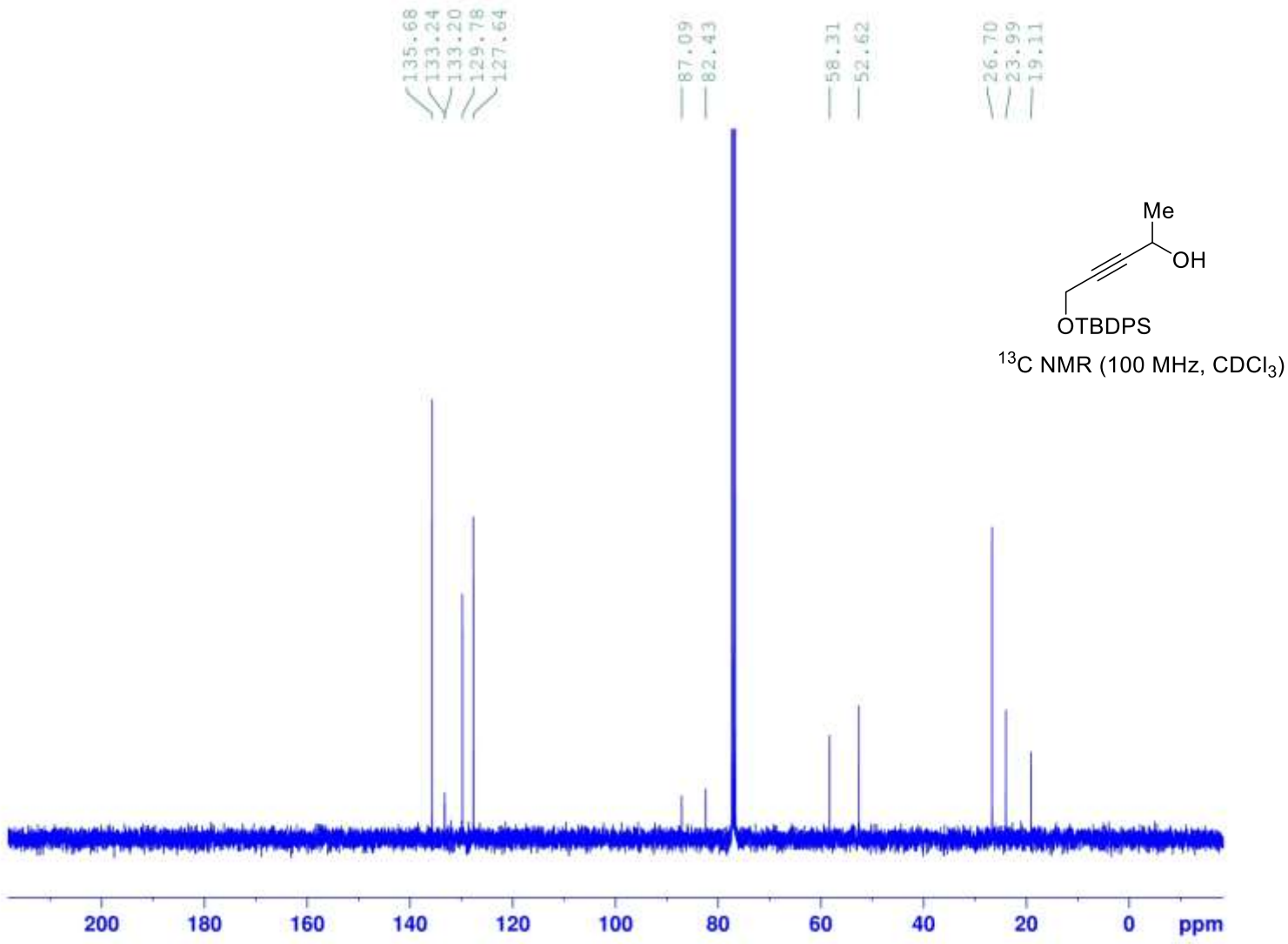



143.819
143.452
141.120
136.507
134.346
130.756
127.922
127.069
126.925
126.838
120.313
117.707
116.004
81.382
77.461
77.144
76.826
76.169
70.634
64.589
64.551
63.773
54.965
CO2Me
13C NMR (100 MHz CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

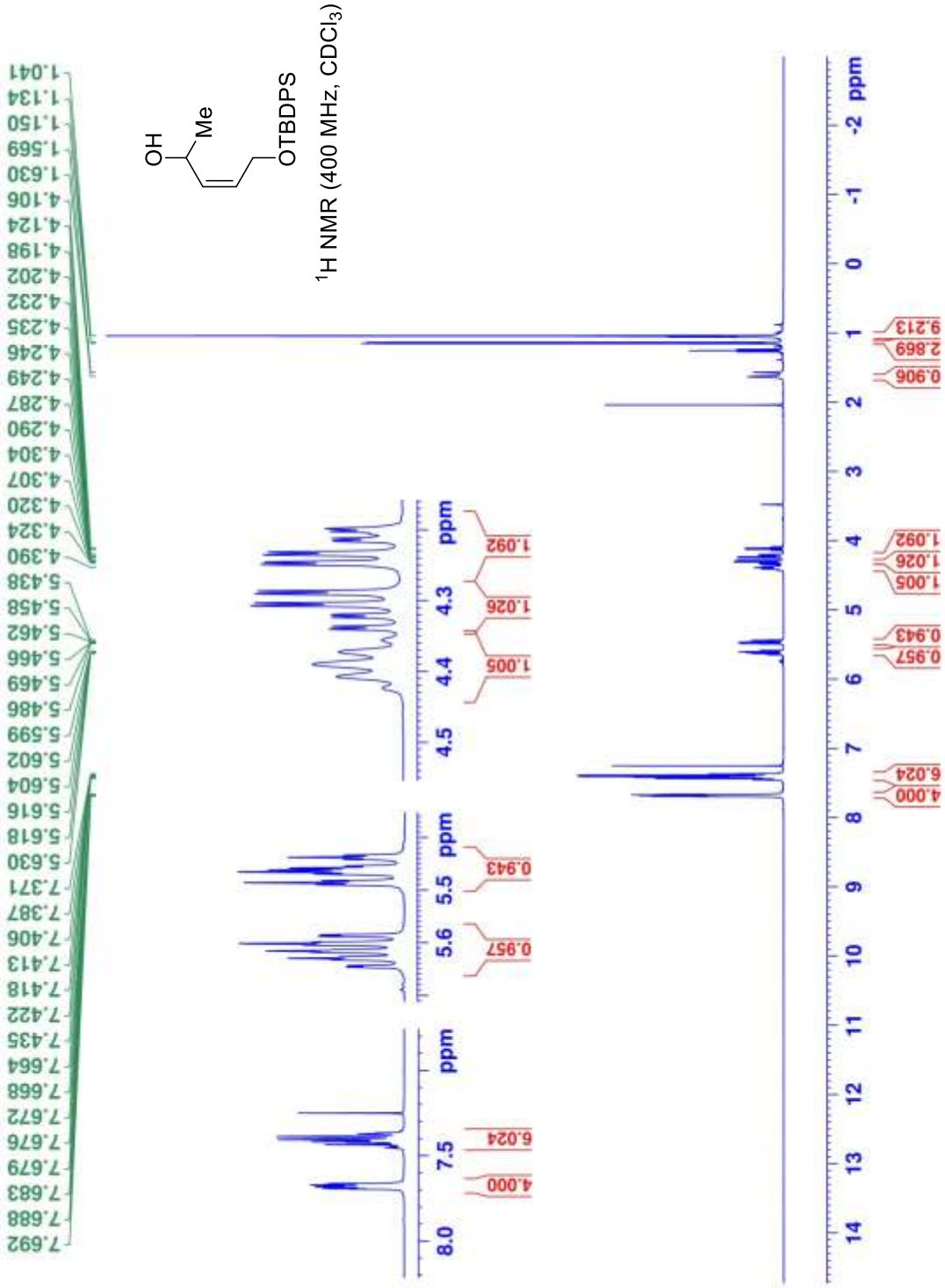

7.565
7.285
7.137
7.132
7.114
7.108
7.093
7.088
6.962
6.941
5.912
5.897
5.884
5.881
5.868
5.853
5.822
5.806
5.793
5.790
5.778
5.761
5.257
5.251
4.777
4.767
4.762
4.753
4.329
4.319
3.810
2.715
2.710
CO2Me
1H NMR (400 MHz CDCl3)
9
8
7
6
5
4
3
2
1
0
-1
ppm
4.43
2.87
1.48
2.47
1.00
1.96
2.17
4.20
4.02
0.95
1.07

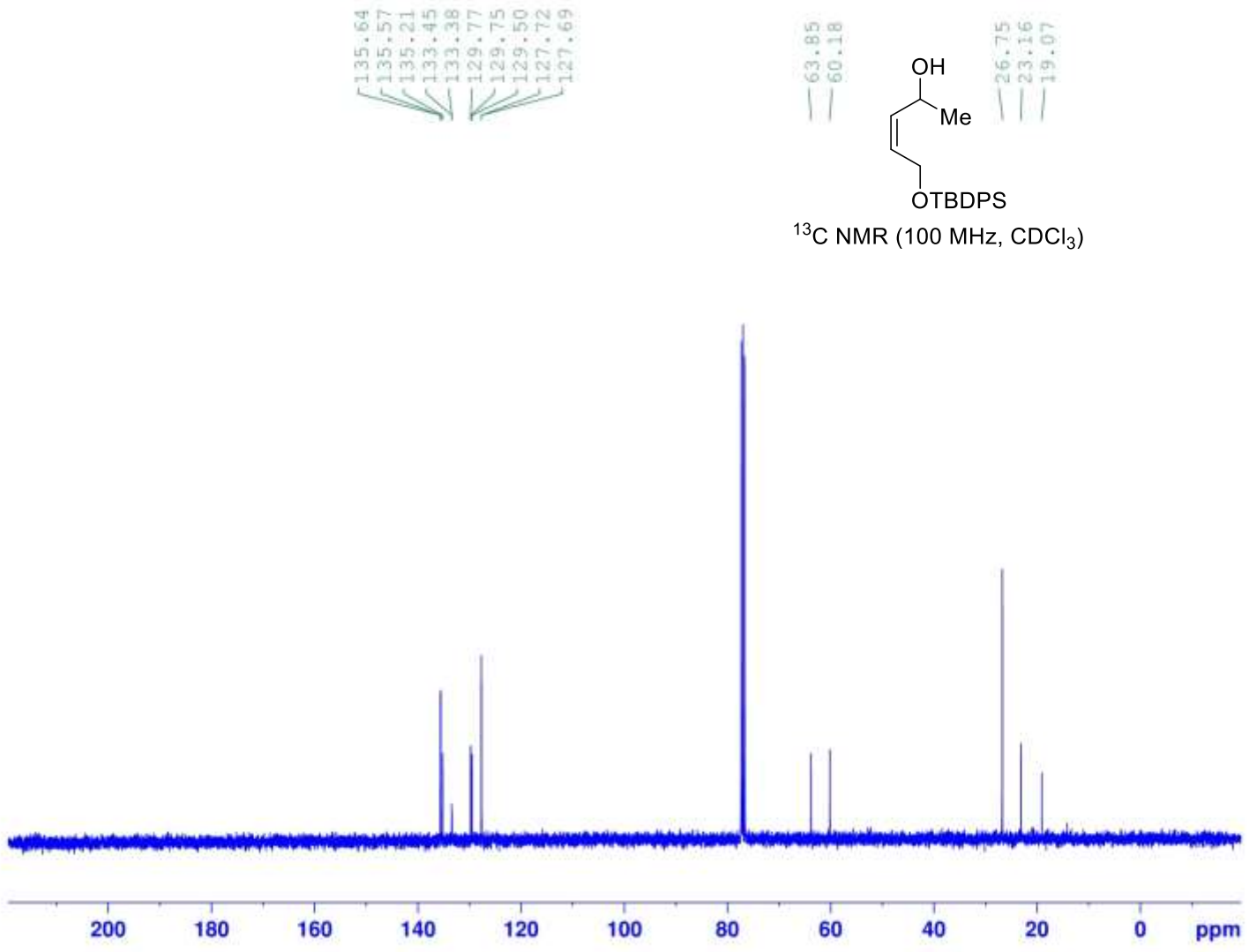
c. *Allyl- Substituted Substrates*



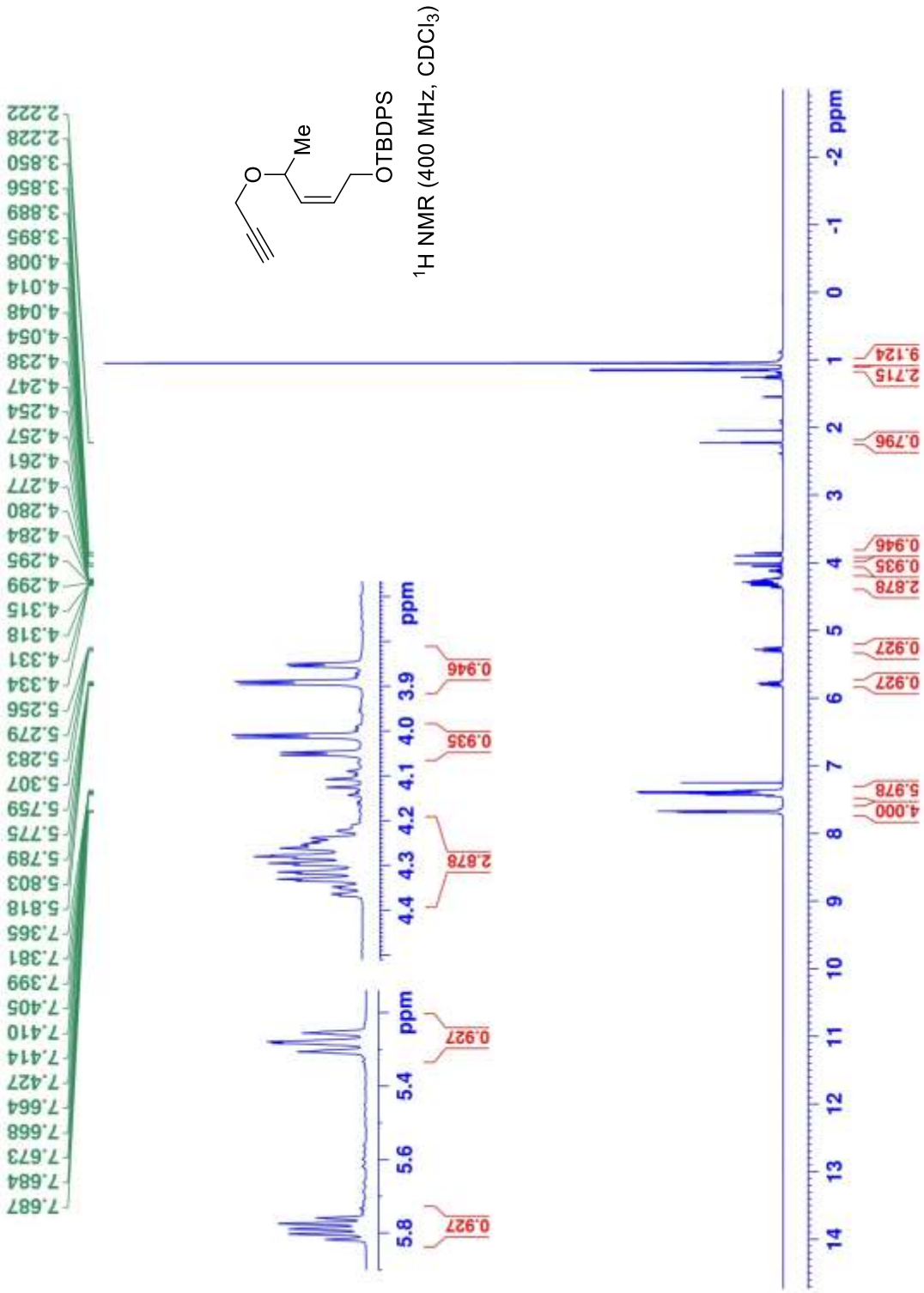


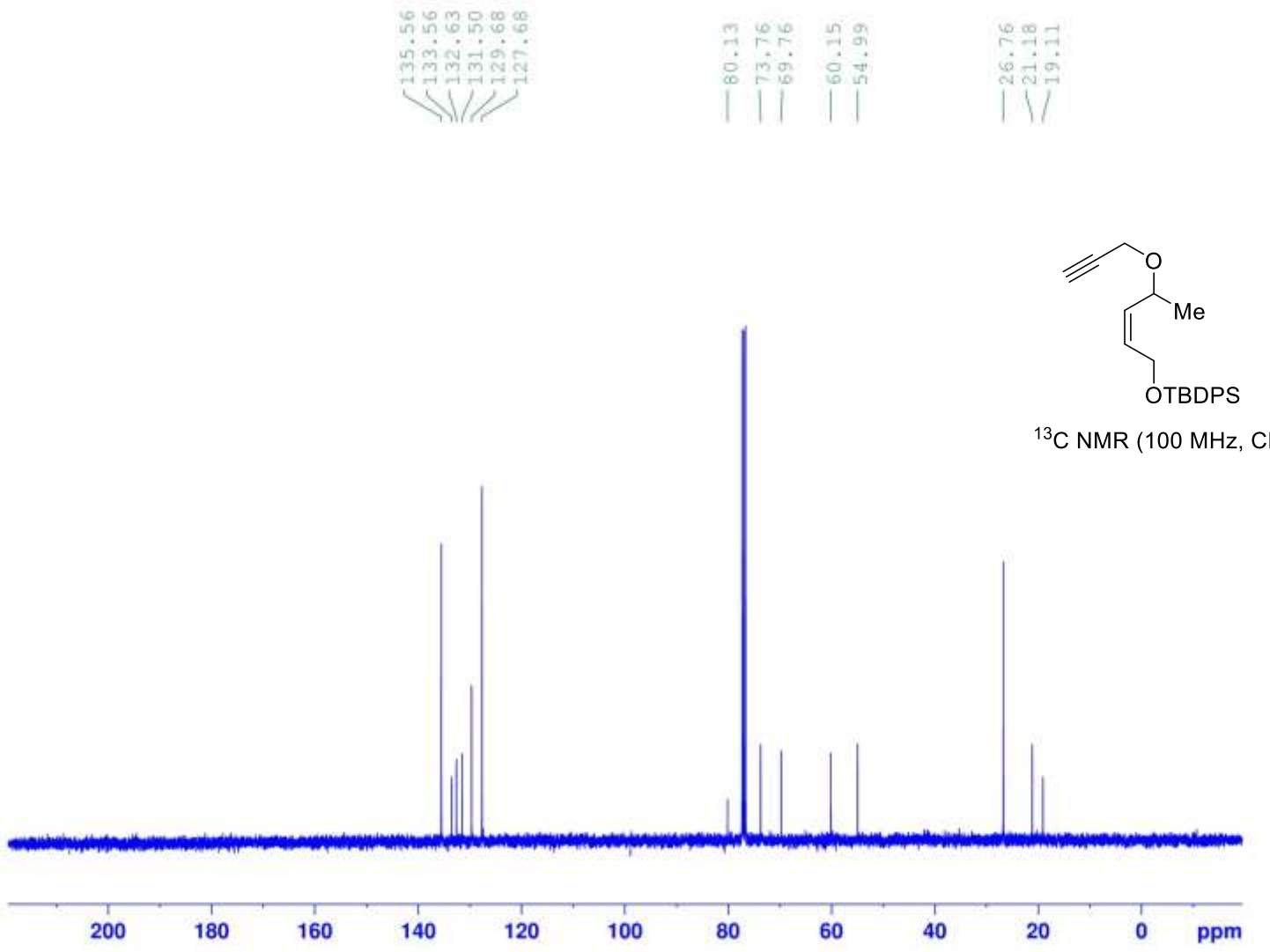
^{13}C NMR (100 MHz, $CDCl_3$)


OH
Me
OTBDPS
^{1}H NMR (400 MHz, CDCl$_3$)

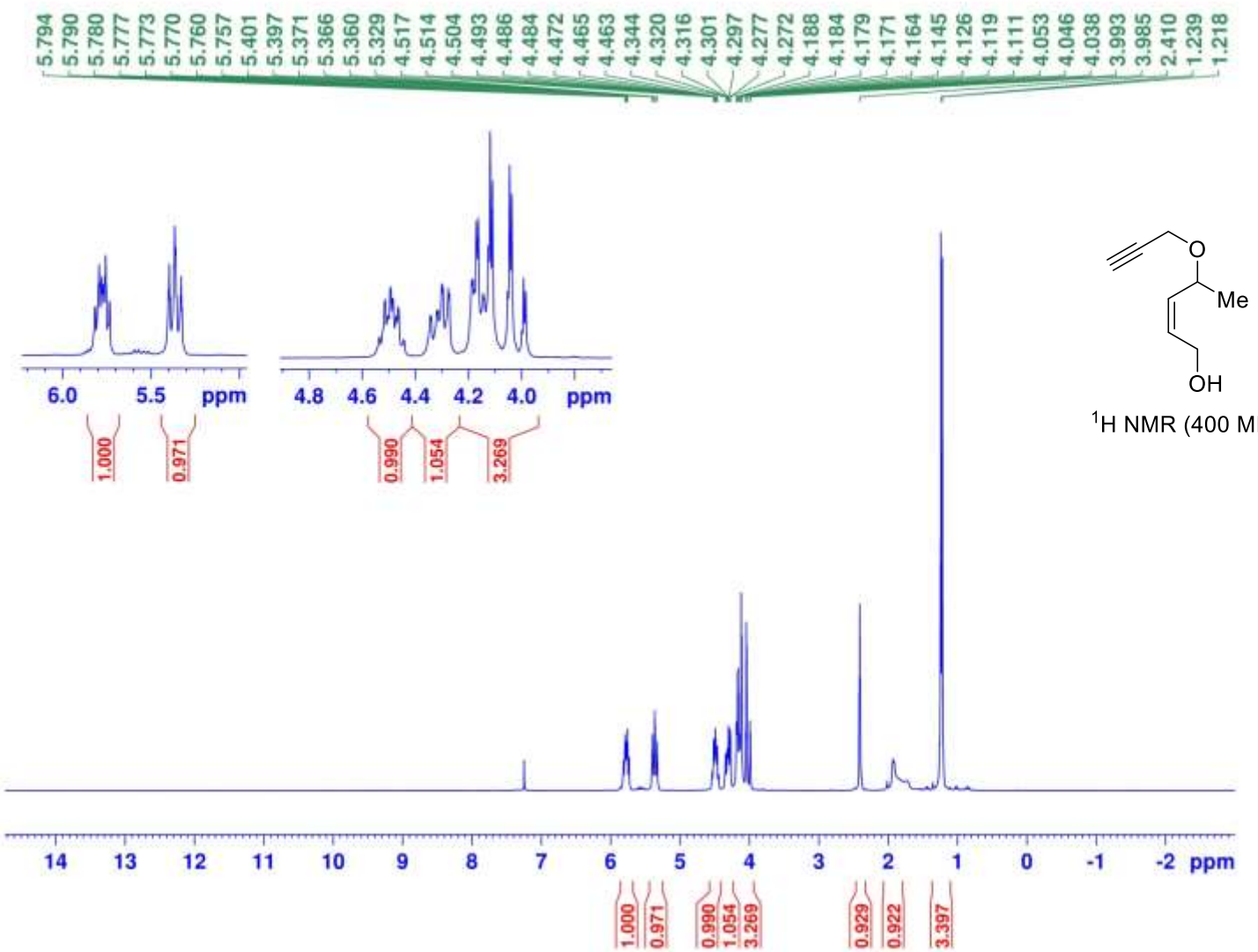


^{13}C NMR (100 MHz, $CDCl_3$)

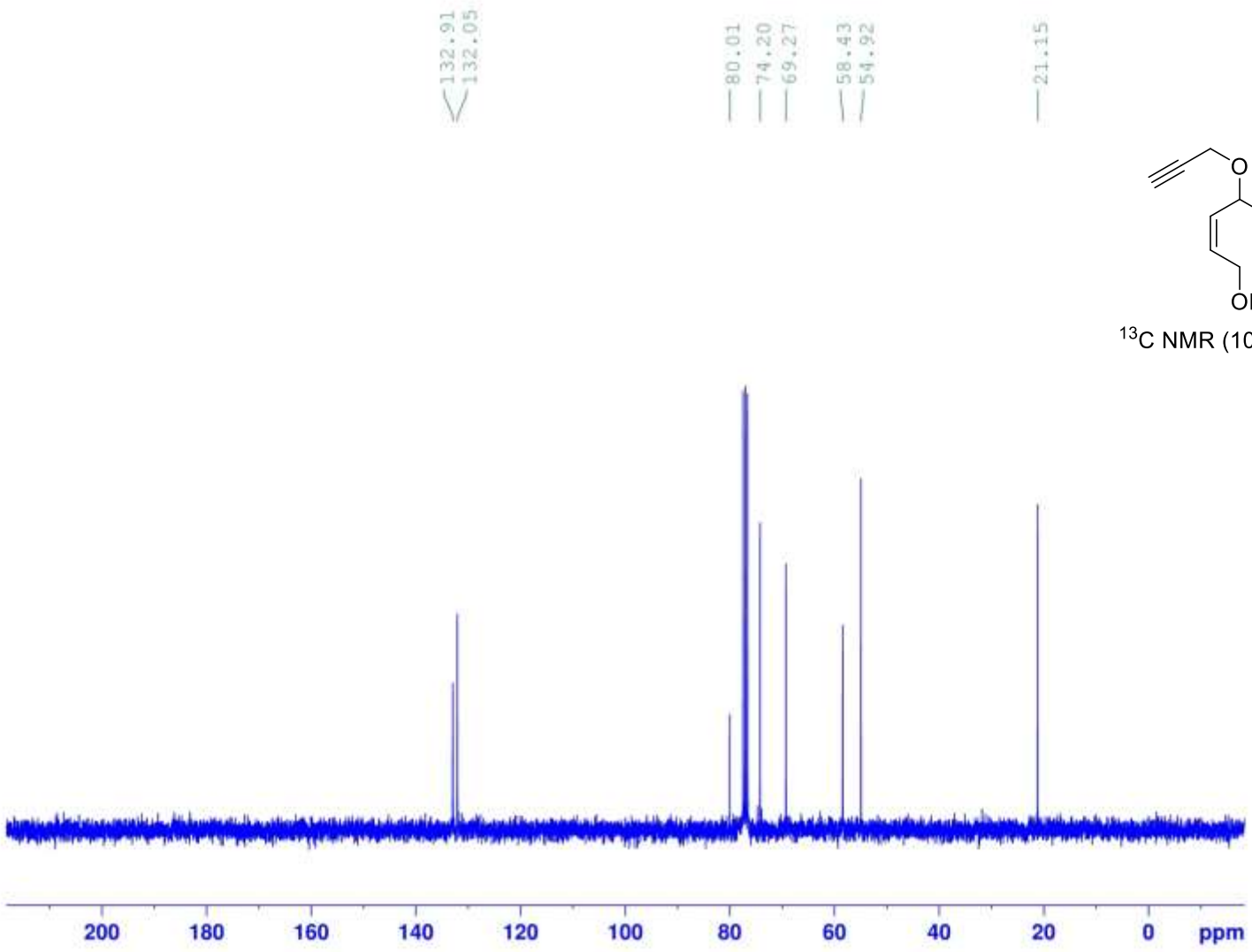

OTBDPS
Me
O
^{1}H NMR (400 MHz, CDCl$_3$)
ppm
9.124
2.715
0.796
0.946
0.935
2.878
0.927
0.927
4.000
5.978



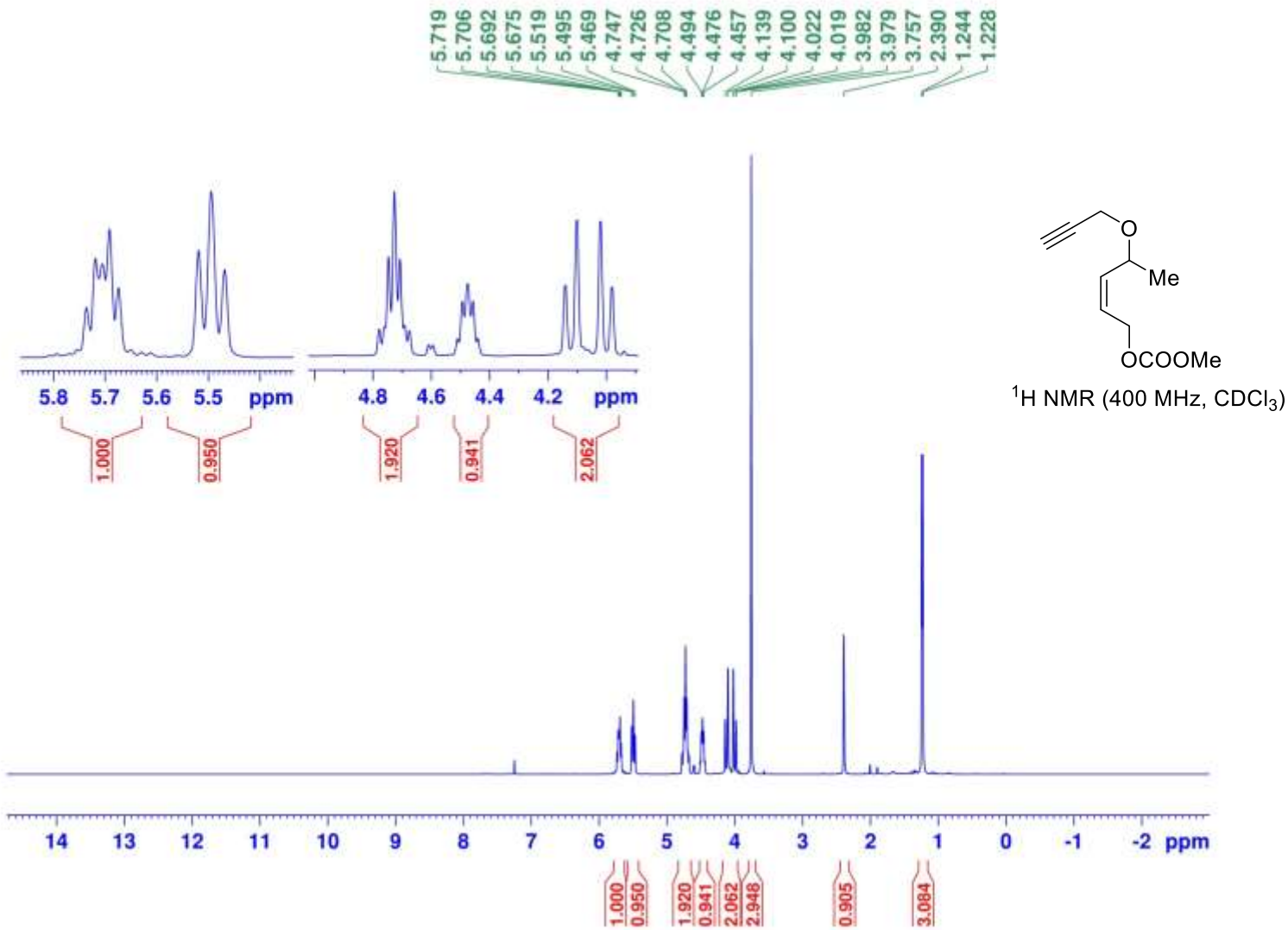
^{13}C NMR (100 MHz, $CDCl_3$)



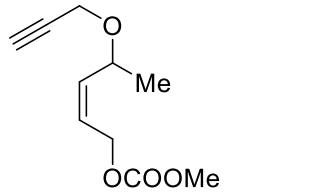
^{1}H NMR (400 MHz, $CDCl_3$)



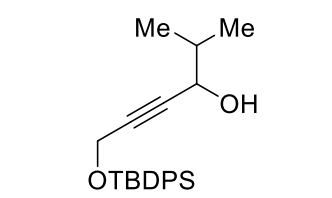
^{13}C NMR (100 MHz, $CDCl_3$)



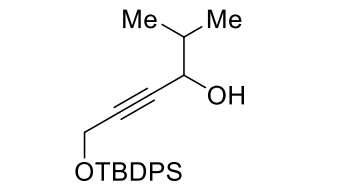
^{1}H NMR (400 MHz, $CDCl_3$)



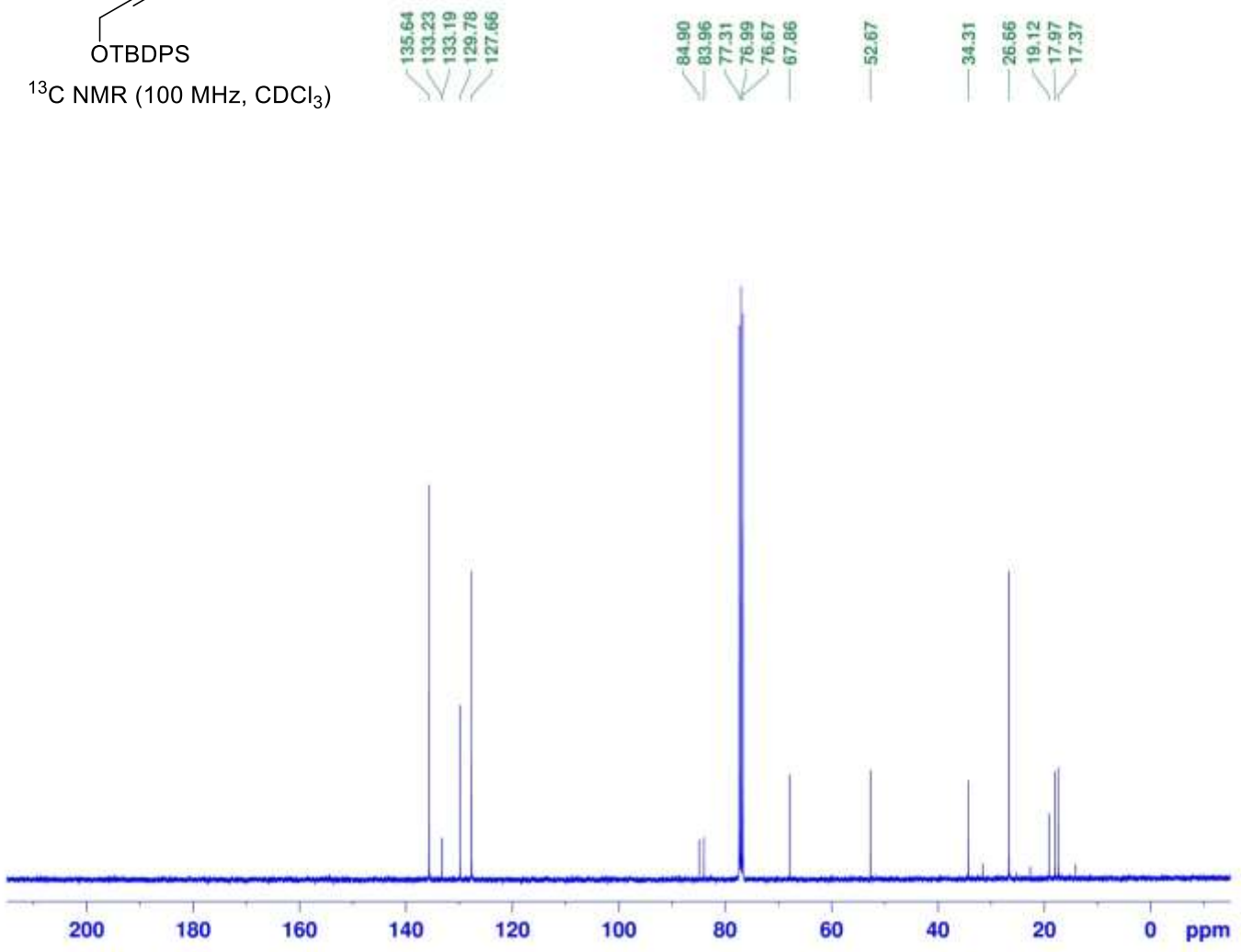
^{13}C NMR (100 MHz, $CDCl_3$)

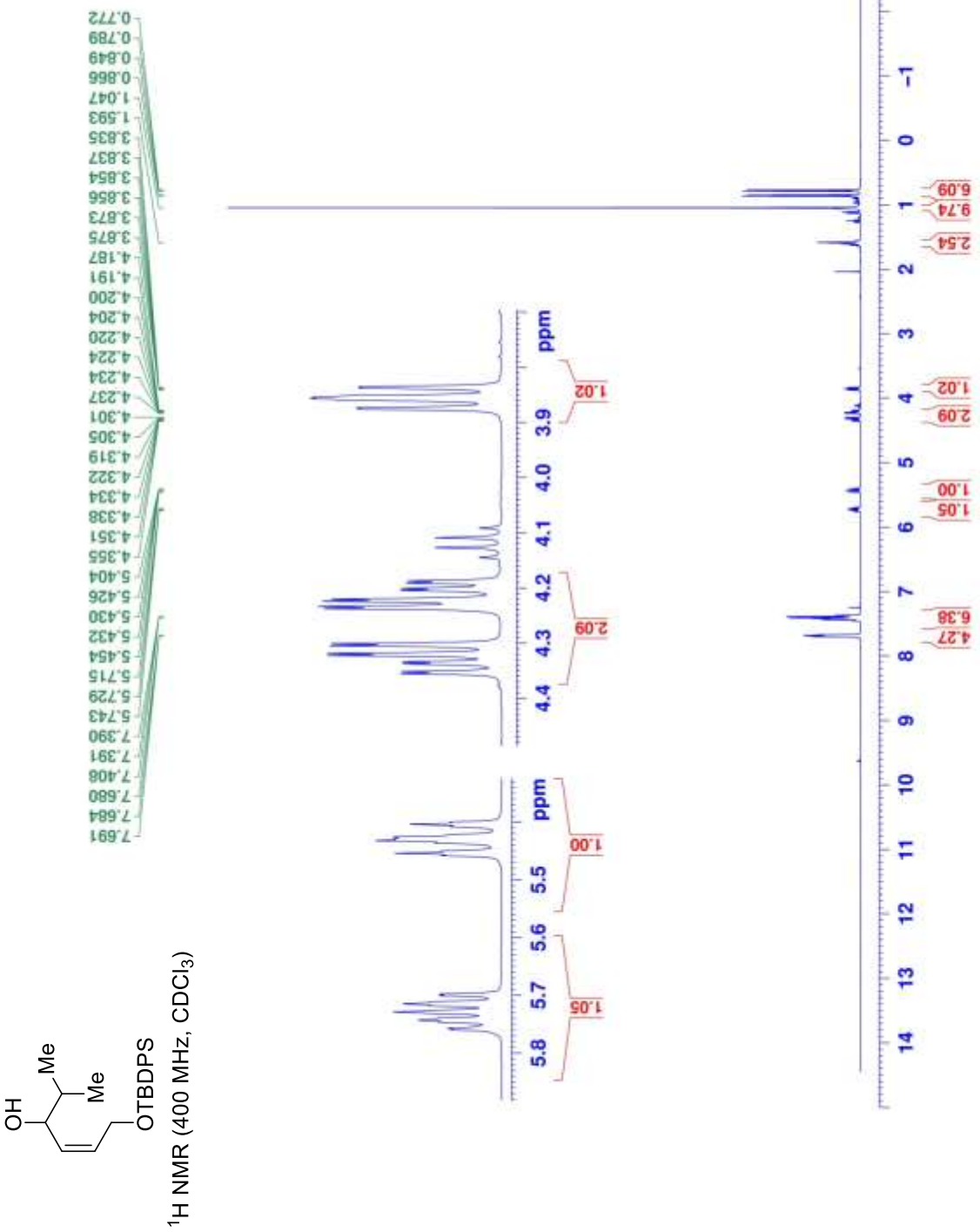


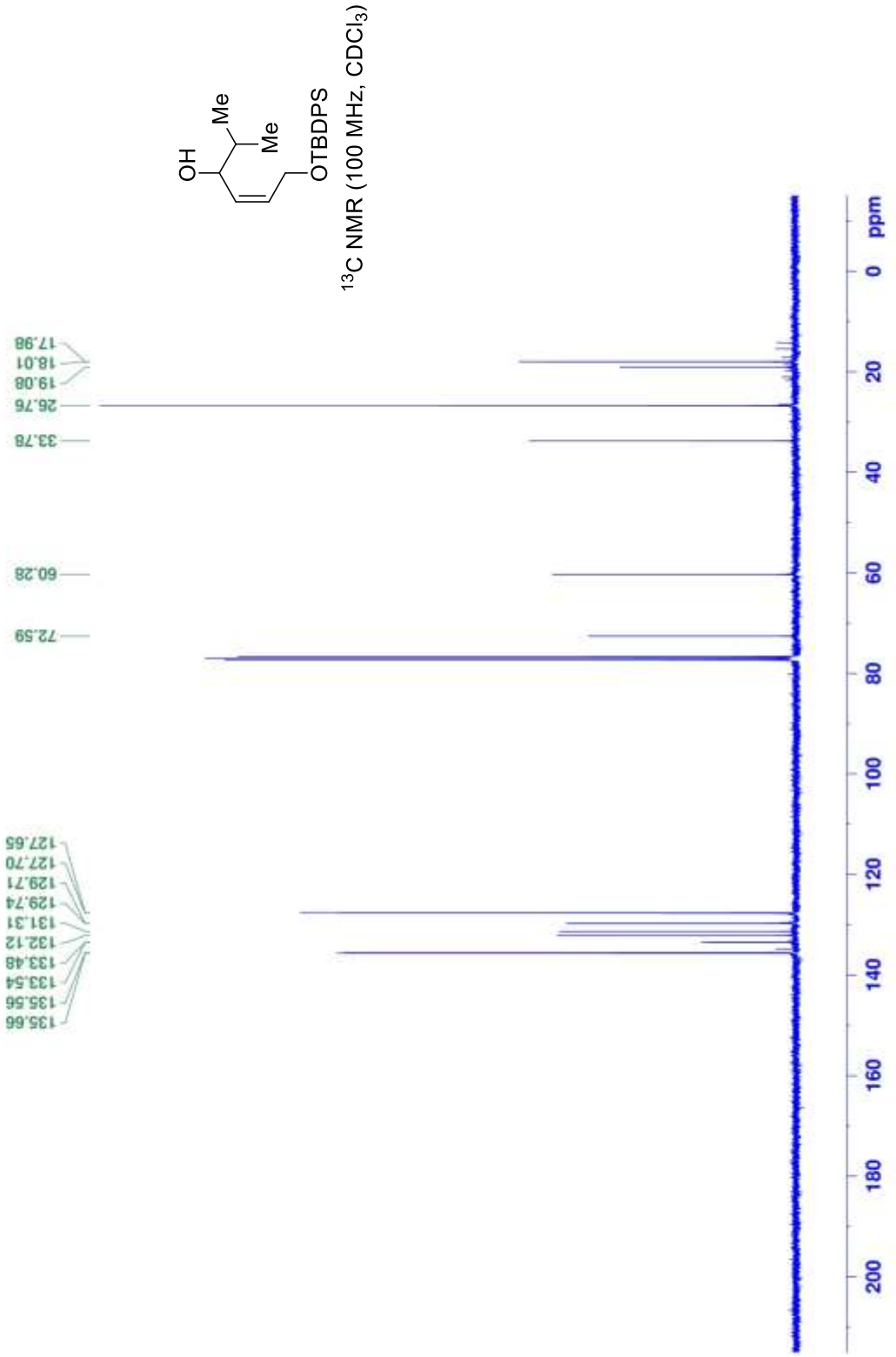
^{1}H NMR (400 MHz, $CDCl_3$)

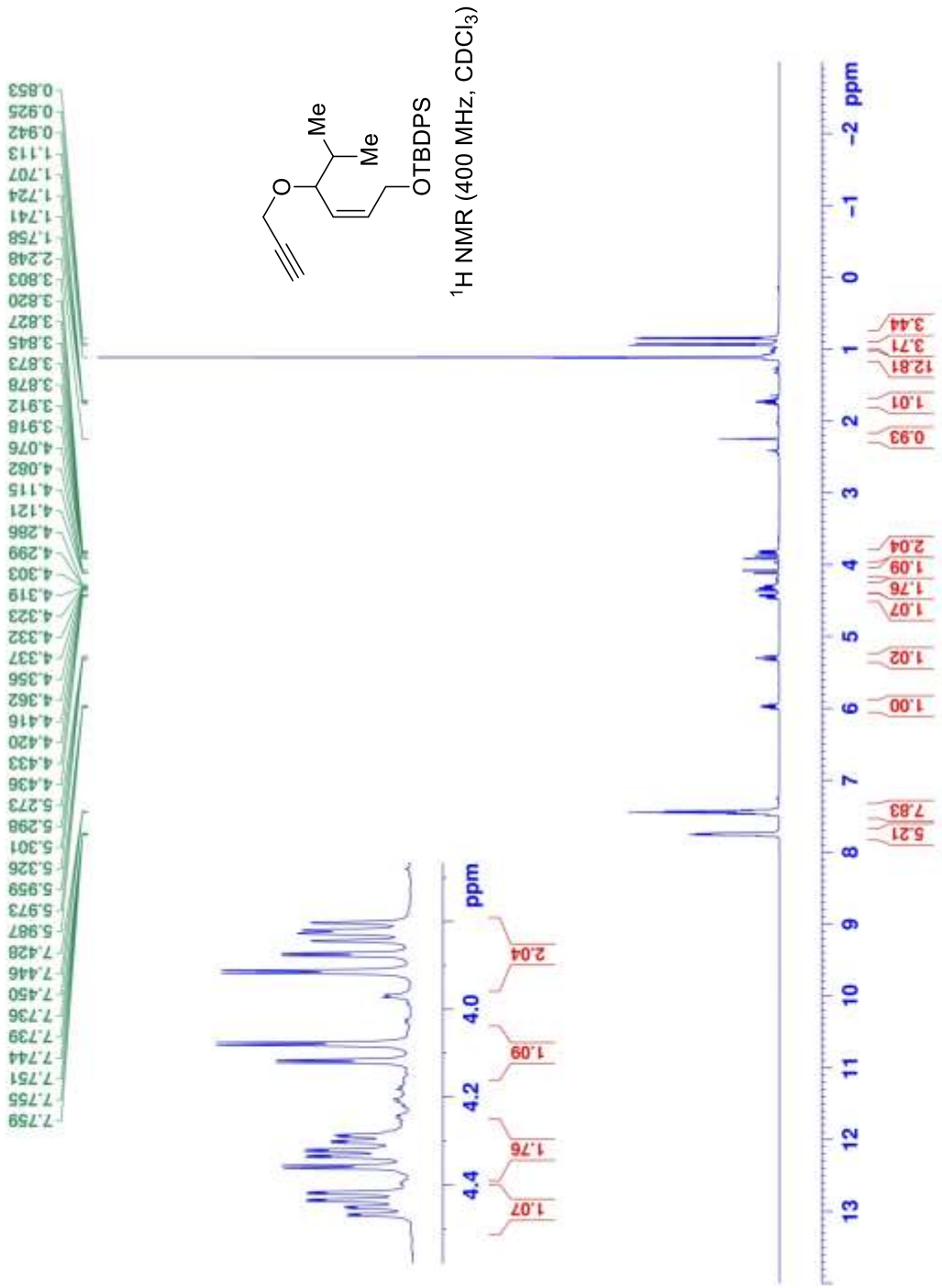


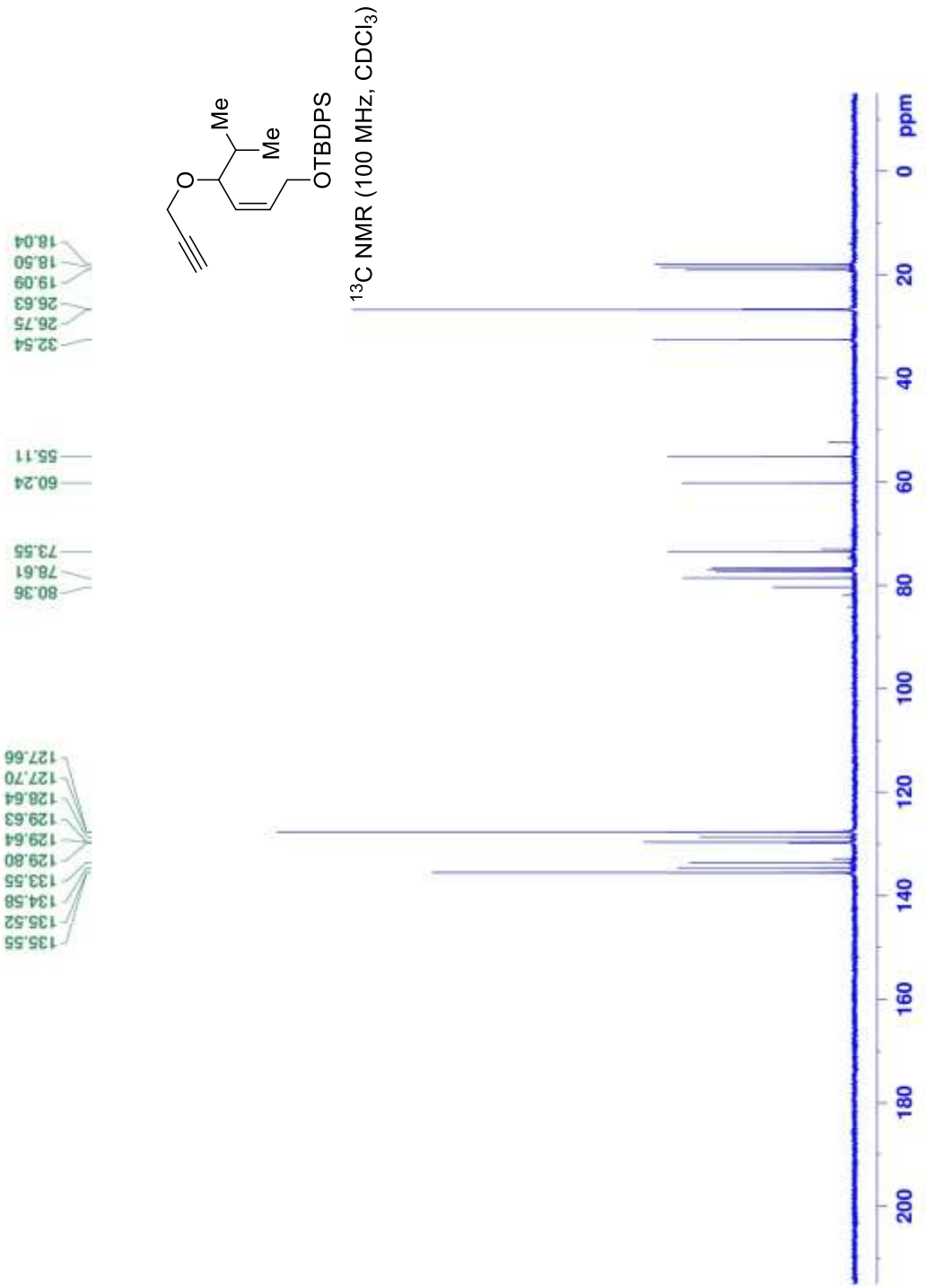
^{13}C NMR (100 MHz, $CDCl_3$)

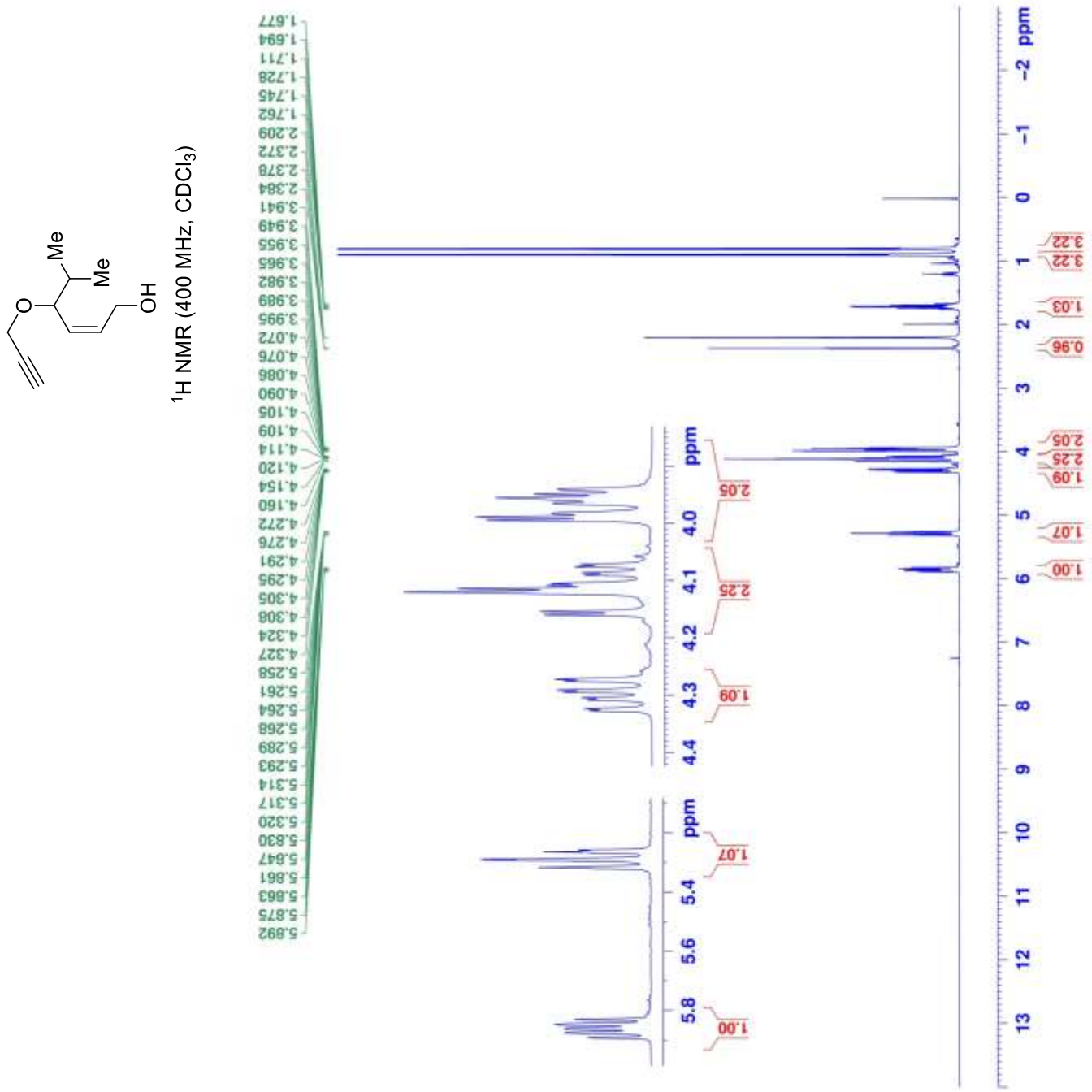


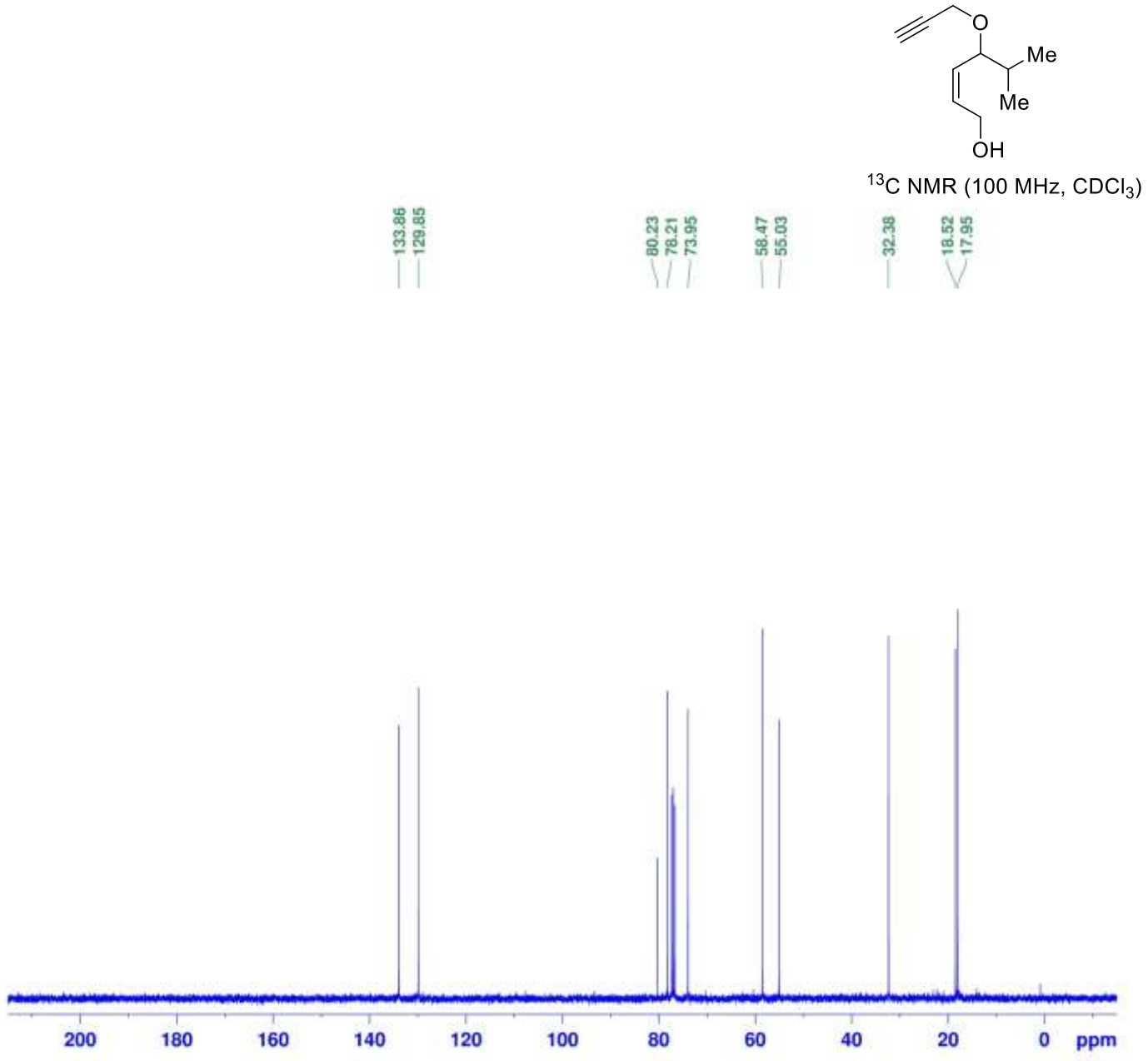

OH
Me
Me
OTBDPS
^{1}H NMR (400 MHz, CDCl$_3$)
ppm

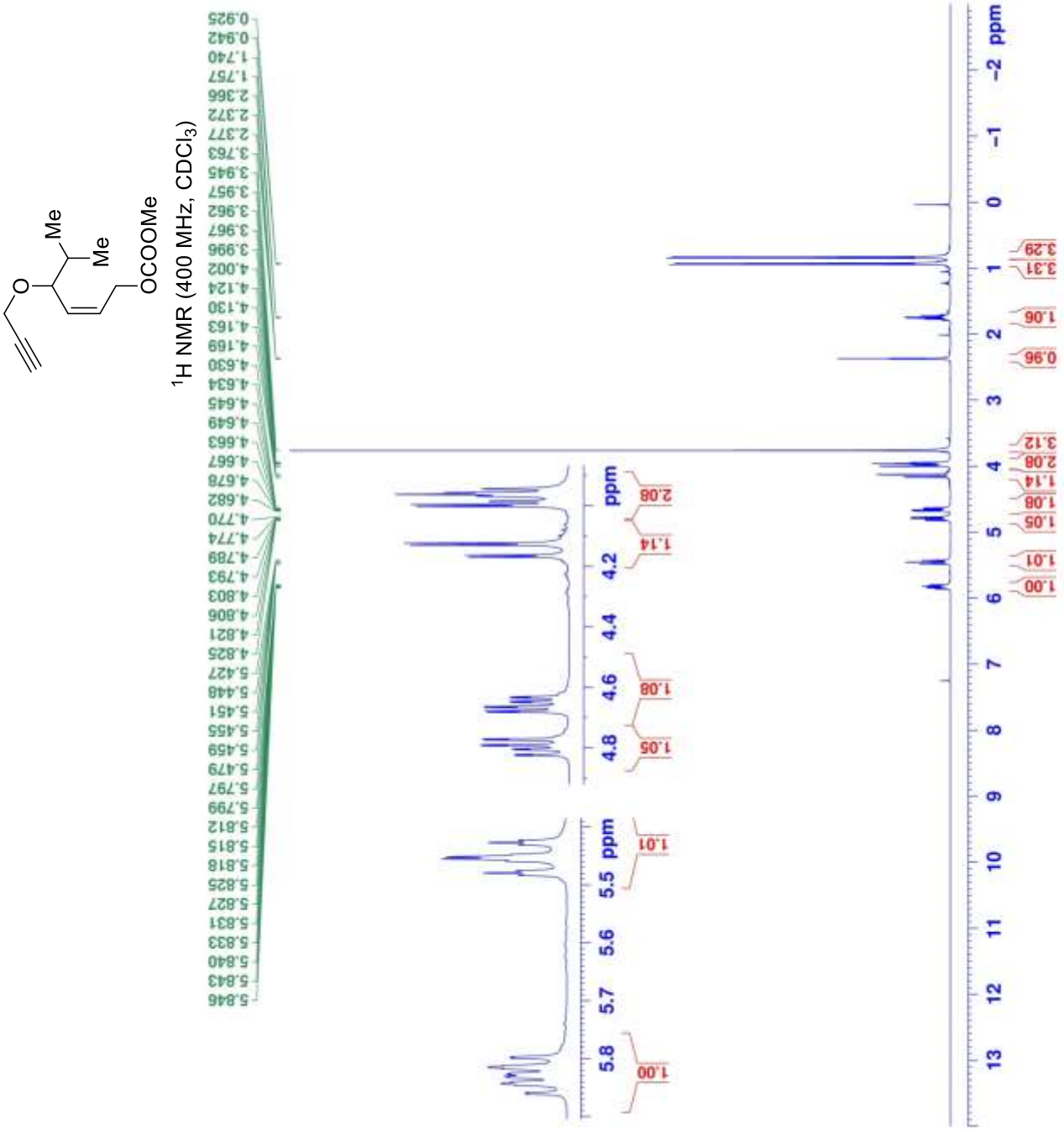

OH
Me
Me
OTBDPS
^{13}C NMR (100 MHz, $CDCl_3$)
17.98
18.01
19.08
26.76
33.78
60.28
72.59
127.65
127.70
129.71
129.74
131.31
132.12
133.48
133.54
135.56
135.66
ppm
0
20
40
60
80
100
120
140
160
180
200

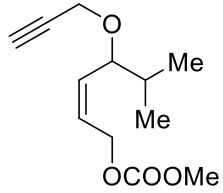

^{1}H NMR (400 MHz, CDCl$_3$)
Me
Me
OTBDPS
O
ppm


^{13}C NMR (100 MHz, $CDCl_3$)
OTBDPS
Me
Me
O
ppm
0
20
40
60
80
100
120
140
160
180
200
18.04
18.50
19.09
26.63
26.75
32.54
55.11
60.24
73.55
78.61
80.36
127.66
127.70
128.64
129.63
129.64
129.80
133.55
134.58
135.52
135.55

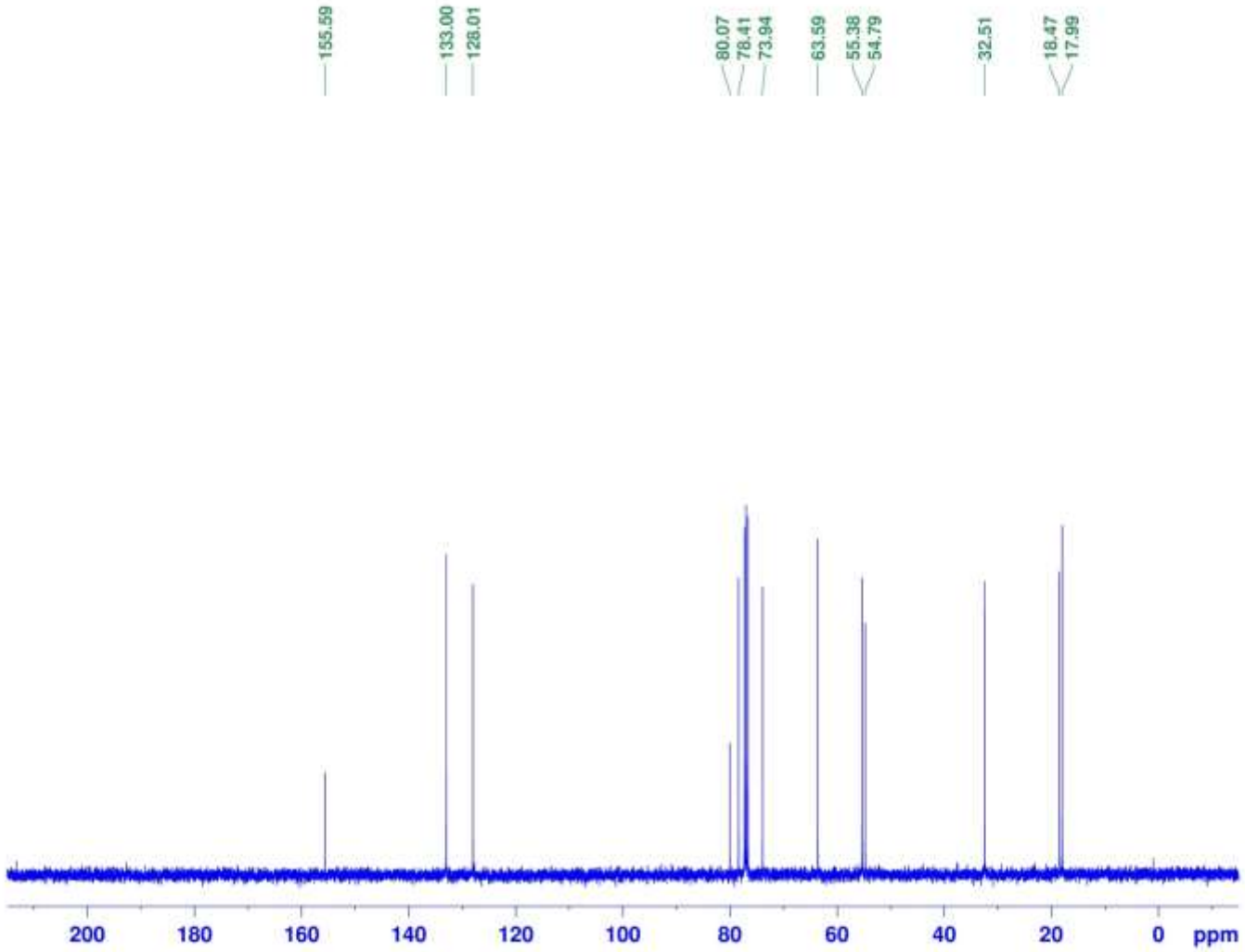

Me
Me
O
OH
^{1}H NMR (400 MHz, CDCl$_3$)

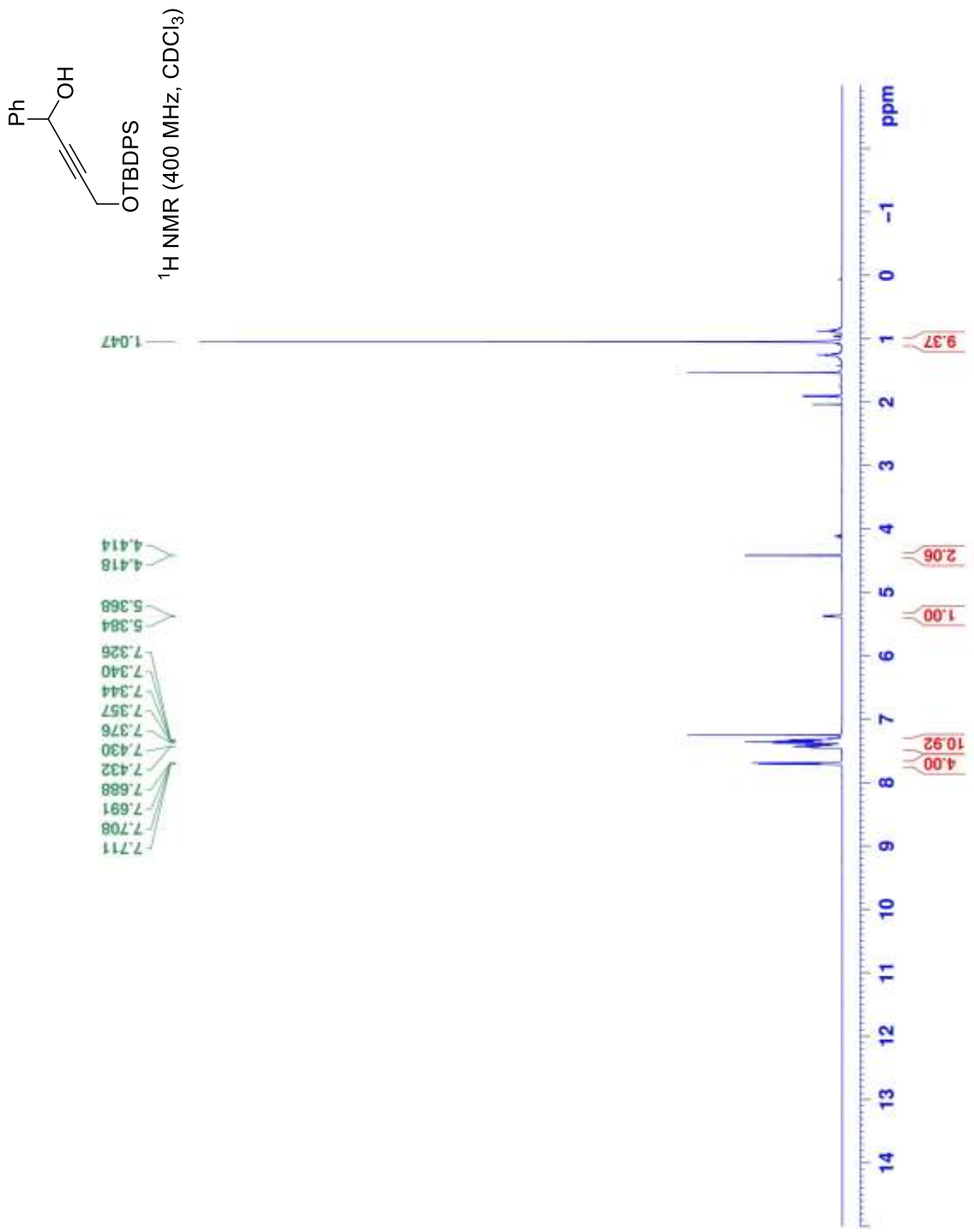

O
Me
Me
OH
^{13}C NMR (100 MHz, $CDCl_3$)
133.86
129.85
80.23
78.21
73.95
58.47
55.03
32.38
18.52
17.95
200
180
160
140
120
100
80
60
40
20
0
ppm

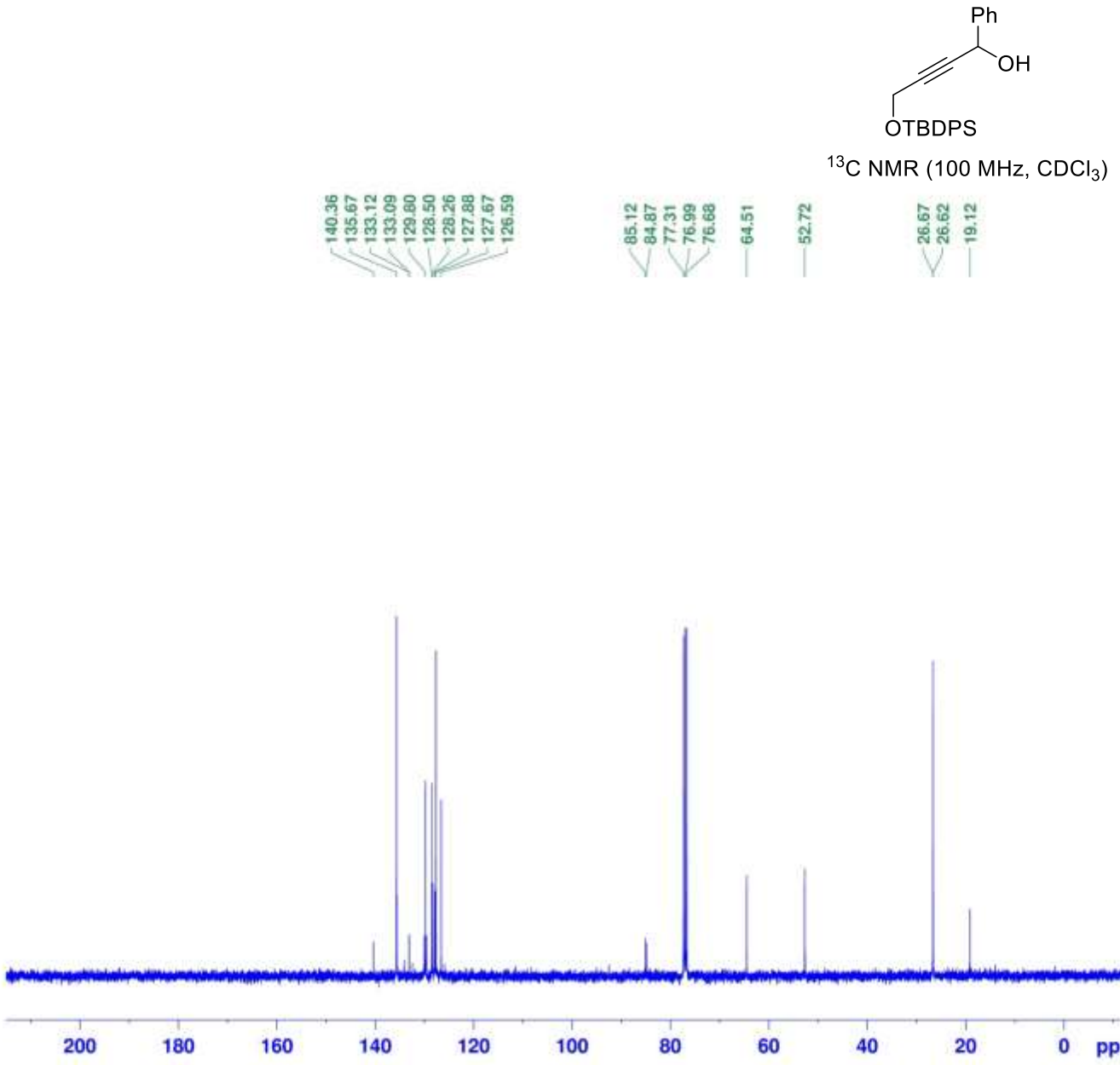

Me
Me
O
OCOOMe
^{1}H NMR (400 MHz, $CDCl_3$)
ppm

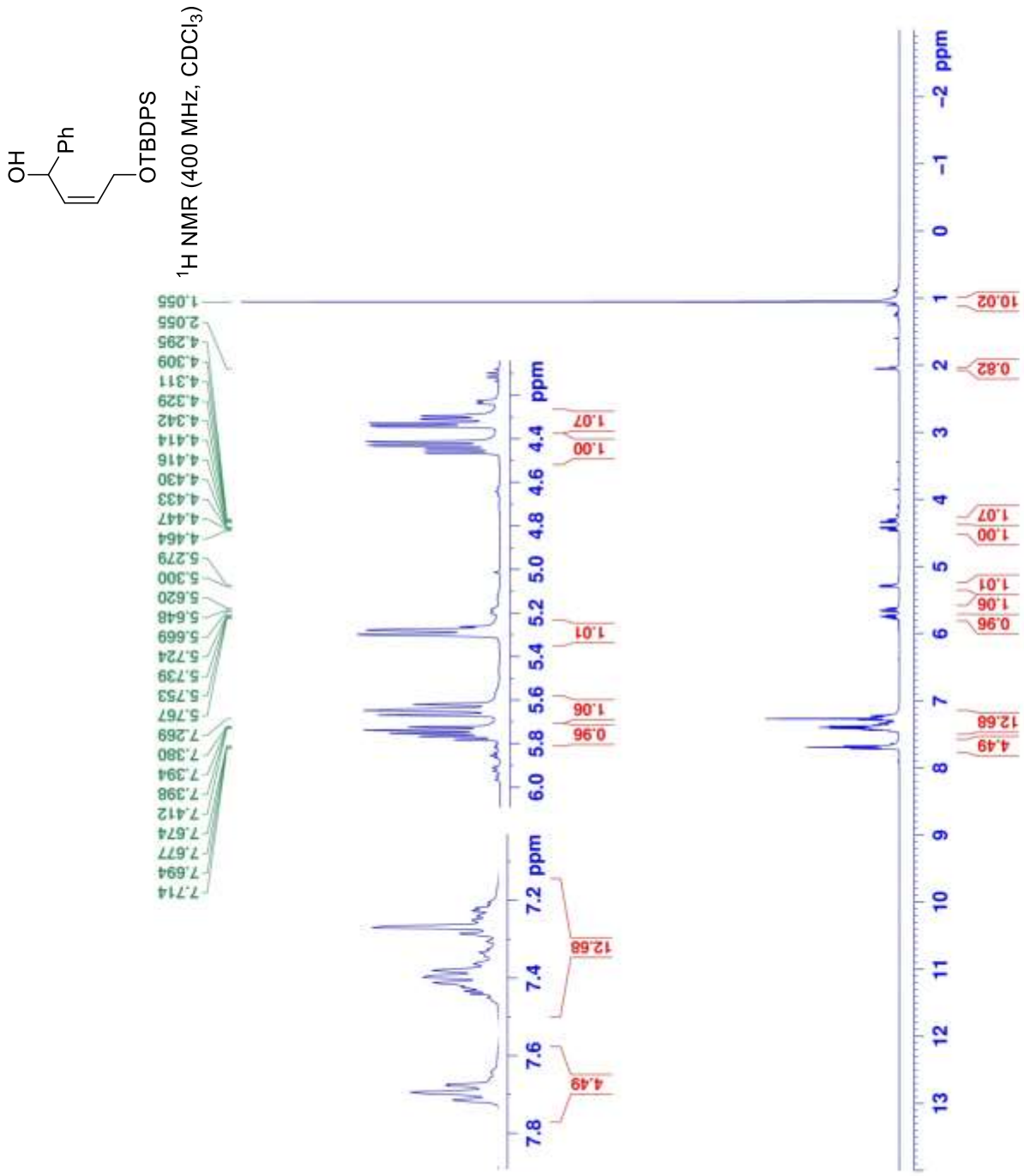


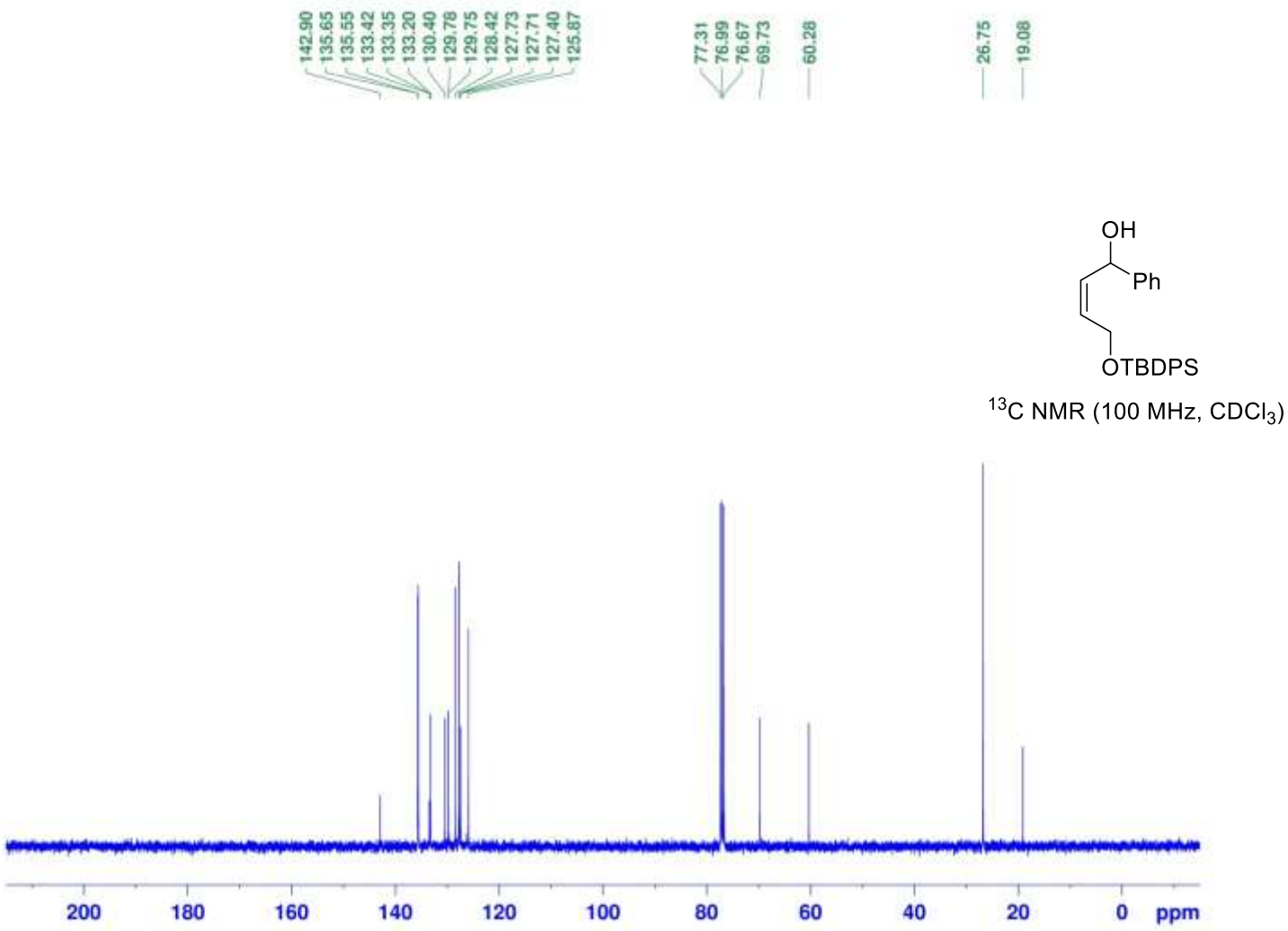
^{13}C NMR (100 MHz, $CDCl_3$)

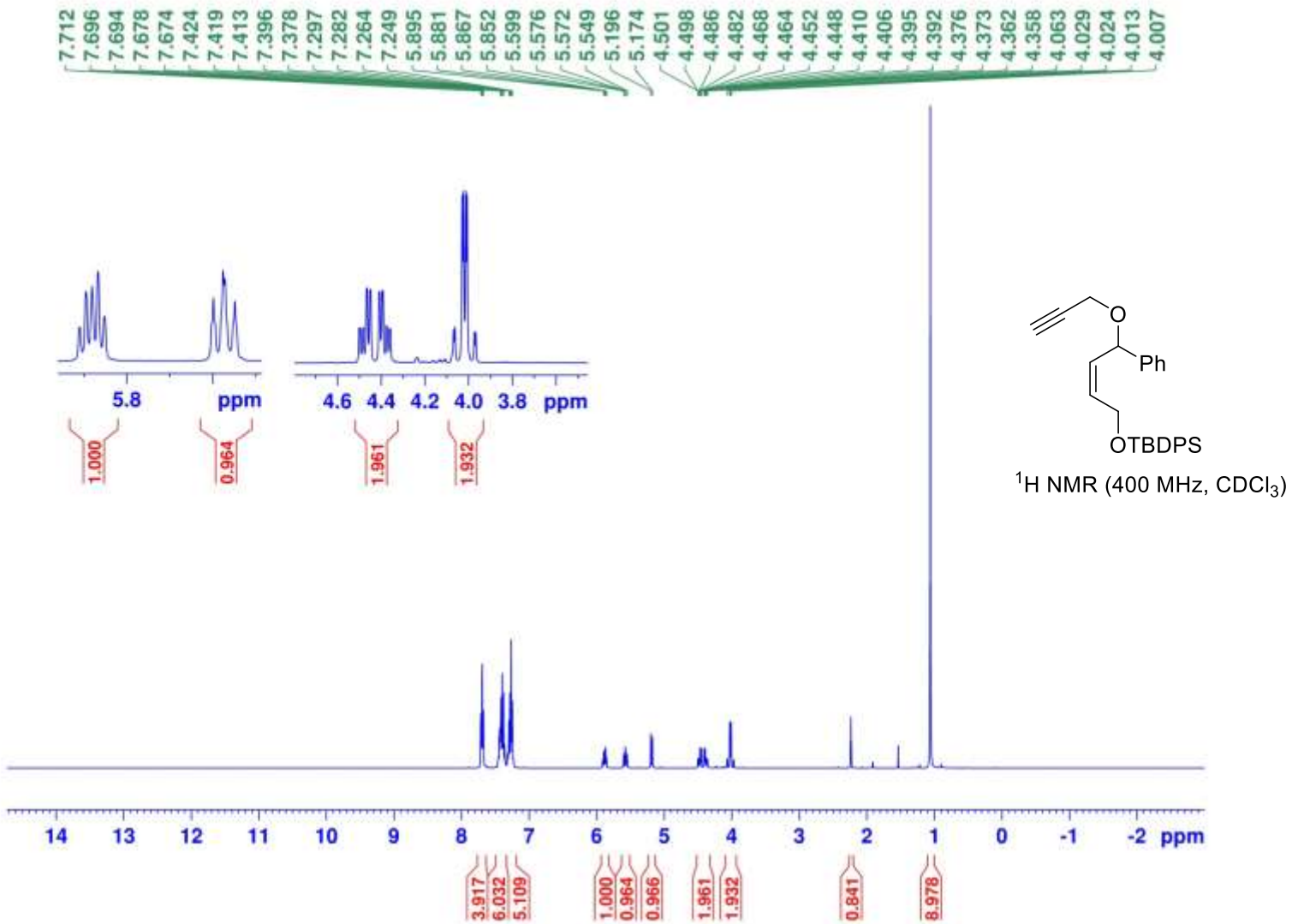



Ph
OH
OTBDPS
^{1}H NMR (400 MHz, $CDCl_3$)
1.047
4.414
4.418
5.364
5.368
7.326
7.340
7.344
7.357
7.376
7.430
7.432
7.688
7.691
7.708
7.711
9.37
2.06
1.00
10.92
4.00
ppm

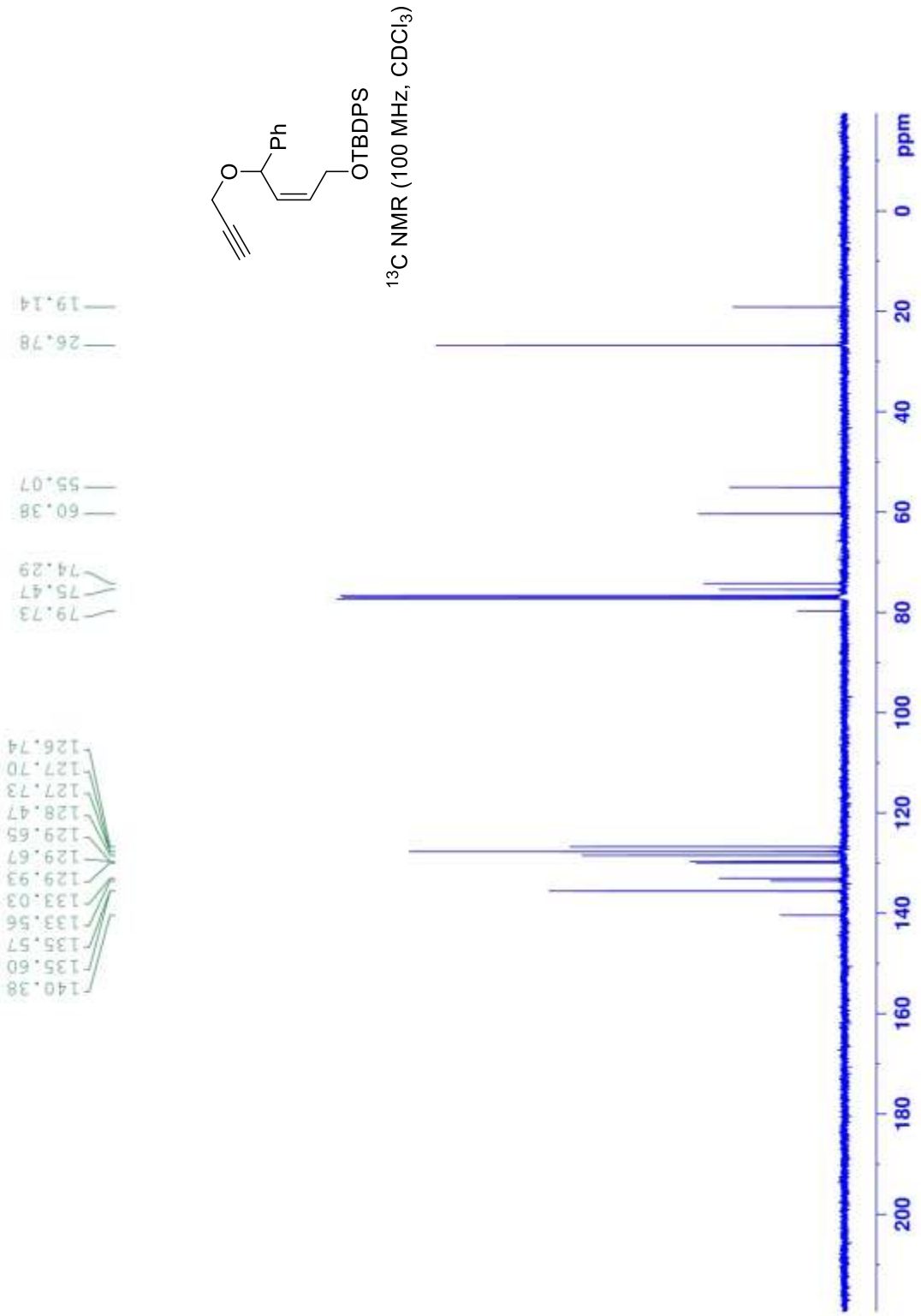

Ph
OH
OTBDPS
13C NMR (100 MHz, CDCl3)
140.36
135.67
133.12
133.09
129.80
128.50
128.26
127.88
127.67
126.59
85.12
84.87
77.31
76.99
76.68
64.51
52.72
26.67
26.62
19.12
200
180
160
140
120
100
80
60
40
20
0
ppm

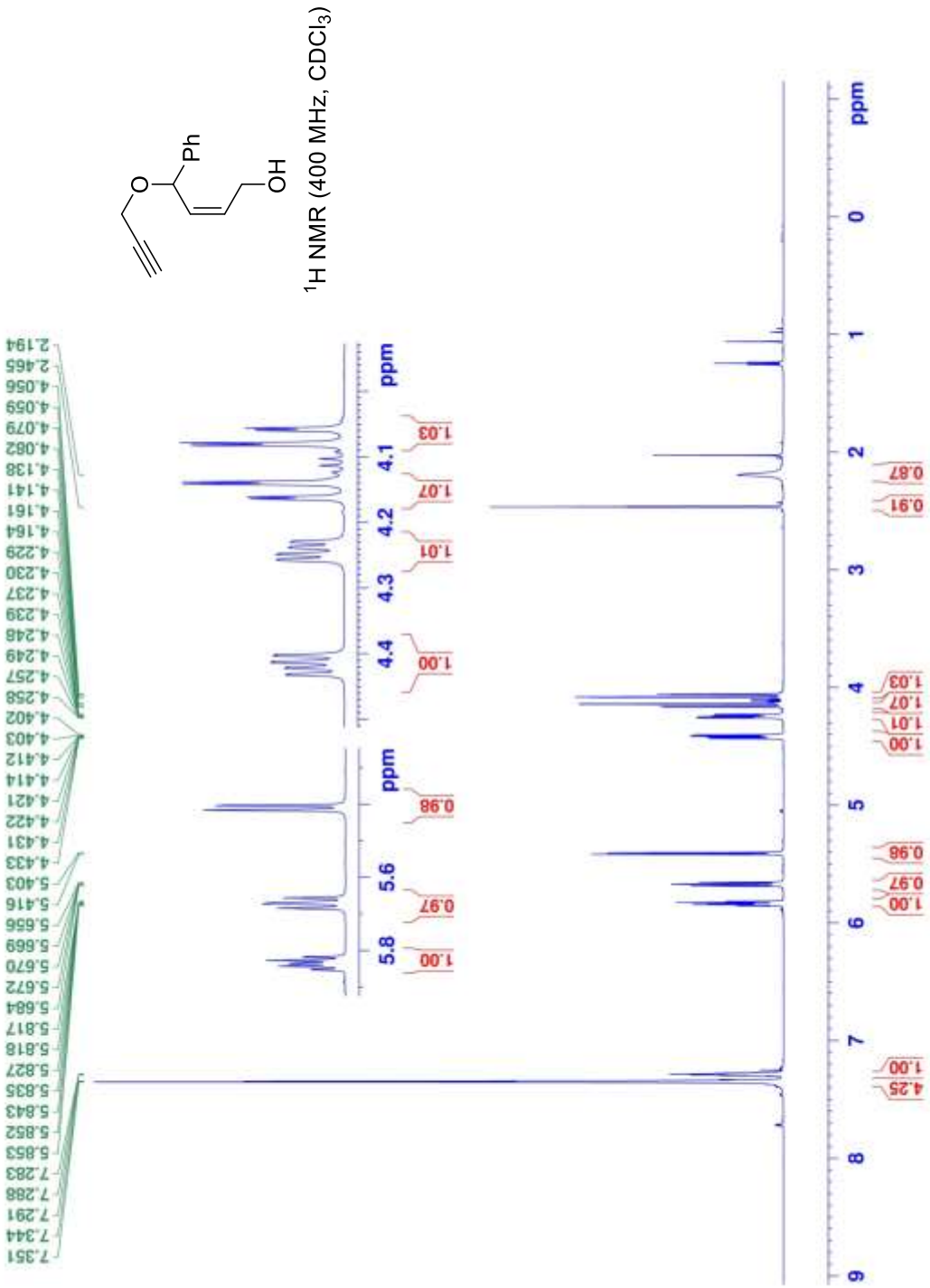

OH
Ph
OTBDPS
^{1}H NMR (400 MHz, CDCl$_3$)

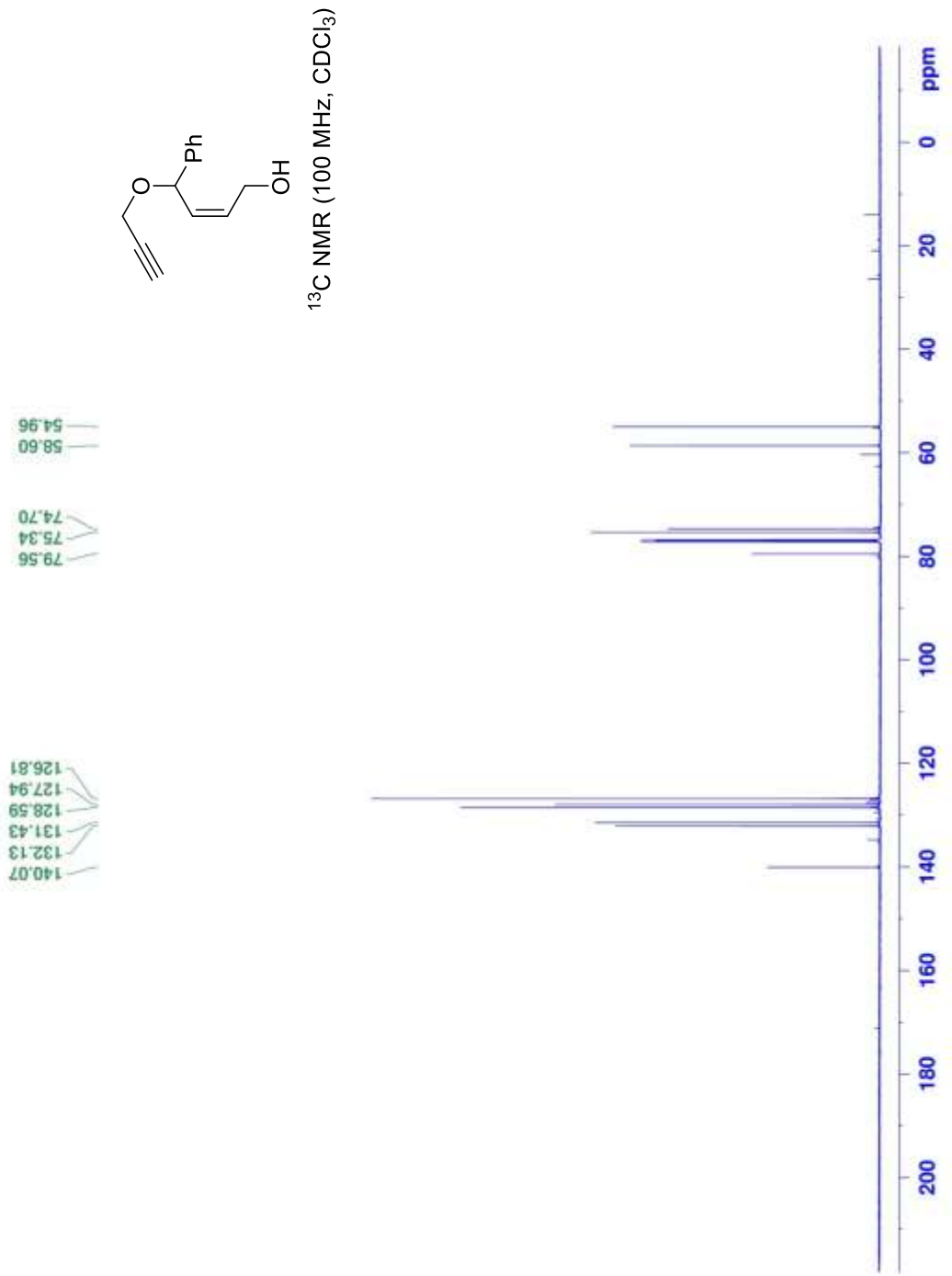

142.90
135.65
135.55
133.42
133.35
133.20
130.40
129.76
129.75
128.42
127.73
127.71
127.40
125.67
77.31
76.99
76.67
69.73
60.28
26.75
19.08
OH
Ph
OTBDPS
^{13}C NMR (100 MHz, $CDCl_3$)
200
180
160
140
120
100
80
60
40
20
0
ppm

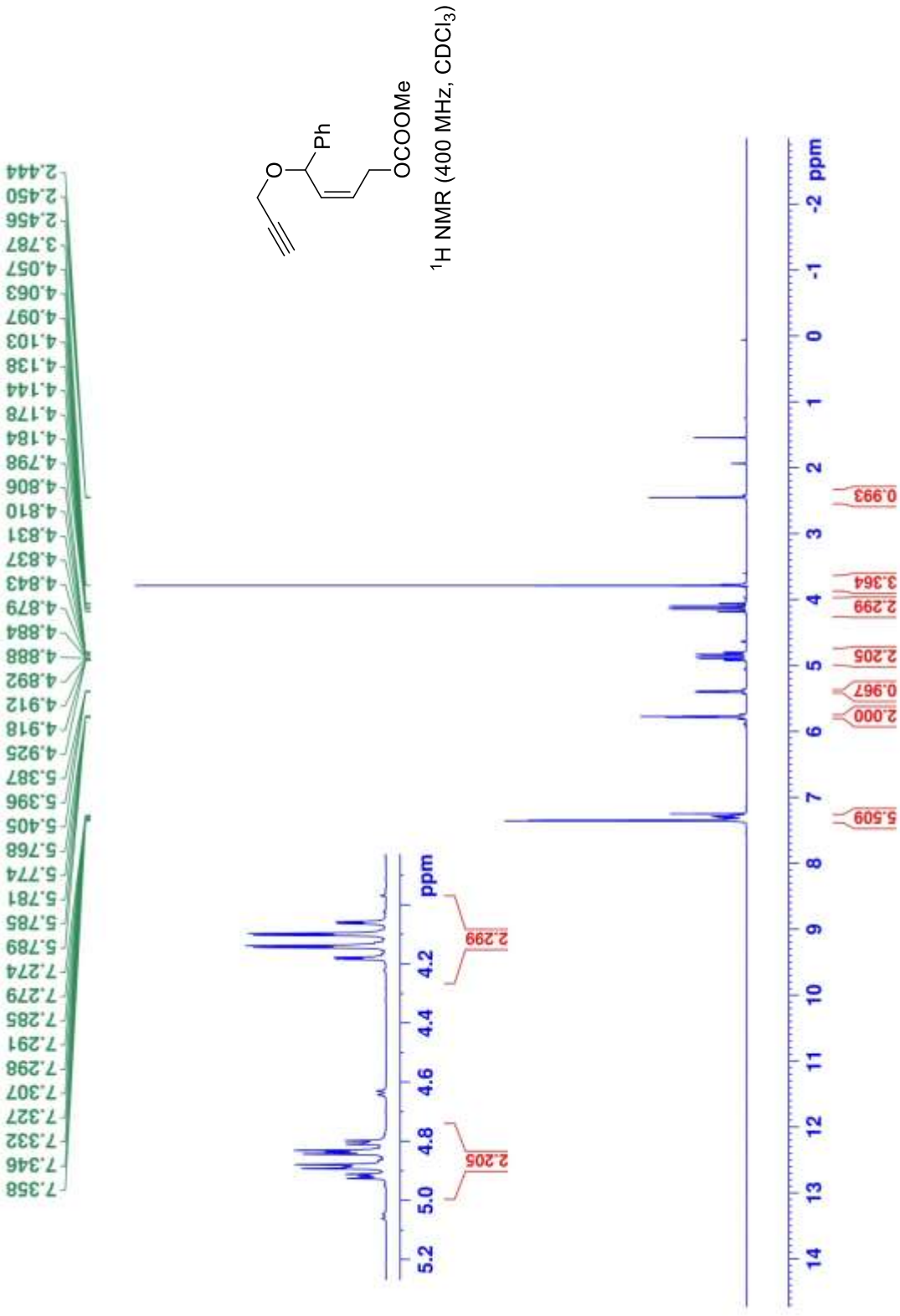


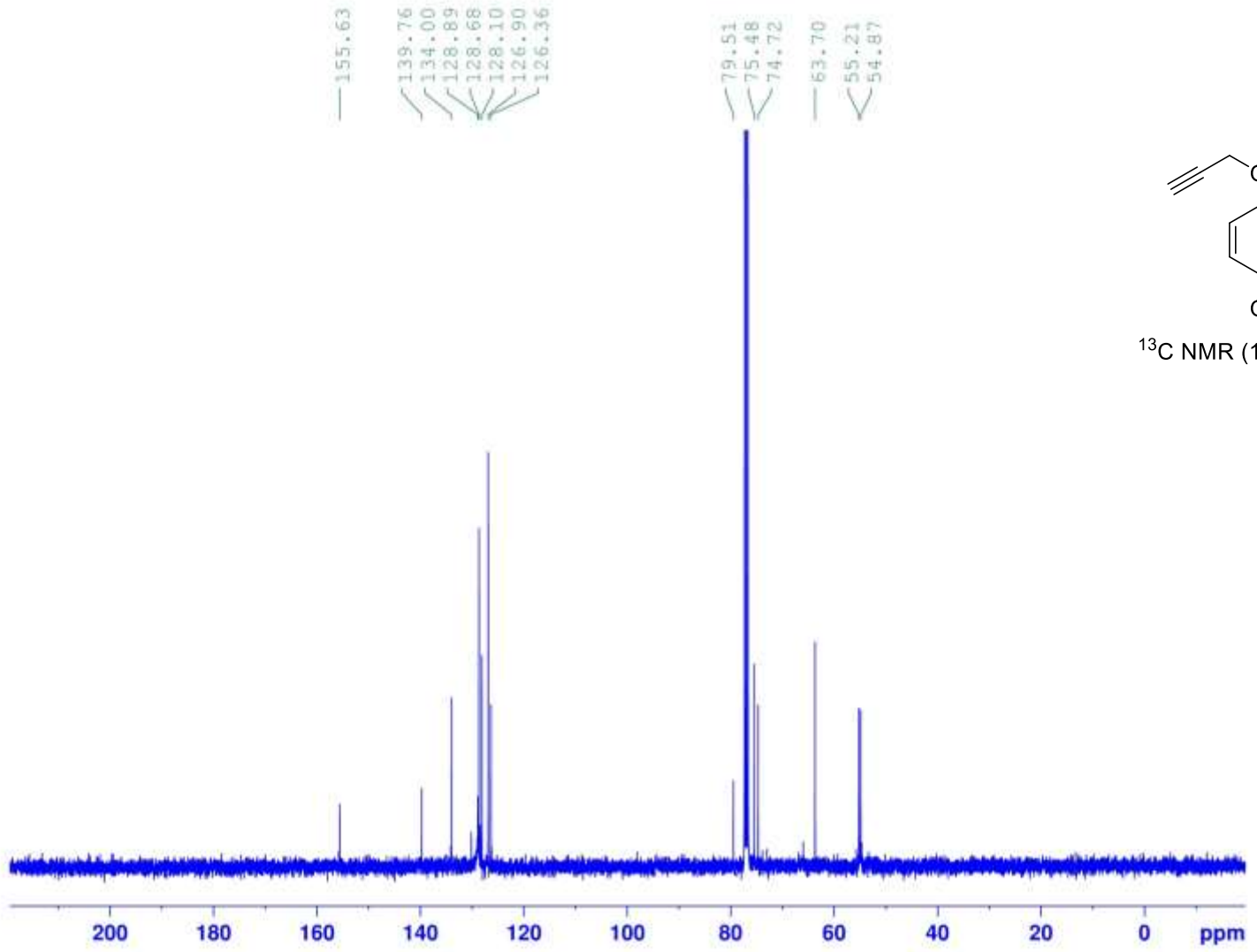
^{1}H NMR (400 MHz, $CDCl_3$)

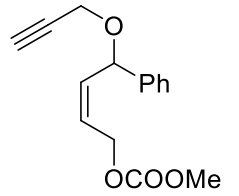

OTBDPS
Ph
O
^{13}C NMR (100 MHz, $CDCl_3$)
19.14
26.78
55.07
60.38
74.29
75.47
79.73
126.74
127.70
127.73
128.47
129.65
129.67
129.93
133.03
133.56
135.57
135.60
140.38
ppm
0
20
40
60
80
100
120
140
160
180
200


^{1}H NMR (400 MHz, CDCl$_3$)
Ph
O
OH
ppm

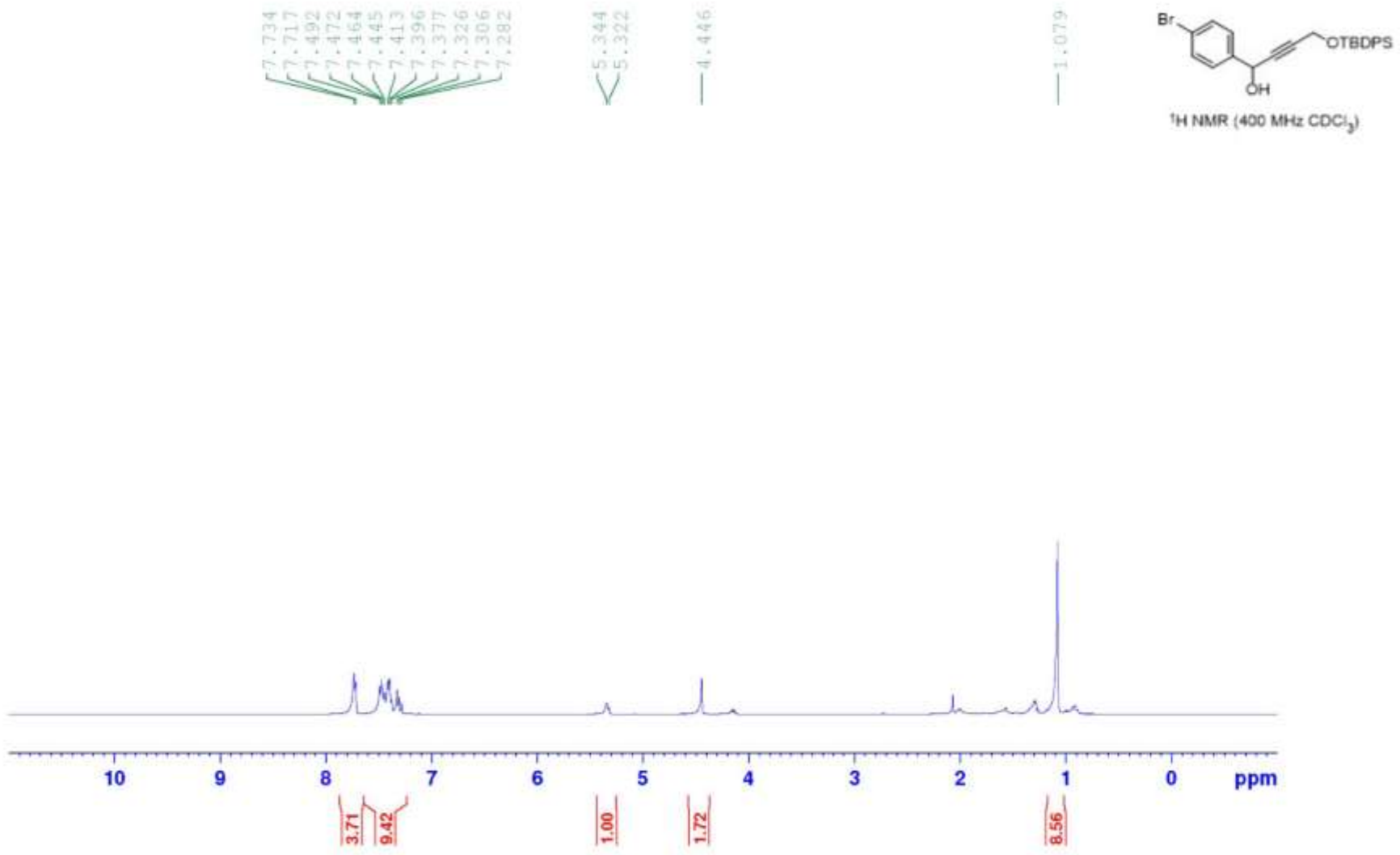

Ph
O
OH
^{13}C NMR (100 MHz, CDCl$_3$)
54.96
58.60
74.70
75.34
79.56
126.81
127.94
128.59
131.43
132.13
140.07
ppm
0
20
40
60
80
100
120
140
160
180
200

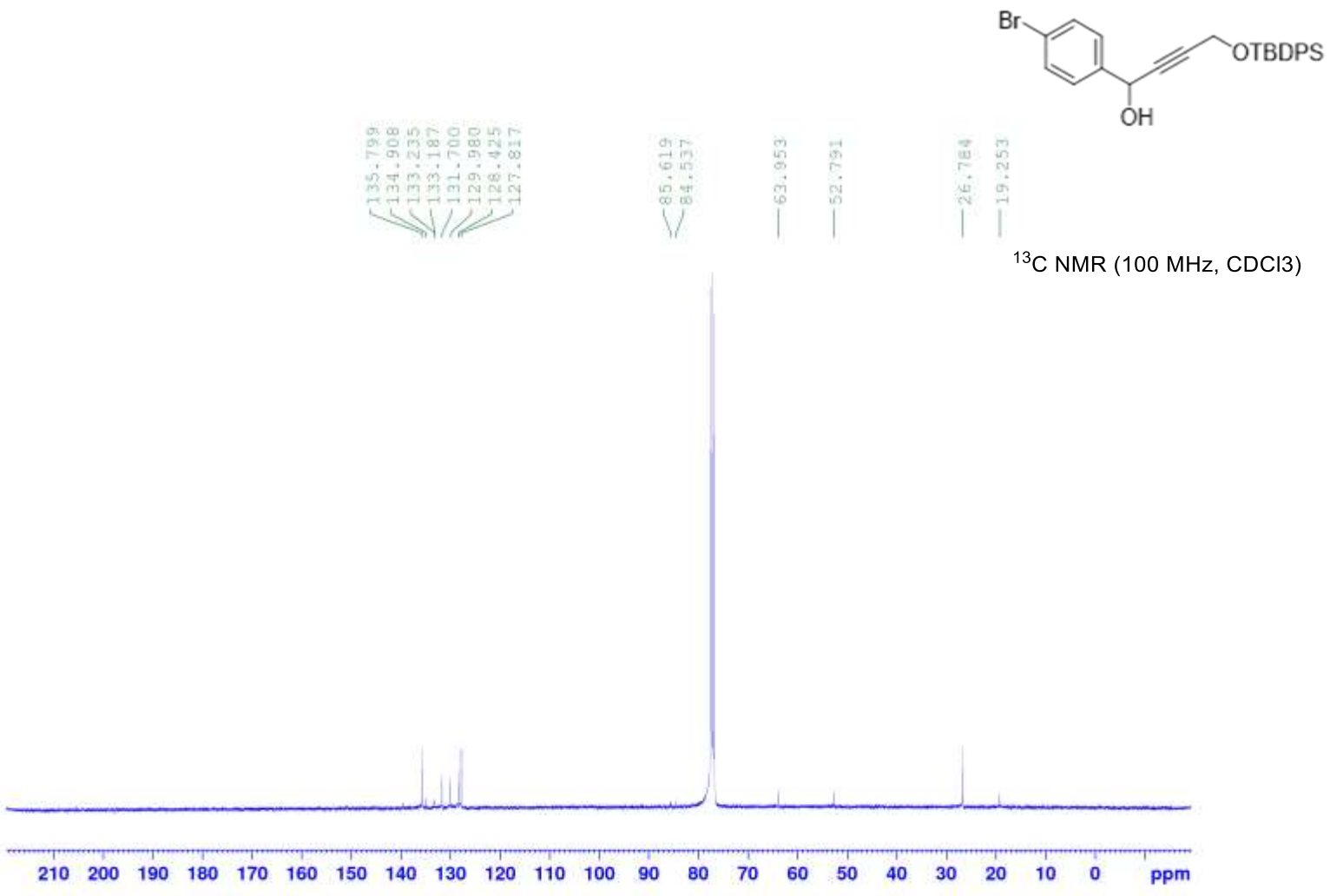

Ph
OCOOMe
^{1}H NMR (400 MHz, CDCl$_3$)
ppm
0.993
3.364
2.299
2.205
0.967
2.000
5.509
2.299
2.205



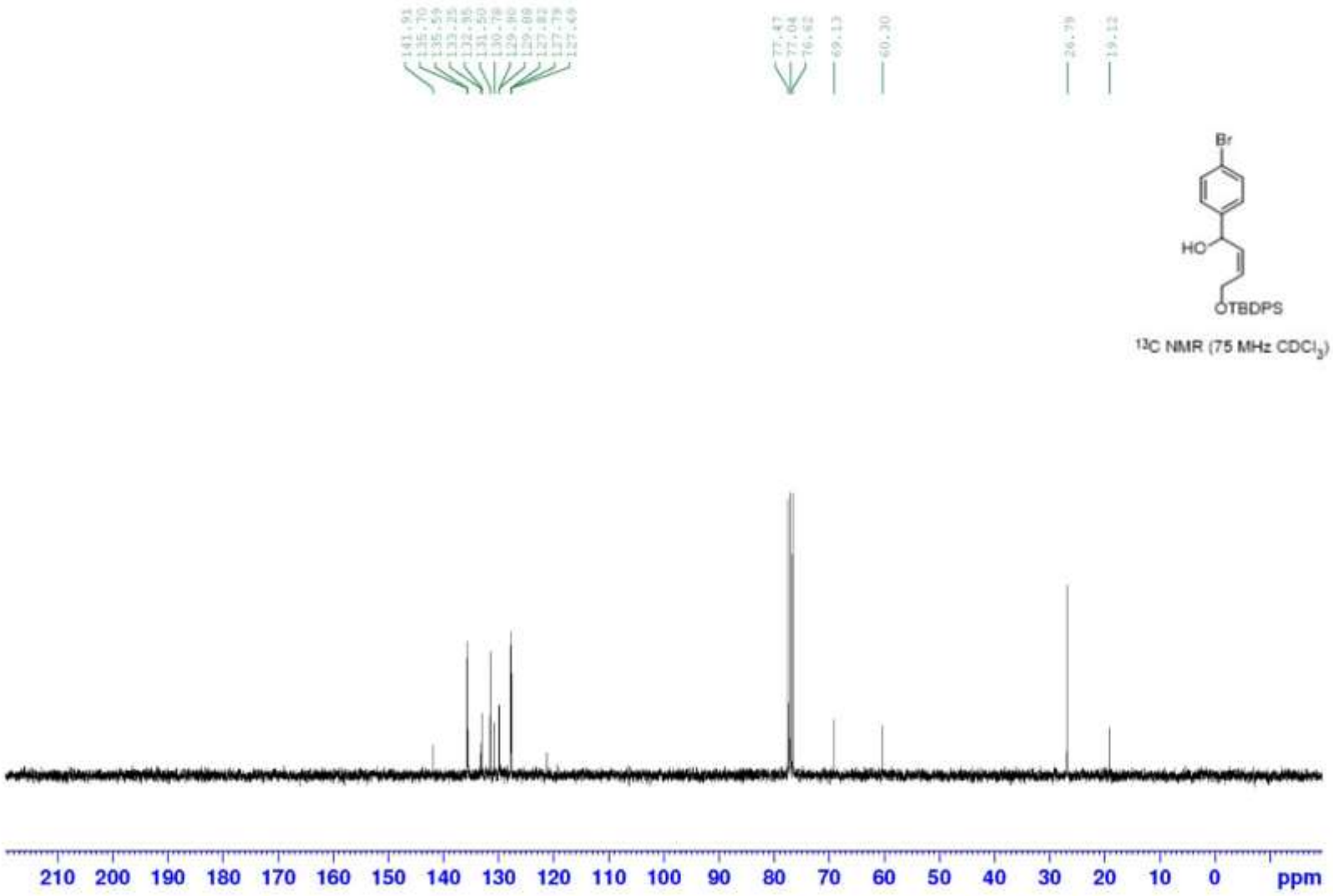


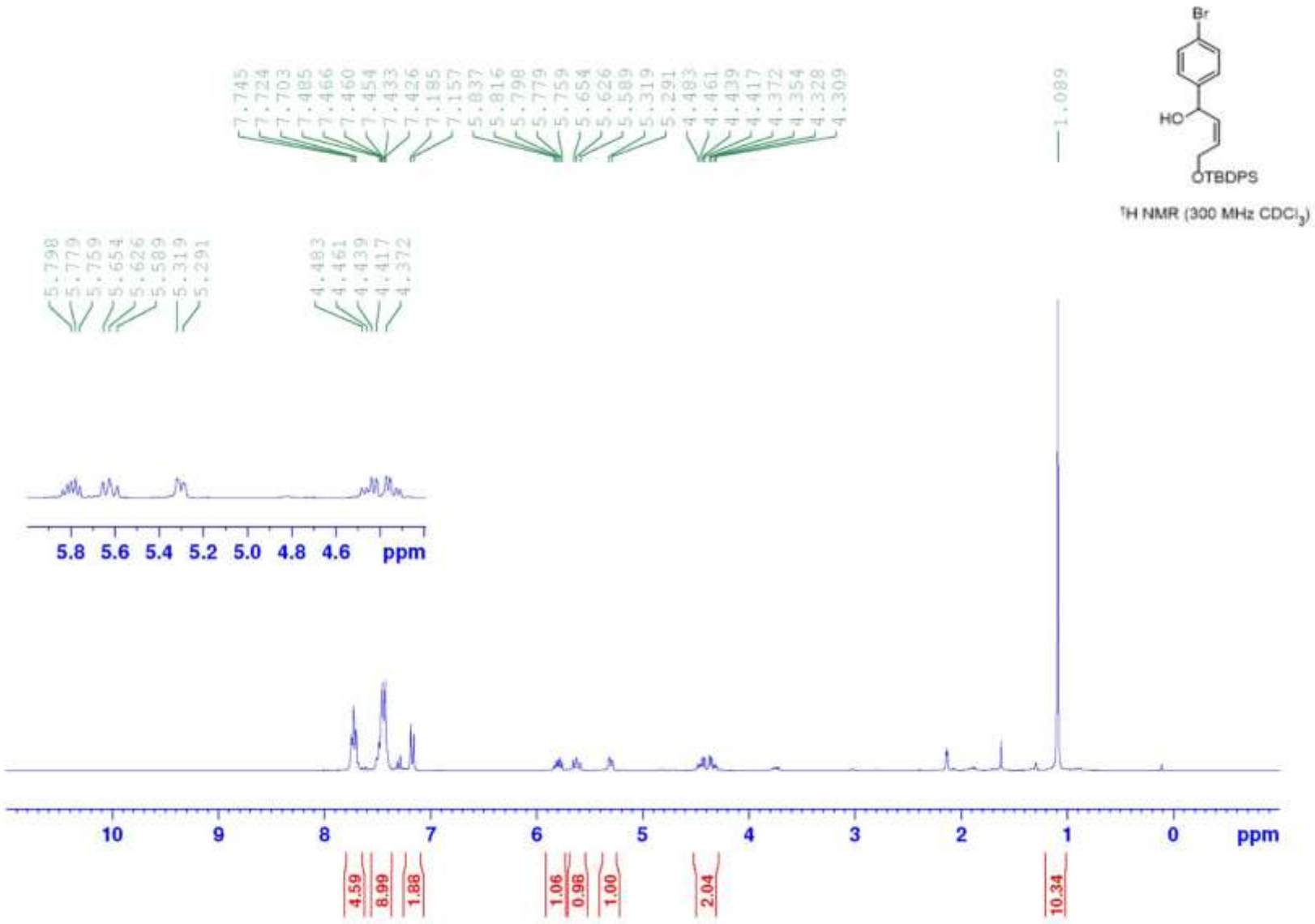
^{13}C NMR (100 MHz, $CDCl_3$)

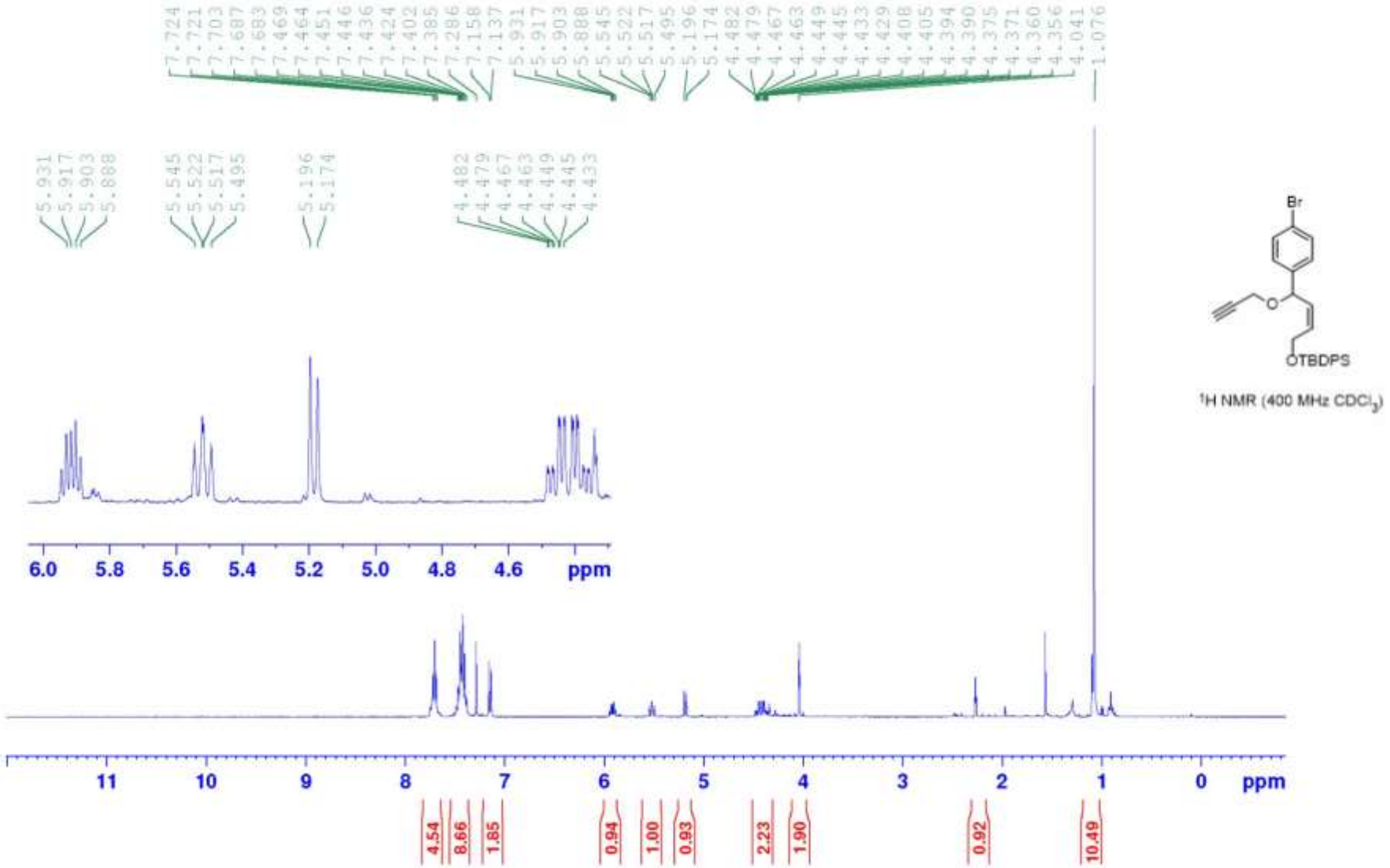

7.734
7.717
7.492
7.472
7.464
7.445
7.413
7.396
7.377
7.326
7.306
7.282
5.344
5.322
4.446
1.079
Br
OTBDPS
OH
^{1}H NMR (400 MHz $CDCl_3$)
10
9
8
7
6
5
4
3
2
1
0
ppm
3.71
9.42
1.00
1.72
8.56



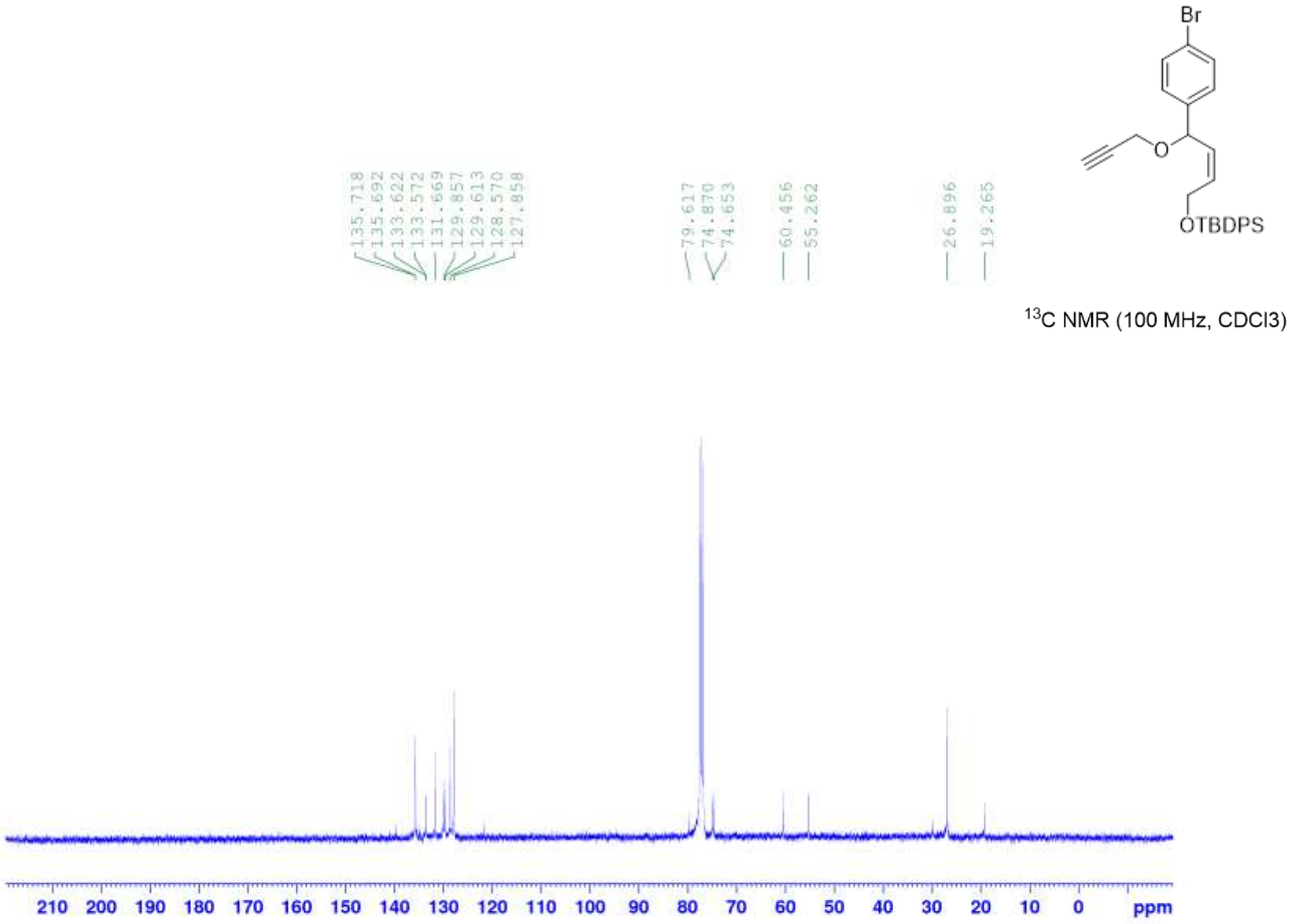
^{13}C NMR (100 MHz, CDCl3)


141.91
135.70
135.59
133.25
132.85
131.50
130.78
129.80
129.69
127.82
127.79
127.49
77.47
77.04
76.62
69.13
60.30
26.79
19.12
Br
HO
OTBDPS
13C NMR (75 MHz CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

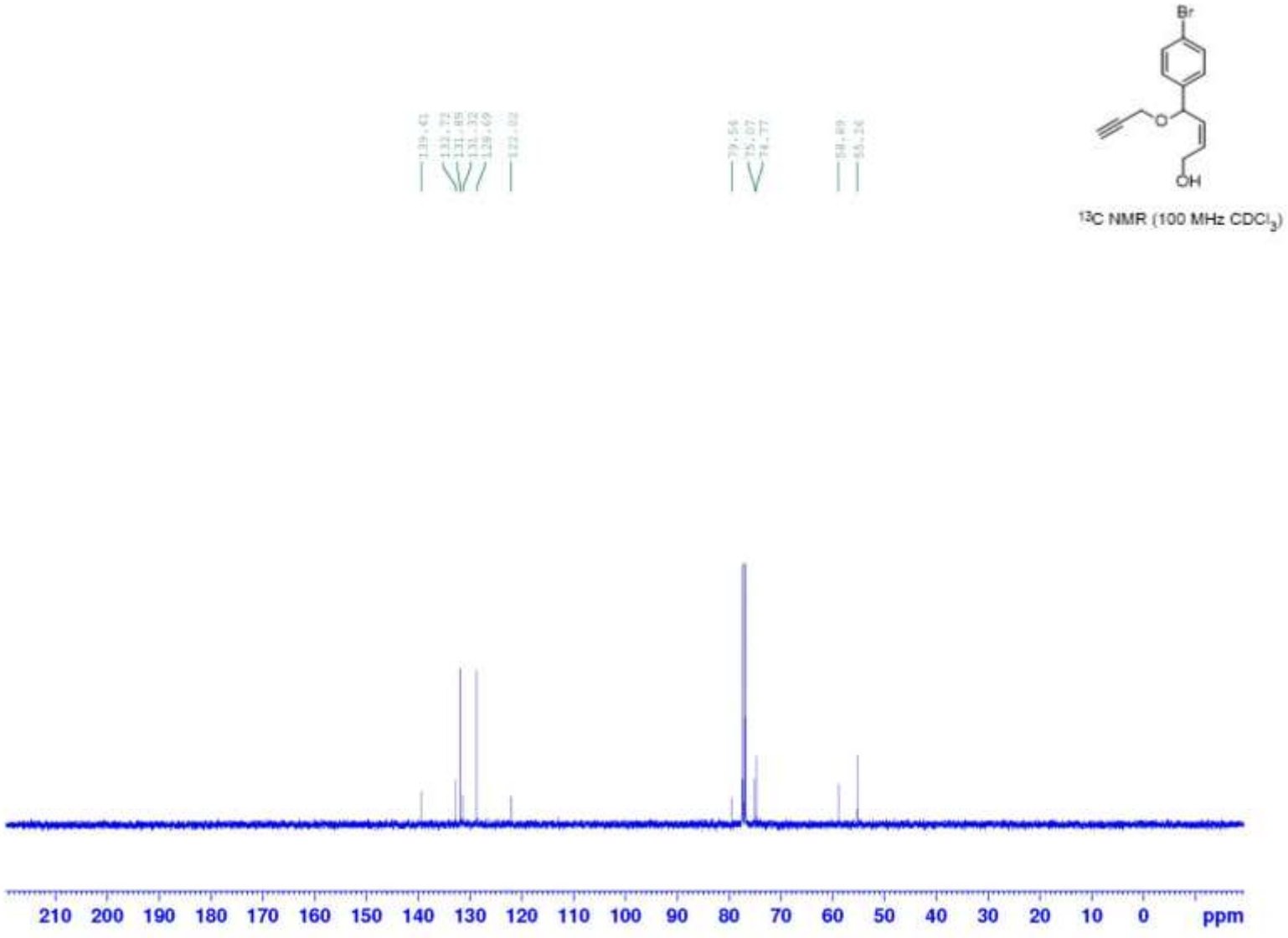

Br
HO
OTBDPS
^{1}H NMR (300 MHz $CDCl_3$)
7.745
7.724
7.703
7.485
7.466
7.460
7.454
7.433
7.426
7.185
7.157
5.837
5.816
5.798
5.779
5.759
5.654
5.626
5.589
5.319
5.291
4.483
4.461
4.439
4.417
4.372
4.354
4.328
4.309
1.089
5.8 5.6 5.4 5.2 5.0 4.8 4.6 ppm
10 9 8 7 6 5 4 3 2 1 0 ppm
4.59
8.99
1.88
1.06
0.98
1.00
2.04
10.34



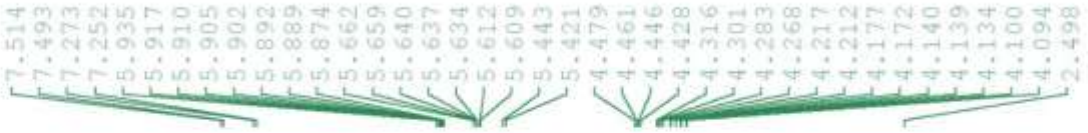
^{1}H NMR (400 MHz $CDCl_3$)

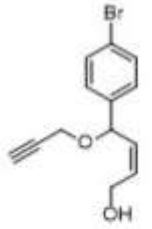


^{13}C NMR (100 MHz, CDCl3)

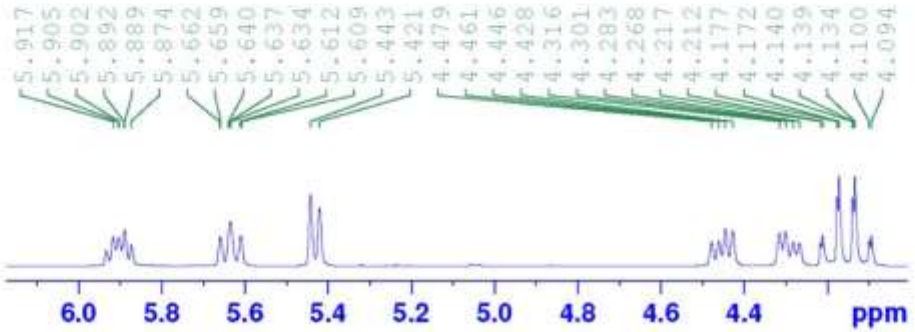


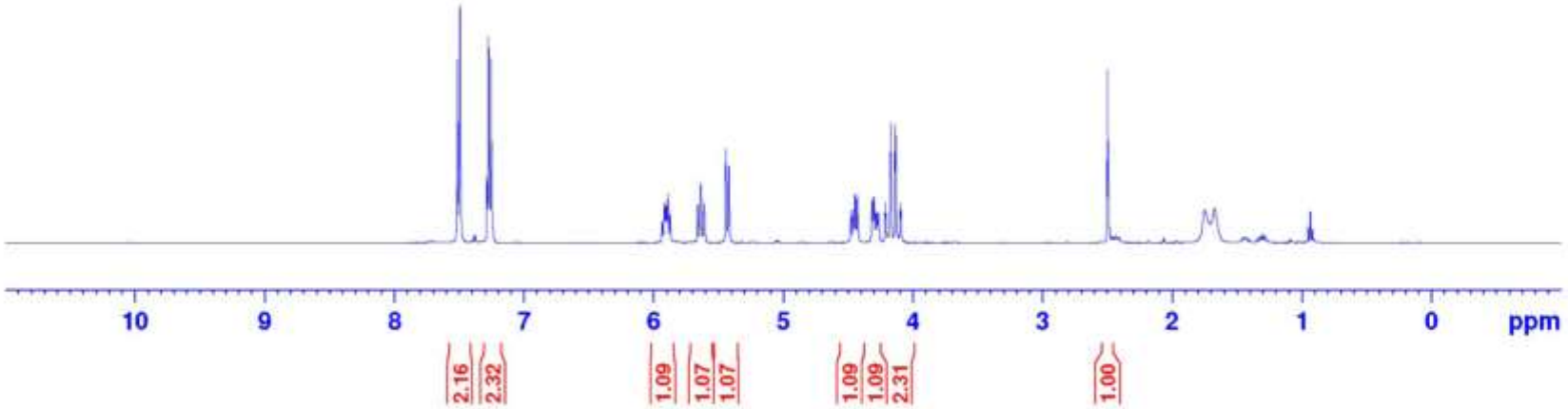
^{13}C NMR (100 MHz $CDCl_3$)

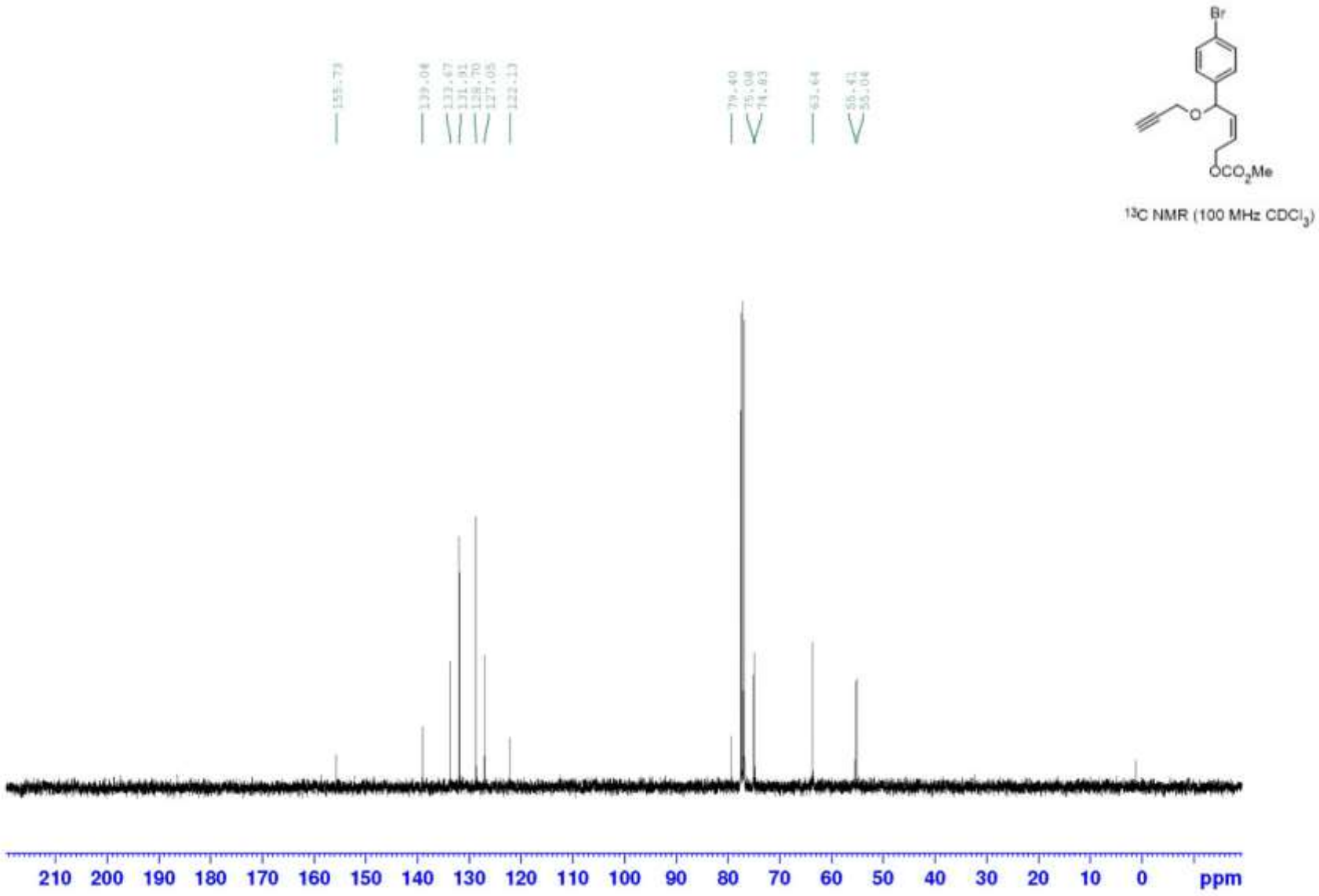


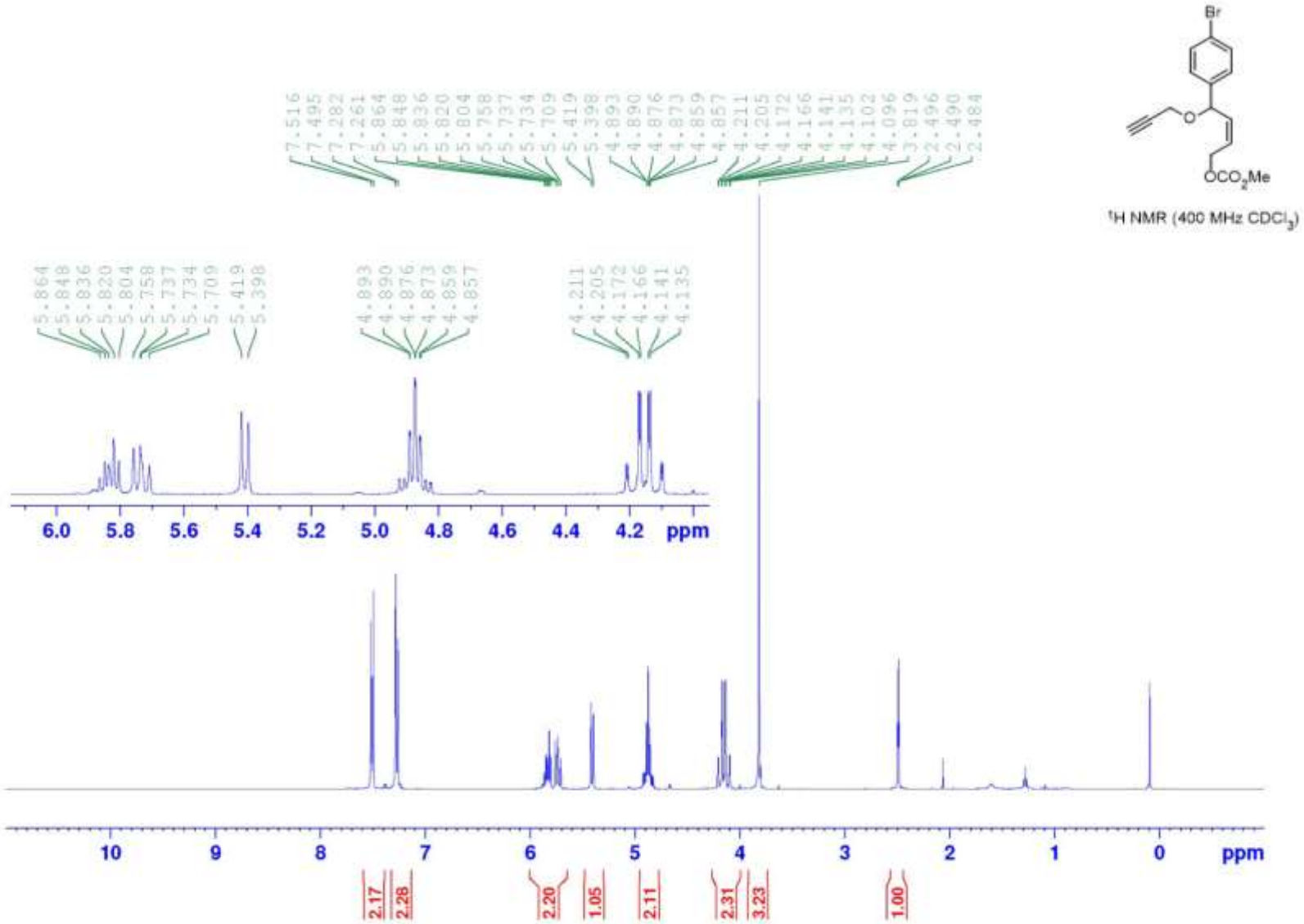


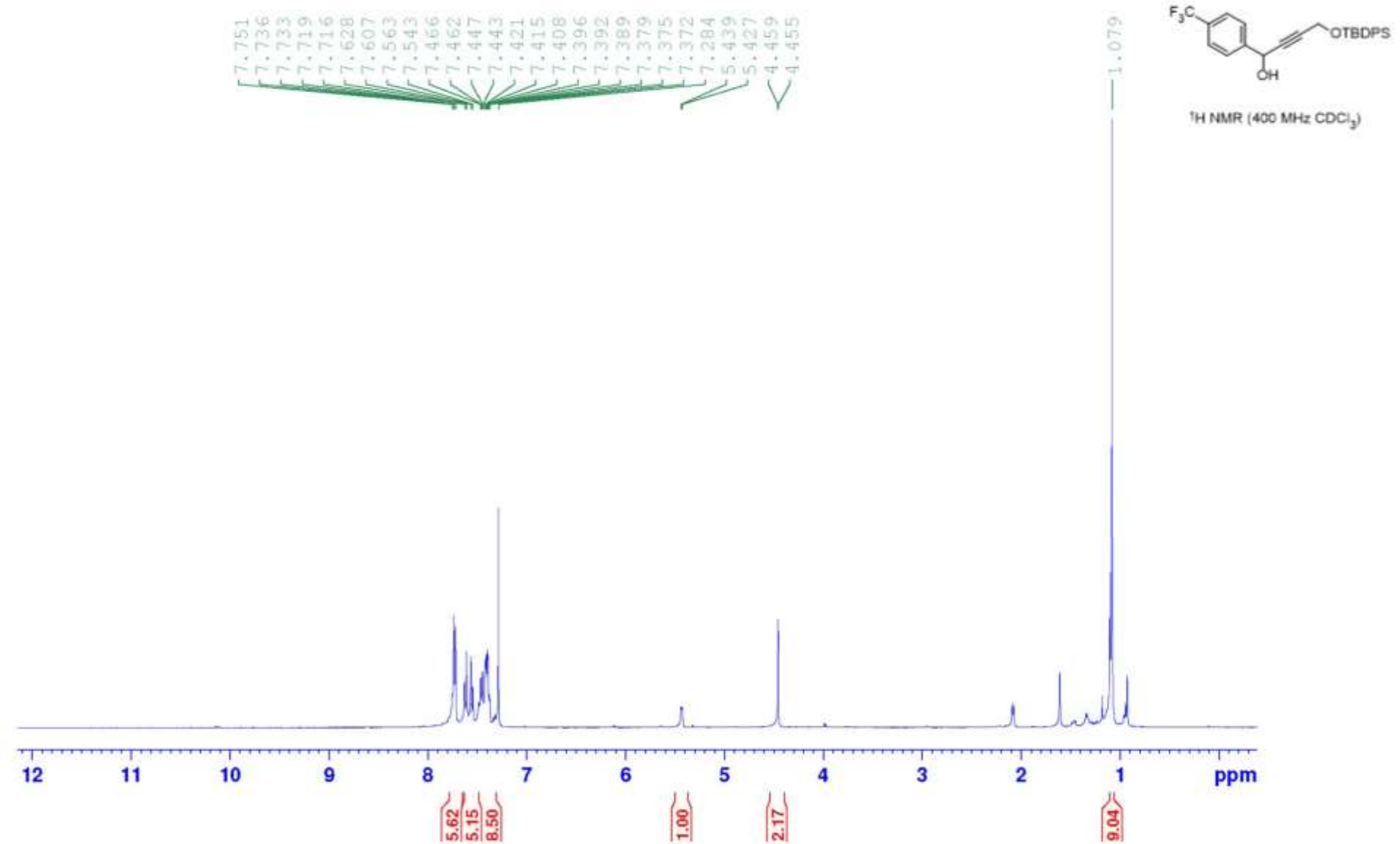
^{1}H NMR (400 MHz $CDCl_3$)

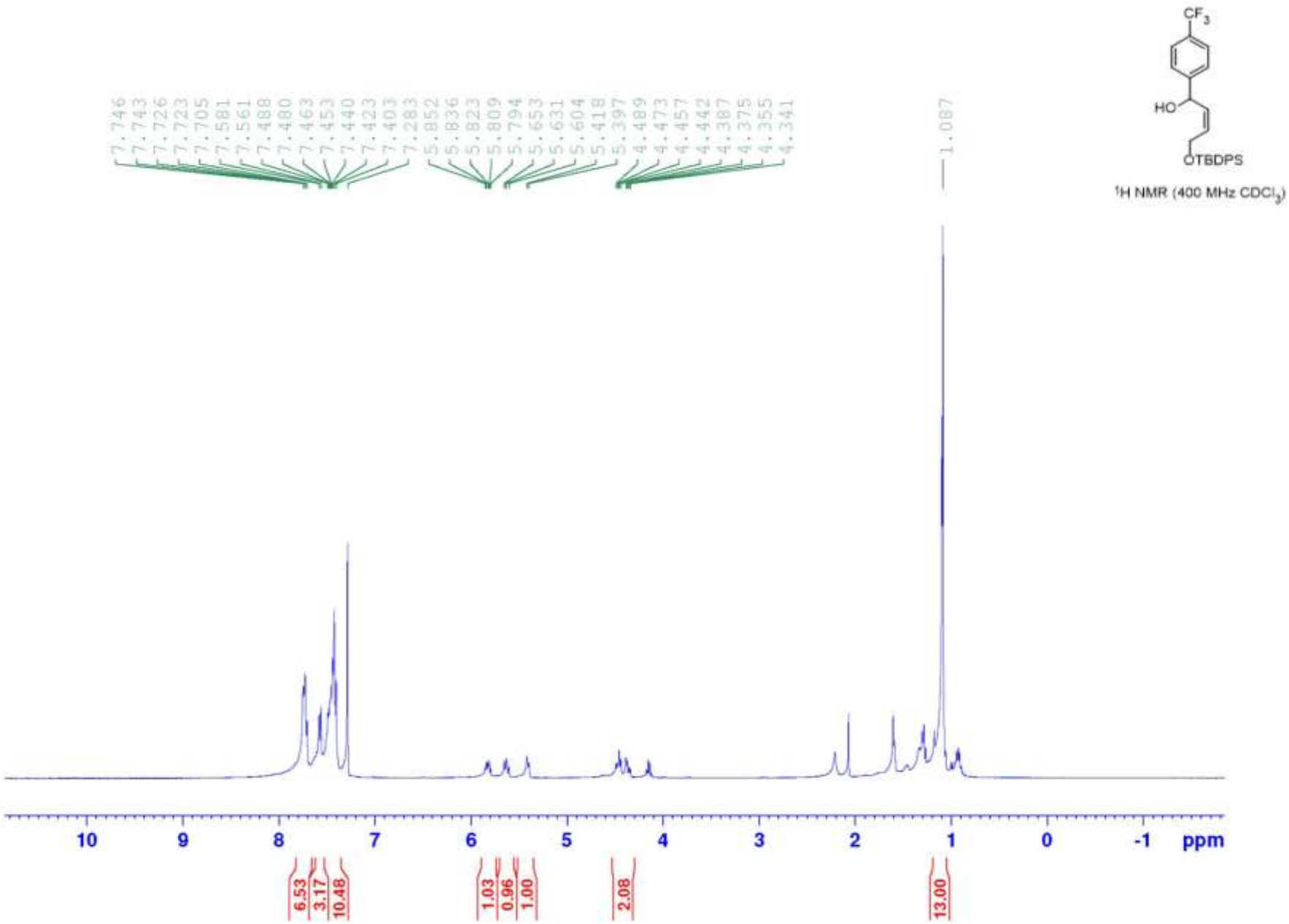


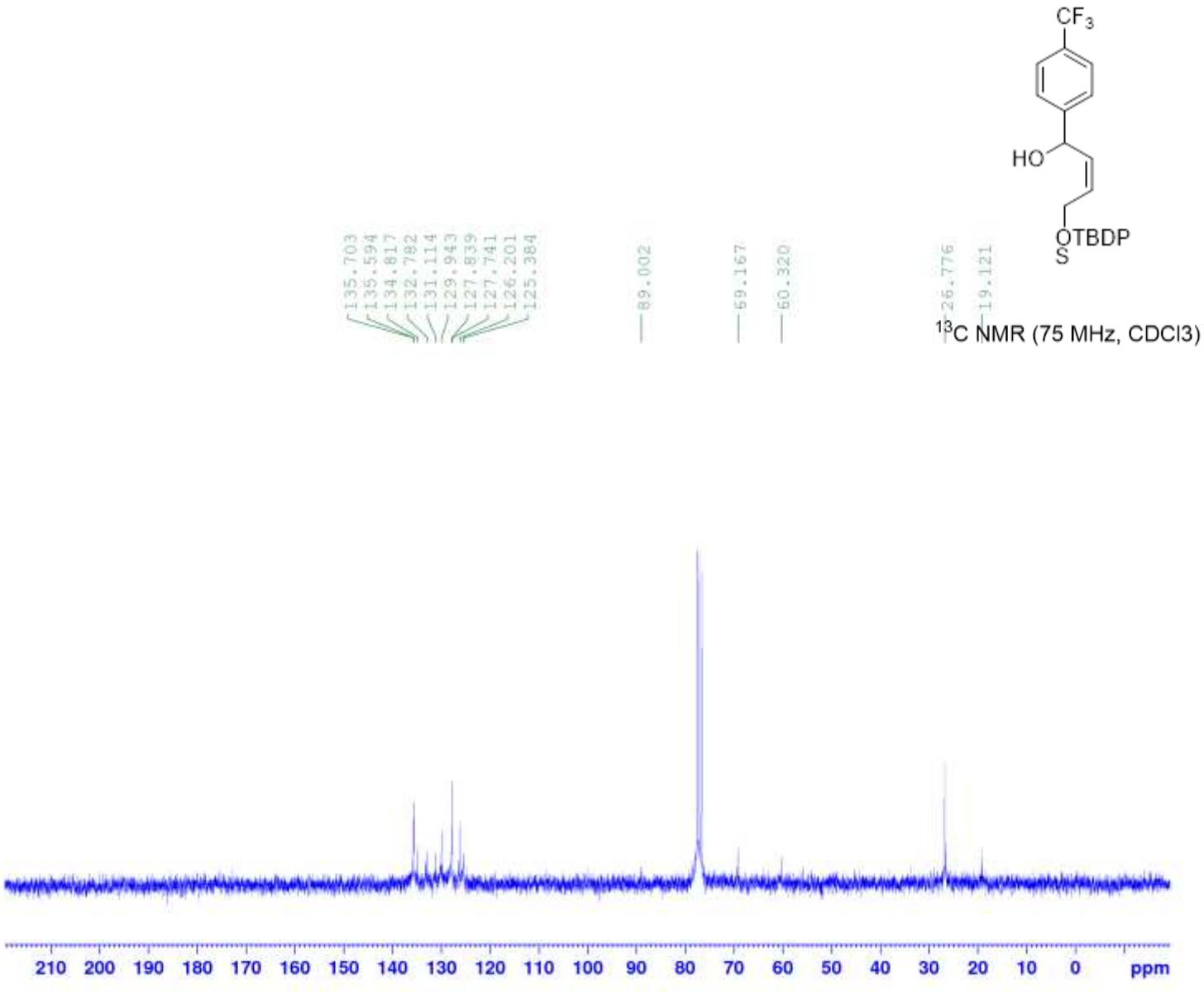


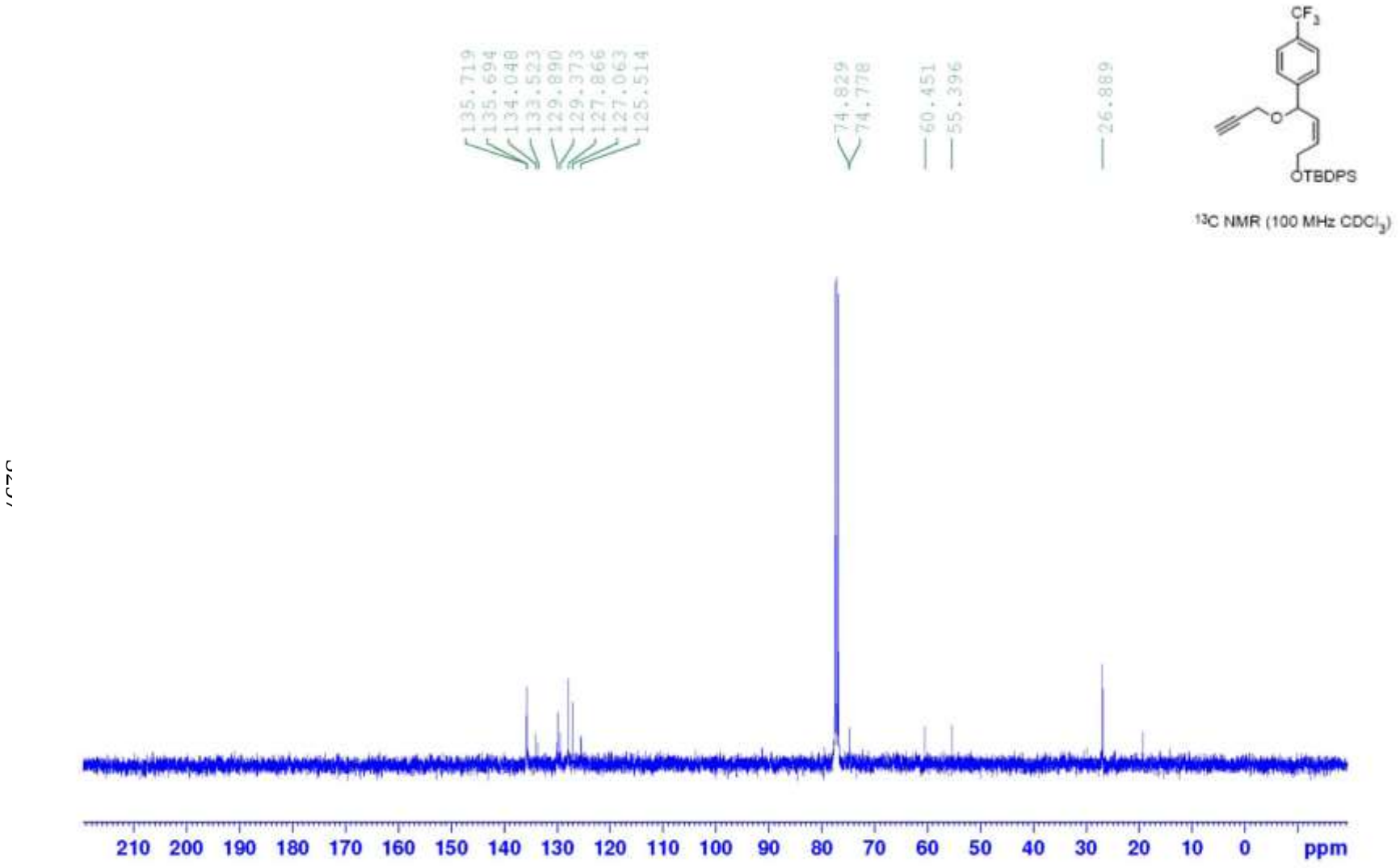

155.73
139.04
133.67
131.91
128.70
127.05
122.13
79.40
75.08
74.83
63.64
55.41
55.04
Br
O
OCO2Me
13C NMR (100 MHz CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

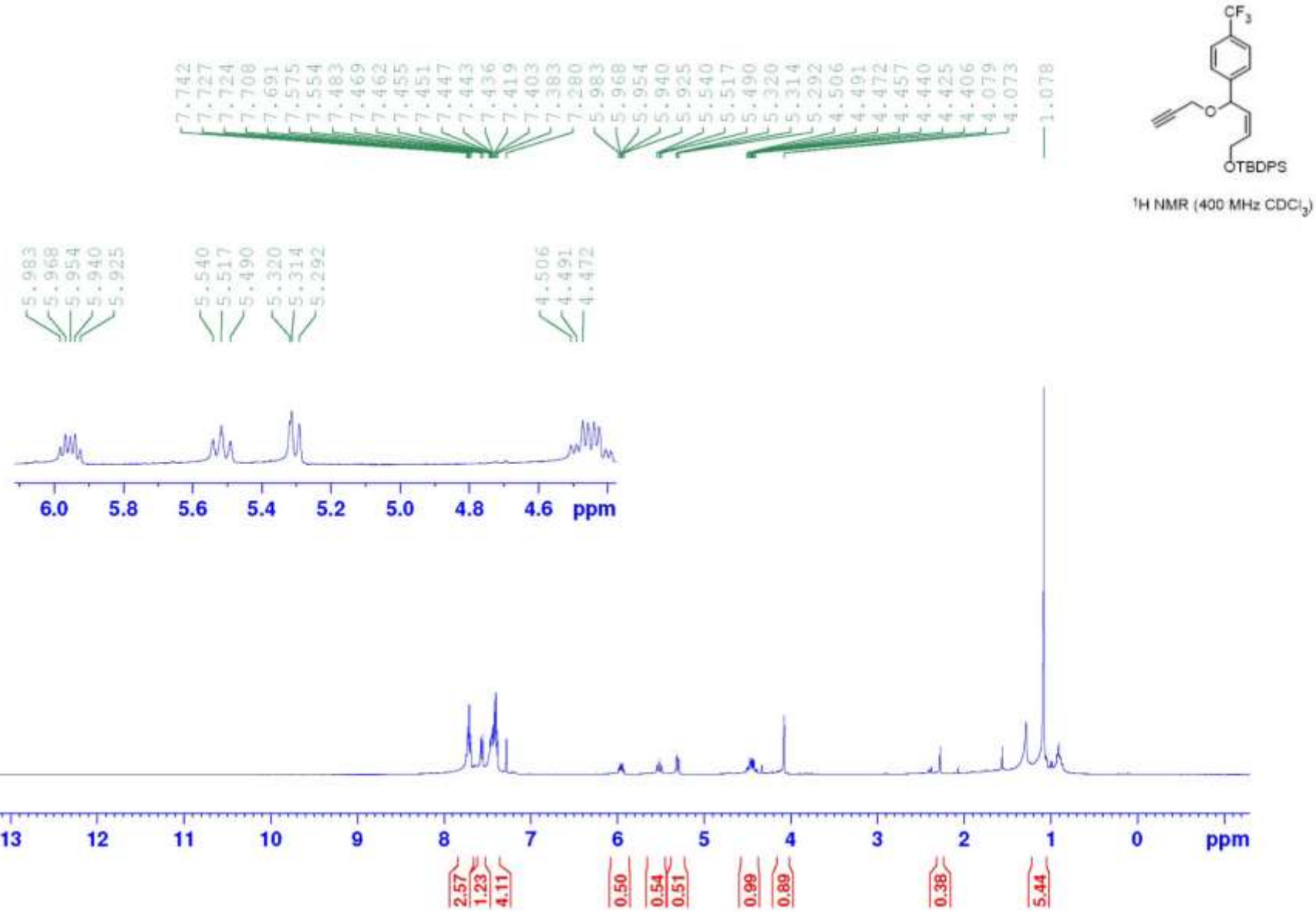

Br
O
OCO2Me
1H NMR (400 MHz CDCl3)
7.516
7.495
7.282
7.261
5.864
5.848
5.836
5.820
5.804
5.758
5.737
5.734
5.709
5.419
5.398
4.893
4.890
4.876
4.873
4.859
4.857
4.211
4.205
4.172
4.166
4.141
4.135
4.102
4.096
3.819
2.496
2.490
2.484
6.0
5.8
5.6
5.4
5.2
5.0
4.8
4.6
4.4
4.2
ppm
10
9
8
7
6
5
4
3
2
1
0
ppm
2.17
2.28
2.20
1.05
2.11
2.31
3.23
1.00

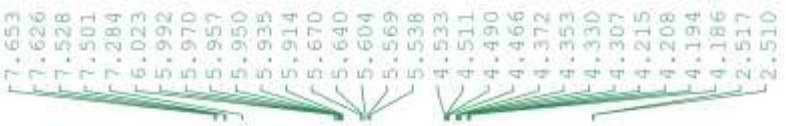

7.751
7.736
7.733
7.719
7.716
7.628
7.607
7.563
7.543
7.466
7.462
7.447
7.443
7.421
7.415
7.408
7.396
7.392
7.389
7.379
7.375
7.372
7.284
5.439
5.427
4.459
4.455
1.079
F3C
OTBDPS
OH
1H NMR (400 MHz CDCl3)
12
11
10
9
8
7
6
5
4
3
2
1
ppm
5.62
5.15
8.50
1.00
2.17
9.04

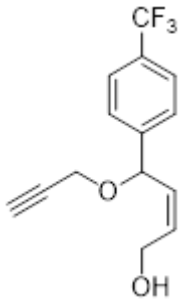

7.746
7.743
7.726
7.723
7.705
7.581
7.561
7.488
7.480
7.463
7.453
7.440
7.423
7.403
7.283
5.852
5.836
5.823
5.809
5.794
5.653
5.631
5.604
5.418
5.397
4.489
4.473
4.457
4.442
4.387
4.375
4.355
4.341
1.087
CF3
HO
OTBDPS
1H NMR (400 MHz CDCl3)
10
9
8
7
6
5
4
3
2
1
0
-1
ppm
6.53
3.17
10.48
1.03
0.96
1.00
2.08
13.00


CF3
HO
OTBDP
S
135.703
135.594
134.817
132.782
131.114
129.943
127.839
127.741
126.201
125.384
89.002
69.167
60.320
26.776
19.121
13C NMR (75 MHz, CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

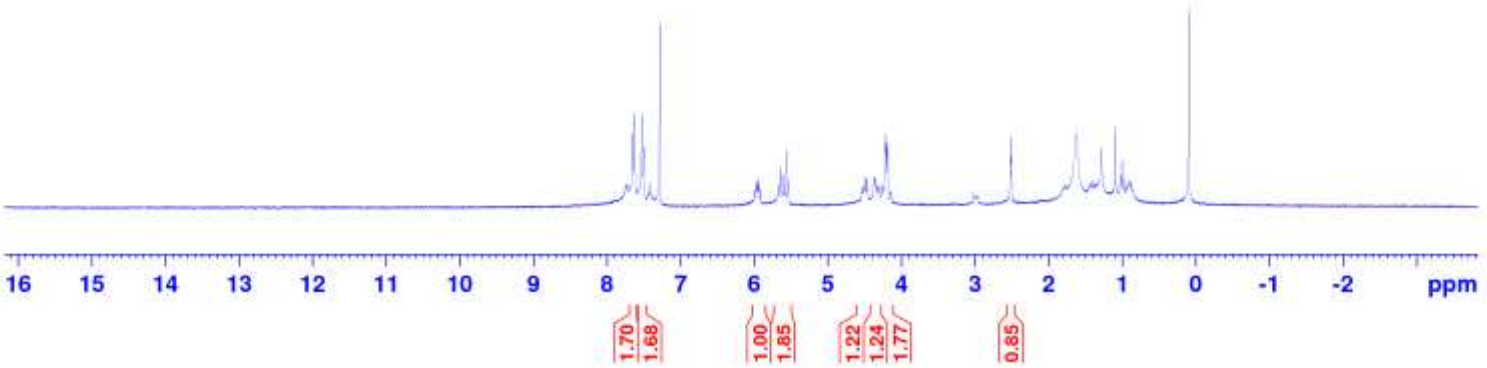

135.719
135.694
134.048
133.523
129.890
129.373
127.866
127.063
125.514
74.829
74.778
60.451
55.396
26.889
CF3
O
OTBDPS
13C NMR (100 MHz CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

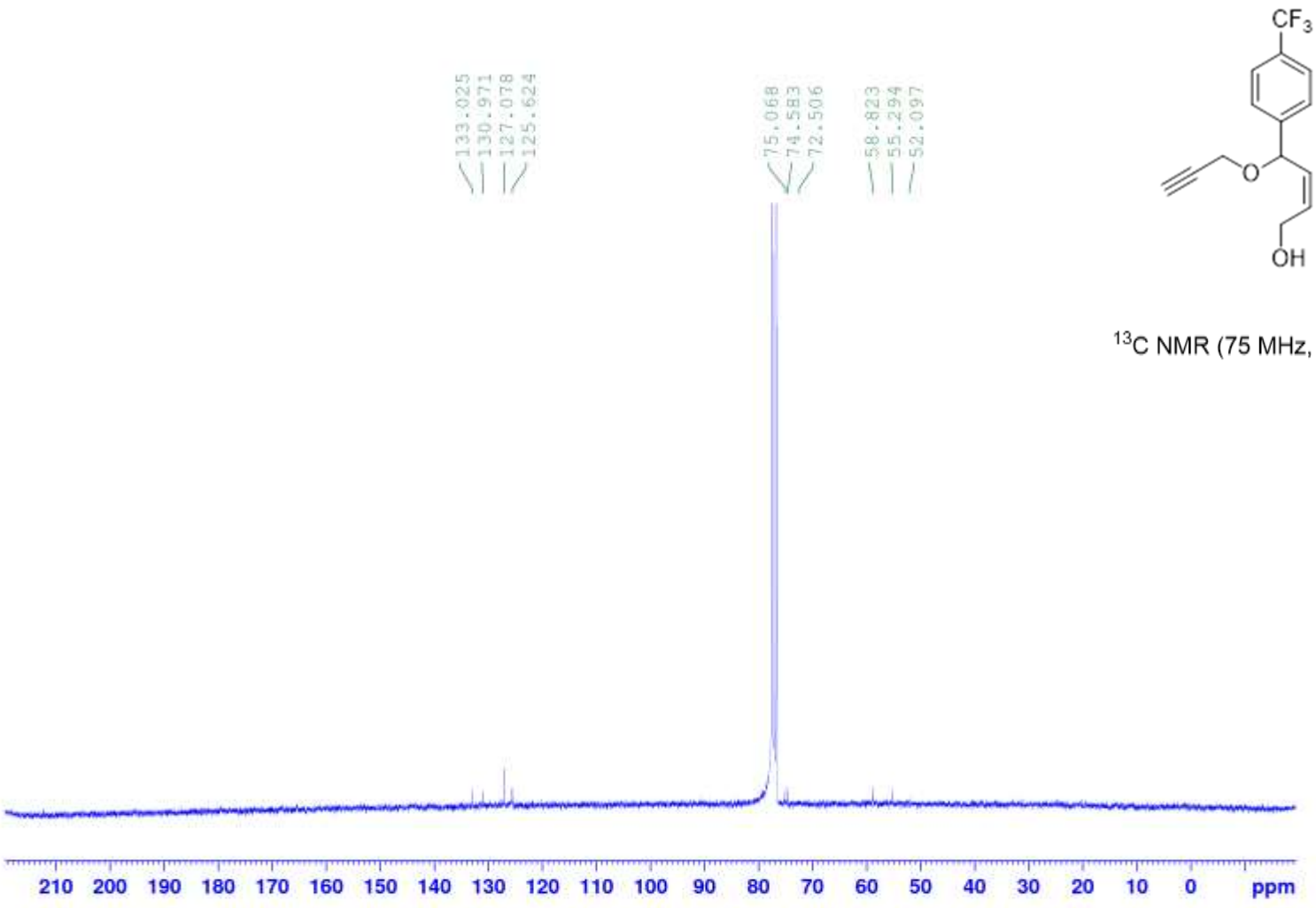

7.742
7.727
7.724
7.708
7.691
7.575
7.554
7.483
7.469
7.462
7.455
7.451
7.447
7.443
7.436
7.419
7.403
7.383
7.280
5.983
5.968
5.954
5.940
5.925
5.540
5.517
5.490
5.320
5.314
5.292
4.506
4.491
4.472
4.457
4.440
4.425
4.406
4.079
4.073
1.078
CF3
O
OTBDPS
1H NMR (400 MHz CDCl3)
6.0
5.8
5.6
5.4
5.2
5.0
4.8
4.6
ppm
13
12
11
10
9
8
7
6
5
4
3
2
1
0
ppm
2.57
1.23
4.11
0.50
0.54
0.51
0.99
0.89
0.38
5.44



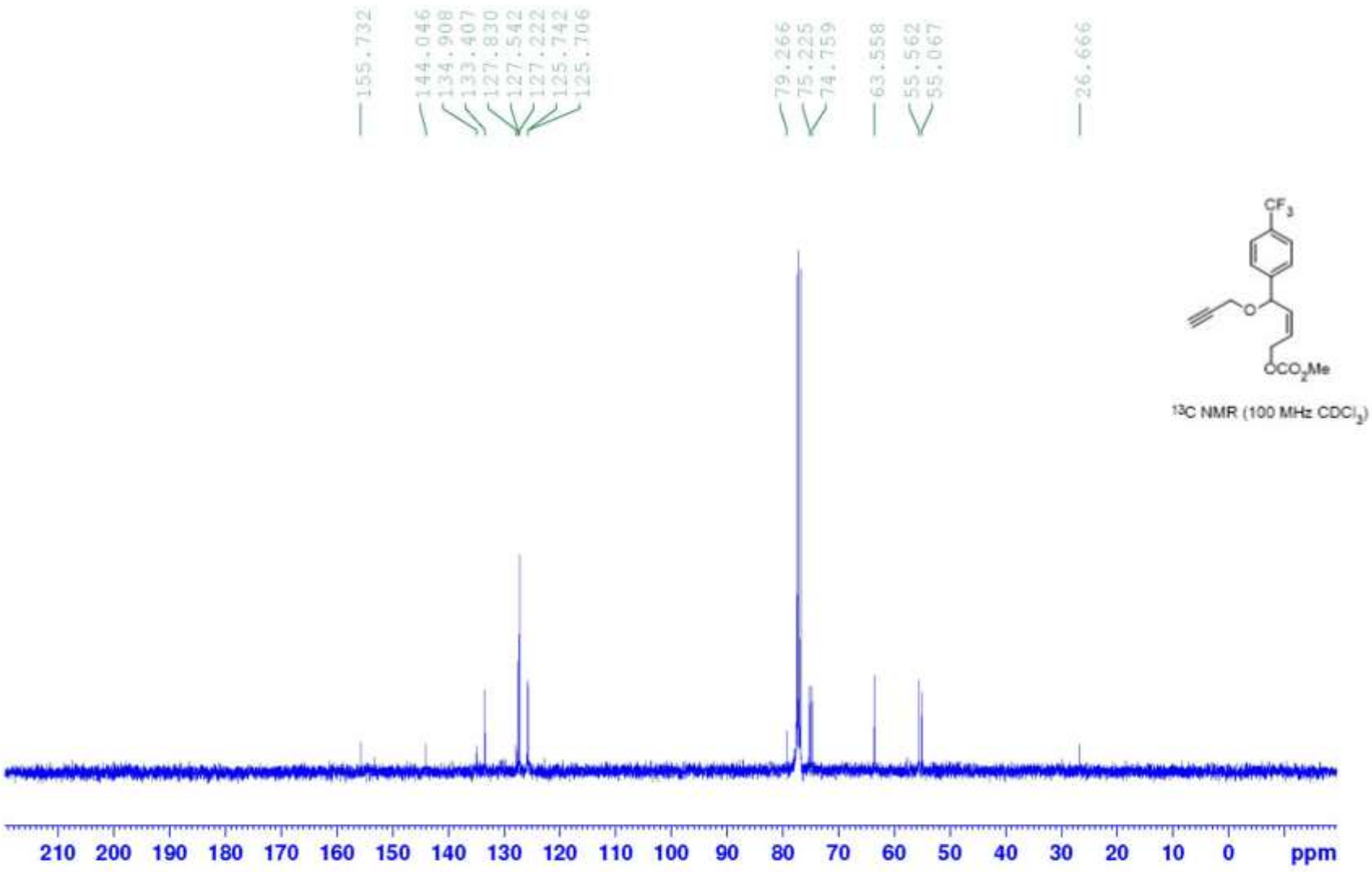


^{1}H NMR (300 MHz, CDCl3)

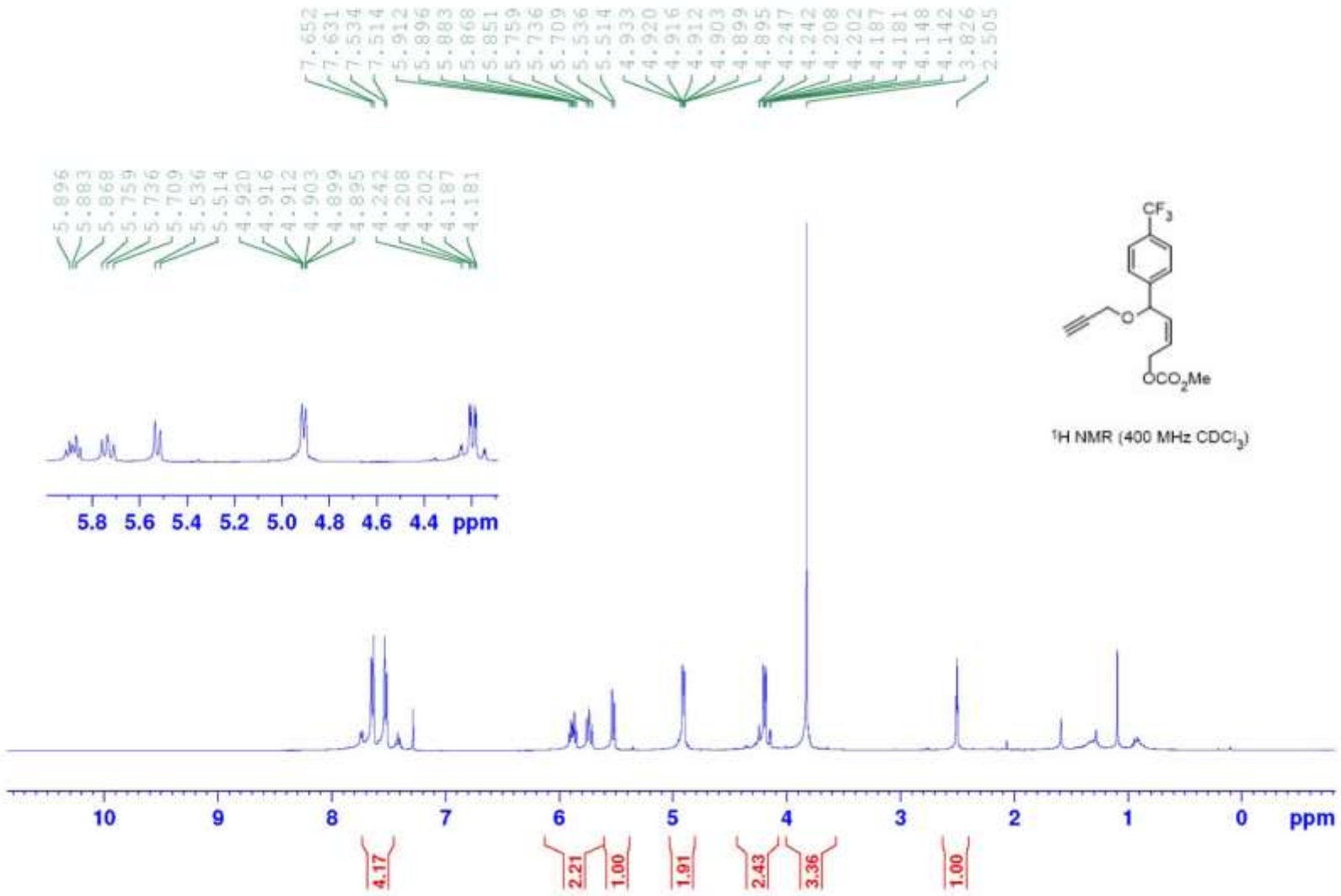


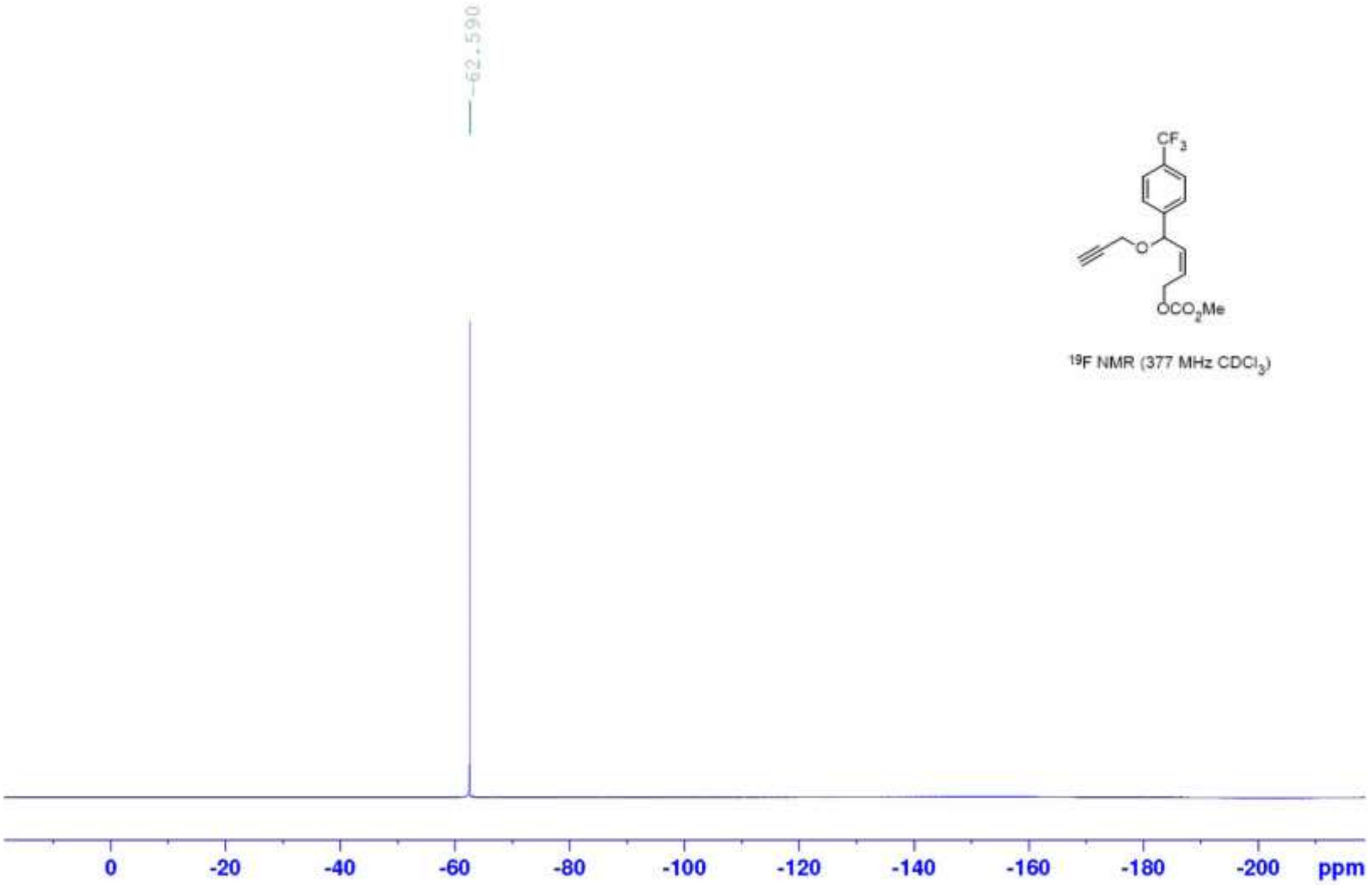


^{13}C NMR (75 MHz, CDCl3)

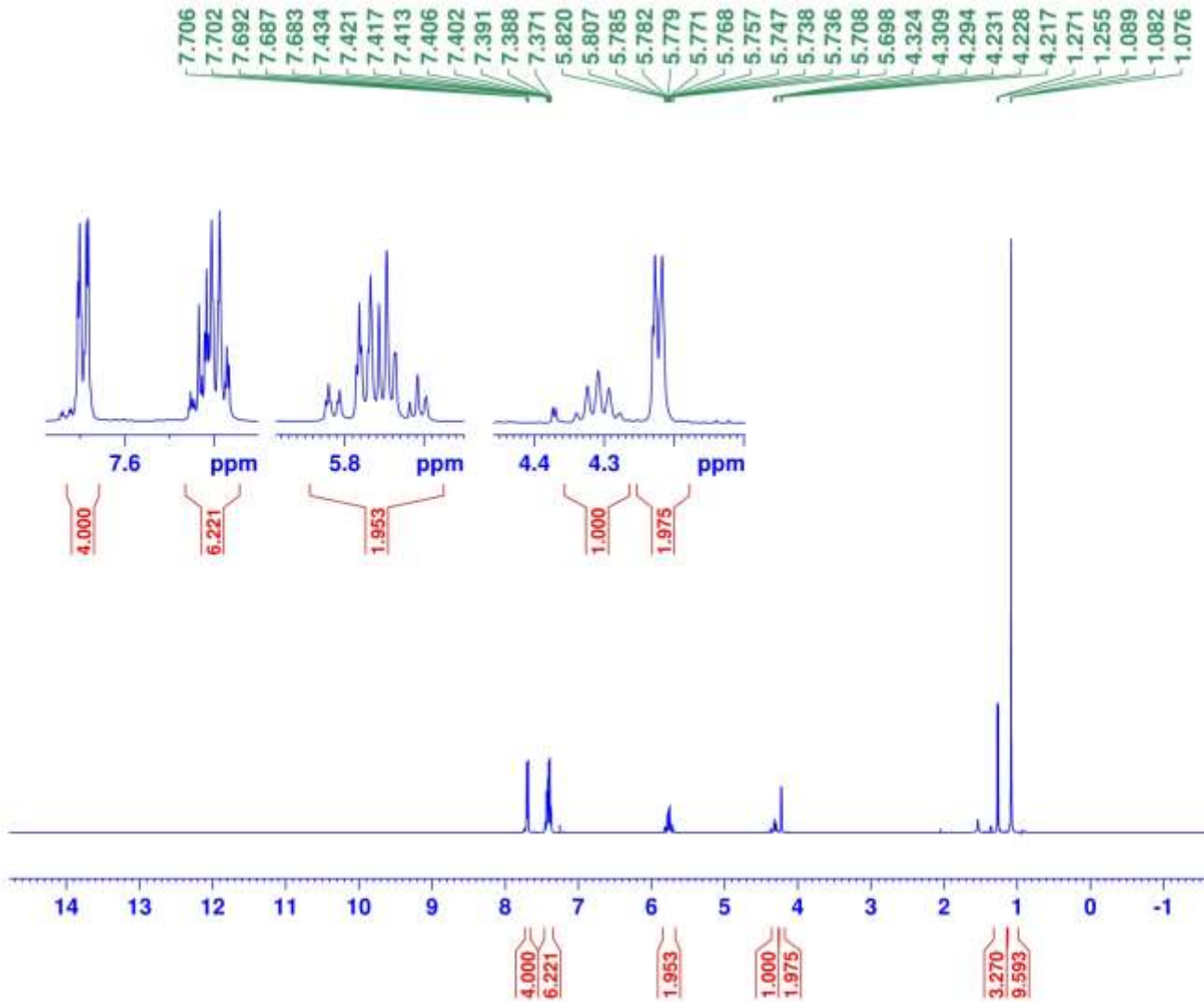


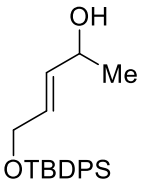
^{13}C NMR (100 MHz $CDCl_3$)


7.652
7.631
7.534
7.514
5.912
5.896
5.883
5.868
5.851
5.759
5.736
5.709
5.536
5.514
4.933
4.920
4.916
4.912
4.903
4.899
4.895
4.247
4.242
4.208
4.202
4.187
4.181
4.148
4.142
3.826
2.505
5.8 5.6 5.4 5.2 5.0 4.8 4.6 4.4 ppm
CF3
OCO2Me
1H NMR (400 MHz CDCl3)
10 9 8 7 6 5 4 3 2 1 0 ppm
4.17
2.21
1.00
1.91
2.43
3.36
1.00

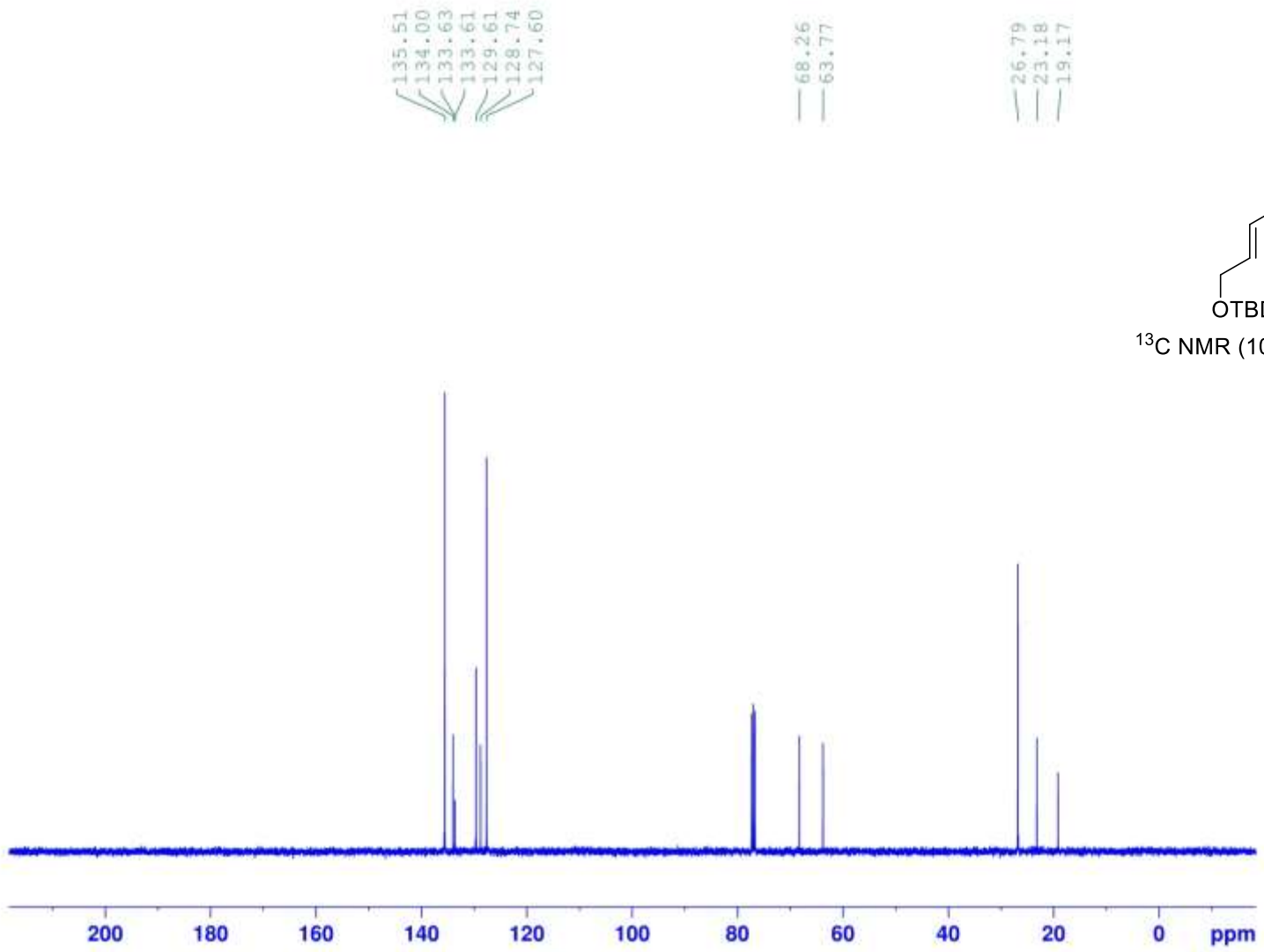


^{19}F NMR (377 MHz $CDCl_3$)

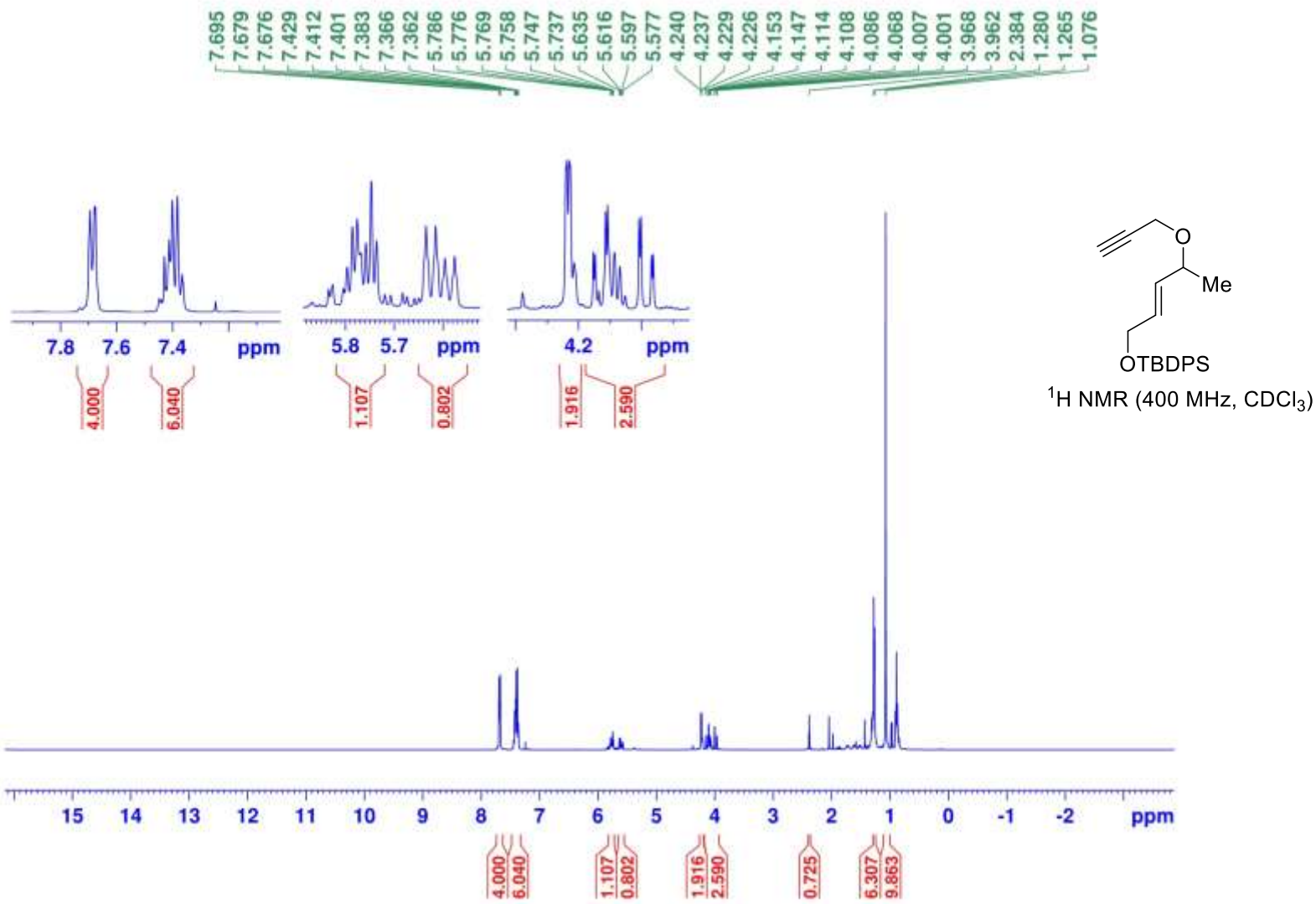




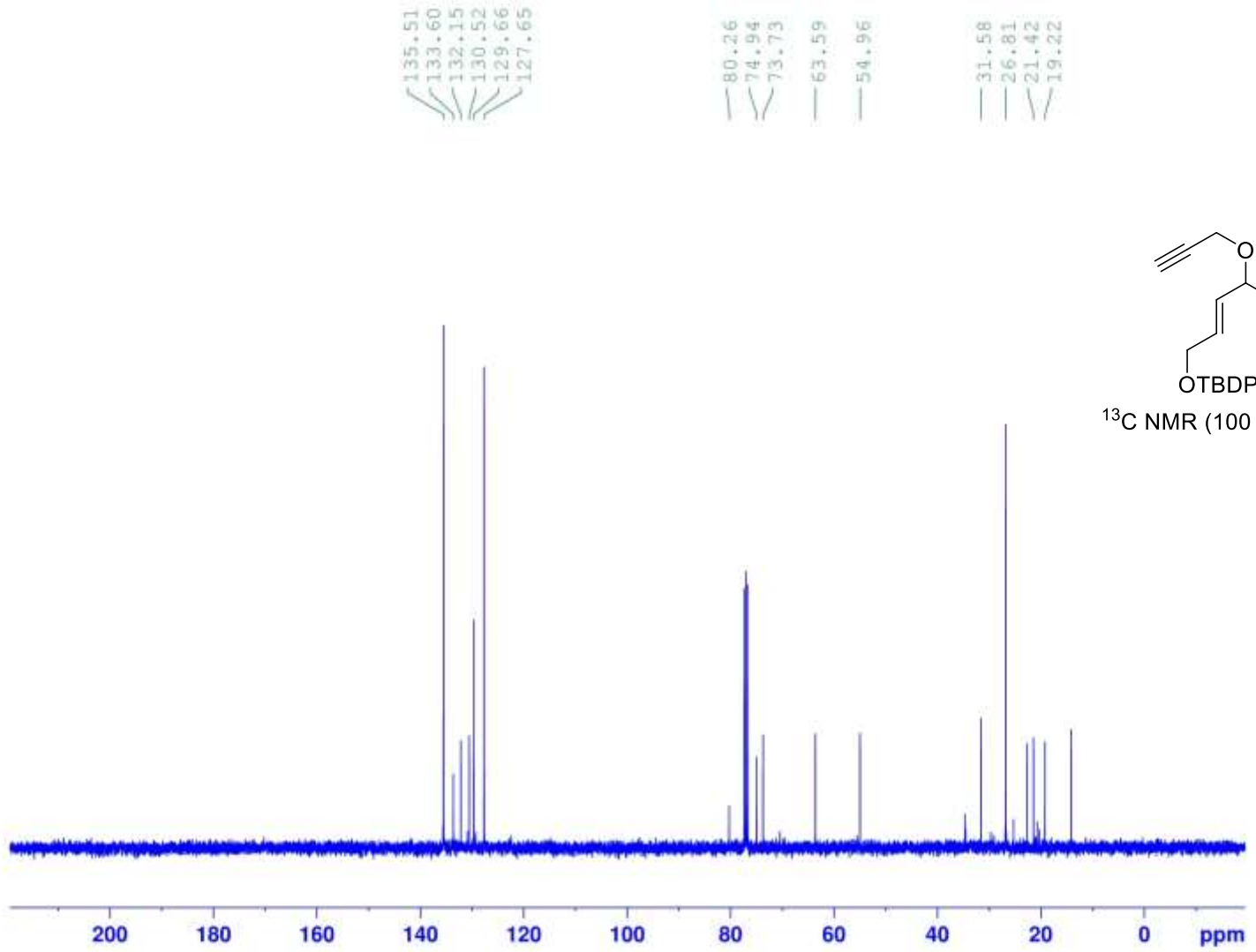
^{1}H NMR (300 MHz, $CDCl_3$)



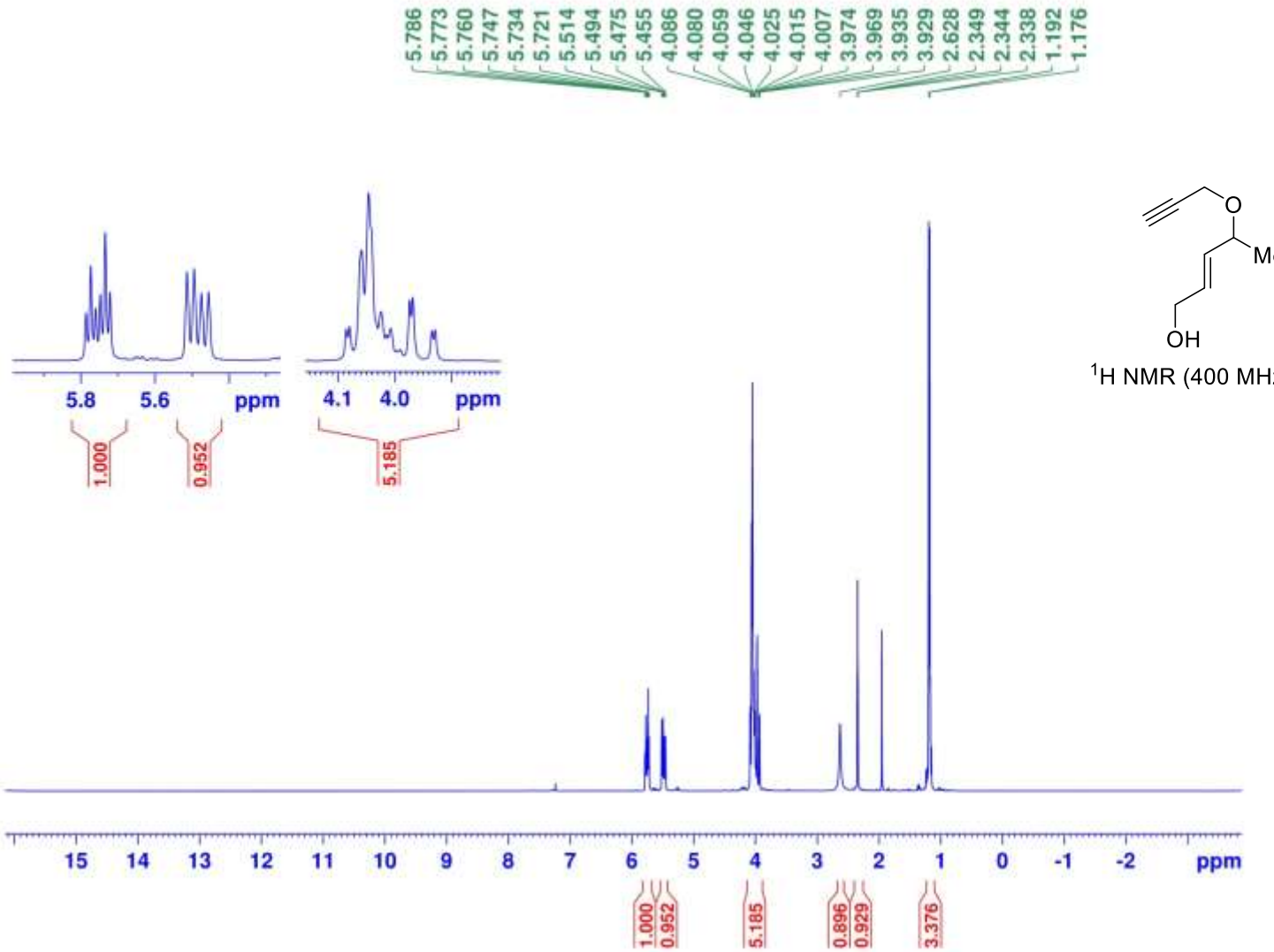
^{13}C NMR (100 MHz, $CDCl_3$)



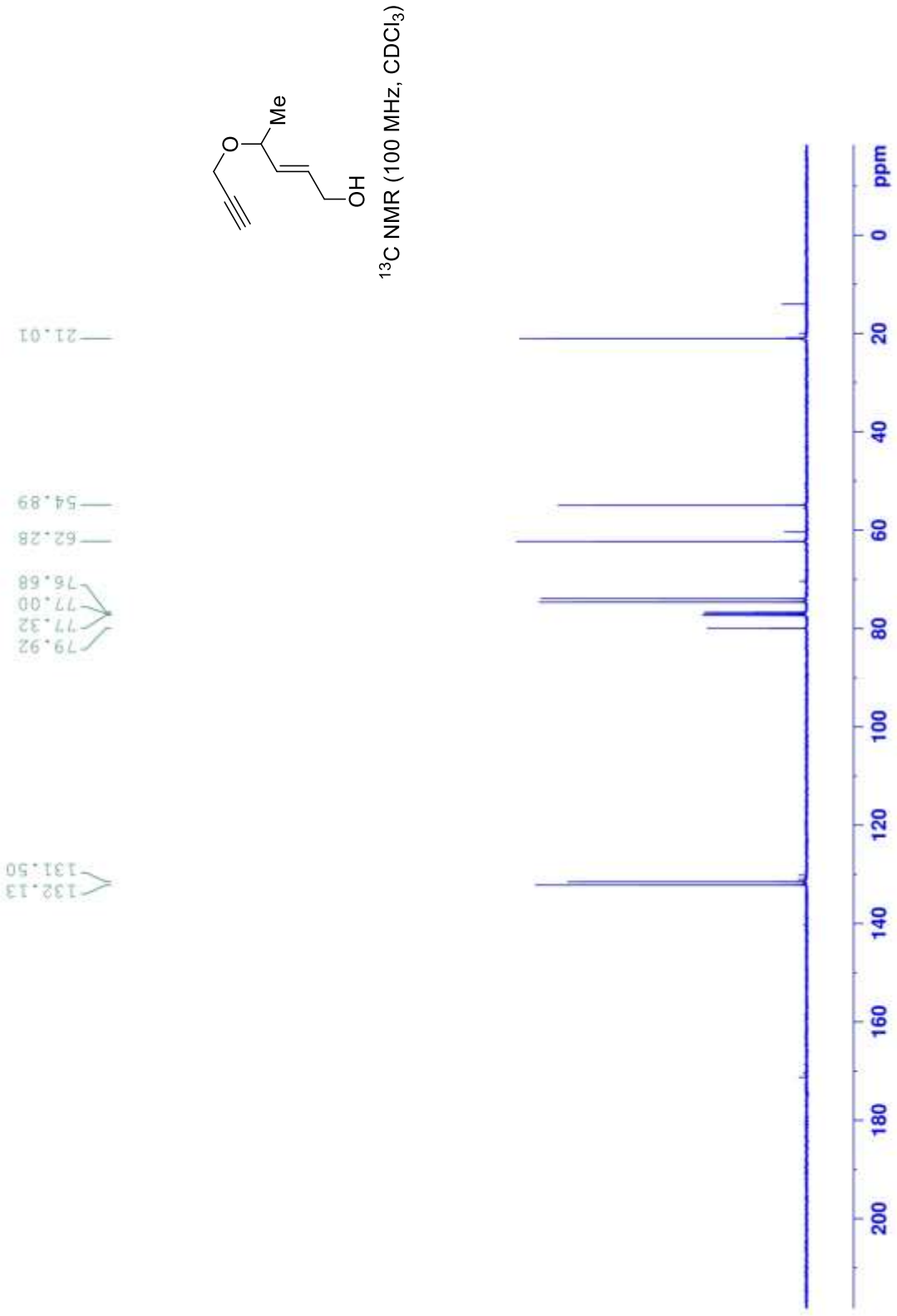
^{1}H NMR (400 MHz, $CDCl_3$)

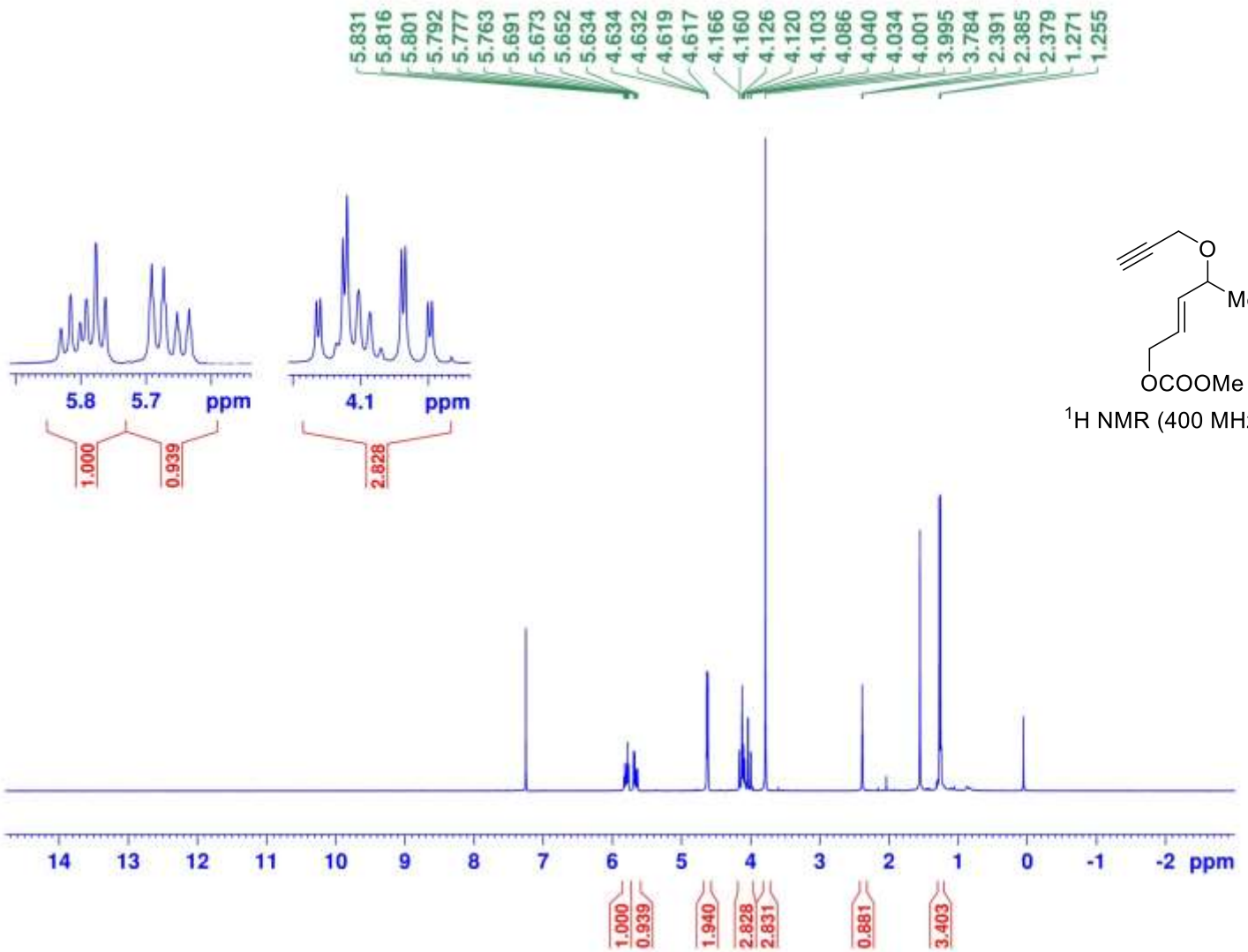


^{13}C NMR (100 MHz, $CDCl_3$)

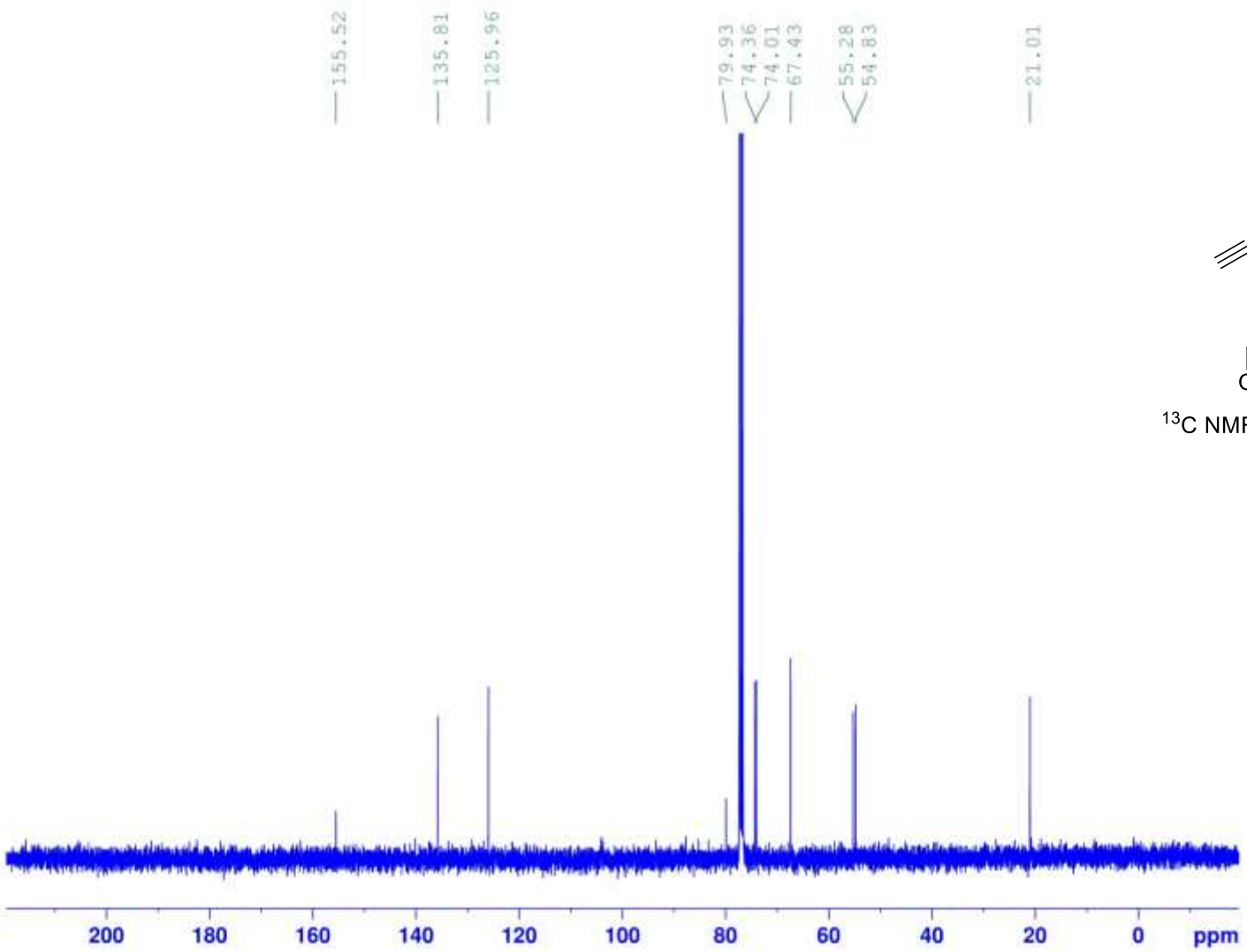


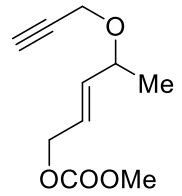
^{1}H NMR (400 MHz, $CDCl_3$)


^{13}C NMR (100 MHz, $CDCl_3$)
Me
O
OH
21.01
54.89
62.28
76.68
77.00
77.32
79.92
131.50
132.13
ppm
0
20
40
60
80
100
120
140
160
180
200



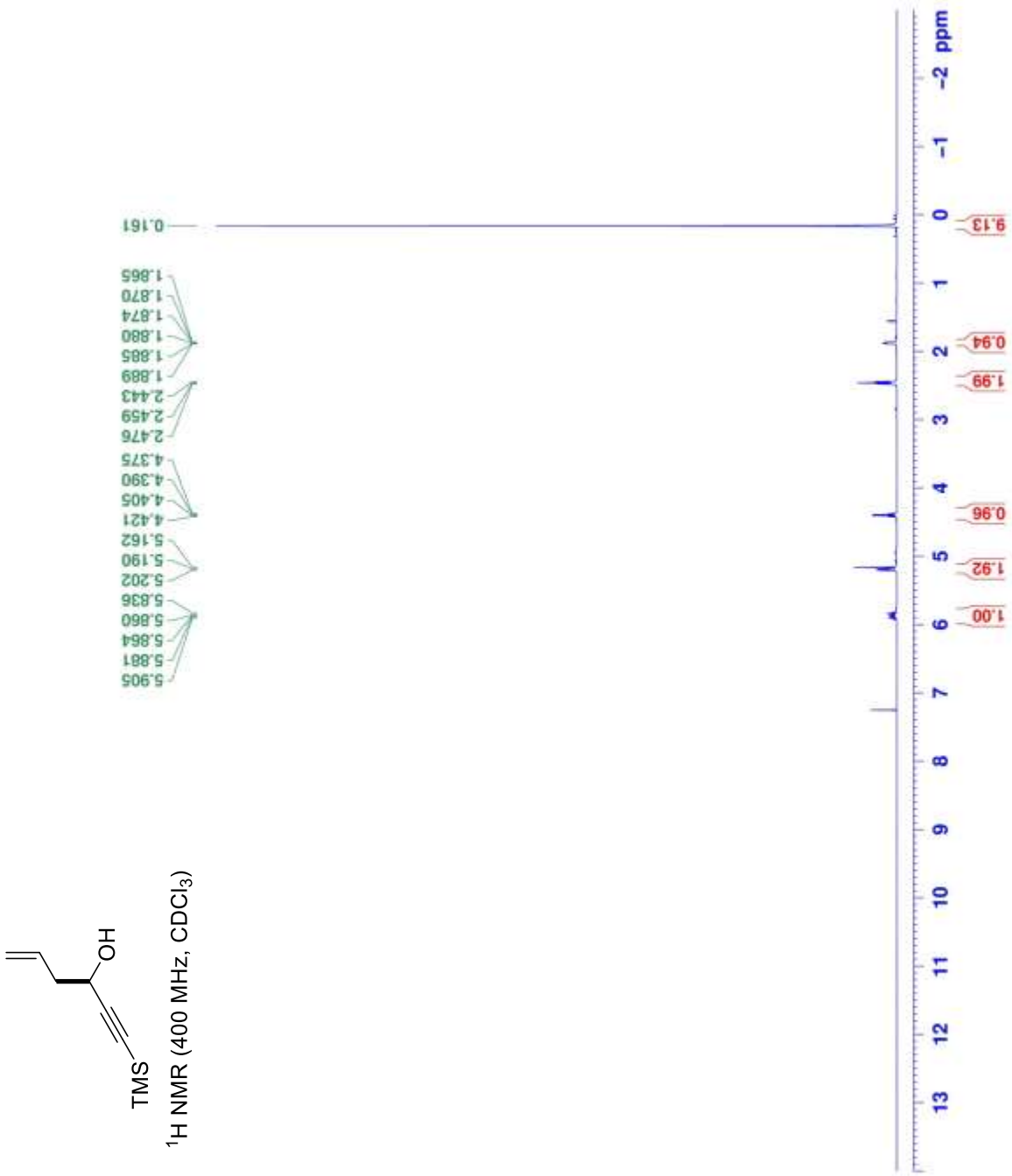
^{1}H NMR (400 MHz, $CDCl_3$)

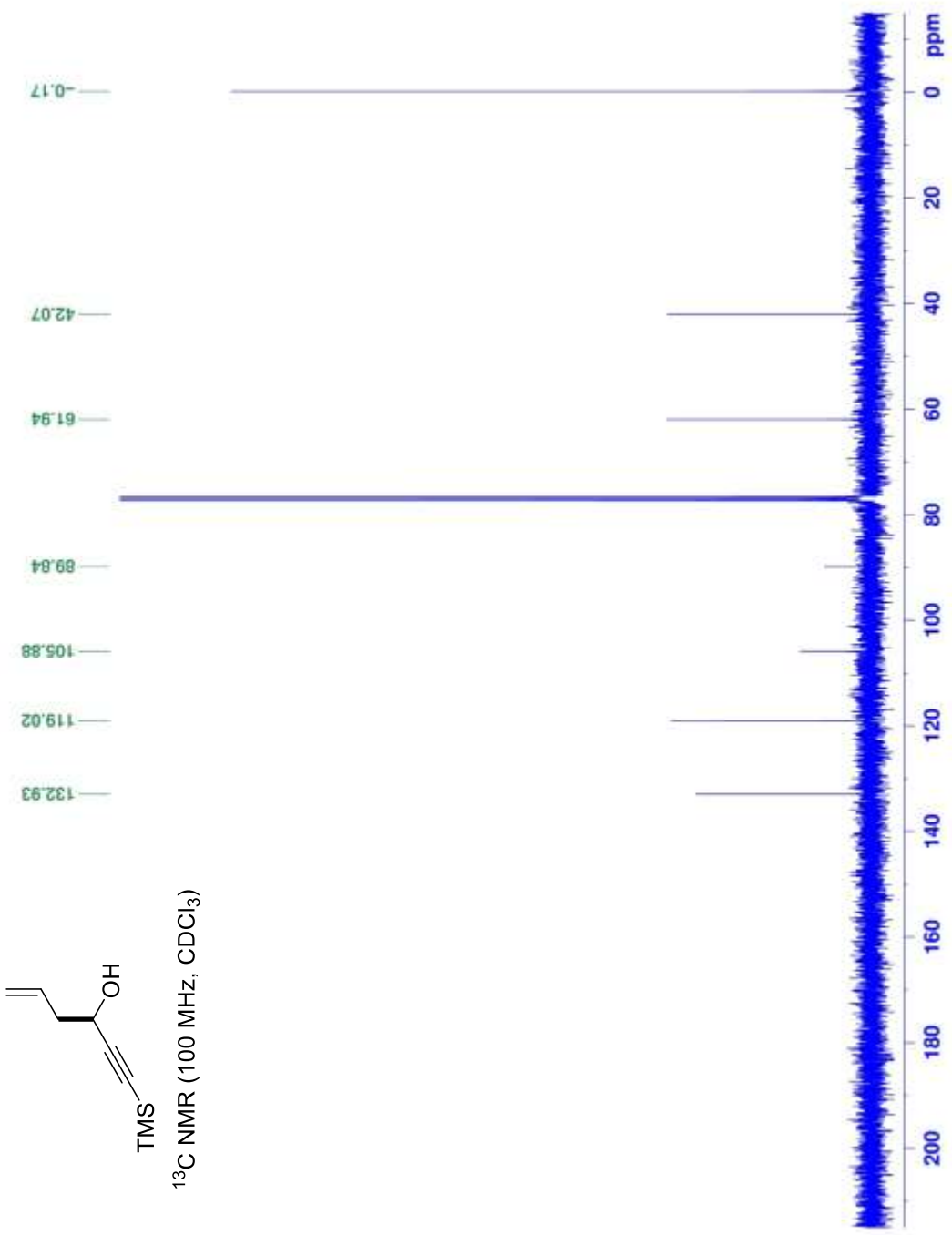




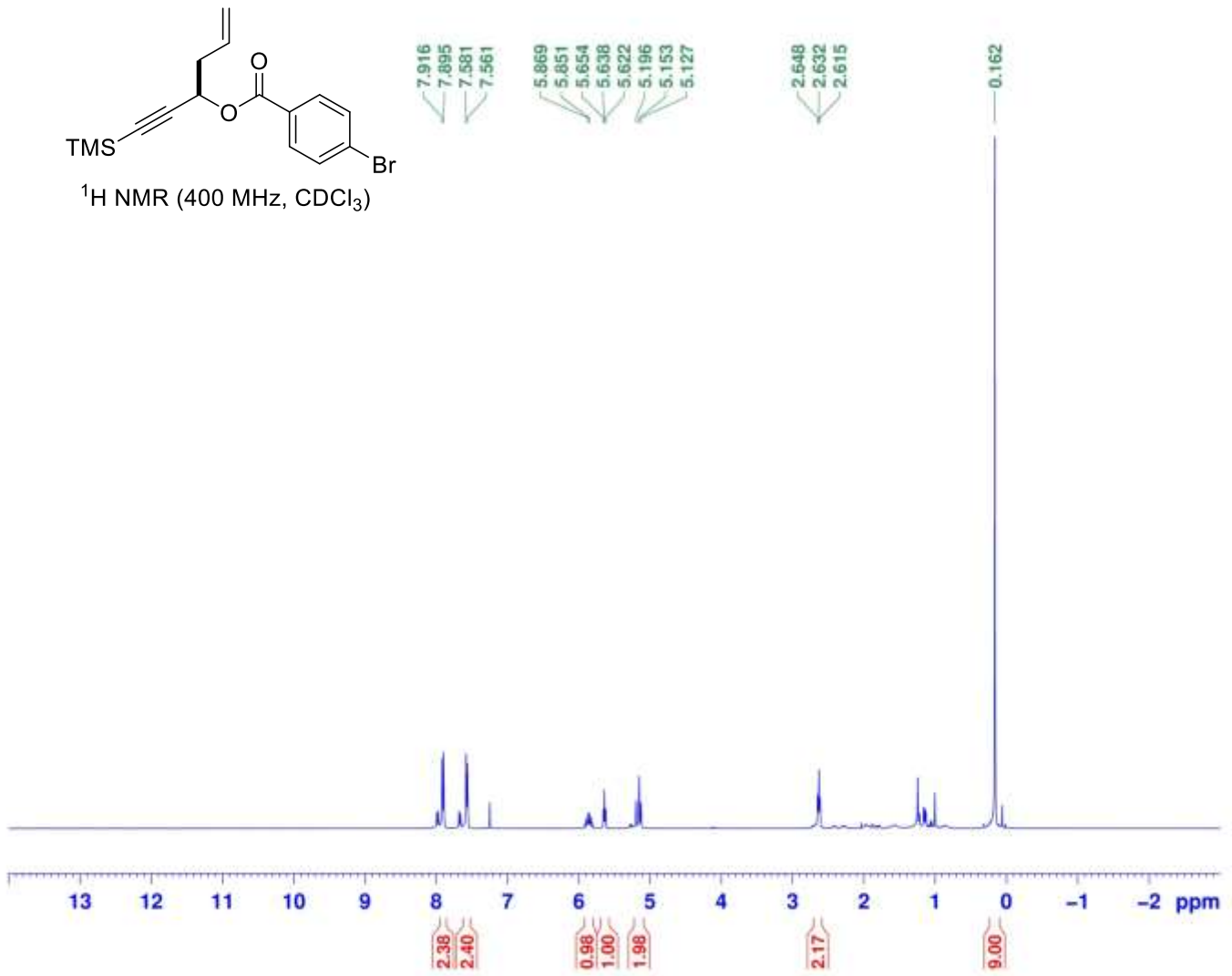
^{13}C NMR (100 MHz, $CDCl_3$)

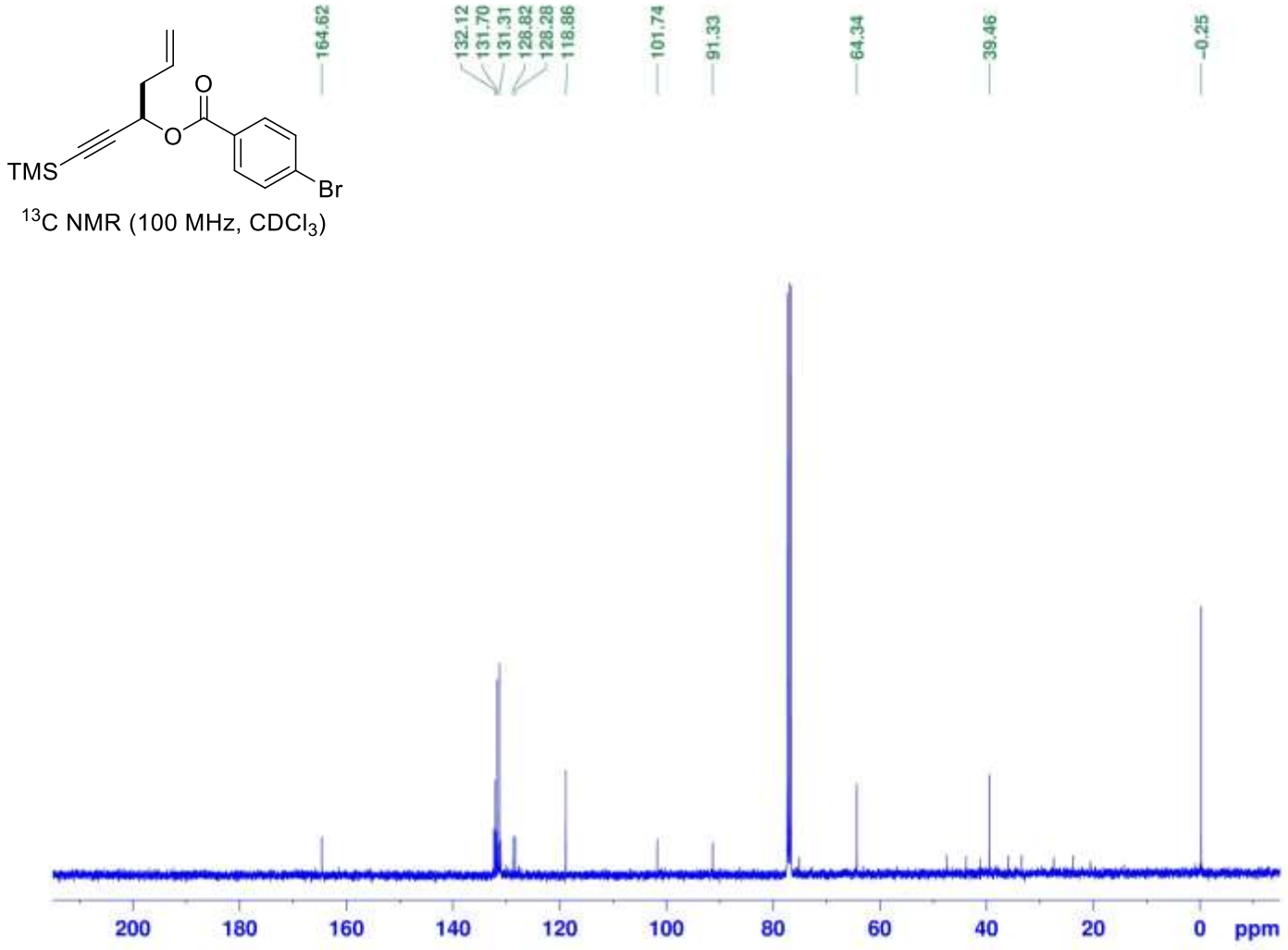
d. *Massarilactone/ Annuionone Core – Leading Intermediates*





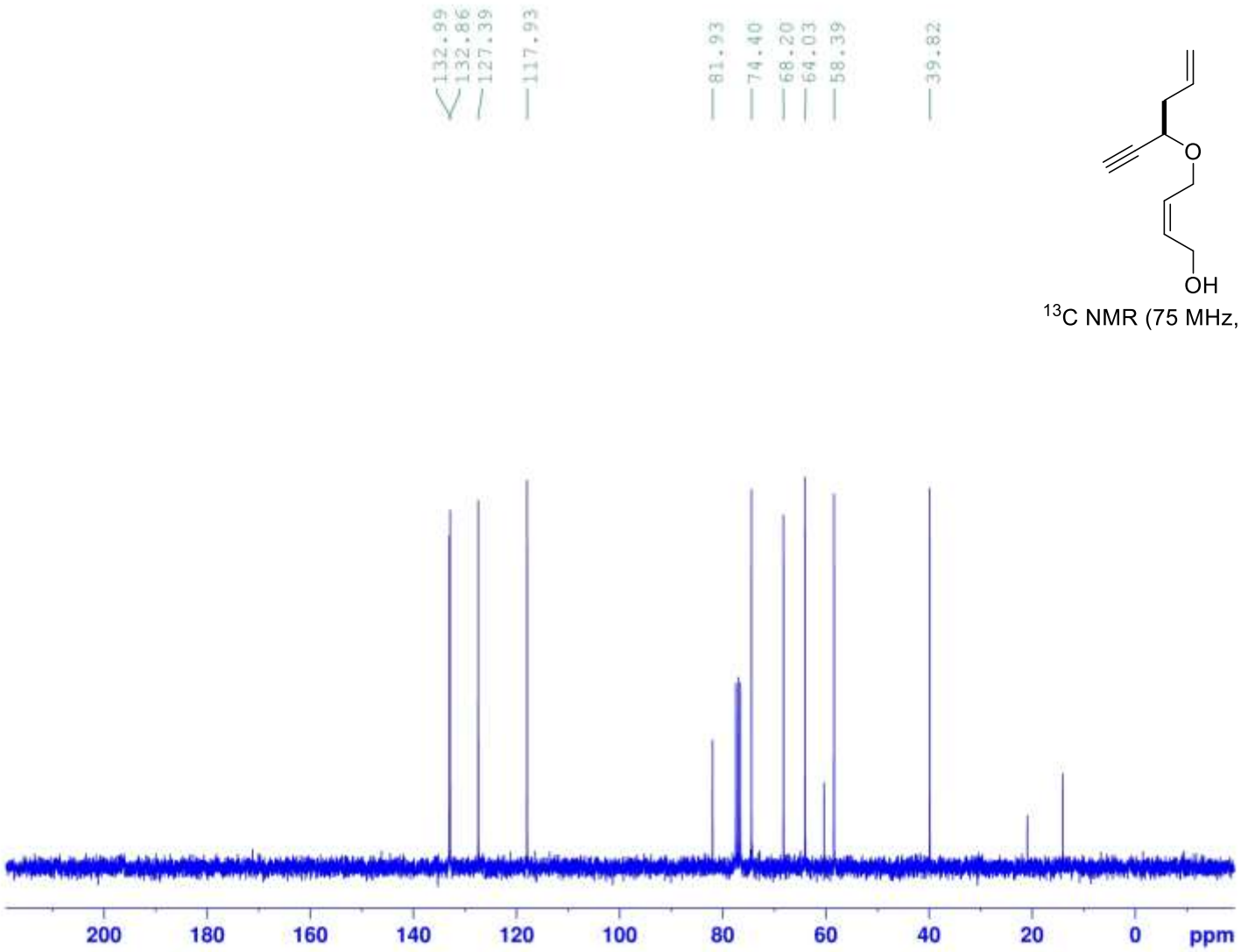
^{13}C NMR (100 MHz, $CDCl_3$)


TMS
O
O
Br
^{1}H NMR (400 MHz, $CDCl_3$)
7.916
7.895
7.581
7.561
5.869
5.851
5.654
5.638
5.622
5.196
5.153
5.127
2.648
2.632
2.615
0.162
13
12
11
10
9
8
7
6
5
4
3
2
1
0
−1
−2 ppm
2.38
2.40
0.98
1.00
1.98
2.17
9.00

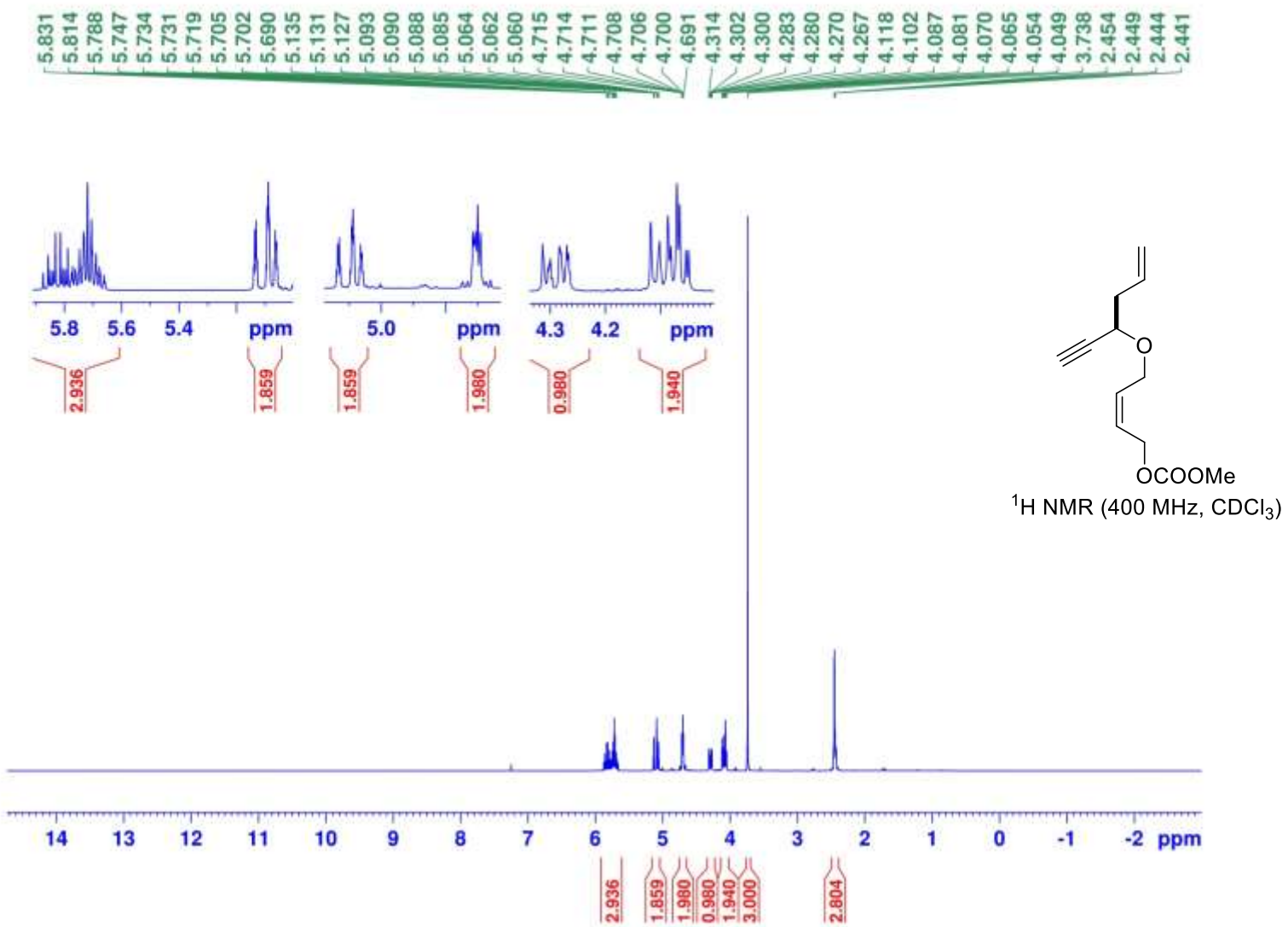


^{13}C NMR (100 MHz, $CDCl_3$)

^{1}H NMR (300 MHz, $CDCl_3$)



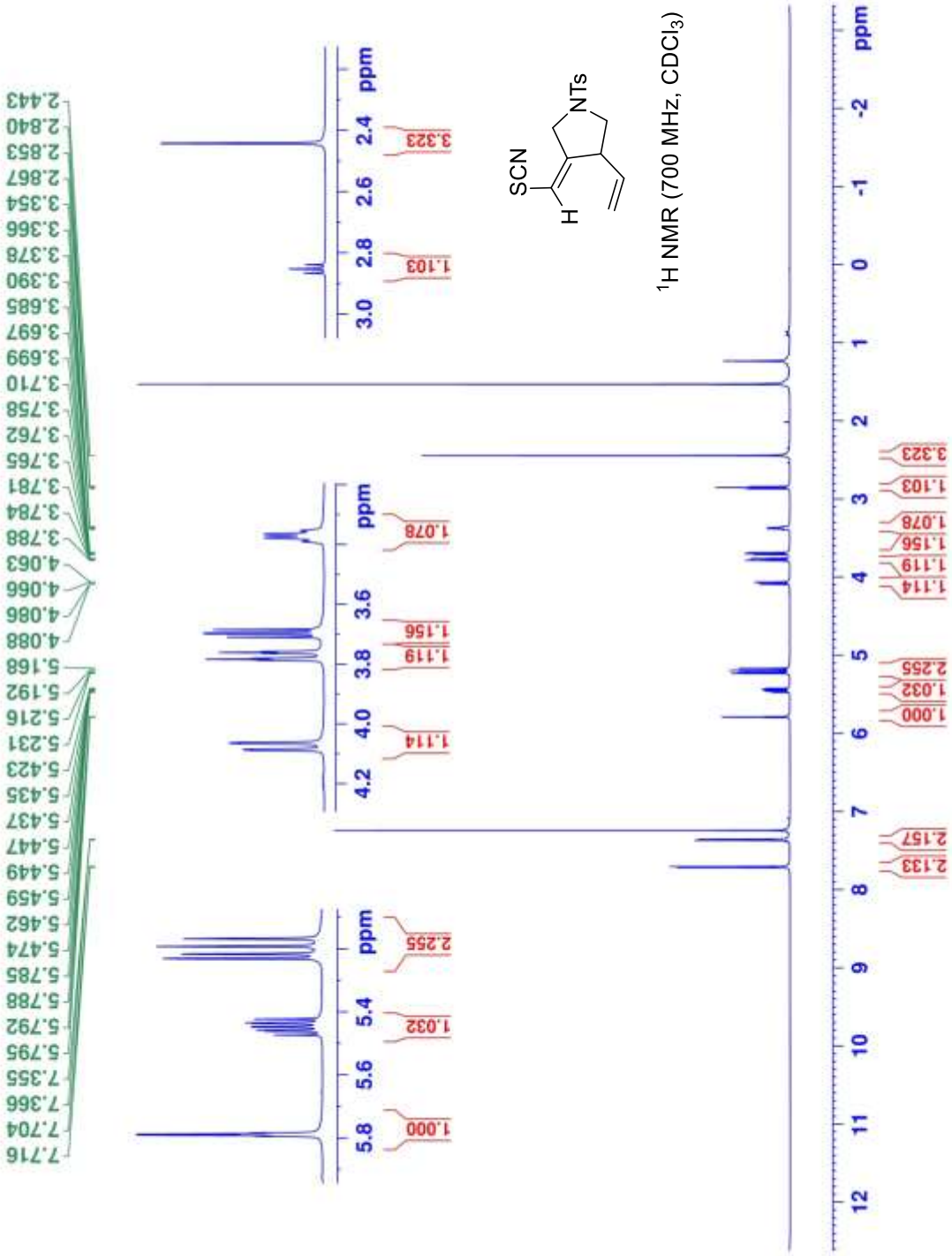
^{13}C NMR (75 MHz, $CDCl_3$)

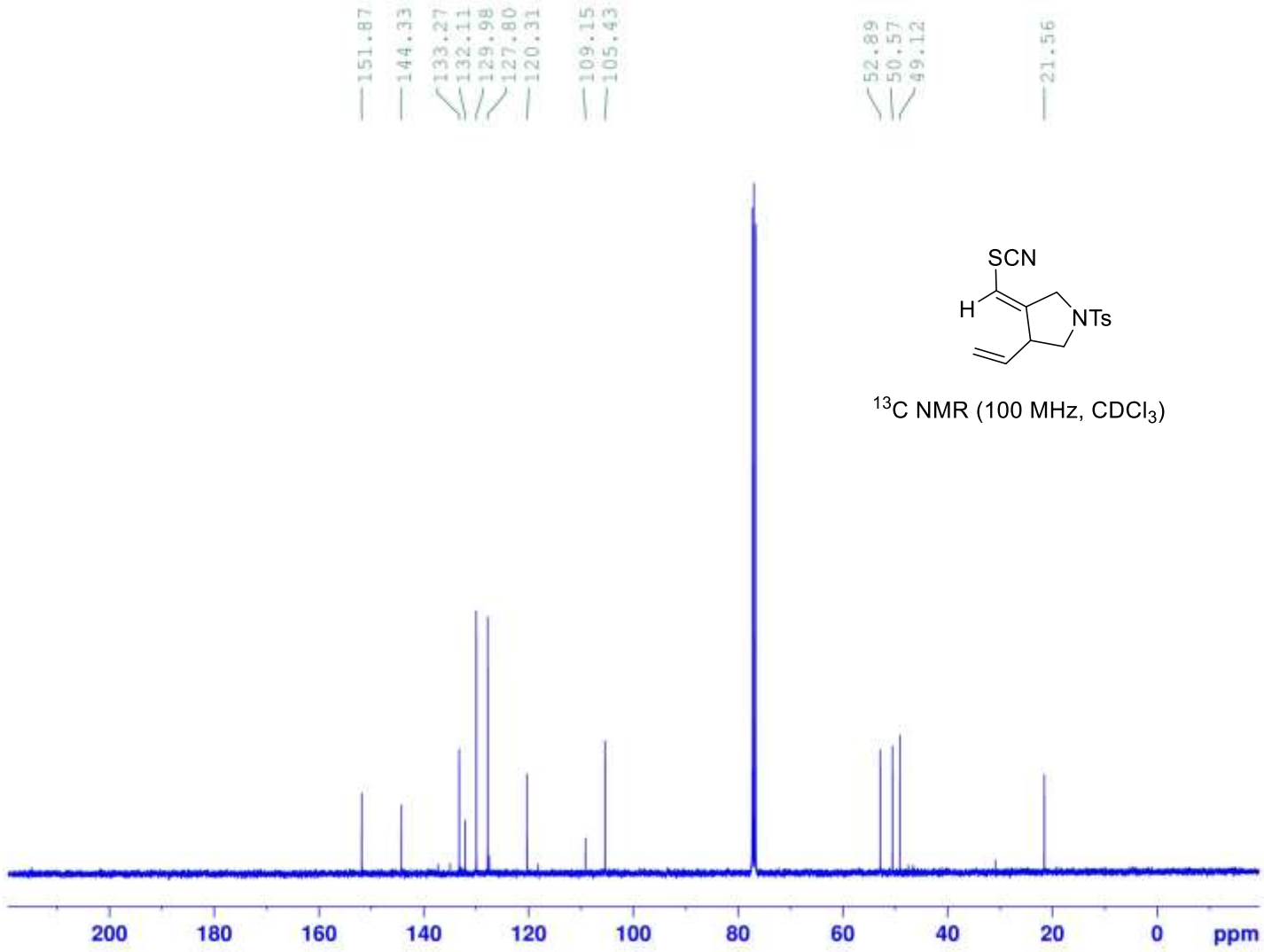


^{1}H NMR (400 MHz, $CDCl_3$)

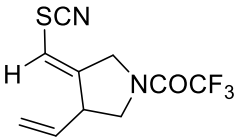
OCOOMe
^{13}C NMR (100 MHz, $CDCl_3$)
39.81
54.67
63.56
64.05
68.30
74.40
81.87
117.83
126.50
130.48
133.04
155.51
ppm
0
20
40
60
80
100
120
140
160
180
200

e. *Thiocyanopalladation products*

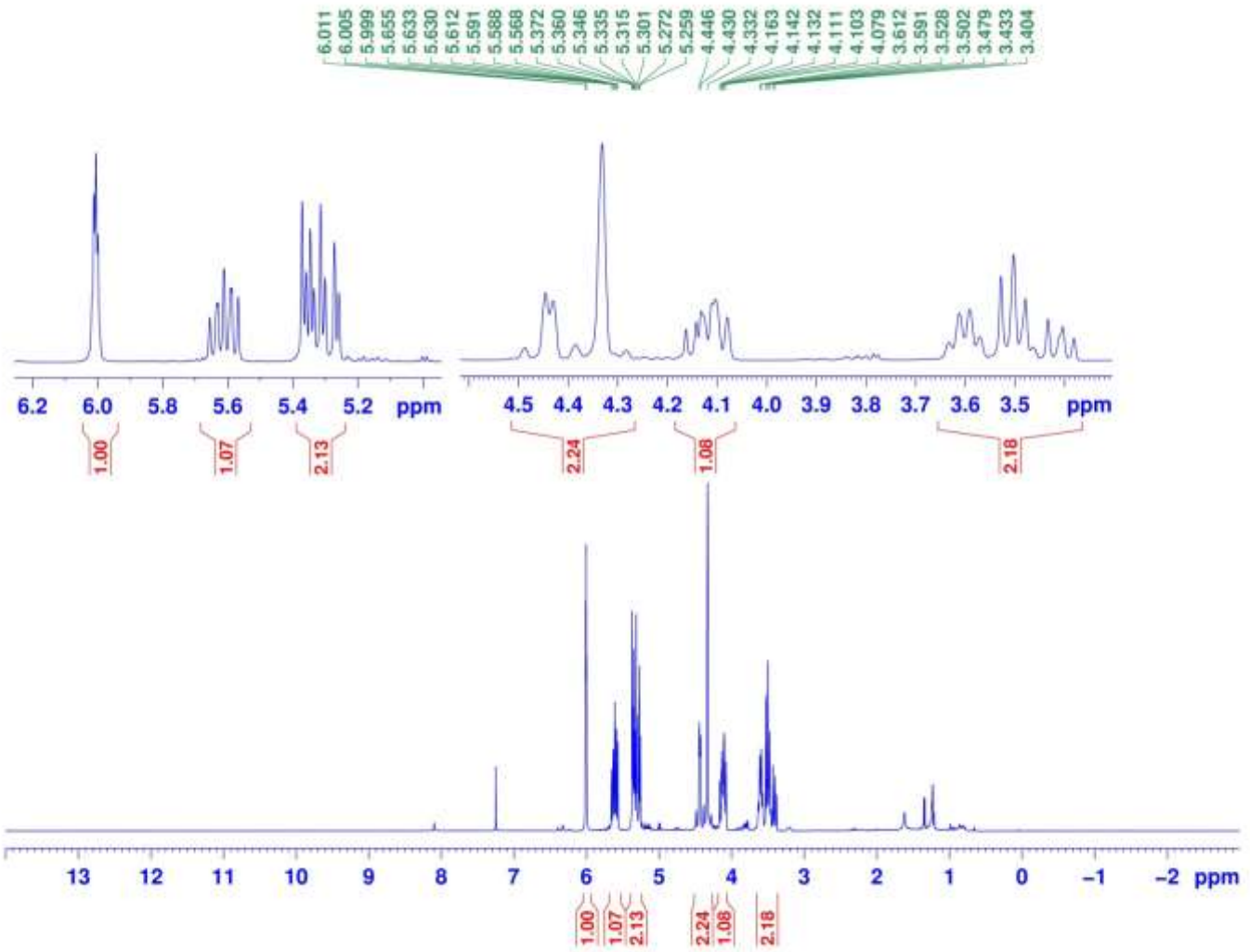


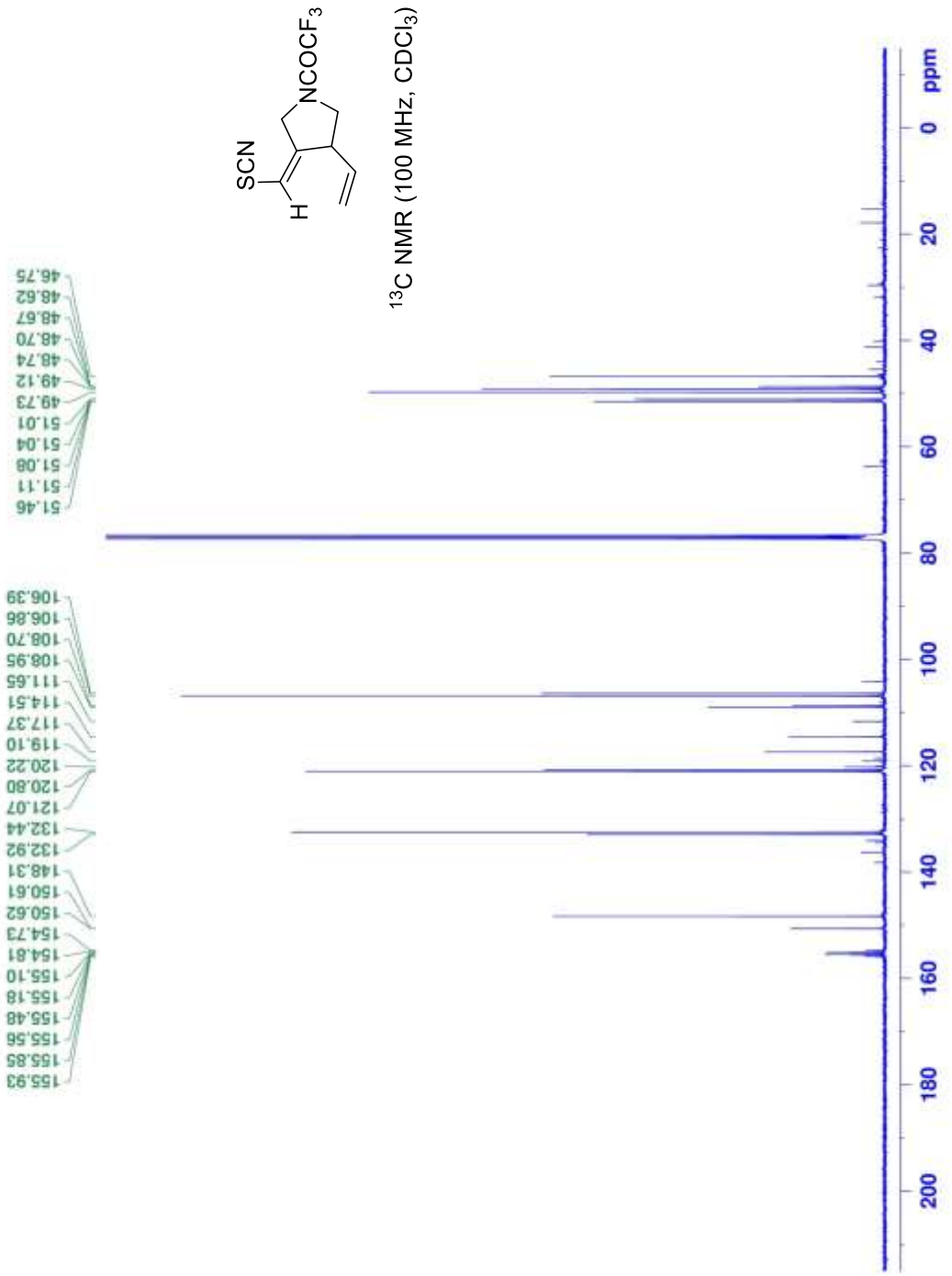


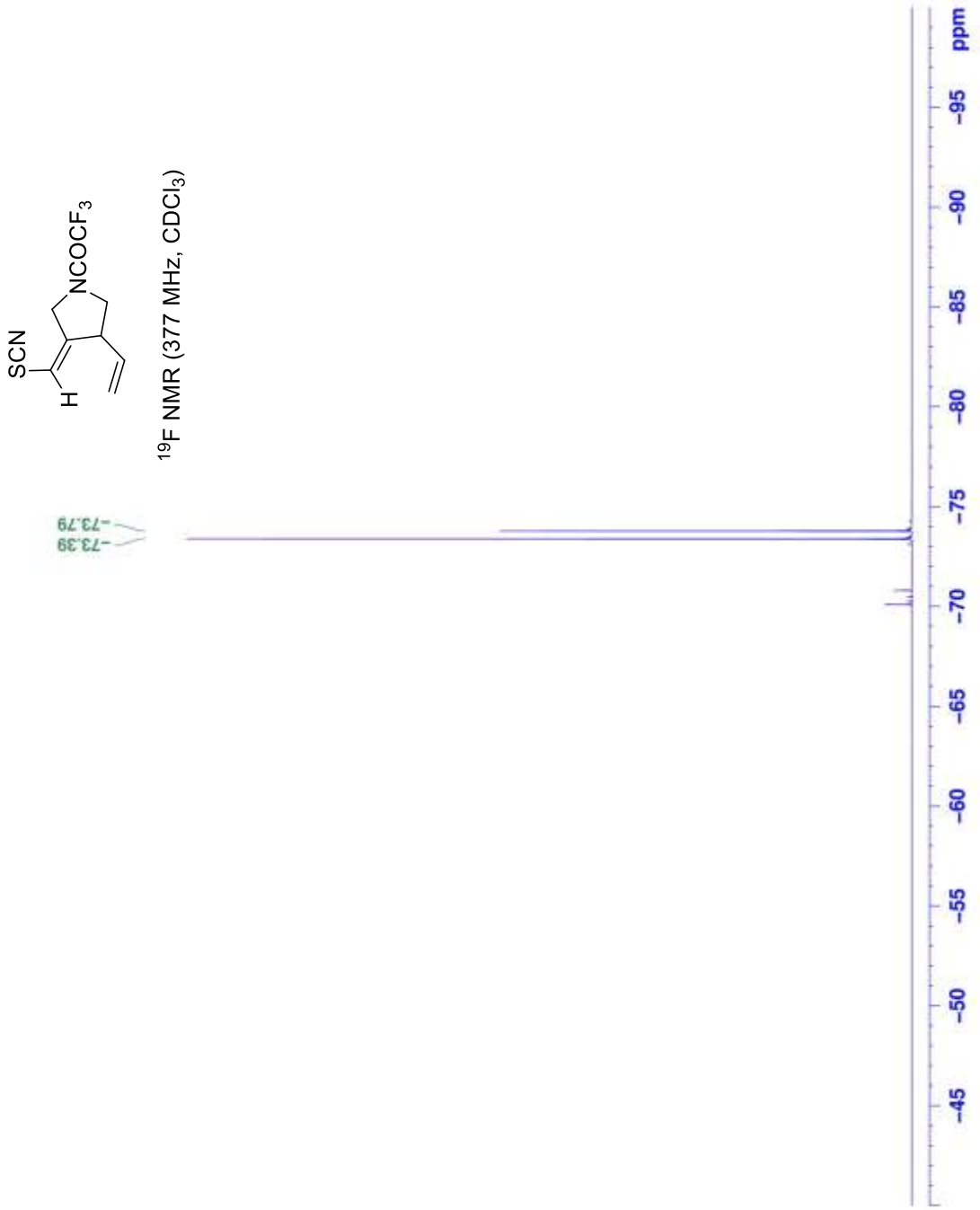
^{13}C NMR (100 MHz, $CDCl_3$)

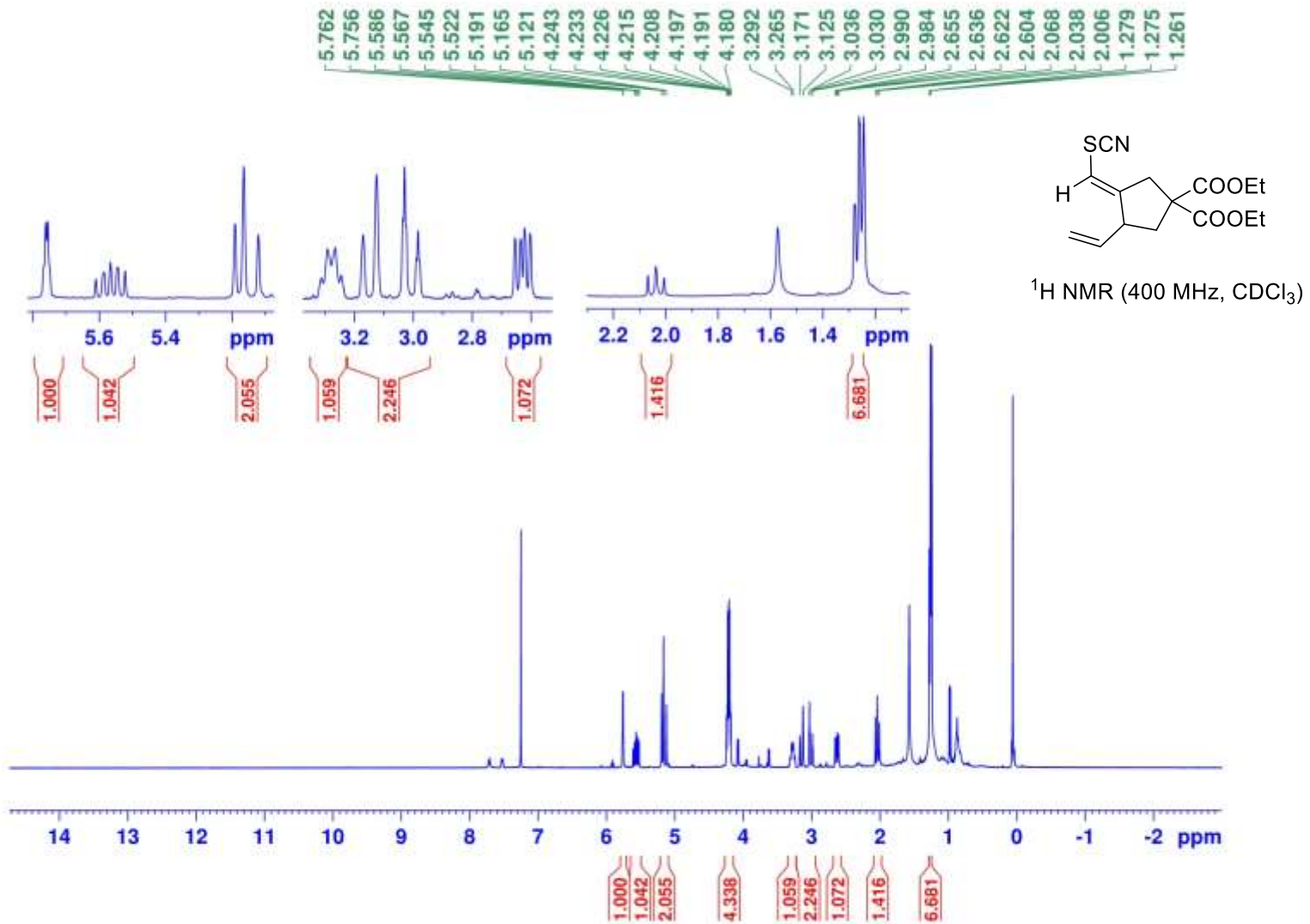


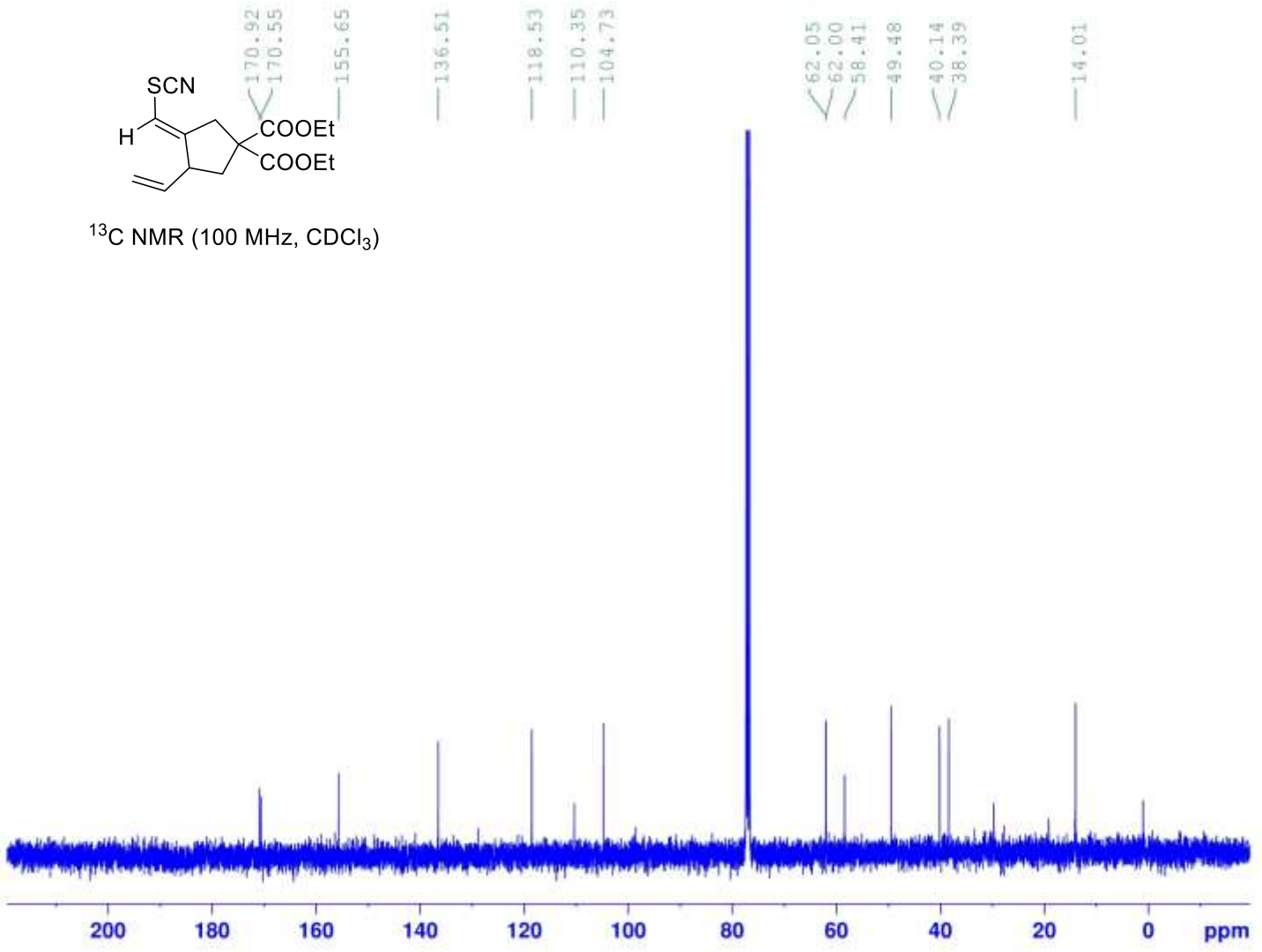
^{1}H NMR (400 MHz, $CDCl_3$)



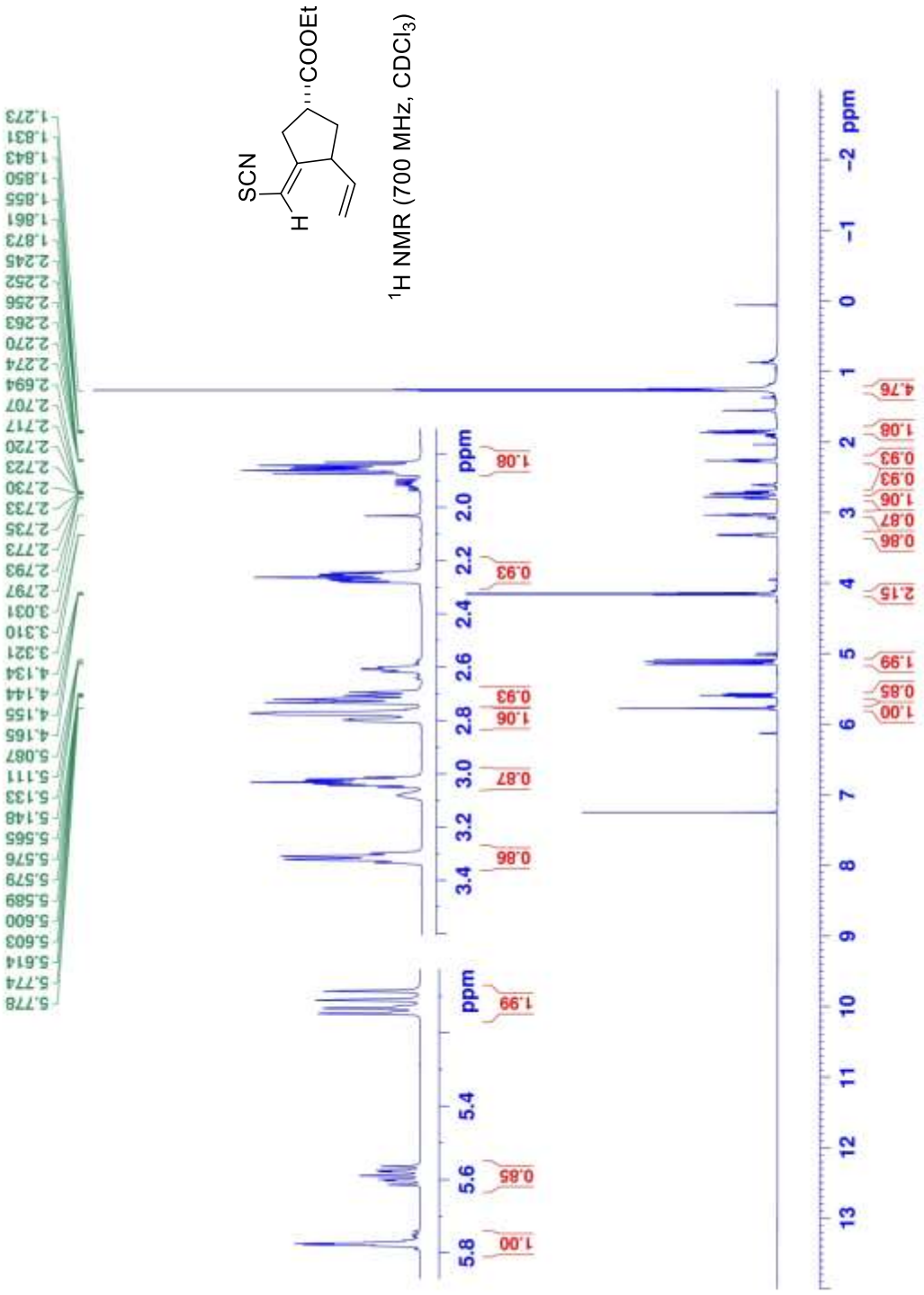

SCN
NCOCF3
H
13C NMR (100 MHz, CDCl3)
ppm
0
20
40
60
80
100
120
140
160
180
200
46.75
48.62
48.67
48.70
48.74
49.12
49.73
51.01
51.04
51.08
51.11
51.46
106.39
106.86
108.70
108.95
111.65
114.51
117.37
119.10
120.22
120.80
121.07
132.44
132.92
148.31
150.61
150.62
154.73
154.81
155.10
155.18
155.48
155.56
155.85
155.93

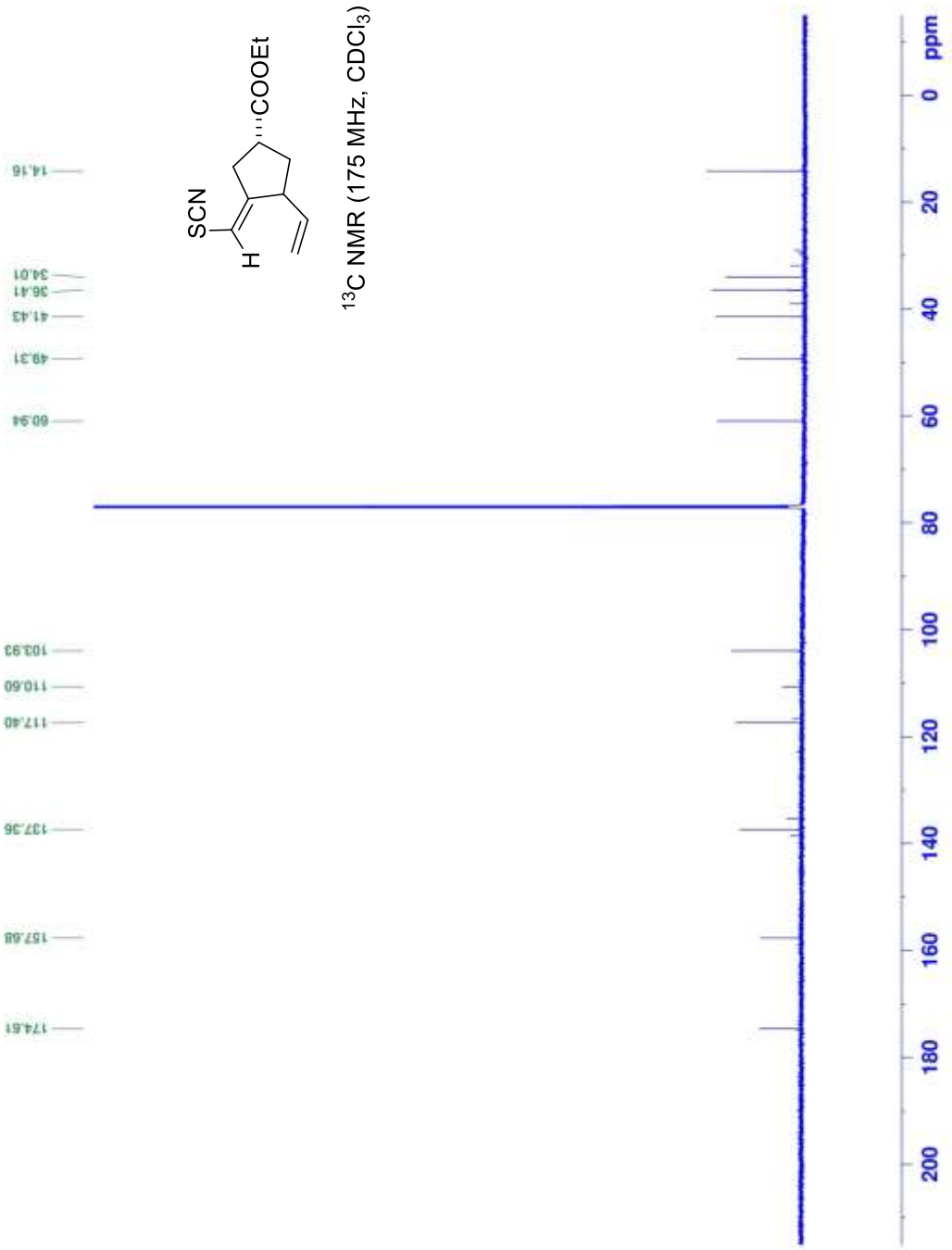

SCN
H
NCOCF3
19F NMR (377 MHz, CDCl3)
-73.39
-73.79
ppm
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
-95

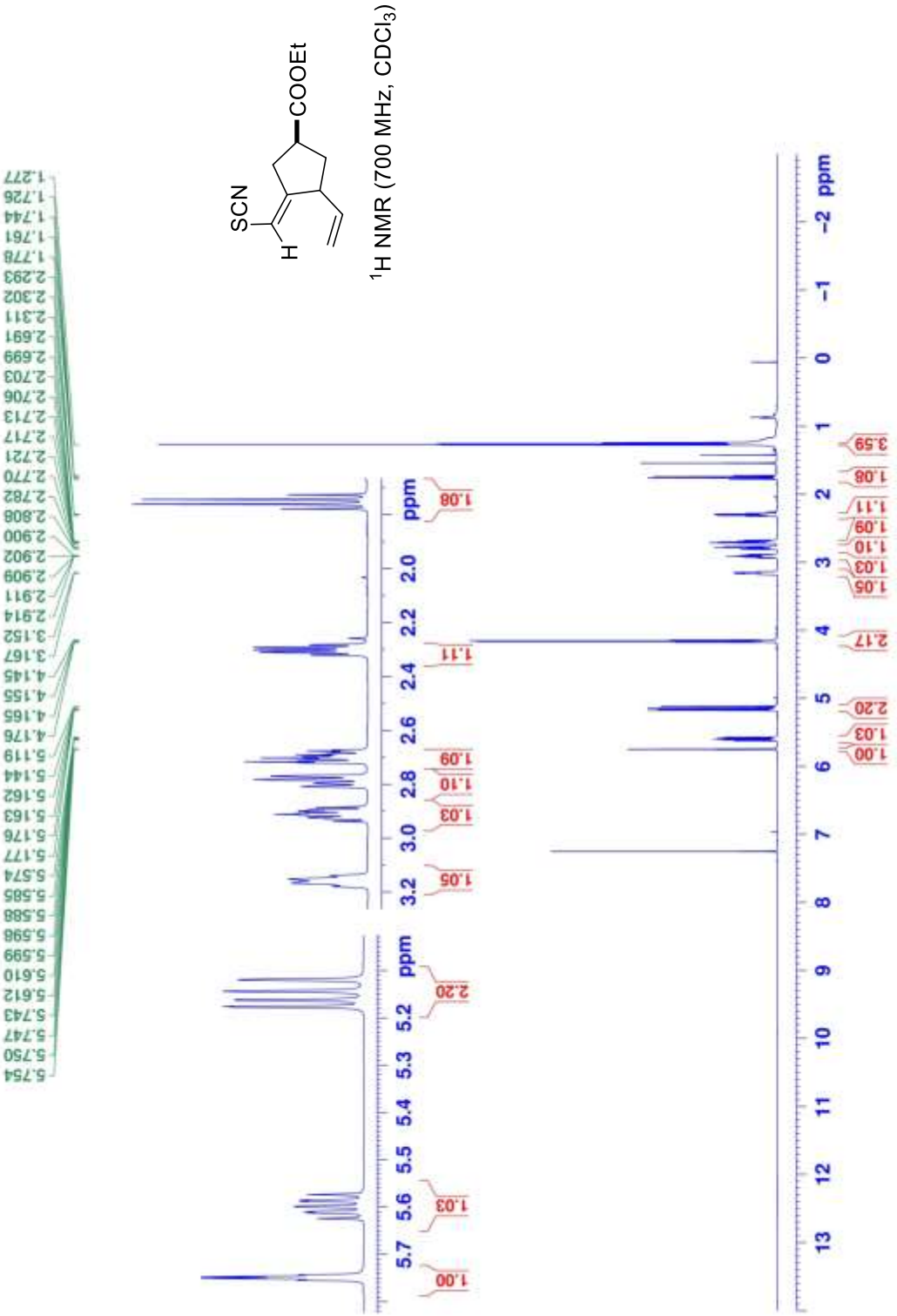

5.762
5.756
5.586
5.567
5.545
5.522
5.191
5.165
5.121
4.243
4.233
4.226
4.215
4.208
4.197
4.191
4.180
3.292
3.265
3.171
3.125
3.036
3.030
2.990
2.984
2.655
2.636
2.622
2.604
2.068
2.038
2.006
1.279
1.275
1.261
SCN
H
COOEt
COOEt
1H NMR (400 MHz, CDCl3)
5.6
5.4
ppm
3.2
3.0
2.8
ppm
2.2
2.0
1.8
1.6
1.4
ppm
1.000
1.042
2.055
1.059
2.246
1.072
1.416
6.681
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
ppm
1.000
1.042
2.055
4.338
1.059
2.246
1.072
1.416
6.681

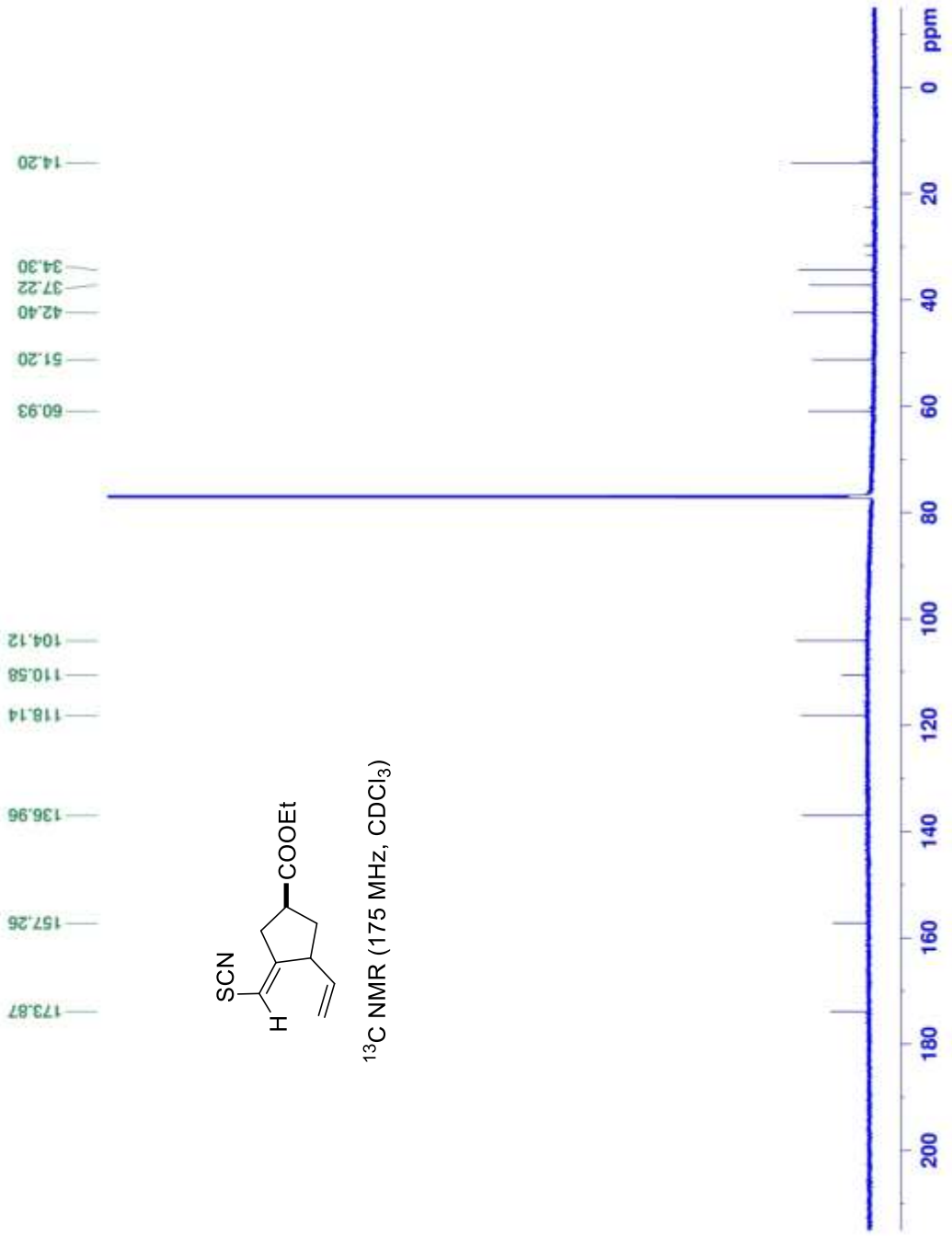


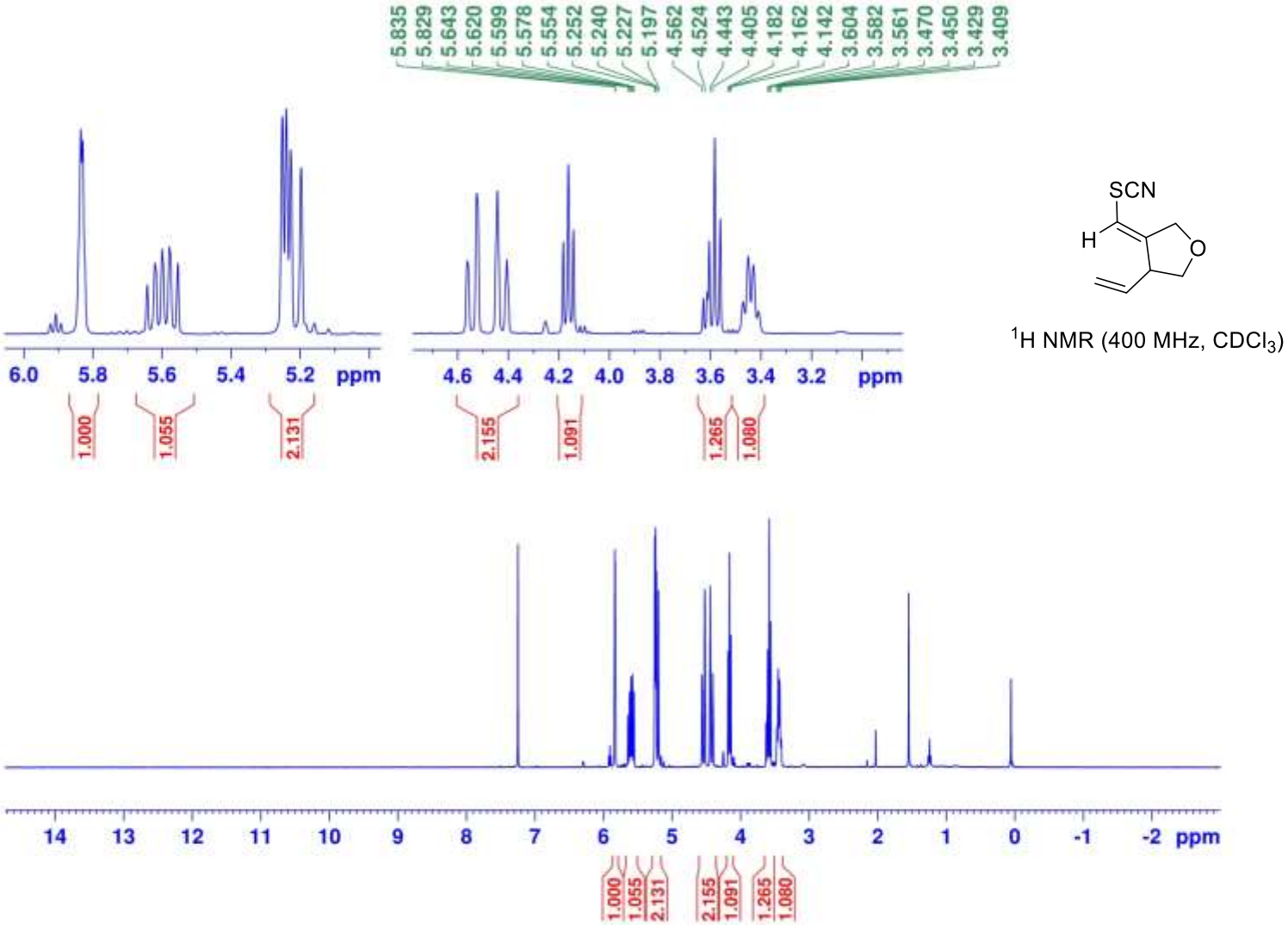
^{13}C NMR (100 MHz, $CDCl_3$)


SCN
COOEt
H
^{1}H NMR (700 MHz, CDCl$_3$)

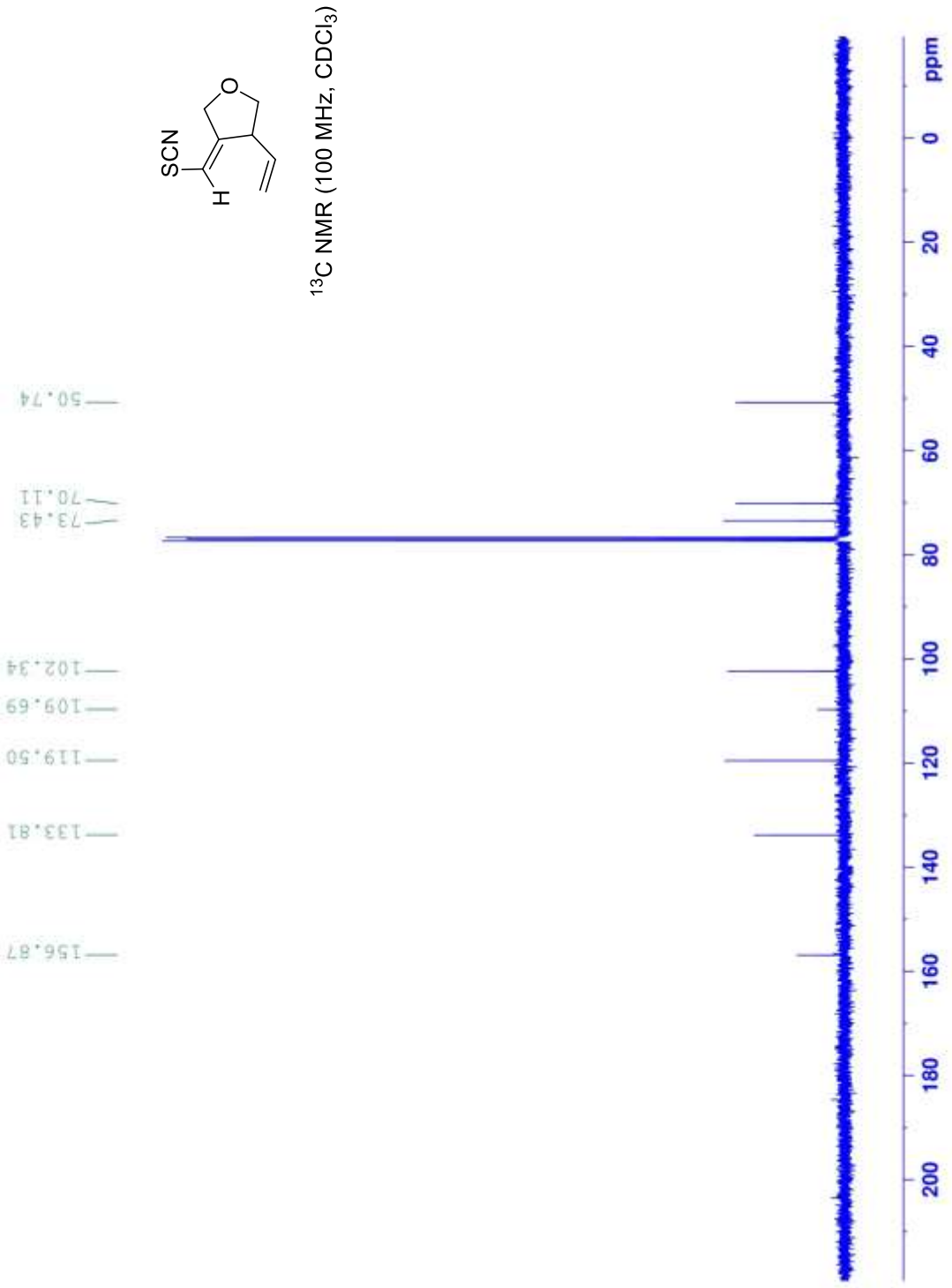

SCN
COOEt
H
^{13}C NMR (175 MHz, $CDCl_3$)
14.16
34.01
36.41
41.43
49.31
60.94
103.93
110.60
117.40
137.36
157.68
174.61
ppm
0
20
40
60
80
100
120
140
160
180
200

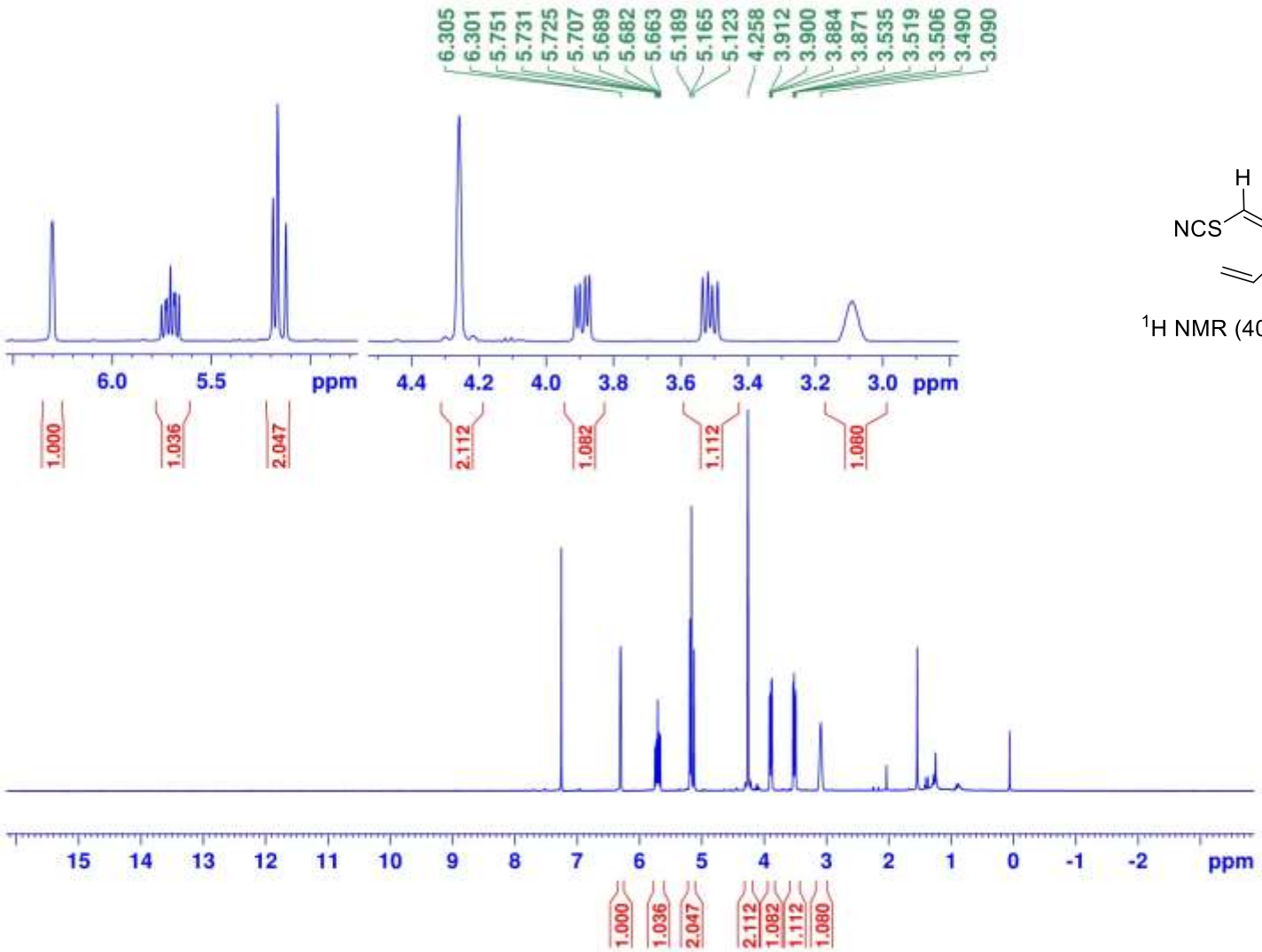

SCN
COOEt
H
^{1}H NMR (700 MHz, CDCl$_3$)


14.20
34.30
37.22
42.40
51.20
60.93
104.12
110.58
118.14
136.96
157.26
173.87
SCN
COOEt
H
^{13}C NMR (175 MHz, $CDCl_3$)
0
20
40
60
80
100
120
140
160
180
200
ppm

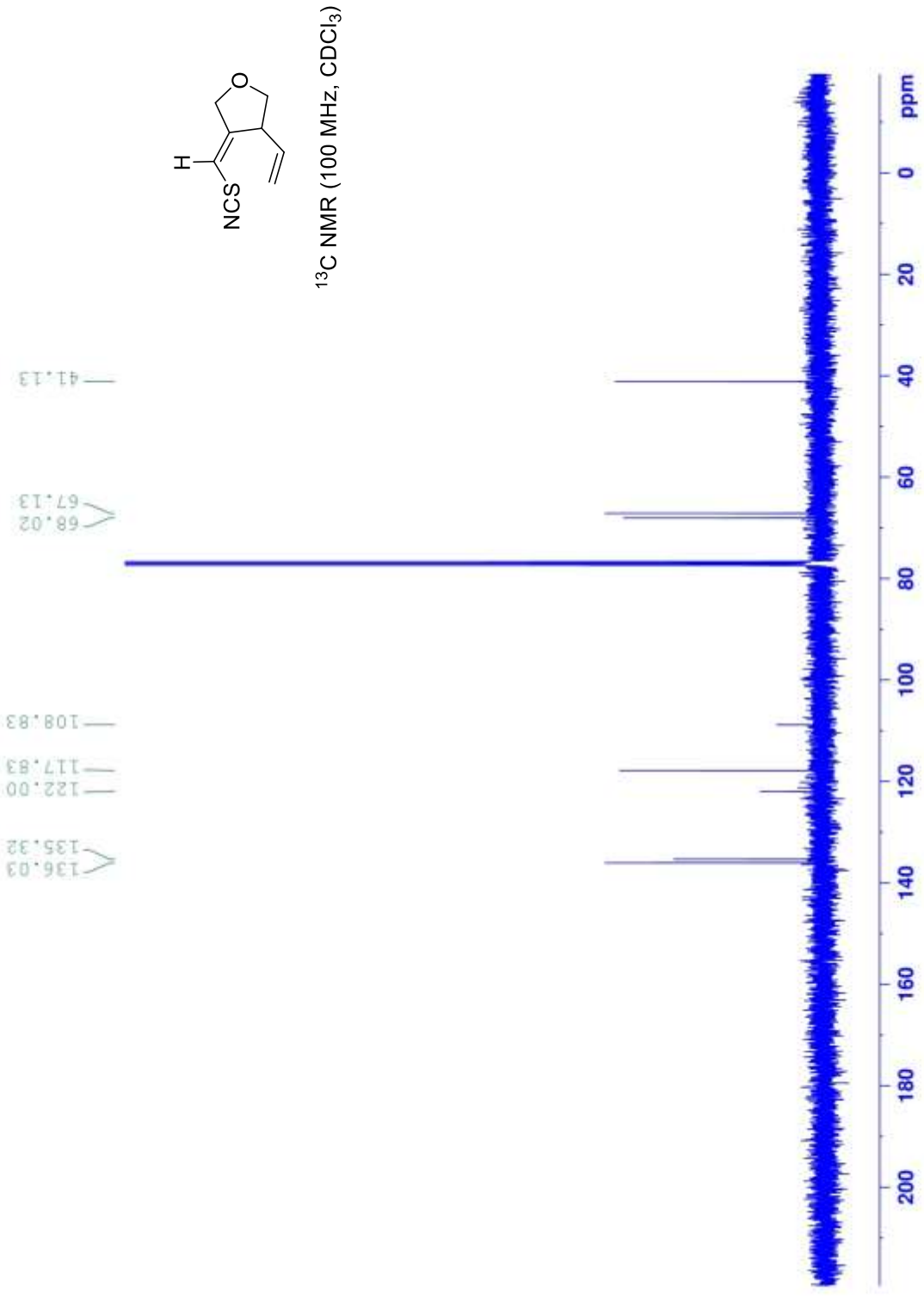


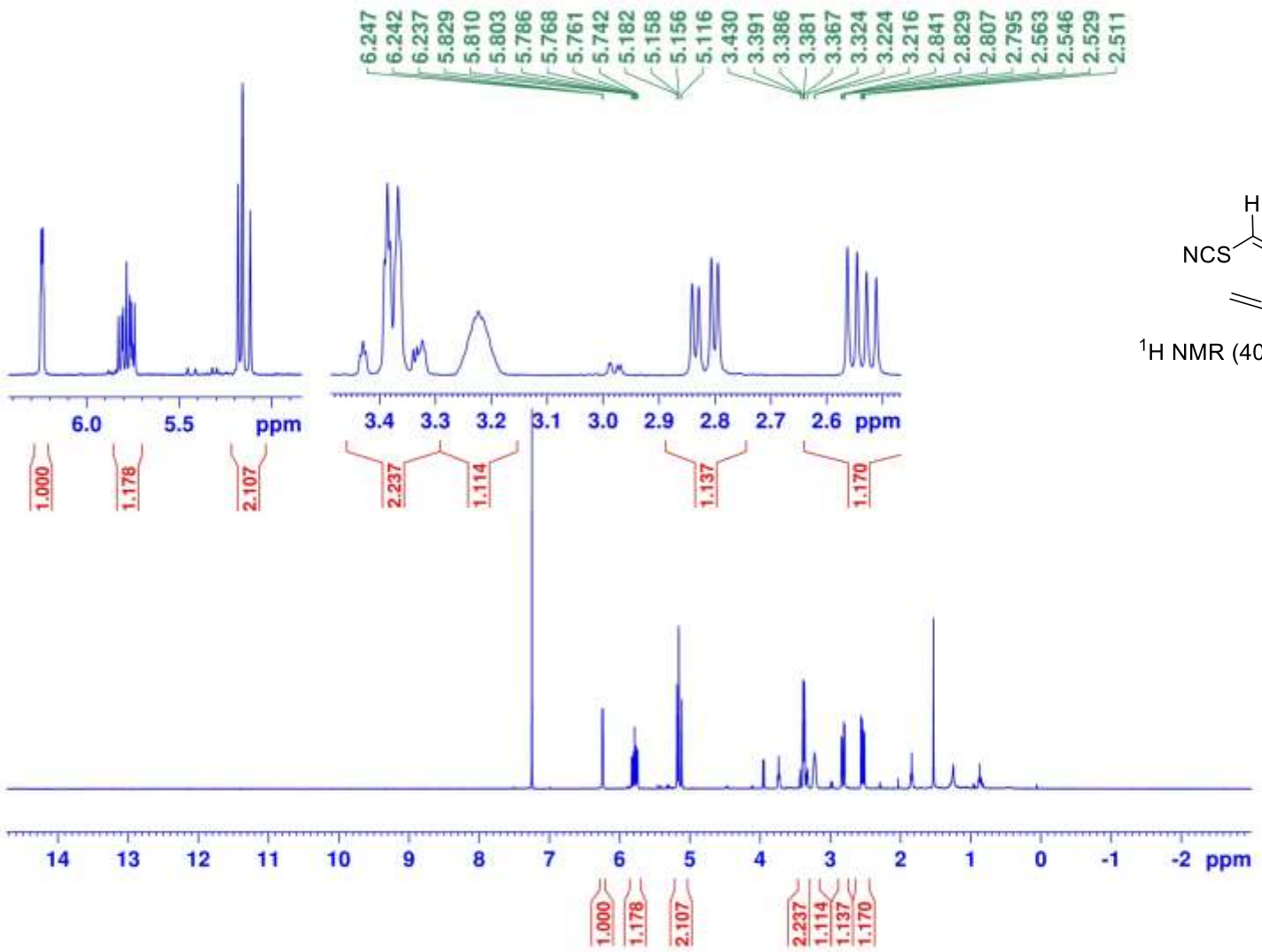
^{1}H NMR (400 MHz, $CDCl_3$)

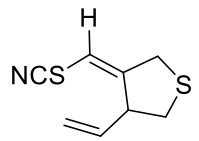

SCN
O
H
^{13}C NMR (100 MHz, CDCl$_3$)
50.74
70.11
73.43
102.34
109.69
119.50
133.81
156.87
ppm
0
20
40
60
80
100
120
140
160
180
200



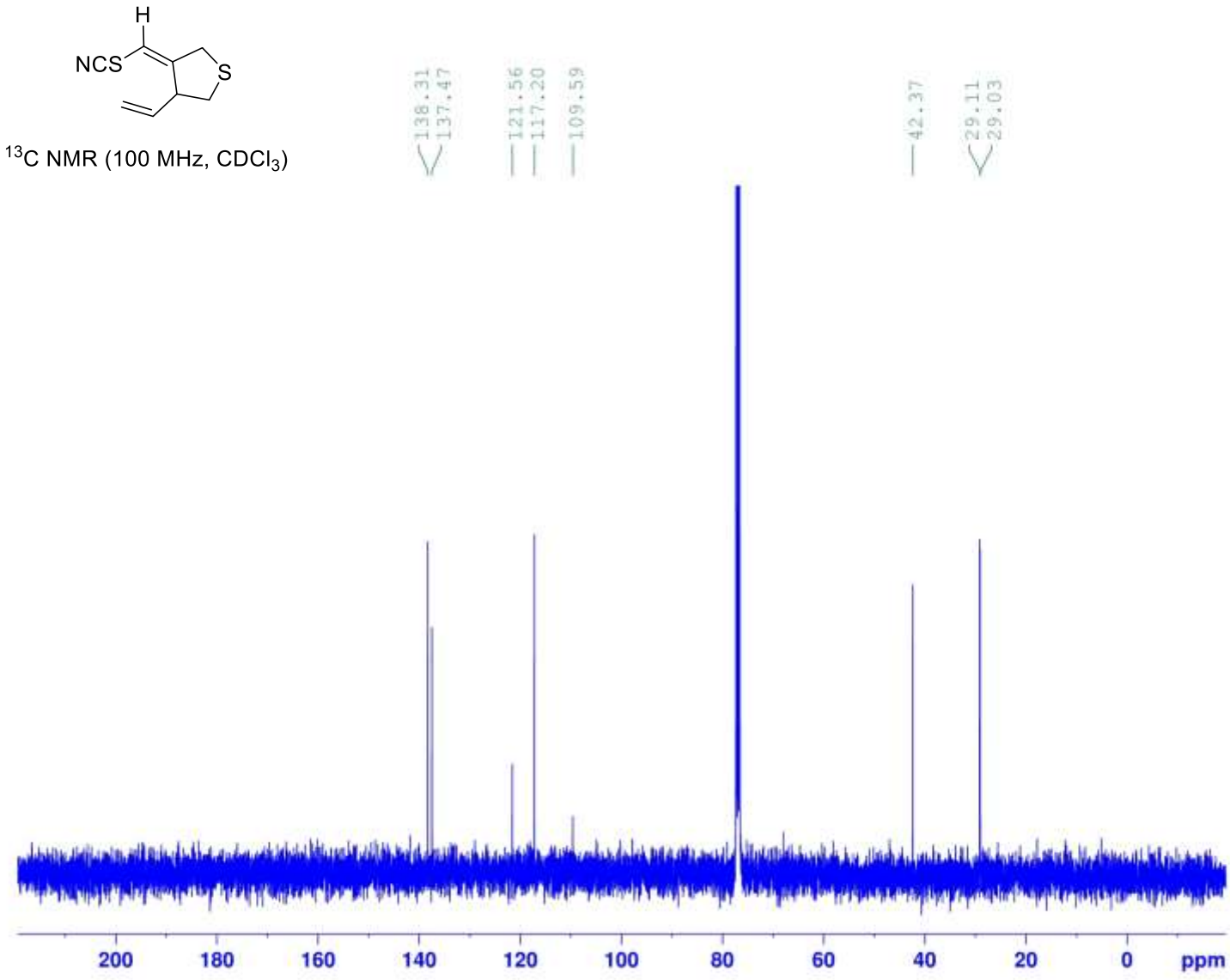
^{1}H NMR (400 MHz, $CDCl_3$)

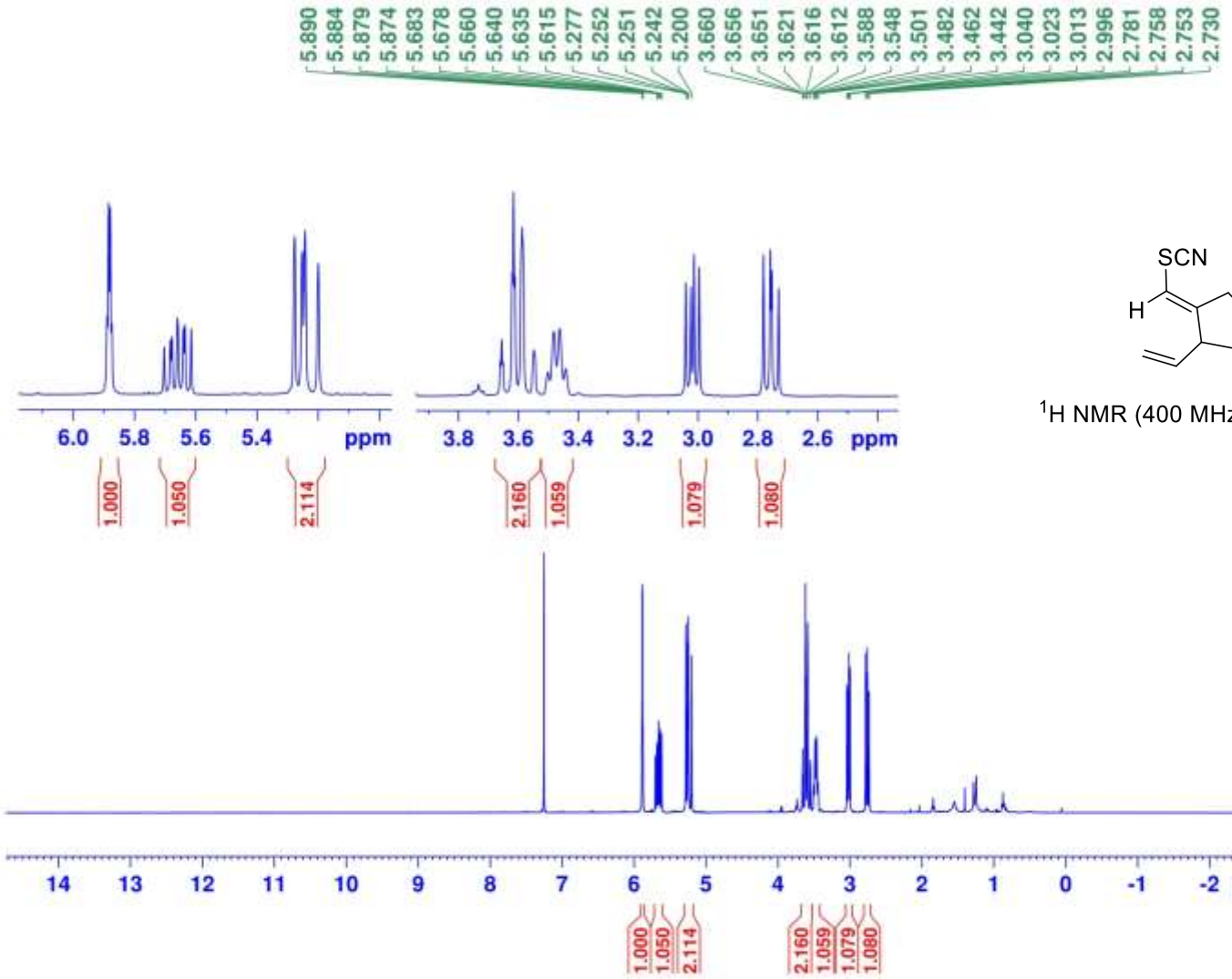

H
NCS
O
^{13}C NMR (100 MHz, $CDCl_3$)
41.13
67.13
68.02
108.83
117.83
122.00
135.32
136.03
ppm
0
20
40
60
80
100
120
140
160
180
200



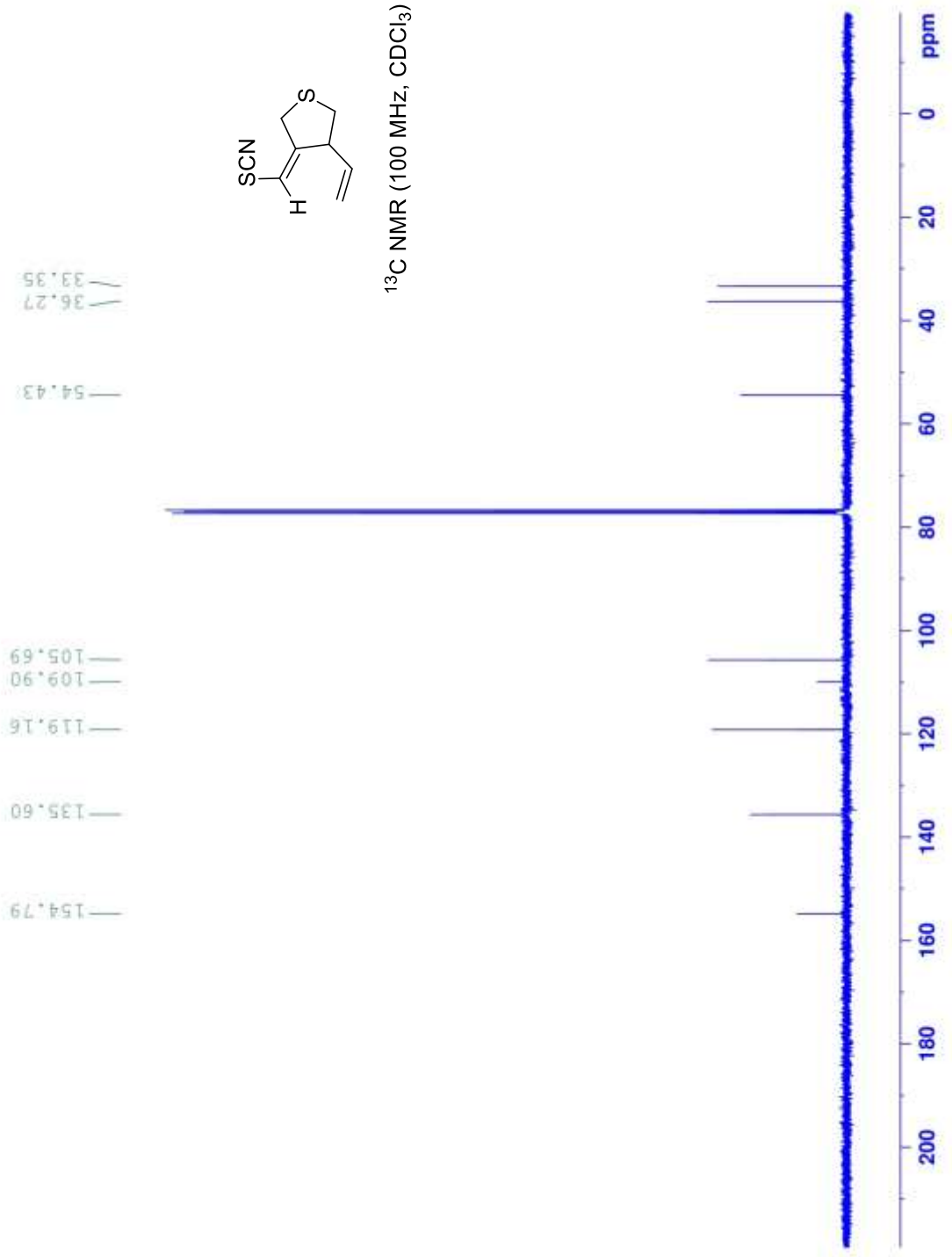


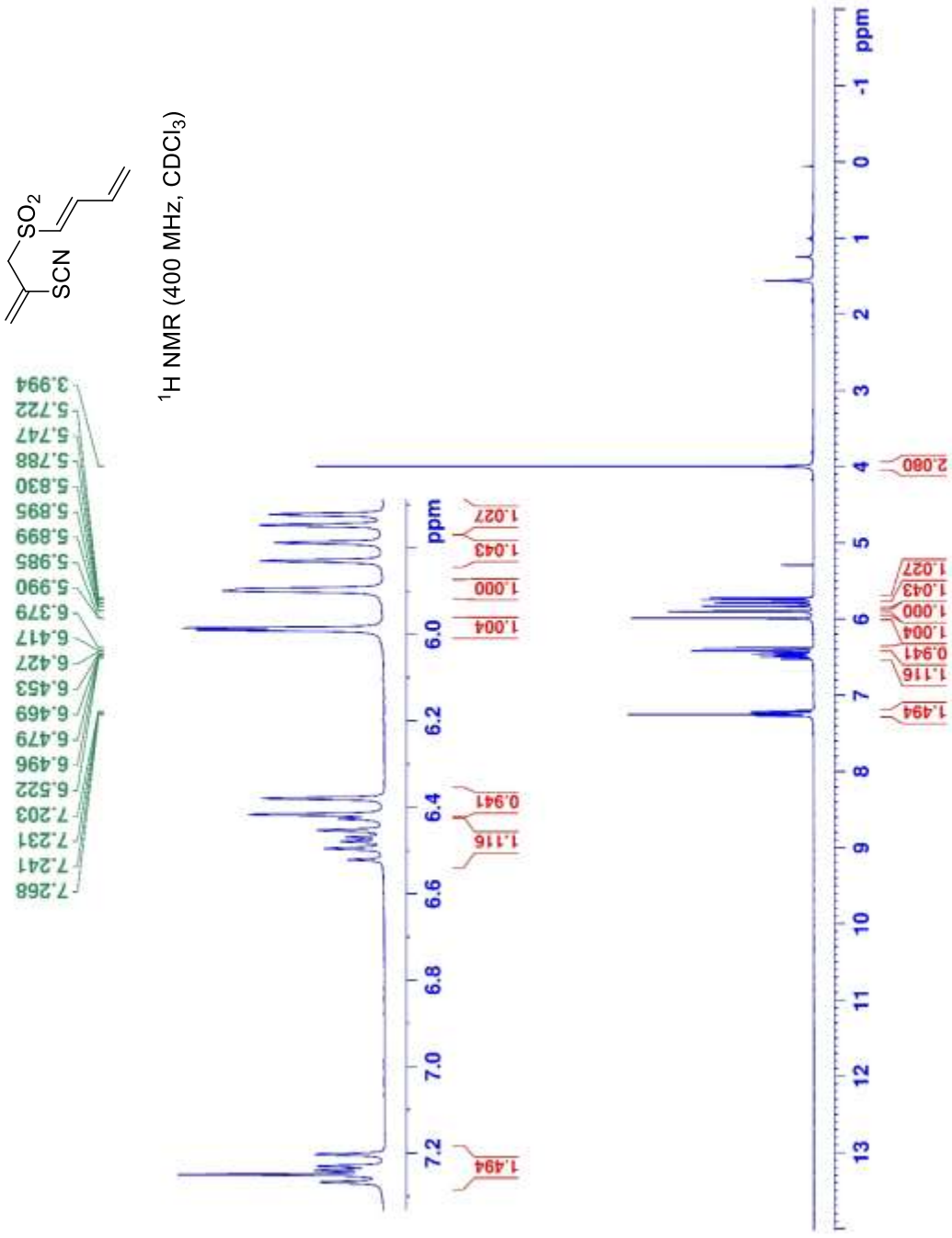
^{1}H NMR (400 MHz, $CDCl_3$)

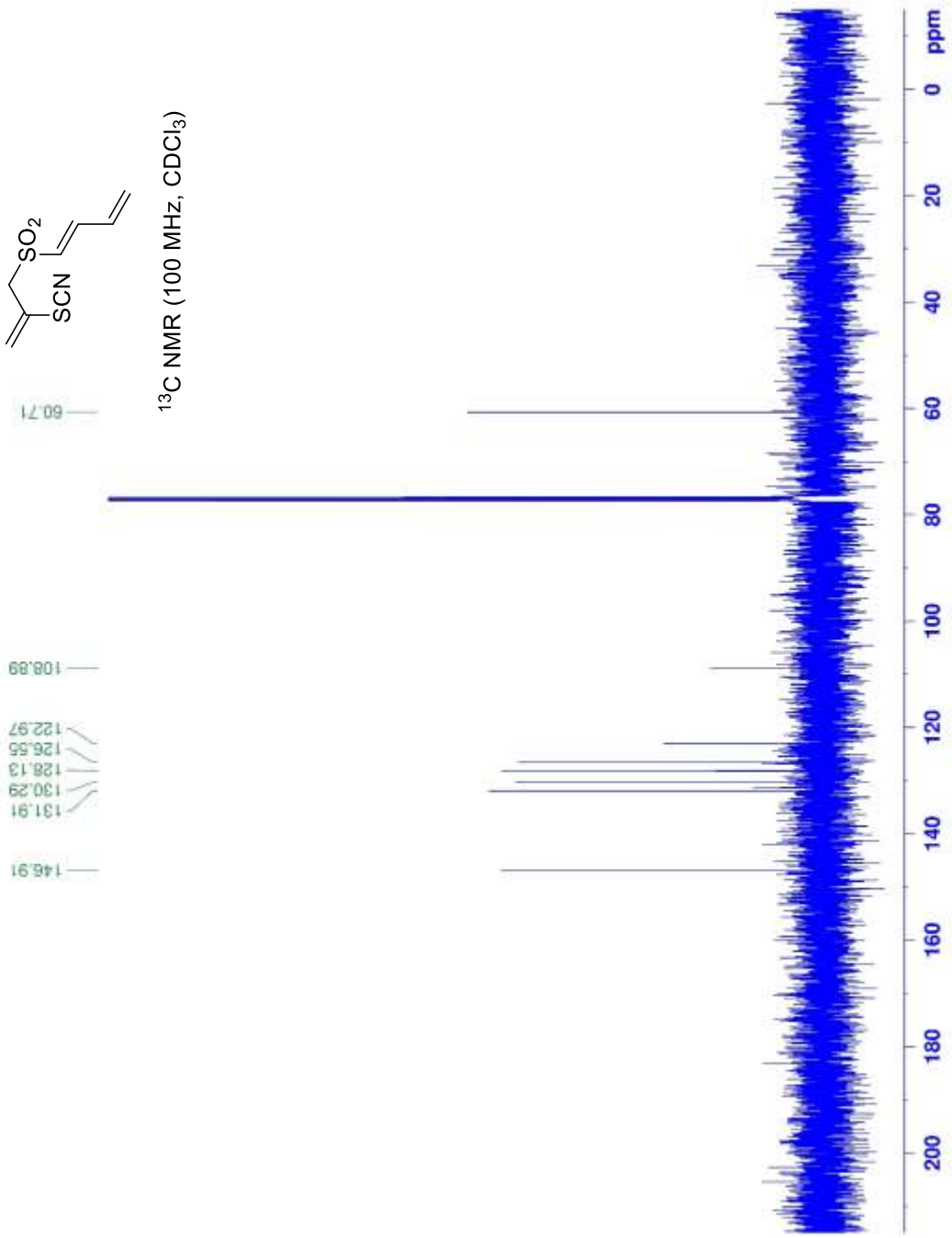

H
NCS
S
^{13}C NMR (100 MHz, $CDCl_3$)
138.31
137.47
121.56
117.20
109.59
42.37
29.11
29.03
200
180
160
140
120
100
80
60
40
20
0
ppm

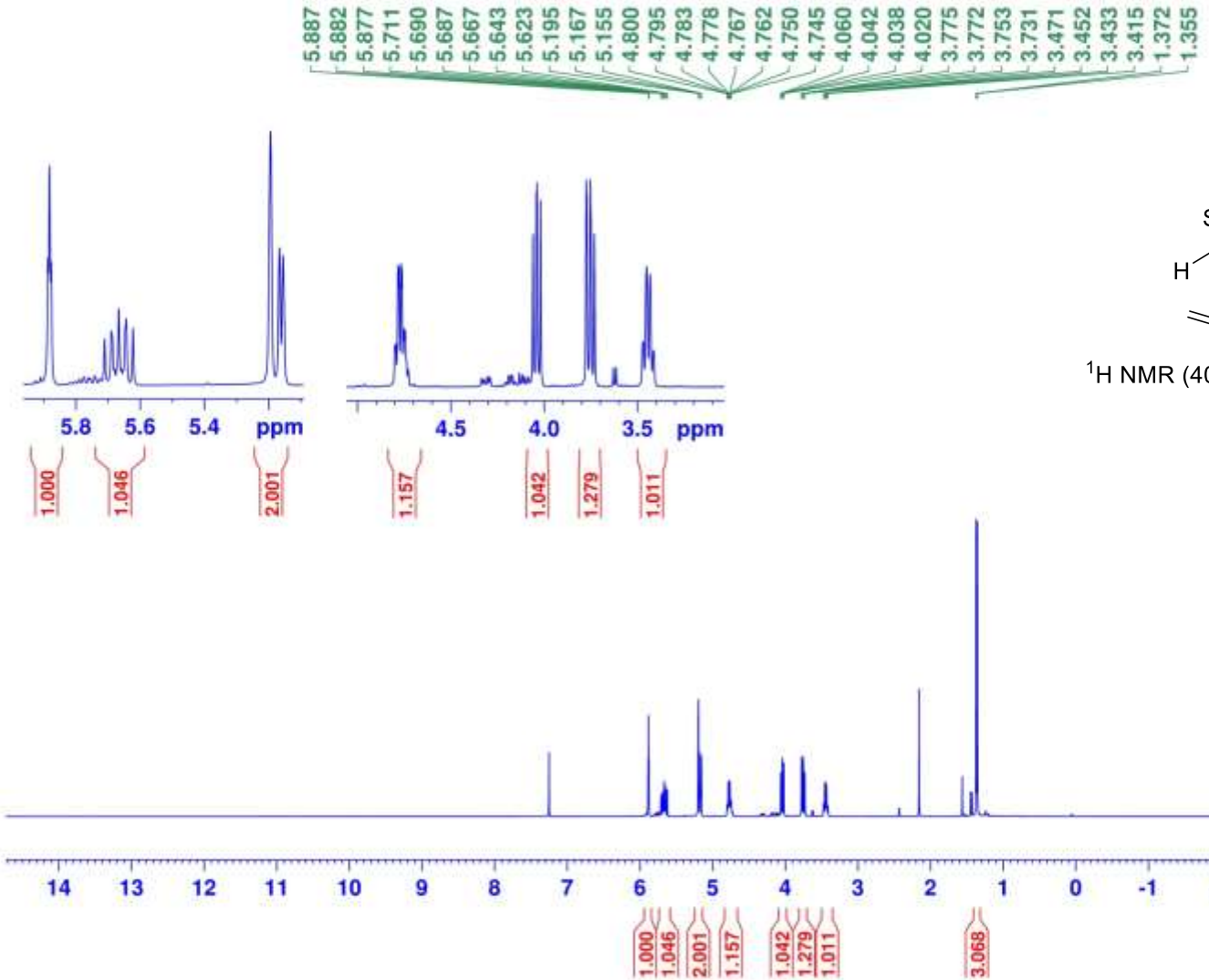


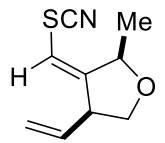
^{1}H NMR (400 MHz, $CDCl_3$)


SCN
H
S
^{13}C NMR (100 MHz, CDCl$_3$)
33.35
36.27
54.43
105.69
109.90
119.16
135.60
154.79
ppm
0
20
40
60
80
100
120
140
160
180
200

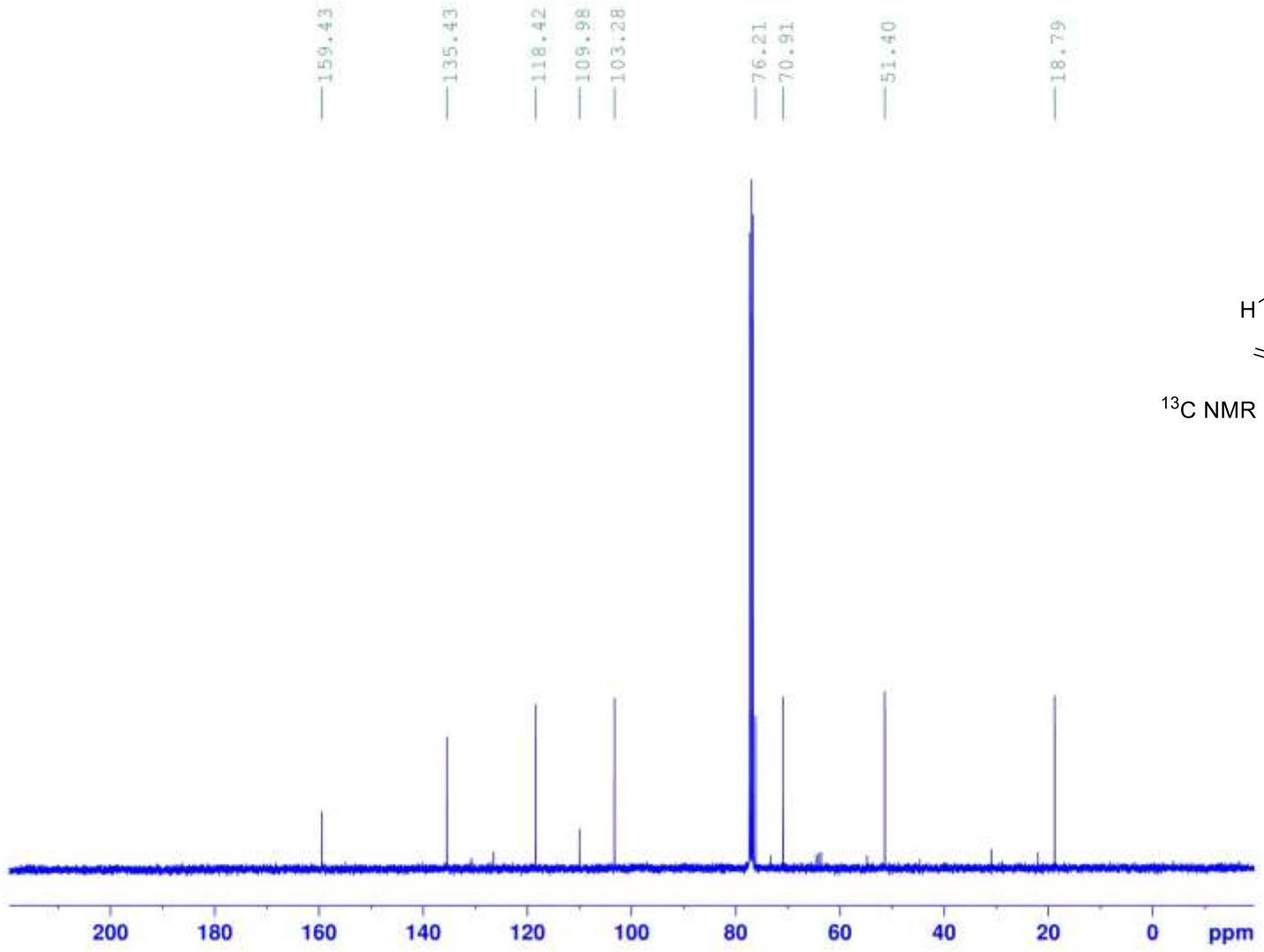

SO2
SCN
1H NMR (400 MHz, CDCl3)
3.994
5.722
5.747
5.788
5.830
5.895
5.899
5.985
5.990
6.379
6.417
6.427
6.453
6.469
6.479
6.496
6.522
7.203
7.231
7.241
7.268
ppm
1.494
0.941
1.116
1.004
1.000
1.043
1.027
2.080

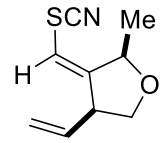

^{13}C NMR (100 MHz, $CDCl_3$)
SO_2
SCN
60.71
108.89
122.97
126.55
128.13
130.29
131.91
146.91
ppm
0
20
40
60
80
100
120
140
160
180
200



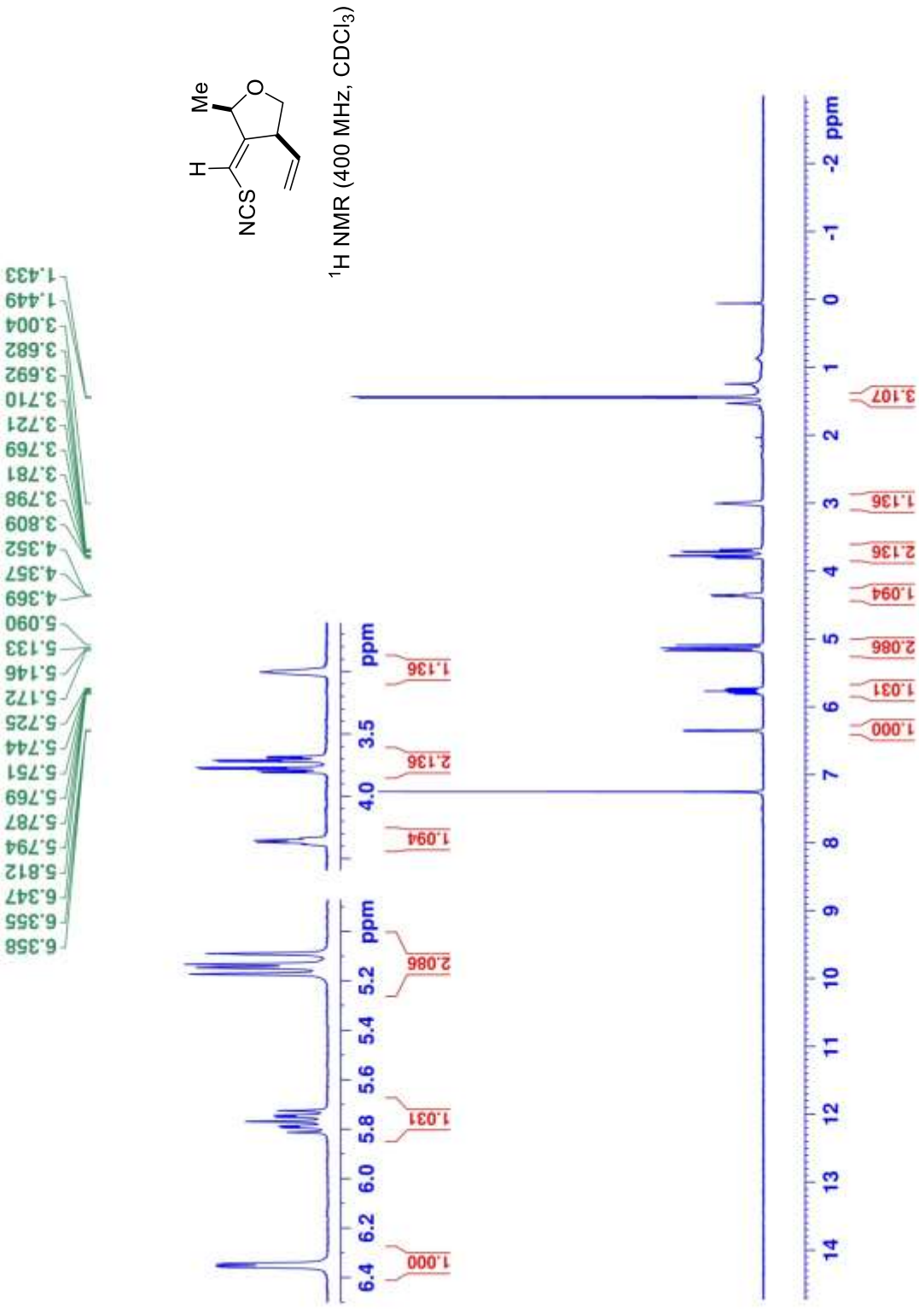


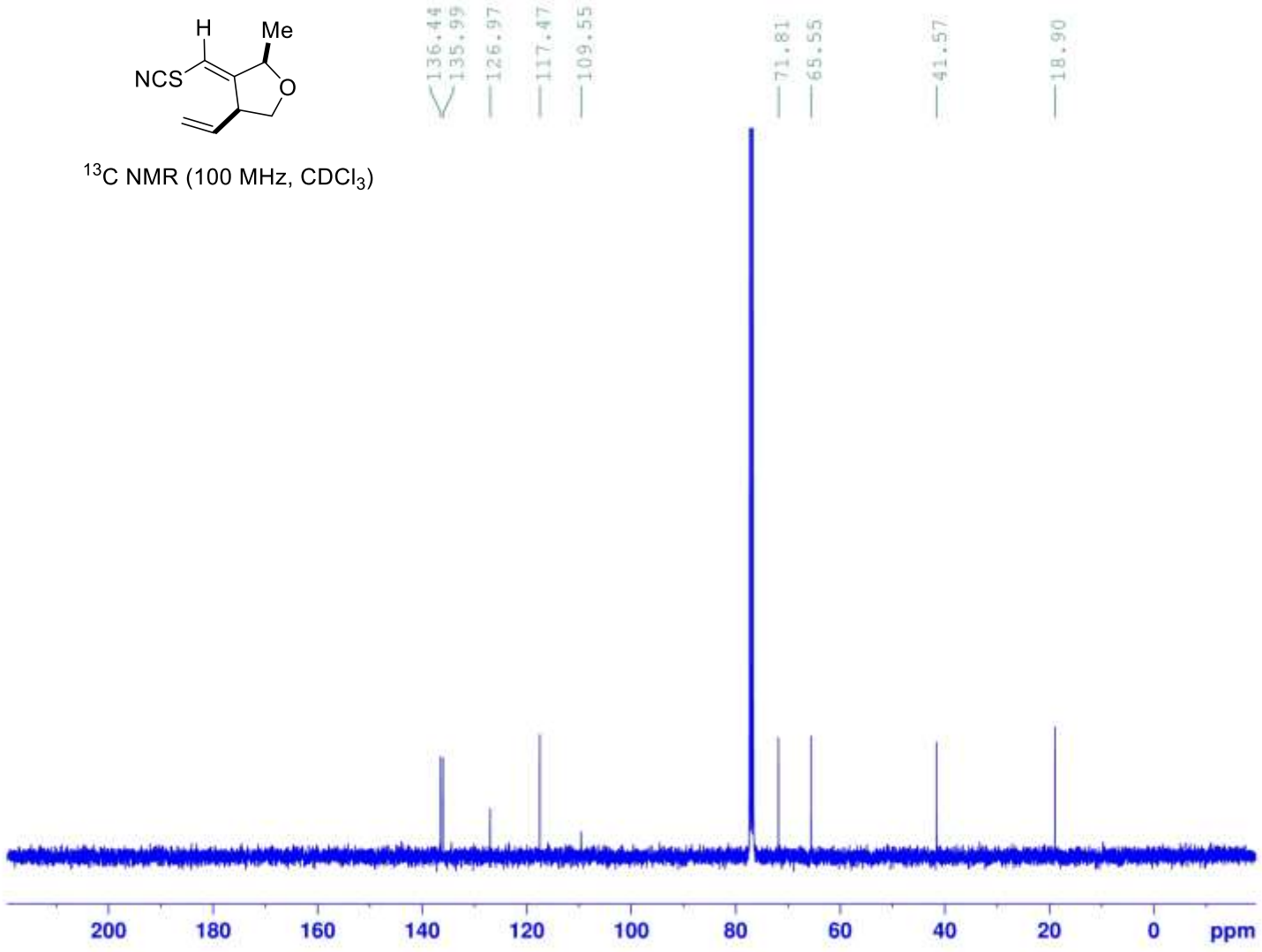
^{1}H NMR (400 MHz, $CDCl_3$)



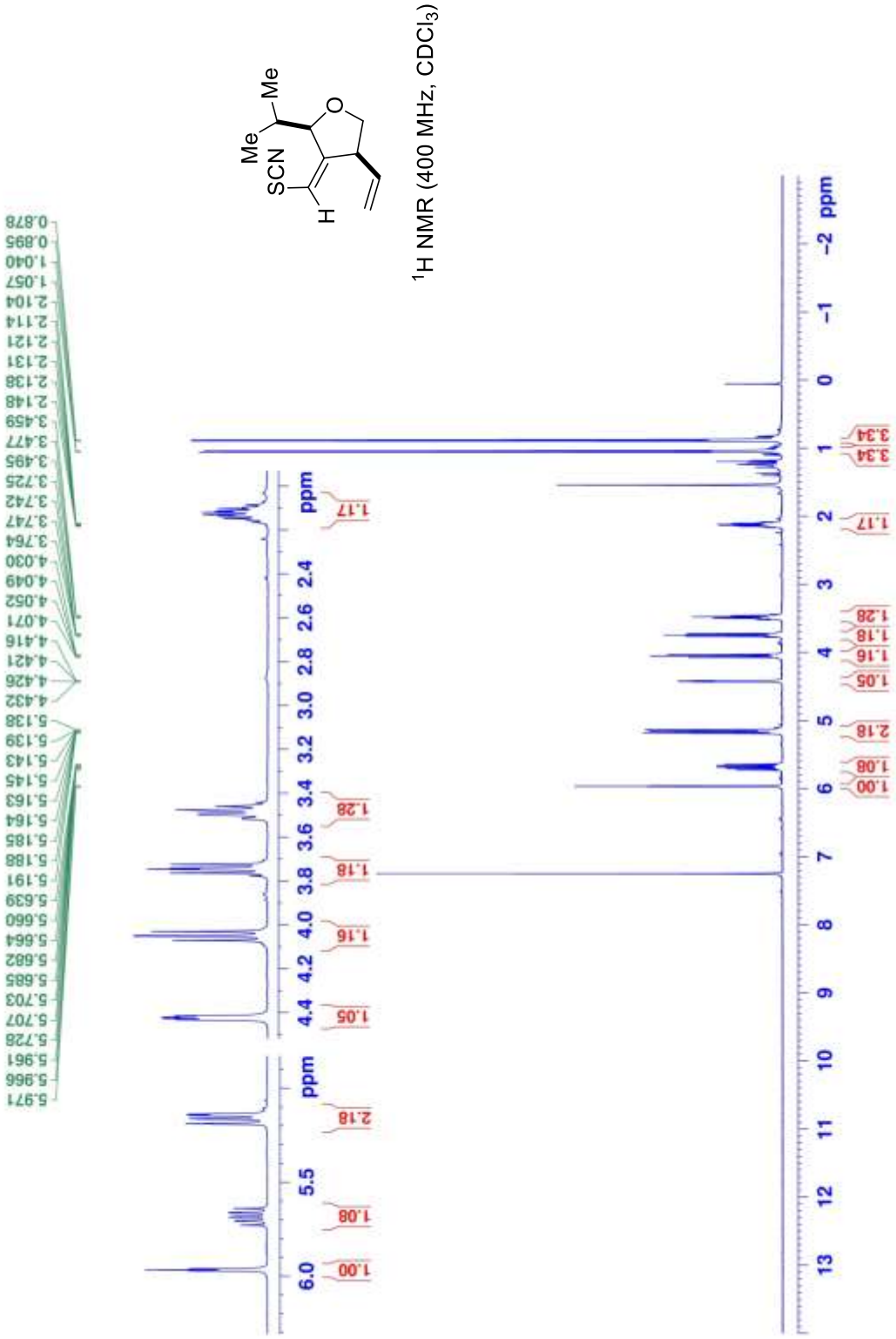


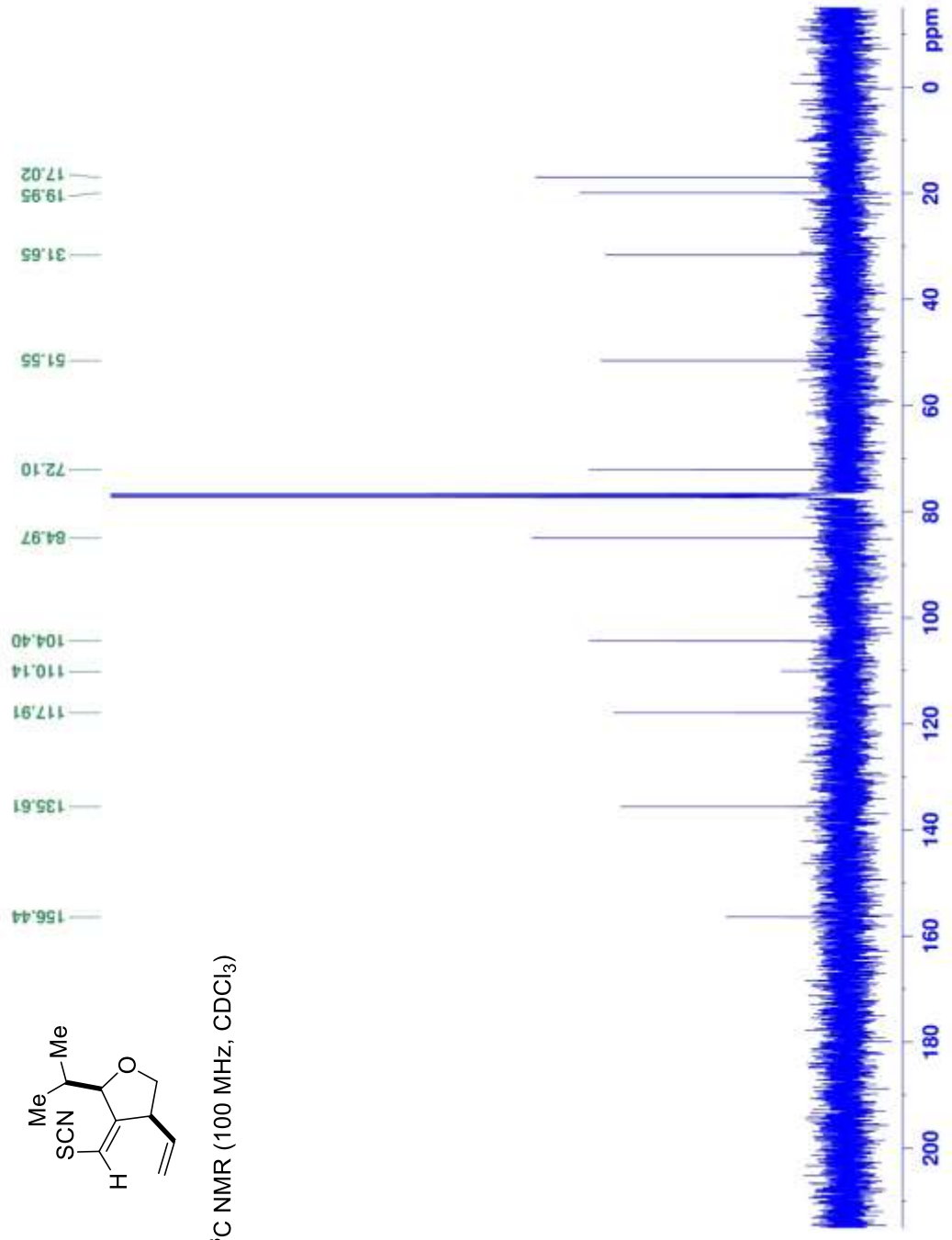
^{13}C NMR (100 MHz, $CDCl_3$)

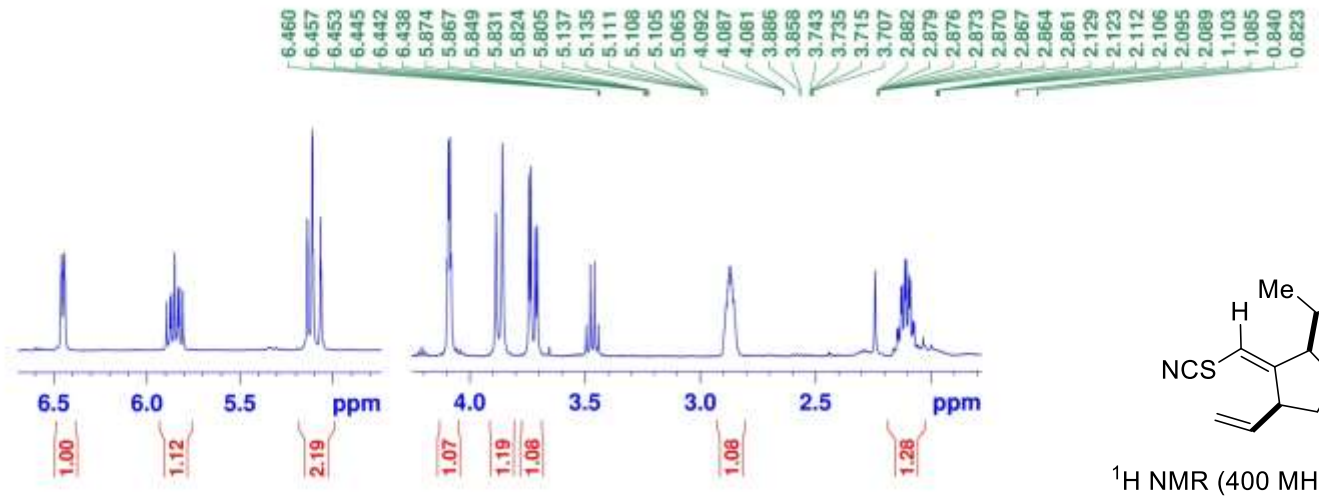

Me
O
H
NCS
^{1}H NMR (400 MHz, CDCl$_3$)
1.433
1.449
3.004
3.682
3.692
3.710
3.721
3.769
3.781
3.798
3.809
4.352
4.357
4.369
5.090
5.133
5.146
5.172
5.725
5.744
5.751
5.769
5.787
5.794
5.812
6.347
6.355
6.358
ppm
1.000
1.031
2.086
1.136
2.136
1.094
3.107



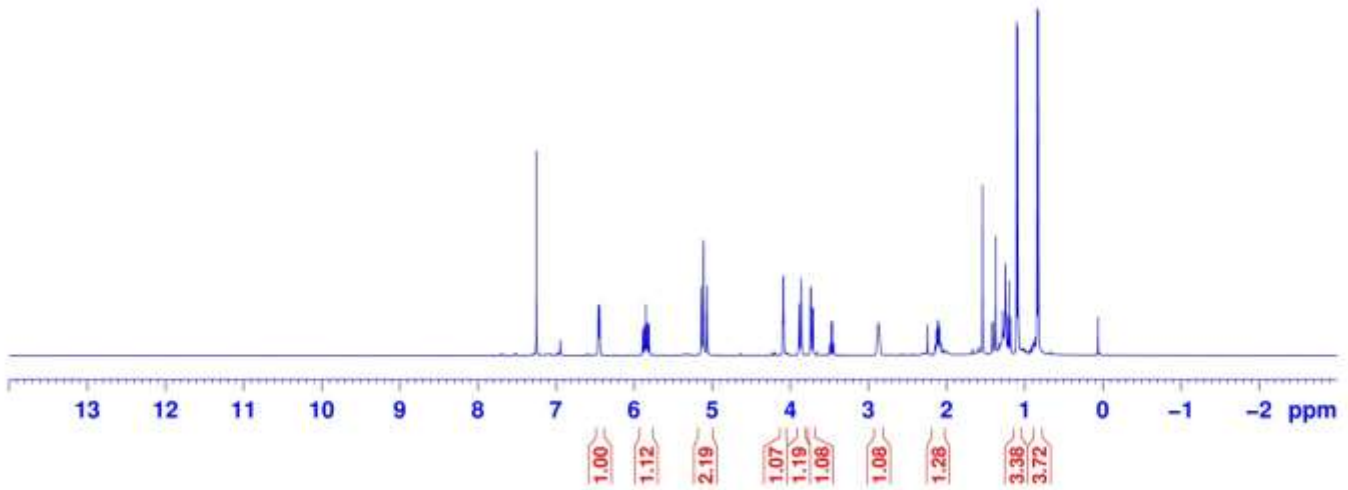
^{13}C NMR (100 MHz, $CDCl_3$)

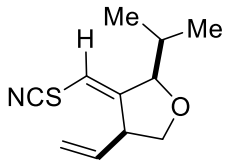

Me
Me
SCN
H
O
^{1}H NMR (400 MHz, CDCl$_3$)
ppm
1.17
1.28
1.18
1.16
1.05
2.18
1.08
1.00
3.34


17.02
19.95
31.65
51.55
72.10
84.97
104.40
110.14
117.91
135.61
156.44
Me
Me
SCN
H
O
^{13}C NMR (100 MHz, $CDCl_3$)
0
20
40
60
80
100
120
140
160
180
200
ppm

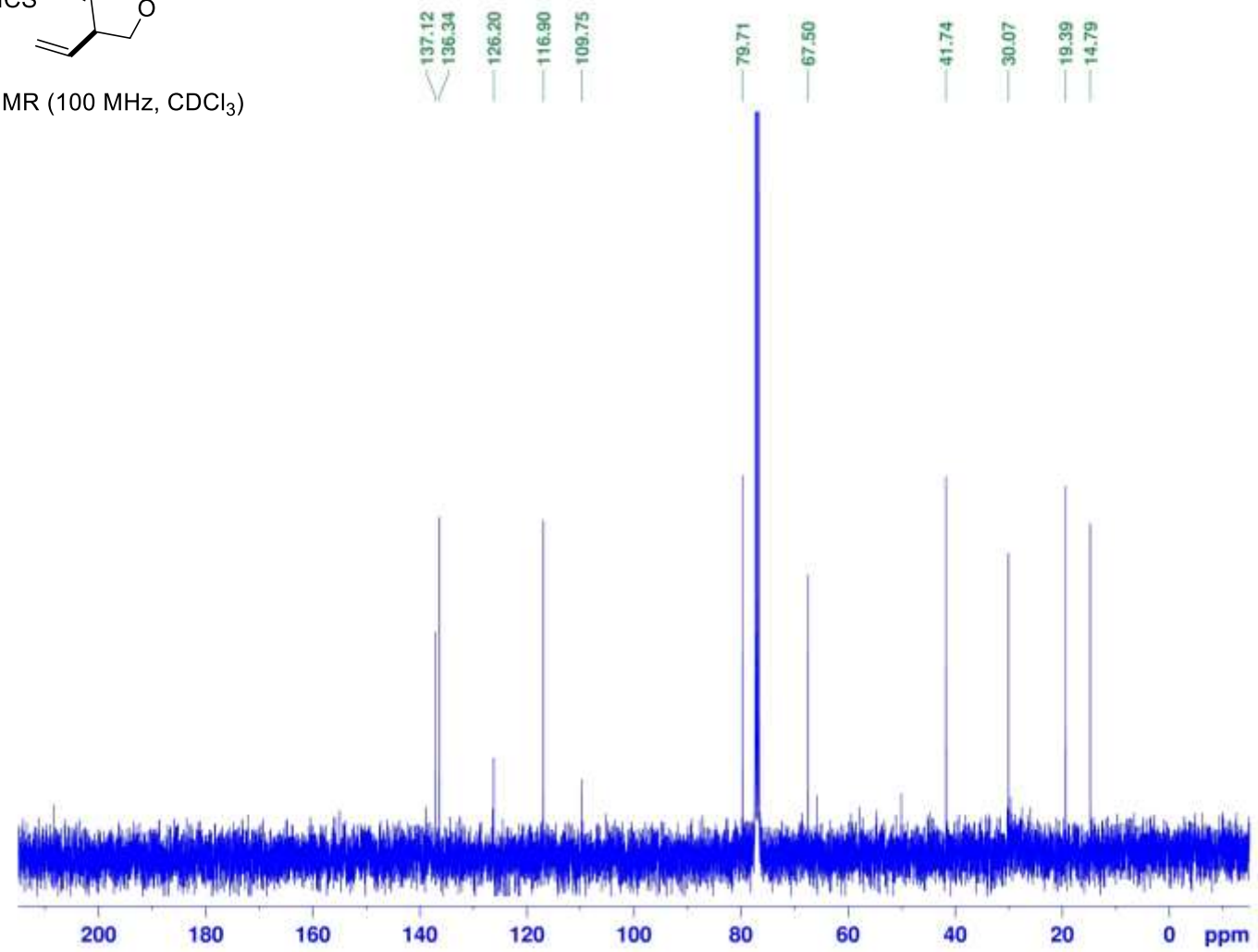


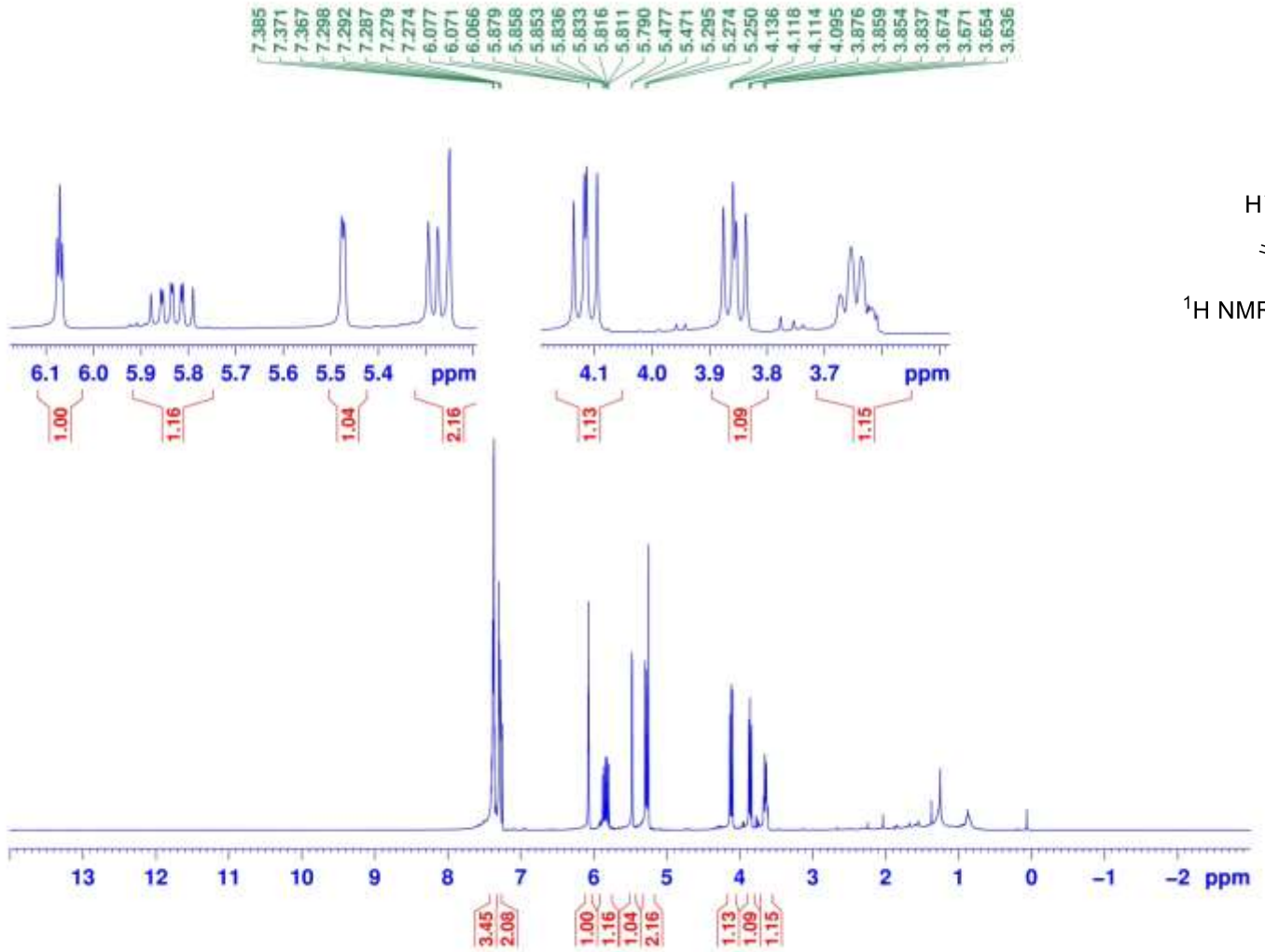
^{1}H NMR (400 MHz, $CDCl_3$)

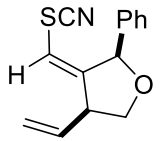




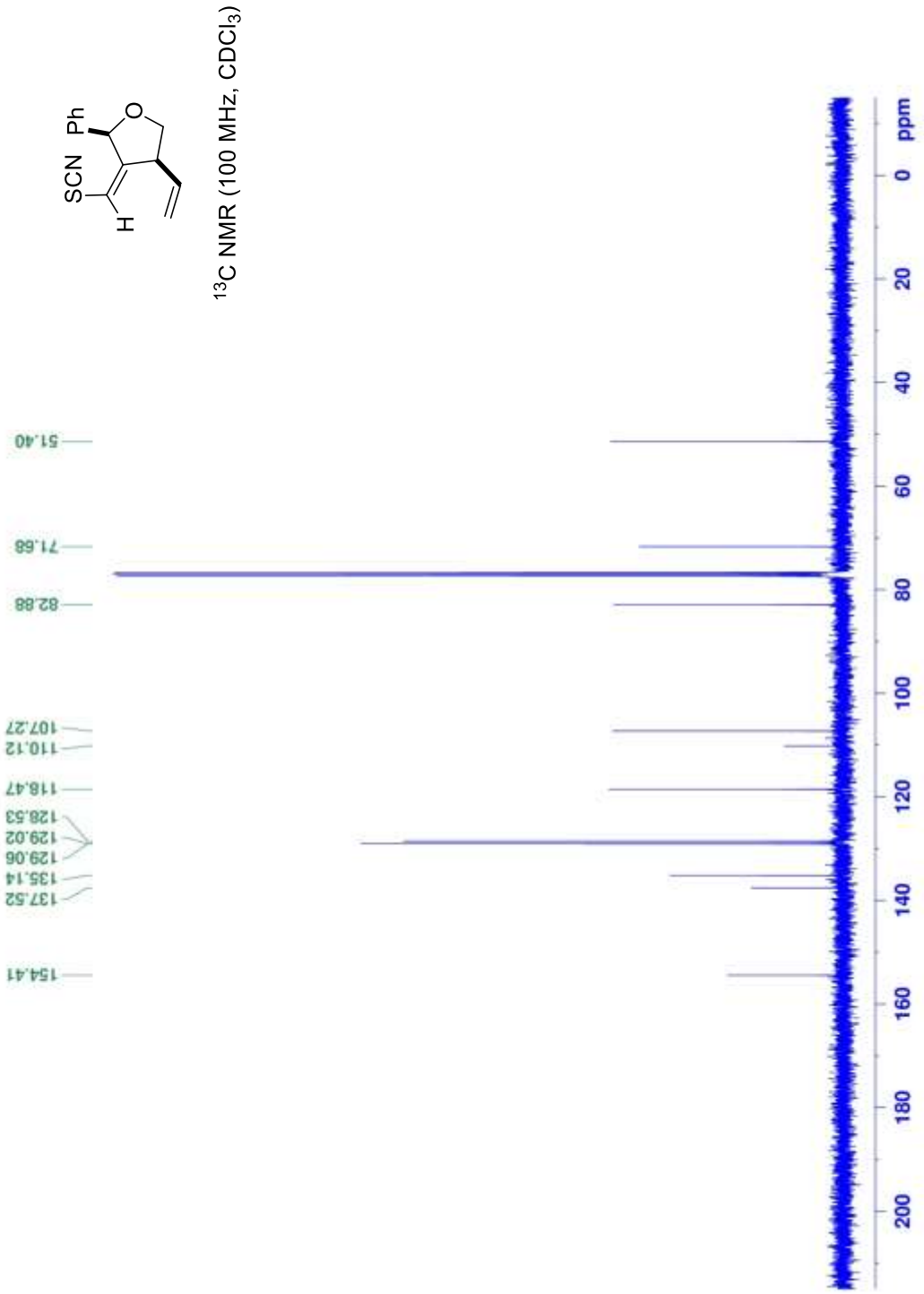
^{13}C NMR (100 MHz, $CDCl_3$)

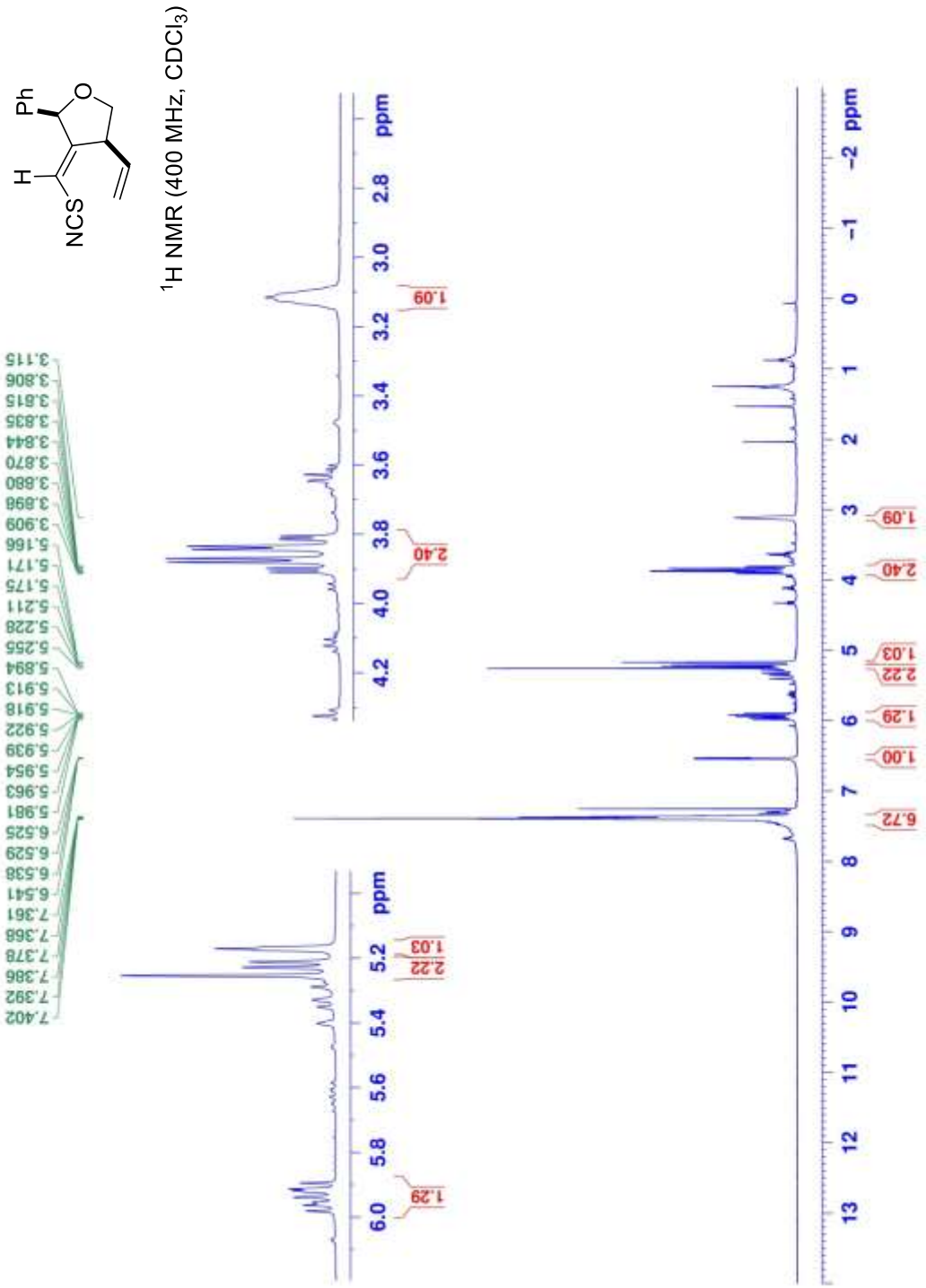


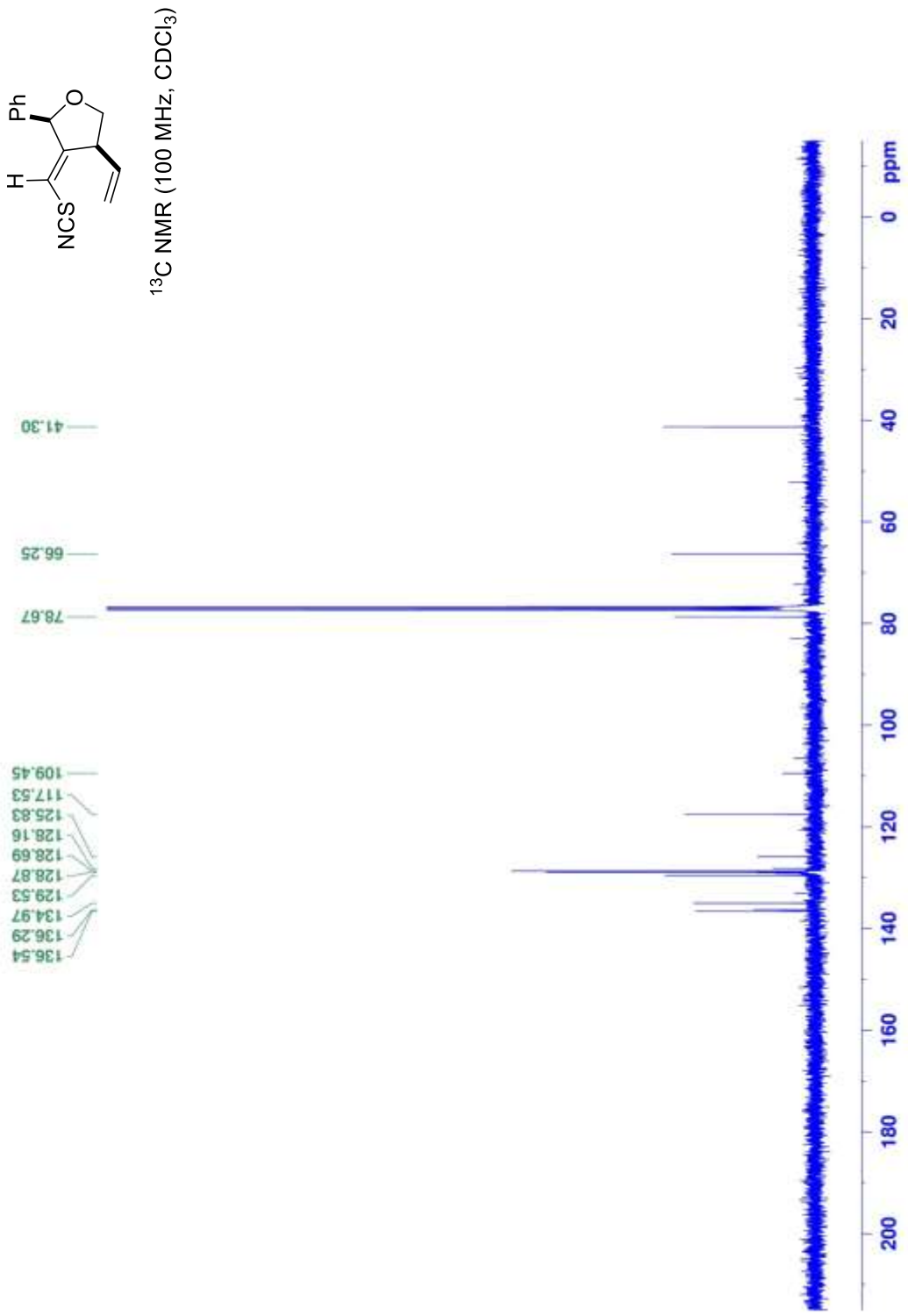


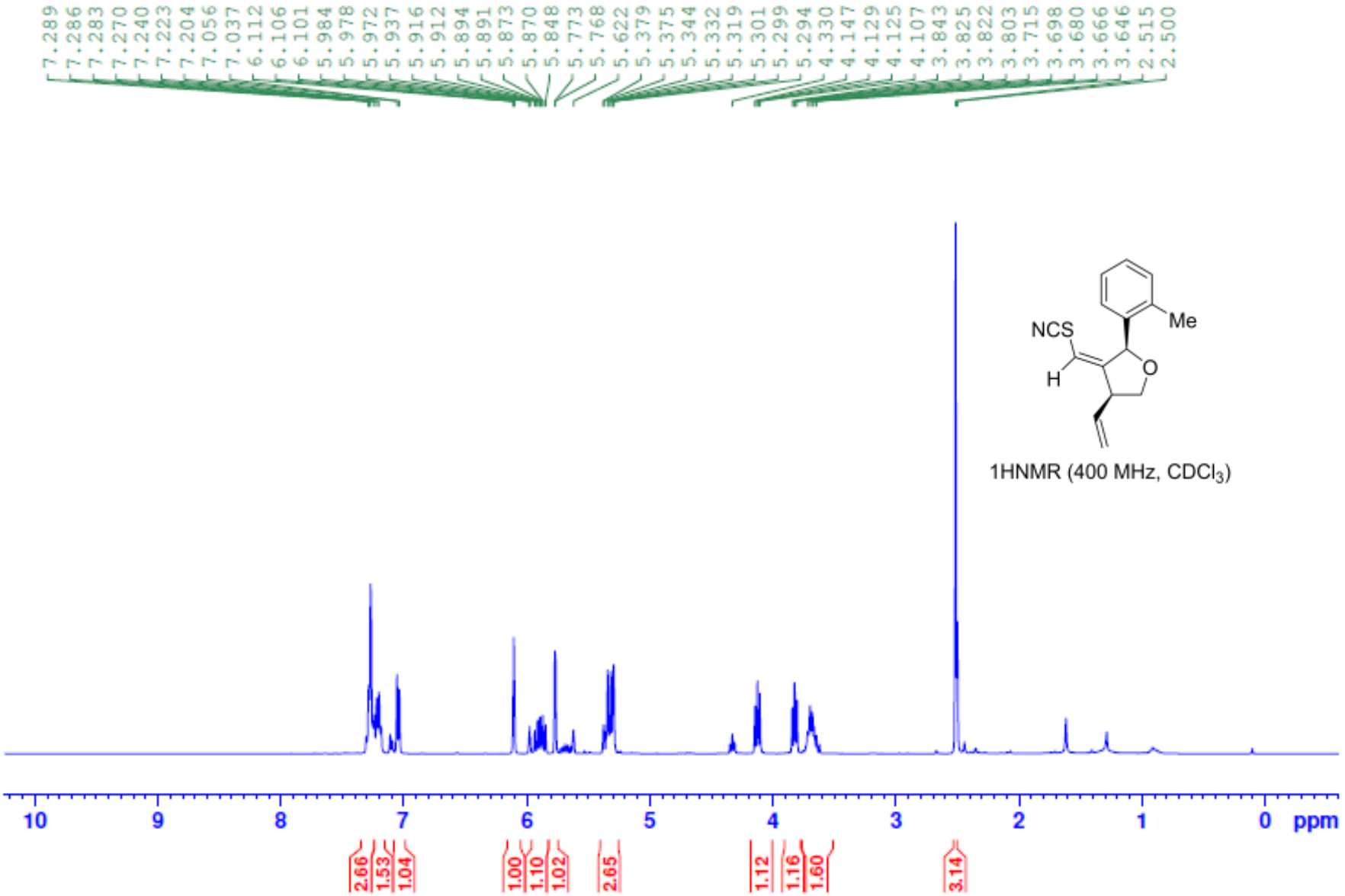


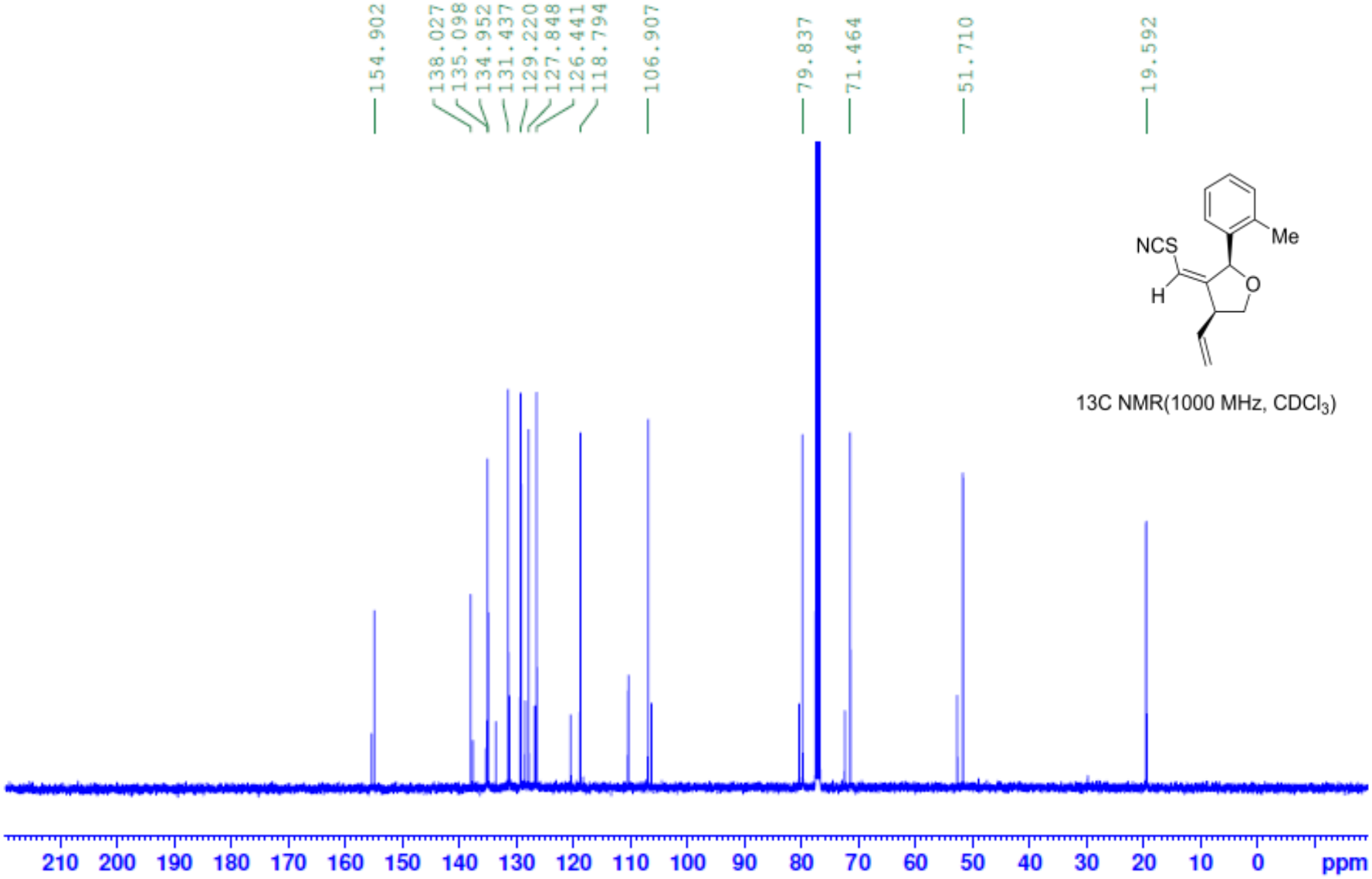
^{1}H NMR (400 MHz, $CDCl_3$)

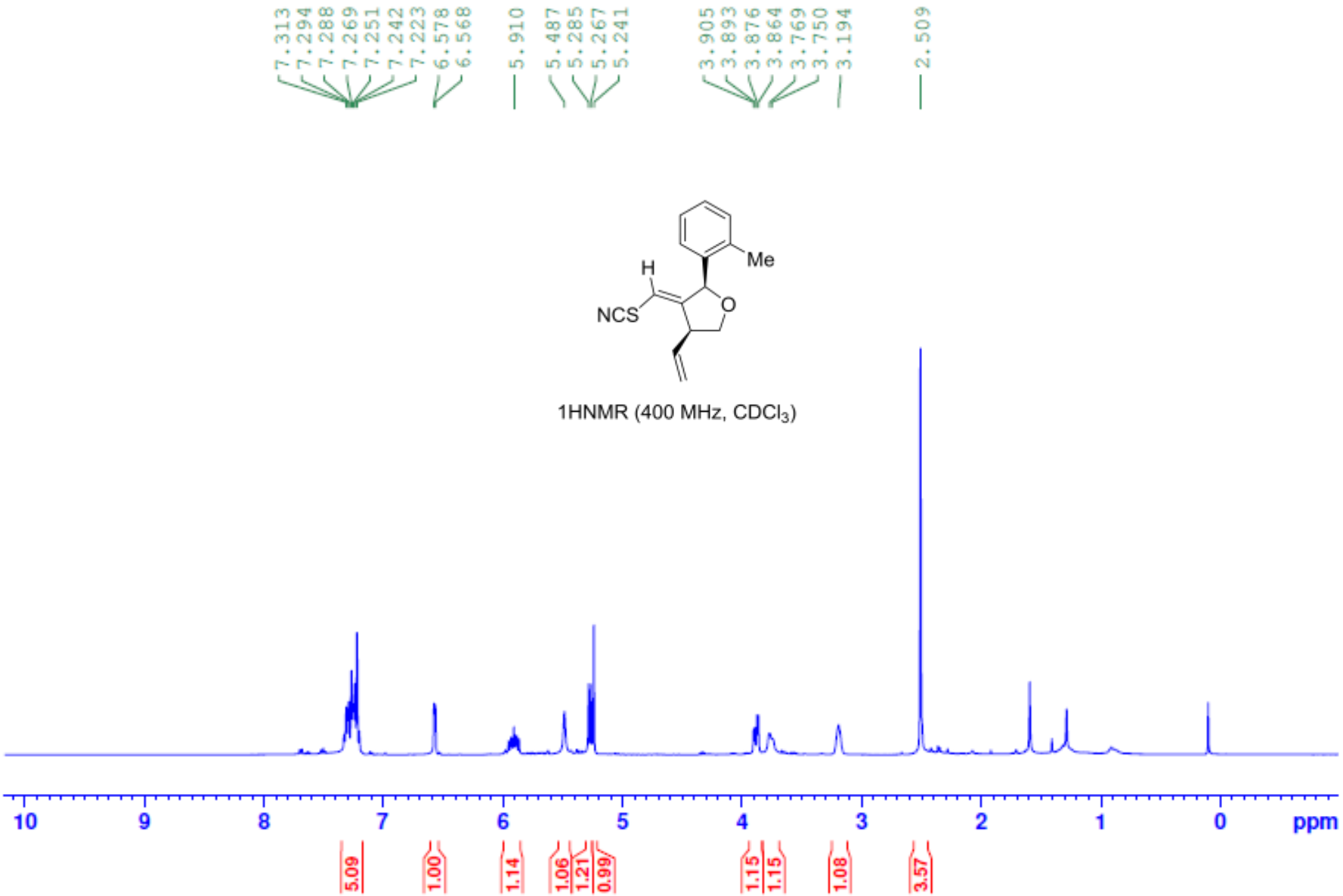

SCN
Ph
O
H
^{13}C NMR (100 MHz, CDCl$_3$)
51.40
71.68
82.88
107.27
110.12
118.47
128.53
129.02
129.06
135.14
137.52
154.41
ppm
0
20
40
60
80
100
120
140
160
180
200


Ph
O
H
NCS
^{1}H NMR (400 MHz, $CDCl_3$)
3.115
3.806
3.815
3.835
3.844
3.870
3.880
3.898
3.909
5.166
5.171
5.175
5.211
5.228
5.255
5.894
5.913
5.918
5.922
5.939
5.954
5.963
5.981
6.525
6.529
6.538
6.541
7.361
7.368
7.378
7.386
7.392
7.402
ppm
1.09
2.40
2.22
1.03
1.29
1.00
6.72

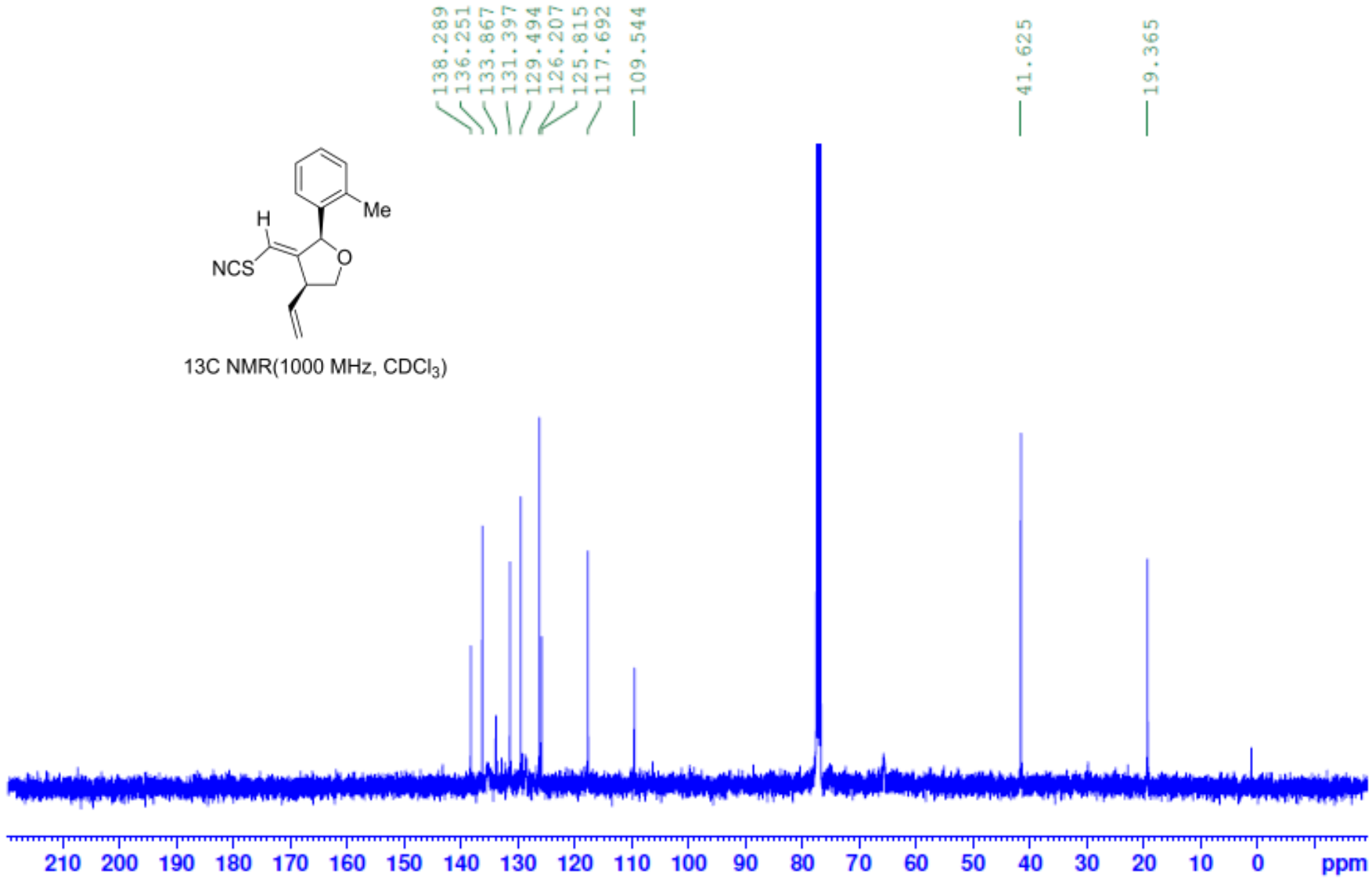

Ph
O
H
NCS
^{13}C NMR (100 MHz, CDCl$_3$)
41.30
66.25
78.67
109.45
117.53
125.83
128.16
128.69
128.87
129.53
134.97
136.29
136.54
0
20
40
60
80
100
120
140
160
180
200
ppm


7.289
7.286
7.283
7.270
7.240
7.223
7.204
7.056
7.037
6.112
6.106
6.101
5.984
5.978
5.972
5.937
5.916
5.912
5.894
5.891
5.873
5.870
5.848
5.773
5.768
5.622
5.379
5.375
5.344
5.332
5.319
5.301
5.299
5.294
4.330
4.147
4.129
4.125
4.107
3.843
3.825
3.822
3.803
3.715
3.698
3.680
3.666
3.646
2.515
2.500
NCS
H
O
Me
1HNMR (400 MHz, CDCl3)
10
9
8
7
6
5
4
3
2
1
0
ppm
2.66
1.53
1.04
1.00
1.10
1.02
2.65
1.12
1.16
1.60
3.14

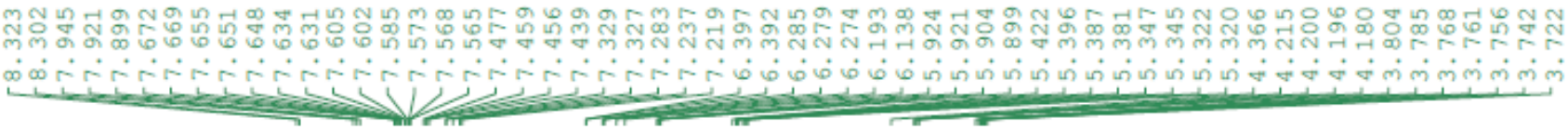

154.902
138.027
135.098
134.952
131.437
129.220
127.848
126.441
118.794
106.907
79.837
71.464
51.710
19.592
NCS
H
O
Me
13C NMR(1000 MHz, CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

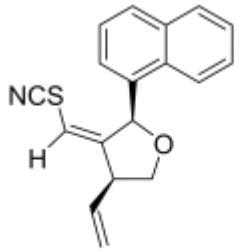


1HNMR (400 MHz, $CDCl_3$)

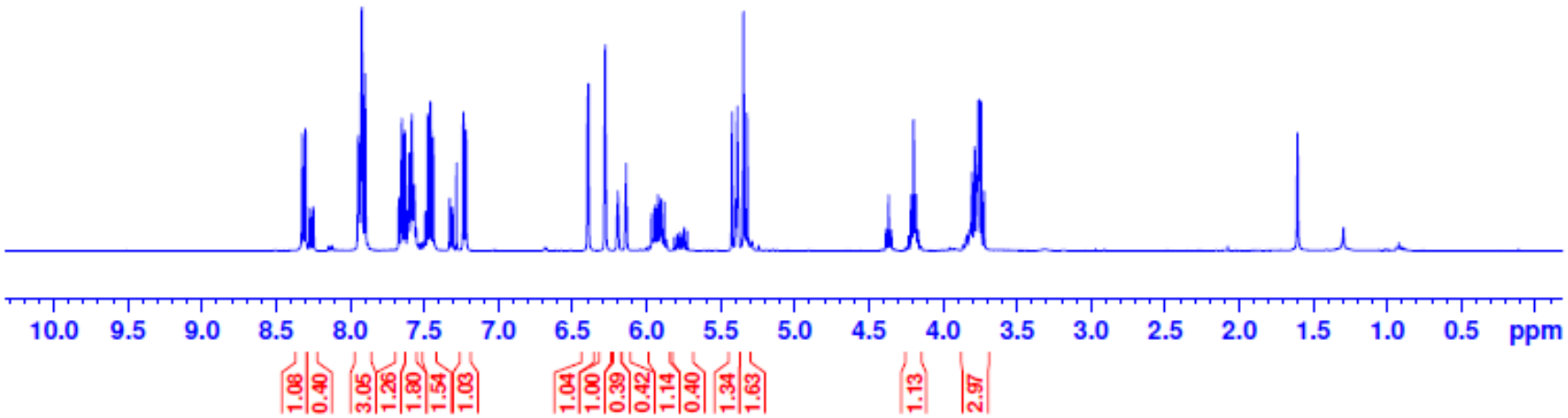


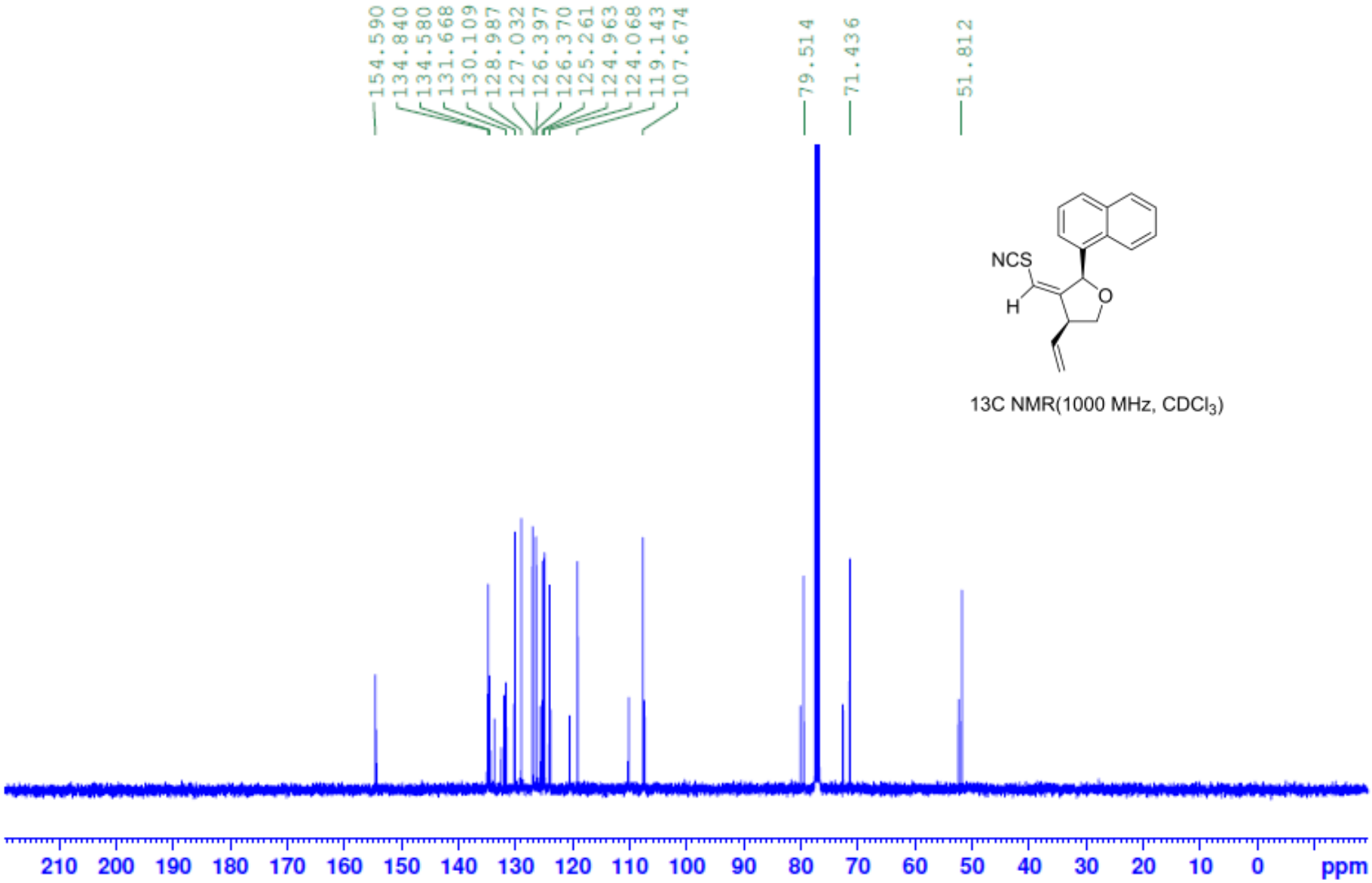
13C NMR(1000 MHz, $CDCl_3$)

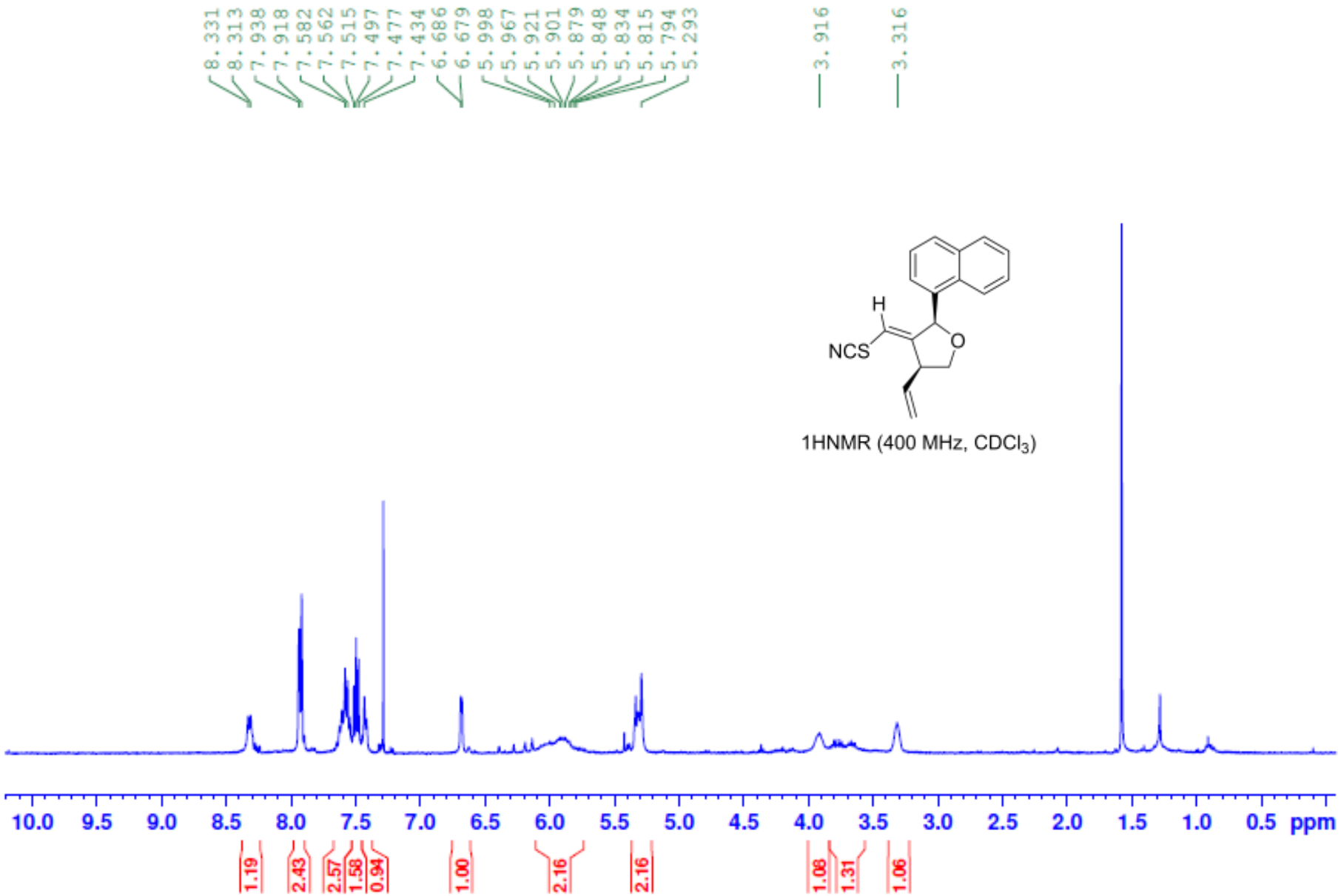




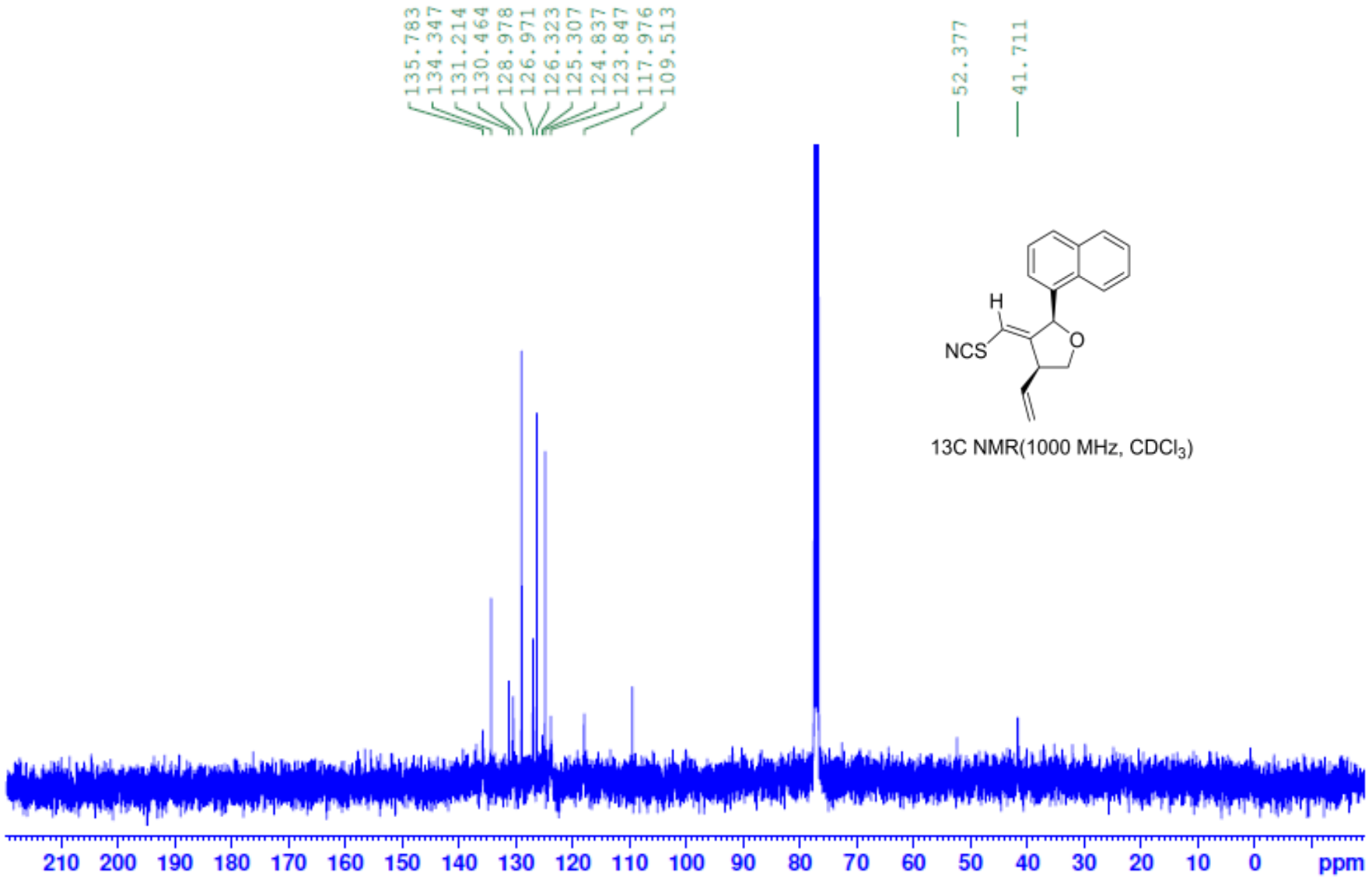
1HNMR (400 MHz, $CDCl_3$)



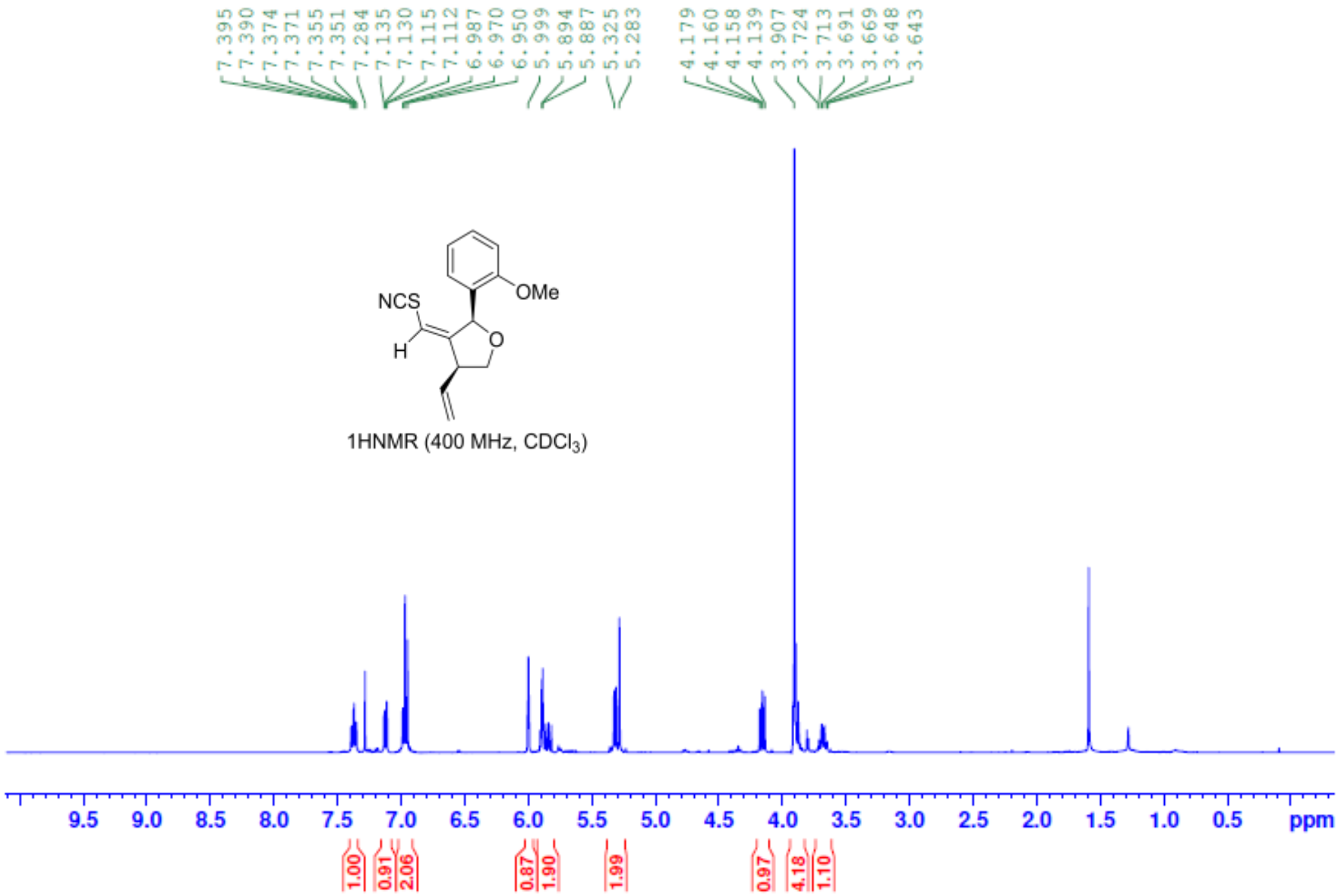

154.590
134.840
134.580
131.668
130.109
128.987
127.032
126.397
126.370
125.261
124.963
124.068
119.143
107.674
79.514
71.436
51.812
NCS
H
O
13C NMR(1000 MHz, CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

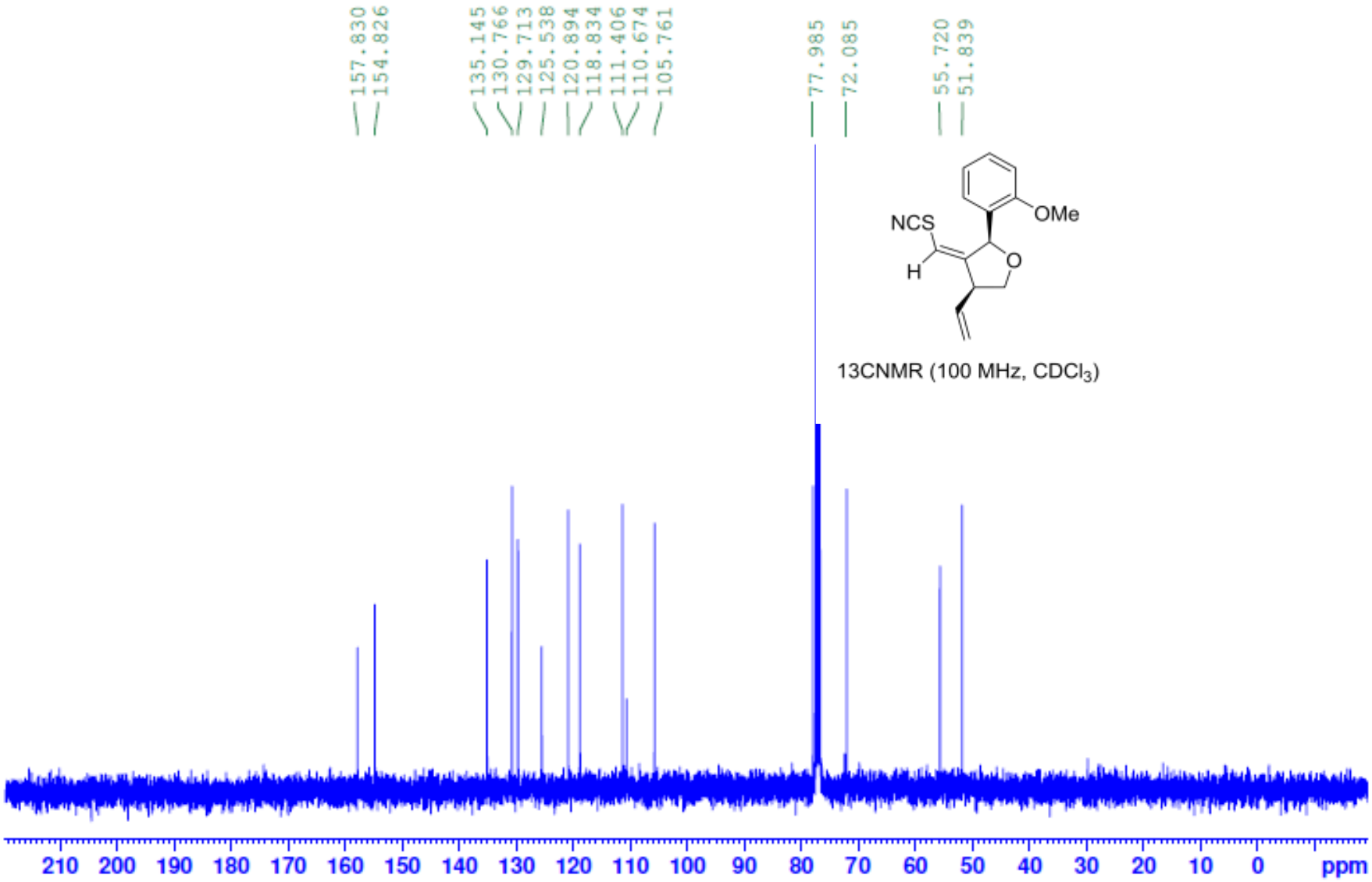


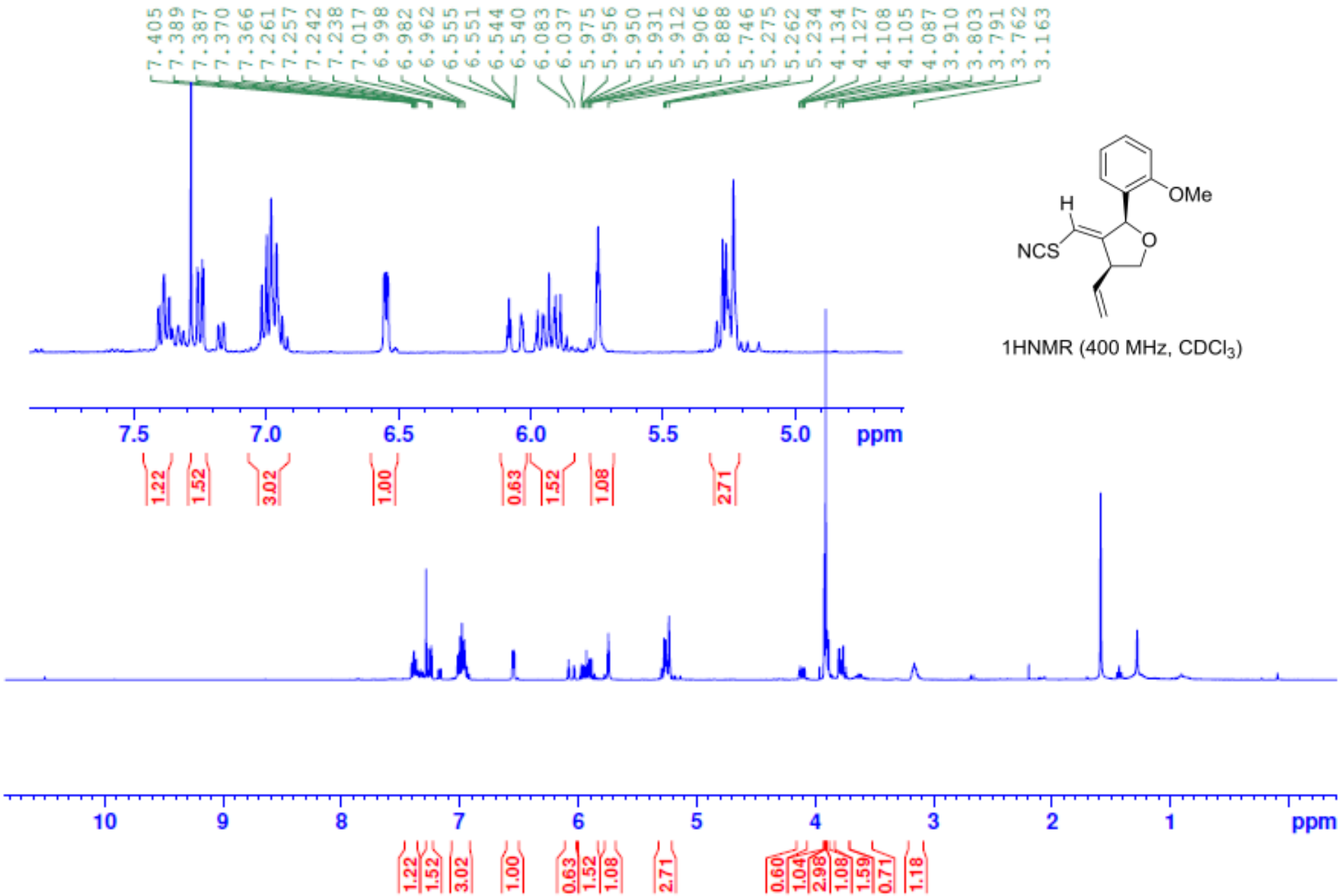
1HNMR (400 MHz, $CDCl_3$)



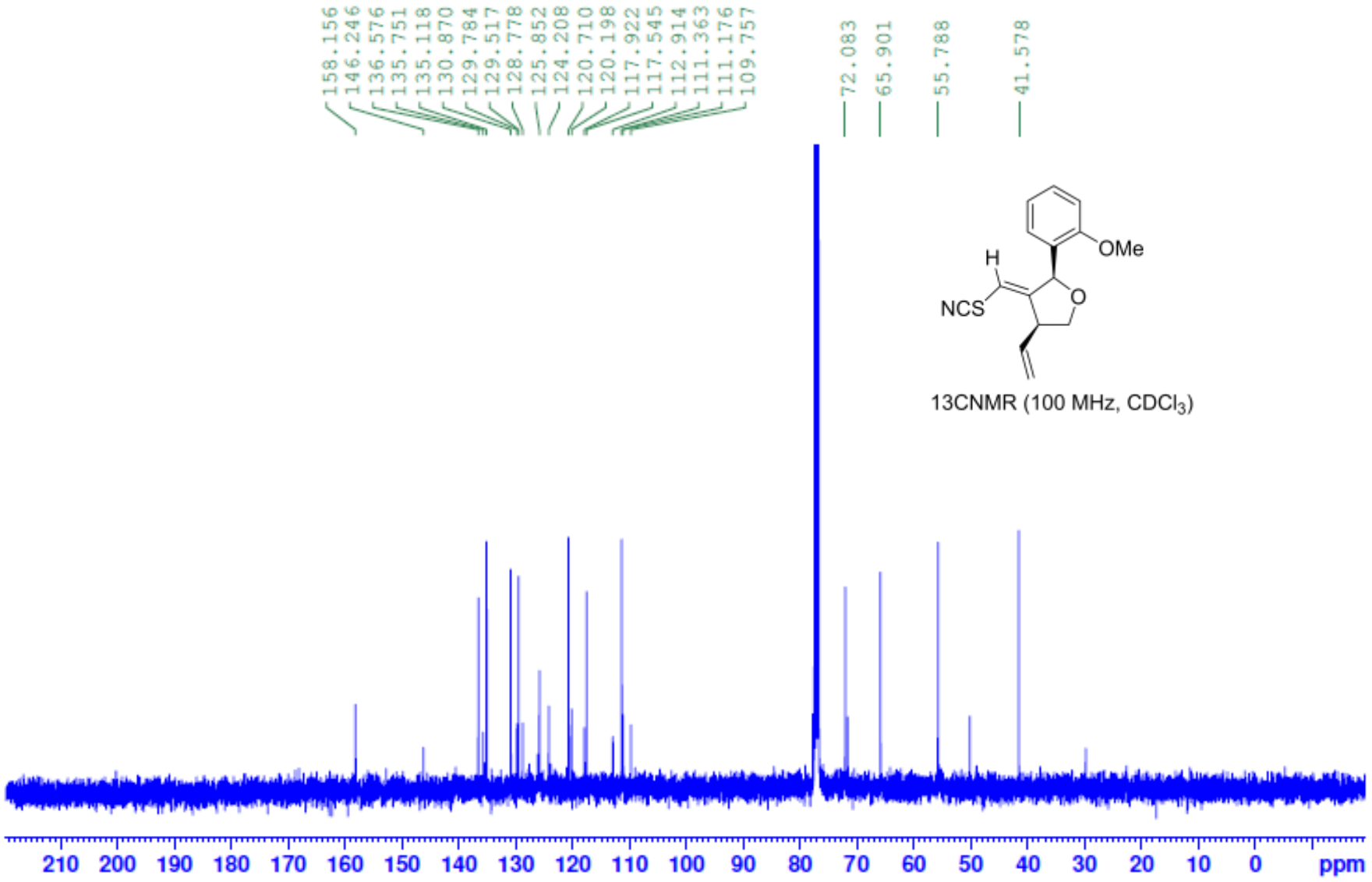
13C NMR(1000 MHz, $CDCl_3$)


7.395
7.390
7.374
7.371
7.355
7.351
7.284
7.135
7.130
7.115
7.112
6.987
6.970
6.950
5.999
5.894
5.887
5.325
5.283
4.179
4.160
4.158
4.139
3.907
3.724
3.713
3.691
3.669
3.648
3.643
NCS
H
O
OMe
1HNMR (400 MHz, CDCl3)
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
ppm
1.00
0.91
2.06
0.87
1.90
1.99
0.97
4.18
1.10

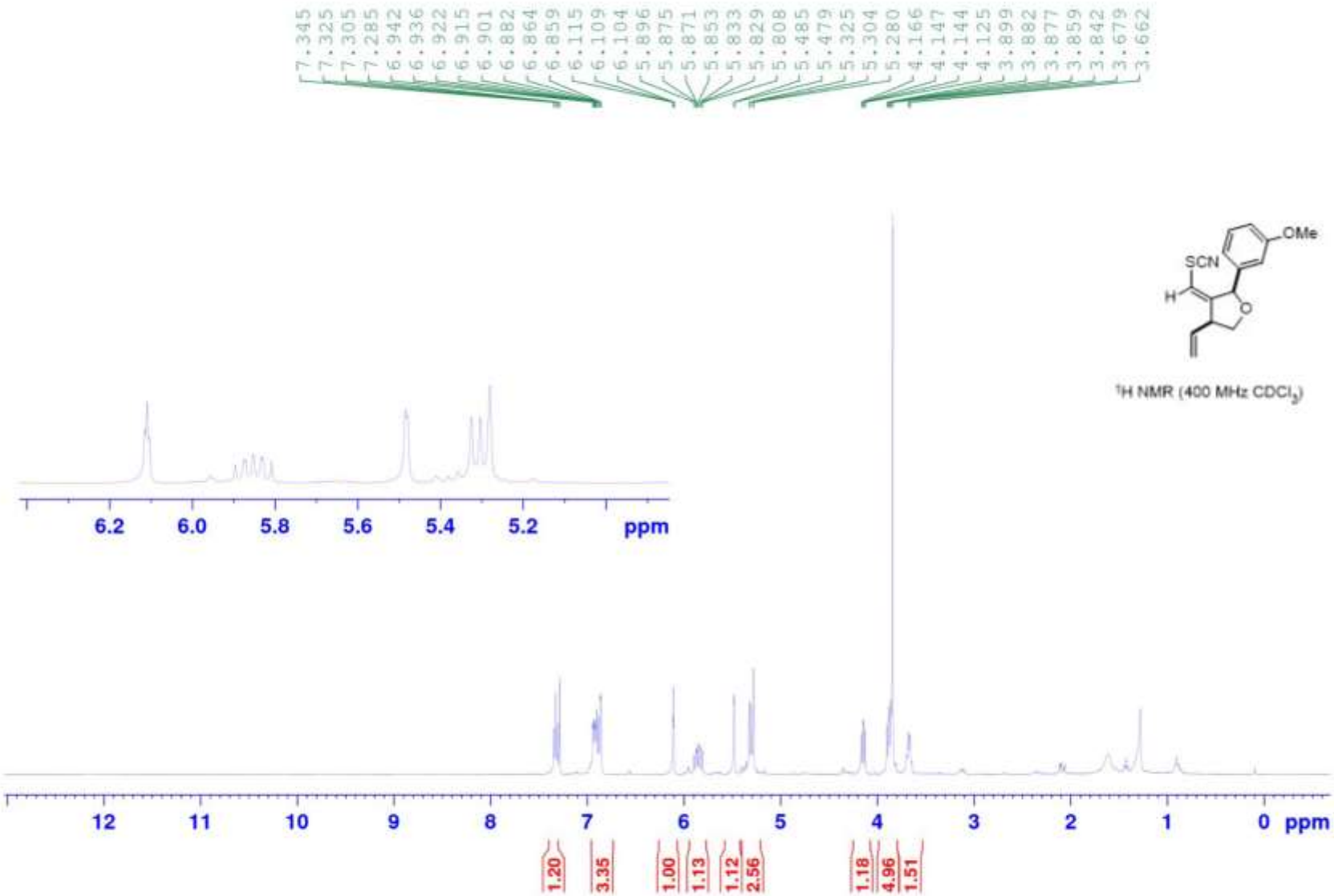

157.830
154.826
135.145
130.766
129.713
125.538
120.894
118.834
111.406
110.674
105.761
77.985
72.085
55.720
51.839
NCS
H
O
OMe
13CNMR (100 MHz, CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

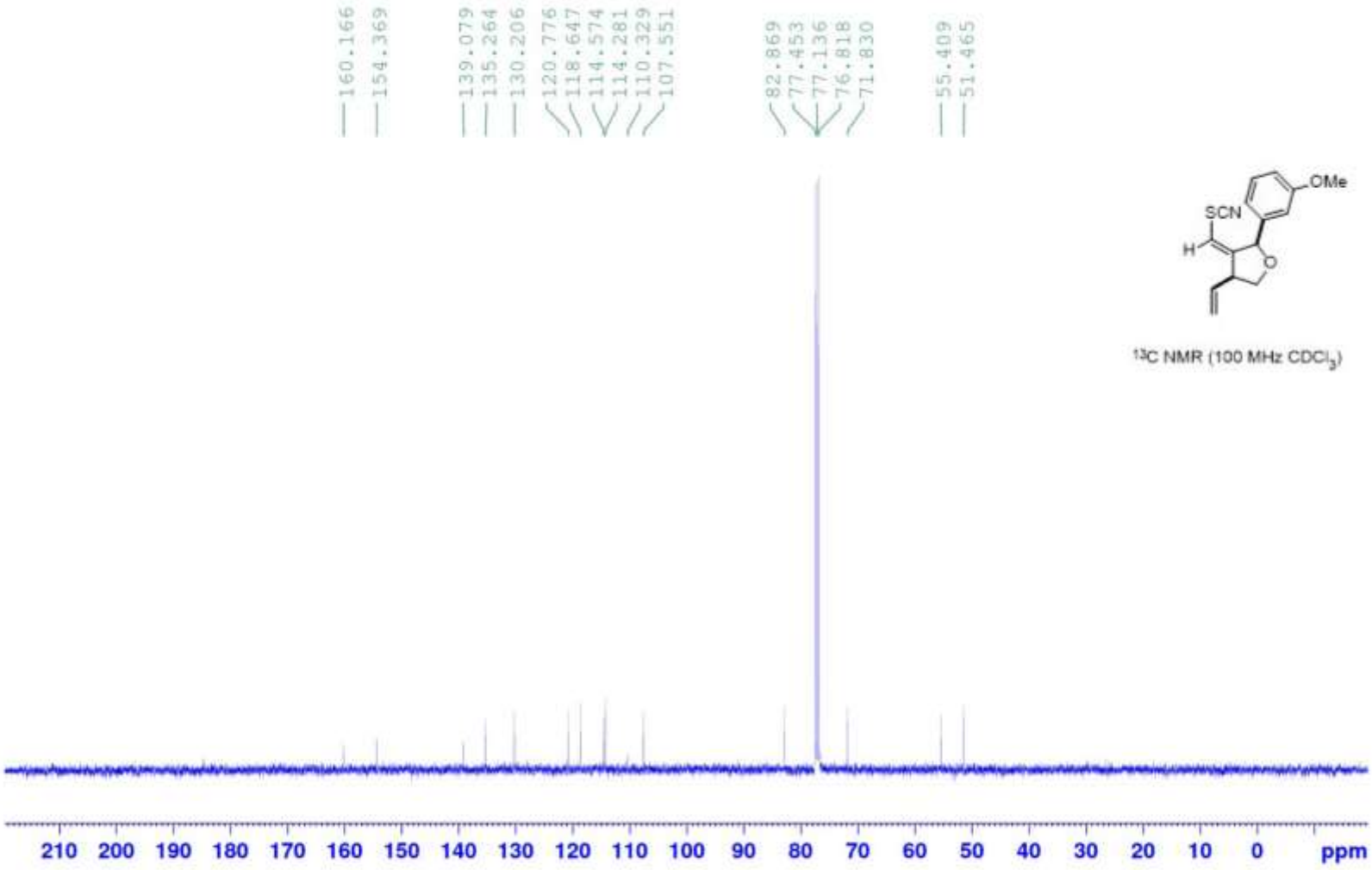


1HNMR (400 MHz, $CDCl_3$)

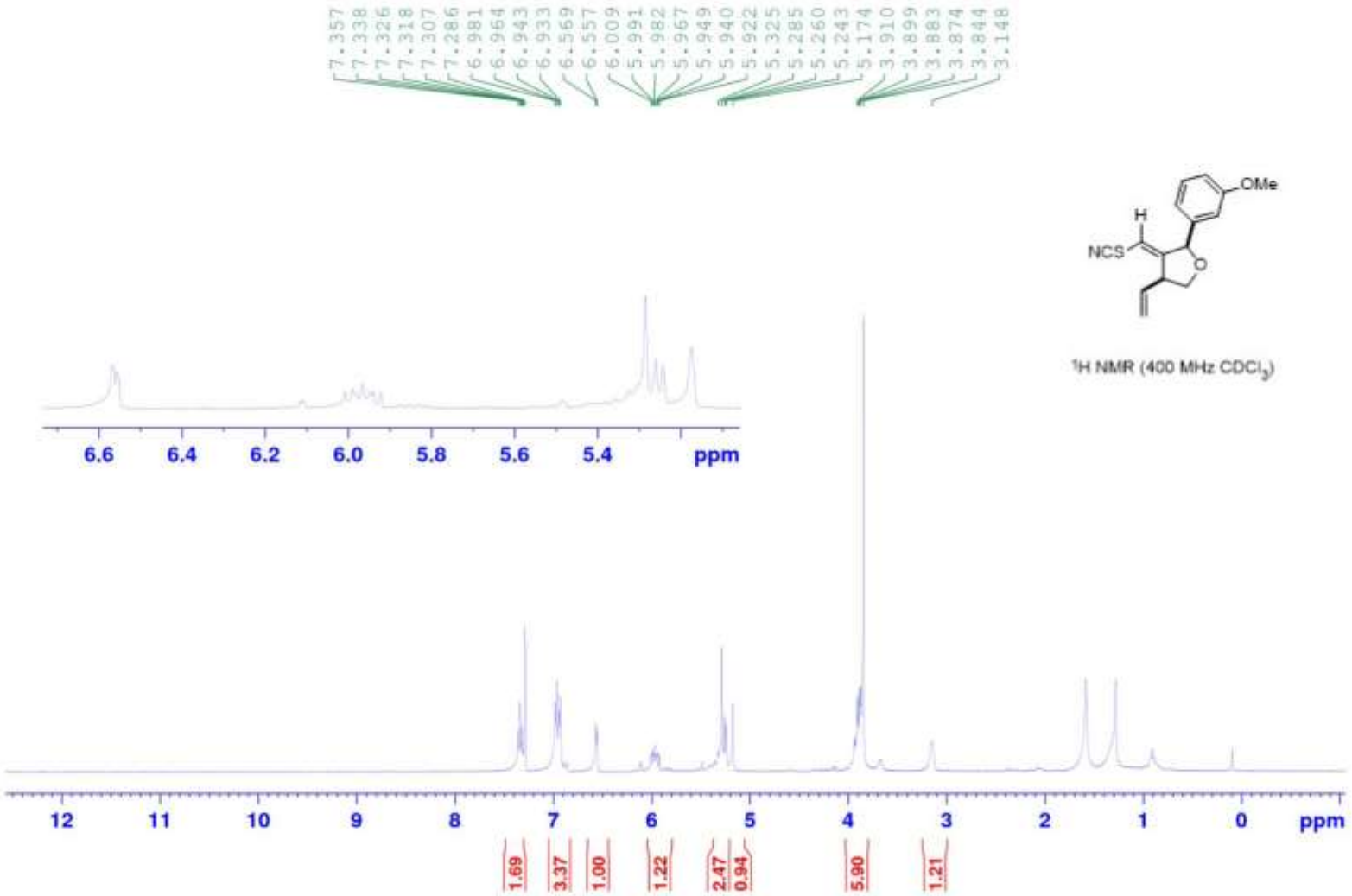


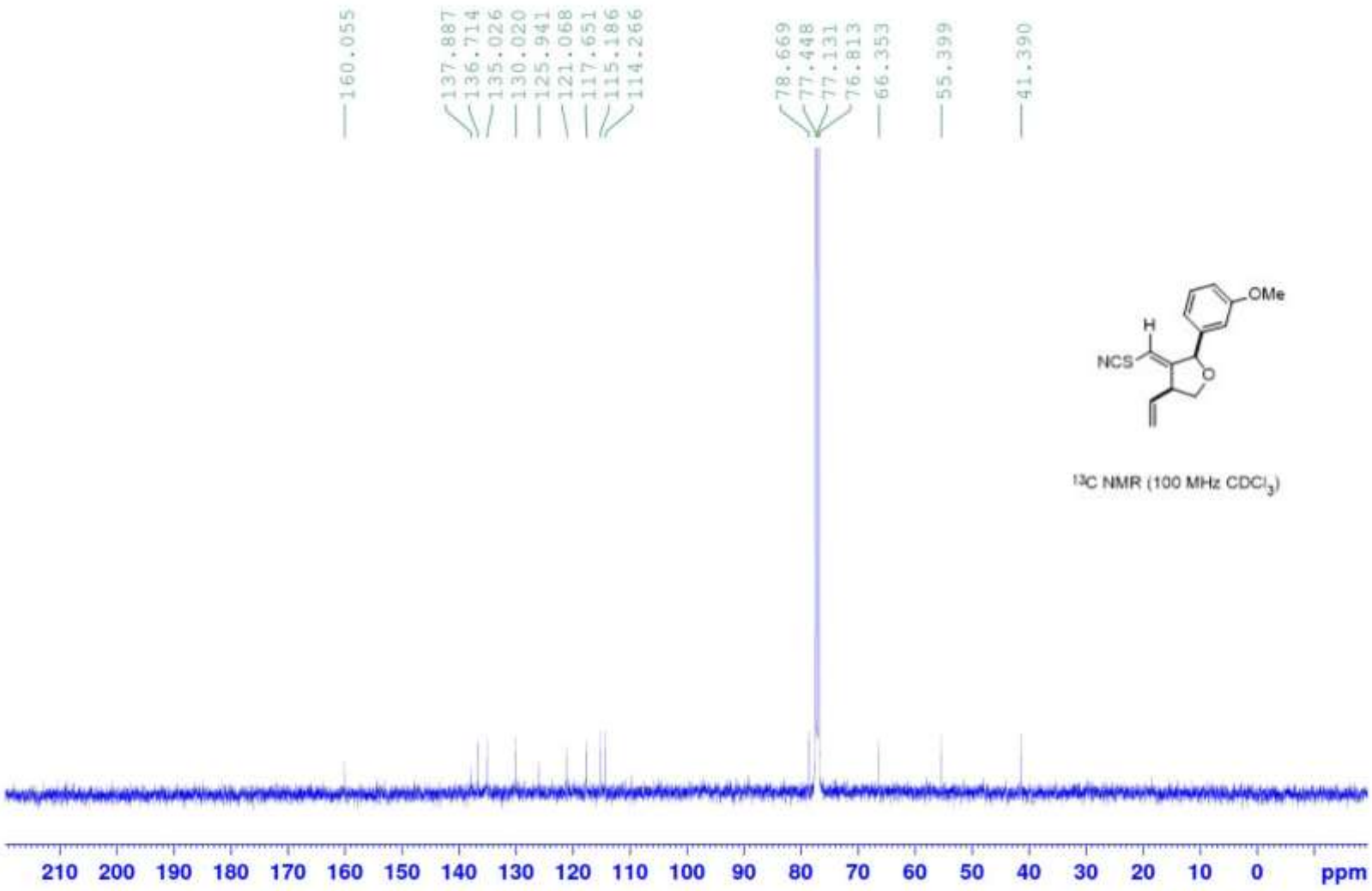
13CNMR (100 MHz, $CDCl_3$)


7.345
7.325
7.305
7.285
6.942
6.936
6.922
6.915
6.901
6.882
6.864
6.859
6.115
6.109
6.104
5.896
5.875
5.871
5.853
5.833
5.829
5.808
5.485
5.479
5.325
5.304
5.280
4.166
4.147
4.144
4.125
3.899
3.882
3.877
3.859
3.842
3.679
3.662
OMe
SCN
H
O
^{1}H NMR (400 MHz CDCl$_3$)
6.2
6.0
5.8
5.6
5.4
5.2
ppm
12
11
10
9
8
7
6
5
4
3
2
1
0 ppm
1.20
3.35
1.00
1.13
1.12
2.56
1.18
4.96
1.51

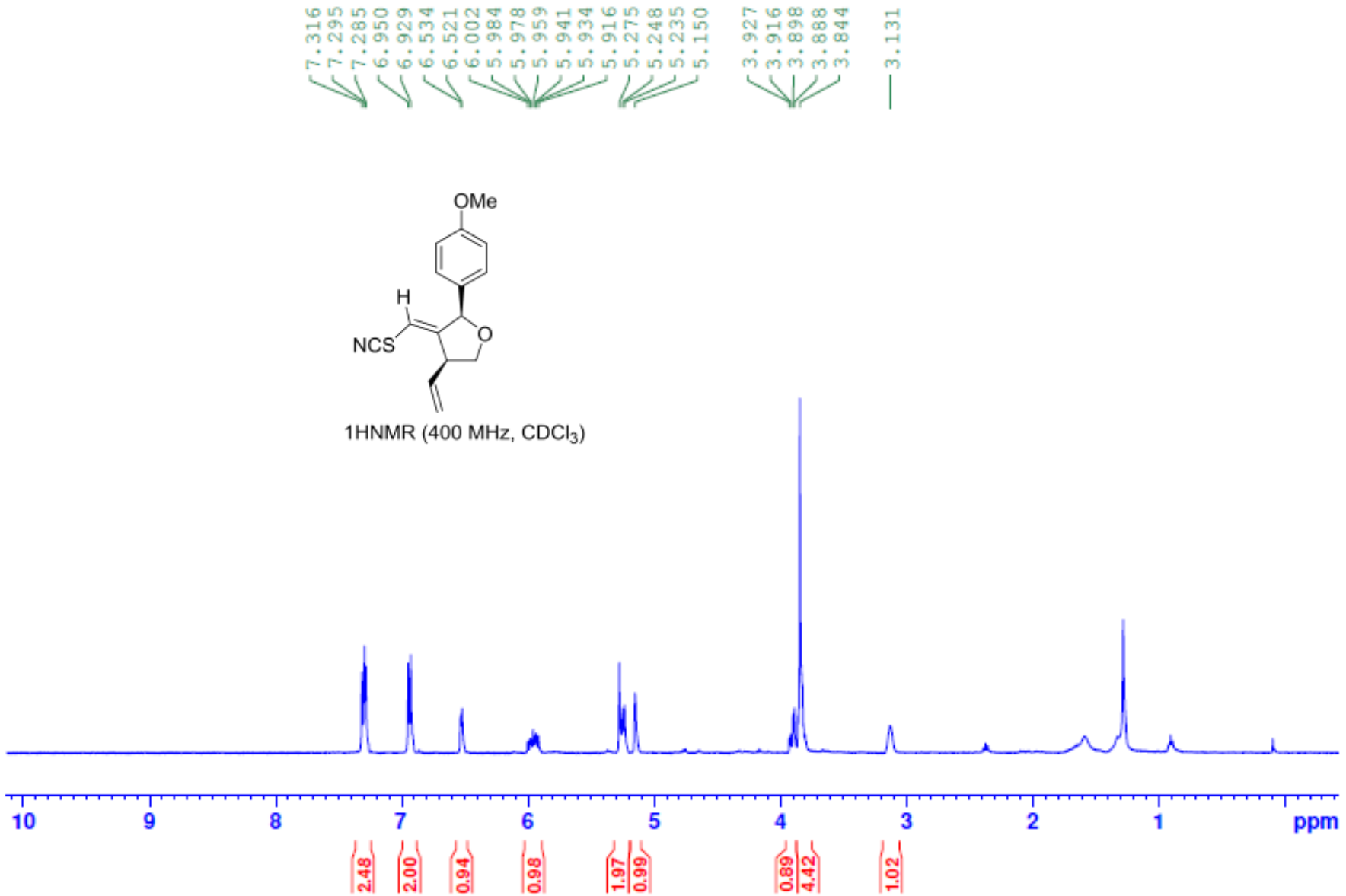


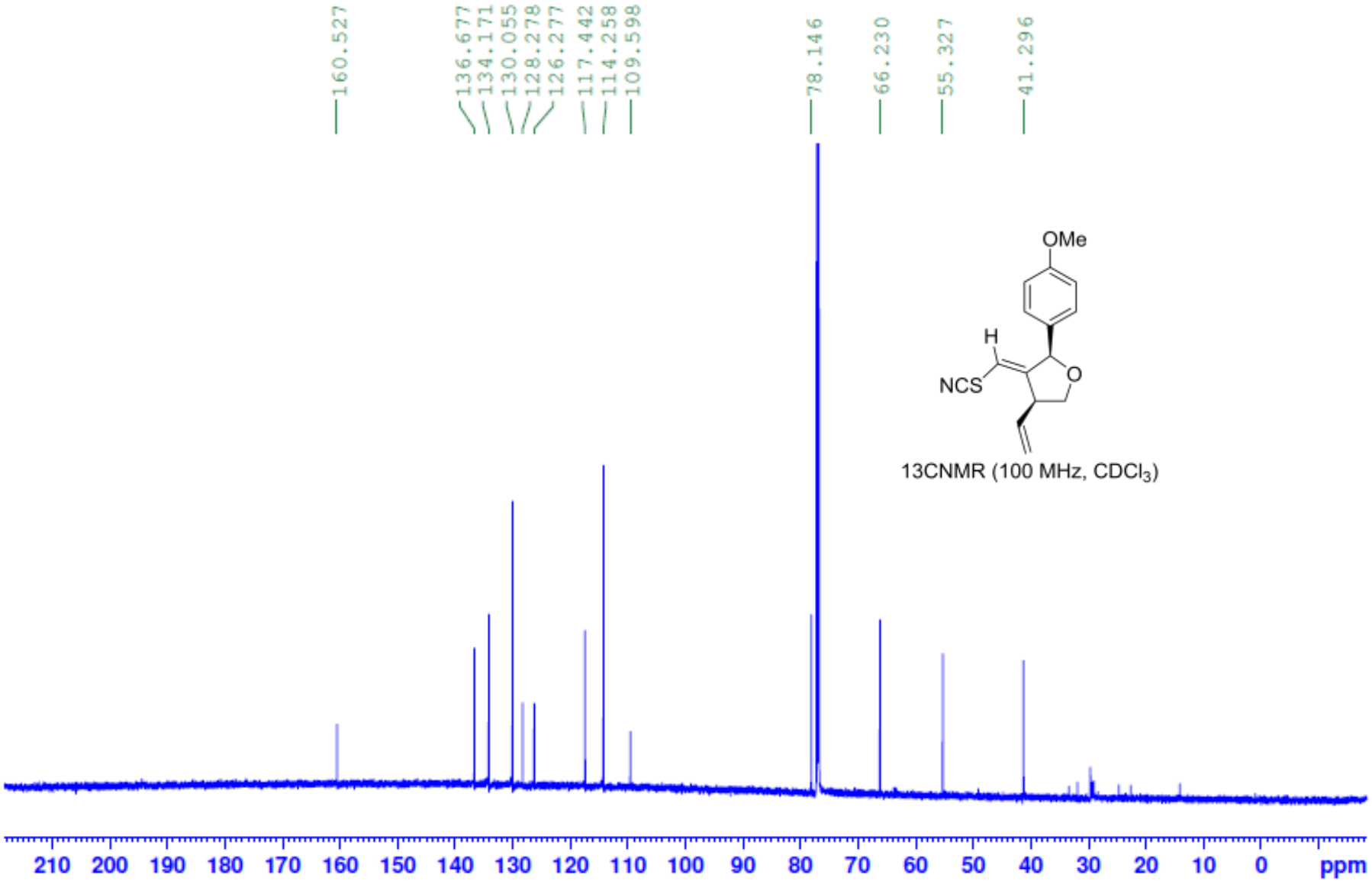
^{13}C NMR (100 MHz $CDCl_3$)

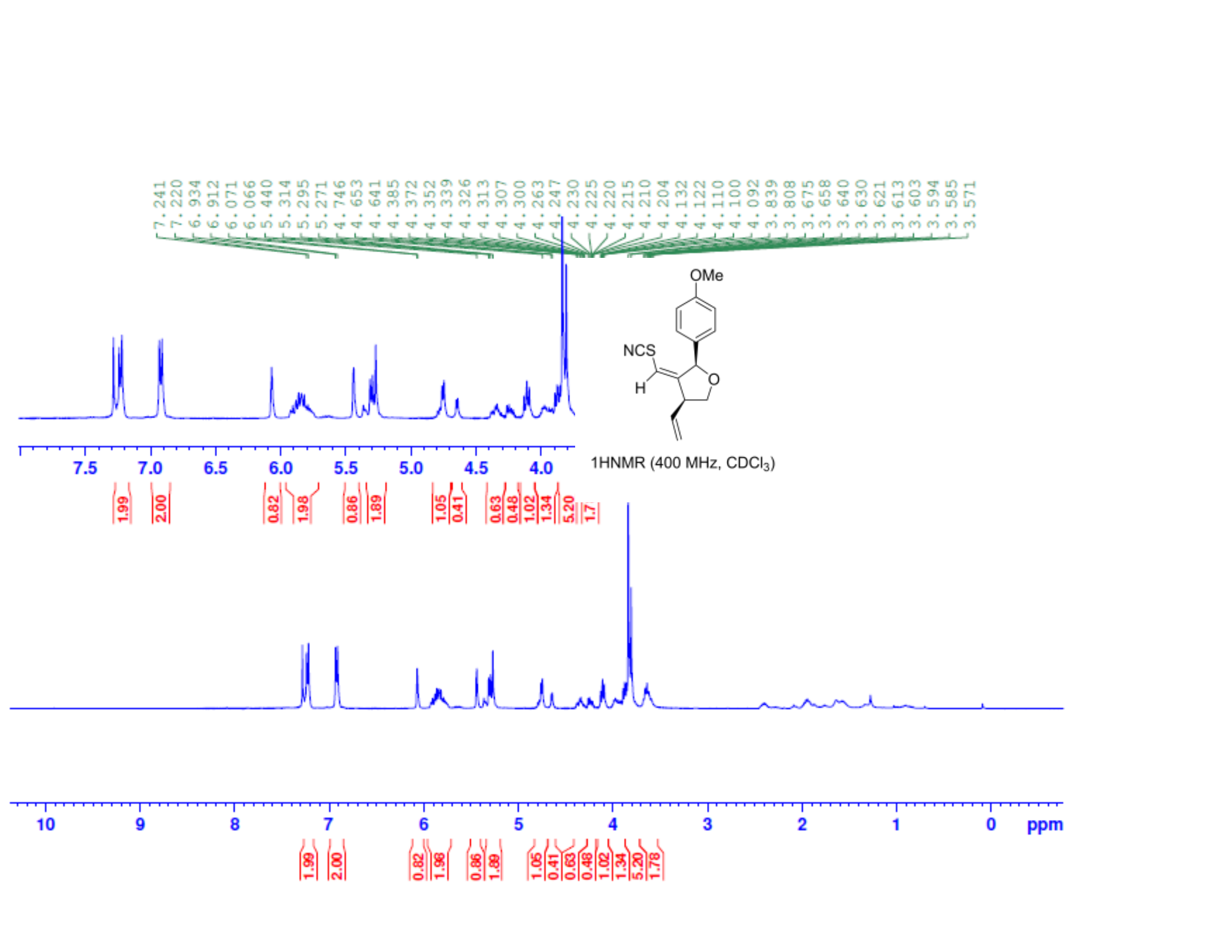

7.357
7.338
7.326
7.318
7.307
7.286
6.981
6.964
6.943
6.933
6.569
6.557
6.009
5.991
5.982
5.967
5.949
5.940
5.922
5.325
5.285
5.260
5.243
5.174
3.910
3.899
3.883
3.874
3.844
3.148
OMe
H
NCS
O
1H NMR (400 MHz CDCl3)
6.6
6.4
6.2
6.0
5.8
5.6
5.4
ppm
12
11
10
9
8
7
6
5
4
3
2
1
0
ppm
1.69
3.37
1.00
1.22
2.47
0.94
5.90
1.21

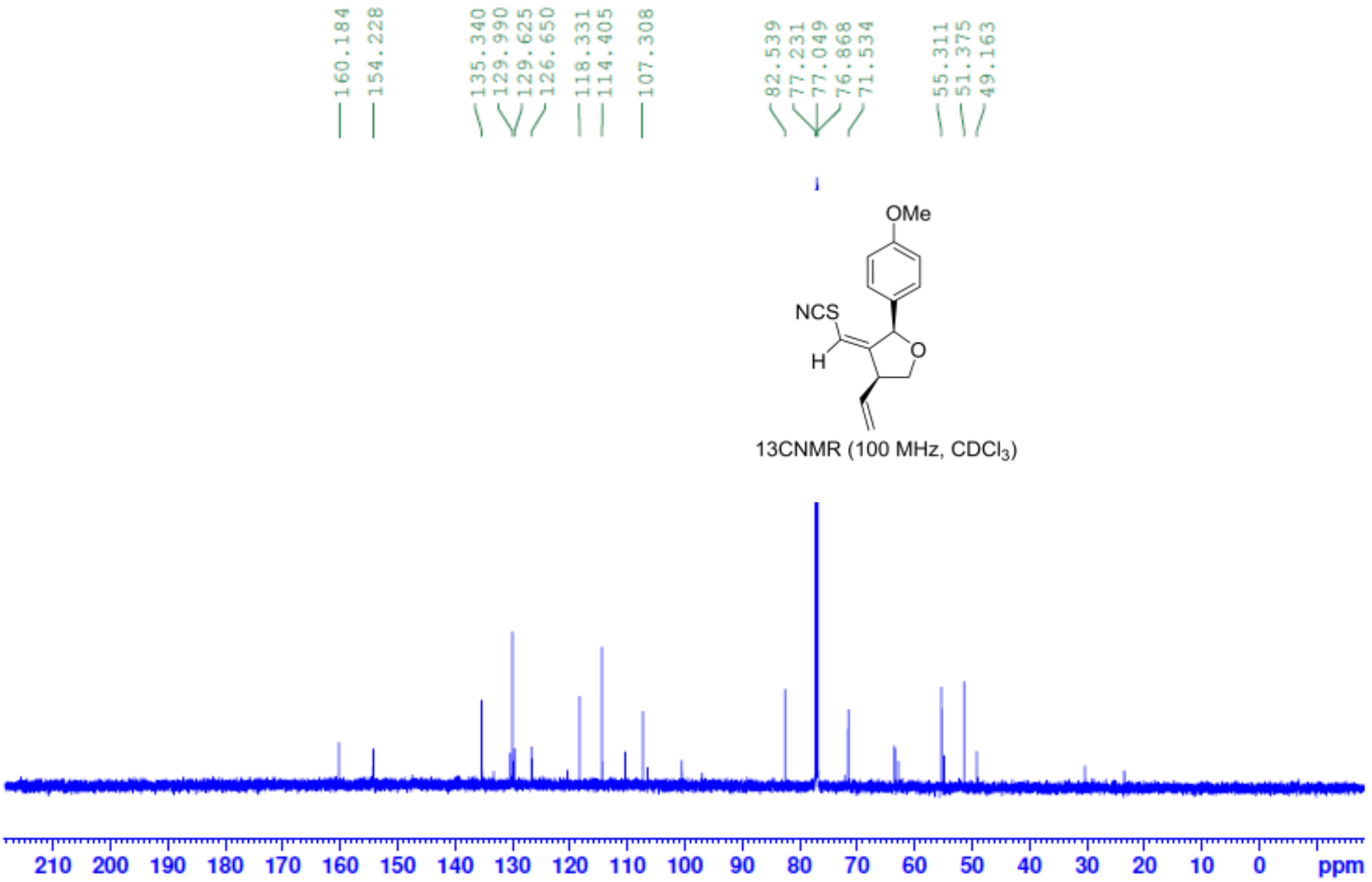


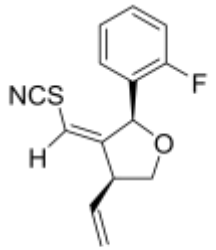
^{13}C NMR (100 MHz $CDCl_3$)


7.316
7.295
7.285
6.950
6.929
6.534
6.521
6.002
5.984
5.978
5.959
5.941
5.934
5.916
5.275
5.248
5.235
5.150
3.927
3.916
3.898
3.888
3.844
3.131
OMe
H
NCS
O
1HNMR (400 MHz, CDCl3)
10
9
8
7
6
5
4
3
2
1
ppm
2.48
2.00
0.94
0.98
1.97
0.99
0.89
4.42
1.02

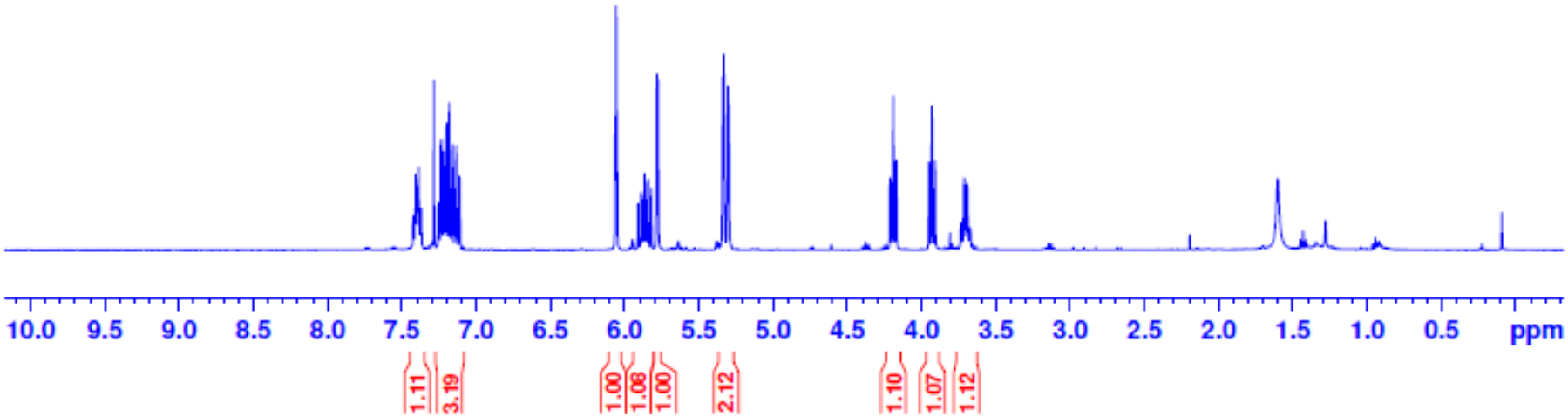

160.527
136.677
134.171
130.055
128.278
126.277
117.442
114.258
109.598
78.146
66.230
55.327
41.296
OMe
H
NCS
O
13CNMR (100 MHz, CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

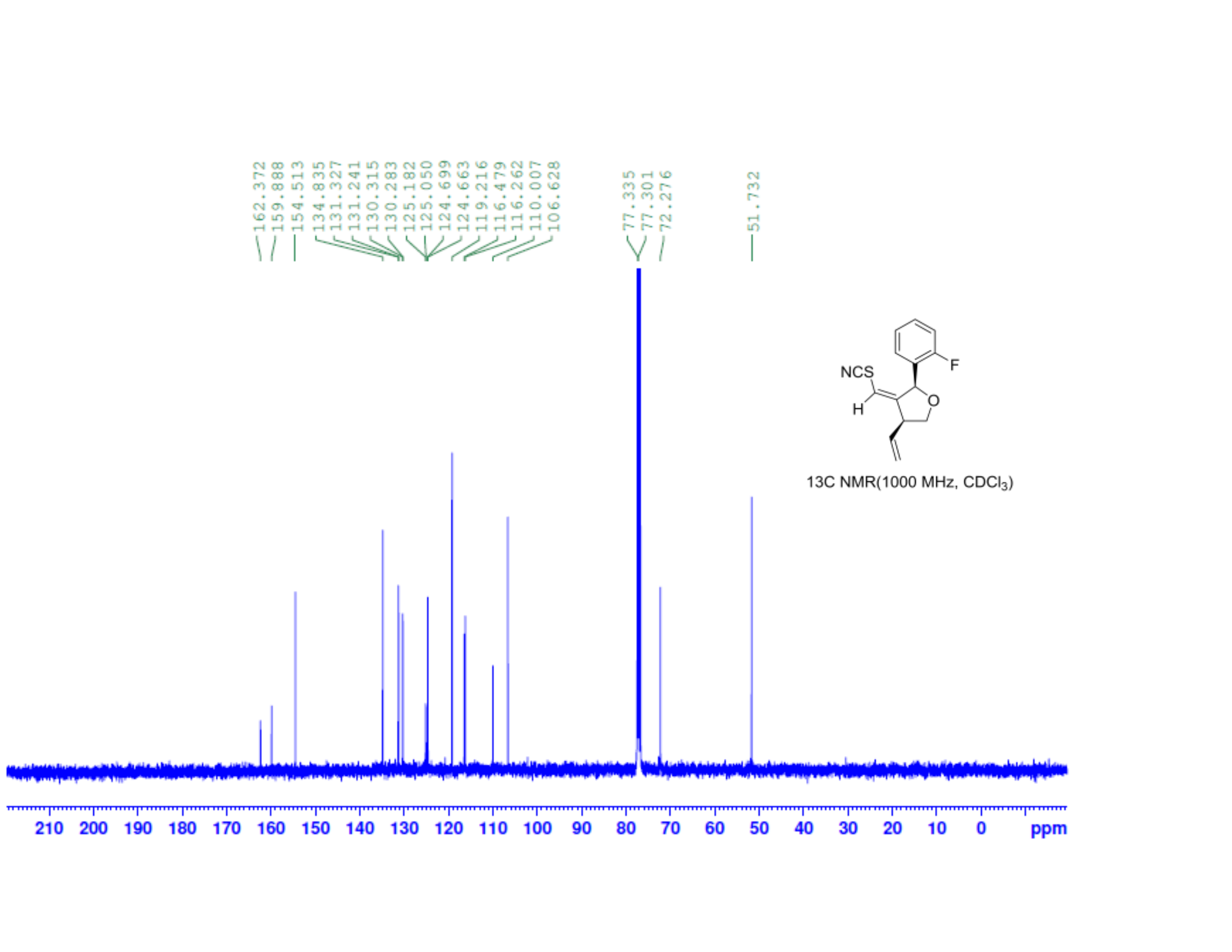

7.241
7.220
6.934
6.912
6.071
6.066
6.440
5.314
5.295
5.271
4.746
4.653
4.641
4.385
4.372
4.352
4.339
4.326
4.313
4.307
4.300
4.263
4.247
4.230
4.225
4.220
4.215
4.210
4.204
4.132
4.122
4.110
4.100
4.092
3.839
3.808
3.675
3.658
3.640
3.630
3.621
3.613
3.603
3.594
3.585
3.571
OMe
NCS
H
O
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
1.99
2.00
0.82
1.98
0.86
1.89
1.05
0.41
0.63
0.48
1.02
1.34
5.20
1.7
1HNMR (400 MHz, CDCl3)
10
9
8
7
6
5
4
3
2
1
0
ppm
1.99
2.00
0.82
1.98
0.86
1.89
1.05
0.41
0.63
0.48
1.02
1.34
5.20
1.78

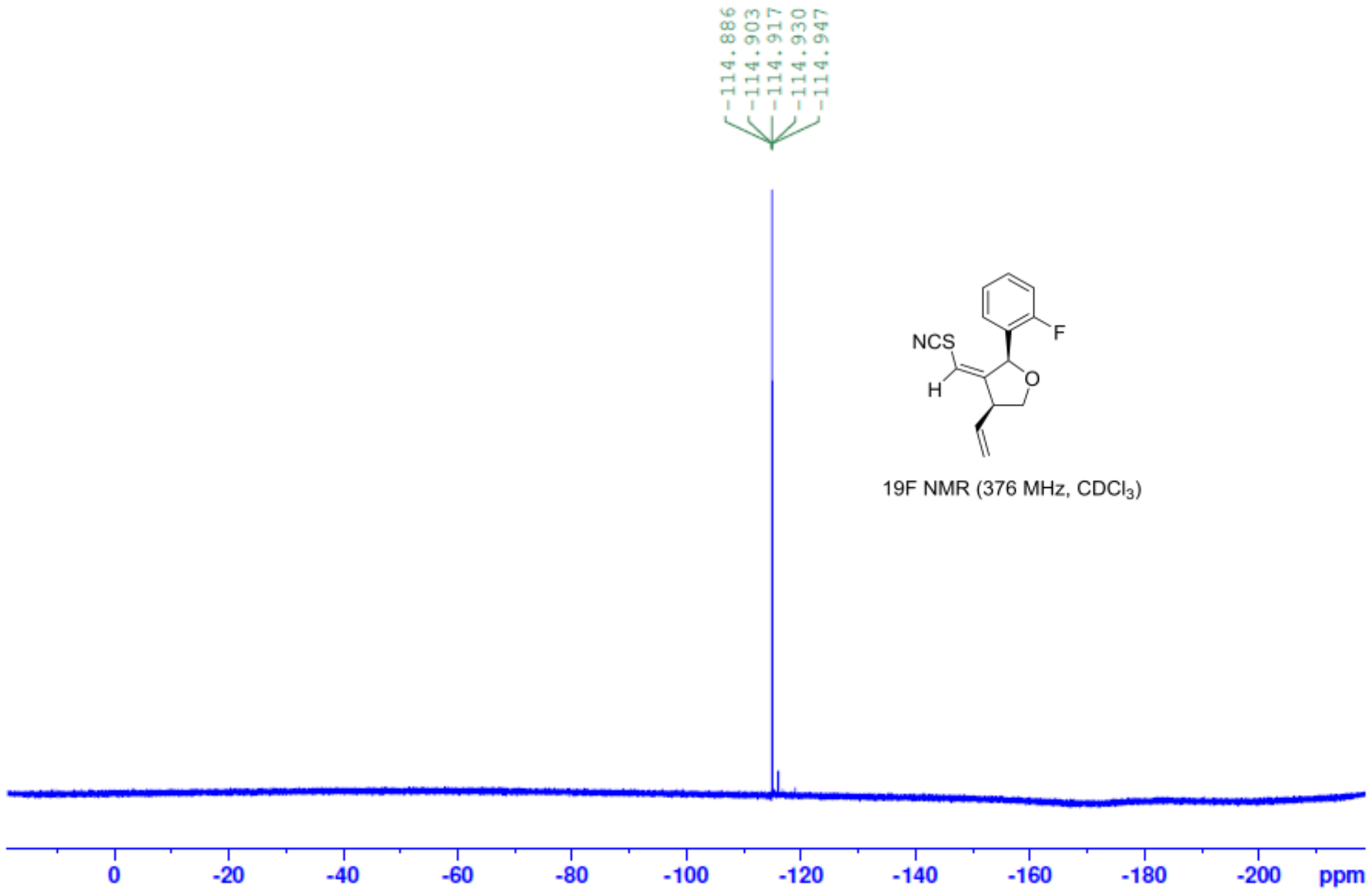

160.184
154.228
135.340
129.990
129.625
126.650
118.331
114.405
107.308
82.539
77.231
77.049
76.868
71.534
55.311
51.375
49.163
OMe
NCS
H
O
13CNMR (100 MHz, CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm



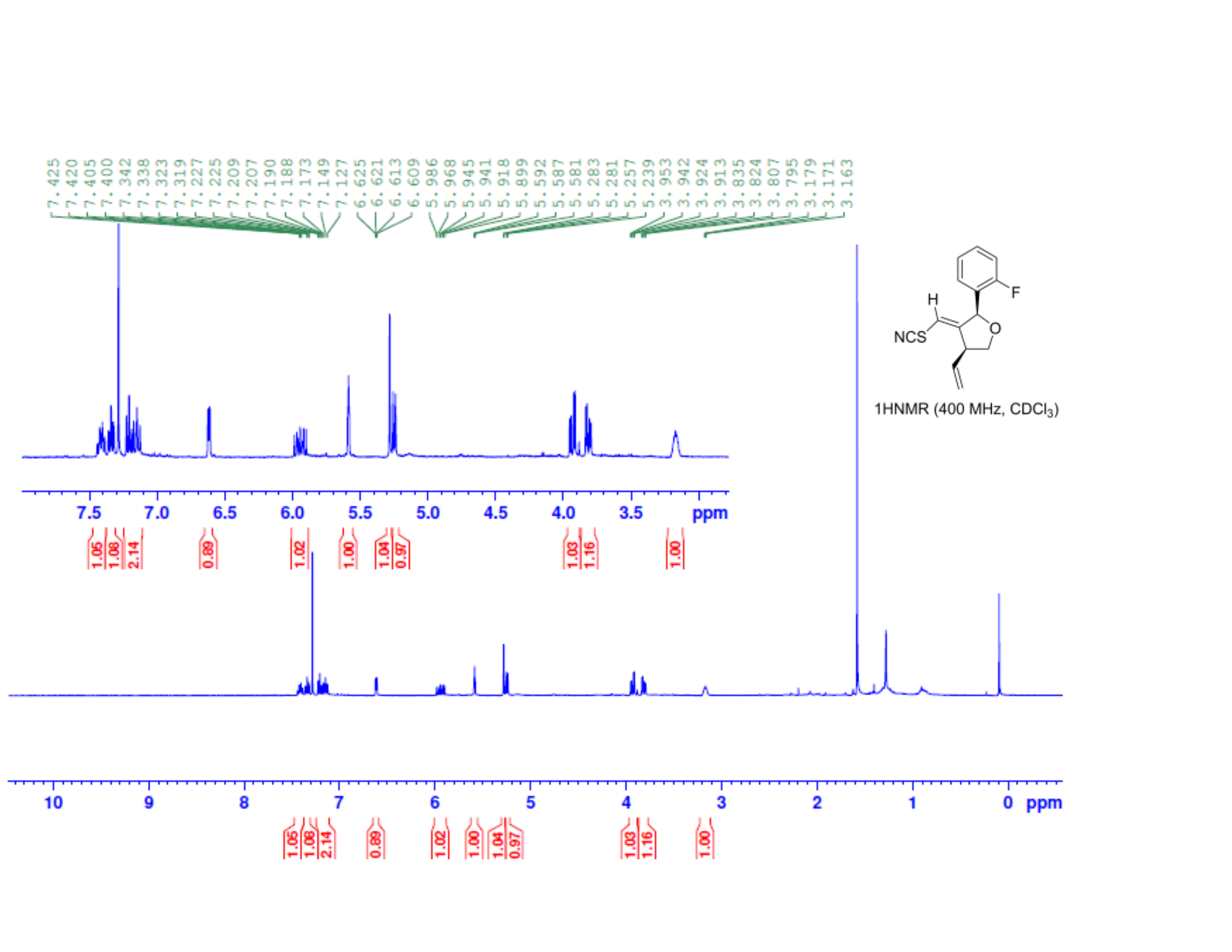
1HNMR (400 MHz, $CDCl_3$)

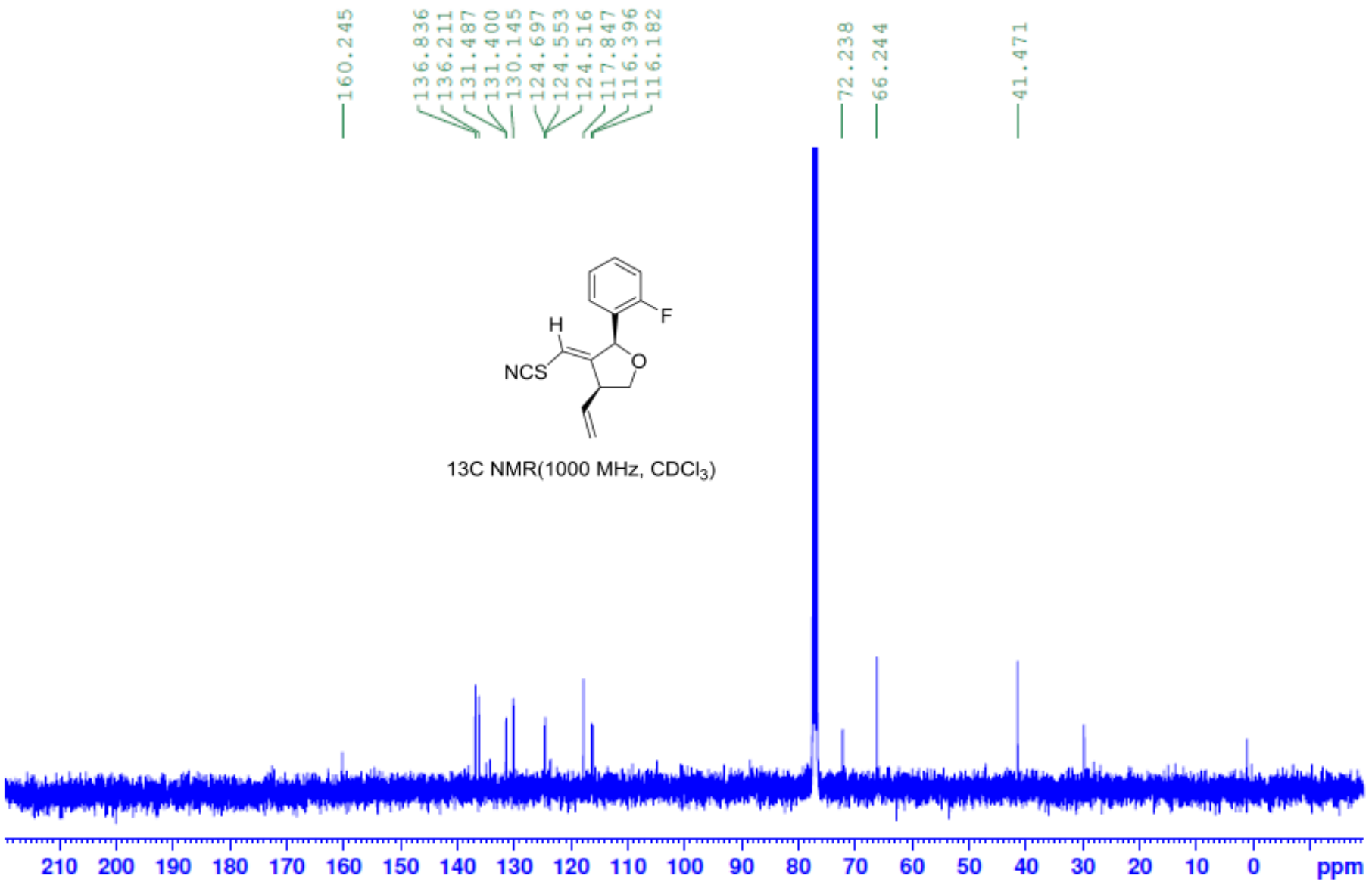



162.372
159.888
154.513
134.835
131.327
131.241
130.315
130.283
125.182
125.050
124.699
124.663
119.216
116.479
116.262
110.007
106.628
77.335
77.301
72.276
51.732
NCS
H
O
F
13C NMR(1000 MHz, CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

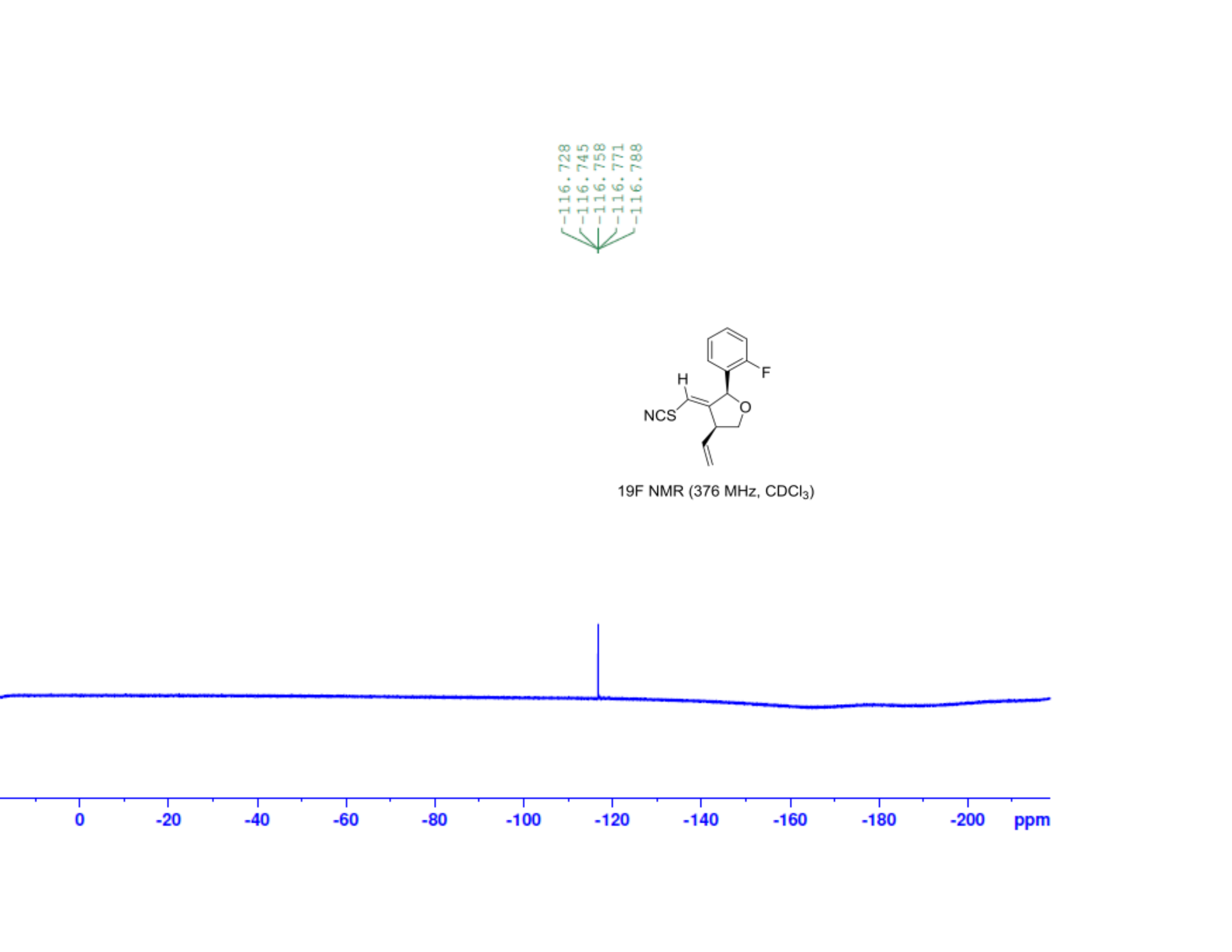


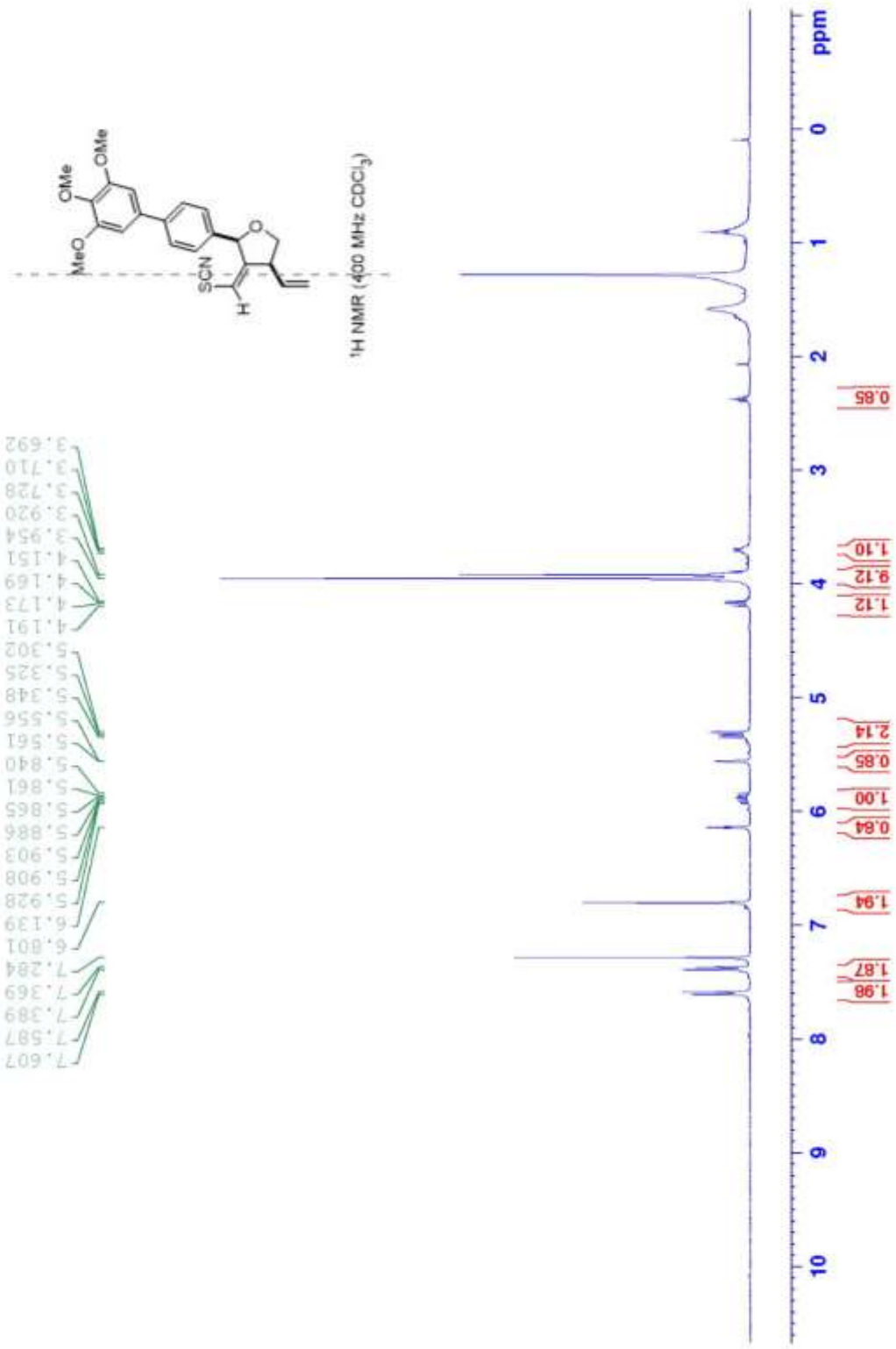
19F NMR (376 MHz, $CDCl_3$)

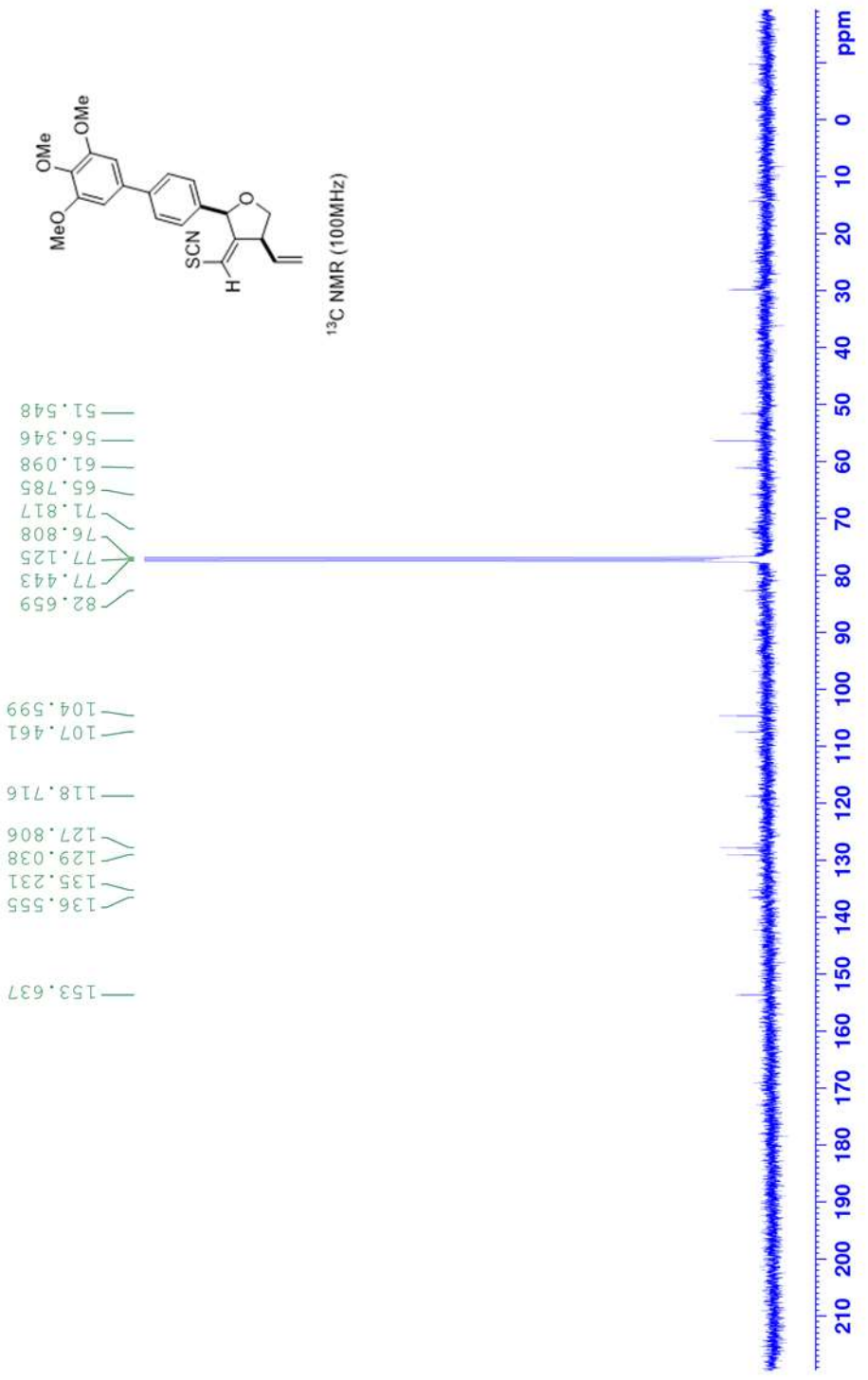

7.425
7.420
7.405
7.400
7.342
7.338
7.323
7.319
7.227
7.225
7.209
7.207
7.190
7.188
7.173
7.149
7.127
6.625
6.621
6.613
6.609
5.986
5.968
5.945
5.941
5.918
5.899
5.592
5.587
5.581
5.283
5.281
5.257
5.239
3.953
3.942
3.924
3.913
3.835
3.824
3.807
3.795
3.179
3.171
3.163
H
F
NCS
O
1HNMR (400 MHz, CDCl3)
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
ppm
1.05
1.08
2.14
0.89
1.02
1.00
1.04
0.97
1.03
1.16
1.00
10
9
8
7
6
5
4
3
2
1
0
ppm

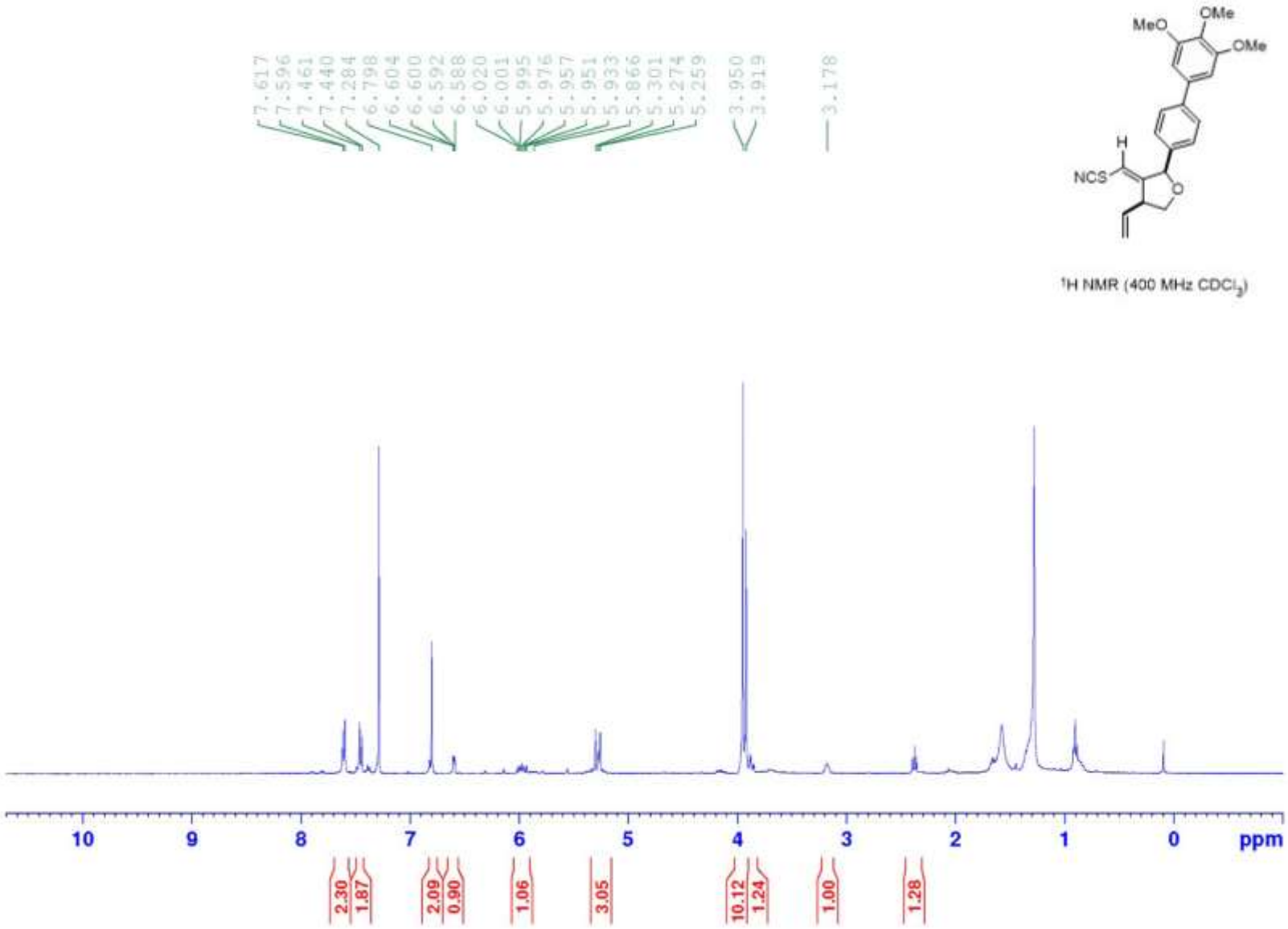


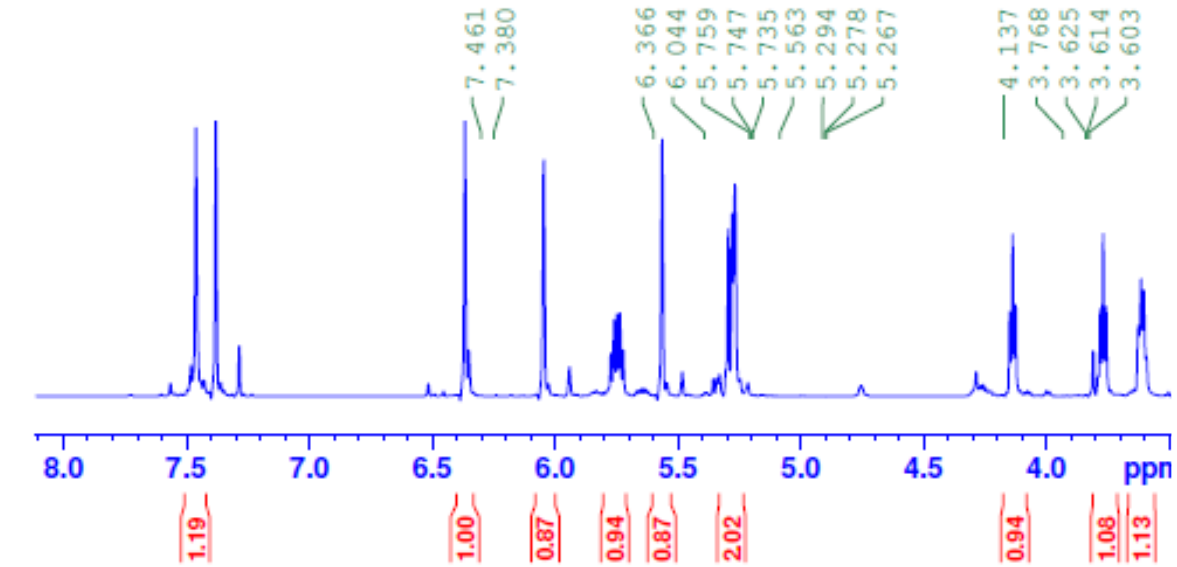
13C NMR(1000 MHz, $CDCl_3$)

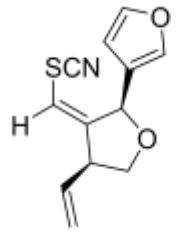

-116.728
-116.745
-116.758
-116.771
-116.788
F
H
NCS
O
19F NMR (376 MHz, CDCl3)
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
ppm


OMe
OMe
MeO
SCN
H
^{1}H NMR (400 MHz CDCl$_3$)
ppm
0.85
1.10
9.12
1.12
2.14
0.85
1.00
0.84
1.94
1.87
1.98
3.692
3.710
3.728
3.920
3.954
4.151
4.169
4.173
4.191
5.302
5.325
5.348
5.556
5.561
5.840
5.861
5.865
5.886
5.903
5.908
5.928
6.139
6.801
7.284
7.369
7.389
7.587
7.607

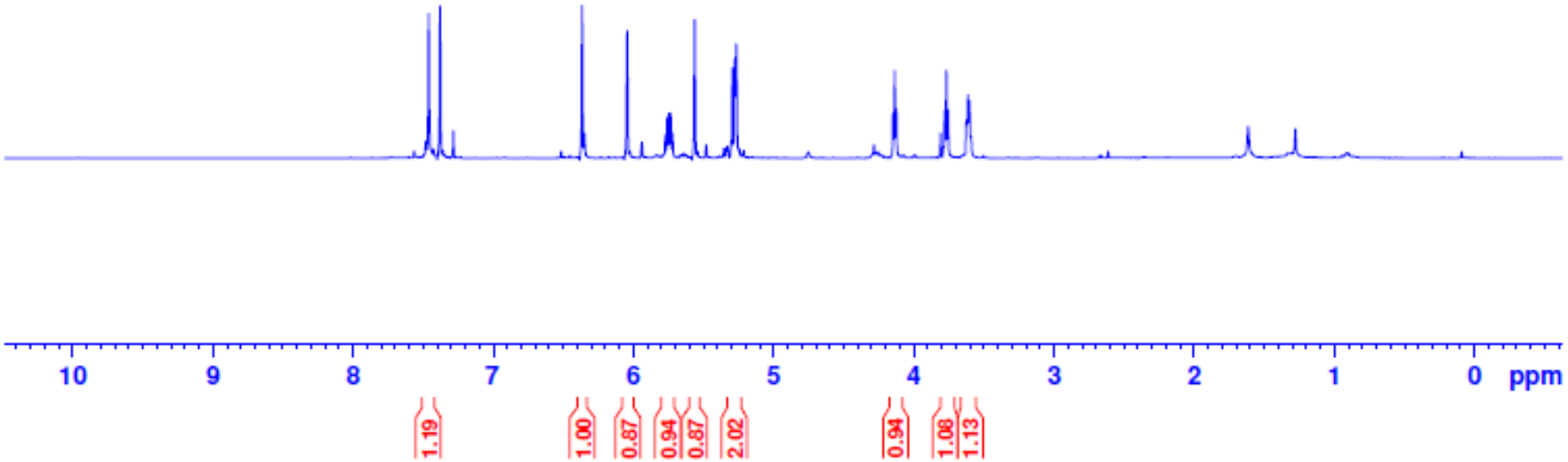

OMe
OMe
MeO
SCN
H
O
^{13}C NMR (100MHz)
51.548
56.346
61.098
65.785
71.817
76.808
77.125
77.443
82.659
104.599
107.461
118.716
127.806
129.038
135.231
136.555
153.637
ppm
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

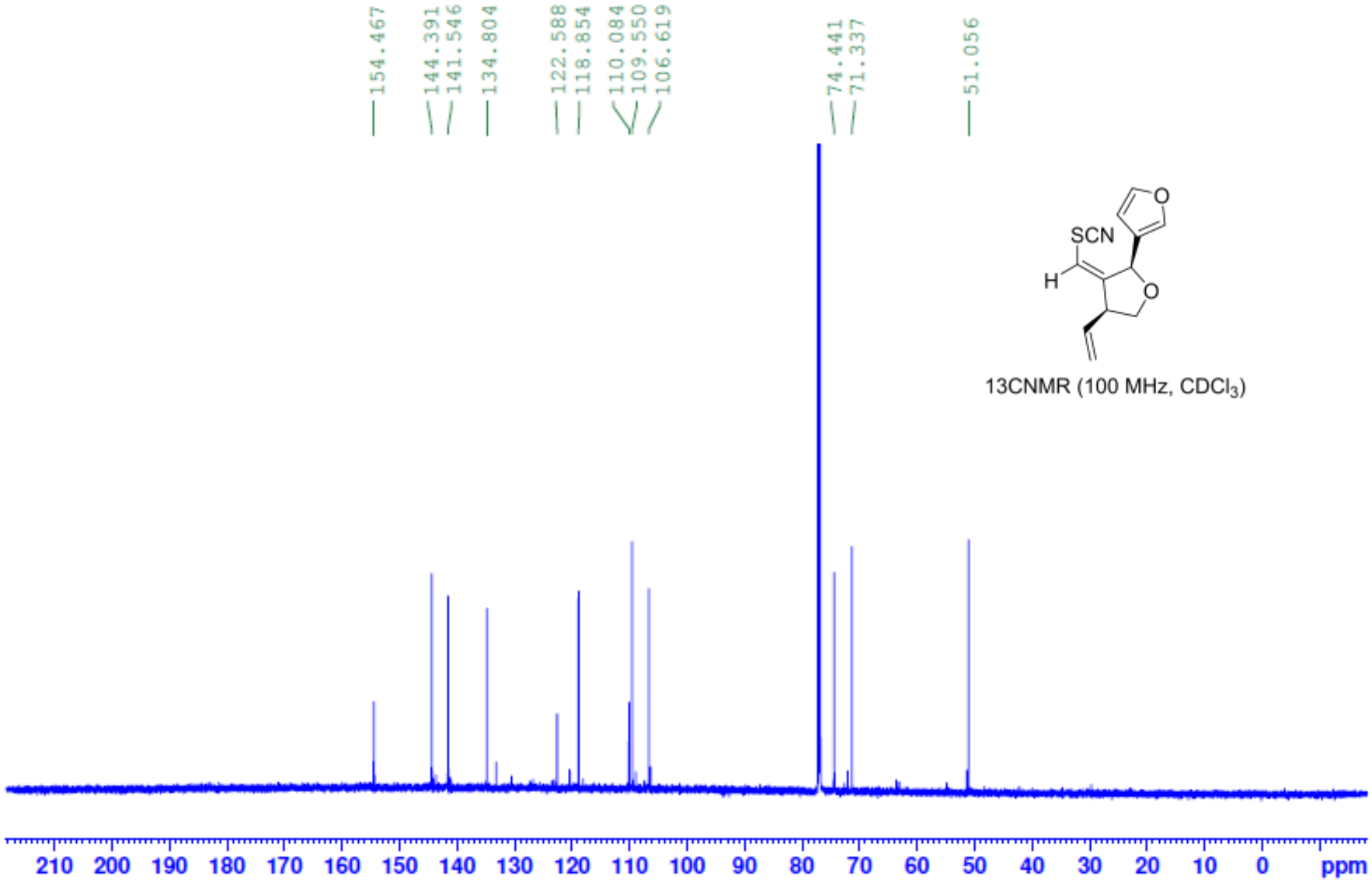

7.617
7.596
7.461
7.440
7.284
6.798
6.604
6.600
6.592
6.588
6.020
6.001
5.995
5.976
5.957
5.951
5.933
5.866
5.301
5.274
5.259
3.950
3.919
3.178
MeO
OMe
OMe
H
NCS
O
1H NMR (400 MHz CDCl3)
10
9
8
7
6
5
4
3
2
1
0
ppm
2.30
1.87
2.09
0.90
1.06
3.05
10.12
1.24
1.00
1.28

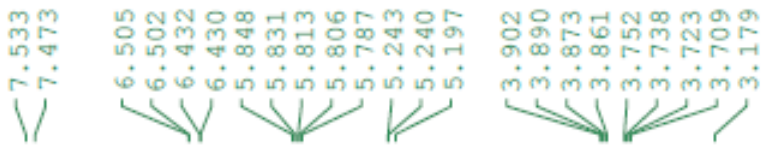


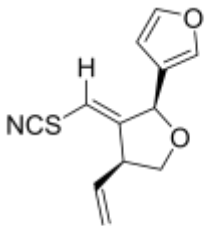


1HNMR (700 MHz, $CDCl_3$)

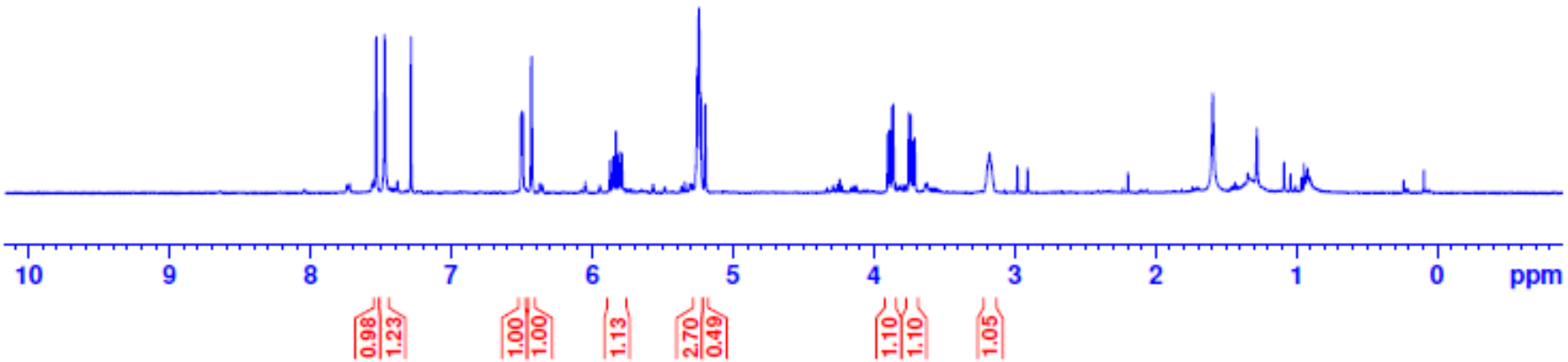


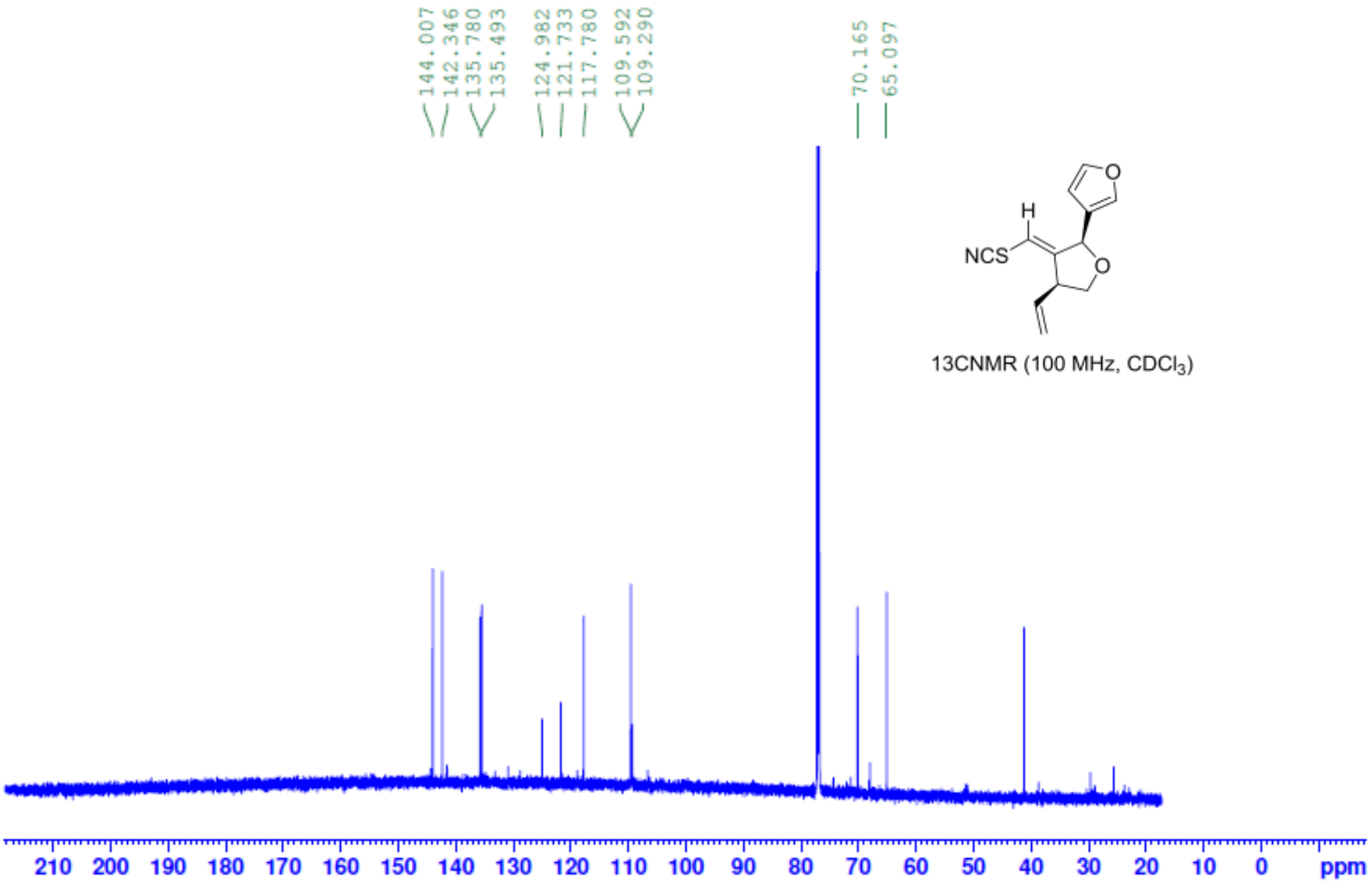

154.467
144.391
141.546
134.804
122.588
118.854
110.084
109.550
106.619
74.441
71.337
51.056
SCN
H
O
O
13CNMR (100 MHz, CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm



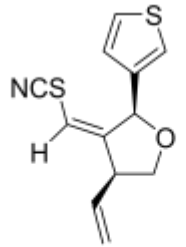


1HNMR (400 MHz, $CDCl_3$)

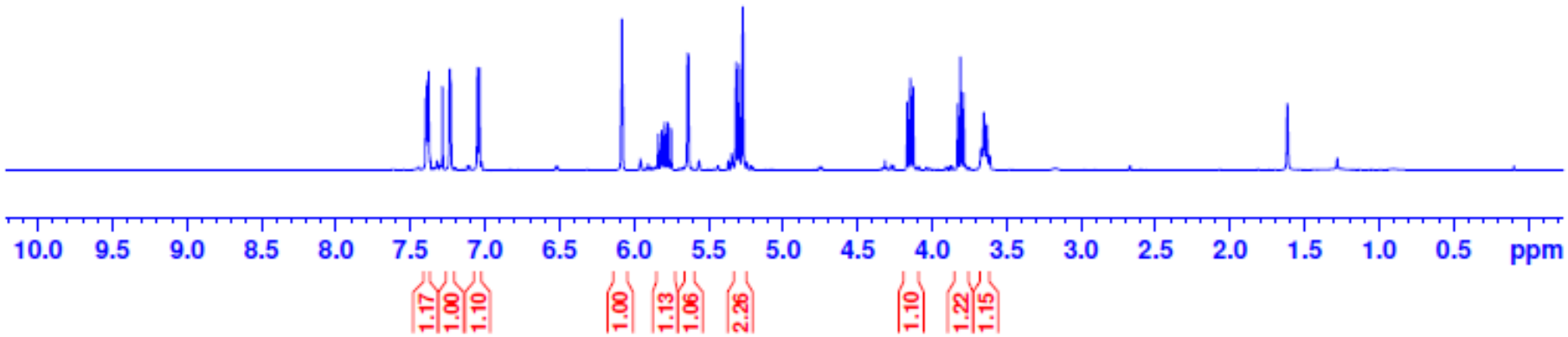


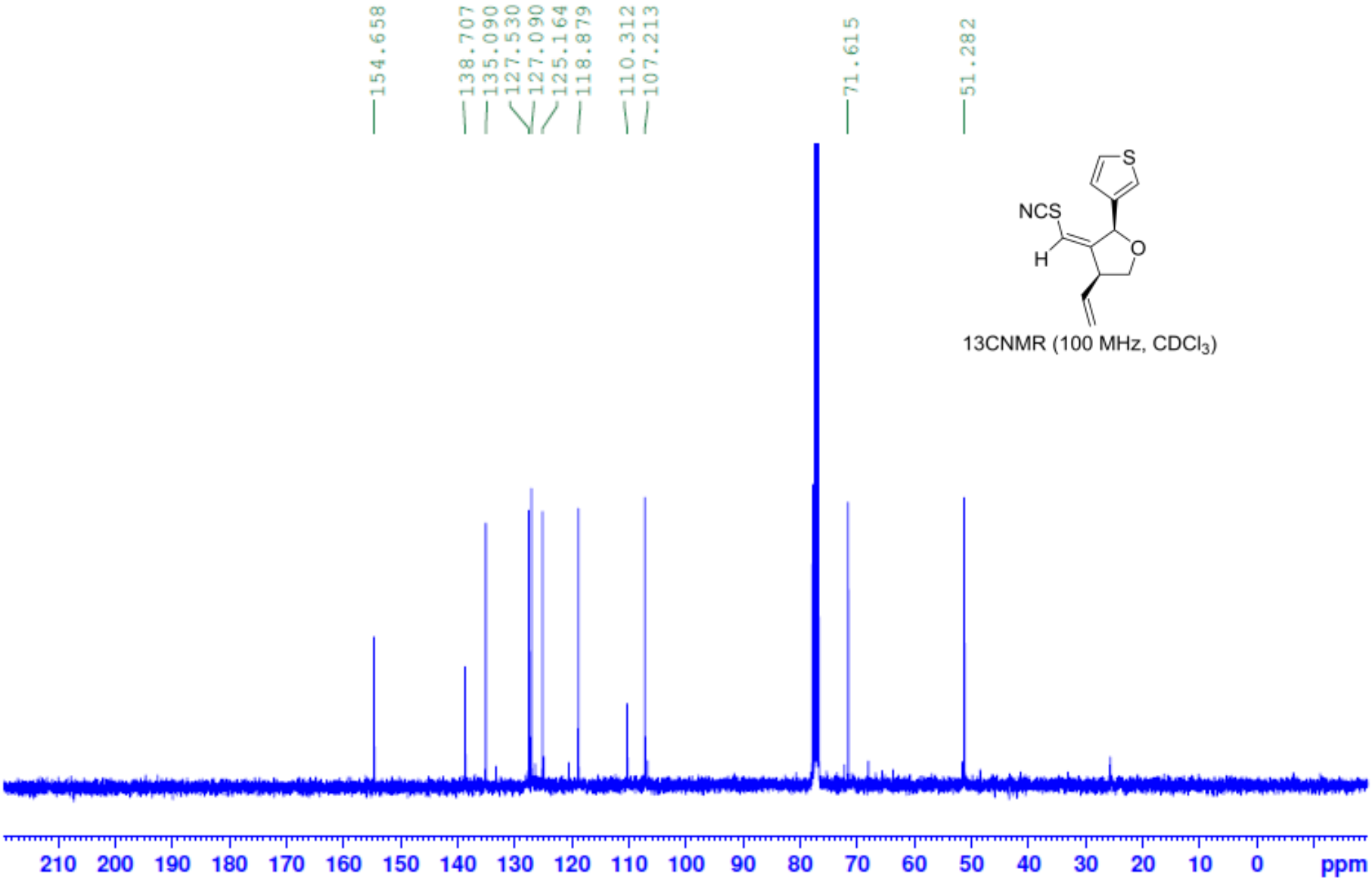


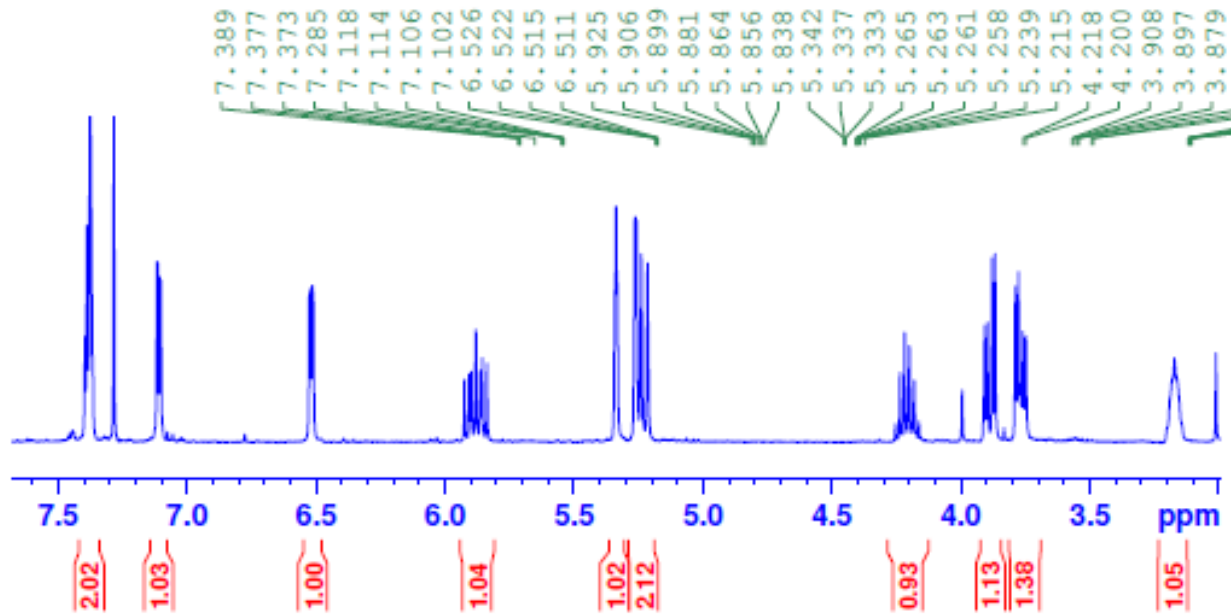
13CNMR (100 MHz, $CDCl_3$)

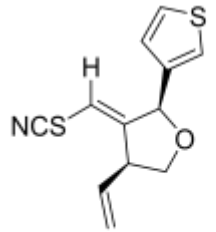


1HNMR (400 MHz, $CDCl_3$)

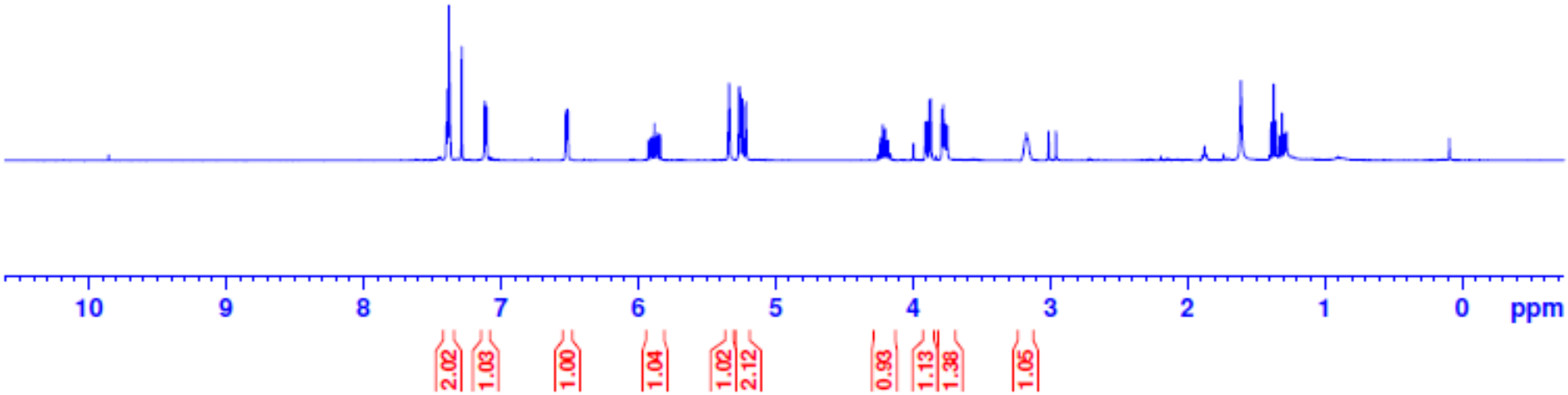


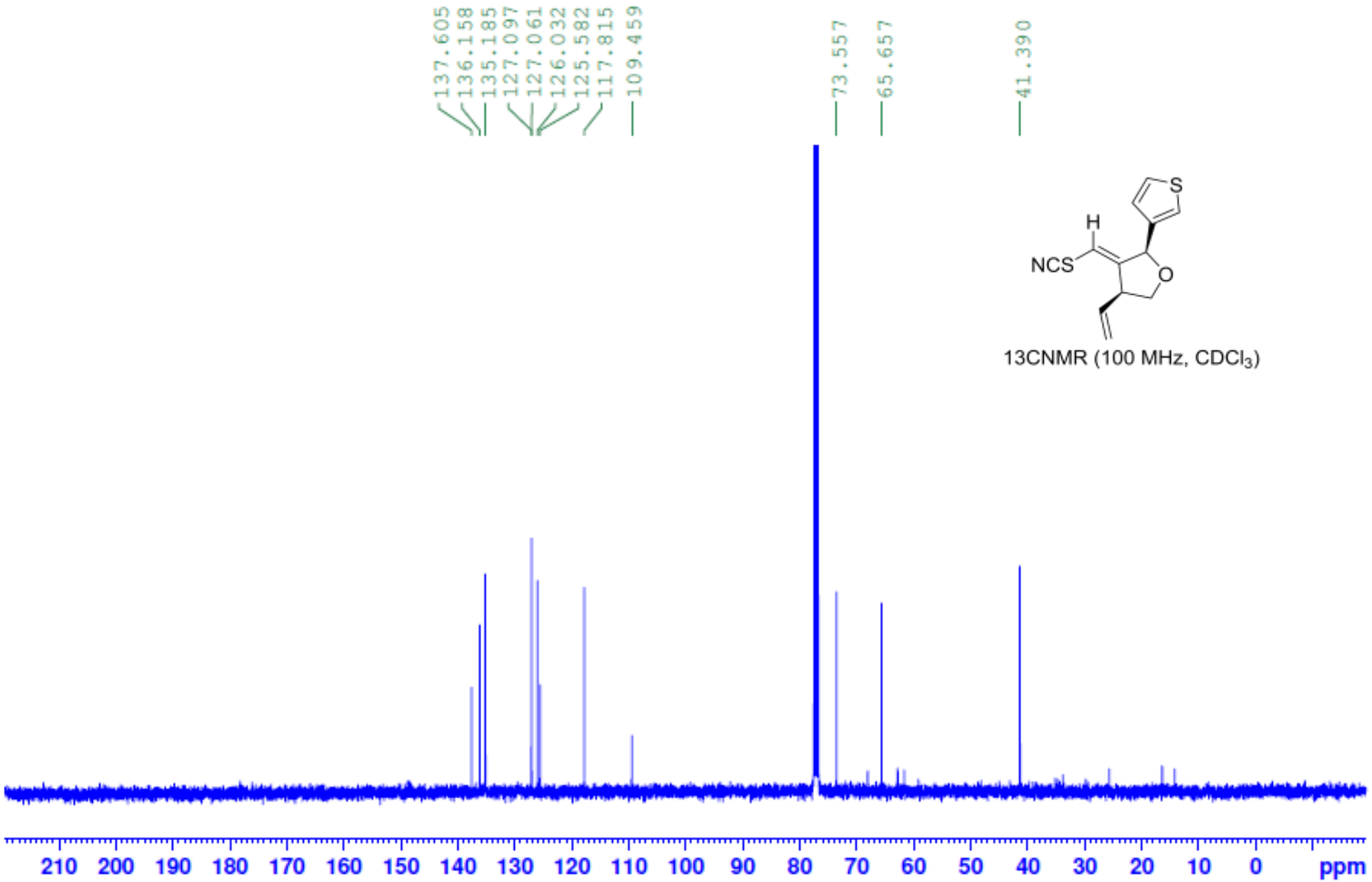

154.658
138.707
135.090
127.530
127.090
125.164
118.879
110.312
107.213
71.615
51.282
S
NCS
H
O
13CNMR (100 MHz, CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

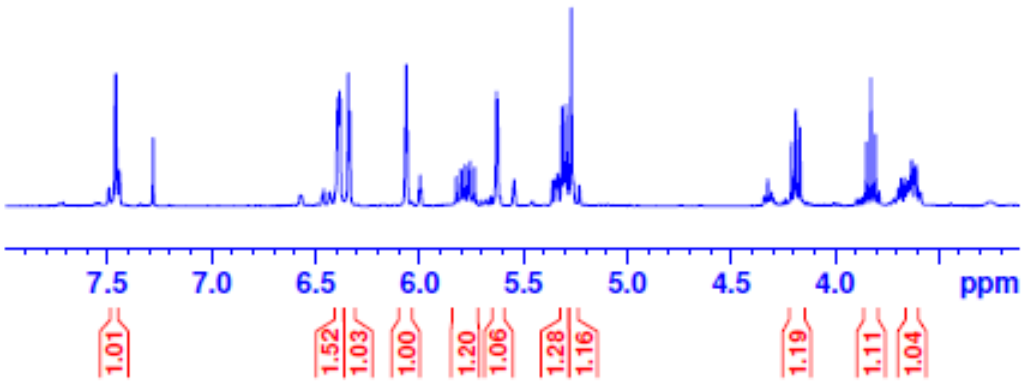


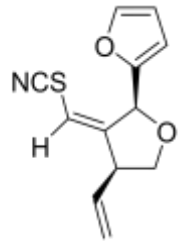


1HNMR (400 MHz, $CDCl_3$)

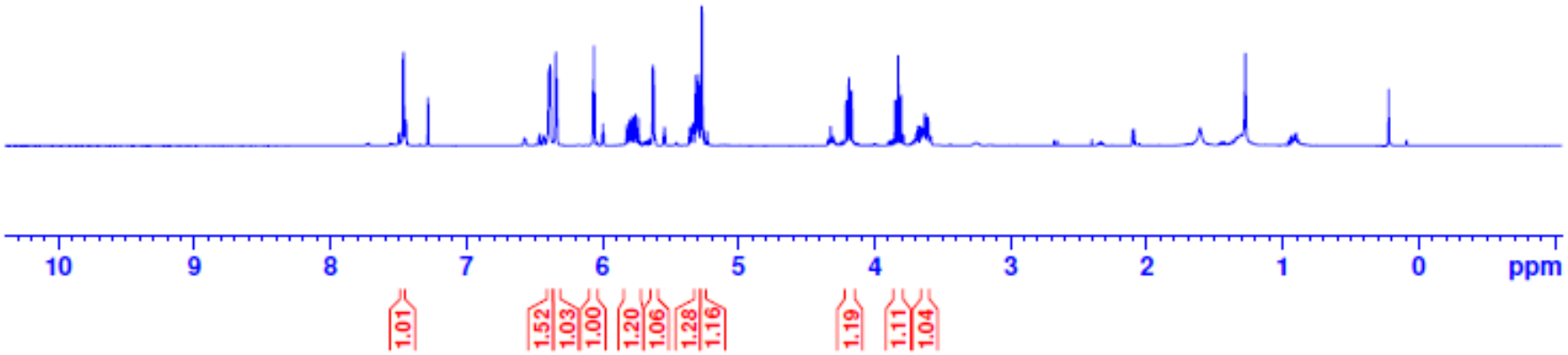


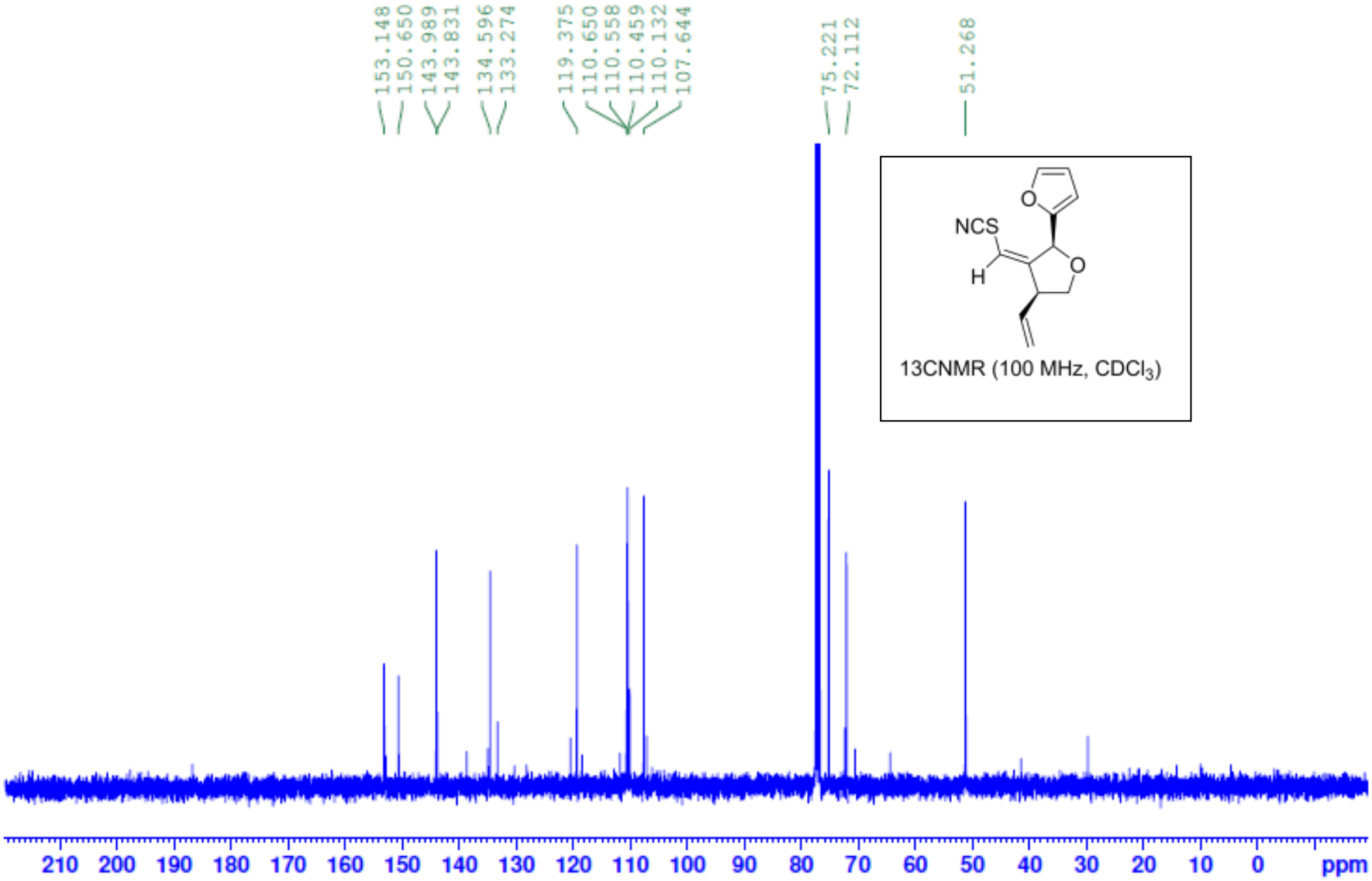

137.605
136.158
135.185
127.097
127.061
126.032
125.582
117.815
109.459
73.557
65.657
41.390
S
H
NCS
O
13CNMR (100 MHz, CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

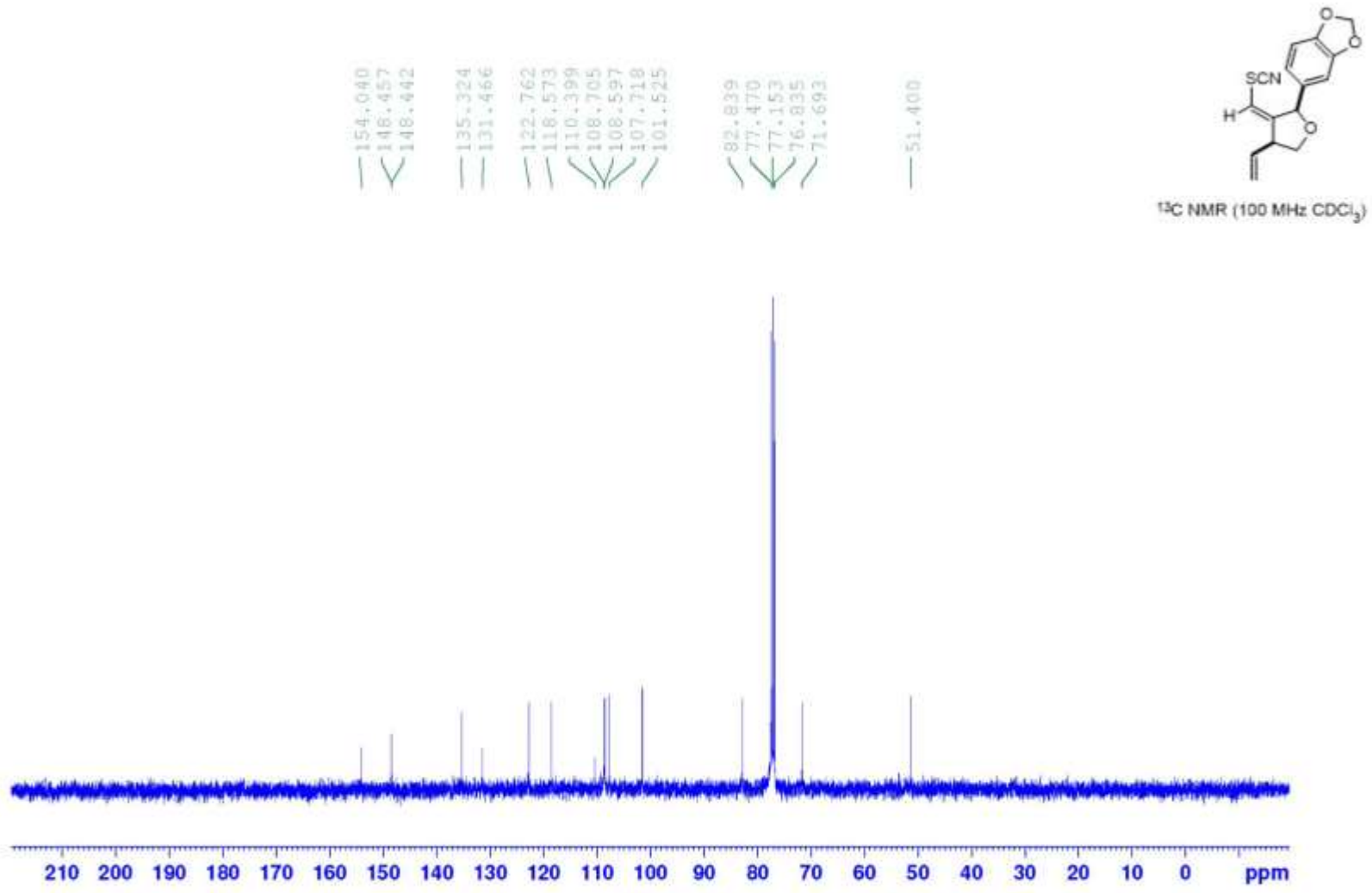


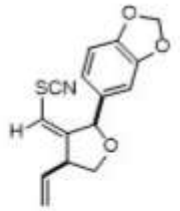


1HNMR (400 MHz, $CDCl_3$)

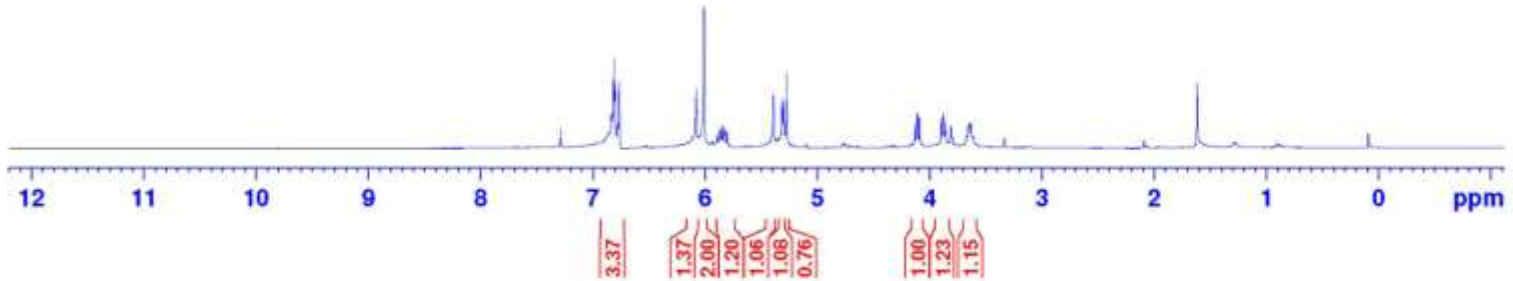


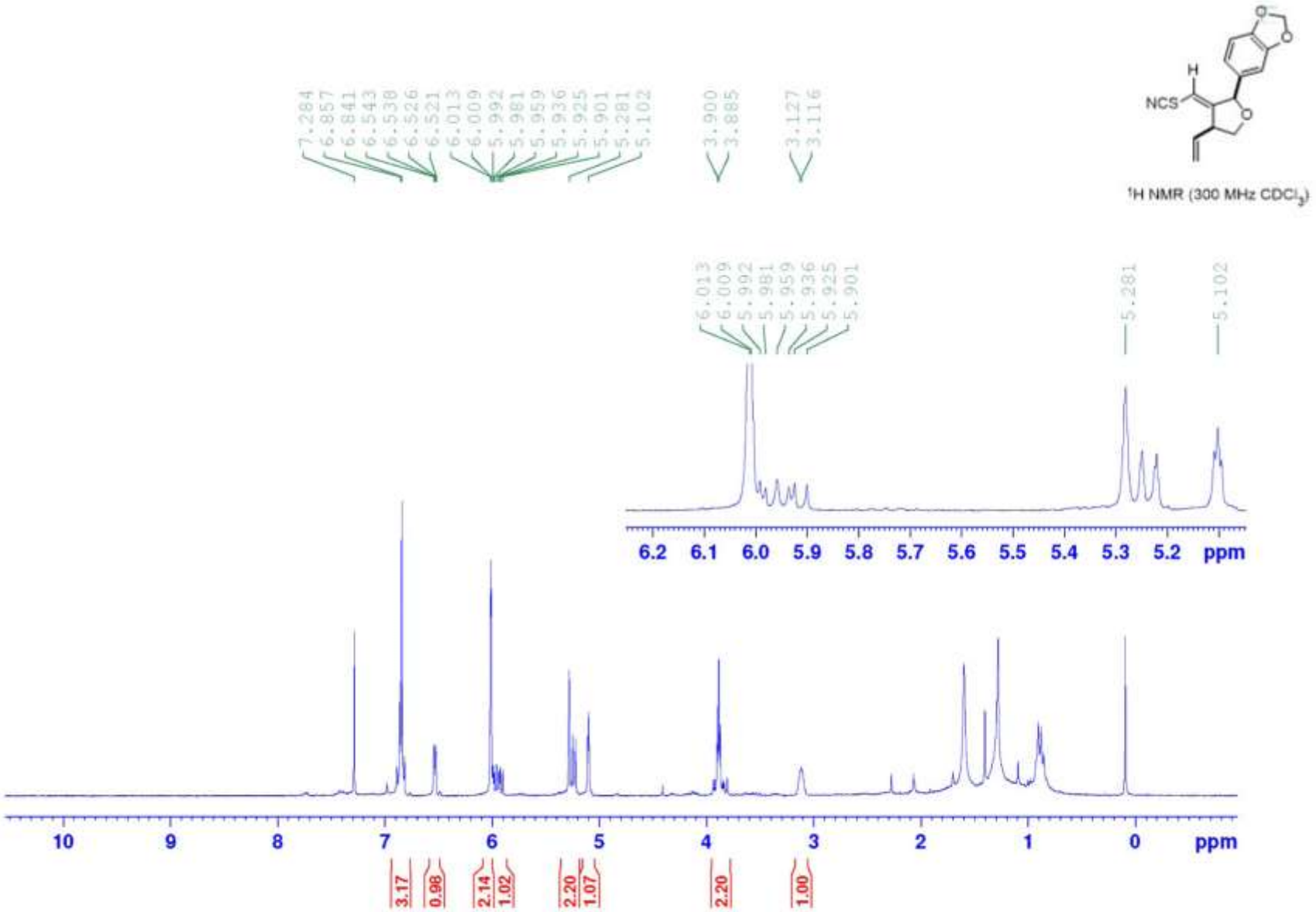

153.148
150.650
143.989
143.831
134.596
133.274
119.375
110.650
110.558
110.459
110.132
107.644
75.221
72.112
51.268
NCS
H
O
O
13CNMR (100 MHz, CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

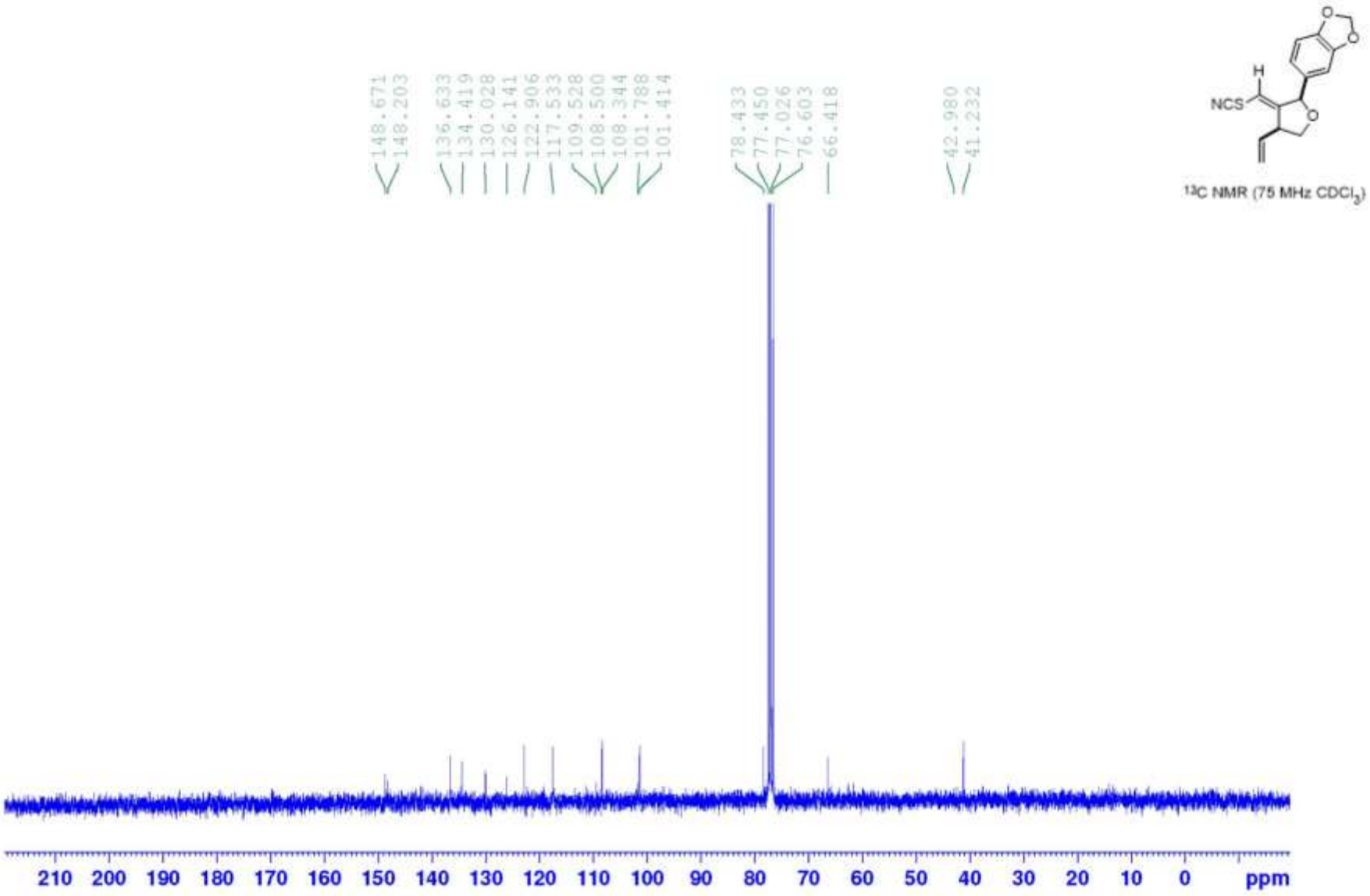

154.040
148.457
148.442
135.324
131.466
122.762
118.573
110.399
108.705
108.597
107.718
101.525
82.839
77.470
77.153
76.835
71.693
51.400
SCN
H
O
O
O
^{13}C NMR (100 MHz CDCl$_3$)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

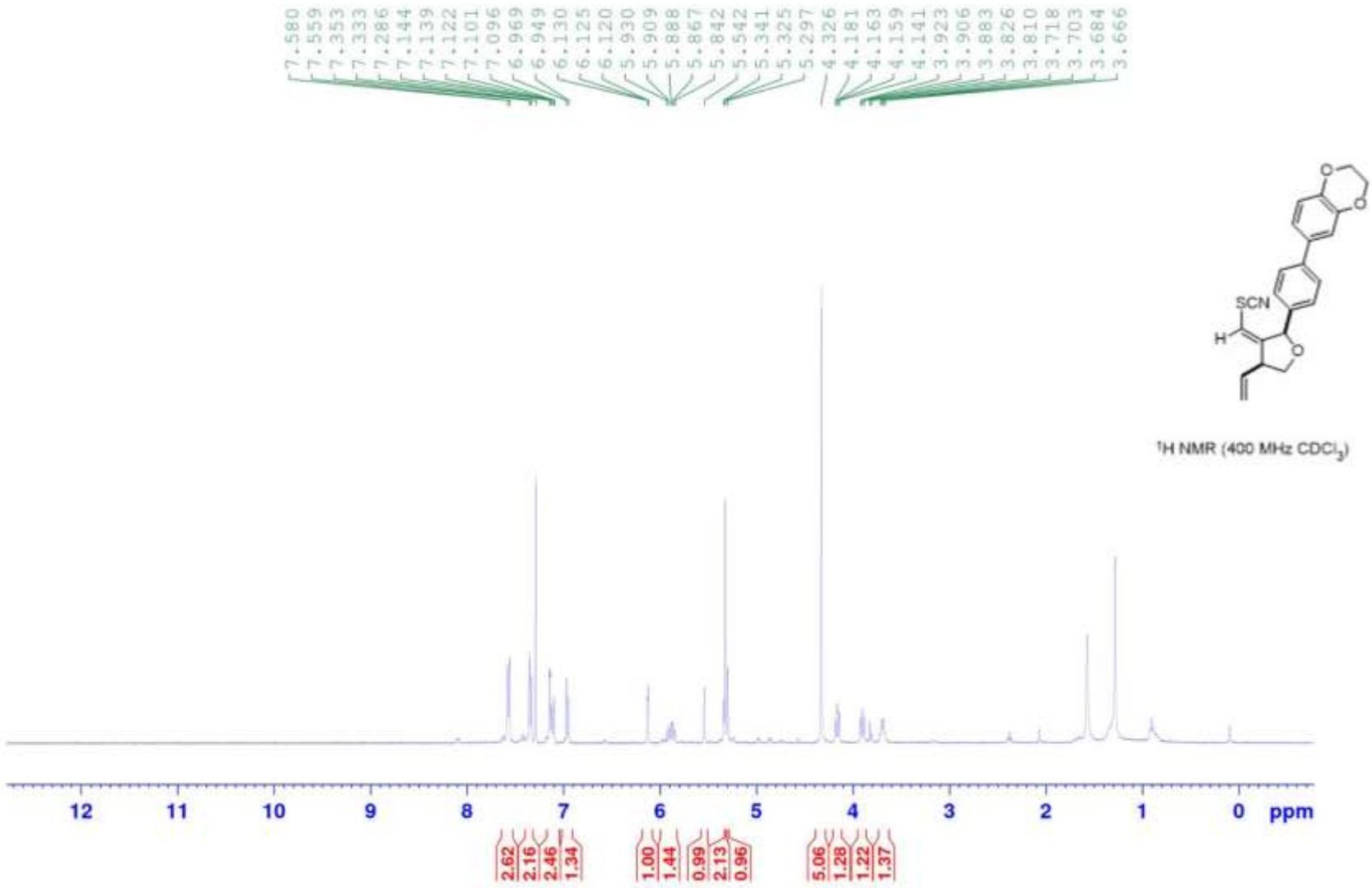


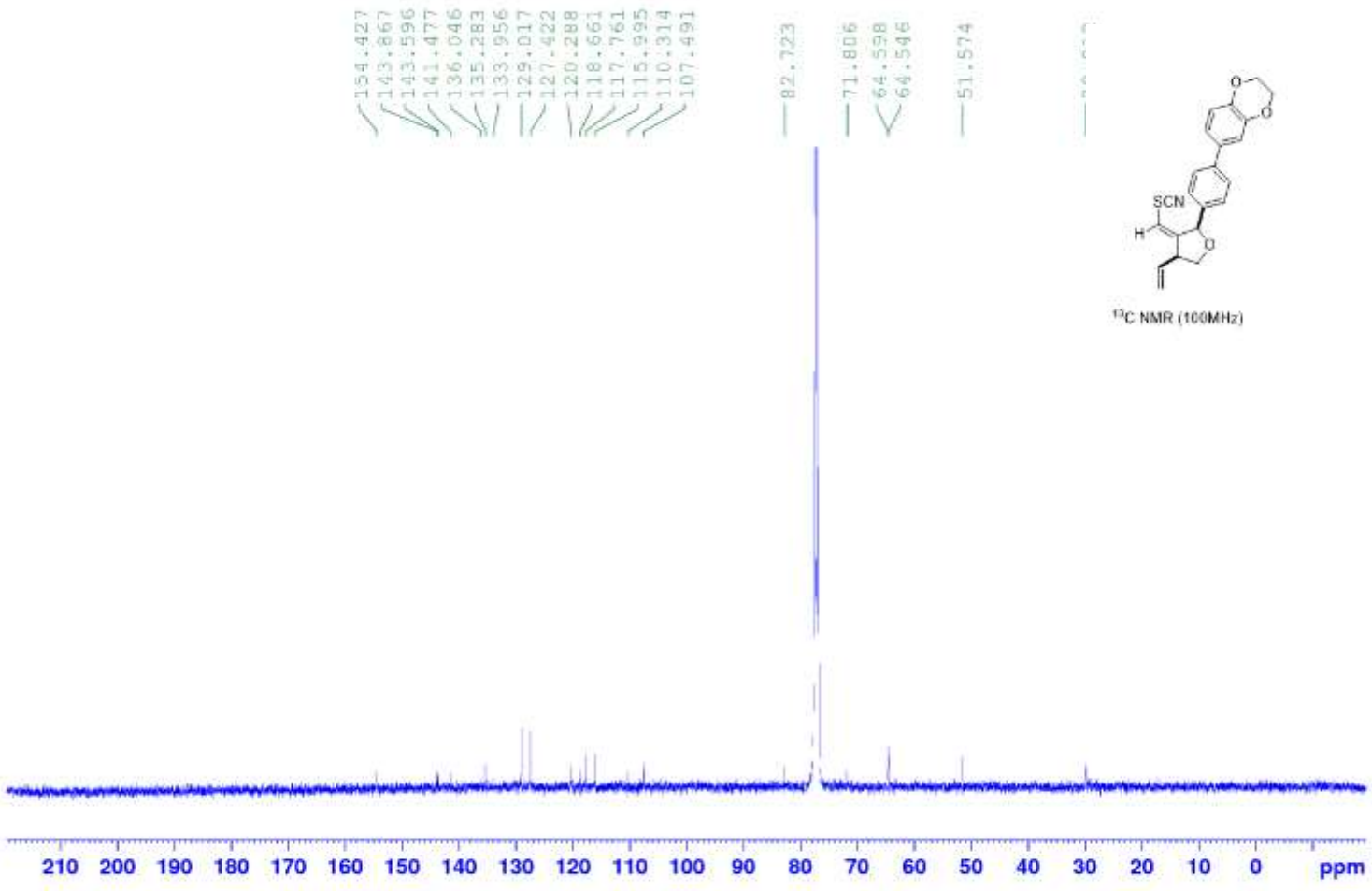
^{1}H NMR (400 MHz $CDCl_3$)

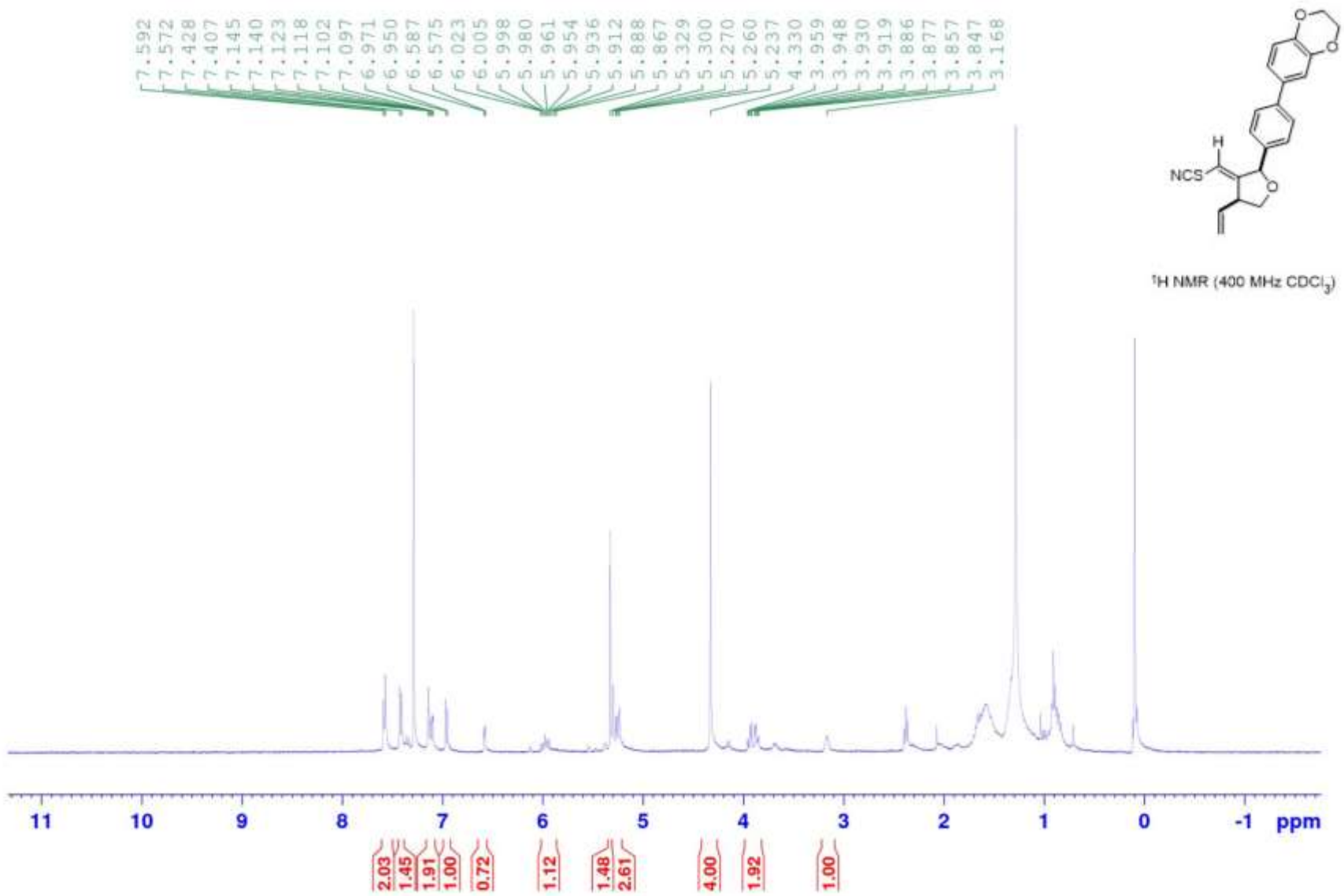


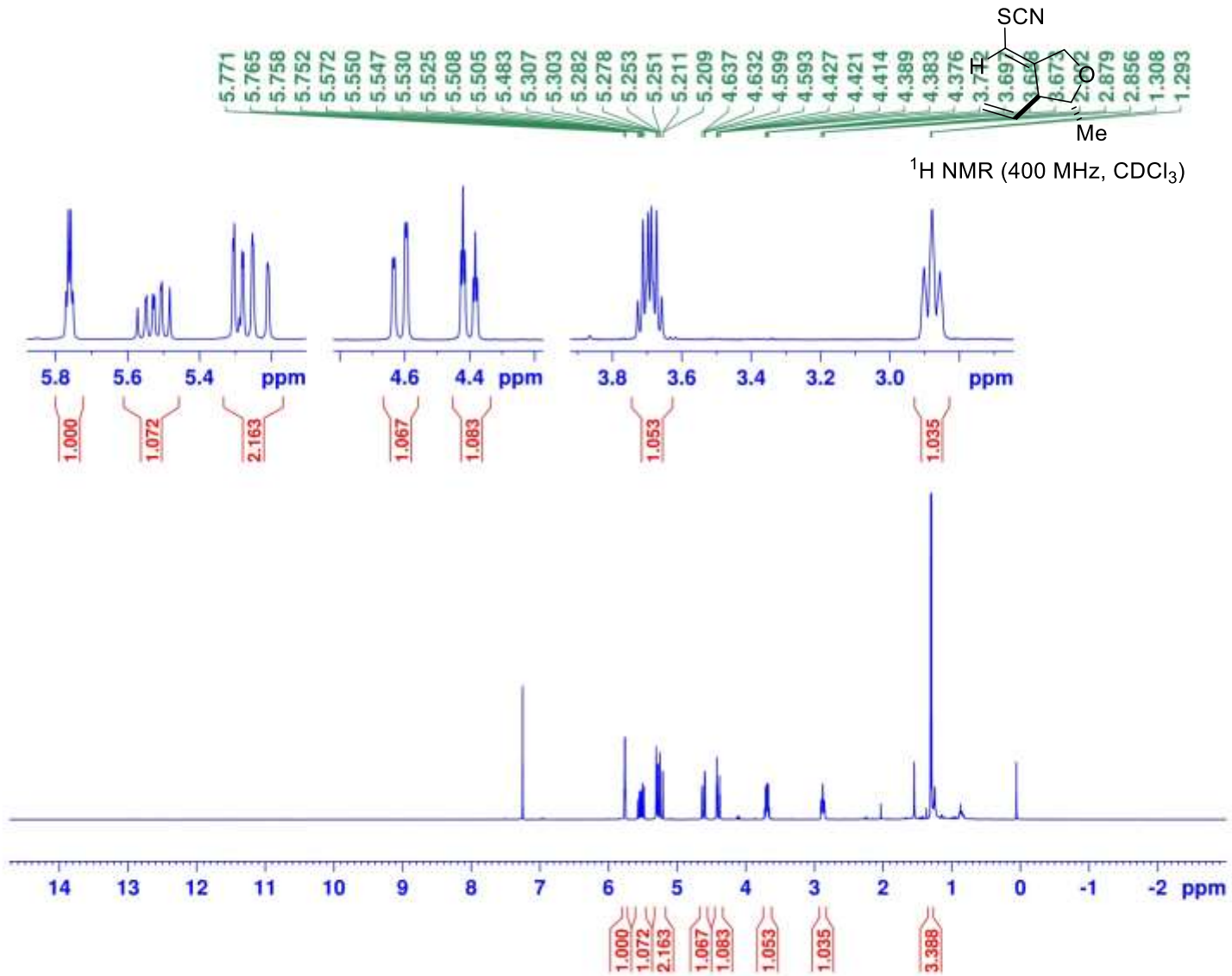

7.284
6.857
6.841
6.543
6.538
6.526
6.521
6.013
6.009
5.992
5.981
5.959
5.936
5.925
5.901
5.281
5.102
3.900
3.885
3.127
3.116
NCS
H
O
O
O
^{1}H NMR (300 MHz CDCl$_3$)
6.2
6.1
6.0
5.9
5.8
5.7
5.6
5.5
5.4
5.3
5.2
ppm
10
9
8
7
6
5
4
3
2
1
0
ppm
3.17
0.98
2.14
1.02
2.20
1.07
2.20
1.00


148.671
148.203
136.633
134.419
130.028
126.141
122.906
117.533
109.528
108.500
108.344
101.788
101.414
78.433
77.450
77.026
76.603
66.418
42.980
41.232
NCS
H
O
O
O
13C NMR (75 MHz CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

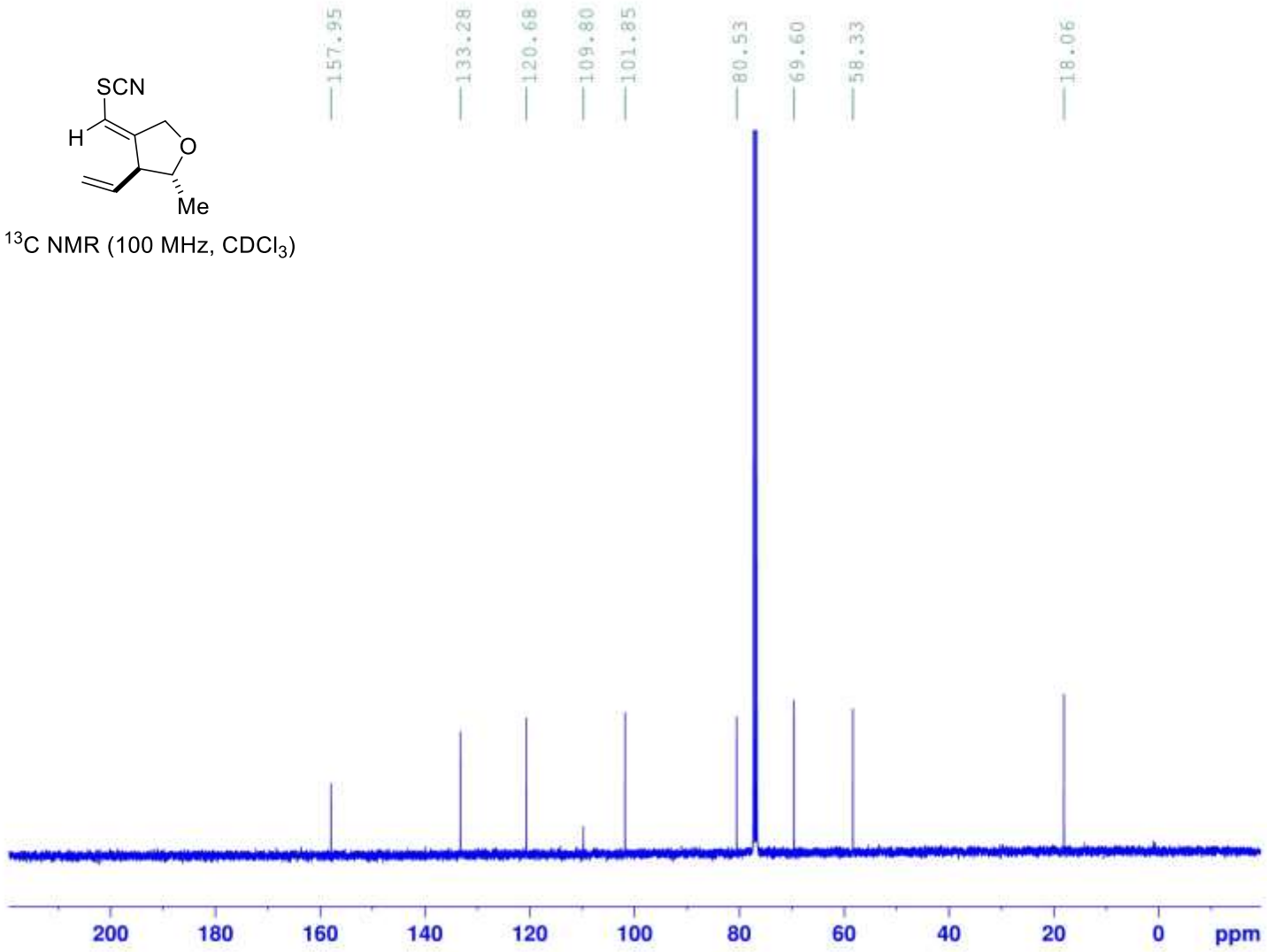

7.580
7.559
7.353
7.333
7.286
7.144
7.139
7.122
7.101
7.096
6.969
6.949
6.130
6.125
6.120
5.930
5.909
5.888
5.867
5.842
5.542
5.341
5.325
5.297
4.326
4.181
4.163
4.159
4.141
3.923
3.906
3.883
3.826
3.810
3.718
3.703
3.684
3.666
SCN
H
O
O
O
^{1}H NMR (400 MHz $CDCl_3$)
12
11
10
9
8
7
6
5
4
3
2
1
0
ppm
2.62
2.16
2.46
1.34
1.00
1.44
0.99
2.13
0.96
5.06
1.28
1.22
1.37


154.427
143.867
143.596
141.477
136.046
135.283
133.956
129.017
127.422
120.288
118.661
117.761
115.995
110.314
107.491
82.723
71.806
64.598
64.546
51.574
SCN
H
O
O
O
13C NMR (100MHz)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

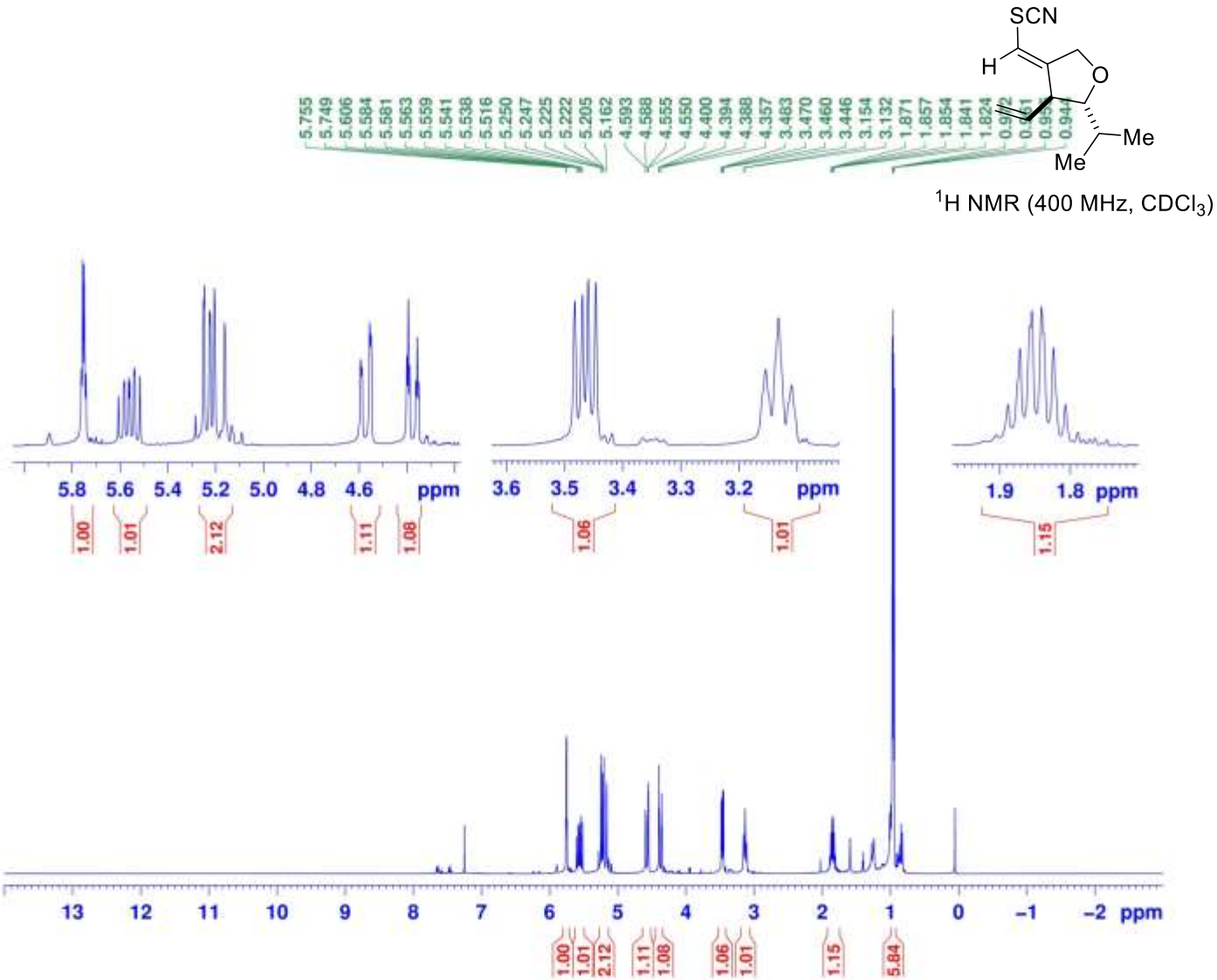

7.592
7.572
7.428
7.407
7.145
7.140
7.123
7.118
7.102
7.097
6.971
6.950
6.587
6.575
6.023
6.005
5.998
5.980
5.961
5.954
5.936
5.912
5.888
5.867
5.329
5.300
5.270
5.260
5.237
4.330
3.959
3.948
3.930
3.919
3.886
3.877
3.857
3.847
3.168
H
NCS
O
O
O
^{1}H NMR (400 MHz $CDCl_3$)
11
10
9
8
7
6
5
4
3
2
1
0
-1
ppm
2.03
1.45
1.91
1.00
0.72
1.12
1.48
2.61
4.00
1.92
1.00



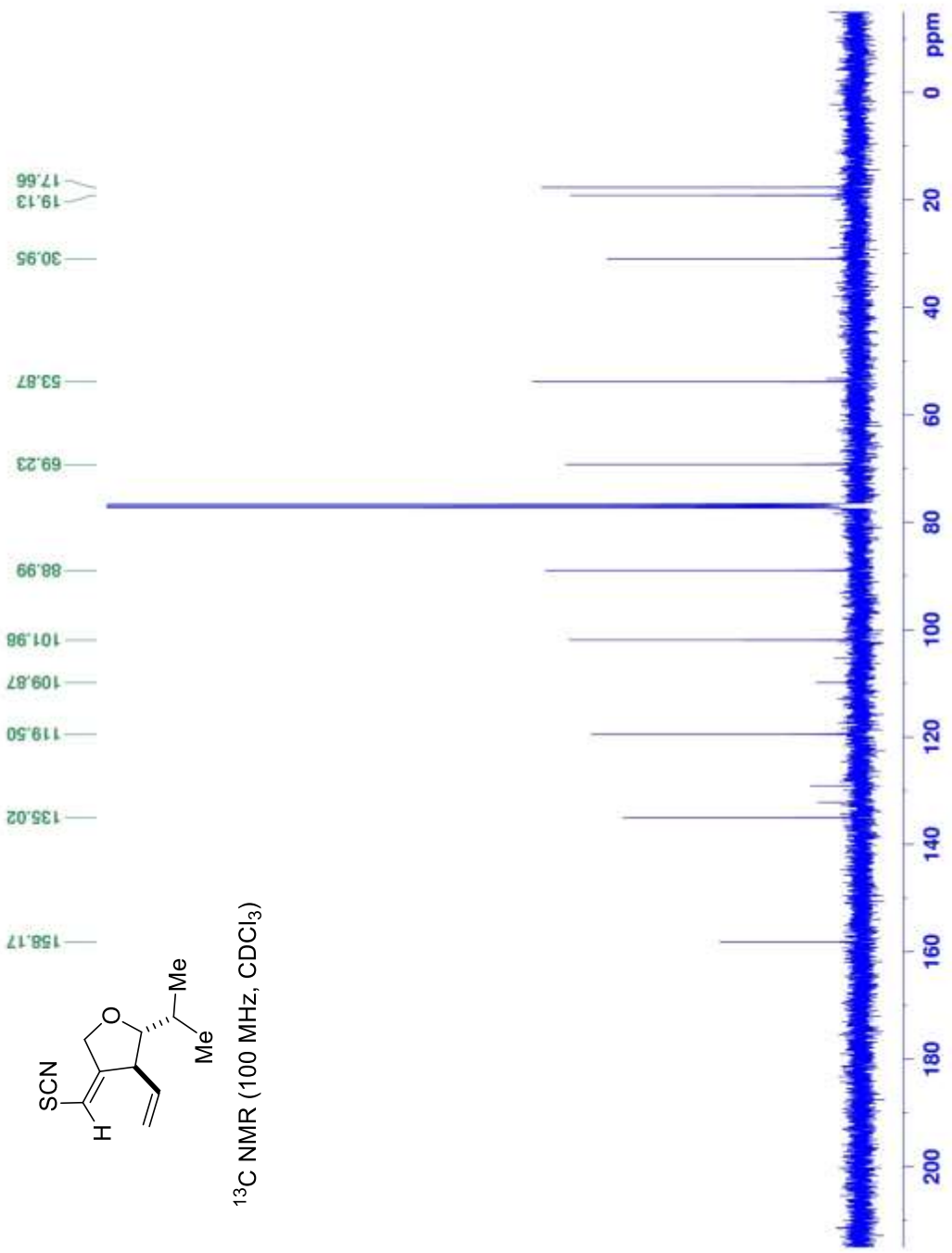
^{1}H NMR (400 MHz, $CDCl_3$)



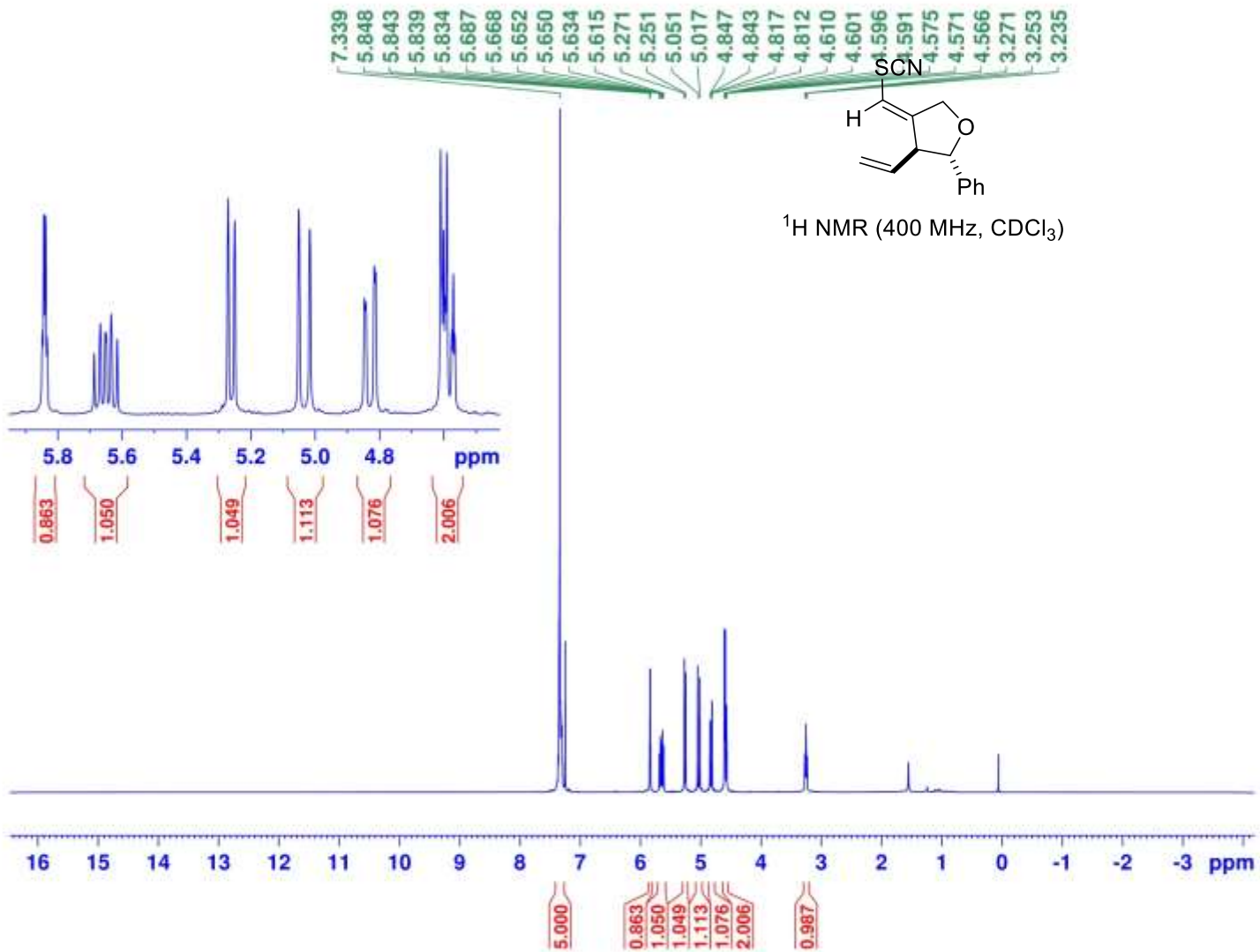
^{13}C NMR (100 MHz, $CDCl_3$)



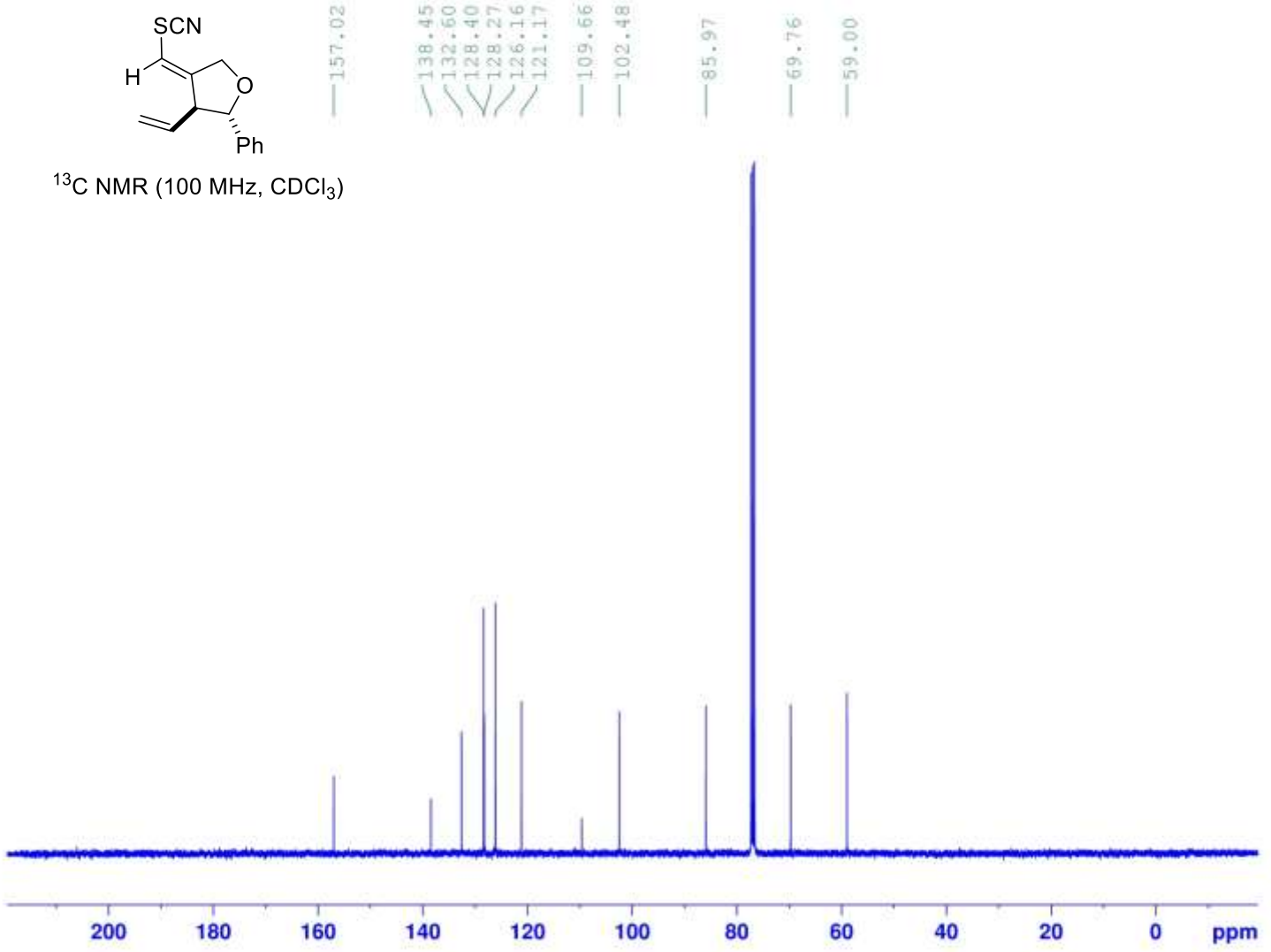
^{1}H NMR (400 MHz, $CDCl_3$)



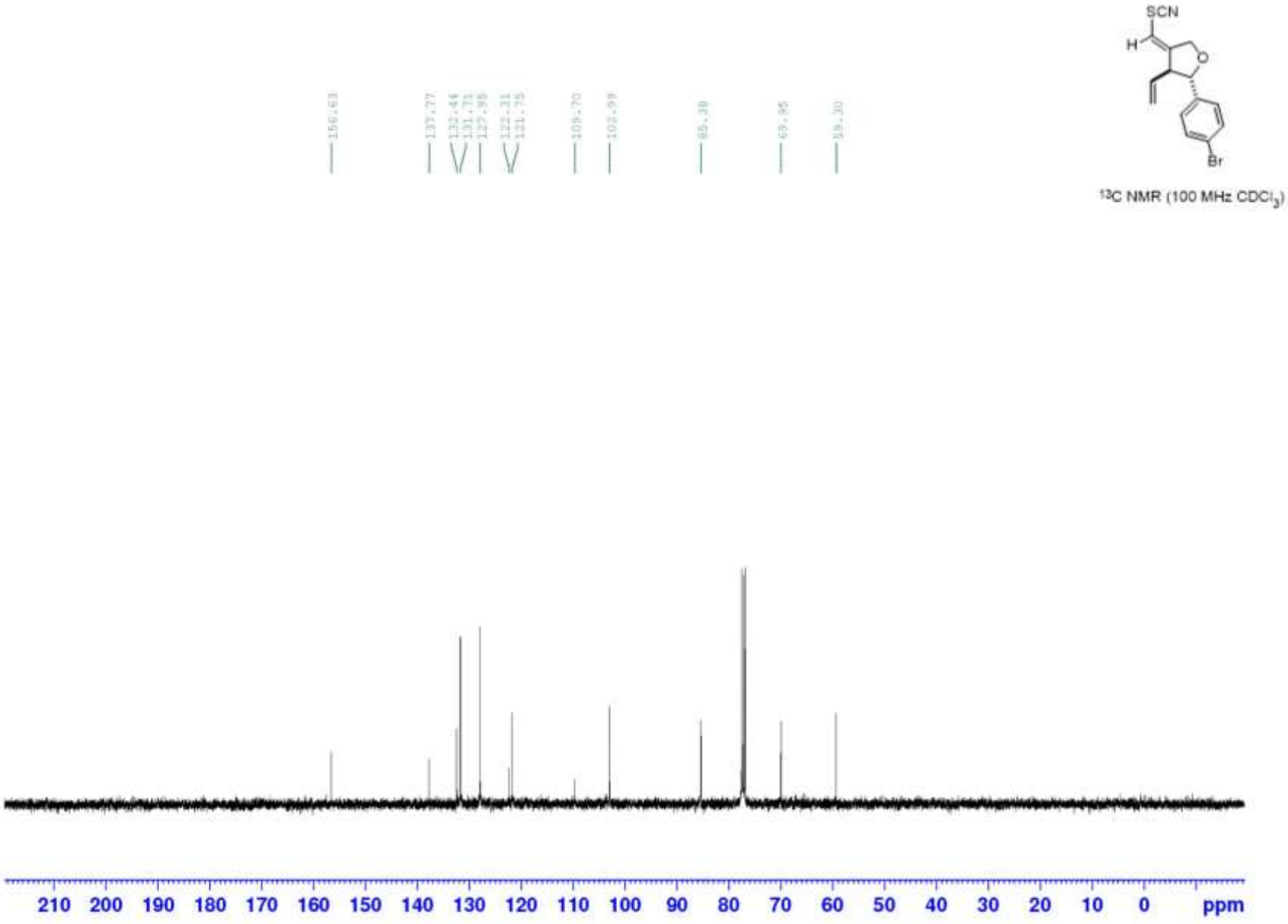
^{13}C NMR (100 MHz, $CDCl_3$)



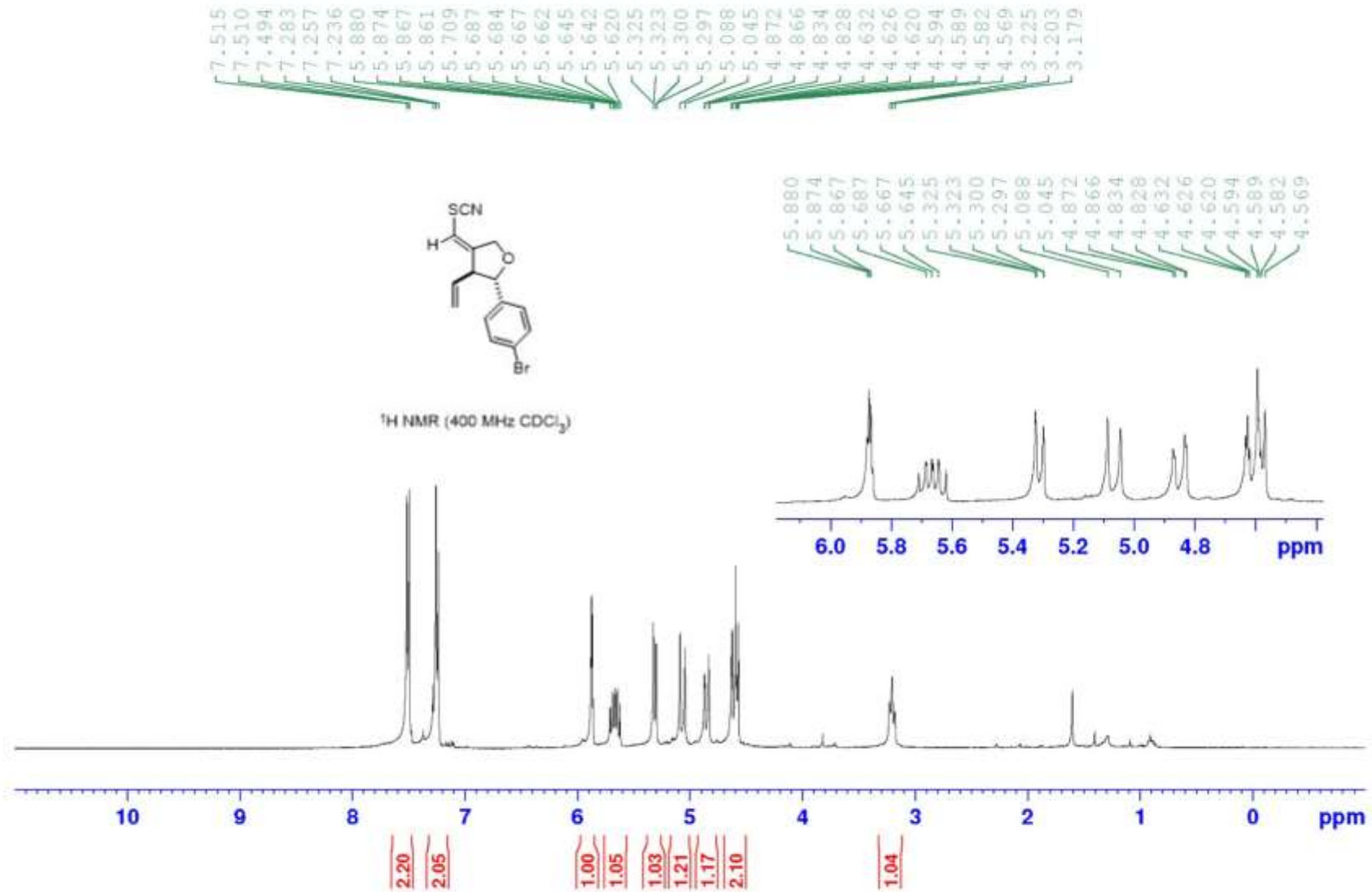
^{1}H NMR (400 MHz, $CDCl_3$)

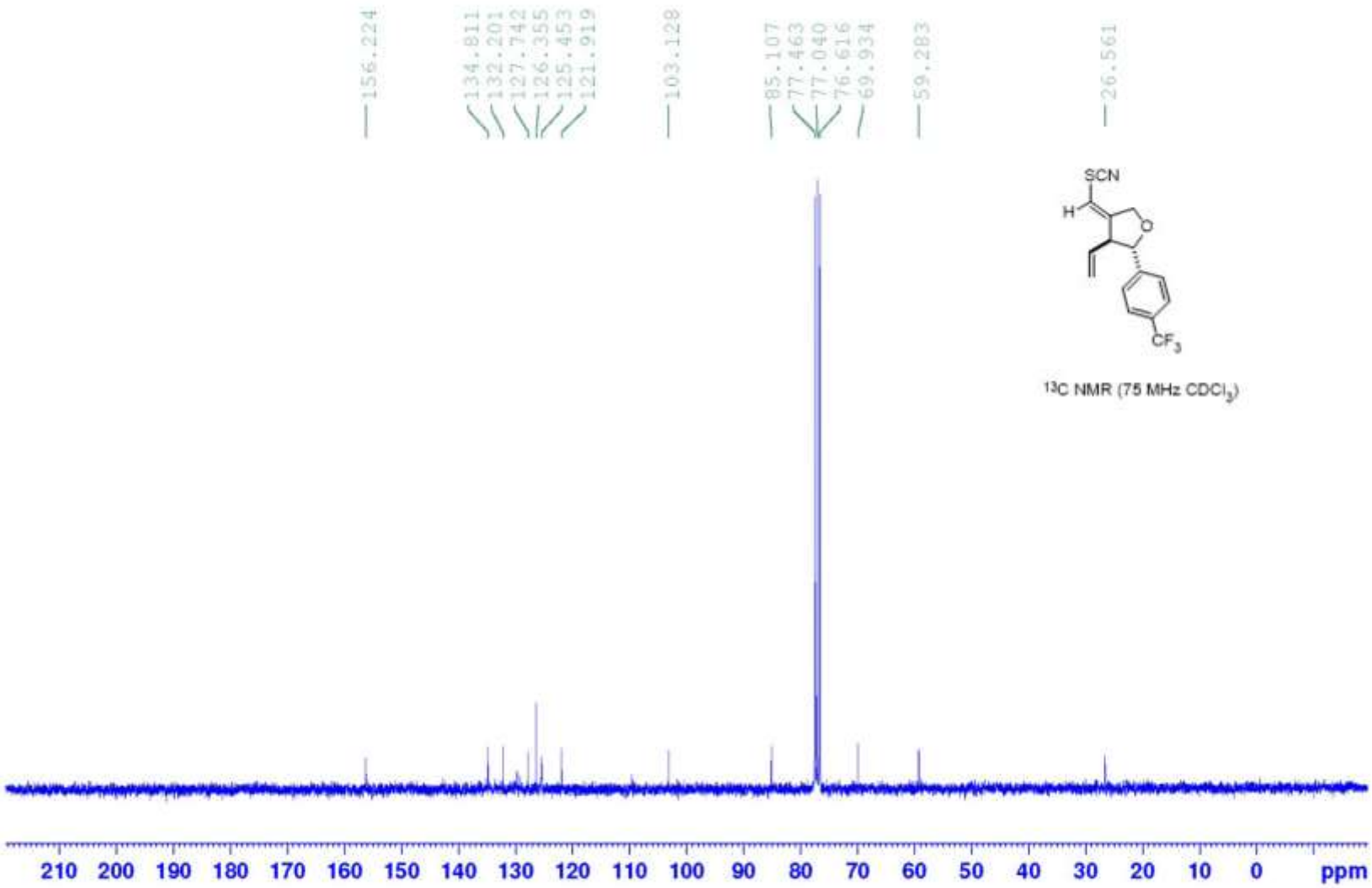


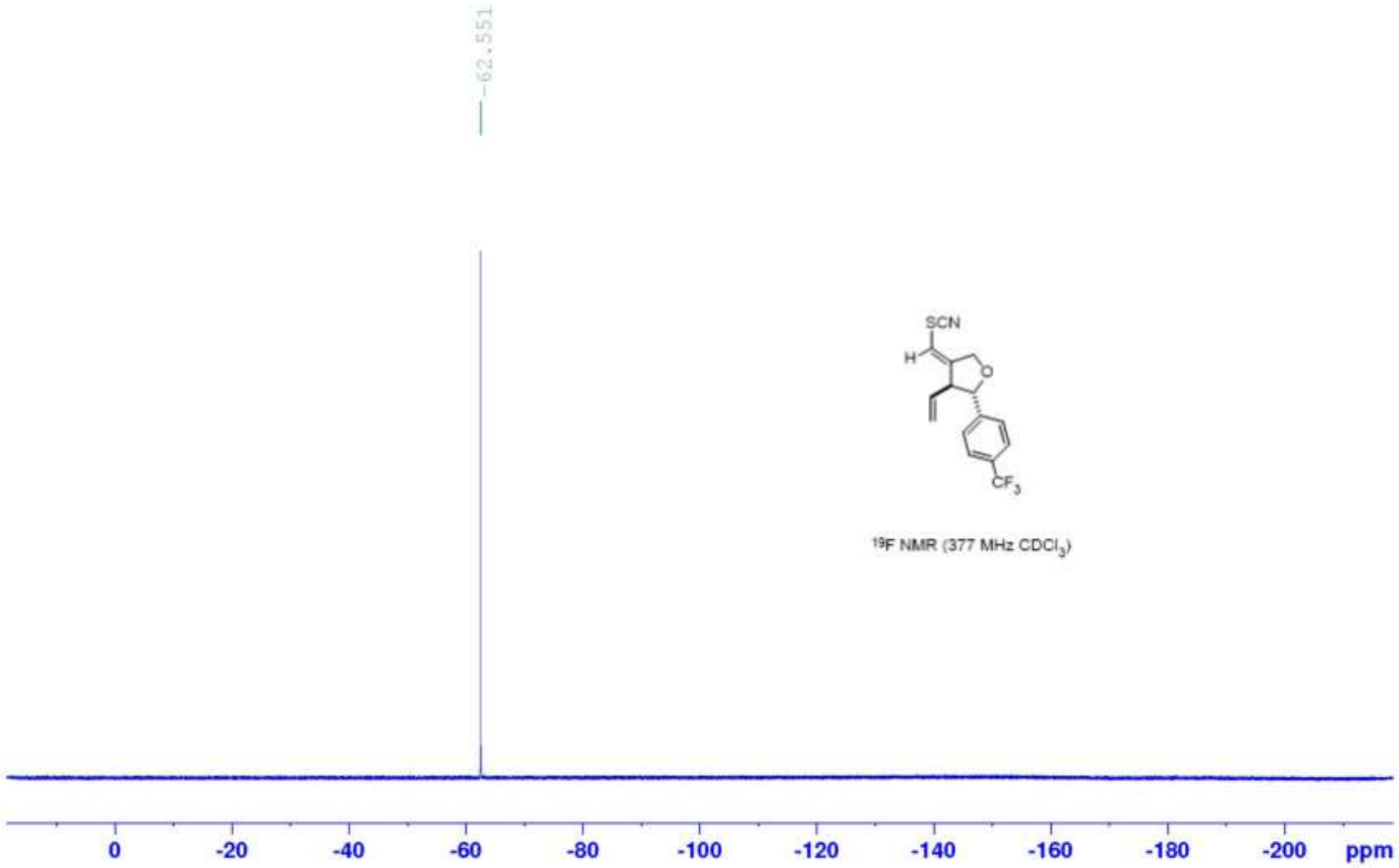
^{13}C NMR (100 MHz, $CDCl_3$)



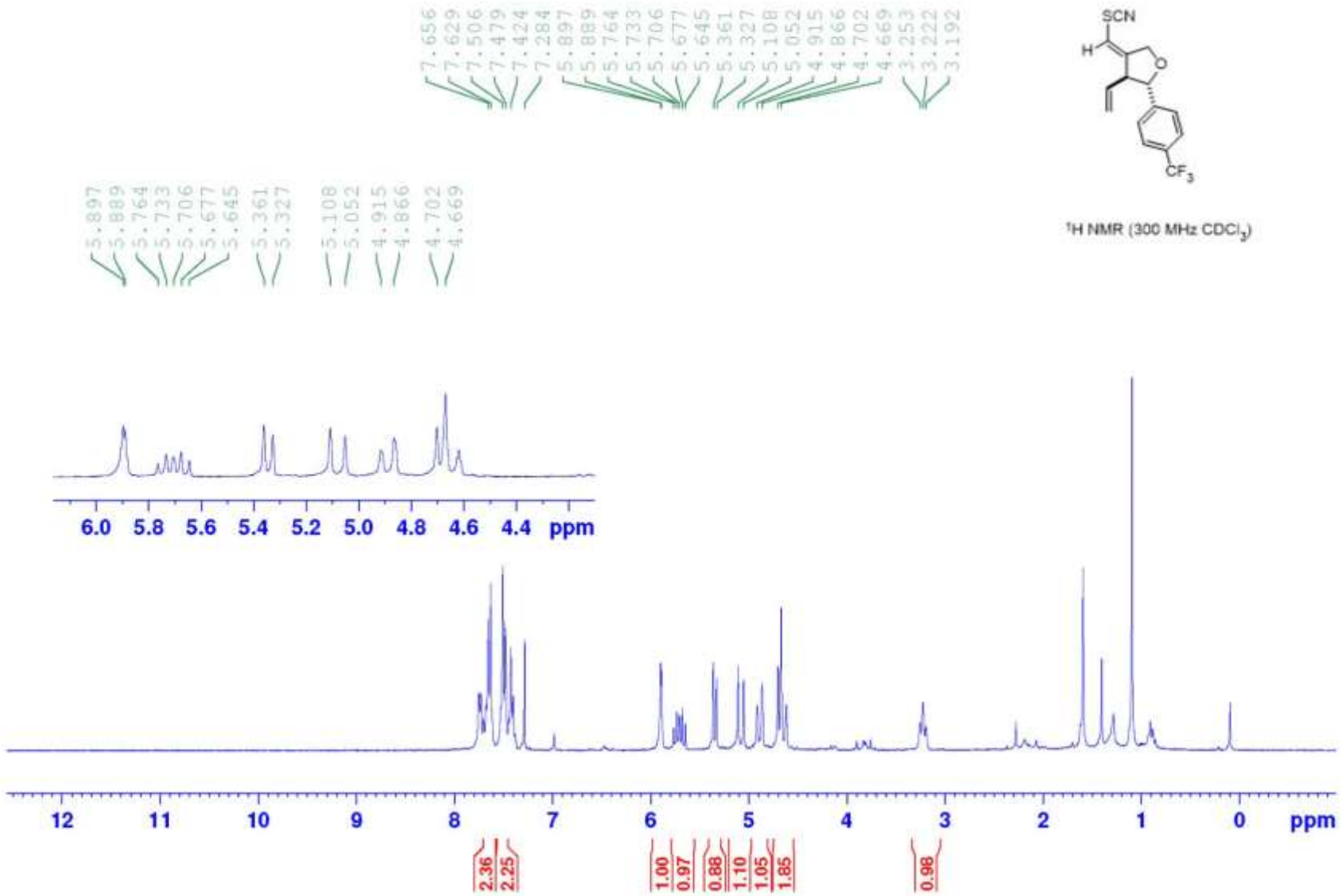
^{13}C NMR (100 MHz $CDCl_3$)

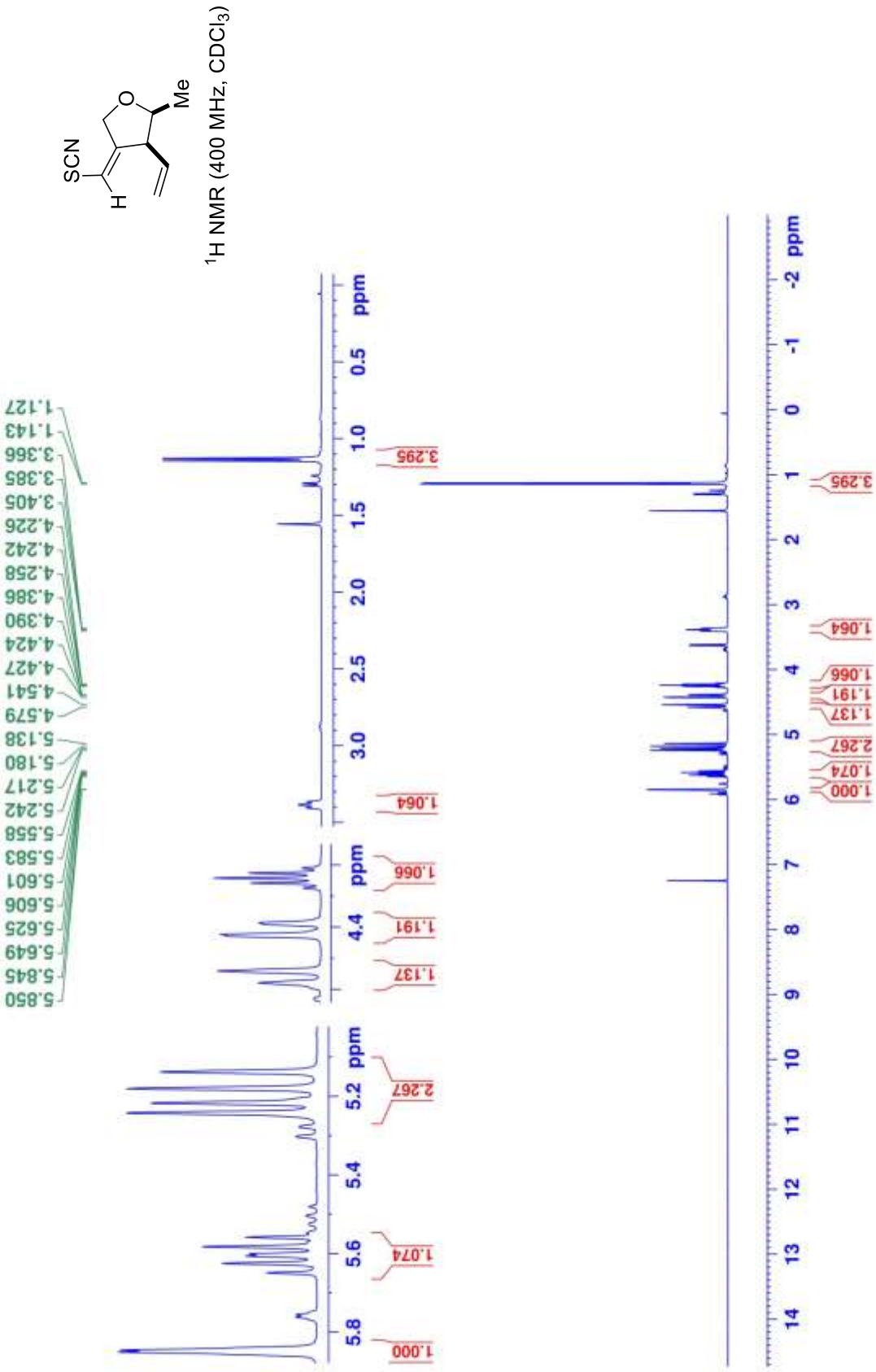

7.515
7.510
7.494
7.283
7.257
7.236
5.880
5.874
5.867
5.861
5.709
5.687
5.684
5.667
5.662
5.645
5.642
5.620
5.325
5.323
5.300
5.297
5.088
5.045
4.872
4.866
4.834
4.828
4.632
4.626
4.620
4.594
4.589
4.582
4.569
3.225
3.203
3.179
SCN
H
O
Br
1H NMR (400 MHz CDCl3)
6.0
5.8
5.6
5.4
5.2
5.0
4.8
ppm
10
9
8
7
6
5
4
3
2
1
0
ppm
2.20
2.05
1.00
1.05
1.03
1.21
1.17
2.10
1.04

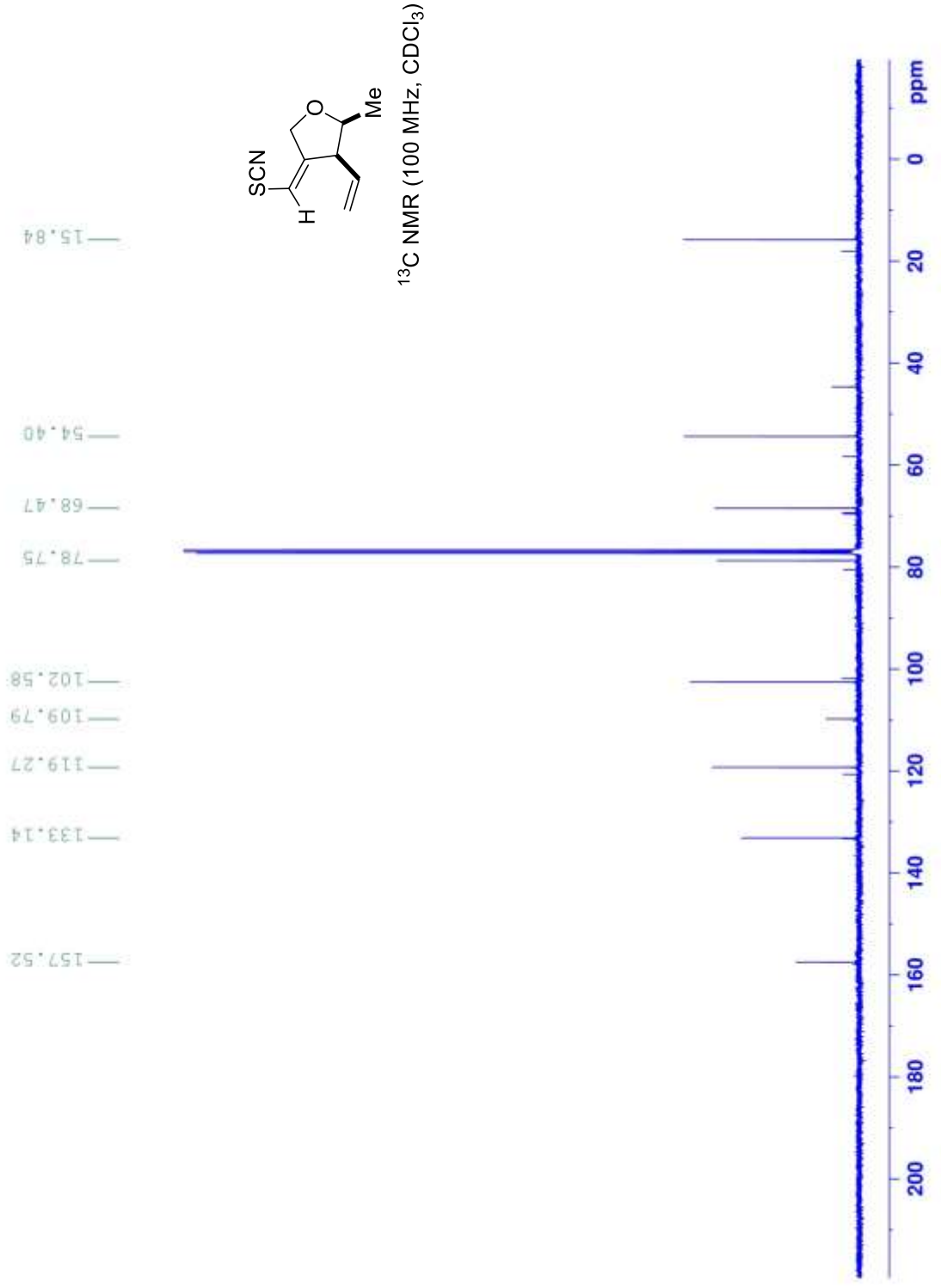

156.224
134.811
132.201
127.742
126.355
125.453
121.919
103.128
85.107
77.463
77.040
76.616
69.934
59.283
26.561
SCN
H
O
CF3
13C NMR (75 MHz CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

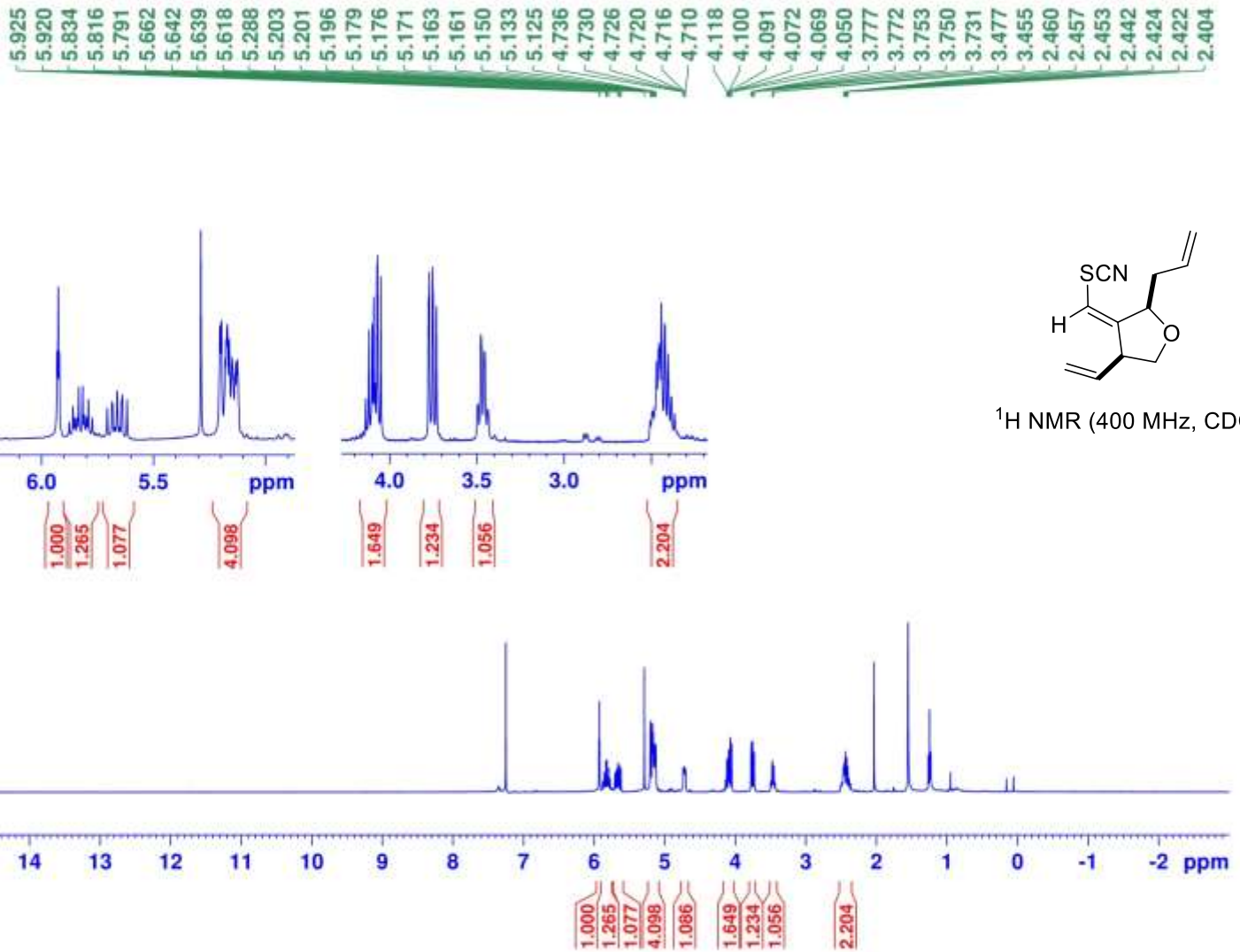


^{19}F NMR (377 MHz $CDCl_3$)


7.656
7.629
7.506
7.479
7.424
7.284
5.897
5.889
5.764
5.733
5.706
5.677
5.645
5.361
5.327
5.108
5.052
4.915
4.866
4.702
4.669
3.253
3.222
3.192
SCN
H
O
CF3
1H NMR (300 MHz CDCl3)
6.0 5.8 5.6 5.4 5.2 5.0 4.8 4.6 4.4 ppm
12 11 10 9 8 7 6 5 4 3 2 1 0 ppm
2.36
2.25
1.00
0.97
0.88
1.10
1.05
1.85
0.98

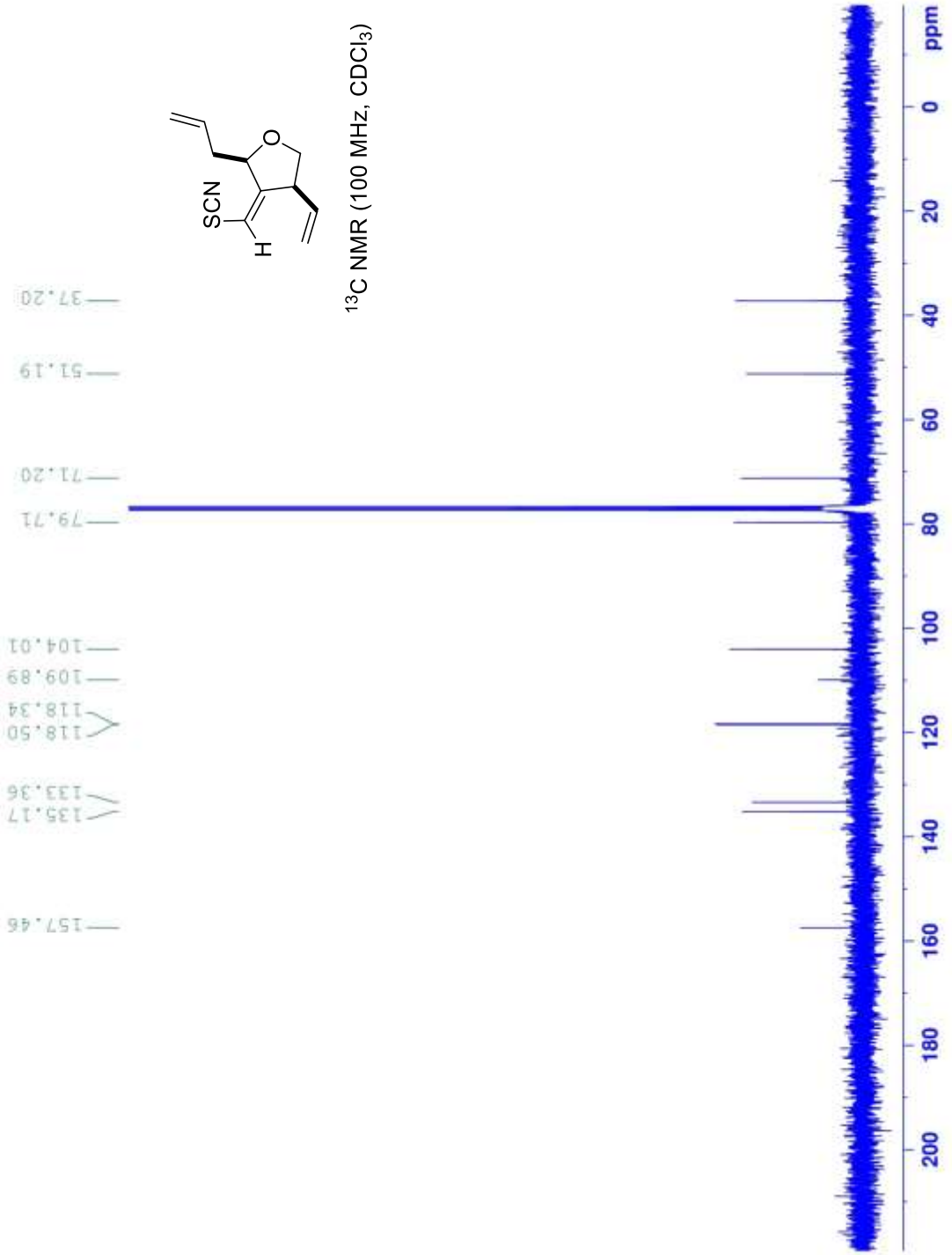

SCN
H
O
Me
^{1}H NMR (400 MHz, CDCl$_3$)

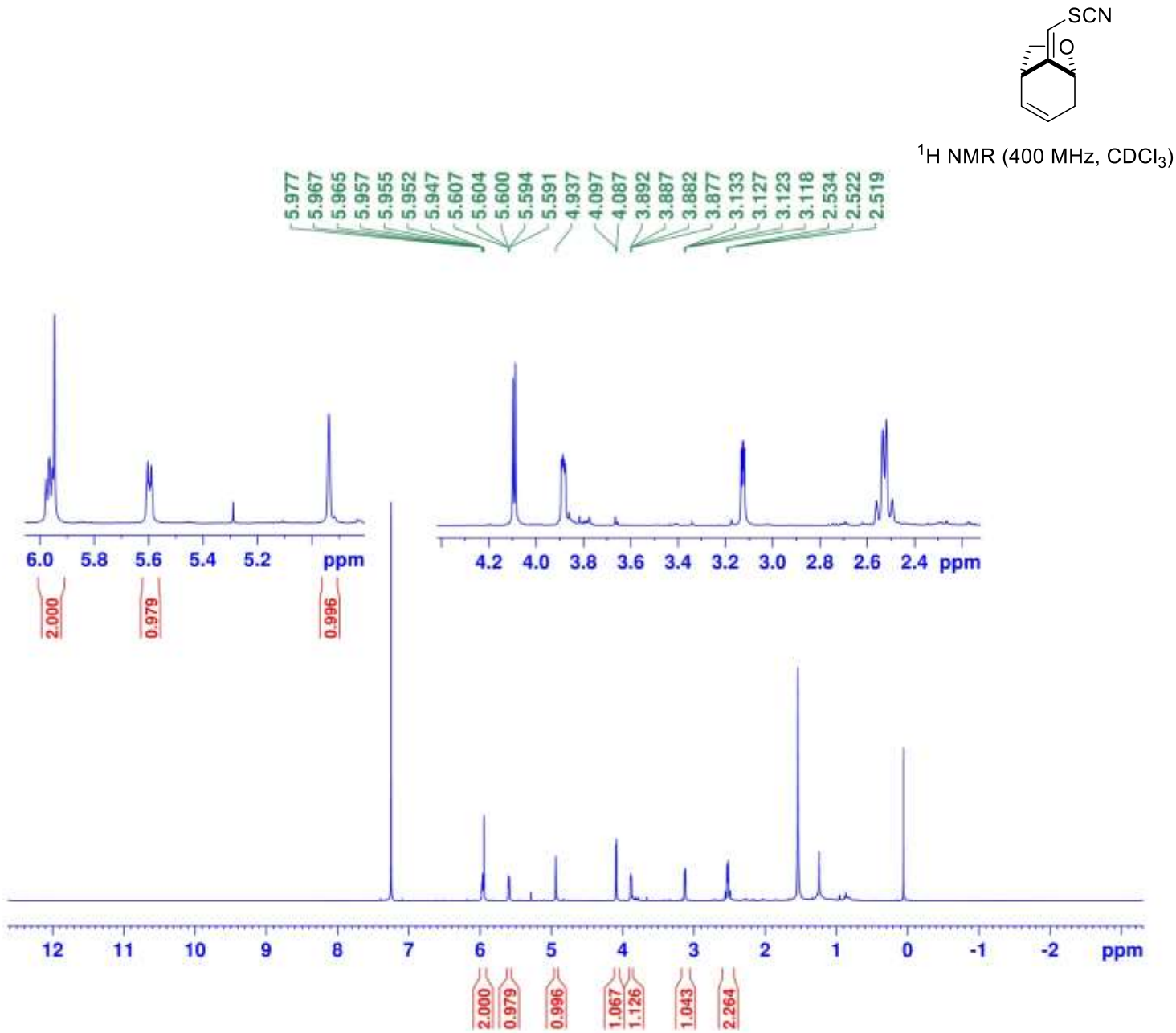

SCN
H
O
Me
^{13}C NMR (100 MHz, CDCl$_3$)
15.84
54.40
68.47
78.75
102.58
109.79
119.27
133.14
157.52
ppm
0
20
40
60
80
100
120
140
160
180
200

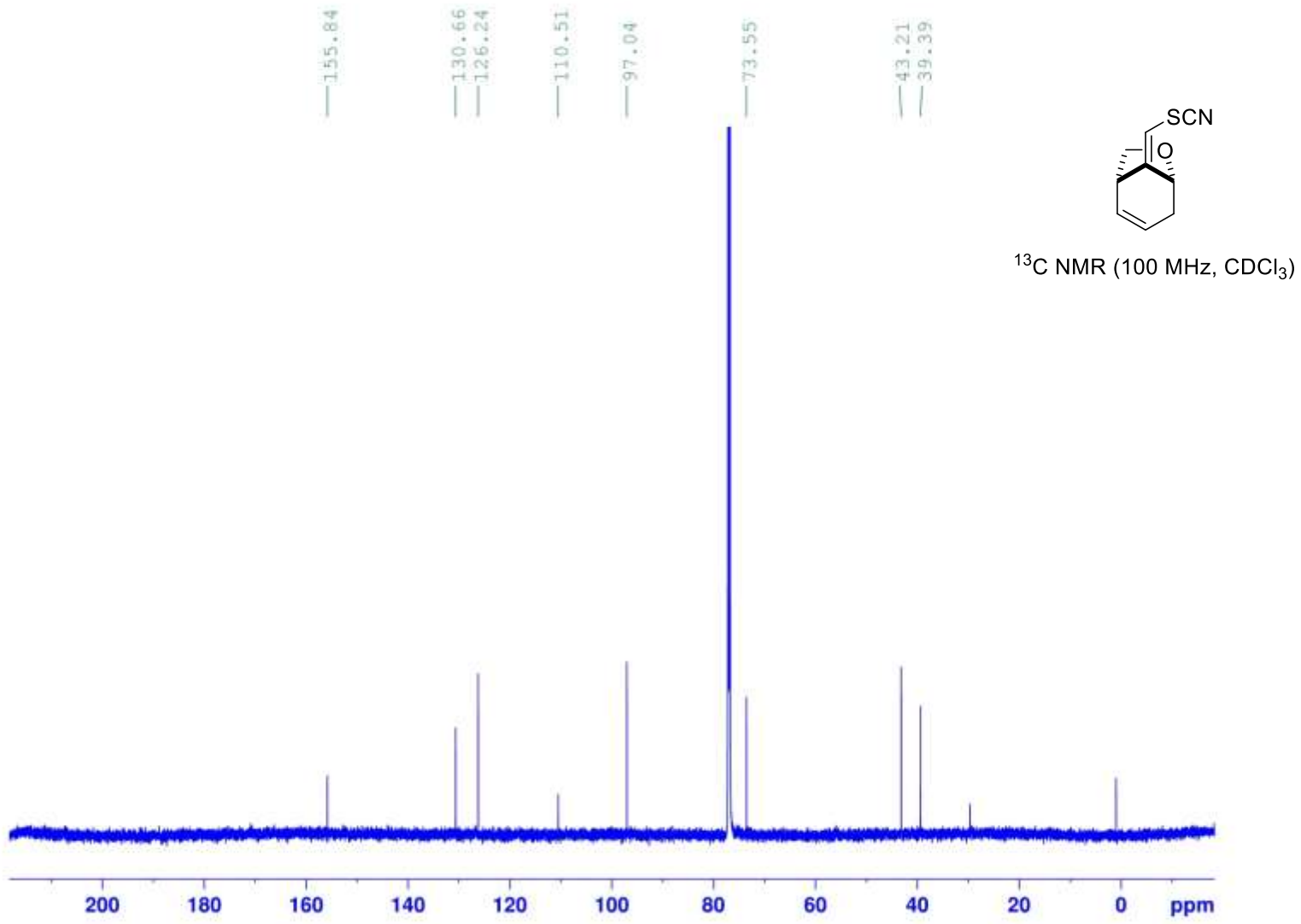


^{1}H NMR (400 MHz, $CDCl_3$)

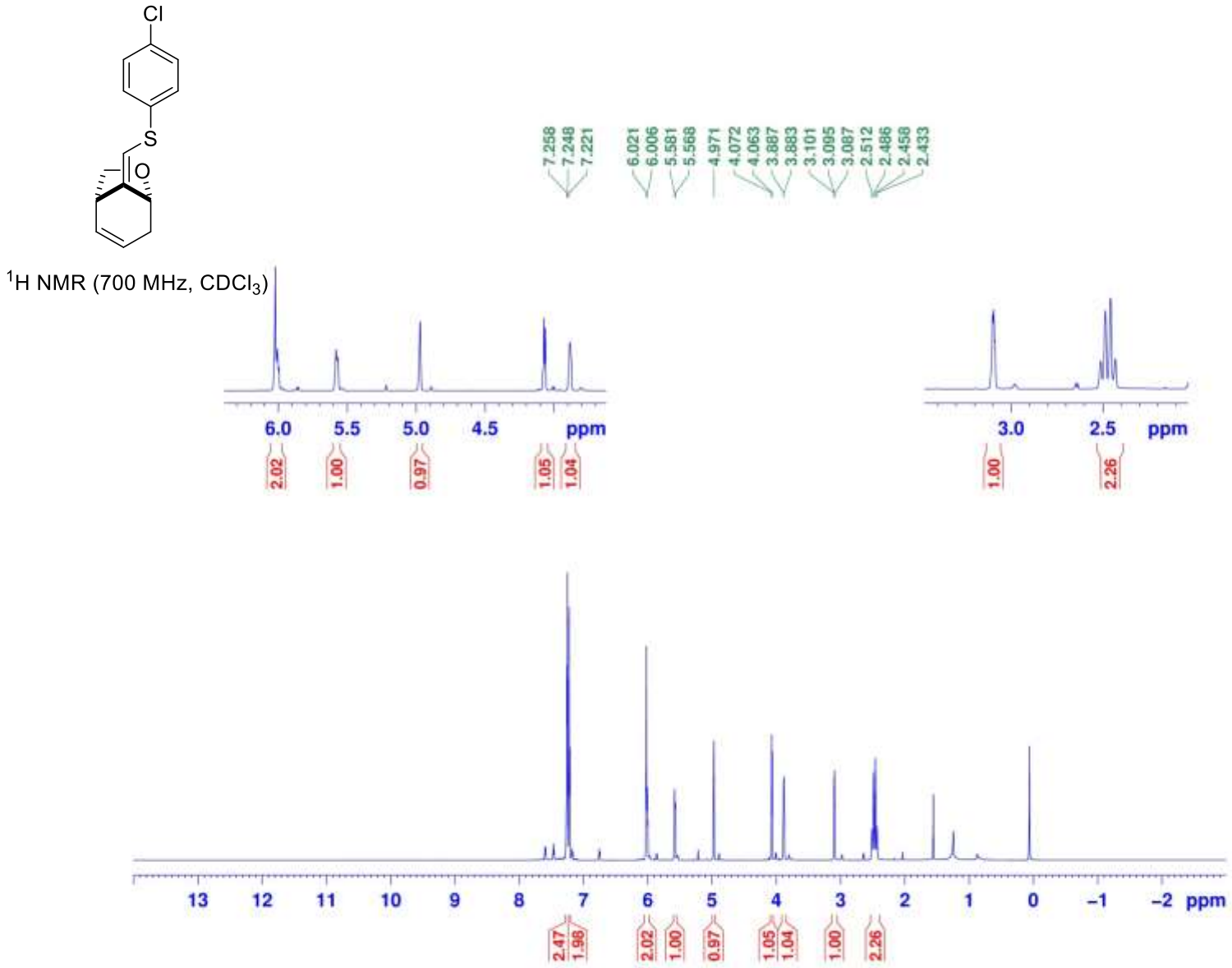
f. *Massarilactione/ Annuionone Core Series and Tailoring Chemistry*

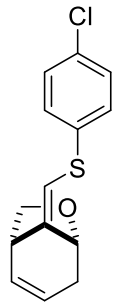



SCN
O
1H NMR (400 MHz, CDCl3)
5.977
5.967
5.965
5.957
5.955
5.952
5.947
5.607
5.604
5.600
5.594
5.591
4.937
4.097
4.087
3.892
3.887
3.882
3.877
3.133
3.127
3.123
3.118
2.534
2.522
2.519
6.0 5.8 5.6 5.4 5.2 ppm
2.000
0.979
0.996
4.2 4.0 3.8 3.6 3.4 3.2 3.0 2.8 2.6 2.4 ppm
12 11 10 9 8 7 6 5 4 3 2 1 0 -1 -2 ppm
2.000
0.979
0.996
1.067
1.126
1.043
2.264

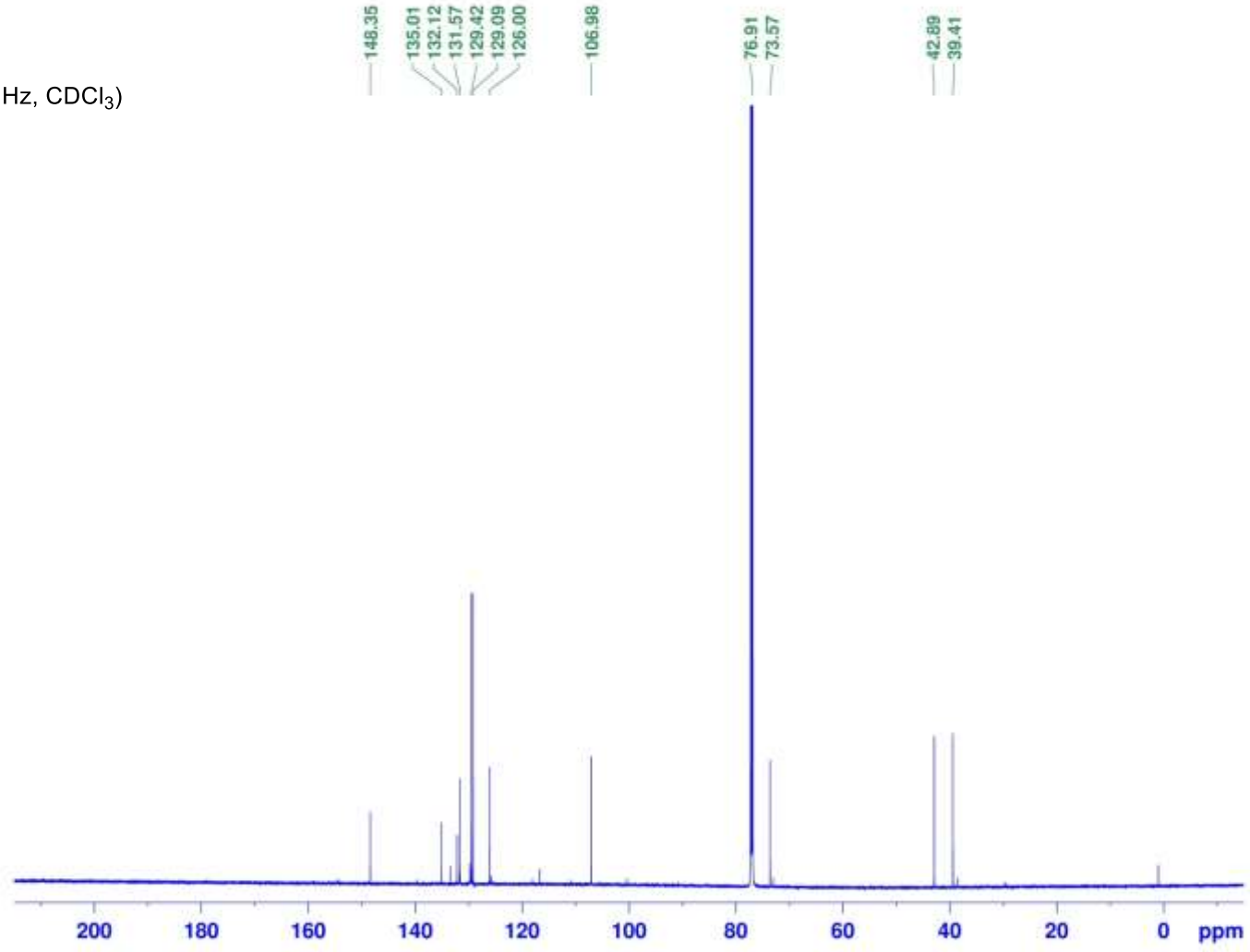


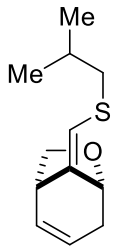
^{13}C NMR (100 MHz, $CDCl_3$)


Cl
S
O
^{1}H NMR (700 MHz, $CDCl_3$)
7.258
7.248
7.221
6.021
6.006
5.581
5.568
4.971
4.072
4.063
3.887
3.883
3.101
3.095
3.087
2.512
2.486
2.458
2.433
6.0
5.5
5.0
4.5
ppm
2.02
1.00
0.97
1.05
1.04
3.0
2.5
ppm
1.00
2.26
13
12
11
10
9
8
7
6
5
4
3
2
1
0
−1
−2
ppm
2.47
1.98
2.02
1.00
0.97
1.05
1.04
1.00
2.26

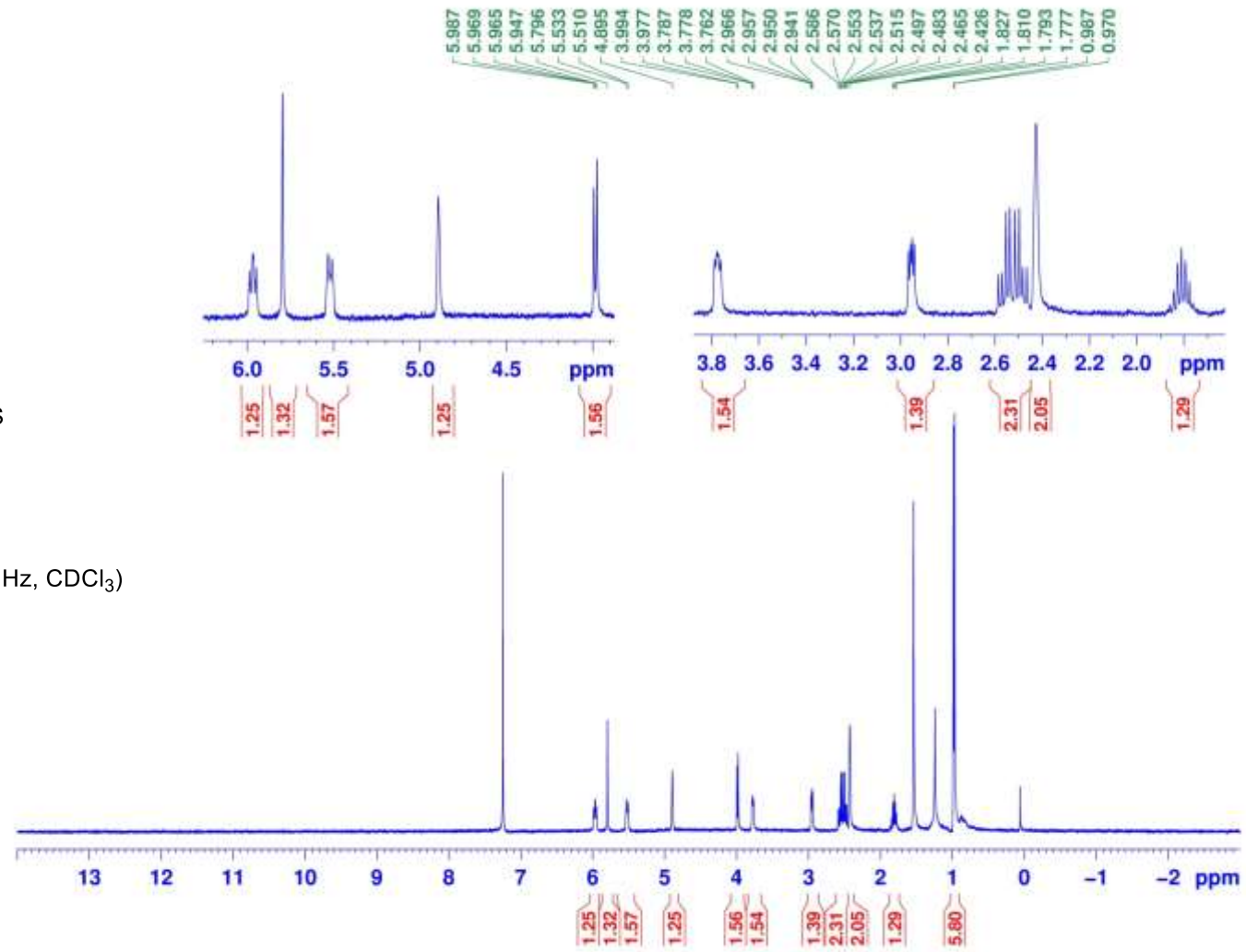


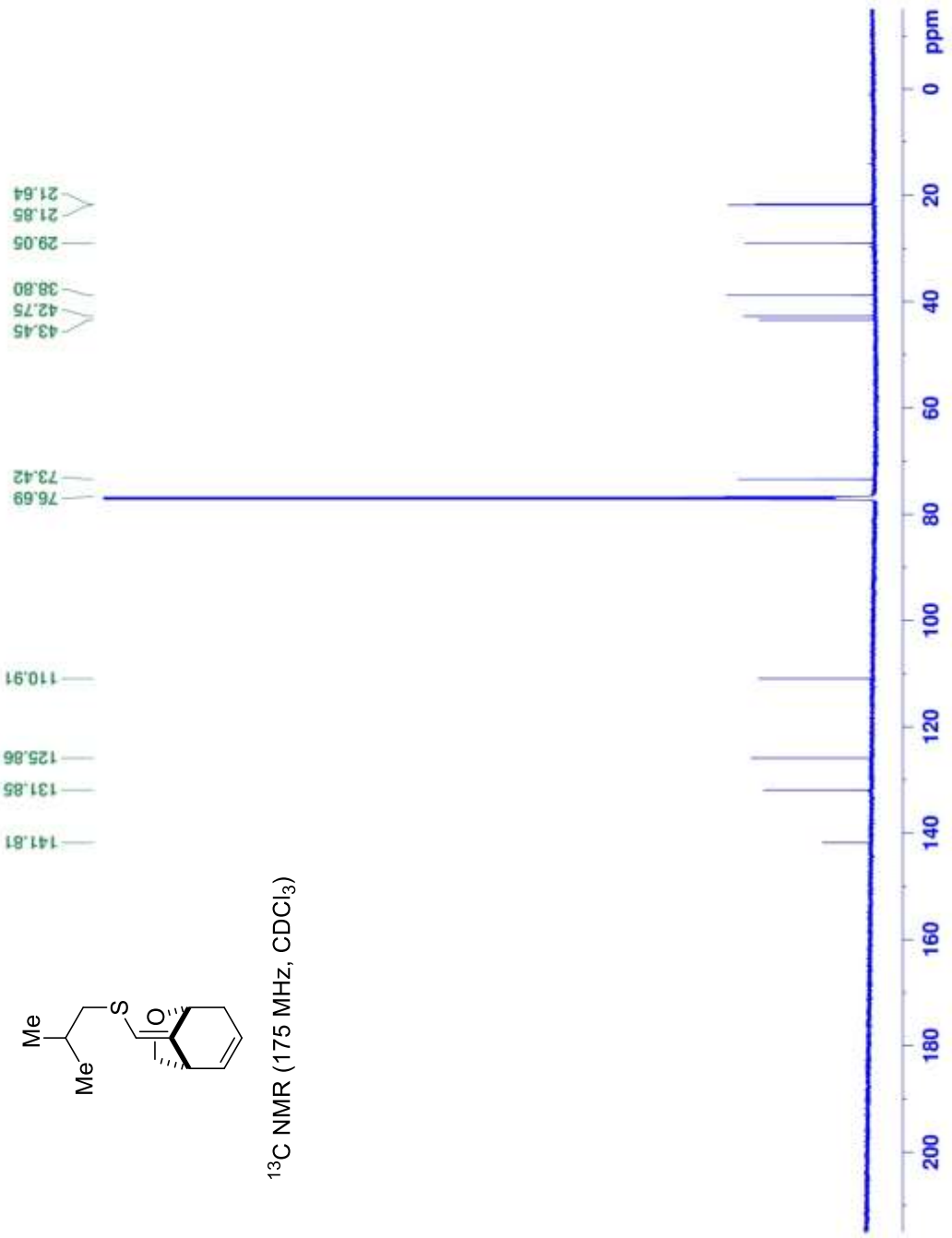
^{13}C NMR (175 MHz, $CDCl_3$)

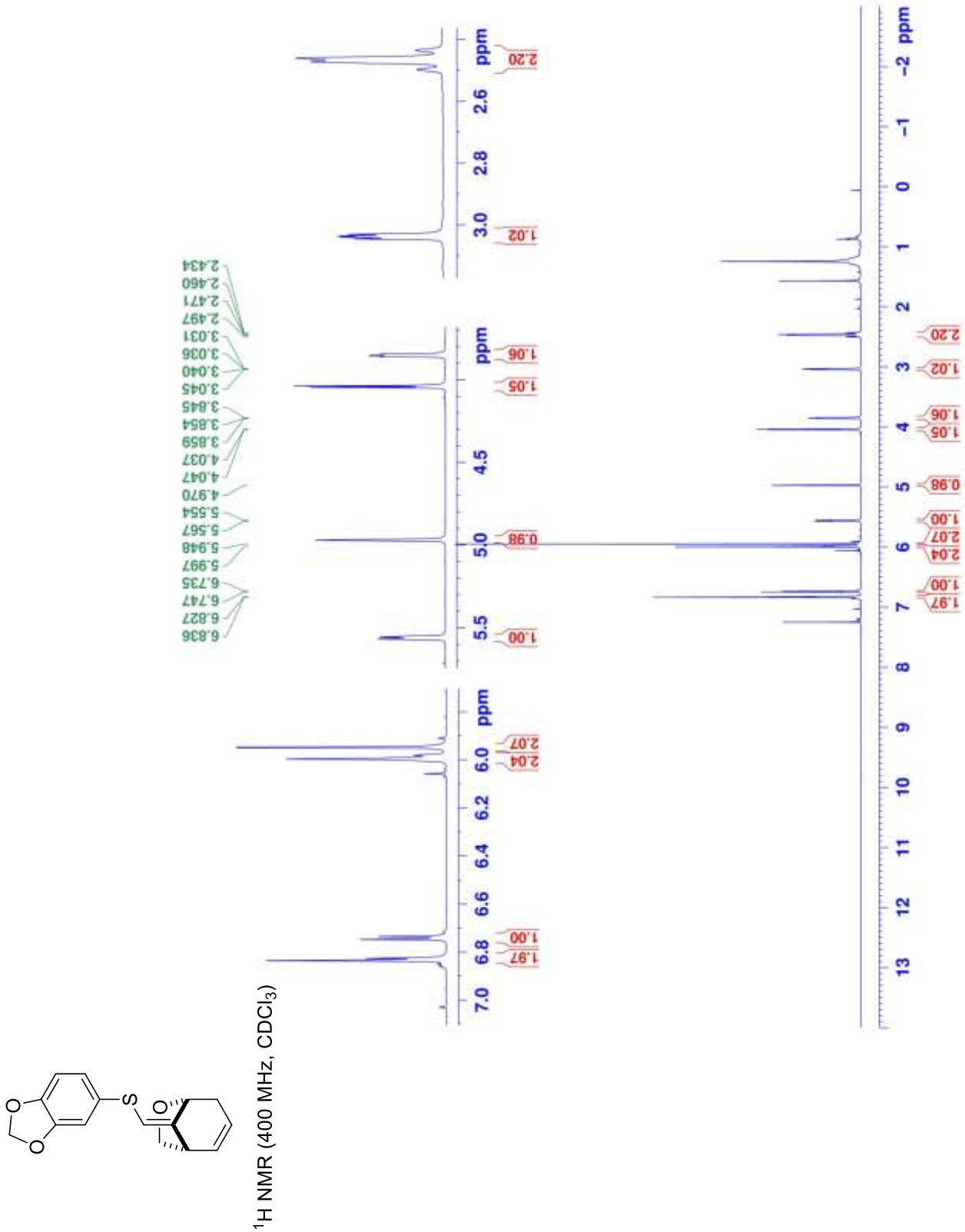


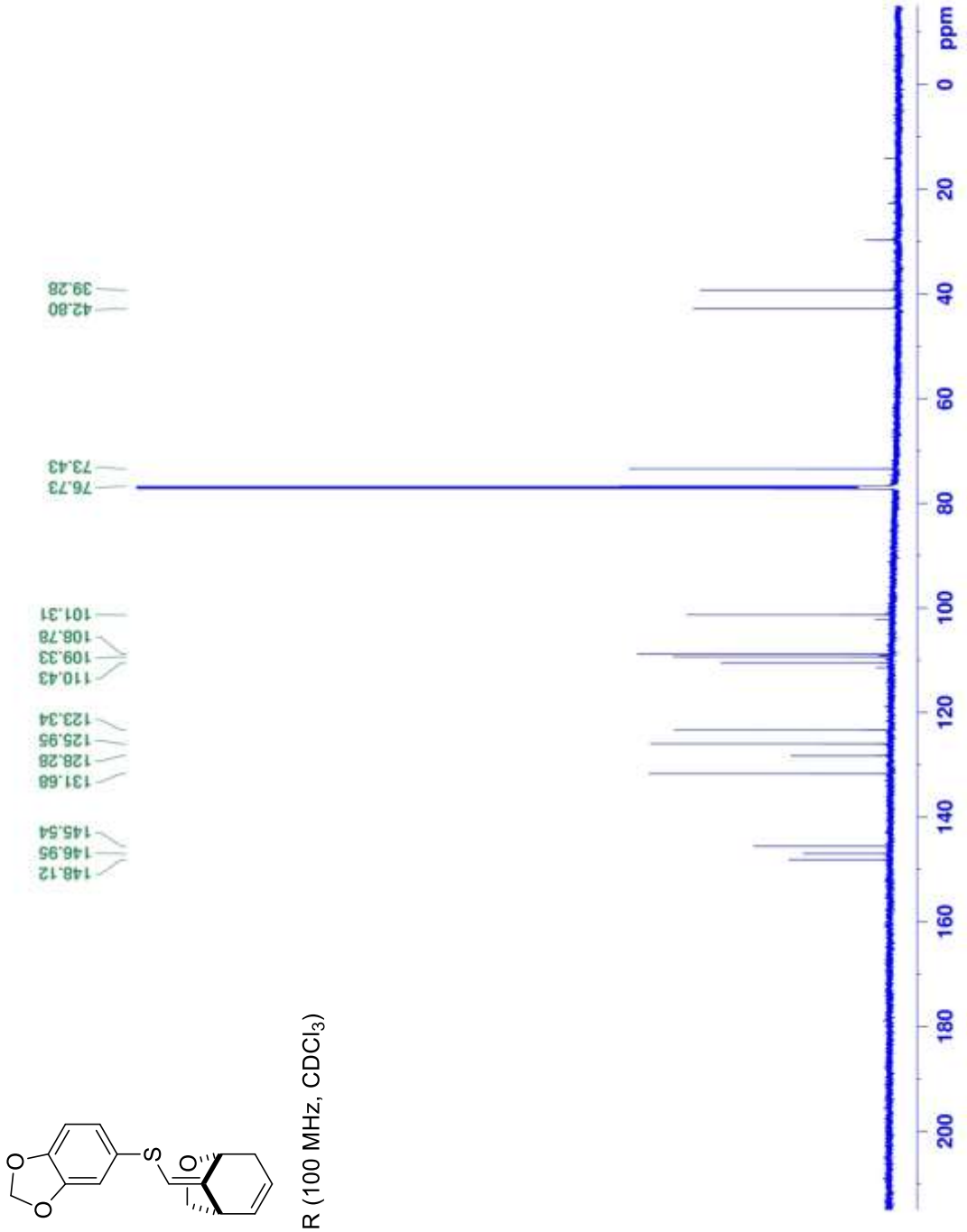


^{1}H NMR (400 MHz, $CDCl_3$)

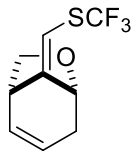



21.64
21.85
29.05
38.80
42.75
43.45
73.42
76.69
110.91
125.86
131.85
141.81
Me
Me
S
O
^{13}C NMR (175 MHz, CDCl$_3$)
0
20
40
60
80
100
120
140
160
180
200
ppm

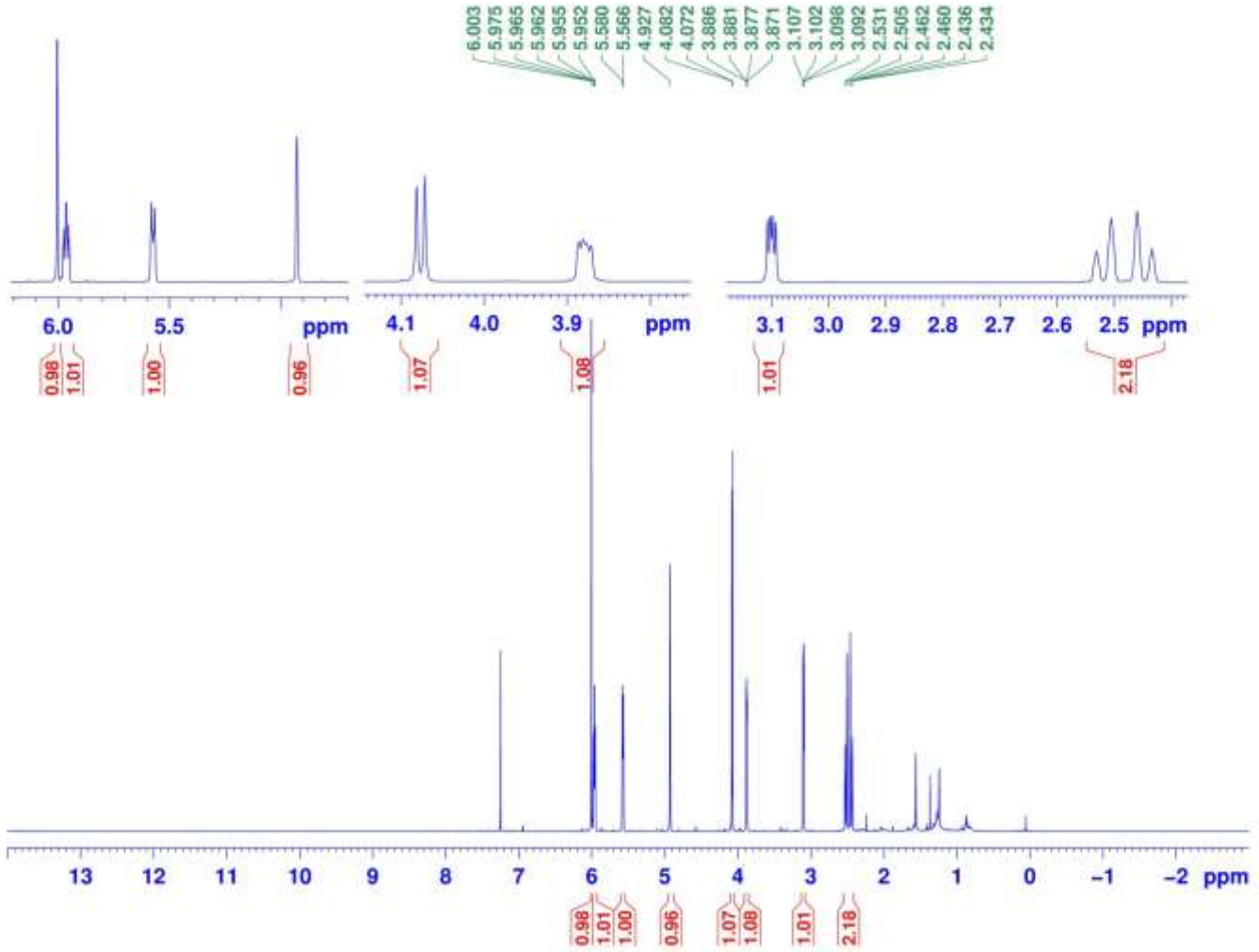

O
O
S
O
^{1}H NMR (400 MHz, $CDCl_3$)

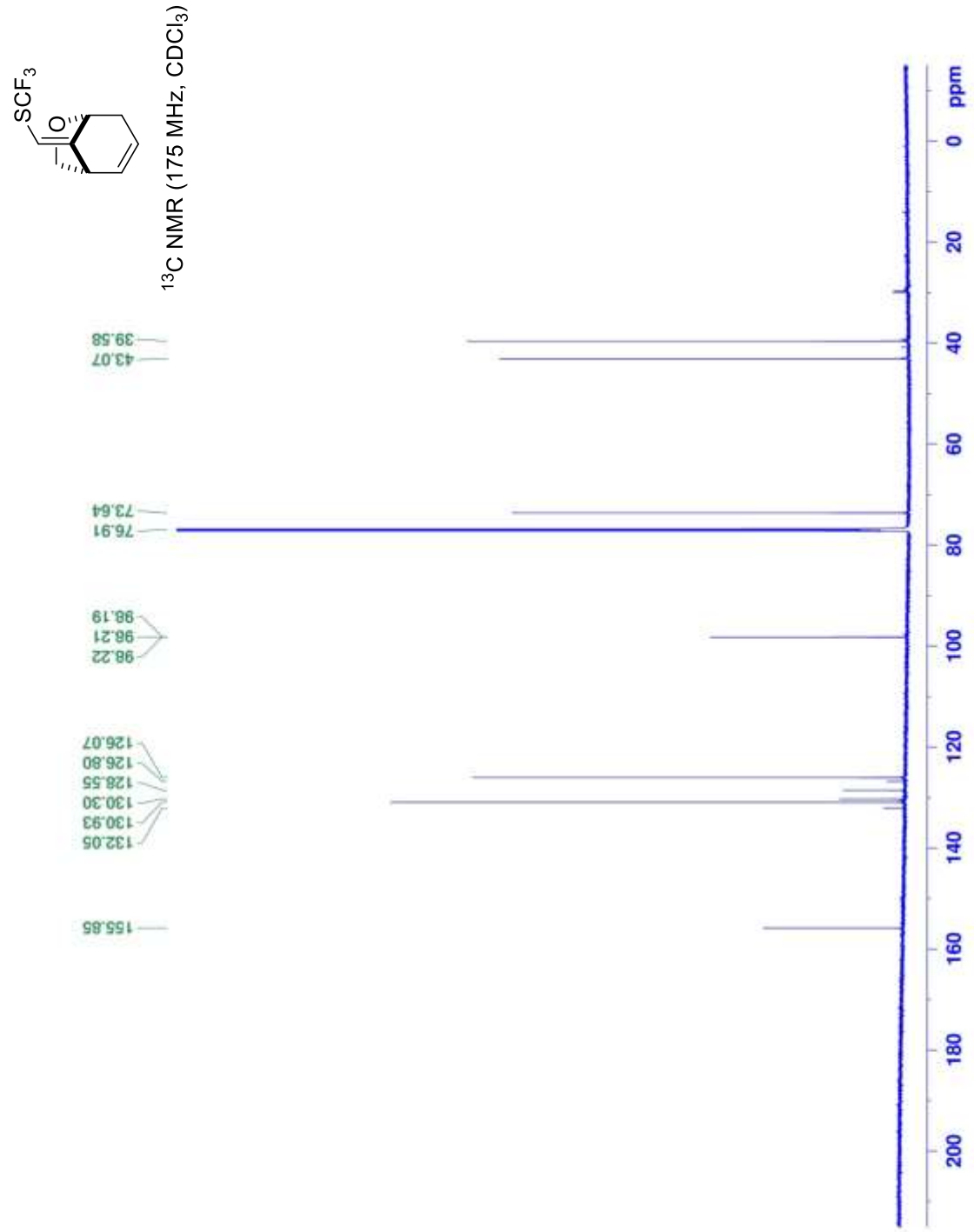


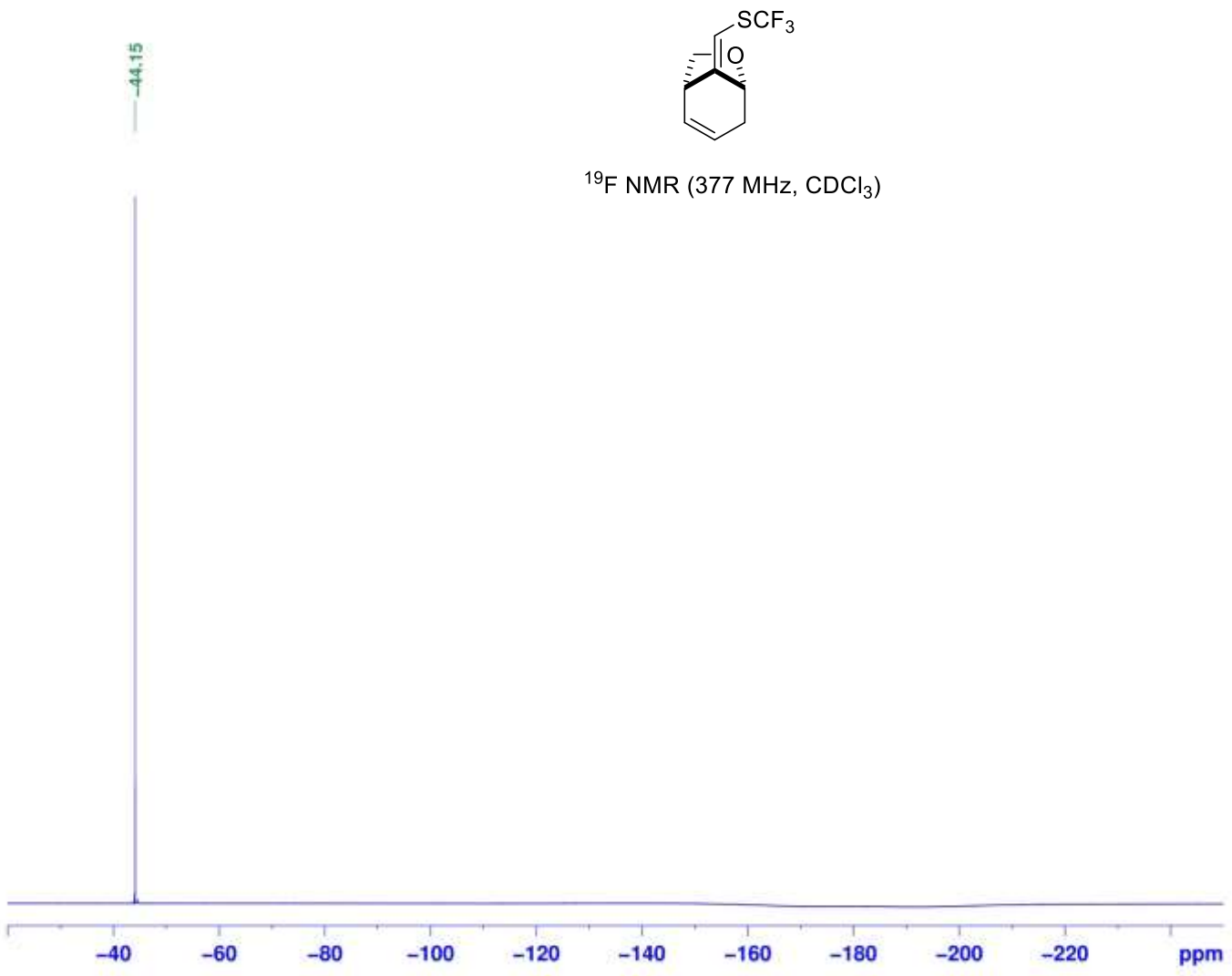
^{13}C NMR (100 MHz, $CDCl_3$)

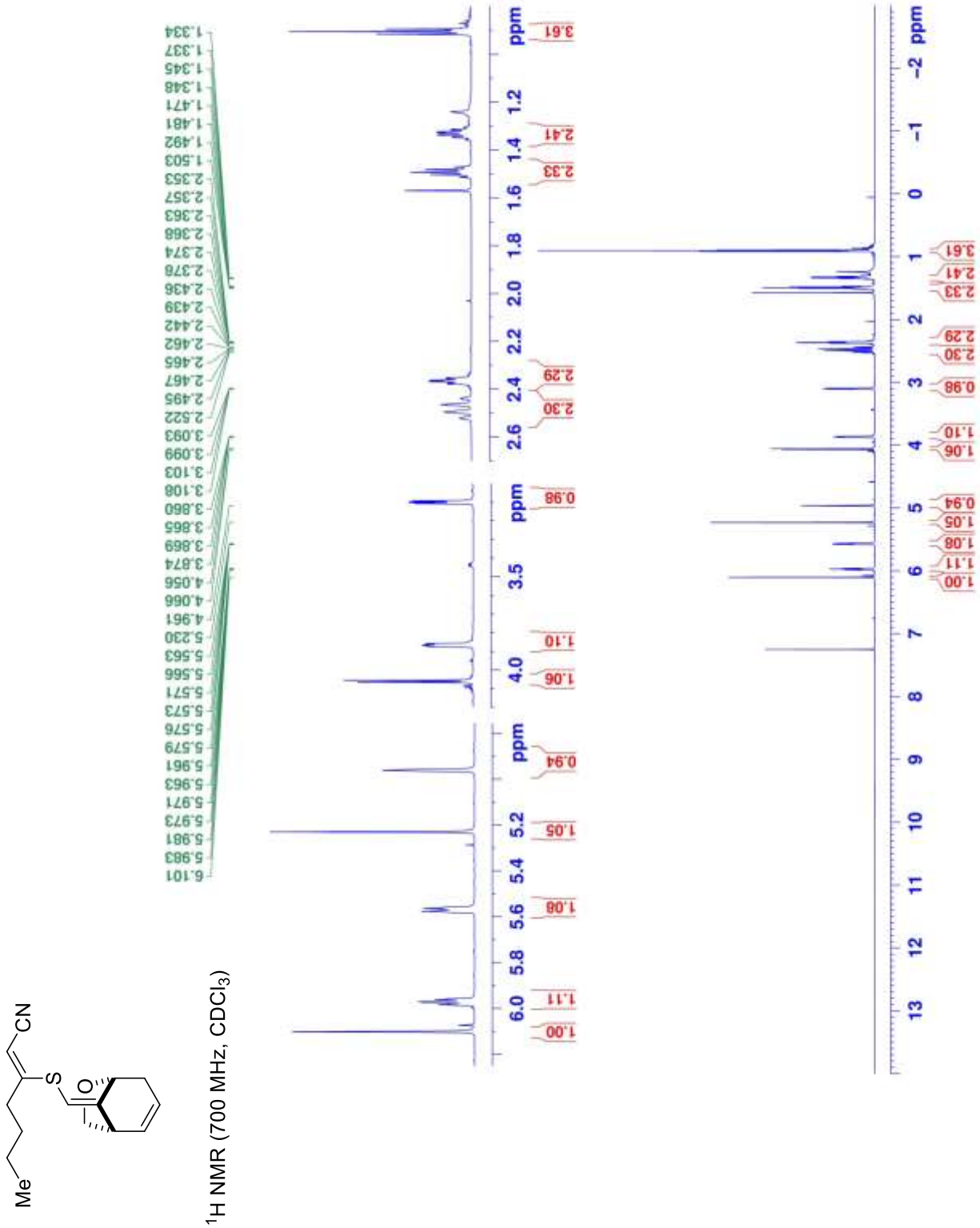


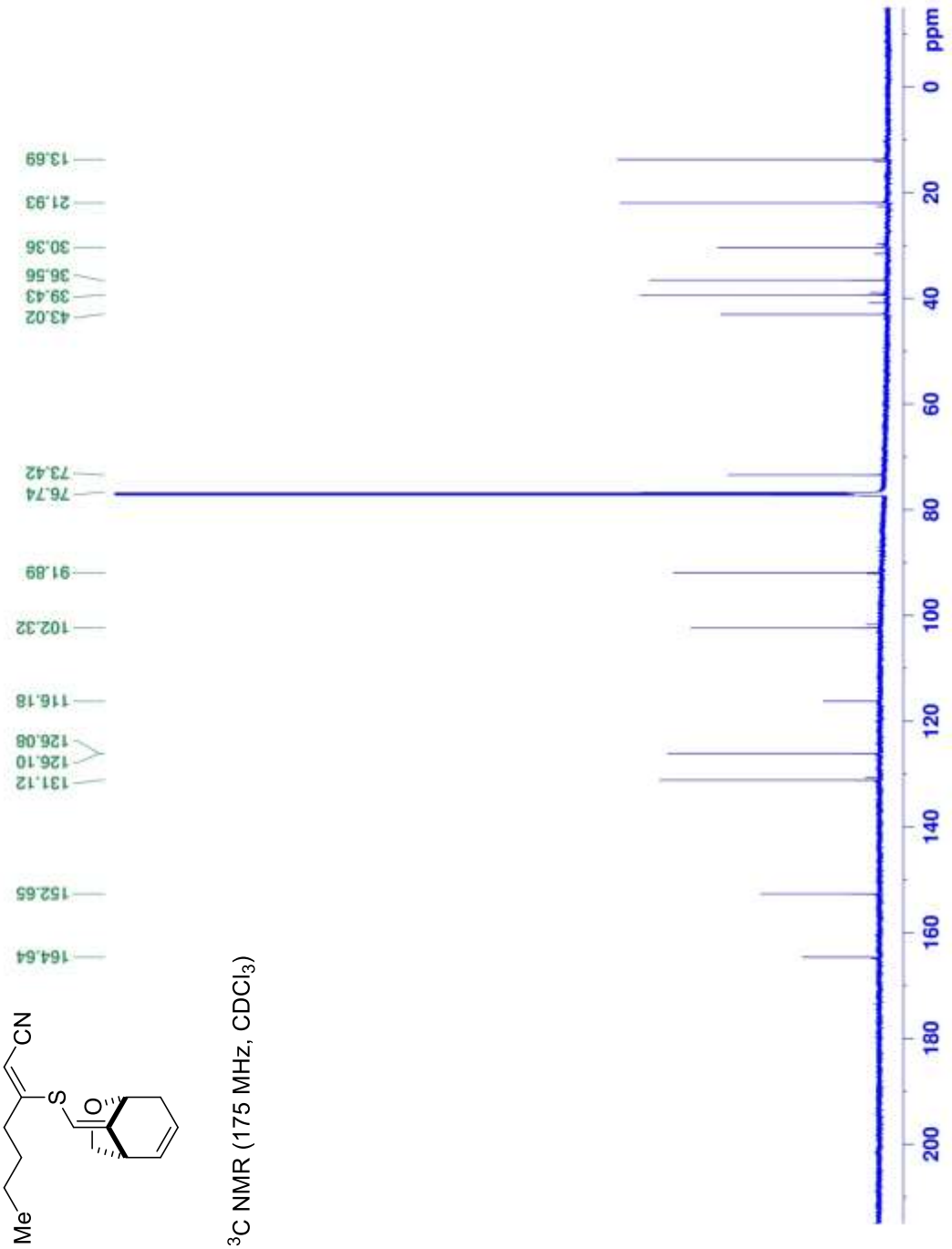
^{1}H NMR (700 MHz, $CDCl_3$)



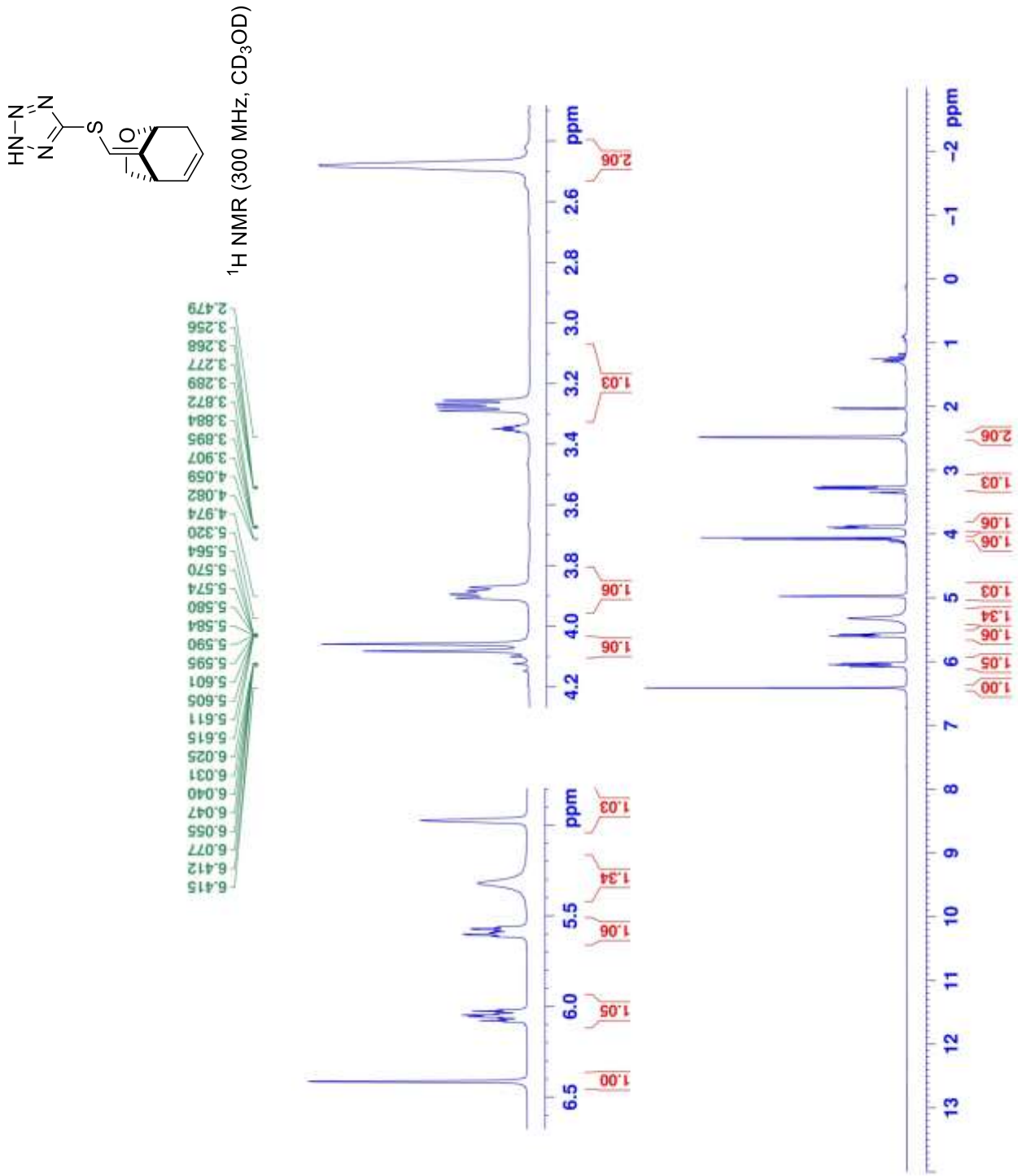

SCF3
O
13C NMR (175 MHz, CDCl3)
39.58
43.07
73.64
76.91
98.19
98.21
98.22
126.07
126.80
128.55
130.30
130.93
132.05
155.85
ppm
0
20
40
60
80
100
120
140
160
180
200

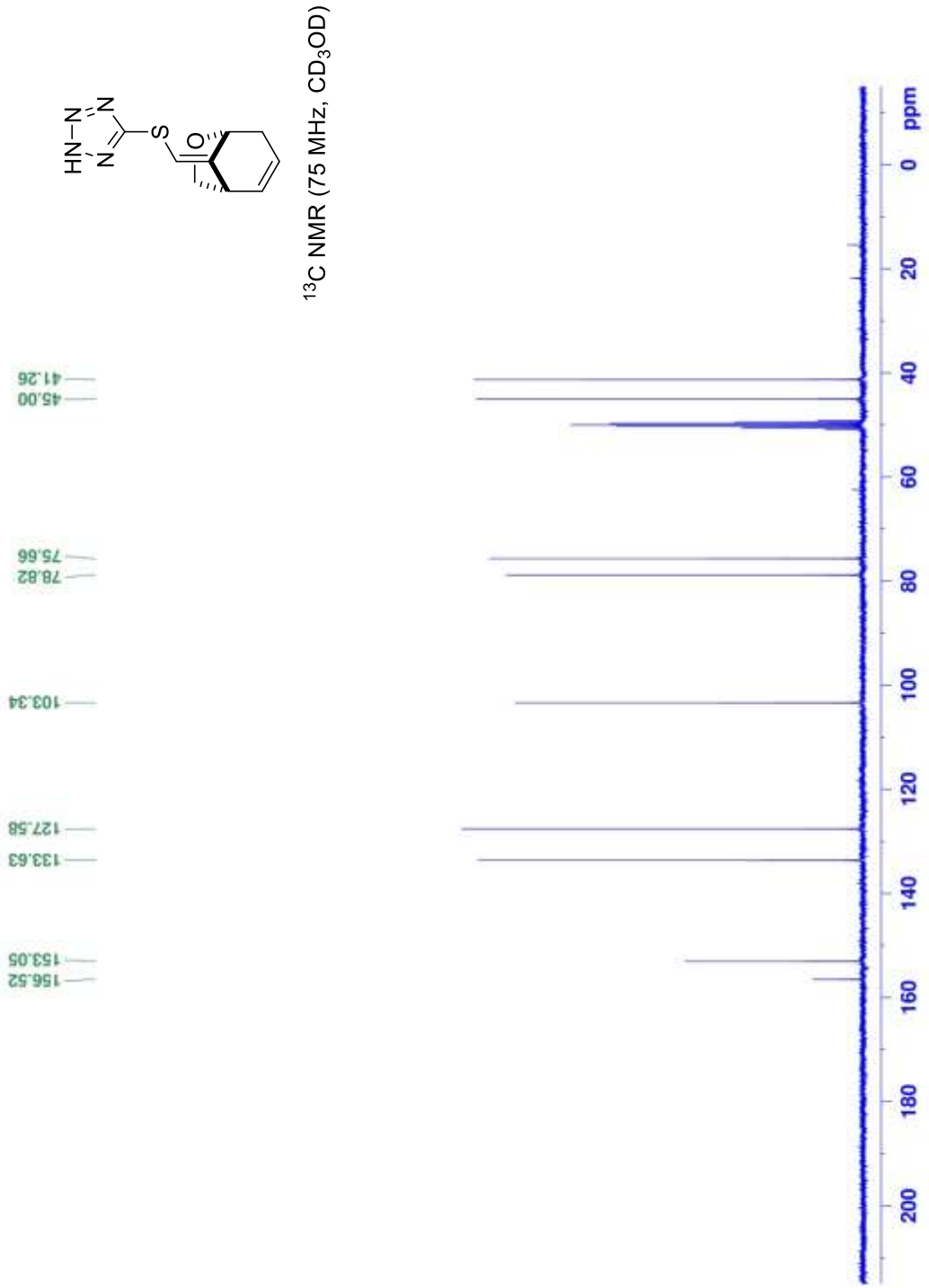

SCF3
O
-44.15
19F NMR (377 MHz, CDCl3)
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
ppm

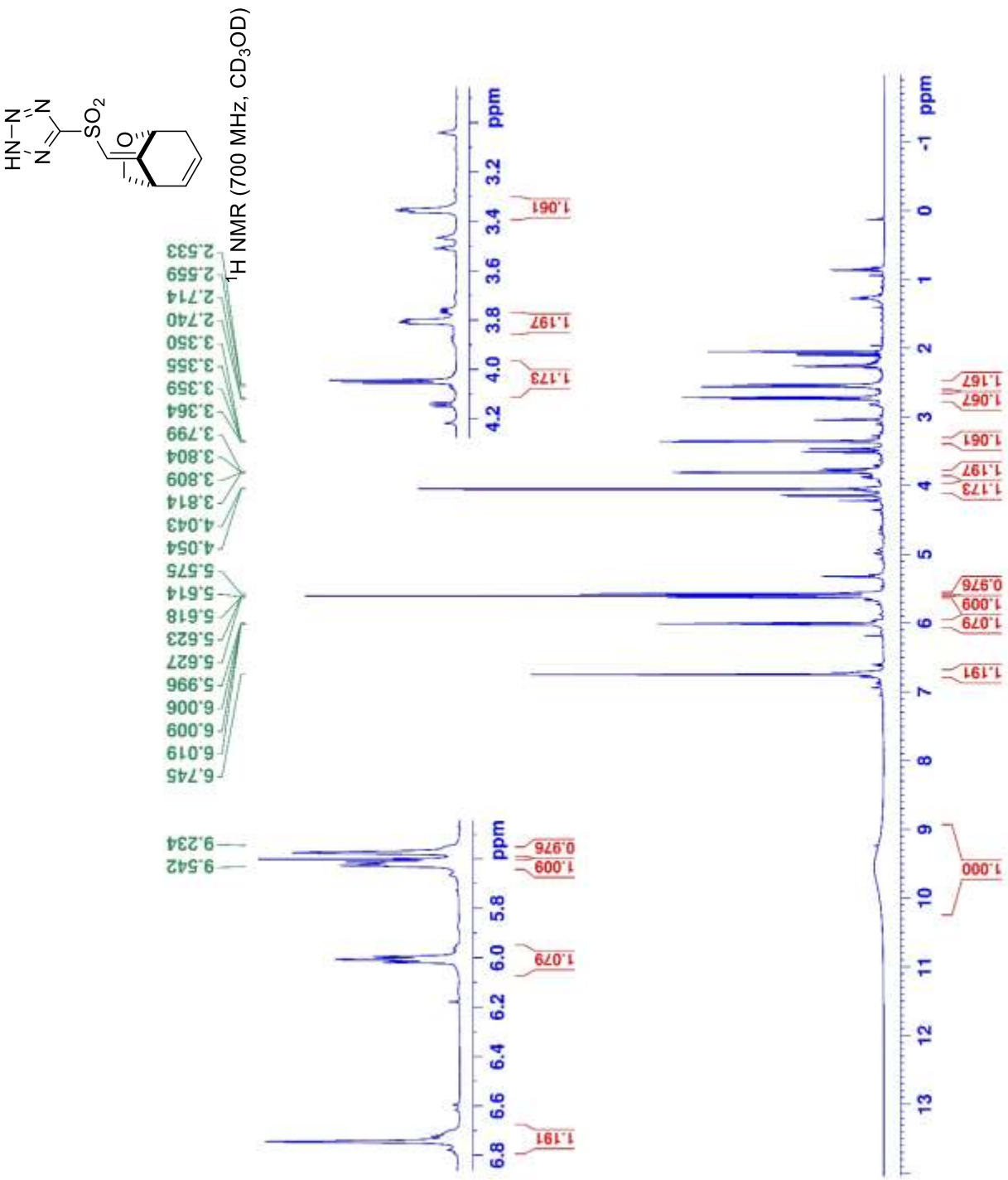

CN
S
O
Me
^{1}H NMR (700 MHz, CDCl$_3$)

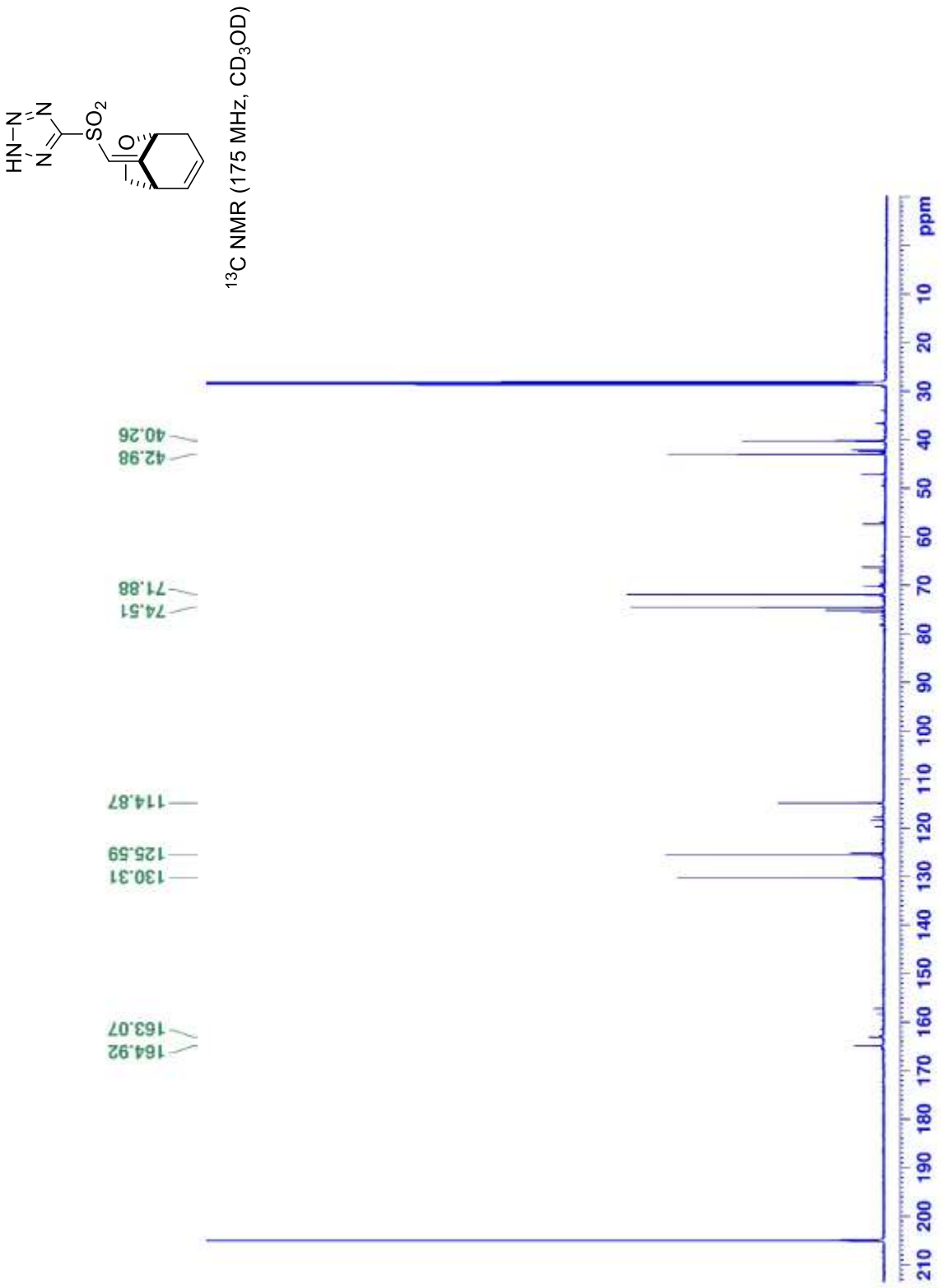


^{13}C NMR (175 MHz, $CDCl_3$)


HN–N
N
N
S
O
^{1}H NMR (300 MHz, CD_3OD)
2.479
3.256
3.268
3.277
3.289
3.872
3.884
3.895
3.907
4.059
4.082
4.974
5.320
5.564
5.570
5.574
5.580
5.584
5.590
5.595
5.601
5.605
5.611
5.615
6.025
6.031
6.040
6.047
6.055
6.077
6.412
6.415
ppm
1.00
1.05
1.06
1.34
1.03
2.06

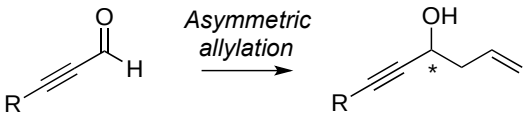

^{13}C NMR (75 MHz, CD_3OD)
41.26
45.00
75.66
78.82
103.34
127.58
133.63
153.05
156.52
ppm
0
20
40
60
80
100
120
140
160
180
200

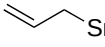
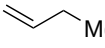

HN–N
N
N
SO2
O
1H NMR (700 MHz, CD3OD)
2.533
2.559
2.714
2.740
3.350
3.355
3.359
3.364
3.799
3.804
3.809
3.814
4.043
4.054
5.575
5.614
5.618
5.623
5.627
5.996
6.006
6.009
6.019
6.745
9.234
9.542
1.061
1.197
1.173
0.976
1.009
1.079
1.191
1.000
1.167
1.067
ppm

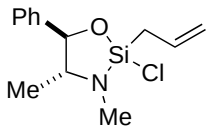

^{13}C NMR (175 MHz, CD_3OD)
HN–N
N
N
SO_2
O
40.26
42.98
71.88
74.51
114.87
125.59
130.31
163.07
164.92
ppm
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

X. Chiral HPLC Traces

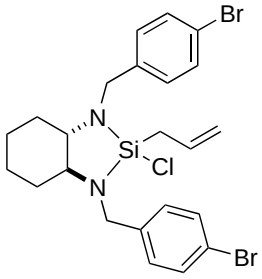
Asymmetric allylation



Entry	R	conditions	Yield	ee (*major enantiomer*)
1	TMS	(R)-Binol/Ti(OiPr)$_4$ (10 mol%)  (1,11 eq), DCM, -20 °C	25%	+27.1% (*R*)
2	TMS	(-)-DIP-(OMe) (1.87 eq)  (1.68 eq), Ether, -100°C	85%	-63.7% (*S*)
3	TMS	(-)-DIP-Cl (1.87 eq)  (1.68 eq), Ether, -78°C	80%	-88.1% (*S*)
4	TMS	Leighton Reagent **A** (1.1 eq), DCM, 0°C	61%	+64.5% (*R*)
5	TMS	Leighton Reagent **B** (1.1 eq), DCM, 0°C	35%	+88.4% (*R*)
6	TBS	Leighton Reagent **B** (1.1 eq), DCM, 0°C	20%	+92.4% (*R*)
7	TBS	(-)-DIP-Cl (2.5 eq)  (2 eq), Ether, -78°C	77%	-90.4% (*S*)

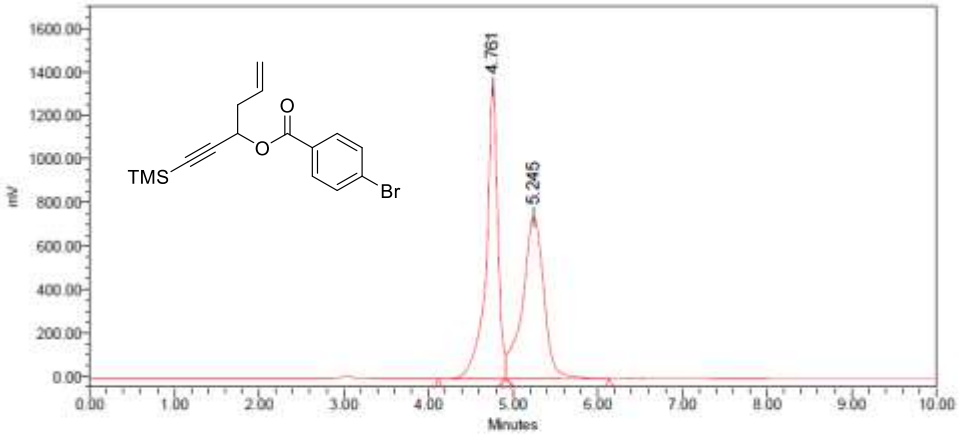


Leighton Reagent **A**



Leighton Reagent **B**

Chromatographic standard-racemic, allylation product ester; TMS-protection (99.5/0.5 eluent)

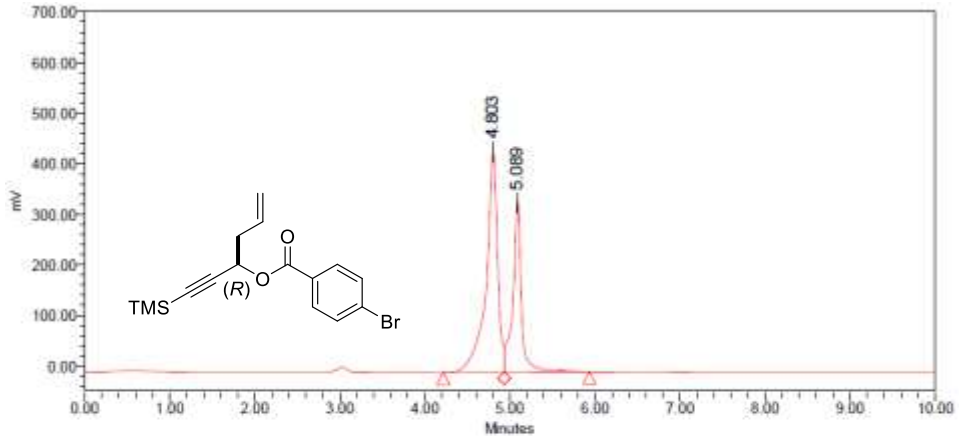


Peak Results

	Name	% Area
1		49.68
2		50.32

Conditions: Column: Pirkle covalent, (S,S) Whelk-O 1 10/100; Eluent – hexane:*i*PrOH 99:1; Flow rate – 1 mL/min; λ = 254 nm

Chromatogram of the allylation product with binol-Ti complex; TMS protection (entry 1)

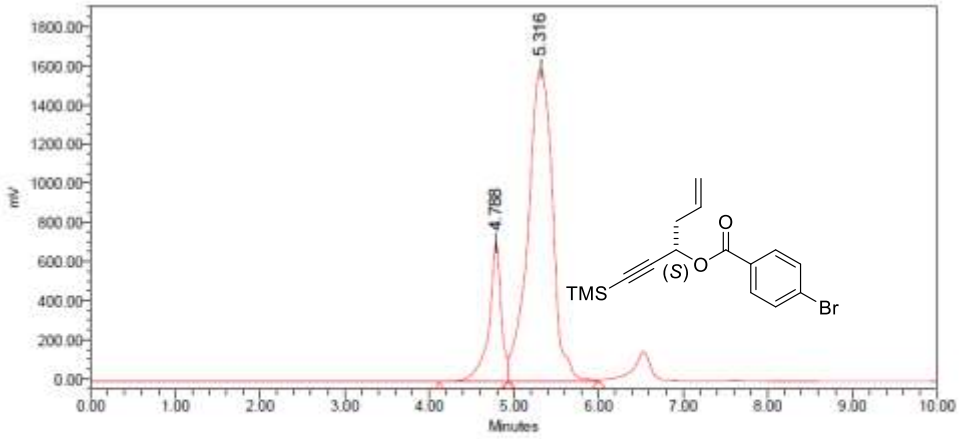


Peak Results

	RT	% Area
1	4.803	63.55
2	5.089	36.45

Conditions: Column: Pirkle covalent, (S,S) Whelk-O 1 10/100; Eluent – hexane:*i*PrOH 99:1; Flow rate – 1 mL/min; λ = 254 nm

Chromatogram of the allylation product (-)-DIP-OMe/allyl-MgCl; TMS protection (entry 2)

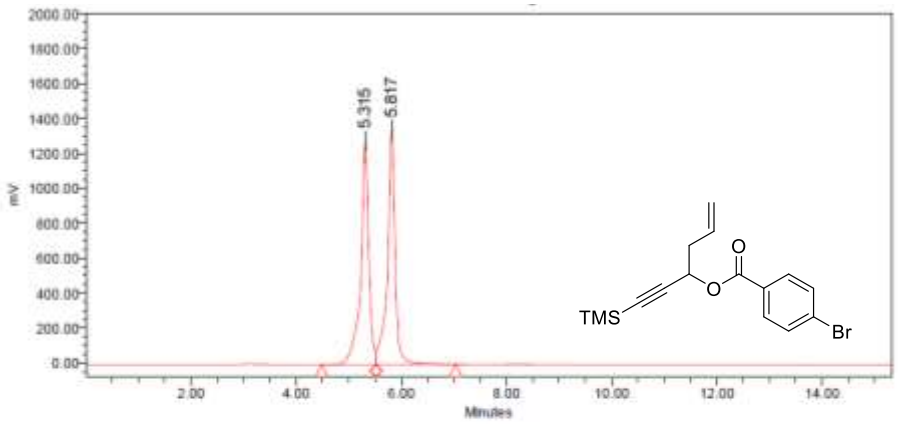


Peak Results

	RT	% Area
1	4.788	18.16
2	5.316	81.84

Conditions: Column: Pirkle covalent, (S,S) Whelk-O 1 10/100; Eluent – hexane:*i*PrOH 99:1; Flow rate – 1 mL/min; λ = 254 nm

Chromatographic standard-racemic, allylation product ester; TMS-protection (99.5/0.5 eluent)

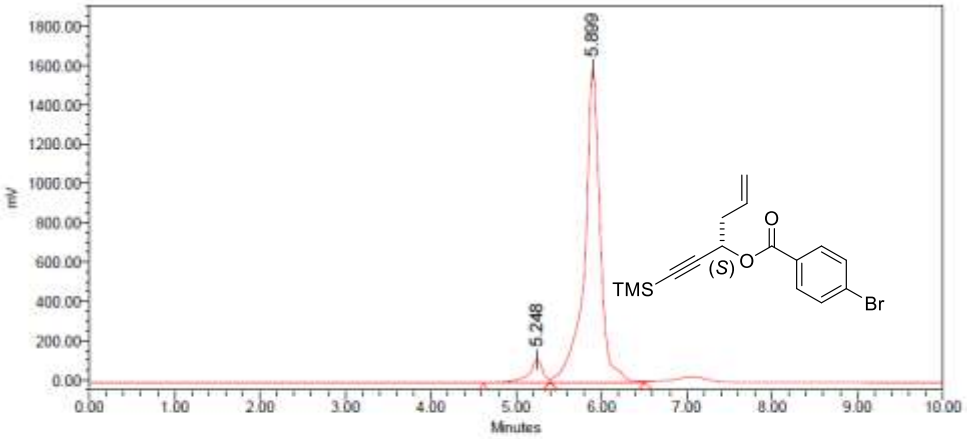


Peak Results

	RT	% Area
1	5.315	49.76
2	5.817	50.24

Conditions: Column: Pirkle covalent, (S,S) Whelk-O 1 10/100; Eluent – hexane:*i*PrOH 99.5:0.5; Flow rate – 1 mL/min; λ = 254 nm

Chromatogram of the allylation product with(-)-DIP-Cl/allyl-MgCl; TMS protection (entry 3)

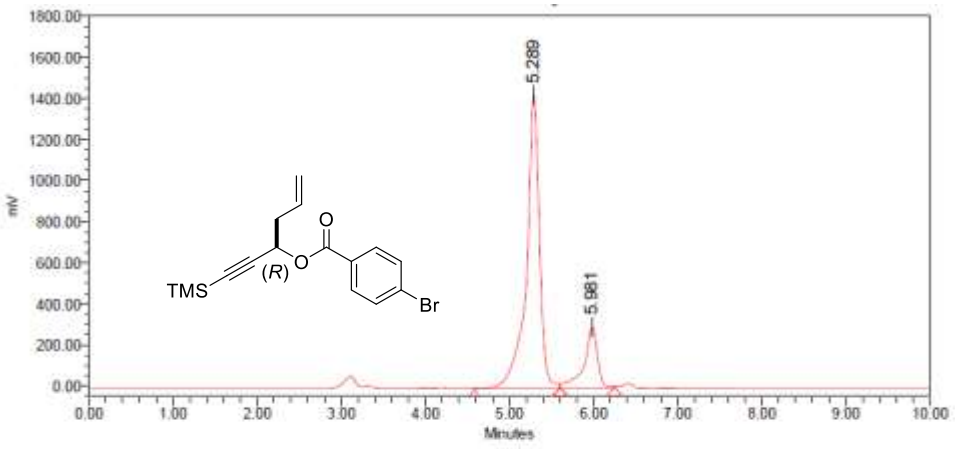


Peak Results

	RT	% Area
1	5.248	5.93
2	5.899	94.07

Conditions: Column: Pirkle covalent, (S,S) Whelk-O 1 10/100; Eluent – hexane:*i*PrOH 99.5:0.5; Flow rate – 1 mL/min; λ = 254 nm

Chromatogram of the allylation product with the Leighton reagent A-TMS protection (entry 4)

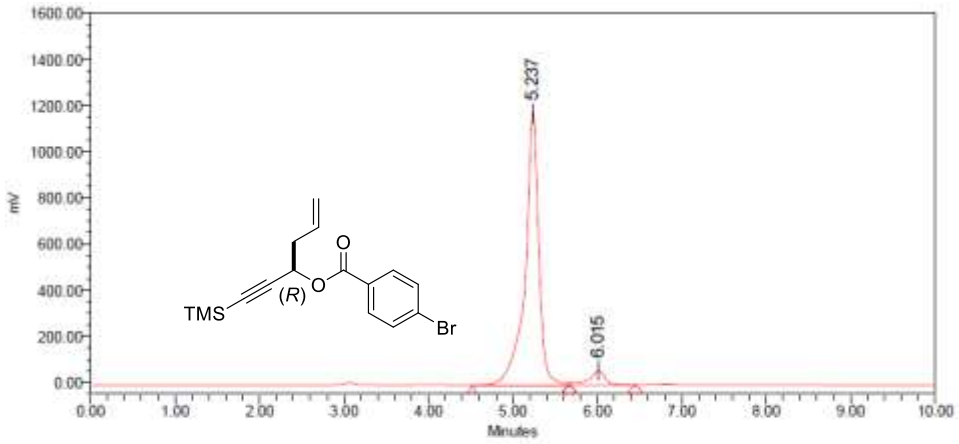


Peak Results

	RT	% Area
1	5.289	82.25
2	5.981	17.75

Conditions: Column: Pirkle covalent, (S,S) Whelk-O 1 10/100; Eluent – Hexane:*i*PrOH 99.5:0.5; Flow rate – 1 mL/min; λ = 254 nm

Chromatogram of the allylation product with the Leighton reagent B-TMS protection (entry 5)

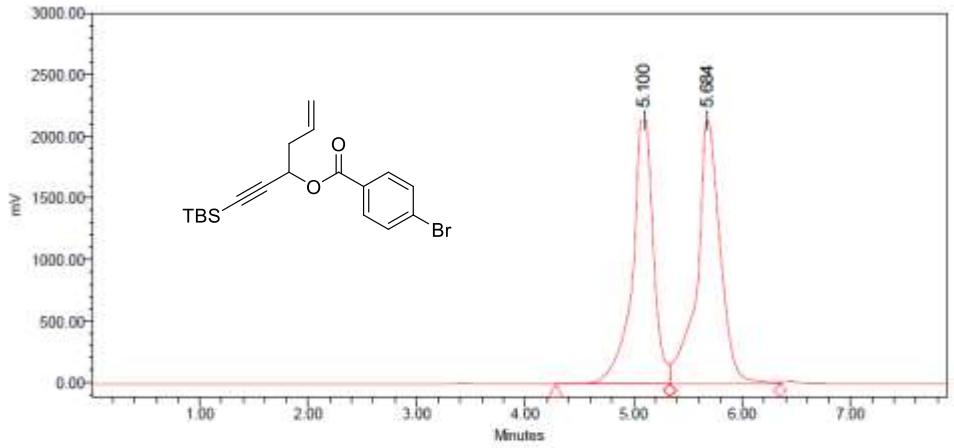


Peak Results

	RT	% Area
1	5.237	94.21
2	6.015	5.79

Conditions: Column: Pirkle covalent, (S,S) Whelk-O 1 10/100; Eluent – Hexane:*i*PrOH 99.5:0.5; Flow rate – 1 mL/min; λ = 254 nm

Chromatographic standard for the allylation product ester; TBS-protection

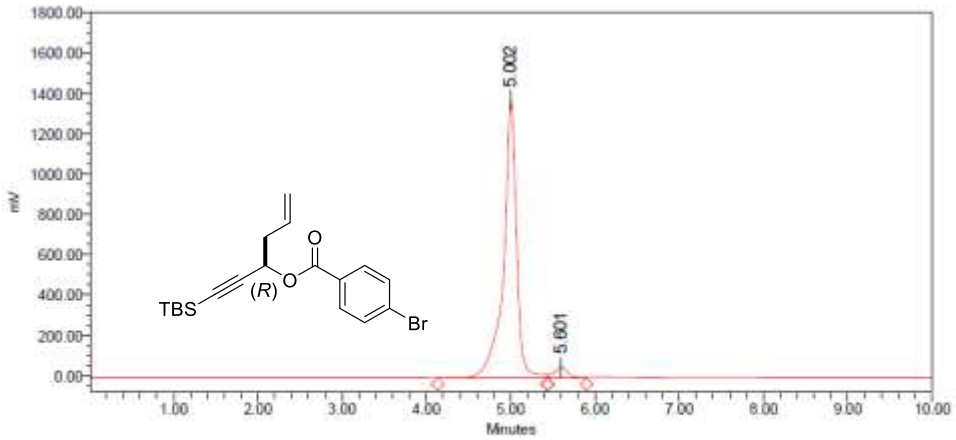


Peak Results

	RT	Area	% Area
1	5.100	29023594	47.50
2	5.684	32074325	52.50

Conditions: Column: Pirkle covalent, (S,S) Whelk-O 1 10/100; Eluent – Hexane:*i*PrOH 99.5:0.5; Flow rate – 1 mL/min; λ = 254 nm

Chromatogram of the allylation product with the Leighton reagent B-TBS protection (entry 6)

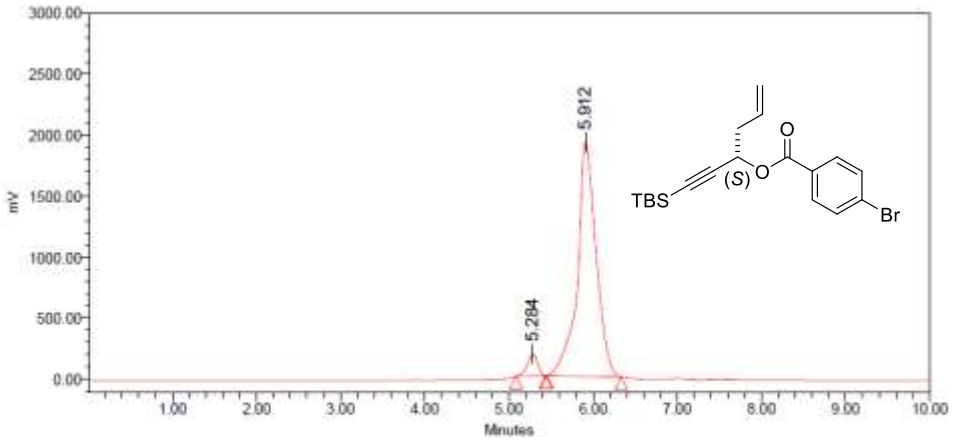


Peak Results

	RT	Area	% Area
1	5.002	14817164	96.21
2	5.601	583277	3.79

Conditions: Column: Pirkle covalent, (S,S) Whelk-O 1 10/100; Eluent – Hexane:*i*PrOH 99.5:0.5; Flow rate – 1 mL/min; λ = 254 nm

Chromatogram of the allylation product with (-)-DIP-Cl/allyl-MgCl; TBS protection (entry 7)

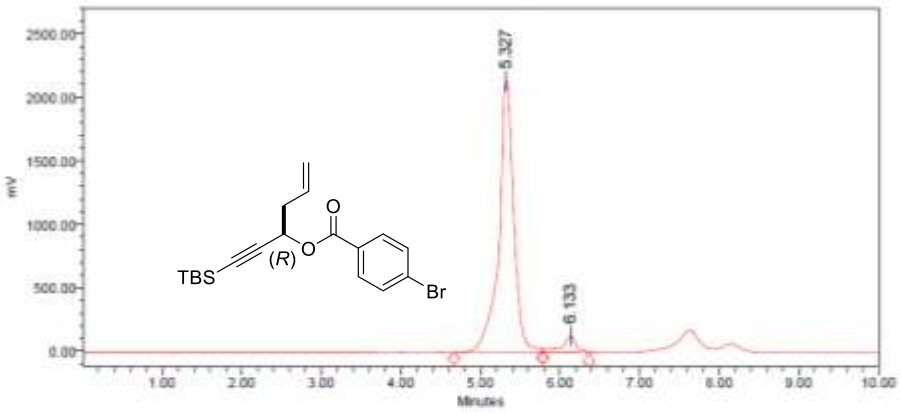


Peak Results

	RT	Area	% Area
1	5.284	1499374	4.82
2	5.912	29597435	95.18

Conditions: Column: Pirkle covalent, (S,S) Whelk-O 1 10/100; Eluent – Hexane:*i*PrOH 99.5:0.5; Flow rate – 1 mL/min; λ = 254 nm

Chromatogram of the allylation product ester from (+)-DIP-Cl/allyl-MgCl; TBS protection

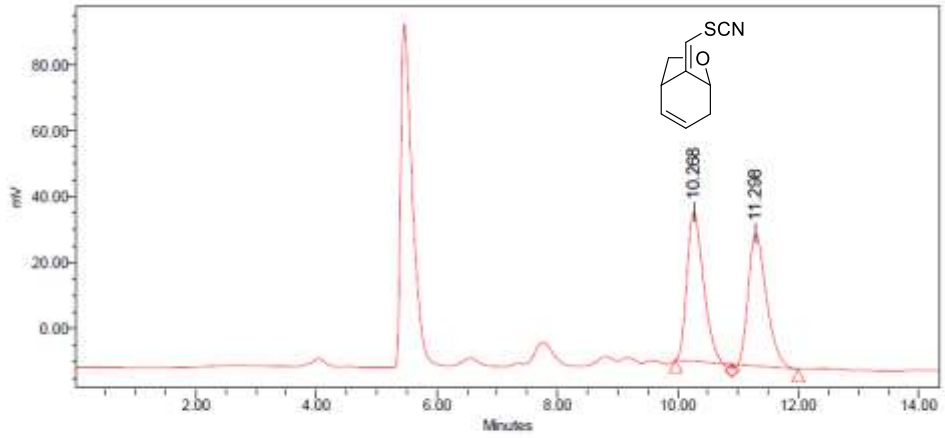


Peak Results

	RT	% Area
1	5.327	95.10
2	6.133	4.90

Conditions: Column: Pirkle covalent, (S,S) Whelk-O 1 10/100; Eluent – Hexane:*i*PrOH 99.5:0.5; Flow rate – 1 mL/min; λ = 254 nm

Chromatographic standard for the racemic oxabicycle 60

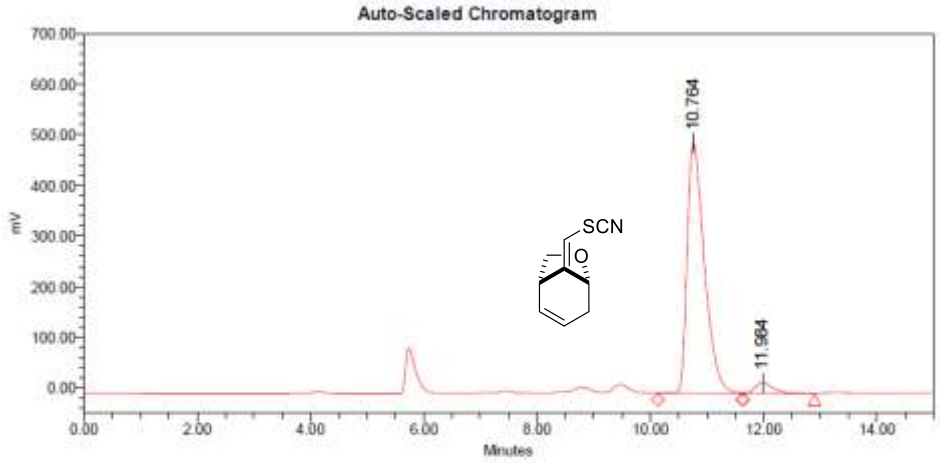


Peak Results

	RT	% Area
1	10.268	50.76
2	11.298	49.24

Conditions: Column: Chiralcel OD; Eluent – Hexane:*i*PrOH 95: 5; Flow rate – 1 mL/min; λ = 254 nm

Chromatogram of the enantioenriched oxabicycle 60

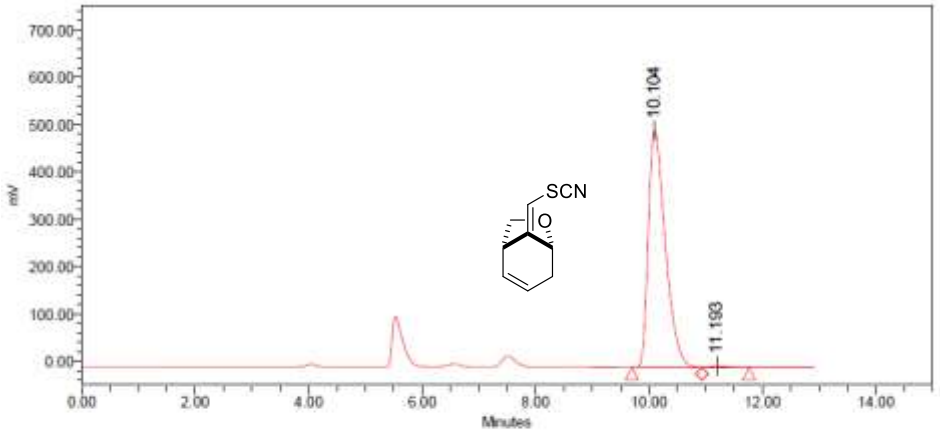


Peak Results

	Retention Time (min)	% Area
1	10.764	95.62
2	11.984	4.38

Conditions: Column: Chiralcel OD; Eluent – Hexane:*i*PrOH 95: 5; Flow rate – 1 mL/min; λ = 254 nm

Chromatogram of the recrystallized oxabicycle 60

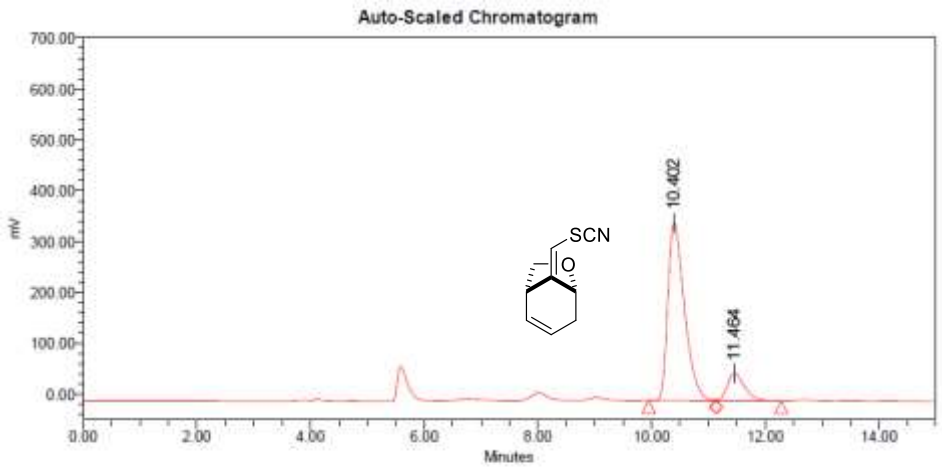


Peak Results

	RT	% Area
1	10.104	99.38
2	11.193	0.62

Conditions: Column: Chiralcel OD; Eluent – Hexane:*i*PrOH 95: 5; Flow rate – 1 mL/min; λ = 254 nm

Chromatogram of the mother liquor from recrystallization of oxabicycle 60



Peak Results

	RT	% Area
1	10.402	86.29
2	11.464	13.71

Conditions: Column: Chiralcel OD; Eluent – Hexane:*i*PrOH 95: 5; Flow rate – 1 mL/min; λ = 254 nm

XI. References

(1) Friest, J. A.; Broussy, S.; Chung, W. J.; Berkowitz, D. B. *Angew. Chem. Int. Ed.* **2011,** *50*, 8895-8899.

(2) Achard, T.; Lepronier, A.; Gimbert, Y.; Clavier, H.; Giordano, L.; Tenaglia, A.; Buono, G. *Angew. Chem. Int. Ed.* **2011,** *50*, 3552-3556.

(3) Hashmi, A. S. K.; Häffner, T.; Yang, W.; Pankajakshan, S.; Schäfer, S.; Schultes, L.; Rominger, F.; Frey, W. *Chem. Eur. J.* **2012,** *18*, 10480-10486.

(4) Mandal, J.; Krishna Prasad, S.; Rao, D. S. S.; Ramakrishnan, S. *J. Am. Chem. Soc.* **2014,** *136*, 2538-2545.

(5) Trost, B. M.; Braslau, R. *J. Org. Chem.* **1988,** *53*, 532-537.

(6) (a) Könning, D.; Hiller, W.; Christmann, M. *Org. Lett.* **2012,** *14*, 5258-5261; (b) Caldwell, J. J.; Cameron, I. D.; Christie, S. D. R.; Hay, A. M.; Johnstone, C.; Kerr, W. J.; Murray, A. *Synthesis* **2005,** *2005*, 3293-3296.

(7) Kamptmann, S. B.; Brückner, R. *Eur. J. Org. Chem.* **2013,** *2013*, 6584-6600.