Merging Chemoenzymatic and Radical-Based Retrosynthetic Logic For Rapid and Modular Synthesis of Oxidized Meroterpenoids

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SUPPLEMENTARY INFORMATION

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General materials and methods

Unless otherwise noted, all chemicals and reagents for chemical reactions were purchased at the highest commercial quality and used without further purification. Reactions were monitored by thin layer chromatography (TLC) and liquid chromatography/mass spectrometry (LC/MS). TLC was performed with 0.25 mm E. Merck silica plates (60F-254) using short-wave UV light as the visualizing agent, and ninhydrin, $KMnO_4$, ammonium molybdate, or phosphomolybdic acid and heat as developing agents. LC/MS was performed with Agilent 1260 Infinity System equipped with Poroshell 120 EC-C18 column (3.0 x 50 mm, 2.7 micron). NMR spectra were recorded on a Bruker AVANCE AV400 (400 MHz and 100 MHz) or Bruker AVANCE AV600 (600 MHz and 151 MHz). Signal positions were recorded in ppm with the abbreviations s, d, t, q, br, m and app denoting singlet, doublet, triplet, quartet, broad, multiplet and apparent respectively. All NMR chemical shifts were referenced to residual solvent peaks or to $Si(CH_3)_4$ as an internal standard. Spectra recorded in $CDCl_3$ were referenced to residual $CHCl_3$ at 7.26 ppm for 1H or 77.16 ppm for ^{13}C, and spectra recorded in CD_3OD were referenced to residual CD_2HOD at 3.31 ppm for ^{1}H or 49.00 ppm for ^{13}C. All coupling constants J are quoted in Hz. Optical rotations were measured on Autopol IV polarimeter (Rudolph Research Analytical). Enzymes (DpnI, Phusion polymerase) were purchased from New England Biolabs (NEB, Ipswich, MA). Sonication was performed using a Qsonica Q500 sonicator. Biochemicals and media components were purchased from standard commercial sources.

Protein and DNA Sequences

The original plasmid encoding for $P450_{BM3}$ variant 1857 was a generous donation from Prof. Frances H. Arnold. Protein sequence of $P450_{BM3}$ variant 1857:

HMTIKEMPQPKTFGELKNLPLLNTDKPVQALMKIADELGEIFKFEAPGRVTRYSSQRLIKEACDESRFDK
NLSQALKFARDFGGDGLVTSWTHEKNWKKAHNILLPSFSQQAMKGYHAMMVDIAVQLVQKWERLNADEHI
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MGTAEGTARDLADIAMSKGFAPQVATLDSHAGNLPREGAVLIVTASYNGHPPDNAKQFVDWLDQASADEV
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LGVIPRNYEGIVNRVTARFGLDASQQIRLEAEEEKLAHLPLAKTVSVEELLQYVELQDPVTRTQLRAMAA
KTVCPPHKVELEALLEKQAYKEQVLAKRLTMLELLEKYPACEMKFSEFIALLPSIRPRYYSISSSPRVDE
KQASITVSVVSGEAWSGYGEYKGIASNYLAELQEGDTITCFISTPQSEFTLPKDPETPLIMVGPGTGVAP
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EQDGKKLIELLDQGAHFYICGDGSQMAPAVEATLMKSYADVHQVSEADARLWLQQLEEKGRYAKDVWAG

Variant 1857 contains the following mutations relative to WT $P450_{BM3}$: V78A, A82G, F87V, P142S, T175I, A184V, F205C, S226R, H236Q, E252G, R255S, A290V, L353V.

DNA sequence of $P450_{BM3}$ variant 1857:

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Plasmid pET15b-Opt13 was a gift from Prof. Huimin Zhao (Addgene plasmid # 61698; http://n2t.net/addgene:61698; RRID:Addgene 61698).

Generation of enzyme variants

The aforementioned DNA sequence for variant 1857 was inserted between the NdeI and XhoI restriction sites of pET22b(+) vector. The resulting vector was used as a cloning and expression vector for all $P450_{BM3}$ variants described in this study. Site-directed mutagenesis for alanine scanning was performed by using standard QuikChange PCR method with primers containing the desired alanine mutation at the desired position(s). The resulting PCR products were digested with DpnI, gel purified, repaired using NEBuilder HiFi DNA assembly (NEB, product number: E2621), and used directly to transform electrocompetent *E. coli* BL21(DE3) (Lucigen, product number: 60300). Variants were stored as glycerol stocks at –80 ˚C.

For compatible co-expression with pET22b(+)-based expression vector, the gene encoding for Opt13 was subcloned from pET15b-Opt13 into pRSF-1b vector, inserting between NcoI and XhoI restriction sites to yield vector pRSF-Opt13. For co-expression of $P450_{BM3}$ variants and Opt13, the pET22b(+)-based vector encoding for the appropriate $P450_{BM3}$ variant and pRSF-Opt13 were used to co-transform electrocompetent *E. coli* strain BL21(DE3). Variants were stored as glycerol stocks at –80 ˚C.

Amino Acid Sequences

Amino acid sequences of mutants, relative to variant 1857.

Variant	*Amino acid substitution(s)*
MERO1	V328A
MERO2	T235A V328A R471A

MERO3	R47C K94I V328A

NADPH consumption assay

To a cuvette containing 0.5 μM of purified P450 variant in 890 μL of 50 mM kPi buffer (pH 8.0) was added a pre-dissolved solution of substrate in DMSO (10 μL of 100 mM stock solution for a final concentration of 1 mM). A solution of NADPH in pH 8.0 kPi buffer (100 μL of 3 mM stock solution for a final concentration of 300 μM) was added to the mixture, and the change in absorbance at 340 nm was measured. The rate of NADPH consumption was calculated using $\varepsilon_{340} = 6.22\ mM^{-1}cm^{-1}$.

Product formation assay

An enzymatic reaction containing 0.5 μM of purified P450 variant and 2 mM substrate in 10 mL of 50 mM kPi buffer (pH = 8.0) was initiated by the addition of NADPH at 5 mM final concentration. A 1 mL aliquot of the reaction was sampled at various time intervals (15 s to 1 h), extracted with EtOAc, and analyzed for product formation by ^{1}H NMR.

Substrate binding assay

In a cuvette, a solution of 2.5 μM of the appropriate P450 variant in 1 mL of 50 mM kPi buffer (pH 8.0) was prepared and was used to baseline the spectrophotometer. Aliquots of substrate (0.5-2.5 μL) from 1 to 100 mM stock solution in DMSO were added to the mixture and the type I difference spectra were recorded until no further change could be detected in the peak-to-trough difference (A_{390} and A_{422}). Dissociation constant values (K_d) were calculated based on nonlinear regression of $\Delta A_{obs} = \Delta A_{max} \times [S] / (K_d + [S])$ where ΔA_{obs}, ΔA_{max}, and [S] represent the observed absorption difference at A_{390} and A_{422}, the extrapolated maximum absorption difference at A_{390} and A_{422}, and substrate concentration, respectively.

General synthetic procedures

Synthesis of Coupling Partners:

Known literature methods were used to synthesize the [3+3] coupling partners **19**[51], **20**[51], and **21**[52], the nickel cross coupling partners **36**[53] and **37**[54], and the [3+2] coupling partner **39**[55].

Preparation of clarified lysate of *E. coli* expressing $P450_{BM3}$ variant and Opt13 for terpene hydroxylation:

An overnight culture of BL21(DE3) *E. coli* cells harboring pET-22b(+)-based vector for expression of $P450_{BM3}$ variant and pRSF-Opt13 plasmid was used to inoculate 400 mL TB media (in 2L Erlenmeyer flasks) containing 50 μg/mL kanamycin, 50 μg/mL ampicillin, and 0.1% by volume of trace metal mix (aqueous solution of 50 mM $FeCl_3$, 20 mM $CaCl_2$, 10 mM $MnSO_4$, 10 mM $ZnSO_4$, 2 mM $CoSO_4$, 2 mM $CuCl_2$, 2 mM $NiCl_2$, 2 mM Na_2MoO_4, 2 mM H_3BO_3). The cultures were shaken at 250 rpm at 37 ˚C until an optical density of OD_{600} = 0.7 – 1.0 was reached. The cultures were cooled on ice for 20 minutes and then induced with 5-aminolevulinic acid and IPTG to final concentrations of 1.0 mM and 0.5 mM, respectively. The cultures were shaken at 250 rpm at 20 ˚C for a further 20 hours. Cells were harvested by centrifugation (4 ˚C, 15 min, 4200 rpm), resuspended in 50 mM kPi (pH = 8.00) to an OD_{600} = 15, lysed by sonification (3 minutes, 1 second on, 4 seconds off, 50% amplitude), and pelleted by centrifugation (4 ˚C, 15 min, 4200 rpm). The supernatant was used directly for subsequent reactions.

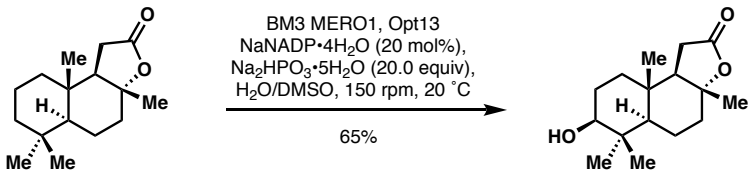
The P450 concentration in the lysate was approximated by hemochrome binding assay. Briefly, a solution of pyridine was made by combining 1.75 mL pyridine with 0.75 mL 1 M NaOH. The solution mixed at room temperature was centrifuged for 30 s at 4200 rpm to remove excess aqueous base. To a cuvette containing 0.75 mL of lysate, 0.25 mL of the pyridine solution was added followed by a few grains (less than 2.0 mg) of sodium dithionite. The cuvette was sealed with parafilm and a UV-vis spectrum was recorded immediately. P450 concentration was determined from the absorbance of the hemochrome complex using extinction coefficient ε_{418} = 196 mM^{-1} cm^{-1}. Absorbance was assigned as the difference between the peak max at 418 nm and the baseline at 420 nm as determined by extrapolating from two points on either side of the hemochrome peak. The expression and lysis conditions outlined above were found to consistently yield *ca*. 1 μM of P450.

Initial screen of enzyme variants

Clarified lysates containing the desired enzyme variants were prepared from 50 mL expression cultures according to the procedure described above.

A scintillation vial was charged with 4 ml of clarified lysate, followed sequentially by a pre-dissolved solution of (+)-sclareolide or sclareol (24 μmol, 1.0 equiv) in 0.20 mL DMSO, $NaNADP•4H_2O$ (4.1 mg, 4.8 μmol, 0.20 equiv) and $Na_2HPO_3•5H_2O$ (104 mg, 0.48 mmol, 20.0 equiv). The vial was shaken at 150 rpm at 20 ˚C for 20 hours, then quenched with 1 M HCl (400 μL), and centrifuged (4 ˚C, 15 min, 4200 rpm). The supernatant was extracted with EtOAc (4 mL x 2), and the combined organic extracts were

concentrated *in vacuo*. Percentage conversion of the reaction was calculated based on ^{1}H NMR analysis of product:starting material ratio.



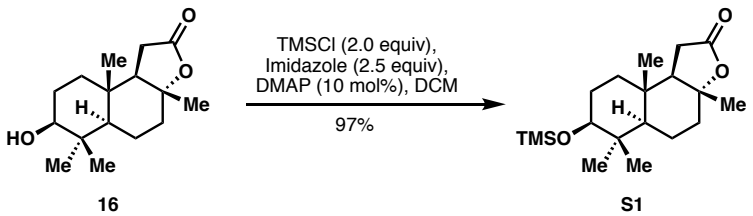
Four 2 L Erlenmeyer flasks were each charged with 400 mL of clarified lysate of *E. coli* expressing $P450_{BM3}$ MERO1 and Opt13. A pre-dissolved solution of (+)-sclareolide (**12**) (600 mg, 2.40 mmol, 1.0 equiv) in 20 mL DMSO was added to the lysate, which became immediately cloudy. Each flask was then charged with NaNADP•4H_2O (406 mg, 0.48 mmol, 0.20 equiv) and Na_2HPO_3•5H_2O (10.36 g, 48.0 mmol, 20.0 equiv). The flasks were shaken at 150 rpm at 20 ˚C for 20 hours, then quenched with 1 M HCl (40 mL per flask), and centrifuged (4 ˚C, 15 min, 4200 rpm). The supernatant was extracted with EtOAc (400 mL × 3) and the combined extracts were washed with brine, dried over anhydrous Na_2SO_4, and concentrated. The crude material was purified by flash column chromatography (1:1 hexanes:EtOAc) to yield **16** (1.66 g, 65% yield) as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ 3.23 (dd, *J* = 11.2, 5.2 Hz, 1H), 2.40 (dd, *J* = 16.2, 14.8 Hz, 1H), 2.21 (dd, *J* = 16.2, 6.5 Hz, 1H), 2.06 (dt, *J* = 11.9, 3.3 Hz, 1H), 1.95 – 1.82 (m, 2H), 1.72 – 1.57 (m, 4H), 1.48 – 1.36 (m, 2H), 1.31 (d, *J* = 1.0 Hz, 3H), 1.21 – 1.09 (m, 1H), 1.01 – 0.96 (s+m, 3H+1H), 0.89 (d, *J* = 0.9 Hz, 3H), 0.78 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 176.7, 86.3, 78.6, 58.9, 55.3, 38.9, 38.5, 37.7, 35.8, 28.8, 27.9, 26.8, 21.6, 20.3, 15.2, 15.1

HRMS (ESI): calcd for $C_{16}H_{26}O_3H^+$ ([M+H]) 267.1955, found 267.1950

$[\alpha]_D^{25}$ = +46.7 (c = 1.0, $CHCl_3$)



A solution of **16** (4.10 g, 15.4 mmol, 1.0 equiv) in dry DCM (150 mL) was treated with imidazole (2.62 g, 38.5 mmol, 2.5 equiv), DMAP (188 mg, 1.54 mmol, 10 mol%), and TMSCl (3.92 mL, 30.8 mmol, 2.0

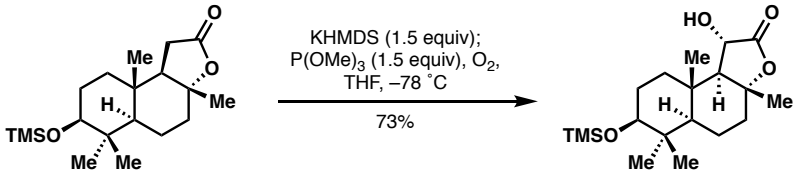
equiv). The reaction was stirred at room temperature for 30 minutes, then quenched with sat. aq. NH_4Cl (80 mL) and extracted with DCM (150 mL × 3). The combined organic extracts were washed with brine, dried over anhydrous Na_2SO_4, filtered, and concentrated *in vacuo*. The crude material was purified by flash column chromatography (20:1 hexanes:EtOAc) to yield **S1** (5.05 g, 97% yield) as a white solid.

^{1}H NMR (600 MHz, $CDCl_3$): δ 3.21 (dd, *J* = 11.5, 4.7 Hz, 1H), 2.41 (dd, *J* = 16.2, 14.8 Hz, 1H), 2.22 (dd, *J* = 16.2, 6.5 Hz, 1H), 2.07 (dt, *J* = 12.0, 3.3 Hz, 1H), 1.94 – 1.84 (m, 2H), 1.73 – 1.63 (m, 2H), 1.57 – 1.51 (m, 1H), 1.46 – 1.38 (m, 2H), 1.33 (s, 3H), 1.14 (td, *J* = 13.3, 3.8 Hz, 1H), 0.99 (dd, *J* = 12.6, 2.8 Hz, 1H), 0.91 (s, 3H), 0.89 (s, 3H), 0.76 (s, 3H), 0.10 (s, 9H).

^{13}C NMR (151 MHz, $CDCl_3$): δ 176.8, 86.4, 79.4, 59.1, 55.5, 39.3, 38.6, 37.8, 35.8, 28.9, 28.4, 27.4, 21.6, 20.6, 15.6, 15.3, 0.6.

HRMS (ESI): calcd for $C_{19}H_{34}O_3SiH^+$ ([M+H]) 339.2350, found 339.2351

$[\alpha]_D^{25}$ = –69.5 (c = 1.4, $CHCl_3$)



S1 18

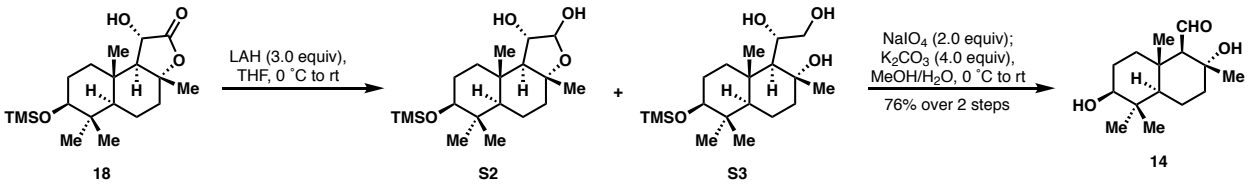
A solution of **S1** (4.80 g, 14.2 mmol, 1.0 eq) in dry THF (140 mL) was treated with 0.5 M KHMDS solution in toluene (42.6 mL, 21.3 mmol, 1.5 equiv) dropwise at –78 ˚C. After stirring at –78 ˚C for 1.5 hours, $P(OMe)_3$ (2.52 mL, 21.3 mmol, 1.5 equiv) was added dropwise and O_2 was bubbled into the reaction. After 30 minutes, the O_2 balloon was raised above the solvent level and the reaction was stirred for a further 1 hour at –78 ˚C under O_2 atmosphere. The reaction was quenched with sat. aq. NH_4Cl (80 mL) and extracted with EtOAc (150 mL × 3). The combined organic extracts were washed with brine, dried over anhydrous Na_2SO_4, filtered, and concentrated *in vacuo*. The crude material was purified by flash column chromatography (3:1 hexanes:EtOAc) to yield **18** (3.67 g, 73% yield) as a white solid.

^{1}H NMR (600 MHz, $CDCl_3$): δ 4.49 (d, *J* = 12.4 Hz, 1H), 3.22 (dd, *J* = 11.2, 4.6 Hz, 1H), 2.59 (br. s, 1H), 2.05 (dt, *J* = 11.9, 3.3 Hz, 1H), 1.93 – 1.85 (m, 2H), 1.75 – 1.64 (m, 3H), 1.59 – 1.53 (m, 1H), 1.47 – 1.39 (m, 1H), 1.37 (s, 3H), 1.32 (td, *J* = 13.3, 3.6 Hz, 1H), 1.04 – 0.98 (s+m, 3H+1H), 0.90 (s, 3H), 0.77 (s, 3H), 0.09 (s, 9H).

^{13}C NMR (151 MHz, $CDCl_3$): δ 178.3, 83.5, 79.3, 68.6, 64.5, 55.3, 39.4, 39.2, 37.6, 36.5, 28.4, 27.3, 23.4, 20.7, 16.1, 15.6, 0.6.

HRMS (ESI): calcd for $C_{19}H_{34}O_4SiH^+$ ([M+H]) 355.2299, found 355.2290

$[\alpha]_D^{25}$ = –8.5 (c = 1.0, $CHCl_3$)



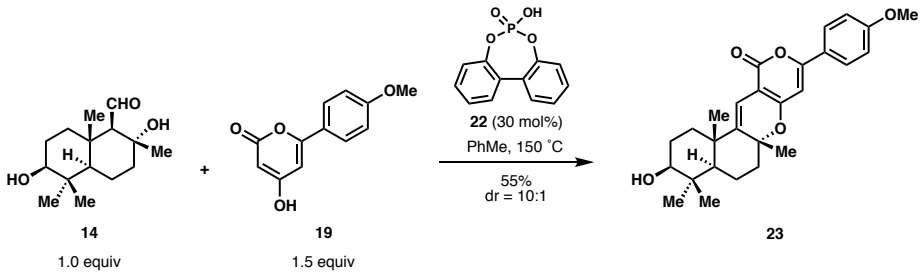
A solution of **18** (1.56 g, 4.4 mmol, 1.0 equiv) in dry THF (50 mL) was treated with $LiAlH_4$ (500 mg, 13.2 mmol, 3.0 equiv) at 0 ˚C. The reaction was warmed to room temperature over 30 minutes, then quenched with sat. aq. potassium sodium tartrate (50 mL) at 0 ˚C and stirred overnight at room temperature. The mixture was extracted with EtOAc (50 mL × 3). The combined organic extracts were washed with brine, dried over anhydrous Na_2SO_4, filtered, and concentrated *in vacuo*. The crude mixture of **S2** and **S3** was then dissolved in a mixture of MeOH/H_2O (5:1, 50 mL MeOH, 10 mL H_2O) and treated with $NaIO_4$ (1.88 g, 8.8 mmol, 2.0 equiv) at 0 ˚C. The reaction mixture was warmed to room temperature and stirred at for 2 hours, then K_2CO_3 (2.43 g, 17.6 mmol, 4.0 equiv) was added and the reaction mixture was stirred for an additional 2 hours at room temperature. The solids were removed by filtration and the filtrate was concentrated *in vacuo*. The residue was diluted by DCM (50 mL), quenched with sat. aq. NH_4Cl (50 mL) and extracted with DCM (50 mL × 3). The combined organic extracts were washed with brine, dried over anhydrous Na_2SO_4, filtered, and concentrated once more *in vacuo*. The crude material was purified by flash column chromatography (2:1 hexanes:EtOAc) to yield **14** (850 mg, 76% yield over 2 steps) as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ 9.99 (d, *J* = 1.5 Hz, 1H), 3.25 (dd, *J* = 11.1, 5.3 Hz, 1H), 2.04 – 2.02 (m, 1H), 1.99 (dt, *J* = 13.1, 3.5 Hz, 1H), 1.82 (dt, *J* = 11.8, 2.8 Hz, 1H), 1.74 – 1.60 (m, 3H), 1.50 – 1.40 (m, 1H), 1.40 – 1.34 (s+m, 3H+1H), 1.33 – 1.27 (m, 1H), 1.09 (s, 3H), 0.99 (s, 3H), 0.92 (dd, *J* = 11.8, 2.4 Hz, 1H), 0.78 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.6, 78.3, 72.7, 71.1, 54.3, 42.8, 39.1, 37.9, 37.2, 28.1, 26.8, 25.3, 19.7, 17.7, 15.4.

HRMS (ESI): calcd for $C_{15}H_{26}O_3HCO_2^-$ ([M+HCO_2^-]) 299.1864, found 299.1872

$[\alpha]_D^{25}$ = +27.6 (c = 1.0, $CHCl_3$)



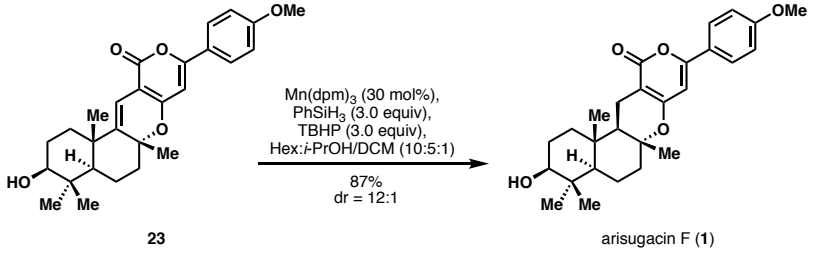
A flame dried microwave vial was charged with **14** (160 mg, 0.63 mmol, 1.0 equiv) in toluene (6 mL), **19** (207 mg, 0.95 mmol, 1.5 equiv), and **22** (47 mg, 0.19 mmol, 30 mol%). The vial was sealed and placed in a pre-heated oil bath at 150 ˚C for 24 hours. The reaction was cooled to room temperature, the solvent was removed *in vacuo*, and the residue was purified by flash column chromatography (1:1 hexanes:EtOAc) to yield **23** (165 mg, 55% yield, dr = 10:1), as a yellow solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.75 (d, *J* = 9.0 Hz, 2H), 6.93 (d, *J* = 9.0 Hz, 2H), 6.34 (s, 1H), 6.26 (s, 1H), 3.85 (s, 3H), 3.25 (dd, *J* = 11.5, 4.5 Hz, 1H), 2.23 (dt, *J* = 12.7, 3.2 Hz, 1H), 2.03 (dt, *J* = 12.9, 3.4 Hz, 1H), 1.92 (td, *J* = 13.3, 4.7 Hz, 1H), 1.86 – 1.78 (m, 2H), 1.74 – 1.62 (m, 2H), 1.60 – 1.54 (m, 1H), 1.51 (s, 3H), 1.15 (s, 3H), 1.07 (dd, *J* = 12.1, 2.1 Hz, 1H), 1.03 (s, 3H), 0.82 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 162.9, 162.5, 161.9, 159.9, 146.3, 127.4, 124.1, 114.5, 109.5, 100.3, 96.2, 82.0, 78.5, 55.7, 51.4, 41.4, 39.4, 39.3, 36.4, 28.4, 27.7, 27.3, 23.9, 19.2, 15.7

HRMS (ESI): calcd for $C_{27}H_{32}O_5H^+$ ([M+H]) 437.2323, found 437.2326

$[\alpha]_D^{25}$ = +40.5 (c = 1.0, $CHCl_3$)



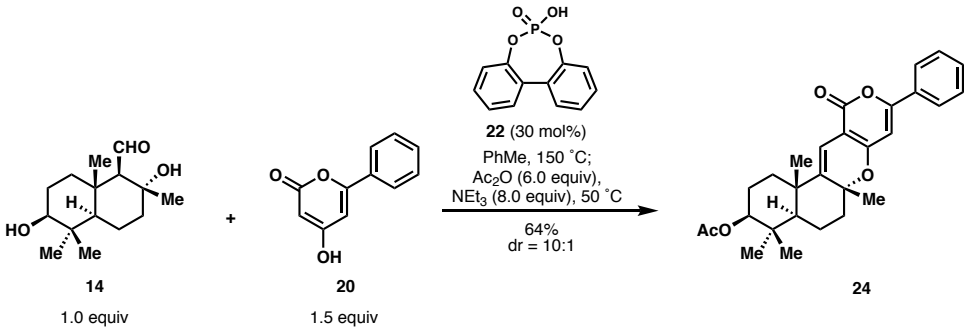
A solution of **23** (15 mg, 0.037 mmol, 1.0 equiv) in dry hexanes/*i*-PrOH/DCM (10:5:1, 1.0 mL hexanes, 0.5 mL *i*-PrOH, 0.1 mL DCM) was treated with phenylsilane (13.6 µL, 0.111 mmol, 3.0 equiv), and 5.5 M TBHP in decanes (20.0 µL, 0.111 mmol, 3.0 equiv). The solution was degassed with argon via subsurface sparging for 10 minutes, then $Mn(dpm)_3$ (7 mg, 0.011 mmol, 30 mol%) was added and the reaction was degassed for a further 30 seconds. The solution was stirred for 3 hours, then concentrated *in vacuo* and purified by preparative thin-layer chromatography (1:1 hexanes:EtOAc) to yield arisugacin F (**1**) (13 mg, 87% yield, dr = 12:1) as a white solid.

^{1}H NMR (600 MHz, $CDCl_3$): δ 7.73 (d, *J* = 8.9 Hz, 2H), 6.93 (d, *J* = 8.9 Hz, 2H), 6.25 (s, 1H), 3.85 (s, 3H), 3.25 (dd, *J* = 11.6, 4.7 Hz, 1H), 2.51 (dd, *J* = 16.9, 4.7 Hz, 1H), 2.23 (dd, *J* = 16.9, 12.9 Hz, 1H), 2.16 – 2.09 (m, 1H), 1.84 – 1.81 (m, 1H), 1.81 – 1.78 (m, 1H), 1.73 – 1.70 (m, 1H), 1.69 – 1.66 (m, 1H), 1.65 – 1.61 (m, 1H), 1.49 (dd, *J* = 12.9, 4.9 Hz, 1H), 1.46 – 1.42 (m, 1H), 1.26 (s, 3H), 1.12 (td, *J* = 13.2, 4.0 Hz, 1H), 1.03 (s, 3H), 0.99 (dd, *J* = 12.2, 2.3 Hz, 1H), 0.91 (s, 3H), 0.82 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$): δ 164.7, 163.6, 161.5, 158.3, 127.0, 124.0, 114.2, 98.4, 96.8, 80.6, 78.5, 55.4, 55.0, 51.6, 40.4, 38.8, 37.5, 36.9, 28.1, 27.2, 20.7, 19.4, 17.2, 15.5, 15.1.

HRMS (ESI): calcd for $C_{27}H_{34}O_5H^+$ ([M+H]) 439.2479, found 439.2471

$[\alpha]_D^{25}$ = +45.7 (c = 1.0, $CHCl_3$)



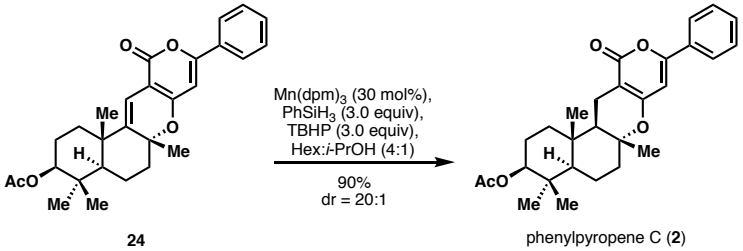
A flame dried microwave vial was charged with **14** (160 mg, 0.63 mmol, 1.0 equiv) in toluene (6 mL), **20** (178 mg, 0.95 mmol, 1.5 equiv), and **22** (47 mg, 0.19 mmol, 30 mol%). The vial was sealed and placed in a pre-heated oil bath at 150 ˚C for 24 hours. After cooling to room temperature, Ac_2O (0.36 mL, 3.78 mmol, 6.0 equiv) and NEt_3 (0.70 mL, 5.04 mmol, 8.0 equiv) were added and the reaction was stirred at 50 ˚C for 2 additional hours. The reaction was cooled to room temperature, quenched with sat. aq. NH_4Cl (10 mL) and extracted with EtOAc (20 mL × 3). The combined organic extracts were washed with brine, dried over anhydrous Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was purified by flash column chromatography (4:1 hexanes:EtOAc) to yield **24** (180 mg, 64% yield, dr = 10:1) as a yellow solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.84 – 7.74 (m, 2H), 7.45 – 7.36 (m, 3H), 6.45 (s, 1H), 6.26 (s, 1H), 4.49 (dd, *J* = 11.3, 4.5 Hz, 1H), 2.23 (dt, *J* = 12.7, 3.3 Hz, 1H), 2.08 – 2.00 (s+m, 3H+1H), 1.92 (td, *J* = 13.3, 4.6 Hz, 1H), 1.86 – 1.78 (m, 2H), 1.77 – 1.67 (m, 1H), 1.67 – 1.53 (m, 2H), 1.50 (s, 3H), 1.19 – 1.11 (s+m, 3H+1H), 0.90 (s, 3H), 0.89 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 170.9, 162.5, 162.1, 159.6, 146.3, 131.4, 130.9, 129.0, 125.6, 109.5, 101.1, 97.7, 81.9, 80.0, 51.3, 41.1, 39.1, 38.1, 35.9, 28.2, 27.1, 23.9, 23.9, 21.4, 18.9, 16.7.

HRMS (ESI): calcd for $C_{28}H_{32}O_5H^+$ ([M+H]) 449.2323, found 449.2324

$[\alpha]_D^{25}$ = +138.2 (c = 1.0, $CHCl_3$)



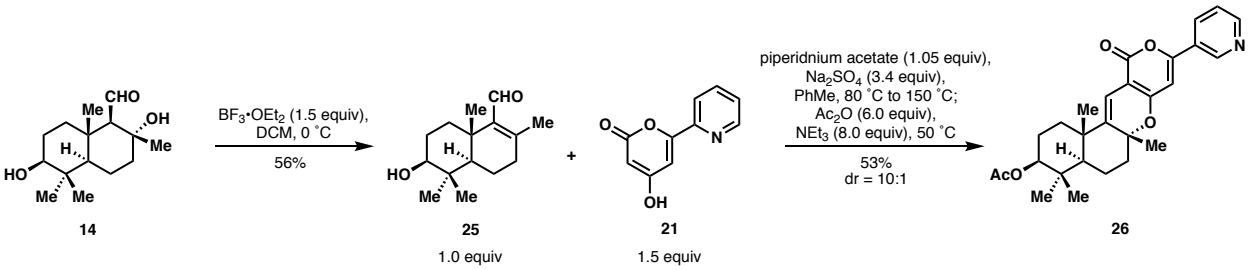
A solution of **24** (19 mg, 0.042 mmol, 1.0 equiv) in dry hexanes/*i*-PrOH (4:1, 1.0 mL hexanes, 0.25 mL *i*-PrOH) was treated with phenylsilane (15.5 µL, 0.126 mmol, 3.0 equiv), and 5.5 M TBHP in decanes (23.0 µL, 0.126 mmol, 3.0 equiv). The solution was degassed with argon via subsurface sparging for 10 minutes, then $Mn(dpm)_3$ (8 mg, 0.0126 mmol, 30 mol%) was added and the reaction was degassed for a further 30 seconds. The solution was stirred for 3 hours, then concentrated *in vacuo* and purified by preparative thin-layer chromatography (4:1 hexanes:EtOAc) to yield phenylpyropene C (**2**) (17 mg, 90% yield, dr = 20:1) as a pale yellow solid.

^{1}H NMR (600 MHz, $CDCl_3$): δ 7.82 – 7.75 (m, 2H), 7.47 – 7.38 (m, 3H), 6.37 (s, 1H), 4.51 (dd, *J* = 11.8, 4.7 Hz, 1H), 2.52 (dd, *J* = 17.3, 4.8 Hz, 1H), 2.25 (dd, *J* = 17.3, 4.4 Hz, 1H), 2.13 (dt, *J* = 12.6, 3.2 Hz, 1H), 2.06 (s, 3H), 1.84 – 1.81 (m, 1H), 1.80 – 1.78 (m, 1H), 1.77 – 1.72 (m, 1H), 1.70 – 1.68 (m, 1H), 1.68 – 1.65 (m, 1H), 1.51 (dd, *J* = 12.9, 4.8 Hz, 1H), 1.49 – 1.41 (m, 1H), 1.26 (s, 3H), 1.18 (td, *J* = 13.3, 4.1 Hz, 1H), 1.09 (dd, *J* = 12.2, 2.2 Hz, 1H), 0.94 (s, 3H), 0.91 (s, 3H), 0.89 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$): δ 171.1, 164.7, 163.4, 158.4, 131.7, 130.7, 129.0, 125.6, 99.6, 98.5, 80.7, 80.4, 55.3, 51.7, 40.5, 37.9, 37.4, 37.0, 28.3, 23.7, 21.5, 20.9, 19.5, 17.5, 16.8, 15.4.

HRMS (ESI): calcd for $C_{28}H_{34}O_5H^+$ ([M+H]) 451.2479, found 451.2468

$[\alpha]_D^{25}$ = +42.7 (c = 0.8, $CHCl_3$)



A solution of **14** (250 mg, 1.00 mmol, 1.0 equiv) in dry DCM (10 mL) was treated with BF_3•OEt_2 (0.19 mL, 1.50 mmol, 1.5 equiv) dropwise at 0 ˚C. After stirring at room temperature for 3 hours, the reaction was quenched with sat. aq. $NaHCO_3$ (10 mL) and extracted with DCM (20 mL × 3). The combined organic extracts were washed with brine, dried over anhydrous Na_2SO_4, filtered, and concentrated *in vacuo*. The crude material was purified by flash column chromatography (1:1 hexanes:EtOAc) to yield enal **25** (132 mg, 56% yield) as a colorless oil. Enal **25** was highly unstable and was used immediately.

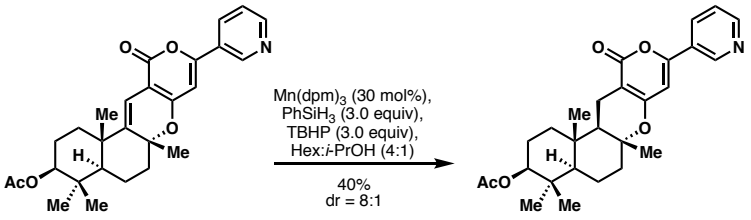
A solution of **25** (130 mg, 0.55 mmol, 1.0 equiv) in toluene (6 mL) was treated with piperidinium acetate (84 mg, 0.58 mmol, 1.05 equiv), and sodium sulfate (260 mg, 1.85 mmol, 3.33 equiv). The reaction mixture was stirred at 80 ˚C for 1.5 hours to effect complete iminium formation. The crude iminium was then transferred via canula to a flame dried microwave vial containing **21** (155 mg, 0.83 mmol, 1.5 equiv). The vial was then placed into a pre-heated oil bath at 150 ˚C for 24 hours. After cooling to room temperature, Ac_2O (0.31 mL, 3.30 mmol, 6.0 equiv) and NEt_3 (0.61 mL, 4.40 mmol, 8.0 equiv) were added and the reaction was stirred at 50 ˚C for 2 additional hours. The reaction was cooled to room temperature, quenched with sat. aq. NH_4Cl (10 mL) and extracted with EtOAc (20 mL × 3). The combined organic extracts were washed with brine, dried over anhydrous Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was purified by flash column chromatography (1:1 hexanes:EtOAc) to yield **26** (130 mg, 53% yield, dr = 10:1) as a yellow solid.

^{1}H NMR (600 MHz, $CDCl_3$): δ 9.06 – 8.96 (m, 1H), 8.71 – 8.61 (m, 1H), 8.11 (ddd, *J* = 8.1, 2.4, 1.6 Hz, 1H), 7.39 (ddd, *J* = 8.1, 4.8, 0.9 Hz, 1H), 6.51 (s, 1H), 6.26 (s, 1H), 4.51 (dd, *J* = 11.7, 4.5 Hz, 1H), 2.25 (dt, *J* = 13.0, 3.2 Hz, 1H), 2.09 – 2.02 (s+m, 3H+1H), 1.94 (td, *J* = 13.4, 4.5 Hz, 1H), 1.87 – 1.80 (m, 2H), 1.71 (tdd, *J* = 12.8, 11.5, 3.2 Hz, 1H), 1.65 – 1.61 (m, 1H), 1.61 – 1.56 (m, 1H), 1.53 (d, *J* = 1.0 Hz, 3H), 1.19 (d, *J* = 0.9 Hz, 3H), 1.17 (dd, *J* = 12.1, 2.1 Hz, 1H), 0.92 (s, 3H), 0.90 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$): δ 170.9, 161.9, 161.7, 157.0, 151.4, 147.1, 146.9, 133.0, 127.6, 123.8, 109.4, 102.0, 98.8, 82.2, 80.0, 51.3, 41.2, 39.2, 38.2, 36.0, 28.2, 27.2, 23.9, 23.9, 21.4, 19.0, 16.8.

HRMS (ESI): calcd for $C_{27}H_{31}NO_5H^+$ ([M+H]) 450.2275, found 450.2283.

$[\alpha]_D^{25}$ = +102.9 (c = 1.0, $CHCl_3$)



26 pyripyropene E (**4**)

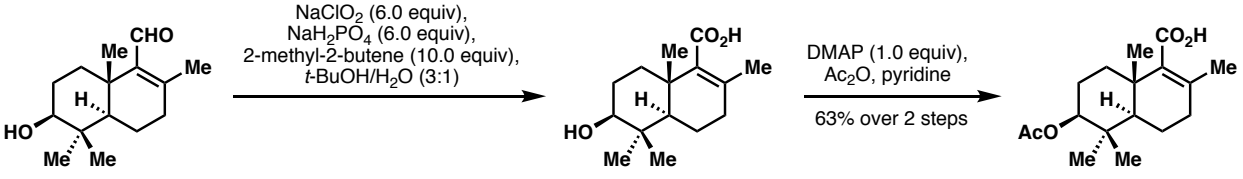
A solution of **26** (12 mg, 0.027 mmol, 1.0 equiv) in dry hexanes/*i*-PrOH (4:1, 0.4 mL hexanes, 0.1 mL *i*-PrOH) was treated with phenylsilane (10 μL, 0.081 mmol, 3.0 equiv), and 5.5 M TBHP in decanes (14.7 μL, 0.081 mmol, 3.0 equiv). The solution was degassed with argon via subsurface sparging for 10 minutes, then $Mn(dpm)_3$ (5 mg, 0.0081 mmol, 30 mol%) was added and the reaction was degassed for a further 30 seconds. The solution was stirred at room temperature for 1 hour, then concentrated *in vacuo* and purified by preparative thin-layer chromatography (3:2 hexanes:EtOAc) to yield pyripyropene E (**4**) (5 mg, 40% yield, dr = 8:1) as a white solid.

^{1}H NMR (600 MHz, $CDCl_3$): δ 8.99 (dd, *J* = 2.4, 0.9 Hz, 1H), 8.65 (dd, *J* = 4.8, 1.6 Hz, 1H), 8.10 (ddd, *J* = 8.1, 2.4, 1.6 Hz, 1H), 7.38 (ddd, *J* = 8.1, 4.8, 0.9 Hz, 1H), 6.42 (s, 1H), 4.51 (dd, *J* = 11.8, 4.7 Hz, 1H), 2.52 (dd, *J* = 17.1, 4.7 Hz, 1H), 2.25 (dd, *J* = 17.1, 12.9 Hz, 1H), 2.14 (dt, *J* = 12.6, 3.2 Hz, 1H), 2.06 (s, 3H), 1.85 – 1.81 (m, 1H), 1.81 – 1.78 (m, 1H), 1.77 – 1.72 (m, 1H), 1.71 – 1.67 (m, 1H), 1.67 – 1.63 (m, 1H), 1.51 (dd, J = 12.9, 4.8 Hz, 1H), 1.50 – 1.40 (m, 1H), 1.27 (s, 3H), 1.19 (td, *J* = 13.2, 3.9 Hz, 1H), 1.09 (dd, *J* = 12.2, 2.2 Hz, 1H), 0.94 (s, 3H), 0.91 (s, 3H), 0.89 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$): δ 170.8, 164.0, 162.8, 155.6, 151.1, 146.6, 132.7, 127.6, 123.5, 100.2, 99.3, 80.8, 80.1, 55.0, 51.4, 40.2, 37.7, 37.1, 36.7, 28.0, 23.4, 21.2, 20.7, 19.2, 17.3, 16.6, 15.1.

HRMS (ESI): calcd for $C_{27}H_{33}NO_5H^+$ ([M+H]) 452.2431, found 452.2431

$[\alpha]_D^{25}$ = +55.4 (c = 0.6, $CHCl_3$)



25 **S4** **S5**

A solution of aldehyde **25** (236 mg, 1.0 mmol, 1.0 equiv) in *t*-BuOH (10 mL) and H_2O (3 mL) was treated with 2-methy-2-butene (1.12 mL, 10 mmol, 10 equiv), $NaClO_2$ (80%, 678 mg, 6 mmol, 6.0 equiv), and NaH_2PO_4•H_2O (828 mg, 6 mmol, 6.0 equiv). The mixture was stirred for 1 hour, and the reaction was quenched by the addition of 5% aqueous sodium thiosulfate (10 mL) and extracted with

EtOAc (30 mL × 3). The combined organic layers were washed with brine, dried with Na_2SO_4, filtered, and concentrated *in vacuo* to give **S4** as a colorless oil that was used immediately without further purification.

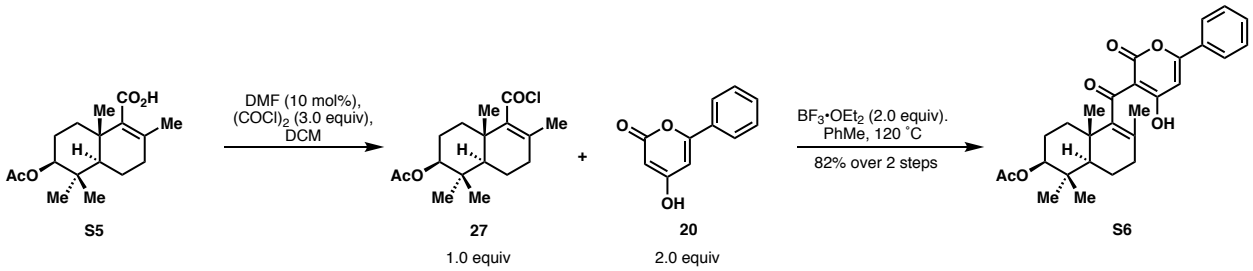
A solution of **S4** in dry pyridine/Ac_2O (4:1, 5 mL pyridine, 1.25 mL Ac_2O) was treated with DMAP (122 mg, 1.0 mmol, 1.0 equiv) at room temperature. The solution was stirred at room temperature for 3 hours, and then concentrated *in vacuo*. The residue was purified by flash column chromatography (50:1 DCM:MeOH) to yield **S5** (186 mg, 63% yield over 2 steps) as a white foam.

^{1}H NMR (400 MHz, $CDCl_3$): δ 4.51 (dd, *J* = 11.6, 4.5 Hz, 1H), 2.16 – 2.10 (m, 2H), 2.06 (s, 3H), 1.83 – 1.76 (m, 1H), 1.76 – 1.72 (s+m, 3H+1H), 1.70 (dd, *J* = 5.1, 2.6 Hz, 1H), 1.68 – 1.63 (m, 1H), 1.63 – 1.57 (m, 1H), 1.56 – 1.45 (m, 1H), 1.25 – 1.21 (s+m, 3H+1H), 0.90 (s, 6H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 174.6, 171.2, 136.7, 135.2, 80.7, 49.9, 37.9, 36.5, 34.5, 32.5, 28.2, 23.9, 21.5, 21.2, 20.6, 18.2, 16.6.

HRMS (ESI): calcd for $C_{17}H_{25}O_4^-$ ([M–H]) 293.1758, found 293.1762

$[\alpha]_D^{25}$ = +61.6 (c = 1.0, $CHCl_3$)



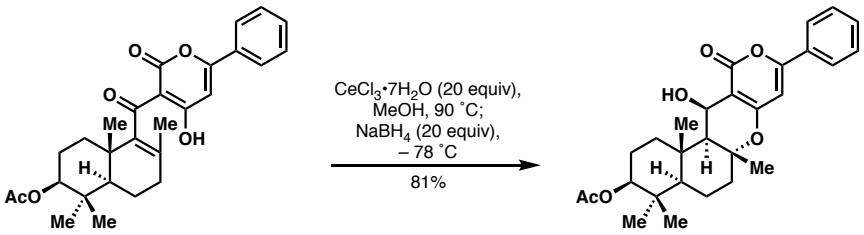
A solution of **S5** (15 mg, 0.051 mmol, 1.0 equiv) in DCM (0.5 mL) was treated with $(COCl)_2$ (13.2 μL, 0.153 mmol, 3.0 equiv), and 0.1 M DMF in DCM (51 μL DMF in 0.5 mL DCM, 0.0051 mmol, 10 mol%). The solution was stirred at room temperature for 2 hours, and then concentrated *in vacuo*. The crude residue was dissolved in toluene (0.5 mL), and treated with BF_3•Et_2O (12. 6 μL, 0.102 mmol, 2.0 equiv) and pyrone **20** (19 mg, 0.102 mmol, 2.0 equiv). The resulting solution was stirred at room temperature for 15 mins, and heated at 150˚C for 12 hours. The reaction was poured into ice water (5 mL) and extracted with DCM (10 mL × 3). The combined organic extracts were washed with brine, dried over anhydrous Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was purified by flash column chromatography (4:1 hexanes:EtOAc) to yield **S6** (19.4 mg, 82% yield over 2 steps) as a yellow oil.

^{1}H NMR (600 MHz, $CDCl_3$): δ 7.88 (d, *J* = 7.9 Hz, 2H), 7.55 (dd, *J* = 8.3, 5.9 Hz, 1H), 7.50 (t, *J* = 7.6 Hz, 2H), 6.57 (s, 1H), 4.58 (dd, *J* = 10.9, 4.6 Hz, 1H), 2.16 (d, *J* = 6.7 Hz, 2H), 2.03 (s, 3H), 1.77 (t, *J* = 8.7 Hz, 1H), 1.70 – 1.58 (m, 5H), 1.53 (s, 3H), 1.48 – 1.44 (m, 1H), 1.26 (s, 3H), 1.25 (s, 1H), 0.94 (s, 3H), 0.91 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$): δ 206.0, 181.0, 170.9, 166.1, 159.5, 140.2, 132.7, 130.3, 130.0, 129.3, 126.7, 102.4, 98.4, 80.7, 48.8, 38.0, 38.0, 32.7, 31.9, 28.0, 23.7, 21.7, 21.4, 20.2, 18.5, 16.6.

HRMS (ESI): calcd for $C_{28}H_{32}O_6H^+$ ([M+H]) 465.2272, found 465.2277

$[\alpha]_D^{25}$ = +18.2 (c = 1.0, $CHCl_3$)



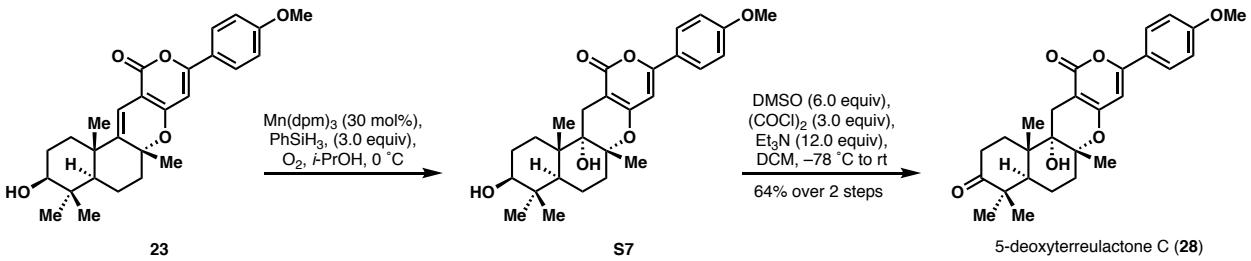
A flame dried microwave vial containing $CeCl_37•H_2O$ (253 mg, 0.68 mmol, 20. 0 equiv) was heated to 90 °C. A solution of **S6** (16 mg, 0.034 mmol, 1.0 equiv) in MeOH (4.0 mL) was added into the mixture at the same temperature under an argon atmosphere. After stirring at 90 °C for 3 hours, the reaction was cooled to –78 °C and treated with $NaBH_4$ (26 mg, 0.68 mmol, 20. 0 equiv). The reaction was stirred at –78 ˚C for 1 hour, then quenched with acetone (0.1 mL). The mixture was concentrated *in vacuo* and the crude residue was diluted with ethyl acetate (10 mL) and water (10 mL) and extracted with EtOAc (10 mL × 3). The combined organic extracts were washed with brine, dried over anhydrous Na_2SO_4, filtered, and concentrated *in vacuo*. The crude material was purified by flash column chromatography (4:1 hexanes:EtOAc) to yield phenylpyropene F (**3**) (13 mg, 81% yield) as a white solid.

^{1}H NMR (600 MHz, MeOD): δ 7.86 – 7.82 (m, 2H), 7.50 – 7.45 (m, 3H), 6.62 (s, 1H), 4.94 (d, *J* = 3.6 Hz, 1H), 4.51 (dd, *J* = 11.8, 4.6 Hz, 1H), 2.16 – 2.12 (m, 1H), 2.12 – 2.09 (m, 1H), 2.03 (s, 3H), 1.85 – 1.80 (m, 1H), 1.80 – 1.77 (m, 1H), 1.77 – 1.74 (m, 1H), 1.74 – 1.71 (m, 1H), 1.69 – 1.64 (m, 1H), 1.67 (s, 3H), 1.49 (d, *J* = 3.6 Hz, 1H), 1.43 – 1.37 (s+m, 3H+1H), 1.12 (dd, *J* = 11.9, 2.1 Hz, 1H), 0.93 (s, 3H), 0.89 (s, 3H).

^{13}C NMR (151 MHz, MeOD): δ 171.4, 164.6, 164.0, 159.6, 131.1, 130.7, 128.7, 125.2, 102.2, 98.3, 81.9, 80.6, 59.1, 55.7, 55.3, 41.5, 37.8, 37.4, 36.3, 27.2, 23.0, 21.4, 19.7, 19.2, 16.2, 15.6.

HRMS (ESI): calcd for $C_{28}H_{33}O_5^+$ ([M – H_2O+H]) 449.2323, found 449.2325

$[\alpha]_D^{25}$ = +43.8 (c = 0.6, $CHCl_3$)



To a suspension of **23** (18 mg, 0.041 mmol, 1.0 equiv) and $Mn(dpm)_3$ (7.5 mg, 0.012 mmol, 30 mol%) in *i*-PrOH (0.8 mL) was added $PhSiH_3$ (15 μL, 0.12 mmol, 3.0 equiv) at 0 ºC under an oxygen atmosphere. After stirring at 0 ˚C for 2 hours, the mixture was slowly warmed to room temperature and stirred for 12 hours. The reaction was quenched with sat. aq. $Na_2S_2O_3$ (1.0 mL) and diluted with EtOAc (10 mL). The layers were separated and the aqueous phase was extracted with EtOAc (10 mL × 4). The combined organic extracts were washed with brine, dried over anhydrous Na_2SO_4, filtered, and concentrated *in vacuo* to afford crude product **S7**, which was used immediately for the next step after a short column filtration.

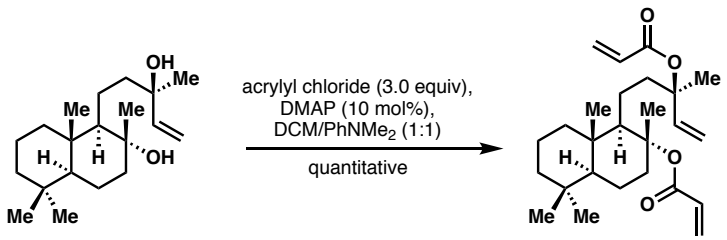
To a solution of oxalyl chloride (10.5 μL, 0.12 mmol, 3.0 equiv) in CH_2Cl_2 (0.5 mL) was added DMSO (17.4 μL, 0.25 mmol, 6.0 equiv) dropwise at –78 ˚C. After stirring for 30 min, crude **S7** in CH_2Cl_2 (0.5 mL) was added at –78 °C. After stirring for 1 hour, the reaction was treated with Et_3N (68.0 μL, 0.49 mmol, 12.0 equiv), and stirred for 30 minutes at ambient temperature. After that, the reaction quenched with sat. aq. NH_4Cl (5 mL) and extracted with EtOAc (10 mL × 3). The combined organic extracts were washed with brine, dried over anhydrous Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was purified by flash column chromatography (1:1 hexanes:EtOAc) to yield 5-deoxyterreulactone C (**28**) (12 mg, 64% yield over 2 steps) as a white solid.

^{1}H NMR (600 MHz, MeOD): δ 7.80 (d, *J* = 9.0 Hz, 2H), 7.03 (d, *J* = 9.0 Hz, 2H), 6.58 (s, 1H), 3.86 (s, 3H), 2.75 (d, *J* = 17.2 Hz, 1H), 2.64 (ddd, *J* = 15.2, 10.3, 7.2 Hz, 1H), 2.50 – 2.45 (m, 1H), 2.45 – 2.41 (m, 1H), 2.40 – 2.35 (m, 1H), 2.23 – 2.16 (m, 1H), 1.83 – 1.77 (m, 1H), 1.73 – 1.70 (m, 1H), 1.70 – 1.67 (m, 1H), 1.67 – 1.59 (m, 2H), 1.45 (d, *J* = 0.9 Hz, 3H), 1.22 (s, 3H), 1.11 (s, 3H), 1.08 (s, 3H).

^{13}C NMR (151 MHz, MeOD): δ 219.5, 167.2, 166.0, 163.4, 160.0, 128.1, 125.0, 115.5, 98.2, 98.1, 83.9, 75.1, 56.0, 48.3, 46.9, 42.6, 35.0, 34.7, 32.6, 27.1, 25.6, 23.8, 21.5, 21.1, 18.2.

HRMS (ESI): calcd for $C_{27}H_{32}O_6H^+$ ([M+H]) 453.2272, found 453.2271

$[\alpha]_D^{25}$ = +21.6 (c = 0.6, $CHCl_3$)



sclareol (**13**) **S8**

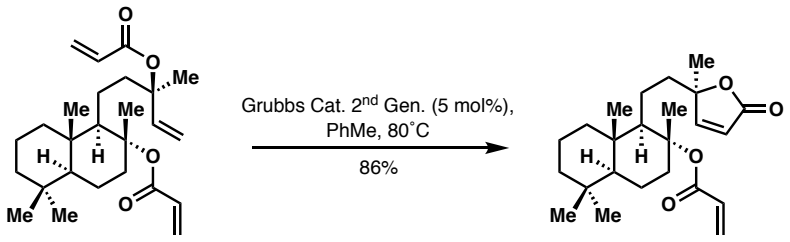
A solution of sclareol (**13**, 10.0 g, 32.4 mmol, 1.0 equiv) in DCM (12 mL) was sequentially treated with $PhNMe_2$ (12 mL), acryloyl chloride (7.86 mL, 97.2 mmol, 3.0 equiv), and DMAP (395 mg, 3.24 mmol, 10 mol%). The mixture was stirred at room temperature for 30 hours then poured to sat. aq. $NaHCO_3$ (200 mL) and extracted with DCM (100 mL × 3). The combined organic extracts were washed with brine, dried over anhydrous $MgSO_4$, filtered, and concentrated *in vacuo*. The residue was purified by flash column chromatography (100:1 to 10:1 hexanes:EtOAc) to yield **S8** (13.5 g, quantitative yield) as pale yellow powder.

^{1}H NMR (600 MHz, $CDCl_3$): δ 6.37 – 6.19 (m, 2H), 6.11 – 5.87 (m, 3H), 5.82 – 5.63 (m, 2H), 5.21 – 5.03 (m, 2H), 2.68 (ddd, *J* = 12.5, 3.4, 3.4 Hz, 1H), 2.00 – 1.89 (m, 2H), 1.76 (ddd, *J* = 13.1, 4.4, 4.4 Hz, 1H), 1.72 – 1.64 (m, 1H), 1.62 – 1.56 (m, 5H), 1.53 (dd, *J* = 4.0, 4.0 Hz, 1H), 1.49 (s, 3H), 1.47 – 1.40 (m, 2H), 1.40 – 1.35 (m, 1H), 1.35 – 1.22 (m, 2H), 1.19 – 1.11 (m, 1H), 1.03 – 0.91 (m, 2H), 0.86 (s, 3H), 0.83 (s, 3H), 0.78 (s, 3H)

^{13}C NMR (151 MHz, $CDCl_3$): δ 165.7, 165.3, 142.1, 131.1, 130.3, 130.1, 129.5, 113.6, 88.8, 83.8, 59.0, 56.0, 43.2, 42.2, 39.9, 39.9, 39.1, 33.7, 33.5, 23.8, 21.8, 20.9, 20.4, 19.8, 18.7, 16.1.

HRMS (ESI): calcd for $C_{26}H_{40}O_4Na^+$ ([M+Na]) 439.2819, found 439.2843.

$[\alpha]_D^{24}$ = –10.4 (c = 1.0, $CHCl_3$)



S8 **S9**

A solution of diester **S8** (5.00 g, 12.0 mmol, 1.0 equiv) in toluene (24 mL) was treated with Grubbs catalyst 2nd generation (509 mg, 0.60 mmol, 5 mol%). The reaction mixture was heated to 80 ˚C for 24 hours. The solvent was then evaporated *in vacuo* and the residue was purified by flash column

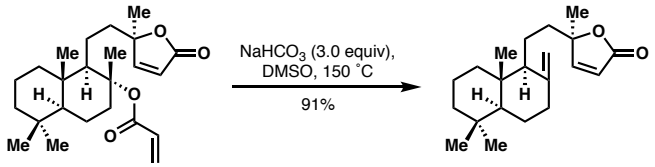
chromatography (10:1 to 4:1 hexanes:EtOAc) to yield lactone **S9** (4.0 g, 86% yield) as a pale yellow powder.

^{1}H NMR (600 MHz, $CDCl_3$): δ 7.29 (d, *J* = 5.6 Hz, 1H), 6.25 (dd, *J* = 17.3, 1.6 Hz, 1H), 6.02 (d, *J* = 5.6 Hz, 1H), 5.96 (dd, *J* = 17.4, 10.3 Hz, 1H), 5.73 (dd, *J* = 10.4, 1.6 Hz, 1H), 2.61 – 2.56 (m, 1H), 1.93 – 1.86 (m, 1H), 1.86 – 1.78 (m, 2H), 1.70 – 1.64 (m, 1H), 1.62 – 1.52 (m, 3H), 1.47 – 1.40 (m, 7H), 1.40 – 1.35 (m, 1H), 1.34 – 1.22 (m, 3H), 1.18 – 1.10 (m, 1H), 0.99 (dd, *J* = 12.4, 2.3 Hz, 1H), 0.96 – 0.90 (m, 1H), 0.86 (s, 3H), 0.81 (s, 3H), 0.77 (s, 3H)

^{13}C NMR (151 MHz, $CDCl_3$): δ 172.7, 165.3, 160.4, 130.7, 129.5, 120.8, 89.3, 88.7, 58.4, 55.7, 42.0, 41.2, 39.8, 39.7, 38.7, 33.4, 33.3, 24.2, 21.5, 20.9, 20.1, 19.8, 18.4, 15.8.

HRMS (ESI): calcd for $C_{24}H_{36}O_4H^+$ ([M+H]) 389.2686, found 389.2690.

$[\alpha]_D^{24}$ = –69.1 (c = 1.2, $CHCl_3$)



S9 **29**

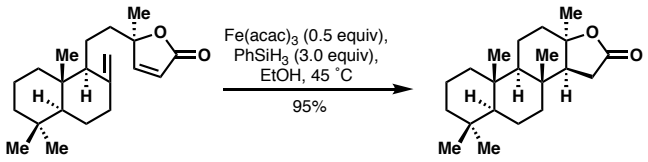
A solution of **S9** (4.01 g, 10.3 mmol, 1.0 equiv) in DMSO (50 mL) was treated with $NaHCO_3$ (2.60 g, 30.9 mmol, 3.0 equiv). The reaction mixture was heated to 150 ˚C for 6 hours then cooled back down to room temperature and poured into sat. aq. $NaHCO_3$ (200 mL) and extracted with EtOAc (100 mL × 3). The combined organic extracts were washed with brine, dried over anhydrous $MgSO_4$, filtered, and concentrated *in vacuo*. The residue was purified by flash column chromatography (50:1 to 15:1 hexanes:EtOAc) to olefin **29** (2.96 g, 91% yield) as a white powder.

^{1}H NMR (600 MHz, $CDCl_3$): δ = 7.32 (d, *J* = 5.6 Hz, 1H), 6.03 (d, *J* = 5.6 Hz, 1H), 4.81 (d, *J* = 1.6 Hz, 1H), 4.35 (d, *J* = 1.5 Hz, 1H), 2.43 – 2.33 (m, 1H), 2.01 – 1.83 (m, 2H), 1.77 – 1.66 (m, 2H), 1.66 – 1.57 (m, 1H), 1.56 (s, 3H), 1.51 – 1.46 (m, 1H), 1.45 (s, 3H), 1.41 – 1.33 (m, 1H), 1.30 (dd, *J* = 12.9, 4.3 Hz, 1H), 1.26 – 1.11 (m, 2H), 1.06 (dd, *J* = 12.6, 2.8 Hz, 1H), 1.03 – 0.94 (m, 1H), 0.86 (s, 3H), 0.78 (s, 3H), 0.63 (d, *J* = 0.7 Hz, 3H)

^{13}C NMR (151 MHz, $CDCl_3$): δ = 172.8, 160.4, 148.7, 120.8, 106.4, 89.5, 57.0, 55.6, 42.2, 40.0, 39.2, 38.4, 37.4, 33.7, 33.7, 24.5, 24.4, 21.8, 19.4, 17.6, 14.5.

HRMS (ESI): calcd for $C_{21}H_{32}O_2H^+$ ([M+H]) 317.2475, found 317.2473.

$[\alpha]_D^{24}$ = +6.5 (c = 1.0, $CHCl_3$)



29 30

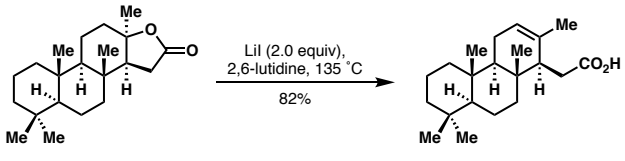
A solution of **29** (2.96 g, 9.35 mmol, 1.0 equiv) and $Fe(acac)_3$ (1.65 g, 4.68 mmol, 0.5 equiv) in ethanol (50 mL) was treated with $PhSiH_3$ (3.46 mL, 28.1 mmol, 3.0 equiv) at 45 ˚C. The resulting mixture was stirred at 45 ˚C for 5 hours. The solvent was removed *in vacuo* and the residue was purified by flash column chromatography (10:1 to 4:1 hexanes:EtOAc) to give lactone **30** (2.81 g, 95% yield) as a white powder.

^{1}H NMR (600 MHz, $CDCl_3$): δ = 2.71 (dd, *J* = 17.9, 7.9 Hz, 1 H), 2.39 (d, *J* = 17.8 Hz, 1 H), 2.33–2.25 (m, 1H), 1.77 (d, *J* = 7.9 Hz, 1 H), 1.75 – 1.70 (m, 2 H), 1.67 – 1.36 (m, 7 H), 1.36 – 1.28 (m, 1 H), 1.31 (s, 3 H), 1.17 – 1.08 (m, 1 H), 1.01 – 0.94 (m, 1 H), 0.92 (d, *J* = 0.9 Hz, 3 H), 0.87 (s, 3 H), 0.86 (s, 3 H), 0.83 – 0.77 (m, 3 H) 0.81 (s, 3 H)

^{13}C NMR (151 MHz, $CDCl_3$): δ = 177.9, 85.7, 56.8, 56.6, 55.5, 42.7, 42.2, 40.2, 37.6, 36.6, 35.2, 33.5, 33.5, 32.6, 29.9, 21.7, 18.6, 18.1, 17.4, 16.7, 15.8.

HRMS (ESI): calcd for $C_{21}H_{33}O_2H^+$ ([M+H]) 319.2632, found 319.2653.

$[\alpha]_D^{24}$ = +25.1 (c = 1.0, $CHCl_3$)



30 31

A solution of lactone **30** (1.50 g, 4.71 mmol) in 2,6-lutidine (25 mL) was treated with LiI (630 mg, 9.42 mmol, 2.0 equiv). The reaction mixture was heated to 135 ˚C and stirred for 10 min. The resultant mixture was passed through a short plug of Celite and washed with EtOAc (100mL). The organic solution was sequentially washed with 1M HCl (100mL), sat. aq. $Na_2S_2O_3$ (100mL) and brine (100 mL). The organic layer was dried over anhydrous Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was purified via to flash column chromatography (6:1 to 2:1 hexanes:EtOAc) to give acid **31** (1.23 g, 82% yield) as a white powder.

^{1}H NMR (600 MHz, $CDCl_3$): δ = 5.41 (s, 1 H), 2.54 – 2.40 (m, 2 H), 2.21 (dd, *J* = 17.0, 9.9 Hz, 1 H), 1.99 – 1.76 (m, 3 H), 1.65 – 1.50 (m, 7 H), 1.45 – 1.31 (m, 3 H), 1.31 – 1.05 (m, 3 H), 0.88 (s, 3 H), 0.85 (s, 3 H), 0.84 – 0.78 (m, 5 H), 0.73 (s, 3 H)

^{13}C NMR (151 MHz, $CDCl_3$): δ = 180.7, 133.4, 122.9, 56.2, 54.8, 51.1, 42.0, 40.8, 40.0, 37.3, 36.1, 33.5, 33.3, 32.3, 22.9, 21.8, 21.4, 18.9, 18.7, 15.7, 15.0.

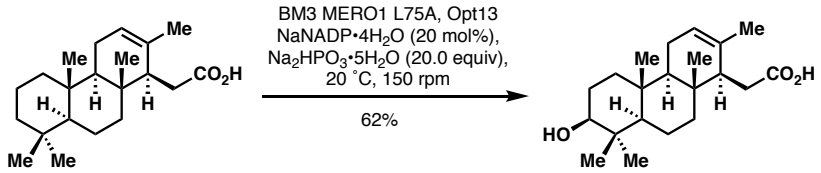
HRMS (ESI): calcd for $C_{21}H_{33}O_2^-$ ([M–H]) 317.2486, found 317.2480.

$[\alpha]_D^{24}$ = –40.8 (c = 1.0 in $CHCl_3$)

Screening of enzyme variants for hydroxylation of 31

The following $P450_{BM3}$ variants were tested for hydroxylation of **31**: BM3 MERO1, BM3 MERO1 M177A, BM3 MERO1 I263A, and BM3 MERO1 L75A. Clarified lysates containing the desired enzyme variants were prepared from 50 mL expression cultures according to the procedure described on page S6 and small-scale enzymatic hydroxylation reactions of **31** were performed according to the procedure described on page S7. Percentage conversion of the reaction was calculated based on ^{1}H NMR analysis of product:starting material ratio.

$P450_{BM3}$ variant	Conversion (%)
BM3 MERO1	33
BM3 MERO1 M177A	35
BM3 MERO1 I263A	28
BM3 MERO1 L75A	65



31 **32**

Two 2 L Erlenmeyer flasks were each charged with 400 mL clarified lysate of *E. coli* expressing BM3 MERO1 L75A and Opt13. A solution of **31** (500 mg, 2.40 mmol, 1.0 equiv) in 20 mL DMSO was added to the lysate, which became immediately cloudy. Each flask was then charged with NaNADP•$4H_2O$ (406 mg, 0.48 mmol, 0.20 equiv) and Na_2HPO_3•$5H_2O$ (10.36 g, 48.0 mmol, 20.0 equiv). The flasks were shaken at 150 rpm at 20 °C for 20 hours, then quenched with 1M HCl (40 mL per flask), and centrifuged (4 °C, 15 min, 4200 rpm). The supernatant was extracted with EtOAc (400 mL × 3) and the combined extracts were washed with brine, dried over anhydrous Na_2SO_4, and concentrated. The crude material was

purified by flash column chromatography (1:1 hexanes:EtOAc) to yield **32** (660 mg, 62% yield) as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 5.48 – 5.34 (m, 1H), 3.33 (dd, *J* = 10.7, 4.7 Hz, 1H), 2.67 – 2.55 (m, 1H), 2.53 – 2.39 (m, 2H), 2.22 (ddd, *J* = 16.9, 9.6, 1.3 Hz, 1H), 2.10 – 1.97 (m, 1H), 1.83 (dd, *J* = 12.8, 3.4 Hz, 1H), 1.65 – 1.52 (m, 6H), 1.50 – 1.40 (m, 2H), 1.40 – 1.32 (m, 1H), 1.31 – 1.24 (m, 3H), 1.19 (dd, *J* = 13.1, 4.3 Hz, 1 H), 0.95 (s, 3H), 0.91 – 0.83 (m, 4H), 0.81 (s, 3H), 0.75 (s, 3H)

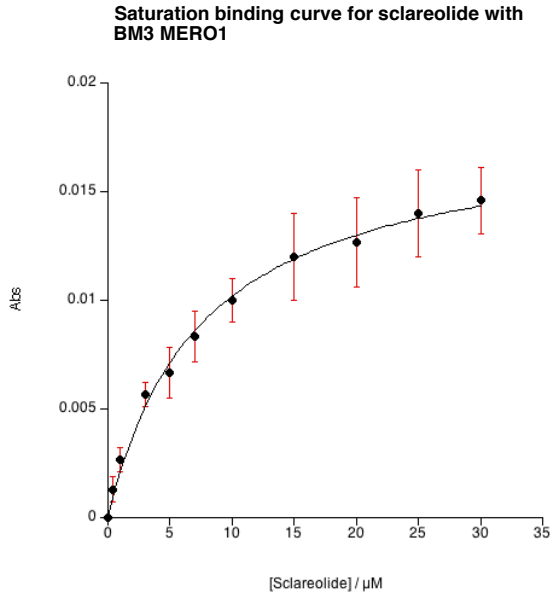
^{13}C NMR (101 MHz, $CDCl_3$): δ = 179.6, 132.4, 123.6, 80.9, 55.4, 54.9, 51.0, 43.3, 40.7, 39.9, 36.6, 33.1, 33.0, 32.1, 29.9, 26.4, 21.4, 21.2, 19.0, 15.2, 11.4.

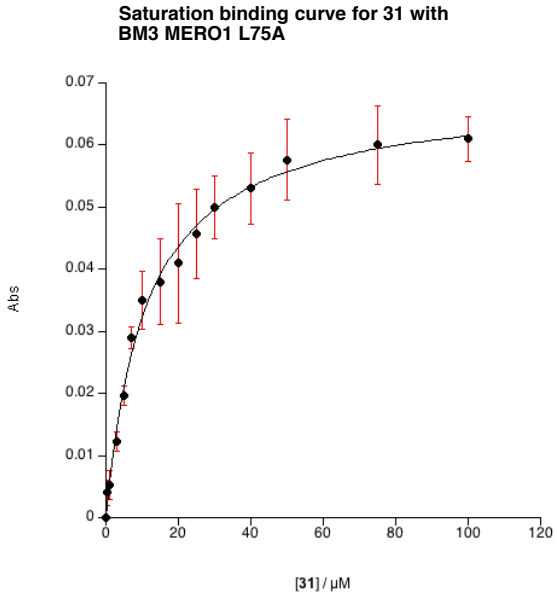
HRMS (ESI): calcd for $C_{21}H_{33}O_3^-$ ([M–H]) 333.2435, found 333.2431.

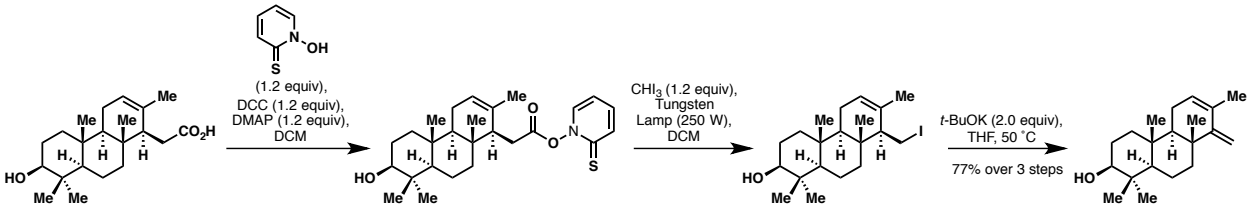
$[\alpha]_D^{24}$ = –35.0 (c = 0.3, $CHCl_3$)

Substrate binding and kinetic data for hydroxylation of sclareolide and acid 31

Enzyme	Substrate	NADPH (min^{-1})	Product (min^{-1})	K_d (μM)
BM3 MERO1	Sclareolide	1608 ± 308	328 ± 46	7.6 ± 0.7
BM3 MERO1 L75A	**31**	141 ± 7	24.7 ± 0.7	11.4 ± 0.8







32 33 34 35

A solution of acid **32** (153 mg, 0.457 mmol, 1.0 equiv) in DCM (5 mL) was sequentially treated with pyrithione (70.0 mg, 0.548 mmol, 1.2 equiv), DCC (113 mg, 0.548 mmol, 1.2 equiv) and DMAP (61.5 mg, 0.548 mmol, 1.2 equiv). The reaction mixture was stirred at room temperature for 30 min then the reaction was quenched with sat. aq. $NaHCO_3$ solution (5 mL) and extracted with DCM (5 mL × 3). The combined organic extracts were washed with 1M HCl (10 mL), dried over anhydrous $MgSO_4$, filtered, and concentrated *in vacuo* to give crude **33**. The residue was then dissolved into DCM (5 mL) and iodoform (216 mg, 0.548 mmol, 1.2 equiv) was added to the solution. The reaction mixture was irradiated with tungsten lamp (250 W) for 2 hours in a water bath, keeping the internal temperature under 45 ˚C. The reaction mixture was passed through a short pad of silica gel and washed with hexanes:EtOAc (4:1) to give iodide **34** (146 mg, 77% yield over 2 steps) as a pale yellow powder. Compound **34** was used immediately without further purification.

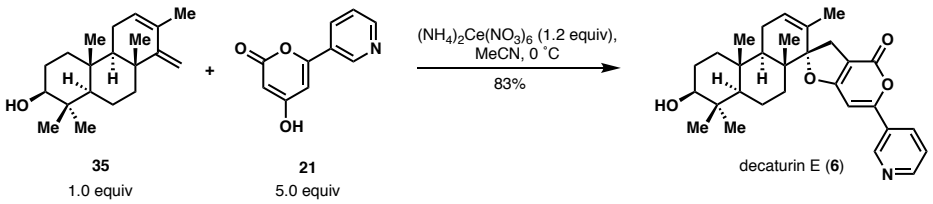
A solution of **34** (135 mg, 0.324 mmol, 1.0 equiv) in THF (12 mL) was treated with *t*-BuOK (70.5 mg, 0.648 mmol, 2.0 equiv). The reaction mixture was heated to 50 ˚C for 10 min, then poured to sat. aq. $NaHCO_3$ (20 mL) and extracted with EtOAc (10 mL × 3). The combined organic extracts were washed with brine, dried over anhydrous $MgSO_4$, filtered, and concentrated *in vacuo*. The residue was purified by flash column chromatography (8:1 hexanes:EtOAc) to give diene **35** (74.0 mg, quantitative yield, 77% yield over 3 steps) as a white powder.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 5.60 – 5.52 (m, 1H), 4.75 (s, 1H), 4.72 (s, 1H), 3.11 (dd, *J* = 11.1, 5.1 Hz, 1H), 2.01 – 1.95 (m, 2H), 1.95 – 1.88 (m, 1H), 1.73 – 1.69 (m, 3H), 1.64 – 1.33 (m, 6H), 1.13 (dd, *J* = 8.3, 8.3 Hz, 1H), 0.94 – 0.90 (m, 4H), 0.88 (s, 3H), 0.86 (s, 3H), 0.76 – 0.66 (m, 4H)

^{13}C NMR (101 MHz, $CDCl_3$): δ = 158.3, 131.1, 126.4, 104.2, 79.0, 55.3, 53.4, 39.5, 38.9, 38.2, 37.9, 37.4, 28.2, 27.3, 23.3, 22.5, 20.6, 18.8, 16.2, 15.7.

HRMS (ESI): calcd for $C_{20}H_{32}OH^+$ ([M+H]) 289.2526, found 289.2520.

$[\alpha]_D^{24}$ = –10.9 (c = 1.0, $CHCl_3$)



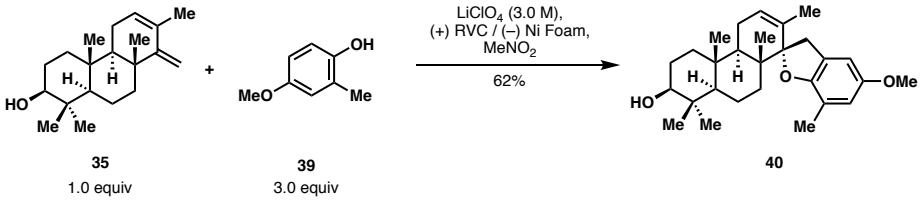
A solution of diene **35** (13.5 mg, 0.0324 mmol, 1.0 equiv) and pyrone **21** (30.6 mg, 0.162 mmol, 5.0 equiv) in MeCN (2 mL) was treated with $(NH_4)_2Ce(NO_3)_6$ (22.7 mg, 0.0389 mmol, 1.2 equiv) at 0 °C . The reaction mixture was stirred at 0 °C for 30 min then quenched with sat. aq. $Na_2S_2O_3$ solution (5 mL) and extracted with EtOAc (10 mL × 3). The combined organic extracts were washed with brine, dried over anhydrous $MgSO_4$, filtered, and concentrated *in vacuo*. The residue was purified by flash column chromatography (2:1 to 1:2 hexanes:EtOAc) to give decaturin E (**6**) (12.8 mg, 83% yield) as a yellow powder.

^{1}H NMR (600 MHz, DMSO-d$_6$): δ = 9.07 (dd, *J* = 2.4, 0.9 Hz, 1H), 8.67 (dd, *J* = 4.8, 1.6 Hz, 1H), 8.23 (ddd, *J* = 8.1, 2.4, 1.6 Hz, 1H), 7.54 (ddd, *J* = 8.1, 4.8, 0.9 Hz, 1H), 7.34 (s, 1H), 5.66 (br. s, 1H), 4.34 (d, *J* = 5.2 Hz, 1H), 3.01 (d, *J* = 16.1 Hz, 1H), 2.98 (dd, *J* = 7.5, 3.7 Hz, 1H), 2.86 (d, *J* = 16.1 Hz, 1H), 2.00 – 1.94 (m, 2H), 1.62 (s, 3H), 1.59 (m, 1H), 1.58 – 1.56 (m, 1H), 1.56 (m, 1H), 1.54 – 1.49 (m, 1H), 1.49 – 1.42 (m, 2H), 1.42 – 1.37 (m, 1H), 1.31 (td, *J* = 12.7, 4.1 Hz, 1H), 0.93 – 0.90 (m, 1H), 0.89 (s, 3H), 0.88 (s, 3H), 0.87 (s, 3H), 0.70 (m, 1H), 0.68 (s, 3H).

^{13}C NMR (151 MHz, DMSO-d$_6$): δ = 170.0, 159.6, 159.5, 151.4, 146.7, 133.1, 130.9, 128.2, 127.2, 124.0, 101.2, 100.1, 94.2, 76.8, 54.5, 47.4, 40.4, 38.4, 37.9, 36.4, 31.7, 28.2, 27.8, 26.9, 22.5, 18.1, 17.5, 16.0, 16.0, 15.4.

HRMS (ESI): calcd for $C_{30}H_{37}NO_4H^+$ ([M+H]) 476.2975, found 476.2812.

$[\alpha]_D^{24}$ = +80.1 (c = 0.5, MeOH)



In an Electrasyn 2.0 reaction cell, a solution of diene **35** (20.1 mg, 0.0694 mmol, 1.0 equiv) and phenol **39** (28.2 mg, 0.208 mmol, 3.0 equiv) in $MeNO_2$ (2 mL) was treated with $LiClO_4$ (638 mg, 6.0 mmol, 3.0 M). The reaction cell was capped with a septum equipped with an RVC anode and Ni-foam cathode. The reaction mixture was stirred and under a constant potential of 2.10 V for 30 min then quenched with

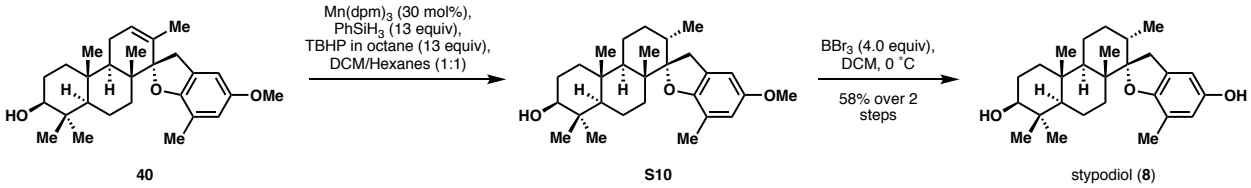
saturated aq. $NaHCO_3$ solution (5 mL) and extracted with EtOAc (10 mL × 3). The combined organic extracts were washed with brine, dried over anhydrous $MgSO_4$, filtered, and concentrated *in vacuo*. The residue was purified by flash column chromatography (2:1 to 1:1 hexanes:EtOAc) to give **40** (18.2 mg, 62% yield) as a white powder.

^{1}H NMR (600 MHz, $CDCl_3$): δ 6.55 – 6.52 (m, 1H), 6.48 – 6.46 (m, 1H), 5.57 (ddd, *J* = 5.5, 2.5, 1.4 Hz, 1H), 3.73 (s, 3H), 3.26 (dd, *J* = 11.6, 4.6 Hz, 1H), 3.22 (d, *J* = 16.6 Hz, 1H), 3.04 (d, *J* = 16.6 Hz, 1H), 2.19 (t, *J* = 0.7 Hz, 3H), 2.07 – 2.00 (m, 1H), 1.95 (ddt, *J* = 18.2, 11.7, 2.5 Hz, 1H), 1.88 – 1.83 (m, 1H), 1.79 (dd, *J* = 11.7, 5.4 Hz, 1H), 1.72 – 1.62 (m, 2H), 1.60 (dt, *J* = 3.0, 1.6 Hz, 3H), 1.59 – 1.51 (m, 2H), 1.44 – 1.38 (m, 2H), 1.13 – 1.06 (m, 1H), 0.97 – 0.94 (m, 6H), 0.91 (d, *J* = 0.7 Hz, 3H), 0.81 (dd, *J* = 11.9, 2.1 Hz, 1H), 0.79 (s, 3H)

^{13}C NMR (151 MHz, $CDCl_3$): δ 153.4, 153.1, 133.6, 127.5, 126.1, 118.7, 114.2, 107.7, 93.4, 79.0, 56.0, 54.9, 47.8, 41.2, 38.9, 38.3, 36.9, 33.1, 32.4, 28.3, 27.4, 23.2, 19.0, 18.0, 16.7, 16.0, 15.9, 15.8.

HRMS (ESI): calcd for $C_{28}H_{40}O_3H^+$ ([M+H]) 425.3050, found 425.3039

$[\alpha]_D^{24}$ = –6.3 (c = 1.0, $CHCl_3$)



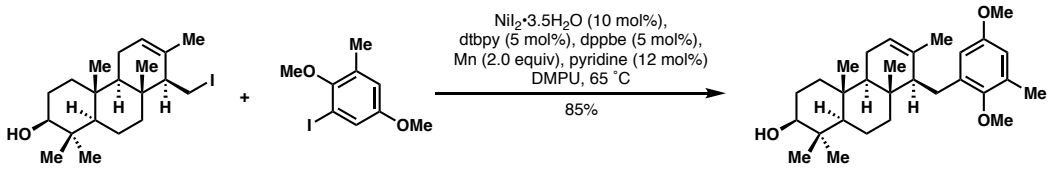
A solution of **40** (11.0 mg, 0.0259 mmol, 1.0 equiv) in DCM/hexanes (1:1, 1 mL DCM, 1 mL hexanes) was treated with $Mn(dpm)_3$ (4.1 mg, 0.0069 mmol, 30 mol%), $PhSiH_3$ (69 µl, 0.330 mmol, 13 equiv) and 5.5 M TBHP in octane (60 µl, 0.330 mmol, 13 equiv). The reaction mixture was stirred for 8 hours then quenched with saturated aq. $Na_2S_2O_3$ solution (5 mL) and extracted with EtOAc (10 mL × 3). The combined organic extracts were washed with brine, dried over anhydrous $MgSO_4$, filtered, and concentrated *in vacuo*. Crude **S10** was dissolved into DCM (1 mL) and cooled to 0 ˚C. To this solution, 1.0 M BBr_3 in DCM (0.100 mL, 0.100 mmol, 4.0 equiv) was added and the solution was stirred at 0 ˚C for 30 minutes. The reaction was quenched with saturated aq. $NaHCO_3$ solution (5 mL) and extracted with EtOAc (5 mL × 3). The combined organic extracts were washed with brine, dried over anhydrous $MgSO_4$, filtered, and concentrated *in vacuo*. The residue was purified by flash column chromatography (2:1 to 1:1 hexanes:EtOAc) to give stypodiol (**8**) (6.2 mg, 58% yield over 2 steps) as a white powder.

^{1}H NMR (400 MHz, CD_3OD): δ 6.34 – 6.31 (m, 1H), 6.29 (dt, *J* = 2.7, 0.8 Hz, 1H), 3.18 (d, *J* = 16.7 Hz, 1H), 3.12 (dd, *J* = 11.5, 4.9 Hz, 1H), 2.72 (d, *J* = 16.5 Hz, 1H), 2.08 (d, *J* = 0.7 Hz, 3H), 1.75 – 1.72 (m, 1H), 1.71 – 1.67 (m, 1H), 1.63 – 1.60 (m, 1H), 1.59 – 1.58 (m, 1H), 1.56 – 1.54 (m, 2H), 1.55 – 1.53 (m 1H), 1.51 – 1.50 (m, 1H), 1.49 – 1.47 (m, 1H), 1.47 – 1.45 (m, 1H), 1.45 – 1.42 (m, 1H), 1.42 – 1.37 (m, 1H), 1.35 (dd, *J* = 13.2, 4.4 Hz, 1H), 1.04 – 0.97 (m, 1H), 0.95 (d, *J* = 0.7 Hz, 3H), 0.90 (s, 3H), 0.86 (m, 3H), 0.73 (s, 3H), 0.72 (d, *J* = 3.3 Hz, 1H), 0.62 (d, *J* = 6.5 Hz, 3H).

^{13}C NMR (101 MHz, CD_3OD): δ 154.3, 151.2, 128.1, 119.1, 116.1, 109.5, 95.6, 79.7, 56.6, 52.8, 43.6, 39.9, 39.8, 38.3, 38.2, 36.1, 34.0, 32.4, 28.6, 28.1, 21.5, 18.9, 17.6, 16.9, 16.1, 16.0, 15.6.

HRMS (ESI): calcd for $C_{27}H_{40}O_3H^+$ ([M+H]) 413.3050, found 413.3041

$[\alpha]_D^{24}$ = –11.2 (c = 0.20, $CHCl_3$)



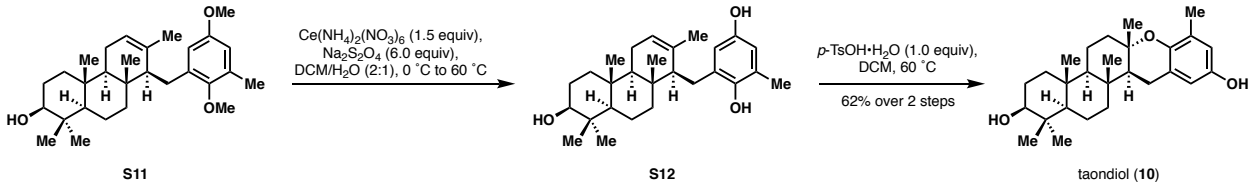
A solution of iodide **34** (41.6 mg, 0.10 mmol, 1.0 equiv) and **36** (27.8 mg, 0.10 mmol, 1.0 equiv) in DMPU (0.4 mL) was treated with $NiI_2 \cdot 3.5H_2O$ (4.0 mg, 0.01 mmol, 10 mol%), 1,2-bis(diphenylphosphino)benzene (2.23 mg, 0.005 mmol, 5 mol%), 4,4'-di-tert-butyl-2,2'-dipyridyl (1.3 mg, 0.05 mmol, 5 mol%), manganese powder (11.0 mg, 0.20 mmol, 2.0 equiv), and pyridine (1 μL, 0.012 mmol, 12 mol%). The reaction mixture was heated to 65 ˚C for 8 hours then quenched with saturated aq. $Na_2S_2O_3$ solution (5 mL) and extracted with EtOAc (10 mL × 3). The combined organic extracts were washed with brine, dried over anhydrous $MgSO_4$, filtered, and concentrated *in vacuo*. The residue was purified by flash column chromatography (4:1 to 2:1 hexanes:EtOAc) to yield **S11** (37.4 mg, 85% yield) as a white powder.

^{1}H NMR (400 MHz, $CDCl_3$): δ 6.65 (d, *J* = 3.2 Hz, 1H), 6.53 (d, *J* = 3.1 Hz, 1H), 5.33 (s, 1H), 3.76 (s, 3H), 3.66 (s, 3H), 3.22 (dd, *J* = 11.1, 5.0 Hz, 1H), 2.72 – 2.57 (m, 2H), 2.34 (d, *J* = 8.4 Hz, 1H), 2.27 (s, 3H), 2.01 (dt, *J* = 12.9, 3.3 Hz, 1H), 1.95 – 1.87 (m, 2H), 1.73 – 1.54 (m, 4H), 1.45 – 1.39 (m, 3H), 1.27 – 1.16 (m, 3H), 0.99 (s+m, 3H+1H), 0.91 (d, *J* = 0.8 Hz, 3H), 0.88 (s, 3H), 0.86 – 0.81 (m, 1H), 0.80 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 155.4, 150.6, 137.7, 135.7, 131.8, 121.8, 112.8, 79.1, 77.4, 60.5, 55.6, 55.3, 55.3, 55.1, 41.3, 38.9, 38.5, 37.2, 36.9, 28.3, 27.4, 26.5, 22.9, 22.4, 18.8, 16.7, 15.9, 15.7, 14.9.

HRMS (ESI): calcd for $C_{29}H_{44}O_3H^+$ ([M+H]) 441.3363, found 441.3353.

$[\alpha]_D^{24}$ = –79.3 (c = 1.0, $CHCl_3$)



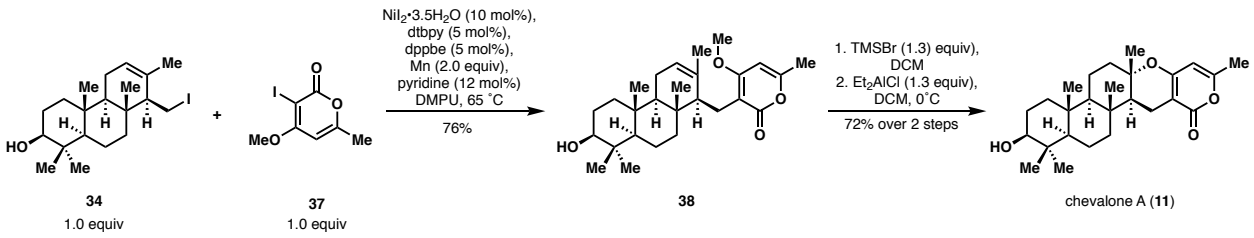
A solution of **S11** (37.4 mg, 0.0850 mmol, 1.0 equiv) in DCM/H_2O (2:1, 1.0 mL DCM, 0.5 mL H_2O) was treated with $Ce(NH_4)_2(NO_3)_6$ (70.0 mg, 0.128 mmol, 1.5 equiv) at 0 ˚C. The reaction mixture was stirred at 0 ˚C for 1 hour and then treated with $Na_2S_2O_4$ (89.1 mg, 0.510 mmol, 6.0 equiv). The reaction mixture was heated to 60 ˚C for 1 hour then quenched with saturated aq. $NaHCO_3$ solution (5 mL) and extracted with EtOAc (10 mL × 3). The combined organic extracts were washed with brine, dried over anhydrous $MgSO_4$, filtered, and concentrated *in vacuo*. Crude **S12** was dissolved in DCM (1.0 mL) and *p*-toluenesulfonic acid monohydrate (16.5 mg, 0.0850 mmol, 1.0 equiv) was added to the solution. The reaction mixture was heated to 60 °C for 30 min then quenched with saturated aq. $NaHCO_3$ solution (5 mL) and extracted with EtOAc (5 mL × 3). The combined organic extracts were washed with brine, dried over anhydrous $MgSO_4$, filtered, and concentrated *in vacuo*. The residue was purified by flash column chromatography (2:1 to 1:1 hexanes:EtOAc) to yield taondiol (**10**) (21.8 mg, 62% yield over 2 steps) as a white powder.

^{1}H NMR (600 MHz, $CDCl_3$): δ 6.45 (d, *J* = 3.0 Hz, 1H), 6.38 (d, *J* = 3.0 Hz, 1H), 3.22 (dd, *J* = 11.6, 4.7 Hz, 1H), 2.55 (d, *J* = 8.4 Hz, 1H), 2.54 (s, 1H), 2.12 – 2.06 (m, 3H), 2.05 – 2.00 (m, 1H), 1.79 (dt, *J* = 13.2, 3.6 Hz, 1H), 1.75 (dt, *J* = 13.0, 3.7 Hz, 1H), 1.73 – 1.70 (m, 1H), 1.70 – 1.67 (m, 2H), 1.65 – 1.61 (m, 1H), 1.60 – 1.59 (m, 1H), 1.58 – 1.56 (m, 1H), 1.50 – 1.42 (m, 1H), 1.40 – 1.36 (m, 1H), 1.13 (s, 3H), 1.06 – 1.02 (m, 1H), 1.02 – 1.00 (m, 1H), 0.98 (s, 3H), 0.95 (dd, *J* = 11.9, 2.0 Hz, 1H), 0.87 (s, 3H), 0.85 (s, 3H), 0.78 (s+m, 3H+1H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 147.9, 145.5, 127.3, 122.5, 115.5, 113.1, 79.0, 76.2, 60.7, 55.5, 52.6, 41.2, 41.1, 39.0, 38.5, 37.3, 37.0, 28.1, 27.5, 22.8, 21.0, 18.9, 18.1, 16.6, 16.3, 16.0, 15.4.

HRMS (ESI): calcd for $C_{27}H_{40}O_3H^+$ ([M+H]) 413.3050, found 413.3040.

$[\alpha]_D^{24}$ = –46.9 (c = 0.35, $CHCl_3$)



A solution of iodide **34** (41.6 mg, 0.10 mmol) and pyrone **37** (26.6 mg, 0.10 mmol, 1.0 equiv) in DMPU (0.4 mL) was treated with $NiI_2 \cdot 3.5H_2O$ (4.0 mg, 0.01 mmol, 10 mol%), 1,2-bis(diphenylphosphino)benzene (2.23 mg, 0.005 mmol, 5 mol%), 4,4'-di-tert-butyl-2,2'-dipyridyl (1.3 mg, 0.05 mmol, 5 mol%), manganese powder (11.0 mg, 0.20 mmol, 2.0 equiv), and pyridine (1 μL, 0.012 mmol, 12 mol%). The reaction mixture was heated to 65 °C for 8 hours then quenched with saturated aq. $Na_2S_2O_3$ solution (5 mL) and extracted with EtOAc (10 mL × 3). The combined organic extracts were washed with brine, dried over anhydrous $MgSO_4$, filtered, and concentrated *in vacuo*. The residue was purified by flash column chromatography (4:1 to 2:1 hexanes:EtOAc) to yield **38** (31.5 mg, 76% yield) as a white powder which was used immediately.

A stirred solution of **38** (31.5 mg, 0.076 mmol, 1.0 equiv) in DCM (1.0 mL) was treated with TMSBr (15.3 mg, 0.10 mmol, 1.3 equiv) at room temperature. The reaction was stirred for 8 hours then quenched with sat. aq. $NaHCO_3$ solution (5 mL) and extracted with EtOAc (10 mL × 3). The combined organic extracts were washed with brine (10 mL), dried over anhydrous $MgSO_4$, filtered, and concentrated *in vacuo*. The crude residue was dissolved in DCM (1.0 mL), cooled to 0 ˚C, and treated with 1.0 M Et_2AlCl in toluene (0.100 mL, 0.10 mmol, 1.3 equiv). The reaction mixture was stirred at 0 ˚C for 2 hours then quenched with sat. aq. $NaHCO_3$ (5 mL) and extracted with EtOAc (5 mL × 3). The combined organic extracts were washed with brine, dried over anhydrous $MgSO_4$, filtered, and concentrated *in vacuo*. The residue was purified by flash column chromatography (2:1 to 1:1 hexanes:EtOAc) to yield chevalone A (**11**) (22.6 mg, 72% yield over 2 steps) as a white powder.

^{1}H NMR (400 MHz, $CDCl_3$): δ 5.68 (d, *J* = 1.1 Hz, 1H), 3.19 (dd, *J* = 11.4, 4.9 Hz, 1H), 2.42 (dd, *J* = 16.8, 4.9 Hz, 1H), 2.17 (s, 3H), 2.13 – 2.08 (m, 1H), 2.04 (dt, *J* = 12.5, 3.2 Hz, 1H), 1.84 (dt, *J* = 12.8, 3.3 Hz, 1H), 1.76 – 1.71 (m, 1H), 1.70 – 1.67 (m, 1H), 1.66 – 1.62 (m, 1H), 1.62 – 1.59 (m, 1H), 1.59 – 1.58 (m, 1H), 1.58 – 1.55 (m, 1H), 1.46 (dd, *J* = 7.4, 4.2 Hz, 1H), 1.43 – 1.37 (m, 1H), 1.37 – 1.30 (m, 1H), 1.19 (d, *J* = 0.9 Hz, 3H), 1.02 (dd, *J* = 12.7, 4.2 Hz, 1H), 0.96 (s, 3H), 0.94 – 0.91 (m, 1H), 0.87 (d, *J* = 0.8 Hz, 3H), 0.86 – 0.81 (s+m, 3H+1H), 0.79 – 0.74 (s+m, 3H+1).

^{13}C NMR (101 MHz, $CDCl_3$): δ 165.5, 163.4, 159.9, 100.8, 98.0, 80.7, 78.9, 60.5, 55.5, 52.1, 41.1, 40.4, 39.0, 38.5, 37.4, 37.3, 28.1, 27.4, 20.7, 19.9, 18.8, 18.1, 17.0, 16.5, 16.2, 15.4.

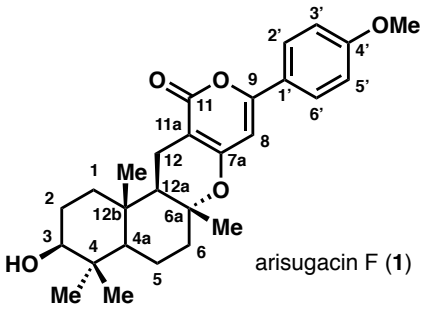
HRMS (ESI): calcd for $C_{26}H_{38}O_4H^+$ ([M+H]) 415.2843, found 415.2850.

$[\alpha]_D^{24}$ = –98.3 (c = 1.0, $CHCl_3$)

Table 1. Comparison table of this work and previous syntheses of 1, 2, 3, 4, 6, 8, 10, 11.

Compound	**Previous synthesis**	**This work**
Arisugacin F (**1**)	7 steps, 4.8% overall yield, racemic (Ōmura, 2003)[56] Note: stoichiometric Hg^{2+} used	7 steps, 18.1% overall yield, asymmetric
Phenylpyropene C (**2**)	None	7 steps, 21.8% overall yield, asymmetric
Phenylpyropene F (**3**)	None	11 steps, 8.8% overall yield, asymmetric
Pyripyropene E (**4**)	9 steps, 7.1% overall yield, asymmetric (Smith, 1996)[12] Note: lack of selectivity in asymmetric dihydroxylation	8 steps, 4.5% overall yield, asymmetric
Decaturin E (**6**)	None	10 steps, 24.0% overall yield, asymmetric
Stypodiol (**8**)	13 steps, 5.8% overall yield, asymmetric (Abad, 1998)[15] Note: lack of selectivity at C14 stereocenter 16 steps, 0.66% overall yield, asymmetric (Falck, 1993)[42] 29 steps, 0.13% overall yield, (Mori, 1995)[57]	12 steps, 10.4% overall yield, asymmetric
Taondiol (**10**)	14 steps (from methyl Wieland Miescher ketone), 3.1% overall yield, asymmetric (Dethe, 2018)[58]	11 steps, 15.4% overall yield, asymmetric
Chevalone A (**11**)	None	11 steps, 15.8% overall yield, asymmetric

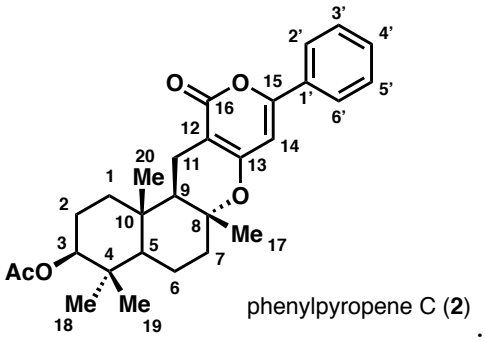
NMR Comparisons:



arisugacin F (**1**)

Table 2: NMR Chemical Shift Comparison of Synthetic and Natural[59] Arisugacin F

Pos.	Natural δ_H [ppm, mult *J*(Hz)] 400 MHz	Synthetic δ_H [ppm, mult, *J*(Hz)] 600 MHz	Natural δ_C [ppm] 101 MHz	Synthetic δ_C [ppm] 151 MHz
1	1.11, ddd (4.0, 13.0, 13.0) 1.81, m	1.12, td (4.0, 13.2) 1.81 – 1.78, m	37.5	37.4
2	1.70, m 1.62, m	1.73 – 1.70, m 1.65 – 1.61, m	27.2	27.2
3	3.24, dd (4.8, 11.6)	3.25, dd (4.7, 11.6)	78.5	78.5
4			38.8	38.8
4a	1.00, dd (2.0, 12.1)	0.99, dd (2.3, 12.2)	55.0	55.0
4α-Me	1.03, s	1.03, s	28.1	28.1
4β-Me	0.81, s	0.82, s	15.5	15.5
5	1.81, m 1.44 dddd (3.0, 12.1, 13.5, 13.5)	1.84 – 1.81, m 1.46 – 1.42, m	19.4	19.4
6	1.67, m 2.12, ddd (3.0, 3.0, 12.4)	1.69 – 1.66, m 2.16 – 2.09, m	40.4	40.4
6a			80.5	80.6
6a-Me	1.25, s	1.26, s	20.7	20.7
7a			163.5	163.6
8	6.25, s	6.25, s	96.7	96.8
9			158.3	158.3
11			164.7	164.7
11a			98.4	98.4
12	2.51, dd (4.8, 16.9) 2.22, dd (12.9, 16.9)	2.51, dd (4.7, 16.9) 2.23, dd (12.9, 16.9)	17.2	17.2
12a	1.49, dd (4.8, 12.9)	1.49, dd (4.9, 12.9)	51.6	51.6
12b			36.9	36.9
12b-Me	0.91, s	0.91	15.1	15.1
1'			124.0	124.0
2'	7.73, d (8.8)	7.73, d (8.9)	127.0	127.0
3'	6.93, d (8.8)	6.93, d (8.9)	114.2	114.2
4'			161.5	161.5
4'-OMe	3.85, s	3.85, s	55.4	55.4
5'	6.93, d (8.8)	6.93, d (8.9)	114.2	114.2
6'	7.73, d (8.8)	7.73, d (8.9)	127.0	127.0

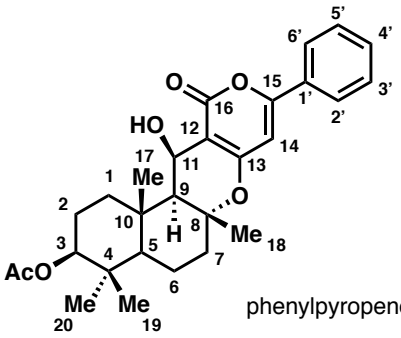


phenylpyropene C (**2**)

Table 3: NMR Chemical Shift Comparison of Synthetic and Natural[60] Phenylpyropene C

Pos.	Natural δ_H [ppm, mult *J*(Hz)] 400 MHz	Synthetic δ_H [ppm, mult *J*(Hz)] 600 MHz	Natural δ_C [ppm] 101 MHz	Synthetic δ_C [ppm] 151 MHz
1	1.18, ddd (4.8, 10.5, 15.0) 1.82, m	1.18, td (4.4, 13.3) 1.84 – 1.81, m	37.42	37.4
2	1.78, m 1.68, m	1.77 – 1.72 m 1.70 – 1.68, m	23.77	23.7
3	4.51, dd (4.8, 11.2)	4.51, dd (4.7, 11.8)	80.38	80.4
4			38.00	37.9
5	1.10, dd (1.6, 12.0)	1.09, dd (2.2, 12.2)	55.31	55.3
6*	1.79, m	1.80 – 1.78, m 1.49 – 1.41, m	19.57	19.5
7	2.14, dt (3.2, 12.4) 1.71, m	2.13, dt (3.2, 12.6) 1.68 – 1.65, m	40.53	40.5
8			80.74	80.7
9	1.52, dd (4.4, 17.2)	1.51, dd (4.8, 12.9)	51.74	51.7
10			37.03	37.0
11	2.53, dd (4.4, 17.2) 2.25, dd (17.2, 17.2)	2.52, dd (4.8, 17.3) 2.25, dd (4.4, 17.3)	17.57	17.5
12			99.57	99.6
13			163.36	163.4
14	6.37, s	6.37, s	98.50	98.5
15			158.38	158.4
3-OAc	2.06, s	2.06, s	21.53 170.97	21.5 171.1
16			164.62	164.7
17	1.27, s	1.26, s	28.36	28.3
18	0.92, s	0.91, s	20.98	20.9
19	0.89, s	0.89, s	16.91	16.8
20	0.95, s	0.94, s	15.44	15.4
1'			131.65	131.7
2'	7.43, m	7.47 –7.38, m	125.52	125.6
3'	7.43, m	7.47 –7.38, m	128.98	129.0
4'	7.43, m	7.47 –7.38, m	130.63	130.7
5'	7.43, m	7.82 – 7.75, m	128.98	129.0
6'	7.79, m	7.82 – 7.75, m	125.52	125.6

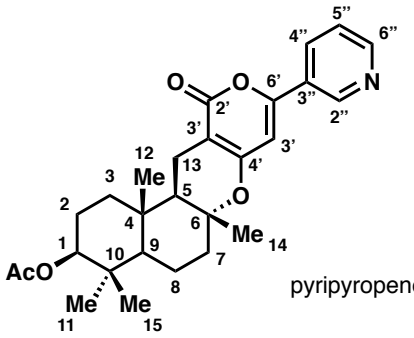
*****The reported ^{1}H NMR is missing one C6 proton.



phenylpyropene F (**3**)

Table 4: NMR Chemical Shift Comparison of Synthetic and Natural[61] Phenylpyropene F

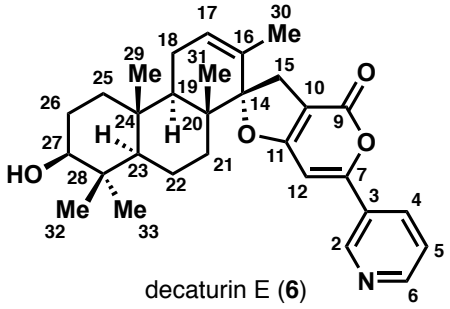
Pos.	Natural δ_H [ppm, mult *J*(Hz)] 500 MHz	Synthetic δ_H [ppm, mult *J*(Hz)] 600 MHz	Natural δ_C [ppm] 126 MHz	Synthetic δ_C [ppm] 151 MHz
1	2.12, m 1.42, m	2.12 – 2.09, m 1.43 – 1.37, m	36.3	36.3
2	1.81, m 1.73, m	1.85 – 1.80, m 1.74 – 1.71, m	23.0	23.0
3	4.53, dd (4.8, 12.0)	4.51, dd (4.6, 11.8)	80.6	80.6
4			37.8	37.8
5	1.13, m	1.12, dd (2.1, 11.9)	55.2	55.3
6	1.75, m 1.67, m	1.77 – 1.74, m 1.69 – 1.64, m	19.1	19.2
7	2.15, m 1.78, m	2.16 – 2.12, m 1.80 – 1.77, m	41.5	41.5
8			81.8	81.9
9	1.50, d (3.8)	1.49, d (3.6)	55.6	55.7
10			37.4	37.4
11	4.94, d (3.8)	4.94, d (3.6)	59.1	59.1
12			102.2	102.2
13			164.0	164.0
14	6.62, s	6.62, s	98.3	98.3
15			159.5	159.6
16			164.6	164.6
17	1.40, s	1.43 – 1.37, s	15.4	15.6
18	1.68, s	1.67, s	19.7	19.7
19	0.90, s	0.89, s	16.2	16.2
20	0.93, s	0.93, s	27.2	27.2
3-OAc	2.04, s	2.03, s	21.4 171.3	21.4 171.4
1'			131.1	131.1
2'	7.84, d (7.8)	7.86 –7.82, m	125.2	125.2
3'	7.48, dd (7.8, 8.0)	7.50 –7.45, m	128.7	128.7
4'	7.48, d (7.8)	7.50 –7.45, m	130.6	130.7
5'	7.48, dd (7.8, 8.0)	7.50 –7.45, m	128.7	128.7
6'	7.84, d (7.8)	7.86 –7.82, m	125.2	125.2



pyripyropene E (**4**)

Table 5: NMR Chemical Shift Comparison of Synthetic and Natural[62] Pyripyropene E

Pos.	Natural δ_H [ppm, mult *J*(Hz)] 400 MHz	Synthetic δ_H [ppm, mult *J*(Hz)] 600 MHz	Natural δ_C [ppm] 101 MHz	Synthetic δ_C [ppm] 151 MHz
1	4.49, dd (4.5, 11.5)	4.51, dd (4.7, 11.8)	80.1	80.1
2	1.70, m 1.70, m	1.77 –1.72, m 1.71 –1.67, m	23.5	23.4
3	1.17, m 1.78, m	1.19, td (3.9, 13.2) 1.81 – 1.78, m	37.1	37.1
4			37.7	37.7
5	1.50, dd (4.5, 12.5)	1.51,dd (4.8, 12.9)	51.4	51.4
6			80.8	80.8
7	2.13, dt (3.0, 12.5) 1.68, m	2.14, dt (3.2, 12.6) 1.67 –1.63, m	40.2	40.2
8	1.80, m 1.44, m	1.85 – 1.81, m 1.50 –1.40, m	19.2	19.2
9	1.08, m	1.09, dd (2.2, 12.2)	55.0	55.0
10			36.7	36.7
11	0.90, s	0.91, s	28.1	28.0
12	0.88, s	0.89, s	15.1	15.1
13	2.51, dd (3.0, 17.0) 2.23, dd (13.0, 17.0)	2.52, dd (4.7, 17.1) 2.25, dd (12.9, 17.1)	17.3	17.3
14	1.26, s	1.27, s	20.7	20.7
15	0.93, s	0.94, s	16.6	16.6
1-OAc	2.05, s	2.06, s	21.1 170.8	21.2 170.8
2'			163.9	164.0
3'			100.2	100.2
4'			162.8	162.8
5'	6.41, s	6.42, s	99.3	99.3
6'			155.6	155.6
2''	8.97, d (2.0)	8.99, dd (0.9, 2.4)	146.6	146.6
3''			127.6	127.6
4''	8.08, ddd (1.5, 2.5, 8.0)	8.10, ddd (1.6, 2.4, 8.1)	132.7	132.7
5''	7.37, dd (4.5, 8.0)	7.38, ddd (0.9, 4.8, 8.1)	123.5	123.5
6''	8.63, dd (1.5, 4.5)	8.65, dd (1.6, 4.8)	151.0	151.1

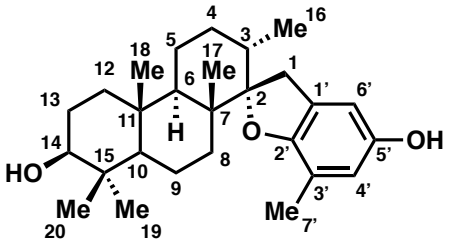


decaturin E (**6**)

Table 6: NMR Chemical Shift Comparison of Synthetic and Natural[63] Decaturin E

Pos.	Natural δ_H [ppm, mult *J*(Hz)] 600 MHz	Synthetic δ_H [ppm, mult *J*(Hz)] 600 MHz	Natural δ_C [ppm] 151MHz	Synthetic δ_C [ppm] 151 MHz
2	9.07, d (1.9)	9.07, dd (2.4, 0.9)	146.7	146.7
3			127.2	127.2
4	8.23, ddd (1.4, 1.9, 8.2)	8.23, ddd (1.6, 2.4, 8.1)	133.1	133.1
5	7.54, dd (4.7, 8.2)	7.54, ddd (0.9, 4.8, 8.1)	124.0	124.0
6	8.67, dd (1.4, 4.7)	8.67, dd (1.6, 4.8)	151.4	151.4
7			159.5	159.5
9			170.0	170.0
10			101.2	101.2
11			159.6	159.6
12	7.36, s	7.34, s	94.2	94.2
14			100.1	100.1
15	3.01, d (16.1) 2.85, d (16.1)	3.01, d (16.1) 2.86, d (16.1)	27.8	27.8
16			130.9	130.9
17*	4.34, d (4.9)	4.34, d (5.2)	128.1	128.2
18	1.98, m	2.00 – 1.94, m	22.5	22.5
19	1.58, m	1.58–1.56, m	47.4	47.4
20			40.3	40.4
21	1.56, m 1.28, m	1.56, m 1.31, td (4.1, 12.7)	31.7	31.7
22	1.52, m 1.41, m	1.54 – 1.49, m 1.42 – 1.37, m	17.5	17.5
23	0.70, m	0.70, m	54.5	54.5
24			36.4	36.4
25	1.60, m 0.91, m	1.59, m 0.93 – 0.90, m	37.9	37.9
26	1.48, m	1.49 – 1.42, m	26.9	26.9
27	2.98, m	2.98, dd (3.7, 7.5)	76.8	76.8
28			38.4	38.4
29	0.89, s	0.89, s	15.4	15.4
30	1.62, s	1.62, s	18.1	18.1
31	0.87, s	0.88, s	15.9	16.0
32	0.68, s	0.68, s	16.0	16.0
33	0.86, s	0.87, s	28.2	28.2
27-OH*	5.66, br. s	5.66, br. s		

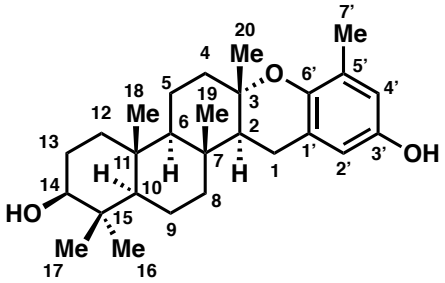
*These two proton signals were switched in the previously reported spectrum.



stypodiol (**8**)

Table 7: NMR Chemical Shift Comparison of Synthetic and Natural[64] Stypodiol

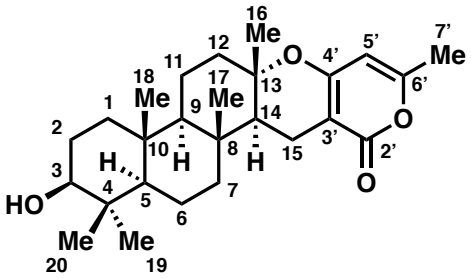
Pos.	Natural δ_H [ppm, mult *J*(Hz)] 500 MHz	Synthetic δ_H [ppm, mult *J*(Hz)] 400 MHz	Natural δ_C [ppm] 126 MHz	Synthetic δ_C [ppm] 101 MHz
1	2.72, d (16.5) 3.18, d (16.4)	2.72, d (16.5) 3.18, dd (16.7)	36.5	36.1
2			96.0	95.6
3	1.68, m	1.75 – 1.72, m	38.7	38.3
4	1.41, m 1.35, dd (4.2, 13.1)	1.42 – 1.37, m 1.35, dd (4.4, 13.2)	34.3	34.0
5	1.67, m 1.51, m	1.71 – 1.67, m 1.59 – 1.58, m	28.5	28.1
6	1.54, m		53.2	53.8
7			44.0	43.6
8	1.50, m 1.50, m	1.55 – 1.53, m 1.56 – 1.54, m	32.7	32.4
9	1.59, m 1.49, m	1.63 – 1.60, m 1.51 – 1.50, m	21.8	21.5
10	0.73, m	0.72, d (3.3)	56.9	56.6
11			38.6	38.2
12	1.47, m 1.00, m	1.49 – 1.47, m 1.04 – 0.97, m	40.1	39.8
13	1.46, m 1.46, m	1.45 – 1.42 1.47 – 1.47	19.3	18.9
14	3.13 dd, (5.1, 11.3)	3.12, dd (4.9, 11.5)	80.0	79.7
15			40.3	39.9
16	0.63, d (6.5)	0.62, d (6.5)	16.4	16.1
17	0.90, s	0.90, s	18.0	17.6
18	0.86, s	0.86, s	17.2	16.9
19	0.95, s	0.95, d (0.7)	29.0	28.6
20	0.73, s	0.73, s	16.4	16.0
1’			128.4	128.1
2’			154.7	154.3
3’			119.4	119.1
4’	6.30, s	6.29, dt (0.8, 2.7)	116.4	116.1
5’			151.5	151.2
6’	6.33, s	6.34 – 6.31, m	109.8	109.5
7’	2.08, s	2.08, d (0.7)	15.9	15.6



taondiol (**10**)

Table 8: NMR Chemical Shift Comparison of Synthetic and Natural[65] Taondiol

Pos.	Natural δ_H [ppm, mult *J*(Hz)] 400 MHz	Synthetic δ_H [ppm, mult *J*(Hz)] 600 MHz	Natural δ_C [ppm] 101 MHz	Synthetic δ_C [ppm] 151 MHz
1	2.56, d (5.1) 2.54, s	2.55, d (8.4) 2.54, s	22.6	22.8
2	1.60, m	1.60 – 1.59, m	52.5	52.6
3	1.65, m	1.70 – 1.67, m	76.1	76.2
4	1.65, m 1.03, m	1.70 – 1.67, m 1.06 – 1.02, m	41.0	41.1
5	1.70, m 1.36, d (15.3)	1.73 – 1.70, m 1.40 – 1.32, m	18.7	18.9
6	0.96, d (12.2)	0.95, dd (2.0, 11.9)	60.6	60.7
7			36.9	37.0
8	2.03, d (14.2) 1.79, d (14.2)	2.05 – 2.00, m 1.79, dt (3.6, 13.2)	41.1	41.2
9	1.47, m 1.59, m	1.50 – 1.42, m 1.58 – 1.56, m	17.9	18.1
10	0.79, d (11.7)	0.78, m	55.4	55.5
11			37.2	37.3
12	1.63, m	1.65 – 1.61, m	27.3	27.5
13	1.76, d (14.8) 1.00, m	1.75, dt (3.7, 13.0) 1.02 – 1.00, m	38.4	38.5
14	3.22, dd (4.6, 11.2)	3.22, dd (4.7, 11.6)	78.8	79.0
15			38.9	90.0
16	0.98, s	0.98, s	28.0	28.1
17	0.79, s	0.78, s	15.3	15.4
18	0.86, s	0.85, s	16.4	16.6
19	0.88, s	0.87, s	15.8	16.0
20	1.13, s	1.13, s	20.8	21.0
1’			122.4	122.5
2’			145.4	145.5
3’			127.1	127.3
4’	6.45, d (2.5)	6.45, d (3.0)	115.4	115.5
5’			147.8	147.9
6’	6.38, d (2.5)	6.38, d (3.0)	112.9	113.1
7’	2.09, s	2.12 – 2.06, m	16.1	16.3



chevalone A (**11**)

Table 9: NMR Chemical Shift Comparison of Synthetic and Natural[66] Chevalone A

Pos.	Natural δ_H [ppm, mult *J*(Hz)] 400 MHz	Synthetic δ_H [ppm, mult *J*(Hz)] 400 MHz	Natural δ_C [ppm] 101 MHz	Synthetic δ_C [ppm] 101 MHz
1	1.72, m 0.96, m	1.76 – 1.71, m 0.94 – 0.91, m	38.3	38.5
2	1.64, m 1.56, m	1.66 – 1.62, m 1.59 – 1.58, m	27.2	27.4
3	3.18, dd (4.4, 11.2)	3.19, dd (4.9, 11.4)	78.7	78.9
4			38.8	39.0
5	0.75, m	0.79 – 0.74, m	55.3	55.5
6	1.55, m 1.45, m	1.58 – 1.55, m 1.46, dd (4.2, 7.4)	17.8	18.1
7	1.82, tt (3.2, 13.2) 1.02, m	1.84, dt (3.3, 12.8) 1.02, dd (4.2, 12.7)	40.9	41.1
8			37.2	37.4
9	0.89, dd (2.0, 12.2)	0.86 – 0.81, m	60.3	60.5
10			37.1	37.3
11	1.69, m 1.33, m	1.70 – 1.67, m 1.37 – 1.30, m	18.6	18.8
12	2.05, td (3.0, 12.4) 1.59, m	2.04, dt (3.2, 12.5) 1.62 – 1.59, m	40.2	40.4
13			80.5	80.7
14	1.41, m	1.43 – 1.37, m	51.9	52.1
15	2.42, dd (4.8, 16.8) 2.14, m	2.42, dd (4.9, 16.8) 2.13 – 2.08, m	16.8	17.0
16	1.18, s	1.19, d (0.9)	20.5	20.7
17	0.86, s	0.87, d (0.8)	16.3	16.5
18	0.82, s	0.86 – 0.81, s	16.0	16.2
19	0.95, s	0.96, s	27.9	28.1
20	0.77, s	0.79 – 0.74, s	15.2	15.4
1’				
2’			165.3	165.5
3’			97.8	98.0
4’			163.2	163.4
5’	5.66, s	5.68, d (1.1)	100.6	100.8
6’			159.7	159.9
7’	2.16, s	2.17, s	19.6	19.9

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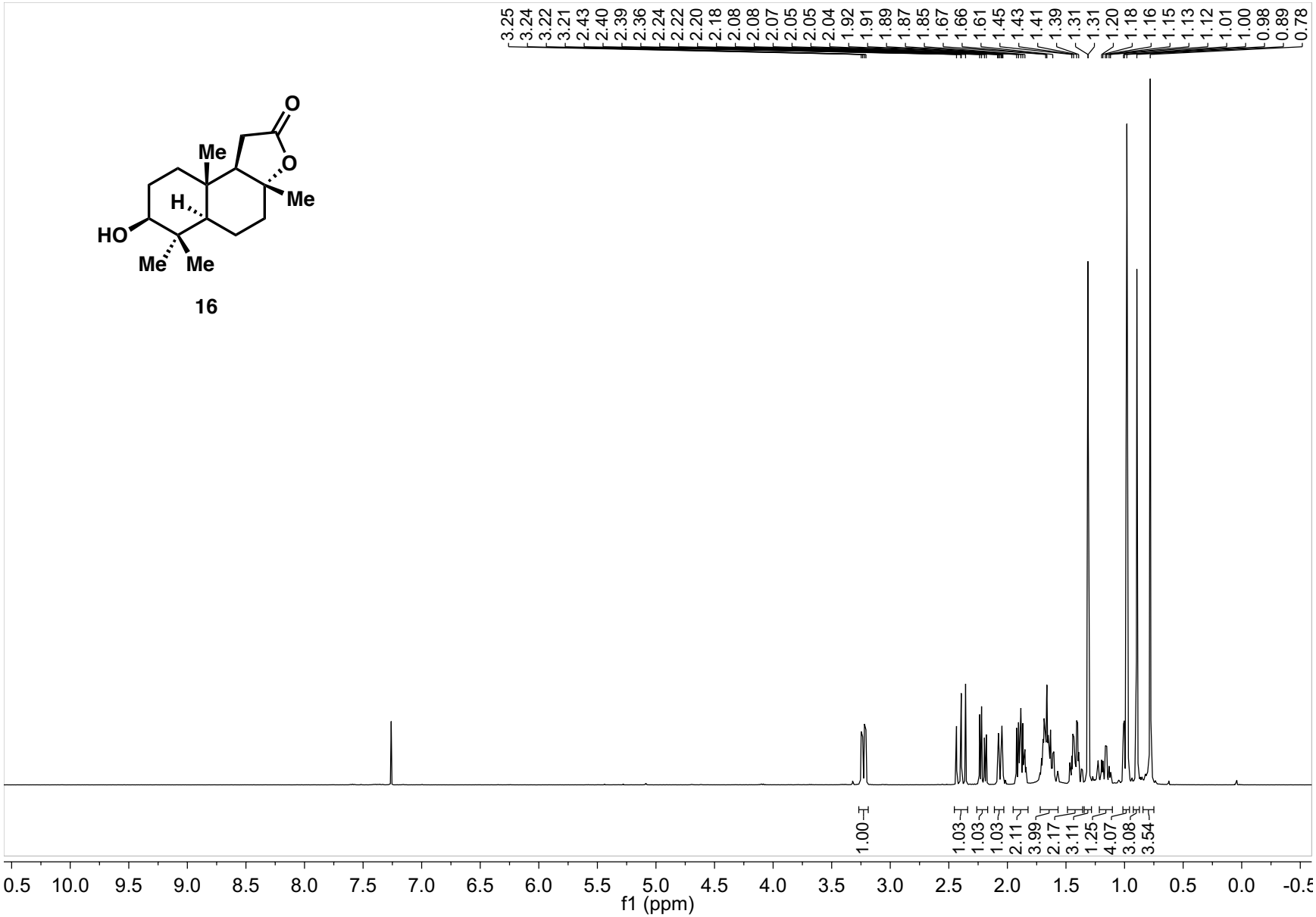
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2.08
2.08
2.07
2.05
2.05
2.04
1.92
1.91
1.89
1.87
1.85
1.67
1.66
1.61
1.45
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1.41
1.39
1.31
1.31
1.20
1.18
1.16
1.15
1.13
1.12
1.01
1.00
0.98
0.89
0.78
O
O
Me
Me
H
HO
Me
Me
16
1.00
1.03
1.03
1.03
2.11
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2.17
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1.25
4.07
3.08
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8.5
8.0
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7.0
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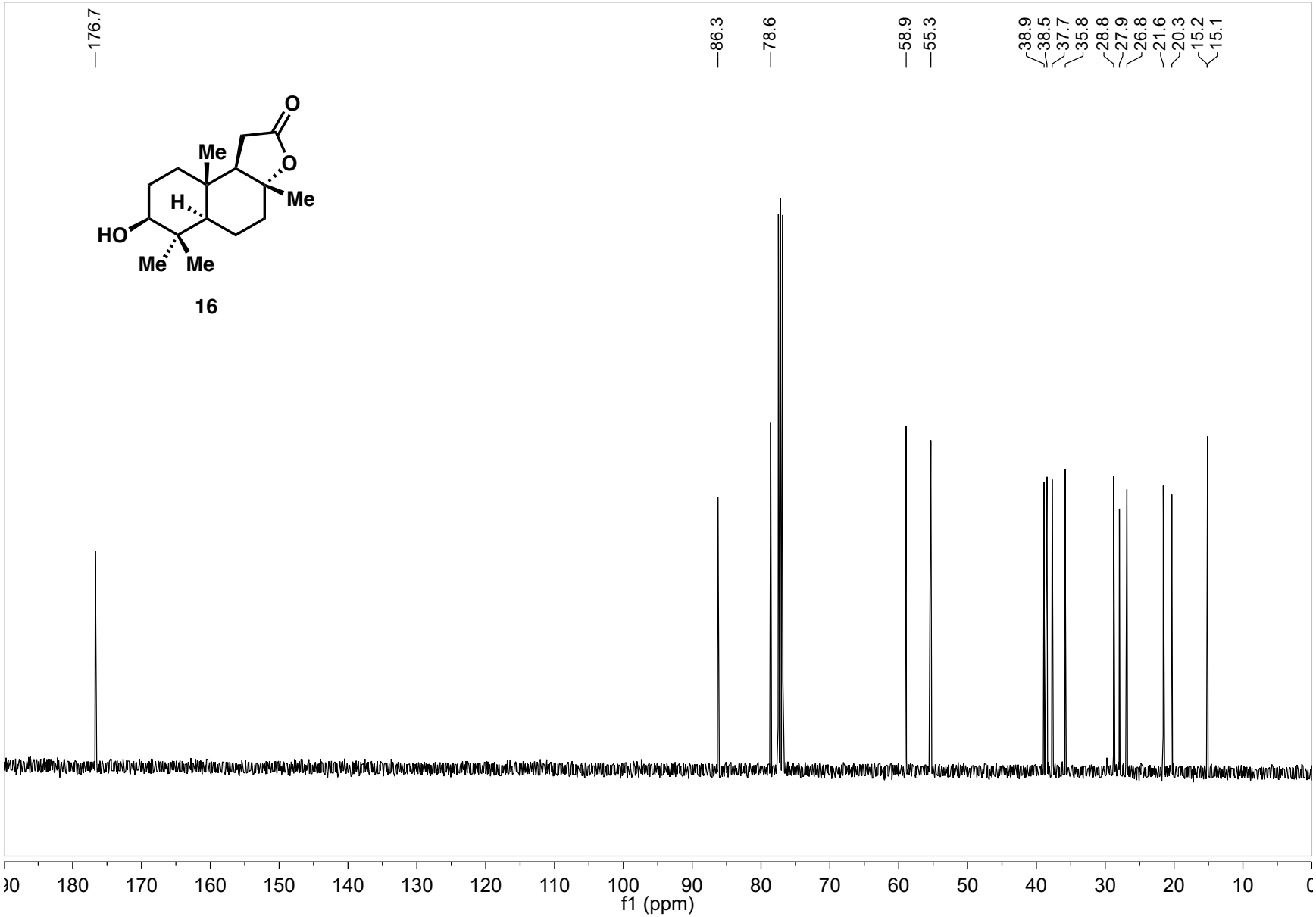
f1 (ppm)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21.6
20.3
15.2
15.1
O
O
Me
Me
H
HO
Me
Me
16
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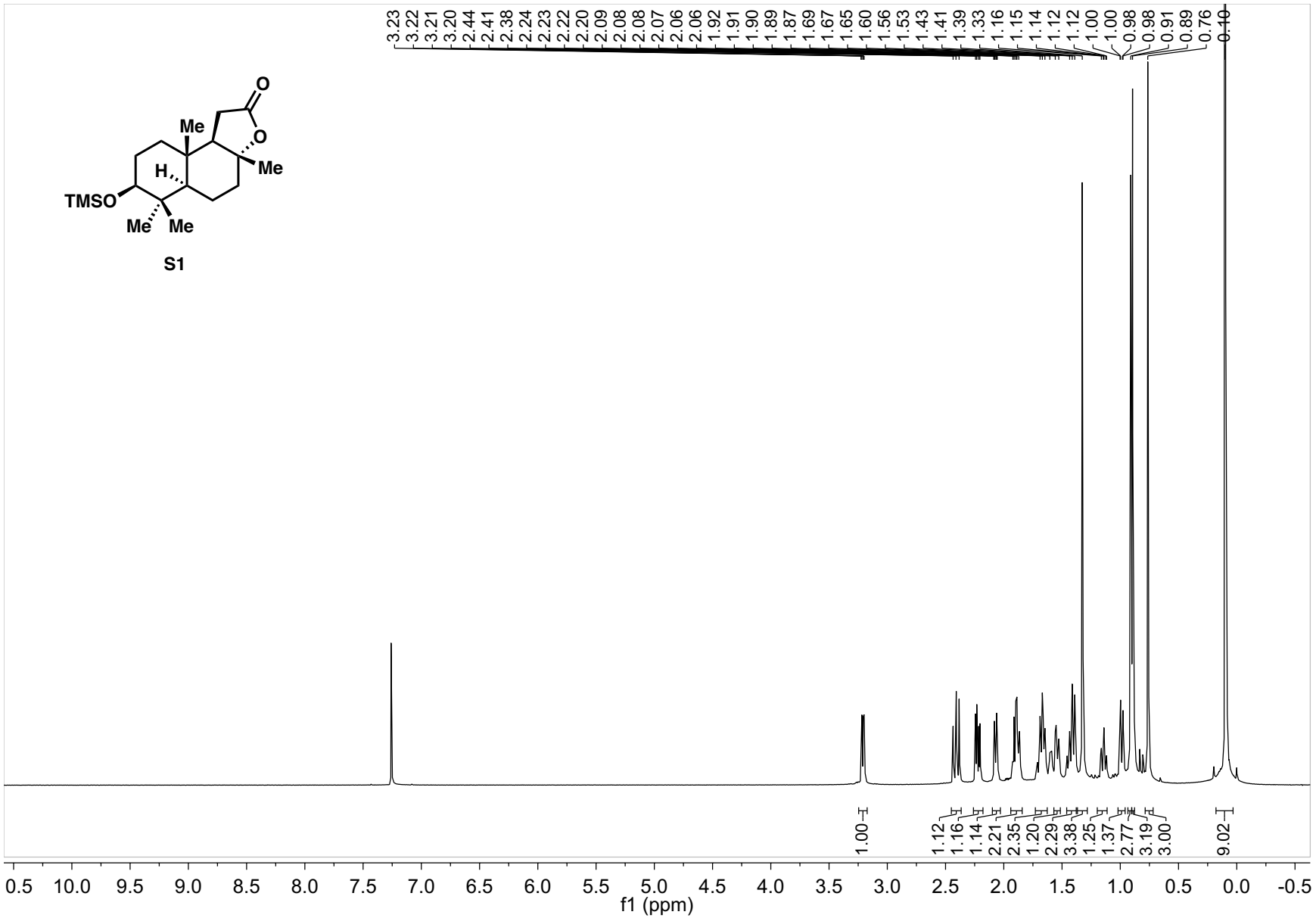
10
f1 (ppm)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Me
H
TMSO
Me
Me
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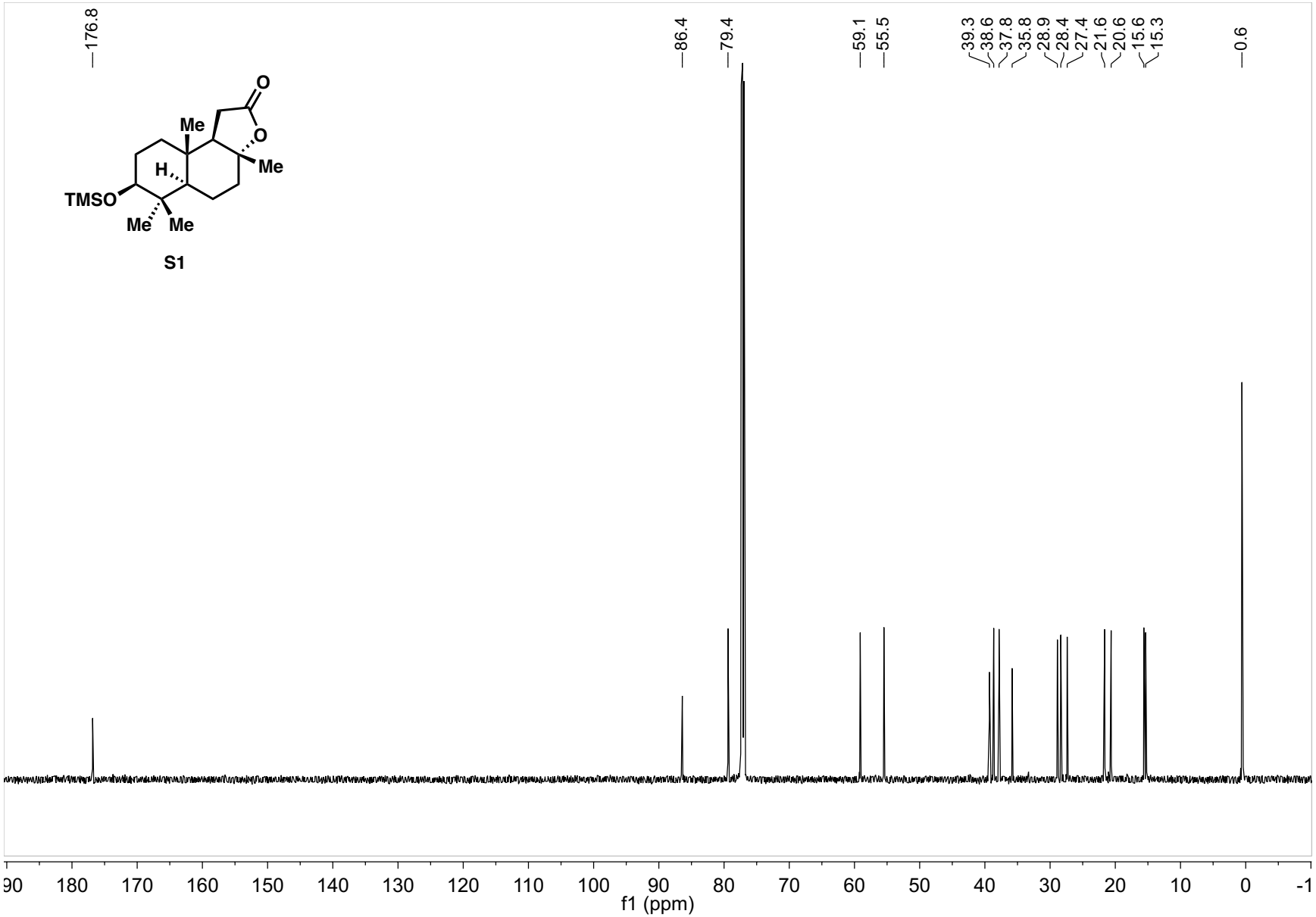
1.00 1.12 1.16 1.14 2.21 2.35 1.20 2.29 3.38 1.25 1.37 2.77 3.19 3.00 9.02
0.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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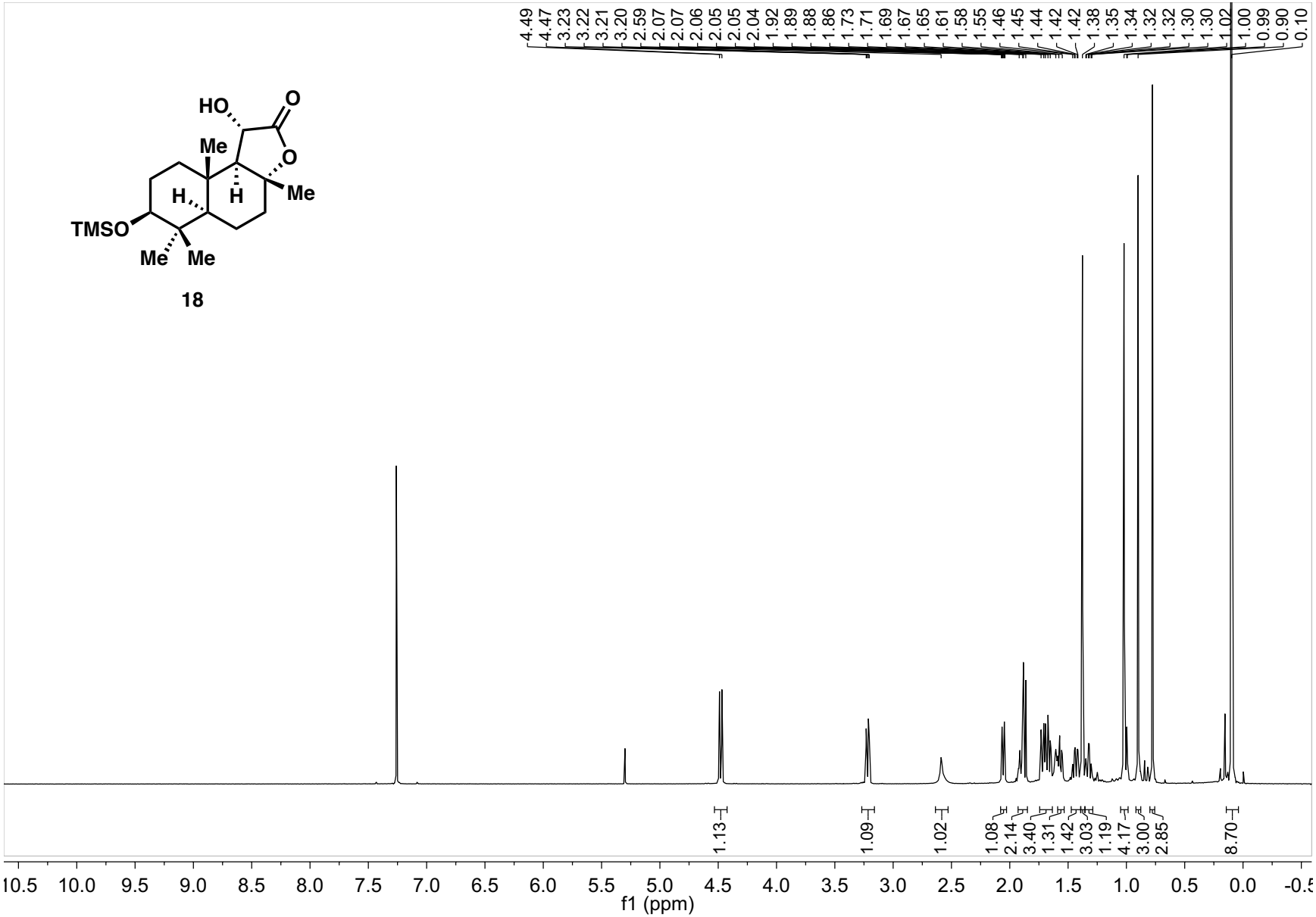
H
TMSO
Me
Me
S1
f1 (ppm)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2.07
2.07
2.06
2.05
2.05
2.04
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1.88
1.86
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1.71
1.69
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1.58
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1.32
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1.42
3.03
1.19
4.17
3.00
2.85
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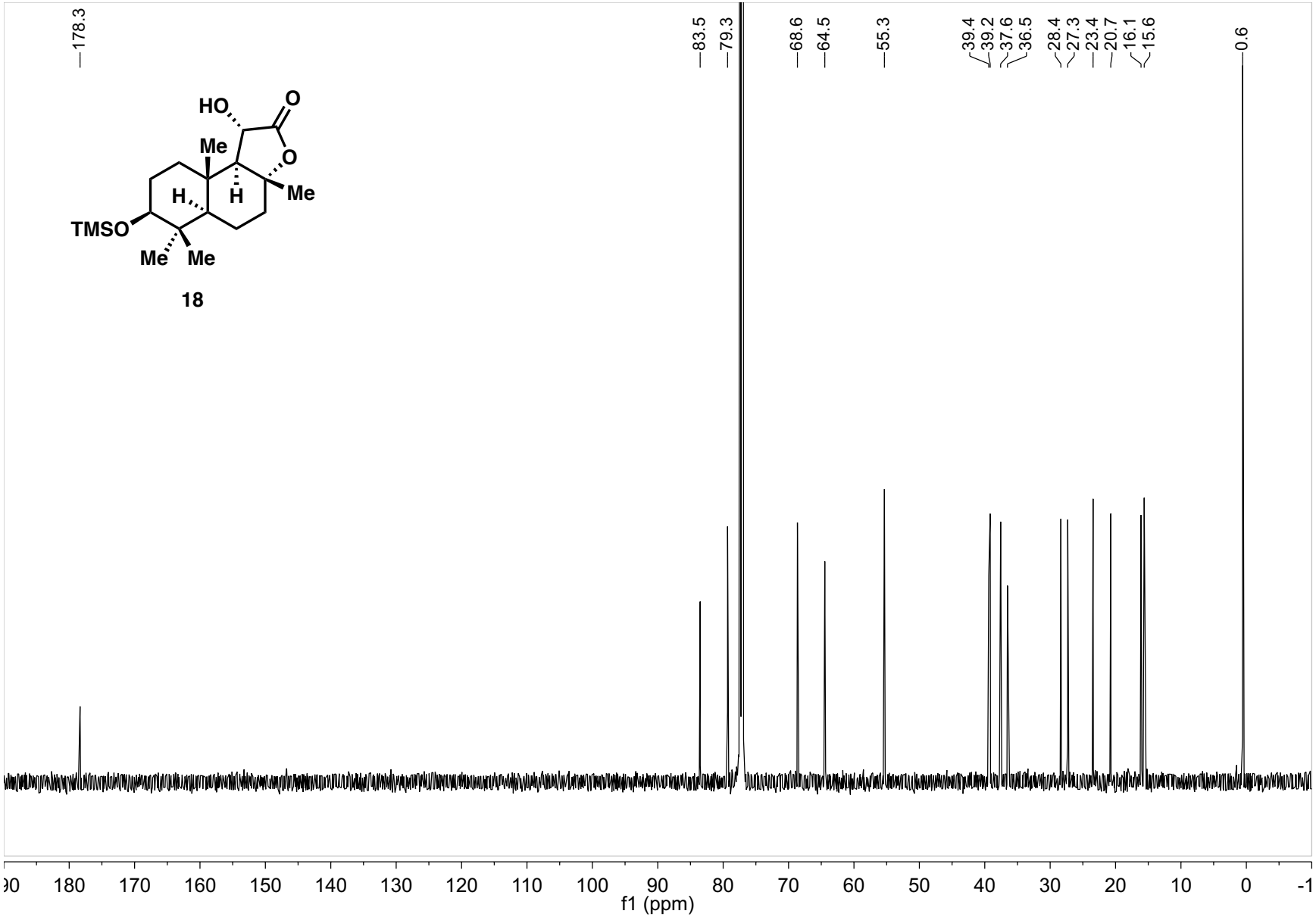
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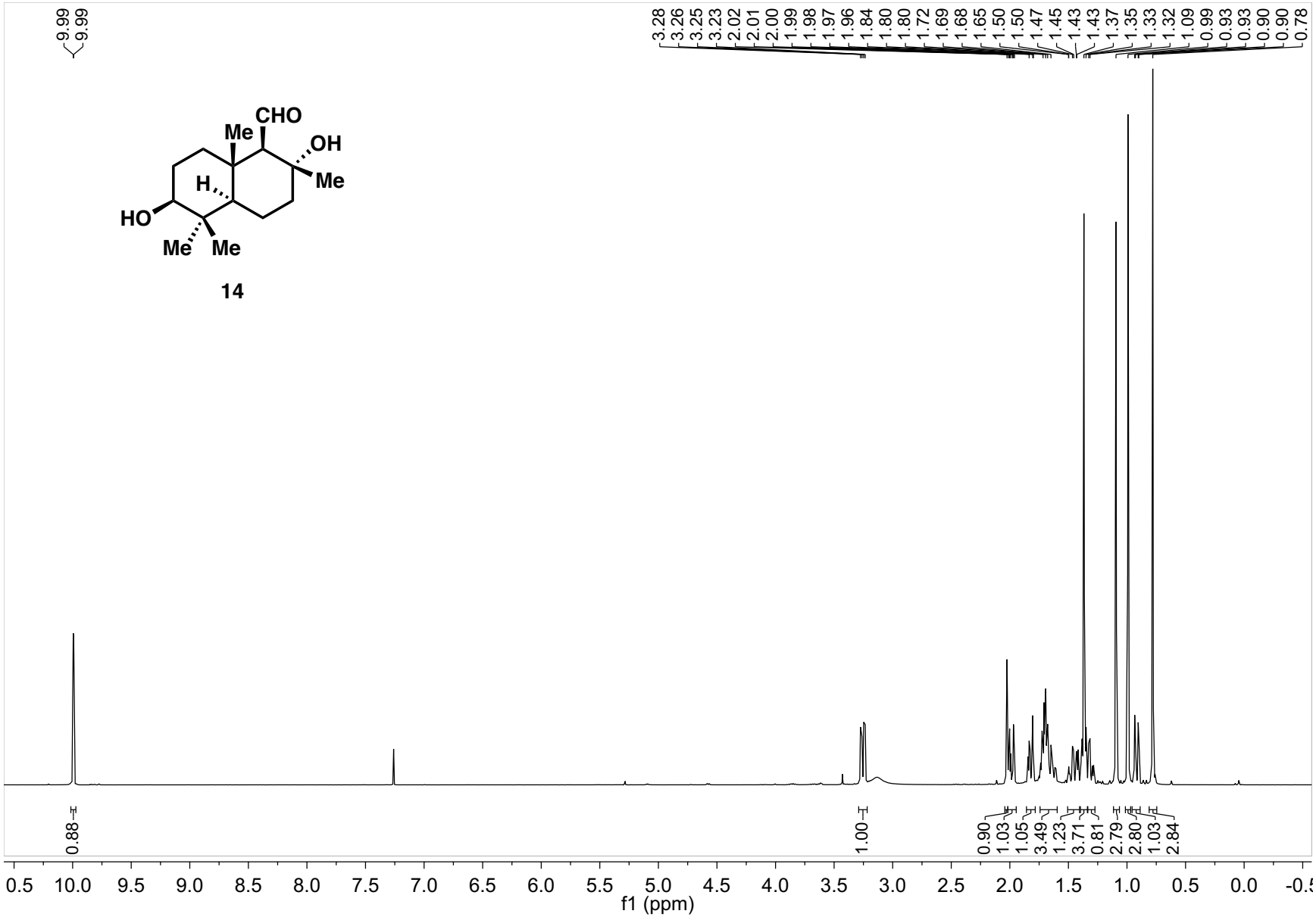
H
Me
TMSO
Me
Me
18
f1 (ppm)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1.47
1.45
1.43
1.43
1.37
1.35
1.33
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H
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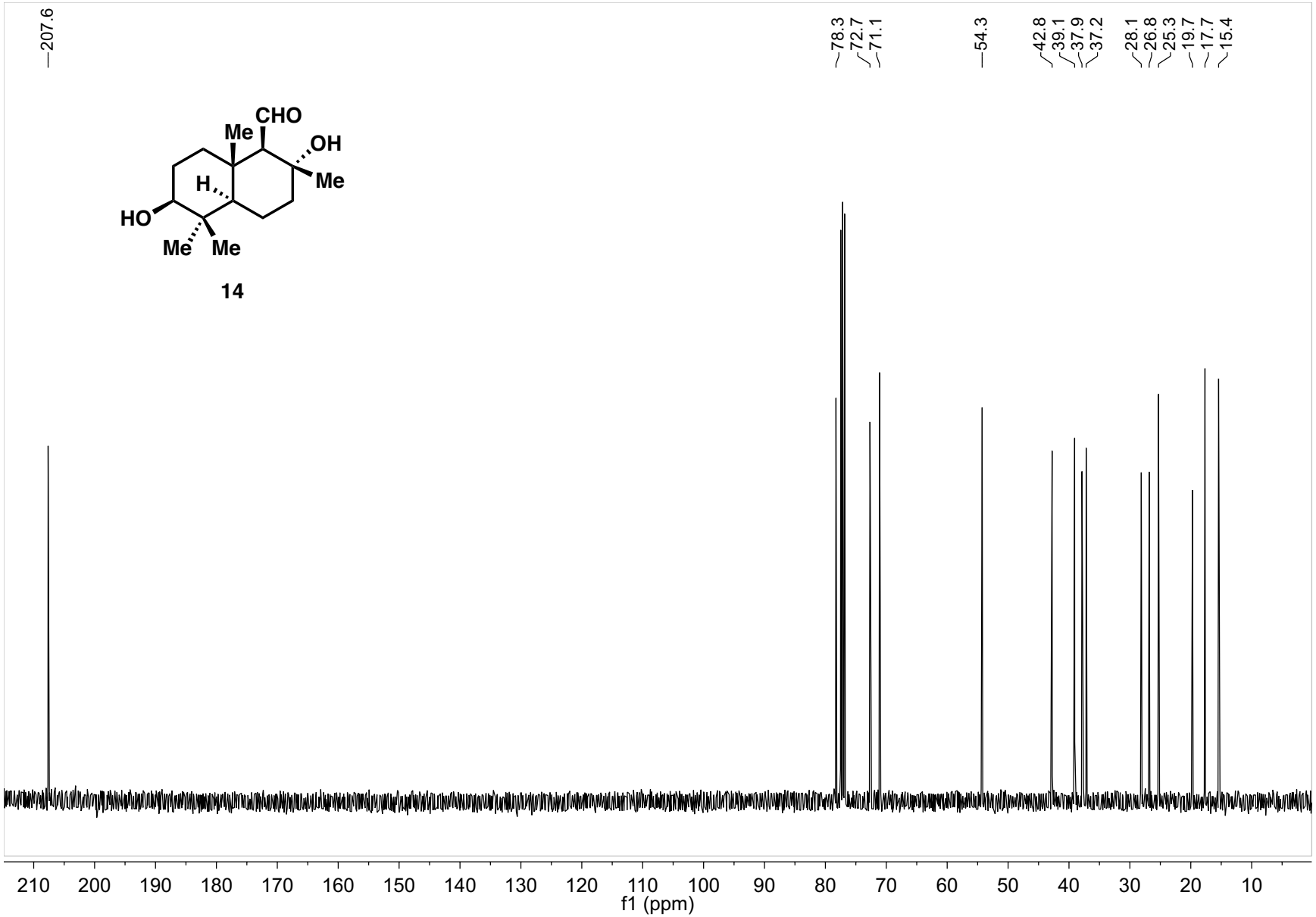
f1 (ppm)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HO
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Me
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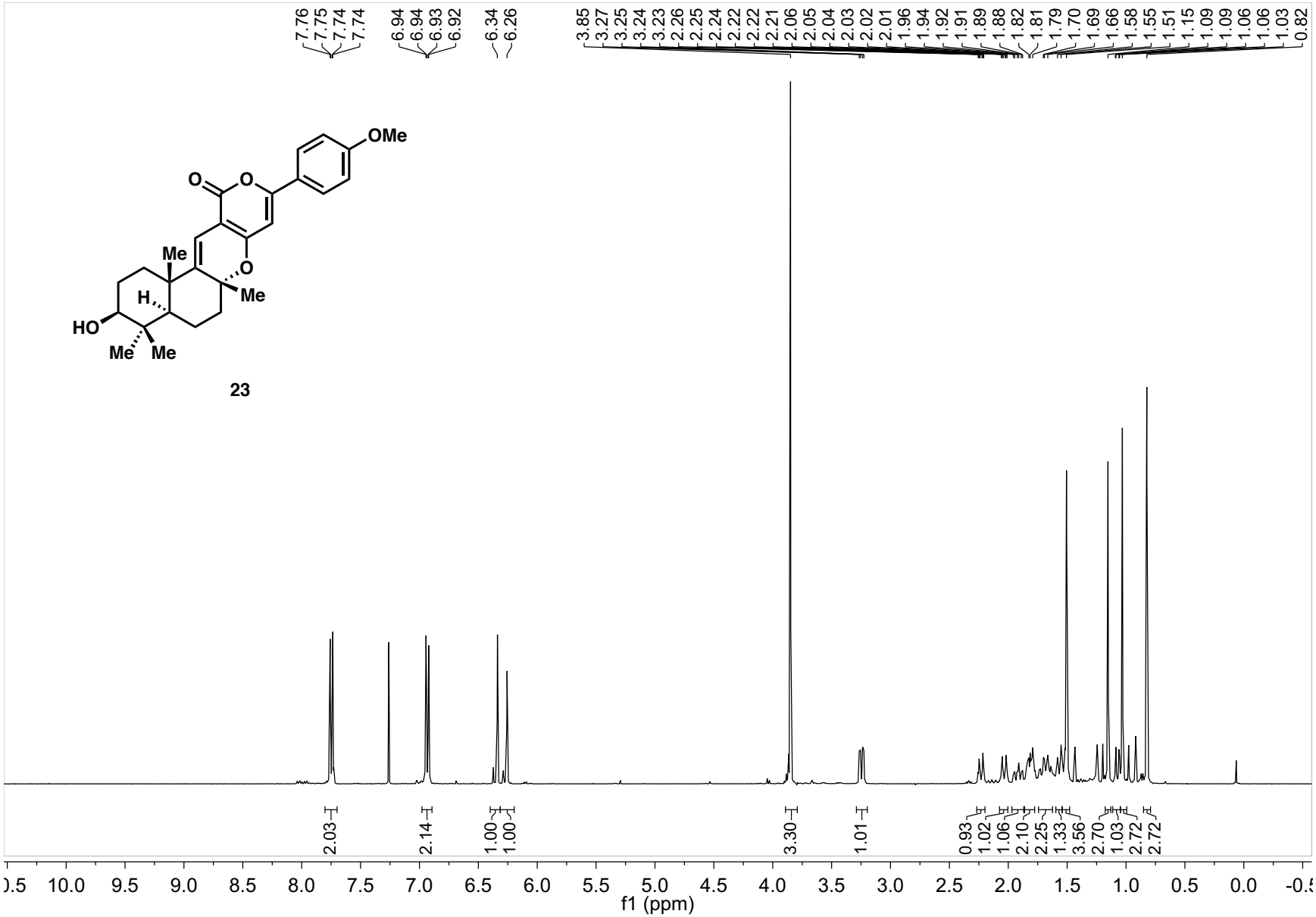
f1 (ppm)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2.24
2.22
2.22
2.21
2.06
2.05
2.04
2.03
2.02
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1.15
1.09
1.09
1.06
1.06
1.03
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Me
O
Me
H
HO
Me
Me
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2.14
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1.00
3.30
1.01
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1.03
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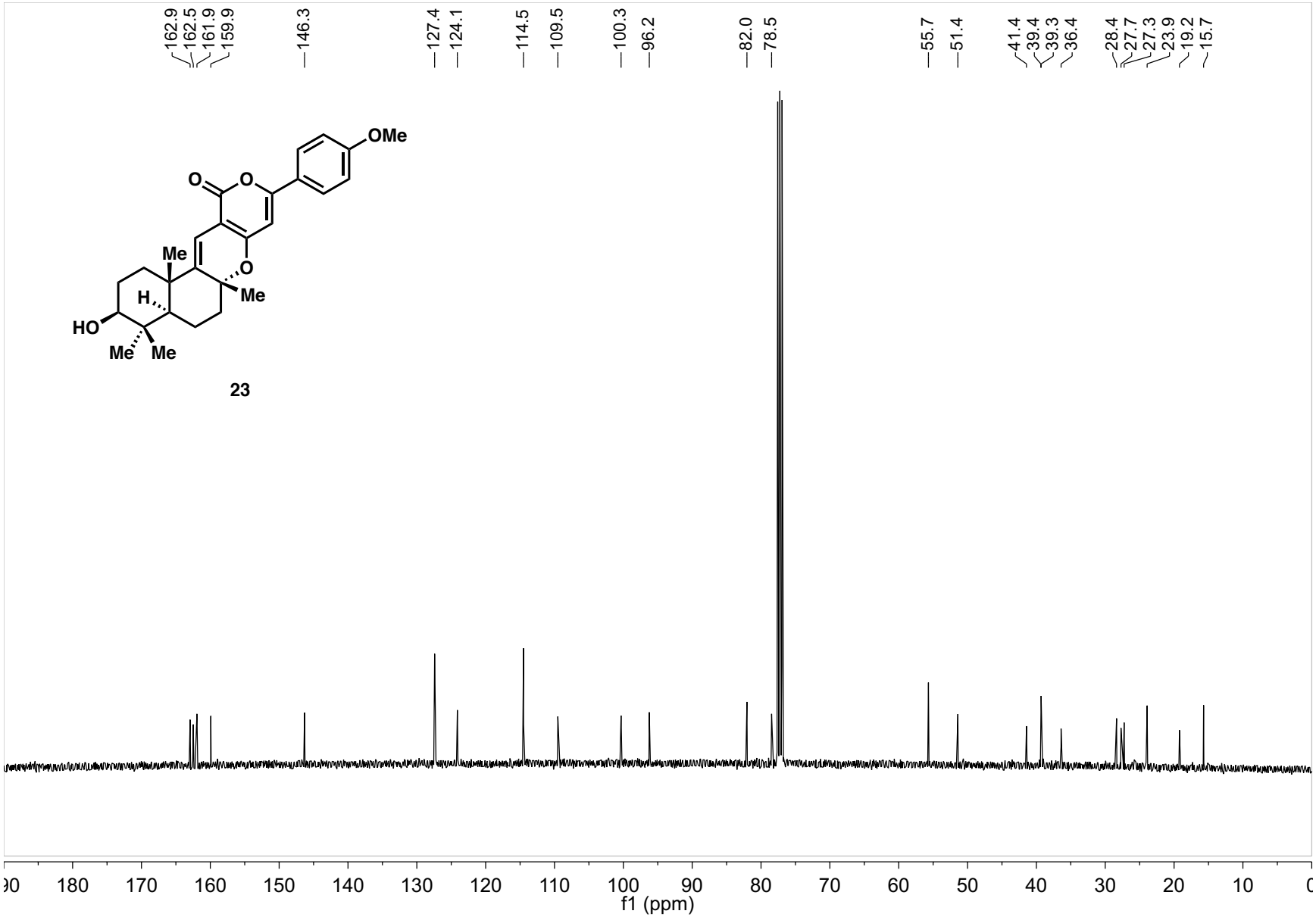
f1 (ppm)

23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51.4
41.4
39.4
39.3
36.4
28.4
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19.2
15.7
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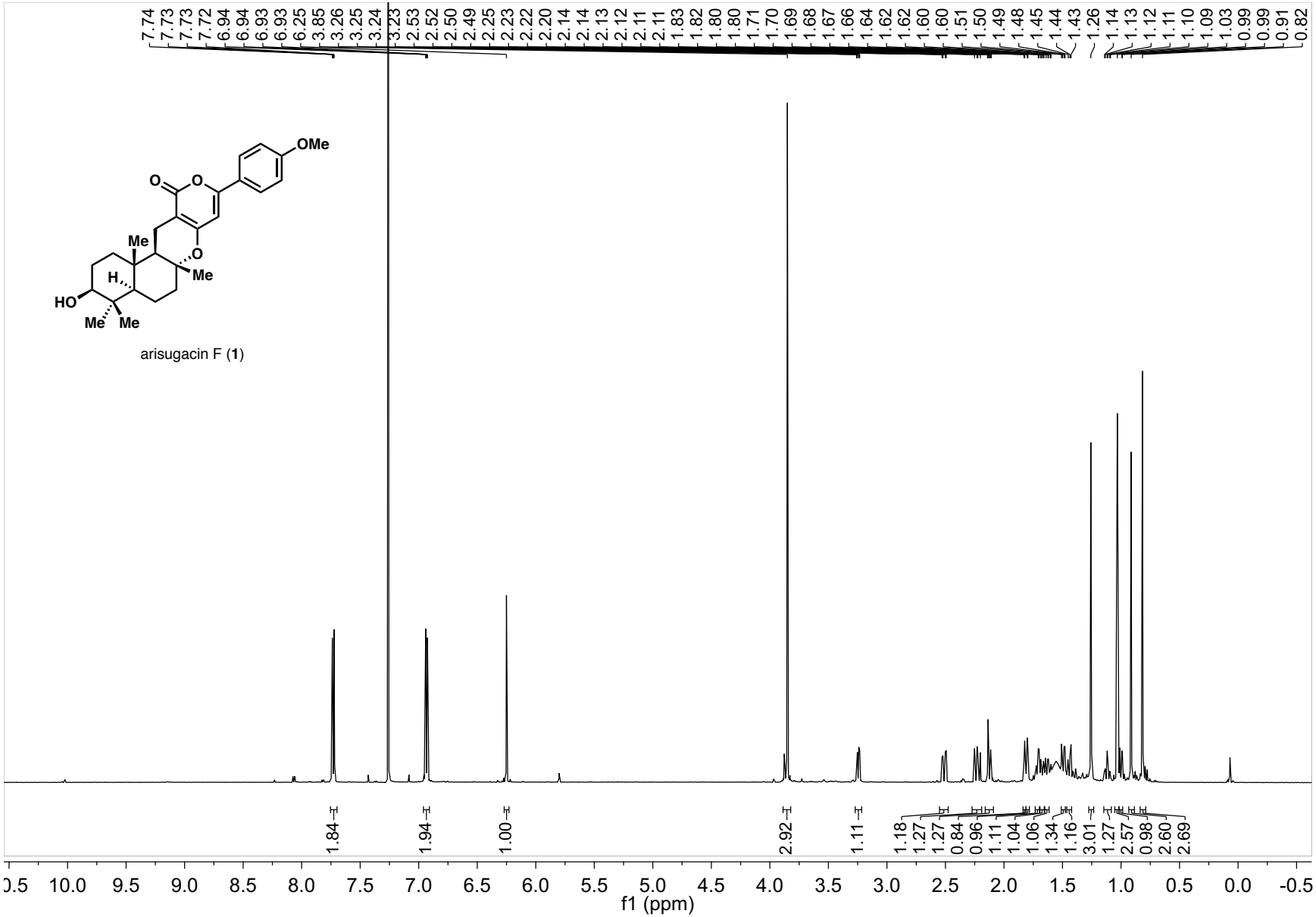
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OMe
O
O
Me
O
H
Me
HO
Me
Me
arisugacin F (1)
1.84
1.94
1.00
2.92
1.11
1.18 1.27 1.27 0.84 0.96 1.11 1.04 1.06 1.34 1.16
3.01
1.27 2.57 0.98 2.60 2.69
0.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
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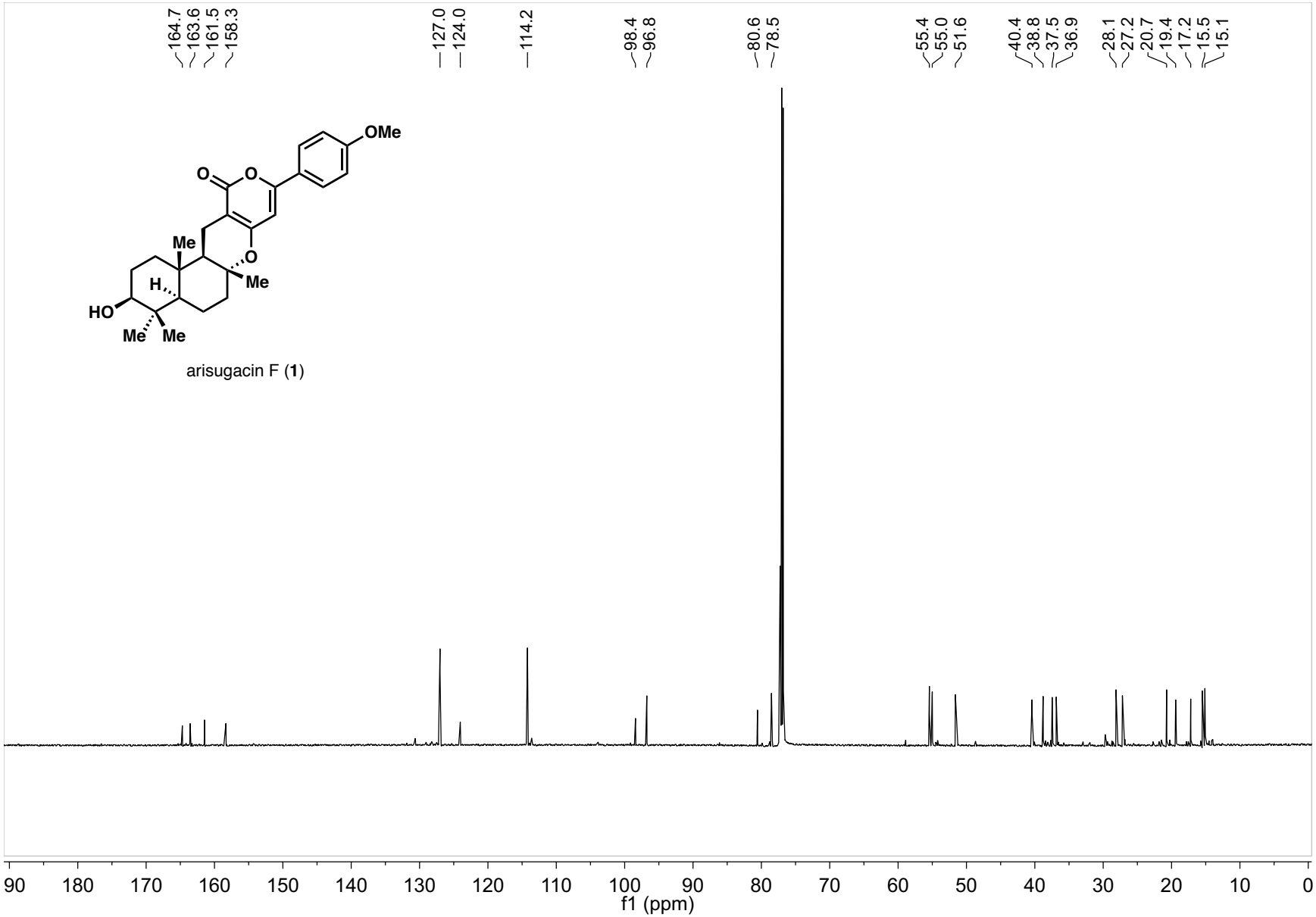
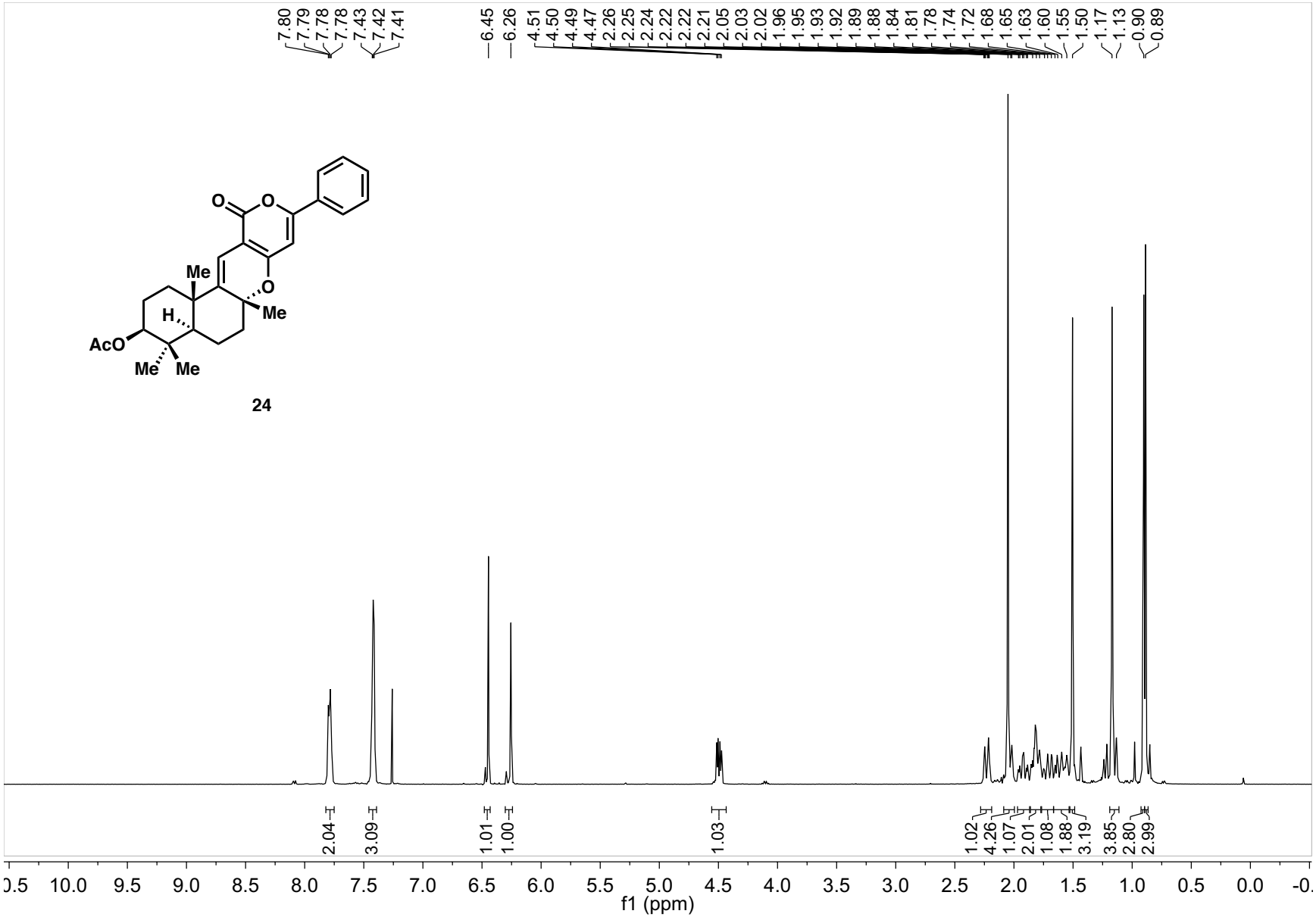


arisugacin F (**1**)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O
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H
AcO
Me
Me
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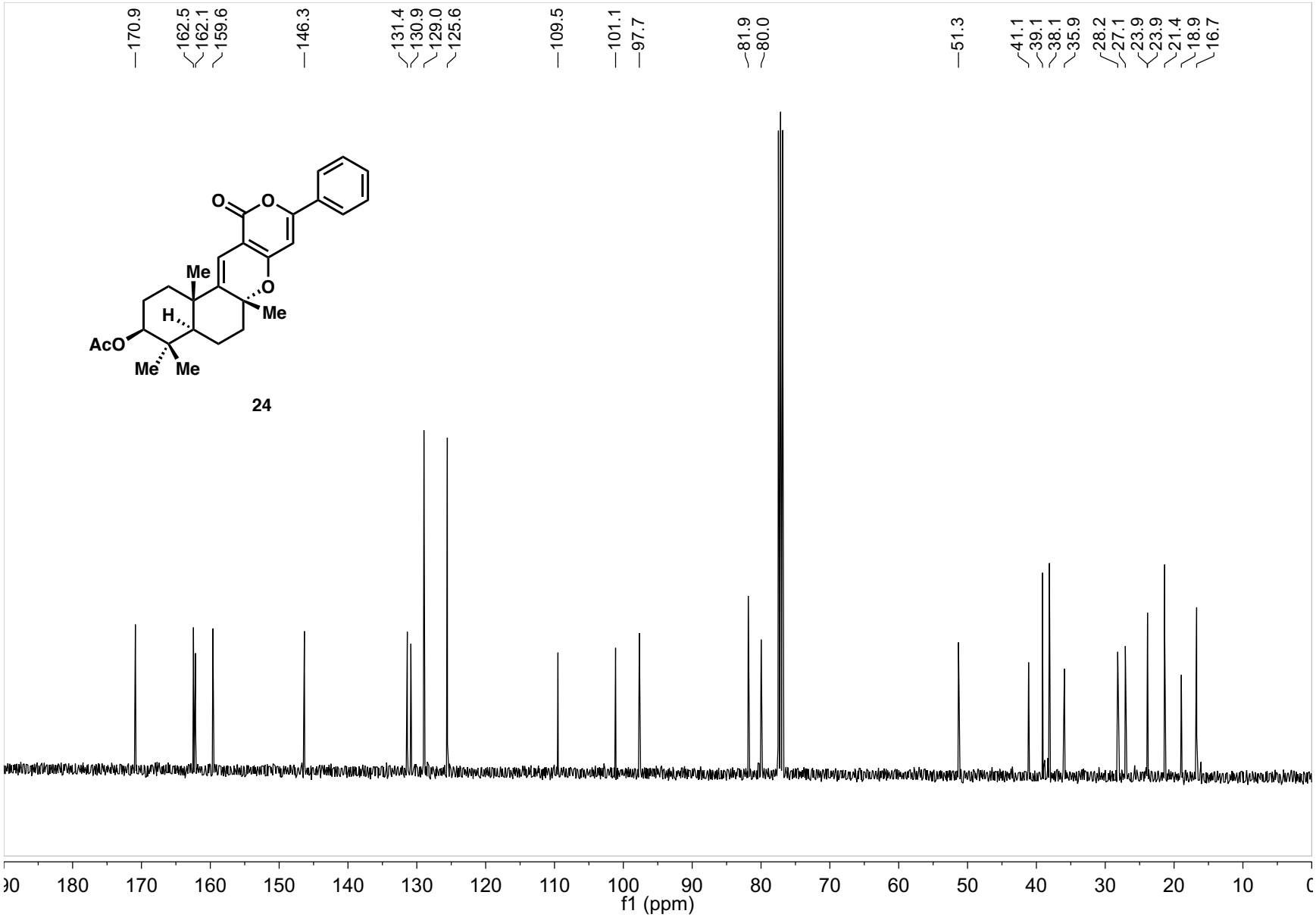
2.99
f1 (ppm)

24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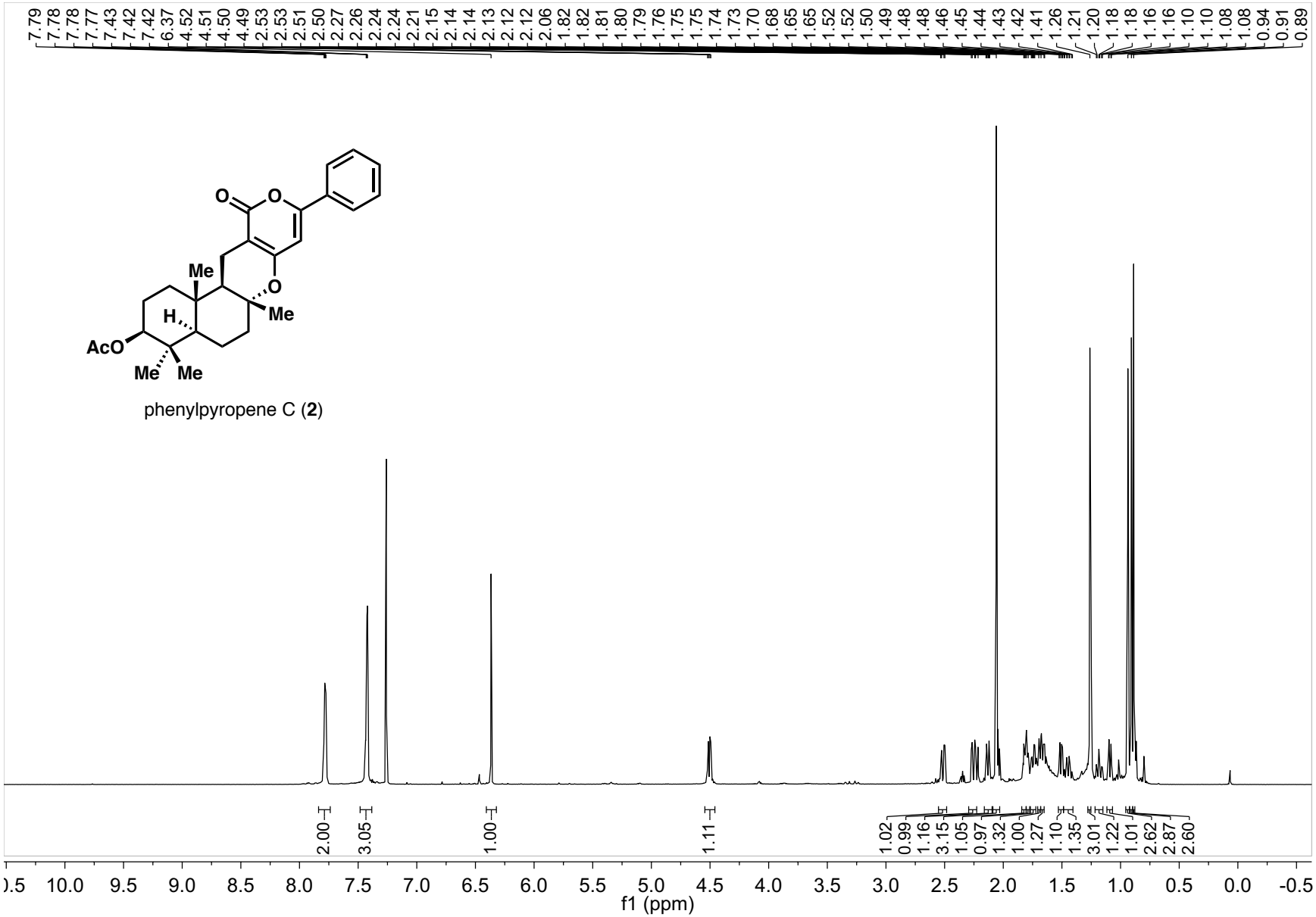

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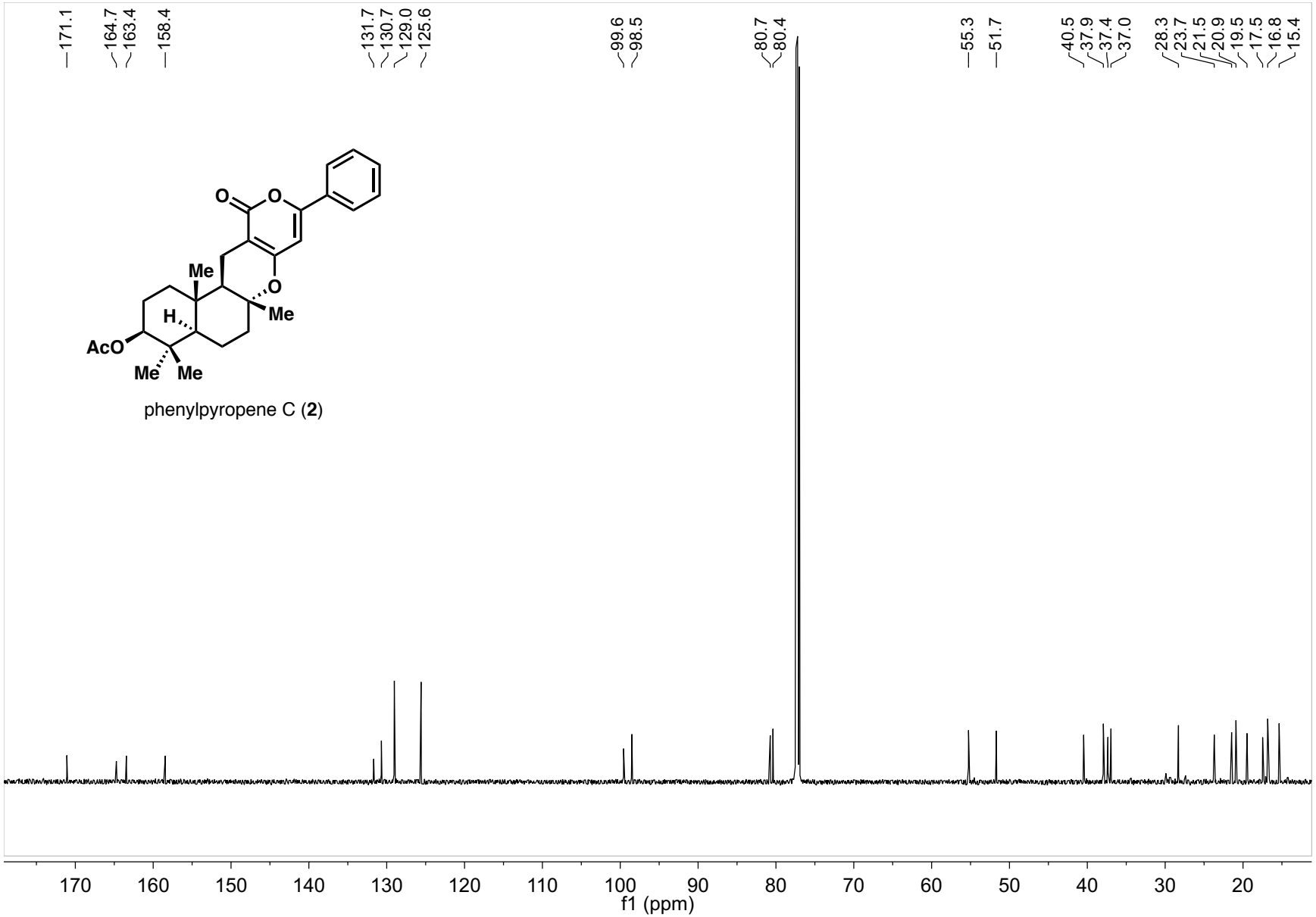
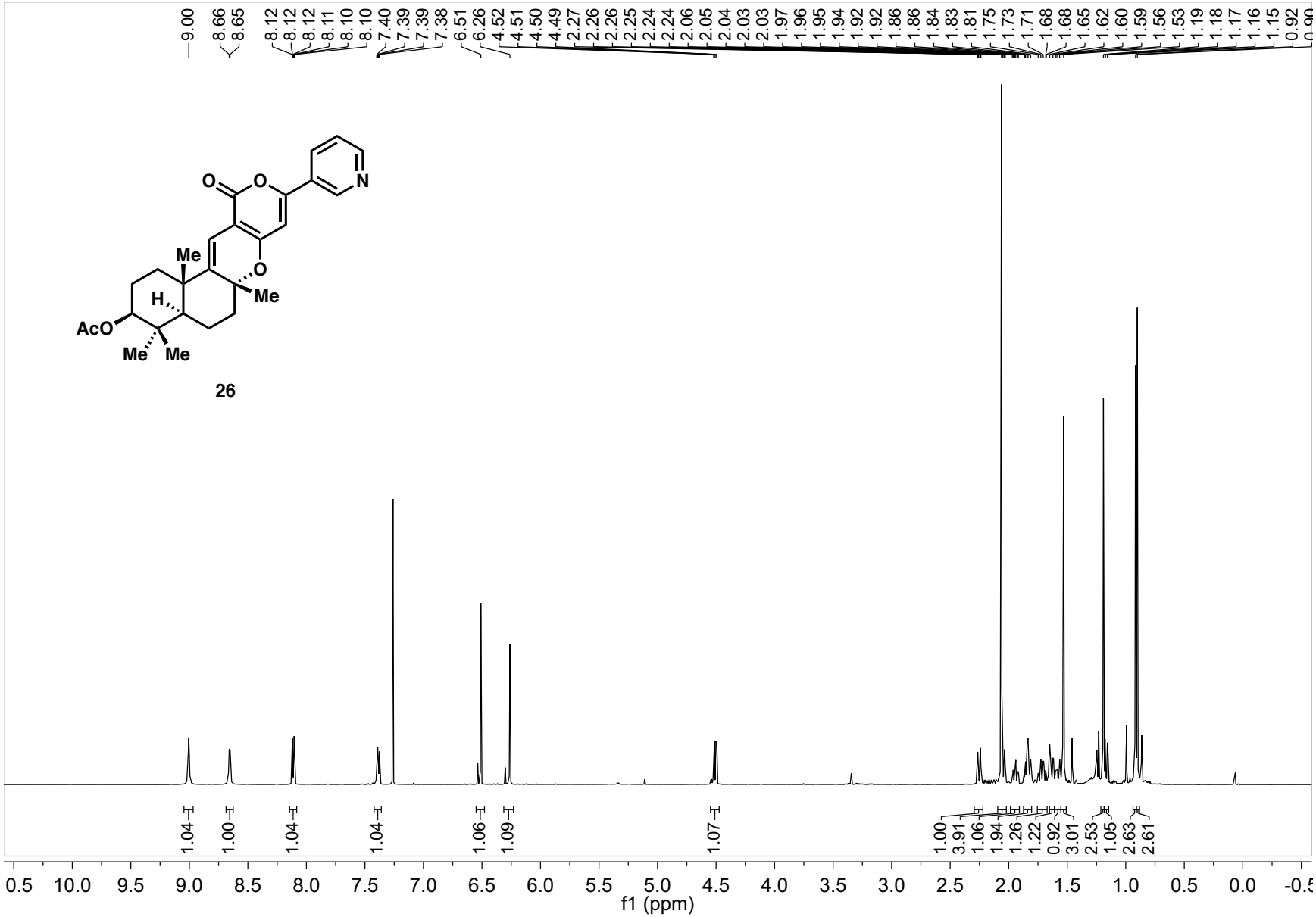


phenylpyropene C (**2**)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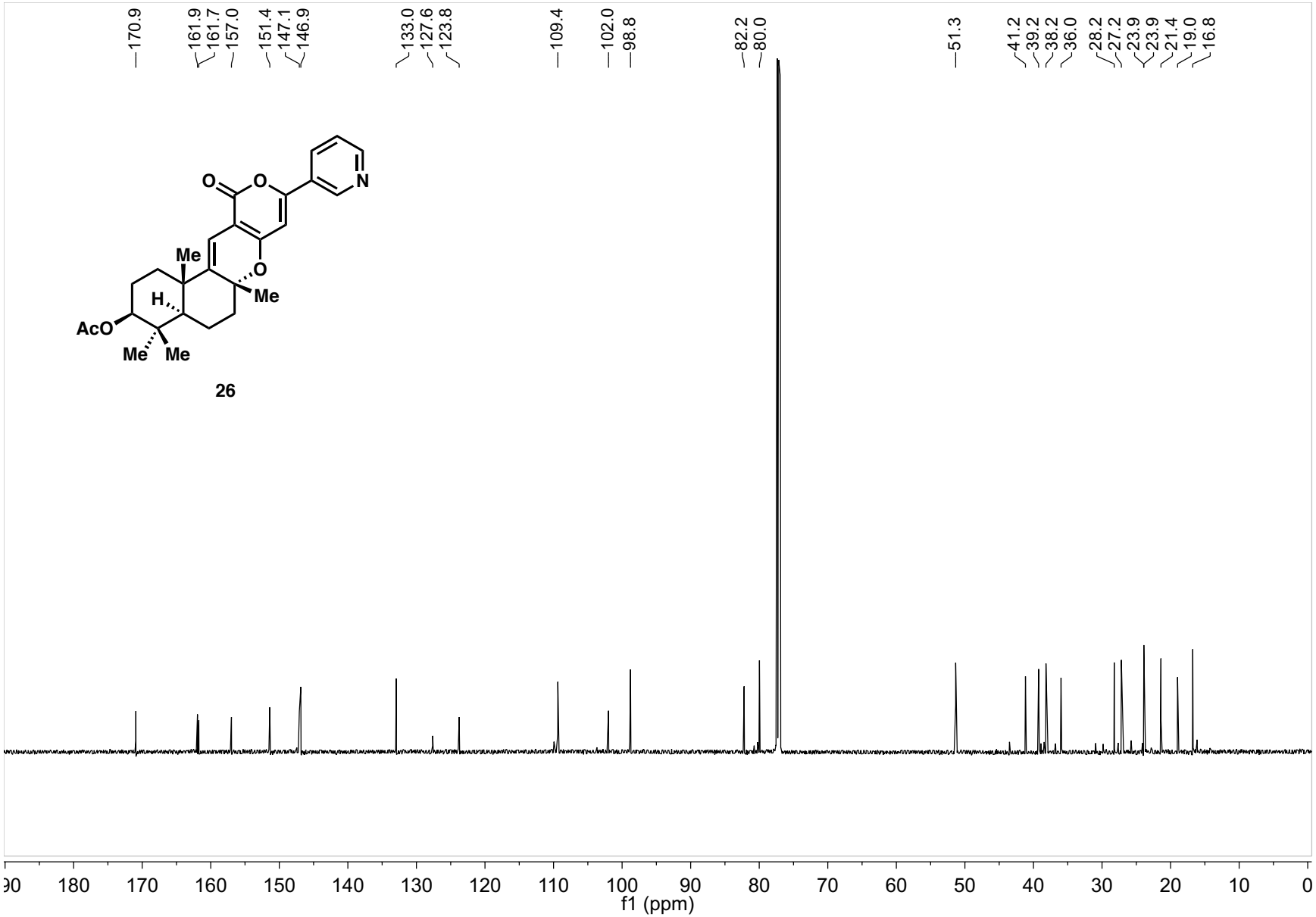
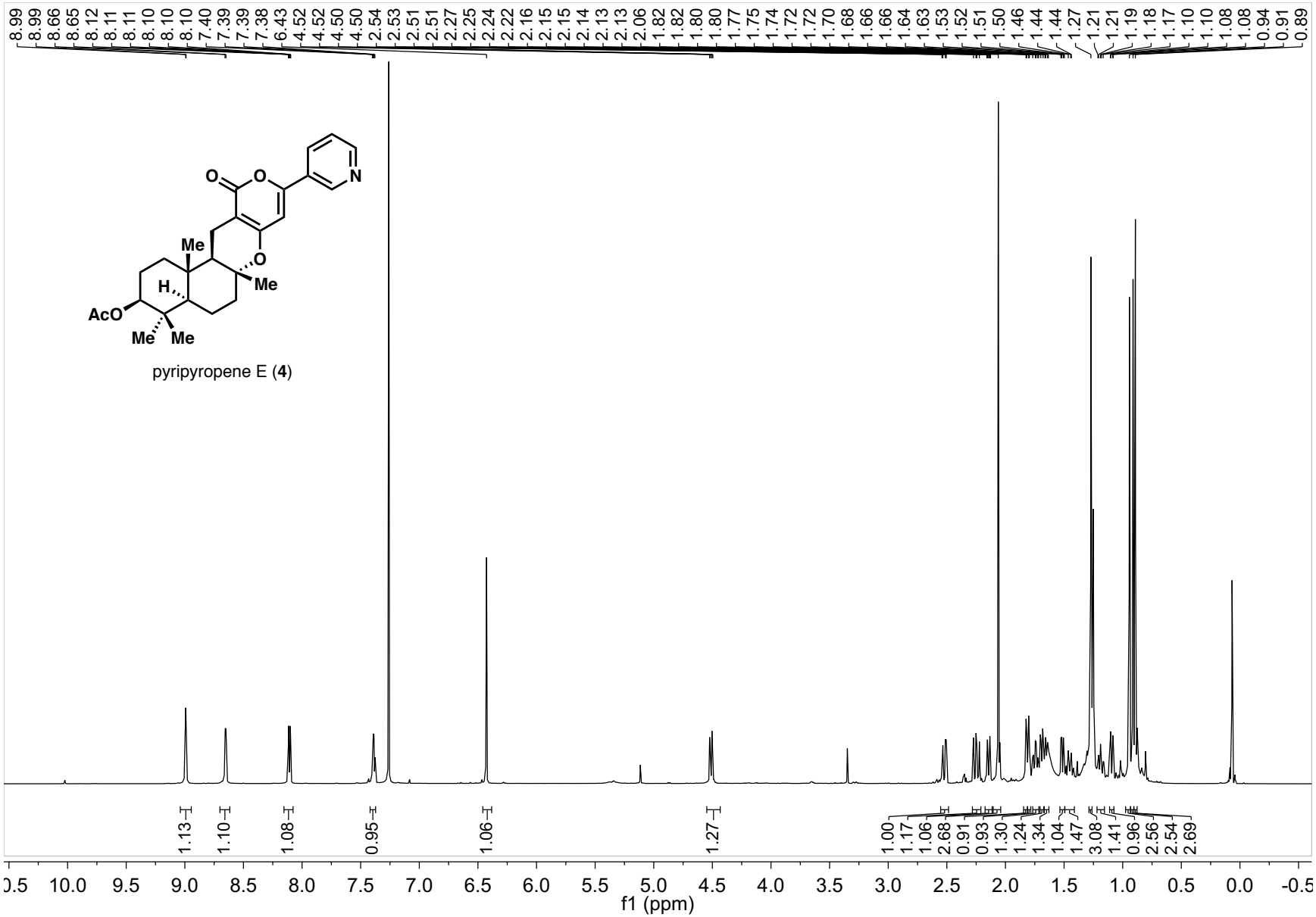
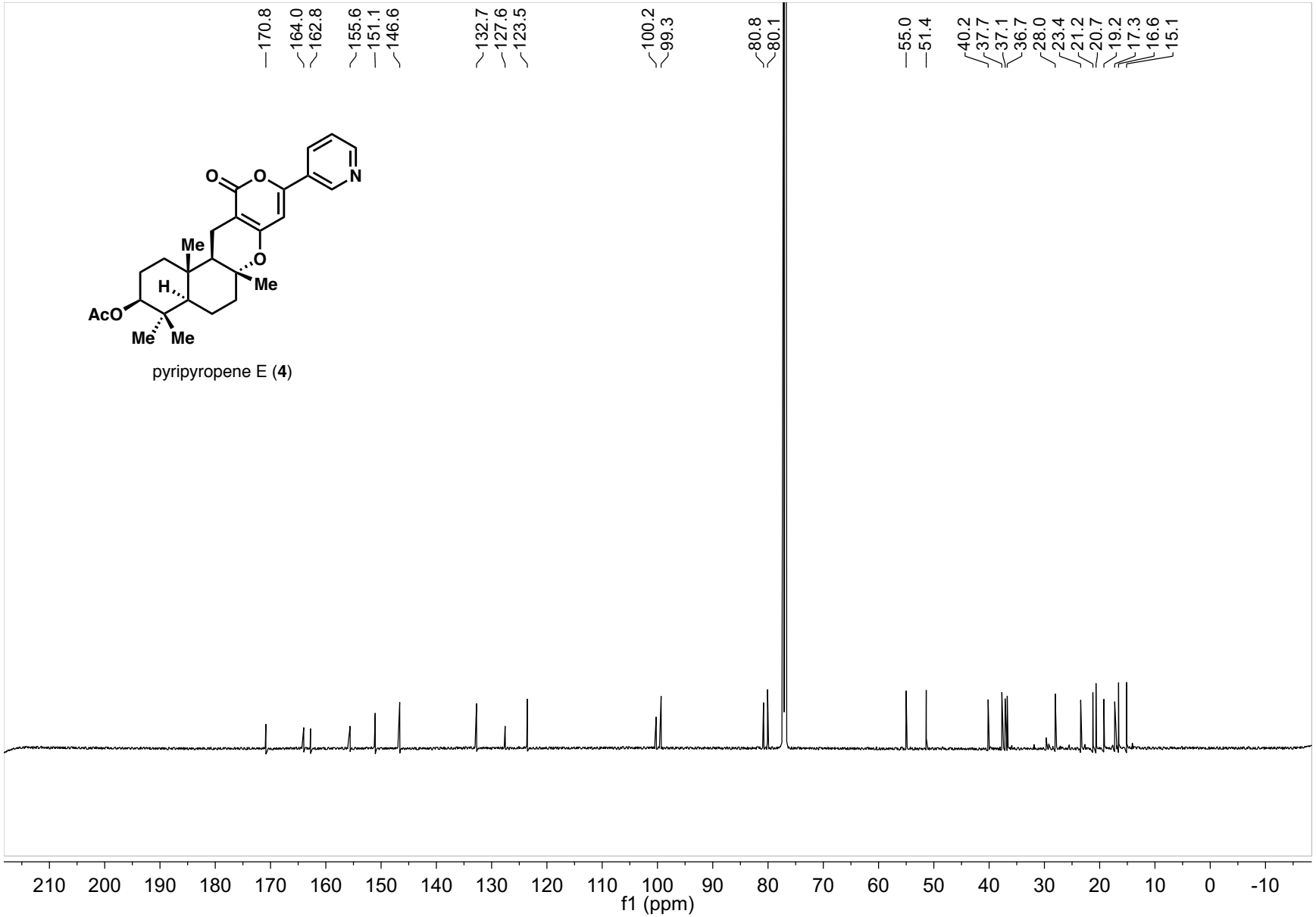
3.01
2.53
1.05
2.63
2.61
f1 (ppm)

26

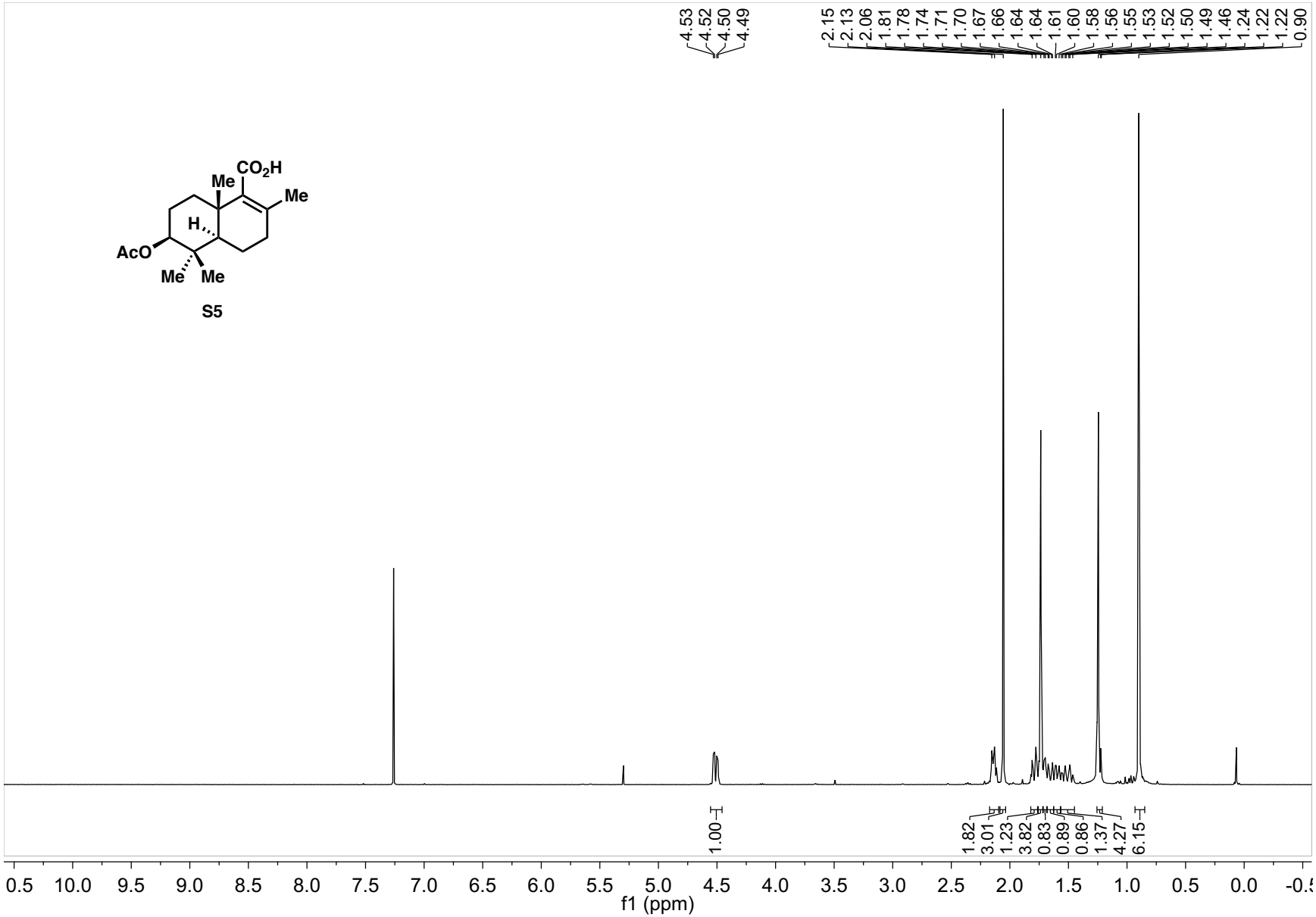

170.9
161.9
161.7
157.0
151.4
147.1
146.9
133.0
127.6
123.8
109.4
102.0
98.8
82.2
80.0
51.3
41.2
39.2
38.2
36.0
28.2
27.2
23.9
23.9
21.4
19.0
16.8
O
O
N
Me
O
Me
H
AcO
Me
Me
f1 (ppm)

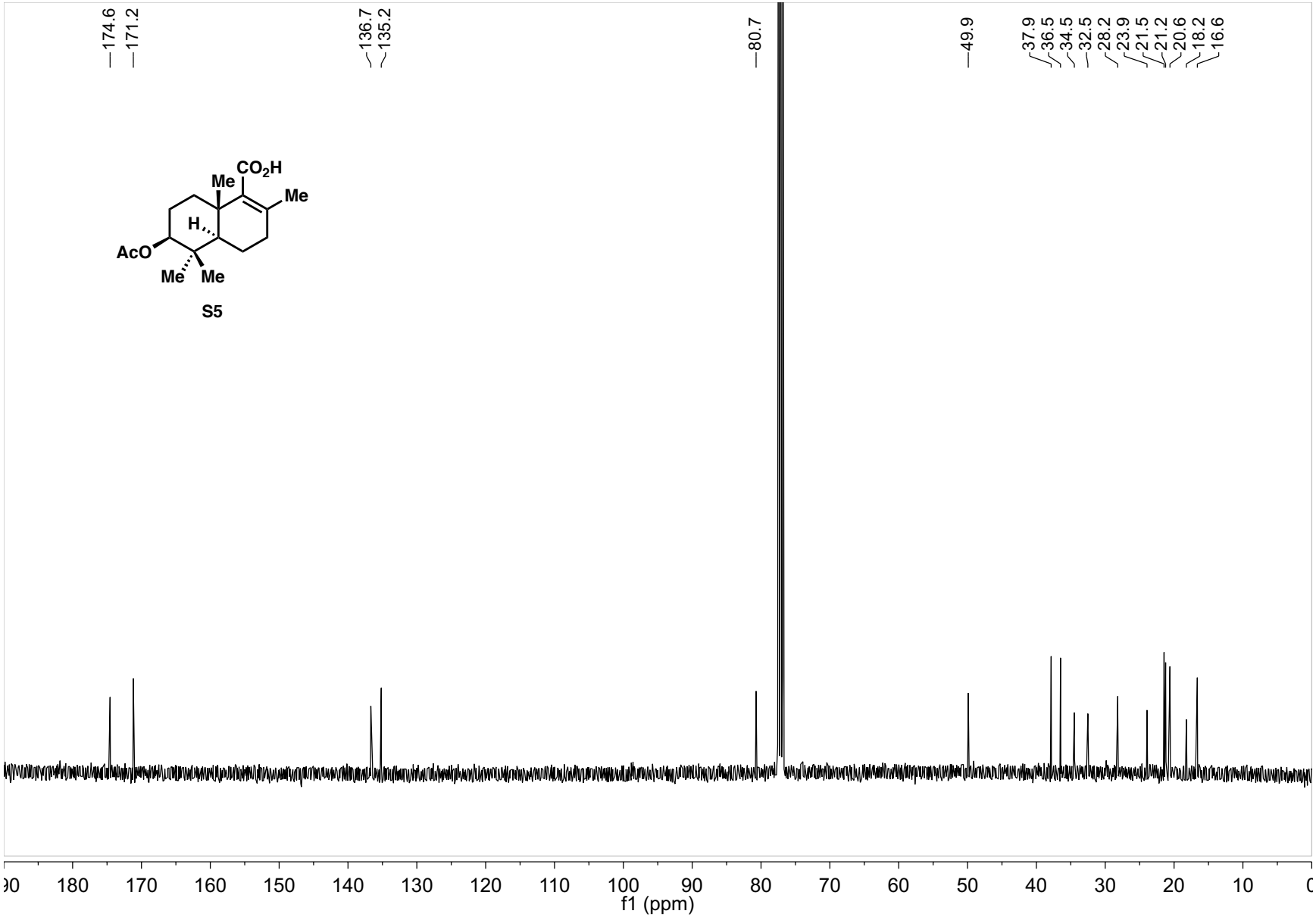
26

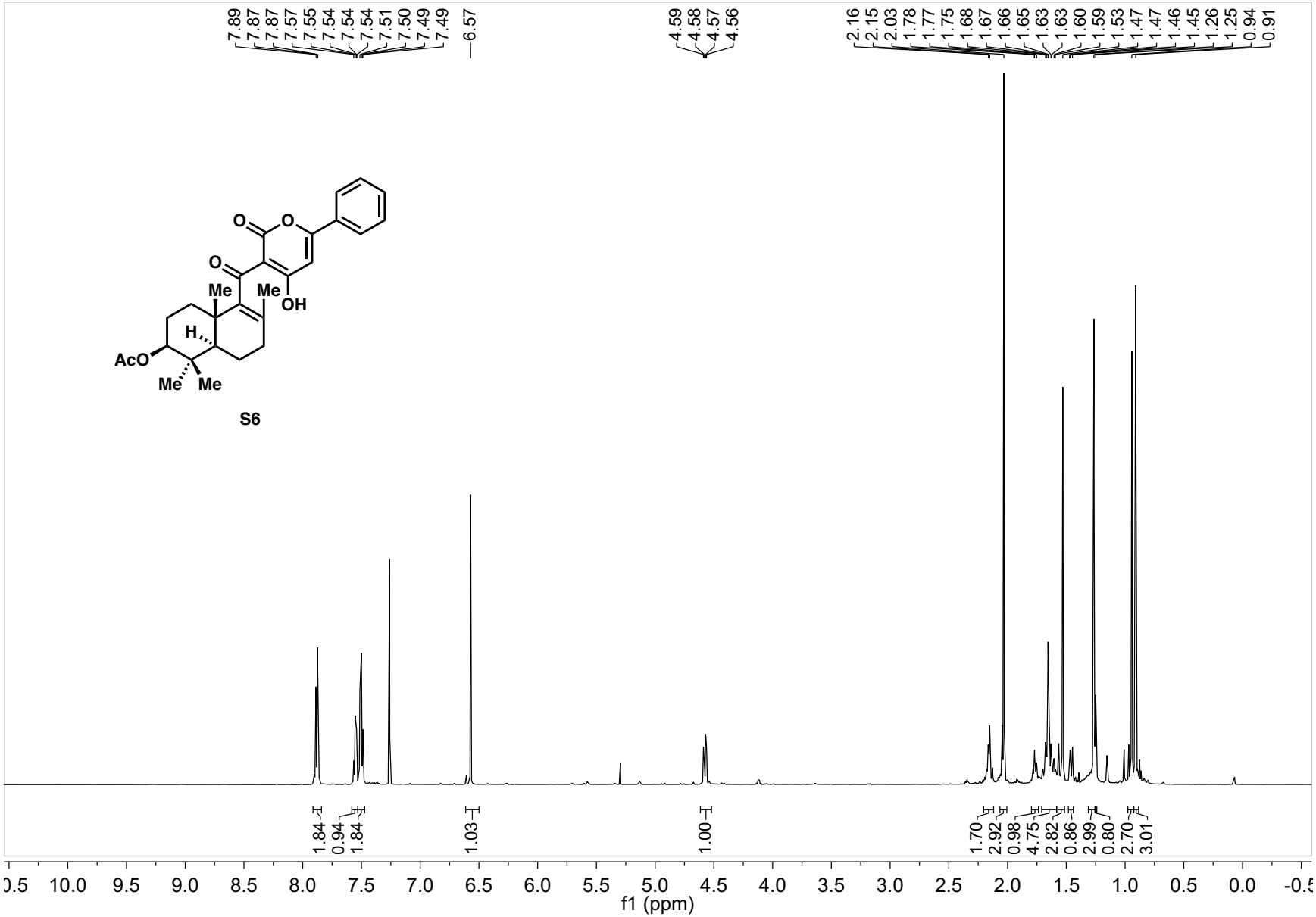

pyripyropene E (4)
f1 (ppm)



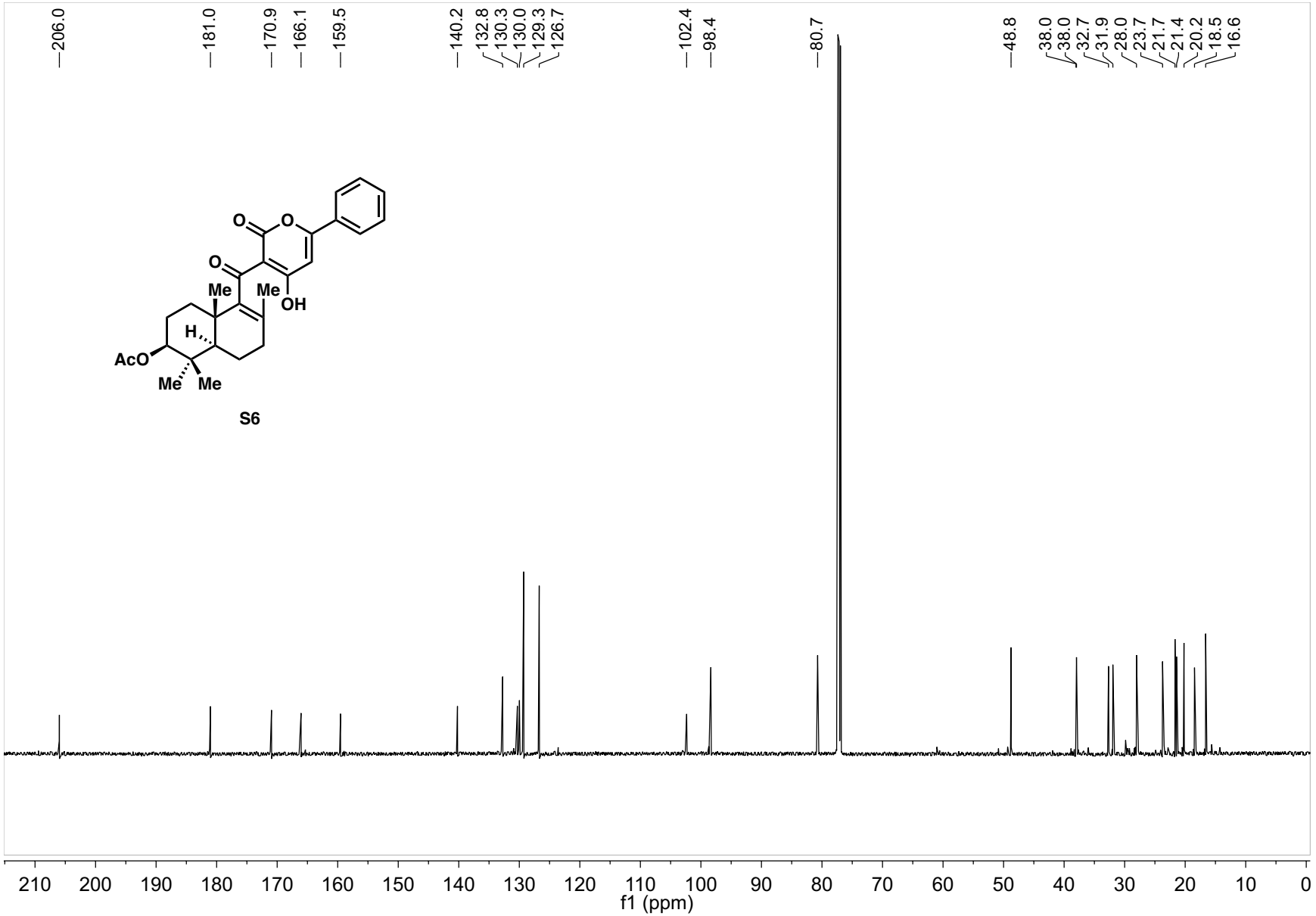
pyripyropene E (**4**)

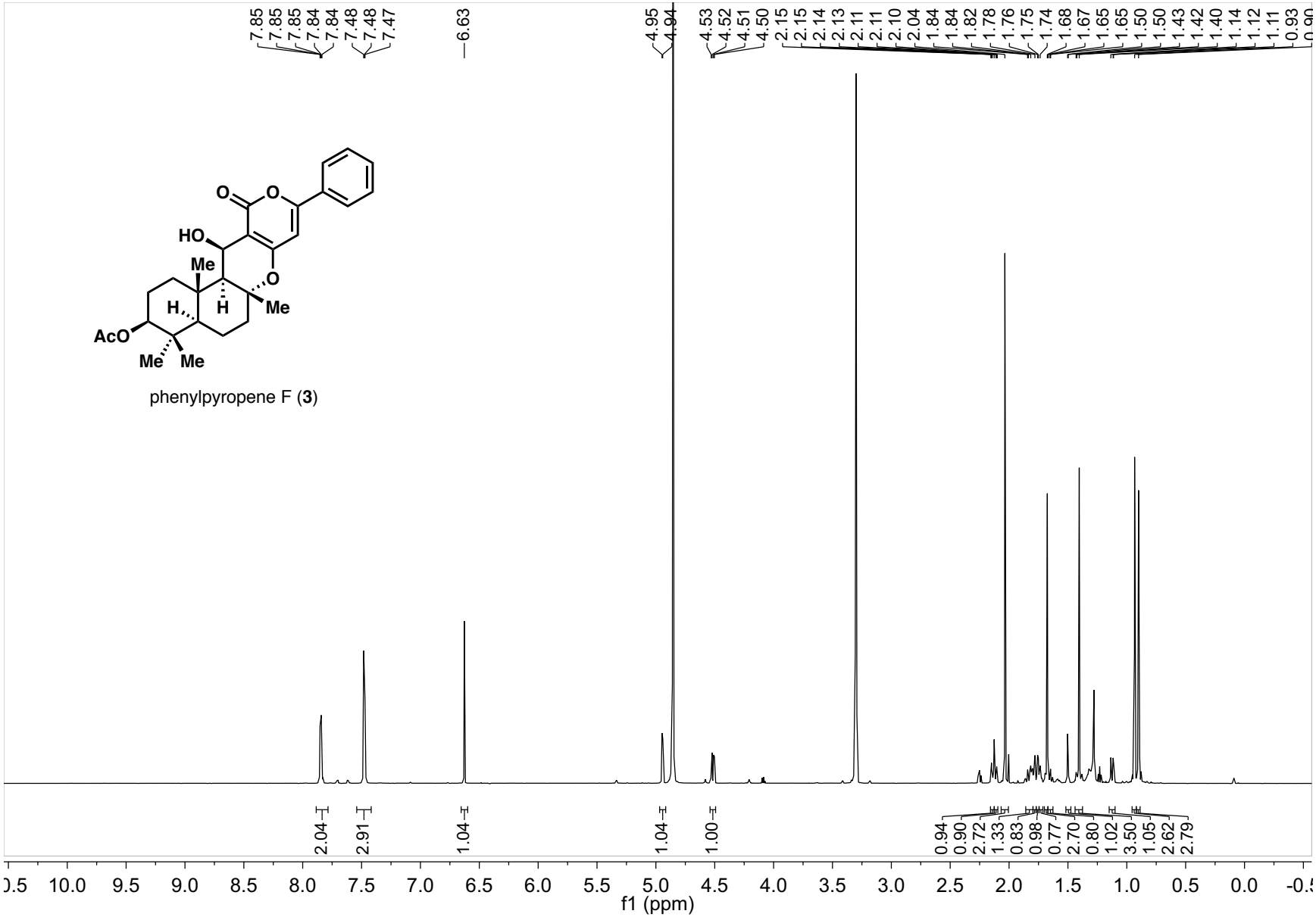

4.53
4.52
4.50
4.49
2.15
2.13
2.06
1.81
1.78
1.74
1.71
1.70
1.67
1.66
1.64
1.64
1.61
1.60
1.58
1.56
1.55
1.53
1.52
1.50
1.49
1.46
1.24
1.22
1.22
0.90
CO2H
Me
Me
H
AcO
Me
Me
S5
1.00
1.82
3.01
1.23
3.82
0.83
0.89
0.86
1.37
4.27
6.15
f1 (ppm)


174.6
171.2
136.7
135.2
80.7
49.9
37.9
36.5
34.5
32.5
28.2
23.9
21.5
21.2
20.6
18.2
16.6
CO2H
Me
Me
H
AcO
Me
Me
S5
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)

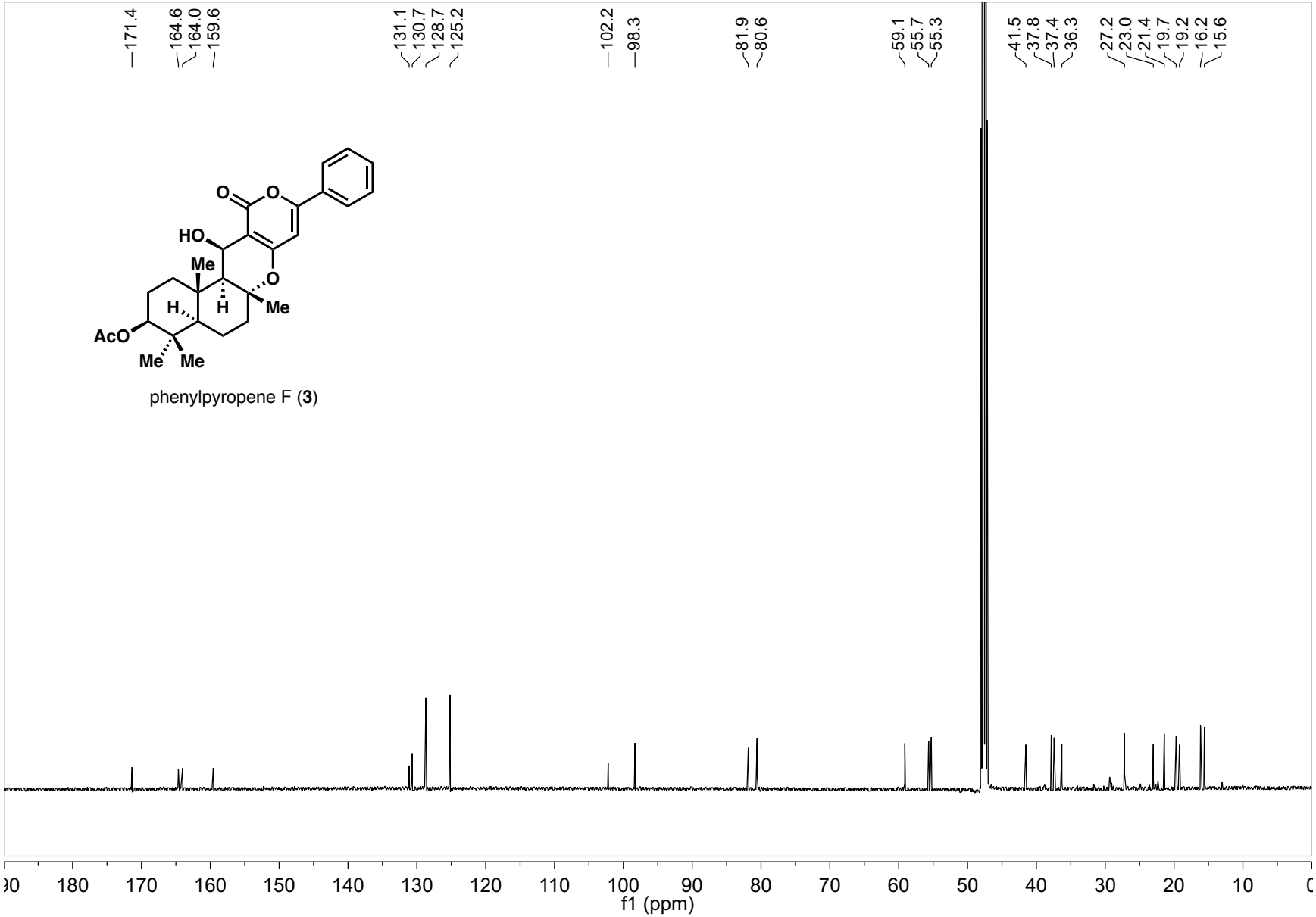

7.89
7.87
7.87
7.57
7.55
7.54
7.54
7.54
7.51
7.50
7.49
7.49
6.57
4.59
4.58
4.57
4.56
2.16
2.15
2.03
1.78
1.77
1.75
1.68
1.67
1.66
1.65
1.63
1.63
1.60
1.59
1.53
1.47
1.47
1.46
1.45
1.26
1.25
0.94
0.91
O
O
O
Me
Me
OH
H
AcO
Me
Me
1.84
0.94
1.84
1.03
1.00
1.70
2.92
0.98
4.75
2.82
0.86
2.99
0.80
2.70
3.01
f1 (ppm)

S6

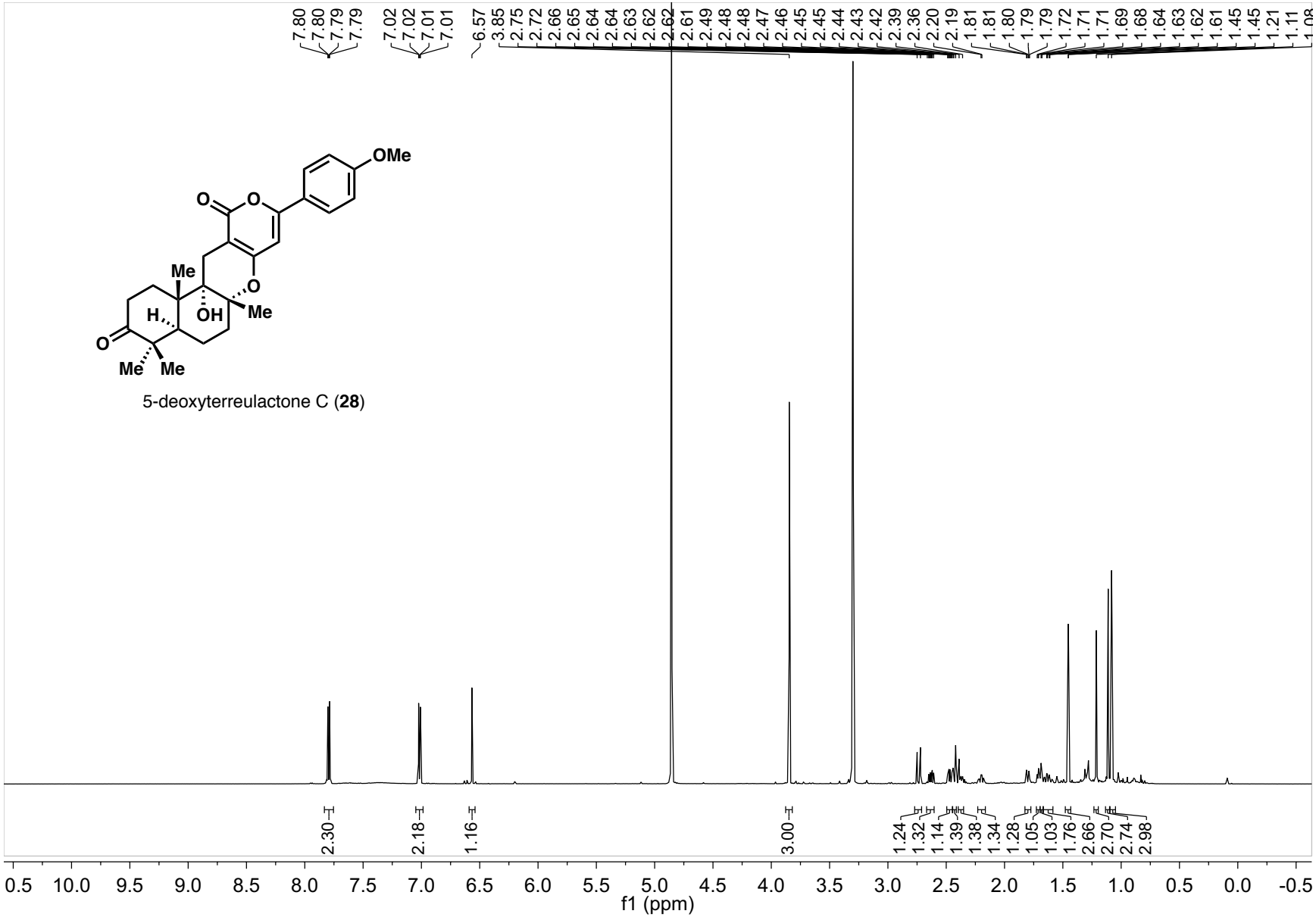

206.0
181.0
170.9
166.1
159.5
140.2
132.8
130.3
130.0
129.3
126.7
102.4
98.4
80.7
48.8
38.0
38.0
32.7
31.9
28.0
23.7
21.7
21.4
20.2
18.5
16.6
O
O
O
Me
Me
OH
H
AcO
Me
Me
S6
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

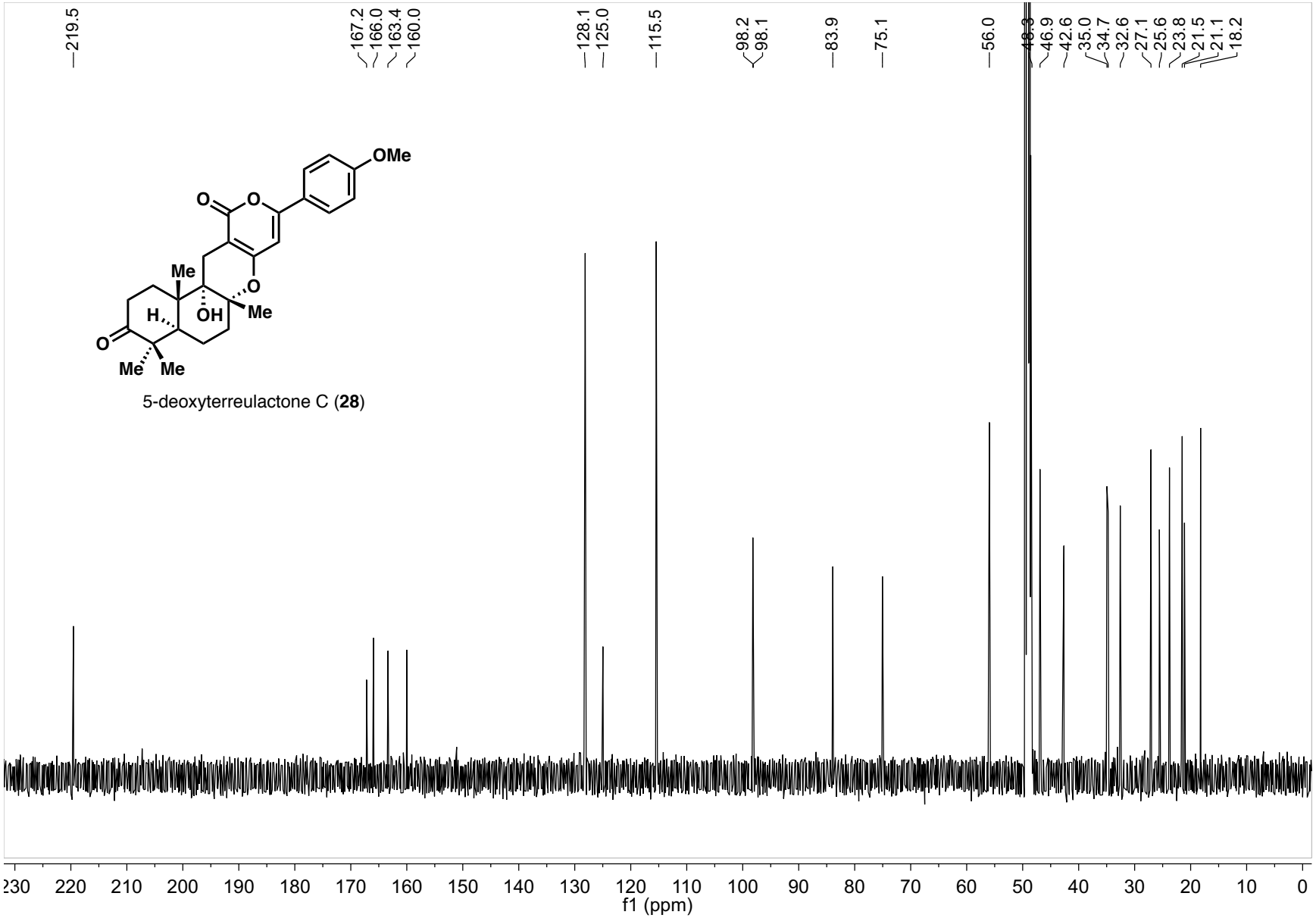


phenylpyropene F (**3**)

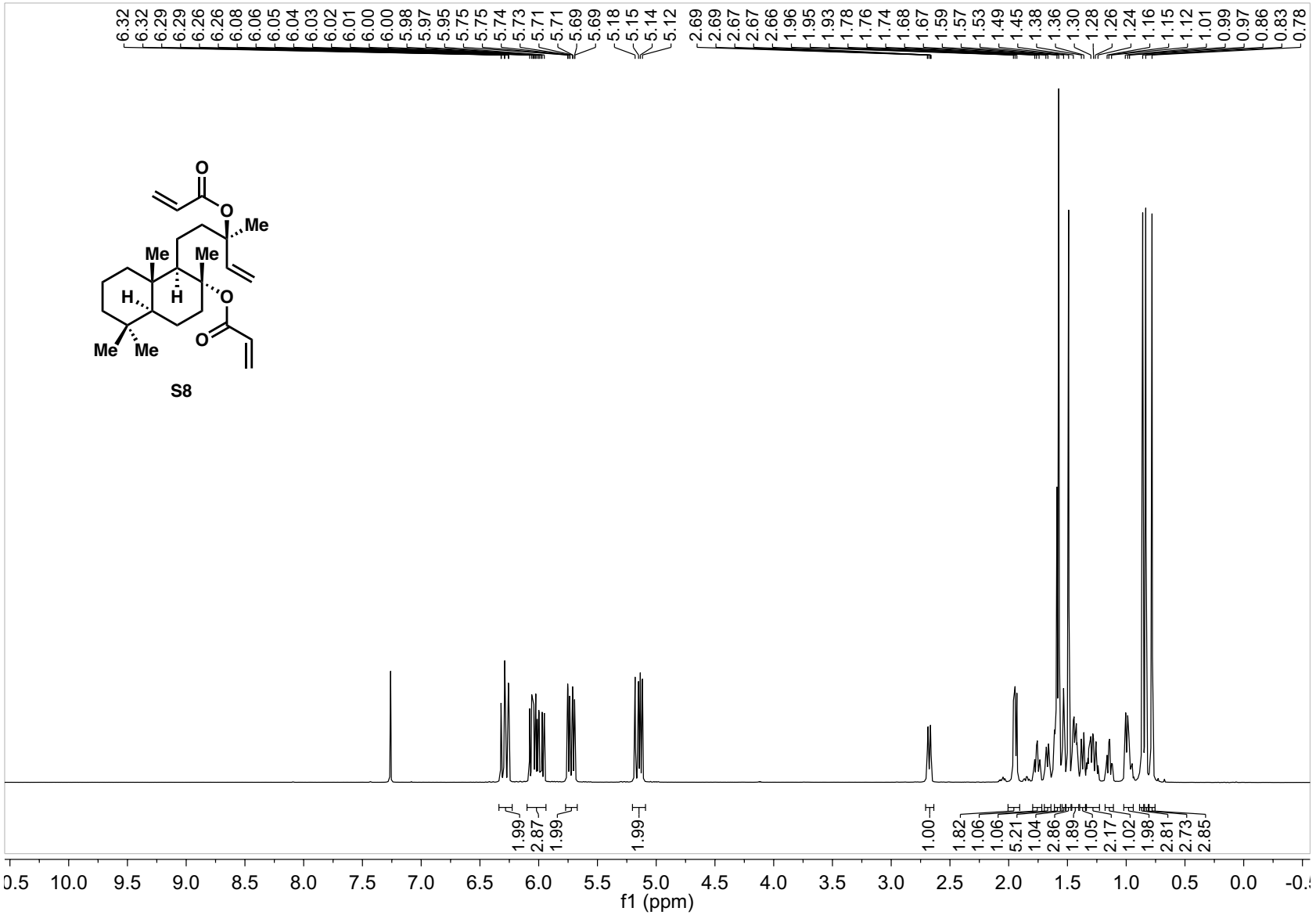


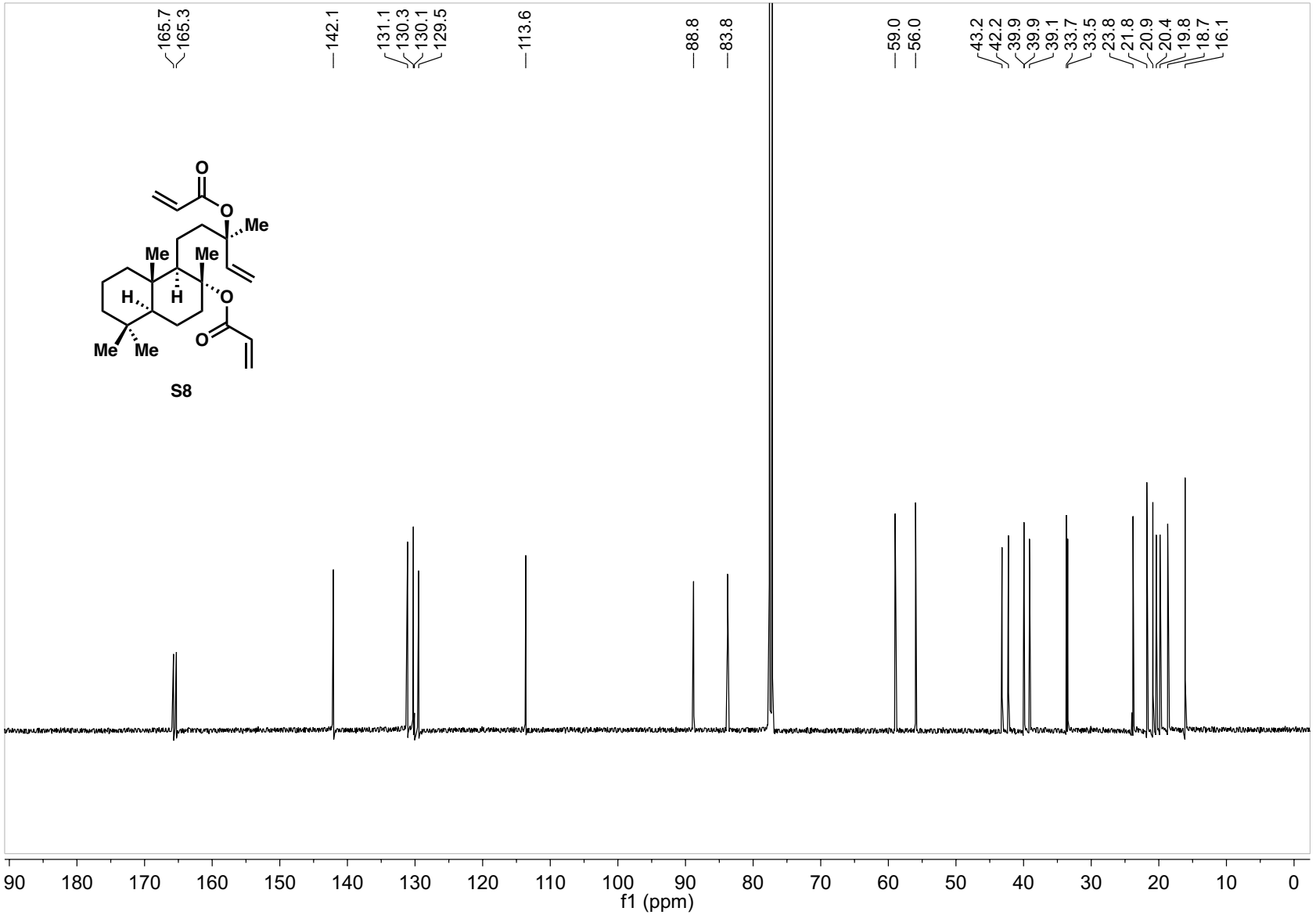
phenylpyropene F (**3**)


OMe
O
O
O
Me
O
H
OH
Me
O
Me
Me
5-deoxyterreulactone C (28)
f1 (ppm)

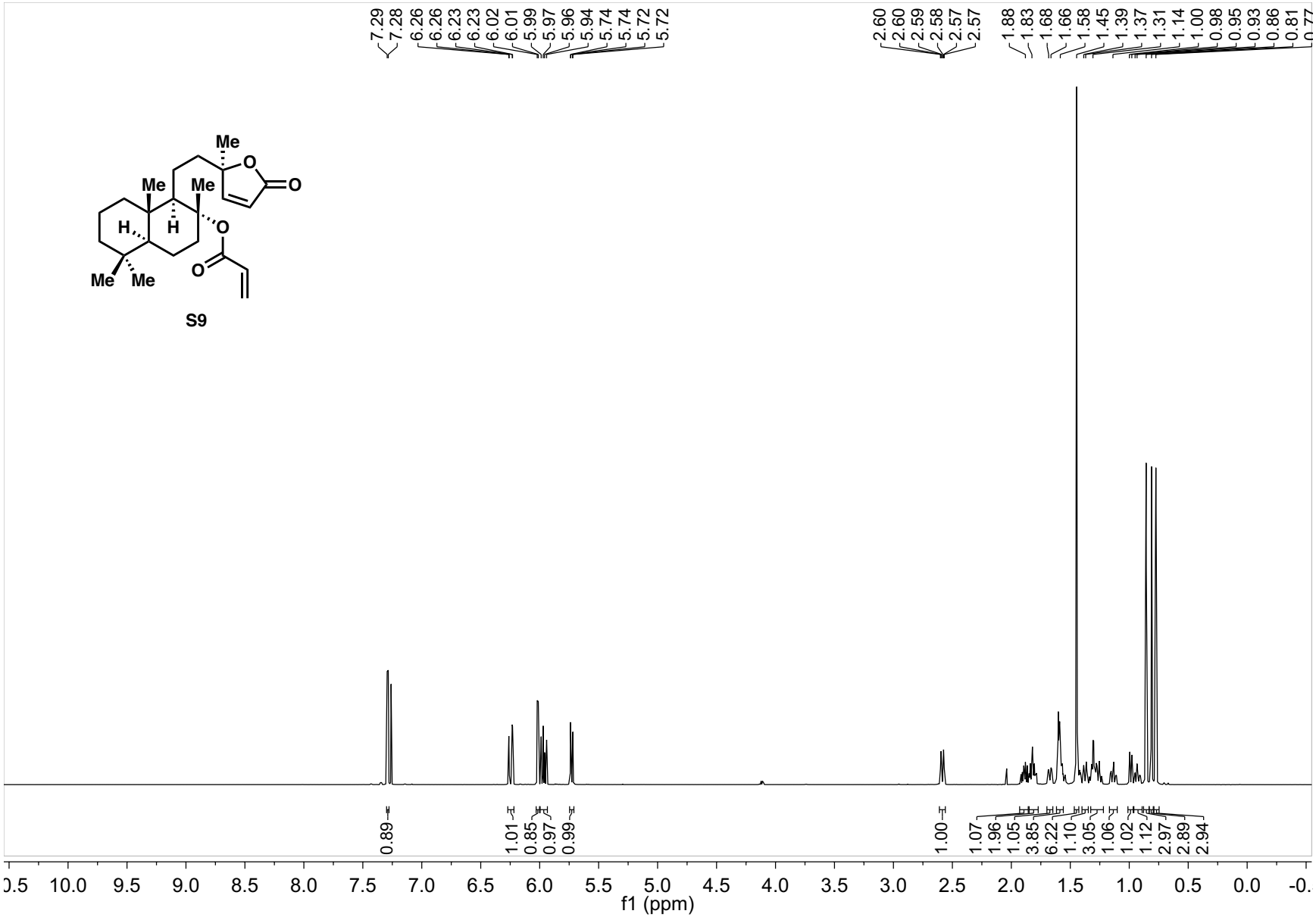


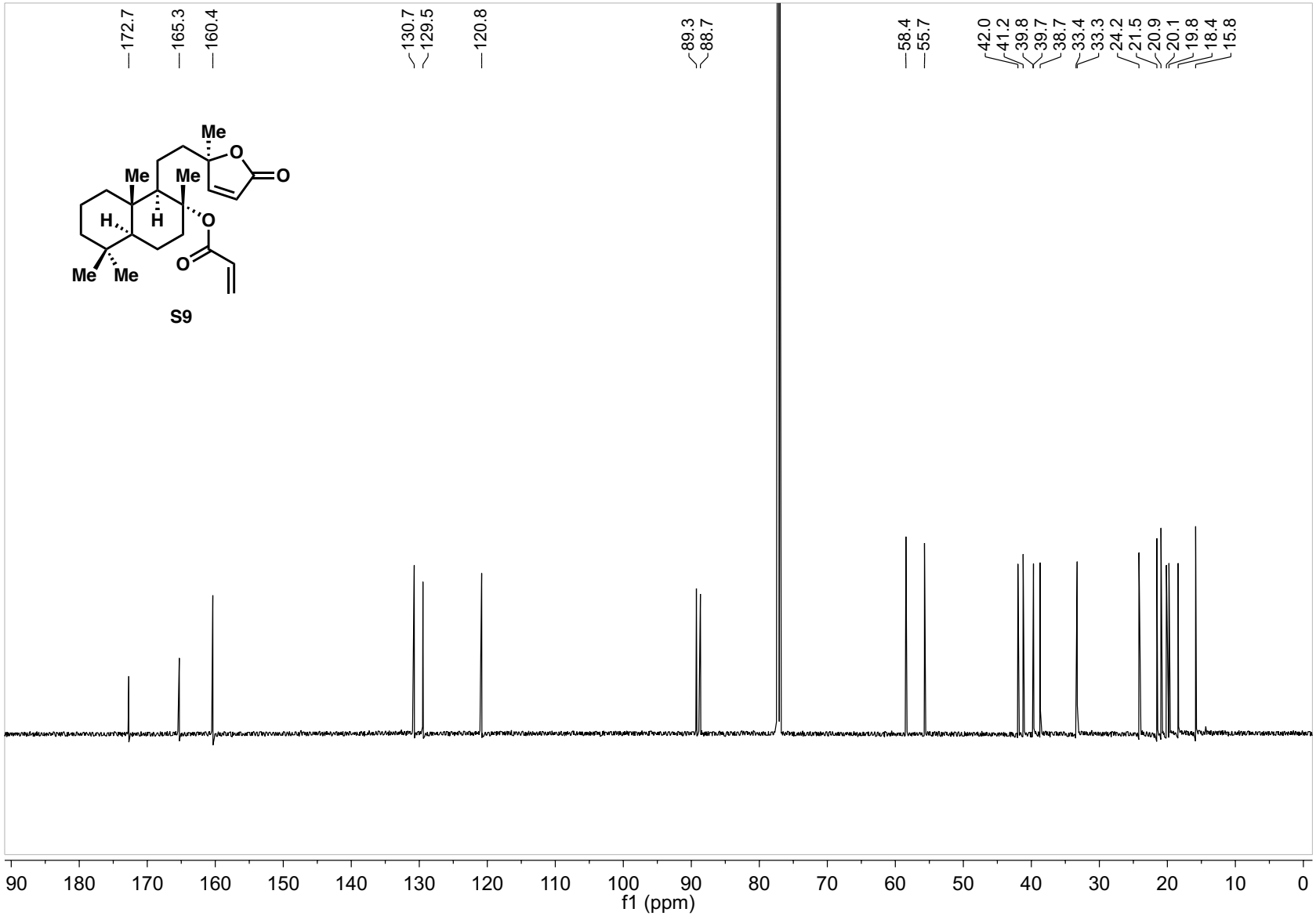
5-deoxyterreulactone C (**28**)

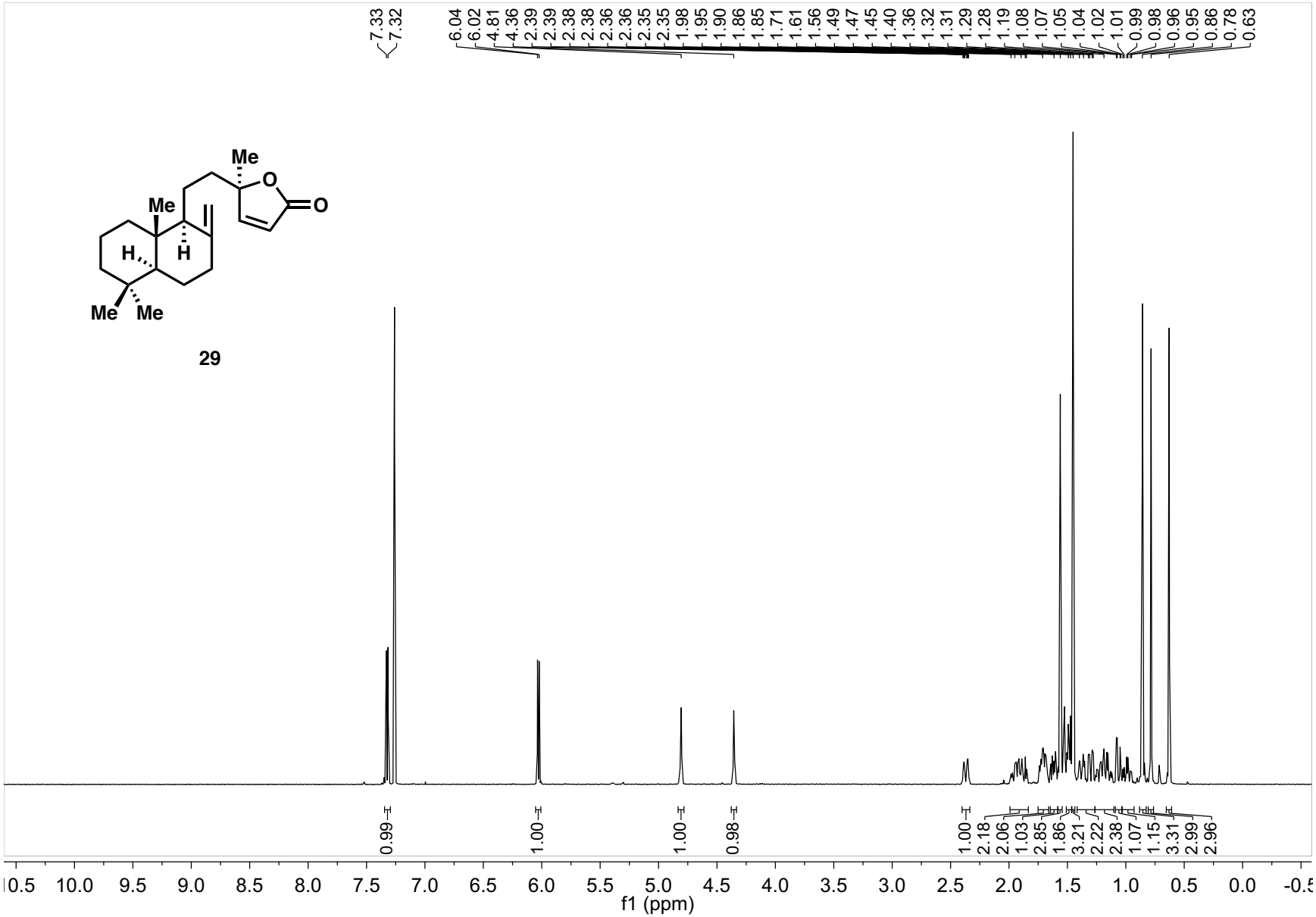

6.32 6.32 6.29 6.29 6.26 6.26 6.08 6.06 6.05 6.04 6.03 6.02 6.01 6.00 6.00 5.98 5.97 5.95 5.75 5.75 5.74 5.73 5.71 5.71 5.69 5.69 5.18 5.15 5.14 5.12
2.69 2.69 2.67 2.67 2.66 1.96 1.95 1.93 1.78 1.76 1.74 1.68 1.67 1.59 1.57 1.53 1.49 1.45 1.38 1.36 1.30 1.28 1.26 1.24 1.16 1.15 1.12 1.01 0.99 0.97 0.86 0.83 0.78
O
O
Me
Me
Me
H
H
O
O
Me
Me
S8
1.99 2.87 1.99 1.99 1.00 1.82 1.06 1.06 5.21 1.04 2.86 1.89 1.05 2.17 1.02 1.98 2.81 2.73 2.85
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

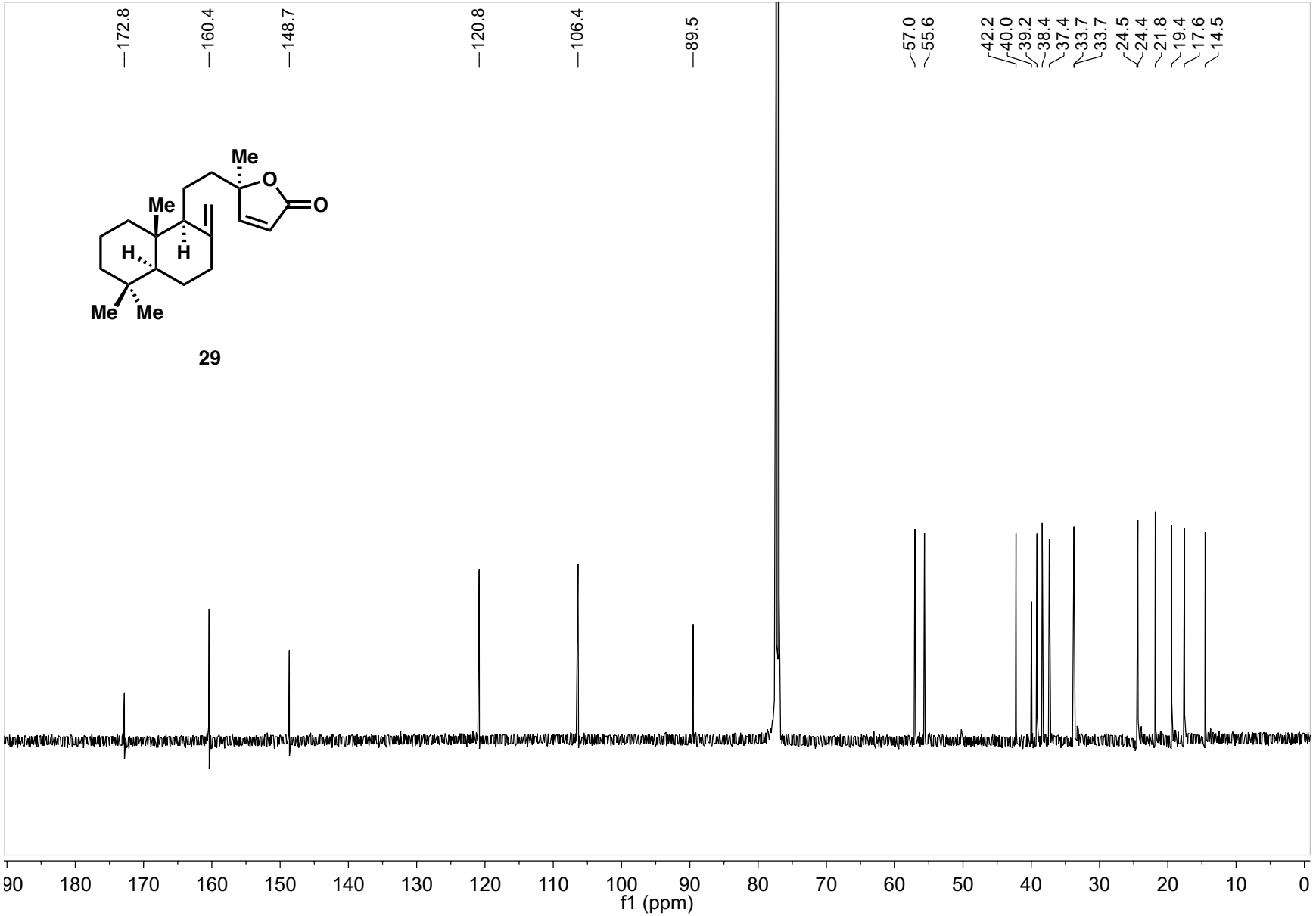

165.7
165.3
142.1
131.1
130.3
130.1
129.5
113.6
88.8
83.8
59.0
56.0
43.2
42.2
39.9
39.9
39.1
33.7
33.5
23.8
21.8
20.9
20.4
19.8
18.7
16.1
O
O
Me
Me
Me
H
H
O
O
Me
Me
90
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

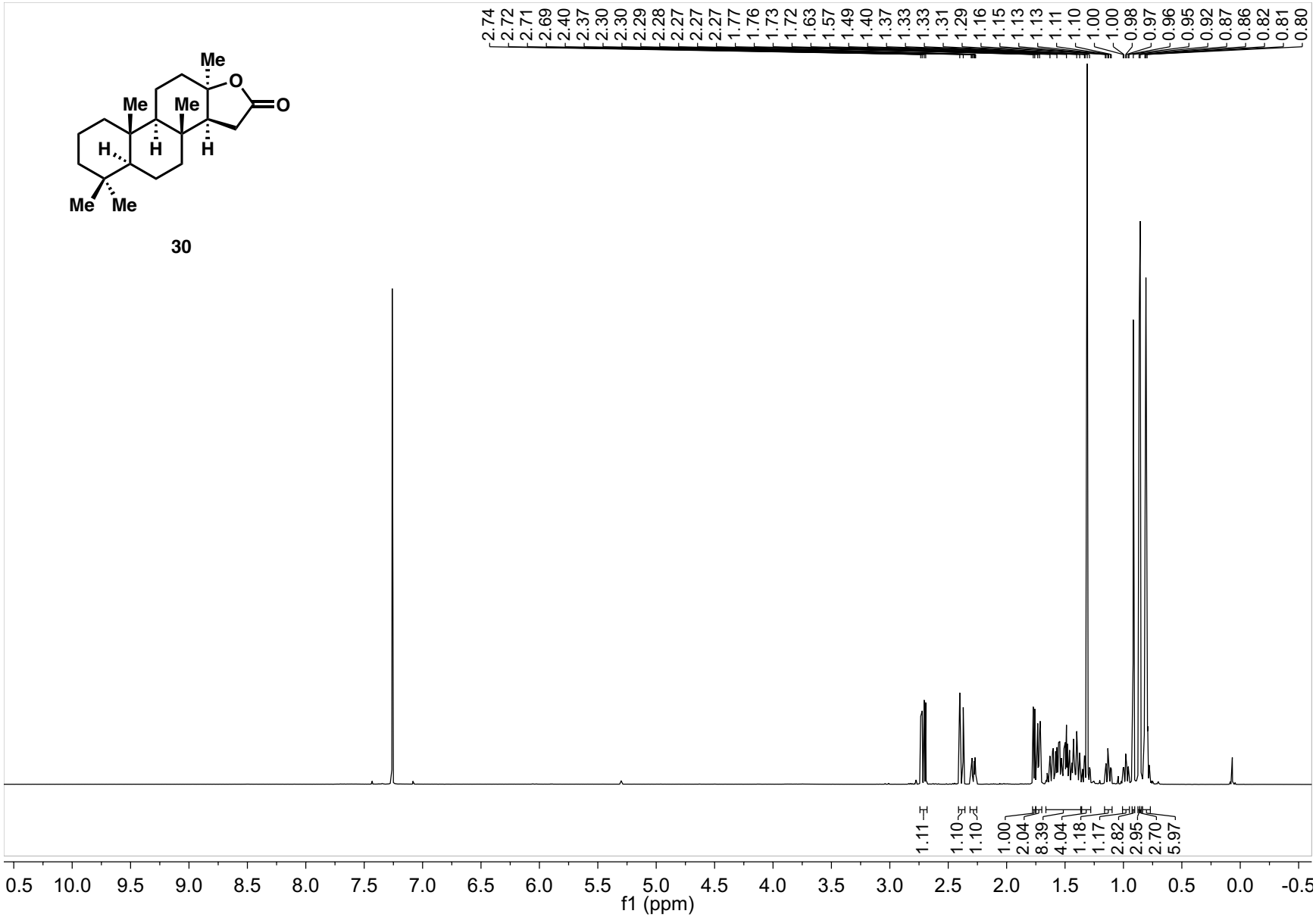
S8

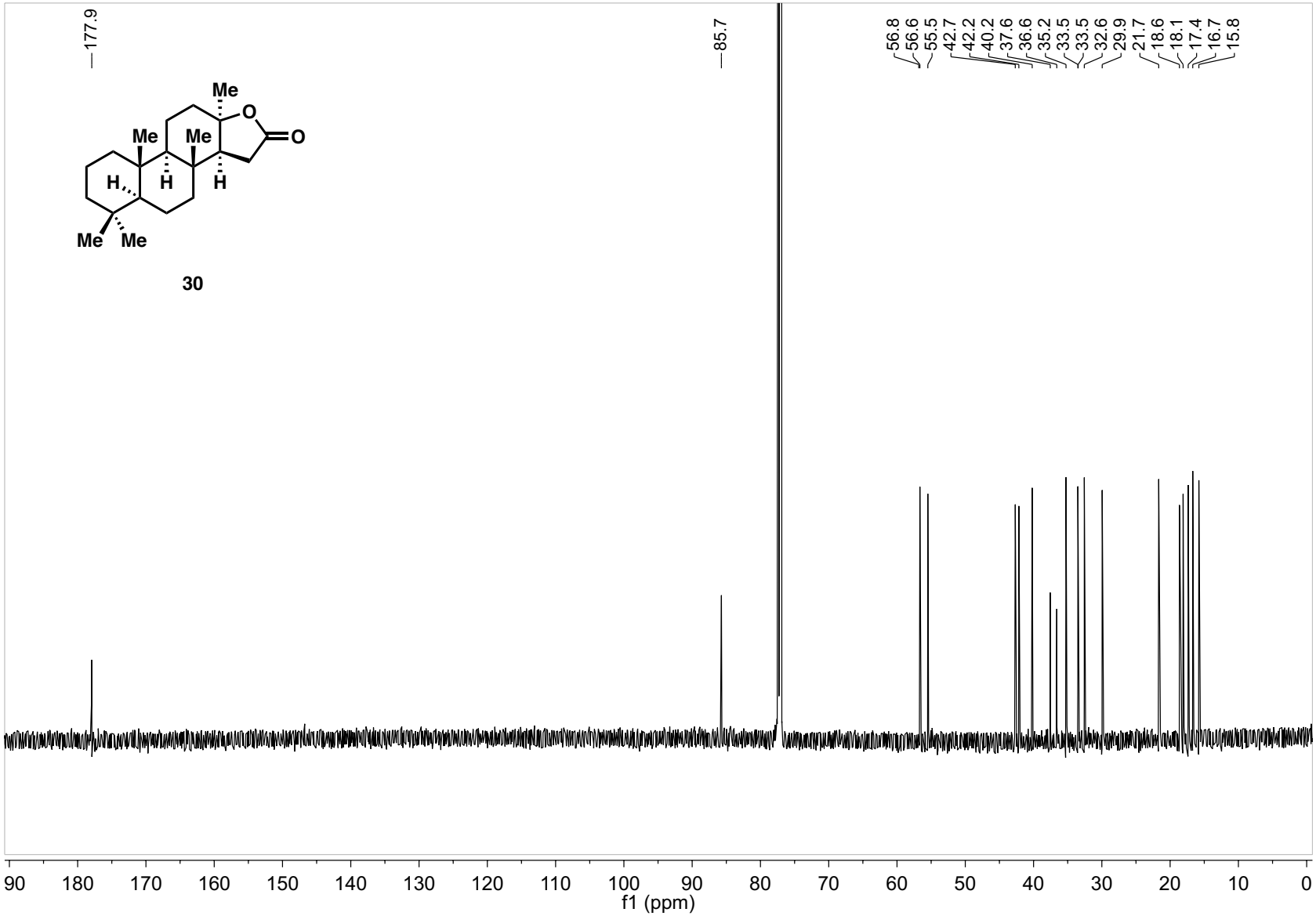

7.29
7.28
6.26
6.26
6.23
6.23
6.02
6.01
5.99
5.97
5.96
5.94
5.74
5.74
5.72
5.72
2.60
2.60
2.59
2.58
2.57
2.57
1.88
1.83
1.68
1.66
1.58
1.45
1.39
1.37
1.31
1.14
1.00
0.98
0.95
0.93
0.86
0.81
Me
O
O
Me
Me
H
H
O
O
Me
Me
S9
0.89
1.01
0.85
0.97
0.99
1.00
1.07
1.96
1.05
3.85
6.22
1.10
3.05
1.06
1.02
1.12
2.97
2.89
2.94
f1 (ppm)


172.7
165.3
160.4
130.7
129.5
120.8
89.3
88.7
58.4
55.7
42.0
41.2
39.8
39.7
38.7
33.4
33.3
24.2
21.5
20.9
20.1
19.8
18.4
15.8
Me
O
O
Me
Me
H
H
O
O
Me
Me
S9
90
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

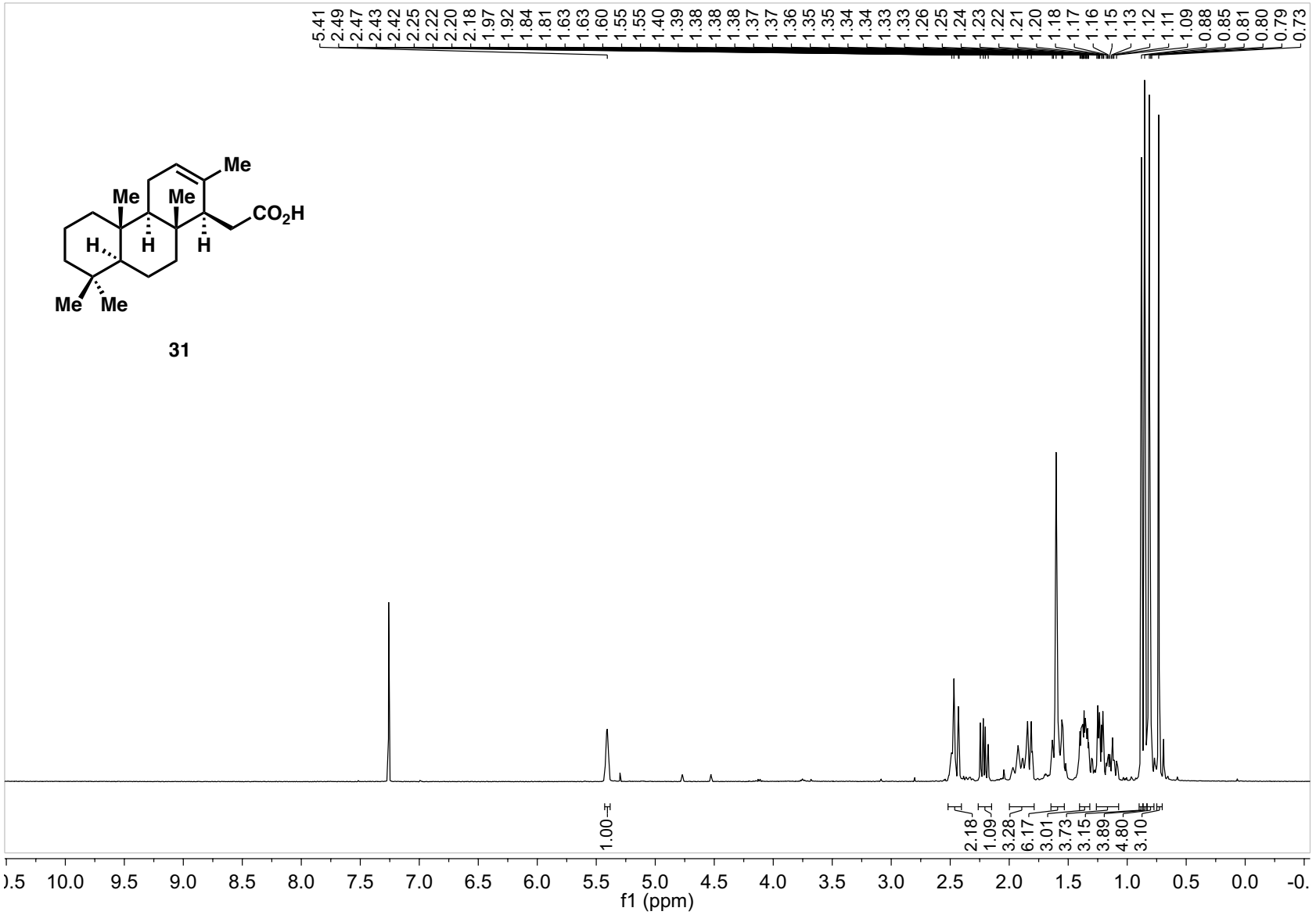

7.33
7.32
6.04
6.02
4.81
4.36
2.39
2.39
2.38
2.38
2.36
2.36
2.35
2.35
1.98
1.95
1.90
1.86
1.85
1.71
1.61
1.56
1.49
1.47
1.45
1.40
1.36
1.32
1.31
1.29
1.28
1.19
1.08
1.07
1.05
1.04
1.02
1.01
0.99
0.98
0.96
0.95
0.86
0.78
0.63
Me
O
O
Me
H
H
Me
Me
29
0.99
1.00
1.00
0.98
1.00
2.18
2.06
1.03
2.85
1.86
3.21
2.22
2.38
1.07
1.15
3.31
2.99
2.96
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

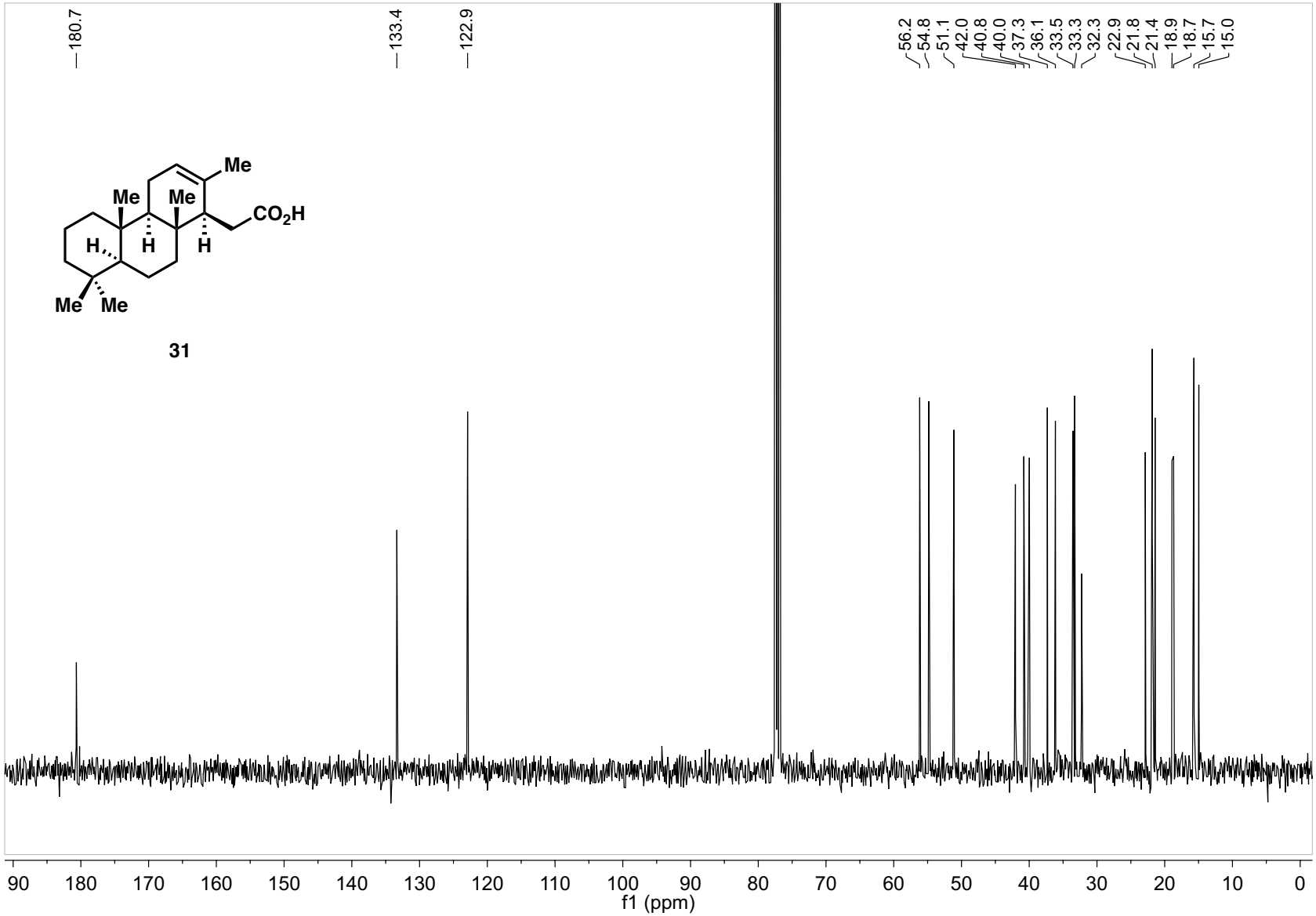

172.8
160.4
148.7
120.8
106.4
89.5
57.0
55.6
42.2
40.0
39.2
38.4
37.4
33.7
33.7
24.5
24.4
21.8
19.4
17.6
14.5
Me
O
O
Me
H
H
Me
Me
29
f1 (ppm)


Me
O
Me
Me
O
H
H
H
Me
Me
30
2.74 2.72 2.71 2.69 2.40 2.37 2.30 2.30 2.29 2.28 2.27 2.27 2.27 1.77 1.76 1.73 1.72 1.63 1.57 1.49 1.40 1.37 1.33 1.33 1.31 1.29 1.16 1.15 1.13 1.13 1.11 1.10 1.00 1.00 0.98 0.97 0.96 0.95 0.92 0.87 0.86 0.82 0.81 0.80
1.11 1.10 1.10 1.00 2.04 8.39 4.04 1.18 1.17 2.82 2.95 2.70 5.97
0.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

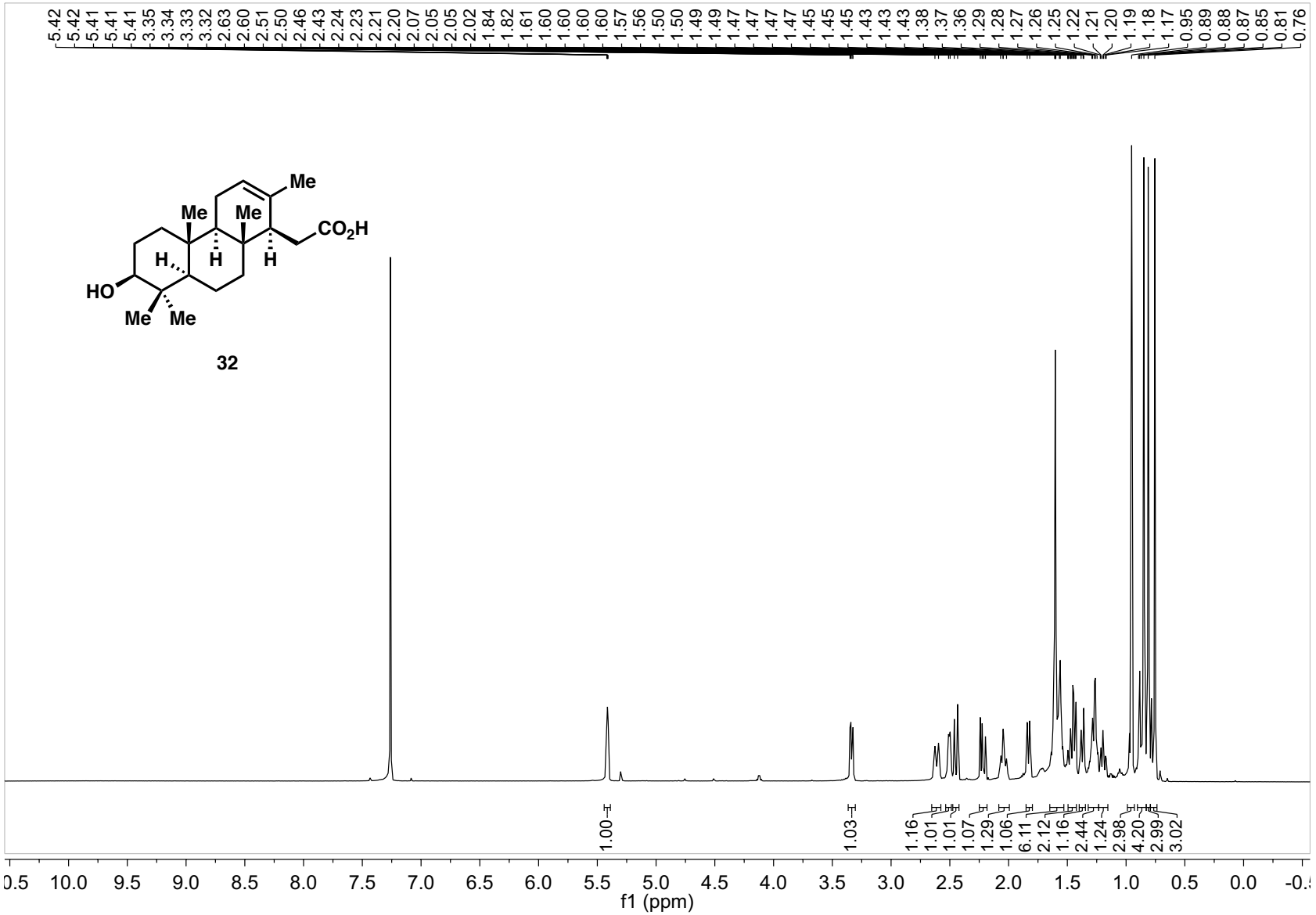

177.9
85.7
56.8
56.6
55.5
42.7
42.2
40.2
37.6
36.6
35.2
33.5
33.5
32.6
29.9
21.7
18.6
18.1
17.4
16.7
15.8
Me
O
Me
Me
O
H
H
H
Me
Me
90
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

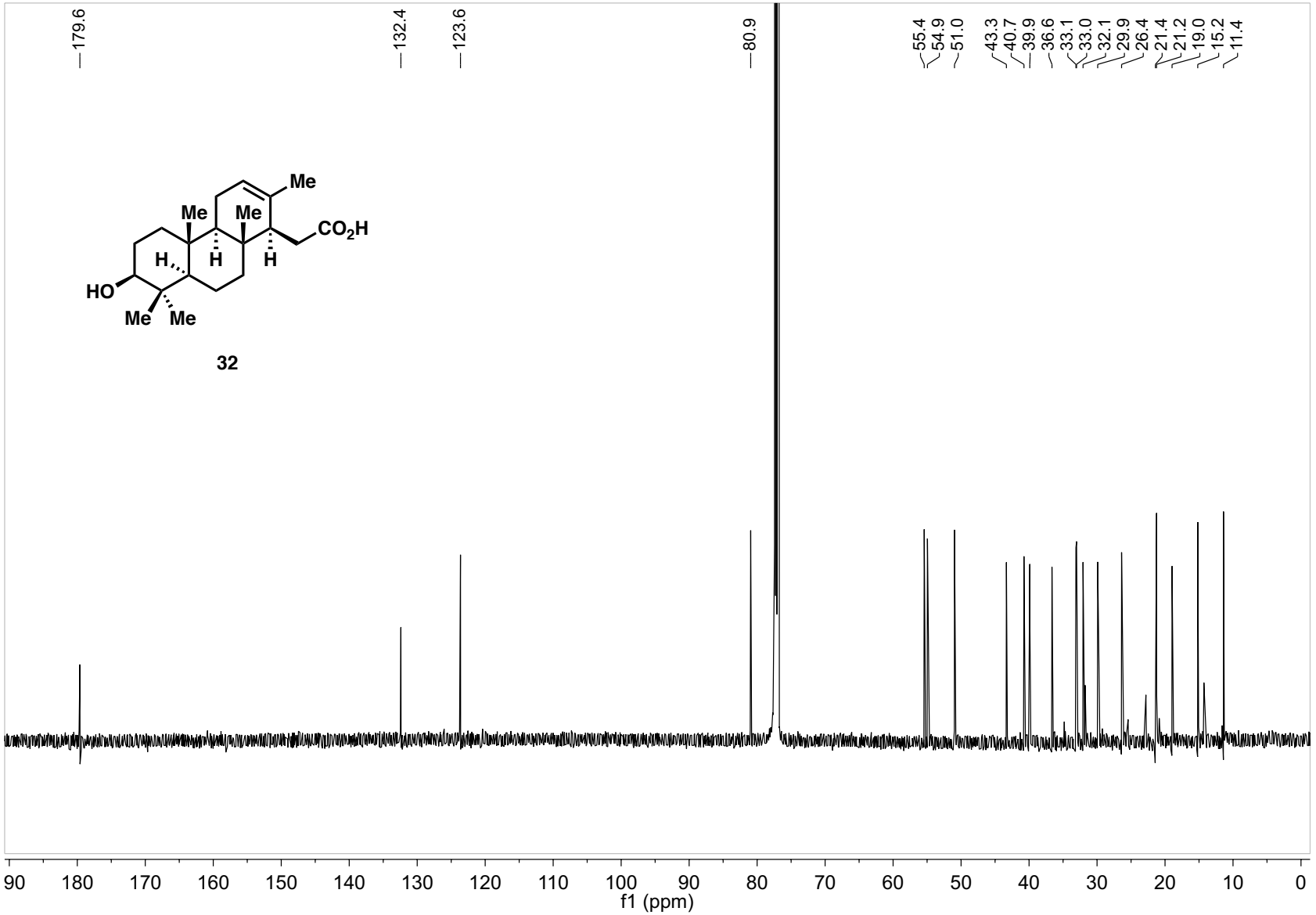
30


Me
Me
Me
CO2H
H
H
H
Me
Me
31
f1 (ppm)

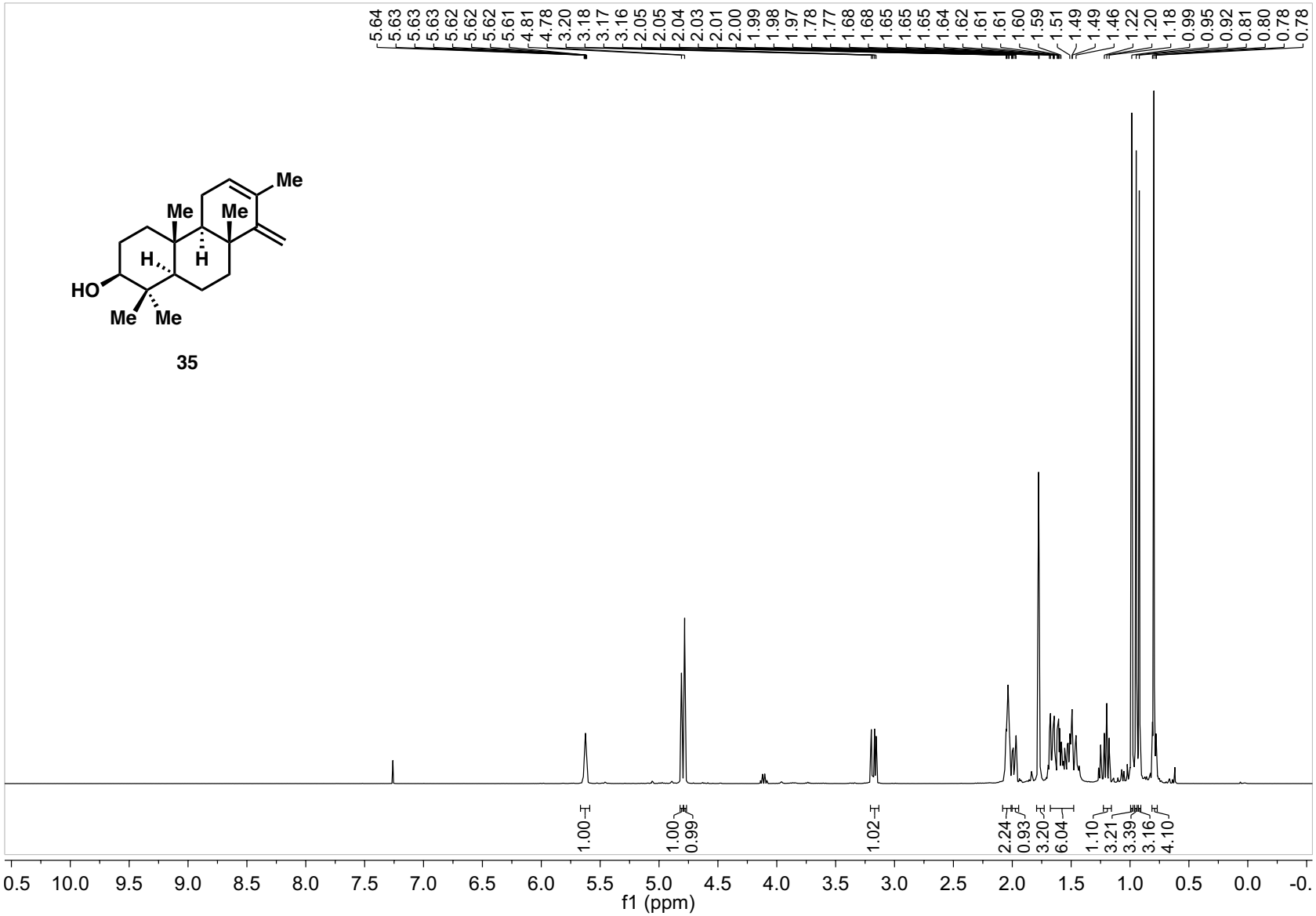

180.7
133.4
122.9
56.2
54.8
51.1
42.0
40.8
40.0
37.3
36.1
33.5
33.3
32.3
22.9
21.8
21.4
18.9
18.7
15.7
15.0
Me
Me
Me
CO2H
H
H
H
Me
Me
90
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

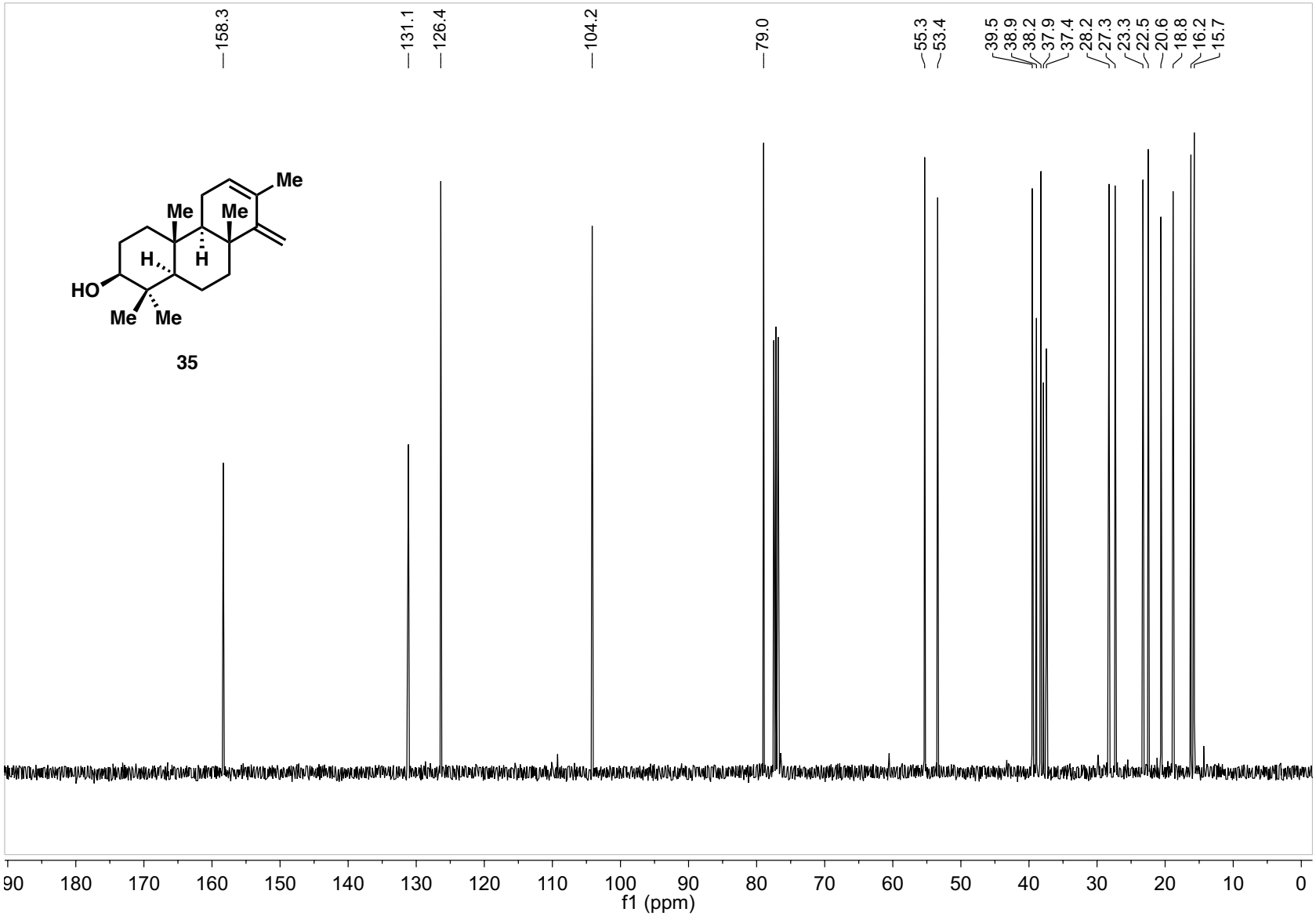
31

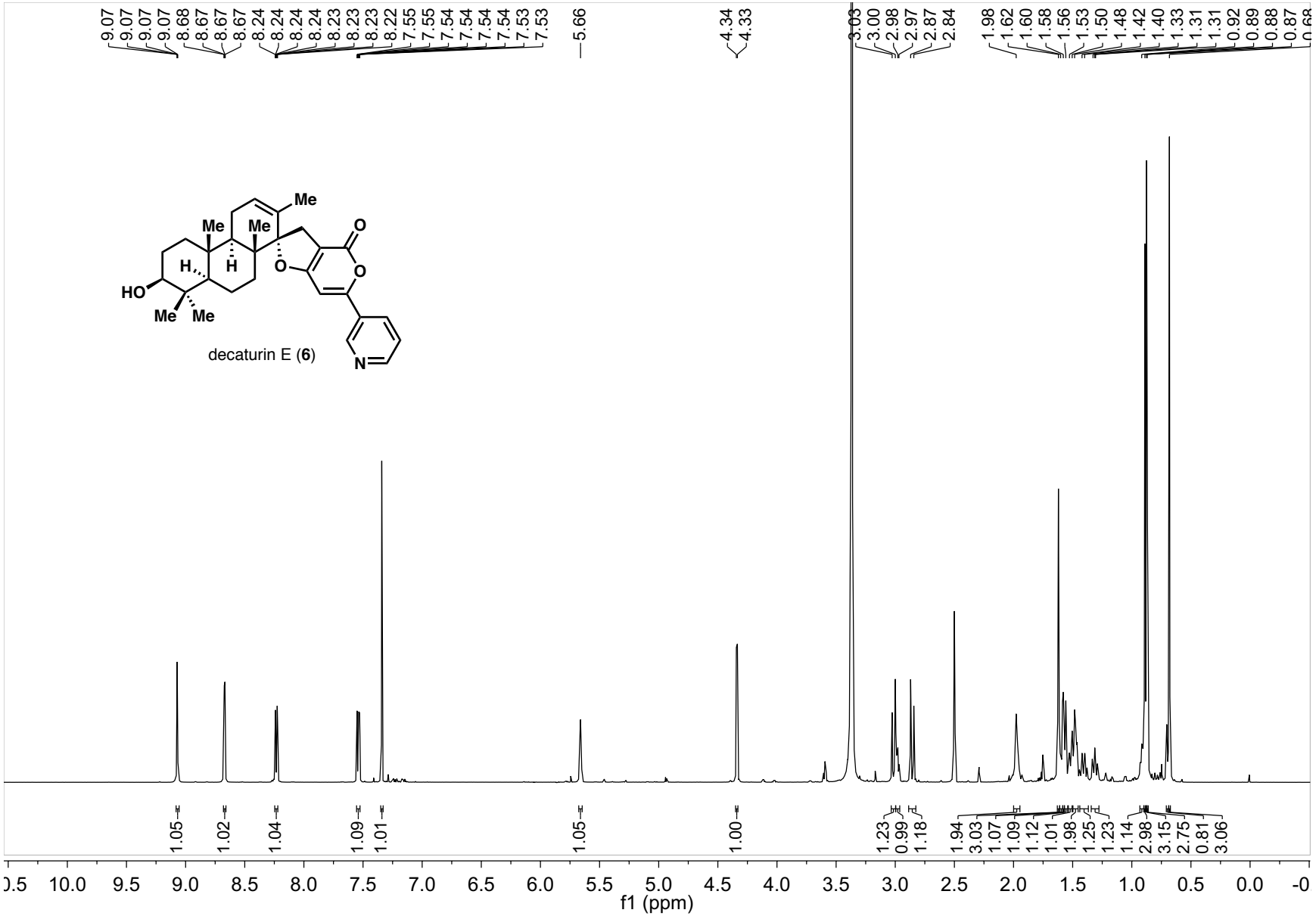

Me
Me
Me
CO2H
H
H
H
HO
Me
Me
32
f1 (ppm)

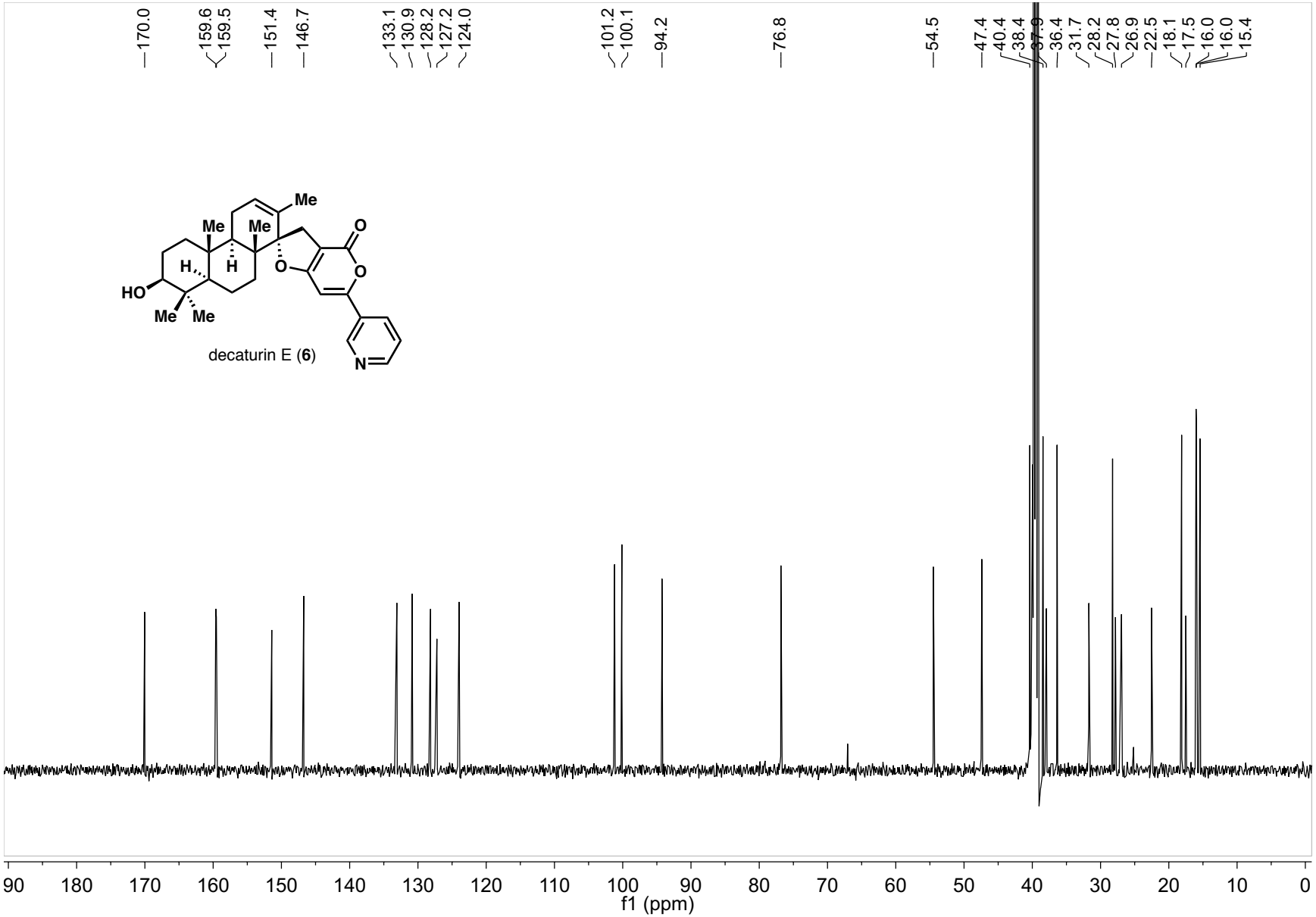

179.6
132.4
123.6
80.9
55.4
54.9
51.0
43.3
40.7
39.9
36.6
33.1
33.0
32.1
29.9
26.4
21.4
21.2
19.0
15.2
11.4
Me
Me
Me
CO2H
H
H
H
HO
Me
Me
90
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

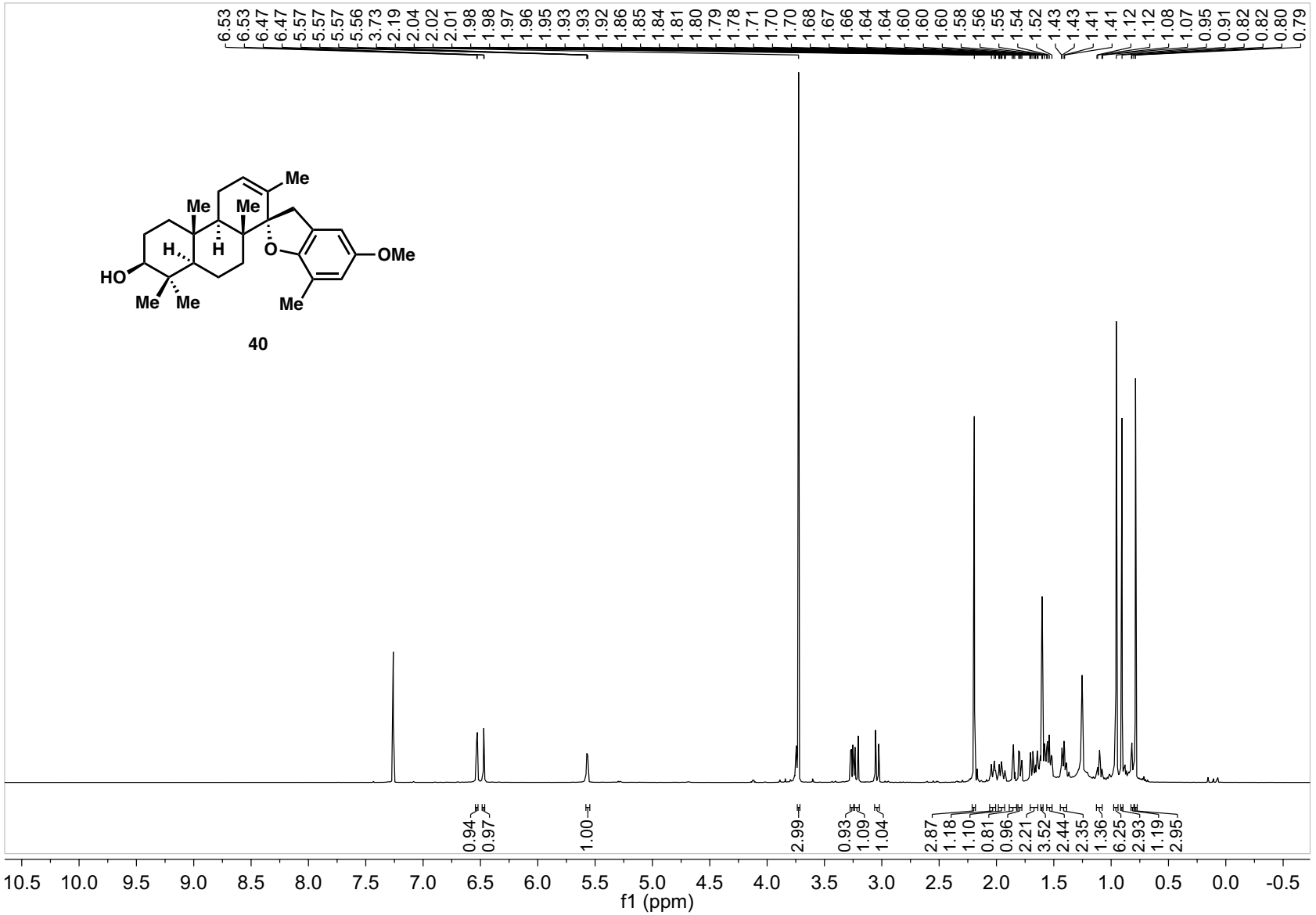
32

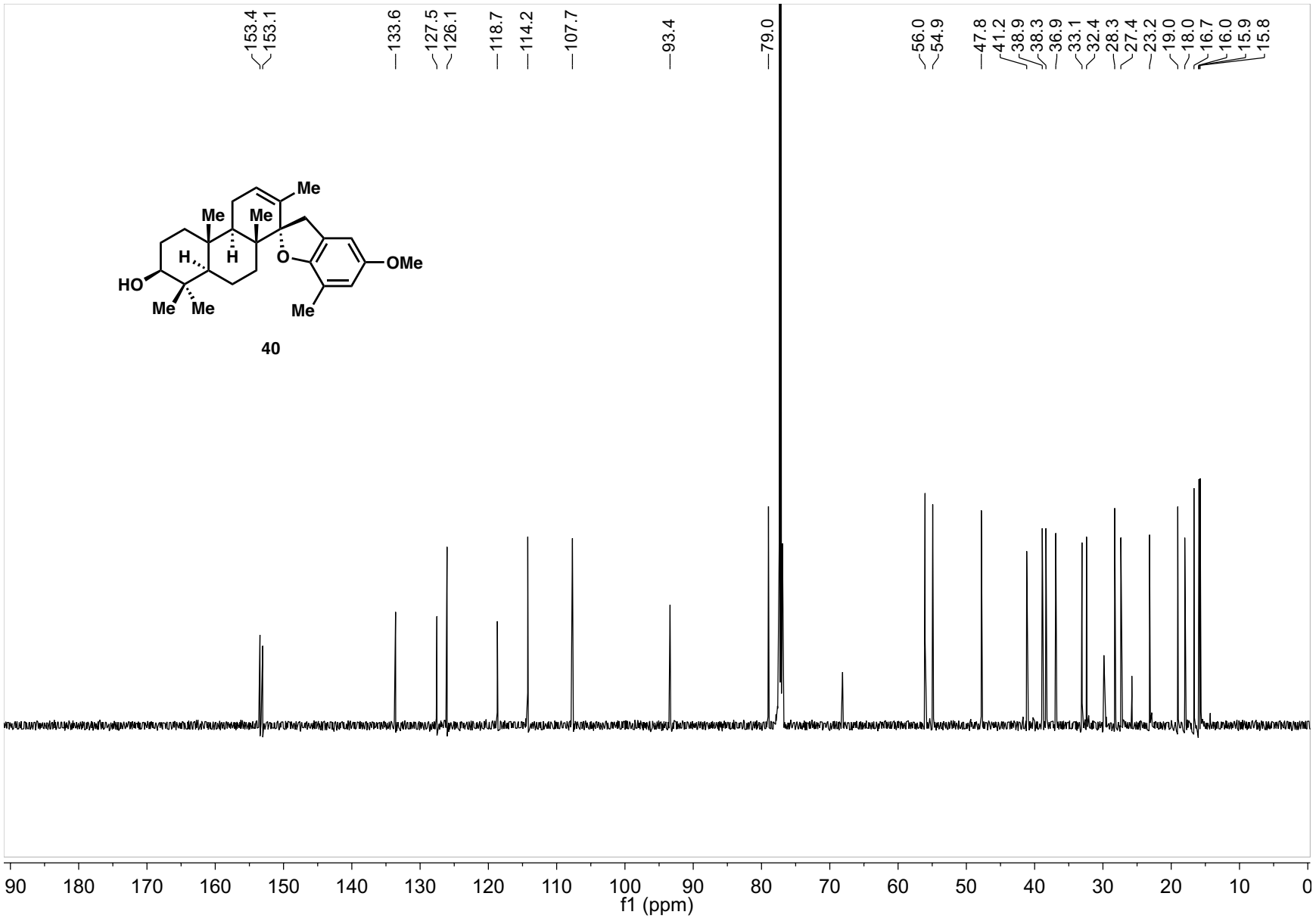

Me
Me
Me
H
H
HO
Me
Me
35
f1 (ppm)


158.3
131.1
126.4
104.2
79.0
55.3
53.4
39.5
38.9
38.2
37.9
37.4
28.2
27.3
23.3
22.5
20.6
18.8
16.2
15.7
Me
Me
Me
H
H
HO
Me
Me
35
f1 (ppm)

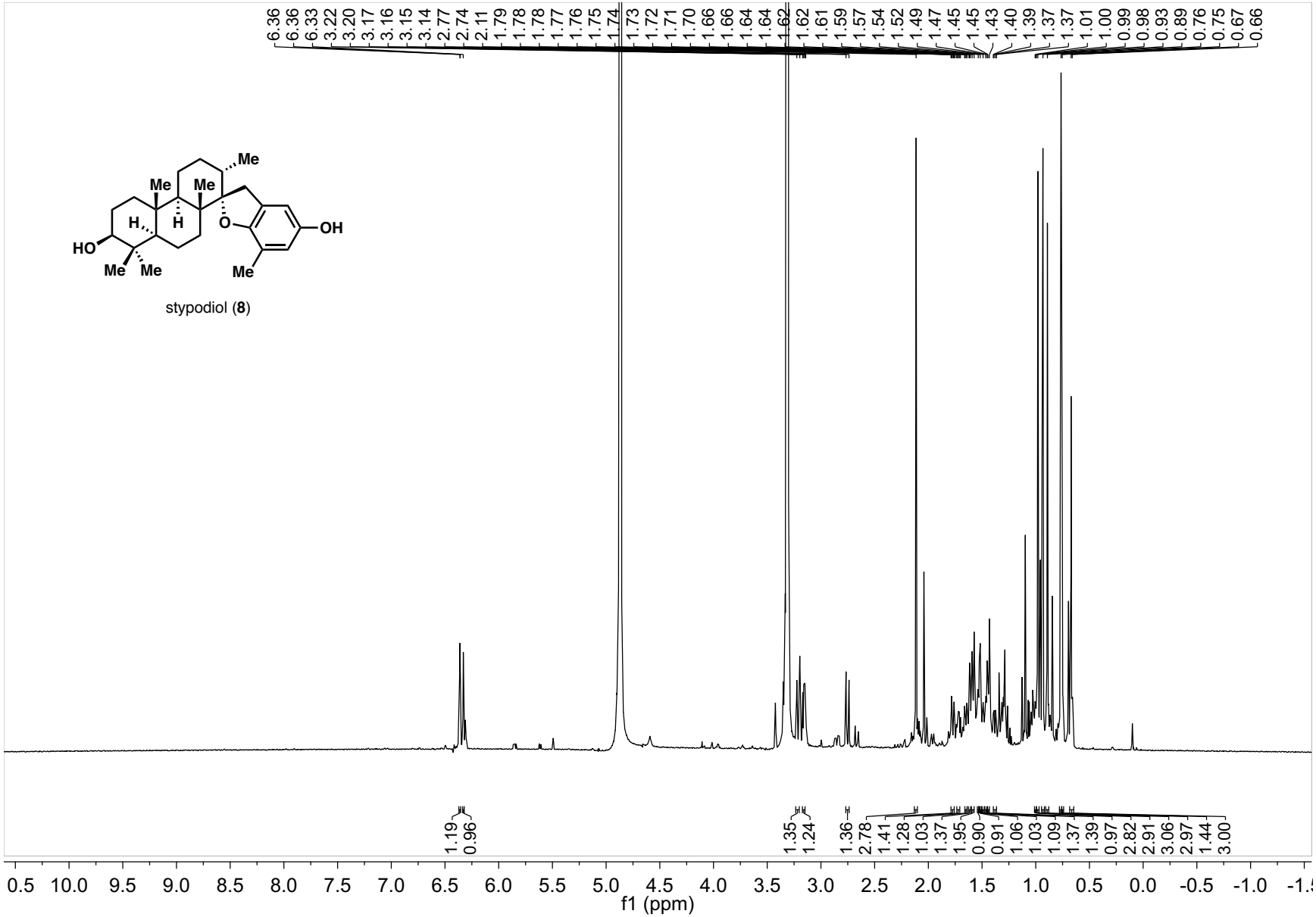

9.07
9.07
9.07
9.07
8.68
8.67
8.67
8.67
8.24
8.24
8.24
8.24
8.23
8.23
8.22
7.55
7.55
7.54
7.54
7.54
7.54
7.53
7.53
5.66
4.34
4.33
3.03
3.00
2.98
2.97
2.87
2.84
1.98
1.62
1.60
1.58
1.56
1.53
1.50
1.48
1.42
1.40
1.33
1.31
1.31
0.92
0.89
0.88
0.87
Me
Me
Me
H
H
HO
Me
Me
O
O
O
N
decaturin E (6)
1.05
1.02
1.04
1.09
1.01
1.05
1.00
1.23
0.99
1.18
1.94
3.03
1.07
1.09
1.12
1.01
1.98
1.25
1.23
1.14
2.98
3.15
2.75
0.81
3.06
f1 (ppm)

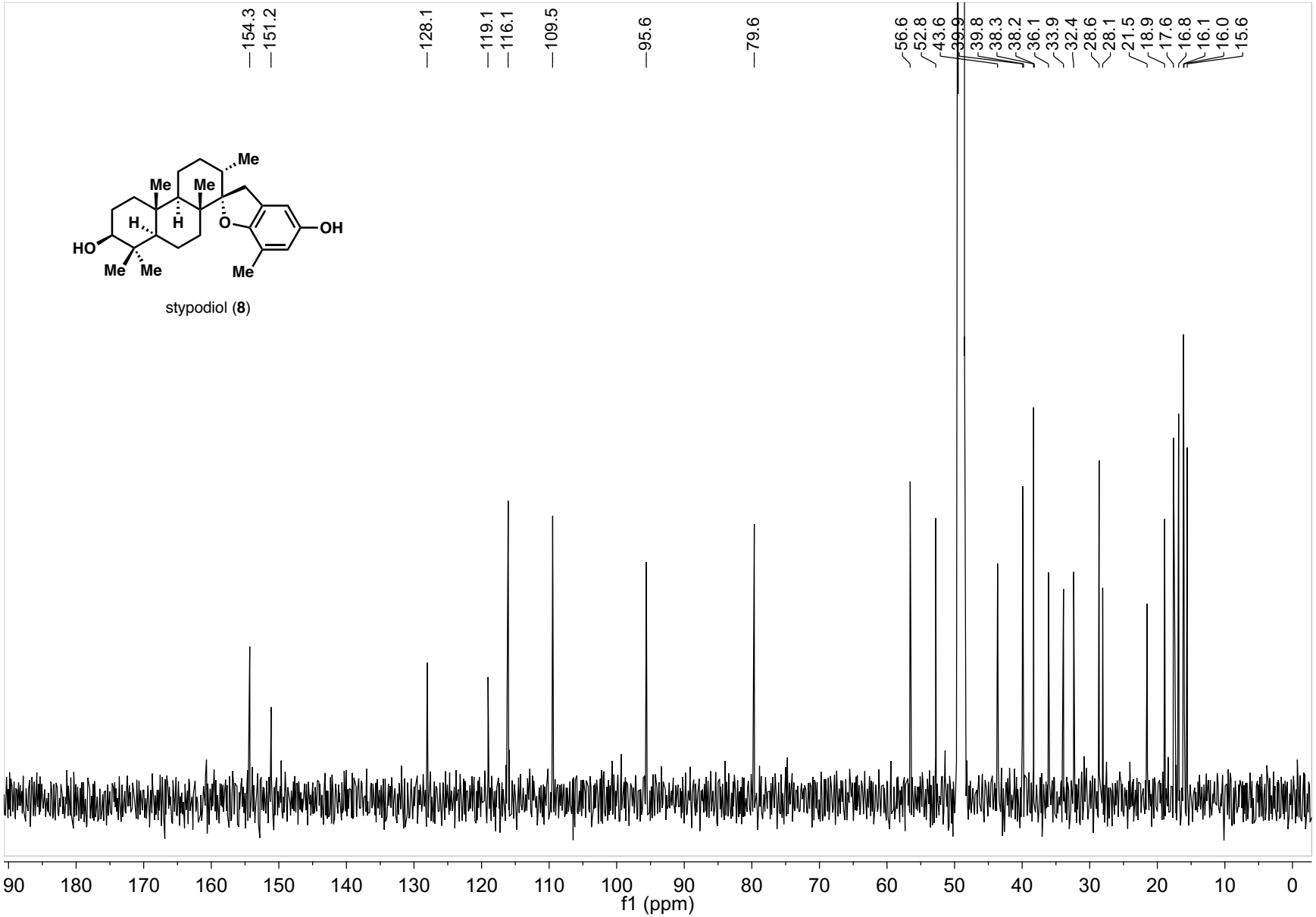

170.0
159.6
159.5
151.4
146.7
133.1
130.9
128.2
127.2
124.0
101.2
100.1
94.2
76.8
54.5
47.4
40.4
38.4
36.4
31.7
28.2
27.8
26.9
22.5
18.1
17.5
16.0
16.0
15.4
Me
Me
Me
H
H
HO
Me
Me
O
O
O
N
decaturin E (6)
90
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


6.53 6.53 6.47 6.47 5.57 5.57 5.57 5.56 3.73 2.19 2.04 2.02 2.01 1.98 1.98 1.97 1.96 1.95 1.93 1.93 1.92 1.86 1.85 1.84 1.81 1.80 1.79 1.78 1.71 1.70 1.70 1.68 1.67 1.66 1.64 1.64 1.60 1.60 1.60 1.58 1.56 1.55 1.54 1.52 1.43 1.43 1.41 1.41 1.12 1.12 1.08 1.07 0.95 0.91 0.82 0.82 0.80 0.79
Me
Me
Me
H
H
O
OMe
HO
Me
Me
Me
40
0.94 0.97 1.00 2.99 0.93 1.09 1.04 2.87 1.18 1.10 0.81 0.96 2.21 3.52 2.44 2.35 1.36 6.25 2.93 1.19 2.95
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

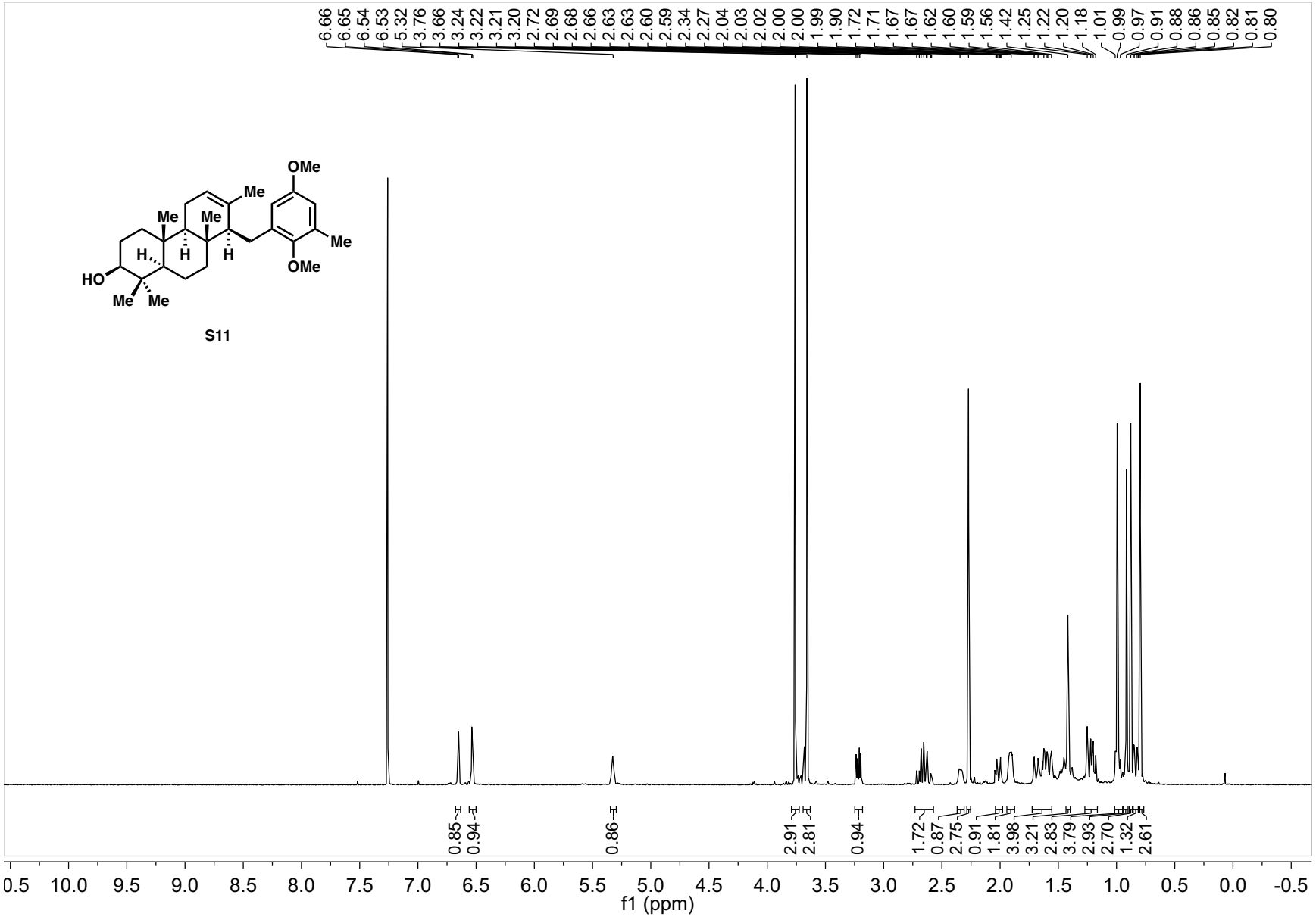

153.4
153.1
133.6
127.5
126.1
118.7
114.2
107.7
93.4
79.0
56.0
54.9
47.8
41.2
38.9
38.3
36.9
33.1
32.4
28.3
27.4
23.2
19.0
18.0
16.7
16.0
15.9
15.8
Me
Me
Me
H
H
O
OMe
HO
Me
Me
Me
90
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

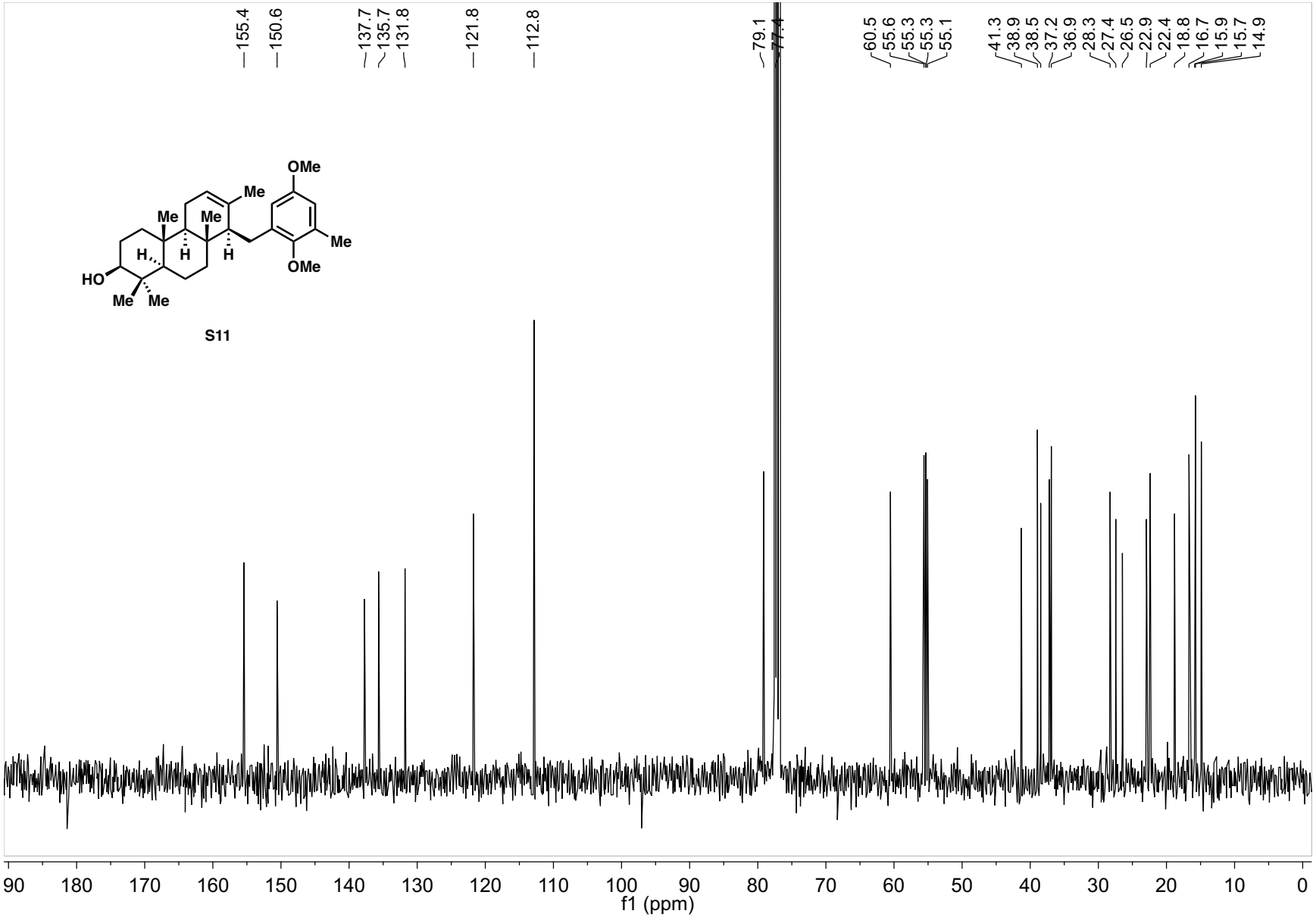
40

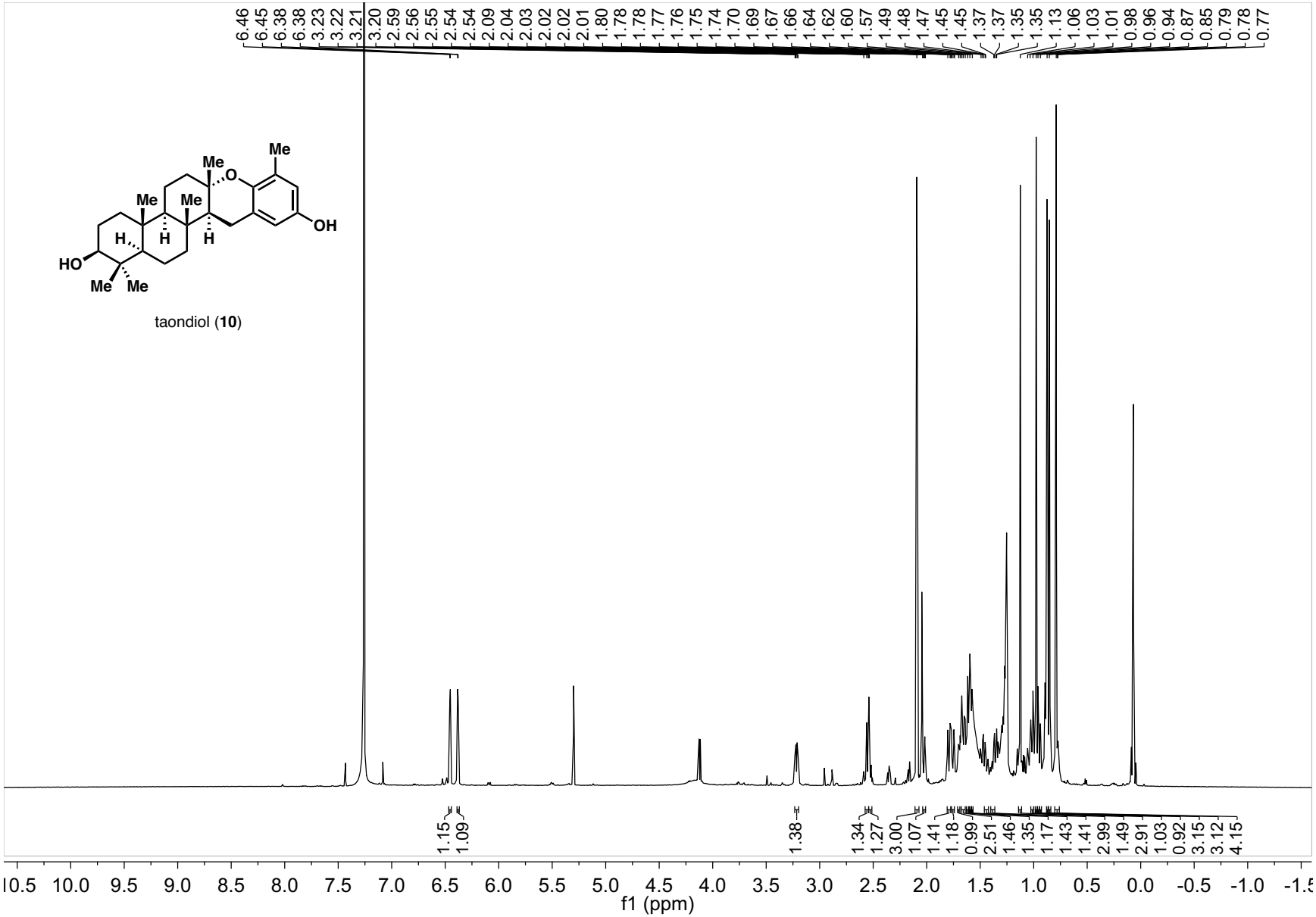

6.36 6.36 6.33 3.22 3.20 3.17 3.16 3.15 3.14 2.77 2.74 2.11 1.79 1.78 1.78 1.77 1.76 1.75 1.74 1.73 1.72 1.71 1.70 1.66 1.66 1.64 1.64 1.62 1.62 1.61 1.59 1.57 1.54 1.52 1.49 1.47 1.45 1.45 1.43 1.40 1.39 1.37 1.37 1.01 1.00 0.99 0.98 0.93 0.89 0.76 0.75 0.67 0.66
Me
Me
Me
H
H
O
OH
HO
Me
Me
Me
stypodiol (8)
1.19 0.96 1.35 1.24 1.36 2.78 1.41 1.28 1.03 1.37 1.95 0.90 0.91 1.06 1.03 1.09 1.37 1.39 0.97 2.82 2.91 3.06 2.97 1.44 3.00
0.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)

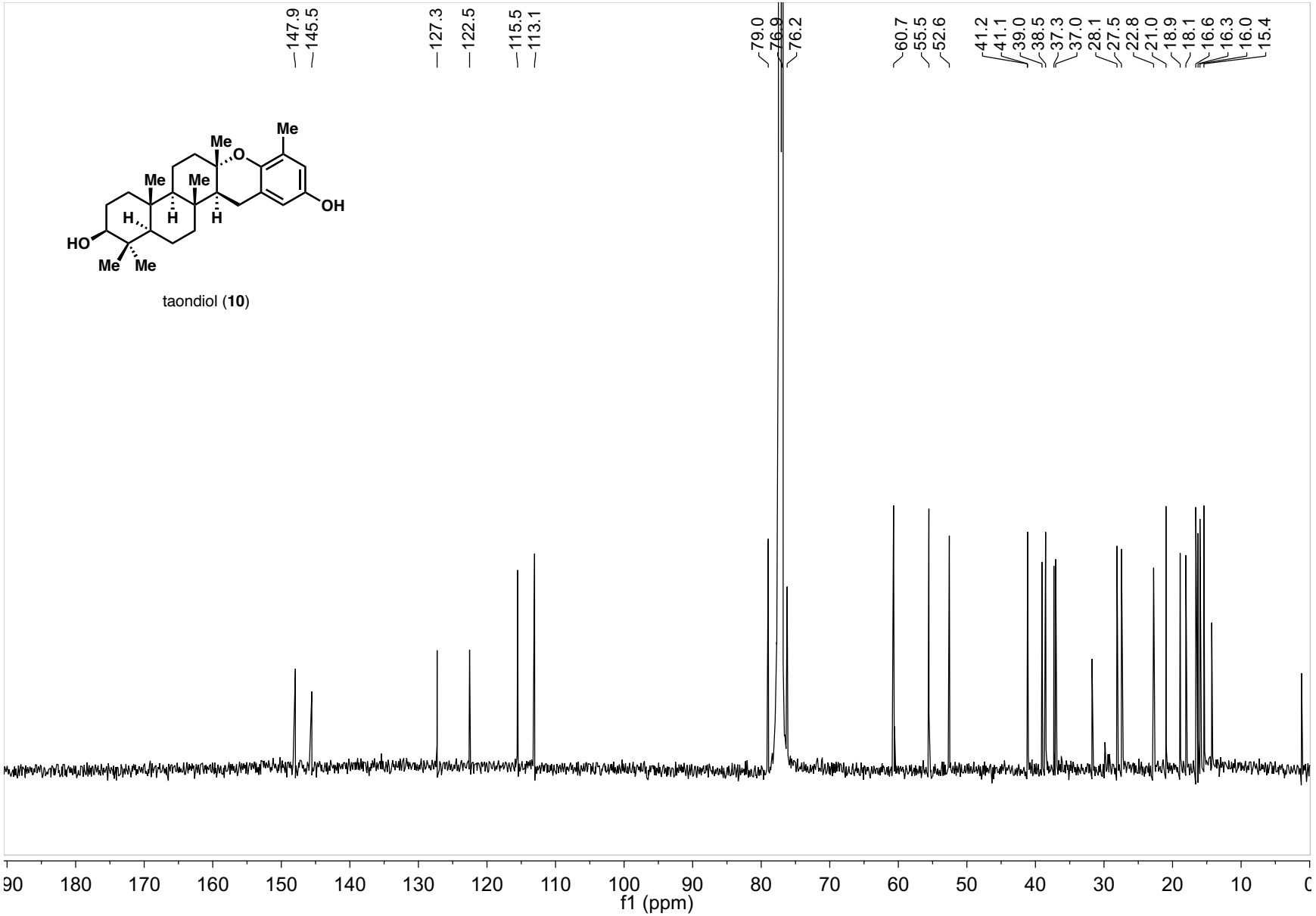

154.3
151.2
128.1
119.1
116.1
109.5
95.6
79.6
56.6
52.8
43.6
39.9
39.8
38.3
38.2
36.1
33.9
32.4
28.6
28.1
21.5
18.9
17.6
16.8
16.1
16.0
15.6
Me
Me
Me
H
H
O
OH
HO
Me
Me
Me
90
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

stypodiol (**8**)

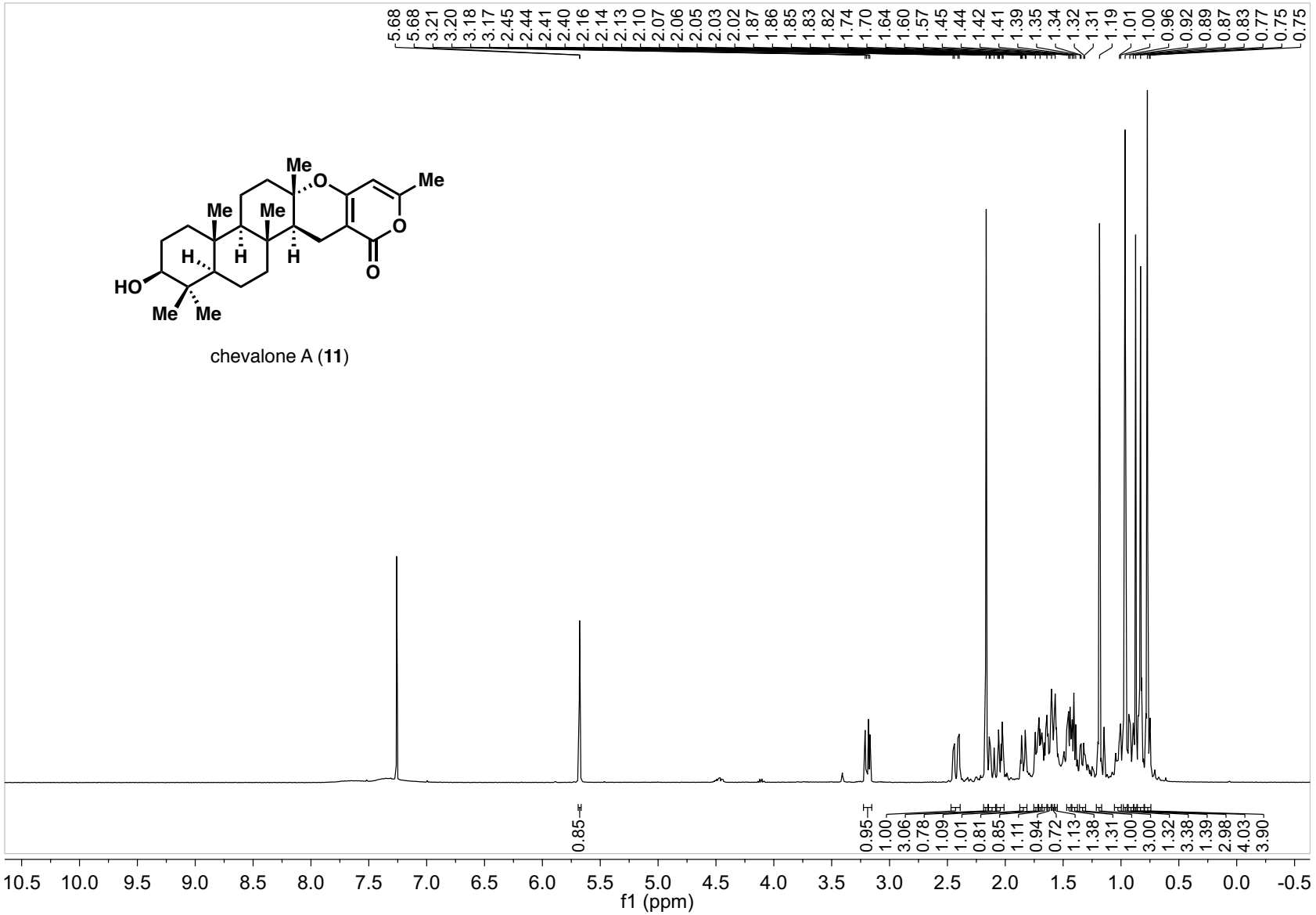

6.66 6.65 6.54 6.53 5.32 3.76 3.66 3.24 3.22 3.21 3.20 2.72 2.69 2.68 2.66 2.63 2.63 2.60 2.59 2.34 2.27 2.04 2.03 2.02 2.00 2.00 1.99 1.90 1.72 1.71 1.67 1.67 1.62 1.60 1.59 1.56 1.42 1.25 1.22 1.20 1.18 1.01 0.99 0.97 0.91 0.88 0.86 0.85 0.82 0.81 0.80
OMe
Me
Me
Me
Me
H
H
H
HO
Me
Me
OMe
S11
0.85 0.94 0.86 2.91 2.81 0.94 1.72 0.87 2.75 0.91 1.81 3.98 3.21 2.83 3.79 2.93 2.70 1.32 2.61
f1 (ppm)

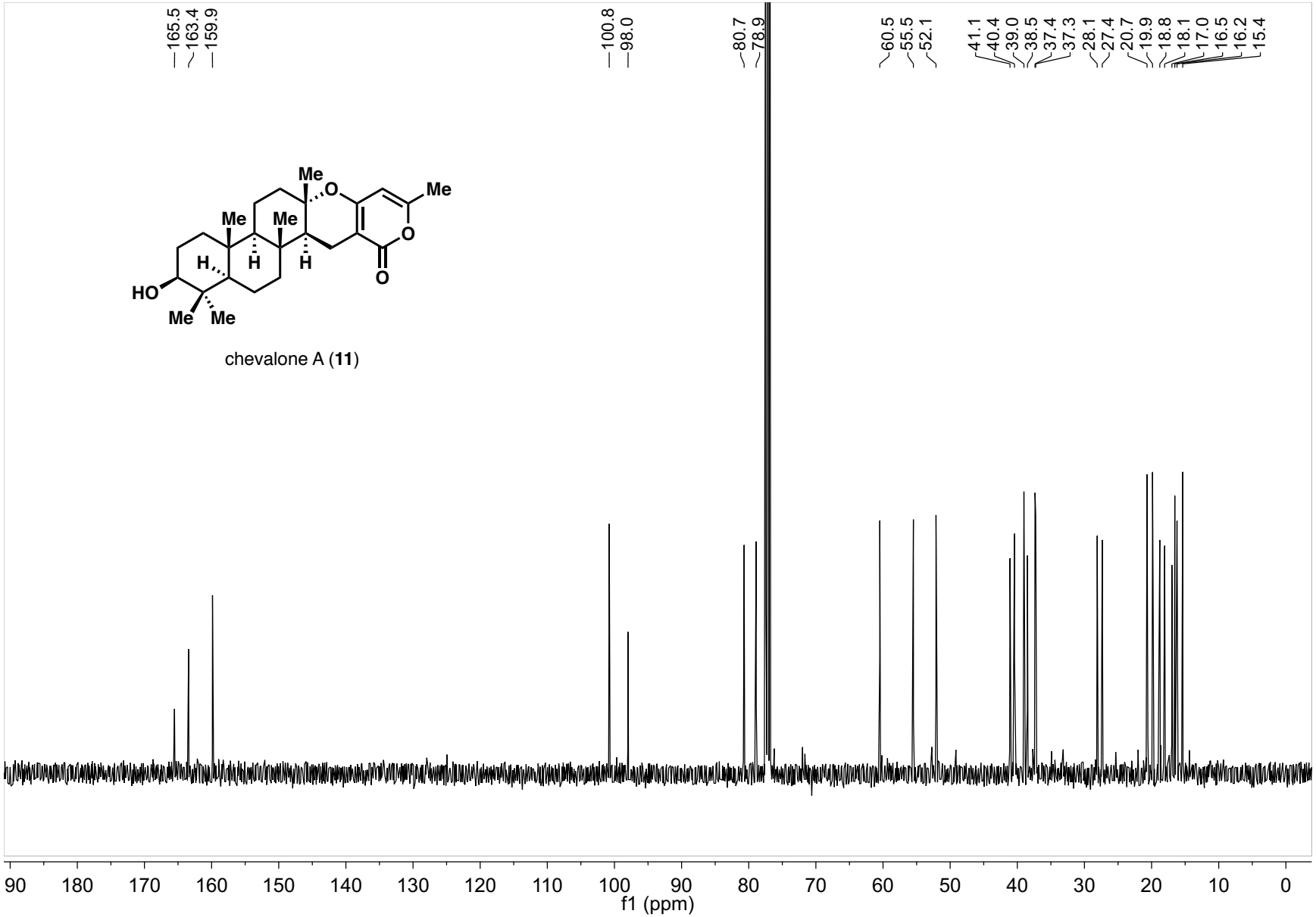

155.4
150.6
137.7
135.7
131.8
121.8
112.8
79.1
77.4
60.5
55.6
55.3
55.3
55.1
41.3
38.9
38.5
37.2
36.9
28.3
27.4
26.5
22.9
22.4
18.8
16.7
15.9
15.7
14.9
OMe
Me
Me
Me
Me
H
H
H
HO
Me
Me
OMe
S11
90
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


6.46 6.45 6.38 6.38 3.23 3.22 3.21 3.20 2.59 2.56 2.55 2.54 2.54 2.09 2.04 2.03 2.02 2.02 2.01 1.80 1.78 1.78 1.77 1.76 1.75 1.74 1.70 1.69 1.67 1.66 1.64 1.62 1.60 1.57 1.49 1.48 1.47 1.45 1.45 1.37 1.37 1.35 1.35 1.13 1.06 1.03 1.01 0.98 0.96 0.94 0.87 0.85 0.79 0.78 0.77
Me
Me
O
Me
Me
Me
OH
H
H
H
HO
Me
Me
taondiol (10)
1.15 1.09 1.38 1.34 1.27 3.00 1.07 1.41 1.18 0.99 2.51 1.46 1.35 1.17 1.43 1.41 2.99 1.49 2.91 1.03 0.92 3.15 3.12 4.15
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5
f1 (ppm)


147.9
145.5
127.3
122.5
115.5
113.1
79.0
76.9
76.2
60.7
55.5
52.6
41.2
41.1
39.0
38.5
37.3
37.0
28.1
27.5
22.8
21.0
18.9
18.1
16.6
16.3
16.0
15.4
Me
Me
O
Me
Me
OH
H
H
H
HO
Me
Me
f1 (ppm)

taondiol (**10**)


Me
O
Me
Me
Me
O
H
H
H
O
HO
Me
Me
chevalone A (11)
f1 (ppm)



chevalone A (**11**)