Electronic Supplementary Material (ESI) for ChemComm.

Metal-free transfer hydrochlorination of internal C–C triple bonds with a bicyclo[3.1.0]hexane-based surrogate releasing two molecules of hydrogen chloride

Andreas J. Weidkamp and Martin Oestreich*

Institut für Chemie, Technische Universität Berlin
Straße des 17. Juni 115, 10623 Berlin, Germany
martin.oestreich@tu-berlin.de

Electronic Supplementary Information

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1 General Information

Reagents and solvents

Standard solvents and reagents were obtained from *ABCR*, *Acros*, *Alfa Aesar*, *Carbolution Chemicals*, *Merck*, *Sigma-Aldrich* or *Tokyo Chemical Industry* (TCI). $B(C_6F_5)_3$ (purchased from *Boulder Scientific Company*) was sublimed prior to use. Et_2O, THF and toluene were dried over sodium/benzophenone and freshly distilled prior to use. CH_2Cl_2 was dried over CaH_2 and freshly distilled prior to use. Chlorobenzene for the developed catalytic hydrochlorination was degassed by three freeze-pump-thaw cycles and stored over thermally activated 4 Å molecular sieves in a glovebox. Brine refers to a saturated solution of NaCl in deionized H_2O. The following aryl iodides are already described in the literature and have been prepared by the reported methods: 4-iodophenyl pivalate,[S1] 4-iodophenyl methanesulfonate,[S2] 1-iodo-2,4-dimethoxybenzene[S3] and 2-bromo-5-iodothiophene.[S4]

Reactions

All reactions were performed in flame-dried glassware using conventional Schlenk techniques under a constant pressure of nitrogen or argon unless otherwise noted. Heating was effected using oil baths unless otherwise stated and all temperatures refer to external bath/heating mantle temperatures. All reactions were stirred with magnetic followers unless otherwise stated.

Chromatography

Flash column chromatography was carried out on *Grace* 60 (40–63 µm, 230–400 mesh, ASTM) silica gel according to the method reported by W. C. Still and coworkers.[S5] Thin-layer chromatography was performed on *Macherey-Nagel* Alugram® Xtra SIL G/UV254 silica gel 60 pre-coated aluminum-backed plates (200 µm layer thickness). Product spots were visualized under UV light (λ_{max} = 254 nm) and/or by staining with the ceric ammonium molybdate solution described by Seebach and coworkers.[S6]

Characterization

Alkene diastereomers (*E* and *Z*) were assigned based on their coupling in a NOESY experiment (C_{vinyl}–H to Ar–H and C_{allyl}–H to Ar–H).

Analytical gas liquid chromatography (GLC) was performed on an *Agilent Technologies* 7820A gas chromatograph equipped with an *Agilent Technologies* J&W HP-5 capillary column (30 m × 0.32 mm, 0.25 µm film thickness) by using the following conditions: carrier gas: N_2, injection temperature: 250 °C, detector temperature: 300 °C, flow rate: 1.7 mL/min; temperature

program: start temperature: 40 °C, heating rate: 10 °C/min, end temperature: 280 °C for 10–30 min.

Nuclear magnetic resonance (NMR) spectra were recorded in $CDCl_3$ on a *Bruker* AV 400 or *Bruker* AV 500 with the deuterated solvent acting as an internal deuterium lock. ^{1}H NMR spectra were recorded at 400 or 500 MHz. $^{13}C\{^{1}H\}$ NMR spectra were recorded at 101 or 126 MHz, ^{19}F spectra at 471 MHz using broadband proton decoupling when indicated. ^{1}H and $^{13}C\{^{1}H\}$ NMR spectra are referenced to the residual protic solvent resonances and the deuterated solvent carbon resonances, respectively ($CHCl_3$: δ = 7.26 ppm for ^{1}H NMR and $CDCl_3$: δ = 77.16 ppm for $^{13}C\{^{1}H\}$ NMR). Chemical shifts are reported relative to tetramethylsilane to the 0.01 ppm for ^{1}H NMR spectra and to the 0.1 ppm for ^{13}C and ^{19}F NMR spectra. Coupling constants are quoted to the nearest 0.1 Hz for ^{1}H NMR spectra and to full Hz for ^{13}C and ^{19}F NMR spectra. ^{19}F NMR spectra were calibrated according to the IUPAC recommendation, using a unified chemical shift scale based on the proton resonance of tetramethylsilane as the primary reference.[S7] Data are reported as follows: chemical shift, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, sept = septet, m = multiplet, m_c = centrosymmetric multiplet, br = broad, and combinations thereof), coupling constant(s) (Hz), and integration.

High resolution mass spectra (HRMS) were recorded on a *Thermo Scientific* LTQ Orbitrap XL (APCI, ESI, LIFDI) or a *Thermo Finnigan* MAT 95 (EI) by the *Analytical Facility* at the *Institut für Chemie, Technische Universität Berlin*.

2 General Procedures

GP 1 for the synthesis of alkynes *via* Sonogashira coupling

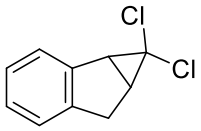
A 50-mL Schlenk tube is charged with $(Ph_3P)_2PdCl_2$ (140 mg, 0.200 mmol, 5.00 mol%), CuI (76.2 mg, 0.400 mmol, 10.0 mol%), the indicated (hetero)aryl iodide or (hetero)aryl bromide (4.00 mmol, 1.00 equiv), triethylamine (10 mL), DMF (10 mL) and the indicated alkyne (4.40 mmol, 1.10 equiv). The reaction mixture is stirred for 16 h, poured into a saturated aqueous solution of NH_4Cl (150 mL), acidified with aqueous HCl solution (2M, approx. 35 mL) to a pH of 4–6 and extracted with methyl *tert*-butyl ether (3 × 100 mL). The combined organic extracts are washed with a freshly prepared solution of NaOH (3.52 g) and L-cysteine (2.42 g) in H_2O (100 mL) (2 × 50 mL) and brine (50 mL). Drying over $MgSO_4$, filtration, concentration under reduced pressure and purification by flash column chromatography on silica gel using the indicated eluent affords the product.

GP 2 for transfer hydrochlorination of alkynes

In a glovebox, an oven-dried 4-mL pressure tube is charged with the indicated alkyne (0.400 mmol, 1.00 equiv), surrogate *trans*-**9** (51.9 mg, 0.260 mmol, 0.650 equiv) and chlorobenzene (1.0 mL). $B(C_6F_5)_3$ (20.5 mg, 40.0 µmol, 10.0 mol%) is added, the tube's walls are rinsed by addition of more chlorobenzene (1.0 mL), the tube is sealed and the reaction mixture is heated outside the glovebox to 140 °C in an aluminum block for the indicated time. The reaction mixture is quenched into a saturated aqueous solution of $NaHCO_3$ (10 mL). Extraction with CH_2Cl_2 (3 × 15 mL), drying over $MgSO_4$, filtration, concentration under reduced pressure and purification by flash column chromatography using the indicated eluent affords the product.

3 Preparation of the Surrogates

1,1-Dichloro-1,1a,6,6a-tetrahydrocyclopropa[*a*]indene (6)



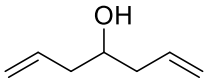
6
$C_{10}H_8Cl_2$
M = 199.07 g/mol

Following a modified literature procedure,[S8] indene (5.81 g, 50.0 mmol, 1.00 equiv) and $BnEt_3NCl$ (114 mg, 500 µmol, 1.00 mol%) were dissolved in a mixture of $CHCl_3$ (23.88 g, 80.00 mmol, 4.000 equiv) and ethanol (0.50 mL) in a 250-mL round-bottom flask without exclusion of air. A freshly prepared 50% solution of NaOH (8.00 g, 200 mmol, 4.00 equiv) in H_2O (8.0 mL) was precooled to 0 °C and added dropwise over 10 min. After stirring for 2 h at room temperature, the mixture was poured into H_2O (250 mL) and it was extracted with $CHCl_3$ (3 × 200 mL). The combined organic extracts were filtered over silica, eluting with *n*-pentane (500 mL), dried over $MgSO_4$, filtered and concentrated under reduced pressure to give a yellow solid. Recrystallization from *n*-pentane afforded the title compound (**6**, 4.029 g, 20.24 mmol, 40%) as a colorless solid.

R_f = 0.57 (*n*-pentane). **m.p.**: 76–78 °C (*n*-pentane). **^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 2.58 (ddd, *J* = 7.4 Hz, 7.3 Hz, 1.2 Hz, 1H), 3.15 (d, *J* = 17.7 Hz, 1H), 3.25 (dd, *J* = 7.4 Hz, 1.5 Hz, 1H), 3.32 (dd, *J* = 17.7 Hz, 7.3 Hz, 1H), 7.14–7.24 (m, 1H), 7.35–7.39 (m, 3H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 34.3, 35.6, 43.1, 66.3, 124.6, 125.4, 126.6, 127.8, 139.8, 144.3. **IR** (ATR): $\tilde{\nu}$/cm^{-1} = 3069, 3039, 2944, 2910, 2829, 1473, 1460, 1422, 1352, 1306, 1265, 1229, 1211, 1178, 1160, 1100, 1057, 1017, 983, 969, 940, 899, 853, 812, 778, 753, 718, 682.

The ^{1}H NMR spectroscopic data[S9] and the melting point[S10] are in accordance with those reported in the literature.

Hepta-1,6-dien-4-ol (S1)



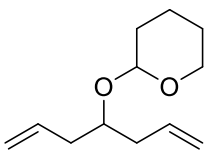
S1
$C_7H_{12}O$
M = 112.17 g/mol

Following a modified literature procedure,[S11] magnesium turnings (12.66 g, 520.9 mmol, 2.101 equiv) were mechanically activated by stirring without solvent in a 250-mL three-necked flask equipped with reflux condenser connected to the Schlenk line, 100-mL dropping funnel and glass stopper. THF (20 mL) and a few drops of allyl bromide were added and the mixture was gently heated with a heat gun until the suspension became cloudy. A mixture of allyl bromide (61.46 g, 508.0 mmol, 2.049 equiv) and ethyl formate (18.37 g, 248.0 mmol, 1.000 equiv) was added dropwise over 30 min resulting in a gentle reflux. The hot reaction mixture was heated at reflux for 2 h and carefully treated with aqueous HCl solution (1M, 150 mL) while still hot. The mixture was extracted with methyl *tert*-butyl ether (3 × 200 mL) and the combined organic extracts were dried over $MgSO_4$ and concentrated under reduced pressure. Purification by vacuum distillation (53 °C, 20 mbar) gave hepta-1,6-dien-4-ol (**S1**, 15.32 g, 136.6 mmol, 55%) as a colorless liquid.

R_f = 0.34 (*n*-pentane/methyl *tert*-butyl ether 10:1). **b.p.**: 53 °C (20 mbar). **^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 1.85 (br s, 1H), 2.15–2.23 (m, 2H), 2.26–2.34 (m, 2H), 3.71 (m_c, 1H), 5.11 (m_c, 2H), 5.14 (m_c, 2H), 5.77–5.89 (m, 2H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 41.3, 70.0, 118.2, 134.8.

The analytical data are in accordance with those reported in the literature.[S12]

2-(Hepta-1,6-dien-4-yloxy)tetrahydro-2*H*-pyran (S2)

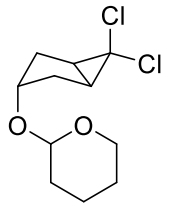


S2
$C_{12}H_{20}O_2$
M = 196.29 g/mol

Following a modified literature procedure,[S12] hepta-1,6-dien-4-ol (**S1**, 5.47 g, 48.8 mmol, 1.00 equiv) was dissolved in CH_2Cl_2 (75 mL) in a 250-mL Schlenk flask. 3,4-Dihydro-2*H*-pyran (6.16 g, 73.2 mmol, 1.50 equiv) was added and the mixture was cooled to 0 °C. Pyridinium *para*-toluenesulfonate (2.45 g, 9.76 mmol, 20.0 mol%) was added in one portion and the mixture was allowed to warm to room temperature over 2 h. It was stirred for 18 h at room temperature and poured into a mixture of saturated aqueous $NaHCO_3$ solution (100 mL), brine (100 mL) and H_2O (100 mL). The mixture was extracted with CH_2Cl_2 (3 × 200), the combined organic extracts were dried over $MgSO_4$ and concentrated under reduced pressure. Purification by flash column chromatography (*n*-pentane:methyl *tert*-butyl ether = 100:1) afforded the title compound (**S2**, 6.95 g, 35.4 mmol, 73%) as a colorless liquid.

R_f = 0.43 (*n*-pentane/methyl *tert*-butyl ether 50:1). **^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 1.46–1.62 (m, 4H), 1.63–1.72 (m, 1H), 1.76–1.89 (m, 1H), 2.19–2.30 (m, 2H), 2.30–2.37 (m, 2H), 3.44–3.52, 7.76 (tt, *J* = 6.0 Hz, 6.0 Hz), 3.88–3.96 (m, 1H), 4.69–4.73 (m, 1H), 5.01–5.08 (m, 3H), 5.08–5.12 (m, 1H), 5.74–5.94 (m, 4H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 19.8, 25.7, 31.1, 37.9, 39.5, 62.6, 75.4, 97.5, 117.0, 117.3, 134.8, 135.4. **IR** (ATR): $\tilde{\nu}$/cm^{-1} = 3075, 2938, 2870, 2849, 1640, 1438, 1381, 1341, 1322, 1281, 1259, 1200, 1182, 1161, 1130, 1115, 1076, 1020, 995, 963, 908, 868, 812, 712. **HRMS** (APCI) calculated for $C_{12}H_{21}O_2^+$ [(M+H)$^+$]: 197.1536; found: 197.1537.

trans-2-((6,6-Dichlorobicyclo[3.1.0]hexan-3-yl)oxy)tetrahydro-2*H*-pyran (*trans*-S3)



trans-**S3**
$C_{11}H_{16}Cl_2O_2$
M = 251.15 g/mol

Following a modified literature procedure,[S13] CH_2Cl_2 (100 mL) was degassed by three freeze-pump-thaw cycles in a 250-mL Schlenk flask. 2-(Hepta-1,6-dien-4-yloxy)tetrahydro-2*H*-pyran (**S2**, 6.785 g, 35.57 mmol, 1.000 equiv) and benzylidene-bis(tricyclohexylphosphine)dichlororuthenium (Grubbs I catalyst) (284 mg, 0.345 mmol, 0.998 mol%) were each added in one portion. After stirring for 48 h at room temperature, a second batch of Grubbs I catalyst (569 mg, 0.691 mmol, 2.00 mol%) and after stirring for another 24 h at room temperature, a third batch of Grubbs I catalyst (284 mg, 0.345 mmol, 0.998 mol%)

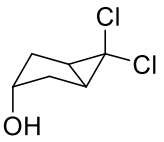
was added. The reaction mixture was stirred for another 24 h, filtered over silica eluting with a mixture of *n*-pentane (300 mL) and methyl *tert*-butyl ether (300 mL) and concentrated under reduced pressure to give the cyclopentene as a dark oil that was used in the next step without further purification.

Following a modified literature procedure,[S14] the residue was taken up in CH_2Cl_2 (70 mL) and $BnEt_3NCl$ (83 mg, 0.36 mmol, 1.0 mol%) was added without exclusion of air. A freshly prepared 50% solution of NaOH (138.3 g, 3.457 mol, 100.0 equiv) in H_2O (138 mL) was added in one portion. $CHCl_3$ (33.02 g, 276.6 mmol, 8.000 equiv) was added dropwise over 4 h. It was stirred for 2 h and filtered. The filtrate was poured into H_2O (500 mL) and it was extracted with CH_2Cl_2 (3 × 250 mL). The combined organic extracts were dried over $MgSO_4$, filtered and concentrated under reduced pressure. Purification by flash column chromatography (*n*-pentane:methyl *tert*-butyl ether = 100:1) gave the title compound (*trans*-**S3**, 1.386 g, 5.519 mmol, 16% over two steps) as a colorless oil.

R_f = 0.53 (*n*-pentane/methyl *tert*-butyl ether 10:1). **^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 1.44–1.60 (m, 4H), 1.63–1.73 (m, 1H), 1.73–1.85 (m, 1H), 1.98–2.06 (m, 1H), 2.11–2.23 (m, 3H), 2.23–2.36 (m, 2H), 3.43–3.51 (m, 1H), 3.79–3.87 (m, 1H), 4.23–4.30 (m, 1H), 4.47–4.51 (m, 1H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 20.0, 25.5, 31.2, 35.1, 35.9, 36.0, 36.3, 63.1, 68.5, 79.5, 98.4.

The ^{1}H NMR spectroscopic data are in accordance with those reported in the literature.[S15]

trans-6,6-Dichlorobicyclo[3.1.0]hexan-3-ol (_trans_-S4)



trans-**S4**
$C_6H_8Cl_2O$
M = 167.03 g/mol

Following a modified literature procedure,[S16] THP ether *trans*-**S3** (1.08 g, 4.32 mmol, 1.00 equiv) was dissolved in MeOH (164 mL) in a 250-mL Schlenk flask. H_2O (8.0 mL) and *p*TsOH·H_2O (205 mg, 1.08 mmol, 25.0 mol%) were added and it was stirred for 2 h at room temperature. Saturated aqueous $NaHCO_3$ solution (100 mL) and H_2O (200 mL) were added and it was extracted with CH_2Cl_2 (5 × 150 mL). The combined organic extracts were washed with brine (2 × 250 mL), dried over $MgSO_4$, filtered and concentrated under reduced pressure. Purification by flash column chromatography (*n*-pentane:methyl *tert*-butyl ether = 3:1) gave

trans-6,6-dichlorobicyclo[3.1.0]hexan-3-ol (*trans*-**S4**, 680 mg, 4.07 mmol, 94%) as a colorless oil.

R_f = 0.33 (*n*-pentane/methyl *tert*-butyl ether 1:1). **^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 1.71–1.85 (br m, 1H), 1.96–2.03 (m, 2H), 2.20–2.27 (m, 4H), 4.34–4.40 (br s, 1H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 36.4, 38.1, 68.9, 76.5.

The ^{1}H NMR spectroscopic data are in accordance with those reported in the literature.[S15]

cis-3,6,6-Trichlorobicyclo[3.1.0]hexane (_cis_-7)

cis-**7**
$C_6H_7Cl_3$
M = 185.47 g/mol

By Appel reaction of alcohol _trans_-S4:

Following a modified literature procedure,[S17] Ph_3P (377 mg, 1.44 mmol, 2.00 equiv) was dissolved in dry CH_2Cl_2 (4.0 mL) and the solution was cooled to 0 °C. CCl_4 (276 mg, 1.80 mmol, 2.50 equiv) was added dropwise over 1 min and the mixture was stirred at 0 °C for 15 min. A solution of alcohol *trans*-**S4** (120 mg, 718 µmol, 1.00 equiv) in non-dried CH_2Cl_2 (1.0 mL) was added dropwise over 10 min. The ice bath was allowed to warm to room temperature and the reaction mixture was stirred for 17 h. Remaining Ph_3P was destroyed by stirring with MeOH (0.5 mL) for 16 h. The reaction mixture was poured into *n*-pentane (300 mL), filtered and concentrated under reduced pressure. The solid residue was extracted by swirling with *n*-pentane (4 × 20 mL), the combined extracts were filtered and concentrated under reduced pressure. Purification by flash column chromatography (*n*-pentane) afforded *cis*-3,6,6-trichlorobicyclo[3.1.0]hexane (*cis*-**7**, 92 mg, 0.50 mmol, 69%) as a colorless oil.

By direct chlorination of THP ether _trans_-S3:

Following a modified literature procedure,[S18] THP ether *trans*-**S3** (1.40 g, 5.57 mmol, 1.00 equiv) and Et_4NCl (1.85 g, 11.1 mmol, 2.00 equiv) were dissolved in MeCN (20 mL) and cooled to 0 °C. Dichloromethylene-dimethyliminium chloride (Viehe salt) (995 mg, 6.12 mmol, 1.10 equiv) was added in one portion. The ice bath was allowed to warm to room temperature and the reaction mixture was stirred for 16 h. It was poured into saturated aqueous $NaHCO_3$ solution (100 mL) and the mixture was extracted with *n*-pentane (3 × 100 mL). The combined organic extracts were dried over $MgSO_4$, filtered and concentrated under reduced pressure.

Purification by flash column chromatography (*n*-pentane) afforded the title compound (*cis*-**S7**, 269 mg, 1.45 mmol, 26%) as a colorless oil.

Although a variety of staining solutions was tested, the compound could not be visualized on TLC plates.

^{1}H NMR (400 MHz, $CDCl_3$): δ/ppm = 1.89 (m_c, 2H), 2.12 (m_c, 2H), 2.67 (m_c, 2H), 4.29 (m_c, 1H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 36.1, 37.6, 59.8, 70.0. **IR** (ATR): $\tilde{\nu}$/cm^{-1} = 2975, 2942, 2870, 1449, 1442, 1357, 1303, 1287, 1255, 1190, 1073, 980, 959, 928, 903, 828, 822, 778, 753. **HRMS** (EI) calculated for $C_6H_6Cl_2^+$ [(M–HCl)$^+$]: 147.9841; found: 147.9848.

cis-6,6-Dichlorobicyclo[3.1.0]hexan-3-ol (*cis*-S4)

cis-**S4**
$C_6H_8Cl_2O$
M = 167.03 g/mol

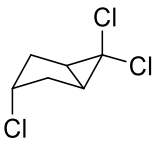
Following a modified literature procedure,[S19] alcohol *trans*-**S4** (340 mg, 2.04 mmol, 1.00 equiv) was dissolved in CH_2Cl_2 (10 mL) in a 50-mL Schlenk flask. 1,1,1-Tris(acetyloxy)-1,1-dihydro-1,2-benziodoxol-3-(1*H*)-one (Dess-Martin periodinane) (1.08 g, 2.54 mmol, 1.25 equiv) was added in one portion. The reaction mixture was stirred at room temperature for 12 h and poured into a mixture of saturated aqueous Na_2SO_3 solution (40 mL) and saturated aqueous $NaHCO_3$ solution (40 mL). The mixture was extracted with CH_2Cl_2 (3 × 40 mL), the combined organic extracts were dried over $MgSO_4$, filtered and concentrated under reduced pressure to give 6,6-dichlorobicyclo[3.1.0]hexan-3-one as a colorless solid which was directly used in the next step without further purification.

Following a modified literature procedure,[S20] the residue was taken up in MeOH (20 mL) and cooled to 0 °C. Without exclusion of air, $NaBH_4$ (92.6 mg, 2.45 mmol, 1.20 equiv) was added in portions over 10 min and the reaction mixture was allowed to warm to room temperature over 1 h. It was poured into H_2O (50 mL), extracted with CH_2Cl_2 (3 × 40 mL), the combined organic extracts were dried over $MgSO_4$, filtered and concentrated under reduced pressure. Purification by flash column chromatography (*n*-pentane:methyl *tert*-butyl ether = 3:1) gave *cis*-6,6-dichlorobicyclo[3.1.0]hexan-3-ol (*cis*-**S4**, 294 mg, 1.76 mmol, 86% over two steps) as a colorless oil.

R_f = 0.20 (*n*-pentane/methyl *tert*-butyl ether 3:1). **^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 1.61–1.70 (m, 2H), 1.77 (br s, 1H), 1.99–2.05 (m, 2H), 2.48–2.60 (m, 2H), 4.54 (m_c, 1H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 35.8, 36.9, 70.5, 78.7.

The ^{1}H NMR spectroscopic data are in accordance with those reported in the literature.[S15]

trans-3,6,6-Trichlorobicyclo[3.1.0]hexane (*trans*-7)

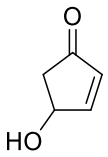


trans-**7**
$C_6H_7Cl_3$
M = 185.47 g/mol

Following a modified literature procedure,[S17] Ph_3P (377 mg, 1.44 mmol, 2.00 equiv) was dissolved in dry CH_2Cl_2 (4.0 mL) and the solution was cooled to 0 °C. CCl_4 (232 mg, 1.51 mmol, 2.10 equiv) was added and the mixture was stirred at 0 °C for 15 min. A solution of alcohol *cis*-**S4** (120 mg, 718 µmol, 1.00 equiv) in non-dried CH_2Cl_2 (2.0 mL) was added dropwise over 10 min. The ice bath was allowed to warm to room temperature and the reaction mixture was stirred for 14 h. The reaction mixture was poured into *n*-pentane (300 mL), filtered and concentrated under reduced pressure. Filtration over silica eluting with *n*-pentane (200 mL) gave the title compound (*trans*-**7**, 103 mg, 555 µmol, 77%) as a colorless oil. Although a variety of staining solutions was tested, the compound could not be visualized on TLC plates.

^{1}H NMR (400 MHz, $CDCl_3$): δ/ppm = 2.30–2.35 (m, 2H), 2.35–2.42 (m, 2H), 2.44–2.52 (m, 2H), 4.36 (m_c, 1H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 36.8, 39.6, 61.5, 68.2. **IR** (ATR): $\tilde{\nu}$/cm^{-1} = 2930, 2855, 1434, 1355, 1312, 1298, 1260, 1188, 1080, 1050, 955, 906, 894, 817, 784, 745, 696. **HRMS**: All attempts to obtain a high resolution mass spectrum failed.

4-Hydroxycyclopent-2-en-1-one (S5)



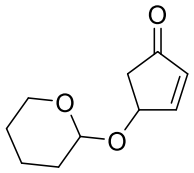
S5
$C_5H_6O_2$
M = 98.10 g/mol

Following a modified literature procedure,[S21] furfuryl alcohol (12.5 g, 127 mmol, 1.00 equiv) was dissolved in H_2O (740 mL) in a 1-L three-necked flask equipped with reflux condenser, mechanical stirrer and glass stopper. The mixture was treated with KH_2PO_4 (1.26 g, 9.26 mmol, 7.29 mol%). Controlled by measurement with a pH meter, the pH value was adjusted to 4.1 by addition of a solution of H_3PO_4 (500 mg, 5.10 mmol, 4.02 mol%) in H_2O (1.0 mL). The reaction mixture was heated at 99 °C open to the atmosphere for 3 d and concentrated under reduced pressure after cooling to room temperature. The residue was taken up in CH_2Cl_2 (200 mL), dried over $MgSO_4$, filtered and concentrated under reduced pressure. Purification by vacuum distillation (106 °C, 16 mbar) of the residue gave 4-hydroxycyclopent-2-en-1-one (**S5**, 1.178 g, 12.01 mmol, 9%) as a red oil.

b.p.: 106 °C (16 mbar). **^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 2.28 (dd, *J* = 18.5 Hz, 2.2 Hz, 1H), 2.77 (dd, *J* = 18.5, 6.3 Hz, 1H), 5.05 (m_c, 1H), 6.22 (dd, *J* = 5.6 Hz, 2.3 Hz, 1H), 7.57 (dd, *J* = 5.7 Hz, 2.3 Hz, 1H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 44.4, 70.6, 135.3, 163.4, 206.9.

The NMR spectroscopic data are in accordance with those reported in the literature.[S21]

4-((Tetrahydro-2*H*-pyran-2-yl)oxy)cyclopent-2-en-1-one (S6)



S6
$C_{10}H_{14}O_3$
M = 182.22 g/mol

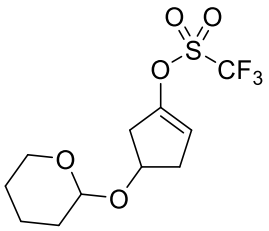
Following a modified literature procedure,[S21] 4-hydroxycyclopent-2-en-1-one (**S5**, 1.20 g, 12.2 mmol, 1.00 equiv) was dissolved in THF (20 mL). 3,4-Dihydro-2*H*-pyran (1.54 g, 18.3 mmol, 1.50 equiv) and pyridinium *para*-toluenesulfonate (461 mg, 1.83 mmol, 15.0 mol%) were added and the reaction mixture was stirred at room temperature for 18 h. It was diluted with methyl *tert*-butyl ether (50 mL) and washed with half saturated aqueous NaCl solution (2 × 25 mL), dried over $MgSO_4$, filtered and concentrated under reduced pressure. Purification by flash column chromatography (*n*-pentane:methyl *tert*-butyl ether = 4:1→3:1) afforded the title compound (**S6**, 1.31 g, 7.18 mmol, 59%, d.r. = 50:50) as a yellowish oil. The diastereomeric ratio was determined by comparing the signals at 7.59 ppm and 7.64 ppm in ^{1}H NMR spectroscopy. The relative stereochemistry was not assigned.

Diastereomer A: **^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 1.48–1.66 (m, 3H), 1.68–1.87 (m, 3H), 2.28 (dd, *J* = 18.4 Hz, 2.3 Hz, 1H), 2.68 (dd, *J* = 18.0 Hz, 6.1 Hz, 1H), 3.50–3.59 (m, 1H), 3.85–3.93 (m, 1H), 4.71–4.74 (m, 1H), 4.97 (m_c, 1H), 6.21 (dd, *J* = 5.8 Hz, 1.3 Hz, 1H), 7.63 (dd, *J* = 5.7 Hz, 2.4 Hz, 1H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 19.6, 25.4, 30.9, 41.8, 62.9, 75.0, 98.9, 135.4, 162.9, 206.2.

Diastereomer B: **^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 1.45–1.63 (m, 3H), 1.68–1.83 (m, 3H), 2.42 (dd, *J* = 18.4 Hz, 2.3 Hz, 1H), 2.73 (ddd, *J* = 18.6 Hz, 6.3 Hz, 0.5 Hz, 1H), 3.45–3.50 (m, 1H), 3.81–3.86 (m, 1H), 4.80 (m_c, 1H), 4.91–4.94 (m, 1H), 6.22 (d, *J* = 5.8 Hz, 1H), 7.58 (ddd, *J* = 5.8 Hz, 2.3 Hz, 0.5 Hz, 1H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 19.5, 25.4, 30.8, 42.9, 62.9, 75.0, 98.7, 135.7, 161.1, 206.6.

The NMR spectroscopic data are in accordance with those reported in the literature.[S21]

4-((Tetrahydro-2*H*-pyran-2-yl)oxy)cyclopent-1-en-1-yl trifluoromethanesulfonate (S7)



S7
$C_{11}H_{15}F_3O_5S$
M = 316.29 g/mol

Following a modified literature procedure,[S22] a 100-mL Schlenk flask was charged with lithium tri-*sec*-butylborohydride in THF (1.0M, 3.2 mL, 3.2 mmol, 1.0 equiv) and THF (25 mL). It was cooled to –78 °C and a solution of enone **S6** (585 mg, 3.21 mmol, 1.00 equiv) in THF (21 mL) was added dropwise over 2 h. It was stirred for another 2 h before a solution of *N*-(5-chloro-2-pyridyl)bis(trifluoromethanesulfonimide) (Comins' reagent) (1.32 g, 3.37 mmol, 1.05 equiv) in THF (5 mL) was added dropwise. The reaction mixture was stirred for another 1 h at –78 °C and then allowed to warm to –20 °C. MeOH (2.5 mL), H_2O (45 mL) and methyl *tert*-butyl ether (50 mL) were added and the phases were separated. The aqueous phase was extracted with methyl *tert*-butyl ether (3 × 50 mL) and the combined organic extracts were dried over $MgSO_4$, filtered and concentrated under reduced pressure. The residue was dissolved in a mixture of *n*-pentane (50 mL) and methyl *tert*-butyl ether (50 mL) and washed with aqueous NaOH solution (10%, 3 × 50 mL), H_2O (50 mL), saturated aqueous $CuSO_4$ solution (2 × 50 mL) and brine (100 mL). The organic phase was dried over K_2CO_3, filtered, concentrated under reduced pressure and purified by flash column chromatography (*n*-pentane:triethylamine:methyl *tert*-

butyl ether = 200:1:0→100:1:1) to give the title compound (**S7**, 572 mg, 1.81 mmol, 56%, d.r. = 60:40) as a yellowish oil. The diastereomeric ratio was determined by comparing the signals at 5.60 ppm and 5.56 ppm in ^{1}H NMR spectroscopy. The relative stereochemistry was not assigned.

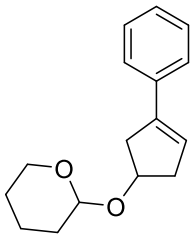
$\mathbf{R_f}$ = 0.10 (*n*-pentane/methyl *tert*-butyl ether 50:1).

Diastereomer A (major): ^{1}H NMR (500 MHz, $CDCl_3$): δ/ppm = 1.48–1.63 (m, 4H), 1.66–1.75 (m, 1H), 1.77–1.88 (m, 1H), 2.50–2.61 (m, 2H), 2.67–2.93 (m, 2H) 3.48–3.54 (m, 1H), 3.82–3.88 (m, 1H), 4.59 (m_c, 1H), 4.62–4.67 (m, 1H), 5.60 (m_c, 1H). **^{13}C{^{1}H} NMR** (126 MHz, $CDCl_3$): δ/ppm = 19.8, 25.5, 31.0, 36.6, 38.0, 63.0, 72.7, 97.9 (m_c), 116.0, 118.7 (q, $^1J_{C,F}$ = 322 Hz), 146.6. The two outer peaks of the quartet of the CF_3 group are only poorly visible. **^{19}F NMR** (471 MHz, $CDCl_3$): δ/ppm = –73.6 (s).

Diastereomer B (minor): ^{1}H NMR (500 MHz, $CDCl_3$): δ/ppm = 1.48–1.63 (m, 4H), 1.66–1.75 (m, 1H), 1.77–1.88 (m, 1H), 2.38–2.44 (m, 1H), 2.67–2.93 (m, 3H), 3.48–3.54 (m, 1H), 3.82–3.88 (m, 1H), 4.54 (m_c, 1H), 4.62–4.67 (m, 1H), 5.56 (m_c, 1H). **^{13}C{^{1}H} NMR** (126 MHz, $CDCl_3$): δ/ppm = 19.7, 25.5, 31.0, 35.8, 39.1, 62.8, 73.3, 97.9 (m_c), 115.1, 118.7 (q, $^1J_{C,F}$ = 322 Hz), 147.0. The two outer peaks of the quartet of the CF_3 group are only poorly visible. **^{19}F NMR** (471 MHz, $CDCl_3$): δ/ppm = –73.6 (s).

IR (ATR): $\tilde{\nu}$/cm^{-1} = 2943, 2869, 1661, 1420, 1343, 1285, 1201, 1136, 1111, 1073, 1033, 1019, 997, 969, 896, 869, 834, 814, 765. **HRMS** (ESI) calculated for $C_{11}H_{15}F_3NaO_5S^+$ [(M+Na)$^+$]: 339.0484; found: 339.0484.

2-((3-Phenylcyclopent-3-en-1-yl)oxy)tetrahydro-2*H*-pyran (S8)



S8
$C_{16}H_{20}O_2$
M = 244.33 g/mol

Following a modified literature procedure,[S23] a 100-mL two-neck round-bottom flask equipped with a reflux condenser and a septum was charged with alkenyl triflate **S7** (500 mg, 1.58 mmol, 1.00 equiv) and phenylboronic acid (485 mg, 3.95 mmol, 2.50 equiv) followed by toluene (15 mL), ethanol (5 mL) and aqueous Na_2CO_3 solution (2.0M, 7.2 mL, 9.0 equiv). Argon was

bubbled through the reaction mixture for 10 min, then $(Ph_3P)_4Pd$ (76.7 mg, 66.3 µmol, 5.00 mol%) was added in one portion. The suspension was heated at reflux for 3 h and poured into a saturated aqueous NH_4Cl solution (100 mL). The aqueous phase was extracted with methyl *tert*-butyl ether (3 × 100 mL) and the combined organic extracts were concentrated under reduced pressure. The residual solid was dissolved in methyl *tert*-butyl ether (300 ml) and washed with aqueous NaOH solution (10%, 3 × 80 mL), H_2O (100 mL) and brine (100 mL). The organic phase was dried over $MgSO_4$, filtered and concentrated under reduced pressure. Purification by flash column chromatography (*n*-pentane:methyl *tert*-butyl ether = 100:1→50:1) afforded the title compound (**S8**, 260 mg, 1.06 mmol, 67%, d.r. = 61:39) as a yellowish oil. The diastereomeric ratio was determined by comparing the signals at 6.14 ppm and 6.09 ppm in ^{1}H NMR spectroscopy. The relative stereochemistry was not assigned.

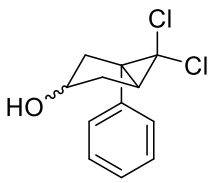
R_f = 0.21 (*n*-pentane/methyl *tert*-butyl ether 50:1).

Diastereomer A (major): ^{1}H NMR (400 MHz, $CDCl_3$): δ/ppm = 1.48–1.62 (m, 2H), 1.68–1.78 (m, 2H), 1.79–1.89 (m, 2H), 2.50–3.11 (m, 4H), 3.50–3.59 (m, 1H), 3.90–3.98 (m, 1H), 4.64–4.72 (m, 1H), 4.72–4.72 (m, 1H), 6.14 (m_c, 1H), 7.22 (m_c, 1H), 7.28–7.34 (m, 2H), 7.40–7.46 (m, 2H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 20.0, 25.7, 31.3, 39.8, 41.2, 63.0, 75.8, 97.8, 123.8, 125.7, 127.2, 128.4, 136.5, 139.8.

Diastereomer B (minor): ^{1}H NMR (400 MHz, $CDCl_3$): δ/ppm = 1.48–1.62 (m, 6H), 2.50–3.11 (m, 4H), 3.50–3.59 (m, 1H), 3.90–3.98 (m, 1H), 4.64–4.72 (m, 2H), 6.09 (m_c, 1H), 7.22 (m_c, 1H), 7.28–7.34 (m, 2H), 7.40–7.46 (m, 2H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 20.0, 25.7, 31.3, 40.0, 41.0, 63.0, 76.0, 97.9, 122.8, 125.7, 127.2, 128.4, 136.4, 140.6.

IR (ATR): $\tilde{\nu}$/cm^{-1} = 3446, 2938, 2866, 1721, 1683, 1447, 1344, 1200, 1118, 1072, 1020, 972, 915, 867, 811, 755, 694. **HRMS** (APCI) calculated for $C_{16}H_{21}O_2^+$ [$(M+H)^+$]: 245.1536; found: 245.1533.

(1*RS*,3*SR*,5*SR*)-6,6-Dichloro-1-phenylbicyclo[3.1.0]hexan-3-ol (S9)



S9

$C_{12}H_{12}Cl_2O$

M = 243.13 g/mol

Following a modified literature procedure,[S24] alkene **S8** (1.30 g, 5.32 mmol, 1.00 equiv) was dissolved in $CHCl_3$ (8.0 mL) and $BnEt_3NCl$ (121 mg, 53.2 µmol, 1.00 mol%) was added. While stirring in an ambient temperature water bath, an aqueous NaOH solution (50%, 2.1 mL, 3.3 g, 41 mmol, 7.6 equiv) was added dropwise over 10 min. The mixture was stirred for 2 h, poured into a saturated aqueous solution of NH_4Cl (100 mL) and filtered. The filtrate was extracted with CH_2Cl_2 (3 × 80 mL), the combined organic extracts were dried over $MgSO_4$, filtered and concentrated under reduced pressure to give the crude dichlorocarbene adduct (1.60 g, 4.89 mmol, 92%) which was directly used in the next step without further purification.

Following a modified literature procedure,[S16] the residue was taken up in MeOH (190 mL). Without exclusion of air, H_2O (10 mL) and *p*TsOH·H_2O (101 mg, 532 µmol, 10.0 mol%) were added and it was stirred for 48 h at room temperature. Saturated aqueous $NaHCO_3$ solution (50 mL) and H_2O (100 mL) were added and it was extracted with CH_2Cl_2 (5 × 100 mL). The combined organic extracts were washed with brine (300 mL), dried over $MgSO_4$, filtered and concentrated under reduced pressure. Purification by flash column chromatography (*n*-pentane:methyl *tert*-butyl ether = 6:1→3:1) gave the title compound (**S9**, 1.03 g, 4.24 mmol, 80% over two steps, d.r. = 76:24) as a colorless oil. The diastereomeric ratio was determined by comparing the signals at 4.46 ppm and 4.62 ppm in ^{1}H NMR spectroscopy. The relative stereochemistry was not assigned.

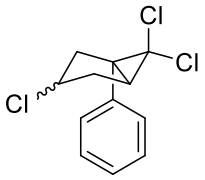
R_f = 0.22 (*n*-pentane/methyl *tert*-butyl ether 3:1).

Diastereomer A (major): ^{1}H NMR (400 MHz, $CDCl_3$): δ/ppm = 1.96 (br s, 1H), 2.16–2.22 (m, 1H), 2.23–2.29 (m, 1H), 2.43–2.49 (m, 1H), 2.49–2.52 (m, 1H), 2.86 (dd, *J* = 14.7 Hz, 6.4 Hz, 1H), 4.46 (m_c, 1H), 7.19–7.23 (m, 2H), 7.27–7.33 (m, 3H), 7.33–7.39 (m, 2H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 38.7, 39.6, 46.7, 48.0, 72.3, 76.0, 127.5, 128.4, 128.6, 138.9.

Diastereomer B (minor): ^{1}H NMR (400 MHz, $CDCl_3$): δ/ppm = 1.88–1.94 (m, 1H), 1.96 (br s, 1H), 2.33–2.36 (m, 1H), 2.36–2.40 (m, 1H), 2.68 (m_c, 1H), 2.76 (m_c, 1H), 4.61 (m_c, 1H), 7.19–7.24 (m, 2H), 7.27–7.33 (m, 1H), 7.33–7.39 (m, 2H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 37.6, 38.5, 45.1, 47.5, 74.1, 76.9, 127.5, 128.4, 128.5, 138.9.

IR (ATR): ṽ/cm^{-1} = 3394, 2971, 2932, 1601, 1495, 1446, 1432, 1387, 1364, 1330, 1264, 1234, 1198, 1070, 1021, 979, 941, 921, 841, 819, 760, 723, 696, 672. **HRMS** (EI) calculated for $C_{12}H_{12}Cl_2O^+$ [M^+]: 242.0260; found: 242.0252.

(1*RS*,3*RS*,5*SR*)-3,6,6-Trichloro-1-phenylbicyclo[3.1.0]hexane (8)



8

$C_{12}H_{11}Cl_3$

M = 261.57 g/mol

Following a modified literature procedure,[S17] Ph_3P (1.99 g, 7.57 mmol, 2.00 equiv) was dissolved in CH_2Cl_2 (19 mL) in a 100-mL Schlenk flask and cooled to 0 °C. CCl_4 (1.22 g, 7.95 mmol, 2.10 equiv) was added slowly over 1 min and it was stirred for 15 min. A solution of alcohol **S9** (920 mg, 3.78 mmol, 1.00 equiv) in CH_2Cl_2 (5 mL) was added dropwise over 10 min and the reaction mixture was allowed to warm to room temperature. It was stirred for 14 h and remaining Ph_3P was destroyed by stirring with MeOH (0.5 mL) for 2 h. The reaction was poured into *n*-pentane (200 mL), Celite (5 g) and $MgSO_4$ were added and it was filtered. The filtrate was concentrated under reduced pressure. The residue was taken up in *n*-pentane (100 mL), filtered and the filtrate was concentrated under reduced pressure. Purification of the residue by flash column chromatography (*n*-pentane) gave the trichloride **8** (755 mg, 2.89 mmol, 76%, d.r. = 77:23) as a white, deliquescent solid. The diastereomeric ratio was determined by comparing the signals at 4.40 ppm and 4.61 ppm in ^{1}H NMR spectroscopy. The relative stereochemistry was not assigned.

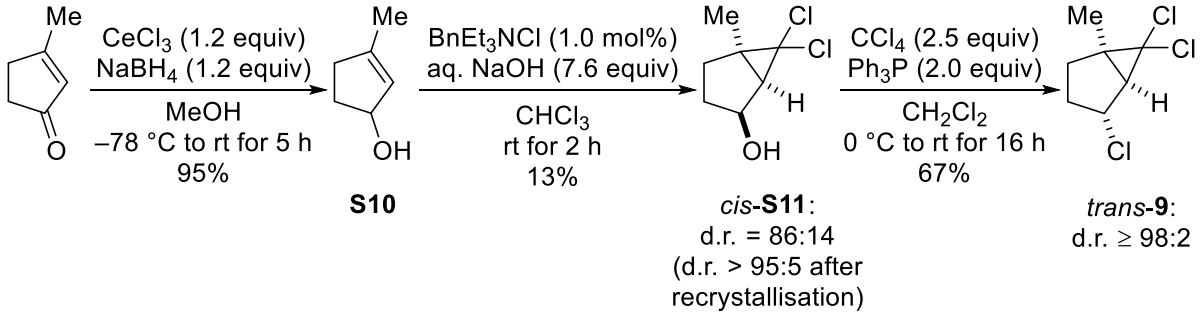
R_f = 0.33 (major) and 0.23 (minor) (*n*-pentane). **m.p.**: 38–40 °C (*n*-pentane).

Diastereomer A (major): ^{1}H NMR (400 MHz, $CDCl_3$): δ/ppm = 2.17 (ddd, *J* = 14.0 Hz, 9.9 Hz, 2.8 Hz, 1H), 2.43 (dd, *J* = 7.3 Hz, 2.8 Hz, 1H), 2.62 (dd, *J* = 14.3, 10.1 Hz, 1H), 2.81 (ddd, *J* = 14.3 Hz, 8.8 Hz, *J* = 1.7 Hz, 1H), 2.91 (m_c, 1H), 4.40 (m_c, 1H), 7.19–7.23 (m, 2H), 7.28–7.38 (m, 3H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 38.4, 38.8, 45.8, 48.1, 58.2, 73.7, 127.8, 2 × 128.6, 138.1.

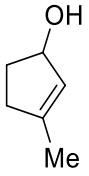
Diastereomer B (minor): ^{1}H NMR (400 MHz, $CDCl_3$): δ/ppm = 1.88–1.94 (m, 1H), 1.96 (br s, 1H), 2.33–2.36 (m, 1H), 2.36–2.40 (m, 1H), 2.68 (m_c, 1H), 2.76 (m_c, 1H), 4.61 (m_c, 1H), 7.19–7.24 (m, 2H), 7.27–7.33 (m, 1H), 7.33–7.39 (m, 2H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 40.0, 40.5, 47.5, 48.7, 61.0, 71.7, 127.8, 128.5, 128.6, 138.1.

IR (ATR): $\tilde{\nu}$/cm^{-1} = 3045, 3029, 2972, 2944, 2872, 1601, 1580, 1560, 1543, 1494, 1444, 1366, 1304, 1279, 1259, 1201, 1192, 1178, 1144, 1109, 1098, 1089, 1071, 1052, 1025, 1000, 965, 952, 922, 911, 838, 758, 697, 672. **HRMS** (APCI) calculated for $C_{12}H_{11}Cl_3^+$ [$(M+H)^+$]: 259.9921; found: 259.9921.

Scheme S1. Synthesis of HCl-surrogate *trans*-**9**.



3-Methylcyclopent-2-en-1-ol (S10)



S10

$C_6H_{10}O$

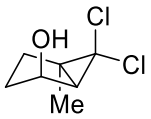
M = 98.15 g/mol

Following a modified literature procedure,[S25] 3-methylcyclopent-2-en-1-one (4.00 g, 41.6 mmol, 1.00 equiv) was dissolved in MeOH (100 mL) in a 250-mL round-bottom flask and cooled to –78 °C. $CeCl_3 \cdot 7H_2O$ (18.60, 49.92 mmol, 1.200 equiv) was added in one portion and the resulting suspension was stirred for 15 min. $NaBH_4$ (1.89 g, 49.9 mmol, 1.20 equiv) was added in portions over 15 min and the reaction mixture was allowed to warm to room temperature over 4 h and stirred for another 1 h. H_2O (8 mL) was added, it was stirred for 5 min and the reaction mixture was poured into H_2O (300 mL). It was extracted with methyl *tert*-butyl ether (3 × 200 mL) and the combined organic extracts were washed with brine (200 mL). Drying over $MgSO_4$, filtration and careful concentration under reduced pressure yielded 3-methylcyclopent-2-en-1-ol (**S10**, 3.88 g, 39.5 mmol, 95%) as a volatile, colorless oil which was directly used in the next step without further purification. An analytical sample was obtained by vacuum distillation (41 °C, 10 mbar).

R_f = 0.44 (*n*-pentane/methyl *tert*-butyl ether 1:1). **b.p.**: 41 °C (10 mbar). **^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 1.41–1.47 (br m, 1H), 1.66–1.76 (m, 1H), 1.77 (m_c, 3H), 2.10–2.21 (m, 1H), 2.24–2.36 (m, 1H), 2.37–2.51 (m, 1H), 4.81 (br s, 1H), 5.45 (m_c, 1H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 16.9, 34.6, 35.3, 78.2, 127.7, 140.2.

The NMR spectroscopic data are in accordance with those reported in the literature.[S25,S26]

(1*RS*,2*SR*,5*RS*)-6,6-Dichloro-5-methylbicyclo[3.1.0]hexan-2-ol (*cis*-S11)



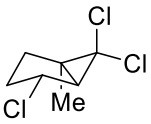
cis-**S11**
$C_7H_{10}ClO_2$
M = 181.06 g/mol

Following a modified literature procedure,[S24] crude 3-methylcyclopent-2-en-1-ol (**S10**, 3.50 g, 35.7 mmol, 1.00 equiv) was dissolved in $CHCl_3$ (53 mL) and $BnEt_3NCl$ (83 mg, 0.36 mmol, 1.0 mol%) was added. While stirring in an ambient temperature water bath, a freshly prepared 50% solution of NaOH (10.9 g, 273 mmol, 7.63 equiv) in H_2O (10.9 mL) was added dropwise over 10 min. The mixture was stirred for 2 h, poured into a saturated aqueous solution of NH_4Cl (200 mL) and filtered. The filtrate was extracted with CH_2Cl_2 (3 × 100 mL), the combined organic extracts were dried over $MgSO_4$, filtered, concentrated under reduced pressure and purified by flash column chromatography (*n*-pentane:methyl *tert*-butyl ether = 6:1→2:1) to yield a diastereomeric mixture of 6,6-dichloro-5-methylbicyclo[3.1.0]hexan-2-ol (*cis*-**S11** and *trans*-**S11**, 2.32 g, 12.8 mmol, 36%, *cis*-**S11**/*trans*-**S11** = 86:14) as a yellowish solid. Recrystallization from *n*-pentane afforded the pure diastereomer *cis*-**S11** (805 mg, 4.47 mmol, 13%) as a white, fluffy solid. The diastereomeric ratio was determined by comparing the signals at 4.80 ppm and 4.46 ppm in ^{1}H NMR spectroscopy.

R_f = 0.14 (*n*-pentane/methyl *tert*-butyl ether 6:1). **m.p.**: 76–78 °C (*n*-pentane). **^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 1.42 (s, 3H), 1.62–1.72 (m, 1H), 1.92–1.98 (m, 2H), 1.99–2.05 (m, 1H), 2.20–2.29 (m, 2H), 4.80 (m_c, 1H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 19.0, 33.4, 33.6, 39.9, 45.3, 70.9, 77.4. **IR** (ATR): $\tilde{\nu}$/cm^{-1} = 3246, 2985, 2958, 2927, 1450, 1381, 1335, 1307, 1279, 1244, 1204, 1163, 1118, 1064, 1045, 1014, 997, 939, 870, 827, 809, 718. **HRMS** (APCI) calculated for $C_7H_9Cl_2O^+$ [(M–H)$^+$]: 179.0025; found: 179.0029.

The ^{1}H NMR spectroscopic data and the melting point are in accordance with those reported in the literature.[S24]

(1*RS*,4*SR*,5*RS*)-4,6,6-Trichloro-1-methylbicyclo[3.1.0]hexane (*trans*-9)

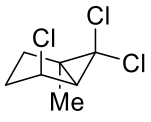


trans-**9**
$C_7H_9Cl_3$
M = 199.50 g/mol

Following a modified literature procedure,[S17] Ph_3P (3.62 g, 13.8 mmol, 2.00 equiv) was dissolved in dry CH_2Cl_2 (35 mL) and the solution was cooled to 0 °C. CCl_4 (2.65 g, 17.3 mmol, 2.50 equiv) was added and the mixture was stirred at 0 °C for 15 min. A solution of (1*RS*,2*SR*,5*RS*)-6,6-dichloro-5-methylbicyclo[3.1.0]hexan-2-ol (***cis*-S11**, 1.25 g, 6.90 mmol, 1.00 equiv) in non-dried CH_2Cl_2 (10 mL) was added dropwise over 10 min. The ice bath was allowed to warm to room temperature and the reaction mixture was stirred for 16 h. The mixture was poured into *n*-pentane (200 mL), Celite (5 g) and $MgSO_4$ (1 g) were added and it was filtered and concentrated under reduced pressure. Purification by flash column chromatography (*n*-pentane) yielded (1*RS*,4*SR*,5*RS*)-4,6,6-trichloro-1-methylbicyclo[3.1.0]hexane (*trans*-**9**, 917 mg, 4.60 mmol, 67%) as a colorless oil. Although a variety of staining solutions was tested, the compound could not be visualized on TLC plates.

^{1}H NMR (400 MHz, $CDCl_3$): δ/ppm = 1.56 (s, 3H), 2.03–2.17 (m, 3H), 2.29–2.44 (m, 2H), 4.49–4.54 (m, 1H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 18.4, 33.6, 37.1, 41.2, 48.7, 62.2, 69.8. **IR** (ATR): $\tilde{\nu}$/cm^{-1} = 2985, 2960, 2930, 2869, 1738, 1655, 1453, 1378, 1339, 1315, 1287, 1259, 1214, 1192, 1164, 1133, 1081, 1047, 1013, 975, 943, 896, 872, 809, 766, 749, 733, 713, 672, 653. **HRMS** (APCI) calculated for $C_7H_8Cl_3^+$ [(M–H)$^+$]: 196.9686; found: 196.9692.

(1*RS*,4*RS*,5*RS*)-4,6,6-Trichloro-1-methylbicyclo[3.1.0]hexane (*cis*-9)



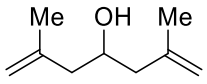
cis-**9**
$C_7H_9Cl_3$
M = 199.50 g/mol

Following a modified literature procedure,[S17] Ph_3P (2.75 g, 10.5 mmol, 2.00 equiv) was dissolved in dry CH_2Cl_2 (26 mL) and the solution was cooled to 0 °C. CCl_4 (1.70 g, 11.0 mmol, 2.50 equiv) was added and the mixture was stirred at 0 °C for 15 min. A solution of non-recrystallized 6,6-dichloro-5-methylbicyclo[3.1.0]hexan-2-ol (**S11**, 950 mg, 5.25 mmol, 1.00

equiv, *cis*-**S11**/*trans*-**S11** = 79:21) in non-dried CH_2Cl_2 (10 mL) was added dropwise over 10 min. The ice bath was allowed to warm to room temperature, the reaction mixture was stirred for 44 h and remaining Ph_3P was destroyed by stirring with MeOH (0.5 mL) for 1 h. The mixture was poured into *n*-pentane (200 mL), Celite (5 g) and $MgSO_4$ (1 g) were added and it was filtered and concentrated under reduced pressure. Purification by flash column chromatography (*n*-pentane) yielded (1*RS*,4*RS*,5*RS*)-4,6,6-trichloro-1-methylbicyclo[3.1.0]hexane (*cis*-**9**, 153 mg, 767 µmol, 15%) as a colorless oil. Although a variety of staining solutions was tested, the compound could not be visualized on TLC plates.

^{1}H NMR (400 MHz, $CDCl_3$): δ/ppm = 1.46 (s, 3H), 1.98–2.13 (m, 3H), 2.19–2.39 (m, 2H), 4.71–4.78 (m, 1H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 18.7, 34.0, 34.3, 41.0, 45.6, 60.7, 70.4. **IR** (ATR): $\tilde{\nu}$/cm^{-1} = 2993, 2958, 2931, 2864, 1458, 1440, 1381, 1346, 1305, 1288, 1257, 1241, 1204, 1154, 1129, 1047, 1002, 981, 944, 905, 868, 844, 808, 757, 721, 705. **HRMS** (LIFDI) calculated for $C_7H_9Cl_3^+$ [M$^+$]: 197.9764; found: 197.9766.

2,6-Dimethylhepta-1,6-dien-4-ol (S12)



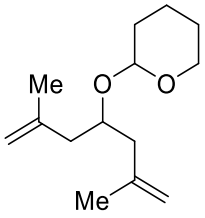
S12
$C_9H_{16}O$
M = 140.23 g/mol

Following a modified literature procedure,[S11] magnesium turnings (1.26 g, 52.0 mmol, 2.10 equiv) were mechanically activated by stirring without solvent in a 50-mL two-necked flask equipped with reflux condenser connected to the Schlenk line and septum. THF (2.0 mL) and a few drops of methallyl bromide were added and the mixture was gently heated with a heat gun until the suspension became cloudy. A mixture of methallyl bromide (6.89 g, 51.0 mmol, 2.06 equiv) and ethyl formate (1.837 g, 24.8 mmol, 1.00 equiv) was added dropwise over 15 min resulting in a gentle reflux. The hot reaction mixture was heated at reflux for 2 h and carefully treated with aqueous HCl solution (1M, 15 mL) while still hot. The mixture was extracted with methyl *tert*-butyl ether (3 × 100 mL). The combined organic extracts were washed with brine (100 mL), dried over $MgSO_4$ and concentrated under reduced pressure to give the crude alcohol **S12** (2.26 g, 16.1 mmol, 65%) which was directly used in the next step without further purification.

^{1}H NMR (500 MHz, $CDCl_3$): δ/ppm = 1.78 (m_c, 6H), 2.14–2.20 (m, 4H), 3.90 (m_c, 1H), 3.90 (tt, *J* = 8.3 Hz, 3.4 Hz, 1H), 4.79–4.81 (m, 2H), 4.88 (m_c, 2H).

The ^{1}H NMR spectroscopic data are in accordance with those reported in the literature.[S27]

2-((2,6-Dimethylhepta-1,6-dien-4-yl)oxy)tetrahydro-2*H*-pyran (S13)

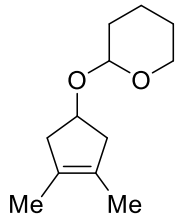


S13
$C_{14}H_{24}O_2$
M = 224.34 g/mol

Following a modified literature procedure,[S12] crude 2,6-dimethylhepta-1,6-dien-4-ol (**S12**, 630 mg, 4.49 mmol, 1.00 equiv) was dissolved in CH_2Cl_2 (7 mL) in a 25-mL Schlenk flask. 3,4-Dihydro-2*H*-pyran (56 mg, 6.74 mmol, 1.50 equiv) was added and the mixture was cooled to 0 °C. Pyridinium *para*-toluenesulfonate (2.23 mg, 899 µmol, 20.0 mol%) was added in one portion and the mixture was allowed to warm to room temperature over 2 h. It was stirred for 16 h at room temperature and poured into a mixture of saturated aqueous $NaHCO_3$ solution (10 mL), brine (10 mL) and H_2O (10 mL). The mixture was extracted with CH_2Cl_2 (3 × 25), the combined organic extracts were dried over $MgSO_4$ and concentrated under reduced pressure. Purification by flash column chromatography (*n*-pentane:methyl *tert*-butyl ether = 100:1) afforded the title compound (**S13**, 609 mg, 2.72 mmol, 60%) as a colorless liquid.

R_f = 0.52 (*n*-pentane/methyl *tert*-butyl ether 25:1). **^{1}H NMR** (500 MHz, $CDCl_3$): δ/ppm = 1.45–1.60 (m, 4H), 1.63–1.72 (m, 1H), 1.72–1.84 (m, 7H), 2.12–2.25 (m, 3H), 2.31–2.37 (m, 1H), 3.42–3.49 (m, 1H), 3.88–4.00 (m, 2H), 4.69–4.81 (m, 5H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 19.6, 22.9, 23.1, 25.7, 31.0, 42.7, 44.0, 62.2, 73.2, 97.4, 112.9, 113.0, 143.0, 143.3. **IR** (ATR): $\tilde{\nu}$/cm^{-1} = 2938, 2871, 2849, 1647, 1440, 1374, 1343, 1322, 1283, 1259, 1226, 1200, 1181, 1156, 1131, 1114, 1076, 1062, 1021, 1003, 985, 924, 885, 869, 812, 715. **HRMS** (APCI) calculated for $C_{14}H_{25}O_2^+$ [(M+H)$^+$]: 225.1849; found: 197.1534.

2-((3,4-Dimethylcyclopent-3-en-1-yl)oxy)tetrahydro-2*H*-pyran (S14)



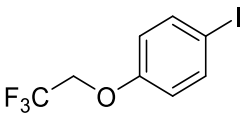
S14
$C_{12}H_{20}O_2$
M = 196.29 g/mol

Following a modified literature procedure,[S28] toluene (100 mL) was degassed by three freeze-pump-thaw cycles in a 250-mL Schlenk flask. Diene **S13** (1.00 g, 4.46 mmol, 1.00 equiv) and (1,3-Bis-(2,4,6-trimethylphenyl)-2-imidazolidinylidene)dichloro(*o*-isopropoxyphenylmethylene)ruthenium (Grubbs-Hoveyda II catalyst) (27.9 mg, 44.6 µmol, 1.00 mol%) were each added in one portion. The reaction mixture was stirred for 16 h, filtered over silica eluting with a mixture of *n*-pentane (500 mL) and methyl *tert*-butyl ether (50 mL) and concentrated under reduced pressure to give the title compound (**S14**, 848 mg, 4.32 mmol, 97%) as a colorless oil that was used in next step without further purification. Attempts for dichlorocarbene addition to the obtained product failed.

R_f = 0.39 (*n*-pentane/methyl *tert*-butyl ether 25:1). **^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 1.45–1.58 (m, 4H), 1.58–1.63 (m, 6H), 1.64–1.76 (m, 1H), 1.77–1.90 (m, 1h), 2.22–2.33 (m, 1H), 2.33–2.45 (m, 1H), 2.48–2.68 (m, 2H), 3.45–3.53 (m, 1H), 3.86–3.94 (m, 1H), 4.44 (m_c, 1H), 4.61–4.65 (m, 1H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 13.8, 13.9, 20.1, 25.7, 31.4, 44.9, 45.9, 63.0, 74.1, 97.7, 128.3, 129.1. **IR** (ATR): $\tilde{\nu}$/cm^{-1} = 2916, 2871, 2851, 1440, 1380, 1342, 1321, 1278, 1259, 1200, 1180, 1157, 1133, 1114, 1068, 1028, 1018, 1003, 975, 937, 917, 904, 868, 847, 812, 747, 687. **HRMS** (APCI) calculated for $C_{12}H_{21}O_2^+$ [(M+H)$^+$]: 197.1536; found: 197.1534.

4 Preparation of the Starting Materials

1-Iodo-4-(2,2,2-trifluoroethoxy)benzene (S15)



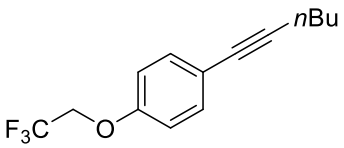
S15
$C_8H_6F_3IO$
M = 302.03 g/mol

Following a modified literature procedure,[S29] a 100-mL pressure tube was charged with 4-iodophenol (1.32 g, 6.00 mmol, 1.00 equiv), Cs_2CO_3 (5.86 g, 18.0 mmol, 3.00 equiv) and dry DMF (30 mL). 1,1,1-Trifluoro-2-iodoethane (2.52 g, 12.0 mmol, 2.00 equiv) was added, the pressure tube was sealed and the resulting suspension was stirred at 60 °C for 20 h. After cooling to room temperature, the mixture was poured into a mixture of H_2O (200 mL) and saturated aqueous NH_4Cl solution (50 mL). Extraction with methyl *tert*-butyl ether/*n*-pentane (1:1, 3 × 200 mL), drying over $MgSO_4$, filtration and concentration under reduced pressure gave a pale-yellow oil. Purification by flash column chromatography (*n*-pentane) afforded 1-iodo-4-(2,2,2-trifluoroethoxy)benzene (**S15**, 739 mg, 2.45 mmol, 41%) as a colorless solid.

$\mathbf{R_f}$ = 0.30 (*n*-pentane). **^{1}H NMR** (500 MHz, $CDCl_3$): δ/ppm = 4.32 (q, *J* = 8.1 Hz, 2H), 6.73 (m_c, 2H), 7.61 (m_c, 2H). **^{13}C{^{1}H} NMR** (126 MHz, $CDCl_3$): δ/ppm = 66.0 (q, *J* = 35.6 Hz), 85.2, 117.4, 138.7, 157.4. The carbon atom of the CF_3 group could not be detected. **^{19}F NMR** (471 MHz, $CDCl_3$): δ/ppm = –73.9 (t, *J* = 8.1 Hz, 3F).

The NMR spectroscopic data are in accordance with those reported in the literature.[S30]

1-(Hex-1-yn-1-yl)-4-(2,2,2-trifluoroethoxy)benzene (4b)

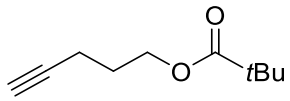


4b
$C_{14}H_{15}F_3O$
M = 256.29 g/mol

Following a scaled down version of **GP 1**, 1-iodo-4-(2,2,2-trifluoroethoxy)benzene (**S15**, 640 mg, 2.12 mmol, 1.00 equiv) and 1-hexyne (191 mg, 2.33 mmol, 1.10 equiv) were used. Purification by flash column chromatography (*n*-pentane) afforded the title compound (**4b**, 426 mg, 1.66 mmol, 78%) as a colorless solid.

$\mathbf{R_f}$ = 0.15 (*n*-pentane). **m.p.**: 30–31 °C (*n*-pentane). **^{1}H NMR** (500 MHz, $CDCl_3$): δ/ppm = 0.95 (t, *J* = 7.4 Hz, 3H), 1.44–1.52 (m, 2H), 1.55–1.62 (m, 2H), 2.39 (t, *J* = 7.1 Hz, 2H), 4.33 (q, *J* = 8.1 Hz, 2H), 6.85 (m_c, 2H), 7.36 (m_c, 2H). **^{13}C{^{1}H} NMR** (126 MHz, $CDCl_3$): δ/ppm = 13.8, 19.2, 22.2, 31.0, 66.0 (q, *J* = 36.3 Hz), 79.9, 89.8, 114.9, 118.6, 133.2, 156.8. The carbon atom of the CF_3 group could not be detected. **^{19}F NMR** (471 MHz, $CDCl_3$): δ/ppm = –74.0 (t, *J* = 8.1 Hz, 3F). **IR** (ATR): $\tilde{\nu}$/cm^{-1} = 2955, 2927, 2895, 2860, 2826, 1607, 1508, 1456, 1426, 1378, 1279, 1241, 1176, 1152, 1109, 1077, 1007, 968, 941, 865, 838, 816, 746, 694. **HRMS** (EI) calculated for $C_{14}H_{15}F_3O^+$ [M^+]: 256.1075; found: 256.1070.

Pent-4-yn-1-yl pivalate (S16)



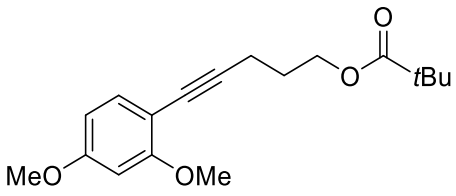
S16
$C_{10}H_{16}O_2$
M = 168.24 g/mol

Following a modified literature procedure,[S31] a 100-mL Schlenk tube was charged with pent-4-yn-1-ol (1.682 g, 20.00 mmol, 1.000 equiv), *N*,*N*-dimethylpyridin-4-amine (122 mg, 1.00 mmol, 5.00 mol%), CH_2Cl_2 (30 mL) and triethylamine (2.429 g, 24.00 mmol, 1.200 equiv). The mixture was cooled to 0 °C and pivaloyl chloride (2.894 g, 24.00 mmol, 1.200 equiv) was added dropwise over 15 min. It was stirred at 0 °C for 1 h and then at room temperature for 19 h. The reaction mixture was poured into H_2O (200 mL) and extracted with *n*-pentane (3 × 200 mL). The combined organic extracts were washed with aqueous HCl solution (1M, 50 mL), saturated aqueous $NaHCO_3$ solution (50 mL) and brine (50 mL), dried over $MgSO_4$, filtered and concentrated under reduced pressure to give the title compound (**S16**, 3.315 g, 19.70 mmol, 99%) as a colorless liquid which was directly used in the next steps without further purification.

^{1}H NMR (400 MHz, $CDCl_3$): δ/ppm = 1.20 (s, 9H), 1.86 (tt, *J* = 7.1 Hz, 6.2 Hz, 2H), 1.97 (t, *J* = 2.8 Hz, 1H), 2.29 (td, *J* = 7.1 Hz, 2.8 Hz, 2H), 4.15 (t, *J* = 6.2 Hz, 2H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 15.3, 27.3, 27.8, 38.9, 63.0, 69.1, 88.2, 178.6.

The NMR spectroscopic data are in accordance with those reported in the literature.[S31]

5-(2,4-Dimethoxyphenyl)pent-4-yn-1-yl pivalate (4c)

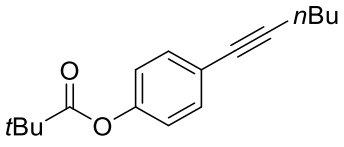


4
$C_{18}H_{24}O_4$
M = 304.39 g/mol

Following **GP 1**, 1-iodo-2,4-dimethoxybenzene (1.06 g, 4.00 mmol, 1.00 equiv) and crude pent-4-yn-1-yl pivalate (**S16**, 740 mg, 4.40 mmol, 1.10 equiv) were used. Purification by flash column chromatography (*n*-pentane:methyl *tert*-butyl ether = 10:1→5:1) afforded the title compound (**4c**, 440 mg, 1.45 mmol, 36%) as a yellowish oil.

R_f = 0.56 (*n*-pentane/methyl *tert*-butyl ether 10:1). **^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 1.21 (s, 9H), 1.95 (t, *J* = 6.3 Hz, 7.1 Hz, 2H), 2.55 (t, *J* = 7.1 Hz, 2H), 3.80 (s, 3H), 3.85 (s, 3H), 4.22 (t, *J* = 6.3 Hz, 2H), 6.40–6.44 (m, 2H), 7.28 (m_c, 1H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 16.7, 27.4, 28.3, 38.9, 55.6, 55.9, 63.4, 77.3, 91.3, 98.6, 104.8, 105.6, 134.4, 160.8, 161.2, 178.7. **IR** (ATR): ṽ/cm^{-1} = 2960, 2935, 2908, 2873, 2837, 1722, 1605, 1572, 1503, 1458, 1438, 1415, 1364, 1301, 1280, 1239, 1207, 1151, 1082, 1031, 985, 960, 933, 914, 886, 831, 797, 770, 725. **HRMS** (APCI) calculated for $C_{18}H_{25}O_4^+$ [(M+H)$^+$]: 305.1747; found: 305.1748.

4-(Hex-1-yn-1-yl)phenyl pivalate (4d)

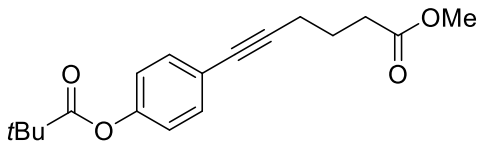


4d
$C_{17}H_{22}O_2$
M = 258.36 g/mol

Following **GP 1**, 4-iodophenyl pivalate (1.22 g, 4.00 mmol, 1.00 equiv) and 1-hexyne (361 mg, 4.40 mmol, 1.10 equiv) were used. Purification by flash column chromatography (*n*-pentane:methyl *tert*-butyl ether = 100:1) afforded the title compound (**4d**, 848 mg, 3.28 mmol, 82%) as a yellowish oil.

R_f = 0.33 (*n*-pentane/methyl *tert*-butyl ether 100:1). **^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 0.95 (t, *J* = 7.3 Hz, 3H), 1.34 (s, 9H), 1.48 (m_c, 2H), 1.55–1.62 (m, 2H), 2.40 (t, *J* = 7.1 Hz, 2H), 6.98 (m_c, 2H), 7.39 (m_c, 2H). **^{13}C{^{1}H} NMR** (126 MHz, $CDCl_3$): δ/ppm = 13.8, 19.2, 22.2, 27.2, 30.9, 39.2, 79.9, 90.5, 121.6, 121.7, 132.7, 150.5, 177.0. **IR** (ATR): ṽ/cm^{-1} = 2958, 2931, 2870, 1752, 1600, 1502, 1478, 1460, 1430, 1396, 1365, 1276, 1229, 1197, 1162, 1104, 1028, 1014, 940, 893, 847, 811, 793, 757, 666. **HRMS** (APCI) calculated for $C_{17}H_{23}O_2^+$ [(M+H)$^+$]: 259.1693; found: 259.1696.

Methyl 6-(4-(pivaloyloxy)phenyl)hex-5-ynoate (4e)

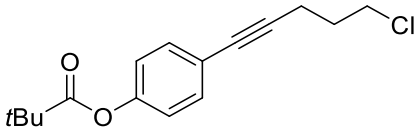


4e
$C_{18}H_{22}O_4$
M = 302.37 g/mol

Following **GP 1**, 4-iodophenyl pivalate (1.22 g, 4.00 mmol, 1.00 equiv) and methyl hex-5-ynoate (555 mg, 4.40 mmol, 1.10 equiv) were used. Purification by flash column chromatography (*n*-pentane:methyl *tert*-butyl ether = 10:1) afforded the title compound (**4e**, 1.12 g, 3.69 mmol, 92%) as a colorless oil.

R_f = 0.24 (*n*-pentane/methyl *tert*-butyl ether 10:1). **^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 1.34 (s, 9H), 1.93 (tt, *J* = 6.9 Hz, 7.0 Hz, 2H), 2.48 (t, *J* = 6.9 Hz, 2H), 2.53 (t, *J* = 7.0 Hz, 2H), 3.68 (s, 3H), 6.98 (m_c, 2H), 7.39 (m_c, 2H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 19.0, 24.0, 27.2, 33.0, 39.2, 51.7, 80.9, 88.9, 121.3, 121.6, 132.7, 150.7, 173.7, 177.0. **IR** (ATR): $\tilde{\nu}$/cm^{-1} = 2970, 2908, 2873, 1735, 1600, 1502, 1478, 1458, 1435, 1397, 1366, 1314, 1276, 1225, 1197, 1162, 1105, 1028, 941, 894, 849, 813, 794, 757, 712, 666. **HRMS** (APCI) calculated for $C_{18}H_{23}O_4^+$ [(M+H)$^+$]: 303.1591; found: 303.1584.

4-(5-Chloropent-1-yn-1-yl)phenyl pivalate (4f)



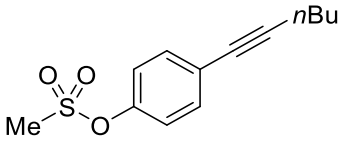
4f
$C_{16}H_{19}ClO_2$
M = 278.78 g/mol

Following **GP 1**, 4-iodophenyl pivalate (1.22 g, 4.00 mmol, 1.00 equiv) and 5-chloropent-1-yne (451 mg, 4.40 mmol, 1.10 equiv) were used. Purification by flash column chromatography (*n*-pentane:methyl *tert*-butyl ether = 100:1) afforded the title compound (**4f**, 1.05 g, 3.78 mmol, 94%) as a colorless solid.

R_f = 0.56 (*n*-pentane/methyl *tert*-butyl ether 10:1). **m.p.**: 42–44 °C (*n*-pentane:methyl *tert*-butyl ether = 100:1). **^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 1.35 (s, 9H), 2.06 (t, *J* = 6.4 Hz, 6.8 Hz, 2H), 2.60 (t, *J* = 6.8 Hz, 2H), 3.71 (t, *J* = 6.4 Hz, 2H), 6.99 (m_c, 2H), 7.39 (m_c, 2H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 17.0, 27.2, 31.6, 39.2, 43.9, 80.9, 88.2, 121.1, 121.7, 132.8,

150.7, 177.0. **IR** (ATR): $\tilde{\nu}$/cm^{-1} = 2960, 2937, 2917, 2872, 1739, 1703, 1598, 1502, 1476, 1453, 1421, 1395, 1365, 1344, 1328, 1275, 1232, 1198, 1163, 1111, 1030, 1014, 967, 946, 896, 852, 812, 795, 762, 723, 664. **HRMS** (APCI) calculated for $C_{16}H_{20}ClO_2^+$ [(M+H)$^+$]: 279.1146; found: 279.1148.

4-(Hex-1-yn-1-yl)phenyl methanesulfonate (4g)

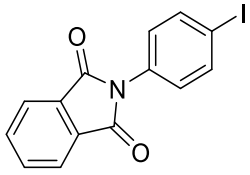


4g
$C_{13}H_{16}O_3S$
M = 252.33 g/mol

Following **GP 1**, 4-iodophenyl methanesulfonate (1.19 g, 4.00 mmol, 1.00 equiv) and 1-hexyne (361 mg, 4.40 mmol, 1.10 equiv) were used. Purification by flash column chromatography (*n*-pentane:methyl *tert*-butyl ether = 2:1) afforded the title compound (**4g**, 973 mg, 3.86 mmol, 96%) as a yellow oil.

R$_f$ = 0.54 (*n*-pentane/methyl *tert*-butyl ether 1:1). **^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 0.95 (t, *J* = 7.3 Hz, 3H), 1.42–1.53 (m, 2H), 1.54–1.64 (m, 2H), 2.41 (t, *J* = 7.3 Hz, 2H), 3.13 (s, 3H), 7.20 (m$_c$, 2H), 7.43 (m$_c$, 2H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 13.9, 19.3, 22.3, 31.0, 37.7, 79.5, 92.1, 122.2, 124.0, 133.4, 148.5. **IR** (ATR): $\tilde{\nu}$/cm^{-1} = 2956, 2932, 2863, 2229, 1498, 1463, 1416, 1364, 1331, 1198, 1171, 1099, 1016, 967, 861, 842, 786, 731, 715, 654. **HRMS** (APCI) calculated for $C_{20}H_{18}NO_2^+$ [(M+H)$^+$]: 253.0893; found: 253.0995.

2-(4-Iodophenyl)isoindoline-1,3-dione (S17)



S17
$C_{14}H_8INO_2$
M = 348.13 g/mol

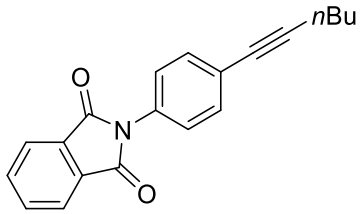
Following a modified literature procedure,[S32] an oven-dried 50-mL pressure tube was charged with phthalic anhydride (741 mg, 5.00 mmol, 1.00 equiv) and 4-iodoaniline (1.10 g, 5.00 mmol, 1.00 equiv). Acetic acid (50 mL) was added and the tube was sealed. The mixture was stirred

at 140 °C for 20 h, poured into ice-cold H_2O (250 mL) and the precipitate was collected by filtration. It was washed with aqueous HCl solution (1M, 2 × 20 mL), saturated aqueous $NaHCO_3$ solution (2 × 20 mL) and H_2O (2 × 20 mL). The residue was dried under reduced pressure at 45 °C to give 2-(4-iodophenyl)isoindoline-1,3-dione (**S17**, 1.54 g, 4.42 mmol, 88%) as a white solid which was directly used in the next step without further purification.

^{1}H NMR (500 MHz, $CDCl_3$): δ/ppm = 7.23 (m_c, 2H), 7.81 (m_c, 2H), 7.84 (m_c, 2H), 7.96 (m_c, 2H).

The ^{1}H NMR spectroscopic data are in accordance with those reported in the literature.[S33]

2-(4-(Hex-1-yn-1-yl)phenyl)isoindoline-1,3-dione (4h)



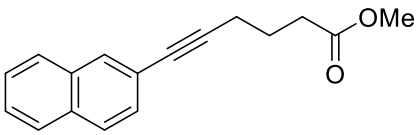
4h
$C_{20}H_{17}NO_2$
M = 303.36 g/mol

Following **GP 1**, 2-(4-iodophenyl)isoindoline-1,3-dione (**S17**, 1.40 g, 4.00 mmol, 1.00 equiv) and 1-hexyne (361 mg, 4.40 mmol, 1.10 equiv) were used. Purification by flash column chromatography (*n*-pentane:acetone = 3:1) afforded the title compound (**4h**, 534 mg, 1.76 mmol, 44%) as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ/ppm = 0.96 (t, *J* = 7.3 Hz, 3H), 1.41–1.53 (m, 2H), 1.53–1.65 (m, 2H), 2.43 (t, *J* = 7.0 Hz, 2H), 7.39 (m_c, 2H), 7.51 (m_c, 2H), 7.79 (m_c, 2H), 7.95 (m_c, 2H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 13.8, 19.3, 22.2, 30.9, 80.1, 91.7, 123.9, 124.2, 126.3, 130.9, 131.9, 132.3, 134.6, 167.2.

The NMR spectroscopic data are in accordance with those reported in the literature.[S34]

Methyl 6-(naphthalen-2-yl)hex-5-ynoate (4i)

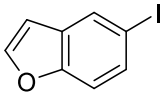


4i
$C_{17}H_{16}O_2$
M = 252.31 g/mol

Following a scaled down version of **GP 1**, 2-iodonaphthalene (889 mg, 3.50 mmol, 1.00 equiv) and methyl hex-5-ynoate (486 mg, 3.85 mmol, 1.10 equiv) were used. Purification by flash column chromatography (*n*-pentane:methyl *tert*-butyl ether = 25:1) afforded the title compound (**4i**, 884 mg, 3.50 mmol, quant.) as an off-white solid.

$\mathbf{R_f}$ = 0.25 (*n*-pentane/methyl *tert*-butyl ether 20:1). **m.p.**: 31–32 °C (*n*-pentane:methyl *tert*-butyl ether = 25:1). **^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 1.98 (m_c, 2H), 2.52–2.58 (m, 4H), 3.70 (s, 3H), 7.43–7.50 (m, 3H), 7.73–7.82 (m, 3H), 7.91 (s, 1H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 19.2, 24.1, 33.1, 51.8, 82.0, 89.4, 121.2, 2 × 126.5, 127.7, 127.8, 128.0, 128.8, 131.3, 132.7, 133.2, 173.8. **IR** (ATR): $\tilde{\nu}$/cm^{-1} = 3045, 3018, 2951, 2897, 2228, 1725, 1687, 1625, 1592, 1496, 1453, 1432, 1375, 1334, 1276, 1250, 1189, 1168, 1129, 1076, 1034, 996, 981, 951, 886, 857, 819, 770, 749, 698. **HRMS** (APCI) calculated for $C_{17}H_{17}O_2^+$ [(M+H)$^+$]: 253.1223; found: 253.1217.

5-Iodobenzofuran (S18)



S18
C_8H_5IO
M = 244.03 g/mol

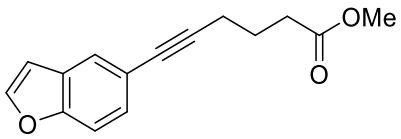
Following a modified literature procedure,[S35] a 20-mL pressure tube was charged with CuI (95 mg, 0.50 mmol, 10 mol%) and NaI (1.50 g, 10.0 mmol, 2.00 equiv). *N*^{1},*N*^{2}-Dimethylethane-1,2-diamine (88 mg, 1.0 mmol, 0.20 mol%), 5-bromobenzofuran (980 mg, 5.00 mmol, 1.00 equiv) and dioxane (5.0 mL) were added. The sealed tube was stirred at 110 °C for 24 h. After cooling to room temperature, the reaction was quenched by addition of aqueous ammonia solution (30%, 25 mL) and poured into H_2O (100 mL). It was extracted with CH_2Cl_2 (3 × 100 mL), the combined organic extracts were dried over $MgSO_4$, filtered and concentrated under

reduced pressure. Purification by flash column chromatography (*n*-pentane) afforded the title compound (**S18**, 1.130 g, 4.631 mmol, 93%) as a colorless oil.

R_f = 0.38 (*n*-pentane). **^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 6.69–6.73 (m, 1H), 7.28 (m_c, 1H), 7.57 (m_c, 1H), 7.59 (m_c, 1H), 7.94 (m_c, 1H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 86.4, 106.0, 113.6, 130.2, 130.3, 133.0, 145.9, 154.5.

The NMR spectroscopic data are in accordance with those reported in the literature.[S35]

Methyl 6-(benzofuran-5-yl)hex-5-ynoate (10a)

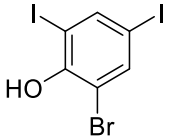


10a
$C_{15}H_{14}O_3$
M = 242.27 g/mol

Following **GP 1**, 5-iodobenzofuran (**S18**, 976 mg, 4.00 mmol, 1.00 equiv) and methyl hex-5-ynoate (555 mg, 4.40 mmol, 1.10 equiv) were used. Purification by flash column chromatography (*n*-pentane:methyl *tert*-butyl ether = 25:1→20:1→15:1) afforded the title compound (**10a**, 841 mg, 3.47 mmol, 87%) as a pale-yellow oil.

R_f = 0.18 (*n*-pentane/methyl *tert*-butyl ether 20:1). **^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 1.95 (m_c, 2H), 2.47–2.56 (m, 4H), 3.69 (s, 3H), 6.72 (m_c, 1H), 7.33 (m_c, 1H), 7.41 (m_c, 1H), 7.62 (m_c, 1H), 7.65 (m_c, 1H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 19.0, 24.1, 33.1, 51.7, 81.8, 87.3, 106.6, 111.5, 118.4, 124.7, 127.6, 128.1, 145.8, 154.4, 173.8. **IR** (ATR): $\tilde{\nu}$/cm^{-1} = 2948, 2841, 1730, 1611, 1536, 1485, 1462, 1434, 1366, 1326, 1314, 1278, 1254, 1212, 1150, 1128, 1108, 1056, 1028, 993, 879, 813, 767, 735. **HRMS** (APCI) calculated for $C_{15}H_{15}O_3^+$ [(M+H)$^+$]: 243.1016; found: 243.1011.

2-Bromo-4,6-diiodophenol (S19)



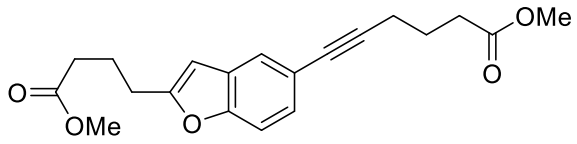
S19
$C_6H_3BrI_2O$
M = 424.80 g/mol

Following a modified literature procedure,[S3] concentrated sulfuric acid (96%, 580 µL, 10.5 mmol, 1.50 equiv) was dissolved in MeOH (35 mL) in a 100-mL round-bottom flask open to the atmosphere. 2-Bromophenol (1.21 g, 7.00 mmol, 1.00 equiv) and KI (2.44 g, 14.7 mmol, 2.10 equiv) were added. To the resulting yellow suspension, aqueous H_2O_2 (30%, 2.86 mL, 28.0 mmol, 4.00 equiv) was added dropwise over 5 min. The reaction mixture was stirred at room temperature for 17 h. It was poured into a mixture of saturated aqueous Na_2SO_3 solution (100 mL) and H_2O (100 mL) and extracted with CH_2Cl_2 (3 × 100 mL). The combined organic extracts were dried over $MgSO_4$, filtered and concentrated under reduced pressure to give 2-bromo-4,6-diiodophenol (**S19**, 2.76 g, 6.49 mmol, 93%) as an off-white solid which was directly used in the next step without further purification.

^{1}H NMR (400 MHz, $CDCl_3$): δ/ppm = 5.90 (s, 1H), 7.75 (d, *J* = 2.0 Hz, 1H), 7.93 (d, *J* = 2.0 Hz, 1H).

The ^{1}H NMR spectroscopic data are in accordance with those reported in the literature.[S36]

Methyl 6-(2-(4-methoxy-4-oxobutyl)benzofuran-5-yl)hex-5-ynoate (10b)

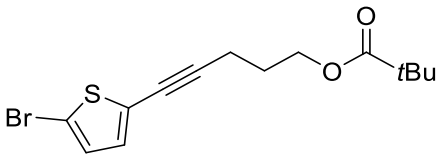


10b
$C_{20}H_{22}O_5$
M = 342.39 g/mol

Following a modified version of **GP 1**, a 50-mL Schlenk tube was charged with $(Ph_3P)_2PdCl_2$ (140 mg, 0.200 mmol, 5.00 mol%), CuI (76.2 mg, 0.400 mmol, 10.0 mol%), crude 2-bromo-4,6-diiodophenol (**S19**, 850 mg, 2.00 mmol, 1.00 equiv), triethylamine (5 mL) and methyl hex-5-ynoate (517 mg, 4.10 mmol, 2.05 equiv). The reaction mixture was stirred at room temperature for 12 h and then opened to the atmosphere. Following a modified literature procedure,[S37] zinc powder (654 mg, 10.0 mmol, 5.00 equiv), a saturated aqueous solution of NH_4Cl (8.0 mL) and THF (4.0 mL) were added and it was stirred at room temperature for 1 h. The reaction mixture was filtered, poured into H_2O (80 mL) and extracted with methyl *tert*-butyl ether (3 × 100 mL). The combined organic extracts were washed with brine (100 mL), dried over $MgSO_4$, filtered and concentrated under reduced pressure. Purification by flash column chromatography (*n*-pentane:methyl *tert*-butyl ether = 4:1) afforded the title compound (**10b**, 374 mg, 1.09 mmol, 55% over two steps) as a yellow oil.

R_f = 0.38 (*n*-pentane/methyl *tert*-butyl ether 2:1). **^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 1.94 (m_c, 2H), 2.07 (m_c, 2H), 2.41 (t, *J* = 7.4 Hz, 2H), 2.47–2.56 (m, 4H), 2.81 (t, *J* = 7.4 Hz, 2H), 3.67 (s, 3H), 3.69 (s, 3H), 6.35–6.37 (m, 1H), 7.23–7.26 (m, 1H), 7.28–7.32 (m, 1H), 7.51–7.53 (m, 1H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 19.0, 23.0, 24.1, 27.8, 33.1, 33.3, 2 × 51.7, 81.9, 87.1, 102.5, 110.8, 118.0, 123.8, 127.2, 129.0, 154.2, 159.2, 173.7, 173.8. **IR** (ATR): $\tilde{\nu}$/cm^{-1} = 2996, 2951, 2910, 1729, 1594, 1454, 1435, 1408, 1376, 1361, 1337, 1316, 1298, 1281, 1266, 1223, 1193, 1171, 1144, 1065, 1048, 1027, 981, 950, 907, 880, 846, 821, 799, 737, 720, 688, 671. **HRMS** (APCI) calculated for $C_{20}H_{23}O_5^+$ [(M+H)$^+$]: 343.1540; found: 343.1537.

5-(5-Bromothiophen-2-yl)pent-4-yn-1-yl pivalate (10c)



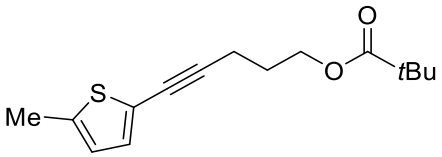
10c
$C_{14}H_{17}BrO_2S$
M = 329.25 g/mol

Following a modified version of **GP 1**, crude 2-bromo-5-iodothiophene (1.16 g, 4.00 mmol, 1.00 equiv) was dissolved in a mixture of triethylamine (10 mL) and DMF (10 mL) in a 100-mL Schlenk tube. The solution was cooled to 0 °C and $(Ph_3P)_2PdCl_2$ (140 mg, 0.200 mmol, 5.00 mol%) and CuI (76.2 mg, 0.400 mmol, 10.0 mol%) were each added in one portion. Crude pent-4-yn-1-yl pivalate (**S16**, 707 mg, 4.20 mmol, 1.05 equiv) was added dropwise over 30 min and the reaction mixture was stirred at 0 °C for 2 h. The reaction mixture was allowed to warm to room temperature and stirred at room temperature for 16 h. It was poured into a saturated aqueous solution of NH_4Cl (150 mL), acidified with aqueous HCl solution (2M, approx. 35 mL) to a pH of 4–6 and extracted with methyl *tert*-butyl ether (3 × 100 mL). The combined organic extracts were washed with a freshly prepared solution of NaOH (3.52 g) and L-cysteine (2.42 g) in H_2O (100 mL) (2 × 50 mL) and brine (50 mL). Drying over $MgSO_4$, filtration, concentration under reduced pressure and purification by flash column chromatography (*n*-pentane:methyl *tert*-butyl ether = 100:1→50:1) afforded the title compound (**10c**, 977 mg, 2.97 mmol, 74%) as a yellowish oil.

R_f = 0.36 (*n*-pentane/methyl *tert*-butyl ether 20:1). **^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 1.21 (s, 9H), 1.93 (m_c, 2H), 2.51 (t, *J* = 7.1 Hz, 2H), 4.17 (t, *J* = 6.3 Hz, 2H), 6.86 (m_c, 1H), 6.88 (m_c, 1H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 16.7, 27.4, 27.8, 38.9, 63.1, 73.7, 94.1, 111.9,

125.7, 129.9, 131.7, 178.6. **IR** (ATR): ṽ/cm^{-1} = 2960, 2932, 2904, 2870, 1723, 1525, 1477, 1459, 1428, 1397, 1363, 1280, 1223, 1185, 1146, 1088, 1035, 970, 935, 908, 883, 791, 769, 664. **HRMS** (ESI) calculated for $C_{14}H_{18}BrO_2S^+$ [(M+H)$^+$]: 329.0205; found: 329.0208.

5-(5-Methylthiophen-2-yl)pent-4-yn-1-yl pivalate (10d)



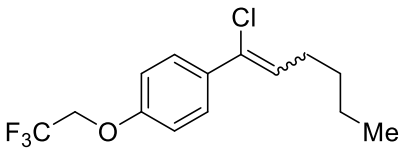
10d
$C_{15}H_{20}O_2S$
M = 264.38 g/mol

Following **GP 1**, 2-bromo-5-methylthiophene (708 mg, 4.00 mmol, 1.00 equiv) and crude pent-4-yn-1-yl pivalate (**S16**, 740 mg, 4.40 mmol, 1.10 equiv) were used. Purification by flash column chromatography (*n*-pentane:methyl *tert*-butyl ether = 50:1) afforded the title compound (**10d**, 806 mg, 3.05 mmol, 76%) as a yellowish oil.

R$_f$ = 0.61 (*n*-pentane/methyl *tert*-butyl ether 10:1). **^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 1.21 (s, 9H), 1.92 (m$_c$, 2H), 2.44 (d, *J* = 1.0 Hz, 3H), 2.51 (t, *J* = 7.2 Hz, 2H), 4.18 (t, *J* = 6.3 Hz, 2H), 6.57 (m$_c$, 1H), 6.91 (d, *J* = 3.6 Hz, 1H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 15.4, 16.7, 27.4, 28.0, 38.9, 63.2, 74.8, 91.9, 121.5, 125.1, 131.5, 141.0, 178.6. **IR** (ATR): ṽ/cm^{-1} = 2960, 2929, 2870, 1724, 1540, 1477, 1459, 1397, 1363, 1281, 1236, 1193, 1147, 1085, 1035, 985, 935, 909, 884, 848, 796, 769, 735, 678. **HRMS** (APCI) calculated for $C_{15}H_{21}O_2S^+$ [(M+H)$^+$]: 265.1257; found: 265.1255.

5 Preparation of Alkenyl Chlorides by Transfer Hydrochlorination

(*Z*/*E*)-1-(1-Chlorohex-1-en-1-yl)-4-(2,2,2-trifluoroethoxy)benzene (5b)

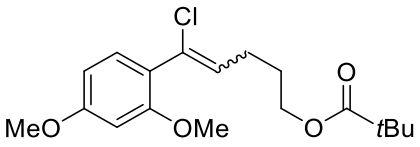


5b
$C_{14}H_{16}ClF_3O$
M = 292.73 g/mol

Following **GP 2**, 1-(hex-1-yn-1-yl)-4-(2,2,2-trifluoroethoxy)benzene (**4b**, 106 mg, 0.414 mmol, 1.00 equiv) was used. After heating for 20 h and workup as described, purification by flash column chromatography (*n*-pentane) afforded the title compound (**5b**, 67 mg, 0.23 mmol, 55%, *Z*/*E* = 94:6) as a colorless oil. The *E*/*Z* ratio was determined by comparing the signals at 5.93 ppm and 6.05 ppm in ^{1}H NMR spectroscopy. The alkene diastereomer (*E* or *Z*) was assigned based on its coupling in a NOESY experiment (C_{vinyl}–H to Ar–H).

R_f = 0.29 (*n*-pentane). **^{1}H NMR** (500 MHz, $CDCl_3$): δ/ppm = 0.94 (t, *J* = 7.3 Hz, 3H), 1.35–1.44 (m, 2H), 1.45–1.54 (m, 2H), 2.35–2.40 (m, 2H), 4.33–4.39 (m, 2H), 6.05 (t, *J* = 7.1 Hz, 1H), 6.89–6.92 (m, 2H), 7.50–7.54 (m, 2H). **^{13}C{^{1}H} NMR** (126 MHz, $CDCl_3$): δ/ppm = 13.9, 22.4, 29.3, 30.8, 65.9 (q, *J* = 35.4 Hz), 114.6, 127.4, 127.8, 128.8, 131.8, 157.3. The carbon atom of the CF_3 group could not be detected. **^{19}F NMR** (471 MHz, $CDCl_3$): δ/ppm = –74.0–(–73.9) (m). The intensity of the signals for the minor alkene isomer was too low for complete assignment. **IR** (ATR): ṽ/cm^{-1} = 2957, 2931, 1774, 1738, 1674, 1601, 1581, 1507, 1458, 1421, 1379, 1284, 1237, 1158, 1119, 1073, 972, 881, 864, 828, 731, 681. **HRMS** (LIFDI) calculated for $C_{14}H_{17}ClF_3O^+$ [(M+H)$^+$]: 293.0915; found: 293.0912.

(*Z*/*E*)-5-Chloro-5-(2,4-dimethoxyphenyl)pent-4-en-1-yl pivalate (5c)



5c
$C_{18}H_{25}ClO_4$
M = 340.84 g/mol

Following **GP 2**, 5-(2,4-dimethoxyphenyl)pent-4-yn-1-yl pivalate (**4c**, 123 mg, 0.403 mmol, 1.00 equiv) was used. After heating for 173 h and workup as described, purification by flash column chromatography (*n*-pentane:methyl *tert*-butyl ether = 10:1) afforded the title compound (**5c**, 31 mg, 0.091 mmol, 23%, *E*/*Z* = 48:52) as a yellowish oil. The *E*/*Z* ratio was determined by comparing the signals at 5.96 ppm and 5.89 ppm in ^{1}H NMR spectroscopy. Alkene diastereomers (*E* and *Z*) were assigned based on their coupling in a NOESY experiment (C_{vinyl}–H to Ar–H and C_{allyl}–H to Ar–H).

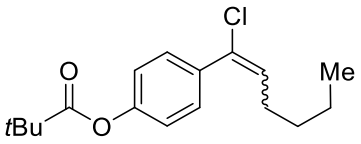
R_f = 0.44 (*n*-pentane/methyl *tert*-butyl ether 5:1).

***Z*-5c: ^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 1.21 (s, 9H), 1.83 (m_c, 2H), 2.45 (m_c, 2H), 3.81 (s, 3H), 3.82 (s, 3H), 4.13 (t, *J* = 6.5 Hz, 2H), 5.89 (t, *J* = 7.1 Hz, 1H), 6.44–6.49 (m, 2H), 7.24–7.28 (m, 1H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 26.0, 27.4, 27.8, 38.9, 55.5, 55.8, 63.8, 98.9, 104.7, 121.5, 129.3, 129.8, 131.3, 157.9, 161.1, 178.7.

***E*-5c: ^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 1.11 (s, 9H), 1.67 (m_c, 2H), 1.96 (m_c, 2H), 3.81 (s, 3H), 3.83 (s, 3H), 3.98 (t, *J* = 6.5 Hz, 2H), 5.96 (t, *J* = 7.8 Hz, 1H), 6.44–6.49 (m, 2H), 7.11 (m_c, 1H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 26.5, 27.2, 28.3, 38.8, 55.5, 55.8, 63.7, 99.0, 104.3, 119.0, 128.2, 130.5, 131.4, 157.9, 161.5, 178.6.

IR (ATR): $\tilde{\nu}$/cm^{-1} = 2958, 2935, 2971, 2838, 1722, 1649, 1605, 1576, 1502, 1458, 1414, 1364, 1304, 1281, 1261, 1207, 1152, 1031, 936, 833, 796, 770, 731. **HRMS** (APCI) calculated for $C_{18}H_{26}ClO_4^+$ [(M+H)$^+$]: 341.1514; found: 341.1518.

(*E*/*Z*)-4-(1-Chlorohex-1-en-1-yl)phenyl pivalate (5d)



5d
$C_{17}H_{23}ClO_2$
M = 294.82 g/mol

Following **GP 2**, 4-(hex-1-yn-1-yl)phenyl pivalate (**4d**, 104 mg, 0.402 mmol, 1.00 equiv) was used. After heating for 12 h and workup as described, purification by flash column chromatography (*n*-pentane) afforded the title compound (**5d**, 86 mg, 0.29 mmol, 73%, *E*/*Z* = 51:49) as a colorless oil. The *E*/*Z* ratio was determined by comparing the signals at 6.10 ppm and 5.96 ppm in ^{1}H NMR spectroscopy. Olefin diastereomers (*E* and *Z*) were assigned based on their coupling in a NOESY experiment (C_{vinyl}–H to Ar–H and C_{allyl}–H to Ar–H).

R_f = 0.54 (*n*-pentane/methyl *tert*-butyl ether 25:1).

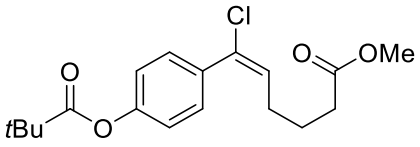
***E*-5d: ^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 0.85 (t, *J* = 7.2 Hz, 3H), 1.25–1.52 (m, 13H), 2.06–2.13 (m, 2H), 5.96 (t, *J* = 7.8 Hz, 1H), 7.00–7.09 (m, 2H), 7.36–7.40 (m, 2H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 14.0, 22.3, 27.3, 29.6, 31.8, 39.3, 121.4, 129.6, 130.1, 131.0, 136.1, 151.1, 177.1.

***Z*-5d: ^{1}H NMR** (500 MHz, $CDCl_3$): δ/ppm = 0.95 (t, *J* = 7.2 Hz, 3H), 1.25–1.52 (m, 13H), 2.35–2.42 (m, 2H), 6.10 (t, *J* = 7.1 Hz, 1H), 7.00–7.09 (m, 2H), 7.53–7.58 (m, 2H). **^{13}C{^{1}H} NMR**

(101 MHz, $CDCl_3$): δ/ppm = 14.1, 22.6, 27.3, 29.5, 30.9, 39.3, 121.4, 127.5, 128.4, 132.0, 134.9, 151.1, 177.0.

IR (ATR): ṽ/cm^{-1} = 2958, 2928, 2870, 1751, 1600, 1501, 1478, 1459, 1396, 1365, 1275, 1229, 1201, 1165, 1105, 1028, 941, 882, 844, 792, 756, 674. **HRMS** (APCI) calculated for $C_{17}H_{24}ClO_2^+$ [(M+H)$^+$]: 295.1459; found: 295.1458.

Methyl (*E*/*Z*)-6-chloro-6-(4-(pivaloyloxy)phenyl)hex-5-enoate (5e)



5e
$C_{18}H_{23}ClO_4$
M = 338.83 g/mol

Following **GP 2**, methyl 6-(4-(pivaloyloxy)phenyl)hex-5-ynoate (**4e**, 120 mg, 0.398 mmol, 1.00 equiv) was used. After heating for 67 h and workup as described, purification by flash column chromatography (*n*-pentane:methyl *tert*-butyl ether = 5:1) afforded the title compound (**5e**, 88 mg, 0.26 mmol, 64%, *E*/*Z* = 69:31) as a yellowish liquid. The *E*/*Z* ratio was determined by comparing the signals at 5.93 ppm and 6.08 ppm in ^{1}H NMR spectroscopy. Alkene diastereomers (*E* and *Z*) were assigned based on their coupling in a NOESY experiment (C_{vinyl}–H to Ar–H and C_{allyl}–H to Ar–H).

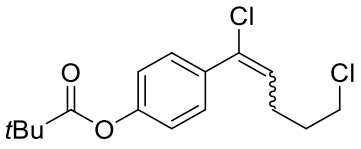
R_f = 0.26 (*n*-pentane/methyl *tert*-butyl ether 10:1).

***E*-5e: ^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 1.36 (s, 9H), 1.73 (m_c, 2H), 2.14 (m_c, 2H), 2.27 (t, *J* = 7.4 Hz), 3.63 (s, 3H), 5.93 (t, *J* = 7.8 Hz, 1H), 7.07 (m_c, 2H), 7.39 (m_c, 2H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 24.8, 27.3, 29.2, 33.4, 39.3, 51.7, 121.5, 129.5, 130.0, 130.8, 134.6, 151.2, 173.7, 177.0.

***Z*-5e: ^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 1.36 (s, 9H), 1.85 (m_c, 2H), 2.37–2.47 (m, 4H), 3.68 (s, 3H), 6.08 (t, *J* = 7.2 Hz, 1H), 7.03 (m_c, 2H), 7.55 (m_c, 2H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 24.0, 27.3, 29.1, 33.6, 39.3, 51.7, 121.5, 126.8, 127.6, 133.1, 135.8, 151.3, 174.0, 177.1.

IR (ATR): ṽ/cm^{-1} = 2955, 2872, 1735, 1636, 1600, 1502, 1479, 1457, 1435, 1397, 1365, 1276, 1200, 1164, 1106, 1028, 943, 893, 844, 791, 757, 731, 672. **HRMS** (APCI) calculated for $C_{18}H_{24}ClO_4^+$ [(M+H)$^+$]: 339.1358; found: 339.1358.

(*E*/*Z*)-4-(1,5-dichloropent-1-en-1-yl)phenyl pivalate (5f)



5f

$C_{16}H_{20}Cl_2O_2$

M = 315.23 g/mol

Following **GP 2**, 4-(5-chloropent-1-yn-1-yl)phenyl pivalate (**4f**, 114 mg, 0.409 mmol, 1.00 equiv) was used. After heating for 34 h and workup as described, purification by flash column chromatography (*n*-pentane:methyl *tert*-butyl ether = 100:1) afforded the title compound (**5f**, 47 mg, 0.15 mmol, 36%, *E*/*Z* = 54:46) as a yellowish oil. The *E*/*Z* ratio was determined by comparing the signals at 5.93 ppm and 6.10 ppm in ^{1}H NMR spectroscopy. Alkene diastereomers (*E* and *Z*) were assigned based on their coupling in a NOESY experiment (C_{vinyl}–H to Ar–H and C_{allyl}–H to Ar–H).

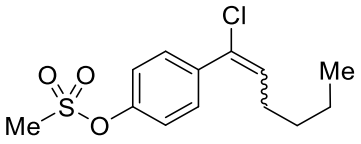
R_f = 0.32 (*n*-pentane/methyl *tert*-butyl ether 50:1).

***E*-5f: ^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 1.36 (s, 9H), 1.81–1.90 (m, 2H), 2.23–2.30 (m, 2H), 3.49 (t, *J* = 6.6 Hz, 2H), 5.93 (t, *J* = 7.8 Hz, 1H), 7.08 (m_c, 2H), 7.39 (m_c, 2H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 27.1, 27.2, 32.4, 39.3, 44.1, 121.5, 128.7, 130.0, 131.1, 134.4, 151.3, 177.0.

***Z*-5f: ^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 1.36 (s, 9H), 1.95–2.03 (m, 2H), 2.51–2.58 (m, 2H), 3.60 (t, *J* = 6.7 Hz, 2H), 6.10 (t, *J* = 7.3 Hz, 1H), 7.04 (m_c, 2H), 7.56 (m_c, 2H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 2 × 27.2, 31.6, 39.3, 44.5, 121.5, 126.1, 127.6, 133.5, 135.6, 151.4, 177.0.

IR (ATR): $\tilde{\nu}$/cm^{-1} = 2971, 2934, 2872, 1750, 1600, 1501, 1478, 1458, 1396, 1364, 1275, 1229, 1201, 1166, 1106, 1082, 1028, 942, 893, 848, 792, 758, 724. **HRMS** (APCI) calculated for $C_{16}H_{21}Cl_2O_2^+$ [(M+H)$^+$]: 315.0913; found: 315.0923.

(*E*/*Z*)-4-(1-Chlorohex-1-en-1-yl)phenyl methanesulfonate (5g)



5g
$C_{13}H_{17}ClO_3S$
M = 288.79 g/mol

Following **GP 2**, 4-(hex-1-yn-1-yl)phenyl methanesulfonate (**4g**, 106 mg, 0.418 mmol, 1.00 equiv) was used. After heating for 57 h and workup as described, purification by flash column chromatography (*n*-pentane:methyl *tert*-butyl ether = 3:1) afforded the title compound (5g, 80 mg, 0.28 mmol, 66%, *E*/*Z* = 74:26) as a colorless oil. The *E*/*Z* ratio was determined by comparing the signals at 6.00 ppm and 6.14 ppm in ^{1}H NMR spectroscopy. Alkene diastereomers (*E* and *Z*) were assigned based on their coupling in a NOESY experiment (C_{vinyl}–H to Ar–H and C_{allyl}–H to Ar–H).

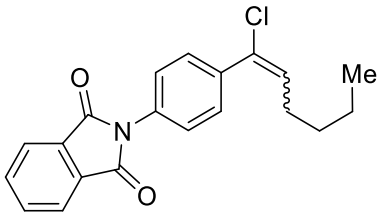
R_f = 0.49 (*n*-pentane/methyl *tert*-butyl ether 2:1).

***E*-5g: ^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 0.86 (t, *J* = 7.2 Hz, 3H), 1.24–1.52 (m, 4H), 2.07–2.13 (m, 2H), 3.17 (s, 3H), 6.00 (t, *J* = 7.9 Hz, 1H), 7.24–7.32 (m, 2H), 7.40–7.46 (m, 2H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 14.0, 22.3, 29.6, 31.8, 37.7, 121.9, 128.8, 130.7, 131.7, 136.7, 148.9.

***Z*-5g: ^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 0.92–0.97 (m, 3H), 1.25–1.52 (m, 4H), 2.36–2.43 (m, 2H), 3.15 (s, 1H), 6.14 (t, *J* = 7.1 Hz, 1H), 7.24–7.32 (m, 2H), 7.58–7.63 (m, 2H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 22.6, 128.1, 129.6. (Due to the low concentration of the minor alkene isomer, not all signals could be detected.)

IR (ATR): $\tilde{\nu}$/cm^{-1} = 2955, 2929, 2858, 1598, 1498, 1366, 1200, 1175, 1148, 1104, 1017, 968, 863, 783, 732, 709. **HRMS** (APCI) calculated for $C_{13}H_{18}ClO_3S^+$ [(M+H)$^+$]: 289.0660; found: 289.0664.

(*E*/*Z*)-2-(4-(1-Chlorohex-1-en-1-yl)phenyl)isoindoline-1,3-dione (5h)



5h
$C_{20}H_{18}ClNO_2$
M = 339.82 g/mol

Following **GP 2**, 2-(4-(hex-1-yn-1-yl)phenyl)isoindoline-1,3-dione (**4h**, 121 mg, 0.400 mmol, 1.00 equiv) was used. After heating for 47 h and workup as described, purification by flash column chromatography (*n*-pentane:acetone = 7:1) afforded the title compound (**5h**, 120 mg, 0.354 mmol, 88%, *E*/*Z* = 50:50) as a white solid. The *E*/*Z* ratio was determined by comparing the signals at 6.01 ppm and 6.20 ppm in ^{1}H NMR spectroscopy. Alkene diastereomers (*E* and *Z*) were assigned based on their coupling in a NOESY experiment (C_{vinyl}–H to Ar–H and C_{allyl}–H to Ar–H).

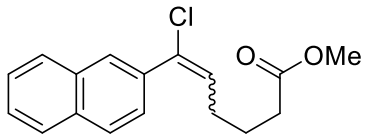
R_f = 0.29 (*n*-pentane/acetone 6:1). **m.p.**: 118–121 °C (*n*-pentane:acetone = 7:1).

***E*-5h: ^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 0.88 (t, *J* = 7.3 Hz, 3H), 1.24–1.58 (m, 4H), 2.12–2.19 (m, 2H), 6.01 (t, *J* = 7.9 Hz, 1H), 7.42–7.55 (m, 4H), 7.77–7.84 (m, 2H), 7.92–7.98 (m, 2H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 14.0, 22.3, 29.6, 31.8, 123.9, 126.0, 129.2, 129.6, 131.3, 131.5, 131.6, 131.8, 134.6, 167.2.

***Z*-5h: ^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 0.95 (t, *J* = 7.3 Hz, 3H), 1.24–1.58 (m, 4H), 2.37–2.45 (m, 2H), 6.20 (t, *J* = 7.1 Hz, 1H), 7.42–7.55 (m, 2H), 7.67–7.72 (m, 2H), 7.77–7.84 (m, 2H), 7.92–7.98 (m, 2H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 14.1, 22.5, 29.5, 30.8, 123.8, 126.2, 127.1, 129.2, 2 × 131.8, 131.9, 134.5, 138.2, 167.2.

IR (ATR): $\tilde{\nu}$/cm^{-1} = 2953, 2926, 2857, 1911, 1784, 1707, 1600, 1508, 1164, 1369, 1284, 1221, 1175, 1119, 1077, 1018, 883, 825, 788, 761, 711. **HRMS** (ESI) calculated for $C_{20}H_{19}ClNO_2^+$ [(M+H)$^+$]: 340.1099; found: 340.1097.

Methyl (*E*/*Z*)-6-chloro-6-(naphthalen-2-yl)hex-5-enoate (5i)



5i

$C_{17}H_{17}ClO_2$

M = 288.77 g/mol

Following **GP 2**, methyl 6-(naphthalen-2-yl)hex-5-ynoate (**4i**, 103 mg, 0.407 mmol, 1.00 equiv) was used. After heating for 24 h and workup as described, purification by flash column chromatography (*n*-pentane:methyl *tert*-butyl ether = 25:1) afforded the title compound (**5i**, 86 mg, 0.30 mmol, 73%, *E*/*Z* = 70:30) as a colorless oil. The *E*/*Z* ratio was determined by comparing the signals at 6.03 ppm and 6.28 ppm in ^{1}H NMR spectroscopy. Alkene diastereomers (*E* and *Z*) were assigned based on their coupling in a NOESY experiment (C_{vinyl}–H to Ar–H and C_{allyl}–H to Ar–H).

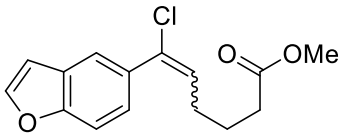
R_f = 0.36 (*n*-pentane/methyl *tert*-butyl ether 10:1).

***E*-5i: ^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 1.77 (m_c, 2H), 2.21 (m_c, 2H), 2.28 (t, *J* = 7.5 Hz, 2H), 3.59 (s, 3H), 6.03 (t, *J* = 7.2 Hz, 1H), 7.45–7.54 (m, 3H), 7.78–7.89 (m, 4H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 24.8, 29.2, 33.3, 51.6, 126.4, 126.6, 126.8, 127.8, 128.1, 128.2, 128.4, 129.5, 131.6, 132.9, 133.2, 134.5, 173.7.

***Z*-5i: ^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 1.91 (m_c, 2H), 2.44 (t, *J* = 7.5 Hz, 2H), 2.52 (m_c, 2H), 3.70 (s, 3H), 6.28 (t, *J* = 7.2 Hz, 1H), 7.45–7.54 (m, 2H), 7.67 (m_c, 1H), 7.78–7.89 (m, 3H), 8.06 (m_c, 1H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 24.0, 29.2, 33.6, 51.7, 123.9, 126.0, 2 × 126.6, 127.2, 127.6, 128.0, 128.5, 2 × 133.2, 134.0, 135.3, 174.0.

IR (ATR): $\tilde{\nu}$/cm^{-1} = 3055, 2947, 1732, 1626, 1595, 1502, 1434, 1361, 1313, 1243, 1196, 1165, 1083, 1017, 964, 896, 859, 815, 746, 668. **HRMS** (APCI) calculated for $C_{17}H_{18}ClO_2^+$ [$(M+H)^+$]: 289.0990; found: 289.0992.

Methyl (*E*/*Z*)-6-(benzofuran-5-yl)-6-chlorohex-5-enoate (11a)



11a
$C_{15}H_{15}ClO_3$
M = 278.73 g/mol

On 0.4 mmol scale:

Following **GP 2**, methyl 6-(benzofuran-5-yl)hex-5-ynoate (**10a**, 97 mg, 0.40 mmol, 1.0 equiv) was used. After heating for 110 h and workup as described, purification by flash column chromatography (*n*-pentane:methyl *tert*-butyl ether = 25:1) afforded the title compound (**11a**, 57 mg, 0.20 mmol, 51%, *E*/*Z* = 67:33) as a yellow oil.

On 2.0 mmol scale:

In a glovebox, an oven-dried 40-mL pressure tube was charged with methyl 6-(benzofuran-5-yl)hex-5-ynoate (**10a**, 499 mg, 2.06 mmol, 1.00 equiv), surrogate *trans*-**9** (268 mg, 1.34 mmol, 0.650 equiv) and chlorobenzene (5.0 mL). $B(C_6F_5)_3$ (108 mg, 211 µmol, 10.2 mol%) was added, the tube's walls were rinsed by addition of more chlorobenzene (5.0 mL), the tube was sealed and the reaction mixture was stirred outside the glovebox at 140 C for 58 h. The reaction mixture was cooled to room temperature and quenched into a saturated aqueous solution of $NaHCO_3$ (50 mL). Extraction with CH_2Cl_2 (3 × 50 mL), drying over $MgSO_4$, filtration, concentration under reduced pressure and purification by flash column chromatography (*n*-pentane:methyl *tert*-butyl ether = 25:1) afforded the title compound (**11a**, 415 mg, 1.49 mmol, 74%, *E*/*Z* = 71:29) as a yellow oil.

Alkene diastereomers (*E* and *Z*) were assigned based on their coupling in a NOESY experiment (C_{vinyl}–H to Ar–H and C_{allyl}–H to Ar–H). The *E*/*Z* ratio was determined by comparing the signals at 5.95 ppm and 6.07 ppm in ^{1}H NMR spectroscopy.

$\mathbf{R_f}$ = 0.16 (*n*-pentane/methyl *tert*-butyl ether 25:1).

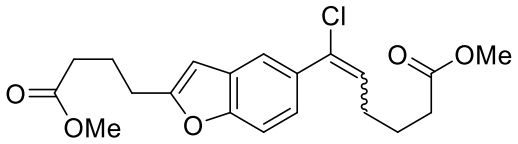
***E*-14a: ^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 1.74 (m_c, 2H), 2.14 (m_c, 2H), 2.27 (t, *J* = 7.5 Hz, 2H), 3.60 (s, 3H), 5.95 (t, *J* = 7.8 Hz, 1H), 6.76–6.79 (m, 1H), 7.30 (m_c, 1H), 7.49 (m_c, 1H), 7.59 (m_c, 1H), 7.65 (m_c, 1H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 24.8, 29.2, 33.4, 51.7, 106.9, 111.4, 121.9, 125.4, 127.5, 128.9, 131.9, 132.1, 146.0, 154.8, 173.8.

***Z*-14a: ^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 1.87 (m_c, 2H), 2.38–2.49 (m, 4H), 3.68 (s, 3H), 6.07 (t, *J* = 7.1 Hz, 1H), 6.76–6.79 (m, 1H), 7.45 (m_c, 1H), 7.47–7.51 (m, 1H), 7.63 (m_c, 1H),

7.79 (m_c, 1H). **$^{13}C\{^1H\}$ NMR** (101 MHz, $CDCl_3$): δ/ppm = 24.1, 29.2, 33.7, 51.7, 106.9, 111.2, 119.7, 123.3, 126.3, 127.6, 133.7, 134.1, 146.0, 155.0, 174.0.

IR (ATR): $\tilde{\nu}$/cm^{-1} = 2948, 1731, 1363, 1536, 1517, 1492, 1463, 1435, 1359, 1317, 1254, 1194, 1159, 1123, 1108, 1028, 995, 952, 884, 810, 767, 736, 701, 685. **HRMS** (APCI) calculated for $C_{15}H_{16}ClO_3^+$ [$(M+H)^+$]: 279.0782; found: 279.0786.

Methyl (*E*/*Z*)-6-chloro-6-(2-(4-methoxy-4-oxobutyl)benzofuran-5-yl)hex-5-enoate (11b)



11b
$C_{20}H_{22}ClO_5$
M = 378.85 g/mol

Following **GP 2**, methyl 6-(2-(4-methoxy-4-oxobutyl)benzofuran-5-yl)hex-5-ynoate (**10b**, 141 mg, 0.411 mmol, 1.00 equiv) was used. After heating for 112 h and workup as described, purification by flash column chromatography (*n*-pentane:methyl *tert*-butyl ether = 4:1) afforded the title compound (**11b**, 82 mg, 0.22 mmol, 53%, *E*/*Z* = 68:32) as a yellow oil. The *E*/*Z* ratio was determined by comparing the signals at 5.92 ppm and 6.04 ppm in ^{1}H NMR spectroscopy. Alkene diastereomers (*E* and *Z*) were assigned based on their coupling in a NOESY experiment (C_{vinyl}–H to Ar–H and C_{allyl}–H to Ar–H).

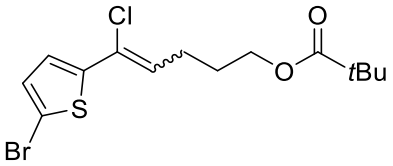
R_f = 0.21 (*n*-pentane/methyl *tert*-butyl ether 4:1).

***E*-14b: ^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 1.72 (m_c, 2H), 2.03–2.16 (m, 4H), 2.26 (t, *J* = 7.5 Hz, 2H), 2.37–2.47 (m, 2H), 2.78–2.85 (m, 2H), 3.60 (s, 3H), 3.67 (s, 3H), 5.92 (t, *J* = 7.8 Hz, 1H), 6.41 (m, 1H), 7.21 (m_c, 1H), 7.32–7.39 (m, 1H), 7.46 (m_c, 1H). **$^{13}C\{^1H\}$ NMR** (101 MHz, $CDCl_3$): δ/ppm = 23.0, 24.8, 27.8, 29.2, 33.2, 33.3, 51.6, 51.7, 102.8, 110.7, 120.9, 124.4, 128.7, 128.8, 131.8, 132.1, 154.5, 159.4, 173.2, 173.7.

***Z*-14b: ^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 1.86 (m_c, 2H), 2.03–2.16 (m, 2H), 2.37–2.47 (m, 6H), 2.78–2.85 (m, 2H), 3.66 (s, 3H), 3.67 (s, 3H), 6.04 (t, *J* = 7.2 Hz, 1H), 6.41 (m, 1H), 7.32–7.39 (m, 1H), 7.41 (m_c, 2H), 7.66 (m_c, 1H). **$^{13}C\{^1H\}$ NMR** (101 MHz, $CDCl_3$): δ/ppm = 23.0, 24.1, 27.8, 29.1, 33.2, 33.6, 2 × 51.7, 102.8, 110.5, 118.8, 122.3, 126.0, 128.9, 133.4, 134.2, 154.8, 159.4, 173.2, 174.0.

IR (ATR): ṽ/cm^{-1} = 2948, 1731, 1597, 1467, 1434, 1363, 1319, 1255, 1195, 1162, 1116, 994, 937, 881, 805, 750, 689. **HRMS** (APCI) calculated for $C_{20}H_{24}ClO_5^+$ [(M+H)$^+$]: 379.1307; found: 379.1311.

(*Z*/*E*)-5-(5-Bromothiophen-2-yl)-5-chloropent-4-en-1-yl pivalate (11c)



11c
$C_{14}H_{18}BrClO_2S$
M = 365.71 g/mol

Following **GP 2**, 5-(5-bromothiophen-2-yl)pent-4-yn-1-yl pivalate (**10c**, 135 mg, 0.411 mmol, 1.00 equiv) was used. After heating for 27 h and workup as described, purification by flash column chromatography (*n*-pentane:methyl *tert*-butyl ether = 50:1→25:1) afforded the title compound (**11c**, 91 mg, 0.25 mmol, 61%, *Z*/*E* = 61:39) as a colorless oil. The *E*/*Z* ratio was determined by comparing the signals at 5.94 ppm and 6.05 ppm in ^{1}H NMR spectroscopy. Alkene diastereomers (*E* and *Z*) were assigned based on their coupling in a NOESY experiment (C_{vinyl}–H to Ar–H and C_{allyl}–H to Ar–H).

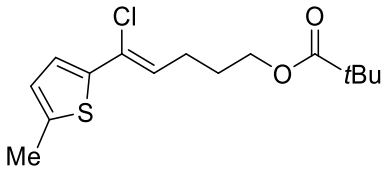
R_f = 0.33 (*n*-pentane/methyl *tert*-butyl ether 25:1).

***Z*-14c: ^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 1.21 (s, 9H), 1.77–1.87 (m, 2H), 2.35 –2.47 (m, 2H), 4.07–4.12 (m, 2H), 6.05 (t, *J* = 7.2 Hz, 1H), 6.92–6.98 (m, 2H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 26.0, 27.4, 27.7, 38.9, 63.7, 112.3, 125.6, 125.8, 129.7, 130.3, 143.0, 178.7.

***E*-14c: ^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 1.18 (s, 9H), 1.77–1.87 (m, 2H), 2.35 –2.47 (m, 2H), 4.07–4.12 (m, 2H), 5.94 (t, *J* = 7.8 Hz, 1H), 6.92–6.98 (m, 2H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 26.9, 27.3, 28.5, 38.9, 63.6, 114.2, 124.1, 126.4, 128.6, 130.2, 140.2, 178.6.

IR (ATR): ṽ/cm^{-1} = 3097, 2959, 2933, 2870, 2721, 1722, 1521, 1477, 1458, 1430, 1398, 1364, 13919, 1281, 1212, 1147, 1035, 968, 938, 880, 792, 659. **HRMS** (APCI) calculated for $C_{14}H_{19}BrClO_2S^+$ [(M+H)$^+$]: 364.9972; found: 364.9975.

(*Z*)-5-Chloro-5-(5-methylthiophen-2-yl)pent-4-en-1-yl pivalate (11d)



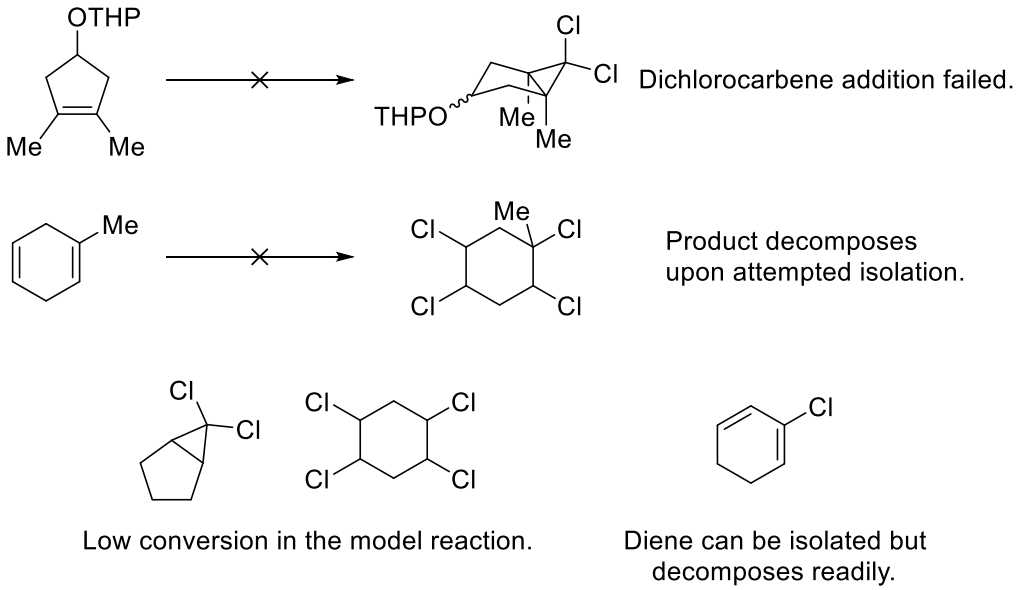
11d
$C_{15}H_{21}ClO_2S$
M = 300.84 g/mol

Following **GP 2**, methyl 6-(5-methylthiophen-2-yl)hex-5-ynoate (**10d**, 106 mg, 0.400 mmol, 1.00 equiv) was used. After heating for 238 h and workup as described, purification by flash column chromatography (*n*-pentane:methyl *tert*-butyl ether = 25:1) afforded the title compound (**11d**, 45 mg, 0.15 mmol, 37%, *Z*/*E* > 95:5) as a colorless oil. The alkene diastereomer (*E* or *Z*) was assigned based on its coupling in a NOESY experiment (C_{vinyl}–H to Ar–H).

R_f = 0.23 (*n*-pentane/methyl *tert*-butyl ether 50:1). **^{1}H NMR** (400 MHz, $CDCl_3$): δ/ppm = 1.21 (s, 9H), 1.81 (m_c, 2H), 2.39–2.46 (m, 2H), 2.44 (s, 3H), 4.10 (m_c, 2H), 6.00 (t, *J* = 6.3 Hz, 1H), 6.61 (m_c, 1H), 7.00 (m_c, 1H). **^{13}C{^{1}H} NMR** (101 MHz, $CDCl_3$): δ/ppm = 15.6, 25.9, 27.4, 27.9, 38.9, 63.8, 124.0, 125.5, 125.6, 127.5, 139.2, 140.2, 178.7. **IR** (ATR): $\tilde{\nu}$/cm^{-1} = 2970, 1723, 1656, 1452, 1397, 1364, 1282, 1231, 1200, 1150, 1081, 1035, 987, 938, 848, 807, 770, 722, 678. **HRMS** (APCI) calculated for $C_{15}H_{22}ClO_2S^+$ [(M+H)$^+$]: 301.1024; found: 301.1023.

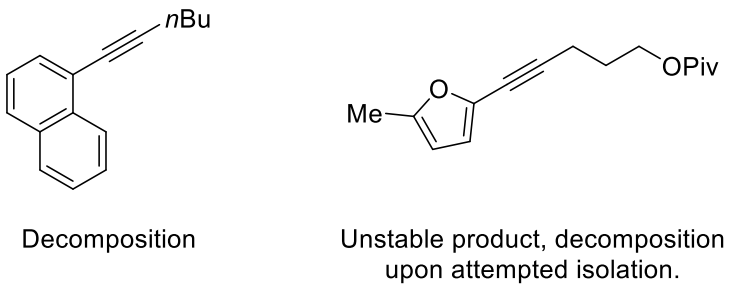
6 Overview of Failed Surrogates (Selection)

Scheme S2. Overview of Failed Surrogates (Selection).



7 Outcome of Unsuccessfully Tested Substrates (Selection)

Figure S1. Outcome of Unsuccessfully Tested Substrates (Selection).



8 NMR Spectra of New Compounds

Figure S2. ^{1}H NMR (400 MHz, $CDCl_3$) of **2-(hepta-1,6-dien-4-yloxy)tetrahydro-2*H*-pyran** (**S2**).

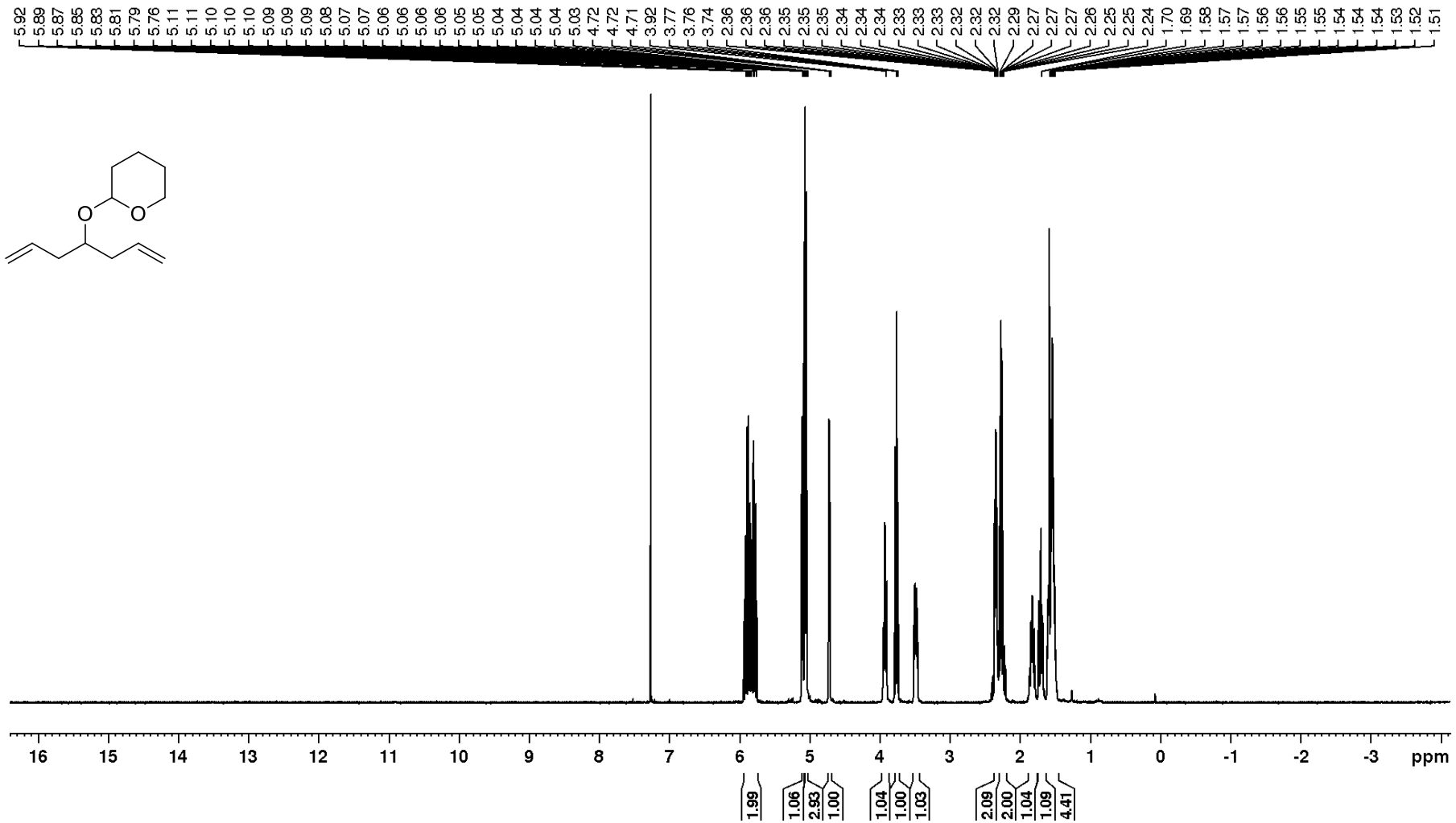


Figure S3. $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) of **2-(hepta-1,6-dien-4-yloxy)tetrahydro-2*H*-pyran** (**S2**).

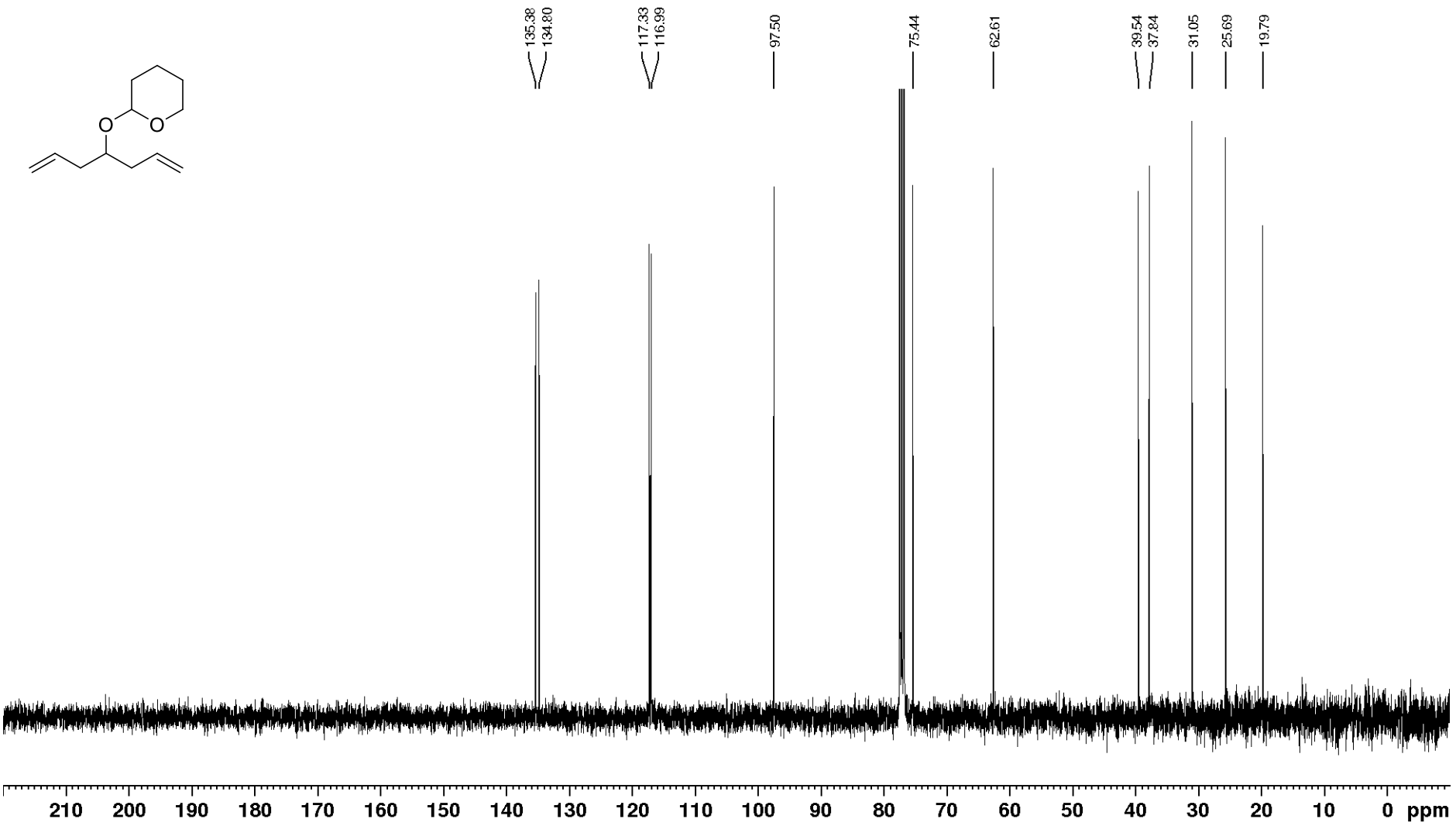


Figure S4. ^{1}H NMR (400 MHz, $CDCl_3$) of ***cis*-3,6,6-trichlorobicyclo[3.1.0]hexane** (*cis*-**7**).

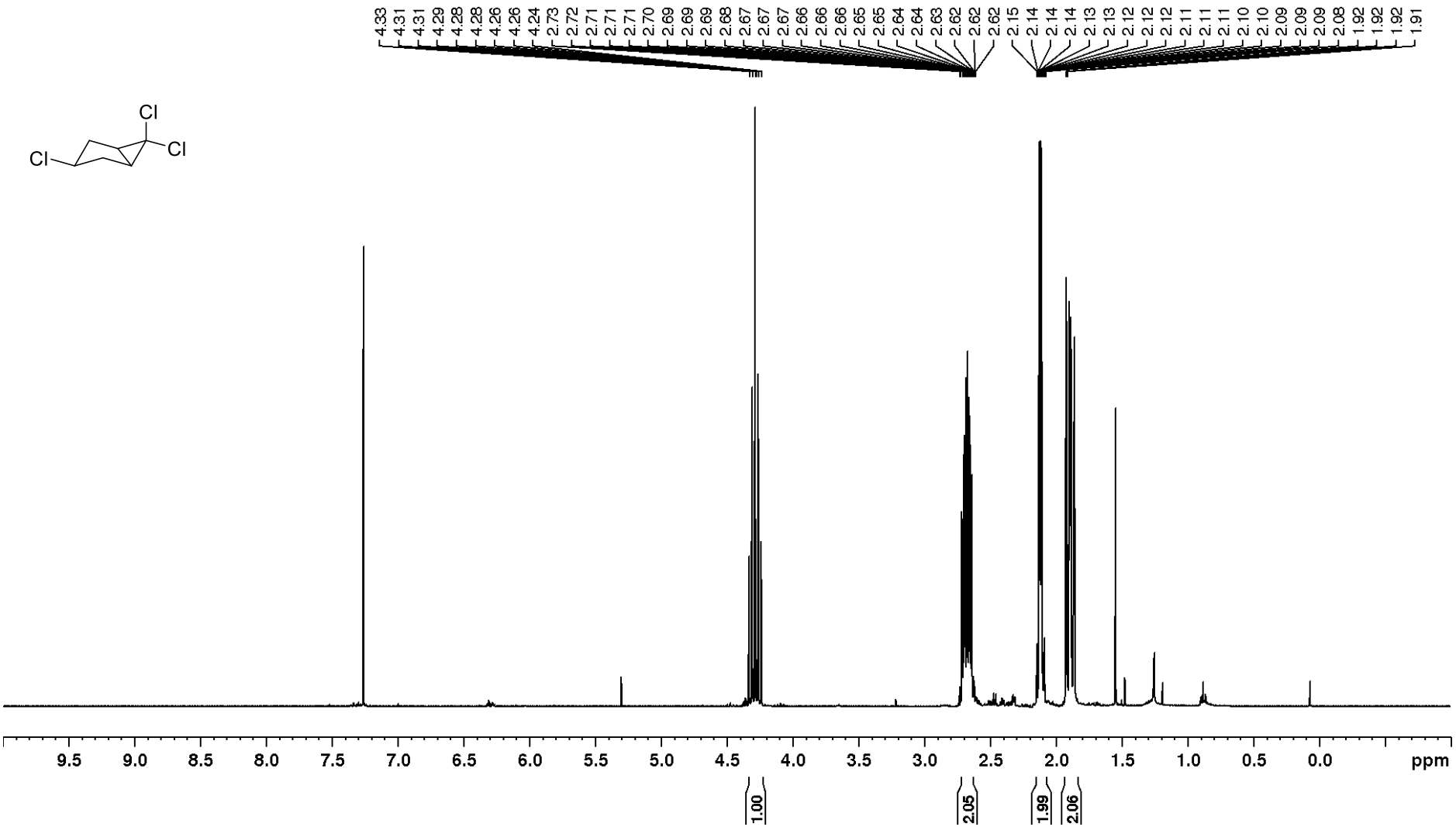


Figure S5. $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) of ***cis*-3,6,6-trichlorobicyclo[3.1.0]hexane** (*cis*-**7**).

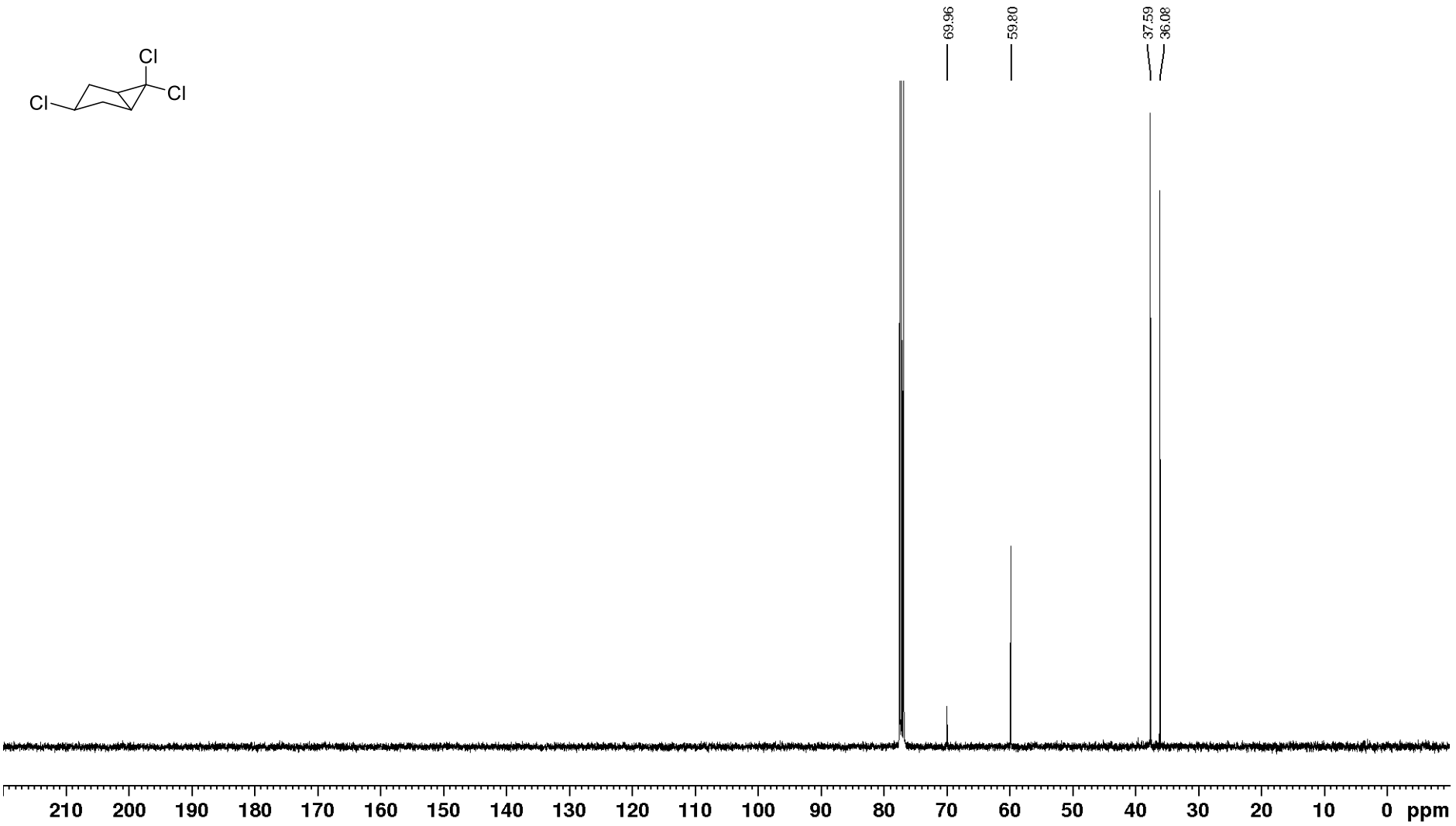


Figure S6. ^{1}H NMR (400 MHz, $CDCl_3$) of ***trans*-3,6,6-trichlorobicyclo[3.1.0]hexane** (*trans*-**7**).

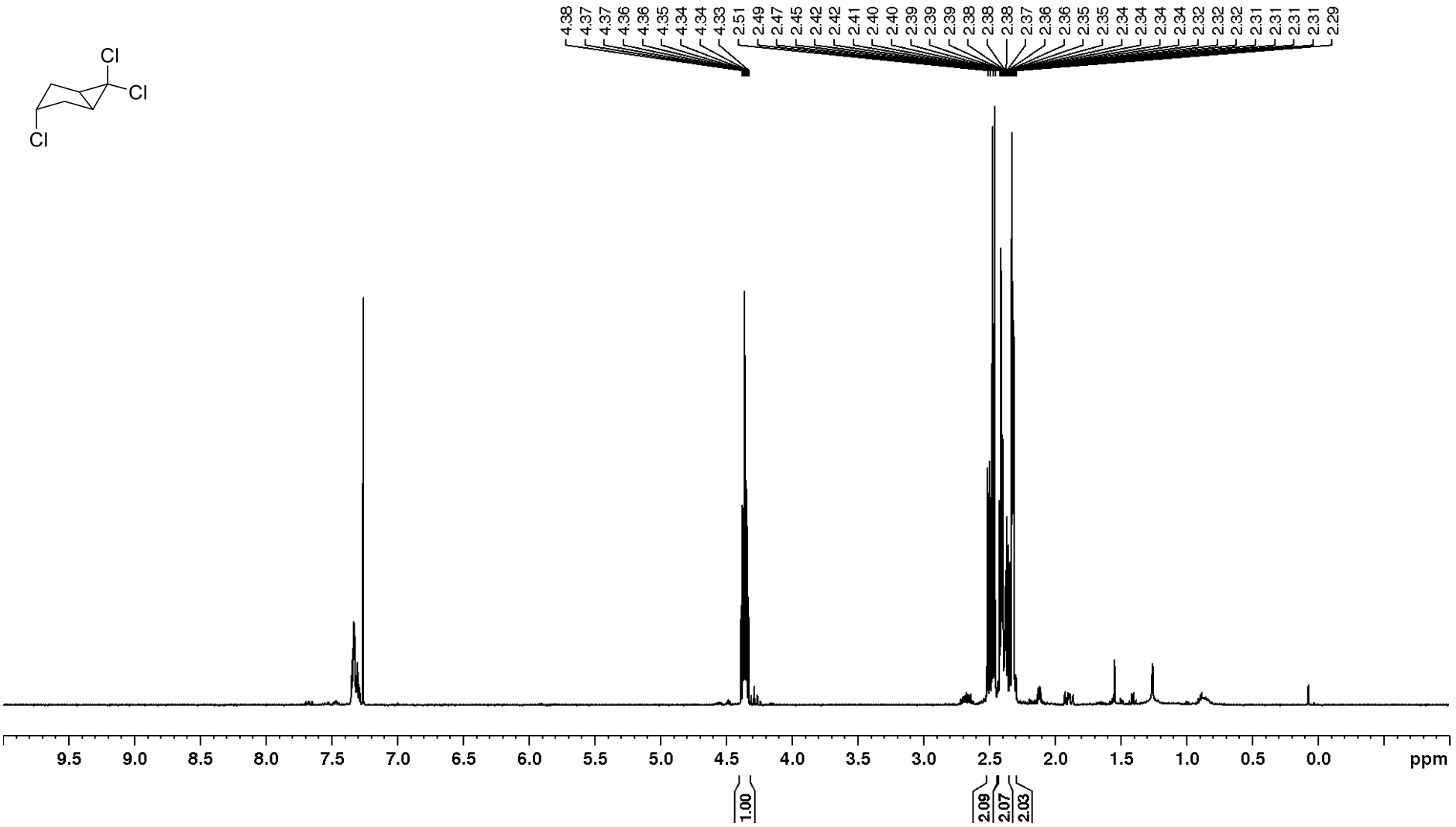


Figure S7. $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) of ***trans*-3,6,6-trichlorobicyclo[3.1.0]hexane** (*trans*-**7**).

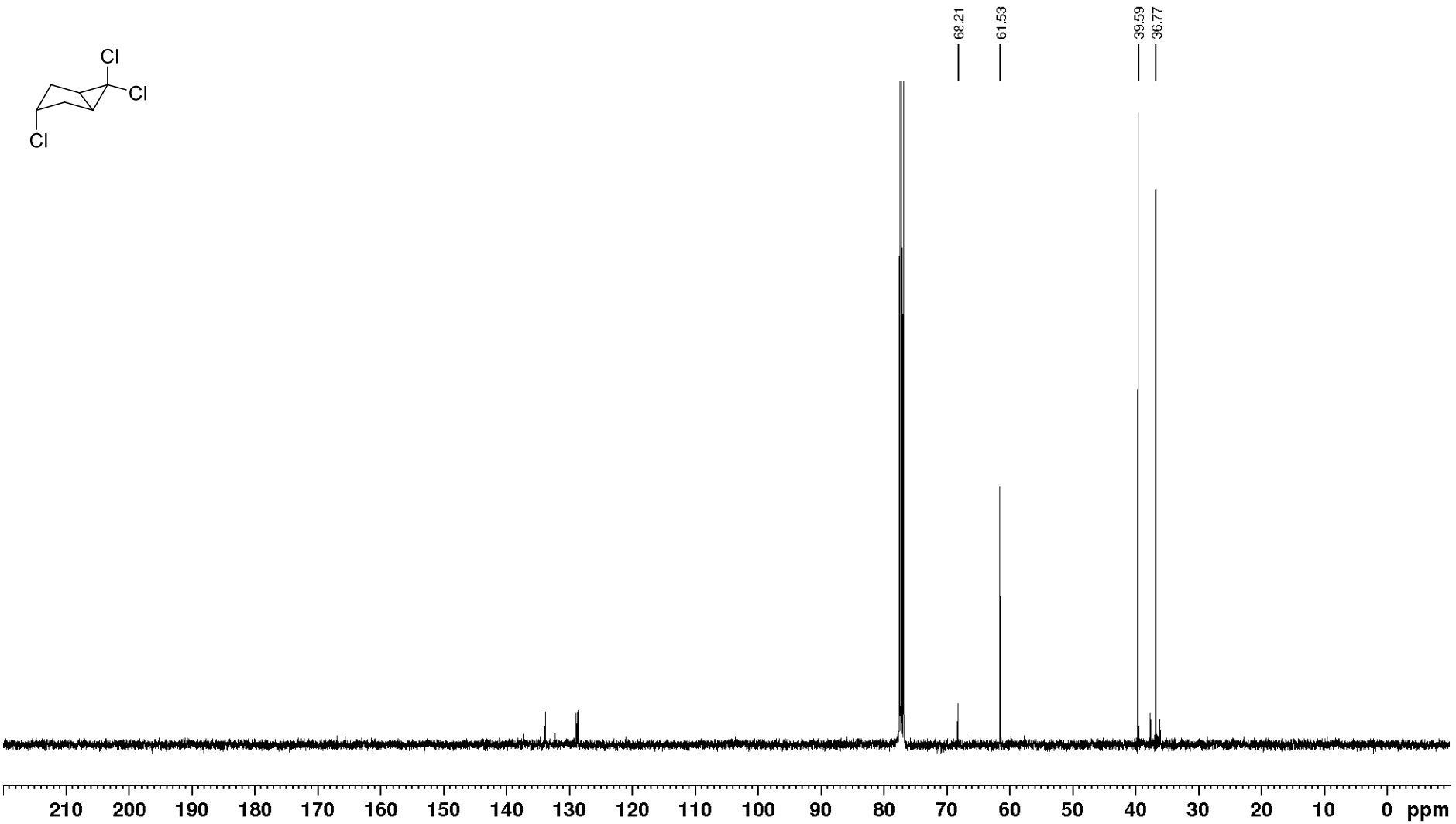


Figure S8. ^{1}H NMR (500 MHz, $CDCl_3$) of **4-((tetrahydro-2*H*-pyran-2-yl)oxy)cyclopent-1-en-1-yl trifluoromethanesulfonate** (**S7**).

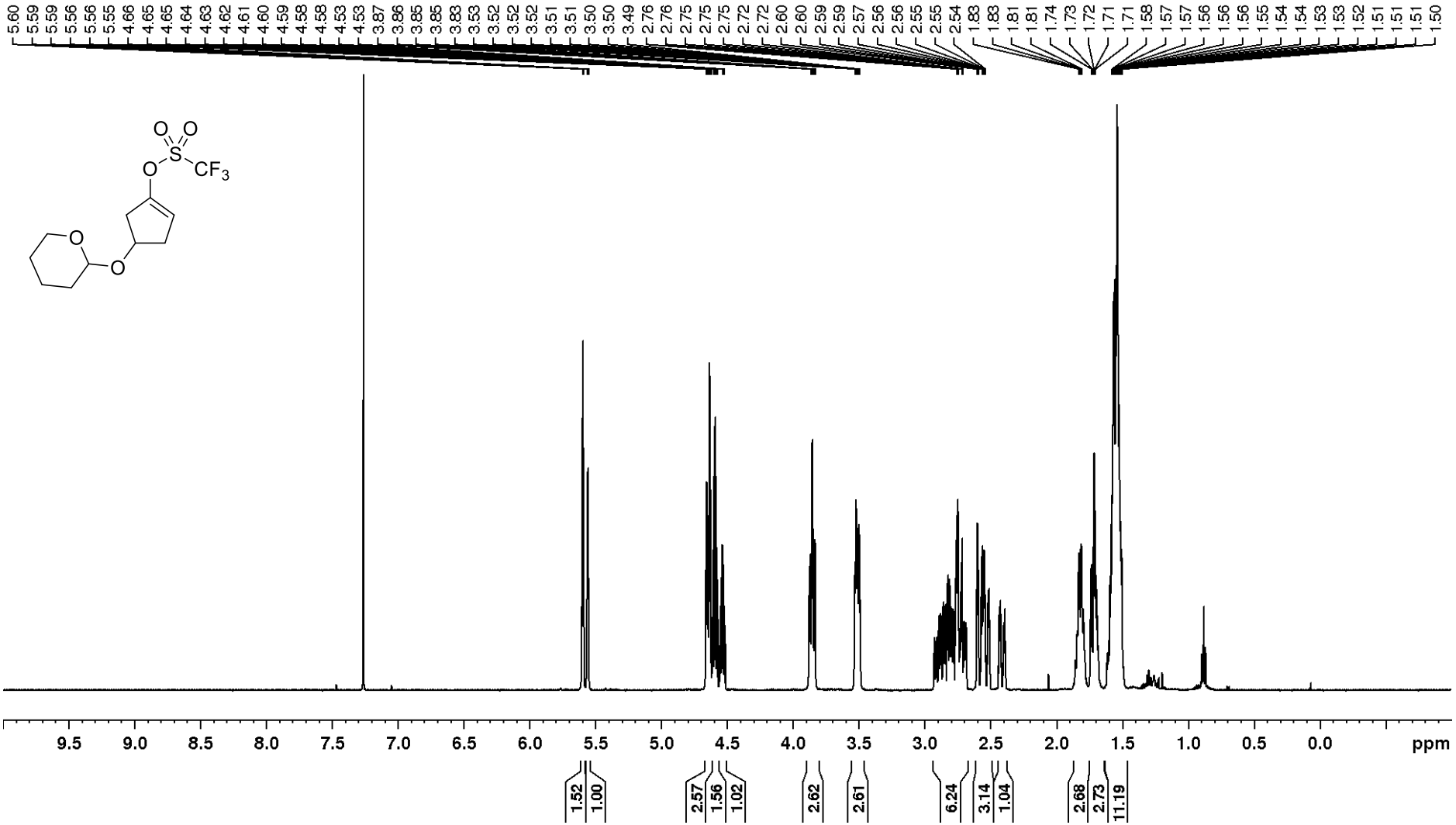


Figure S9. $^{13}C\{^{1}H\}$ NMR (126 MHz, $CDCl_3$) of **4-((tetrahydro-2*H*-pyran-2-yl)oxy)cyclopent-1-en-1-yl trifluoromethanesulfonate** (**S7**).

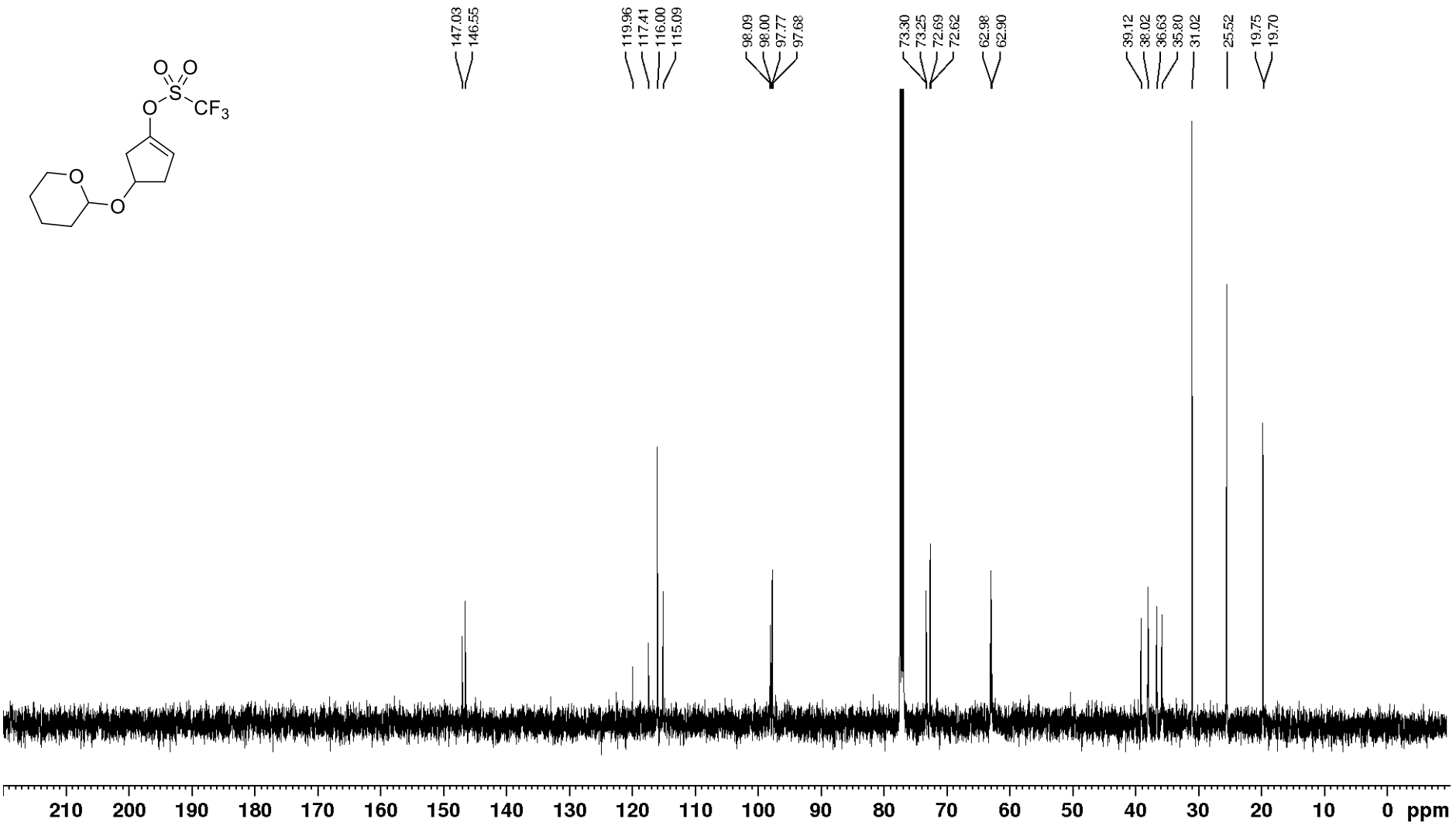


Figure S10. ^{19}F NMR (471 MHz, $CDCl_3$) of **4-((tetrahydro-2*H*-pyran-2-yl)oxy)cyclopent-1-en-1-yl trifluoromethanesulfonate** (**S7**).

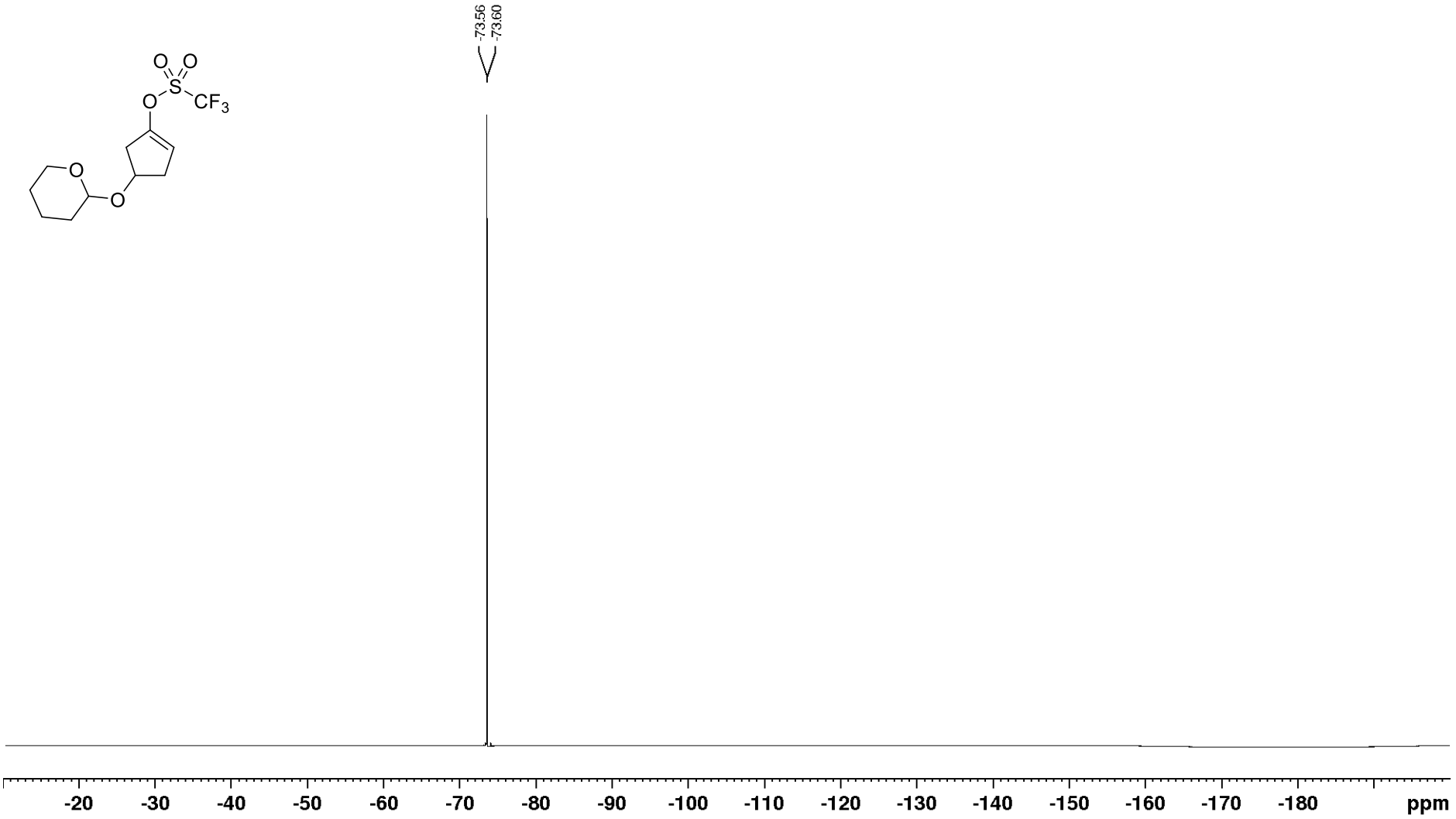


Figure S11. ^{1}H NMR (400 MHz, $CDCl_3$) of **2-((3-phenylcyclopent-3-en-1-yl)oxy)tetrahydro-2*H*-pyran** (**S8**).

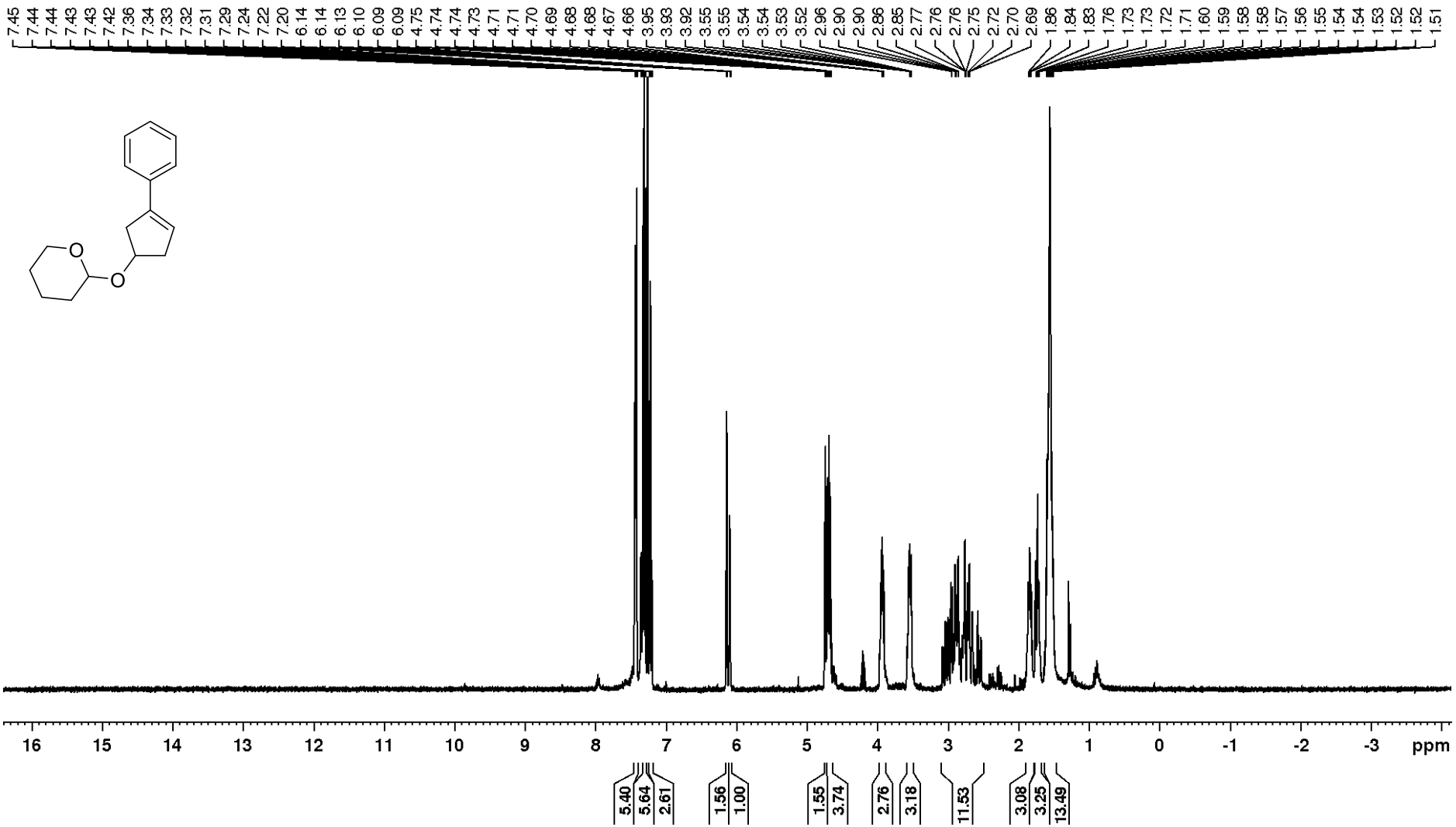


Figure S12. $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) of **2-((3-phenylcyclopent-3-en-1-yl)oxy)tetrahydro-2*H*-pyran** (**S8**).

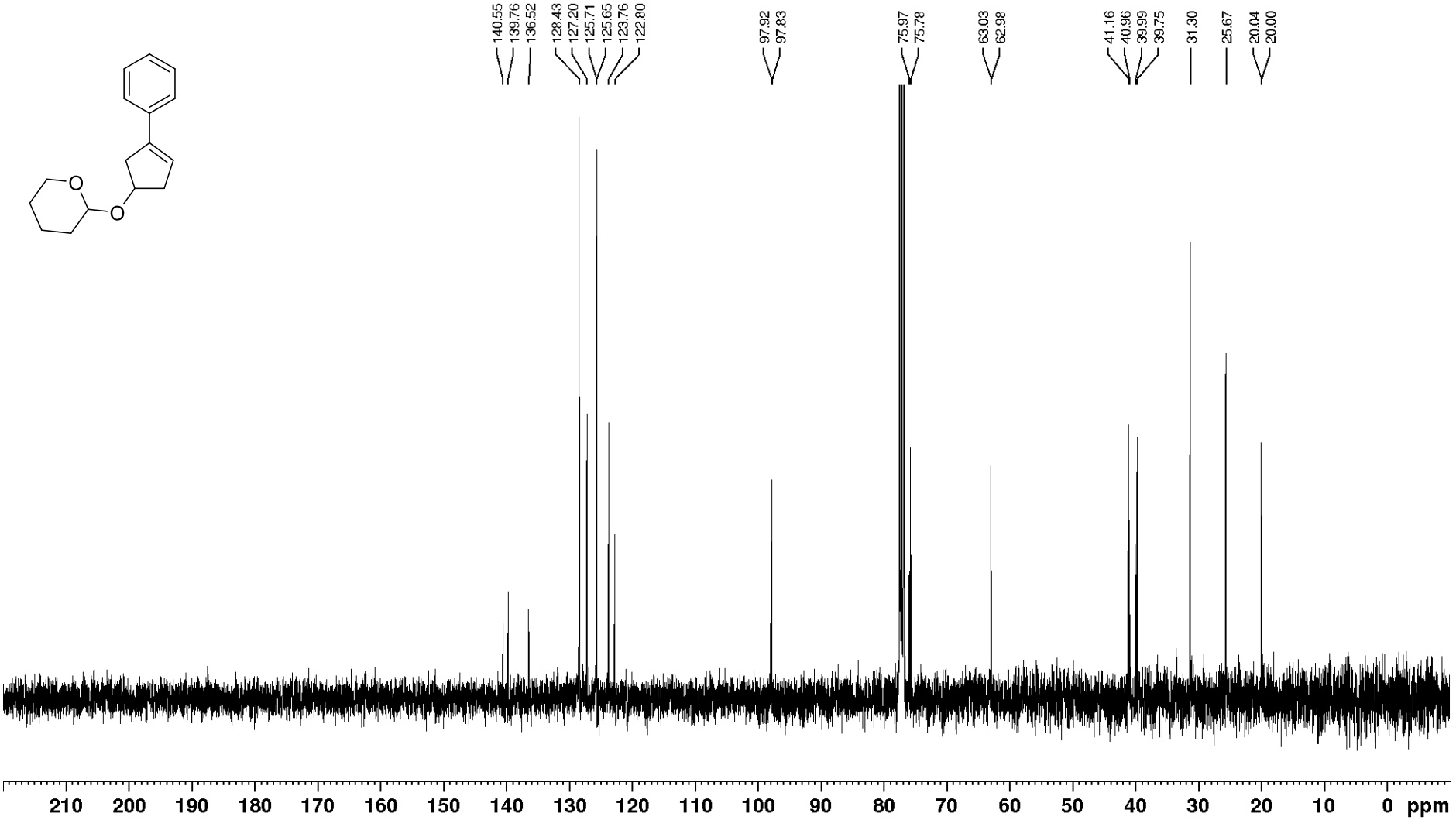


Figure S13. ^{1}H NMR (400 MHz, $CDCl_3$) of **6,6-dichloro-1-phenylbicyclo[3.1.0]hexan-3-ol** (**S9**).

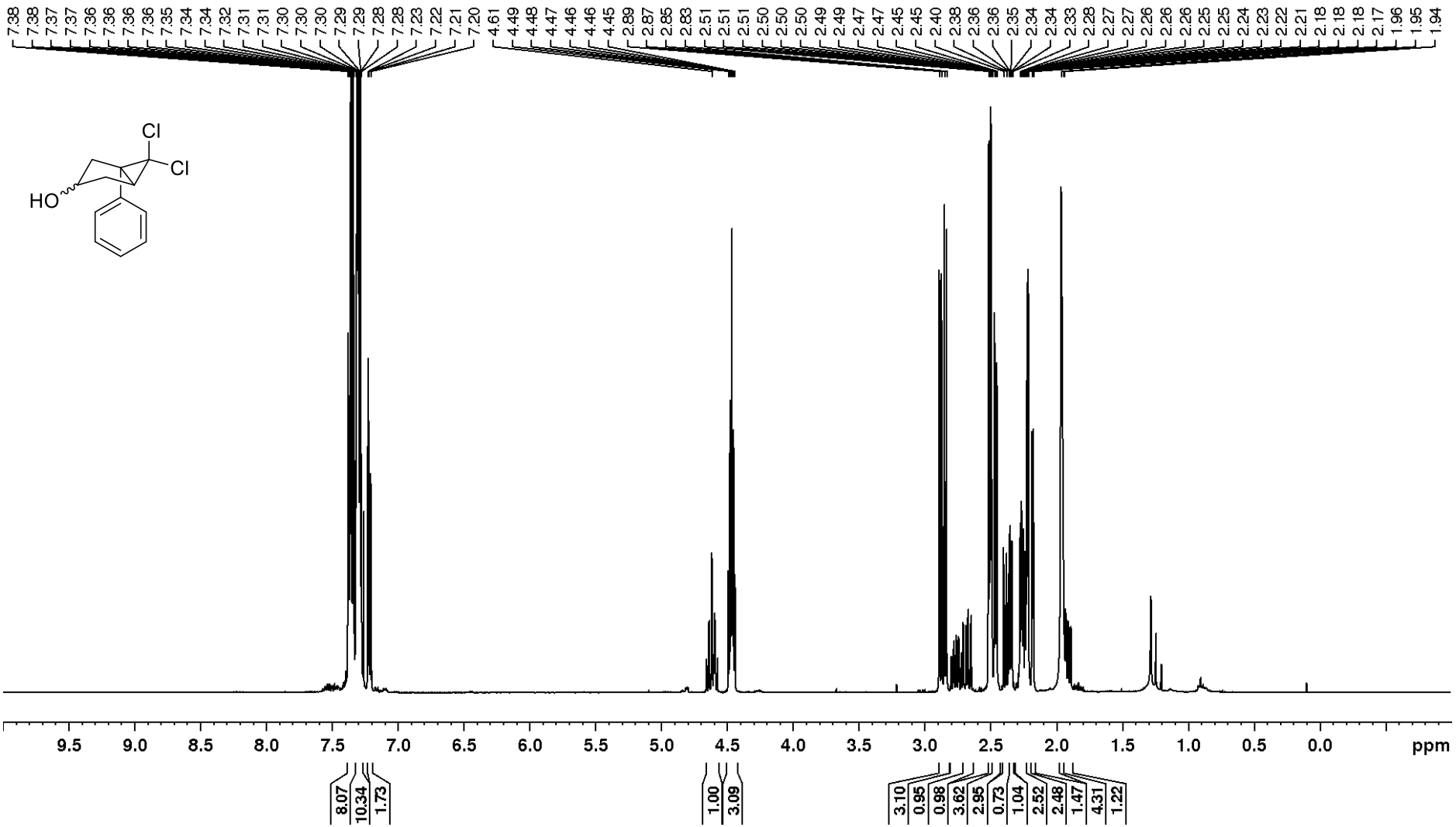


Figure S14. $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) of **6,6-dichloro-1-phenylbicyclo[3.1.0]hexan-3-ol** (**S9**).

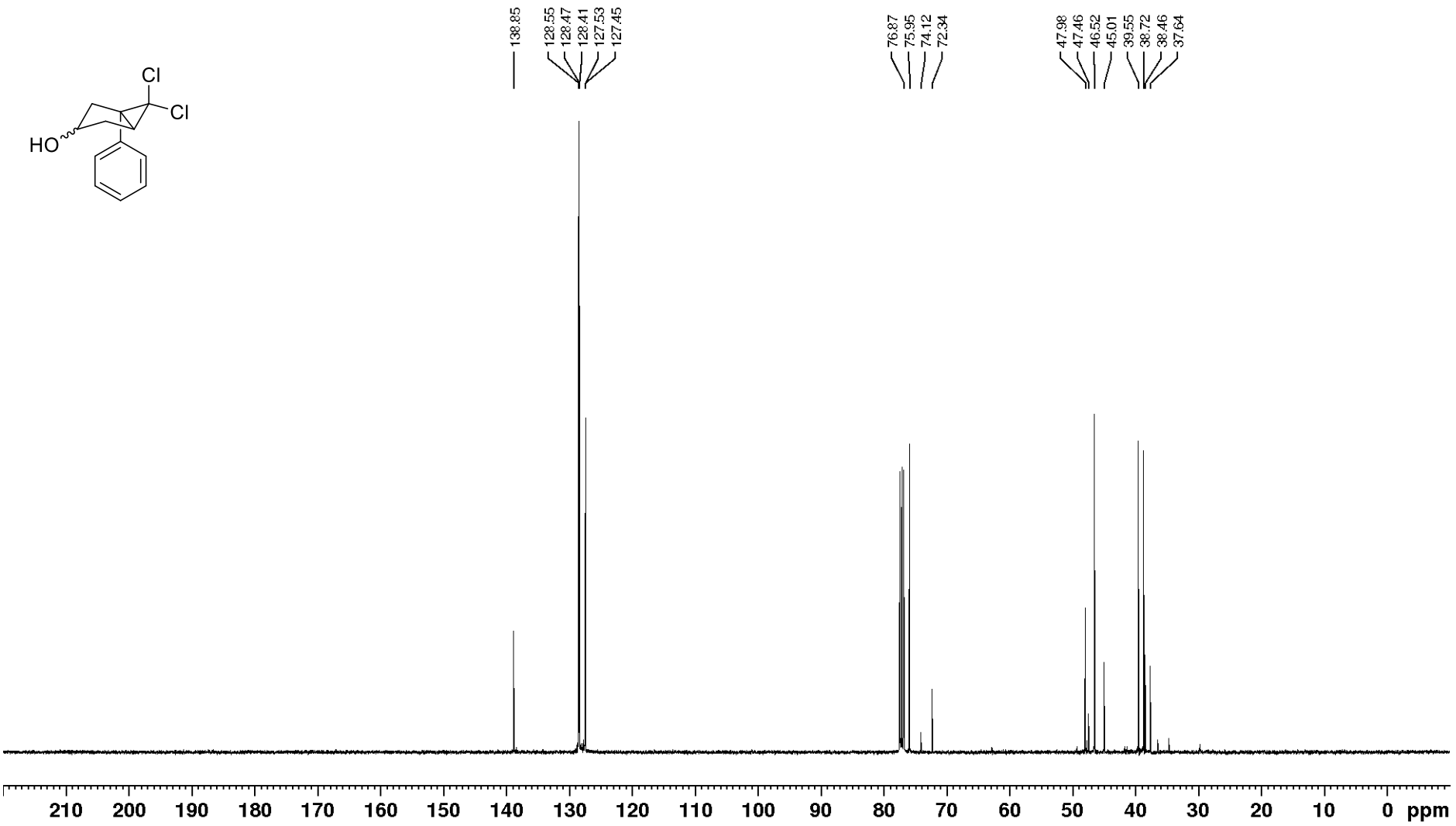


Figure S15. ^{1}H NMR (400 MHz, $CDCl_3$) of **(1*RS*,3*RS*,5*SR*)-3,6,6-trichloro-1-phenylbicyclo[3.1.0]hexane** (**8**).

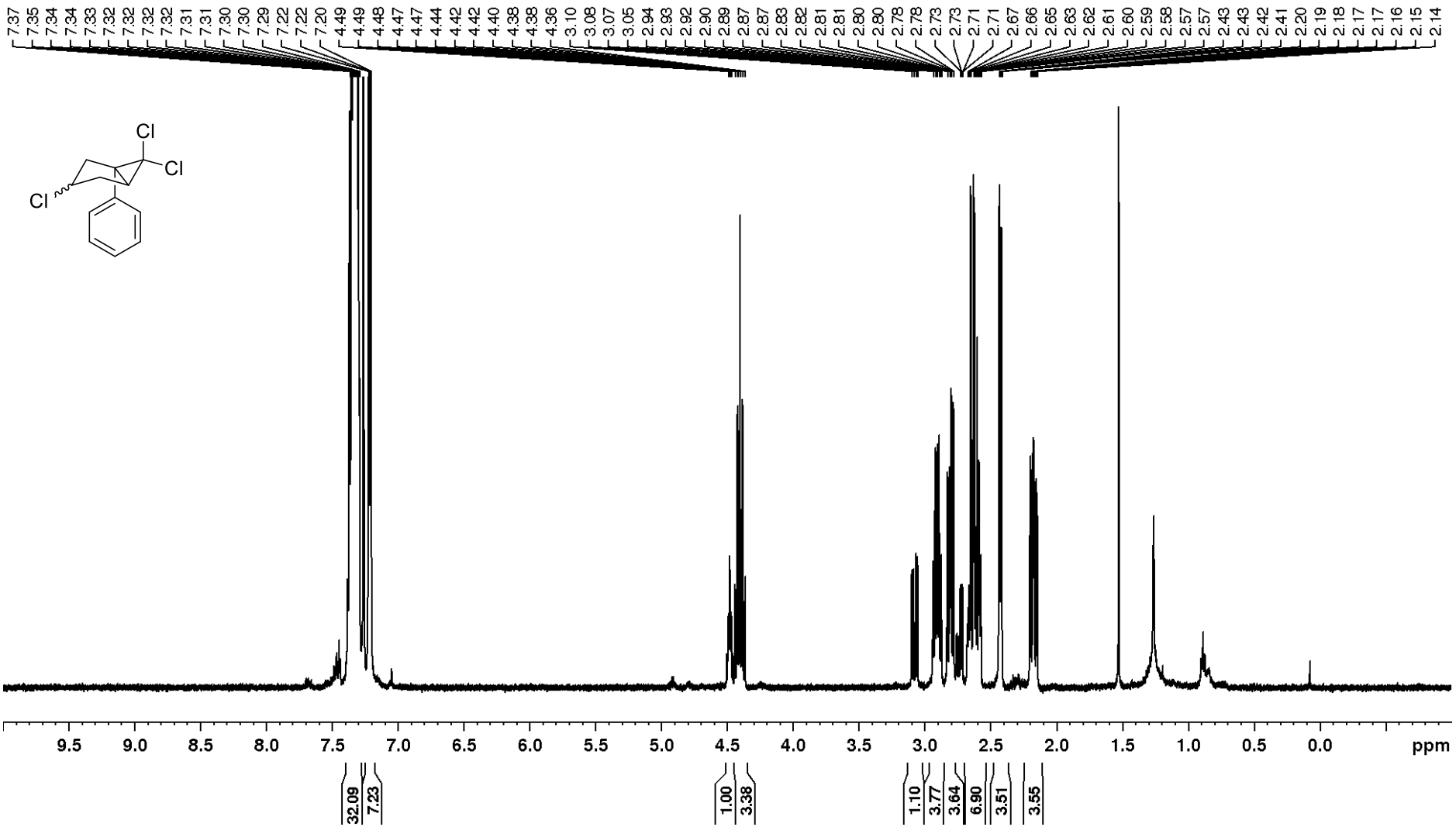


Figure S16. $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) of **(1*RS*,3*RS*,5*SR*)-3,6,6-trichloro-1-phenylbicyclo[3.1.0]hexane** (*trans*-**8**).

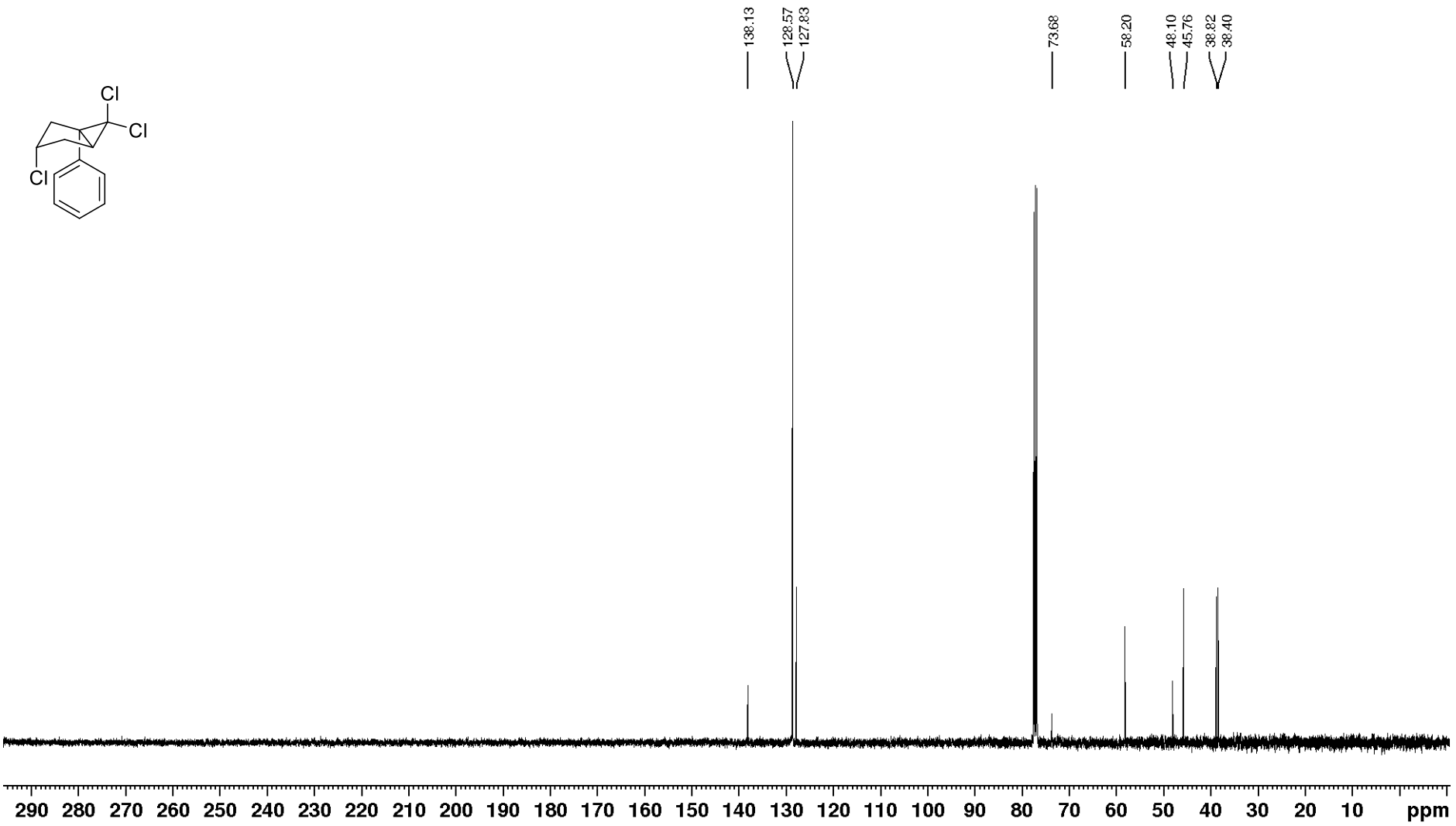


Figure S17. $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) of **(1*RS*,3*SR*,5*RS*)-3,6,6-trichloro-1-phenylbicyclo[3.1.0]hexane** (*cis*-**8**).

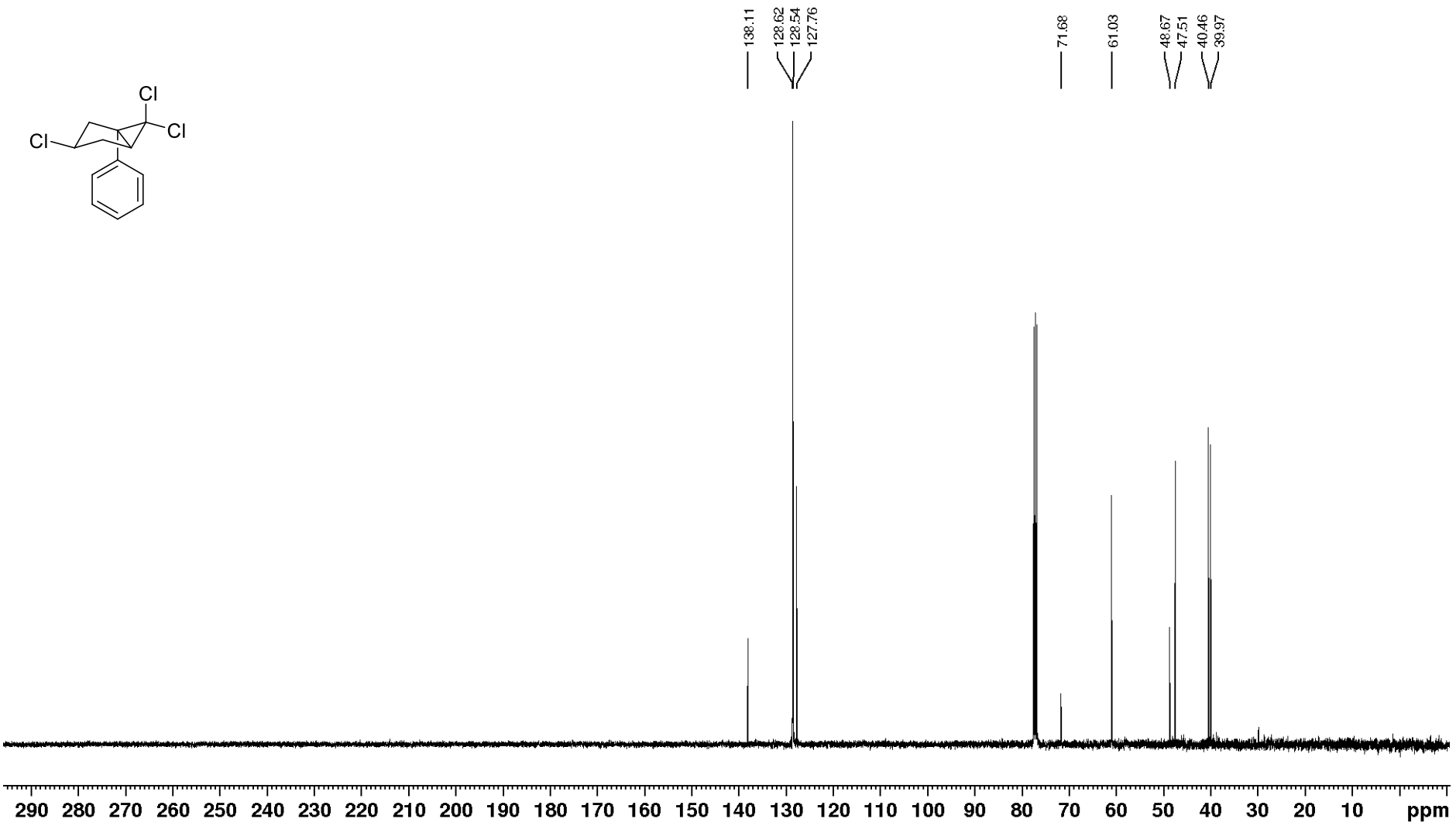


Figure S18. ^{1}H NMR (400 MHz, $CDCl_3$) of **(1*RS*,4*SR*,5*RS*)-4,6,6-trichloro-1-methylbicyclo[3.1.0]hexane** (*trans*-**9**).

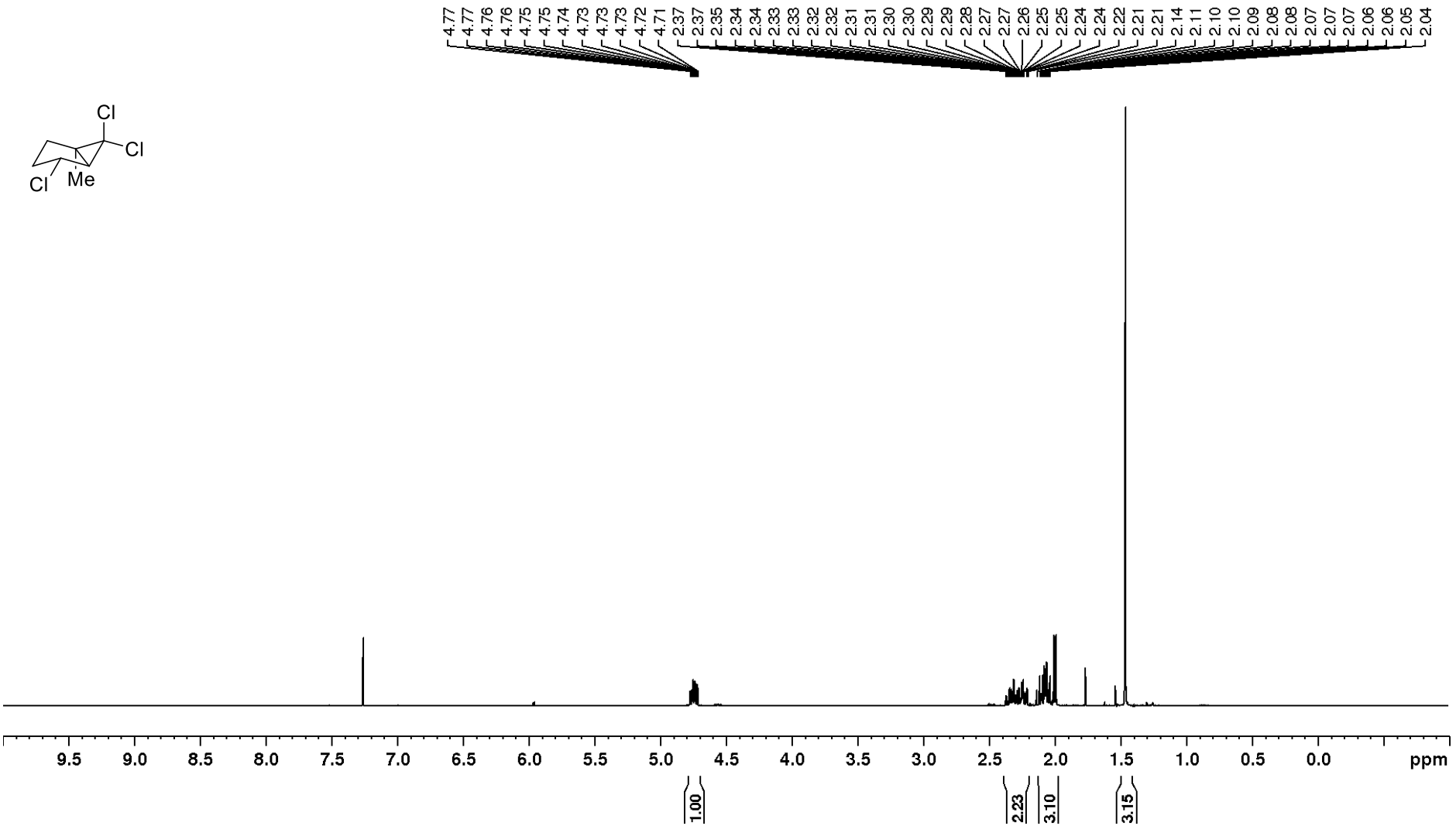


Figure S19. $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) of **(1*RS*,4*SR*,5*RS*)-4,6,6-trichloro-1-methylbicyclo[3.1.0]hexane** (*trans*-**9**).

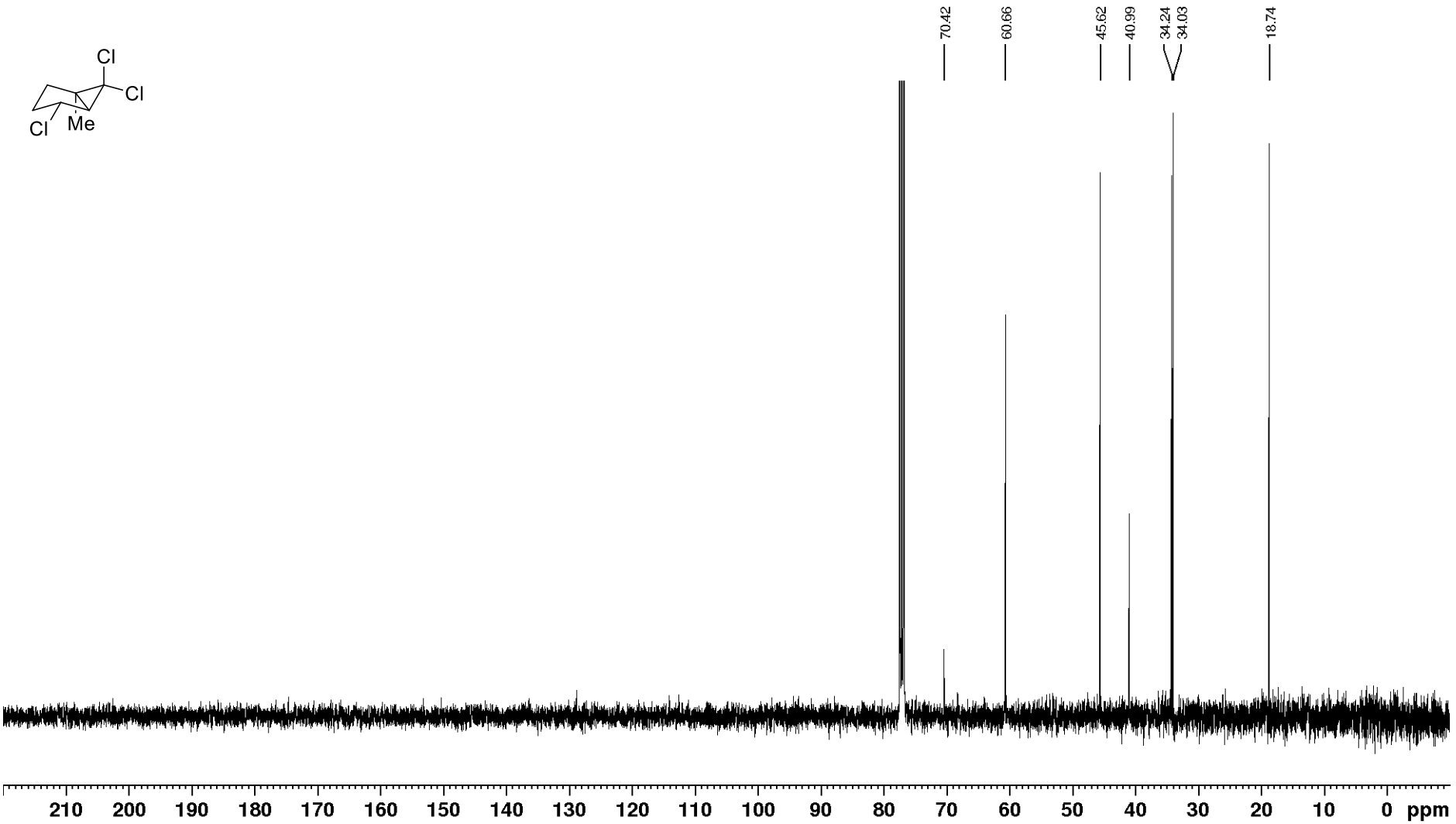


Figure S20. ^{1}H NMR (400 MHz, $CDCl_3$) of **(1*RS*,4*RS*,5*RS*)-4,6,6-trichloro-1-methylbicyclo[3.1.0]hexane** (*cis*-**9**).

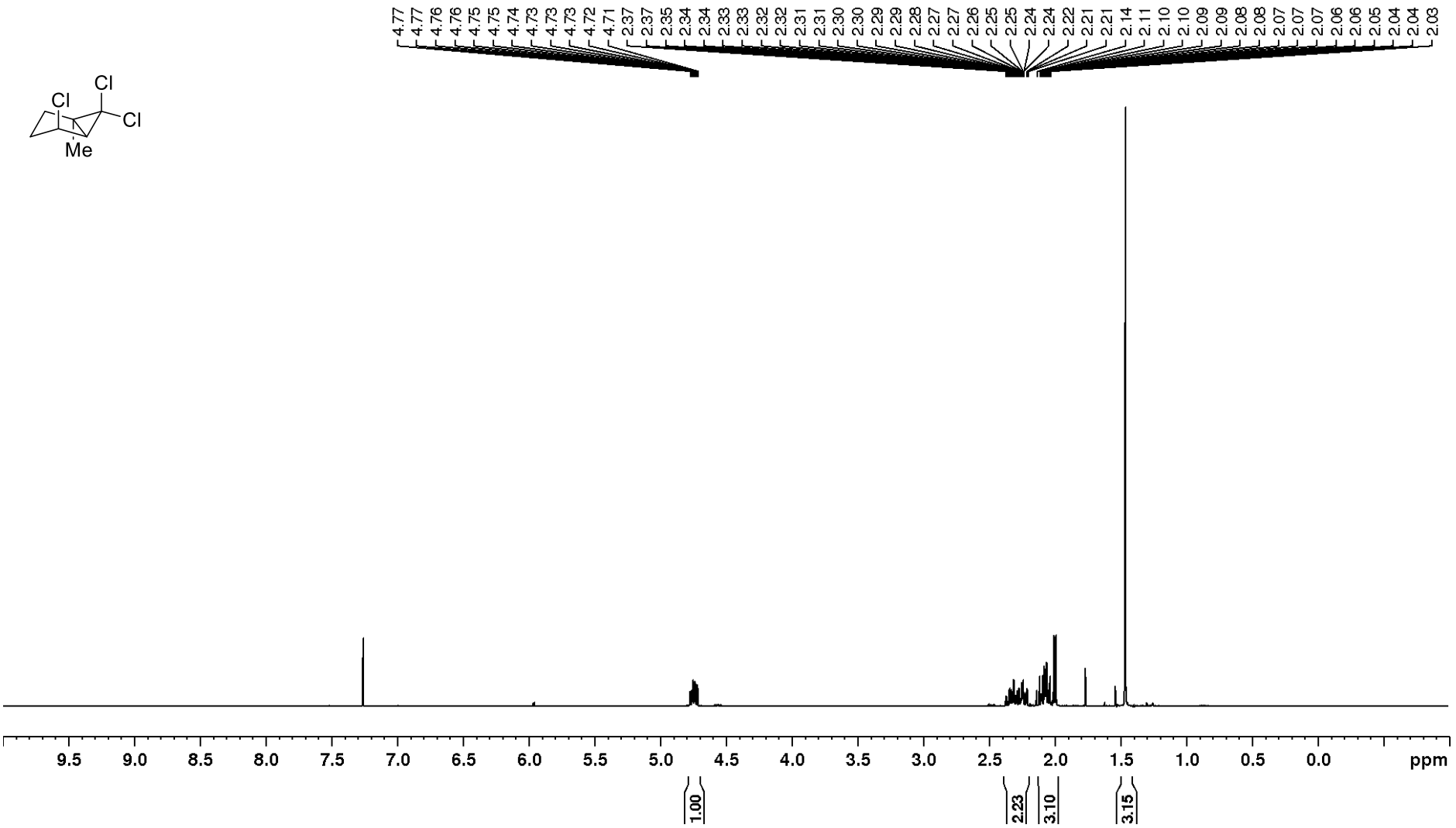


Figure S21. $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) of **(1*RS*,4*RS*,5*RS*)-4,6,6-trichloro-1-methylbicyclo[3.1.0]hexane** (*cis*-**9**).

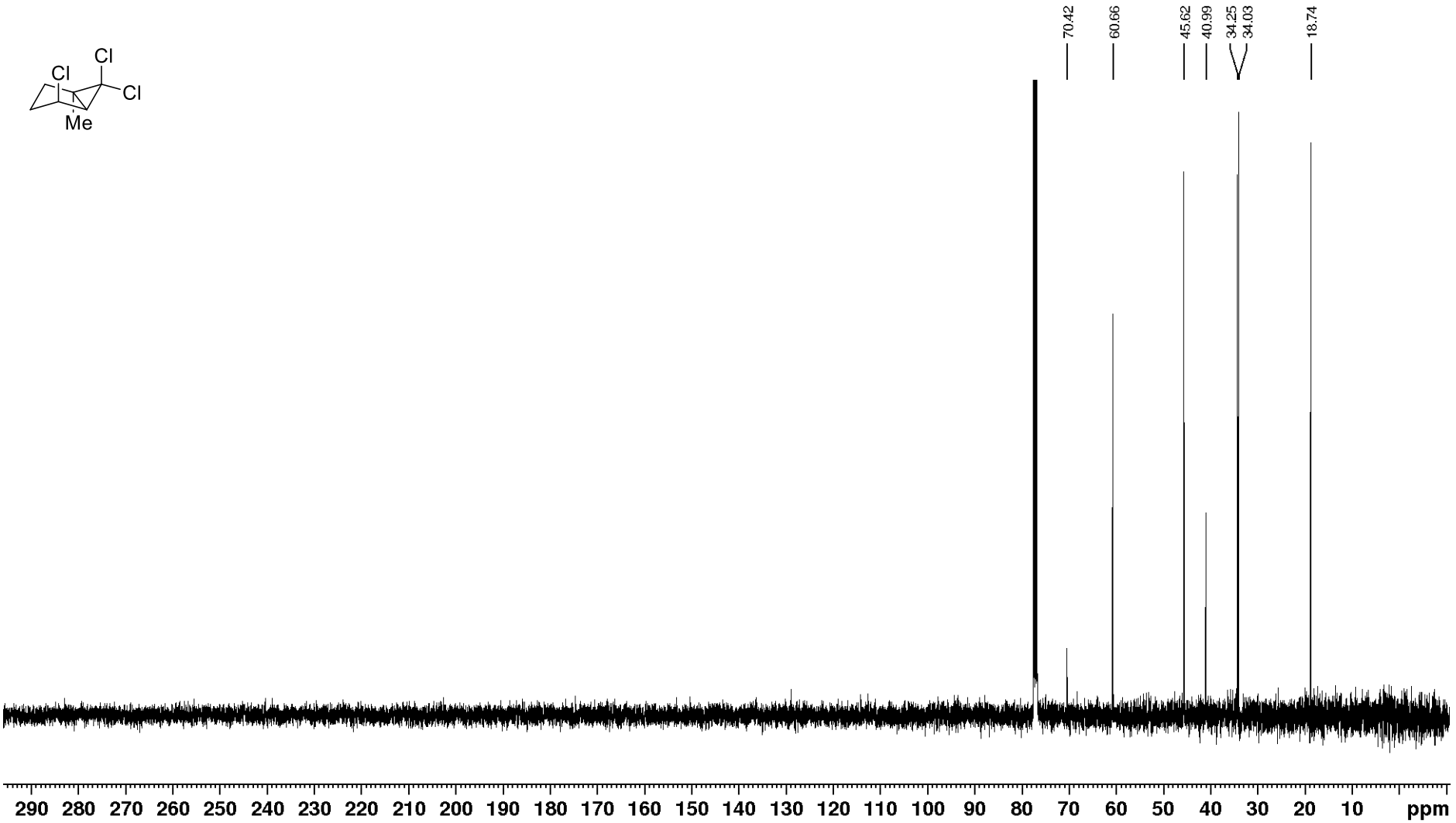


Figure S22. ^{1}H NMR (400 MHz, $CDCl_3$) of **2-((2,6-Dimethylhepta-1,6-dien-4-yl)oxy)tetrahydro-2*H*-pyran** (**S13**).

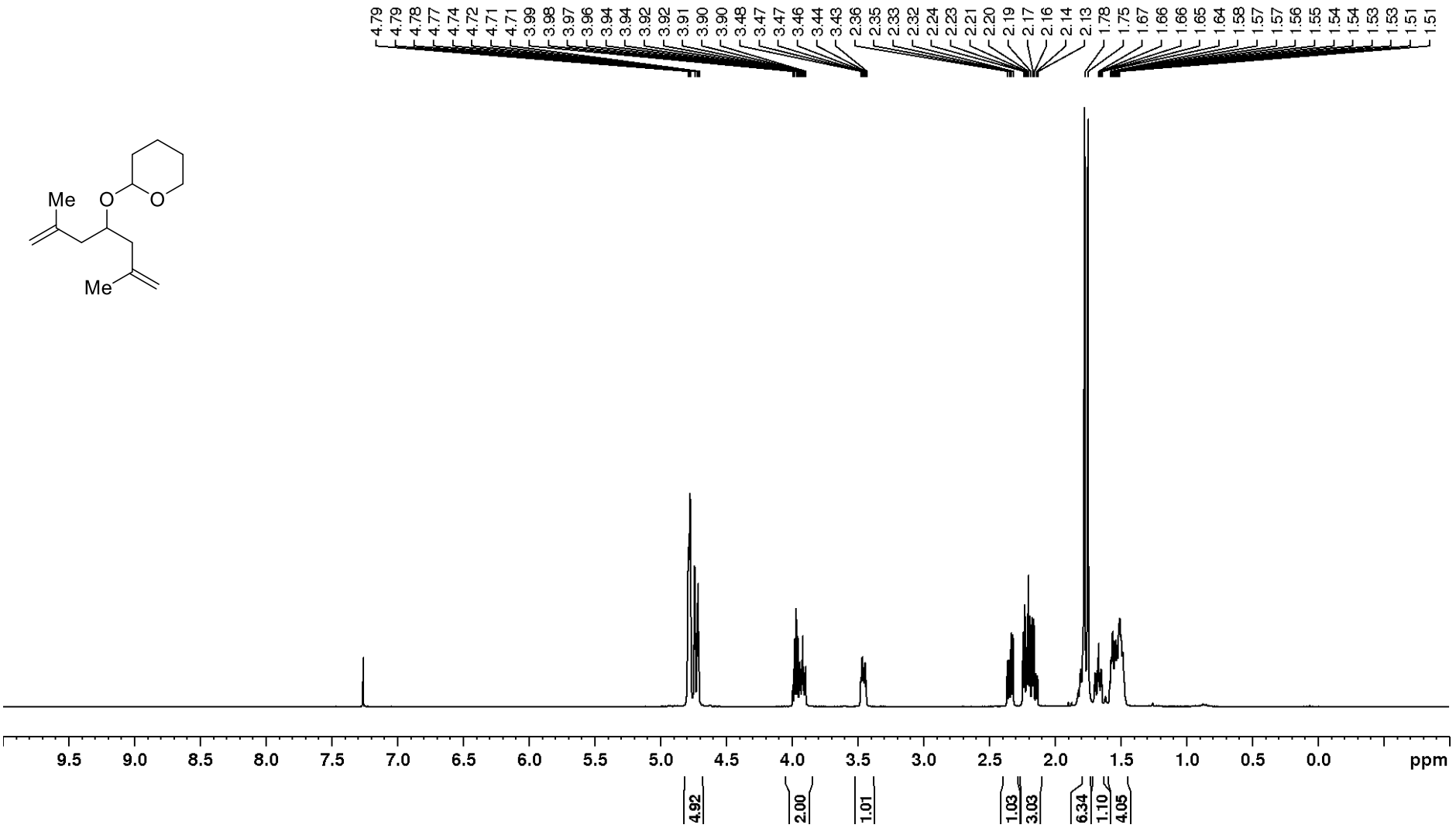


Figure S23. $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) of **2-((2,6-dimethylhepta-1,6-dien-4-yl)oxy)tetrahydro-2*H*-pyran** (**S13**).

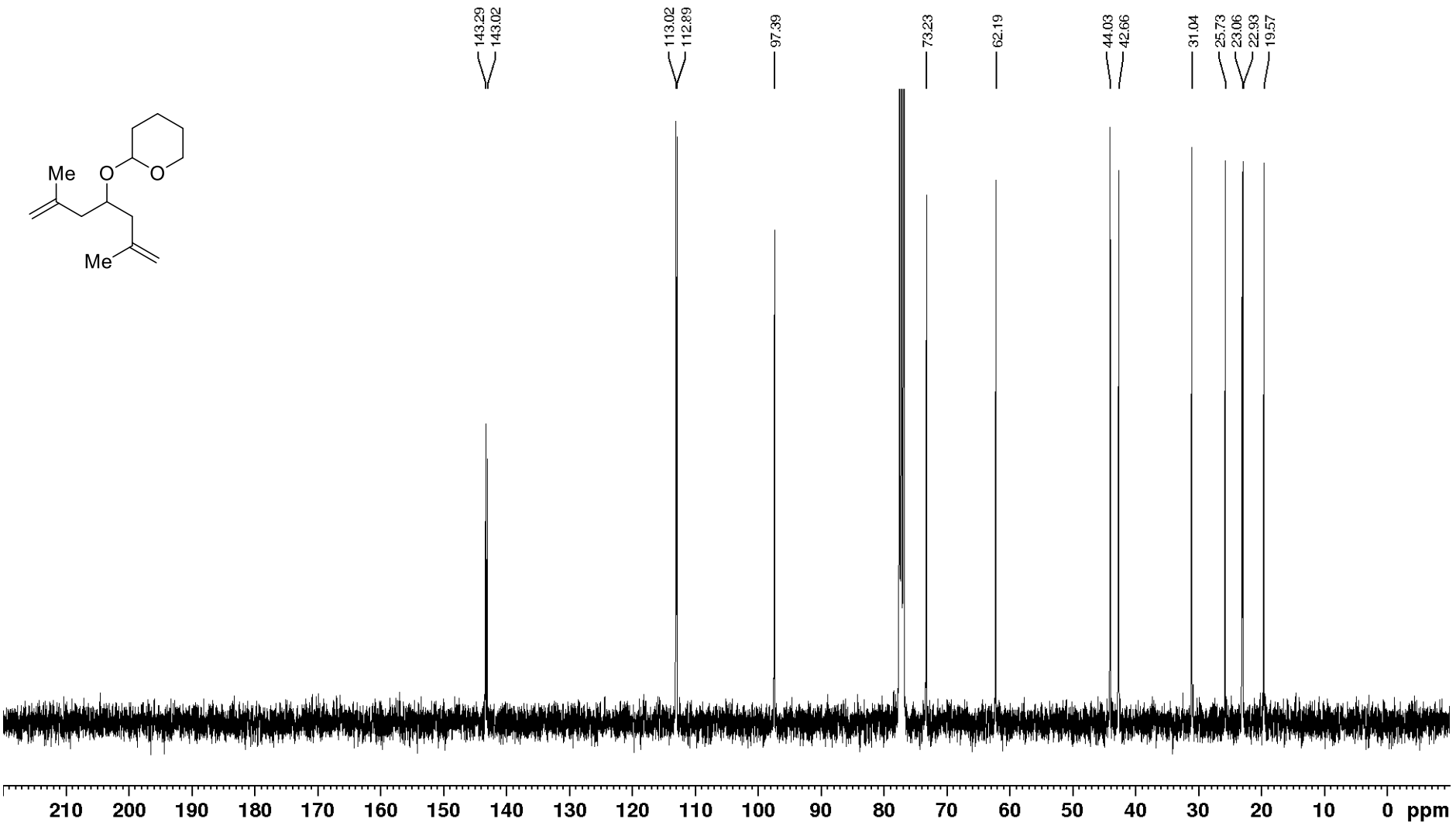


Figure S24: ^{1}H NMR (400 MHz, $CDCl_3$) of **2-((3,4-dimethylcyclopent-3-en-1-yl)oxy)tetrahydro-2*H*-pyran** (**S14**).

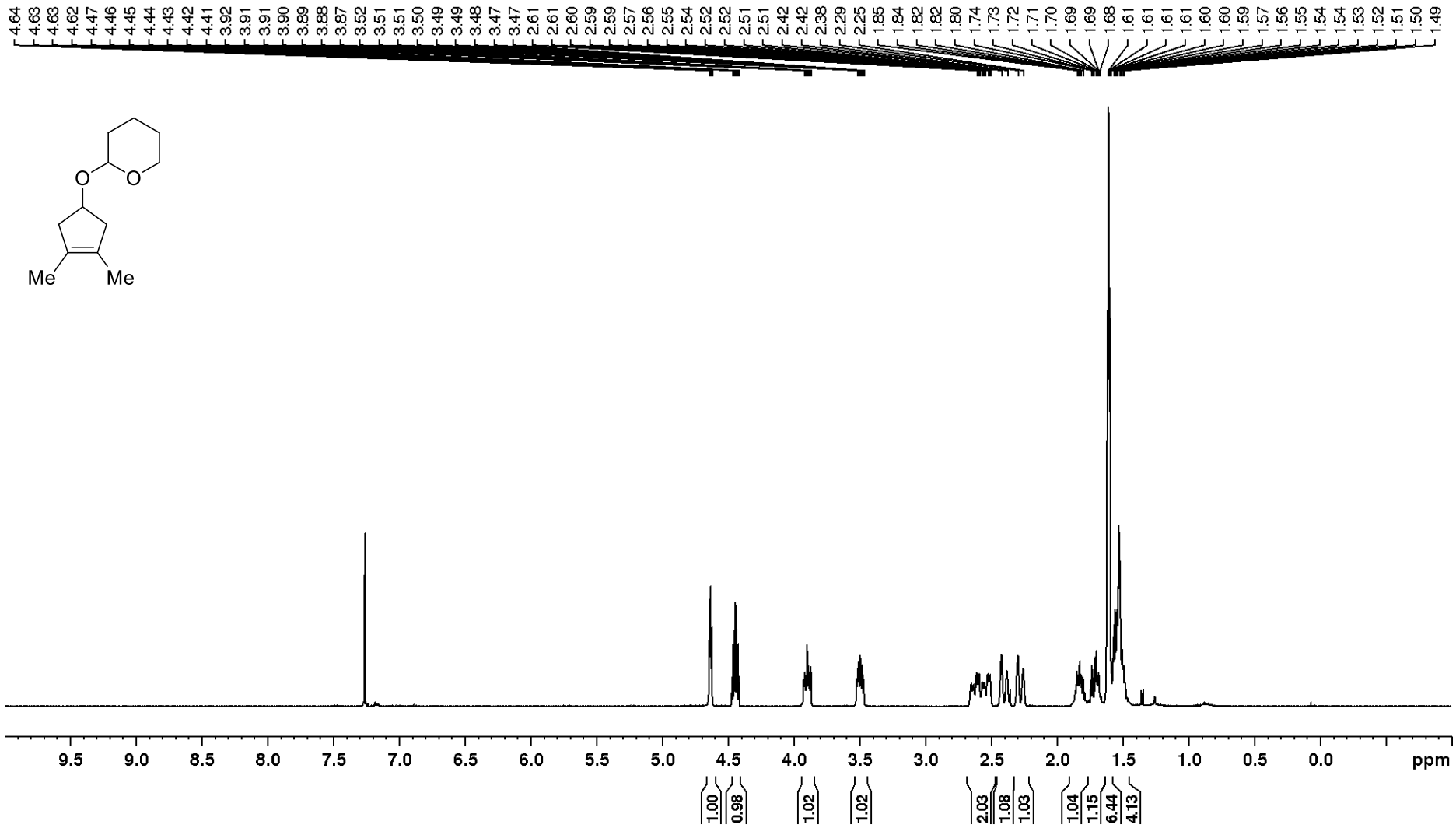


Figure S25: $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) of **2-((3,4-dimethylcyclopent-3-en-1-yl)oxy)tetrahydro-2*H*-pyran** (**S14**).

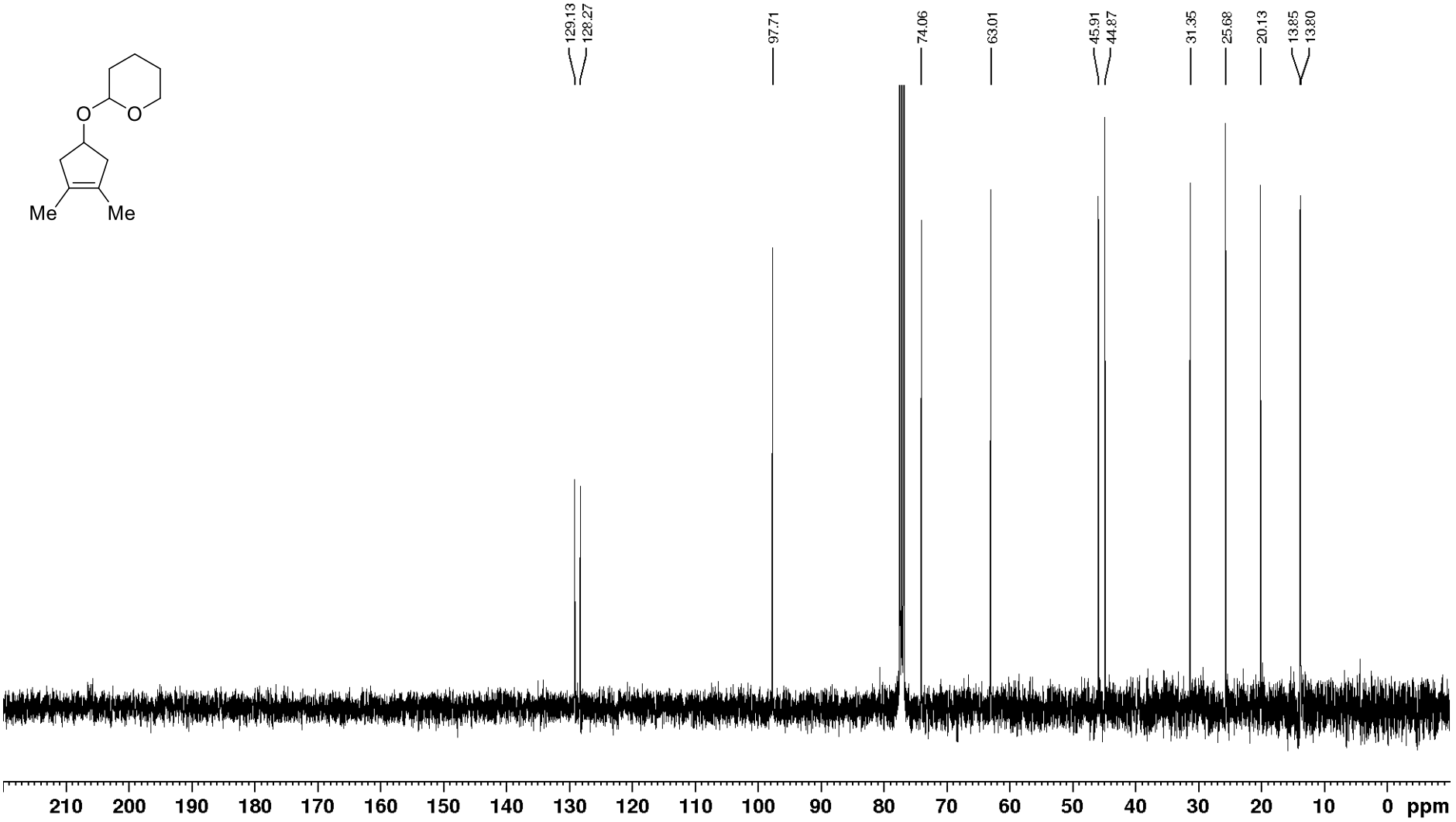


Figure S26. ^{1}H NMR (500 MHz, $CDCl_3$) of **1-(hex-1-yn-1-yl)-4-(2,2,2-trifluoroethoxy)benzene** (**4b**).

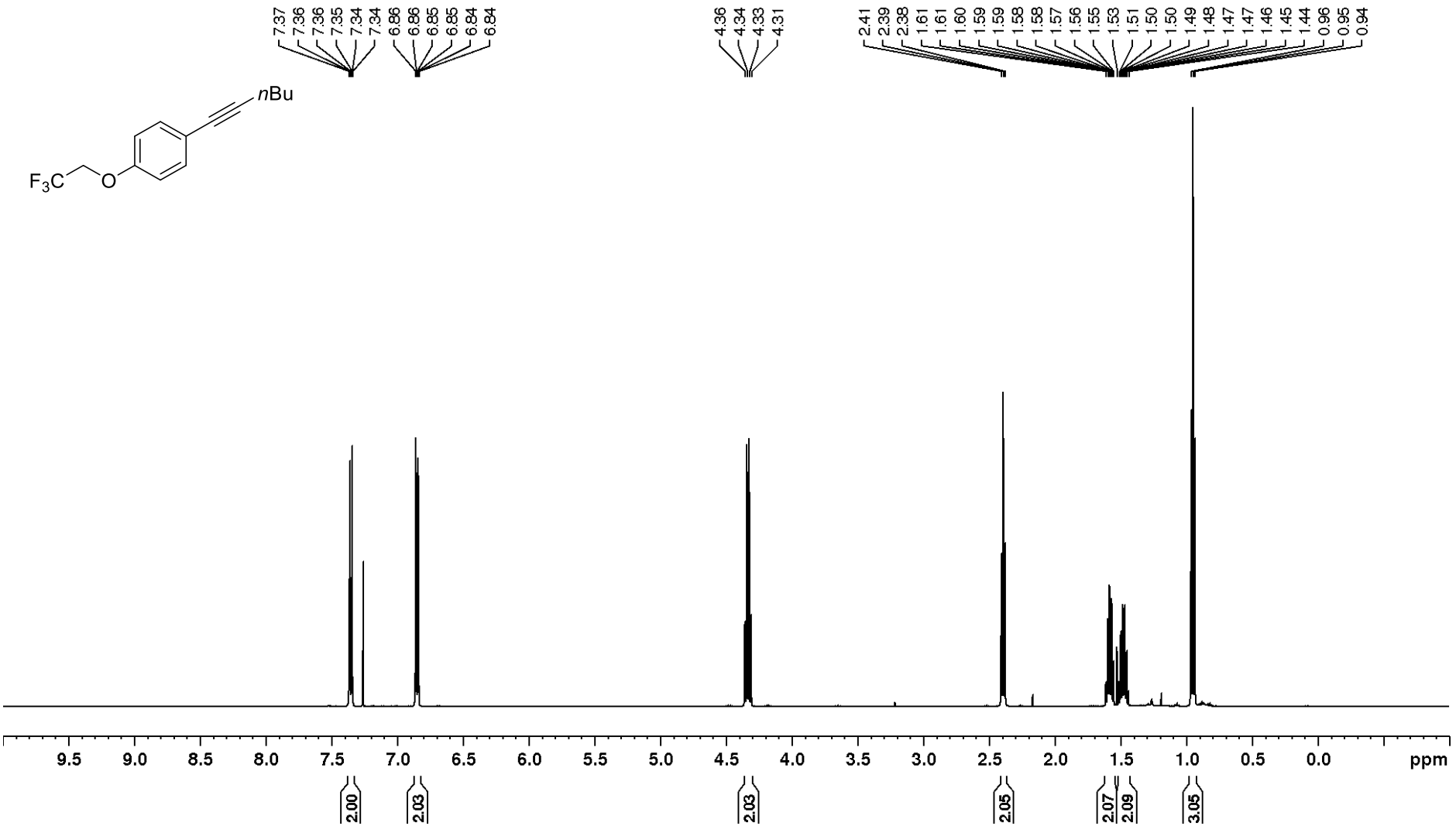


Figure S27. $^{13}C\{^{1}H\}$ NMR (126 MHz, $CDCl_3$) of **1-(hex-1-yn-1-yl)-4-(2,2,2-trifluoroethoxy)benzene** (**4b**).

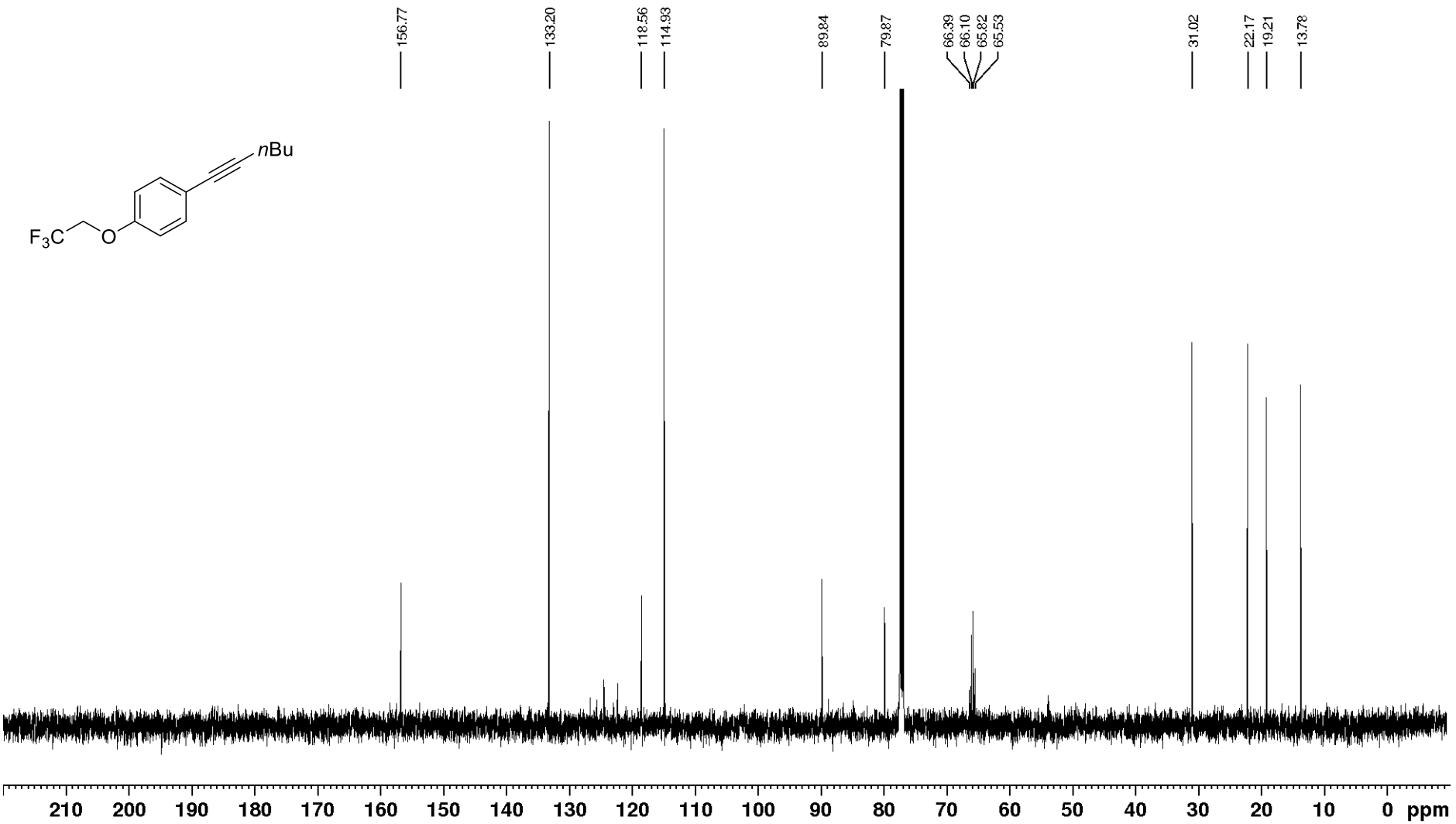


Figure S28. ^{19}F NMR (471 MHz, $CDCl_3$) of **1-(hex-1-yn-1-yl)-4-(2,2,2-trifluoroethoxy)benzene** (**4b**).

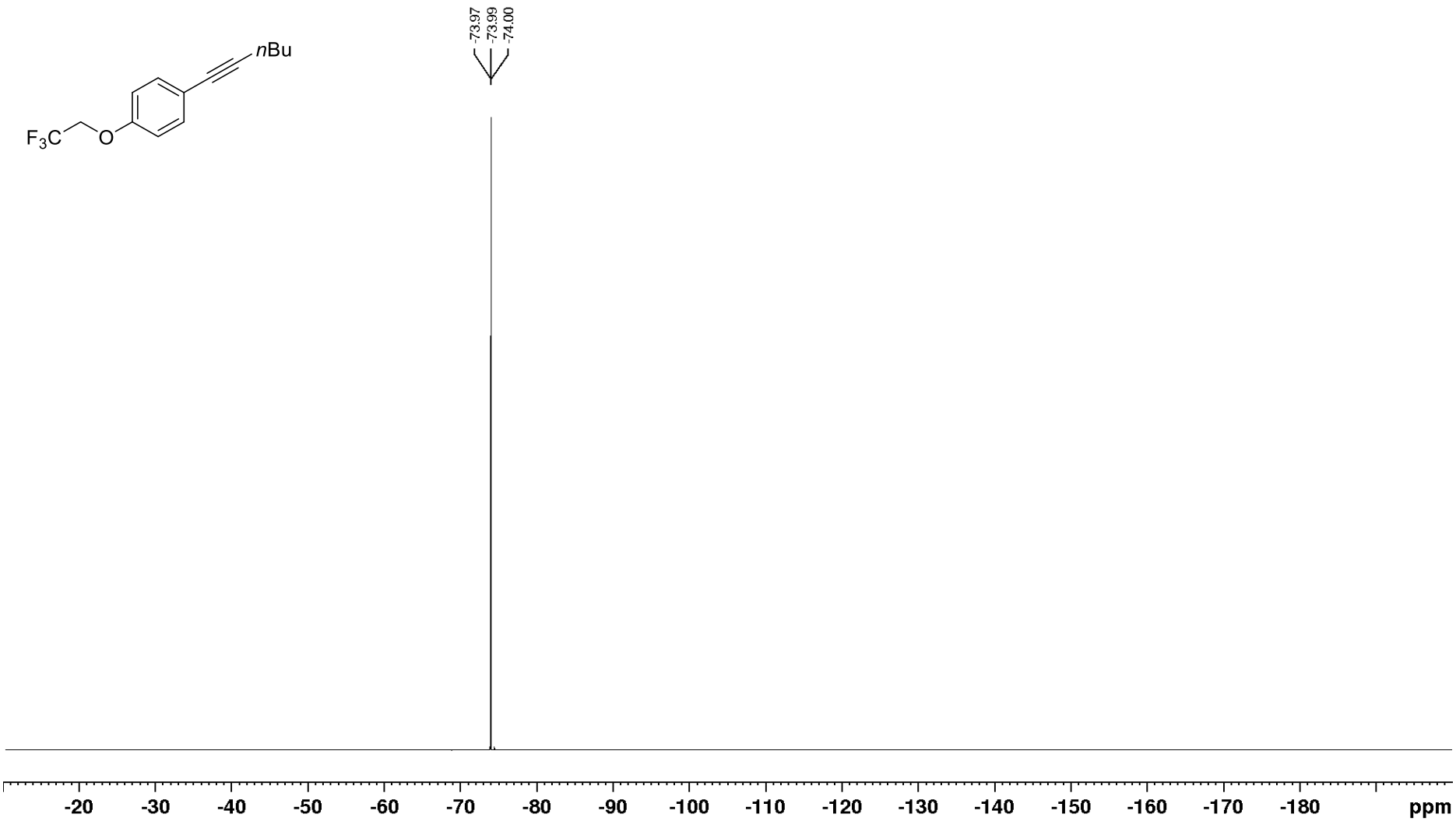


Figure S29. ^{1}H NMR (400 MHz, $CDCl_3$) of **5-(2,4-dimethoxyphenyl)pent-4-yn-1-yl pivalate** (**4c**).

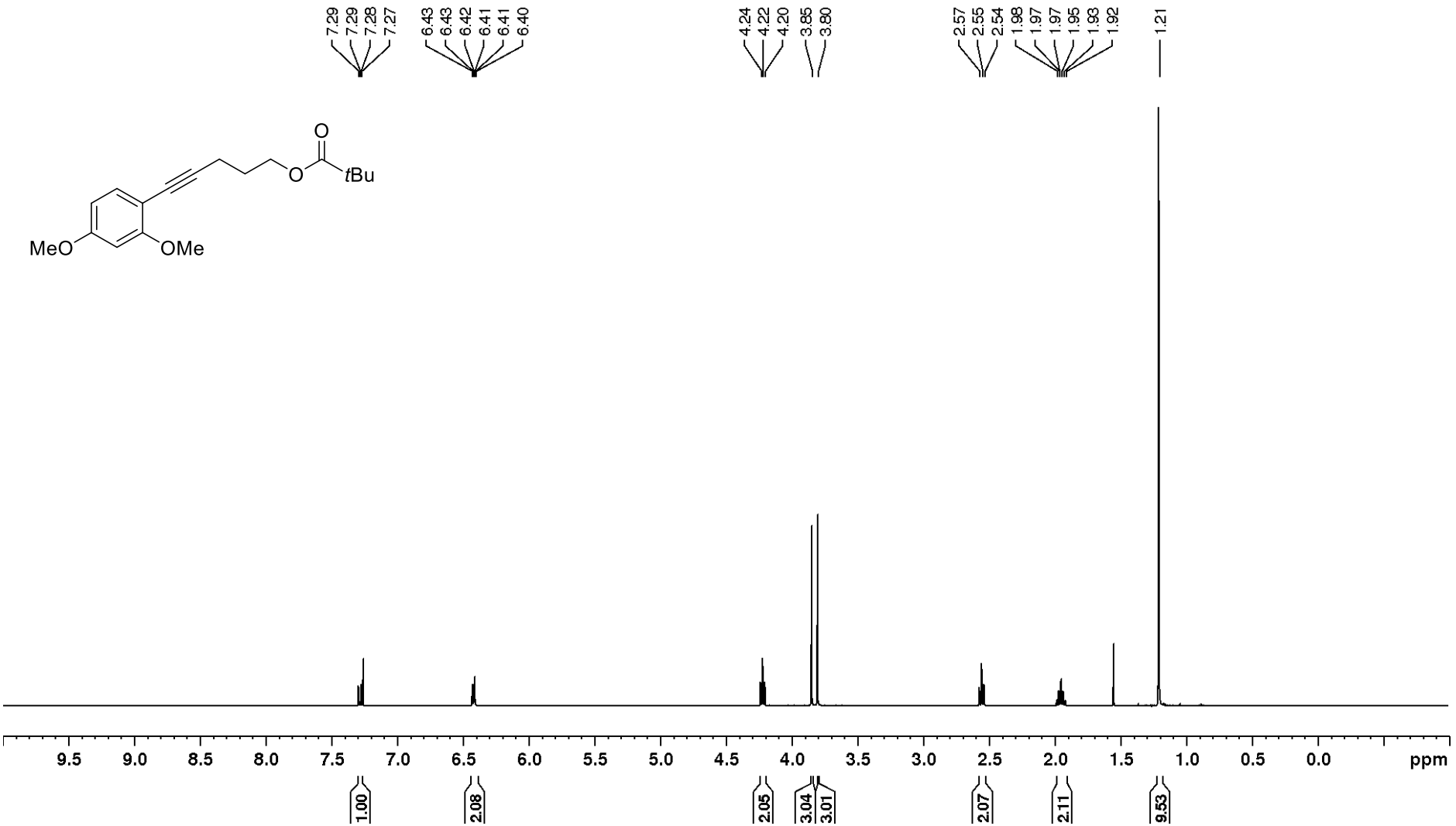


Figure S30. $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) of **5-(2,4-dimethoxyphenyl)pent-4-yn-1-yl pivalate** (**4c**).

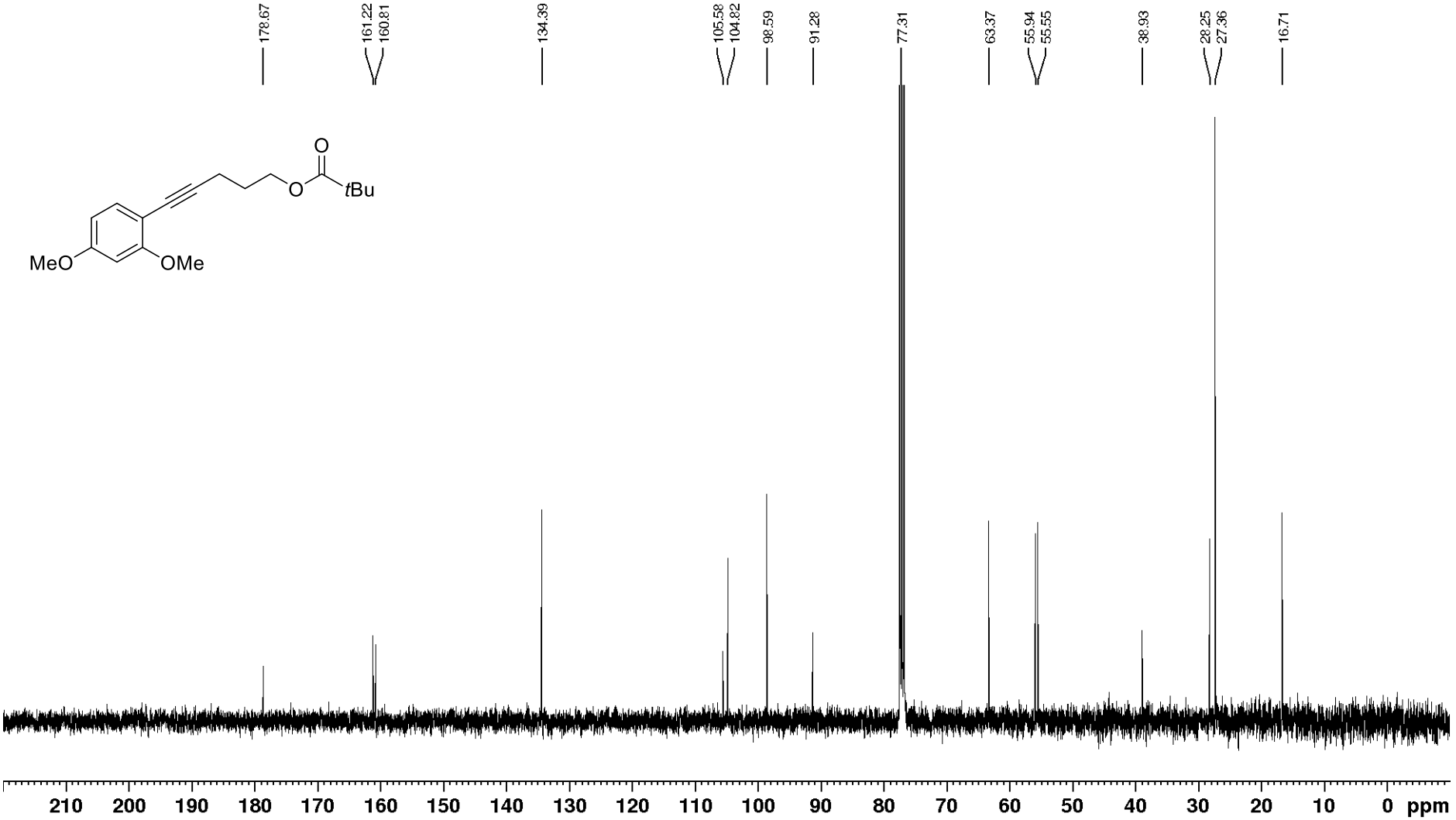


Figure S31. ^{1}H NMR (400 MHz, $CDCl_3$) of **4-(hex-1-yn-1-yl)phenyl pivalate** (**4d**).

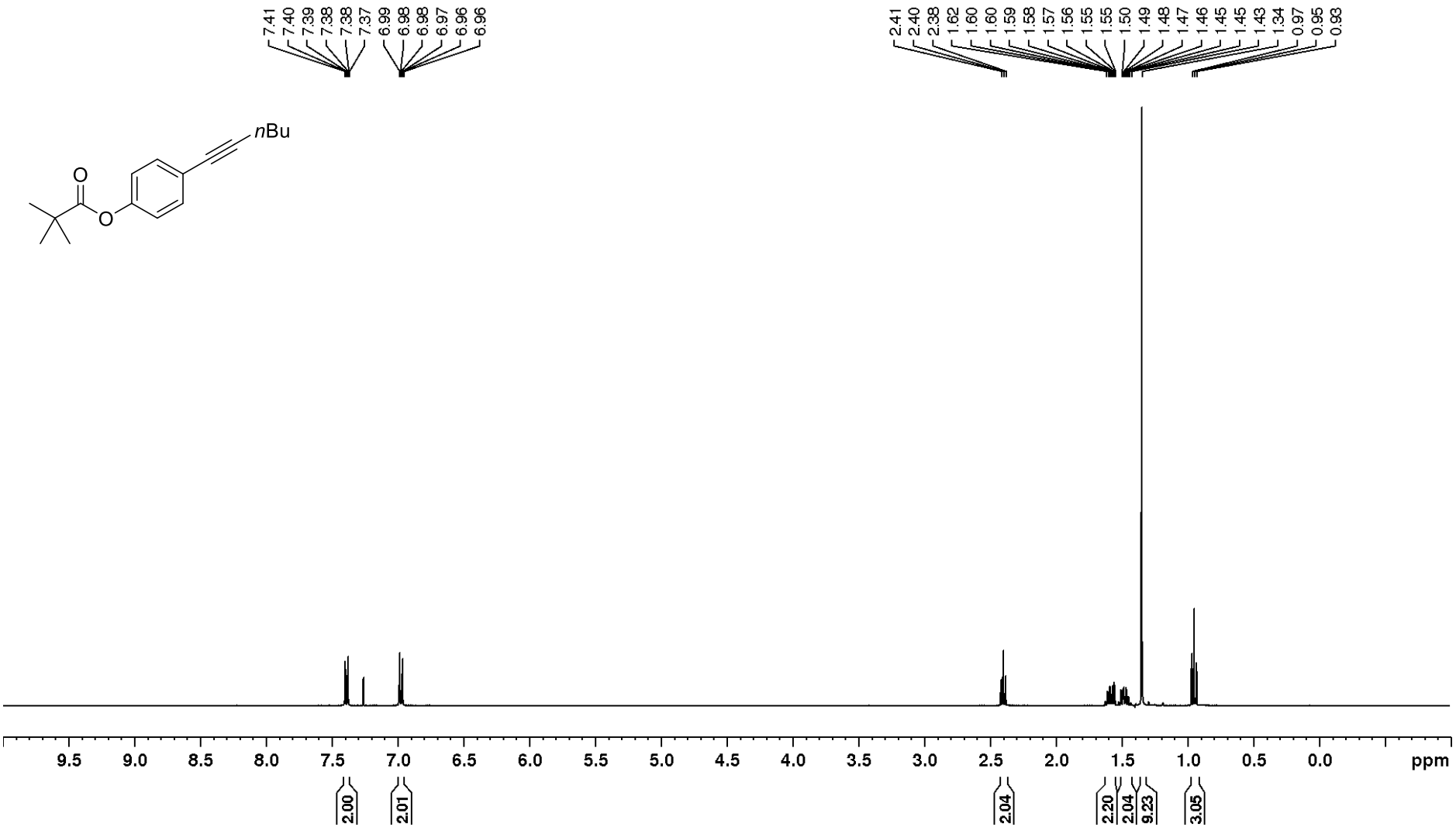


Figure S32. $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) of **4-(hex-1-yn-1-yl)phenyl pivalate** (**4d**).

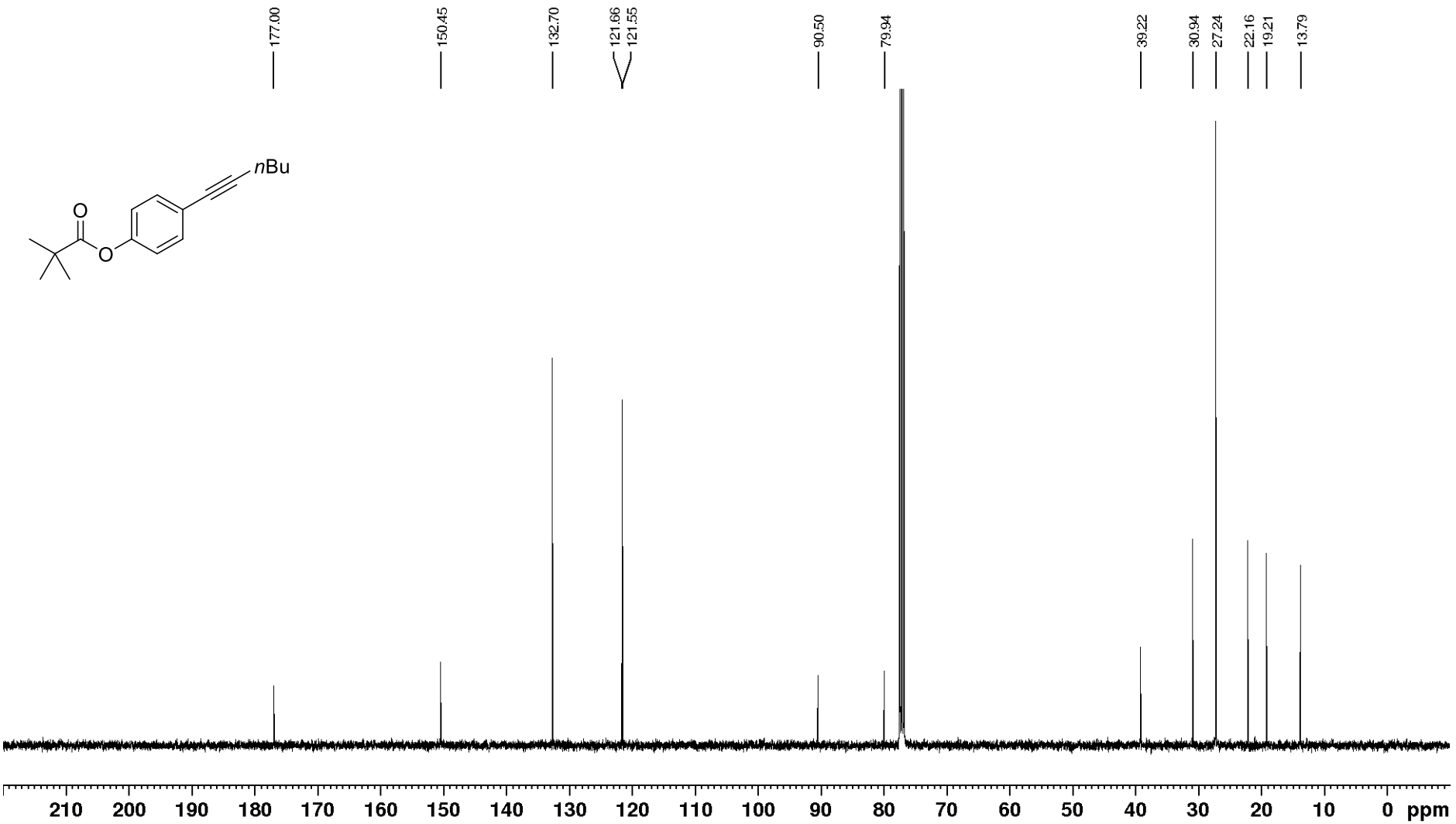


Figure S33. ^{1}H NMR (400 MHz, $CDCl_3$) of **methyl 6-(4-(pivaloyloxy)phenyl)hex-5-ynoate** (**4e**).

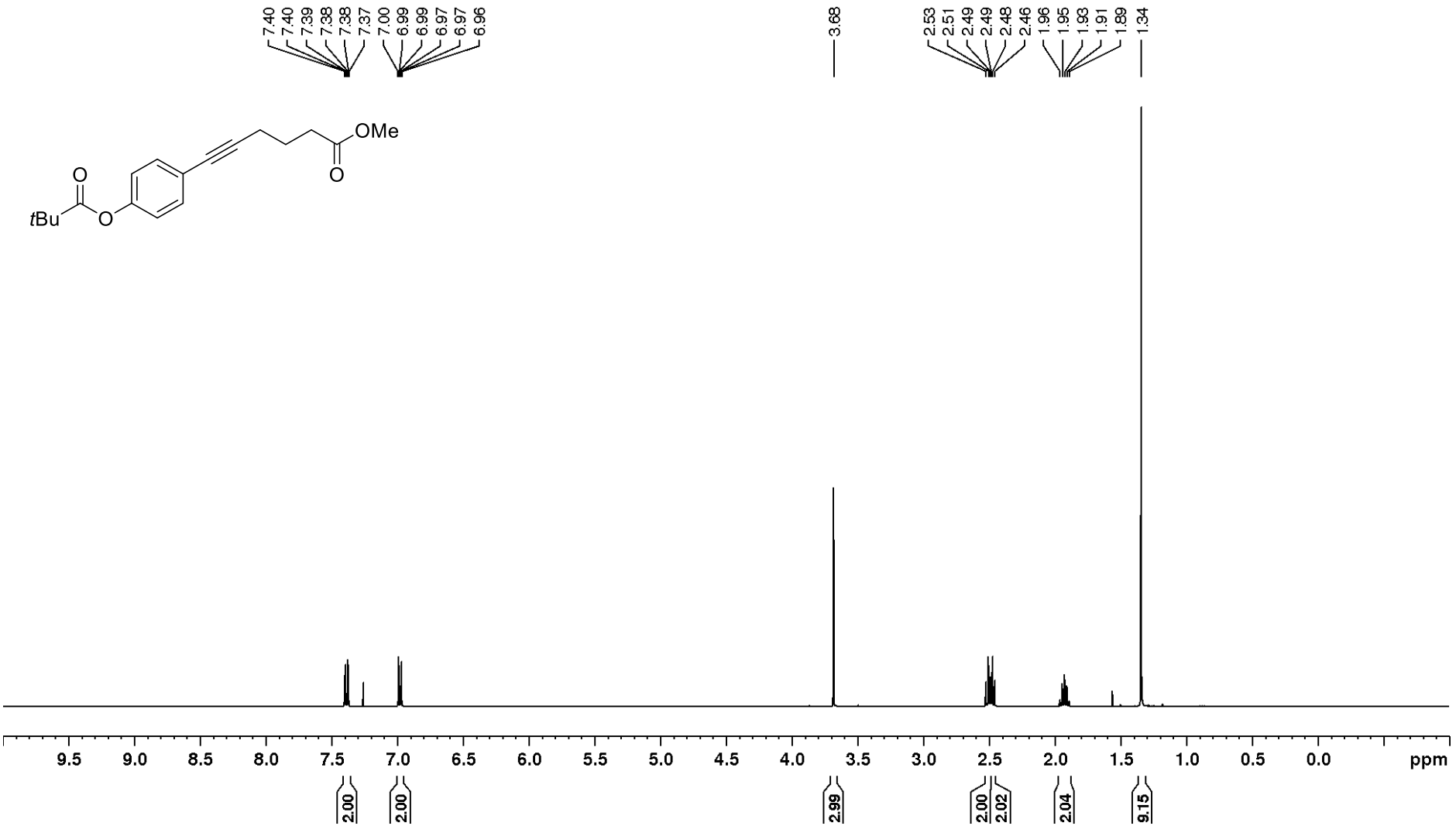


Figure S34. $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) of **methyl 6-(4-(pivaloyloxy)phenyl)hex-5-ynoate** (**4e**).

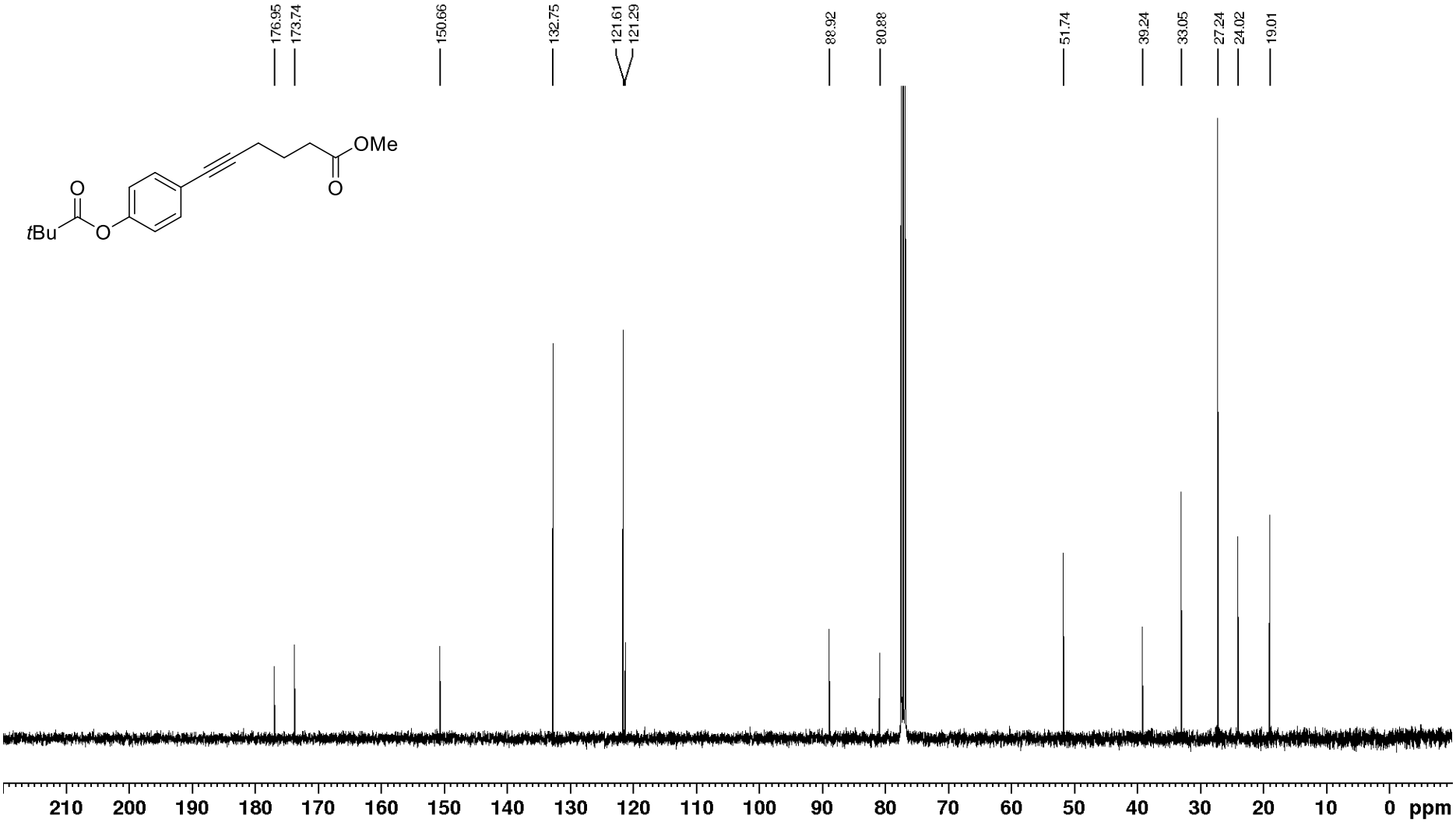


Figure S35. ^{1}H NMR (400 MHz, $CDCl_3$) of **4-(5-chloropent-1-yn-1-yl)phenyl pivalate** (**4f**).

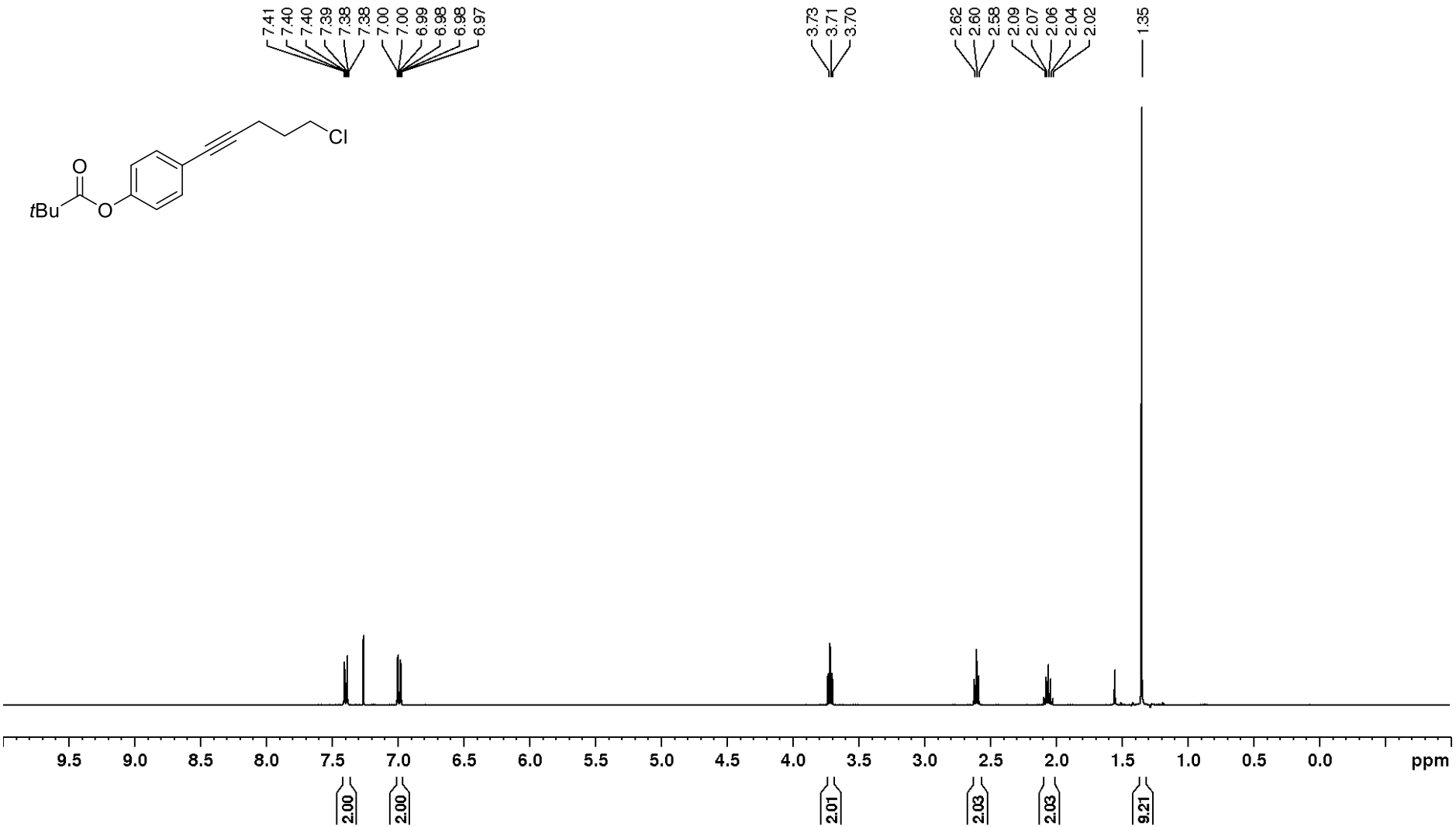


Figure S36. $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) of **4-(5-chloropent-1-yn-1-yl)phenyl pivalate** (**4f**).

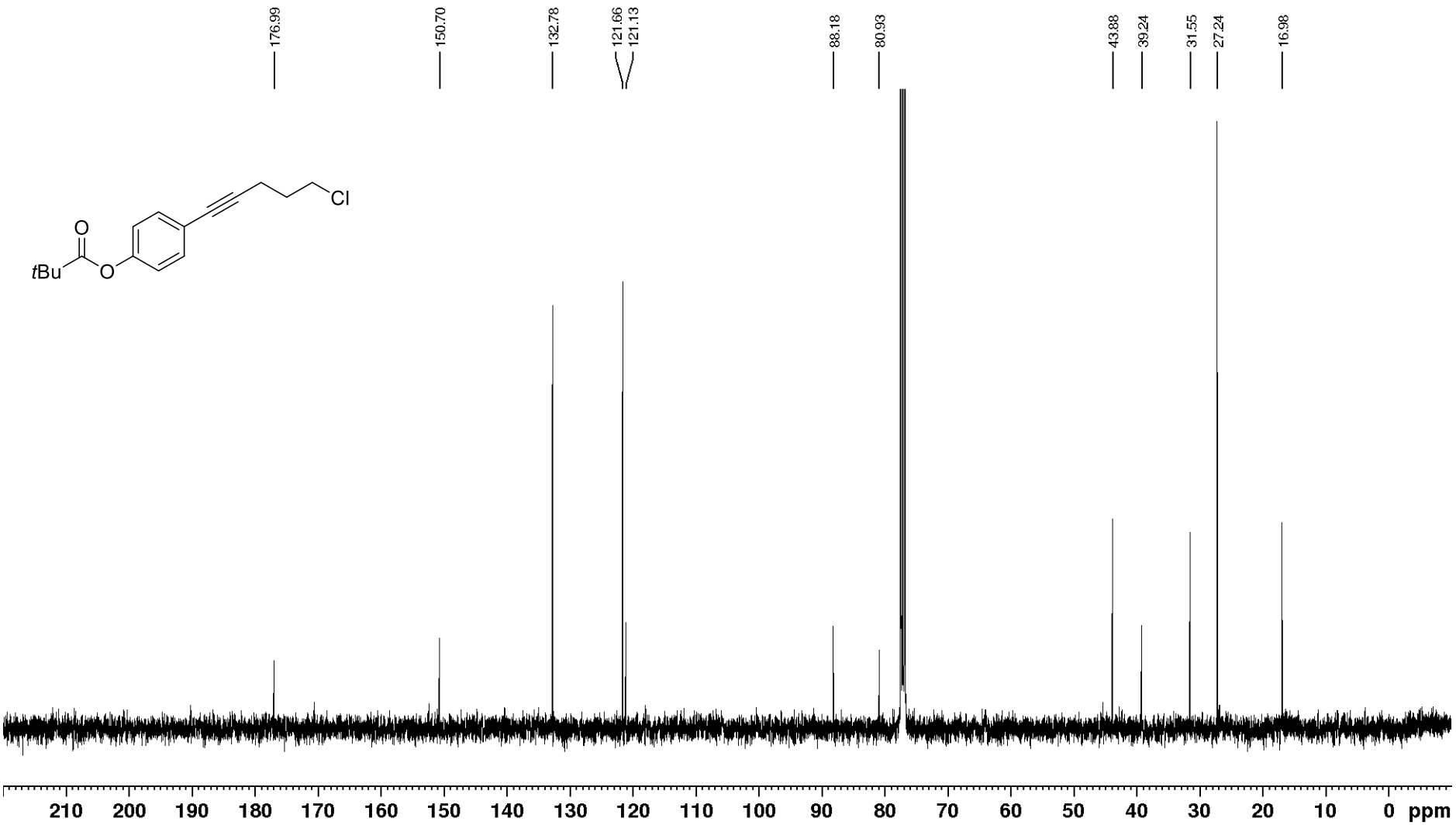


Figure S37. ^{1}H NMR (400 MHz, $CDCl_3$) of **4-(hex-1-yn-1-yl)phenyl methanesulfonate** (**4g**).

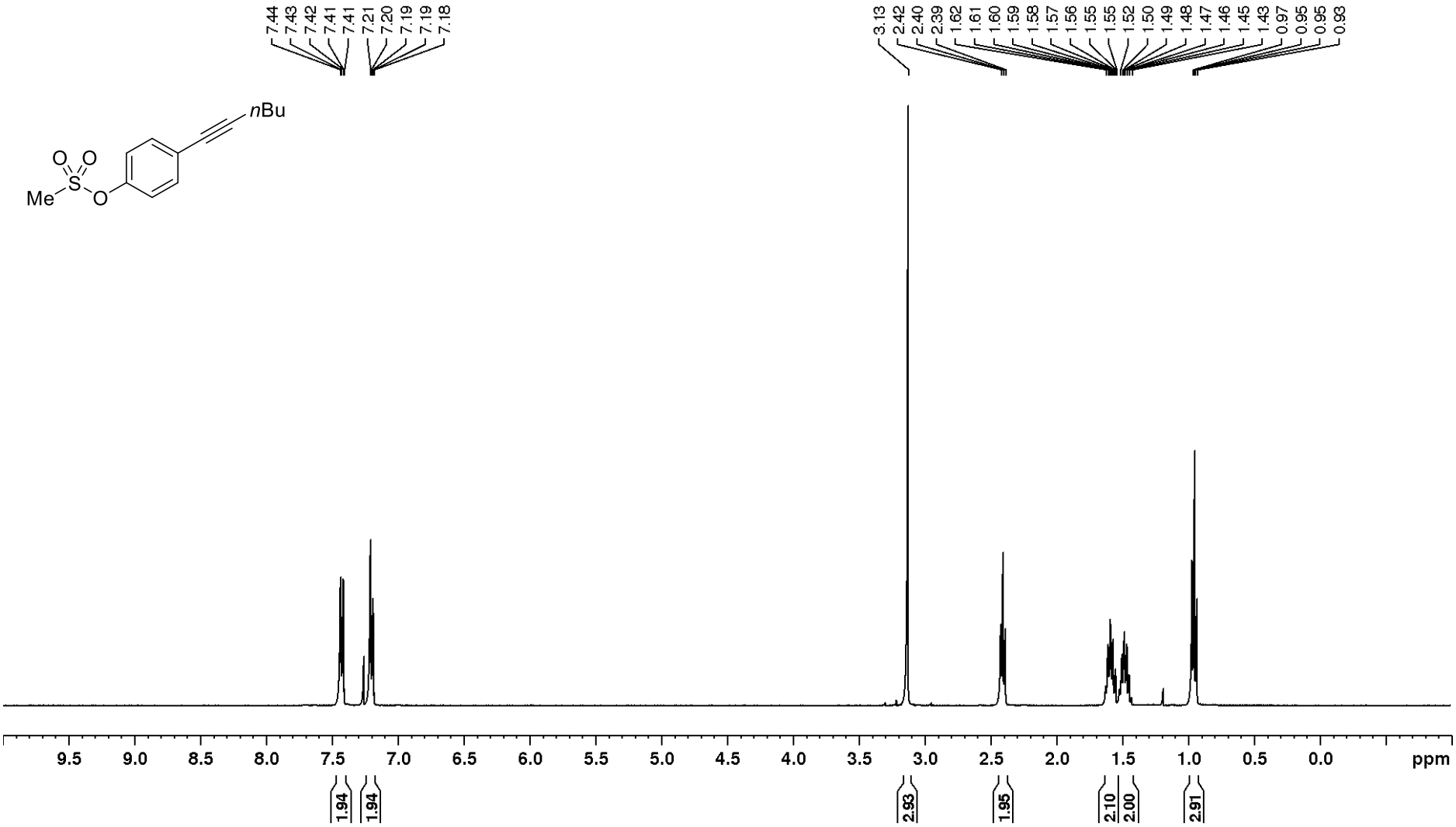


Figure S38. $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) of **4-(hex-1-yn-1-yl)phenyl methanesulfonate** (**4g**).

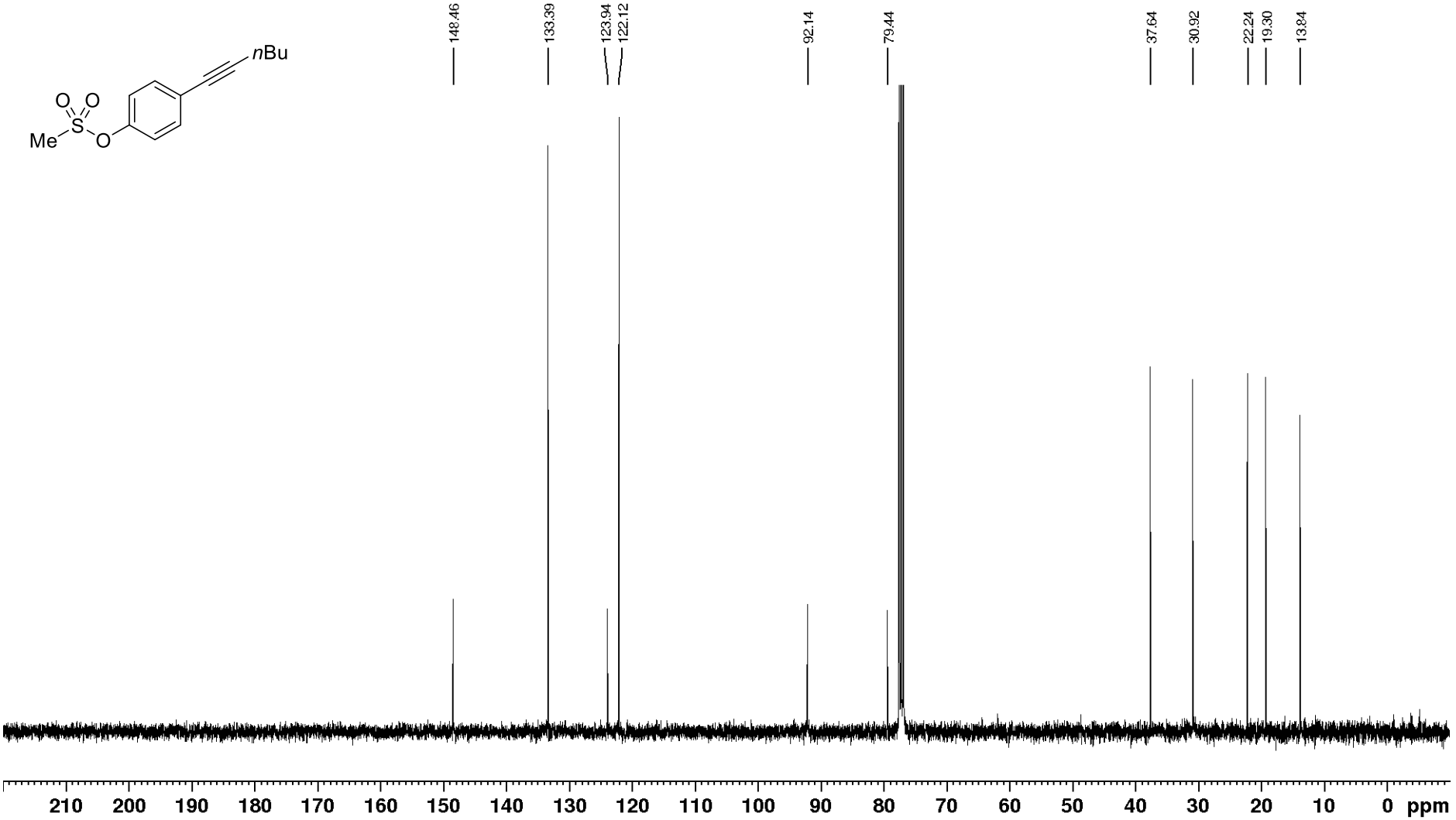


Figure S39. ^{1}H NMR (400 MHz, $CDCl_3$) of **methyl 6-(naphthalen-2-yl)hex-5-ynoate** (**4i**).

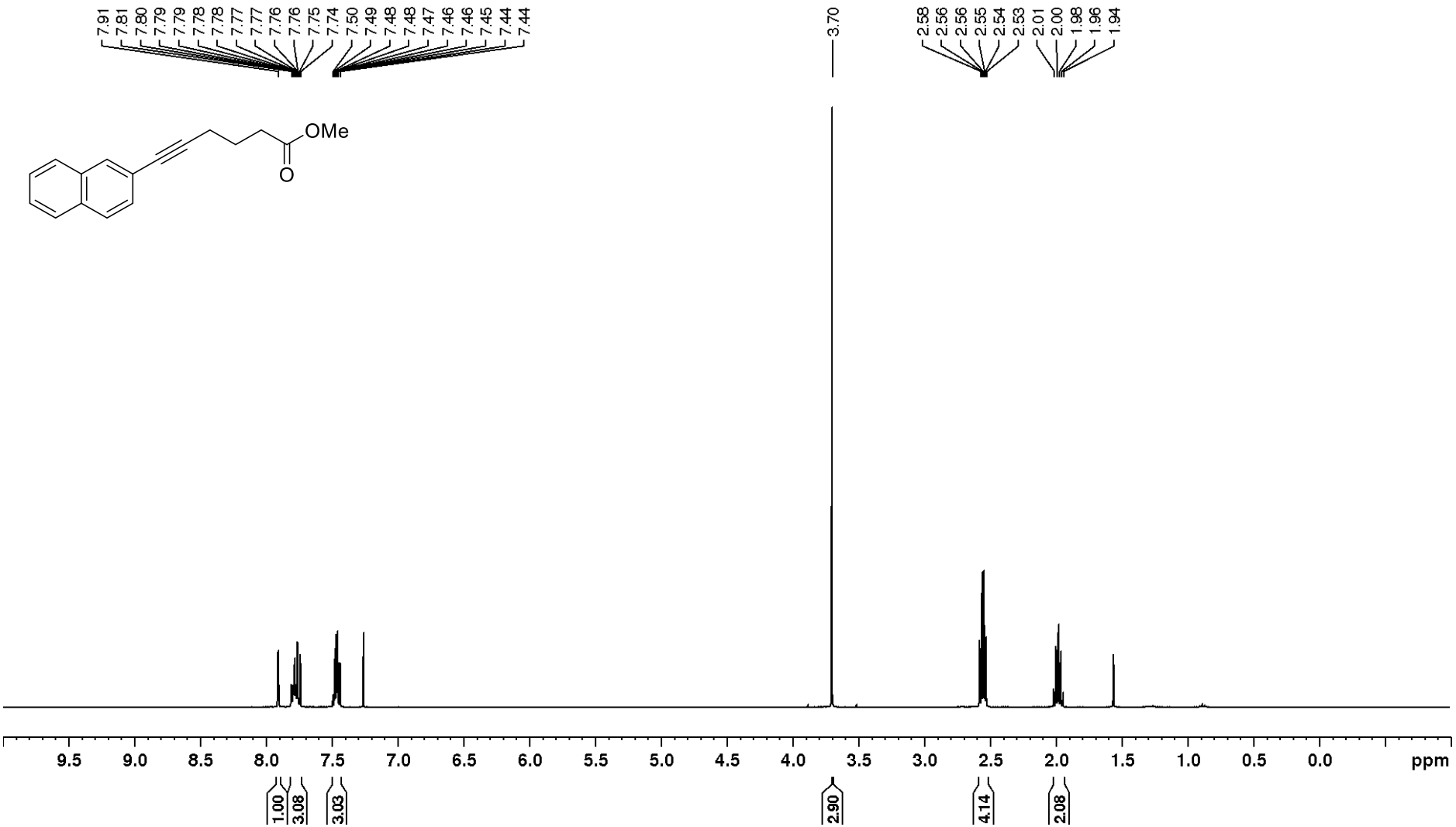


Figure S40. ^{1}H NMR (400 MHz, $CDCl_3$) of **methyl 6-(naphthalen-2-yl)hex-5-ynoate** (**4i**).

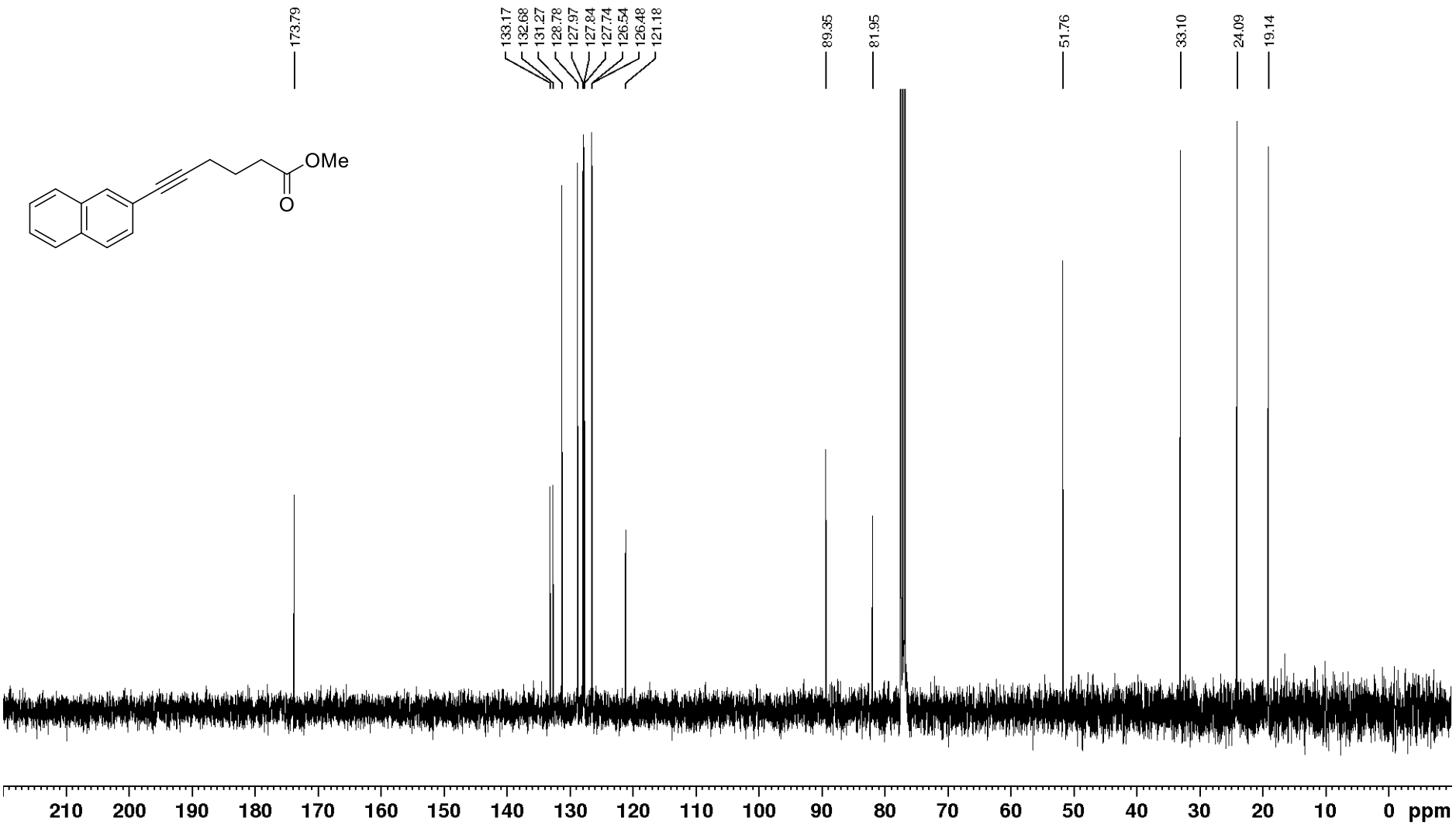


Figure S41. ^{1}H NMR (400 MHz, $CDCl_3$) of **methyl 6-(benzofuran-5-yl)hex-5-ynoate** (**10a**).

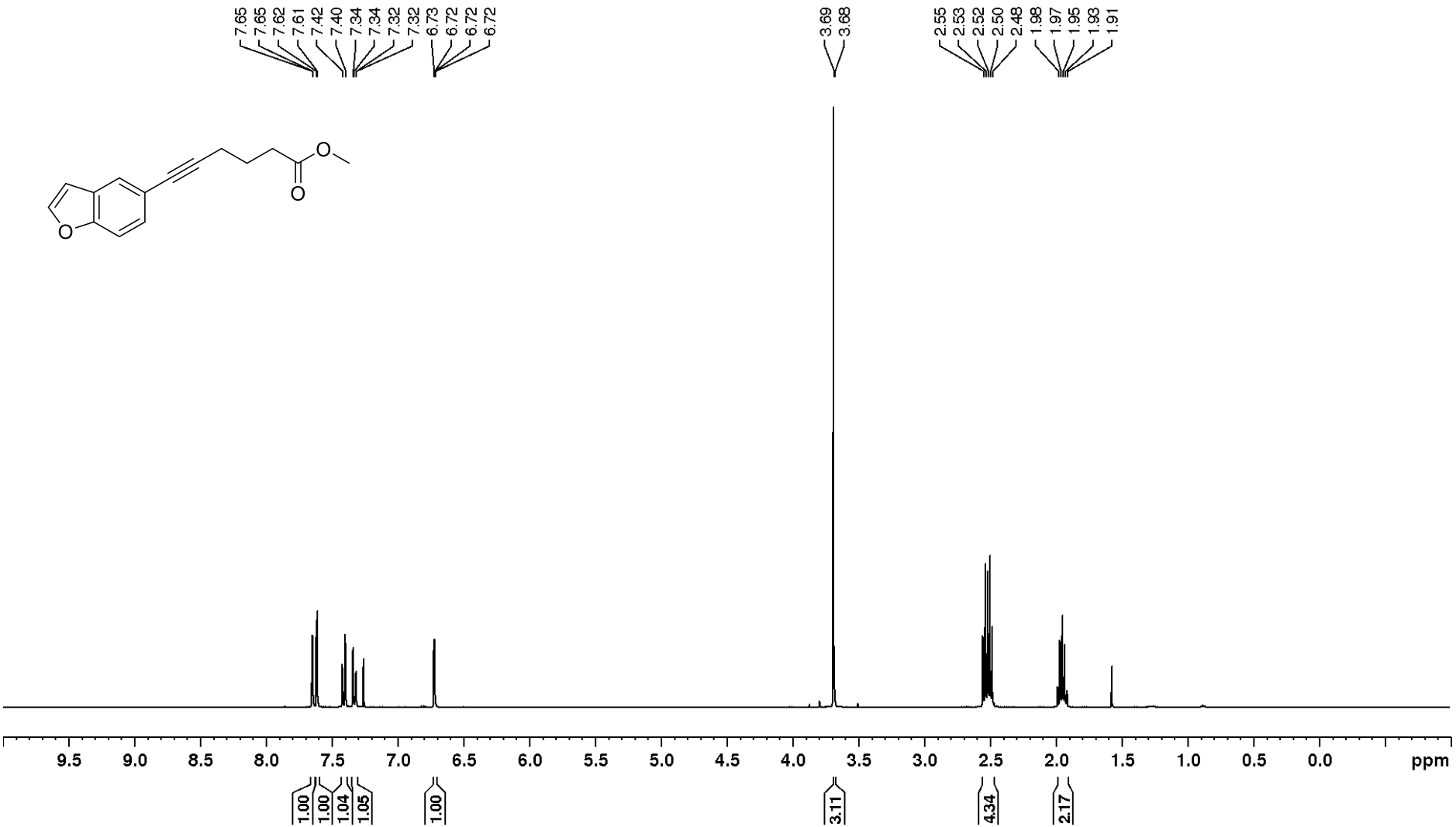


Figure S42. $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) of **methyl 6-(benzofuran-5-yl)hex-5-ynoate** (**10a**).

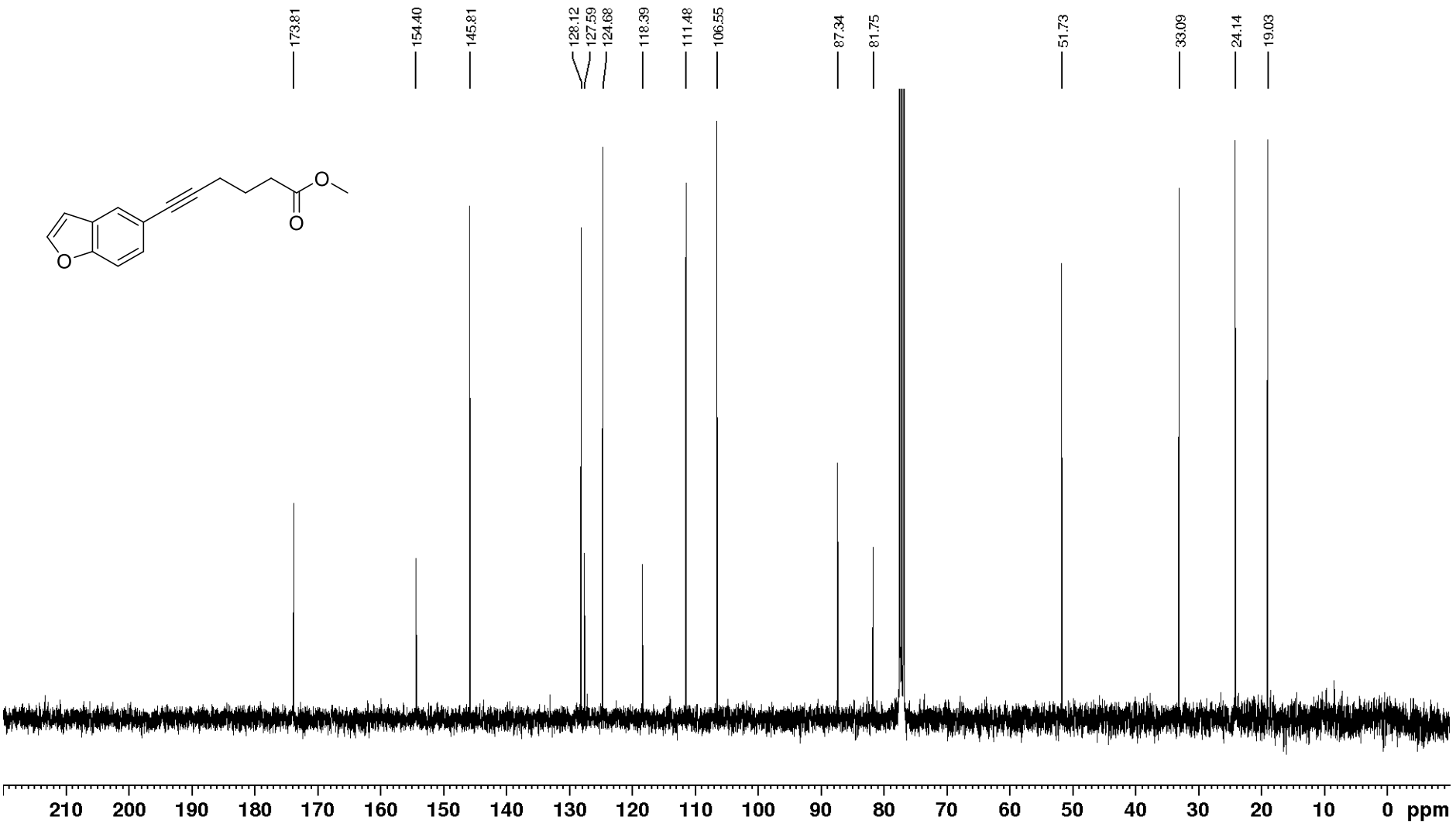


Figure S43. ^{1}H NMR (101 MHz, $CDCl_3$) of **methyl 6-(2-(4-methoxy-4-oxobutyl)benzofuran-5-yl)hex-5-ynoate** (**10b**).

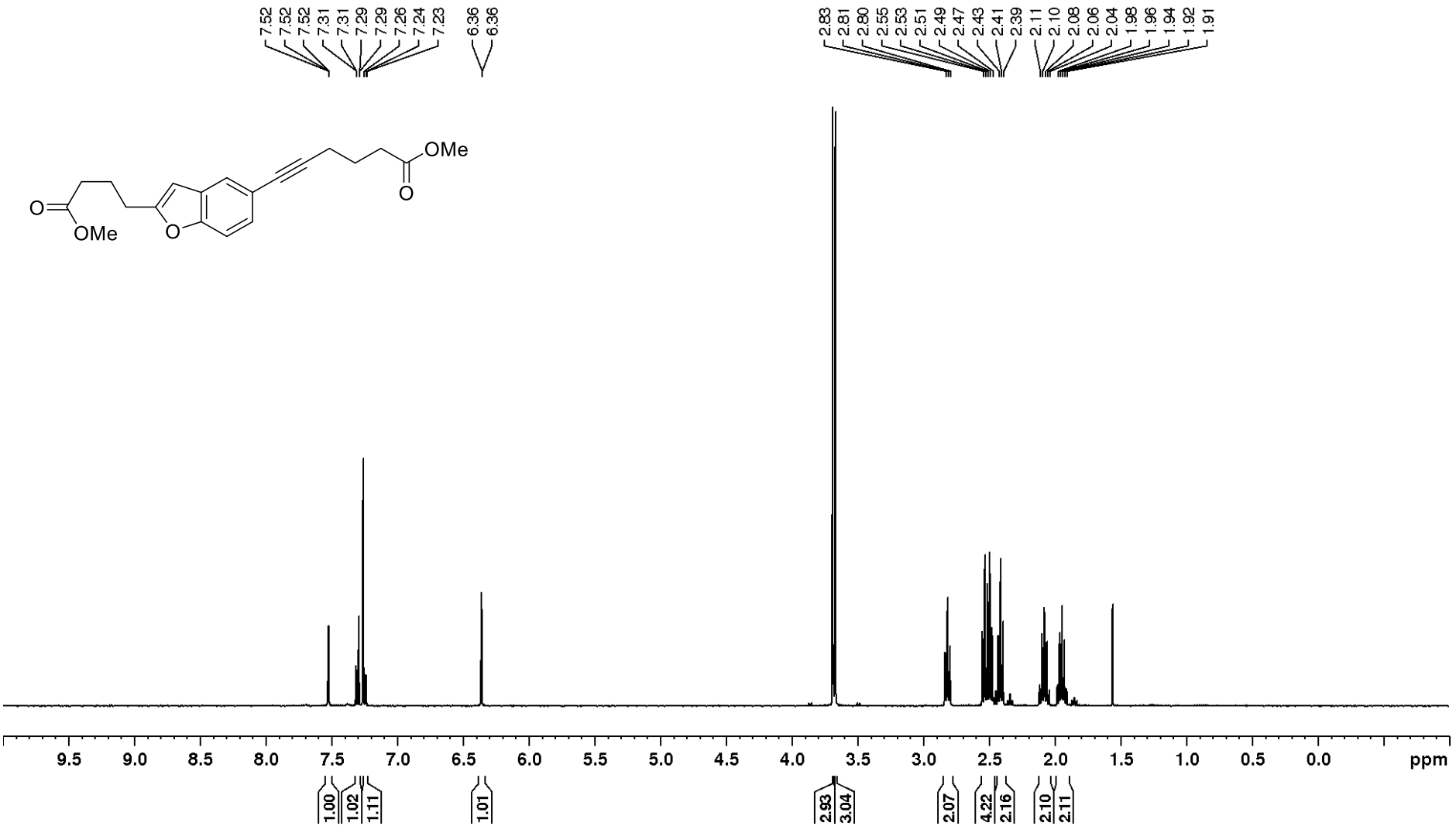


Figure S44. $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) of **methyl 6-(2-(4-methoxy-4-oxobutyl)benzofuran-5-yl)hex-5-ynoate** (**10b**).

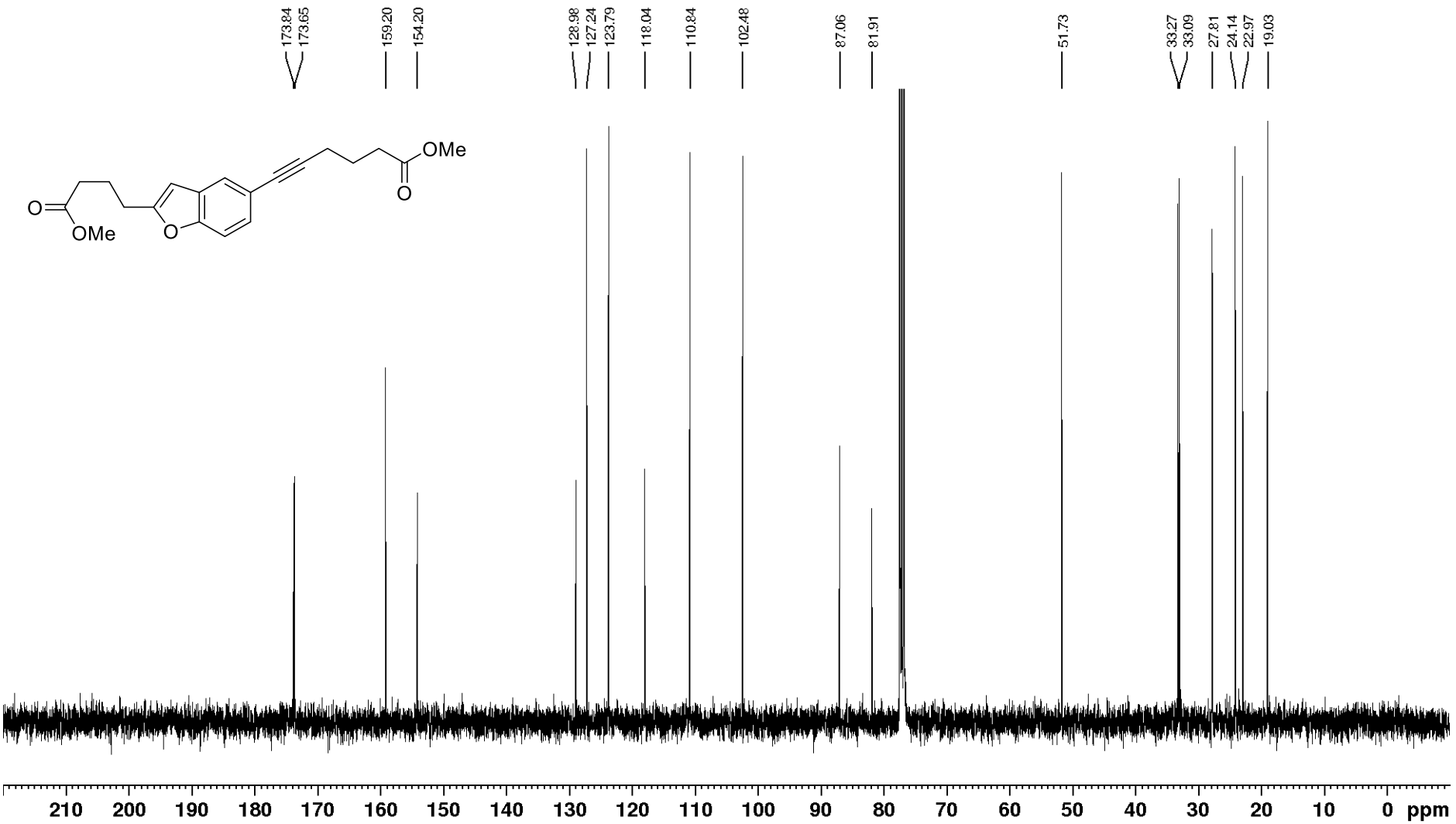


Figure S45. ^{1}H NMR (400 MHz, $CDCl_3$) of **5-(5-bromothiophen-2-yl)pent-4-yn-1-yl pivalate** (**10c**).

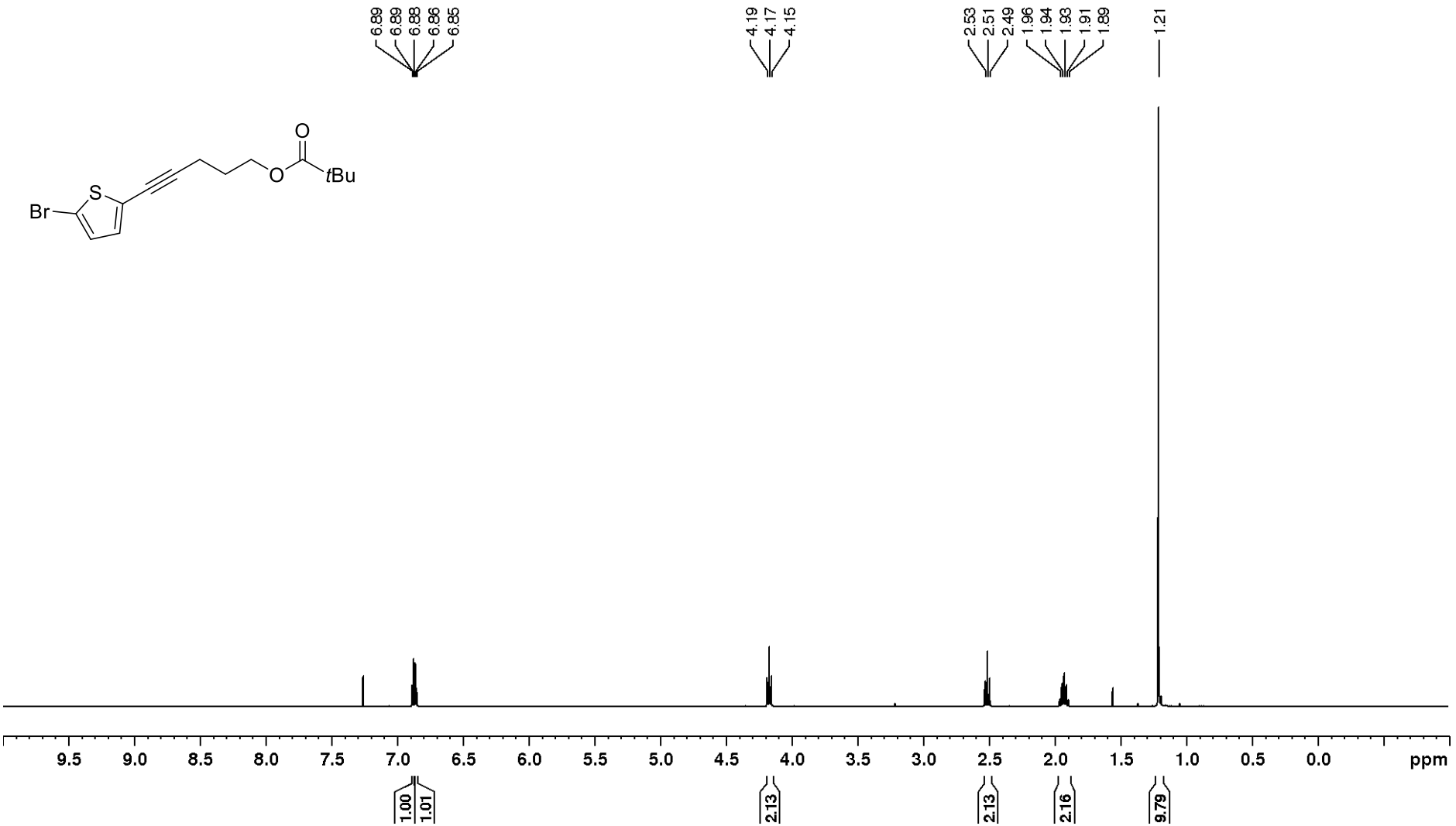


Figure S46. $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) of **5-(5-bromothiophen-2-yl)pent-4-yn-1-yl pivalate** (**10c**).

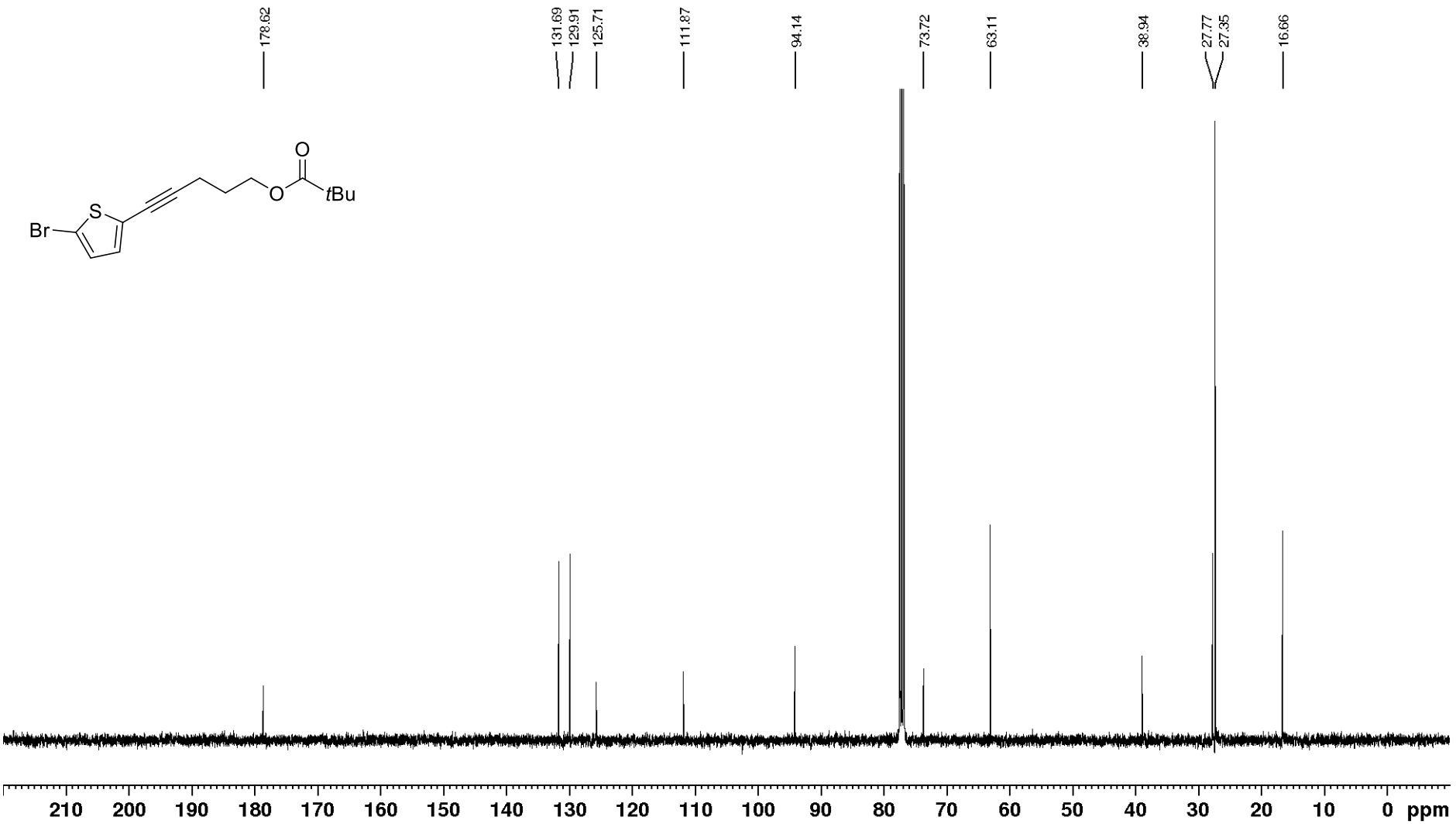


Figure S47. ^{1}H NMR (400 MHz, $CDCl_3$) of **5-(5-methylthiophen-2-yl)pent-4-yn-1-yl pivalate** (**10d**).

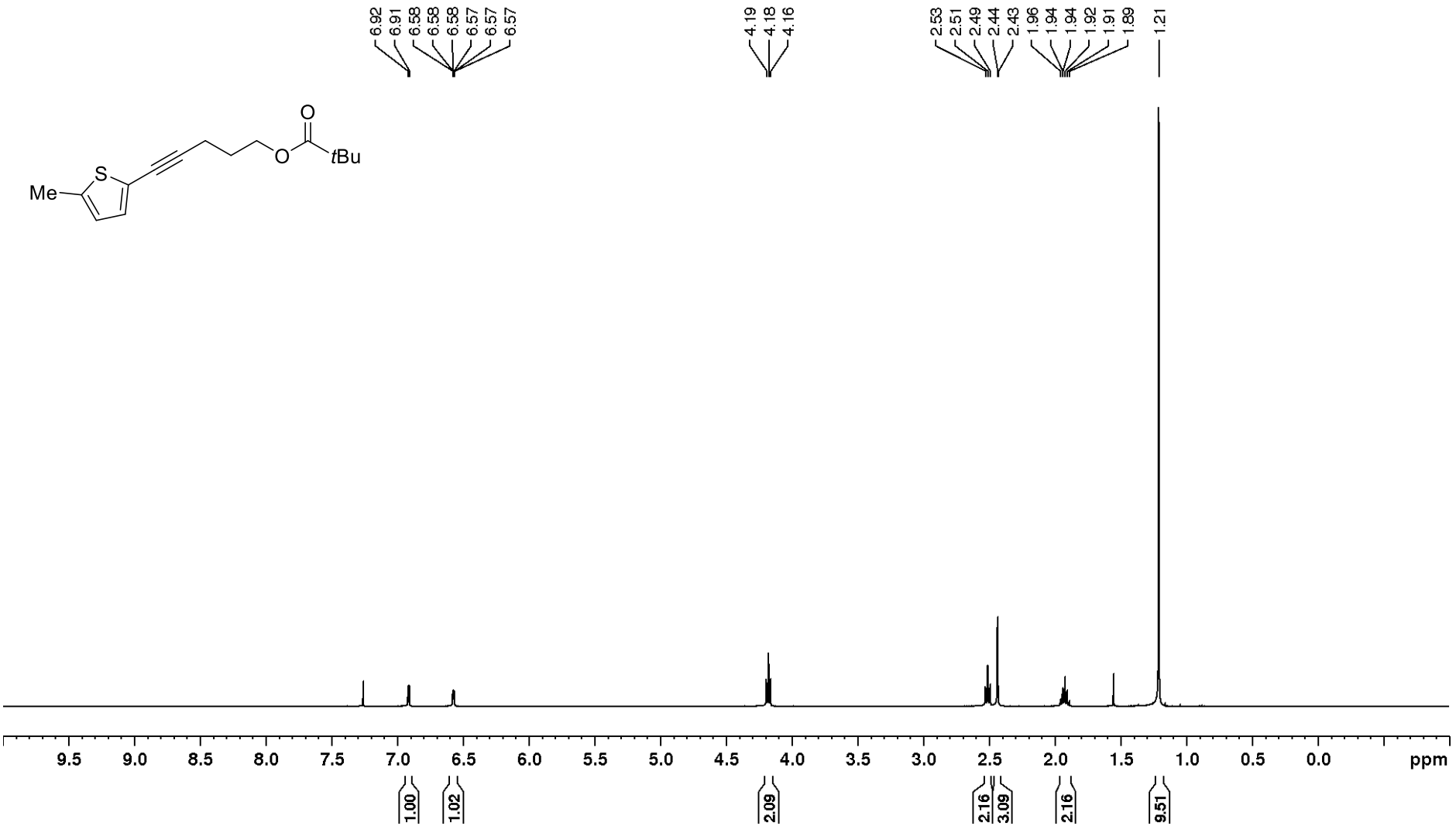


Figure S48. $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) of **5-(5-methylthiophen-2-yl)pent-4-yn-1-yl pivalate** (**10d**).

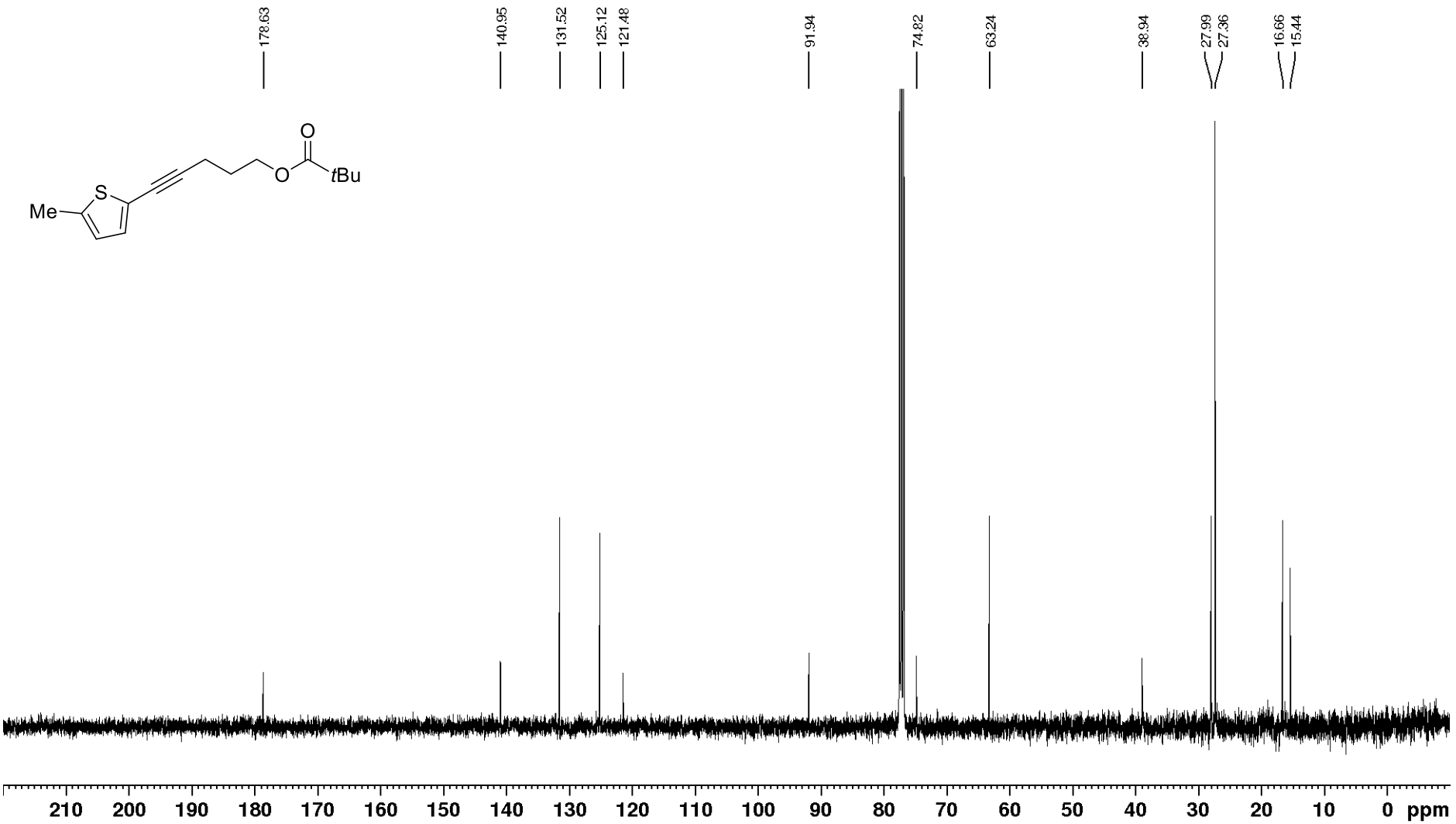


Figure S49. ^{1}H NMR (500 MHz, $CDCl_3$) of **(*ZlE*)-1-(1-Chlorohex-1-en-1-yl)-4-(2,2,2-trifluoroethoxy)benzene** (**5b**).

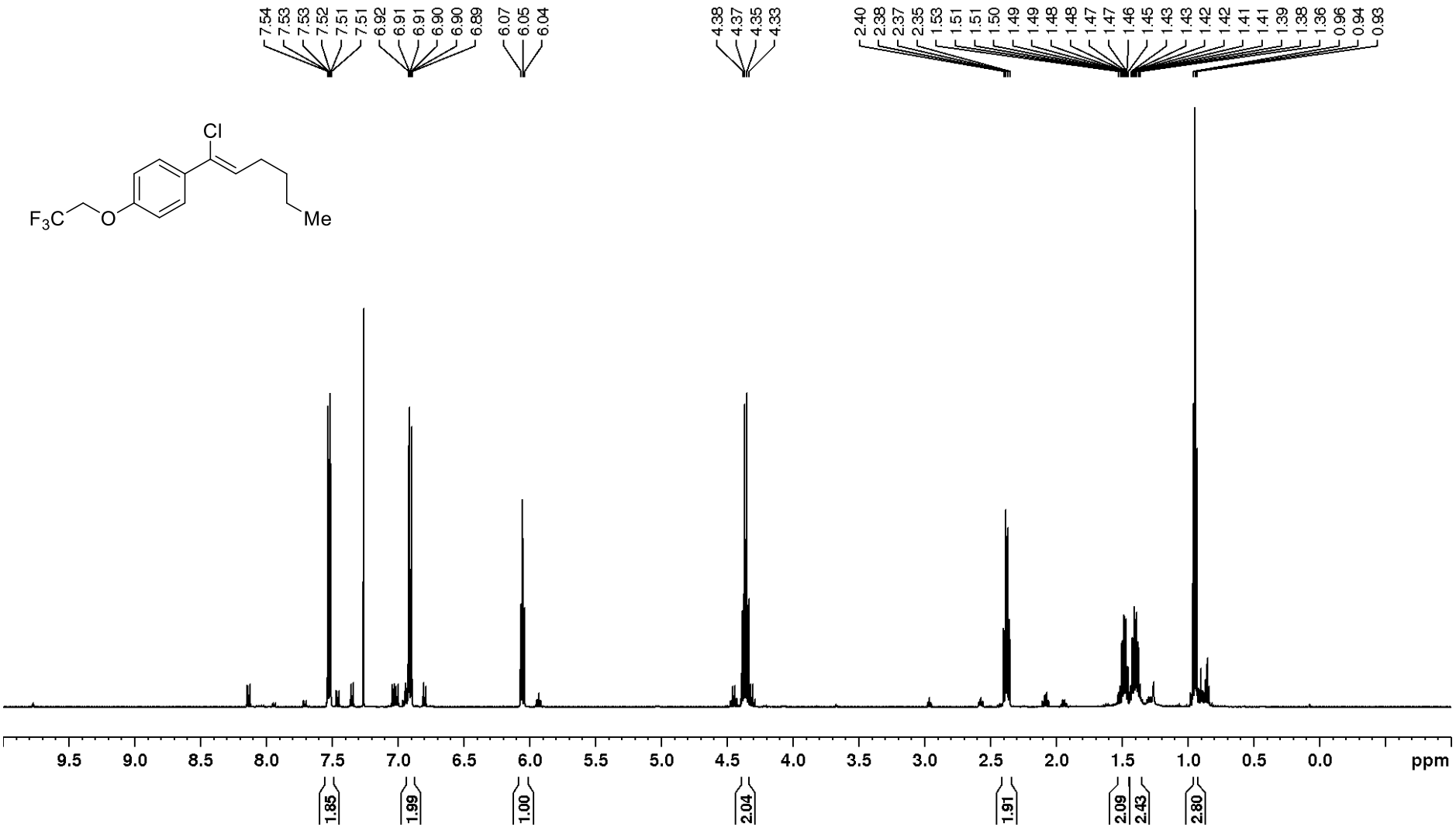


Figure S50. $^{13}C\{^{1}H\}$ NMR (126 MHz, $CDCl_3$) of **(*Z*/*E*)-1-(1-chlorohex-1-en-1-yl)-4-(2,2,2-trifluoroethoxy)benzene** (**5b**).

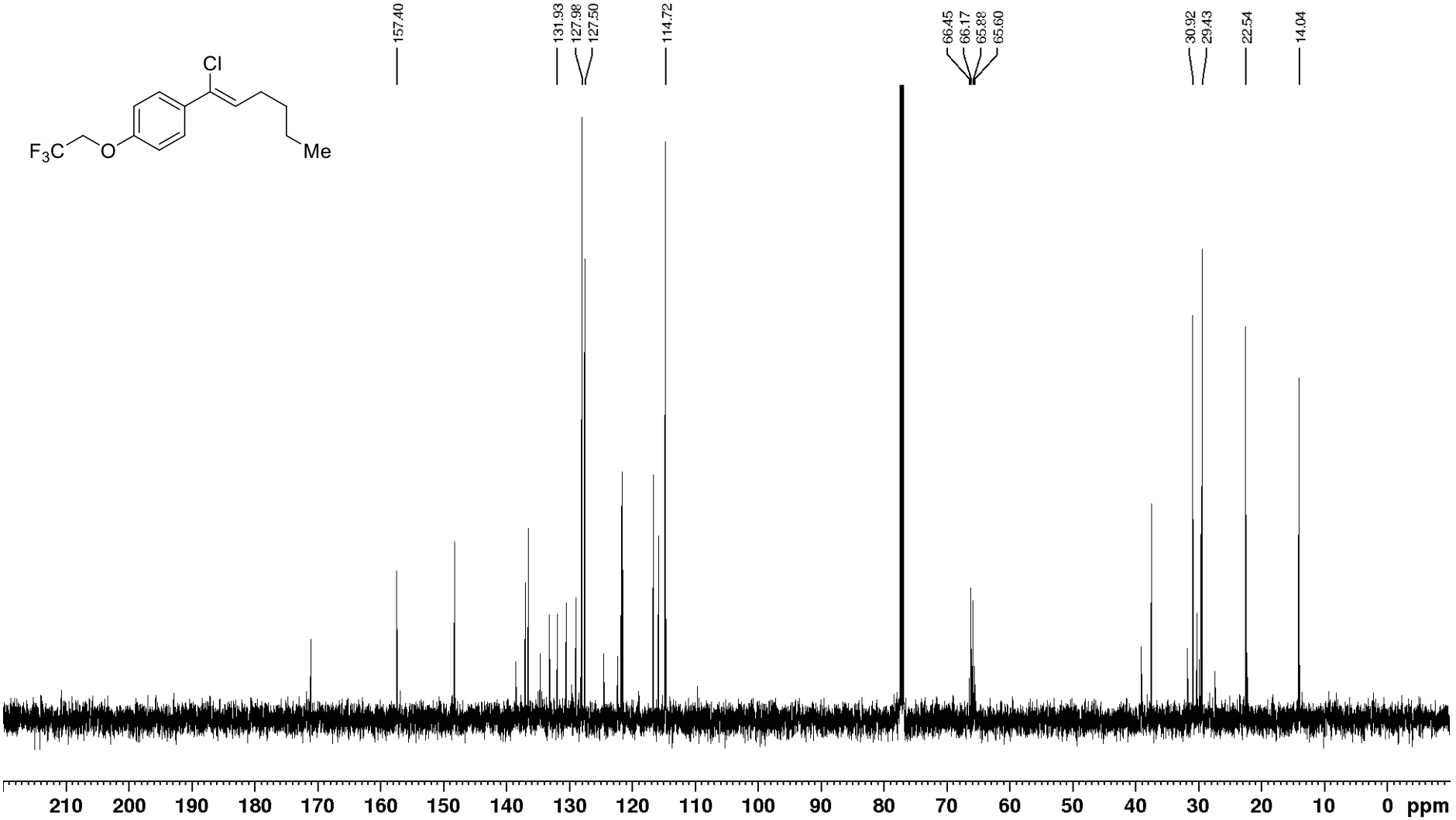


Figure S51. ^{19}F NMR (471 MHz, $CDCl_3$) of **(*Z*/*E*)-1-(1-chlorohex-1-en-1-yl)-4-(2,2,2-trifluoroethoxy)benzene** (**5b**).

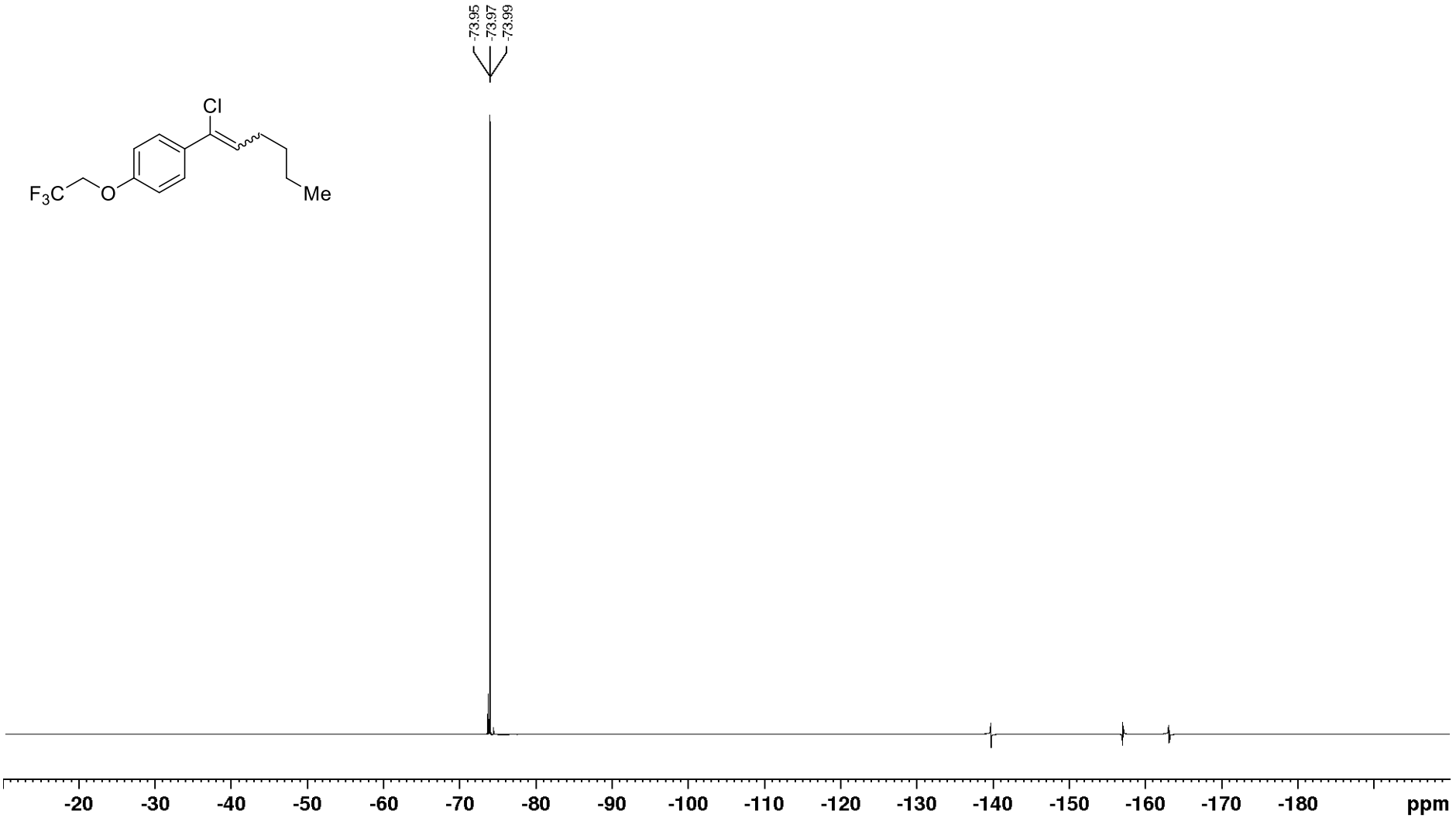


Figure S52. ^{1}H NMR (400 MHz, $CDCl_3$) of **(*ZlE*)-5-chloro-5-(2,4-dimethoxyphenyl)pent-4-en-1-yl pivalate** (**5c**).

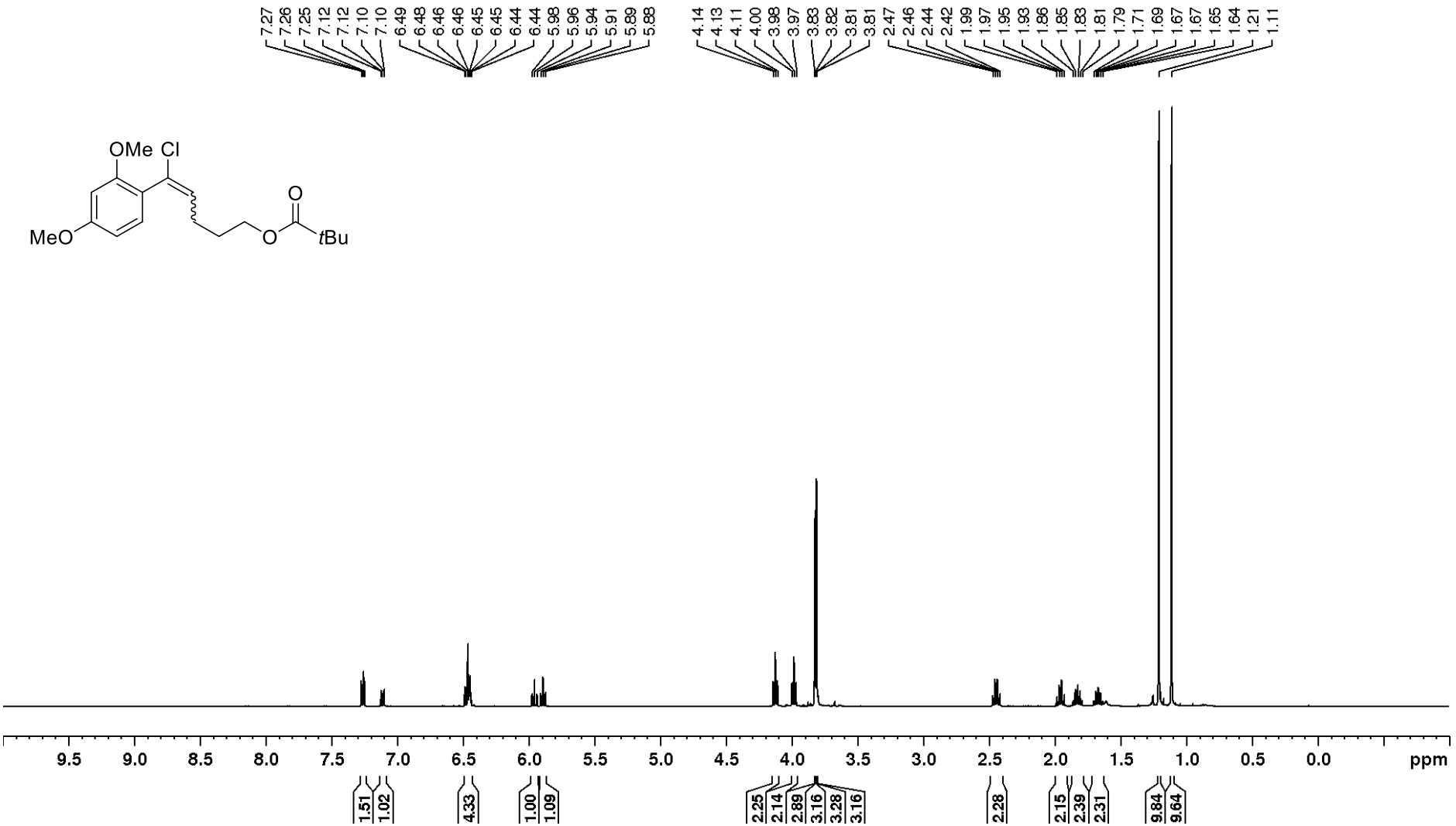


Figure S53. $^{13}C\{^{1}H\}$ NMR (400 MHz, $CDCl_3$) of **(*ZIE*)-5-chloro-5-(2,4-dimethoxyphenyl)pent-4-en-1-yl pivalate** (**5c**).

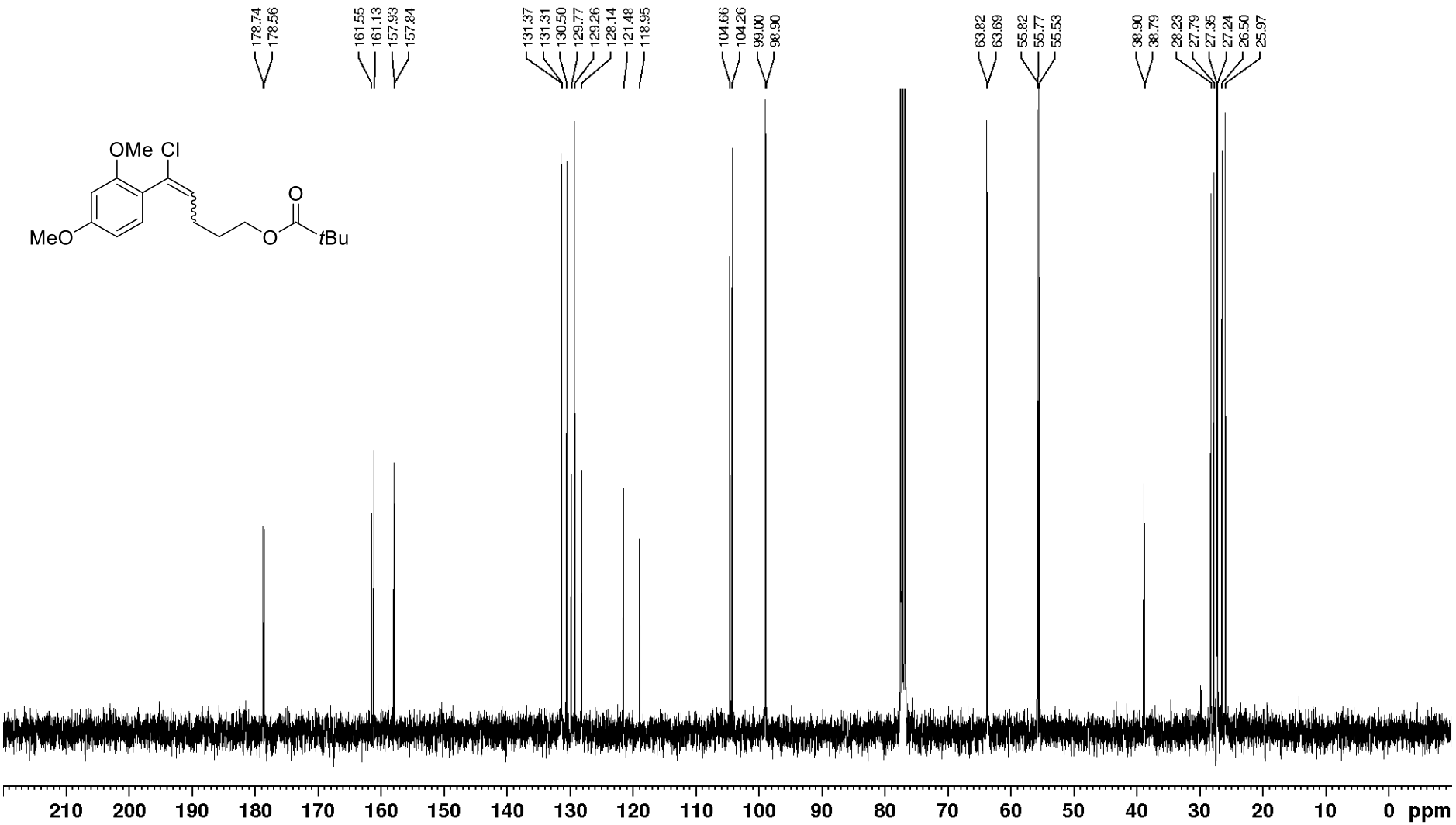


Figure S54. ^{1}H NMR (400 MHz, $CDCl_3$) of **(*E*/*Z*)-4-(1-chlorohex-1-en-1-yl)phenyl pivalate** (**5d**).

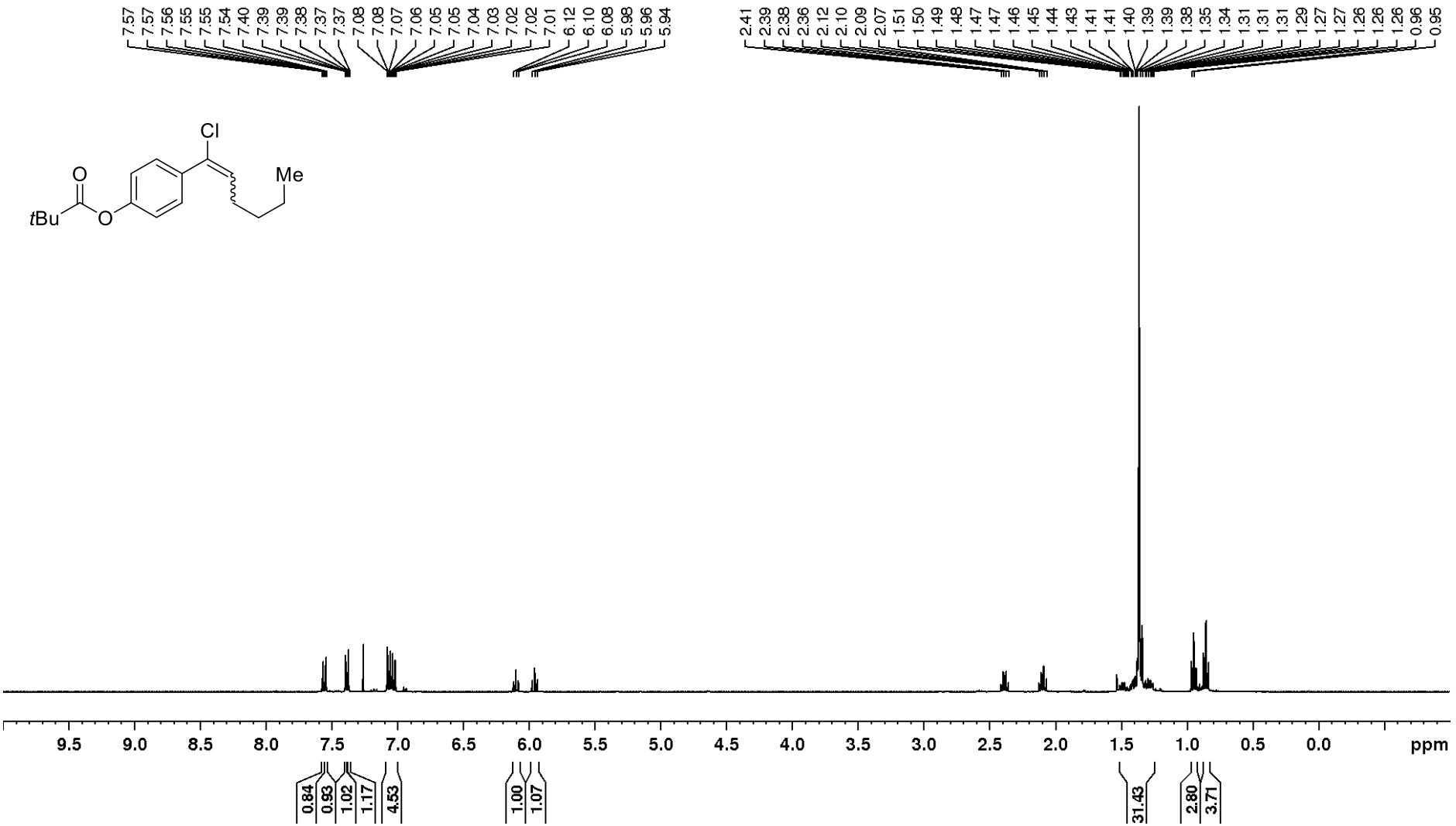


Figure S55. $^{13}C\{^{1}H\}$ NMR (400 MHz, $CDCl_3$) of **(*E*/*Z*)-4-(1-chlorohex-1-en-1-yl)phenyl pivalate** (**5d**).

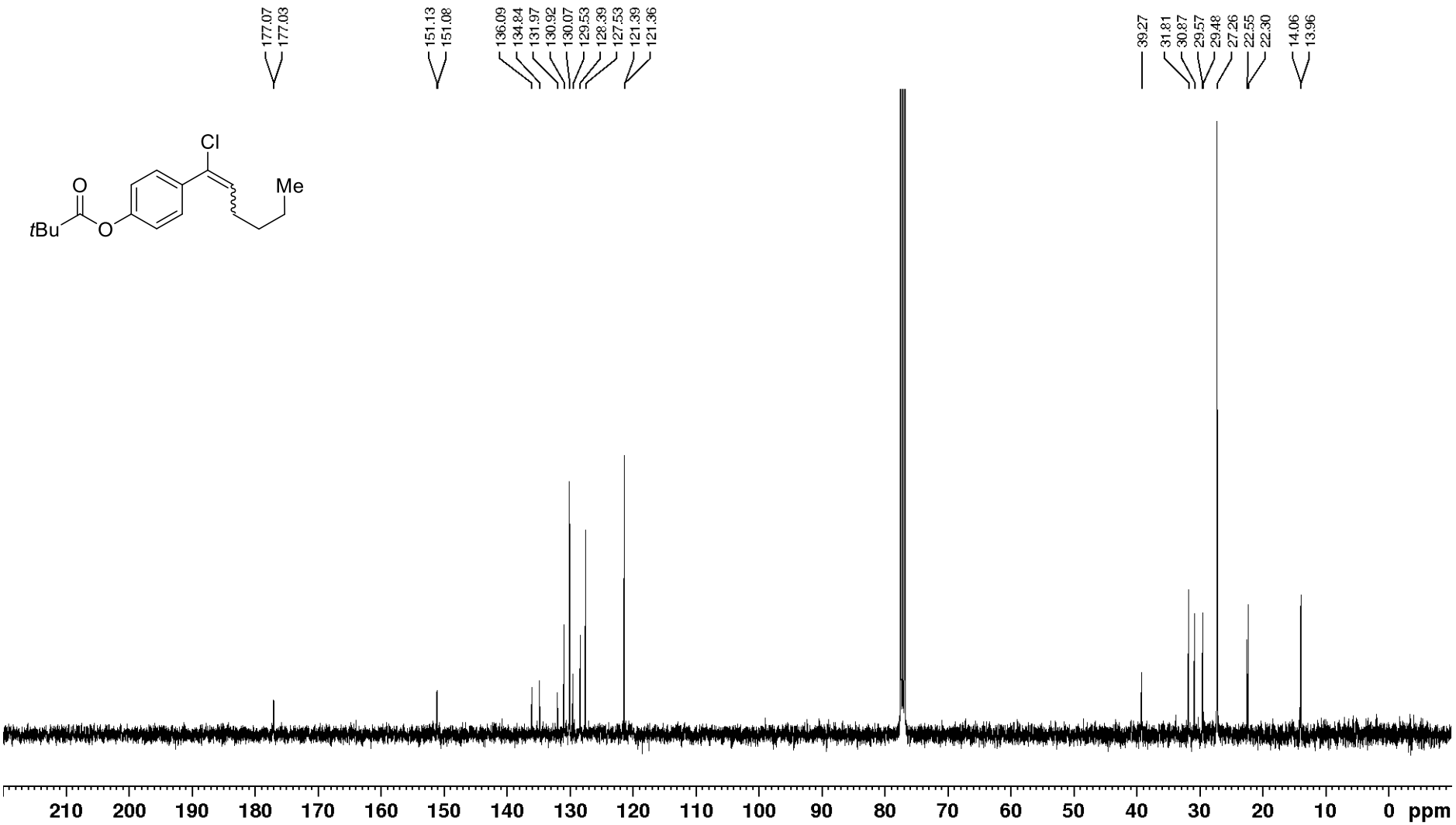


Figure S56. ^{1}H NMR (400 MHz, $CDCl_3$) of **methyl (*E*/*Z*)-6-chloro-6-(4-(pivaloyloxy)phenyl)hex-5-enoate** (**5e**).

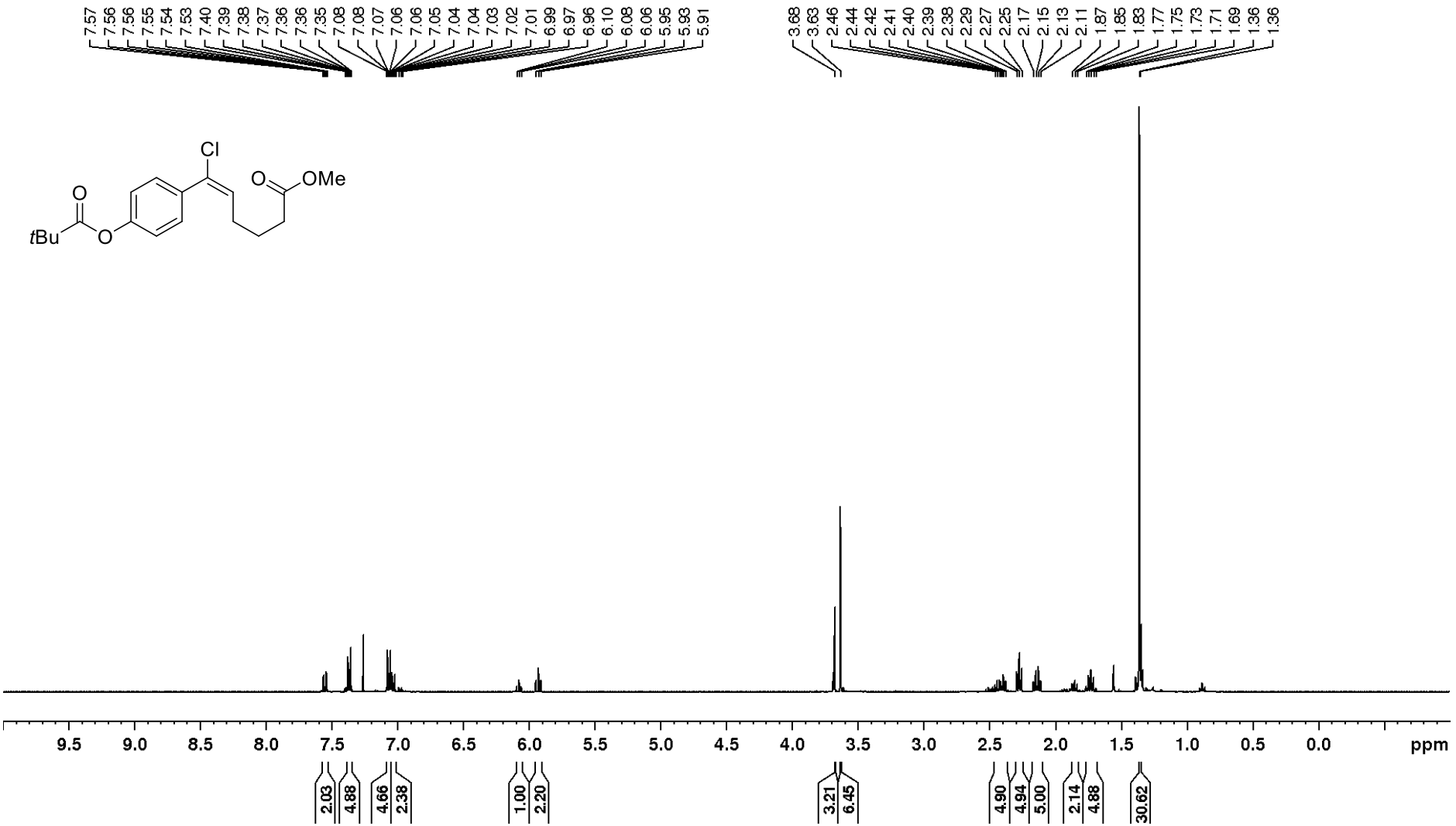


Figure S57. $^{13}C\{^{1}H\}$ NMR (400 MHz, $CDCl_3$) of **methyl (*E*/*Z*)-6-chloro-6-(4-(pivaloyloxy)phenyl)hex-5-enoate** (**5e**).

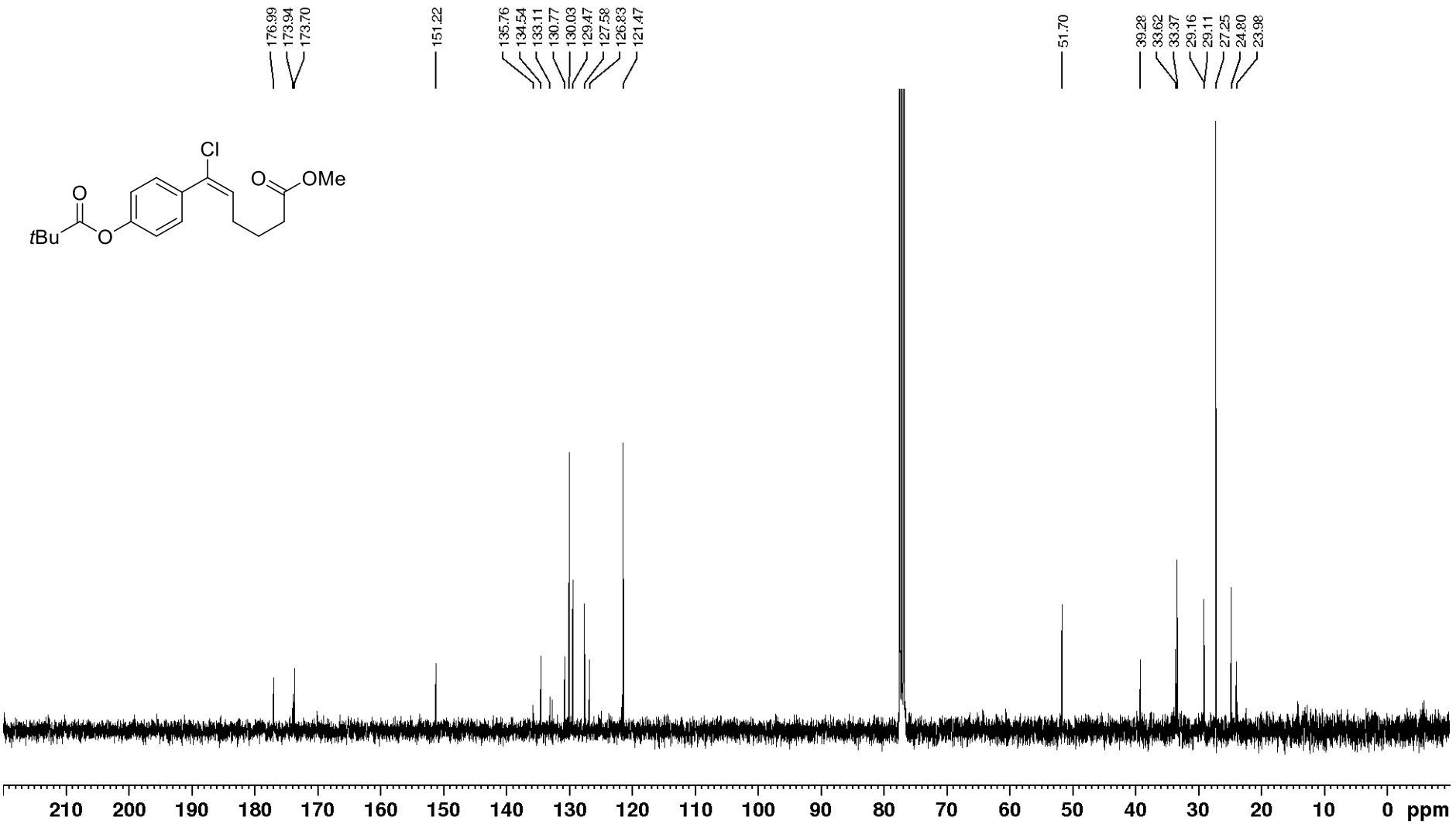


Figure S58. ^{1}H NMR (400 MHz, $CDCl_3$) of **(*E*/*Z*)-4-(1,5-dichloropent-1-en-1-yl)phenyl pivalate** (**5f**).

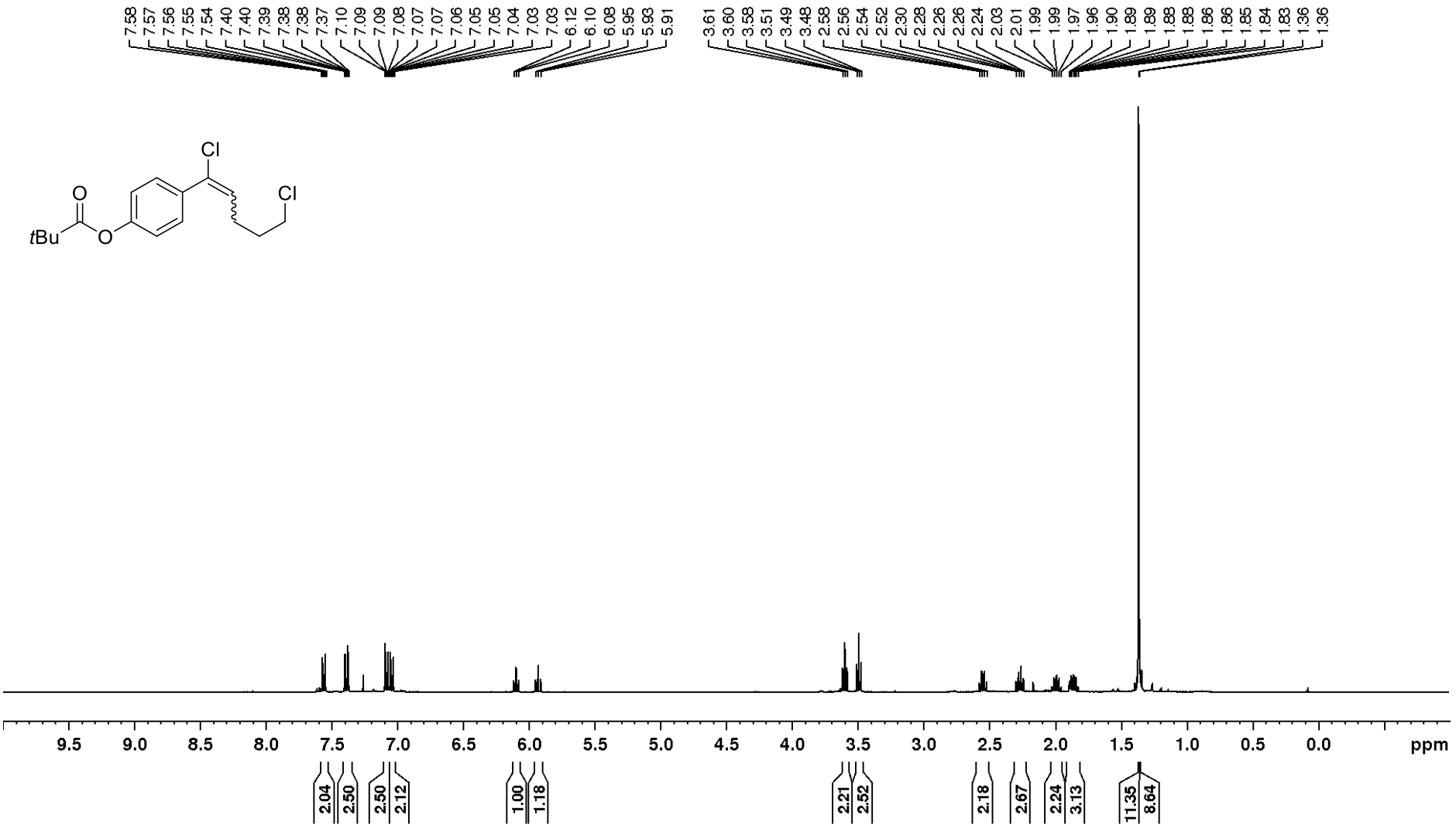


Figure S59. $^{13}C\{^{1}H\}$ NMR (400 MHz, $CDCl_3$) of **(*E*/*Z*)-4-(1,5-dichloropent-1-en-1-yl)phenyl pivalate** (**5f**).

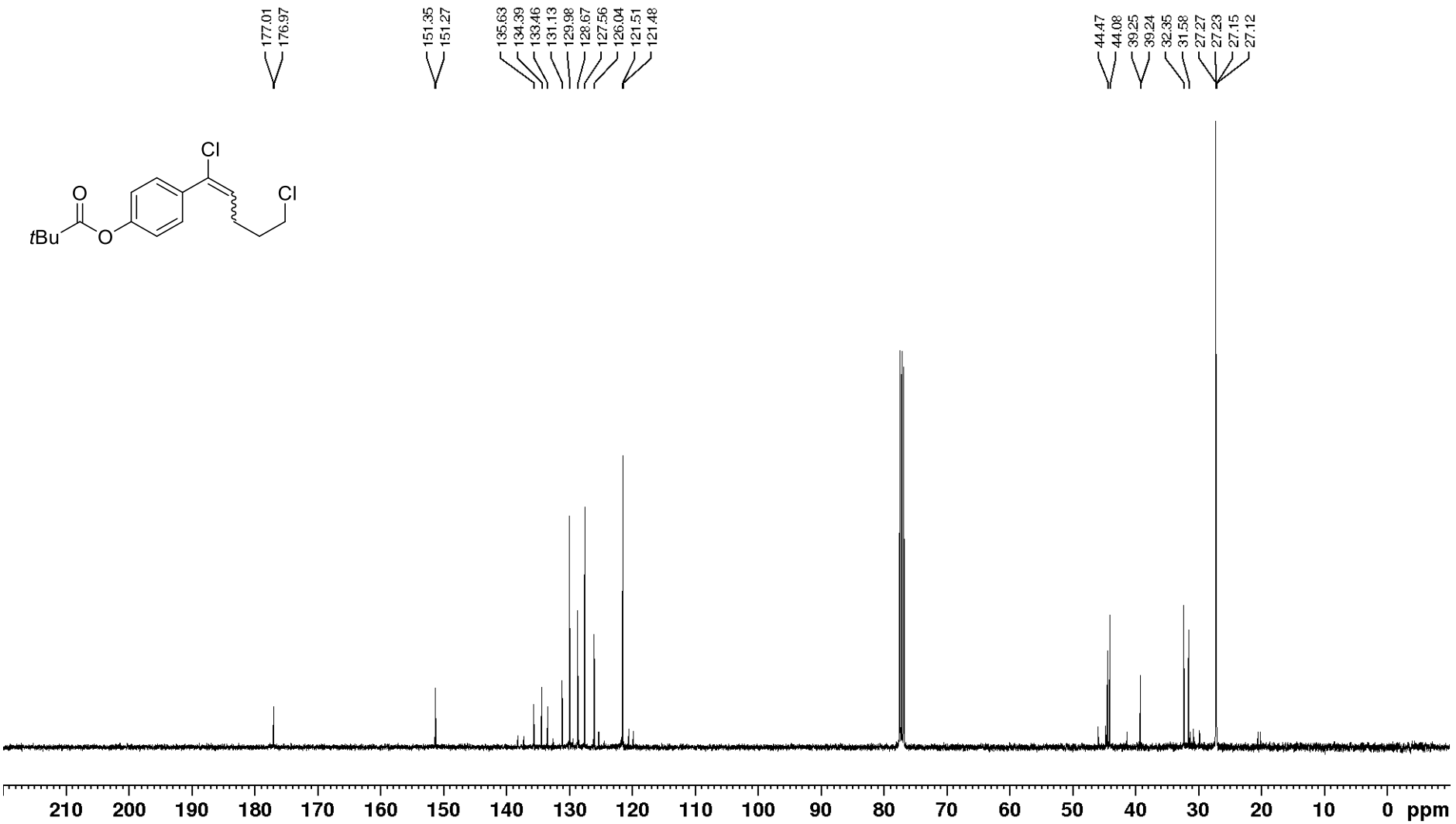


Figure S60. ^{1}H NMR (400 MHz, $CDCl_3$) of **(*E*/*Z*)-4-(1-chlorohex-1-en-1-yl)phenyl methanesulfonate** (**5g**).

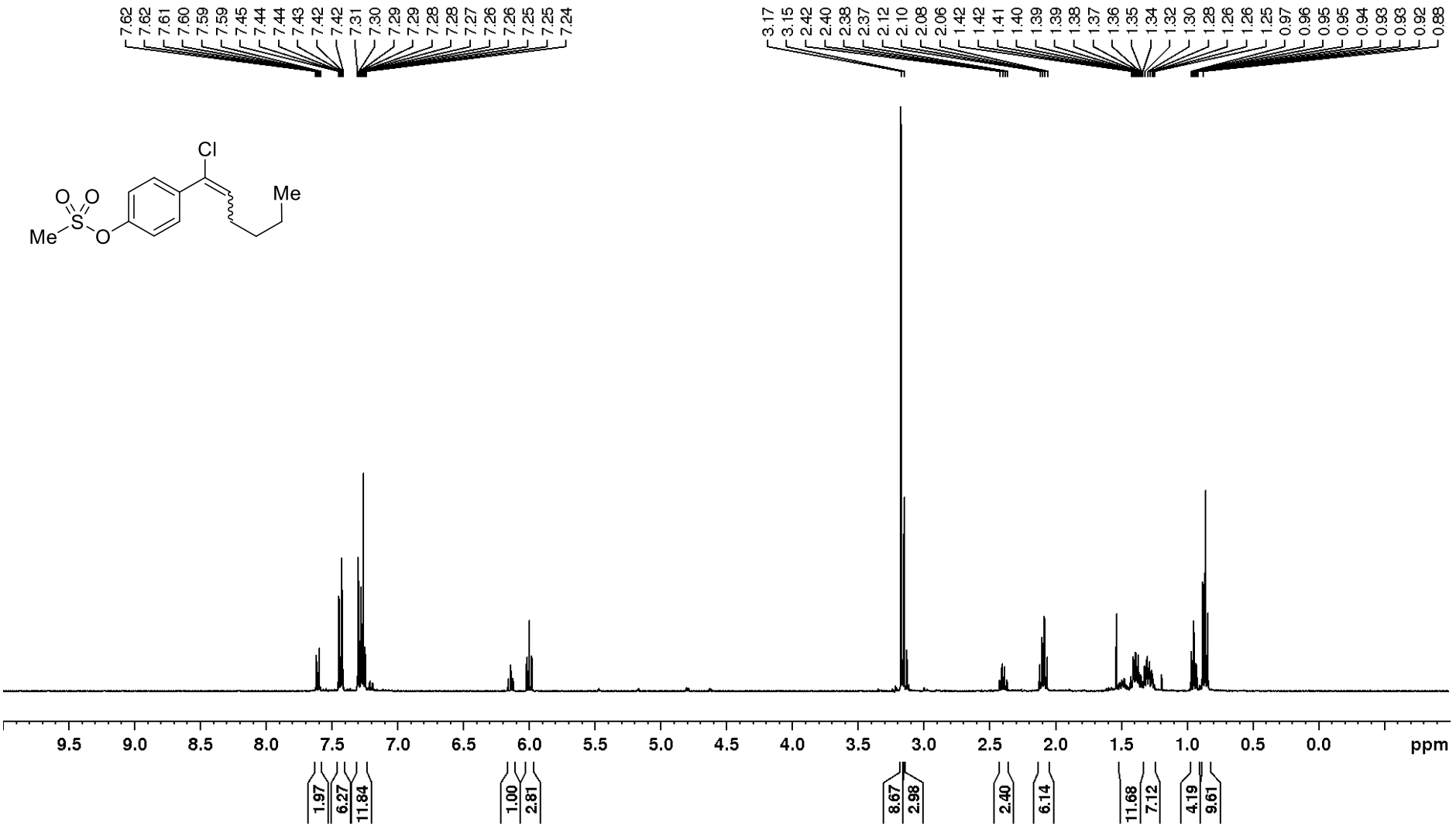


Figure S61. $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) of **(*E*/*Z*)-4-(1-chlorohex-1-en-1-yl)phenyl methanesulfonate** (**5g**).

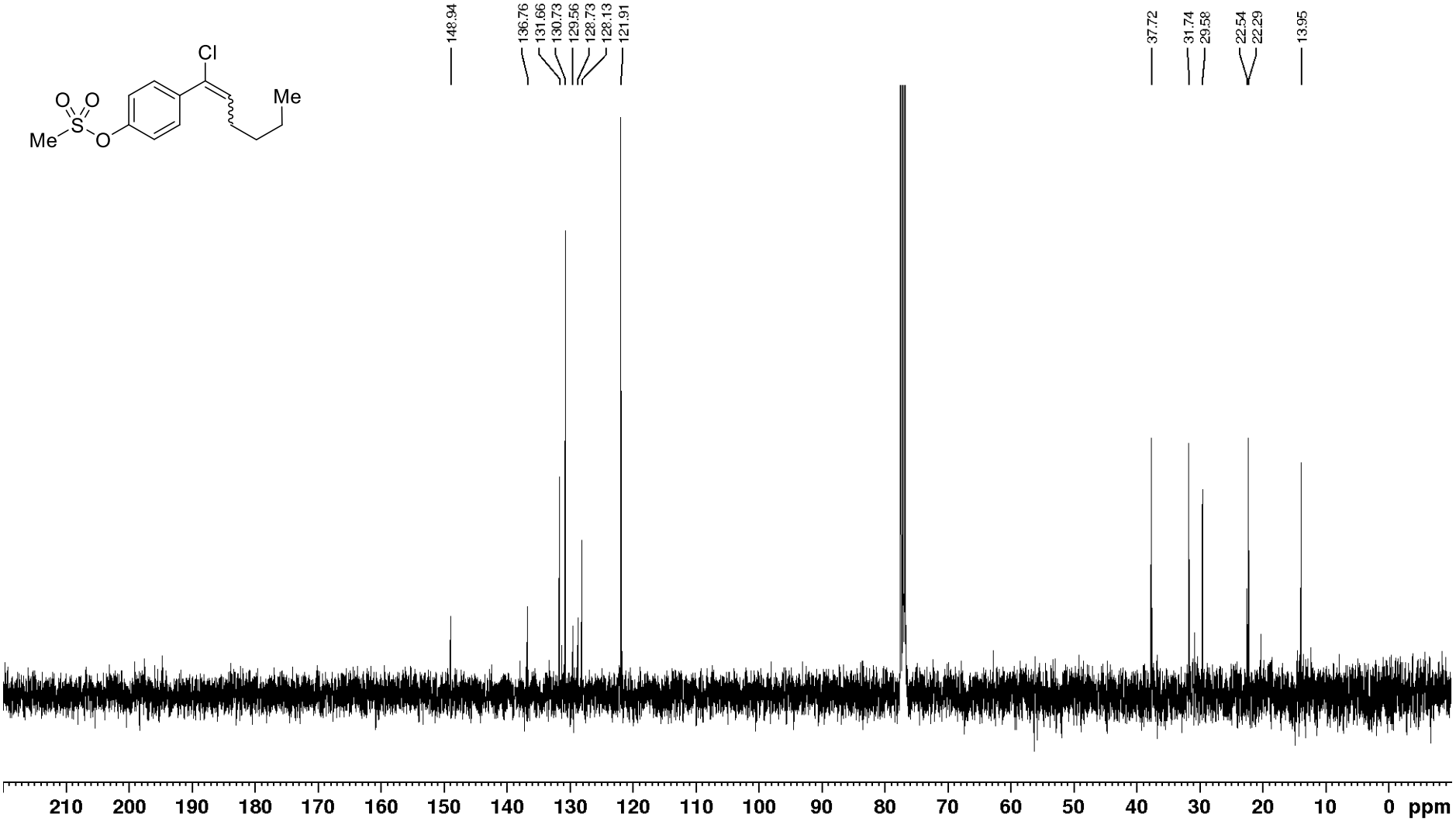


Figure S62. ^{1}H NMR (400 MHz, $CDCl_3$) of **(*E*/*Z*)-2-(4-(1-Chlorohex-1-en-1-yl)phenyl)isoindoline-1,3-dione** (**5h**).

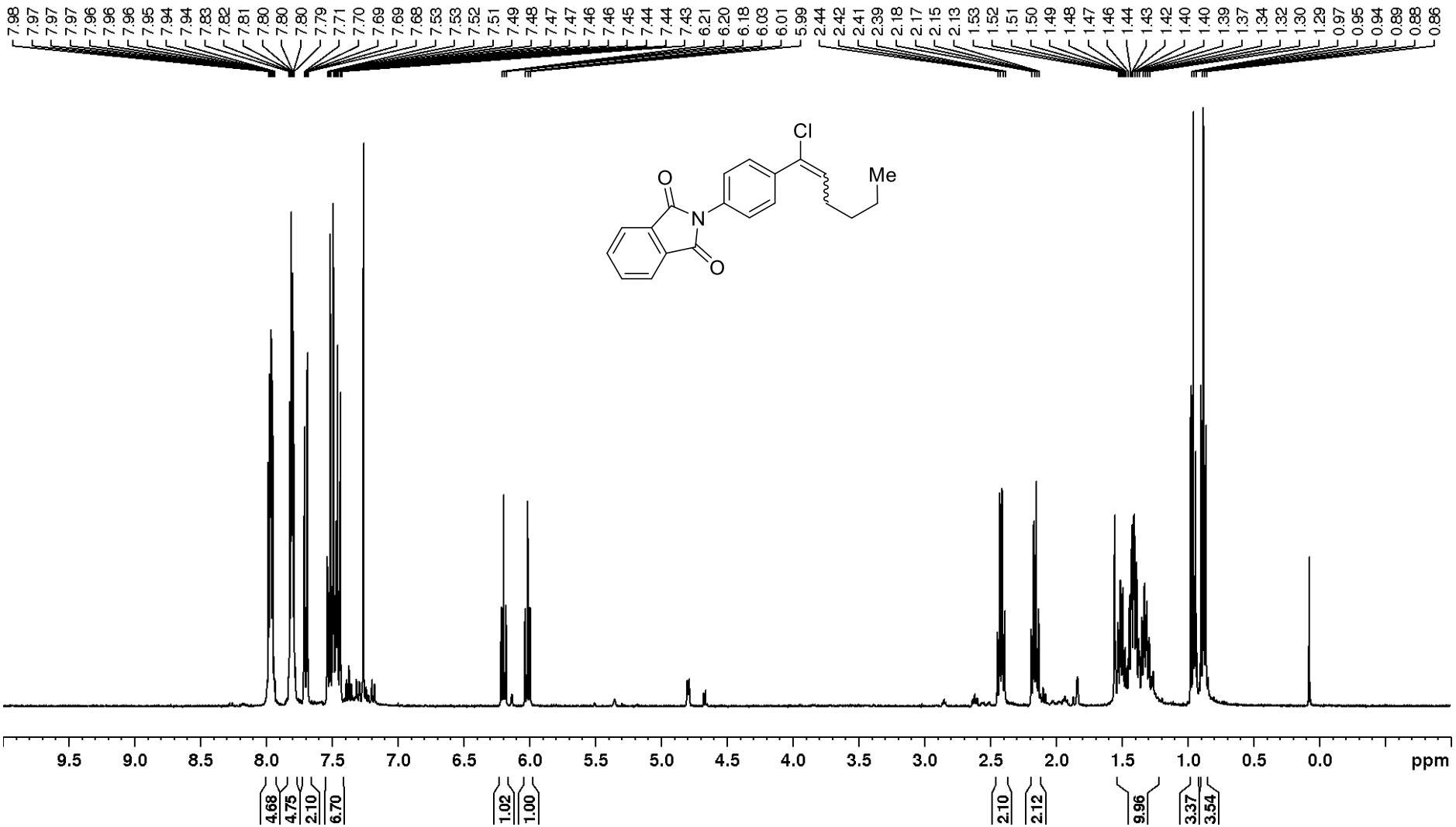


Figure S63. $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) of **(*E*/*Z*)-2-(4-(1-chlorohex-1-en-1-yl)phenyl)isoindoline-1,3-dione** (**5h**).

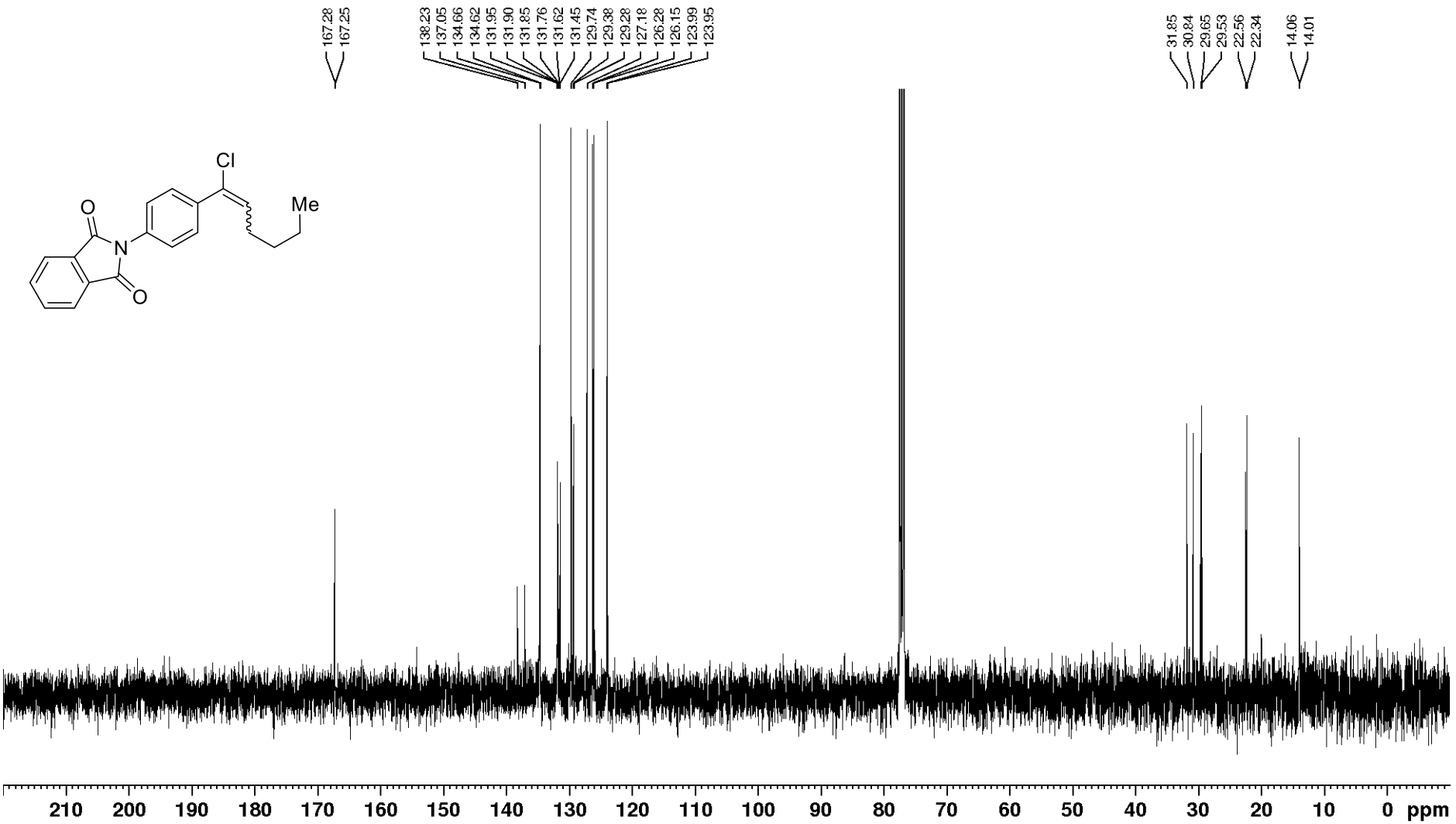


Figure S64. ^{1}H NMR (400 MHz, $CDCl_3$) of **methyl (*E*/*Z*)-6-chloro-6-(naphthalen-2-yl)hex-5-enoate** (**5i**).

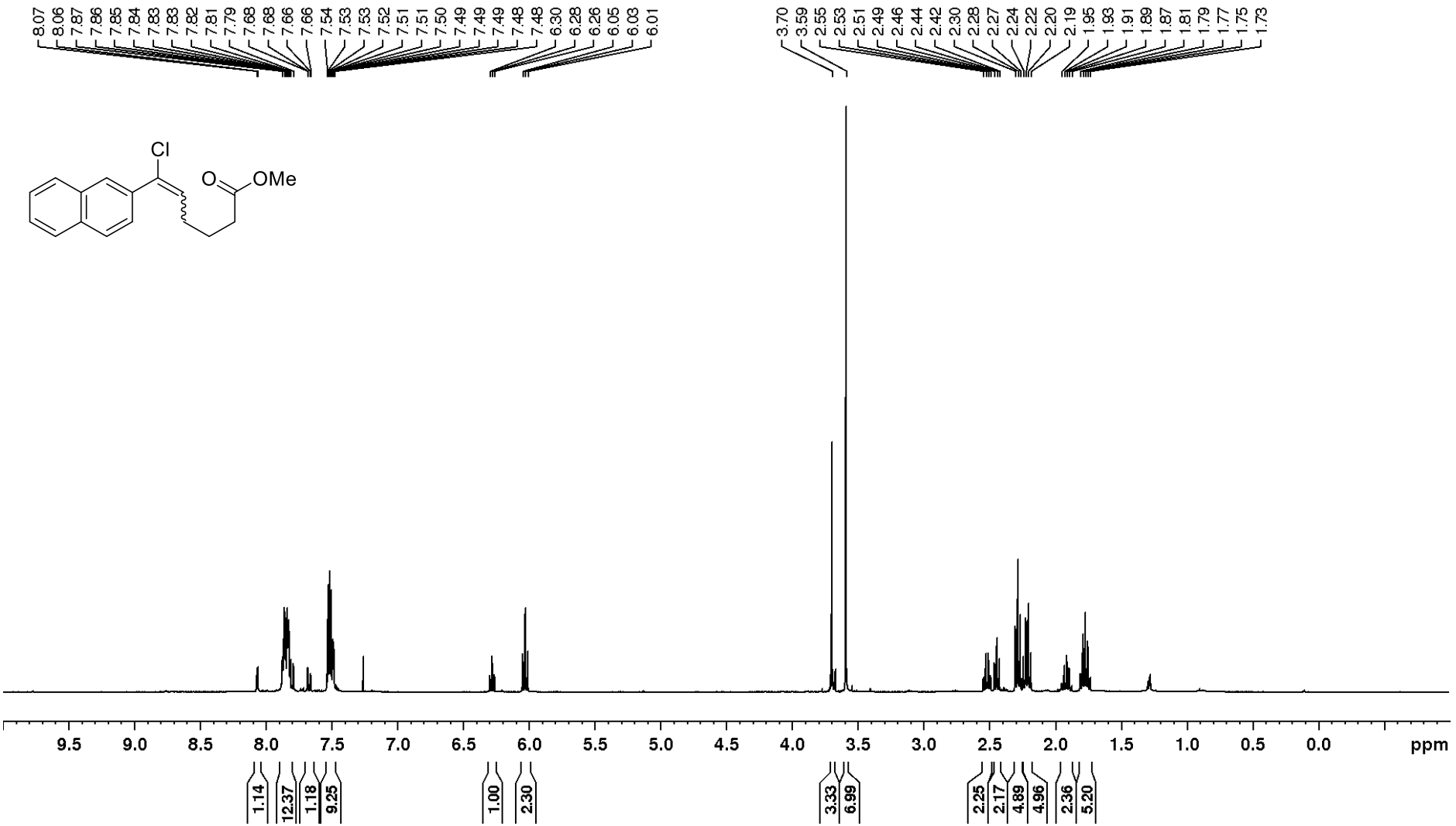


Figure S65. $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) of **methyl (*E*/*Z*)-6-chloro-6-(naphthalen-2-yl)hex-5-enoate** (**5i**).

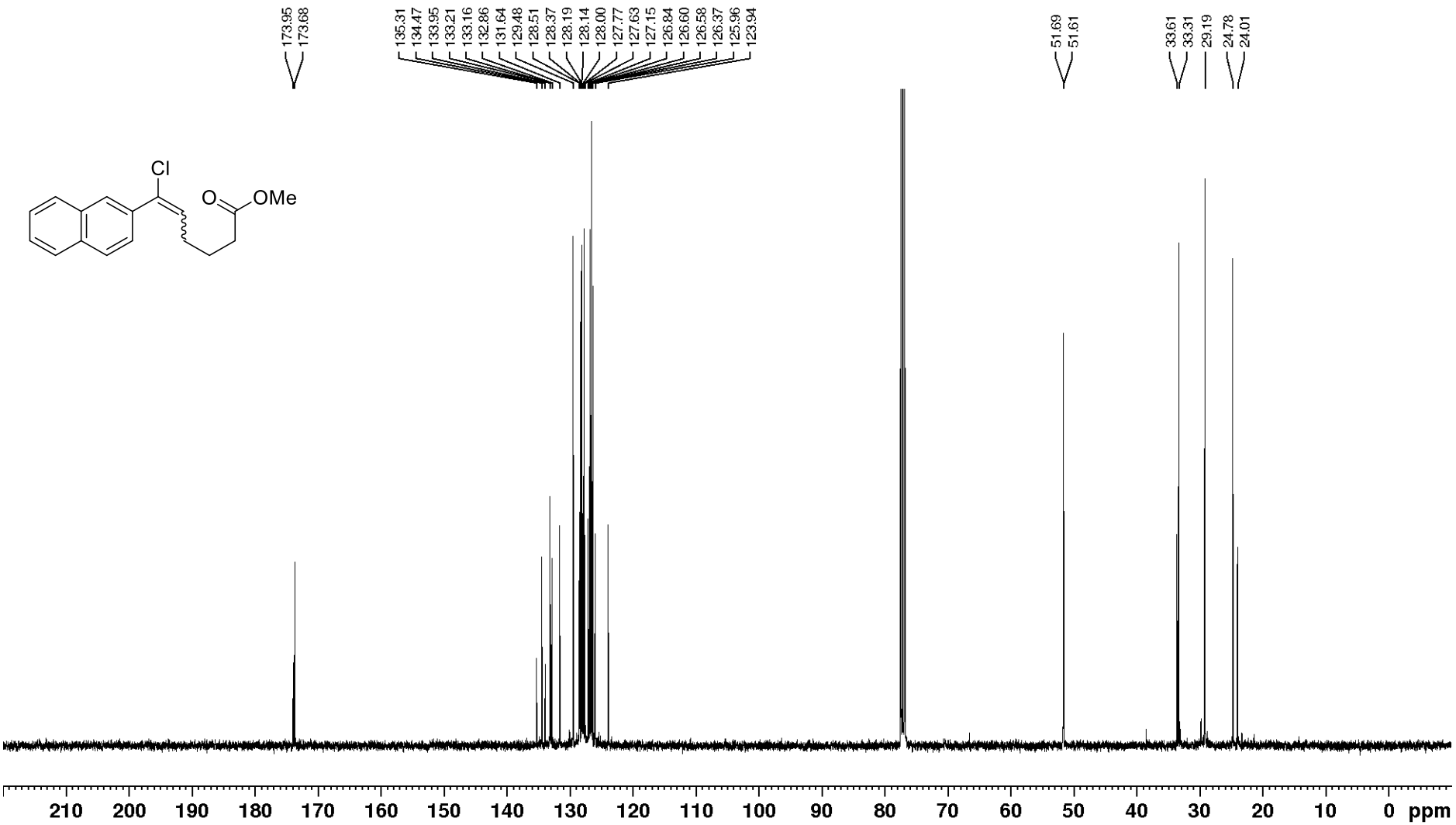


Figure S66. ^{1}H NMR (400 MHz, $CDCl_3$) of **methyl (*E*/*Z*)-6-(benzofuran-5-yl)-6-chlorohex-5-enoate (11a).**

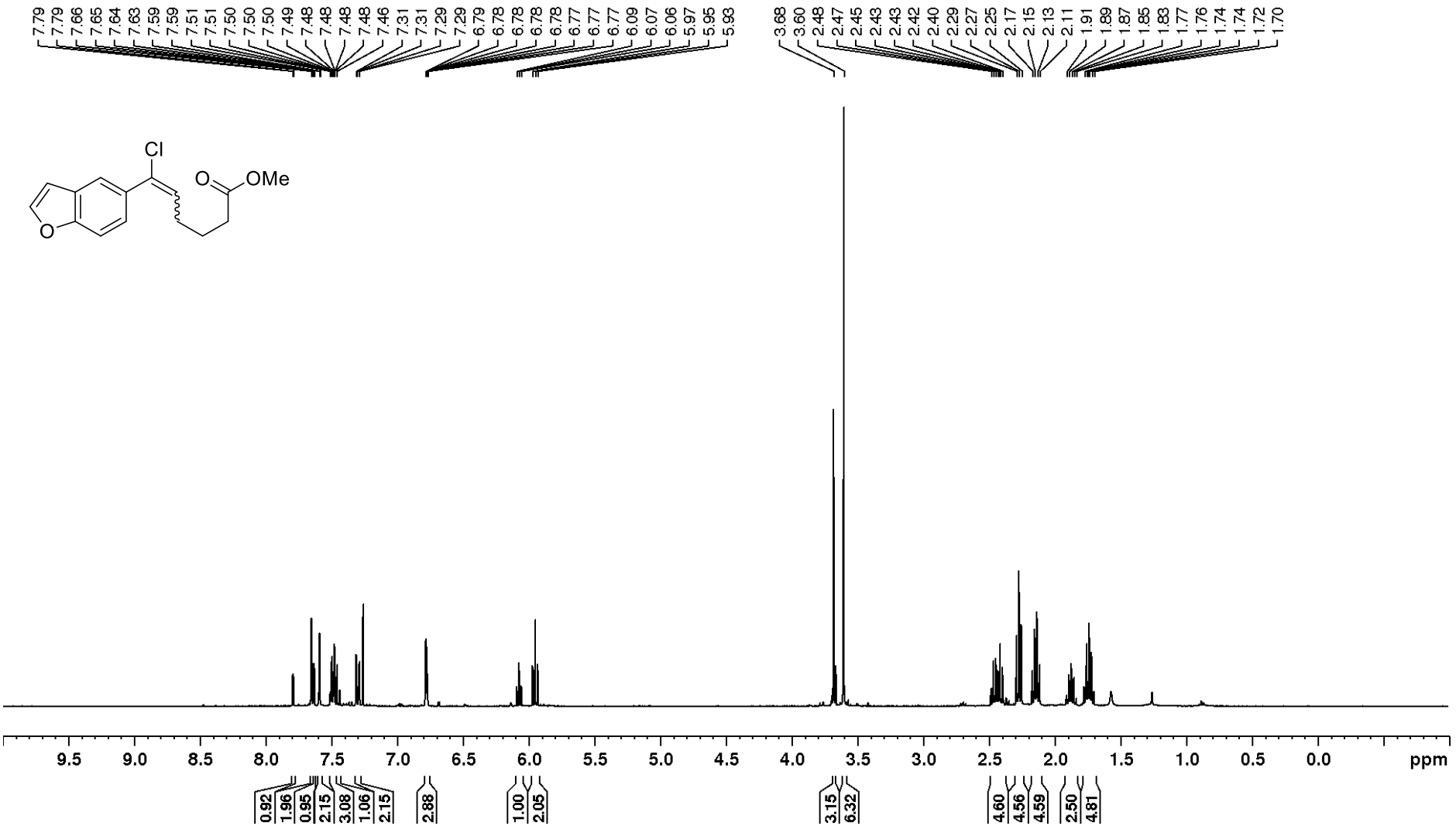


Figure S67. $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) of **methyl (*E*/*Z*)-6-(benzofuran-5-yl)-6-chlorohex-5-enoate (11a).**

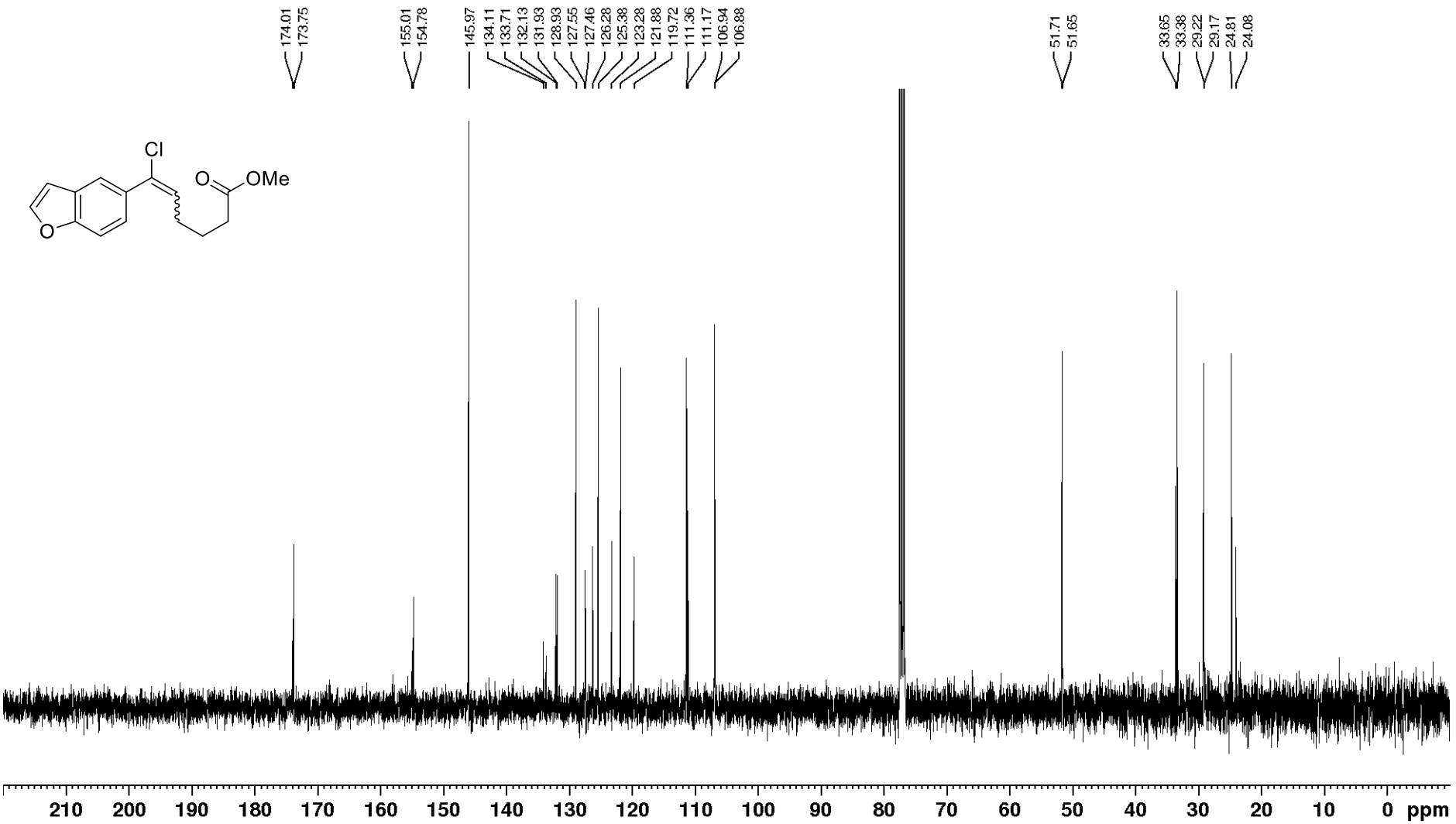


Figure S68. ^{1}H NMR (400 MHz, $CDCl_3$) of **methyl (*E*/*Z*)-6-chloro-6-(2-(4-methoxy-4-oxobutyl)benzofuran-5-yl)hex-5-enoate** (**11b**).

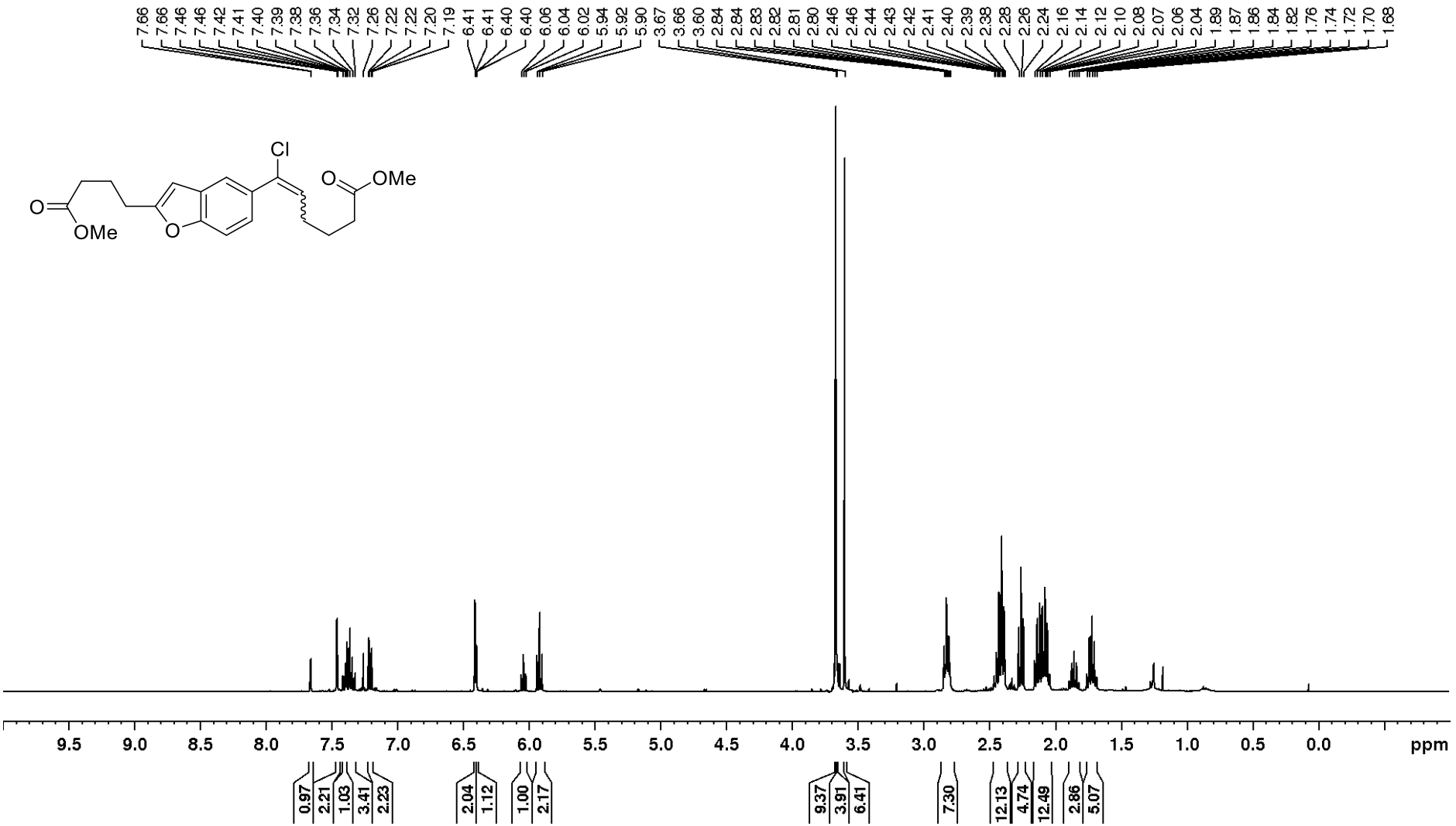


Figure S69. $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) of **methyl (*E*/*Z*)-6-chloro-6-(2-(4-methoxy-4-oxobutyl)benzofuran-5-yl)hex-5-enoate** (**11b**).

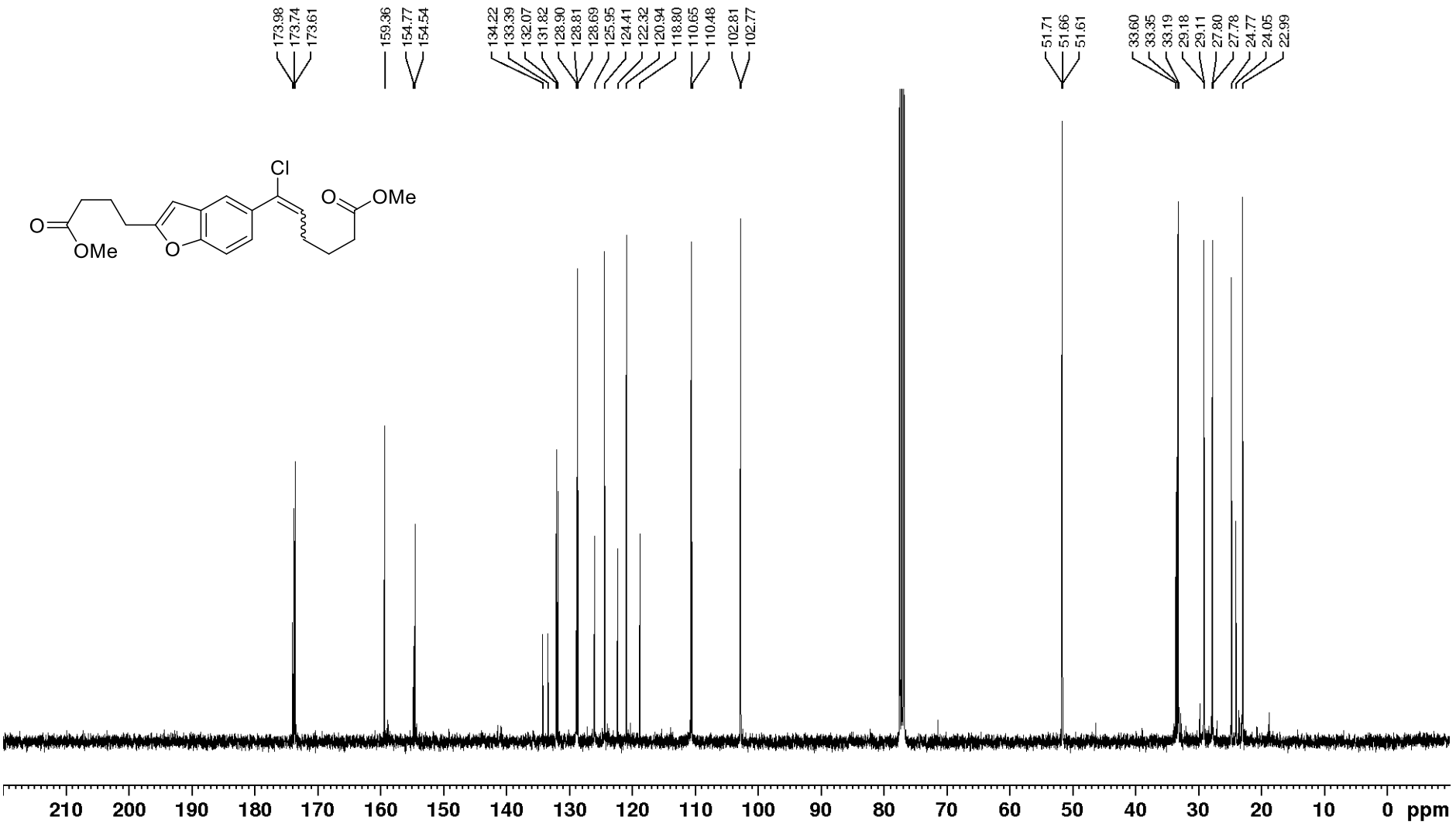


Figure S70. ^{1}H NMR (400 MHz, $CDCl_3$) of **(*ZlE*)-5-(5-Bromothiophen-2-yl)-5-chloropent-4-en-1-yl pivalate** (**11c**).

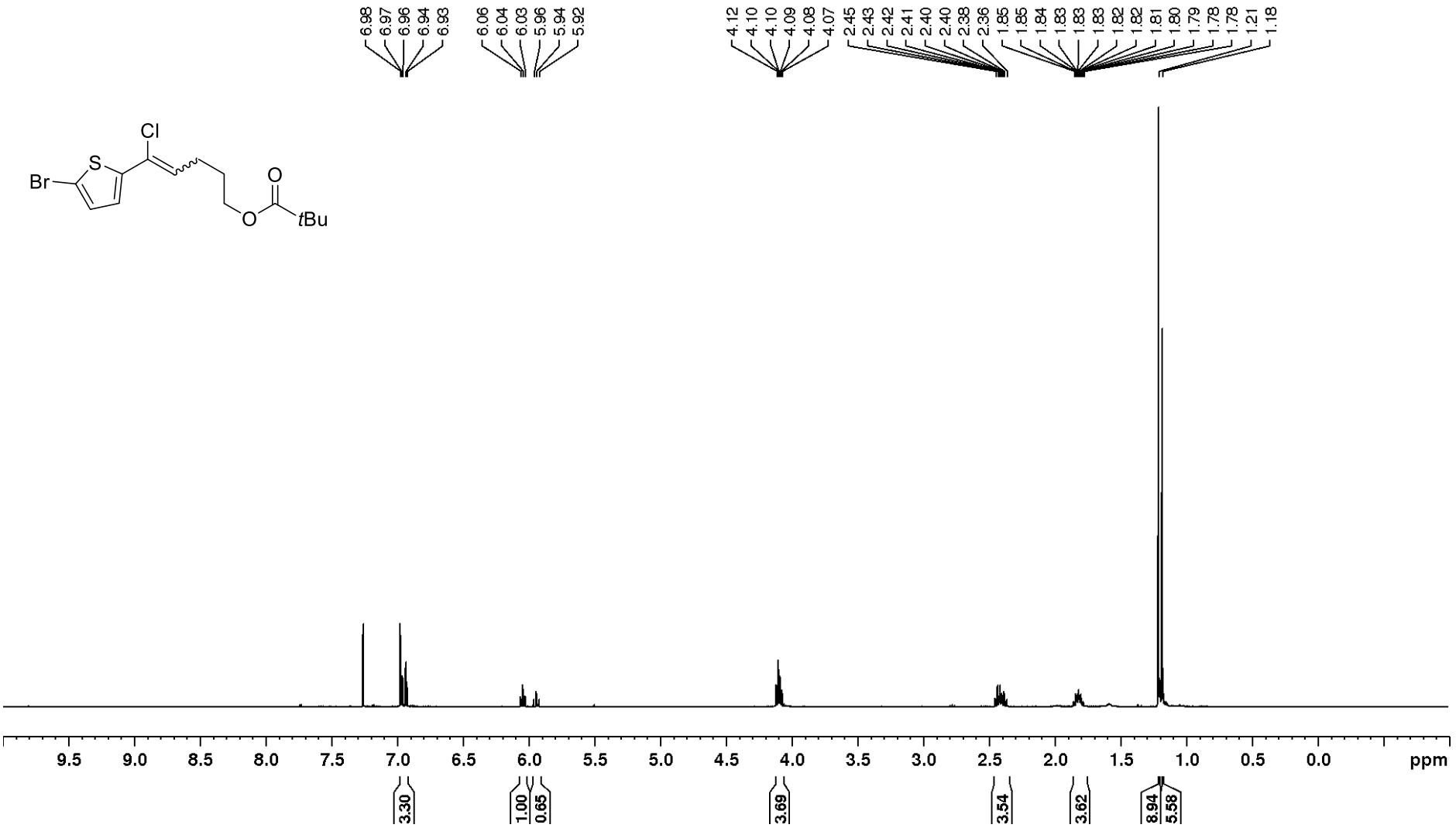


Figure S71. $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) of **(*ZlE*)-5-(5-Bromothiophen-2-yl)-5-chloropent-4-en-1-yl pivalate** (**11c**).

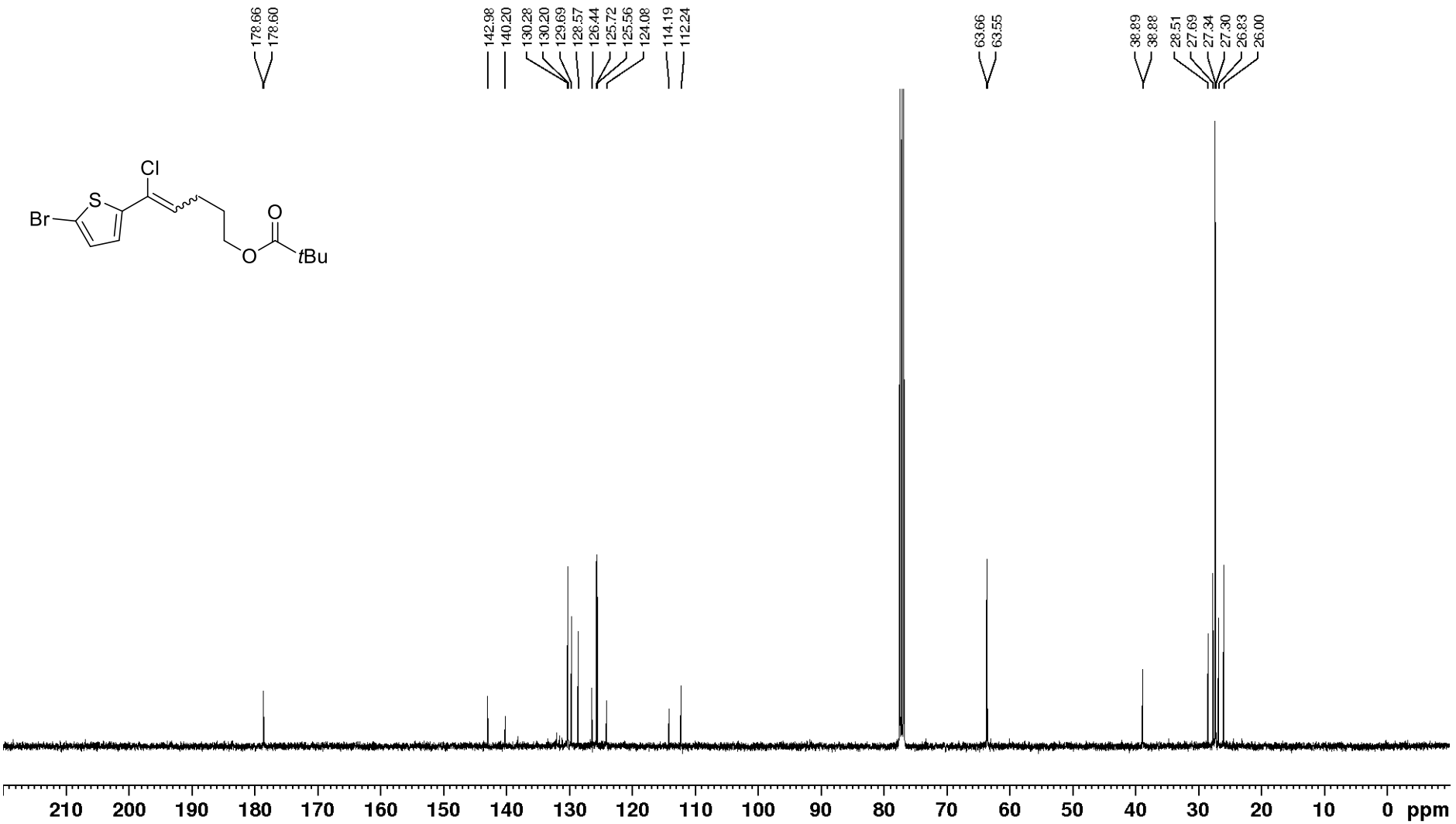


Figure S72. ^{1}H NMR (400 MHz, $CDCl_3$) of **(*Z*)-5-Chloro-5-(5-methylthiophen-2-yl)pent-4-en-1-yl pivalate** (**11d**).

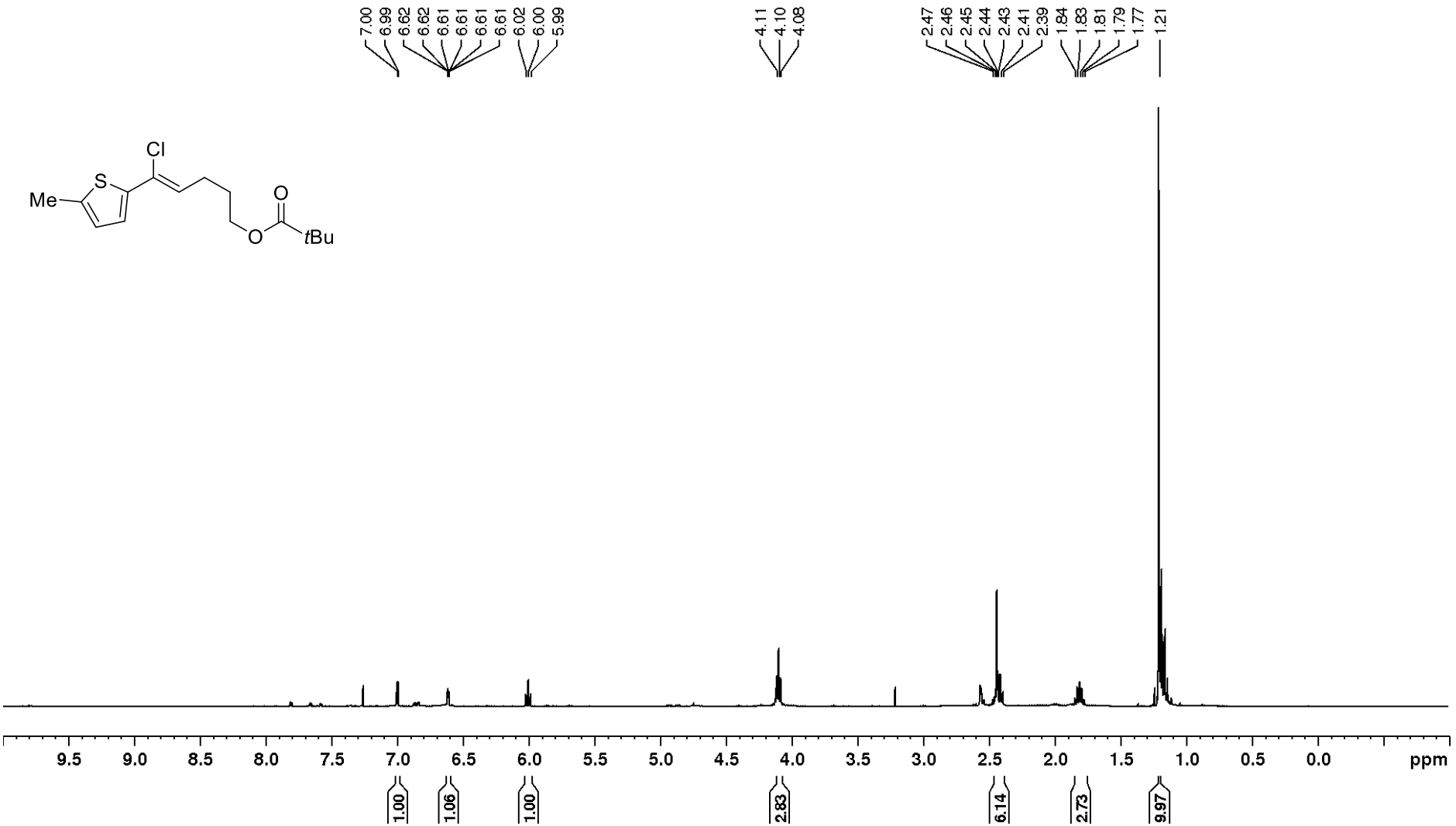
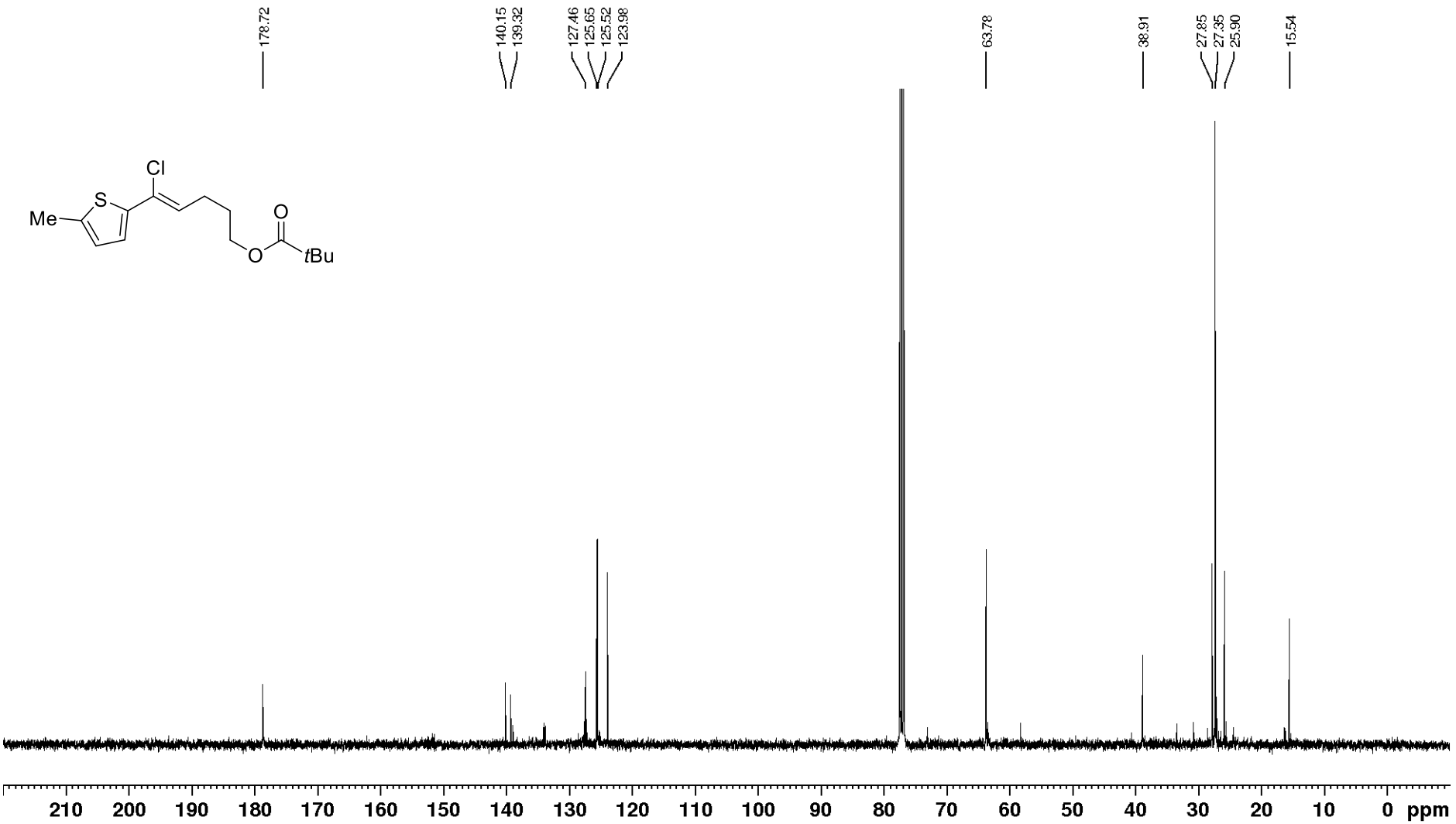


Figure S73. $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) of **(*Z*)-5-Chloro-5-(5-methylthiophen-2-yl)pent-4-en-1-yl pivalate** (**11d**).



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