Electronic Supplementary Information for

Diastereoselective, Lewis acid-mediated Diels-Alder reactions of allenoic acid derivatives and 1,3-cyclopentadienes

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1. General Information

All reactions sensitive to air or moisture were carried out in flame-dried glassware under positive pressure of argon using standard *Schlenk* techniques.

Commercially available chemicals were used without further purification, unless otherwise specified. For moisture sensitive reactions, dichloromethane (CH_2Cl_2), diethylether (Et_2O) and tetrahydrofuran (THF) were purified using a MBSPS 800 MBraun solvent purification system. Anhydrous acetonitrile (MeCN), dimethylsulfoxide (DMSO), dimethyl formamide (DMF), toluene, and methanol (MeOH) were purchased from Acros Organics, supplied over 3 Å molecular sieves. Technical solvents [ethyl acetate (EtOAc), methanol (MeOH), acetone, pentane, and diethyl ether (Et_2O)] were distilled before use.

Flash column chromatography was performed on silica 60 (*Merck*, 230-400 mesh) with the indicated eluent mixture.

Photochemical reactions at $\lambda = 254$ nm were carried out inside quartz phototubes (Ø 1 cm, 10 mL) in a positive geometry setup (cylindrical array of 16 lamps, $\lambda max = 254$ nm) with the reaction placed in the centre of the illumination chamber.

2. Analytical Methods

Thin layer chromatography (TLC) was performed on silica coated glass plates (silica gel 60 F_{254}) with detection by UV-light ($\lambda = 254$ nm) or potassium permanganate stain [$KMnO_4$].

Infrared spectra (IR) were recorded on a JASCO IR-4100 or a *Perkin Elmer* Frontier IR-FTR spectrometer by ATR technique.

Melting points (M.p.) were determined using a Kofler ("Thermopan", Fs Reichert, Wien) apparatus.

Nuclear magnetic resonance (NMR) spectra were recorded at room temperature on a Bruker AVHD-300, AVHD-400, or AVHD-500. Chemical shifts of the NMR spectra are reported relative to $CHCl_3$ (^{1}H-NMR: $\delta = 7.26$ ppm, ^{13}C-NMR: $\delta = 77.16$ ppm) or acetonitrile-d_3 (^{1}H-NMR: $\delta = 2.13, 1.94$ ppm, ^{13}C-NMR: $\delta = 118.2, 1.3$ ppm). The data are reported as follows: chemical shift (δ) [multiplicity, coupling constant J (Hz), relative integral, attributed proton] where multiplicity is defined as: m = multiplet, s = singlet, d = doublet, t = triplet, q = quartet, quint = quintet, sext = sextet, br = broad, virt. = virtual or combinations thereof.

Original NMR datasets (FIDs) are available at Open Science Framework at: https://osf.io/q65gw/

High-Resolution Mass Spectroscopy (HRMS) was performed by either electron ionization (EI, 70 eV) or electronspray ionization (ESI). EI was recorded on a *Thermo Scientific* DFS-HRMS spectrometer, ESI on a *Thermo Scientific* LTQ-FT spectrometer.

Specific Rotation was determined using an ADP440+ polarimeter (Fa *Bellingham+Stanley*) and is reported as follows: $[\alpha]_D^T$ (c in g per 100 mL solvent).

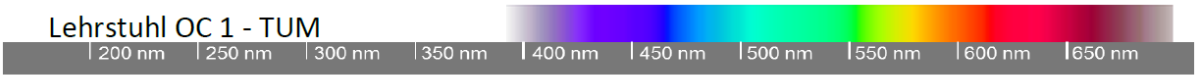
High performance liquid chromatography (HPLC) was performed (Dionex Ultimate 3000 pump, Dionex Ultimate 3000 Autosampler, Dionex Ultimate 3000 photodiode array detector) using different chiral stationary phases (Daicel ChiralCel, *Chemical Industries*) and UV detection (λ = 215 and 254 nm) at 20 °C or 25 °C.

X-ray crystallographic details: X-ray intensity data were collected on a Bruker D8 Venture single crystal X-Ray diffractometer equipped with a CPAD detector (Bruker Photon-II), a TXS rotating anode with MoKα (λ=0.71073 Å) and a Helios mirror optic using the software package APEX4.[1] Measurements were performed on a single crystal coated with perfluorinated ether and the crystal was fixed on top of a Kapton micro sampler, transferred to the diffractometer and frozen under a stream of cold nitrogen. A matrix scan was used to determine the initial lattice parameters. Reflections were merged and corrected for Lorenz and polarisation effects, scan speed and background using SAINT.[2] Absorption corrections, including odd and even ordered spherical harmonics were performed using SADABS.[2] Based on systematic absences, E-statistics, and successful refinement of the structures, the space group was assigned. The structure was solved by direct methods with aid of successive difference fourier maps, refined using APEX4 software, in conjugation with SHELXL and SHELXLE.[3,4] Hydrogen atoms were calculated in ideal positions with $U_{iso}(H) = 1.2\ U_{eq}(C)$. Non-hydrogen atoms were refined using anisotropic displacement parameters. Full-matrix least-squares refinements were carried out by minimising $\Sigma w(F_o^2 - F_c^2)^2$ with the SHELXL weighting scheme.[4] Neutral atom scattering factors for all atoms and anomalous dispersion corrections for the non-hydrogen atoms were taken from *International Tables for Crystallography*.[5]

Images of the crystal structure were generated with MERCURY and PLATON.21.[6] CCDC 2247008 contain the supplementary crystallographic data for this paper. This data is provided free of charge by The Cambridge Crystallographic Data Centre.

IR and VCD spectroscopy. The IR and VCD spectra were recorded on a Bruker Invenio-R FT-IR spectrometer equipped with a PMA 50 module for VCD measurements. The sample was held in a transmission cell with BaF_2 windows and 100 µm path length. Concentration are given in the main text. Spectra were recorded at room temperature with 4 cm^{-1} spectral resolution by accumulating 32 scans for the IR and ~32000 scans (4 hours accumulation time) for VCD. Baseline correction of the VCD spectra was done by subtraction of the spectra of the solvent recorded under identical conditions.

Computational details. The conformational search was performed using Spartan 14.[7] All DFT calculations, i.e. geometry optimizations and frequency calculations, were carried out at B3PW91/6-311G++(2d,p) level of theory using the Gaussian 09 Rev. E software package.[8] Solvent effects were taken into account implicitly by using the integral equation formalism of the polarizable continuum model (IEFPCM)[9] of chloroform. Vibrational line broadening was simulated by assigning a Lorentzian band shape with half-width at half-height of 6 cm^{-1} to the calculated dipole and rotational strength. The calculated frequencies were scaled by 0.98 to account for anharmonic effects not captured by the harmonic approximation employed in the frequency calculations.



Datasheet FLT014 RPR-2537A

Basic Information

Type	Fluorescent light tube
Description	S. N. E. Ultraviolet Co. RPR-2537 Å
Manufacturer / Supplier	n/a / Ryonet
Order number / Date of purch.	n/a / n/a
Internal lot / serial number	n/a / FLT014

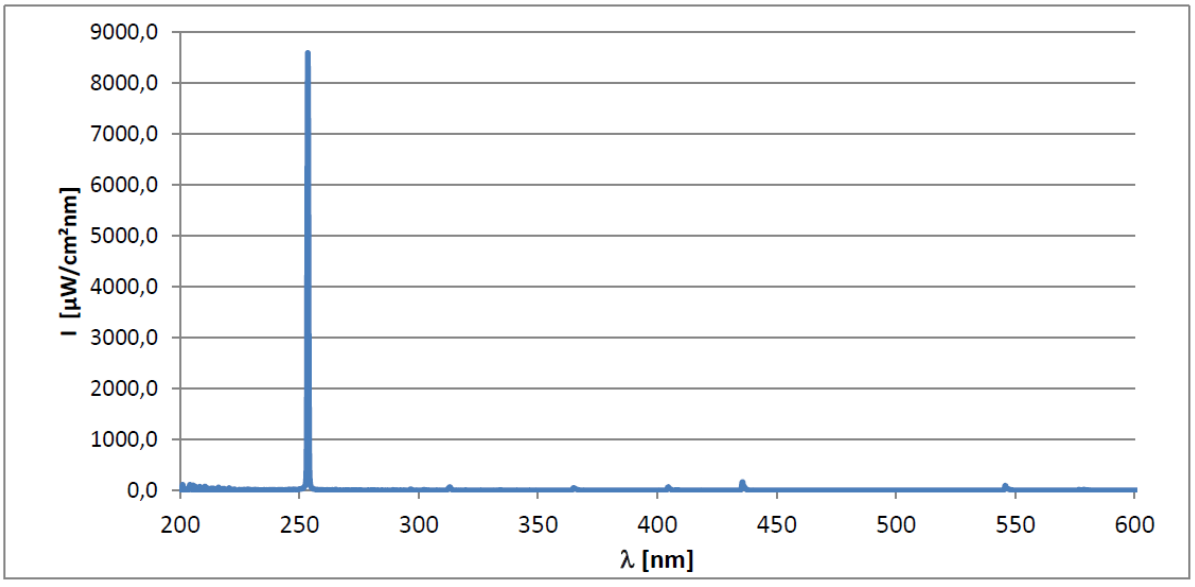
Specification Manufacturer

Type / size	T5 tube, G5 socket
Mechanical specification	16 mm diameter, 288 mm length
Electrical specification	n/a
Wavelength (range, typ.)	254 nm
Spectral width (FWHM)	n/a
Datasheet	n/a

Characterization

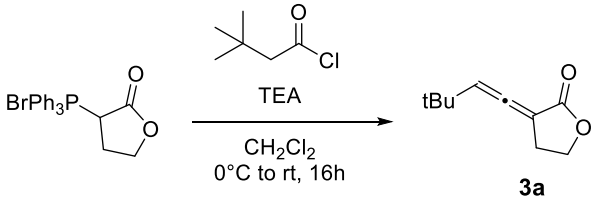
Description of measurement	Measured with Ocean-optics USB4000 spectrometer using a calibrated setup (cosine corrector/fibre). The cosine corrector was placed at 20 mm distance from a single fluorescent tube at half height.	
Measured dominant wavelength / Int.	253 nm	311 µW/mm²nm
Measured spectral width (FWHM)	2 nm	
Integral Reference intensity / range	6089 µW/cm²	245-270 nm

Spectrum



3. Synthesis of starting allenes

3-(3,3-dimethylbut-1-en-1-ylidene)dihydrofuran-2(3H)-one (3a)



3-(bromotriphenyl-λ^5-phosphaneyl)dihydrofuran-2(3*H*)-one[10] (1500 mg, 3.51 mmol, 1 eq.) was stirred vigorously in CH_2Cl_2 (20 ml) and NaOH 2M (20 ml) for 10 min. The organic layer was removed, and the aqueous layer was extracted with CH_2Cl_2 (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo* to afford the ylid as a white foam. It was dissolved in dry CH_2Cl_2 (11 ml) under argon and triethylamine (1.13 ml, 8.07 mmol, 2.3 eq.) was added. The reaction was stirred for 5 minutes, then cooled to 0°C. 3,3-dimethylbutanoyl chloride (0.54 ml, 3.86 mmol, 1.1 eq.) was injected dropwise into the reaction. The mixture was allowed to warm to rt. After 16h, the reaction was quenched with NH_4Cl sat. sol. and diluted with CH_2Cl_2. The layers were separated, and the aqueous layer was extracted with CH_2Cl_2 (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was purified by flash chromatography (eluting with pentane:Et_2O 7:3 → 1:1) to afford **3a** (491 mg, 2.95 mmol, 84% yield) as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ 5.76 (t, *J* = 4.7 Hz, 1H), 4.44 – 4.29 (m, 2H), 3.02 (tdd, *J* = 7.5, 4.7, 1.4 Hz, 2H), 1.12 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 203.84, 170.56, 110.32, 94.87, 65.91, 33.47, 30.16 (3 C), 26.89.

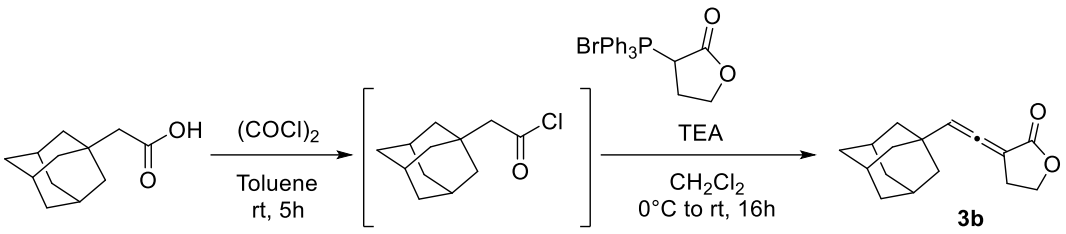
R_f = 0.54 (pentane:Et_2O 1:1) [UV] [$KMnO_4$]

Mp: 98°C

IR: $\tilde{\nu}$ [cm^{-1}] = 2961, 2869, 1969, 1749, 1655, 1465, 1447, 1415, 1366, 1341, 1250, 1199, 1168, 1152, 1079, 1051, 1022, 954, 913, 881, 857, 847, 830, 797, 786, 762, 745, 731, 702, 675.

HRMS (ESI): calculated for $C_{10}H_{15}O_2^+$, $[M+H]^+$ = 167.1067; found = 167.1073.

3-(2-((3r,5r,7r)-adamantan-1-yl)vinylidene)dihydrofuran-2(3H)-one (3b)



1-Adamantaneacetic acid (217 mg, 1.12 mmol, 1.1 eq.) was dissolved in dry toluene (9 ml) under argon. $(COCl)_2$ (1.31 ml, 15.23 mmol, 15 eq.) was added, and the reaction was stirred at rt for 5h. Toluene and excess $(COCl)_2$ were removed under reduced pressure to afford the intermediate acyl chloride as a pale yellow oil.

3-(bromotriphenyl-λ^5-phosphaneyl)dihydrofuran-2(3*H*)-one[10] (434 mg, 1.01 mmol, 1 eq.) was stirred vigorously in CH_2Cl_2 (10 ml) and NaOH 2M (10 ml) for 10 min. The organic layer was removed, and the aqueous layer was extracted with CH_2Cl_2 (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo* to afford the ylid as a white foam. It was dissolved in dry CH_2Cl_2 (5 ml) under argon and triethylamine (0.33 ml, 2.34 mmol, 2.3 eq.) was added. The reaction was stirred for 5 minutes, then cooled to 0°C. The acyl chloride in dry CH_2Cl_2 (1.5 ml) was injected dropwise into the reaction. The mixture was allowed to warm to rt. After 16h, the reaction was quenched with NH_4Cl sat. sol. and diluted with CH_2Cl_2. The layers were separated, and the aqueous layer was extracted with CH_2Cl_2 (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was purified by flash chromatography (eluting with pentane:Et_2O 3:2) to afford **3b** (209 mg, 0.85 mmol, 84% yield) as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ 5.64 (t, *J* = 4.7 Hz, 1H), 4.38 (t, *J* = 7.5 Hz, 2H), 3.02 (tdd, *J* = 7.2, 4.7, 2.0 Hz, 2H), 2.00 (br. s., 3 H), 1.79 – 1.60 (m, 12H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 204.62, 170.73, 110.05, 94.86, 65.92, 42.82 (3 C), 36.62 (3 C), 35.59, 28.68 (3 C), 27.04.

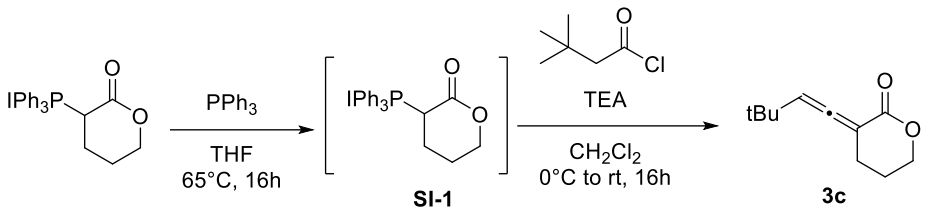
R_f = 0.44 (pentane:Et_2O 3:2) [UV] [$KMnO_4$]

Mp: 119°C

IR: $\tilde{\nu}$ [cm^{-1}] = 2978, 2903, 2848, 1965, 1742, 1445, 1418, 1374, 1343, 1316, 1199, 1184, 1131, 1098, 1042, 1021, 988, 977, 956, 912, 849, 734, 722.

HRMS (ESI): calculated for $C_{16}H_{21}O_2^+$, $[M+H]^+$ = 245.1536; found = 245.1546.

3-(3,3-dimethylbut-1-en-1-ylidene)tetrahydro-2H-pyran-2-one (3c)



PPh_3 (1768 mg, 6.74 mmol, 1.7 eq.) was placed in a flask under argon and 3-iodotetrahydro-2*H*-pyran-2-one[11] (896 mg, 3.96 mmol, 1 eq.) in dry THF (4 ml) was injected. The reaction was stirred at 65°C for 16 h. THF was removed under reduced pressure, and the residue was taken up in a small amount of CH_2Cl_2. It was pipetted into 150 ml of ice-cooled and stirred Et_2O. The precipitated phosphonium salt was collected by vacuum filtration and washed with Et_2O to afford a batch of phosphonium salt **SI-1** (1848 mg, 3.78 mmol, 95%) as a white solid. It was used without further purification and stored at -40°C.

SI-1 (700 mg, 1.43 mmol, 1 eq.) was stirred vigorously in CH_2Cl_2 (10 ml) and NaOH 2M (10 ml) for 10 min. The organic layer was removed, and the aqueous layer was extracted with CH_2Cl_2 (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo* to afford the ylid as a white foam. It was dissolved in dry CH_2Cl_2 (5 ml) under argon and triethylamine (0.46 ml, 3.30 mmol, 2.3 eq.) was added. The reaction was stirred for 5 minutes, then cooled to 0°C. 3,3-dimethylbutanoyl chloride (0.22 ml, 1.58 mmol, 1.1 eq.) was injected dropwise into the reaction. The mixture was allowed to warm to rt. After 16 h, the reaction was quenched with NH_4Cl sat. sol. and diluted with CH_2Cl_2. The layers were separated, and the aqueous layer was extracted with CH_2Cl_2 (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was purified by flash chromatography (eluting with pentane:Et_2O 1:9) to afford **3c** (108 mg, 0.60 mmol, 42% yield) as a transparent oil.

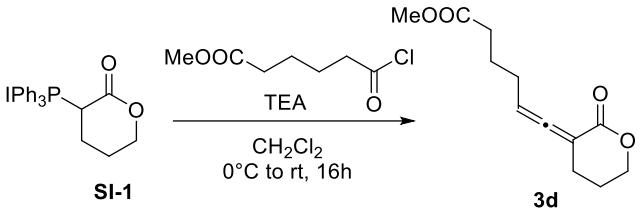
^{1}H NMR (400 MHz, $CDCl_3$): δ 5.61 (t, *J* = 3.5 Hz, 1H), 4.45 – 4.20 (m, 2H), 2.72 – 2.42 (m, 2H), 1.94 (dt, *J* = 12.0, 6.2 Hz, 2H), 1.11 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 209.19, 165.15, 107.07, 96.61, 69.56, 33.32, 30.23 (3 C), 26.21, 22.99.

R_f = 0.60 (pentane:Et_2O 1:9) [UV] [$KMnO_4$]

IR: ṽ [cm^{-1}] = 2957, 2904, 2867, 1955, 1710, 1476, 1463, 1396, 1363, 1327, 1265, 1247, 1148, 1111, 1084, 1064, 1038, 997, 965, 892, 855, 812, 742, 722, 689.

HRMS (ESI): calculated for $C_{11}H_{17}O_2^+$, $[M+H]^+$ = 181.1223; found = 181.1233.

Methyl 6-(2-oxodihydro-2H-pyran-3(4H)-ylidene)hex-5-enoate (3d)



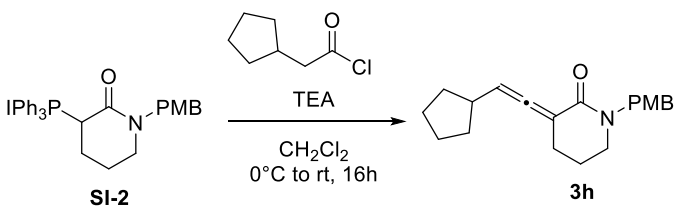
SI-1 (255 mg, 0.52 mmol, 1 eq.) was stirred vigorously in CH_2Cl_2 (10 ml) and NaOH 2M (10 ml) for 10 min. The organic layer was removed, and the aqueous layer was extracted with CH_2Cl_2 (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo* to afford the ylid as a white foam. It was dissolved in dry CH_2Cl_2 (2 ml) under argon and triethylamine (0.17 ml, 1.20 mmol, 2.3 eq.) was added. The reaction was stirred for 5 minutes, then cooled to 0°C. Methyl 6-chloro-6-oxohexanoate (0.09 ml, 0.57 mmol, 1.1 eq.) was injected dropwise into the reaction. The mixture was allowed to warm to rt. After 16 h, the reaction was quenched with NH_4Cl sat. sol. and diluted with CH_2Cl_2. The layers were separated, and the aqueous layer was extracted with CH_2Cl_2 (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was purified by flash chromatography (eluting with pentane:Et_2O 1:9) to afford **3d** (39 mg, 0.22 mmol, 41% yield) as a transparent oil.

Analysis was complicated due to the rapid degradation of the compound. An ESI-MS measurement showed the correct mass. The product was used immediately after isolation in the Diels-Alder reaction.

$\mathbf{R_f}$ = 0.39 (pentane:Et_2O 1:9) [UV] [$KMnO_4$]

HRMS (ESI): calculated for $C_{12}H_{17}O_4^+$, $[M+H]^+$ = 225.1121; found = 225.1130.

3-(2-cyclopentylvinylidene)-1-(4-methoxybenzyl)piperidin-2-one (3h)



Phosphonium salt **SI-2**[12] (500 mg, 0.82 mmol, 1 eq.) was dissolved in dry CH_2Cl_2 (4 ml) under argon and triethylamine (0.26 ml, 1.89 mmol, 2.3 eq.) was added. The reaction was stirred for

5 minutes, then cooled to 0°C. Cyclopentylacetyl chloride (0.12 ml, 0.90 mmol, 1.1 eq.) was injected dropwise into the reaction. The mixture was allowed to warm to rt. After 16 h, the reaction was quenched with NH_4Cl sat. sol. and diluted with CH_2Cl_2. The layers were separated, and the aqueous layer was extracted with CH_2Cl_2 (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was purified by flash chromatography (eluting with pentane:Et_2O 1:4) to afford **3h** (190 mg, 0.61 mmol, 74% yield) as a white solid.

Crystals were obtained by slow evaporation of a solution of **3h** in 1:1 $CHCl_3$:CH_2Cl_2 (50 mg/ml) in a 5 ml glass vial.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.25 – 7.20 (m, 2H), 6.89 – 6.78 (m, 2H), 5.60 (dt, *J* = 6.3, 3.1 Hz, 1H), 4.80 (d, *J* = 14.4 Hz, 1H), 4.36 (d, *J* = 14.3 Hz, 1H), 3.79 (s, 3H), 3.24 (t, *J* = 5.9 Hz, 2H), 2.61 (h, *J* = 7.2 Hz, 1H), 2.56 – 2.47 (m, 2H), 1.93 – 1.76 (m, 4H), 1.74 – 1.49 (m, 4H), 1.49 – 1.37 (m, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 206.87, 163.92, 159.07, 129.78 (2 C), 129.72, 114.03 (2 C), 99.94, 99.81, 55.41, 50.32, 47.39, 38.86, 32.99, 32.85, 28.05, 24.88, 24.86, 23.26.

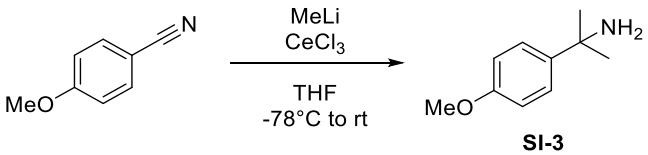
R_f = 0.42 (pentane:Et_2O 1:4) [UV] [$KMnO_4$]

Mp: 84°C

IR: $\tilde{\nu}$ [cm^{-1}] = 2932, 2861, 1953, 1617, 1585, 1511, 1483, 1452, 1434, 1342, 1322, 1303, 1279, 1263, 1241, 1213, 1191, 1175, 1159, 1109, 1072, 1029, 1012, 975, 944, 925, 893, 866, 836, 819, 761, 734, 715, 688.

HRMS (ESI): calculated for $C_{20}H_{26}NO_2^+$, $[M+H]^+$ = 312.1958; found = 312.1968.

2-(4-methoxyphenyl)propan-2-amine (SI-3)



SI-3

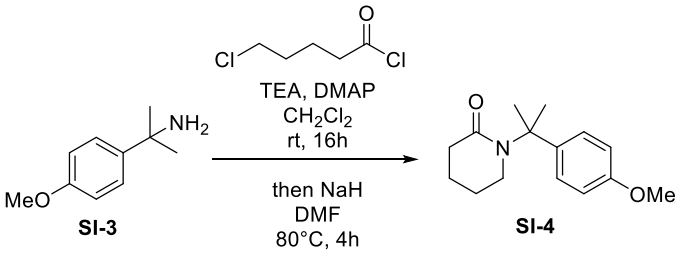
Anhydrous $CeCl_3$ (8515 mg, 34.55 mmol, 2 eq.) was stirred vigorously in dry THF (70 ml) at rt under argon for 3 h. The mixture was cooled to -78 °C and MeLi 1.6 M in Et_2O (27 ml, 43.18 mmol, 2.5 eq.) was injected. The reaction was stirred for 45 min at -78 °C. Then, a solution of

4-methoxybenzonitrile in dry THF (20 ml) was injected. The reaction was stirred at -78°C for 15 min, then at rt for 2h. It was quenched by addition of 25% NH_4OH (23 ml) and stirred for 15 min at rt to precipitate the Ce by-products. The suspension was filtered into an extraction funnel and the filter cake was washed with Et_2O. Then HCl 6 M was added to the filtrate until pH ≤2. The layers were shaken and separated. The organic layer was discarded, and the aqueous layer was basified with NaOH 50% until pH ≥9. It was extracted with Et_2O (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo* to afford 2-(4-methoxyphenyl)propan-2-amine **SI-3** (2724 mg, 16.48 mmol, 95% yield) as a pale yellow oil. It was used without further purification.

The NMR data were in accordance with the literature.[13]

^{1}H NMR (300 MHz, $CDCl_3$): δ 7.48 - 7.40 (m, 2 H), 6.91 - 6.83 (m, 2 H), 3.81 (s, 3 H), 2.18 (br. s., 2 H), 1.51 (s, 6 H) **^{13}C NMR** (101 MHz, $CDCl_3$): δ 157.9, 142.5, 125.8 (2 C), 113.4 (2 C), 55.2, 51.9, 32.9 (2 C)

1-(2-(4-methoxyphenyl)propan-2-yl)piperidin-2-one (SI-4)



SI-3 (1362 mg, 8.24 mmol, 1 eq.) was dissolved in dry CH_2Cl_2 (20 ml) under argon. Triethylamine (3.45 ml, 24.73 mmol, 3 eq.) and DMAP (50 mg, 0.41 mmol, 0.05 eq.) were added, then 5-chlorovaleroyl chloride (1.08 ml, 8.41 mmol, 1.02 eq.) was injected dropwise. The reaction was stirred at rt. After 16 h, the reaction was quenched with NH_4Cl sat. sol. and diluted with CH_2Cl_2. The layers were separated, and the aqueous layer was extracted with CH_2Cl_2 (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was dissolved in dry DMF (16 ml) under argon and NaH 60% dispersion in mineral oil (560 mg, 14.01 mmol, 1.7 eq.) was added. The reaction was stirred at 80°C for 4 h, then quenched with NH_4Cl sat. sol. and diluted with EtOAc. The layers were separated, and the aqueous layer was extracted with EtOAc (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was purified by flash

chromatography (eluting with EtOAc 100%) to afford **SI-4** (1800 mg, 7.28 mmol, 88% yield) as a pale yellow oil which slowly solidified.

Note: deuterated solvents for analysis must be pH neutral or basic to avoid cleavage of the amide protecting group.

^{1}H NMR (400 MHz, CD_3CN): δ 7.27 – 7.15 (m, 2H), 6.88 – 6.75 (m, 2H), 3.75 (s, 3H), 3.44 (t, *J* = 6.0 Hz, 2H), 2.22 – 2.13 (m, 2H), 1.86 – 1.66 (m, 4H), 1.60 (s, 6H). **^{13}C NMR** (101 MHz, CD_3CN): δ 170.67, 158.45, 143.12, 126.29 (2 C), 114.07 (2 C), 61.67, 55.78, 45.66, 35.26, 28.68, 24.85 (2 C), 21.43.

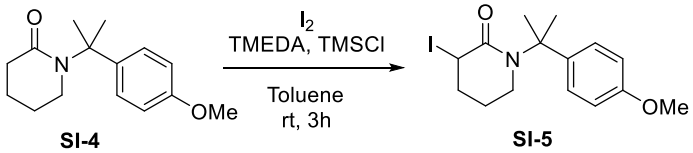
R_f = 0.51 (EtOAc 100%) [UV] [$KMnO_4$]

Mp: 45°C

IR: ṽ [cm^{-1}] = 3055, 2956, 2870, 2834, 1639, 1612, 1583, 1511, 1486, 1463, 1447, 1413, 1361, 1347, 1326, 1308, 1299, 1280, 1241, 1212, 1170, 1162, 1135, 1112, 1024, 977, 926, 895, 831, 820, 804, 732, 671, 655.

HRMS (ESI): calculated for $C_{15}H_{22}NO_2^+$, $[M+H]^+$ = 248.1645; found = 248.1647.

3-iodo-1-(2-(4-methoxyphenyl)propan-2-yl)piperidin-2-one (SI-5)



SI-4 **SI-5**

SI-4 (1311 mg, 5.30 mmol, 1 eq.) was dissolved in dry toluene (20 ml) under argon and TMEDA (1.28 ml, 8.59 mmol, 1.62 eq.) and TMSCl (2.02 ml, 15.90 mmol, 3 eq.) were added at rt. The reaction was stirred for 10 min, then cooled to 0°C. I_2 (1750 mg, 6.89 mmol, 1.3 eq.) was added, and the reaction was stirred at rt. After 3h, the reaction was quenched with 10% $Na_2S_2O_3$ and diluted with EtOAc. The layers were separated, and the aqueous layer was extracted with EtOAc (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was purified by flash chromatography (eluting with pentane:Et_2O 3:7) to afford **SI-5** (1673 mg, 4.48 mmol, 85% yield) as a pale yellow oil.

^{1}H NMR (400 MHz, CD_3CN): δ 7.26 – 7.16 (m, 2H), 6.87 – 6.78 (m, 2H), 4.68 (ddd, *J* = 5.2, 3.8, 1.5 Hz, 1H), 3.76 (s, 3H), 3.72 – 3.62 (m, 1H), 3.57 – 3.47 (m, 1H), 2.19 – 2.01 (m, 3H),

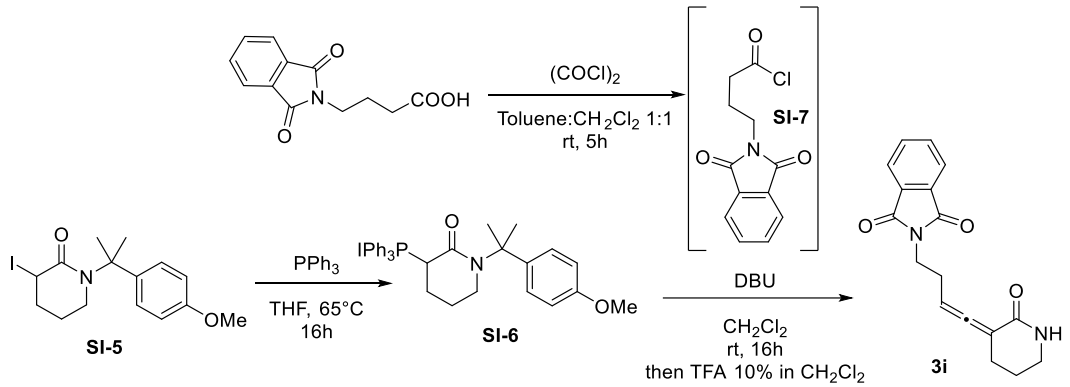
1.91 – 1.80 (m, 1H), 1.64 (s, 3H), 1.52 (s, 3H). **^{13}C NMR** (101 MHz, CD_3CN): δ 167.84, 158.61, 142.34, 126.14 (2 C), 114.10 (2 C), 62.23, 55.78, 45.34, 33.26, 29.36, 28.85, 26.75, 22.49.

R_f = 0.62 (pentane:Et_2O 1:4) [UV] [$KMnO_4$]

IR: $\tilde{\nu}$ [cm^{-1}] = 2961, 2929, 2834, 1634, 1584, 1511, 1483, 1448, 1421, 1383, 1360, 1341, 1316, 1302, 1241, 1211, 1180, 1161, 1134, 1112, 1094, 1033, 1013, 987, 934, 922, 904, 884, 833, 809, 757, 730, 668.

HRMS (ESI): calculated for $C_{15}H_{21}INO_2^+$, $[M+H]^+$ = 374.0611; found = 374.0628.

2-(4-(2-oxopiperidin-3-ylidene)but-3-en-1-yl)isoindoline-1,3-dione (3i)



PPh_3 (1310 mg, 4.99 mmol, 1.3 eq.) was placed in a flask under argon and **SI-5** (1434 mg, 3.84 mmol, 1 eq.) in dry THF (5.5 ml) was injected. The reaction was stirred at 65°C for 16 h. THF was removed under reduced pressure, and the oily residue was taken up in a small amount of CH_2Cl_2. It was pipetted into ice-cooled and stirred Et_2O (250 ml). The precipitated product was filtered, washed with Et_2O, and dried under vacuum to afford a batch of phosphonium salt **SI-6** (1840 mg, 2.89 mmol, 75% yield) as a pale yellow solid. It was used without further purification and stored at -40°C.

4-(1,3-dioxoisoindolin-2-yl)butanoic acid[14] (264 mg, 1.13 mmol, 1.2 eq.) was dissolved in dry toluene (5 ml) and dry CH_2Cl_2 (5 ml) under argon. $(COCl)_2$ (1.26 ml, 14.72 mmol, 15.6 eq.) was added, and the reaction was stirred at rt for 5h. The solvents and excess $(COCl)_2$ were removed under reduced pressure to afford the intermediate acyl chloride **SI-7** as a pale yellow oil which slowly solidified.

SI-6 (600 mg, 0.94 mmol, 1 eq.) was dissolved in dry CH_2Cl_2 (3.2 ml) under argon, and DBU (0.37 ml, 2.45 mmol, 2.6 eq.) was added. The reaction was stirred for 5 minutes, then cooled to 0°C. The acyl chloride **SI-7** was dissolved in dry CH_2Cl_2 (1.5 ml) and injected dropwise into the reaction. The mixture was allowed to warm to rt. After 16 h, the reaction was quenched with NH_4Cl sat. sol. and diluted with CH_2Cl_2. The layers were separated, and the aqueous layer was extracted with CH_2Cl_2 (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was filtered over a short plug of silica gel (eluting with Et_2O 100%) and the filtrate was concentrated *in vacuo*. The residue dissolved in CH_2Cl_2 (16 ml) and TFA (1.6 ml, 10% of volume of CH_2Cl_2) was added. The reaction was stirred for 10 minutes, then $NaHCO_3$ sat. sol. was added slowly. The mixture was stirred until bubbling ceased. The layers were separated, and the aqueous layer was extracted with CH_2Cl_2 (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was purified by flash chromatography (eluting with EtOAc 100% → EtOAc:MeOH 4:1) to afford **3i** (164 mg, 0.55 mmol, 59% yield) as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.87 (dd, *J* = 5.5, 3.0 Hz, 2H), 7.73 (dd, *J* = 5.5, 3.0 Hz, 2H), 6.13 (s, 1H), 5.60 (ddt, *J* = 7.8, 6.4, 3.2 Hz, 1H), 3.93 – 3.76 (m, 2H), 3.39 – 3.23 (m, 2H), 2.70 – 2.47 (m, 2H), 2.47 – 2.31 (m, 2H), 1.81 (qt, *J* = 5.7, 3.3 Hz, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 207.94, 168.35 (2 C), 165.44, 134.05 (2 C), 132.24 (2 C), 123.32 (2 C), 99.30, 91.72, 42.58, 37.35, 27.25, 27.20, 22.67.

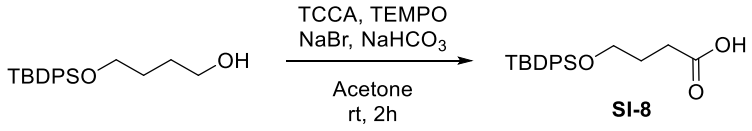
R_f = 0.56 (EtOAc:MeOH 4:1) [UV] [$KMnO_4$]

Mp: 169°C

IR: $\tilde{\nu}$ [cm^{-1}] = 2932, 1967, 1774, 1706, 1663, 1472, 1432, 1392, 1350, 1335, 1316, 1297, 1210, 1188, 1120, 1089, 1028, 1018, 992, 928, 906, 868, 814, 718, 675.

HRMS (ESI): calculated for $C_{17}H_{17}N_2O_3^+$, $[M+H]^+$ = 297.1234; found = 297.1253.

4-((tert-butyldiphenylsilyl)oxy)butanoic acid (SI-8)



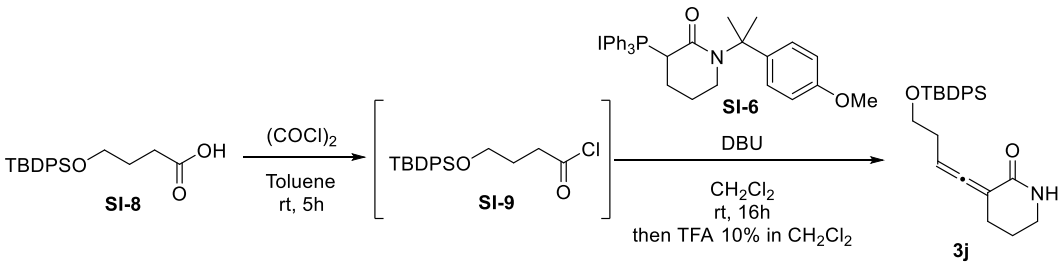
SI-8

Based on a modified literature procedure:[15] 4-((tert-butyldiphenylsilyl)oxy)butan-1-ol[16] (1164 mg, 3.54 mmol, 1 eq.) was dissolved in acetone (35 ml) and TEMPO (28 mg, 0.18 mmol, 0.05 eq.) was added followed by 15% aqueous $NaHCO_3$ (11 ml) and NaBr (73 mg, 0.71 mmol, 0.2 eq.). Then TCCA (1647 mg, 7.09 mmol, 2 eq.) was added in portions. The reaction was stirred at rt for 3h, then quenched with $Na_2S_2O_3$ 10% solution and diluted with EtOAc. The layers were separated, and the aqueous layer was extracted with EtOAc (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was purified by flash chromatography (eluting with pentane:Et_2O 4:1 → 1:1) to afford **SI-8** (961 mg, 2.81 mmol, 79% yield) as a transparent oil which slowly solidified.

The NMR data were in accordance with the literature.[17]

^{1}H NMR (500 MHz, $CDCl_3$): δ 7.74 - 7.63 (m, 4 H), 7.50 - 7.34 (m, 6 H), 3.73 (t, *J* = 6.0 Hz, 2 H), 2.54 (t, *J* = 7.3 Hz, 2 H), 1.97 - 1.87 (m, 2 H), 1.08 (s, 9 H) **^{13}C NMR** (101 MHz, $CDCl_3$): δ 179.2, 135.5 (4 C), 133.6 (2 C), 129.6 (2 C), 127.7 (4 C), 62.8, 30.7, 27.4, 26.8 (3 C), 19.2

3-(4-((tert-butyldiphenylsilyl)oxy)but-1-en-1-ylidene)piperidin-2-one (3j)



Carboxylic acid **SI-8** (1293 mg, 3.78 mmol, 1.2 eq.) was dissolved in dry toluene (30 ml) under argon. $(COCl)_2$ (4.21 ml, 49.08 mmol, 15.6 eq.) was added, and the reaction was stirred at rt for 5h. Toluene and excess $(COCl)_2$ were removed under reduced pressure to afford the intermediate acyl chloride **SI-9** as a pale yellow oil.

SI-6 (2000 mg, 3.15 mmol, 1 eq.) was dissolved in dry CH_2Cl_2 (10 ml) under argon, and DBU (1.22 ml, 8.18 mmol, 2.6 eq.) was added. The reaction was stirred for 5 minutes, then cooled to 0°C. The acyl chloride **SI-9** was dissolved in dry CH_2Cl_2 (6 ml) and injected dropwise into the reaction. The mixture was allowed to warm to rt. After 16 h, the reaction was quenched with NH_4Cl sat. sol. and diluted with CH_2Cl_2. The layers were separated, and the aqueous layer was extracted with CH_2Cl_2 (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was filtered over a short plug of silica gel (eluting with

pentane:Et_2O 1:1) and the filtrate was concentrated *in vacuo*. The residue dissolved in CH_2Cl_2 (50 ml) and TFA (5 ml, 10% of volume of CH_2Cl_2) was added. The reaction was stirred for 10 minutes, then $NaHCO_3$ sat. sol. was added slowly. The mixture was stirred until bubbling ceased. The layers were separated, and the aqueous layer was extracted with CH_2Cl_2 (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was purified by flash chromatography (eluting with EtOAc:MeOH 95:5) to afford **3j** (610 mg, 1.50 mmol, 48% yield) as a transparent oil.

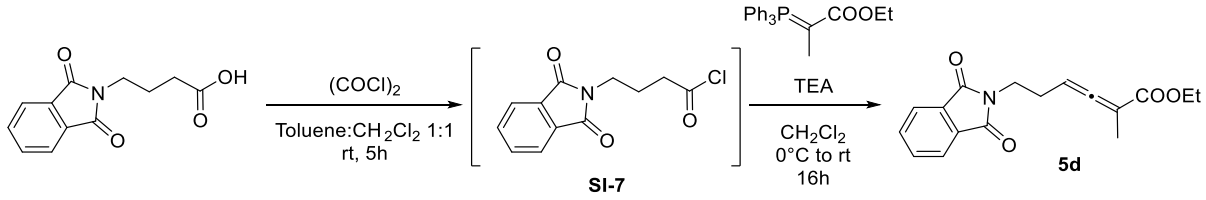
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.74 – 7.60 (m, 4H), 7.48 – 7.31 (m, 6H), 6.46 (s, 1H), 5.64 (tt, *J* = 6.5, 3.1 Hz, 1H), 3.76 (t, *J* = 6.5 Hz, 2H), 3.33 (td, *J* = 5.8, 2.6 Hz, 2H), 2.58 – 2.46 (m, 2H), 2.45 – 2.35 (m, 2H), 1.89 – 1.76 (m, 2H), 1.05 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 207.89, 165.93, 135.69 (4 C), 133.94, 133.91, 129.73 (2 C), 127.77 (4 C), 98.39, 92.18, 63.44, 42.66, 31.71, 27.45, 26.96 (3 C), 22.82, 19.34.

R_f = 0.48 (EtOAc:MeOH 95:5) [UV] [$KMnO_4$]

IR: $\tilde{\nu}$ [cm^{-1}] = 3201, 3070, 2930, 2857, 2232, 1960, 1655, 1589, 1484, 1471, 1443, 1427, 1390, 1334, 1314, 1271, 1204, 1105, 1006, 909, 822, 730, 700.

HRMS (ESI): calculated for $C_{25}H_{32}NO_2Si^+$, $[M+H]^+$ = 406.2197; found = 406.2202.

ethyl 6-(1,3-dioxoisoindolin-2-yl)-2-methylhexa-2,3-dienoate (5d)



4-(1,3-dioxoisoindolin-2-yl)butanoic acid[14] (772 mg, 3.31 mmol, 1.2 eq.) was dissolved in dry toluene (13 ml) and dry CH_2Cl_2 (13 ml) under argon. $(COCl)_2$ (3.69 ml, 43 mmol, 15.6 eq.) was added, and the reaction was stirred at rt for 5h. The solvents and excess $(COCl)_2$ were removed under reduced pressure to afford the intermediate acyl chloride **SI-7** as a pale yellow oil which slowly solidified.

(Carbethoxyethylidene)triphenylphosphorane (1000 mg, 2.76 mmol, 1 eq.) was dissolved in dry CH_2Cl_2 (9 ml) under argon, and triethylamine (0.88 ml, 6.35 mmol, 2.3 eq.) was added. The reaction was stirred for 5 minutes, then cooled to 0°C. The acyl chloride **SI-7** was dissolved

in dry CH_2Cl_2 (4 ml) and injected dropwise into the reaction. The mixture was allowed to warm to rt. After 16 h, the reaction was quenched with NH_4Cl sat. sol. and diluted with CH_2Cl_2. The layers were separated, and the aqueous layer was extracted with CH_2Cl_2 (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was purified by flash chromatography (eluting with pentane:Et_2O 1:1) to afford **5d** (713 mg, 2.38 mmol, 86% yield) as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.85 (dd, *J* = 5.4, 3.1 Hz, 2H), 7.72 (dd, *J* = 5.5, 3.0 Hz, 2H), 5.52 – 5.38 (m, 1H), 4.10 – 3.91 (m, 2H), 3.82 (td, *J* = 7.1, 3.8 Hz, 2H), 2.52 (qd, *J* = 7.2, 4.1 Hz, 2H), 1.73 (d, *J* = 2.9 Hz, 3H), 1.14 (t, *J* = 7.1 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 210.48, 168.35 (2 C), 167.62, 134.11 (2 C), 132.24 (2 C), 123.37 (2 C), 96.54, 90.30, 60.95, 37.26, 27.27, 15.16, 14.33.

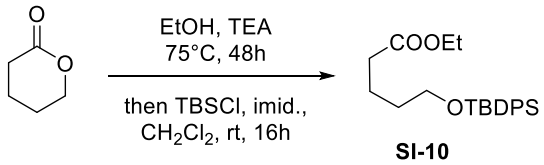
R_f = 0.59 (pentane:Et_2O 1:1) [UV] [$KMnO_4$]

Mp: 95°C

IR: $\tilde{\nu}$ [cm^{-1}] = 2991, 2962, 2929, 1958, 1772, 1697, 1613, 1476, 1467, 1438, 1391, 1368, 1354, 1337, 1293, 1275, 1199, 1187, 1156, 1119, 1077, 1039, 1027, 1018, 1005, 990, 955, 894, 883, 866, 857, 824, 804, 746, 726, 708, 694

HRMS (ESI): calculated for $C_{17}H_{17}NNaO_4^+$, $[M+Na]^+$ = 322.1050; found = 322.1052.

ethyl 5-((tert-butyldiphenylsilyl)oxy)pentanoate (SI-10)



SI-10

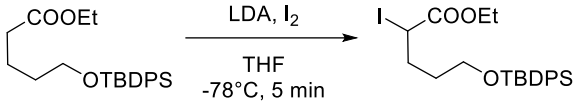
To a solution of δ-valerolactone (3 ml, 31.66 mmol, 1 eq.) in EtOH (30 ml) was added triethylamine (1.5 ml, 10.76 mmol, 0.34 eq.). The reaction was heated to 75°C for 48h. The solvent and triethylamine were removed *in vacuo*. The remaining oil was dissolved in CH_2Cl_2 (100 ml) under argon and TBDPSCl (9.06 ml, 34.83 mmol, 1.1 eq.) and imidazole (4742 mg, 69.66 mmol, 2.2 eq.) were added. The reaction was stirred for 16h at rt. The reaction was quenched with NH_4Cl sat. sol. and the layers were separated. The aqueous layer was extracted with CH_2Cl_2 (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was purified by flash chromatography (eluting with

pentane:Et_2O 95:5 → 9:1) to afford **SI-10** (10292 mg, 26.76 mmol, 85% yield) as a transparent oil.

The NMR data were in accordance with the literature.[18]

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.72 - 7.66 (m, 4 H), 7.47 - 7.37 (m, 6 H), 4.14 (q, *J* = 7.2 Hz, 2 H), 3.70 (t, *J* = 6.1 Hz, 2 H), 2.32 (t, *J* = 7.5 Hz, 2 H), 1.81 - 1.70 (m, 2 H), 1.66 - 1.57 (m, 2 H), 1.27 (t, *J* = 7.1 Hz, 3 H), 1.08 (s, 9 H) **^{13}C NMR** (101 MHz, $CDCl_3$): δ 173.6, 135.5 (4 C), 133.9 (2 C), 129.5 (2 C), 127.6 (4 C), 63.4, 60.1, 34.0, 31.9, 26.8 (3 C), 21.5, 19.2, 14.2

ethyl 5-((tert-butyldiphenylsilyl)oxy)-2-iodopentanoate (SI-11)



SI-10 **SI-11**

Diisopropylamine (0.76 ml, 5.46 mmol, 1.05 eq.) was dissolved in dry THF (14 ml) under argon. The mixture was cooled to -78°C and nBuLi 2.5 M in hexanes (2.18 ml, 5.46 mmol, 1.05 eq.) was added. The reaction was warmed to -40°C for 5 minutes, then cooled back down to -78°C. Then **SI-10** (2000 mg, 5.2 mmol, 1 eq.) in dry THF (6 ml) was added dropwise. The reaction was stirred for 15 minutes at -78°C to create the lithium enolate. In a separate flask, iodine (1451 mg, 5.72 mmol, 1.1 eq.) was dissolved in dry THF (14 ml) under argon and cooled to -78°C. The lithium enolate solution was injected onto the iodine solution at -78°C. After 5 minutes, the reaction was quenched with $Na_2S_2O_3$ 10% solution and diluted with Et_2O. The layers were separated, and the aqueous layer was extracted with Et_2O (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The resulting oil was purified by filtration over a short column of silica gel (eluting with pentane:Et_2O 9:1) to afford **SI-11** (2418 mg, 4.74 mmol, 91% yield) as a pale yellow oil.

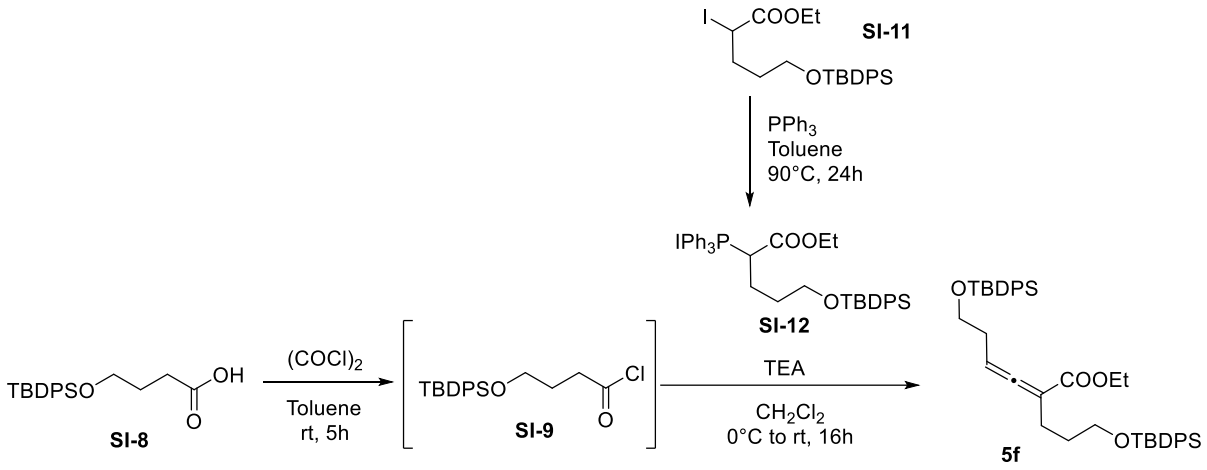
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.67 (dt, *J* = 6.4, 1.7 Hz, 4H), 7.53 – 7.32 (m, 6H), 4.37 (t, *J* = 7.6 Hz, 1H), 4.22 (qd, *J* = 7.1, 3.1 Hz, 2H), 3.69 (t, *J* = 6.1 Hz, 2H), 2.17 – 2.06 (m, 2H), 1.76 – 1.53 (m, 2H), 1.29 (t, *J* = 7.1 Hz, 3H), 1.07 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 171.49, 135.68 (4 C), 133.80 (2 C), 129.79 (2 C), 127.82 (4 C), 62.87, 61.83, 33.06, 32.20, 26.99 (3 C), 21.47, 19.33, 13.91.

R_f = 0.66 (pentane:Et_2O 9:1) [UV] [$KMnO_4$]

IR: $\tilde{\nu}$ [cm^{-1}] = 3071, 3049, 2958, 2931, 2894, 2857, 1731, 1589, 1472, 1444, 1427, 1389, 1371, 1341, 1284, 1248, 1216, 1174, 1105, 1029, 1007, 997, 967, 938, 855, 822, 738, 700, 686.

HRMS (ESI): calculated for $C_{23}H_{31}INaO_3Si^+$, $[M+Na]^+$ = 533.0979; found = 533.0984

ethyl 6-((tert-butyldiphenylsilyl)oxy)-2-(3-((tert-butyldiphenylsilyl)oxy)propyl)hexa-2,3-dienoate (5f)



PPh_3 (4487 mg, 17.11 mmol, 3.4 eq.) was placed in a flask under argon and **SI-11** (2569 mg, 5.03 mmol, 1 eq.) in dry THF (7 ml) was injected. The reaction was stirred at 65°C for 24h. THF was removed under reduced pressure, and CH_2Cl_2 (15 ml) was added. The mixture was pipetted into ice-cooled and vigorously stirred Et_2O:pentane 2:1 (300 ml) in an Erlenmeyer flask. The product precipitated as a gum. The supernatant was discarded, and the gum was washed with cold Et_2O:pentane 2:1 (2×). It was dissolved in CH_2Cl_2, transferred to a round-bottom flask and the solvents were removed *in vacuo* to afford a batch of the phosphonium salt **SI-12** (3666 mg, 4.74 mmol, 94% yield) as a transparent oil which foams under vacuum. It was used without further purification and stored at -40°C.

Carboxylic acid **SI-8** (912 mg, 2.66 mmol, 1.2 eq.) was dissolved in dry toluene (22 ml) under argon. $(COCl)_2$ (2.97 ml, 34.6 mmol, 15.6 eq.) was added, and the reaction was stirred at rt for 5h. Toluene and excess $(COCl)_2$ were removed under reduced pressure to afford the intermediate acyl chloride **SI-9** as a pale yellow oil.

Phosphonium salt **SI-12** (1431 mg, 2.22 mmol, 1 eq.) was stirred vigorously in CH_2Cl_2 (20 ml) and NaOH 2M (20 ml) for 2 min. The organic layer was removed, and the aqueous layer was extracted with CH_2Cl_2 (2×). The combined organic layers were dried over Na_2SO_4, filtered,

and concentrated *in vacuo* to afford the ylid as a yellow foam. It was dissolved in dry CH_2Cl_2 (7 ml) under argon and triethylamine (0.71 ml, 5.1 mmol, 2.3 eq.) was added. The reaction was cooled to 0°C, and the acyl chloride was dissolved in dry CH_2Cl_2 (3 ml) and injected dropwise into the reaction. The mixture was allowed to warm to rt. After 16h, the reaction was quenched with NH_4Cl sat. sol. and diluted with CH_2Cl_2. The layers were separated, and the aqueous layer was extracted with CH_2Cl_2 (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was purified by flash chromatography (eluting with pentane:Et_2O 98:2) to afford **5f** (1172 mg, 1.69 mmol, 76% yield) as a pale yellow oil.

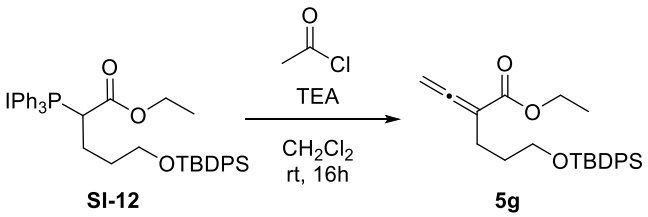
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.65 (ddd, *J* = 6.5, 2.7, 1.4 Hz, 8H), 7.47 – 7.29 (m, 12H), 5.53 (td, *J* = 7.3, 3.6 Hz, 1H), 4.13 (q, *J* = 7.1 Hz, 2H), 3.71 (td, *J* = 6.7, 2.5 Hz, 2H), 3.64 (t, *J* = 6.2 Hz, 2H), 2.36 – 2.23 (m, 4H), 1.71 – 1.60 (m, 2H), 1.20 (t, *J* = 7.1 Hz, 3H), 1.04 (d, *J* = 4.5 Hz, 18H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 210.01, 167.67, 135.71 (4 C), 135.67 (4 C), 134.14 (2 C), 133.85 (2 C), 129.79 (2 C), 129.65 (2 C), 127.80 (4 C), 127.73 (4 C), 100.40, 92.00, 63.60, 63.35, 60.85, 31.72, 31.10, 27.00, 26.97 (3 C), 24.97, 19.36, 19.34, 14.37.

R_f = 0.58 (pentane:Et_2O 98 :2) [UV] [$KMnO_4$]

IR: $\tilde{\nu}$ [cm^{-1}] = 3071, 3050, 2931, 2895, 2858, 1959, 1709, 1590, 1472, 1446, 1428, 1389, 1362, 1262, 1238, 1189, 1105, 1007, 998, 963, 937, 882, 857, 822, 737, 699, 688.

HRMS (ESI): calculated for $C_{43}H_{54}NaO_4Si_2^+$, $[M+Na]^+$ = 713.3453; found = 713.3449.

ethyl 5-((tert-butyldiphenylsilyl)oxy)-2-vinylidenepentanoate (5g)



SI-12 **5g**

Phosphonium salt **SI-12** (3643 mg, 4.71 mmol, 1 eq.) was stirred vigorously in CH_2Cl_2 (50 ml) and NaOH 2M (50 ml) for 2 min. The organic layer was removed, and the aqueous layer was extracted with CH_2Cl_2 (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo* to afford the ylid as a yellow foam. It was dissolved in dry CH_2Cl_2 (16 ml) under argon and triethylamine (1.51 ml, 10.84 mmol, 2.3 eq.) was added. The reaction was cooled to 0°C, and acetyl chloride (0.35 ml, 4.95 mmol, 1.05 eq.) was injected dropwise

into the reaction. The mixture was allowed to warm to rt. After 16h, the reaction was quenched with NH_4Cl sat. sol. and diluted with CH_2Cl_2. The layers were separated, and the aqueous layer was extracted with CH_2Cl_2 (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was purified by flash chromatography (eluting with pentane:Et_2O 95:5) to afford **5g** (1833 mg, 4.48 mmol, 95% yield) as a transparent oil.

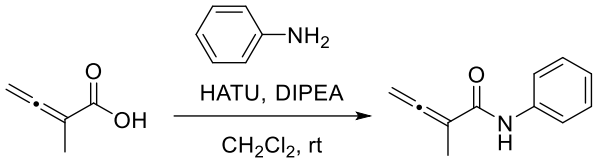
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.73 – 7.61 (m, 4H), 7.52 – 7.33 (m, 6H), 5.07 (t, *J* = 3.2 Hz, 2H), 4.20 (q, *J* = 7.1 Hz, 2H), 3.69 (t, *J* = 6.3 Hz, 2H), 2.35 (ddt, *J* = 8.0, 6.4, 3.2 Hz, 2H), 1.73 (dq, *J* = 8.2, 6.4 Hz, 2H), 1.28 (t, *J* = 7.1 Hz, 3H), 1.05 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 213.79, 167.36, 135.72 (4 C), 134.13 (2 C), 129.67 (2 C), 127.74 (4 C), 100.28, 79.25, 63.26, 61.09, 30.93, 26.99 (3 C), 24.61, 19.37, 14.41.

R_f = 0.35 (pentane:Et_2O 95:5) [UV] [$KMnO_4$]

IR: $\tilde{\nu}$ [cm^{-1}] = 3071, 2932, 2858, 1967, 1941, 1710, 1590, 1473, 1446, 1428, 1390, 1365, 1253, 1215, 1183, 1106, 1054, 1008, 999, 960, 846, 823, 777, 738, 700, 688.

HRMS (ESI): calculated for $C_{25}H_{33}O_3Si^+$, $[M+H]^+$ = 409.2193; found = 409.2194.

2-methyl-N-phenylbuta-2,3-dienamide (5i)



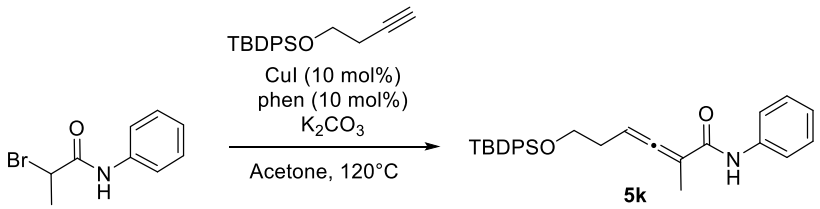
5i

2-methylbuta-2,3-dienoic acid[19] (156 mg, 1.59 mmol, 1 eq.) was dissolved in dry CH_2Cl_2 (15 ml) under argon. DIPEA (0.33 ml, 1.91 mmol, 1.2 eq.) and aniline (0.17 ml, 1.91 mmol, 1.2 eq.) were injected. HATU (725 mg, 1.91 mmol, 1.2 eq.) was added, and the reaction was stirred for 16h at rt. HCl 1M was added to quench the reaction, and it was diluted with CH_2Cl_2. The layers were separated, and the aqueous layer was extracted with CH_2Cl_2 (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was purified by flash chromatography (eluting with pentane:Et_2O 4:1) to afford **5i** (61 mg, 0.35 mmol, 22% yield) as a white solid.

The NMR data were in accordance with the literature.[20]

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.79 (br. s., 1 H), 7.59 - 7.48 (m, 2 H), 7.39 - 7.28 (m, 2 H), 7.14 - 7.03 (m, 1 H), 5.26 (q, *J* = 3.3 Hz, 2 H), 1.96 (t, *J* = 3.3 Hz, 3 H) **^{13}C NMR** (101 MHz, $CDCl_3$): δ 209.7, 164.1, 137.8, 128.9 (2 C), 124.0, 119.2 (2 C), 98.7, 80.4, 13.8

6-((tert-butyldiphenylsilyl)oxy)-2-methyl-N-phenylhexa-2,3-dienamide (5k)



According to a literature procedure:[21] to a solution of 2-bromo-*N*-phenylpropanamide[22] (120 mg, 0.53 mmol, 1 eq.) in acetone (8 mL) was added (but-3-yn-1-yloxy)(tert-butyl)diphenylsilane[23] (195 mg, 0.63 mmol, 1.2 eq.), Phen (10 mg, 0.05 mmol, 0.1 eq.), CuI (10 mg, 0.05 mmol, 0.1 eq.), and K_2CO_3 (145 mg, 1.05 mmol, 2 eq.) under air in an Ace glass pressure tube. The reaction mixture was heated to 120°C. After 1.5 h, the reaction was cooled to rt, quenched with NH_4Cl sat. sol. and diluted with Et_2O. The layers were separated, and the aqueous layer was extracted with Et_2O (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was purified by flash chromatography (eluting with pentane:Et_2O 4:1) to afford **5k** (85 mg, 0.19 mmol, 35% yield) as a transparent oil.

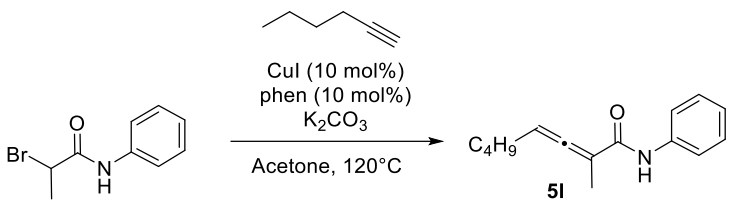
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.33 (s, 1H), 7.27 (dt, *J* = 8.0, 1.5 Hz, 4H), 7.06 – 6.93 (m, 8H), 6.91 – 6.82 (m, 2H), 6.70 – 6.62 (m, 1H), 5.32 (td, *J* = 7.2, 3.7 Hz, 1H), 3.41 (td, *J* = 6.2, 0.9 Hz, 2H), 2.02 (dt, *J* = 7.3, 6.3 Hz, 2H), 1.53 (d, *J* = 3.1 Hz, 3H), 0.66 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 205.63, 164.80, 138.05, 135.65 (4 C), 133.65, 133.61, 129.92 (2 C), 129.04 (2 C), 127.88 (4 C), 123.99, 119.43 (2 C), 99.27, 93.87, 63.45, 32.12, 26.98 (3 C), 19.35, 14.40.

R_f = 0.47 (pentane:Et_2O 4:1) [UV] [$KMnO_4$]

IR: $\tilde{\nu}$ [cm^{-1}] = 3321, 3070, 2957, 2930, 2857, 1956, 1671, 1598, 1521, 1499, 1472, 1439, 1428, 1389, 1362, 1312, 1236, 1189, 1157, 1105, 1029, 1007, 999, 936, 822, 800, 752, 738, 700, 689.

HRMS (ESI): calculated for $C_{58}H_{67}N_2O_4Si_2^+$, $[2M+H]^+$ = 911.4634; found = 911.4660.

2-methyl-N-phenylocta-2,3-dienamide (5l)



According to a literature procedure:[21] to a solution of 2-bromo-*N*-phenylpropanamide[22] (120 mg, 0.53 mmol, 1 eq.) in acetone (8 mL) was added hex-1-yne (195 mg, 0.63 mmol, 1.2 eq.), Phen (10 mg, 0.05 mmol, 0.1 eq.), CuI (10 mg, 0.05 mmol, 0.1 eq.), and K_2CO_3 (145 mg, 1.05 mmol, 2 eq.) under air in an Ace glass pressure tube. The reaction mixture was heated to 120°C. After 1.5 h, the reaction was cooled to rt, quenched with NH_4Cl sat. sol. and diluted with Et_2O. The layers were separated, and the aqueous layer was extracted with Et_2O (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was purified by flash chromatography (eluting with pentane:Et_2O 4:1) to afford **5l** (85 mg, 0.19 mmol, 35% yield) as a transparent oil.

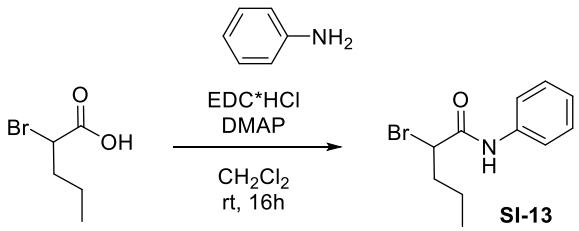
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.79 (s, 1H), 7.59 – 7.44 (m, 2H), 7.40 – 7.28 (m, 2H), 7.16 – 7.01 (m, 1H), 5.72 – 5.57 (m, 1H), 2.19 (q, *J* = 7.1 Hz, 2H), 1.94 (d, *J* = 3.0 Hz, 3H), 1.57 – 1.36 (m, 4H), 0.94 (t, *J* = 7.2 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 205.19, 164.97, 138.21, 129.13 (2 C), 123.96, 119.20 (2 C), 99.37, 97.00, 31.20, 28.35, 22.37, 14.40, 13.93.

R_f = 0.37 (pentane:Et_2O 9:1) [UV] [$KMnO_4$]

IR: $\tilde{\nu}$ [cm^{-1}] = 3402, 3326, 3059, 2957, 2928, 2858, 1953, 1657, 1597, 1519, 1499, 1456, 1438, 1379, 1368, 1312, 1235, 1177, 1157, 1118, 1078, 1030, 960, 924, 900, 879, 816, 750, 690.

HRMS (ESI): calculated for $C_{15}H_{20}NO^+$, $[M+H]^+$ = 230.1539; found = 230.1549.

2-bromo-N-phenylpentanamide (SI-13)



2-bromopentanoic acid (0.3 ml, 2.29 mmol, 1 eq.) was dissolved in dry CH_2Cl_2 under argon. EDC*HCl (527 mg, 2.75 mmol, 1.2 eq.) and DMAP (336 mg, 2.75 mmol, 1.2 eq.) were added, followed by aniline (0.41 ml, 4.58 mmol, 2 eq.). The reaction was stirred at rt. After 16h, it was quenched with 1M HCl and diluted with CH_2Cl_2. The layers were separated, and the aqueous layer was extracted with Et_2O (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was purified by flash chromatography (eluting with pentane:Et_2O 4:1 → 3:1) to afford **SI-13** (223 mg, 0.87 mmol, 38% yield) as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ 8.06 (s, 1H), 7.63 – 7.45 (m, 2H), 7.42 – 7.31 (m, 2H), 7.21 – 7.08 (m, 1H), 4.45 (dd, *J* = 8.3, 5.2 Hz, 1H), 2.27 – 2.01 (m, 2H), 1.68 – 1.42 (m, 2H), 0.98 (t, *J* = 7.4 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 166.89, 137.28, 129.24 (2 C), 125.15, 120.11 (2 C), 52.29, 38.07, 20.72, 13.40.

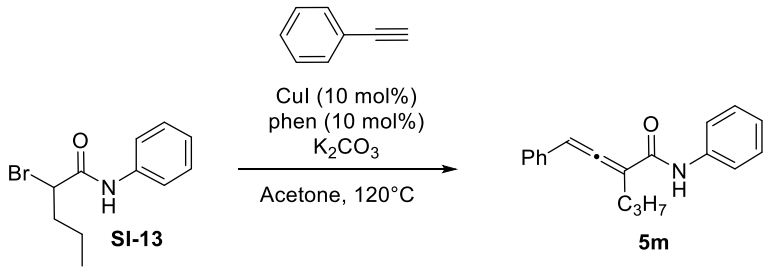
R_f = 0.40 (pentane:Et_2O 4:1) [UV] [$KMnO_4$]

Mp: 91°C

IR: $\tilde{\nu}$ [cm^{-1}] = 3258, 3202, 3142, 3062, 2962, 2929, 2874, 1659, 1619, 1600, 1536, 1498, 1463, 1445, 1378, 1312, 1255, 1232, 1203, 1169, 1104, 1072, 1055, 1026, 1005, 967, 953, 906, 885, 842, 790, 749, 693.

HRMS (ESI): calculated for $C_{11}H_{15}BrNO^+$, $[M+H]^+$ = 256.0332; found = 256.0336.

N-phenyl-2-(2-phenylvinylidene)pentanamide (5m)



According to a literature procedure:[21] to a solution of **SI-13** (207 mg, 0.81 mmol, 1 eq.) in acetone (12 mL) was added phenylacetylene (0.11 ml, 0.97 mmol, 1.2 eq.), Phen (15 mg, 0.08 mmol, 0.1 eq.), CuI (15 mg, 0.08 mmol, 0.1 eq.), and K_2CO_3 (223 mg, 1.61 mmol, 2 eq.) under air in an Ace glass pressure tube. The reaction mixture was heated to 120°C. After 1.5 h, the reaction was cooled to rt, quenched with NH_4Cl sat. sol. and diluted with Et_2O. The layers were separated, and the aqueous layer was extracted with Et_2O (2×). The combined organic layers

were dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was purified by flash chromatography (eluting with pentane:Et_2O 9:1) to afford **5m** (86 mg, 0.31 mmol, 38% yield) as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.63 (s, 1H), 7.43 – 7.35 (m, 2H), 7.31 – 7.23 (m, 4H), 7.23 – 7.14 (m, 3H), 7.03 – 6.92 (m, 1H), 6.60 (t, *J* = 3.0 Hz, 1H), 2.48 – 2.27 (m, 2H), 1.58 – 1.37 (m, 2H), 0.89 (t, *J* = 7.4 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 206.80, 163.39, 137.94, 132.24, 129.23 (2 C), 129.09 (2 C), 128.37, 127.32 (2 C), 124.21, 119.56 (2 C), 108.30, 100.86, 30.25, 21.61, 14.03.

R_f = 0.36 (pentane:Et_2O 9:1) [UV] [$KMnO_4$]

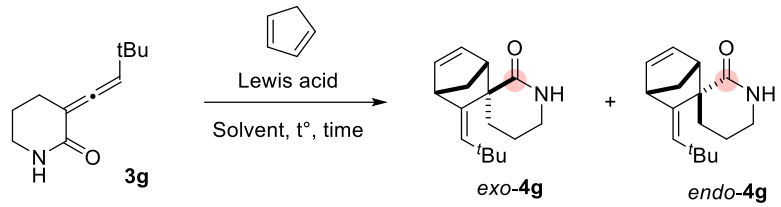
IR: $\tilde{\nu}$ [cm^{-1}] = 3269, 3059, 2956, 2928, 2869, 1933, 1640, 1596, 1523, 1498, 1459, 1439, 1374, 1317, 1237, 1195, 1127, 1073, 1029, 1001, 914, 880, 831, 767, 752, 690.

Mp: 64°C

HRMS (ESI): calculated for $C_{19}H_{20}NO^+$, $[M+H]^+$ = 278.1539; found = 278,1541.

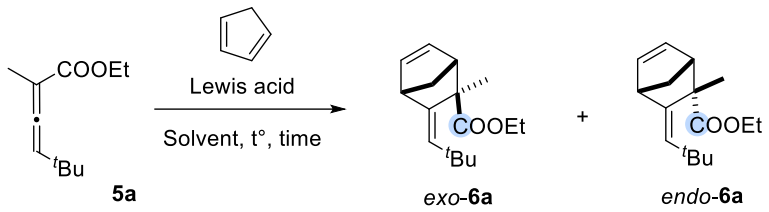
4. Diels-Alder reactions

Optimization of the reaction conditions:



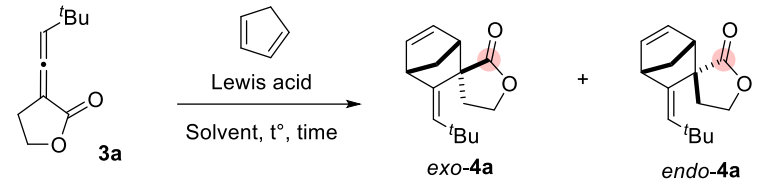
Entry	Solvent	Lewis acid	Temp. (°C), time (h)	Conversion	Ratio *exo:endo*
1	Toluene	-	70°C, 16h	18%	~6:1
2	MeOH	-	70°C, 16h	3%	~10:1
3	1-Butyl-3-methylimidazolium Tetrafluoroborate	-	70°C, 16h	8%	~9:1
4	5M $LiClO_4$ in Et_2O	-	rt, 16h	-	-[a]
5	Toluene	$LiBF_4$	70°C, 16h	100%	~4:1[a]
6	Toluene	$ZnCl_2$	rt, 16h	100%	~4:1[a]
7	Toluene	$AlCl_3$	-78°C to rt, 16h	100%	~4:1[a]
8	Toluene	BBr_3	-78°C to rt, 16h	100%	~4:1[a]
9	Toluene	Cu(I)Cl	70°C, 16h	-	-[a]
10	Toluene	$Cu(II)(BF_4)_2$	70°C, 16h	-	-[a]
11	Toluene	I_2	70°C, 16h	-	-[a]
12	Toluene	$B(C_6F_5)_3$	rt, 16h	100%	~3:1
13	Toluene	$Eu(fod)_3$	70°C, 16h	100%	~4:1

The *exo:endo* ratio was obtained by integrating the alkene proton of the products in the ^{1}H-NMR spectrum of the crude reaction mixture. [a] Significant degradation or side-reactions were observed.



Entry	Solvent	Lewis acid	Temp. (°C), time (h)	Conversion	Ratio *exo:endo*
1	Toluene	$Eu(fod)_3$	70°C, 16h	100%	~1:2
2	Toluene	$B(C_6F_5)_3$	70°C, 16h	100%	- [a]
3	Toluene	Et_2AlCl	0°C to rt, 4h	100%	~6:20
4	Toluene	$EtAlCl_2$	0°C to rt, 4h	100%	~1:4

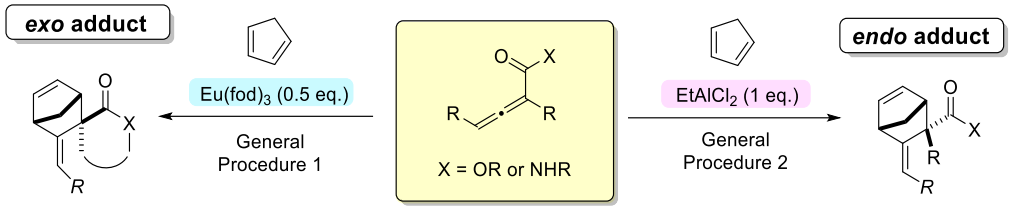
The *exo:endo* ratio was obtained by integrating the alkene proton of the products in the ^{1}H-NMR spectrum of the crude reaction mixture. [a] Complete degradation was observed.



Entry	Solvent	Lewis acid	Temp. (°C), time (h)	Conversion	Ratio *exo:endo*
1	Toluene	$Eu(fod)_3$	70°C, 16h	100%	~3:2
2	Toluene	$EtAlCl_2$	0°C to rt, 4h	100%	~3:1

The *exo:endo* ratio was obtained by integrating the alkene proton of the products in the ^{1}H-NMR spectrum of the crude reaction mixture.

Diels-Alder reactions: general procedures



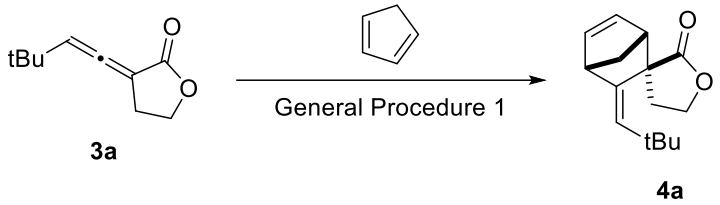
General procedure 1: Synthesis of *exo* Diels-Alder products

The allene was dissolved in the specified solvent (0.15 M concentration) under argon. $Eu(fod)_3$ (0.5 eq.) was added, followed by freshly cracked cyclopentadiene (4 eq.). The reaction was stirred at the specified temperature until reaction completion. The solvent was removed under reduced pressure, and the residue was purified by flash chromatography using the specified eluent to afford the Diels-Alder products. In the following examples, the major *exo* isomer elutes first (less polar) and the minor *endo* isomer elutes second (more polar). When a mixture was obtained, the ratio of *endo:exo* isomers was determined by NMR integration of the alkene proton.

General procedure 2: Synthesis of *endo* Diels-Alder products

The allene was dissolved in the specified solvent (0.15 M concentration) under argon and cooled to 0°C. $EtAlCl_2$ 1M in hexanes (1 eq.) was injected, followed by freshly cracked cyclopentadiene (4 eq.). The reaction was stirred at the specified temperature until reaction completion. Rochelle salt sat. sol. was added, and the mixture was stirred vigorously for 10 min. The layers were separated, and the aqueous layer was extracted with the specified solvent (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was purified by flash chromatography using the specified eluent to afford the Diels-Alder products. In the following examples, the minor *exo* isomer elutes first (less polar) and the major *endo* isomer elutes second (more polar). When a mixture was obtained, the ratio of *endo:exo* isomers was determined by NMR integration of the alkene proton.

(*Z*)-3-(2,2-dimethylpropylidene)-4',5'-dihydro-2'H-spiro[bicyclo[2.2.1]heptane-2,3'-furan]-5-en-2'-one (4a)

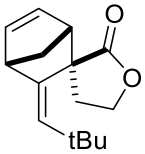


3a 4a

According to General Procedure 1: **3a** (100 mg, 0.60 mmol, 1 eq.) was reacted in toluene as the solvent for 16 h at 80°C. After evaporation of the solvent, the crude was purified by column chromatography (eluting with pentane:ether 4:1) to afford the following products in order of elution:

- *Exo*-**4a** (major isomer, white solid, 85 mg, 0.36 mmol, 61% yield)
- A mixture of *exo:endo* **4a** 17:83 (white solid, 36 mg, 0.15 mmol, 26% yield)

Total Diels-Alder products: 121 mg, 0.52 mmol, 87% yield. Ratio: *exo:endo* 3:1



Compound *exo*-**4a**: white solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ 6.38 (dd, *J* = 5.5, 3.0 Hz, 1H), 6.21 (dd, *J* = 5.6, 2.9 Hz, 1H), 5.51 (s, 1H), 4.38 (td, *J* = 9.4, 1.6 Hz, 1H), 4.28 (ddd, *J* = 11.0, 9.2, 7.2 Hz, 1H), 3.18 (s, 1H), 3.08 (s, 1H), 2.63 (dt, *J* = 13.6, 10.3 Hz, 1H), 2.26 (dt, *J* = 8.8, 1.6 Hz, 1H), 2.00 (ddd, *J* = 13.7, 7.2, 1.6 Hz, 1H), 1.50 (dt, *J* = 8.8, 1.8 Hz, 1H), 1.04 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 180.66, 140.02, 139.12, 134.41, 134.16, 64.75, 56.51, 52.00, 51.92, 46.66, 36.23, 33.73, 31.03 (3 C).

R_f = 0.45 (pentane:Et_2O 4:1) [$KMnO_4$]

Mp: 101°C

IR: $\tilde{\nu}$ [cm^{-1}] = 3059, 2981, 2959, 2938, 2915, 2866, 1751, 1622, 1510, 1476, 1395, 1364, 1346, 1326, 1278, 1222, 1213, 1178, 1163, 1121, 1107, 1070, 1054, 1024, 970, 960, 945, 923, 910, 873, 833, 793, 770, 746, 720, 696, 652.

HRMS (ESI): calculated for $C_{15}H_{21}O_2^+$, $[M+H]^+$ = 233.1536; found = 233.1537.

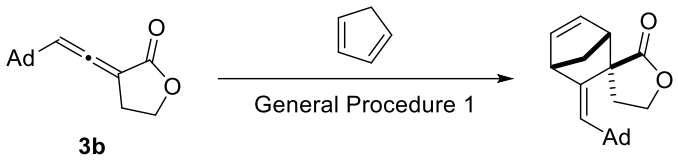
According to General Procedure 2: **3a** (100 mg, 0.60 mmol, 1 eq.) was reacted in toluene as the solvent for 4 h at 0°C → rt. After quenching, the aqueous layer was extracted with Et_2O.

The crude was purified by column chromatography (eluting with pentane:ether 4:1) to afford the following products in order of elution:

- *Exo*-**4a** (major isomer, white solid, 62 mg, 0.27 mmol, 44% yield)
- A mixture of *exo:endo* **4a** 2:3 (transparent oil, 15 mg, 0.06 mmol, 11% yield)
- *Endo*-**4a** (minor isomer, transparent oil which slowly solidifies, 31 mg, 0.13 mmol, 22% yield)

Total Diels-Alder products: 108 mg, 0.46 mmol, 77% yield. Ratio: *exo:endo* 3:2

(*Z*)-3-((-adamantan-1-yl)methylene)-4',5'-dihydro-2'H-spiro[bicyclo[2.2.1]heptane-2,3'-furan]-5-en-2'-one (4b)

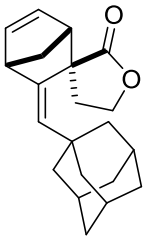


3b **4b**

According to <u>General Procedure 1:</u> **3b** (192 mg, 0.78 mmol, 1 eq.) was reacted in toluene as the solvent for 16 h at 80°C. After evaporation of the solvent, the crude was purified by column chromatography (eluting with pentane:ether 9:1 → 4:1) to afford the following products in order of elution:

- *Exo*-**4b** (major isomer, white solid, 164 mg, 0.53 mmol, 67% yield)
- A mixture of *exo:endo* **4b** 17:83 (white solid, 62 mg, 0.20 mmol, 25% yield)

Total Diels-Alder products: 226 mg, 0.73 mmol, 93% yield. Ratio: *exo:endo* 77:23



Compound *exo*-**4b**: white solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ 6.39 (dd, *J* = 5.6, 3.1 Hz, 1H), 6.21 (dd, *J* = 5.6, 2.9 Hz, 1H), 5.30 (s, 1H), 4.40 (td, *J* = 9.4, 1.6 Hz, 1H), 4.28 (ddd, *J* = 11.0, 9.1, 7.2 Hz, 1H), 3.18 (s, 1H), 3.08 (s, 1H), 2.69 (dt, *J* = 13.5, 10.3 Hz, 1H), 2.27 (dd, *J* = 8.7, 1.8 Hz, 1H), 2.01 (ddd, *J* = 13.7, 7.3, 1.7 Hz, 1H), 1.97 – 1.91 (m, 3H), 1.72 – 1.57 (m, 12H), 1.51 (dt, *J* = 8.9, 1.8 Hz, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 180.90, 140.12, 139.36, 135.00, 134.40, 64.77, 56.75, 52.24, 52.01, 46.84, 42.85 (3 C), 36.84, 36.79 (3 C), 35.92, 28.61 (3 C).

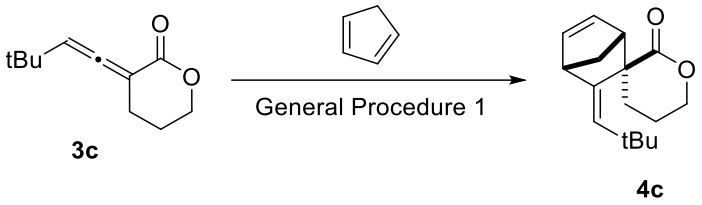
R_f = 0.38 (pentane:ether 4:1) [$KMnO_4$]

Mp: 175°C

IR: $\tilde{\nu}$ [cm^{-1}] = 2980, 2897, 2851, 1752, 1448, 1377, 1323, 1206, 1166, 1099, 1051, 1025, 986, 972, 958, 936, 911, 856, 830, 799, 744, 722, 695.

HRMS (ESI): calculated for $C_{42}H_{53}O_4^+$, $[2M+H]^+$ = 621.3938; found = 621.3961

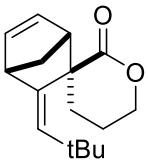
(*Z*)-3-(2,2-dimethylpropylidene)-5',6'-dihydro-2'H,4'H-spiro[bicyclo[2.2.1]heptane-2,3'-pyran]-5-en-2'-one (4c)



According to <u>General Procedure 1</u>: **3c** (53 mg, 0.29 mmol, 1 eq.) was reacted in toluene as the solvent for 16 h at 80°C. After evaporation of the solvent, the crude was purified by column chromatography (eluting with pentane:ether 4:1 → 7:3) to afford the following products in order of elution:

- *Exo*-**4c** (major isomer, white solid, 36 mg, 0.15 mmol, 50% yield)
- A mixture of *exo:endo* **4c** 15:85 (transparent oil, 24 mg, 0.10 mmol, 33% yield)

Total Diels-Alder products: 60 mg, 0.24 mmol, 83% yield. Ratio: *exo:endo* 67:33



Compound *exo*-**4c**: crystalline white solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ 6.42 (dd, *J* = 5.6, 3.1 Hz, 1H), 6.26 (dd, *J* = 5.6, 2.9 Hz, 1H), 5.63 (s, 1H), 4.75 – 4.63 (m, 2H), 3.48 (s, 1H), 3.31 (s, 1H), 2.71 (d, *J* = 8.7 Hz, 1H), 2.61 – 2.46 (m, 1H), 2.29 – 2.13 (m, 1H), 1.97 – 1.84 (m, 2H), 1.60 (d, *J* = 8.7 Hz, 1H), 1.20 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 139.82, 139.20, 134.00, 133.75, 71.13, 56.71, 54.09, 53.06, 47.21, 33.82, 33.57, 31.54 (3 C), 21.47.

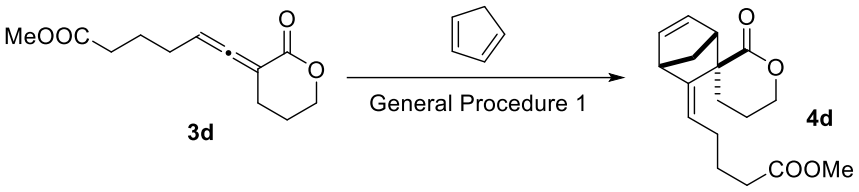
R_f = 0.23 (pentane:Et_2O 4:1) [$KMnO_4$]

Mp: 116°C

IR: ṽ [cm^{-1}] = 3064, 2958, 1719, 1624, 1510, 1474, 1393, 1346, 1333, 1323, 1274, 1247, 1225, 1199, 1176, 1154, 1115, 1105, 1084, 1073, 1033, 1016, 991, 965, 912, 862, 833, 792, 755, 737, 711, 689.

HRMS (ESI): calculated for $C_{16}H_{23}O_2^+$, $[M+H]^+$ = 247.1693; found = 247.1706.

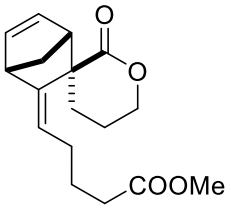
Methyl (Z)-5-(-2'-oxo-5',6'-dihydro-2'H,4'H-spiro[bicyclo[2.2.1]heptane-2,3'-pyran]-5-en-3-ylidene) pentanoate (4d)



According to General Procedure 1: **3d** (47 mg, 0.21 mmol, 1 eq.) was reacted in toluene as the solvent for 16 h at 80°C. After evaporation of the solvent, the crude was purified by column chromatography (eluting with pentane:ether 2:3) to afford the following products in order of elution:

- *Exo*-**4d** (major isomer, transparent oil, 20 mg, 0.07 mmol, 33% yield)
- A mixture of *exo:endo* **4d** 1:3 (transparent oil, 18 mg, 0.06 mmol, 30% yield)

Total Diels-Alder products: 38 mg, 0.13 mmol, 62% yield. Ratio: *exo:endo* 63:37



Compound *exo*-**4d**: transparent oil.

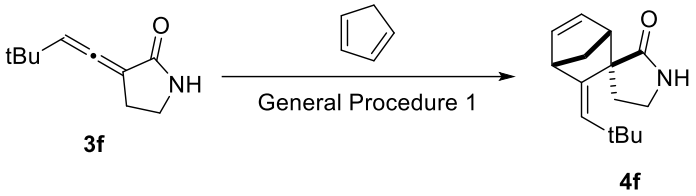
^{1}H NMR (400 MHz, $CDCl_3$): δ 6.28 (dd, *J* = 5.6, 3.1 Hz, 1H), 6.16 (dd, *J* = 5.6, 2.9 Hz, 1H), 5.36 (t, *J* = 7.4 Hz, 1H), 4.57 – 4.32 (m, 2H), 3.65 (s, 3H), 3.20 (dd, *J* = 18.3, 1.4 Hz, 2H), 2.41 – 2.24 (m, 2H), 2.20 (dt, *J* = 8.7, 1.7 Hz, 1H), 2.08 – 1.88 (m, 4H), 1.85 – 1.63 (m, 4H), 1.58 (dt, *J* = 8.6, 1.7 Hz, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 174.55, 174.12, 145.13, 138.50, 133.94, 121.27, 70.46, 53.32, 52.69, 51.85, 51.61, 47.40, 33.62, 31.42, 30.34, 24.69, 21.42.

R_f = 0.37 (pentane:ether 2:3) [$KMnO_4$]

IR: ṽ [cm^{-1}] = 2950, 1721, 1631, 1480, 1437, 1397, 1365, 1336, 1323, 1266, 1244, 1223, 1201, 1150, 1106, 1082, 1061, 1013, 964, 904, 876, 833, 798, 739, 716, 662.

HRMS (ESI): calculated for $C_{17}H_{23}O_4^+$, $[M+H]^+$ = 291.1591; found = 291.1603.

(*Z*)-3-(2,2-dimethylpropylidene)spiro[bicyclo[2.2.1]heptane-2,3'-pyrrolidin]-5-en-2'-one (4f)

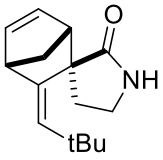


3f **4f**

According to General Procedure 1: **3f**[24] (68 mg, 0.41 mmol, 1 eq.) was reacted in toluene as the solvent for 16 h at 80°C. After evaporation of the solvent, the crude was purified by column chromatography (eluting with ether 100% → EtOAc:MeOH 9:1) to afford the following products in order of elution:

- *Exo*-**4f** (major isomer, white solid, 70 mg, 0.30 mmol, 73% yield)
- *Endo*-**4f** (yellow oil, 13 mg, 0.06 mmol, 14% yield)

Total Diels-Alder products: 83 mg, 0.36 mmol, 87% yield. Ratio: *exo:endo* 84:16



Compound *exo*-**4f**: white solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ 6.36 (dd, *J* = 5.6, 3.1 Hz, 1H), 6.23 (dd, *J* = 5.6, 2.9 Hz, 1H), 5.81 (s, 1H), 5.52 (s, 1H), 3.47 – 3.30 (m, 2H), 3.13 (s, 1H), 2.97 (s, 1H), 2.49 (dt, *J* = 13.6, 9.7 Hz, 1H), 2.37 (d, *J* = 8.5 Hz, 1H), 1.90 (dd, *J* = 13.6, 7.1 Hz, 1H), 1.45 (dt, *J* = 8.5, 1.8 Hz, 1H), 1.06 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 181.87, 140.31, 139.65, 135.32, 133.74, 56.82, 53.56, 52.45, 46.78, 38.66, 35.24, 33.67, 31.11 (3 C).

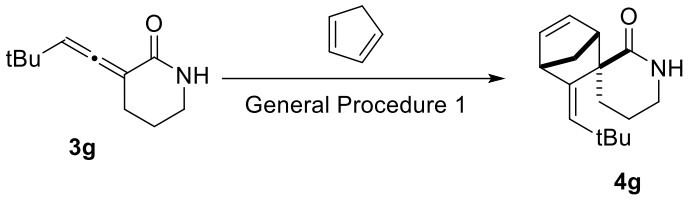
R_f = 0.56 (ether 100%) [$KMnO_4$]

Mp: 187°C (degrades)

IR: $\tilde{\nu}$ [cm^{-1}] = 3192, 3088, 2948, 2900, 1679, 1467, 1450, 1374, 1323, 1299, 1274, 1229, 1200, 1120, 1079, 1055, 1021, 971, 951, 912, 887, 861, 804, 768, 735, 703, 690, 656.

HRMS (ESI): calculated for $C_{15}H_{22}NO^+$, $[M+H]^+$ = 232.1696; found = 232.1707

(*Z*)-3-(2,2-dimethylpropylidene)spiro[bicyclo[2.2.1]heptane-2,3'-piperidin]-5-en-2'-one (4g)

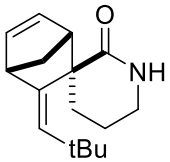


3g **4g**

According to <u>General Procedure 1:</u> **3g**[12] (28 mg, 0.16 mmol, 1 eq.) was reacted in toluene as the solvent for 16 h at 80°C. After evaporation of the solvent, the crude was purified by column chromatography (eluting with ether 100% → EtOAc:MeOH 9:1) to afford the following products in order of elution:

- *Exo*-**4g** (major isomer, white solid, 17 mg, 0.07 mmol, 44% yield)
- *Endo*-**4g** (yellow solid, 5 mg, 0.02 mmol, 13% yield)

Total Diels-Alder products: 22 mg, 0.09 mmol, 57% yield. Ratio: *exo:endo* 77:23



Compound *exo*-**4g**: white solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ 6.34 – 6.22 (m, 1H), 6.13 (dd, *J* = 6.5, 2.2 Hz, 1H), 5.85 (s, 1H), 5.47 (s, 1H), 3.47 – 3.33 (m, 2H), 3.11 (p, *J* = 1.8 Hz, 2H), 2.45 (d, *J* = 8.4 Hz, 1H), 2.12 (td, *J* = 14.0, 3.3 Hz, 1H), 1.94 – 1.78 (m, 1H), 1.77 – 1.66 (m, 1H), 1.60 (dt, *J* = 14.0, 3.6 Hz, 1H), 1.45 (dd, *J* = 8.4, 1.4 Hz, 1H), 1.06 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 177.20, 139.97, 138.49, 134.37, 133.39, 56.51, 53.73, 47.04, 43.10, 33.65, 33.46, 31.39, 19.84.

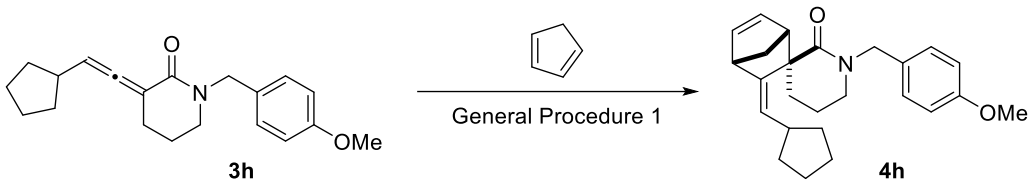
R_f = 0.79 (EtOAc 100%) [$KMnO_4$]

Mp: 166°C

IR: ṽ [cm^{-1}] = 3209, 3060, 2972, 2948, 2864, 1647, 1484, 1464, 1449, 1401, 1357, 1342, 1312, 1271, 1230, 1204, 1143, 1132, 1112, 1082, 1020, 993, 976, 961, 911, 897, 860, 836, 800, 763, 734, 680.

HRMS (ESI): calculated for $C_{16}H_{24}NO^+$, $[M+H]^+$ = 246.1852; found = 246.1861.

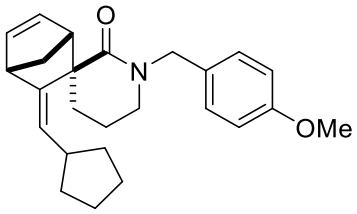
(*Z*)-3-(cyclopentylmethylene)-1'-(4-methoxybenzyl)spiro[bicyclo[2.2.1]heptane-2,3'-piperidin]-5-en-2'-one (4h)



According to General Procedure 1: **3h** (184 mg, 0.59 mmol, 1 eq.) was reacted in toluene as the solvent for 16 h at 80°C. After evaporation of the solvent, the crude was purified by column chromatography (eluting with pentane:ether 4:1 → 3:2) to afford the following products in order of elution:

- *Exo*-**4h** (major isomer, white solid, 126 mg, 0.33 mmol, 56% yield)
- A mixture of *exo:endo* **4h** 1:1 (transparent oil, 20 mg, 0.05 mmol, 9% yield)
- *Endo*-**4h** (transparent oil, 27 mg, 0.07 mmol, 12% yield)

Total Diels-Alder products: 173 mg, 0.46 mmol, 78% yield. Ratio: *exo:endo* 79:21



Compound *exo*-**4h**: white crystalline solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.23 (d, *J* = 8.6 Hz, 2H), 6.83 (d, *J* = 8.6 Hz, 2H), 6.24 (dd, *J* = 5.6, 3.1 Hz, 1H), 6.13 (dd, *J* = 5.5, 2.9 Hz, 1H), 5.21 (d, *J* = 10.3 Hz, 1H), 5.09 (d, *J* = 14.1 Hz, 1H), 3.98 (d, *J* = 14.1 Hz, 1H), 3.79 (s, 3H), 3.35 – 3.22 (m, 2H), 3.18 (d, *J* = 1.5 Hz, 1H), 3.07 (d, *J* = 1.6 Hz, 1H), 2.52 (d, *J* = 8.2 Hz, 1H), 2.24 – 2.07 (m, 1H), 1.94 – 1.76 (m, 3H), 1.72 – 1.51 (m, 5H), 1.50 – 1.37 (m, 2H), 1.28 – 1.07 (m, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 173.61, 158.96, 143.61, 138.08, 134.84, 130.51, 129.86 (2 C), 126.52, 113.93 (2 C), 55.40, 53.55, 52.65, 51.98, 50.64, 48.01, 47.84, 42.50, 33.76, 33.26, 33.22, 25.48, 25.39, 20.13.

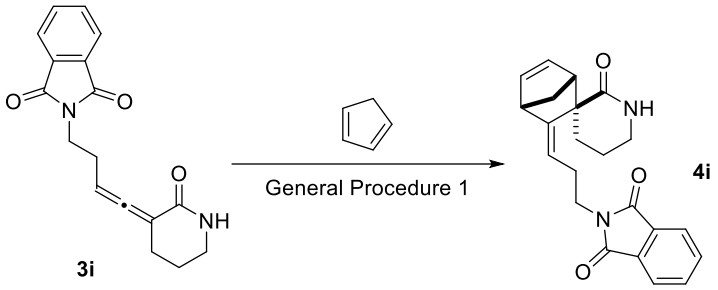
R_f = 0.6 (pentane:ether 3:2) [UV] [$KMnO_4$]

Mp: 104°C

IR: $\tilde{\nu}$ [cm^{-1}] = 3058, 2958, 2897, 2872, 1629, 1585, 1510, 1485, 1451, 1440, 1419, 1347, 1321, 1306, 1252, 1236, 1204, 1187, 1175, 1107, 1023, 1008, 969, 933, 913, 899, 879, 853, 830, 802, 753, 737, 719, 675.

HRMS (ESI): calculated for $C_{25}H_{32}NO_2^+$, $[M+H]^+$ = 378.2428; found = 378.2447.

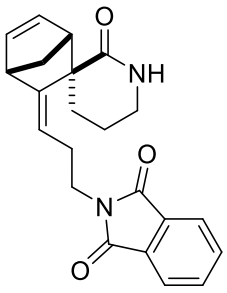
2-((Z)-3-(2'-oxospiro[bicyclo[2.2.1]heptane-2,3'-piperidin]-5-en-3-ylidene)propyl)isoindoline-1,3-dione (4i)



According to General Procedure 1: **3i** (145 mg, 0.49 mmol, 1 eq.) was reacted in toluene as the solvent for 16 h at 80°C. After evaporation of the solvent, the crude was purified by column chromatography (eluting with pentane:EtOAc 1:9) to afford the following products in order of elution:

- *Exo*-**4i** (major isomer, white solid, 92 mg, 0.25 mmol, 52% yield)
- A mixture of *exo:endo* **4i** 72:28 (transparent oil, 6 mg, 0.02 mmol, 3% yield)
- *Endo*-**4i** (transparent oil, 23 mg, 0.06 mmol, 13% yield)

Total Diels-Alder products: 121 mg, 0.33 mmol, 68% yield. Ratio: *exo:endo* 87:13



Compound *exo*-**4i**: white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.81 (dd, *J* = 5.4, 3.1 Hz, 2H), 7.69 (dd, *J* = 5.5, 3.0 Hz, 2H), 6.18 (ddd, *J* = 25.9, 5.5, 2.9 Hz, 2H), 5.70 (s, 1H), 5.41 (t, *J* = 7.7 Hz, 1H), 3.76 (ddd, *J* = 13.5, 8.4, 6.7 Hz, 1H), 3.60 (ddd, *J* = 13.5, 8.3, 7.0 Hz, 1H), 3.54 – 3.44 (m, 1H), 3.42 – 3.34 (m, 1H), 3.22 (d, *J* = 1.5 Hz, 1H), 3.07 (s, 1H), 2.40 – 2.26 (m, 3H), 2.01 (td, *J* = 13.4, 3.5 Hz, 1H), 1.89 – 1.69 (m, 2H), 1.59 (d, *J* = 13.8 Hz, 1H), 1.53 (d, *J* = 8.4 Hz, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 175.82, 168.49 (2 C), 148.08, 137.65, 135.18, 133.95 (2 C), 132.37 (2 C), 123.19 (2 C), 117.18, 53.25, 52.87, 52.03, 47.69, 43.15, 37.57, 32.17, 30.12, 19.85.

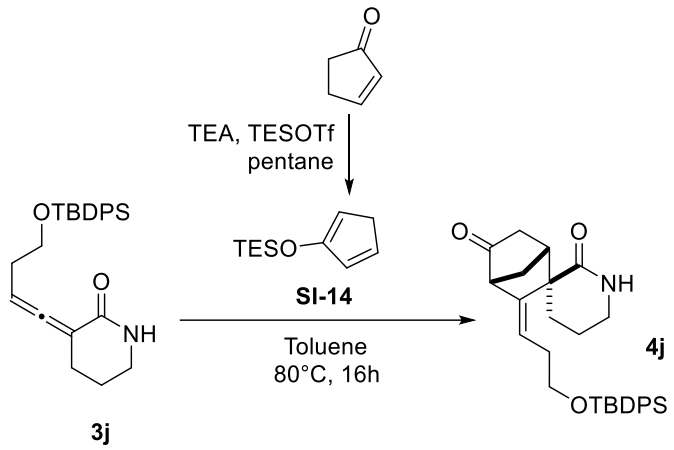
R_f = 0.46 (pentane:EtOAc 1:9) [UV] [$KMnO_4$]

Mp: 219°C

IR: ṽ [cm^{-1}] = 3191, 3061, 2937, 1766, 1709, 1656, 1492, 1465, 1433, 1393, 1357, 1319, 1248, 1186, 1161, 1109, 1081, 1051, 1031, 1006, 971, 858, 839, 796, 741, 723.

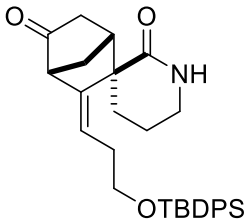
HRMS (ESI): calculated for $C_{22}H_{23}N_2O_3^+$, $[M+H]^+$ = 363.1703; found = 363.1717.

(*Z*)-3-(3-((tert-butyldiphenylsilyl)oxy)propylidene)spiro[bicyclo[2.2.1]heptane-2,3'-piperidine]-2',5-dione (4j)



Preparation of TES enol ether **SI-14**: cyclopentenone (0.14 ml, 1.71 mmol, 6 eq.) and TEA (0.28 ml, 2.00 mmol, 7 eq.) were dissolved in dry pentane (3 ml) under argon. The reaction was cooled to 0°C (ice bath) and stirred for 5 minutes. Then TESOTf (0.39 ml, 1.71 mmol, 6 eq.) was added slowly and with vigorous stirring. The ice bath was removed. After 20 min, the solid salt of TEA*TfOH had precipitated. The pentane layer was removed and extracted with a phosphate buffer until neutral pH (3×). The organic layer was dried over Na_2SO_4, filtered, and the solvents were removed *in vacuo* to give the TES enol ether **SI-14** as a transparent oil. Due to its instability, it was used immediately and without further purification.

3j (116 mg, 0.28 mmol, 1 eq.) was dissolved in toluene (2 ml) under argon. $Eu(fod)_3$ (148 mg, 0.14 mmol, 0.5 eq.) was added, followed by the freshly prepared enol ether **SI-14**. The reaction was heated to 80°C. After 16h, the reaction was diluted with MeOH (2 ml) and HCl 1M (0.5 ml), and stirred for 10 min to cleave the enol ether. Solid $NaHCO_3$ was added to quench the HCl until bubbling ceased. Then the reaction was filtered, and the filtrate was concentrated *in vacuo*. The residue was purified by flash chromatography (eluting with EtOAc 100%) to afford **4j** as a transparent oil (54 mg, 0.11 mmol, 39%).



Compound **4j**: transparent oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.73 – 7.55 (m, 4H), 7.50 – 7.35 (m, 6H), 5.88 (s, 1H), 5.63 (t, *J* = 7.6 Hz, 1H), 3.80 – 3.57 (m, 2H), 3.45 – 3.30 (m, 2H), 3.12 (s, 1H), 2.89 (d, *J* = 2.8 Hz, 1H), 2.70 (d, *J* = 8.4 Hz, 1H), 2.39 – 1.96 (m, 5H), 1.85 – 1.66 (m, 4H), 1.06 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 211.82,

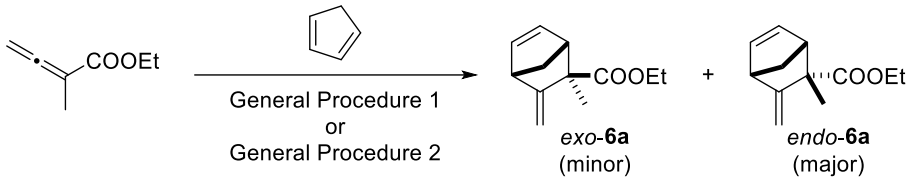
175.00, 139.88, 135.72 (2 C), 135.70 (2 C), 133.92 (2 C), 129.73 (2 C), 127.78 (4 C), 123.32, 63.11, 61.85, 51.19, 44.12, 42.71, 40.93, 36.22, 33.58, 28.83, 27.01 (3 C), 19.32, 19.06.

R_f = 0.37 (EtOAc 100%) [UV] [$KMnO_4$]

IR: $\tilde{\nu}$ [cm^{-1}] = 3206, 3071, 2954, 2858, 2244, 1744, 1655, 1589, 1489, 1472, 1462, 1428, 1409, 1389, 1350, 1317, 1302, 1271, 1205, 1141, 1106, 1093, 1008, 993, 979, 910, 823, 791, 730, 701.

HRMS (ESI): calculated for $C_{30}H_{37}NNaO_3Si^+$, $[M+Na]^+$ = 510.2435; found = 510.2446.

Ethyl-2-methyl-3-methylenebicyclo[2.2.1]hept-5-ene-2-carboxylate (6a)



According to General Procedure 2: ethyl 2-methylbuta-2,3-dienoate[25] (152 mg, 1.20 mmol, 1 eq.) was reacted in toluene as the solvent for 4 h at rt. After quenching, the aqueous layer was extracted with Et_2O. The crude was purified by column chromatography (eluting with pentane:ether 98:2) to afford the following products in order of elution:

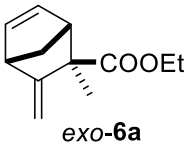
- A mixture of *exo:endo* **6a** 3:2 (transparent oil, 60 mg, 0.31 mmol, 26% yield).
- *Endo*-**6a** (major isomer, transparent oil, 129 mg, 0.67 mmol, 56% yield)

Total Diels-Alder products: 189 mg, 0.98 mmol, 82% yield. Ratio: *exo:endo* 1:4

A pure sample of the minor *exo*-**6a** product was obtained by using General Procedure 1: ethyl 2-methylbuta-2,3-dienoate[25] (143 mg, 1.13 mmol, 1 eq.) was reacted in toluene as the solvent for 16h at 80°C. The crude was purified by column chromatography (eluting with pentane:ether 98:2) to afford the following products in order of elution:

- *Exo*-**6a** (minor isomer, transparent oil, 44 mg, 0.23 mmol, 20% yield)
- A mixture of *exo:endo* **6a** 3:5 (transparent oil, 70 mg, 0.36 mmol, 32% yield)
- *Endo*-**6a** (major isomer, transparent oil, 62 mg, 0.32 mmol, 28% yield)

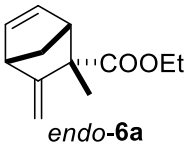
Total Diels-Alder products: 176 mg, 0.91 mmol, 81% yield. Ratio: *exo:endo* 2:3



exo-**6a** (minor)

exo-**6a**: transparent oil.

^{1}H NMR (500 MHz, $CDCl_3$): δ 6.20 (dd, *J* = 5.7, 3.1 Hz, 1H), 6.13 (dd, *J* = 5.6, 3.0 Hz, 1H), 5.11 (s, 1H), 5.00 (s, 1H), 4.15 (q, *J* = 7.2 Hz, 2H), 3.18 (dd, *J* = 13.6, 1.4 Hz, 2H), 1.70 (dt, *J* = 8.9, 1.6 Hz, 1H), 1.66 (dt, *J* = 8.9, 1.8 Hz, 1H), 1.26 (t, *J* = 7.1 Hz, 3H), 1.23 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 176.16, 154.13, 137.42, 135.25, 106.90, 60.86, 53.65, 51.64, 50.75, 49.87, 25.61, 14.26. The NMR data were in accordance with the literature.[26]

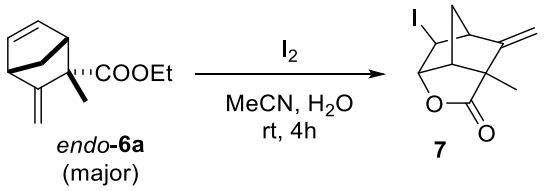


endo-**6a** (major)

endo-**6a**: transparent oil.

^{1}H NMR (500 MHz, $CDCl_3$): δ 6.21 (dd, *J* = 5.6, 2.8 Hz, 1H), 6.16 (dd, *J* = 5.5, 3.0 Hz, 1H), 5.14 (s, 1H), 5.05 (s, 1H), 4.14 – 3.97 (m, 2H), 3.20 (s, 1H), 2.93 (s, 1H), 1.69 (dt, *J* = 8.8, 1.5 Hz, 1H), 1.60 (dt, *J* = 8.8, 1.7 Hz, 1H), 1.49 (s, 3H), 1.23 (t, *J* = 3.7 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 175.60, 153.97, 137.76, 136.15, 106.89, 60.51, 54.10, 52.04, 51.25, 47.04, 26.62, 14.29. The NMR data were in accordance with the literature.[26]

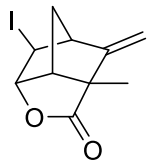
6-iodo-3-methyl-7-methylenehexahydro-2H-3,5-methanocyclopenta[b]furan-2-one (7)



Iodolactonization: structure confirmation of *endo*-**6a**.

endo-**6a** (128 mg, 0.66 mmol, 1 eq.) was dissolved in MeCN (6.25 ml) and water (0.25 ml), and iodine (828 mg, 3.26 mmol, 4.9 eq.) was added. The reaction was stirred at rt. After 4h, the reaction was quenched with 10% $Na_2S_2O_3$ and diluted with Et_2O. The layers were separated, and the aqueous layer was extracted with Et_2O (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was purified by flash chromatography (eluting with pentane:Et_2O 4:1) to afford **7** (127 mg, 0.44 mmol, 66% yield) as a white solid.

No reaction took place when *exo*-**6a** was used, confirming the structure of *endo*-**6a**.



Compound **7**: white solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ 5.25 (s, 1H), 5.16 (dd, *J* = 5.2, 1.2 Hz, 1H), 5.10 (s, 1H), 3.91 (dd, *J* = 2.6, 0.8 Hz, 1H), 3.15 (s, 1H), 2.92 (dt, *J* = 5.1, 1.4 Hz, 1H), 2.39 (dt, *J* = 11.5, 1.5 Hz, 1H), 1.94 (dd, *J* = 11.5, 2.0 Hz, 1H), 1.28 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 177.94, 151.47, 110.00, 86.98, 55.71, 52.31, 48.47, 35.76, 29.62, 17.46.

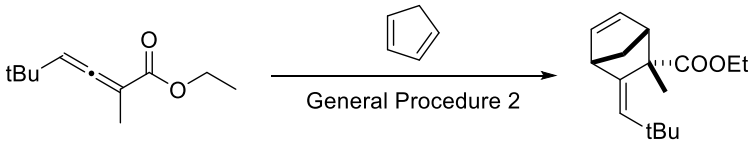
R_f = 0.45 (pentane:Et_2O 4:1) [$KMnO_4$]

Mp: 105°C

IR: $\tilde{\nu}$ [cm^{-1}] = 2984, 2968, 2881, 1825, 1784, 1652, 1462, 1448, 1402, 1375, 1342, 1309, 1289, 1279, 1253, 1236, 1218, 1195, 1155, 1141, 1124, 1087, 1068, 1002, 971, 939, 908, 875, 826, 769, 752, 728, 714, 672.

HRMS (EI): calculated for $C_{10}H_{12}IO_2^+$, $[M+H]^+$ = 290.9876; found = 290.9884

Ethyl (*Z*)-3-(2,2-dimethylpropylidene)-2-methylbicyclo[2.2.1]hept-5-ene-2-carboxylate (6b)

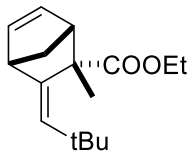


5b **6b**

According to <u>General Procedure 2</u>: **5b** (156 mg, 0.86 mmol, 1 eq.)[27] was reacted in toluene as the solvent for 4 h at 0°C → rt. After quenching, the aqueous layer was extracted with Et_2O. The crude was purified by column chromatography (eluting with pentane:ether 95:5) to afford the following products in order of elution:

- A mixture of *exo:endo* **6b** 35:65 (transparent oil, 72 mg, 0.34 mmol, 34% yield)
- *Endo*-**6b** (major isomer, transparent oil, 115 mg, 0.46 mmol, 54% yield)

Total Diels-Alder products: 187 mg, 0.75 mmol, 88% yield. Ratio: *exo:endo* 13:87



Compound **6b:** transparent oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ 6.26 (dd, *J* = 5.6, 3.1 Hz, 1H), 5.93 (dd, *J* = 5.6, 2.8 Hz, 1H), 5.35 (s, 1H), 4.17 – 3.91 (m, 2H), 3.09 (s, 1H), 2.80 (s, 1H), 1.74 (dt, *J* = 8.6, 0.8 Hz, 1H), 1.64 (s, 3H), 1.44 (dt, *J* = 8.6, 1.7 Hz, 1H), 1.21 (t, *J* = 7.1 Hz,

3H), 1.01 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 176.53, 139.44, 137.54, 134.16, 133.02, 60.37, 57.81, 57.12, 51.30, 47.44, 33.63, 30.76 (3 C), 26.24, 14.32.

R_f = 0.45 (pentane:Et_2O 95:5) [$KMnO_4$]

IR: ṽ [cm^{-1}] = 3066, 2976, 2953, 2905, 2873, 1738, 1716, 1572, 1479, 1464, 1447, 1393, 1379, 1361, 1324, 1269, 1244, 1200, 1169, 1114, 1097, 1051, 1026, 995, 973, 950, 908, 860, 791, 745, 711, 677.

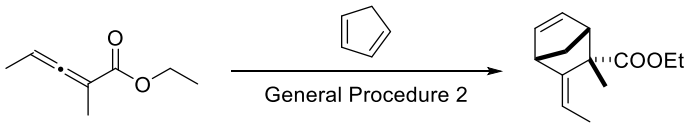
HRMS (ESI): calculated for $C_{16}H_{25}O_2^+$, $[M+H]^+$ = 249.1849; found = 249.1847.

According to General Procedure 1: **5b** (100 mg, 0.55 mmol, 1 eq.) was reacted in toluene as the solvent for 16 h at 80°C. After evaporation of the solvent, the crude was purified by column chromatography (eluting with pentane:ether 95:5) to afford the following products in order of elution:

- *Exo*-**6b** (minor isomer, transparent oil, 19 mg, 0.08 mmol, 14% yield)
- A mixture of *exo:endo* **6b** 2:3 (transparent oil, 51 mg, 0.21 mmol, 37% yield)
- *Endo*-**6b** (major isomer, transparent oil, 46 mg, 0.18 mmol, 34% yield)

Total Diels-Alder products: 116 mg, 0.47 mmol, 85% yield. Ratio: *exo:endo* 1:2

Ethyl (*Z*)-3-ethylidene-2-methylbicyclo[2.2.1]hept-5-ene-2-carboxylate (6c)

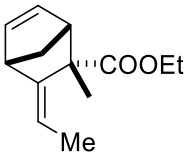


5c **6c**

According to General Procedure 2: **5c**[25] (100 mg, 0.71 mmol, 1 eq.) was reacted in toluene as the solvent for 4 h at 0°C → rt. After quenching, the aqueous layer was extracted with Et_2O. The crude was purified by column chromatography (eluting with pentane:ether 96:4) to afford the following products in order of elution:

- A mixture of *exo:endo* **6c** 1:1 (transparent oil, 42 mg, 0.20 mmol, 29% yield)
- *Endo*-**6c** (major isomer, transparent oil, 68 mg, 0.33 mmol, 46% yield)

Total Diels-Alder products: 110 mg, 0.75 mmol, 75% yield. Ratio: *exo:endo* 25:75



Compound **6c:** transparent oil.

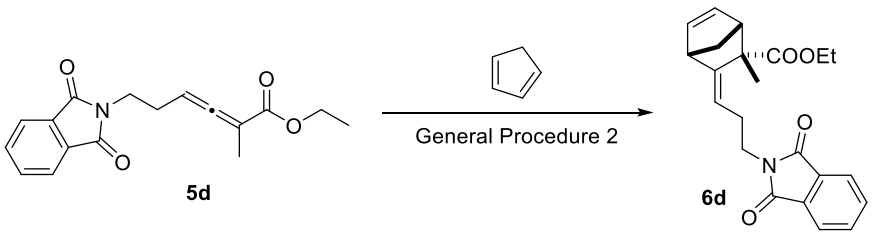
^{1}H NMR (400 MHz, $CDCl_3$): δ 6.20 (dd, *J* = 5.6, 3.0 Hz, 1H), 6.01 (dd, *J* = 5.6, 2.8 Hz, 1H), 5.51 (q, *J* = 7.0 Hz, 1H), 4.20 – 3.98 (m, 2H), 3.11 (s, 1H), 2.87 (s, 1H), 1.69 (dt, *J* = 8.7, 1.7 Hz, 1H), 1.64 (d, *J* = 7.0 Hz, 3H), 1.57 (s, 3H), 1.51 (dt, *J* = 8.7, 1.7 Hz, 1H), 1.22 (t, *J* = 7.1 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 175.39, 143.99, 137.01, 134.76, 117.26, 60.40, 54.43, 53.12, 52.51, 47.03, 23.61, 15.93, 14.40.

R_f = 0.43 (pentane:Et_2O 96:4) [$KMnO_4$]

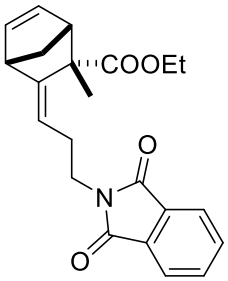
IR: $\tilde{\nu}$ [cm^{-1}] = 2979, 2873, 1738, 1716, 1465, 1446, 1375, 1321, 1263, 1240, 1168, 1116, 1093, 1025, 1006, 974, 939, 907, 884, 861, 833, 788, 730.

HRMS (ESI): calculated for $C_{13}H_{19}O_2^+$, $[M+H]^+$ = 207.1380; found = 207.1378.

Ethyl (*Z*)-3-(3-(1,3-dioxoisoindolin-2-yl)propylidene)-2-methylbicyclo[2.2.1]hept-5-ene-2-carboxyl-ate (6d)



According to <u>General Procedure 2</u>: **5d** (180 mg, 0.60 mmol, 1 eq.) was reacted in dichloromethane as the solvent for 4 h at 0°C → rt. After quenching, the aqueous layer was extracted with Et_2O. The crude was purified by column chromatography (eluting with pentane:ether 1:1) to afford **6d** as an inseparable mixture of *endo* and *exo* isomers (white solid, 215 mg, 0.59 mmol, 98% yield) in a ratio of 23:77 *exo:endo*.



Compound **6d**: white solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.85 (dd, *J* = 5.4, 3.1 Hz, 2H), 7.72 (dd, *J* = 5.5, 3.0 Hz, 2H), 6.26 – 6.15 (m, 1H), 6.13 – 6.08 (m, 1H, *exo*), 6.03 (dd, *J* = 5.5, 2.8 Hz, 1H, *endo*), 5.58 – 5.37 (m, 1H), 4.18 (q, *J* = 7.1 Hz, 2H, *exo*), 4.09 (qq, *J* = 7.3, 3.7 Hz, 2H, *endo*), 3.86 – 3.63 (m, 2H), 3.26 – 3.12 (m, 1H), 3.03 (s, 1H, *exo*), 2.93 – 2.83 (m, 1H, *endo*), 2.62 – 2.33 (m, 2H), 1.85 – 1.47 (m, 5H), 1.42 – 1.14 (m, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 176.03, 175.07, 168.49, 168.46, 146.62,

146.01, 137.59, 136.89, 135.20, 134.62, 133.94, 132.36, 123.23, 123.21, 118.72, 118.65, 60.99, 60.56, 54.33, 53.66, 53.28, 53.26, 53.25, 52.96, 48.28, 46.96, 37.84, 37.79, 30.10, 29.76, 24.07, 23.81, 14.36, 14.34.

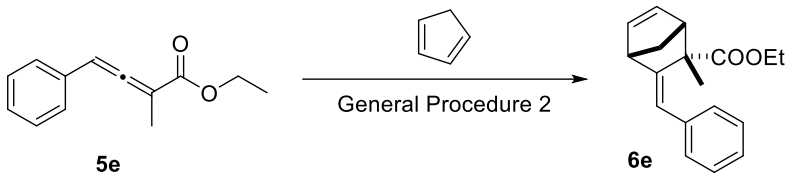
R_f = 0.57 (pentane:ether 1:1) [UV] [$KMnO_4$]

Mp: 219°C

IR: $\tilde{\nu}$ [cm^{-1}] = 2976, 1768, 1705, 1615, 1466, 1437, 1396, 1366, 1326, 1267, 1246, 1184, 1155, 1139, 1098, 1063, 1027, 1004, 985, 891, 850, 797, 764, 745, 717, 711.

HRMS (ESI): calculated for $C_{22}H_{24}NO_4^+$, $[M+H]^+$ = 366.1700; found = 366.1704.

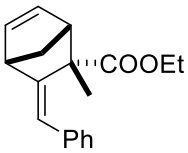
Ethyl 3-((Z)-benzylidene)-2-methylbicyclo[2.2.1]hept-5-ene-2-carboxylate (6e)



According to General Procedure 2: **5e**[25] (120 mg, 0.59 mmol, 1 eq.) was reacted in toluene as the solvent for 4 h at 0°C → rt. After quenching, the aqueous layer was extracted with Et_2O. The crude was purified by column chromatography (eluting with pentane:ether 96:4) to afford the following products in order of elution:

- A mixture of *exo:endo* **6e** 1:1 (transparent oil, 40 mg, 0.15 mmol, 25% yield)
- *Endo*-**6e** (major isomer, transparent oil, 95 mg, 0.35 mmol, 60% yield)

Total Diels-Alder products: 135 mg, 0.50 mmol, 85% yield. Ratio: *exo:endo* 15:85



Compound **6e**: transparent oil.

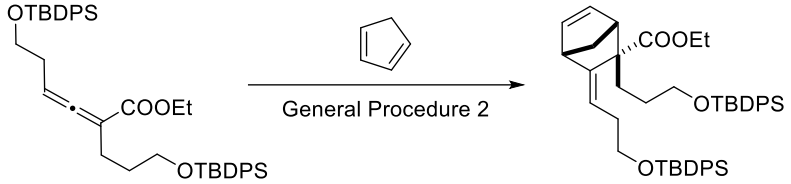
^{1}H NMR (400 MHz, $CDCl_3$): δ 77.33 – 7.14 (m, 5H), 6.60 (s, 1H), 6.35 (dd, *J* = 5.6, 3.1 Hz, 1H), 6.10 (dd, *J* = 5.6, 2.8 Hz, 1H), 4.11 (qd, *J* = 7.1, 4.9 Hz, 2H), 3.38 (s, 1H), 2.96 (s, 1H), 1.82 (d, *J* = 8.4 Hz, 1H), 1.65 (dt, *J* = 8.8, 1.7 Hz, 1H), 1.52 (s, 3H), 1.19 (t, *J* = 7.1 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 175.68, 146.08, 137.47, 136.70, 134.94, 128.72 (2 C), 128.06 (2 C), 126.43, 123.03, 60.62, 55.98, 52.85, 47.58, 22.22, 14.28.

R_f = 0.40 (pentane:Et_2O 96:4) [UV] [$KMnO_4$]

IR: ṽ [cm^{-1}] = 3062, 3024, 2978, 2873, 1733, 1713, 1597, 1570, 1494, 1465, 1447, 1375, 1323, 1264, 1243, 1177, 1165, 1120, 1097, 1047, 1023, 1002, 969, 952, 916, 896, 883, 857, 836, 809, 791, 745, 719, 696.

HRMS (ESI): calculated for $C_{18}H_{21}O_2^+$, $[M+H]^+$ = 269.1536; found = 269.1531.

Ethyl (*Z*)-2-(3-((tert-butyldiphenylsilyl)oxy)propyl)-3-(3-((tert-butyldiphenylsilyl)oxy) propylidene)bicyclo[2.2.1]hept-5-ene-2-carboxylate (6f)

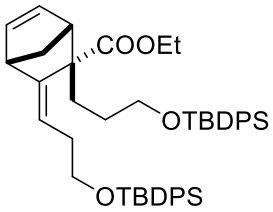


5f **6f**

According to General Procedure 2: **5f** (120 mg, 0.59 mmol, 1 eq.) was reacted in toluene as the solvent for 4 h at 0°C → rt. After quenching, the aqueous layer was extracted with Et_2O. The crude was purified by column chromatography (eluting with pentane:ether 92:8) to afford the following products in order of elution:

- A mixture of *exo:endo* **6f** 45:55 (transparent oil, 24 mg, 0.03 mmol, 23% yield)
- *Endo*-**6f** (major isomer, transparent oil, 64 mg, 0.08 mmol, 61% yield)

Total Diels-Alder products: 88 mg, 0.12 mmol, 85% yield. Ratio: *exo:endo* 13:87



Compound **6f**: transparent oil.

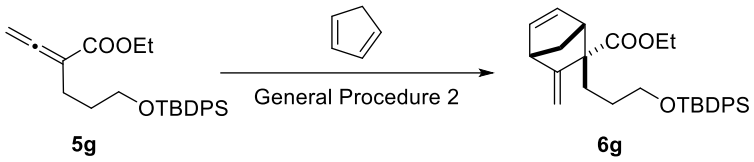
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.66 (ddt, *J* = 8.2, 6.8, 1.5 Hz, 8H), 7.46 – 7.29 (m, 12H), 6.18 (dd, *J* = 5.6, 3.0 Hz, 1H), 6.11 (dd, *J* = 5.5, 2.8 Hz, 1H), 5.49 (t, *J* = 7.4 Hz, 1H), 4.10 – 3.94 (m, 2H), 3.77 – 3.52 (m, 4H), 3.07 (d, *J* = 14.8 Hz, 2H), 2.50 (q, *J* = 6.9 Hz, 2H), 2.32 – 2.17 (m, 1H), 1.79 – 1.59 (m, 4H), 1.46 (dt, *J* = 8.7, 1.8 Hz, 1H), 1.19 (t, *J* = 7.1 Hz, 3H), 1.04 (d, *J* = 2.7 Hz, 18H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 174.65, 144.70, 137.16, 136.73, 135.75 (4 C), 135.69 (4 C), 134.26, 134.24, 134.10 (2 C), 129.70 (2 C), 129.61 (2 C), 127.76 (4 C), 127.69 (4 C), 119.81, 64.15, 64.12, 60.34, 57.54, 53.49, 49.44, 46.18, 33.73, 33.62, 28.88, 27.03 (3 C), 26.99 (3 C), 19.38, 19.33, 14.38.

R_f = 0.41 (pentane:ether 92:8) [UV] [$KMnO_4$]

IR: ṽ [cm^{-1}] = 3071, 2958, 2931, 2895, 2858, 1732, 1590, 1472, 1462, 1446, 1428, 1389, 1362, 1309, 1242, 1192, 1166, 1106, 1090, 1030, 1007, 998, 936, 857, 822, 799, 736, 699, 688.

HRMS (ESI): calculated for $C_{48}H_{61}O_4Si_2^+$, $[M+H]^+$ = 757.4103; found = 757.4110.

Ethyl 2-(3-((tert-butyldiphenylsilyl)oxy)propyl)-3-methylenebicyclo[2.2.1]hept-5-ene-2-carboxylate (6g)

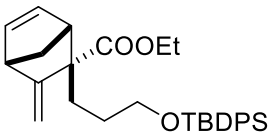


5g **6g**

According to General Procedure 2: **5g** (3049 mg, 7.46 mmol, 1 eq.) was reacted in toluene as the solvent for 4 h at 0°C → rt. After quenching, the aqueous layer was extracted with Et_2O. The crude was purified by column chromatography (eluting with pentane:ether 96:4) to afford the following products in order of elution:

- A mixture of *exo:endo* **6g** 78:22 (transparent oil, 585 mg, 1.23 mmol, 16% yield)
- *Endo*-**6g** (major isomer, transparent oil, 2266 mg, 4.77 mmol, 64% yield)

Total Diels-Alder products: 2851 mg, 6.00 mmol, 80% yield. Ratio: *exo:endo* 1:3



Compound **6g**: transparent oil.

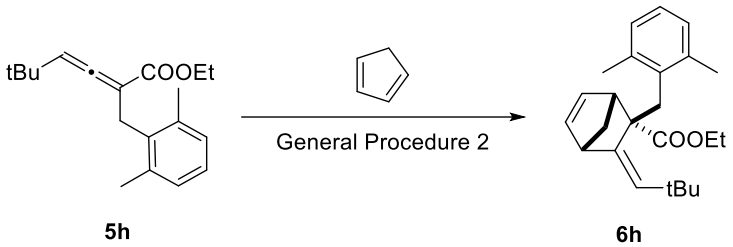
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.74 – 7.61 (m, 4H), 7.50 – 7.33 (m, 6H), 6.27 (dd, *J* = 5.5, 2.9 Hz, 1H), 6.18 (dd, *J* = 5.5, 3.1 Hz, 1H), 5.12 (s, 2H), 4.08 (qq, *J* = 10.8, 7.1 Hz, 2H), 3.71 – 3.58 (m, 2H), 3.19 (s, 1H), 3.06 (s, 1H), 2.01 (ddd, *J* = 13.7, 11.9, 5.1 Hz, 1H), 1.82 (ddd, *J* = 13.7, 12.2, 4.5 Hz, 1H), 1.71 – 1.52 (m, 6H), 1.23 (t, *J* = 7.1 Hz, 3H), 1.07 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 174.64, 153.82, 138.42, 136.38, 135.71 (4 C), 134.09 (2 C), 129.71 (2 C), 127.75 (4 C), 106.90, 63.98, 60.44, 58.23, 51.81, 48.42, 46.65, 36.78, 29.03, 26.99 (3 C), 19.35, 14.34.

$\mathbf{R_f}$ = 0.23 (pentane:ether 96:4) [UV] [$KMnO_4$]

IR: ṽ [cm^{-1}] = 3071, 2957, 2932, 2858, 1728, 1655, 1590, 1472, 1463, 1428, 1389, 1363, 1310, 1262, 1242, 1191, 1107, 1032, 998, 937, 889, 863, 823, 806, 737, 700, 687.

HRMS (ESI): calculated for $C_{30}H_{39}O_3Si^+$, $[M+H]^+$ = 475.2663; found = 475.2672.

Ethyl (*Z*)-2-(2,6-dimethylbenzyl)-3-(2,2-dimethylpropylidene)bicyclo[2.2.1]hept-5-ene-2-carboxyl-ate (6h)

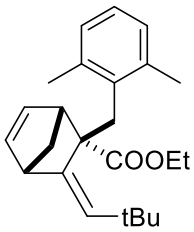


5h **6h**

According to General Procedure 2: **5h**[27] (89 mg, 0.31 mmol, 1 eq.) was reacted in toluene as the solvent for 16 h at 0°C → rt. After quenching, the aqueous layer was extracted with Et_2O. The crude was purified by column chromatography (eluting with pentane:ether 99:1) to afford the following products in order of elution:

- A mixture of *exo:endo* **6h** 1:1 (transparent oil, 48 mg, 0.14 mmol, 44% yield)
- *Endo*-**6h** (major isomer, transparent oil, 31 mg, 0.09 mmol, 28% yield)

Total Diels-Alder products: 79 mg, 0.22 mmol, 72% yield. Ratio: *exo:endo* 29:61



Compound **6h**: transparent oil.

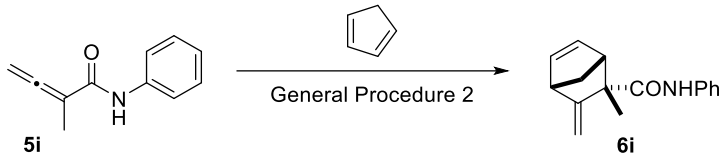
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.00 (s, 2H), 6.87 (s, 1H), 6.28 (dd, *J* = 5.6, 3.1 Hz, 1H), 5.89 (dd, *J* = 5.5, 2.9 Hz, 1H), 5.44 (s, 1H), 4.03 (dddd, *J* = 18.0, 10.9, 7.2, 3.8 Hz, 2H), 3.78 (d, *J* = 14.2 Hz, 1H), 3.08 (s, 1H), 3.00 – 2.85 (m, 2H), 2.30 (s, 6H), 1.69 (d, *J* = 8.5 Hz, 1H), 1.29 (dt, *J* = 8.5, 1.7 Hz, 1H), 1.19 (t, *J* = 7.1 Hz, 3H), 1.14 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 175.93, 140.29, 138.96, 138.41, 137.22 (2 C), 135.01, 133.55, 129.06 (2 C), 128.03, 60.40, 57.18, 56.41, 52.36, 46.59, 43.71, 34.08, 31.08 (3 C), 21.48 (2 C), 14.21.

R_f = 0.2 (pentane:ether 99:1) [UV] [$KMnO_4$]

IR: $\tilde{\nu}$ [cm^{-1}] = 2952, 2869, 1733, 1714, 1604, 1478, 1462, 1360, 1324, 1295, 1248, 1224, 1198, 1166, 1120, 1106, 1087, 1066, 1039, 950, 908, 848, 805, 729, 703, 664.

HRMS (ESI): calculated for $C_{24}H_{33}O_2^+$, $[M+H]^+$ = 353.2475; found = 353.2486.

2-methyl-3-methylene-N-phenylbicyclo[2.2.1]hept-5-ene-2-carboxamide (6i)

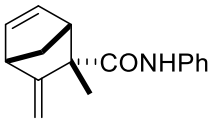


5i 6i

According to General Procedure 2: **5i** (110 mg, 0.63 mmol, 1 eq.) was reacted in toluene as the solvent for 4 h at 0°C → rt. After quenching, the aqueous layer was extracted with Et_2O. The crude was purified by column chromatography (eluting with pentane:ether 9:1 → 4:1) to afford the following products in order of elution:

- *Exo*-**6i** (minor isomer, transparent oil, 5 mg, 0.02 mmol, 3% yield)
- A mixture of *exo:endo* **6i** 56:44 (white paste, 12 mg, 0.05 mmol, 8% yield)
- *Endo*-**6i** (major isomer, white solid, 132 mg, 0.55 mmol, 87% yield)

Total Diels-Alder products: 149 mg, 0.62 mmol, 98% yield. Ratio: *exo:endo* 8:92



Compound **6i:** white solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ 8.01 (s, 1H), 7.52 – 7.39 (m, 2H), 7.38 – 7.24 (m, 2H), 7.15 – 7.03 (m, 1H), 6.26 (qd, *J* = 5.6, 2.8 Hz, 2H), 5.43 (s, 1H), 5.13 (s, 1H), 3.38 (s, 1H), 3.13 (s, 1H), 1.81 (dt, *J* = 8.9, 1.6 Hz, 1H), 1.74 (dt, *J* = 8.9, 1.7 Hz, 1H), 1.63 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 173.60, 158.56, 138.38, 137.79, 135.35, 129.03 (2 C), 124.26, 119.65 (2 C), 107.73, 56.32, 53.00, 52.95, 48.20, 25.74.

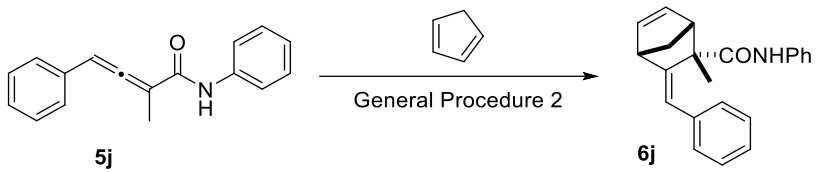
R_f = 0.51 (pentane:Et_2O 9:1) [UV] [$KMnO_4$]

Mp: 75°C

IR: $\tilde{\nu}$ [cm^{-1}] = 3395, 3059, 2984, 2943, 2872, 1668, 1593, 1514, 1438, 1366, 1323, 1312, 1242, 1178, 1157, 1134, 1079, 1016, 963, 946, 925, 902, 888, 856, 837, 817, 793, 762, 748, 728, 693, 662.

HRMS (ESI): calculated for $C_{16}H_{18}NO^+$, $[M+H]^+$ = 240.1383; found = 240.1402.

3-((Z)-benzylidene)-2-methyl-N-phenylbicyclo[2.2.1]hept-5-ene-2-carboxamide (6j)

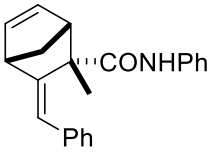


5j **6j**

According to General Procedure 2: **5j**[21] (40 mg, 0.16 mmol, 1 eq.) was reacted in toluene as the solvent for 4 h at 0°C → rt. After quenching, the aqueous layer was extracted with Et_2O. The crude was purified by column chromatography (eluting with pentane:ether 17:3) to afford the following products in order of elution:

- A mixture of *exo:endo* **6j** 18:82 (transparent oil, 4 mg, 0.01 mmol, 8% yield)
- *Endo*-**6j** (major isomer, crystalline solid, 35 mg, 0.11 mmol, 69% yield)

Total Diels-Alder products: 39 mg, 0.12 mmol, 77% yield. Ratio: *exo:endo* 5:95



Compound **6j**: crystalline solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.47 – 7.16 (m, 10H), 7.13 – 7.00 (m, 1H), 6.76 (s, 1H), 6.40 (dd, *J* = 5.5, 3.1 Hz, 1H), 6.32 (dd, *J* = 5.6, 2.9 Hz, 1H), 3.52 (s, 1H), 3.16 (s, 1H), 1.97 (dt, *J* = 8.9, 1.6 Hz, 1H), 1.86 – 1.70 (m, 4H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 173.24, 147.02, 137.38, 137.08, 135.50, 135.38, 129.00 (2 C), 128.93 (2 C), 128.69 (2 C), 127.37, 124.81, 124.46, 120.37 (2 C), 56.92, 56.44, 54.69, 48.12, 21.70.

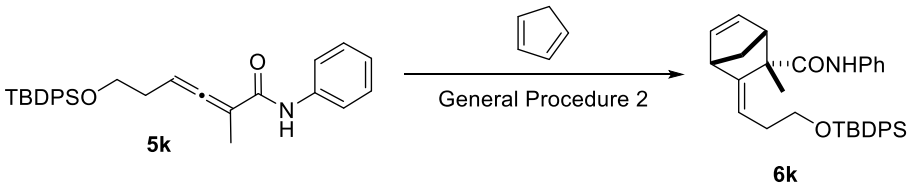
R_f = 0.31 (pentane:ether 17:3) [UV] [$KMnO_4$]

Mp: 100°C

IR: $\tilde{\nu}$ [cm^{-1}] = 3367, 3059, 3022, 2989, 2957, 1665, 1595, 1520, 1490, 1438, 1369, 1317, 1305, 1240, 1174, 1155, 1132, 1079, 1032, 998, 951, 936, 913, 889, 877, 832, 807, 796, 754, 745, 727, 692.

HRMS (ESI): calculated for $C_{22}H_{22}NO^+$, $[M+H]^+$ = 316.1696; found = 316.1708.

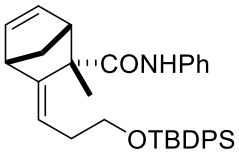
(*Z*)-3-(3-((tert-butyldiphenylsilyl)oxy)propylidene)-2-methyl-N-phenylbicyclo [2.2.1]hept-5-ene-2-carboxamide (6k)



According to General Procedure 2: **5k** (55 mg, 0.12 mmol, 1 eq.) was reacted in toluene as the solvent for 4 h at 0°C → rt. After quenching, the aqueous layer was extracted with Et_2O. The crude was purified by column chromatography (eluting with pentane:ether 17:3) to afford the following products in order of elution:

- A mixture of *exo:endo* **6k** 2:3 (transparent oil, 8 mg, 0.01 mmol, 13% yield)
- *Endo*-**6k** (major isomer, transparent oil, 52 mg, 0.10 mmol, 82% yield)

Total Diels-Alder products: 60 mg, 0.11 mmol, 95% yield. Ratio: *exo:endo* 5:95



Compound **6k**: transparent oil.

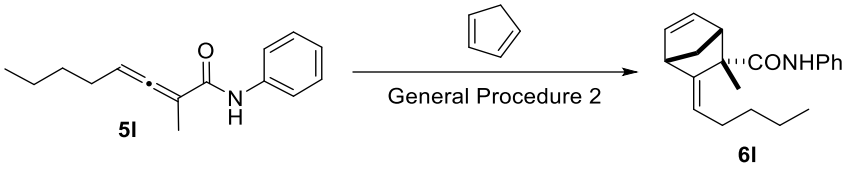
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.64 (ddd, *J* = 8.1, 6.6, 1.5 Hz, 4H), 7.50 (s, 1H), 7.46 – 7.30 (m, 9H), 7.30 – 7.18 (m, 3H), 7.06 (t, *J* = 7.2 Hz, 1H), 6.27 (dd, *J* = 5.7, 3.1 Hz, 1H), 6.17 (dd, *J* = 5.6, 2.8 Hz, 1H), 5.68 (t, *J* = 7.4 Hz, 1H), 3.71 (qt, *J* = 9.9, 6.4 Hz, 2H), 3.26 (s, 1H), 2.99 (s, 1H), 2.51 – 2.22 (m, 2H), 1.81 (d, *J* = 8.8 Hz, 1H), 1.66 – 1.56 (m, 4H), 1.04 (s, 10H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 173.61, 147.84, 137.73, 136.85, 135.74, 135.69 (4 C), 133.87, 133.70, 129.82, 129.80, 129.01 (2 C), 127.81 (4 C), 124.22, 120.79, 119.84 (2 C), 63.34, 55.52, 54.30, 53.51, 48.17, 33.89, 27.01 (3 C), 23.54, 19.35.

R_f = 0.54 (4:1 pentane:ether) [UV] [$KMnO_4$]

IR: $\tilde{\nu}$ [cm^{-1}] = 3395, 3070, 2931, 2858, 1676, 1596, 1520, 1500, 1472, 1438, 1428, 1388, 1361, 1312, 1243, 1177, 1105, 1038, 998, 909, 822, 796, 732, 700, 689.

HRMS (ESI): calculated for $C_{34}H_{40}NO_2Si^+$, $[M+H]^+$ = 522.2823; found = 522.2841.

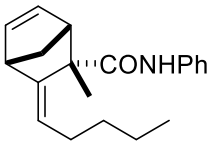
(*Z*)-2-methyl-3-pentylidene-N-phenylbicyclo[2.2.1]hept-5-ene-2-carboxamide (6l)



According to General Procedure 2: **5l** (55 mg, 0.12 mmol, 1 eq.) was reacted in toluene as the solvent for 4 h at 0°C → rt. After quenching, the aqueous layer was extracted with Et_2O. The crude was purified by column chromatography (eluting with pentane:ether 9:1) to afford the following products in order of elution:

- A mixture of *exo:endo* **6l** 45:55 (transparent oil, 5 mg, 0.02 mmol, 12% yield)
- *Endo*-**6l** (major isomer, transparent oil, 20 mg, 0.07 mmol, 47% yield)

Total Diels-Alder products: 25 mg, 0.09 mmol, 59% yield. Ratio: *exo:endo* 8:92



Compound **6l**: transparent oil.

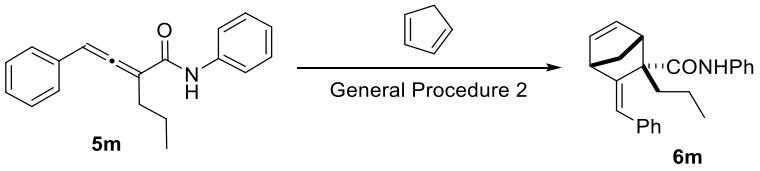
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.56 (s, 1H), 7.42 (d, *J* = 7.4 Hz, 2H), 7.29 (t, *J* = 7.9 Hz, 2H), 7.07 (t, *J* = 7.4 Hz, 1H), 6.27 (dd, *J* = 5.6, 3.1 Hz, 1H), 6.16 (dd, *J* = 5.6, 2.9 Hz, 1H), 5.59 (t, *J* = 7.5 Hz, 1H), 3.25 (s, 1H), 2.99 (s, 1H), 2.07 (ddt, *J* = 37.4, 14.6, 7.3 Hz, 2H), 1.82 (d, *J* = 8.8 Hz, 1H), 1.64 (s, 4H), 1.43 – 1.23 (m, 4H), 0.84 (t, *J* = 7.1 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 173.82, 145.97, 137.85, 136.65, 135.86, 129.04 (2 C), 124.50, 124.15, 119.60 (2 C), 55.51, 54.23, 53.32, 48.22, 31.91, 30.61, 23.45, 22.63, 14.08.

R_f = 0.4 (pentane:ether 9:1) [UV] [$KMnO_4$]

IR: $\tilde{\nu}$ [cm^{-1}] = 3396, 3060, 2956, 2928, 2872, 1677, 1596, 1519, 1500, 1465, 1437, 1375, 1311, 1243, 1177, 1136, 1101, 1077, 1030, 1000, 935, 899, 859, 801, 743, 726, 690, 658.

HRMS (ESI): calculated for $C_{20}H_{26}NO^+$, $[M+H]^+$ = 296.2009; found = 296.2031.

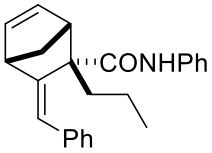
3-((Z)-benzylidene)-N-phenyl-2-propylbicyclo[2.2.1]hept-5-ene-2-carboxamide (6m)



According to General Procedure 2: **5m** (63 mg, 0.23 mmol, 1 eq.) was reacted in toluene as the solvent for 4 h at 0°C → rt. After quenching, the aqueous layer was extracted with Et_2O. The crude was purified by column chromatography (eluting with pentane:ether 9:1) to afford the following products in order of elution:

- A mixture of *exo:endo* **6m** 1:5 (transparent oil, 21 mg, 0.06 mmol, 27% yield)
- *Endo*-**6m** (major isomer, transparent oil, 51 mg, 0.15 mmol, 65% yield)

Total Diels-Alder products: 72 mg, 0.21 mmol, 92% yield. Ratio: *exo:endo* 4:96



Compound **6m**: transparent oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.51 – 7.17 (m, 10H), 7.10 (t, *J* = 7.1 Hz, 1H), 6.80 (s, 1H), 6.45 (dd, *J* = 5.4, 3.0 Hz, 1H), 6.37 (dd, *J* = 5.6, 2.9 Hz, 1H), 3.52 (s, 1H), 3.44 (s, 1H), 2.50 (td, *J* = 12.9, 2.9 Hz, 1H), 2.06 – 1.80 (m, 3H), 1.72 (d, *J* = 8.8 Hz, 1H), 1.64 – 1.52 (m, 1H), 0.92 (t, *J* = 6.9 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 173.51, 147.93, 137.78, 137.43, 136.40, 135.92, 128.99 (2 C), 128.90 (2 C), 128.68 (2 C), 127.38, 124.56, 124.35, 120.37 (2 C), 58.19, 56.27, 53.03, 47.33, 38.33, 19.61, 14.98.

R_f = 0.48 (pentane:ether 9:1) [UV] [$KMnO_4$]

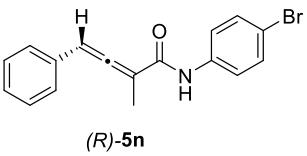
IR: $\tilde{\nu}$ [cm^{-1}] = 3398, 3058, 2960, 2870, 1938, 1672, 1596, 1517, 1499, 1437, 1378, 1310, 1241, 1176, 1157, 1111, 1078, 1029, 1006, 902, 880, 832, 802, 782, 746, 690, 656.

HRMS (ESI): calculated for $C_{20}H_{26}NO^+$, $[M+H]^+$ = 344.2009; found = 344.2031.

(R)- and *(S)*-N-(4-bromophenyl)-2-methyl-4-phenylbuta-2,3-dienamide (5n)

rac-**5n** was synthesized according to the literature.[21] The enantiomers were separated by chiral *prep*-HPLC (AD-H 250 × 20 mm), and their absolute configuration was elucidated by VCD (see section 8 for details).

Chiral HPLC: (AD-H 250 × 4.6 mm, *n*-Hep/*iso*-PrOH = 90/10, 1 ml/min, λ = 210 nm); t_R = 10.51 min ((*R*)-**5n**), 16.43 min ((*S*)-**5n**).

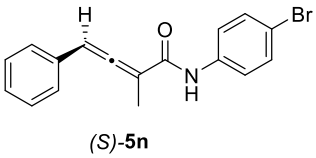


(R)-**5n**

Enantiomer 1 (E1): *(R)*-**5n** (white solid)

Optical rotation: $[\alpha]_D^{20}$: -455 (*c* = 1.0 $CHCl_3$) [100% *ee*].

t_R = 10.51 min



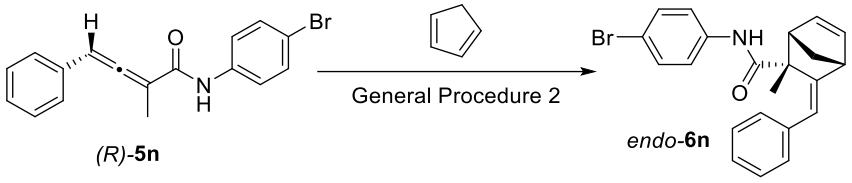
(S)-**5n**

Enantiomer 2 (E 2): *(S)*-**5n** (white solid)

Optical rotation: $[\alpha]_D^{20}$: +489 (c = 1.0 $CHCl_3$) [100% *ee*].

$\mathbf{t_R}$ = 16.43 min

(*1S,2R,4R*)-3-((*Z*)-benzylidene)-N-(4-bromophenyl)-2-methylbicyclo[2.2.1]hept-5-ene-2-carbox-amide (6n)

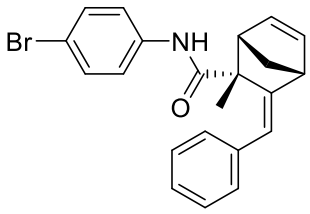


(R)-**5n** *endo*-**6n**

According to <u>General Procedure 2:</u> *(R)*-**5n**[21] (54 mg, 0.16 mmol, 1 eq.) was reacted in toluene as the solvent for 4 h at 0°C → rt. After quenching, the aqueous layer was extracted with Et_2O. The crude was purified by column chromatography (eluting with pentane:ether 17:3) to afford the following products in order of elution:

- A mixture of *exo:endo* **6n** 15:85 (transparent oil, 4 mg, 0.01 mmol, 6% yield)
- *Endo*-**6n** (major isomer, transparent oil, 54 mg, 0.14 mmol, 83% yield, 99% *ee*)

Total Diels-Alder products: 58 mg, 0.15 mmol, 89% yield. Ratio: *exo:endo* 2:98



Compound **6n**: transparent oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.36 – 7.24 (m, 6H), 7.18 (ddd, J = 8.6, 4.8, 3.2 Hz, 1H), 7.12 – 7.05 (m, 2H), 6.71 (s, 1H), 6.36 (dd, J = 5.6, 3.1 Hz, 1H), 6.26 (dd, J = 5.6, 2.9 Hz, 1H), 3.48 (s, 1H), 3.11 (s, 1H), 1.94 (d, J = 8.9 Hz, 1H), 1.83 – 1.65 (m, 4H). ^{13}C NMR (101 MHz, $CDCl_3$): δ 173.33, 146.94, 136.97, 136.45, 135.53, 135.42, 131.91 (2 C), 128.93 (2 C), 128.75 (2 C), 127.50, 124.89, 121.81 (2 C), 117.07, 56.95, 56.36, 54.74, 48.16, 21.87.

$\mathbf{R_f}$ = 0.44 (pentane:ether 17:3) [UV] [$KMnO_4$]

IR: $\tilde{\nu}$ [cm^{-1}] = 3395, 3057, 3025, 2979, 2946, 2873, 1675, 1587, 1504, 1489, 1448, 1392, 1320, 1303, 1287, 1239, 1176, 1136, 1114, 1087, 1071, 1030, 1008, 969, 949, 918, 899, 882, 857, 823, 795, 777, 751, 721, 695, 654.

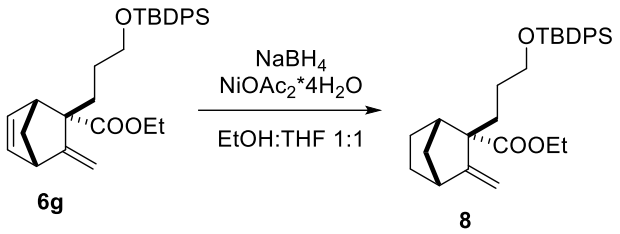
Chiral HPLC: (IA 250 × 4.6 mm, *n*-Hep/*iso*-PrOH = 90/10, 1 ml/min, λ = 210 nm); t_R = 8.19 min (*(R)*-**6n**)

Optical rotation: $[\alpha]_D^{20}$: -189 (*c* = 1.0 $CHCl_3$) [99% *ee*].

HRMS (ESI): calculated for $C_{22}H_{21}BrNO^+$, $[M+H]^+$ = 394.0801; found = 394.0792

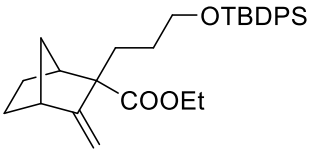
5. β-Santalol and derivatives

ethyl 2-(3-(tert-butyldiphenylsilyl)oxy)propyl)-3-methylenebicyclo[2.2.1]heptane-2-carboxylate (8)



6g **8**

Nickel acetate tetrahydrate (314 mg, 1.26 mmol, 0.27 eq.) was dissolved in EtOH (25 ml) under an H_2 atmosphere. Then $NaBH_4$ 1M in EtOH (1.26 ml, 1.26 mmol, 0.27 eq.) was injected. The reaction mixture turns black. After 30 min, a solution of **6g** (2220 mg, 4.68 mmol, 1 eq.) in THF (25 ml) was injected. The reaction was stirred for 3h under H_2.Then the reaction was diluted with Et_2O (50 ml) and filtered on celite. The filtrate was concentrated *in vacuo* and the residue was purified by flash chromatography (eluting with pentane:ether 95:5) to afford **8** (2208 mg, 4.63 mmol, 99% yield) as a transparent oil.



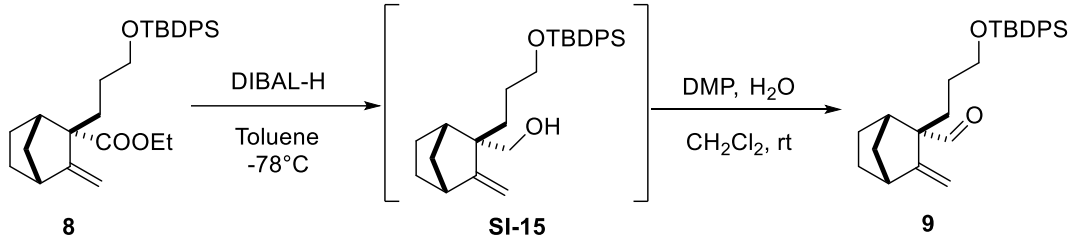
Compound **8**: transparent oil. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.71 – 7.59 (m, 4H), 7.48 – 7.32 (m, 6H), 5.04 (s, 1H), 4.92 (s, 1H), 4.13 (qq, *J* = 7.0, 3.7 Hz, 2H), 3.68 – 3.55 (m, 2H), 2.71 (d, *J* = 2.5 Hz, 1H), 2.40 (d, *J* = 3.1 Hz, 1H), 1.83 (td, *J* = 12.3, 3.7 Hz, 1H), 1.75 – 1.17 (m, 12H), 1.04 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 174.55, 155.76, 135.71 (4 C), 134.15 (2 C), 129.67 (2 C), 127.73 (4 C), 106.61, 64.19, 60.33, 58.36, 46.95, 46.03, 36.21, 35.44, 29.38, 28.38, 26.99 (3 C), 25.52, 19.36, 14.45.

R_f = 0.44 (pentane:ether 96:4) [UV] [$KMnO_4$]

IR: $\tilde{\nu}$ [cm^{-1}] = 3072, 2960, 2931, 2858, 1733, 1659, 1590, 1473, 1462, 1446, 1428, 1389, 1363, 1302, 1249, 1187, 1157, 1107, 1031, 1008, 998, 938, 892, 853, 822, 738, 700, 687

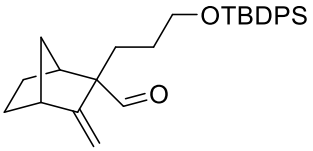
HRMS (ESI): calculated for $C_{30}H_{41}O_3Si^+$, $[M+H]^+$ = 477.2819; found = 477.2824.

2-(3-((tert-butyldiphenylsilyl)oxy)propyl)-3-methylenebicyclo[2.2.1]heptane-2-carbaldehyde (9)



8 **SI-15** **9**

8 (2181 mg, 4.57 mmol, 1 eq.) was dissolved in toluene (100 ml) under argon and cooled to -78°C (dry ice/acetone bath). DIBAL-H 1M in toluene (13.72 ml, 13.72 mmol, 3 eq.) was injected slowly. After 1h at -78°C, the reaction was quenched with Rochelle salt sat. sol., diluted with Et_2O, and allowed to warm to room temperature with vigorous stirring. The layers were separated, and the aqueous layer was extracted with Et_2O (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo* to give the primary alcohol **SI-15** (2118 mg) as a transparent oil. It was dissolved in CH_2Cl_2 (38 ml) and water (0.08 ml, 4.57 mmol, 1 eq.) was added. The mixture was stirred vigorously to disperse the water, and then DMP (2910 mg, 6.86 mmol, 1.5 eq.) was added. The reaction turns milky-white. After 1 h, the reaction was quenched with $Na_2S_2O_3$ 10% (60 ml) and $NaHCO_3$ sat. sol. (60 ml) and diluted with CH_2Cl_2. The layers were separated, and the aqueous layer was extracted with CH_2Cl_2 (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was purified by flash chromatography (eluting with pentane:ether 96:4) to afford **9** (1813 mg, 4.19 mmol, 92% yield over 2 steps) as a transparent oil.



Compound **9**: transparent oil.

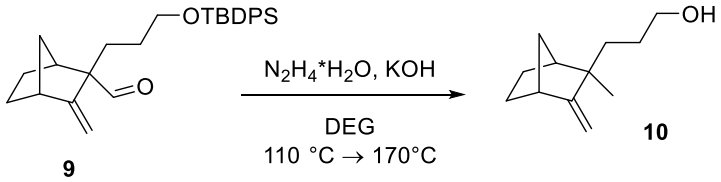
^{1}H NMR (400 MHz, $CDCl_3$): δ 9.60 (s, 1H), 7.73 – 7.58 (m, 4H), 7.50 – 7.29 (m, 6H), 5.07 (s, 1H), 4.67 (s, 1H), 3.69 – 3.55 (m, 2H), 2.80 (d, *J* = 3.8 Hz, 1H), 2.47 (d, *J* = 2.0 Hz, 1H), 1.84 – 1.44 (m, 8H), 1.36 – 1.25 (m, 2H), 1.05 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 204.34, 156.39, 135.71 (4 C), 134.07 (2 C), 129.70 (2 C), 127.75 (4 C), 105.71, 64.10, 61.69, 46.63, 43.22, 37.17, 31.94, 29.65, 27.91, 27.00 (3 C), 24.36, 19.35.

R_f = 0.42 (pentane:ether 96:4) [UV] [$KMnO_4$]

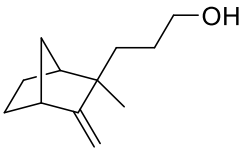
IR: $\tilde{\nu}$ [cm^{-1}] = 2957, 2903, 2867, 1955, 1712, 1476, 1463, 1396, 1363, 1327, 1265, 1247, 1148, 1110, 1084, 1064, 1038, 997, 965, 892, 855, 811, 741, 703, 688.

HRMS (ESI): calculated for $C_{28}H_{37}O_2Si^+$, $[M+H]^+$ = 433.2557; found = 433.2559.

3-(2-methyl-3-methylenebicyclo[2.2.1]heptan-2-yl)propan-1-ol (10)



9 (1696 mg, 3.92 mmol, 1 eq.) was dissolved in diethylene glycol (40 ml) and KOH 85% (2587 mg, 39.20 mmol, 10 eq.) and hydrazine monohydrate (3.80 ml, 78.39 mmol, 20 eq.) were added under air. The suspension was heated to 110°C with vigorous stirring. After 30 min at 110°C, the reaction was homogeneous. It was heated to 170°C. After 4 h at 170°C, the reaction was cooled to rt, quenched with HCl 1M, and diluted with Et_2O. The layers were separated, and the aqueous layer was extracted with Et_2O (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was purified by flash chromatography (eluting with pentane:ether 3:2) to afford **10** (558 mg, 3.09 mmol, 79% yield) as a transparent oil.

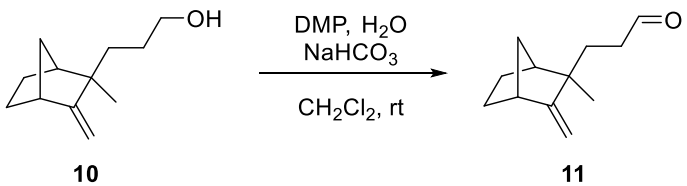


Compound **10**: transparent oil.

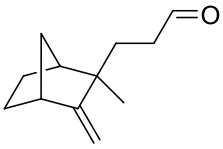
^{1}H NMR (400 MHz, $CDCl_3$): δ 4.74 (s, 1H), 4.47 (s, 1H), 3.61 (t, *J* = 6.6 Hz, 2H), 2.66 (d, *J* = 2.9 Hz, 1H), 2.08 (d, *J* = 3.0 Hz, 1H), 1.72 – 1.48 (m, 4H), 1.47 – 1.34 (m, 3H), 1.29 – 1.20 (m, 2H), 1.18 (dt, *J* = 9.8, 1.5 Hz, 1H), 1.03 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 166.42, 99.85, 63.91, 46.93, 44.84, 44.55, 37.20 (2 C), 29.82, 28.45, 23.83, 22.81.

The NMR data were in accordance with the literature.[28]

3-(2-methyl-3-methylenebicyclo[2.2.1]heptan-2-yl)propanal (11)



$NaHCO_3$ (2212 mg, 26.34 mmol, 10 eq.) and **10** (475 mg, 2.63 mmol, 1 eq.) were suspended in CH_2Cl_2 (30 ml) and water (0.05 ml, 2.63 mmol, 1 eq.) was added under argon. The reaction was stirred vigorously to disperse the water, and then DMP (1676 mg, 3.95 mmol, 1.5 eq.) was added. The reaction turns milky-white. After 1 h, the reaction was quenched with $Na_2S_2O_3$ 10% (30 ml) and $NaHCO_3$ sat. sol. (30 ml) and diluted with CH_2Cl_2. The layers were separated, and the aqueous layer was extracted with CH_2Cl_2 (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was purified by flash chromatography (eluting with pentane:ether 95:5) to afford **11** (348 mg, 1.95 mmol, 74% yield) as a transparent oil.

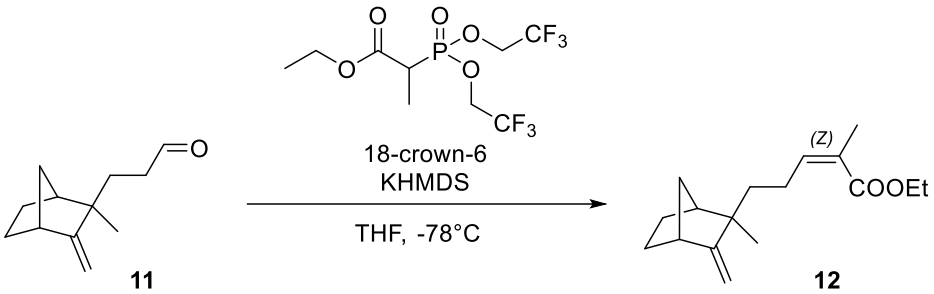


Compound **11**: transparent oil.

^{1}H NMR (500 MHz, CD_3CN) δ 9.70 (t, *J* = 1.8 Hz, 1H), 4.77 (d, *J* = 0.8 Hz, 1H), 4.52 (s, 1H), 2.67 (d, *J* = 2.6 Hz, 1H), 2.43 (dtd, *J* = 9.7, 6.2, 1.7 Hz, 2H), 2.05 (d, *J* = 3.5 Hz, 1H), 1.73 – 1.60 (m, 4H), 1.55 – 1.38 (m, 2H), 1.25 – 1.18 (m, 2H), 1.01 (s, 3H). **^{13}C NMR** (101 MHz, CD_3CN) δ 204.13, 166.85, 100.76, 47.69, 45.68, 44.97, 40.59, 37.61, 33.34, 30.35, 24.22, 22.81.

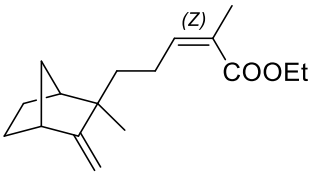
The NMR data were in accordance with the literature.[29]

ethyl (*Z*)-2-methyl-5-(2-methyl-3-methylenebicyclo[2.2.1]heptan-2-yl)pent-2-enoate (12)



To a stirred solution of ethyl 2-(bis(2,2,2-trifluoroethoxy)phosphoryl)propanoate[30] (469 mg, 1.35 mmol, 1.05 eq.) and 18-crown-6 (392 mg, 1.48 mmol, 1.15 eq.) in THF (6 mL) at −78 °C was added KHMDS 1 M in THF (1.35 ml, 1.35 mmol, 1.05 eq.) dropwise. After 20 min, a solution of **11** (230 mg, 1.29 mmol, 1 eq.) in THF (3 mL) was added dropwise. The reaction mixture was stirred for 50 min at -78°C, then quenched with NH_4Cl sat. sol. and diluted with Et_2O. The layers were separated, and the aqueous layer was extracted with Et_2O (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The

residue was purified by flash chromatography (eluting with pentane:ether 98:2) to afford **12** (219 mg, 0.83 mmol, 65% yield) as a transparent oil.

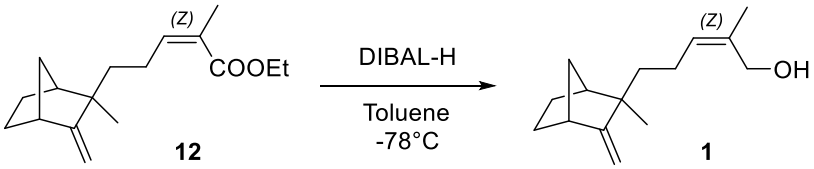


Compound **12**: transparent oil.

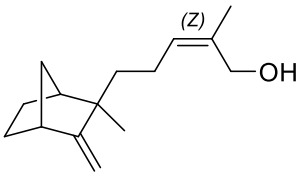
^{1}H NMR (400 MHz, $CDCl_3$): δ 5.90 (tq, *J* = 7.6, 1.6 Hz, 1H), 4.74 (s, 1H), 4.47 (s, 1H), 4.20 (q, *J* = 7.1 Hz, 2H), 2.66 (d, *J* = 3.6 Hz, 1H), 2.50 – 2.41 (m, 2H), 2.12 (d, *J* = 4.0 Hz, 1H), 1.88 (d, *J* = 1.4 Hz, 3H), 1.72 – 1.59 (m, 3H), 1.52 – 1.35 (m, 2H), 1.34 – 1.16 (m, 7H), 1.05 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 168.36, 166.37, 143.41, 126.96, 99.87, 60.19, 46.94, 44.90, 44.73, 40.72, 37.25, 29.81, 25.60, 23.82, 22.75, 20.87, 14.49.

The NMR data were in accordance with the literature.[31]

β-santalol (1)



12 (100 mg, 0.38 mmol, 1 eq.) was dissolved in toluene (8 ml) under argon and cooled to -78°C (dry ice/acetone bath). DIBAL-H 1M in toluene (1.14 ml, 1.14 mmol, 3 eq.) was injected slowly. After 1h at -78°C, the reaction was quenched with Rochelle salt sat. sol., diluted with Et_2O, and allowed to warm to room temperature with vigorous stirring. The layers were separated, and the aqueous layer was extracted with Et_2O (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was purified by flash chromatography (eluting with pentane:ether 7:3) to afford β-Santalol **1** (72 mg, 0.33 mmol, 86% yield) as a transparent oil.

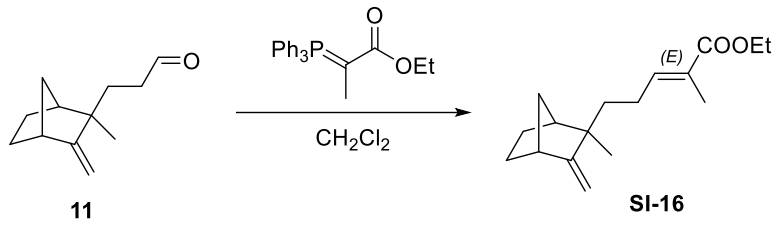


β-santalol **1:** transparent oil.

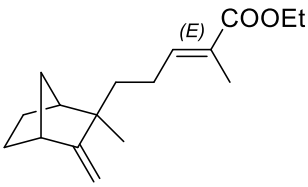
^{1}H NMR (400 MHz, $CDCl_3$) δ 5.29 (td, *J* = 7.4, 1.6 Hz, 1H), 4.73 (s, 1H), 4.45 (s, 1H), 4.14 (s, 2H), 2.66 (d, *J* = 2.9 Hz, 1H), 2.13 – 1.93 (m, 3H), 1.78 (d, *J* = 1.3 Hz, 3H), 1.72 – 1.56 (m, 3H), 1.45 – 1.35 (m, 2H), 1.27 – 1.14 (m, 3H), 1.03 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 166.30, 134.07, 129.17, 99.85, 61.76, 46.92, 44.88, 44.78, 41.66, 37.21, 29.81, 23.82, 23.34, 22.76, 21.38.

The NMR data were in accordance with the literature.[31]

ethyl (*E*)-2-methyl-5-(2-methyl-3-methylenebicyclo[2.2.1]heptan-2-yl)pent-2-enoate (SI-16)



11 (62 mg, 0.35 mmol, 1 eq.) was dissolved in CH_2Cl_2 (2.2 ml) and (carbethoxyethylidene)-triphenylphosphorane (141 mg, 0.39 mmol, 1.12 eq.) was added. The reaction was stirred for 16 h under argon. Then the mixture was concentrated *in vacuo* and the residue was purified by flash chromatography (eluting with pentane:ether 96:4) to afford **SI-16** (77 mg, 0.29 mmol, 84% yield) as a transparent oil.

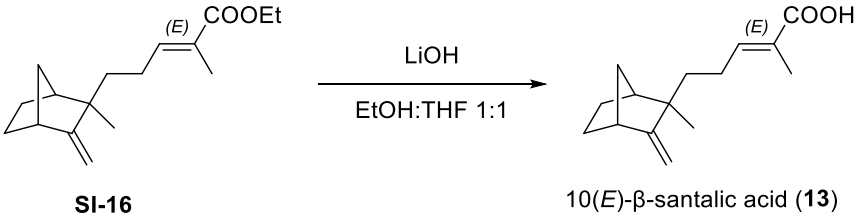


Compound **SI-16**: transparent oil.

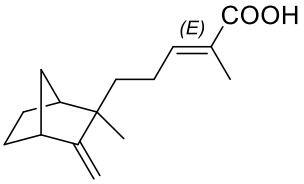
^{1}H NMR (500 MHz, $CDCl_3$): δ 6.74 (tq, *J* = 7.4, 1.5 Hz, 1H), 4.75 (s, 1H), 4.47 (s, 1H), 4.18 (q, *J* = 7.1 Hz, 2H), 2.67 (d, *J* = 2.9 Hz, 1H), 2.24 – 2.07 (m, 3H), 1.83 (d, *J* = 1.3 Hz, 3H), 1.71 – 1.60 (m, 3H), 1.53 – 1.37 (m, 2H), 1.36 – 1.17 (m, 7H), 1.06 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 168.44, 165.94, 142.73, 127.64, 100.14, 60.52, 46.91, 44.84, 44.82, 39.71, 37.21, 29.78, 24.58, 23.83, 22.71, 14.45, 12.39.

The NMR data were in accordance with the literature.[31]

10(*E*)-β-santalic acid (13)



SI-16 (26 mg, 0.10 mmol, 1 eq.) was dissolved in 1:1 EtOH:THF (1 ml) and LiOH 1M (0.7 ml, 0.7 mmol, 7 eq.) was added. After 12 h, the reaction was quenched with HCl 1M and diluted with Et_2O. The layers were separated, and the aqueous layer was extracted with Et_2O (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was purified by flash chromatography (eluting with pentane:ether 1:1 → 2:3) to afford **13** (20 mg, 0.08 mmol, 86% yield) as a white solid.

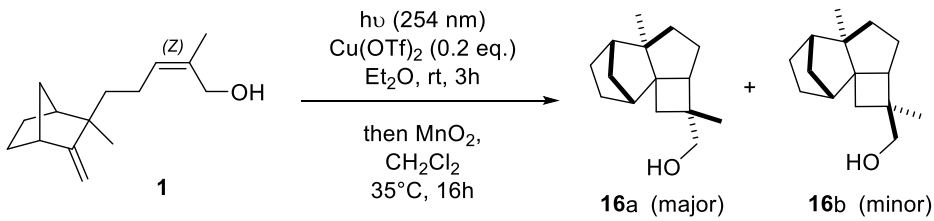


Compound **13**: white solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ 6.90 (tq, *J* = 7.5, 1.4 Hz, 1H), 4.76 (s, 1H), 4.48 (s, 1H), 2.74 – 2.61 (m, 1H), 2.31 – 2.04 (m, 3H), 1.84 (s, 3H), 1.74 – 1.58 (m, 3H), 1.57 – 1.16 (m, 6H), 1.07 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 173.18, 165.82, 145.60, 126.85, 100.24, 46.92, 44.87, 44.85, 39.51, 37.21, 29.79, 24.84, 23.83, 22.71, 12.05.

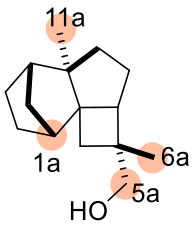
The NMR data were in accordance with the literature.[32]

(5,8a-dimethyloctahydro-2H-1,4:4a,6-dimethanonaphthalen-5-yl)methanol (16)

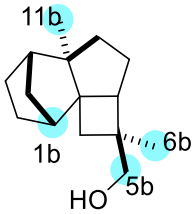


β-Santalol **1** (50 mg, 0.23 mmol, 1 eq.) and $Cu(OTf)_2$ (4 mg, 0.01 mmol, 0.05 eq.) were dissolved in Et_2O (10 ml) under air.* The reaction mixture was irradiated at rt (λ = 254 nm). After 3h, the reaction was poured into NH_3 25% (15 ml), and the mixture was stirred vigorously for 10 minutes. The organic layer was removed, and the aqueous layer was extracted with Et_2O (2×). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The residue was dissolved in CH_2Cl_2 (5 ml) and MnO_2 (197 mg, 2.27 mmol, 10 eq.) was added. The reaction was heated to 35°C for 16h. Then the reaction was filtered on celite, and the filtrate was concentrated *in vacuo*. The residue was purified by flash chromatography (eluting with pentane:ether 1:1) to afford **16** (11 mg, 0.05 mmol, 22% yield) as a transparent oil consisting of a mixture of two isomers **16a:16b** in a 71:29 ratio.

* Screening of the reaction conditions showed that the [2+2] photocycloaddition reaction can be run under air and without the need for dry solvents.



16a (major)



16b (minor)

Transparent oil (71:29 mixture of isomers **16a** and **16b**)

^{1}H NMR (400 MHz, $CDCl_3$): δ 3.60 (d, J = 10.9 Hz, 1H, H-5a), 3.55 (s, 2H, H-5b), 3.31 (d, J = 10.9 Hz, 1H, H-5a), 2.20 – 2.10 (m, 1H, H-1a), 2.02 (d, *J* = 4.7 Hz, 1H, H-1b), 1.97 – 1.76 (m, 2H), 1.75 – 1.03 (m, 11H), 1.25 (s, 3H, H-6a), 1.01 – 0.97 (m, 1H), 0.96 (s, 3H H-6b), 0.86 (s, 3H, H-11b), 0.82 (s, 3H, H-11a). **^{13}C NMR** (101 MHz, $CDCl_3$): δ 72.45, 69.23, 54.79, 54.13, 53.45, 51.16, 49.18, 48.76, 47.42, 47.12, 46.85, 46.81, 43.29, 43.26, 34.17, 33.48, 33.38, 33.16, 31.42, 31.07, 25.66, 25.44, 25.04, 23.73, 23.61, 21.89, 21.71, 21.69, 21.60, 20.12.

R_f = 0.87 (pentane:ether 4:1) [$KMnO_4$]

IR: $\tilde{\nu}$ [cm^{-1}] = 3341, 2944, 2868, 1459, 1373, 1295, 1118, 1021, 971, 877, 747.

HRMS (ESI): calculated for $C_{15}H_{24}O$, $[M+H]^+$ = 220.1827; found = 220.1833.

6. Stereochemical Assignments

exo-**4a**

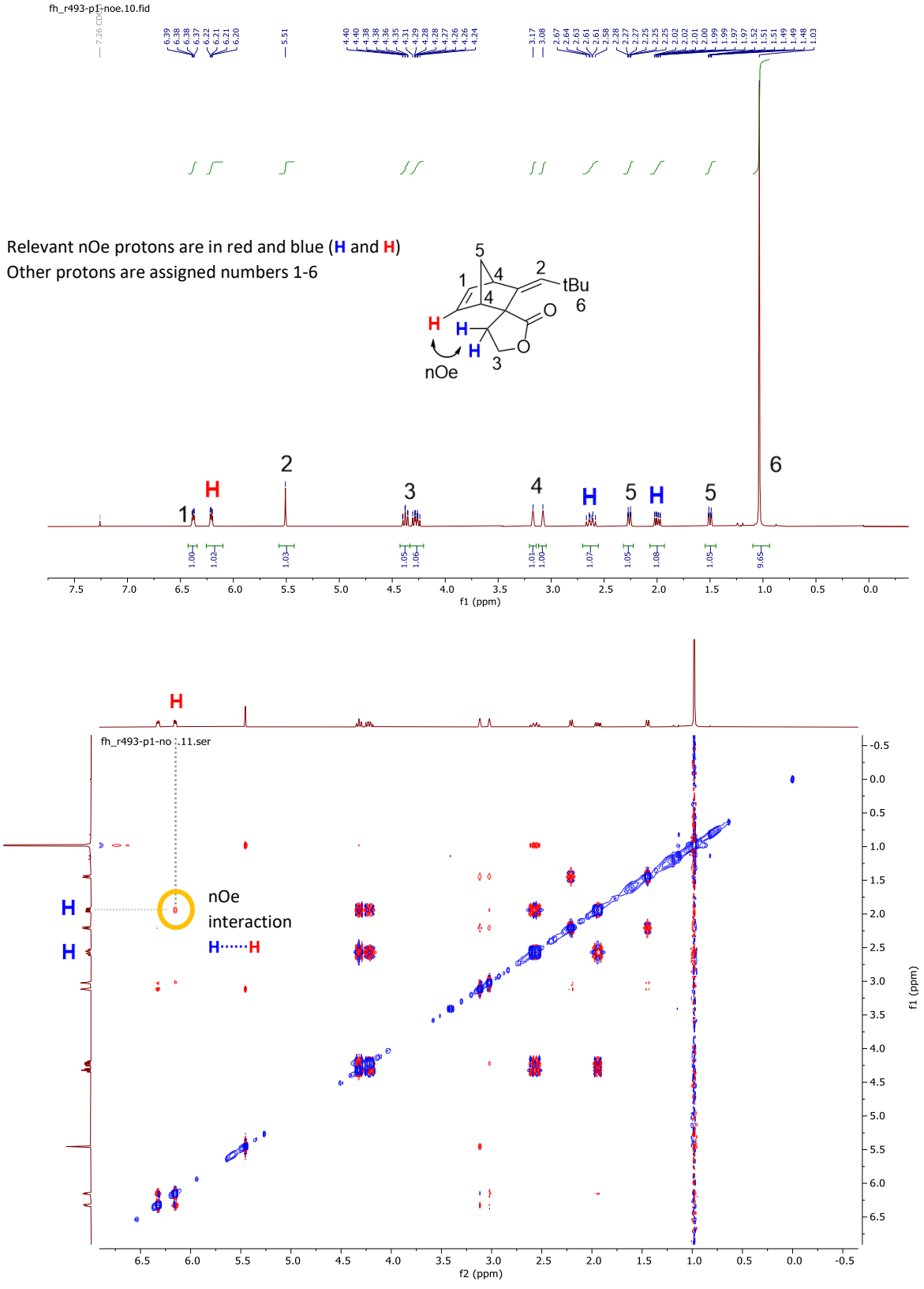
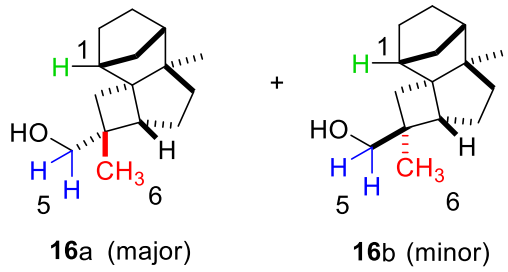


Figure S1. nOe spectrum of *exo*-**4a** showing the characteristic nOe interaction.

Cyclobutane **16**: mixture of isomers **16a** and **16b**



In the ^{1}H NMR spectrum, a mixture of two isomers in a 71:29 ratio is visible. The H-5 protons (blue), the H-6 methyl groups (red), and the H-1 proton (green) of both isomers can be identified.

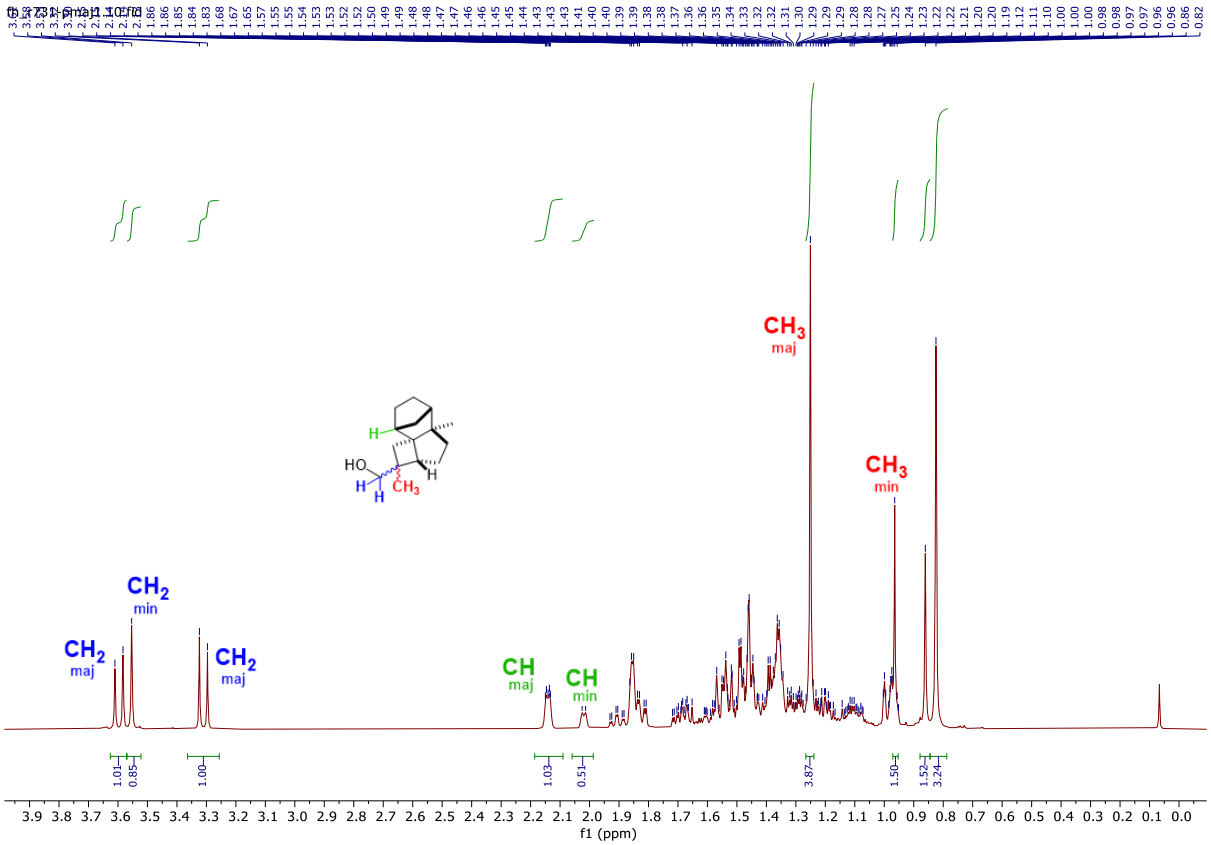


Figure S2. ^{1}H-NMR spectrum of the mixture of isomers **16a** and **16b**.

COSY and NOESY Spectra of cyclobutane 16

In the COSY spectrum, the H-5 CH_2-OH groups (blue) can be assigned to their neighbouring H-6 methyl groups (red):

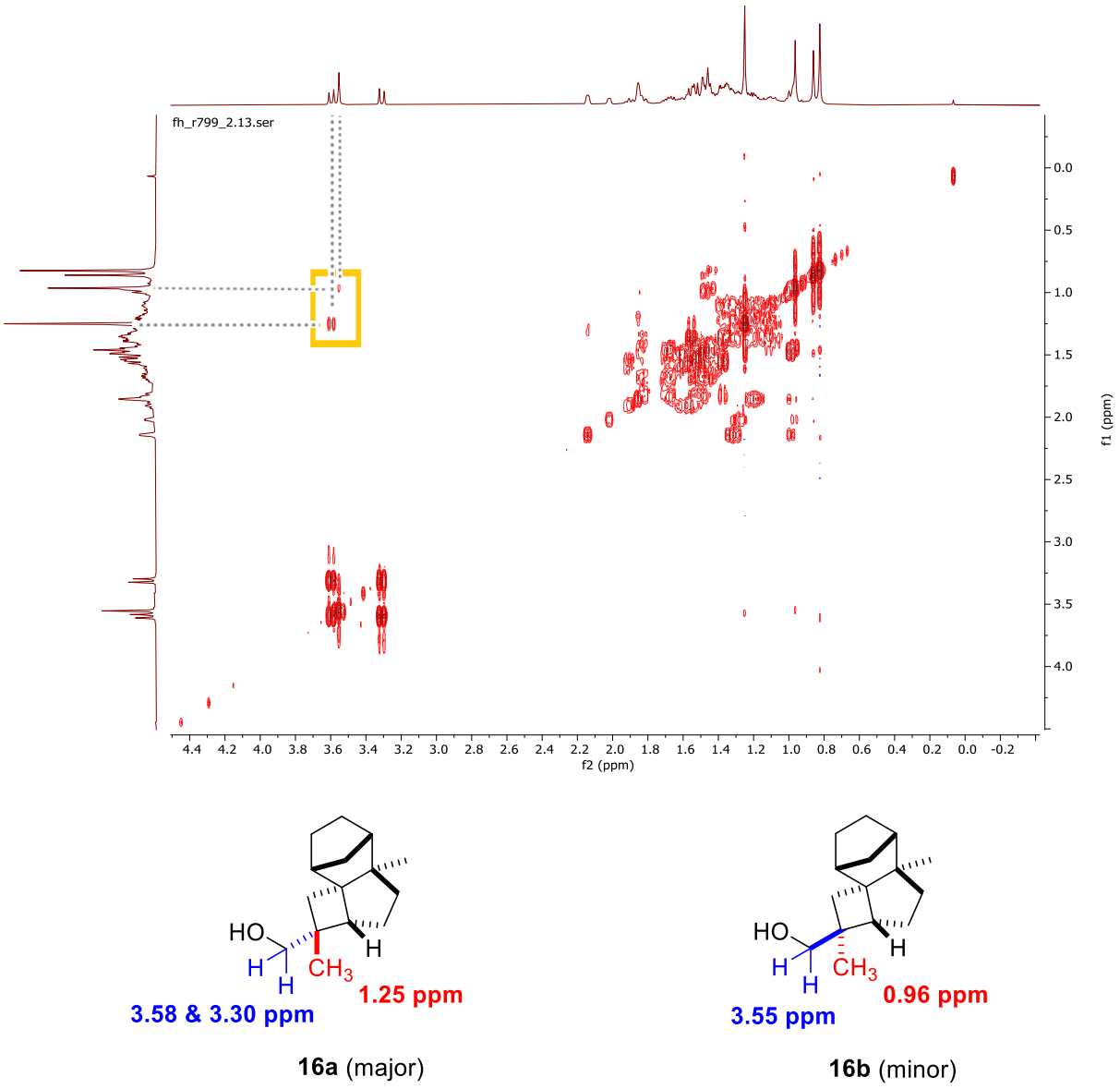


Figure S3. COSY spectrum of the mixture of isomers **16a** and **16b**.

The NOESY spectrum shows nOe interactions of the cyclobutane H-6 CH_3 (red) or H-5 CH_2-OH (blue) with H-1 (green), allowing for the stereochemical assignment of the cyclobutane substituents:

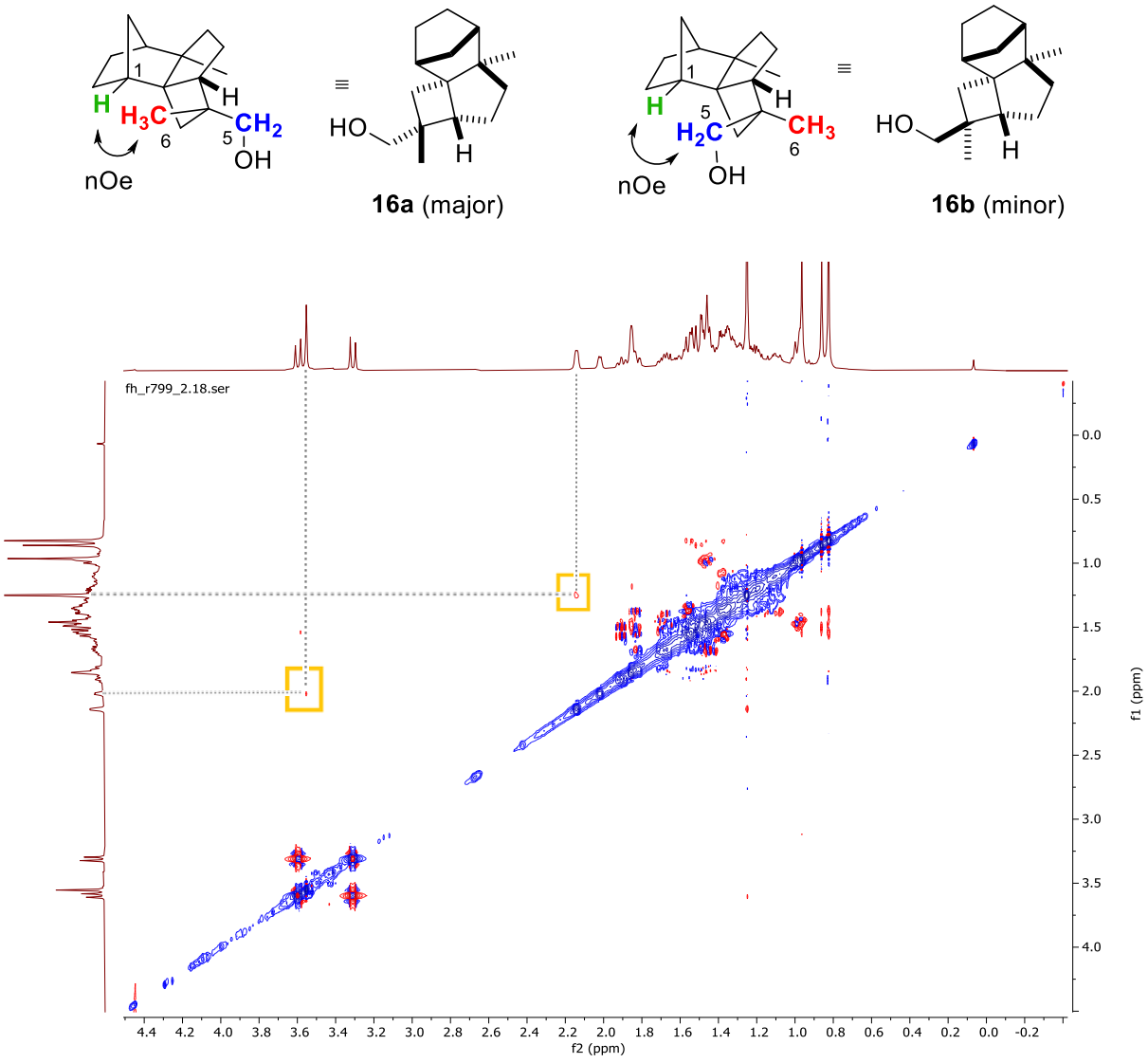
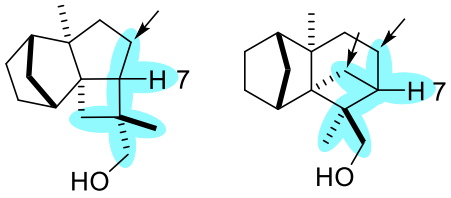


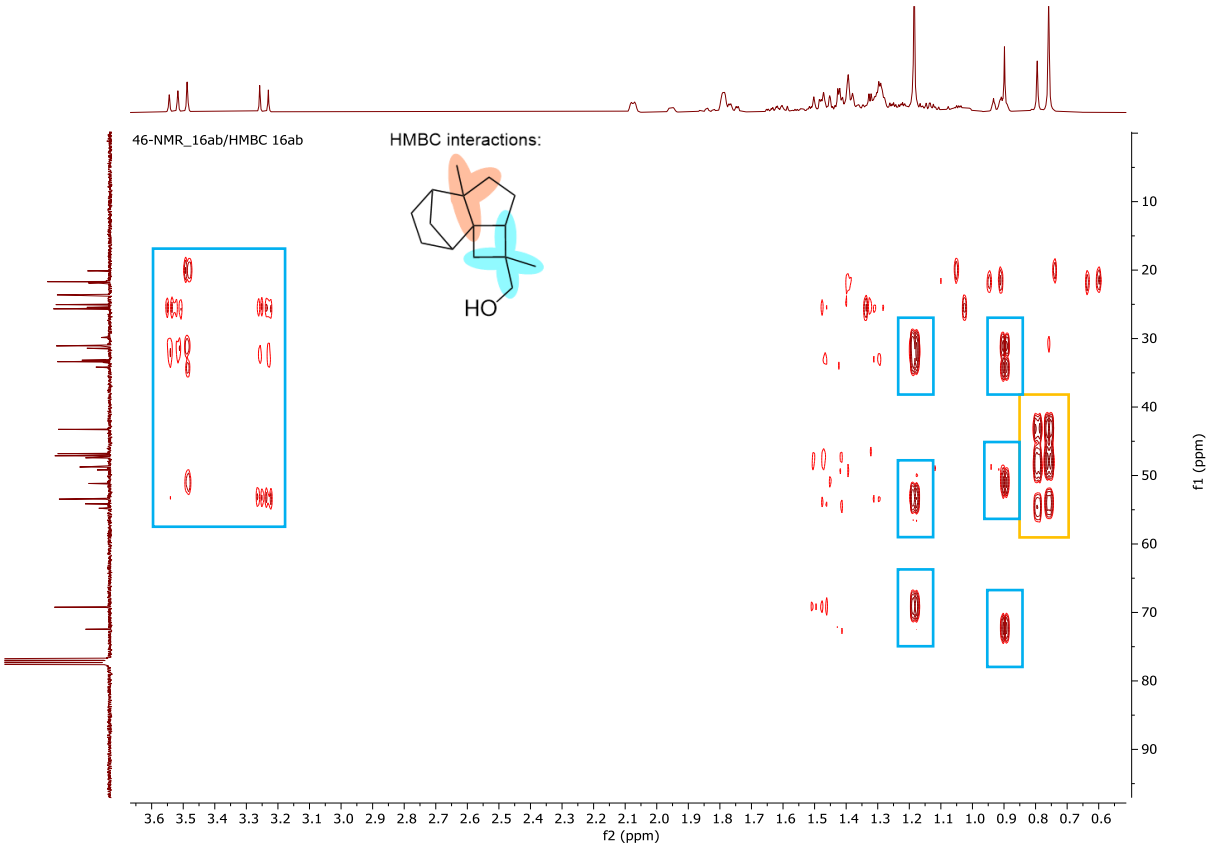
Figure S4. NOESY spectrum of the mixture of isomers **16a** and **16b**.

While one would expect the H-6 CH_3 (red) or H-5 CH_2-OH (blue) interaction with H-1 (green) to suggest the crossed product rather than the straight product, the geometry of both crossed and straight products is such that the cyclobutane substituents can interact with H-1 in both cases. To assign the crossed or straight product structure, the HMBC spectrum was measured: in the HMBC, the interactions of C-H 7 with the cyclobutane are characteristic (blue, *vide infra*). In the straight product, C-H 7 will interact with one -CH_2- group, whereas in the crossed product, C-H 7 will interact with two -CH_2- groups:



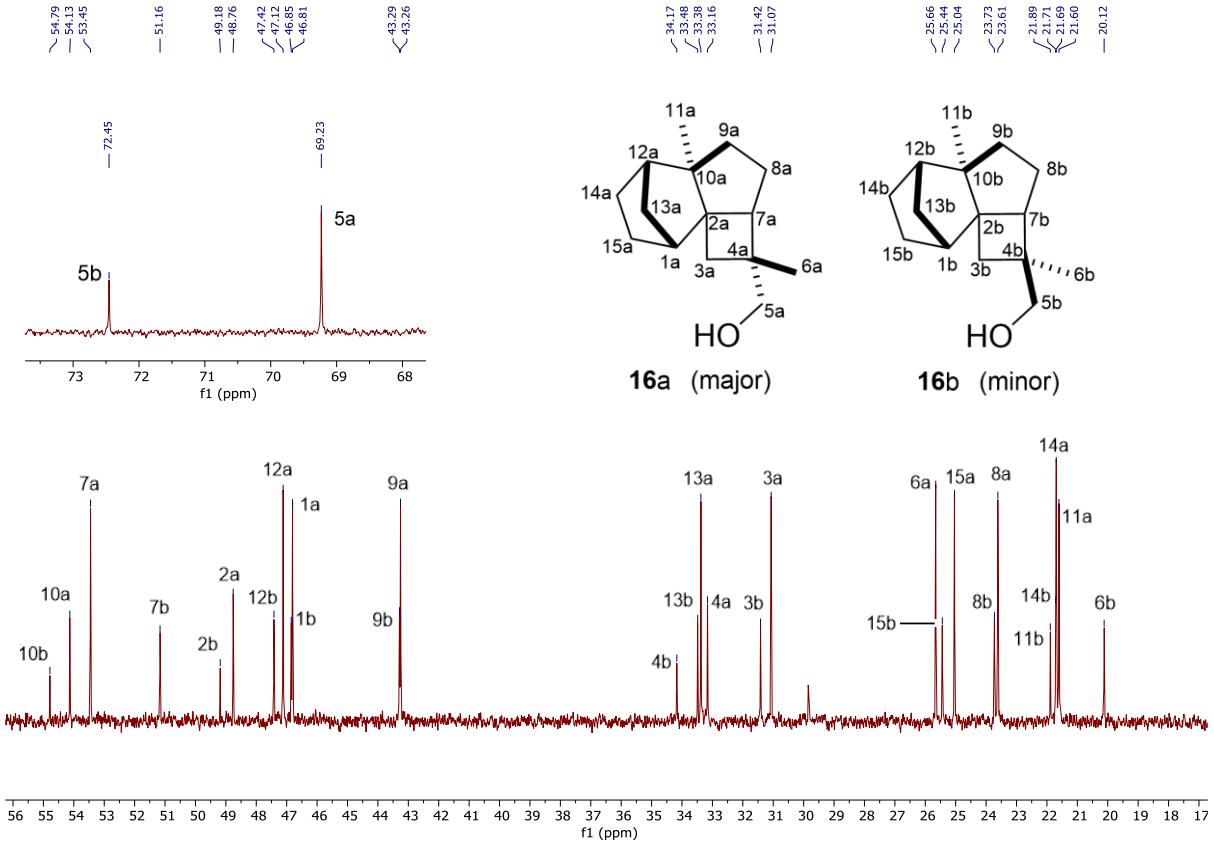
straight product crossed product

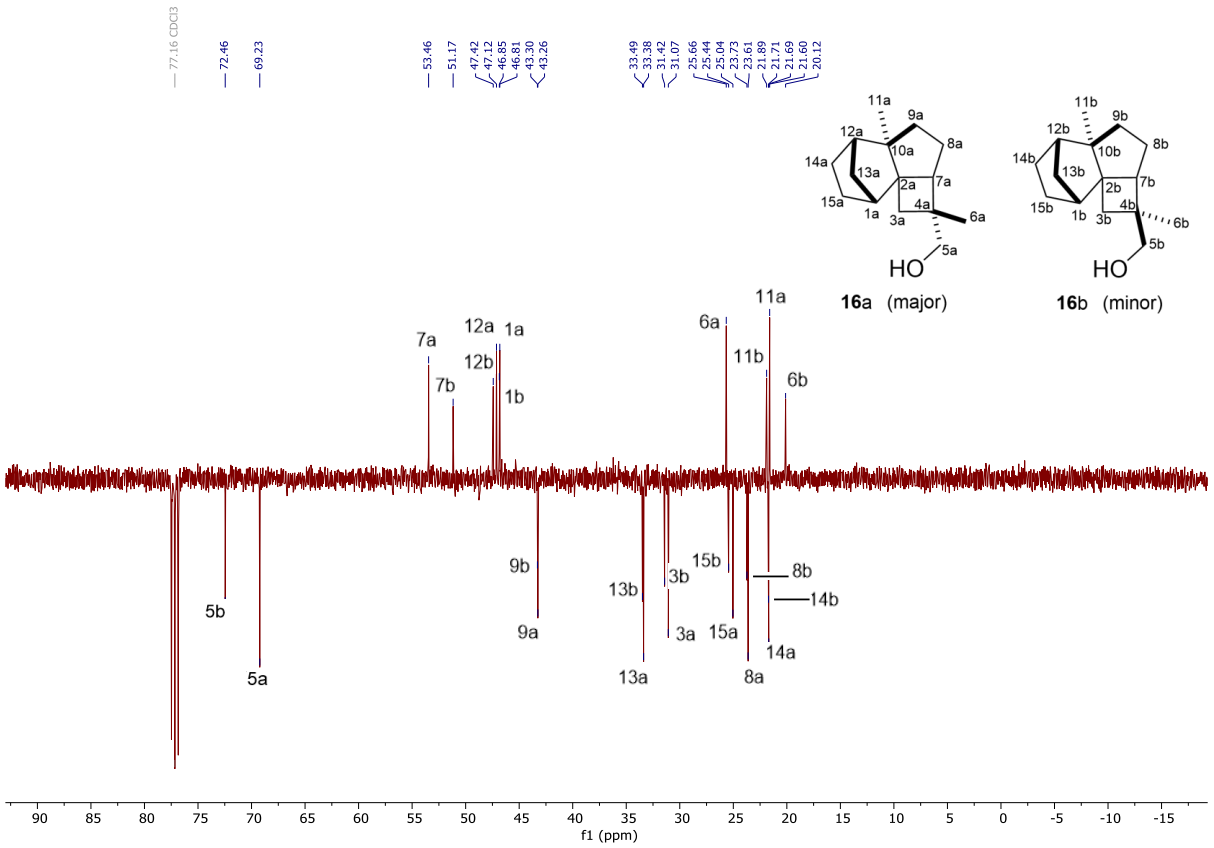
The interaction pattern corresponding to the straight cycloadduct was observed:



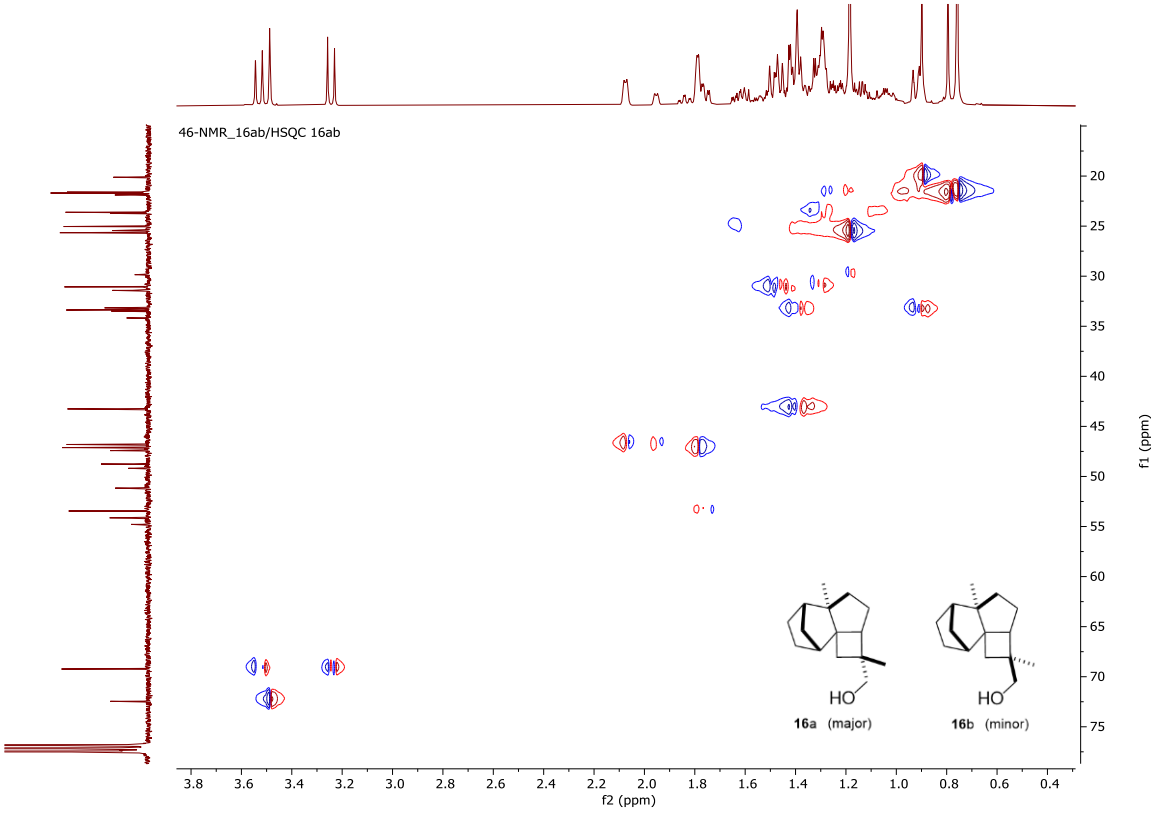
The same interaction with the bridgehead proton as seen in the nOe was not observed in the HMBC spectrum. The ^{13}C signals were assigned as follows (*vide infra*).

^{13}C NMR assignments 16a and 16b





HSQC spectrum of 16a and 16b



7. Crystal Structure of *exo*-4h (CCDC 2247008)

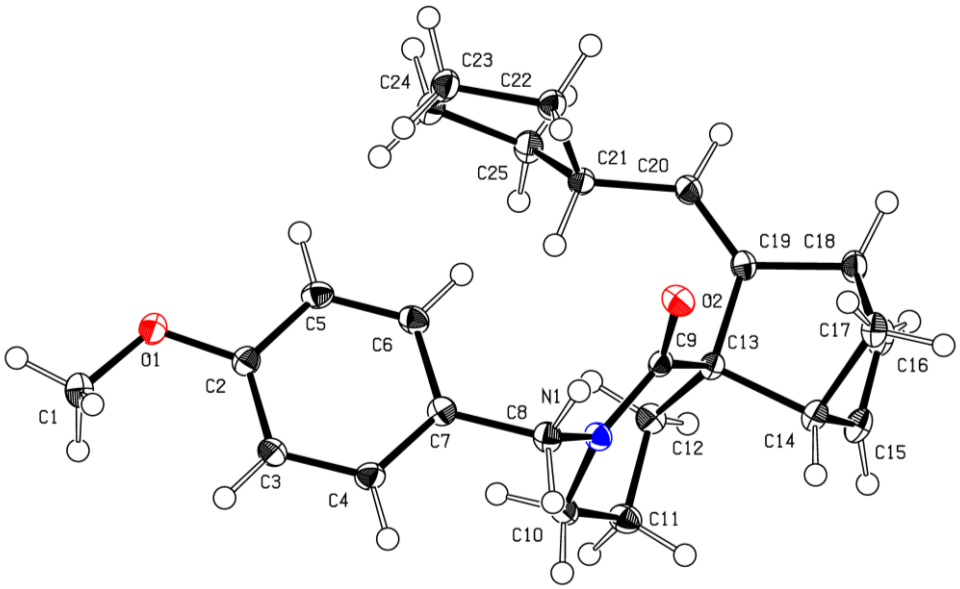


Figure S5. Ortep plot of compound **4h** – HarFr2. ADPs are shown at 50 % probability.

Table 1: Table of crystal data, data collection and structure refinement.

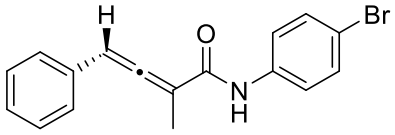
Identification code	**HarFr2**
Chemical formula	$C_{25}H_{31}NO_2$
Formula weight / g mol^{-1}	377.51
Temperature / K	100(2)
Wavelength / Å	0.71073
Crystal size / mm	0.152 x 0.137 x 0.129
Crystal habit	colourless fragment
Crystal system	triclinic *P* -1
Unit cell dimensions **a** / Å	10.2906(8)
b / Å	10.4146(8)
c / Å	10.5305(7)
α / °	115.040(3)
β / °	94.445(3)

γ / °	99.671(3)
Volume / Å^3	993.93(13)
Z	2
Density (calculated) / g cm^{-3}	1.261
Absorption coefficient / mm^{-1}	0.079
F(000)	408

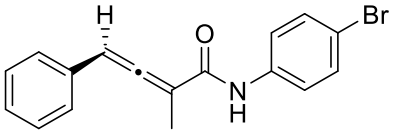
Diffractometer	Bruker D8 Venture
Diffractometer operator	A. A. Heidecker
Radiation source	TXS rotating anode, Mo (λ = 0.71073 Å)
Theta range for data collection / °	2.2138 to 28.3102
Index ranges	-13<=h<=13, -13<=k<=13, -13<=l<=13
Reflections collected	55199
Independent reflections	4723 [R(int) = 0.0562]
Coverage independent reflections / %	99.4
Absorption correction	Multi-Scan
Max., min. transmission	0.6874, 0.7457
Structure solution technique	direct methods
Structure solution program	SHELXT 2018/2 (Sheldrick, 2018)
Refinement method	Full-matrix least-squares on F^2
Refinement program	SHELXL-2018/3 (Sheldrick, 2018)
Function minimised	$\Sigma\, w(F_o^2 - F_c^2)^2$
Data / restraints / parameters	4723 / 0 / 254
Goodness-of-fit on F^2	1.075

Final R indices; I>2σ(I),	4255 data, R1 = 0.0480, wR2 = 0.1224
Final R indices; all data	R1 = 0.0527, wR2 = 0.1274
Weighting scheme where $P=(F_o^2+2F_c^2)/3$	$w=1/[\sigma^2(F_o^2)+(0.0699P)^2+$ $0.3783P]$
Largest diff. peak, hole / $eÅ^{-3}$	0.519, -0.338
R.M.S. deviation from mean / $eÅ^{-3}$	0.076

8. Determination of absolute configuration: *(R)*-5n and *(S)*-5n

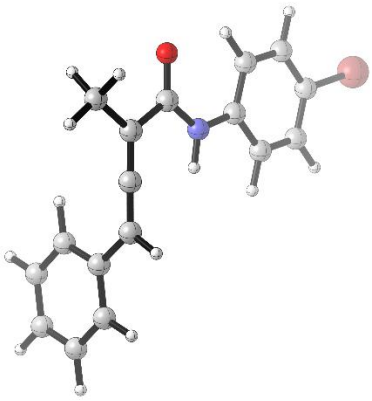


(R)-**5n** (E1)



(S)-**5n** (E2)

Results of the VCD analysis. The conformational analysis gave, after DFT-based geometry optimizations, only one populated conformer. Comparison of the experimental spectra recorded for the enantiomers E1/E2 with the computed spectra allows an unambiguous assignment of the (R)-configuration to E1 and in turn (S) to E2.



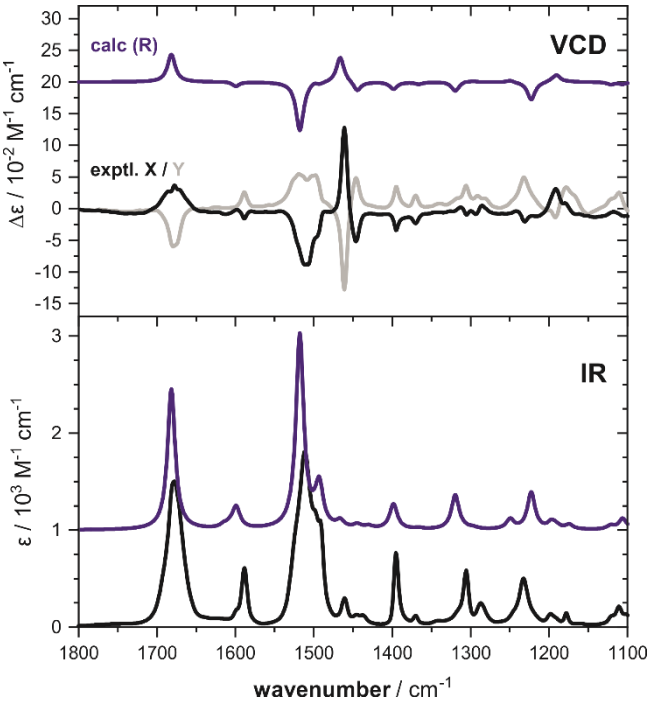


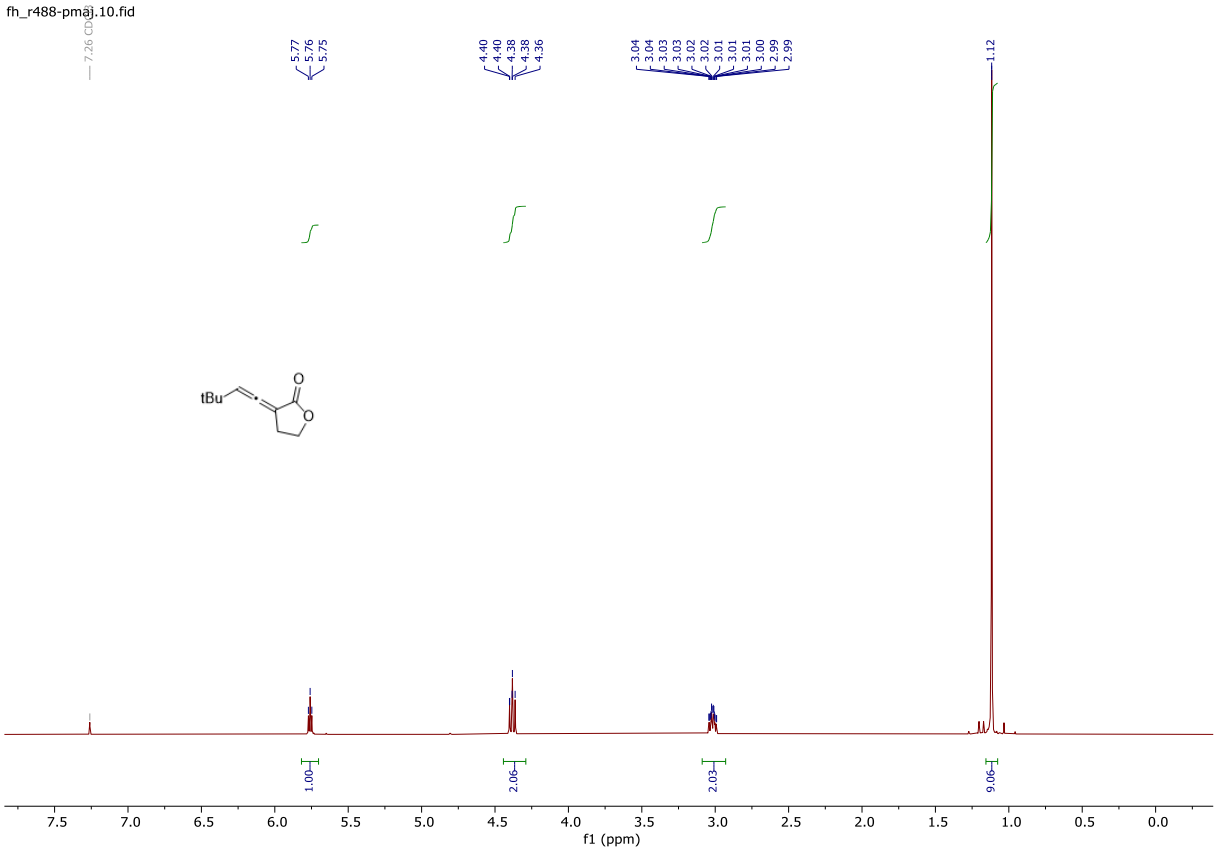
Figure S6. Left: Structures of *(R)*-**5n**. Right: Comparison of experimental and computed IR and VCD spetra of **5n**.

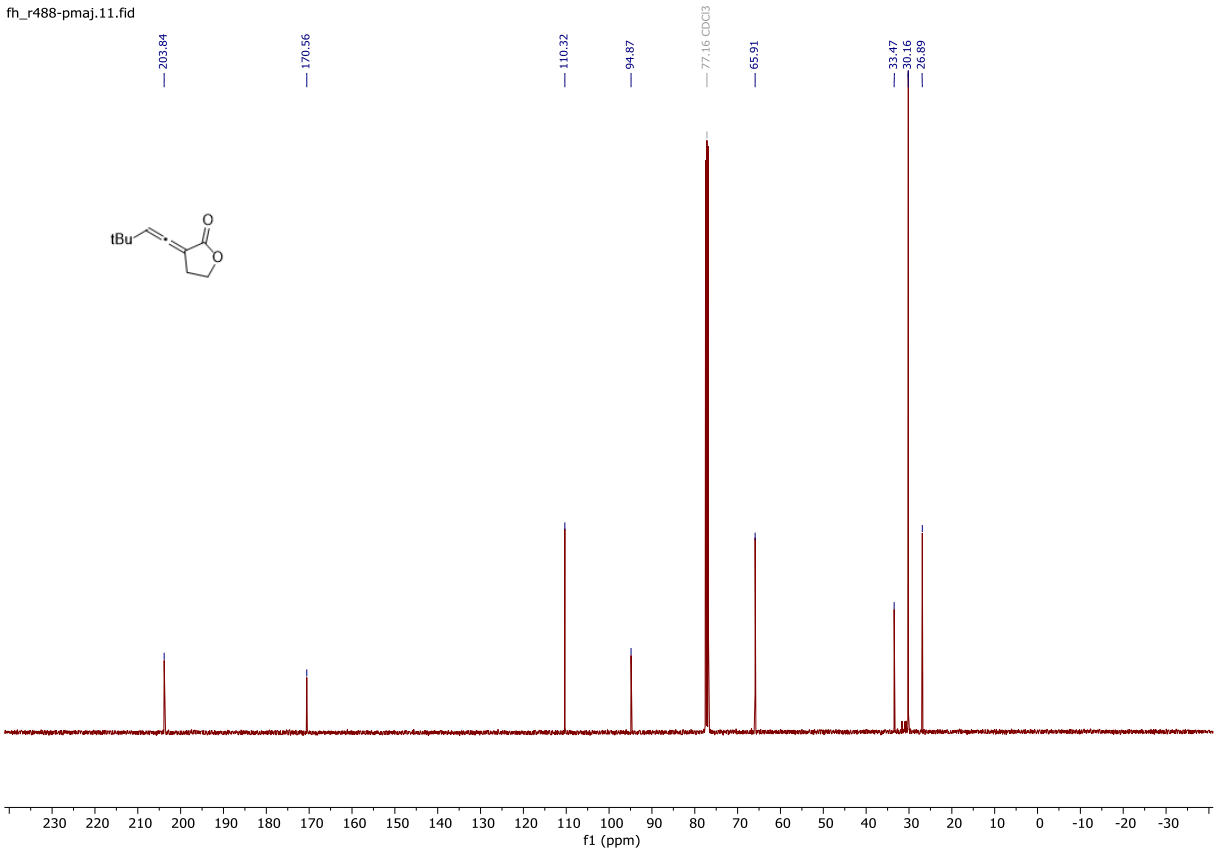
Cartesian coordinates of *(R)*-5n.

C	4.90150400	-1.73063600	1.65410500
C	4.25295800	-0.71190500	0.97576600
C	4.25110300	-0.67887600	-0.42307800
C	4.91673400	-1.69099400	-1.11961500
C	5.56661400	-2.71149100	-0.43793500
C	5.56111900	-2.73541800	0.95068500
H	4.89496800	-1.74288300	2.73867200
H	3.74296300	0.06936900	1.52987000
H	4.92429400	-1.67553300	-2.20496000
H	6.07874300	-3.48903800	-0.99422600
H	6.06827300	-3.53122500	1.48491300
C	3.57281500	0.38266300	-1.18029800
H	3.65164600	0.32378400	-2.26616100
C	2.89413400	1.38424500	-0.67900500
C	2.19816600	2.38016100	-0.19360000
C	2.80251800	3.71335500	0.15305500
H	2.63172100	3.94485900	1.20678800
H	3.87367700	3.71445200	-0.04465000
H	2.33008200	4.50631600	-0.43146700
C	0.71861500	2.25245400	0.05446800
C	-1.14993000	0.61193700	-0.17394900
C	-1.43225800	-0.69073300	-0.59860800
C	-2.18793600	1.40032500	0.32894000
C	-2.71676300	-1.20093000	-0.52587800
H	-0.63636700	-1.31534600	-0.99166600
C	-3.47630200	0.88741100	0.40149000
H	-1.98466600	2.40738600	0.65986400
C	-3.73456900	-0.40445400	-0.02376200
H	-2.91753800	-2.21149400	-0.85876400
H	-4.27459100	1.50586700	0.79282800
O	0.08651900	3.18560700	0.52540600
N	0.17415300	1.04716300	-0.28199500
H	0.82795600	0.37508600	-0.66172900
Br	-5.50724300	-1.09826500	0.08099200

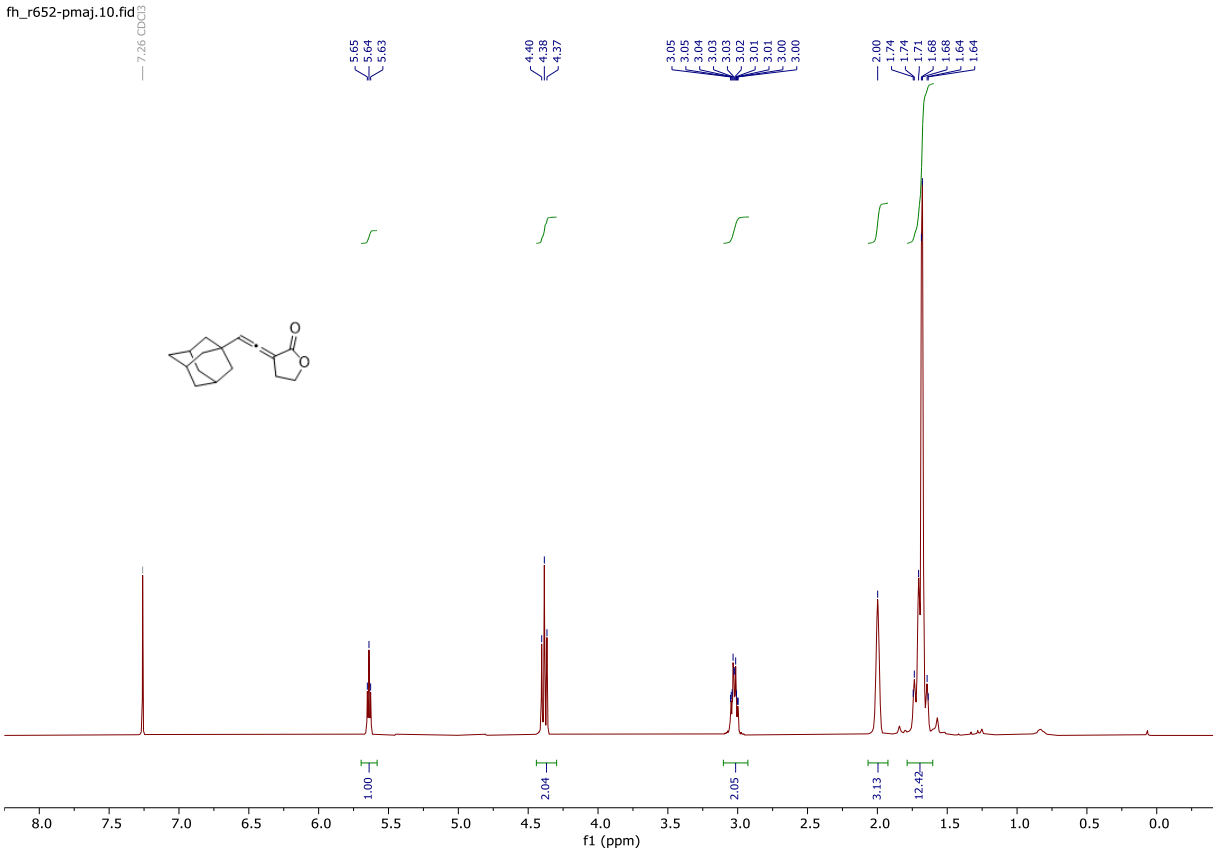
9. NMR Spectra

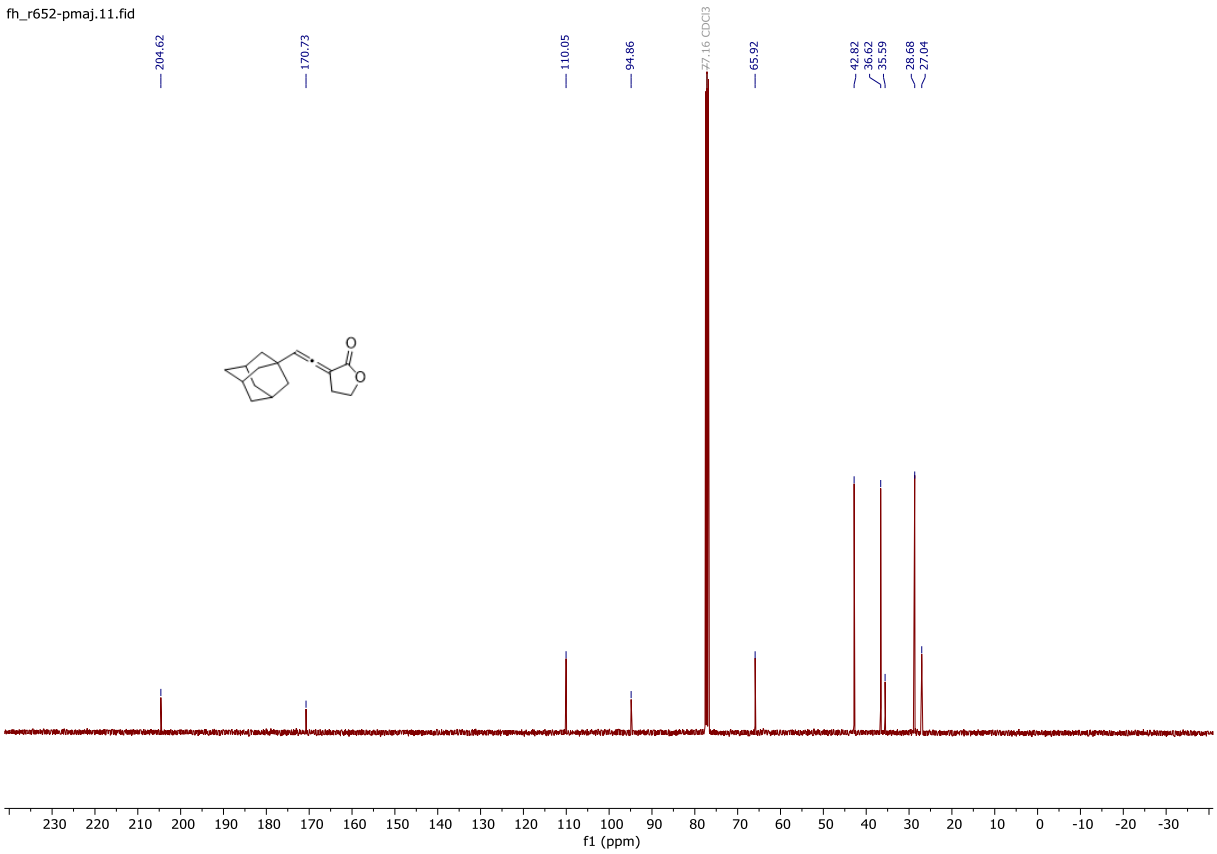
3-(3,3-dimethylbut-1-en-1-ylidene)dihydrofuran-2(3H)-one (3a)



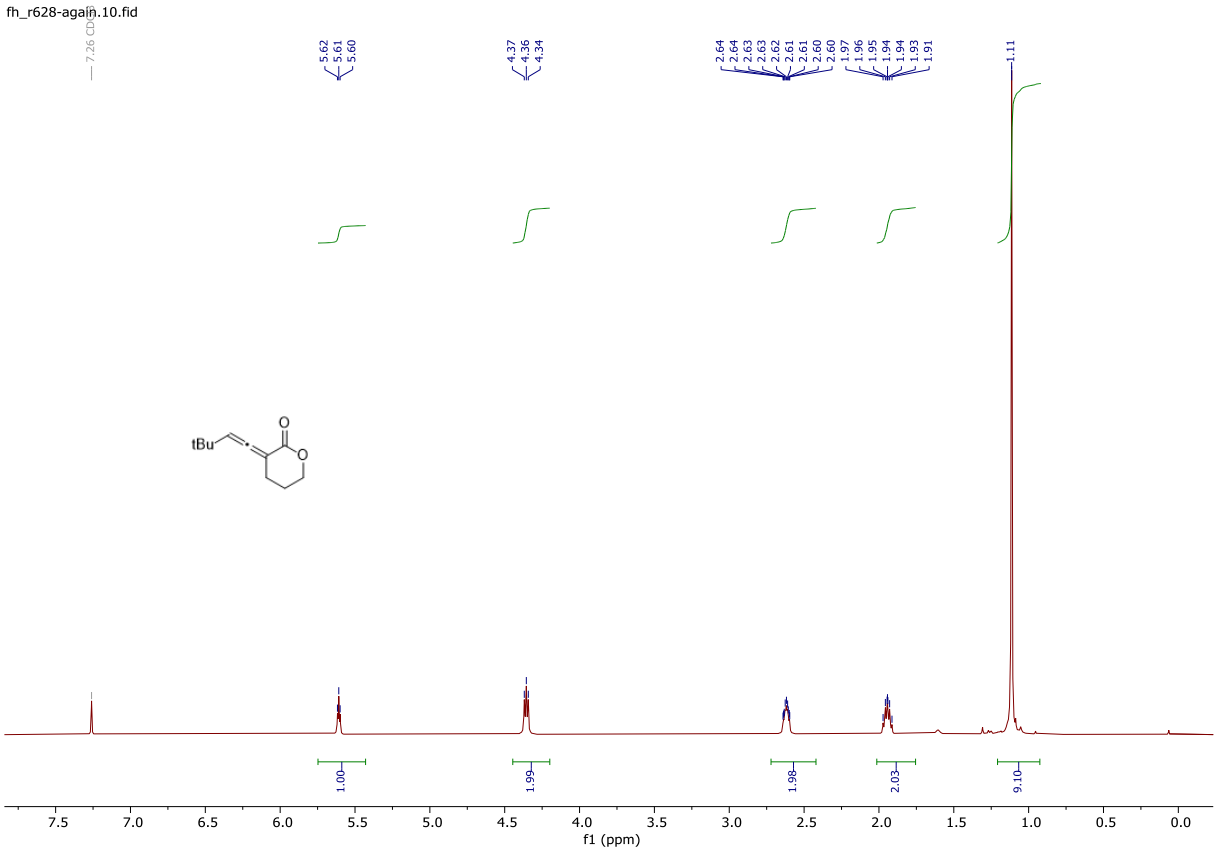


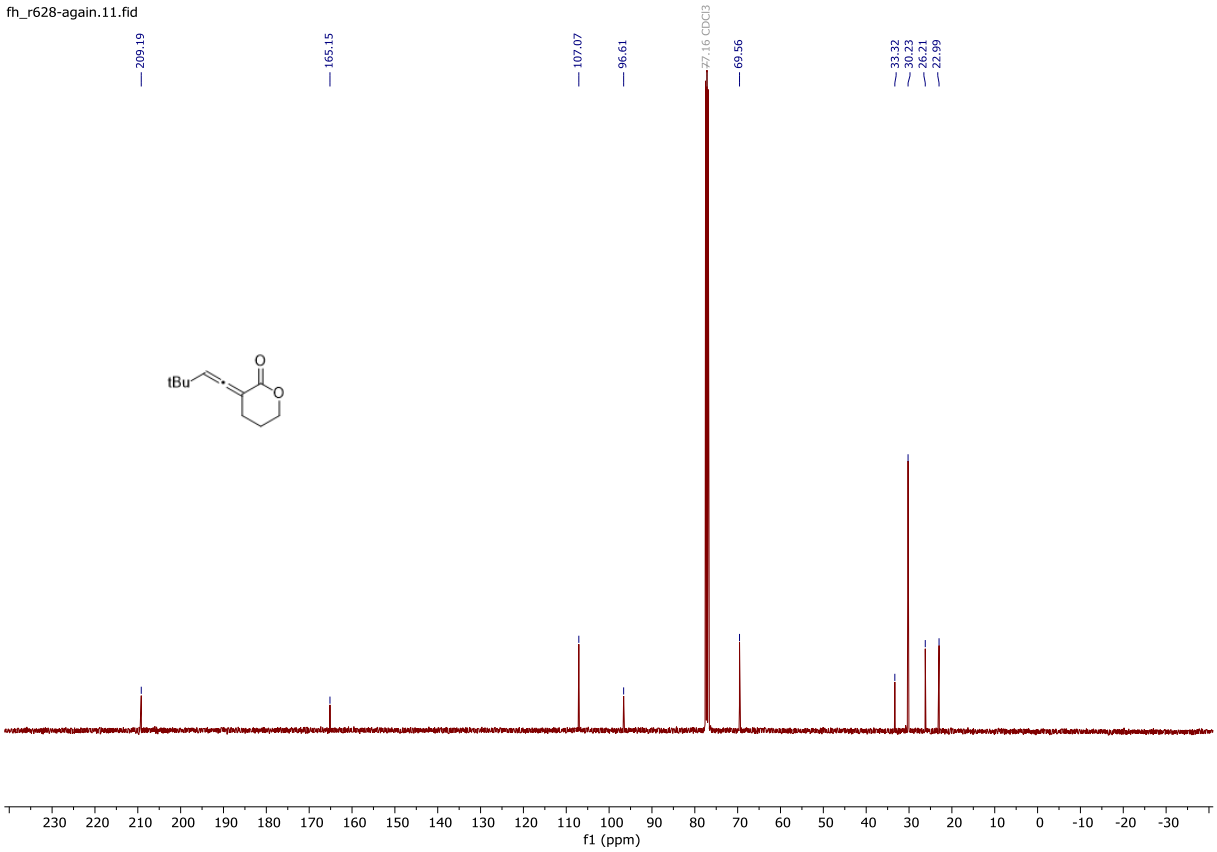
3-((2-adamantan-1-yl)vinylidene)dihydrofuran-2(3H)-one (3b)



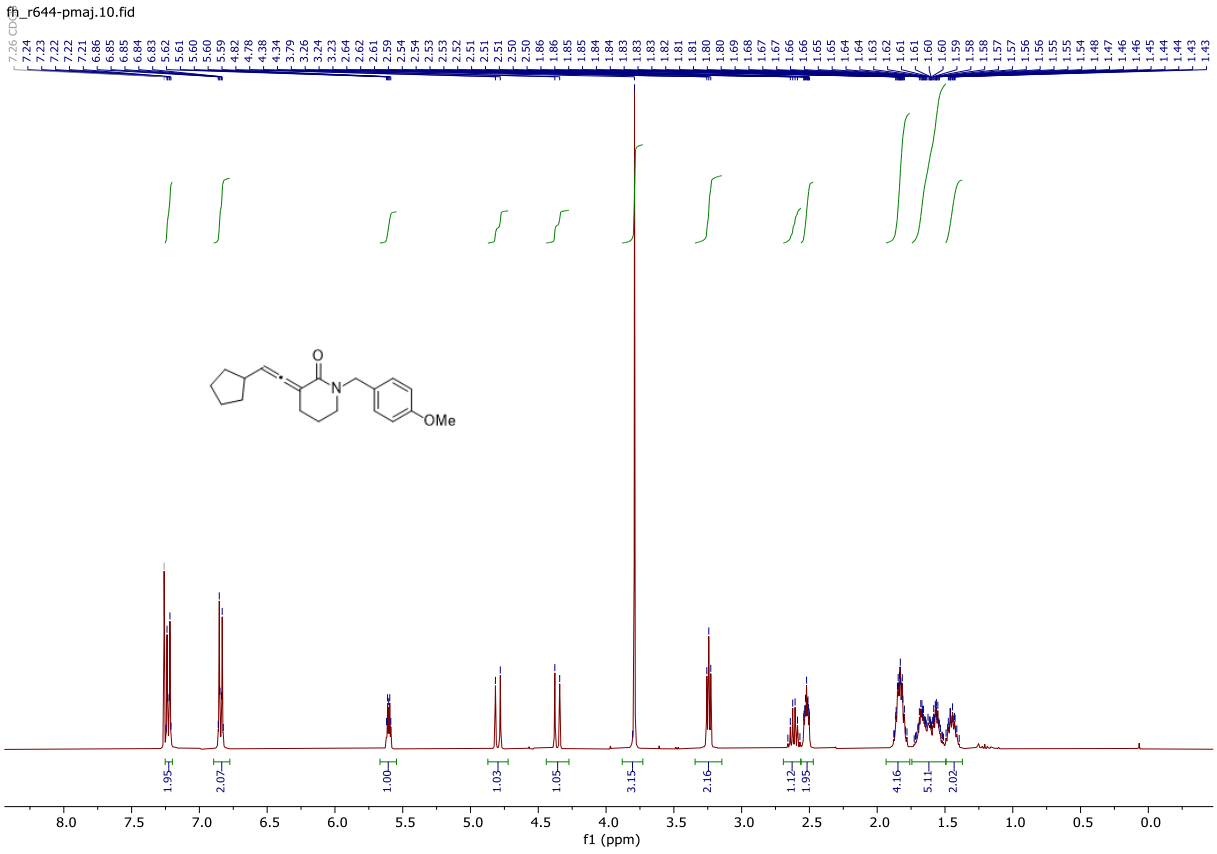


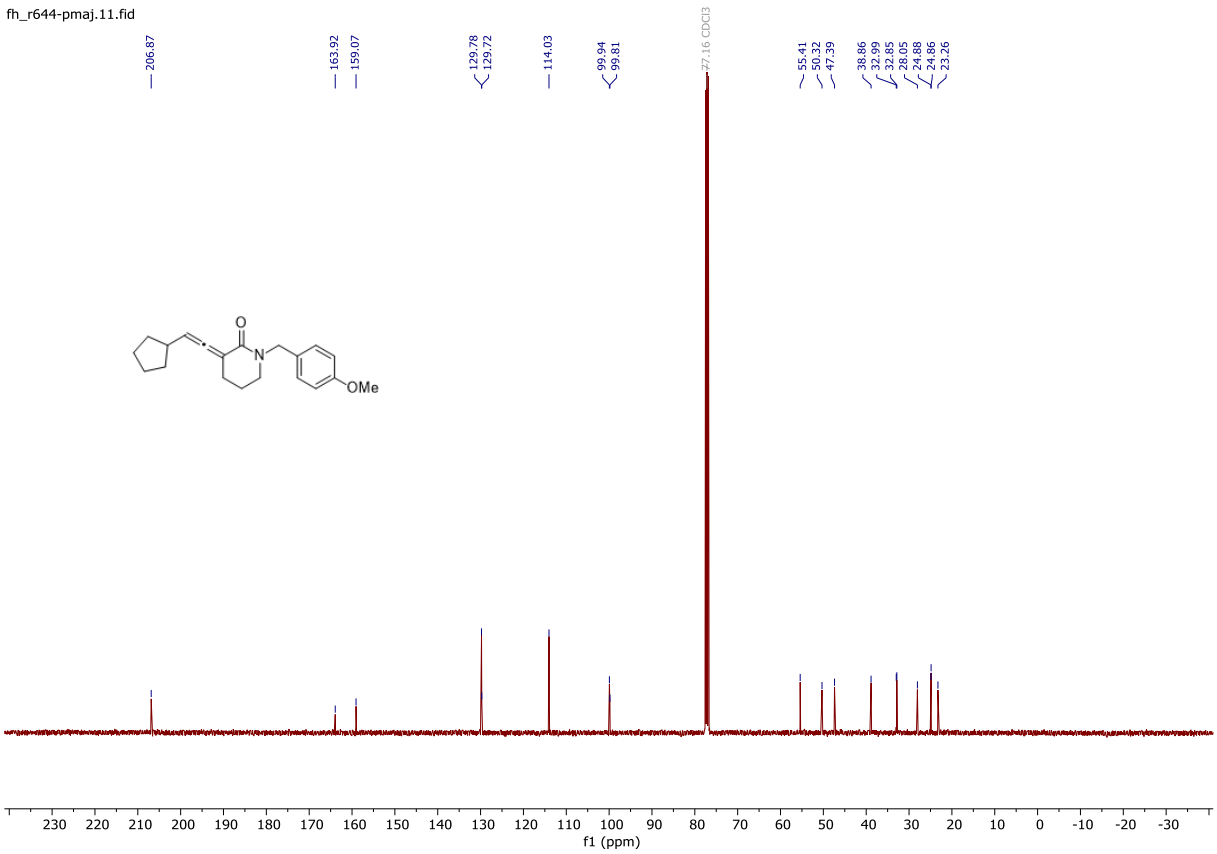
3-(3,3-dimethylbut-1-en-1-ylidene)tetrahydro-2H-pyran-2-one (3c)





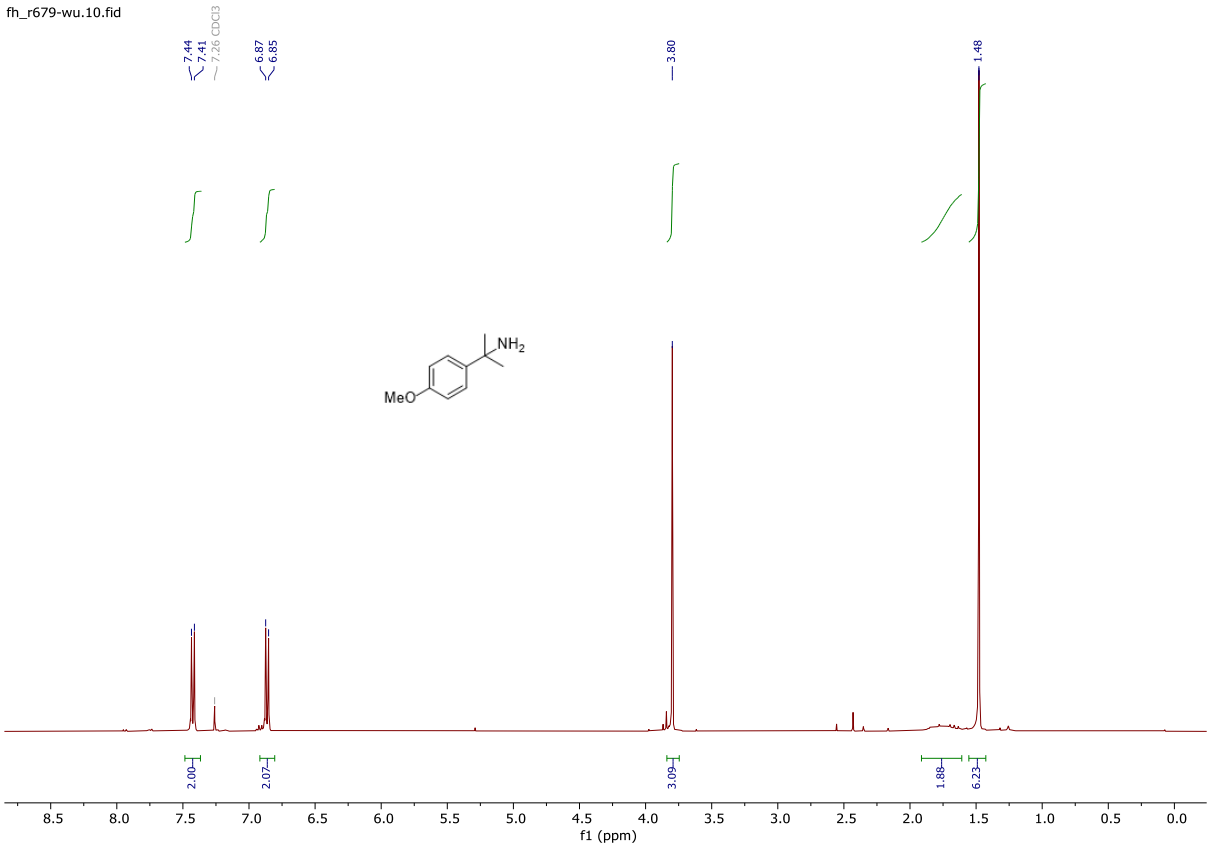
3-(2-cyclopentylvinylidene)-1-(4-methoxybenzyl)piperidin-2-one (3h)



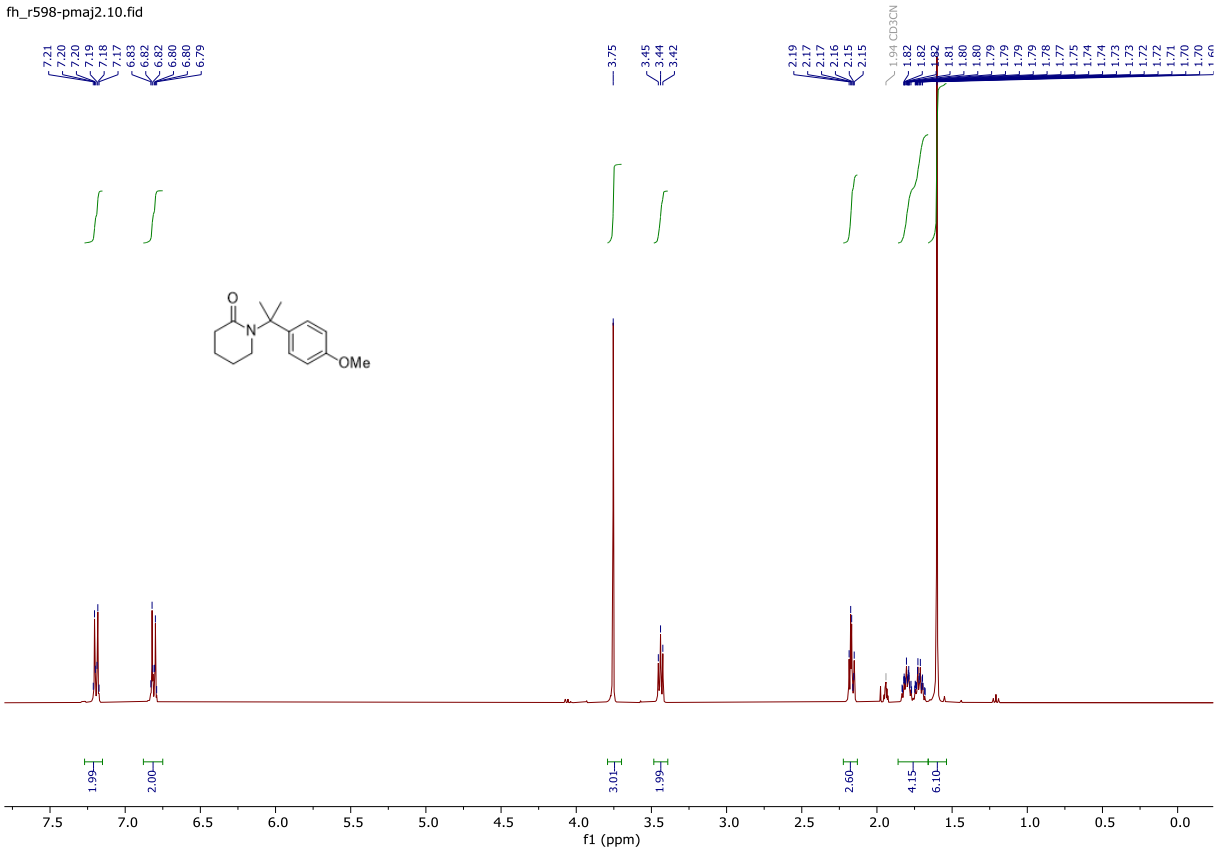


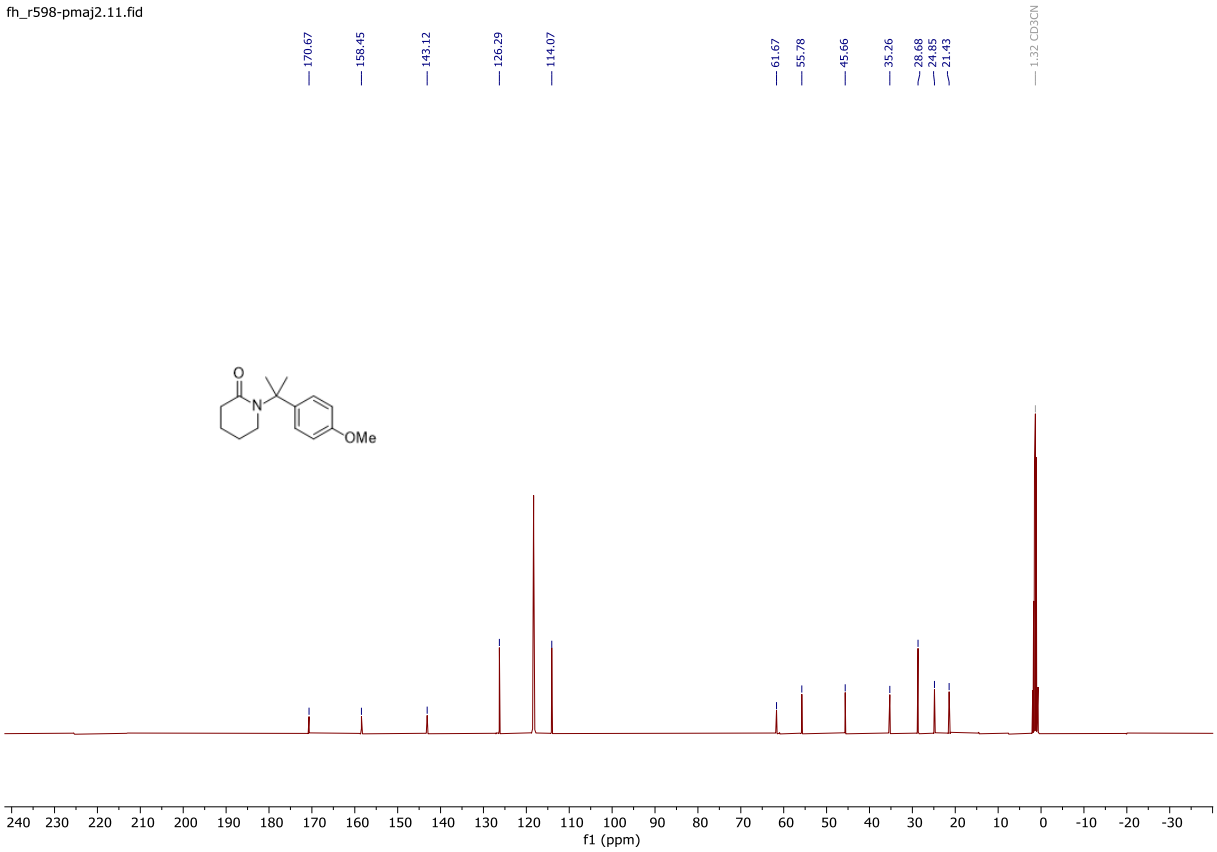
2-(4-methoxyphenyl)propan-2-amine (SI-3)

The NMR data were in accordance with the literature.[13]

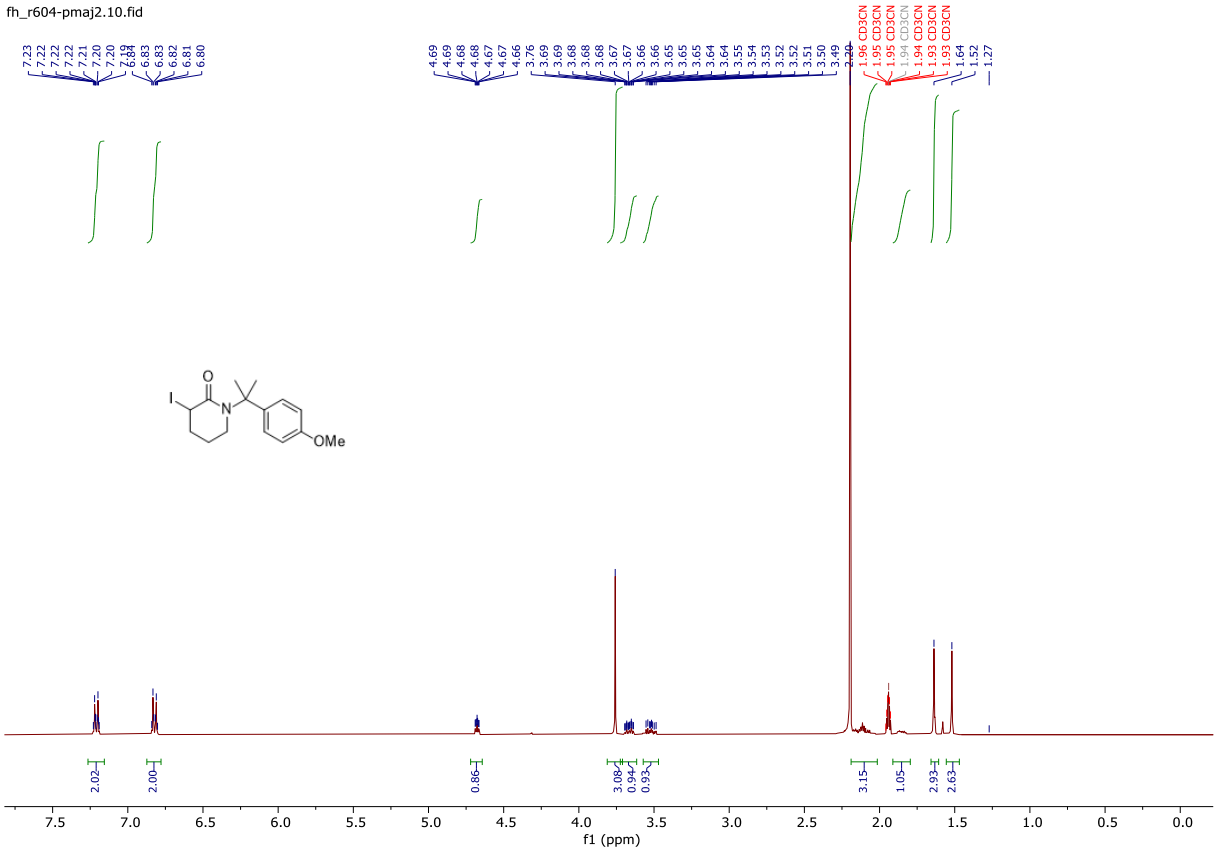


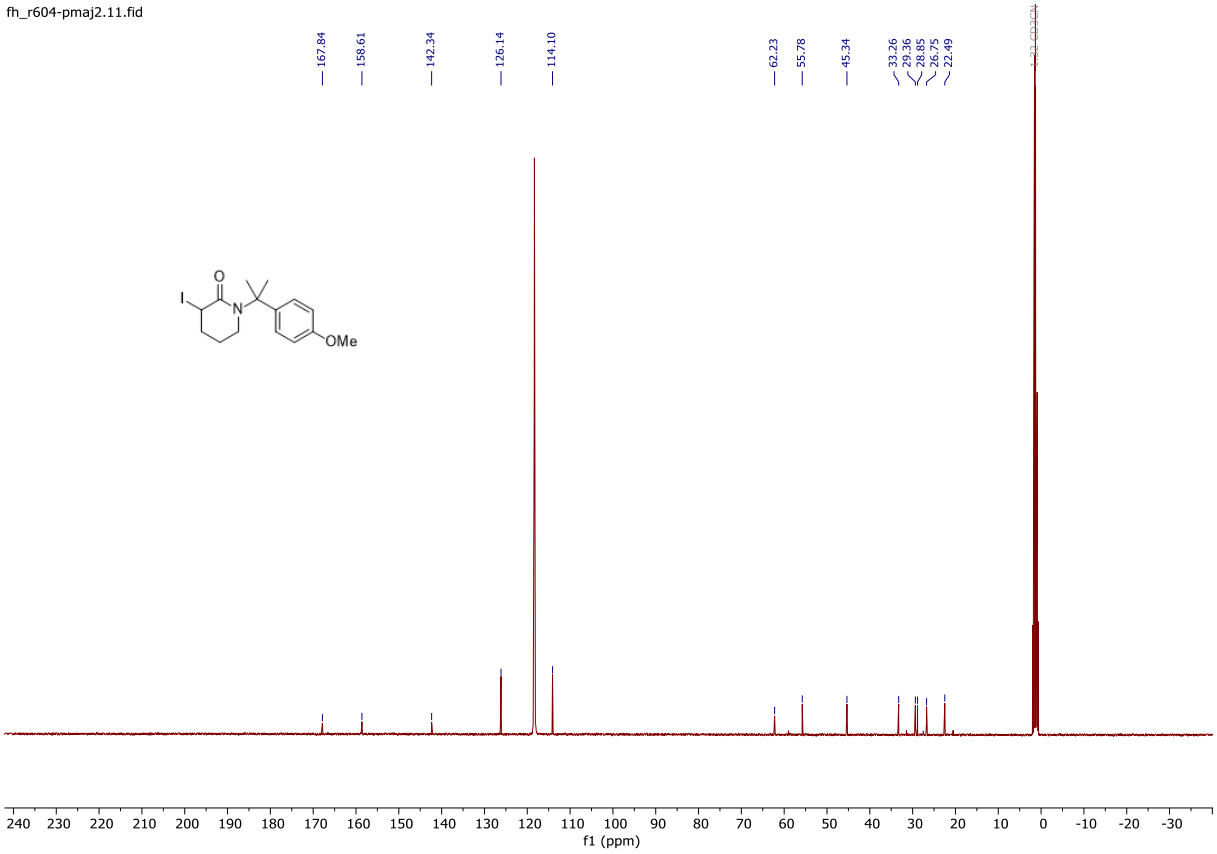
1-(2-(4-methoxyphenyl)propan-2-yl)piperidin-2-one (SI-4)



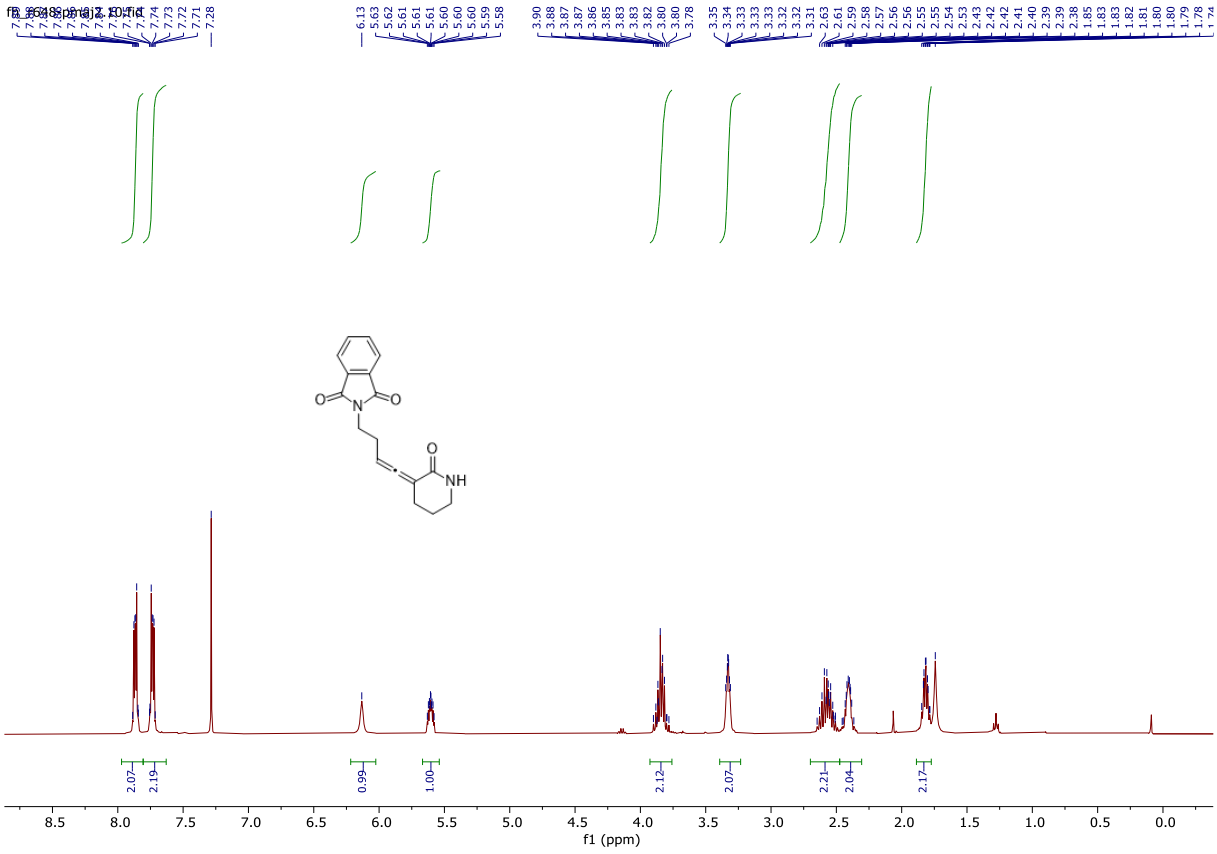


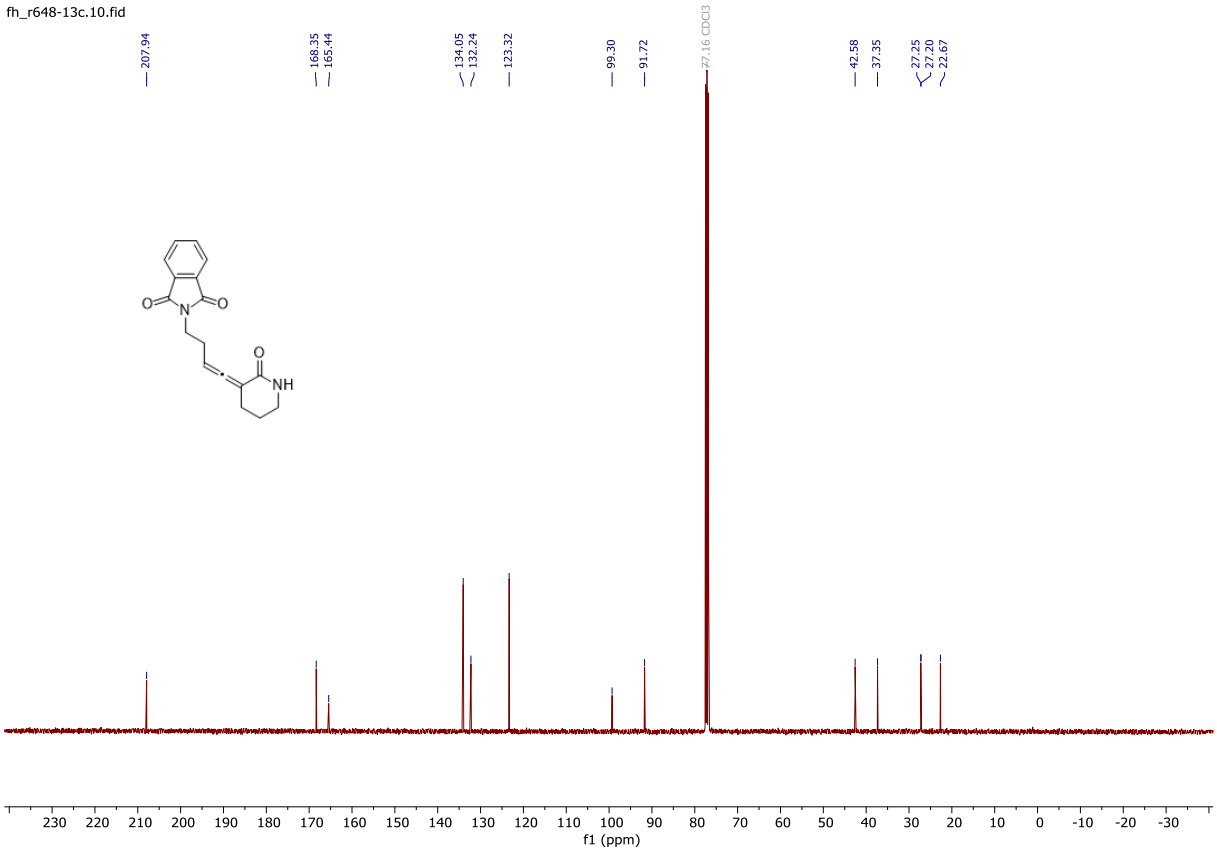
3-iodo-1-(2-(4-methoxyphenyl)propan-2-yl)piperidin-2-one (SI-5)





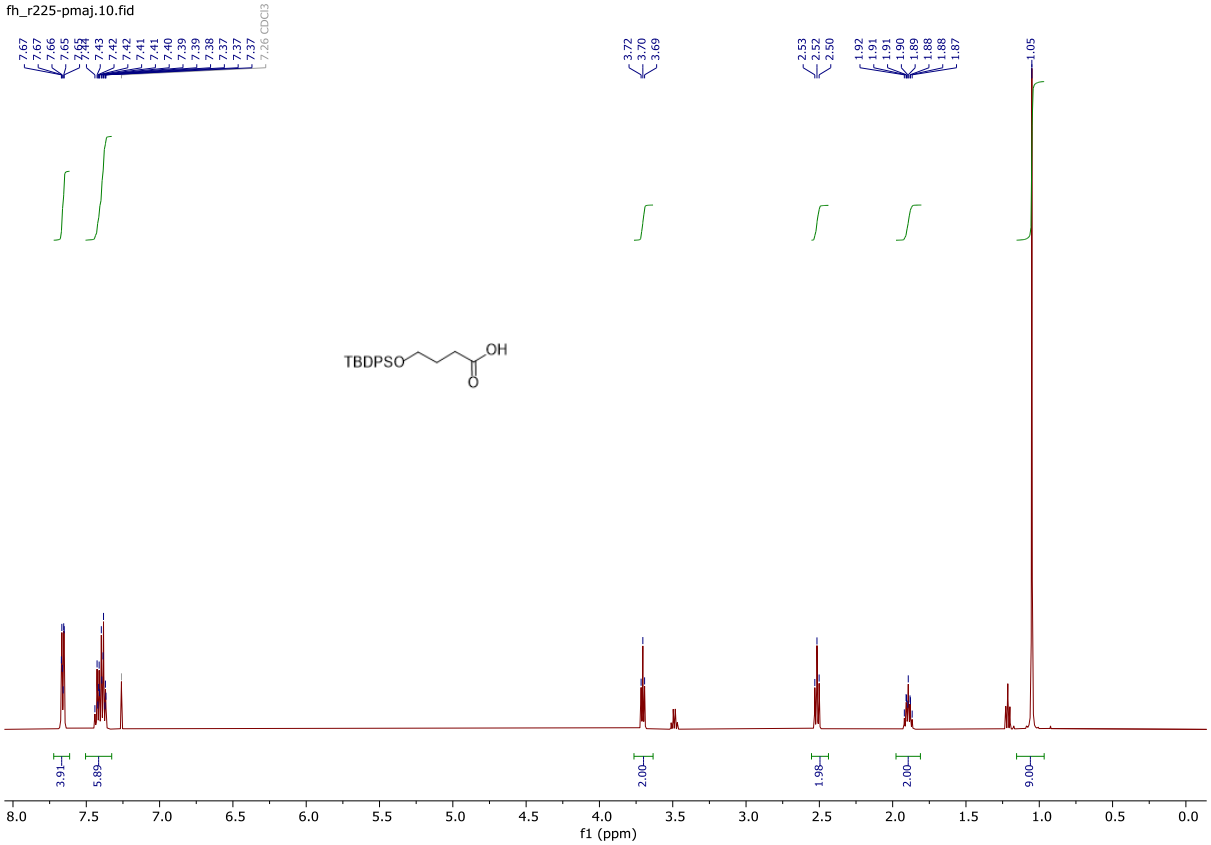
2-(4-(2-oxopiperidin-3-ylidene)but-3-en-1-yl)isoindoline-1,3-dione (3i)



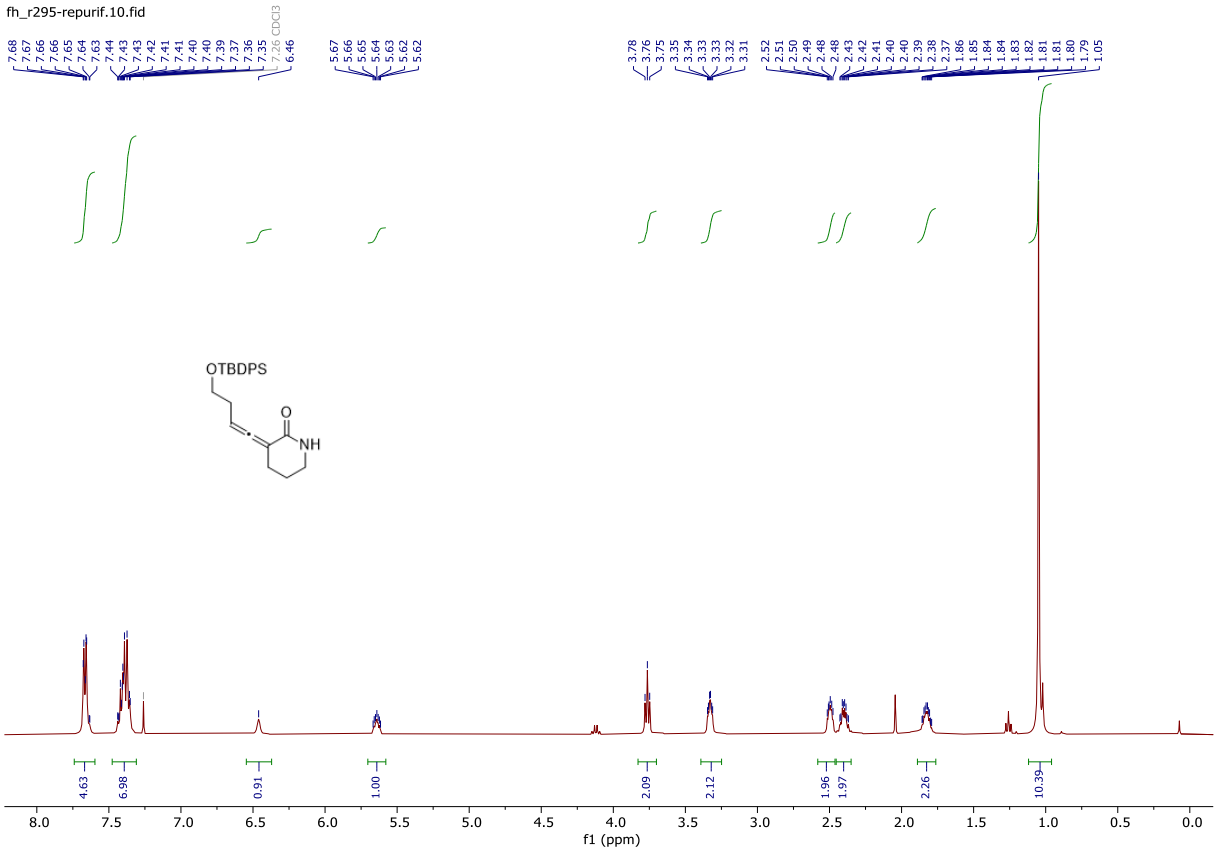


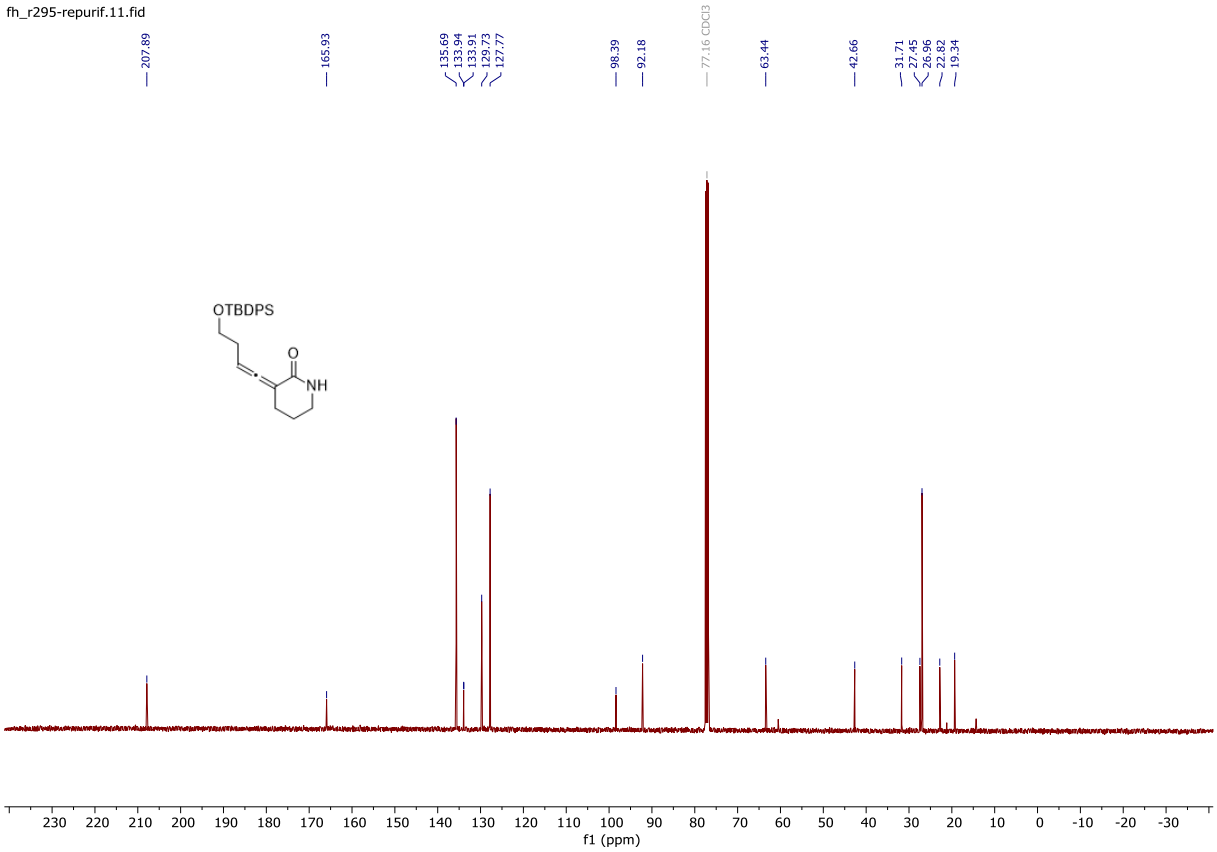
4-((tert-butyldiphenylsilyl)oxy)butanoic acid (SI-8)

The NMR data were in accordance with the literature.[17]

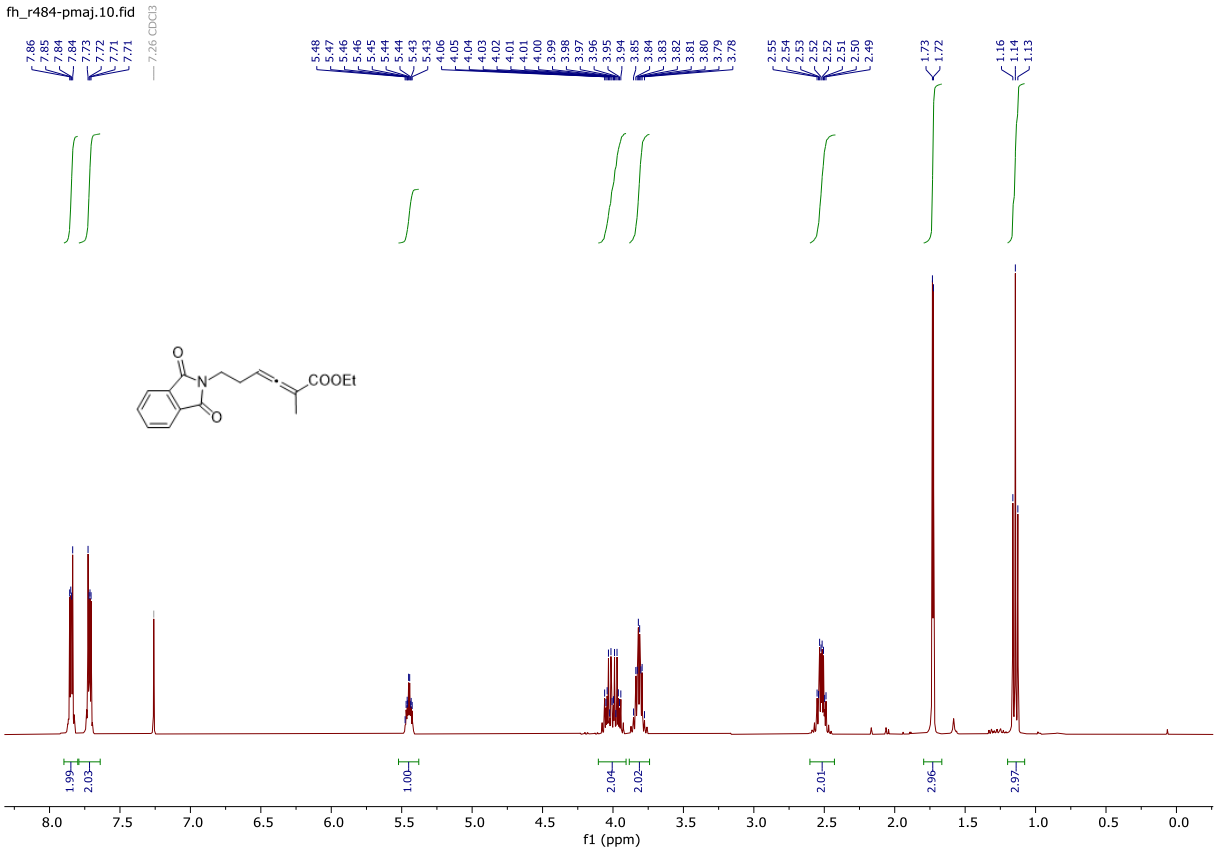


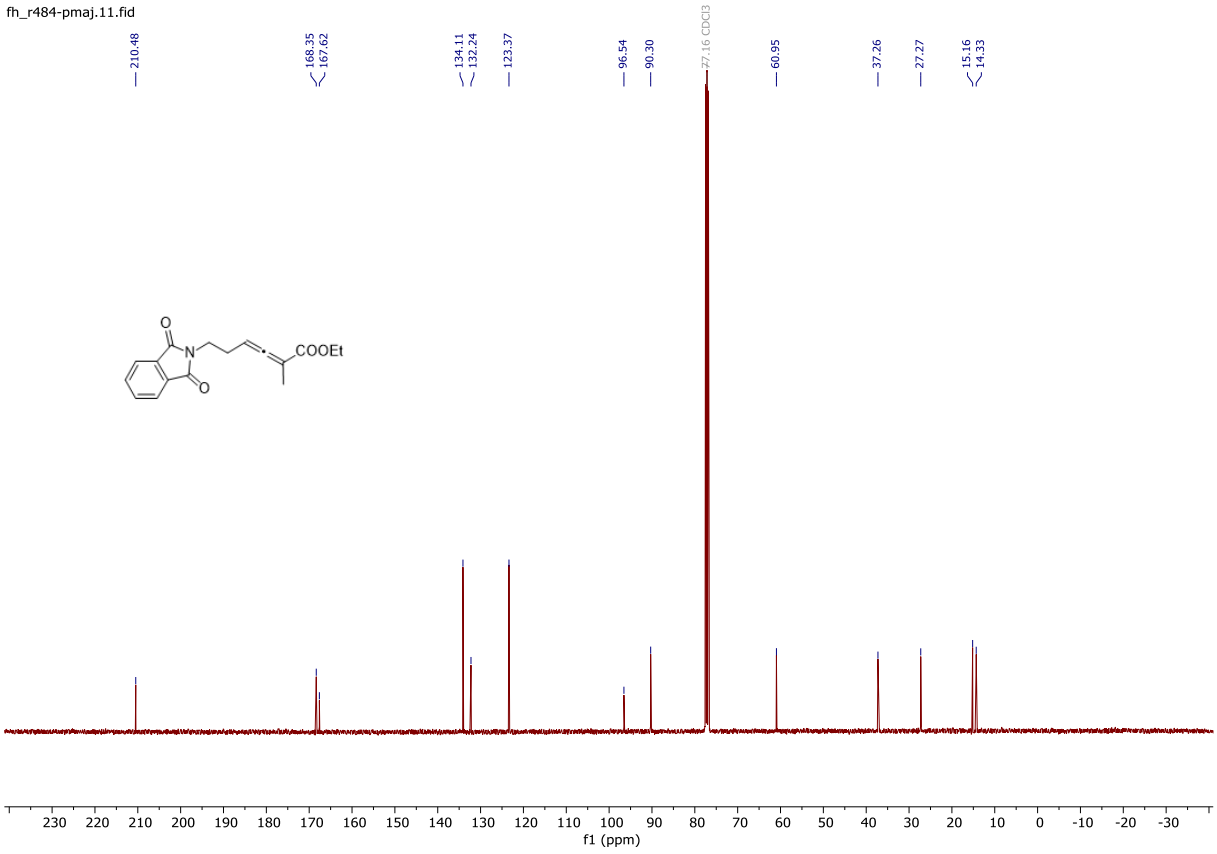
3-(4-((tert-butyldiphenylsilyl)oxy)but-1-en-1-ylidene)piperidin-2-one (3j)





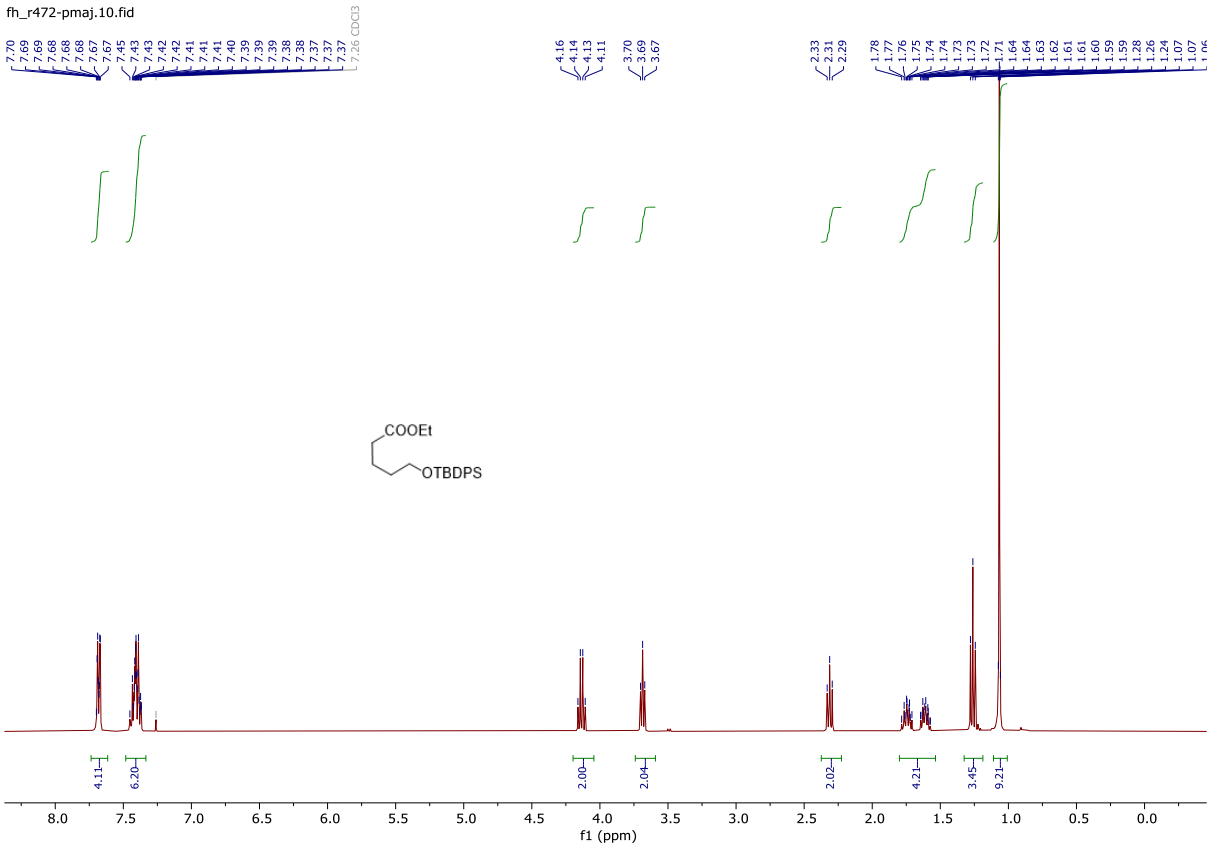
ethyl 6-(1,3-dioxoisoindolin-2-yl)-2-methylhexa-2,3-dienoate (5d)



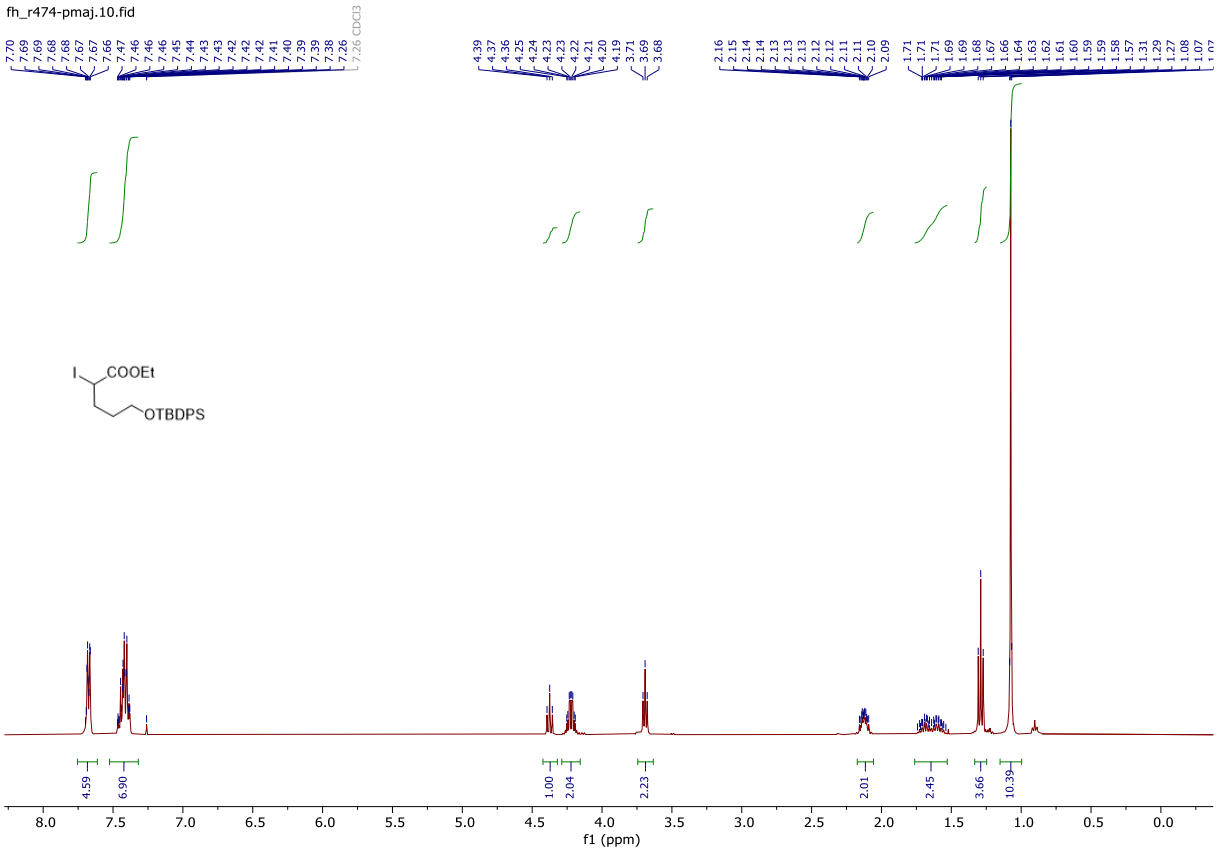


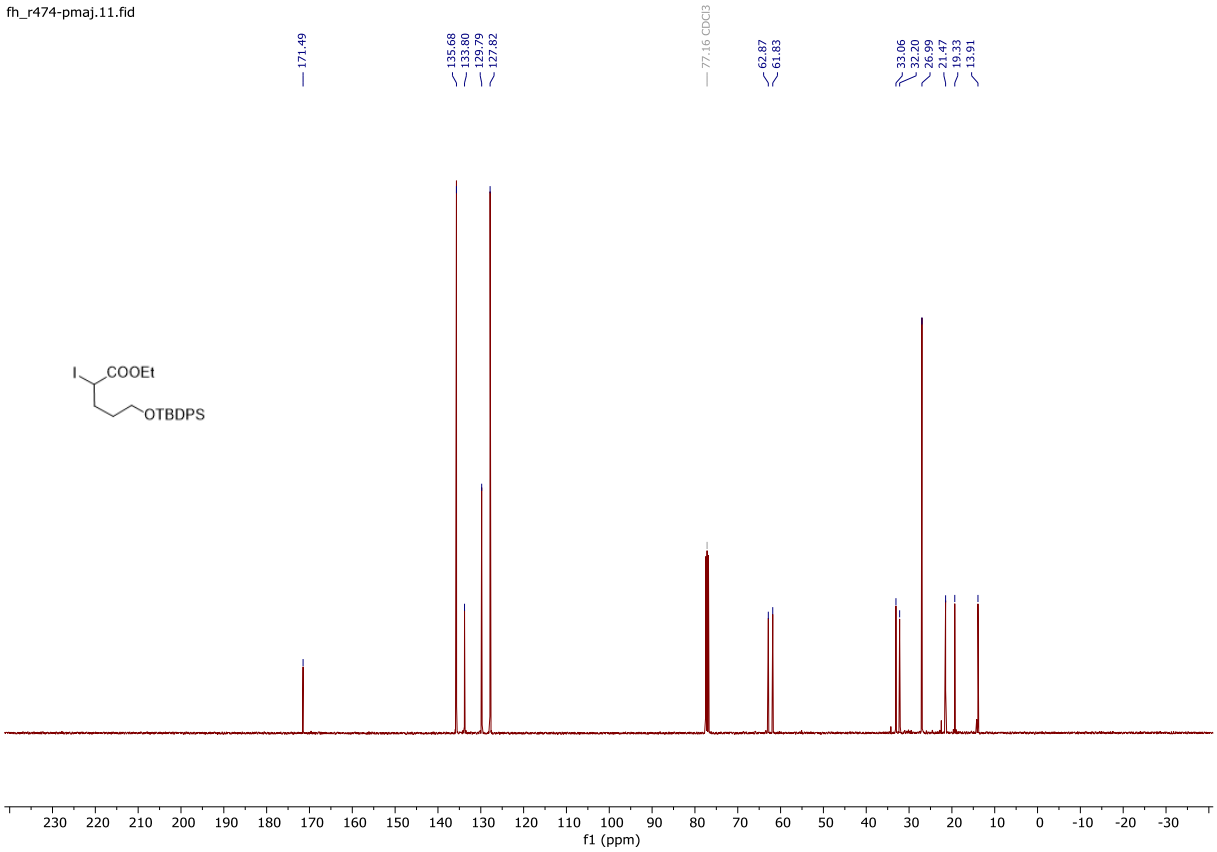
ethyl 5-((tert-butyldiphenylsilyl)oxy)pentanoate (SI-10)

The NMR data were in accordance with the literature.[18]

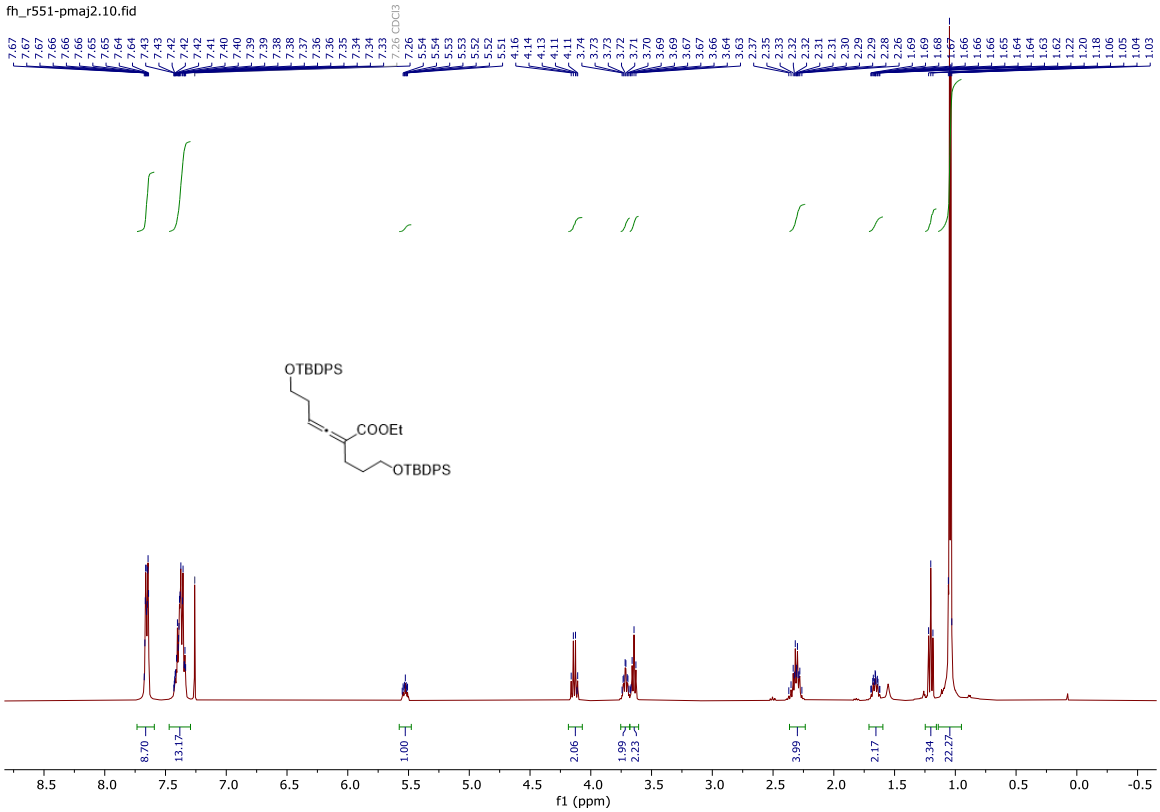


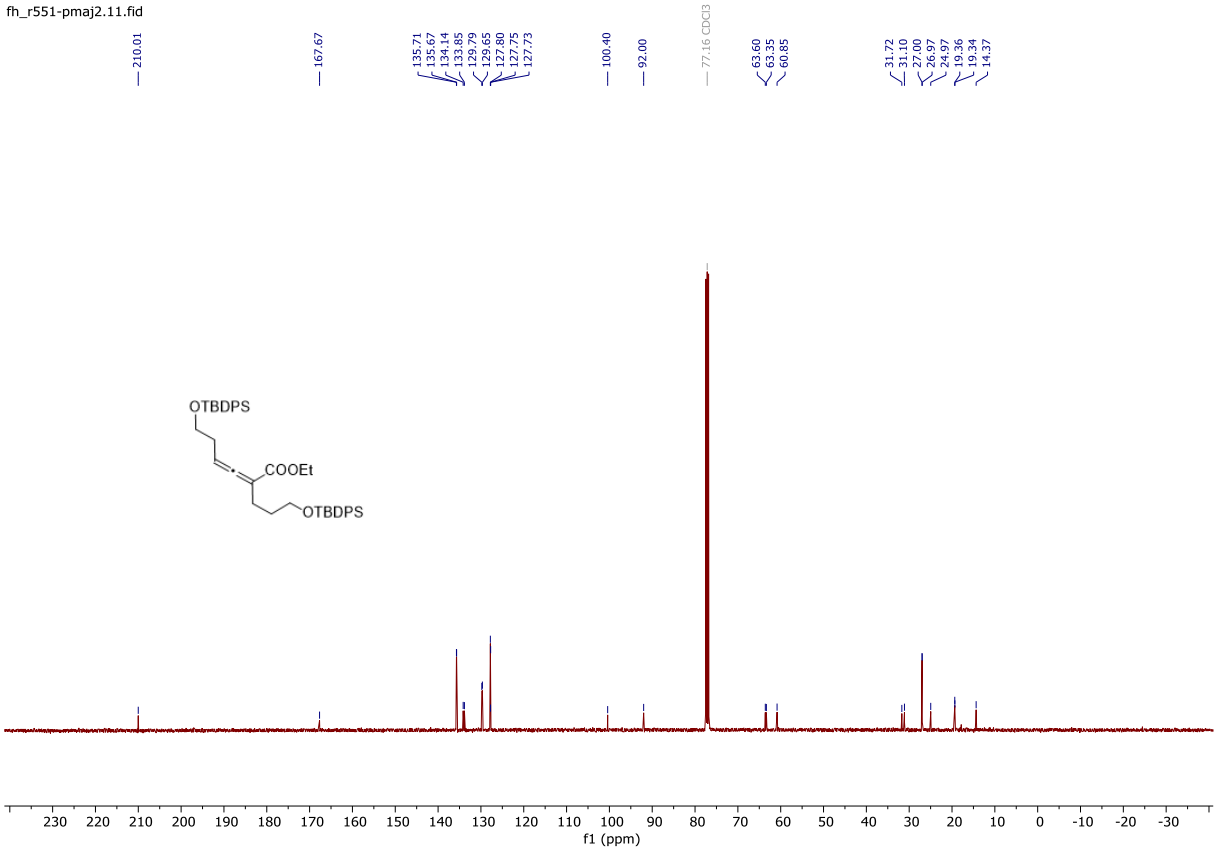
ethyl 5-((tert-butyldiphenylsilyl)oxy)-2-iodopentanoate (SI-11)



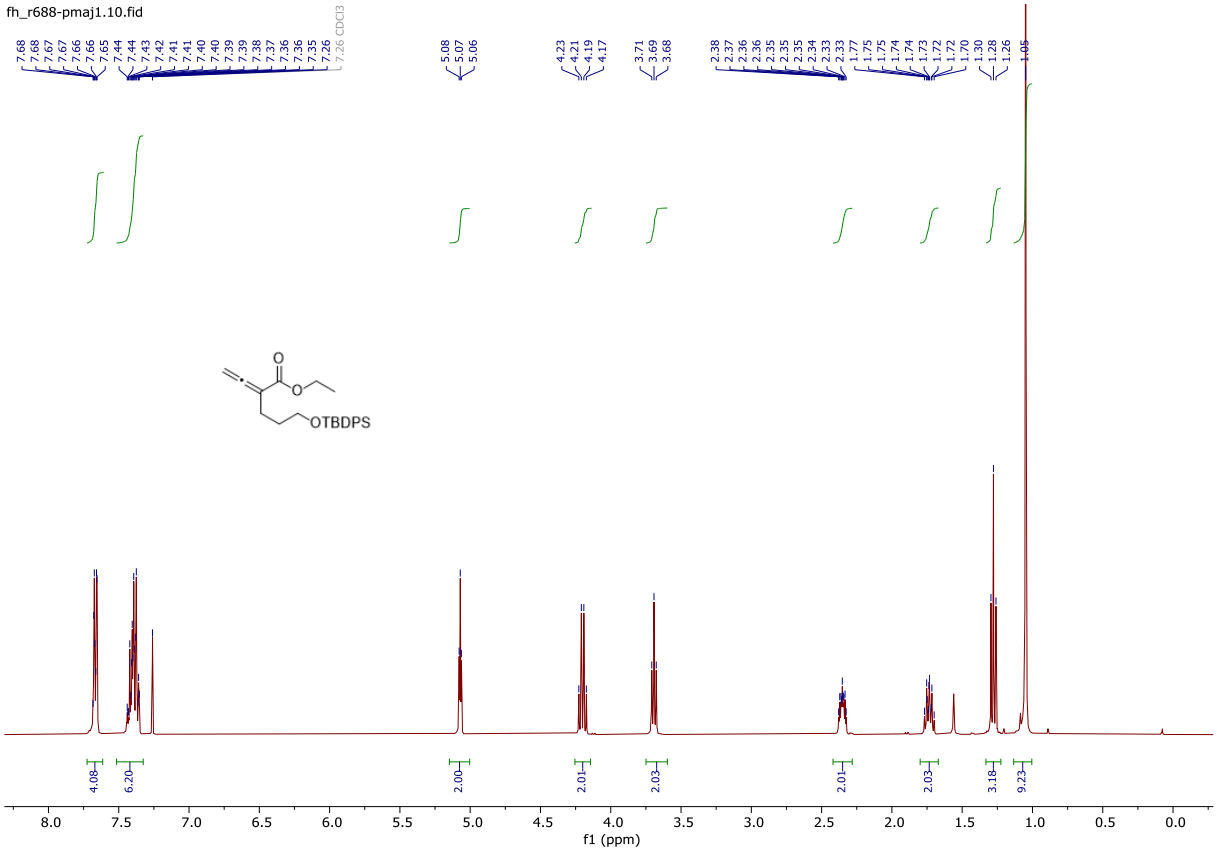


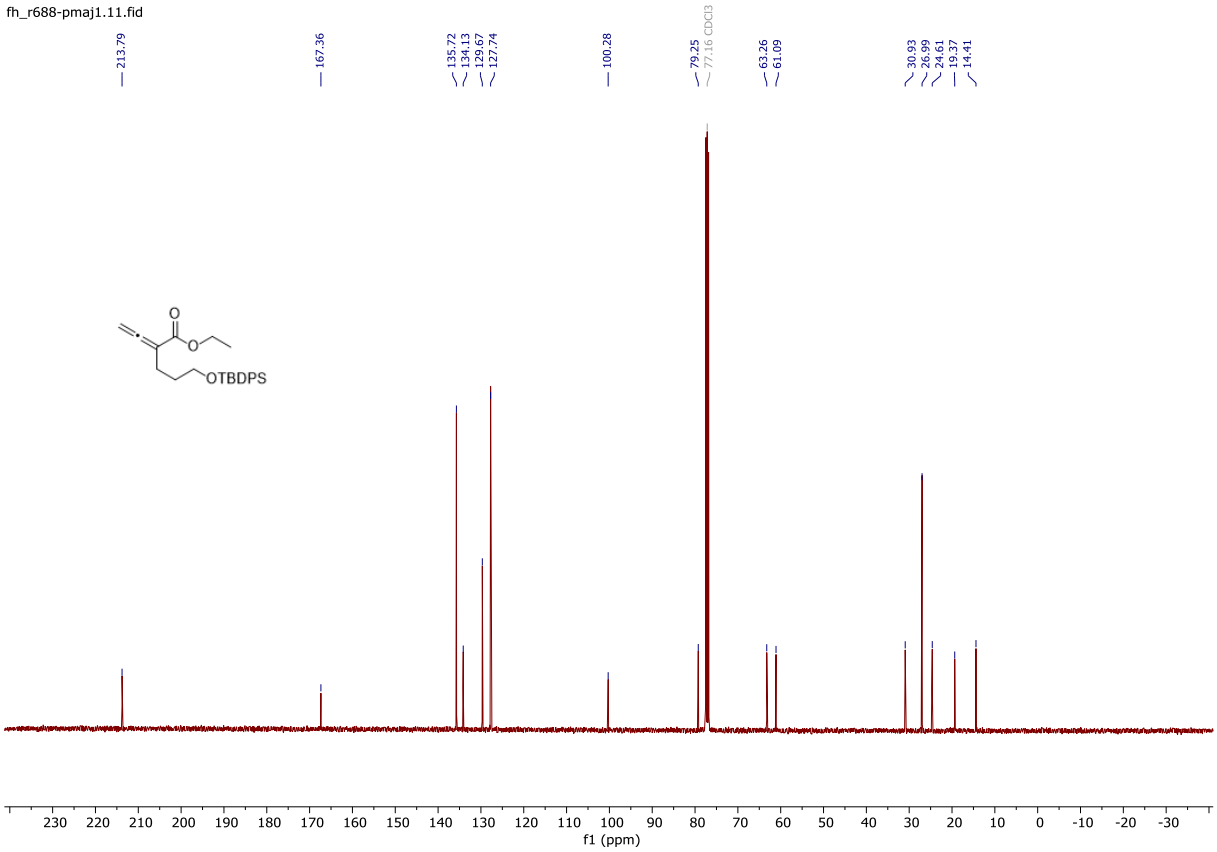
ethyl 6-((tert-butyldiphenylsilyl)oxy)-2-(3-((tert-butyldiphenylsilyl)oxy)propyl)hexa-2,3-dienoate (5f)





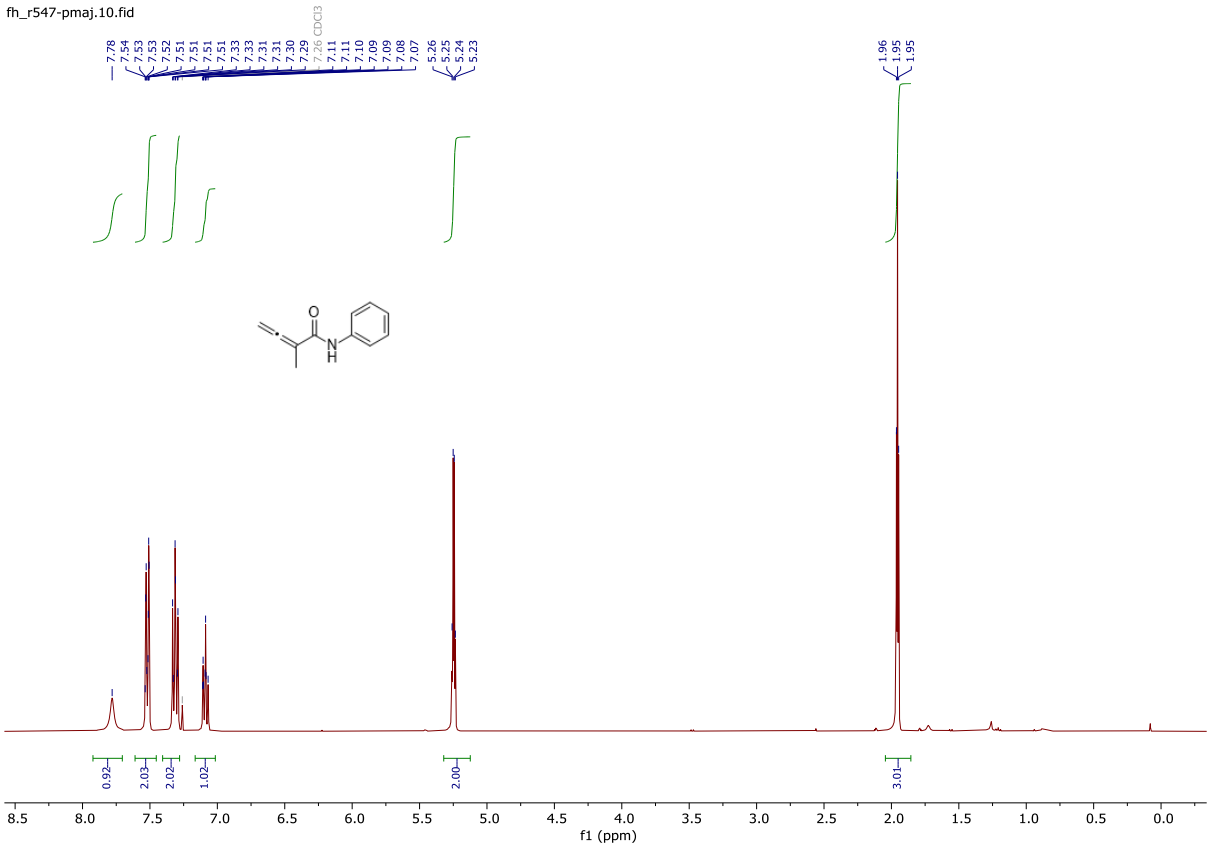
ethyl 5-((tert-butyldiphenylsilyl)oxy)-2-vinylidenepentanoate (5g)



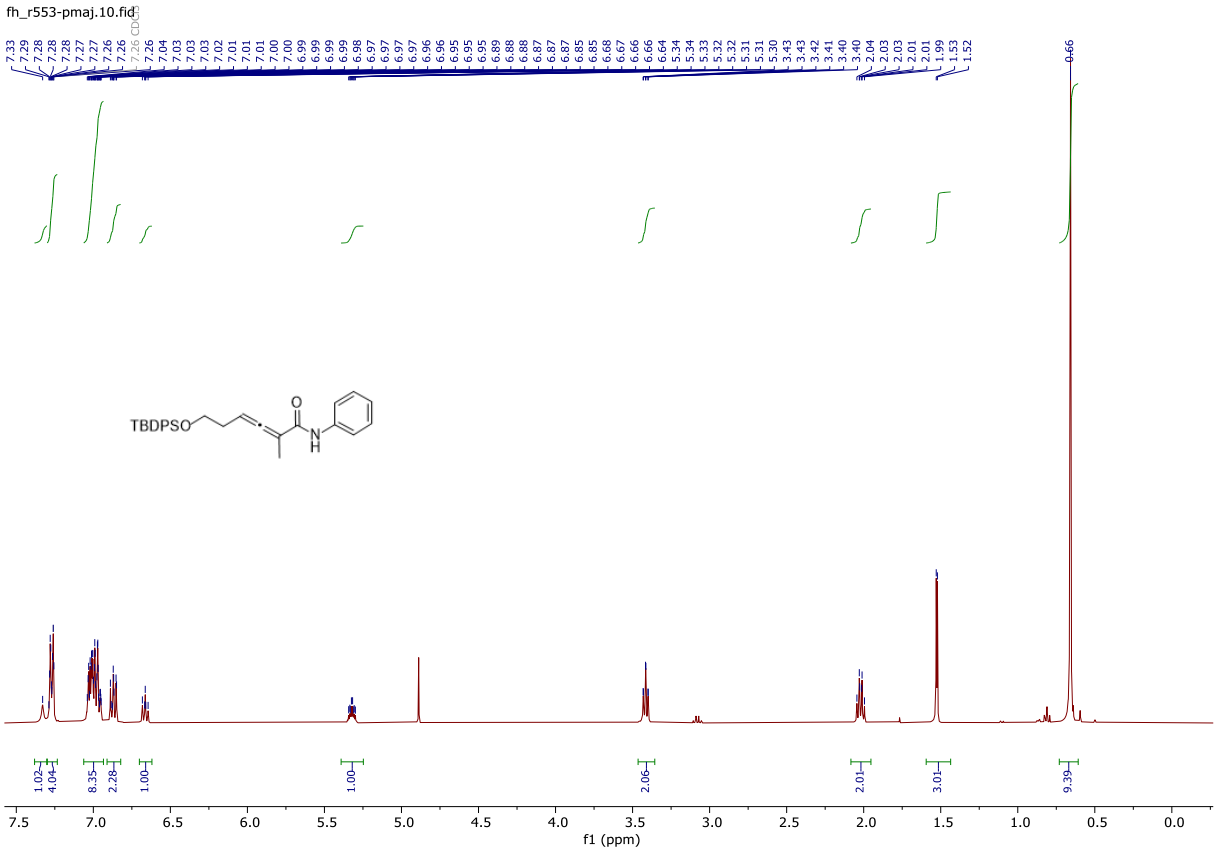


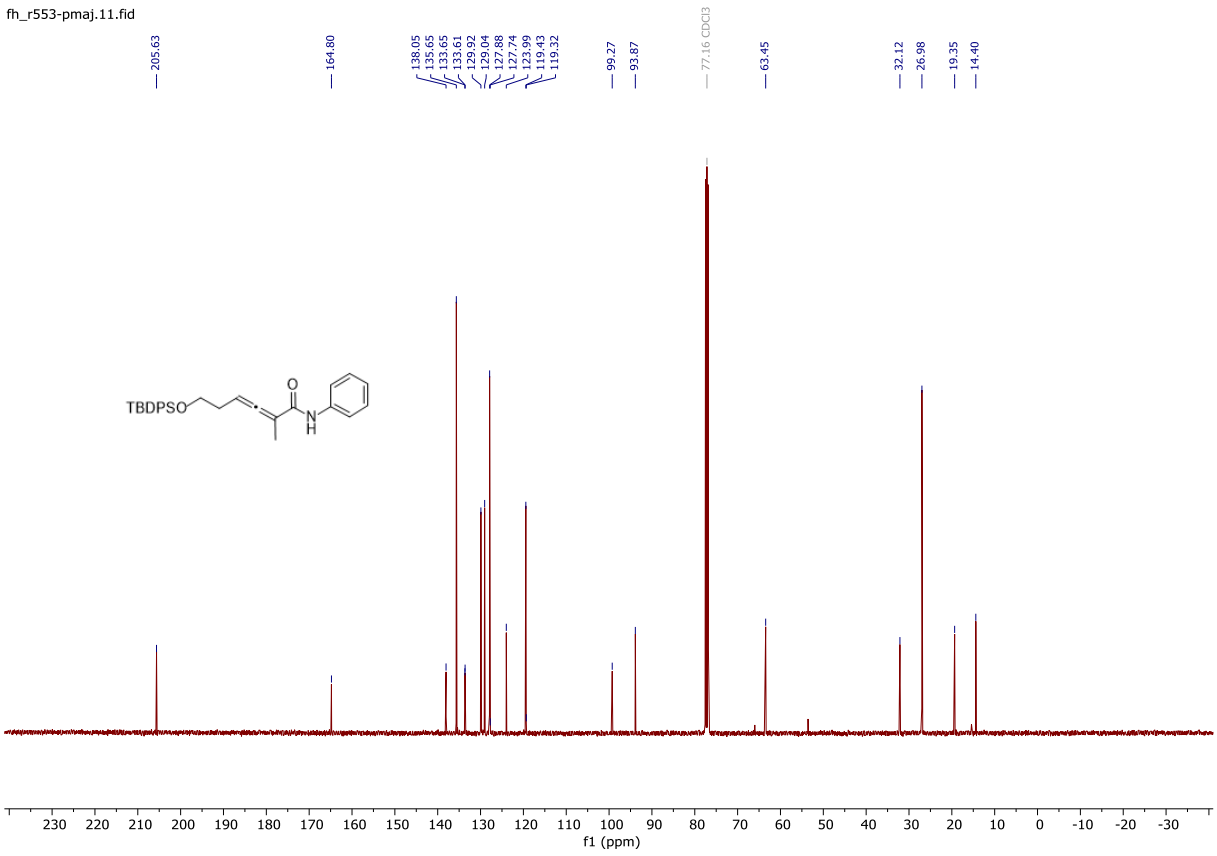
2-methyl-N-phenylbuta-2,3-dienamide (5i)

The NMR data were in accordance with the literature.[20]

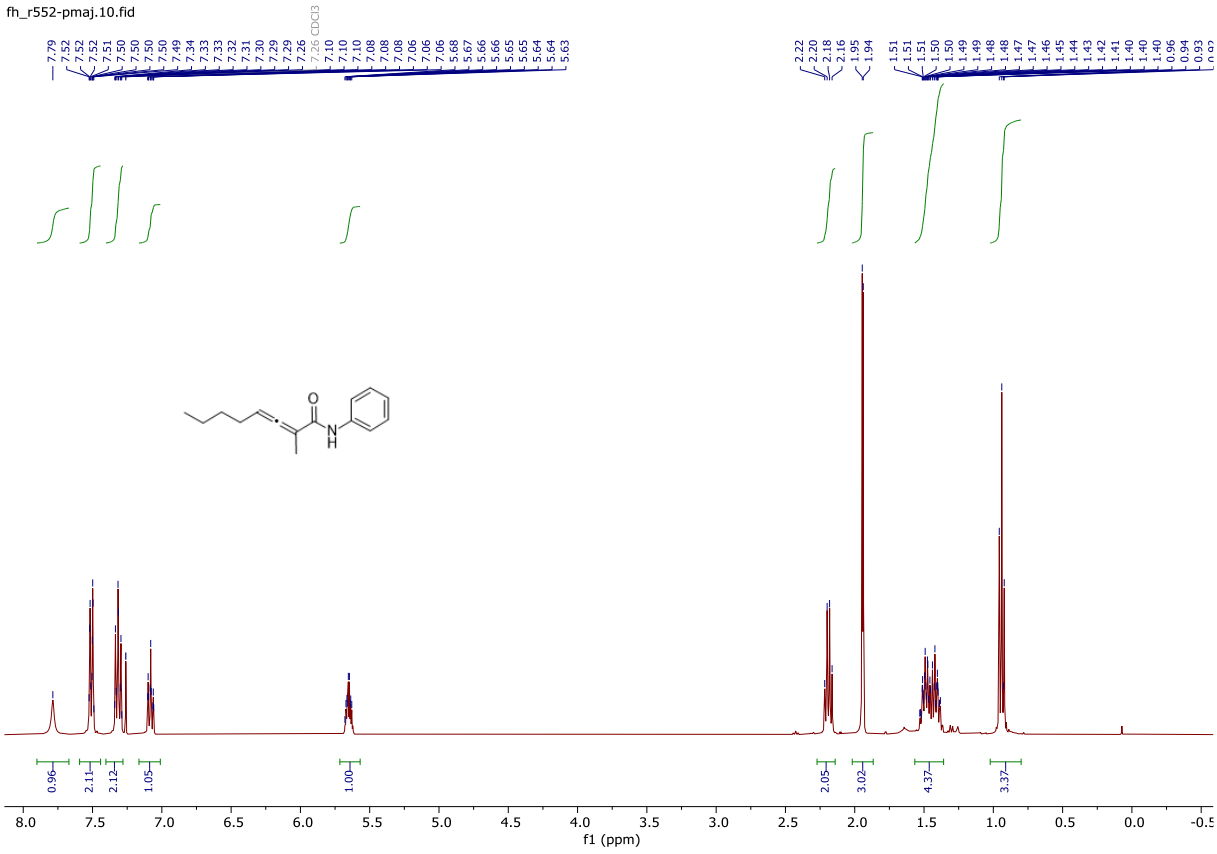


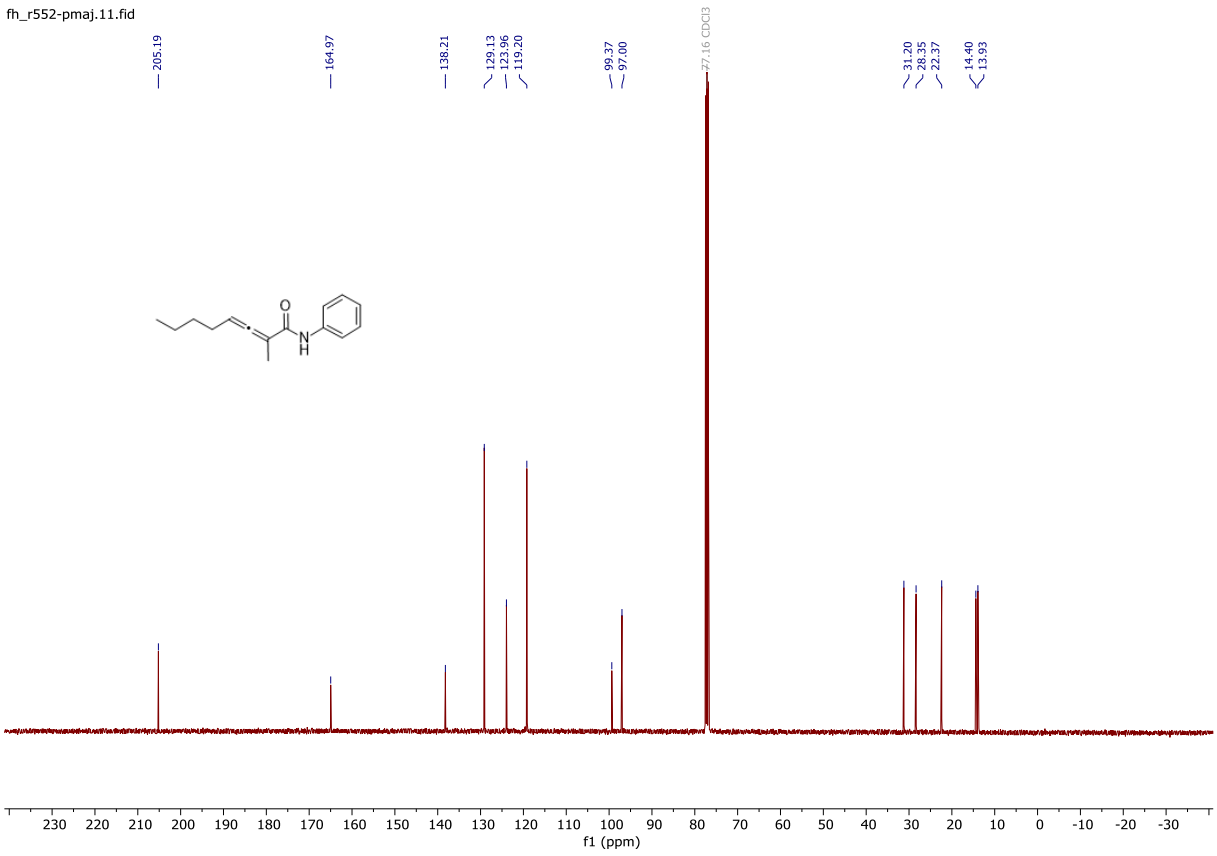
6-((tert-butyldiphenylsilyl)oxy)-2-methyl-N-phenylhexa-2,3-dienamide (5k)



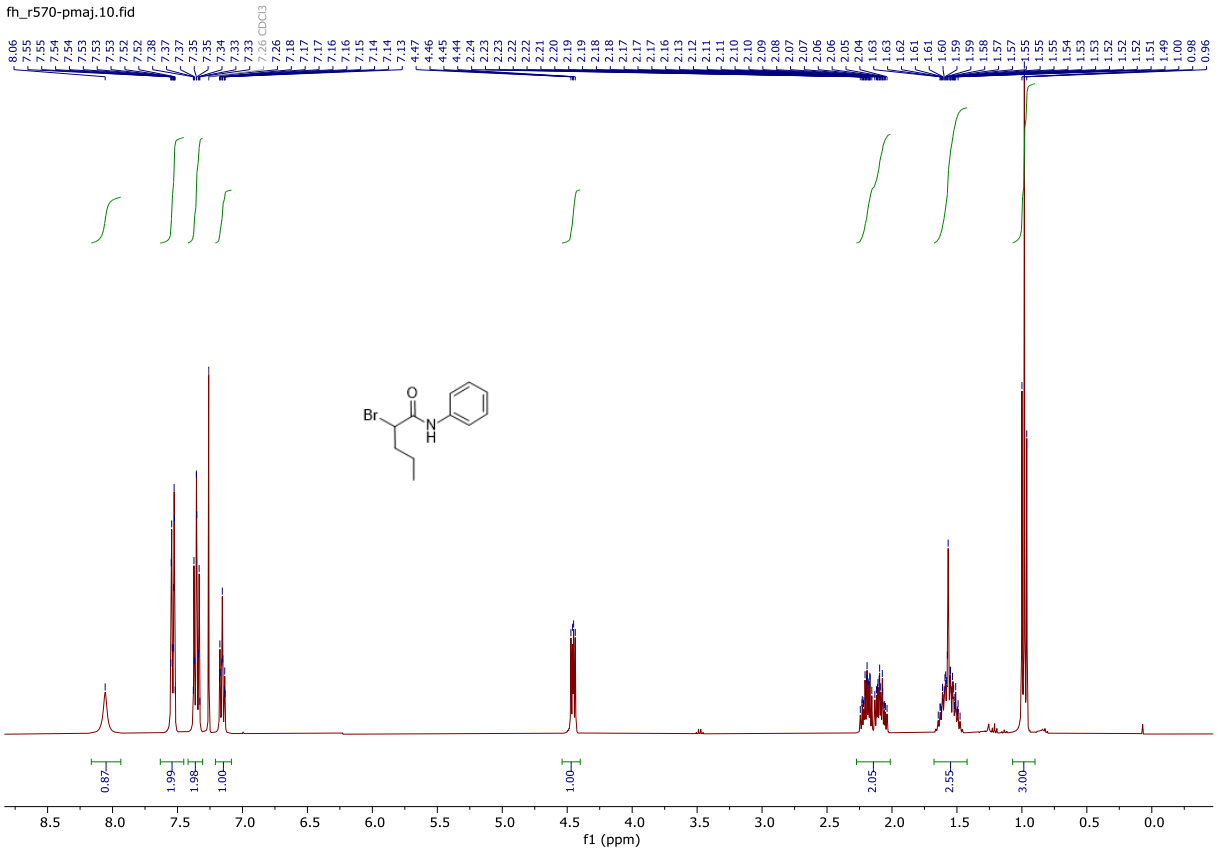


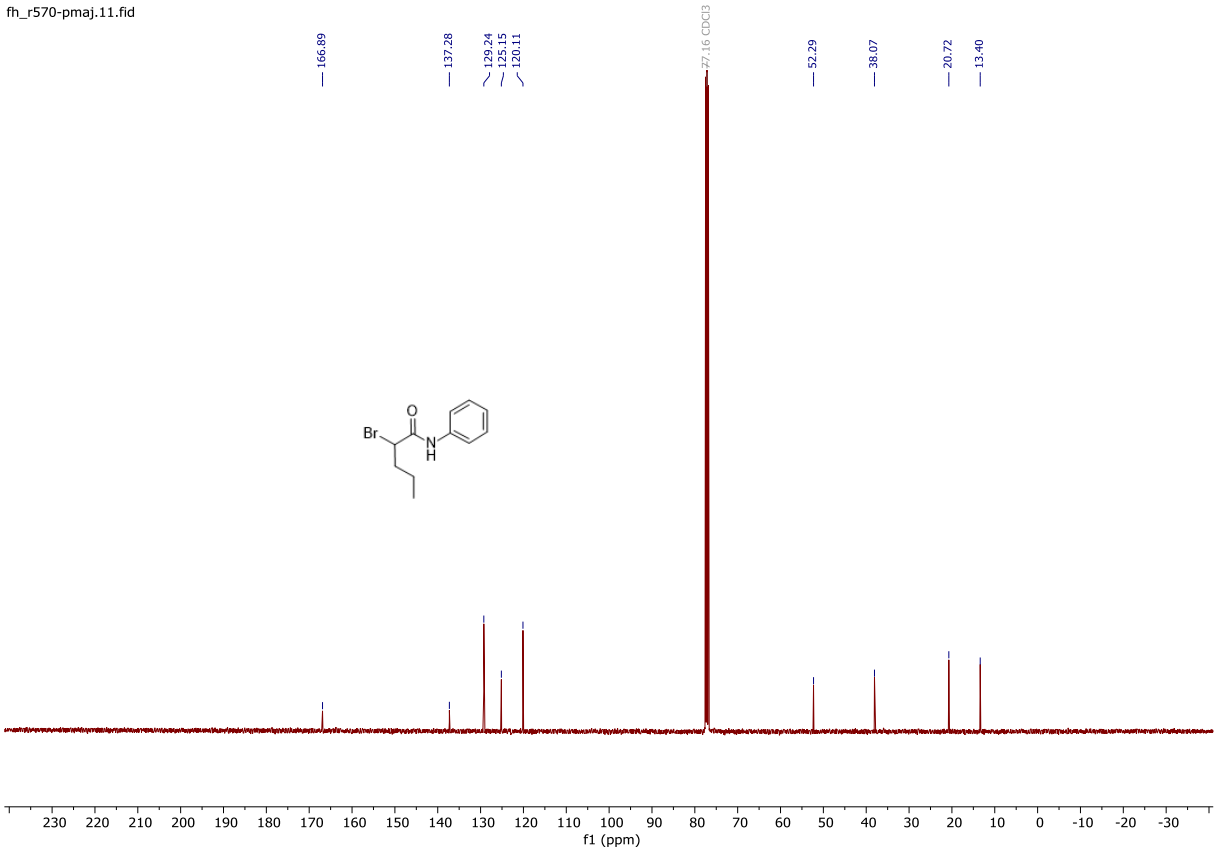
2-methyl-N-phenylocta-2,3-dienamide (5l)



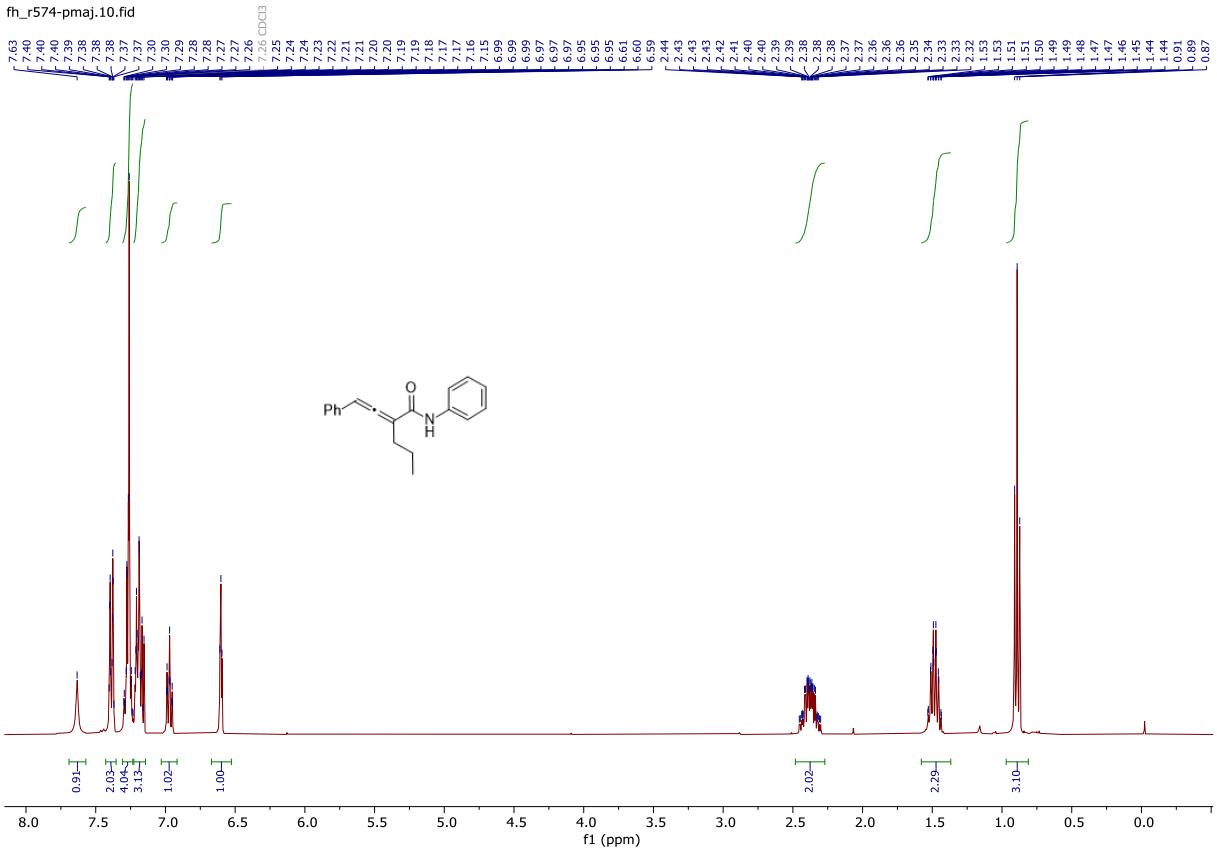


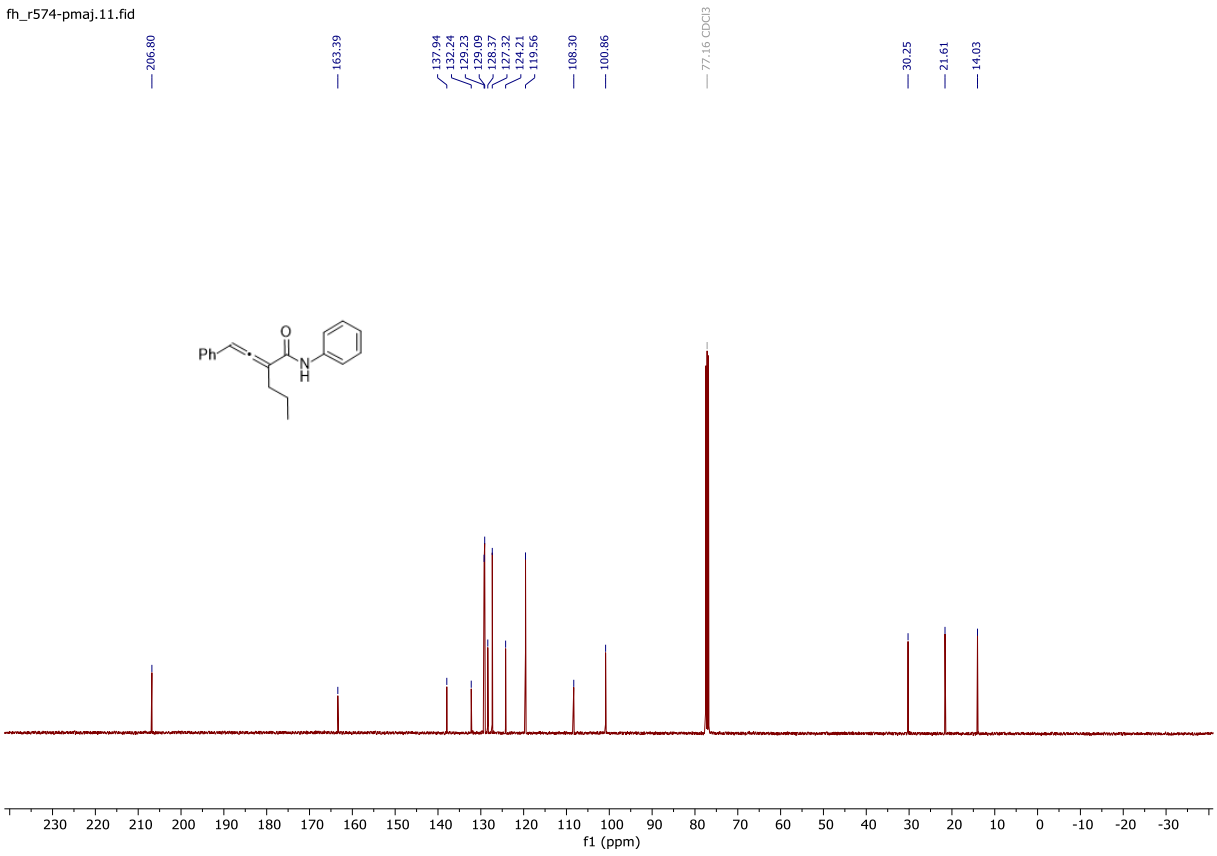
2-bromo-N-phenylpentanamide (SI-13)



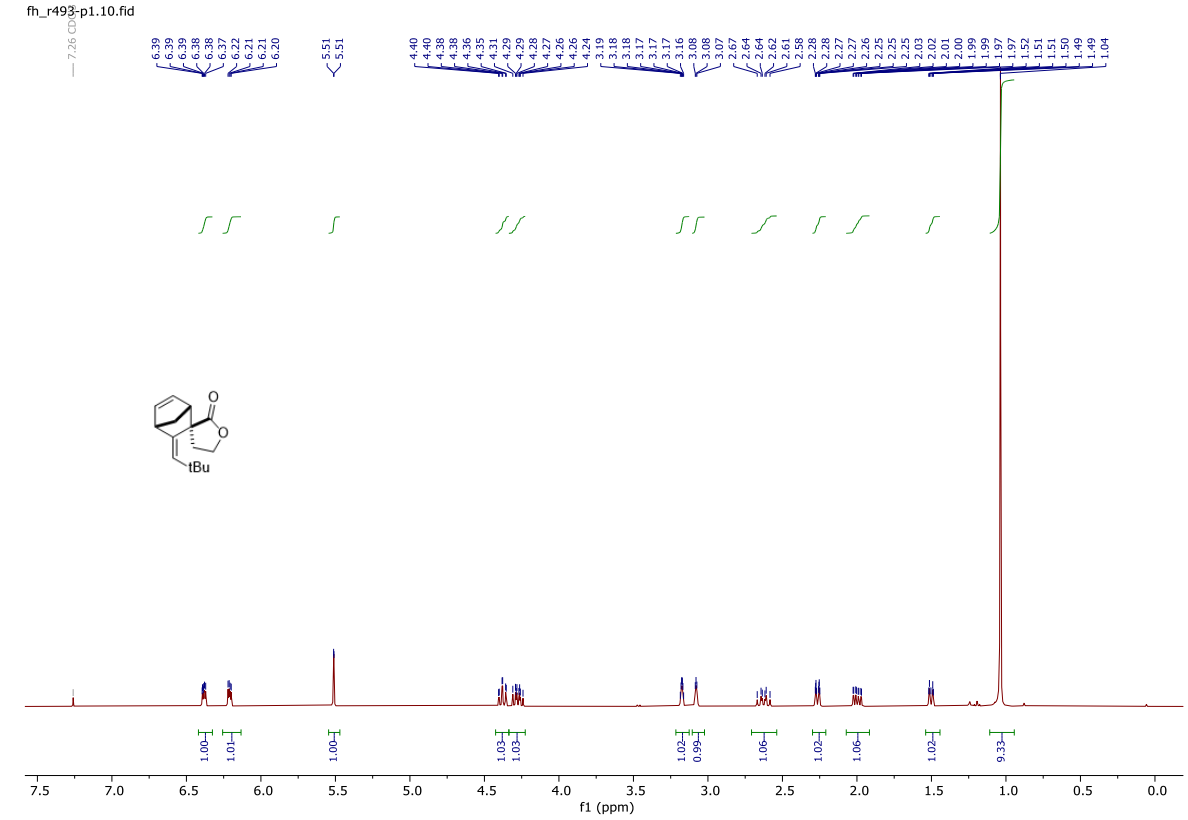


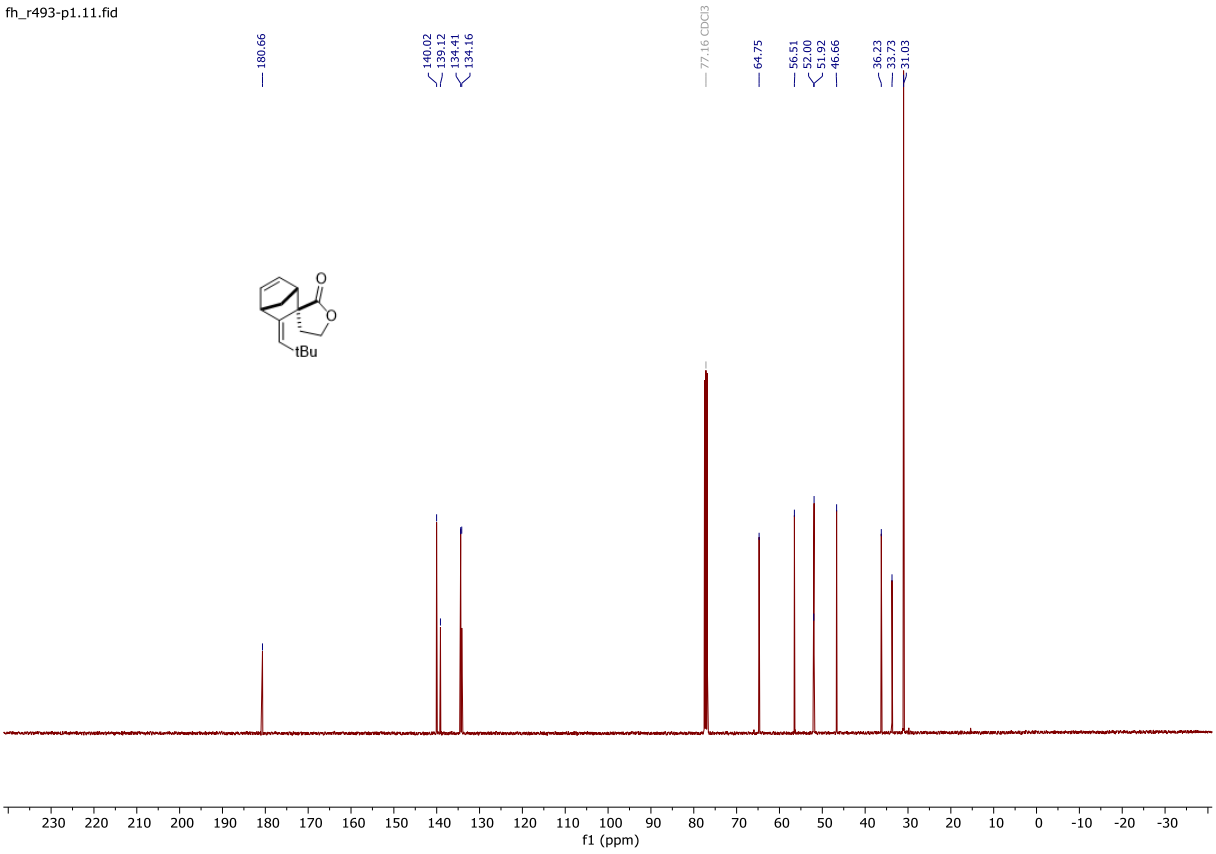
N-phenyl-2-(2-phenylvinylidene)pentanamide (5m)



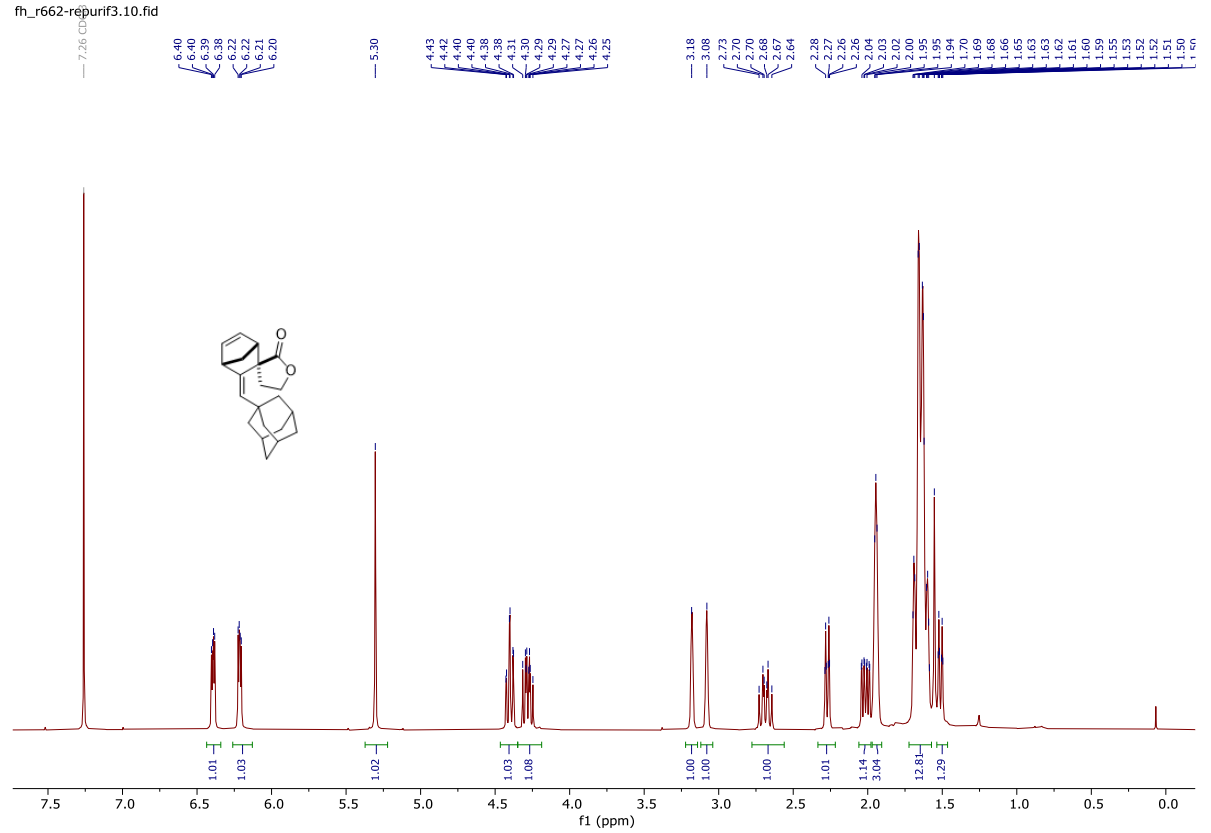


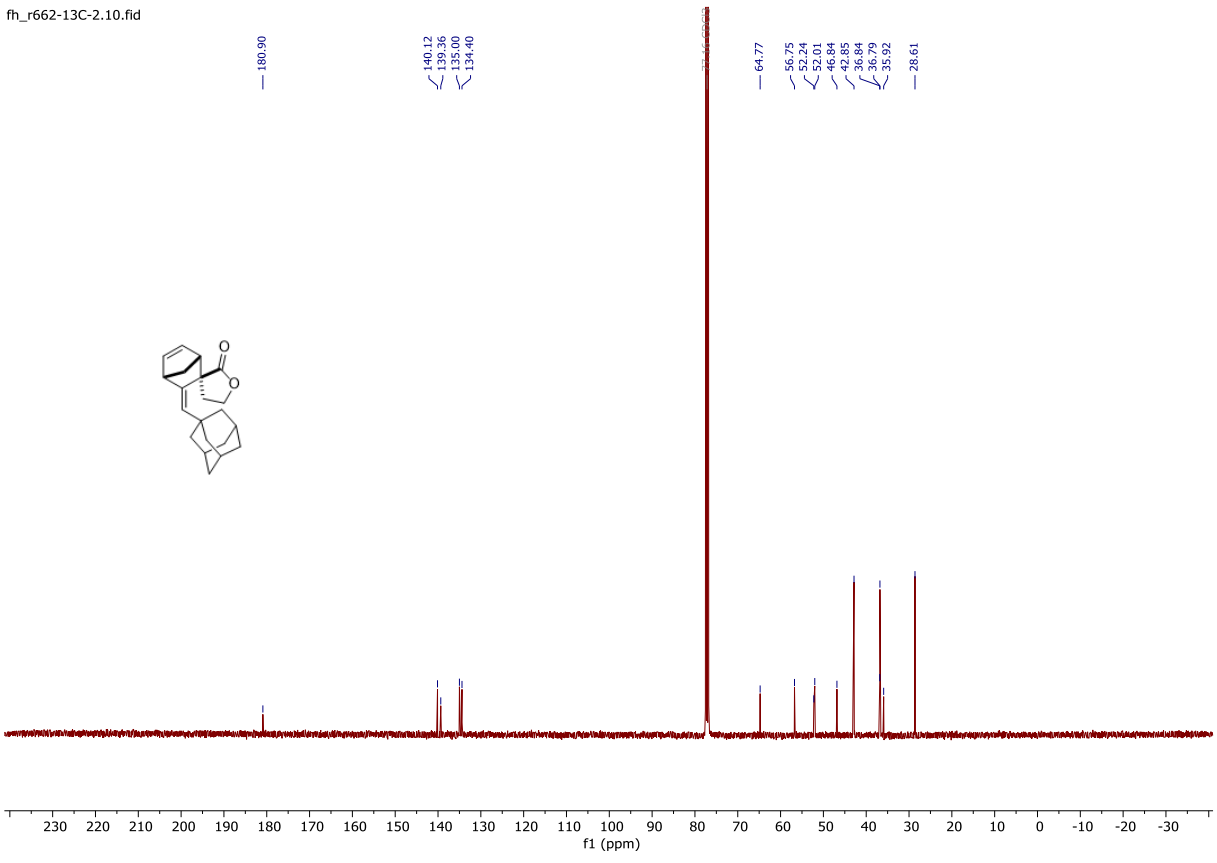
(*Z*)-3-(2,2-dimethylpropylidene)-4',5'-dihydro-2'H-spiro[bicyclo[2.2.1]heptane-2,3'-furan]-5-en-2'-one (4a)



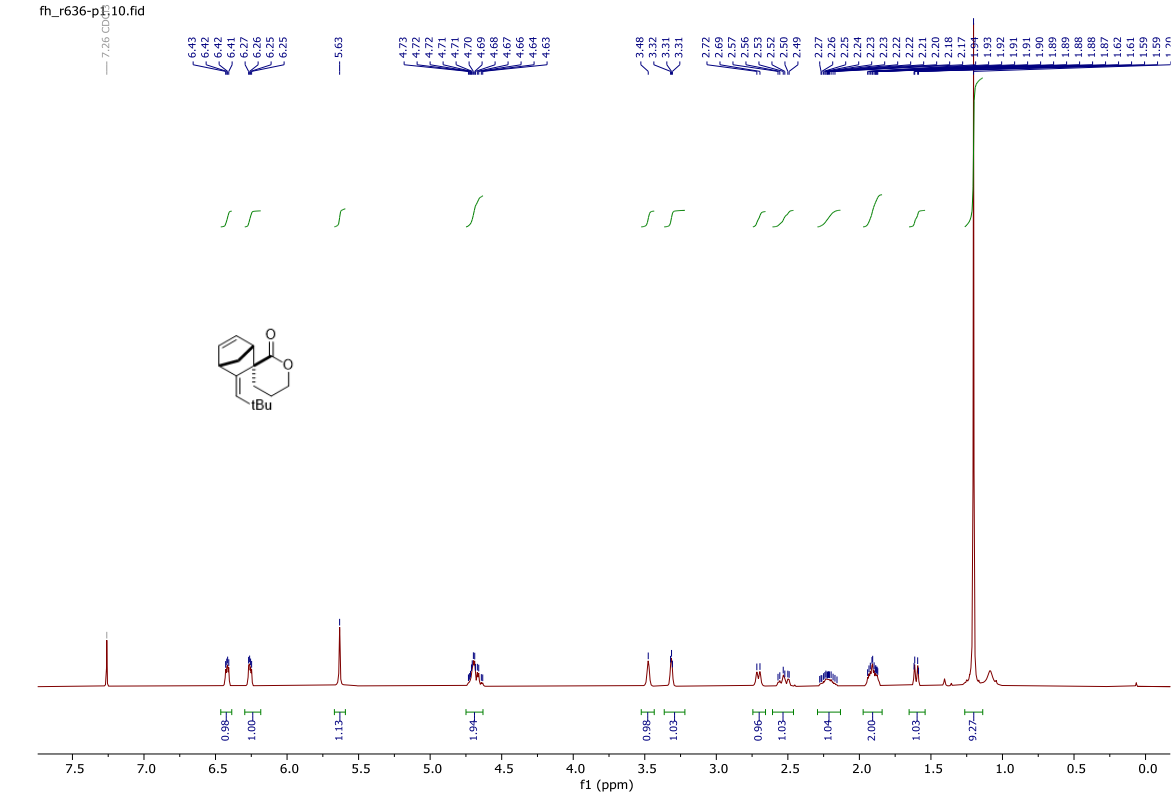


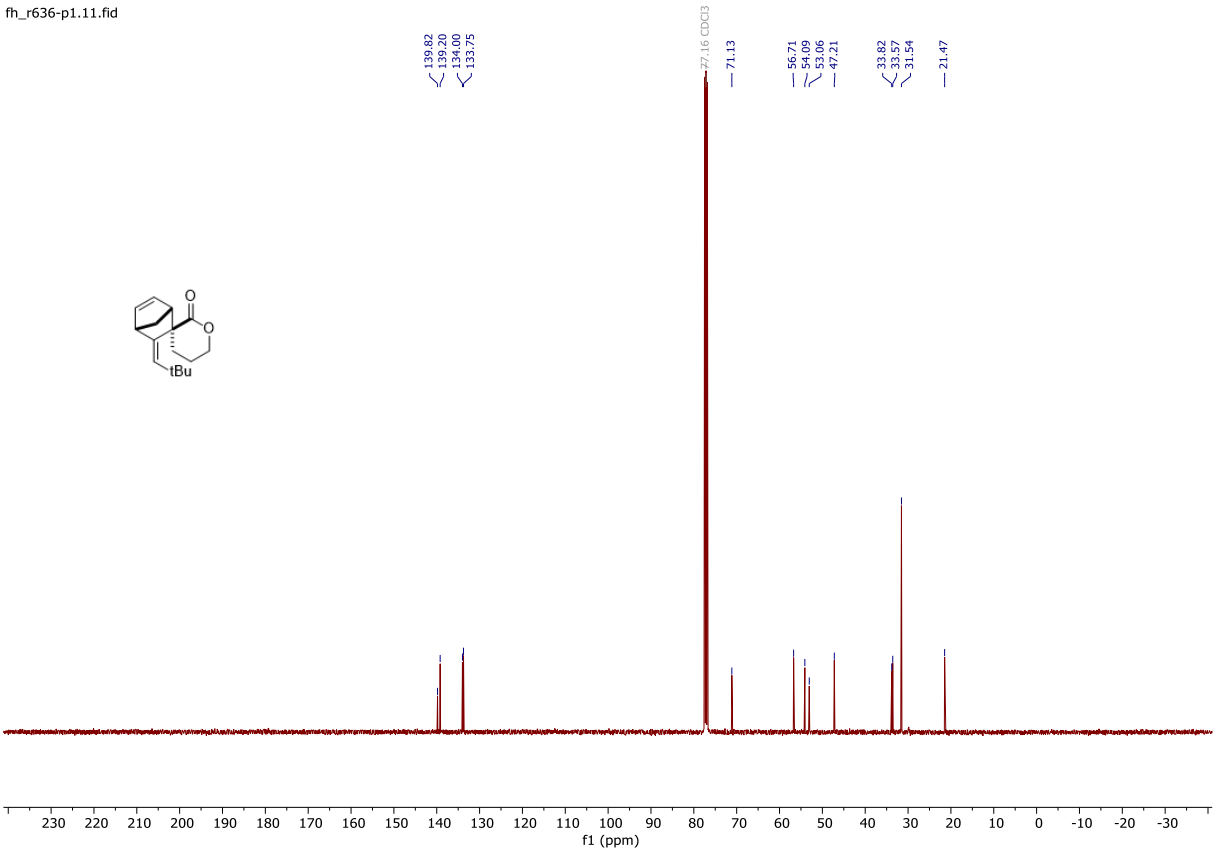
(*Z*)-3-((-adamantan-1-yl)methylene)-4',5'-dihydro-2'H-spiro[bicyclo[2.2.1]heptane-2,3'-furan]-5-en-2'-one (4b)



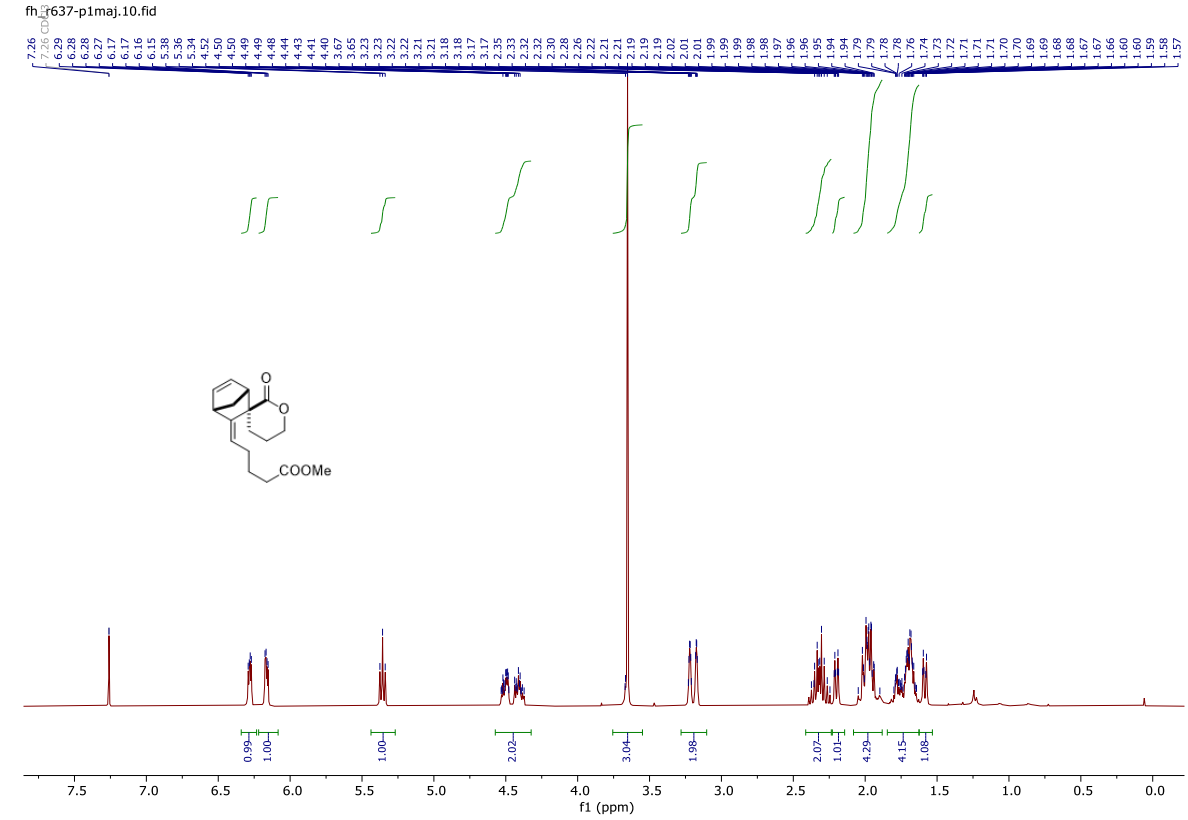


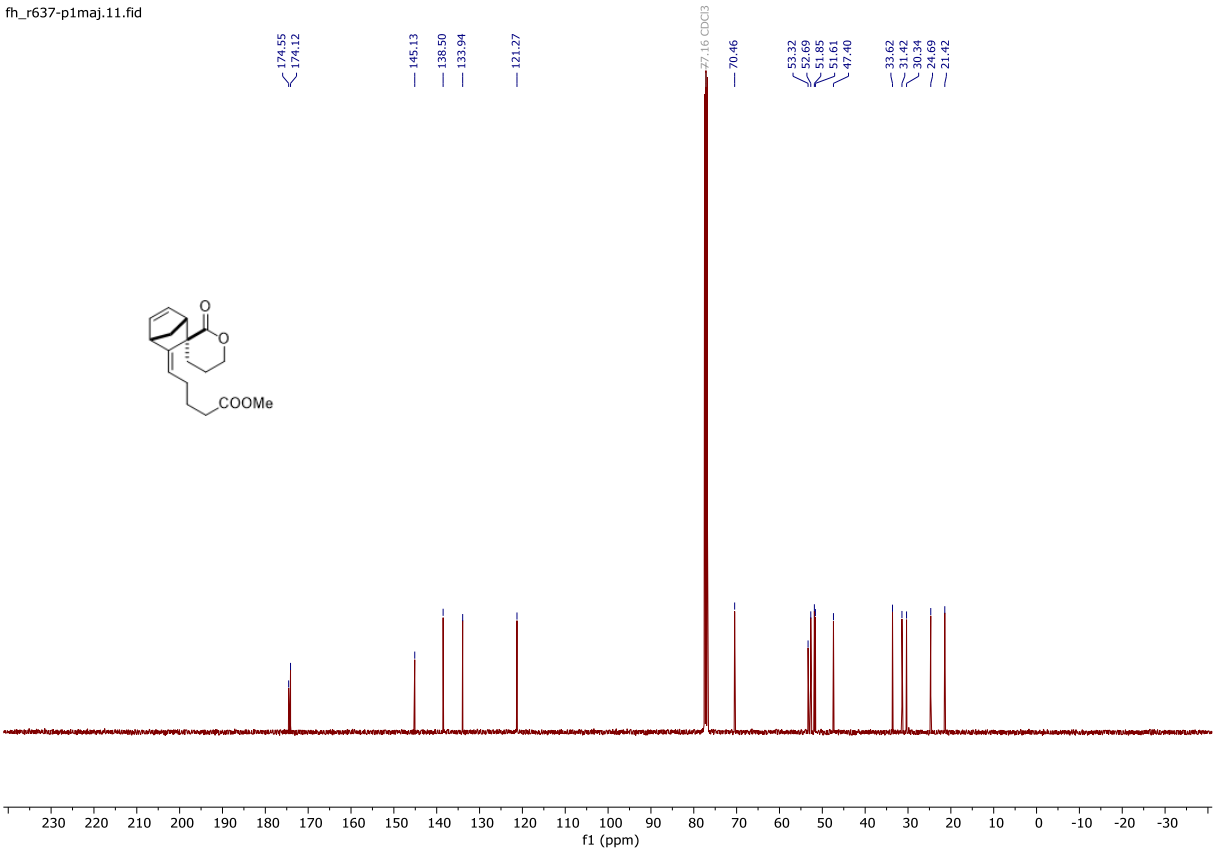
(*Z*)-3-(2,2-dimethylpropylidene)-5',6'-dihydro-2'H,4'H-spiro[bicyclo[2.2.1]heptane-2,3'-pyran]-5-en-2'-one (4c)



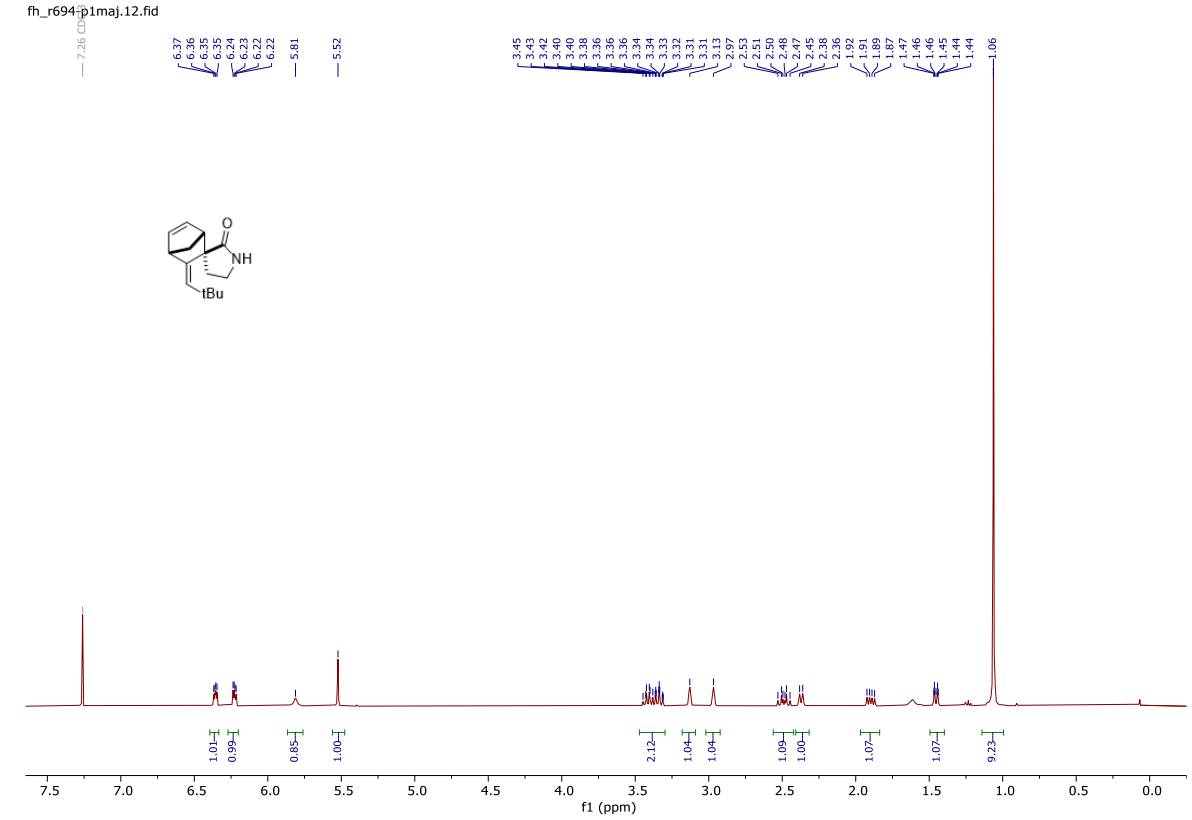


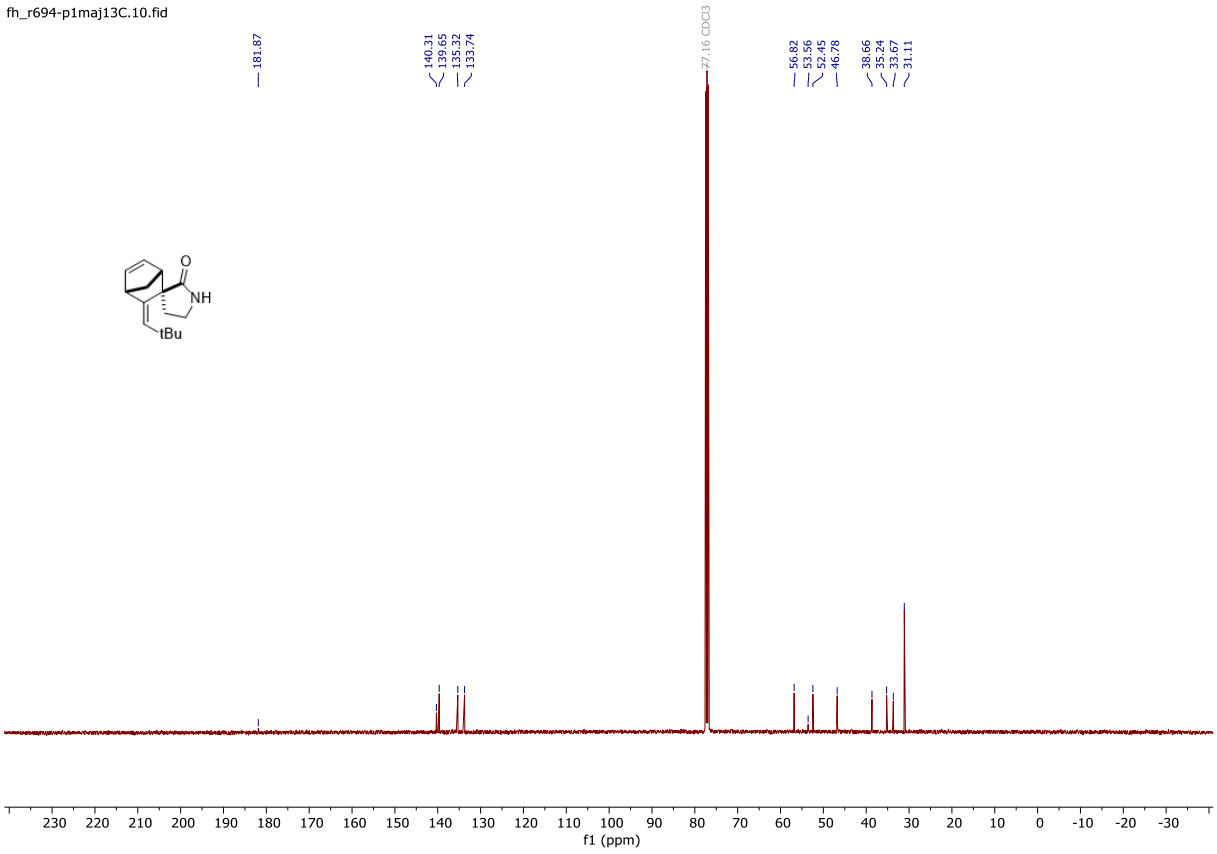
methyl (Z)-5-(-2'-oxo-5',6'-dihydro-2'H,4'H-spiro[bicyclo[2.2.1]heptane-2,3'-pyran]-5-en-3-ylidene) pentanoate (4d)



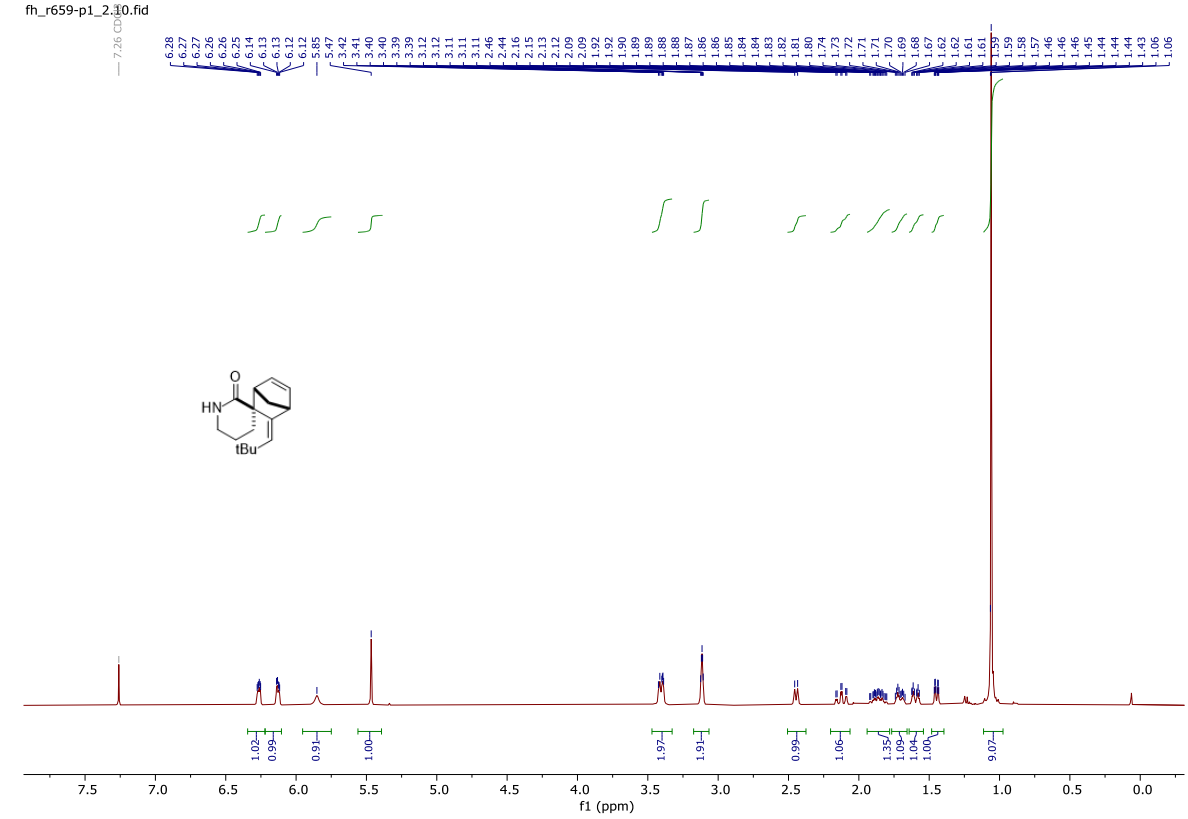


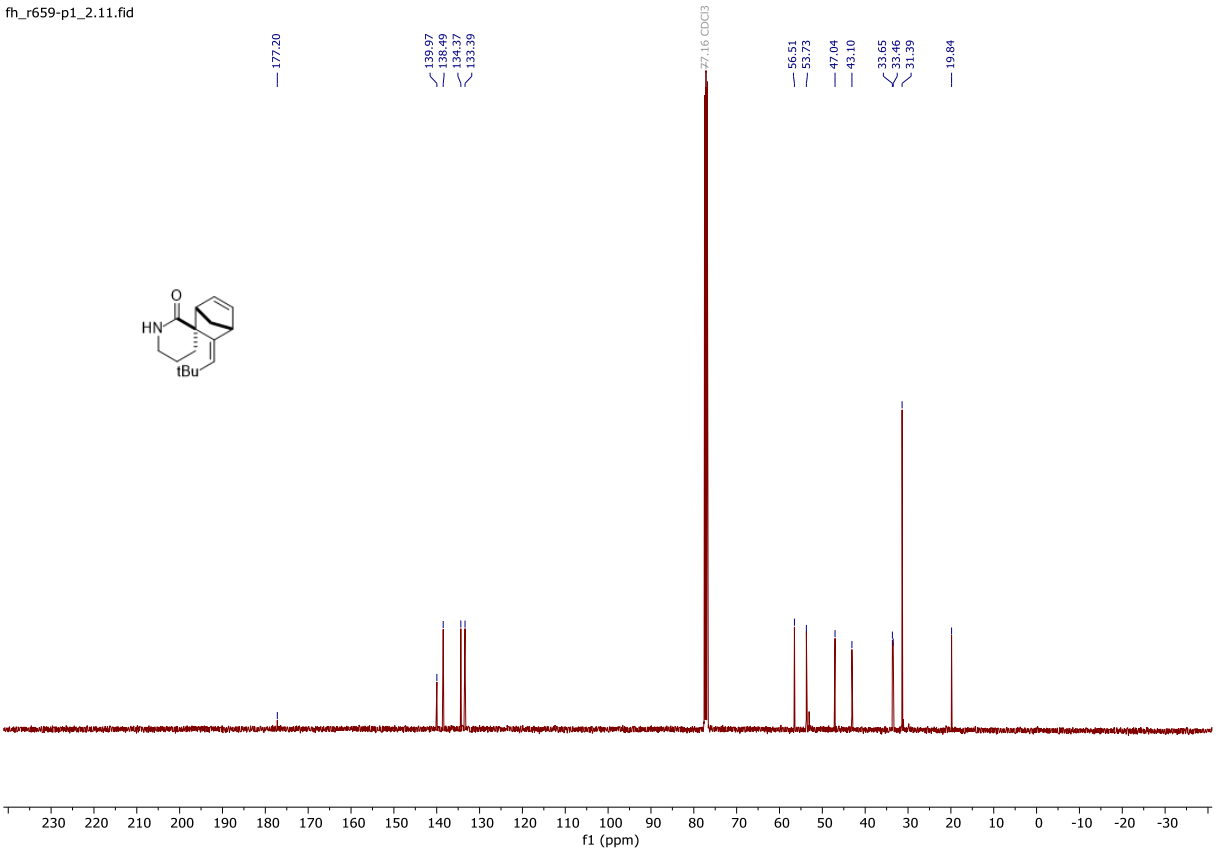
(*Z*)-3-(2,2-dimethylpropylidene)spiro[bicyclo[2.2.1]heptane-2,3'-pyrrolidin]-5-en-2'-one (4f)



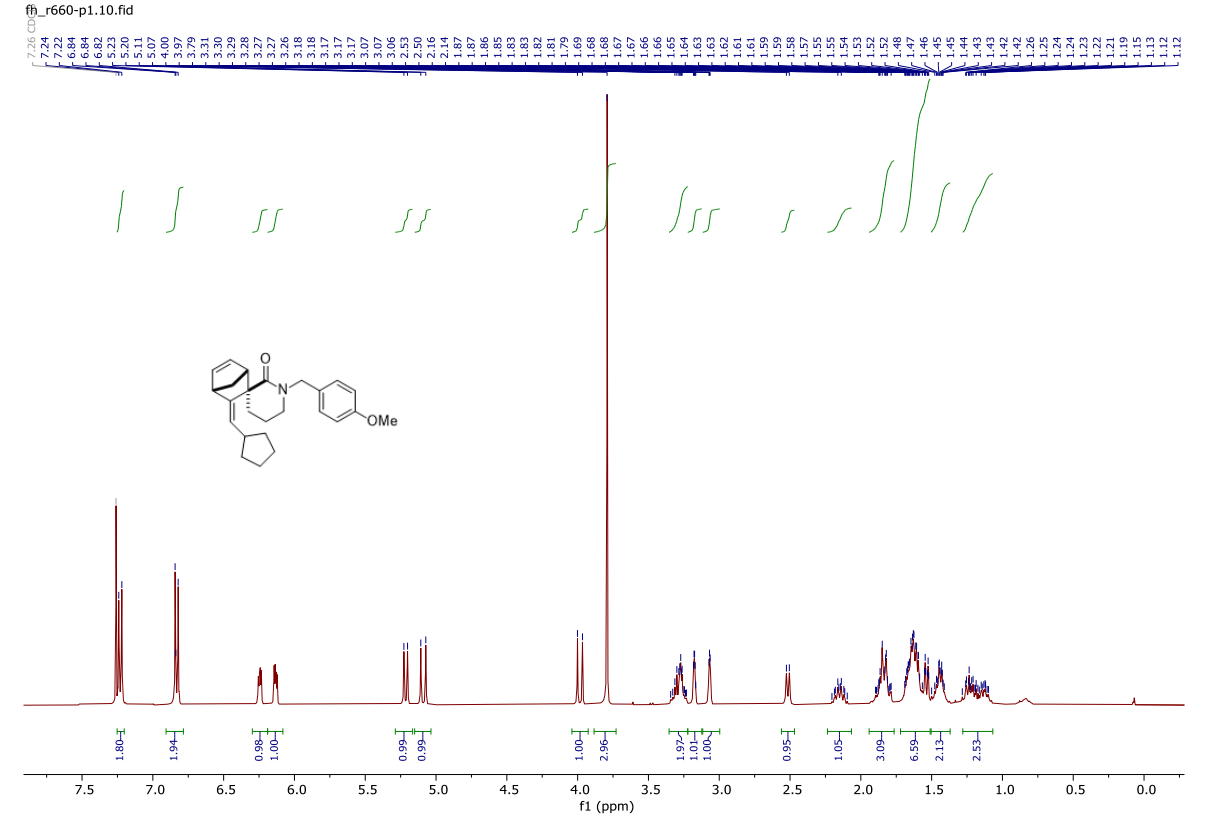


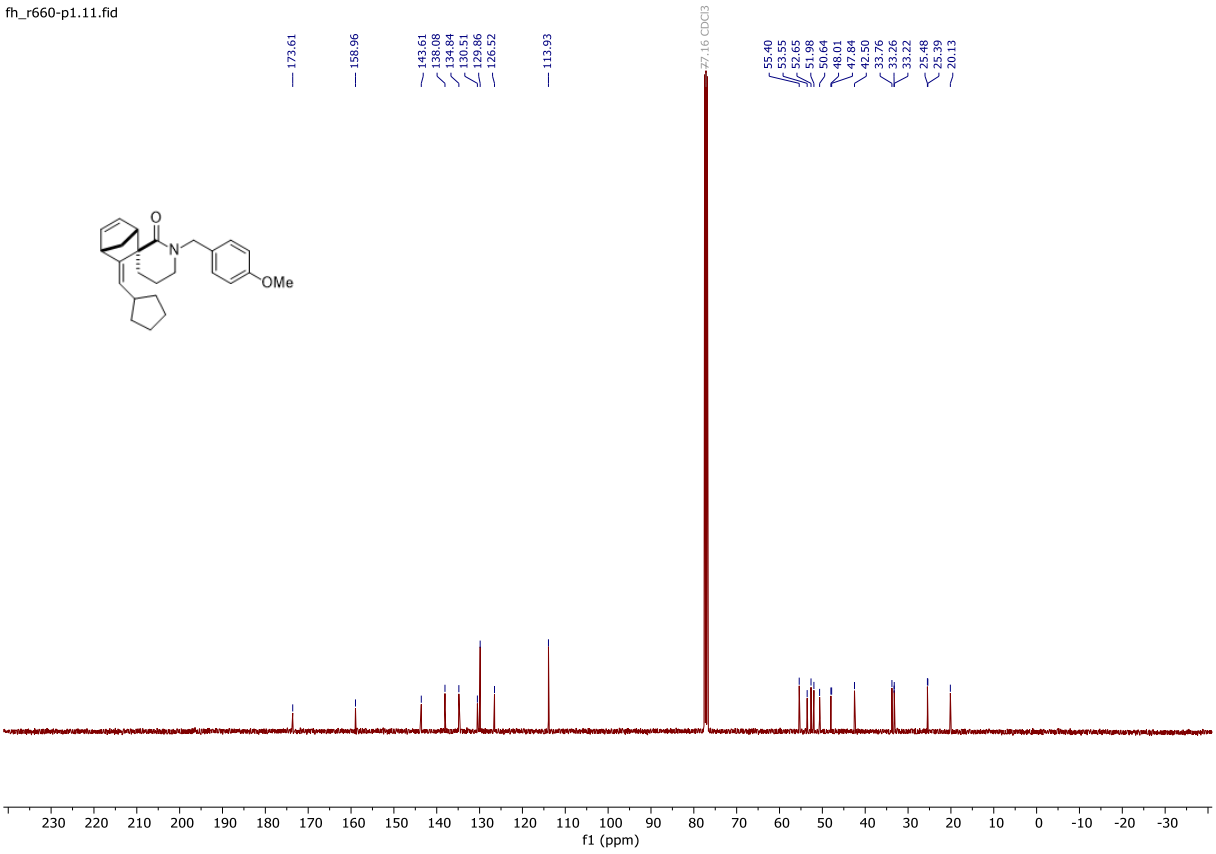
(*Z*)-3-(2,2-dimethylpropylidene)spiro[bicyclo[2.2.1]heptane-2,3'-piperidin]-5-en-2'-one (4g)



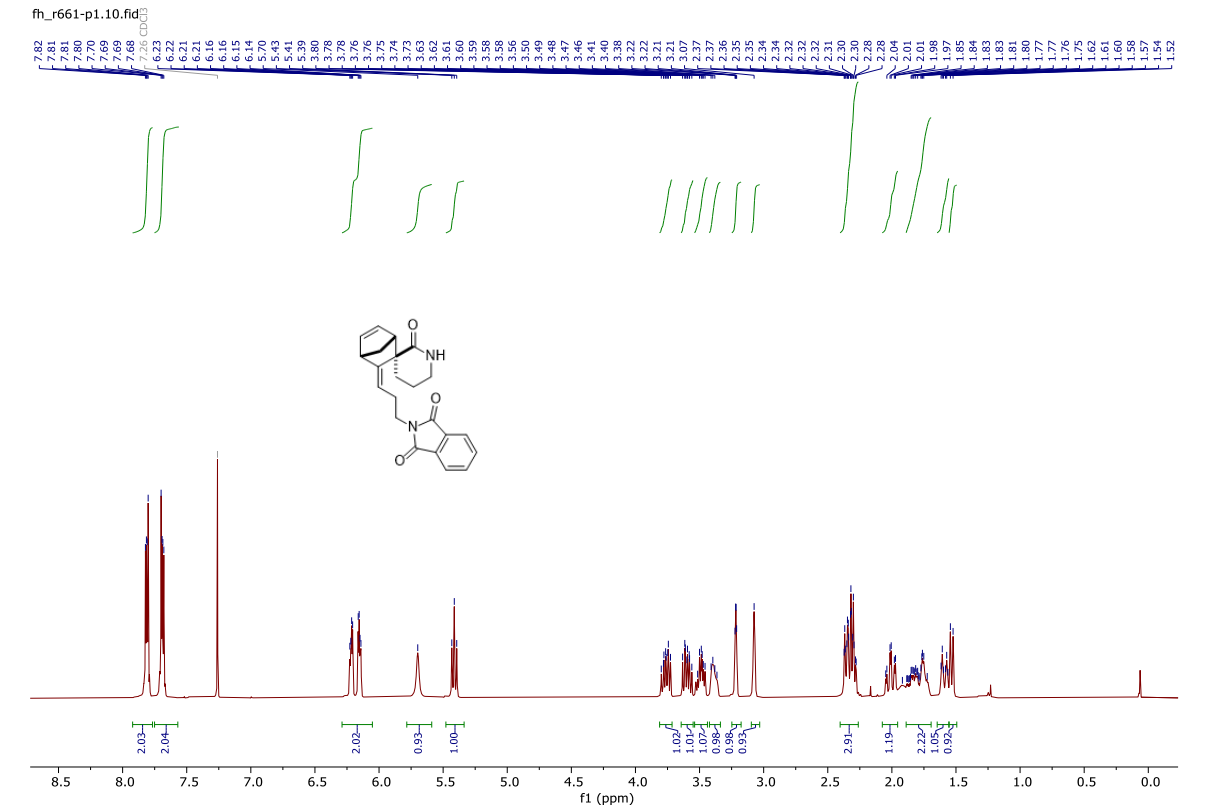


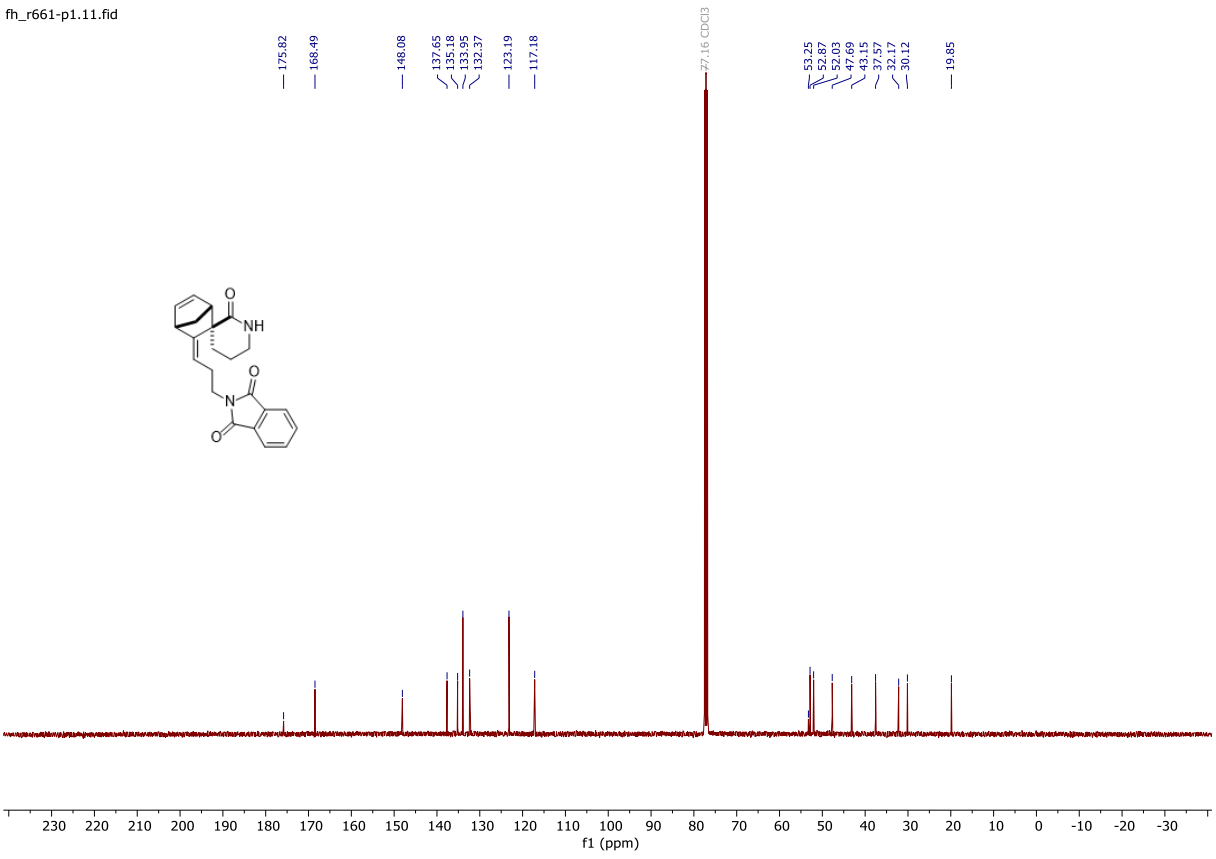
(*Z*)-3-(cyclopentylmethylene)-1'-(4-methoxybenzyl)spiro[bicyclo[2.2.1]heptane-2,3'-piperidin]-5-en-2'-one (4h)



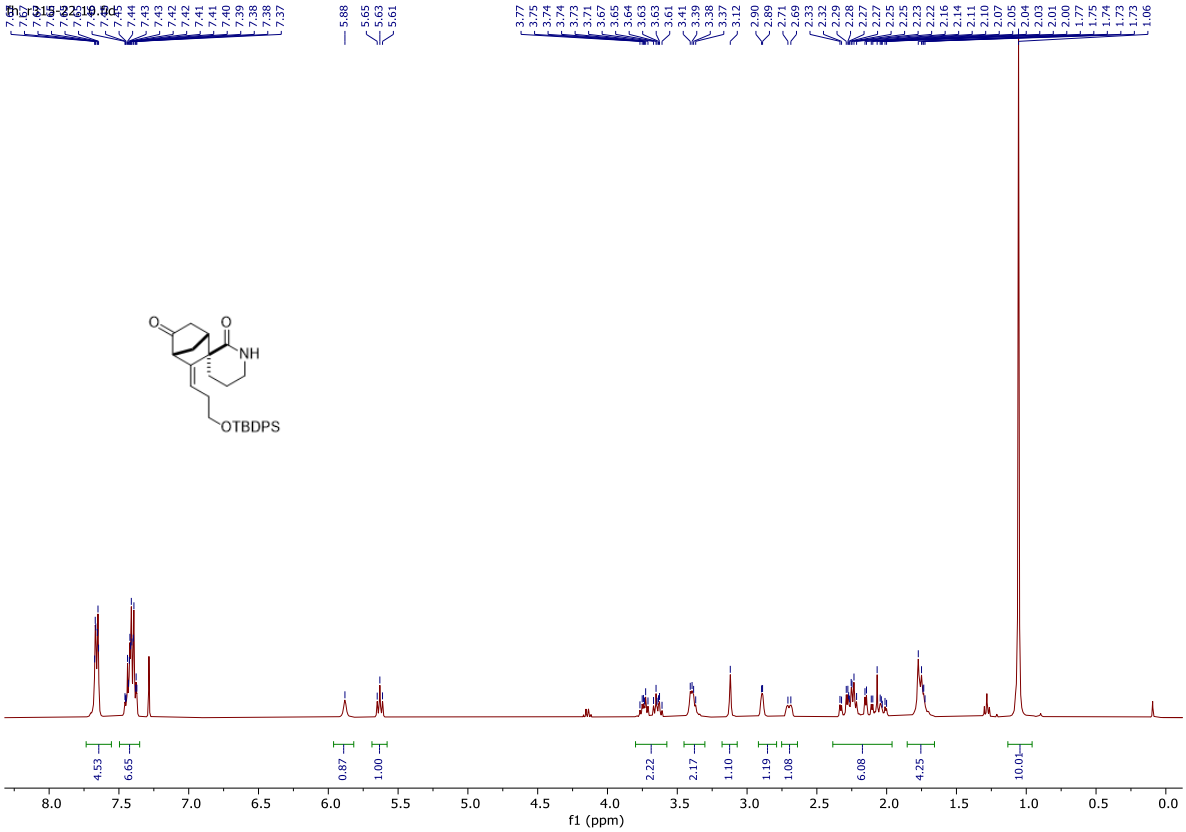


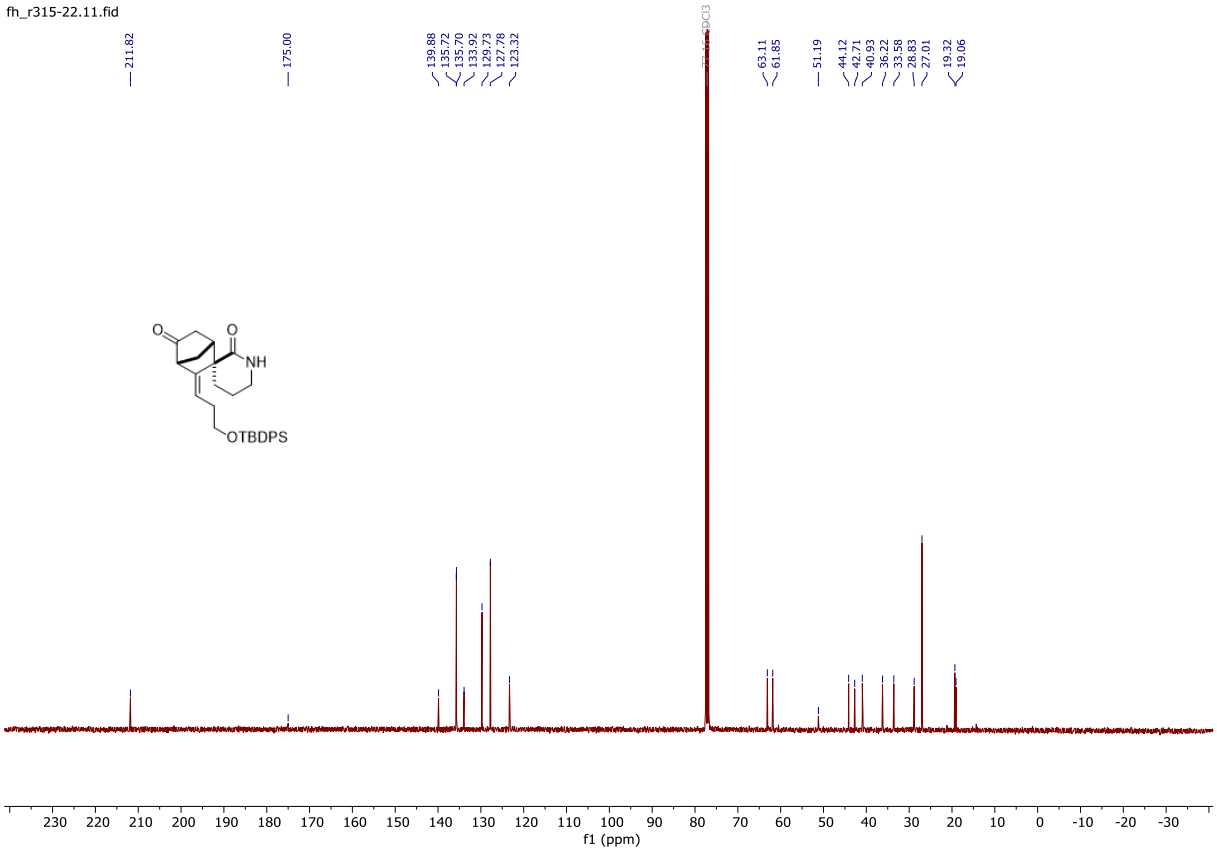
2-((Z)-3-(2'-oxospiro[bicyclo[2.2.1]heptane-2,3'-piperidin]-5-en-3-ylidene)propyl)isoindoline-1,3-dione (4i)



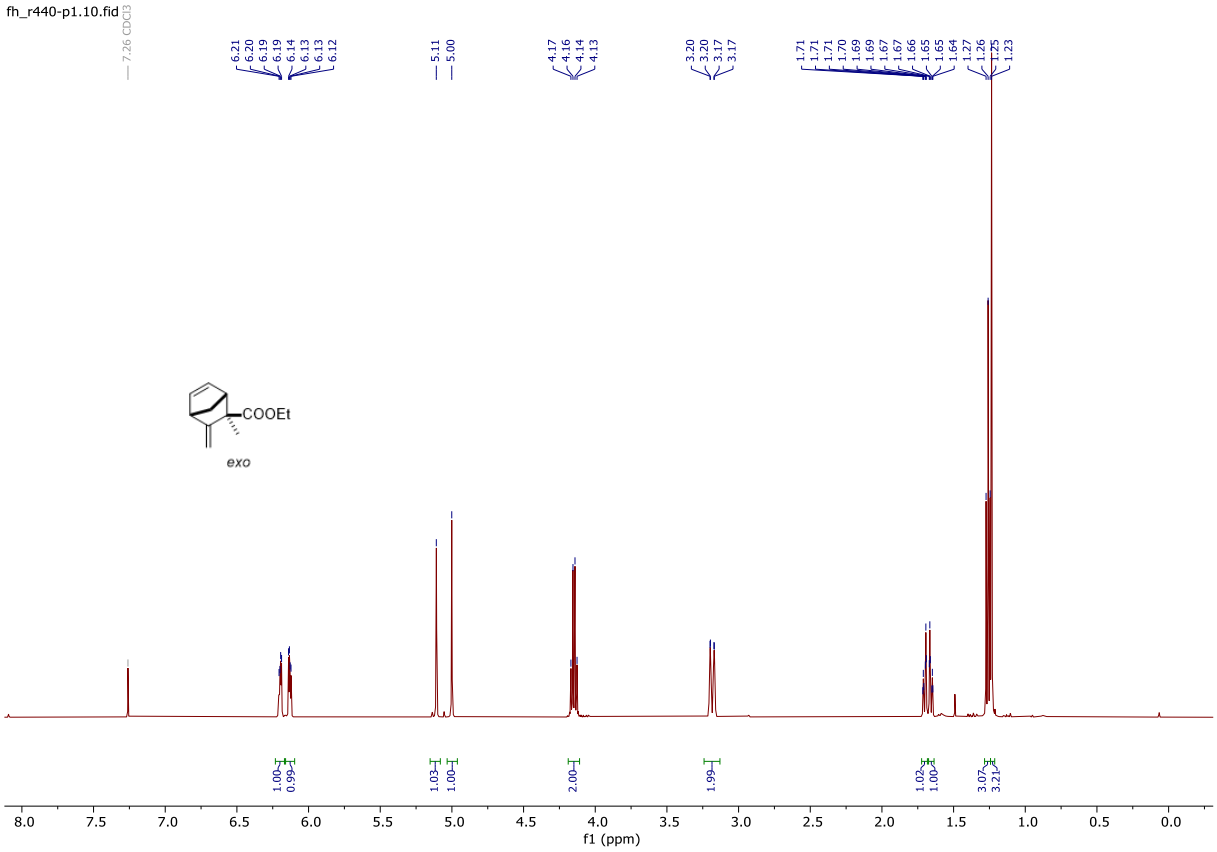


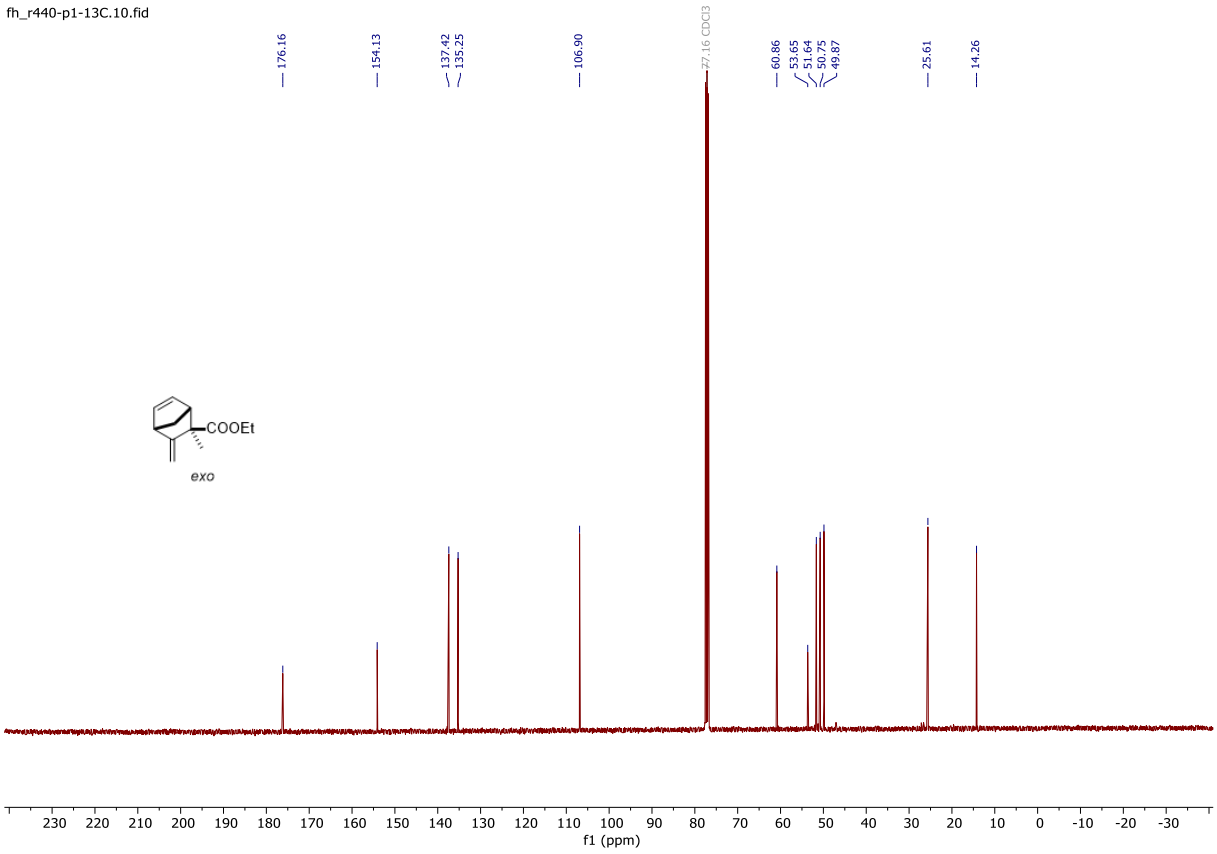
(*Z*)-3-(3-((tert-butyldiphenylsilyl)oxy)propylidene)spiro[bicyclo[2.2.1]heptane-2,3'-piperidine]-2',5-dione (4j)



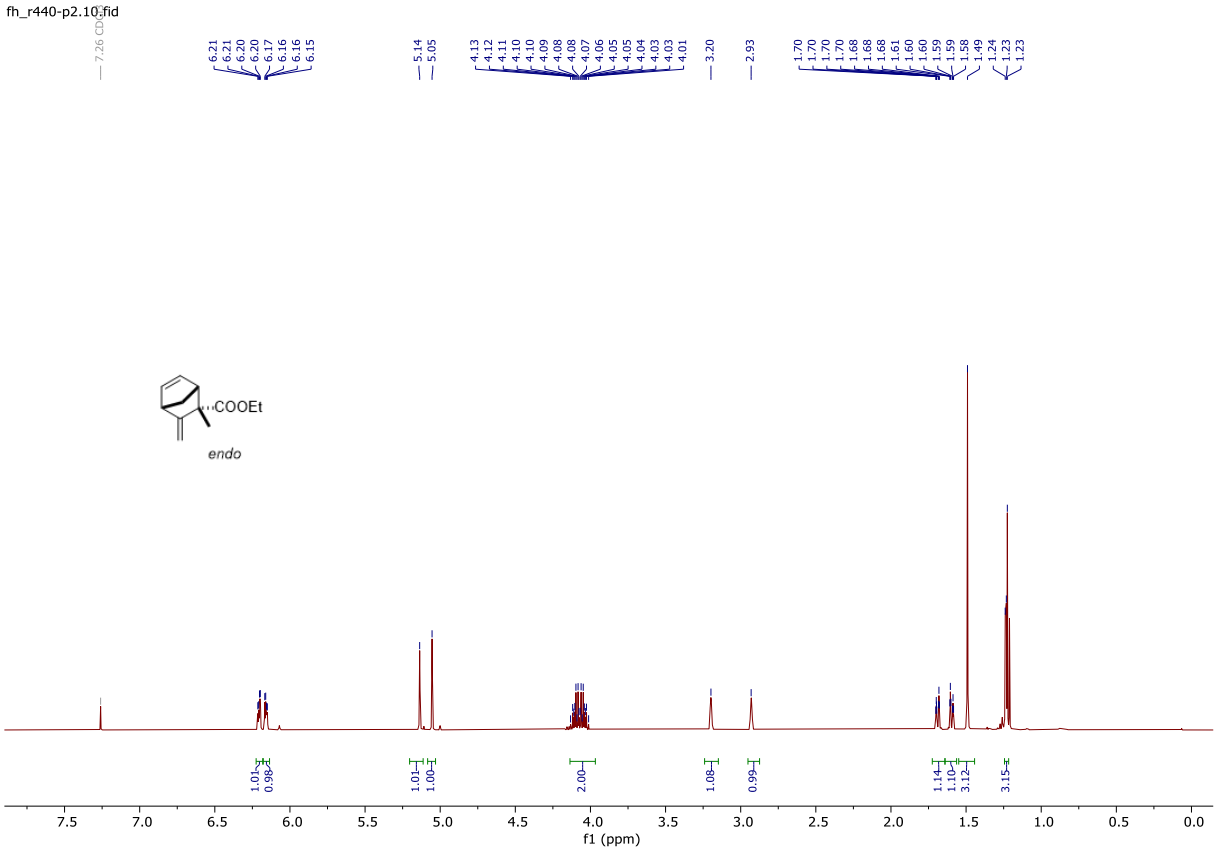


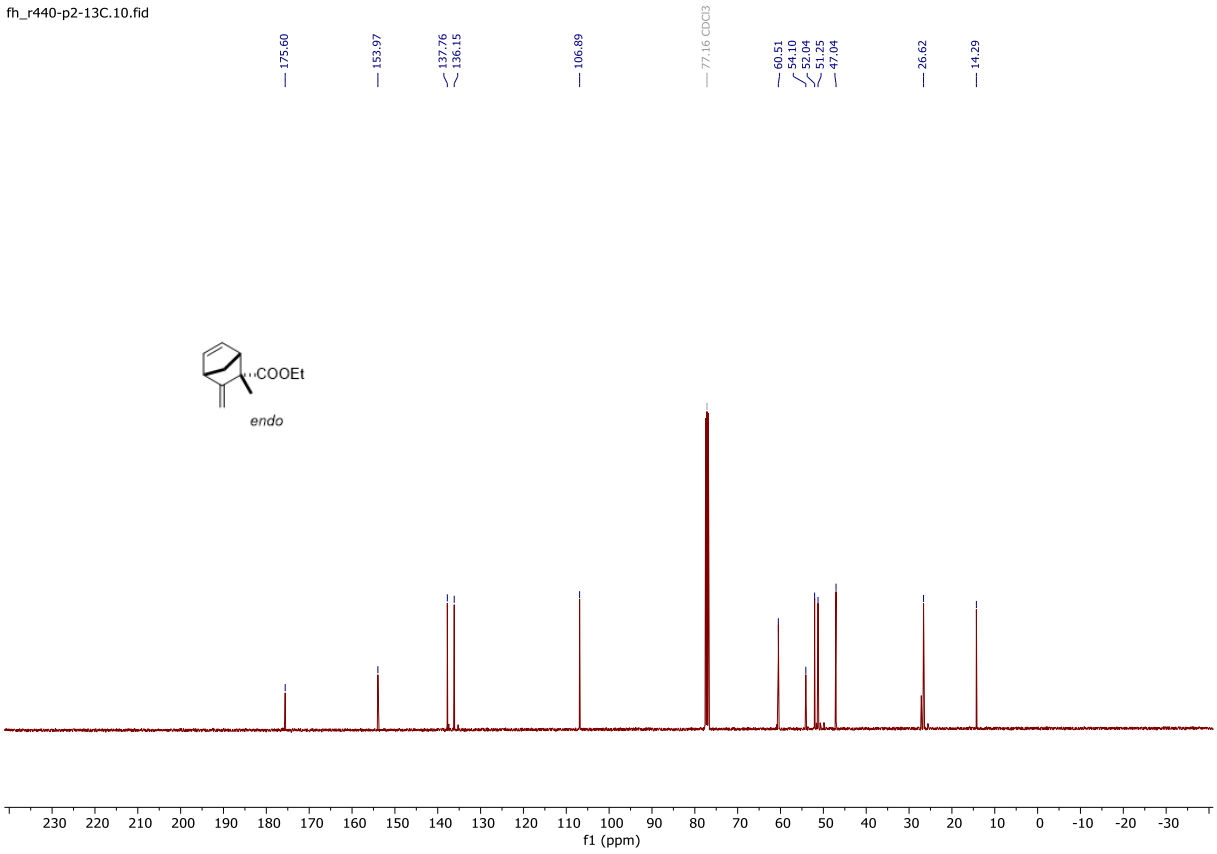
Exo-ethyl-2-methyl-3-methylenebicyclo[2.2.1]hept-5-ene-2-carboxylate (*exo*-6a)



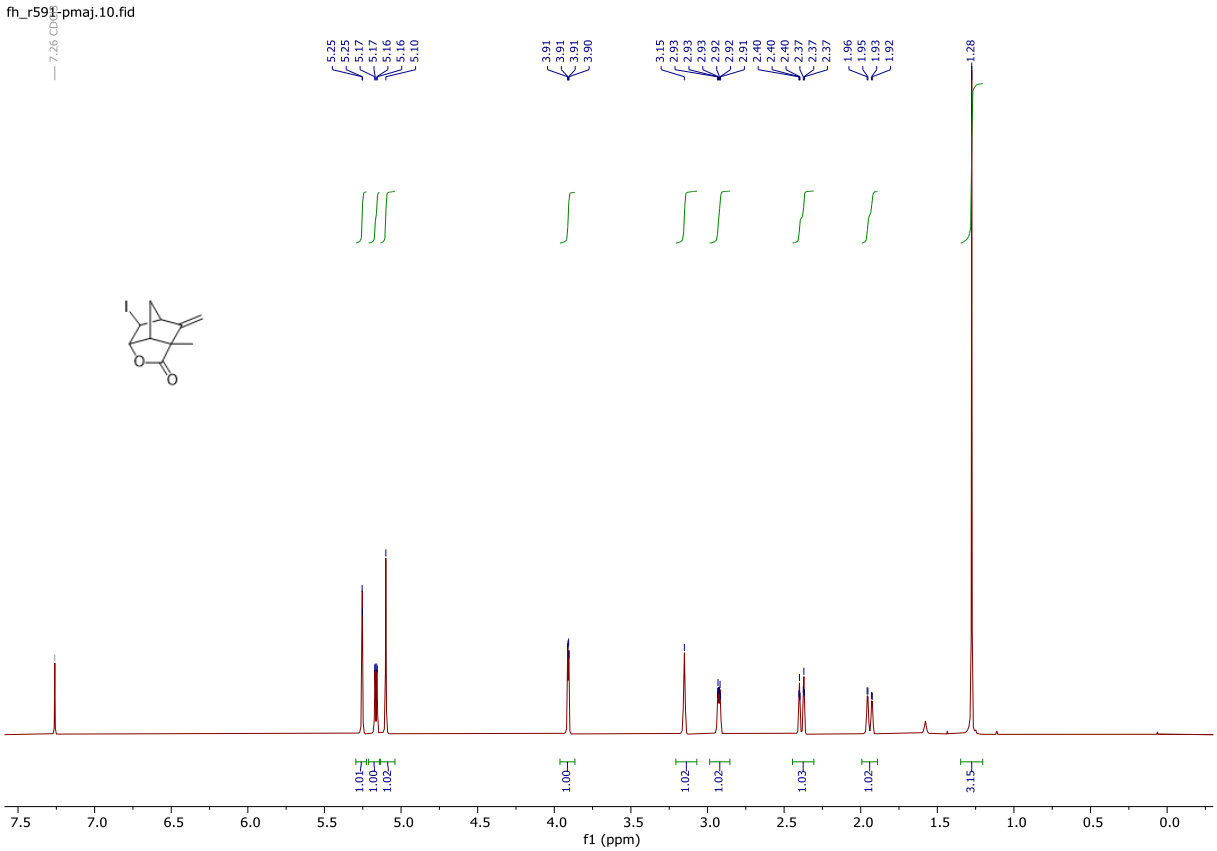


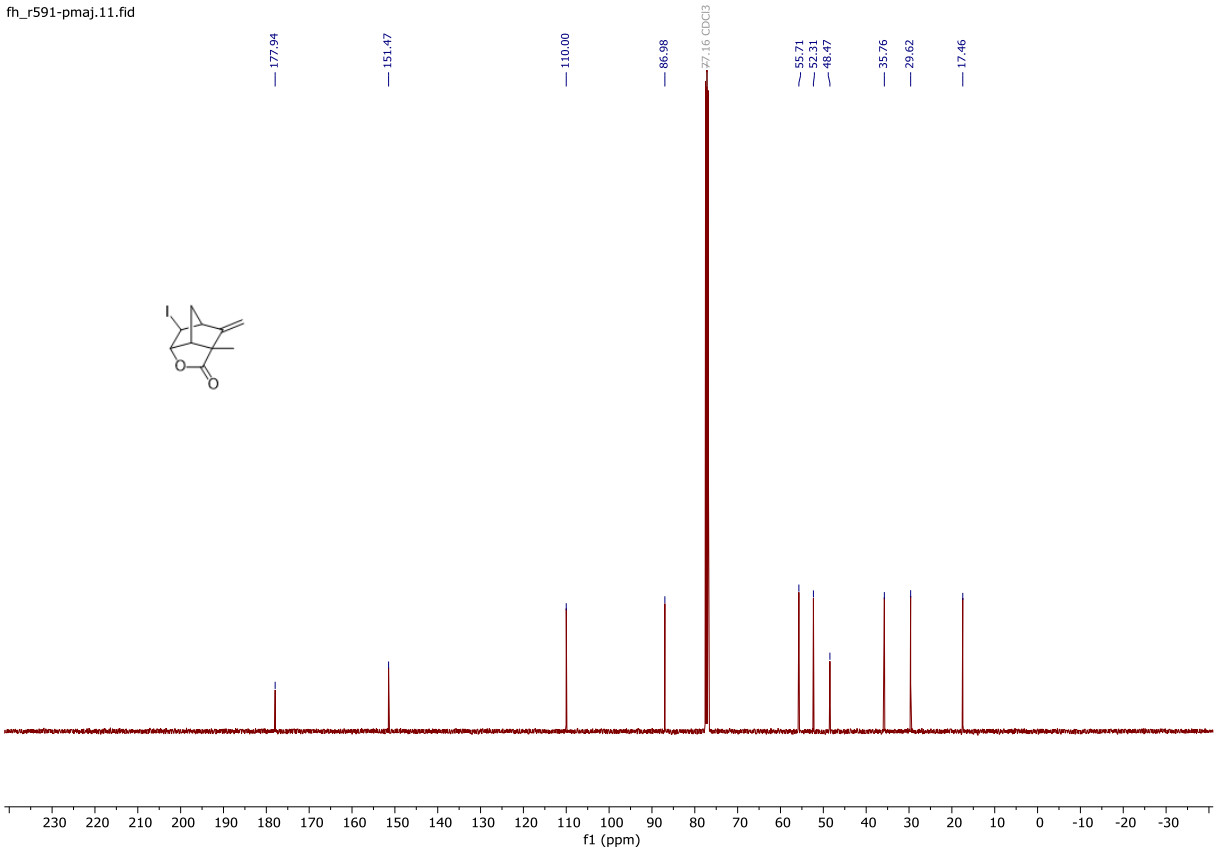
Endo-ethyl-2-methyl-3-methylenebicyclo[2.2.1]hept-5-ene-2-carboxylate (*endo*-6a)



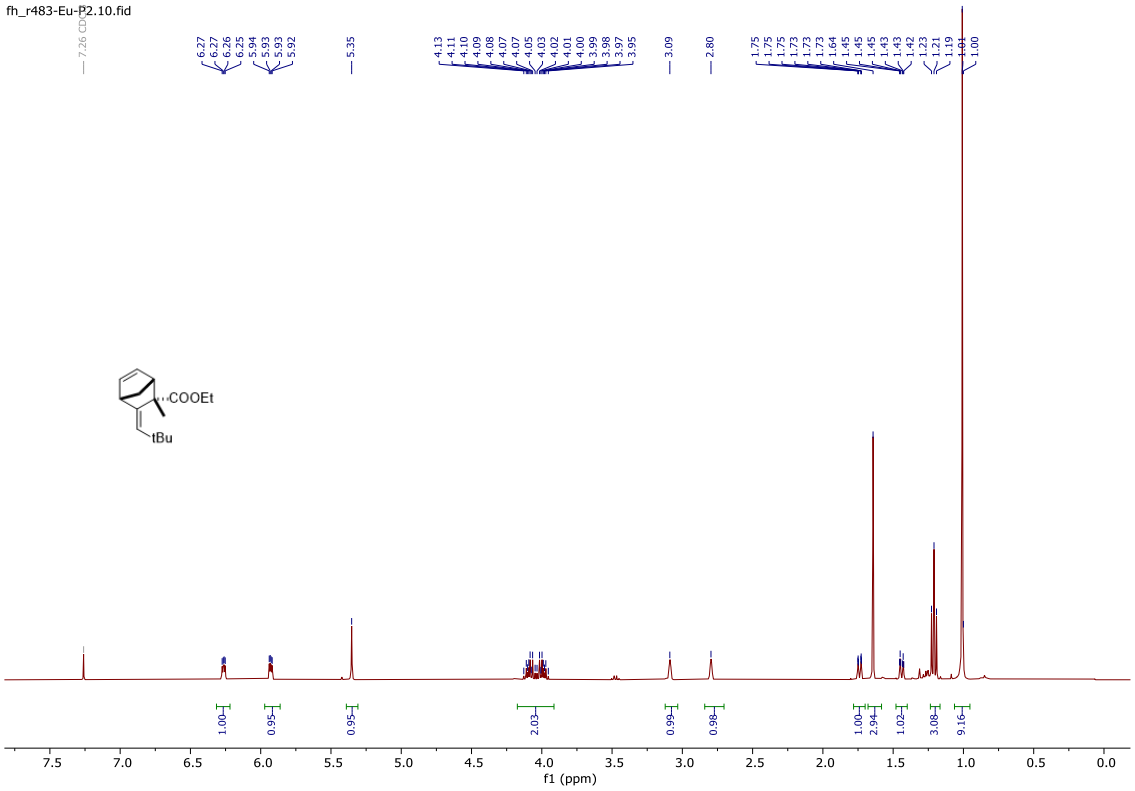


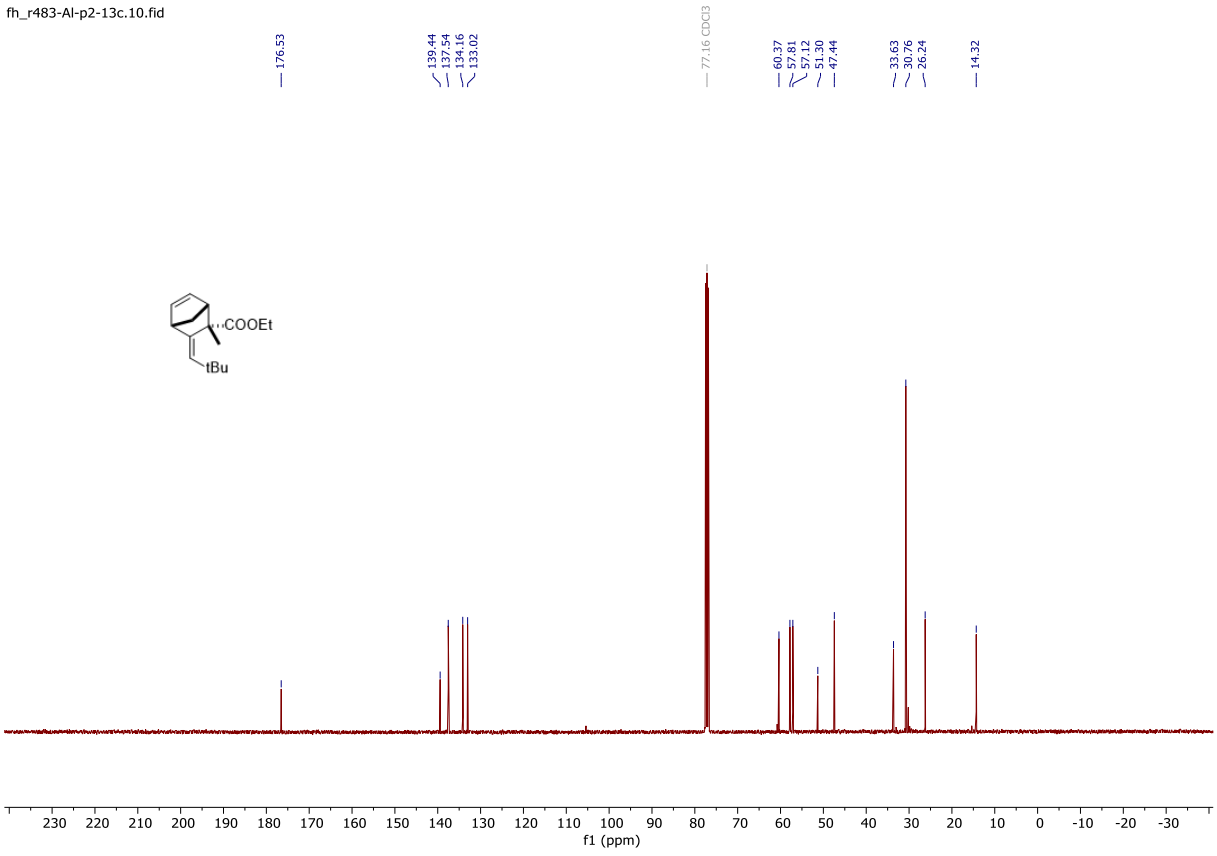
6-iodo-3-methyl-7-methylenehexahydro-2H-3,5-methanocyclopenta[b]furan-2-one (7)



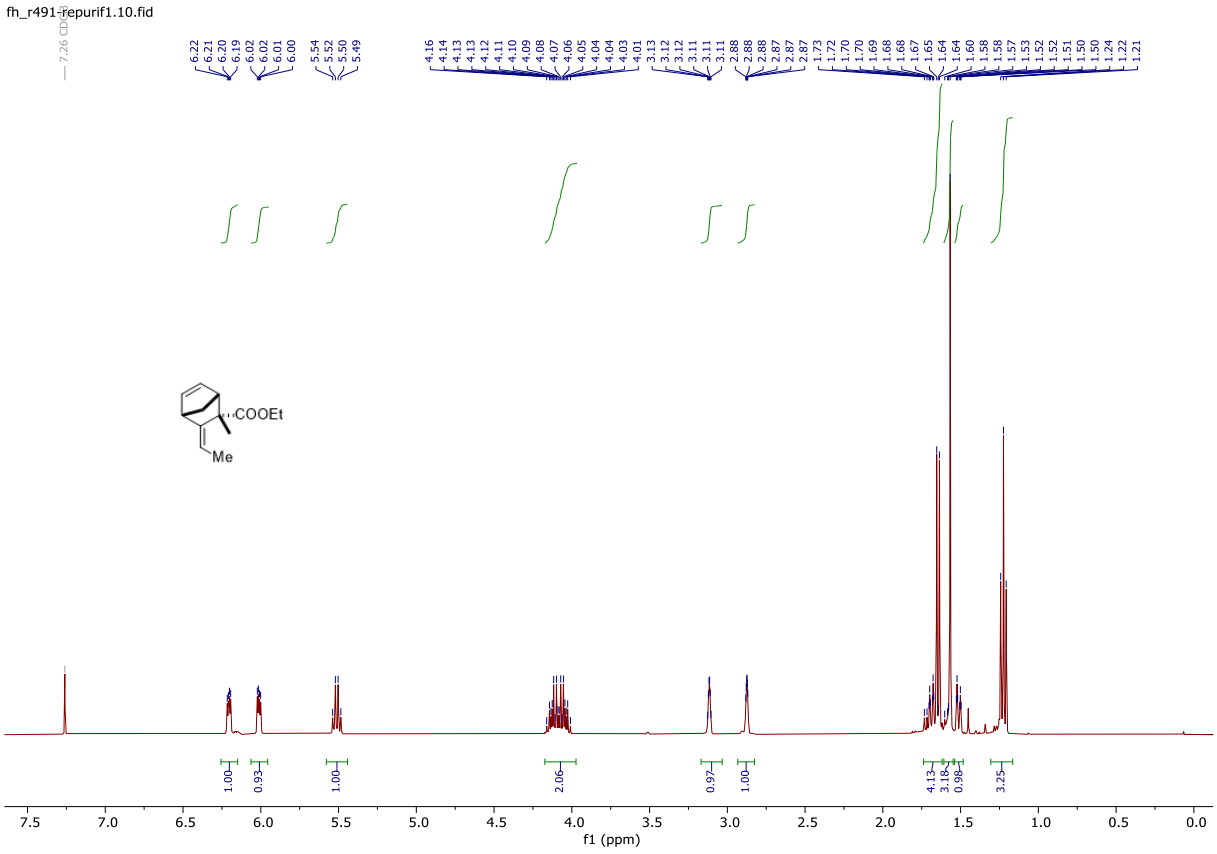


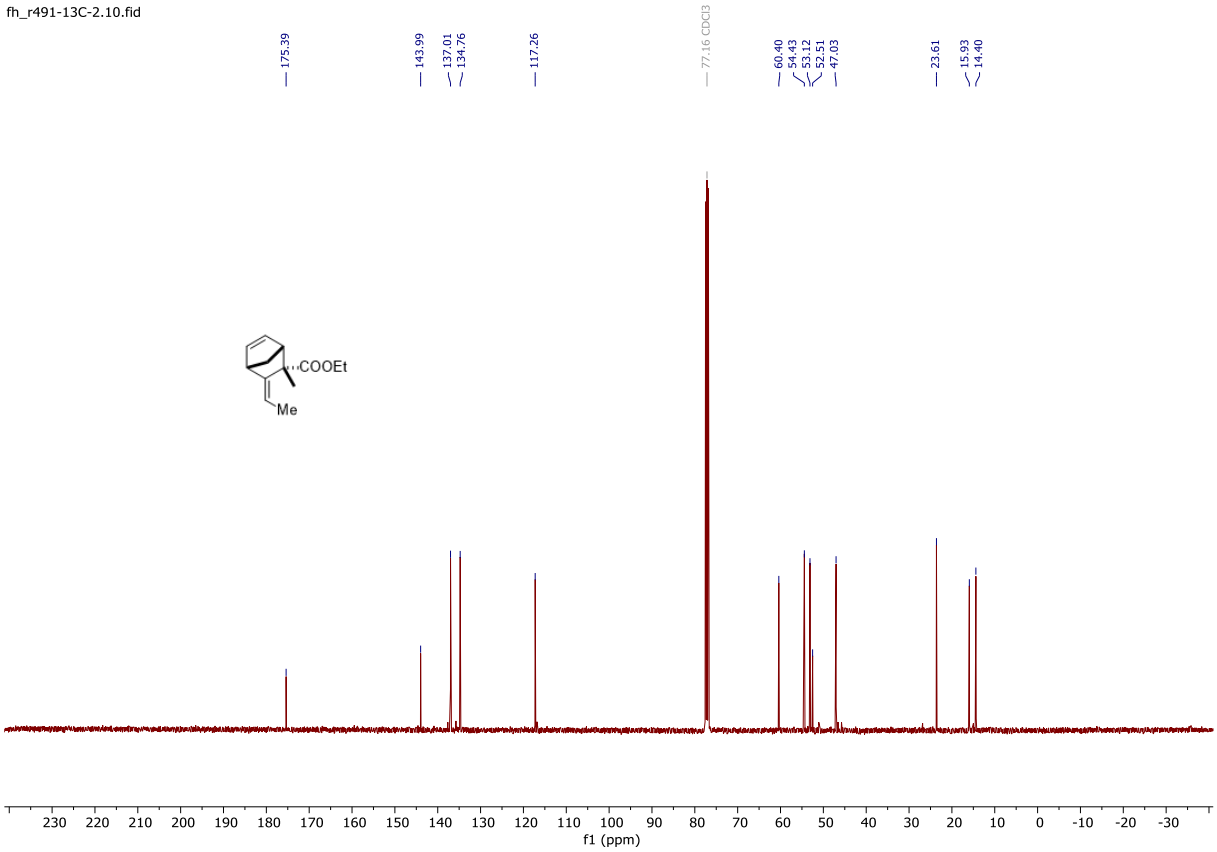
ethyl (*Z*)-3-(2,2-dimethylpropylidene)-2-methylbicyclo[2.2.1]hept-5-ene-2-carboxylate (6b)



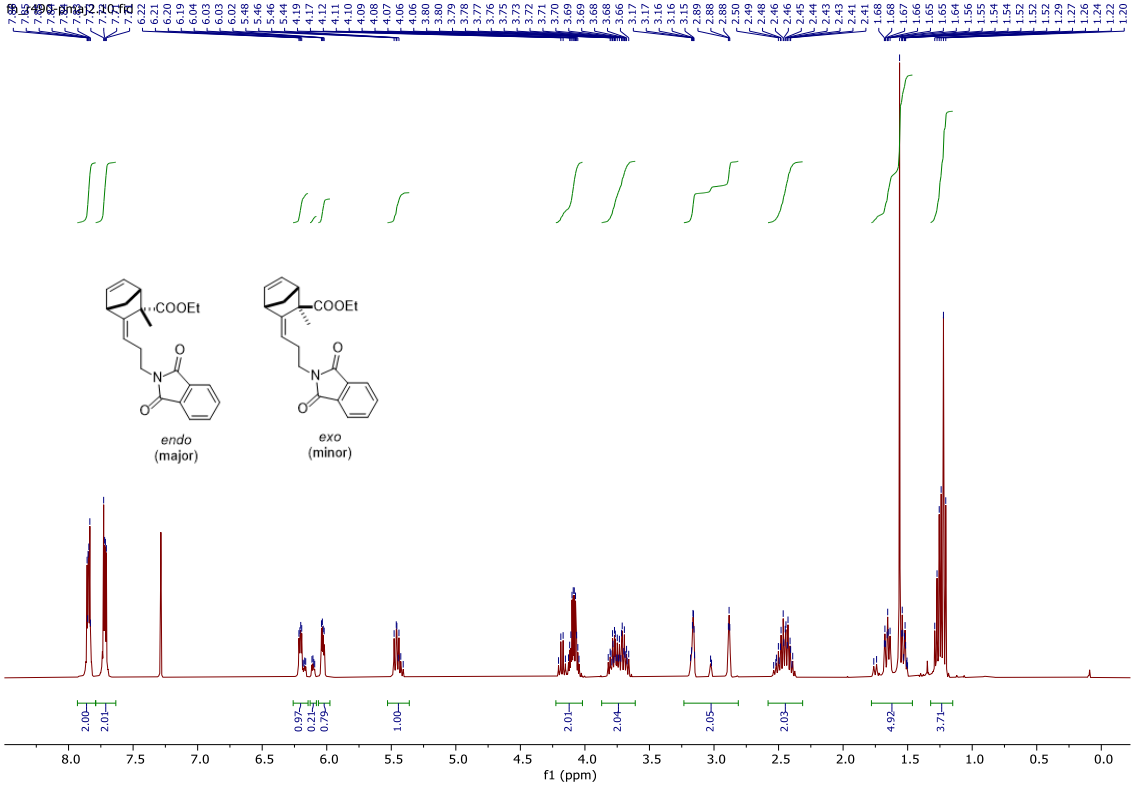


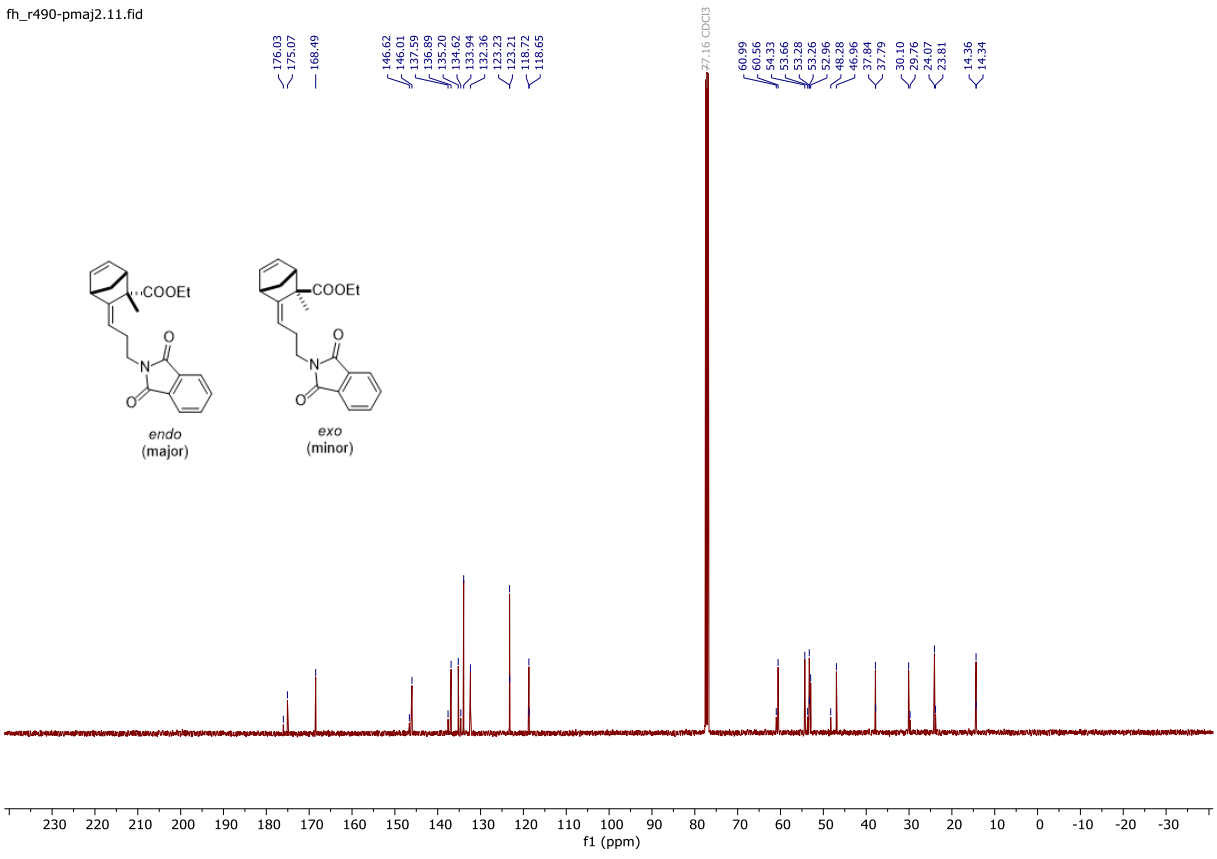
ethyl (*Z*)-3-ethylidene-2-methylbicyclo[2.2.1]hept-5-ene-2-carboxylate (6c)



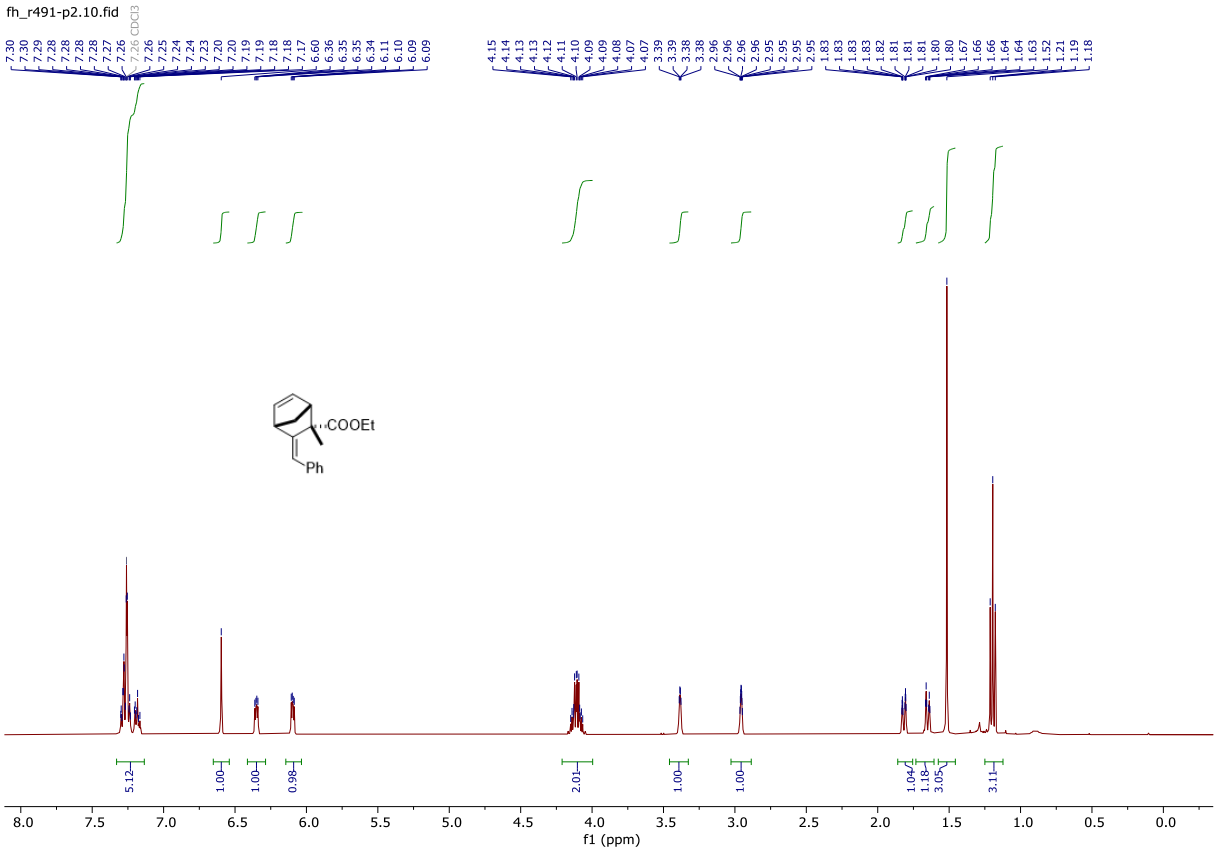


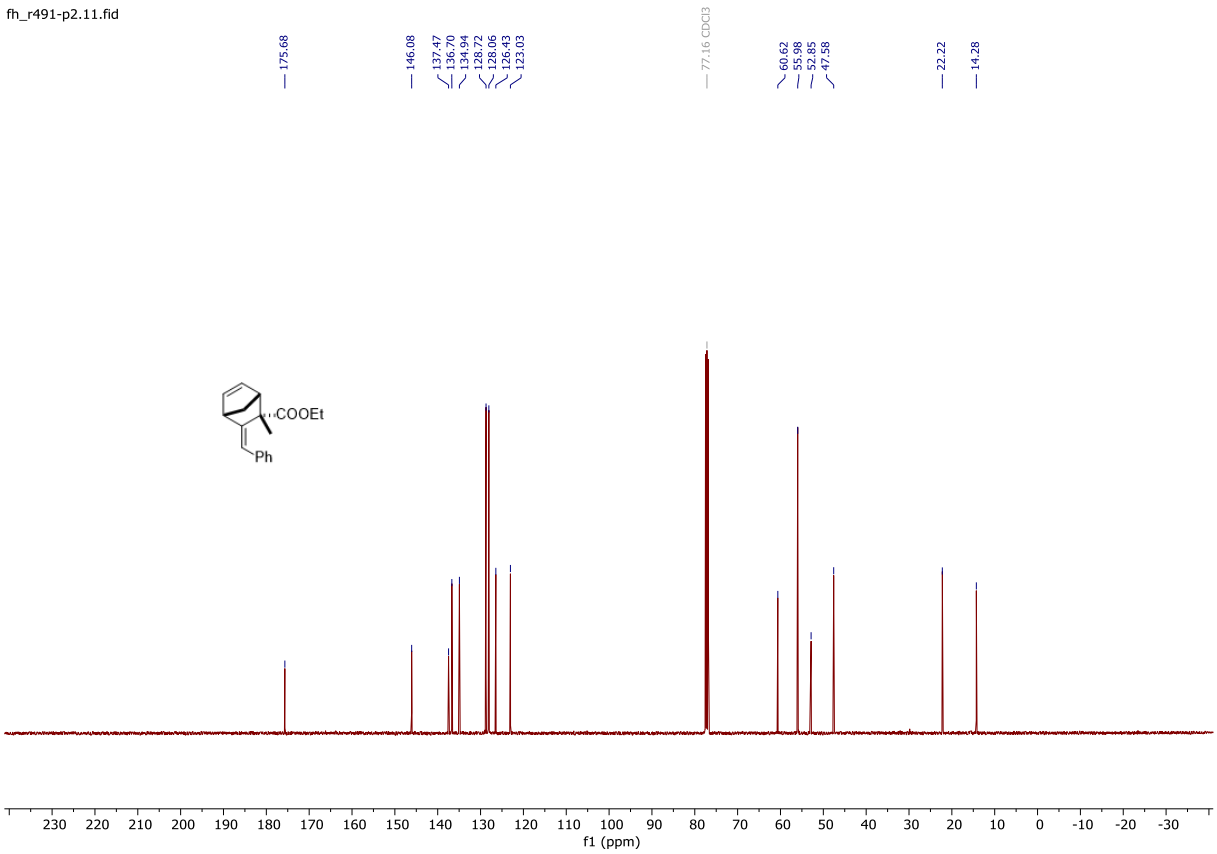
ethyl (*Z*)-3-(3-(1,3-dioxoisoindolin-2-yl)propylidene)-2-methylbicyclo[2.2.1]hept-5-ene-2-carboxyl-ate (6d)



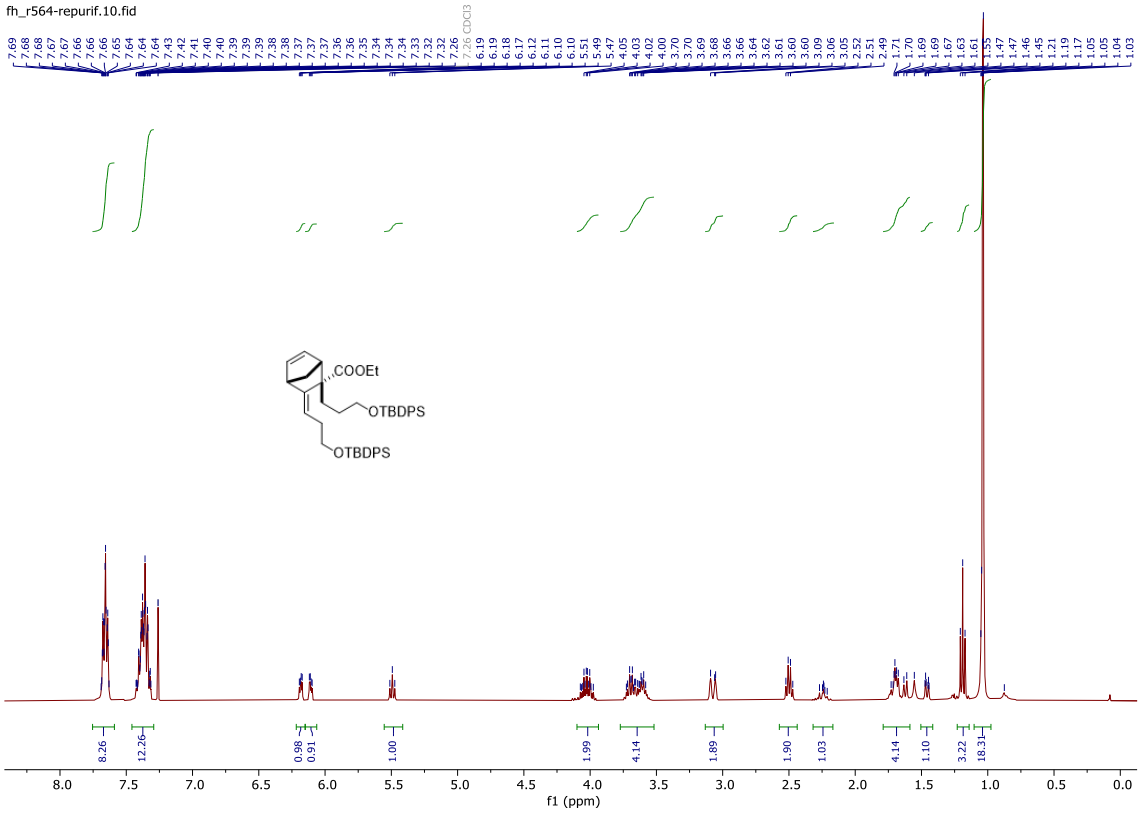


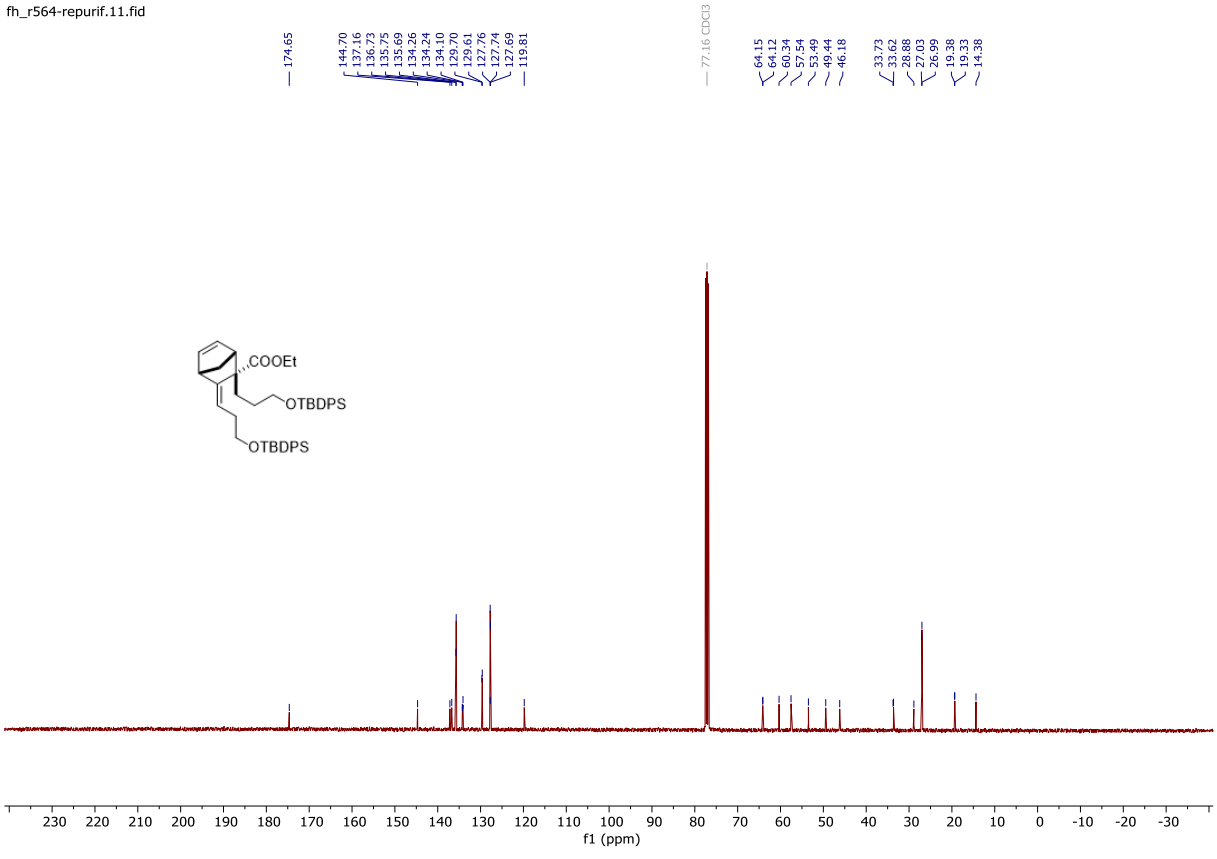
ethyl 3-((Z)-benzylidene)-2-methylbicyclo[2.2.1]hept-5-ene-2-carboxylate (6e)



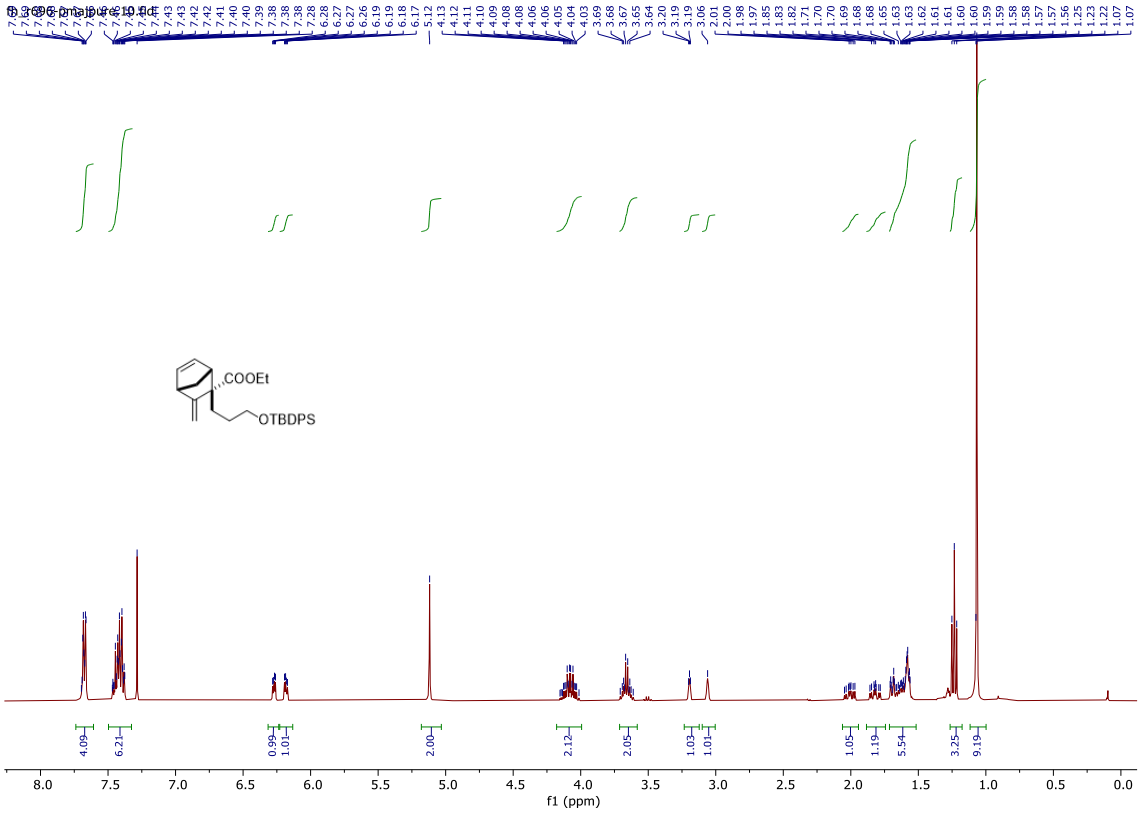


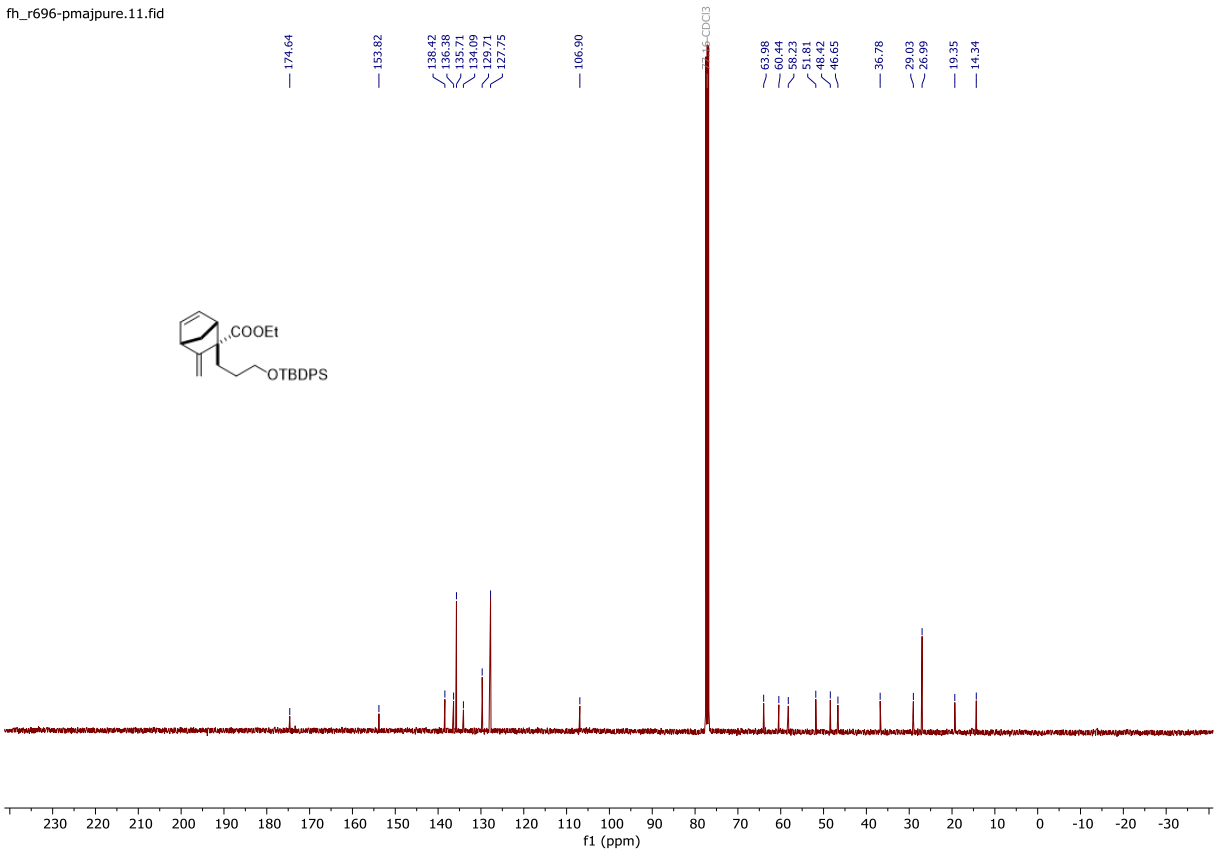
ethyl (*Z*)-2-(3-((tert-butyldiphenylsilyl)oxy)propyl)-3-(3-((tert-butyldiphenylsilyl)oxy)propylidene) bicyclo[2.2.1]hept-5-ene-2-carboxylate (6f)



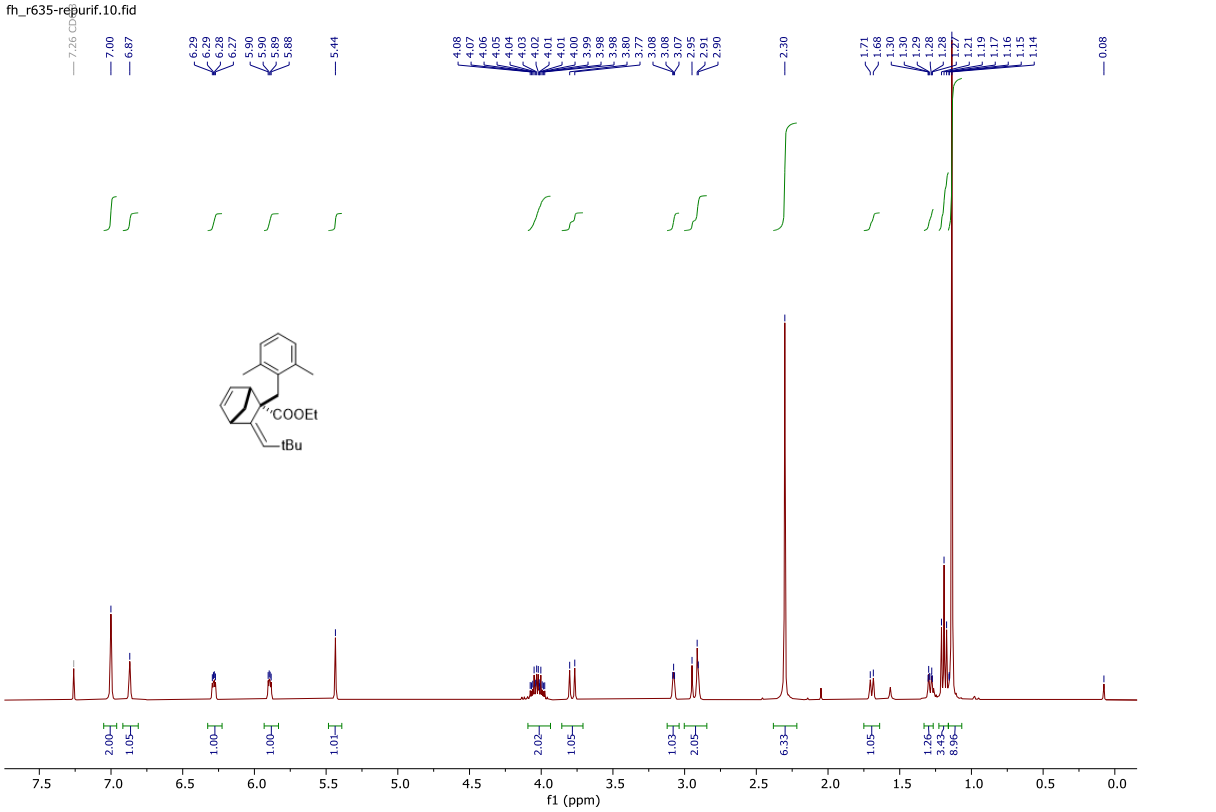


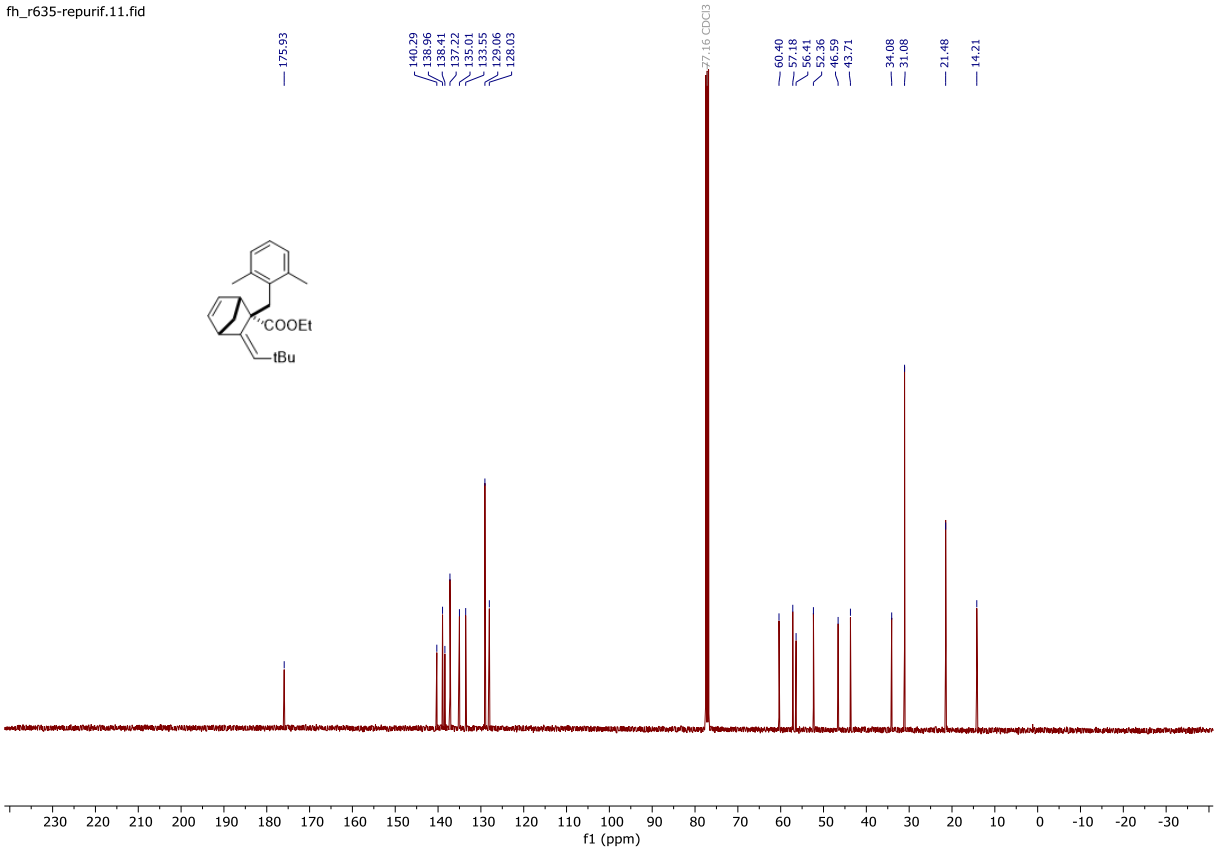
ethyl 2-(3-((tert-butyldiphenylsilyl)oxy)propyl)-3-methylenebicyclo[2.2.1]hept-5-ene-2-carboxylate (6g)



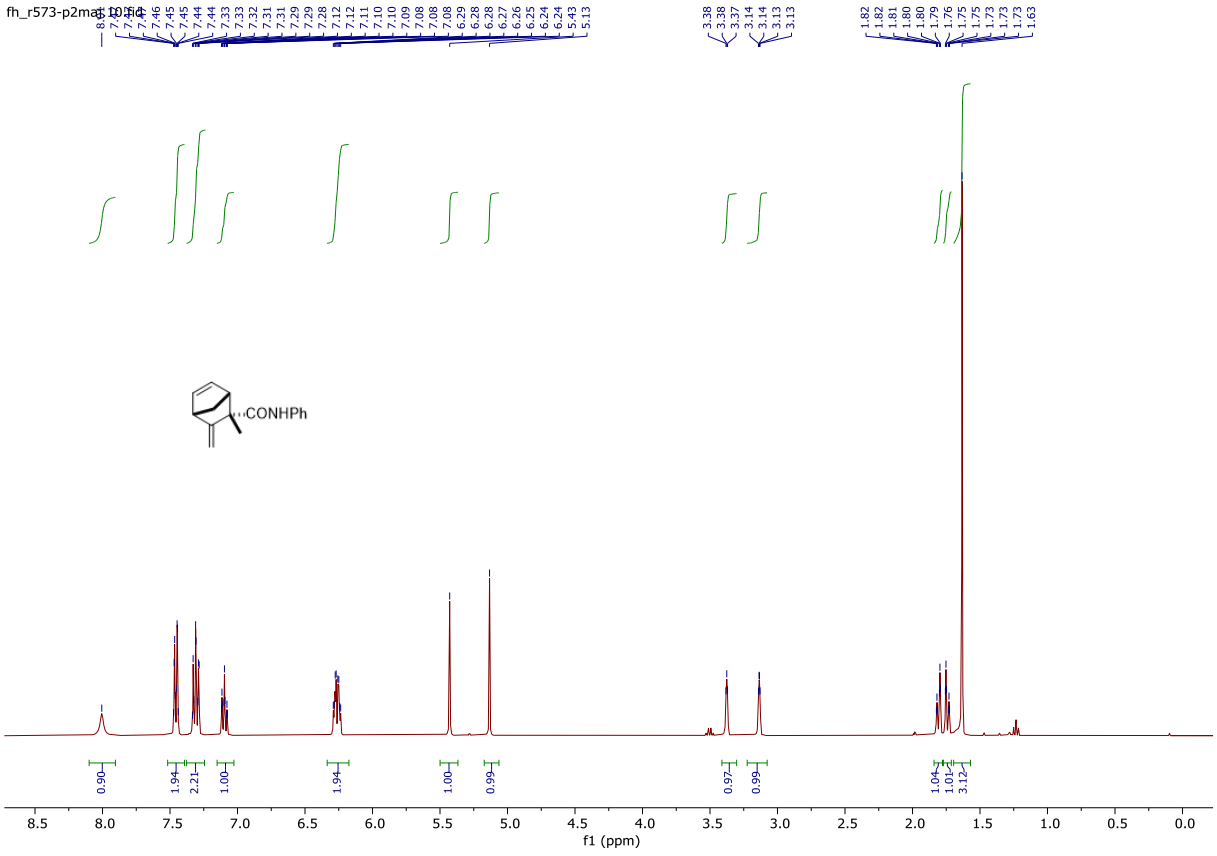


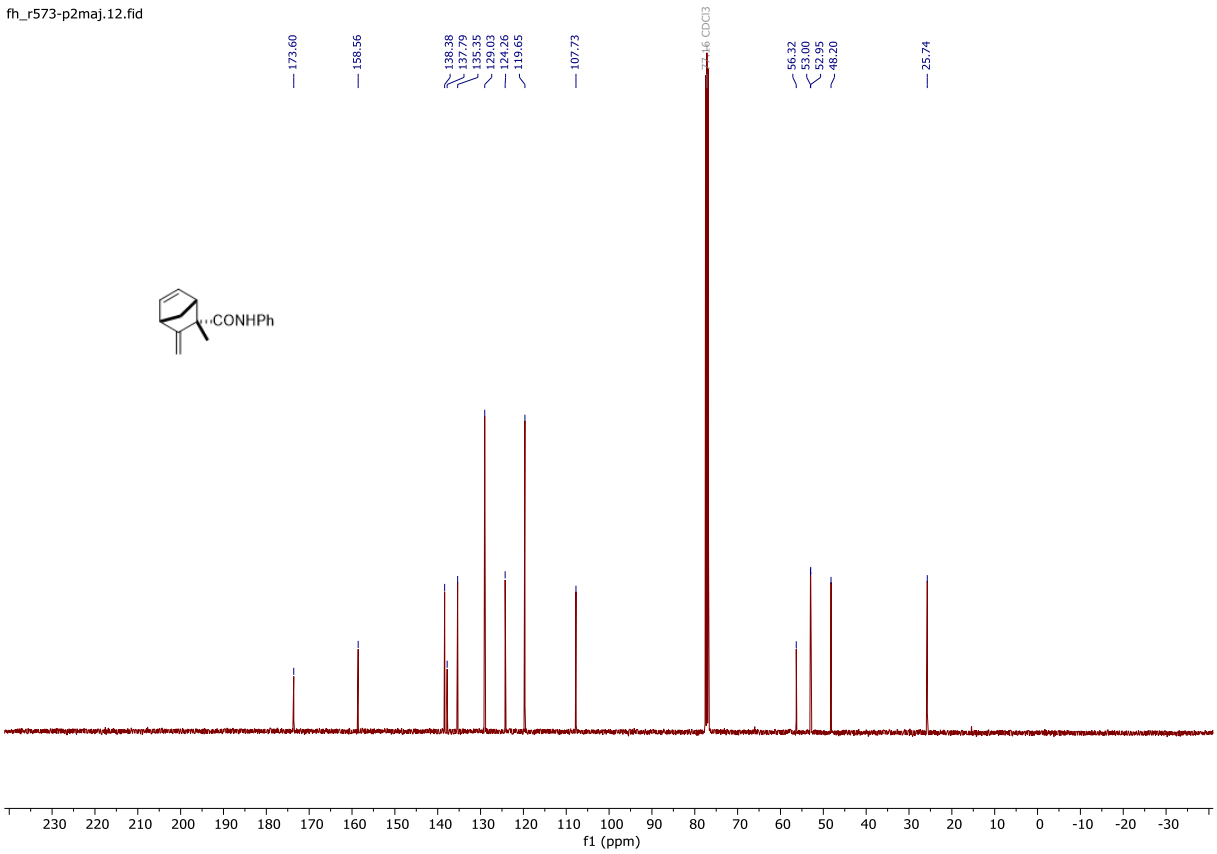
ethyl (*Z*)-2-(2,6-dimethylbenzyl)-3-(2,2-dimethylpropylidene)bicyclo[2.2.1]hept-5-ene-2-carboxyl-ate (6h)



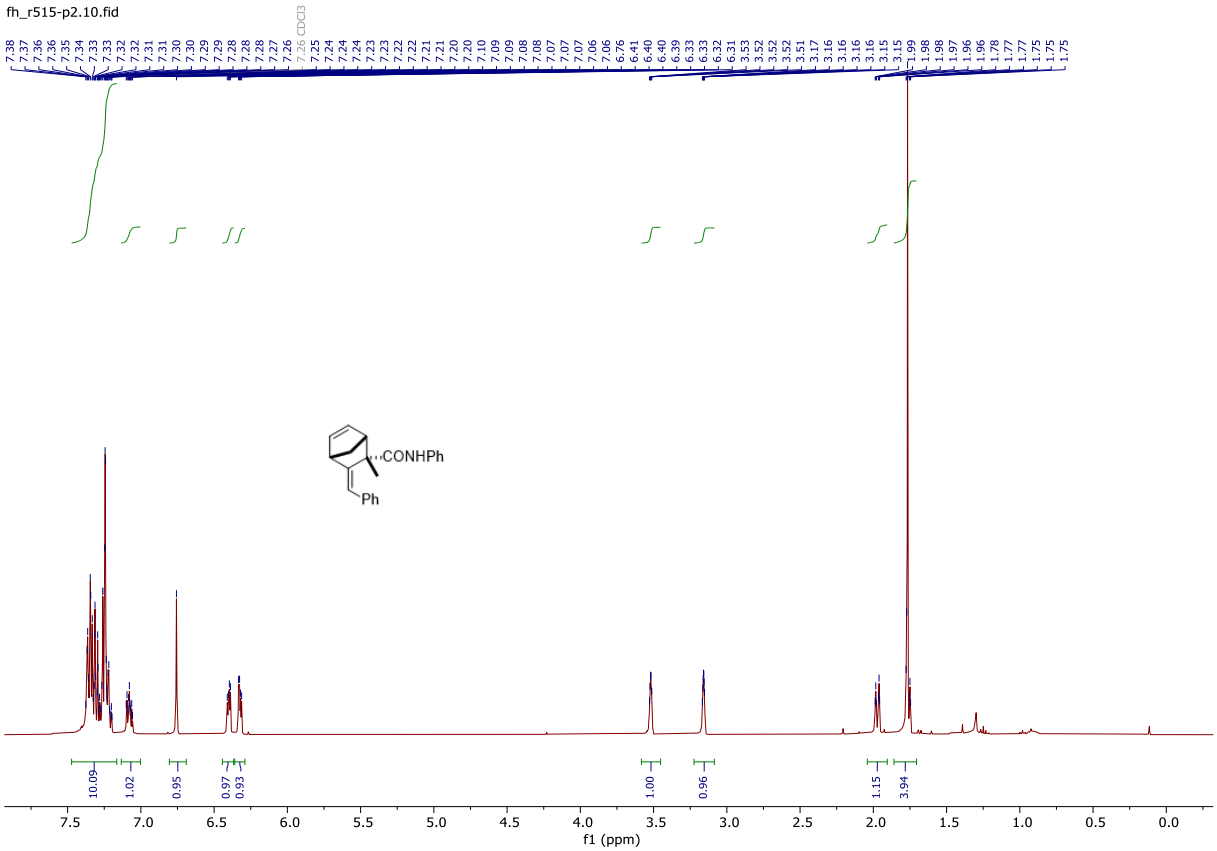


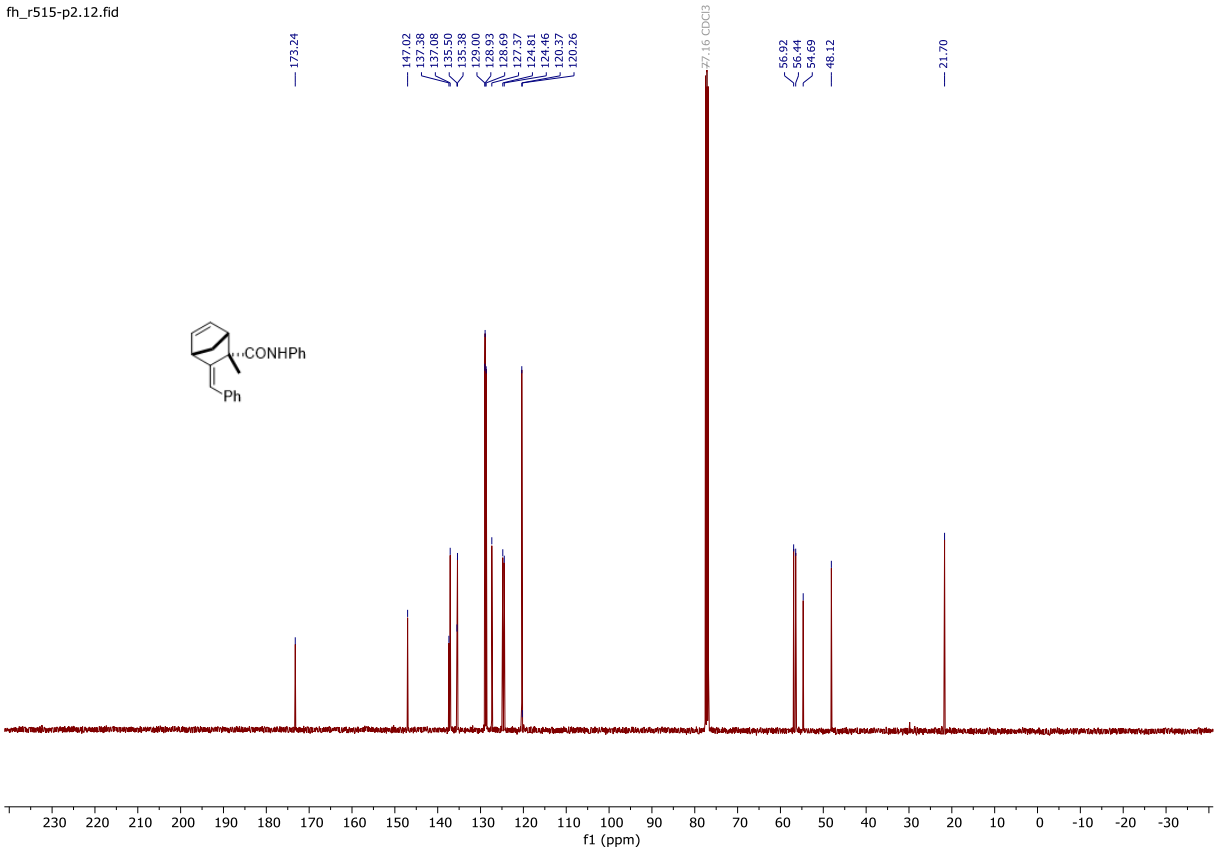
2-methyl-3-methylene-N-phenylbicyclo[2.2.1]hept-5-ene-2-carboxamide (6i)



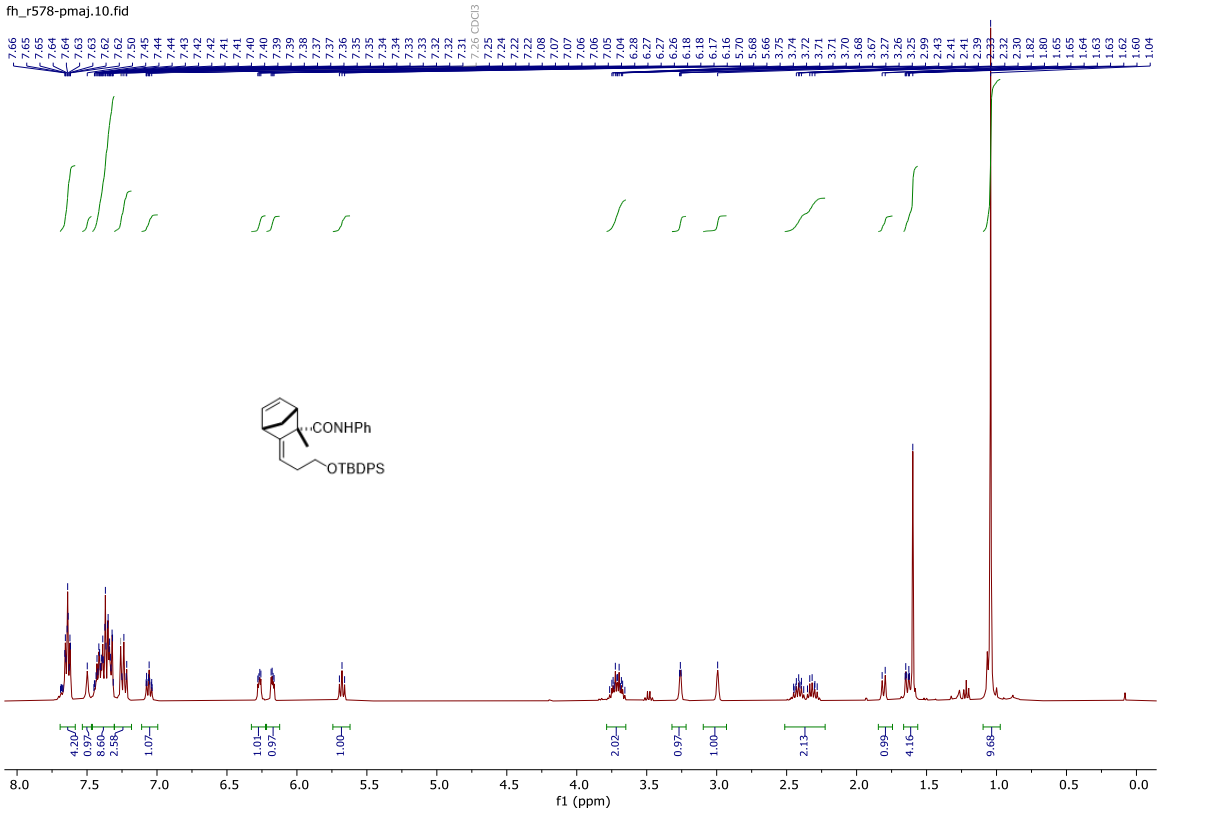


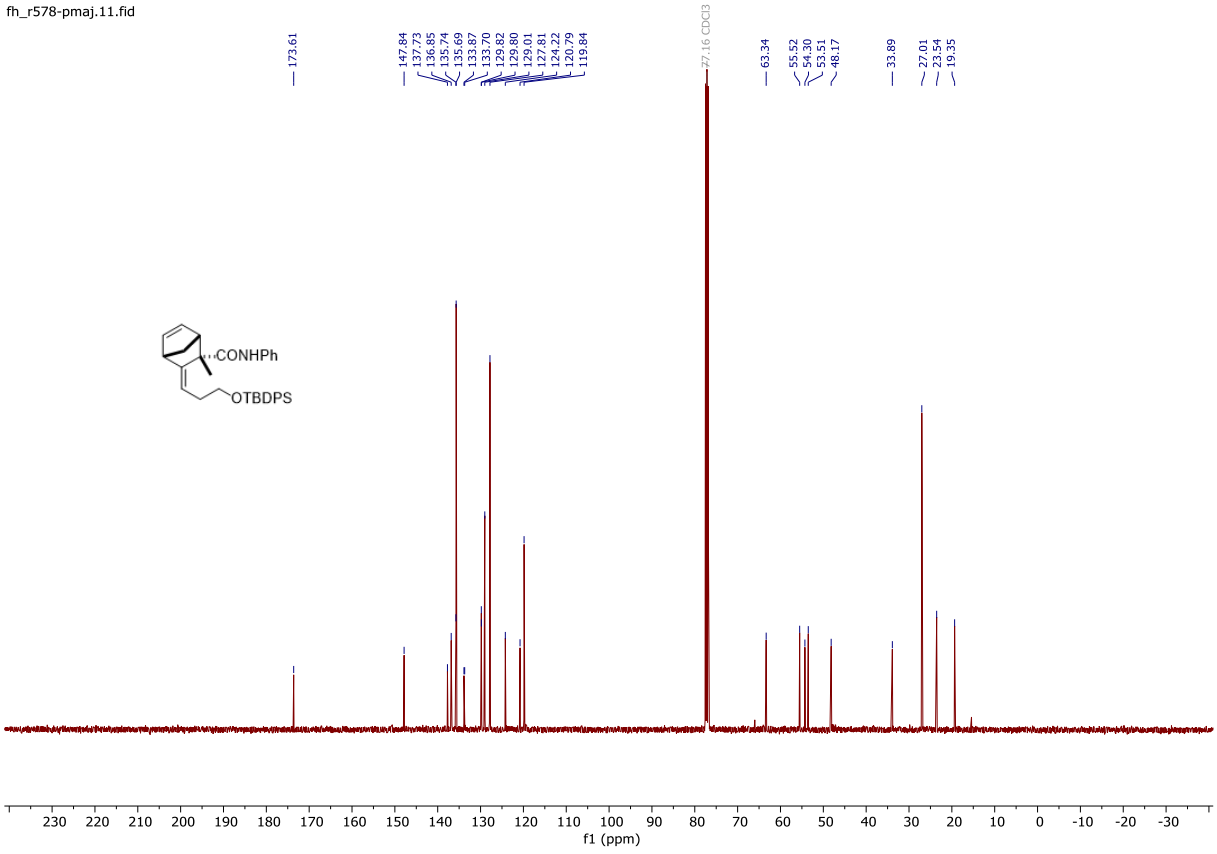
3-((Z)-benzylidene)-2-methyl-N-phenylbicyclo[2.2.1]hept-5-ene-2-carboxamide (6j)



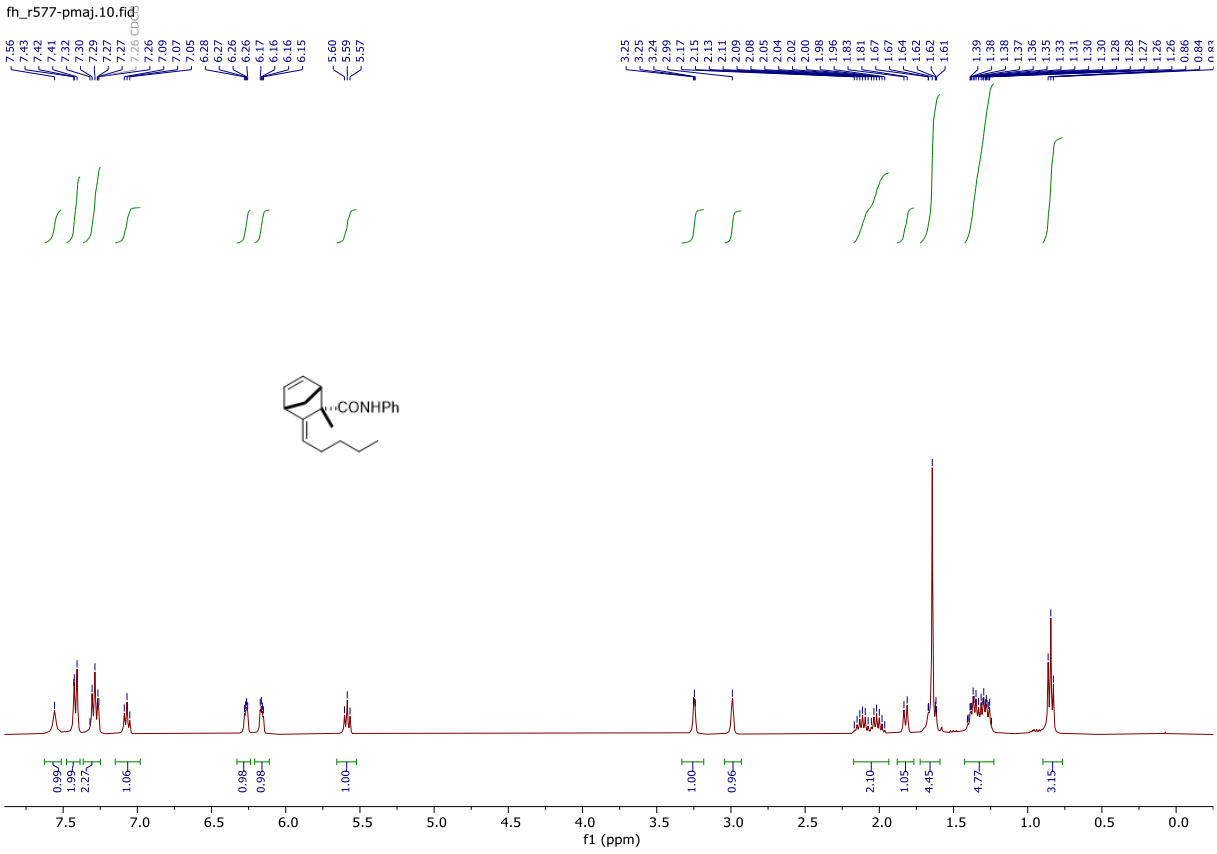


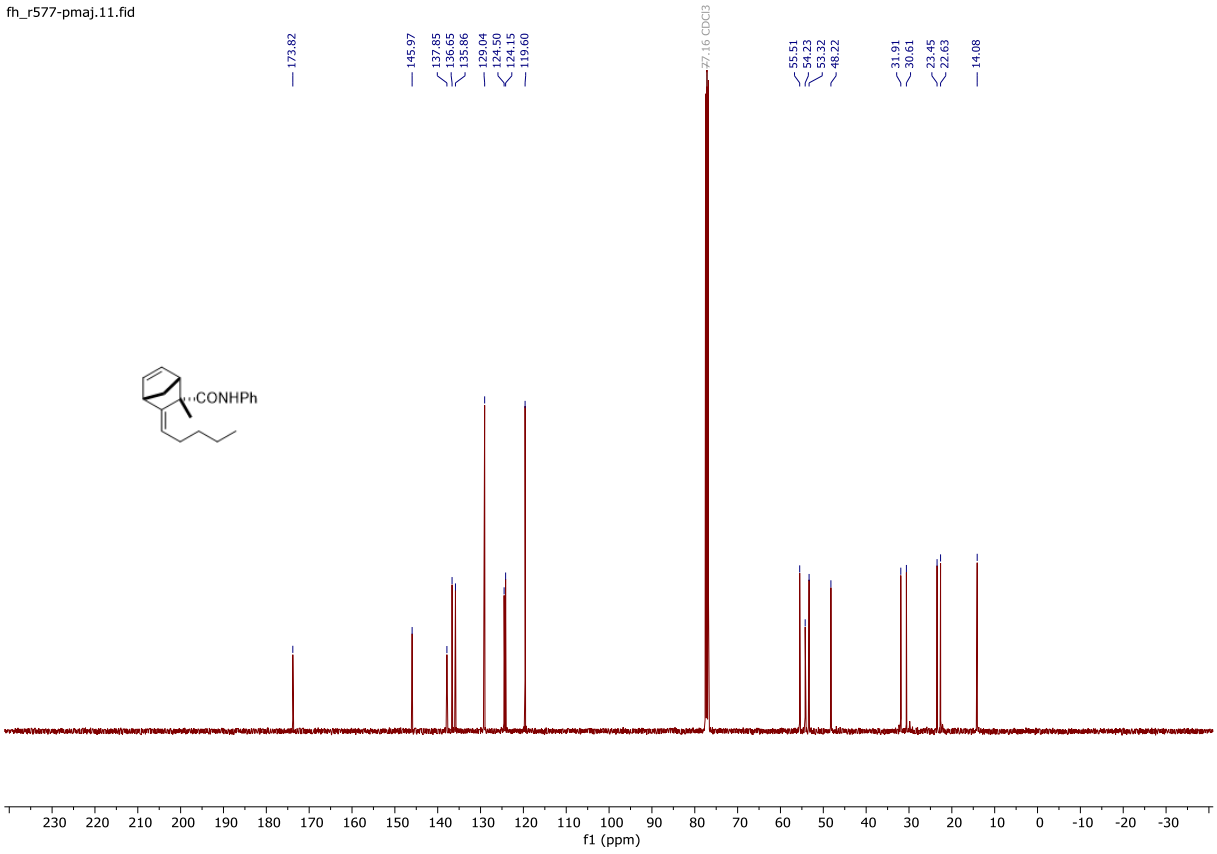
(*Z*)-3-(3-((tert-butyldiphenylsilyl)oxy)propylidene)-2-methyl-N-phenylbicyclo[2.2.1]hept-5-ene-2-carboxamide (6k)



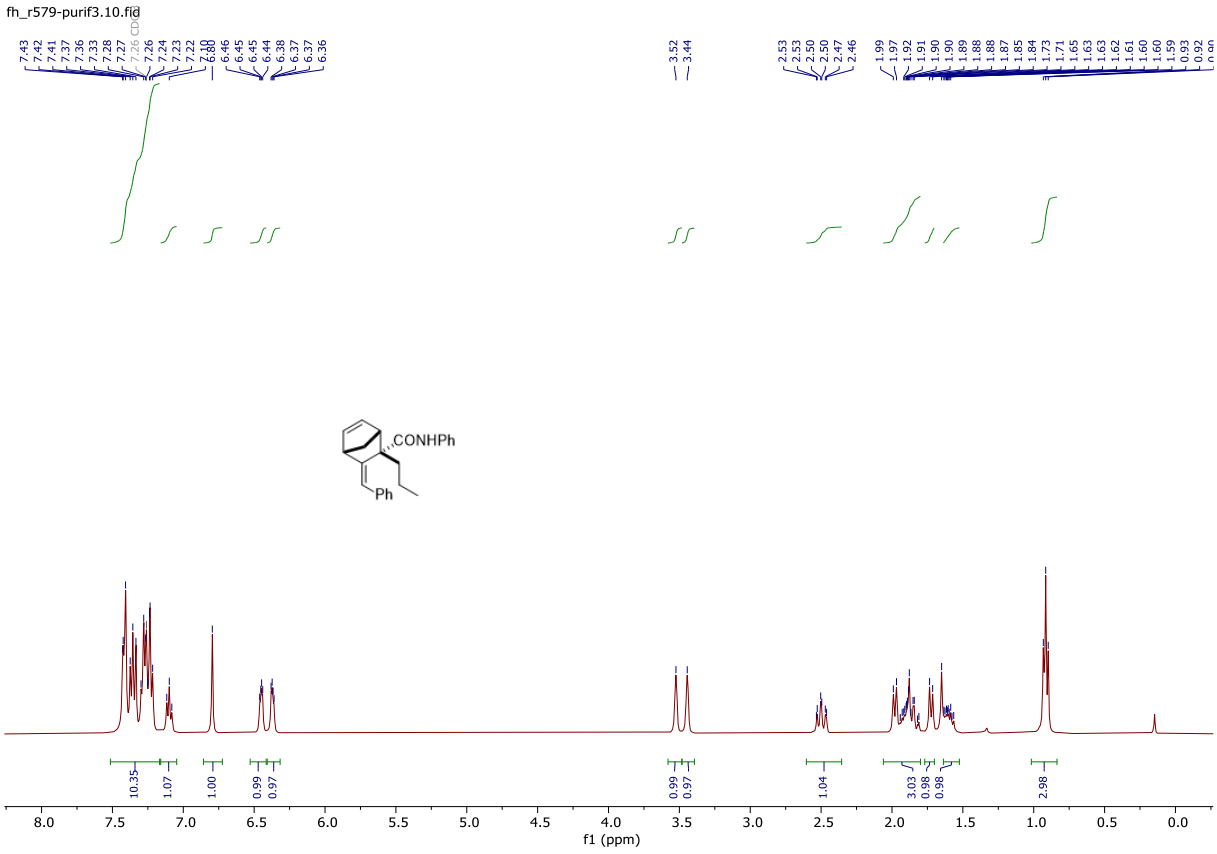


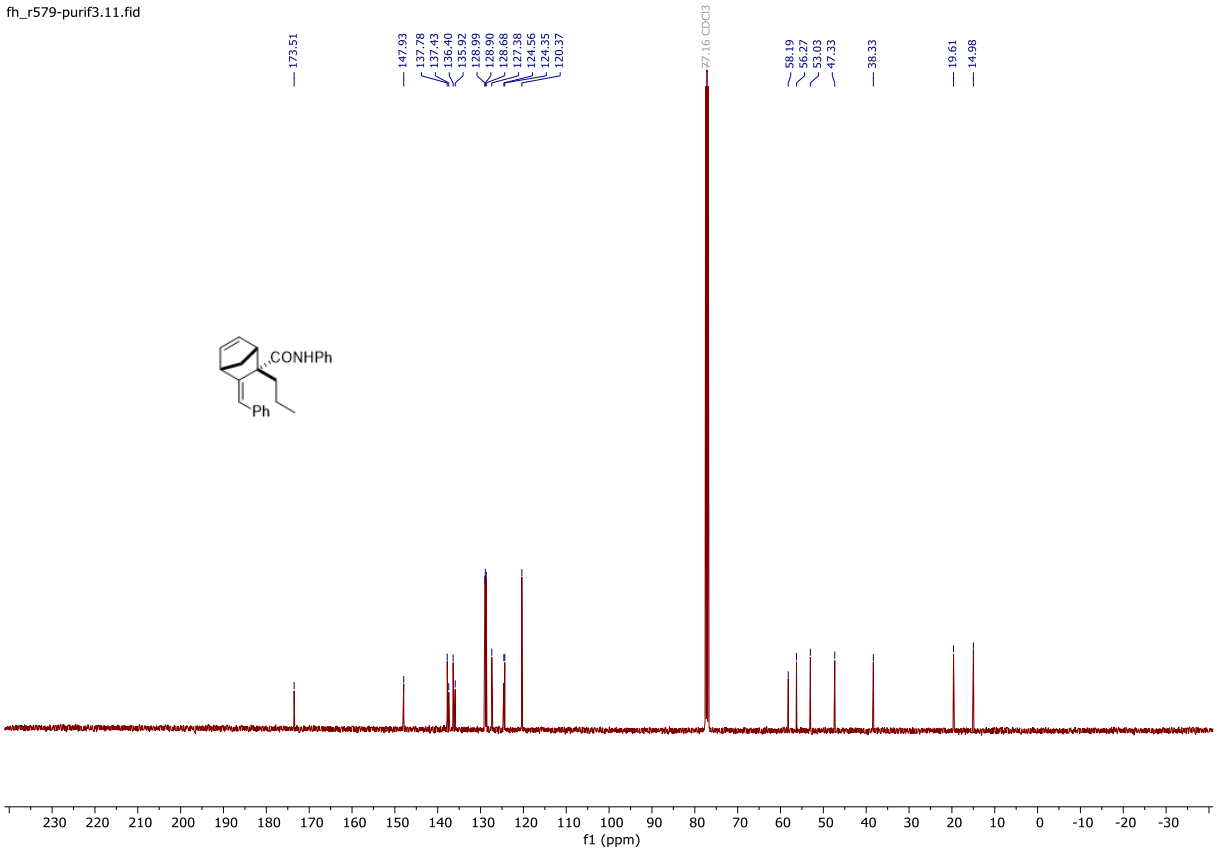
(*Z*)-2-methyl-3-pentylidene-N-phenylbicyclo[2.2.1]hept-5-ene-2-carboxamide (6l)



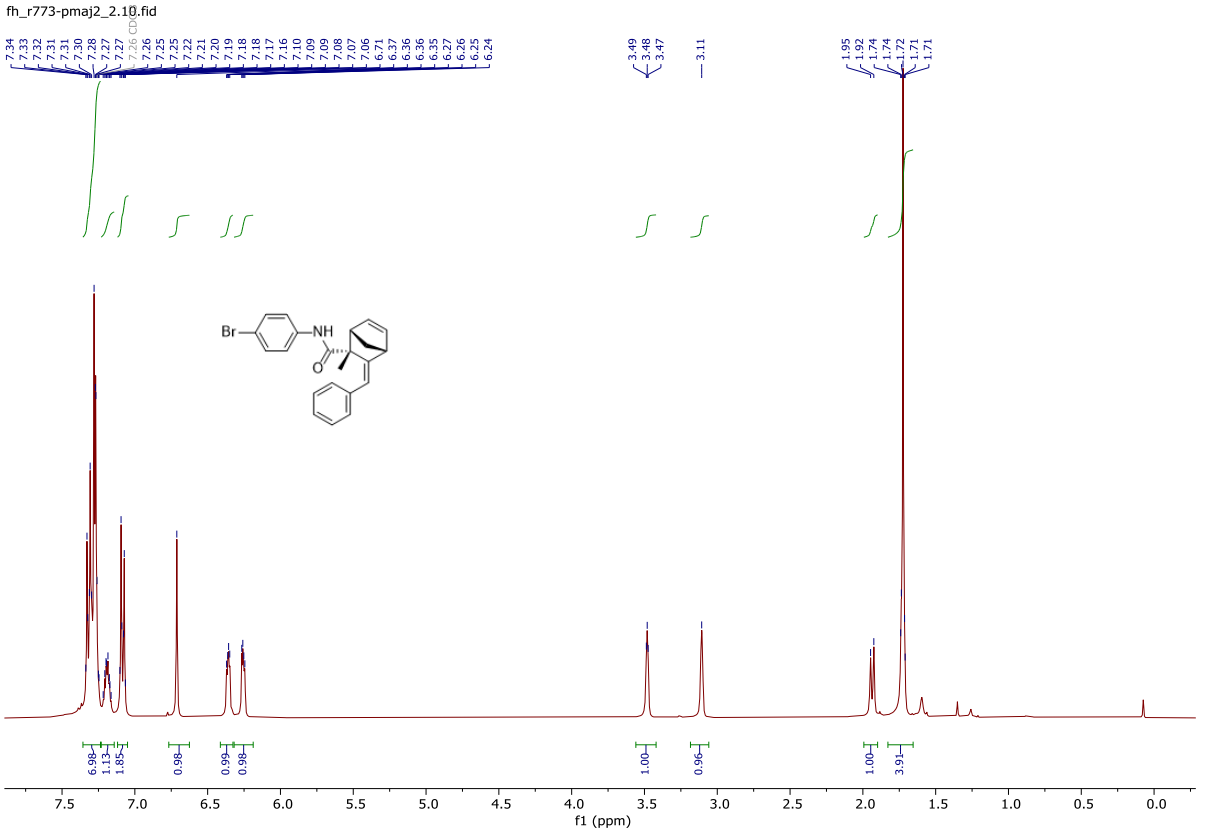


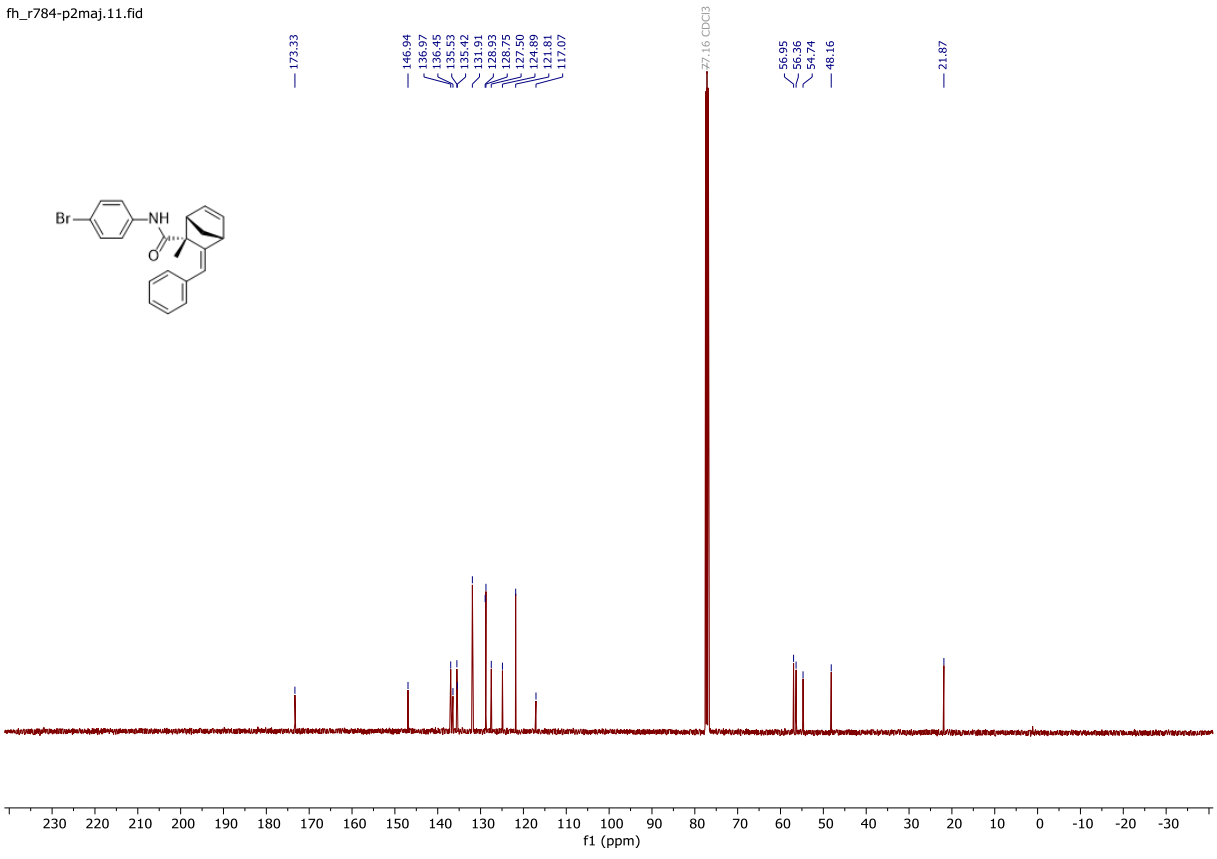
3-((Z)-benzylidene)-N-phenyl-2-propylbicyclo[2.2.1]hept-5-ene-2-carboxamide (6m)



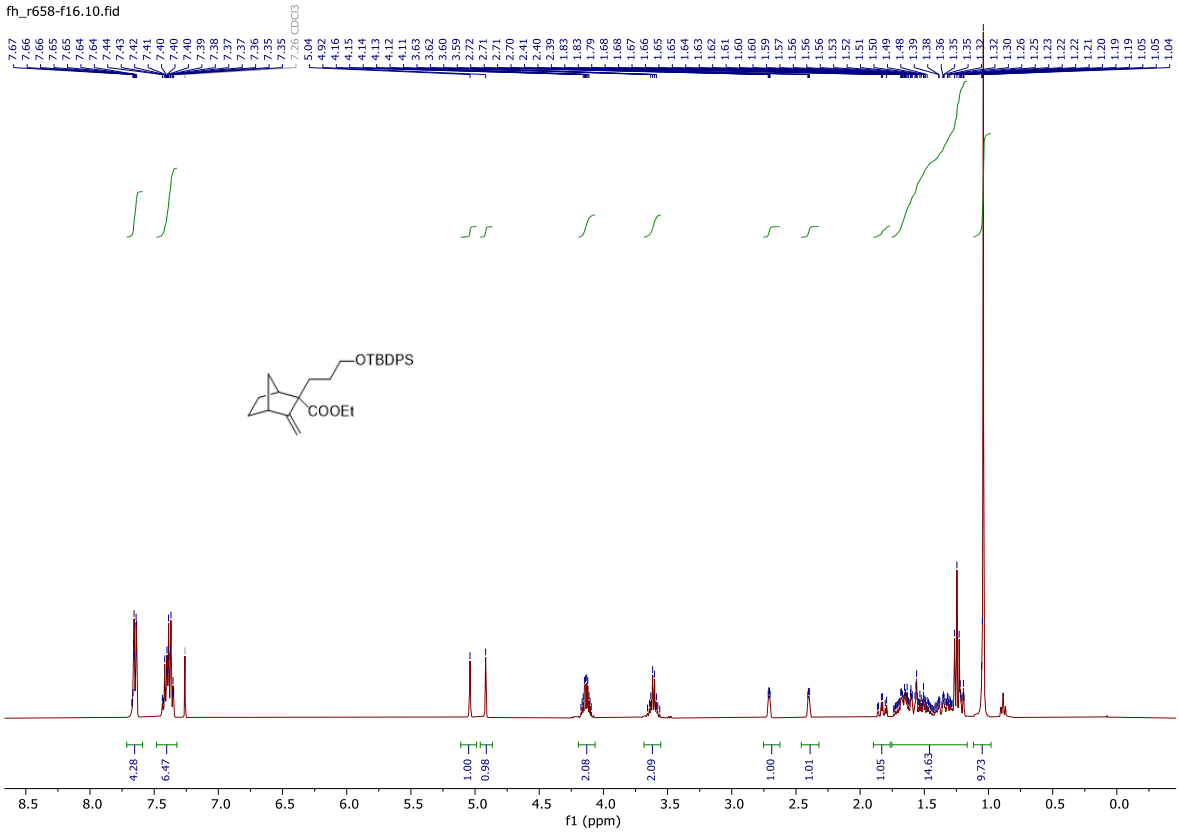


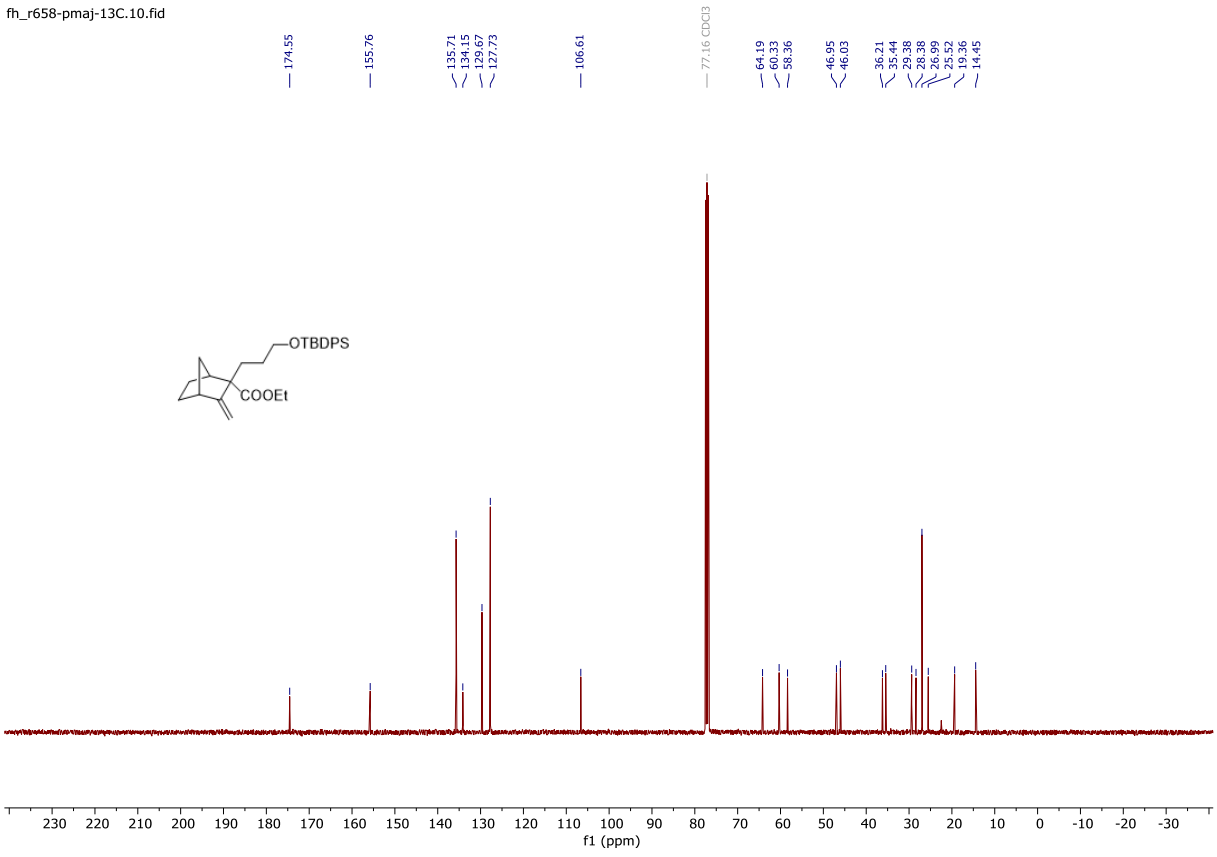
(*1S,2R,4R*)-3-((*Z*)-benzylidene)-N-(4-bromophenyl)-2-methylbicyclo[2.2.1]hept-5-ene-2-carbox-amide (6n)



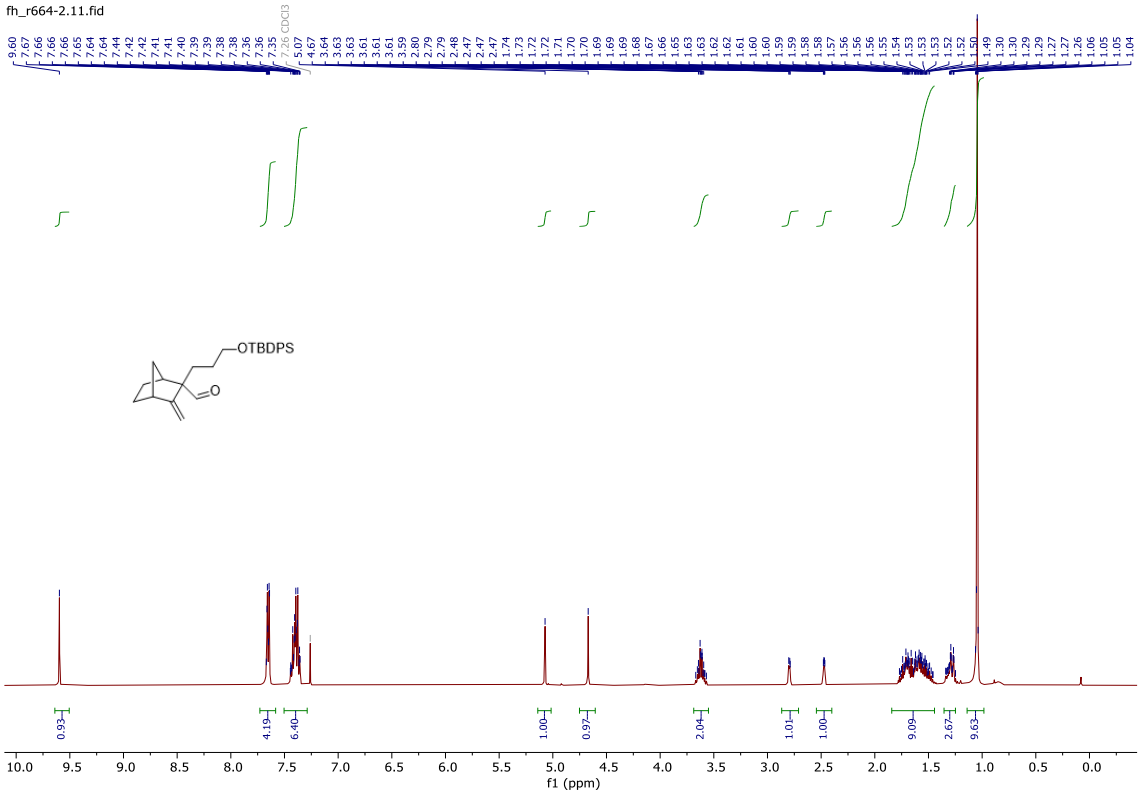


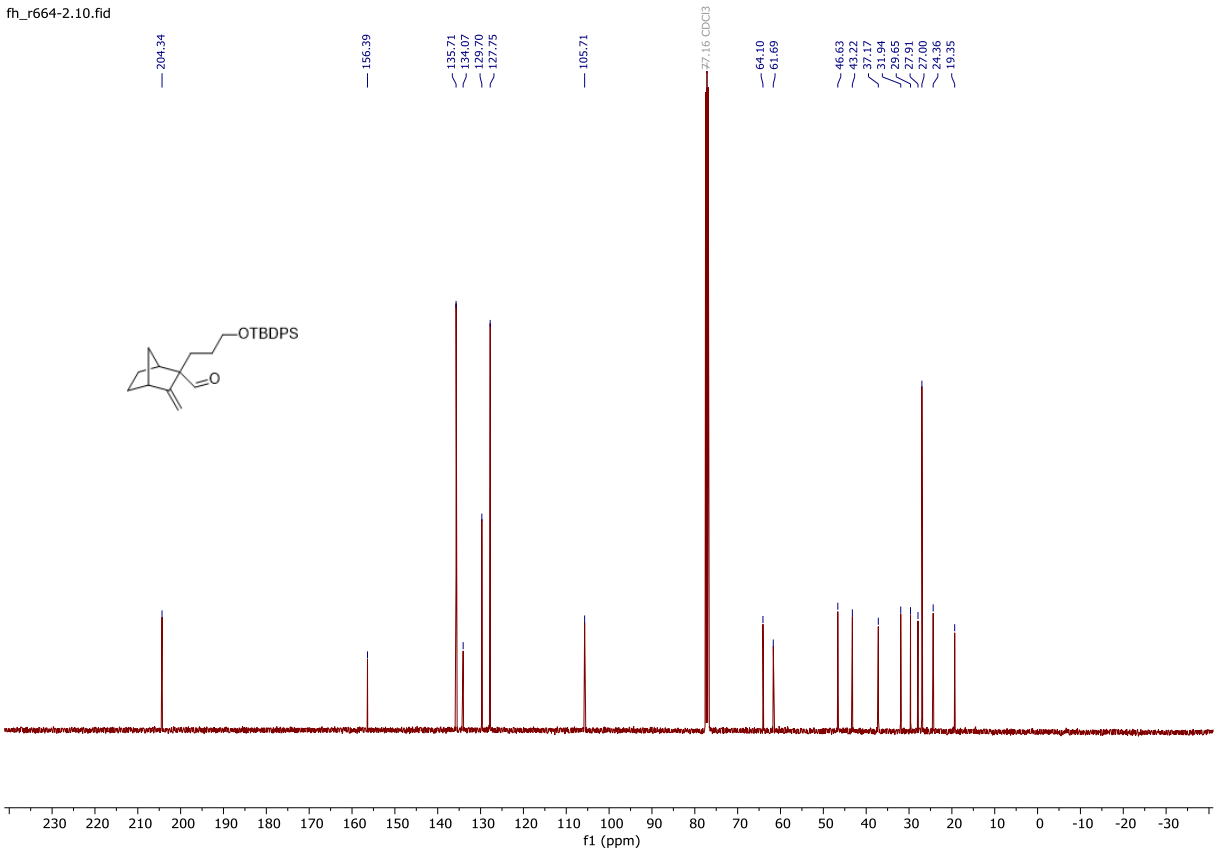
ethyl 2-(3-(tert-butyldiphenylsilyl)oxy)propyl)-3-methylenebicyclo[2.2.1]heptane-2-carboxylate (8)





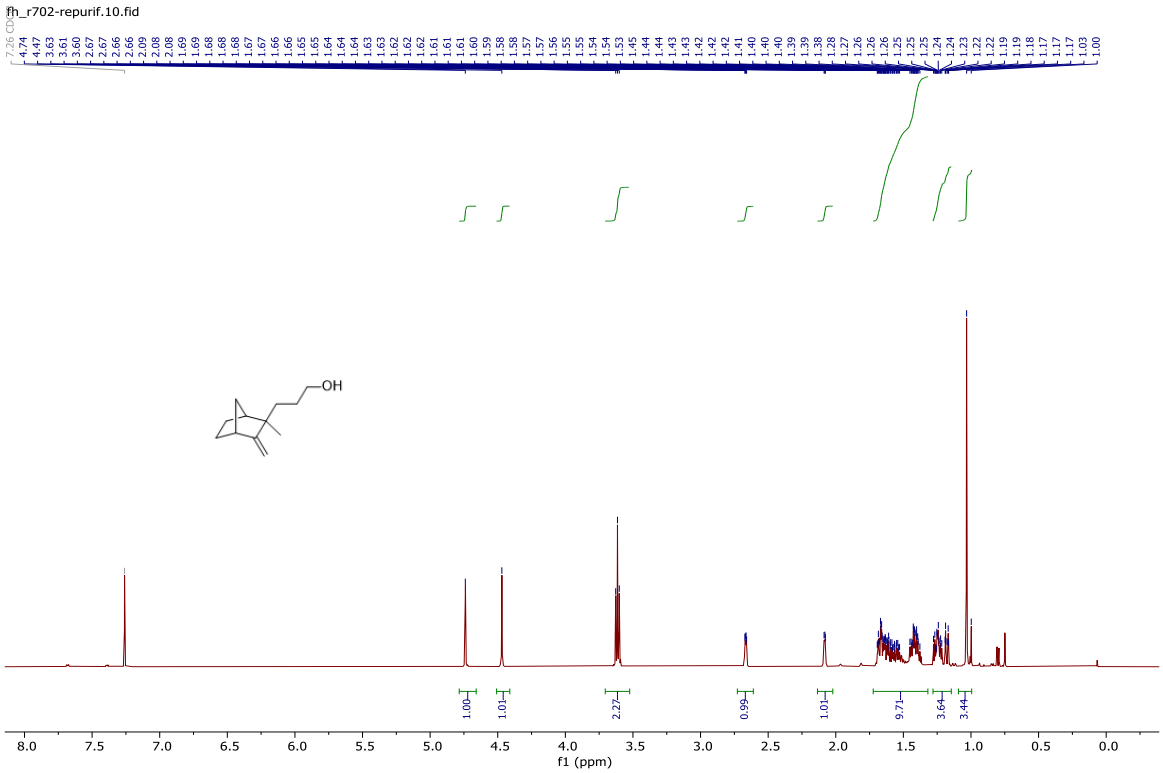
2-(3-((tert-butyldiphenylsilyl)oxy)propyl)-3-methylenebicyclo[2.2.1]heptane-2-carbaldehyde (9)





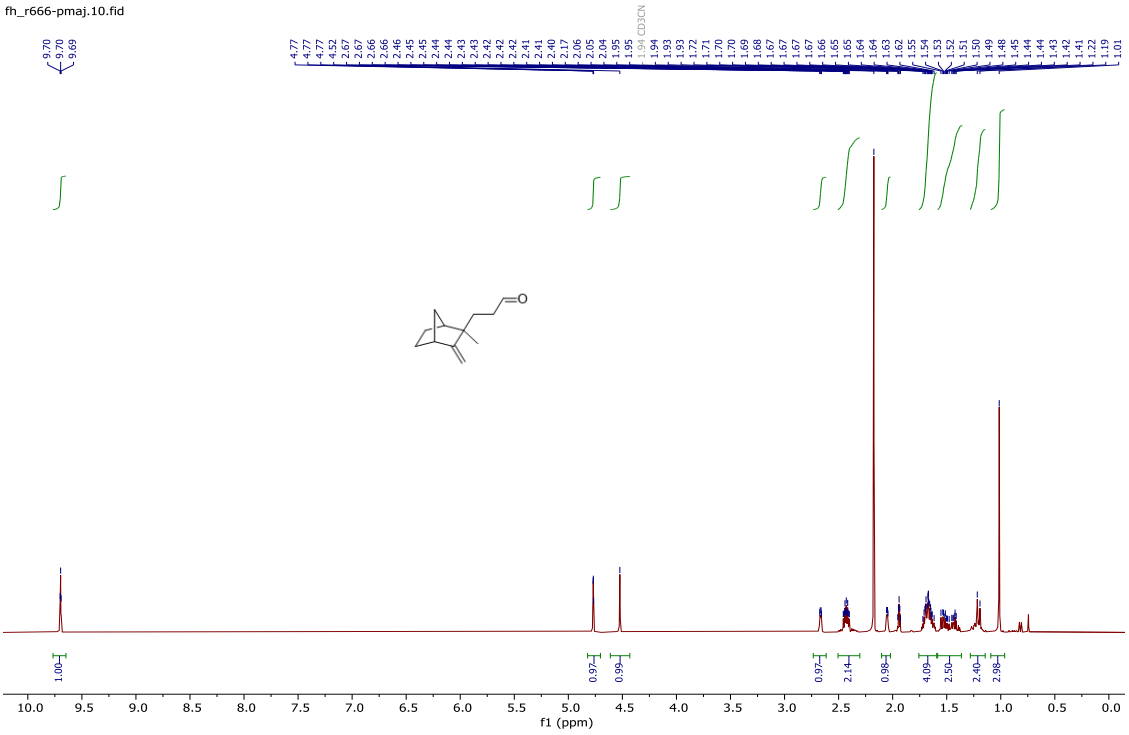
3-(2-methyl-3-methylenebicyclo[2.2.1]heptan-2-yl)propan-1-ol (10)

The NMR data were in accordance with the literature.[28]



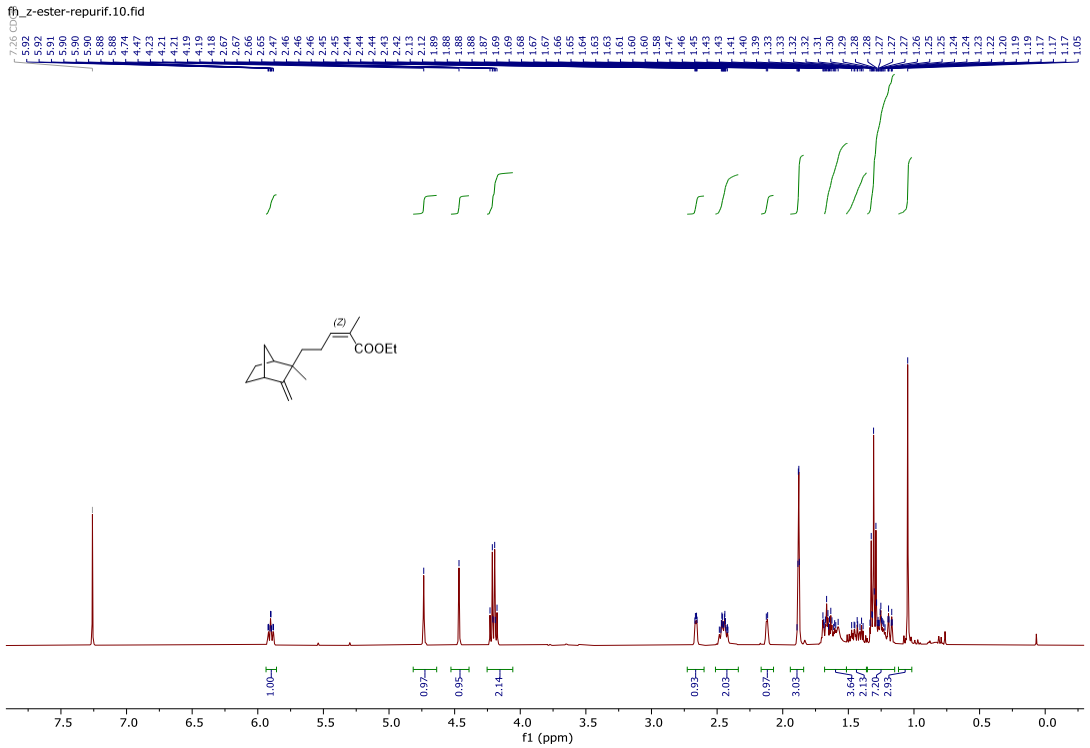
3-(2-methyl-3-methylenebicyclo[2.2.1]heptan-2-yl)propanal (11)

The NMR data were in accordance with the literature.[29]



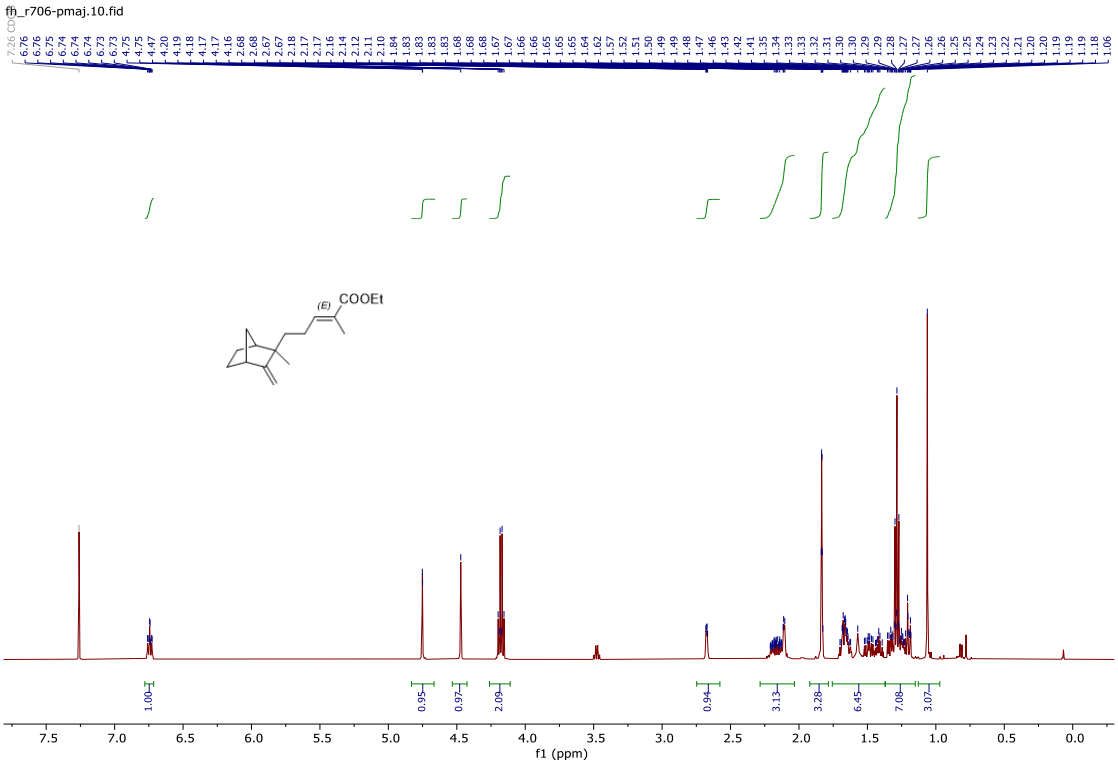
ethyl (*Z*)-2-methyl-5-(2-methyl-3-methylenebicyclo[2.2.1]heptan-2-yl)pent-2-enoate (12)

The NMR data were in accordance with the literature.[31]

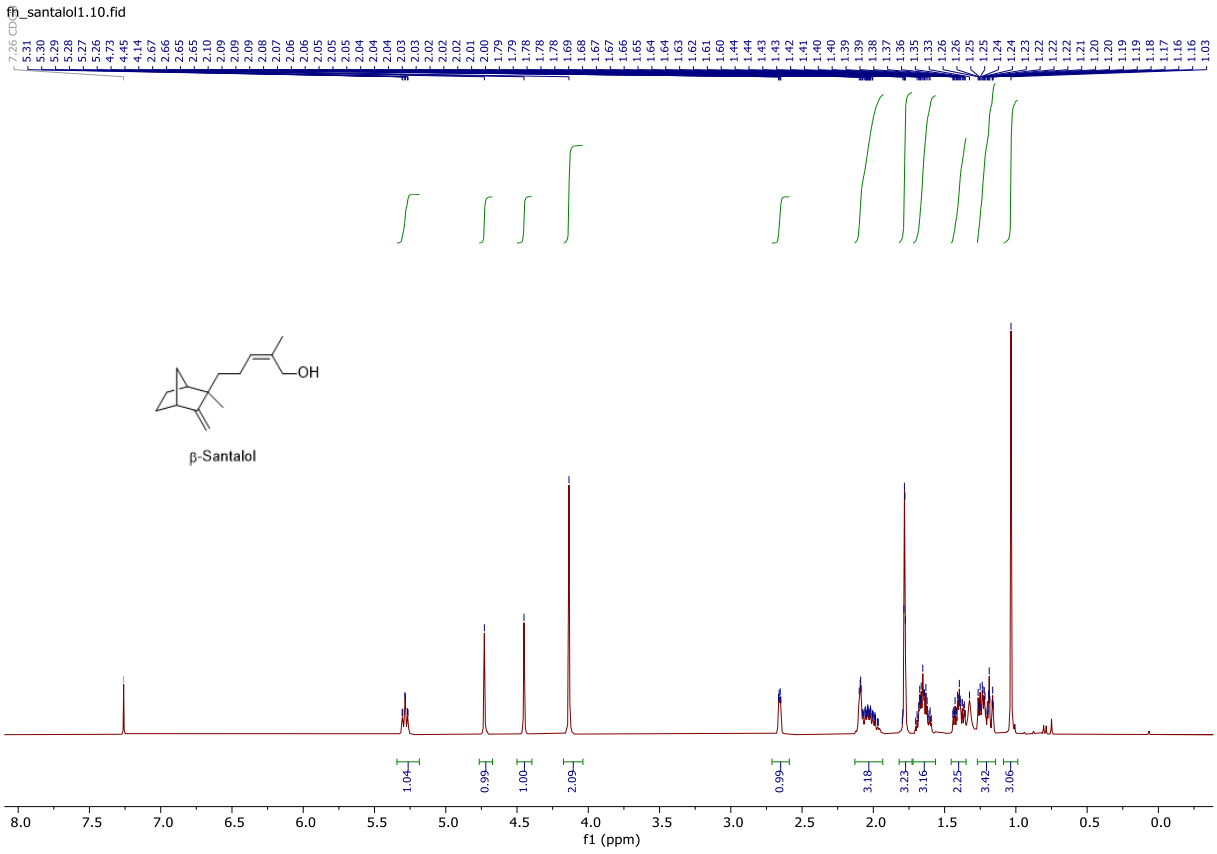


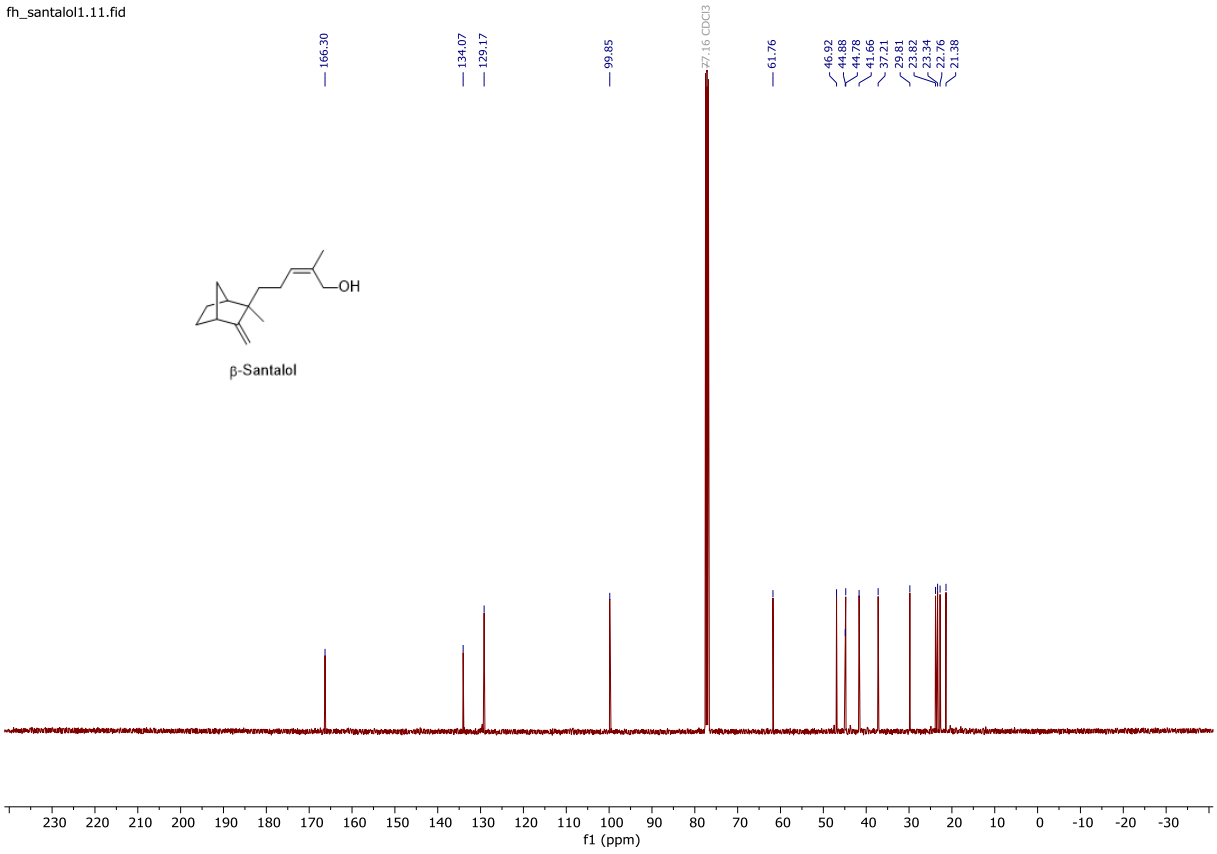
ethyl (*E*)-2-methyl-5-(2-methyl-3-methylenebicyclo[2.2.1]heptan-2-yl)pent-2-enoate (SI-16)

The NMR data were in accordance with the literature.[31]

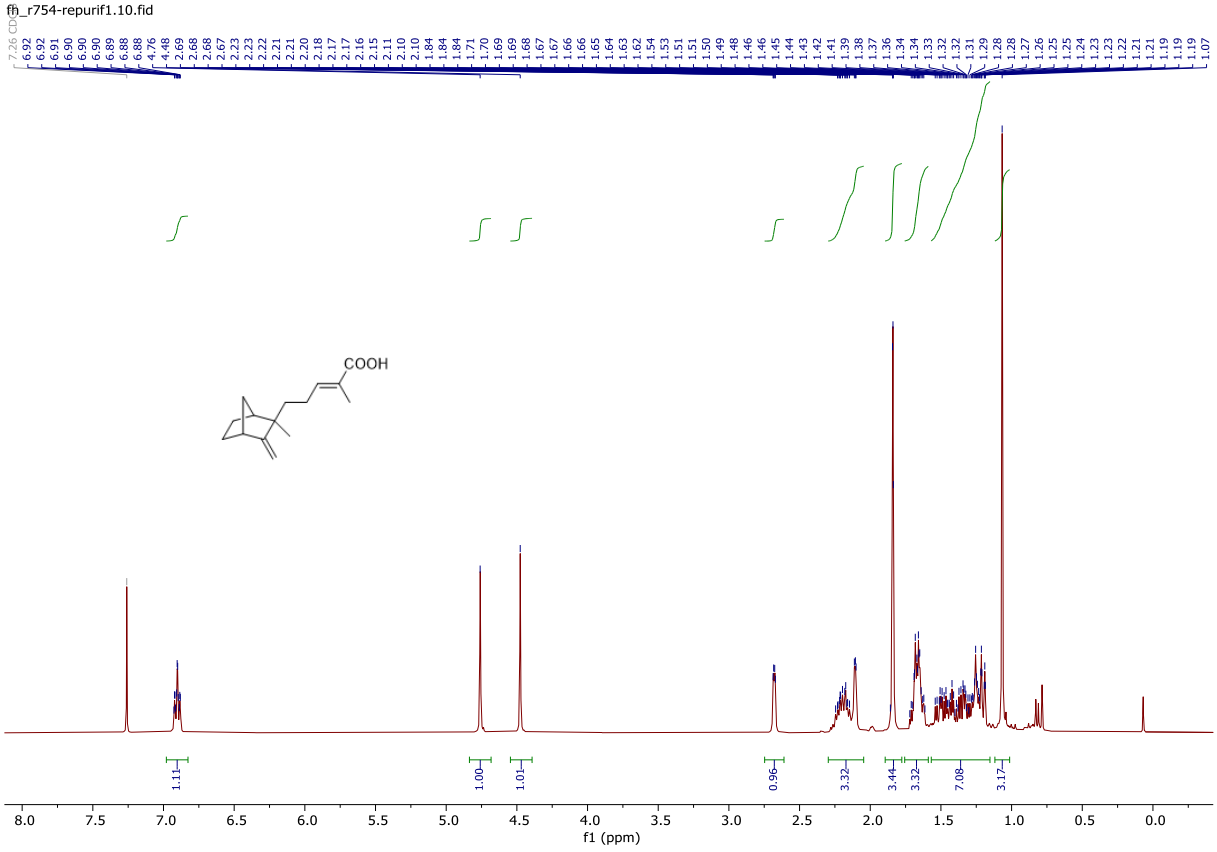


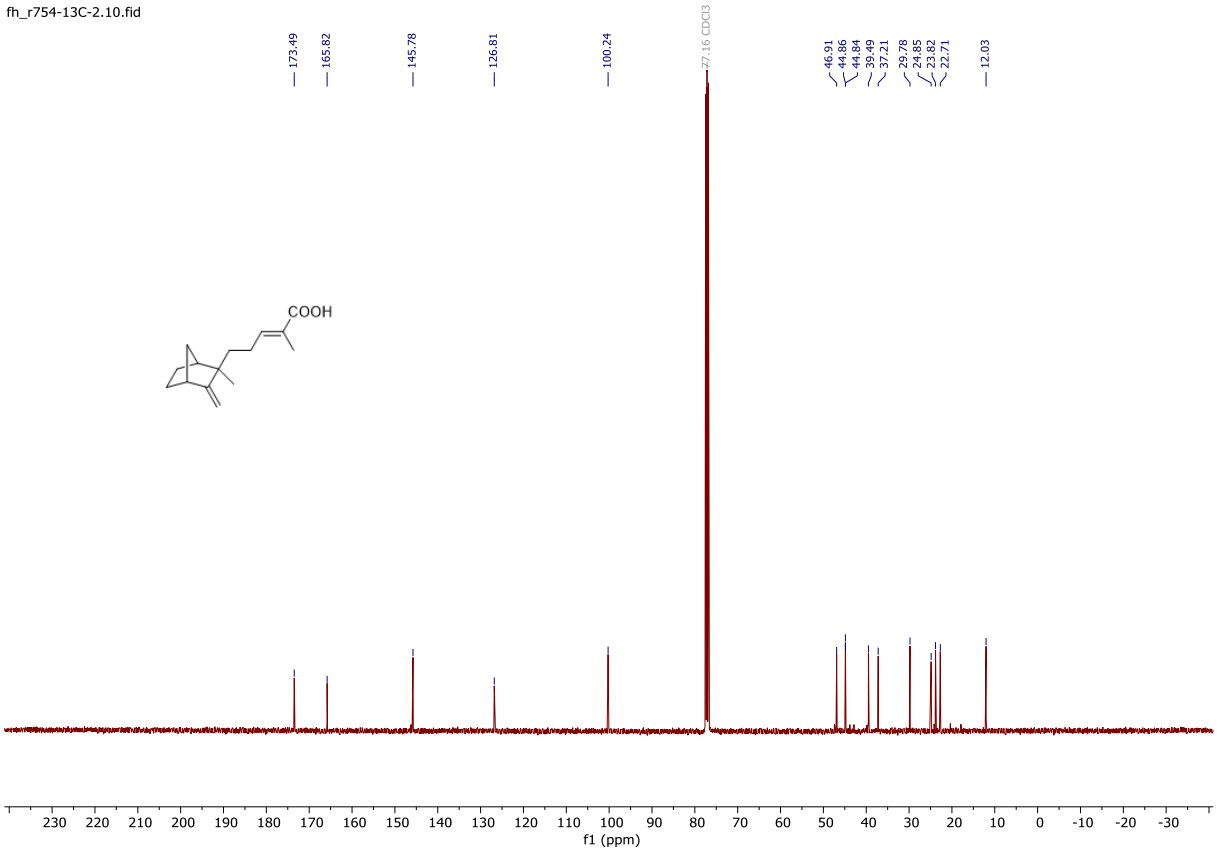
β-santalol (1)


fh_santalol1.10.fid
OH
β-Santalol
1.04
0.99
1.00
2.09
0.99
3.18
3.23
3.16
2.25
3.42
3.06
f1 (ppm)

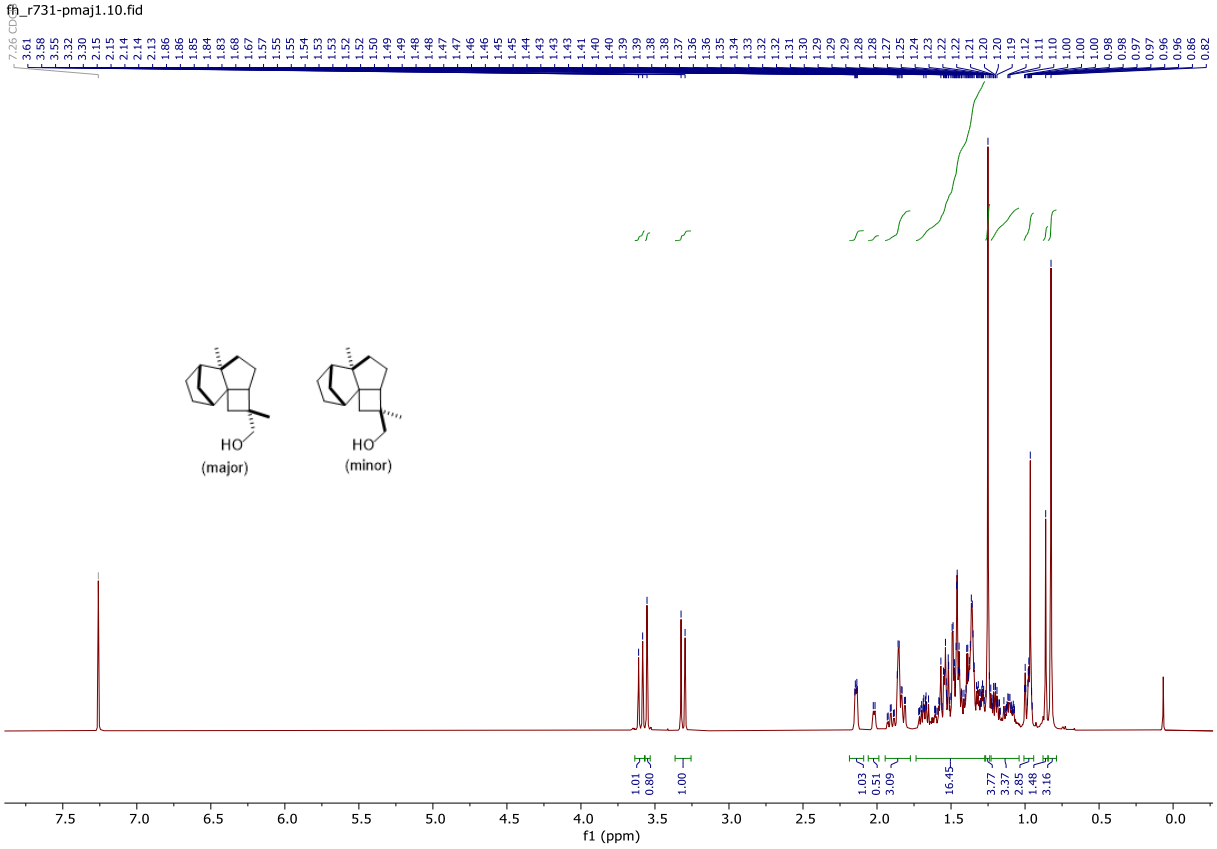

fh_santalol1.11.fid
166.30
134.07
129.17
99.85
77.16 CDCl3
61.76
46.92
44.88
44.78
41.66
37.21
29.81
23.82
23.34
22.76
21.38
OH
β-Santalol
f1 (ppm)

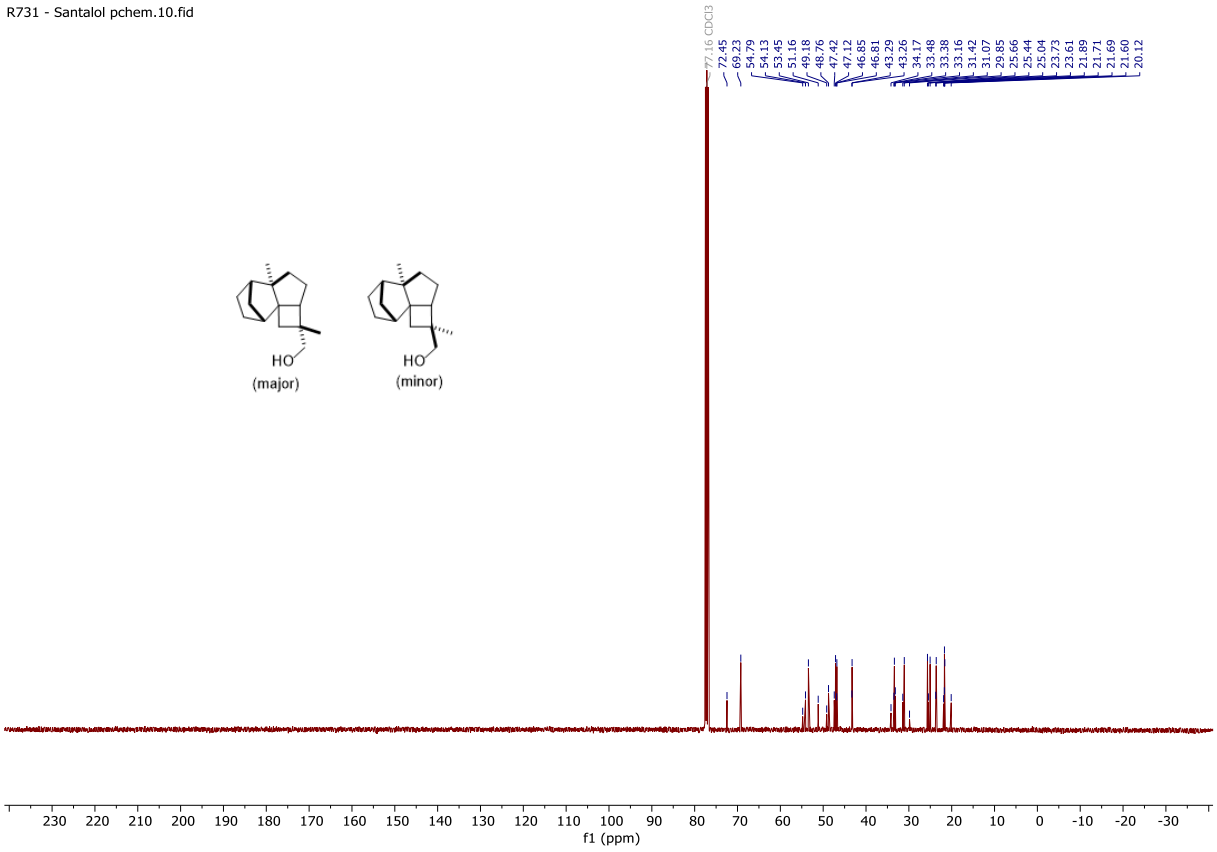
10(*E*)-β-santalic acid (13)





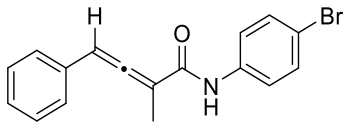
(5,8a-dimethyloctahydro-2H-1,4:4a,6-dimethanonaphthalen-5-yl)methanol (16)



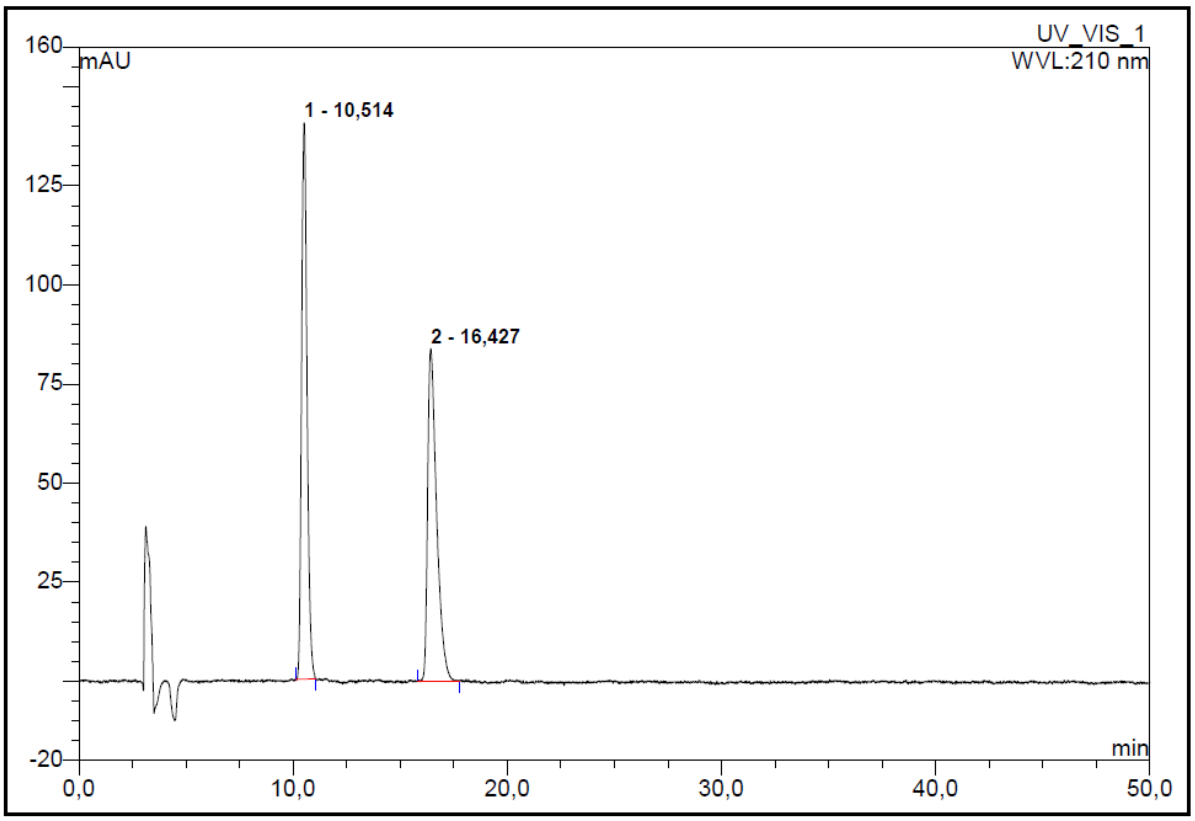


10. HPLC Traces

rac-N-(4-bromophenyl)-2-methyl-4-phenylbuta-2,3-dienamide (*rac*-5n)



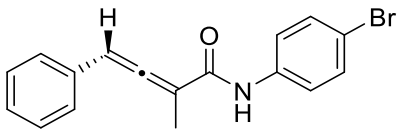
rac-**5n**



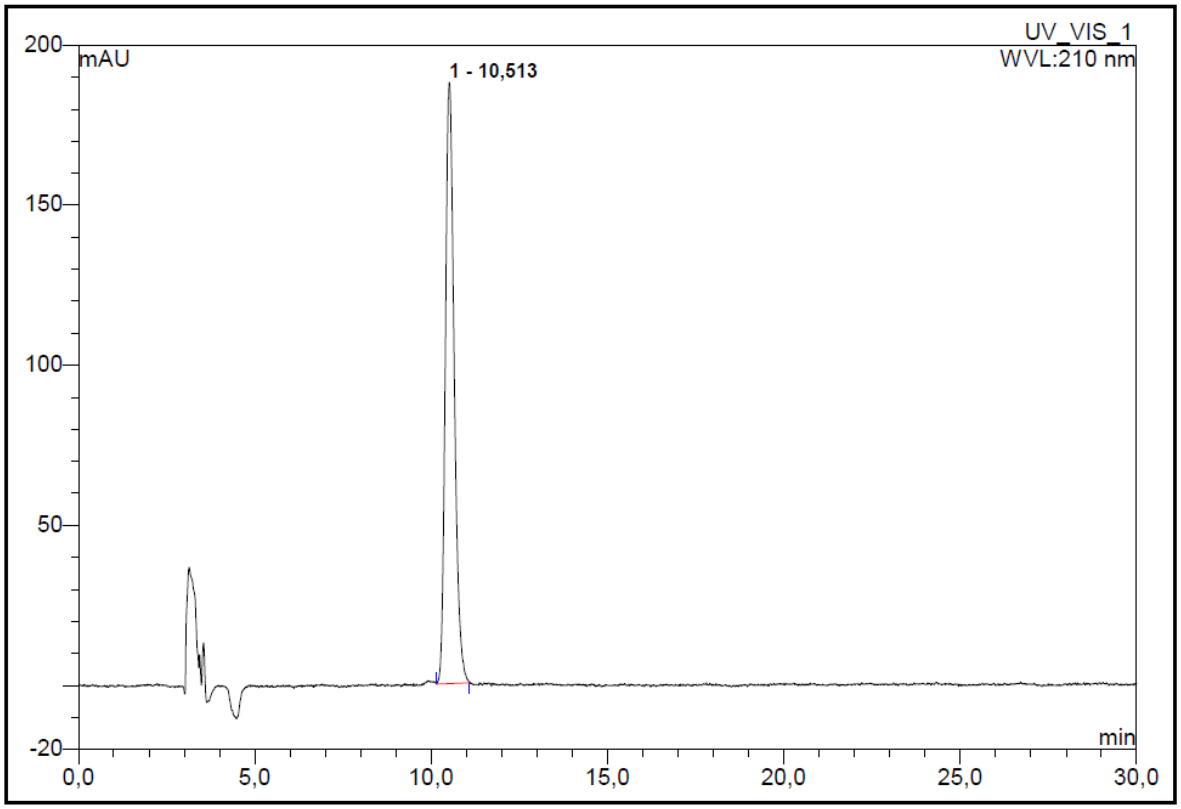
No.	Ret.Time min	Peak Name	Height mAU	Area mAU*min	Rel.Area %	Amount	Type
1	10,51	n.a.	140,418	40,618	49,76	n.a.	BMB*
2	16,43	n.a.	83,921	41,014	50,24	n.a.	BMB*
Total:			224,339	81,632	100,00	0,000	

Chiral HPLC: (AD-H 250 × 4.6 mm, *n*-Hep/*iso*-PrOH = 90/10, 1 ml/min, λ = 210 nm); t_R = 10.51 min (*(R)*-**5n**); t_R = 16.43 min (*(S)*-**5n**)

***(R)*-N-(4-bromophenyl)-2-methyl-4-phenylbuta-2,3-dienamide (*(R)*-5n)** (100% *ee*)



(R)-**5n**

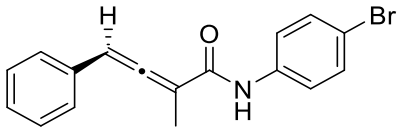


No.	Ret.Time min	Peak Name	Height mAU	Area mAU*min	Rel.Area %	Amount	Type
1	10,51	n.a.	187,726	54,409	100,00	n.a.	BMB
Total:			187,726	54,409	100,00	0,000	

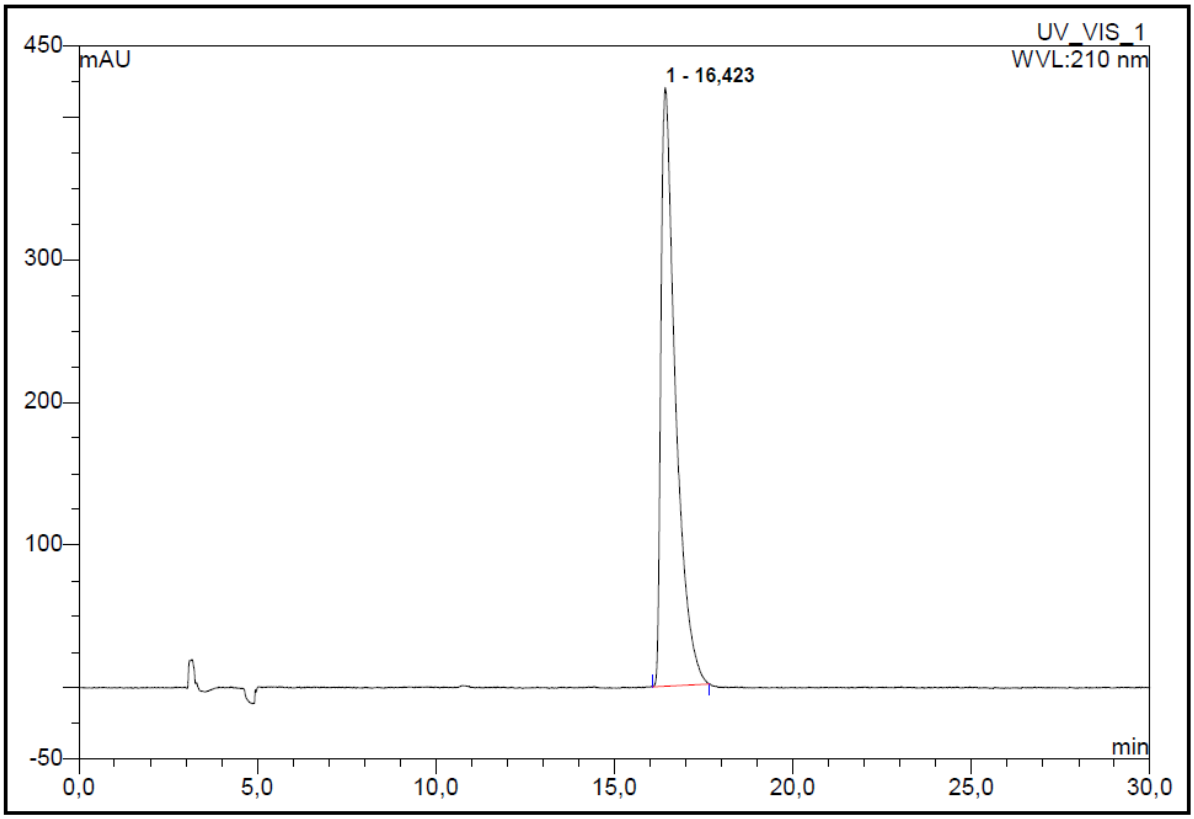
Chiral HPLC: (AD-H 250 × 4.6 mm, *n*-Hep/*iso*-PrOH = 90/10, 1 ml/min, λ = 210 nm)

t_R = 10.51 min (*(R)*-**5n**)

***(S)*-N-(4-bromophenyl)-2-methyl-4-phenylbuta-2,3-dienamide (*(S)*-5n)** (100% *ee*)



(S)-**5n**

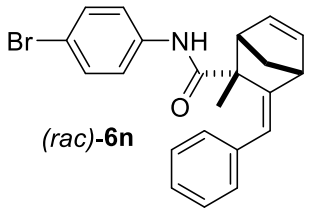


No.	Ret.Time min	Peak Name	Height mAU	Area mAU*min	Rel.Area %	Amount	Type
1	16,42	n.a.	419,380	198,868	100,00	n.a.	BMB
Total:			419,380	198,868	100,00	0,000	

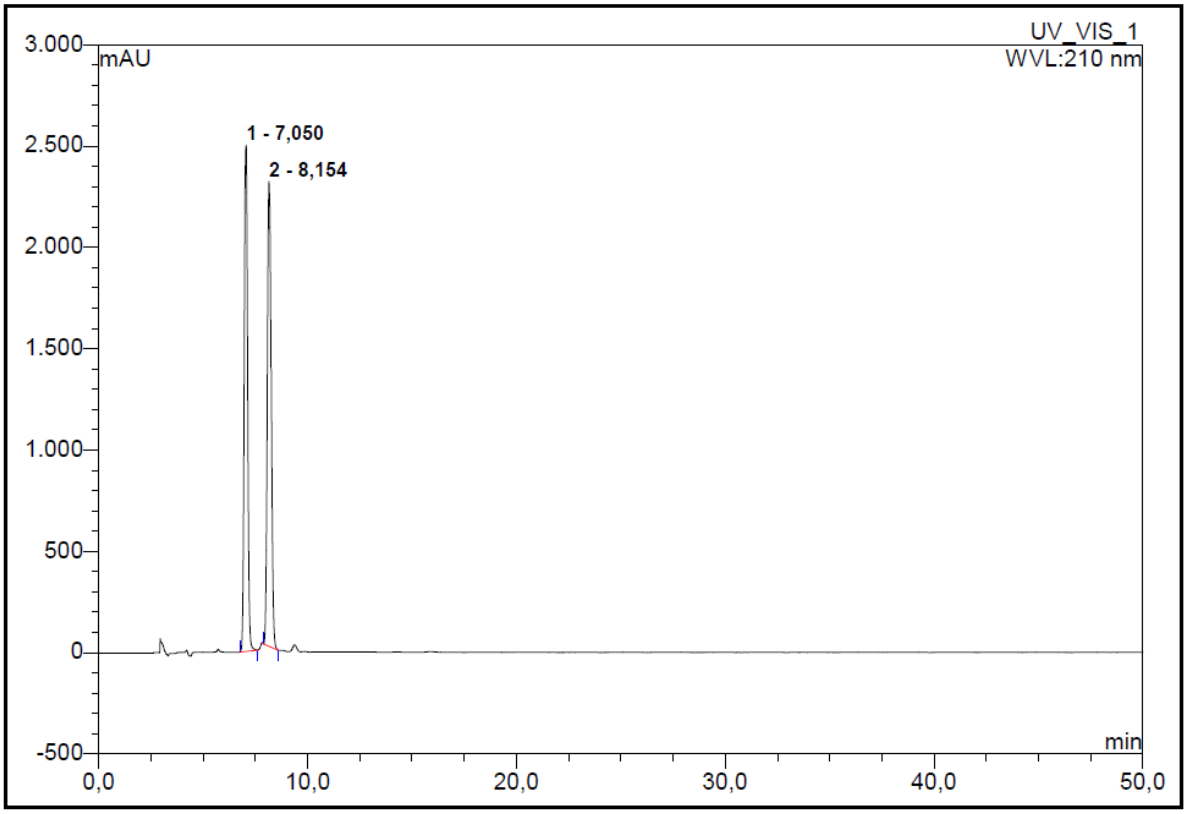
Chiral HPLC: (AD-H 250 × 4.6 mm, *n*-Hep/*iso*-PrOH = 90/10, 1 ml/min, λ = 210 nm)

t_R = 16.42 min (*(S)*-**5n**)

(*rac*)-3-((*Z*)-benzylidene)-N-(4-bromophenyl)-2-methylbicyclo[2.2.1]hept-5-ene-2-carbox-amide (*rac*-6n)



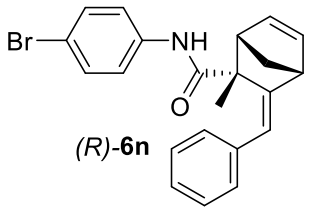
(rac)-**6n**



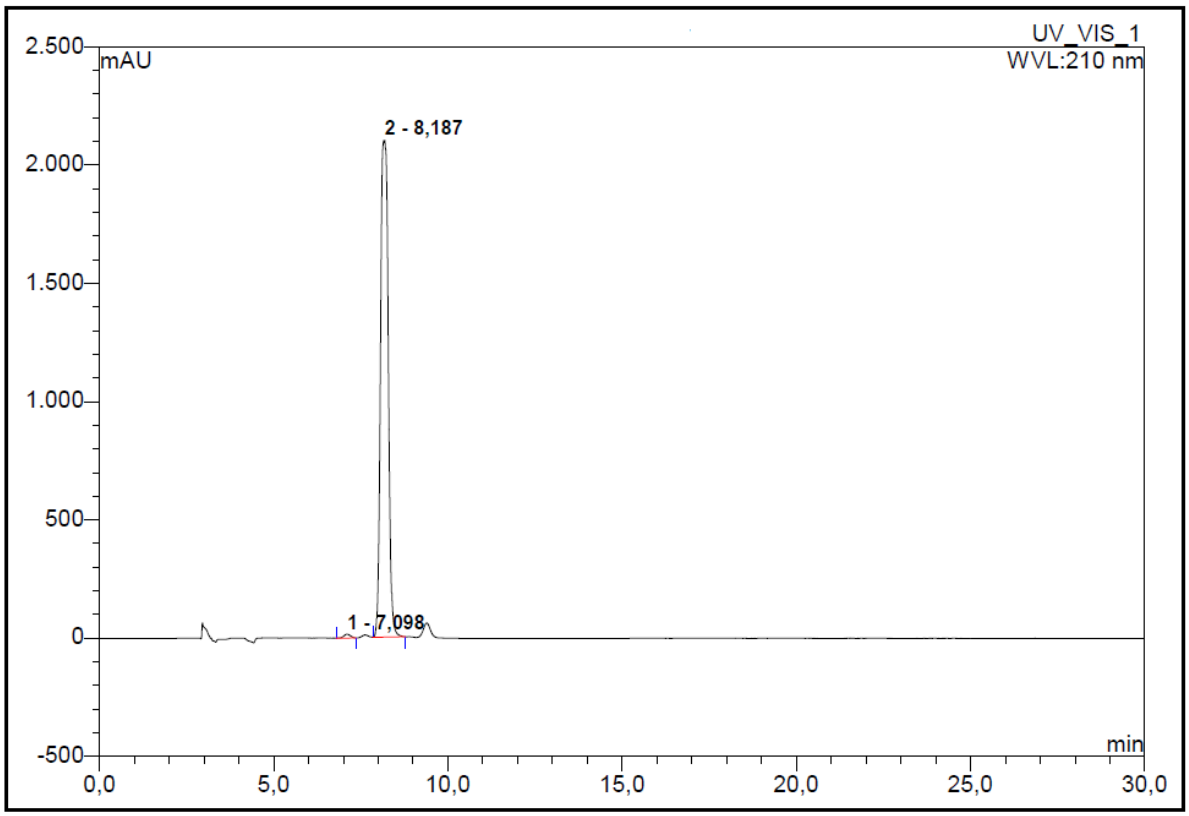
No.	Ret.Time min	Peak Name	Height mAU	Area mAU*min	Rel.Area %	Amount	Type
1	7,05	n.a.	2498,404	483,528	49,53	n.a.	BMB
2	8,15	n.a.	2294,683	492,743	50,47	n.a.	BMB
Total:			4793,087	976,270	100,00	0,000	

Chiral HPLC: (IA 250 × 4.6 mm, *n*-Hep/*iso*-PrOH = 90/10, 1 ml/min, λ = 210 nm); t_R = 7.05 min (*(S)*-**6n**); t_R = 8.15 min (*(R)*-**6n**)

(*1S,2R,4R*)-3-((*Z*)-benzylidene)-N-(4-bromophenyl)-2-methylbicyclo[2.2.1]hept-5-ene-2-carbox-amide (*(R)*-6n) (99% *ee*)



(R)-**6n**



No.	Ret.Time min	Peak Name	Height mAU	Area mAU*min	Rel.Area %	Amount	Type
1	7,10	n.a.	15,325	3,451	0,63	n.a.	BMB*
2	8,19	n.a.	2099,823	547,164	99,37	n.a.	BMB
Total:			2115,148	550,615	100,00	0,000	

Chiral HPLC: 99% *ee* (IA 250 × 4.6 mm, *n*-Hep/*iso*-PrOH = 90/10, 1 ml/min, λ = 210 nm); t_R = 7.10 min (minor, *(S)*-**6n**); t_R = 8.19 min (major, *(R)*-**6n**)

11. References

1 *APEX suite of crystallographic software*, APEX4 Version 2021-10-0, Bruker AXS Inc., Madison, Wisconsin, USA, 2021.

2 *SAINT*, Version 8.40A and SADABS, Version 2016/2, Bruker AXS Inc., Madison, Wisconsin, USA, 2016/2019.

3 a) C. B. Hübschle, G. M. Sheldrick and B. Dittrich, *J. Appl. Cryst.*, 2011, **44**, 1281; b) G. M. Sheldrick, *Acta Crystallogr. Sect. C*, 2015, **71**, 3.

4 G. M. Sheldrick, *Acta Crystallogr. Sect. A*, 2015, **71**, 3.

5 *International Tables for Crystallography, Vol. C* (Ed.: A. J. Wilson), Kluwer Academic Publishers, Dordrecht, The Netherlands, 1992, Tables 6.1.1.4 (pp. 500–502), 4.2.6.8 (pp. 219–222), and 4.2.4.2 (pp. 193–199).

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