Effect of tether length on endo/exo stereoselectivity in alkene–arene meta-photocycloaddition reactions towards the Aphidocolin/Stemodin scaffolds

Article

Supplemental Material

SI with experimental procedures and spectra

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SUPPLEMENTARY INFORMATION

Effect of Tether Length on *endo*/*exo* Stereoselectivity in Alkene–Arene *meta*-Photocycloaddition Reactions towards the Aphidocolin/Stemodin Scaffolds

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Table of Contents

EXPERIMENTAL

Materials Used

All chemicals and solvents were supplied by Sigma-Aldrich (Merck), Avocado, Acros, Fluka, Lancaster Synthesis, VWR or Fluorochem. The solvents used in anhydrous reactions were distilled before use in the following manners: tetrahydrofuran (THF) and diethyl ether (sodium/benzophenone); dichloromethane and toluene (calcium hydride); methanol (magnesium methoxide); 1,3-dimethyl-3,4,5,6-tetrahydro-2-(1*H*)pyrimidone and acetone (calcium sulphate/magnesium sulphate). An MBRAUN SPS 7 solvent purifier was also used to dry THF.

The following reagents were dried by distillation from the drying agent calcium hydride; chlorotrimethylsilane, di*iso*propylamine, and 2,6-lutidine.

The moisture/air sensitive reagents 9-borabicyclo[3.3.1]nonane, boron trifluoride diethyl etherate, *n*-butyllithium, lithium-tri-*sec*-butylborohydride, methyllithium, methyl magnesium bromide and phosphorous tribromide were purchased in sureseal® bottles and kept under an inert atmosphere in a refrigerator.

Finally, magnesium turnings were activated by stirring vigorously under argon overnight,[1] and allyl iodide was purified by filtration through a short plug of alumina.

Separation techniques

Thin Layer Chromatography

All thin layer chromatography was carried out on Merck silica gel 60 F_{254} aluminium backed plates. The plates were visualised by the quenching of Ultra Violet fluorescence (λ_{max}= 254 nm) and then permanent staining by iodine on silica and solutions of vanillin, potassium permanganate or phosphomolybdic acid.

Flash Column Chromatography

Silica gel (particle size 40-63 μm) was used for all flash column chromatography.

Analytical techniques

Ultra-Violet/Visible Spectroscopy

All UV/VIS spectra were recorded between 190 and 300 nm wavelength on a Kontron Uvikon 860 Spectrophotometer or a Perkin Elmer Lambda 25 UV/VIS Spectrometer using two-way quartz cuvettes with a 1 cm path length.

Fluorescence Spectrophotometry

A Shimadzu Spectrofluorophotometer RF-540 and a a Varian Eclipse Fluorescence Spectrophotometer were used to record all fluorescence quenching data using four-way quartz cells with a 1 cm path length.

Infrared Spectroscopy

A Perkin Elmer 1720-X Infrared Fourier Transform Spectrometer or a Perkin Elmer Paragon 1000 FT-IR Spectrometer were used to record all IR spectra of samples either as a thin film or in a KBr disk.

Nuclear Magnetic Resonance Spectroscopy

Unless stated otherwise, all ^{1}H and ^{13}C NMR spectra were recorded at either 250 MHz and 63 MHz respectively using a Bruker DPX250 spectrometer or at 400 MHz and 100 MHz respectively on Bruker AMX400, Bruker DPX-400 or Bruker Nanobay spectrometers. All COSY, DEPT, C-H correlation, nOeSY and nOe irradiation techniques were carried out on Bruker AMX400, Bruker DPX-400 or Bruker Nanobay spectrometers. Deuterated chloroform ($CDCl_3$), deuterated benzene (C_6D_6), dimethylsulphoxide-d$_6$ (DMSO-D$_6$) and methanol-d$_4$ (CD_3OD) were all used as solvents. Chemical shifts (δ values) were reported in parts per million (ppm) and referenced to the residual solvent peak or tetramethylsilane. All coupling constants (*J*) were quoted in hertz.

Mass Spectrometry

Low resolution and Accurate mass data was recorded on a V.G. Micromass 70-70F machine under chemical ionisation (CI) or under electrospray conditions on a Thermo Scientific LTQ Orbitrap XL instrument.

Melting Points

A Gallenkamp melting point detector was used to record all melting points. All values were rounded to the nearest whole degree centigrade and are uncorrected.

Finally, concentrated *in vacuo* refers to the evaporation of solvents under water aspirator vacuum on a Buchi or IKA Rotavapor at 30-40 °C.

Experimental Description for Single Crystal X-ray

Colourless plate-shaped crystals were mounted on a thin glass fibre using silicon grease and cooled on the diffractometer to 100 K using an Oxford Cryostream cooler. A total of 80 and 287 oscillation frames of 10 and 7.5 s exposure time with 2° rotation in ϕ were recorded using a Nonius $^{\mathrm{Kappa}}$CCD diffractometer, with a detector to crystal distance of 30 mm. The crystal was indexed from ten preliminary frames using the Collect + DENZO package and positional data were refined along with diffractometer constants to give the final unit cell parameters. Integration and scaling of the whole dataset resulted in complete data to $2\theta \leq 55°$ (Mo-K_α radiation, $\lambda = 0.71073$ Å) which were corrected for Lorentz and polarisation effects and for absorption and were used in subsequent refinement. The structures were solved using direct methods and developed *via* alternating least squares cycles and difference Fourier synthesis with the aid of the Maxus package. All non-hydrogen atoms were modelled anisotropically. For CCDC-246802 (ketone of **16**) all hydrogen atom parameters were allowed to refine freely because of the strained nature of portions of the molecule. This resulted in an excellent model for H atom positions, clearly showing CH…O interactions. Compound CCDC-246802 (ketone of **16**) has two unique molecules in the asymmetric unit, which are not significantly chemically different, but appear to be diastereomeric. The configuration shown in the diagrams is the most likely.

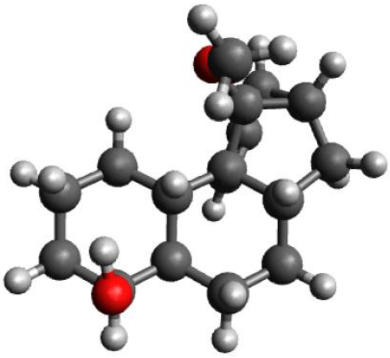
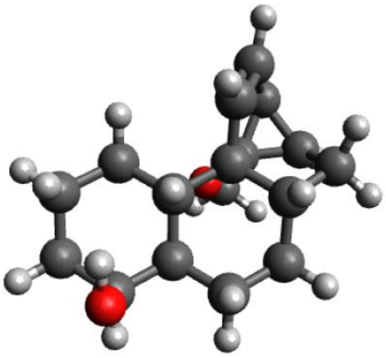
Crystal data for ketone **17 CCDC-246801**: $C_{16}H_{20}O_2$, $M = 244.32$, colourless block, 0.60 × 0.30 × 0.20 mm^3, monoclinic, space group $P2_1/n$ (No. 14), $a = 10.0994(3)$, $b = 9.8419(4)$, $c = 13.8692(4)$ Å, $\beta = 108.588(2)°$, $V = 1306.65(8)$ Å^3, $Z = 4$, $D_c = 1.242$ g/cm^3, $F_{000} = 528$, KappaCCD, MoKα radiation, $\lambda = 0.71070$ Å, $T = 100(2)$K, $2\theta_{\max} = 55.0$º, 9726 reflections collected, 3004 unique ($R_{int} = 0.0432$). Final $GooF = 1.030$, $R1 = 0.0427$, $wR2 = 0.1063$, R indices based on 2500 reflections with I >2sigma(I) (refinement on F^2), 165 parameters, 0 restraints. Lp and absorption corrections applied, $\mu = 0.080$ mm^{-1}.

Crystal data for **ketone of 16 CCDC-246802**: $C_{32}H_{40}O_4$, $M = 488.64$, colourless plate, 0.30 × 0.10 × 0.10 mm^3, triclinic, space group P-1 (No. 2), $a = 9.7193(4)$, $b = 11.0209(5)$, $c = 12.6844(7)$ Å, $\alpha = 96.475(3)$, $\beta = 92.135(3)$, $\gamma = 102.443(3)°$, $V = 1315.66(11)$ Å^3, $Z = 2$, $D_c = 1.233$ g/cm^3, $F_{000} = 528$, KappaCCD, MoKα radiation, $\lambda = 0.71070$ Å, $T = 100(2)$K, $2\theta_{\max} = 55.0$º, 10806 reflections collected, 6012 unique ($R_{int} = 0.0617$). Final $GooF = 1.026$, $R1 = 0.0577$, $wR2 = 0.1188$, R indices based on 3620 reflections with I >2sigma(I) (refinement on F^2), 486 parameters, 0 restraints. Lp and absorption corrections applied, $\mu = 0.079$ mm^{-1}.

Crystal data for **20 CCDC-246803**: $C_{17}H_{22}O_2$, M = 258.35, colourless prism, 0.80 × 0.60 × 0.60 mm^3, monoclinic, space group $P2_1/c$ (No. 14), a = 14.0686(3), b = 7.5569(2), c = 12.8458(6) Å, β = 102.310(2)°, V = 1334.30(8) Å^3, Z = 4, D_c = 1.286 g/cm^3, F_{000} = 560, Nonis KappaCCD CCD diffractometer, MoKα radiation, λ = 0.71070 Å, T = 100(2)K, $2\theta_{max}$ = 55.0º, 9005 reflections collected, 3053 unique (R_{int} = 0.0372). Final $GooF$ = 1.030, $R1$ = 0.0389, $wR2$ = 0.0978, R indices based on 2681 reflections with I >2sigma(I) (refinement on F^2), 174 parameters, 0 restraints. Lp and absorption corrections applied, μ = 0.082 mm^{-1}.

Calculations of Lowest Energy Isomer of 4-Unit Tether: *endo* (**18**) versus *exo* (**19**)

All calculations were performed using the conformer-rotamer ensemble sampling tool (CREST),[2] and the ORCA 5.0.3 electronic structure program.[3] Cartesian coordinates for all complexes were built using Avogadro.[4] Conformational sampling was performed at the extended tight-binding level GFN2-xTB.[5] GBSA implicit solvation[6] for toluene was applied during conformational sampling. The lowest energy conformers were refined further at the DFT level using ORCA 5.0.3. Geometry optimisations were performed with tight convergence without symmetry constraints using the B3LYP/G hybrid functional,[7,8] with a def2-TZVPP basis set,[9] and def2/J auxiliary basis set.[10] The RIJCOSX approximation was implemented to speed up optimisations.[11] Dispersion effects were taken into account using the atom-pairwise dispersion correction with the Becke-Jonson damping scheme.[12,13] The solvent environment was modelled using the Conductor-like Polarisable Continuum Model (CPCM),[14] *via* the PCM implicit solvent model for toluene. Frequency calculations were taken on the optimised geometries to identify if the molecule is in a true energy minima. Avogadro was used as an aid in the quantitative analysis of ORCA output files and the visualisation of molecular orbitals (isosurface: 0.03).

Endo **lowest energy conformer (18)**	***Exo*** **lowest energy conformer (19)**
	

ΔE(B3LYP/G) = Single point calculation energy/Electronic energy. The more negative, the more stable the configuration.

Hence, *endo* structure (18) is more stable, wrt *exo* (19).

Compounds	E_{HOMO} / eV	E_{LUMO} / eV	E_{gap} / eV	E(B3LYP/G) / Eh	E(B3LYP/G) / kJ/mol	E_G / Eh	E_G / kJ/mol	ΔE(B3LYP) / kJ/mol	ΔG / kJ/mol
Endo (18)	−6.34	−0.02	6.32	−813.054496023433	−2134674.579	−812.7143418	**−2133781.504**	4.07 Endo favoured	2.78
Exo (19)	−6.12	0.04	6.16	−813.052943961402	−2134670.504	−812.7132841	−2133778.727		

E_G = Final Gibbs free energy (from thermodynamics calculation).

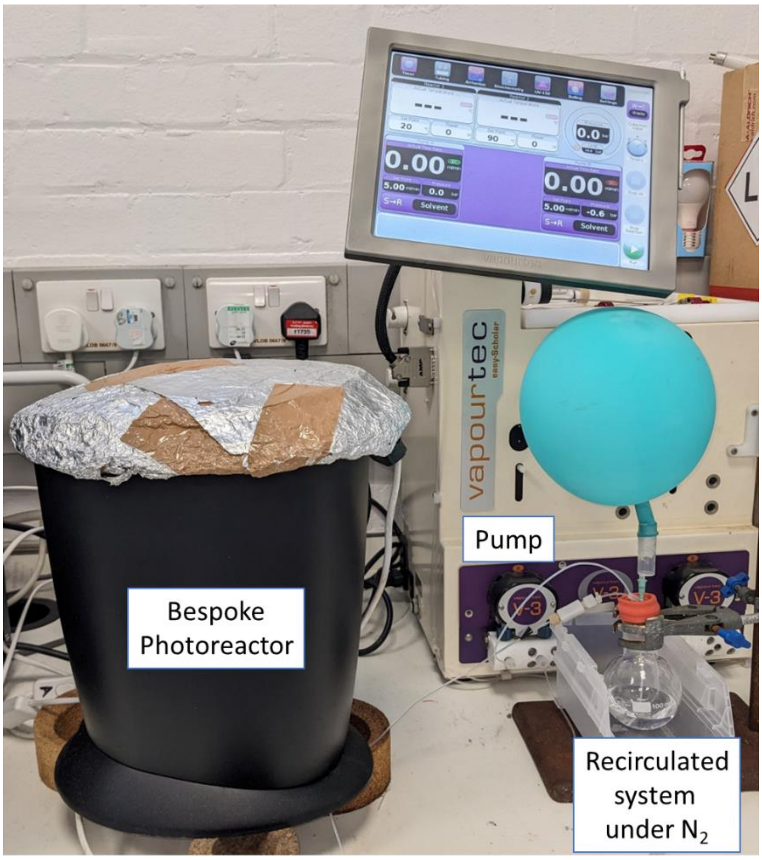
Photochemical Apparatus

Falling film photochemical reactions

Falling film photochemical reactions were carried out using a Photochemical Reactors Ltd. Thin Film Photochemical Reactor containing a low-pressure mercury arc lamp. This apparatus has the advantage of subjecting the reactants to high light exposure, as a thin film of reaction solution is kept constantly flowing over the lamp. The low-pressure mercury arc lamp was employed as it emits over 90% of its Ultra Violet light at a wavelength of 254 nm, which is sufficient to excite benzenoid arenes to their first excited state without producing many reaction by-products that can form as a result of emissions at lower wavelengths.

Continuous Flow Photochemical Reactions

Continuous flow photochemical reactions were performed using a bespoke flow photochemical system. The flask was connected to the flow system by threading the input tube through a red rubber septa and the output into the collection flask. The flow system using consists of a Vapourtec E-Scholar peristaltic pump, and a 10 mL or 3 mL FEP (1/16” o.d., 0.5 mm i.d.) reactor placed around a 25 W germicide lamp inside a light box with a gentle flow of compressed air for cooling (not essential). The reaction mixture was degassed by bubbling N_2 for 20 minutes and then a balloon was used to keep the flask under a positive pressure of N_2. The reaction mixture was then pumped at the requisite flow rate for the desired residence time.



Initial optimisation was performed by using the reactor in recirculatory mode. The **Actual Time Of Irradiation (ATOI) ratio** for the reaction was calculated as below in equation (1). The **Actual Time Of Irradiation (ATOI) / Residence Time** by multiplying the ATOI ratio by the time required to reach a satisfactory result, equation (2).

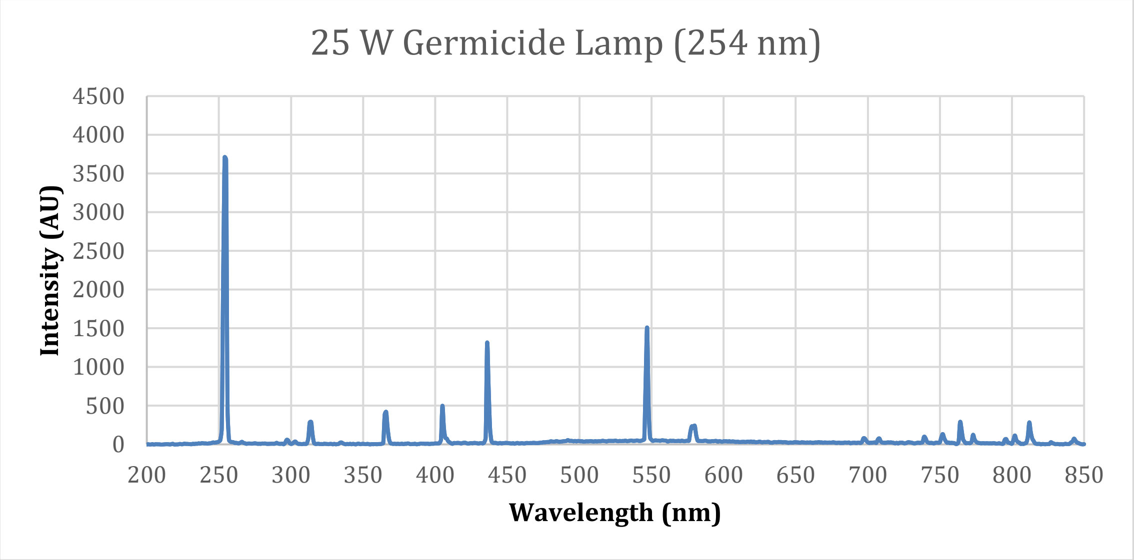
This **ATOI** is thus the residence time required in continuous mode.

$$(1)\ ATOI\ ratio = \frac{Reactor\ Vol}{Reactor\ Vol{+}Vol\ solvent\ in\ flask} = \frac{Reactor\ Vol}{Total\ Solvent\ Vol}$$

$$(2)\ ATOI = Residence\ Time\ (continous\ flow) = Recirculatory\ Time \times ATOI\ ratio$$

Emission Spectra of the 25 W Germicidal Lamp

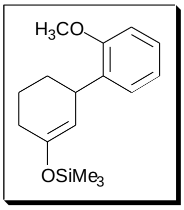
The emission spectrum from the 25 W germicidal lamp was measured using an Ocean Optics Red Tide USB650 fibre optic spectrometer.



CHARACTERISATION

Synthesis of the 3-carbon tether substrate (**7**)

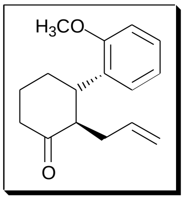
a. [3-(2’-Methoxyphenyl)cyclohex-1-enyloxy]trimethylsilane (**10**)[15]



To a vigorously stirred suspension of activated magnesium turnings (1.550g, 63.80mmol) in anhydrous THF (10ml) was added 2-bromoanisole (93) (2.50ml, 20.10mmol) under nitrogen. Once the initial reaction had subsided, a solution of 2-bromoanisole (4.90ml, 39.30mmol) in dry THF (15ml) was added to the reaction mixture drop-wise over a period of 10 minutes. TLC indicated completion of the reaction after 1.5 hours. The reaction mixture was then added *via* syringe to a solution of copper cyanide (0.200g, 2.20mmol) and DMPU (12.05ml, 99.60mmol) in THF (10ml) under nitrogen at -78°C. After 10 minutes, a solution of 2-cyclohexen-1-one (4.800g, 50.00mmol) and chlorotrimethylsilane (12.55ml, 98.90mmol) in THF (15ml) was added drop-wise to the reaction mixture. TLC indicated completion after 3 hours so triethylamine (15ml) and hexane (150ml) was added to the reaction mixture. The organics were separated from the precipitated solids then washed with water (2x150ml) before being dried over $MgSO_4$, filtered and concentrated *in vacuo* to give a crude yellow oil. The crude product was purified using flash column chromatography (95:5 petroleum ether [40-60]/ ethyl acetate) to afford the pure oil *[3-(2’-methoxyphenyl)cyclohex-1-enyloxy]trimethylsilane* (**10**) (11.130g, 68%).

R_f = 0.70 (95:5 petroleum ether [40-60]/ ethyl acetate). λ_{max} (cyclohexane) 279nm. ν_{max} (thin film, cm^{-1}) 1599 (aromatic stretch), 1411 ($SiCH_3$), 844 ($Si(CH_3)_3$). δ_H (250MHz, $CDCl_3$) 0.03 (9H, s, $OSi(C\underline{H}_3)_3$), 1.11- 1.26 (1H, m, one of $C\underline{H}_2CH(Ar)$), 1.36- 1.59 (2H, m, $C\underline{H}_2CH_2COSi$), 1.66- 1.78 (1H, m, one of $C\underline{H}_2CH(Ar)$), 1.83- 1.95 (2H, m, $C\underline{H}_2COSi$), 3.63 (3H, s, $OC\underline{H}_3$), 3.69- 3.80 (1H, m, $C\underline{H}(Ar)$), 4.67- 4.69 (1H, m, $C\underline{H}{=}COSi$), 6.65 (1H, dd, *J* 1.0 and 7.5Hz, $C\underline{H}{=}COCH_3$), 6.72 (1H, app. dt, *J* 1.0 and 7.5Hz, $C\underline{H}CHCH{=}COCH_3$), 6.98 (1H, app. dt, *J* 1.5 and 7.5Hz, $C\underline{H}CH{=}COCH_3$), 7.02 (1H, dd, *J* 1.5 and 7.5Hz, $C\underline{H}C(CH){=}COCH_3$). δ_C (63MHz, $CDCl_3$) 0.0 ($(\underline{C}H_3)_3$), 20.7 ($\underline{C}H_2CH_2COSi$), 29.5 ($\underline{C}H_2CH(Ar)$) and ($\underline{C}H_2COSi$), 33.1 ($\underline{C}H(Ar)$), 54.9 ($O\underline{C}H_3$), 107.3 ($\underline{C}H{=}COSi$), 109.7 ($\underline{C}H{=}COCH_3$), 119.8 ($\underline{C}HCHCH{=}COCH_3$), 126.4 ($\underline{C}HCH{=}COCH_3$), 128.1 ($\underline{C}HC(CH){=}COCH_3$), 134.6 ($\underline{C}(CH){=}COCH_3$), 151.4 ($\underline{C}OSi$), 156.4 ($\underline{C}OCH_3$). m/z (CI, NH_3, high resolution) found 277.1623 [$C_{16}H_{24}O_2Si$] ($(MH)^+$, 100%) [requires 277.1625], 276 (33), 248.1183 (14), 217.1042 (18), 73.0480 (23).

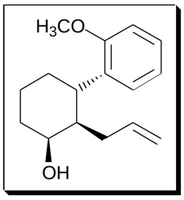
b. (±) (2*R*, 3*S*)-2-Allyl-3-(2'-methoxyphenyl)cyclohexanone (**11**)[15]



To a stirred solution of the silyl enol ether *[3-(2'-methoxyphenyl)cyclohex-1-enyloxy]trimethylsilane* (**10**) (1.510g, 5.48mmol) in anhydrous THF (32ml) was added a 1.5M solution of methyllithium in Et_2O (4.00ml, 6.00mmol). TLC confirmed cleavage of the silyl enol ether after 5 minutes. The reaction flask was then cooled to -78°C before a solution of allyl iodide (4.90ml, 5.40mmol) in THF (11ml) was added drop-wise. The reaction was then allowed to warm to room temperature over 3 hours. TLC indicated completion of the reaction after 6 hours and the mixture was quenched with ethyl acetate (100ml) and water (100ml). The aqueous layer was extracted with ethyl acetate (3x50ml). The combined extracts were washed with saturated NaCl solution (150ml), dried over $MgSO_4$, filtered and concentrated *in vacuo* to afford a pale yellow crude oil. Pure (±) (*2R, 3S)-2-allyl-3-(2'-methoxyphenyl)cyclohexanone* (**11**) (1.058g, 79%) was obtained using flash column chromatography (95:5 petroleum ether [40-60]/ ethyl acetate) as a pale yellow oil.

R_f = 0.21 (95:5 petroleum ether [40-60]/ ethyl acetate). λ_{max} (cyclohexane) 231 and 265nm. ν_{max} (thin film, cm^{-1}) 1710 (C=O), 1599 (aromatic stretch). δ_H (400MHz, $CDCl_3$) 1.60- 1.78 (1H, m, one of $C\underline{H}_2CH_2CO$), 1.79- 1.95 (3H, m, one of $C\underline{H}_2CH{=}CH_2$ and $C\underline{H}_2CH_2CH_2CO$), 1.96- 2.07 (1H, m, one of $C\underline{H}_2CH_2CO$), 2.10- 2.22 (1H, m, one of $C\underline{H}_2CH{=}CH_2$), 2.35- 2.44 (2H, m, $C\underline{H}_2C{=}O$), 2.79 (1H, ddd, *J* 11.5, 8.5 and 3.0Hz, $C\underline{H}(C_3H_5)$), 3.15 (1H, ddd, *J* 11.5, 11.0 and 5.0Hz, $C\underline{H}(Ar)$), 3.74 (3H, s, $OC\underline{H}_3$), 4.68 (1H, app. ddt, *J* 17.0, 2.0 and 1.5Hz, $CH{=}C\underline{H}_2$ (*trans*-H)), 4.76 (1H, app. ddt, *J* 10.0, 2.0 and 1.0Hz, $CH{=}C\underline{H}_2$ (*cis*-H)), 5.65 (1H, app. ddt, *J* 17.0, 10.0 and 7.0Hz, $C\underline{H}{=}CH_2$), 6.80 (1H, dd, *J* 1.0 and 8.0Hz, $C\underline{H}{=}COCH_3$), 6.88 (1H, app. dt, *J* 1.0 and 7.5Hz, $C\underline{H}CHCH{=}COCH_3$), 7.10 (1H, dd, *J* 1.5 and 7.5Hz, $C\underline{H}C(CH){=}COCH_3$), 7.14 (1H, ddd, *J* 1.5, 7.5 and 8.0Hz, $C\underline{H}CH{=}COCH_3$). δ_C (100MHz, $CDCl_3$) 26.9 ($\underline{C}H_2CH_2CO$), 31.4 ($\underline{C}H_2CH{=}CH_2$), 33.2 ($\underline{C}H_2CH_2CH_2CO$), 42.7 ($\underline{C}H_2CO$), 44.4 ($\underline{C}H(Ar)$), 55.0 ($\underline{C}H(C_3H_5)$), 55.7 ($O\underline{C}H_3$), 111.2 ($\underline{C}H{=}COCH_3$), 115.8 ($CH{=}\underline{C}H_2$), 121.1 ($\underline{C}HCHCH{=}COCH_3$), 127.9 ($\underline{C}HCH{=}COCH_3$), 128.2 ($\underline{C}HC(CH){=}COCH_3$), 131.9 ($\underline{C}(CH){=}COCH_3$), 137.4 ($\underline{C}H{=}CH_2$), 157.5 ($\underline{C}OCH_3$), 212.5 ($\underline{C}{=}O$). m/z (CI, NH_3, high resolution) found 245.1539 [$C_{16}H_{20}O_2$] ($(MH)^+$, 100%) [requires 245.1542], 147 (16).

c. (±) (1*S*, 2*R*, 3*S*)-2-Allyl-3-(2'-methoxyphenyl)cyclohexanol (**7**)[15]

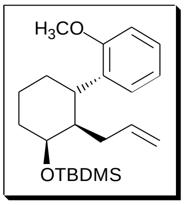


To a stirred solution of (±) *(2R, 3S)-2-allyl-3-(2'-methoxyphenyl)cyclohexanone* (**11**) (1.803g, 7.38mmol) in anhydrous THF (35ml) was added a 1M solution of lithium tri-*sec*-butylborohydride in THF (8.20ml, 8.20mmol) drop-wise at -78°C under nitrogen. The reaction was allowed to warm to room temperature over 3 hours and stirred at that temperature for a further 23 hours until TLC confirmed completion. The reaction was then quenched by the addition of ethanol (15ml) and water (25ml). After 50 minutes, 6N NaOH solution (25ml) was added followed by careful drop-wise addition of aqueous hydrogen peroxide solution (25ml, 30% w/v in water). After 35 minutes, the evolution of oxygen had ceased and the mixture was transferred to a separating funnel where it was extracted with diethyl ether (3x75ml). The organic layer was back extracted with water (2x75ml), dried over $MgSO_4$, filtered and concentrated under vacuum to give a colourless oil. Pure (±) *(1S, 2R, 3S)-2-allyl-3-(2'-methoxyphenyl)cyclohexanol* (**7**) (1.769g, 97%) was obtained by flash column chromatography (95:5 petroleum ether [40-60]/ ethyl acetate) as a white crystalline solid.

Mp. 60-62 °C. R_f = 0.23 (90:10 petroleum ether [40-60]/ ethyl acetate). λ_{max} (cyclohexane) 228 and 267nm (225 $M^{-1}cm^{-1}$). ν_{max} (thin film, cm^{-1}) 3302 (OH), 1599 (aromatic stretch). δ_H (400MHz, C_6D_6 at 70°C) 0.98 (1H, bs, $CHO\underline{H}$), 1.36- 1.58 (3H, m, one of $C\underline{H}_2CH_2CHOH$), one of $C\underline{H}_2CH(Ar)$ and one of $C\underline{H}_2CHOH$), 1.74- 1.95 (4H, m, one of $C\underline{H}_2CH(Ar)$, one of $C\underline{H}_2CHOH$), one of $C\underline{H}_2CH_2CHOH$) and $C\underline{H}(C_3H_5)$), 1.95- 2.04 (1H, m, one of $C\underline{H}_2CH{=}CH_2$), 2.12- 2.22 (1H, m, one of $C\underline{H}_2CH{=}CH_2$), 3.42 (3H, s, $OC\underline{H}_3$), 3.52 (1H, app. dt, *J* 3.5 and 12.0Hz, $C\underline{H}(Ar)$), 4.00 (1H, app. bd, *J* 2.5Hz, $C\underline{H}OH$), 4.87- 4.95 (2H, m, $CH{=}C\underline{H}_2$), 5.66- 5.78 (1H, m, $C\underline{H}{=}CH_2$), 6.64 (1H, d, *J* 7.5Hz, $C\underline{H}{=}COCH_3$), 6.89 (1H, app. t, *J* 7.5Hz, $C\underline{H}CHCH{=}COCH_3$), 7.06 (1H, app. dt, *J* 1.5 and 7.5Hz, $C\underline{H}CH{=}COCH_3$), 7.13 (1H, d, *J* 7.5Hz, $C\underline{H}C(CH){=}COCH_3$). δ_C (100MHz, C_6D_6 at 70°C) 20.8 ($\underline{C}H_2CH_2CHOH$), 34.2, 34.6 and 34.8 ($\underline{C}H_2CHOH$, $\underline{C}H_2CH(Ar)$ and $\underline{C}H_2CH{=}CH_2$), 36.6 ($\underline{C}H(Ar)$), 46.3 ($\underline{C}H(C_3H_5)$), 55.2 ($O\underline{C}H_3$), 67.5 ($\underline{C}HOH$), 111.5 ($\underline{C}H{=}COCH_3$), 115.3 ($CH{=}\underline{C}H_2$), 121.3 ($\underline{C}HCHCH{=}COCH_3$), 127.0 ($\underline{C}HCH{=}COCH_3$), 128.6 ($\underline{C}HC(CH){=}COCH_3$), 134.8 ($\underline{C}(CH){=}COCH_3$), 138.2 ($\underline{C}H{=}CH_2$), 158.3 ($\underline{C}OCH_3$). m/z (EI, high resolution) found 246.1619 [$C_{16}H_{22}O_2$] (($M)^+$, 100%) [requires 246.1620], 280.9820 (42), 230.9853 (96).

Synthesis of the 4-carbon tether substrate (**8**) Route A

a. (±) [(1*S*, 2*R*, 3*S*)-2-Allyl-3-(2'-methoxyphenyl)cyclohexyloxy-*tert*-butyldimethylsilane[15]

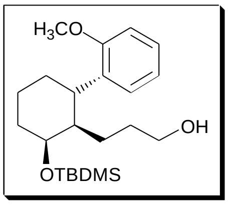


To a stirred solution of (±) *(1S, 2R, 3S)-2-allyl-3-(2'-methoxyphenyl)cyclohexanol* (**7**) (0.256g, 1.04mmol) in dry DCM (5ml) was added 2,6-lutidine (0.24ml, 2.06mmol) under a nitrogen atmosphere. The mixture was cooled to 0°C and *tert*-butyldimethylsilyl triflate (0.35ml, 1.52mmol) was added drop-wise *via* syringe. After 30 minutes, TLC indicated that the reaction was complete and it was subsequently quenched with saturated sodium bicarbonate solution (15ml). The reaction mixture was transferred to a separating funnel where the aqueous phase was extracted with dichloromethane (3x30ml). The combined organic extracts were then washed with 0.73M hydrochloric acid (30ml) and then saturated sodium bicarbonate solution (30ml) and water (30ml). The organic layer was dried over $MgSO_4$, filtered and concentrated *in vacuo* to give a colourless crude oil. Pure (±) *[(1S, 2R, 3S)-2-allyl-3-(2'-methoxyphenyl)cyclohexyloxy-tert-butyldimethylsilane* (0.366g, 98%) was obtained by flash column chromatography (95:5 petroleum ether [40-60]/ ethyl acetate) as a colourless oil.

R_f = 0.70 (95:5 petroleum ether [40-60]/ ethyl acetate). λ_{max} (cyclohexane) 232 and 257nm. ν_{max} (thin film, cm^{-1}) 3074 (H_2C=), 3026 (HC=), 1600 (aromatic stretch). δ_H (400MHz, C_6D_6) 0.11 (3H, s, $OSiC\underline{H}_3$), 0.12 (3H, s, $OSiC\underline{H}_3$), 1.09 (9H, s, $OSiC(C\underline{H}_3)_3$), 1.32- 1.44 (2H, m, one of $C\underline{H}_2CH(Ar)$ and one of $C\underline{H}_2CHOTBDMS$, 1.44- 1.53 (1H, m, one of $C\underline{H}_2CH_2CHOTBDMS$, 1.57 (1H, app. bs, $C\underline{H}(C_3H_5)$), 1.79- 1.94 (2H, m, one of $C\underline{H}_2CH(Ar)$ and one of $C\underline{H}_2CHOTBDMS$), 1.94- 2.07 (2H, m, one of $C\underline{H}_2CH{=}CH_2$ and one of $C\underline{H}_2CH_2CHOTBDMS$), 2.20- 2.32 (1H, m, one of $C\underline{H}_2CH{=}CH_2$), 3.36 (3H, s, $OC\underline{H}_3$), 3.67 (1H, app. bs, $C\underline{H}(Ar)$), 4.12 (1H, app. t, *J* 1.5Hz, $C\underline{H}OTBDMS$), 4.93- 5.03 (2H, m, $CH{=}C\underline{H}_2$), 5.65- 5.78 (1H, m, $C\underline{H}{=}CH_2$), 6.58 (1H, dd, *J* 1.0 and 7.5Hz, $C\underline{H}{=}COCH_3$), 6.93 (1H, app. t, *J* 7.5Hz, $C\underline{H}CHCH{=}COCH_3$), 7.03 (1H, dt, *J* 1.5 and 7.5Hz, $C\underline{H}CH{=}COCH_3$), 7.17 (1H, dd, *J* 1.5 and 7.5Hz, $C\underline{H}C(CH){=}COCH_3$). δ_C (100MHz, C_6D_6) –4.8 and –3.6 ($OSi\underline{C}H_3$ and $OSi\underline{C}H_3$), 18.6 ($OSi\underline{C}(CH_3)_3$), 20.9 ($\underline{C}H_2CH_2CHOTBDMS$), 26.2 ($OSiC(\underline{C}H_3)_3$), 33.8 ($\underline{C}H_2CH{=}CH_2$), 34.4 ($\underline{C}H_2CHOTBDMS$ and $\underline{C}H_2CH(Ar)$), 34.5 ($\underline{C}H(Ar)$), 47.0 ($\underline{C}H(C_3H_5)$), 55.0 ($O\underline{C}H_3$), 68.4 ($\underline{C}HOTBDMS$), 110.9 ($\underline{C}H{=}COCH_3$), 115.3 ($CH{=}\underline{C}H_2$), 121.1 ($\underline{C}HCHCH{=}COCH_3$), 126.9 ($\underline{C}HCH{=}COCH_3$), 128.2 ($\underline{C}HC(CH){=}COCH_3$), 134.6 ($\underline{C}(CH){=}COCH_3$), 138.5 ($\underline{C}H{=}CH_2$), 158.0 ($\underline{C}OCH_3$). m/z (CI, NH_3, high resolution) found 361.2599 [$C_{22}H_{36}O_2Si$]

((MH)$^+$, 54%) [requires 361.2564], 303.1541 (100), 229.1533 (41), 147.0784 (24), 121.0648 (29), 82.9509 (56).

b. (±) 3-[(1*R*, 2*S*, 6*S*)-2'-(*tert*-Butyldimethylsilanyloxy)-6'-(2''-methoxyphenyl)cyclohexyl]propan-1-ol[15]

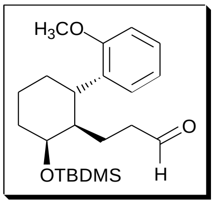


To a stirred solution of (±) *[(1S, 2R, 3S)-2-allyl-3-(2'-methoxyphenyl)cyclohexyloxy-tert-butyldimethylsilane* (0.366g, 1.00mmol) in dry THF (7ml) under nitrogen was added 0.5M 9-borabicyclo[3.3.1]nonane solution in THF (3.00ml, 1.50mmol) *via* syringe. After 45 minutes, TLC indicated that the reaction had run to completion, so the mixture was quenched with 3M NaOH solution (0.5ml). This was followed by careful, drop-wise addition of hydrogen peroxide 27.5% wt. solution in water (0.50ml, 4.10mmol). The mixture was left stirring for 10 minutes after which time the THF was removed *in vacuo*. The remaining mixture was transferred to a separating funnel where the aqueous layer was extracted with ethyl acetate (2x30ml). The combined organic washings were collected and washed with saturated sodium hydrogen carbonate solution (2x20ml) and then water (20ml). The organic layer was dried over MgSO$_4$, filtered and concentrated *in vacuo* to give a colourless, crude oil. Pure (±) *3-[(1R, 2S, 6S)-2'-(tert-butyldimethylsilanyloxy)-6'-(2''-methoxyphenyl)cyclohexyl]propan-1-ol* (0.363g, 94%) was obtained by flash column chromatography (90:10 petroleum ether [40-60]/ ethyl acetate) as a colourless oil.

R_f = 0.31 (85:15 petroleum ether [40-60]/ ethyl acetate). λ_{max} (cyclohexane) 231 and 267nm. ν_{max} (thin film, cm^{-1}) 3384 (OH), 1600 (aromatic stretch). δ_H (400MHz, C$_6$D$_6$) 0.10 (3H, s, OSiC$\underline{H}_3$), 0.11 (3H, s, OSiC$\underline{H}_3$), 1.09 (9H, s, OSiC(C$\underline{H}_3$)$_3$), 1.15- 1.80 (8H, m, one of C$\underline{H}_2$CHOTBDMS, one of C$\underline{H}_2$CH$_2$CHOTBDMS, one of C$\underline{H}_2$CH(Ar), C$\underline{H}$(C$_3$H$_6$OH), C$\underline{H}_2$(CH$_2$)$_2$OH, C$\underline{H}_2$CH$_2$OH), 1.80- 1.87 (1H, m, one of C$\underline{H}_2$CHOTBDMS), 1.89- 1.95 (1H, m, one of C$\underline{H}_2$CH(Ar)), 1.95- 2.08 (1H, m, one of C$\underline{H}_2$CH$_2$CHOTBDMS), 3.36 (3H, s, OC$\underline{H}_3$), 3.66 (1H, app. bs, C$\underline{H}$(Ar)), 3.87- 3.99 (2H, m, C$\underline{H}_2$OH), 4.07 (1H, app. bs, C$\underline{H}$OTBDMS), 6.60 (1H, d, *J* 8.0Hz, C$\underline{H}$=COCH$_3$), 6.95 (1H, t, *J* 8.0Hz, C$\underline{H}$CHCH=COCH$_3$), 7.08 (1H, dt, *J* 1.5 and 8.0Hz, C$\underline{H}$CH=COCH$_3$), 7.18 (1H, d, *J* 8.0Hz, C$\underline{H}$C(CH)=COCH$_3$). δ_C (100MHz, C$_6$D$_6$) −4.9 and −3.8 (OSi$\underline{C}$H$_3$ and OSi$\underline{C}$H$_3$), 18.5 (OSi$\underline{C}$(CH$_3$)$_3$), 20.9 ($\underline{C}$H$_2$CH$_2$CHOTBDMS), 26.2 (OSiC($\underline{C}$H$_3$)$_3$), 30.2

and 30.7 ($\underline{C}H_2(CH_2)_2OH$ and $\underline{C}H_2CH_2OH$), 34.5 ($\underline{C}H_2CH(Ar)$ and $\underline{C}H_2CHOTBDMS$), 34.7 ($\underline{C}H(Ar)$), 46.4 ($\underline{C}H(C_3H_6OH)$), 55.0 ($O\underline{C}H_3$), 62.9 ($\underline{C}H_2OH$), 68.3 ($\underline{C}HOTBDMS$), 111.0 ($\underline{C}H{=}COCH_3$), 121.1 ($\underline{C}HCHCH{=}COCH_3$), 126.8 ($\underline{C}HCH{=}COCH_3$), 128.6 ($\underline{C}HC(CH){=}COCH_3$), 135.1 ($\underline{C}(CH){=}COCH_3$), 158.0 ($\underline{C}OCH_3$).). m/z (CI, NH_3, high resolution) found 379.2773 [$C_{22}H_{38}O_3Si$] ($(MH)^+$, 100%) [requires 379.2769].

c. (±) 3-[(1*R*, 2*S*, 6*S*)-2'-(*tert*-Butyldimethylsilanyloxy)-6'-(2''-methoxyphenyl)cyclohexyl]propionaldehyde (**12**)[15]

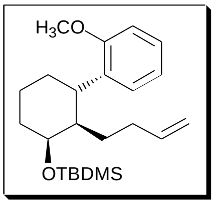


To a stirred solution of (±) *3-[(1R, 2S, 6S)-2'-(tert-butyldimethylsilanyloxy)-6'-(2''-methoxyphenyl)-cyclohexyl]-propan-1-ol* (0.343g, 0.90mmol) in dry DCM (2.5ml) under a nitrogen atmosphere was added the Dess-Martin periodinane (102) (0.499g, 1.18mmol) in dry DCM (2.5ml) *via* syringe. The reaction mixture was left stirring for 1.75 hours at which time TLC indicated that the reaction had run to completion. The mixture was diluted with diethyl ether (20ml) before a 1M solution of NaOH (20ml) was added. The reaction mixture was left to stir for 10 minutes and was then transferred to a separating funnel where the aqueous layer was extracted with diethyl ether (2x30ml). The organic extracts were collected together and washed with 1M NaOH solution (30ml) and then water (30ml). The organic layer was dried over $MgSO_4$, filtered and concentrated *in vacuo* to give the colourless pure oil of (±) *3-[(1R, 2S, 6S)-2'-(tert-butyldimethylsilanyloxy)-6'-(2''-methoxyphenyl)-cyclohexyl]propionaldehyde* (**12**) (0.337g, 99%).

R_f = 0.26 (95:5 petroleum ether [40-60]/ ethyl acetate). λ_{max} (cyclohexane) 228 and 270nm. ν_{max} (thin film, cm^{-1}) 1727 (C=O), 1599 (aromatic stretch). δ_H (400MHz, C_6D_6) 0.02 (3H, s, $OSiC\underline{H}_3$), 0.06 (3H, s, $OSiC\underline{H}_3$), 1.02 (9H, s, $OSiC(C\underline{H}_3)_3$), 1.26- 1.65 (6H, m, one of $C\underline{H}_2CH(Ar)$, one of $C\underline{H}_2CHOTBDMS$, $C\underline{H}_2CH_2CHO$, one of $C\underline{H}_2CH_2CH(Ar)$ and $C\underline{H}(CH_2)_2CHO$), 1.72- 1.97 (5H, m, one of $C\underline{H}_2CH(Ar)$, one of $C\underline{H}_2CHOTBDMS$, one of $C\underline{H}_2CH_2CH(Ar)$ and $C\underline{H}_2CHO$), 3.38 (3H, s, $OC\underline{H}_3$), 3.52 (1H, app. bs, $C\underline{H}(Ar)$), 3.90 (1H, app. s, $C\underline{H}OTBDMS$), 6.59 (1H, d, *J* 7.5Hz, $C\underline{H}{=}COCH_3$), 6.90 (1H, app. t, *J* 7.5Hz, $C\underline{H}CHCH{=}COCH_3$), 7.06 (1H, app. dt, *J* 1.5 and 7.5Hz, $C\underline{H}CH{=}COCH_3$), 7.10 (1H, dd, *J* 1.5 and 7.5Hz, $C\underline{H}C(CH){=}COCH_3$), 9.20 (1H, t, *J* 2.0Hz, $CH\underline{O}$). δ_C (100MHz, C_6D_6) −5.0 and −3.8 ($OSi\underline{C}H_3$ and $OSi\underline{C}H_3$), 18.5 ($OSi\underline{C}(CH_3)_3$), 20.7

($\underline{C}H_2CH_2CHOTBDMS$), 22.4 ($\underline{C}H_2CH_2CHO$), 26.1 ($OSiC(\underline{C}H_3)_3$), 34.2 ($\underline{C}H(Ar)$, $\underline{C}H_2CH(Ar)$ and $\underline{C}H_2CHOTBDMS$), 41.5 ($\underline{C}H_2CHO$), 46.0 ($\underline{C}H(CH_2)_2CHO$), 55.0 ($O\underline{C}H_3$), 68.4 ($\underline{C}HOTBDMS$), 111.0 ($\underline{C}H{=}COCH_3$), 121.1 ($\underline{C}HCHCH{=}COCH_3$), 127.1 ($\underline{C}HCH{=}COCH_3$), 128.2 ($\underline{C}HC(CH){=}COCH_3$), 134.4 ($\underline{C}(CH){=}COCH_3$), 157.9 ($\underline{C}OCH_3$), 201.1 ($\underline{C}HO$). m/z (CI, NH_3, high resolution) found 377.2497 [$C_{22}H_{36}O_3Si$] (($MH)^+$, 27%) [requires 377.2513], 319.1723 (93), 245.2347 (74), 227.1139 (100), 147.0804 (81), 121.0650 (44), 75.0267 (27).

d. (±) [(1*S*, 2*R*, 3*S*)-2-But-3'-enyl-3-(2''-methoxyphenyl)cyclohexyloxy]-*tert*-butyldimethylsilane[15]



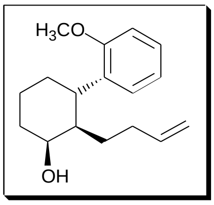
General Procedure A

To a stirred solution of methyltriphenylphosphonium bromide (0.272g, 0.76mmol) in anhydrous THF (5ml) was added a 1.6M solution of methyllithium in hexanes (0.43ml, 0.70mmol) at 0°C under nitrogen. The reaction mixture changed to a bright yellow colour almost immediately and was left to stir at 0°C for 45 minutes. After this time, a solution of (±) *3-[(1R,2S,6S)-2'-(tert-butyldimethyl-silanyloxy)-6'-(2''-methoxyphenyl)-cyclohexyl]propionaldehyde* (**12**) (0.191g, 0.51mmol) in dry THF (5ml) was added to the reaction mixture *via* syringe. The mixture was then left stirring at 0°C for another hour until TLC confirmed that no more starting material was being consumed. The reaction was quenched with saturated NH_4Cl solution (20ml) before being transferred to a separating funnel where the aqueous layer was extracted with ethyl acetate (2x30ml). The combined organic extracts were washed with saturated NaCl solution (30ml) and then water (30ml). The organic layer was dried over $MgSO_4$, filtered and concentrated *in vacuo* to give a colourless crude oil. Pure (±) *[(1S, 2R, 3S)-2-but-3'-enyl-3-(2''-methoxyphenyl)cyclo-hexyloxy]tert-butyldimethylsilane* (0.163g, 86%) was obtained by flash column chromatography (petroleum ether [40-60]) as a colourless oil.

R_f = 0.23 (petroleum ether [40-60]). λ_{max} (cyclohexane) 235 and 265nm. ν_{max} (thin film, cm^{-1}) 3075 ($H_2C{=}$), 3027 ($HC{=}$), 1600 (aromatic stretch). δ_H (400MHz, C_6D_6) 0.09 (3H, s, $OSiC\underline{H}_3$), 0.11 (3H, s, $OSiC\underline{H}_3$), 1.07 (9H, s, $OSiC(C\underline{H}_3)_3$), 1.22- 1.33 (1H, m, one of

$C\underline{H}_2CH_2CH=CH_2$), 1.33- 1.46 (2H, m, one of $C\underline{H}_2CH(Ar)$ and one of $C\underline{H}_2CHOTBDMS$), 1.45-1.53 (1H, m, one of $C\underline{H}_2CH_2CH(Ar)$), 1.52- 1.63 (1H, m, one of $C\underline{H}_2CH_2CH=CH_2$), 1.65 (1H, app. bs, $C\underline{H}(C_4H_7)$), 1.78- 1.93 (3H, m, one of $C\underline{H}_2CH=CH_2$, one of $C\underline{H}_2CH(Ar)$ and one of $C\underline{H}_2CHOTBDMS$), 1.93-2.11 (2H, m, one of $C\underline{H}_2CH_2CH(Ar)$ and one of $C\underline{H}_2CH=CH_2$), 3.36 (3H, s, $OC\underline{H}_3$), 3.63 (1H, app. bs, $C\underline{H}(Ar)$), 4.07- 4.10 (1H, m, $C\underline{H}OTBDMS$), 4.88 (1H, app. ddt, *J* 10.5, 2.0 and 1.0Hz, $CH=C\underline{H}_2$ (*cis*-H)), 4.95 (1H, app. dq, *J* 17.0 and 2.0Hz, $CH=C\underline{H}_2$ (*trans*-H)), 5.64 (1H, app. ddt, *J* 17.0, 10.5 and 6.5Hz, $C\underline{H}=CH_2$), 6.59 (1H, dd, *J* 1.0 and 8.0Hz, $C\underline{H}=COCH_3$), 6.93 (1H, app. t, *J* 7.5Hz, $C\underline{H}CHCH=COCH_3$), 7.07 (1H, ddd, *J* 2.0, 7.5 and 8.0Hz, $C\underline{H}CH=COCH_3$), 7.17 (1H, dd, *J* 2.0 and 7.5Hz, $C\underline{H}C(CH)=COCH_3$). δ_C (100MHz, C_6D_6) −4.9 and −3.8 ($OSi\underline{C}H_3$ and $OSi\underline{C}H_3$), 18.5 ($OSi\underline{C}(CH_3)_3$), 20.9 ($\underline{C}H_2CH_2CHOTBDMS$), 26.2 ($OSiC(\underline{C}H_3)_3$), 28.0 ($\underline{C}H_2CH_2CH=CH_2$), 31.6 ($\underline{C}H_2CH=CH_2$), 34.5 ($\underline{C}H_2CH(Ar)$ and $\underline{C}H_2CHOTBDMS$), 34.6 ($\underline{C}H(Ar)$), 46.0 $\underline{C}H(CH_2)_2CH=CH_2$), 55.0 ($O\underline{C}H_3$), 68.3 ($\underline{C}HOTBDMS$), 110.9 ($\underline{C}H=COCH_3$), 114.3 ($CH=\underline{C}H_2$), 121.1 ($\underline{C}HCHCH=COCH_3$), 126.8 ($\underline{C}HCH=COCH_3$), 128.2 ($\underline{C}HC(CH)=COCH_3$), 134.9 ($\underline{C}(CH)=COCH_3$), 139.3 ($\underline{C}H=CH_2$), 158.0 ($\underline{C}OCH_3$). m/z (CI, NH_3, high resolution) found 375.2730 [$C_{23}H_{38}O_2$ Si] ($(MH)^+$, 17%) [requires 375.2720], 317.1927 (100), 243.1993 (56), 201.1372 (15), 147.0193 (34), 121.0662 (58), 74.9939 (40).

e. (±) (1*S*, 2*R*, 3*S*)-2-But-3'-enyl-3-(2''-methoxyphenyl)cyclohexanol (**8**)[15]



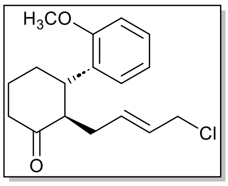
General Procedure B

To a stirred solution of the protected alkene (±) *[(1S, 2R, 3S)-2-but-3'-enyl-3-(2''-methoxyphenyl)cyclohexyloxy]tert-butyl-dimethylsilane* (0.045g, 0.12mmol) in anhydrous THF (2ml) was added tetrabutylammonium fluoride 1M solution in THF (0.40ml, 0.40mmol) drop-wise, under nitrogen. The reaction mixture was heated to 50°C and left to stir for 146 hours until TLC indicated that no more starting material was being consumed. The reaction mixture was quenched with water (20ml) before being transferred to a separating funnel where the aqueous layer was extracted with diethyl ether (3x20ml). The combined organic extracts were washed with saturated NaCl solution (20ml) and then water (20ml). The organic layer was dried over $MgSO_4$, filtered and concentrated *in vacuo* to give a crude oil. Pure (±) *(1S, 2R, 3S)-2-but-3'-enyl-3-(2''-methoxyphenyl)cyclohexanol* (**8**) (0.030g, 94%) was obtained by flash column chromatography (90:10 petroleum ether [40-60]/ ethyl acetate) as a colourless oil.

R_f = 0.23 (90:10 petroleum ether [40-60]/ ethyl acetate). λ_{max} (cyclohexane) 228 and 272nm (48 $M^{-1}cm^{-1}$). ν_{max} (thin film, cm^{-1}) 3422 (OH), 3072 ($H_2C=$), 1598 (aromatic stretch). δ_H (400MHz, C_6D_6) 0.90 (1H, bs, $CHO\underline{H}$), 1.28- 1.48 (4H, m, one of $C\underline{H}_2CH_2CH=CH_2$, one of $C\underline{H}_2CHOH$, one of $C\underline{H}_2CH(Ar)$ and one of $C\underline{H}_2CH_2CHOH$), 1.52- 1.63 (1H, m, one of $C\underline{H}_2CH_2CH=CH_2$), 1.63- 1.77 (2H, m, $C\underline{H}(C_4H_7)$ and one of $C\underline{H}_2CHOH$), 1.81- 1.95 (3H, m, one of $C\underline{H}_2CH(Ar)$, one of $C\underline{H}_2CH=CH_2$ and one of $C\underline{H}_2CH_2CHOH$), 2.01- 2.11 (1H, m, one of $C\underline{H}_2CH=CH_2$), 3.33 (3H, s, $OC\underline{H}_3$), 3.60 (1H, app. bs, $C\underline{H}(Ar)$), 3.92 (1H, app. bd, *J* 2.0Hz, $C\underline{H}OH$), 4.86- 4.97 (2H, m, $CH=C\underline{H}_2$), 5.58- 5.69 (1H, m, $C\underline{H}=CH_2$), 6.59 (1H, dd, *J* 1.0 and 7.5Hz, $C\underline{H}=COCH_3$), 6.93 (1H, dt, *J* 1.0 and 7.5Hz, $C\underline{H}CHCH=COCH_3$), 7.07 (1H, dt, *J* 2.0 and 7.5Hz, $C\underline{H}CH=COCH_3$), 7.15 (1H, dd, *J* 2.0 and 7.5Hz, $C\underline{H}C(CH)=COCH_3$). δ_C (100MHz, C_6D_6) 20.6 ($\underline{C}H_2CH_2CHOH$), 28.7 ($\underline{C}H_2CH_2CH=CH_2$), 31.3 ($\underline{C}H_2CH=CH_2$), 34.1 ($\underline{C}H_2CHOH$ and $\underline{C}H_2CH(Ar)$), 35.0 ($\underline{C}H(Ar)$), 45.0 ($\underline{C}H(C_4H_7)$), 54.9 ($O\underline{C}H_3$), 66.7 ($\underline{C}HOH$), 110.9 ($\underline{C}H=COCH_3$), 114.3 ($CH=\underline{C}H_2$), 121.0 ($\underline{C}HCHCH=COCH_3$), 126.8 ($\underline{C}HCH=COCH_3$), 128.6 ($\underline{C}HC(CH)=COCH_3$), 134.7 ($\underline{C}(CH)=COCH_3$), 139.4 ($\underline{C}H=CH_2$), 157.9 ($\underline{C}OCH_3$). m/z (CI, NH_3, high resolution) found 260.1787 [$C_{17}H_{24}O_2$] ($(M)^+$, 63%) requires [260.1776], 201.1253 (37), 134.0834 (32), 121.0822 (100).

Synthesis of the 4-carbon tether substrate (**8**) Route B

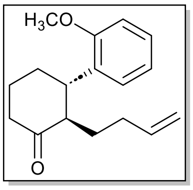
a. (±) (2*R*,3*S*)-2-((*E*)-4-chlorobut-2-en-1-yl)-3-(2-methoxyphenyl)cyclohexan-1-one – novel



To a stirred solution of the *[3-(2'-methoxyphenyl)cyclohex-1-enyloxy]trimethylsilane* (**10**) (0.70 g, 2.53 mmol) in anhydrous THF (30 ml) was added a 1.6 M solution of methyllithium in Et_2O (1.70 ml, 2.79 mmol). TLC confirmed cleavage of the silyl enol ether after 5 minutes. The reaction flask was then cooled to -78 °C before a solution of 1-chloro-4-iodobut-2-ene (2.2 g, 10.13 mmol) in THF (10ml) was added drop-wise. The reaction was then allowed to warm to room temperature over 3 hours. TLC indicated completion of the reaction after 15 hours and the mixture was quenched with ethyl acetate (50 ml) and water (50 ml). The aqueous layer was extracted with ethyl acetate (3×50ml) then the combined extracts were washed with saturated NaCl solution (50 ml), dried over anhydrous $MgSO_4$, filtered and concentrated *in vacuo* to afford a pale brown oil. The crude product was purified using flash column chromatography (80%:20%) petroleum ether [40-60]/ ethyl acetate) to afford *(±) (2R,3S)-2-((E)-4-chlorobut-2-en-1-yl)-3-(2-methoxyphenyl)cyclohexan-1-one* as a pale-brown oil (0.40g, 58%).

R_f = 0.45 (80%:20%) petroleum ether [40-60]/ ethyl acetate). IR (thin film) ν_{max} / cm^{-1} = 2936 brm, 2863w, 1705s (CO), 1599w, 1586w, 1492m, 1463m, 1438m, 1344w, 1290w, 1241s, 1175w, 1118w 1051m, 1027m, 972m, 751s, 737m, 674m; ^1H NMR (400 MHz, $CDCl_3$) δ 7.21 (td, *J* = 8.2, 1.1 Hz, 1H, Ar-H), 7.16 (dd, *J* = 7.6, 1.7 Hz, 1H, Ar-H), 6.95 (td, *J* = 7.5, 1.1 Hz, 1H, Ar-H), 6.87 (dd, *J* = 8.2, 1.2 Hz, 1H, Ar-H), 5.66 (m, 1H, $CH_2C\underline{H}$=), 5.30 (m, , 1H, $ClCH_2C\underline{H}$=), 3.90 (dd, *J* = 7.2, 1.0 Hz, 2H, CH_2Cl), 3.81 (s, 3H, CH_3O), 3.17 (td, *J* = 11.7, 4.1 Hz, 1H, CH-Ar), 2.87 (td, *J* = 11.0, 2.8 Hz, 1H, CHCO), 2.51 – 2.42 (m, 2H, CH_2CO), 2.20 (app dt, *J* = 14.8, 7.4 Hz, 1H, 1 of CH_2-CH=), 2.11 (m, 1H, CH_2), 2.02 – 1.89 (m, 3H), 1.75 (m, 1H, $C\underline{H_2}CH_2C$=O); ^{13}C NMR (101 MHz, $CDCl_3$) δ 211.90 (CO), 157.22 ($\underline{C}OCH_3$), 134.18 ($CH_2\underline{C}H$=), 131.25 (C), 128.0 (Ar-H), 127.74 (Ar-H), 127.15 ($ClCH_2\underline{C}H$=), 120.90 (Ar-H), 110.93 (Ar-H), 55.42 (CH_3O), 54.51 (COCH), 45.58 (CH_2Cl), 44.41 ($\underline{C}H$-Ar), 42.43 (CH_2C=O), 32.96 ($\underline{C}H_2CH_2CH_2C$=O), 29.46 ($\underline{C}H_2$-CH=), 26.59 ($\underline{C}H_2CH_2C$=O); HRMS ($[M + H]^+$, +ESI) m/z $C_{17}H_{22}O_2{}^{35}Cl$ = calculated 293.1303, found 293.1304; HRMS ($[M + H]^+$, +ESI) m/z $C_{17}H_{22}O_2{}^{37}Cl$ = calculated 295.1273, found 295.1275;

b. (±) (2*R*,3*S*)-2-(But-3-en-1-yl)-3-(2-methoxyphenyl)cyclohexan-1-one (**13**) – novel

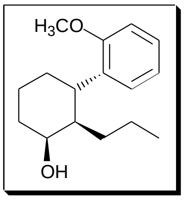


To palladium (II) acetate (0.026g, 0.115 mmol) and HCO_2NH_4 (0.266g, 4.21 mmol) in toluene (25 mL), *n*-Bu_3P (1.6 ml, 0.860 mmol) was added at 23 °C. The light-yellow solution turned to dark yellow over the course of 10 minutes at which point a solution of *(±) (2R,3S)-2-((Z)-4-chlorobut-2-en-1-yl)-3-(2-methoxyphenyl)cyclohexan-1-one* (0.57g, 1.91 mmol) in toluene (10 mL) was added *via* cannula. The resulting suspension was heated at 105 °C until TLC analysis revealed consumption of the allyl chloride after 18 hours and the mixture was quenched with ethyl acetate (50 ml) and water (50 ml). The aqueous layer was extracted with ethyl acetate (2×50 ml). The combined extracts were dried over anhydrous $MgSO_4$, filtered and concentrated *in vacuo* to afford a yellow oil. The crude product was purified using flash column chromatography (70:30 petroleum ether [40-60]/ ethyl acetate) to afford *(±) (2R,3S)-2-(but-3-en-1-yl)-3-(2-methoxyphenyl)cyclohexan-1-one* (**13**) as a pale-yellow oil (0.30g, 60%).

R_f = 0.80 (70:30 petroleum ether [40-60]/ ethyl acetate). IR (thin film) ν_{max} / cm^{-1} = 2931brm, 1708s (CO), 1597w, 1493m, 1463m, 1290w, 1242s, 1174w, 1053w, 1029m, 909w, 753m; ^1H NMR (400 MHz, $CDCl_3$) δ 7.24 – 7.16 (m, 2H, Ar-H), 6.95 (td, *J* = 7.5, 1.2 Hz, 1H, Ar-H), 6.87 (dd, *J* = 8.2, 1.1 Hz, 1H, Ar-H), 5.73 (ddt, *J* = 17.1, 10.2, 6.9 Hz, 1H, $C\underline{H}=CH_2$), 4.83 (ddt, *J* = 10.1, 2.2, 1.1 Hz, 1H, $C=C\underline{H_2}$), 4.75 (app. dq, *J* = 17.2, 1.6 Hz, 1H, $C=C\underline{H_2}$), 3.80 (s, 3H, OCH_3), 3.21 (app. td, *J* = 11.7, 4.7 Hz, 1H, CH-Ar), 2.87 (ddd, *J* = 11.6, 8.1, 3.1 Hz, 1H, CHC=O), 2.50 – 2.44 (m, 2H, $CH_2C=O$), 2.23 (dddt, *J* = 14.2, 8.1, 6.9, 1.2 Hz, 1H, CH_2), 2.12 – 2.04 (m, 1H, CH_2), 1.99 – 1.89 (m, 3H, 3 of 2 x CH_2), 1.75 (m, 1H, 1 of 2 x CH_2); ^{13}C NMR (101 MHz, $CDCl_3$) δ 212.73 (CO), 157.14 ($\underline{C}$-OMe), 139.05 (vinyl-CH), 131.92 (C), 127.79 (Ar-H), 127.51 (Ar-H), 120.86 (Ar-H), 114.44 (vinyl-CH_2), 110.89 (Ar-H), 55.43 (CH_3O), 53.91 ($\underline{C}HC=O$), 44.33 (br, CH-Ar), 42.63 ($CH_2C=O$), 33.10 (CH_2), 31.90 (CH_2), 26.80 (CH_2), 25.89 (CH_2); HRMS ($[M + H]^+$, +ESI) m/z $C_{17}H_{23}O_2$ = calculated 259.1693, found 259.1694.

Synthesis of substrates for fluorescence comparison

a. (±) (1*S*, 2*R*, 3*S*)-3-(2'-Methoxyphenyl)-2-propylcyclohexanol – novel

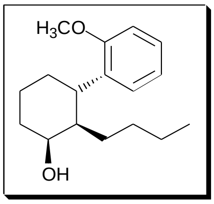


General Procedure C

To a round-bottomed flask was added (±) *(1S, 2R, 3S)-2-allyl-3-(2'-methoxyphenyl)cyclohexanol* (**8**) (0.043g, 0.17mmol) in anhydrous methanol (2ml) under argon. To the stirred solution was added a catalytic amount of 10% palladium on carbon. The flask was then evacuated before being filled with hydrogen. The reaction mixture was vigorously stirred under a positive pressure of hydrogen for 70 minutes until TLC indicated that the reaction had run to completion. The reaction mixture was filtered through celite and the filtrate concentrated *in vacuo* to give white star crystals of pure (±) *(1S, 2R, 3S)-3-(2'-methoxyphenyl)-2-propylcyclohexanol* (0.043g, 99%).

Mp. 65-67 °C. R_f = 0.64 (70:30 petroleum ether [40-60]/ ethyl acetate). λ_{max} (cyclohexane) 227 and 272nm. ν_{max} (KBr disc, cm^{-1}) 3268 (OH), 1599 (aromatic stretch). δ_H (400MHz, C_6D_6) 0.74 (3H, t, *J* 7.0Hz, $CH_2C\underline{H}_3$), 0.99 (1H, bs, $CHO\underline{H}$), 1.02- 1.14 (1H, m, one of $C\underline{H}_2CH_3$), 1.14- 1.25 (1H, m, one of $C\underline{H}_2CH_2CH_3$), 1.28- 1.52 (6H, m, one of $C\underline{H}_2CH_3$, $C\underline{H}_2CH(Ar)$, one of $C\underline{H}_2CHOH$, one of $C\underline{H}_2CH_2CH_3$ and one of $C\underline{H}_2CH_2CHOH$), 1.73- 1.81 (1H, m, one of $C\underline{H}_2CHOH$), 1.85- 1.98 (2H, m, one of $C\underline{H}_2CH_2CHOH$ and $C\underline{H}(C_3H_7)$), 3.35 (3H, s, $OC\underline{H}_3$), 3.60 (1H, app. bs, $C\underline{H}(Ar)$), 3.95 (1H, app. bd, *J* 2.5Hz, $C\underline{H}OH$), 6.60 (1H, d, *J* 8.0Hz, $C\underline{H}{=}COCH_3$), 6.95 (1H, t, *J* 8.0Hz, $C\underline{H}CHCH{=}COCH_3$), 7.08 (1H, dt, *J* 1.5 and 8.0Hz, $C\underline{H}CH{=}COCH_3$), 7.16 (1H, dd, *J* 1.5 and 8.0Hz, $C\underline{H}C(CH){=}COCH_3$). δ_C (100MHz, C_6D_6) 14.4 ($CH_2\underline{C}H_3$), 20.2 ($\underline{C}H_2CH_3$), 20.7 ($\underline{C}H_2CH_2CHOH$), 30.2 ($\underline{C}H_2CH(Ar)$), 31.7 ($\underline{C}H_2CH_2CH_3$), 34.1 ($\underline{C}H_2CHOH$), 35.0 ($\underline{C}H(Ar)$), 45.6 ($\underline{C}H(C_3H_7)$), 54.9 ($O\underline{C}H_3$), 66.9 ($\underline{C}HOH$), 110.9 ($\underline{C}H{=}COCH_3$), 121.0 ($\underline{C}HCHCH{=}COCH_3$), 126.8 ($\underline{C}HCH{=}COCH_3$), 128.2 ($\underline{C}HC(CH){=}COCH_3$), 134.9 ($\underline{C}(CH){=}COCH_3$), 157.9 ($\underline{C}OCH_3$). m/z (EI, high resolution) found 248.1775 [$C_{16}H_{24}O_2$] ($(M)^+$, 66%) [requires 248.1776], 280.9819 (44), 230.9854 (100).

b. (±) (1*S*, 2*R*, 3*S*)-2-Butyl-3-(2'-methoxyphenyl)cyclohexanol[15]



Substrate was synthesised according to general procedure C using (±) *(1S, 2R, 3S)-2-but-3'-enyl-3-(2"-methoxyphenyl)cyclohexanol* (**8**) (0.030g, 0.12mmol) in anhydrous methanol (2ml), a catalytic amount of 10% palladium on carbon and excess hydrogen. After 70 minutes of reaction the mixture was filtered through celite and the filtrate concentrated *in vacuo* to afford the pure (±) *(1S, 2R, 3S)-2-butyl-3-(2'-methoxyphenyl)cyclohexanol* (0.028g, 91%) as a yellow oil.

R_f = 0.64 (70:30 petroleum ether [40-60]/ ethyl acetate). λ_{max} (cyclohexane) 222 and 273nm. ν_{max} (thin film, cm^{-1}) 3417 (OH), 1599 (aromatic stretch). δ_H (400MHz, C_6D_6) 0.78 (3H, t, *J* 7.0Hz, $CH_2C\underline{H}_3$), 1.00- 1.17 (3H, m, $C\underline{H}_2CH_3$ and one of $C\underline{H}_2CH_2CH_3$), 1.17- 1.52 (7H, m, $C\underline{H}_2(CH_2)_2CH_3$, one of $C\underline{H}_2CH_2CH_3$, $C\underline{H}_2CH(Ar)$, one of $C\underline{H}_2CHOH$, and one of $C\underline{H}_2CH_2CHOH$), 1.74- 1.81 (1H, m, one of $C\underline{H}_2CHOH$), 1.85- 1.95 (2H, m, one of $C\underline{H}_2CH_2CHOH$ and $C\underline{H}(C_4H_9)$), 3.34 (3H, s, $OC\underline{H}_3$), 3.60 (1H, app. bs, $C\underline{H}(Ar)$), 3.96 (1H, app. bd, *J* 2.5Hz, $C\underline{H}OH$), 6.60 (1H, d, *J* 8.0Hz, $C\underline{H}=COCH_3$), 6.95 (1H, t, *J* 8.0Hz, $C\underline{H}CHCH=COCH_3$), 7.08 (1H, dt, *J* 1.5 and 8.0Hz, $C\underline{H}CH=COCH_3$), 7.16 (1H, dd, *J* 1.5 and 8.0Hz, $C\underline{H}C(CH)=COCH_3$). δ_C (100MHz, C_6D_6) 14.3 ($CH_2\underline{C}H_3$), 20.7 ($\underline{C}H_2CH_2CHOH$), 23.1 ($\underline{C}H_2CH_3$), 29.0 ($\underline{C}H_2(CH_2)_2CH_3$), 29.4 ($\underline{C}H_2CH_2CH_3$), 30.2 ($\underline{C}H_2CH(Ar)$), 34.1 ($\underline{C}H_2CHOH$), 35.0 ($\underline{C}H(Ar)$), 45.6 ($\underline{C}H(C_4H_9)$), 54.9 ($O\underline{C}H_3$), 66.9 ($\underline{C}HOH$), 110.9 ($\underline{C}H=COCH_3$), 121.0 ($\underline{C}HCHCH=COCH_3$), 126.8 ($\underline{C}HCH=COCH_3$), 128.6 ($\underline{C}HC(CH)=COCH_3$), 134.9 ($\underline{C}(CH)=COCH_3$), 157.9 ($\underline{C}OCH_3$). m/z (EI, high resolution) found 262.1933 [$C_{17}H_{26}O_2$] ($(M)^+$, 26%) [requires 262.1933], 280.9818 (45), 242.9861 (50), 230.9860 (100).

Photolysis of the 3-carbon tether substrate (**7**)

1) Falling film

General Procedure D

A 8.3mM solution of (±) *(1S, 2R, 3S)-2-allyl-3-(2'-methoxyphenyl)cyclo-hexanol* (**7**) was prepared by dissolving 0.204g (0.83mmol) of the substrate in 100ml of cyclohexane. The flask was connected to a condenser and placed inside a thin-film photoreactor containing a low-pressure mercury arc lamp. The photoreactor pump was initiated and the system was completely de-gassed by bubbling nitrogen through the solution for 1 hour. After this time the flow of nitrogen was stopped and the lamp was switched on. After 1 hour of photoreaction TLC and NMR indicated that no more starting material remained and that four major photoproducts appeared to have formed. The reaction mixture was transferred to a separate flask before the system was thoroughly washed through with cyclohexane (4x50ml). All the washings were collected together and concentrated *in vacuo* to give a crude yellow oil. The three major products were separated from all the reaction by-products and then purified using flash column chromatography by gradually increasing the solvent polarity (95:5→90:10→85:15 petroleum ether [40-60]/ ethyl acetate).

2) Flow Photochemistry Recirculation Optimisation

A 4 mM solution of (±) *(1S, 2R, 3S)-2-allyl-3-(2'-methoxyphenyl)cyclo-hexanol* (**7**) was prepared by dissolving (0.020 g, 0.081mmol) of the substrate in 20 ml of cyclohexane. The flask was connected to the flow system by threading the input and output tubes through a red rubber septa. The flow system using consists of a Vapourtec peristatic pump, a cyclohexane-filled 10 mL reactor placed around a 25 W germicide lamp inside a light box with a gentle flow of compressed air for cooling (not essential). The pump flow rate was set to recirculate at 5 mL and the solvent was degassed by bubbling N_2 for 20 minutes. A balloon was then used to keep the flask under a positive pressure of N_2. The lamp was switched on and the reaction was analysed periodically. After 1h30, TLC and NMR indicated that no more starting material remained. The reactor was flushed with cyclohexane, concentrated *in vacuo* and then purified using flash column chromatography.

The ATOI ratio for this experiment was 0.33

$$ATOI\ ratio = \frac{Vol\ reactor}{Vol\ solvent\ used} = \frac{10}{10+20} = {}^{1}\!/_{3} \approx 0.33$$

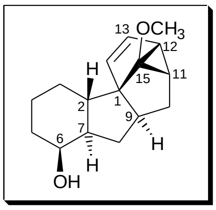
Hence **ATOI / Actual Time Of Irradiation = 30 minutes.**

3) Flow Photochemistry Continuous Flow / One Pass Manner

The flask containing a 4mM solution of (±) *(1S, 2R, 3S)-2-allyl-3-(2'-methoxyphenyl)cyclohexanol* (**7**) in cyclohexane was connected to the flow system by threading the input tube through a red rubber septa and the output went into the collection flask. The flow system using consists of a Vapourtec peristatic pump, and a 10 mL reactor placed around a 25 W germicide lamp inside a light box with a gentle flow of compressed air for cooling (not essential). The reaction mixture was degassed by bubbling N_2 for 20 minutes and then a balloon was used to keep the flask under a positive pressure of N_2. As the **ATOI / Actual Time Of Irradiation** for this 10 mL reactor system was known (30 minutes), the reaction was then performed in a continuous manner with a residence time of 30 minutes by flowing at 0.3 mL/min (10 mL / 30 minutes).

a. (±) (1*S*, 2*S*, 6*S*, 7*R*, 9*S*, 11*S*, 12*R*, 15*R*)-15-Methoxypentacyclo[10.2.1.0^{1,9}.0^{2,7}.0^{11,15}]pentadec-13-en-6-ol (**14**) – novel

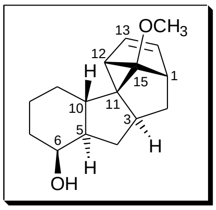
Fraction 3 was identified as the pure colourless oil (0.044g, 21%)



R_f = 0.15 (85:15 petroleum ether [40-60]/ ethyl acetate). λ_{max} (cyclohexane) 196, 222 and 274nm. ν_{max} (thin film, cm^{-1}) 3445 (OH). δ_H (400MHz, $CDCl_3$) 1.26- 1.37 (1H, m, one of $C\underline{H}_2CHCHOH$), 1.38- 1.59 (3H, m, one of $C\underline{H}_2CHOH$, one of $C\underline{H}_2CHCHOH$ and $C\underline{H}CHCHOH$), 1.62- 1.88 (7H, m, $C\underline{H}_2CHCHCHOH$, $C\underline{H}_2CHCHCH{=}CH$, $C\underline{H}_2CH_2CHOH$ and one of $C\underline{H}_2CHOH$), 2.03 (1H, ddd, *J* 1.0, 2.5 and 8.5Hz, $C\underline{H}CH{=}CH$), 2.05- 2.14 (1H, m, $C\underline{H}CH_2CHCHOH$), 2.21 (1H, app. dd, *J* 8.5 and 6.0Hz, $C\underline{H}CHCH{=}CH$), 2.40 (1H, app. dt, *J* 3.0 and 12.5Hz, $C\underline{H}CHOH$), 3.27 (3H, s, $OC\underline{H}_3$), 4.15 (1H, app. bs, $C\underline{H}OH$), 5.52 (1H, dd, *J* 2.5 and 5.5Hz, $CHC\underline{H}{=}CH$), 5.66 (1H, app. d, *J* 5.5Hz, $CHCH{=}C\underline{H}$). δ_C (100MHz, $CDCl_3$) 22.0 ($\underline{C}H_2CH_2CHOH$), 27.0 ($\underline{C}H_2CHCHCH{=}CH$), 29.5 ($\underline{C}H_2CHCHCHOH$), 32.3 ($\underline{C}H_2CHCHOH$), 33.2 ($\underline{C}H_2CHOH$), 34.7 ($\underline{C}HCHOH$), 35.1 ($\underline{C}HCH{=}CH$), 41.0 ($\underline{C}HCHCH{=}CH$), 54.2 ($\underline{C}HCHCHOH$), 56.5 ($O\underline{C}H_3$), 60.1 ($\underline{C}HCH_2CHCHOH$), 67.9 ($\underline{C}COCH_3$), 68.5 ($\underline{C}HOH$), 91.5 ($\underline{C}OCH_3$), 124.2 ($CH\underline{C}H{=}CH$), 136.2 ($CHCH{=}\underline{C}H$). m/z (EI, high resolution) found 246.1617 [$C_{16}H_{22}O_2$] ((M)$^+$, 46%) [requires 246.1620], 280.9817 (47), 230.9854 (100).

b. (±) (1*S*, 3*S*, 5*R*, 6*S*, 10*S*, 11*S*, 12*R*, 15*R*)-15-Methoxypentacyclo[10.2.1.$0^{3,11}$.$0^{5,10}$.$0^{11,15}$]pentadec-13-en-6-ol (**15**) – novel

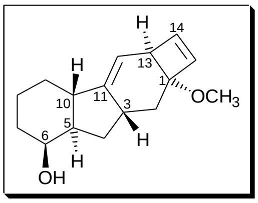
Fraction 2 contained the pure colourless oil (0.063g, 31%).



R_f = 0.20 (85:15 petroleum ether [40-60]/ ethyl acetate). λ_{max} (cyclohexane) 196 and 218nm. ν_{max} (thin film, cm^{-1}) 3422 (OH). δ_H (400MHz, CD_3OD) 1.09- 1.20 (1H, m, one of $C\underline{H}_2CHCHOH$), 1.42- 1.52 (1H, m, one of $C\underline{H}_2CHCHCHOH$), 1.55- 1.65 (1H, m, one of $C\underline{H}_2CHOH$), 1.65- 1.86 (4H, m, $C\underline{H}_2CH_2CHOH$, one of $C\underline{H}_2CHCHOH$ and $C\underline{H}CHCHOH$), 1.86- 1.98 (4H, m, $C\underline{H}CH_2CHCH{=}CH$, one of $C\underline{H}_2CHCH{=}CH$, one of $C\underline{H}_2CHOH$ and one of $C\underline{H}_2CHCHCHOH$), 2.19- 2.29 (2H, m, one of $C\underline{H}_2CHCH{=}CH$ and $CC\underline{H}CH{=}CH$), 2.35 (1H, app. dt, *J* 12.0 and 3.0Hz, one of $C\underline{H}CHOH$), 3.43- 3.47 (1H, m, $CH_2C\underline{H}CH{=}CH$), 3.53 (3H, s, $OC\underline{H}_3$), 4.14- 4.18 (1H, m, $C\underline{H}OH$), 5.70 (1H, ddd, *J* 1.5, 2.5 and 5.5Hz, $CH_2CHC\underline{H}{=}CH$), 5.74 (1H, dd, *J* 2.5 and 5.5Hz, $CH_2CHCH{=}C\underline{H}$). δ_C (100MHz, CD_3OD) 22.5 ($\underline{C}H_2CH_2CHOH$), 31.9 ($\underline{C}H_2CHCHOH$), 35.3 ($\underline{C}H_2CHOH$), 36.1 ($\underline{C}HCHOH$), 36.4 ($\underline{C}H_2CHCHCHOH$), 39.2 ($C\underline{C}HCH{=}CH$), 45.4 ($\underline{C}HCH_2CHCH{=}CH$), 45.5($\underline{C}H_2CHCH{=}CH$), 56.6 ($CH_2\underline{C}HCH{=}CH$ and $\underline{C}COCH_3$), 57.4 ($\underline{C}HCHCHOH$), 57.8 ($O\underline{C}H_3$), 69.8 ($\underline{C}HOH$), 89.2 ($\underline{C}OCH_3$), 129.5 ($CH_2CHCH{=}\underline{C}H$), 134.5 ($CH_2CH\underline{C}H{=}CH$). m/z (CI, NH_3, high resolution) found 247.1704 [$C_{16}H_{22}O_2$] ($(MH)^+$, 22%) [requires 247.1698], 215.1396 (100), 197.1553 (49).

c. (±) (1*S*, 3*S*, 5*R*, 6*S*, 10*S*, 13*R*)-1-Methoxytetracyclo[11.2.$0^{1,13}$.$0^{3,11}$.$0^{5,10}$]pentadec-11,14-dien-6-ol (**16**) – novel

Fraction 1 was found to contain the pure cream coloured solid (0.044g, 22%).

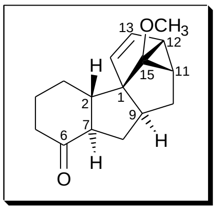


Mp. 83-86 °C. R_f = 0.24 (85:15 petroleum ether [40-60]/ ethyl acetate). λ_{max} (cyclohexane) 197 and 275nm. ν_{max} (KBr disc, cm^{-1}) 3322 (OH). δ_H (400MHz, $CDCl_3$) 0.99- 1.10 (1H, m, one of $C\underline{H}_2CHCHCHOH$), 1.18- 1.26 (1H, m, one of $C\underline{H}_2COCH_3$), 1.32- 1.48 (3H, m, $C\underline{H}CHOH$, one of $C\underline{H}_2CHCHOH$ and one of $C\underline{H}_2CHOH$), 1.56- 1.64 (2H, m, $C\underline{H}_2CH_2CHOH$), 1.81- 1.93 (2H, m, one of $C\underline{H}_2CHOH$ and one of $C\underline{H}_2CHCHOH$), 1.96- 2.03 (1H, m, one of $C\underline{H}_2CHCHCHOH$), 2.05 (1H, dd, *J* 5.0 and 12.0Hz, one of $C\underline{H}_2COCH_3$), 2.16- 2.26 (1H, m, $C\underline{H}CHCHOH$), 2.28- 2.38 (1H, m, $C\underline{H}CH_2COCH_3$), 3.28- 3.31 (1H, m, $C\underline{H}CH{=}CH$), 3.33 (3H, s, $OC\underline{H}_3$), 4.08- 4.11 (1H, m, $C\underline{H}OH$), 5.33- 5.37 (1H, m,

$C\underline{H}=C(CH)_2$), 6.09 (1H, dd, *J* 0.5 and 3.0Hz, $CHCH=C\underline{H}$), 6.11 (1H, app. dt, *J* 3.0 and 1.0Hz, $CHC\underline{H}=CH$). δ_C (100MHz, $CDCl_3$) 19.5 ($\underline{C}H_2CH_2CHOH$), 28.2 ($\underline{C}H_2CHCHCHOH$), 30.7 ($\underline{C}H_2CHCHOH$), 33.2 ($\underline{C}HCH_2COCH_3$), 33.6 ($\underline{C}H_2CHOH$), 37.6 ($\underline{C}H_2COCH_3$), 41.9 ($\underline{C}HCHCHOH$), 46.4 ($\underline{C}HCH=CH$), 48.5 ($\underline{C}HCHOH$), 51.7 ($O\underline{C}H_3$), 67.5 ($\underline{C}HOH$), 84.8 ($\underline{C}OCH_3$), 113.4 ($\underline{C}H=C(CH)_2$), 136.0 ($CH\underline{C}H=CH$), 139.3 ($CHCH=\underline{C}H$), 154.1 ($CH=\underline{C}(CH)_2$). m/z (CI, NH_3, high resolution) found 247.1702 [$C_{16}H_{22}O_2$] ($(MH)^+$, 12%) [requires 247.1698], 232.2001 (52), 215.1418 (100).

Identification of 3-carbon tether cycloadducts

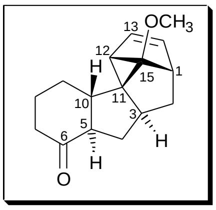
a. (±) (1*S*, 2*S*, 7*R*, 9*S*, 11*S*, 12*R*, 15*R*)-15-Methoxypentacyclo-[10.2.1.0^{1,9}.0^{2,7}.0^{11,15}]pentadec-13-en-6-one (**17**)[15]



Cycloadduct (**17**) was synthesised according to general procedure E from a solution of the compound (±) *(1S, 2S, 6S, 7R, 9S, 11S, 12R, 15R)-15-methoxypentacyclo-[10.2.1.0^{1,9}.0^{2,7}.0^{11,15}]pentadec-13-en-6-ol* (**14**) (0.064g, 0.26mmol) in dry DCM (2ml) and pyridinium chlorochromate (0.100g, 0.55mmol) in anhydrous DCM (2x1ml). The reaction mixture was stirred for 1 hour under argon until TLC indicated that no more starting material remained. Flash column chromatography (80:20 petroleum ether [40-60]/ ethyl acetate) yielded the pure semi-solid *meta* cycloadduct ketone (±) *(1S, 2S, 7R, 9S, 11S, 12R, 15R)-15-methoxypenta-cyclo[10.2.1.0^{1,9}.0^{2,7}.0^{11,15}]pentadec-13-en-6-one* (**17**) (0.028g, 44%).

Mp. 85-88 °C. $R_f = 0.22$ (80:20 petroleum ether [40-60]/ ethyl acetate). λ_{max} (cyclohexane) 194, 216 and 282nm. ν_{max} (KBr disc, cm^{-1}) 1712 (C=O). δ_H (400MHz, $CDCl_3$) 1.55- 1.74 (4H, m, $C\underline{H}_2CHC{=}O$, one of $C\underline{H}_2CHCHC{=}O$ and one of $C\underline{H}_2CHCHCH{=}CH$), 1.74- 1.85 (1H, m, one of $C\underline{H}_2CH_2C{=}O$), 1.87 (1H, ddd, *J* 1.0, 6.0 and 14.0Hz, one of $C\underline{H}_2CHCHCH{=}CH$), 1.92- 1.99 (1H, m, one of $C\underline{H}_2CHCHC{=}O$), 2.05 (1H, dd, *J* 2.5 and 8.5Hz, $C\underline{H}CH{=}CH$), 2.10- 2.28 (3H, m, $C\underline{H}CH_2CHC{=}O$, one of $C\underline{H}_2CH_2C{=}O$ and $C\underline{H}CHCH{=}CH$), 2.28- 2.40 (3H, m, $C\underline{H}_2C{=}O$ and $C\underline{H}CHC{=}O$), 2.44 (1H, dt, *J* 4.5 and 12.0Hz, $C\underline{H}C{=}O$), 3.21 (3H, s, $OC\underline{H}_3$), 5.58 (1H, dd, *J* 2.5 and 5.5Hz, $CHC\underline{H}{=}CH$), 5.71 (1H, d, *J* 5.5Hz, $CHCH{=}C\underline{H}$). δ_C (100MHz, $CDCl_3$) 26.8 ($\underline{C}H_2CHCHCH{=}CH$), 27.9 ($\underline{C}H_2CH_2C{=}O$), 28.6 ($\underline{C}H_2CHCHC{=}O$), 29.3 ($\underline{C}H_2CHC{=}O$), 35.2 ($\underline{C}HCH{=}CH$), 40.7 ($\underline{C}HCHCH{=}CH$), 40.9 ($\underline{C}H_2C{=}O$), 45.1 ($\underline{C}HCHC{=}O$), 56.4 ($O\underline{C}H_3$), 59.6 ($\underline{C}HCH_2CHC{=}O$), 61.4 ($\underline{C}HC{=}O$), 68.0 ($\underline{C}COCH_3$), 91.3 ($\underline{C}OCH_3$), 125.1 ($CH\underline{C}H{=}CH$), 135.0 ($CHCH{=}\underline{C}H$), 210.7 ($\underline{C}{=}O$). m/z (CI, NH_3, high resolution) found 245.1552 [$C_{16}H_{20}O_2$] (($MH)^+$, 16%) [requires 245.1542], 212.9707 (100), 146.9782 (43).

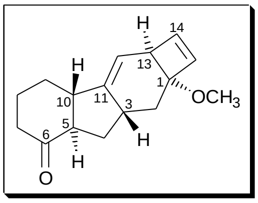
b. (±) (1*S*, 3*S*, 5*R*, 10*S*, 11*S*, 12*R*, 15*R*)-15-Methoxypentacyclo-[10.2.1.$0^{3,11}$.$0^{5,10}$.$0^{11,15}$]pentadec-13-en-6-one – novel



Prepared according to general procedure E from a solution of cycloadduct (±) *(1S, 3S, 5R, 6S, 10S, 11S, 12R, 15R)-15-methoxypentacyclo[10.2.1.$0^{3,11}$.$0^{5,10}$.$0^{11,15}$]-pentadec-13-en-6-ol* (**15**) (0.050g, 0.20mmol) in anhydrous DCM (1ml) and pyridinium chlorochromate (0.112g, 0.61mmol) in anhydrous DCM (2x1ml). After 1.5 hours of stirring under argon, TLC indicated that the reaction had run to completion. Pure *meta* cycloadduct ketone (±) *(1S, 3S, 5R, 10S, 11S, 12R, 15R)-15-methoxypentacyclo[10.2.1.$0^{3,11}$.$0^{5,10}$.$0^{11,15}$]-pentadec-13-en-6-one* was obtained by flash column chromatography (90:10 petroleum ether [40-60]/ ethyl acetate) as a yellow coloured crystalline solid (0.039g, 77%).

Mp. 62-64 °C. $R_f = 0.22$ (90:10 petroleum ether [40-60]/ ethyl acetate). λ_{max} (cyclohexane) 198, 218 and 275nm. ν_{max} (KBr disc, cm^{-1}) 1717 (C=O). δ_H (400MHz, CD_3OD) 1.53 (1H, app. dt, *J* 10.0 and 12.0Hz, one of $C\underline{H}_2CHC=O$), 1.67 (1H, app. dt, *J* 4.0 and 12.0Hz, one of $C\underline{H}_2CHCH=CH$), 1.79- 1.90 (1H, m, one of $C\underline{H}_2CH_2C=O$), 1.90- 2.02 (3H, m, one of $C\underline{H}_2CHCH=CH$ and $C\underline{H}_2CHCHC=O$), 2.19 (1H, ddd, *J* 5.0, 7.5 and 12.0Hz, one of $C\underline{H}_2CHC=O$), 2.30 (1H, app. dt, *J* 3.0 and 13.0Hz, $C\underline{H}CHC=O$), 2.31- 2.40 (2H, m, one of $C\underline{H}_2CH_2C=O$ and $C\underline{H}CH_2CHC=O$), 2.40- 2.47 (2H, m, $CC\underline{H}CH=CH$ and one of $C\underline{H}_2C=O$), 2.58 (1H, ddt, *J* 1.5, 7.0 and 14.0Hz, one of $C\underline{H}_2C=O$), 2.96 (1H, dddd, *J* 1.5, 5.0, 12.0 and 13.0Hz, $C\underline{H}C=O$), 3.50- 3.53 (1H, m, $CH_2C\underline{H}CH=CH$), 3.57 (3H, s, $OC\underline{H}_3$), 5.79 (1H, ddd, *J* 1.5, 2.5 and 5.5Hz, $CH_2CHC\underline{H}=CH$), 5.83 (1H, dd, *J* 2.5 and 5.5Hz, $CCHC\underline{H}=CH$). δ_C (100MHz, CD_3OD) 28.5 ($\underline{C}H_2CH_2C=O$), 29.8 ($\underline{C}H_2CHCH=CH$), 32.3 ($\underline{C}H_2CHC=O$), 38.8 ($C\underline{C}HCH=CH$), 41.9 ($\underline{C}H_2C=O$), 44.1 ($\underline{C}HCH_2CHC=O$), 44.7 ($\underline{C}H_2CHCHC=O$), 46.5 ($\underline{C}HCHC=O$), 54.8 ($\underline{C}CHCH=CH$), 55.5 ($CH_2\underline{C}HCH=CH$), 57.1 ($O\underline{C}H_3$), 62.8 ($\underline{C}HC=O$), 87.8 ($\underline{C}OCH_3$), 128.2 ($CCH\underline{C}H=CH$), 134.0 ($CH_2CH\underline{C}H=CH$), 213.5 ($\underline{C}=O$). m/z (CI, NH_3, high resolution) found 245.1537 [$C_{16}H_{20}O_2$] (($MH)^+$, 100%) [requires 245.1542], 207.0275 (24), 147.0860 (43), 56.0610 (33).

c. (±) (1*S*, 3*S*, 5*R*, 10*S*, 13*R*)-1-Methoxytetracyclo[11.2.0^{1,13}.0^{3,11}.0^{5,10}]-pentadec-11,14-dien-6-one – novel



General Procedure E

To an argon flushed round-bottomed flask containing a solution of cycloadduct alcohol (±) *(1S, 3S, 5R, 6S, 10S, 13R)-1-methoxytetracyclo[11.2.0^{1,13}.0^{3,11}.0^{5,10}]pentadec-11,14-dien-6-ol* (**16**) (0.089g, 0.36mmol) in anhydrous DCM (5ml) was added a solution of pyridinium chlorochromate (0.134g, 0.73mmol) in dry DCM (2x2ml) *via* syringe. On stirring, the reaction mixture turned dark brown as the insoluble reduced reagent was deposited. After 2 hours of stirring under argon, TLC indicated that no more starting material remained. The mixture was diluted with diethyl ether (15 ml), the solvent decanted, and the black solid washed with diethyl ether (3x20ml). The crude product was isolated simply by filtration of the combined organic washings through Florisil and evaporation of the solvent *in vacuo*. Flash column chromatography (95:5 petroleum ether [40-60]/ ethyl acetate) afforded the pure cycloadduct ketone (±) *(1S, 3S, 5R, 10S, 13R)-1-methoxytetracyclo-[11.2.0^{1,13}.0^{3,11}.0^{5,10}]pentadec-11,14-dien-6-one* as a cream coloured crystalline solid (0.033g, 37%).

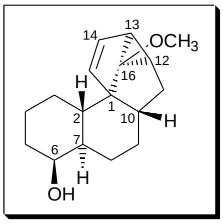
Mp. 66-68 °C. R_f = 0.24 (95:5 petroleum ether [40-60]/ ethyl acetate). λ_{max} (cyclohexane) 203nm. ν_{max} (KBr disc, cm^{-1}) 1710 (C=O). δ_H (400MHz, $CDCl_3$) 1.20 (1H, app. t, *J* 12.5Hz, one of $C\underline{H}_2COCH_3$), 1.40- 1.52 (1H, m, one of $C\underline{H}_2CHCHC{=}O$), 1.53 (1H, ddd, *J* 2.0, 6.0 and 13.0Hz, one of $C\underline{H}_2CHC{=}O$), 1.65- 1.78 (1H, m, one of $C\underline{H}_2CH_2C{=}O$), 2.05- 2.22 (4H, m, one of $C\underline{H}_2COCH_3$, one of $C\underline{H}_2CHC{=}O$, one of $C\underline{H}_2CHCHC{=}O$ and one of $C\underline{H}_2CH_2C{=}O$), 2.23- 2.41 (5H, m, $C\underline{H}CHC{=}O$, $C\underline{H}_2C{=}O$, $C\underline{H}C{=}O$ and $C\underline{H}CH_2COCH_3$), 3.28- 3.33 (1H, m, $C\underline{H}CH{=}CHCOCH_3$), 3.33 (3H, s, $OC\underline{H}_3$), 5.45- 5.49 ($C\underline{H}{=}C(CH)_2$), 6.08 (1H, dd, *J* 1.0 and 3.0Hz, $CH{=}C\underline{H}COCH_3$), 6.13 (1H, app. dt, *J* 3.0 and 1.0Hz, $C\underline{H}{=}CHCOCH_3$). δ_C (100MHz, $CDCl_3$) 27.2 ($\underline{C}H_2CH_2C{=}O$), 27.4 ($\underline{C}H_2CHCHC{=}O$), 27.9 ($\underline{C}H_2CHC{=}O$), 33.0 ($\underline{C}HCH_2CHC{=}O$), 37.5 ($\underline{C}H_2COCH_3$), 41.7 ($\underline{C}H_2C{=}O$), 46.2 ($\underline{C}HCH{=}CHCOCH_3$), 51.7 ($O\underline{C}H_3$), 52.2 ($\underline{C}HCHC{=}O$), 55.9 ($\underline{C}HC{=}O$), 84.4 ($\underline{C}OCH_3$), 114.7 ($\underline{C}H{=}C(CH)_2$), 136.2 ($\underline{C}H{=}CHCOCH_3$), 139.0 ($CH{=}\underline{C}HCOCH_3$), 151.7 ($CH{=}\underline{C}(CH)_2$), 211.3 ($\underline{C}{=}O$). m/z (EI, high resolution) found 244.1470 [$C_{16}H_{20}O_2$] ((M)$^+$, 2%) [requires 244.1463], 254.9849 (17), 230.9858 (100).

Photolysis of the 4-carbon tether substrate (**8**)

Photolysis of substrate (**8**) was carried out according to general procedure D. A 4.5mM solution of (±) *(1S, 2R, 3S)-2-but-3'-enyl-3-(2"-methoxyphenyl)cyclo-hexanol* (**8**) (0.118g, 0.45mmol) in cyclohexane (100ml) was irradiated for 1.5 hours until TLC and NMR spectroscopy indicated that no more starting material remained. Analysis also suggested that two major products had formed. All the washings from the thin film photoreactor were collected together and concentrated *in vacuo* to give a crude yellow oil. The two main photoproducts were separated from all the reaction by-products and then purified using flash column chromatography by gradually increasing the solvent polarity (95:5→90:10→85:15 petroleum ether [40-60]/ diethyl ether).

a. (±) (1*R*, 2*S*, 6*S*, 7*R*, 10*S*, 12*R*, 13*S*, 16*S*)-16-Methoxypentacyclo[11.2.1.$0^{1,10}$.$0^{2,7}$.$0^{12,16}$]hexadec-14-en-6-ol (**19**)[15]

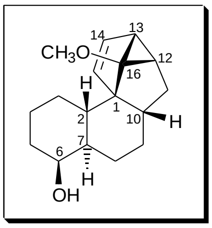
Fraction 1 was found to contain the pure colourless oil (0.048g, 40%).



R_f = 0.27 (90:10 dichloromethane/ petroleum ether [40-60]). λ_{max} (cyclohexane) 224 and 287nm. ν_{max} (thin film, cm^{-1}) 3432 (OH). δ_H (400MHz, CD_3OD) 1.34 (1H, dd, *J* 6.5 and 13.0Hz, one of $\mathrm{C\underline{H}_2CHCHCH{=}CH}$), 1.42- 1.56 (6H, m, $\mathrm{C\underline{H}_2CHCHOH}$, one of $\mathrm{C\underline{H}_2CH_2CHOH}$, one of $\mathrm{C\underline{H}_2CHCHCH{=}CH}$, one of $\mathrm{C\underline{H}_2CHOH}$ and one of $\mathrm{C\underline{H}_2CH_2CHCHOH}$), 1.58- 1.78 (7H, m, $\mathrm{C\underline{H}CH_2CHCHCH{=}CH}$, $\mathrm{C\underline{H}_2CHCHCHOH}$, one of $\mathrm{C\underline{H}_2CH_2CHOH}$, one of $\mathrm{C\underline{H}_2CH_2CHCHOH}$, $\mathrm{C\underline{H}CHCHOH}$ and $\mathrm{C\underline{H}CHOH}$), 1.80- 1.87 (1H, m, one of $\mathrm{C\underline{H}_2CHOH}$), 2.14- 2.19 (1H, m, $\mathrm{C\underline{H}CHCH{=}CH}$), 2.34 (1H, app. dt, *J* 8.5 and 2.0Hz, $\mathrm{C\underline{H}CH{=}CH}$), 3.25 (3H, s, $\mathrm{OC\underline{H}_3}$), 3.77- 3.80 (1H, m, $\mathrm{C\underline{H}OH}$), 5.31 (1H, dd, *J* 2.0 and 5.5Hz, $\mathrm{CHCH{=}C\underline{H}}$), 5.54 (1H, dd, *J* 2.0 and 5.5Hz, $\mathrm{CHC\underline{H}{=}CH}$). δ_C (100MHz, CD_3OD) 21.6 ($\mathrm{\underline{C}H_2CH_2CHOH}$), 28.5 ($\mathrm{\underline{C}H_2CHCHCHOH}$), 29.3 ($\mathrm{\underline{C}H_2CHCHCH{=}CH}$), 29.8 ($\mathrm{\underline{C}H_2CH_2CHCHOH}$), 29.9 ($\mathrm{\underline{C}H_2CHCHOH}$), 31.3 ($\mathrm{\underline{C}HCHCH{=}CH}$), 34.8 ($\mathrm{\underline{C}H_2CHOH}$), 37.3 ($\mathrm{\underline{C}HCH{=}CH}$), 39.3 ($\mathrm{\underline{C}HCHCHOH}$), 43.0 ($\mathrm{\underline{C}HCHOH}$), 53.2 ($\mathrm{\underline{C}HCH_2CHCHCH{=}CH}$), 55.0 ($\mathrm{O\underline{C}H_3}$), 66.1 ($\mathrm{\underline{C}CH{=}CH}$), 71.4 ($\mathrm{\underline{C}HOH}$), 90.6 ($\mathrm{\underline{C}OCH_3}$), 125.0 ($\mathrm{CH\underline{C}H{=}CH}$), 139.5 ($\mathrm{CHCH{=}\underline{C}H}$). m/z (CI, NH_3, high resolution) found 261.1856 [$C_{17}H_{24}O_2$] ($(MH)^+$, 26%) [requires 261.1855], 211.1435 (100), 146.0965 (20).

b. (±) (1*S*, 2*S*, 6*S*, 7*R*, 10*S*, 12*S*, 13*R*, 16*R*)-16-Methoxypentacyclo[11.2.1.$0^{1,10}$.$0^{2,7}$.$0^{12,16}$]hexadec-14-en-6-ol (**18**)[15]

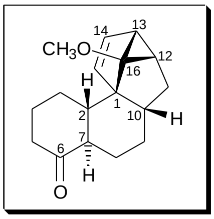
Fraction 2 contained the pure solid (0.059g, 50%).



Mp. 62-64 °C. $R_f = 0.15$ (dichloromethane). λ_{max} (cyclohexane) 231 and 276nm. ν_{max} (thin film, cm^{-1}) 3448 (OH). δ_H (400MHz, CD_3OD) 0.98- 1.15 (2H, m, one of $C\underline{H}_2CHCHCH{=}CH$ and one of $C\underline{H}_2CHCHOH$), 1.15- 1.25 (1H, m, one of $C\underline{H}_2CH_2CHCHOH$), 1.40- 1.60 (6H, m, one of $C\underline{H}_2CH_2CHOH$, $C\underline{H}_2CHCHCHOH$, $C\underline{H}CHOH$, one of $C\underline{H}_2CHOH$ and one of $C\underline{H}_2CH_2CHCHOH$), 1.71- 1.81 (1H, m, one of $C\underline{H}_2CH_2CHOH$), 1.81- 1.90 (2H, m, one of $C\underline{H}_2CHOH$ and one of $C\underline{H}_2CHCHCH{=}CH$), 1.95- 2.11 (4H, m, one of $C\underline{H}_2CHCHOH$, $C\underline{H}CH_2CHCHCH{=}CH$, $C\underline{H}CHCH{=}CH$ and $C\underline{H}CHCHOH$), 2.21 (1H, dt, *J* 8.5 and 2.0Hz, $C\underline{H}CH{=}CH$), 3.51 (3H, s, $OC\underline{H}_3$), 3.84 (1H, app. bq, *J* 2.5Hz, $C\underline{H}OH$), 5.63- 5.68 (2H, m, $CHC\underline{H}{=}CH$ and $CHCH{=}C\underline{H}$). δ_C (100MHz, CD_3OD) 21.0 ($\underline{C}H_2CH_2CHOH$), 27.7 ($\underline{C}H_2CH_2CHCHOH$ and $\underline{C}H_2CHCHCH{=}CH$), 30.0 ($\underline{C}H_2CHCHOH$), 30.4 ($\underline{C}HCHCH{=}CH$), 31.1 ($\underline{C}H_2CHCHCHOH$), 35.0 ($\underline{C}H_2CHOH$), 39.0 ($\underline{C}HCHOH$), 39.7 ($\underline{C}HCH{=}CH$), 44.2 ($\underline{C}HCHCHOH$), 57.9 ($O\underline{C}H_3$), 60.5 ($\underline{C}HCH_2CHCHCH{=}CH$), 65.1 ($\underline{C}CH{=}CH$), 71.1 ($\underline{C}HOH$), 91.9 ($\underline{C}OCH_3$), 127.2 and 132.4 ($CHCH{=}\underline{C}H$ and $CH\underline{C}H{=}CH$). m/z (EI, high resolution) found 260.1778 [$C_{17}H_{24}O_2$] ($(M)^+$, 9%) [requires 260.1776], 280.9822 (44), 242.9863 (49), 230.9862 (100).

Identification of 4-carbon tether cycloadducts

a. (±) (1*S*, 2*S*, 7*R*, 10*S*, 12*S*, 13*R*, 16*R*)-16-Methoxypentacyclo-[11.2.1.$0^{1,10}$.$0^{2,7}$.$0^{12,16}$]hexadec-14-en-6-one (**20**) [15]

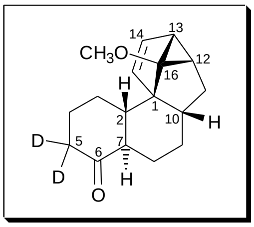


Compound (**20**) was prepared according to general procedure E using solutions of cycloadduct (±) *(1S, 2S, 6S, 7R, 10S, 12S, 13R, 16R)-16-methoxypentacyclo-[11.2.1.$0^{1,10}$.$0^{2,7}$.$0^{12,16}$]-hexadec-14-en-6-ol* (**18**) (0.020g, 0.08mmol) in anhydrous DCM (2ml) and pyridinium chlorochromate (0.023g, 0.12mmol) in anhydrous DCM (2x1ml). After 30 minutes of stirring under nitrogen, TLC indicated that no more starting material remained. Pure ketone cycloadduct (±) *(1S, 2S, 7R, 10S, 12S, 13R, 16R)-16-methoxypentacyclo[11.2.1.$0^{1,10}$.$0^{2,7}$.$0^{12,16}$]-hexadec-14-en-6-one* (**20**) (0.016g, 81%) was obtained by flash column chromatography (90:10 petroleum ether [40-60]/ ethyl acetate) as a cream coloured solid.

Mp. 102-105 °C. R_f = 0.22 (90:10 petroleum ether [40-60]/ ethyl acetate). λ_{max} (cyclohexane) 209 and 275nm. ν_{max} (thin film, cm^{-1}) 1713 (C=O). δ_H (400MHz, CD_3OD) 1.06 (1H, app. ddd, *J* 1.5, 11.5 and 13.0Hz, one of $\mathrm{C\underline{H}_2CHCHCH{=}CH}$), 1.15 (1H, dt, *J* 3.5 and 13.0Hz, one of $\mathrm{C\underline{H}_2CH_2CHC{=}O}$), 1.33- 1.46 (1H, m, one of $\mathrm{C\underline{H}_2CHC{=}O}$), 1.51- 1.63 (2H, m, one of $\mathrm{C\underline{H}_2CH_2CHC{=}O}$ and one of $\mathrm{C\underline{H}_2(CH_2)_2C{=}O}$), 1.64- 1.77 (1H, m, one of $\mathrm{C\underline{H}_2CH_2C{=}O}$), 1.85- 1.95 (3H, m, one of $\mathrm{C\underline{H}_2CHC{=}O}$, one of $\mathrm{C\underline{H}_2CHCHCH{=}CH}$ and $\mathrm{C\underline{H}CHC{=}O}$), 1.99- 2.09 (1H, m, $\mathrm{C\underline{H}CH_2CH_2CHC{=}O}$), 2.09- 2.22 (3H, m, $\mathrm{C\underline{H}CHCH{=}CH}$, one of $\mathrm{C\underline{H}_2CH_2C{=}O}$ and one of $\mathrm{C\underline{H}_2(CH_2)_2C{=}O}$), 2.28 (1H, dt, *J* 8.5 and 2.0Hz, $\mathrm{C\underline{H}CH{=}CH}$), 2.34 (1H, app. dquintet, *J* 13.5 and 2.0Hz, one of $\mathrm{C\underline{H}_2C{=}O}$), 2.46 (1H, app. tdd, *J* 13.5, 6.0 and 1.5Hz, one of $\mathrm{C\underline{H}_2C{=}O}$), 2.50 (1H, app. ddt, *J* 1.5, 4.0 and 12.0Hz, $\mathrm{C\underline{H}C{=}O}$), 3.45 (3H, s, $\mathrm{OC\underline{H}_3}$), 5.75- 5.79 (2H, m, $\mathrm{CHCH{=}C\underline{H}}$ and $\mathrm{CHC\underline{H}{=}CH}$). δ_C (100MHz, $CDCl_3$) 25.4 ($\mathrm{\underline{C}H_2CHC{=}O}$), 25.5 ($\mathrm{\underline{C}H_2CH_2CHC{=}O}$), 26.6 ($\mathrm{\underline{C}H_2CHCHCH{=}CH}$), 26.7 ($\mathrm{\underline{C}H_2CH_2C{=}O}$), 28.3 ($\mathrm{\underline{C}H_2(CH_2)_2C{=}O}$), 29.5 ($\mathrm{\underline{C}HCHCH{=}CH}$), 38.5 ($\mathrm{\underline{C}HCH{=}CH}$), 42.3 ($\mathrm{\underline{C}H_2C{=}O}$), 47.2 ($\mathrm{\underline{C}HCHC{=}O}$), 51.4 ($\mathrm{\underline{C}HC{=}O}$), 57.5 ($\mathrm{O\underline{C}H_3}$), 58.7 ($\mathrm{\underline{C}HCH_2CH_2CHC{=}O}$), 63.9 ($\mathrm{\underline{C}CH{=}CH}$), 90.8 ($\mathrm{\underline{C}OCH_3}$), 127.6 ($\mathrm{CH\underline{C}H{=}CH}$), 129.5 ($\mathrm{CHCH{=}\underline{C}H}$), 213.0 ($\mathrm{\underline{C}{=}O}$). m/z (CI, NH_3, high resolution) found 259.1699 [$C_{17}H_{22}O_2$] ($(MH)^+$, 100%) [requires 259.1699], 204.1044 (72), 84.0956 (14).

Deuteration and desaturation for identification of 4-carbon tether cycloadduct

a. (±) (1*S*, 2*S*, 7*R*, 10*S*, 12*S*, 13*R*, 16*R*)-5,5-Dideutero-16-methoxypentacyclo-[11.2.1.$0^{1,10}$.$0^{2,7}$.$0^{12,16}$]hexadec-14-en-6-one – novel

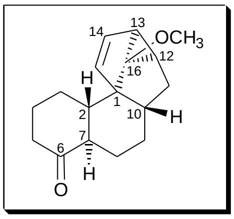


General Procedure F

To a vial containing a small volume of methanol-d_4 was added a tiny piece of sodium metal. After 10 minutes, the sodium had completely dissolved to form a solution of sodium methoxide-d_3. Two drops of this mixture were added to a vial containing a solution of the cycloadduct ketone (±) *(1S, 2S, 7R, 10S, 12S, 13R, 16R)-16-methoxypentacyclo-[11.2.1.$0^{1,10}$.$0^{2,7}$.$0^{12,16}$]hexadec-14-en-6-one* (**18**) (0.016g, 0.06mmol) dissolved in methanol-d_4. The vial was shaken vigorously and within 15-20 minutes the two most acidic protons (α to the carbonyl) had become fully deuterated. The contents of the vial containing the deuterated product were then transferred to a tube containing a mixture of NH_4Cl solution and ethyl acetate. The tube was shaken vigorously before the mixture was transferred to a small separating funnel. The organic product was separated and the aqueous layer washed with ethyl acetate (3x10ml). The combined organic extracts were washed with NH_4Cl solution (10ml) and water (10ml). The organic layer was then dried over $MgSO_4$, filtered and concentrated *in vacuo* to afford the pure deuterated cycloadduct ketone (±) *(1S, 2S, 7R, 10S, 12S, 13R, 16R)-5,5-dideutero-16-methoxypentacyclo[11.2.1.$0^{1,10}$.$0^{2,7}$.$0^{12,16}$]-hexadec-14-en-6-one* (quantitative).

Mp. 101-103 °C. R_f = 0.22 (90:10 petroleum ether [40-60]/ ethyl acetate). λ_{max} (cyclohexane) 219 and 274nm. ν_{max} (thin film, cm^{-1}) 1709 (C=O). δ_H (400MHz, CD_3OD) 1.06 (1H, ddd, *J* 1.5, 11.5 and 13.0Hz, one of $C\underline{H}_2CHCHCH=CH$), 1.15 (1H, dt, *J* 3.5 and 13.0Hz, one of $C\underline{H}_2CH_2CHC=O$), 1.33- 1.46 (1H, m, one of $C\underline{H}_2CHC=O$), 1.51- 1.63 (2H, m, one of $C\underline{H}_2CH_2CD_2$ and one of $C\underline{H}_2CH_2CHC=O$), 1.63- 1.76 (1H, m, one of $C\underline{H}_2CD_2$), 1.84- 1.94 (3H, m, one of $C\underline{H}_2CHCHCH=CH$, one of $C\underline{H}_2CHC=O$ and $C\underline{H}CHC=O$), 1.98- 2.08 (1H, m, $C\underline{H}CH_2CH_2CHC=O$), 2.08- 2.14 (2H, m, one of $C\underline{H}_2CD_2$ and $C\underline{H}CHCH=CH$), 2.14- 2.22 (1H, m, one of $C\underline{H}_2CH_2CD_2$), 2.27 (1H, dt, *J* 8.5 and 2.0Hz, $C\underline{H}CH=CH$), 2.50 (1H, app. dt, *J* 4.0 and 12.0Hz, $C\underline{H}C=O$), 3.45 (3H, s, $OC\underline{H}_3$), 5.75- 5.79 (2H, m, $CHCH=C\underline{H}$ and $CHC\underline{H}=CH$). δ_C (100MHz, CD_3OD) 26.5 ($\underline{C}H_2CH_2CHC=O$), 26.6 ($\underline{C}H_2CHC=O$), 27.5 ($\underline{C}H_2CHCHCH=CH$), 27.7 ($\underline{C}H_2CD_2$), 29.2 ($\underline{C}H_2CH_2CD_2$), 30.3 ($\underline{C}HCHCH=CH$), 39.5 ($\underline{C}HCH=CH$), 42.6 (bquintet, $\underline{C}D_2$), 48.8 ($\underline{C}HCHC=O$), 52.3 ($\underline{C}HC=O$), 57.7 ($O\underline{C}H_3$), 60.0 ($\underline{C}HCH_2CH_2CHC=O$), 65.2 ($\underline{C}CH=CH$), 92.1 ($\underline{C}OCH_3$), 128.3 and 131.0 ($CH\underline{C}H=CH$ and $CHCH=\underline{C}H$), 215.5 ($\underline{C}=O$). m/z (CI, NH_3, high resolution) found 260.1761 [$C_{17}H_{20}D_2O_2$] ((M)$^+$, 100%) [requires 260.1743], 205.1155 (41), 147.0861 (26), 121.0670 (17), 96.0557 (21).

b. (±) (1*R*, 2*S*, 7*R*, 10*S*, 12*R*, 13*S*, 16*S*)-16-Methoxypentacyclo-[11.2.1.0^{1,10}.0^{2,7}.0^{12,16}]hexadec-14-en-6-one – novel

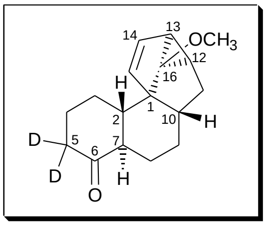


Cycloadduct was synthesised according to general procedure E from a solution of the cycloadduct alcohol (±) *(1R, 2S, 6S, 7R, 10S, 12R, 13S, 16S)-16-methoxypentacyclo-[11.2.1.0^{1,10}.0^{2,7}.0^{12,16}]hexadec-14-en-6-ol* (**19**) (0.027g, 0.10mmol) in dry DCM (2ml) and a solution of pyridinium chlorochromate (0.057g, 0.31mmol) in anhydrous DCM (2x1ml). After 1 hour of stirring under argon, TLC indicated that the reaction had run to completion. The pure semi-solid cycloadduct ketone (±) *(1R, 2S, 7R, 10S, 12R, 13S, 16S)-16-methoxypentacyclo-[11.2.1.0^{1,10}.0^{2,7}.0^{12,16}]hexadec-14-en-6-one* (123) was obtained by flash column chromatography (90:10 petroleum ether [40-60]/ ethyl acetate) (0.021g, 78%). Slow re-crystallisation of the product from cyclohexane afforded a cream/yellow crystalline solid.

Mp. 58-61 °C. $R_f = 0.23$ (90:10 petroleum ether [40-60]/ ethyl acetate). λ_{max} (cyclohexane) 207 and 267nm. ν_{max} (thin film, cm^{-1}) 1710 (C=O). δ_H (400MHz, CD_3OD) 1.17- 1.29 (1H, m, one of $C\underline{H}_2CHC=O$), 1.38 (1H, dd, *J* 6.5 and 13.0Hz, one of $C\underline{H}_2CHCHCH=CH$), 1.50- 1.68 (5H, m, one of $C\underline{H}_2CHCHCH=CH$, $C\underline{H}CH_2CH_2CHC=O$, one of $C\underline{H}_2CH_2C=O$ and $C\underline{H}_2CH_2CHC=O$), 1.71 (1H, app. dt, *J* 3.5 and 12.0Hz, $C\underline{H}CHC=O$), 1.82- 1.89 (1H, m, one of $C\underline{H}_2(CH_2)_2C=O$), 1.96 (1H, app. dq, *J* 13.5 and 3.0Hz, one of $C\underline{H}_2CHC=O$), 2.07- 2.23 (2H, m, one of $C\underline{H}_2CH_2C=O$ and one of $C\underline{H}_2(CH_2)_2C=O$), 2.22- 2.27 (1H, m, $C\underline{H}CHCH=CH$), 2.28- 2.34 (1H, m, one of $C\underline{H}_2C=O$), 2.41- 2.44 (1H, m, $C\underline{H}CH=CH$), 2.45 (1H, ddt, *J* 1.5, 6.0 and 13.5Hz, one of $C\underline{H}_2C=O$), 2.80 (1H, ddt, *J* 1.5, 3.5 and 12.0Hz, $C\underline{H}C=O$), 3.27 (3H, s, $OC\underline{H}_3$), 5.33 (1H, dd, *J* 1.5 and 5.5Hz, $CHCH=C\underline{H}$), 5.60 (1H, dd, *J* 2.5 and 5.5Hz, $CHC\underline{H}=CH$). δ_C (100MHz, $CDCl_3$) 25.4 ($\underline{C}H_2CH_2CHC=O$), 25.5 ($\underline{C}H_2CHC=O$), 26.6 ($\underline{C}H_2CHCHCH=CH$), 26.7 ($\underline{C}H_2CH_2C=O$), 28.3 ($\underline{C}H_2(CH_2)_2C=O$), 29.5 ($\underline{C}HCHCH=CH$), 38.5 ($\underline{C}HCH=CH$), 42.3 ($\underline{C}H_2C=O$), 47.2 ($\underline{C}HCHC=O$), 51.4 ($\underline{C}HC=O$), 57.5 ($O\underline{C}H_3$), 58.7 ($\underline{C}HCCH=CH$), 63.9 ($\underline{C}COCH_3$), 90.8 ($\underline{C}OCH_3$), 127.6

($\mathrm{CH\underline{C}H{=}CH}$), 129.5 ($\mathrm{CHCH{=}\underline{C}H}$), 213.0 (C=O). m/z (CI, NH_3, high resolution) found 259.1701 [$C_{17}H_{22}O_2$] ($(MH)^+$, 100%) [requires 259.1699], 227.1478 (14), 205.2420 (17), 181.1893 (11).

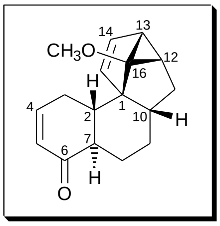
c. (±) (1*R*, 2*S*, 7*R*, 10*S*, 12*R*, 13*S*, 16*S*)-5,5-Dideutero-16-methoxypentacyclo-[11.2.1.0^{1,10}.0^{2,7}.0^{12,16}]hexadec-14-en-6-one – novel



Deuterated cycloadduct was obtained from the cycloadduct ketone (±) *(1R, 2S, 7R, 10S, 12R, 13S, 16S)-16-methoxypentacyclo[11.2.1.0^{1,10}.0^{2,7}.0^{12,16}]hexadec-14-en-6-one* (123) (0.021g, 0.08mmol) by following general procedure F. Slow re-crystallisation of the semi-solid from cyclohexane afforded a yellow solid of pure (±) *(1R, 2S, 7R, 10S, 12R, 13S, 16S)-5,5-dideutero-16-methoxypentacyclo[11.2.1.0^{1,10}.0^{2,7}.0^{12,16}]hexadec-14-en-6-one* in a quantitative yield.

Mp. 57-59 °C. $R_f = 0.23$ (90:10 petroleum ether [40-60]/ ethyl acetate). λ_{max} (cyclohexane) 209 and 273nm. ν_{max} (thin film, cm^{-1}) 1721 (C=O). δ_H (400MHz, CD_3OD) 1.17- 1.29 (1H, m, one of $\mathrm{C\underline{H}_2CHC{=}O}$), 1.38 (1H, dd, *J* 6.5 and 13.0Hz, one of $\mathrm{C\underline{H}_2CHCHCH{=}CH}$), 1.50- 1.68 (5H, m, one of $\mathrm{C\underline{H}_2CHCHCH{=}CH}$, $\mathrm{C\underline{H}_2CH_2CHC{=}O}$, one of $\mathrm{C\underline{H}_2CD_2}$ and $\mathrm{C\underline{H}CH_2CH_2CHC{=}O}$), 1.71 (1H, app. dt, *J* 3.5 and 12.0Hz, $\mathrm{C\underline{H}CHC{=}O}$), 1.86 (1H, app. dq, *J* 13.5 and 3.5Hz, one of $\mathrm{C\underline{H}_2CH_2CD_2}$), 1.96 (1H, app. dq, *J* 13.5 and 3.0Hz, one of $\mathrm{C\underline{H}_2CHC{=}O}$), 2.07- 2.14 (1H, m, one of $\mathrm{C\underline{H}_2CD_2}$), 2.14- 2.23 (1H, m, one of $\mathrm{C\underline{H}_2CH_2CD_2}$), 2.22- 2.27 (1H, m, $\mathrm{C\underline{H}CHCH{=}CH}$), 2.44 (1H, app. dt, *J* 8.5 and 2.0Hz, $\mathrm{C\underline{H}CH{=}CH}$), 2.80 (1H, dt, *J* 3.0 and 12.0Hz, $\mathrm{C\underline{H}C{=}O}$), 3.27 (3H, s, $\mathrm{OC\underline{H}_3}$), 5.33 (1H, dd, *J* 1.5 and 5.5Hz, $\mathrm{CHCH{=}C\underline{H}}$), 5.60 (1H, dd, *J* 2.5 and 5.5Hz, $\mathrm{CHC\underline{H}{=}CH}$). δ_C (100MHz, CD_3OD) 25.7 ($\mathrm{\underline{C}H_2CHC{=}O}$), 27.7 ($\mathrm{\underline{C}H_2CD_2}$), 27.9 ($\mathrm{\underline{C}H_2CH_2CD_2}$), 28.5 ($\mathrm{\underline{C}H_2CH_2CHC{=}O}$), 29.3 ($\mathrm{\underline{C}H_2CHCHCH{=}CH}$), 30.8 ($\mathrm{\underline{C}HCHCH{=}CH}$), 36.6 ($\mathrm{\underline{C}HCH{=}CH}$), 42.5 ($\mathrm{\underline{C}D_2}$), 48.6 ($\mathrm{\underline{C}HCHC{=}O}$), 51.8 ($\mathrm{\underline{C}HC{=}O}$), 52.6 ($\mathrm{\underline{C}HCH_2CH_2CHC{=}O}$), 54.7 ($\mathrm{O\underline{C}H_3}$), 65.8 ($\mathrm{\underline{C}CH{=}CH}$), 90.8 ($\mathrm{\underline{C}OCH_3}$), 125.8 ($\mathrm{CH\underline{C}H{=}CH}$), 138.3 ($\mathrm{CHCH{=}\underline{C}H}$), 216.1 ($\mathrm{\underline{C}{=}O}$). m/z (EI, high resolution) found 260.1747 [$C_{17}H_{20}D_2O_2$] ($(M)^+$, 1%) [requires 260.1743], 268.9826 (23), 242.9862 (50), 230.9865 (100).

d. (±) (1*S*, 2*S*, 7*R*, 10*S*, 12*S*, 13*R*, 16*R*)-16-Methoxypentacyclo[11.2.1.0^{1,10}.0^{2,7}.0^{12,16}]hexadec-4,14-dien-6-one – novel



General Procedure G

To prepare a 0.2M solution of lithium di*iso*propylamide an oven dried round-bottomed flask was evacuated and flushed with argon before anhydrous diisopropylamine (distilled from calcium hydride) (0.46ml, 3.28mmol) was added *via* syringe. To the flask was also added anhydrous THF (15ml) and the mixture was stirred under argon whilst being cooled to -78°C using an acetone/dry ice bath. To the cold, stirred solution was slowly added 1.6M *n*-butyllithium solution (1.88ml, 3.00mmol) drop-wise *via* syringe, over a period of 20 minutes. The newly formed 0.2M LDA solution was left stirring at -78°C for a further 15-20 minutes whilst the other reaction vessel containing the cycloadduct was prepared.

General Procedure H

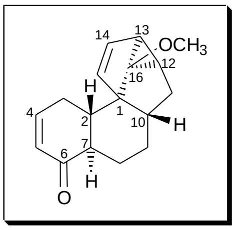
Into a reaction tube was placed the *meta* cycloadduct ketone (±) *(1S, 2S, 7R, 10S, 12S, 13R, 16R)-16-methoxypentacyclo[11.2.1.0^{1,10}.0^{2,7}.0^{12,16}]hexadec-14-en-6-one* (121) (0.029g, 0.11mmol) and anhydrous THF (1ml). The stirred solution was cooled to -78°C using an acetone/dry ice bath and then the cold LDA solution (0.2M, 0.62ml, 0.12mmol) was added drop-wise, down the inside of the tube, over a period of 15 minutes. After leaving to stir under argon at -78°C for a further 15 minutes to ensure complete formation of the enolate, a solution of phenylselenenyl chloride (0.028g, 0.15mmol) in THF (2x1ml) was added rapidly to the reaction mixture. The mixture was left to stir at -78°C for 45 minutes after which time TLC indicated that no more starting material remained so the reaction was quenched by the addition of saturated NH_4Cl solution (15ml). The mixture was transferred to a separating funnel where the aqueous layer was extracted and washed with diethyl ether (3x15ml). The combined organic extracts were collected together and washed with saturated NH_4Cl solution (15ml) and then water (15ml). The organic layer was dried over $MgSO_4$, filtered and concentrated *in vacuo* to give a clear oil. Purification using silica gel flash column chromatography (dichloromethane) afforded the two separate diastereoisomers of the pure α-phenylseleno ketone derivative (±) *(1S, 2S, 5RS, 7R, 10S, 12S, 13R, 16R)-5-phenylselanyl-16-methoxypentacyclo[11.2.1.0^{1,10}.0^{2,7}.0^{12,16}]-hexadec-14-en-6-one*, one as a colourless oil and the other as a white crystalline solid (Mp. 125-127 °C). The overall yield of the two diastereoisomers was 71% (0.033 g). The two isomers were collected together and directly reacted on to give the desired α,β-unsaturated ketone in the following manner.

To the α-phenylseleno ketone (0.033g, 0.08mmol) was added THF (1ml). The flask was then cooled to 0°C before 27.5% wt. hydrogen peroxide solution in water (0.03ml, 0.24mmol) was added drop-wise, *via* syringe, over a period of 5 minutes. The reaction mixture was stirred at 0°C for 30 minutes and then the flask was allowed to warm up to room temperature, with stirring, for a further 30 minutes. After this time, TLC indicated that the reaction had run to completion and was therefore terminated by quenching with saturated sodium bicarbonate solution (15ml). The mixture was transferred to a separating funnel where the organic layer was separated and the aqueous layer washed with a 1:1 mixture of ether and pentane (3x15ml). All the organic extracts were collected together and washed with saturated sodium bicarbonate solution (15ml) and then water (15ml). The organic layer was dried over $MgSO_4$, filtered and concentrated *in vacuo* to give a barely solid crude product. The desired α,β-unsaturated ketone cycloadduct (±) *(1S, 2S, 7R, 10S, 12S, 13R, 16R)-16-methoxypentacyclo[11.2.1.0*^{1,10}*.0*^{2,7}*.0*^{12,16}*]hexadec-4,14-dien-6-one* was obtained by purification of the crude product using flash column chromatography (80:20 petroleum ether [40-60]/ ethyl acetate) as cream coloured, fine needle crystals (0.017g, 83%). The overall yield for the process of converting the cycloadduct ketone to its α,β-unsaturated derivative (126) was 59%.

Mp. 120-121 °C. R_f = 0.31 (80:20 petroleum ether [40-60]/ ethyl acetate). λ_{max} (cyclohexane) 223 and 275nm. ν_{max} (thin film, cm^{-1}) 1670 (α,β-unsaturated C=O). δ_H (400MHz, CD_3OD) 1.04- 1.12 (1H, m, one of C$\underline{H}_2$CHCHCH=CH), 1.15- 1.38 (2H, m, one of C$\underline{H}_2$CH$_2$CHC=O and one of C$\underline{H}_2$CHC=O), 1.61- 1.67 (1H, m, one of C$\underline{H}_2$CH$_2$CHC=O), 1.92 (1H, ddd, *J* 6.5, 7.5 and 12.5Hz, one of C$\underline{H}_2$CHCHCH=CH), 2.05- 2.13 (1H, m, C$\underline{H}$CH$_2$CH$_2$CHC=O), 2.13- 2.18 (1H, m, C$\underline{H}$CHCH=CH), 2.22- 2.40 (4H, m, CC$\underline{H}$CHC=O, one of C$\underline{H}_2$CHC=O, C$\underline{H}$CH=CH and one of C$\underline{H}_2$CH=CHC=O), 2.45- 2.55 (1H, m, CH$_2$C$\underline{H}$C=O), 2.70- 2.82 (1H, m, one of C$\underline{H}_2$CH=CHC=O), 3.47 (3H, s, OC$\underline{H}_3$), 5.75- 5.80 (2H, m, CHC$\underline{H}$=CH and CHCH=C$\underline{H}$), 5.94- 5.99 (1H, m, CH=C$\underline{H}$C=O), 7.07- 7.12 (1H, m, C$\underline{H}$=CHC=O). δ_C (100MHz, CD_3OD) 26.6 ($\underline{C}$H$_2$CH$_2$CHC=O), 26.8 ($\underline{C}$H$_2$CHC=O), 27.6 ($\underline{C}$H$_2$CHCHCH=CH), 30.2 ($\underline{C}$H$_2$CH=CHC=O), 30.3 ($\underline{C}$HCHCH=CH), 39.4 (C$\underline{C}$HCHC=O), 44.2 ($\underline{C}$HCH=CH), 48.4 (CH$_2\underline{C}$HC=O), 57.8 (O$\underline{C}$H$_3$), 59.7 ($\underline{C}$HCH$_2$CH$_2$CHC=O), 64.6 ($\underline{C}$CH=CH), 91.8 ($\underline{C}$OCH$_3$), 128.7 (CHCH=$\underline{C}$H or CH$\underline{C}$H=CH), 129.3 (CH=$\underline{C}$HC=O), 131.0 (CH$\underline{C}$H=CH or CHCH=$\underline{C}$H), 152.3 ($\underline{C}$H=CHC=O), 203.9 ($\underline{C}$=O). m/z (CI,

NH_3, high resolution) found 257.1534 [$C_{17}H_{20}O_2$] ($(MH)^+$, 100%) [requires 257.1542], 202.1075 (30).

e. (±) (1*R*, 2*S*, 7*R*, 10*S*, 12*R*, 13*S*, 16*S*)-16-Methoxypentacyclo-[11.2.1.0^{1,10}.0^{2,7}.0^{12,16}]hexadec-4,14-dien-6-one – novel



Firstly, a 0.2M solution of lithium diisopropylamide was prepared according to general procedure G. Cycloadduct enone was then synthesised according to general procedure H from a solution of the ketone (±) *(1R, 2S, 7R, 10S, 12R, 13S, 16S)-16-methoxypentacyclo-[11.2.1.0^{1,10}.0^{2,7}.0^{12,16}]hexadec-14-en-6-one* (0.019g, 0.07mmol) in anhydrous THF (1ml), and the 0.2M LDA solution (0.41ml, 0.08mmol). A solution of phenylselenenyl chloride (0.017g, 0.09mmol) in THF (2x1ml) was added rapidly to the reaction mixture at -78°C and left to stir under argon for 45 minutes after which time TLC indicated that the reaction had run to completion. The pure α-phenylseleno ketone derivative (±) *(1R, 2S, 5RS, 7R, 10S, 12R, 13S, 16S)-5-phenylselanyl-16-methoxypentacyclo[11.2.1.0^{1,10}.0^{2,7}.0^{12,16}]-hexadec-14-en-6-one* was obtained as a mixture of two diastereoisomers by purification using silica-gel flash column chromatography (90:10 dichloromethane/ petroleum ether [40-60]) in an overall yield of 73% (0.022g).

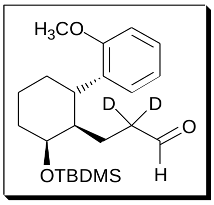
The pure, clear oil was then directly reacted on to give the desired α,β-unsaturated ketone by following general procedure H from the α-phenylseleno cycloadduct ketone (0.022g, 0.05mmol), anhydrous THF (1ml) and 27.5% wt. hydrogen peroxide solution in water (0.02ml, 0.16mmol). The reaction mixture was left to stir at 0°C for 30 minutes and room temperature for a further 30 minutes. After this time, TLC indicated that the reaction had run to completion. Purification of the crude oil using flash column chromatography (85:15 petroleum ether [40-60]/ ethyl acetate) afforded the desired α,β-unsaturated ketone cycloadduct (±) *(1R, 2S, 7R, 10S, 12R, 13S, 16S)-16-methoxypentacyclo[11.2.1.0^{1,10}.0^{2,7}.0^{12,16}]hexadec-4,14-dien-6-one* as a colourless oil (0.010g, 75%). The overall yield for the process of converting the cycloadduct ketone to its α,β-unsaturated derivative was calculated to be 55%.

R_f = 0.27 (85:15 petroleum ether [40-60]/ ethyl acetate). λ_{max} (cyclohexane) 218 and 276nm. ν_{max} (thin film, cm^{-1}) 1669 (α,β-unsaturated C=O). δ_H (400MHz, CD_3OD) 1.07- 1.18

(1H, m, one of $C\underline{H}_2CHC=O$), 1.42 (1H, dd, *J* 6.5 and 13.0Hz, one of $C\underline{H}_2CHCHCH=CH$), 1.54-1.77 (4H, m, one of $C\underline{H}_2CHCHCH=CH$, $C\underline{H}_2CH_2CHC=O$ and $C\underline{H}CH_2CH_2CHC=O$), 2.11 (1H, ddd, *J* 4.5, 11.5 and 13.5Hz, $CC\underline{H}CHC=O$), 2.25- 2.33 (2H, m, one of $C\underline{H}_2CHC=O$ and $C\underline{H}CHCH=CH$), 2.37- 2.46 (2H, m, one of $C\underline{H}_2CHCHC=O$ and $C\underline{H}CH=CH$), 2.71 (1H, ddd, *J* 4.0, 11.5 and 13.5Hz, $CH_2C\underline{H}C=O$), 2.92 (1H, dddd, *J* 2.0, 3.0, 11.5 and 19.5Hz, one of $C\underline{H}_2CHCHC=O$), 3.22 (3H, s, $OC\underline{H}_3$), 5.35 (1H, dd, *J* 1.5 and 5.5Hz, $CHCH=C\underline{H}$), 5.65 (1H, dd, *J* 2.5 and 5.5Hz, $CHC\underline{H}=CH$), 5.96 (1H, ddd, *J* 1.0, 3.0 and 10.0Hz, $CH=C\underline{H}C=O$), 7.12 (1H, ddd, *J* 2.0, 6.0 and 10.0Hz, $C\underline{H}=CHC=O$). δ_C (100MHz, CD_3OD) 25.9 ($\underline{C}H_2CHC=O$), 28.7 ($\underline{C}H_2CH_2CHC=O$), 29.3 ($\underline{C}H_2CHCHCH=CH$), 29.6 ($\underline{C}H_2CHCHC=O$), 29.9 ($\underline{C}HCHCH=CH$), 36.3 ($\underline{C}HCH=CH$), 42.9 ($C\underline{C}HCHC=O$), 47.9 ($CH_2\underline{C}HC=O$), 52.3 ($\underline{C}HCH_2CH_2CHC=O$), 54.1 ($O\underline{C}H_3$), 65.2 ($\underline{C}CH=CH$), 90.9 ($\underline{C}OCH_3$), 126.6 ($CH\underline{C}H=CH$), 129.3 ($CH=\underline{C}HC=O$), 137.5 ($CHCH=\underline{C}H$), 153.2 ($\underline{C}H=CHC=O$), 204.3 ($\underline{C}=O$). m/z (CI, NH_3, high resolution) found 257.1544 [$C_{17}H_{20}O_2$] ($(MH)^+$, 100%) [requires 257.1542], 202.1012 (63), 121.0640 (28), 55.0382 (32).

Synthesis of the deuterated 4-carbon tether substrate (**23**)

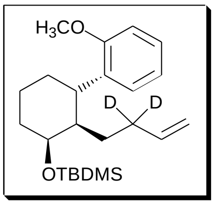
a. (±) 3-[(1*R*, 2*S*, 6*S*)-2'-(*tert*-Butyldimethylsilanyloxy)-6'-(2''-methoxyphenyl)cyclohexyl]-2,2-dideuteropropionaldehyde[15]



In a reaction tube was placed a solution of the aldehyde (±) *3-[(1R, 2S, 6S)-2'-(tert-butyldimethylsilanyloxy)-6'-(2''-methoxyphenyl)cyclohexyl]propionaldehyde* (**12**) (0.104g, 0.28mmol) in methanol-d (5ml). To a separate vial containing methanol-d_4 (0.5ml) was added 3 small lumps of sodium metal. Once the sodium had completely dissolved, the newly formed solution of sodium methoxide was transferred *via* syringe to the reaction tube containing the aldehyde. The tube was shaken vigorously before being left to stand for 1.5 hours. After this time, ^{1}H NMR spectroscopy indicated that the two most acidic protons (α to the carbonyl) had become fully exchanged with deuterium. The reaction mixture was then transferred to a separating funnel where it was diluted with ethyl acetate and saturated NH_4Cl solution. The organic layer was separated and the aqueous layer washed with ethyl acetate (3x15ml). The combined organic extracts were washed with sat. NH_4Cl solution (15ml) and water (15ml). The organic product was then dried over $MgSO_4$, filtered and concentrated *in vacuo* to afford the pure deuterated aldehyde (±) *3-[(1R, 2S, 6S)-2'-(tert-butyldimethylsilanyloxy)-6'-(2''-methoxyphenyl)cyclohexyl]-2,2-dideuteropropionaldehyde* (quantative).

R_f = 0.26 (95:5 petroleum ether [40-60]/ ethyl acetate). λ_{max} (cyclohexane) 227 and 272nm. ν_{max} (thin film, cm^{-1}) 1726 (C=O), 1599 (aromatic stretch). δ_H (400MHz, $CDCl_3$) 0.06 (3H, s, $OSiC\underline{H}_3$), 0.11 (3H, s, $OSiC\underline{H}_3$), 0.96 (9H, s, $OSiC(C\underline{H}_3)_3$), 1.19- 1.34 (1H, m, one of $C\underline{H}_2CD_2CHO$), 1.42- 1.65 (5H, m, one of $C\underline{H}_2CH_2CH(Ar)$, one of $C\underline{H}_2CH(Ar)$, one of $C\underline{H}_2CHOTBDMS$, $C\underline{H}CH_2CD_2CHO$ and one of $C\underline{H}_2CD_2CHO$), 1.65- 1.73 (1H, m, one of $C\underline{H}_2CH_2CH(Ar)$), 1.77- 1.90 (2H, m, one of $C\underline{H}_2CH(Ar)$ and one of $C\underline{H}_2CHOTBDMS$), 3.33 (1H, app. bs, $C\underline{H}(Ar)$), 3.79 (3H, s, $OC\underline{H}_3$), 4.05 (1H, app. s, $C\underline{H}OTBDMS$), 6.84 (1H, dd, *J* 0.5 and 8.0Hz, $C\underline{H}{=}COCH_3$), 6.91 (1H, dt, *J* 0.5 and 7.5Hz, $C\underline{H}CHCH{=}COCH_3$), 7.10- 7.18 (2H, m, $C\underline{H}CH{=}COCH_3$ and $C\underline{H}C(CH){=}COCH_3$), 9.50 (1H, s, $C\underline{H}O$). δ_C (100MHz, $CDCl_3$) –5.0 and –3.8 ($OSi\underline{C}H_3$ and $OSi\underline{C}H_3$), 18.3 ($OSi\underline{C}(CH_3)_3$), 20.3 ($\underline{C}H_2CH_2CH(Ar)$), 22.0 ($\underline{C}H_2CD_2CHO$), 25.9 ($OSiC(\underline{C}H_3)_3$), 33.9 ($\underline{C}H(Ar)$), 34.0 ($\underline{C}H_2CH(Ar)$ and $\underline{C}H_2CHOTBDMS$), 41.4 (bquintet, $\underline{C}D_2$), 45.7 ($\underline{C}HCH_2CD_2$), 55.0 ($O\underline{C}H_3$), 68.0 ($\underline{C}HOTBDMS$), 110.9 ($\underline{C}H{=}COCH_3$), 120.8 ($\underline{C}HCHCH{=}COCH_3$), 126.7 ($\underline{C}HCH{=}COCH_3$), 127.9 ($\underline{C}HC(CH){=}COCH_3$), 133.6 ($\underline{C}(CH){=}COCH_3$), 157.6 ($\underline{C}OCH_3$), 203.5 ($\underline{C}HO$). m/z (CI, NH_3, high resolution) found 379.2649 [$C_{22}H_{34}D_2O_3Si$] ($(MH)^+$, 18%) [requires 379.2635], 321.1857 (43), 246.8471 (100).

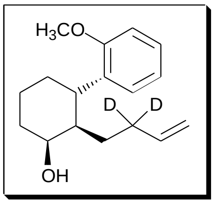
b. (±) *tert*-Butyl-[(1*S*, 2*R*, 3*S*)-2-(2′,2′-dideuterobut-3′-enyl)-3-(2′′-methoxyphenyl)cyclohexyloxy]dimethylsilane[15]



The substrate was prepared according to general procedure A using methyltriphenylphosphonium bromide (0.462g, 1.29mmol), anhydrous THF (5ml), 1.6M methyllithium solution in hexanes (0.74ml, 1.18mmol) and a solution of the deuterated aldehyde (±) *3-[(1R, 2S, 6S)-2′-(tert-butyldimethylsilanyloxy)-6′-(2″-methoxyphenyl)cyclohexyl]-2,2-dideuteropropionaldehyde* (0.326g, 0.86mmol) in dry THF (2x5ml). Pure (±) *tert-butyl-[(1S, 2R, 3S)-2-(2′,2′-dideuterobut-3′-enyl)-3-(2″-methoxyphenyl)cyclohexyloxy]-dimethylsilane* (0.249g, 77%) was obtained by flash column chromatography (petroleum ether [40-60]) as a colourless oil.

R_f = 0.22 (petroleum ether [40-60]). λ_{max} (cyclohexane) 228 and 267nm. ν_{max} (thin film, cm^{-1}) 1600 (aromatic stretch). δ_H (400MHz, C_6D_6) 0.09 (3H, s, $OSiC\underline{H}_3$), 0.11 (3H, s, $OSiC\underline{H}_3$), 1.07 (9H, s, $OSiC(C\underline{H}_3)_3$), 1.22- 1.29 (1H, m, one of $C\underline{H}_2CD_2$), 1.34- 1.78 (5H, m, one of $C\underline{H}_2CH(Ar)$, one of $C\underline{H}_2CHOTBDMS$, one of $C\underline{H}_2CH_2CH(Ar)$, one of $C\underline{H}_2CD_2$ and $C\underline{H}CH_2CD_2$), 1.80- 1.93 (2H, m, one of $C\underline{H}_2CH(Ar)$ and one of $C\underline{H}_2CHOTBDMS$), 2.00 (1H, app. qt, *J* 13.0 and 3.5Hz, one of $C\underline{H}_2CH_2CH(Ar)$), 3.36 (3H, s, $OC\underline{H}_3$), 3.63 (1H, app. bs, $C\underline{H}(Ar)$), 4.09 (1H, app. s, $C\underline{H}OTBDMS$), 4.90 (1H, dd, *J* 2.0 and 10.0Hz, $CH=C\underline{H}_2$ (*cis*-H)), 4.94 (1H, dd, *J* 2.0 and 17.0Hz, $CH=C\underline{H}_2$ (*trans*-H)), 5.63 (1H, dd, *J* 10.0 and 17.0Hz, $C\underline{H}=CH_2$), 6.59 (1H, dd, *J* 1.0 and 8.0Hz, $C\underline{H}=COCH_3$), 6.93 (1H, app. t, *J* 7.5Hz, $C\underline{H}CHCH=COCH_3$), 7.07 (1H, ddd, *J* 2.0, 7.5 and 8.0Hz, $C\underline{H}CH=COCH_3$), 7.17 (1H, dd, *J* 2.0 and 7.5Hz, $C\underline{H}C(CH)=COCH_3$). δ_C (100MHz, C_6D_6) −4.9 ($OSi\underline{C}H_3$), -3.8 ($OSi\underline{C}H_3$), 18.5 ($OSi\underline{C}(CH_3)_3$), 20.9 ($\underline{C}H_2CH_2CH(Ar)$), 26.2 ($OSiC(\underline{C}H_3)_3$), 28.4 ($\underline{C}H_2CD_2$), 30.5 (bquintet, $\underline{C}D_2$), 34.5 ($\underline{C}H_2CH(Ar)$ and $\underline{C}H_2CHOTBDMS$), 34.6 ($\underline{C}H(Ar)$), 46.0 ($\underline{C}HCH_2CD_2$), 55.0 ($O\underline{C}H_3$), 68.3 ($\underline{C}HOTBDMS$), 110.9 ($\underline{C}H=COCH_3$), 114.3 ($CH=\underline{C}H_2$), 121.1 ($\underline{C}HCHCH=COCH_3$), 126.8 ($\underline{C}HCH=COCH_3$), 128.2 ($\underline{C}HC(CH)=COCH_3$), 135.0 ($\underline{C}(CH)=COCH_3$), 139.2 ($\underline{C}H=CH_2$), 158.0 ($\underline{C}OCH_3$). m/z (CI, NH_3, high resolution) found 377.2853 [$C_{23}H_{36}D_2O_2Si$] ($(MH)^+$, 25%) [requires 377.2843], 319.2086 (68), 245.1884 (100), 121.0638 (50).

c. (±) (1*S*, 2*R*, 3*S*)-2-(2’,2’-Dideuterobut-3’-enyl)-3-(2’’-methoxyphenyl)-cyclohexanol (**21**)[15]



Compound (134) was synthesised according to general procedure B from a solution of the deuterated alkene (±) *tert-butyl-[(1S, 2R, 3S)-2-(2’,2’-dideuterobut-3’-enyl)-3-(2”-methoxyphenyl)cyclohexyloxy]dimethylsilane* (0.236g, 0.63mmol) in anhydrous THF (15ml) and 1M tetrabutylammonium fluoride solution in THF (2.10ml, 2.10mmol). The reaction mixture was heated to 50°C and left to stir for 119 hours until TLC indicated that no more starting material was being consumed. Flash column chromatography (90:10 petroleum ether [40-60]/ ethyl acetate) afforded the pure deuterated 4-carbon tether substrate (±) *(1S, 2R, 3S)-2-(2’,2’-dideuterobut-3’-enyl)-3-(2”-methoxyphenyl)cyclohexanol* (**21**) (0.158g, 96%) as a white solid.

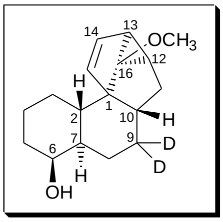
Mp. 63-65 °C. R_f = 0.13 (90:10 petroleum ether [40-60]/ ethyl acetate). λ_{max} (cyclohexane) 220 and 273nm. ν_{max} (KBr disc, cm^{-1}) 3267 (OH). δ_H (400MHz, C_6D_6) 0.96 (1H, bs, CHO$\underline{H}$), 1.29- 1.48 (4H, m, one of C$\underline{H}_2$CD$_2$, one of C$\underline{H}_2$CHOH, one of C$\underline{H}_2$CH(Ar) and one of C$\underline{H}_2$CH$_2$CHOH), 1.52- 1.60 (1H, m, one of C$\underline{H}_2$CD$_2$), 1.70- 1.77 (1H, m, one of C$\underline{H}_2$CHOH), 1.81- 1.95 (2H, m, one of C$\underline{H}_2$CH(Ar) and one of C$\underline{H}_2$CH$_2$CHOH), 3.34 (3H, s, OC$\underline{H}_3$), 3.59 (1H, app. bs, C$\underline{H}$(Ar)), 3.93 (1H, app. bs, C$\underline{H}$OH), 4.89 (1H, dd, *J* 2.0 and 10.0Hz, CH=C$\underline{H}_2$ (*cis*-H)), 4.94 (1H, dd, *J* 2.0 and 17.0Hz, CH=C$\underline{H}_2$ (*trans*-H)), 5.62 (1H, dd, *J* 10.0 and 17.0Hz, C$\underline{H}$=CH$_2$), 6.59 (1H, dd, *J* 1.0 and 7.5Hz, C$\underline{H}$=COCH$_3$), 6.93 (1H, app. t, *J* 7.5Hz, C$\underline{H}$CHCH=COCH$_3$), 7.07 (1H, dt, *J* 2.0 and 7.5Hz, C$\underline{H}$CH=COCH$_3$), 7.15 (1H, dd, *J* 2.0 and 7.5Hz, C$\underline{H}$C(CH)=COCH$_3$). δ_C (100MHz, C_6D_6) 20.6 ($\underline{C}$H$_2$CH$_2$CHOH and $\underline{C}$H$_2$CH(Ar)), 28.5 ($\underline{C}$H$_2$CD$_2$), 31.3 (bquintet, $\underline{C}$D$_2$), 34.1 ($\underline{C}$H$_2$CHOH), 35.0 ($\underline{C}$H(Ar)), 45.0 ($\underline{C}$HCHOH), 54.9 (O$\underline{C}$H$_3$), 66.7 ($\underline{C}$HOH), 110.9 ($\underline{C}$H=COCH$_3$), 114.4 (CH=$\underline{C}$H$_2$), 121.0 ($\underline{C}$HCHCH=COCH$_3$), 126.8 ($\underline{C}$HCH=COCH$_3$), 128.2 ($\underline{C}$HC(CH)=COCH$_3$), 134.7 ($\underline{C}$(CH)=COCH$_3$), 139.4 ($\underline{C}$H=CH$_2$), 157.9 ($\underline{C}$OCH$_3$). m/z (EI, high resolution) found 262.1901 [$C_{17}H_{22}D_2O_2$] ((M)$^+$, 26%) [requires 262.1900], 203.1075 (84), 180.9882 (100).

Photolysis of the deuterated 4-carbon tether substrate (**21**)

Photolysis of substrate (**21**) was carried out according to general procedure D. A 6.0mM solution of (±) *(1S, 2R, 3S)-2-(2',2'-dideuterobut-3'-enyl)-3-(2''-methoxyphenyl)cyclohexanol* (**21**) (0.158g, 0.60mmol) in cyclohexane (100ml) was irradiated for 3 hours until TLC and NMR spectroscopy indicated that no more starting material remained and that two major products had formed. All the washings from the thin film photoreactor were collected together and concentrated *in vacuo* to give a crude yellow oil. The two main photoproducts were separated from all the reaction by-products and then purified using flash column chromatography by gradually increasing the solvent polarity (90:10→85:15→80:20 petroleum ether [40-60]/ diethyl ether).

a. (±) (1*R*, 2*S*, 6*S*, 7*R*, 10*S*, 12*R*, 13*S*, 16*S*)-9,9-Dideutero-16-methoxypentacyclo[11.2.1.0^{1,10}.0^{2,7}.0^{12,16}]-hexadec-14-en-6-ol[15]

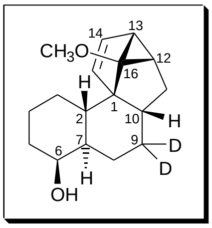
Fraction 1 was found to contain the cycloadduct alcohol as a pure colourless oil (0.055g, 35%).



R_f = 0.22 (80:20 petroleum ether [40-60]/ diethyl ether). λ_{max} (cyclohexane) 218 and 275nm. ν_{max} (thin film, cm^{-1}) 3439 (OH). δ_H (400MHz, CD_3OD) 1.34 (1H, dd, *J* 6.5 and 13.0Hz, one of $CD_2CHC\underline{H}_2$), 1.44- 1.57 (5H, m, $C\underline{H}_2CD_2$, one of $CD_2CHC\underline{H}_2$, one of $C\underline{H}_2CH_2CHOH$ and one of $C\underline{H}_2CHOH$), 1.58- 1.80 (6H, m, $C\underline{H}CD_2$, $C\underline{H}_2CHCHCHOH$, one of $C\underline{H}_2CH_2CHOH$, $C\underline{H}CHOH$ and $C\underline{H}CHCHOH$), 1.80- 1.87 (1H, m, one of $C\underline{H}_2CHOH$), 2.13- 2.19 (1H, m, $C\underline{H}CHCH{=}CH$), 2.32- 2.36 (1H, m, $C\underline{H}CH{=}CH$), 3.24 (3H, s, $OC\underline{H}_3$), 3.77- 3.80 (1H, m, $C\underline{H}OH$), 5.31 (1H, dd, *J* 1.5 and 5.5Hz, $CHCH{=}C\underline{H}$), 5.54 (1H, dd, *J* 2.5 and 5.5Hz, $CHC\underline{H}{=}CH$). δ_C (100MHz, CD_3OD) 21.6 ($\underline{C}H_2CH_2CHOH$), 28.5 ($\underline{C}H_2CHCHCHOH$), 29.3 ($CD_2CH\underline{C}H_2$), 29.7 ($\underline{C}H_2CD_2$), 29.8 (bquintet, $\underline{C}D_2$), 31.3 ($\underline{C}HCHCH{=}CH$), 34.8 ($\underline{C}H_2CHOH$), 37.3 ($\underline{C}HCH{=}CH$), 39.3 ($\underline{C}HCHCHOH$), 42.9 ($\underline{C}HCHOH$), 53.0 ($\underline{C}HCD_2$), 55.0 ($O\underline{C}H_3$), 66.1 ($\underline{C}CH{=}CH$), 71.4 ($\underline{C}HOH$), 90.6 ($\underline{C}OCH_3$), 125.0 ($CH\underline{C}H{=}CH$), 139.5 ($CHCH{=}\underline{C}H$). m/z (CI, NH_3, high resolution) found 262.1911 [$C_{17}H_{22}D_2O_2$] ((M)$^+$, 21%) [requires 262.1900], 213.1669 (100), 148.0052 (24), 96.0563 (27).

b. (±) (1*S*, 2*S*, 6*S*, 7*R*, 10*S*, 12*S*, 13*R*, 16*R*)-9,9-Dideutero-16-methoxypentacyclo-$[11.2.1.0^{1,10}.0^{2,7}.0^{12,16}]$hexadec-14-en-6-ol – novel

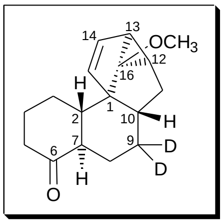
Fraction 2 contained the pure known deuterated cycloadduct alcohol (0.071g, 45%).



Mp. 42-44 °C. R_f = 0.15 (60:40 petroleum ether [40-60]/ diethyl ether). λ_{max} (cyclohexane) 209 and 278nm. ν_{max} (thin film, cm^{-1}) 3441 (OH). δ_H (400MHz, CD_3OD) 0.98- 1.14 (2H, m, one of $CD_2CHC\underline{H}_2$ and one of $C\underline{H}_2CD_2$), 1.40- 1.59 (5H, m, $C\underline{H}CHCHOH$, $C\underline{H}_2CHCHCHOH$, one of $C\underline{H}_2CH_2CHOH$ and one of $C\underline{H}_2CHOH$), 1.71- 1.80 (1H, m, one of $C\underline{H}_2CH_2CHOH$), 1.81- 1.89 (2H, m, one of $CD_2CHC\underline{H}_2$ and one of $C\underline{H}_2CHOH$), 1.95- 2.08 (4H, m, one of $C\underline{H}_2CD_2$, $C\underline{H}CHCH=CH$, $C\underline{H}CHOH$ and $C\underline{H}CD_2$), 2.21 (1H, dt, *J* 8.5 and 2.0Hz, $C\underline{H}CH=CH$), 3.50 (3H, s, $OC\underline{H}_3$), 3.84 (1H, app. bq, *J* 2.5Hz, $C\underline{H}OH$), 5.62- 5.67 (2H, m, $CHC\underline{H}=CH$ and $CHCH=C\underline{H}$). δ_C (100MHz, CD_3OD) 21.0 ($\underline{C}H_2CH_2CHOH$), 27.1 (bquintet, $\underline{C}D_2$), 27.6 ($CD_2CH\underline{C}H_2$), 30.0 ($\underline{C}H_2CD_2$), 30.4 ($\underline{C}HCHCH=CH$), 30.9 ($\underline{C}H_2CHCHCHOH$), 35.0 ($\underline{C}H_2CHOH$), 39.0 ($\underline{C}HCHOH$), 39.7 ($\underline{C}HCH=CH$), 44.2 ($\underline{C}HCHCHOH$), 57.9 ($O\underline{C}H_3$), 60.3 ($\underline{C}HCD_2$), 65.0 ($\underline{C}CH=CH$), 71.1 ($\underline{C}HOH$), 91.9 ($\underline{C}OCH_3$), 127.2 and 132.4 ($CH\underline{C}H=CH$ and $CHCH=\underline{C}H$). m/z (EI, high resolution) found 262.1898 [$C_{17}H_{22}D_2O_2$] ($(M)^+$, 35%) [requires 262.1900], 230.1655 (71), 203.1078 (98), 180.9884 (100).

Identification of the deuterated analogues of cycloadducts (**18**) and (**19**)

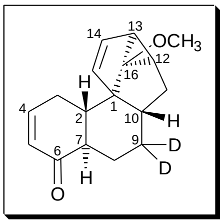
a. (±) (1*R*, 2*S*, 7*R*, 10*S*, 12*R*, 13*S*, 16*S*)-9,9-Dideutero-16-methoxypentacyclo-[11.2.1.0^{1,10}.0^{2,7}.0^{12,16}]hexadec-14-en-6-one (**22**)[15]



Compound (**22**) was synthesised according to general procedure E from a solution of the deuterated cycloadduct alcohol (±) *(1R, 2S, 6S, 7R, 10S, 12R, 13S, 16S)-9,9-dideutero-16-methoxypentacyclo-[11.2.1.0^{1,10}.0^{2,7}.0^{12,16}]-hexadec-14-en-6-ol* (0.029g, 0.11mmol) in dry DCM (2ml), and a solution of pyridinium chlorochromate (0.045g, 0.24mmol) in anhydrous DCM (2x1ml). After 1.5 hours of stirring under argon, TLC indicated that no more starting material remained. Flash column chromatography (70:30 dichloromethane/ petroleum ether [40-60]) afforded the pure deuterated cycloadduct ketone (±) *(1R, 2S, 7R, 10S, 12R, 13S, 16S)-9,9-dideutero-16-methoxypentacyclo[11.2.1.0^{1,10}.0^{2,7}.0^{12,16}]-hexadec-14-en-6-one* (**22**) as a colourless oil (0.021g, 73%).

R_f = 0.20 (70:30 dichloromethane/ petroleum ether [40-60]). λ_{max} (cyclohexane) 213 and 277nm. ν_{max} (thin film, cm^{-1}) 1706 (C=O). δ_H (400MHz, CD_3OD) 1.17- 1.25 (1H, m, one of $C\underline{H}_2CD_2$), 1.38 (1H, dd, *J* 6.5 and 13.0Hz, one of $CD_2CHC\underline{H}_2$), 1.49- 1.65 (3H, m, one of $CD_2CHC\underline{H}_2$, one of $C\underline{H}_2CH_2C=O$ and $CD_2C\underline{H}$), 1.71 (1H, dt, *J* 3.5 and 12.0Hz, $C\underline{H}CHC=O$), 1.82- 1.90 (1H, m, one of $C\underline{H}_2CHCHC=O$), 1.92- 1.98 (1H, m, one of $C\underline{H}_2CD_2$), 2.08- 2.22 (2H, m, one of $C\underline{H}_2CH_2C=O$ and one of $C\underline{H}_2CHCHC=O$), 2.22- 2.27 (1H, m, $C\underline{H}CHCH=CH$), 2.29- 2.35 (1H, m, one of $C\underline{H}_2C=O$), 2.41- 2.50 (2H, m, $C\underline{H}CH=CH$ and one of $C\underline{H}_2C=O$), 2.80 (1H, app. ddt, *J* 1.5, 3.5 and 12.0Hz, $C\underline{H}C=O$), 3.28 (3H, s, $OC\underline{H}_3$), 5.33 (1H, dd, *J* 1.5 and 5.5Hz, $CHCH=C\underline{H}$), 5.60 (1H, dd, *J* 2.5 and 5.5Hz, $CHC\underline{H}=CH$). δ_C (100MHz, CD_3OD) 26.5 ($\underline{C}H_2CHC=O$), 28.8 (bquintet, $\underline{C}D_2$), 28.9 ($\underline{C}H_2CH_2C=O$ and $\underline{C}H_2CHCHC=O$), 30.2 ($\underline{C}H_2CHCD_2$), 31.7 ($\underline{C}HCHCH=CH$), 37.6 ($\underline{C}HCH=CH$), 43.9 ($C\underline{H}_2C=O$), 49.4 ($\underline{C}HCHC=O$), 52.8 ($\underline{C}HC=O$), 53.5 ($\underline{C}HCD_2$), 55.7 ($O\underline{C}H_3$), 66.7 ($\underline{C}CH=CH$), 91.8 ($\underline{C}OCH_3$), 126.8 ($CH\underline{C}H=CH$), 139.3 ($CHCH=\underline{C}H$), 217.0 ($\underline{C}=O$). m/z (EI, high resolution) found 260.1748 [$C_{17}H_{20}D_2O_2$] ((M)$^+$, 11%) [requires 260.1743], 205.1206 (100), 180.9890 (74), 168.9882 (75).

b. (±) (1*R*, 2*S*, 7*R*, 10*S*, 12*R*, 13*S*, 16*S*)-9,9-Dideutero-16-methoxypentacyclo-[11.2.1.0^{1,10}.0^{2,7}.0^{12,16}]hexadec-4,14-dien-6-one (**23**)[15]



Firstly, a 0.2M solution of lithium di*iso*propylamide was prepared according to general procedure G. Deuterated cycloadduct enone (**22**) was then synthesised according to general procedure H from a solution of the ketone (±) *(1R, 2S, 7R, 10S, 12R, 13S, 16S)-9,9-dideutero-16-methoxypentacyclo-[11.2.1.0^{1,10}.0^{2,7}.0^{12,16}]hexadec-14-en-6-one* (**22**) (0.020g, 0.08mmol) in anhydrous THF (1ml), and the 0.2M LDA solution (0.41ml, 0.08mmol). A solution of phenylselenenyl chloride (0.016g, 0.09mmol) in THF (2x1ml) was added rapidly to the reaction mixture and left to stir under argon at -78°C for 1.5 hours after which time TLC indicated that the reaction had run to completion. The pure α-phenylseleno ketone intermediate (±) *(1R, 2S, 5RS, 7R, 10S, 12R, 13S, 16S)-9,9-dideutero-5-phenylselanyl-16-methoxypentacyclo-[11.2.1.0^{1,10}.0^{2,7}.0^{12,16}]hexadec-14-en-6-one* was obtained as a mixture of two diastereoisomers by purification using silica gel flash column chromatography (50:50 dichloromethane/ petroleum ether [30-40]) in an overall yield of 61% (0.019g).

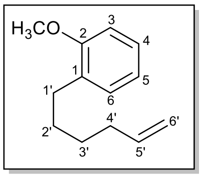
The pure, clear oil was then directly reacted on to give the desired α,β-unsaturated ketone (**23**) by following procedure H from the α-phenylseleno ketone (0.019g, 0.05mmol), anhydrous THF (1ml) and 27.5% wt. hydrogen peroxide solution in water (0.02ml, 0.14mmol). The reaction mixture was left to stir at 0°C for 30 minutes and room temperature for a further 30 minutes, after which time TLC indicated that the reaction had run to completion. Purification of the crude oil using flash column chromatography (70:30 dichloromethane/ petroleum ether [30-40]) afforded the desired α,β-unsaturated ketone cycloadduct (±) *(1R, 2S, 7R, 10S, 12R, 13S, 16S)-9,9-dideutero-16-methoxypentacyclo[11.2.1.0^{1,10}.0^{2,7}.0^{12,16}]-hexadec-4,14-dien-6-one* (**23**) as a colourless oil (0.011g, 94%). The overall yield for the process of converting the cycloadduct ketone (**22**) to its α,β-unsaturated derivative (**23**) was calculated to be 57%.

R_f = 0.20 (70:30 dichloromethane/ petroleum ether [30-40]). λ_{max} (cyclohexane) 220nm. ν_{max} (thin film, cm^{-1}) 1671 (α,β-unsaturated C=O). δ_H (400MHz, CD_3OD) 1.06- 1.14 (1H, m, one of $C\underline{H}_2CD_2$), 1.41 (1H, dd, *J* 6.5 and 13.0Hz, one of $CD_2CHC\underline{H}_2$), 1.56 (1H, ddd, *J* 1.5, 5.5 and 13.0Hz, one of $CD_2CHC\underline{H}_2$), 1.67 (1H, app. bd, *J* 5.5Hz, $CD_2C\underline{H}$), 2.10 (1H, ddd, *J* 4.5, 11.5

and 13.5Hz, $CC\underline{H}CHC=O$), 2.24- 2.32 (2H, m, one of $C\underline{H}_2CD_2$ and $C\underline{H}CHCH=CH$), 2.36- 2.45 (2H, m, one of $C\underline{H}_2CHCHC=O$ and $C\underline{H}CH=CH$), 2.70 (1H, ddd, *J* 4.0, 11.5 and 13.5Hz, $CH_2C\underline{H}C=O$), 2.91 (1H, app. ddt, *J* 2.0, 11.5 and 19.5Hz, one of $C\underline{H}_2CH=CHC=O$), 3.22 (3H, s, $OC\underline{H}_3$), 5.34 (1H, dd, *J* 1.5 and 5.5Hz, $CHCH=C\underline{H}$), 5.64 (1H, dd, *J* 2.5 and 5.5Hz, $CHC\underline{H}=CH$), 5.95 (1H, ddd, *J* 1.0, 3.0 and 10.0Hz, $CH=C\underline{H}C=O$), 7.12 (1H, ddd, *J* 2.0, 6.0 and 10.0Hz, $C\underline{H}=CHC=O$). δ_C (100MHz, CD_3OD) 26.6 ($\underline{C}H_2CD_2$), 28.7 ($\underline{C}D_2$), 30.1 ($CD_2CH\underline{C}H_2$), 30.4 ($\underline{C}H_2CH=CHC=O$), 30.8 ($\underline{C}HCHCH=CH$), 37.1 ($\underline{C}HCH=CH$), 43.8 ($C\underline{C}HCHC=O$), 48.7 ($CH_2\underline{C}HC=O$), 53.0 ($CD_2\underline{C}H$), 55.0 ($O\underline{C}H_3$), 66.1 ($\underline{C}COCH_3$), 91.8 ($\underline{C}OCH_3$), 127.4 ($CH\underline{C}H=CH$), 130.1 ($CH=\underline{C}HC=O$), 138.4 ($CHCH=\underline{C}H$), 154.1 ($\underline{C}H=CHC=O$), 205.2 ($\underline{C}=O$). m/z (CI, NH_3, high resolution) found 259.1675 [$C_{17}H_{18}D_2O_2$] ($(MH)^+$, 100%) [requires 259.1665], 227.1395 (17), 202.1081 (31).

Synthesis of the control substrate

a. 1-(Hex-5-en-1-yl)-2-methoxybenzene (**9**)[16]

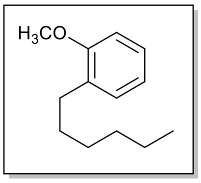


2-Methoxybenzyl alcohol (1.90ml, 14.47mmol) in anhydrous toluene (20ml) was warmed to 50°C before phosphorous tribromide (0.48ml, 5.06mmol) was added drop-wise *via* syringe. The oil bath was then heated to 100°C and the mixture stirred at this temperature, under argon, for 1.5 hours. After this time, TLC indicated that no more starting material remained and the reaction was terminated by the addition of water and saturated NaCl solution. The mixture was transferred to a separating funnel where the aqueous layer was extracted with diethyl ether (3x20ml). The combined organic extracts were then washed with saturated NaCl solution (2x20ml) and water (2x20ml). The organic layer was dried over $MgSO_4$, filtered and concentrated *in vacuo* to give a golden yellow crude oil of *2-methoxybenzyl bromide* (3.215g), which was directly reacted on.

To activated magnesium turnings (0.490g, 20.16mmol) under argon was added dry THF (1.5ml) followed shortly by neat 5-bromopent-1-ene (0.21ml, 1.76mmol). After 10 minutes the mixture began to exotherm as the reaction initiated. At this stage, a solution of the remaining 5-bromopent-1-ene (1.87ml, 15.83mmol) in dry THF (5ml) was added to the reaction mixture drop-wise over a period of 15 minutes. The solution was then stirred under argon for 45 minutes to ensure complete formation of the Grignard reagent (139). At this stage, *2-methoxybenzyl bromide* (3.215g, 15.99mmol) was added drop-wise, *via* syringe, to the reaction mixture, which was then heated to 60°C and stirred under argon for 20 hours. After this time TLC indicated that the reaction had run to completion and was quenched with water and 1M HCl solution. The mixture was transferred to a separating funnel where the aqueous layer was extracted with diethyl ether (3x30ml). The organic washings were then collected together and washed with 1M HCl solution and water (2x30ml). The organic layer was dried over $MgSO_4$, filtered and concentrated *in vacuo* to give a crude oil. The majority of the by-products formed were removed using flash column chromatography (pentane) and then purified further using Kugelrohr distillation. The oil was initially heated to 170°C to remove any remaining impurities and then heated further to 180°C to afford a pure fraction of the desired *1-hex-5'-enyl-2-methoxybenzene* (**9**) (0.313g, 10%).

Bp. 178-179°C. R_f = 0.27 (pentane). λ_{max} (cyclohexane) 223 and 272nm. ν_{max} (thin film, cm^{-1}) 1601 (aromatic stretch). δ_H (400MHz, $CDCl_3$) 1.43- 1.52 (2H, m, $C\underline{H}_2CH_2CH=CH_2$), 1.59- 1.68 (2H, m, $C\underline{H}_2CH_2Ar$), 2.09- 2.16 (2H, m, $C\underline{H}_2CH=CH_2$), 2.65 (2H, t, *J* 7.5Hz, $C\underline{H}_2Ar$), 3.84 (3H, s, $OC\underline{H}_3$), 4.96 (1H, ddt, $J_{H6\textit{cis}\text{-}H5}$ 10.0, J_{gem} 2.0 and $J_{H6\text{-}H4}$ 1.0Hz, $CH=C\underline{H}_2$ (*cis*-H5)), 5.03 (1H, app. dq, $J_{H6\textit{trans}\text{-}H5}$ 17.0 and $J_{gem/H6\text{-}H4}$ 2.0Hz, $CH=C\underline{H}_2$ (*trans*-H5)), 5.85 (1H, ddt, *J* 17.0, 10.0 and 6.5Hz, $C\underline{H}=CH_2$), 6.87 (1H, app. d, *J* 7.5Hz, $C\underline{H}=COCH_3$), 6.91 (1H, app. dt, *J* 1.0 and 7.5Hz, $C\underline{H}CHCH=COCH_3$), 7.16 (1H, dd, *J* 1.5 and 7.5Hz, $C\underline{H}C(C_6H_{11})=COCH_3$), 7.20 (1H, dt, *J* 1.5 and 7.5Hz, $C\underline{H}CH=COCH_3$). δ_C (63MHz, $CDCl_3$) 29.3 ($\underline{C}H_2CH_2CH=CH_2$), 30.0 ($\underline{C}H_2CH_2Ar$), 30.4 ($\underline{C}H_2Ar$), 34.1 ($\underline{C}H_2CH=CH_2$), 55.6 ($O\underline{C}H_3$), 110.6 ($\underline{C}H=COCH_3$), 114.6 ($CH=\underline{C}H_2$), 120.7 ($\underline{C}HCHCH=COCH_3$), 127.2 ($\underline{C}HCH=COCH_3$), 130.2 ($\underline{C}HC(C_6H_{11})=COCH_3$), 131.5 ($\underline{C}(C_6H_{11})=COCH_3$), 139.5 ($\underline{C}H=CH_2$), 157.8 ($\underline{C}OCH_3$). m/z (CI, NH_3, high resolution) found 190.1358 [$C_{13}H_{18}O$] (($M)^+$, 76%) [requires 190.1358], 147.0863 (35), 121.0636 (100), 91.0545 (39).

b. 1-Hexyl-2-methoxybenzene[17]



The substrate was prepared according to general procedure C using *1-hex-5'-enyl-2-methoxybenzene* (**9**) (0.026g, 0.14mmol) in anhydrous methanol (2ml), a catalytic amount of 10% palladium on carbon and excess hydrogen. After 1 hour of vigorous stirring TLC indicated that the reaction had run to completion, so the mixture was filtered through celite and the filtrate concentrated *in vacuo* to afford the pure oil *1-hexyl-2-methoxybenzene* in a quantitative yield.

R_f = 0.53 (95:5 petroleum ether [40-60]/ diethyl ether). λ_{max} (cyclohexane) 198, 222 and 273nm. ν_{max} (thin film, cm^{-1}) 1601 (aromatic stretch), 1242 ($_{ar}C\text{-}O\text{-}C_{al}$). δ_H (250MHz, $CDCl_3$) 0.77- 0.85 (3H, m, $CH_2C\underline{H}_3$), 1.15- 1.34 (6H, m, $C\underline{H}_2(CH_2)_2CH_3$, $C\underline{H}_2CH_2CH_3$ and $C\underline{H}_2CH_3$), 1.43- 1.57 (2H, m, $C\underline{H}_2CH_2Ar$), 2.52 (2H, t, *J* 7.5Hz, $C\underline{H}_2Ar$), 3.73 (3H, s, $OC\underline{H}_3$), 6.75 (1H, app. d, *J* 7.5Hz, $C\underline{H}=COCH_3$), 6.79 (1H, app. dt, *J* 1.0 and 7.5Hz, $C\underline{H}CHCH=COCH_3$), 7.02- 7.13 (2H, m, $C\underline{H}CH=COCH_3$ and $C\underline{H}C(C_6H_{13})=COCH_3$). δ_C (63MHz, $CDCl_3$) 14.6 ($CH_2\underline{C}H_3$), 23.1 ($\underline{C}H_2CH_3$), 29.7 ($\underline{C}H_2CH_2CH_3$ or $\underline{C}H_2(CH_2)_2CH_3$), 30.3 ($\underline{C}H_2CH_2Ar$), 30.7 ($\underline{C}H_2Ar$), 32.2 ($\underline{C}H_2CH_2CH_3$ or $\underline{C}H_2(CH_2)_2CH_3$), 55.6 ($O\underline{C}H_3$), 110.6 ($\underline{C}H=COCH_3$), 120.7 ($\underline{C}HCHCH=COCH_3$), 127.1 ($\underline{C}HCH=COCH_3$), 130.1 ($\underline{C}HC(C_6H_{13})=COCH_3$), 131.8 ($\underline{C}(C_6H_{13})=COCH_3$), 157.8 ($\underline{C}OCH_3$). m/z

(CI, NH_3, high resolution) found 192.1512 [$C_{13}H_{20}O$] ($(M)^+$, 35%) [requires 192.1514], 121.0647 (100).

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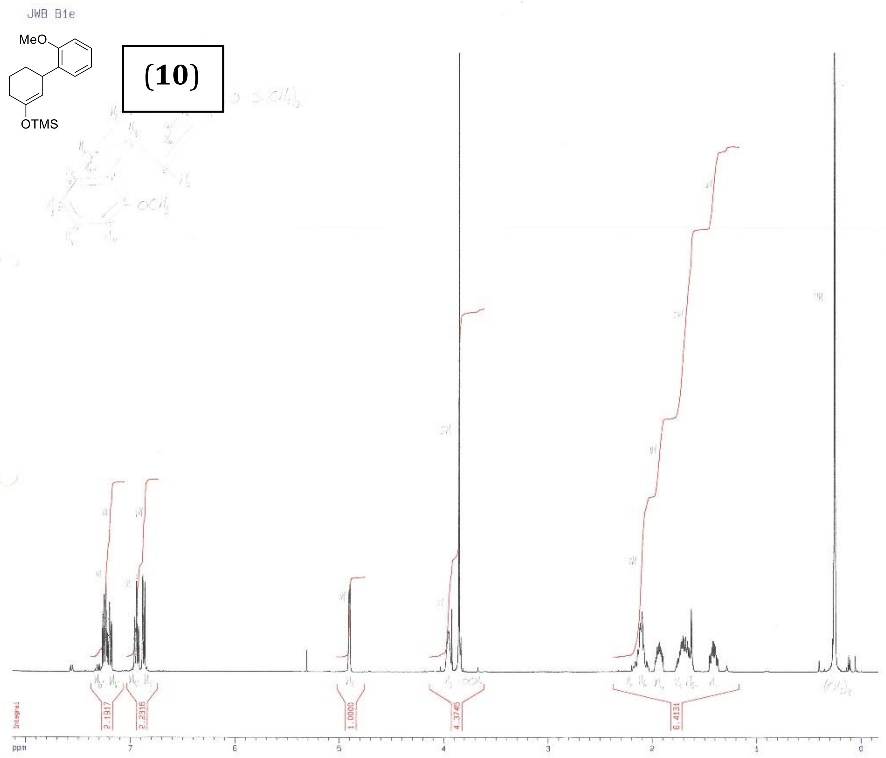
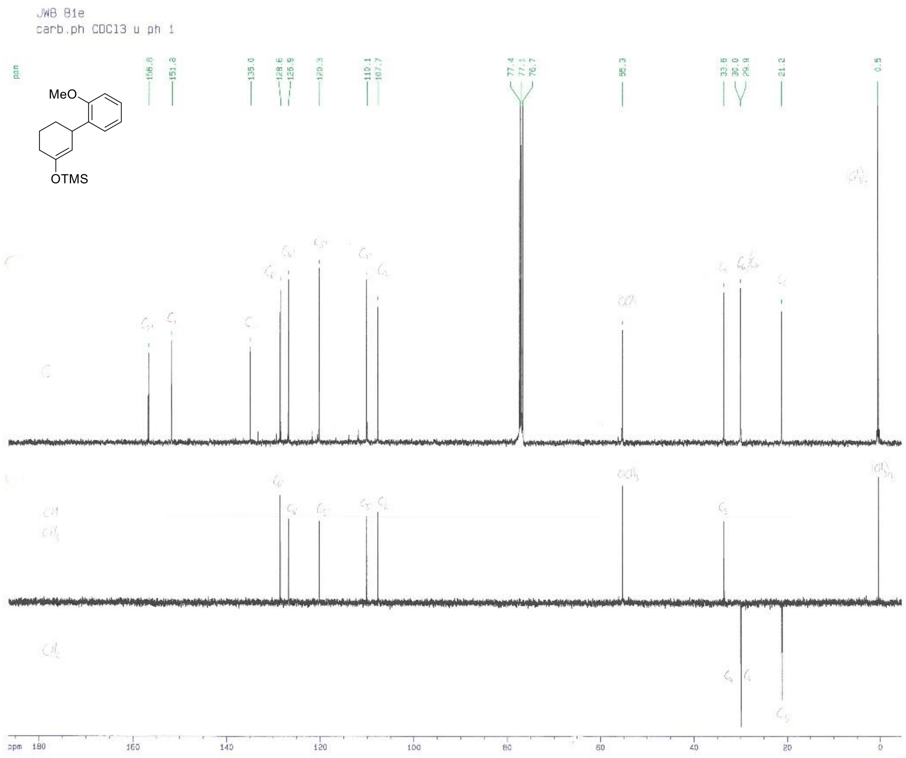
NMR SPECTRA

Synthesis of the 3-carbon tether substrate

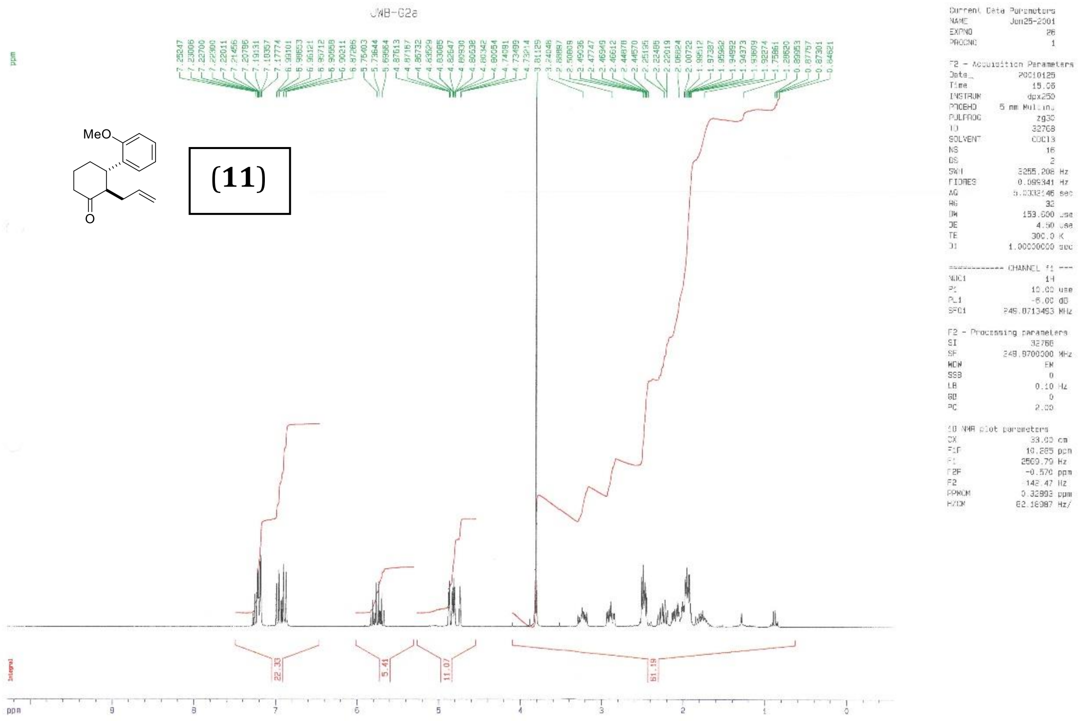


(10)

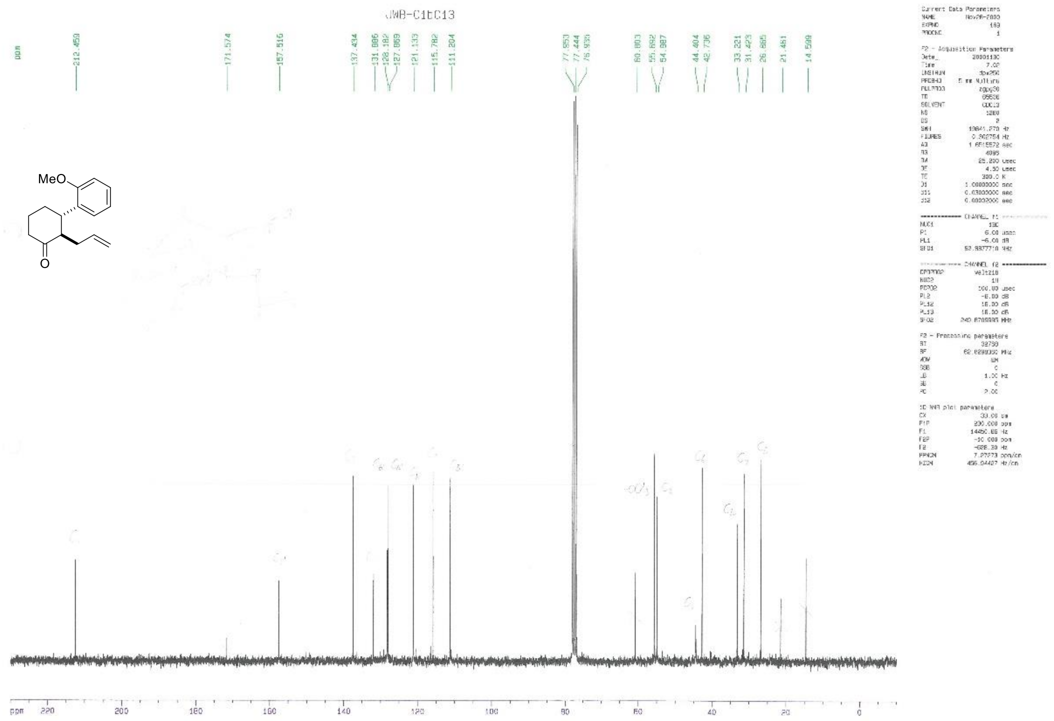
```
Current Data Parameters
NAME             jwbb1e
EXPNO                 1
PROCNO                1

F2 - Acquisition Parameters
Date_          20010214
Time              12.34
INSTRUM          amx400
PROBHD     5 mm Multinu
PULPROG            zg30
TD                32768
SOLVENT           CDCl3
NS                   32
DS                    2
SWH            6024.105 Hz
FIDRES         0.183841 Hz
AQ            2.7197940 sec
RG                  256
DW               83.000 usec
DE               118.57 usec
TE                300.0 K
HL1                   1 dB
D1           3.00000000 sec
P1                 8.20 usec
SFO1        400.1367510 MHz
NUCLEUS              1H

F2 - Processing parameters
SI                32768
SF          400.1343905 MHz
WDW                  EM
SSB                   0
LB                 0.20 Hz
GB                    0
PC                 1.00

1D NMR plot parameters
CX                32.00 cm
F1P               8.129 ppm
F1              3252.54 Hz
F2P              -0.163 ppm
F2               -65.18 Hz
PPMCM           0.25911 ppm/cm
HZCM          103.67654 Hz/cm
```

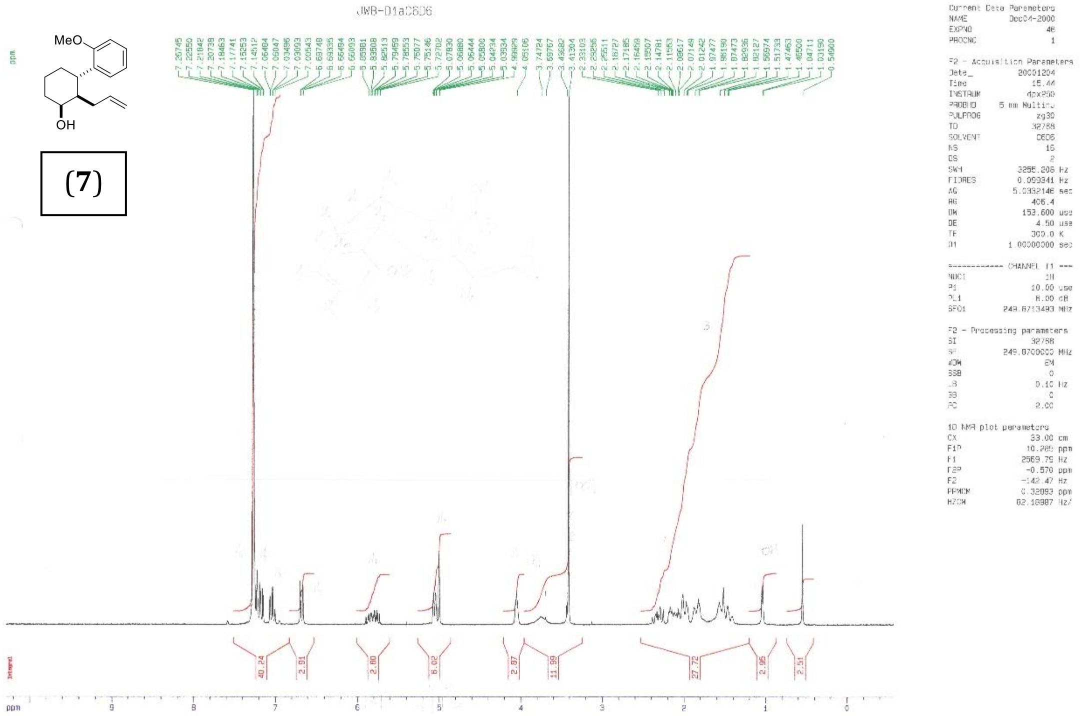


```
Current Data Parameters
NAME             jwbb1e
EXPNO                 5
PROCNO                1

F2 - Acquisition Parameters
Date_          20010214
Time              13.16
INSTRUM          amx400
PROBHD     5 mm Multinu
PULPROG          zgpg30
TD                65536
SOLVENT           CDCl3
NS                 1058
DS                    2
SWH           38461.538 Hz
FIDRES         0.586877 Hz
AQ            0.8520180 sec
RG                32768
DW               13.000 usec
DE                18.57 usec
TE                300.0 K
HL1                   1 dB
D1           2.00000000 sec
CPDPRG          waltz16
P31              110.00 usec
S4                   30 dB
D11          0.03000000 sec
S2                   26 dB
P1                 7.15 usec
SFO1        100.6250000 MHz
NUCLEUS             13C

F2 - Processing parameters
SI                65536
SF          100.6138729 MHz
WDW                  EM
SSB                   0
LB                 2.00 Hz
GB                    0
PC                 1.00

1D NMR plot parameters
CX                33.00 cm
F1P             186.631 ppm
F1             18777.62 Hz
F2P              -4.504 ppm
F2              -453.14 Hz
PPMCM           5.79185 ppm/cm
HZCM          582.75061 Hz/cm
```


JWB-G2a
MeO
O
ppm
Integral
22.33
5.41
11.07
61.19
9
8
7
6
5
4
3
2
1
0

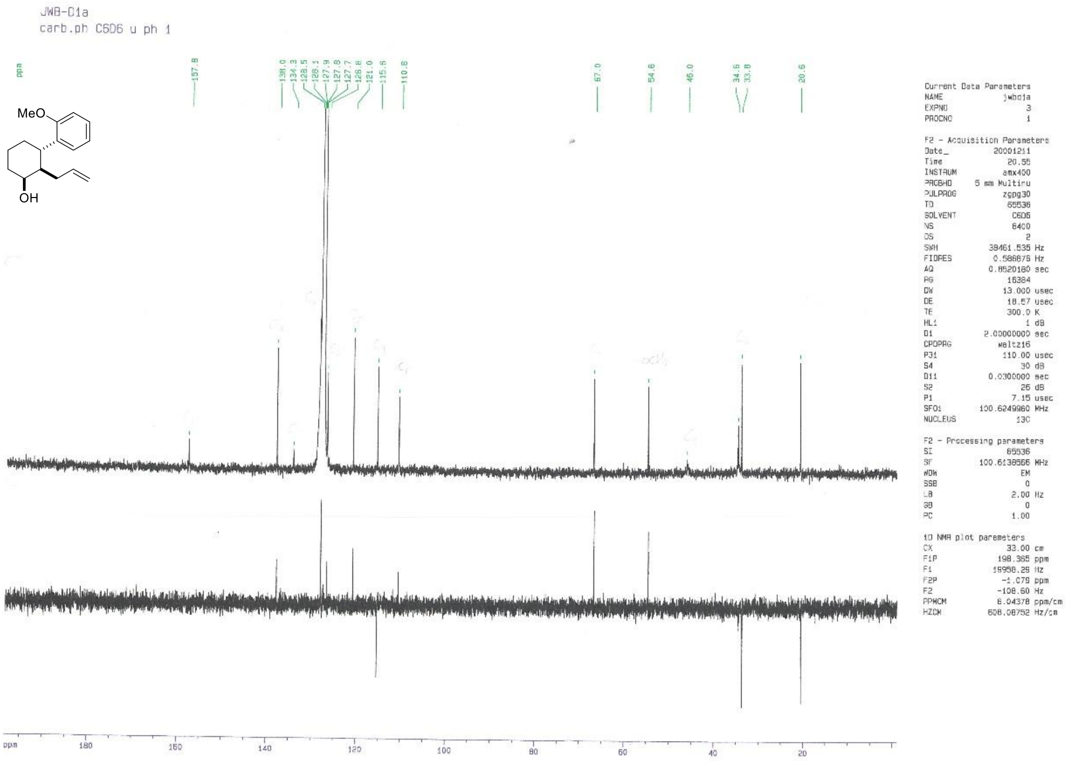
(11)


JWB-C1tC13
212.459
171.574
157.516
137.434
131.895
128.182
127.959
121.133
115.782
111.204
77.953
77.444
76.935
59.893
55.692
54.987
44.404
42.736
33.221
31.423
26.885
21.481
14.599
MeO
O
ppm
220
200
180
160
140
120
100
80
60
40
20
0



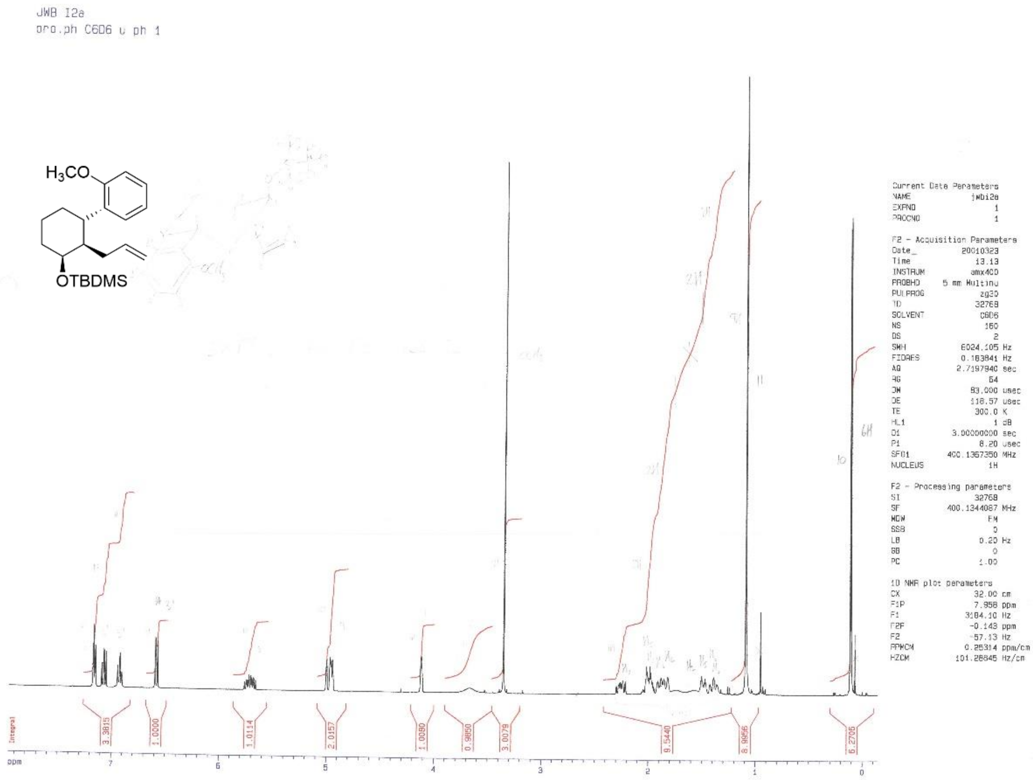
(7)

```
Current Data Parameters
NAME            Dec04-2000
EXPNO                   46
PROCNO                   1

F2 - Acquisition Parameters
Date_             20001204
Time                 15.44
INSTRUM             dpx250
PROBHD      5 mm Multinu
PULPROG               zg30
TD                   32768
SOLVENT               C6D6
NS                      16
DS                       2
SWH             3255.208 Hz
FIDRES          0.099341 Hz
AQ             5.0332146 sec
RG                   406.4
DW               153.600 use
DE                  4.50 use
TE                 300.0 K
D1            1.00000000 sec

============ CHANNEL f1 ===
NUC1                    1H
P1                 10.00 use
PL1                 6.00 dB
SFO1         249.8713493 MHz

F2 - Processing parameters
SI                   32768
SF           249.8700000 MHz
WDW                     EM
SSB                      0
LB                    0.10 Hz
GB                       0
PC                    2.00

1D NMR plot parameters
CX                   33.00 cm
F1P                 10.265 ppm
F1                 2569.79 Hz
F2P                 -0.570 ppm
F2                 -142.47 Hz
PPMCM              0.32093 ppm
HZCM              82.18987 Hz/
```



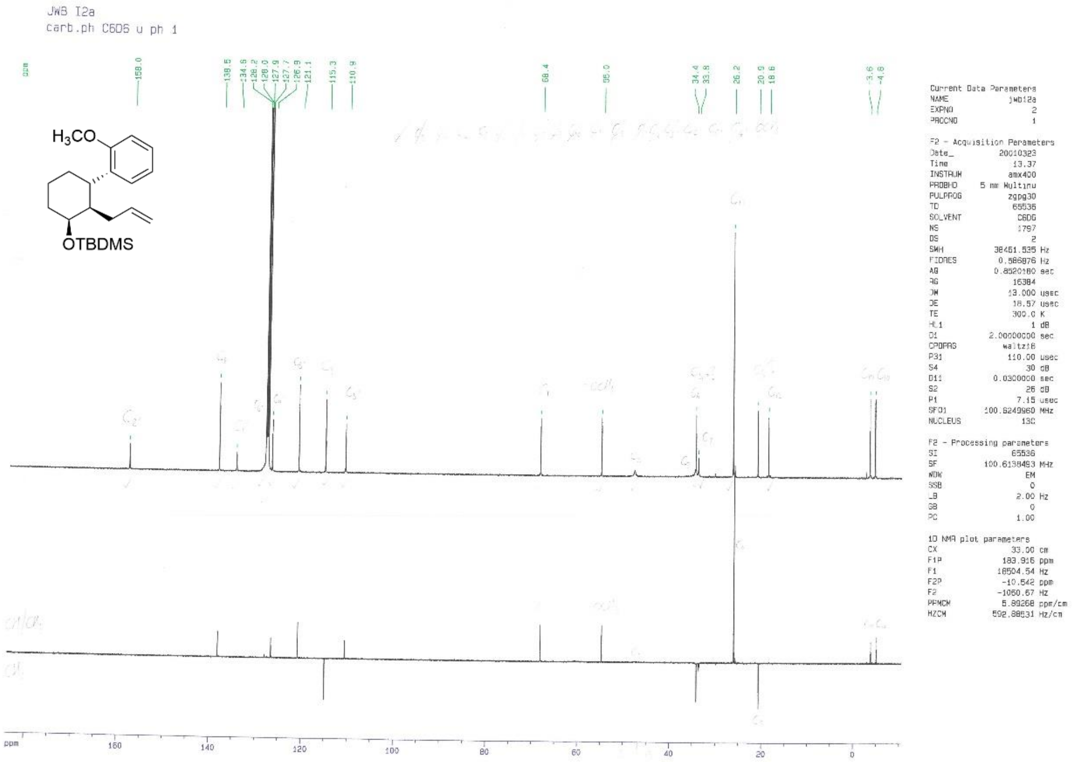
```
Current Data Parameters
NAME                jwbd1a
EXPNO                    3
PROCNO                   1

F2 - Acquisition Parameters
Date_             20001211
Time                 20.55
INSTRUM             amx400
PROBHD      5 mm Multinu
PULPROG             zgpg30
TD                   65536
SOLVENT               C6D6
NS                    6400
DS                       2
SWH            39461.535 Hz
FIDRES          0.586676 Hz
AQ             0.8520180 sec
RG                   16384
DW                13.000 usec
DE                 18.57 usec
TE                 300.0 K
HL1                      1 dB
D1            2.00000000 sec
CPDPRG             waltz16
P31               110.00 usec
S4                      30 dB
D11           0.0300000 sec
S2                      26 dB
P1                  7.15 usec
SFO1        100.6249960 MHz
NUCLEUS                13C

F2 - Processing parameters
SI                   65536
SF          100.6138566 MHz
WDW                     EM
SSB                      0
LB                    2.00 Hz
GB                       0
PC                    1.00

1D NMR plot parameters
CX                   33.00 cm
F1P                198.365 ppm
F1                15958.29 Hz
F2P                 -1.079 ppm
F2                 -108.60 Hz
PPMCM             6.04378 ppm/cm
HZCM            608.08752 Hz/cm
```

Synthesis of the 4-carbon tether substrate: Route A



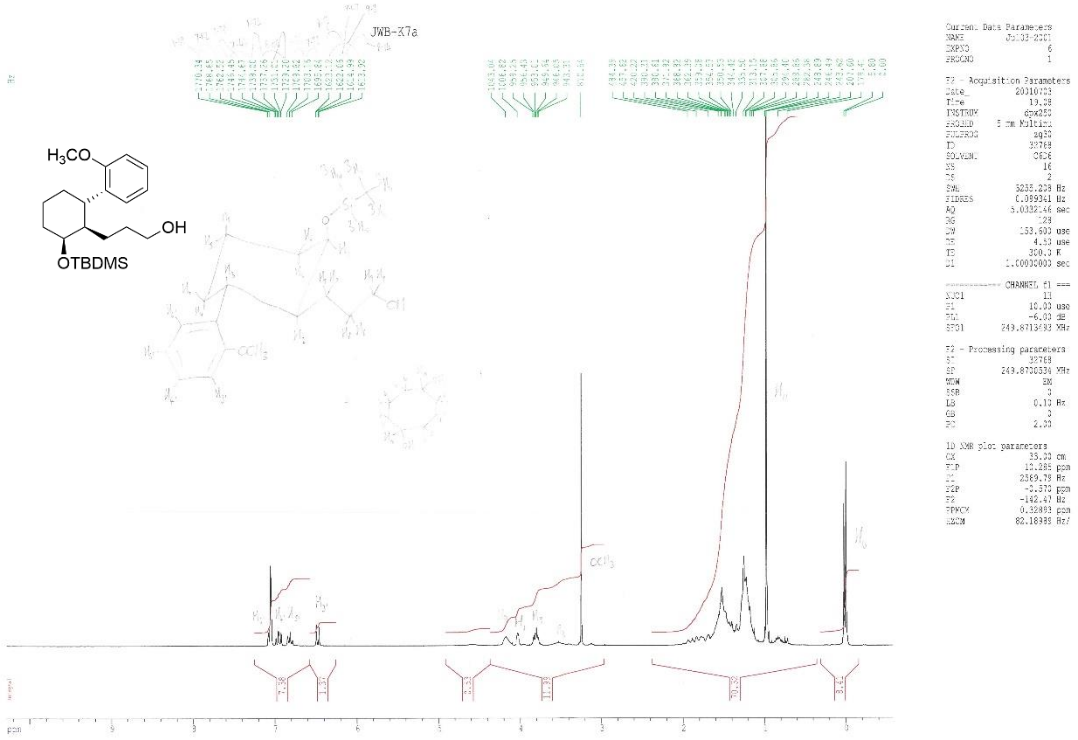
JWB I2a
pro.ph C6D6 u ph 1

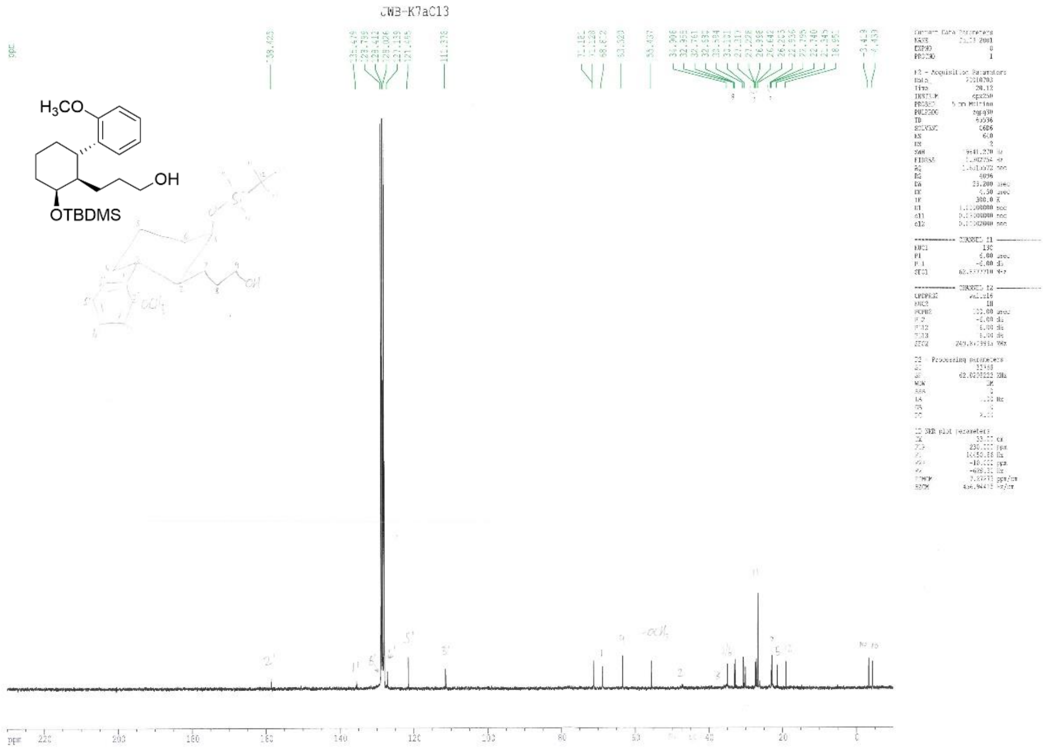
```
Current Data Parameters
NAME            jwbi2a
EXPNO                1
PROCNO               1

F2 - Acquisition Parameters
Date_         20010323
Time             13.13
INSTRUM         amx400
PROBHD   5 mm Multinu
PULPROG           zg30
TD               32768
SOLVENT           C6D6
NS                 160
DS                   2
SWH           6024.105 Hz
FIDRES        0.183841 Hz
AQ           2.7197940 sec
RG                  64
DW              83.000 usec
DE              116.57 usec
TE               300.0 K
HL1                  1 dB
D1          3.00000000 sec
P1                8.20 usec
SFO1       400.1357350 MHz
NUCLEUS             1H

F2 - Processing parameters
SI               32768
SF         400.1344087 MHz
WDW                 EM
SSB                  0
LB                0.20 Hz
GB                   0
PC                1.00

1D NMR plot parameters
CX               32.00 cm
F1P              7.958 ppm
F1             3184.10 Hz
F2P             -0.143 ppm
F2              -57.13 Hz
PPMCM          0.25314 ppm/cm
HZCM         101.26845 Hz/cm
```

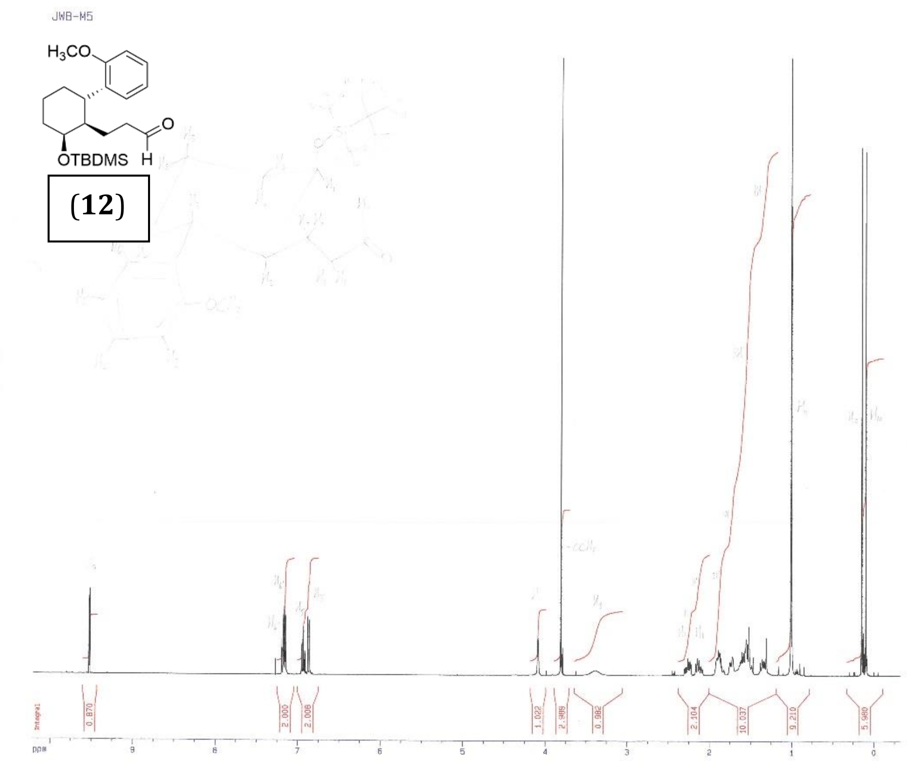


JWB I2a
carb.ph C6D6 u ph 1

```
Current Data Parameters
NAME            jwb12a
EXPNO                2
PROCNO               1

F2 - Acquisition Parameters
Date_         20010323
Time             13.37
INSTRUM         amx400
PROBHD   5 mm Multinu
PULPROG         zgpg30
TD               65536
SOLVENT           C6D6
NS                1797
DS                   2
SWH          38461.535 Hz
FIDRES        0.586876 Hz
AQ           0.8520180 sec
RG               16384
DW              13.000 usec
DE               18.57 usec
TE               300.0 K
HL1                  1 dB
D1          2.00000000 sec
CPDPRG        waltz16
P31             110.00 usec
S4                  30 dB
D11         0.03000000 sec
S2                  26 dB
P1                7.15 usec
SFO1       100.6249960 MHz
NUCLEUS            13C

F2 - Processing parameters
SI               65536
SF         100.6138493 MHz
WDW                 EM
SSB                  0
LB                2.00 Hz
GB                   0
PC                1.00

1D NMR plot parameters
CX               33.00 cm
F1P            183.916 ppm
F1            18504.54 Hz
F2P            -10.542 ppm
F2            -1060.67 Hz
PPMCM          5.89268 ppm/cm
HZCM         592.88531 Hz/cm
```

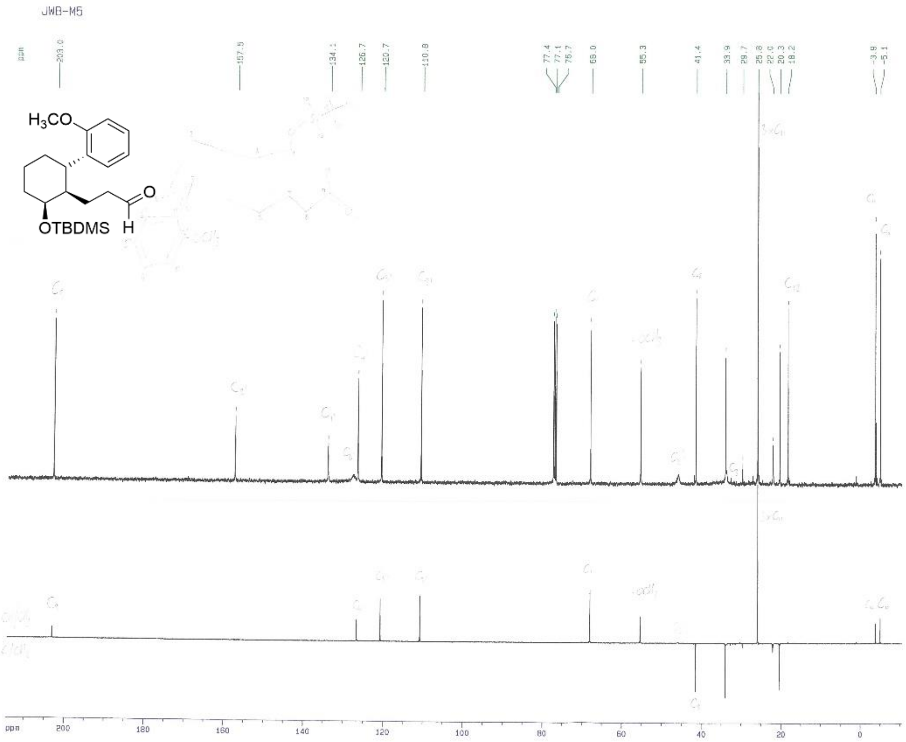

JWB-K7a
H3CO
OH
OTBDMS
Current Data Parameters
CHANNEL f1
F2 - Acquisition Parameters
F2 - Processing parameters
1D NMR plot parameters
OCH3
ppm
9
8
7
6
5
4
3
2
1
0


JWB-K7aC13
H3CO
OH
OTBDMS
OCH3
ppm
220
200
180
160
140
120
100
80
60
40
20
0

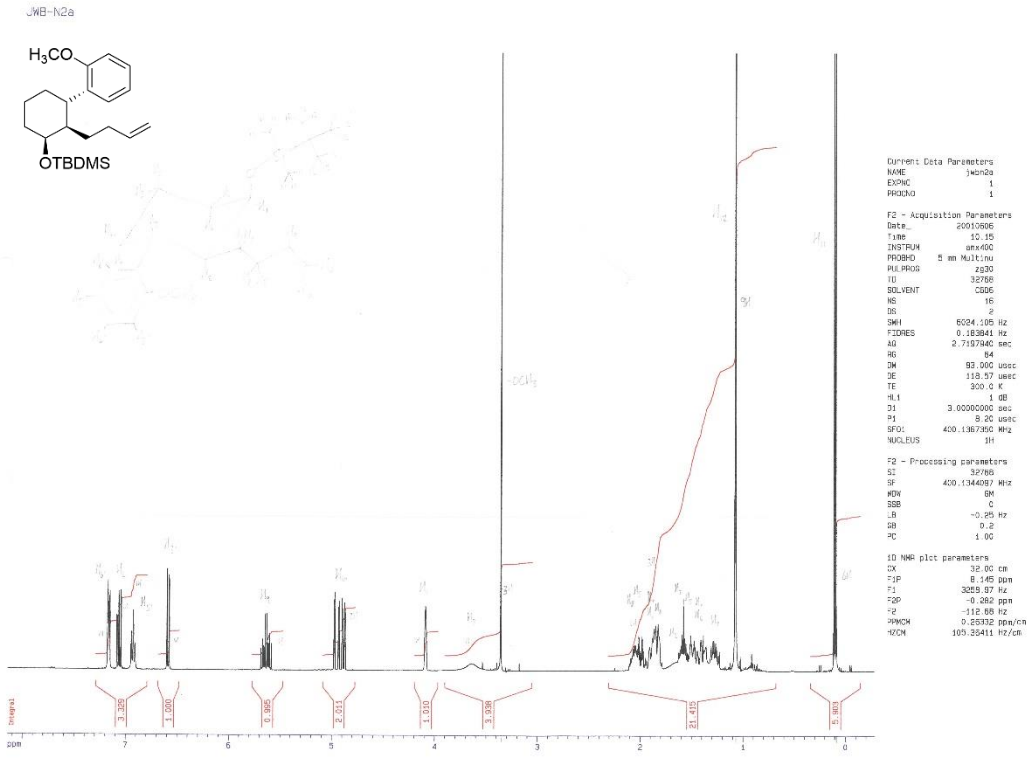


(12)

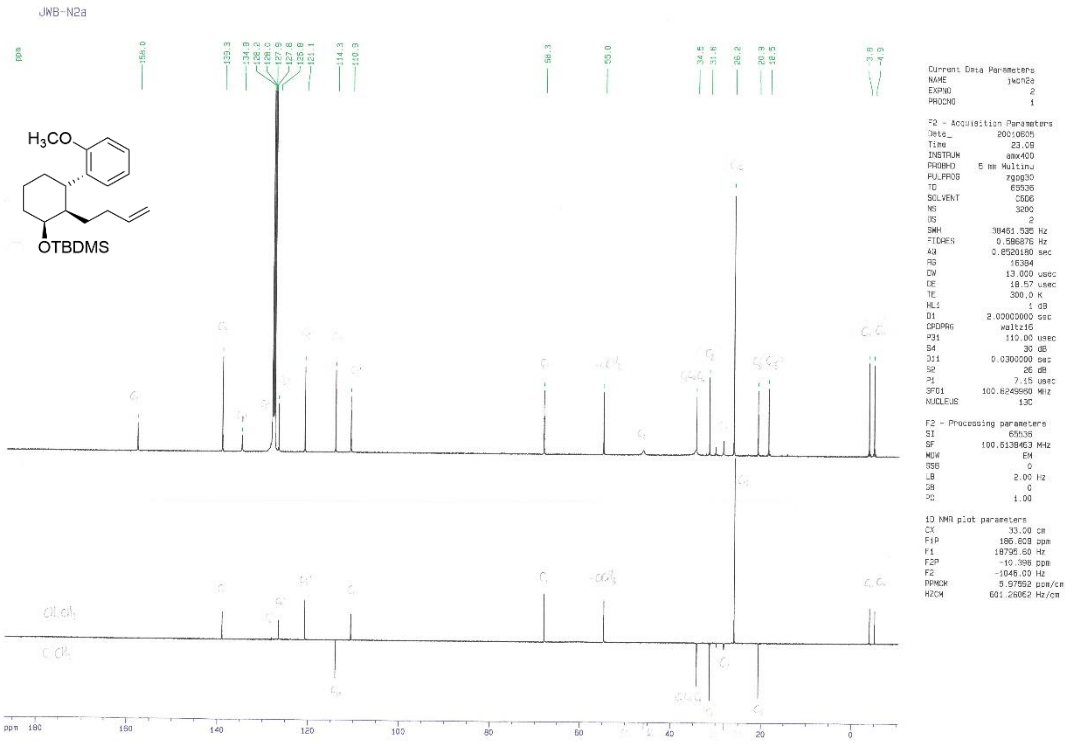
```
Current Data Parameters
NAME              jwbm5
EXPNO                 1
PROCNO                1

F2 - Acquisition Parameters
Date_          20010514
Time              12.27
INSTRUM          amx400
PROBHD     5 mm Multinu
PULPROG            zg30
TD                32768
SOLVENT           CDCl3
NS                   34
DS                    2
SWH            6024.105 Hz
FIDRES         0.183841 Hz
AQ            2.7197940 sec
RG                   32
DW               83.000 usec
DE               118.57 usec
TE                300.0 K
HL1                   1 dB
D1           3.00000000 sec
P1                 8.20 usec
SFO1        400.1367510 MHz
NUCLEUS              1H

F2 - Processing parameters
SI                32768
SF          400.1343893 MHz
WDW                  GM
SSB                   0
LB                -0.35 Hz
GB                  0.2
PC                 1.00

1D NMR plot parameters
CX                32.00 cm
F1P              10.205 ppm
F1              4083.24 Hz
F2P              -0.318 ppm
F2              -127.09 Hz
PPMCM           0.32882 ppm/cm
HZCM          131.57268 Hz/cm
```



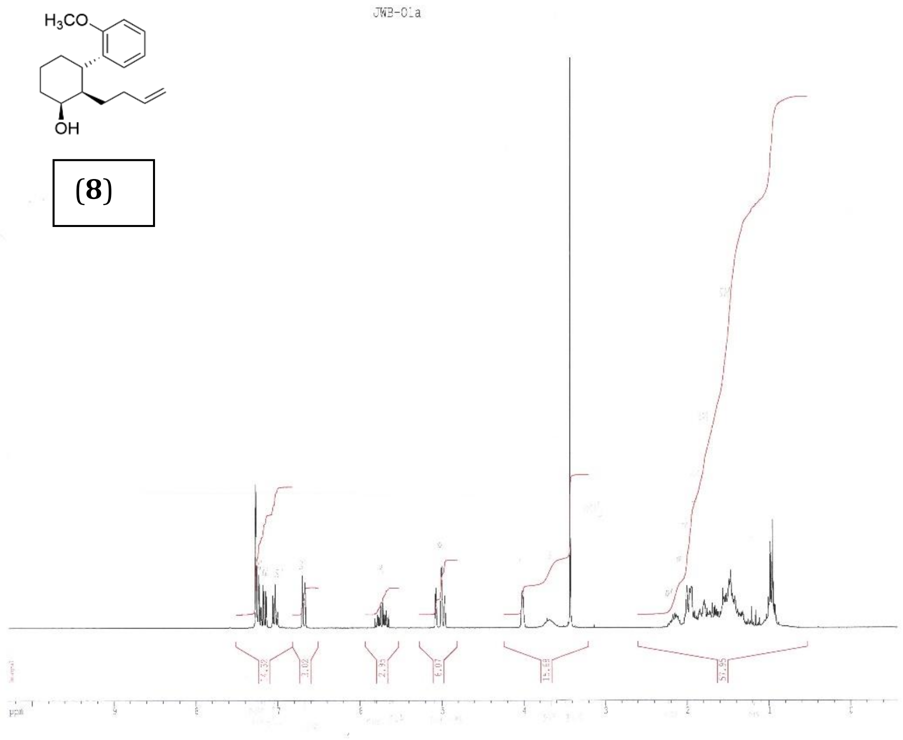
```
Current Data Parameters
NAME              jwbm5
EXPNO                 3
PROCNO                1

F2 - Acquisition Parameters
Date_          20010514
Time              15.36
INSTRUM          amx400
PROBHD     5 mm Multinu
PULPROG          zgpg30
TD                65536
SOLVENT           CDCl3
NS                  512
DS                    2
SWH           38461.539 Hz
FIDRES         0.586877 Hz
AQ            0.8520190 sec
RG                32768
DW               13.000 usec
DE                18.57 usec
TE                300.0 K
HL1                   1 dB
D1           2.00000000 sec
CPDPRG          waltz16
P31              110.00 usec
S4                   30 dB
D11          0.03000000 sec
S2                   26 dB
P1                 7.15 usec
SFO1        100.6250000 MHz
NUCLEUS             13C

F2 - Processing parameters
SI                65536
SF          100.6138820 MHz
WDW                  EM
SSB                   0
LB                 2.00 Hz
GB                    0
PC                 1.00

1D NMR plot parameters
CX                33.00 cm
F1P             214.379 ppm
F1             21569.53 Hz
F2P             -10.411 ppm
F2             -1047.52 Hz
PPMCM           6.81194 ppm/cm
HZCM          685.36536 Hz/cm
```



```
Current Data Parameters
NAME             jwbn2a
EXPNO                 1
PROCNO                1

F2 - Acquisition Parameters
Date_          20010606
Time              10.15
INSTRUM          amx400
PROBHD     5 mm Multinu
PULPROG            zg30
TD                32768
SOLVENT            C6D6
NS                   16
DS                    2
SWH            6024.105 Hz
FIDRES         0.183841 Hz
AQ            2.7197940 sec
RG                   64
DW               83.000 usec
DE               118.57 usec
TE                300.0 K
HL1                   1 dB
D1           3.00000000 sec
P1                 8.20 usec
SFO1        400.1367350 MHz
NUCLEUS              1H

F2 - Processing parameters
SI                32768
SF          400.1344097 MHz
WDW                  GM
SSB                   0
LB                -0.25 Hz
GB                  0.2
PC                 1.00

1D NMR plot parameters
CX                32.00 cm
F1P               8.145 ppm
F1              3259.97 Hz
F2P              -0.282 ppm
F2              -112.68 Hz
PPMCM           0.25332 ppm/cm
HZCM          105.35411 Hz/cm
```

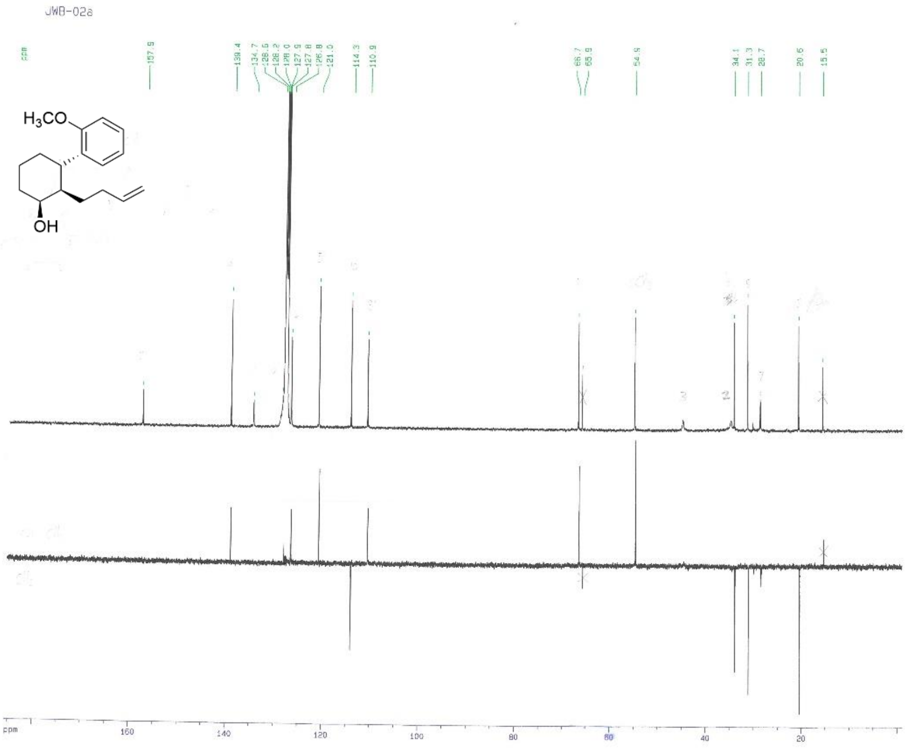


```
Current Data Parameters
NAME             jwbn2a
EXPNO                 2
PROCNO                1

F2 - Acquisition Parameters
Date_          20010605
Time              23.09
INSTRUM          amx400
PROBHD     5 mm Multinu
PULPROG          zgpg30
TD                65536
SOLVENT            C6D6
NS                 3200
DS                    2
SWH           38461.535 Hz
FIDRES         0.586876 Hz
AQ            0.8520180 sec
RG                16384
DW               13.000 usec
DE                18.57 usec
TE                300.0 K
HL1                   1 dB
D1           2.00000000 sec
CPDPRG          waltz16
P31              110.00 usec
S4                   30 dB
D11          0.03000000 sec
S2                   26 dB
P1                 7.15 usec
SFO1        100.6249960 MHz
NUCLEUS             13C

F2 - Processing parameters
SI                65536
SF          100.6138463 MHz
WDW                  EM
SSB                   0
LB                 2.00 Hz
GB                    0
PC                 1.00

1D NMR plot parameters
CX                33.00 cm
F1P             186.809 ppm
F1             18795.60 Hz
F2P             -10.396 ppm
F2             -1046.00 Hz
PPMCM           5.97592 ppm/cm
HZCM          601.26062 Hz/cm
```



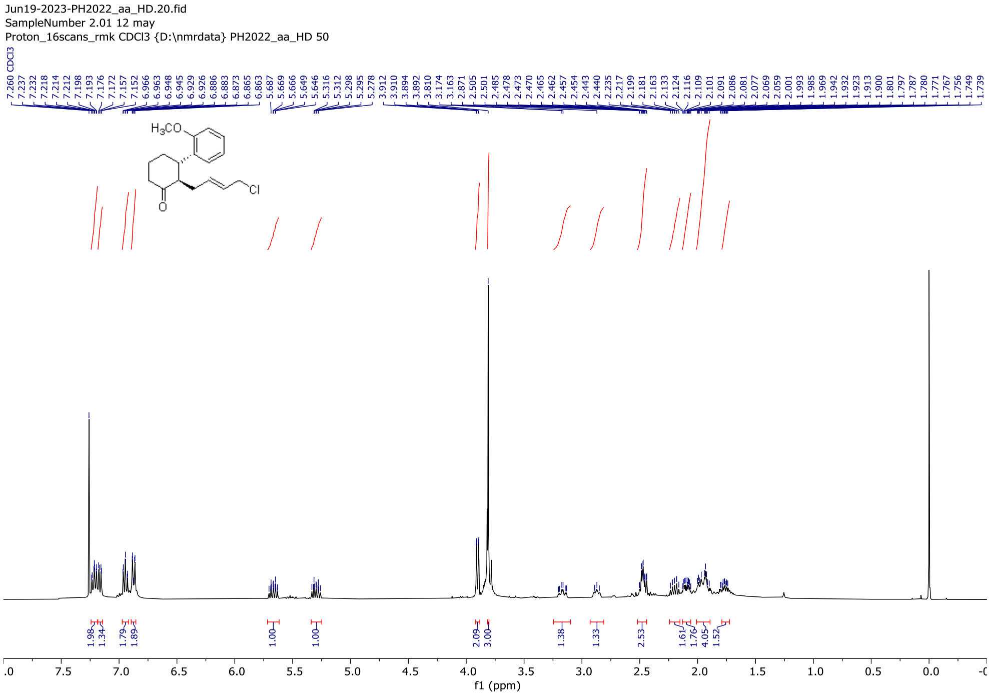
(**8**)

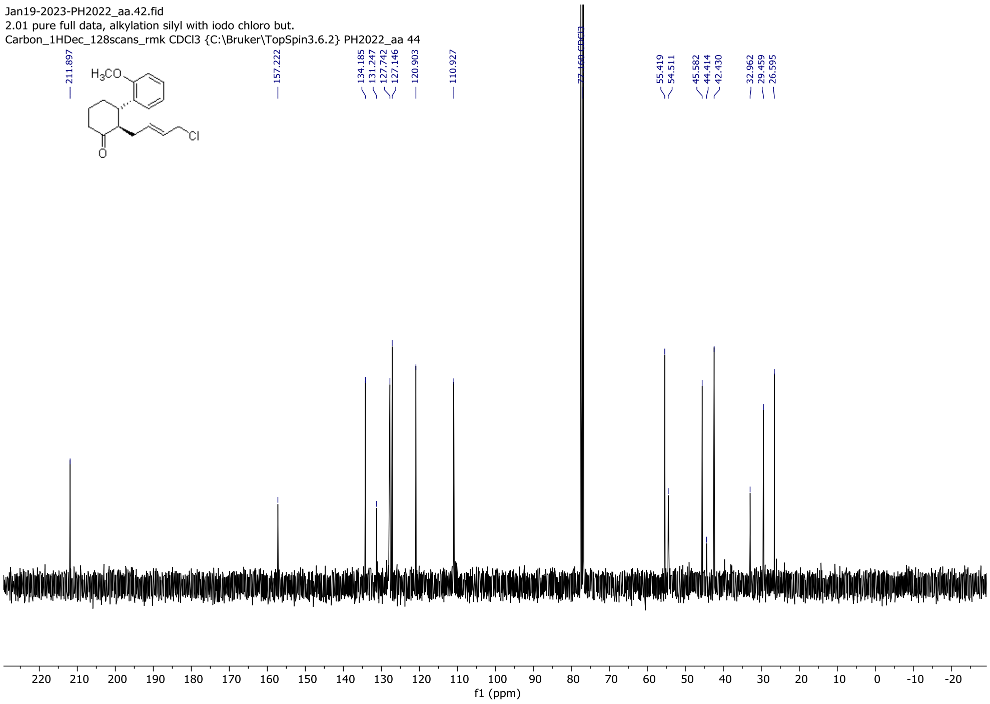
```
Current Data Parameters
NAME        Jun26-2001
EXPNO               22
PROCNO               1

F2 - Acquisition Parameters
Date_         20010626
Time             20.46
INSTRUM         dpx250
PROBHD    5 mm Multinu
PULPROG           zg30
TD               32768
SOLVENT           C6D6
NS                  16
DS                   2
SWH           3255.208 Hz
FIDRES        0.099341 Hz
AQ           5.0332146 sec
RG                 128
DW             153.600 use
DE                4.50 use
TE               300.0 K
D1          1.00000000 sec

============ CHANNEL f1 ===
NUC1                1H
P1               10.00 use
PL1              -6.00 dB
SFO1       249.8713493 MHz

F2 - Processing parameters
SI               32768
SF         249.8700000 MHz
WDW                 EM
SSB                  0
LB                0.10 Hz
GB                   0
PC                3.00

1D NMR plot parameters
CX               33.00 cm
F1P             10.285 ppm
F1             2569.79 Hz
F2P             -0.570 ppm
F2             -142.47 Hz
PPMCM          0.32893 ppm
HZCM          82.18987 Hz/
```

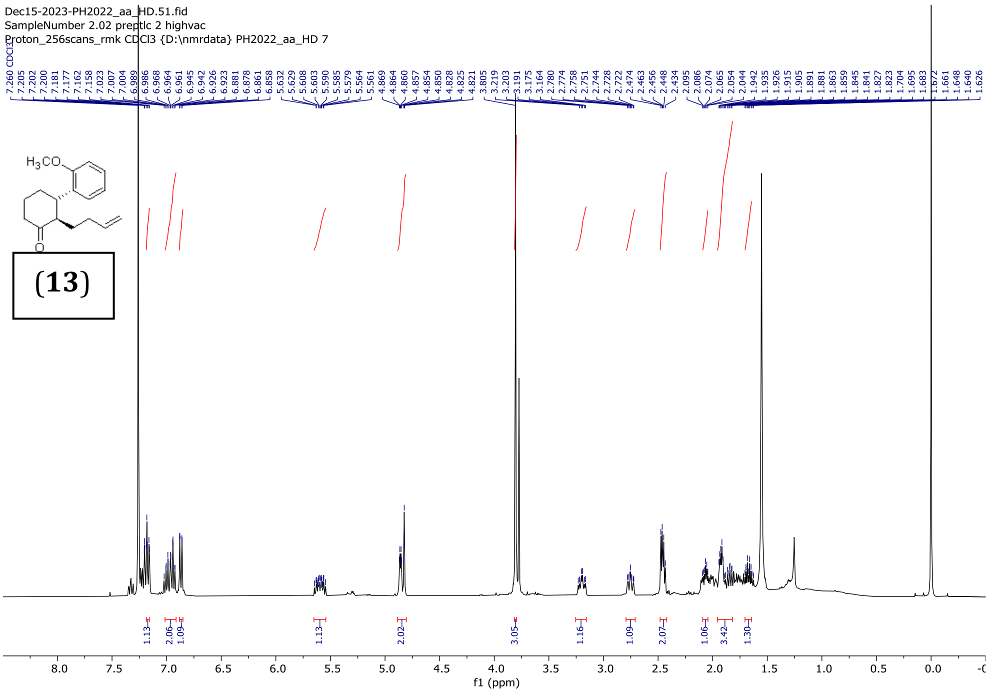


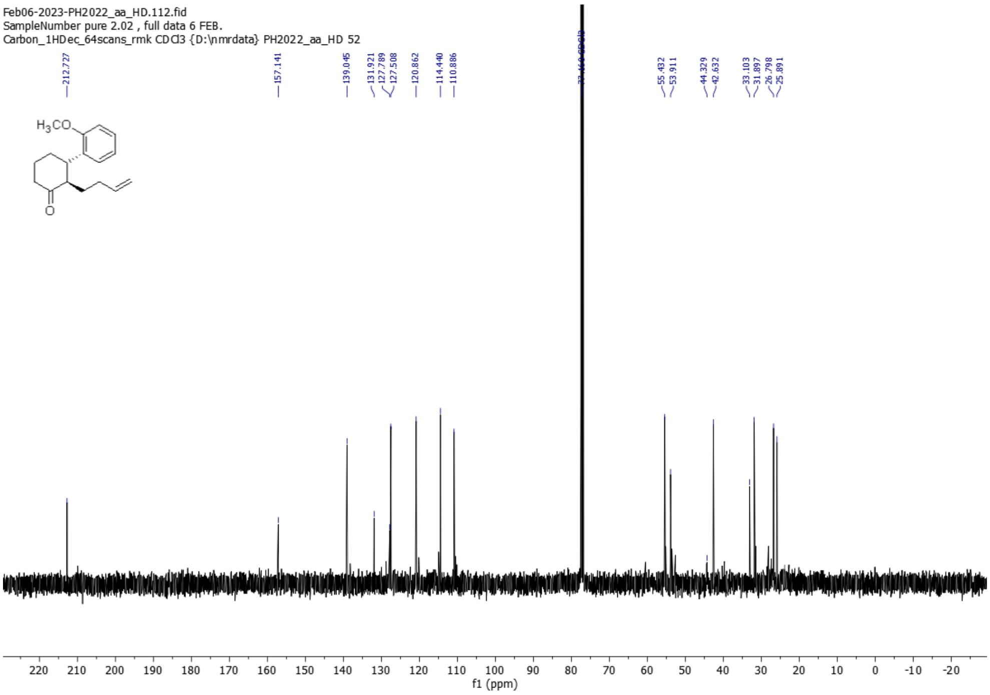
```
Current Data Parameters
NAME            jwb02a
EXPNO                2
PROCNO               1

F2 - Acquisition Parameters
Date_         20010823
Time             15.26
INSTRUM         amx400
PROBHD    5 mm Multinu
PULPROG         zgpg30
TD               65536
SOLVENT           C6D6
NS                6400
DS                   2
SWH          38461.535 Hz
FIDRES        0.586876 Hz
AQ           0.8520180 sec
RG               32768
DW              13.000 usec
DE               18.57 usec
TE               300.0 K
HL1                  1 dB
D1          2.00000000 sec
CPDPRG         waltz16
P31             110.00 usec
S4                  30 dB
D11         0.03000000 sec
S2                  26 dB
P1                7.15 usec
SFO1       100.6249960 MHz
NUCLEUS            13C

F2 - Processing parameters
SI               65536
SF         100.6138493 MHz
WDW                 EM
SSB                  0
LB                2.00 Hz
GB                   0
PC                1.00

1D NMR plot parameters
CX               33.00 cm
F1P            185.577 ppm
F1            18681.56 Hz
F2P             -1.088 ppm
F2             -109.48 Hz
PPMCM          5.65955 ppm/cm
HZCM         569.42302 Hz/cm
```

Synthesis of the 4-carbon tether substrate: Route B

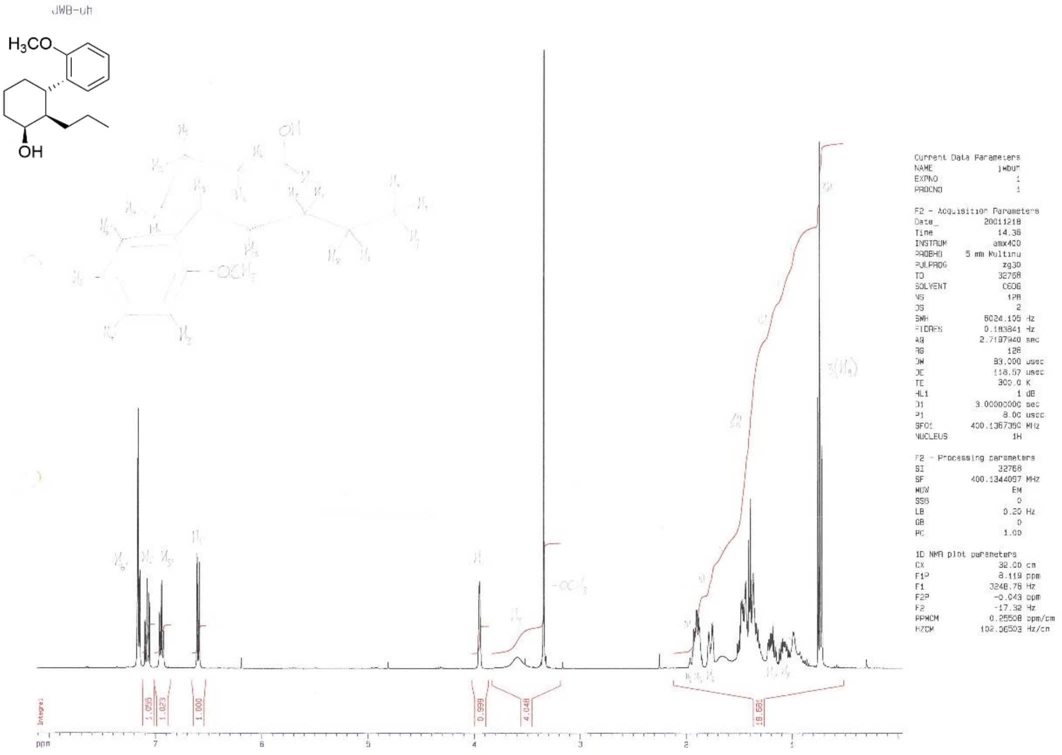




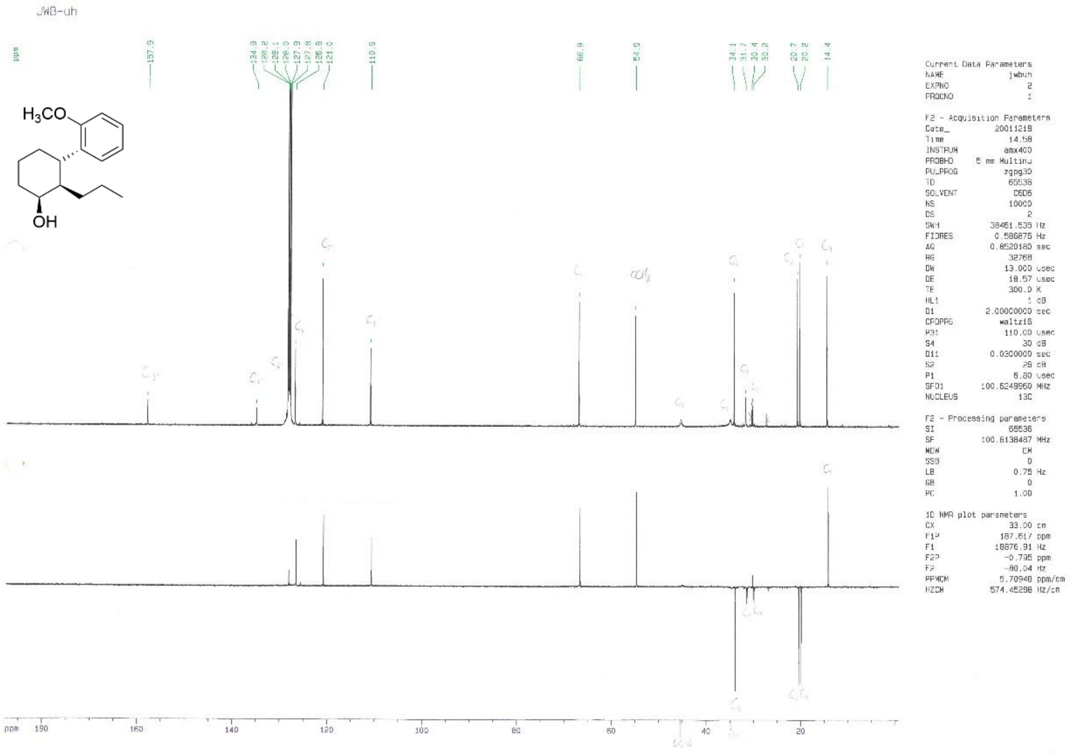

Dec15-2023-PH2022_aa_HD.51.fid
SampleNumber 2.02 preptlc 2 highvac
Proton_256scans_rmk CDCl3 {D:\nmrdata} PH2022_aa_HD 7
7.260 CDCl3
7.205
7.202
7.200
7.181
7.177
7.162
7.158
7.023
7.007
7.004
6.989
6.986
6.968
6.964
6.961
6.945
6.942
6.926
6.923
6.881
6.878
6.861
6.858
5.632
5.629
5.608
5.603
5.590
5.585
5.579
5.564
5.561
4.869
4.864
4.860
4.857
4.854
4.850
4.828
4.825
4.821
3.805
3.219
3.203
3.191
3.175
3.164
2.780
2.774
2.758
2.751
2.744
2.728
2.722
2.474
2.463
2.456
2.448
2.434
2.095
2.086
2.074
2.065
2.054
2.044
1.942
1.935
1.926
1.915
1.905
1.891
1.881
1.863
1.859
1.845
1.841
1.827
1.823
1.704
1.695
1.683
1.672
1.661
1.648
1.640
1.626
H3CO
O
(13)
1.13
2.06
1.09
1.13
2.02
3.05
1.16
1.09
2.07
1.06
3.42
1.30
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0
f1 (ppm)


Feb06-2023-PH2022_aa_HD.112.fid
SampleNumber pure 2.02 , full data 6 FEB.
Carbon_1HDec_64scans_rmk CDCl3 {D:\nmrdata} PH2022_aa_HD 52
212.727
157.141
139.045
131.921
127.789
127.508
120.862
114.440
110.886
55.432
53.911
44.329
42.632
33.103
31.897
26.798
25.891
H3CO
O
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
f1 (ppm)

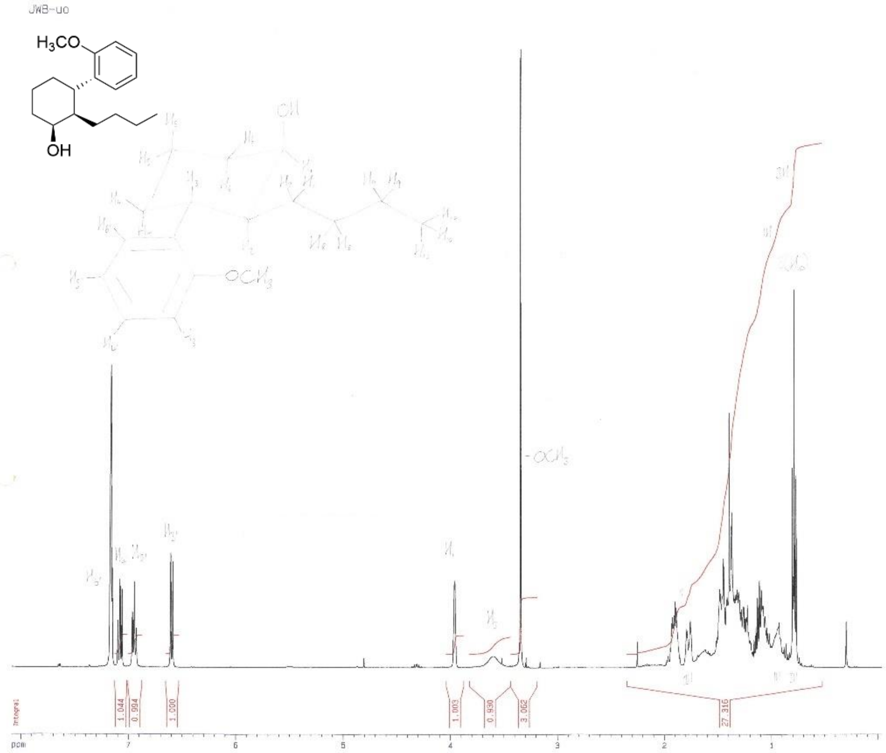
Synthesis of substrates for fluorescence comparison



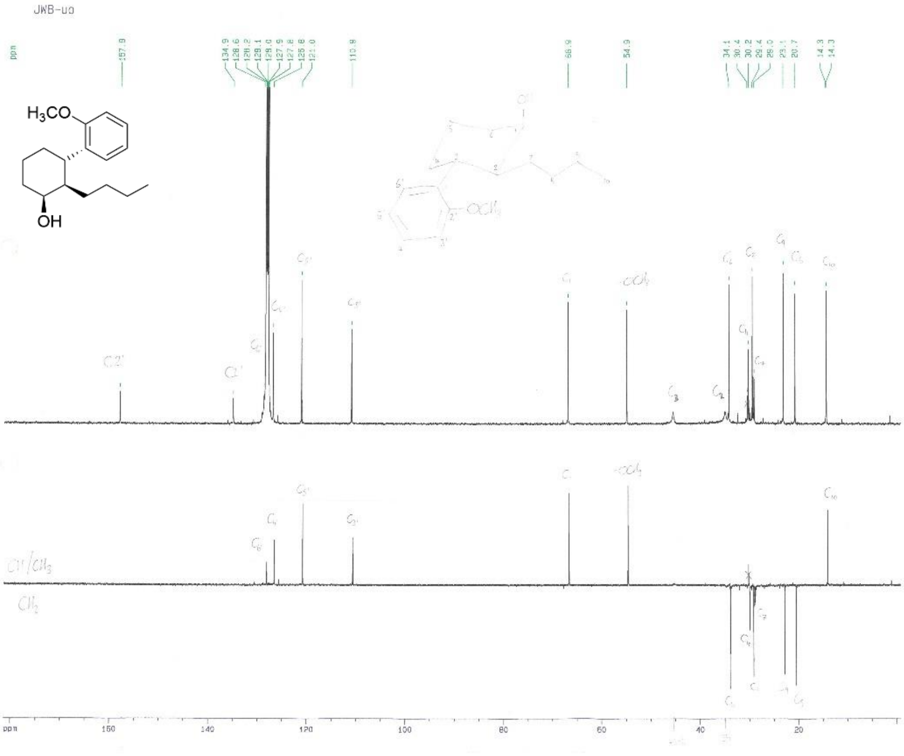
```
Current Data Parameters
NAME                jwbuh
EXPNO                   1
PROCNO                  1

F2 - Acquisition Parameters
Date_            20011218
Time                14.36
INSTRUM            amx400
PROBHD       5 mm Multinu
PULPROG              zg30
TD                  32768
SOLVENT              C6D6
NS                    128
DS                      2
SWH              6024.105 Hz
FIDRES           0.183841 Hz
AQ              2.7197940 sec
RG                    128
DW                 83.000 usec
DE                 118.57 usec
TE                  300.0 K
HL1                     1 dB
D1             3.00000000 sec
P1                   8.00 usec
SFO1          400.1367350 MHz
NUCLEUS                1H

F2 - Processing parameters
SI                  32768
SF            400.1344097 MHz
WDW                    EM
SSB                     0
LB                   0.20 Hz
GB                      0
PC                   1.00

1D NMR plot parameters
CX                  32.00 cm
F1P                 8.119 ppm
F1                3248.76 Hz
F2P                -0.043 ppm
F2                 -17.32 Hz
PPMCM             0.25508 ppm/cm
HZCM            102.06503 Hz/cm
```



```
Current Data Parameters
NAME                jwbuh
EXPNO                   2
PROCNO                  1

F2 - Acquisition Parameters
Date_            20011218
Time                14.58
INSTRUM            amx400
PROBHD       5 mm Multinu
PULPROG            zgpg30
TD                  65536
SOLVENT              C6D6
NS                  10000
DS                      2
SWH             38461.535 Hz
FIDRES           0.586875 Hz
AQ              0.8520180 sec
RG                  32768
DW                 13.000 usec
DE                  18.57 usec
TE                  300.0 K
HL1                     1 dB
D1             2.00000000 sec
CPDPRG            waltz16
P31                110.00 usec
S4                     30 dB
D11            0.03000000 sec
S2                     26 dB
P1                   6.80 usec
SFO1          100.6249960 MHz
NUCLEUS               13C

F2 - Processing parameters
SI                  65536
SF            100.6138487 MHz
WDW                    EM
SSB                     0
LB                   0.75 Hz
GB                      0
PC                   1.00

1D NMR plot parameters
CX                  33.00 cm
F1P               187.617 ppm
F1               18876.91 Hz
F2P                -0.795 ppm
F2                 -80.04 Hz
PPMCM             5.70948 ppm/cm
HZCM            574.45298 Hz/cm
```



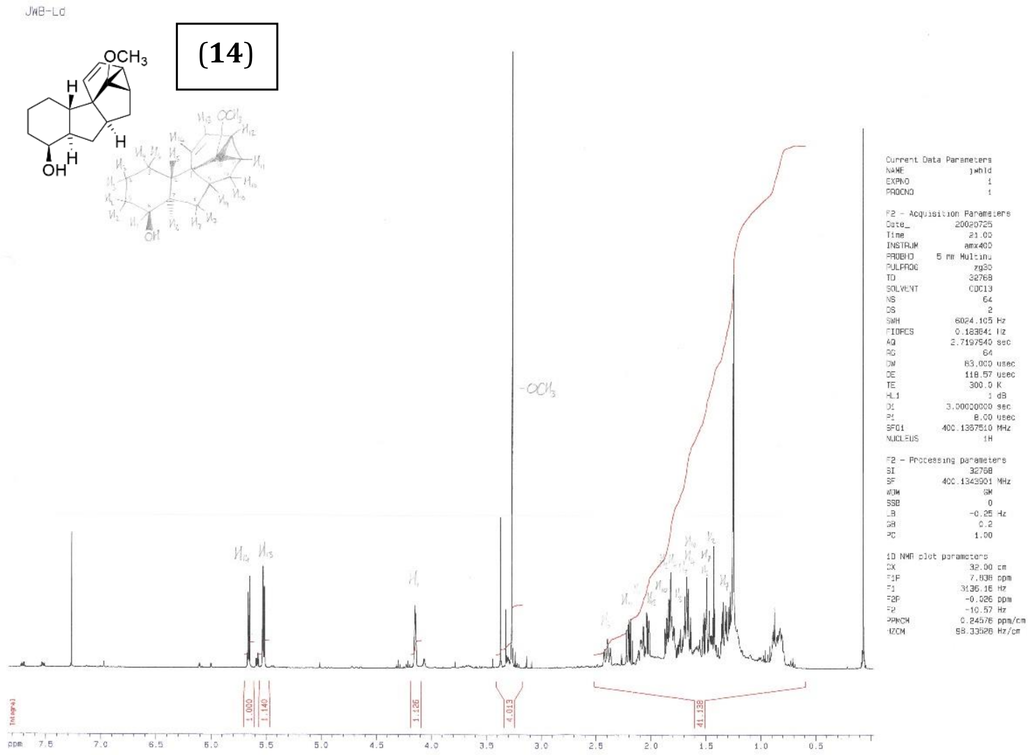
```
Current Data Parameters
NAME              jwbuo
EXPNO                 1
PROCNO                1

F2 - Acquisition Parameters
Date_          20011217
Time              16.27
INSTRUM          amx400
PROBHD    5 mm Multinu
PULPROG            zg30
TD                32768
SOLVENT            C6D6
NS                  128
DS                    2
SWH            6024.105 Hz
FIDRES         0.183841 Hz
AQ            2.7197940 sec
RG                  128
DW               83.000 usec
DE              118.57 usec
TE                300.0 K
HL1                   1 dB
D1           3.00000000 sec
P1                 8.00 usec
SFO1        400.1367350 MHz
NUCLEUS              1H

F2 - Processing parameters
SI                32768
SF          400.1344095 MHz
WDW                  EM
SSB                   0
LB                 0.20 Hz
GB                    0
PC                 1.00

1D NMR plot parameters
CX                32.00 cm
F1P               8.086 ppm
F1              3235.39 Hz
F2P              -0.036 ppm
F2               -14.37 Hz
PPMCM           0.25380 ppm/cm
HZCM          101.55518 Hz/cm
```



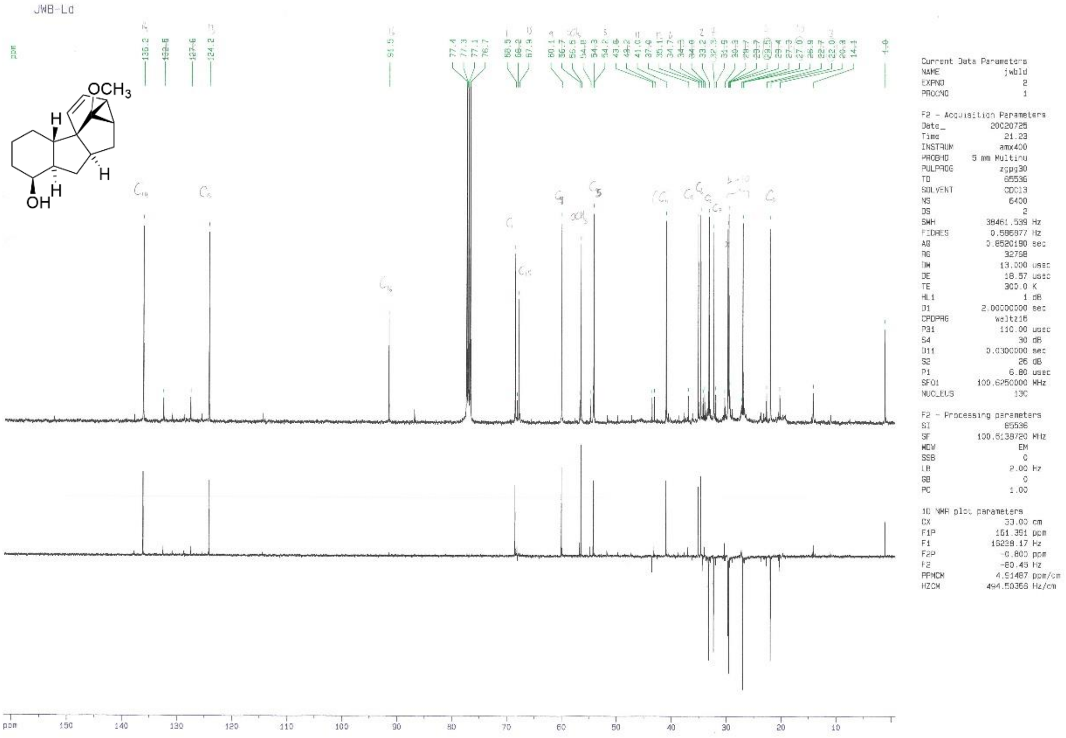
```
Current Data Parameters
NAME              jwbuo
EXPNO                 2
PROCNO                1

F2 - Acquisition Parameters
Date_          20011217
Time              16.49
INSTRUM          amx400
PROBHD    5 mm Multinu
PULPROG          zgpg30
TD                65536
SOLVENT            C6D6
NS                 9600
DS                    2
SWH           38461.535 Hz
FIDRES         0.586876 Hz
AQ            0.8520180 sec
RG                16384
DW               13.000 usec
DE                18.57 usec
TE                300.0 K
HL1                   1 dB
D1           2.00000000 sec
CPDPRG         waltz16
P31              110.00 usec
S4                   30 dB
D11          0.0300000 sec
S2                   26 dB
P1                 6.80 usec
SFO1        100.6249960 MHz
NUCLEUS             13C

F2 - Processing parameters
SI                65536
SF          100.6138487 MHz
WDW                  EM
SSB                   0
LB                 2.00 Hz
GB                    0
PC                 1.00

1D NMR plot parameters
CX                33.00 cm
F1P             181.343 ppm
F1             18245.61 Hz
F2P              -0.790 ppm
F2               -79.44 Hz
PPMCM           5.51917 ppm/cm
HZCM          555.30444 Hz/cm
```

Photolysis of the 3-carbon

(14)

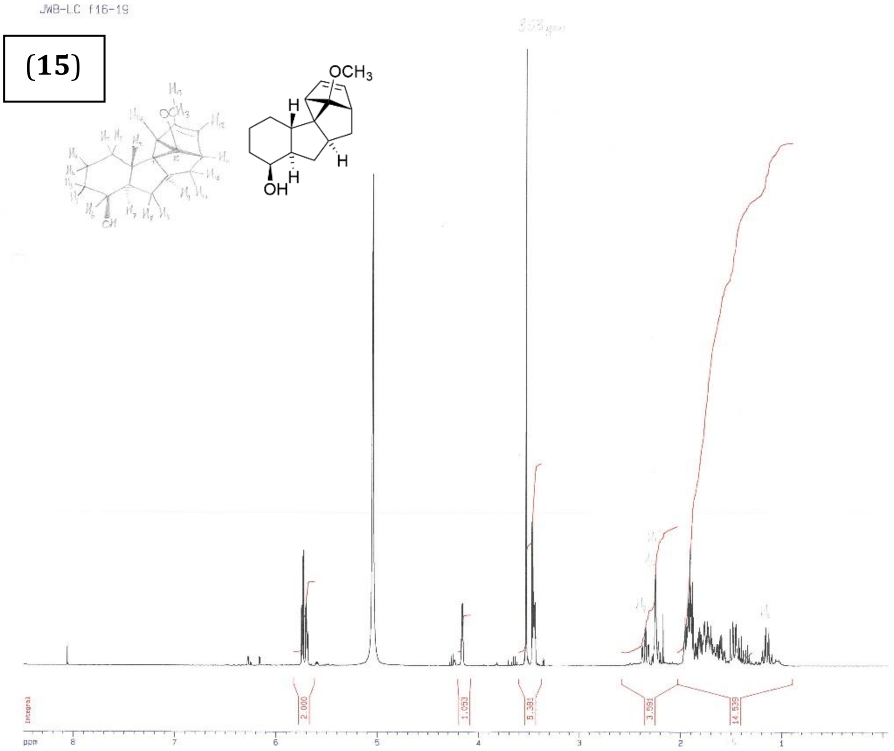


```
Current Data Parameters
NAME               jwbld
EXPNO                  1
PROCNO                 1

F2 - Acquisition Parameters
Date_           20020725
Time               21.00
INSTRUM           amx400
PROBHD     5 mm Multinu
PULPROG             zg30
TD                 32768
SOLVENT            CDCl3
NS                    64
DS                     2
SWH             6024.105 Hz
FIDRES          0.183841 Hz
AQ             2.7197540 sec
RG                    64
DW                63.000 usec
DE                118.57 usec
TE                 300.0 K
HL1                    1 dB
D1            3.00000000 sec
P1                  8.00 usec
SFO1         400.1367510 MHz
NUCLEUS               1H

F2 - Processing parameters
SI                 32768
SF           400.1343901 MHz
WDW                   GM
SSB                    0
LB                 -0.25 Hz
GB                   0.2
PC                  1.00

1D NMR plot parameters
CX                 32.00 cm
F1P                7.836 ppm
F1               3136.16 Hz
F2P               -0.026 ppm
F2                -10.57 Hz
PPMCM            0.24576 ppm/cm
HZCM            98.33526 Hz/cm
```

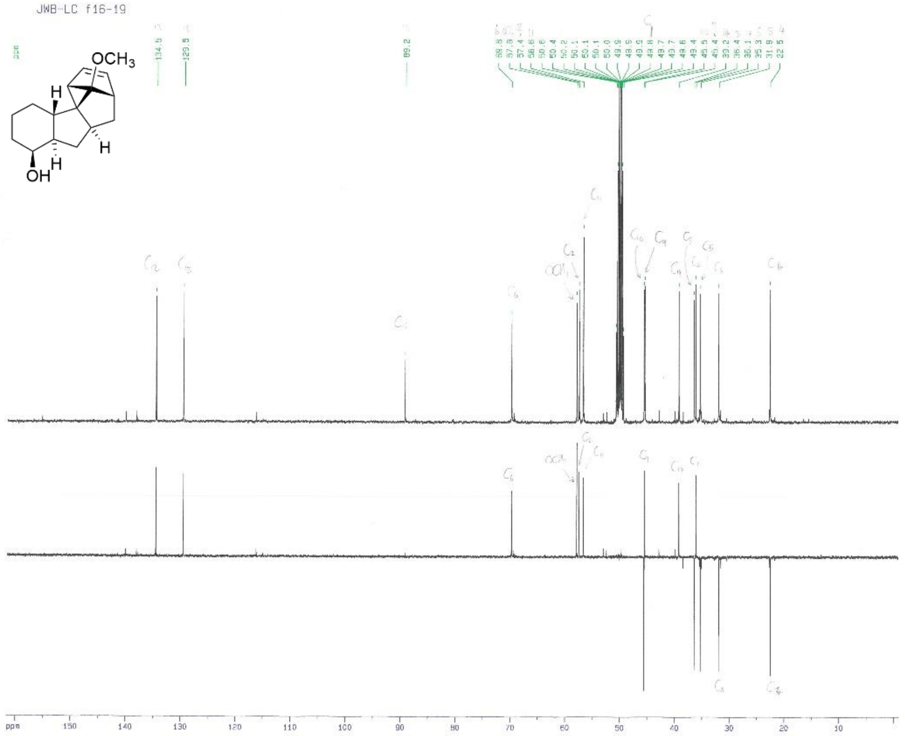


```
Current Data Parameters
NAME               jwbld
EXPNO                  2
PROCNO                 1

F2 - Acquisition Parameters
Date_           20020725
Time               21.23
INSTRUM           amx400
PROBHD     5 mm Multinu
PULPROG           zgpg30
TD                 65536
SOLVENT            CDCl3
NS                  6400
DS                     2
SWH            38461.539 Hz
FIDRES          0.586877 Hz
AQ             0.8520190 sec
RG                 32768
DW                13.000 usec
DE                 18.57 usec
TE                 300.0 K
HL1                    1 dB
D1            2.00000000 sec
CPDPRG           waltz16
P31               110.00 usec
S4                    30 dB
D11           0.03000000 sec
S2                    26 dB
P1                  6.80 usec
SFO1         100.6250000 MHz
NUCLEUS              13C

F2 - Processing parameters
SI                 65536
SF           100.6138720 MHz
WDW                   EM
SSB                    0
LB                  2.00 Hz
GB                     0
PC                  1.00

1D NMR plot parameters
CX                 33.00 cm
F1P              161.391 ppm
F1              16238.17 Hz
F2P               -0.800 ppm
F2                -80.49 Hz
PPMCM            4.91487 ppm/cm
HZCM           494.50366 Hz/cm
```

(15)

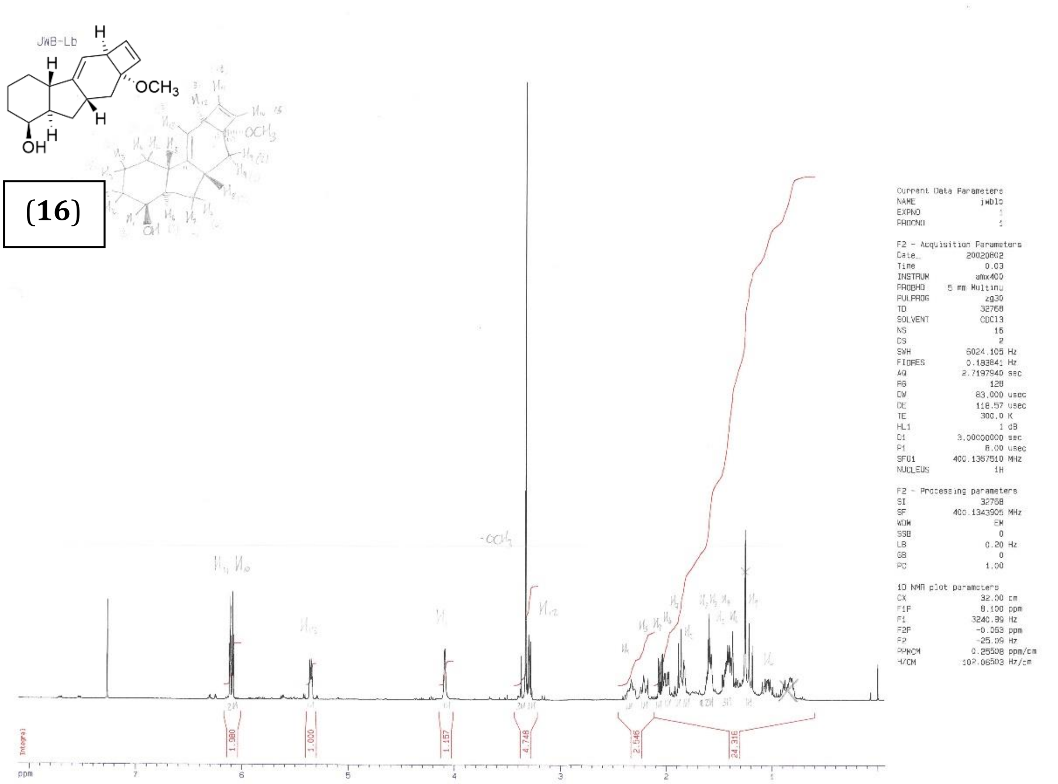


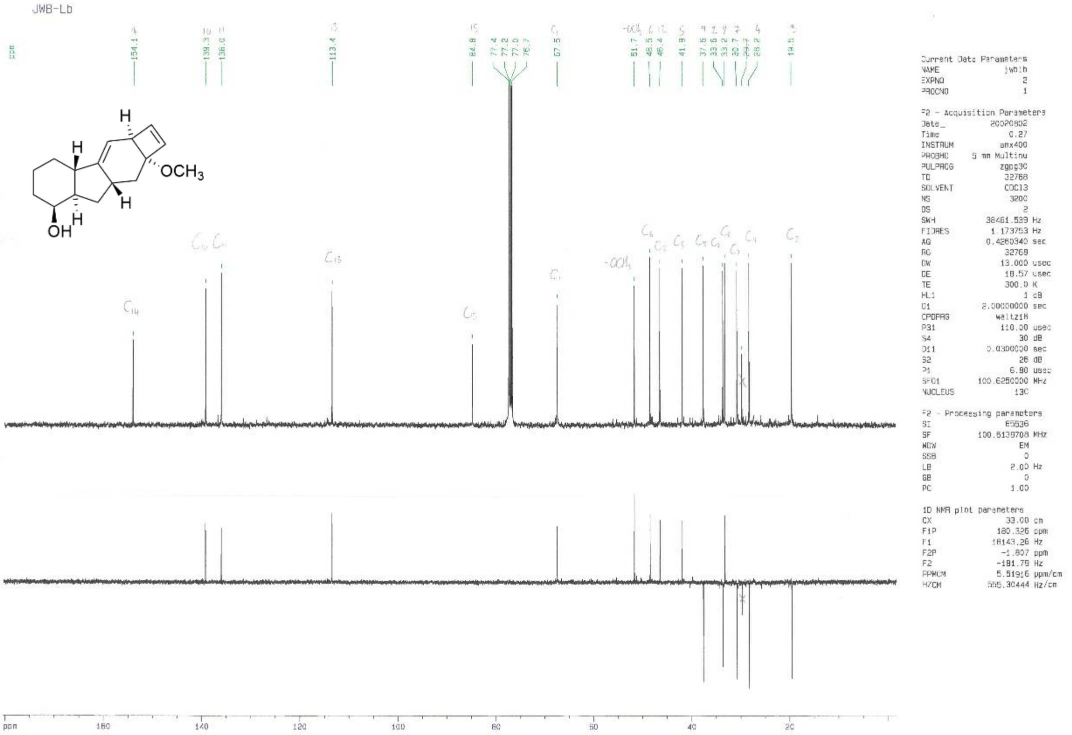
```
Current Data Parameters
NAME             jwhlc
EXPNO                1
PROCNO               1

F2 - Acquisition Parameters
Date_         20020911
Time             17.25
INSTRUM         amx400
PROBHD    5 mm Multinu
PULPROG           zg30
TD               32768
SOLVENT           MeOH
NS                 160
DS                   2
SWH           6024.129 Hz
FIDRES        0.183842 Hz
AQ           2.7197940 sec
RG                 256
DW              83.000 usec
DE              118.57 usec
TE               300.0 K
HL1                  1 dB
D1          3.00000000 sec
P1                8.00 usec
SFO1       400.1383275 MHz
NUCLEUS             1H

F2 - Processing parameters
SI               32768
SF         400.1359068 MHz
WDW                 EM
SSB                  0
LB                0.20 Hz
GB                   0
PC                1.00

1D NMR plot parameters
CX               32.00 cm
F1P              8.488 ppm
F1             3396.26 Hz
F2P             -0.054 ppm
F2              -21.77 Hz
PPMCM          0.26694 ppm/cm
HZCM         106.81369 Hz/cm
```



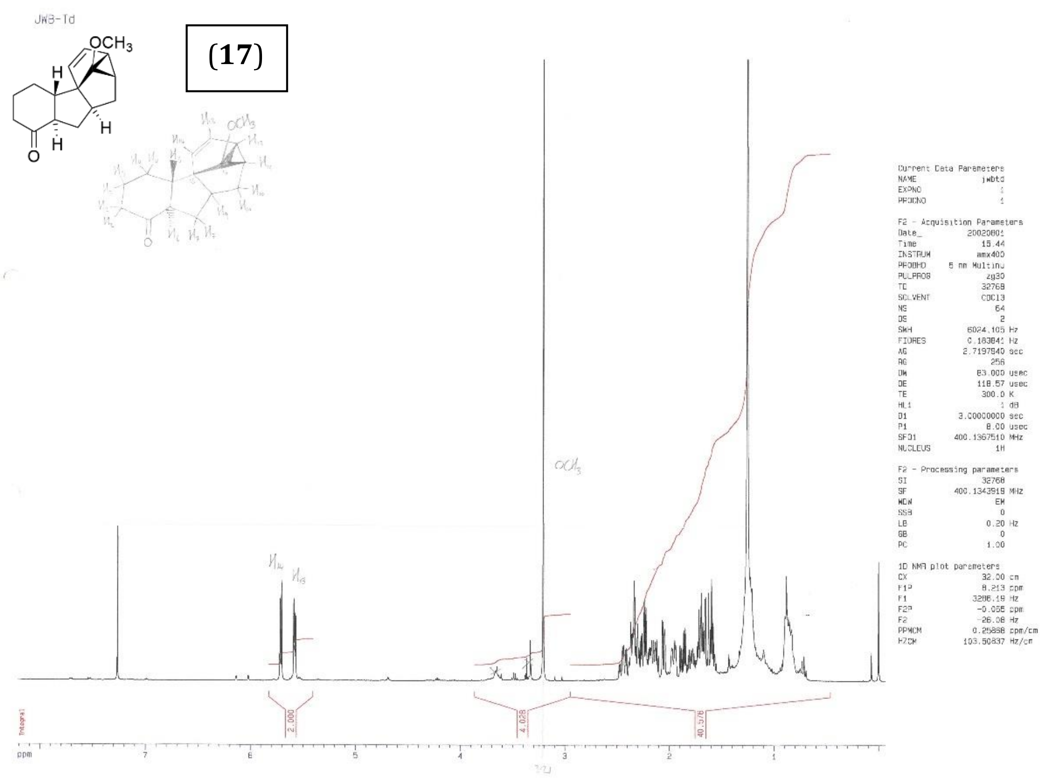
```
Current Data Parameters
NAME             jwhlc
EXPNO                2
PROCNO               1

F2 - Acquisition Parameters
Date_         20020911
Time             17.51
INSTRUM         amx400
PROBHD    5 mm Multinu
PULPROG         zgpg30
TD               32768
SOLVENT           MeOH
NS                8205
DS                   2
SWH          38461.691 Hz
FIDRES        1.173758 Hz
AQ           0.4260340 sec
RG               32768
DW              13.000 usec
DE               18.57 usec
TE               300.0 K
HL1                  1 dB
D1          2.00000000 sec
CPDPRG         waltz16
P31             110.00 usec
S4                  30 dB
D11         0.03000000 sec
S2                  26 dB
P1                6.80 usec
SFO1       100.6253965 MHz
NUCLEUS            13C

F2 - Processing parameters
SI               65536
SF         100.6140291 MHz
WDW                 EM
SSB                  0
LB                2.00 Hz
GB                   0
PC                1.00

1D NMR plot parameters
CX               33.00 cm
F1P            161.605 ppm
F1            16259.73 Hz
F2P             -0.860 ppm
F2              -86.49 Hz
PPMCM          4.92317 ppm/cm
HZCM         495.33994 Hz/cm
```

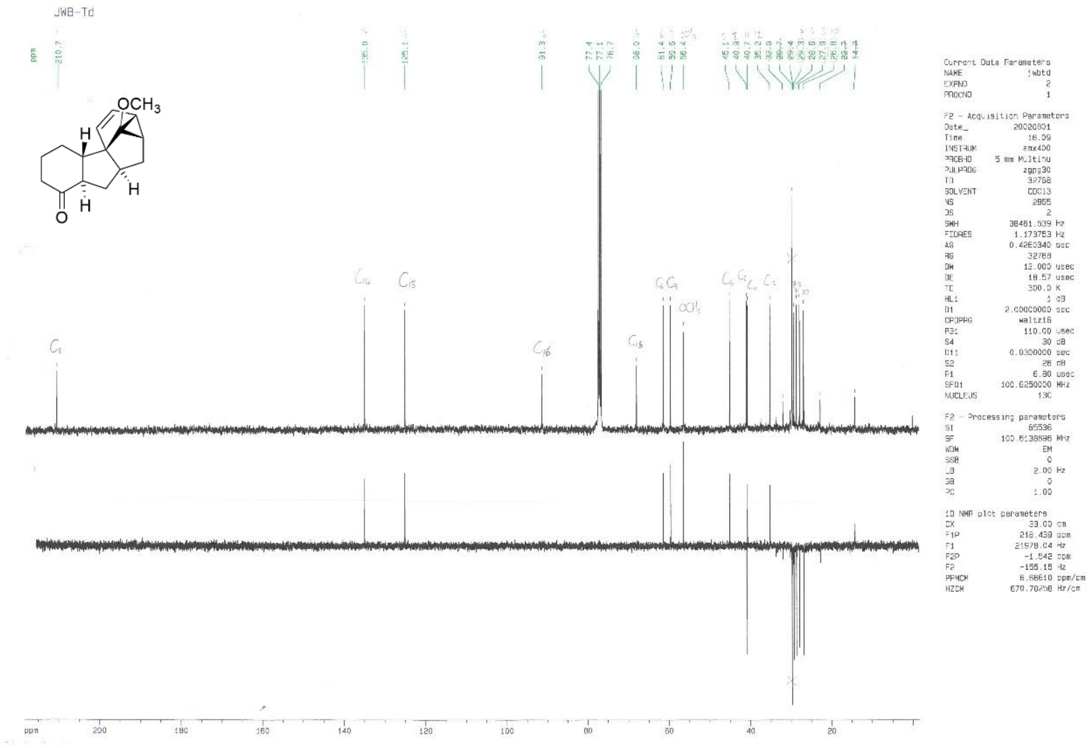
(16)

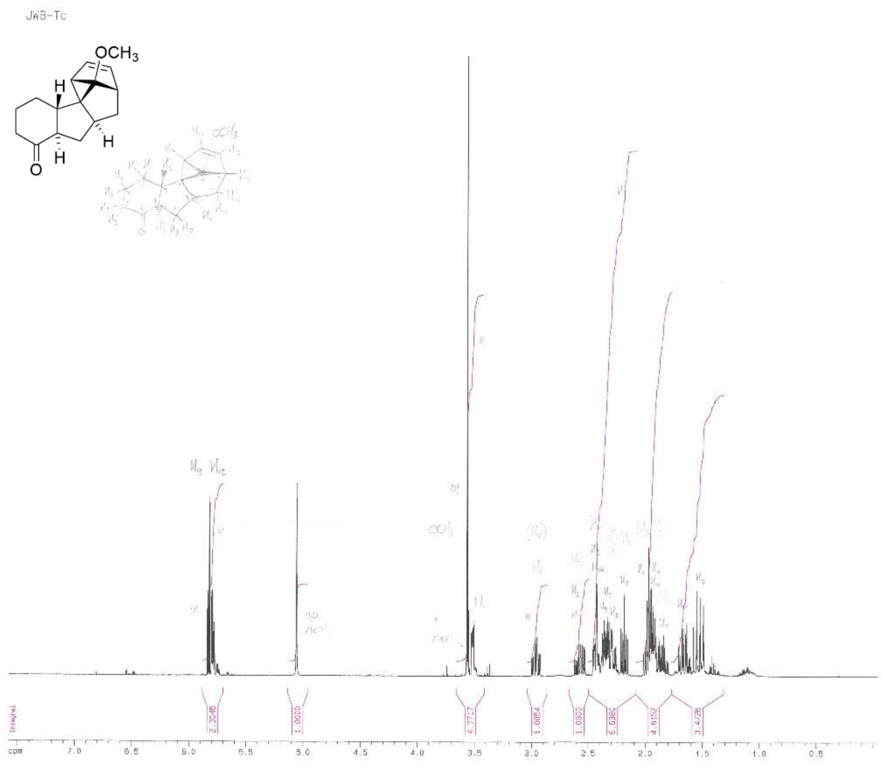

JWB-Lb
H
H
OCH3
H
OH
H
-OCH3
Current Data Parameters
NAME jwb1b
EXPNO 1
PROCNO 1
F2 - Acquisition Parameters
Date_ 20020802
INSTRUM amx400
PROBHD 5 mm Multinu
PULPROG zg30
TD 32768
SOLVENT CDCl3
NS 16
DS 2
SWH 6024.106 Hz
AQ 2.7197940 sec
SFO1 400.1357510 MHz
NUCLEUS 1H
F2 - Processing parameters
SI 32768
SF 400.1343905 MHz
WDW EM
LB 0.20 Hz
1D NMR plot parameters
Integral
1.980
1.000
1.157
4.748
2.546
24.316
ppm
7
6
5
4
3
2
1


JWB-Lb
154.1
139.3
136.0
113.4
84.8
77.4
77.2
77.0
76.7
67.5
51.7
48.5
46.4
41.9
37.6
33.6
33.2
30.7
29.7
28.2
19.5
H
H
OCH3
H
OH
H
C14
C10
C11
C13
C15
C1
-OCH3
Current Data Parameters
NAME jwb1b
EXPNO 2
PROCNO 1
F2 - Acquisition Parameters
Date_ 20020802
INSTRUM amx400
PROBHD 5 mm Multinu
PULPROG zgpg30
TD 32768
SOLVENT CDCl3
NS 3200
DS 2
SWH 38461.539 Hz
AQ 0.4260340 sec
CPDPRG waltz16
SFO1 100.6256000 MHz
NUCLEUS 13C
F2 - Processing parameters
SI 65536
SF 100.6130708 MHz
WDW EM
LB 2.00 Hz
1D NMR plot parameters
ppm
160
140
120
100
80
60
40
20

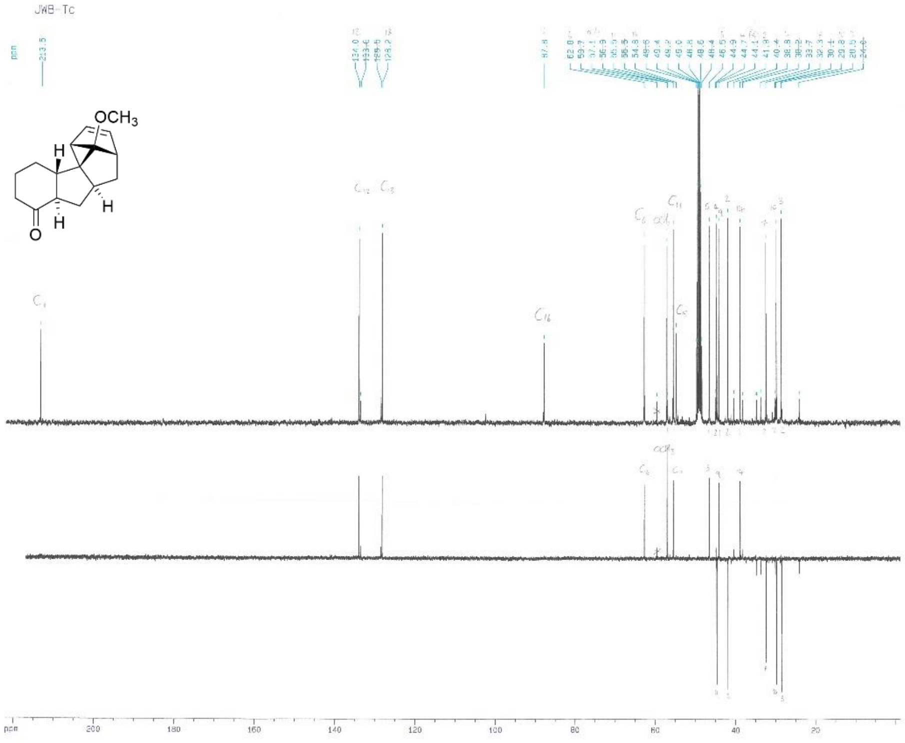
Identification of 3-carbon tether cycloadducts


(17)

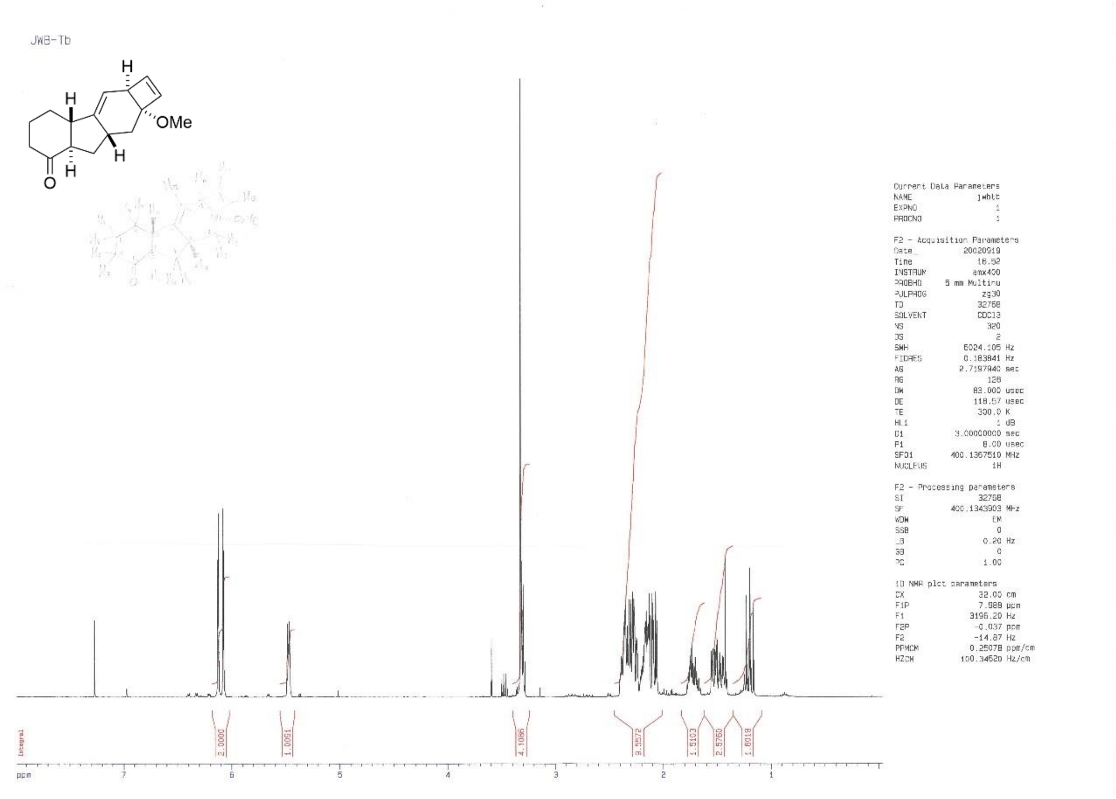




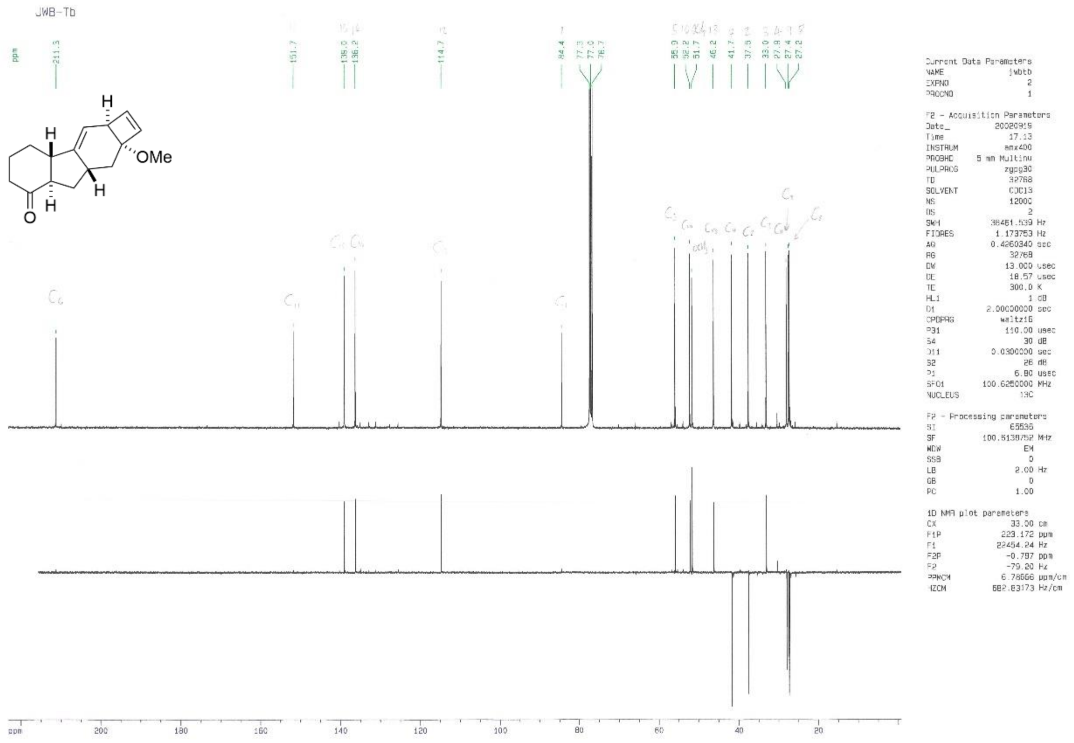
```
Current Data Parameters
NAME               jwbtc
EXPNO                  1
PROCNO                 1

F2 - Acquisition Parameters
Date_           20020416
Time               10.35
INSTRUM           amx400
PROBHD     5 mm Multinu
PULPROG             zg30
TD                 32768
SOLVENT             MeOH
NS                    16
DS                     2
SWH           6024.129 Hz
FIDRES        0.183842 Hz
AQ           2.7197940 sec
RG                    64
DW              83.000 usec
DE              118.57 usec
TE               300.0 K
HL1                    1 dB
D1          3.00000000 sec
P1                8.00 usec
SFO1       400.1383276 MHz
NUCLEUS               1H

F2 - Processing parameters
SI                 32768
SF         400.1358800 MHz
WDW                   GM
SSB                    0
LB               -0.30 Hz
GB                   0.3
PC                  1.00

1D NMR plot parameters
CX               32.00 cm
F1P              7.575 ppm
F1             3031.02 Hz
F2P             -0.037 ppm
F2              -14.81 Hz
PPMCM          0.23787 ppm/cm
HZCM          95.18225 Hz/cm
```



```
Current Data Parameters
NAME               jwbtc
EXPNO                  2
PROCNO                 1

F2 - Acquisition Parameters
Date_           20020416
Time               11.11
INSTRUM           amx400
PROBHD     5 mm Multinu
PULPROG           zgpg30
TD                 32768
SOLVENT             MeOH
NS                   829
DS                     2
SWH          38461.691 Hz
FIDRES        1.173758 Hz
AQ           0.4260340 sec
RG                 16384
DW              13.000 usec
DE               19.57 usec
TE               300.0 K
HL1                    1 dB
D1          2.00000000 sec
CPDPRG           waltz16
P31             110.00 usec
S4                    30 dB
D11         0.03000000 sec
S2                    26 dB
P1                6.80 usec
SFO1       100.6253965 MHz
NUCLEUS              13C

F2 - Processing parameters
SI                 65536
SF         100.6141310 MHz
WDW                   EM
SSB                    0
LB                2.00 Hz
GB                     0
PC                  1.00

1D NMR plot parameters
CX               33.00 cm
F1P            222.105 ppm
F1            22346.90 Hz
F2P             -1.171 ppm
F2             -117.83 Hz
PPMCM          6.76594 ppm/cm
HZCM         680.74945 Hz/cm
```

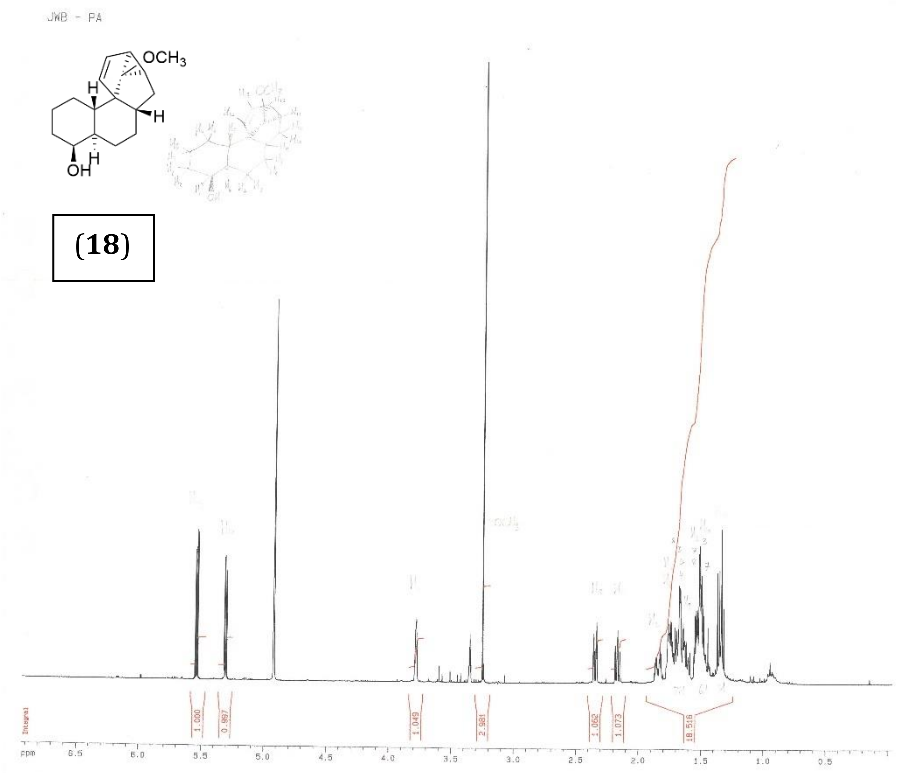


```
Current Data Parameters
NAME             jwbtt
EXPNO                1
PROCNO               1

F2 - Acquisition Parameters
Date_         20020919
Time             16.52
INSTRUM         amx400
PROBHD   5 mm Multinu
PULPROG           zg30
TD               32768
SOLVENT          CDCl3
NS                 320
DS                   2
SWH           6024.105 Hz
FIDRES        0.183841 Hz
AQ           2.7197940 sec
RG                 128
DW              83.000 usec
DE              118.57 usec
TE               300.0 K
HL1                  1 dB
D1          3.00000000 sec
P1                8.00 usec
SFO1       400.1367510 MHz
NUCLEUS             1H

F2 - Processing parameters
SI               32768
SF         400.1343903 MHz
WDW                 EM
SSB                  0
LB                0.20 Hz
GB                   0
PC                1.00

1D NMR plot parameters
CX               32.00 cm
F1P              7.988 ppm
F1             3196.20 Hz
F2P             -0.037 ppm
F2              -14.87 Hz
PPMCM          0.25078 ppm/cm
HZCM         100.34620 Hz/cm
```



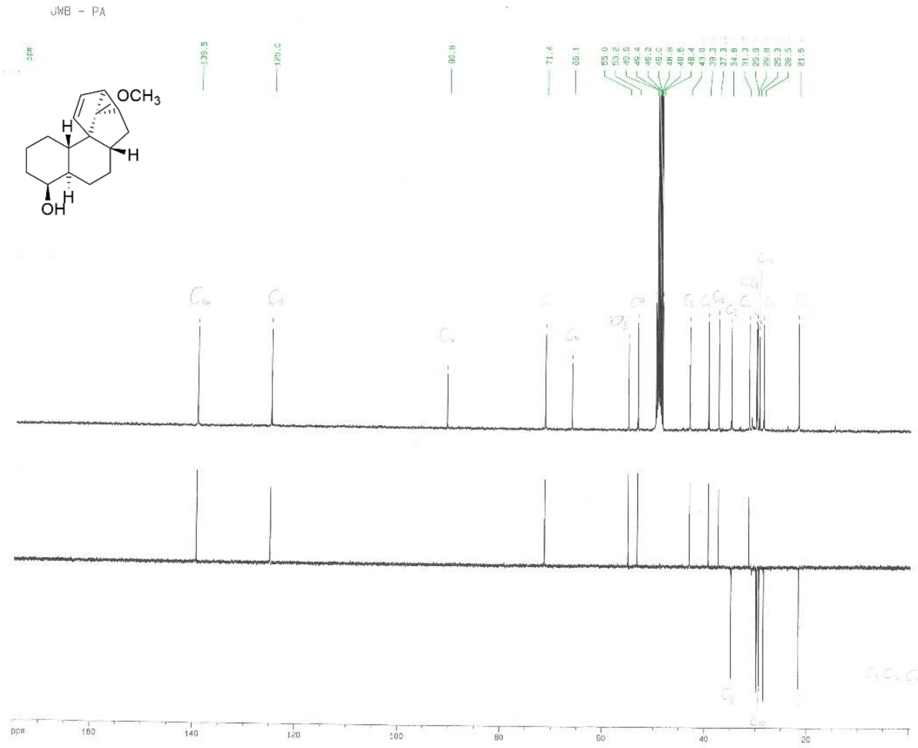
```
Current Data Parameters
NAME             jwbtb
EXPNO                2
PROCNO               1

F2 - Acquisition Parameters
Date_         20020915
Time             17.13
INSTRUM         amx400
PROBHD   5 mm Multinu
PULPROG        zgpg30
TD               32768
SOLVENT          CDCl3
NS               12000
DS                   2
SWH          38461.539 Hz
FIDRES        1.173753 Hz
AQ           0.4260340 sec
RG               32768
DW              13.000 usec
DE               18.57 usec
TE               300.0 K
HL1                  1 dB
D1          2.00000000 sec
CPDPRG         waltz16
P31             110.00 usec
S4                  30 dB
D11         0.03000000 sec
S2                  26 dB
P1                6.80 usec
SFO1       100.6250000 MHz
NUCLEUS            13C

F2 - Processing parameters
SI               65536
SF         100.5138752 MHz
WDW                 EM
SSB                  0
LB                2.00 Hz
GB                   0
PC                1.00

1D NMR plot parameters
CX               33.00 cm
F1P            223.172 ppm
F1            22454.24 Hz
F2P             -0.787 ppm
F2              -79.20 Hz
PPMCM          6.78666 ppm/cm
HZCM         682.83173 Hz/cm
```

Photolysis of the 4-carbon tether substrate (**8**)

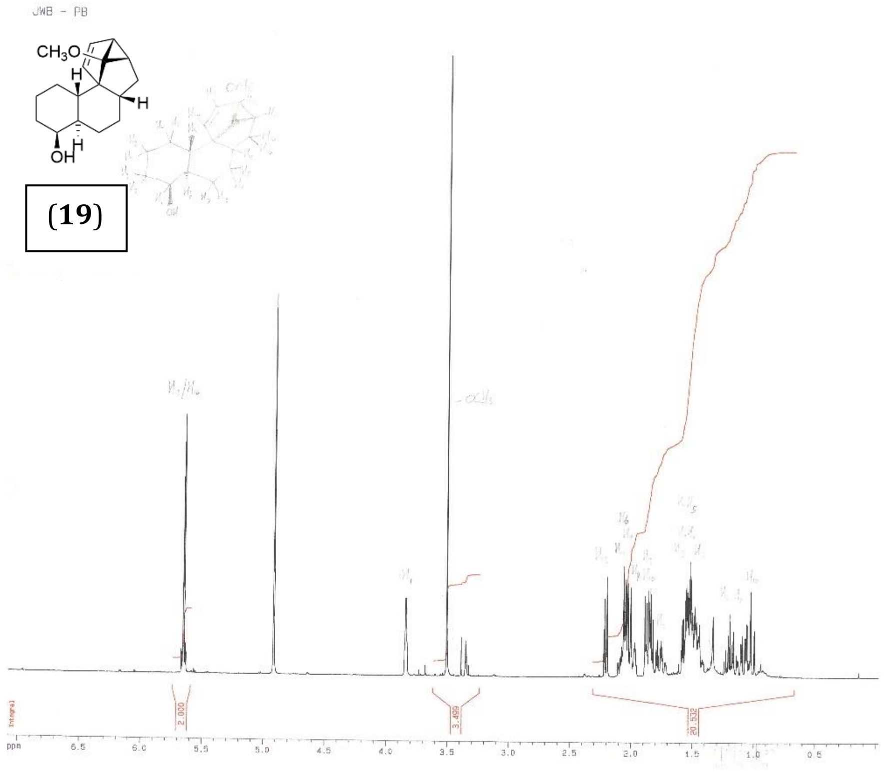


(18)

```
Current Data Parameters
NAME             jwbpa2
EXPNO                 1
PROCNO                1

F2 - Acquisition Parameters
Date_          20020219
Time               9.29
INSTRUM          amx400
PROBHD     5 mm Multinu
PULPROG            zg30
TD                32768
SOLVENT            MeOH
NS                   16
DS                    2
SWH            6024.129 Hz
FIDRES         0.183842 Hz
AQ            2.7197940 sec
RG                  128
DW               83.000 usec
DE               118.57 usec
TE                300.0 K
HL1                   1 dB
D1           3.00000000 sec
P1                 8.00 usec
SFO1        400.1383276 MHz
NUCLEUS              1H

F2 - Processing parameters
SI                32768
SF          400.1359528 MHz
WDW                  GM
SSB                   0
LB                -0.20 Hz
GB                  0.2
PC                 1.00

1D NMR plot parameters
CX                32.00 cm
F1P               6.933 ppm
F1              2773.95 Hz
F2P              -0.043 ppm
F2               -17.07 Hz
PPMCM           0.21797 ppm/cm
HZCM           87.21955 Hz/cm
```

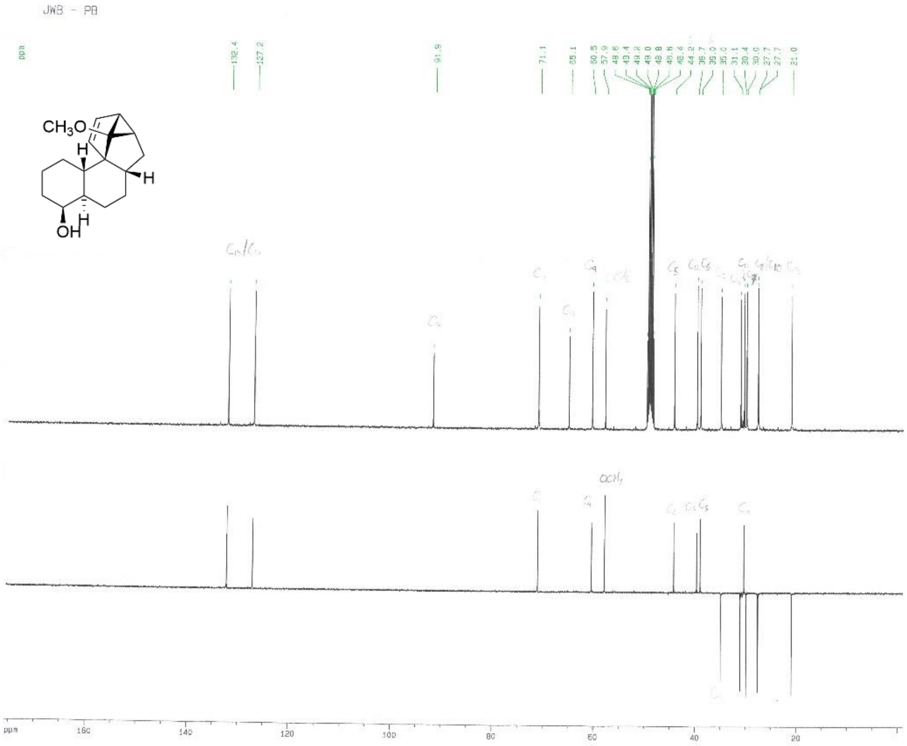


```
Current Data Parameters
NAME             jwbpa2
EXPNO                 2
PROCNO                1

F2 - Acquisition Parameters
Date_          20020215
Time              17.59
INSTRUM          amx400
PROBHD     5 mm Multinu
PULPROG          zgpg30
TD                65536
SOLVENT            MeOH
NS                 6400
DS                    2
SWH           38461.691 Hz
FIDRES         0.586879 Hz
AQ            0.8520180 sec
RG                32768
DW               13.000 usec
DE                18.57 usec
TE                300.0 K
HL1                   1 dB
D1           2.00000000 sec
CPDPRG          waltz16
P31              110.00 usec
S4                   30 dB
D11          0.03000000 sec
S2                   26 dB
P1                 6.80 usec
SFO1        100.6253955 MHz
NUCLEUS             13C

F2 - Processing parameters
SI                65536
SF          100.6141269 MHz
WDW                  EM
SSB                   0
LB                 2.00 Hz
GB                    0
PC                 1.00

1D NMR plot parameters
CX                33.00 cm
F1P             175.021 ppm
F1             17609.63 Hz
F2P              -0.412 ppm
F2               -41.46 Hz
PPMCM           5.31617 ppm/cm
HZCM          534.88159 Hz/cm
```



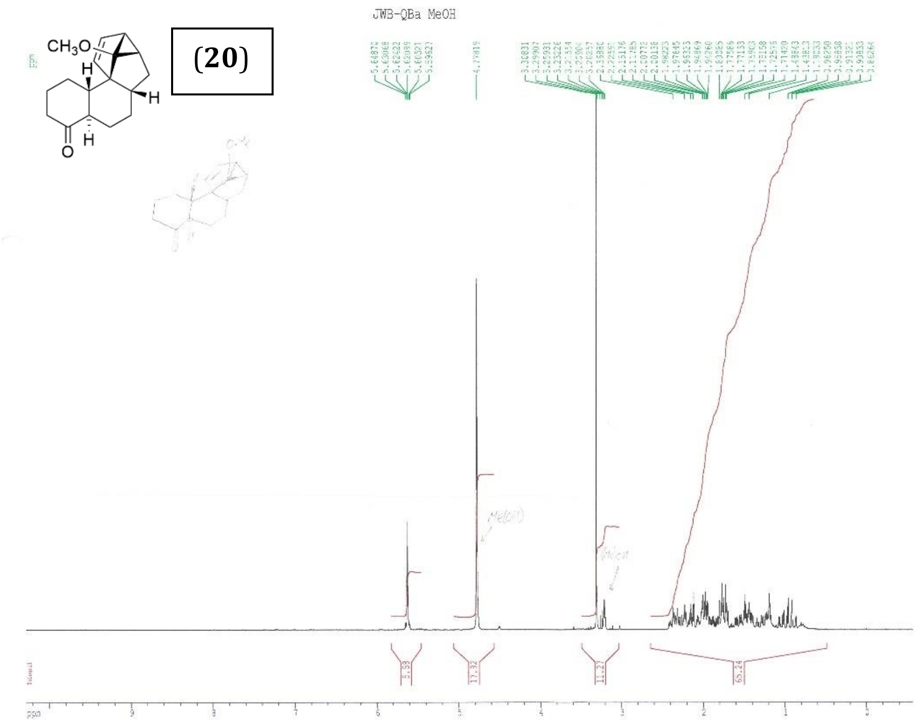
(**19**)

```
Current Data Parameters
NAME              jwbpb2
EXPNO                  1
PROCNO                 1

F2 - Acquisition Parameters
Date_           20020218
Time               11.12
INSTRUM           amx400
PROBHD     5 mm Multinu
PULPROG             zg30
TD                 32768
SOLVENT             MeOH
NS                    16
DS                     2
SWH             6024.129 Hz
FIDRES          0.183842 Hz
AQ             2.7197940 sec
RG                   128
DW                83.000 usec
DE               118.57 usec
TE                 300.0 K
HL1                    1 dB
D1            3.00000000 sec
P1                  8.00 usec
SFO1         400.1383276 MHz
NUCLEUS               1H

F2 - Processing parameters
SI                 32768
SF           400.1359530 MHz
WDW                   GM
SSB                    0
LB                 -0.25 Hz
GB                   0.2
PC                  1.00

1D NMR plot parameters
CX                 32.00 cm
F1P                7.078 ppm
F1               2832.13 Hz
F2P               -0.024 ppm
F2                 -9.66 Hz
PPMCM            0.22194 ppm/cm
HZCM            88.80582 Hz/cm
```

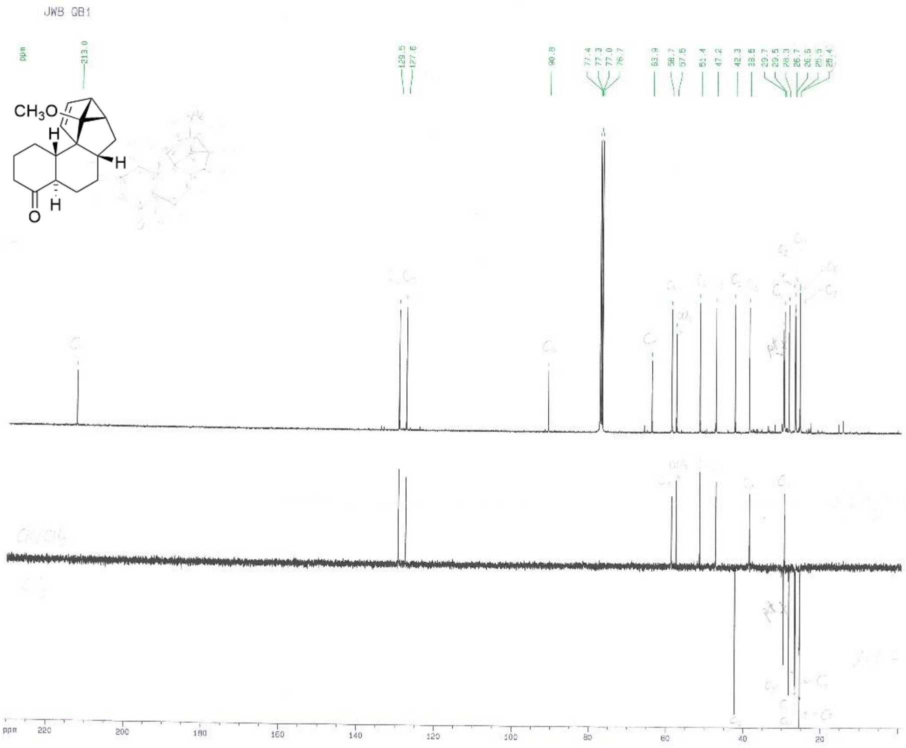


```
Current Data Parameters
NAME              jwbpb2
EXPNO                  2
PROCNO                 1

F2 - Acquisition Parameters
Date_           20020216
Time                4.56
INSTRUM           amx400
PROBHD     5 mm Multinu
PULPROG          zgpg30
TD                 65536
SOLVENT             MeOH
NS                  6400
DS                     2
SWH            38461.691 Hz
FIDRES          0.586879 Hz
AQ             0.8520180 sec
RG                 32768
DW                13.000 usec
DE                 18.57 usec
TE                 300.0 K
HL1                    1 dB
D1            2.00000000 sec
CPDPRG           waltz16
P31               110.00 usec
S4                    30 dB
D11           0.0300000 sec
S2                    26 dB
P1                  6.80 usec
SFO1         100.6253965 MHz
NUCLEUS              13C

F2 - Processing parameters
SI                 65536
SF           100.6141287 MHz
WDW                   EM
SSB                    0
LB                  2.00 Hz
GB                     0
PC                  1.00

1D NMR plot parameters
CX                 33.00 cm
F1P              175.698 ppm
F1              17676.65 Hz
F2P               -1.003 ppm
F2               -100.87 Hz
PPMCM            5.35425 ppm/cm
HZCM           538.71283 Hz/cm
```

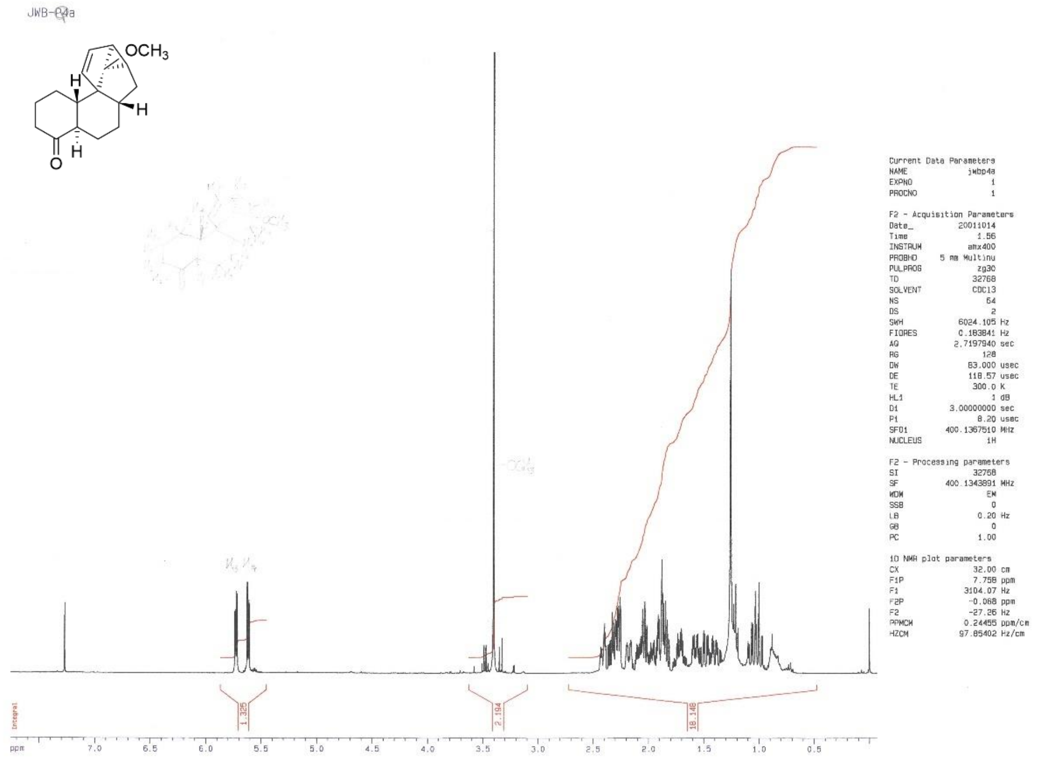
Identification of 4-carbon tether cycloadducts


(20)

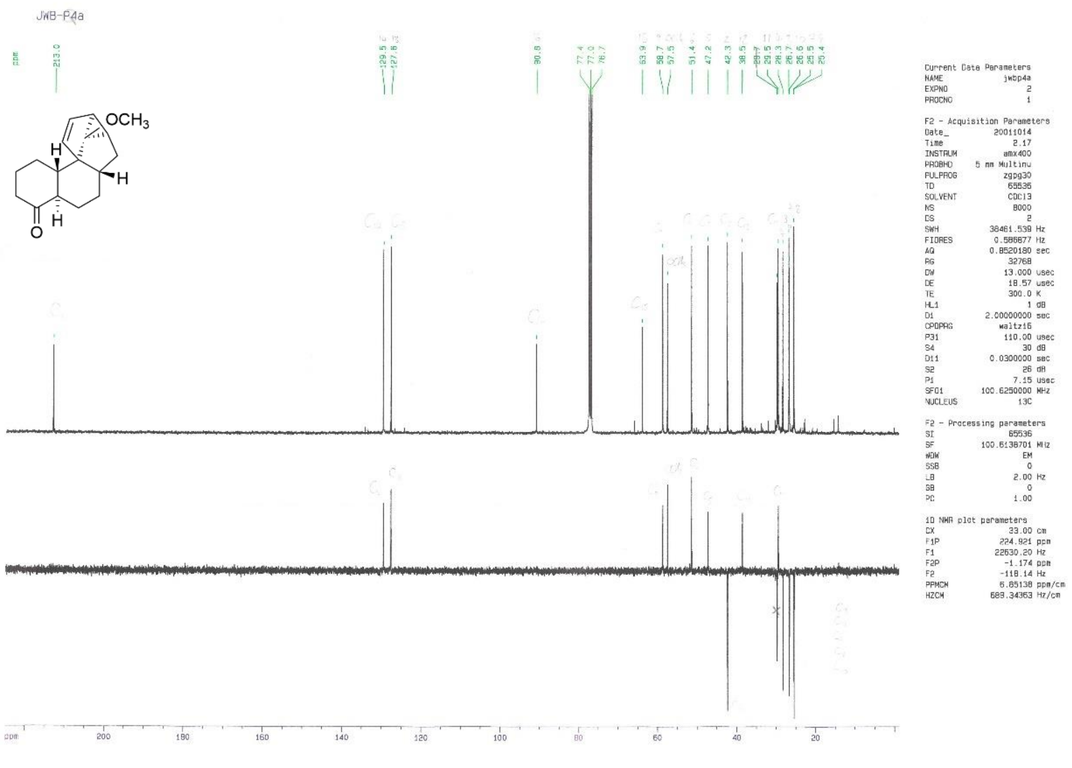
```
Current Data Parameters
NAME          Oct29-2001
EXPNO                 45
PROCNO                 1

F2 - Acquisition Parameters
Date_           20011029
Time               17.42
INSTRUM           dpx250
PROBHD      5 mm Multinu
PULPROG             zg30
TD                 32768
SOLVENT             MeOH
NS                    16
DS                     2
SWH             3255.208 Hz
FIDRES          0.099341 Hz
AQ             5.0332146 sec
RG                 228.1
DW               153.600 use
DE                  4.50 use
TE                 300.0 K
D1            1.00000000 sec

============ CHANNEL f1 ===
NUC1                  1H
P1                 10.00 use
PL1                -6.00 dB
SFO1         249.8713493 MHz

F2 - Processing parameters
SI                 32768
SF           249.8700289 MHz
WDW                   EM
SSB                    0
LB                  0.10 Hz
GB                     0
PC                  2.00

1D NMR plot parameters
CX                 33.00 cm
F1P               10.285 ppm
F1               2569.79 Hz
F2P               -0.570 ppm
F2               -142.47 Hz
PPMCM            0.32893 ppm
HZCM            82.18987 Hz/
```



```
Current Data Parameters
NAME              jwbqb1
EXPNO                  2
PROCNO                 1

F2 - Acquisition Parameters
Date_           20011023
Time               16.48
INSTRUM           amx400
PROBHD      5 mm Multinu
PULPROG          zgpg30
TD                 65536
SOLVENT            CDC13
NS                  9600
DS                     2
SWH            38461.539 Hz
FIDRES          0.586877 Hz
AQ             0.8520180 sec
RG                 32768
DW                13.000 usec
DE                 18.57 usec
TE                 300.0 K
HL1                    1 dB
D1            2.00000000 sec
CPDPRG           waltz16
P31               110.00 usec
S4                    30 dB
D11           0.0300000 sec
S2                    26 dB
P1                  7.15 usec
SFO1        100.6250000 MHz
NUCLEUS              13C

F2 - Processing parameters
SI                 65536
SF          100.6138720 MHz
WDW                   EM
SSB                    0
LB                  2.00 Hz
GB                     0
PC                  1.00

1D NMR plot parameters
CX                 33.00 cm
F1P              230.655 ppm
F1              23207.09 Hz
F2P               -0.985 ppm
F2                -99.08 Hz
PPMCM            7.01939 ppm/cm
HZCM           706.24756 Hz/cm
```

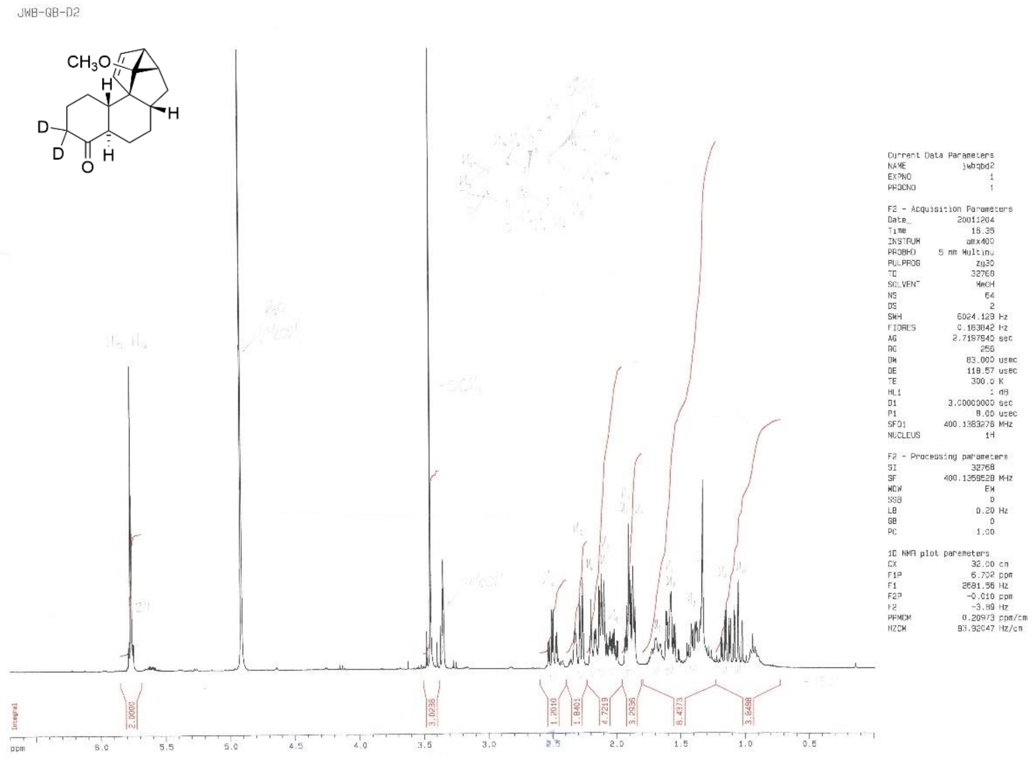


```
Current Data Parameters
NAME              jwbp4a
EXPNO                  1
PROCNO                 1

F2 - Acquisition Parameters
Date_           20011014
Time                1.56
INSTRUM           amx400
PROBHD     5 mm Multinu
PULPROG             zg30
TD                 32768
SOLVENT            CDC13
NS                    64
DS                     2
SWH             6024.105 Hz
FIDRES          0.183841 Hz
AQ             2.7197940 sec
RG                   128
DW                83.000 usec
DE                118.57 usec
TE                 300.0 K
HL1                    1 dB
D1            3.00000000 sec
P1                  8.20 usec
SFO1         400.1367510 MHz
NUCLEUS               1H

F2 - Processing parameters
SI                 32768
SF           400.1343891 MHz
WDW                   EM
SSB                    0
LB                  0.20 Hz
GB                     0
PC                  1.00

1D NMR plot parameters
CX                 32.00 cm
F1P                7.758 ppm
F1               3104.07 Hz
F2P               -0.068 ppm
F2                -27.26 Hz
PPMCM            0.24455 ppm/cm
HZCM            97.85402 Hz/cm
```

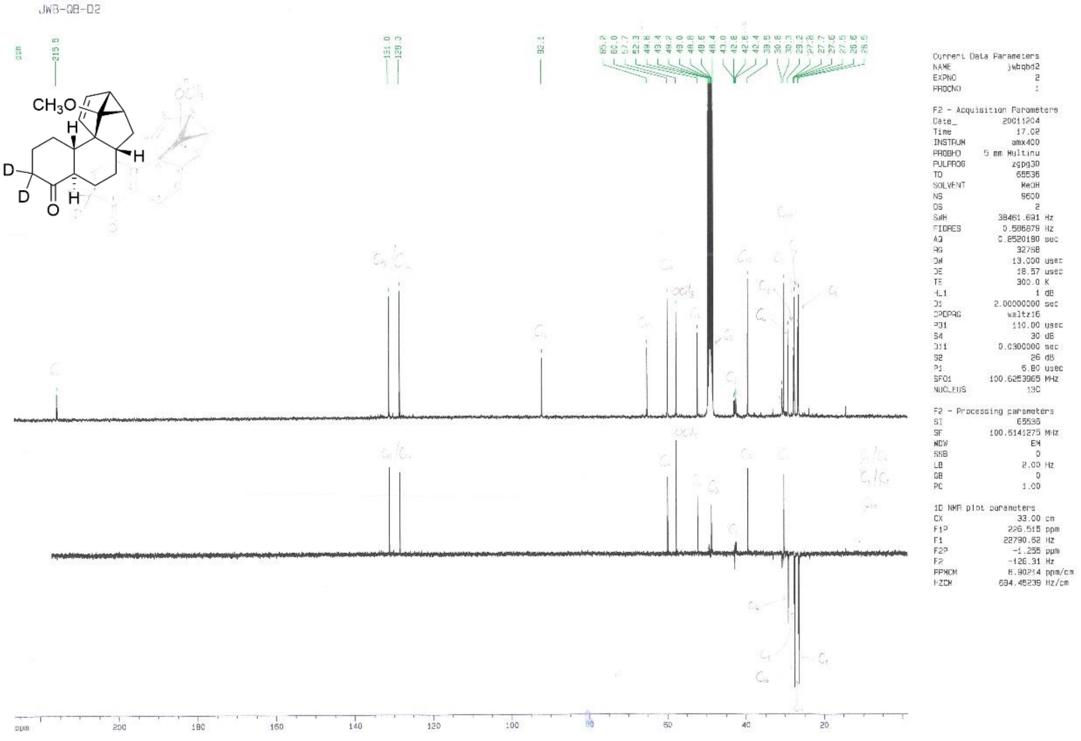


```
Current Data Parameters
NAME              jwbp4a
EXPNO                  2
PROCNO                 1

F2 - Acquisition Parameters
Date_           20011014
Time                2.17
INSTRUM           amx400
PROBHD     5 mm Multinu
PULPROG          zgpg30
TD                 65536
SOLVENT            CDC13
NS                  8000
DS                     2
SWH            38461.539 Hz
FIDRES          0.586877 Hz
AQ             0.8520180 sec
RG                 32768
DW                13.000 usec
DE                 18.57 usec
TE                 300.0 K
HL1                    1 dB
D1            2.00000000 sec
CPDPRG           waltz16
P31               110.00 usec
S4                    30 dB
D11           0.03000000 sec
S2                    26 dB
P1                  7.15 usec
SFO1         100.6250000 MHz
NUCLEUS              13C

F2 - Processing parameters
SI                 65536
SF           100.6138701 MHz
WDW                   EM
SSB                    0
LB                  2.00 Hz
GB                     0
PC                  1.00

1D NMR plot parameters
CX                 33.00 cm
F1P              224.921 ppm
F1              22630.20 Hz
F2P               -1.174 ppm
F2               -118.14 Hz
PPMCM            6.85138 ppm/cm
HZCM           689.34363 Hz/cm
```

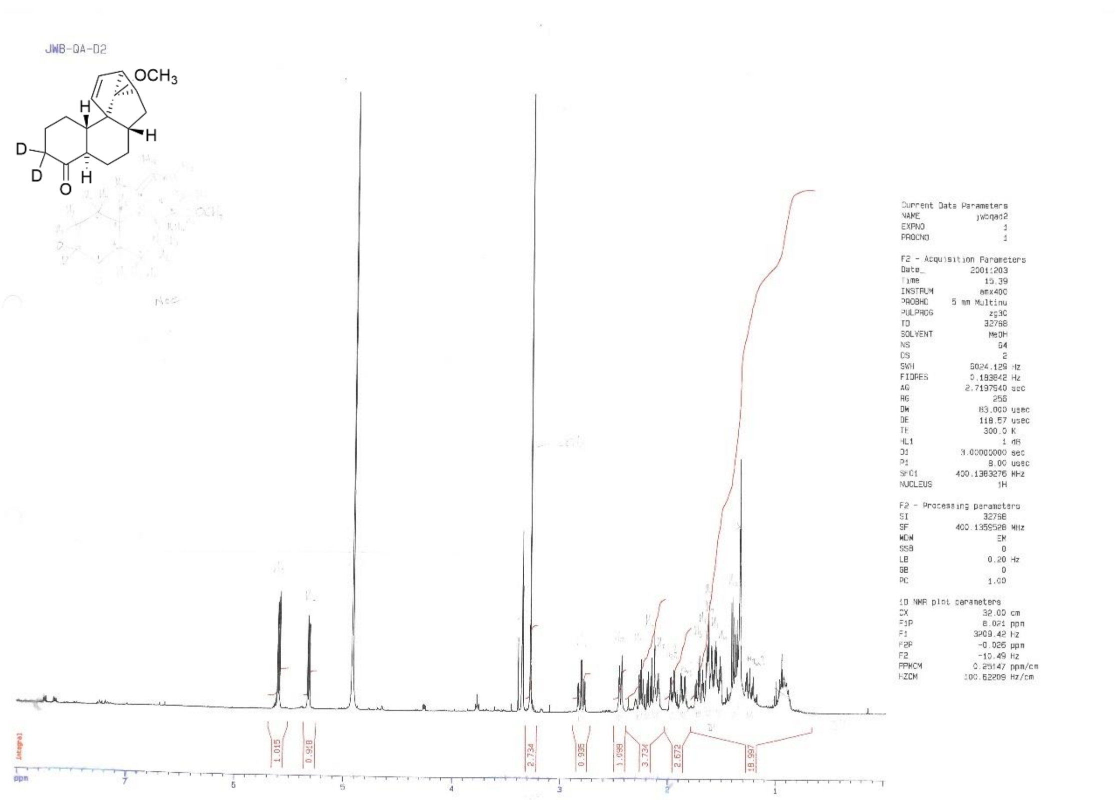
Deuteration and desaturation for identification of 4-carbon tether cycloadduct



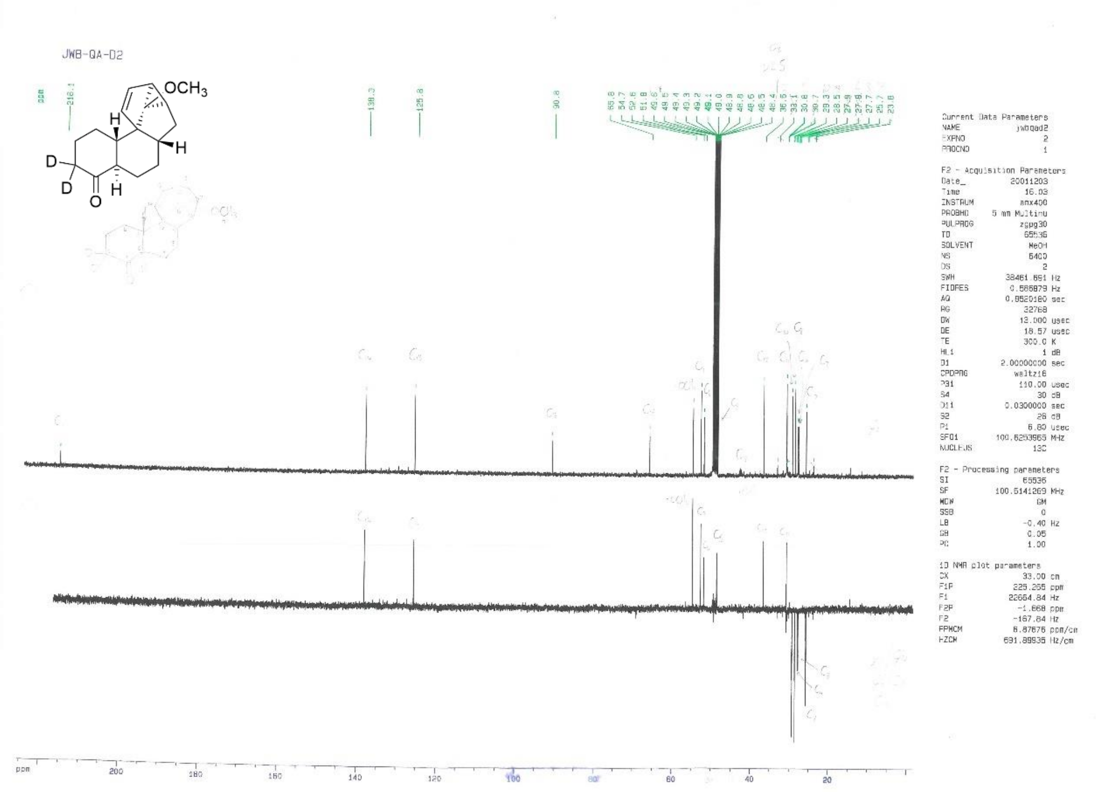
```
Current Data Parameters
NAME            jwbqbd2
EXPNO                 1
PROCNO                1

F2 - Acquisition Parameters
Date_          20011204
Time              16.35
INSTRUM          amx400
PROBHD     5 mm Multinu
PULPROG            zg30
TD                32768
SOLVENT            MeOH
NS                   64
DS                    2
SWH            6024.129 Hz
FIDRES         0.183842 Hz
AQ            2.7197940 sec
RG                  256
DW               83.000 usec
DE               118.57 usec
TE                300.0 K
HL1                   1 dB
D1           3.00000000 sec
P1                 8.00 usec
SFO1        400.1383276 MHz
NUCLEUS              1H

F2 - Processing parameters
SI                32768
SF          400.1359528 MHz
WDW                  EM
SSB                   0
LB                 0.20 Hz
GB                    0
PC                 1.00

1D NMR plot parameters
CX                32.00 cm
F1P               6.702 ppm
F1              2681.56 Hz
F2P              -0.010 ppm
F2                -3.89 Hz
PPMCM           0.20973 ppm/cm
HZCM           83.92047 Hz/cm
```



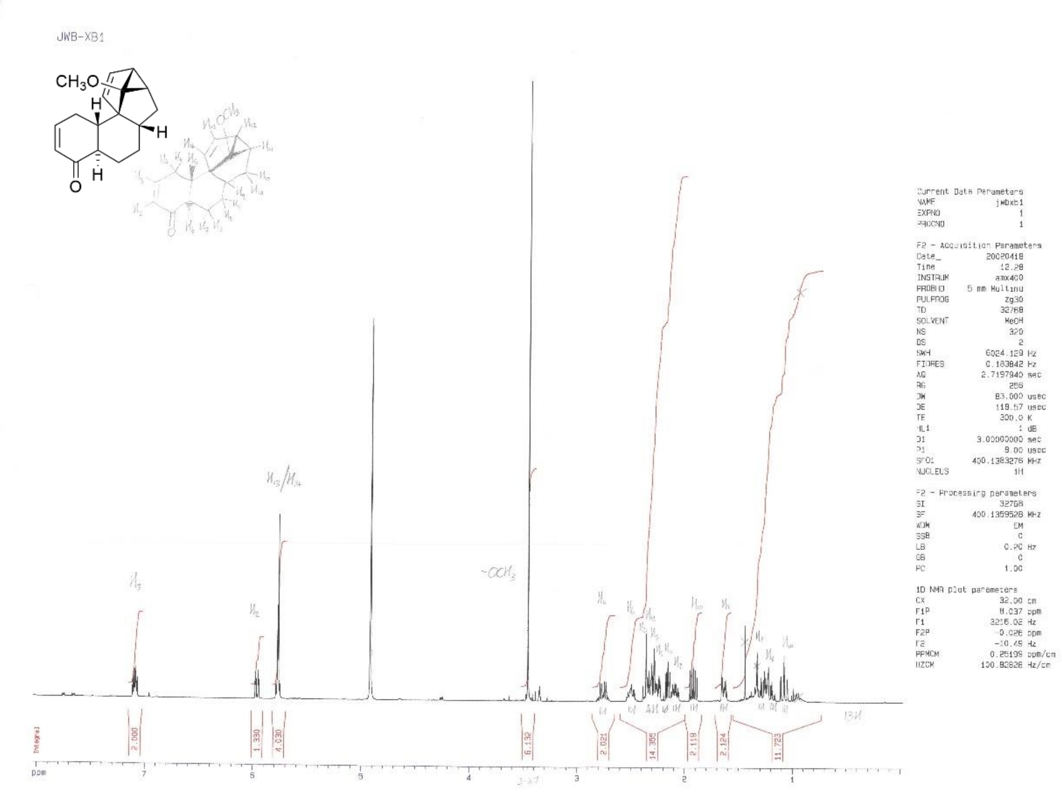
```
Current Data Parameters
NAME            jwbqbd2
EXPNO                 2
PROCNO                1

F2 - Acquisition Parameters
Date_          20011204
Time              17.02
INSTRUM          amx400
PROBHD     5 mm Multinu
PULPROG          zgpg30
TD                65536
SOLVENT            MeOH
NS                 9600
DS                    2
SWH           38461.691 Hz
FIDRES         0.586879 Hz
AQ            0.8520180 sec
RG                32768
DW               13.000 usec
DE                18.57 usec
TE                300.0 K
HL1                   1 dB
D1           2.00000000 sec
CPDPRG          waltz16
PD1              110.00 usec
S4                   30 dB
D11          0.03000000 sec
S2                   26 dB
P1                 6.80 usec
SFO1        100.6253965 MHz
NUCLEUS             13C

F2 - Processing parameters
SI                65536
SF          100.6141275 MHz
WDW                  EM
SSB                   0
LB                 2.00 Hz
GB                    0
PC                 1.00

1D NMR plot parameters
CX                33.00 cm
F1P             226.515 ppm
F1             22790.62 Hz
F2P              -1.255 ppm
F2              -126.31 Hz
PPMCM           6.90214 ppm/cm
HZCM          694.45239 Hz/cm
```



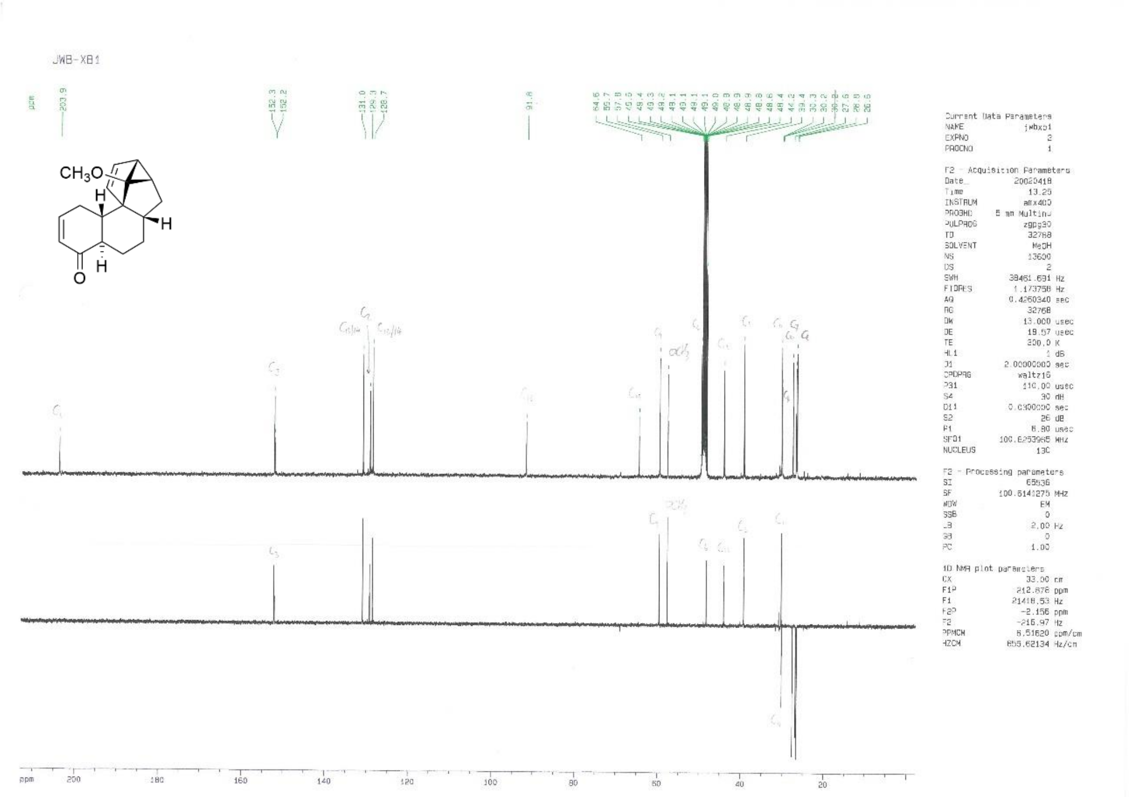
```
Current Data Parameters
NAME             jwbqad2
EXPNO                  1
PROCNO                 1

F2 - Acquisition Parameters
Date_           20011203
Time               15.39
INSTRUM           amx400
PROBHD     5 mm Multinu
PULPROG             zg30
TD                 32768
SOLVENT             MeOH
NS                    64
DS                     2
SWH             6024.129 Hz
FIDRES          0.183842 Hz
AQ             2.7197540 sec
RG                   256
DW                83.000 usec
DE                118.57 usec
TE                 300.0 K
HL1                    1 dB
D1            3.00000000 sec
P1                  8.00 usec
SFO1         400.1383276 MHz
NUCLEUS               1H

F2 - Processing parameters
SI                 32768
SF           400.1359528 MHz
WDW                   EM
SSB                    0
LB                  0.20 Hz
GB                     0
PC                  1.00

1D NMR plot parameters
CX                 32.00 cm
F1P                8.021 ppm
F1               3209.42 Hz
F2P               -0.026 ppm
F2                -10.49 Hz
PPMCM            0.25147 ppm/cm
HZCM           100.62209 Hz/cm
```



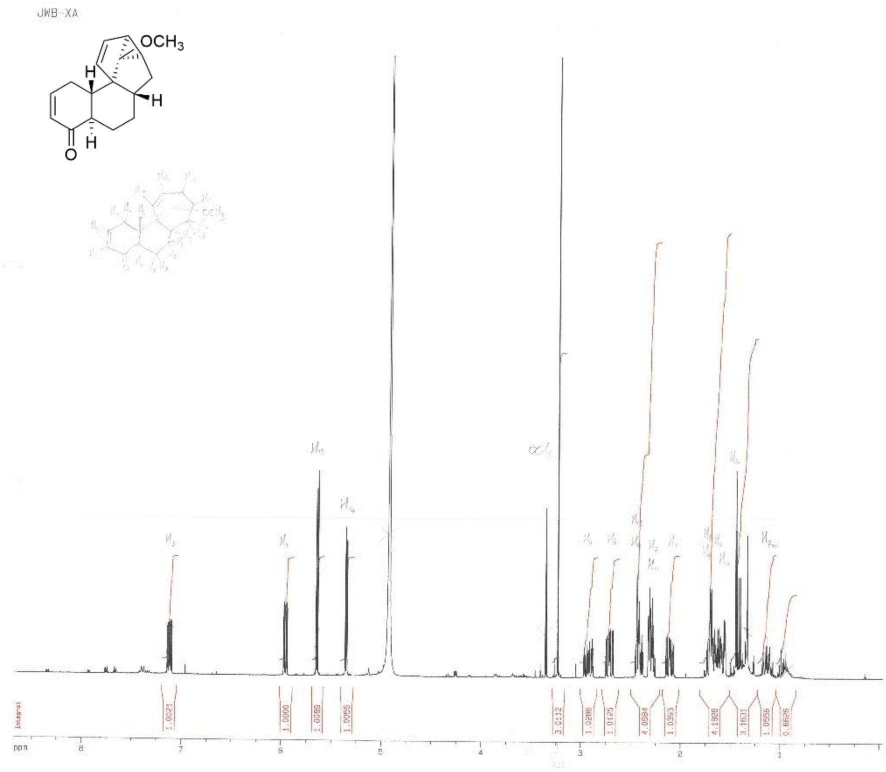
```
Current Data Parameters
NAME             jwbqad2
EXPNO                  2
PROCNO                 1

F2 - Acquisition Parameters
Date_           20011203
Time               16.03
INSTRUM           amx400
PROBHD     5 mm Multinu
PULPROG           zgpg30
TD                 65536
SOLVENT             MeOH
NS                  6400
DS                     2
SWH            38461.691 Hz
FIDRES          0.586879 Hz
AQ             0.8520180 sec
RG                 32768
DW                13.000 usec
DE                 18.57 usec
TE                 300.0 K
HL1                    1 dB
D1            2.00000000 sec
CPDPRG           waltz16
P31               110.00 usec
S4                    30 dB
D11           0.03000000 sec
S2                    26 dB
P1                  6.80 usec
SFO1         100.6253965 MHz
NUCLEUS              13C

F2 - Processing parameters
SI                 65536
SF           100.5141269 MHz
WDW                   GM
SSB                    0
LB                 -0.40 Hz
GB                  0.05
PC                  1.00

1D NMR plot parameters
CX                 33.00 cm
F1P              225.265 ppm
F1              22664.84 Hz
F2P               -1.668 ppm
F2               -167.84 Hz
PPMCM            6.87676 ppm/cm
HZCM           691.89935 Hz/cm
```



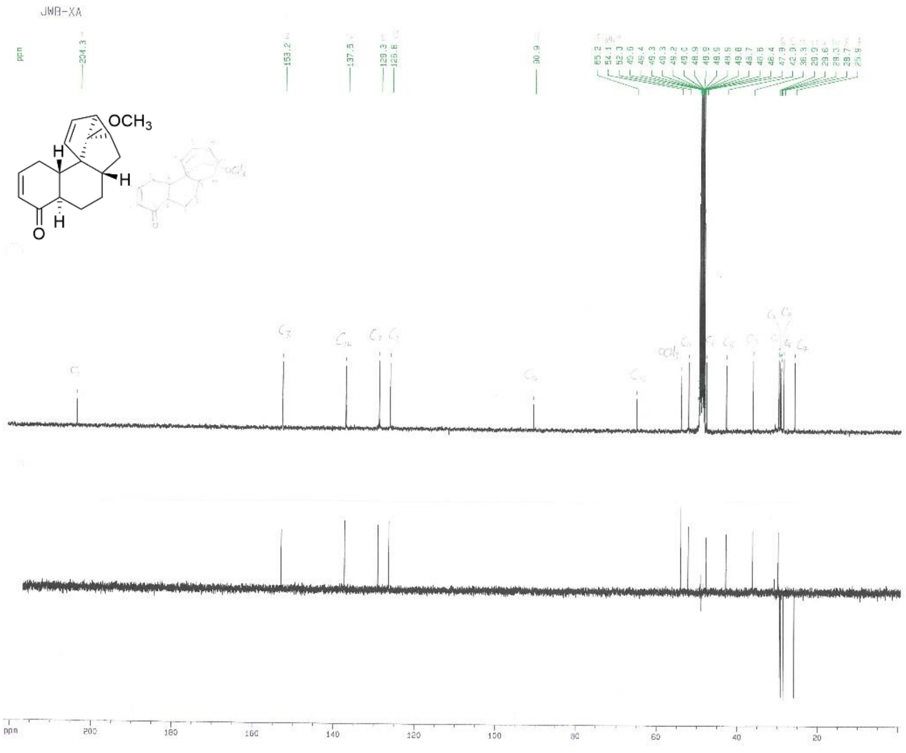
```
Current Data Parameters
NAME             jwbxb1
EXPNO                 1
PROCNO                1

F2 - Acquisition Parameters
Date_          20020418
Time              12.28
INSTRUM          amx400
PROBHD    5 mm Multinu
PULPROG            zg30
TD                32768
SOLVENT            MeOH
NS                  320
DS                    2
SWH            6024.129 Hz
FIDRES         0.183842 Hz
AQ            2.7197940 sec
RG                  256
DW               83.000 usec
DE               119.57 usec
TE                300.0 K
HL1                   1 dB
D1           3.00000000 sec
P1                 9.00 usec
SFO1        400.1383276 MHz
NUCLEUS              1H

F2 - Processing parameters
SI                32768
SF          400.1359528 MHz
WDW                  EM
SSB                   0
LB                 0.20 Hz
GB                    0
PC                 1.00

1D NMR plot parameters
CX                32.00 cm
F1P               8.037 ppm
F1              3216.02 Hz
F2P              -0.026 ppm
F2               -10.45 Hz
PPMCM           0.25109 ppm/cm
HZCM          100.82828 Hz/cm
```



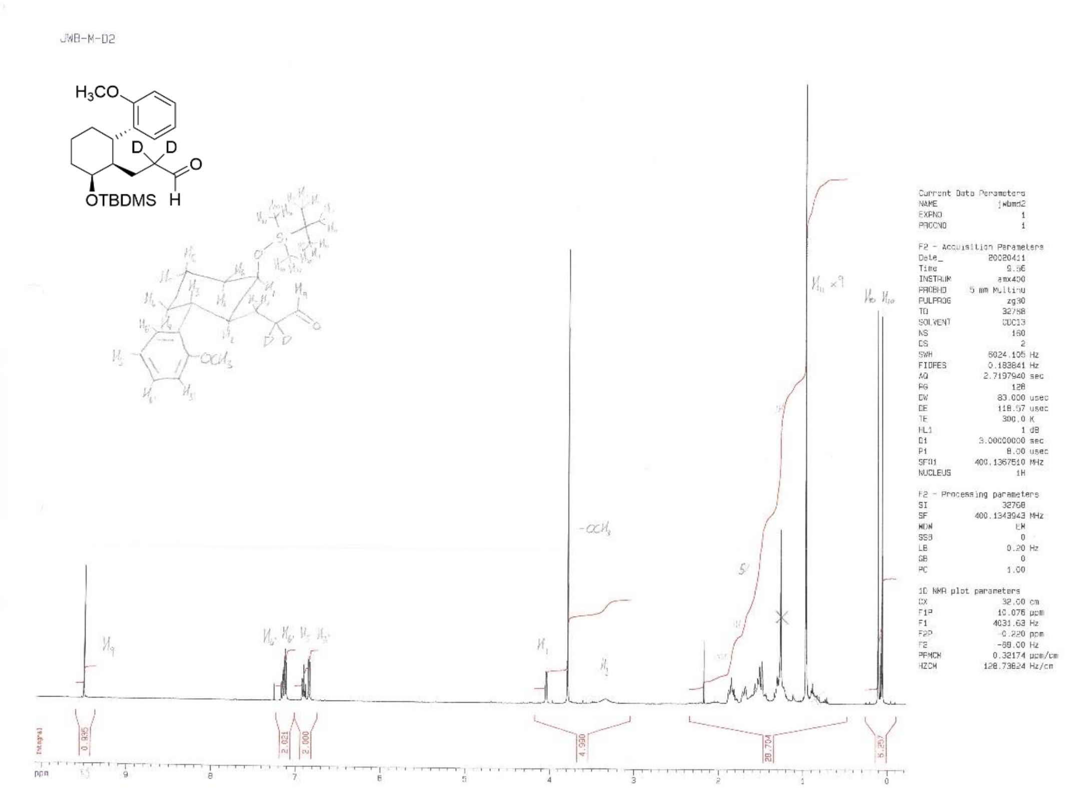
```
Current Data Parameters
NAME             jwbxb1
EXPNO                 2
PROCNO                1

F2 - Acquisition Parameters
Date_          20020418
Time              13.25
INSTRUM          amx400
PROBHD    5 mm Multinu
PULPROG          zgpg30
TD                32768
SOLVENT            MeOH
NS                13600
DS                    2
SWH           38461.691 Hz
FIDRES         1.173758 Hz
AQ            0.4260340 sec
RG                32768
DW               13.000 usec
DE                19.57 usec
TE                300.0 K
HL1                   1 dB
D1           2.00000000 sec
CPDPRG          waltz16
P31              110.00 usec
S4                   30 dB
D11          0.03000000 sec
S2                   26 dB
P1                 6.80 usec
SFO1        100.6253965 MHz
NUCLEUS             13C

F2 - Processing parameters
SI                65536
SF          100.6141275 MHz
WDW                  EM
SSB                   0
LB                 2.00 Hz
GB                    0
PC                 1.00

1D NMR plot parameters
CX                33.00 cm
F1P             212.878 ppm
F1             21418.53 Hz
F2P              -2.156 ppm
F2              -216.97 Hz
PPMCM           6.51620 ppm/cm
HZCM          655.62134 Hz/cm
```



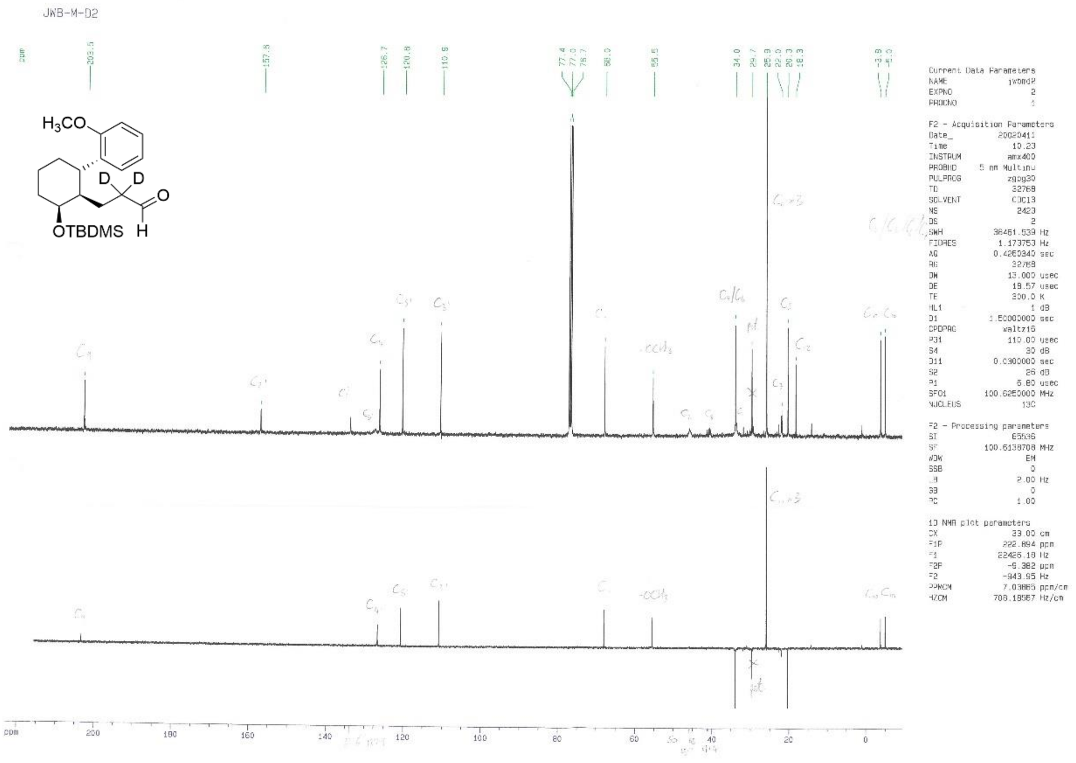
```
Current Data Parameters
NAME              jwbxa
EXPNO                 1
PROCNO                1

F2 - Acquisition Parameters
Date_          20020424
Time              16.11
INSTRUM          amx400
PROBHD    5 mm Multinu
PULPROG            zg30
TD                32768
SOLVENT            MeOH
NS                  160
DS                    2
SWH            6024.129 Hz
FIDRES         0.183842 Hz
AQ            2.7197940 sec
RG                  512
DW               83.000 usec
DE               119.57 usec
TE                300.0 K
HL1                   1 dB
D1           3.00000000 sec
P1                 8.00 usec
SFO1        400.1383276 MHz
NUCLEUS              1H

F2 - Processing parameters
SI                65536
SF          400.1359530 MHz
WDW                  GM
SSB                   0
LB                -0.20 Hz
GB                  0.2
PC                 1.00

1D NMR plot parameters
CX                32.00 cm
F1P               8.672 ppm
F1              3469.95 Hz
F2P              -0.035 ppm
F2               -13.88 Hz
PPMCM           0.27208 ppm/cm
HZCM          108.86980 Hz/cm
```



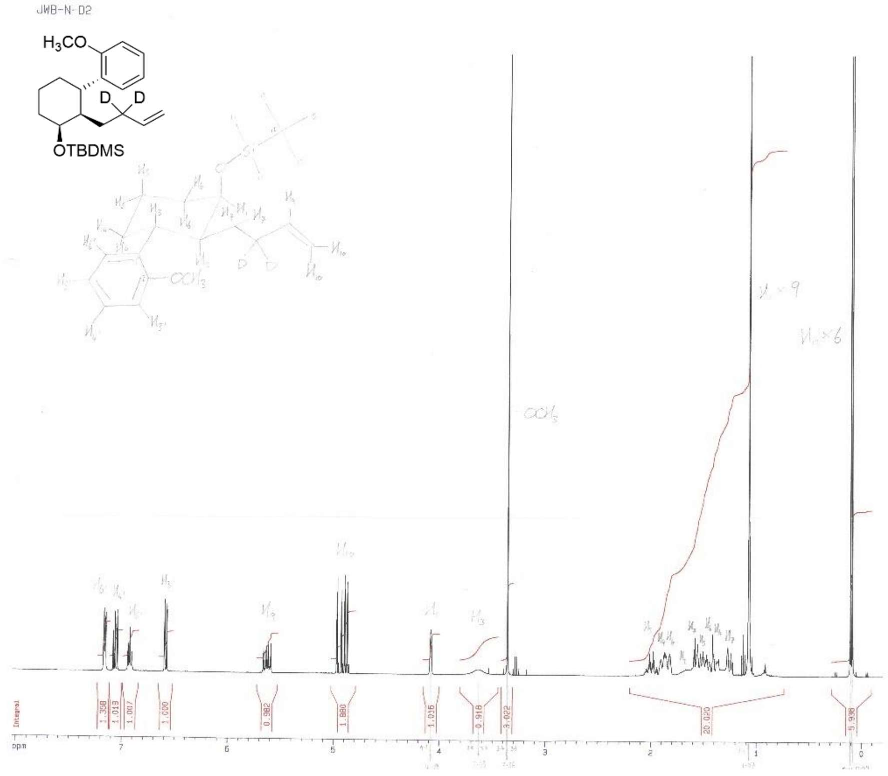
```
Current Data Parameters
NAME              jwbxa
EXPNO                 2
PROCNO                1

F2 - Acquisition Parameters
Date_          20020424
Time              16.32
INSTRUM          amx400
PROBHD    5 mm Multinu
PULPROG          zgpg30
TD                32768
SOLVENT            MeOH
NS                12000
DS                    2
SWH           38461.691 Hz
FIDRES         1.173758 Hz
AQ            0.4260340 sec
RG                32768
DW               13.000 usec
DE                18.57 usec
TE                300.0 K
HL1                   1 dB
D1           2.00000000 sec
CPDPRG          waltz16
P31              110.00 usec
S4                   30 dB
D11          0.03000000 sec
S2                   26 dB
P1                 6.80 usec
SFO1        100.6253965 MHz
NUCLEUS             13C

F2 - Processing parameters
SI                65536
SF          100.5141269 MHz
WDW                  EM
SSB                   0
LB                 2.00 Hz
GB                    0
PC                 1.00

1D NMR plot parameters
CX                33.00 cm
F1P             221.326 ppm
F1             22258.47 Hz
F2P              -0.584 ppm
F2               -58.74 Hz
PPMCM           6.72453 ppm/cm
HZCM          676.58240 Hz/cm
```



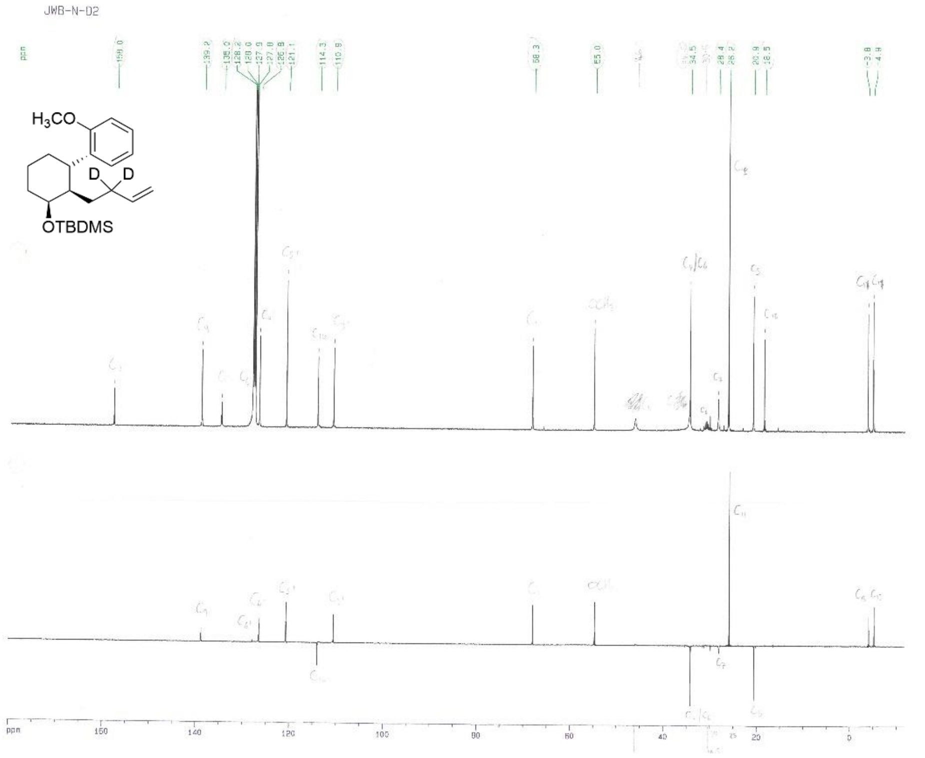
```
Current Data Parameters
NAME             jwbmd2
EXPNO                 1
PROCNO                1

F2 - Acquisition Parameters
Date_          20020411
Time               9.56
INSTRUM          amx400
PROBHD     5 mm Multinu
PULPROG            zg30
TD                32768
SOLVENT           CDCl3
NS                  160
DS                    2
SWH            5024.105 Hz
FIDRES         0.183841 Hz
AQ            2.7197940 sec
RG                  128
DW               83.000 usec
DE               118.57 usec
TE                300.0 K
HL1                   1 dB
D1           3.00000000 sec
P1                 8.00 usec
SFO1        400.1367510 MHz
NUCLEUS              1H

F2 - Processing parameters
SI                32768
SF          400.1343943 MHz
WDW                  EM
SSB                   0
LB                 0.20 Hz
GB                    0
PC                 1.00

1D NMR plot parameters
CX                32.00 cm
F1P              10.076 ppm
F1              4031.63 Hz
F2P              -0.220 ppm
F2               -88.00 Hz
PPMCM           0.32174 ppm/cm
HZCM          128.73824 Hz/cm
```



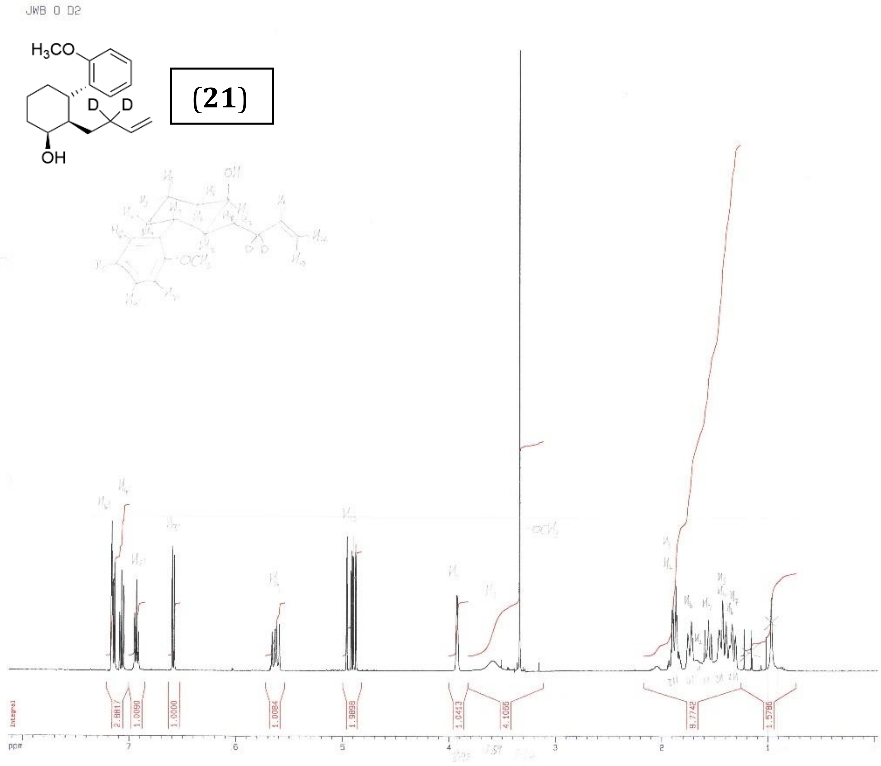
```
Current Data Parameters
NAME             jwbmd2
EXPNO                 2
PROCNO                1

F2 - Acquisition Parameters
Date_          20020411
Time              10.23
INSTRUM          amx400
PROBHD     5 mm Multinu
PULPROG          zgpg30
TD                32768
SOLVENT           CDCl3
NS                 2423
DS                    2
SWH           36461.539 Hz
FIDRES         1.173753 Hz
AQ            0.4260340 sec
RG                32768
DW               13.000 usec
DE                19.57 usec
TE                300.0 K
HL1                   1 dB
D1           1.50000000 sec
CPDPRG          waltz16
P31              110.00 usec
S4                   30 dB
D11          0.03000000 sec
S2                   26 dB
P1                 6.80 usec
SFO1        100.6250000 MHz
NUCLEUS             13C

F2 - Processing parameters
SI                65536
SF          100.6138708 MHz
WDW                  EM
SSB                   0
LB                 2.00 Hz
GB                    0
PC                 1.00

1D NMR plot parameters
CX                33.00 cm
F1P             222.894 ppm
F1             22426.18 Hz
F2P              -9.382 ppm
F2              -943.95 Hz
PPMCM           7.03865 ppm/cm
HZCM          708.18567 Hz/cm
```



```
Current Data Parameters
NAME             jwond2
EXPNO                 1
PROCNO                1

F2 - Acquisition Parameters
Date_          20020416
Time              10.19
INSTRUM          amx400
PROBHD   5 mm Multinu
PULPROG            zg30
TD                32768
SOLVENT            C6D6
NS                   16
DS                    2
SWH           6024.105 Hz
FIDRES        0.183841 Hz
AQ           2.7197940 sec
RG                   32
DW               83.000 usec
DE               118.57 usec
TE                300.0 K
HL1                   1 dB
D1          3.00000000 sec
P1                 8.00 usec
SFO1       400.1367350 MHz
NUCLEUS              1H

F2 - Processing parameters
SI                32768
SF         400.1344097 MHz
WDW                  GM
SSB                   0
LB                -0.30 Hz
GB                  0.3
PC                 1.00

1D NMR plot parameters
CX                32.00 cm
F1P               8.029 ppm
F1              3212.79 Hz
F2P              -0.200 ppm
F2               -80.03 Hz
PPMCM           0.25716 ppm/cm
HZCM          102.90043 Hz/cm
```

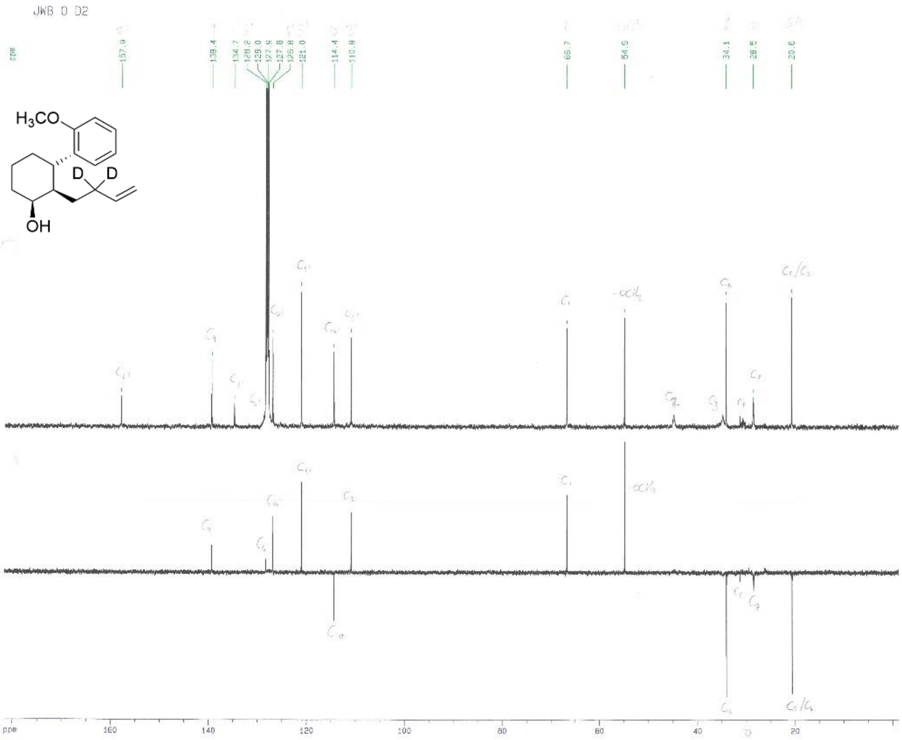


```
Current Data Parameters
NAME             jwbnd2
EXPNO                 2
PROCNO                1

F2 - Acquisition Parameters
Date_          20020415
Time              12.38
INSTRUM          amx400
PROBHD   5 mm Multinu
PULPROG          zgpg30
TD                32768
SOLVENT            C6D6
NS                 6400
DS                    2
SWH          38461.535 Hz
FIDRES        1.173753 Hz
AQ           0.4260340 sec
RG                32768
DW               13.000 usec
DE                18.57 usec
TE                300.0 K
HL1                   1 dB
D1          2.00000000 sec
CPDPRG          waltz16
P31              110.00 usec
S4                   30 dB
D11          0.0300000 sec
S2                   26 dB
P1                 6.80 usec
SFO1       100.6249960 MHz
NUCLEUS             13C

F2 - Processing parameters
SI                65536
SF         100.6138458 MHz
WDW                  EM
SSB                   0
LB                 2.00 Hz
GB                    0
PC                 1.00

1D NMR plot parameters
CX                33.00 cm
F1P             180.116 ppm
F1             18122.17 Hz
F2P             -11.646 ppm
F2             -1171.79 Hz
PPMCM           5.81098 ppm/cm
HZCM          584.65541 Hz/cm
```

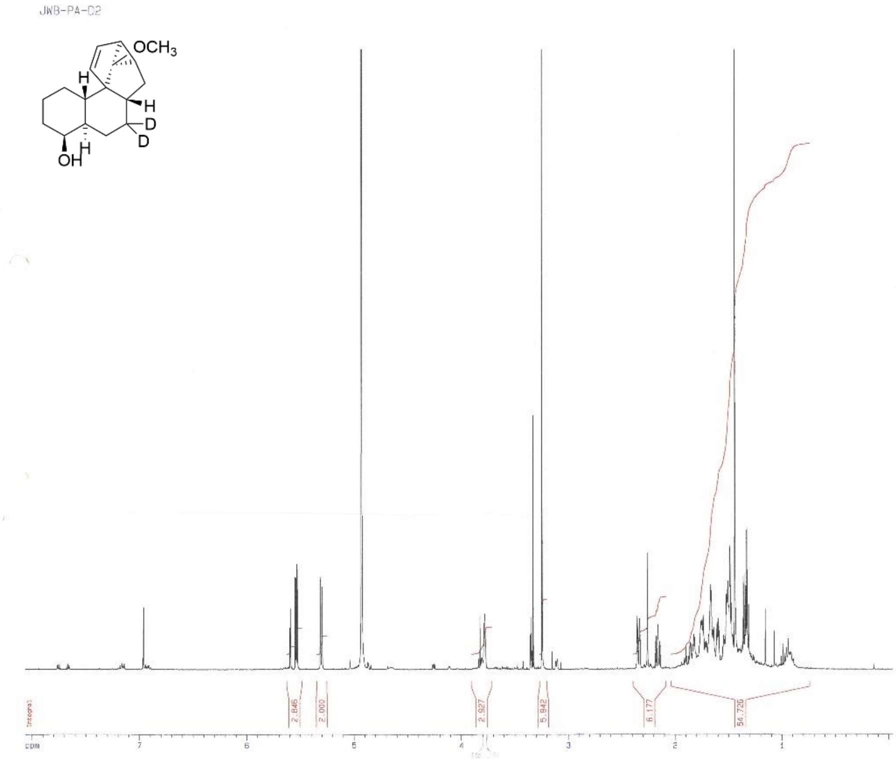


(21)

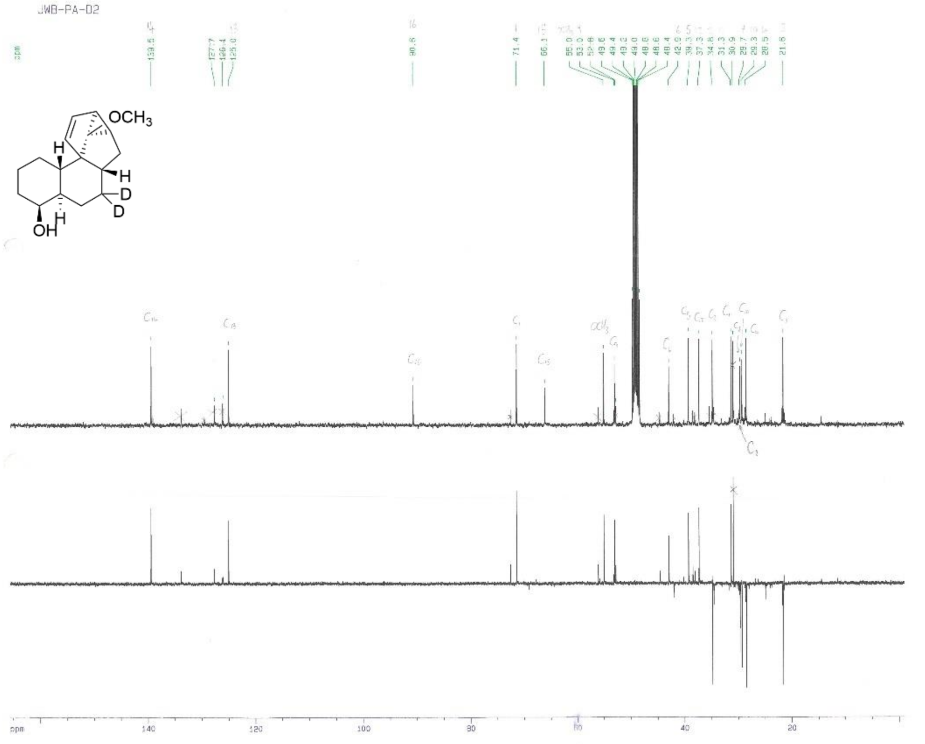
```
Current Data Parameters
NAME             jwbod2
EXPNO                 1
PROCNO                1

F2 - Acquisition Parameters
Date_          20020524
Time              12.38
INSTRUM          amx400
PROBHD     5 mm Multinu
PULPROG            zg30
TD                32768
SOLVENT            C6D6
NS                   16
DS                    2
SWH            6024.105 Hz
FIDRES         0.183841 Hz
AQ            2.7197940 sec
RG                  128
DW               83.000 usec
DE              116.57 usec
TE                300.0 K
HL1                   1 dB
D1           3.00000000 sec
P1                 6.00 usec
SFO1        400.1357350 MHz
NUCLEUS              1H

F2 - Processing parameters
SI                32768
SF          400.1344097 MHz
WDW                  GM
SSB                   0
LB                -0.25 Hz
GB                  0.2
PC                 1.00

1D NMR plot parameters
CX                32.00 cm
F1P               8.129 ppm
F1              3252.53 Hz
F2P              -0.034 ppm
F2               -13.55 Hz
PPMCM           0.25508 ppm/cm
HZCM          102.06503 Hz/cm
```



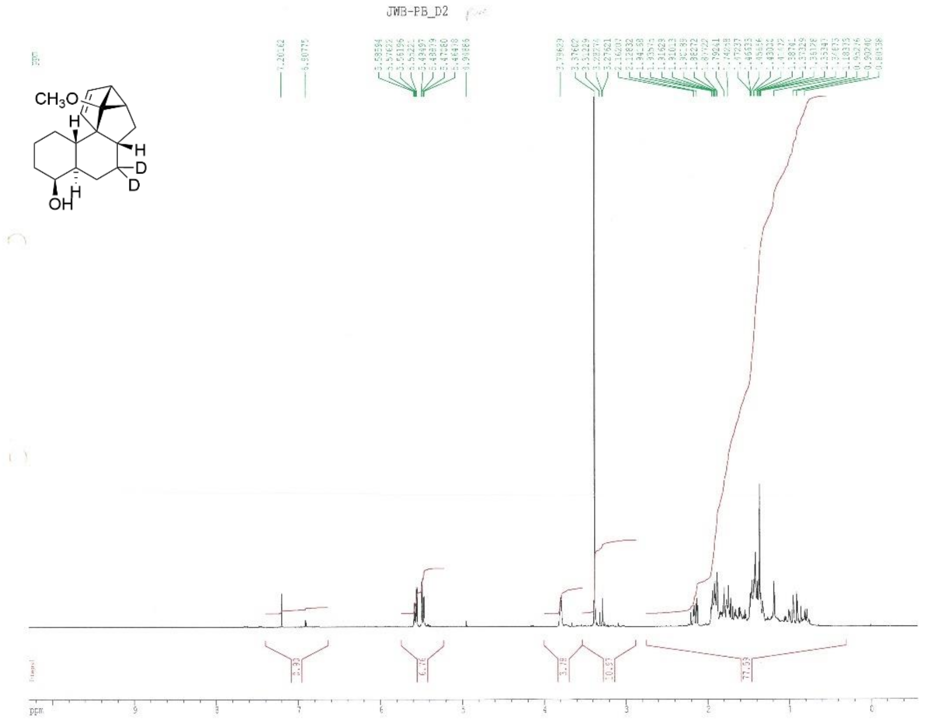
```
Current Data Parameters
NAME             jwbod2
EXPNO                 2
PROCNO                1

F2 - Acquisition Parameters
Date_          20020524
Time              12.42
INSTRUM          amx400
PROBHD     5 mm Multinu
PULPROG          zgpg30
TD                32768
SOLVENT            C6D6
NS                  434
DS                    2
SWH           38461.535 Hz
FIDRES         1.173753 Hz
AQ            0.4260340 sec
RG                32768
DW               13.000 usec
DE                18.57 usec
TE                300.0 K
HL1                   1 dB
D1           2.00000000 sec
CPDPRG          waltz16
P31              110.00 usec
S4                   30 dB
D11          0.03000000 sec
S2                   26 dB
P1                 6.90 usec
SFO1        100.6249950 MHz
NUCLEUS             13C

F2 - Processing parameters
SI                65536
SF          100.6138493 MHz
WDW                  EM
SSB                   0
LB                 2.00 Hz
GB                    0
PC                 1.00

1D NMR plot parameters
CX                33.00 cm
F1P             181.756 ppm
F1             18287.13 Hz
F2P              -1.214 ppm
F2              -122.17 Hz
PPMCM           5.54454 ppm/cm
HZCM          557.85760 Hz/cm
```



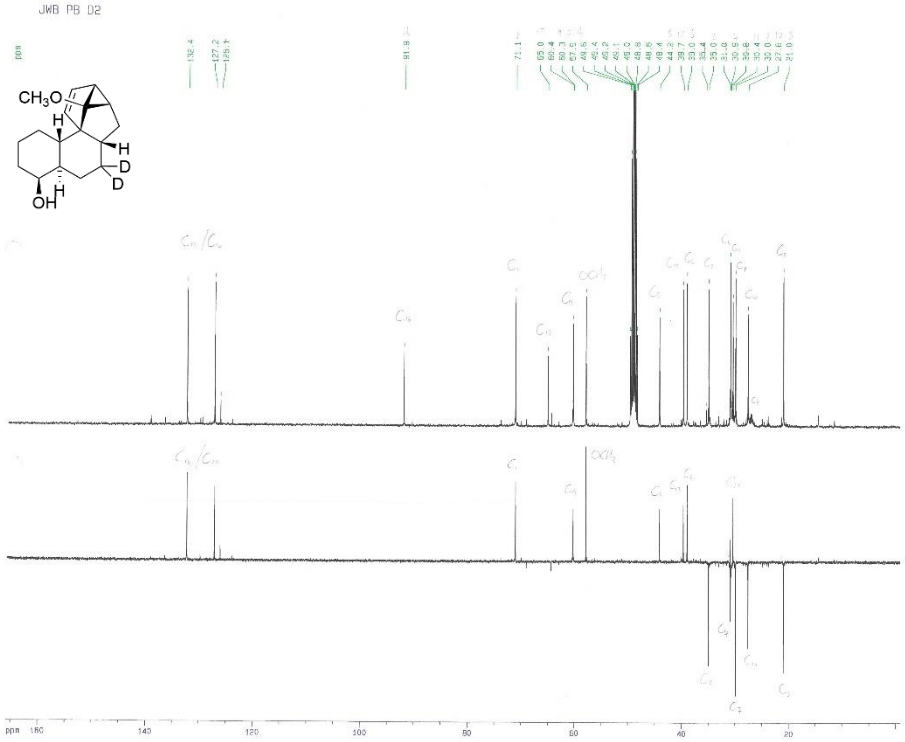
```
Current Data Parameters
NAME             jwbpad2
EXPNO                  1
PROCNO                 1

F2 - Acquisition Parameters
Date_           20020605
Time               11.28
INSTRUM           amx400
PROBHD     5 mm Multinu
PULPROG             zg30
TD                 32768
SOLVENT             MeOH
NS                    16
DS                     2
SWH             6024.096 Hz
FIDRES          0.183841 Hz
AQ             2.7197940 sec
RG                   128
DW                83.000 usec
DE                116.57 usec
TE                 300.0 K
HL1                    1 dB
D1            3.00000000 sec
P1                  8.00 usec
SFO1         400.1383276 MHz
NUCLEUS               1H

F2 - Processing parameters
SI                 32768
SF           400.1359530 MHz
WDW                   GM
SSB                    0
LB                 -0.20 Hz
GB                   0.2
PC                  1.00

1D NMR plot parameters
CX                 32.00 cm
F1P                8.063 ppm
F1               3226.22 Hz
F2P               -0.034 ppm
F2                -13.56 Hz
PPMCM            0.25302 ppm/cm
HZCM           101.24298 Hz/cm
```



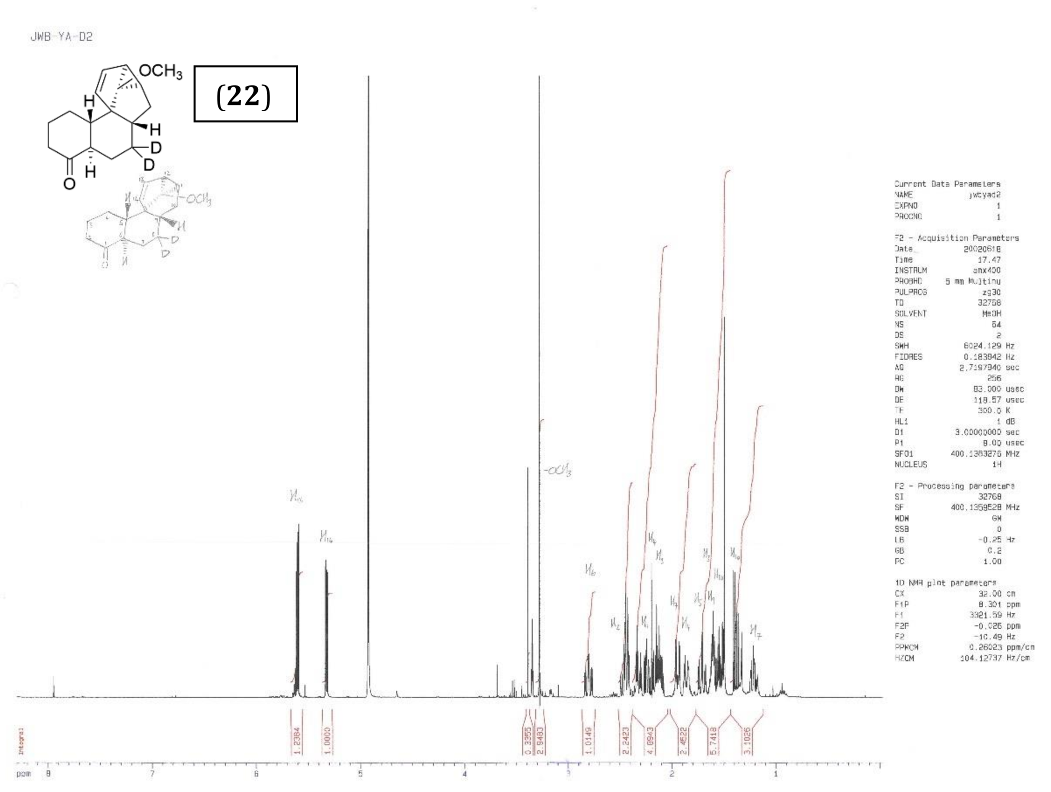
```
Current Data Parameters
NAME             jwbpad2
EXPNO                  2
PROCNO                 1

F2 - Acquisition Parameters
Date_           20020605
Time               12.26
INSTRUM           amx400
PROBHD     5 mm Multinu
PULPROG           zgpg30
TD                 65536
SOLVENT            CDCl3
NS                  2144
DS                     2
SWH            38461.539 Hz
FIDRES          0.586877 Hz
AQ             0.8520180 sec
RG                 32768
DW                13.000 usec
DE                 18.57 usec
TE                 300.0 K
HL1                    1 dB
D1            2.00000000 sec
CPDPRG           waltz16
P31               110.00 usec
S4                    30 dB
D11           0.03000000 sec
S2                    26 dB
P1                  7.15 usec
SFO1         100.6250000 MHz
NUCLEUS              13C

F2 - Processing parameters
SI                 65536
SF           100.6141284 MHz
WDW                   EM
SSB                    0
LB                  2.00 Hz
GB                     0
PC                  1.00

1D NMR plot parameters
CX                 33.00 cm
F1P              165.623 ppm
F1              16664.03 Hz
F2P               -1.017 ppm
F2               -102.34 Hz
PPMCM            5.04971 ppm/cm
HZCM           508.07169 Hz/cm
```



```
Current Data Parameters
NAME          May01-2002
EXPNO               1100
PROCNO                 1

F2 - Acquisition Parameters
Date_           20020501
Time               12.46
INSTRUM           dpx250
PROBHD     5 mm Multinu
PULPROG             zg30
TD                 32768
SOLVENT            CDCl3
NS                    16
DS                     2
SWH             3255.208 Hz
FIDRES          0.099341 Hz
AQ             5.0332146 sec
RG                   128
DW               153.600 use
DE                  4.50 use
TE                 300.0 K
D1            1.00000000 sec

============ CHANNEL f1 ===
NUC1                  1H
P1                 10.00 use
PL1                -6.00 dB
SFO1         249.8713493 MHz

F2 - Processing parameters
SI                 32768
SF           249.8700195 MHz
WDW                   EM
SSB                    0
LB                  0.10 Hz
GB                     0
PC                  2.00

1D NMR plot parameters
CX                 33.00 cm
F1P               10.285 ppm
F1               2569.79 Hz
F2P               -0.570 ppm
F2               -142.47 Hz
PPMCM            0.32893 ppm
HZCM            82.18987 Hz/
```

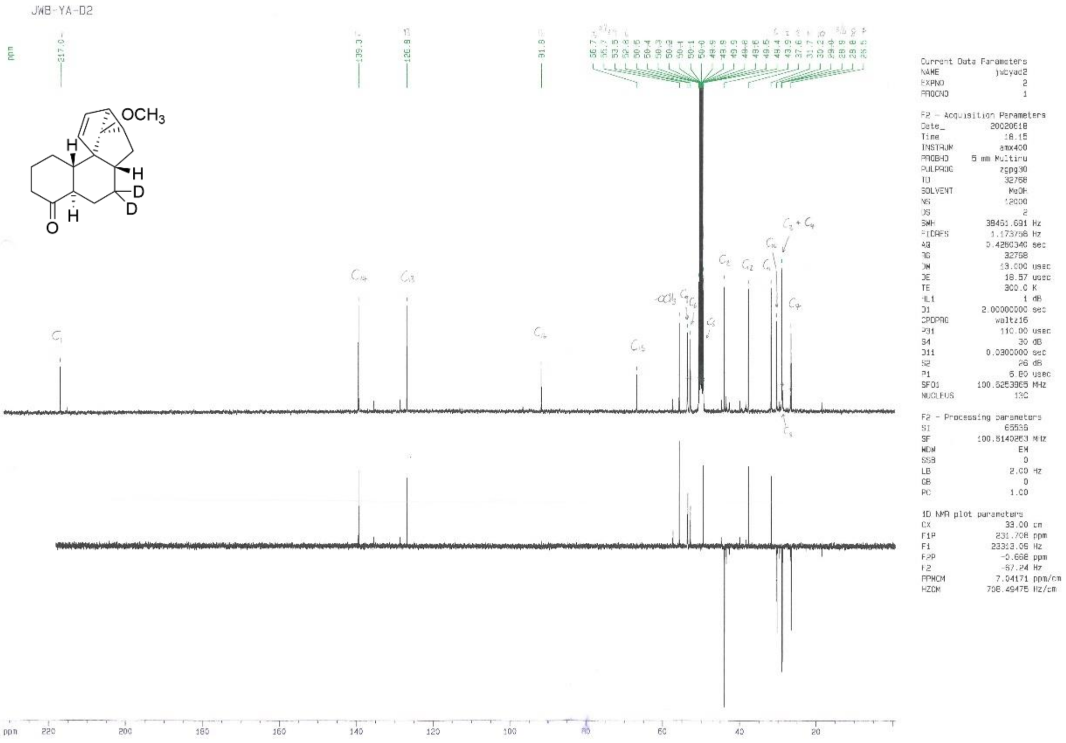


```
Current Data Parameters
NAME              jwbpbd2
EXPNO                   2
PROCNO                  1

F2 - Acquisition Parameters
Date_            20020523
Time                21.01
INSTRUM            amx400
PROBHD      5 mm Multinu
PULPROG            zgpg30
TD                  32768
SOLVENT              MeOH
NS                   9600
DS                      2
SWH             38461.691 Hz
FIDRES           1.173758 Hz
AQ              0.4260340 sec
RG                  32768
DW                 13.000 usec
DE                  18.57 usec
TE                  300.0 K
HL1                     1 dB
D1             2.00000000 sec
CPDPRG            waltz16
P31                110.00 usec
S4                     30 dB
D11            0.03000000 sec
S2                     26 dB
P1                   5.80 usec
SFO1          100.6253965 MHz
NUCLEUS               13C

F2 - Processing parameters
SI                  65536
SF            100.6141292 MHz
WDW                    EM
SSB                     0
LB                   2.00 Hz
GB                      0
PC                   1.00

1D NMR plot parameters
CX                  33.00 cm
F1P               165.787 ppm
F1               16680.49 Hz
F2P                -0.854 ppm
F2                 -85.94 Hz
PPMCM             5.04973 ppm/cm
HZCM            508.07370 Hz/cm
```

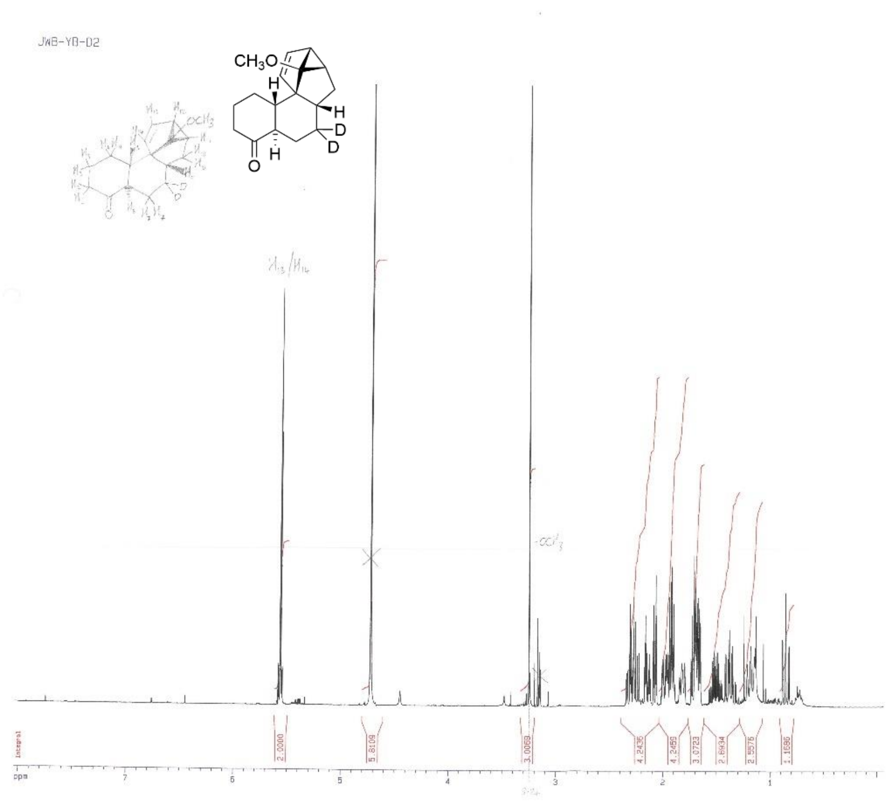


(22)

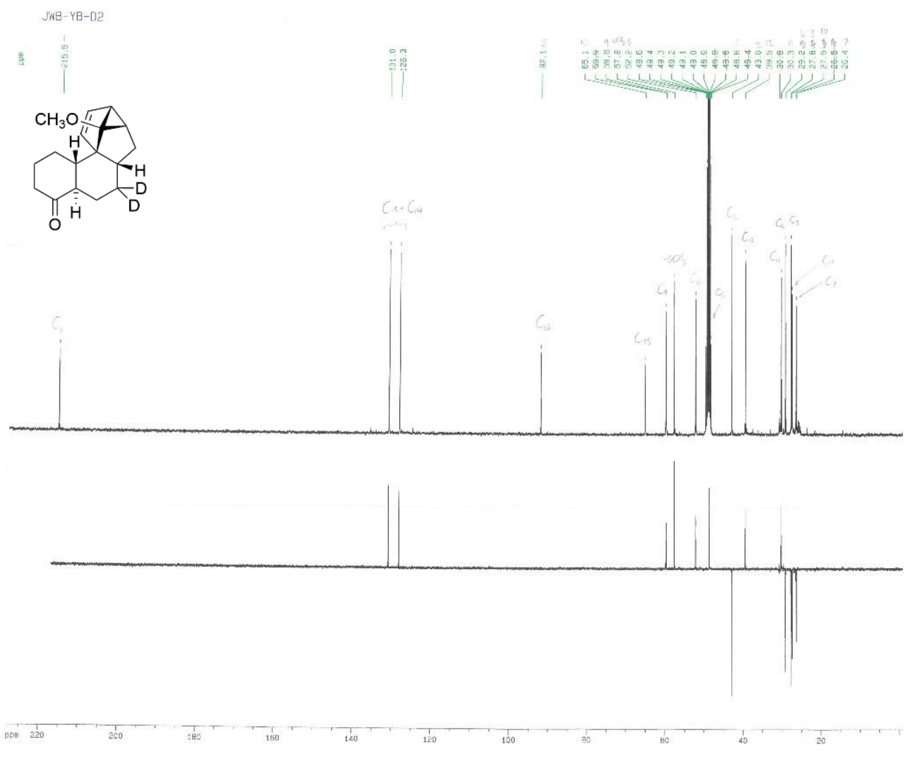
```
Current Data Parameters
NAME              jwcyad2
EXPNO                   1
PROCNO                  1

F2 - Acquisition Parameters
Date_            20020618
Time                17.47
INSTRUM            amx400
PROBHD     5 mm Multinu
PULPROG              zg30
TD                  32768
SOLVENT              MeOH
NS                     64
DS                      2
SWH              6024.129 Hz
FIDRES           0.183842 Hz
AQ              2.7197940 sec
RG                    256
DW                 83.000 usec
DE                 118.57 usec
TE                  300.0 K
HL1                     1 dB
D1             3.00000000 sec
P1                   8.00 usec
SFO1          400.1363276 MHz
NUCLEUS                1H

F2 - Processing parameters
SI                  32768
SF            400.1359528 MHz
WDW                    GM
SSB                     0
LB                  -0.25 Hz
GB                    0.2
PC                   1.00

1D NMR plot parameters
CX                  32.00 cm
F1P                 8.301 ppm
F1                3321.59 Hz
F2P                -0.026 ppm
F2                 -10.49 Hz
PPMCM             0.26023 ppm/cm
HZCM            104.12737 Hz/cm
```



```
Current Data Parameters
NAME              jwcyad2
EXPNO                   2
PROCNO                  1

F2 - Acquisition Parameters
Date_            20020618
Time                18.15
INSTRUM            amx400
PROBHD     5 mm Multinu
PULPROG           zgpg30
TD                  32768
SOLVENT              MeOH
NS                  12000
DS                      2
SWH             38461.691 Hz
FIDRES           1.173758 Hz
AQ              0.4260340 sec
RG                  32768
DW                 13.000 usec
DE                  18.57 usec
TE                  300.0 K
HL1                     1 dB
D1             2.00000000 sec
CPDPRG            waltz16
P31                110.00 usec
S4                     30 dB
D11            0.03000000 sec
S2                     26 dB
P1                   6.80 usec
SFO1          100.6253965 MHz
NUCLEUS               13C

F2 - Processing parameters
SI                  65536
SF            100.6140263 MHz
WDW                    EM
SSB                     0
LB                   2.00 Hz
GB                      0
PC                   1.00

1D NMR plot parameters
CX                  33.00 cm
F1P               231.708 ppm
F1               23313.05 Hz
F2P                -0.668 ppm
F2                 -67.24 Hz
PPMCM             7.04171 ppm/cm
HZCM            708.49475 Hz/cm
```

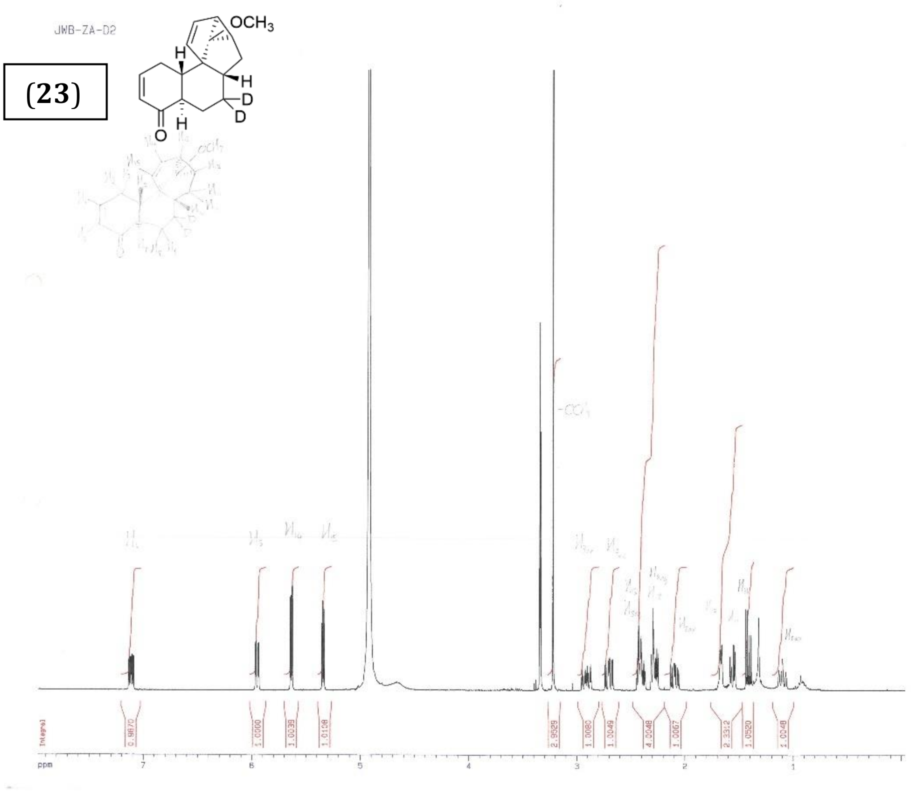


```
Current Data Parameters
NAME             Jwbyod2
EXPNO                  1
PROCNO                 1

F2 - Acquisition Parameters
Date_           20020716
Time               16.34
INSTRUM           amx400
PROBHD     5 mm Multinu
PULPROG             zg30
TD                 32768
SOLVENT             MeOH
NS                   160
DS                     2
SWH             6024.129 Hz
FIDRES          0.183842 Hz
AQ             2.7197940 sec
RG                   128
DW                93.000 usec
DE                118.57 usec
TE                 300.0 K
HL1                    1 dB
D1            3.00000000 sec
P1                  8.00 usec
SFO1         400.1383276 MHz
NUCLEUS               1H

F2 - Processing parameters
SI                 32768
SF           400.1360329 MHz
WDW                   GM
SSB                    0
LB                 -0.25 Hz
GB                   0.2
PC                  1.00

1D NMR plot parameters
CX                 32.00 cm
F1P                8.035 ppm
F1               3215.17 Hz
F2P               -0.061 ppm
F2                -24.53 Hz
PPMCM            0.25302 ppm/cm
HZCM           101.24066 Hz/cm
```

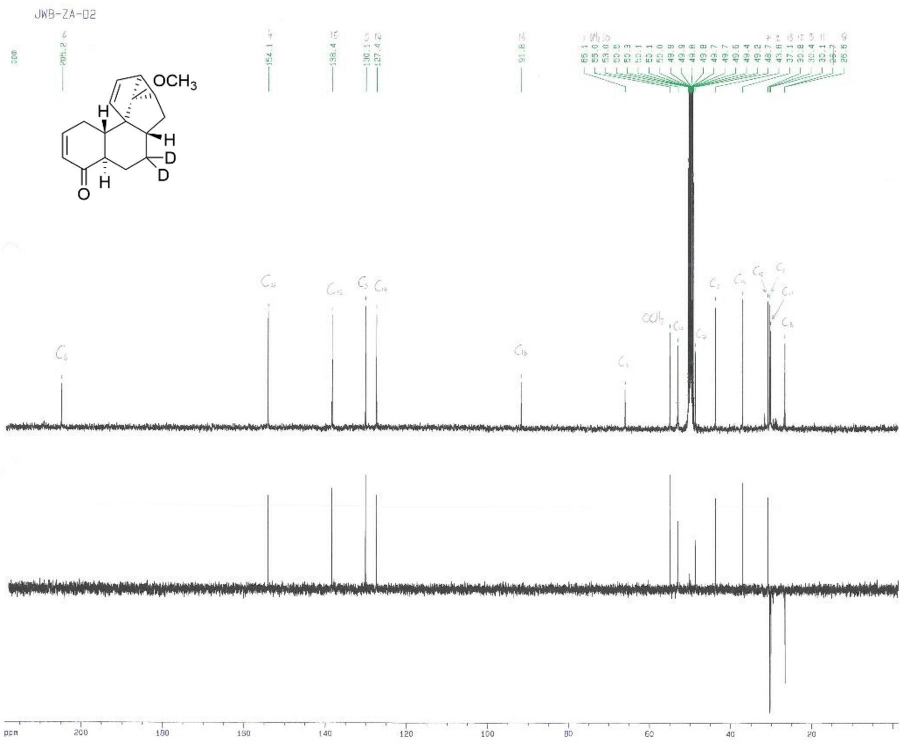


```
Current Data Parameters
NAME             Jwbybd2
EXPNO                  2
PROCNO                 1

F2 - Acquisition Parameters
Date_           20020716
Time               17.17
INSTRUM           amx400
PROBHD     5 mm Multinu
PULPROG           zgpg30
TD                 32768
SOLVENT             MeOH
NS                  9600
DS                     2
SWH            38461.691 Hz
FIDRES          1.173758 Hz
AQ             0.4260340 sec
RG                 32768
DW                13.000 usec
DE                 18.57 usec
TE                 300.0 K
HL1                    1 dB
D1            2.00000000 sec
CPDPRG           waltz16
P31               110.00 usec
S4                    30 dB
D11           0.03000000 sec
S2                    26 dB
P1                  6.80 usec
SFO1         100.6253965 MHz
NUCLEUS              13C

F2 - Processing parameters
SI                 65536
SF           100.6141287 MHz
WDW                   EM
SSB                    0
LB                  2.00 Hz
GB                     0
PC                  1.00

1D NMR plot parameters
CX                 33.00 cm
F1P              228.178 ppm
F1              22957.96 Hz
F2P               -0.848 ppm
F2                -85.35 Hz
PPMCM            5.94020 ppm/cm
HZCM           598.28210 Hz/cm
```

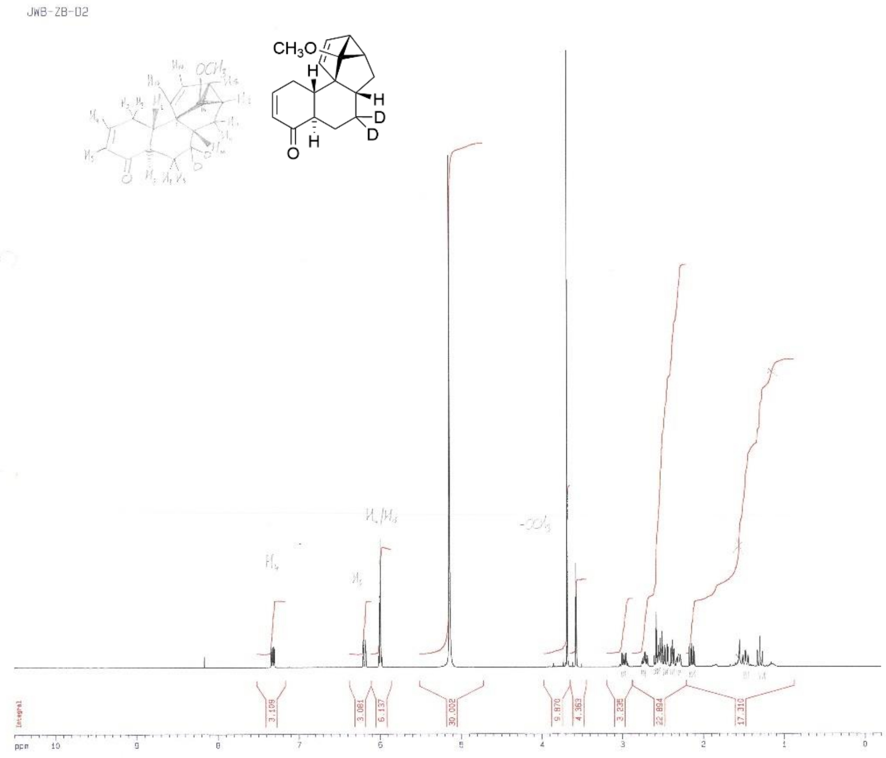
(23)



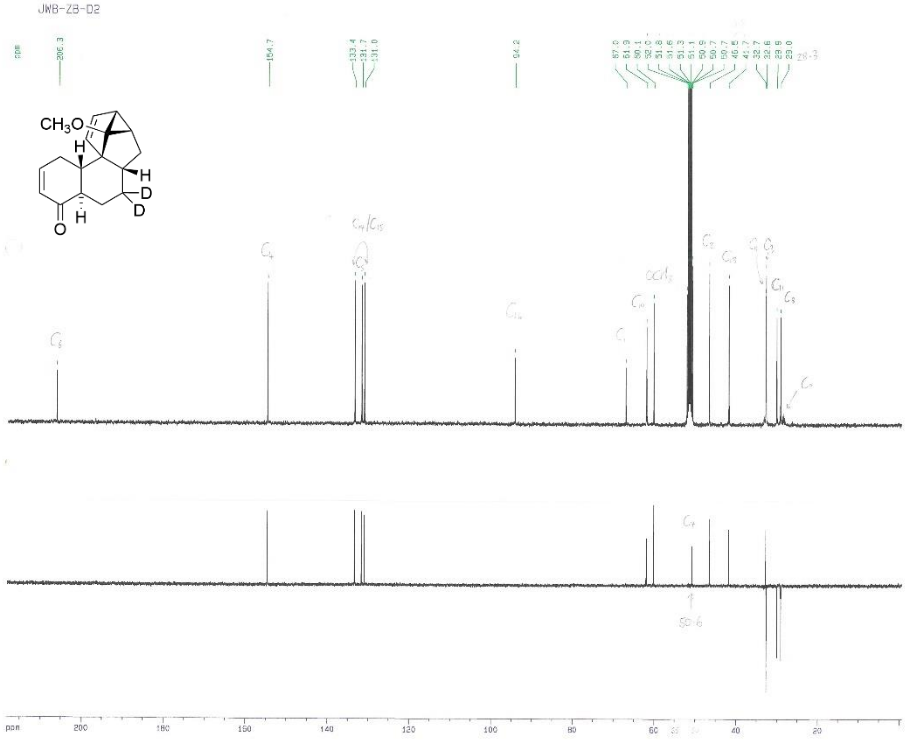
```
Current Data Parameters
NAME            jw0zad2
EXPNO                 1
PROCNO                1

F2 - Acquisition Parameters
Date_          20020916
Time              16.51
INSTRUM          amx400
PROBHD     5 mm Multinu
PULPROG            zg30
TD                32768
SOLVENT            MeOH
NS                   16
DS                    2
SWH            6024.125 Hz
FIDRES         0.183842 Hz
AQ            2.7197940 sec
RG                  256
DW               83.000 usec
DE               118.57 usec
TE                300.0 K
HL1                   1 dB
D1           3.00000000 sec
P1                 8.00 usec
SFO1        400.1383276 MHz
NUCLEUS              1H

F2 - Processing parameters
SI                32768
SF          400.1359570 MHz
WDW                  EM
SSB                   0
LB                 0.20 Hz
GB                    0
PC                 1.00

1D NMR plot parameters
CX                32.00 cm
F1P               7.966 ppm
F1              3187.54 Hz
F2P              -0.036 ppm
F2               -14.42 Hz
PPMCM           0.25007 ppm/cm
HZCM          100.06112 Hz/cm
```



```
Current Data Parameters
NAME            jw0zad2
EXPNO                 2
PROCNO                1

F2 - Acquisition Parameters
Date_          20020916
Time              17.25
INSTRUM          amx400
PROBHD     5 mm Multinu
PULPROG          zgpg30
TD                32768
SOLVENT            MeOH
NS                12000
DS                    2
SWH           38461.691 Hz
FIDRES         1.173758 Hz
AQ            0.4260340 sec
RG                32768
DW               13.000 usec
DE                18.57 usec
TE                300.0 K
HL1                   1 dB
D1           2.00000000 sec
CPDPRG          waltz16
P31              110.00 usec
S4                   30 dB
D11          0.03000000 sec
S2                   25 dB
P1                 6.80 usec
SFO1        100.6253965 MHz
NUCLEUS             13C

F2 - Processing parameters
SI                65536
SF          100.6140410 MHz
WDW                  EM
SSB                   0
LB                 2.00 Hz
GB                    0
PC                 1.00

1D NMR plot parameters
CX                33.00 cm
F1P             218.817 ppm
F1             22016.07 Hz
F2P              -1.403 ppm
F2              -141.21 Hz
PPMCM           6.67335 ppm/cm
HZCM          671.43268 Hz/cm
```



```
Current Data Parameters
NAME             jwbzcd2
EXPNO                  1
PROCNO                 1

F2 - Acquisition Parameters
Date_           20020904
Time               16.49
INSTRUM           amx400
PROBHD     5 mm Multinu
PULPROG             zg30
TD                 32768
SOLVENT             MeOH
NS                    16
DS                     2
SWH             6024.129 Hz
FIDRES          0.183842 Hz
AQ             2.7197940 sec
RG                   256
DW                83.000 usec
DE                118.57 usec
TE                 300.0 K
HL1                    1 dB
D1            3.00000000 sec
P1                  8.00 usec
SFO1         400.1383276 MHz
NUCLEUS               1H

F2 - Processing parameters
SI                 32768
SF           400.1359535 MHz
WDW                   EM
SSB                    0
LB                  0.20 Hz
GB                     0
PC                  1.00

1D NMR plot parameters
CX                 32.00 cm
F1P               10.500 ppm
F1               4201.43 Hz
F2P               -0.200 ppm
F2                -80.03 Hz
PPMCM            0.33437 ppm/cm
HZCM           133.79543 Hz/cm
```



```
Current Data Parameters
NAME             jwbzbc2
EXPNO                  2
PROCNO                 1

F2 - Acquisition Parameters
Date_           20020904
Time               17.01
INSTRUM           amx400
PROBHD     5 mm Multinu
PULPROG           zgpg30
TD                 32768
SOLVENT             MeOH
NS                  9600
DS                     2
SWH            38461.691 Hz
FIDRES          1.173758 Hz
AQ             0.4260340 sec
RG                 32768
DW                13.000 usec
DE                 18.57 usec
TE                 300.0 K
HL1                    1 dB
D1            2.50000000 sec
CPDPRG           waltz16
P31               110.00 usec
S4                    30 dB
D11           0.03000000 sec
S2                    26 dB
P1                  6.80 usec
SFO1         100.6253965 MHz
NUCLEUS              13C

F2 - Processing parameters
SI                 65536
SF           100.6138897 MHz
WDW                   EM
SSB                    0
LB                  2.00 Hz
GB                     0
PC                  1.00

1D NMR plot parameters
CX                 33.00 cm
F1P              218.181 ppm
F1              21952.06 Hz
F2P               -0.649 ppm
F2                -65.30 Hz
PPMCM            6.63122 ppm/cm
HZCM           667.19250 Hz/cm
```

Synthesis of the control substrate (**9**)