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Highly Efficient Synthesis of the Tricyclic Core of Taxol by Cascade Metathesis

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1. General Experimental

Reactions involving air-sensitive agents and dry solvents were performed in glassware that had been dried in an oven (150°C) or flame-dried prior to use. These reactions were carried out with the exclusion of air using an argon atmosphere. All microwave reactions were carried out using a Biotage Initiator system. Melting points were determined on a Stuart scientific-Melting Point SMP1 apparatus and are uncorrected. NMR spectra were recorded on a Bruker DPX-400 spectrometer (1H NMR at 400 MHz and 13C NMR at 100 MHz) or a Bruker DPX-500 spectrometer (1H NMR at 500 MHz and 13C NMR at 126 MHz). Chemical shifts are reported in ppm. 1H NMR spectra were recorded with CDC_{13} as the solvent using residual $CHCl_3$ (= 7.26) as internal standard, and for 13C NMR spectra the chemical shifts are reported relative to the central resonance of CDCl₃ (' = 77.16). Signals in NMR spectra are described as singlet (s), doublet (d), triplet (t), quartet (q), quintet (quint), septet (sept), multiplet (m), broad (br) or combination of these, which refers to the spin-spin coupling pattern observed. Spin-spin coupling constants reported are uncorrected. Two dimensional (COSY, HSQC, HMBC, NOESY) NMR spectroscopy was used where appropriate to assist the assignment of signals in the 1H and 13C NMR spectra. IR spectra were obtained employing a Shimadzu FTIR-8400 instrument with a Golden GateTM attachment that uses a type IIa diamond as a single reflection element so that the IR spectrum of the compound (solid or liquid) could be detected directly (thin layer). High resolution mass spectra were recorded under FAB, ESI and CI conditions by the analytical services at the University of Glasgow. Flash column chromatography was performed using forced flow of the indicated solvent system on EMD Geduran Silica Gel 60 as solid support and HPLC graded solvents as eluant. Reactions were monitored by thin layer chromatography (TLC) on Merck silica gel 60 covered aluminum sheets. TLC plates were developed under UV-light and/or with an acidic ethanolic anisaldehyde solution or a KMnO₄-solution. Liquid reagents were distilled prior to use where stated. All reagents were purchased from commercial suppliers and used without further purification unless otherwise stated.

2. Experimental Procedures and Characterisation Data

Ethyl 2,2-dimethylpent-4-ynoate



Formula: C₉H₁₄O₂

MW: 154.2

Spect. Reference: J. Am. Chem. Soc. 2007, 129, 5838-5839

To a solution of DIPA (23 mL, 163 mmol, 1.1 equiv) in 400 mL of THF at -78°C was added *n*BuLi (71 mL, 2.2M in hexane, 156 mmol, 1.05 equiv). The mixture was stirred at this temperature for 30 min and ethyl isobutyrate (20 mL, 149 mmol) in 300 mL of THF was added drop wise over 3 h and the reaction mixture was allowed to warm to 0°C for 45 min and then cooled down to -78°C. A solution of propargyl bromide (17.6 mL, 80% in toluene, 156 mmol) in 100 mL of THF was added and the mixture was stirred at RT for 3 h. The reaction mixture was quenched with NH₄Cl (sat. aq.) and the aqueous phase was extracted with DCM. The combined organic layers were washed with brine, dried over MgSO₄, filtered and concentrated *in vacuo*. The crude mixture was purified by flash chromatography on silica gel (petroleum ether/diethyl ether: 95/5) to afford the title compound (20 g, 130 mmol, 87%) as a pale yellow oil.

¹**H NMR** (400MHz, *CDCl₃*) ′ ppm: 4.14 (q, *J* = 7.1 Hz, 2H), 2.43 (d, *J* = 2.6 Hz, 2H), 1.99 (t, *J* = 2.6 Hz, 1H), 1.26 (s, 6H), 1.24 (d, *J* = 7.1 Hz, 3H).

¹³C NMR (100 MHz, *CDCl₃*) [~] ppm: 176.6, 81.1, 70.4, 60.7, 41.9, 29.5, 24.5, 14.2.

IR (¹/₂ cm⁻¹): 3296, 2978, 2934, 2120, 1727, 1471, 1386, 1366, 1317, 1302, 1255, 1197, 1130, 1471, 1386, 1366, 1317, 1302, 1255, 1197, 1132, 1028.



Formula: C₇H₁₀O₂

MW: 126.2

Spect. Reference: J. Am. Chem. Soc. 1983, 105, 5368-5372

To a solution of propargylated ethyl ester (20 g, 130 mmol) in 250 mL of MeOH and 100 mL of water was added KOH (11.7 g, 208 mmol, 1.60 equiv). The reaction mixture was stirred overnight at RT. A 2N aqueous HCl solution was added to adjust the pH to 1 and the aqueous phase was extracted with DCM. The combined organic extracts were washed with a 2N aqueous HCl solution, dried over Na_2SO_4 , filtered and concentrated *in vacuo* to afford the title compound (6) (15.3 g, 121 mmol, 93%) as a pale yellow oil which can be used in the next step without further purification.

¹**H NMR** (400MHz, *CDCl*₃) \checkmark ppm: 2.47 (d, J = 2.7 Hz, 2H), 2.03 (t, J = 2.7 Hz, 1H), 1.32 (s, 6H).

¹³C NMR (100 MHz, *CDCl*₃) ′ ppm: 183.2, 80.7, 70.7, 41.9, 29.3, 24.3.

IR (¹/₂ cm⁻¹): 3515, 3297, 2977, 2936, 2120, 1699, 1474, 1410, 1367, 1316, 1283, 1227, 1160.

HRMS (EI) Calcd. for [C₇H₁₀O₂]: 126.0681, found: 126.0684.

2,2-Dimethylpent-3-ynoic acid (7)



Formula: C₇H₁₀O₂

MW: 126.2

To a solution of acid (6) (17 g, 134 mmol) in DMSO (200 mL) was added potassium *tert*butoxide (32.9 g, 269 mmol, 2.0 equiv), and the mixture was stirred at 75°C for 10 min. A 1N aqueous HCl solution was then added to adjust to pH 1, and the aqueous phase was extracted with Et₂O. The combined organic extracts were washed with 1N aqueous HCl, dried over anhydrous MgSO₄, filtered and concentrated *in vacuo*. The crude mixture was then purified by flash chromatography on silica gel (diethyl ether/petroleum ether: 5/5) to afford the title acid (7) (15.9 g, 94%) as a pale yellow oil.

¹H NMR (500 MHz, *CDCl₃*) ´ ppm: 11.23 (br. s, CO₂H), 1.83 (s, 3H), 1.48 (s, 6H).
¹³C NMR (126 MHz, *CDCl₃*) ´ ppm: 180.6, 80.7, 78.1, 38.2, 27.2, 3.6.
IR (¹/₂ cm⁻¹): 3532, 2984, 2923, 1707, 1470, 1411, 1267, 1234, 1172, 1057.
HRMS (EI) Calcd. for [C₇H₁₀O₂]: 126.0681, found: 126.0685.





Formula: C₇H₁₀O

MW: 110.2

To a suspension of lithium aluminum hydride (0.75 g, 19.8 mmol, 1.0 equiv) in Et₂O (90 mL) at 0°C was added dropwise a solution of (7) (2.5 g, 19.8 mmol, 1.0 equiv) in Et₂O (10 mL). The mixture was stirred at this temperature for 30 min. Excess of lithium aluminum hydride was then quenched with careful addition of ice. A 1N aqueous HCl solution was then added to dissolve lithium salts. The aqueous phase was then extracted with Et₂O. The combined organic extracts were washed with 1N aqueous HCl, dried over anhydrous MgSO₄, filtered and concentrated *in vacuo* to give a pale yellow oil that was directly used without further purification. To a solution of oxalyl chloride (2.0 mL, 24 mmol, 1.2 equiv) in CH₂Cl₂ (40 mL) at -50°C was added dropwise DMSO (3.3 mL, 46 mmol, 2.3 equiv). The mixture was stirred at this temperature for 10 min, and a solution of the previous alcohol (19.8 mmol) in CH₂Cl₂ (20 mL) was then added. The temperature was allowed to warm to 0°C, and the mixture was stirred for 30 min. The reaction was quenched with saturated aqueous NH₄Cl. The aqueous layer was extracted with Et₂O, and the combined organic extracts were washed with brine, dried over anhydrous MgSO₄, filtered and concentrated *in vacuo*.

flash chromatography on silica gel (dichloromethane/pentane: 20/80) to afford the title aldehyde (7a) (1.7 g, 76%) as a colorless oil.

¹**H NMR** (400MHz, *CDCl*₃) δ ppm: 9.45 (s, 1H), 1.84 (s, 3H), 1.29 (s, 6H).

¹³C NMR (100 MHz, *CDCl₃*) [~] ppm: 199.0, 80.9, 79.6, 42.7, 23.2, 3.7.

IR (¹/₂ cm⁻¹): 2983, 2924, 2872, 2816, 2715, 1737, 1466, 1391, 1364, 1264, 1246, 1056.

HRMS (EI) Calcd. for C₇H₁₀O: 110.0732, found: 110.0736.



Formula: C7H14O

MW: 114.2

Spect. Reference: J. Am. Chem. Soc. 1998, 120, 6609-6610

To a solution of crotyl chloride (30 mL, 70%, 190 mmol) in acetone (1 L) and aqueous saturated NH₄Cl (100 mL) was added activated zinc dust (25 g, 380 mmol, 2.0 equiv). The resulting mixture was stirred at rt for one week. A 1N aqueous HCl solution was then added to dissolve zinc salts, and acetone was removed *in vacuo*. The aqueous phase was extracted with Et_2O . The combined organic extracts were washed with brine, dried over anhydrous MgSO₄, filtered and concentrated *in vacuo*. The crude mixture was then purified by flash chromatography on silica gel (diethyl ether/petroleum ether: 20/80) to afford (**7b**) (18 g, 83 %) as a colorless oil.

¹**H NMR** (400MHz, *CDCl*₃) δ ppm: 5.80 (m, 1H), 5.10 (m, 1H), 5.07 (d, J = 0.6 Hz, 1H), 2.20 (dd, J = 13.9, 6.9 Hz, 1H), 1.68 (bs, 1H), 1.18 (s, 3H), 1.15 (s, 3H), 1.03 (d, J = 6.9 Hz, 3H).

¹³C NMR (126 MHz, *CDCl*₃) [′] ppm: 140.6, 116.3, 72.3, 49.4, 27.2, 26.6, 15.2.

IR (¹/₂ cm⁻¹): 3620, 3580, 3490, 3079, 2976, 2937, 2880, 1836, 1636, 1460, 1419, 1371, 1339, 1217, 1173, 1118, 1040, 1001, 943, 915.

MS (CI, DI, NH₃): 97, 115 (M+H⁺), 133, (M+NH₄⁺).



Formula: C₁₁H₁₈O

MW: 166.3

To a solution of aldehyde (**7a**) (3.5 g, 31.5 mmol) and alcohol (**7b**) (5.4 g, 47.3 mmol, 1.5 equiv) in CH_2Cl_2 (170 mL) was added 4Å molecular sieves (1.0 g) and tin trifluoromethanesulfonate (0.6 g, 1.6 mmol, 5 mol%). The mixture was stirred overnight at rt. A 1N aqueous HCl solution was then added and the aqueous phase was extracted with CH_2Cl_2 . The combined organic extracts were washed with brine, dried over anhydrous MgSO₄, filtered and concentrated *in vacuo*. The crude mixture was then purified by flash chromatography on silica gel (diethyl ether/petroleum ether: 2/98) to afford (**7c**) (4.0 g, 76 %, E/Z = 3:1) as a colorless oil.

E Isomer

¹**H NMR** (400MHz, *CDCl*₃) δ ppm: 5.47-5.67 (m, 2H), 3.28 (d, J = 10.6 Hz, 1H), 2.40 (m, 1H), 2.05 (m, 1H), 1.85 (bs, 1H), 1.80 (s, 3H), 1.69 (d, J = 5.0 Hz, 3H), 1.19 (s, 3H), 1.16 (s, 3H).

¹³C NMR (100 MHz, *CDCl₃*) ´ ppm: 128.5, 128.2, 84.1, 78.1, 77.5, 36.9, 35.8, 25.7, 25.6, 18.1, 3.6.

IR (¹/₂ cm⁻¹): 3563, 2970, 2923, 1711, 1456, 1391, 1364, 1190, 1062, 1013, 972.

HRMS (EI) Calcd. for [C₁₁H₁₈O]: 166.1358, found: 166.1358.

Z Isomer

¹**H NMR** (400MHz, *CDCl₃*) δ ppm: 5.47-5.67 (m, 2H), 3.3 (m, 1H), 2.40 (m, 1H), 2.21 (m, 1H), 1.85 (bs, 1H), 1.81 (s, 3H), 1.65 (d, *J* = 6.5 Hz, 3H), 1.22 (s, 3H), 1.18 (s, 3H).

¹³C NMR (100 MHz, *CDCl₃*) ´ ppm: 127.5, 126.6, 84.1, 77.7, 77.5, 37.1, 30.0, 25.7, 25.6, 13.0, 3.6.



Formula: C₁₁H₁₆O

MW: 164.2

To a solution of alcohol (**7c**) (0.42 g, 2.5 mmol, E/Z = 3:1) in THF (10 mL) was added a solution of IBX (2.1 g, 7.5 mmol, 3.0 equiv) in DMSO (10 mL). The mixture was stirred overnight. Water was then added, and the mixture was stirred for 2 h to form a white precipitate that was filtered off on Celite. The aqueous layer was extracted with Et₂O, and the combined organic extracts were washed with brine, dried over anhydrous MgSO₄, filtered and concentrated *in vacuo*. The crude mixture was then purified by flash chromatography on silica gel (diethyl ether/petroleum ether: 2/98) to afford the title ketone (**8**) (0.38 g, 93%, E/Z = 3:1) as a colorless oil.

E Isomer

¹**H** NMR (400MHz, *CDCl*₃) δ ppm: 5.50-5.71 (m, 2H), 3.48 (d, *J* = 5.3 Hz, 2H), 1.84 (s, 3H), 1.71 (d, *J* = 4.6 Hz, 3H), 1.32 (s, 6H).

¹³C NMR (100 MHz, *CDCl*₃) ´ ppm: 209.4, 129.0, 123.9, 82.3, 79.1, 43.6, 41.6, 26.4, 18.1, 3.7.

IR (¹/₂ cm⁻¹): 2982, 2923, 2857, 1715, 1455, 1381, 1363, 1252, 1113, 1079, 1038, 968.

HRMS (EI) Calcd. for [C₁₁H₁₆O]: 164.1201, found: 164.1199

Z Isomer

¹**H NMR** (400MHz, *CDCl*₃) δ ppm: 5.50-5.71 (m, 2H), 3.56 (d, *J* = 7.3 Hz, 2H), 1.85 (s, 3H), 1.65 (d, *J* = 6.5 Hz, 3H), 1.34 (s, 6H).

¹³C NMR (100 MHz, *CDCl₃*) ´ ppm: 208.9, 127.1, 122.8, 82.3, 79.2, 43.8, 36.2, 26.5, 13.2, 3.7.

2-(2-Methylpent-3-yn-2-yl)-2-(trimethylsilyloxy)hex-4-enenitrile (8a)



Formula: C₁₅H₂₅NOSi

MW: 263.5

To a solution of ketone (8) (1.0 g, 6.1 mmol, E/Z = 3:1) in CH₂Cl₂ (30 mL) was added zinc iodide (0.2 g, 0.6 mmol, 0.1 equiv) and trimethylsilylcyanide (1.5 mL, 12.2 mmol, 2.0 equiv). The mixture was stirred at reflux for 2h, and the solvent was removed *in vacuo* to give a yellow oil that was purified by flash chromatography on silica gel (diethylether/pentane: 1/99) to afford the title compound (8a) (1.5 g, 93%, E/Z = 3:1) as a colorless oil.

E Isomer

¹**H NMR** (400MHz, *CDCl*₃) δ ppm: 5.53-5.67 (m, 2H), 2.67 (dd, *J* = 13.6, 6.0 Hz, 1H), 2.44 (dd, *J* = 13.5, 6.9 Hz, 1H), 1.81 (s, 3H), 1.74 (d, *J* = 5.1 Hz, 3H), 1.34 (s, 3H), 1.23 (s, 3H), 0.22 (s, 9H).

¹³**C NMR** (100 MHz, *CDCl₃*) [′] ppm: 130.6, 125.6, 120.2, 82.5, 79.7, 79.4, 40.7, 40.7, 26.1, 23.8, 18.2, 3.8, 1.8.

IR (¹/₂ cm⁻¹): 2982, 2963, 2921, 2243, 1702, 1450, 1381, 1363, 1253, 1139, 1117, 1052, 971.

HRMS (EI) Calcd. for [C₁₅H₂₅NOSi]: 263.1705, found: 263.1701.

Z Isomer

¹**H NMR** (400MHz, *CDCl₃*) δ ppm: 5.75 (m, 1H), 5.53-5.67 (m, 1H), 2.80 (dd, J = 14.5, 7.1 Hz, 1H), 2.58 (dd, J = 14.6, 7.8 Hz, 1H), 1.82 (s, 3H), 1.68 (d, J = 6.7, 3H), 1.36 (s, 3H), 1.26 (s, 3H), 0.23 (s, 9H).

¹³**C NMR** (100 MHz, *CDCl₃*) [′] ppm: 128.6, 124.6, 120.2, 82.6, 79.7, 79.5, 41.0, 35.1, 26.1, 23.8, 13.3, 3.7, 1.8.



Formula: C15H26O2Si

MW: 266.5

To a solution of nitrile (8a) (0.38 g, 1.5 mmol) in hexane (10 mL) at -78°C was slowly added DIBALH (3.8 mL, 1M in hexane, 3.8 mmol, 2.5 equiv). The mixture was allowed to warm to 0°C and was stirred at this temperature for 20 min. The mixture was then cooled down to -78°C, and AcOEt was added. After stirring for 10 min, SiO₂ (~1 g) was added. The mixture was then allowed to warm to rt overnight. Anhydrous MgSO₄ was added and the mixture was stirred for 1h. The solids were filtered off, and the solvent was removed *in vacuo* to give an oil that was purified by flash chromatography on silica gel (diethylether/petroleum ether: 1/99) to afford the title aldehyde (±9) (0.26 g, 67%, E/Z = 3:1) as a colorless oil.

¹**H** NMR (400MHz, *CDCl*₃) δ ppm: 9.83 (s, 1H), 5.46 (dt, *J* = 13.0, 6.3 Hz, 1H), 5.23 (dt, *J* = 14.9, 7.3 Hz, 1H), 2.90 (dd, *J* = 14.3, 7.2 Hz, 1H), 2.39 (dd, *J* = 14.2, 7.3 Hz, 1H), 1.79 (s, 3H), 1.62 (d, *J* = 6.3 Hz, 3H), 1.19 (s, 3H), 1.06 (s, 3H), 0.12 (s, 9H).

¹³C NMR (100 MHz, *CDCl₃*) [′] ppm: 204.5, 129.2, 125.8, 86.9, 83.9, 78.9, 37.3, 36.6, 25.7, 24.5, 18.1, 3.7, 2.9.

IR (¹/₂ cm⁻¹): 2977, 2958, 2856, 2722, 1738, 1450, 1379, 1361, 1249, 1168, 1121, 1049, 972.

HRMS (EI) Calcd. for [C₁₅H₂₆O₂Si]: 266.1702, found: 266.1706.



Formula: C₉H₁₅NO₂

MW: 169.2

To a solution of acid (7) (4.25 g, 33.7 mmol) in dichloromethane (80 mL) was added 1,1'-carbonyl diimidazole (6.55 g, 40.4 mmol, 1.2 equiv). The resulting mixture was stirred for 30 min, then *N*,*O*-dimethylhydroxylamine hydrochloride (3.94 g, 40.4 mmol, 1.2 equiv). The mixture was allowed to stir at rt for 16 h. The reaction mixture was then quenched with a solution of 1N aqueous HCl and stirred vigorously for 10 min. The solution was separated and the aqueous layer was extracted with dichloromethane. The combined organic extracts were washed with a solution of 1N aqueous HCl, washed with brine, dried over anhydrous MgSO₄, filtered and concentrated *in vacuo*. The crude mixture was then purified by flash chromatography on silica gel (petroleum ether/diethyl ether: 95/5) to afford the title Weinreb amide (**10**) (5.13 g, 90%) as a colorless oil.

¹**H NMR** (500MHz, *CDCl*₃) ´ ppm: 3.76 (s, 3H), 3.23 (s, 3H), 1.84 (s, 3H), 1.44 (s, 6H).

¹³C NMR (126 MHz, *CDCl₃*) [′] ppm: 174.0, 82.9, 76.5, 60.5, 37.1, 33.8, 27.3, 3.7.

IR (¹/₂ cm⁻¹): 2983, 2935, 2869, 2242, 1659, 1455, 1408, 1382, 1356, 1254, 1169, 1115, 1085, 1021, 999.

HRMS (CI, ISO) Calcd for $[C_9H_{16}NO_2]^+$: *m*/z 170.1181, found 170.1186.

2,6,6-trimethylnon-2-en-7-yn-5-one (11)

Formula: C₁₂H₁₈O

MW: 178.3

To a suspension of magnesium turnings (1.95 g, 80.9 mmol, 10 equiv) in THF (20 mL) was added a catalytic amount of 1,2-dibromoethane, followed by prenyl chloride (1.10 mL, 9.31 mmol, 1.1 equiv) dropwise. The resulting suspension was stirred for 15 min. Then the freshly made Grignard reagent was added *via cannula* to a solution of Weinreb amide (**10**) (1.37 g, 8.1 mmol) in THF (20 mL). The resulting mixture was allowed to stir at rt for 1 h. The reaction was quenched with brine. The aqueous layer was extracted with Et_2O , and the combined organic extracts were washed with brine, dried over anhydrous MgSO₄, filtered and concentrated *in*

vacuo. The crude mixture was then purified by flash chromatography on silica gel (petroleum ether/diethyl ether: 99/1) to afford (**11**) (1.37 g, 7.7 mmol, 95%) as a colorless oil.

¹**H NMR** (400MHz, *CDCl*₃) δ ppm: 5.32 (m, 1H), 3.48 (d, *J* = 5.6 Hz, 2H), 1.83 (s, 3H), 1.74 (s, 3H), 1.63 (s, 3H), 1.32 (s, 6H).

¹³**C NMR** (100 MHz, *CDCl₃*) [′] ppm: 209.2, 134.9, 116.7, 82.3, 78.9, 43.6, 37.3, 26.4, 25.7, 18.1, 3.6.

IR (¹/₂ cm⁻¹): 2981, 2923, 1716, 1450, 1380, 1264, 1113, 1080, 1040.

HRMS (CI, ISO) Calcd. for [C₁₂H₁₉O]: 179.1436, found: 179.1433.





Formula: C₁₆H₂₇NOSi

MW: 277.48

To a solution of ketone (**11**) (1.25 g, 6.95 mmol) in 100 mL of CH_2Cl_2 was added ZnI_2 (443 mg, 1.39 mmol, 0.2 equiv) and TMSCN (2.8 mL, 21 mmol, 3.0 equiv). The reaction mixture was refluxed for 2 h and the solvent was removed *in vacuo*. A trap of aqueous NaOCl/NaOH was set up to quench the excess of TMSCN. The crude mixture was purified by flash chromatography (petroleum ether/Et₂O: 99/1) to afford the title compound (±**11a**) (1.83 g, 6.59 mmol, 95%) as a colorless oil.

¹**H NMR** (400MHz, *CDCl₃*) δ ppm: 5.34 (ddq, *J* = 8.1, 6.9, 1.2 Hz, 1H), 2.73 (ddt, *J* = 14.5, 6.9, 0.8 Hz, 1H), 2.52 (dd, *J* = 14.5, 8.1 Hz, 1H), 1.82 (s, 3H), 1.79 (d, *J* = 1.2 Hz, 3H), 1.67 (s, 3H), 1.35 (s, 3H), 1.25 (s, 3H), 0.22 (s, 9H).

¹³C NMR (126 MHz, *CDCl₃*) ′ ppm: 136.2, 120.2, 118.7, 82.5, 79.5, 79.2, 40.7, 36.0, 26.0, 26.0, 23.5, 18.1, 3.6, 1.5.

IR (¹/₂ cm⁻¹): 2978, 2922, 2876, 2240, 1674, 1447, 1382, 1363, 1252, 1126, 1112, 1070.

HRMS (EI) Calcd for $[C_{16}H_{27}NOSi]^+$: *m*/z 277.1862, found 277.1863.



Formula: C₁₆H₂₈O₂Si

MW: 280.48

To a solution of nitrile ($\pm 11a$) (0.50 g, 1.8 mmol) in freshly distilled hexane (50 mL) was added DIBALH (3.1 mL, 1 M in hexane, 3.1 mmol, 1.7 equiv). The reaction mixture was allowed to warm to 0°C and was stirred at this temperature for 20 min. The mixture was then cooled down to -78°C, and EtOAc was added. After stirring for 10 min, SiO₂ (1.5 g) was added. The mixture was then allowed to warm to room temperature overnight. Saturated aqueous NH₄Cl was added, the aqueous layer was extracted with Et₂O, and the combined organic extracts were washed with brine, dried over anhydrous MgSO₄, filtered and concentrated *in vacuo*. The crude mixture was purified by flash chromatography (*n*Pentane/CH₂Cl₂: 9/1) to afford the title aldehyde (± 12) (0.40 g, 1.6 mmol, 87%) as a colorless oil.

¹**H NMR** (500MHz, *CDCl*₃) δ ppm: 9.83 (s, 1H), 5.01 (ddq, J = 7.8, 7.4, 1.2 Hz, 1H), 2.93 (ddq, J = 14.7, 7.4, 0.8 Hz, 1H), 2.46 (dd, J = 14.7, 7.8 Hz, 1H), 1.82 (s, 3H), 1.69 (d, J = 1.2 Hz, 3H), 1.63 (s, 3H), 1.24 (s, 3H), 1.08 (s, 3H), 0.13 (s, 9H).

¹³**C NMR** (126 MHz, *CDCl*₃) δ ppm: 204.3, 134.6, 118.9, 87.3, 84.0, 78.8, 37.4, 32.1, 25.9, 25.7, 24.5, 17.8, 3.6, 2.7.

IR (¹/₂ cm⁻¹): 2960, 2921, 2857, 2725, 2253, 1734, 1451, 1380, 1280, 1249, 1211, 1152, 1115, 1049, 1021.

HRMS (ESI) Calcd for [C₁₆H₂₈O₂SiNa]⁺: *m*/z 303.1751, found 303.1741.

<u>1-((*R**)-6-Methyl-6-(3-(trityloxy)propyl)cyclohex-1-enyl)-2-(2-methylpent-3-yn-2-yl)hex-4-</u> ene-1,2-diol (18a) and (18b)





MW: 590.8

To a solution of hydrazone (±13) (1.0 g, 1.5 mmol, 1.5 equiv) in THF (8 mL) at -78°C was added dropwise *t*BuLi (2.4 mL, 1.4 M in pentane, 3.3 mmol, 3.3 equiv). The solution turned dark red. The solution was stirred at this temperature for 30 min and warmed for a few min to room temperature and intense nitrogen bubbling appeared. The mixture was then cooled down to -78°C and a solution of aldehyde (±10) (0.26 g, 1.0 mmol) in THF (2 mL) was then added. The resulting mixture was stirred at -78°C for 5 h and became yellow. The reaction was quenched with saturated aqueous NaHCO₃. The aqueous layer was extracted with Et₂O, and the combined organic extracts were washed with brine, dried over anhydrous MgSO₄, filtered and concentrated *in vacuo*. The crude mixture was dissolved in THF (10 mL) and a 1N aqueous solution of hydrochloric acid (1.5 mL, 1.5 mmol, 1.5 equiv) was then added. The resulting mixture was extracted with Et₂O, and the combined organic extracts were washed with brine, dried organic extracts were washed with brine, dried over anhydrous MgSO₄, filtered and concentrated *in vacuo*. The resulting mixture was quenched with saturated aqueous NaHCO₃. The aqueous layer was then added. The resulting mixture was stirred at rt overnight. The reaction was quenched with saturated aqueous NaHCO₃. The aqueous layer was extracted with Et₂O, and the combined organic extracts were washed with brine, dried over anhydrous MgSO₄, filtered and concentrated *in vacuo*. The crude mixture was then purified over anhydrous MgSO₄, filtered and concentrated *in vacuo*. The crude mixture was then purified by flash chromatography on silica gel (diethyl ether/petroleum ether: 5/95) to afford (14a) (0.25 g, 43%, *E*/*Z* = 3:1) and (14b) (0.23 g, 40%, *E*/*Z* = 3:1), both as a white solids.

(1R*,2R*,E)-1-((S*)-6-methyl-6-(3-(trityloxy)propyl)cyclohex-1-enyl)-2-(2-methylpent-3-yn-2-yl)hex-4-ene-1,2-diol (14a)



¹**H NMR** (500MHz, *CDCl₃*) δ ppm: 7.49 (m, 6H), 7.32 (t, J = 7.7 Hz, 6H), 7.25 (m, 3H), 6.16 (t, J = 3.9 Hz, 1H), 5.65 (ddd, J = 14.1, 7.0, 3.5 Hz, 1H), 5.37 (m, 1H), 4.47 (d, J = 2.8 Hz, 1H), 3.34 (s, 1H), 3.10 (m, 2H), 2.89 (d, J = 3.9 Hz, 1H), 2.46 (d, J = 7.0 Hz, 2H), 2.06 (dd, J = 10.0, 5.8 Hz, 2H), 1.73 (d, J = 6.4 Hz, 3H), 1.71 (d, J = 6.4 Hz, 3H), 1.47-1.63 (m, 8H), 1.32 (s, 6H), 1.04 (s, 3H).

¹³**C NMR** (126 MHz, *CDCl*₃) δ ppm: 146.0, 144.6, 128.7, 128.3, 128.0, 127.8, 126.9, 126.2, 86.8, 86.5, 78.4, 77.8, 69.9, 64.6, 42.1, 37.8, 37.1, 36.5, 35.1, 26.1, 26.0, 25.8, 25.7, 24.6, 18.9, 18.3, 3.7.

IR (¹/₂ cm⁻¹): 3610, 3506, 3062, 3034, 2935, 2872, 1598, 1555, 1491, 1449, 1384, 1358, 1223, 1182, 1153, 1086, 1071, 1034, 972, 909.

HRMS (EI) Calcd. for [C₄₁H₅₀O₃]: 590.3760, found: 590.3753.

(1R*,2R*,E)-1-((R*)-6-methyl-6-(3-(trityloxy)propyl)cyclohex-1-enyl)-2-(2-methylpent-3yn-2-yl)hex-4-ene-1,2-diol (14b)



¹**H NMR** (500MHz, *CDCl*₃) δ ppm: 7.45 (d, *J* = 7.9 Hz, 5H), 7.27 (m, 10H), 6.15 (t, *J* = 3.9 Hz, 1H), 5.60 (m, 1H), 5.30 (m, 1H), 4.44 (s, 1H), 3.24 (s, 1H), 3.06 (t, *J* = 6.4 Hz, 2H), 2.79 (s, 1H),

2.41 (d, *J* = 6.6 Hz, 2H), 2.05 (dd, *J* = 9.9, 5.7 Hz, 2H), 1.65 (d, *J* = 7.5 Hz, 3H), 1.64 (s, 3H), 1.38-1.61 (m, 8H), 1.28 (s, 3H), 1.23 (s, 3H), 1.13 (s, 3H).

¹³**C NMR** (126 MHz, *CDCl*₃) δ ppm: 147.0, 144.5, 128.8, 128.7, 128.5, 127.8, 126.9, 126.5, 86.6, 86.4, 78.4, 77.8, 70.4, 64.4, 42.1, 37.8, 36.7, 35.6, 35.0, 26.2, 26.1, 25.9, 25.0, 24.5, 18.8, 18.3, 3.7.

IR (¹/₂ cm⁻¹): 3610, 3512, 3062, 2933, 2857, 2736, 1955, 1899, 1819, 1598, 1491, 1449, 1384, 1358, 1222, 1182, 1153, 1073, 1034, 971.

HRMS (EI) Calcd. for [C₄₁H₅₀O₃]: 590.3760, found: 590.3752.

<u>4-(But-2-enyl)-5-((S*)-6-methyl-6-(3-(trityloxy)propyl)cyclohex-1-enyl)-4-(2-methylpent-3-yn-2-yl)-1,3-dioxolan-2-one</u>



Formula: C₄₂H₄₈O₄

MW: 616.8

To a solution of diol (14a) (0.45 g, 0.68 mmol) in DMF (15 mL) was added sodium hydride (68 mg, 60% in mineral oil, 1.7 mmol, 2.5 equiv) and carbonyl diimidazole (0.55 g, 3.4 mmol, 5.0 equiv). The mixture was stirred at rt for 15 min. The reaction was quenched with saturated aqueous NH₄Cl. The aqueous layer was extracted with Et₂O, and the combined organic extracts were washed with brine, dried over anhydrous MgSO₄, filtered and concentrated *in vacuo*. The crude mixture was then purified by flash chromatography on silica gel (diethyl ether/ petroleum ether: 10/90) to afford the title protected diol (14aa) (0.40 g, 95%, E/Z = 3:1) as a white solid.

The same procedure repeated with (14b) (0.12 g, 0.20 mmol) afforded the desired title protected diol (14ba) (0.09 g, 73%, E/Z = 3:1) as a white solid.

<u>(4*R**,5*R**)-4-((*E*)-but-2-enyl)-5-((*S**)-6-methyl-6-(3-(trityloxy)propyl)cyclohex-1-enyl)-4-(2methylpent-3-yn-2-yl)-1,3-dioxolan-2-one (14aa)</u>



¹**H NMR** (500MHz, *CDCl*₃) δ ppm: 7.48 (m, 6H), 7.32 (t, *J* = 7.4 Hz, 6H), 7.25 (t, *J* = 7.3 Hz, 3H), 5.82 (t, *J* = 3.9 Hz, 1H), 5.53 (dtd, *J* = 7.9, 6.8, 1.4 Hz, 1H), 5.41 (m, 1H), 5.30 (s, 1H), 3.11 (dt, *J* = 8.8, 5.9 Hz, 1H), 3.03 (m, 1H), 2.80 (dd, *J* = 15.5, 6.5 Hz, 1H), 2.68 (dd, *J* = 15.6, 6.9 Hz, 1H), 2.12 (dd, *J* = 10.1, 5.4 Hz, 2H), 1.84 (m, 1H), 1.72 (s, 3H), 1.68 (dd, *J* = 6.9, 1.1 Hz, 3H), 1.56-1.69 (m, 7H), 1.36 (s, 3H), 1.30 (s, 3H), 1.10 (s, 3H).

¹³**C NMR** (126 MHz, *CDCl*₃) δ ppm: 155.4, 144.5, 139.0, 132.7, 128.7, 127.8, 127.6, 126.9, 126.1, 89.4, 86.4, 83.1, 80.0, 79.7, 64.1, 41.8, 36.9, 36.8, 35.4, 35.2, 26.2, 25.9, 24.9, 24.7, 24.3, 18.6, 18.2, 3.8.

IR (¹/₂ cm⁻¹): 3061, 3035, 2937, 2871, 1805, 1598, 1491, 1449, 1388, 1346, 1321, 1262, 1190, 1069, 1048, 970.

HRMS (EI) Calcd. for [C₄₂H₄₈O₄]: 616.3553, found: 616.3554.



¹**H NMR** (500MHz, *CDCl*₃) δ ppm: 7.46 (d, *J* = 7.2 Hz, 6H), 7.31 (t, *J* = 7.4 Hz, 6H), 7.25 (t, *J* = 7.2 Hz, 3H), 5.76 (t, *J* = 3.9 Hz, 1H), 5.45-5.54 (m, 1H), 5.37 (dd, *J* = 13.9, 7.6 Hz, 1H), 5.28 (s, 1H), 3.06 (m, 2H), 2.76 (dd, *J* = 15.6, 6.6 Hz, 1H), 2.61 (dd, *J* = 15.6, 6.0 Hz, 1H), 2.13 (dd, *J* = 10.0, 6.0 Hz, 2H), 1.36-1.74 (m, 8H), 1.63 (d, J = 6.2 Hz, 3H), 1.55 (s, 3H), 1.30 (s, 6H), 1.14 (s, 3H).

¹³**C NMR** (126 MHz, *CDCl*₃) δ ppm: 155.3, 144.3, 140.9, 131.3, 128.7, 128.7, 127.8, 127.0, 125.8, 89.3, 86.5, 82.8, 80.7, 79.5, 64.3, 41.7, 36.5, 35.5, 35.1, 34.6, 25.8, 25.0, 24.9, 24.8, 24.4, 18.3, 18.2, 3.6.

IR (¹/₂ cm⁻¹): 3062, 2938, 2873, 1806, 1598, 1491, 1449, 1388, 1379, 1321, 1263, 1190, 1070, 1047, 971, 908.

HRMS (EI) Calcd. for [C₄₂H₄₈O₄]: 616.3553 , found: 616.3546.

<u>4-(But-2-enyl)-5-((S*)-6-(3-hydroxypropyl)-6-methylcyclohex-1-enyl)-4-(2-methylpent-3-yn-2-yl)-1,3-dioxolan-2-one</u>



Formula: C₂₃H₃₄O₄

MW: 374.5

To a solution of protected alcohol (**14aa**) (0.40 g, 0.65 mmol) in MeOH (20 mL) was added Amberlyst H-15 (0.2 g). The mixture was stirred at rt for 2 days. The resin was filtered off and the solvents were removed *in vacuo*. The crude mixture was then purified by flash chromatography on silica gel (diethyl ether/ petroleum ether: 20/80 to 50/50) to afford the primary **alcohol** (**14ab**) (0.22 g, 90%, E/Z = 3:1) as a colorless viscous oil.

The same procedure repeated with the *Taxol like* protected alcohol (**14ba**) (90 mg, 0.15 mmol) afforded the desired *Taxol like* alcohol the primary alcohol (**14bb**) (51 mg, 91%, E/Z = 3:1) as a colorless viscous oil.



¹**H NMR** (500MHz, *CDCl*₃) δ ppm: 5.80 (t, *J* = 4.0 Hz, 1H), 5.49 (dtd, *J* = 7.9, 6.7, 1.3 Hz, 1H), 5.38 (m, 1H), 5.22 (s, 1H), 3.64 (m, 2H), 2.75 (m, 1H), 2.65 (m, 1H), 2.10 (dd, *J* = 9.7, 5.3 Hz, 2H), 1.76 (s, 3H), 1.65 (dd, J = 6.2, 1.2 Hz, 3H), 1.36-1.70 (m, 8H), 1.32 (s, 3H), 1.29 (s, 3H), 1.08 (s, 3H).

¹³C NMR (126 MHz, *CDCl₃*) δ ppm: 155.4, 139.0, 132.9, 127.7, 125.9, 89.4, 83.0, 79.8, 79.7, 63.3, 41.7, 36.9, 36.2, 35.5, 35.2, 26.0, 25.8, 24.8, 24.8, 24.6, 18.6, 18.2, 3.7.

IR (¹/₂ cm⁻¹): 3620, 2958, 2931, 1807, 1558, 1463, 1380, 1263, 1188, 1117.

HRMS (EI) Calcd. for [C₂₃H₃₄O₄]: 374.2457, found: 374.2461.



¹**H NMR** (500MHz, *CDCl*₃) δ ppm: 6.10 (t, *J* = 4.1 Hz, 1H), 5.51 (m, 1H), 5.40 (m, 1H), 5.29 (s, 1H), 3.62 (dt, *J* = 6.6, 1.9 Hz, 2H), 2.75 (ddt, *J* = 15.6, 6.4, 1.3 Hz, 1H), 2.61 (dd, *J* = 15.6, 7.0

Hz, 1H), 2.12 (dd, *J* = 10.2, 6.1 Hz, 1H), 1.81 (s, 3H), 1.66 (dd, *J* = 6.1, 1.2 Hz, 3H), 1.38-1.61 (m, 8H), 1.32 (s, 3H), 1.30 (s, 3H), 1.13 (s, 3H).

¹³C NMR (126 MHz, *CDCl₃*) δ ppm: 155.4, 140.9, 131.3, 128.0, 125.9, 89.5, 82.8, 81.2, 79.6, 63.6, 41.9, 36.5, 35.6, 35.0, 34.9, 27.2, 25.8, 25.0, 24.9, 18.4, 18.2, 3.7.

IR (¹/₂ cm⁻¹): 3638, 2937, 2874, 1806, 1462, 1388, 1379, 1321, 1255, 1189, 1111, 1047, 971.

HRMS (EI) Calcd. for [C₂₃H₃₄O₄]: 374.2457, found: 374.2457.

5-((S*)-6-Allyl-6-methylcyclohex-1-enyl)-4-(but-2-enyl)-4-(2-methylpent-3-yn-2-yl)-1,3dioxolan-2-one (15a) and (15b)



Formula: C₂₃H₃₂O₃

MW: 356.5

To a solution of primary alcohol (**14ab**) (75 mg, 0.20 mmol) in THF (3 mL) was added *o*nitrophenylselenocyanate (110 mg, 0.49 mmol, 2.4 equiv) and tri-*n*-butylphosphine (120 μ L, 0.49 mmol, 2.4 equiv). The mixture was stirred at rt for 20 min. The reaction was quenched with water. The aqueous layer was extracted with Et₂O, and the combined organic extracts were washed with brine, dried over anhydrous MgSO₄, filtered and concentrated *in vacuo* to give a brown oil that was used without further purification. A solution of ammonium molybdate (86 mg) in water (6 mL) and aqueous hydrogen peroxide (3 mL) was then prepared. This solution (1.7 mL) was added at -10°C to a solution of the previous compound in THF (2 mL). The mixture was stirred at this temperature for 20 min. The reaction was quenched with water. The aqueous layer was extracted with Et₂O, and the combined organic extracts were washed with brine, dried over anhydrous MgSO₄, filtered and concentrated *in vacuo*. The crude mixture was then purified by flash chromatography on silica gel (diethyl ether/ petroleum ether: 5/95) to afford (**15a**) (60 mg, 84%, *E/Z* = 3:1) as a pale yellow viscous oil. The same procedure repeated with *Taxol like* primary alcohol (**14bb**) (33 mg, 88 μ mol) afforded the desired *Taxol like* triene (**15b**) (27 mg, 86%, E/Z = 3:1) as a pale yellow viscous oil.

$\underbrace{(4R^*,5R^*)-5-((S^*)-6-allyl-6-methylcyclohex-1-enyl)-4-((E)-but-2-enyl)-4-(2-methylpent-3-yn-2-yl)-1,3-dioxolan-2-one (15a)}_{yn-2-yl)-1,3-dioxolan-2-one (15a)}$



¹**H NMR** (500MHz, *CDCl₃*) δ ppm: 5.79 (m, 2H), 5.50 (dtd, J = 14.9, 6.8, 1.3 Hz, 1H), 5.37 (m, 1H), 5.27 (s, 1H), 5.08 (m, 2H), 2.76 (dd, J = 15.5, 6.5 Hz, 1H), 2.66 (dd, J = 15.6, 6.9 Hz, 1H), 2.38 (dd, J = 14.2, 6.7 Hz, 1H), 2.15 (dd, J = 12.5, 6.3 Hz, 1H), 2.10 (m, 2H), 1.77 (s, 3H), 1.65 (dd, J = 6.3, 1.1 Hz, 1H), 1.54-1.70 (m, 4H), 1.32 (s, 3H), 1.29 (s, 3H), 1.08 (s, 3H).

¹³**C NMR** (126 MHz, *CDCl*₃) δ ppm: 155.4, 139.1, 134.2, 132.7, 127.7, 126.0, 118.1, 89.4, 83.1, 80.0, 79.7, 44.9, 41.7, 36.9, 35.7, 35.5, 25.8, 25.4, 24.9, 24.7, 18.3, 18.2, 3.7.

IR (¹/₂ cm⁻¹): 3075, 2979, 2936, 2856, 1805, 1638, 1516, 1430, 1389, 1378, 1323, 1237, 1190, 1173, 1133, 1311, 1048, 971, 917.

HRMS (EI) Calcd. for [C₂₃H₃₂O₃]: 356.2352, found: 356.2352.

$\frac{(4R^*,5R^*)-5-((R^*)-6-allyl-6-methylcyclohex-1-enyl)-4-((E)-but-2-enyl)-4-(2-methylpent-3-yn-2-yl)-1,3-dioxolan-2-one (15b)}{yn-2-yl)-1,3-dioxolan-2-one (15b)}$



¹**H NMR** (500MHz, *CDCl₃*) δ ppm: 5.77 (m, 2H), 5.51 (m, 1H), 5.42 (m, 1H), 5.29 (s, 1H), 5.07 (m, 2H), 2.80 (m, 1H), 2.67 (dd, *J* = 15.6, 7.0 Hz, 1H), 2.31 (dd, *J* = 15.6, 6.7 Hz, 1H), 2.13 (m, 3H), 1.76 (s, 3H), 1.67 (dd, *J* = 6.2, 0.9 Hz, 1H), 1.61 (m, 4H), 1.33 (s, 3H), 1.30 (s, 3H), 1.13 (s, 3H).

¹³C NMR (126 MHz, *CDCl₃*) δ ppm: 155.3, 140.7, 134.4, 131.8, 128.0, 125.9, 118.0, 89.4, 83.1, 80.6, 79.9, 43.4, 41.7, 37.0, 35.7, 34.9, 25.8, 25.0, 24.7, 18.2, 18.2, 3.7.

IR (¹/₂ cm⁻¹): 3077, 2936, 2857, 1813, 1698, 1638, 1591, 1522, 1462, 1389, 1378, 1347, 1330, 1255, 1189, 1146, 1111, 1046, 997, 971, 917.

HRMS (EI) Calcd. for C₂₃H₃₂O₃: 356.2352, found: 356.2366.

5-Methyl-1-((S)-6-methyl-6-(3-(trityloxy)propyl)cyclohex-1-enyl)-2-(2-methylpent-3-yn-2yl)hex-4-ene-1,2-diol (16a) and (16b)



Formula: C₄₂H₅₂O₃

MW: 604.9

To a solution of hydrazone (13) (2.02 g, 1.80 mmol, 1.5 equiv) in THF (15 mL) at -78°C was added dropwise *t*BuLi (4.6 mL, 1.4 M in hexane, 6.4 mmol, 3.3 equiv). The solution turned black red. The solution was stirred at this temperature for 30 min and warmed for a few min to room temperature and intense nitrogen bubbling appeared. The mixture was then cooled down to -78° C and a solution of aldehyde (±12) (545 mg, 1.94 mmol) in THF (5 mL) was then added. The resulting mixture was stirred at -78°C for 5 h and became yellow. The reaction was quenched with saturated aqueous NaHCO₃. The aqueous layer was extracted with Et₂O, and the combined organic extracts were washed with brine, dried over anhydrous MgSO₄, filtered and concentrated *in vacuo*. The crude mixture was dissolved in THF (10 mL) and a 1 N aqueous solution of HCl (2.9 mL, 2.9 mmol, 1.5 equiv) was then added. The resulting mixture was stirred at room temperature overnight. The reaction was quenched with saturated aqueous NaHCO₃. The aqueous layer was extracted approximately at room temperature was dissolved in THF (10 mL) and a 1 N aqueous solution of HCl (2.9 mL, 2.9 mmol, 1.5 equiv) was then added. The resulting mixture was stirred at room temperature overnight. The reaction was quenched with saturated aqueous NaHCO₃. The aqueous layer was extracted with Et₂O, and the combined organic extracts were washed with brine, dried organic extracts were washed with saturated aqueous NaHCO₃. The aqueous layer was extracted with Et₂O, and the combined organic extracts were washed with extracts were washed with saturated aqueous NaHCO₃. The aqueous layer was extracted with Et₂O, and the combined organic extracts were washed with saturated aqueous NaHCO₃. The aqueous layer was extracted with Et₂O, and the combined organic extracts were washed with

brine, dried over anhydrous MgSO₄, filtered and concentrated *in vacuo*. The crude mixture was then purified by flash chromatography (petroleum ether/Et₂O: 95/5) to afford the title compound (**16a**) (440 mg, 0.73 mmol, 38%) and the title compound (**16b**) (440 mg, 0.73 mmol, 38%) as colorless highly viscous oils.

(1R,2R)-5-Methyl-1-((S)-6-methyl-6-(3-(trityloxy)propyl)cyclohex-1-enyl)-2-(2-methylpent-3-yn-2-yl)hex-4-ene-1,2-diol (16a)



¹**H NMR** (500MHz, *CDCl*₃) δ ppm: 7.47 (dd, J = 8.3, 1.1 Hz, 6H), 7.34-7.28 (m, 6H), 7.26-7.21 (m, 3H), 6.16 (t, J = 4.0 Hz, 1H), 5.43 (ddq, J = 8.2, 6.8, 1.6 Hz, 1H), 4.48 (d, J = 4.5 Hz, 1H), 3.32 (s, 1H), 3.15-3.02 (m, 2H), 2.81 (d, J = 4.5 Hz, 1H), 2.42 (m, 2H), 2.08-2.01 (m, 2H), 1.74–1.71 (m, 1H), 1.73 (s, 3H), 1.72 (s, 3H), 1.69-1.48 (m, 9H), 1.32-1.40 (m, 1H), 1.30 (s, 3H), 1.30 (s, 3H), 1.03 (s, 3H).

¹³C NMR (126 MHz, *CDCl₃*) δ ppm: 146.3, 144.5, 131.2, 128.7, 128.2, 127.7, 126.8, 121.6, 86.9, 86.4, 78.3, 78.3, 70.0, 64.5, 42.0, 37.1, 36.5, 35.2, 33.3, 26.3, 26.2, 26.0, 25.8, 25.7, 24.6, 18.8, 18.0, 3.6.

IR (¹/₂ cm⁻¹): 3500, 3482, 3090, 3063, 3029, 2957, 2936, 2873, 2250, 1682, 1652, 1490, 1448, 1381, 1226, 1092, 1070, 1037, 996.

HRMS (CI, ISO) Calcd for $[C_{42}H_{53}O_3]^+$: *m/z* 605.3995, found 605.3996.

 $[\pm]_{\mathbf{D}}^{25}$: +11.4 (*c* 0.9, CH₂Cl₂).

(15,25)-5-Methyl-1-((S)-6-methyl-6-(3-(trityloxy)propyl)cyclohex-1-enyl)-2-(2-methylpent-3-yn-2-yl)hex-4-ene-1,2-diol (16b)



¹**H NMR** (500MHz, *CDCl₃*) δ ppm: 7.44 (dd, J = 8.3, 1.1 Hz, 6H), 7.31-7.27 (m, 6H), 7.25-7.21 (m, 3H), 6.17 (t, J = 4.0 Hz, 1H), 5.38 (ddq, J = 8.3, 7.0, 1.4 Hz, 1H), 4.46 (d, J = 4.7 Hz, 1H), 3.22 (s, 1H), 3.08-3.03 (m, 2H), 2.72 (d, J = 4.7 Hz, 1H), 2.41 (dd, J = 15.8, 7.0 Hz, 1H), 2.35 (dd, J = 15.8, 7.0 Hz, 1H), 2.07-2.00 (m, 2H), 1.67 (d, J = 1.1 Hz, 3H), 1.64 (s, 3H), 1.64-1.50 (m, 6H), 1.49 (s, 3H), 1.44-1.37 (m, 2H), 1.27 (s, 3H), 1.26 (s, 3H), 1.13 (s, 3H).

¹³C NMR (126 MHz, *CDCl₃*) δ ppm: 147.4, 144.4, 131.2, 128.6, 127.7, 127.5, 126.8, 121.4, 86.7, 86.4, 78.3, 78.3, 70.5, 64.5, 42.0, 36.7, 35.6, 35.0, 33.5, 26.4, 26.3, 26.0, 25.9, 24.9, 24.5, 18.7, 18.0, 3.5.

IR (¹/₂ cm⁻¹): 3615, 3501, 3088, 3062, 3026, 2959, 2933, 2870, 2249, 1685, 1648, 1541, 1489, 1448, 1378, 1363, 1341, 1229, 1088, 1074, 1053, 992.

HRMS (EI) Calcd for $[C_{42}H_{52}O_3]^+$: *m/z* 604.3916, found 604.3919.

 $[\pm]_{\mathbf{D}}^{25}$: +2.5 (*c* 0.5, CH₂Cl₂).

5-((S)-6-Methyl-6-(3-(trityloxy)propyl)cyclohex-1-enyl)-4-(3-methylbut-2-enyl)-4-(2methylpent-3-yn-2-yl)-1,3-dioxolan-2-one



Formula: C₄₃H₅₀O₄

MW: 630.8

To a solution of (**16a**) (300 mg, 0.48 mmol) in DMF (15 mL) was added sodium hydride (70 mg, 60% in mineral oil, 1.8 mmol, 2.5 equiv) and carbonyl diimidazole (569 mg, 3.51 mmol, 5.0 equiv). The mixture was stirred at room temperature for 30 min. The reaction was quenched with saturated aqueous NH₄Cl. The aqueous layer was extracted with Et₂O, and the combined organic extracts were washed with brine, dried over anhydrous MgSO₄, filtered and concentrated *in vacuo*. The crude mixture was then purified by flash chromatography (petroleum ether/Et₂O: 9/1) to afford the title compound (**16aa**) (284 mg, 0.45 mmol, 93%) as a colorless highly viscous oil.

The same procedure was repeated with (16b) (425 mg, 0.70 mmol) to afford the title compound (16ba) (420 mg, 0.66 mmol, 95%) as a colorless highly viscous oil.

(4R,5R)-5-((S)-6-Methyl-6-(3-(trityloxy)propyl)cyclohex-1-enyl)-4-(3-methylbut-2-enyl)-4-(2-methylpent-3-yn-2-yl)-1,3-dioxolan-2-one (16aa)



¹**H NMR** (500MHz, *CDCl₃*) δ ppm: 7.46 (dd, J = 8.3, 1.1 Hz, 6H), 7.33-7.29 (m, 6H), 7.26-7.21 (m, 3H), 5.83 (t, J = 4.0 Hz, 1H), 5.34-5.28 (m, 2H), 3.11-3.03 (m, 2H), 2.74 (dd, J = 16.0, 6.3 Hz, 1H), 2.65 (dd, J = 16.0, 7.0 Hz, 1H), 2.10 (dt, J = 6.7, 4.6 Hz, 2H), 1.88-1.79 (m, 1H), 1.72 (s, 3H), 1.71 (d, J = 1.0 Hz, 3H), 1.68- 1.58 (m, 8H), 1.41-1.34 (m, 2H), 1.33 (s, 3H), 1.29 (s, 3H), 1.11 (s, 3H).

¹³**C NMR** (126 MHz, *CDCl*₃) δ ppm: 155.4, 144.5, 139.2, 132.5, 132.1, 128.7, 127.7, 126.8, 119.3, 89.9, 86.4, 83.3, 80.0, 79.6, 64.1, 41.8, 36.9, 36.7, 35.3, 31.1, 26.4, 25.9, 25.8, 24.9, 24.7, 24.3, 18.5, 18.0, 3.7.

IR (¹/₂ cm⁻¹): 3088, 3059, 3028, 2936, 2873, 2249, 1797, 1656, 1649, 1541, 1489, 1448, 1389, 1330, 1211, 1181, 1062, 1033.

HRMS (ESI) Calcd for $[C_{43}H_{50}O_4Na]^+$: *m/z* 653.3601, found 653.3575.

 $[\pm]_{\mathbf{D}}^{25}$: -3.6 (*c* 0.65, CH₂Cl₂).

(45,55)-5-((5)-6-Methyl-6-(3-(trityloxy)propyl)cyclohex-1-enyl)-4-(3-methylbut-2-enyl)-4-(2-methylpent-3-yn-2-yl)-1,3-dioxolan-2-one (16ba)



¹**H NMR** (500MHz, *CDCl₃*) δ ppm: 7.43 (dd, J = 8.4, 1.3 Hz, 6H), 7.32-7.27 (m, 6H), 7.25-7.21 (m, 3H), 5.76 (t, J = 4.0 Hz, 1H), 5.31-5.26 (m, 2H), 3.11-3.02 (m, 2H), 2.69 (ddq, J = 16.2, 6.3, 1.0 Hz, 1H), 2.58 (dd, J = 16.2, 7.0 Hz, 1H), 2.16-2.06 (m, 2H), 1.73-1.68 (m, 1H), 1.66 (d, J = 1.2 Hz, 3H), 1.63-1.58 (m, 4H), 1.57 (s, 3H), 1.51 (s, 3H), 1.49-1.45 (m, 2H), 1.43-1.38 (m, 1H), 1.29 (s, 3H), 1.28 (s, 3H), 1.13 (s, 3H).

¹³**C NMR** (126 MHz, *CDCl*₃) δ ppm: 155.2, 144.4, 141.3, 132.4, 131.1, 128.7, 127.7, 126.9, 119.1, 89.9, 86.6, 83.0, 80.8, 79.4, 64.4, 41.9, 36.6, 35.5, 34.9, 31.2, 26.0, 25.8, 25.0, 25.0, 24.8, 24.5, 18.3, 18.1, 3.5.

IR (¹/₂ cm⁻¹): 3089, 3063, 3026, 2940, 2873, 2254, 1790, 1652, 1597, 1541, 1489, 1448, 1382, 1333, 1211, 1185, 1066, 1037.

HRMS (ESI) Calcd for $[C_{43}H_{50}O_4Na]^+$: *m/z* 653.3601, found 653.3573.

 $[\pm]_{\mathbf{D}}^{25}$: +3.7 (*c* 0.65, CH₂Cl₂).

5-((S)-6-(3-Hydroxypropyl)-6-methylcyclohex-1-enyl)-4-(3-methylbut-2-enyl)-4-(2methylpent-3-yn-2-yl)-1,3-dioxolan-2-one



Formula: C₂₄H₃₆O₄

MW: 388.5

To a solution of protected diol (**16aa**) (391 mg, 0.62 mmol) in MeOH (20 mL) was added Amberlyst H-15 (0.15 g). The mixture was stirred at room temperature for 2 days. The resin was filtered off and the solvents were removed *in vacuo*. The crude mixture was then purified by flash chromatography (petroleum ether/Et₂O: 8/2 to 5/5) to afford the title primary alcohol (**16ab**) (214 mg, 0.55 mmol, 89%) as a colorless highly viscous oil.

The same procedure was repeated with *Taxol like* protected diol (**16ba**) (300 mg, 0.47 mmol) to afford the *Taxol like* primary alcohol (**16bb**) (167 mg, 0.43 mmol, 90%) as a colorless highly viscous oil.

(4R,5R)-5-((S)-6-(3-Hydroxypropyl)-6-methylcyclohex-1-enyl)-4-(3-methylbut-2-enyl)-4-(2methylpent-3-yn-2-yl)-1,3-dioxolan-2-one (16ab)



¹**H NMR** (500MHz, *CDCl*₃) δ ppm: 5.82 (t, *J* = 4.0 Hz, 1H), 5.29 (ddq, *J* = 7.7, 6.5, 1.5 Hz, 1H), 5.24 (s, 1H), 3.71-3.58 (m, 2H), 2.72 (ddt, *J* = 16.2, 6.5, 1.0 Hz, 1H), 2.64 (dd, *J* = 16.2, 7.7 Hz, 1H), 2.12-2.05 (m, 2H), 1.78 (s, 3H), 1.75-1.71 (m, 1H), 1.69 (d, J = 1.3 Hz, 3H), 1.67-1.63 (m, 1H), 1.69 (d, J = 1.3 Hz

2H), 1.60-1.53 (m, 5H), 1.53-1.42 (m, 2H), 1.39-1.33 (m, 2H), 1.30 (s, 3H), 1.30 (s, 3H), 1.10 (s, 3H).

¹³C NMR (126 MHz, *CDCl₃*) δ ppm: 155.2, 139.3, 132.6, 132.1, 119.2, 90.0, 83.3, 79.9, 79.5, 63.3, 41.8, 36.9, 36.3, 35.5, 31.2, 27.2, 26.2, 25.9, 25.7, 24.9, 24.7, 18.4, 18.0, 3.5.

IR (¹/₂ cm⁻¹): 3486, 3055, 2937, 2873, 2254, 1789, 1652, 1541, 1460, 1389, 1378, 1337, 1255, 1189, 1048.

HRMS (CI, ISO) Calcd for $[C_{24}H_{37}O_4]^+$: m/z 689.2692, found 389.2689.

 $[\pm]_{\mathbf{p}}^{25}$: +16.5 (*c* 1.6, CH₂Cl₂).

(4S,5S)-5-((S)-6-(3-Hydroxypropyl)-6-methylcyclohex-1-enyl)-4-(3-methylbut-2-enyl)-4-(2methylpent-3-yn-2-yl)-1,3-dioxolan-2-one (16bb)



¹**H NMR** (500MHz, *CDCl*₃) δ ppm: 5.77 (t, J = 4.0 Hz, 1H), 5.32-5.29 (m, 2H), 3.62 (t, J = 6.1 Hz, 2H), 2.70 (ddt, J = 16.2, 6.3, 1.0 Hz, 1H), 2.62 (dd, J = 16.2, 7.1 Hz, 1H), 2.15-2.06 (m, 2H), 1.81 (s, 3H), 1.69 (d, J = 1.0 Hz, 3H), 1.68-1.64 (m, 1H), 1.60-1.54 (m, 6H), 1.54-1.46 (m, 3H), 1.45-1.35 (m, 2H), 1.31 (s, 3H), 1.30 (s, 3H), 1.13 (s, 3H).

¹³C NMR (126 MHz, *CDCl₃*) δ ppm: 155.2, 140.9, 132.4, 131.0, 119.1, 90.0, 83.0, 81.0, 79.4, 63.5, 41.8, 36.4, 35.0, 34.8, 31.2, 27.1, 25.9, 25.8, 24.9, 24.9, 24.8, 18.2, 18.0, 3.6.

IR (¹/₂ cm⁻¹): 3508, 3059, 2936, 2877, 2254, 1782, 1649, 1541, 1460, 1389, 1378, 1333, 1207, 1189, 1059, 1037.

HRMS (EI) Calcd for $[C_{24}H_{36}O_4]^+$: *m*/*z* 388.2614, found 388.2608.

 $[\pm]_{\mathbf{p}}^{25}$: -10.6 (*c* 2.1, CH₂Cl₂).

5-((S)-6-Allyl-6-methylcyclohex-1-enyl)-4-(3-methylbut-2-enyl)-4-(2-methylpent-3-yn-2-yl)-1,3-dioxolan-2-one (17a) and (17b)



Formula: C₂₄H₃₄O₃

MW: 370.5

To a solution of primary alcohol (**16ab**) (75 mg, 0.2 mmol) in THF (7 mL) was added *o*nitrophenylselenocyanate (106 mg, 0.47 mmol 2.4 equiv) and tri-*n*-butylphosphine (117 μ L, 0.47 mmol 2.4 equiv). The mixture was stirred at room temperature for 20 min. The reaction was quenched with water. The aqueous layer was extracted with Et₂O and the combined organic extracts were washed with brine, dried over MgSO₄, filtered and concentrated *in vacuo* to give a brown oil that was used without further purification. A solution of ammonium molybdate (86 mg) in water (6 mL) and hydrogen peroxide (3 mL, 30% solution) was then prepared. This solution (1.7 mL) was added at -10°C to a solution of the previous compound in THF (3 mL). The mixture was stirred at this temperature for 20 min. The reaction was quenched with water. The aqueous layer was extracted with Et₂O, and the combined organic extracts were washed with brine, dried over anhydrous MgSO₄, filtered and concentrated *in vacuo*. The crude mixture was then purified by flash chromatography (petroleum ether/Et₂O: 95/5) to afford the title compound (**17a**) (69 mg, 0.19 mmol, 93%) as a pale yellow viscous oil.

The same procedure was repeated with *Taxol like* primary alcohol (**16bb**) (100 mg, 0.26 mmol) to afford (**17b**) (86 mg, 0.23 mmol, 89%) as a pale yellow viscous oil.

(4R,5R)-5-((S)-6-Allyl-6-methylcyclohex-1-enyl)-4-(3-methylbut-2-enyl)-4-(2-methylpent-3yn-2-yl)-1,3-dioxolan-2-one (17a)



¹**H NMR** (500MHz, *CDCl*₃) δ ppm: 5.82-5.71 (m, 2H), 5.31-5.25 (m, 2H), 5.11-5.03 (m, 2H), 2.70 (ddt, J = 16.1, 6.3, 1.0 Hz, 1H), 2.63 (dd, J = 16.1, 7.1 Hz, 1H), 2.39 (dd, J = 14.1, 6.6 Hz, 1H), 2.16-2.05 (m, 3H), 1.79 (s, 3H), 1.69 (d, J = 1.0 Hz, 3H), 1.67-1.61 (m, 2H), 1.61-1.55 (m, 1H), 1.59 (s, 3H), 1.37-1.33 (m, 1H), 1.31 (s, 3H), 1.31 (s, 3H), 1.10 (s, 3H).

¹³C NMR (126 MHz, *CDCl₃*) δ ppm: 155.3, 139.1, 134.1, 132.5, 132.1, 119.2, 117.9, 89.9, 83.2, 80.1, 79.5, 44.7, 41.7, 36.8, 35.6, 31.1, 25.8, 25.7, 25.5, 24.9, 24.7, 18.1, 18.0, 3.6.

IR (¹/₂ cm⁻¹): 3077, 2977, 2936, 2877, 2254, 1790, 1649, 1638, 1460, 1389, 1378, 1333, 1252, 1188, 1048.

HRMS (ESI) Calcd for $[C_{24}H_{34}O_3Na]^+$: *m/z* 393.2400, found 393.2385.

 $[\pm]_{\mathbf{p}}^{\mathbf{26}}$: +17.6 (*c* 1.4, CH₂Cl₂).

(4S,5S)-5-((S)-6-Allyl-6-methylcyclohex-1-enyl)-4-(3-methylbut-2-enyl)-4-(2-methylpent-3yn-2-yl)-1,3-dioxolan-2-one (17b)



¹**H NMR** (500MHz, *CDCl₃*) δ ppm: 5.83-5.73 (m, 2H), 5.35-5.29 (m, 2H), 5.11-5.01 (m, 2H), 2.74 (ddt, *J* = 16.1, 6.2, 1.4 Hz, 1H), 2.67 (dd, *J* = 16.1, 7.1 Hz, 1H), 2.34 (dd, *J* = 13.5, 6.8 Hz, 1H), 2.18-2.08 (m, 3H), 1.77 (s, 3H), 1.70 (d, *J* = 1.2 Hz, 3H), 1.68-1.62 (m, 1H), 1.62-1.56 (m, 2H), 1.60 (s, 3H), 1.37 (ddd, *J* = 12.5, 8.8, 3.5 Hz, 1H), 1.31 (s, 3H), 1.31 (s, 3H), 1.14 (s, 3H).

¹³C NMR (126 MHz, *CDCl₃*) δ ppm: 155.2, 140.7, 134.3, 132.4, 131.6, 119.1, 117.9, 89.8, 83.1, 80.5, 79.4, 43.5, 41.7, 36.9, 34.8, 31.2, 25.9, 25.8, 24.9, 24.9, 24.6, 18.1, 18.0, 3.5.

IR (¹/₂ cm⁻¹): 3156, 3077, 2980, 2933, 2876, 2254, 1786, 1643, 1463, 1380, 1330, 1201, 1190, 1064, 1046.

HRMS (ESI) Calcd for $[C_{24}H_{34}O_3Na]^+$: *m/z* 393.2400, found 393.2389.

 $[\pm]_{\mathbf{D}}^{\mathbf{24}}$: -6.2 (*c* .1.35, CHCl₃).

<u>(Z)-(6-(1,1-Dimethyl-but-2-ynyl)-11-methyl-3,5-dioxa-tricyclo[9.4.0.0^{2,6}]pentadeca-1(15),8-</u> dien-4-one (18a) and (18b)



Formula: C₂₀H₂₆O₃

MW: 314.4

A solution of (15a) (18 mg, 51 μ mol) in toluene (5 mL) was thoroughly degassed (using the freeze-thaw pump technique) and second-generation Grubbs' catalyst (3.5 mg, 4.0 μ mol, 0.05 equiv) was added and the mixture was stirred at reflux for 6 h. At that time second-generation Grubbs' catalyst (3.5 mg, 4.0 μ mol, 0.05 equiv) was added and the mixture was stirred at reflux for 16 h. After cooling, the solvent was removed *in vacuo*. The crude mixture was then purified by flash chromatography (petroleum ether/Et₂O: 95/5) to afford the title compound (18a) (10 mg, 63%) as a white solid.

The same procedure repeated with (15b) (20 mg, 56 μ mol) afforded the triene (18b) (12 mg, 68%) as a colorless oil.

<u>(Z)-(2R,6R,11R)-6-(1,1-Dimethyl-but-2-ynyl)-11-methyl-3,5-dioxa-</u> tricyclo[9.4.0.0^{2,6}]pentadeca-1(15),8-dien-4-one (18a)



M.p.: 144°C.

¹**H NMR** (500MHz, *CDCl*₃) δ ppm: 5.95-5.87 (m, 2H), 5.68-5.61 (m, 1H), 5.57 (s, 1H), 2.56-2.45 (m, 3H), 2.25-2.16 (m, 1H), 2.11 (ddt, *J* = 18.9, 7.1, 3.9 Hz, 1H), 1.90 (dd, *J* = 13.7, 8.1 Hz,

1H), 1.79 (s, 3H), 1.76-1.65 (m, 2H), 1.64-1.58 (m, 1H), 1.57-1.50 (m, 1H), 1.38 (s, 3H), 1.25 (s, 3H), 1.19 (s, 3H).

¹³C NMR (126 MHz, *CDCl₃*) δ ppm: 154.0, 139.4, 135.3, 131.7, 125.6, 91.9, 90.0, 81.9, 79.5, 42.4, 42.0, 40.8, 39.3, 28.0, 27.2, 26.4, 24.9, 24.5, 17.7, 3.5.

IR (¹/₂ cm⁻¹): 3033, 2986, 2940, 2874, 2254, 1786, 1630, 1461, 1390, 1378, 1353, 1309, 1259, 1280, 1203, 1059.

HRMS (EI) Calcd for $[C_{20}H_{26}O_3]^+$: *m*/*z* 314.1882, found 314.1881.

 $[\pm]_{\mathbf{D}}^{25}$: +131 (*c* 0.46, CHCl₃).

<u>(Z)-(2R,6R,11S)-6-(1,1-Dimethyl-but-2-ynyl)-11-methyl-3,5-dioxa-</u> <u>tricyclo[9.4.0.0^{2,6}]pentadeca-1(15),8-dien-4-one (18b)</u>



M.p.: 80°C.

¹**H NMR** (500MHz, *CDCl*₃) δ ppm: 5.75 (m, 3H), 5.39 (brs, 1H), 2.62-2.48 (m, 3H), 2.29-2.21 (m, 2H), 1.92-1.81 (m, 2H), 1.74 (s, 3H), 1.65-1.72 (m, 1H), 1.58-1.54 (m, 2H), 1.40 (s, 3H), 1.34 (s, 3H), 1.11 (s, 3H).

¹³C NMR (126 MHz, *CDCl₃*) δ ppm: 155.1, 139.4, 129.6, 127.0, 126.5, 91.0, 83.3, 80.9, 80.7, 41.7, 40.0, 39.2, 39.2, 31.8, 25.7, 25.0, 24.9, 23.8, 17.3, 3.7.

IR (¹/₂ cm⁻¹): 3032, 2981, 2928, 2875, 2855, 2253, 1791, 1643, 1461, 1381, 1332, 1261, 1185, 1127, 1100, 1052, 1037.

HRMS (CI, ISO) Calcd for $[C_{20}H_{27}O_3]^+$: *m/z* 315.1960, found 315.1965.

 $[\pm]_{\mathbf{D}}^{25}$: +109 (*c* 0.74, CHCl₃).

<u>1-((S*)-6-Allyl-6-methylcyclohex-1-enyl)-2-hydroxy-2-(2-methyl-pent-3-yn-2-yl)hex-4-enyl</u> benzoate (19a) and (19b)



Formula: C₂₉H₃₈O₃

MW: 434.6

To a solution of triene (**15a**) (20 mg, 56 μ mol) in THF (3 mL) at -78°C was added phenyllithium (330 μ L, 1.5M in Et₂O, 0.5 mmol, 9.0 equiv). The mixture was stirred at this temperature for 3 h. Saturated aqueous NaHCO₃ was then added, and the aqueous phase was extracted with Et₂O. The combined organic extracts were washed with brine, dried over anhydrous MgSO₄, filtered and concentrated *in vacuo*. The crude mixture was then purified by flash chromatography on silica gel (diethyl ether/petroleum ether: 5/95) to afford (**19a**) (23 mg, 94%, E/Z = 3:1) as a pale yellow oil.

The same procedure repeated with (15b) (25 mg, 80 μ mol) afforded the benzoate (19b) (31 mg, 91%) as a colorless oil.

(1R*, 2R*)-1-((S*)-6-Allyl-6-methylcyclohex-1-enyl)-2-hydroxy-2-(2-methyl-pent-3-yn-2yl)hex-4-enyl benzoate (19a)



¹**H NMR** (500MHz, *CDCl*₃) δ ppm: 8.07 (d, *J* = 7.2 Hz, 2H), 7.54 (t, *J* = 7.2 Hz, 1H), 7.44 (t, *J* = 7.7 Hz, 2H), 6.53 (t, *J* = 3.9 Hz, 1H), 5.97 (s, 1H), 5.66 (m, 2H), 5.39 (dq, *J* = 12.9, 6.4 Hz, 1H),

4.95 (m, 2H), 2.49 (d, J = 6.7 Hz, 2H), 2.36 (m, 1H), 2.13 (m, 3H), 1.70 (dd, J = 6.3, 0.9 Hz, 3H), 1.47-1.65 (m, 4H), 1.35 (s, 3H), 1.27 (s, 3H), 1.25 (s, 3H), 1.12 (s, 3H).

¹³**C NMR** (126 MHz, *CDCl*₃) δ ppm: 165.0, 142.3, 135.3, 132.7, 131.5, 131.3, 130.0, 128.4, 127.9, 126.8, 117.1, 85.0, 78.8, 78.5, 72.5, 44.1, 42.1, 37.1, 36.3, 35.1, 27.5, 25.9, 25.4, 25.2, 18.3, 18.2, 3.4.

IR (¹/₂ cm⁻¹): 3550, 3074, 2934, 2755, 1761, 1719, 1669, 1637, 1450, 1384, 1315, 1268, 1200, 1176, 1113, 1069, 1026, 998, 973, 909.

HRMS (ESI) Calcd. for [C₂₉H₃₈O₃]: 434.2821, found: 434.2811.

(1R*, 2R*)-1-((R*)-6-Allyl-6-methylcyclohex-1-enyl)-2-hydroxy-2-(2-methyl-pent-3-yn-2yl)hex-4-enyl benzoate (19b)



¹**H NMR** (500MHz, *CDCl*₃) δ ppm: 8.07 (d, J = 7.4 Hz, 2H), 7.54 (t, J = 7.4 Hz, 1H), 7.44 (t, J = 7.6 Hz, 2H), 6.49 (t, J = 3.9 Hz, 2H), 5.97 (s, 1H), 5.78-5.89 (m, 1H), 5.60-5.68 (m, 1H), 5.40 (dq, J = 12.9, 6.3 Hz, 1H), 5.05 (m, 2H), 2.85 (s, 1H), 2.50 (t, J = 8.2 Hz, 2H), 2.42 (dd, J = 13.2, 6.8 Hz, 1H), 2.19 (dd, J = 13.2, 7.7 Hz, 1H), 2.11 (m, 2H), 1.70 (d, J = 6.3 Hz, 3H), 1.52-1.62 (m, 4H), 1.36 (s, 3H), 1.31 (s, 3H), 1.29 (s, 3H), 1.07 (s, 3H).

¹³**C NMR** (126 MHz, *CDCl*₃) δ ppm: 165.3, 142.6, 135.2, 132.8, 131.4, 131.3, 130.0, 128.4, 127.8, 127.0, 117.5, 85.1, 78.9, 78.5, 73.7, 44.2, 42.1, 37.0, 35.8, 32.0, 27.4, 26.0, 25.7, 25.4, 18.3, 18.2, 3.4.

IR (¹/₂ cm⁻¹): 3550, 2960, 2930, 2873, 1720, 1602, 1451, 1379, 1315, 1268, 1176, 1112, 1069, 1026.

HRMS (EI) Calcd. for [C₂₉H₃₈O₃]: 434.2821, found: 434.2816.

<u>6-Hydroxy-10a-methyl-6-(2-methylpent-3-yn-2yl)-1,2,3,5,6,7,10,10a-octahydrobenzo</u> [8]annulen-5-yl benzoate (20a) and (20b)



Formula: C₂₆H₃₂O₃

MW: 392.5

A solution of benzoate (**19a**) (16 mg, 39 μ mol) in toluene (15 mL) was thoroughly degassed (using the freeze-thaw pump technique) and second-generation Grubbs' catalyst (5 mg, 6 μ mol, 0.05 equiv) was added and the mixture was stirred at reflux for 6 h. At that time second-generation Grubbs' catalyst (5 mg, 6 μ mol, 0.05 equiv) was added and the mixture was stirred at reflux for 16 h. At that time second-generation Grubbs' catalyst (5 mg, 6 μ mol, 0.05 equiv) was added and the mixture was stirred at reflux for 16 h. After cooling, the solvent was removed *in vacuo*. The crude mixture was then purified by flash chromatography (petroleum ether/Et₂O: 95/5) to afford the title compound (**20a**) (12 mg, 78%) as a colorless oil.

The same procedure was repeated with (19b) (10 mg, 23 μ mol) to afford the title compound (20b) (6 mg, 83%) as a colorless oil.

(5R,6R,10aS)-6-Hydroxy-10a-methyl-6-(2-methylpent-3-yn-2yl)-1,2,3,5,6,7,10,10aoctahydrobenzo[8]annulen-5-yl benzoate (20a)



¹**H NMR** (500MHz, *CDCl₃*) δ ppm: 8.15 (dd, J = 8.2, 1.1 Hz, 2H), 7.61-7.56 (m, 1H), 7.50-7.46 (m, 2H), 6.19 (brs, 1H), 6.02 (brs, 1H), 5.79 (dt, J = 11.2, 8.1 Hz, 1H), 5.67-5.59 (m, 1H), 3.25 (dd, J = 13.4, 8.3 Hz, 1H), 2.81 (dd, J = 15.8, 7.9 Hz, 1H), 2.50 (s, 1H), 2.32 (dd, J = 15.8, 5.6 Hz, 1H), 2.21-2.14 (m, 1H), 2.04-1.96 (m, 1H), 1.83-1.74 (m, 3H), 1.71 (s, 3H), 1.64-1.60 (m, 1H), 1.34 (s, 3H), 1.34 (s, 3H), 1.30-1.28 (m, 1H), 1.03 (s, 3H).
¹³C NMR (126 MHz, *CDCl₃*) δ ppm: 165.8, 140.5, 133.1, 133.0, 130.6, 129.8, 129.7, 128.5, 127.0, 84.8, 83.0, 80.1, 79.1, 41.5, 40.1, 38.3, 37.3, 30.5, 29.7, 26.6, 26.3, 25.5, 18.3, 3.7.

IR (¹/₂ cm⁻¹): 3602, 3070, 3020, 2977, 2924, 2874, 2402, 1714, 1605, 1523, 1453, 1275, 1219, 1116, 1099, 1070, 1027.

HRMS (CI, ISO) Calcd for $[C_{26}H_{33}O_3]^+$: *m/z* 393.2430, found 393.2435.

 $[\pm]_{\mathbf{D}}^{25}$: +80.8 (*c* 0.58, CHCl₃).

(55,65,10aS)-6-Hydroxy-10a-methyl-6-(2-methylpent-3-yn-2yl)-1,2,3,5,6,7,10,10a-octa hydrobenzo[8]annulen-5-yl benzoate (20b)



¹**H NMR** (500MHz, *CDCl₃*) δ ppm: 8.10-8.05 (m, 2H), 7.57-7.52 (m, 1H), 7.47-7.42 (m, 2H), 6.21 (dd, J = 4.4, 3.3 Hz, 1H), 5.99 (s, 1H), 5.87-5.82 (m, 1H), 5.68 (tdd, J = 10.9, 6.3, 1.7 Hz, 1H), 2.84 (s, 1H), 2.65 (dd, J = 13.1, 6.7 Hz, 1H), 2.55 (dd, J = 13.1, 11.7 Hz, 1H), 2.27 (dd, J = 13.2, 6.3 Hz, 1H), 2.25-2.18 (m, 1H), 2.08-1.99 (m, 1H), 1.79-1.71 (m, 2H), 1.61-1.55 (m, 2H), 1.53-1.47 (m, 1H), 1.37 (s, 3H), 1.36 (s, 3H), 1.32 (s, 3H), 1.25 (s, 3H).

¹³**C NMR** (126 MHz, *CDCl₃*) δ ppm: 164.3, 142.6, 132.6, 131.2, 130.4, 129.9, 129.4, 128.2, 127.4, 85.2, 79.4, 78.5, 72.4, 41.4, 40.4, 39.7, 39.1, 33.6, 28.0, 26.4, 26.1, 25.9, 18.4, 3.3.

IR (¹/₂ cm⁻¹): 3530, 3155, 3026, 2978, 2933, 2872, 2253, 1713, 1604, 1469, 1453, 1386, 1319, 1277, 1177, 1119.

HRMS (EI) Calcd for $[C_{26}H_{33}O_3]^+$: *m/z* 392.2351, found 392.2352.

 $[\pm]_{\mathbf{D}}^{25}$: +163.4 (*c* 1.48, CHCl₃).

<u>1-((S)-6-Allyl-6-methylcyclohex-1-enyl)-2-hydroxy-5-methyl-2-(2-methylpent-3-yn-2-yl)hex-</u> 4-enyl benzoate (21a) and (21b)



Formula: C₃₀H₄₀O₃

MW: 448.6

To a solution of (**17a**) (56 mg, 0.15 mmol) in THF (5 mL) at -78°C was added phenyllithium (1.15 mL, 0.8 M in nBu_2O , 1.43 mmol, 9.0 equiv). The mixture was stirred at this temperature for 1.5 h. A solution of saturated aqueous NaHCO₃ was then added and the aqueous phase was extracted with Et₂O. The combined organic extracts were washed with brine, dried over anhydrous MgSO₄, filtered and concentrated *in vacuo*. The crude mixture was then purified by flash chromatography (petroleum ether/Et₂O: 95/5) to afford the title benzoate (**21a**) (58 mg, 0.13 mmol, 83%) as a pale yellow viscous oil.

The same procedure was repeated with (17b) (27 mg, 73 μ mol) to afford the title benzoate (21b) (30 mg, 68 μ mol, 93%) as a pale yellow viscous oil.

(1R,2R)-1-((S)-6-Allyl-6-methylcyclohex-1-enyl)-2-hydroxy-5-methyl-2-(2-methylpent-3-yn-2-yl)hex-4-enyl benzoate (21a)



¹**H NMR** (500MHz, *CDCl₃*) δ ppm: 8.07 (dd, J = 8.2, 1.2 Hz, 2H), 7.57-7.51 (m, 1H), 7.41-7.40 (m, 2H), 6.52 (t, J = 4.0 Hz, 1H), 5.99 (s, 1H), 5.68 (ddt, J = 17.2, 10.0, 7.3 Hz, 1H), 5.44 (ddq, J = 8.1, 6.8, 1.5 Hz, 1H), 5.00-4.92 (m, 2H), 2.88 (s, 1H), 2.54-2.38 (m, 3H), 2.17-2.08 (m, 3H), 1.74 (d, J = 0.9 Hz, 3H), 1.66-1.58 (m, 2H), 1.61 (s, 3H), 1.54-1.48 (m, 1H), 1.37 (s, 3H), 1.35-1.29 (m, 1H), 1.27 (s, 3H), 1.25 (s, 3H), 1.12 (s, 3H).

¹³C NMR (126 MHz, *CDCl₃*) δ ppm: 164.9, 142.7, 135.2, 132.6, 131.5, 131.3, 131.2, 129.9, 128.3, 120.9, 117.0, 85.1, 78.9, 78.6, 72.5, 44.0, 42.0, 36.9, 35.0, 32.3, 27.6, 26.1, 25.8, 25.3, 25.3, 18.1, 18.0, 3.2.

IR (¹/₂ cm⁻¹): 3539, 3155, 3065, 2973, 2933, 2253, 1709, 1602, 1450, 1382, 1317, 1272, 1216, 1177, 1095, 1070.

HRMS (ESI) Calcd for $[C_{30}H_{40}O_3Na]^+$: *m/z* 471.2870, found 471.2852.

 $[\pm]_{\mathbf{D}}^{25}$: -12.3 (*c* 0.5 CHCl₃).

(15,25)-1-((5)-6-Allyl-6-methylcyclohex-1-enyl)-2-hydroxy-5-methyl-2-(2-methylpent-3-yn-2-yl)hex-4-enyl benzoate (21b)



¹**H NMR** (500MHz, *CDCl₃*) δ ppm: 8.07 (dd, J = 8.2, 1.2 Hz, 2H), 7.57-7.51 (m, 1H), 7.47-7.40 (m, 2H), 6.49 (t, J = 3.9 Hz, 1H), 6.00 (s, 1H), 5.84 (m, 1H), 5.44 (tt, J = 6.8, 1.3 Hz, 1H), 5.08-5.01 (m, 2H), 2.89 (s, 1H), 2.53 (dd, J = 15.8, 7.3 Hz, 1H), 2.49-2.40 (m, 2H), 2.18 (dd, J = 13.2, 7.8 Hz, 1H), 2.13-2.07 (m, 2H), 1.74 (d, J = 0.9 Hz, 3H), 1.61 (s, 3H), 1.59-1.53 (m, 3H), 1.43-1.39 (m, 1H), 1.38 (s, 3H) 1.29 (s, 3H), 1.27 (s, 3H), 1.09 (s, 3H).

¹³**C NMR** (126 MHz, *CDCl*₃) δ ppm: 165.0, 142.8, 135.1, 132.6, 131.7, 131.2, 131.1, 129.8, 128.3, 120.7, 117.3, 85.2, 78.8, 78.6, 73.5, 44.2, 42.0, 36.9, 35.7, 32.6, 27.5, 26.1, 25.9, 25.6, 25.4, 18.0, 18.0, 3.3.

IR (¹/₂ cm⁻¹): 3542, 3154, 2976, 2932, 2253, 1711, 1452, 1382, 1316, 1271, 1177, 1113, 995.

HRMS (EI) Calcd for $[C_{30}H_{40}O_3]^+$: *m/z* 448. 2977, found 448.2973.

 $[\pm]_{\mathbf{D}}^{\mathbf{25}}$: +23.6 (*c* 1.8, CHCl₃).

(1R,5R,8Z,11S)-11-Methyl-6-(2-methylpent-3-yn-2-yl)-3,5-dioxatricyclo[9.4.0]pentadeca-1(15),8dien-4-one (18a)



A solution of (**17a**) (30 mg, 80 μ mol) in toluene (25 mL) was thoroughly degassed (using the freeze-thaw pump technique) and second-generation Grubbs' catalyst (3.5 mg, 4.0 μ mol, 0.05 equiv) was added and the mixture was stirred at reflux for 6 h. At that time second-generation Grubbs' catalyst (3.5 mg, 4.0 μ mol, 0.05 equiv) was added and the mixture was stirred at reflux for 16 h. After cooling, the solvent was removed *in vacuo*. The crude mixture was then purified by flash chromatography (petroleum ether/Et₂O: 95/5) to afford the title compound (**18a**) (20 mg, 63 μ mol, 79%) as a white solid.



A solution of benzoate (**21a**) (53 mg, 0.12 mmol) in toluene (15 mL) was thoroughly degassed (using the freeze-thaw pump technique) and second-generation Grubbs' catalyst (5 mg, 6 μ mol, 0.05 equiv) was added and the mixture was stirred at reflux for 6 h. At that time second-generation Grubbs' catalyst (5 mg, 6 μ mol, 0.05 equiv) was added and the mixture was stirred at reflux for 6 h. At that time second-generation Grubbs' catalyst (5 mg, 6 μ mol, 0.05 equiv) was added and the mixture was stirred at reflux for 16 h. After cooling, the solvent was removed *in vacuo*. The crude mixture was then purified by flash chromatography (petroleum ether/Et₂O: 95/5) to afford the title compound (**20a**) (37 mg, 96 μ mol, 80%) as a colourless oil.

The same procedure was repeated with (21b) (11 mg, 25 μ mol) to afford the title compound (20b) (8.8 mg, 23 μ mol, 90%) as a colorless oil.

<u>(15,55,115)-11,15,18,18-Tetramethyl-2,4-dioxatetracyclo[12.3.1.0]octadeca-6,13,15-trien-3-one (22) and (18b)</u>



MW: 314.4

A solution of (**17b**) (37 mg, 0.1 mmol) in toluene (33 mL) was thoroughly degassed under argon (using the freeze-thaw pump technique) and Zhan-1B catalyst (7 mg, 10 μ mol, 0.1 equiv) was added and the mixture was stirred at reflux for 24 h. The resulting mixture was allowed to cool down and the solvent was removed *in vacuo*. The crude mixture was then purified by flash chromatography (petroleum ether/Et₂O: 95/5) to afford the title tricycle compound (**22**) (22 mg, 70 μ mol, 75%) as a colorless oil and (**17b**) (6.3 mg, 20 μ mol, 20%) as a white solid.



¹**H NMR** (500MHz, *CDCl₃*) δ ppm: 5.97 (dd, J = 5.5, 2.3 Hz, 1H), 5.73 (dd, J = 13.2, 6.2 Hz, 1H), 5.13 (s, 1H), 4.98 (m, 1H), 2.83 (dquin, J = 18.8, 2.0 Hz, 1H), 2.70 (t, J = 13.2 Hz, 1H), 2.19 (dquin, J = 18.8, 2.5 Hz, 1H), 2.09 (dtd, J = 18.1, 5.5, 1.6 Hz, 1H), 1.98 (dd, J = 13.2, 6.2 Hz, 1H), 1.95-1.86 (m, 1H), 1.80 (m, 3H), 1.75 (dd, J = 13.2, 3.6 Hz, 1H), 1.72-1.66 (m, 1H), 1.65-1.60 (m, 1H), 1.58 (s, 3H), 1.48-1.43 (m, 1H), 1.34 (s, 3H), 1.18 (s, 3H).

¹³**C NMR** (126 MHz, *CDCl*₃) δ ppm: 154.4, 146.2, 138.1, 134.7, 129.1, 127.5, 115.9, 93.4, 79.4, 42.1, 41.1, 39.2, 35.4, 30.6, 27.2, 25.2, 24.9, 21.3, 18.9, 18.6.

IR (¹/₂ cm⁻¹): 3025, 2938, 2872, 1704, 1454, 1433, 1395, 1378, 1275, 1218, 1188, 1025, 1003.

HRMS (EI) Calcd for $[C_{20}H_{26}O_3]^+$: *m/z* 314.1882, found 314.1879.

$$[\pm]_{\mathbf{D}}^{25}$$
: +77 (*c* 0.56, CHCl₃).

[(15,25,85,10Z)-8,12,15,15-tetramethyltricyclo[9.3.1.0]pentadeca-3,10,12-triene-1,2-diol



Formula: C₁₉H₂₈O₂

MW: 288.4

To a solution of tricycle (22) (30 mg, 95 μ mol) in 1,4-dioxane (4 mL) at 0°C was added a solution of 2N aqueous NaOH (2 mL). The reaction mixture was allowed to stir at rt for 2 days. A solution of saturated aqueous NH₄Cl was then added and the aqueous phase was extracted with Et₂O. The combined organic extracts were washed with brine, dried over anhydrous MgSO₄, filtered and concentrated *in vacuo*. The crude mixture was then purified by flash chromatography (petroleum ether/Et₂O: 8/2) to afford the title diol (22a) (22 mg, 80%) as a white solid.

¹**H NMR** (400MHz, *CDCl*₃) δ ppm: 5.89 (dd, J = 5.6, 2.8 Hz, 1H), 5.67 (dd, J = 12.7, 6.5 Hz, 1H), 4.98 (m, 1H), 4.38 (br. s, 1H), 2.91 (dd, J = 12.7, 12.5 Hz, 1H), 2.87-2.80 (m, 1H), 2.53 (s, 1H), 2.10 (d, J = 1.4 Hz, 1H), 2.03-1.88 (m, 3H), 1.82-1.70 (m, 5H), 1.56-1.48 (m, 2H), 1.47 (s, 3H), 1.27-1.22 (m, 4H), 1.20 (s, 3H).

¹³**C NMR** (100 MHz, *CDCl*₃) δ ppm: 149.4, 145.0, 136.5, 125.7, 124.7, 118.3, 81.4, 71.7, 42.9, 42.6, 40.3, 39.2, 33.2, 26.6, 25.9, 25.9, 22.8, 19.5, 18.5.

[(15,25,85,10Z)-1-hydroxy-8,12,15,15-tetramethyltricyclo[9.3.1.0]pentadeca-3,10,12-trien-2-yl 4-nitrobenzoate (22b)



Formula: C₂₆H₃₁NO₅

MW: 437.5

To a solution of diol (22a) (22 mg, 76 μ mol) in dichloromethane (2 mL) were added triethylamine (26 μ L, 0.19 mmol, 2.5 equiv), DMAP (9.6 mg, 76 μ mol, 1 equiv) and 4nitrobenzoyl chloride (28 mg, 0.15 mmol, 2 equiv). The reaction mixture was allowed to stir at rt for 16 h. A solution of saturated aqueous NaHCO₃ was then added and the aqueous phase was extracted with Et₂O. The combined organic extracts were washed with brine, dried over anhydrous MgSO₄, filtered and concentrated *in vacuo*. The crude mixture was then purified by flash chromatography (petroleum ether/Et₂O: 85/15) to afford the title benzoate (22b) (27 mg, 80%) as a white solid.

¹**H NMR** (500MHz, *CDCl₃*) δ ppm: 8.32-8.27 (m, 2H), 8.23-8.19 (m, 2H), 5.97 (dd, J = 3.2, 5.0 Hz, 1H), 5.88 (s, 1H), 5.74 (dd, J = 12.1, 6.9 Hz, 1H), 5.06 (m, 1H), 3.04 (dd, J = 13.5, 12.1 Hz, 1H), 2.95 (m, 1H), 2.13-2.06 (m, 1H), 2.03 (dd, J = 13.5, 6.9 Hz, 1H), 1.99-1.90 (m, 1H), 1.85-1.82 (m, 1H), 1.81 (m, 3H), 1.76-1.71 (m, 1H), 1.57-1.54 (m, 4H), 1.52-1.45 (m, 2H), 1.30 (s, 3H), 1.26 (s, 1H), 1.25 (s, 3H).

¹³C NMR (126 MHz, *CDCl₃*) δ ppm: 163.9, 150.5, 148.5, 141.4, 136.9, 136.3, 130.7, 128.1, 125.3, 123.6, 117.7, 81.0, 76.5, 43.2, 42.4, 40.6, 40.3, 33.6, 27.2, 26.1, 25.8, 22.8, 19.2, 18.6.

3. X-ray Data of 22b:



CCDC 976581

The crystallographic data have been deposited with the Cambridge Crystallographic Data Centre as supplementary publication number CCDC-976581. Copies of the data can be obtained, free of charge, via the internet (<u>http://www.ccdc.cam.ac.uk/data_request/cif</u>), email (<u>data_request@ccdc.cam.ac.uk</u>), or fax: +44 1223336033.

Table 1. Crystal data and structure refinement for CCDC 976581.

Identification code	CCDC 976581
Empirical formula	C26 H31 N O5
Formula weight	437.52
Temperature	150(2) K
Wavelength	0.71073 A
Crystal system, space group	Orthorhombic, P 21 21 21
Unit cell dimensions	a = 7.4950(6) A alpha = 90 deg.
	b = 10.4454(9) A beta = 90 deg.
	c = 35.197(3) A gamma = 90 deg.
Volume	2755.5(4) A^3

Z, Calculated density	4, 1.055 Mg/m^3
Absorption coefficient	0.073 mm^-1
F(000)	936
Crystal size	0.370 x 0.102 x 0.060 mm
Theta range for data collection	2.034 to 23.296 deg.
Limiting indices	-7<=h<=8, -11<=k<=11, -33<=l<=39
Reflections collected / unique	12353 / 3802 [R(int) = 0.0806]
Completeness to theta = 25.242	78.0 %
Absorption correction	Empirical
Max. and min. transmission	1.000 and 0.786
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	3802 / 22 / 276
Goodness-of-fit on F^2	1.054
Final R indices [I>2sigma(I)]	R1 = 0.1164, wR2 = 0.2886
R indices (all data)	R1 = 0.1565, wR2 = 0.3085
Absolute structure parameter	-1.9(10)
Extinction coefficient	0.103(15)
Largest diff. peak and hole	0.34 and -0.31 e.A^-3

<u>Table 2.</u> Atomic coordinates ($x \ 10^{4}$) and equivalent isotropic displacement parameters (A² $x \ 10^{3}$) for CCDC 976581 U(eq) is defined as one third of the trace of the orthogonalized Uij tensor.

	Х	У	Z	U(eq)
C(1)	5477(13)	4164(10)	1175(3)	33(3)
C(2)	7380(13)	4134(15)	1016(3)	50(3)
C(3)	7450(20)	4009(15)	578(3)	70(4)
C(4)	6006(17)	3919(17)	349(4)	71(5)
C(5)	6240(20)	3798(18)	-73(4)	94(6)

C(6)	4263(15)	4162(15)	536(3)	55(4)
C(7)	4141(14)	3430(10)	924(3)	42(3)
C(8)	4730(20)	2005(13)	883(5)	84(5)
C(9)	2260(14)	3401(16)	1102(3)	67(4)
C(10)	3301(15)	5041(13)	390(3)	48(3)
C(11)	1935(16)	5852(13)	610(4)	65(4)
C(12)	2800(30)	6945(17)	866(6)	52(6)
C(13)	1450(40)	7260(30)	1169(7)	85(9)
C(14)	2850(40)	8190(30)	642(11)	141(14)
C(12')	3050(30)	7010(20)	707(8)	24(8)
C(13')	2150(50)	7740(30)	1025(9)	51(11)
C(14')	3520(40)	7860(30)	373(8)	41(10)
C(15')	5020(40)	8850(30)	441(13)	71(15)
C(16')	6680(40)	8030(30)	496(10)	41(9)
C(17')	6270(40)	6920(30)	754(10)	46(11)
C(15)	4440(30)	8440(30)	402(7)	78(8)
C(16)	6190(40)	8370(30)	628(8)	82(9)
C(17)	6240(20)	7242(18)	892(6)	37(6)
C(18)	4758(15)	6545(12)	953(4)	65(4)
C(19)	4833(15)	5523(9)	1264(3)	37(3)
C(20)	5352(17)	6508(13)	1862(4)	55(3)
C(21)	6739(15)	7043(12)	2120(4)	51(3)
C(22)	6244(17)	7700(17)	2459(4)	84(6)
C(23)	7474(17)	8236(18)	2705(3)	78(5)
C(24)	9280(14)	8029(13)	2611(3)	45(3)

C(25)	9797(15)	7377(12)	2305(3)	45(3)
C(26)	8536(14)	6912(13)	2060(4)	53(4)
N(1)	10511(14)	8601(11)	2889(3)	56(3)
O (1)	5418(10)	3552(10)	1536(2)	62(3)
O(2)	6059(9)	6029(8)	1558(2)	45(2)
O(3)	3806(11)	6566(9)	1942(2)	68(3)
O(4)	10033(11)	9104(10)	3177(2)	65(3)
O(5)	12132(11)	8489(12)	2802(3)	89(4)

Table 3. Bond lengths [A] and angles [deg] for CCDC 976581.

C(1)-O(1)	1.423(12)
C(1)-C(19)	1.531(14)
C(1)-C(2)	1.532(14)
C(1)-C(7)	1.538(15)
C(2)-C(3)	1.550(15)
C(3)-C(4)	1.352(19)
C(4)-C(6)	1.485(17)
C(4)-C(5)	1.500(17)
C(6)-C(10)	1.275(16)
C(6)-C(7)	1.570(15)
C(7)-C(9)	1.542(15)
C(7)-C(8)	1.559(17)
C(10)-C(11)	1.539(16)
C(11)-C(12)	1.594(19)
C(12)-C(13)	1.51(2)

C(12)-C(14)	1.53(2)
C(12)-C(18)	1.55(2)
C(14)-C(15)	1.48(2)
C(12')-C(13')	1.52(2)
C(12')-C(14')	1.52(2)
C(12')-C(18)	1.62(3)
C(14')-C(15')	1.54(3)
C(15')-C(16')	1.52(2)
C(16')-C(17')	1.50(2)
C(17')-C(18)	1.39(2)
C(15)-C(16)	1.53(2)
C(16)-C(17)	1.50(2)
C(17)-C(18)	1.344(17)
C(18)-C(19)	1.531(15)
C(19)-O(2)	1.483(12)
C(20)-O(3)	1.194(13)
C(20)-O(2)	1.293(14)
C(20)-C(21)	1.489(17)
C(21)-C(26)	1.370(15)
C(21)-C(22)	1.427(16)
C(22)-C(23)	1.384(17)
C(23)-C(24)	1.410(16)
C(24)-C(25)	1.333(15)
C(24)-N(1)	1.471(15)
C(25)-C(26)	1.367(16)

N(1)-O(4)	1.197(12)
N(1)-O(5)	1.258(13)

O(1)-C(1)-C(19)	103.0(8)
O(1)-C(1)-C(2)	110.2(8)
C(19)-C(1)-C(2)	112.8(10)
O(1)-C(1)-C(7)	105.5(8)
C(19)-C(1)-C(7)	112.0(8)
C(2)-C(1)-C(7)	112.7(9)
C(1)-C(2)-C(3)	113.3(9)
C(4)-C(3)-C(2)	124.9(12)
C(3)-C(4)-C(6)	115.4(11)
C(3)-C(4)-C(5)	120.0(12)
C(6)-C(4)-C(5)	123.8(12)
C(10)-C(6)-C(4)	116.3(11)
C(10)-C(6)-C(7)	132.0(11)
C(4)-C(6)-C(7)	110.7(11)
C(1)-C(7)-C(9)	111.9(9)
C(1)-C(7)-C(8)	110.2(9)
C(9)-C(7)-C(8)	106.0(11)
C(1)-C(7)-C(6)	102.6(8)
C(9)-C(7)-C(6)	114.5(9)
C(8)-C(7)-C(6)	111.6(11)
C(6)-C(10)-C(11)	124.7(11)
C(10)-C(11)-C(12)	114.0(12)

C(13)-C(12)-C(14)	101(2)
C(13)-C(12)-C(18)	123.6(18)
C(14)-C(12)-C(18)	108.0(19)
C(13)-C(12)-C(11)	106.3(16)
C(14)-C(12)-C(11)	109(2)
C(18)-C(12)-C(11)	107.6(13)
C(15)-C(14)-C(12)	118(3)
C(13')-C(12')-C(14')	112(2)
C(13')-C(12')-C(18)	96(2)
C(14')-C(12')-C(18)	113.9(19)
C(12')-C(14')-C(15')	116(2)
C(16')-C(15')-C(14')	104(3)
C(17')-C(16')-C(15')	110(3)
C(18)-C(17')-C(16')	134(3)
C(14)-C(15)-C(16)	113(2)
C(17)-C(16)-C(15)	112(2)
C(18)-C(17)-C(16)	120.4(18)
C(17)-C(18)-C(19)	117.5(12)
C(17')-C(18)-C(19)	121.9(16)
C(17)-C(18)-C(12)	126.9(14)
C(19)-C(18)-C(12)	111.2(12)
C(17')-C(18)-C(12')	107.0(18)
C(19)-C(18)-C(12')	128.3(12)
O(2)-C(19)-C(1)	106.2(8)
O(2)-C(19)-C(18)	105.9(8)

C(1)-C(19)-C(18)	120.8(9)
O(3)-C(20)-O(2)	127.7(11)
O(3)-C(20)-C(21)	121.0(11)
O(2)-C(20)-C(21)	111.3(10)
C(26)-C(21)-C(22)	115.6(12)
C(26)-C(21)-C(20)	123.7(12)
C(22)-C(21)-C(20)	120.6(10)
C(23)-C(22)-C(21)	123.0(12)
C(22)-C(23)-C(24)	115.5(12)
C(25)-C(24)-C(23)	123.2(12)
C(25)-C(24)-N(1)	124.3(10)
C(23)-C(24)-N(1)	112.5(11)
C(24)-C(25)-C(26)	119.3(10)
C(25)-C(26)-C(21)	123.2(12)
O(4)-N(1)-O(5)	122.4(10)
O(4)-N(1)-C(24)	123.6(10)
O(5)-N(1)-C(24)	114.0(11)
C(20)-O(2)-C(19)	117.5(8)

Symmetry transformations used to generate equivalent atoms:

<u>Table 4.</u> Anisotropic displacement parameters (A^2 x 10^3) for CCDC 976581 The anisotropic displacement factor exponent takes the form:

-2 pi^2 [h^2 a*^2 U11 + ... + 2 h k a* b* U12]

	U11	U22	U33	U23	U13	U12
C(2)	21(6)	111(11)	18(6)	-5(6)	-1(5)	13(7)

66(10)	107(12)	39(7)	-9(8)	14(8)	39(9)
38(8)	131(14)	44(8)	-6(8)	10(7)	30(8)
124(14)	118(14)	40(8)	-12(9)	4(9)	21(12)
21(6)	106(10)	37(7)	-3(7)	-2(5)	-15(7)
92(11)	52(9)	107(13)	-16(8)	-33(10) 6(8)
22(6)	125(13)	53(8)	22(8)	-7(6)	-23(7)
28(7)	77(9)	38(7)	9(7)	-3(6)	14(7)
49(8)	82(10)	64(9)	-13(8)	-19(7)	38(8)
46(8)	59(9)	89(10)	-16(8)	-22(8)	13(7)
38(8)	76(9)	53(8)	-18(7)	1(7)	10(7)
26(7)	54(8)	72(9)	-12(7)	6(6)	4(6)
29(7)	157(16)	66(10)	-72(10)) 5(7)	-7(8)
47(8)	160(16)	28(7)	-18(9)	-2(7)	38(10)
24(6)	78(8)	34(7)	2(6)	-7(5)	15(6)
24(6) 24(6)	78(8) 86(9)	34(7) 25(6)	2(6) 3(6)	-7(5) -3(6)	15(6) 1(6)
24(6) 24(6) 24(7)	78(8) 86(9) 72(9)	34(7) 25(6) 63(9)	2(6) 3(6) -18(7)	-7(5) -3(6) 5(6)	15(6) 1(6) 19(6)
24(6) 24(6) 24(7) 45(7)	78(8) 86(9) 72(9) 75(8)	34(7) 25(6) 63(9) 48(7)	2(6) 3(6) -18(7) 4(6)	-7(5) -3(6) 5(6) -7(6)	15(6) 1(6) 19(6) -4(6)
24(6) 24(6) 24(7) 45(7) 35(5)	78(8) 86(9) 72(9) 75(8) 113(7)	34(7) 25(6) 63(9) 48(7) 39(5)	2(6) 3(6) -18(7) 4(6) 27(5)	-7(5) -3(6) 5(6) -7(6) 1(4)	15(6) 1(6) 19(6) -4(6) -30(5)
24(6) 24(6) 24(7) 45(7) 35(5) 33(4)	78(8) 86(9) 72(9) 75(8) 113(7) 60(5)	 34(7) 25(6) 63(9) 48(7) 39(5) 43(5) 	2(6) 3(6) -18(7) 4(6) 27(5) -20(4)	-7(5) -3(6) 5(6) -7(6) 1(4) 0(4)	15(6) 1(6) 19(6) -4(6) -30(5) 11(4)
24(6) 24(6) 24(7) 45(7) 35(5) 33(4) 32(5)	78(8) 86(9) 72(9) 75(8) 113(7) 60(5) 102(7)	34(7) 25(6) 63(9) 48(7) 39(5) 43(5) 70(6)	2(6) 3(6) -18(7) 4(6) 27(5) -20(4) -44(6)	-7(5) -3(6) 5(6) -7(6) 1(4) 0(4) 13(5)	15(6) 1(6) 19(6) -4(6) -30(5) 11(4) 1(5)
24(6) 24(7) 45(7) 35(5) 33(4) 32(5) 62(6)	78(8) 86(9) 72(9) 75(8) 113(7) 60(5) 102(7) 102(7)	 34(7) 25(6) 63(9) 48(7) 39(5) 43(5) 70(6) 30(5) 	2(6) 3(6) -18(7) 4(6) 27(5) -20(4) -44(6) -12(5)	-7(5) -3(6) 5(6) -7(6) 1(4) 0(4) 13(5) 7(4)	15(6) 1(6) 19(6) -4(6) -30(5) 11(4) 1(5) 8(5)
	38(8) 124(14) 21(6) 92(11) 22(6) 28(7) 49(8) 46(8) 38(8) 26(7) 29(7) 47(8)	38(8)131(14)124(14)118(14)21(6)106(10)92(11)52(9)22(6)125(13)28(7)77(9)49(8)82(10)46(8)59(9)38(8)76(9)26(7)54(8)29(7)157(16)47(8)160(16)	38(8)107(12)39(7)38(8)131(14)44(8)124(14)118(14)40(8)21(6)106(10)37(7)92(11)52(9)107(13)22(6)125(13)53(8)28(7)77(9)38(7)49(8)82(10)64(9)46(8)59(9)89(10)38(8)76(9)53(8)26(7)54(8)72(9)29(7)157(16)66(10)47(8)160(16)28(7)	38(8) $131(14)$ $44(8)$ $-6(8)$ $124(14)$ $118(14)$ $40(8)$ $-12(9)$ $21(6)$ $106(10)$ $37(7)$ $-3(7)$ $92(11)$ $52(9)$ $107(13)$ $-16(8)$ $22(6)$ $125(13)$ $53(8)$ $22(8)$ $28(7)$ $77(9)$ $38(7)$ $9(7)$ $49(8)$ $82(10)$ $64(9)$ $-13(8)$ $46(8)$ $59(9)$ $89(10)$ $-16(8)$ $38(8)$ $76(9)$ $53(8)$ $-18(7)$ $26(7)$ $54(8)$ $72(9)$ $-12(7)$ $29(7)$ $157(16)$ $66(10)$ $-72(10)$ $47(8)$ $160(16)$ $28(7)$ $-18(9)$	38(8) $131(14)$ $44(8)$ $-6(8)$ $10(7)$ $124(14)$ $118(14)$ $40(8)$ $-12(9)$ $4(9)$ $21(6)$ $106(10)$ $37(7)$ $-3(7)$ $-2(5)$ $92(11)$ $52(9)$ $107(13)$ $-16(8)$ $-33(10)$ $22(6)$ $125(13)$ $53(8)$ $22(8)$ $-7(6)$ $28(7)$ $77(9)$ $38(7)$ $9(7)$ $-3(6)$ $49(8)$ $82(10)$ $64(9)$ $-13(8)$ $-19(7)$ $46(8)$ $59(9)$ $89(10)$ $-16(8)$ $-22(8)$ $38(8)$ $76(9)$ $53(8)$ $-18(7)$ $1(7)$ $26(7)$ $54(8)$ $72(9)$ $-12(7)$ $6(6)$ $29(7)$ $157(16)$ $66(10)$ $-72(10)$ $5(7)$ $47(8)$ $160(16)$ $28(7)$ $-18(9)$ $-2(7)$



4. NMR Spectra of New Compounds

7a

7c

8

8a

±9



S58







14a

14b

14aa

14ba

14ab

14bb

15a

15b



S70




l

















19a



















