Cyclooctatrienes from pyran-2-ones via a tandem [4+4]-photocycloaddition/decarboxylation process

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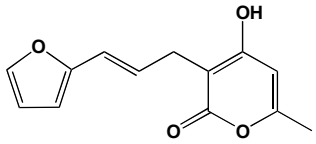
Electronic Supporting Information

General information. Reactions were carried out in oven-dried (110 °C) or flame-dried glassware under argon atmosphere unless otherwise noted. Transfer of anhydrous solvents and reagents was accomplished with oven-dried syringes or cannulae. Solvents were distilled before use: methylene chloride from calcium hydride, tetrahydrofuran, diethylether and benzene from sodium/benzophenone ketyl, toluene from sodium metal. The 4-hydroxypyran-2-one starting materials were prepared using literature procedures.[1] Irradiations were carried out using an Ace-Hanovia 450W medium pressure, quartz, mercury-vapor lamp in a quartz water cooled jacket. Reactions were carried out in a pyrex round bottom flask under argon after deoxygenation with a slow stream of argon for 10 min.

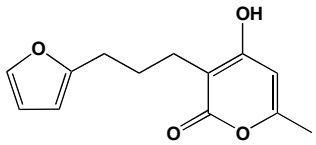
The solution of the pyran-2-one substrate in a Pyrex vessel was clamped at a distance of 10 cm from the lamp, inside a light-proof enclosure. Thin layer chromatography (TLC) was performed on glass plates precoated with 0.25 mm Kieselgel 60 F_{254} (Merck). Flash chromatography columns were packed with 230-400 mesh silica gel (Silicycle, Pharma grade). Proton nuclear magnetic resonance spectra (^{1}H NMR) were recorded at 400 MHz or 500 MHz and are reported (ppm) relative to the centerline of the triplet from chloroform-d (7.26 ppm). Coupling constants (*J*) are reported in Hertz (Hz). Carbon nuclear magnetic resonance spectra (^{13}C NMR) were recorded at 100 MHz or 125 MHz and are reported (ppm) relative to the centerline of the triplet from chloroform-d (77.23 ppm). Infrared (IR) spectra were measured with a Mattson Galaxy Series FT-IR 3000 spectrophotometer. Mass spectra were determined on a PerSeptive Biosystems Mariner high-resolution electrospray positive ion mode spectrometer or a Kratos Analytical MS-50G spectrometer.

Preparation of Photosubstrates

Representative Example: Preparation of 3-[3-(2'-furyl)-propyl]-4-acetoxy-6-methylpyran-2-one 1a.

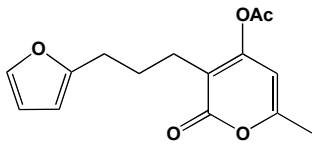


A solution of 3-(2'-furyl)-2-propenylacetate[2] (1.130 g, 6.81 mmol) in toluene (40 mL) was added to $Pd(PPh_3)_4$ (510 mg, 0.44 mmol). The resulting yellow solution was added to a solution of 4-hydroxy-6-methyl-2-pyrone (860 mg, 6.82 mmol) and DBU (1.02 mL, 6.82 mmol) in toluene (15 mL) at 80 °C and stirred for 14 h. The brownish-red heterogeneous mixture was diluted with EtOAc (150 mL) and cooled to rt. The solution was washed with 1N HCl (2 x 15mL), saturated $NaHCO_3$ (15 mL) and H_2O (15 mL). The combined aqueous layers were back extracted with EtOAc (3 x 50 mL). The combined organic layers were washed with brine (15 mL) and dried over $MgSO_4$. After filtration, solvent was removed to give 2.017 g of crude product. The solid was triturated with Et_2O (70 ml) to give the allylation product (1.25 g, 5.39 mmol, 79%) as pale yellow crystals: mp 194-196 °C; R_f 0.49 (3:7 hexane/EtOAc); IR (thin film) 3424, 1661 cm^{-1}; ^1H NMR (500 MHz, DMSO-d_6) □ 7.39 (br d, 1H, *J* = 1.7 Hz), 6.36 (dd, 1H, *J* = 3.4, 1.7 Hz), 6.28 (br d, 1H, *J* = 15.8 Hz), 6.21 (d, 1H, *J* = 3.4 Hz), 6.17 (dt, 1H, *J* = 15.8, 6.1 Hz), 6.03 (br q, 1H, *J* = 0.9 Hz), 3.22 (d, 2H, *J* = 6.1 Hz), 2.80 (br s, 1H), 2.14 (d, 3H, *J* = 0.9 Hz); ^{13}C NMR (125 MHz, DMSO-d_6) □ 155.8, 154.8, 150.7, 142.7, 132.3, 116.2, 108.8, 101.7, 97.1, 90.1, 88.9, 16.0, 9.6; Anal. Calcd. for $C_{13}H_{12}O_4$: C, 65.22; H, 5.84. Found: C, 65.27; H, 5.89.



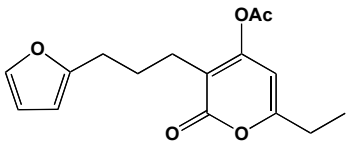
A solution of the allylated adduct above (0.724 g, 3.12 mmol) in THF (50 mL) was added to 5% Pd/C (670 mg, 0.31 mmol) in a 100mL 3-neck flask which had been purged with Ar. The reaction was stirred under H_2 (balloon pressure) for 2h. The mixture was then filtered over Celite, and the filtrate was concentrated to give crude 3-[3-(2'furyl)-propyl]-4-hydroxy-6-methylpyran-2-one (0.711 mg, 3.04 mmol, 97%) as a white solid which was used without further purification: mp 128-130 °C; R_f 0.57 (3:7 hexane/EtOAc); IR (thin film) 3435, 1688 cm^{-1}; ^1H NMR (500 MHz, DMSO-d_6) □ 8.28 (br s, 1H), 7.31 (dd, 1H, *J* = 1.8, 0.8 Hz), 6.29 (dd, 1H, *J* = 3.2, 1.8 Hz), 6.05 (dq, 1H, *J* = 3.2, 0.8 Hz), 6.00 (br s, 1H), 2.66 (t, 2H, *J* = 7.2 Hz), 2.51 (t, 2H,

J = 7.2 Hz), 2.21 (br s, 3H), 1.89 (tt, 2H, *J* = 7.2, 7.2 Hz); ^{13}C NMR (125 MHz, acetone-d_6) 165.6, 165.3, 161.0, 157.0, 141.6, 110.9, 105.4, 102.5, 100.4, 28.3, 27.2, 23.5, 19.6; Anal. Calcd. for $C_{13}H_{14}O_4$: C, 66.66; H, 6.04.Found: C, 66.58; H, 6.06.



1a

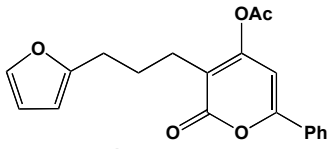
To a solution of the hydrogenation product from above (1.12 g, 4.81 mmol) in CH_2Cl_2 (50 mL) and NEt_3 (6.0 mL, 81 mmol) was added acetic anhydride (0.710 mL, 7.51 mmol). The solution was allowed to stir at rt under Ar for 0.5 h, then the solution was diluted with dichloromethane and washed with 1N HCl (20 mL), saturated $NaHCO_3$ (20 mL) and brine (20 mL). The organic layer was dried over $MgSO_4$ and concentrated. The crude oil was purified via flash chromatography (silica gel, 230-400 mesh, hexane/EtOAc 2:1) to yield **1a** (1.126 g, 4.08 mmol, 85%) as a yellow oil: R_f 0.57 (5:5:1 hexane/Et_2O/CH_2Cl_2); IR (neat) 1773, 1721 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$) 7.29 (dd, 1H, *J* = 1.8, 0.8 Hz), 6.28 (dd, 1H, *J* = 3.2, 1.8 Hz), 6.01 (dd, 1H, *J* = 3.2, 0.8 Hz), 5.92 (br q, 1H, *J* = 0.8 Hz), 2.65 (br t, 2H, *J* = 7.4 Hz), 2.42 (t, 2H, *J* = 7.4 Hz), 2.23 (d, 3H, *J* = 0.7 Hz), 2.22 (s, 3H), 1.85 (tt, 2H, *J* = 7.4, 7.4 Hz); ^{13}C NMR (125 MHz, $CDCl_3$) 167.3, 164.6, 159.7, 158.5, 155.6, 140.7, 114.7, 110.1, 105.0, 102.0, 27.4, 25.7, 23.5, 20.6, 19.7; Anal. Calcd. for $C_{15}H_{16}O_5$: C, 65.22; H, 5.84. Found: C, 65.30; H, 5.87.



1b

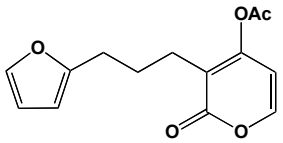
3-[3-(2'-furyl)-propyl]-4-acetoxy-6-ethylpyran-2-one 1b. The procedure described above for **1a** was applied using 6-ethyl-4-hydroxypyran-2-one to yield **1b** as a yellow oil: R_f 0.43 (4:1 hexane/EtOAc); IR (DCM cast film; microscope) 1775, 1749, 1722 cm^{-1}; UV (CH_2Cl_2) λ_{max} 294 nm; ^{1}H NMR (500 MHz, $CDCl_3$) 7.28 (dd, 1H, *J* = 1.8, 0.8 Hz), 6.26 (dd, 1H, *J* = 3.2, 1.8 Hz), 6.00 (ddt, 1H, *J* = 3.2, 0.8, 0.8 Hz), 5.89 (t, 1H, *J* = 0.8 Hz), 2.64 (br t, 2H, *J* = 7.5 Hz), 2.51 (qd, 2H, *J* = 7.5, 0.8 Hz), 2.41 (t, 2H, *J* = 7.5 Hz), 2.21 (s, 3H), 1.85 (m, 2H), 1.20 (t, 3H, *J* = 7.5 Hz); ^{13}C NMR (125 MHz, $CDCl_3$) 167.3, 164.6, 164.5, 158.7, 155.7, 140.8, 114.9, 110.1, 105.0,

100.4, 27.5, 26.7, 25.8, 23.7, 20.7, 10.8; HRMS (EI) calcd. for $C_{16}H_{18}O_5$ ($M^{\bullet+}$) 290.1154, found 290.1154.



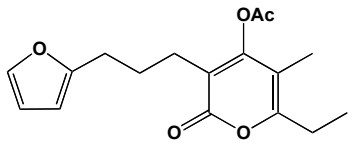
1c

3-[3-(2'-furyl)-propyl]-4-acetoxy-6-phenylpyran-2-one 1c. The procedure described above for **1a** was applied using 6-phenyl-4-hydroxypyran-2-one to yield **1c** as a yellow oil: R_f 0.60 (5:5:1 hexane/Et_2O/CH_2Cl_2); IR (DCM cast film; microscope) 1747, 1641, 1572, 1497 cm^{-1}; UV (CH_2Cl_2) λ_{max} 329 nm; ^1H NMR (500 MHz, $CDCl_3$) δ 7.80-7.76 (m, 2H), 7.46-7.42 (m, 3H), 7.30 (dd, 1H, J = 1.8, 0.8 Hz), 6.57 (s, 1H), 6.28 (dd, 1H, J = 3.1, 1.8 Hz), 6.03 (dd, 1H, J = 3.1, 0.8 Hz), 2.69 (br t, 2H, J = 7.2 Hz), 2.50 (t, 2H, J = 7.6 Hz), 2.27 (s, 3H), 1.95-1.88 (m, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 167.4, 163.8, 158.7, 158.1, 155.6, 140.8, 131.0, 130.9, 128.9, 125.5, 116.2, 110.2, 105.1, 99.7, 27.5, 25.8, 23.9, 20.8; HRMS (EI) calcd. for $C_{20}H_{18}O_5$ ($M^{\bullet+}$) 338.1154, found 338.1153.



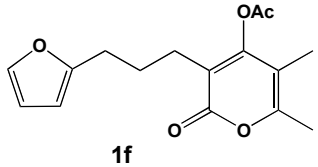
1d

3-[3-(2'-furyl)-propyl]-4-acetoxy-pyran-2-one 1d. The procedure described above for **1a** was applied using 4-hydroxypyran-2-one to yield **1d** as a yellow oil: R_f 0.60 (3:7 hexane/EtOAc); IR (DCM cast film; microscope) 3114, 1773, 1719, , 1643, 1371, 1183 cm^{-1}; UV (CH_2Cl_2) λ_{max} 286 nm; ^1H NMR (500 MHz, $CDCl_3$) δ 7.37 (d, 1H, J = 5.8 Hz), 7.29 (dd, 1H, J = 1.8, 0.8 Hz), 6.28 (dd, 1H, J = 3.2, 1.8 Hz), 6.18 (d, 1H, J = 5.8 Hz), 6.02 (dd, 1H, J = 3.2, 0.8 Hz), 2.66 (br t, 2H, J = 7.5 Hz), 2.46 (t, 2H, J = 7.5 Hz), 2.24 (s, 3H), 1.87 (tt, 2H, J = 7.5, 7.5 Hz); ^{13}C NMR (125 MHz, $CDCl_3$) δ 167.2, 163.9, 157.4, 155.5, 148.7, 140.8, 118.6, 110.2, 105.1, 104.9, 27.5, 25.6, 23.9, 20.7; HRMS (EI) calcd. for $C_{14}H_{14}O_5$ ($M^{\bullet+}$) 262.0841, found 262.0841.



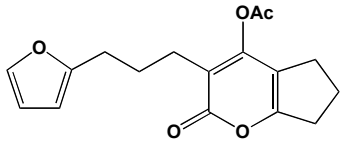
1e

3-[3-(2'-furyl)-propyl]-4-acetoxy-6-ethyl-5-methylpyran-2-one 1e. The procedure described above for **1a** was applied using 6-ethyl-4-hydroxy-5-methylpyran-2-one to yield **1e** as a yellow oil: R_f 0.62 (5:5:1 hexane/Et_2O/CH_2Cl_2); IR (DCM cast film; microscope) 1775, 1715, 1179 cm^{-1}; UV (CH_2Cl_2) λ_{max} 302 nm; ^1H NMR (500 MHz, $CDCl_3$) δ 7.30 (dd, 1H, J = 1.8, 0.8 Hz), 6.28 (dd, 1H, J = 3.1, 1.8 Hz), 6.02 (dd, 1H, J = 3.1, 0.8 Hz), 2.66 (br t, 2H, J = 7.6 Hz), 2.55 (q, 2H, J = 7.6 Hz), 2.36 (t, 2H, J = 7.6 Hz), 2.24 (s, 3H), 1.84 (tt, 2H, J = 7.6, 7.6 Hz), 1.80 (s, 3H), 1.21 (t, 2H, J = 7.6 Hz); ^{13}C NMR (125 MHz, $CDCl_3$) δ 167.3, 164.2, 160.8, 159.7, 155.7, 140.8, 116.3, 110.2, 107.5, 105.1, 27.6, 25.7, 24.5, 24.3, 20.2, 11.6, 10.0; HRMS (EI) calcd. for $C_{17}H_{20}O_5$ ($M^{\bullet+}$) 304.1311, found 304.1306.



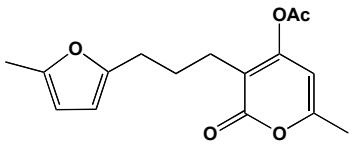
1f

3-[3-(2'-furyl)-propyl]-4-acetoxy-5,6-dimethylpyran-2-one 1f. The procedure described above for **1a** was applied using 4-hydroxy-5,6-dimethylpyran-2-one to yield **1f** as a yellow oil: R_f 0.23 (4:1 hexane/EtOAc); IR (DCM cast film microscope) 1774, 1718, 1182 cm^{-1}; UV (CH_2Cl_2) λ_{max} 302 nm; ^1H NMR (500 MHz, $CDCl_3$) δ 7.29 (dd, 1H, J = 1.8, 0.8 Hz), 6.27 (dd, 1H, J = 3.2, 1.8 Hz), 6.01 (dd, 1H, J = 3.2, 0.8 Hz), 2.65 (br t, 2H, J = 7.4 Hz), 2.36 (t, 2H, J = 7.4 Hz), 2.24 (br s, 3H), 2.23 (s, 3H), 1.84 (tt, 2H, J = 7.4, 7.4 Hz), 1.80 (q, 3H, J = 0.6 Hz); ^{13}C NMR (125 MHz, $CDCl_3$) δ 167.2, 164.0, 159.6, 156.3, 155.7, 140.8, 116.3, 110.1, 108.2, 105.1, 27.6, 25.7, 24.3, 20.2, 17.4, 10.5; HRMS (EI) calcd. for $C_{16}H_{18}O_5$ ($M^{\bullet+}$) 290.1154, found 290.1154.



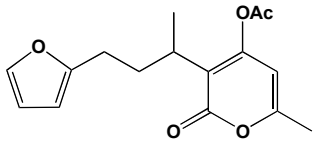
1g

3-[3-(2'-furyl)-propyl]-4-acetoxy-cyclopenta[b]pyran-2-one 1g. The procedure described above for **1a** was applied using 4-hydroxy-cyclopenta[b]pyran-2-one to yield **1g** as a yellow oil: R_f 0.86 (3:7 hexane/EtOAc); IR (DCM cast; film microscope) 1747, 1222 cm^{-1}; UV (CH_2Cl_2) λ_{max} 312 nm ^1H NMR (400 MHz, $CDCl_3$) δ 7.28 (dd, 1H, J = 1.8, 0.8 Hz), 6.26 (dd, 1H, J = 3.2, 1.8 Hz), 6.00 (dd, 1H, J = 3.2, 0.8 Hz), 2.80 (br t, 2H, J = 7.5 Hz), 2.64 (t, 2H, J = 7.5 Hz), 2.55 (tt, 2H, J = 7.5, 7.5 Hz), 2.40 (t, 2H, J = 7.5 Hz), 2.21 (br s, 3H), 2.06 (br tt, 2H, J = 7.5, 7.5 Hz), 1.84 (br tt, 2H, J = 7.5, 7.5 Hz); ^{13}C NMR (125 MHz, $CDCl_3$) δ 167.0, 165.5, 162.6, 158.1, 155.7, 140.7, 114.4, 113.4, 110.1, 105.0, 31.3, 27.5, 26.6, 25.9, 24.1, 20.3, 20.0; HRMS (ESI) calcd for $C_{17}H_{18}O_5Na$ ($[M•Na]^+$) 325.1047, found 325.1048.



1h

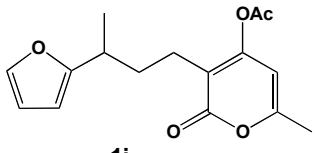
3-[3-(5'-methyl-2'-furyl)-propyl]-4-acetoxy-6-methylpyran-2-one 1h. The procedure described above for **1a** was applied using 4-hydroxy-6-methylpyran-2-one and 3-(5'methyl-2'-furyl)-2-propenylacetate[3] to yield **1h** as a yellow oil: R_f 0.23 (4:1 hexane/EtOAc); IR (DCM cast film; microscope) 1671, 1639, 1227 cm^{-1}; UV (CH_2Cl_2) λ_{max} 293 nm; ^1H NMR (500 MHz, $CDCl_3$) δ 5.92 (q, 1H, J = 1.0 Hz), 5.87 (dqt, 1H, J = 3.0, 0.3, 0.3 Hz), 5.83 (dq, 1H, J = 3.0, 1.1 Hz), 2.58 (br t, 2H, J = 7.4 Hz), 2.43 (t, 2H, J = 7.4 Hz), 2.24 (dd, 3H, J = 1.0, 0.3 Hz), 2.23 (br s, 6H), 1.83 (tt, 2H, J = 7.4, 7.4 Hz); ^{13}C NMR (125 MHz, $CDCl_3$) δ 167.3, 164.6, 159.6, 158.5, 153.8, 150.2, 114.9, 105.8, 105.6, 102.0, 27.6, 25.9, 23.7, 20.7, 19.8, 13.5; HRMS (EI) calcd. for $C_{16}H_{18}O_5$ ($M^{\bullet+}$) 290.1154, found 290.1154.



1i

3-[3-(2'-Furyl)-1-methylpropyl]-4-acetoxy-6-methylpyran-2-one 1i. The procedure described above for **1a** was applied using 4-hydroxy-6-methylpyran-2-one and 4-(2'-furyl)-2-acetoxy-3-butene[3] to yield **1i** as a yellow oil: R_f 0.89 (3:7 hexane/EtOAc); IR (DCM cast film; microscope) 1774, 1721, 1188 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.27 (dd, 1H, J = 1.8, 0.8 Hz), 6.25 (dd,

1H, *J* = 3.1, 1.8 Hz), 5.94 (app ddt, 1H, *J* = 3.1, 0.8, 0.8 Hz), 5.86 (q, 1H, *J* = 0.9 Hz), 2.89 (ddq, 1H, *J* = 8.7, 7.0, 7.0 Hz), 2.54 (ddd, 1H, *J* = 15.6, 7.5, 7.5 Hz), 2.53 (ddd, 1H, *J* = 15.6, 7.5, 7.5 Hz), 2.22 (s, 3H), 2.21 (d, 3H, *J* = 0.9 Hz), 2.16 (dddd, 1H, *J* = 13.6, 8.7, 7.5, 7.5 Hz), 1.92 (dddd, 1H, *J* = 13.6, 7.5, 7.5, 7.0 Hz), 1.24 (d, 3H, *J* = 7.0 Hz); ^{13}C NMR (125 MHz, $CDCl_3$) □ 167.3, 163.3, 159.9, 158.4, 155.8, 140.7, 117.9, 110.0, 104.9, 102.1, 31.6, 30.0, 26.2, 20.8, 19.7, 17.7; HRMS (EI) calcd. for $C_{16}H_{18}O_5$ ($M^{\bullet+}$) 290.1154, found 290.1154.



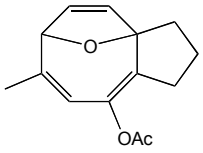
1j

3-[3-(2'-Furyl)-3-methylpropyl]-4-acetoxy-6-methylpyran-2-one 1j. The procedure described above for **1a** was applied using 4-hydroxy-6-methylpyran-2-one and 3-(2'-furyl)-2-butenylacetate[3] to yield **1j** as a yellow oil: R_f 0.80 (3:7 hexane/EtOAc); IR (DCM cast film; microscope) 1775, 1720, 1592, 1189 cm^{-1}; UV (CH_2Cl_2) □$_{max}$ 291 nm; ^{1}H NMR (500 MHz, $CDCl_3$) □ 7.29 (dd, 1H, *J* = 1.8, 0.8 Hz), 6.27 (ddd, 1H, *J* = 3.1, 1.8, 1.4 Hz), 6.01 (ddd, 1H, *J* = 3.1, 0.8, 0.8 Hz), 5.89 (q, 1H, *J* = 1.0 Hz), 2.81 (ddq, 1H, *J* = 6.9, 6.9, 6.9 Hz), 2.36-2.30 (m, 2H), 2.20 (s, 3H), 2.18 (d, 3H, *J* = 1.0 Hz), 1.79-1.74 (m, 2H), 1.24 (dd, 3H, *J* = 6.9, 1.3 Hz); ^{13}C NMR (125 MHz, $CDCl_3$) □ 167.3, 164.6, 159.9, 159.6, 158.4, 140.6, 115.2, 109.9, 103.9, 102.0, 33.3, 30.0, 22.0, 20.6, 19.7, 19.4; HRMS (EI) calcd. for $C_{16}H_{18}O_5$ ($M^{\bullet+}$) 290.1154, found 290.1161.

Tandem Photocycloaddition/Thermolysis of 1a-j

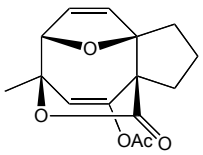
Representative Procedure: 4-Acetoxy-2-methyl-12-oxatricyclo[7.2.1.0^{5,9}]dodeca-2,4,10-triene 4a. A solution of **1a** (100 mg, 0.36 mmol) in 40mL MeOH and 60mL H_2O was placed in a 250 mL rb flask (Pyrex). The solution was irradiated under argon gas with ice/water bath for 2h, during which time reaction progress was monitored by TLC. After complete consumption of **1a**, the reaction mixture was immersed in an oil bath and heated at 55 °C for 16h. (In cases where the initial ratio of **2a** and **3a** was determined, an aliquot was removed and concentrated

and a crude ^{1}H NMR spectrum was obtained. *Endo* and *exo* isomers are easily distinguished by characteristic chemical shifts of alkene protons, and ratios were determined by integration of these signals.) After cooling, the mixture was extracted with CH_2Cl_2 (3 x 50mL). The combined organic layers were washed with brine (10 mL), dried over $MgSO_4$ and concentrated to give crude product. Flash chromatography (silica gel, 230-400 mesh, 5:5:1 hexane/Et_2O/CH_2Cl_2) gave **4a** (51mg, 0.22 mmol, 61%) and **3a** (6.3 mg, 0.023 mmol, 6%).



4a

4a: pale yellow oil; R_f 0.54 (5:5:1 hexane/Et_2O/CH_2Cl_2); IR (neat) 1753 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$) 5.64 (dd, 1H, *J* = 5.9, 1.6 Hz), 5.57 (br q, 1H, *J* = 1.2 Hz), 5.54 (dd, 1H, *J* = 5.9, 1.6 Hz), 4.90 (br s, 1H), 2.59-2.22 (m, 2H), 2.14 (s, 3H), 2.08-1.86 (m, 2H), 1.94 (br d, 3H, *J* = 1.2 Hz), 1.82-1.68 (m, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) 168.9, 143.9, 142.3, 138.1, 122.5, 121.1, 119.5, 92.5, 84.1, 36.1, 27.9, 22.7, 22.5, 20.7; HRMS calcd. for $C_{14}H_{16}O_3$ *m*/*e* 232.1111, found *m*/*e* 232.1105.

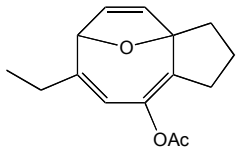


3a

3a: white solid, mp 143-145 °C; R_f 0.32 (5:5:1 hexane/Et_2O/CH_2Cl_2); IR (DCM cast film microscope) 1767, 1746 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$) 6.54 (dd, 1H, *J* = 5.7, 1.8 Hz), 5.96 (d, 1H, *J* = 5.7 Hz), 5.95 (s, 1H), 4.26 (d, 1H, *J* = 1.8 Hz), 2.52-2.38 (m, 1H), 2.29-2.17 (m, 1H), 2.13 (s, 3H), 2.09-1.90 (m, 2H), 1.75-1.61 (m, 2H), 1.45 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) 173.8, 167.7, 153.9, 135.1, 134.1, 121.9, 97.5, 85.7, 80.5, 69.6, 33.7, 27.5, 24.5, 24.4, 20.8; Anal. Cald. for $C_{15}H_{16}O_5$: C, 65.22; H, 5.84. Found: C, 65.27; H, 5.89.

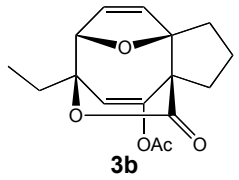
4-Acetoxy-2-ethyl-12-oxatricyclo[7.2.1.0^{5,9}]dodeca-2,4,10-triene 4b. The procedure described above was applied to substrate **1b** (200 mg, 0.69 mmol) in 50 mL MeOH/75 mL H_2O. Flash

chromatography of the crude product (silica gel, 230-400 mesh, 4:1 hexane/EtOAc) gave **4b** (105mg, 0.43 mmol, 62%) and **3b** (21 mg, 0.072 mmol, 11%).



4b

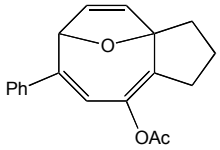
4b: pale yellow oil; R_f 0.53 (4:1 hexane/EtOAc); IR (DCM cast film; microscope) 3060, 1771, 1689, 1601, 1446 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) 5.59 (dd, 1H, *J* = 5.9, 1.6 Hz), 5.55-5.53 (m, 2H), 4.94 (br s, 1H), 2.50 (ddd, 1H, *J* = 18.5, 8.8, 8.8 Hz), 2.36 (br dd, 1H, *J* = 17.2, 8.8 Hz), 2.24 (br q, 2H, *J* = 7.4 Hz), 2.15 (br s, 3H), 2.06-2.00 (m, 2H), 1.97-1.90 (m, 1H), 1.77-1.69 (m, 1H), 1.09 (t, 3H, *J* = 7.4 Hz); ^{13}C NMR (125 MHz, $CDCl_3$) 169.1, 150.1, 142.6, 138.4, 122.7, 121.5, 118.4, 92.8, 83.7, 36.4, 29.8, 28.2, 22.8, 21.0, 13.4; HRMS (EI) calcd. for $C_{15}H_{18}O_3$ ($M^{\bullet+}$) 246.1260, found 246.1254.



3b

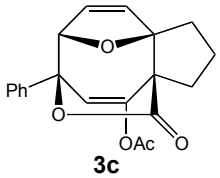
3b: pale yellow oil; R_f 0.53 (4:1 hexane/EtOAc); IR (DCM cast film; microscope) 1767, 1747, 1670 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) 6.49 (br d, 1H, *J* = 5.8 Hz), 6.04 (br s, 1H), 5.95 (dd, 1H, *J* = 5.8, 1.5 Hz), 4.31 (br s, 1H), 2.46 (dq, 1H, *J* = 7.2, 7.2 Hz), 2.26-2.17 (m, 1H), 2.13 (s, 3H), 2.09 (ddd, 1H, *J* = 14.4, 7.2, 7.2 Hz), 1.98 (ddd, 1H, *J* = 13.5, 6.3, 6.3 Hz), 1.81 (dq, 1H, *J* = 7.2, 7.2 Hz), 1.75-1.66 (m, 3H), 0.99 (dd, 3H, *J* = 7.4, 7.4 Hz); ^{13}C NMR (125 MHz, $CDCl_3$) 174.1, 167.9, 154.4, 135.1, 134.8, 120.5, 98.2, 85.1, 83.5, 69.7, 34.0, 30.6, 27.7, 24.7, 21.1, 7.0; HRMS (EI) calcd. for $C_{16}H_{18}O_5$ ($M^{\bullet+}$) 290.1154, found 290.1157.

4-Acetoxy-2-phenyl-12-oxatricyclo[7.2.1.$0^{5,9}$]dodeca-2,4,10-triene 4c. The procedure described above was applied to substrate **1c** (500 mg, 1.48 mmol) in 200 mL MeOH/150 mL H_2O. Flash chromatography of the crude product (silica gel, 230-400 mesh, 4:1 hexane/EtOAc) gave **4c** (170mg, 0.57 mmol, 39%) and **3c** (61 mg, 0.18 mmol, 12%).



4c

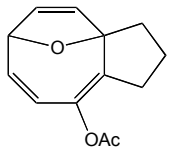
4c: pale yellow oil; R_f 0.68 (5:5:1 hexane/Et_2O/CH_2Cl_2); IR (DCM cast film; microscope) 3060, 1771, 1689, 1601, 1497 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) □ 7.41-7.28 (m, 5H), 5.98 (s, 1H), 5.66 (dd, 1H, *J* = 5.9, 1.6 Hz), 5.63 (dd, 1H, *J* = 5.9, 1.3 Hz), 5.58 (br s, 1H), 2.57 (ddd, 1H, *J* = 18.7, 10.2, 8.3 Hz), 2.44 (dddd, 1H, *J* = 18.7, 8.3, 1.5, 1.5 Hz), 2.18 (s, 3H), 2.16-2.08 (m, 2H), 2.04-1.97 (m, 1H), 1.84-1.74 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) □ 168.8, 146.3, 144.7, 139.8, 138.4, 128.6, 127.9, 126.5, 123.0, 121.5, 121.4, 93.0, 83.6, 36.1, 28.2, 22.6, 20.8; HRMS (EI) calcd. for $C_{19}H_{18}O_3$ ($M^{\bullet+}$) 294.1256, found 294.1256.



3c

3c: pale yellow oil; R_f 0.58 (5:5:1 hexane/Et_2O/CH_2Cl_2); IR (DCM cast film; microscope) 3060, 1771, 1601 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) □ 7.45-7.41 (m, 2H), 7.35-7.30 (m, 2H), 7.27-7.22 (m, 1H), 6.54 (dd, 1H, *J* = 5.6, 1.8 Hz), 6.33 (br d, 1H, *J* = 5.6 Hz), 5.75 (br s, 1H), 4.61 (br d, 1H, *J* = 1.8 Hz), 2.14-2.08 (m, 1H), 2.10 (s, 3H), 1.98-1.86 (m, 1H), 1.84-1.78 (m, 2H), 1.50 (app. dt, 1H, *J* = 14.2, 9.0 Hz), 1.35 (app. dt, 1H, *J* = 14.2, 5.3 Hz); ^{13}C NMR (125 MHz, $CDCl_3$) □ 167.3, 151.4, 141.5, 135.1, 134.9, 128.1, 127.6, 126.3, 115.1, 99.4, 83.7, 71.4, 58.4, 29.6, 25.1, 22.3, 20.9 (lactone carbonyl carbon was not detected).

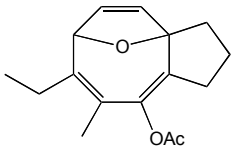
4-Acetoxy-12-oxatricyclo[7.2.1.0^{5,9}]dodeca-2,4,10-triene 4d. Substrate **1c** (55 mg, 0.21 mmol) was dissolved in 20 mL MeOH/30 mL H_2O and irradiated under the usual conditions. Following complete consumption in the photoreaction, the mixture was immersed in an oil bath and heated at 90 °C for 48 h. Work-up and flash chromatography of the crude product (silica gel, 230-400 mesh, 1:1 hexane/EtOAc) gave **4d** (6 mg, 0.027 mmol, 13%).



4d

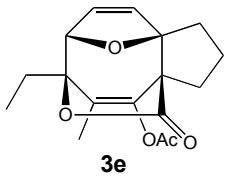
4d: pale yellow oil; R_f 0.72 (3:7 hexane/EtOAc); ^{1}H NMR (500 MHz, CD_2Cl_2) δ 6.05 (dddd, 1H, *J* = 12.0, 5.0, 1.7, 1.3 Hz), 5.74 (d, 1H, *J* = 12.0 Hz), 5.66 (br dd, 1H, *J* = 5.8, 1.7 Hz), 5.53 (dd, 1H, *J* = 5.8, 1.3 Hz), 4.97 (ddd, 1H, *J* = 5.0, 1.7, 1.7 Hz), 2.48 (br dd, 1H, *J* = 18.3, 8.3 Hz), 2.39 (br dd, 1H, *J* = 18.3, 8.3 Hz), 2.12 (s, 3H), 2.08-1.91 (m, 3H), 1.80-1.72 (m, 1H); ^{13}C NMR (125 MHz, C_2Cl_2) δ 169.2, 145.8, 139.2, 133.1, 124.0, 122.3, 121.2, 92.9, 80.2, 36.7, 28.4, 22.9, 20.9.

4-Acetoxy-2-ethyl-3-methyl-12-oxatricyclo[7.2.1.0^{5,9}]dodeca-2,4,10-triene 4e. The procedure described above for **1a** was applied to substrate **1e** (162 mg, 0.53 mmol) in 120 mL MeOH/250 mL H_2O. Flash chromatography of the crude product (silica gel, 230-400 mesh, 2:1 hexane/EtOAc) gave **4e** (82 mg, 0.31 mmol, 60%) and **3e** (16 mg, 0.052 mmol, 10%).



4e

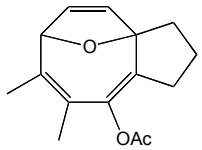
4e: pale yellow oil; R_f 0.75 (5:5:1 hexane/Et_2O/CH_2Cl_2); IR (DCM cast film; microscope) 1747, 1444, 1200 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.59-5.55 (m, 2H), 4.98 (br s, 1H), 2.52 (br m, 1H), 2.38-2.30 (m, 2H), 2.16 (br s, 3H), 2.13-2.08 (m, 1H), 2.02 (q, 2H, *J* = 7.5 Hz), 1.97-1.90 (m, 1H), 1.80-1.72 (m, 1H), 1.74 (s, 3H), 1.10 (t, 3H, *J* = 7.5 Hz); ^{13}C NMR (125 MHz, $CDCl_3$) δ 169.2, 143.9, 142.6, 139.6, 123.0, 122.4, 120.4, 92.1, 84.3, 35.9, 28.6, 27.0, 22.4, 20.5, 15.3, 12.9; HRMS (EI) calcd. for $C_{16}H_{20}O_3$ ($M^{\bullet+}$) 260.1412, found 260.1414.



3e

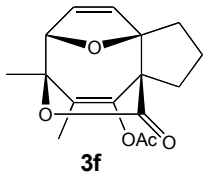
3e: pale yellow oil; R_f 0.50 (5:5:1 hexane/Et_2O/CH_2Cl_2); IR (DCM cast film; microscope) 1763, 1747, 1687, 1198 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) □ 6.45 (dd, 1H, *J* = 5.8, 1.9 Hz), 6.07 (d, 1H, *J* = 5.8Hz), 4.42 (d, 1H, *J* = 1.9 Hz), 2.43 (ddd, 1H, *J* = 12.8, 6.4, 6.4 Hz), 2.21 (ddd, 1H, *J* = 12.8, 7.8, 6.7 Hz), 2.16 (s, 3H), 2.07 (ddd, 1H, *J* = 14.5, 7.4, 7.4 Hz), 1.96 (ddd, 1H, *J* = 13.7, 7.7, 5.7 Hz), 1.90 (dq, 1H, *J* = 7.3, 7.3 Hz), 1.73-1.64 (m, 2H), 1.62 (s, 3H), 1.50 (ddd, 1H, *J* = 13.2, 7.5, 7.5 Hz), 1.11 (dd, 3H, *J* = 7.3 Hz); ^{13}C NMR (125 MHz, $CDCl_3$) □ 167.6, 148.4, 136.6, 133.1, 130.4, 97.5, 84.9, 83.6, 67.6, 33.6, 27.9, 27.8, 24.2, 20.1, 12.4, 7.4 (lactone carbonyl carbon was not detected); HRMS (EI) calcd. for $C_{17}H_{20}O_5$ ($M^{\bullet+}$) 304.1311, found 304.1313.

4-Acetoxy-2,3-dimethyl-12-oxatricyclo[7.2.1.0^{5,9}]dodeca-2,4,10-triene 4f. The procedure described above for **1a** was applied to substrate **1f** (100 mg, 0.34 mmol) in 20 mL MeOH/30 mL H_2O. Flash chromatography of the crude product (silica gel, 230-400 mesh, 2:1 hexane/EtOAc) gave **4f** (53 mg, 0.18 mmol, 63%) and **3f** (7.5 mg, 0.026 mmol, 8%).



4f

4f: pale yellow oil; R_f 0.81 (1:1 hexane/EtOAc); IR (DCM cast film; microscope) 1756, 1434, 1082 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) □ 5.60 (dd, 1H, *J* = 5.7, 1.7 Hz), 5.54 (br d, 1H, *J* = 5.7 Hz), 4.96 (br s, 1H), 2.50 (br m, 1H), 2.37-2.30 (m, 1H), 2.17 (s, 3H), 2.03-2.00 (m, 2H), 1.93 (q, 3H, *J* = 1.0 Hz), 1.91-1.89 (m, 1H), 1.75-1.72 (m, 1H), 1.71 (br s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) □ 169.2, 142.5, 140.0, 138.0, 123.5, 122.4, 120.6, 92.4, 86.1, 36.3, 28.8, 22.7, 20.8, 20.4, 16.3; HRMS (ESI) calcd for $C_{15}H_{18}O_3Na$ ($[M•Na]^+$) 269.1148, found 269.1147.

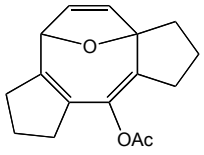


3f

3f: pale yellow oil; R_f 0.60 (1:1 hexane/EtOAc); IR (DCM cast film; microscope) 1748, 1194 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) □ 6.47 (dd, 1H, *J* = 5.8, 1.8 Hz), 6.06 (d, 1H, *J* = 5.8Hz), 4.25 (d, 1H, *J* = 1.8 Hz), 2.42 (dddd, 1H, *J* = 12.8, 6.2, 5.8, 0.7 Hz), 2.21 (ddd, 1H, *J* = 12.8, 8.4, 6.6

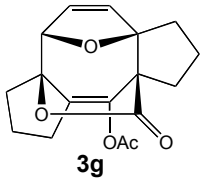
Hz), 2.15 (s, 3H), 2.06 (ddd, 1H, *J* = 13.9, 7.5, 7.5 Hz), 1.96 (ddd, 1H, *J* = 13.9, 7.9, 5.9 Hz), 1.68 (ddd, 1H, *J* = 12.5, 5.9, 5.2 Hz), 1.59 (s, 3H), 1.50 (ddd, 1H, *J* = 13.3, 8.4, 7.3 Hz), 1.45 (s, 3H, *J* = 7.3 Hz); ^{13}C NMR (125 MHz, $CDCl_3$) 173.6, 168.1, 148.2, 137.1, 132.9, 130.1, 97.5, 86.6, 83.2, 68.2, 34.0, 28.3, 24.5, 22.4, 20.3, 12.7; HRMS (EI) calcd. for $C_{16}H_{18}O_5$ ($M^{\bullet+}$) 290.1154, found 290.1154.

Tetracyclic Triene 4g. The procedure described above for **1a** was applied to substrate **1f** (185 mg, 0.61 mmol) in 100 mL MeOH/100 mL H_2O. Flash chromatography of the crude product (silica gel, 230-400 mesh, 2:1 hexane/EtOAc) gave **4g** (100 mg, 0.39 mmol, 63%) and **3g** (26 mg, 0.086 mmol, 14%).



4g

4g: pale yellow oil; R_f 0.64 (2:1 hexane/EtOAc); IR ($CHCl_3$ cast film; microscope) 1753, 1444, 1077 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$) 5.61 (dd, 1H, *J* = 5.9, 1.5 Hz), 5.50 (dd, 1H, *J* = 5.9, 1.1 Hz), 5.05 (br s, 1H), 2.68-2.61 (m, 2H), 2.56-2.45 (m, 2H), 2.44-2.34 (m, 2H), 2.14 (s, 3H), 2.06-2.00 (m, 2H), 1.95-1.66 (m, 4H); ^{13}C NMR (125 MHz, $CDCl_3$) 168.6, 143.4, 141.6, 138.5, 129.8, 121.6, 121.1, 92.2, 80.6, 36.5, 36.3, 34.1, 28.1, 22.0, 21.5, 20.5; HRMS (EI) calcd. for $C_{16}H_{18}O_3$ ($M^{\bullet+}$) 258.1256, found 258.1261.

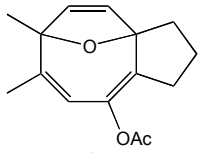


3g

3g: pale yellow oil; R_f 0.36 (2:1 hexane/EtOAc); IR ($CHCl_3$ cast film; microscope) 1746, 1437, 1189 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) 6.49 (dd, 1H, *J* = 5.8, 1.8 Hz), 6.03 (d, 1H, *J* = 5.8Hz), 4.39 (d, 1H, *J* = 1.8 Hz), 2.48-2.42 (m, 2H), 2.32-2.28 (m, 1H), 2.22-2.16 (m, 1H), 2.14 (s, 3H), 2.11-2.05 (m, 2H), 2.04-1.95 (m, 2H), 1.79-1.54 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) 168.0, 144.1, 137.7, 137.0, 132.4, 97.2, 89.4, 83.4, 68.9, 35.9, 34.2, 28.6, 28.1, 24.2, 23.7, 20.3 (lactone

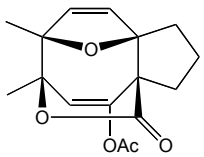
carbonyl carbon was not detected); HRMS (EI) calcd. for $C_{17}H_{18}O_5$ ($M^{\bullet+}$) 302.1154, found 302.1166.

4-Acetoxy-1,2-dimethyl-12-oxatricyclo[7.2.1.0^{5,9}]dodeca-2,4,10-triene 4h. The procedure described above for **1a** was applied to substrate **1h** (141 mg, 0.49 mmol) in 100 mL MeOH/150 mL H_2O. Flash chromatography of the crude product (silica gel, 230-400 mesh, 4:1 hexane/EtOAc) gave **4h** (60 mg, 0.24 mmol, 52%) and **3h** (11 mg, 0.038 mmol, 8%).



4h

4h: pale yellow oil; R_f 0.70 (4:1 hexane/EtOAc); IR (DCM cast film; microscope) 1759, 1437, 1370, 1190 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$) □ 5.58 (br s, 1H), 5.47 (d, 1H, *J* = 5.7 Hz), 5.39 (d, 1H, *J* = 5.7 Hz), 2.48 (dd, 1H, *J* = 18.4, 9.2 Hz), 2.33 (dd, 1H, *J* = 18.4, 8.3 Hz), 2.14 (s, 3H), 2.01-1.98 (m, 2H), 1.95 (br s, 3H), 1.93-1.89 (m, 1H), 1.75-1.68 (m, 1H), 1.51 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) □ 168.9, 145.8, 142.4, 138.6, 125.6, 120.6, 119.8, 92.8, 87.7, 36.8, 27.7, 23.0, 22.7, 22.6, 20.8; HRMS (EI) calcd for $C_{15}H_{18}O_3$ 246.1256, found 246.1253.

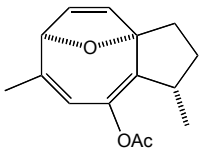


3h

3h (partial data): pale yellow oil; R_f 0.48 (2:1 hexane/EtOAc); ^{1}H NMR (500 MHz, $CDCl_3$) □ 6.28 (d, 1H, *J* = 5.6 Hz), 6.19 (d, 1H, *J* = 5.6 Hz), 6.14 (s, 1H), 2.55-2.48 (m, 1H), 2.43-2.38 (m, 1H), 2.34 (s, 3H), 2.23 (s, 3H), 1.98-1.80 (m, 2H), 1.78-1.62 (m, 2H), 1.45 (s, 3H).

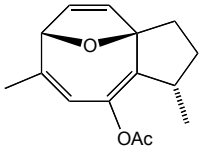
4-Acetoxy-2,6-dimethyl-12-oxatricyclo[7.2.1.0^{5,9}]dodeca-2,4,10-triene 4i. The procedure described above for **1a** was applied to substrate **1i** (180 mg, 0.62 mmol) in 150 mL MeOH/180 mL H_2O. Flash chromatography of the crude product (silica gel, 230-400 mesh, 4:1 hexane/EtOAc) gave diastereomeric trienes **4i(syn)** (56mg, 0.23 mmol, 36%) and **4i(anti)**

(12.5mg, 0.051 mmol, 8%), relative configuration tentatively assigned as shown, along with **3i(syn)** (single diastereomer; 30 mg, 0.10 mmol, 20%).



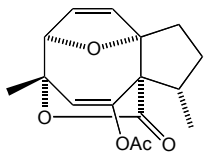
4i(syn)

4i(syn): pale yellow oil; R_f 0.49 (4:1 hexane/EtOAc); IR (DCM cast film; microscope) 1755, 1371, 1213 cm^{-1}; ^1H NMR (500 MHz, CD_2Cl_2) □ 5.68 (ddd, 1H, *J* = 5.9, 1.7, 0.7 Hz), 5.53 (dd, 1H, *J* = 5.9, 1.3 Hz), 5.51 (br q, 1H, *J* = 1.1 Hz), 4.85 (dd, 1H, *J* = 1.7, 1.3 Hz), 2.75 (br dq, 1H, *J* = 7.3, 7.3 Hz), 2.14 (br dd, 1H, *J* = 13.7, 7.0 Hz), 2.12 (s, 3H), 1.94 (ddd, 1H, *J* = 12.9, 6.1, 0.3 Hz), 1.93 (br d, 3H, *J* = 1.1 Hz), 1.84 (dddd, 1H, *J* = 12.0, 6.1, 0.8, 0.8 Hz), 1.55 (dddd, 1H, *J* = 12.6, 7.1, 0.8, 0.8 Hz), 1.14 (br d, 3H, *J* = 7.3 Hz); ^{13}C NMR (125 MHz, $CDCl_3$) □ 169.2, 146.7, 144.2, 138.9, 122.4, 121.3, 120.1, 92.9, 84.2, 34.9, 33.6, 30.8, 22.8, 20.9, 19.7; HRMS (ESI) calcd for $C_{15}H_{18}O_3Na$ ($[M•Na]^+$) 269.1148, found 269.1148.



4i(anti)

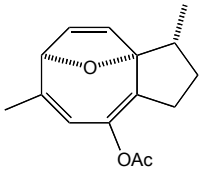
4i(anti): pale yellow oil; R_f 0.44 (4:1 hexane/EtOAc); IR (DCM cast film; microscope) 1755, 1370, 1214 cm^{-1}; ^1H NMR (500 MHz, CD_2Cl_2) □ 5.63 (br dd, 1H, *J* = 5.9, 1.7 Hz), 5.53 (dd, 1H, *J* = 5.9, 1.4 Hz), 5.50 (br q, 1H, *J* = 1.3 Hz), 4.85 (br s, 1H), 2.84 (ddq, 1H, *J* = 7.5, 7.5, 7.5 Hz), 2.12 (s, 3H), 2.11-2.05 (m, 2H), 1.96-1.93 (m, 1H), 1.92 (br s, 3H), 1.35 (ddd, 1H, *J* = 10.4, 8.6, 8.6 Hz), 1.07 (d, 3H, *J* = 6.9 Hz); ^{13}C NMR (125 MHz, $CDCl_3$) □ 169.2, 146.7, 143.9, 138.9, 122.7, 120.7, 120.2, 92.8, 83.9, 35.7, 34.9, 32.0, 22.6, 20.9, 20.0; HRMS (ESI) calcd for $C_{15}H_{18}O_3Na$ ($[M•Na]^+$) 269.1148, found 269.1145.



3i(syn)

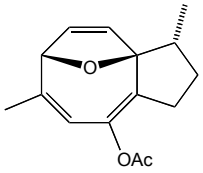
3i(syn): white solid, mp 80-82 °C; R_f 0.25 (4:1 hexane/EtOAc); IR (DCM cast film; microscope) 1771, 1748, 1202, 1176 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 6.53 (dd, 1H, *J* = 5.7, 1.9 Hz), 6.10 (s, 1H), 5.88 (d, 1H, *J* = 5.7 Hz), 4.24 (d, 1H, *J* = 1.9 Hz), 2.47 (dd, 1H, *J* = 12.8, 9.3 Hz), 2.19 (m, 1H), 2.14 (s, 3H), 2.13 (dq, 1H, *J* = 6.6, 6.6 Hz), 2.04 (ddd, 1H, *J* = 14.9, 9.3, 0.5 Hz), 1.78 (dddd, 1H, *J* = 12.8, 8.0, 6.7, 0.5 Hz), 1.42 (br s, 3H), 1.28 (d, 3H, *J* = 6.6 Hz); ^{13}C NMR (125 MHz, $CDCl_3$) δ 171.4, 167.4, 153.4, 135.4, 134.4, 121.9, 97.4, 86.3, 79.7, 71.9, 37.7, 33.2, 31.1, 24.5, 21.2, 13.4; HRMS (ESI) calcd for $C_{16}H_{18}O_5Na$ ($[M•Na]^+$) 313.1047, found 313.1049.

4-Acetoxy-2,8-dimethyl-12-oxatricyclo[7.2.1.0^{5,9}]dodeca-2,4,10-triene 4j. The procedure described above for **1a** was applied to substrate **1j** (200 mg, 0.69 mmol) in 110 mL MeOH/140 mL H_2O. Flash chromatography of the crude product (silica gel, 230-400 mesh, 4:1 hexane/EtOAc) gave **4j(syn)** (42.8mg, 0.17 mmol, 25%) and **4j(anti)** (38.8mg, 0.16 mmol, 23%), relative configuration tentatively assigned as shown, along with **3j** (24 mg, 0.10 mmol, 12%) as an inseparable mixture of diastereomers (d.r. = 1 : 2.35; not assigned).



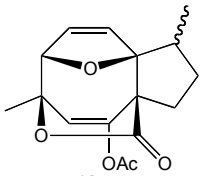
4j(syn)

4j(syn): pale yellow oil; R_f 0.70 (4:1 hexane/EtOAc); IR (DCM cast film; microscope) 1755, 1434, 1370, 1212 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 5.62 (dd, 1H, *J* = 5.9, 1.4 Hz), 5.57 (br s, 1H), 5.52 (dd, 1H, *J* = 5.9, 0.3 Hz), 4.91 (br s, 1H), 2.54 (ddd, 1H, *J* = 17.0, 9.0, 9.0 Hz), 2.33 (m, 1H), 2.27 (qd, 1H, *J* = 7.0, 2.2 Hz), 2.14 (s, 3H), 1.94 (br s, 3H), 1.90 (m, 1H), 1.60 (dddd, 1H, *J* = 12.8, 8.2, 2.3, 2.3 Hz), 1.01 (d, 3H, *J* = 7.0 Hz); ^{13}C NMR (125 MHz, $CDCl_3$) δ 168.8, 144.0, 141.9, 138.7, 123.6, 120.6, 119.7, 94.0, 84.2, 40.6, 30.1, 25.6, 22.8, 20.8, 13.5; HRMS (EI) calcd. for $C_{15}H_{18}O_3$ ($M^{•+}$) 246.1256, found 246.1254.



4j(anti)

4j(anti): pale yellow oil; R_f 0.63 (4:1 hexane/EtOAc); IR (DCM cast film; microscope) 1755, 1370, 1213 cm^{-1}; ^1H NMR (500 MHz, CD_2Cl_2) δ 5.62 (ddq, 1H, *J* = 5.9, 1.2, 1.2 Hz), 5.58 (q, 1H, *J* = 1.0 Hz), 5.46 (dd, 1H, *J* = 5.9, 1.2 Hz), 4.91 (br s, 1H), 2.44 (ddd, 1H, *J* = 18.8, 9.3, 9.3 Hz), 2.31 (dd, 1H, *J* = 18.8, 8.5 Hz), 2.18 (dq, 1H, *J* = 6.7, 6.7 Hz), 2.14 (s, 3H), 2.00 (ddd, 1H, *J* = 12.6, 7.5, 7.5 Hz), 1.94 (br d, 3H, *J* = 1.0 Hz), 1.44 (m, 1H, *J* = 12.6, 8.5 Hz), 0.90 (d, 3H, *J* = 6.7 Hz); ^{13}C NMR (125 MHz, $CDCl_3$) δ 168.9, 143.7, 142.7, 138.0, 121.4, 119.5, 119.4, 95.3, 83.9, 40.9, 30.7, 26.1, 22.8, 20.7, 13.3; HRMS (ESI) calcd for $C_{15}H_{18}O_3Na$ ($[M•Na]^+$) 269.1148, found 269.1146.



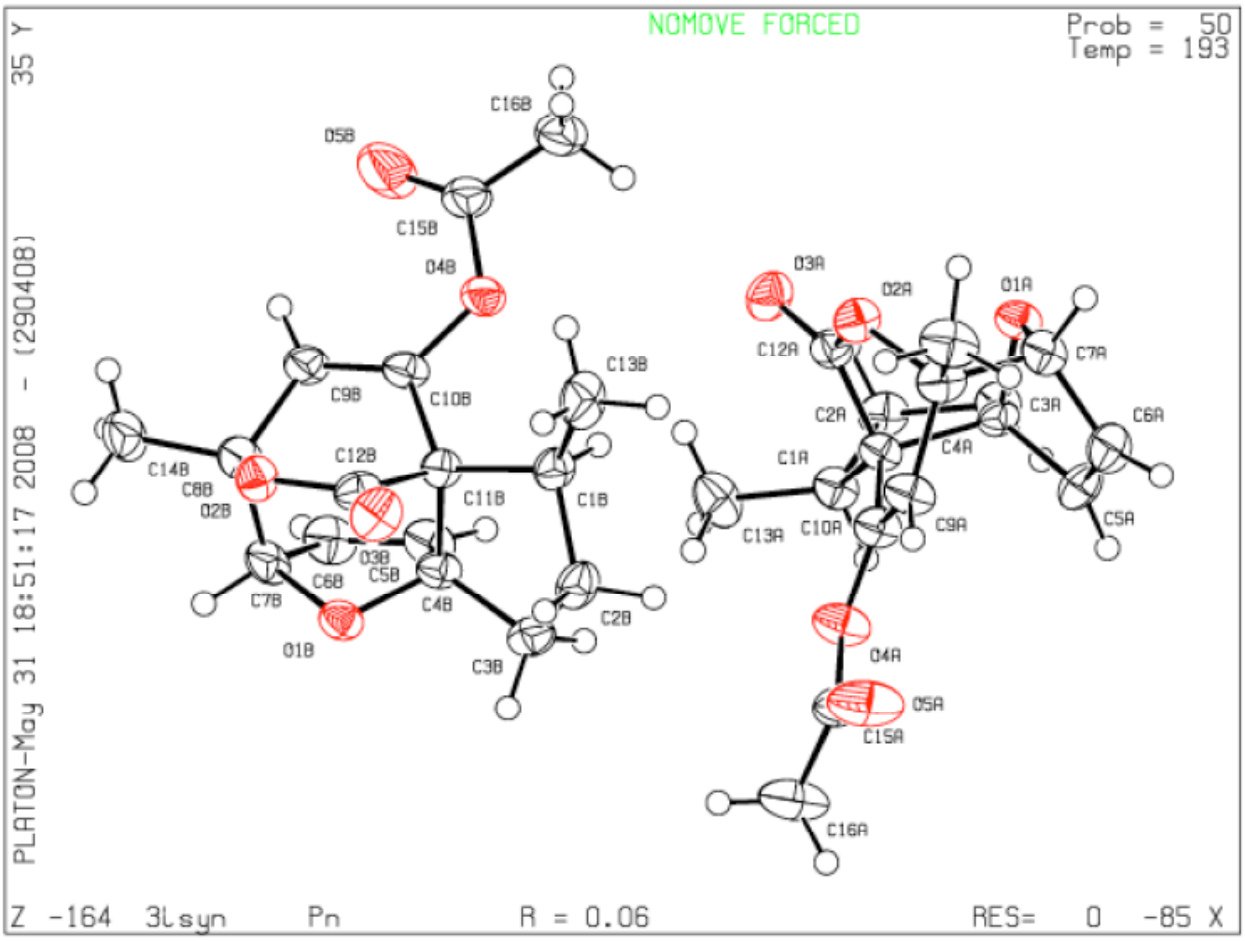
3j

Partial Data for 3j (inseparable mixture): R_f 0.33 (4:1 hexane/EtOAc); IR ($CDCl_3$ cast film; microscope) 3084, 1768, 1747, 1670, 1206, 1178 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) major diastereomer: δ 6.55 (dd, 1H, *J* = 5.7, 1.8 Hz), 5.95 (s, 1H), 5.85 (d, 1H, *J* = 5.7 Hz), 4.31 (d, 1H, *J* = 1.8 Hz), 2.30 (ddd, 1H, *J* = 13.1, 5.7, 2.8 Hz), 2.22 (dq, 1H, *J* = 10.4, 7.1 Hz), 2.13 (s, 3H), 2.00-1.88 (m, 2H), 1.56 (ddd, 1H, *J* = 13.1, 11.3, 6.6 Hz), 1.44 (s, 3H), 0.99 (d, 3H, *J* = 7.1 Hz); minor diastereomer: δ 6.53 (ddd, 1H, *J* = 5.9, 1.8, 1.0 Hz), 6.03 (d, 1H, *J* = 5.9 Hz), 5.91 (s, 1H), 4.24 (d, 1H, *J* = 1.8 Hz), 2.66 (ddd, 1H, *J* = 14.1, 11.5, 7.5 Hz), 2.22-2.16 (m, 1H), 2.14 (s, 3H), 2.14-1.96 (m, 1H), 1.77 (ddd, 1H, *J* = 14.1, 8.1, 1.6 Hz), 1.46 (s, 3H), 1.30-1.24 (m, 1H), 0.97 (d, 3H, *J* = 7.2 Hz); ^{13}C NMR (125 MHz, $CDCl_3$) major diastereomer: δ 173.7, 167.6, 154.0, 136.4, 134.3, 122.0, 97.5, 86.3, 80.4, 70.6, 39.2, 33.2, 26.5, 24.5, 20.8, 13.3; minor diastereomer: δ 174.2, 167.7, 154.3, 134.5, 131.0, 121.8, 100.9, 84.5, 80.5, 68.8, 39.1, 32.3, 24.6, 23.8, 20.9, 14.0.

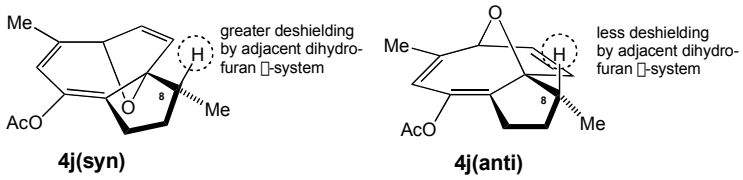
Rationale for Stereochemical Assignments of 4i and 4j

The relative configuration of *endo* [4+4]-cycloadduct **3i(syn)** was determined unambiguously by single crystal x-ray diffraction analysis (see ORTEP structure below). A solution of **3i** (10 mg, 0.034 mmol) in 40% MeOH/H_2O (2 mL) was added to a Biotage Microwave vial (0.5-2mL) with magnet and cap with septa which had been purged with Ar. The solution was irradiated under

microwave (Biotage Initiator) at 120 °C for 1h. After cooling, the mixture was extracted with CH_2Cl_2 (3 x 50mL). The combined organic layers were washed with brine (10 mL), dried over $MgSO_4$ and concentrated to give crude product. ^{1}H NMR spectra indicated a 0.68 : 1 mixture of **3i** and the previously isolated major diastereomer of **4i**, which was therefore assigned as **4i(syn)**.



For the other series, diastereomeric [4+4]-cycloadducts **3j** could not be obtained in pure form. However, a difference in chemical shifts for the methine proton at C-8 in the decarboxylation products is consistent with the tentatively assigned structures of **4j(syn)** and **4j(anti)**. This proton appears approximately 0.1 ppm further downfield in one isomer. Structures minimized using molecular mechanics indicate that H-8 in **4j(syn)** should be held close to the plane of the adjacent dihydrofuran □-system leading to greater anisotropic deshielding, whereas the same proton in **4j(anti)** is further away and unlikely to experience the same degree of deshielding.



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2. Moreno-Manas, M.; Ribas, J.; Virgili, A. *J. Org. Chem.* **1988**, *53*, 5328-5335.
3. Iwasaki, M.; Kobayashi, Y.; Li, J.; Matsuzaka, H.; Ishii, Y.; Hidai, M. *J. Org. Chem*., **1991**, *56*, 1922-1927.