Two-Directional Cross-Metathesis

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Supplementary Information

Experimental details
(2E,11E)-diethyl 7-oxotrideca-2,11-dienedioate.

To a solution of undeca-1,10-dien-6-one (0.60 mmol, 0.10 g, 1 eq) in dichloromethane (5 mL) under Ar, was added ethyl acrylate (3.61 mmol, 0.36g, 6 eq), followed by Hoveyda-Grubbs 2nd generation catalyst (0.015 mmol, 9 mg, 2.5 mol%) as a solid. The solution was stirred for 24 h, at which time another portion of catalyst (0.015 mmol, 0.009g, 2.5 mol%) was added. The solution stirred for a further 72 h, concentrated, and purification by column chromatography (eluting with 6:1 PE/EA) gave the product as a clear oil (0.54 mmol, 168 mg, 90%):

\[ \delta H(400 \text{ MHz, CDCl}_3) 6.85 (1H, dt, J 6.9, 15.6), 5.77 (1H, d, J 15.6), 4.13 (2H, q, J 7.1), 2.37 (2H, t, J 7.3), 2.15 (2H, q, J 7.1), 1.69 (2H, p, J 7.3), 1.23 (3H, t, J 7.1); \]

\[ \delta C(100 \text{ MHz, CDCl}_3) 210, 167, 148, 122, 60, 42, 32, 22, 14; \text{ IR (thin film, } \nu/\text{cm}^{-1}) \text{ C=O 1712}; \text{ HRMS calculated for } C_{17}H_{30}NO_5 (M+NH}_4^+ 328.2118, \text{ found 328.2117.} \]

(2E,11E)-Dimethyl 7-oxotrideca-2,11-dienedioate

To a solution of undeca-1,10-dien-6-one (6.02 mmol, 1.0 g, 1 eq) in dichloromethane (100 mL) under N\_2, was added methyl acrylate (36.1 mmol, 3.12 g, 6 eq), followed by Hoveyda-Grubbs 2nd generation catalyst (0.15 mmol, 94 mg, 2.5 mol%) as a solid. The solution was stirred for 24 h, at which time another portion of catalyst (0.15 mmol, 94 mg, 2.5 mol%) was added. The solution stirred for a further 72 h, concentrated, and purification by column chromatography (eluting with 5:1 H/EA) gave the product as a clear oil (0.54 mmol, 168 mg, 90%): \( R_f \) 0.20 in 3:1 H/EA; \( \delta H(400 \text{ MHz, CDCl}_3) 6.92 (2H, dt, J 7.0 and 15.7), 5.83 (2H, dt, J 1.5 and 15.7), 3.73 (6H, s), 2.42 (4H, t, J 7.3), 2.21 (4H, ddd, J 1.5, 7.0 and 7.3), 1.75 (4H, p, J 7.3); \( \delta C(125 \text{ MHz, CDCl}_3) 209, 166, 148, 122, 51, 42, 31, 22; \text{ IR (thin film, } \nu/\text{cm}^{-1}) \text{ C=O 1716; HRMS calculated for } C_{15}H_{23}O_5 (M+H) 283.1545, \text{ found 283.1573.} \]

(2E,11E)-Dibenzyl 7-oxotrideca-2,11-dienedioate

To a solution of undeca-1,10-dien-6-one (1.20 mmol, 200 mg, 1 eq) in dichloromethane (20 mL) under N\_2, was added benzyl acrylate (7.22 mmol, 1.171 g, 6 eq), followed by Hoveyda-Grubbs 2nd generation catalyst (0.03 mmol, 19 mg, 2.5 mol%) as a solid. The solution was stirred for 24 h, at which time another portion of catalyst (0.03 mmol, 19 mg, 2.5 mol%) was added. The solution stirred for a further 72 h, concentrated, and purification by column chromatography (eluting with 3:1 H / EA) gave the product as a clear oil (0.54 mmol, 168 mg, 90%): \( R_f \) 0.24 in 3:1 H / EA; \( \delta H(400 \text{ MHz, CDCl}_3) 7.40-7.30 (10H, m, 1-H), 6.96 (2H, dt, J 6.9 and 15.6), 5.87 (2H, dt, J 1.5 and 15.7), 5.17 (4H, s), 2.41 (4H, t, J 7.3), 2.20 (4H, ddd, J 1.5, 7.3 and 7.4), 1.74 (4H, p, J 7.4); \( \delta C(125 \text{ MHz, CDCl}_3) 209, 166, 148, 136,
129, 128, 122, 66, 42, 31, 22; IR (thin film, \( \nu/cm^{-1} \)) C=O 1712, 1654, Ar 3034; HRMS calculated for \( \text{C}_{27}\text{H}_{31}\text{O}_{5} \) (M+H) 435.2171, found 435.2195

\[ (2E,11E)-\text{Di-tert-butyl 7-oxotrideca-2,11-dinedioate} \]

\[ \begin{align*} &\text{To a solution of undeca-1,10-dien-6-one (1.20 mmol, 200 mg, 1 eq) in} \\
&\text{dichloromethane (20 mL) under N}_2, \text{was added tert-butyl acrylate (7.22 mmol, 0.925 g, 6 eq),} \\
&\text{followed by Hoveyda-Grubbs 2}^{\text{nd}} \text{ generation catalyst (0.03 mmol, 19 mg,} \\
&\text{2.5 mol\%)} \text{ as a solid. The solution was stirred for 24 h, at which time another} \\
&\text{portion of catalyst (0.03 mmol, 19 mg, 2.5 mol\%) was added. The solution stirred} \\
&\text{for a further 72 h, concentrated, and purification by column chromatography (over} \\
&\text{SiO}_2 \text{ eluting with 6:1 H / EA) gave the product as a clear oil (0.939 mmol, 344 mg,} \\
&\text{78\%) R} \text{f 0.37 in 3:1 H / EA; } \delta_\text{H} \text{(400 MHz, CDCl}_3 \text{) 6.80 (2H, dt, } \text{J} \text{6.9 and 15.6),} \\
&\text{5.74 (2H, dt, J 1.6 and 15.6), 2.41 (4H, t, J 7.3), 2.18 (4H, ddd, J 1.5, 7.0 and 7.4),} \\
&\text{1.74 (4H, p, J 7.4), 1.48 (9H, s); } \delta_\text{C} \text{(CDCl}_3 \text{, 125 MHz) 210, 166, 147, 124, 80, 42, 31, 28,} \\
&\text{22; IR (thin film, } \nu/cm^{-1} \text{) C=O 1707; HRMS calculated for} \text{C}_{21}\text{H}_{35}\text{O}_{5} \text{(M+H) 397.2484,} \\
&\text{found 367.2513.} \end{align*} \]

\[ (2E,11E)-\text{7-oxotrideca-2,11-diendial} \]

\[ \begin{align*} &\text{To a solution of undeca-1,10-dien-6-one (1.34 mmol, 222 mg, 1 eq) in} \\
&\text{dichloromethane (26 mL) under N}_2, \text{was added acrolein (6.69 mmol, 0.45 mL, 5 eq),} \\
&\text{followed by Hoveyda-Grubbs 2}^{\text{nd}} \text{ generation catalyst (0.03 mmol, 20 mg,} \\
&\text{2.5 mol\%) as a solid. The solution was stirred for 24 h, at which time another} \\
&\text{portion of catalyst (0.03 mmol, 20 mg, 2.5 mol\%) was added. The solution stirred} \\
&\text{for a further 144 h, concentrated, and purification by column chromatography (over} \\
&\text{SiO}_2 \text{ eluting with 1:1 ether/hexane to 7:3 ether / hexane) gave the product as a clear oil (0.837 mmol,} \\
&\text{186 mg, 63\%). } \delta_\text{H} \text{(400 MHz, CDCl}_3 \text{) 9.48 (d, } \text{J} \text{8.0 Hz, 2H), 6.78 (dt, } \text{J} \text{8.0, 15.5} \\
&\text{Hz, 2H), 6.08 (dd, } \text{J} \text{8.0, 15.5 Hz), 2.43 (t, } \text{J} \text{7.0 Hz, 4H), 2.32 (dt, } \text{J} \text{7.0, 8.0} \\
&\text{Hz, 4H), 1.78 (q, } \text{J} \text{7.0 Hz, 4H); } \delta_\text{C} \text{(CDCl}_3 \text{, 100MHz) 209, 194.0, 157.0, 132.5,} \\
&\text{42.0, 32.0, 21.5; HRMS m/z/(MH}^+): \text{calcd for} \text{C}_{13}\text{H}_{19}\text{O}_3: 223.1334, \text{found: 223.1329.} \end{align*} \]

\[ (E)-\text{Ethyl 7-hydroxydodeca-2,11-dien-2-oate} \]

\[ \begin{align*} &\text{To a solution of undeca-1,10-dien-6-ol (0.59 mmol, 100 mg, 1 eq) in} \\
&\text{dichloromethane (5 mL) under Ar, was added ethyl acrylate (3.61 mmol, 360 mg, 6 eq),} \\
&\text{followed by Hoveyda-Grubbs 2}^{\text{nd}} \text{ generation catalyst (0.015 mmol, 9 mg,} \\
&\text{2.5 mol\%) as a solid. The solution was stirred for 72 h, at which time another portion} \\
&\text{of catalyst (0.015 mmol, 9 mg, 2.5 mol\%) was added. The solution was stirred for a} \\
&\text{further 48 h, concentrated, and purification by column chromatography (eluting with}
6:1 PE / EA) gave the mono-substituted product as a clear oil (0.204 mmol, 49 mg, 35%); HRMS calculated for C_{14}H_{25}O_{3} (M+H) 241.1798, found 241.1797; \( \delta_{H} \) (400 MHz, CDCl\(_3\)) 6.89 (1H, dt, \( J \) 15.6 and 7.0), 5.80-5.66 (2H, m), 4.94 (1H, dd, \( J \) 1.6 and 17.1), 4.89 (1H, dd, \( J \) 1.2 and 10.9), 4.10 (2H, q, \( J \) 7.1), 3.53 (1H, m), 2.21-2.07 (2H, m), 2.06-1.94 (2H, m), 1.63-1.25 (8H, m), 1.22 (3H, t, \( J \) 7.1); \( \delta_{C} \) (100 MHz, CDCl\(_3\)) 167, 149, 139, 122, 115, 72, 60, 37, 34, 32, 25, 24, 14; IR (thin film, \( \nu/cm^{-1} \)) OH 3442 C=O 1718.

To a solution of undeca-1,10-dien-6-one (0.30 mmol, 50 mg, 1 eq) and buten-4-one (1.81 mmol, 127 mg, 6 eq) in dichloromethane (5 mL) under Ar, was added Hoveyda-Grubbs 2nd generation catalyst (0.015 mmol, 9 mg, 5.0 mol%). The vial was sealed and irradiated in a microwave reactor for 2 h at 120 ºC (pressure 12 bar). Another portion of the catalyst (0.015 mmol, 9 mg, 5.0 mol%) was added, and the vial irradiated for 1.5 h at 120 ºC (9 bar). After which time the solvent was removed. Purification by column chromatography (eluting with 8:1 PE / EA, followed by dichloromethane) afforded the disubstituted product as a clear oil (0.116 mmol, 29 mg, 19%).

\[ \text{(3E,12E)-Pentadeca-3,12-diene-2,8,14-trione} \]

To a solution of undeca-1,10-dien-6-one (0.60 mmol, 100 mg, 1 eq) and buten-4-one (3.61 mmol, 253 mg, 6 eq) in dichloromethane (5 mL) under Ar, was added Hoveyda-Grubbs 2nd generation catalyst (0.015 mmol, 9 mg, 2.5 mol%). The green solution slowly turned brown, and was stirred for 1 week, after which time the solution was concentrated. Purification by column chromatography (eluting with 8:1 PE / EA, followed by dichloromethane) afforded the mono-substituted product as a clear oil (0.204 mmol, 49 mg, 35%).

\[ \text{Heptadeca-4,13-diene-3,9,15-trione} \]

To a solution of undeca-1,10-dien-6-one (0.30 mmol, 50 mg, 1 eq) and buten-4-one (1.81 mmol, 127 mg, 6 eq) in dichloromethane (5 mL) under Ar, was added Hoveyda-Grubbs 2nd generation catalyst (0.015 mmol, 9 mg, 5.0 mol%). The vial was sealed and irradiated in a microwave reactor for 2 h at 120 ºC (pressure 12 bar). Another portion of the catalyst (0.015 mmol, 9 mg, 5.0 mol%) was added, and the vial irradiated for 1.5 h at 120 ºC (9 bar). After which time the solvent was removed. Purification by column chromatography (eluting with 8:1 PE / EA, followed by dichloromethane) afforded the disubstituted product as a clear oil (0.116 mmol, 29 mg, 19%).

\[ \text{Heptadeca-4,13-diene-3,9,15-trione} \]

To a solution of undeca-1,10-dien-6-one (250 mg, 1.50 mmol) in 35.0 mL of CH\(_2\)Cl\(_2\) was added pentenone (0.89 mL, 9.02 mmol) and 2.5 mol % of Hoveyda-Grubbs II catalyst (23 mg, 0.038 mmol). The mixture was stirred for 4 days, upon which an additional amount of 2.5 mol% of Hoveyda-Grubbs II catalyst was added. The resulting mixture was then stirred for 3 days and concentrated in vacuo. The residue was purified by flash column chromatography on silica gel (20% EtOAc/petrol ether) to give the title compound (365 mg, 87%) as a brown oil. \(^1H\) NMR (300 MHz ,
To a solution of undeca-1,10-dien-6-one (0.60 mmol, 100 mg, 1 eq) and phenyl vinyl sulfone (3.61 mmol, 607 mg, 6 eq) in dichloromethane (15 mL) under Ar, was added Hoveyda-Grubbs 2nd generation catalyst (0.0015 mmol, 9 mg, 2.5 mol%), and the solution was heated to ~50 ºC and stirred for 24 h, after which time another portion of catalyst (0.0015 mmol, 9 mg, 2.5 mol%) was added. The solution was stirred at 50 ºC for a further 72 h, cooled to room temperature and concentrated. Purification by column chromatography (eluting with 2:1 H / EA) yielded the product as a brown oil (0.44 mmol, 197 mg, 73%): HRMS calculated for C_{23}H_{27}O_{5}S (M+H) 447.1300, found 447.1295; \( \delta^H (400 MHz; CDCl_3) 7.80 (4H, d, J 8.2), 7.51 (6H, m), 6.87 (2H, dt, J 13.8 and 6.8), 6.26 (2H, d, J 14.1), 2.32 (4H, t, J 7.0), 2.16 (4H, dt, J 7.0 and 6.8), 1.65 (4H, m); \( \delta^C (75 MHz, CDCl_3) 209, 146, 141, 133, 131, 129, 127, 41, 30, 21; IR (thin film, \( \mu/cm^{-1} \)) CO 1713, S=O 1140.

To a stirring solution of undeca-1,10-dien-6-one (0.60 mmol, 100 mg, 1 eq) and vinyl boronic acid pinacol ester (1.81 mmol, 278 mg, 3 eq) in dichloromethane (5 mL) under argon, was added Hoveyda-Grubbs 2nd generation catalyst (0.0015 mmol, 9 mg, 2.5 mol%). The green solution slowly turned brown, and was stirred for 1 week, after which time another portion of catalyst (0.0015 mmol, 9 mg, 2.5 mol%) was added. The solution was stirred for a further week, and concentrated. Purification by column chromatography (eluting with 6:1 PE/EA) gave the mono-substituted product as a clear oil (0.28 mmol, 82 mg, 47%) HRMS calculated for C_{17}H_{29}BO_{3}Na (M+Na\(^+\)) 315.2102, found 315.2102; \( \delta^H (400 MHz; CDCl_3) 6.55 (1H, dt, J 6.5 and 18.0), 5.74 (1H, dtd, J 1.6, 6.7 and 16.9), 5.42 (1H, d, J 18.0), 5.04-4.91 (2H, m), 2.37 (4H, t, J 7.4), 2.14 (2H, q, J 6.4), 2.03 (2H, q, J 7.1), 1.66 (4H, m), 1.25 (12H, s); \( \delta^C (100 MHz, CDCl_3) 22.1, 22.8, 24.6, 24.7, 24.8, 24.8, 33.1, 35.0, 41.9, 42.0, 83.1, 83.4, 115.2, 115.3, 138.0, 153.3, 210.8; IR (thin film, \( \mu/cm^{-1} \)) CO 1713; and the di-substituted product as a clear oil (0.053 mmol, 22 mg, 9%) HRMS calculated for C_{23}H_{40}B_{2}O_{5}Na (M+Na\(^+\)) 441.2954, found 441.2953; \( \delta^H (400 MHz; CDCl_3) 6.50 (2H, dt, J 6.5 and 17.9), 5.36 (2H, dt, J 1.3 and 18.0), 2.32 (4H, t, J 7.4), 2.08 (4H, ddt, J 1.5, 6.7 and 13.7), 1.63 (4H, tt, J 7.4 and 13.5), 1.20 (12H, s); \( \delta^C (100 MHz, CDCl_3) 22, 25, 35, 42, 83, 115, 153, 211; IR (thin film, \( \mu/cm^{-1} \)) CO 1712.

**1,13-Dibromo-trideca-2,11-dien-7-one**
To a solution of undeca-1,10-dien-6-one (100 mg, 0.60 mmol) in 7.0 mL of CH$_2$Cl$_2$ was added allyl bromide (0.32 mL, 3.61 mmol) and 2.5 mol % of Hoveyda-Grubbs II catalyst (9 mg, 0.015 mmol). The mixture was stirred at rt for 8 days under nitrogen, and then a second portion of Hoveyda-Grubbs II catalyst (2.5 mol%) was added. The resulting mixture was then stirred for 2 days and concentrated in vacuo. The residue was purified by flash column chromatography on silica gel (10% EtOAc/petrol ether) to give the title compound (74 mg, 35%) as a brown oil. 

$\text{max (thin film) cm}^{-1}$ 2972, 1709, 1661, 1591, 1371, 1265, 1155, 1091, 1047, 965; $\delta$H (300 MHz, CDCl$_3$) 5.73-5.69 (m, 4H), 3.94 (d, $J = 6.3$ Hz, 4H), 2.40 (d, $J = 7.2$ Hz, 4H), 2.07 (q, $J = 7.2$ Hz, 4H), 1.67 (quint, $J = 7.2$ Hz, 4H); $\delta$C (75 MHz, CDCl$_3$) 210.3, 135.5, 127.2, 41.8, 33.2, 31.3, 22.7. 

$\text{m/z (ES+)}$ 273 (M-81, 16%), 271 (17), 191 (11), 353 (8); HRMS: Found: 271.0692. C$_{13}$H$_{20}$Br$_2$O (M-79Br) Requires 271.0698.

5-Hydroxynona-2,7-dienedioic acid diethyl ester and 5-hydroxy-octa-2,7-dienoic acid ethyl ester

General procedure I was followed using ethyl acrylate (1.17 mL, 10.7 mmol), 295 (100 mg, 0.892 mmol) and stirring over 89 hours. Purification by column chromatography over silica gel (eluting with 1:3 ethyl acetate / hexane) gave the title compound 302 (101 mg, 44%) as a colourless oil; R$_f$ 0.13 (1:2 ethyl acetate / hexane); $\text{max (thin film) cm}^{-1}$ 3481 (alcohol), 1709 (ester), 1654 (olefin); $\delta$H (400 MHz, CDCl$_3$) 6.92 (2H, dt, $J = 15.7$ and 7.3), 5.86 (2H, d, $J = 15.7$), 4.13 (4H, q, $J = 7.1$), 3.92-3.83 (1H, m), 2.83 (1H, d, $J = 4.3$), 2.42-2.27 (4H, m), 1.23 (6H, t, $J = 7.1$); $\delta$C (101 MHz, CDCl$_3$) 166.2, 144.4, 124.0, 69.0, 60.3, 39.6, 14.1; $\text{m/z (Cl)}$ 274.2 (M+NH$_4^+$, 28%), 257.1 (M+H$^+$, 50), 132.0 (100); HRMS: Found 274.1649. C$_{13}$H$_{20}$NO$_5$ (M+NH$_4^+$) Requires 274.1649.

The column chromatography also yielded the title compound 301 (31.8 mg, 19%) as a colourless oil; R$_f$ 0.23 (1:2 ethyl acetate / hexane); $\text{max (thin film) cm}^{-1}$ 3465 (alcohol), 1708 (ester), 1653 (olefin); $\delta$H (400 MHz, CDCl$_3$) 6.97 (1H, dt, $J = 15.7$ and 7.4), 5.90 (1H, dd, $J = 15.7$ and 1.3), 5.86-5.74 (1H, m), 5.15 (1H, d, $J = 11.2$), 5.14 (1H d, $J = 15.8$), 4.17 (2H, q, $J = 7.1$), 3.85-3.76 (1H, m), 2.46-2.26 (3H, m), 2.24-2.13 (1H, m), 1.92 (1H, d, $J = 2.9$), 1.27 (3H, t, $J = 7.1$); $\delta$C (101 MHz, CDCl$_3$) 166.3, 144.9, 134.0, 123.9, 118.7, 69.3, 60.3, 41.5, 39.3, 14.2; $\text{m/z (Cl)}$ 202.1 (M+NH$_4^+$, 100%), 185.1 (30), 158.0 (31); HRMS: Found 202.1439. C$_{10}$H$_{16}$NO$_3$ (M+NH$_4^+$) Requires 202.1438.

5-Oxonona[2,6]/[2,7]/[3,6]dienedioic acid diethyl esters
To a solution of the hept-1,7-dien-4-one (100 mg, 0.908 mmol in DCM (5 mL)) under argon was added ethyl acrylate (0.59 mL, 5.45 mmol), 6 eq) followed by Grubbs Hoveyda 2\textsuperscript{nd} generation catalyst (2.5 mol%). The solution was stirred at ambient temperature for 24 hours then additional catalyst (2.5 mol%) was added. The reaction was stirred for a further 65 hours after which the reaction was concentrated \textit{in vacuo} and the crude purified directly by column chromatography over silica gel (eluting with 1:3 ethyl acetate / hexane) gave the \textit{title compounds} (18.0 mg, 8.0%) as an inseparable mixture of olefin regioisomers as a colourless oil; \(R_f\) 0.12-0.14 (1:3 ethyl acetate / hexane); \(\nu_{\text{max}}\) (neat)/cm\(^{-1}\) 1750-1650 (broad carbonyl bands); \(\delta_H\) (400 MHz, CDCl\(_3\)) 7.10-6.84 (2H, m, 3-H, 7-H), 6.47-5.84 (2H, m), 4.22-4.11 (4H, m), 3.51-3.21 (4H, m), 1.30-1.22 (6H, m); \(\delta_C\) (101 MHz, CDCl\(_3\)) 202.2, 195.3 and 188.4, 169.8, 169.7, 165.7 and 165.6, 140.0, 139.4, 138.8 and 138.8, 132.1, 131.1, 125.5 and 125.0, 61.3, 61.2, 60.6 and 60.5, 45.4, 42.9, 37.8, 37.6, 14.2 and 14.1.

\((2E,9E)\)-Diethyl 6-hydroxyundeca-2,9-dienedioate

To a solution of nona-1,8-dien-5-ol (0.71 mmol, 100 mg, 1 eq) in dichloromethane (5 mL) under Ar, was added ethyl acrylate (4.28 mmol, 428 mg, 6 eq), followed by Hoveyda-Grubbs 2\textsuperscript{nd} generation catalyst (0.018 mmol, 11 mg, 2.5 mol%) as a solid. The solution was stirred for 150 h, monitoring by TLC, after which time another portion of catalyst (0.018 mmol, 11 mg, 2.5 mol%) and was stirred for a further 24 h. The reaction mixture was concentrated and purification by column chromatography (eluting with 6:1 H / EA) gave the product as a clear oil (0.10 mmol, 29 mg, 14%): HRMS calculated for C\(_{15}\)H\(_{25}\)O\(_5\) (M+H) 285.1697, found 283.1700; \(\delta_H\) (400 MHz, CDCl\(_3\)) 6.92 (2H, dt, \(J_{6.9}\) and 16.1), 5.83 (2H, dd, \(J_{1.3}\) and 16.0), 4.17 (2H, q, \(J_{7.2}\)), 3.60 (1H, m), 2.46 (4H, m), 1.61 (4H, m), 1.30 (6H, t, \(J_{7.2}\)).

\((2E,9E)\)-Diethyl 6-tert-butyldimethylsilyloxyundeca-2,9-dienedioate

To a solution of tert-butyldimethyl(nona-1,8-dien-5-yloxy)silane (0.39 mmol, 100 mg, 1 eq) in dichloromethane (5 mL) under Ar, was added ethyl acrylate (2.36 mmol, 354 mg, 6 eq), followed by Hoveyda-Grubbs 2\textsuperscript{nd} generation catalyst (0.01 mmol, 6 mg, 2.5 mol%) as a solid. The solution was stirred for 120 h, monitoring by TLC, after which time the reaction mixture was concentrated and purification by column chromatography (eluting with 9:1 H / EA) gave the product as a clear oil (0.23 mmol, 90 mg, 57%): HRMS calculated for C\(_{21}\)H\(_{39}\)O\(_5\)Si (M+H) 399.2561, found 399.2568; \(\delta_H\) (400 MHz, CDCl\(_3\)) 6.96 (2H, dt, \(J_{15.6}\) and 7.2), 5.83 (2H, dd, \(J_{15.6}\) and 7.2), 4.19 (4H, q, \(J_{7.2}\)), 3.60 (1H, m), 2.46 (4H, m), 1.61 (4H, m), 1.30 (6H, t, \(J_{7.2}\)).
Diethyl (2E,9E)-6-oxoundeca-2,9-dienedioate:

To a solution of nona-1,8-dien-5-one (1.54 g, 11.09 mmol) in dichloromethane (60 cm³) under inert N₂ atmosphere, was added sequentially ethyl acrylate (7.25 cm³, 66.6 mmol) and Hoveyda-Grubbs second generation catalyst (174 mg, .28 mmol). The mixture was stirred at room temperature for 5 days. More catalyst (90 mg, 0.14 mmol) was then added and the reaction was stirred for further 2 days. After TLC monitoring, more catalyst (40 mg, 0.06 mmol) was added and the reaction mixture was allowed to stir for 2 days. Then the solvent was evaporated and the resulting brown oil was purified by column chromatography on silica, using a mixture of petroleum ether and ethyl acetate (75:25) as eluent, to afford the title compound (2.07 g, 66%) as a clear oil.

6-[[2'-(Trimethylsilyl)ethyl]sulfonylamino]undeca-2,9-dienedioic acid diethyl ester

To a solution of the 5-[[2'-(trimethylsilyl)ethyl]sulfonylamino]nona-1,8-diene (100 mg, 0.329 mmol) in DCM (5 mL) under argon was added ethyl acrylate (0.22 mL, 1.98 mmol, 6 eq) followed by Grubbs Hoveyda 2nd generation catalyst (2.5 mol%). The solution was stirred at ambient temperature for 24 hours then additional catalyst (2.5 mol%) was added. The reaction was stirred for a further 24 hours after which the reaction was concentrated in vacuo and the crude purified directly by column chromatography over silica gel (eluting with 1:3 ethyl acetate / hexane) gave the title compound 305 (114 mg, 77%) as a colourless oil; Rf 0.27 (1:2 ethyl acetate / hexane); νmax (thin film)/cm⁻¹ 3278 (N-H), 1716 (ester), 1654 (olefin), 1369 and 1142 (sulfonamide); δH (400 MHz, CDCl₃) 6.91 (2H, t, J 7.1), 5.83 (2H, dt, J 15.6 and 6.8), 4.53 (1H, d, J 9.3), 4.16 (4H, q, J 7.1), 3.44-3.33 (1H, m), 2.93-2.86 (2H, m), 2.39-2.20 (4H, m), 1.74-1.55 (4H, m), 1.26 (6H, t, J 7.1), 1.03-0.96 (2H, m), 0.03 (9H, s); δC (101 MHz, CDCl₃) 166.3, 147.3, 122.1, 60.3, 53.4, 50.3, 34.1, 28.3, 14.2, 10.7, -2.0; m/z (ES) 465.4 (M+H⁺, 90%), 448.3 (M+H⁺, 100); HRMS: Found 448.2182. C₂₀H₃₈NO₆S₂₈Si (M+H⁺) Requires 448.2184.

5-Benzylxycarbonylamino-deca-2,8-dienedioic acid diethyl ester
To a solution of the 4-benzyloxycarbonylamino-octa-1,7-diene (40 mg, 0.135 mmol) in DCM (5 mL) under argon was added ethyl acrylate (0.18 mL, 1.63 mmol, 6 eq) followed by Grubbs Hoveyda 2nd generation catalyst (2.5 mol%). The solution was stirred at ambient temperature for 24 hours then additional catalyst (2.5 mol%) was added. The reaction was stirred for a further 65 hours after which the reaction was concentrated in vacuo and the crude purified directly by column chromatography over silica gel (eluting with 1:3 ethyl acetate / hexane) which gave the title compound (10.0 mg, 18%) as a colourless oil; Rf 0.35 (1:3 ethyl acetate / hexane); \( \delta_H \) (400 MHz, CDCl3) 7.39-7.30 (5H, m), 6.96-6.82 (2H, m), 5.87 (1H, d, J 16.0), 5.82 (1H, d, J 15.7), 5.09 (2H, s), 4.58 (1H, d, J 8.8), 4.19 (2H, q, J 7.1), 4.18 (2H, q, J 7.1), 5.82 (1H, d, J 15.7), 5.09 (2H, s), 4.58 (1H, d, J 8.8), 4.19 (2H, q, J 7.1), 4.18 (2H, q, J 7.1), 5.87-3.76 (1H, m), 2.49-2.35 (2H, m), 2.31-2.20 (2H, m), 1.73-1.62 (1H, m), 1.61-1.51 (1H, m), 1.29 (3H, t, J 7.1), 1.28 (3H, t, J 7.1); \( \delta_C \) (101 MHz, CDCl3) 166.1, 155.9, 147.4, 143.6, 136.5, 128.7, 128.3, 128.2, 124.8, 122.2, 66.9, 60.4, 60.2, 50.0, 37.7, 33.1, 28.6, 14.1; m/z (ES) 421.3 (M+H2O+, 35%), 404.2 (M+H+, 100), 296.2 (70); HRMS: Found 404.2066. C22H30NO6 (M+H+) Requires 404.2068.

The column chromatography also yielded 77% of the ring-closed product: M.p. 64-66 ºC, (lit. 1 64-67 ºC); Rf 0.37 (1:4 ethyl acetate / hexane); \( \delta_H \) (400 MHz, CDCl3) 7.36-7.29 (5H, m), 5.67 (1H, m), 5.59 (1H, m), 5.09 (2H, s), 4.80 (1H, br s), 3.87 (1H, m), 2.39 (1H, m), 2.12 (2H, m), 1.94-1.86 (2H, m), 1.63-1.50 (1H, m).

\( (E) \)-Ethyl 7-hydroxydodeca-2,11-dienoate

To a solution of undeca-1,10-dien-6-ol (0.59 mmol, 100 mg, 1 eq) in dichloromethane (5 mL) under Ar, was added ethyl acrylate (3.61 mmol, 360 mg, 6 eq), followed by Hoveyda-Grubbs 2nd generation catalyst (0.015 mmol, 9 mg, 2.5 mol%) as a solid. The solution was stirred for 72 h, at which time another portion of catalyst (0.015 mmol, 9 mg, 2.5 mol%) was added. The solution was stirred for a further 48 h, concentrated, and purified by column chromatography (eluting with 6:1 PE / EA) gave the mono-substituted product as a clear oil (0.204 mmol, 49 mg, 35%); HRMS calculated for C14H25O3 (M+H) 241.1798, found 241.1797; \( \delta_H \) (400 MHz, CDCl3) 6.89 (1H, dt, J 15.6 and 7.0), 5.80-5.66 (2H, m), 4.94 (1H, dd, J 16.6 and 17.1), 4.89 (1H, dd, J 1.2 and 10.9), 4.10 (2H, q, J 7.1), 3.53 (1H, m), 2.21-2.07 (2H, m), 2.06-1.94 (2H, m), 1.63-1.25 (8H, m), 1.22 (3H, t, J 7.1); \( \delta_C \) (100 MHz, CDCl3) 167, 149, 139, 122, 115, 72, 60, 37, 34, 32, 25, 24, 14; IR (thin film, \( \nu/cm^{-1} \)) OH 3442 C=O 1718.

The disubstituted product was also obtained as a clear oil (0.083 mmol, 26 mg, 14%): HRMS calculated for C17H30O5 (M+H) 313.2010, found 313.2007; \( \delta_H \) (400 MHz, CDCl3) 6.90 (2H, dt, J 15.6 and 7.0), 5.77 (2H, d, J 15.6), 4.12 (4H, t, J 7.1), 3.55 (1H, m), 2.18 (4H, d, J 6.8), 1.60-1.52 (4H, m), 1.42 (4H, m), 1.24 (6H, q, J 7.1); \( \delta_C \) (100 MHz, CDCl3) 167, 149, 122, 72, 60, 37, 34, 32, 25, 24, 14; IR (thin film, \( \nu/cm^{-1} \)) OH 3483 C=O 1718.
(2E,11E)-Diethyl 7-tert-butyldimethylsilyloxytrideca-2,11-dienedioate

![Chemical structure](image)

To a solution of tert-butyldimethyl(undeca-1,10-dien-6-yloxy)silane (0.35 mmol, 100 mg, 1 eq) in dichloromethane (5 mL) under Ar, was added ethyl acrylate (2.12 mmol, 213 mg, 6 eq), followed by Hoveyda-Grubbs 2nd generation catalyst (0.009 mmol, 6 mg, 2.5 mol%) as a solid. The solution was stirred for 96 h, monitoring by TLC, after which time the reaction mixture was concentrated and purification by column chromatography (eluting with 9:1 H / EA) gave the product as a brown oil (0.23 mmol, 99 mg, 67%): HRMS calculated for C$_{23}$H$_{43}$O$_5$Si (M+H) 427.2874, found 427.2870; $\delta$H (400 MHz, CDCl$_3$) 6.92 (2H, dt, J 15.4 and 6.9) 5.78 (2H, dd, J 15.6 and 1.3), 4.15 (4H, q, J 7.1), 3.62 (1H, s), 2.16 (4H, m), 1.56-1.32 (8H, m), 1.26 (6H, t, J 7.1), 0.85 (9H, s), 0.03 (6H, s); $\delta$C (100 MHz, CDCl$_3$) 171, 153, 125, 76, 65, 41, 37, 30, 28, 23, 19, 0; IR (thin film, $\nu$/cm$^{-1}$) C=O 1719.

(2E,11E)-Diethyl 7-(1,3-dioxoisindolin-2-yl)trideca-2,11-dienedioate

![Chemical structure](image)

To a stirring solution of 2-(undeca-1,10-dien-6-y1)isoindoline-1,3-dione (0.168 mmol, 50 mg, 1 eq) in dichloromethane was added ethyl acrylate (1.02 mmol, 0.11 mL, 6 eq) followed by Hoveyda-Grubbs 2nd generation catalyst (0.0042 mmol, 3 mg, 2.5 mol%) as solid. The solution was stirred for at room temperature 96 h, monitoring by TLC, after which time another portion of catalyst (0.0042 mmol, 3 mg, 2.5 mol%) was added. The reaction mixture was stirred at room temperature for a further 24 h, at which point it was concentrated and subjected to purification by column chromatography (over SiO$_2$ eluting with 6:1 H/EA) yielding the product (0.149 mmol, 66 mg, 89%) as a clear yellow oil: R$_f$ 0.6 in 2:1 H/EA; HRMS calculated for C$_{25}$H$_{32}$NO$_6$ (M+H) 442.2224, found 442.2220; $\delta$H (270 MHz, CDCl$_3$) 7.79-7.84 (2H, m, Ar-H), 7.69-7.74 (2H, m, Ar-H), 6.84 (2H, dd, J 15.70 and 7.02), 5.79 (2H, dt, J 15.70 and 1.45), 4.14 (4H, q, J 7.16), 2.03-2.25 (5H, m), 1.61-1.79 (4H, m), 1.33-1.46 (4H, m), 1.19-1.30 (6H, m); $\delta$C (270 MHz, CDCl$_3$) 166.7, 148.4, 134.1, 131.7, 123.4, 121.8, 60.3, 51.5, 32.0, 31.8, 25.1, 14.3; IR (thin film, $\nu$/cm$^{-1}$) C=O 1706.

(2E)-Ethyl 6-((E)-ethyl 5-(para-methoxybenzylcarbamoyl)pent-2-enoyl)hex-2-enoate

![Chemical structure](image)
To a solution of $N$-(para-methoxybenzyl)$-N$-(pent-4-enyl)pent-4-enamide (0.35 mmol, 100 mg, 1 eq) in dichloromethane (5 mL) under Ar, was added ethyl acrylate (2.09 mmol, 209 mg, 6 eq), followed by Hoveyda-Grubbs 2nd generation catalyst (0.009 mmol, 5 mg, 2.5 mol%) as a solid. The solution was stirred for 48 h, at which time another portion of catalyst (0.009 mmol, 0.005g, 2.5 mol%) was added. The solution stirred for a further 96 h, concentrated, and purification by column chromatography (eluting with 2:1 H / EA) gave the product as a brown oil (0.27 mmol, 118 mg, 79%): HRMS calculated for C$_{24}$H$_{34}$N$_2$O$_6$ (M+H) 432.2381, found 432.2382; $\delta$H (400 MHz, CDCl$_3$) 7.14-6.72 (6H, m), 5.85 and 5.78 (2H, dd, J 1.6 and 15.6, rotomers), 4.46 and 4.39 (2H, s, rotomers), 4.11 ( 4H, q, J 7.0), 3.78 and 3.77 (3H, s, rotomers), 3.31 and 3.11 (2H, t, J 7.8, rotomers), 2.62-2.33 (4H, m), 2.10 (2H, dt, J 6.7 and 15.1), 1.61 (2H, p, J 7.3), 1.28-1.13 (6H, m); $\delta$C (75 MHz, CDCl$_3$) 171.7, 171.1, 166.5, 159.3, 147.8, 147.5, 146.8, 129.4, 127.4, 122.5, 122.1, 121.8, 114.4, 114.0, 60.2, 60.0, 55.2, 55.1, 50.6, 47.7, 46.0, 45.8, 31.4, 31.2, 29.5, 29.1, 27.6, 27.4, 26.7, 25.8, 14.0; IR (thin film, $\nu$/cm$^{-1}$) C=O 1711 1643.

References