An Efficient Route to Triene Synthons for Putative Intermediates in Polyether Antibiotic Biosynthesis

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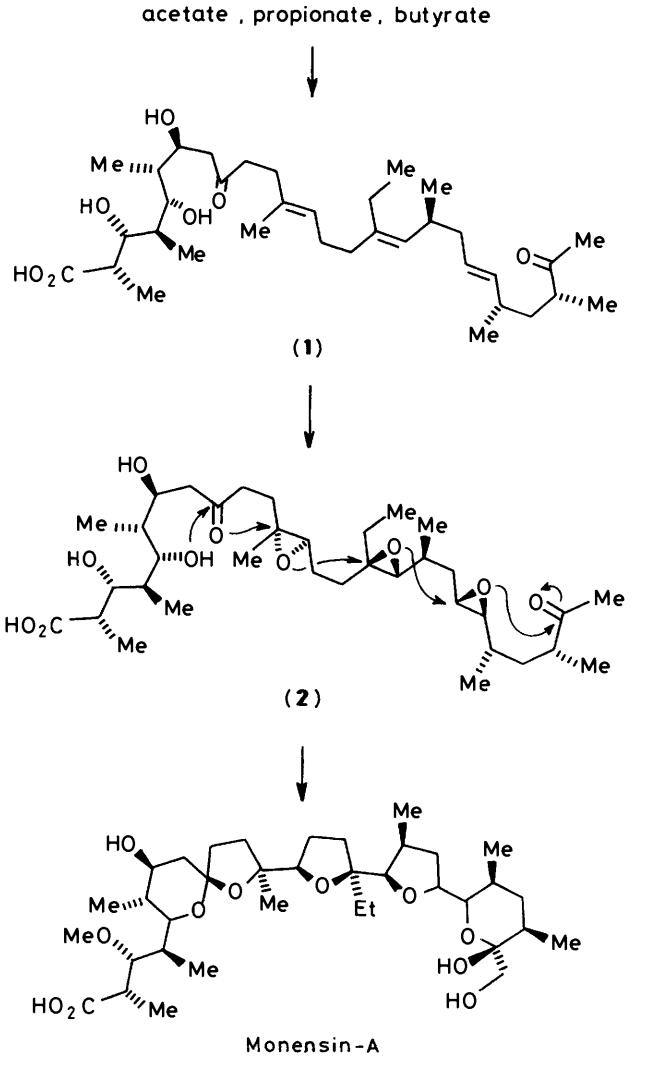
Current research to establish the late stages of polyether antibiotic biosynthesis *via* polyepoxide cyclization cascades, as formulated by Cane, Celmer, and Westley, requires the availability through synthesis of relevant putative triene intermediates. The development of practical synthetic methodology to one such triene system is reported in this paper. A synthesis of the triene building block (**4**) has been accomplished from inexpensive starting materials, using in a key step a modification of the Julia-Lythgoe olefination reaction. Thus the sulphone (**8**) was prepared in 14 steps from geranyl bromide, in an overall yield of 23%. The optically pure ester (**9**) was derived from *meso*-2,4-dimethylglutaric anhydride in four steps with an overall yield of 17%. The sulphone (**8**) was coupled efficiently with the ester (**9**), and the coupled product was subsequently transformed into the triene (**4**).

The Cane-Celmer-Westley model[1] for polyether antibiotic biosynthesis provides an attractive rationale for the formation of the oxygen-heterocyclic ring systems in these natural products from acyclic fatty acid-like precursors. According to this model the formation of monensin-A would proceed *via* the triene intermediate (**1**) and the triepoxide (**2**) (Scheme 1) with an elegant cyclization cascade leading then to the polyether antibiotic.[2-4] The design of experiments that might provide support for this scheme is now of great interest and recently there have appeared reports[5,7] of total syntheses of the putative intermediates (**1**) and (**3**). With these and other closely related derivatives available, incorporation experiments with whole-cell or cell-free systems derived from the antibiotic producing organism might be undertaken. As a part of our programme of research on polyether antibiotic biosynthesis, we sought to develop synthetic methodology that would furnish such triene systems on a practicable scale, affording quantities of material sufficient for in-depth biochemical investigations. We report in this paper some results of this work which comprise an efficient synthesis of the triene (**4**), a model closely related to the synthons (**5**) and (**6**) used in the earlier reported syntheses[5,7] of (**1**) and (**3**), and itself a key synthetic building block for the putative triene intermediate (**7**), in maduramicin biosynthesis[8] (Scheme 2).

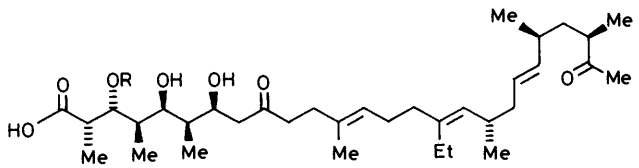


Scheme 1.

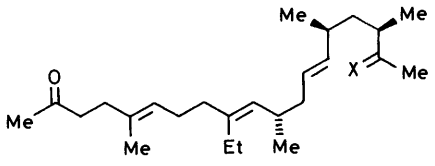
Results and Discussion

The obvious retrosynthetic step from the triene unit (**4**) would generate a sulphone and an aldehyde or ester, which may be coupled by the Julia-Lythgoe olefination reaction[9-12] to afford selectively the desired *E*-disubstituted double bond. After some experimentation, our route to (**4**) focussed on the union of the sulphone (**8**) and the ester (**9**), whose coupling by this method could be achieved in high yields.

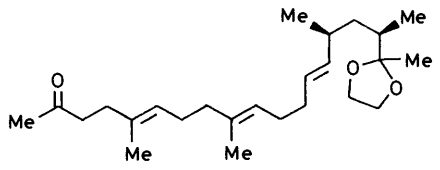
The sulphone (**8**) was readily available in 13 relatively straightforward and high-yielding steps from geranyl bromide, following the route shown in Scheme 3. Thus alkylation of dimethyl sodiomalonate with geranyl bromide afforded a diester, which after demethoxycarbonylation[13] gave the monoester (**10**) in 72% yield. A catalytic selenium dioxide allylic oxidation[14] of (**10**) yielded a mixture of the required *E*-allylic alcohol, the corresponding aldehyde, and starting material in a 1:1:1 ratio. Treatment of this mixture with sodium borohydride afforded the *E*-allylic alcohol (**11**) in 55% overall yield, along with 31% recovered starting material. No isomers of (**11**) were detected in this product, by highfield ^1H and ^{13}C n.m.r. spectroscopy. The alcohol (**11**) was then converted into an allylic chloride for alkylation of methyl sodioacetoacetate. A subsequent demethoxycarbonylation then afforded the keto ester (**12**) in



(1) R = H
(3) R = Me



(5) X = OMe
(6) X = O—CH$_2$ / O—CH$_2$



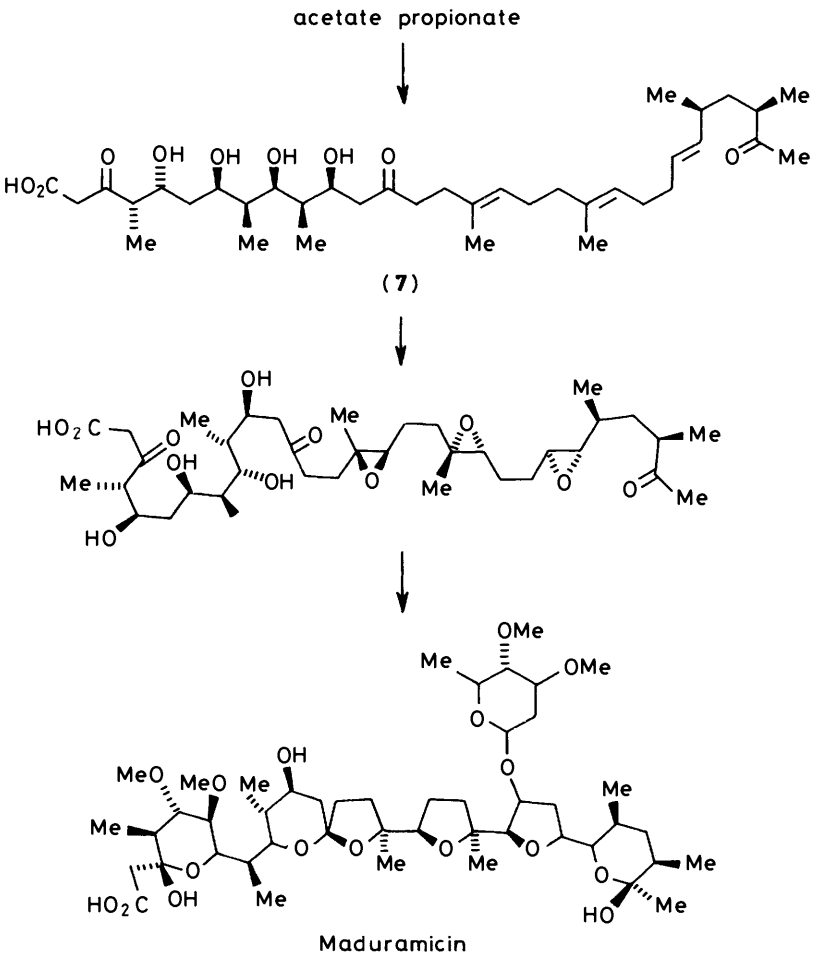
(4)

75% yield from the alcohol (**11**). The keto ester (**12**) could be converted into the sulphone (**8**) efficiently, as shown in Scheme 3.

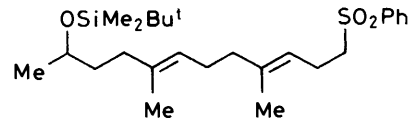
For the right hand fragment of our target triene we required initially the ester (**9**) in an optically pure form, with the requisite (2*S*,4*R*) absolute configuration. Closely related systems have been synthesized previously,[6] and our starting point was the optically pure acid (**13**), which has been prepared previously by two methods. One method used the selective hydrolysis of *meso*-dimethyl 2,4-dimethylglutarate by the fungus *Gliocladium roseum*,[15] whereas the second employed the fractional crystallization of (**13**) as the (*S*)-(−)-1-phenylethylamine salt.[16,17] For our purposes, the latter was considered the more convenient approach.

Configurationally pure *meso*-2,4-dimethylglutaric anhydride[18] was opened by methanolysis and the desired monoacid (**13**) was purified as the (*S*)-(−)-1-phenylethylamine salt by recrystallization from ethyl acetate. Neutralization of the salt gave (**13**) in 20% overall yield, and in 99% enantiomeric excess, based on a comparison of its optical rotation with literature values. The monoacid (**13**) was subsequently converted into the desired ester (**9**) by the route shown in Scheme 4.

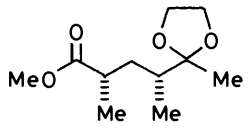
The classical Julia-Lythgoe olefin synthesis[9–12] involves the condensation of a sulphone anion with an aldehyde, followed by reductive elimination of the β-tosyloxy, β-mesyloxy-, or β-benzoyloxy- sulphone, to afford predominantly the *E*-olefin. Our initial experiments with this coupling procedure were carried out with the aldehyde (**14**) and the sulphone (**15**). These



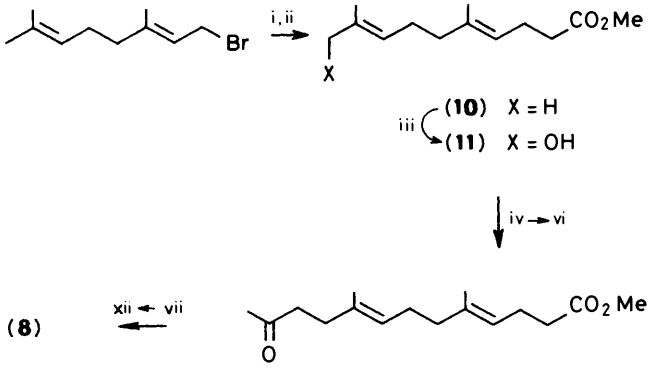
Scheme 2.



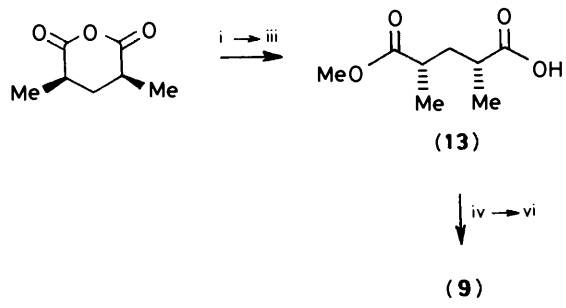
(8)



(9)



Scheme 3. *Reagents:* i, $NaCH(CO_2Et)_2$; ii, Me_2SO, H_2O, NaCl, Heat; iii, SeO_2, Bu^tO_2H, then $NaBH_4$; iv, PPh_3, CCl_4; v, $NaCH(Ac)CO_2Me$; vi, Me_2SO, H_2O, NaCl, Heat; vii, $NaBH_4$; viii, Bu^tMe_2SiCl; ix, $LiAlH_4$; x, Tos·Cl; xi, NaI, EtCOMe; xii, $PhSO_2Na$

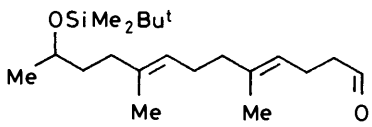


(13)

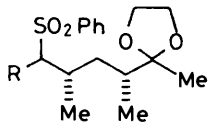
(9)

Scheme 4. *Reagents:* i, MeOH; ii, (−)-PhCH(NH_2)Me, recrystallize; iii, HCl; iv, $(COCl)_2$ C_6H_6; v, Me_2CuLi; vi, $HOCH_2CH_2OH$, $PyrH^+Tos^-$

materials were derived in high yields by conventional methods, starting from the keto ester (**12**) and the ketal ester (**9**), respectively. Condensation of the aldehyde (**14**) with the lithiosulphone (**16**) at −78 °C, followed by quenching of the reaction with benzoyl chloride gave the β-benzoyloxysulphone (**17**) as a mixture of diastereoisomers. Unfortunately, this material with sodium amalgam, gave the triene (**18**) in an unacceptably low yield of 35%. Furthermore, examination of the highfield ^{13}C n.m.r. spectrum of this product revealed it to be a mixture of the all-*E* and *E,E,Z* isomers in a 3:1 ratio. Although minor improvements in the yield of this step could be found through optimization of the reaction conditions, these

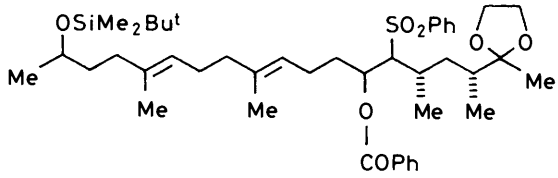


(14)



(15) R = H

(16) R = Li



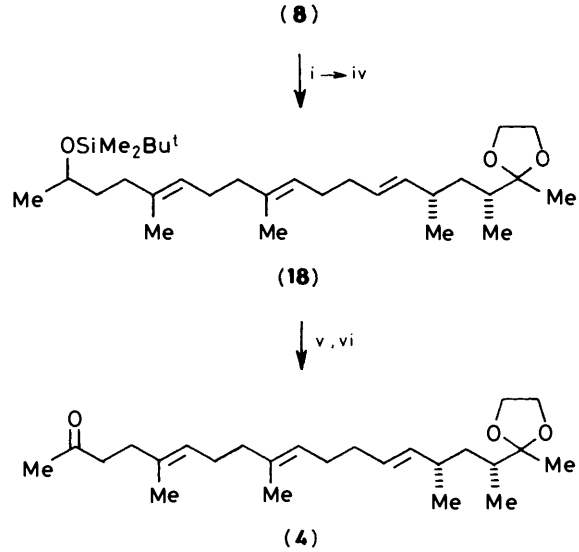
(17)

were considered insufficient for this crucial stage of the synthesis, given our requirement for multigram quantities of the triene (**18**).

As an alternative we investigated the condensation of the sulphone (**8**) with the ketal ester (**9**). Studies of sulphone anion[19,20] and dianion[21,22] additions to esters have been made. Recently Trost and co-workers[23] have converted the product of such a condensation, a β-keto sulphone, through to an *E*-olefin, as part of their synthetic work on brefeldin-A.

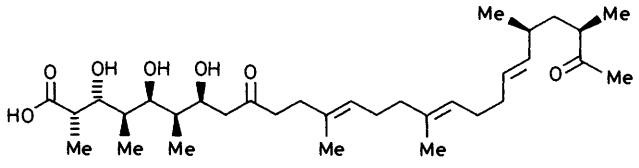
After some experimentation an optimized route was developed, as shown in Scheme 5. This coupling procedure afforded the triene (**18**) in an overall yield of 89% based on the ester (**9**). An analysis of the highfield ^{13}C n.m.r. spectra of this product, showed the presence of both the all-*E* and *E,E,Z* isomers in the ratio 4:1, which could be separated after careful column chromatography on silver nitrate-impregnated silica gel. Finally, the triene (**18**) could be converted easily into the target synthon (**4**) by deprotection of the hydroxy group and subsequent oxidation to the ketone.

The production of the triene (**4**), and the methodology developed in this work, should facilitate studies on the chemistry and biochemistry of polyether antibiotic formation.



Scheme 5. *Reagents:* i, LDA then (**9**); ii, $NaBH_4$; iii, BuLi, PhCOCl; iv, HgNa, MeOH; v, Bu_4NF; vi, CrO_3, Pyr

Thus we are currently applying aspects of the chemistry described above in a new and efficient synthesis of the putative monensin precursor (**1**). In addition, the methyl ketone (**4**) will be of value in the synthesis of the putative maduramicin precursor (**7**), as well as other interesting triene systems. It is also worth noting that for future studies on the enzymology of the late states of polyether antibiotic biosynthesis a triene system such as (**19**), derived from (**4**), may prove suitable for *in*



(**19**)

vitro assays of the relevant epoxidizing and cyclizing enzymes on the monensin pathway, given its ready availability, and given also the likely slack substrate specificities of these secondary metabolic enzymes.[1]

Experimental

I.r. spectra were recorded on a Perkin-Elmer 298 spectrophotometer. N.m.r. spectra were obtained at 360 MHz for proton, and 90.5 MHz for carbon, on a Bruker AM360 spectrometer. Mass spectra and accurate mass measurements were recorded on a Kratos-AEI MS30 spectrometer at an ionizing potential of 70 keV. Flash chromatography was performed according to the procedure described by Still and co-workers,[24] using Kieselgel 60 230—400 mesh. Light petroleum refers to the fraction with b.p. 60—80 °C.

(4E,8E)-*Methyl* 2-*Methoxycarbonyl*-5,9-*dimethyldeca*-4,8-*dienoate*.—Sodium hydride (60% dispersion in oil; 32 g, 0.80 mol) was washed with dry tetrahydrofuran (2 × 20 ml), and the supernatant liquid was decanted. The solid was taken up in tetrahydrofuran (500 ml) and *N*,*N*-dimethylformamide (500 ml), the solution cooled to 0 °C, and dimethyl malonate (106 g, 92.0 ml, 0.80 mol) added over 30 min. Geranyl bromide[25] (168 g, 0.78 mol) was added and the suspension was stirred at 0 °C for 60 min. The suspension was then dissolved in water, and the solution was extracted with diethyl ether. The extracts were washed with water and brine, dried ($MgSO_4$), and evaporated under reduced pressure to give a yellow oil (228 g). A portion of this oil was purified by flash chromatography [diethyl ether–light petroleum (1:5)] to afford pure title compound[26] as a colourless oil, b.p. 135—136 °C at 0.1 mmHg (Found: M^+, 268.1678. Calc. for $C_{15}H_{24}O_{24}$: *M*, 268.1675); $\nu_{max.}$ (liq. film) 2 960s, 2 940s, 2 860m, 1 740s, 1 480m, 1 250m, and 800m cm^{-1}; δ_H (360 MHz; $CDCl_3$, TMS) 1.58 (3 H, s, Me), 1.62 (3 H, s, Me), 1.68 (3 H, s, Me), 2.00 (4 H, m, allyl H), 2.58 (2 H, t, *J* 7.5 Hz, CH_2CHCO_2Me), 3.46 (1 H, t, *J* 7.5 Hz, CH_2CHCO_2Me), 3.65 (6 H, s, Me esters), and 5.05 (2 H, m, vinyl-H); δ_C (90.6 MHz, $CDCl_3$, TMS) 16.03 (q), 17.66 (q), 25.62 (q), 26.68 (t), 27.65 (t), 39.77 (t), 52.00 (d), 52.27 (2 C, q), 119.75 (d), 124.12 (d), 131.39 (s), 138.64 (s), and 169.00 (2 C, s); *m*/*z* (e.i.) 268 (M^+, 2.1%), 132 (100), 109 (30), 93 (56), 81 (54), 69 (67), 59 (31), and 41 (68).

(4E,8E)-*Methyl* 5,9-*Dimethyldeca*-4,8-*dienoate*.—To a solution of (4*E*,8*E*)-methyl 2-methoxycarbonyl-5,9-dimethyldeca-4,8-dienoate (228 g, 0.85 mol) in dimethyl sulphoxide (250 ml) was added water (28.8 ml, 1.6 mol), and sodium chloride (70.13 g, 1.2 mol). The suspension was heated under reflux for 3 h after which it was poured into water and extracted with diethyl ether. The extract was washed with water and brine, dried ($MgSO_4$), and evaporated under reduced pressure. The residue was distilled under vacuum to afford pure title compound[27] (118 g, 72%) as a colourless oil, b.p. 84—86 °C at 0.1 mmHg (Found: M^+, 210.1645. Calc. for $C_{13}H_{22}O_2$: *M*, 210.1620); $\nu_{max.}$ (liq. film) 2 980s, 2 920s, 2 860m, 1 740s, 1 440m, 1 300m, 1 200m, 1 170m, and 860m cm^{-1}; δ_H (360 MHz, $CDCl_3$, TMS) 1.59 (3 H, s, Me), 1.62 (3 H, s, Me), 1.67 (3 H, s, Me), 2.02 (4 H, m, allyl H), 2.32 (4 H, m, 2- and 3-H_2), 3.66 (3 H, s, Me ester), and 5.06 (2 H, m, vinyl-H); δ_C (90.6 MHz, $CDCl_3$, TMS) 15.97 (q), 17.66 (q), 23.74 (t), 25.66 (q), 26.86 (t), 34.33 (t), 39.85 (t), 51.24 (q), 122.68 (d), 124.46 (d), 131.22 (s), 136.63 (s), and 173.46 (s); *m*/*z* (e.i.) 210 (M^+, 1.9%), 167 (18), 99 (25), 81 (34), 69 (100), and 41 (83.5).

(4E,8E)-*Methyl*-10-*Hydroxy*-5,9-*dimethyldeca*-4,8-*dienoate*.—To a solution of (4*E*,8*E*)-methyl 5,9-dimethyldeca-4,8-dienoate (77 g, 0.36 mol) in dichloromethane (250 ml) was added selenium dioxide (0.8 g, 7.2 mmol), salicylic acid (5.0 g, 36 mmol), and t-butyl hydroperoxide (90% solution; 130 ml, 1.0 mol). The solution was stirred for 28 h and then evaporated to 25% volume under reduced pressure at 20 °C. The reaction mixture was poured into 10% aqueous sodium hydroxide and extracted with diethyl ether. The extract was washed with water and brine, dried (Na_2SO_4), and evaporated under reduced pressure. The residue was taken up in methanol (200 ml), the solution cooled to 0 °C, and sodium borohydride (2.2 g, 60 mmol) slowly added. The mixture was stirred for 60 min at 0 °C after which it was evaporated to 25% volume under reduced pressure, poured into brine, and extracted with diethyl ether. The extract was washed with brine and water, dried (Na_2SO_4), and evaporated under reduced pressure. The residue was fractionally distilled from 2% aqueous potassium carbonate *in vacuo* to afford, after a forerun of starting material (23 g, 31%), the *title compound* (45 g, 55%) as a colourless oil, b.p. 118 °C at 0.1 mmHg (Found: M^+, 226.1563. $C_{13}H_{22}O_3$ requires *M*, 226.1569); $\nu_{max.}$ (liq. film) 3 680—3 100br, 2 920s, 2 680s, 1 740s, 1 430m, 1 190m, 1 010m, and 840w cm^{-1}; δ_H (360 MHz, $CDCl_3$, TMS) 1.62 (3 H, s, Me), 1.65 (3 H, s, Me), 2.07 (4 H, m, allyl H), 2.33 (4 H, m, 2- and 3-H_2), 3.66 (3 H, s, Me ester), 3.96 (2 H, s, CH_2OH), 5.10 (1 H, m, 4-H), and 5.35 (1 H, m, 8-H); δ_C (90.6 MHz, $CDCl_3$, TMS) 13.66 (q), 15.92 (q), 23.66 (t), 26.10 (t), 34.37 (t), 39.29 (t), 51.43 (q), 68.80 (t), 122.79 (d), 125.54 (d), 135.15 (s), 136.35 (s), and 173.87 (s); *m*/*z* (e.i.) 226 (M^+, 0.6%), 208 (18, M − H_2O), 195 (3, M − OMe), 140 (11), 99 (46), 81 (82), 74 (27), 59 (24), 43 (100), and 41 (69).

The acetate derivative of the alcohol was made, by standard procedures, for accurate elemental analysis (Found: C, 67.2; H, 8.9. $C_{15}H_{24}O_4$ requires C, 67.1; H, 9.0%).

(4E,8E)-*Methyl* 10-*Chloro*-5,9-*dimethyldeca*-4,8-*dienoate*.—To a solution of (4*E*,8*E*)-methyl-10-hydroxy-5,9-dimethyldeca-4,8-dienoate (24 g, 0.1 mol) in carbon tetrachloride (100 ml, 1.0 mol) and acetonitrile (100 ml) at −25 °C was added triphenylphosphine (30 g, 0.12 mol). After 18 h at −25 °C the reaction mixture was evaporated under reduced pressure at 20 °C to give a slurry. This was taken up in light petroleum (200 ml) and the solution filtered through Celite; evaporation of the filtrate under reduced pressure afforded the *title compound* (24.3 g, 99%) of sufficient purity for the subsequent alkylation. A portion was purified for analysis, by column chromatography on Florisil [diethyl ether–light petroleum (1:9)] to yield pure product as an unstable colourless oil (Found: M^+ − Cl, 209.1521. $C_{13}H_{21}O_2$ requires *M*, 209.1521); $\nu_{max.}$(CCl_4) 2 980s, 2 860m, 1 740s, 1 430s, 1 350s, and 1 250s cm^{-1}; δ_H (360 MHz; $CDCl_3$, TMS), 1.63 (3 H, s, Me), 1.73 (3 H, s, Me), 2.00 (4 H, m, allyl H), 2.30 (4 H, m, 2- and 3-H_2), 3.65 (3 H, s, Me ester), 4.00 (2 H, s, CH_2Cl), 5.10 (1 H, m, 4-H), and 5.51 (1 H, m, 8-H); δ_C (90.6 MHz, $CDCl_3$, TMS) 14.07 (q), 15.91 (q), 23.75 (t), 26.72 (t), 34.21 (t), 39.02 (t), 51.13 (q), 52.16 (t), 123.44 (d), 130.30 (d),

132.10 (s), 135.83 (s), and 173.06 (s); *m/z* (e.i.), 209 (M^+ − Cl, 16.5%), 213 (1), 208 (24), 109 (38), 99 (88), 81 (100), 59 (25), and 43 (22).

(4E,8E)-*Methyl* 11-*Methoxycarbonyl*-5,9-*dimethyl*-12-*oxotrideca*-4,8-*dienoate*.—Sodium hydride (60% dispersion in oil; 4.66 g, 0.11 mol) was washed with dry tetrahydrofuran (2 × 20 ml) and the supernatant liquid was decanted. The solid was resuspended in dry tetrahydrofuran (300 ml) and dry *N*,*N*-dimethylformamide (100 ml) and cooled to 0 °C. Methyl acetoacetate (12.70 ml, 0.11 mol) was added over 30 min followed by the addition of (4*E*,8*E*)-methyl 10-chloro-5,9-dimethyldeca-4,8-dienoate (24.3 g, 0.10 mol). The reaction was then heated under reflux for 3 h, poured into water, and extracted with diethyl ether. The extract was washed with water and brine, dried (Na_2SO_4), and evaporated under reduced pressure to afford, as a yellow oil, the *title compound* (30 g, 93%) of sufficient purity for the subsequent demethoxycarbonylation. A small amount was purified by column chromatography on Florisil [diethyl ether–light petroleum (1:5)] to yield pure product as a colourless oil (Found: M^+, 324.1916. $C_{18}H_{28}O_5$ requires *M*, 324.1936); $\nu_{max.}(CCl_4)$ 2 960s, 2 920s, 2 860m, 1 750s, 1 725s, 1 440m, 1 360s, 1 250s, 1 200s, 1 160s, 890w, and 850m cm^{-1}; δ_H (360 MHz; $CDCl_3$, TMS) 1.60 (6 H, s, 2 × Me), 2.00 (4 H, m, allyl H), 2.20 (3 H, s, Me ketone), 2.30 (4 H, m, 2- and 3-H_2), 2.51 (2 H, d, *J* 7.8 Hz, 10-H_2), 3.70 (1 H, t, *J* 7.8 Hz, 11-H), 3.75 (3 H, s, 1-OMe), 3.80 (3 H, s, 11-CO_2Me), and 5.20 (2 H, m, vinyl-H); δ_C (90.6 MHz; $CDCl_3$, TMS) 15.88 (q), 15.93 (q), 23.63 (t), 26.60 (t), 28.70 (q), 34.27 (t), 38.07 (t), 39.38 (t), 51.34 (q), 52.18 (q), 58.53 (d), 122.78 (d), 127.17 (d), 131.22 (s), 136.30 (s), 170.08 (s). 173.64 (s), and 202.11 (s); *m/z* (e.i.) 324 (M^+, 0.1%), 293 (1), 208 (23), 157 (18), 109 (60), 99 (18), 81 (46), 59 (13), 43 (100), and 41 (16).

(4E,8E)-*Methyl* 5,9-*Dimethyl*-12-*oxotrideca*-4,8-*dienoate*.—To a solution of (4*E*,8*E*)-methyl 11-methoxycarbonyl-5,9-dimethyl-12-oxotrideca-4,8-dienoate (30.0 g, 92 mmol) in dimethyl sulphoxide (100 ml) and water (3.6 ml, 0.2 mmol) was added sodium chloride (12.1 g, 0.2 mol). The reaction mixture was heated under reflux for 3 h after which it was poured into water and extracted with diethyl ether. The extract was then washed with water and brine, dried ($MgSO_4$), and evaporated under reduced pressure. The residue was distilled under vacuum to afford pure title compound (22.5 g, 75%) as a colourless oil, b.p. 138 °C at 0.1 mmHg (Found: M^+ − OMe, 235.1683. $C_{26}H_{23}O_2$ requires *M*, 235.1698); $\nu_{max.}(CCl_4)$ 2 960s, 2 920s, 2 860m, 1 740s, 1 720s, 1 440s, 1 360s, 1 250s, 1 200s, 1 160s, and 890w cm^{-1}; δ_H (360 MHz; $CDCl_3$, TJS) 1.59 (3 H, s, Me), 1.61 (3 H, s, Me), 2.00 (4 H, m, allyl H), 2.06 (3 H, s, Me ketone), 2.18 (2 H, t, *J* 7.0 Hz, 10-H_2), 2.25 (4 H, m, 2- and 3-H_2), 2.45 (2 H, t, *J* 7.0 Hz, 11-H_2), 3.60 (3 H, s, Me ester), and 5.02 (2 H, m, vinyl-H); δ_C (90 6. MHz, $CDCl_3$, TMS) 15.88 (q), 16.00 (q), 23.47 (t), 26.37 (t), 29.38 (q), 33.48 (t), 34.02 (t), 39.41 (t), 42.18 (t), 50.93 (q), 122.73 (d), 124.61 (d), 133.55 (s), 136.03 (s), 172.66 (s), 206.15 (s); *m/z* (e.i.) 266 (M^+, 2.0%), 235 (7), 208 (64), 167 (24), 125 (36), 109 (20), 107 (22), 99 (35), 81 (47), and 43 (100).

(4E,8E,12RS)-*Methyl* 12-*Hydroxy*-5,9-*dimethyltrideca*-4,8-*dienoate*.—To a solution of (4*E*,8*E*)-methyl 5,9-dimethyl-12-oxotrideca-4,8-dienoate (13.77 g, 52 mmol) in methanol (100 ml) at 0 °C was added sodium borohydride (1.98 g, 52 mmol). The reaction mixture was stirred at 0 °C for 2 h after which it was evaporated under reduced pressure to 25% volume, diluted with water, and extracted with diethyl ether. The extract was washed with water and brine, dried ($MgSO_4$), and evaporated under reduced pressure to afford, after flash chromatography [diethyl ether–light petroleum (1:1)], pure *title compound* (13.93 g, 100%), as a colourless oil (Found: M^+, 268.2018. $C_{16}H_{28}O_3$ requires M^+, 268.2038); $\nu_{max.}$ (liq. film) 3 650—3 100br, 2 960s, 2 920, 2 860, 1 740s, 1 440s, 1 370, 1 250m, and 890w cm^{-1}; δ_H (360 MHz; $CDCl_3$, TMS) 1.19 (3 H, d, *J* 6.1 Hz, CHMe), 1.53 (2 H, m, 11-H_2), 1.61 (6 H, s, 5-Me, 9-Me), 1.75 (1 H, br s, absent with D_2O, OH), 2.05 (6 H, m, 6-, 7-, and 10-H_2), 2.33 (4 H, m, 2- and 3-H_2), 3.67 (3 H, s, Me ester), 3.77 (1 H, m, *J* 6.1 Hz, 12-H), and 5.15 (2 H, m, vinyl-H); δ_C (90.6 MHz, $CDCl_3$, TMS), 15.73 (q), 15.78 (q), 23.32 (q), 23.43 (t), 26.34 (t), 34.12 (t), 35.82 (t), 37.42 (t), 39.43 (t), 51.15 (q), 67.51 (d), 122.41 (d), 124.18 (d), 134.88 (s), 136.36 (s), and 172.86 (s); *m/z* (e.i.) 268 (M^+, 0.4%), 250 (2.5, $M - H_2O$), 109 (100), 99 (21), 81 (42), 67 (66), 59 (8), 55 (29), 43 (22), and 41 (32).

(4E,8E,12RS)-*Methyl* 12-*Dimethyl*-*t*-*butylsiloxy*-5,9-*dimethyltrideca*-4,8-*dienoate*.—To a solution of (4*E*,8*E*,12*RS*)-methyl-12-hydroxy-5,9-trideca-4,8-dienoate (2.76 g, 10.32 mmol) in dry *N*,*N*-dimethylformamide (100 ml) was added imidazole (6.8 g, 100 ml) and sublimed dimethyl-t-butylsilyl chloride (1.86 g, 12.3 mmol). The solution was stirred for 18 h at 20 °C and then poured into water and extracted with diethyl ether. The extract was washed with dilute hydrochloric acid (0.1%), saturated aqueous sodium hydrogencarbonate, and brine, dried (Na_2SO_4), and evaporated under reduced pressure to afford, after flash chromatography [dichloromethane–light petroleum (1:2)], pure *title compound* (3.58 g, 95%) as a colourless oil (Found: C, 68.9; H, 10.9%; $M^+ - C_4H_9$, 325.2199. $C_{22}H_{42}O_3Si$ requires C, 69.0; H, 11.0%; $C_{18}H_{33}O_3Si$ requires M^+, 325.2200); $\nu_{max.}(CCl_4)$ 2 960s, 2 940s, 2 860s, 1 745s, 1 460m, 1 440m, 1 380m, 1 360m, 1 250s, 1 140s, 1 100s, 890w, and 850s cm^{-1}; δ_H (360 MHz; $CDCl_3$), 0.10 (6 H, s, SiMe), 0.89 (9 H, s, $SiCMe_3$), 1.19 (3 H, d, *J* 6.1 Hz, CH*Me*), 1.53 (2 H, m, 11-H_2), 1.58 (3 H, s, Me), 1.61 (3 H, s, Me), 2.05 (6 H, m, 6- and 10-H_2), 2.33 (4 H, m, 4- and 3-H_2), 3.67 (3 H, s, Me ester), 3.77 (1 H, m, *J* 6.1 Hz, CHMe), and 5.15 (2 H, m, vinyl-H); δ_C (90.6 MHz, $CDCl_3$) −4.58 (q), −4.27 (q), 15.98 (q), 16.08 (q), 18.23 (s), 23.70 (t), 23.77 (q), 26.01 (q), 26.59 (t), 34.33 (t), 35.92 (t), 38.47 (t), 39.78 (t), 51.15 (q), 68.15 (d), 122.61 (d), 124.00 (d), 135.17 (s), 136.59 (s), and 173.37 (s); *m/z* (e.i.) 325 ($M^+ - C_4H_9$, 48%), 159 (17), 109 (100), 81 (24), 75 (58), 73 (32), 68 (22), 59 (10), 43 (8), and 41 (17).

(4E,8E,12RS)-12-*Dimethyl*-*t*-*butylsilyloxy*-5,9-*dimethyltrideca*-4,8-*dien*-1-*ol*.—To a suspension of lithium aluminium hydride (0.30 g, 7.7 mmol) in dry ether (30 ml) was added a solution of (4*E*,8*E*,12*RS*)-methyl-12-dimethyl-t-butylsiloxy-5,9-dimethyltrideca-4,8-dienoate (2.95 g, 7.7 mmol) in dry diethyl ether (20 ml), the mixture being maintained under gentle reflux. The suspension was stirred for 20 min after which it was carefully quenched with ethyl acetate and saturated aqueous sodium sulphate (7.7 ml). The supernatant liquid was decanted and the solvent evaporated under reduced pressure to afford, after flash chromatography (neat dichloromethane), pure title compound (2.72 g, 100%) as a colourless oil (Found: $M^+ - C_4H_9$, 297.2225·$C_{17}H_{33}O_2Si$ requires M^+, 297.2250); $\nu_{max.}(CCl_4)$ 3 650—3 100br, 2 960s, 2 940s, 2 860s, 1 460m, 1 440m, 1 360m, 1 250s, 1 140, 890w, and 850m cm^{-1}; δ_H (360 MHz, $CDCl_3$), 0.10 (6 H, s, $SiMe_2$), 0.89 (9 H, s, $SiCMe_3$), 1.19 (3 H, d, *J* 6.1 Hz), 1.53 (4 H, m, 11- and 2-H_2), 1.58 (3 H. s, 5-Me), 1.60 (3 H, s, 9-Me), 2.04 (8 H, m, allyl-H), 2.65 (1 H, br s, absent with D_2O, OH), 3.61 (2 H, t, *J* 6.8 Hz, CH_2OH), 3.74 (1 H, m, *J* 6.1 Hz, $CHCH_3$), 5.13 (2 H, m, vinyl-H); δ_C (90.6 MHz; $CDCl_3$) −4.52 (q), −4.22 (q), 16.04 (q), 16.16 (q), 18.23 (s), 23.43 (q), 24.30 (t), 25.95 (q), 26.48 (t), 33.72 (t), 35.95 (t), 37.49 (t), 39.63 (t), 62.72 (t), 68.68 (d), 124.03 (d), 124.52 (d), 135.29 (s), and 135.89 (s); *m/z* (e.i.) 297 ($M^+ - C_4H_9$, 4%), 121 (14), 109 (99), 95 (38), 75 (100), 67 (54), 55 (37), 43 (13), and 41 (34).

(4E,8E,12RS)-12-*Dimethyl-t-butylsiloxy*-5,9-*dimethyltrideca*-4,8-*dienyl Toluene*-p-*sulphonate*.—To a solution of (4*E*,8*E*,12*RS*)-12-dimethyl-t-butylsiloxy-5,9-dimethyltrideca-4,8-dien-1-ol (4.20 g, 11.8 mmol) in dichloromethane (25 ml) was added triethylamine (2.15 ml, 15.4 mmol), 4-dimethylaminopyridine (0.4 g, 1.18 mmol), and toluene-*p*-sulphonyl chloride (2.48 g, 13 mmol). After being stirred at 20 °C for 3 h the reaction mixture was poured into water and extracted with ether. The extract was washed with water and brine, dried (Na_2SO_4), and evaporated to afford, after flash chromatography [diethyl ether–light petroleum (1:3)], pure *title compound* (5.29 g, 97%) as a colourless oil (Found: $M^+ - C_4H_9$, 451.2271. $C_{24}H_{39}O_4SSi$ requires *M*, 451.2271); $\nu_{max.}(CCl_4)$ 3 050w, 2 960s, 2 940s, and 1 610 cm^{-1}; δ_H (360 MHz; $CDCl_3$), 0.10 (6 H, s, $SiMe_2$), 0.90 (9 H, s, $SiCMe_3$), 1.12 (3 H, d, *J* 6.1 Hz, CH-Me), 1.47 (2 H, m, 11-H_2), 1.58 (3 H, s, 9-Me), 1.60 (3 H, s, 5-Me), 1.68 (2 H, m, 2-H_2), 1.95 (8 H, m, allyl-H), 2.45 (3 H, s, ArMe), 3.75 (1 H, m, *J* 6.1 Hz, 12-H), 4.00 (2 H, t, *J* 6.4 Hz, CH_2OTs), 4.98 (1 H, m, vinyl H), 5.07 (1 H, m, vinyl H), 7.35 (2 H, d, *J* 8.5 Hz, ArH), and 7.80 (2 H, d, *J* 8.5 Hz, ArH); δ_C (90.6 MHz; $CDCl_3$) −4.54 (q), −4.22 (q), 16.15 (q), 18.21 (s), 21.64 (q), 23.80 (t), 24.80 (q), 26.04 (3 C, q, CMe_3), 26.71 (t), 29.16 (t), 35.93 (t), 38.42 (t), 39.77 (t), 68.56 (d), 70.15 (t), 122.40 (d), 123.92 (d), 127.86 (d), 129.86 (d), 135.36 (s), 136.91 (s), and 144.61 (s); *m/z* (e.i.) 451 ($M^+ - C_4H_9$, 3%) 376 (10), 229 (100), 205 (33), 149 (21), 109 (90), 95 (28), 67 (24), 43 (8), and 41 (11).

(4E,8E,12RS)-12-*Dimethyl-t-butylsiloxy*-5,9-*dimethyl*-1-(*phenylsulphonyl*)*trideca*-4,8-*diene*.—To a solution of (4*E*,8*E*,12*RS*)-12-dimethyl-t-butylsiloxy-5,9-dimethyltrideca-4,8-dienyl toluene-*p*-sulphonate (5.2 g, 11.5 mmol) in butan-2-one (200 ml) was added sodium iodide (2.25 g, 15 mmol), and the solution was heated under reflux for 30 min. The resulting suspension was poured into water and extracted with diethyl ether. The extract was washed with water and brine, dried (Na_2SO_4), and evaporated under reduced pressure, to afford the product as an unstable yellow oil, δ_H (60 MHz, CCl_4) 0.10 (6 H, s), 0.90 (9 H, s), 1.15 (3 H, d), 1.70—2.2 (12 H, m), 3.20 (2 H, m), 3.90 (1 H, m), and 5.10 (2 H, m). To a solution of the freshly prepared iodide (5.21 g, 11.2 mmol) in dimethyl sulphoxide (100 ml) was added anhydrous sodium benzenesulphinate (2.3 g, 11.5 mmol) and the suspension was stirred at 20 °C for 2 h. The resulting solution was poured into water and extracted with diethyl ether. The extract was washed with water and brine, dried (Na_2SO_4) and evaporated to afford, after flash chromatography [diethyl ether–light petroleum (2:3)], pure *title compound* (5.10 g, 85%) as a colourless oil (Found: C, 67.6; H, 9.5%; $M^+ - C_4H_9$, 421.2070. $C_{27}H_{46}O_3SSi$ requires C, 67.7; H, 9.7%. $C_{23}H_{37}O_3SSi$ requires *M*, 421.2070); $\nu_{max.}(CCl_4)$ 3 050w, 2 960s, 2 940s, 2 860s, 1 610w, 1 465s, 1 380, 1 330s, 1 260s, 1 150s, 1 100s, 1 050m, 890w, and 850s cm^{-1}; δ_H (360 MHz; $CDCl_3$) 0.05 (6 H, s, $SiMe_2$), 0.90 (9 H, s, $SiCMe_3$), 1.12 (3 H, d, *J* 6.1 Hz, CH–Me), 1.45 (2 H, m, 11-H_2), 1.55 (3 H, s, Me), 1.60 (3 H, s, Me), 1.65 (2 H, m, 2-H_2), 2.00 (8 H, m, allyl H), 3.05 (2 H, m, CH_2SO_2Ph), 3.75 (1 H, m, *J* 6.1 Hz, CH–Me), 4.95 (1 H, m, vinyl H), 5.05 (1 H, m, vinyl H), and 7.55—7.95 (5 H, m, ArH); δ_C (90.6 MHz; $CDCl_3$), −4.60 (q), −4.29 (q), 16.15 (q), 18.24 (s), 22.91 (t), 23.71 (q), 25.98 (q), 26.44 (t), 26.66 (t), 35.84 (t), 38.32 (t), 39.70 (t), 55.83 (t), 68.48 (d), 122.04 (d), 123.77 (d), 128.09 (d), 129.04 (d), 133.51 (d), 135.2 (s), 136.8 (s), and 137.7 (s); *m/z* (e.i.) 421 ($M^+ - C_4H_9$, 96%), 199 (29), 109 (95), 75 (100), 77 (23), 67 (68), 55 (52), 43 (34), and 41 (47).

(2S,4R)-(+)-1-*Methyl* 5-*Hydrogen* 2,4-*Dimethylpentanedioate*.—(2*S**,4*R**)-1-Methyl 5-hydrogen 2,4-dimethylpentanedioate was produced by the procedure of Wiley and coworkers[28] from *meso*-2,4-dimethylpentanedioic anhydride.[18] This racemic mixture (25.4 g, 0.146 mol) was mixed with (*S*)-(−)-1-phenylethylamine (18.49 g, 0.152 mol) for 24 h. The resulting solid was recrystallized from ethyl acetate to constant melting point (112.5 °C) and constant optical rotation. The crystals were then dissolved in dichloromethane, and the solution acidified to pH 5 with dilute hydrochloric acid. The organic phase was separated, dried ($MgSO_4$), and evaporated under reduced pressure to give, after distillation *in vacuo* the title compound (5.0 g, 20%) as a colourless oil, b.p. 94 °C at 0.1 mmHg [lit.,[28] (b.p. 110—112 °C at 0.3 mmHg) $[\alpha]_D^{22} = +4.56°$ (*c* 7.050, $CHCl_3$)] [lit.,[16,17] for 2*R*,4*S* enantiomer, $[\alpha]_D^{22} = -4.61$ (*c* 7.050, $CHCl_3$)]; $\nu_{max.}$ (liq. film) 3 600—2 400br, 2 980s, 2 940s, 1 740s, 1 710s, 1 450s, 1 360, 1 260s, 1 190s, 1 170s, and 1 130s cm^{-1}; δ_H (360 MHz; $CDCl_3$, TMS) 1.19 (3 H, d), 1.21 (3 H, d), 1.50 (1 H, m), 2.10 (1 H, m), 2.55 (2 H, m), 3.65 (3 H, s), and 11.2 (1 H, s); δ_C (90.6 MHz; $CDCl_3$, TMS) 17.10 (q), 17.19 (q), 37.08 (t), 37.33 (2 C, d), 51.58 (q), 176.54 (s), and 182.07 (s); *m/z* (e.i.) 143 (M^+ − OMe, 19%), 128 (28), 115 (26), 114 (40), 101 (33), 59 (31), 57 (31), 56 (67), 45 (43), and 43 (33).

(2S,4R)-*Methyl* 2,4-*Dimethyl*-5-*oxohexanoate*.—To a solution of (2*S*,4*R*)-1-methyl 5-hydrogen 2,4-dimethylpentanedioate (5.0 g, 28.7 mmol) in benzene (10 ml) under argon at 0 °C, was added oxalyl chloride (7.25 ml, 32.5 mmol), and the solution was stirred at exactly 0 °C for 12 h. The solvent was then evaporated at reduced pressure at 0 °C and the residue was stirred under vacuum for 30 min. The colourless oil was then taken up in dry diethyl ether (20 ml) and cooled to −78 °C.

To a mechanically stirred slurry of copper iodide (7.55 g, 30 mmol) in dry diethyl ether (100 ml) at 0 °C under argon, was added methyl-lithium (1.049M solution in diethyl ether; 75.5 ml). The pale grey solution was stirred for 15 min at 0 °C and then cooled to −78 °C; after 10 min the solution of acid chloride in ether was injected with positive argon pressure and the resulting yellow suspension was stirred at −78 °C for 20 min. The reaction was quenched with saturated aqueous ammonium chloride (125 ml) and allowed to warm to 20 °C. The green precipitate was filtered off and the blue solution was extracted with diethyl ether. The extract was washed with saturated aqueous sodium hydrogen carbonate and brine, dried (Na_2SO_4), and evaporated under reduced pressure to afford, after flash chromatography [diethyl ether–light petroleum (1:3)], pure title compound (4.87 g, 93%), b.p. (Kugelrohr) 48 °C at 0.1 mmHg; $[\alpha]_D^{25} = +14.7°$ (*c* 7.6, $CHCl_3$)[6] (Found: M^+ − OMe, 141.0914. Calc. for $C_8H_{13}O_2$: *M*, 141.0915); $\nu_{max.}(CCl_4)$ 2 980m, 2 940m, 1 740s, 1 720s, 1 460m, 1 200s, 1 170s, and 1 130s cm^{-1}; δ_H (360 MHz, C_6D_6), 1.07 (3 H, d, 2-Me), 1.21 (3 H, d, 4-Me), 1.36 (1 H, m, 3-H), 2.02 (3 H, s, Me ketone), 2.26 (1 H, m, 3-H), 2.54 (2 H, m, 2- and 4-H), and 3.60 (3 H, s, Me ester); δ_C (90.6 MHz, C_6D_6), 16.99 (q), 18.37 (q), 28.12 (q), 37.49 (t), 38.35 (d), 45.74 (d), 51.81 (q), 176.74 (s), and 210.14 (s); *m/z* (e.i.) 172 (M^+, 1%), 167 (6), 141 (5), 94 (24), 88 (27), 71 (13), 69 (27), 57 (26), 43 (100), and 41 (31).

(2S,4R)-*Methyl* 2-*Methyl*-4-(2′-*methyl*-1′,3′-*dioxolan*-2′-*yl*)-*pentanoate*.—To a solution of (2*S*,4*R*)-methyl 2,4-dimethyl-5-oxohexanoate (5.34 g, 31.1 mmol) in benzene (150 ml) was added ethane-1,2-diol (8.6 ml, 155 mmol) and pyridinium toluene-*p*-sulphonate (0.80 g, 3.1 mmol) and the solution was heated under reflux with azeotropic removal of water. After 3 h the solution was poured into saturated aqueous sodium hydrogencarbonate and extracted with diethyl ether. The extract was washed with water and brine, dried (K_2CO_3), and evaporated under reduced pressure to afford, after flash chromatography [diethyl ether–light petroleum (2:3)] pure title compound[6] (6.11 g, 91%) as a colourless oil $[\alpha]_D^{25}$ +24.5° (*c*, 8.14, $CHCl_3$)[6] (Found: M^+, 216.1338. Calc. for $C_{11}H_{20}O_4$: *M*, 216.1316); $\nu_{max.}(CCl_4)$ 2 990s, 2 960s, 2 890s, 1 745s, and

1 470s cm^{-1}; δ_H (360 MHz; $CDCl_3$, TMS) 0.95 (3 H, d, CH-Me), 1.10 (1 H, m, 3-H), 1.20 (3 H, d, CH-Me), 1.25 (3 H, s, 2′-Me), 1.65 (1 H, m, 4-H), 2.0 (1 H, m, 3-H), 2.6 (1 H, m, 2-H), 3.65 (3 H, s, OMe), and 3.95 (4 H, m, acetal-H); δ_C (90.6, $CDCl_3$, TMS) 14.70 (q), 18.28 (q), 20.24 (q), 36.48 (t), 37.72 (d), 39.27 (d), 51.28 (q), 64.53 and 64.57 (2 C, t), 112.03 (s), and 176.95 (s); *m/z* (e.i.) 216 (M^+, 0.6%), 215 (9), 201 (31), 187 (68), 157 (59), 143 (33), 129 (38), 115 (63), 113 (71), 87 (100), 73 (45), 69 (80), 56 (34), and 43 (92).

(2R,4S,5RS,6RS,9E,13E,17RS)-17-*Dimethyl-t-butylsiloxy*-2-(2′-*methyl*-1′,3′-*dioxolan*-2′-*yl*)-6-*phenylsulphonyl*-4,10,14-*trimethyloctadeca*-13,17-*dien*-5-*ol*.—To a solution of (4*E*,8*E*,12*RS*)-12-dimethyl-t-butylsiloxy-5,9-dimethyl-1-phenylsulphonyltrideca-4,8-diene (0.303 g, 0.633 mmol) in dry tetrahydrofuran (5 ml) at −78 °C under argon was added lithium di-isopropylamide (0.303M solution; 1 ml) and the solution was stirred for 30 min. (2*S*,4*R*)-Methyl 2-methyl-4-(2′-methyl-1′,3′-dioxolan-2′-yl)pentanoate (0.068 g, 0.316 mmol) was then added and the solution was stirred at −78 °C for a further 60 min and at 0 °C for 15 min. The solution was then cooled to −78 °C and a second portion of lithium di-isopropylamide (0.303M solution; 0.5 ml) was added followed by a second portion of the ester (0.034 g, 0.163 mmol); the solution was then stirred at −78 °C for 60 min, and then at 0 °C for 15 min. After being quenched with sodium dihydrogen phosphate, the mixture was extracted with diethyl ether and the extract was washed with water and brine, dried (Na_2SO_4), and evaporated under reduced pressure. The residue was taken up in ethanol (20 ml) and sodium borohydride (0.024 g, 0.633 mmol) added to the solution which was then stirred at 20 °C for 60 min. The solvent was removed under reduced pressure and the residue was taken up in water (10 ml) and extracted with diethyl ether. The extract was washed with water and brine, dried (Na_2SO_4), and evaporated under reduced pressure to give after flash chromatography [diethyl ether–light petroleum (1:1)] the title compound (1 g, 93%) as a colourless oil; $\nu_{max.}(CCl_4)$ 3 650—3 250br, 2 980s, 2 940s, 2 890s, 1 470s, 1 450s, 1 380s, 1 310s, 1 255s, 1 150s, 1 090s, 1 050s, 1 000s, and 850s cm^{-1}; δ_H (360 MHz; $CDCl_3$) 0.05 (6 H, s, $SiCMe_2$), 0.83 (3 H, d, CH-Me), 0.85 (9 H, s, $SiCMe_3$), 0.90 (3 H, d, CH-Me), 1.10 (3 H, d, *J* 6.1 Hz, CH-Me), 1.20 (3 H, s, 2′-Me), 1.45—1.80 (8 H, m), 1.5 (3 H, s, vinyl-Me), 1.55 (3 H, s, vinyl Me), 1.85—2.10 (8 H, m, allyl H), 2.15 (1 H, m, 2-H), 3.2 (1 H, m, 6-H), 3.6 (0.5 H, m, 5-H), 3.75 (1 H, m, *J* 6.1 Hz, CH-Me), 3.90 (4 H, m, acetal H), 4.05 (0.5 H, m, 5-H), 4.85 (1 H, m, vinyl H), 5.05 (1 H, m, vinyl H), and 7.50—7.90 (5 H, m, Ar-H); δ_C (90.6 MHz; $CDCl_3$), −4.55 (q), −4.24 (q), 14.02 (q), 15.99 (q), 16.13 (q), 16.17 (q), 18.02 (s), 20.12 (q), 23.78 (q), 25.36 (t), 26.64 (q), 26.64 and 26.70 (t), 33.078 (d), 35.90 (t), 36.33 (t), 38.37 (t), 38.78 (d), 39.73 (t), 64.61 and 64.66 (d), 67.86 (d), 68.53 (d), 70.55 (d), 112.60 (s), 122.49 (d), 123.84 (d),128.65 (d), 129.10 (d), 133.55 (d), 135.41 (s), 137.18 (s), and 140.07 (s).

(2R,4S,5E,9E,13E,17RS)-17-*Dimethyl-t-butylsiloxy*-2-(2′-*methyl*-1′,3′-*dioxolan*-2′-*yl*)-4,10,14-*trimethyloctadeca*-5,9,13-*triene*.—To a solution of (2*R*,4*S*,5*RS*,6*RS*,9*E*,13*E*,17*RS*)-17-dimethyl-t-butylsiloxy-2-(2′-methyl-1′,3′-dioxolan-2′-yl)-6-phenylsulphonyl-4,10,14-trimethyloctadeca-9,13-dien-5-ol (0.130 g, 0.196 mmol) in dry tetrahydrofuran under argon at −78 °C was added 1,10-phenanthroline (5 mg); n-butyl-lithium (1.7M in hexane) was then slowly added until a dark colour persisted. Benzoyl chloride (0.06 ml, 0.46 mmol) was then added and the temperature was allowed to warm to 20 °C over 2 h. The reaction was then quenched with 3-dimethylaminopropylamine, poured into water, and extracted with diethyl ether. The extract was washed with water and brine, dried (Na_2SO_4), and evaporated at reduced pressure. The residue was taken up in tetrahydrofuran (10 ml) and methanol (2 ml), ethyl acetate (1 ml), and disodium hydrogenphosphate (0.5 g, 0.35 mmol) were added to this solution. The suspension was cooled to −20 °C and sodium–mercury amalgam (6% amalgam; 1.25 g, 0.33 mmol) was added, and the reaction was stirred for 4 h; every 60 min sodium amalgam (1.25 g), disodium hydrogen phosphate (0.5 g), and methanol (1 ml) were added. The reaction mixture was then poured into light petroleum (100 ml), the mixture filtered through Celite, and the solvent evaporated to afford after flash chromatography [diethyl ether–dichloromethane–light petroleum (1:1:18)] the title compound and its (2*R*,4*S*,5*Z*,9*E*,13*E*,17*RS*) isomer in a ratio 4:1 (45.7 mg, 94%) as a colourless oil (Found: C, 73.5; H, 11.5. $C_{31}H_{58}O_2Si$ requires C, 73.7; H, 11.5%); $\nu_{max.}(CCl_4)$ 2 980s, 2 940s, 2 890s, 2 860s, and 1 470s cm^{-1}; δ_H (360 MHz; $CDCl_3$), 0.10 (6 H, s, $SiMe_2$), 0.90 (9 H, s, $SiCMe_3$), 0.92 (3 H, d, CHMe), 0.98 (3 H, d, CHMe), 1.02 (1 H, m, 3-H), 1.15 (3 H, d, CH-Me), 1.20 (3 H, s, 2′-Me), 1.45 (1 H, m, 3-H), 1.60 (6 H, s, vinyl Me), 1.70 (1 H, m, 3-H), 2.05 (11 H, m, allyl H), 3.75 (1 H, m, CH-Me), 3.90 (4 H, m, acetal H), 5.10 (3 H, m, vinyl H), and 5.40 (1 H, m, vinyl H); δ_C (90.6 MHz; $CDCl_3$) −4.55 (q), −4.25 (q), 14.47 (q), 16.18 (q), 18.20 (s), 20.39 (q), 22.68 (q), 23.83 (q), 26.08 (q), 26.90 (t), 28.46 (t), 32.94 (d), 36.00 (t), 38.47 (t), 38.90 (d), 39.28 (t), 39.90 (t), 64.6 (t), 68.63 (d), 113.00 (s), 124.25 (d), 125.04 (d), 129.14 (d), 135.20 (s), and 136.03 (d).

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