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Synthesis of Sesquiterpene Polyene Hydroperoxides By Regio- And Stereoselective Transposition Reactions

Simon Fielder,[a,b] Daryl D. Rowan[a] and Michael S. Sherburn*,[c]

[a] Horticulture and Food Research Institute of New Zealand Ltd, Private Bag 11030, Palmerston North, New Zealand.
[b] Institute of Fundamental Sciences, Massey University, Private Bag 11222, Palmerston North, New Zealand.
[c] School of Chemistry, University of Sydney, Sydney, NSW 2006, Australia.

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Abstract: Isomeric unsaturated alcohols (**8**), (**16**), (**18**) and (**20**), on exposure to hydrogen peroxide or water in the presence of an acid catalyst, undergo exceptionally regio- and stereoselective substitution reactions to form hydroperoxide (**3**) and alcohol (**8**) respectively. *E/Z* isomeric ratios of transposition products indicate that the intermediate acyclic carbocations (**21**) and (**22**) are not interconverting under the reaction conditions. Practical syntheses of α-farnesene autoxidation products have been developed based on these transposition reactions. © 1998 Elsevier Science Ltd. All rights reserved.

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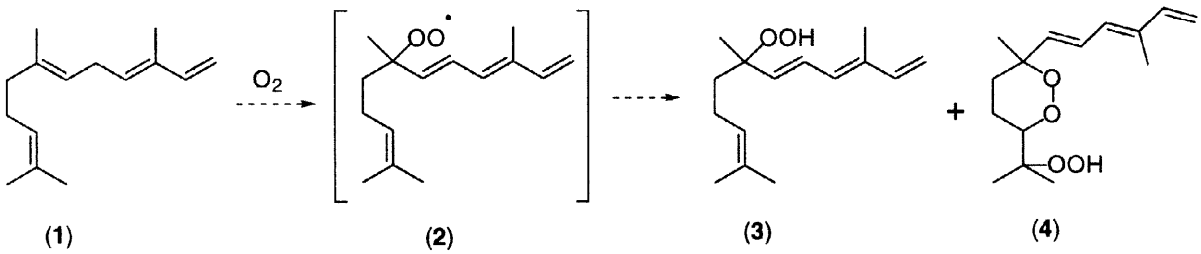
Superficial scald is a physiological disorder of fruit resulting in blackening of the skin during cold storage.[1] α-Farnesene (**1**), an unsaturated sesquiterpene which occurs naturally in the surface wax of apples and pears, is known to suffer autoxidation to hydroperoxide (**3**)[2] and peroxidic compounds (**3**) and (**4**) have been implicated in the development of this disorder.[3]



(**1**) (**2**) (**3**) (**4**)

Scheme 1

In order to further probe the chemical basis of scald, we needed relatively large quantities of hydroperoxides (**3**) and (**4**) for testing on apples. We envisioned a stepwise synthetic approach to trienyl hydroperoxide (**3**) from geraniol. If a synthetic route to trienyl hydroperoxide (**3**) could be found, we would then be able to investigate its conversion into endoperoxy-hydroperoxide (**4**) by way of peroxy radical (**2**), the α-farnesene autoxidation pathway proposed by Anet.[4,5]

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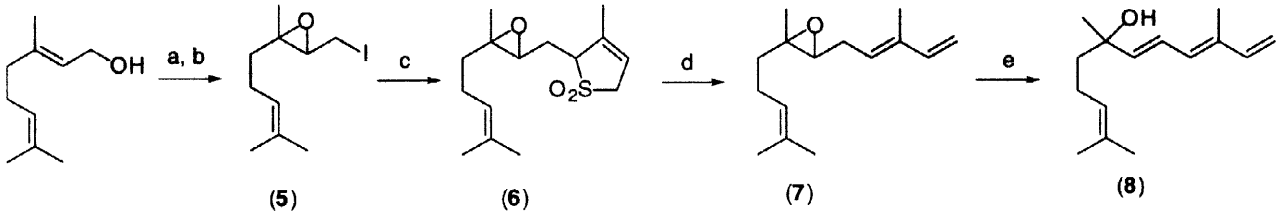
The primary synthetic goal was conjugated trienol (**8**).[6] The preparation of (**8**) from geraniol *via* known iodoepoxide (**5**)[7] is shown in **Scheme 2.**

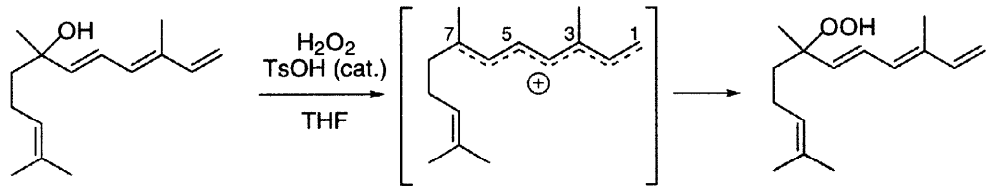


(5) (6) (7) (8)

a) $VO(acac)_2$ (cat.), ^tBuOOH, CH_2Cl_2; 95% b) PPh_3, imidazole, I_2, CH_2Cl_2; 88% c) 3-methylsulfolene, ^nBuLi, THF, TMEDA, -105°C; 38% [+55% recovered (**5**)] d) xylene, reflux; 74% e) ^tBuOK, ^nBuLi, $^iPr_2NH$, THF, -50°C to 25°C, 97%.

Scheme 2

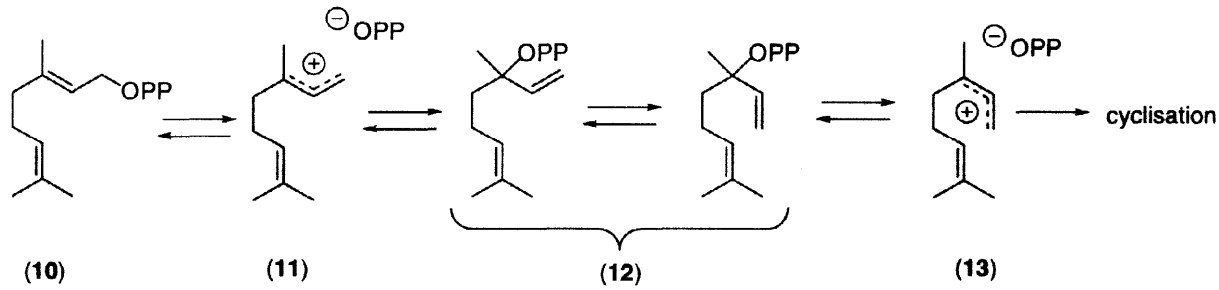
A two step procedure involving reaction between (**5**) and 2-lithio-3-methyl sulfolene[8] followed by thermolytic extrusion of SO_2 was used to introduce the requisite isoprene unit in a regioselective manner. Our initial attempts to alkylate epoxy iodide (**5**) with 2-lithio-3-methyl sulfolene at low temperature in THF-DMPU led to the exclusive formation of linalool, presumably as a result of initial metal-halogen exchange. A similar result was reported by Moody in attempts to alkylate the dianion of methylacetoacetate with (**5**).[7] In our case, it is possible to redirect the reaction to produce the desired sulfolene (**6**) (as a 1:1 mixture of diastereoisomers) using TMEDA as additive rather than DMPU. Thermolysis of sulfolene (**6**) in refluxing xylene afforded diene (**7**) as a colourless oil which was converted smoothly into conjugated trienol (**8**) upon treatment with a strong mixed base.[6,9] Various sets of conditions were examined to effect the conversion of alcohol (**8**) into hydroperoxide (**3**),[10] most of which were not successful. On exposure to hydrogen peroxide and Amberlyst 15,[11] for example, (**3**) was observed as a minor product along with many other peroxidic products. After considerable experimentation, we discovered that anhydrous H_2O_2 in THF[12] (***Caution!***)[13] in the presence of 2 mol % *para*-toluenesulfonic acid (TsOH) for 48h at 20°C caused a clean transformation of (**8**) into (**3**) (**Scheme 3**). The hydroperoxide product (47%) was easily separated from unreacted starting material (24%) chromatographically. We presume that this conversion proceeds through an S_N1 mechanism *via* the delocalised heptatrienyl cation (**9**).



(8) (9) (3)
(47% isolated yield)

Scheme 3

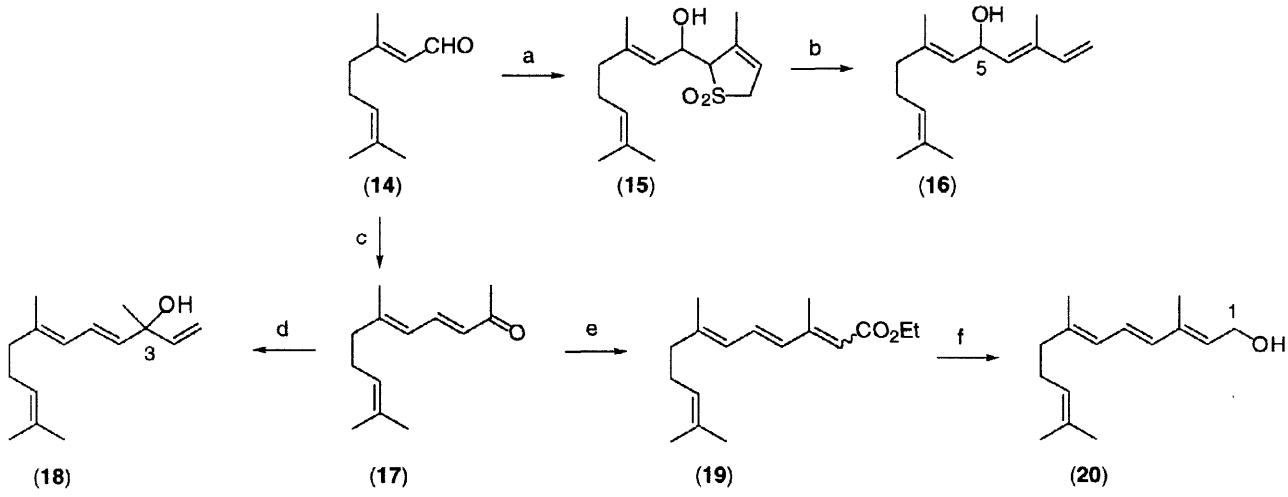
We were intrigued by the chemo- and regioselectivity of this reaction: neither cyclised products nor regioisomeric hydroperoxides (*ie.* oxygenation at C1, C3 or C5) could be detected in the product. To explain the lack of cyclisation products, we suggest the intermediacy of a heptatrienyl carbocation with C6-C7 *transoid* configuration (**9**). A similar argument has been put forward to explain the lack of reactivity of linalool and derivatives towards cyclisation.[14] The stereochemical integrity of cations of this type is further highlighted in the biosynthetic conversion of geranyl diphosphate (**10**) into simple cyclic monoterpenes (**Scheme 4**). This transformation takes place by a stepwise sequence of enzyme-assisted events involving ionisation to a *transoid* carbocation (**11**), ion recombination to form linalyl diphosphate (**12**), C-C single bond rotation and subsequent ionisation to form *cisoid* cation (**13**), a species which can attain the necessary geometry for cyclisation.[15] An analogous sequence of events has also been proposed in the sesquiterpene series.[16]



Scheme 4

Thus, for the conversion of (**8**) into cyclic products, addition of the pendant isolated C=C bond to the heptatrienyl carbocation moiety would require a C6-C7 *cisoid* arrangement of the delocalised carbocation (*cf.* **13**) which, in turn, necessitates the adoption of a much less favourable conformation of protonated alcohol (**8**) during the departure of H_2O.

The absence of the three other possible regioisomeric hydoperoxide products in the reaction between (**8**) and hydrogen peroxide (**Scheme 3**) is less easily rationalised. This result did, however, raise the issue of whether isomers of (**8**) [which might also serve as precursors to the heptatrienyl cation (**9**)] could be similarly transformed into hydroperoxide (**3**), thereby allowing a more streamlined synthesis of this labile compound. To examine this possibility, the three regioisomeric alcohols[17] (**16**), (**18**) and (**20**) were prepared as outlined in **Scheme 5**. Thus, nucleophilic addition of 2-lithio-3-methyl sulfolene to geranial (**14**) gave the desired 1,2-adduct (**15**) as a 2:1 diastereomeric mixture in modest yield. Thermolysis of sulfolene (**15**) in refluxing xylene for 15 minutes in the presence of DBU provided (**16**)[17a] in 50% isolated yield. Tertiary alcohol (**18**)[17b] was obtained by the addition of vinylmagnesium bromide to pseudoionone (**17**). Horner-Emmons reaction of pseudoionone with triethylphosphonoacetate gave a 4:1 (2*E*:2*Z*) mixture of isomeric alkenes (**19**) which were separable by chromatography. Reduction with diisobutylaluminium hydride furnished the corresponding primary alcohols (**20**),[17c] which were also separable by chromatography.

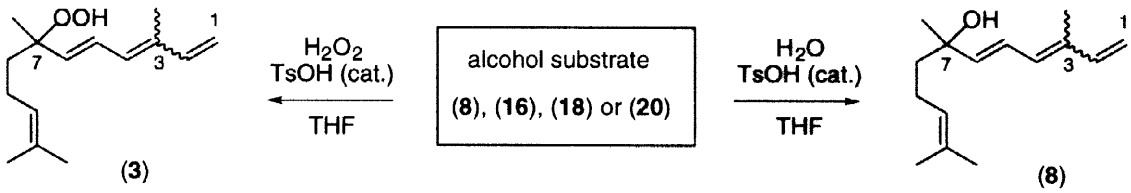


a) 3-methylsulfolene, LiHMDS, $Me_2NCH_2CH_2NMe_2$, THF, -105°C; 37%, 2:1 diastereomeric mixture b) DBU (1.0 equiv), xylene, reflux; 50% c) $Me_2C{=}O$, $Ba(OH)_2$ (0.03 equiv), reflux; 82% d) $CH_2{=}CHMgBr$, THF, 0°C; 71% e) $(EtO)_2P(O)CH_2CO_2Et$, NaH, PhMe, reflux; 49%, 4:1 (2*E*:2*Z*) f) $^iBu_2AlH$, CH_2Cl_2-PhMe, -78°C to -50°C, 97%

Scheme 5

Gratifyingly, exposure of alcohols (**16**), (**18**) and (**20**) to hydrogen peroxide or water in the presence of *para*-toluenesulfonic acid (**Table**) resulted in regioselective oxygen transposition to C7. For (**16**) and (**18**) the reactions proceeded efficiently and very cleanly (entries 2-5) whereby a simple aqueous work up afforded spectroscopically pure products. The primary alcohol (**20**) was unreactive under the standard reaction conditions but a more forcing environment again provided (**1**) and (**2**). The preparative usefulness of (**20**) appears limited, since Hock cleavage of the hydroperoxide[10] (entry 6) and dehydration of the alcohol (entry 7) were competitive even when reactions were quenched after low conversions.

Table. Treatment of alcohols (8), (16), (18) and (20) with H_2O_2 and H_2O under acid catalysis [a]

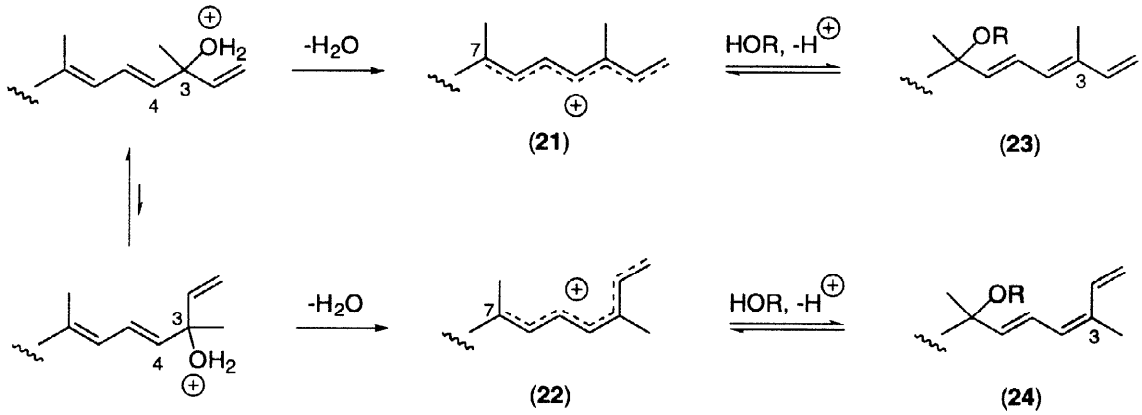


entry	substrate	reagent	time [b]	product	3*E*:3*Z* [c]	yield (%) [d]
1	**8** [e]	H_2O_2	48 h	**3**	96:4	47 [f]
2	**16**	H_2O_2	5 min	**3**	>99:1	100
3	**16**	H_2O	5 min	**8**	>99:1	100
4	**18**	H_2O_2	6 h	**3**	73:27	100
5	**18**	H_2O	6 h	**8**	72:28	96
6	**20**	H_2O_2	6 h [g]	**3**	-	trace [h]
7	**20**	H_2O	6 h [g]	**8**	87:13	7 [i]
8	**8** [j]	H_2O_2	48 h	**3**	69:31	55 [k]

[a] Reactions were carried out at 20°C in THF under nitrogen with 75 equiv. H_2O_2 (**Caution!**)[13] or H_2O and 2-6 mol% *para*-toluenesulfonic acid monohydrate. [b] Reactions were followed by TLC. [c] Ratio determined from ^1H nmr spectra. [d] Isolated yield of spectroscopically pure material. [e] 3*E*:3*Z* ratio 95:5. [f] Starting alcohol (24%; 3*E*:3*Z* = 95:5) was also isolated. [g] 2.0 equiv. TsOH.H_2O used. [h] 6-methyl-5-hepten-2-one was the major product. [i] Starting alcohol (56%) and a mixture of dehydration products (8%) were also isolated. [j] 3*E*:3*Z* ratio 72:28. [k] Starting alcohol (26%; 3*E*:3*Z* = 73:27) was also isolated.

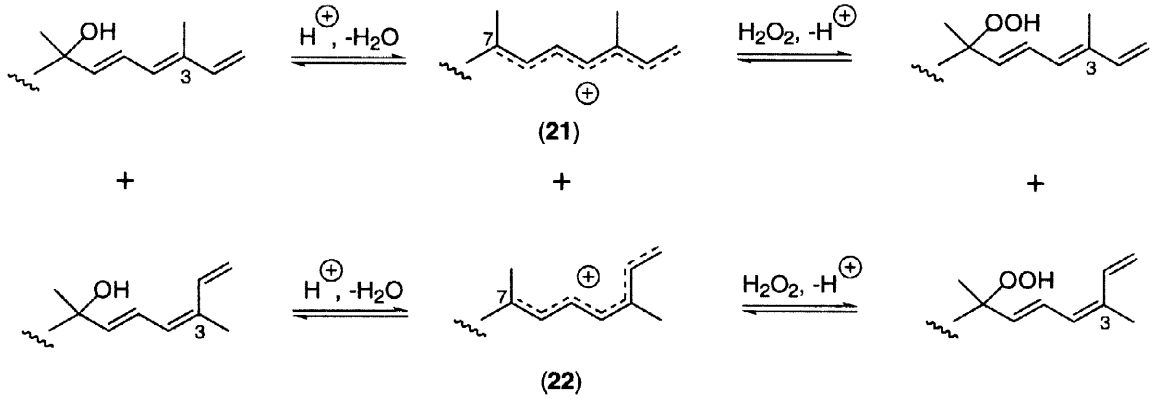
We were intrigued to find that the *stereochemistry of the products* from these reactions was dependent upon the *regiochemistry of the starting alcohol*. Thus, the C7 alcohol substrate (**8**) retained its high stereoisomer ratio on hydroperoxidation (entry 1) and the C5 alcohol (**16**) provided single stereoisomeric products (3*E*) with both hydrogen peroxide and water (entries 2 and 3). In contrast, the C3 alcohol (**18**) and the C1 alcohol (**20**) furnished mixtures of 3*E* and 3*Z* isomers (entries 4, 5 and 7), the ratio of which varied only slightly with temperature.[18] 5*E*-alkenes were formed exclusively in all reactions and the stereochemistry of recovered starting materials from incomplete conversions (entries 1 and 7) was unchanged. It is interesting to note that each substrate affords the same stereoisomer ratio in reactions with both water and hydrogen peroxide.

We propose that the stereochemical outcome of these transposition reactions is best explained by invoking the intermediacy of two configurationally immobile acyclic heptatrienyl carbocationic intermediates. This is represented for the C3 alcohol (**18**) in **Scheme 6**. Thus, loss of water from different C3-C4 conformations of the protonated alcohol produces the two discrete isomeric heptatrienyl carbocations (**21**) and (**22**) with *transoid* and *cisoid* geometries about the C3-C4 bond. Trapping at C7 with an oxygen nucleophile generates the two 3*E*:3*Z* stereoisomeric products (**23**) and (**24**), respectively. Carbocations (**21**) and (**22**) are non-interconvertible under the reaction conditions since orbital overlap from C1 through C7 of the heptatrienyl cation precludes bond rotation. While are not aware of such an argument being applied to a polyenic system, there is ample precedent in the allylic cation system (see **Scheme 4**).[14,15,16,19]



Scheme 6

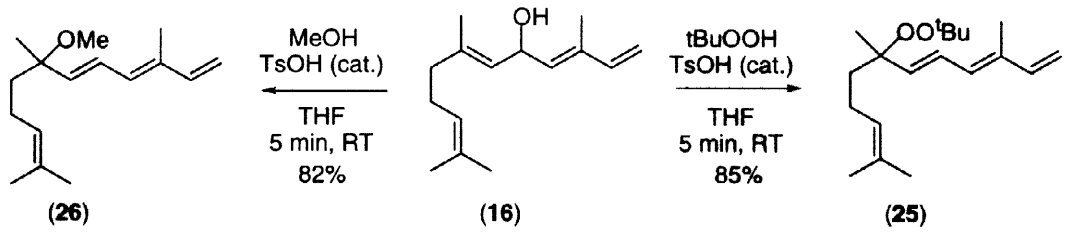
Further evidence for configurationally stable carbocationic intermediates was obtained by subjecting a 72:28 mixture of 3*E* and 3*Z* isomers of C7 alcohol (**8**) (obtained previously: *cf.* **Table**, entry 5) to the standard hydroperoxidation conditions (**Table**, entry 8). After work up and careful chromatographic separation, the *E*/*Z* ratios of the product hydroperoxide (53%) and recovered alcohol (26%) were found to be identical (± 3%) to that of the starting material. This result confirms that the stereoisomer ratio of (**8**) is retained upon hydroperoxidation (**Table**, entry 1) and is strong evidence that 3*E* and 3*Z* isomers of (**8**) are precursors to isomeric heptatrienyl carbocations (**21**) and (**22**), as depicted in **Scheme 7**.



Scheme 7

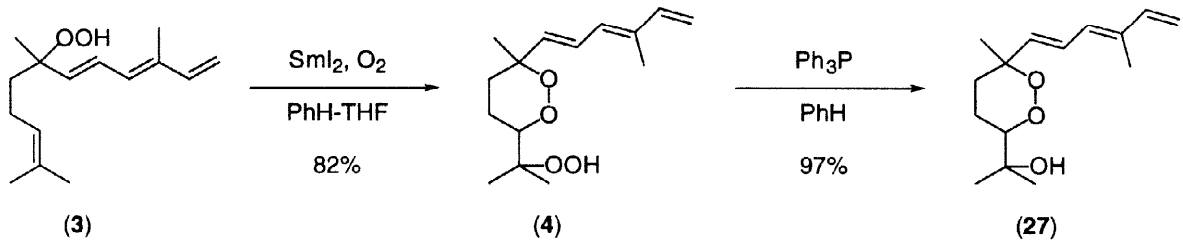
Furthermore, the unchanged *E*:*Z* ratio of this product (and entries 1-3, **Table**) requires that addition of the nucleophile to (**21**) and (**22**) occurs *exclusively* at C7 since addition at C3, and the intermediacy of alcohol (**18**) or the equivalent hydroperoxide, would result in an altered *E*:*Z* ratio of the products (*cf.* **Scheme 6**; entries 4 and 5, **Table**). The addition of the oxygen nucleophile to cationic intermediates (**21**) and (**22**) is therefore essentially *irreversible* for alcohols (**16**) and (**18**), and the formation of the same regioisomeric products from regioisomeric substrates (**8**), (**16**), (**18**) and (**20**) is not simply the result of equilibrium control.

The relatively high reactivities of the C3 alcohol (**18**) and the C5 alcohol (**16**) towards substitution reactions of this type are presumably due to the formation of a significantly more delocalised π-system upon ionisation and, from this perspective, the comparatively sluggish nature of the more stable conjugated trienols (**8**) and (**20**) is not surprising. To briefly examine the generality of this transformation with the most reactive (and most highly stereoselective) substrate, *tert*-butylhydroperoxide and methanol were allowed to react with alcohol (**16**) under the standard conditions. Once again, the products of substitution at C7, unsymmetrical peroxide (**25**) and methyl ether (**26**) were isolated in high yields and high stereochemical purity (3*E*:3*Z* = >99:1) (**Scheme 8**).



Scheme 8

Finally, with workable quantities of hydroperoxide (**3**) in hand, we could explore the preparation of endoperoxy-hydroperoxide (**4**). We were delighted to find that Corey's samarium-based protocol[20] allowed a clean conversion into the desired endoperoxy hydroperoxide (**4**) (82% isolated yield) as a 1.2:1 mixture of diastereoisomers (**Scheme 9**).[21] This result demonstrates that hydroperoxy radical (**2**) (**Scheme 1**), proposed originally by Anet as an intermediate in the autoxidation of α-farnesene,[4] does indeed undergo smooth cyclisation in the presence of oxygen to ultimately afford endoperoxy hydroperoxide (**4**). Further authentication of (**4**) was obtained by reduction to the more stable endoperoxy alcohol (**27**).



Scheme 9

In summary, hydroperoxide (**3**) has been prepared from geraniol in several concise routes, the shortest of which leads to a product of high isomeric purity in only four synthetic steps. Along the way, the first examples of acid-catalysed hydroperoxidation of polyenic alcohols have been carried out and, in general, these reactions proceed cleanly and in high yield when anhydrous hydrogen peroxide in THF is used. The unanticipated stereochemical outcome of oxygen transposition reactions across polyenes can be explained by invoking configurationally immobile acyclic carbocation intermediates. Contemporary means of accomplishing allylic oxygen transposition involves the use of palladium[22] and europium[23] catalysis; the results described herein demonstrate that more traditional acid-catalysed protocols[24] can accomplish synthetically useful regio- and stereoselective transformations with labile starting materials and products. Biological evaluation experiments employing hydroperoxides (**3**) and (**4**) are under way.

Acknowledgments

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Experimental

General Procedures

Reactions were performed under an atmosphere of dry nitrogen and in oven dried glassware, unless otherwise stated. Reagents were generally used as received. Benzene, toluene, xylene, THF and diethyl ether were purified by distillation from sodium benzophenone ketyl. Dichloromethane was distilled from calcium hydride. Thin layer chromatography was carried out on aluminium backed Merck Kieselgel 60 F_{254} silica gel plates. Unless otherwise specified, compounds were visualised under UV (365 and 254nm) followed by treatment with acidified ethanolic vanillin and charring. Flash column chromatography and rapid vacuum filtration were carried out using oven dried (150°C) silica gel (40-63μm, Merck). Radial chromatography was performed on a 7924T chromatotron (Harrison Research) using 230mm diameter glass rotors coated with silica gel 60 HF_{254} (63-200μm, Merck)/calcium sulphate hemihydrate (BDH) (13%). Eluting solvents were freshly distilled laboratory grade. Short path distillation was carried out using a GKR-51 Kugelrohr (Büchi) at the temperatures and pressures described. When handling anhydrous solutions of H_2O_2, hydroperoxides and endoperoxides, protective (blast) shields were placed between the worker and sample/experiment and reactions were conducted on the minimum necessary scale.

NMR spectra were recorded on a Jeol GX270 spectrometer in $CDCl_3$ at ambient temperature. Chemical shifts (δ) are reported in parts per million (ppm) downfield shift relative to chloroform at δ7.27 and δ77.0 for ^1H (270 MHz) and ^{13}C spectra (68 MHz) respectively. Extensive use was made of a variety of 2D NMR techniques (COSY, HETCOR, NOESY) for assigning *E/Z* stereochemistries of products. Mass spectra were carried out on a VG70-250S double focusing magnetic sector mass spectrometer (VG Instruments) operating at either 40eV or 70eV. GCMS was carried out using an HP 5890 Series II gas chromatograph (Hewlett Packard) fitted with a 30m x 0.25mm ID DB1 column, 0.25 micrometer film thickness (Alltech); temperature programmed for 5min @ 40°C, 5°C/min, 20 min @ 280°C, with a 2psi. He head pressure coupled directly to the mass spectrometer. Ultraviolet-visible spectra were recorded on a UV-3101PC scanning spectrophotometer (Shimadzu) using spectroscopic grade solvents. Infrared measurements were carried out on a Paragon 1000 FT-IR spectrometer (Perkin-Elmer) with samples as thin films between NaCl plates.

3,7-Dimethyl-2,3-epoxy-6-octen-1-ol[25]

Anhydrous *t*-butyl hydroperoxide (2.03g, 22.5mmol) was added to a solution of geraniol (2.667g, 17.3mmol) and $VO(acac)_2$ (0.46g, 1.73mmol) in CH_2Cl_2 (50ml) at room temperature under N_2. After 1 h, aqueous $Na_2S_2O_3$ (50% w/v, 50ml) was added and the reaction mixture extracted with ether (3x50ml). The combined organic phases were washed with water (2x50ml) then sat. brine (50ml), dried over $MgSO_4$, filtered and concentrated *in vacuo* to give an oil that was purified by flash chromatography on silica gel eluting with hexane-ethyl acetate (4:1) to yield 3,7-dimethyl-2,3-epoxy-6-octen-1-ol (2.80g, 95%) as a pale yellow oil (R_F = 0.29; hexane-ethyl acetate (4:1)): found M^+ 170.1301, $C_{10}H_{18}O_2$ requires 170.1307; IR ν_{max} (thin film) 3427, 2925, 1484, 1424, 1034 cm^{-1}; ^1H NMR (270 MHz, $CDCl_3$) δ 5.12-5.06 (1H, m, $(CH_3)_2C=CH$-), 3.84 (1H, dd, J=12.0, 4.3Hz, -C(H)*H*-OH), 3.69 (1H, dd, J=12.0, 6.6Hz, -C(*H*)H-OH), 2.98 (1H, dd, J=6.6, 4.3Hz, -C(O)*H*-CH_2OH-), 2.10 (2H, q, J=7.5Hz, =CH-CH_2-CH_2-), 1.75-1.60 (2H, m, -C(H)*H*-C(CH_3)(O)-, -O*H*), 1.69 (3H, s, =C(CH_3)CH_3), 1.62 (3H, s, =C(CH_3)CH_3) 1.58-1.44 (1H, m, -C(*H*)H-C(CH_3)(O)-), 1.31 (3H, s, CH_2-C(CH_3)(O)-) ppm; ^{13}C NMR (67.8 MHz, $CDCl_3$) δ 132.1, 123.3, 63.0, 61.4, 61.2, 38.4, 25.6, 23.6, 17.6, 16.7 ppm; MS *m/z* (rel. int. %) 170(1), 152(3), 149(3), 139(4), 121(7), 110(28), 109(77), 95(24), 82(49), 69(83), 67(48), 61(23), 55(37) , 43(63), 41(100).

3,7-Dimethyl-2,3-epoxy-1-iodooct-6-ene (5)[7]

This compound was previously made from the epoxyalcohol *via* the tosylate.[7] We find that the iodide can be prepared directly from the alcohol according to the iodination procedure of Lange and Gottardo.[26]

Iodine (0.363g, 1.43mmol) was added to a vigorously stirred solution of triphenylphosphine (0.406g, 1.55mmol), and imidazole (0.122g, 1.79mmol) in CH_2Cl_2 (10ml) at 0°C under N_2. After the iodine had completely reacted (*ca.* 5 min) the resulting pale yellow slurry was treated with a solution of 3,7-dimethyl-2,3-epoxy-6-octen-1-ol (0.203g, 1.19mmol) in CH_2Cl_2 (1.0ml) and the reaction mixture warmed to room temperature over 30 mins. The solvent was evaporated and the residue was triturated with hexane-ether (5:1, 20ml). [The presence of a small quantity of silica gel (~1-2g) greatly improved the efficiency of this process.] The supernatant was filtered through a short plug of silica gel, rinsed with hexane-ether (5:1, 20ml) and the filtrate was concentrated *in vacuo* to give an oil that was purified by flash chromatography on silica gel eluting with hexane-ethyl acetate (10:1) to yield the *title compound* (0.293g, 88%) as a pale yellow oil (R_F = 0.47; hexane-ethyl acetate (10:1)): found M^+ 280.0331, $C_{10}H_{17}IO$ requires 280.0324; IR ν_{max} (thin film) 2925, 1450, 1384, 1174, 854 cm^{-1}; ^1H NMR (270 MHz, $CDCl_3$) δ 5.13-5.08 (1H, m, $(CH_3)_2C=CH$-), 3.36 (1H, dd, J=9.4, 5.5Hz, -C(O)*H*-CH_2I), 3.10 (1H, dd, J=8.6, 5.5Hz, -C(H)*H*-I), 2.99 (1H, dd, J=9.4, 8.6Hz, -C(*H*)H-I), 2.10 (2H, q, J=7.4Hz, =CH-CH_2-CH_2-), 1.77-1.67 (1H, m, -C(H)*H*--$C(CH_3)$(O)-), 1.70 (3H, s, =$C(CH_3)CH_3$), 1.62 (3H, s, =$C(CH_3)CH_3$) 1.49-1.38 (1H, m, -C(*H*)H-$C(CH_3)$(O)-), 1.30 (3H, s, CH_2-$C(CH_3)$(O)-), ppm; ^{13}C NMR (67.8 MHz, $CDCl_3$) δ 132.2, 123.4, 63.9, 62.5, 38.4, 25.7, 23.8, 17.7, 15.7, 2.4 ppm; MS *m/z* (rel. int. %) 280(0.3), 153(9), 135(6), 125(7), 109(39), 95(13), 81(25), 69(84), 55(33), 43(100), 41(70).

2-(2',3'-Epoxy-3',7'-dimethylocta-6'-enyl)-3-methyl-2,5-dihydrothiophene-1,1-dioxide (6)

n-Butyl lithium (3.8ml of a 1.56M soln. in hexanes, 5.9mmol) was added dropwise to a stirred solution of 3-methylsulfolene (0.75g, 5.7mmol) in THF (45ml) and TMEDA (5ml) at -105°C under N_2, followed by, after 30 min, a solution of iodoepoxide (**5**) (1.43g, 5.1mmol) in THF (2ml). The reaction was maintained at -105°C and quenched after 1 h by the addition of sat. aq. NH_4Cl solution (2ml) and warmed to room temperature, whereupon water (50ml) was added and the mixture was extracted with ether (2x50ml). The combined ethereal extracts were washed with water (50ml), then sat. brine (50ml), dried over $MgSO_4$, filtered and concentrated *in vacuo* to give an oil that was purified by flash chromatography on silica gel eluting with hexane-ethyl acetate (2:1) to yield recovered 3,7-dimethyl-2,3-epoxy-1-iodooct-6-ene (**5**) (0.78g, 55%), followed by the *title compound* (0.55g, 38%) as a viscous oil as an inseparable *ca.* 1:1 mixture of diastereoisomers (R_F = 0.27; hexane-ethyl acetate (2:1)): found M^+ 284.1432, $C_{15}H_{24}O_3S$ requires 284.1446; IR ν_{max} (thin film) 2924, 1442, 1384, 1306, 1118, 915, 733 cm^{-1}; ^1H NMR (270 MHz, $CDCl_3$) δ 5.75 and 5.71 [each one diastereoisomer] (1H, br s, =C*H*CH_2SO_2R-), 5.07 (1H, m, $(CH_3)_2C=CH$-), 3.82-3.60 (3H, m, =CH-CH_2SO_2CHR-$C(CH_3)$=), 3.02-2.94 (1H, m, -C(O)*H*-CH_2-), 2.32-2.21 and 1.84-1.72 [each one diastereoisomer] (2H, m, -C(O)H-CH_2-CH(SO_2R)-), 2.15-2.05 (2H m, =CH-CH_2-CH_2-), 1.91 and 1.88 [each one diastereoisomer] (3H, br.s, -CH_2SO_2CHR-$C(CH_3)$=), 1.68 (3H, s, =$C(CH_3)CH_3$), 1.53-1.22 (2H, m, -CH_2-$C(CH_3)$(O)-), 1.61 (3H, s, =$C(CH_3)CH_3$), 1.31 (3H, s, -$CH_2C(CH_3)$(O)-) ppm; ^{13}C NMR (67.8 MHz, $CDCl_3$) both diastereoisomers δ 138.1, 137.9, 132.0, 123.3, 123.3, 117.5, 117.3, 65.2 (x2), 61.9, 60.8, 60.4, 59.2, 56.1, 55.6, 38.5 (x2), 27.9, 27.4, 25.7 (x2), 23.8, 23.7, 18.2, 18.1, 17.8, 16.8, 16.6 ppm; MS *m/z* (rel. int. %) 284(0.6), 266(0.7), 220(3), 201(10), 175(23), 161(7), 150(14), 137(25), 135(24), 119(12), 110(100), 95(59), 93(50), 81(46), 69(82), 55(31), 43(39), 41(61).

6,7-Epoxy-3,7,11-trimethyldodeca-1,3*E*,10-triene (7)

A solution of the 1:1 diastereoisomeric mixture of sulfolenes (**6**) (0.322g, 1.13mmol) in xylene (10ml) was heated to reflux for 15 min under N_2. The solvent was removed under reduced pressure to give an oil that was purified by flash chromatography on silica gel eluting with hexane-ethyl acetate (20:1) to yield the *title compound* (0.185g, 74%) as a colourless oil (R_F = 0.25; hexane-ethyl acetate (20:1)): found M^+ 220.1816, $C_{15}H_{24}O$ requires 220.1827; IR ν_{max} (thin film) 3088, 2925, 1714, 16442, 1606, 1451, 1383, 1073, 988, 895cm^{-1}; ^1H NMR (270 MHz, $CDCl_3$) δ 6.40 (1H, dd, J=17.4, 10.7, -C*H*=CH_2), 5.51 (1H, m, -C*H*=$C(CH_3)$-CH=CH_2), 5.14 (1H, d, J=17.4Hz, -CH=C(H)*H*), 5.07 (1H, m, $(CH_3)_2C=CH$-), 4.99 (1H, d, J=10.7Hz, -CH=C(*H*)H), 2.78 (1H, t, J=6.4Hz, -C(O)*H*-CH_2-), 2.56-2.22 (2H, m, -C(O)H-CH_2-CH=), 2.13-2.06 (2H, m, =CH-CH_2-CH_2-), 1.78 (3H, s, -CH=$C(CH_3)$-CH=CH_2), 1.74-1.44 (2H, m, -CH_2-$C(CH_3)$(O)-), 1.68

(3H, s, =C(CH_3)CH_3), 1.30 (3H, s, CH_2-C(CH_3)(O)-) ppm; ^{13}C NMR (67.8 MHz, $CDCl_3$) δ 141.0, 136.0, 131.9, 126.9, 123.5, 111.5, 62.6, 60.7, 38.7, 28.3, 25.7, 23.9, 17.7, 16.6, 12.0 ppm; MS *m/z* (rel. int. %) 220(3), 205(7), 167(13), 149(28), 139(12), 134(18), 123(16), 119(12), 109(23), 95(30), 81(54), 79(52), 69(96), 57(50), 55(56), 43(48), 41(100).

3,7,11-Trimethyldodeca-1,3*E*,5*E*,10-tetraen-7-ol (8)

A solution of epoxide (**7**) (90mg, 0.41mmol) in THF (1ml) was added to a mixture of *tert*-BuOK (0.183g, 1.63mmol), diisopropylamine (41mg, 0.41mmol) and *n*-BuLi (0.26ml of a 1.56M soln. in hexanes, 0.43mmol) in THF (2ml) at -50°C under N_2. The reaction mixture was warmed to room temperature over 15 min and the solvent was removed under reduced pressure. The residue was dissolved in water (10ml) and extracted with ether (2x20ml). The combined ethereal extracts were washed with sat. brine (20ml), dried over $MgSO_4$, filtered and concentrated *in vacuo* to give an oil that was purified by flash chromatography on silica gel eluting with hexane-ethyl acetate (4:1) to yield the *title compound* (87mg, 97%) as a colourless oil (R_F = 0.41; hexane-ethyl acetate (4:1)): found M^+ 220.1824, $C_{15}H_{24}O$ requires 220.1827; λ_{max} (ε) (*n*-hexane) 251 infl. (21300), 260 (36500), 269 (48450), 280 (37600) nm; IR ν_{max} (thin film) 3363, 2922, 1608, 967, 889 cm^{-1}; ^{1}H NMR (270 MHz, $CDCl_3$) δ 6.58 (1H, dd, J=15.2, 11.1Hz, -CH=C*H*-CH=C(CH_3)-), 6.41 (1H, dd, J=17.4, 10.6Hz, -C*H*=CH_2), 6.08 (1H, d, J=11.1Hz, =CH-C*H*=C(CH_3)-), 5.80 (1H, d, J=15.2Hz, -C(OH)-C*H*=CH-), 5.21 (1H, d, J=17.4Hz, -CH=C(H)*H*), 5.15-5.09 (1H, m, $(CH_3)_2$C=C*H*-), 5.03 (1H, d, J=10.6Hz, -CH=C(*H*)H), 2.08-1.98 (2H, m, $(CH_3)_2$C=CH-CH_2-), 1.88 (3H, s, =C(CH_3)-CH=CH_2), 1.71 (1H, s, -O*H*), 1.68 (3H s, =C(CH_3)CH_3), 1.66-1.54 (2H, m, -CH_2-C(OH)), 1.60 (3H, s, =C(CH_3)CH_3), 1.31 (3H, s, -C(CH_3)(OH)-) ppm; ^{13}C NMR (67.8 MHz, $CDCl_3$) δ 141.2 (C6), 141.1 (C2), 134.7 (C3), 131.6 (C11), 130.7 (C4), 124.2 (C10), 123.5 (C5), 112.2 (C1), 73.3 (C7), 42.4 (C8), 28.2 C7-CH_3), 25.6 (C12), 23.0 (C9), 17.7 (C11-CH_3), 12.1 (C3-CH_3) ppm; MS *m/z* (rel. int. %) 220(6), 202(5), 187(3), 159(6), 147(3), 139(20), 138(21), 133(6), 121(34), 105(82), 95(50), 82(100), 81(64), 69(70), 67(51), 59(35), 55(34), 41(85).

3,7-Dimethylocta-2*E*,6-dienal (*geranial*) (14)[27]

Geraniol (1.78g, 11.5mmol) was added to a stirred slurry of the Dess-Martin periodinane (5.85g, 13.8mmol) in CH_2Cl_2 (50ml) under N_2 at 0°C. The reaction mixture was warmed to room temperature over 30 min, diluted with hexane (50ml) and passed through a short plug of silica under reduced pressure. The solvent was removed *in vacuo* and the crude product was purified by short path distillation to give geranial (1.67g, 95%) as a pale yellow oil (R_F = 0.33 in hexane-ethyl acetate (6:1)), bp 115°C/18mmHg (lit[27] bp. 100-103°C/7mmHg): Found 152.1202, $C_{10}H_{16}O$ requires 152.1201; IR ν_{max} (thin film) 2918, 1675, 1632, 1442, 1194, 1121 cm^{-1}; ^{1}H NMR (270 MHz, $CDCl_3$) δ 9.95 (1H, d, J=8.1Hz, -C*H*O), 5.83 (1H, d, J=8.1Hz, =C*H*-CHO), 5.05-5.00 (1H, m, =C*H*-CH_2-), 2.18-2.12 (4H, m, -CH_2-CH_2-), 2.12 (3H, s, -C(CH_3)=CH-CHO), 1.64 (3H, s, =C(CH_3)CH_3), 1.56 (3H, s, =C(CH_3)CH_3) ppm; ^{13}C NMR (67.8 MHz, $CDCl_3$) δ 191.0, 168.6, 132.8, 127.3, 122.4, 40.6, 25.8, 25.7, 17.8, 17.7 ppm; MS *m/z* (rel. int. %) 152(4), 137(5), 123(5), 109(6), 94(12), 84(21), 69(100), 53(8), 41(91).

2-(1'-Hydroxy-3',7'-dimethylocta-2'*E*,6'-dienyl)-3-methyl-2,5-dihydrothiophene-1,1-dioxide (15)

A solution of lithium hexamethyldisilazide (1.3mmol) in THF-hexanes [prepared by the dropwise addition of *n*-butyl lithium (0.79ml of a 1.59M soln. in hexanes, 1.3mmol) to a solution of hexamethyldisilazane (0.20g, 1.25mmol) in THF (3.0ml) at 0°C under N_2] was added dropwise to a stirred solution of 3-methylsulfolene (0.15g, 1.13mmol) and geranial (**14**) (0.173g, 1.13mmol) in THF (7.0ml) at -90°C under N_2. The reaction was quenched after 15 min at -90°C by the addition of saturated NH_4Cl solution (2ml) and warmed to room temperature, whereupon water (10ml) was added the mixture extracted with ether (3x20ml). The combined ethereal extracts were washed with sat. brine (30ml), dried over $MgSO_4$, filtered and concentrated *in vacuo* to give an oil that was purified by flash chromatography on silica gel eluting with hexane-ethyl acetate (2:1) to yield recovered geranial (30.2mg, 18%) followed by the *title compound* (0.119g, 37%) as a pale yellow viscous oil as an inseparable *ca.* 2:1 mixture of diastereoisomers (R_F = 0.20; hexane-ethyl acetate (2:1)): found M^+ 284.1446, $C_{15}H_{24}O_3S$ requires 284.1446; IR ν_{max} (thin film) 3500, 2921, 1666, 1444, 1306, 1113 cm^{-1}; ^{1}H NMR (270 MHz, $CDCl_3$) major diastereoisomer: δ 5.78 (1H, br s, =C*H*CH_2SO_2-), 5.50 (1H, d, J=9.0Hz, =C*H*-CH(OH)-), 5.06 (1H [partly obscured], m, $(CH_3)_2$C=C*H*-), 4.74 (1H, dt, J=8.8, 5.8Hz, =CH-C*H*(OH)-CH),

3.80-3.70 (2H [partly obscured], m, =CHCH_2SO_2-), 3.57 (1H, m, -CH(OH)-CH(SO_2R)-C(CH_3)=), 2.15-2.03 (4H [partly obscured], m, -CH_2-CH_2-), 1.92 (3H [partly obscured], s, -C(CH_3)=CH-), 1.71 (3H [partly obscured], s, -C(CH_3)=CH-), 1.68 (3H [partly obscured], s, =C(CH_3)CH_3), 1.60 (3H, s, =C(CH_3)CH_3) ppm; ^{13}C NMR (67.8 MHz, $CDCl_3$) major diastereoisomer δ 141.4, 136.8, 131.8, 123.5, 122.6, 118.9, 72.3, 66.8, 56.1, 39.6, 26.2, 25.7, 19.1, 17.8, 16.9 ppm; MS *m/z* (rel. int. %) 284(0.2), 266(0.3), 220(0.6), 219(1), 202(6), 159(5), 153(15), 134(9), 119(11), 95(13), 69(100), 59(9), 41(49).

3,7,11-Trimethyldodeca-1,3E,6E,10-tetraen-5-ol (16)

A solution of sulfolene (**15**) (117mg, 0.41mmol) and DBU (62mg, 0.41mmol) in xylene (5.0ml) was heated to reflux for 15 min under N_2. The reaction mixture was cooled to room temperature and sat. aq. KH_2PO_4 (5ml) and water (5ml) were added. The two phase system was extracted with ether (3x20ml) and the combined ethereal extracts were washed with sat. brine (30ml), dried over $MgSO_4$, filtered and concentrated *in vacuo* to give an oil that was purified by flash chromatography on silica gel eluting with hexane-ethyl acetate (5:1)-triethylamine (0.1%), to yield the *title compound* (45mg, 50%) as a colourless oil (R_F = 0.30; hexane-ethyl acetate (5:1)-triethylamine (0.1%)): found M^+ 220.1833, $C_{15}H_{24}O$ requires 220.1827; IR ν_{max} (thin film) 3333, 2923, 1666, 1606, 1444, 1377, 989 cm^{-1}; ^{1}H NMR (270 MHz, $CDCl_3$) δ 6.37 (1H, dd, J=17.4, 10.8Hz, -CH=CH_2), 5.53 (1H, m, -CH(OH)-), 5.25 (2H, d, J=5.3Hz, =CH-CH(OH)-CH=), 5.21 (1H, d, J=17.4Hz, -CH=C(H)H), 5.08 (1H, m, (CH_3)$_2$C=CH-), 5.06 (1H, d, J=10.8Hz, -CH=C(H)H), 2.15-2.00 (4H, m, -CH_2-CH_2-), 1.83 (3H, s, -C(CH_3)=CH-), 1.74 (3H, s, -C(CH_3)=CH-), 1.68 (3H, s, =C(CH_3)CH_3), 1.60 (3H, s, =C(CH_3)CH_3) ppm; ^{13}C NMR (67.8 MHz, $CDCl_3$) δ 140.9, 140.7, 138.5, 134.6, 133.6, 125.9, 123.7, 112.9, 65.6, 39.6, 26.4, 25.9, 25.5, 17.0, 16.6 ppm; MS *m/z* (rel. int. %) 220(2), 202(12), 159(35), 133(24), 119(22), 105(40), 91(37), 81(33), 69(100), 55(30), 41(80).

6,10-Dimethylundeca-3*E*,5*E*,9-trien-2-one (*pseudoionone*) (17)[27]

Geranial (**14**) (17.76g, 0.117mol) was added to a slurry of $Ba(OH)_2.8H_2O$ (1.0g, 3.2 mmol) in acetone (150ml) and the resulting mixture was heated to reflux for 2 h through a soxlet extractor containing freshly activated 4Å molecular sieves under an atmosphere of dry N_2 . The pale yellow reaction mixture was cooled to room temperature, diluted with ether (100ml), washed with dilute HCl (2%v/v, 50ml) then water (3x50ml) and sat. brine (50ml), dried over $MgSO_4$, filtered under reduced pressure and concentrated *in vacuo* to give an oil that was purified by short path distillation to yield pseudoionone (18.34g, 82%) as a pale yellow oil (R_F = 0.13 in hexane-dichloromethane-ethyl acetate (40:20:1)), bp. 110-111°C/1.5mmHg (lit[27] bp. 114-116/2.0mmHg): Found 192.1516, $C_{13}H_{20}O$ requires 192.1514; IR ν_{max} (thin film) 2916, 1666, 1631, 1588, 1440, 1361, 1254, 977 cm^{-1}; ^{1}H NMR (270 MHz, $CDCl_3$) δ 7.43 (1H, dd, J=15.4, 11.4Hz, =CH-CH=CH-C=O), 6.08 (1H, d, J=15.4Hz, -CH=CH-C=O), 6.01 (1H, d, J=11.4Hz, =CH-CH=CH-C=O), 5.08 (1H, m, (CH_3)$_2$C=CH-), 2.28 (3H, s,-C(O)-CH_3), 2.17, (4H, m, -CH_2-CH_2-), 1.92 (3H, s, -CH_2-C(CH_3)=CH-), 1.70 (3H s, =C(CH_3)CH_3), 1.61 (3H, s, =C(CH_3)CH_3) ppm; ^{13}C NMR (67.8 MHz, $CDCl_3$) δ 198.6, 151.0, 139.5, 132.2, 128.3, 123.6, 123.1, 40.5, 27.6, 26.4, 25.8, 17.8, 17.6 ppm; MS *m/z* (rel. int. %) 192(4), 177(1), 149(4), 124(27), 109(30), 81(47), 69(100), 53(7), 43(44), 41(87).

3,7,11-Trimethyldodeca-1,4*E*,6*E*,10-tetraen-3-ol (18)

A solution of vinyl magnesium bromide (10.1mmol) in THF was added dropwise to a stirred solution of pseudoionone (**17**) (1.3g, 6.7mmol) in THF (40ml) at 0°C under N_2. The reaction was quenched after 30 min by the addition of sat. aq. KH_2PO_4 solution (30ml) and extracted with ether (3x30ml). The combined ethereal extracts were washed with water (50ml), sat. brine (50ml), dried over $MgSO_4$, filtered and concentrated *in vacuo* to give an oil that was purified by flash chromatography on silica gel eluting with hexane-ethyl acetate (6:1) to yield the *title compound* (1.05g, 71%) as a viscous, colourless oil (R_F = 0.27; hexane-ethyl acetate (6:1)): found M^+ 220.1824, $C_{15}H_{24}O$ requires 220.1827; IR ν_{max} (thin film) 3387, 2924, 1654, 1424 cm^{-1}; ^{1}H NMR (270 MHz, $CDCl_3$) δ 6.47 (1H, dd, J=15.4, 10.8Hz, =CH-CH=CH-), 6.00 (1H, dd, J=17.4, 10.6Hz, -CH=CH_2), 5.84 (1H, br d, J=10.8Hz, -C(CH_3)=CH-CH=), 5.69 (1H, d, J=15.4Hz, =C-CH=CH-C(OH)), 5.27 (1H, d, J=17.4Hz, -CH=C(H)H), 5.10 (1H, m, (CH_3)$_2$C=CH-), 5.09 (1H, d, J=10.8Hz, -CH=C(H)H), 2.17-2.05 (4H, m, -CH_2-CH_2-), 1.78 (3H, s, -CH_2-C(CH_3)=CH-), 1.70 (3H s, =C(CH_3)CH_3), 1.62 (3H, s, =C(CH_3)CH_3), 1.42 (3H, s, -C(CH_3)OH) ppm; ^{13}C NMR (67.8 MHz, $CDCl_3$) δ 143.8, 139.5, 136.1, 131.6, 124.5, 123.8(x2),

112.0, 73.3, 40.0, 28.2, 26.6, 25.8, 17.8, 16.9 ppm; MS *m/z* (rel. int. %) 220(10), 202(10), 177(7), 159(13), 137(7), 133(17), 119(10), 109(18), 107(18), 105(22), 93(36), 81(24), 69(72), 55(20), 43(100).

Ethyl - 3,7,11 - trimethyldodeca - 2*E*,4*E*,6*E*,10 - tetraenoate (2*E*-19) and ethyl - 3,7,11 - trimethyldodeca -2*Z*,4*E*,6*E*,10 - tetraenoate (2*Z*-19).

Triethylphosphonoacetate (0.87g, 3.9mmol) was added dropwise to a stirred suspension of hexane-washed sodium hydride (94mg, 3.9mmol) in toluene (10ml) under N_2 at 0°C. Pseudoionone (**17**) (0.5g, 2.6mmol) was added and the mixture was heated to reflux. After 5 h the reaction was quenched by the addition of water (20ml) and the resulting yellow emulsion was extracted with ether (3x30ml). The combined ethereal extracts were washed with sat. brine (30ml), dried over $MgSO_4$, filtered and concentrated *in vacuo* to give an oil that was purified by flash chromatography on silica gel eluting with hexane-dichloromethane-ethyl acetate (40:20:1) to yield recovered pseudoionone (0.2g, 40%) and the *title compounds* (0.336g, 49%) as a *ca.* 4:1 mixture of 2*E*:2*Z* isomers. The *title compounds* were separated by preparative centrifugal chromatography on silica rotors, eluting with hexane-dichloromethane-ethyl acetate (40:20:1) to give, firstly, (**2*Z*-19**) as a colourless oil (R_F = 0.33; hexane-dichloromethane-ethyl acetate (40:20:1)): found M^+ 262.1925, $C_{17}H_{26}O_2$ requires 262.1933; IR ν_{max} (thin film) 2925, 1710, 1604, 1238, 1150, 1044, 960 cm^{-1}; ^1H NMR (270 MHz, $CDCl_3$) δ 7.65 (1H, d, J=15.4, =CH-CH=C*H*-C(CH_3)=), 6.85 (1H, dd, J=15.4, 11.2Hz, =CH-C*H*=CH-C(CH_3)=), 6.07 (1H, d, J=11.2Hz, -C(CH_3)=C*H*-CH=CH-), 5.62 (1H, s, =C*H*-CO_2R), 5.11-5.08 (1H, m, $(CH_3)_2$C=C*H*-), 4.17 (2H, q, J=7.0Hz, -$CO_2CH_2CH_3$), 2.14 (4H, br.s, -CH_2-CH_2-), 2.05 (3H, s, -C(CH_3)=CH-CO_2R), 1.85 (3H, s, -C(CH_3)=CH-), 1.70 (3H, s, =C(CH_3)CH_3), 1.62 (3H, s, =C(CH_3)CH_3), 1.30 (3H, t, J=7.0Hz, -$CO_2CH_2CH_3$) ppm; ^{13}C NMR (67.8 MHz, $CDCl_3$) δ 166.3, 151.3, 144.0, 132.2, 131.9, 127.4, 125.5, 123.6, 116.0, 59.6, 40.3, 26.6, 25.8, 21.1, 17.8, 17.3, 14.5 ppm; MS *m/z* (rel. int. %) 262(22), 217(8), 193(29), 169(9), 147(100), 121(27), 119(58), 105(26), 91(16), 69(44), 41(37). Further elution gave (**2*E*-19**), also as a colourless oil (R_F = 0.29; hexane-dichloromethane-ethyl acetate (40:20:1)): found M^+ 262.1924, $C_{17}H_{26}O_2$ requires 262.1933; IR ν_{max} (thin film) 2925, 1710, 1607, 1235, 1152, 1053, 975 cm^{-1}; ^1H NMR (270 MHz, $CDCl_3$) δ 6.85 (1H, dd, J=15.2, 11.0Hz, =CH-C*H*=CH-C(CH_3)=), 6.18 (1H, d, J=15.2, =CH-CH=C*H*-C(CH_3)=), 5.97 (1H, d, J=11.0Hz, -C(CH_3)=C*H*-CH=CH-), 5.75 (1H, s, =C*H*-CO_2R), 5.14-5.07 (1H, m, $(CH_3)_2$C=C*H*-), 4.17 (2H, q, J=7.0Hz, -$CO_2CH_2CH_3$), 2.34 (3H, s, -C(CH_3)=CH-CO_2R), 2.14 (4H, br.s, -CH_2-CH_2-), 1.85 (3H, s, -C(CH_3)=CH-), 1.70 (3H, s, =C(CH_3)CH_3), 1.62 (3H, s, =C(CH_3)CH_3),), 1.30 (3H, t, J=7.0Hz, -$CO_2CH_2CH_3$) ppm; ^{13}C NMR (67.8 MHz, $CDCl_3$) δ 167.1, 152.8, 143.7, 133.3, 131.9, 131.0, 124.8, 123.5, 117.9, 59.6, 40.3, 26.6, 25.8, 17.8, 17.3, 14.5, 13.9 ppm; MS *m/z* (rel. int. %) 262(25), 217(9), 193(32), 169(11), 147(100), 121(30), 119(65), 105(28), 91(18), 69(57), 41(52).

3,7,11-Trimethyldodeca-2*E*,4*E*,6*E*,10-tetraen-1-ol and 3,7,11-trimethyldodeca-2*Z*,4*E*,6*E*,10-tetraen-1-ol (20)

Diisobutylaluminium hydride (1.26ml of a 1.5M solution in toluene, 1.9mmol) was added dropwise to a stirred solution of the isomeric ethyl esters (**19**) (0.226g 0.86mmol) in CH_2Cl_2 (5.0ml) at -78°C under N_2. The reaction mixture was warmed to -50°C over 15 mins and quenched by the addition of 2% NaOH (1.0ml). After warming to room temperature, sat. aq. Rochelle's salt [potassium sodium tartrate] (5.0ml) was added and the reaction mixture was extracted with CH_2Cl_2 (3x10ml). The combined organic extracts were washed with water (20ml), sat. brine (20ml), dried over $MgSO_4$, filtered and concentrated *in vacuo* to give an oil that was purified by flash chromatography on silica gel eluting with hexane-ethyl acetate (3:1) to yield the 2*Z*-isomer (45.9mg 24%) as a colourless oil (R_F = 0.38; hexane-ethyl acetate (3:1)): found M^+ 220.1825, $C_{15}H_{24}O$ requires 220.1827; IR ν_{max} (thin film) 3354, 2920, 1626, 1484, 1424, 1378, 1000, 957 cm^{-1}; ^1H NMR (270 MHz, $CDCl_3$) δ 6.52 (2H, m, =C*H*-CH=C*H*-C(CH_3)=), 5.96 (1H, m, =CH-C*H*=CH-C(CH_3)=), 5.54 (1H, t, J=7.0Hz, =C*H*-CH_2OH), 5.14-5.08 (1H, m, $(CH_3)_2$C=C*H*-), 4.31 (2H, d, J=7.0Hz, -CH_2OH), 2.12 (4H, br.s, -CH_2-CH_2-), 1.92 (3H, s, -C(CH_3)=CH-), 1.82 (3H, s, -C(CH_3)=CH-), 1.70 (3H, s, =C(CH_3)CH_3), 1.63 (3H, s, =C(CH_3)CH_3), 1.32 (1H, s, -O*H*) ppm; ^{13}C NMR (67.8 MHz, $CDCl_3$) δ 140.6, 135.9, 131.7, 127.2, 127.1, 126.3, 125.1, 123.7, 58.5, 40.2, 26.7, 25.8, 20.5, 17.8, 17.0 ppm; MS *m/z* (rel. int. %) 220(62), 202(22), 189(6), 159(27), 151(49), 145(9), 133(72), 123(34), 121(43), 107(76), 105(76), 95(18), 93(55), 91(59), 79(28), 69(70), 55(35), 41(100). Further elution gave (**20**) (0.138g 73%) as a colourless oil (R_F = 0.33; hexane-ethyl acetate (3:1)): found M^+ 220.1829, $C_{15}H_{24}O$ requires 220.1827; IR ν_{max} (thin film) 3288, 2924, 1624, 1483,

1449, 1390, 1000, 955 cm^{-1}; ^1H NMR (270 MHz, $CDCl_3$) δ 6.47 (1H, dd, J=15.2, 10.8Hz, =CH-C*H*=CH-C(CH_3)=), 6.17 (1H, d, J=15.2Hz, -CH=C*H*-C(CH_3)=), 5.91 (1H, d, J=10.8Hz, -C(CH3)=C*H*-CH=CH-), 5.65 (1H, t, J=7.0Hz, =C*H*-CH_2OH), 5.13-5.08 (1H, m, $(CH_3)_2$C=C*H*-), 4.28 (2H, d, J=7.0Hz, -CH_2OH), 2.11 (4H, br.s, -CH_2-CH_2-), 1.85 (3H, s, -C(CH_3)=CH-), 1.81 (3H, s, -C(CH_3)=CH-), 1.70 (3H, s, =C(CH_3)CH_3), 1.62 (3H, s, =C(CH_3)CH_3), 1.47 (1H, s, -O*H*) ppm; ^{13}C NMR (67.8 MHz, $CDCl_3$) δ 139.6, 136.9, 134.2, 131.6, 128.9, 125.1, 125.0, 123.8, 59.5, 40.2, 26.7, 25.8, 17.8, 17.0, 12.7 ppm; MS *m/z* (rel. int. %) 220(61), 202(16), 189(4), 159(18), 151(45), 145(5), 133(60), 123(42), 121(44), 107(79), 105(66), 95(22), 93(47), 91(56), 79(26), 69(60), 55(32), 41(100).

7-Hydroperoxy-3,7,11-trimethyldodeca-1,3*E*,5*E*,10-tetraene (3)

From the C7 alcohol (**8**) (**Table,** entry 1)

para-Toluenesulfonic acid monohydrate (1mg, $5.3x10^{-6}$mol, 2 mol%) was added to a solution of 3,7,11-trimethyldodeca-1,3*E*,5*E*,10-tetraen-7-ol (**8**) (65.5mg, 0.297mmol; 3*E*:3*Z* = 95:5) in anhydrous H_2O_2/THF (0.89M, 10ml, 8.9mmol, 30 equiv.) under an atmosphere of dry N_2 at room temperature. The solution was stirred for 48 h, diluted with water (20ml) and extracted with ether (2x10ml). The combined ethereal extracts were washed with water (2x10ml) then sat. brine (10ml), dried over $MgSO_4$, filtered and concentrated *in vacuo* to give an oil that was purified by preparative centrifugal chromatography on a silica rotor eluting with hexane-ethyl acetate (6:1) to yield recovered 3,7,11-trimethyldodeca-1,3,5*E*,10-tetraen-7-ol (**8**) (15.4mg, 24%; ; 3*E*:3*Z* = 95:5) and the *title compound* (32.3mg, 47%; 3*E*:3*Z* = 96:4) as a colourless oil (R_F = 0.32; hexane-ethyl acetate (6:1)): found M^+ 236.1775, $C_{15}H_{24}O_2$ requires 236.1776; λ_{max} (ε) (***n*-hexane**) 251 infl. (20500), 262 (33200), 270 (43000), 280 (34100) nm; IR ν_{max} (thin film) 3398, 2927, 1616, 1445, 1376, 1105, 986, 967, 893 cm^{-1}; ^1H NMR (270 MHz, $CDCl_3$) δ 7.55 (1H, s, OO*H*), 6.59 (1H, dd, J=15.4, 11.0Hz, -CH=C*H*-CH=C(CH_3)-), 6.42 (1H, dd, J=17.4, 10.6Hz, -C*H*=CH_2), 6.09 (1H, d, J=11.0Hz, =CH-C*H*=C(CH_3)-), 5.77 (1H, d, J=15.4Hz, C(OOH)-C*H*=CH-), 5.25 (1H, d, J=17.4Hz, -CH=C(H)*H*), 5.17-5.06 (1H, m, $(CH_3)_2$C=C*H*-), 5.08 (1H, d, J=10.6Hz, -CH=C(*H*)H), 2.04-1.98 (2H, m, $(CH_3)_2$C=CH-CH_2-), 1.90 (3H, s, =C(CH_3)-CH=CH_2), 1.77-1.66 (2H, m, -CH_2-C(OOH)), 1.69 (3H s, =C(CH_3)CH_3), 1.62 (3H, s, =C(CH_3)CH_3), 1.41 (3H, s, -C(CH_3)(OOH)-) ppm; ^{13}C NMR (67.8 MHz, $CDCl_3$) δ 140.9 (C2), 136.6 (C6), 135.9 (C3), 132.0 (C11), 130.5 (C4), 127.0 (C5), 124.0 (C10), 113.0 (C1), 84.6 (C7), 37.7 (C8), 25.7 (C12), 22.5 (C9), 21.8 (C7-CH_3), 17.7 (C11-CH_3), 12.2 (C3-CH_3) ppm; MS *m/z* (rel. int. %) 236(1), 218(8), 202(19), 162(34), 159(34), 137(29), 119(31), 105(42), 93(55), 81(35), 69(89), 55(52), 43(100), 41(85).

7-Hydroperoxy-3,7,11-trimethyldodeca-1,3*E*,5*E*,10-tetraene (3)

From the C5 alcohol (**16**) (**Table,** entry 2)

para-Toluenesulfonic acid monohydrate (0.5mg, $2.6x10^{-6}$mol, 4 mol%) was added to a solution of 3,7,11-trimethyldodeca-1,3*E*,6*E*,10-tetraen-5-ol (**16**) (12.9mg, $5.9x10^{-5}$mol) in anhydrous H_2O_2/THF (0.89M, 5.0ml, 4.5mmol, 76 equiv.) under an atmosphere of dry N_2 at room temperature. The solution was stirred for 5 min, diluted with water (10ml) and extracted with ether (2x10ml). The combined ethereal extracts were washed with water (2x10ml) then sat. brine (10ml), dried over $MgSO_4$, filtered and concentrated *in vacuo* to give the *title compound* (13.8mg, 100%; 3*E*:3*Z* = >99:1) as a colourless oil.

3,7,11-Trimethyldodeca-1,3*E*,5*E*,10-tetraen-7-ol (8)

From the C5 alcohol (**16**) (**Table,** entry 3)

para-Toluenesulfonic acid monohydrate (0.5mg, $2.6x10^{-6}$mol, 6 mol%) was added to a solution of 3,7,11-trimethyldodeca-1,3E,6E,10-tetraen-5-ol (**16**) (9.8mg, $4.4x10^{-5}$mol) and water (60mg, 3.3mmol, 75 equiv.) in THF (5.0ml) at room temperature under N_2. The solution was stirred for 5 min, diluted with water (10ml) and extracted with ether (2x10ml). The combined ethereal extracts were washed with sat. brine (10ml), dried over $MgSO_4$, filtered and concentrated *in vacuo* to give the *title compound* (9.8mg, 100%; 3*E*:3*Z* = >99:1) as a colourless oil.

7-Hydroperoxy-3,7,11-trimethyldodeca-1,3*E*,5*E*,10-tetraene (3) and 7-hydroperoxy-3,7,11-trimethyldodeca - 1,3*Z*,5*E*,10-tetraene

From the C3 alcohol (**18**) (**Table,** entry 4)

para-Toluenesulfonic acid monohydrate (11mg, $5.8x10^{-5}$mol, 5mol%) was added to a solution of 3,7,11-trimethyldodeca-1,4*E*,6*E*,10-tetraen-3-ol (**18**) (250mg, 1.13mmol) in anhydrous H_2O_2/THF (0.89M, 95ml, 85mmol, 75 equiv.) under an atmosphere of dry N_2 at room temperature. The solution was stirred for 6 h, diluted with water (50ml), worked up as described above and purified by flash chromatography on silica gel eluting with hexane-ethyl acetate (10:1) to yield the *title compounds* (254mg, 95%) as an inseparable mixture of 3*E* and 3*Z* isomers (3*E*:3*Z* = 73:27). NMR data for the 3*Z* isomer of (**3**); ^{1}H NMR (270 MHz, $CDCl_3$) δ 7.53 (1H, s, OO*H*), 6.96 (1H, dd, J=17.1, 10.8Hz, -C*H*=CH_2), 6.71 (1H, dd, J=15.6, 11.2Hz, -CH=C*H*-CH=C(CH_3)-), 6.01 (1H, d, J=11.2Hz, =CH-C*H*=C(CH_3)-), 5.70 (1H, d, J=15.6Hz, -C(OOH)-C*H*=CH-), 5.28 (1H, d, J=17.1Hz, -CH=C(H)*H*), 5.18 (1H, d, J=10.8Hz, -CH=C(*H*)H), 5.17-5.06 (1H, m, (CH_3)$_2$C=C*H*-), 2.04-1.98 (2H, m, (CH_3)$_2$C=CH-CH_2-), 1.91 (3H, s, =C(CH_3)-CH=CH_2), 1.77-1.66 (2H, m, -CH_2-C(OOH)), 1.69 (3H s, =C(CH_3)CH_3), 1.62 (3H, s, =C(CH_3)CH_3), 1.39 (3H, s, -C(CH_3)(OOH)-) ppm; ^{13}C NMR (67.8 MHz, $CDCl_3$) δ 135.5 (C6), 134.6 (C3), 133.0 (C2), 132.0 (C11), 129.0 (C4), 125.8 (C5), 124.0 (C10), 114.7 (C1), 84.6 (C7), 37.7 (C8), 25.7 (C12), 22.5 (C9), 21.8 (C7-CH_3), 19.9 (C3-CH_3), 17.7 (C11-CH_3) ppm.

3,7,11-Trimethyldodeca-1,3*E*,5*E*,10-tetraen-7-ol (8) and 3,7,11-trimethyldodeca-1,3*Z*,5*E*,10-tetraen-7-ol
From the C3 alcohol (**18**) (**Table,** entry 5)
para-Toluenesulfonic acid monohydrate (11mg, $5.8x10^{-5}$mol, 5 mol%) was added to a solution of 3,7,11-trimethyldodeca-1,4*E*,6*E*,10-tetraen-3-ol (**18**) (257mg, 1.17mmol) and water (1.58g, 87mmol, 74 equiv.) in THF (130ml) at room temperature under N_2. The solution was stirred for 6 h, diluted with water (50ml), worked up as described above and purified by flash chromatography on silica gel eluting with hexane-ethyl acetate (8:1) to yield the *title compounds* (246mg, 96%) as an inseparable mixture of 3*E* and 3*Z* isomers (3*E*:3*Z* = 72:28). NMR data for the 3*Z* isomer of (**8**): ^{1}H NMR (270 MHz, $CDCl_3$) δ 6.99 (1H, dd, J=17.4, 10.8Hz, -C*H*=CH_2), 6.72 (1H, dd, J=15.2, 11.2Hz, -CH=C*H*-CH=C(CH_3)-), 6.01 (1H, d, J=11.2Hz, =CH-C*H*=C(CH_3)-), 5.74 (1H, d, J=15.2Hz, -C(OH)-C*H*=CH-), 5.26(1H, d, J=17.4Hz, -CH=C(H)*H*), 5.15-5.09 (2H, m, (CH_3)$_2$C=C*H*- and -CH=C(*H*)H), 2.08-1.98 (2H, m, (CH_3)$_2$C=CH-CH_2-), 2.00 (1H, s, -O*H*), 1.88 (3H, s, =C(CH_3)-CH=CH_2), 1.68 (3H s, =C(CH_3)CH_3), 1.66-1.54 (2H, m, -CH_2-C(OH)), 1.60 (3H, s, =C(CH_3)CH_3), 1.31 (3H, s, -C(CH_3)(OH)-) ppm; ^{13}C NMR (67.8 MHz, $CDCl_3$) δ 140.1 (C6), 133.3 (C3), 133.1 (C2), 131.6 (C11), 129.1 (C4), 124.2 (C10), 122.3 (C5), 114.0 (C1), 73.2 (C7), 42.4 (C8), 28.2 (C7-CH_3), 25.6 (C12), 22.9 (C9), 19.8 (C3-CH_3), 17.7 (C11-CH_3).

Attempted hydroperoxidation of 3,7,11-trimethyldodeca-2*E*,4*E*,6*E*,10-tetraen-1-ol (20) (Table, entry 6)
para-Toluenesulfonic acid monohydrate (26.6mg, $1.4x10^{-4}$mol, 2.0 equiv.) was added to a solution of 3,7,11-trimethyldodeca-2*E*,4*E*,6*E*,10-tetraen-1-ol (**20**) (15.4mg, $7.0x10^{-5}$ mol) in anhydrous H_2O_2/THF (0.89M, 6.0ml, 5.3mmol, 75 equiv.) under an atmosphere of dry N_2 at room temperature. The reaction was monitored by TLC. Trace quantities of 7-hydroperoxy-3,7,11-trimethyldodeca-1,3*E*,5*E*,10-tetraene (3) and 7-hydroperoxy-3,7,11-trimethyldodeca - 1,3*Z*,5*E*,10-tetraene could be detected by comparison with authentic material. The solution was stirred for 6 h, diluted with water (10ml), worked up as described above and purified by flash chromatography on silica gel eluting with hexane-ethyl acetate (10:1) to yield a colourless mobile oil (2mg), identified as 6-methyl-5-hepten-2-one (23%) by comparison with authentic material (Aldrich).

3,7,11-Trimethyldodeca-1,3*E*,5*E*,10-tetraen-7-ol (8) and 3,7,11-trimethyldodeca-1,3*Z*,5*E*,10-tetraen-7-ol
From the C1 alcohol (**20**) (**Table,** entry 7)
para-Toluenesulfonic acid monohydrate (0.122g, 0.64mmol, 2.0 equiv.) was added to a solution of 3,7,11-trimethyldodeca-2*E*,4*E*,6*E*,10-tetraen-1-ol (**20**) (70.6mg, 0.32 mmol) and water (0.58g, 32mmol, 100 equiv.) in THF (25ml) at room temperature under N_2. The solution was stirred for 6 h, diluted with water (25ml) and extracted with ether (2x25ml). The combined ethereal extracts were washed with sat. brine (30ml), dried over $MgSO_4$, filtered and concentrated *in vacuo* to give an oil that was purified by flash chromatography on silica gel eluting with hexane-ethyl acetate (8:1) to give, firstly, 3 unidentified elimination products (5mg) as a colourless oil: found (GC-MS) M^+ 202.1720; M^+ 202.1718; M^+ 202.1720, $C_{15}H_{22}$ requires 202.1722). Further elution gave the *title compounds* (5mg, 15%) as a colourless oil as an inseparable mixture of 3*E* and 3*Z* isomers (3*E*:3*Z* = 87:13) and, finally, recovered starting material (40mg, 56%).

7-Hydroperoxy-3,7,11-trimethyldodeca-1,3*E*,5*E*,10-tetraene (3) and 7-hydroperoxy-3,7,11-trimethyldodeca - 1,3*Z*,5*E*,10-tetraene

From the C7 alcohol (**8**) (**Table,** entry 8)

para-Toluenesulfonic acid monohydrate (2.3mg, $1.2x10^{-5}$mol, 5 mol%) was added to a solution of 3,7,11-trimethyldodeca-1,3*E*,5*E*,10-tetraen-7-ol (**8**) and 3,7,11-trimethyldodeca-1,3*Z*, 5*E*,10-tetraen-7-ol (53.7mg, 0.24mmol; 3*E*:3*Z* = 72:28) in anhydrous H_2O_2/THF (0.89M, 20.5ml, 18.2mmol, 75 equiv.) under an atmosphere of dry N_2 at room temperature. The solution was stirred for 48 h, diluted with water (40ml) and extracted with ether (2x30ml). The combined ethereal extracts were washed with water (2x30ml) then sat. brine (30ml), dried over $MgSO_4$, filtered and concentrated *in vacuo* to give an oil that was purified by preparative centrifugal chromatography on a silica rotor eluting with hexane-ethyl acetate (6:1) to yield recovered 3,7,11-trimethyldodeca-1,3,5*E*,10-tetraen-7-ol (**8**) and 3,7,11-trimethyldodeca-1,3*Z*, 5*E*,10-tetraen-7-ol (15.0mg, 26%; ; 3*E*:3*Z* = 73:27) and the *title compounds* (30.5mg, 53%; 3*E*:3*Z* = 69:31) as colourless oils.

7-*tert*Butylperoxy-3,7,11-trimethyldodeca-1,3*E*,5*E*,10-tetraene (25)

para-Toluenesulfonic acid monohydrate (1.0mg, $5x10^{-6}$mol, 5 mol%) was added to a solution of 3,7,11-trimethyldodeca-1,3*E*,6*E*,10-tetraen-5-ol (**16**) (22mg, $9.9x10^{-5}$mol) and anhydrous *tert*-butylhydroperoxide (0.67g, 7.48mmol, 75 equiv.) in anhydrous THF (4.4ml) under an atmosphere of dry N_2 at room temperature. The solution was stirred for 5 min, diluted with water (10ml) and extracted with ether (2x10ml). The combined ethereal extracts were washed with water (2x10ml) then sat. brine (10ml), dried over $MgSO_4$, filtered and concentrated *in vacuo* to give an oil that was purified by flash chromatography on silica gel eluting with hexane-ethyl acetate (6:1) to yield the *title compound* (25mg, 85%) as a pale yellow oil (R_F = 0.61; hexane-ethyl acetate (6:1)): found M^+ 292.2422, $C_{19}H_{32}O_2$ requires 292.2402; λ_{max} (ε) (*n*-hexane) 252 infl. (17500), 261 (22000), 270 (27000), 281 (22500) nm; IR ν_{max} (thin film) 2975, 1616, 1448, 1384, 1362, 1197 cm^{-1}; ^1H NMR (270 MHz, $CDCl_3$) δ 6.48 (1H, dd, J=15.4, 11.0Hz, -CH=C*H*-CH=C(CH_3)-), 6.42 (1H, dd, J=17.4, 10.7Hz, -C*H*=CH_2), 6.09 (1H, d, J=11.0Hz, C(OOR)-C*H*=CH-), 5.85 (1H, d, J=15.4Hz, =CH-C*H*=C(CH_3)-), 5.21 (1H, d, J=17.4Hz, CH=C(H)*H*), 5.15-5.08 (1H, m, $(CH_3)_2$C=C*H*-), 5.04 (1H, d, J=10.7Hz, -CH=C(*H*)H), 2.05-1.96 (2H, m, $(CH_3)_2$C=CH-CH_2-), 1.88 (3H, s, =C(CH_3)-CH=CH_2), 1.68 (3H s, =C(CH_3)CH_3), 1.66-1.56 (2H, m, -CH_2-C(OOR), 1.60 (3H, s, =C(CH_3)CH_3), 1.36 (3H, s, -C(CH_3)(OOC(CH_3)$_3$), 1.23 (9H, s, OOC(CH_3)$_3$) ppm; ^{13}C NMR (67.8 MHz, $CDCl_3$) δ 141.2 (C2), 138.9 (C6), 134.7 (C3), 131.3 (x2) (C11 and C4), 125.3 (C5), 124.5 (C10), 112.2 (C1), 82.0 (C7), 78.6 (C1'), 38.8 (C8), 26.8 (C2'), 25.8 (C12), 22.7 (C9), 22.6 (C7-CH_3), 17.7 (C11-CH_3), 12.2 (C3-CH_3) ppm; MS *m/z* (rel. int. %) 292(0.1), 219(2), 203(32), 161(6), 147(10), 133(9), 123(9), 121(11), 119(12), 109(18), 103(15), 81(17), 69(100), 55(13), 41(29).

7-Methoxy-3,7,11-trimethyldodeca-1,3*E*,5*E*,10-tetraene (26)

para-Toluenesulfonic acid monohydrate (1.0mg, $5x10^{-6}$mol, 5 mol%) was added to a solution of 3,7,11-trimethyldodeca-1,3*E*,6*E*,10-tetraen-5-ol (**16**) (22mg, $9.9x10^{-5}$mol) and methanol (0.3ml, 75 equiv.) in anhydrous THF (4.7ml) under an atmosphere of dry N_2 at room temperature. The solution was stirred for 5 min, diluted with water (10ml) and extracted with ether (2x10ml). The combined ethereal extracts were washed with sat. brine (10ml), dried over $MgSO_4$, filtered and concentrated *in vacuo* to give an oil that was purified by flash chromatography on silica gel eluting with hexane-ethyl acetate (6:1) to yield the *title compound* (19mg, 81%) as a colourless oil (R_F = 0.60; hexane-ethyl acetate (6:1)): found M^+ 234.1987, $C_{16}H_{26}O$ requires 234.1983; λ_{max} (ε) (*n*-hexane) 251 infl. (20100), 261 (34200), 270 (45500), 281 (36000) nm; IR ν_{max} (thin film) 2928, 1614, 1450, 1375, 1085 cm^{-1}; ^1H NMR (270 MHz, $CDCl_3$) δ 6.48 (1H, dd, J=15.6, 11.0Hz, -CH=C*H*-CH=C(CH_3)-), 6.42 (1H, dd, J=17.2, 10.8Hz, -C*H*=CH_2), 6.10 (1H, d, J=11.0Hz, C(OCH_3)-C*H*=CH-), 5.67 (1H, d, J=15.6Hz, =CH-C*H*=C(CH_3)-), 5.23 (1H, d, J=17.2Hz, CH=C(H)*H*), 5.13-5.08 (1H, m, $(CH_3)_2$C=C*H*-), 5.05 (1H, d, J=10.8Hz, -CH=C(*H*)H), 3.17 (3H, s, -OCH_3), 2.03-1.94 (2H, m, $(CH_3)_2$C=CH-CH_2-), 1.89 (3H, s, =C(CH_3)-CH=CH_2), 1.68 (3H s, =C(CH_3)CH_3), 1.62-1.56 (2H, m, -CH_2-C(OCH_3)-), 1.60 (3H, s, =C(CH_3)CH_3), 1.29 (3H, s, -C(CH_3)(OCH_3)-) ppm; ^{13}C NMR (67.8 MHz, $CDCl_3$) δ 141.0 (C6), 139.3 (C2), 135.0 (C3), 131.3 (C11), 130.9 (C4), 126.0 (C10), 124.3 (C5), 112.5 (C1), 77.2 (C7), 50.1 (C1'), 39.8 (C8), 25.8 (C12), 22.6 (C7-CH_3), 22.5 (C9), 17.8 (C11-CH_3), 12.2 (C3-CH_3) ppm; MS *m/z* (rel. int. %) 234(2), 202(14), 187(7), 159(24), 151(100), 133(32), 119(69), 105(37), 91(41), 73(74), 69(63), 59(63), 41(82).

1-Methyl-1-(6'-methyl-6'-(4''-methyl-1''E, 3''E, 5''-hexatrienyl)-1',2'-dioxan-3'-yl) ethyl hydroperoxide (4)

A solution of samarium (II) iodide (0.1M in THF, 0.13ml, 0.013mmol) was diluted with benzene (1.0ml) and treated with dry oxygen (0.3ml, 0.013mmol). The resulting yellow solution was added dropwise over 2 h (syringe pump) to a stirred solution of the hydroperoxide (**3**) (30.0mg, 0.13mmol) in benzene (12ml) under an atmosphere of dry oxygen at 20°C. After 36 h, the solvent was removed under reduced pressure and the residue purified by preparative centrifugal chromatography on a silica rotor under an argon atmosphere, eluting with cold (0 °C) hexane-ethyl acetate (4:1) to yield the *title compound* (28.2mg, 82%) as a colourless oil as an inseparable *ca.* 1:1.2 mixtures of diastereoisomers (R_F = 0.19; hexane-ethyl acetate (4:1)): found M^+ 268.1685, $C_{15}H_{24}O_4$ requires 268.1675; λ_{max} (ε) (*n*-hexane) 251 infl. (13800), 261 (21800), 269 (27000), 279 (21500) nm; IR ν_{max} 3422, 2926, 1612, 1459, 1366, 1167, 1091, 986, 966 cm^{-1}; ^1H NMR (270 MHz, $CDCl_3$) [major diastereoisomer] δ 7.74 (1H, s, -OO*H*), 6.58 (1H, dd, J=15.7, 11.0Hz, -CH=C*H*-CH=C(CH_3)-), 6.40 (1H, dd, J=17.4, 10.5Hz, -C*H*=CH_2), 6.09 (1H, d, J=11.2Hz, =CH-C*H*=C(CH_3)-), 5.93 (1H, d, J=15.6Hz, -C(CH_3)(OO)-C*H*=CH-), 5.23 (1H, d, J=17.4Hz, -CH=C(H)*H*), 5.06 (1H, d, J=10.5Hz, -CH=C(*H*)H), 4.25 (1H, m, (-CH_2-)C*H*(-OO-), 2.08-1.63 (4H, br m, -CH_2-CH_2-), 1.89 (3H, s, =C(CH_3)-CH=CH_2), 1.30 (3H, s, (-CH2-)C(CH_3)(-OO-)), 1.26 (3H, s, -C(OOH)(CH_3)(CH_3)), 1.22 (3H, s, -C(OOH)(CH_3)(CH_3)) ppm; ^{13}C NMR (67.8 MHz, $CDCl_3$) δ 141.0 (C2) 136.8 (C6), 136.7 (C3), 130.7 (C4), 126.1 (C5), 112.8 (C1), 84.5 (C10), 83.2 (C11), 81.0 (C7), 33.6 (C8), 26.8 (C7-CH_3), 21.1 (C9), 21.0 (C12), 20.9 (C11-CH_3), 12.2 (C3-CH_3) ppm; ^1H NMR (270 MHz, $CDCl_3$) [minor diastereoisomer] δ 7.83 (1H, s, -OO*H*), 6.60 (1H, dd, J=15.6, 11.0Hz, -CH=C*H*-CH=C(CH_3)-), 6.42 (1H, dd, J=17.4, 10.5Hz, -C*H*=CH_2), 6.03 (1H, d, J=11.2Hz, =CH-C*H*=C(CH_3)-), 5.69 (1H, d, J=15.4Hz, -C(CH_3)(OO)-C*H*=CH-), 5.25 (1H, [partly obscured] d, J=17.4Hz, -CH=C(H)*H*), 5.08 (1H, [partly obscured] d, J=10.8Hz, -CH=C(*H*)H), 4.27 (1H, [partly obscured] m, (-CH_2-)C*H*(-OO-), 2.08-1.63 (4H, br m, -CH_2-CH_2-), 1.88 (3H, s, =C(CH_3)-CH=CH_2), 1.50 (3H, s, (-CH2-)C(CH_3)(-OO-)), 1.25 (3H, [partly obscured], s, -C(OOH)(CH_3)(CH_3)), 1.22 (3H, s, -C(OOH)(CH_3)(CH_3)) ppm; ^{13}C NMR (67.8 MHz, $CDCl_3$) δ 140.9 (C2), 136.3 (C6), 135.3 (C3), 130.4 (C4), 126.4 (C5), 113.2 (C1), 84.6 (C10), 83.2 (C11), 80.0 (C7), 32.8 (C8), 21.5 (C7-CH_3), 21.0 (C12), 20.9 (C11-CH_3), 20.4 (C9), 12.2 (C3-CH_3) ppm; MS *m/z* (rel. int. %) 268(1.3), 236(1), 220(1), 205(2), 193(5), 176(3), 149(4), 133(6), 119(10), 105(9), 93(18), 91(18), 86(30), 84(45), 77(17), 58(25), 43(100).

1-Methyl-1-(6'-methyl-6'-(4''-methyl-1''E, 3''E, 5''-hexatrienyl)-1',2'-dioxan-3'-yl) ethan-1-ol (27)

Triphenylphosphine (54mg, 0.2mmol) was added to a solution of hydroperoxides (**4**) (49mg of a 1.2:1 mixture, 0.2mmol) in benzene (10ml) at room temperature under N_2. The reaction mixture was stirred for 5 min and the solvent removed under reduced pressure. The residue was purified immediately by preparative centrifugal chromatography on a silica rotor under an argon atmosphere, eluting with cold (0 °C) hexane-ethyl acetate (4:1) to yield the *title compound* (45mg, 98%) as an inseparable *ca.* 1.2:1 mixture of diastereoisomers (R_F = 0.12; hexane-ethyl acetate (4:1)): found M^+ 252.1724, $C_{15}H_{24}O_3$ requires 252.1725; λ_{max} (ε) (*n*-hexane) 250 infl. (9300), 260 (15400), 269 (19300), 279 (15400) nm; IR ν_{max} 3424, 2925, 1614, 1451, 1378, 1169, 1089, 985, 965 cm^{-1}; ^1H NMR (270 MHz, $CDCl_3$) [major diastereoisomer] δ 6.55 (1H, dd, J=15.8, 11.2Hz, -CH=C*H*-CH=C(CH_3)-), 6.42 (1H, dd, J=17.4, 10.6Hz, -C*H*=CH_2), 6.09 (1H, d, J=11.2Hz, =CH-C*H*=C(CH_3)-), 5.94 (1H, d, J=15.8Hz, -C(CH_3)(OO)-C*H*=CH-), 5.23 (1H, d, J=17.4Hz, -CH=C(H)*H*), 5.06 (1H, d, J=10.7Hz, -CH=C(*H*)H), 3.95-3.86 (1H, m, (-CH_2-)C*H*(-OO-), 2.07-1.61 (4H, br m, -CH_2-CH_2-), 1.89 (3H, s, =C(CH_3)-CH=CH_2), 1.26 (4H, [partly obscured], b s, (-CH2-)C(CH_3)(-OO-), -O*H*), 1.21 (3H, s, -C(OH)(CH_3)CH_3) 1.16 (3H, s, -C(OH)(CH_3)CH_3) ppm; ^{13}C NMR (67.8 MHz, $CDCl_3$) δ 141 (C2), 137.0 (C6), 136.6 (C3), 130.8 (C4), 126.0 (C5), 112.7 (C1), 86.8 (C10), 80.9 (C7), 71.8 (C11), 33.6 (C8), 26.1 (C12), 24.9 (C11-CH_3), 21.6 (C7-CH_3), 20.2 (C9), 12.2 (C3-CH_3) ppm; ^1H NMR (270 MHz, $CDCl_3$) [minor diastereoisomer] δ 6.60 (1H, dd, J=15.6, 11.2Hz, -CH=C*H*-CH=C(CH_3)-), 6.41 (1H, dd, J=17.4, 10.6Hz, -C*H*=CH_2), 6.04 (1H, d, J=11.2Hz, =CH-C*H*=C(CH_3)-), 5.69 (1H, d, J=15.2Hz, -C(CH_3)(OO)-C*H*=CH-), 5.25 (1H, d, J=17.6Hz, -CH=C(H)*H*), 5.08 (1H, d, J=10.4Hz, -CH=C(*H*)H), 3.95-3.86 (1H, m, (-CH_2-)C*H*(-OO-), 2.07-1.61 (4H, br m, -CH_2-CH_2-), 1.88 (3H, s, =C(CH_3)-CH=CH_2), 1.50 (3H, s, (-CH2-)C(CH_3)(-OO-)), 1.26 (4H, [partly obscured], s, -C(OH)(CH_3)CH_3), -O*H*), 1.22 (3H, s, -C(OH)(CH_3)CH_3) ppm; ^{13}C NMR (67.8 MHz, $CDCl_3$) δ 140.9 (C2), 136.5 (C6), 135.2 (C3), 130.4 (C4), 126.3 (C5), 113.2 (C1), 86.8 (C10), 80.0 (C7), 72.0 (C11), 32.8 (C8), 26.7 (C7-CH_3), 26.2 (C12), 25.0 (C11-CH_3), 20.9 (C9), 12.2 (C3-CH_3) ppm; MS *m/z* (rel. int. %) 252(4), 236(2),

220(2), 205(5), 193(10), 183(39), 165(6), 149(6), 133(10), 119(14), 108(19), 93(23), 86(41), 84(63), 77(21), 59(30), 43(100).

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