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The synthesis of Ambra oxide related compounds starting from (+)-larixol. Part 3

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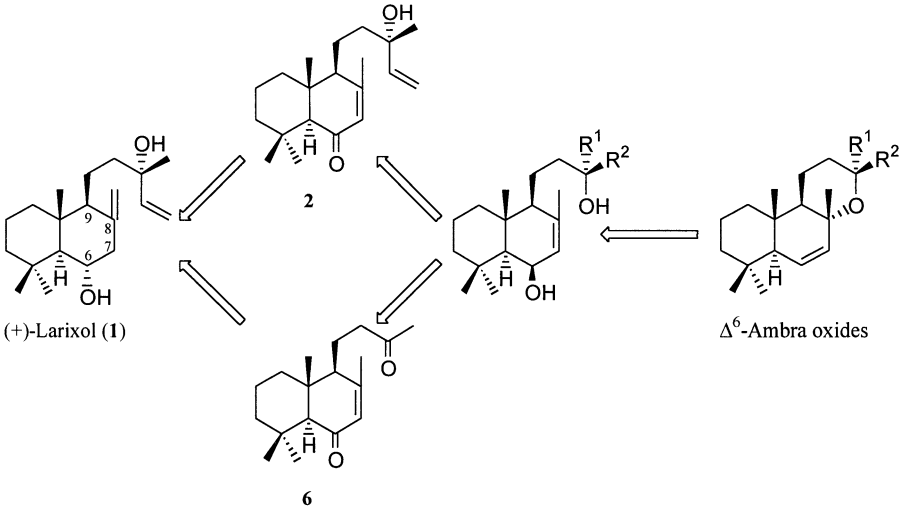
Abstract—(+)-Larixol can be easily transformed into intermediates with an hydroxyl group at C(6), a Δ^7 double bond and a substituted side chain at C(9) with a second hydroxyl group. Abstraction of the allylic hydroxyl group at C(6), followed by interception of the resulting mesomeric carbocation at C(8) by the hydroxyl group in the side chain, allows the synthesis of some C(13) modified Δ^6-tricyclic tetrahydropyranyl ethers (Δ^6-Ambra oxides). The formation of $\Delta^{6,8}$-dienes proves to be a seriously competing reaction. © 2002 Elsevier Science Ltd. All rights reserved.

1. Introduction

Larixol (**1**) and its acetate are readily available from Nature,[1–3] but not much chemistry has been developed for the synthesis of Ambergris odor compounds starting from these labdanes. The combination of the hydroxyl group at C(6) and the exocyclic double bond at C(8) in these compounds offers possibilities for the synthesis of ring B modified Ambergris odor compounds and in a previous publication we have reported on the selective synthesis of Δ^6-Ambrox® related compounds starting from (+)-larixol (**1**).[4] The key transformation in that approach consisted of the easy abstraction of the axial oriented allylic hydroxyl group at C(6) followed by interception of the resulting mesomeric carbocation at C(8) by a nucleophilic hydroxyl group in the side chain. In this publication our attempts to extend this approach to the synthesis of several C(13) modified Δ^6-tricyclic tetrahydropyranyl ethers (Δ^6-Ambra oxides)[5] are described (Scheme 1).

2. Results and discussion

Enones **2** and **6**, which can be obtained in a few reaction steps from (+)-larixol (**1**), are in principle good starting materials for the selective syntheses of a variety of C(13)



Scheme 1.

Keywords: larixol; stereoselective enone reduction; intramolecular etherification; Ambra oxide.
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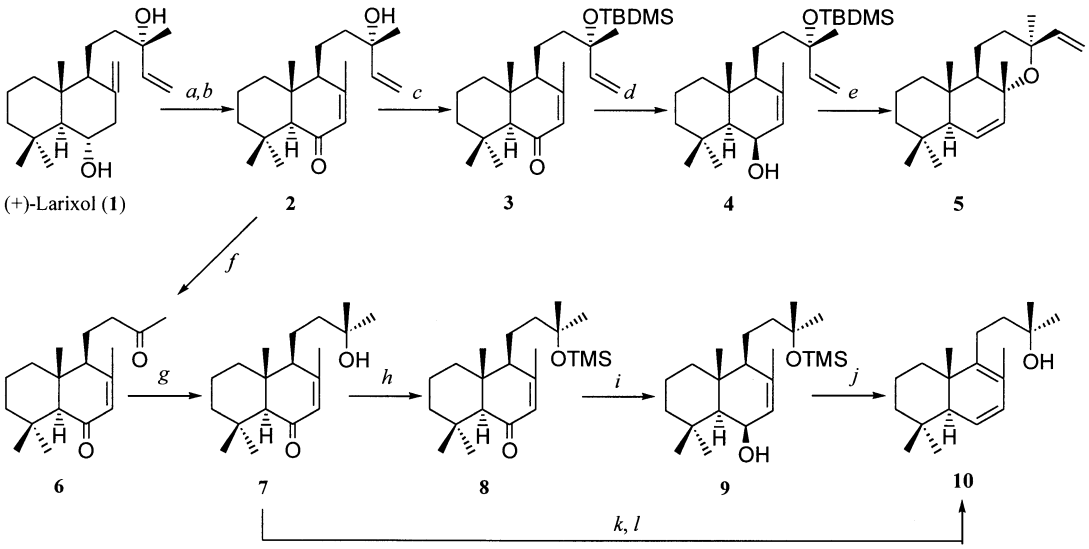


Scheme 2. *Reagents and conditions*: (a) PCC, CH_2Cl_2, 95%; (b) $NaOCH_3$, MeOH, 98%; (c) TBDMSiCl, DMF, imidazole, 70°C, 3 days, 92%; (d) DIBAL-H, toluene, −78°C, 98%; (e) (i) HF (50% aqueous solution), CH_3CN; (ii) SiO_2, 67%; (f) $KMnO_4$, benzyltriethylammonium chloride, CH_2Cl_2, rt, 68%; (g) MeLi, Et_2O, −78°C, 81%; (h) TMSiCl, DMF, imidazole, 99%; (i) DIBAL-H, toluene, −78°C, 76%; (j) (i) HF (50% aqueous solution), CH_3CN; (ii) SiO_2, 80%; (k) DIBAL-H, toluene, −78°C, 40%; (l) PPTS, CH_3NO_2, 79%.

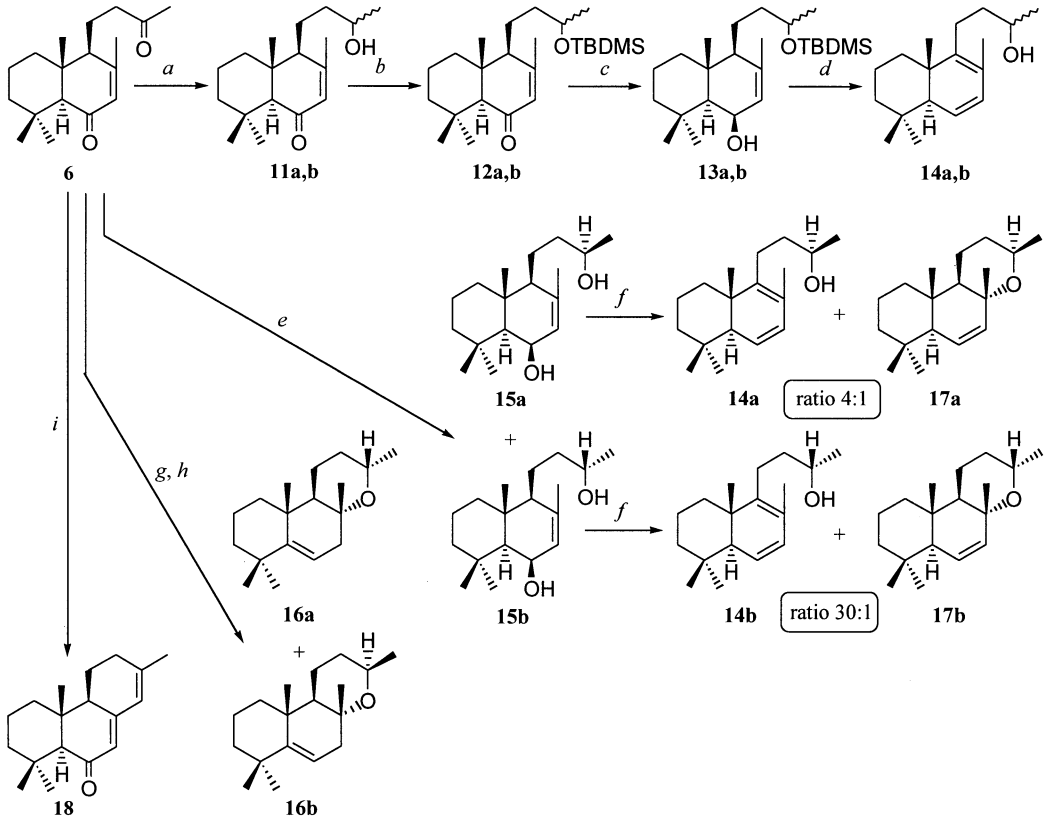
modified Δ^6-tricyclic tetrahydropyranyl ethers (Δ^6-Ambra oxides) (Schemes 1 and 2). Enone **2** was synthesized easily by oxidation of the hydroxyl group at C(6) in (+)-larixol, followed by base catalyzed isomerization of the exocyclic double bond to the conjugate endocyclic position.[6] The reduction of the carbonyl group at C(6) in **3** was carried out in high yield with DIBAL-H, provided that the hydroxyl group in the side chain was protected. On the other hand, deprotection of this hydroxyl group in the side chain with an aqueous HF solution[7] was accompanied by cyclization of the intermediate diol during its purification as was demonstrated in the synthesis of ether **5**, thus providing the first example of the successful synthesis of six-membered cyclic ethers.

Oxidation of the side chain in **2** with $KMnO_4$ gave diketone **6**, in which the non-conjugated carbonyl group in the side chain could be manipulated selectively (Scheme 2). Addition of methyl lithium[8] to **6** proceeded selectively in high yield to give **7**, and after protection of the hydroxyl group, as its trimethylsilyl (TMS) ether, the reduction of the carbonyl group at C(6) to compound **9** also went without difficulties. However, in this case the combined deprotection cyclization reaction did not give cyclization and dehydrated diene **10** was isolated as the only product in 61% yield based on **7**. Reduction with DIBAL-H without protection of the hydroxy group at C(13) in **7** immediately followed by treatment with a catalytic amount of acid to cause cyclization also gave diene **10**, but now in only 30% yield. These different results prompted us to investigate the cyclization behaviour of the C(13) monosubstituted and C(13) unsubstituted compounds as well.

Selective reduction of the carbonyl group in the side chain of **6** gave a mixture of two C(13) epimeric alcohols. When this mixture was submitted to the similar reaction sequence as described before for the synthesis of **5** (Scheme 2) viz protection of the hydroxyl group in the side chain, reduction of the carbonyl group at C(6), deprotection of the hydroxyl group in the side chain and cyclization, again an epimeric mixture of C(13)-mono-methyl substituted dienes **14a**,**b** was obtained (Scheme 3). It should be mentioned that separation of the epimers **12a**,**b** and **13a**,**b** is possible but for convenience this was only done for analytical purposes. Especially **13a**,**b** proved to be unstable and led to a mixture of products which was not investigated further, therefore **13a**,**b** should be used as such.

The reduction of both carbonyl groups in **6** was carried out simultaneously with DIBAL-H at low temperature, to give a separable 5:2 mixture of the two diols **15a** and **15b**, respectively, after aqueous work up. After chromatographic separation each diol was treated with a catalytic amount of PPTS in an attempt to cyclize it into the cyclic ethers **17a** and **17b**, but again only the dienes **14a** and **14b** were obtained. After treatment with aqueous hydrochloric acid both diols **15a** and **15b** gave a small to very small amount of the cyclized products **17a** and **17b**, respectively, but also in this case the dienes **14a** and **14b** were obtained as the main products. The formation of the cyclic ethers **17a** and **17b** allowed the assignment of the correct configuration at C(8) and C(13), because a clear nOe between the methyl groups at C(8) and C(13) could be detected only in the NMR spectrum of **17a**. Moreover, the observed coupling constants for H(13) in the NMR spectra of **17a** and **17b** (**17a**: J= 3.6 Hz; **17b**: J=4.3 Hz) is fully consistent with the proposed structures. Consequently the configuration at C(13) in their precursors **15a** and **15b**, respectively, and in the two dienes **14a** and **14b** respectively, could also be assigned.

When the reduction of both carbonyl groups in **6** was carried out with DIBAL-H and an aqueous acidic work up was practiced, compounds **16a** and **16b** were obtained with the double bond in the Δ^5 position. So acidic work-up in the DIBAL-H reduction should be avoided if Δ^6 derivatives are desired, and an aqueous basic work-up should be used preferentially. Also NMR spectroscopy measurements of the Δ^6-Ambra oxides or the intermediates in deuterated

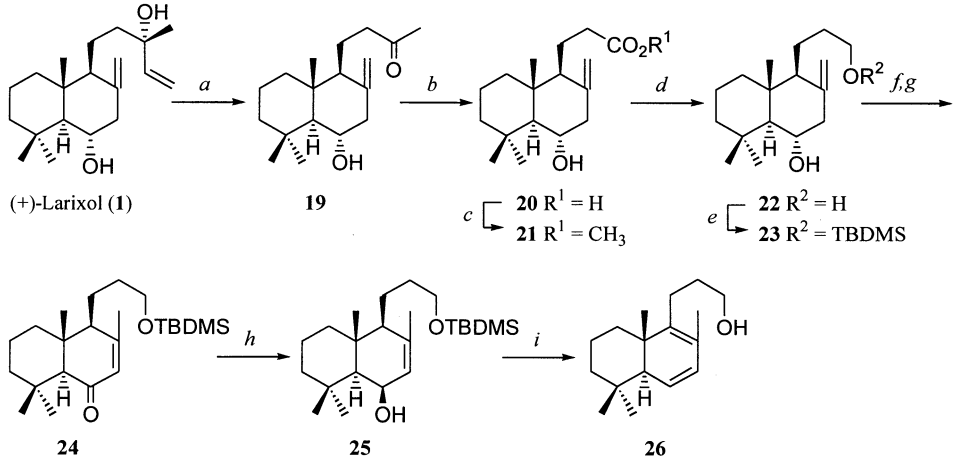


Scheme 3. *Reagents and conditions*: (a) $NaBH_4$, MeOH, 0°C, 94%; (b) TBDMSiCl, DMF, imidazole, 98%; (c) DIBAL-H, toluene, −78°C, 80%; (d) (i) HF (50% aqueous solution), CH_3CN; (ii) SiO_2, 89%; (e) DIBAL-H, toluene, −78°C, NaOH, H_2O, 78%; (f) 4 M aq. HCl, Et_2O, 80–95%; (g) DIBAL-H, toluene, −78°C, HCl, H_2O; (h) *p*-TsOH, CH_3NO_2, 29%; (i) KI, I_2, KOH, 1,4-dioxane, 92%.

chloroform led to degradation and isomerization. However when the NMR spectroscopy experiments were performed in deuterated benzene all compounds were stable and the recording of ^1H, ^{13}C and 2D NMR spectra was no problem.

The synthesis of the unsubstituted C(13) analogue **26** was first tried by shortening the side chain in **6** with one carbon atom through an iodoform reaction,[9] but this reaction did not give the desired compound. Under the basic reaction conditions a seldom observed type of intramolecular aldol condensation took place to give the dienone **18** (Scheme 3). A similar cyclization of **6** could be realized in high yield by simple treatment with base.[10]

Therefore a different route was followed in which the side chain in larixol (**1**) was first shortened to the desired length followed by a modification of ring B (Scheme 4). The oxidation with $KMnO_4$ of (+)-larixol (**1**) to the methyl ketone **19** has been described before[5] and in this compound



Scheme 4. *Reagents and conditions*: (a) $KMnO_4$, benzyltriethylammonium chloride, CH_2Cl_2, 0–3°C, 68%; (b) KI, I_2, KOH, 1,4-dioxane, 56%; (c) CH_2N_2, MeOH/Et_2O 1:1; 98%; (d) R^1=CH_3: $LiAlH_4$, THF, 0°C, 93%; (e) TBDMSiCl, DMF, imidazole, 94%; (f) R^2=TBDMS: PCC, CH_2Cl_2, 82%; (g) $NaOCH_3$, MeOH, 78%; (h) DIBAL-H, toluene, −78°C, 87%; (i) (i) THF (50% aqueous solution), CH_3CN; (ii) SiO_2, 88%.

the iodoform reaction could be accomplished in an acceptable yield. The acid was converted into its methyl ester **21** and reduction of the ester into an alcohol and selective protection of the primary hydroxyl group in the side chain gave compound **23**. Now the β-orientated allylic alcohol in ring B was constructed by oxidation of the hydroxyl group at C(6), isomerization of the double bond to enone **24**, and stereoselective reduction of the carbonyl group to give the allylic alcohol **25**. Upon deprotection of the silyl ether in the side chain the corresponding diene **26** was formed again, and no cyclized product could be detected.

It thus turned out that the already described successful cyclization to a five-membered cyclic ether[4] could not be extended to an equally successful cyclization of the corresponding homologues to the six-membered cyclic ethers, e.g. Δ^6-Ambra oxides. In all but one of the latter cases, elimination of the 6β-hydroxyl group to the corresponding $\Delta^{6,8}$-dienes was observed as the major reaction. In the cyclization reaction of compound **25**, with the unsubstituted sidechain, an explanation for this may be that the speed of formation of the six-membered ring is sufficiently slower to allow the competing elimination to become the predominant reaction. In the cyclization reactions of compounds **13a**,**b** and **9**, with their substituted sidechains, the Thorpe–Ingold effect still cannot compensate for this slower cyclization and elimination remains the predominant reaction. Only in compound **4**, cyclization is observed as the only reaction, probably because the less voluminous vinyl group now occupies the axial position in the cyclized product. When other cyclization conditions are applied, low yields of the mono-methyl substituted cyclic ethers **16a**,**b** or **17a**,**b** can be isolated. The isolation of **17a** and **17b** did facilitate the assignment of the configuration at C(13) in the precursors **15a** and **15b** and in the dienes **14a** and **14b**, respectively, but further research in this direction was stopped because of the low yields of the desired cyclic ethers.

3. Experimental[11]

3.1. Data for compounds.

3.1.1. (+)-(4*S*,4a*R*,8a*S*)-4-((3*S*)-3-([*tert*-Butyl(dimethyl)-silyl]oxy)-3-methyl-4-pentenyl)-3,4a,8,8-tetramethyl-4a,5,6,7,8,8a-hexahydro-1(4*H*)-naphthalenone (3). To a stirred solution of enone **2**[6] (0.98 g, 3.22 mmol) in DMF (35 mL) were added *tert*-butyldimethylsilyl chloride (4.86 g, 32.24 mmol) and imidazole (4.39 g, 64.47 mmol). The reaction mixture was stirred at 60°C for 3 days. After cooling to room temperature a saturated aqueous solution of $NaHCO_3$ was added and the mixture was extracted with ethyl acetate. The organic solution was washed with H_2O and worked up as usual. The crude yellow oil was purified by flash column chromatography (eluent petroleum ether/EtOAc (PE/EA) 25:1) to give **3** (1.24 g, 2.96 mmol; 92%) as a colourless oil.

$[\alpha]_D$=+26.0 (*c* 0.9); IR (film) ν_{max} 2929, 1673, 1462, 1254, 1120, 1037 cm^{-1}; ^1H NMR δ 0.06 (s, 6H), 0.82 (s, 3H), 0.88 (s, 9H), 1.11 (s, 3H), 1.14 (s, 3H), 1.32 (s, 3H), 1.89 (s, 3H), 0.86–2.02 (m, 12H), 5.03 (dd, *J*=1.4, 10.7 Hz, 1H), 5.14 (dd, *J*=1.4, 17.4 Hz, 1H), 5.73 (br s, 1H), 5.87 (dd, *J*=10.7, 17.4 Hz, 1H); ^{13}C NMR δ −2.0 (2×q), 14.7 (q), 18.2 (t), 18.3 (s), 21.4 (t), 21.5 (q), 22.2 (q), 25.9 (3×q), 26.9 (q), 32.3 (s), 33.5 (q), 38.8 (t), 43.2 (t), 43.5 (s), 46.8 (t), 56.6 (d), 63.6 (d), 75.7 (s), 112.3 (t), 128.4 (d), 145.4 (d), 159.3 (s), 200.4 (s); HRMS: (M^+−15), found 403.3030. $C_{25}H_{43}O_2Si$ requires 403.3032; MS *m*/*e* (%) 403 [(M^+−15), 5], 363 (8), 362 (30), 361 (100), 286 (19), 186 (9), 185 (57), 135 (11), 81 (9), 75 (30), 73 (17).

3.1.2. (−)-(1*R*,4*S*,4a*R*,8a*S*)-4-((3*S*)-3-([*tert*-Butyl(dimethyl)-silyl]oxy)-3-methyl-4-pentenyl)-3,4a,8,8-tetramethyl-1,4,4a,5,6,7,8,8a-octahydro-1-naphthalenol (4). To a solution of silyl ether **3** (0.10 g, 0.239 mmol) in dry toluene (5 mL) at −78°C under N_2 was added DIBAL-H (0.64 mL of a 1.5 M solution in toluene; 0.957 mmol). After stirring for 1 h, the excess of DIBAL-H was quenched with ethyl acetate and then with an aqueous solution of 1 M HCl. The mixture was extracted with ethyl acetate. The organic layers were washed with brine, dried and evaporated. The residue was purified by flash column chromatography (eluent PE/EA 25:1) to obtain **4** (0.094 g, 0.234 mmol; 98%) as a colourless oil.

$[\alpha]_D$=−6.6 (*c* 1.6); IR (film) ν_{max} 3472, 2927, 2858, 1461, 1254, 1041, 919 cm^{-1}; ^1H NMR δ 0.06 (s, 6H), 0.86 (s, 3H), 0.87 (s, 9H), 1.01 (s, 3H), 1.03 (s, 3H), 1.30 (s, 3H), 1.72 (s, 3H), 1.00–2.42 (m, 13H), 4.34 (br s, 1H), 4.99 (dd, *J*=1.5, 10.6 Hz, 1H), 5.12 (dd, *J*=1.5, 17.4 Hz, 1H), 5.54 (br s, 1H), 5.91 (dd, *J*=10.6, 17.4 Hz, 1H); ^{13}C NMR δ −1.9 (2×q), 16.1 (q), 18.3 (s), 19.1 (t), 21.8 (t), 22.2 (q), 24.7 (q), 26.0 (3×q), 26.6 (q), 32.7 (q), 34.1 (s), 36.9 (s), 41.4 (t), 44.8 (t), 46.9 (t), 54.3 (d), 55.7 (d), 65.6 (d), 75.9 (s), 111.8 (t), 125.9 (d), 138.0 (s), 145.7 (d); HRMS: M^+, found 420.3429. $C_{26}H_{48}O_2Si$ requires 420.3424; MS *m*/*e* (%) 420 (M^+, 1), 277 (21), 270 (24), 220 (33), 203 (24), 185 (100), 133 (19), 119 (32), 81 (21), 75 (74), 73 (35).

3.1.3. (+)-(3*S*,4a*R*,6a*S*,10a*S*,10b*R*)-3,4a,7,7,10a-Pentamethyl-3-vinyl-2,3,4a,6a,7,8,9,10,10a,10b-decahydro-1*H*-benzo[*f*]chromene (5). A solution of **4** (0.171 g, 0.407 mmol) in CH_3CN (6 mL) was treated with HF (0.144 mL of a 50% aqueous solution) at room temperature. After stirring for 30 min the mixture was quenched with a saturated aqueous solution of $NaHCO_3$ and extracted with ethyl acetate. The organic layers were washed with brine, dried and evaporated to give the corresponding diol, according to NMR spectroscopy. This residue was purified by flash column chromatography (eluent PE/EA 25:1) which gave the *cyclized* compound **5** (0.078 g, 0.273 mmol; 67%) as a colourless oil.

$[\alpha]_D$=+8.8 (*c* 0.25); IR (film) ν_{max} 2925, 1464, 1370, 1214, 921 cm^{-1}; ^1H NMR (benzene-d_6) δ 0.98 (s, 3H), 1.01 (s, 3H), 1.03 (s, 3H), 1.23 (s, 3H), 1.78 (s, 3H), 0.81–2.15 (m, 12H), 5.02 (dd, *J*=1.5, 10.7 Hz, 1H), 5.24 (dd, *J*=1.5, 17.3 Hz, 1H), 5.70–5.91 (m, 2H), 5.98 (dd, *J*=3.2, 9.6 Hz, 1H); ^{13}C NMR (benzene-d_6) δ 15.6 (q), 17.5 (q), 19.1 (t), 21.6 (t), 22.8 (q), 27.9 (q), 32.5 (q), 32.9 (s), 33.4 (t), 39.3 (s), 41.2 (t), 42.5 (t), 53.1 (d), 53.2 (d), 53.4 (s), 72.8 (s), 111.4 (t), 126.3 (d), 129.9 (d), 145.1 (d); HRMS: M^+, found 288.2448. $C_{20}H_{32}O$ requires 288.2453; MS *m*/*e* (%) 288

(M^+, 28), 189 (39), 188 (45), 187 (60), 173 (39), 133 (32), 119 (100), 69 (35), 55 (30), 43 (37).

3.1.4. (+)-(4*S*,4a*R*,8a*S*)-4-(3-Hydroxy-3-methylbutyl)-3,4a,8,8-tetramethyl-4a,5,6,7,8,8a-hexahydro-1(4*H*)-naphthalenone (7). To a solution of **6**[6] (0.18 g, 0.652 mmol) in dry ether (10 mL) at −78°C under N_2 was added MeLi (0.49 mL of a 1.6 M solution in Et_2O, 0.78 mmol). After stirring for 1 h, the mixture was quenched with H_2O and extracted with ethyl acetate and worked up as usual. The crude oil was purified by flash column chromatography (eluent PE/EA 4:1 to 2:1) to yield alcohol **7** (0.154 g, 0.528 mmol; 81%) as a colourless oil.

$[\alpha]_D$=+20.0 (*c* 0.4); IR (film) ν_{max} 3432, 2972, 1668, 1468, 1379, 1292, 1211, 1154, 942 cm^{-1}; ^1H NMR δ 0.84 (s, 3H), 1.11 (s, 3H), 1.14 (s, 3H), 1.24 (s, 6H), 1.91 (s, 3H), 1.04–1.90 (m, 11H), 2.00–2.03 (m, 2H), 5.74 (br s, 1H); ^{13}C NMR δ 14.7 (q), 18.2 (t), 21.5 (q), 21.7 (t), 22.1 (q), 29.1 (q), 29.4 (q), 32.3 (s), 33.5 (q), 38.7 (t), 43.2 (t), 43.4 (s), 46.3 (t), 58.6 (d), 63.6 (d), 71.1 (s), 128.5 (d), 158.3 (s), 200.3 (s); HRMS: M^+, found 292.2399. $C_{19}H_{32}O_2$ requires 292.2402; MS *m/e* (%) 292 (M^+, 2), 277 (15), 274 (44), 219 (31), 218 (86), 136 (12), 135 (100), 109 (19), 108 (27), 95 (16), 69 (13).

3.1.5. (4*S*,4a*R*,8a*S*)-3,4a,8,8-Tetramethyl-4-{3-methyl-3-[(trimethylsilyl)oxy]butyl}-4a,5,6,7,8,8a-hexahydro-1(4*H*)-naphthalenone (8). To a stirred solution of **7** (0.122 g, 0.418 mmol) in DMF (10 mL) were added trimethylsilyl chloride (0.136 g, 1.253 mmol, 0.16 mL) and imidazole (0.171 g, 2.507 mmol). The reaction mixture was stirred at room temperature. After 30 min the mixture was diluted with ethyl acetate and water was added. The mixture was extracted with ethyl acetate. The organic solution was washed with H_2O and worked up as usual. The crude oil was purified by flash column chromatography (eluent PE/EA 25:1) to give silyl ether **8** (0.151 g, 0.415 mmol; 99%) as a colourless oil.

$[\alpha]_D$=+19.9 (*c* 0.9); IR (film) ν_{max} 2929, 1673, 1463, 1382, 1250, 1152, 1041, 839 cm^{-1}; ^1H NMR δ 0.00 (s, 9H), 0.75 (s, 3H), 1.01 (s, 3H), 1.05 (s, 3H), 1.13 (s, 6H), 1.80 (s, 3H), 1.04–1.93 (m, 12H), 5.63 (br s, 1H); ^{13}C NMR δ 2.6 (3×q), 14.7 (q), 18.2 (t), 21.5 (q), 21.6 (t), 22.1 (q), 29.6 (q), 29.7 (q), 32.3 (s), 33.5 (q), 38.8 (t), 43.2 (t), 43.4 (s), 47.5 (t), 56.7 (d), 63.7 (d), 73.9 (s), 128.4 (d), 159.4 (s), 200.4 (s); HRMS: (M^+−15), found 349.2564. $C_{21}H_{37}O_2Si$ requires 349.2563; MS *m/e* (%) 349 [(M^+−15), 13], 274 (47), 219 (34), 218 (100), 148 (15), 135 (87), 131 (89), 109 (16), 108 (28), 75 (22), 73 (38).

3.1.6. (−)-(1*R*,4*S*,4a*R*,8a*S*)-3,4a,8,8-Tetramethyl-4-{3-methyl-3-[(trimethylsilyl)oxy]butyl}-1,4,4a,5,6,7,8,8a-octahydro-1-naphthalenol (9). To a solution of silyl ether **8** (0.108 g, 0.297 mmol) in dry toluene (8 mL) at −78°C under N_2 was added DIBAL-H (0.79 mL of an 1.5 M solution in toluene; 1.188 mmol). After stirring for 1 h, the reaction mixture was diluted with Et_2O (5 mL) and H_2O (three drops) was added. After stirring for 15 min a 4 M aqueous solution of NaOH (three drops) was added, followed by addition of H_2O (three drops) again after 15 min of stirring in between. The mixture was dried by addition of $MgSO_4$, filtrated and evaporated to afford an oil. This residue was purified by flash column chromatography (eluent PE/EA 25:1) to obtain **9** (0.082 g, 0.224 mmol; 75%) as a colourless oil, which crystallizes upon standing.

Mp 65–67°C; $[\alpha]_D$=−33.4 (*c* 0.35); IR (film) ν_{max} 3376, 2926, 1459, 1382, 1364, 1249, 1055, 839 cm^{-1}; ^1H NMR (benzene-d_6) δ 0.24 (s, 9H), 1.14 (s, 6H), 1.20 (s, 6H), 1.55 (s, 3H), 1.77 (s, 3H), 0.89–1.96 (m, 13H), 4.33 (br s, 1H), 5.47 (br d, *J*=4.8 Hz, 1H); ^{13}C NMR (benzene-d_6) δ 2.5 (3×q), 16.2 (q), 19.2 (t), 22.1 (q), 22.2 (t), 24.8 (q), 29.5 (q), 29.6 (q), 32.7 (q), 34.2 (s), 36.9 (s), 41.5 (t), 44.8 (t), 47.8 (t), 54.3 (d), 55.9 (d), 65.7 (d), 74.1 (s), 126.0 (d), 137.6 (s); HRMS: (M^+−15), found 351.2713. $C_{21}H_{39}O_2Si$ requires 351.2719; HRMS: (M^+−18), found 348.2845. $C_{22}H_{40}OSi$ requires 348.2848; MS *m/e* (%) 351 [(M^+−15), 1], 348 (1), 276 (15), 261 (11), 221 (16), 220 (100), 205 (44), 152 (11), 131 (60), 109 (27), 73 (17), 69 (10).

3.1.7. (−)-4-[(4a*S*,8a*S*)-2,5,5,8a-Tetramethyl-4a,5,6,7,8,8a-hexahydro-1-naphthalenyl]-2-methyl-2-butanol (10). A solution of **9** (0.056 g, 0.153 mmol) in CH_3CN (8 mL) was treated with HF (0.10 mL of a 50% solution) at room temperature. After stirring for 30 min the mixture was quenched with a saturated aqueous solution of $NaHCO_3$ and was then extracted with ethyl acetate. The organic layers were washed with brine, dried and evaporated. The residue was purified by flash column chromatography (eluent PE/EA 10:1 to 5:1) and the intermediate diol spontaneously dehydrated to diene **10** (0.034 g, 0.123 mmol; 80%), which was obtained as a colourless oil.

$[\alpha]_D$=−71.7 (*c* 0.75); IR (film) ν_{max} 3385, 2958, 1460, 1369, 1212, 908 cm^{-1}; ^1H NMR (benzene-d_6) δ 0.96 (s, 3H), 1.03 (s, 3H), 1.04 (s, 3H), 1.13 (s, 6H), 1.78 (s, 3H), 0.91–2.34 (m, 12H), 5.80 (dd, *J*=2.8, 9.5 Hz, 1H), 5.98 (dd, *J*=3.1, 9.5 Hz, 1H); ^{13}C NMR (benzene-d_6) δ 15.6 (q), 17.5 (q), 19.1 (t), 22.0 (t), 22.8 (q), 28.9 (q), 29.0 (q), 32.5 (q), 32.9 (s), 35.3 (t), 39.3 (s), 41.2 (t), 44.0 (t), 53.1 (d), 70.1 (s), 124.8 (s), 126.3 (d), 129.9 (d), 144.1 (s); HRMS: M^+, found 276.2456. $C_{19}H_{32}O$ requires 276.2453; MS *m/e* (%) 276 (M^+, 40), 189 (56), 188 (43), 187 (88), 173 (37), 159 (14), 133 (32), 131 (15), 120 (14), 119 (100).

3.1.8. (−)-4-[(4a*S*,8a*S*)-2,5,5,8a-Tetramethyl-4a,5,6,7,8,8a-hexahydro-1-naphthalenyl]-2-methyl-2-butanol (10). To a solution of **7** (0.070 g, 0.2397 mmol) in dry toluene (7 mL) at −78°C under N_2 was added DIBAL-H (0.71 mL of a 1.5 M solution in toluene; 1.068 mmol). After stirring for 1 h, the reaction mixture was diluted with Et_2O (5 mL) and H_2O (three drops) was added. After stirring for 15 min a 4 M aqueous solution of NaOH (three drops) was added, followed by addition of H_2O (three drops) again after 15 min of stirring in between. The mixture was dried by addition of $MgSO_4$, filtrated and evaporated. The residue was purified by flash column chromatography (eluent PE/EA 10:1) to afford diol (1*R*,4*S*,4a*R*,8a*S*)-4-(3-hydroxy-3-methylbutyl)-3,4a,8,8-tetramethyl-1,4,4a,5,6,7,8,8a-octahydro-1-naphthalenol (0.028 g, 0.095 mmol; 40%) as a colourless oil.

$[\alpha]_D$=−50.8 (*c* 0.7); IR (film) ν_{max} 3406, 2924, 1459, 1378,

1027, 914 cm^{-1}; ^1H NMR δ 1.03 (s, 6H), 1.22 (s, 6H), 1.29 (s, 3H), 1.74 (s, 3H), 0.95–1.91 (m, 14H), 4.35 (br s, 1H), 5.55 (br s, 1H); ^{13}C NMR δ 16.3 (q), 19.0 (t), 21.9 (t), 22.1 (q), 24.8 (q), 29.0 (q), 29.3 (q), 32.7 (q), 34.2 (s), 36.9 (s), 41.4 (t), 44.7 (t), 46.6 (t), 54.3 (d), 55.9 (d), 66.2 (d), 71.3 (s), 125.5 (d), 138.3 (s); HRMS: M^+, found 294.2556. $C_{19}H_{34}O_2$ requires 294.2559; MS *m/e* (%) 294 (M^+, 17), 261 (50), 220 (61), 205 (60), 189 (35), 187 (45), 135 (35), 119 (68), 109 (100), 95 (35), 69 (50).

The above obtained diol (0.050 g, 0.170 mmol) was submitted to a catalytic amount of PPTS (0.025 g, 0.0994 mmol) in nitromethane (5 mL) at room temperature for 90 min. Ether was added and the mixture was washed with a saturated aqueous sodium bicarbonate solution and brine, dried and evaporated. Flash column chromatography (eluent PE/EA 10:1 to 3:1) gave diene **10** (0.037 g, 0.134 mmol; 79%) as a colourless oil with analytical data as reported before.

3.1.9. (4*S*,4a*R*,8a*S*)-4-(3ζ-Hydroxybutyl)-3,4a,8,8-tetramethyl-4a,5,6,7,8,8a-hexahydro-1(4*H*)-naphthalenone (11). To a solution of **6**[6] (0.100 g, 0.362 mmol) in MeOH (5 mL) at 0°C was added $NaBH_4$ (0.018 g, 0.471 mmol). After stirring for 15 min, the mixture was quenched with an 1 M aqueous solution of HCl, extracted with ethyl acetate and worked up as usual. The crude residue was purified by flash column chromatography (eluent PE/EA 2:1) to give alcohol **11** (0.095 g, 0.342 mmol; 94%) as a colourless oil as an inseparable C(13) diastereomeric mixture in a ratio of 5:2, determined by ^1H NMR.

IR (film) ν_{max} 3421, 2925, 1654, 1458, 1376, 1129, 974 cm^{-1}; ^1H NMR (major peaks) δ 0.84 (s, 3H), 1.14 (s, 3H), 1.19 (s, 3H), 1.28 (d, *J*=16.3 Hz, 3H), 0.81–1.91 (m, 11H), 1.93 (s, 3H), 2.01–2.05 (m, 2H), 3.82 (m, 1H), 5.75 (br s, 1H); ^{13}C NMR (major peaks) δ 14.6 (q), 18.2 (t), 21.5 (q), 22.1 (q), 23.2 (t), 23.8 (q), 32.3 (q), 33.5 (q), 38.8 (t), 41.5 (t), 41.7 (s), 43.2 (t), 56.3 (d), 63.6 (d), 68.0 (d), 128.5 (d), 158.8 (s), 200.3 (s); ^1H NMR (minor peaks) δ 0.84 (s, 3H), 1.14 (s, 3H), 1.19 (s, 3H), 1.28 (d, *J*=16.3 Hz, 3H), 0.81–1.91 (m, 11H), 1.93 (s, 3H), 2.01–2.05 (m, 2H), 3.81 (m, 1H), 5.74 (br s, 1H); ^{13}C NMR (minor peaks) δ 14.7 (q), 18.2 (t), 21.6 (q), 22.1 (q), 23.2 (t), 23.8 (q), 32.3 (q), 33.5 (q), 38.8 (t), 41.5 (t), 41.7 (s), 43.2 (t), 56.5 (d), 63.6 (d), 67.9 (d), 128.6 (d), 158.7 (s), 200.3 (s); HRMS: M^+, found 278.2244. $C_{18}H_{30}O_2$ requires 278.2246; MS *m/e* (%) 278 (M^+, 42), 247 (41), 218 (35), 177 (29), 154 (22), 135 (100), 109 (60), 108 (33), 95 (25), 69 (28).

3.1.10. (4*S*,4a*R*,8a*S*)-4-((3ζ)-3-([*tert*-Butyl(dimethyl)silyl]-oxy)butyl)-3,4a,8,8-tetramethyl-4a,5,6,7,8,8a-hexa-hydro-1(4*H*)-naphthalenone (12a and 12b). To a stirred solution of **11** (0.095 g, 0.342 mmol) in DMF (12 mL) were added *tert*-butyldimethylsilyl chloride (0.081 g, 0.513 mmol) and imidazole (0.070 g, 1.026 mmol). The reaction mixture was stirred at 0°C. After 150 min the mixture was diluted with ethyl acetate and water and extracted with ethyl acetate. The organic solution was washed with H_2O and worked up as usual. The crude oil was purified by flash column chromatography (eluent PE/EA 50:1) to separate the diastereomeric silyl ethers **12a** (0.094 g, 0.239 mmol; 70%) and **12b** (0.037 g, 0.096 mmol; 28%). Both silyl ethers were obtained as colourless oils.

12a: R_f 0.70 (eluent PE/EA 3:1); $[\alpha]_D$=+28.7 (*c* 1.5); IR (film) ν_{max} 2930, 1674, 1472, 1378, 1255, 1137, 1047, 837 cm^{-1}; ^1H NMR δ 0.04 (s, 6H), 0.82 (s, 3H), 0.87 (s, 9H), 1.11 (s, 3H), 1.14 (s, 3H), 1.15 (d, *J*=13.0 Hz, 3H), 1.02–1.85 (m, 10H), 1.90 (s, 3H), 2.02–2.05 (m, 2H), 3.74–3.82 (m, 1H), 5.73 (br s, 1H); ^{13}C NMR δ −4.8 (q), −4.4 (q), 14.2 (s), 14.6 (q), 18.1 (t), 21.5 (q), 22.1 (q), 23.3 (t), 23.7 (q), 25.9 (3×q), 32.2 (s), 33.5 (q), 38.8 (t), 42.3 (t), 43.2 (t), 43.3 (s), 56.5 (d), 63.5 (d), 68.7 (d), 128.4 (d), 158.9 (s), 200.3 (s); HRMS: M^+, found 392.3110. $C_{24}H_{44}O_2Si$ requires 392.3111; MS *m/e* (%) 392 (M^+, 17), 336 (45), 335 (72), 294 (22), 293 (100), 218 (72), 159 (19), 145 (23), 135 (34), 75 (43), 73 (21).

12b: R_f 0.67 (eluent PE/EA 3:1); $[\alpha]_D$=+38.0 (*c* 0.5); IR (film) ν_{max} 2928, 1673, 1470, 1379, 1257, 1134, 1045, 832 cm^{-1}; ^1H NMR δ 0.05 (s, 6H), 0.83 (s, 3H), 0.88 (s, 9H), 1.11 (s, 3H), 1.14 (s, 3H), 1.16 (d, *J*=13.2 Hz, 3H), 0.96–1.88 (m, 10H), 1.90 (s, 3H), 2.01–2.04 (m, 2H), 3.73–3.81 (m, 1H), 5.74 (br s, 1H); ^{13}C NMR δ −4.7 (q), −4.4 (q), 14.3 (s), 14.6 (q), 18.2 (t), 21.5 (q), 22.1 (q), 23.3 (t), 23.7 (q), 25.9 (3×q), 32.3 (s), 33.5 (q), 38.8 (t), 42.3 (t), 43.2 (t), 43.3 (s), 56.6 (d), 63.6 (d), 68.7 (d), 128.4 (d), 159.0 (s), 200.4 (s); HRMS: M^+, found 392.3110. $C_{24}H_{44}O_2Si$ requires 392.3110; MS *m/e* (%) 392 (M^+, 5), 336 (27), 335 (100), 293 (39), 218 (28), 201 (13), 159 (13), 145 (16), 135 (18), 119 (17), 75 (26).

3.1.11. (1*R*,4*S*,4a*R*,8a*S*)-4-((3ζ)-3-([*tert*-Butyl(dimethyl)-silyl]oxy)butyl)-3,4a,8,8-tetramethyl-1,4,4a,5,6,7,8,8a-octahydro-1-naphthalenol (13a and 13b). To a solution of a diastereomeric mixture of **12** (0.089 g, 0.227 mmol) in dry toluene (5 mL) at −78°C under N_2 was added DIBAL-H (0.60 mL of an 1.5 M solution in toluene; 0.908 mmol). After stirring for 1 h, the excess of DIBAL-H was quenched with ethyl acetate and an aqueous solution of 1 M HCl. The mixture was then extracted with ethyl acetate. The organic layers were washed with brine, dried and evaporated to afford both diastereomers of **13** as an oil. The residue was purified by flash column chromatography (eluent PE/EA 50:1) to obtain **13a** (0.021 g, 0.054 mmol; 24%) as a colourless oil and **13b** (0.050 g, 0.127 mmol; 56%) also as an oil.

13a: R_f 0.32 (eluent PE/EA 15:1); ^1H NMR δ 0.04 (s, 6H), 0.87 (s, 9H), 1.01 (s, 3H), 1.03 (s, 3H), 1.11 (d, *J*=10.1 Hz, 3H), 1.33 (s, 3H), 1.74 (s, 3H), 0.88–2.03 (m, 13H), 3.72–3.79 (m, 1H), 4.35 (br s, 1H), 5.55 (br d, *J*=4.5 Hz, 1H); ^{13}C NMR (benzene-d_6) δ −4.1 (q), −4.2 (q), 16.0 (q), 19.2 (t), 19.5 (q), 22.3 (s), 23.9 (q), 24.7 (q), 25.8 (3×s), 32.7 (q), 34.1 (s), 36.6 (s), 41.3 (t), 41.4 (t), 42.6 (t), 44.9 (t), 54.2 (d), 55.6 (d), 65.6 (d), 69.0 (d), 126.2 (d), 137.4 (s).

13b: R_f 0.29 (eluent PE/EA 15:1); ^1H NMR δ 0.04 (s, 6H), 0.88 (s, 9H), 1.01 (s, 3H), 1.03 (s, 3H), 1.10 (d, *J*=11.6 Hz, 3H), 1.32 (s, 3H), 1.73 (s, 3H), 0.83–2.04 (m, 13H), 3.70–3.78 (m, 1H), 4.33 (br s, 1H), 5.55 (br s, 1H); ^{13}C NMR (benzene-d_6) δ −4.8 (q), −4.5 (q), 16.2 (q), 18.0 (s), 19.1 (t), 22.0 (q), 23.8 (q), 24.7 (q), 25.9 (3×s), 32.7 (q), 34.1 (s), 36.8 (s), 41.4 (t), 42.7 (t), 44.7 (t), 44.9 (t), 54.2 (d), 55.7 (d), 65.7 (d), 69.0 (d), 126.1 (d), 137.3 (s).

3.1.12. 4-[(4a*S*,8a*S*)-2,5,5,8a-Tetramethyl-4a,5,6,7,8,8a-hexahydro-1-naphthalenyl]-2-butanol (14). To a solution of a diastereomeric mixture of **12** (0.100 g, 0.255 mmol) in dry toluene (10 mL) at −78°C under N_2 was added DIBAL-H (0.68 mL of a 1.5 M solution in toluene; 1.02 mmol). After stirring for 1 h, the reaction mixture was diluted with Et_2O (5 mL) and H_2O (three drops) was added. After stirring for 15 min a 4 M aqueous solution of NaOH (three drops) was added, followed by addition of H_2O (three drops) again after 15 min of stirring in between. The mixture was dried by addition of $MgSO_4$, filtrated and evaporated to afford crude **13** as an oil. This mixture of crude **13** (max. 0.255 mmol) in CH_3CN (8 mL) was treated with HF (0.10 mL of a 50% solution) at room temperature. After stirring for 30 min the mixture was quenched with a saturated aqueous solution of $NaHCO_3$ and extracted with ethyl acetate. The organic layers were washed with brine, dried and evaporated. The residue was purified by flash column chromatography (eluent PE/EA 10:1 to 5:1) to obtain an inseparable mixture in a ratio of about 2:5 of diastereomeric dienes **14** (0.034 g, 0.123 mmol; 80%) as a colourless oil.

^{1}H NMR (major peaks) δ 0.78 (s, 3H), 0.82 (s, 3H), 0.89 (s, 3H), 1.16 (d, J=13.9 Hz, 3H), 1.75 (s, 3H), 0.90–2.11 (m, 12H), 3.54–3.65 (m, 1H), 5.59 (dd, J=2.6, 10.3 Hz, 1H), 5.74 (dd, J=3.1, 10.3 Hz, 1H); ^{13}C NMR (major peaks) δ 16.7 (q), 17.8 (t), 18.6 (t), 21.6 (q), 21.7 (q), 22.8 (q), 32.6 (q), 32.8 (s), 35.7 (t), 36.6 (t), 37.2 (s), 41.3 (t), 53.1 (d), 67.9 (d), 124.9 (s), 126.4 (d), 129.9 (d), 143.9 (s).

3.1.13. (−)-(1*R*,4*S*,4a*R*,8a*S*)-4-[(3*R*)-3-Hydroxybutyl]-3,4a,8,8-tetramethyl-1,4,4a,5,6,7,8,8a-octahydro-1-naphthalenol and (−)-(1*R*,4*S*,4a*R*,8a*S*)-4-[(3*S*)-3-hydroxybutyl]-3,4a,8,8-tetramethyl-1,4,4a,5,6,7,8,8a-octahydro-1-naphthalenol (15a and 15b). To a solution of **6**[6] (0.100 g, 0.362 mmol) in dry toluene (8 mL) at −78°C under N_2 was added DIBAL-H (1.21 mL of a 1.5 M solution in toluene; 1.81 mmol). After stirring for 1 h, the reaction mixture was diluted with Et_2O (5 mL) and H_2O (three drops) was added. After stirring for 15 min a 4 M aqueous solution of NaOH (three drops) was added, followed by addition of H_2O (three drops) again after 15 min of stirring in between. The mixture was dried by addition of $MgSO_4$, filtrated and evaporated to afford an oil. The residue was purified by flash column chromatography (eluent PE/EA 10:1) to give **15a** (0.056 g, 0.201 mmol; 56%) as an oil and **15b** (0.022 g, 0.080 mmol; 22%) as an oil, which crystallizes upon standing.

15a: R_f 0.22 (eluent PE/EA 3:1); $[\alpha]_D$=−60.7 (c 0.7); IR (film) ν_{max} 3421, 2926, 1725, 1459, 1374, 1247, 1135, 1025, 991 cm^{-1}; ^{1}H NMR (benzene-d$_6$) δ 1.08 (s, 3H), 1.10 (d, J=13.8 Hz, 3H), 1.14 (s, 3H), 1.57 (s, 3H), 1.80 (s, 3H), 0.92–1.94 (m, 14H), 3.53–3.61 (m, 1H), 4.34 (br s, 1H), 5.47–5.49 (m, 1H); ^{13}C NMR (benzene-d$_6$) δ 16.1 (q), 19.2 (t), 22.0 (q), 23.5 (q), 23.7 (t), 24.8 (q), 32.7 (q), 34.2 (s), 36.7 (s), 41.3 (t), 42.1 (t), 44.8 (t), 54.2 (d), 55.7 (d), 65.7 (d), 68.0 (d), 126.1 (d), 137.2 (s); HRMS: M$^+$, found 280.2401. $C_{18}H_{32}O_2$ requires 280.2402; MS m/e (%) 280 (M$^+$, 35), 265 (33), 247 (43), 189 (46), 125 (45), 123 (39), 119 (62), 109 (100), 95 (62), 69 (48).

15b: R_f 0.18 (eluent PE/EA 3:1); mp 90–92°C; $[\alpha]_D$=−57.1 (c 0.9); IR (KBr) ν_{max} 3418, 2917, 1721, 1462, 1370, 1243, 1129, 1019, 989 cm^{-1}; ^{1}H NMR (benzene-d$_6$/CD$_3$OD) δ 0.72 (s, 3H), 0.74 (s, 3H), 0.82 (d, J=14.0 Hz, 3H), 1.10 (s, 3H), 1.43 (s, 3H), 0.64–1.50 (m, 14H), 3.27–3.38 (m, 1H), 4.00 (br s, 1H), 5.17 (br d, J=5.0 Hz, 1H); ^{13}C NMR (benzene-d$_6$/CD$_3$OD) δ 15.8 (q), 19.2 (t), 22.0 (q), 23.3 (q), 23.7 (t), 24.6 (q), 32.6 (q), 34.1 (s), 36.6 (s), 41.3 (t), 41.9 (t), 44.9 (t), 54.3 (d), 55.6 (d), 65.5 (d), 67.7 (d), 125.8 (d), 137.6 (s); HRMS: M$^+$, found 280.2402. $C_{18}H_{32}O_2$ requires 280.2402; MS m/e (%) 280 (M$^+$, 38), 247 (58), 189 (54), 138 (38), 125 (53), 123 (42), 119 (70), 109 (100), 95 (76), 69 (47).

3.1.14. (−)-(2*R*)-4-[(4a*S*,8a*S*)-2,5,5,8a-Tetramethyl-4a,5,6,7,8,8a-hexahydro-1-naphthalenyl]butan-2-ol (14a). Diol **15a** (0.046 g, 0.164 mmol) in nitromethane (5 mL) was dehydrated by treatment with a catalytic amount of PPTS (0.025 g, 0.0994 mmol) at room temperature for 30 min. Ether was added and the mixture was washed with a saturated aqueous sodium bicarbonate solution and brine, dried and evaporated. Flash column chromatography (eluent PE/EA 6:1) gave diene **14a** (0.031 g, 0.118 mmol; 72%) as a colourless oil.

R_f 0.44 (eluent PE/EA 3:1); $[\alpha]_D$=−172.6 (c 0.35); IR (film) ν_{max} 3346, 3032, 2924, 1459, 1369, 1127 cm^{-1}; ^{1}H NMR (benzene-d$_6$) δ 0.98 (s, 3H), 1.01 (s, 3H), 1.03 (s, 3H), 1.12 (d, J=12.1 Hz, 3H), 1.76 (s, 3H), 0.96–2.23 (m, 12H), 3.60 (dt, J=6.0, 12.1 Hz, 1H), 5.77 (dd, J=2.7, 9.5 Hz, 1H), 5.97 (dd, J=3.1, 9.5 Hz, 1H); ^{13}C NMR (benzene-d$_6$) δ 15.6 (q), 17.6 (q), 19.1 (t), 22.8 (q), 23.4 (q), 23.6 (t), 32.5 (q), 32.9 (s), 35.8 (t), 39.3 (s), 39.9 (t), 41.2 (t), 53.1 (d), 67.9 (d), 124.9 (s), 126.4 (d), 129.9 (d), 144.0 (s); HRMS: M$^+$, found 262.2295. $C_{18}H_{30}O$ requires 262.2297; MS m/e (%) 262 (M$^+$, 26), 229 (17), 189 (48), 187 (27), 173 (17), 133 (26), 120 (21), 119 (100).

3.1.15. (−)-(2*S*)-4-[(4a*S*,8a*S*)-2,5,5,8a-Tetramethyl-4a,5,6,7,8,8a-hexahydro-1-naphthalenyl]butan-2-ol (14b). Diol **15b** (0.057 g, 0.204 mmol) was dehydrated as described above. Flash column chromatography (eluent PE/EA 6:1) of the residue gave diene **14b** (0.042 g, 0.164 mmol; 81%) as a colourless oil.

R_f 0.45 (eluent PE/EA 3:1); $[\alpha]_D$=−69.3 (c 0.95); IR (film) ν_{max} 3348, 3034, 2925, 1461, 1367, 1128 cm^{-1}; ^{1}H NMR (benzene-d$_6$) δ 0.98 (s, 3H), 1.01 (s, 3H), 1.03 (s, 3H), 1.12 (d, J=9.8 Hz, 3H), 1.77 (s, 3H), 0.97–2.35 (m, 12H), 3.60 (dt, J=6.2, 12.1 Hz, 1H), 5.79 (dd, J=2.7, 9.5 Hz, 1H), 5.97 (dd, J=3.1, 9.5 Hz, 1H); ^{13}C NMR (benzene-d$_6$) δ 15.6 (q), 17.6 (q), 19.1 (t), 22.8 (q), 23.4 (q), 23.6 (t), 32.5 (q), 32.9 (s), 35.4 (t), 39.2 (s), 39.8 (t), 41.1 (t), 53.1 (d), 67.9 (d), 124.9 (s), 126.4 (d), 129.9 (d), 143.9 (s); HRMS: M$^+$, found 262.2297. $C_{18}H_{30}O$ requires 262.2297; MS m/e (%) 262 (M$^+$, 26), 229 (17), 189 (43), 187 (26), 173 (18), 159 (16), 133 (26), 131 (14), 120 (21), 119 (100).

3.1.16. (3*R*,4a*R*,6a*S*,10a*S*,10b*R*)-3,4a,7,7,10a-Pentamethyl-2,3,4a,6a,7,8,9,10,10a,10b-decahydro-1*H*-benzo[*f*]chromene (17a). A solution of **15a** (0.075 g, 0.268 mmol) in Et_2O (4 mL) was treated with an aqueous solution of HCl (1 M; 0.5 mL) at room temperature. After stirring for 14 h, the mixture was quenched with a saturated aqueous solution

of $NaHCO_3$ and then extracted with ethyl acetate. The organic layers were washed with brine, dried and evaporated. The residue was purified by flash column chromatography (eluent PE/EA 6:1) to give first the Ambra oxide **17a** (0.013 g, 0.048 mmol; 18%) as a colourless oil. Further elution (eluent PE/EA 4:1) gave diene **14a** (0.049 g, 0.189 mmol; 71%) as a colourless oil. For analytical data of diene **14a** see Section 3.1.4.

17a: R_f 0.71 (eluent PE/EA 3:1); ^{1}H NMR (benzene-d_6) δ 0.87 (s, 3H), 0.92 (s, 3H), 0.96 (s, 3H), 1.30 (d, J=3.6 Hz, 3H), 1.47 (s, 3H), 0.98–1.76 (m, 10H), 1.93–1.96 (m, 2H), 3.87 (dt, J=3.6, 9.7 Hz, 1H), 5.73 (dd, J=2.0, 10.4 Hz, 1H), 5.94 (dd, J=3.6, 10.4 Hz, 1H); ^{13}C NMR (benzene-d_6) δ 17.1 (q), 18.3 (t), 19.1 (t), 21.9 (q), 22.2 (q), 23.4 (q), 32.9 (q), 33.0 (s), 36.4 (t), 37.0 (t), 37.5 (s), 41.7 (t), 56.4 (d), 57.2 (d), 65.7 (d), 74.7 (s), 126.2 (d), 135.3 (d).

3.1.17. (3*S*,4a*R*,6a*S*,10a*S*,10b*R*)-3,4a,7,7,10a-Pentamethyl-2,3,4a,6a,7,8,9,10,10a,10b-decahydro-1*H*-benzo[*f*]chromene (17b). Diol **15b** (0.185 g, 0.661 mmol) was treated with an aqueous HCl solution as described above. Flash column chromatography (eluent PE/EA 6:1) of the residue gave Ambra oxide **17b** (0.005 g, 0.019 mmol; 3%) as a colourless oil. Further elution (eluent PE/EA 3:1) gave diene **14b** (0.152 g, 0.58 mmol; 88%) as a colourless oil with spectral data in accordance with those mentioned above.

17b: R_f 0.73 (eluent PE/EA 3:1); ^{1}H NMR (benzene-d_6) δ 0.81 (s, 3H), 0.85 (s, 3H), 0.90 (s, 3H), 1.09 (d, J=4.3 Hz, 3H), 1.38 (s, 3H), 0.99–1.65 (m, 10 H), 1.85–1.88 (m, 1H), 2.10–2.20 (m, 1H), 4.03 (dt, J=4.3, 9.8 Hz, 1H), 5.58 (dd, J=1.7, 10.3 Hz, 1H), 5.86 (dd, J=3.3, 10.3 Hz, 1H); ^{13}C NMR (benzene-d_6) δ 14.9 (q), 15.1 (t), 18.3 (t), 21.3 (q), 23.3 (q), 28.2 (q), 29.3 (q), 32.1 (s), 32.3 (q), 36.0 (q), 37.6 (s), 41.0 (q), 49.1 (d), 56.5 (d), 65.7 (d), 74.4 (s), 124.2 (d), 135.0 (d).

3.1.18. (3*S*,4a*R*,10a*R*,10b*R*)-3,4a,7,7,10a-Pentamethyl-2,3,4a,5,7,8,9,10,10a,10b-decahydro-1*H*-benzo[*f*]chromene (16a) and (3*R*,4a*R*,10a*R*,10b*R*)-3,4a,7,7,10a-pentamethyl-2,3,4a,5,7,8,9,10,10a,10b-decahydro-1*H*-benzo[*f*]chro-mene (16b). To a solution of **6**[6] (0.200 g, 0.725 mmol) in dry toluene (8 mL) at −78°C under N_2 was added DIBAL-H (2.4 mL of an 1.5 M solution in toluene, 3.62 mmol). After stirring for 90 min, the excess of DIBAL-H was quenched with ethyl acetate and an aqueous solution of 1 M HCl. The residue was treated with ethyl acetate and worked up as usual. The crude residue was not purified but treated with *p*-TsOH (0.025 g, 0.119 mmol) in nitromethane (5 mL). After 2 h ethyl acetate was added and the mixture was washed with saturated aqueous $NaHCO_3$, brine, dried and evaporated. The residue was purified by flash column chromatography (eluent PE/EA 50:1) to yield the cyclized compounds **16a** (0.018 g, 0.069 mmol; 9%) and **16b** (0.037 g, 0.141 mmol; 19%) both as colourless oils.

16a: R_f 0.37 (eluent PE/EA 25:1); ^{1}H NMR δ 0.80 (s, 3H), 0.87 (s, 3H), 0.89 (s, 3H), 1.26 (d, J=5.9 Hz, 3H), 1.71 (s, 3H), 0.83–2.04 (m, 13H), 3.92 (m, J=6.0, 12.0, 6.0 Hz, 1H), 5.50 (br d, J=3.7 Hz, 1H); ^{13}C NMR δ 15.7 (q), 18.6 (t), 19.4 (q), 21.2 (q), 22.4 (q), 23.9 (t), 29.6 (t), 31.9 (t), 33.1 (q), 33.2 (s), 36.3 (t), 42.0 (t), 42.2 (s), 43.3 (d), 76.7 (d), 89.2 (s), 125.6 (d), 134.9 (s); HRMS: M^+, found 262.2294. $C_{18}H_{30}O$ requires 262.2297; MS *m/e* (%) 262 (M^+, 2), 139 (8), 138 (100), 109 (3), 96 (4), 91 (2), 83 (2), 82 (4), 55 (3), 43 (2), 41 (3).

16b: R_f 0.32 (eluent PE/EA 25:1); ^{1}H NMR δ 0.85 (s, 3H), 0.86 (s, 3H), 0.89 (s, 3H), 1.22 (d, J=6.0 Hz, 3H), 1.74 (s, 3H), 0.84–2.14 (m, 13H), 4.20–4.34 (m, J=6.0, 2.5, 2.5 Hz, 1H), 5.53 (br d, J=5.5 Hz, 1H); ^{13}C NMR δ 17.1 (q), 18.6 (t), 21.6 (q), 21.7 (q), 22.1 (q), 24.2 (t), 27.5 (t), 32.2 (t), 33.0 (q), 33.1 (d), 35.0 (t), 40.4 (s), 41.9 (t), 42.5 (d), 76.6 (d), 89.8 (s), 125.6 (d), 135.8 (s); HRMS: M^+, found 262.2296. $C_{18}H_{30}O$ requires 262.2297; MS *m/e* (%) 262 (M^+, 1), 139 (8), 138 (100), 109 (4), 96 (4), 91 (3), 82 (5), 69 (3), 55 (4), 43 (3), 41 (4).

3.1.19. (−)-13-Methylpodocarpa-7,13-dien-6-one (18). To **6** (0.100 g, 0.362 mmol) in 1,4-dioxane (5 mL) was added a 4 M aqueous solution of NaOH (5 mL) and the mixture was stirred at room temperature. A 10% solution of I_2 in a 20% KI solution was added dropwise until the typical iodine colour just disappeared after about 2 min. No precipitate of iodoform was formed immediately, so the mixture was heated to 100°C for 3 h until the starting material had disappeared. The mixture was cooled to room temperature and acidified with an aqueous solution of 4 M HCl. The aqueous mixture was extracted and the combined organic layers are washed with saturated aqueous $NaHSO_3$ followed by brine, dried and evaporated. The residue was purified by flash column chromatography (eluent PE/EA 10:1 to 2:1) to obtain **18** (0.086 g, 0.333 mmol; 92%) as a colourless oil.

$[\alpha]_D$=−206.7 (*c* 2.0); IR (film) ν_{max} 2927, 1661, 1633, 1442, 1383, 1294, 1158, 890 cm^{-1}; ^{1}H NMR δ 0.88 (s, 3H), 1.12 (s, 3H), 1.16 (s, 3H), 1.83 (s, 3H), 1.28–2.25 (m, 12H), 5.56 (br s, 1H), 5.92 (br s, 1H); ^{13}C NMR δ 14.5 (q), 18.2 (t), 21.4 (t), 21.7 (q), 24.2 (q), 31.1 (t), 32.4 (s), 33.7 (q), 39.2 (t), 41.1 (s), 43.1 (t), 50.8 (d), 64.0 (d), 123.3 (d), 124.7 (d), 148.6 (s), 153.3 (s), 201.0 (s); HRMS: M^+, found 258.1988. $C_{18}H_{26}O$ requires 258.1984; MS *m/e* (%) 258 (M^+, 40), 243 (17), 187 (6), 176 (13), 175 (100), 173 (9), 135 (12), 134 (23), 91 (10).

3.1.20. (+)-3-[(1*S*,4*S*,4a*S*,8a*R*)-4-Hydroxy-5,5,8a-trimethyl-2-methylenedecahydro-1-naphthalenyl]propanoic acid (20). To methyl ketone **19**[4,6] (0.250 g, 0.899 mmol) in 1,4-dioxane (7 mL) was added to a 4 M aqueous solution of NaOH (8 mL) and the mixture was stirred at room temperature. A 10% solution of I_2 in 20% KI solution was then added dropwise until the typical iodine colour just had disappeared after about 2 min. A yellow precipitate indicated the formation of iodoform. After 1 h the mixture was acidified with an aqueous solution of 4 M HCl and extracted and the combined organic layers were washed with a saturated aqueous $NaHSO_3$ followed by brine, dried and evaporated. The residue was purified by flash column chromatography (eluent PE/EA 3:1 to 2:1) to yield acid **20** (0.141 g, 0.503 mmol; 56%) as a white solid.

Mp 146–148°C; $[\alpha]_D$=+38.2 (*c* 0.77); IR (KBr) ν_{max} 3328,

2931, 1684, 1437, 1219, 1058, 1013, 902 cm^{-1}; ^1H NMR δ 0.65 (s, 3H), 0.94 (s, 3H), 1.10 (s, 3H), 1.04–2.42 (m, 14H), 2.61 (dd, J=4.8, 12.2 Hz, 1H), 3.15 (br s, 1H), 3.75 (dt, J=4.9, 10.7 Hz, 1H), 4.51 (br s, 1H), 4.85 (br s, 1H); ^{13}C NMR δ 15.9 (q), 19.1 (t), 19.3 (t), 22.2 (q), 33.0 (t), 33.8 (s), 36.5 (q), 39.2 (t), 39.3 (s), 43.7 (t), 48.7 (t), 55.3 (d), 60.2 (d), 71.4 (d), 108.2 (t), 145.0 (s), 176.8 (s); HRMS: M^+, found 280.2034. $C_{17}H_{28}O_3$ requires 280.2038; MS *m/e* (%) 262 [(M^+-18), 100], 153 (82), 138 (37), 125 (48), 109 (67), 95 (41), 81 (42), 55 (53), 43 (37), 41 (61).

3.1.21. (+)-Methyl 3-[(1*S*,4*S*,4a*S*,8a*R*)-4-hydroxy-5,5,8a-trimethyl-2-methylenedecahydro-1-naphthalenyl]propanoate (21). A solution of **20** (0.23 g, 0.82 mmol) in MeOH/Et_2O (1:1) (30 mL) was stirred at room temperature and treated with diazomethane until N_2 development ceased. The excess of diazomethane was destroyed by addition of acetic acid (two drops). The mixture was washed (2×) with an ice-cold solution of 1 M aqueous KOH, followed by brine, dried and evaporated. The residue was purified by flash column chromatography (eluent PE/EA 5:1) to give methyl ester **21** (0.236 g, 0.804 mmol; 98%) as a colourless oil.

$[\alpha]_D$=+47.2 (*c* 1.6); IR (film) ν_{max} 3515, 2928, 1739, 1645, 1439, 1166, 1013, 893 cm^{-1}; ^1H NMR δ 0.68 (s, 3H), 0.98 (s, 3H), 1.14 (s, 3H), 1.07–2.45 (m, 14H), 2.65 (dd, J=4.8, 12.2 Hz, 1H), 3.64 (s, 3H), 3.81 (dt, J=4.8, 10.6 Hz, 1H), 4.54 (br s, 1H), 4.88 (br s, 1H); ^{13}C NMR δ 15.9 (q), 19.0 (t), 19.3 (t), 22.3 (q), 32.9 (t), 33.8 (s), 36.6 (q), 39.1 (t), 39.3 (s), 43.6 (t), 49.0 (t), 51.5 (q), 55.3 (d), 60.3 (d), 71.5 (d), 108.3 (t), 144.9 (s), 174.5 (s); HRMS: M^+, found 294.2192. $C_{18}H_{30}O_3$ requires 294.2195; MS *m/e* (%) 294 (M^+, 1), 276 (100), 189 (33), 153 (67), 119 (32), 109 (56), 95 (34), 82 (39), 81 (32), 69 (86), 55 (32).

3.1.22. (+)-(1*S*,4*S*,4a*R*,8a*S*)-4-(3-Hydroxypropyl)-4a,8,8-trimethyl-3-methylenedecahydro-1-naphthalenol (22). To a solution of methyl ester **21** (0.060 g, 0.204 mmol) in dry THF (8 mL) at 0°C under N_2 was added $LiAlH_4$ (0.077 g, 2.04 mmol). After stirring for 1 h, the reaction mixture was diluted with Et_2O (15 mL) and H_2O (eight drops) was added. After stirring for 15 min a 4 M aqueous solution of NaOH (eight drops) was added, followed by addition of H_2O (eight drops) again after 15 min of stirring in between. The mixture was dried by addition of $MgSO_4$, filtrated and evaporated to afford an oil. The residue was purified by flash column chromatography (eluent PE/EA 2:1) to give alcohol **22** (0.051 g, 0.190 mmol; 93%) as a colourless oil.

$[\alpha]_D$=+34.5 (*c* 0.5); IR (film) ν_{max} 3356, 2925, 1645, 1443, 1381, 1249, 1050, 1011, 980, 890 cm^{-1}; ^1H NMR δ 0.66 (s, 3H), 0.98 (s, 3H), 1.14 (s, 3H), 1.07–2.08 (m, 15H), 2.65 (dd, J=4.8, 12.2 Hz, 1H), 3.59 (t, J=6.4 Hz, 2H), 3.80 (dt, J=4.8, 10.7 Hz, 1H), 4.56 (d, J=1.3 Hz, 1H), 4.86 (d, J=1.3 Hz, 1H); ^{13}C NMR δ 15.9 (q), 19.1 (t), 20.0 (t), 22.3 (q), 31.8 (t), 33.8 (s), 36.6 (q), 39.1 (s), 39.3 (t), 43.2 (t), 49.0 (t), 55.8 (d), 60.4 (d), 63.1 (t), 71.6 (d), 108.2 (t), 145.5 (s); HRMS: M^+, found 266.2245. $C_{17}H_{30}O_2$ requires 266.2246; MS *m/e* (%) 266 (M^+, 3), 248 (67), 153 (93), 109 (70), 96 (34), 95 (56), 93 (43), 81 (41), 69 (100), 55 (40), 41 (40).

3.1.23. (+)-(1*S*,4*S*,4a*R*,8a*S*)-4-(3-([*tert*-Butyl(dimethyl)-silyl]oxy)propyl)-4a,8,8-trimethyl-3-methylenedeca-hydro-1-naphthalenol (23). To a stirred solution of alcohol **22** (0.237 g, 0.891 mmol) in DMF (15 mL) were added *tert*-butyldimethylsilyl chloride (0.134 g, 0.89 mmol) and imidazole (0.121 g, 1.782 mmol). The reaction mixture was stirred at 0°C. After 30 min the mixture was diluted with ethyl acetate and water and extracted with ethyl acetate. The organic solution was washed with H_2O and worked up as usual. The crude oil was purified by flash column chromatography (eluent PE/EA 25:1) to yield silyl ether **23** (0.318 g, 0.837 mmol; 94%) as a colourless oil which turns into a wax-like solid upon standing.

Mp 53–55°C; $[\alpha]_D$=+30.5 (*c* 0.6); IR (KBr) ν_{max} 3421, 2928, 2361, 1647, 1472, 1255, 1103, 1011, 894, 836, 775 cm^{-1}; ^1H NMR δ 0.04 (s, 6H), 0.68 (s, 3H), 0.88 (s, 9H), 1.00 (s, 3H), 1.16 (s, 3H), 0.90–1.74 (m, 13H), 2.04 (br t, J=12.3 Hz, 1H), 2.67 (dd, J=4.9, 11.8 Hz, 1H), 3.58 (t, J=5.5 Hz, 2H), 3.77–3.88 (m, 1H), 4.60 (d, J=1.3 Hz, 1H), 4.87 (d, J=1.3 Hz, 1H); ^{13}C NMR δ −5.2 (2×q), 16.0 (q), 18.3 (s), 19.2 (t), 20.1 (t), 22.4 (q), 26.0 (3×q), 31.9 (t), 33.9 (s), 36.7 (q), 39.3 (t), 39.4 (s), 43.8 (t), 49.2 (t), 55.8 (d), 60.6 (d), 63.4 (t), 71.7 (d), 108.4 (t), 145.6 (s); HRMS: (M^+-15), found 365.2875. $C_{22}H_{41}O_2Si$ requires 365.2876; MS *m/e* (%) 365 [(M^+-15), 1], 323 (15), 306 (24), 305 (100), 231 (16), 135 (11), 109 (12), 95 (14), 75 (22), 73 (10), 69 (18).

3.1.24. (+)-(4*S*,4a*R*,8a*S*)-4-(3-{[*tert*-Butyl(dimethyl)silyl]-oxy}propyl)-3,4a,8,8-tetramethyl-4a,5,6,7,8,8a-hexahydro-1(4*H*)-naphthalenone (24). To a stirred solution of silyl ether **23** (0.276 g, 0.726 mmol) in CH_2Cl_2 (20 mL) were added 3 Å molecular sieves (0.5 g) followed by pyridinium chlorochromate (PCC) (0.235 g, 1.080 mmol) and five drops of acetic acid. After 1 h the mixture was filtered over silica gel and flushed with ethyl acetate. Purification of the crude product by flash column chromatography (PE/EA 3:1) gave (+)-(4*S*,4a*R*,8a*S*)-4-(3-{[*tert*-butyl(dimethyl)silyl]oxy}-propyl)-4a,8,8-trimethyl-3-methylene-octahydro-1(2*H*)-naphthalenone (0.225 g, 0.595 mmol; 82%) as a colourless oil.

$[\alpha]_D$=+59.3 (*c* 0.6); IR (film) ν_{max} 2929, 1719, 1644, 1471, 1387, 1255, 1104, 981, 892, 836, 776 cm^{-1}; ^1H NMR (benzene-d_6) δ −0.15 (s, 6H), 0.54 (s, 3H), 0.91 (s, 9H), 1.03 (s, 3H), 1.29 (s, 3H), 0.76–1.71 (m, 12H), 2.64 (br d, J=13.4 Hz, 1H), 2.92 (d, J=13.4 Hz, 1H), 3.47 (t, J=6.2 Hz, 2H), 4.57 (br s, 1H), 4.66 (br s, 1H); ^{13}C NMR (benzene-d_6) δ −5.6 (2×q), 15.4 (q), 18.5 (s), 18.7 (t), 20.1 (t), 21.4 (q), 25.6 (3×q), 31.6 (t), 32.5 (q), 32.8 (s), 38.4 (t), 41.2 (s), 42.4 (t), 55.3 (t), 56.1 (d), 62.9 (t), 65.5 (d), 109.2 (t), 144.1 (s), 206.4 (s); HRMS: (M^+-15), found 363.2716. $C_{22}H_{39}O_2Si$ requires 363.2719; MS *m/e* (%) 378 (M^+, 1), 363 (3), 322 (26), 321 (100), 170 (7), 169 (43), 151 (9), 123 (8), 109 (7), 95 (8), 75 (19), 73 (9).

The above obtained C(6)-ketone (2.000 g, 6.58 mmol), was isomerized into the conjugated ketone by treatment with a 0.125 M solution of sodium methoxide in methanol (20 mL) at room temperature for 1 h. The methanol was evaporated and 1 M aqueous solution of HCl (200 mL) was added. Extraction with ether followed by the usual work-up gave the crude product which was purified by flash column

chromatography (PE/EA 15:1) to give compound **24** (0.140 g, 0.370 mmol; 78%) as a colourless oil.

$[\alpha]_D$=+24.1 (*c* 0.3); IR (film) ν_{max} 2930, 1673, 1471, 1385, 1360, 1255, 1104, 978, 836, 776 cm^{-1}; ^1H NMR δ 0.05 (s, 6H), 0.83 (s, 3H), 0.89 (s, 9H), 1.12 (s, 3H), 1.15 (s, 3H), 1.91 (s, 3H), 0.93–2.07 (m, 12H), 3.62 (t, *J*=5.5 Hz, 2H), 5.75 (br s, 1H); ^{13}C NMR δ −5.3 (2×q), 14.6 (q), 18.2 (t), 18.3 (s), 21.5 (q), 22.1 (q), 23.4 (t), 25.9 (3×q), 32.3 (s), 33.5 (q), 35.2 (t), 38.8 (t), 43.1 (s), 43.2 (t), 56.2 (d), 62.8 (t), 63.6 (d), 128.5 (d), 159.0 (s), 200.3 (s); HRMS: M^+, found 378.2954. $C_{23}H_{42}O_2Si$ requires 378.2954; MS *m/e* (%) 378 (M^+, 73), 322 (22), 321 (100), 159 (15), 135 (20), 119 (27), 95 (12), 75 (32), 73 (14).

3.1.25. (−)-(1*R*,4*S*,4a*R*,8a*S*)-4-(3-{[*tert*-Butyl(dimethyl)-silyl]oxy}propyl)-3,4a,8,8-tetramethyl-1,4,4a,5,6,7,8,8a-octahydro-1-naphthalenol (25). To a solution of **24** (0.120 g, 0.317 mmol) in dry toluene (10 mL) at −78°C under N_2 was added DIBAL-H (0.85 mL of an 1.5 M solution in toluene; 1.27 mmol). After stirring for 1 h, the reaction mixture was diluted with Et_2O (10 mL) and H_2O (five drops) was added. After stirring for 15 min a 4 M aqueous solution of NaOH (five drops) was added, followed by addition of H_2O (five drops) again after 15 min of stirring in between. The mixture was dried by addition of $MgSO_4$, filtrated and evaporated to afford an oil. The residue was purified by flash column chromatography (eluent PE/EA 6:1) to yield alcohol **25** (0.105 g, 0.276 mmol; 87%) as a colourless oil.

$[\alpha]_D$=−28.3 (*c* 0.2); IR (film) ν_{max} 3470, 2927, 1461, 1387, 1254, 1102, 1030, 971, 917, 835, 775 cm^{-1}; ^1H NMR (benzene-d_6) δ −0.01 (s, 6H), 0.92 (s, 9H), 0.95 (s, 3H), 1.00 (s, 3H), 1.43 (s, 3H), 1.68 (s, 3H), 0.88–1.69 (m, 13H), 3.45 (t, *J*=4.3 Hz, 2H), 4.18 (br s, 1H), 5.32 (br d, *J*=4.3 Hz, 1H); ^{13}C NMR (benzene-d_6) δ −5.4 (2×q), 16.1 (q), 18.2 (s), 19.2 (t), 22.0 (q), 23.7 (t), 24.7 (q), 25.9 (3×q), 32.7 (q), 34.2 (s), 35.5 (t), 36.6 (s), 41.4 (t), 44.8 (t), 54.2 (d), 55.3 (d), 63.1 (t), 65.7 (d), 128.1 (d), 137.4 (s); HRMS: (M^+−18), found 362.3003. $C_{23}H_{42}OSi$ requires 362.3005; MS *m/e* (%) 362 [(M^+−18), 17], 323 (46), 305 (81), 215 (50), 189 (100), 119 (77), 109 (64), 95 (39), 75 (78), 73 (39), 69 (52).

3.1.26. (−)-3-[(4a*S*,8a*S*)-2,5,5,8a-Tetramethyl-4a,5,6,7,8,8a-hexahydro-1-naphthalenyl]-1-propanol (26). A mixture of alcohol **25** (0.085 g, 0.224 mmol) in CH_3CN (6 mL) was treated with HF (0.09 mL of a 50% aqueous solution) at room temperature. After stirring for 20 min the mixture was quenched with a saturated aqueous solution of $NaHCO_3$. The mixture was then extracted with ethyl acetate. The organic layers were washed with brine, dried and evaporated. The residue was purified by flash column chromatography (eluent PE/EA 4:1) to obtain the intermediate diol as a colourless oil. During evaporation and upon standing this diol spontaneously dehydrated to diene **26** (0.049 g, 0.184 mmol; 88%) which was obtained as a colourless oil.

$[\alpha]_D$=−70.9 (*c* 0.53); IR (film) ν_{max} 3327, 2926, 1459, 1369, 1058 cm^{-1}; ^1H NMR (benzene-d_6) δ 0.97 (s, 3H), 0.99 (s, 3H), 1.02 (s, 3H), 1.75 (s, 3H), 1.09–1.79 (m, 9H), 2.06–2.23 (m, 3H), 3.45 (t, *J*=6.3 Hz, 2H), 5.78 (dd, *J*=2.7, 9.5 Hz, 1H), 5.96 (dd, *J*=3.0, 9.5 Hz, 1H); ^{13}C NMR (benzene-d_6) δ 15.6 (q), 17.6 (q), 19.1 (t), 22.8 (q), 23.7 (t), 32.5 (q), 32.9 (s), 33.5 (t), 35.4 (t), 39.2 (s), 41.1 (t), 53.0 (d), 62.7 (t), 125.0 (s), 126.4 (d), 129.9 (d), 143.7 (s); HRMS: M^+, found 248.2140. $C_{17}H_{28}O$ requires 248.2140; MS *m/e* (%) 248 (M^+, 23), 189 (39), 145 (14), 133 (23), 131 (10), 120 (18), 119 (100), 105 (11), 91 (10), 41 (11).

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10. The same dienone **18** is observed with comparable yield when enone **6** is treated with only a 4 M aqueous solution of KOH in 1,4-dioxane.
11. For a general description of the experimental procedures employed in this research see general information and instrumentation in Bolster, M. G.; Jansen, B. J. M.; de Groot, A. *Tetrahedron* **2001**, *57*, 5657–5662.