Organic Chemistry

Synthesis of (*S*)-6-methylhept-5-en-2-ol, the aggregation pheromone of *Gnathotrichus sulcatus*

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An enantioselective (*ee* ~50%) four-step synthesis of (*S*)-6-methylhept-5-en-2-ol ("sulcatol"), which is the aggregation pheromone of *Gnathotrichus sulcatus*, from 3*S*,7-dimethylocta-1,6-diene was developed.

Key words: linear isoprenoids, (*S*)-6-methylhept-5-en-2-ol, aggregation pheromone, ambrosia beetle, 3*S*,7-dimethyloct-6-en-2-one, Baeyer—Villiger reaction, peroxy acid, epoxidation, (2*S*,5*R*/*S*)-2-acetoxy-5,6-dibromo-6-methylheptane, 4*S*,5,7,7-tetramethyl-6,8-dioxabicyclo[3.2.1]octane.

The ambrosia beetle (*Gnathotrichus sulcatus*) is a phytophagan of ambrosia, which is a quarantine weed and allergen. Aggregation pheromone of this insect ("sulcatol") is a mixture of enantiomeric 6-methylhept-5-en-2-ols (**1**) with the *S* isomer predominating (65%).[1] The known methods for the synthesis of (*S*)-**1** involve enzymatic resolution of a racemic mixture of **1**,[2,3] the use of building blocks with the appropriate configuration of the chiral center, which are prepared by enzymatic reduction of ethyl acetoacetate[4] or 2-acetyl-5-methylhex-4-enoate,[5] the use of ethyl *S*-lactate (through chiral methyloxirane),[6] *R*-glutamic acid,[7] or *S*-γ-trityloxymethyl-γ-butyrolactone,[8] or deoxygenation of L-fucose.[9]

We developed a new approach based on transformations of readily available 3*S*,7-dimethylocta-1,6-diene (**2**) (*ee* ~50%),[10] yielding enantiomerically enriched (*S*)-**1** in which the isomer ratio is close to that occurring in nature. Originally, it was attempted to perform successive oxidation of the terminal double bond in diene **2** with oxygen in the presence of a Pd catalyst to form the corresponding α-methyl ketone (**3**)[11] followed by oxidation of the latter under conditions of the regio- and stereospecific Baeyer—Villiger reaction yielding 2*S*-acetoxy-6-methylhept-5-ene (**4**). Hydrolysis of the latter would afford the target pheromone **1**.

An example of oxidation of the enone with *m*-chloroperbenzoic acid (MCPBA) in the presence of $NaHCO_3$ with retention of the terminal double bond was reported in the literature.[12] However, in our case, oxidation of ketone **3** containing the trisubstituted double bond afforded a mixture of compounds.

Analysis of the IR and NMR spectra of the reaction products demonstrated that the reaction proceeded predominantly at the trisubstituted double bond to yield diastereomers of epoxy ketone (**5**) and its acid-catalyzed cyclization product, *viz.*, 4*S*,5,7,7-tetramethyl-6,8-dioxabicyclo[3.2.1]octane (**6**) (Scheme 1). In addition, 2-acetoxy-6-methyl-5,6-epoxyheptane (**7**) was obtained in an insignificant amount. Compound **7** was addition-

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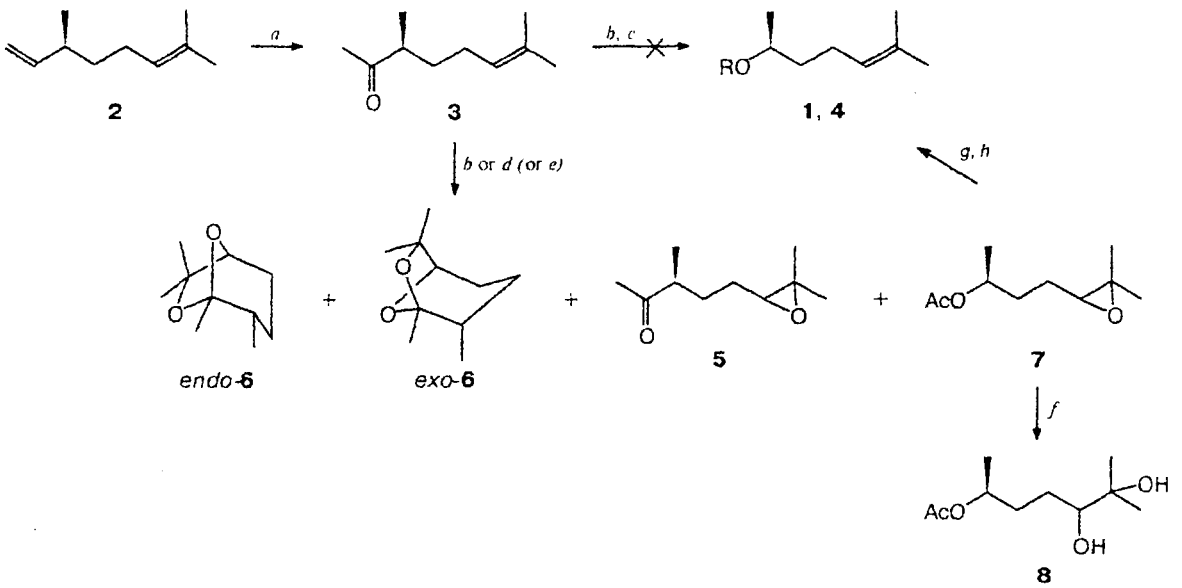
Scheme 1



R = H (**1**) or Ac (**4**)

Reagents and conditions: *a*. See Ref. 10; *b*. MCPBA/$NaHCO_3$; *c*. OH^-; *d*. MCPBA; *e*. MPPA; *f*. $HClO_4$; *g*. AlI_3; *h*. K_2CO_3/MeOH.

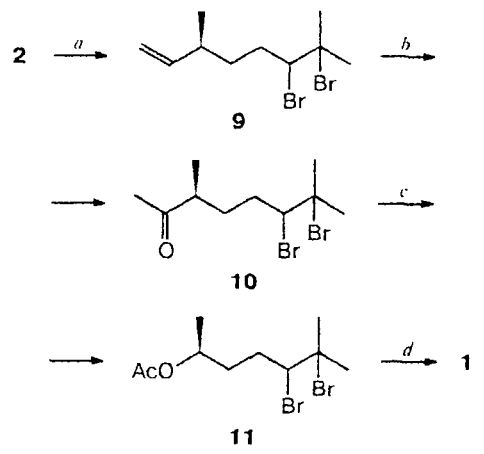
ally characterized by its conversion into the corresponding acetoxydiol (**8**).

In the broad-band ^1H decoupled ^{13}C NMR spectrum of the diastereomers of acetoxydiol **8**, splitting of the signals for the C(3) (at δ 77.82 and 78.28) and C(6) (δ 70.77 and 71.51) atoms as well as for the C(4) and C(5) atoms is observed. This splitting results from the difference in the shielding of the corresponding C atoms of the diastereomeric pair. The chemical shifts of the diastereotopic *gem*-dimethyl groups of the diastereomers (δ 23.06 and 26.31) differ only slightly. The presence of the epoxy function in compound **5** is confirmed by the noticeable upfield chemical shifts (compared to those for diol **8**) of the C(6) atoms belonging to two diastereomers (δ 64.19 and 64.04, respectively), the C(7) atom (δ 58.29), and the *cis*-Me group at the C(7) atom. The chemical shift of the proton at the C(6) atom at δ 2.69—2.77 is also characteristic of substituted epoxides. The assignment of the signals in the ^{13}C NMR spectra of stereoisomeric bicyclic ketals **6** was made based on the difference in the *endo*/*exo* isomer ratio in samples prepared by oxidation of ketone **3** with MCPBA/$NaHCO_3$ (6 : 4), MCPBA (9 : 1), or monoperphthalic acid (MPPA) (9 : 1). The difference in the chemical shifts of the *exo* and *endo* Me groups at the C(4) atom typical of these bicyclic structures[13,14] was also taken into account. The assignment of the signals in the ^1H NMR spectra of these stereoisomers, which are strongly coupled multispin systems, was performed with the use of the H—H COSY method. The low-field signal for the proton at the C(1) atom (at δ 3.87), which is characterized by cross-peaks with the signals for the protons at the C(2) atom (H_{eq}, δ 1.85; H_{ax}, δ 1.65), and the doublet signals for the *endo* and *exo* Me groups at the C(4) atom, which have cross-peaks with the signal for the proton at the C(4) atom, served as the initial signals in the assignment of cross-peaks of the coupled protons. The assignment of the chemical shifts of the multiplets for the axial and equatorial protons at the C(3) atom (δ 1.2 and 2.2, respectively) was carried out based on consideration of cross-peaks with the signal for the proton at the C(4) atom.

Regeneration of the isopropylidene group in compound **7** by deoxygenation under the action of AlI_3[15] followed by hydrolysis afforded the target pheromone **1** in a total yield of 8.1% with respect to the initial diene **2**. Attempts to increase the yield of acetoxyepoxide **7** using an excess of peroxy acids (MCPBA or MPPA) failed. In these cases, mixtures of the same compounds were formed, but the content of **7** was sharply decreased.

Since the above-described conversions afforded compound **7** in insignificant yield, we employed a procedure (Scheme 2) based on the use of a synthetic equivalent of diene **2**, *viz.*, vicinal dibromide (**9**), which was prepared by the chemoselective reaction of compound **2** with pyridinium bromide-perbromide. The conversion of (3*S*,6*R*/*S*)-6,7-dibromo-3,7-dimethyloct-1-ene (**9**) using successive oxidation according to Walker—Tsuji and Baeyer—Villiger afforded (2*S*,5*R*/*S*)-5,6-dibromo-6-methylheptan-2-ol acetate (**11**) *via* intermediate (3*S*,6*R*/*S*)-6,7-dibromo-3,7-dimethyl-

Scheme 2



Reagents and conditions: *a*. Py · Br_2 · HBr; *b*. $O_2/PdCl_2$—CuCl; *c*. MCPBA; *d*. $LiAlH_4$.

octan-2-one (**10**). Under the action of lithium aluminum hydride,[16] compound **11** was converted into the target pheromone **1** in a total yield of 23% with respect to the initial compound **2**.

Experimental

The IR spectra were recorded on a UR-20 instrument in a thin layer. The NMR spectra were measured on a Bruker AM-300 spectrometer (at 300.13 MHz for ^1H and at 75.47 MHz for ^{13}C) in $CDCl_3$ relative to Me_4Si. The GLC-mass spectrometric analysis was carried out on an HP 5890A gas chromatograph equipped with an HP 5972A mass-selective detector (Hewlett Packard, USA; an Ultra-2 silicone capillary column with grafted phenylsilicone (5%); the column length was 50 m, the diameter was 0.2 mm; the thickness of the stationary phase was 0.33 μm). The chromatographic analysis was performed on a Chrom-5 instrument (the column length was 1.2 m; silicone SE-30 (5%) on Chromaton N-AW-DMCS (0.16—0.20 mm) as the stationary phase; the operating temperature was 50—300 °C); helium was used as the carrier gas. The purity of compounds **8**—**10** was checked by thin-layer chromatography on SiO_2 (Silufol, Czech Republic). Elution was carried out with the use of light petroleum (LP), b.p. 40—70 °C. The optical rotation was measured on a Perkin—Elmer MC-241 polarimeter. Oxidation was carried out with the use of MCPBA containing 45% of the major compound.

Oxidation of 3*S*,7-dimethyloct-6-en-2-one (3). ***A.*** $NaHCO_3$ (0.73 g, 8.7 mmol) was added to a stirred solution of enone **3** (0.50 g, 3.2 mmol) in CH_2Cl_2 (10 mL) at 0 °C. Then a solution of MCPBA (3.7 mmol) in CH_2Cl_2 (15 mL) was added dropwise. The resulting mixture was stirred at ~20 °C for 48 h. After the disappearance of the initial ketone **3** (TLC control), the reaction mixture was poured into water (5 mL), the organic layer was separated, and the aqueous layer was extracted with CH_2Cl_2 (3×20 mL). The extract was combined with the organic layer and successively washed with 10% solutions of $NaHCO_3$ and Na_2SO_3 and then with brine. Then the mixture was dried with $MgSO_4$ and filtered and the solvent was evaporated. A crude product which contained (according to the GLC data) compounds **5**, **6**, and **7** in a ratio of 8 : 10 : 3 was obtained in a yield of 0.55 g. This mixture was chromatographed on a column with SiO_2 using gradient elution (LP—Et_2O, 100 : 0 → 2 : 1), and products **5** (0.18 g), **6** (0.24 g), and **7** (0.08 g) were isolated.

B. A solution of MCPBA (7.4 mmol) in $CHCl_3$ (15 mL) was added dropwise to a stirred (0 °C) solution of enone **3** (0.50 g, 3.2 mmol) in $CHCl_3$ (20 mL). Then the reaction mixture was worked up as described in method ***A***. A product which contained (according to the GLC data) compounds **5**, **6**, and **7** in a ratio of 10 : 20 : 1 was obtained in a yield of 0.49 g.

C. A 0.82 *M* ethereal solution (15 mL) of MPPA (12.3 mmol) was added dropwise to a stirred solution (0 °C) of enone **3** (0.50 g, 3.2 mmol) in Et_2O (10 mL). The resulting mixture was stirred at ~20 °C for 72 h. After the disappearance of the initial ketone **3** (TLC control), the reaction mixture was poured into water (5 mL), the organic layer was separated, and the aqueous layer was extracted with Et_2O (3×20 mL). The extract was combined with the organic layer and successively washed with 10% solutions of $NaHCO_3$ and Na_2SO_3 and then with brine. Then the mixture was dried with $MgSO_4$ and filtered and the solvent was evaporated. A crude product which contained (according to the GLC data) compounds **5**, **6**, and **7** in a ratio of 10 : 30 : 1 was obtained in a yield of 0.55 g. These products were isolated by chromatography.

(3*S*,6*R*/*S*)-3,7-Dimethyl-6,7-epoxyoctan-2-one (5). R_f 0.33 (LP—ether, 2 : 1). Found (%): C, 70.35; H, 18.91. $C_{10}H_{18}O_2$. Calculated (%): C, 70.55; H, 18.80. IR, ν/cm^{-1}: 1720 (C=O); 1480, 1400 (H_3C—C); 1265, 1145, 1050 (C—O—C). ^1H NMR ($CDCl_3$), δ: 1.12 (d, 3 H, $H_3CC(3)$, ^3J = 7.2 Hz); 1.25 (1.27) (s, 3 H, *cis*-$H_3CC(7)$); 1.31 (s, 3 H, *trans*-$H_3CC(7)$); 1.42—1.64 (m, 2 H, $H_2C(4)$); 1.70—1.95 (m, 2 H, $H_2C(5)$); 2.18 (s, 3 H, $H_3C(1)$); 2.55—2.68 (m, 1 H, HC(3)); 2.69—2.77 (m, 1 H, HC(6)). ^{13}C NMR ($CDCl_3$), δ: 16.79 (16.11) (q, *cis*-$H_3\underline{C}C(7)$); 18.69 (q, $H_3\underline{C}C(3)$); 21.38 (22.70) (q, *trans*-$H_3CC(7)$); 24.86 (q, C(1)); 27.39 (26.64) (t, C(4)); 29.62 (29.27) (t, C(5)); 46.29 (46.60) (d, C(3)); 58.29 (s, C(7)); 64.19 (64.04) (d, C(6)); 212.36 (212.51) (s, C(2)). MS (EI, 70 eV), *m*/*z* (I_{rel} (%)): 170 $[M]^{\cdot+}$ (3.4), 127 (15.1), 99 (37.4), 86 (8.4), 85 (6.3), 71 (17.4), 55 (19.0), 43 (100), 42 (5.6), 41 (15.5), 39 (7.2).

4*S*,5,7,7-Tetramethyl-6,8-dioxabicyclo[3.2.1]octane (*exo*- and *endo*-6). R_f 0.63 (LP—Et_2O, 2 : 1). Found (%): C, 70.77; H, 18.68. $C_{10}H_{18}O_2$. Calculated (%): C, 70.55; H, 18.80. ^1H NMR ($CDCl_3$), δ: 0.82 (*exo*-**6**) and 1.05 (*endo*-**6**) (d, 3 H, $H_3CC(4)$, *J* = 6.6 Hz); 1.15—1.22 (m, 1 H, $H_{ax}C(3)$); 1.30 (*exo*-**6**) and 1.31 (*endo*-**6**) (s, 3 H, $H_3CC(5)$); 1.37 (*endo*-**6**) and 1.39 (*exo*-**6**) (3 H, *exo*-$H_3CC(7)$); 1.40 (*endo*-**6**) and 1.42 (*exo*-**6**) (s, *endo*-$H_3CC(7)$); 1.55—1.88 (m, 2 H, $H_2C(2)$); 1.65—1.72 (*exo*-**6**) and 1.70—1.73 (*endo*-**6**) (m, 1 H, HC(4)); 2.17—2.25 (m, 1 H, $H_{eq}C(3)$); 3.87 (m, 1 H, HC(1)). ***Exo*-(6).** ^{13}C NMR ($CDCl_3$), δ: 16.59 (q, $H_3CC(4)$); 20.69 (q, *exo*-$H_3CC(7)$); 23.23 (q, $H_3CC(5)$); 25.42 (t, C(3)); 26.19 (t, C(2)); 29.00 (q, *endo*-$H_3CC(7)$); 37.93 (d, C(4)); 80.51 (s, C(7)); 80.37 (d, C(1)); 109.28 (s, C(5)). MS (EI, 70 eV), *m*/*z* (I_{rel} (%)): 170 $[M]^{\cdot+}$ (0.4), 112 (18.1), 98 (5.2), 97 (52.2), 85 (9.8), 83 (11.9), 72 (6.8), 71 (8.7), 70 (8.3), 69 (22.8), 68 (8.7), 59 (16.3), 57 (11.0), 55 (15.5), 43 (100), 41 (28.1), 39 (13.5). ***Endo*-(6).** ^{13}C NMR ($CDCl_3$), δ: 20.57 (q, *exo*-$H_3\underline{C}C(7)$); 20.92 (t, C(3)); 22.22 (q, $H_3CC(4)$); 23.72 (q, $H_3\underline{C}C(5)$); 24.76 (t, C(2)); 28.83 (q, *endo*-$H_3CC(7)$); 36.14 (d, C(4)); 79.81 (s, C(7)); 81.46 (d, C(1)); 109.28 (s, C(5)). MS (EI, 70 eV), *m*/*z* (I_{rel} (%)): 170 $[M]^{\cdot+}$ (0.4), 112 (20.3), 98 (5.1), 97 (55.9), 85 (9.1), 83 (12.4), 72 (6.6), 71 (8.8), 70 (8.0), 69 (24.0), 68 (8.3), 59 (16.9), 57 (11.2), 55 (15.4), 43 (100), 41 (28.4), 39 (13.5).

(2*S*,5*R*/*S*)-2-Acetoxy-6-methyl-5,6-epoxyheptane (7). R_f 0.30 (LP—Et_2O, 2 : 1). Found (%): C, 64.58; H, 9.61. $C_{10}H_{18}O_3$. Calculated (%): C, 64.49; H, 9.74. IR, ν/cm^{-1}: 1745 (C=O); 1260, 1145, 1050 (C—O—C). ^{1}H NMR ($CDCl_3$), δ: 1.11—1.35 (m, 2 H, $H_2C(3)$); 1.21 (1.24) (s, 3 H, *cis*-$H_3CC(6)$); 1.25 (d, 3 H, $H_3C(1)$, J = 6.1 Hz); 1.32 (s, 3 H, *trans*-$H_3CC(6)$); 1.55—2.00 (m, $H_2C(4)$); 2.10 (s, 3 H, H_3CC=O); 2.60—2.78 (m, 1 H, HC(5)); 4.84—5.06 (m, HC(2)). ^{13}C NMR ($CDCl_3$), δ: 16.51 (16.07) (q, *cis*-$H_3CC(6)$); 20.37 (q, C(1)); 21.05 (q, H_3CC=O); 21.43 (21.66) (q, *trans*-$H_3CC(6)$); 26.11 (26.29) (t, C(4)); 32.41 (32.26) (t, C(3)); 58.63 (s, C(6)); 64.42 (64.11) (d, C(5)); 70.31 (71.25) (d, C(2)); 171.46 (s, C=O). Under conditions of GLC/MS, diastereomers of **7** were separated: MS (EI, 70 eV), m/z (I_{rel} (%)): a) 171 [M − Me]$^+$ (0.1), 111 (5.8), 97 (6.3), 85 (32.6), 84 (9.0), 83 (9.7), 71 (6.8), 70 (20.3), 69 (8.1), 67 (11.5), 59 (18.6), 57 (10.3), 55 (11.4), 43 (100), 41 (23.4), 39 (11.1); b) 171 [M − Me]$^+$ (0.1), 111 (5.8), 97 (7.7), 85 (32.5), 84 (9.0), 83 (9.9), 71 (7.1), 70 (20.6), 69 (8.7), 67 (11.4), 59 (18.6), 57 (10.3), 55 (13.1), 43 (100), 41 (23.1), 39 (10.9).

(6*S*,3*R*/*S*)-6-Acetoxy-2-methylheptane-2,3-diol (8). A solution of epoxy ketone **5** (0.11 g, 0.6 mmol) in THF (0.5 mL) was added to a 0.1 *M* $HClO_4$ solution (0.33 mL) in THF (0.2 mL) cooled to 0 °C. The reaction mixture was stirred at 0 °C for 1 h and then at ~20 °C for 5 h. Then the mixture was diluted with Et_2O (10 mL), successively washed with a saturated $NaHCO_3$ solution and brine, dried with Na_2SO_4, filtered, and concentrated. Acetoxydiol **8** was obtained in a yield of 0.09 g (75%). Found (%): C, 59.98; H, 9.61. $C_{10}H_{18}O_4$. Calculated (%): C, 58.80; H, 9.87. IR, ν/cm^{-1}: 3450 (O—H); 1745 (C=O); 1480, 1380 (H_3C—C); 1275 (C—O—C); 1145, 1110, 1045 (C—O). ^{1}H NMR ($CDCl_3$), δ: 1.14 and 1.19 (s, 6 H, $H_3CC(2)$, $H_3C(1)$); 1.23 (d, 3 H, $H_3C(7)$, J = 6.2 Hz); 1.10—1.40 (m, 2 H, $H_2C(5)$); 1.50—1.95 (m, 2 H, $H_2C(4)$); 2.09 (s, 3 H, H_3CC=O); 3.33 (dd, 1 H, HC(3), ^3J = 10.3 Hz, J = 4.1 Hz); 3.77 (br.s, 2 H, OH); 4.85—5.01 (m, 1 H, HC(6)). ^{13}C NMR ($CDCl_3$), δ: 20.05 (q, C(7)); 21.39 (q, H_3CC=O); 23.06 (q, C(1)); 26.31 (q, $H_3CC(2)$); 27.04 (27.51) (t, C(4)); 32.92 (33.24) (t, C(5)); 70.77 (71.51) (d, C(6)); 73.19 (s, C(2)); 77.82 (78.28) (d, C(3)); 171.31 (q, C=O).

(3*S*,6*R*/*S*)-6,7-Dibromo-3,7-dimethyloct-1-ene (9). $Py \cdot Br_2 \cdot HBr$ (2.97 g, 9.40 mmol) was added portionwise with stirring (−60 °C) to a solution of diene **2** (the content of the major compound was 90%, 1.55 g, 10.1 mmol) in $CHCl_3$ (15 mL). The reaction mixture was stirred with gradual warming to ~20 °C over 1 h and then poured into water (3 mL). The organic layer was separated and successively washed with water, 5% HCl, and water, dried with Na_2SO_4, and concentrated. The reside was chromatographed on a column with SiO_2 (LP as the eluent) and dibromide **9** was obtained in a yield of 1.63 g (54%), R_f 0.71. Found (%): C, 40.52; H, 5.91; Br, 53.57. $C_{10}H_{18}Br_2$. Calculated (%): C, 40.30; H, 6.09; Br, 53.62. IR, ν/cm^{-1}: 3090 (H—C=); 1655 (H—C=); 1470 (H_3C—C); 1020, 935 (C=C); 680, 565 (C—Br). ^{1}H NMR ($CDCl_3$), δ: 1.04 (dd, 3 H, $H_3CC(3)$, ^3J = 6.8 Hz, ^4J = 2.5 Hz); 1.30—1.51 and 1.64—1.85 (2 m, 2 H, $H_2C(4)$); 1.64—1.85 and 2.12—2.28 (2 m, 2 H, $H_2C(5)$); 1.80 and 1.98 (2 s, 6 H, $H_3CC(7)$); 2.32—2.51 (m, 1 H, HC(3)); 4.14—4.23 (m, 1 H, HCBr); 4.93—5.06 (m, 1 H, HC=); 5.61—5.80 (m, 2 H, H_2C=). ^{13}C NMR ($CDCl_3$), δ: 20.04 (19.99) (q, $H_3CC(3)$); 28.26 (28.20) (t, C(5)); 33.80 (33.66) (q, $(H_3C)_2C(7)$); 35.44 (35.30) (t, C(4)); 37.24 (d, C(3)); 67.08 (67.20) (d, C(6)); 68.79 (s, C(6)); 113.55 (113.09) (t, H_2C=); 144.20 (143.76) (d, C(2)).

(3*S*,6*R*/*S*)-6,7-Dibromo-3,7-dimethyloct-2-ene (10). A mixture of $PdCl_2$ (0.10 g, 0.56 mmol) and CuCl (0.57 g, 5.7 mmol) in DMF (2.6 mL) and water (0.37 mL) was stirred for 1 h (20 °C) under an atmosphere of O_2. Then olefin **9** (1.60 g, 5.4 mmol) was added and the reaction mixture was stirred. After consumption of 121 mL of O_2, 10% HCl (200 mL) was added to the reaction mixture and the mixture was extracted with $CHCl_3$ (3×100 mL). The combined extracts were successively washed with water, a saturated $CuSO_4$ solution, and water, dried with $MgSO_4$, and concentrated. After chromatography on a column with SiO_2 (a 10 : 1 LP—Et_2O mixture as the eluent), ketone **10** was obtained in a yield of 1.05 g (62%), R_f 0.35. Found (%): C, 38.41; H, 5.57; Br, 51.10. $C_{10}H_{18}Br_2O$. Calculated (%): C, 38.24; H, 5.78; Br, 50.88. IR, ν/cm^{-1}: 1720 (C=O); 1480 (H_3C—C); 680, 560 (C—Br). ^{1}H NMR ($CDCl_3$), δ: 1.05—1.15 (m, 3 H, $H_3CC(3)$); 1.30—1.52 and 1.62—1.87 (2 m, 2 H, $H_2C(4)$); 1.72 and 1.90 (2 s, 6 H, $H_3CC(6)$); 2.12 (s, 3 H, $H_3C(1)$); 2.16—2.25 (m, 2 H, $H_2C(5)$); 2.45—2.62 (m, 1 H, HC(3)); 4.06—4.12 (m, HC(6)). ^{13}C NMR ($CDCl_3$), δ: 16.70 (15.89) (q, $H_3CC(3)$); 28.08 (27.91) (s, C(1)); 31.06 (31.41) (t, C(5)); 33.20 (33.56) (q, $(H_3C)_2C(7)$); 35.24 (35.30) (t, C(4)); 46.37 (46.08) (d, C(3)); 66.24 (66.30) (d, C(3)); 68.38 (68.58) (s, C(7)); 211.81 (s, C=O).

(2*S*,5*R*/*S*)-2-Acetoxy-5,6-dibromo-6-methylheptane (11). A solution of MCPBA (3.5 mmol) in $CHCl_3$ (3 mL) was added dropwise with stirring to a solution of dibromoketone **10** (1.00 g, 3.2 mmol) in $CHCl_3$ (1 mL). The reaction mixture was stirred for 4 days (TLC control) and the precipitate that formed was filtered off and washed with $CHCl_3$. The filtrate was successively washed with 10% solutions of $NaHCO_3$ and Na_2SO_3 and then with brine. Then the mixture was dried with $MgSO_4$ and concentrated. The residue was chromatographed on a column with SiO_2 (CH_2Cl_2 as the eluent). Acetate **11** was obtained in a yield of 0.84 g (80%), R_f 0.60. Found (%): C, 36.58; H, 5.31; Br, 48.25. $C_{10}H_{18}Br_2O_2$. Calculated (%): C, 36.39; H, 5.50; Br, 48.42. IR, ν/cm^{-1}: 1740 (C=O); 1480 (H_3C—C); 1265 (O—C—O); 680, 570 (C—Br). ^{1}H NMR ($CDCl_3$), δ: 1.21 (dt, 3 H, $H_3C(1)$, J = 7.6 and 2.4 Hz); 1.15—1.40 and 1.45—1.75 (2 m, 2 H, $H_2C(3)$); 1.75 and 1.98 (2 s, 6 H, $H_3CC(6)$); 2.00 (s, 3 H, H_3CC=O); 2.28—2.63 (m, 2 H, $H_2C(4)$); 4.15—4.23 (m, 1 H, HC(5)); 4.84—5.00 (m, 1 H, HC(2)). ^{13}C NMR ($CDCl_3$), δ: 20.01 (19.87) (q, C(1)); 21.23 (q, H_3CC=O); 32.09 (31.37) (t, C(4)); 34.73 (34.20) (t, C(3)); 35.28 and 35.22 (q, $(H_3C)_2C(6)$); 66.33 (65.66) (d, C(5)); 70.28 (69.11) (d, C(2)); 71.70 (66.44) (s, C(6)); 170.47 (173.78) (s, OCO).

(*S*)-6-Methylhept-5-en-2-ol (1). *A.* A freshly prepared solution of AlI_3 in benzene (10 mL, 3.5 mmol) was added dropwise to a stirred solution of acetoxyepoxide **7** (0.47 g, 2.5 mmol) in MeCN (40 mL) at 20 °C and the mixture was stirred. After completion of the reaction (0.5 h, TLC control), the reaction mixture was decomposed with cold water and extracted with Et_2O. The extract was washed with water, dried with $MgSO_4$, and concentrated. The residue (0.40 g) was dissolved in MeOH (7 mL). Then K_2CO_3 (3.26 g, 23.6 mmol) was added and the mixture was heated at 50 °C for 2 h. The reaction mixture was cooled, acidified with 10% HCl to pH ≤ 3, and extracted with Et_2O (3×30 mL). The extract was successively washed with saturated NaCl, Na_2CO_3, and NaCl solutions, dried with Na_2SO_4, and concentrated. Alcohol **1** was obtained in a yield of 0.29 g (90%), $[\alpha]_D^{21}$ +7.3° (*c* 0.95; EtOH) (*cf.* Ref. 7 for (*S*)-**1**: $[\alpha]_D^{23}$ +14.3° (EtOH)). The IR spectrum corresponds to that reported previously.[7] ^{1}H NMR ($CDCl_3$), δ: 1.10 (d, 3 H, $H_3C(1)$, J = 7.0 Hz); 1.30—1.50 (m, 2 H, $H_2C(3)$); 1.53 (s, 3 H, *cis*-$H_3CC(6)$); 1.60 (s, 3 H, $H_3C(7)$); 1.85—2.11 (m, 2 H, H_2CC=); 2.40 (br.s, 1 H, OH); 3.61—3.80 (m, HCO); 5.11 (t, 1 H, HC=, J = 6.4 Hz).

^{13}C NMR ($CDCl_3$), δ: 17.07 (q, *cis*-$H_3CC(6)$); 23.09 (q, $H_3C(7)$); 24.45 (q, C(1)); 25.66 (t, C(4)); 39.16 (t, C(3)); 67.80 (d, C(2)); 124.10 (d, C(5)); 131.87 (s, C(6)).

B. $LiAlH_4$ (0.23 g, 60 mmol) was added portionwise with stirring (Ar, 0 °C) to a solution of dibromoacetate **11** (0.79 g, 2.4 mmol) in THF (12 mL). The reaction mixture was refluxed for 2 h and then cooled to 5 °C. Water (5 mL) and 10% HCl (10 mL) were successively added with stirring. Then the reaction mixture was stirred for 0.5 h, the organic layer was separated, and the aqueous layer was extracted with Et_2O (3×30 mL). The extract was combined with the organic layer, successively washed with saturated $NaHCO_3$ and NaCl solutions, dried with Na_2SO_4, and concentrated. After chromatography (SiO_2; CH_2Cl_2 as the eluent; R_f 0.40), alcohol **1** was obtained in a yield of 0.26 g (85%). The resulting alcohol was identical in all parameters to that obtained according to procedure ***A***.

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