Formal synthesis of strobilurins A and X

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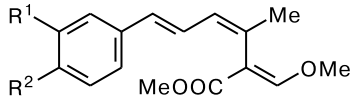
Known synthetic precursors of strobilurins A and X, *i.e.*, methyl (3*Z*,5*E*)-6-aryl-3-methylhexa-3,5-dienoates (aryl is phenyl, 4-methoxyphenyl), were synthesized by highly stereospecific reactions from 2-(2-*tert*-butyldimethylsilyloxyethyl)- and 2-[2-(4-methoxybenzyloxy)ethyl]-5-arylpenta-2*E*,4*E*-dien-1-ols. These dienols were efficiently dehydroxylated to (1*E*,3*Z*)-4-methyl-6-(4-methoxybenzyloxy)hexa-1,3-dienylarenes with their subsequent demethoxybenzylation to (3*Z*,5*E*)-6-aryl-3-methylhexa-3,5-dien-1-ols. The latter through the step of corresponding aryldienals and aryldienoic acids were transformed to the target methyl (3*Z*,5*E*)-6-aryl-3-methylhexa-3,5-dienoates, which completes a formal synthesis of strobilurins A and X. Configuration of the C=C bonds of the conjugated aryldiene system is preserved in the considered transformations by 95—97%.

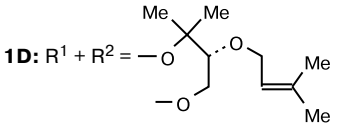
Key words: stereocontrolled synthesis, strobilurins, dienes, dienals, aryldienoic acids, dehydroxylation, debenzylation, oxidation.

Strobilurins are biologically active compounds produced by bazidomicetes.[1] At present, there are known 15 representatives of this group of natural compounds of general formula **1** with different substituents in the benzene ring.[2,3] The structures of some of them are given below.



1

1A: $R^1 = R^2 = H$ **1X:** $R^1 = H$, $R^2 = OMe$
1B: $R^1 = OMe$, $R^2 = Cl$ **1C:** $R^1 = Me_2C{=}CHCH_2O$, $R^2 = H$



All the known strobilurins are capable of inhibiting the respiratory cycle in mitochondria and due to this exhibit high fungicide activity.

The structure of strobilurins is characterized by the presence of a (*E*,*Z*,*E*)-aryltriene fragment, whose stereoselective construction is poorly investigated. It is known from the literature that syntheses of strobilurins, except of one of them,[4] are based on the Wittig—Horner reaction and are not stereoselective.

Retrosynthetic analysis of molecule **1** (Scheme 1) together with the method developed by us earlier[5] for the creation of internal (*Z*)-trisubstituted C=C bond allowed us to expect success in development of highly stereoselective pathway for the construction of (3*Z*,5*E*)-esters **2**, the known[6,7] precursors of **1** and, thus, in accomplishment of formal total synthesis of compounds **1**.[8]

To check a plausibility of such an approach, for the synthesis of esters **2a** ($R^1 = R^2 = H$) and **2b** ($R^1 = H$, $R^2 = OMe$), precursors of simple strobilurins A (**1A**) and X (**1X**), earlier[9] we have accomplished the syntheses of (2*E*,4*E*)-dienals **5a—c,e,f** in high yields and stereoselectivity ~100% (Scheme 2). The latter are the key intermediates in the approach under consideration, since they contain a required aryldiene fragment.

The present work is aimed on the development of highly stereoselective methods for the transformation of dienals **5a**—**d** through the steps of dienols **8a**—**d**, dienols **3a**,**b**, and dienoic acids **13a**,**b** (see below) to esters **2a**,**b**.

Dienals **5a**—**d** (see Scheme 2), like dienals **5e**,**f**,[10] are smoothly and stereospecifically reduced with $NaBH_4$ under standard conditions to give (2*E*,4*E*)-dienols **8a**—**d**. The structure of the latter was confirmed by elemental analysis and combination of physico-chemical methods, first of all, NOE ^{1}H NMR. Thus, the olefinic region in the ^{1}H NMR spectrum of dienol **8a** shows the presence of two doublets at δ 6.31 and 6.59, as well as a doublet of doublets at δ 6.99, and only the first of these signals (δ 6.31) reveals the NOE (5.3%) with the protons of the $C\underline{H}_2OH$ group, whereas the doublet of doublets gives the NOE (7.5%)

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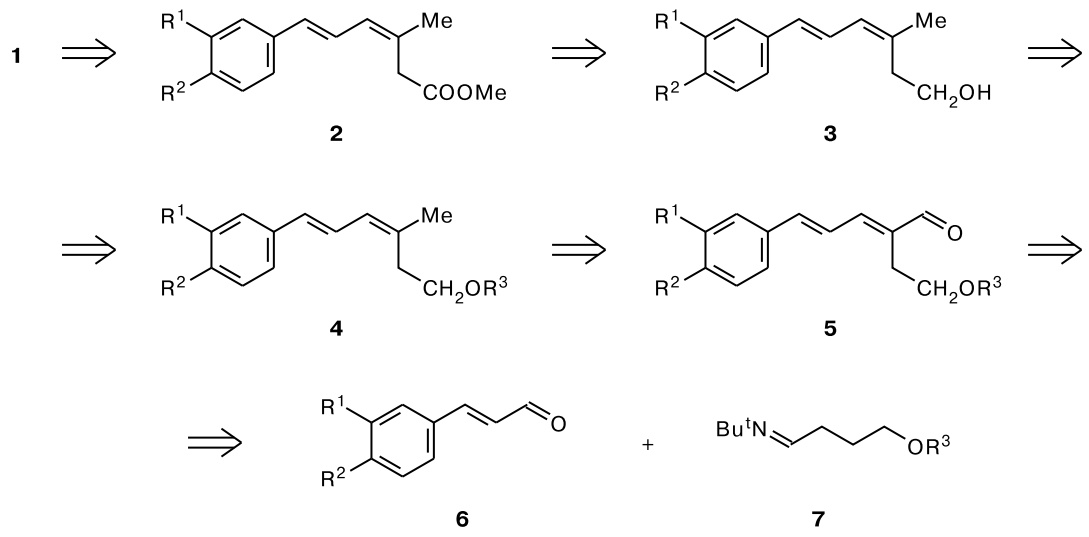
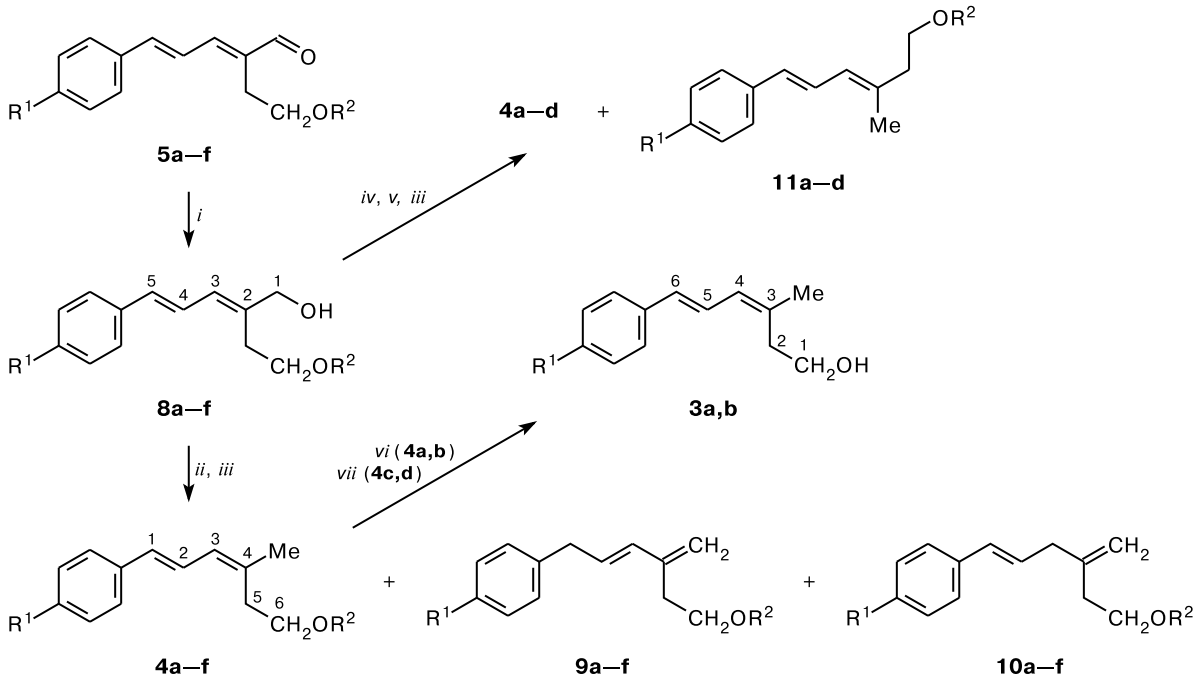
Scheme 1



with the protons of the allylic CH_2 group. These data allowed us, first, to assign the doublet at δ 6.31 to the HC(3), and, second, to draw conclusion on the (*E*)-configuration of the C(2)=C(3) bond. The second doublet signal in the ^{1}H NMR spectrum of dienol **8a** (δ 6.59) is assigned to the HC(5). Its spin-spin coupling constant with HC(4) (15.5 Hz) evidences the (*E*)-configuration of the C(4)=C(5) bond. The (*E*,*E*)-configuration of dienols **8b—d** was established similarly.

It was more difficult to preserve configuration of the diene system of C=C bonds during dehydroxylation of the free CH_2OH group of dienols **8a—d**. Transformation of

Scheme 2



Reagents and conditions: *i.* $NaBH_4$/EtOH, 20 °C, 2 h; *ii.* Py·SO_3/THF, 0 °C, 2.5 h; *iii.* $LiAlH_4$, 20 °C, 20 h; *iv.* BuLi/Et_2O—HMPA, 0 °C; *v.* TsCl/HMPA, 0 °C, 2.5 h; *vi.* Bu_4NF/THF, 20 °C, 30 min; *vii.* $PhNMe_2$, then, $AlCl_3$, 0 °C, 1.5 h.

alcohol using a $Py \cdot SO_3$ complex to sulfonic ester and reduction of the latter (without isolation) with $LiAlH_4$, was good in dehydroxylation of allylic alcohols (see, for example, Refs 11 and 12). However, its extension on dienols gave satisfactory results only in the case of dienol **8c**, which was successfully converted to (1*E*,3*Z*)-diene **4c** in more than 95% purity (^{1}H NMR data). Analytically pure sample of **4c** was isolated by HPLC in 50% yield calculated on two steps. Its structure, as well as structures of dienes **4a,b,d** described below, were confirmed by high resolution mass spectrometry (HRMS) and NOE ^{1}H NMR similarly to that described above for dienol **8a**.

Dehydroxylation of dienols **8a,b** bearing *tert*-butyldimethylsilyl (TBS) O-protecting group and dienol **8d** bearing 4-methoxybenzyl protecting group through the step of their sulfonic esters is less selective. For instance, (2*E*,4*E*)-dienol **8a** gives in the best experiment of this series (1*E*,3*Z*)-diene **4a** containing totally 11% of dienes **9a** and **10a** in the ratio 8 : 3 as an admixture. The structure and content of the latter in the mixture were established by NMR spectroscopy. In fact, in the ^{1}H NMR spectra of the mixture of products of dehydroxylation of dienol **8a**, in addition to the signals for diene **4a**, there are two minor doublet signals for the terminal methylene group at δ 5.0 and 4.96 and the ratio of integral intensities ~8 : 3. In addition, the spectra contain a doublet signal for the CH_2 group placed between the Ph ring and the C=C bond (δ 3.46), as well as a signal for the CH_2 group placed between two C=C bonds (δ 2.98).[13] The ratio of their integral intensities is also ~8 : 3, while the ratio of integral intensities of the first of them and the signal for the $H_2C(5)$ group of diene **4a** is 11 : 1. These results, as well as the fact that the high resolution mass spectrum of the mixture of products of dehydroxylation of dienol **8a** exhibits only ions $[M + H]^+$, $[M + Na]^+$, and $[M + K]^+$, allowed us to assign the structure **9a** to the major product in the admixture, while the minor admixture product has the structure **10a**. Similar situation is also observed in the reduction of sulfonic esters of dienols **8b** and **8d**. However, here in the first case the total content and the ratio of isomers **9b** and **10b** in the mixture are ~33% and 4 : 1, in the second case, the total content and the ratio of isomers **9d** and **10d** are ~38% and 5 : 1 (^{1}H NMR spectroscopic data).

To find an alternative method for the preparation of dienes **4a—d** from dienols **8a—d**, we studied the $LiAlH_4$ reduction of their crude tosylates. Dienols **8b,d** are thus converted in two steps to dienes **4b,d** in ~60% yield, which contain no admixtures of **9b,d** and **10b,d**. However, dienes **4b** and **4d** in such a case contained ~5 and ~8% of (1*E*,3*E*)-dienes **11b** and **11d**, respectively. At the same time, tosylate of dienol **8c** is reduced with $LiAlH_4$ to diene **4c** containing totally ~2% of isomers **9c** and **10c** and containing no isomer **11c** (the data of ^{1}H NMR spectrum). Reduction of tosylate of dienol **8a** leads to a mixture of dienes **4a** and **11a** in the ratio ~3 : 1. Analytically pure samples of **4b,d,c** were isolated by flash-chromatography.

Formation of (1*E*,3*E*)-dienes **11** during preparation of (1*E*,3Z)-dienes **4** was inferred from the NMR spectroscopic data. Thus, the ^{1}H NMR spectrum of diene **4a**, together with signals for its $H_2C(5)$ (t, δ 2.53), HC(3) (d, δ 6.09), and HC(1) (d, δ 6.45) groups, exhibits additional signals close to each of them: a triplet at δ 2.34 and two doublets at δ 6.05 and 6.43, respectively. The ^{13}C NMR spectrum, together with the signal for the MeC(4) of *Z*-isomer (δ 24.72), shows the signal for the MeC(4) of (*E*)-isomer (δ 17.34). Similarly, admixture isomers **11b—d** were found in dienes **4b—d**.

Analysis of considered transformations of dienals **5a—d**, as well as recently described[10] transformations of dienals **5e,f** to diens **4a-f**, allows us to conclude that stereochemistry of formation of dienals **5a—f**, determined by a thermodynamic factor,[5] depends little on both the presence of a substituent in the benzene ring and the nature of the O-protecting group. This regularity also operates in the transformation of dienals **5a—f** to (2*E*,4*E*)-dienols **8a—f**. At the same time, the stereoselectivity of dehydroxylation processes of the latter significantly depends on their structure. Dienols **8b,d,f** with a MeO substituent in the benzene ring can be converted to the desired dienes with high stereoselectivity starting from their tosylates. In the case of dienols **8a,e** unsubstituted in the benzene ring, it is reasonable to use their sulfonic esters. The high (98%) stereospecificity of dehydroxylation of both sulfonic esters and tosylates was reached only in the case of dienol **8c** with *O*-methoxybenzyl protection.

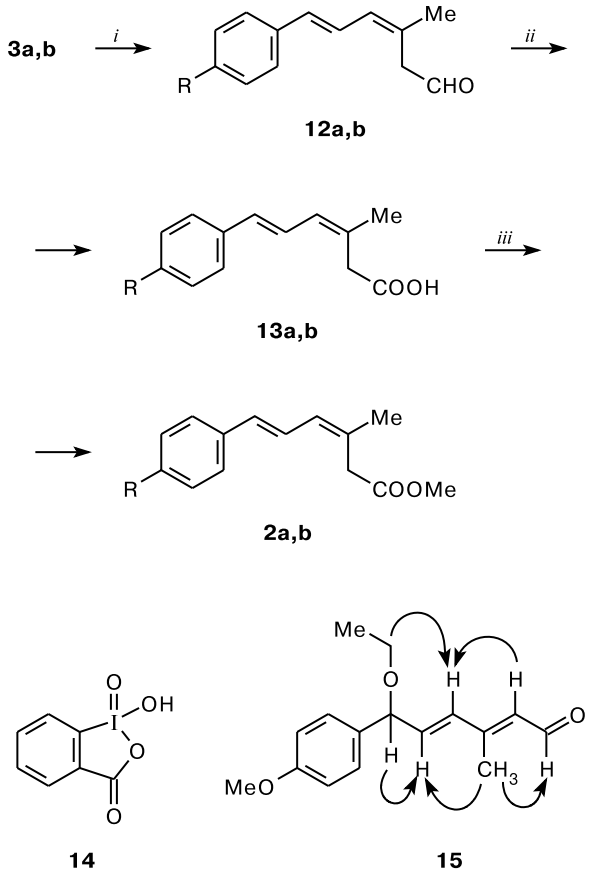
Deprotection of dienes **4a,b** with O-TBS-protection was accomplished with Bu_4NF in aqueous THF and gave dienols **3a,b** in 78—80% yield with full preservation of configuration of the C=C bonds. Removal of *O*-methoxybenzyl protection from diene **4c** was successfully accomplished by their treatment with $AlCl_3$ at 0 °C in the presence of $PhNMe_2$[14] (80—82% yield, see similar[10] deprotection of benzyloxydienes **4e,f**). In this case, the dienol **3a** obtained contains totally no more than 2% of corresponding isomers **9a**, **10a**, and **11a** (^{1}H NMR spectroscopic data). However, deprotection in diene **4d** under these conditions is accompanied by isomerization and gives a mixture of dienol **3b** and its (3*E*,5*E*)-isomer in the ratio 4 : 1.

Note that according to the data published earlier,[15,16] dienol **3a** is a metabolite of ascomicete *Bolinea lutea*, the only known by now strobilurins producer other than bazidomicete. The authors of the work[15] assumed that dienol **3a** is a biosynthetic precursor of strobilurin A; physico-chemical parameters of the sample of **3a** isolated by them are in good correlation with those described earlier[10] and in the present work.

A search for the method of clean oxidation of dienols **3a,b** to acids **13a,b** turned out to be difficult, too

(Scheme 3). Attempted direct transformation of dienol **3b** to acid **13b** with PDC in DMF (see Ref. 17) or $NaIO_4$ in the presence of catalytic amounts of $Na_2Cr_2O_7$ and HNO_3 (see Ref. 18) did not give the desired result: complex mixtures of isomerization and destruction products were obtained in both cases (NMR spectroscopic data).

Scheme 3



R = H (**a**), OMe (**b**)

Reagents and conditions: *i*. IBX (**14**)/DMF, 20 °C, 2 h; *ii*. $NaClO_2$—DMSO/H_2O—THF, phosphate buffer with pH 9, 0 °C, 2.5 h; *iii*. CH_2N_2/Et_2O, 0 °C.

Dienols **3a,b** were smoothly converted to acids **13a,b** through the step of preparation of the corresponding dienals **12a,b**. The best oxidant for obtaining the latter was found to be *o*-iodoxybenzoic acid (IBX, **14**),[19,20] which gave dienals **12a,b** chemo- and stereospecifically in high yields. Note that both the Swern and Corey (using PCC or PDC in CH_2Cl_2) procedures, as well as oxidation with iodosuccinimide in methanol in the presence of K_2CO_3 (see Ref. 21), led to complex mixtures (^{1}H NMR spectroscopic data).

Attempted oxidation of dienal **12b** with Ag_2O, generated *in situ* in aqueous ethanol from $AgNO_3$ with KOH,[22] was unsuccessful. A mixture of ethoxydienal **15** (δ_{CHO} 10.10) (see Scheme 3) and its 2*Z*-isomer (δ_{CHO} 9.66) in the ratio ~7 : 1 (^{1}H NMR spectroscopic data) was isolated from the reaction products in ~30% yield instead of expected acid **13b** or its ester. The structure of compound **15** was established by HRMS and ^{1}H NMR using the double resonance and NOE techniques.

Dienals **12a,b** were successfully oxidized with full preservation of configuration of the C=C bonds by treatment with $NaClO_2$ in the presence of DMSO at pH 9 using modified by us procedure.[23] The obtained acids **13a,b** were quantitatively converted to methyl esters **2a** and **2b**, that formally finishes the total synthesis of strobilurins A and X, respectively.

The structure of compounds **2a,b**, **3a,b**, **12a,b**, and **13a,b** was established by physico-chemical methods, first of all by HRMS and ^{1}H NMR spectroscopy using the NOE procedure, as it was described above taken dienol **8a** as an example.

In conclusion, we have developed a new efficient eight-step formal synthesis of strobilurins A and X. The configuration of aryldiene system of conjugate C=C bonds, created by cross-condensation of aldimines **7** with (*E*)-cinnamic aldehydes, remained intact during the synthesis by 95—97%.

Experimental

UV spectra were recorded on a Specord UV—Vis spectrometer in ethanol, IR spectra were recorded on a Specord M-80 spectrometer for neat samples or (for alcohols) for solutions in $CHCl_3$. ^{1}H and ^{13}C NMR spectra were recorded on a Bruker AC-200 spectrometer in $CDCl_3$ relatively to the signal of the solvent (δ 7.27 and 77.0, respectively). Assignment of signals for the vinylic protons in the ^{1}H NMR spectra was made based on the NOE experiment. Mass spectra (EI, 70 eV) were recorded on a Kratos MS-30 instrument with exhibiting peaks of >10% relative intensities, except peaks of molecular ions. High resolution mass spectra (HRMS) were recorded on a micrOTOF II instrument (Bruker Daltonics) using electrospray ionization (ESI), the scanning range from *m/z* 50 to *m/z* 3000, positive ions (the voltage on a capillary was 4500 V). Compounds were injected with a syringe. Acetonitrile was a solvent, the solution flow rate was 3 μL min^{-1}, the interface temperature was 180 °C, nitrogen was the spray gas (4.0 L min^{-1}). Melting points were measured on a Kofler heating stage. Column chromatography was performed on Silica gel 60 (0.04—0.06 mm, Fluka); TLC, unless indicated otherwise, was performed in the systems *1* (TBME—hexane (1 : 1)) or *2* (acetone—hexane (2 : 3)). Analytical and preparative HPLC was performed on a Armofer Sil 10 column (10 μm, 150×24 mm); a RIDK-102 detector, using a 5% (vol.) solution of ethyl acetate in heptane as an eluent (the flow rate was 6 mL min^{-1}). Solvents were purified as follows: diethyl ether and THF were kept over KOH, sequentially distilled over Na and $LiAlH_4$, then refluxed with benzophenone Na-ketyl until blue color was persistent and distilled directly into the reaction vessel; hexane was distilled over Na. Hexane solution of BuLi was obtained according to the standard procedure. Experiments

with unstable compound were performed under argon; chemical glassware used was heated at 160 °C for 12 h and cooled in the flow of argon.

Usual treatment of organic extracts included their washing to pH ~7, drying with Na_2SO_4, and concentration *in vacuo* on a rotary evaporator.

Dienals **5a—c** were obtained as described in the work.[9]

(2*E*,4*E*)-2-(2-*tert*-Butyldimethylsilyloxyethyl)-5-phenylpenta-2,4-dien-1-ol (8a) was obtained by reduction of dienal **5a** (see Ref. 9) with $NaBH_4$ according to the standard procedure. The yield was ~100%, R_f 0.49 (system *1*). HRMS (*m/z*): found: 341.1890 $[M + Na]^+$. $C_{19}H_{30}O_2NaSi$. Calculated: 341.1901 $[M + Na]^+$. UV, λ_{max}/nm (ε): 239 (7950), 298.5 (27380), 320 (15900). IR, ν/cm^{-1}: 3600, 3392, 3080, 3064, 3048, 3008, 2952, 2856, 2256, 1792, 1676, 1620, 1592, 1520, 1492, 1468, 1392, 1376, 1256, 1188, 1148, 1080, 1008, 960, 912, 840, 696. ^{1}H NMR, δ: 0.11 (s, 6 H, Me_2Si); 0.93 (s, 9 H, Bu^t); 2.62 (t, 2 H, $H_2C(1')$, J = 6.1 Hz); 3.81 (t, 2 H, $H_2C(2')$, J = 6.1 Hz); 4.16 (s, 2 H, $H_2C(1)$); 6.31 (d, 1 H, HC(3), J = 11.0 Hz); 6.59 (d, 1 H, HC(5), J = 15.5 Hz); 6.99 (dd, 1 H, HC(4), J_1 = 11.0 Hz, J_2 = = 15.5 Hz); 7.35 (m, 5 H, Ph). ^{13}C NMR, δ: –5.50 (Me_2Si); 18.26 (CMe_3); 25.84 (CMe_3); 32.62(C(1′)); 63.06 (C(2′)); 67.91 (C(1)); 124.11 (C(4)); 126.33 (C(3)); 127.46, 127.86, 128.55 (Ar); 133.11 (C(5)); 137.39 (Ar); 139.36 (C(2)). MS, *m/z* (I_{rel} (%)): 318 $[M]^+$ (8), 261 (23), 259 (14), 243 (13), 186 (30), 185 (15), 171 (14), 170 (15), 169 (45), 167 (17), 158 (14), 157 (32), 156 (17), 155 (53), 154 (41.5), 153 (22), 143 (32), 142 (21), 141 (57), 129 (37), 128 (36), 118 (27), 117 (81), 116 (10), 115 (46), 106 (24), 105 (88), 103 (13), 101 (17), 99 (14), 95 (14), 92 (15.5), 91 (52), 90 (15.5), 89 (100), 83 (10), 77 (29), 76 (39), 75 (93), 74 (51), 73 (84.5), 61 (14), 57 (23), 43 (14), 38 (14).

(2*E*,4*E*)-2-(2-*tert*-Butyldimethylsilyloxyethyl)-5-(4-methoxyphenyl)penta-2,4-dien-1-ol (8b) was obtained similarly to dienol **8a** from dienal **5b** (see Ref. 9). The yield was 90%, b.p. 170 °C ($7 \cdot 10^{-2}$ Torr) (bath). Found (%): C, 68.95; H, 9.30; Si, 7.70. $C_{20}H_{32}O_3Si$. Calculated (%): C, 68.92; H, 9.25; Si, 8.06. UV, λ_{max}/nm (ε): 226 (7700), 304 (25100). IR, ν/cm^{-1}: 3612, 3400, 3040, 3000, 2930, 2860, 1600, 1580, 1512, 1472, 1440, 1392, 1364, 1300, 1260, 1176, 1076, 1036, 1000, 960, 920, 888, 836, 660. ^{1}H NMR, δ: 0.01 (s, 6 H, Me_2Si); 0.92 (s, 9 H, Bu^t); 2.60 (t, 2 H, $H_2C(1')$, J = 6.1 Hz); 3.00 (br.s, 1 H, OH); 3.79 (t, 2 H, $H_2C(2')$, J = 6.1 Hz); 3.82 (s, 3 H, MeO); 4.14 (s, 2 H, $H_2C(1)$; 6.27 (d, 1 H, HC(3), J = 10.5 Hz); 6.53 (d, 1 H, HC(5), J = 15.4 Hz); 6.84 (dd, 1 H, HC(4), J_1 = 10.5 Hz, J_2 = 15.4 Hz); 6.87 (d, 2 H, Ar, J = 8.7 Hz); 7.35 (d, 2 H, Ar, J = 8.7 Hz). ^{13}C NMR, δ: –5.56 (Me_2Si); 18.19 (CMe_3); 25.78 (Me_3C); 32.61 (C(1′)); 55.16 (MeO); 62.97 (C(2′)); 68.00 (C(1)); 113.99 (Ar); 122.16 (C(4)); 127.47 (Ar); 128.06 (C(3)); 132.64 (C(5)); 138.36 (C(2)); 159.17 (COMe). MS, *m/z* (I_{rel} (%)): 348 $[M]^+$ (12), 289 (20), 200 (10), 199 (20), 187 (16), 185 (32), 173 (15), 171 (16), 165 (10), 158 (14), 147 (25), 145 (12), 141 (15), 134 (36), 129 (17), 121 (13), 115 (50), 105 (21), 112 (14), 91 (21), 89 (11), 77 (28), 75 (100), 74 (86), 57 (13), 55 (15).

(2*E*,4*E*)-2-[2-(4-Methoxybenzyloxy)ethyl]-5-phenylpenta-2,4-dien-1-ol (8c) was obtained similarly to dienols **8a,b** from **5c** (see Ref. 9). The yield was ~100%, m.p. 43—45 °C (from hexane—diethyl ether (1 : 1)). HRMS (*m/z*), found: 347.1624 $[M + Na]^+$; 363.1360 $[M + K]^+$. $C_{21}H_{24}O_3$. Calculated (%): 347.1618 $[M + Na]^+$; 363.1357 $[M + K]^+$. UV, λ_{max}/nm (ε): 234 (21380), 301 (30560). IR, ν/cm^{-1}: 3608, 3420, 3036, 3008, 2950, 2930, 2910, 2864, 2835, 1612, 1588, 1520, 1512, 1464, 1448, 1364, 1304, 1248, 1172, 1088, 1036, 1004, 964, 824. ^{1}H NMR, δ: 2.67 (t, 2 H, $H_2C(1')$, J = 6.10 Hz); 2.89 (br.s, 1 H, OH); 3.63 (t, 2 H, $H_2C(2')$, J = 6.10 Hz); 3.79 (s, 3 H, MeO); 4.14 (s, 2 H, $H_2C(1)$); 4.49 (s, 2 H, H_2CPh); 6.30 (d, 1 H, HC(3), J = 11.2 Hz); 6.59 (d, 1 H, HC(5), J = 15.7 Hz); 6.87 (d, 2 H, Ar, J = 8.4 Hz); 6.97 (dd, 1 H, HC(4), J_1 = 11.2 Hz, J_2 = 15.7 Hz); 7.34 (m, 7 H, Ar). ^{13}C NMR, δ: 29.85 (C(1′)); 55.15 (MeO); 67.87 (C(1)); 69.33 C(2′); 72.83 (CH_2Ph); 113.81 (Ar), 124.15 (C(4)); 126.36 (C(3)); 127.48, 127.85, 128.10, 128.54, 129.25 (Ar); 133.19 (C(5)); 137.40 (Ar); 139.49 (C(2)); 159.23 (Ar). MS, *m/z* (I_{rel} (%)): 324 $[M]^+$ (1), 203 (3), 137 (14), 122 (8.5), 121 (100), 91 (10).

(2*E*,4*E*)-2-[2-(4-Methoxybenzyloxy)ethyl]-5-(4-methoxyphenyl)penta-2,4-dien-1-al (5d) was obtained by condensation of (*E*)-4-methoxycinnamaldehyde with 4-(4-methoxybenzyloxy)butanal *N*-*tert*-butylimine according to the procedure described earlier,[9] yellow crystals, m.p. 74—76 °C (from benzene—hexane (1 : 1)). Found (%): C, 74.70; H, 6.72. $C_{22}H_{24}O_4$. Calculated (%): C, 74.97; H, 6.86. UV, λ_{max}/nm (ε): 203 (17000), 226 (16000), 351 (37000). IR, ν/cm^{-1}: 3000, 2850, 2836, 1656, 1592, 1512, 1464, 1440, 1424, 1376, 1360, 1332, 1316, 1252, 1172, 1112, 1096, 1052, 1032, 984, 968, 884, 840, 808, 764, 640. ^{1}H NMR, δ: 2.78 (t, 2 H, $H_2C(1')$, J = 6.8 Hz); 3.55 (t, 2 H, $H_2C(2')$, J = 6.8 Hz); 3.75, 3.85 (both s, 3 H each, MeO); 4.44 (s, 2 H, H_2CPh); 6.79 (d, 2 H, Ar, J = 8.6 Hz); 6.90 (d, 2 H, Ar, J = 8.8 Hz); 6.96 (d, 1 H, HC(5), J = 15.2 Hz); 7.06 (d, 1 H, HC(3), J = 11.2 Hz); 7.18 (dd, 1 H, HC(4), J_1 = 15.2 Hz, J_2 = 11.2 Hz); 7.23 (d, 2 H, Ar, J = 8.6 Hz); 7.43 (d, 2 H, Ar, J = 8.7 Hz); 9.47 (s, 1 H, HC(1)). ^{13}C NMR, δ: 25.18 (C(1′)); 55.17, 55.35 (MeO); 68.75 (C(2′)); 72.57 (CH_2Ph); 113.72, 114.36 (Ar); 121.93 (C(4)); 129.03, 129.12 (Ar); 137.71 (C(2)); 141.55 (C(5)); 151.23 (C(3)); 159.05, 160.78 (Ar); 194.22 (C(1)).

(2*E*,4*E*)-2-[2-(4-Methoxybenzyloxy)ethyl]-5-(4-methoxyphenyl)penta-2,4-dien-1-ol (8d) was obtained similarly to dienols **8a—c** from **5d**. The yield was ~100%, m.p. 75—76 °C. Found (%): C, 74.72; H, 7.13. $C_{22}H_{26}O_4$. Calculated (%): C, 74.55; H, 7.39. UV, λ_{max}/nm (ε): 229 (23400), 303 (46700). IR, ν/cm^{-1}: 3608, 3400, 3032, 3008, 2936, 2912, 2840, 1604, 1508, 1464, 1436, 1420, 1356, 1304, 1248, 1176, 1088, 1060, 1036, 1004, 964, 820, 664. ^{1}H NMR, δ: 2.65 (t, 2 H, $H_2C(1')$, J = 6.2 Hz); 2.90 (br.s, 1 H, OH); 3.62 (t, 2 H, $H_2C(2')$, J = 6.2 Hz); 3.79, 3.82 (both s, 3 H each, MeO); 4.12 (s, 2 H, $H_2C(1)$); 4.48 (s, 2 H, H_2CPh); 6.27 (d, 1 H, HC(3), J = 10.9 Hz); 6.53 (d, 1 H, HC(5), J = 15.4 Hz); 6.84 (dd, 1 H, HC(4), J_1 = 10.9 Hz, J_2 = 15.4 Hz); 6.87 (d, 4 H, Ar, J = 8.7 Hz); 7.26 (d, 2 H, Ar, J = 8.6 Hz); 7.34 (d, 2 H, Ar, J = 8.7 Hz). ^{13}C NMR, δ: 29.90 (C(1′)); 55.17, 55.23 (MeO); 68.07 (C(1)); 69.39 (C(2′)); 72.85 (CH_2Ph); 113.04, 113.81 (Ar); 122.14 (C(4)); 127.58 (C(3)); 128.17, 129.25 (Ar); 132.85 (C(5)); 138.18 (C(2)); 159.24 (COMe).

(1*E*,3*Z*)-6-*tert*-Butyldimethylsilyloxy-4-methyl-1-phenylhexa-1,3-diene (4a). ***A***. A solution of dienol **8a** (180 mg, 0.61 mmol) in THF (5 mL) was added dropwise to a vigorously stirred suspension of $Py \cdot SO_3$ (159 mg, 1 mmol) in THF (10 mL) at –15 °C. The reaction mixture was heated to 0 °C and stirred at this temperature for 2.5 h, then cooled to –10 °C, followed by a dropwise addition of a solution of $LiAlH_4$ (3.4 mmol) in THF (2 mL), then the mixture was slowly heated to ~20 °C and stirred at this temperature for 20 h. The mixture again was cooled to –10 °C, followed by sequential dropwise addition of water (0.12 mL), 15% aqueous NaOH (0.12 mL), and water (0.36 mL). A precipitate formed was filtered off and thoroughly washed with TBME.

The residue after usual treatment of the filtrate was subjected to chromatography on SiO_2 (20 g). The gradient elution from benzene to TBME (to 10% of the latter) yielded a mixture of dienes **4a**, **9a**, and **10a** (100 mg, 59%) in the ratio 89 : 8 : 3 (^{1}H NMR spectroscopic data). Analytically pure diene **4a** was isolated by HPLC, R_f 0.63 (10% TBME in hexane). HRMS (*m/z*), found: 303.2116 $[M + H]^+$; 325.1939 $[M + Na]^+$; 341.1696 $[M + K]^+$. $C_{19}H_{30}OSi$. Calculated: 303.2139 $[M + H]^+$; 325.1958 $[M + Na]^+$; 341.1696 $[M + K]^+$. UV, λ_{max}/nm (ε): 297 (24470), 316.5 (17180). IR, ν/cm^{-1}: 3080, 3060, 3028, 2960, 2932, 2856, 1684, 1640, 1596, 1496, 1472, 1464, 1436, 1384, 1360, 1256, 1096, 1008, 960, 912, 872, 836, 776, 748, 692, 664. ^{1}H NMR, δ: 0.08 (s, 6 H, Me_2Si); 0.91 (s, 9 H, Bu^t); 1.89 (s, 3 H, MeC(4)); 2.53 (t, 2 H, $H_2C(5)$, J = 7.1 Hz); 3.74 (t, 2 H, $H_2C(6)$, J = 7.1 Hz); 6.09 (d, 1 H, HC(3), J = 10.9 Hz); 6.45 (d, 1 H, HC(1), J = 15.45 Hz); 7.02 (dd, 1 H, HC(2), J_1 = 10.9 Hz, J_2 = 15.45 Hz); 7.30 (m, 5 H, Ph). ^{13}C NMR, δ: −5.30 (Me_2Si); 18.33 ($Me_3\underline{C}$); 24.72 (MeC(4)); 25.93 ($\underline{Me}_3C$); 36.35 (C(5)); 61.97 (C(6)); 125.42 (C(2)); 126.09 (C(3)); 126.94, 127.36, 128.49 (Ar); 130.14 (C(1)); 136.95 (C(4)); 137.95 (Ar).

B. A solution of BuLi (2.8 mL, 4.76 mmol) in hexane and after 10 min a solution of TsCl (0.95 g, 5 mmol) in HMPA (5 mL) were sequentially added to a vigorously stirred solution of dienol **8a** (1.20 g, 4.08 mmol) in the mixture of Et_2O (30 mL) and HMPA (5 mL) at 0 °C (Ar). The reaction mixture was stirred for 2.5 h at 0 °C, then cooled to −15 °C, followed by a dropwise addition of a solution of $LiAlH_4$ (20.4 mmol) in THF (12 mL). The mixture was slowly heated to ~20 °C and stirred at this temperature for 20 h. Then, the mixture was again cooled to −15 °C, followed by a sequential dropwise addition of H_2O (0.8 mL), 15% aq. NaOH (0.8 mL), and H_2O (2.4 mL). A precipitate formed was filtered off, thoroughly washed with TBME. The residue (1.30 g) after usual treatment of the filtrate was subjected to chromatography on SiO_2 (50 g). The gradient elution from hexane to benzene (to 40% of the latter) yielded a mixture of dienes **4a** and **11a** (0.6 g, 52%) in the ratio 3 : 1 (^{1}H NMR spectroscopic data).

(1*E*,3*Z*)-6-*tert*-Butyldimethylsilyloxy-4-methyl-1-(4-methoxyphenyl)hexa-1,3-diene (4b). A mixture of dienes **4b**, **9b**, and **10b** (52% yield) in the ratio 10 : 4 : 1 (^{1}H NMR spectroscopic data) was obtained by dehydroxylation of dienol **8b** by method ***A*** similarly to the described above for dienol **8a**. Dehydroxylation of dienol **8b** by method ***B*** and flash-chromatography of the reaction products led to the isolation of pure (NMR data) diene **4b** in 58% yield as colorless light oil with b.p. 150 °C (0.1 Torr) (bath). Found (%): C, 71.99; H, 9.73; Si, 8,45. $C_{20}H_{32}O_2Si$. Calculated (%): C, 72.23; H, 9.70; Si, 8.45. UV, λ_{max}/nm (ε): 226 (10600), 304 (33200). IR, ν/cm^{-1}: 3032, 2952, 2928, 2856, 1640, 1604, 1512, 1470, 1450, 1440, 1400, 1384, 1304, 1288, 1256, 1176, 1096, 1040, 1008, 960, 912, 836, 824, 812, 792, 776, 750, 664. ^{1}H NMR, δ: 0.09 (s, 6 H, Me_2Si); 0.92 (s, 9 H, Bu^t); 1.87 (s, 3 H, $CH_3C(4)$); 2.52 (t, 2 H, $H_2C(5)$, J = 7.2 Hz); 3.74 (t, 2 H, $H_2C(6)$, J = 7.2 Hz); 3.82 (s, 3 H, MeO); 6.06 (d, 1 H, HC(3), J = 10.8 Hz); 6.40 (d, 1 H, HC(6), J = 15.3 Hz); 6.86 (d, 2 H, Ar, J = 8.7 Hz); 6.88 (dd, 1 H, HC(2), J_1 = 10.8 Hz, J_2 = 15.3 Hz); 7.34 (d, 2 H, Ar, J = 8.7 Hz). ^{13}C NMR, δ: −5.27 (Me_2Si); 18.37 ($\underline{C}Me_3$); 24.64 ($\underline{C}H_3C(4)$); 25.96 ($\underline{Me}_3C$); 36.40 (C(5)); 55.28 (CH_3O); 62.02 (C(6)); 114.04 (Ar); 123.56 (C(2)); 127.27 (Ar); 127.49 (C(3)); 129.75 (C(1)); 130.89 (Ar); 135.64 (C(4)); 158.87 ($\underline{C}OMe$). MS, *m/z* (I_{rel} (%)): 332 $[M]^+$ (95), 334 (11), 277 (18), 276 (100), 260 (22), 245 (14), 230 (11), 215 (10), 212 (15), 211 (51), 201 (47), 200 (47), 199 (43), 189 (15), 188 (58), 184 (15), 173 (19), 172 (52), 169 (16), 165 (26), 159 (56), 158 (47), 145 (26), 159 (55), 158 (47), 145 (26), 141 (25), 138 (19), 121 (22), 89 (12), 75 (22), 73 (40).

(1*E*,3*Z*)-6-(4-Methoxybenzyloxy)-4-methyl-1-phenylhexa-1,3-diene (4c). Dehydroxylation of dienol **8c** by method ***A*** similarly to that described above for dienols **8a,b** gave diene **4c** in 55% yield, the total admixtures of dienes **9c** and **10c** in which did not exceed 3% (^{1}H NMR spectroscopic data). Dehydroxylation of diene **4c** by method ***B*** gave a mixture of dienes **4c** and **11c** in 62% yield in the ratio 96 : 4 (^{1}H NMR spectroscopic data). Analytically pure diene **4c** was isolated by flash-chromatography as colorless oil, which crystallizes on standing in refrigerator; m.p. 25—27 °C. HRMS (*m/z*), found: 309.1847 $[M + H]^+$; 326.2111 $[M + NH_4]^+$; 331.1666 $[M + Na]^+$; 347.1419 $[M + K]^+$. $C_{21}H_{24}O_2$. Calculated: 309.1849 $[M + H]^+$; 326.2115 $[M + NH_4]^+$; 331.1669 $[M + Na]^+$; 347.1408 $[M + K]^+$. UV, λ_{max}/nm (ε): 234 (21560), 301 (32030). IR, ν/cm^{-1}: 3028, 3000, 2960, 2936, 2904, 2852, 1640, 1616, 1596, 1516, 1464, 1452, 1360, 1348, 1304, 1248, 1172, 1096, 1036, 960, 820, 748, 692. ^{1}H NMR, δ: 1.88 (s, 3 H, MeC(4)); 2.61 (t, 2 H, $H_2C(5)$, J = 7.1 Hz); 3.58 (t, 2 H, $H_2C(6)$, J = 7.1 Hz); 3.80 (s, 3 H, MeO); 4.49 (s, 2 H, CH_2Ph); 6.09 (d, 1 H, HC(3), J = 11.0 Hz); 6.46 (d, 1 H, HC(1), J = 15.4 Hz); 6.86 (d, 2 H, Ar, J = 8.7 Hz); 7.02 (dd, 1 H, HC(2), J_1 = 11.0 Hz, J_2 = 15.4 Hz); 7.35 (m, 7 H, Ar). ^{13}C NMR, δ: 24.54 (MeC(4)); 33.21 (C(5)); 55.26 (MeO); 68.60 (C(6)); 72.63 (CH_2Ph); 113.81 (Ar); 125.30 (C(2)); 126.21 (Ar); 127.05 (C(3)); 128.55, 129.17 (Ar); 130.46 (C(1)); 136.82 (C(4)); 137.99 (Ar); 159.17 ($\underline{C}OMe$).

(1*E*,3*Z*)-6-(4-Methoxybenzyloxy)-1-(4-methoxyphenyl)-4-methylhexa-1,3-diene (4d). Dehydroxylation of dienol **8d** by method ***A*** similarly to that described for dienols **8a—c** gave a mixture of dienes **4d**, **9d**, and **10d** in ~50% yield in the ratio ~10 : 5 : 1. Dehydroxylation of dienol **8d** by method ***B*** gave diene **4d** containing ~8% of *E*,*E*-isomer **11d**. Analytically pure **4c** was isolated by flash-chromatography as colorless viscous oil with R_f 0.60 (system *1*). HRMS (*m/z*), found: 339.1956 $[M + H]^+$; 356.2219 $[M + NH_4]^+$; 361.1771 $[M + Na]^+$. $C_{22}H_{26}O_3$. Calculated: 339.1955 $[M + H]^+$; 356.2220 $[M + NH_4]^+$; 361.1774 $[M + Na]^+$. UV, λ_{max}/nm (ε): 228 (22000), 303 (45300). IR, ν/cm^{-1}: 3028, 3000, 2952, 2836, 1748, 1684, 1652, 1604, 1584, 1508, 1484, 1456, 1440, 1420, 1360, 1300, 1248, 1176, 1096, 1036, 960, 848, 816, 756, 668. ^{1}H NMR, δ: 1.89 (s, 3 H, MeC(4)); 2.62 (t, 2 H, $H_2C(5)$, J = 7.2 Hz); 3.59 (t, 2 H, $H_2C(6)$, J = 7.2 Hz); 3.80, 3.83 (both s, 3 H each, MeO); 4.50 (s, 2 H, $C\underline{H}_2Ph$); 6.05 (d, 1 H, HC(3), J = 10.9 Hz); 6.43 (d, 1 H, HC(1), J = 15.4 Hz); 6.88 (d, 4 H, Ar, J = 8.4 Hz); 6.90 (dd, 1 H, HC(2), J_1 = 10.9 Hz, J_2 = 15.4 Hz); 7.30 (d, 2 H, Ar, J = 8.3 Hz); 7.34 (d, 2 H, Ar, J = 8.3 Hz). ^{13}C NMR, δ: 24.35 (MeC(4)); 33.05 (C(5)); 55.12, 55.15 (MeO); 68.50 (C(6)); 72.48 ($\underline{C}H_2Ph$); 113.68, 113.94 (Ar); 123.28 (C(2)); 127.24, 127.42 (Ar); 129.05 (C(3)); 129.90 (C(1)); 130.47, 130.71 (Ar); 135.33 (C(4)); 158.22, 159.05 ($\underline{C}OMe$).

(3*Z*,5*E*)-3-Methyl-6-phenylhexa-3,5-dien-1-ol (3a). ***A.*** A solution of Bu_4NF in THF (1 *M*, 2 mL) was added to a solution of diene **4a** (0.15 g, 0.496 mmol) in THF (10 mL) and the mixture was stirred for 50 min at ~20 °C (TLC monitoring). Then, H_2O (5 mL) was added to the mixture, which was extracted with TBME. After usual treatment of combined extracts, the residue was subjected to chromatography on SiO_2 (10 g). The gradient elution from hexane to TBME (to 60% of the latter) gives pure (NMR data) dienol **3a** in 80% yield, physico-chem-

ical parameters agree with those for the samples described earlier.[10,15]

B. *N,N*-Dimethylaniline (1.51 mL, 11.92 mmol) and anhydrous $AlCl_3$ (1.19 g, 8.94 mmol) were sequentially added to a vigorously stirred solution of diene **4c** (0.9 g, 2.98 mmol) in CH_2Cl_2 (14 mL) at 0 °C (Ar). The reaction mixture was stirred for 1 h, followed by a dropwise addition of dilute (1 : 10) HCl (25 mL), the layers formed were separated after 10 min. The aqueous layer was extracted with CH_2Cl_2 (3×15 mL). The residue after usual treatment of combined extracts contained a mixture of dienol **3a** and its isomer (*E*,*E*)-**11a** in the ratio ~97 : 3 (^{1}H NMR spectroscopic data). Flash-chromatography of this mixture on SiO_2 (25 g) with the gradient elution from hexane to TBME (to 60% of the latter) gives analytically pure (NMR data) dienol **3a** in 81% yield, physico-chemical parameters agree with those described above.

(3*Z*,5*E*)-6-(4-Methoxyphenyl)-3-methylhexa-3,5-dien-1-ol (3b) was obtained similarly to dienol **3a** from diene **4b** by method ***A***. The yield after flash-chromatography was 80%, physico-chemical parameters agree with those for the samples described earlier.[10] Deprotection of diene **4d** by method ***B*** similarly to that described above for diene **4a** gave a mixture of dienol **3b** and its (3*E*,5*E*)-isomer in the ratio 4 : 1 (^{1}H NMR spectroscopic data).

(3*Z*,5*E*)-3-Methyl-6-phenylhexa-3,5-dienal (12a). The oxidant IBX (**14**)[19,20] (867 mg, 3.12 mmol) was added in one portion to a stirred solution of dienol **3a** (387 mg, 2.06 mmol) in DMF (15 mL) at ~20 °C under argon and with protection from light and the mixture was stirred for 2 h (TLC monitoring), followed by addition of TBME (50 mL). The mixture was filtered through SiO_2 (10 g) and the adsorbent was washed with TBME (75 mL). Combined filtrates were washed with saturated aq. Na_2SO_4 (3×50 mL), dried with anhydrous Na_2SO_4, concentrated on a rotary evaporator, dried in vacuum at 1 Torr at ~20 °C until the weight was constant to obtain dienal **12a** (390 mg, ~100%) as a light yellow light oil; the admixture of (*E*,*E*)-isomer in the sample formed did not exceed 1—2% (^{1}H NMR spectroscopic data). Dienal **12a** is unstable on heating. HRMS (*m*/*z*), found: 209.0941 $[M + Na]^+$. $C_{13}H_{14}O$. Calculated: 209.0937 $[M + Na]^+$. UV, λ_{max}/nm (ε): 297 (25960), 317 (20150). IR, ν/cm^{-1}: 3028, 2968, 2924, 2852, 2728, 2368, 2328, 1720, 1668, 1616, 1596, 1496, 1448, 1436, 1384, 1356, 1300, 1208, 1124, 1072, 1048, 1016, 960, 748, 692. ^{1}H NMR, δ: 1.94 (s, 3 H, MeC(3)); 3.37 (d, 2 H, H_2C(2), J = 2.35 Hz); 6.31 (d, 1 H, HC(4), J = 10.9 Hz); 6.56 (d, 1 H, HC(6), J = 15.4 Hz); 6.90 (dd, 1 H, HC(5), J_1 = 10.9 Hz, J_2 = 15.4 Hz); 7.38 (m, 5 H, Ph); 9.66 (t, 1 H, HC(1), J = 2.35 Hz). ^{13}C NMR, δ: 24.88 (MeC(3)); 47.80 (C(2)); 123.93 (C(5)); 126.27, 127.49, 128.55 (Ar); 129.06 (C(3)); 129.99 (C(4)); 132.46 (C(6)); 137.28 (Ar); 198.38 (C(1)).

(3*Z*,5*E*)-6-(4-Methoxyphenyl)-3-methylhexa-3,5-dienal (12b) was obtained similarly to dienal **12a** from dienol **3b**, the yield was ~100%, R_f 0.55 (system *1*). ^{1}H NMR, δ: 1.92 (s, 3 H, MeC(3)); 3.35 (d, 2 H, H_2C(2), J = 2.2 Hz); 3.83 (s, 3 H, MeO); 6.28 (d, 1 H, HC(4), J = 10.9 Hz); 6.50 (d, 1 H, HC(6), J = 15.5 Hz); 6.76 (dd, 1 H, HC(5), J_1 = 10.9 Hz, J_2 = 15.5 Hz); 6.87 (d, 2 H, Ar, J = 8.7 Hz); 7.34 (d, 2 H, Ar, J = 8.7 Hz); 9.65 (t, 1 H, HC(1), J = 2.2 Hz). ^{13}C NMR, δ: 24.90 (MeC(3)); 47.89 (C(2)); 55.29 (MeO); 114.13 (Ar); 122.06 (C(5)); 127.57, 127.76 (Ar); 130.19 (C(4)); 130.24 (C(3)); 130.99 (C(6)); 159.31 (COMe); 198.61 (C(1)). Unstable dienal **12b** was immediately used in subsequent oxidation.

(2*E*,4*E*)-6-Ethoxy-6-(4-methoxyphenyl)-3-methylhexa-2,4-dienal (15). A solution of freshly prepared dienal **12b** (0.11 g, 0.5 mmol) in 95% aq. EtOH (5 mL) was added to a stirred solution of $AgNO_3$ (0.17 g, 1 mmol) in H_2O (0.5 mL) at ~20 °C. The reaction mixture was cooled to −15 °C, followed by a dropwise addition of a solution of KOH (56 mg, 1 mmol) in H_2O (2 mL). A suspension formed was stirred for 30 h at ~20 °C, a precipitate formed was filtered off, a solution of KOH (0.5 *M*) was added to the filtrate to pH 9, and a suspension formed was again filtered off. The filtrate was diluted with H_2O (7 mL) and extracted with TBME (3×7 mL). The aqueous layer was acidified with dilute (1 : 4) HCl to pH 2 and extracted with TBME (3×10 mL). Usual treatment of combined extracts from the acidic solution gave a complex mixture (10 mg) of the reaction products (^{1}H NMR spectroscopic data), which was discarded. Usual treatment of combined extracts from the alkaline solution and chromatography of the residue (94 mg) on SiO_2 (5 g) with the gradient elution from hexane to TBME (to 50% of the latter) yielded dienal **15** (33 mg) containing ~12% of (2*Z*)-isomer (^{1}H NMR spectroscopic data). Dienal **15**, HRMS (*m*/*z*), found: 283.1277 $[M + Na]^+$. $C_{16}H_{20}O_3$. Calculated: 283.1305 $[M + Na]^+$. UV, λ_{max}/nm (ε): 226 (12100), 278 (15130). ^{1}H NMR, δ: 1.23 (t, 3 H, $CH_2C\underline{H}_3$, J = 7.0 Hz); 2.24 (s, 3 H, MeC(3)); 3.46 (m, 2 H, $C\underline{H}_2CH_3$); 3.81 (s, MeO); 4.86 (d, 1 H, HC(6), J = 4.9 Hz); 5.96 (d, 1 H, HC(2), J = 8.1 Hz); 6.35 (dd, 1 H, HC(5), J_1 = 15.1 Hz, J_2 = 4.9 Hz); 6.42 (d, 1 H, HC(4), J = 15.1 Hz); 6.91 (d, 2 H, Ar, J = 8.7 Hz); 7.26 (d, 2 H, Ar, J = 8.7 Hz); 10.10 (d, 1 H, HC(1), J = 8.1 Hz). ^{13}C NMR, δ: 13.09 ($\underline{C}H_3CH_2$); 15.24 (MeC(3)); 55.28 (MeO); 64.05 ($CH_3\underline{C}H_2$); 81.45 (C(6)); 114.11, 128.18 (Ar); 129.95, 133.03 (C(2), C(5)); 138.60 (C(4)); 153.87 (C(3)); 159.45 (COMe); 191.34 (C(1)).

(3*Z*,5*E*)-3-Methyl-6-phenylhexa-3,5-dienoic acid (13a). Dimethyl sulfoxide (11 mL) and a solution of $NaH_2PO_4 \cdot 2\,H_2O$ (839 mg, 5.38 mmol) in H_2O (6.64 mL) were sequentially added to a solution of freshly prepared dienal **12a** (360 mg, 1.93 mmol) in THF (13 mL). The mixture was cooled to 0 °C, followed by a dropwise addition of $NaClO_2$ (318.6 mg, 5.52 mmol) solution in H_2O (6.64 mL), and the mixture was stirred for 2.5 h at 0 °C (TLC monitoring) with protection from light. After addition of TBME (100 mL), the layers were separated. The organic layer was extracted with 10% aq NaOH (2×50 mL). The combined alkaline extracts were acidified at 0 °C with dilute (1 : 3) HCl to pH 2, then, they were extracted with TBME (3×50 mL). Usual treatment of combined extracts yielded acid **13a** (264 mg, 69%) containing less than 2% of (*E*,*E*)-isomer (^{1}H NMR spectroscopic data). Acid **13a** is a light yellow crystalline compound, m.p. 105—107 °C (from hexane—TBME (3 : 1)); R_f 0.48 (system *1*), 0.42 (hexane—acetone (3 : 1)). HRMS (*m*/*z*), found: 225.0882 $[M + Na]^+$. $C_{13}H_{14}O_2$. Calculated: 225.0886 $[M + Na]^+$. UV, λ_{max}/nm (ε): 301.4 (44190). IR, ν/cm^{-1}: 3028, 3012, 2968, 2924, 2900,2400, 1708, 1596, 1540, 1520, 1492, 1448, 1412, 1296, 1228, 964, 928, 800, 692, 624. ^{1}H NMR, δ: 2.01 (s, 3 H, MeC(3)); 3.33 (s, 2 H, H_2C(2)); 6.22 (d, 1 H, HC(4), J = 10.8 Hz); 6.54 (d, 1 H, HC(6), J = 15.4 Hz); 6.95 (dd, 1 H, HC(5), J_1 = 10.8 Hz, J_2 = 15.4 Hz); 7.32 (m, 5 H, Ph). ^{13}C NMR, δ: 24.55 (MeC(3)); 37.92 (C(2)); 124.28 (C(5)); 126.39; 127.48, 128.60 (Ar); 129.48 (C(4)); 130.67 (C(3)); 132.34 (C(6)); 137.49 (COMe); 177.24 (C(1)).

(3*Z*,5*E*)-6-(4-Methoxyphenyl)-3-methylhexa-3,5-dienoic acid (13b) was obtained similarly to acid **13a** from dienal **12b**, the yield was 45%, the content of (*E*,*E*)-isomer in the sample

was <3% (^{1}H NMR spectroscopic data), R_f 0.62 (system *1*), 0.42 (system *2*). HRMS (*m/z*), found: 233.1172 $[M + H]^+$; 255.0997 $[M + Na]^+$. $C_{14}H_{16}O_3$. Calculated: 233.1175 $[M + H]^+$; 255.0992 $[M + Na]^+$. UV, λ_{max}/nm (ε): 201 (13000), 297 (23000). IR, ν/cm^{-1}: 3028, 3012, 2936, 2840, 2400, 1708, 1604, 1576, 1508, 1464, 1440, 1420, 1304 1248, 1228, 1176, 1032, 964, 932, 848, 800, 676, 624. ^{1}H NMR, δ: 1.96 (s, 3 H, MeC(3)); 3.32 (s, 2 H, H_2C(2)); 3.82 (MeO); 6.19 (d, 1 H, HC(4), J = 10.0 Hz); 6.49 (d, 1 H, HC(6), J = 15.2 Hz); 6.82 (dd, 1 H, HC(5), J_1 = 10.0 Hz, J_2 = 15.2 Hz); 6.86 (d, 2 H, Ar, J = 10.3 Hz); 7.30 (d, 2 H, Ar, J = 10.3 Hz). ^{13}C NMR, δ: 24.48 (MeC(3)); 37.84 (C(2)); 55.29 (MeO); 114.08 (Ar); 122.33 (C(5)); 127.58 (Ar); 129.63 (C(3)); 129.82 (C(4)); 131.91 (C(6)); 159.20 (COMe); 177.28 (C(1)).

Methyl (3*Z*,5*E*)-3-methyl-6-phenylhexa-3,5-dienoate (2a) was obtained by treatment of acid **13a** with an ethereal solution of CH_2N_2 at 0 °C according to the standard procedure. The yield was ~100%, stereochemical purity was 98% (^{1}H NMR spectroscopic data), light yellow viscous oil solidified at −18 °C; R_f 0.57 (system *1*), 0.55 (hexane—acetone, 3 : 1). HRMS (*m/z*), found: 239.1041 $[M + Na]^+$. $C_{14}H_{16}O_2$. Calculated: 239.1043 $[M + Na]^+$. UV, λ_{max}/nm (ε): 308.5 (33750). IR, ν/cm^{-1}: 3028, 2952, 2916, 2848, 2328, 1732, 1644, 1596, 1520, 1492, 1448, 1436, 1328, 1256, 1192, 1164, 1108, 1028, 1008, 960, 876, 748, 692. ^{1}H NMR, δ: 1.96 (s, 3 H, MeC(3)); 3.31 (s, 2 H, H_2C(2)); 3.72 (s, 3 H, COOMe); 6.20 (d, 1 H, HC(4), J = 10.9 Hz); 6.53 (d, 1 H, HC(6), J = 15.4 Hz); 6.98 (dd, 1 H, HC(5), J_1 = 10.9 Hz, J_2 = 15.4 Hz); 7.30 (m, 5 H, Ph). ^{13}C NMR, δ: 24.51 (MeC(3)); 38.04 (C(2)); 51.96 (OMe); 124.49 (C(5)); 126.33, 127.39, 128.58 (Ar); 129.02 (C(4)); 131.37 (C(3)); 132.00 (C(6)); 137.60 (Ar); 171.39 (C(1)).

Methyl (3*Z*,5*E*)-6-(4-methoxyphenyl)-3-methylhexa-3,5-dienoate (2b) was obtained by treatment of acid **13b** with an ethereal solution of CH_2N_2 at 0 °C according to the standard procedure. The yield was ~100%, stereochemical purity was >98%, R_f 0.53 (system *1*). HRMS (*m/z*), found: 247.1334 $[M + H]^+$; 269.1151 $[M + Na]^+$; 285.0901 $[M + K]^+$. $C_{15}H_{18}O_3$. Calculated: 247.1340 $[M + H]^+$; 269.1159 $[M + Na]^+$; 285.0898 $[M + K]^+$. UV, λ_{max}/nm (ε): 213 (46700), 297 (48000). IR, ν/cm^{-1}: 3015, 2968, 2840, 1760, 1732, 1720, 1640, 1604, 1572, 1508, 1460, 1440, 1380, 1364, 1320, 1304, 1280, 1252, 1192, 1176, 1160, 1112, 1032, 996, 972, 820, 748. ^{1}H NMR, δ: 1.94 (s, 3 H, MeC(3)); 3.29 (s, 2 H, H_2C(2)); 3.72, 3.82 (both s, 3 H each, MeO); 6.16 (d, 1 H, HC(4), J = 10.3 Hz); 6.18 (d, 1 H, HC(6), J = 15.4 Hz); 6.83 (dd, 1 H, HC(5), J_1 = 10.3 Hz, J_2 = 15.4 Hz); 6.87 (d, 2 H, Ar, J = 8.7 Hz); 7.36 (d, 2 H, Ar, J = 8.7 Hz). ^{13}C NMR, δ: 24.41 (MeC(3)); 37.98 (C(2)); 51.89, 55.25 (OMe); 114.04 (Ar); 122.52 (C(5)); 127.49 (Ar); 129.18 (C(4)); 130.03 (C(3)); 131.51 (C(6)); 159.13 (COMe); 171.47 (C(1)).

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