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Dedicated to Full Member of the Russian Academy of Sciences N.S. Zefirov on His 70th Anniversary

Stereochemistry of Hydride Reduction of 20-Hydroxyecdysone Derivatives

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Abstract—The 6-oxo group in 2,3:20,22-di-*O*-isopropylidene derivatives of 20-hydroxyecdysone and its 24,25/25,26-anhydro analog is reduced with $NaBH_4$–$CeCl_3$ in a stereoselective fashion to afford the corresponding 6α-alcohols. In the first case, the reaction is accompanied by dehydration to give Δ^{14}-bond. Reduction of the same substrates with $NaBH_4$ or $LiAlH_4$ in the absence of $CeCl_3$ leads to mixtures of 6α- and 6β-hydroxy derivatives, the latter prevailing. In all cases, epimerization at C^5 occurs.

Compounds of the ecdysteroid series were subjected most frequently to transformations of the side-chain hydroxy groups and those located in the A ring. The reactivity of the Δ^7-6-oxo group in ecdysteroids was poorly studied. For example, it is known that the carbonyl group in the B ring can be reduced with metal hydrides; however, the stereochemistry of this reaction was not studied [1]. Reduction of the 6-oxo group in ecdysteroids to 6-hydroxy may be used in the synthesis of compounds possessing various kinds of biological activity, as well as a method for protection of the 6-oxo group while performing synthetic transformations in the side chain (the subsequent oxidation of the allylic 6-OH group could restore the Δ^7-6-oxo fragment) [2].

We studied transformations of 20-hydroxyecdysone derivatives by the action of complex alkali metal hydrides. Treatment of 2,3:20,22-di-*O*-isopropylidene-20-hydroxyecdysone (**I**) with sodium tetrahydridoborate in the presence of cerium chloride in methanol at –5°C, following the procedure described in [3, 4], resulted in stereoselective reduction of the 6-oxo group to give the corresponding 6α-hydroxy derivative. The reduction was accompanied by dehydration at the 14α-hydroxy group, and the product was 14,15-anhydro-6α-hydroxy steroid **II** (Scheme 1) whose structure was confirmed by spectral data.

The formation of Δ^{14}-bond follows from the presence in the ^{13}C NMR spectrum of **II** of a singlet at δ_C 134.6 ppm and a doublet at δ_C 122.2 ppm (JMOD technique), which belong, respectively, to the sp^2-hybridized C^{14} and C^{15} atoms. The C^6 signal of initial ketone **I** (δ_C 203 ppm, singlet) [5] disappeared, but a new signal appeared at δ_C 66.7 ppm as a doublet, unambiguously indicating transformation of the 6-carbonyl group into hydroxy. Loss of conjugation with carbonyl group leads to an appreciable upfield shift of the C^8 signal of **II** ($\Delta\delta_C$ 15.3 ppm). The presence of only one signal from C^6 in the ^{13}C NMR spectrum and from the 6-H proton (δ 4.60 ppm) in the ^1H NMR spectrum suggests that the product is a single diastereoisomer; in keeping with the data of [4], alcohol **II** is 6α-epimer. Unlike $NaBH_4$–$CeCl_3$, the reduction of **I** with the system $LiAlH_4$–$CeCl_3$ was not selective, and a complex mixture of products was obtained.

No dehydration occurred in the reduction of diacetonide **I** with $NaBH_4$ or $LiAlH_4$ in the absence of cerium chloride. In these cases, we obtained a mixture of 6α- and 6β-epimeric alcohols **III**, the 6β-epimer prevailing (6α:6β ≈ 1:2, according to the 6-H signal intensities in the ^1H NMR spectrum; δ 4.57 ppm for 6α-epimer and δ 3.77 ppm for 6β-epimer) (cf. [4]). Pure stereoisomers **IIIa** (6α) and **IIIb** (6β) were

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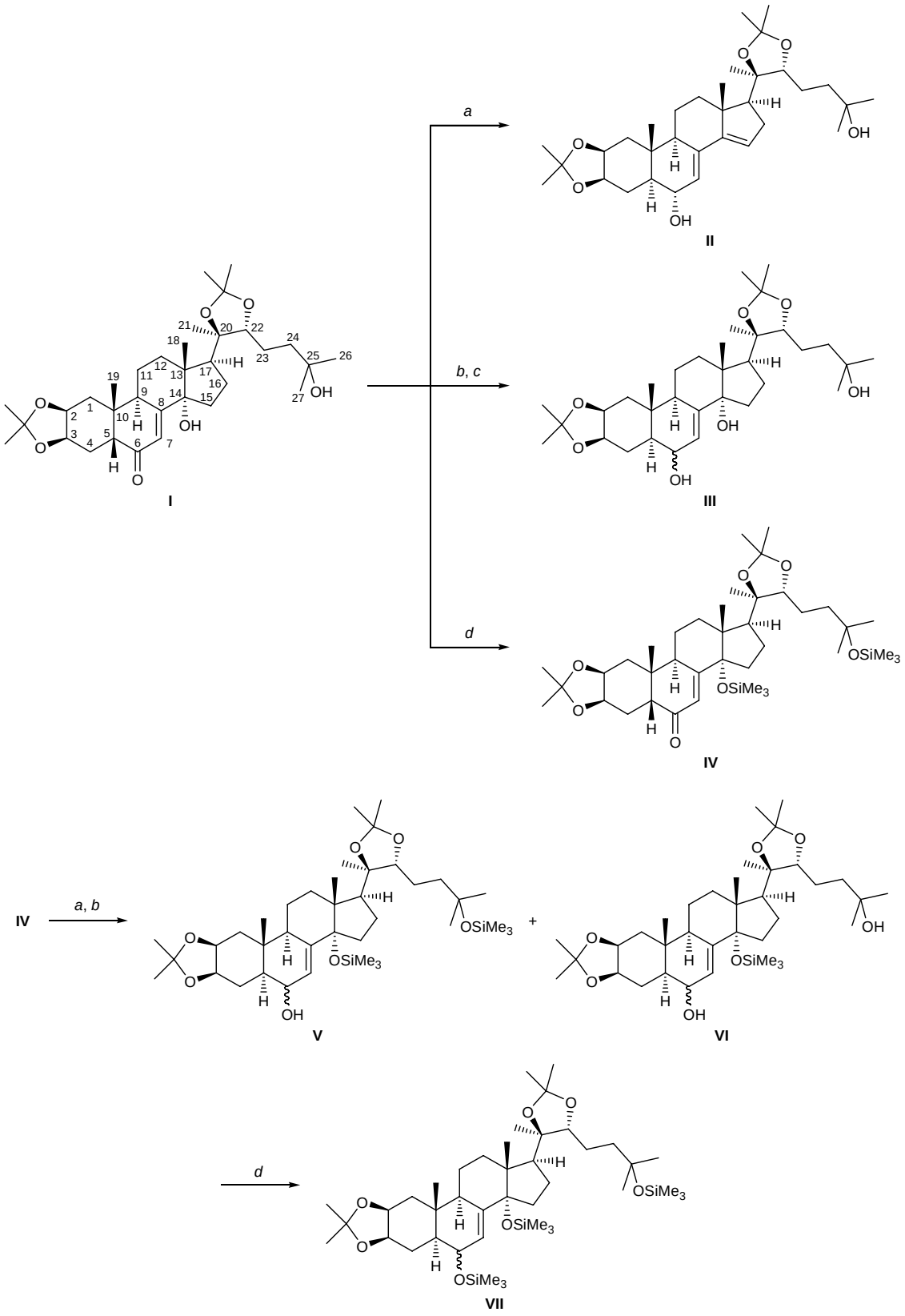
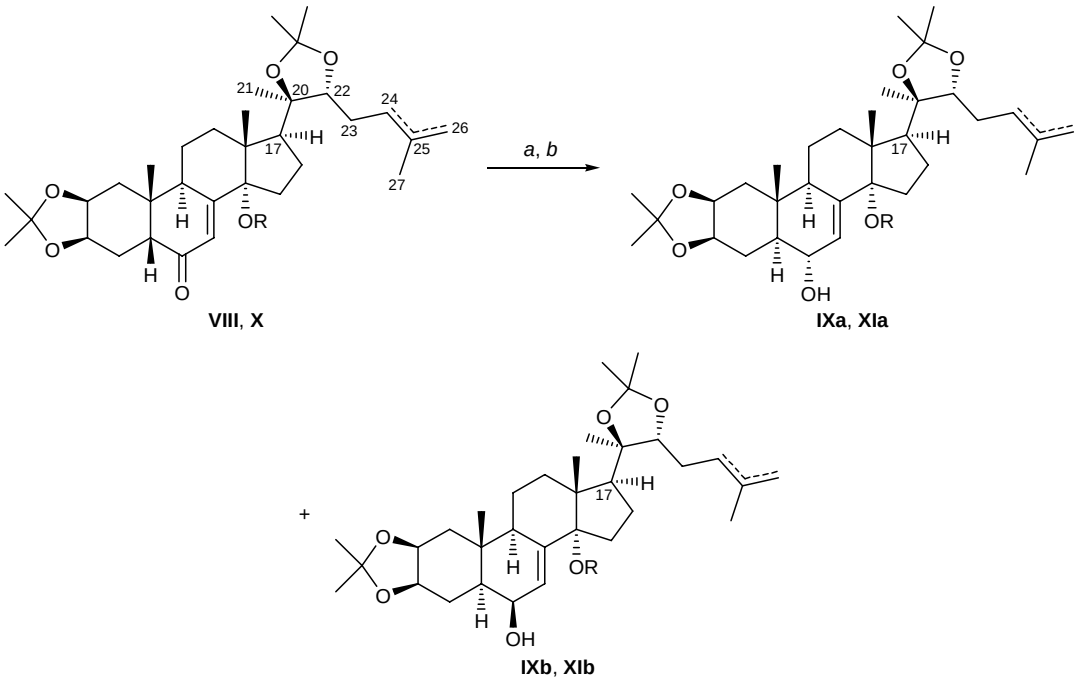
Scheme 1.



a: $NaBH_4/CeCl_3$; *b*: $LiAlH_4$; *c*: $NaBH_4$/MeOH; *d*: $Me_3SiCF_3/Bu_4N^+F^-$.

Scheme 2.



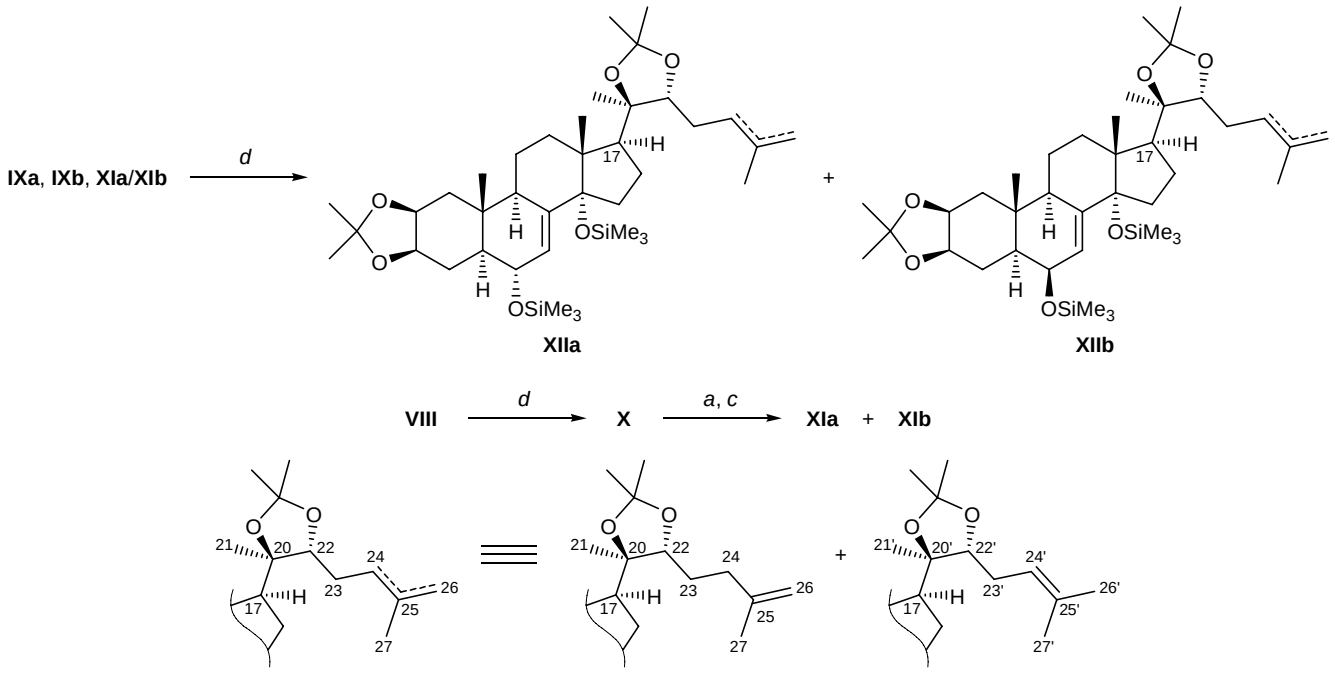
VIII, **IX**, R = H; **X**, **XI**, R = $SiMe_3$.

isolated by column chromatography. Apart from the difference in the position of the 6-H signals, the ^{1}H NMR spectra of alcohols **IIIa** and **IIIb** revealed considerable differences in the positions of signals from the 7-H, 9-H, and $C^{19}H_3$ protons. The hydroxy group in 6β-epimer **IIIb** exerts a deshielding effect on the vinylic 7-H proton and protons in the $C^{19}H_3$ group; therefore, their signals are displaced downfield relative to the corresponding signals of 6α-epimer **IIIa** ($\Delta\delta$ = 0.25 and 0.16 ppm, respectively). By contrast, the 9-H proton in 6α-epimer **IIIa** is deshielded to a stronger extent ($\Delta\delta$ = 0.12 ppm). The most appreciable differences in the ^{13}C NMR spectra of epimers **IIIa** and **IIIb** were observed in the positions of the C^5, C^6, and C^8 signals which appeared in a weaker field for 6β-epimer **IIIb** ($\Delta\delta_C$ = 1.4, 3.8, and 1.2 ppm, respectively); the C^7 signal of the latter was located in a stronger field ($\Delta\delta_C$ = 2.0 ppm).

No stereoselectivity in the reduction of the 6-oxo group was observed when the hydroxy groups on C^{14} and C^{25} in **I** were protected by silylation. Treatment of 14,25-bis(trimethylsilyl) ether **IV** with $NaBH_4$–$CeCl_3$ gave a mixture of 6α- and 6β-hydroxy derivatives at a ratio of about 3:2 (according to the 6-H signal intensities in the ^{1}H NMR spectrum). Compound **IV** was synthesized by reaction of **I** with Me_3SiCF_3 in the presence of tetrabutylammonium fluoride (cf. [6]). The reduction of **IV** was accompanied by partial deprotection of the 25-OH group. The resulting mixture of compounds **V** and **VI** was separated by column chromatography. Stereoisomeric diols **VI** were treated with CF_3SiMe_3–$Bu_4N^+F^-$ to obtain 6,14,25-tris(trimethylsilyl) ether **VII** (6α/6β ≈ 3:2). The reduction of **IV** with $LiAlH_4$ in the absence of $CeCl_3$ afforded a mixture of 6α- and 6β-epimers **V** (the latter prevailing) with complete conservation of the protecting groups (Scheme 1).

The results obtained in the reduction of steroid **I** and its bis-silyl ether **IV** suggest that stereoselective reduction of the 6-oxo group with $NaBH_4$–$CeCl_3$ requires the presence of a free hydroxy group and an additional double bond (apart from the existing C^7=C^8 bond). Presumably, the C^{14}=C^{15} bond (which is formed by dehydration during the reduction of **I**) together with the Δ^7-bond and 25-hydroxy group create favorable conditions for stereoselective reduction of the 6-oxo group. Formation of a complex with cerium at the α-side of intermediate ensures β-orientation of hydride attack on the carbonyl group to afford 6α-alcohol. In the absence of $CeCl_3$, the reaction is not stereoselective, for hydride attack on the 6-oxo group is likely to occur preferentially from the less sterically hindered α-side, leading to predominant formation of 6β-alcohol.

Scheme 3.



We anticipated that the presence of a double bond in the side chain of the substrate together with unprotected 14α-hydroxy group should force the reaction with $NaBH_4$–$CeCl_3$ to proceed in a stereoselective fashion to give the corresponding 6α-alcohol without dehydration at the 14α-hydroxy group. In fact, the reduction of 24,25/25,26-anhydro derivatives **VIII** (which were obtained by dehydration of **I** according to [7]) with $NaBH_4$–$CeCl_3$ afforded exclusively 6α-epimeric alcohol **IXa**. Its ^1H and ^{13}C NMR spectra each contained only one signal from 6-H (δ 4.57 ppm) and C^6 (δ_C 66.4 ppm). On the other hand, the reduction of 14α-trimethylsiloxy derivative **X** with $NaBH_4$–$CeCl_3$ was not stereoselective: it resulted in formation of an equimolar mixture of 6α- and 6β-epimeric alcohols **XIa** and **XIb** (6-H: δ 4.61 and 3.82 ppm, respectively). Epimer mixture **XIa**/**XIb** was converted into a mixture of stereoisomeric bis(trimethylsilyl) ethers **XIIa**/**XIIb** (Scheme 3), and we failed to separate the latter into individual α- and β-epimers.

The reduction of trimethylsilyl ether **X** with sodium tetrahydridoborate in the absence of $CeCl_3$ gave a mixture of stereoisomeric alcohols **XIa** (6α) and **XIb** (6β), the latter prevailing. The same stereoselectivity (6α/6β ≈ 1:2) was observed in the reduction of **VIII** with $LiAlH_4$ in the absence of $CeCl_3$. In this case, the resulting mixture of epimers **IXa** and **IXb** was separated into individual components. Signals in the ^1H and ^{13}C NMR spectra of compounds **IXa** and **IXb** were assigned using homo- and heteronuclear correlation techniques.

The configuration of alcohols **IXa** and **IXb** was confirmed by the NOE spectra (Bruker DRX-500). α-Epimer **IXa** showed polarization transfer between 6-H and $C^{19}H_3$, while β-epimer **IXb** was characterized by correlation between 6-H and 9-H. In addition, we observed interaction between 5-H and 6-hydroxy proton in α-epimer **IXa** and between 5-H and 6-H in β-epimer **IXb**, while no correlation was found between 5-H and $C^{19}H_3$ in both stereoisomers. These data indicate epimerization at C^5 during the reduction of **VIII** with lithium tetrahydridoaluminate. Analogous epimerization occurred in the reduction of **VIII** with $NaBH_4$–$CeCl_3$: here, the resulting alcohol **IXa** was identical to the corresponding 6α-epimeric alcohol isolated in the reaction with $LiAlH_4$. Thus the products of hydride reduction of compound **VIII** are α-epimers at C^5, i.e., the A and B rings therein are fused *trans*.

Presumably, the other hydride reduction products, compounds **II**, **IIIa**, **IIIb**, **V**, and **VI**, also belong to the 5α-series. This follows from the chemical shift of the 9-H proton in their ^1H NMR spectra (δ 2.3–2.5 ppm); the corresponding signal of 5β-epimers is located in an appreciably weaker field (δ 2.8–3.2 ppm) [8].

Alcohols **IXa** and **IXb** were converted into the corresponding 6,14-bis(trimethylsilyl) ethers **XIIa** and **XIIb**. It should be noted that, according to the TLC data, ether **XIIb** in $CDCl_3$ undergoes complete de-

silylation of the 6-$OSiMe_3$ group in 24 h after recording the NMR spectra (analogous desilylation of **XIIa** occurs only partially under the same conditions. Crystalline epimer **XIIa** is stable, while crystalline compound **XIIb** undergoes complete transformation into **XIb** in about a month (TLC data).

EXPERIMENTAL

The IR spectra were recorded on a Specord 75IR spectrometer from samples dispersed in mineral oil. The UV spectra were measured on a Specord M-40 spectrophotometer from solutions in methanol or chloroform. The ^1H and ^{13}C NMR spectra were obtained on a Bruker AM-300 instrument at 300.13 (^1H) and 75 MHz (^{13}C) using $CDCl_3$ as solvent. Homo- and heteronuclear correlation experiments (COSY, TOCSY, ROESY, HSQC, and HBMC) were run on a Bruker DRX-500 spectrometer (500.13 MHz for ^1H and 125.76 MHz for ^{13}C) using DMSO as solvent. The chemical shifts were measured relative to tetramethylsilane as internal reference. The melting points were determined on a Boetius melting point apparatus. The specific optical rotations were measured on a Perkin–Elmer 141 polarimeter. Thin-layer chromatography was performed on silica gel (Silufol plates); spots were developed by treatment with a solution of 4-hydroxy-3-methoxybenzaldehyde in ethanol acidified with sulfuric acid.

(20*R*,22*R*)-6*α*,25-Dihydroxy-2β,3β : 20,22-bis(isopropylidenedioxy)-5*α*-cholesta-7,14-diene (II). To a solution of 0.2 g (0.36 mmol) of compound **I** (prepared according to [5], mp 233–234°C) in 2 ml of methanol we added under stirring 0.18 g (0.51 mmol) of $CeCl_3 \cdot 6H_2O$, the mixture was cooled to –5°C, and 0.03 g (0.75 mmol) of $NaBH_4$ was added in one portion. The mixture was slowly warmed up to room temperature, stirred for 2 h, and evaporated under reduced pressure. The residue was subjected to chromatography on silica gel (5 g) using $CHCl_3$–MeOH (10:1) as eluent to isolate 0.15 g (75%) of compound **II**, R_f 0.5 ($CHCl_3$–MeOH, 10:1), mp 116–118°C, $[\alpha]_D^{18}$ = –30.3° (*c* = 6.03, $CHCl_3$). IR spectrum: ν(OH) 3400 cm^{-1}. UV spectrum ($CHCl_3$): λ_{max} 287 nm (ε 1166). ^1H NMR spectrum, δ, ppm: 0.87 s (3H, $C^{18}H_3$); 0.94 s (3H, $C^{19}H_3$); 1.16 s (3H, $C^{21}H_3$); 1.20 s (6H, $C^{26}H_3$, $C^{27}H_3$); 1.27 s, 1.30 s, 1.39 s, and 1.47 s (3H each, Me_2C); 1.50–2.57 m (14H, CH, CH_2); 2.49 m (1H, 9-H, $W_{1/2}$ = 25.0 Hz); 3.71 m (1H, 22-H, $W_{1/2}$ = 13.3 Hz); 4.12 m (1H, 2-H, $W_{1/2}$ = 13.2 Hz); 4.25 m (1H, 3-H, $W_{1/2}$ = 8.3 Hz); 4.57 br.s (1H, 6-H, $W_{1/2}$ = 10.9 Hz); 5.58 br.s (1H, 15-H, $W_{1/2}$ = 7.3 Hz); 5.62 br.s (1H, 7-H, $W_{1/2}$ = 7.3 Hz). ^{13}C NMR spectrum, δ_C, ppm: 18.4 q (C^{18}); 20.7 t (C^{11}); 21.1 q (C^{21}); 22.6 t (C^4); 23.6 t (C^{23}); 23.8 q (C^{19}); 26.5 q (C^{26}); 26.7 q (C^{27}); 28.5 q, 28.8 q, 28.9 q, and 29.5 q (**Me**$_2$CO$_2$); 31.0 t (C^{12}); 36.9 s (C^{10}); 37.4 d (C^9); 39.2 t (C^{16}); 40.7 t (C^{24}); 41.2 t (C^1); 41.5 d (C^5); 47.4 s (C^{13}); 57.5 d (C^{17}); 66.7 d (C^6); 70.3 s (C^{25}); 72.2 d (C^2); 72.9 d (C^3); 81.7 d (C^{22}); 83.5 s (C^{20}); 106.8 s (20,22-Me$_2$**C**O$_2$); 107.7 s (2,3-Me$_2$**C**O$_2$); 120.2 d (C^7); 122.2 d (C^{15}); 134.6 s (C^{14}); 149.8 s (C^8).

(20*R*,22*R*)-6*α*,14*α*,25- and (20*R*,22*R*)-6β,14*α*,25-Trihydroxy-2β,3β : 20,22-bis(isopropylidenedioxy)-5*α*-cholest-7-enes IIIa and IIIb. *a*. A solution of 0.82 g (1.46 mmol) of compound **I** in 25 ml of anhydrous tetrahydrofuran was added in one portion to a suspension of 0.27 g (7 mmol) of $LiAlH_4$ in 20 ml of anhydrous THF under stirring at 0°C in an argon atmosphere. The mixture was stirred for 20 min at room temperature and for 30 min at 60°C, cooled to 0°C, and treated with 3 ml of water and 2 ml of 5% hydrochloric acid to a weakly acidic reaction. The organic phase was separated, the aqueous phase was extracted with diethyl ether (3×20 ml), and the extracts were combined with the organic phase and evaporated to obtain 0.71 g of a mixture of alcohols **IIIa** and **IIIb** (6α/6β ratio ~2:3, according to the ^1H NMR data: δ 4.57 and 3.77 ppm for 6-H in 6α- and 6β-epimer, respectively). By chromatography in a column charged with 8 g of silica gel (gradient elution with $CHCl_3$ to $CHCl_3$–MeOH, 20:1) we isolated 0.38 g (46%) of alcohol **IIIb** (R_f 0.27, $CHCl_3$–MeOH, 10:1) and 0.26 g (31%) of **IIIa** (R_f 0.25, $CHCl_3$–MeOH, 10:1).

Epimer **IIIa**. mp 134–136°C, $[\alpha]_D^{18}$ = 26.5° (*c* = 1.79, $CHCl_3$). IR spectrum: ν(OH) 3400 cm^{-1}. ^1H NMR spectrum, δ, ppm: 0.75 s (3H, $C^{18}H_3$); 0.88 s (3H, $C^{19}H_3$); 1.12 s (3H, $C^{21}H_3$); 1.21 s (6H, $C^{26}H_3$, $C^{27}H_3$); 1.30 s, 1.32 s, 1.39 s, and 1.48 s (3H each, Me_2C); 1.71–2.18 m (17H, CH, CH_2); 2.36 m (1H, 9-H, $W_{1/2}$ = 25.0 Hz); 3.65 m (1H, 22-H, $W_{1/2}$ = 11.1 Hz); 4.19 m (1H, 2-H, $W_{1/2}$ = 17.4 Hz); 4.25 m (1H, 3-H, $W_{1/2}$ = 10.1 Hz); 4.57 br.s (1H, 6-H, $W_{1/2}$ = 11.7 Hz); 5.46 br.s (1H, 7-H, $W_{1/2}$ = 4.5 Hz). ^{13}C NMR spectrum, δ_C, ppm: 17.2 q (C^{18}); 19.8 t (C^{11}); 21.4 t (C^{16}); 21.8 q (C^{21}); 22.5 t (C^{23}); 23.4 t (C^4); 24.3 q (C^{19}); 26.6 q (C^{26}); 26.8 q (C^{27}); 28.6 q, 28.9 q, 29.2 q, and 29.3 q (**Me**$_2$CO$_2$); 31.7 t (C^{12}, C^{15}); 32.1 d (C^9); 36.7 s (C^{10}); 41.4 t (C^1); 41.9 d (C^5); 46.9 s (C^{13}); 49.1 d (C^{17}); 66.3 d (C^6); 70.4 s (C^{25}); 72.2 d (C^2); 73.0 d (C^3); 82.0 d (C^{22}); 84.6 s (C^{14}); 85.2 s (C^{20}); 106.7 s (20,22-Me$_2$**C**O$_2$); 107.7 s (2,3-Me$_2$**C**O$_2$); 122.1 d (C^7); 141.9 s (C^8).

Epimer **IIIb**. mp 125–127°C, $[\alpha]_D^{24}$ = 8.4° (*c* = 2.97, $CHCl_3$). IR spectrum: ν(OH) 3400 cm^{-1}. ^1H NMR spectrum, δ, ppm: 0.75 s (3H, $C^{18}H_3$); 1.03 s (3H, $C^{19}H_3$); 1.12 s (3H, $C^{21}H_3$); 1.20 s (6H, $C^{26}H_3$, $C^{27}H_3$); 1.30 s (3H), 1.38 s (6H), and 1.48 s (3H) (Me_2C); 1.66–2.24 m (17H, CH, CH_2); 2.27 m (1H, 9-H, $W_{1/2}$ = 25.0 Hz); 3.62 m (1H, 22-H, $W_{1/2}$ = 15.5 Hz); 3.77 br.s (1H, 6-H, $W_{1/2}$ = 9.5 Hz); 4.09 m (1H, 2-H, $W_{1/2}$ = 15.3 Hz); 4.21 br.s (1H, 3-H, $W_{1/2}$ = 10.8 Hz); 5.62 br.s (1H, 7-H, $W_{1/2}$ = 8.9 Hz). ^{13}C NMR spectrum, δ_C, ppm: 17.2 q (C^{18}); 20.4 t (C^{11}); 21.2 t (C^{16}); 21.8 q (C^{21}); 23.5 t (C^{23}); 25.0 q (C^{19}); 26.5 q (C^{26}); 26.8 q (C^{27}); 28.2 t (C^4); 28.5 q, 28.9 q, 29.0 q, and 29.6 q (**Me**$_2CO_2$); 31.2 t (C^4); 31.9 t (C^{15}); 32.5 d (C^9); 34.3 s (C^{10}); 41.3 t (C^1); 43.2 d (C^5); 46.8 s (C^{13}); 49.1 d (C^{17}); 70.0 d (C^6); 70.2 s (C^{25}); 72.3 d (C^2); 72.7 d (C^3); 81.9 d (C^{22}); 84.6 s (C^{14}); 85.4 s (C^{20}); 106.6 s (20,22-Me$_2$**C**O_2); 107.8 s (2,3-Me$_2$**C**O_2); 120.0 d (C^7); 143.8 s (C^8).

b. A solution of 0.5 g (0.89 mmol) of compound **I** in 10 ml of anhydrous MeOH was cooled to –5°C, 0.2 g (4.45 mmol) of $NaBH_4$ was added under stirring, and the mixture was allowed to warm up to room temperature, stirred for 1 h, and evaporated. The residue, 0.6 g, was subjected to column chromatography on silica gel (3 g; $CHCl_3$–MeOH, 20:1) to isolate 0.3 g (62%) of a mixture of epimeric alcohols **IIIa** and **IIIb** (6α/6β ≈ 2:3).

(20*R*,22*R*)-6α(β)-Hydroxy-2β,3β : 20,22-bis(isopropylidenedioxy)-14α,25-bis(trimethylsilyloxy)-5α-cholest-7-ene (V) and (20*R*,22*R*)-6α(β),25-dihydroxy-2β,3β : 20,22-bis(isopropylidenedioxy)-14α-trimethylsilyloxy-5α-cholest-7-ene (VI). *a*. To a solution of 0.2 g (0.28 mmol) of compound **IV** (prepared according to [6], mp 48–50°C) in 2 ml of MeOH we added under stirring 0.14 g (0.39 mmol) of $CeCl_3 \cdot 6H_2O$, the mixture was cooled to –5°C, and 0.02 g (0.6 mmol) of $NaBH_4$ was added. The mixture was warmed up to room temperature, stirred for 0.5 h, and evaporated under reduced pressure, and the residue was subjected to column chromatography on silica gel (6 g; $CHCl_3$–MeOH, 10:1) to isolate 0.1 g (59%) of compound **V**, R_f 0.54 ($CHCl_3$–MeOH, 10:1) (a mixture of 6α- and 6β-epimers at a ratio of ~3:2, according to the ^1H NMR data: δ 4.55 and 3.78 ppm for 6-H in 6α- and 6β-epimer, respectively), and 0.05 g (25%) of **VI**, R_f 0.3 ($CHCl_3$–MeOH, 10:1) (a mixture of 6α- and 6β-epimers at a ratio of ~3:2, according to the ^1H NMR data: δ 4.59 and 3.82 ppm for 6-H in 6α- and 6β-epimer, respectively).

Compound **V** (mixture of 6α- and 6β-epimers). IR spectrum, ν, cm^{-1}: 850, 1250 ($OSiMe_3$); 3400 (OH). UV spectrum ($CHCl_3$): λ_{max} 239 nm (ε 4982). ^1H NMR spectrum, δ, ppm: 0.06 s (9H, Me_3Si); 0.68 s (1.8H, $C^{18}H_3$, 6α); 0.71 s (1.2H, $C^{18}H_3$, 6β); 0.86 s (1.8H, $C^{19}H_3$, 6α); 0.99 s (1.2H, $C^{19}H_3$, 6β); 1.04 s (3H, $C^{21}H_3$); 1.18 s (6H, $C^{26}H_3$, $C^{27}H_3$); 1.26 s, 1.30 s, 1.35 s, and 1.41 s (3H each, Me_2C); 1.54–2.12 m (19H, CH, CH_2); 3.60 m (1H, 22-H, $W_{1/2}$ = 15.4 Hz); 3.78 br.s (0.4H, 6α-H, $W_{1/2}$ = 10.2 Hz); 4.14 m (1H, 2-H); 4.21 br.s (0.4H, 3-H, 6β, $W_{1/2}$ = 6.2 Hz); 4.26 br.s (0.6H, 3-H, 6α, $W_{1/2}$ = 11.5 Hz); 4.55 br.s (0.6H, 6β-H, $W_{1/2}$ = 11.8 Hz); 5.31 br.s (0.6H, 7-H, 6α, $W_{1/2}$ = 6.5 Hz); 5.51 d (0.4H, 7-H, 6β, *J* = 3.4 Hz). ^{13}C NMR spectrum, δ_C, ppm: 2.5 q ($SiMe_3$); 16.4 q (C^{18}); 19.8 t (C^{11}); 21.5 t (C^{16}); 22.5 q (C^{21}); 23.5 t (C^{23}); 23.5 t and 27.9 t (C^4); 24.8 q and 25.2 q (C^{19}); 26.5 q (C^{26}); 28.5 q, 28.9 q, 29.2 q, and 29.6 q (**Me**$_2$C); 27.8 t (C^{15}); 30.1 t (C^{12}); 34.3 s and 36.6 s (C^{10}); 41.9 d (C^5, 6α); 42.0 t (C^1); 43.2 d (C^5, 6β); 48.5 s (C^{13}); 49.2 d and 49.3 d (C^{17}); 66.3 d (C^6, 6α); 69.9 d (C^6, 6β); 72.3 d and 72.5 d (C^2, C^3); 73.4 s (C^{25}); 81.6 d (C^{22}); 84.4 s (C^{20}); 88.1 s (C^{14}, 6α); 88.4 s (C^{14}, 6β); 106.5 s (20,22-Me$_2$**C**O_2); 107.7 s and 108.1 s (2,3-Me$_2$**C**O_2); 120.3 d (C^7, 6α); 122.5 d (C^7, 6β); 141.3 s (C^8, 6α); 142.6 s (C^8, 6β).

Compound **VI** (mixture of 6α- and 6β-epimers). IR spectrum, ν, cm^{-1}: 850, 1250 ($OSiMe_3$); 3400 (OH). ^1H NMR spectrum, δ, ppm: 0.03 s and 0.08 s (9H each, Me_3Si); 0.71 s (1.8H, $C^{18}H_3$, 6α); 0.73 s (1.2H, $C^{18}H_3$, 6β); 0.89 s (1.8H, $C^{19}H_3$, 6α); 1.07 s (1.2H, $C^{19}H_3$, 6β); 1.12 s (3H, $C^{21}H_3$); 1.23 s (6H, $C^{26}H_3$, $C^{27}H_3$); 1.31 s, 1.34 s, 1.40 s, 1.51 s (3H each, Me_2C); 1.55–2.35 m (19H, CH, CH_2); 3.64 m (1H, 22-H, $W_{1/2}$ = 15.3 Hz); 3.82 br.s (0.4H, 6α-H, $W_{1/2}$ = 10.2 Hz); 4.21 m (1H, 2-H); 4.23 br.s (0.4H, 3-H, 6β, $W_{1/2}$ = 10.6 Hz); 4.29 br.s (0.6H, 3-H, 6α, $W_{1/2}$ = 11.7 Hz); 4.59 br.s (1H, 6β-H, $W_{1/2}$ = 14.8 Hz); 5.34 br.s (0.6H, 7-H, 6α, $W_{1/2}$ = 5.2 Hz); 5.56 d (0.4H, 7-H, 6β, *J* = 3.1 Hz). ^{13}C NMR spectrum, δ_C, ppm: 1.8 q and 1.9 q ($SiMe_3$); 16.4 q (C^{18}); 19.6 t (C^{11}); 21.6 t (C^{16}); 22.5 q (C^{21}); 23.0 t and 23.7 t (C^{23}); 23.7 t and 28.7 t (C^4); 24.7 q and 25.3 q (C^{19}); 26.5 q (C^{26}); 28.6 q, 28.7 q, 28.9 q, and 29.7 q (**Me**$_2$C); 28.0 t (C^{15}); 30.0 t (C^{12}); 32.3 d (C^9); 34.3 s and 36.7 s (C^{10}); 41.4 t (C^1); 41.9 d (C^5, 6α); 43.3 d (C^5, 6β); 48.5 s (C^{13}); 49.2 d (C^{17}, 6α); 49.3 d (C^{17}, 6β); 66.6 d (C^6, 6α), 70.2 d (C^6, 6β); 70.3 d (C^{25}); 72.3 d, 72.6 d, and 72.9 d (C^2, C^3); 82.0 d (C^{22}); 84.6 s (C^{20}); 88.2 s (C^{14}, 6α); 88.4 s (C^{14}, 6β); 106.8 s (20,22-Me$_2$**C**O_2); 107.8 s and 108.0 s (2,3-Me$_2$**C**O_2); 120.3 d (C^7, 6α); 122.5 d (C^7, 6β); 141.3 s (C^8, 6α); 142.8 s (C^8, 6β).

b. A solution of 0.2 g (0.28 mmol) of bis-silyl ether **IV** in 2 ml of dry diethyl ether was added dropwise under stirring to a suspension of 0.002 g (0.05 mmol) of $LiAlH_4$ in 3 ml of dry diethyl ether. The mixture was stirred for 20 min at room temperature, cooled to 0°C, and treated in succession with 2 ml of water and 1 ml of 5% hydrochloric acid (to pH ≈ 3). The organic phase was separated, the aqueous phase was extracted with diethyl ether (3×10 ml), and the extracts were combined with the organic phase and evaporated to obtain 0.17 g (85%) of compound **V** as a mixture of 6α- and 6β-epimers at a ratio of ~1:2.

(20*R*,22*R*)-2,3:20,22-Bis(isopropylidenedioxy)-6α(β),14α,25-tris(trimethylsilyloxy)-5α-cholest-7-ene (VII). To a solution of 0.1 g (0.16 mmol) of epimer mixture **VI** in 5 ml of anhydrous THF we added at 0°C under stirring 0.07 g (0.48 mmol) of Me_3SiCF_3. The mixture was stirred for 15 min, 0.01 g of $Bu_4N^+F^-$ was added, and the mixture was allowed to slowly warm up to room temperature, stirred for 15 min, and evaporated under reduced pressure. The residue was subjected to column chromatography on silica gel (5 g, $CHCl_3$) to isolate 0.1 g (95%) of compound **VII**, R_f 0.89 ($CHCl_3$–MeOH, 20:1) (a mixture of 6α- and 6β-epimers at a ratio of ~3:2, according to the ^{1}H NMR data: δ 4.51 and and 3.73 ppm for 6-H in 6α- and 6β-epimer, respectively). IR spectrum, ν, cm^{-1}: 850, 1245 ($OSiMe_3$). ^{1}H NMR spectrum, δ, ppm: 0.03 s, 0.06 s, 0.08 s, and 0.09 s (27H, $SiMe_3$); 0.71 s (1.8H, $C^{18}H_3$, 6α); 0.74 s (1.2H, $C^{18}H_3$, 6β); 0.88 s (1.8H, $C^{19}H_3$, 6α); 1.01 s (1.2H, $C^{19}H_3$, 6β); 1.12 s (3H, $C^{21}H_3$); 1.20 s and 1.21 s (3H each, $C^{26}H_3$, $C^{27}H_3$); 1.28 s, 1.32 s, 1.37 s, and 1.48 s (3H each, Me_2C); 1.50–2.28 m (19H, CH, CH_2); 3.60 m (1H, 22-H, $W_{1/2}$ = 11.8 Hz); 3.73 m (0.4H, 6α-H); 4.05–4.15 m (1H, 2-H); 4.20 m (0.4H, 3-H, 6β, $W_{1/2}$ = 10.8 Hz); 4.24 m (0.6H, 3-H, 6α, $W_{1/2}$ = 9.8 Hz); 4.51 m (0.6H, 6β-H, $W_{1/2}$ = 8.2 Hz); 5.19 m (0.6H, 7-H, 6α, $W_{1/2}$ = 6.2 Hz); 5.38 (0.4H, 7-H, 6β, $W_{1/2}$ = 8.5 Hz). ^{13}C NMR spectrum, δ_C, ppm: 0.2 q, 0.4 q, 1.9 q, 2.6 q ($SiMe_3$); 16.5 q (C^{18}); 19.8 t (C^{11}); 21.6 t (C^{16}); 21.8 q (C^{21}); 23.0 t (C^{23}, 6β); 23.7 t (C^{23}, 6α); 24.6 q (C^{19}, 6α); 25.1 q (C^{19}, 6β); 26.5 q and 26.8 q (C^{26}, C^{27}); 27.9 t (C^4); 27.9 t (C^{15}); 28.6 q, 29.0 q, 29.4 q, and 30.1 q (**Me**$_2$CO$_2$); 31.5 t (C^{12}); 32.2 d (C^9); 34.5 s (C^{10}, 6β); 36.7 t (C^{10}, 6α); 42.1 t (C^1); 42.4 d (C^5, 6α); 43.2 d (C^5, 6β); 48.6 s (C^{13}, 6α); 48.8 s (C^{13}, 6β); 49.4 d (C^{17}, 6α); 49.6 d (C^{17}, 6β); 66.9 d (C^6, 6α); 70.3 (C^6, 6β); 72.4 d, 72.6 d, and 72.8 d (C^2, C^3); 73.5 s (C^{25}); 81.8 d (C^{22}); 84.5 s (C^{20}); 88.2 s (C^{14}, 6α); 88.6 s (C^{14}, 6β); 106.3 s (20,22-Me_2**C**O_2); 107.6 s and 107.8 s (2,3-Me_2**C**O_2); 121.2 d (C^7, 6β); 123.7 d (C^7, 6α); 140.0 s (C^8, 6α); 141.5 s (C^8, 6β).

(20*R*,22*R*)-6α,14α- and (20*R*,22*R*)-6β,14α-Dihydroxy-2,3:20,22-bis(isopropylidenedioxy)-5α-cholesta-7,24/(25)-dienes IXa and IXb. *a*. A solution of 0.5 g (0.92 mmol) of compound **VIII** (a mixture of Δ^{24}- and Δ^{25}-isomers at a ratio of ~2:1; prepared according to [7]) in 5 ml of dry diethyl ether was added dropwise to a suspension of 0.17 g (4.61 mmol) of $LiAlH_4$ in 5 ml of dry diethyl ether. The mixture was stirred for 30 min, cooled to 0°C, and acidified with 5% hydrochloric acid to pH ≈ 4–5. The organic phase was separated, the aqueous phase was extracted with diethyl ether (3×20 ml), and the extracts were combined with the organic phase and evaporated to obtain 0.5 g of a mixture of alcohols **IXa** and **IXb** (ratio 6α/6β ≈ 1:2, according to the ^{1}H NMR data: δ 4.57 and 3.77 ppm for 6-H in v 6α- and 6β-epimer, respectively). By column chromatography on silica gel (5 g; $CHCl_3$–MeOH, 20:1) we isolated 0.25 g (50%) of epimer **IXb** (R_f 0.4, $CHCl_3$–MeOH, 10:1) and 0.16 g (32%) of epimer **IXa** (R_f 0.38, $CHCl_3$–MeOH, 10:1).

Epimer **IXa**. mp 120–122°C, $[\alpha]_D^{17}$ = 20.2° (*c* = 7.51, $CHCl_3$). IR spectrum: ν(OH) 3400 cm^{-1}. UV spectrum ($CHCl_3$): λ_{max} 243.4 nm (ε 7444). ^{1}H NMR spectrum, δ, ppm: 0.75 s (3H, $C^{18}H_3$); 0.89 s (3H, $C^{19}H_3$); 1.11 s and 1.12 s (3H, $C^{21}H_3$, $C^{21'}H_3$); 1.31 s (3H), 1.39 s (6H), and 1.48 s (3H) (Me_2C); 1.61 s and 1.71 s (~3H, $C^{27}H_3$, $C^{27'}H_3$); 1.69 s (~2.7H, $C^{26'}H_3$); 1.50–2.30 m (18H, CH, CH_2); 2.37 m (1H, 9-H, $W_{1/2}$ = 12.9 Hz); 3.68 m (1H, 22-H, 22'-H, $W_{1/2}$ = 9.2 Hz); 4.23 m (1H, 2-H, $W_{1/2}$ = 20.5 Hz); 4.29 m (1H, 3-H, $W_{1/2}$ = 9.2 Hz); 4.57 br.s (1H, 6-H, $W_{1/2}$ = 9.5 Hz); 4.68 br.s and 4.71 br.s (1.3H, $C^{26}H_2$, $W_{1/2}$ = 2.7 Hz); 5.15 t (0.7H, $C^{24'}H_3$, *J* = 6.5 Hz); 5.37 br.s (1H, 7-H, $W_{1/2}$ = 3.2 Hz). ^{13}C NMR spectrum, δ_C, ppm: 17.2 q (C^{18}); 17.9 q ($C^{27'}$); 19.8 t (C^{11}); 21.4 t (C^{16}); 21.8 q (C^{21}, $C^{21'}$); 22.5 q (C^{27}); 22.5 t (C^4); 24.3 q (C^{19}); 25.6 q ($C^{26'}$); 26.7 t (C^{23}); 26.5 q, 26.8 q, 28.5 q, and 28.9 q (**Me**$_2$C); 27.7 t ($C^{23'}$); 31.4 t (C^{15}); 31.8 t (C^{12}); 32.1 d (C^9); 34.7 t (C^{24}); 36.7 s (C^{10}); 39.6 t (C^1); 41.9 d (C^5); 46.8 s (C^{13}); 49.1 d ($C^{17'}$); 49.2 d (C^{17}); 66.4 d (C^6); 71.2 d (C^2); 72.9 d (C^3); 80.7 d (C^{22}); 81.1 d ($C^{22'}$); 84.3 s (C^{14}); 85.0 s (C^{20}); 85.1 s ($C^{20'}$); 106.6 s (20,22-Me_2**C**O_2); 107.7 s (2,3-Me_2**C**O_2); 109.9 t (C^{26}); 120.5 d (C^7); 121.8 d ($C^{24'}$); 133.4 q ($C^{25'}$); 142.2 s (C^8); 145.3 s (C^{25}). ^{1}H NMR spectrum (500.13 MHz, DMSO-d_6), δ, ppm: 0.66 s (3H, $C^{18}H_3$); 0.80 s (3H, $C^{19}H_3$); 1.05 s and 1.07 s (3H, $C^{21'}H_3$, $C^{21}H_3$); 1.23 s and 1.31 s

(3H each, 20,22-Me_2C); 1.23 s and 1.38 s (3H each, 2,3-Me_2C); 1.30 m and 1.44 m (2H, $C^{11}H_2$); 1.47 m and 1.75 m (2H, $C^{15}H_2$); 1.58 s and 1.69 s (3H, $C^{27}H_3$, $C^{27'}H_3$); 1.66 s (~2.7H, $C^{26'}H_3$); 1.67 m and 1.77 m (2H, $C^{16}H_2$); 1.74 m (2H, 5-H); 1.08 m and 1.78 m (2H, $C^{1}H_2$); 1.46 m and 2.09 m (2H, $C^{23}H_2$, $C^{23'}H_2$); 1.55 m and 2.00 m (2H, $C^{4}H_2$); 1.61 m and 1.90 m (2H, $C^{12}H_2$); 2.06 m and 2.15 m (~1.3H, $C^{24}H_2$); 2.14 m and 2.18 m (1H, 17'-H, 17-H); 2.32 m (1H, 9-H); 3.63 d.d (1H, 22-H, 22'-H, ^3J = 5.0, 9.0 Hz), 4.02 s (1H, 14-OH); 4.07 d.d.d (1H, 2-H, ^3J = 2.0, 4.5, 10.0 Hz); 4.18 d.t (1H, 3-H, ^3J = 2.5, 4.5 Hz); 4.31 d.d (1H, 6-H, ^3J = 4.5, 9.0 Hz); 4.53 d.d (1H, 6-OH, ^3J = 9.0, ^4J = 2.0 Hz); 4.68 s and 4.71 s (1.3H, $C^{26}H_2$); 5.14 t (0.7H, 24'-H, ^3J = 8.0 Hz); 5.19 br.s (1H, 7-H). ^{13}C NMR spectrum (125.76 MHz, DMSO), δ_C, ppm: 16.9 (C^{18}), 17.7 ($C^{27'}$), 19.6 (C^{11}), 21.2 (C^{16}), 21.6 (C^{21}, $C^{21'}$), 22.2 (C^4, C^{27}), 24.5 (C^{19}), 25.5 ($C^{26'}$), 26.5 (C^{23}), 26.6 and 28.5 (2,3-**Me**$_2$C), 26.6 and 28.9 (20,22-**Me**$_2$C), 27.4 ($C^{23'}$), 30.5 (C^{15}), 31.2 (C^{12}), 31.5 (C^9), 34.6 (C^{24}), 36.0 (C^{10}), 39.7 (C^1), 41.8 (C^5), 46.5 (C^{13}), 48.7 ($C^{17'}$), 48.8 (C^{17}), 64.6 (C^6), 71.6 (C^2), 72.7 (C^3), 80.0 (C^{22}), 80.6 ($C^{22'}$), 83.2 (C^{14}), 84.2 (C^{20}, $C^{20'}$), 105.9 (20,22-Me_2**C**O_2), 106.7 (2,3-Me_2**C**O_2), 110.2 (C^{26}), 122.4 (C^7), 120.8 ($C^{24'}$), 132.2 ($C^{25'}$), 140.4 (C^8), 144.9 (C^{25}).

Epimer **IXb**. mp 112–114°C, $[\alpha]_D^{17}$ = 6.5° (*c* = 1.79, $CHCl_3$). IR spectrum: ν(OH) 3400 cm^{-1}. ^1H NMR spectrum, δ, ppm: 0.77 s (3H, $C^{18}H_3$); 1.03 s (3H, $C^{19}H_3$); 1.11 s and 1.12 s (3H, $C^{21}H_3$, $C^{21'}H_3$); 1.29 s (6H), 1.38 s (3H), and 1.48 s (3H) (Me_2C); 1.60 s and 1.70 s (3H, $C^{27}H_3$, $C^{27'}H_3$); 1.67 s (~2.7H, $C^{26'}H_3$); 1.70–2.20 m (18H, CH, CH_2); 2.22 m (1H, 9-H, $W_{1/2}$ = 24.6 Hz); 3.70 m (1H, 22-H, 22'-H, $W_{1/2}$ = 19.0 Hz); 3.77 m (1H, 6-H, $W_{1/2}$ = 8.1 Hz); 4.11 m (1H, 2-H, $W_{1/2}$ = 19.8 Hz); 4.20 m (1H, 3-H, $W_{1/2}$ = 19.5 Hz); 4.67 br.s and 4.70 br.s (1.3H, $C^{26}H_2$, $W_{1/2}$ = 2.2 Hz); 5.16 t (0.7H, 24'-H, *J* = 6.5 Hz); 5.61 br.s (1H, 7-H, $W_{1/2}$ = 9.1 Hz). ^{13}C NMR spectrum, δ_C, ppm: 17.2 q (C^{18}); 17.9 q ($C^{27'}$); 20.4 t (C^{11}); 21.2 t (C^{16}); 21.7 q (C^{21}, $C^{21'}$); 22.5 q (C^{27}); 25.1 q (C^{19}); 25.6 q ($C^{26'}$); 26.4 q, 26.7 q, 28.5 q, and 28.9 q (**Me**$_2$C); 26.8 t (C^{23}); 27.2 t ($C^{23'}$); 27.7 t (C^4); 31.2 t (C^{15}); 31.9 t (C^{12}); 32.5 d (C^9); 34.2 s (C^{10}); 35.0 t (C^{24}); 39.2 t (C^1); 43.2 d (C^5); 46.8 s (C^{13}); 49.1 d ($C^{17'}$); 49.3 d (C^{17}); 70.0 d (C^6); 72.3 d (C^2); 72.7 d (C^3); 80.7 d (C^{22}); 81.0 d ($C^{22'}$); 84.2 s (C^{14}); 85.3 s (C^{20}); 85.4 s ($C^{20'}$); 106.6 s (20,22-Me_2**C**O_2); 107.7 s (2,3-Me_2**C**O_2); 109.9 t (C^{26}); 120.5 d (C^7); 121.8 d ($C^{24'}$); 133.4 q ($C^{25'}$); 142.2 s (C^8); 145.3 s (C^{25}). ^1H NMR spectrum (500.13 MHz, DMSO-d_6), δ, ppm: 0.67 s (3H, $C^{18}H_3$), 0.94 s (3H, $C^{19}H_3$), 1.07 s (3H, $C^{21}H_3$, $C^{21'}H_3$), 1.23 s and 1.40 s (3H each, 2,3-Me_2C), 1.25 s and 1.34 s (3H each, 20,22-Me_2C), 1.38 m and 1.46 m (2H, $C^{11}H_2$), 1.45 m and 1.75 m (2H, $C^{15}H_2$), 1.59 s and 1.69 s (3H, $C^{27}H_3$, $C^{27'}H_3$), 1.66 s (~2.7H, $C^{26'}H_3$), 1.63 m (1H, 5-H), 1.70 m and 1.80 m (2H, $C^{16}H_2$), 1.13 m and 1.74 m (2H, $C^{1}H_2$), 1.44 m and 2.08 m (2H, $C^{23}H_2$, $C^{23'}H_2$), 1.56 m and 1.70 m (2H, $C^{4}H_2$), 1.60 m and 1.92 m (2H, $C^{12}H_2$), 2.03 m and 2.16 m (~1.3H, $C^{24}H_2$), 2.14 m and 2.19 m (1H, 17-H, 17'-H), 2.26 m (1H, 9-H), 3.62 m (2H, 6-H, 22-H, 22'-H), 3.98 s (1H, 14-OH), 4.03 d.d.d (1H, 2-H, ^3J = 2.0, 4.5, 10.0 Hz), 4.14 d.t (1H, 3-H, ^3J = 2.0, 4.5 Hz), 4.52 d.d (1H, 6-OH, ^3J = 2.5, ^4J = 4.0 Hz), 4.68 s and 4.72 s (0.7H, $C^{26}H_2$), 5.16 t (1.3H, $C^{24'}H_3$, ^3J = 8.5 Hz), 5.38 d.d (1H, 7-H, ^3J = 4.5, ^4J = 2.0 Hz). ^{13}C NMR spectrum (125.76 MHz, DMSO), δ_C, ppm: 16.8 (C^{18}), 17.7 ($C^{27'}$), 20.4 (C^{11}), 21.1 (C^{16}), 21.6 (C^{21}, $C^{21'}$), 22.2 (C^{27}), 27.5 (C^4), 25.0 (C^{19}), 25.4($C^{26'}$), 26.5 (C^{23}), 26.6 and 28.5 (2,3-**Me**$_2$C), 26.6 and 28.9 (20,22-**Me**$_2$C), 27.4 ($C^{23'}$), 30.6 (C^{15}), 31.1 (C^{12}), 32.3 (C^9), 33.3 (C^{10}), 34.6 (C^{24}), 39.5 (C^1), 42.8 (C^5), 46.5 (C^{13}), 48.7 ($C^{17'}$), 48.8 (C^{17}), 70.3 (C^6), 71.4 (C^2), 72.5 (C^3), 79.8 (C^{22}), 80.4 ($C^{22'}$), 83.3 (C^{14}), 84.1 (C^{20}, $C^{20'}$), 105.9 (20,22-Me_2**C**O_2), 106.8 (2,3-Me_2**C**O_2), 110.2 (C^{26}), 120.0 (C^7), 120.8 ($C^{24'}$), 132.2 ($C^{25'}$), 141.3 (C^8), 144.8 (C^{25}).

b. To a solution of 0.2 g (0.37 mmol) of isomer mixture **VIII** in 2 ml of methanol we added under stirring 0.19 g (0.53 mmol) of $CeCl_3 \cdot 6H_2O$, the mixture was cooled to –5°C, and 0.03 g (0.8 mmol) of $NaBH_4$ was added in one portion. The mixture was warmed up to room temperature, stirred for 1 h, and evaporated under reduced pressure. The residue was subjected to column chromatography on silica gel (5 g, $CHCl_3$–MeOH) to isolate 0.16 g (80%) of alcohol **IXa** which was identical in the IR, UV, and ^1H and ^{13}C NMR spectra to a sample prepared as described in *a*.

(20*R*,22*R*)-6α(β)-Hydroxy-2,3:20,22-bis(isopropylidenedioxy)-14α-trimethylsilyloxy-5α-cholesta-7,24(25)-diene (XI) (mixture of 6α- and 6β-epimers). *a*. To a solution of 0.2 g (0.32 mmol) of compound **X** (prepared according to [9], mp 76–79°C) in 5 ml of anhydrous methanol we added 0.14 g (0.6 mmol) of $CeCl_3$, the mixture was cooled to –5°C, and 0.02 g (0.6 mmol) $NaBH_4$ was added in one portion under stirring. The mixture was allowed to slowly warm up to room temperature, stirred for 1 h, filtered through a layer of silica gel, and evaporated under reduced pressure. The residue was subjected to column chromatography on silica gel (5 g; $CHCl_3$–MeOH, 10:1) to isolate 0.14 g (70%) of compound **XI**,

R_f 0.7 ($CHCl_3$–MeOH, 10:1) (a mixture of 6α- and 6β-epimers at a ratio of ~1:1, according to the ^{1}H NMR data: δ 4.61 and 3.82 ppm for 6-H in 6α- and 6β-epimers, respectively). ^{1}H NMR spectrum, δ, ppm: 0.06 s and 0.09 s (9H, Me_3Si); 0.72 s and 0.75 s (3H, $C^{18}H_3$); 0.91 s and 1.08 s (3H, $C^{19}H_3$); 1.13 s and 1.15 s (3H, $C^{21}H_3$, $C^{21'}H_3$); 1.31 s, 1.32 s, 1.35 s, and 1.42 s (3H each, Me_2C); 1.64 s, 1.73 s, and 1.74 s (~5H, $C^{26'}H_3$, $C^{27}H_3$, $C^{27'}H_3$); 1.80–2.30 m (17.5H, CH, CH_2); 3.69 m (1H, 22-H, 22'-H, $W_{1/2}$ = 25.0 Hz); 3.82 br.s (0.5H, 6α-H, $W_{1/2}$ = 9.4 Hz); 4.16 m (1H, 2-H, $W_{1/2}$ = 17.8 Hz); 4.25 br.s (0.5H, 3-H, 6β, $W_{1/2}$ = 25.0 Hz); 4.30 br.s (0.5H, 3-H, 6α, $W_{1/2}$ = 12.2 Hz); 4.61 br.s (~0.5H, 6β-H, $W_{1/2}$ = 15.0 Hz); 4.71 br.s and 4.75 br.s (~0.7H, $C^{26}H_2$, $W_{1/2}$ = 5.1 Hz); 5.22 t (~0.7H, 24'-H, J = 6.5 Hz); 5.35 br.s (~0.5H, 7-H, 6α, $W_{1/2}$ = 6.5 Hz); 5.57 br.s (~0.5H, 7-H, 6β, $W_{1/2}$ = 10.5 Hz). ^{13}C NMR spectrum, δ_C, ppm: 1.8 q (Me_3Si), 16.5 q and 16.6 q (C^{18}); 17.9 q ($C^{27'}$); 19.6 t (C^{11}, 6α); 20.9 t (C^{11}, 6β); 21.5 t (C^{16}, 6β); 21.6 t (C^{16}, 6α); 21.9 q (C^{21}); 22.6 t (C^4, 6α); 22.6 t (C^{27}); 24.7 q (C^{19}, 6α); 25.3 q (C^{19}, 6β); 25.8 q ($C^{26'}$); 26.5 q, 26.9 q, 28.6 q, and 29.0 q (**Me**$_2$C); 28.0 t (C^{23}, $C^{23'}$); 28.6 t (C^4, 6β); 30.1 t and 30.2 t (C^{15}); 30.8 s (C^9, 6β); 31.3 t and 31.4 t (C^{12}); 32.4 d (C^9, 6α); 34.4 s (C^{10}, 6α); 34.9 t (C^{24}); 36.8 s (C^{10}, 6β); 38.8 t (C^1, 6β); 39.5 t (C^1, 6α); 41.9 d (C^5, 6α); 43.4 d (C^5, 6β); 48.6 s (C^{13}); 49.2 d (C^{17}); 49.3 d ($C^{17'}$); 66.7 d (C^6, 6α); 70.2 d (C^6, 6β); 71.5 d (C^2, 6α); 72.4 d and 72.6 d (C^2, C^3, 6β); 72.7 d (C^3, 6α); 80.5 d (C^{22}); 81.0 d ($C^{22'}$); 84.3 s and 84.4 s (C^{20}); 88.2 s (C^{14}, 6α); 88.5 s (C^{14}, 6β); 106.6 s (20,22-Me_2**C**O_2); 107.6 s and 107.9 s (2,3-Me_2**C**O_2); 110.2 t (C^{26}); 120.3 d (C^7, 6β); 122.5 d (C^7, 6α); 122.5 d ($C^{24'}$); 133.2 s ($C^{25'}$); 141.5 s (C^8, 6α); 142.9 s (C^8, 6β); 145.1 s (C^{25}).

b. A solution of 0.1 g (0.16 mmol) of compound **X** in 2 ml of methanol was cooled to –5°C, 0.01 g (0.35 mmol) of $NaBH_4$ was added under stirring, and the mixture was stirred for 1 h at room temperature and evaporated under reduced pressure. The residue was subjected to column chromatography on silica gel (2 g; $CHCl_3$–MeOH, 10:1) to isolate 0.7 g (70%) of compound **XI** as a mixture of 6α- and 6β-epimers at a ratio of ~1:2 (according to the ^{1}H NMR data: δ 4.57 and 3.82 ppm for 6-H in 6α- and 6β-epimers, respectively).

(20*R*,22*R*)-6α,14α- and (20*R*,22*R*)-6β,14α-Bis(trimethylsilyloxy)-2,3:20,22-bis(isopropylidenedioxy)-5α-cholesta-7,24(25)-dienes XIIa and XIIb. To a solution of 0.1 g (0.18 mmol) of compound **IXa** or **IXb** in 2 ml of anhydrous tetrahydrofuran we added 0.05 g (0.36 mmol) of Me_3SiCF_3, the mixture was stirred for 15 min at 0°C, and 0.01 g of $Bu_4N^+F^-$ was added. After 3 min (TLC), the mixture was evaporated, and the residue was subjected to column chromatography on silica gel (3 g, $CHCl_3$) to isolate 0.12 g (95%) of compound **XIIa** or 0.13 g (98%) of **XIIb**, respectively.

Compound **XIIa**. mp 106–108°C, $[\alpha]_D^{17}$ = 17.5° (*c* = 1.14, $CHCl_3$). IR spectrum, ν, cm^{-1}: 850, 1250 (Me_3Si); 1670 (C=C, C=O). UV spectrum ($CHCl_3$): λ_{max} 239 nm (ε 3507). ^{1}H NMR spectrum, δ, ppm: 0.07 s and 0.15 s (9H each, Me_3Si); 0.72 s (3H, $C^{18}H_3$); 0.90 s (3H, $C^{19}H_3$); 1.11 s (3H, $C^{21}H_3$, $C^{21'}H_3$); 1.34 s (6H), 1.41 s (3H), and 1.51 s (3H) (Me_2C); 1.61 s, 1.70 s, and 1.73 s (~5H, $C^{26}H_3$, $C^{27}H_3$, $C^{27'}H_3$); 1.55–2.53 m (~17.5H, CH, CH_2); 3.57–3.80 m (1H, 22-H, 22'-H, $W_{1/2}$ = 9.9 Hz); 4.15 m (1H, 2-H, $W_{1/2}$ = 24.1 Hz); 4.27 br.s (1H, 3-H, $W_{1/2}$ = 12.2 Hz); 4.52 br.s (1H, 6-H, $W_{1/2}$ = 9.8 Hz); 4.72 br.s and 4.74 br.s (0.7H, $C^{26}H_2$, $W_{1/2}$ = 5.0 Hz); 5.16 t (0.7H, 24'-H, J = 6.5 Hz); 5.21 br.s (1H, 7-H, $W_{1/2}$ = 6.4 Hz). ^{13}C NMR spectrum, δ_C, ppm: 0.2 q and 1.2 q (Me_3Si); 16.6 q (C^{18}); 18.5 q ($C^{27'}$); 19.8 t (C^{11}); 20.4 q and 20.5 q (C^{21}, $C^{21'}$); 20.8 t (C^{16}); 21.7 t (C^4); 21.8 q (C^{27}); 22.1 t and 23.0 t (C^{23}, $C^{23'}$); 24.1 q (C^{19}); 24.7 q ($C^{26'}$); 26.5 q, 26.9 q, 28.6 q, and 29.0 q (**Me**$_2$C); 29.7 t (C^{15}); 30.0 t (C^{12}); 32.2 d (C^9); 35.0 t (C^{24}); 37.0 s (C^{10}); 39.6 t (C^1); 42.4 d (C^5); 48.5 s (C^{13}); 49.2 d (C^{17}); 67.3 d (C^6); 72.5 d and 73.2 d (C^2, C^3); 80.6 d and 80.9 d (C^{22}, $C^{22'}$); 83.2 s and 83.3 s (C^{20}, $C^{20'}$); 88.1 s (C^{14}); 106.8 s (20,22-Me_2**C**O_2); 107.8 s (2,3-Me_2**C**O_2); 110.3 t (C^{26}); 120.4 d ($C^{24'}$); 123.7 d (C^7); 134.0 s ($C^{25'}$); 140.0 s (C^8); 145.2 s (C^{25}).

Compound **XIIb**. mp 96–98°C, $[\alpha]_D^{17}$ = 11.2° (*c* = 2.24, $CHCl_3$). IR spectrum, ν, cm^{-1}: 860, 1250 (Me_3Si); 1670 (C=C, C=O). UV spectrum ($CHCl_3$): λ_{max} 245 nm (ε 2490). ^{1}H NMR spectrum, δ, ppm: 0.06 s and 0.14 s (9H each, Me_3Si); 0.75 s (3H, $C^{18}H_3$); 1.02 s (3H, $C^{19}H_3$); 1.11 s (3H, $C^{21}H_3$, $C^{21'}H_3$); 1.32 s (6H), 1.40 s (3H), and 1.51 s (3H) (Me_2C); 1.66 s, 1.72 s, and 1.76 s (~5H, $C^{26}H_3$, $C^{27}H_3$, $C^{27'}H_3$); 1.55–2.50 m (~17.5H, CH, CH_2); 3.57–3.70 m (1H, 22-H, 22'-H, $W_{1/2}$ = 10.5 Hz); 3.75 m (1H, 6-H, $W_{1/2}$ = 9.4 Hz); 4.21 m (1H, 2-H, $W_{1/2}$ = 17.0 Hz); 4.32 m (1H, 3-H, $W_{1/2}$ = 12.9 Hz); 4.70 br.s and 4.74 br.s (~0.7H, $C^{26}H_2$, $W_{1/2}$ = 6.1 Hz); 5.18 t (0.7H, 24'-H, J = 6.5 Hz); 5.39 br.s (1H, 7-H, $W_{1/2}$ = 9.4 Hz). ^{13}C NMR spectrum, δ_C, ppm: 0.4 q and 1.9 q (Me_3Si); 16.5 q (C^{18}); 17.9 q ($C^{27'}$); 20.4 q and 20.5 q (C^{21}, $C^{21'}$); 20.9 t (C^{11}); 21.6 t (C^{16}); 22.1 q (C^{27}); 22.5 q (C^{19}); 23.9 t and 25.6 t (C^{23}, $C^{23'}$); 25.1 q ($C^{26'}$); 26.4 q, 26.8 q, 28.0 q, and 29.0 q (**Me**$_2$$CO_2$); 27.8 t ($C^4$); 30.1 t ($C^{15}$); 31.5 t ($C^{12}$); 33.7 d ($C^9$); 34.5 s ($C^{10}$); 34.9 t ($C^{24}$); 38.9 t ($C^1$);

43.1 d (C^5); 48.8 s (C^{13}); 49.2 d (C^{17}); 70.3 d (C^6); 72.8 d and 73.2 d (C^2, C^3); 80.2 d and 80.6 d (C^{22}, $C^{22'}$); 84.4 s and 84.5 s (C^{20}, $C^{20'}$); 88.5 s (C^{14}); 106.8 s (20,22-$Me_2\mathbf{C}O_2$); 107.9 s (2,3-$Me_2\mathbf{C}O_2$); 110.2 t (C^{26}); 120.4 d ($C^{24'}$); 121.2 d (C^7); 133.2 s ($C^{25'}$); 141.5 s (C^8); 145.1 s (C^{25}).

(20*R*,22*R*)-6α(β),14α-Bis(trimethylsilyloxy)-2,3:20,22-bis(isopropylidenedioxy)-5α-cholesta-7,24(25)-diene (XIIa/XIIb, mixture of epimers). To a solution of 0.2 g (0.3 mmol) of compound **XI** (a mixture of 6α- and 6β-epimers at a ratio of ~1:1) in 5 ml of anhydrous THF we added 0.12 g (0.9 mmol) of Me_3SiCF_3, the mixture was stirred for 15 min at 0°C, and 0.001 g of $Bu_4N^+F^-$ was added. After 3 min (TLC), the mixture was evaporated, and the residue was subjected to column chromatography on silica gel (6 g, $CHCl_3$) to isolate 0.2 g (92%) of a mixture of epimers **XIIa** and **XIIb** (6α/6β ratio ~1:1, according to the ^{1}H NMR data: δ 4.52 and 3.75 ppm for 6-H in 6α- and 6β-epimer, respectively).

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