# Reaction of 3-Hydroxycholesta-4,6-dienes with *m*-Chloroperbenzoic acid

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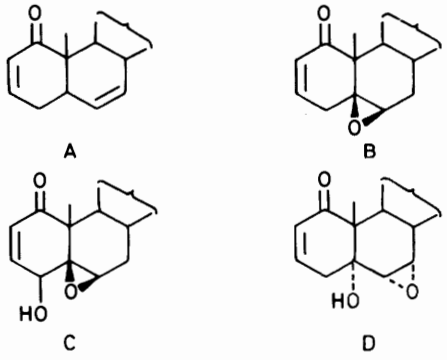
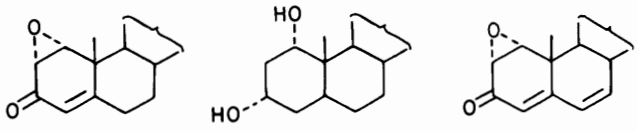
The reaction of two conjugated dienols, 1α,3α-dihydroxycholesta-4,6-diene and 3β-hydroxycholesta-4,6-diene with *m*-chloroperbenzoic acid was studied. The only products are 4,7-dihydroxy-5-ene 7-chlorobenzoate derivatives. The formation of these compounds is discussed.

In a previous publication,[1] we have described a synthetic approach to cholestane derivatives possessing partial structures A, B, and C, which are encountered in many natural steroidal lactones of the withanolide type.[2] Other workers[3] have developed a different approach which proved to be more advantageous for the construction of compounds with partial structures A and B. An additional group of withanolides and related compounds which occur mainly in Nicandra spp. (Solanaceae), possess partial structure D. Compounds possessing this substitution pattern have never been synthesized.




In our scheme[1] for the synthesis of cholestane derivatives with partial structures A, B, and C, 1α,2α-epoxycholest-4-en-3-one (**1**) was used as starting material; reduction with $LiAlH_4$ afforded 1α,3α-dihydroxycholest-4-ene (**2a**) which was then transformed into the corresponding epoxide (**2b**). In one of the several routes devised for the synthesis of the cholestane derivative D, 1α,2α-epoxycholesta-4,6-dien-3-one (**3**) was considered as possible starting material; it was reduced with $LiAlH_4$ to 1α,3α-dihydroxycholesta-4,6-diene (**4**)[4] which was expected to yield on epoxidation 1α,3α-dihydroxy-4α,5α-epoxycholest-6-ene (I).




a; $\Delta^4$
b; 4α,5α-epoxy

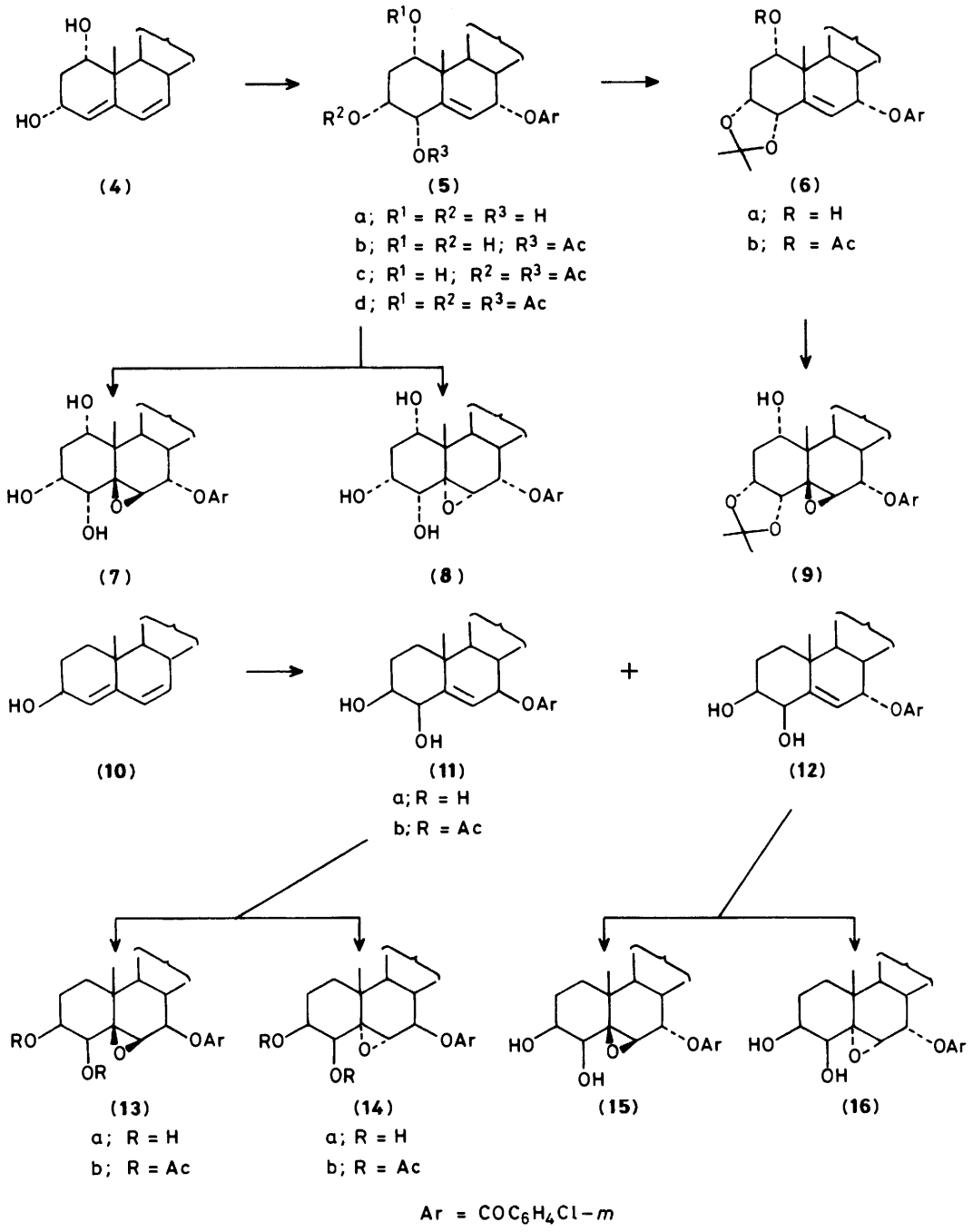
This approach had to be abandoned in view of the failure to obtain such a compound. There is evidence (*vide infra*) that (I) was actually formed, but the epoxide ring was spontaneously opened by the *m*-chlorobenzoate anion present in the medium to give (**5a**). The chemical behaviour of (**4**) and of the related allylic alcohol (**10**) are discussed in this paper.

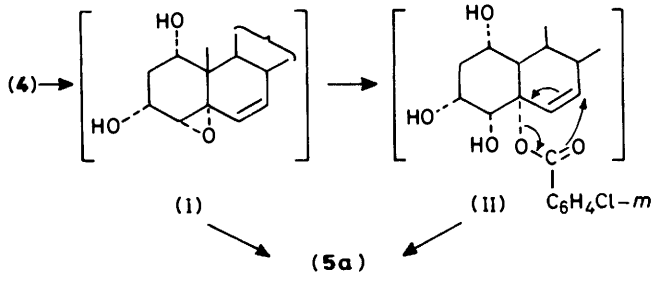
The configurational assignment at C-3 in 1α,3α-dihydroxycholesta-4,6-diene (**4**) is based on spectral analysis ($^1$H n.m.r.) and on the analogy with the reaction leading to the formation of compound (**2a**);[1] this is also supported by the reaction with *m*-chloroperbenzoic acid described below. In the spectrum of (**4**), in addition to the lowfield signals due to the three vinylic protons, there are two narrow multiplets at δ 3.90 ($W_{\frac{1}{2}}$ 6 Hz) and δ 4.21 ($W_{\frac{1}{2}}$ 10 Hz) which are assigned to 1β-H and 3β-H, respectively. In compound (**2a**) the corresponding signals are at δ 3.87 ($W_{\frac{1}{2}}$ 6 Hz) and δ 4.15 ($W_{\frac{1}{2}}$ 10 Hz).

In contrast to the epoxidation of androsta-3,5-diene,[5] leading to unsaturated vicinal diols resulting from initial attack of the peracid on the disubstituted double bond, along with significant amount of diepoxide, no traces of mono- or di-epoxides could be isolated after treatment of (**4**) with *m*-chloroperbenzoic acid. The only isolatable product (65% yield) was a tetrol mono-ester (**5a**) resulting from '1,4-addition': initial electrophilic attack of the peracid on the trisubstituted double bond and subsequent nucleophilic attack of the *m*-chlorobenzoate anion at the other end of the conjugated system (C-7). There is an obvious influence of the allylic axial 3α-OH, eventually combined with that of the homoallylic axial 1α-OH, not only on the position ($\Delta^4$), but also on the direction of attack of the peracid (rearside of the molecule). The formation of (**5a**) can be rationalized by assuming an intermediate unstable allylic epoxide (I), in which C-5 and C-7 have resonance stabilized partial carbocation character. Although nucleophilic attack at C-7 can take place from both sides of the system, only the rear attack introducing an axial oriented substituent is operative. A possible explanation of this apparent stereospecificity is based on the assumption that the nucleophilic attack occurred actually at C-5 from the rear, less hindered side; allylic rearrangement of the intermediate unsaturated ester (II) could eventually lead to the final product (**5a**).

Acetylation of (**5a**) under very mild conditions (−10 °C for 48 h) afforded a 2:1 mixture of the equatorial 4-monoacetate (**5b**) and the axial equatorial 3,4-diacetate (**5c**). Of the two axial hydroxy groups, the 1α-OH is more hindered than the 3α-OH; at room and higher temperature, mixtures of di- and tri-acetates were obtained. Acetylation was complete when conducted at 80 °C for 12 h.

The $^1$H n.m.r. spectrum of compound (**5a**) is characterized by the presence of three narrow multiplets due to the resonances of 1β-H (δ 3.75), 3β-H (δ 4.13), and 4β-H (δ 4.37). The assignments are confirmed by suitable shifts in the mono-, di-, and tri-acetates (**5b**—**d**) and by double resonance experiments. Upon irradiation at the frequency of 3-H, the signal of 4-H becomes a slightly broadened singlet; concomitantly, the signals of the methylene protons at C-2 (apparent double triplets at δ 1.93 and 2.23) are converted into double doublets with couplings of 2.5 Hz due to the interaction with 1β-H, thus pointing to the equatorial orientation of this proton. Conversely, upon irradiation at the frequency of 1β-H, the C-2 methylene protons become double doublets with couplings of 3 Hz due to the interaction with the equatorial 3β-H.




The equatorial orientation of the 4-hydroxy group was further confirmed by formation of a 3α,4α-acetonide (**6a**), characterized in the $^1H$ n.m.r. spectrum by signals for two additional tertiary methyl groups at δ 1.21 and 1.29. Acetylation of (**6a**) took place under rather drastic conditions (acetic anhydride–pyridine, 20 h, 80 °C) to give only a monoacetate (**6b**).

The final proof for the location of the double bond in (**5a**) [$\Delta^5$ or eventually $\Delta^6$ as required by structure (II)] was obtained by $^{13}C$ n.m.r. spectroscopy. In addition to the ester type carbonyl carbon (δ 165.22, s), the off-resonance decoupled spectrum disclosed in the lowfield region the presence of 8 $sp^2$ carbons, three singlets and five doublets, as required by structure (**5a**): δ 146.08 (s, C-5), 121.10 (d, c-6); aromatic carbons, 132.59 (s, C-1′), 129.72 (d, C-2′ + C-5′), 134.53 (s, C-3′), 132.81 (d, C-4′), and 127.73 (d, C-6′). The alternative structure (II) would have required two singlets and six doublets.

The axial orientation of the 7-chlorobenzoyloxy substituent is confirmed by the small coupling constant between 7-H and

8β-H. The signals of 6-H and 7-H in (**5a**) appear as a double doublet (*J* 6 and 1.5 Hz) at δ 6.35 for the former and an unresolved multiplet ($W_{\frac{1}{2}}$ 12 Hz) at δ 5.31 for the latter. Upon irradiation at the frequency of 7-H, the signal of 6-H becomes a doublet (*J* 1.5 Hz) due to allylic coupling with 4β-H; the signal of 4β-H becomes a double doublet (*J* 3.5 and 1.5 Hz) due to coupling with 3β-H and 6-H, respectively; the signal of 8β-H (δ 1.69) becomes a triplet (*J* 11.5 Hz) due to coupling with its two axial neighbours, 9α-H and 14α-H.

After irradiation at the frequency of 6-H, the signal of 7-H becomes a narrow multiplet ($W_{\frac{1}{2}}$ 4 Hz), thus pointing not only to an interaction with the vicinal 8β-H but also to a homoallylic interaction with 4β-H. Indeed, irradiation at the frequency of 4β-H transformed the signal of 6-H into a doublet (*J* 6 Hz) and that of 7-H into a double doublet (*J* 6, 4 Hz). The size of the coupling between 7-H and 8β-H (4 Hz) was confirmed by irradiation of 8β-H which determined the appearance of 7-H as double doublet (*J* 6, 1.5 Hz).

Similar results were obtained by decoupling the $^1$H n.m.r. spectrum of the acetonide (**6a**). The small conformational distortion due to the 1,3-dioxolane ring in (**6a**) cancelled the homoallylic coupling between 4β-H and 7-H. Upon irradiation at the frequency of 6-H, the 7-H signal becomes a doublet (*J* 2.7 Hz) due to coupling with 8β-H only.

The small coupling constants between 7-H and 8β-H in these compounds are in agreement with an equatorial axial interaction, as required by a 7α-*m*-chlorobenzoyloxy substituent.

As expected, the allylic and homoallylic couplings referred to above are missing in compounds (**11**) and (**12**) in which 4-H is equatorial (4α-H).

The stereochemistry of the epoxidation of $\Delta^5$ in compounds (**5a**) and (**6a**) is influenced by the two groups flanking the double bond. The directing effect of the equatorial 4α-hydroxy group is weaker than the hindrance of the axial 7α-*m*-chlorobenzoyloxy group and, consequently, a 5:1 mixture of the 5β,6β-(**7**) and 5α,6α-epoxide (**8**) is obtained on treatment of (**5a**) with *m*-chloroperbenzoic acid.

Epoxidation of (**6a**) gives only the 5β,6β-epoxide (**9**) due to the strong hindrance to the rear approach of the epoxidizing agent.

The structures assigned to these compounds are confirmed by their n.m.r. spectra. In compound (**7**) the signal of 6α-H is a doublet (*J* 3.5 Hz, at δ 3.80) and that of 7β-H, an apparent triplet (*J* 3 Hz, at δ 5.52). Irradiation at δ 3.80 converts the 7-H signal into a narrow doublet (*J* 2.2 Hz, due to coupling with 8β-H).

In compound (**8**), 6β-H gives rise to a doublet (*J* 4.4 Hz, at δ 3.65) and 7β-H to an apparent triplet (*J* 5.4 Hz at δ 5.26). Irradiation of 6β-H transforms the signal of 7-H into a doublet (*J* 5.9 Hz).

There is indeed a significant difference between the equatorial axial interactions 7β-H, 8β-H as reflected in the corresponding coupling constants in these two compounds. This is probably due to the difference between the conformations of ring B. This view is supported by comparing the corresponding signals in compounds (**7**), (**9**), and (**15**) with those found in compounds (**8**) and (**16**). A coupling constant of 5 Hz between 7β-H and 8β-H was also found in a derivative of a natural compound possessing a 5α,6α-epoxy-7α-acetoxy substitution pattern.[6]

In order to confirm that the axial 3α-hydroxy group in (**4**) influences the stereochemistry of the epoxidation of the 4,6-diene system, the related 3β-hydroxycholesta-4,6-diene (**10**)[7] was similarly treated with *m*-chloroperbenzoic acid. As in the previous case, the initial attack takes place only at the trisubstituted double bond. The structures of the two compounds (**11a**) and (**12**) which were obtained in this reaction in a ratio of *ca.* 5:1 can be eventually rationalized by assuming the formation of an initial unstable 4β,5β-oriented epoxide which undergoes nucleophilic attack at C-7 to give the mixture of 7β- and 7α-allylic *m*-chlorobenzoates (**11**) and (**12**), respectively.

Size of the coupling between 7-H and 8β-H in several compounds

| Compound | Configuration | Coupling (Hz) |
|---|---|---|
| (**5a**) | $\Delta^5$, 7β-H | 4.0 |
| (**6a**) | $\Delta^5$, 7β-H | 2.8 |
| (**11a**) | $\Delta^5$, 7α-H | 8.6 |
| (**11b**) | $\Delta^5$, 7α-H | 9.0 |
| (**12**) | $\Delta^5$, 7β-H | 4.7 |
| (**7**) | 5β,6β-epoxy; 7β-H | 2.2 |
| (**9**) | 5β,6β-epoxy; 7β-H | 2.7 |
| (**15**) | 5β,6β-epoxy; 7β-H | 2.7 |
| (**8**) | 5α,6α-epoxy; 7β-H | 5.9 |
| (**16**) | 5α,6α-epoxy; 7β-H | 5.7 |
| (**13**) | 5β,6β-epoxy; 7α-H | 9.2 |
| (**14**) | 5α,6α-epoxy; 7α-H | 7.1 |

The structures of (**11**) and (**12**) were determined by n.m.r. spectroscopy. The signals of 3α-H and 4α-H, respectively, are similar in both compounds. Decouplings were performed with compound (**11a**): upon irradiation at the frequency of 3-H, the signal of 4-H becomes a singlet; conversely, irradiation at the frequency of 4-H transforms the signal of 3-H into a double doublet (*J* 10.2 and 4.2 Hz) thus confirming the axial orientation of 3α-H. The signal of 6-H is a doublet, δ 5.62 (*J* 2.3 Hz) and that of 7-H is a double doublet, δ 5.29 (*J* 8.6 and 2.3 Hz). On irradiation of 6-H, the signal of 7-H becomes a doublet (*J* 8.6 Hz), thus confirming its axial orientation (7α-H, 8β-H coupling).

Epoxidation of the allylic *m*-chlorobenzoate (**11a**) afforded a 1:1 mixture of 5β,6β- and 5α,6α-epoxides [(**13a**) and (**14a**), respectively]. Under similar conditions, the stereoisomeric *m*-chlorobenzoate (**12**) gave a 4:1 mixture of the 5β,6β- and 5α,6α-epoxides [(**15a**) and (**16a**) respectively].

The ratio between the stereoisomeric epoxides in each pair reflects the influences of the functional groups on the two sides of the double bond. In compound (**11a**), the 7β-equatorial *m*-chlorobenzoate hinders to some extent the β-approach of the reagent, whereas the 7α-axial *m*-chlorobenzoate in (**12**) strongly hinders the rear approach. In both cases, the common denominator is the 4β-axial hydroxy group which directs the epoxidizing agent from the β-side.

## Experimental

M.p.s were taken with a Fisher-Johns apparatus. $^1$H N.m.r. spectra were determined at 80 MHz on a Varian FT-80A and at 270 or 300 MHz on Bruker WH instruments. $^{13}$C N.m.r. spectra were determined at 22.63 MHz on a WH-90 instrument for *ca.* 5% solutions in deuteriochloroform containing tetramethylsilane. Column chromatography was done on silica gel 60, 230—400 mesh (Merck); t.l.c. was carried out on plates of silica gel 60 $F_{254}$ (Merck); preparative chromatoplates (1 mm thick) were prepared with silica gel $PF_{254}$ (Merck). Analyses were performed in the microanalytical laboratory of the Weizmann Institute, under the direction of Mr. R. Heller.

7α-m-*Chlorobenzoyloxy*-1α,3α,4α-*trihydroxycholest*-5-*ene* (**5a**).—To a solution of 1α,3α-dihydroxycholesta-4,6-diene (**4a**) (1.65 g) in dry benzene (50 ml), a solution of 85% *m*-chloroperbenzoic acid (0.66 g; 1.1 equiv.) in dry benzene (40 ml) was added, and the solution was kept overnight at room temperature. After being washed with 5% aqueous $Na_2CO_3$ and with water, the solution was dried, the solvent was removed under reduced pressure, and the crude product (one major spot

on a chromatoplate) crystallized from ethyl acetate, m.p. 175—177 °C, $[\alpha]_D$ −174.5° (*c* 0.1) (Found: C, 71.3; H, 8.7. $C_{34}H_{49}ClO_5$ requires C, 71.2; H, 8.6%).

Acetylation of (**5a**) (85 mg) with acetic anhydride (0.8 ml) and pyridine (1 ml) at −10 °C for 48 h afforded a mixture of mono- (**5b**) and diacetate (**5c**) that was separated on a 20 × 40 cm preparative chromatoplate in toluene–ethyl acetate (3:4). Extraction of the lower band gave 7α-*m*-chlorobenzoyloxy-4α-acetoxy-1α,3α-dihydroxycholest-5-ene (**5b**) (51 mg), m.p. 89—90 °C (from methanol), $[\alpha]_D$ −121° (*c* 0.1) (Found: C, 70.3; H, 8.6. $C_{36}H_{51}ClO_6$ requires C, 70.3; H, 8.4%). The upper band gave 3α,4α-diacetoxy-7α-*m*-chlorobenzoyloxy-1α-hydroxycholest-5-ene (**5c**) (27 mg). The compound could not be crystallized. A similar *acetylation* conducted at 80 °C for 12 h gave the triacetate (**5d**). The compound was purified on a preparative chromatoplate but it could not be crystallized.

*Reaction of* (**5a**) *with Acetone to give the Acetonide* (**6a**).—To a solution of (**5a**) (60 mg) in acetone (20 ml), 10 drops of aqueous 2M-$H_2SO_4$ were added and the solution was kept overnight at room temperature. Most of the solvent was then removed, water was added, and the precipitate was filtered off, washed and crystallized from hexane. 7α-*m*-Chlorobenzoyloxy-1α-hydroxy-3α,4α-isopropylidenedioxycholest-5-ene (**6a**) (57 mg) had m.p. 101—103 °C, $[\alpha]_D$ −183.8° (*c* 0.1) (Found: C, 72.4; H, 8.6. $C_{37}H_{53}ClO_5$ requires C, 72.5; H, 8.7%).

Acetylation of (**6a**) (210 mg) with acetic anhydride (3 ml) and pyridine (3.5 ml) at 80 °C for 20 h afforded the 1α-monoacetate (**6b**) (178 mg) which was purified on preparative chromatoplates. The compound could not be crystallized.

Epoxidation of (**6a**) (200 mg) as described for compound (**4a**), gave 7α-*m*-chlorobenzoyloxy-1α-hydroxy-3α,4α-isopropylidenedioxy-5β,6β-epoxycholestane (**9**) (182 mg), which was purified on a preparative chromatoplate. The compound could not be crystallized.

*Epoxidation of* (**5a**). The reaction was carried out with (**5a**) (115 mg) as described for compound (**4a**). The crude product showed two major spots on a chromatoplate. Separation was achieved by flash column chromatography on silica gel 60. Elution with ethyl acetate–dichloromethane (1:4) gave 7α-*m*-chlorobenzoyloxy-1α,3α,4α-trihydroxy-5β,6β-epoxycholestane (**7**) (56 mg), m.p. 194—196 °C (from methanol), $[\alpha]_D$—11.5° (*c* 0.15) (Found: C, 67.3; H, 8.4. $C_{34}H_{47}ClO_6 \cdot H_2O$ requires C, 67.5; H, 8.2%). Further elution with ethyl acetate—dichloromethane (2:3) gave 7α-*m*-chlorobenzoyloxy-1α,3α,4α-trihydroxy-5α,6α-epoxycholestane (**8**) (12 mg) as an oil which could not be crystallized.

*Reaction of* 3β-*Hydroxycholesta*-4,6-*diene*[7] (**10**) *with* m-*Chloroperbenzoic Acid*.—The reaction was carried out with compound (**10**) (1 g) as described above. The crude product obtained after removing the solvent showed two major spots on a chromatoplate. Separation was achieved on preparative chromatoplates (toluene–ethyl acetate, 3:4). Extraction of the lower band gave 7α-*m*-chlorobenzoyloxy-3β,4β-dihydroxycholest-5-ene (**12**) (155 mg), m.p. 142—144 °C (from methanol), $[\alpha]_D$ −147.5° (*c* 0.1) (Found: C, 73.7; H, 8.9. $C_{34}H_{49}ClO_4$ requires C, 73.3; H, 8.9%). Extraction of the upper band gave 7β-*m*-chlorobenzoyloxy-3β,4β-dihydroxycholest-5-ene (**11a**) (590 mg), which was acetylated to give the corresponding 3β,4β-

**Table.** N.m.r data*

| Compound | 1-H | 3-H | 4-H | 6-H | 7-H | 18-H | 19-H | Other signals |
|---|---|---|---|---|---|---|---|---|
| (**5a**) | 3.75m ($W_{\frac{1}{2}}$ 7) | 4.13m ($W_{\frac{1}{2}}$ 8) | 4.37m ($W_{\frac{1}{2}}$ 8) | 6.35dd (6.0; 2.0) | 5.31m ($W_{\frac{1}{2}}$ 12) | 0.70s | 0.09s | |
| (**5b**) | 3.74m ($W_{\frac{1}{2}}$ 6) | 4.22m ($W_{\frac{1}{2}}$ 7) | 5.64m ($W_{\frac{1}{2}}$ 7) | 6.01dd (5.9; 2.0) | 5.31m ($W_{\frac{1}{2}}$ 12) | 0.69s | 1.09s | 2.18 acetate |
| (**5d**) | 4.96m ($W_{\frac{1}{2}}$ 6) | 5.30m ($W_{\frac{1}{2}}$ 7) | 5.65m ($W_{\frac{1}{2}}$ 7) | 6.00dd (5.5; 1.7) | 5.37m ($W_{\frac{1}{2}}$ 12) | 0.69s | 1.20s | 1.76, 2.09 2.10 acetates |
| (**6a**) | 3.73m ($W_{\frac{1}{2}}$ 8) | 4.34m ($W_{\frac{1}{2}}$ 11) | 4.64m ($W_{\frac{1}{2}}$ 11) | 6.49dd (5.6; 2.1) | 5.34m ($W_{\frac{1}{2}}$ 11) | 0.70s | 0.92s | 1.21, 1.29 acetonide methyls |
| (**6b**) | 4.89m ($W_{\frac{1}{2}}$ 6) | 4.23m ($W_{\frac{1}{2}}$ 11) | 4.64m ($W_{\frac{1}{2}}$ 10) | 6.41m ($W_{\frac{1}{2}}$ 10) | 5.29m ($W_{\frac{1}{2}}$ 12) | 0.68s | 0.98s | 1.96 acetate 1.20, 1.29 acetonide methyls |
| (**7**) | 3.77m ($W_{\frac{1}{2}}$ 9) | 4.30m ($W_{\frac{1}{2}}$ 7) | 4.09d (3) | 3.80d (3.5) | 5.52t (3) | 0.69s | 1.04s | |
| (**8**) | 3.88m ($W_{\frac{1}{2}}$ 8) | 4.11m ($W_{\frac{1}{2}}$ 11) | 3.99m ($W_{\frac{1}{2}}$ 13) | 3.65d (4.4) | 5.26t (5) | 0.65s | 1.06s | |
| (**9**) | 3.81m ($W_{\frac{1}{2}}$ 14) | 4.52m ($W_{\frac{1}{2}}$ 12) | 4.28d (5.1) | 3.88d (3.1) | 5.53t (2.7) | 0.67s | 0.95s | 1.21, 1.25 acetonide methyls |
| (**11a**) | | 3.56m ($W_{\frac{1}{2}}$ 21) | 4.14d (3.1) | 5.62d (2.3) | 5.29dd (8.6; 2.3) | 0.73s | 1.30s | |
| (**11b**) | | 4.75dt (12.4; 3.4) | 5.52d (2.3) | 5.73d (2.3) | 5.30dd (9.0; 2.3) | 0.73 | 1.27s | 2.00, 2.07 acetates |
| (**12**) | | 3.60dt (11.6; 3.5) | 4.17d (3.5) | 5.94d (4.7) | 5.29t (4.7) | 0.70s | 1.24s | |
| (**13b**) | | 5.03dt (12.0; 3.7) | 4.57d (3.7) | 3.17s | 4.98d (7.5) | 0.65s | 1.32s | 1.99, 2.13 acetates |
| (**14b**) | | 4.84dt (11.8; 3.1) | 4.81d (2.1) | 3.44d (1.0) | 5.11dd (9.2; 1.0) | 0.68s | 1.23s | 1.98, 2.12 acetates |
| (**15**) | | 3.60dt (10.8; 3.6) | 3.34d (3.6) | 3.31d (2.9) | 5.47t (2.9) | 0.66s | 1.21s | |
| (**16**) | | 3.83dt (11.4; 4.4) | 3.22d (3.1) | 3.53d (3.8) | 5.28dd (5.7; 3.8) | 0.64s | 1.28s | |

* Recorded in $CDCl_3$ at 270 or 300 MHz. The spectra of compound (**6b**) was taken at 80 MHz. The aromatic signals in all compounds are at δ 7.3—8.0. Signals recorded as δ values; coupling constants or signal widths ($W_{\frac{1}{2}}$, Hz) are in parentheses.

diacetate (**11b**), m.p. 190—191 °C (from methanol), $[\alpha]_D$ +42.5° (*c* 0.1) (Found: C, 71.4; H, 8.4. $C_{38}H_{53}ClO_6$ requires C, 71.2; H, 8.3%).

*Reaction of* 7β-m-*Chlorobenzoyloxy*-3β,4β-*dihydroxycholest*-5-*ene* (**11a**) *with* m-*Chloroperbenzoic Acid*.—The reaction was carried out with (**11a**) (300 mg) as described above. An inseparable mixture of 7β-*m*-chlorobenzoyl-3β,4β-dihydroxy-5α,6α-epoxyoxycholestane (**14a**) and 7β-*m*-chlorobenzoyl-3β,4β-dihydroxy-5β,6β-epoxyoxycholestane (**13a**) (53:47 by integration of the n.m.r. spectrum) was obtained. Acetylation gave the corresponding diacetates (**14b**) and (**13b**). Separation was achieved on preparative chromatoplates (toluene–ethyl acetate, 9:1). Extraction of the lower band gave 3β,4β-diacetoxy-7β-*m*-chlorobenzoyloxy-5α,6α-epoxycholestane (**14b**) (108 mg). Extraction of the upper band gave 3β,4β-diacetoxy-7β-*m*-chlorobenzoyloxy-5β,6β-epoxycholestane (**13b**) (103 mg).

Neither of these compounds could be crystallized. The configurational assignments are based on the pattern of the 6-H signal in the $^1$H n.m.r. spectra (see Table).

*Reaction of* 7α-m-*Chlorobenzoyloxy*-3β,4β-*dihydroxycholest*-5-*ene* (**12**) *with* m-*Chloroperbenzoic Acid*. The reaction was carried out with (**12**) (70 mg). After removal of the solvent, the crude product showed two major spots on a chromatoplate. Separation was achieved on preparative chromatoplates (toluene–ethyl acetate 11:9). Extraction of the lower band gave 7α-*m*-chlorobenzoyloxy-3β,4β-dihydroxy-5α,6α-epoxycholestane (**16**) (9 mg), and that of the upper band gave 7α-*m*-chlorobenzoyloxy-3β,4β-dihydroxy-5β,6β-epoxycholestane (**15**) (36 mg). The compounds could not be crystallized; the assignments are based on the 6-H signal in their $^1$H n.m.r. spectra (see Table).

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