Studies on Conformation and Reactivity. Part XII.[1] Acetolysis and Stereospecific Rearrangement of 4-Bromocholest-4-en-3-one

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Treatment of 4-bromocholest-4-en-3-one (I) with potassium acetate in boiling acetic acid affords a mixture containing the product of normal displacement at C(4) [4-acetoxycholest-4-en-3-one (IV)], products of S_N2' displacement at C(6) and C(2) [6β-acetoxy- (VII) (major product) and 2α-acetoxy- (V) cholest-4-en-3-ones], and 4-hydroxycholest-4-en-3-one (II), cholesta-4,6-dien-3-one (III), and 5α-cholestane-3,6-dione (VI). Treatment of bromo-enone (I) with potassium acetate in absolute ethanol gives the 4-acetoxy-compound (IV) as the major product, two 6β-substituted products [(VII) and 6β-ethoxycholest-4-en-3-one (VIII)], the 4-hydroxy-compound (II), cholest-4-en-3-one (IX), 4-(3-oxocholest-4-en-4-yloxy)cholesta-4,6-dien-3-one (X), and an unidentified substance.

α-HALOGENO-KETONES, *e.g.*, 4β-bromo-3-oxo-5β-,[2] 2α-bromo-3-oxo-5α-,[3,4] 9α-bromo-11-oxo-,[5] and 17α-bromo-16-oxo-[6] steroids, frequently undergo nucleophilic displacement at an alternative or α′ position, with the enolic form of the ketone as intermediate. A similar reaction has been observed in a vinylogue of the α-bromo-ketone system; 6β-bromo-Δ⁴-3-ketones gave, under acetolytic conditions, 2α- and 2β-acetoxy-Δ⁴-3-ketones.[3,7-10] It was suggested[3] that the observed 6 ⟶ 2 shift might proceed *via* a dienol, which underwent two 1,3 bromine shifts. A similar rearrangement but in the opposite direction, *i.e.* 2 ⟶ 6, was observed with the 2-acetoxy-Δ⁴-3-ketone system, which, on acidic methanolysis, gave the corresponding 3,6-diketone.[11] Stork and White[12] found that in S_N2' reactions, the entering group approaches the allylic system on the same side as the leaving anion recedes. With ketones, stereochemical inversion of an initially produced compound can occur.

We considered that the bromine atom of 4-bromocholest-4-en-3-one[13] (I) might be reactive to acetolysis in spite of its vinylic character since the system might first isomerise to the βγ-unsaturated form (Ia) with the halogen atom at an allylic position. In fact the reaction resulted in a new stereospecific rearrangement of the substituent from C(4) to C(6) and C(2).

Acetolysis with Potassium Acetate in Acetic Acid or in Ethanol.—Acetolysis of the bromo-enone (I) with an excess of potassium acetate in boiling acetic acid gave six compounds (II)—(VII) lacking a bromine atom. The least polar product [(II); 4·1%] ($C_{27}H_{44}O_2$) was thought to contain a diosphenol system as indicated by u.v., i.r., and n.m.r. spectra, and was assigned as 4-hydroxycholest-4-en-3-one by comparison (mixed m.p., $[\alpha]_D$, u.v. and i.r. spectra) with an authentic specimen.[13b,14] In a similar way, five other more polar compounds were identified as cholesta-4,6-dien-3-one[15] [(III); 8·5%], 4-acetoxycholest-4-en-3-one[14b,16] [(IV); 11·6%], 2α-acetoxycholest-4-en-3-one[3,8a,14b] [(V); 14·5%], 5α-cholestane-3,6-dione[17] [(VI); 4·7%], and 6β-acetoxycholest-4-en-one[17,18] [(VII); 38·3%].

Acetolysis of the bromo-enone (I) in boiling anhydrous ethanol gave the 4-hydroxy- [(II); 7·8%], 4-acetoxy- [(IV); 19·4%], and 6β-acetoxy- [(VII); 5·3%] compounds, accompanied by four other products. One of these [(IX); 5·1%], was cholest-4-en-3-one.[19] Another (m.p. 71—72·5°; one spot on t.l.c.) showed u.v. and i.r. absorptions due to a keto-group, and the n.m.r. and mass spectra showed peaks assignable to an ethoxy-group. However, the mass spectrum suggested that the material was a mixture of two compounds, and it was not investigated further.

A third product (VIII) (6·7%) ($C_{29}H_{48}O_2$) had u.v. (237 nm)[20] and i.r. spectra characteristic of a Δ⁴-3-ketone system with a substituent at C(6). The n.m.r. spectrum showed peaks due to a vinylic 4-proton and an ethoxy-group, and a peak (τ 8·73) due to the C-19 protons deshielded by an electronegative group at the 6β-position. A multiplet (τ 6·23) with $W_{\frac{1}{2}}$ 6 Hz was

[1] Part XI, A. Miyake and M. Tomoeda, *J.C.S. Perkin I*, 1972, 663.

[2] (*a*) Y. Satoh, M. Mukoh, Y. Ogaki, T. Takahashi, T. Kimura, H. Aoki, and A. Hagitani, *Bull. Chem. Soc. Japan*, 1966, **39**, 855; (*b*) T. Takahashi, Y. Satoh, and A. Hagitani, *J. Chem. Soc. Japan*, 1968, **89**, 974.

[3] L. F. Fieser and M. A. Romero, *J. Amer. Chem. Soc.*, 1953, **75**, 4716.

[4] K. L. Williamson and W. S. Johnson, *J. Org. Chem.*, 1961, **26**, 4563.

[5] J. S. G. Cox, *J. Chem. Soc.*, 1960, 4508.

[6] W. F. Johns, *J. Org. Chem.*, 1963, **28**, 1616.

[7] D. H. R. Rivett and E. S. Wallis, *J. Org. Chem.*, 1950, **15**, 35.

[8] (*a*) F. Sondheimer, S. Kaufmann, J. Romo, H. Martinez and G. Rosenkranz, *J. Amer. Chem. Soc.*, 1953, **75**, 4712; (*b*) G. Rosenkranz, O. Mancera, and F. Sondheimer, *ibid.*, 1955, **77**, 145.

[9] R. L. Clarke, K. Dobriner, A. Mooradian, and C. M. Martini, *J. Amer. Chem. Soc.*, 1955, **77**, 661.

[10] P. N. Rao and L. R. Axelrod, *J. Amer. Chem. Soc.*, 1960, **82**, 2830.

[11] R. L. Clarke, *J. Amer. Chem. Soc.*, 1960, **82**, 4629.

[12] G. Stork and W. N. White, *J. Amer. Chem. Soc.*, 1953, **75**, 4119.

[13] (*a*) J. I. Shaw and R. Stevenson, *J. Chem. Soc.*, 1955, 3549; (*b*) B. Camerino, B. Pattelli, A. Vercellone, and F. Media, *Il. Farmaco (Pavia), Ed. Sci.*, 1956, **11**, 586.

[14] (*a*) D. J. Collins, *J. Chem. Soc.*, 1959, 3919; (*b*) M. Tomoeda, M. Ishizaki, H. Kobayashi, S. Kanatomo, T. Koga, M. Inuzuka, and T. Furuta, *Tetrahedron*, 1965, **21**, 733.

[15] (*a*) F. Sondheimer and G. Rosenkranz, *Experientia*, 1953, **9**, 62; (*b*) P. N. Rao, *J. Org. Chem.*, 1961, **26**, 2149.

[16] L. F. Fieser and R. Stevenson, *J. Amer. Chem. Soc.*, 1954, **76**, 1728.

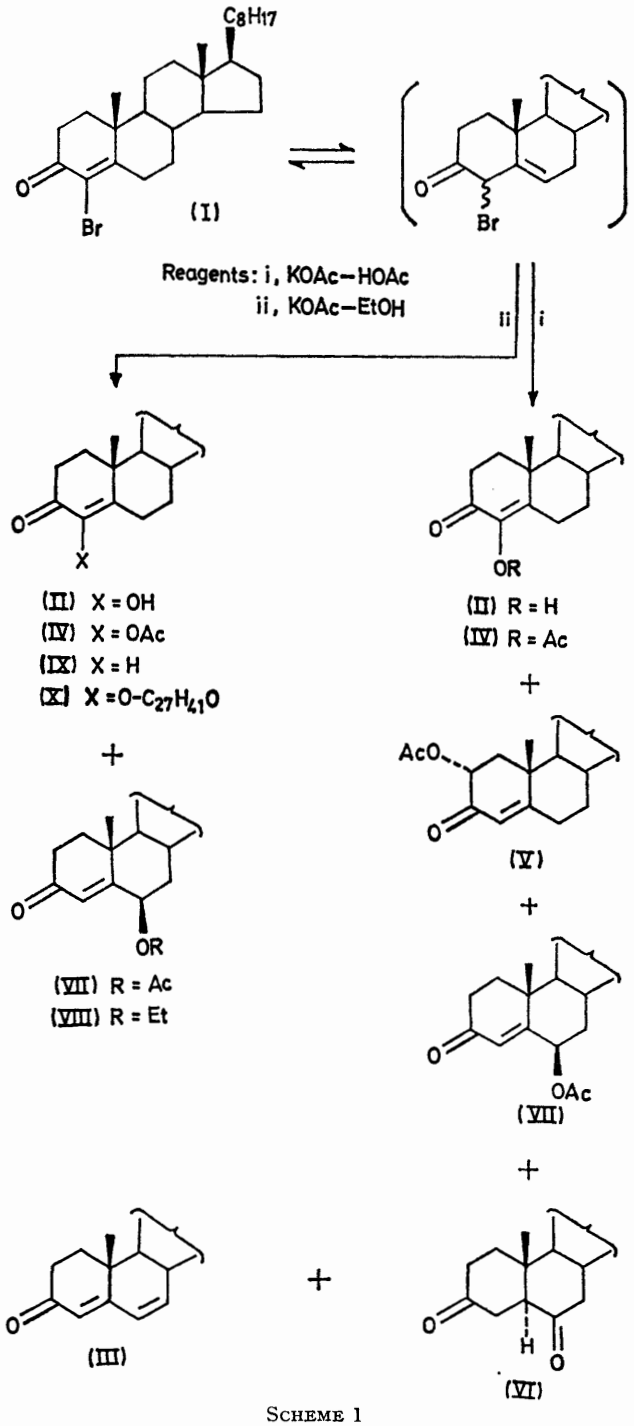
[17] L. F. Fieser, *J. Amer. Chem. Soc.*, 1953, **75**, 4377.

[18] C. Amendolla, G. Rosenkranz, and F. Sondheimer, *J. Chem. Soc.*, 1954, 1226.

[19] J. F. Eastham and R. Teranishi, *Org. Synth.*, 1955, **35**, 39.

[20] (*a*) C. W. Bird, R. C. Cookson, and S. H. Dandegaonker, *J. Chem. Soc.*, 1956, 3675; (*b*) K. Morita, *J. Chem. Soc. Japan*, 1957, **78**, 1581.

assigned to an equatorial 6α-proton.[21] The presence of an ethoxy-group was further supported by the (M^+ — EtOH) peak in the mass spectrum, and the data



SCHEME 1

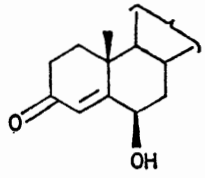
supported the identification of the compound (VIII) as 6β-ethoxycholest-4-en-3-one.

[21] (*a*) L. M. Jackman, 'Applications of Nuclear Magnetic Resonance Spectroscopy in Organic Chemistry,' Pergamon, London, 1959, p. 84; (*b*) T. Koga and M. Tomoeda, *Tetrahedron*, 1970, **26**, 1043.

The fourth product (X) (6·2%) ($C_{54}H_{84}O_3$) had u.v. (313 nm), i.r. (five absorptions between 1690 and 1576 cm^{-1}), and n.m.r. (AB quartet at τ 3·66) spectra which suggested the presence of both Δ^4- and $\Delta^{4,6}$-3-ketone systems. The n.m.r. spectrum futher exhibited a characteristic doublet (τ 6·96) with a large coupling constant assignable to a 6α-proton deshielded by an electronegative function at C(4).[22] The mass spectrum showed ($M^+ - C_{27}H_{42}O$) and ($M^+ - C_{27}H_{41}O_2$) peaks, suggesting a dimeric structure, and the compound was assigned as 4-(3-oxocholest-4-en-4-yloxy)cholesta-4,6-dien-3-one.

DISCUSSION

The reactions can be envisaged as proceeding *via* the 4-bromo-Δ^5-3-ketone (Ia), possibly with β or axial configuration[23] at C(4). The normal displacement of bromine by acetate ion or water at C(4) [route *a* in Scheme 2] gave the 4-acetoxy- (IV) or 4-hydroxy- (II) compounds.



(XI)

Formation of compounds (VII) and (VIII) and 6β-hydroxycholest-4-en-3-one (XI) with thermodynamically less stable axial 6β-substituents might be governed by stereoelectronic requirements[24] around C(6) favouring maximum overlap of the *p* orbital of the oxygen atom of the attacking nucleophile (OAc^-, EtOH, or H_2O) with the vacant *p* orbital at C(6), from the β or axial side (route *b*). The reaction is an example of an S_N2' displacement. In acetic acid, the 6β-hydroxy-compound (XI), once formed, might immediately isomerize to the 5α-3,6-dione (VI); in fact treatment of (XI)[17] with potassium acetate in boiling acetic acid gave (VI) in 95% yield. On the other hand, as expected, the 6β-acetate (VII) did not isomerize to its 6α-isomer under such acidic conditions, but was recovered unchanged.

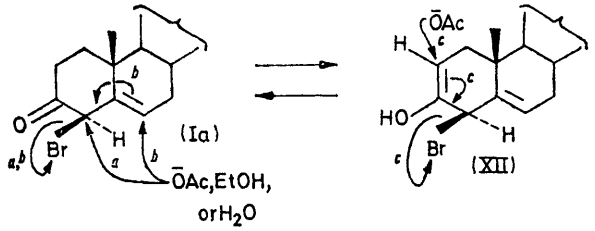
It is reasonable to assume that under acidic conditions, the keto-group of the intermediate (Ia) enolizes towards the 2-position, forming the enol (XII). Acetate ion could attack C(2) (route *c*) from the axial β-side to form

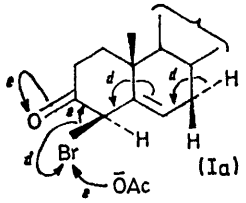
[22] (*a*) M. Tomoeda, M. Inuzuka, T. Furuta, and T. Takahashi, *Tetrahedron Letters*, 1964, 1233; (*b*) M. Tomoeda, M. Inuzuka, T. Furuta, M. Shinozuka, and T. Takahashi, *Tetrahedron*, 1968, **24**, 959.

[23] E. J. Corey, *J. Amer. Chem. Soc.*, 1953, **75**, 2301.

[24] (*a*) E. L. Eliel, 'Stereochemistry of Carbon Compounds,' McGraw-Hill, New York, 1962, pp. 139, 227, and 241; (*b*) E. L. Eliel, N. L. Allinger, S. J. Angyal, and G. A. Morrison, 'Conformational Analysis,' Wiley-Interscience, New York, 1965, pp. 72, 92, 291, and 307; (*c*) N. L. Allinger and E. L. Eliel (eds.), 'Topics in Stereochemistry,' Wiley-Interscience, New York, 1967, vol. 2, p. 163; (*d*) D. N. Kirk and M. P. Hartshorn, 'Steroid Reaction Mechanisms,' Elsevier, Amsterdam, 1968, pp. 157, 231, and 382.

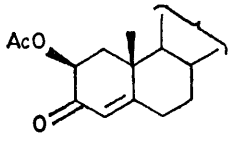
the thermodynamically less stable 2β-acetate (XIII), which might then isomerize to the more stable equatorial 2α-acetate (V). When acetolysis of 17-acetoxy-6β-bromotestosterone was stopped after *ca.* 12 min,





SCHEME 2

the less stable 2β-acetoxy-derivative could be isolated,[9,10] and this supports our proposed mechanism for the eventual formation of the 2α-acetoxy-compound (V).

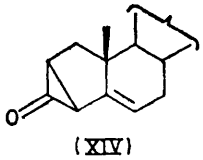


(XIII)

The 4,6-dien-3-one (III) might be derived from the 4-bromo-Δ^5-intermediate (Ia) by dehydrobromination (7-H and 4-Br) (route *d*).

Compound (IX) might be formed by abstraction of bromine by acetate ion (route *e*); a similar reaction has been reported for 3-*endo*-bromocamphor.[25] The mechanism of formation of the dimeric ether (X) is uncertain.

A cyclopropanone intermediate (XIV) might be involved in the reaction: this could give compounds (IV), (V), and (VII). However, the fact [2b] that an acetal derivative of a 4β-bromo-3-oxo-5β-steroid did not react under acetolytic conditions favours the enolization of the 3-oxo-group as the first and requisite step for the reaction.



(XIV)

EXPERIMENTAL

M.p.s were taken on a Kofler hot-stage apparatus. Optical rotation values were determined for solutions in $CHCl_3$, u.v. spectra were measured for solutions in 95% EtOH, and i.r. spectra for Nujol mulls, unless otherwise stated. N.m.r. spectra were measured for solutions in [^{2}H]chloroform on a Varian A-60 spectrometer or on a JEOL JNM C-60H instrument. Mass spectroscopic analysis was performed with a JEOL JMS-OlSG double-focusing spectrometer. Silica gel (Kanto Chemical Co.) was used for chromatographic separations. Known compounds were identified by comparison (mixed m.p., i.r. and u.v. spectra, and $[\alpha]_D$) with authentic samples.

4-*Bromocholest*-4-*en*-3-*one* (I).—This compound, synthesized by a slight modification of the literature [13] method, had m.p. 116·5—117·5° (from methanol), $\lambda_{max.}$ 263 nm (ε 11,800), $\nu_{max.}$ 1690s (C=O), 1571s cm^{-1} (C=C–Br), τ 6·72 (1H, d, *J* 14·5 Hz, 6α-H), 8·76 (3H, s, 19-H), and 9·28 (3H, s, 18-H).

Acetolysis of (I) *with Potassium Acetate in Acetic Acid.*—To a solution of (I) (19·0 g, 0·022 mol) in glacial acetic acid (400 ml), anhydrous KOAc (70·0 g, 0·713 mol) was added and the mixture was heated under reflux for 3·5 h. The reaction was almost complete in 3 h (t.l.c. and $\lambda_{max.}$ 263 nm). The yellow mixture was cooled and poured into ice–water to deposit crystals. These were dissolved in ether, and the solution was washed with H_2O, saturated aqueous $NaHCO_3$, and H_2O, then dried (Na_2SO_4). Concentration of the filtrate *in vacuo* gave a yellow oil (9·5 g), which was chromatographed over silica gel (1200 g). Elution with petroleum–benzene (1 : 4) (3600 ml) gave 4-hydroxycholest-4-en-3-one (II) as needles (352 mg, 4·1%), m.p. and mixed m.p. [13b,14] 150—151° (from methanol), τ 3·91 (1H, s, 4-OH), 6·97 (1H, d, *J* 14·5 Hz, 6α-H), 8·81 (3H, s, 19-H), and 9·28 (3H, s, 18-H), *m/e* 400·337 ($C_{27}H_{44}O_2$) (M^+).

Elution with benzene–ether (199 : 1) (3600 ml) gave cholesta-4,6-dien-3-one (III) as needles (702 mg, 8·5%), m.p. and mixed m.p.[15] 79·5—81° (from methanol).

Further elution with benzene–ether (199 : 1) (3600 ml) gave 4-acetoxycholest-4-en-3-one (IV) as needles (1·108 g, 11·6%), m.p. and mixed m.p. [14b,16] 104·5—105° (from methanol), τ 7·28 (1H, d, *J* 14·5 Hz, 6α-H), 7·76 (3H, s, 4-OAc), 8·76 (3H, s, 19-H), and 9·28 (3H, s, 18-H), *m/e* 442·341 ($C_{29}H_{46}O_3$) (M^+).

Further elution with benzene–ether (199 : 1) (7600 ml) gave 2α-acetoxycholest-4-en-3-one (V) as needles (1·387 g, 14·5%), m.p. and mixed m.p. [3,9a,14b] 140·5—141·5° (from methanol), τ 4·26 (1H, s, 4-H), 4·56 (1H, q, $J_{2\beta,1\alpha}$ 14 Hz, $J_{2\beta,1\beta}$ 6 Hz, 2β-H), 7·82 (3H, s, 2α-OAc), 8·70 (3H, s, 19-H), and 9·29 (3H, s, 18-H), *m/e* 442·340 ($C_{29}H_{46}O_3$) (M^+).

Further elution with benzene–ether (199 : 1) (4400 ml) gave needles (608 mg), m.p. 158—171°, which were rechromatographed over silica gel (350 g). Elution with benzene–ether (49 : 1) (1620 ml) gave 5α-cholestane-3,6-dione (VI) as prisms (406 mg, 4·7%), m.p. and mixed m.p.[17] 175—176·5° (from ethyl acetate), u.v. end absorption at 210 (ε 900), $\lambda_{max.}$ 286 nm (55), τ 9·04 (3H, s, 19-H) and 9·31 (3H, s, 18-H), *m/e* 400·336 ($C_{27}H_{44}O_2$) (M^+).

Further elution with benzene–ether (199 : 1) (26,400 ml) gave 6β-acetoxycholest-4-en-3-one (VII) as needles (3·658 g, 38·3%), m.p. and mixed m.p. [17,18] 103·5—104·5° (from methanol), τ 4·08 (1H, s, 4-H), 4·59 (1H, m, $W_{\frac{1}{2}}$ 6 Hz, 6α-H), 7·98 (3H, s, 6β-OAc), 8·72 (3H, s, 19-H), and 9·24 (3H, s, 18-H), *m/e* 442·343 ($C_{29}H_{46}O_3$) (M^+).

Acetolysis of (I) *with Potassium Acetate in Ethanol.*—To

[25] E. W. Warnhoff and W. D. Chambers, Abstracts 151st Meeting of the American Chemical Society, Division of Organic Chemistry, Pittsburgh, Penn., March, 1966.

a solution of (I) (10·0 g, 0·022 mol) in anhydrous EtOH (400 ml), anhydrous KOAc (70·0 g, 0·713 mol) was added and the mixture was heated under reflux for 40 min. A solid began to precipitate. The reaction was complete in 3·5 h (t.l.c. and $\lambda_{max.}$ 263 nm). The mixture was cooled, and was concentrated *in vacuo* to give a yellow residue. Work-up as before gave an orange oil (9·2 g). This was chromatographed over silica gel (1200 g). Elution with petroleum–benzene (1 : 3) (1600 ml) gave (II) as needles (672 mg, 7·8%), m.p. and mixed m.p.[13b,14] 150·5—151·5° (from methanol). Elution with benzene (2800 ml) gave needles (623 mg), m.p. 64—68°, which were rechromatographed over silica gel (190 g). Elution with benzene–ether (499 : 1) (1800 ml) gave prisms of an unidentified material (one spot on t.l.c., 567 mg), m.p. 71—72·5° (from methanol) (Found: C, 78·1, 78·0; H, 11·35, 11·35%), $[\alpha]_D^{17}$ −18·3° (*c* 1·04), $\lambda_{max.}$ 305 nm [O.D. (1% soln., 1 cm cell) 1·18], $\nu_{max.}$ 1731s cm^{-1} (C=O), τ 6·20—7·00 (4H, m, OCH_2CH_3), 8·78 (3H, t, *J* 7 Hz, OCH_2CH_3), 8·82 (3H, t, *J* 7 Hz, OCH_2CH_3), 9·27 (3H, s, 18-H), and 9·35 (3H, s, 18-H), *m/e* 446·413 ($C_{30}H_{54}O_2$) [$(M^1)^+$], 428·365 ($C_{29}H_{48}O_2$), [$(M^2)^+$], 400·369 ($C_{28}H_{48}O$) [$(M^1)^+ - C_2H_5OH$], 384·340 ($C_{27}H_{44}O$) [$(M^2)^+ - C_2H_4O$].

Elution with benzene (3200 ml) gave 6β-*ethoxycholest*-4-*en*-3-*one* (VIII) as needles (619 mg, 6·7%), m.p. 112·5—113° (from methanol) (Found: C, 81·1; H, 11·2. $C_{29}H_{48}O_2$ requires C, 81·25; H, 11·3%), $[\alpha]_D^{16}$ +35·6° (*c* 1·04), $\lambda_{max.}$ 237 nm (ε 14,200), $\nu_{max.}$ 3030w (C=C–H), 1692s (C=O), 1620m cm^{-1} (C=C), τ 4·23 (1H, s, 4-H), 6·23 (1H, m, $W_{\frac{1}{2}}$ 6 Hz, 6α-H), 6·43—6·98 (2H, m, 6β-OCH_2CH_3), 8·73 (3H, s, 19-H), 8·86 (3H, t, *J* 7 Hz, 6β-OCH_2CH_3), and 9·26 (3H, s, 18-H), *m/e* 428·367 ($C_{29}H_{48}O_2$) (M^+) and 382·322 ($C_{27}H_{42}O$) ($M^+ - C_2H_5OH$).

Further elution with benzene (4000 ml) gave needles (625 mg), m.p. 57—78°, which were rechromatographed over silica gel (240 g). Elution with benzene–ether (49 : 1) (880 ml) gave cholest-4-en-3-one (IX) as needles (420 mg, 5·1%), m.p. and mixed m.p.[19] 85—85·5° (from methanol) τ 4·35 (1H, s, 4-H), 8·82 (3H, s, 19-H), and 9·29 (3H, s, 18-H).

Further elution with benzene (19,200 ml) gave (IV) as needles (1·857 g, 19·4%), m.p. and mixed m.p.[14b,16] 104—105° (from methanol). Elution with benzene–ether (399 : 1) (7200 ml) gave 4-(3-*oxocholest*-4-*en*-4-*yloxy*)*cholesta*-4,6-*dien*-3-*one* (X) as plates (522 mg, 6·2%), m.p. 221—223° (from ethanol) (Found: C, 82·8; H, 10·6. $C_{54}H_{84}O_3$ requires C, 83·0; H, 10·85%), $\lambda_{max.}$ 313 nm (ε 23,100), $\nu_{max.}$ 3034w (C=C–H), 1690s (C=O), 1667s (C=O), 1626m, 1608m, and 1576s cm^{-1} (C=C), τ 3·34 (1H, d, J_{AB} 9 Hz, 6-H), 3·98 (1H, d, J_{AB} 9 Hz, 7-H), 6·96 (1H, d, *J* 14·5 Hz, 6α-H), 8·78 and 8·85 (3H each, s, 19-H), and 9·24 and 9·29 (3H each, s, 18-H), *m/e* 780·643 ($C_{54}H_{84}O_3$) (M^+), 398·316 ($C_{27}H_{42}O_2$) ($M^+ - C_{27}H_{42}O$), and 383·332 ($C_{27}H_{43}O$) ($M^+ - C_{27}H_{41}O_2$).

Elution with benzene–ether (99 : 1) (7600 ml) gave (VII) as needles (503 mg, 5·3%), m.p. and mixed m.p.[17,18] 103—104° (from methanol).

Treatment of 6β-*Hydroxycholest*-4-*en*-3-*one* (XI) *with Potassium Acetate in Acetic Acid: Isomerization of* (XI) *to* (VI).—To a solution of (XI)[17] (300 mg, 0·75 mmol) in glacial acetic acid (12 ml), anhydrous KOAc (2·38 g, 24·3 mmol) was added and the mixture was heated under reflux for 4 h. The reaction was complete in 2 h (t.l.c.). The mixture was cooled, and poured into ice–water to deposit crystals. These were worked up as before to give needles (298 mg), m.p. 151—167°, which were chromatographed over silica gel (45 g). Elution with benzene–ether (99 : 1) (510 ml) gave (VI) as needles (285 mg, 95·0%), m.p. and mixed m.p.[17] 175—176·5° (from ethyl acetate), u.v. end absorption at 210 (ε 960), $\lambda_{max.}$ 286 nm (55).

Treatment of (VII) *with Potassium Acetate in Acetic Acid.*—To a solution of (VII)[17,18] (500 mg, 1·13 mmol) in glacial acetic acid (20 ml), anhydrous KOAc (3·59 g, 36·6 mmol) was added. The mixture was refluxed for 4 h, cooled, and poured into ice–water, depositing crystals, which were worked up as usual. The product (493 mg), m.p. 83—97°, was chromatographed over silica gel (150 g). Elution with benzene–ether (49 : 1) (960 ml) gave unchanged starting material (VII) as needles (476 mg, 95·2%).

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