The NMR spectrum was determined by Mr. S. Shimokawa of School of Technology, Hokkaido University, and a part of the elementary analyses was carried out by the Shimotakaido Laboratory, Kowa Co., Ltd. to all of whom the authors' thanks are due.

Summary

1-Thio-2-deoxy-β-D-glucose sodium salt dihydrate (X), m.p. 114~115°, $[\alpha]_D^{15}$ +22° was prepared starting from 3,4,6-tri-O-acetyl-D-glucal (I) *via* 2-deoxy-3,4,6-tri-O-acetyl-D-glucopyranosyl bromide (VII) and 2-deoxy-3,4,6-tri-O-acetyl-β-D-glucopyranosyl ethylxanthate (VIII). The product afforded 2-deoxy-D-glucose anilide, benzyl 1-thio-2-deoxy-β-D-glucoside, m.p. 96~97°, $[\alpha]_D^{21}$ −242°, and benzyl 1-thio-2-deoxy-3,4,6-tri-O-acetyl-β-D-glucoside, m.p. 60~61°, $[\alpha]_D^{18}$ −192°. The optical rotatory dispersion of VIII reveals the similarity with that of 2,3,4,6-tetra-O-acetyl-β-D-glucopyranosyl ethylxanthate, which supports the β-configuration of VIII, together with that of the compounds derived from VIII.

Heating of I with thioacetic acid for 5.5 hours in the presence of a small amount of sulfuric acid, afforded crystals, m.p. 104~105°, $[\alpha]_D^{22}$ +164°, in 60% yield. The structure was assigned to be 1-S-acetyl-1-thio-2,3-didehydro-2,3-dideoxy-4,6-di-O-acetyl-α-D-*eryhtro*-hexose (II).

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101. Munemitsu Tomoeda, Manabu Inuzuka, Tetsuya Furuta,[*1] and Toshitaka Koga: Studies on Conformation and Reactivity. II.[*2] The Polyphosphoric Acid-catalyzed Ring Opening of 4,5-Epoxy-3-oxo Steroids. 2. The Synthesis of 4-Ethylthio-17β-acetoxyandrost-4-en-3-one and its Analogs.[*3]

(*Faculty of Pharmacy, Kanazawa University*[*4])

In the first paper of this series,[1] it has been revealed that polyphosphoric acid (PPA) can work as an efficient catalyst, when used in the presence of suitable nucleophiles, of both normal and abnormal ring opening[*5] of 4β-, 5-epoxy-5β-cholestan-3-one (I). In acetic acid, I afforded 2α-acetoxycholest-4-en-3-one (II) as the sole and abnormal product. Ethanethiol, in marked contrast, reacted with I in dioxane affording 4-ethylthiocholest-4-en-3-one (III), as the normal product, and a further product, 3,4-bis-(ethylthio)cholesta-3,5-diene (IV). A further interesting fact was observed that ethanedithiol and 2-mercaptoethanol reacted with I, affording cholesta-3,5-dieno [3,4-*b*] dithiane (V) and its oxathiane (VI) derivative respectively.

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*1 Present address: Research Laboratories, Yoshitomi Pharmaceutical Co., Ltd., Fukuoka.

*2 Part I: Tetrahedron, **21**, 733 (1965).

*3 Presented at the meeting of the Kinki-Blanch of the Pharmaceutical Society of Japan, Kyoto, on 18th January, 1964, and published in part, as a communication, in this Bulletin, **12**, 383 (1964).

*4 Takara-machi, Kanazawa (友枝宗光, 犬塚 学, 古田哲弥, 古賀俊隆).

*5 For definition of the terms "normal" and "abnormal" regarding the ring opening of 4,5-epoxy-3-oxo steroids, see ref. 1.

1) Part I[*2] of this series published by M. Tomoeda, M. Ishizaki, H. Kobayashi, S. Kanatomo, T. Koga, M. Inuzuka, and T. Furuta.

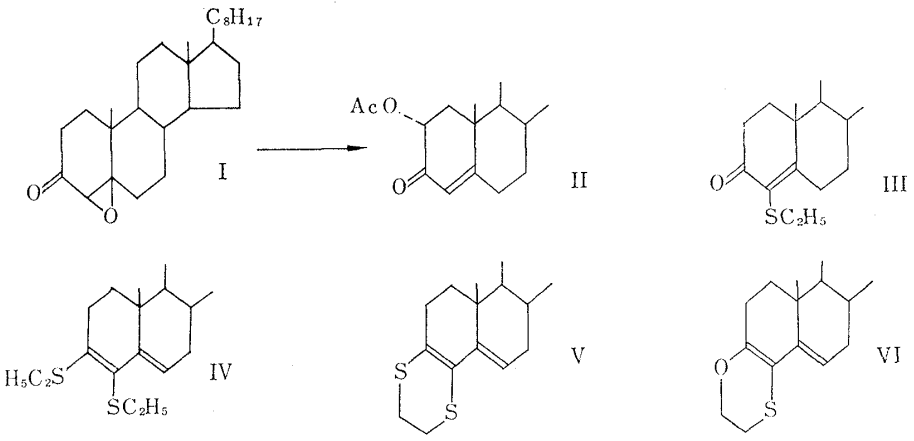


Chart 1.

It has thus been evident from these observations that under PPA catalysis mercapto groups can be selectively introduced at position 4 of 4,5-epoxy-3-oxo systems affording 4-thiosubstituted 4-en-3-oxo steroids. The present paper deals with the generalization of the reaction to the testosterone series with 17β-acetoxy-4,5-epoxyandrostan-3-one (Ⅶ) as starting material.

The epoxide (Ⅶ) was prepared from testosterone by the method of Camerino, *et al.*[2] Separation of the α and β isomers of the epoxide has also been reported by the same authors. For the present study, however, a mixture of these isomers possibly in the ratio of ca. 3:7,*[6] once crystallized from ether, was used without further recrystallization for the subsequent reactions.

Ethanethiol was firstly chosen as a nucleophilic reagent for the ring opening of the epoxide (Ⅶ). The epoxide (Ⅶ) was dissolved in a mixture of ethanethiol and PPA in dioxane and the reaction (room temperature) was followed by thin-layer chromatography; it was complete in 48 hr. Usual work up of the reaction mixture and chromatography of the pale yellow oily product on silica gel afforded 4-ethylthio-17β-acetoxyandrost-4-en-3-one (Ⅷ), the normal product of epoxide fission, and a further product, 17β-acetoxy-3,4-bis(ethylthio)androsta-3,5-diene(Ⅸ), accompanied by the third crystalline product, the structure of which was tentatively assigined as 4β-ethylthio-5α-hydroxy-17β-acetoxy-5α-androstan-3-one (Ⅹ), in 29.1%, 9.0%, and 7.7% yields respectively. The elemental analyses of these new thiosteroids were in agreement with the expected formulae, $C_{23}H_{34}O_3S$, $C_{25}H_{38}O_2S_2$, and $C_{23}H_{36}O_4S$ respectively. The spectroscopic evidence for the structure of Ⅷ is as follows: the ultraviolet absorption spectrum exhibits λ_{max} mμ (ε): 247 (13900), 314 (3200), and the infrared spectrum ν_{max} cm^{-1}: 1730 (s), 1672 (s), 1566 (m), which support the 4-ethylthio-substituted 4-en-3-oxo system.[1,4] The nuclear magnetic resonance spectrum does not show any peak in the olefinic proton region, but does show a triplet at τ 5.38 (J=8.0 c.p.s.), a doublet at τ 6.22 (J=14.5 c.p.s.),*[7] a multiplet at τ 7.13~7.62 and a singlet at τ 7.97 which can be assigned to $C_{17}\alpha$-H, $C_6\alpha$-H, and -S-CH_2- and $C_{17}\beta$-$OCOCH_3$ groups respectively. The positive sign of the specific rotation, $[\alpha]_D^{27.5}$ +96°, also corresponds to the 4-substituted 4-en-3-oxo steroids.[1,2]

*[6] It has been reported[3] that alkaline hydrogen peroxide oxidation reactions of 17-substituted 4-en-3-oxo steroids give the 4β-epoxide as the normal product, however, up to 30% of the α-epoxide is formed when an electron-attracting substituent such as hydroxyl is present at position 17.

*[7] For the assignment of the signal at τ 6.22, doublet, to the $C_6\alpha$-H, see M. Tomoeda, M. Inuzuka, T. Furuta, T. Takahashi: Tetrahedron Letters, **1964**, 1233.

2) B. Camerino, B. Pattelli, A. Vercellone: J. Am. Chem. Soc., 78, 3540 (1956).
3) H.B. Henbest: Proc. Chem. Soc., **1963**, 159.
4) J.M. Krämer, K. Brüchner, K. Irmscher, Karl-Heinz Bork: Ber., **96**, 2803 (1963).

The spectroscopic evidence for the structure of IX is as follows: the ultraviolet spectrum exhibits λ_{max} (ε) : 292 mμ (17500) and the infrared spectrum ν_{max} 1735 (s), and 1545 (w) cm^{-1}, which correspond not to the 3,5-bis(ethylthio)-4-ene system but to the 3,4-bis(ethylthio)substituted 3,5-diene system.[1,5] The negative sign of the specific rotation, $[\alpha]_D^{27}$ −227°, also corresponds to the 3,4-dithiosubstituted 3,5-diene system.[1,5]

The structures of VIII and IX were further proved chemically that treatment of VIII with ethanethiol in PPA-dioxane afforded IX.

Tentative assignment of the structure (X) for the third product is based on consideration of possible mechanisms involved in the reaction and also physical properties of the compound. It has been reported[1,2,6~8] that the ring opening at C-4 by S_N2 of 4β,5-epoxy-5β-3-oxo steroids always affords 4-substituted 4-en-3-oxo systems as products; it is thus apparent that the ring opening is followed by immediate dehydration of the

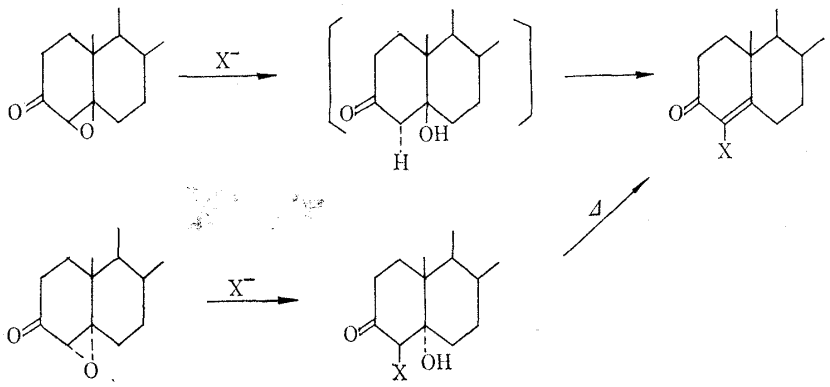


Chart 2.

remaining C_5-hydroxyl group. It has been noted,[2] however, that in the 4α,5-epoxy-5α-3-oxo systems, the ring opening by S_N2 at C-4 is not necessarily followed by the dehydration, and 4β-substituted 5α-hydroxy systems can be isolated as stable intermediate of the reaction. Added to the mechanistic consideration, the spectroscopic evidence of the compound, *i.e.* no intensive ultraviolet absorption due to any conjugated chromophore and the infrared spectrum ν_{max} 3468 (s) and 1702 (s) cm^{-1}, would be a support for assignment of the structure of the compound to be the saturated intermediate (X) of the ring opening of the 4α,5-epoxide present, if little, in the starting material (VII) used for the reaction. The nuclear magnetic resonance spectrum provides the evidence for $C_{17}\alpha$-H, and -S-CH_2- and $C_{17}\beta$-$OCOCH_3$ groups, showing a triplet at τ 5.35 (J=6.5 c.p.s.), a multiplet at τ 7.11~7.60 and a singlet at τ 7.93 for them respectively. The signal by 19-CH_3 appears at such lower field as τ 8.74; this might provide an evidence for the presence of the $C_4\beta$-ethylthio group giving a long-range deshielding effect*[7] to 19-CH_3. The signal by $C_4\alpha$-H has, however, remained not assigned in the spectrum; inspite of our original expectation that the proton would adopt its position at lower field than ca. τ 6.5,*[8] the spectrum appears not showing any characteristic signal for such proton at lower field than τ 7.0 except the triplet by $C_{17}\alpha$-H. We might suggest as a possible explanation that the signal in question would be at higher field than τ 7.0 being buried in the back ground due to cyclic methylenes in the compound,

*[8] It has been reported[5] that cyclic α-protons of methine type to a mercapto function appear at lower field than τ 6.5.

5) L. F. Fieser, C. Yuan, T. Goto: J. Am. Chem. Soc., 82, 1996 (1960).
6) Farmaceutici Italia Soc. Anon., Brit. Pat., 864,608 and 864,610 (1959).
7) Syntex S. A., Brit. Pat., 855,800 and 855,802 (1957).
8) J. I. Shaw, R. Stevenson: J. Chem. Soc., **1955**, 3549.

because of a net effect of shielding*9 by the 3-oxo group toward the proton which is equatorial. Study on further confirmation of the structure of the third product is underway.

Attention was then directed to the use of ethanedithiol and 2-mercaptoethanol as nucleophiles for the ring opening of the epoxide (Ⅶ). They reacted with Ⅶ in PPA-dioxane at room temperature, as expected, affording 17β-acetoxyandrosta-3,5-dieno-[3,4-*b*] dithiane (Ⅺ) and its oxathiane (Ⅻ) derivative in 20.8% and 63% yields respectively; No thioketalization was observed. The elemental analyses of these new thiosteroids were in agreement with the expected formulae, $C_{23}H_{32}O_2S_2$ and $C_{23}H_{32}O_3S$ respectively. The spectroscopic evidence for the structure of Ⅺ is as follows: the ultraviolet spectrum exhibits λ_{max} 240 (ε 12800) and 294 mμ (ε 14500), and the infrared spectrum ν_{max} 1718 (s) and 1565 (w) cm^{-1}, which correspond to the 3,5-dieno [3,4-*b*] dithiane system.[1,5] The nuclear magnetic resonance spectrum does show peaks at τ 4.08 (broad), τ 5.35 (broad), τ 6.83 (singlet), and τ 7.93 (singlet), which can be assigned to C_6-H (vinylic), $C_{17}\alpha$-H, and -S-CH_2CH_2-S- and $C_{17}\beta$-$OCOCH_3$ groups respectively. The negative sign of the specific rotation, $[\alpha]_D^{25}$ −188°, also supports the 3,4-dithiosubstituted 3,5-diene system in the compound.[1,5]

The spectroscopic evidence for the structure of Ⅻ is as follows: the ultraviolet spectrum λ_{max} 222 (ε 9100) and 270 mμ (ε 8500), and the infrared spectrum ν_{max} 1718 (s), 1636 (w), and 1615 (m) cm^{-1}, correspond to the 3,5-dieno [3,4-*b*] oxathiane system in the compound.[1,5] The nuclear magnetic resonance spectrum shows peaks at τ 4.50 (broad), τ 5.41 (triplet, J=7.0 c.p.s.), τ 5.65~5.96 (multiplet), τ 6.94~7.11 (multiplet), and τ 8.00 (singlet), which can be assigned to C_6-H (vinylic), $C_{17}\alpha$-H, and -O-CH_2-, -S-CH_2-, and $C_{17}\beta$-$OCOCH_3$ groups respectively. The negative sign of the specific rotation, $[\alpha]_D^{22}$ −185°, also supports the 3,5-diene system in the compound.

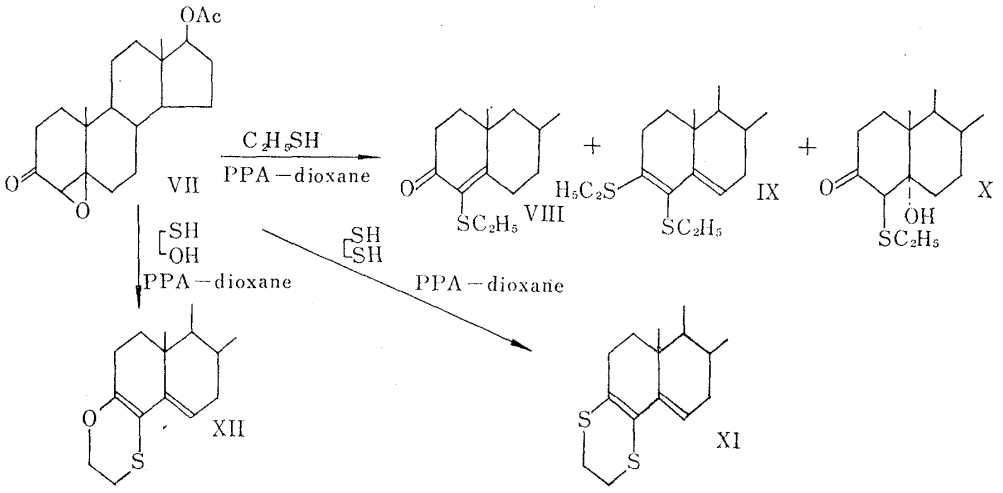


Chart 3.

The present study has thus revealed that the efficient catalytic action of PPA for the normal ring opening of the 4,5-epoxy-3-oxo system with alkylmercaptans as nucleophile could be generalized in the testosterone series, and that the reaction certainly represents a useful approach to the introduction of a thio-function at C-4 in biologically

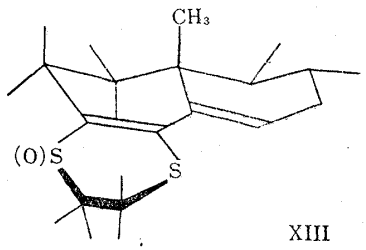
*9 It has been reported[9,10] that a carbonyl group in α-monohalogenated ketones can have the net effect of deshielding the remaining α-hydrogen when it is axial and of shielding it when it is equatorial.

9) A. Nickon, M. A. Castle, R. Harada, C. E. Borkoff, R. O. Williams: J. Am. Chem. Soc., 85, 2185 (1963).

10) K. M. Wellman, F. G. Bordwell: Tetrahedron Letters, 1963, 1703.

active 4-en-3-oxo steroids. With respect to machanisms involved in the reactions referred to in the present paper, they might, as has been discussed,[1] proceed mainly by S_N2 mechanism with rupture of the α-oxide bond. With ethanedithiol and 2-mercaptoethanol as reagents, the reactions start with attack of mercapto groups at C-4 and break of the α-oxide bond, in an analogous manner to the formation of Ⅷ with ethanethiol, followed by a spontaneous intramolecular cyclization at C-3, to form heterocycles, dithiane, and oxathiane, respectively.

In the previous paper,[1] we have dealt with the unique ultraviolet absorption spectra of cholesta-3,5-dieno [3,4-*b*] dithiane (Ⅴ) (240 and 292 mμ), and its oxathiane (Ⅵ) derivative (223 and 270 mμ), and have suggested that the first absorption bands at 240 mμ for Ⅴ and at 223 mμ for Ⅵ might be due to some unique conjugation present in the $-S-C_3=C_4-S-$ or $-O-C_3=C_4-S-$ systems in the conformationally rather fixed dithiane or oxathiane rings (XIII) in a half-chair conformation. It has now been proved that the dithiane (Ⅺ) and oxathiane (Ⅻ) of the testosterone series do exhibit the unique ultraviolet spectra of absolutely same type with two strong bands at 240 and 292 mμ and at 222 and 270 mμ respectively. The origin of these first bands for Ⅺ and Ⅻ would certainly be same with that in the cholestane series. Attempt at confirmation of the character of the absorption is still in progress.



XIII

Chart 4.

Experimental*10

PPA-Catalyzed Ring Opening of 17β-Acetoxy-4,5-epoxyandrostan-3-one (VII) with Ethanethiol : Formation of 4-Ethylthio-17β-acetoxy-androst-4-en-3-one (VIII), 17β-Acetoxy-3, 4-bis(ethylthio)androsta-3,5-diene (IX) and 4β-Ethylthio-5α-hydroxy-17β-acetoxy-5α-androstan-3-one (X)——The epoxide,[2] (m.p. 135～150°, UV λ_{max} : transparent above 215 mμ, IR ν_{max} cm^{-1} : 1716 (s)) (1.0 g.) was dissolved in a mixture of ethanethiol (4.0 ml.), PPA (4.0 g.) and dioxane (80 ml.) and the reaction mixture kept at room temperature for 48 hr. when the reaction was complete (thin-layer chromatography). The mixture was poured into ice-water depositing a solid which was extracted into ether, and the ethereal layer washed with sat. $NaHCO_3$ aq. and water, and dried (Na_2SO_4). Concentration of the filtrate afforded a pale yellow oil, (wt. 1.512 g.). This was chromatographed on silica gel (Davison Co.) (45 g.) when elution with benzene (840 ml.) afforded 17β-acetoxy-3,4-bis(ethylthio)androsta-3,5-diene (Ⅸ) as pale yellow crystals, (wt. 180 mg.). They were recrystallized from pet. ether to give pale yellow needles, m.p. 130～132°, (wt. 113 mg., 9.0%). *Anal.* Calcd. for $C_{25}H_{38}O_2S_2$ (Ⅸ) : C, 69.07; H, 8.81; S, 14.75. Found : C, 69.34; H, 8.92; S, 14.95. $[\alpha]_D^{27}$ −227° (c=0.81); UV λ_{max} mμ (ε) : 292 (17500); IR ν_{max} cm^{-1} : 1735 (s), 1545 (w).

Further elution with 19:1 benzene-ether (720 ml.) afforded a pale yellow oil, (wt. 417 mg.), which, on addition of ether, crystallized. Recrystallization from the same solvent gave 4-ethylthio-17β-acetoxy-androst-4-en-3-one (Ⅷ) as pale yellow needles, m.p. 135～137°, (wt. 273 mg., 24.2%). A further crop of Ⅷ, m.p. 127～130°, (wt. 55 mg., 4.9%), was obtained from the recrystallization mother liquor. The total yield then reached 27.1%. *Anal.* Calcd. for $C_{23}H_{34}O_3S$ (Ⅷ) : C, 70.72; H, 8.77; S, 8.20. Found : C, 70.59; H, 9.00; S, 7.97. $[\alpha]_D^{27.5}$ +96° (c=0.50); UV λ_{max} mμ (ε) : 247 (13900), 314 (3200); IR ν_{max} cm^{-1} : 1730 (s), 1672 (s), 1566 (m); NMR τ : 5.38 (one proton, triplet, J=8.0 c.p.s.) ($C_{17}\alpha$-H), 6.22 (one proton, doublet, J=14.5 c.p.s.) ($C_6\alpha$-H),*7 7.13～7.62 (multiplet) (-S-CH_2-), 7.97 (three protons, singlet) ($C_{17}\beta$-OCO-CH_3), 8.76 (singlet, three protons) (19-CH_3), 9.16 (singlet, three protons) (18-CH_3).

Further elution with ether (200 ml.) afforded 4β-ethylthio-5α-hydroxy-17β-acetoxy-5α-androstan-3-one (X) as yellow crystals, (wt. 171 mg.), which, on recrystallization from acetone, gave colorless needles, m.p. 203～206°, (wt. 91 mg., 7.7%). Further recrystallization from methanol gave material, m.p. 204～206°. *Anal.* Calcd. for $C_{23}H_{36}O_4S$ (X) : C, 67.60; H, 8.88. Found : C, 67.59; H, 9.11. $[\alpha]_D^{30}$ −68° (c=0.50); UV λ_{max} : no intensive absorption at wave lengths longer than 215 mμ : IR ν_{max} cm^{-1} : 3468 (m), 1702 (s). NMR τ : 5.35 (one proton, triplet, J=6.5 c.p.s.) ($C_{17}\alpha$-H), 7.11～7.60 (multiplet) (-S-CH_2-), 7.93 (three

*10 Melting points were taken on a Kofler-type hot stage, and are uncorrected. $[\alpha]_D$ Refers to chloroform, ultraviolet absorption spectra to 95% ethanol, and infrared spectra to Nujol unless otherwise stated. NMR spectra were run on a Varian Associates A-60 high resolution spectrometer, and the intensities were measured by the integrator.

protons, singlet) ($C_{17}\beta$-$OCOCH_3$), 8.74 (singlet, three protons) (19-CH_3), 9.18 (singlet, three protons) (18-CH_3).

Treatment of VIII with Ethanethiol in PPA-dioxane : Formation of IX——A mixture of Ⅷ (112 mg.), ethanethiol (0.9 ml.), and PPA (0.45 g.) in dioxane (9.0 ml.) was kept at room temperature for 72 hr. A mixture of ethanethiol (0.9 ml.) and PPA (0.45 g.) was then added to the reaction mixture, and the mixture kept for further 48 hr. when the reaction was almost complete (thin-layer chromatography). The mixture was poured into ice-water depositing a pale yellow oil which was extracted into ether. The ethereal layer was washed with sat. $NaHCO_3$ aq. and water, and dried (Na_2SO_4). Concentration of the filtrate afforded a yellow oil, (wt. 94 mg.). This was chromatographed on silica gel (Davison Co.) (2.8 g.) and elution with benzene (140 ml.) afforded Ⅸ as pale yellow needles, m.p. 120～124°, alone and on admixture wlth a sample of Ⅸ, (wt. 31 mg., 25.0%). IR ν_{max} cm^{-1} : 1737 (s), 1548 (w). Their infrared spectra were superposable.

PPA-Catalyzed Ring Opening of VII with Ethanedithiol : Formation of 17β-Acetoxyandrosta-3,5-dieno [3,4-*b*] dithiane (XI)——A mixture of Ⅶ (1.0 g.), ethanedithiol (2.0 ml.), and PPA (2.0 g.) in dioxane (80 ml.) was kept at room temperature for 34 hr. when the reaction was complete (thin-layer chromatography). The reaction mixture was poured into ice-water depositing a colorless solid, m.p. 162～165°, (wt. 441 mg.). Recrystallization of the solid from ether gave 17β-acetoxyandrosta-3,5-dieno[3,4-*b*]-dithiane (Ⅺ) as colorless needles, m.p. 199～200.5°, (wt. 189 mg., 16.2%). Further recrystallization from the same solvent afforded material, m.p. 201.5～203°. *Anal.* Calcd. for $C_{23}H_{32}O_2S_2$ (Ⅺ) : C, 68.36; H, 7.71; S, 15.85. Found : C, 68.38; H, 8.29; S, 15.91. $[\alpha]_D^{25}$ −188° (c=0.76); UV λ_{max} mμ (ε) : 240 (12800), 294 (14500); IR ν_{max} cm^{-1} : 1718 (s), 1565 (w); NMR τ : 4.08(one proton, broad) (C_6-H), 5.35 (one proton, triplet, J=7.5 c.p.s.) ($C_{17}\alpha$-H), 6.83 (four protons, singlet) (-S-CH_2CH_2-S-), 7.93 (three protons, singlet) ($C_{17}\beta$-$OCOCH_3$), 8.98 (singlet, three protons) (19-CH_3), 9.16 (singlet, three protons) (18-CH_3).

The filtrate of the solid was extracted into ether and the ethereal layer washed with sat. $NaHCO_3$ aq. and water, and dried (Na_2SO_4). Concentration of the filtrate afforded a yellow oil, (wt. 325 mg.). This was chromatographed on silica gel (9.8 g.) when elution with 1:4 pet. ether-benzene (150 ml.) afforded colorless crystals, (wt. 77 mg.). Recrystallization from ether gave Ⅺ as colorless needles, m.p. 201～203°, (wt. 58 mg., 5.1%). The total yield of Ⅸ then reached 21.3%.

PPA-Catalyzed Ring Opening of VII with 2-Mercaptoethanol : Formation of 17β-Acetoxyandrosta-3,5-dieno [3,4-*b*] oxathiane (XII)——A solution of Ⅶ (500 mg.), 2-mercaptoethanol (1.0 ml.), and PPA(2.0 g.) in dioxane (40 ml.) was kept at room temperature for 65 hr. when the reaction was complete (thin-layer chromatography). The reaction mixture was poured into ice-water depositing a colorless solid, m.p. 205～209°, (wt. 626 mg.). The solid was not thin-layer chromatographically homogeneous, and was chromatographed on silica gel (Merck Co.) (31.3 g.) when elution with 1:4 pet. ether-benzene (760 ml.) afforded 17β-acetoxyandrosta-3,5-dieno [3,4-*b*] oxathiane (Ⅻ) as colorless crystals, m.p. 206.5～213.5°, (wt. 354 mg., 63%). Recrystallization from ether gave colorless needles, m.p. 212～214.5°, (wt. 175 mg., 31.3%). Further recrystallization from the same solvent gave material, m.p. 213.5～215°. *Anal.* Calcd. for $C_{23}H_{32}O_3S$ (Ⅻ) : C, 71.09; H, 8.30; S, 8.25. Found : C, 71.17; H, 8.71; S, 8.01. $[\alpha]_D^{22}$ −185° (c=0.80); UV λ_{max} mμ (ε) : 222 (9100), 270 (8500), IR $\nu_{max}^{CHCl_3}$ cm^{-1} : 1718 (s), 1636 (w), 1615 (m); NMR τ : 4.50 (one proton, broad) (C_6-H), 5.41 (one proton, triplet, J=7.0 c.p.s.), ($C_{17}\alpha$-H), 5.65～5.96 (two protons, multiplet) (-O-CH_2-), 6.94～7.11 (two protons, multiplet) (-S-CH_2-), 8.00 (three protons, singlet) ($C_{17}\beta$-$OCOCH_3$), 9.01 (singlet, three protons) (19-CH_3), 9.20 (singlet, three protons) (18-CH_3).

We are indebted to the Research Laboratories of Takeda Chemical Industries for some microanalyses, for the measurement of NMR absorption spectra, and for supply of testosterone. Our thanks are due to Mr. Y. Itatani of the Faculty of Pharmacy, Kanazawa University, for the remaining microanalyses, and to Mrs. M. Urata of our laboratory for skilled technical assistance.

Summary

The efficient catalytic action of polyphosphoric acid, when used in the presence of alkylmercaptans as nucleophiles, of normal ring opening of 17β-acetoxy-4,5-epoxy-androstan-3-one (Ⅶ), was reported. With ethanethiol in PPA-dioxane at room temperature, Ⅶ afforded 4-ethylthio-17β-acetoxyandrost-4-en-3-one (Ⅷ), and a further product, 17β-acetoxy-3,4-bis(ethylthio)androsta-3,5-diene (Ⅸ), accompanied by the third product with a transparent ultraviolet spectrum, the structure of which was tentatively assigned as 4β-ethylthio-5α-hydroxy-17β-acetoxy-5α-androstan-3-one (Ⅹ). Ethanedithiol and 2-mercaptoethanol also reacted with Ⅶ, as expected, affording 17β-acetoxyandrosta 3,5-dieno [3,4-*b*] dithiane (Ⅺ) and its oxathiane (Ⅻ) derivative respectively. Unique ultraviolet absorption data of the dithiane (Ⅺ) and oxathiane (Ⅻ) was referred to in connection with the suggestion of presence of some unique conjugation in the -S-C_3=C_4-S- and -O-C_3=C_4-S- systems in these compounds. (Received February 11, 1965)