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186. Genkichi Ohta, Toshio Takegoshi, Katsujiro Ueno, and Masao Shimizu: Investigations on Steroids. IV.*1 Syntheses of Androstano[2,3-*c*]-furazans and Related Compounds.*2

(*Central Research Laboratory, Daiichi Seiyaku Co., Ltd.**3)

In continuation of the search for heterocyclic steroids[1] which might have favorable biological activities, syntheses of 17β-hydroxyandrostane and its analogues possessing a furazan ring fused at the 2,3-positions were undertaken. Furazan or 1,2,5-oxadiazole is a new type of heterocycle to be fused to steroids. Among the known steroidal heterocycles of this type androstano[3,2-*c*]pyrazoles[2a] and [2,3-*d*]isoxazoles[2b] were reported to show high anabolic/androgenic ratios and it would be of interest to compare the effect on biological activities produced by substitution of this heterocyclic ring. In this paper preparation and chemical properties of the steroidal[2,3-*c*]furazans are reported.

The general synthetic sequence involved transformation of 3-keto steroids into 2,3-dihydroxyimino derivatives and subsequent cyclization to steroidal furazans. According to Camerino, *et al.*,[3] 17β-hydroxy-17α-methylandrostan-3-one (Ia) was oxidized with oxygen in the presence of potassium *t*-butoxide to give the corresponding 2,3-diketone (IIa) or its enol form. The diketone, isolated or unisolated from the reaction mixture, was readily converted into the 2,3-dihydroxyimino compound (IIIa) by treatment with hydroxylamine. Alternatively, nitrosation of the 3-ketone (Ia) with alkyl nitrite, followed by oximation of the resultant hydroxyimino ketone (IVa) led to the same 2,3-dihydroxyimino compound (IIIa). Conversion of the ketone (Ia) into the 2-hydroxyimino derivative was effected by the usual method of nitrosation with isoamyl nitrite and potassium *t*-butoxide, which has already been used for the preparation of 2-hydroxyiminocholestan-3-one.[4a] However, reaction of the ketone with alkyl nitrite in the presence of hydrogen chloride[5a,b] more conveniently afforded the hydroxyimino ketone (IVa). Similarly, 17β-hydroxyandrostan-3-one (Ib) was converted into the 2,3-dihydroxyimino derivative (IIIb), *via* the diketone (IIb) or the hydroxyimino ketone (IVb).

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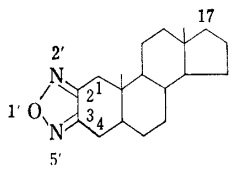
*1 Part III. This Bulletin, **12**, 92 (1964).

*2 In this paper simplified nomenclature and numbering system are adopted, because formal nomenclature of the heterocycle-fused steroid is complicated.



androstano[2,3-*c*]furazan

*3 Minamifunabori-cho, Edogawa-ku, Tokyo (太田元吉, 竹越敏夫, 上野勝次郎, 清水正夫).

1) M. Shimizu, G. Ohta, K. Ueno, T. Takegoshi: This Bulletin, **12**, 77 (1964).

2) *a*) R.O. Clinton, A. J. Manson, F.W. Stonner, H.C. Neumann, R.G. Christiansen, R. L. Clarke, J.H. Ackerman, D.F. Page, J.W. Dean, W.B. Dickinson, C. Carabateas: J. Am. Chem. Soc., **83**, 1478 (1961). *b*) A. J. Manson, F.W. Stonner, H.C. Neumann, R.G. Christiansen, R. L. Clarke, J.H. Ackerman, D.F. Page, J.W. Dean, D.K. Phillips, G.O. Potts, A. Arnold, A. L. Beyler, R. O. Clinton: J. Med. Chem., **6**, 1 (1963). *c*) cf. ref. 2~8 of Part I.[1]

3) B. Camerino, B. Patelli, R. Sciaky: Tetrahedron Letters, **1961**, No. 16, 554; Gazz. chim. ital., **92**, 676 (1962).

4) *a*) J.C. Sheehan, W.F. Erman: J. Am. Chem. Soc., **79**, 6050 (1957). *b*) cf. H. Mori, V.S. Gandhi, E. Schwenk: This Bulletin, **10**, 842 (1962).

5) *a*) O. Touster: Organic Reactions VII, 327 (1953). *b*) cf. W. L. Semon, V. R. Damerell: Org. Syntheses, II, 204.

17β-Acyloxy-3-ketones (Ic,d) being unstable in alkali were nitrosated with alkyl nitrite and hydrogen chloride and subsequently converted into the 2,3-dihydroxyimino compounds (IIIc, d).

As for the configuration of the 2-hydroxyimino-3-ketone (IV), the *anti* configuration of the hydroxy group with respect to the 3-carbonyl was indicated by comparing the following data with those published for analogous hydroxyimino ketones. Compound (IVa) gave a green complex with cupric ion which is characteristic of an *anti* form.[6] The carbonyl band at 1717 cm^{-1} in the infrared spectrum of IVa excluded the presence of intramolecular hydrogen bond between a carbonyl and a hydroxyl group which is expected for the *syn* form. In chloroform solution, IVa showed bands of an unassociated hydroxyl group at 3555 cm^{-1} and an associated hydroxyl group at 3270 cm^{-1}; the latter band is due to intermolecular association.[7] The shift of ultraviolet absorption maximum of IVa from 243 mμ to 300 mμ on addition of base is consistent with *anti* configuration, whereas no shift is known to be observed in a *syn* hydroxyimino ketone.[7,8] Furthermore, careful acetylation of IVa with acetic anhydride and pyridine afforded the rather unstable acetoxyimino ketone (V) with ultraviolet absorption maximum at 220 mμ, and the hypsochromic shift accompanied by acetylation was observed.[8a,b] The acetoxyimino ketone was readily cleaved in the presence of aqueous alkaline solution by "second order" Beckmann rearrangement[9] to give the 2,3-seco-2-nitrile-3-carboxylic acid (VI), the structure of which was proved by infrared absorption indicative of a nitrile and a carboxylic group. These properties of the acetoxyimino ketone are comparable with those of *anti* 16-acetoxyimino-17-ketones.[8a,b]

The 2,3-dihydroxyimino compound (IIIa) furnished a colored precipitate with nickel or cobalt ion indicating *anti* configuration and the shift of its ultraviolet absorption maximum from 239~241 mμ in neutral to 284 mμ in alkaline solution was also comparable with those of the known *anti* dioximes.[7,8c]

For introduction of a hydroxyimino group into the C-2 position of Δ^4-androsten-3-ones, the procedure of Fried, *et al.*[10] was employed. Thus, 17β-hydroxyandrost-4-en-3-one (VIIb) was formylated to give the corresponding 2-hydroxymethylene derivative (VIIIb) which by treatment with sodium nitrite and acetic acid or hydrochloric acid was converted into the 2-hydroxyimino compound (IXb). Oximation of IXb gave the Δ^4-2,3-dihydroxyimino compound (Xb). 17α-Methyl derivative (Xa) was prepared similarly. Metal complex formation was again observed in both cases of the 2-hydroxyimino-Δ^4-3-ketone (IXa, b) and Δ^4-2,3-dione dioxime (Xa, b) and *anti* configuration was assigned to these compounds, although spectral data did not provide conclusive information about the configuration.

For the syntheses of 2,3-dihydroxyimino-Δ^4-compounds, other methods were not available. Oxidation of a Δ^4-3-ketone with oxygen and alkali is known to give a Δ^5-3,4-diketone along with a Δ^4-3,6-diketone.[3] Nitrosation of the Δ^4-3-ketone (VIIa) with alkyl nitrite and hydrogen chloride gave the unchanged starting material.[11] Reaction of VIIa with isoamyl nitrite and potassium *t*-butoxide afforded a compound, which by elemental analysis was shown to contain two hydroxyimino groups. On treatment with acetic anhydride and pyridine at room temperature this was converted into a

6) T.W.J. Taylor : J. Chem. Soc., **1931**, 2081.
7) cf. D.H.R. Barton, J.M. Beaton : J. Am. Chem. Soc., **83**, 4083 (1961).
8) *a*) A. Hassner, I.H. Pomerantz : J. Org. Chem., **27**, 1760 (1962). *b*) A. Hassner, W.A. Wentworth, I.H. Pomerantz : J. Org. Chem., **28**, 304 (1963). *c*) J.L. Mateos, O. Chao, H. Flores R : Tetrahedron, **19**, 1051 (1963). *d*) S. Huneck : Tetrahedron Letters, **1963**, No. 6, 375.
9) A.F. Ferris : J. Org. Chem., **25**, 12 (1960).
10) J.H. Fried, P. Buchschacher, H. Mrozik : Steroids, **2**, 399 (1963).
11) cf. R. Huettenrauch : Ger. Pat., 22,356 (1961) (C.A., **58**, 9202 (1963)).

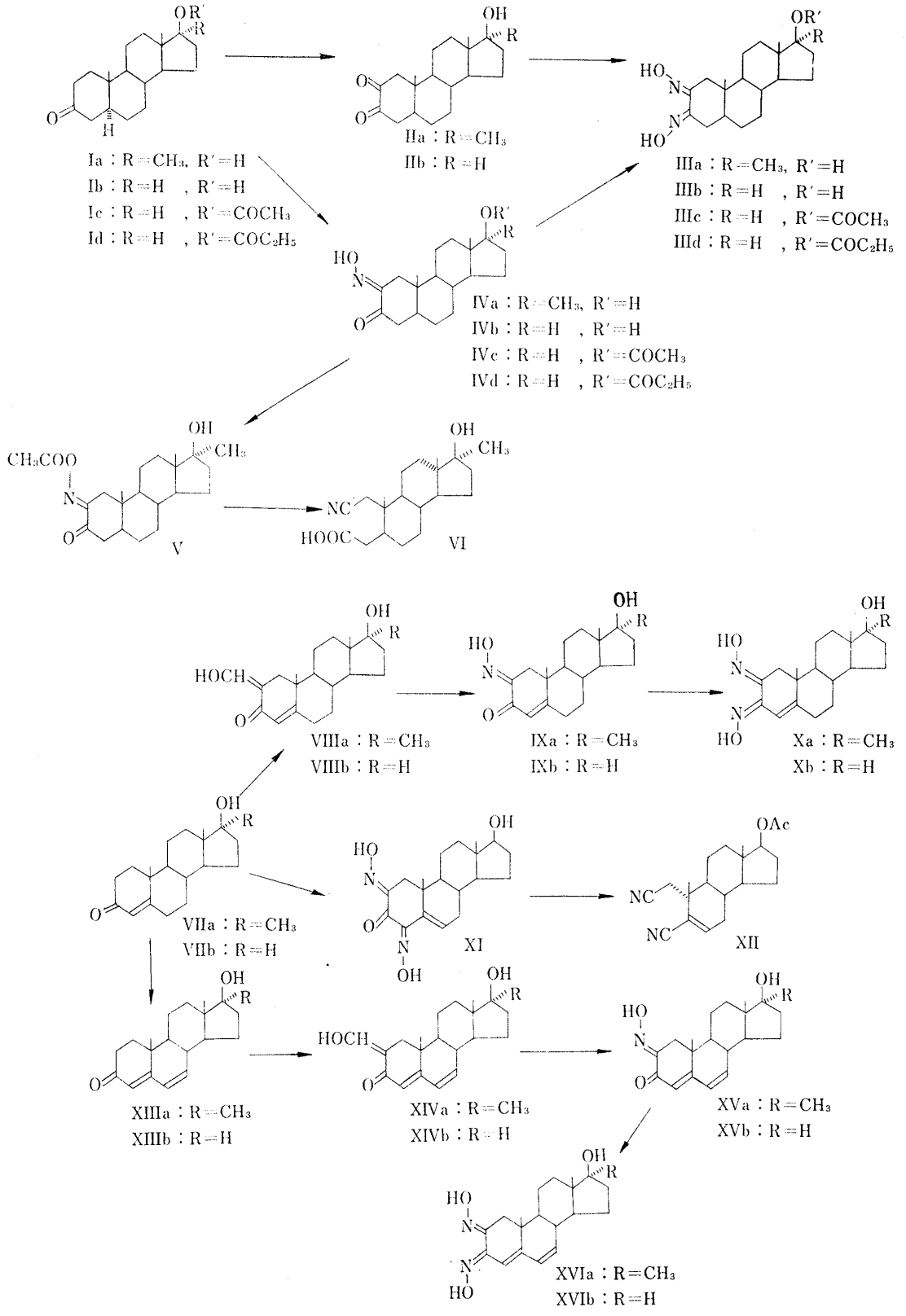


Chart 1.

cleaved product by "second order" Beckmann rearrangement.[9] In the infrared spectrum the product revealed bands at 2240 cm^{-1}, characteristic of an isolated nitrile, at 2210 cm^{-1} of a conjugated nitrile group and at 1623 cm^{-1} of a conjugated double bond. The ultraviolet absorption maximum at 210 mμ is ascribed to the α,β-unsa-

turated nitrile. From the spectral data, the structure of the nitrilo compound was proved to be 17β-acetoxy-A-nor-2,3-seco-androst-5-ene-2,3-dinitrile (XII) and hence the Δ^5-2,4-dihydroxyimino-3-keto structure (XI) was assigned to the dihydroxyimino ketone. Hydrolysis of XII with alkali met difficulty and the corresponding dicarboxylic acid was not obtained in an analytically pure state.

Similarly, $\Delta^{4,6}$-2,3-dihydroxyimino compounds (XVIa, b) were synthesized from $\Delta^{4,6}$-androstadien-3-ones (XIIIa, b), *via* the 2-hydroxymethylene[2a] (XIVa, b) and the 2-hydroxyimino derivatives (XVa, b).

The furazan ring was formed by treatment of the dioxime with potassium hydroxide in ethylene glycol at 160~200°.[12] 17β-Hydroxyandrostano[2,3-*c*]furazan (XVIIb) and corresponding compounds with one and two double bonds (XVIIIb, XIXb), inclusive of their 17α-methyl derivatives (XVIIa, XVIIIa, XIXa), were prepared by this procedure. Fusion of the 17β-acetoxy dioxime (IIIc) with succinic anhydride at 160~190°[13] was also effective for preparing the acetoxy furazan (XVIIc). Alternatively, reaction of the 17β-acyloxy dioxime (IIIc, d) with thionyl chloride in liquid sulfur dioxide[14] furnished furazan derivative (XVIIc, d). Protection of the 17β-hydroxy group was necessary to these dehydrating agents. On treatment with either succinic anhydride or thionyl chloride, the 17β-hydroxy-17α-methyl dioxime (IIIa) was converted into the 17-

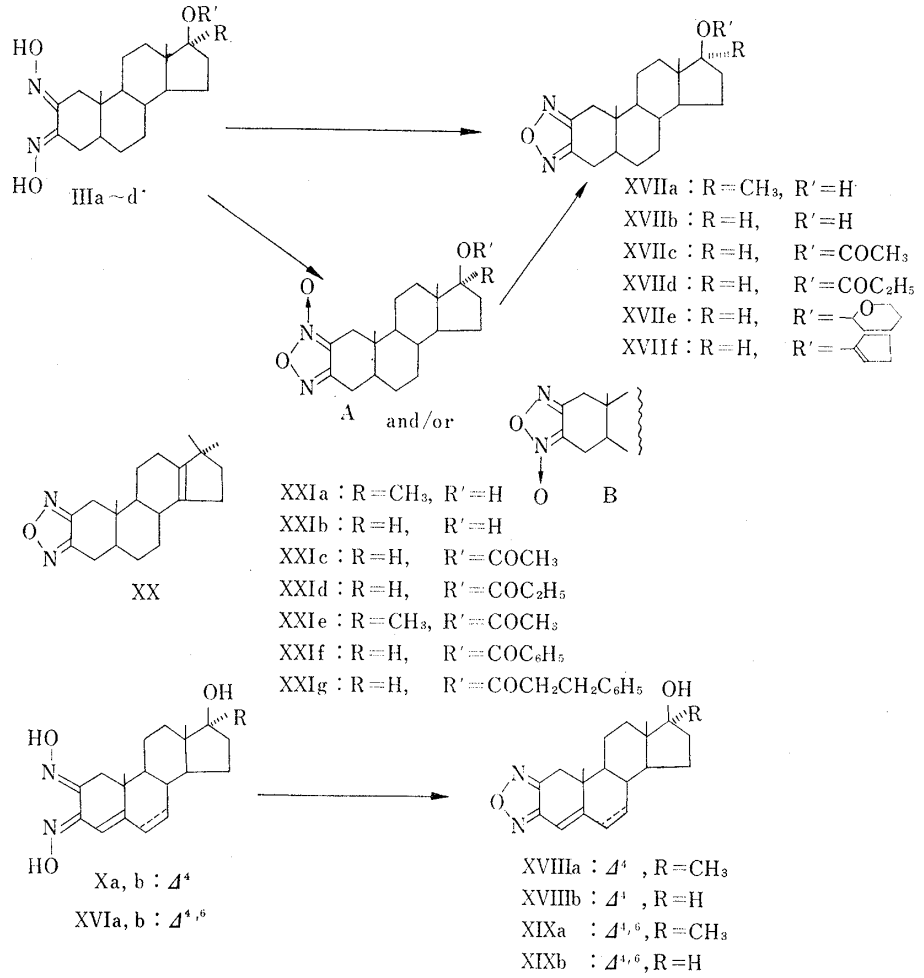


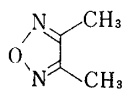
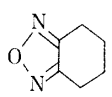
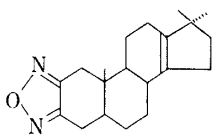
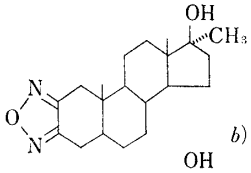
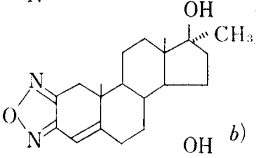
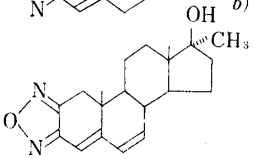
Chart 2.

12) *a*) L. Wolf : Chem. Ber., **28**, 69 (1895). *b*) C.K. Ingold, C.W. Shoppee : J. Chem. Soc., **1928**, 396.
13) L.C. Behr, J.T. Brent : Org. Syntheses, **34**, 40 (1954).
14) N. Tokura, R. Tada, K. Yokoyama : Bull. Chem. Soc. Japan, **34**, 270 (1961).

dehydrated furazan derivative, identical with the product formed by Wagner-Meerwein rearrangement of 17β-hydroxy-17α-methylandrostano[2,3-*c*]furazan (XVIIa) using acetic anhydride and *p*-toluenesulfonic acid. The product exhibited infrared bands at 1386 and 1363 cm^{-1} characteristic of a *gem*-dimethyl group and lacked bands indicative of a di- or tri-substituted double bond. Structure (XX) was assigned to this compound which was also supported by nuclear magnetic resonance spectrum, which showed a singlet at 9.26 τ due to the 19-methyl group, and a singlet at 9.04 τ corresponding to 6 protons of the two magnetically equivalent methyl groups at the 17-position. No signal due to a vinyl proton was observed. The molecular rotatory difference of XX from the parent compound (XVIIa) (ΔM_D −143°) was consistent with those of analogous compounds.[15]

The androstano[2,3-*c*]furazan (XVII) possesses an ultraviolet absorption maximum at 217 mμ, with neighboring inflections at 220, 225, and 234 mμ, which agrees well with the spectrum of cyclohexano[*c*]furazan. 3,4-Dimethyl furazan shows a similar curve with a maximum at 212 mμ; the difference of position of the maximum between 3,4-dimethyl and steroidal furazan is comparable with that between the corresponding pyridine derivatives.[16] In the spectrum of XVIIa no shift of the maximum was observed by addition of either alkali or acid.*4 Conjugation of the furazan ring with one and two double bonds, as in androst-4-eno[2,3-*c*]furazan (XVIII) and androsta-4,6-dieno-[2,3-*c*]furazan (XIX), shifted the maximum to 255 mμ and 286 mμ, respectively.

Table I. Infrared Absorption Bands of Furazans (cm^{-1})

 *a)*	1690	1590	1490	1440	1400	1215	1040	945	890	708
 *a)*	1625	1585	1495	1435	1395	1210	998	960	880	835
 *b)*	—	1590	1503	1433	1406	1210	1003	955	875	775 740
 *b)*	1633	1590	1500	1430	1405	1208	1006	934	885 876	768 740
 *b)*	—	1572	1509	1435	—	1215	1002	932	854 844	788
 *b)*	1624	1565	1502	1431	—	—	995	934	882 852	798 773

a) liq. film *b)* KBr disc.

*4 The furazan compounds were shown to be almost neutral by titration in 80% methyl cellosolve with 0.1*N* HCl and 0.1*N* KOH.

15) K. Ueno : This Bulletin, **12**, 92 (1964).

16) cf. Part II : *Ibid.*, **12**, 87 (1964).

The infrared absorptions which seemed to be characteristic of the steroid[2,3-*c*]-furazan were compared with those of 3,4-dimethyl- and cyclohexano[*c*]furazan as shown in Table I. In addition to these bands interference absorptions attributed to methylene (1470～1450 cm^{-1}), methyl (1390～1360 cm^{-1}) and cyclohexane ring (1055～1000, 1005～952 cm^{-1}) were observed as expected.[17] The band at 1510～1490 cm^{-1} is prominent, and readily found in all the furazan compounds. Androst-4-eno[2,3-*c*]furazan lacked the band at 1400 cm^{-1}, and exhibited only one band below 800 cm^{-1}, instead of two comparatively strong bands found in androstano[2,3-*c*]furazan. On the other hand, androsta-4,6-dieno[2,3-*c*]furazan lacked the band not only at 1400 cm^{-1} but also at 1215～1205 cm^{-1}, although it had two bands below 800 cm^{-1}. In the literature[18] bands between 1650～1300 cm^{-1} were attributed to a ring stretching mode.

The nuclear magnetic resonance spectrum of XVIIa showed singlets at 8.79 and 9.13 τ due to the methyl groups at C-17 and C-18 respectively, and a singlet at 9.23 τ which was assignable to the 19-methyl in accordance with the assignment in the spectrum of XX described above. The 19-methyl signal of androstano-furazans shows an upfield shift from that of androstan-3-one (8.99 τ) and this shift is comparable with those observed in the case of similarly substituted steroidal pyrazoles, isoxazoles,[19] and pyridines.*5

An attempted reduction of androst-4-eno[2,3-*c*]furazan (XVIII) to androstano[2,3-*c*]-furazan (XVII) with sodium or lithium in liquid ammonia was unsuccessful. The infrared and ultraviolet spectra of the crude resinous product showed that the furazan ring was completely destroyed.

Reaction of dihydroxyimino androstanes (IIIa, b) with sodium hypochlorite[20a] in aqueous alcoholic solution or with lead tetraacetate in acetic acid[21] provided the corresponding furazan N-oxides (furoxans) (XXIa, b). The furazan N-oxide structure was supported by the absorption bands of the product at 264 mμ in ultraviolet and at 1620 and 1465 cm^{-1} in infrared spectrum which agreed well with the characteristic bands of cyclohexano[*c*]furazan N-oxide.[20b] It was not determined, however, whether the N-oxide is located as in A or B of XXI, or whether or not the product is homogeneous.

Deoxygenation of the N-oxide (XXI) was effected by heating with triethyl phosphite[22] at 170～180°. In this case, protection of the 17-hydroxy group was desirable. Thus, 17-acyloxy furazan N-oxide (XXIc, d, e, f) was deoxygenated to the corresponding furazan in good yield, while the 17β-hydroxy compound (XXIb) was converted into the furazan (XVIIb) only in poor yield and deoxygenation reaction of the 17β-hydroxy-17α-methyl compound (XXIa) was accompanied by elimination of the 17-hydroxy group. The dehydrated product was shown by gas chromatography to consist of two components different from XX.

A number of derivatives of androstano[2,3-*c*]furazan were prepared for biological studies. From the 17β-hydroxy compound (XVIIb) were obtained the 17-acyloxy derivatives, tetrahydropyranyl ether (XVIIe), 1-ethoxycyclopentyl ether and 1-cyclopentenyl

*5 In Part II,[16] the signals at 9.22 and 9.13 τ of the NMR spectrum of 17α-methyl-17β-hydroxyandrostano[3,2-*b*]pyridine were erroneously assigned to the 18-methyl and 19-methyl group respectively. The assignments should be revised, *i.e.* reversed, on the basis of comparison with 17,17-dimethyl-18-nor-androst-13-eno[3,2-*b*]pyridine.[15]

17) cf. L. J. Bellamy : "The Infrared Spectra of Complex Molecules," Methuen & Co. (1957) p. 20.

18) cf. M. Milone, E. Borello : Gazz. chim. ital., **81**, 368 (1951). (A. R. Katritzky, A. P. Ambler : Physical Methods in Heterocyclic Chemistry II, p. 233.)

19) E. Caspi, D. M. Piatak : Canad. J. Chem., **41**, 2294 (1963).

20) *a*) J. H. Boyer, U. Toggweiler : J. Am. Chem. Soc., **79**, 895 (1957). *b*) J. H. Boyer, U. Toggweiler, G. A. Stoner : *Ibid.*, **79**, 1748 (1957).

21) Y. Yukawa, Y. Sakai : Abstract of the 17th annual meeting of the Chem. Soc. Japan, 1964, p. 188.

22) *a*) C. Grundmann : Chem. Ber., **97**, 575 (1964). *b*) T. Mukaiyama, H. Nambu, M. Okamoto : J. Org. Chem., **27**, 3651 (1962).

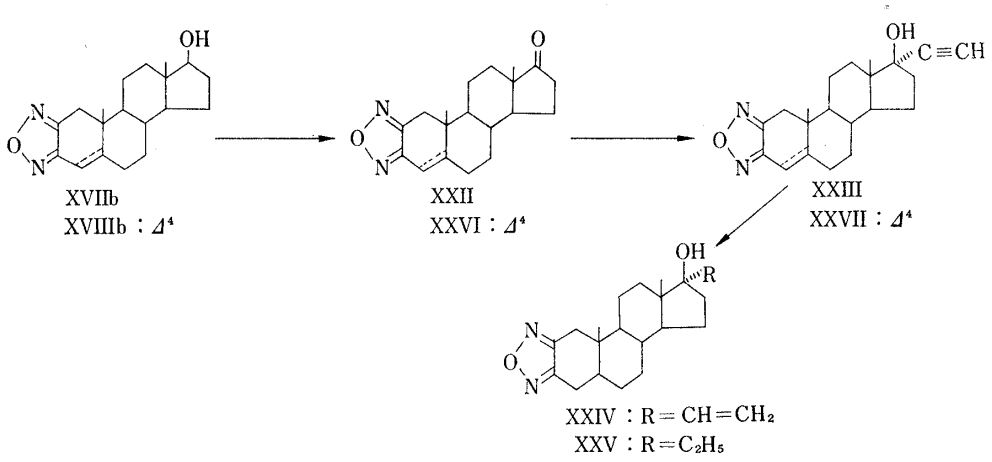


Chart 3.

ether (XVIIf)[23] by known procedures. Compound XVIIa possessing a tertiary hydroxy group was acylated by application of the method of Evans, *et al.*[24] *via* a magnesium compound. Oxidation of XVIIb with chromic acid gave the 17-ketone (XXII), which on treatment with acetylene and potassium *t*-butoxide provided the 17α-ethynyl-17β-ol (XXIII). Hydrogenation of XXIII with Lindlar's catalyst and with palladium on carbon afforded the 17α-vinyl (XXIV) and 17α-ethyl derivative (XXV) respectively. Similarly, the Δ^4-17β-ol (XVIIIb) was converted to the Δ^4-17-ketone (XXVI) and then to the Δ^4-17α-ethynyl-17β-ol (XXVII). An attempted reaction of the ketone (XXII) with ethyl magnesium bromide or ethyl lithium failed to give 17α-ethyl compound (XXV). The infrared and ultraviolet spectrum of the crude reaction product contained no characteristic bands of furazan ring. The ring seemingly was destroyed by these agents.[25]

Certain members of the series have favorable myotrophic/androgenic ratios. Details of the endocrine effects of the compounds will be given in the following papers.

Experimental*6

2-Hydroxyimino-5α-3-oxosteroids——Method A : The 5α-3-ketosteroid was treated with *t*-BuOK and isoamyl nitrite in *t*-BuOH, under essentially the same conditions as those described by Sheehan and Erman.[4]

Method B : The ketone in benzene or in benzene-MeOH was treated with 35% HCl and *t*-butyl nitrite. The solvent system was arranged so that the reaction product was separated from the solution. By this procedure further reaction of the product was minimized.

Method C : The ketone in benzene-ether was treated with anhydrous HCl and isoamyl nitrite.

The typical examples of method A, B, and C are described below.

2-Hydroxyimino-17β-hydroxy-17α-methylandrostan-3-one (IVa)——a) By method A. To a stirred solution of 17β-hydroxy-17α-methylandrostan-3-one (Ia) (10 g.) in *t*-BuOH (350 ml.) at 20~23° was added under N_2 a solution of *t*-BuOK prepared from K (3.5 g.) and *t*-BuOH (50 ml.). Isoamyl nitrite (4.3 g.) was then added and stirring was continued for 2 hr. The mixture was poured into ice-water and shaken with ether. The aqueous layer was separated and ethereal solution was extracted with 5% KOH. The aqueous solutions were combined and acidified with 10% HCl. The precipitate was collected by centrifugation, washed with 5% $NaHCO_3$ and water, dried and crystallized from MeOH to give IVa (5.71 g.), m.p. 245~247°(decomp.). Recrystallization from the same solvent gave an analytical sample, m.p. 249~251°(decomp.), $[\alpha]_D$ +39°(c=1.014, pyridine). UV λ_{max} mμ (ε) : 243 (7,000), $\lambda_{max}^{0.1N\ EtONa\text{-}EtOH}$ mμ (ε) : 300 (14,200). IR ν_{max} cm^{-1} : 3445, 3210, 1717, 1615, 978. *Anal.* Calcd. for $C_{20}H_{31}O_3N$: C, 72.03; H, 9.37; N, 4.20. Found : C, 71.77; H, 9.20; N, 3.99.

*6 Melting points are uncorrected. IR spectra were taken in a KBr disc, UV spectra in EtOH. Unless otherwise stated, optical rotations were measured in $CHCl_3$ solution at ca. 20°.

23) A. Ercoli, R. Gardi, R. Vitali : Chem. & Ind.(London), **1962**, 1284.
24) D. D. Evans, D. E. Evans, G. S. Lewis, P. J. Weyll : J. Chem. Soc., **1963**, 3578.
25) cf. A. Dornow, F. J. Fust, H. D. Jordan : Chem. Ber., **90**, 2124 (1957).

The hydroxyiminoketone (Va) gave green precipitate with cupric acetate in MeOH.

b) By method B. To a solution of the ketone (Ia) (12.16 g.) in benzene (480 ml.) and MeOH (8 ml.) was added a mixture of 35% HCl (8 ml.), MeOH (4 ml.) and water (1 ml.). A solution of *t*-butyl nitrite (4.8 g.) in benzene (10 ml.) was then added with vigorous stirring over a period of 15 min. at 19~23°, while crystals began to separate. After stirring for 1 hr., water (100 ml.) was added to the mixture and the crystals were filtered, washed with 2% $NaHCO_3$ and water and dried (10.45 g., m.p. 220~245°(decomp.)). Recrystallization from MeOH gave Va, identical with that described above, m.p. and mixed m.p. 248~250°(decomp.).

c) By method C. Anhydrous HCl was saturated in ether (20 ml.) at −5~0° and the solution was added to the ketone (Ia) (1.0 g.) in benzene (30 ml.). To the cooled mixture (−5~0°), isoamyl nitrite (0.46 g.) was added with stirring. After 2 hr., the separated precipitate was filtered, washed with water and dried. Recrystallization from MeOH gave Va (0.32 g.), m.p. and mixed m.p. 247~248° (decomp.). The filtrate was washed with water, dried and evaporated. Crystallization of the residue gave an additional crop (0.01 g.), m.p. 249~250°(decomp.).

2-Hydroxyimino-17β-hydroxyandrostan-3-one (IVb)——a) Vb (0.14 g.) was obtained from 17β-hydroxyandrostan-3-one (Ib) (0.30 g.) by method A and recrystallized from MeOH to give an analytical sample, m.p. 266~267°(decomp.), $[\alpha]_D$ +48.1°(c=0.77, pyridine). UV λ_{max} mμ (ε): 243 (6,850), $\lambda_{max}^{0.1N\ EtONa\text{-}EtOH}$ mμ (ε): 301 (13,300). IR ν_{max} cm^{-1}: 3540, 3400, 3140, 1704, 1612, 971. *Anal.* Calcd. for $C_{19}H_{29}O_3N$: C, 71.44; H, 9.15; N, 4.39. Found: C, 71.66; H, 9.15; N, 4.39.

b) Ib (17.4 g.) in benzene (350 ml.) and MeOH (6 ml.) was treated with 35% HCl (6 ml.) in MeOH (3 ml.) and *t*-butyl nitrite (7.2 g.) in benzene (10 ml.) by method B to give Vb (16.42 g.).

c) Method C gave a 39% yield.

2-Hydroxyimino-17β-acetoxyandrostan-3-one (IVc)——a) Treatment of 17β-acetoxyandrostan-3-one (Ic) (3.09g.) in benzene (60ml.) with 35% HCl (1 ml.) and *t*-butyl nitrite (1.20 g.) in benzene (5ml.) by method B gave Vc (2.98 g.). The analytical sample, recrystallized from $CHCl_3$–isopropanol, had m.p. 254~256° (decomp.), $[\alpha]_D$ +27.2°(c=0.88, pyridine). UV λ_{max} mμ (ε): 243 (8,300). IR ν_{max} cm^{-1}: 3120, 1736, 1716, 1620, 1243, 972. *Anal.* Calcd. for $C_{21}H_{31}O_4N$: C, 69.77; H, 8.65; N, 3.88. Found: C, 69.89; H, 8.54; N, 3.82.

b) Method C gave a 42% yield.

2-Hydroxyimino-17β-propionyloxyandrostan-3-one (IVd)——a) Treatment of 17β-propionyloxyandrostan-3-one (Id) (3.25 g.) in benzene (60 ml.) with 35% HCl (1 ml.) and *t*-butyl nitrite (1.20 g.) in benzene (5 ml.) by method B gave Vd (2.96 g.), m.p. 220~245°(decomp.). Recrystallization from MeOH gave an analytical sample, m.p. 250~251°(decomp.), $[\alpha]_D$ +29.5°(c=0.98, pyridine). UV λ_{max} mμ(ε): 243 (7,200). IR ν_{max} cm^{-1}: 3132, 1730, 1716, 1618, 1185, 972. *Anal.* Calcd. for $C_{22}H_{33}O_4N$: C, 70.37; H, 8.86; N, 3.73. Found: C, 70.18; H, 8.75; N, 3.98.

b) Method C gave a 28% yield.

4- and 4,6-Unsaturated 2-Hydroxyimino-3-oxosteroids——Method D: The 2-hydroxymethylene-3-oxosteroid in EtOH was treated with aq. $NaNO_2$-solution and 35% HCl.

Method E: The above method D was modified by the use of MeOH in place of EtOH and AcOH in place of 35% HCl. The typical example is described below.

2-Hydroxyimino-17β-hydroxy-17α-methylandrost-4-en-3-one (IXa)——By method D. To a solution of 2-hydroxymethylene-17β-hydroxy-17α-methylandrost-4-en-3-one[2a] (VIIIa) (2.0 g.) in EtOH (40 ml.) was added an aq. $NaNO_2$-solution (2.0 g. in 4 ml.). The mixture was cooled in an ice-bath and 35% HCl (3.5 g.) was added dropwise with stirring. After 30 min., the mixture was poured into water and the precipitate was filtered, washed with water and dried. Recrystallization from AcOEt gave IXa as pale yellow rods (1.28 g.), m.p. 234~235°(decomp.). Further recrystallization from the same solvent afforded an analytical sample, m.p. 235~236°(decomp.), $[\alpha]_D$ +89.1°(c=0.86, pyridine). UV λ_{max} mμ(ε): 264 (13,700). IR ν_{max} cm^{-1}: 3425, 3248, 1680, 1615, 981, 964. *Anal.* Calcd. for $C_{20}H_{29}O_3N$: C, 72.47; H, 8.82; N, 4.23. Found: C, 72.62; H, 8.82; N, 4.37.

The compound (IXa) gave a yellow green color with cupric acetate in MeOH.

2-Hydroxyimino-17β-hydroxyandrost-4-en-3-one (IXb)——By method D, IXb was prepared from 2-hydroxymethylene-17β-hydroxyandrost-4-en-3-one[2a] (VIIIb). Pale yellow needles (from AcOEt), m.p. 236~238°(decomp.), $[\alpha]_D$ +100.6°(c=1.23, pyridine). UV λ_{max} mμ(ε): 264 (14,400). IR ν_{max} cm^{-1}: 3290, 3050, 1672, 1611, 984, 973, 892, 873. *Anal.* Calcd. for $C_{19}H_{27}O_3N$: C, 71.89; H, 8.57; N, 4.41. Found: C, 71.69; H, 8.61; N, 4.31.

2-Hydroxyimino-17β-hydroxy-17α-methylandrosta-4,6-dien-3-one (XVa)——By method E, XVa (2.68 g.) was obtained from 2-hydroxymethylene-17β-hydroxy-17α-methylandrosta-4,6-dien-3-one[2a] (XIVa) (4.13 g.). Recrystallization from acetone–H_2O gave an analytical sample, m.p. 235~235.5°(decomp.), $[\alpha]_D$ +12.5° (c=0.88, pyridine). UV λ_{max} mμ(ε): 215 (8,300), 310 (21,300). IR ν_{max} cm^{-1}: 3400~3200, 3027, 1665, 1600, 1563, 990, 977, 952, 932, 889, 878. *Anal.* Calcd. for $C_{20}H_{27}O_3N \cdot \frac{1}{4}H_2O$: C, 71.93; H, 8.30; N, 4.19. Found: C, 72.07; H, 8.25; N, 4.37.

The compound (XVa) gave a yellow-green color with $Cu(OAc)_2$ in MeOH.

2-Hydroxyimino-17β-hydroxyandrosta-4,6-dien-3-one (XVb)——XVb was prepared from 2-hydroxymethylene-17β-hydroxyandrosta-4,6-dien-3-one (XIVb)[2a] by method E. Yield 70.4%. Pale yellow needles (from acetone-H_2O), m.p. 233~234° (decomp.), $[\alpha]_D$ +28.9° (c=0.76, pyridine). UV λ_{max} mμ (ε): 215 (6,450), 310 (17,000). IR ν_{max} cm^{-1}: 3280, 3020, 1666, 1606, 1580, 985, 876. *Anal.* Calcd. for $C_{19}H_{25}O_3N \cdot \frac{1}{4}H_2O$: C, 71.33; H, 8.03; N, 4.38. Found: C, 71.45; H, 7.93; N, 4.32.

2,3-Dihydroxyimino Steroids——Method F: The solution of 5α-3-oxosteroid and *t*-BuOK in *t*-BuOH was stirred under oxygen until 1 equimolar oxygen was absorbed. The reaction mixture was neutralized and treated with $NH_2OH \cdot HCl$.

Method G: 2-Hydroxyimino-3-oxosteroid in MeOH and pyridine was treated with $NH_2OH \cdot HCl$.

The typical examples of method F and G are described in the following section.

17α-Methyl-2,3-dihydroxyiminoandrostan-17β-ol (IIIa)——a) By method F. A solution of *t*-BuOK prepared from K (15 g.) and *t*-BuOH (540 ml.) was stirred under oxygen at 25~27° until there was no further uptake of the gas. A solution of Ia (18.3 g.) in *t*-BuOH (350 ml.) was then added and stirring under oxygen was continued for 40 min., during which 1.51 L. of oxygen was absorbed (theory: 1.48 L./27°). The solution was neutralized with AcOH (23.1 g.) in water (70 ml.), and $NH_2OH \cdot HCl$ (10 g.) was added. The mixture was refluxed for 1 hr., concentrated in vacuum and diluted with water. The separated product was filtered, washed with water and dried (18.9 g., m.p. 239°(decomp.)). Recrystallization from MeOH gave the dihydroxyimino compound (IIIa), m.p. 234~235°(decomp.), $[\alpha]_D$ +63.6°(c=0.88, pyridine). UV λ_{max} mμ (ε): 238~241 (6,600). IR ν_{max} cm^{-1}: 3390, 1640~1630, 970, 942, 932, 921. *Anal.* Calcd. for $C_{20}H_{32}O_3N_2$: C, 68.93; H, 9.26; N, 8.04. Found: C, 68.99; H, 9.17; N, 7.98.

Oxidation of Ia in a similar manner and isolation of the oxidized product gave 17β-hydroxy-17α-methylandrostane-2,3-dione (IIa) as its enol form, m.p. 179~180°, UV λ_{max} mμ (ε): 270 (8,200) (reported m.p. 183~186°[3]). Oximation of IIa afforded the dihydroxyimino compound (IIIa), m.p. 234~235°(decomp.), identical with that described above.

b) By method G. A mixture of 2-hydroxyimino-17β-hydroxy-17α-methylandrostan-3-one (IVa) (0.76 g.), $NH_2OH \cdot HCl$ (0.23 g.), pyridine (5 ml.) and MeOH (15 ml.) was refluxed for 2 hr. The mixture was poured into water and the precipitate was filtered, washed with water, dried and crystallized from MeOH to give IIIa (0.62 g.), m.p. 239~240° (decomp.). Recrystallization from the same solvent afforded a pure sample, m.p. 234~235°(decomp.), identical with IIIa described above.

2,3-Dihydroxyiminoandrostan-17β-ol (IIIb)——a) Method F gave a 90% yield. Recrystallization from MeOH afforded an analytical sample, m.p. 262~263°(decomp.), $[\alpha]_D$ +72.4°(c=1.04, pyridine). UV λ_{max} mμ (ε): 239~240 (6,300). IR ν_{max} cm^{-1}: 3210, 3082, 1661, 1628, 985, 964, 947, 928, 824. *Anal.* Calcd. for $C_{19}H_{30}O_3N_2$: C, 68.23; H, 9.04; N, 8.38. Found: C, 68.46; H, 8.95; N, 8.54.

The compound gave a crimson complex with nickel nitrate.

b) Method G gave a 95% yield.

2,3-Dihydroxyiminoandrostan-17β-ol 17-Acetate (IIIc)——IVc (1.3 g.) was oximated by method G to give IIIc (1.32 g.), m.p. 248°(decomp.). Recrystallization of the crude product from MeOH furnished a pure sample, m.p. 256~257°(decomp.), $[\alpha]_D$ +50.3°(c=1.09, pyridine). UV λ_{max} mμ (ε): 239 (7,000). IR ν_{max} cm^{-1}: 3415, 3185, 1740, 1640, 1270, 1259, 1245, 1032, 980, 957, 945, 926, 917. *Anal.* Calcd. for $C_{21}H_{32}O_4N_2$: C, 66.99; H, 8.57; N, 7.44. Found: C, 67.12; H, 8.54; N, 7.55.

2,3-Dihydroxyiminoandrostan-17β-ol 17-Propionate (IIId)——IIId was prepared by method G. The analytical sample (from MeOH-$CHCl_3$) had m.p. 244~245°(decomp.), $[\alpha]_D$ +53.5°(c=1.14, pyridine). UV λ_{max} mμ (ε): 237~239 (6,300). IR ν_{max} cm^{-1}: 3300, 3140, 1737, 1650, 1000, 955, 940, 925~920. *Anal.* Calcd. for $C_{22}H_{34}O_4N_2$: C, 67.66; H, 8.78; N, 7.17. Found: C, 67.64; H, 8.66; N, 6.91.

2,3-Dihydroxyimino-17α-methylandrost-4-en-17β-ol (Xa)——Xa was prepared by method G. Needles (from MeOH), m.p. 252~253°(decomp.), $[\alpha]_D$ +112.3°(c=0.74, pyridine). UV λ_{max} mμ (ε): 230 (14,000), 261 (13,600); $\lambda_{max}^{0.1N\ EtONa\text{-}EtOH}$ mμ (ε): 253 (12,200), 306 (9,100). IR ν_{max} cm^{-1}: 3300, 1618, 970, 926. *Anal.* Calcd. for $C_{20}H_{30}O_3N_2$: C, 69.33; H, 8.73; N, 8.09. Found: C, 69.11; H, 8.71; N, 8.04.

Addition of an aqueous nickel nitrate solution to a methanolic solution of this compound gave an orange-red precipitate.

2,3-Dihydroxyiminoandrost-4-en-17β-ol (Xb)——Xb was prepared by method G. Repeated recrystallization from pyridine-ether gave an analytical sample as needles, m.p. 259~261°(decomp.), $[\alpha]_D$ +121.8° (c=1.02, pyridine). UV λ_{max} mμ (ε): 230 (14,000), 261 (13,700); $\lambda_{max}^{0.1N\ EtONa\text{-}EtOH}$ mμ (ε): 253 (12,300), 306 (9,300). IR ν_{max} cm^{-1}: 3220, 1650, 1621, 992, 964, 958, 931, 870. *Anal.* Calcd. for $C_{19}H_{28}O_3N_2$: C, 68.64; H, 8.49; N, 8.43. Found: C, 68.55; H, 8.54; N, 8.24.

17α-Methyl-2,3-dihyroxyiminoandrosta-4,6-dien-17β-ol (XVIa)——XVIa was prepared by method G. Pale yellow needles (from MeOH), m.p. 245°(decomp.), $[\alpha]_D$ −86.7°(c=0.98, pyridine). UV λ_{max} mμ(ε): 297 (27,000); inflections at 251 mμ (ε 10,900) and 260 mμ (ε 11,500); $\varepsilon_{210\ m\mu}$ (end absorption)=6,000. IR ν_{max} cm^{-1}: 3360~3220, 3019, 1613 (w. broad), 1588 (w.), 987, 940, 930, 882. *Anal.* Calcd. for $C_{20}H_{28}O_3N_2$: C, 69.74; H, 8.19; N, 8.13. Found: C, 69.66; H, 8.17; N, 8.01.

Addition of an aqueous $Ni(NO_3)_2$ solution to a methanolic solution of this compound (XVIa) gave an orange-red precipitate.

2,3-Dihydroxyiminoandrosta-4,6-dien-17β-ol (XVIb)——By method G XVIb was obtained from XVb. The analytical sample (from pyridine-ether) had m.p. 252~253°(decomp.), $[\alpha]_D$ −65.0°(c=0.59, pyridine). UV λ_{max} mμ (ε) : 213 (4,500), 297 (24,100), inflections at 251 mμ (ε 10,800) and 260 mμ (ε 11,500). IR ν_{max} cm^{-1} : 3340, 3300~3200, 3016, 1616, 1590, 1562, 992, 970, 955, 934, 882. *Anal.* Calcd. for $C_{19}H_{26}O_3N_2$: C, 69.06; H, 7.93; N, 8.48. Found : C, 68.98; H, 8.25; N, 8.60.

2-Acetoxyimino-17β-hydroxy-17α-methylandrostan-3-one (V)——Acetic anhydride (1.5 ml.) was added to a solution of IVa (0.67 g.) in pyridine (3 ml.) at 0~3°. The mixture was kept at this temperature for 10 min., poured into ice-water (200 ml.) and stirred for 10 min. The precipitate was filtered, washed with water and desiccated in vacuum at room temperature. Crystallization from isopropyl ether-acetone (7:3) afforded V as needles (0.64 g.), m.p. 178~185°(decomp.). The analytical sample had the same melting point, $[\alpha]_D$ +53.1° (c=1.28). UV λ_{max}^{ether} mμ (ε) : 220 (7,400). IR ν_{max} cm^{-1} : 3560, 1785~1775, 1715, 1615~1605, 1185. *Anal.* Calcd. for $C_{22}H_{33}O_4N$: C, 70.37; H, 8.86; N, 3.73. Found : C, 70.62; H, 8.74; N, 3.64.

In ethanolic solution the UV maximum of V disappeared rapidly.

17β-Hydroxy-17α-methyl-2, 3-seco-androstane-2-nitrile-3-oic Acid (VI)——To a solution of the acetate (V) (0.47 g) in acetone (20 ml.) was added an aq. $KHCO_3$-solution (0.40 g. in 10 ml.). The mixture was kept at room temperature for 1 hr., and then concentrated in vacuum to its half volume. The resulting solution was washed with AcOEt. Acidification of the aqueous layer with dil. HCl precipitated the crude product (0.40 g.), m.p. 200~215/229°. Recrystallization from aqueous acetone afforded VI, m.p. 212~215/229°, $[\alpha]_D$ −10°(c=1.54, EtOH). IR ν_{max} cm^{-1} : 3410, 3385, 2600~2500, 2250, 1723, 1705. The two bands at 1723 and 1705 cm^{-1} are due to association and unassociation of the carbonyl group.[26] *Anal.* Calcd. for $C_{20}H_{31}O_3N$: C, 72.03; H, 9.37; N, 4.20. Found : C, 71.93; H, 9.42; N, 4.21.

17β-Hydroxy-2,4-dihydroxyiminoandrost-5-en-3-one (XI)——A solution of *t*-BuOK prepared from K (0.40 g.) and *t*-BuOH (10 ml.) was mixed under N_2 with testosterone (1.0 g.) in *t*-BuOH (30 ml.). Isoamyl nitrite (0.88 g., 2.15 mol. equiv.) was dropped into the mixture with stirring at 25°. After being stirred for 1.5 hr., the mixture was neutralized with AcOH and concentrated under reduced pressure. The product separated by addition of water was crystallized from MeOH to afford XI as yellow crystalline powder (0.62 g.), m.p. 228~230° (decomp.). The analytical sample, after repeated recrystallization from the same solvent, had m.p. 234~236° (decomp.), $[\alpha]_D$ +25.8° (c=1.32, pyridine). UV λ_{max} mμ(ε) : 263 (9,800). IR ν_{max} cm^{-1} : 3200, 1700, 1633, 1615~1588, 1537, 1018, 973, 887. *Anal.*Calcd. for $C_{19}H_{26}O_4N_2 \cdot CH_3OH$: C, 63.47; H, 7.99; N, 7.40. Found : C, 63.42; H, 8.15; N, 7.47.

When 1 mol. equiv. of isoamyl nitrite was used in the above reaction, XI and the starting material were obtained.

17β-Acetoxy-2,3-seco-A-norandrost-5-ene-2,3-dinitrile (XII)——A solution of 17β-hydroxy-2,4-dihydroxyiminoandrost-5-en-3-one (XI) (0.40 g.) in pyridine (5 ml.) and acetic anhydride (1 ml.) was kept at room temperature for 1 hr. The mixture was poured into ice-water and extracted with AcOEt. The extract was washed with 5% $NaHCO_3$ and water, dried and evaporated to dryness. The residue was recrystallized from MeOH to give XII as prisms (0.26 g.), m.p. 188~191°. The pure sample, after recrystallization from the same solvent, showed m.p. 193~194°, $[\alpha]_D$ −69.3° (c=0.90). UV λ_{max} mμ (ε) : 210 (12,000). IR ν_{max} cm^{-1} : 2240, 2210, 1722, 1638, 1243, 1028. *Anal.* Calcd. for $C_{20}H_{26}O_2N_2$: C, 73.59; H, 8.03; N, 8.58. Found : C, 73.45; H, 8.18; N, 8.58.

Hydrolysis of XII (0.5 g.) with KOH (1.0 g.) in glycerine (5 ml.) and water (1 ml.) at 220° for 10 hr. gave an acidic compound (0.37 g.), which was crystallized from MeOH-AcOEt to separate needles, m.p. 234~235°(decomp.). IR ν_{max} cm^{-1} : 2700~2300, 1690, 1636. This is impure 17β-hydroxy-2,3-seco-A-norandrost-5-ene-2,3-dioic acid. Elemental analysis was unsatisfactory.

Steroid[2,3-*c*]furazans from 2,3-Dihydroxyimino Steroids——Method H : The 2,3-dihydroxyimino steroid and KOH were suspended in ethylene glycol and heated at 170~190°.

Method I : The 2,3-dihydroxyimino steroid was suspended in SO_2 and treated with $SOCl_2$.

Method J : The mixture of the 2,3-dihydroxyimino steroid and succinic anhydride was heated at 180~190°.

The typical examples of method H, I, and J are described below.

17β-Hydroxy-17α-methylandrostano[2,3-*c*]furazan (XVIIa)——By method H. A suspension of the dihydroxyimino derivative (IIIa) (2.0 g.) and KOH (0.50 g.) in ethylene glycol (20 ml.) was heated at 180~190° for 30 min., during which all the compounds dissolved. The solution was poured into water, and the precipitate was filtered and dried. The product in benzene was adsorbed on Al_2O_3(10g.) and eluted with ether. Evaporation of the effluent and crystallization of the residue from MeOH gave XVIIa as needles (1.52 g.), m.p. 151~153°. Further crystallization from MeOH raised the m.p. to 152~153°, $[\alpha]_D$ +39.4° (c=1.42). UV λ_{max} mμ (ε): 217(4,300), inflections at 220, 225, and 234 mμ; $\lambda_{max}^{0.1N HCl\text{-}EtOH}$ mμ (ε): 217 (3,900), $\lambda_{max}^{0.1N KOH\text{-}EtOH}$ mμ : 217 (correct ε-value was not determined in presence of alkali). IR ν_{max} cm^{-1} : 3430, 1633, 1590,

26) A. R. H. Cole, A. J. Michell : J. Chem. Soc., **1959**, 2005.

1500, 1430, 1405, 1225, 1208, 1006, 934, 885, 876, 768, 740. *Anal.* Calcd. for $C_{20}H_{30}O_2N_2$: C, 72.69; H, 9.15; N, 8.48. Found : C, 72.76; H, 9.06; N, 8.45.

The use of K_2CO_3, $NaHCO_3$, pyridine or piperidine instead of KOH in the reaction afforded the similar result.

17β-Hydroxyandrostano[2,3-*c*]furazan (XVIIb)——XVIIb was prepared by method H. The analytical sample (from EtOH) had m.p. 160~161°, $[\alpha]_D$ +62.2°(c=2.22). UV λ_{max} mμ (ε) : 217 (4,799), inflections at 220, 225, and 234 mμ. IR ν_{max} cm^{-1} : 3465, 1630, 1587, 1496, 1430, 1402, 1224, 1210, 1002, 958, 940, 874, 766, 738. *Anal.* Calcd. for $C_{19}H_{28}O_2N_2$: C, 72.11; H, 8.90; N, 8.85. Found : C, 72.24; H, 8.80; N, 9.15.

17β-Hydroxy-17α-methylandrost-4-eno[2,3-*c*]furazan (XVIIIa)——XVIIIa was prepared by method H. The analytical sample (from aqueous MeOH) had m.p. 182~183°, $[\alpha]_D$ +144°(c=0.99). UV λ_{max} mμ(ε): 255 (11,400). IR ν_{max} cm^{-1}: 3606, 3430, 1625, 1572, 1509, 1435, 1215, 1002, 970, 932, 854, 844, 788. *Anal.* Calcd. for $C_{20}H_{28}O_2N_2$: C, 73.13; H, 8.59; N, 8.53. Found : C, 73.44; H, 8.39; N, 8.49.

17β-Hydroxyandrost-4-eno[2,3-*c*]furazan (XVIIIb)——XVIIIb was prepared by method H and recrystallized from aqueous MeOH. M.p. 175~176°, $[\alpha]_D$ +181.0° (c=1.16). UV λ_{max} mμ (ε) : 255 (10,600). IR ν_{max} cm^{-1} : 3522, 1624, 1574, 1508, 1001, 939, 866, 856. *Anal.* Calcd. for $C_{19}H_{26}O_2N_2$: C, 72.58; H, 8.34; N, 8.91. Found : C, 72.49; H, 8.40; N, 8.73.

17β-Hydroxy-17α-methylandrosta-4,6-dieno[2,3-*c*]furazan (XIXa)——XIXa was prepared by method H. M.p. 194~195°, $[\alpha]_D$ −102.7°(c=1.13). UV λ_{max} mμ (ε) : 286 (25,000). IR ν_{max} cm^{-1} : 3575, 3540~3420, 3055, 1624, 1611, 1565, 1502, 1431, 995, 934, 882, 852, 798, 773. *Anal.* Calcd. for $C_{20}H_{26}O_2N_2$: C, 73.59; H, 8.03; N, 8.58. Found : C, 73.71; H, 8.12; N, 8.71.

17β-Hydroxyandrosta-4,6-dieno[2,3-*c*]furazan (XIXb)——XIXb was prepared by method H. M.p. 173.5~174.5°, $[\alpha]_D$ −57.5°(c=0.91). UV λ_{max} mμ (ε) : 286 (23,700). IR ν_{max} cm^{-1} : 3345, 3028, 1611, 1562, 1503, 1431, 997, 868, 857, 842, 801, 777. *Anal.* Calcd. for $C_{19}H_{24}O_2N_2$: C, 73.04; H, 7.74; N, 8.97. Found : C, 73.24; H, 7.91; N, 8.79.

17β-Acetoxyandrostano[2,3-*c*]furazan (XVIIc)——a) Acetylation of XVIIb with acetic anhydride and pyridine at 100° for 2 hr. gave the acetate (XVIIc), which was crystallized from MeOH. M.p. 179~180°, $[\alpha]_D$ +43.1°(c=2.37). UV λ_{max} mμ (ε) : 217 (5,000). IR ν_{max} cm^{-1} : 1725, 1635, 1585, 1496, 1240, 1038, 1001, 874, 765, 736. *Anal.* Calcd. for $C_{21}H_{30}O_3N_2$: C, 70.36; H, 8.44; N, 7.82. Found : C, 70.56; H, 8.30; N, 7.73.

b) By method I. Thionyl chloride (0.12 g.) was added to a stirred suspension of the acetate dioxime (IIIc) (0.19 g.) in liquid sulfur dioxide (30 ml.) at −10°. The dioxime dissolved immediately. After removal of the cold bath, sulfur dioxide was allowed to evaporate at room temperature. The residue was dissolved in $CHCl_3$, washed successively with water, 5% $NaHCO_3$ and water, and dried. The solvent was removed and the residue dissolved in benzene was chromatographed on Al_2O_3 (3 g.), and eluted with benzene and benzene-ether (9:1). Evaporation of the combined solution and crystallization of the residue from MeOH gave XVIIc (0.115 g.), m.p. and mixed m.p. 179~180°.

c) By method J. A mixture of the acetate dioxime (IIIc) (0.30 g.) and succinic anhydride (0.30 g.) was heated at 180~190° for 8 min. and cooled. The mixture was dissolved in $CHCl_3$, washed with water and dried. After evaporation of $CHCl_3$, the residue in benzene solution was chromatographed over Florisil (11 g.). The fractions eluted with benzene-ether (9:1) were collected and crystallized from MeOH to give XVIIc (0.15 g.), m.p. and mixed m.p. 179~180°.

17β-Propionyloxyandrostano[2,3-*c*]furazan (XVIId)——a) The 17-hydroxy compound (XVIIb) in pyridine was treated with propionic anhydride at 100° for 2 hr. The product was crystallized from EtOH to give XVIId, m.p. 137~138°, $[\alpha]_D$ +43.2°(c=1.14). UV λ_{max} mμ (ε) : 217 (4,950). IR ν_{max} cm^{-1} : 1732, 1639, 1585, 1497, 1193, 1003, 875, 765, 738. *Anal.* Calcd. for $C_{22}H_{32}O_3N_2$: C, 70.93; H, 8.66; N, 7.52. Found : C, 70.89; H, 8.67; N, 7.63.

b) Method I gave a 55% yield.

17β-Hydroxyandrostano[2,3-*c*]furazan 17-Hydrogen Succinate (XVII, R=H, R′=$COCH_2CH_2COOH$)——a) A mixture of XVIIb (0.30 g.), succinic anhydride (0.50 g.) and pyridine (3 ml.) was heated at 100° for 5.5 hr. The mixture was poured into water and the separated product was suspended in 1% HCl and extracted with ether. Evaporation of the solvent and crystallization of the residue from ether-cyclohexane gave the 17-hydrogen succinate, m.p. 146.5~147.5°, $[\alpha]_D$ +35.7°(c=1.33). UV λ_{max} mμ (ε) : 217~220 (4,000). IR ν_{max} cm^{-1} : 3400, 2800~2300, 1730~1700, 1620, 1260. *Anal.* Calcd. for $C_{23}H_{32}O_5N_2$: C, 66.32; H, 7.74; N, 6.73. Found : C, 65.85; H, 7.63; N, 6.75.

b) Method J gave a 13% yield.

17,17-Dimethyl-18-norandrost-13-eno[2,3-*c*]furazan (XX)——A mixture of 17β-hydroxy-17α-methylandrostano[2,3-*c*]furazan (XVIIa) (0.33 g.), *p*-toluenesulfonic acid monohydrate (0.19 g.) in AcOH (10 ml.) and acetic anhydride (20 ml.) was heated at 100° for 1 hr. The mixture was diluted with water and the separated product was collected. The product in benzene solution was chromatographed over Al_2O_3. Fractions melting at 108~110.5°(0.29 g.) were collected and crystallized from MeOH to separate XX as plates, m.p. 114~115°, $[\alpha]_D$ −4.0°(c=1.33). IR, cf. Table I. UV : no maximum above 210 mμ. $\varepsilon_{210\,m\mu}$

(end absorption): 7,730. *Anal.* Calcd. for $C_{20}H_{28}ON_2$: C, 76.88; H, 9.03; N, 8.97. Found: C, 77.27; H, 9.32; N, 8.87.

The same compound was obtained from IIIa by method I or method J.

Acyl Derivatives of XVIIa——Grignard reagent was prepared under N_2 from Mg (72 mg.), ethyl bromide (0.39 g.) and anhydrous ether (15 ml.). To this was added a solution of XVIIa (0.33 g.) in ether (20 ml.). An amorphous precipitate separated. A solution of acetic anhydride (0.31 g.) in ether (5 ml.) was then added with stirring. After stirring for 2 hr., the mixture was heated under reflux for 2 hr. and then allowed to stand overnight. The mixture was diluted with water and the product obtaind from the ether layer was chromatographed over Al_2O_3 (14 g.). Fractions eluted with petroleum ether-benzene (9:1) (160 ml.) were discarded. From the following fraction eluted with petroleum ether-benzene (1:1) (200 ml.), there was obtained 17β-acetoxy-17α-methylandrostano[2,3-*c*]furazan (XVII, R=CH_3, R'=$COCH_3$) (0.28 g.) which was crystallized from ether, m.p. 166.5~168.5°, $[\alpha]_D$ +40.6° (c=1.53). UV λ_{max} mμ (ε): 217 (4,600). IR ν_{max} cm^{-1}: 1723, 1495, 1257, 1232, 873, 766, 736. *Anal.* Calcd. for $C_{22}H_{32}O_3N_2$: C, 70.93; H, 8.66; N, 7.52. Found: C, 70.96; H, 8.79; N, 7.35.

Instead of acetic anhydride, acetyl chloride was used similarly. In another way, heating XVIIa with acetic anhydride and pyridine at reflux temperature gave the same result as above.

The following compounds were prepared as described above.

17α-Methyl-17β-propionyloxyandrostano[2,3-*c*]furazan. M.p. 130.5~131.5°, $[\alpha]_D$ +46.6° (c=1.18). *Anal.* Calcd. for $C_{23}H_{34}O_3N_2$: C, 71.47; H, 8.87; N, 7.25. Found: C, 71.47; H, 8.75; N, 7.47.

17α-Methyl-17β-(3-phenylpropionyloxy)androstano[2,3-*c*]furazan. M.p. 165~166°, $[\alpha]_D$ +35.3° (c=1.24). *Anal.* Calcd. for $C_{29}H_{38}O_3N_2$: C, 75.29; H, 8.28; N, 6.06. Found: C, 75.21; H, 8.50; N, 5.94.

Acyl Derivatives of XVIIb——XVIIb was treated with pyridine and acid anhydride at 100° or at room temperature. Acid chloride was used in some cases instead of acid anhydride. The acetate (XVIIc) and the propionate (XVIId) were described above.

17β-Butyroyloxyandrostano[2,3-*c*]furazan. M.p. 89~90°, $[\alpha]_D$ +41.6° (c=1.16). *Anal.* Calcd. for $C_{23}H_{34}O_3N_2$: C, 71.47; H, 8.87; N, 7.25. Found: C, 71.10; H, 8.78; N, 7.23.

17β-(*n*-Heptanoyloxy)androstano[2,3-*c*]furazan. M.p. 65~66.5°, $[\alpha]_D$ +45° (c=0.74). *Anal.* Calcd. for $C_{26}H_{40}O_3N_2$: C, 72.86; H, 9.41; N, 6.54. Found: C, 73.20; H, 9.44; N, 6.52.

17β-(*n*-Decanoyloxy)androstano[2,3-*c*]furazan. M.p. 72.5~73.5°, $[\alpha]_D$ +36.5° (c=1.09). *Anal.* Calcd. for $C_{29}H_{46}O_3N_2$: C, 74.00; H, 9.85; N, 5.95. Found: C, 73.82; H, 9.65; N, 6.10.

17β-(*n*-Hexadecanoyloxy)androstano[2,3-*c*]furazan. M.p. 77~78°. *Anal.* Calcd. for $C_{35}H_{58}O_3N_2$: C, 75.76; H, 10.54; N, 5.05. Found: C, 75.53; H, 10.50; N, 4.88.

17β-(3-Phenylpropionyloxy)androstano[2,3-*c*]furazan. M.p. 111~112°, $[\alpha]_D$ +45.7° (c=1.56). *Anal.* Calcd. for $C_{28}H_{36}O_3N_2$: C, 74.97; H, 8.09; N, 6.25. Found: C, 74.85; H, 8.10; N, 6.19.

17β-(3-Cyclohexylpropionyloxy)androstano[2,3-*c*]furazan. Amorphous powder (from EtOH), m.p. 115~117°. *Anal.* Calcd. for $C_{28}H_{42}O_3N_2$: C, 73.97; H, 9.31; N, 6.16. Found: C, 73.72; H, 9.16; N, 5.93.

17β-Benzoyloxyandrostano[2,3-*c*]furazan. M.p. 239~241°, $[\alpha]_D$ +81° (c=1.10). *Anal.* Calcd. for $C_{26}H_{32}O_3N_2$: C, 74.25; H, 7.67; N, 6.66. Found: C, 74.05; H, 7.60; N, 6.71.

Steroid[2,3-*c*]furazan N-Oxides——Method K: The 2,3-dihydroxyimino steroid in aqueous MeOH was treated with aqueous NaOCl solution.

Method L: The 2,3-dihydroxyimino steroid in AcOH was treated with lead tetraacetate. The examples of method K and L are described below.

17β-Hydroxy-17α-methylandrostano[2,3-*c*]furazan N-Oxide (XXIa)——a) By method K. An aqueous solution of sodium hypochlorite was prepared by bubbling Cl_2 into 20% NaOH until the solution became neutral. 2,3-Dihydroxyimino-17α-methylandrostan-17β-ol (IIIa) (1.0 g.) was dissolved in a solution of NaOH (3 g.) in MeOH (20 ml.) and water (10 ml.), cooled (0~10°) and stirred. To this was added dropwise the above NaOCl solution until there was no further precipitation. The separated product was crystallized from MeOH to yield the N-oxide (XXIa) as plates (0.95 g.), m.p. 179~180°. Recrystallization gave an analytical sample, m.p. 180°, $[\alpha]_D$ +34.7° (c=0.98). UV λ_{max} mμ (ε): 263 (7,500). IR ν_{max} cm^{-1}: 3490, 1638, 1620, 993, 932. *Anal.* Calcd. for $C_{20}H_{30}O_3N_2$: C, 69.33; H, 8.73; N, 8.09. Found: C, 69.27; H, 8.55; N, 7.92.

b) By method L. To a suspension of the dioxime (IIIa) (0.65 g.) in AcOH (8 ml.) was added lead tetraacetate (0.88 g.) at room temperature. The mixture was set aside for 20 min., heated at 50° for 15 min. and cooled. The clear solution obtained was diluted with water (100 ml.) and the separated product was collected. Crystallization from MeOH gave XXIa, identical with that described above, m.p. and mixed m.p. 179~180°.

Acetylation of XXIa (1 g.) with acetic anhydride (8 ml.) and pyridine (4 ml.) at reflux temperature gave the acetate (XXIe) (0.83 g.). The analytical sample was crystallized from MeOH. Needles, m.p. 177~178°, $[\alpha]_D$ +50.5° (c=1.17). UV λ_{max} mμ (ε): 264 (6,900). IR ν_{max} cm^{-1}: 1731, 1643, 1625, 1480, 1469, 1257, 1230. *Anal.* Calcd. for $C_{22}H_{32}O_4N_2$: C, 68.01; H, 8.30; N, 7.21. Found: C, 67.91; H, 8.15; N, 7.38.

17β-Hydroxyandrostano[2,3-*c*]furazan N-Oxide (XXIb)——This was prepared by method K and also by method L. Plates (from MeOH), m.p. 221~222°, $[\alpha]_D$ +67.8° (c=1.03). UV λ_{max} mμ (ε): 264 (7,000).

IR ν_{max} cm^{-1} : 3600, 3460, 1622, 1513, 1008, 999, 989, 937. *Anal.* Calcd. for $C_{19}H_{28}O_3N_2$: C, 68.64; H, 8.49; N, 8.43. Found : C, 68.33; H, 8.61; N, 8.33.

Treatment of XXIb with benzoyl chloride in pyridine solution at room temperature gave the benzoate (XXIf). Needles (from benzene-MeOH), m.p. 277~278°(decomp.), $[\alpha]_D$ +92.4°(c=0.80). UV λ_{max} mμ(ε): 230 (17,000) and 264 (7,800). IR ν_{max} cm^{-1} : 3058, 1708, 1623, 1602, 1583, 1466, 1273, 1115, 724. *Anal.* Calcd. for $C_{26}H_{32}O_4N_2$: C, 71.53; H, 7.39; N, 6.42. Found : C, 71.53; H, 7.17; N, 6.59.

Treatment of XXIb with 3-phenylpropionic anhydride in pyridine at room temperature gave the 3-phenylpropionate (XXIg) which was crystallized from acetone-EtOH. M.p. 138~139°, $[\alpha]_D$ +56.4°(c=1.17). UV λ_{max} mμ (ε) : 208 (9,600) and 264 (7,000). IR ν_{max} cm^{-1} : 3056, 3026, 1727, 1625, 1475, 1163, 699. *Anal.* Calcd. for $C_{28}H_{36}O_4N_2$: C, 72.38; H, 7.81; N, 6.03. Found : C, 72.49; H, 7.59; N, 5.96.

17β-Acetoxyandrostano[2,3-*c*]furazan N-Oxide (XXIc)—— This was prepared by method L. Plates (from MeOH), m.p. 209~210°, $[\alpha]_D$ +41.5°(c=1.04). UV λ_{max} mμ (ε) : 264 (6,700). IR ν_{max} cm^{-1} : 1734, 1625, 1475, 1240, 1042. *Anal.* Calcd. for $C_{21}H_{30}O_4N_2$: C, 67.35; H, 8.08; N, 7.48. Found : C, 67.09; H, 8.05; N, 7.50.

The same compound was obtained by acetylation of XXIb.

17β-Propionyloxyandrostano[2,3-*c*]furazan N-Oxide (XXId)——This was prepared by method L. M.p. 156~157°, $[\alpha]_D$ +38.4°(c=0.81). UV λ_{max} mμ (ε) : 264 (6,700). IR ν_{max} cm^{-1} : 1747, 1621, 1470, 1183. *Anal.* Calcd. for $C_{22}H_{32}O_4N_2$: C, 68.01; H, 8.30; N, 7.21. Found : C, 67.75; H, 8.05; N, 7.50.

The same compound was obtained by treatment of XXIb with propionyl chloride in pyridine.

Deoxygenation of the Furazan N-Oxide (XXI)——The N-oxide was suspended in triethyl phosphite and heated at 170~180°. The reaction product was purified by crystallization or by chromatography on alumina. The example is described below.

17β-Acetoxyandrostano[2,3-*c*]furazan N-oxide (XXIc) (0.5 g.) was suspended in triethyl phosphite (2 ml.) and heated at 170~180° under N_2 for 6 hr. To the cooled reaction mixture was added water (2 ml.) and 10% H_2SO_4 (4 ml.) to decompose excess of the reagent. After a few minutes, a crystalline precipitate was collected, washed with water and dried. Recrystallization from MeOH gave the furazan (XVIIc) (0.38 g.), m.p. and mixed m.p. 179~180°.

XXId, XXIe, XXIf, and XXIg were deoxygenated similarly to the corresponding furazans, respectively.

Treatment of XXIb by this method gave XVIIb in 15% yield.

Treatment of XXIa by this method gave a dehydrated mixture, m.p. 144~146°. IR ν_{max} cm^{-1} : 3035 (C=CH), 1653 (C=C), 1635, 1494 (furazan), 1002, 880, 874. The IR spectrum showed no absorption due to a hydroxyl group. Gas chromatography*7 showed two peaks at retention time of 8.75 and 9.30 min. The peaks were different from that of XX (retention time, 7.85 min.). The mixture was not examined further but it was probably a mixture of Δ^{16}-17-methyl- and 17-methyleneandrostano[2,3-*c*]furazan. Cf. ref. *1.

17β-Hydroxyandrostano[2,3-*c*]furazan 17-Tetrahydro-2′-pyranyl Ether (XVIIe)——A mixture of the 17β-ol (XVIIb) (0.47 g.), 2,3-dihydropyran (2 ml.), *p*-toluenesulfonic acid monohydrate (85 mg.) in ether (30 ml.) was set aside at room temperature for 1.5 hr. The mixture was diluted with water and the ethereal layer was separated, washed with 5% $NaHCO_3$ and water, dried and evaporated. The product, after chromatography on Al_2O_3, crystallized from MeOH to give XVIIe (0.40 g.), m.p. 109.5~113.5°. *Anal.* Calcd. for $C_{24}H_{36}O_3N_2$: C, 71.96; H, 9.06; N, 6.99. Found : C, 71.88; H, 8.79; N, 7.15.

17β-Hydroxyandrostano[2,3]furazan 17-1′-Ethoxycyclopentyl Ether (XVII, R=H, R′=$C_5H_8(OC_2H_5)$)—— A mixture of XVIIb (0.50 g.) and cyclopentanone diethyl acetal (freshly prepared, 2.0 ml.) was heated at 120~125° for 1 hr., during which the volatile materials were distilled off. The product, after chromatography in benzene solution over Al_2O_3, was crystallized from ether-EtOH to give the ethoxycyclopentyl ether (0.30 g.), m.p. 120~122°, $[\alpha]_D$ +45.3°(c=1.03). UV λ_{max} mμ (ε) : 217 (4,800). IR ν_{max} cm^{-1} : 1494, 1115, 1102, 1054, 1041, 1032, 876, 764, 737. *Anal.* Calcd. for $C_{26}H_{40}O_3N_2$: C, 72.86; H, 9.41; N, 6.54. Found : C, 72.86; H, 9.42; N, 6.61.

17β-Hydroxyandrostano[2,3-*c*]furazan 17-1′-Cyclopentenyl Ether (XVIIf)——A mixture of XVIIb (1.58 g.) and cyclopentanone diethyl acetal (5.0 ml.) was heated at 130~135° for 30 min. and then at 180~185° for 30 min., during which the volatile fractions were distilled off. The reaction mixture was dissolved in benzene and filtered through Al_2O_3 (30 g.). The product from the effluents was recrystallized from MeOH containing a few drops of pyridine to give needles of XVIIf, m.p. 120~124°(1.3 g.). Recrystallization from ether-MeOH containing pyridine afforded a pure sample, m.p. 124~126°, $[\alpha]_D$ +43.6°(c=1.02). UV : No maximum above 210 mμ. IR ν_{max} cm^{-1} : 3080, 1641, 1495, 1240, 1014, 1003, 874, 766, 755, 738. *Anal.* Calcd. for $C_{24}H_{34}O_2N_2$: C, 75.35; H, 8.96; N, 7.32. Found : C, 74.99; H, 8.89; N, 7.11.

*7 Gas chromatography was carried out by using a Barber-Colman Model 10 chromatographic unit. The column was packed with 1% SE-30 (G.E.) silicone polymer on Anakrom ABS. The conditions used were as follows : column temperature 220°, detector temperature 210°, flash heater temperature 235°, argon gas flow rate 75 ml./min.

17-Oxoandrostano[2,3-*c*]furazan (XXII)——To a solution of 17β-hydroxyandrostano[2,3-*c*]furazan (XVIIb) (3.16 g.) in acetone (100 ml.) was added dropwise 8*N* CrO_3-H_2SO_4 solution[27] (4.8 ml.) at room temperature. After stirring for 15 min., the mixture was diluted with water to separate a solid which was crystallized from MeOH to give XXII as needles (2.42 g.), m.p. 184~185°, $[\alpha]_D$ +128.5° (c=1.08). IR ν_{max} cm^{-1} : 1735, 1580, 1495, 1007, 1001, 875, 865, 766, 737. *Anal.* Calcd. for $C_{19}H_{26}O_2N_2$: C, 72.58; H, 8.34; N, 8.91. Found : C, 72.54; H, 8.49; N, 8.75.

17α-Ethynyl-17β-hydroxyandrostano[2,3-*c*]furazan (XXIII)——Acetylene was bubbled into ether (100 ml.) at room temperature. After 30 min., to this were added a solution of the ketone (XXII) (4.30 g.) in ether (50 ml.) and benzene (80 ml.) and a solution of potassium *t*-butoxide (5.0 g. of K in 180 ml. of *t*-BuOH) at the same time. Acetylene was bubbled for further 31 hr. The reaction mixture was diluted with dil. HCl. The organic layer was separated, washed successively with water, 5% $NaHCO_3$ and water, and dried. The solvent was removed in vacuum and the residue in benzene solution was chromatographed through a column of Al_2O_3 (150 g.). The column was eluted with a) benzene (300 ml.), b) benzene-ether (19:1, 300 ml.), and c) benzene-ether (19:1, 300 ml. and 1:1, 800 ml.). From fraction c) there was obtained the crude product (3.37 g.) which was crystallized from MeOH to give XXIII, m.p. 217.5~219°. The analytical sample had m.p. 219~220°, $[\alpha]_D$ −5.1°(c=1.25). UV λ_{max} mμ (ε) : 217~218 (4,280). IR ν_{max} cm^{-1} : 3480, 3240, 2085, 1590, 1495, 1045, 1004, 883, 765, 738. *Anal.* Calcd. for $C_{21}H_{28}O_2N_2$: C, 74.08; H, 8.29; N, 8.23. Found : C, 74.05; H, 8.11; N, 8.42.

17β-Hydroxy-17α-vinylandrostano[2,3-*c*]furazan (XXIV)——The ethynyl compound (XXIII) (0.34 g.) in a mixture of benzene (30 ml.) and quinoline (60 mg.) was hydrogenated over Lindlar's catalyst[28] (100 mg.) at room temperature. Absorption of hydrogen (25 ml.; theory, 24 ml.) stopped after 6 min. The product, after chromatography over Al_2O_3 in benzene solution, was crystallized from ether to give XXIV as needles (0.24 g.), m.p. 177~178.5°, $[\alpha]_D$ +30.6°(c=1.14). UV λ_{max} mμ (ε) : 217 (4,400). IR ν_{max} cm^{-1} : 3545, 3080, 1635, 1583, 1495, 1003, 990, 922, 880, 765, 738. *Anal.* Calcd. for $C_{21}H_{30}O_2N_2$: C, 73.64; H, 8.83; N, 8.18. Found : C, 73.76; H, 8.66; N, 8.37.

17α-Ethyl-17β-hydroxyandrostano[2,3-*c*]furazan (XXV)——The ethynyl compound (XXIII) (0.34 g.) in MeOH (30 ml.) was hydrogenated over 20% Pd/C (100 mg.). The crude product in benzene solution was chromatographed over Al_2O_3 and crystallized from ether-petroleum ether to give XXV (0.225 g.), m.p. 141.5~143°. The analytical sample had m.p. 143~144.5°, $[\alpha]_D$ +39° (c=1.16). UV λ_{max} mμ (ε) : 217 (4,400). IR ν_{max} cm^{-1} : 3570, 1580, 1496, 1002, 877, 765, 737. *Anal.* Calcd. for $C_{21}H_{32}O_2N_2$: C, 73.21; H, 9.36; N, 8.13. Found : C, 72.88; H, 9.48; N, 7.78.

The compound (XXV) was also obtained by hydrogenation of XXIV, m.p. and mixed m.p. 143~144°.

17-Oxoandrost-4-eno[2,3-*c*]furazan (XXVI)——To an ice-cooled solution of 17β-hydroxyandrost-4-eno[2,3-*c*]furazan (XVIIIb) (4.00 g.) in acetone (200 ml.) was added dropwise 8*N* CrO_3-H_2SO_4 solution[27] (3.5 ml.). After stirring for 5 min., the mixture was diluted with water to separate a solid which was crystallized from acetone to give XXVI (3.46 g.), m.p. 242~243°. The analytical sample had m.p. 243.5~244.5°, $[\alpha]_D$ +256.5°(c=0.70). UV λ_{max} mμ (ε) : 254 (10,700). IR ν_{max} cm^{-1} : 1741, 1628, 1575, 1512, 1010, 1000, 866, 853, 845, 814. *Anal.* Calcd. for $C_{19}H_{24}O_2N_2$: C, 73.04; H, 7.74; N, 8.97. Found : C, 72.90; H, 7.67; N, 8.93.

17α-Ethynyl-17β-hydroxyandrost-4-eno[2,3-*c*]furazan (XXVII)——Acetylene was bubbled into benzene (100 ml.) for 30 min. at room temperature, and then a solution of the Δ^4-17-ketone (XXVI) (3.16 g.) in benzene (200 ml.) and a solution of potassium *t*-butoxide (4.0 g. of K in 150 ml. of *t*-BuOH) were added dropwise during 30 min. at the same time. Acetylene was bubbled for further 30 hr. The reaction mixture was diluted with dil. HCl. The organic layer was separated, washed successively with water, 5% $NaHCO_3$ and water, and dried. The solvent was removed in vacuum and the residue in benzene solution was chromatographed over Al_2O_3 (120 g.). The column was eluted with a) benzene (300 ml.), b) benzene-ether (19:1, 100 ml.), and c) benzene-ether (19:1, 500 ml.) and (1:1, 200 ml.). From the fraction c) there was obtained the crude product which was crystallized from MeOH to give XXVII (1.56 g.), m.p. 210~212°. The analytical sample had m.p. 212~213°, $[\alpha]_D$ +75.3°(c=0.88). UV λ_{max} mμ (ε) : 254~255 (11,100). IR ν_{max} cm^{-1}; 3445, 3260, 2090, 1629, 1575, 1513, 1055, 1004, 867, 859. *Anal.* Calcd. for $C_{21}H_{26}O_2N_2$: C, 74.52; H, 7.74; N, 8.28. Found : C, 74.23; H, 7.71; N, 8.12.

3,4-Dimethylfurazan——a) Prepared by the method of Behr and Brent,[13] b.p. 159~161°. UV λ_{max} mμ (ε) : 212 (3,100), inflections at 215, 220, and 226 mμ. IR $\nu_{max}^{liq.}$ cm^{-1} : 1690, 1590, 1490, 1460, 1440, 1400, 1385, 1215, 1040, 945, 890, 708. *Anal.* Calcd. for $C_4H_6ON_2$: C, 48.97; H, 6.17; N, 28.56. Found : C, 49.08; H, 6.22; N, 28.32.

b) A mixture of dimethyl glyoxime (6.96 g.), KOH (0.34 g.) and ethylene glycol (10 ml.) was placed in a distillation flask and heated at 160~190° for 30 min. The distillate was collected. To the residue water (30 ml.) was added and the mixture was again distilled. All the distillates were combined and

27) K. Bowden, I.M. Heilbron, E.R.H. Jones, B.C.L. Weeden : J. Chem. Soc., **1946**, 39.
28) H. Lindlar : Helv. Chim. Acta, **35**, 446 (1952).

extracted with ether. The extract was washed with water, dried and concentrated. Distillation of the residue gave 3,4-dimethylfurazan (4.84 g.), identical with that described above, b.p. 159~161°.

Cyclohexano[*c*]furazan——A mixture of 1,2-cyclohexanedione dioxime (1.52 g.), KOH (0.56 g.) and ethylene glycol (3 ml.) was heated at 160° for 45 min. The mixture was diluted with water and extracted with ether. The extract was washed with water, dried and concentrated. The residue was distilled under reduced pressure to give cyclohexano[*c*]furazan, b.p. 80~85°/5 mm. Hg, m.p. 24°. UV λ_{max} mμ (ε): 217 (3,300), inflections at 220, 225, and 233 mμ. IR $\nu_{max}^{liq.}$ cm^{-1} : 1625, 1585, 1495, 1435, 1395, 1210, 998, 960, 880, 835. *Anal.* Calcd. for $C_6H_8ON_2$: C, 58.05; H, 6.50; N, 22.57. Found : C, 58.20; H, 6.58; N, 22.90. (Reported m.p. 26°, λ_{max}^{MeOH} mμ (log ε) : 220 (3.56)[*8,14]).

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Summary

Steroids with a furazan ring fused to the 2,3-positions were synthesized. 2,3-Dihydroxyiminoandrostanes (Ⅲ) prepared from androstan-3-ones (Ⅰ), *via* 2-hydroxyimino-3-ketones (Ⅳ), or 2,3-diketones (Ⅱ), were cyclized directly to androstano[2,3-*c*]furazans (XVII) by means of alkali, succinic anhydride or thionyl chloride. Alternatively, 2,3-dihydroxyimino compounds (Ⅲ) were treated with sodium hypochlorite or lead tetraacetate to afford the corresponding furazan N-oxides (furoxans) (XXI), which were deoxygenated to the furazans (XVII) by heating with triethyl phosphite. Similarly, androst-4-eno and androsta-4,6-dieno[2,3-*c*]furazans (XVII, XIX) were prepared. Syntheses of their derivatives were also described.

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[*8] Note added in proof. The synthesis of steroidal oxadiazoles by Havranek and Hoey appeared after subscription of our manuscript. R. E. Havranek, G. B. Hoey : Abstracts of the 150th Meeting of the American Chemical Society, Sept. 1965, p. 27 P. The preliminary account of portions of our study was reported in this Bulletin, **13**, 895 (1965).