Steroids. VI. The Synthesis and Reactions of Some 2,4-Bisoximino-3-keto Steroids[1a]

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Cholestan-3-one, 5α-androstan-17β-ol-3-one, 5β-androstan-17β-ol-3-one, and testosterone have been converted to the corresponding 2,4-bisoximino 3-ketones (IV, V, VI, and XX) by base-catalyzed nitrosation. Beckmann rearrangement of the bisoximino ketones afforded a series of 2,3-seco-A-nor steroid 2,3-dinitriles IX, X, XI, XII, XIII, and XXI). 2,4-Bisoximino-5α-androstan-17β-ol-3-one (V) and its 5β epimer (VI) were converted by chloramine to the corresponding crystalline 2,4-bisdiazo 3-ketones (VII and VIII, respectively), which represent the first reported steroidal α,α′-bisdiazo ketones.

The Beckmann rearrangement has been frequently employed to alter the framework of steroid molecules. Aza,[2] homoaza,[3] and bishomoaza steroids[4] have been prepared *via* rearrangement of oximes, while rearrangement of 16-oximino 17-ketones has led to cleavage of the D-ring.[5] We now wish to report the synthesis of several 2,4-bisoximino-3-keto steroids in the cholestane and androstane series, and their behavior under Beckmann rearrangement conditions.

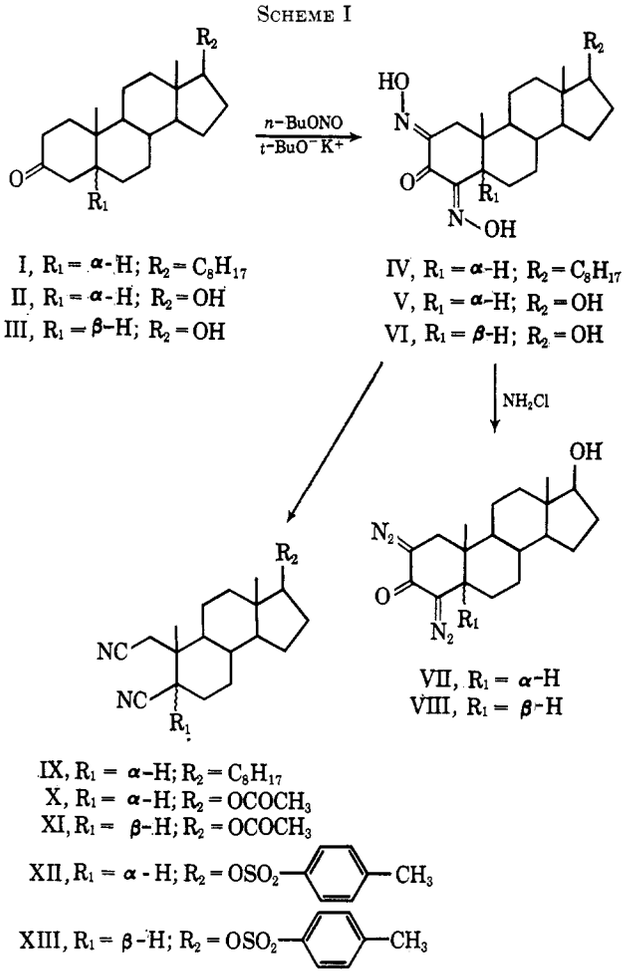
Sheehan and Erman[6] have described the preparation of 2-oximinocholestan-3-one by treatment of cholestan-one with one equivalent of both *n*-butyl nitrite and potassium *t*-butoxide as catalyst. We have found that by using an excess of these reagents, two oximino groups are readily introduced into the molecule, giving 2,4-bisoximinocholestan-3-one (IV) in 81% yield. 5α-Androstan-17β-ol-3-one (II) and 5β-androstan-17β-ol-3-one (III) were nitrosated in a similar manner, although in lower yield, affording 2,4-bisoximino-5α-androstan-17β-ol-3-one (V) and 2,4-bisoximino-5β-androstan-17β-ol-3-one (VI), respectively (see Scheme I).

The oximino groups in IV, V, and VI have been tentatively assigned the *anti,anti* configuration.

At least one of the oxime functions in these compounds is definitely *anti* to the C_3-ketone, as evidenced by the colored complexes which they form with divalent copper and cobalt ions.[7] In addition, a comparison of their ultraviolet absorption spectra in neutral solution suggests that both oximino groups may have the *anti* configuration. All three compounds (IV, V, and VI) exhibit a single maximum in the region of 248–268 mμ which is intensified and shifted to 333–348 mμ upon addition of base. This bathochromic shift under alkaline conditions is characteristic of α-oximino ketones having the *anti* configuration.[5b,8] The complete disappearance of the band at 248–268 mμ implies that the second oxime function is also *anti*, since the absorption band in the 250–270-mμ region of a *syn*-oximino ketone is known to be retained in a basic solution.[8a,c] It must be recognized, however, that the known spectral behavior of *syn* and *anti* α-oximino ketones may not follow a simple additive pattern in the α,α′-bisoximino ketones.

All of the new bisoximino ketones were found to undergo a second-order Beckmann rearrangement[9] with

SCHEME I



I, R_1 = α-H; R_2 = C_8H_{17}
II, R_1 = α-H; R_2 = OH
III, R_1 = β-H; R_2 = OH
IV, R_1 = α-H; R_2 = C_8H_{17}
V, R_1 = α-H; R_2 = OH
VI, R_1 = β-H; R_2 = OH
VII, R_1 = α-H
VIII, R_1 = β-H
IX, R_1 = α-H; R_2 = C_8H_{17}
X, R_1 = α-H; R_2 = $OCOCH_3$
XI, R_1 = β-H; R_2 = $OCOCH_3$
XII, R_1 = α-H; R_2 = OSO_2–C_6H_4–CH_3
XIII, R_1 = β-H; R_2 = OSO_2–C_6H_4–CH_3

(1) (a) Abstract in part from the Ph.D. dissertations of E. J. Glamkowski (1963) and P. M. Weintraub (1964), The Ohio State University. After the submission of this manuscript for publication, a recent paper came to our attention in which certain of our results were independently reported: G. Ohta, T. Takegoshi, K. Ueno and M. Shimizu, *Chem. Pharm. Bull.* (Tokyo), **13**, 1445 (1965). (b) Department of Chemistry, Wayne State University, Detroit, Mich. 48202.

(2) (a) T. A. Jacobs and R. B. Brownfield [*J. Am. Chem. Soc.*, **82**, 4033 (1960)] cover the literature to 1960; (b) C. W. Shoppe, R. W. Killick, and G. Krüger, *J. Chem. Soc.*, 2275 (1962); (c) Y. Morisawa, Y. Kishida and K. Tanabe, *Chem. Pharm. Bull. (Tokyo)*, **11**, 686 (1963).

(3) (a) C. W. Shoppee and G. Krüger, *J. Chem. Soc.*, 3641 (1961); (b) J. A. Zderic and J. Iriarte, *J. Org. Chem.*, **27**, 1756 (1962); (c) C. W. Shoppee, G. Krüger, and R. N. Mirrington, *J. Chem. Soc.*, 1050 (1962); (d) R. H. Mazur, *J. Org. Chem.*, **28**, 248 (1963); (e) C. W. Shoppee, R. E. Lack, and S. K. Roy, *J. Chem. Soc.*, 3767 (1963); (f) C. W. Shoppee, R. E. Lack, R. N. Mirrington, and L. R. Smith, *ibid*, 5868 (1965).

(4) H. Heusser, J. Wohlfahrt, M. Müller, and R. Anliker, *Helv. Chim. Acta*, **38**, 1399 (1955).

(5) (a) F. Litvan and R. Robinson, *J. Chem. Soc.*, 1997 (1938), and, more recently, (b) A. Hassner and I. H. Pomerantz, *J. Org. Chem.*, **27**, 1760 (1962).

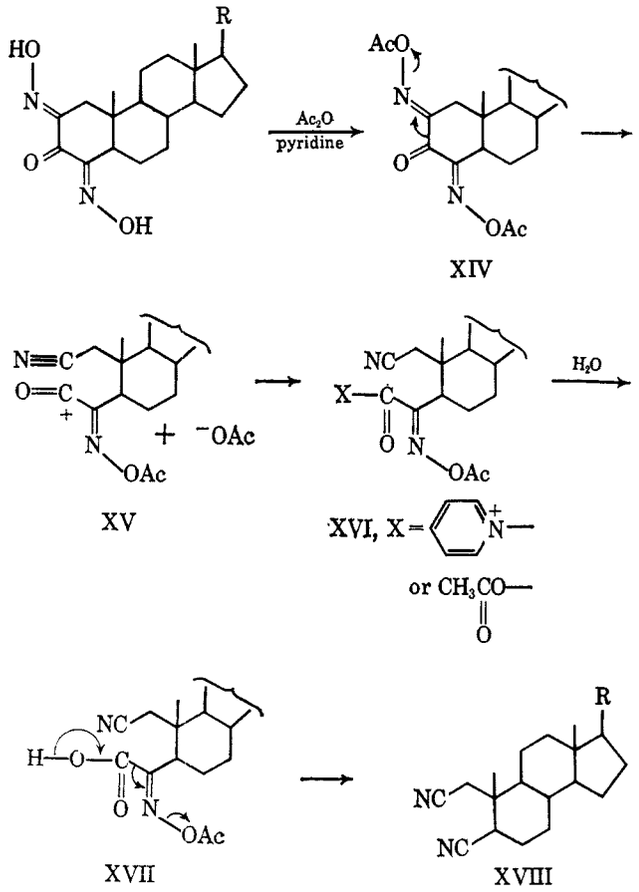
(6) J. C. Sheehan and W. F. Erman, *J. Am. Chem. Soc.*, **79**, 6050 (1957).

(7) N. V. Sidgwick, "The Organic Chemistry of Nitrogen," Oxford University Press, Oxford, 1937, p 195.

(8) (a) D. H. R. Barton and J. Beaton, *J. Am. Chem. Soc.*, **83**, 4083 (1961); (b) M. P. Cava and P. M. Weintraub, *Steroids*, **2**, 41 (1965); (c) M. P. Cava and B. R. Vogt, *J. Org. Chem.*, **30**, 3775 (1965).

(9) (a) A. Werner and A. Piguet, *Ber.*, **37**, 4295 (1904); (b) A. H. Blatt and R. P. Barnes, *J. Am. Chem. Soc.*, **56**, 448 (1934); (c) A. F. Ferris, *J. Org. Chem.*, **25**, 12 (1960).

SCHEME II



acetic anhydride in pyridine solution. The reactions were allowed to proceed for 6 to 16 hr at room temperature and were then quenched with water. Chromatography of the resulting precipitates on alumina afforded 29–36% yield of crystalline products, assigned the structure of 2,3-seco-A-nor steroid 2,3-dinitriles (IX, X, and XI) on the basis of analytical and infrared evidence. All three compounds exhibited characteristic nitrile absorption at 4.47 μ in the infrared; the androstane derivatives X and XI also showed an ester carbonyl at 5.79 μ due to acetylation of the original C-17 hydroxyl group.

Bisoximino ketones V and VI underwent a similar cleavage when treated with tosyl chloride in pyridine. The resulting tosyl ester dinitriles (XII and XIII) were obtained in somewhat poorer yields (<20%) than their acetoxy analogs X and XI. It may be noted, however, that no systematic effort was made to obtain maximum yields of any of the dinitriles which are reported here.

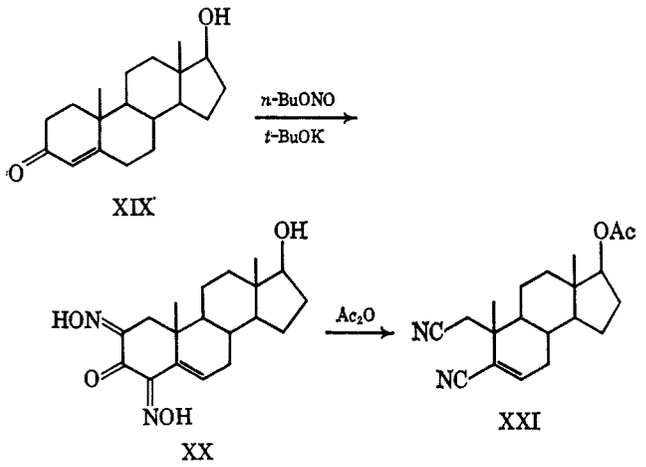
A plausible mechanism for the second-order Beckmann rearrangement of the 2,4-bisoximino 3-ketones to dinitriles is illustrated in Scheme II in the case of the acetic anhydride–pyridine reagent.

The initially formed dioximine ester (XIV) can fragment to give, either *via* a transient oxocarbonium ion (XV) or *via* direct displacement by pyridine, an acylpyridium ion (XVI). Aqueous hydrolysis of XVI would give an acylated α-keto acid oxime (XVII), decarboxylation of which can take place with elimination of acetate ion to give the observed dinitrile (XVIII). The formation of XVIII as a final product would result also, of course, if the initial fragmentation (XIV → XV) took place between C-3 and C-4 rather than between C-2 and C-3. (See Scheme II).

The steps leading to the cleaved acid XVII find a close analogy in the second-order Beckmann rearrangement of 2,6-diacetoximinocyclohexanone, which has been found to give 5-cyano-2-oximinovaleric acid or a derivative of the latter acid.[10] The transformation of the acetate of an α-oximino acid to a nitrile has ample analogy in the literature.[11]

There appears to be only one previous detailed report of the preparation of a dinitrile using the second order Beckmann rearrangement.[12] In the course of stereochemical studies in the morphine series, the α,α'-bisoximino derivatives of thebenone and its C_{14} epimer were treated with tosyl chloride in pyridine solution, affording the corresponding ring cleavage products, thebedinitrile and *epi*-thebedinitrile.[13]

The base-catalyzed nitrosation of testosterone (XIX) by excess alkyl nitrite was investigated in order to determine whether oximino groups would be introduced into the 2,4 positions or the 2,6 positions of a typical Δ^4-3-keto steroid. The product obtained was assigned the structure 2,4-bisoximinoandrost-5-en-17β-ol-3-one (XX), since it afforded a crystalline acetoxy dinitrile (XXI) when treated with acetic anhydride in pyridine. The saturated and the α,β-unsaturated nitrile functions are clearly distinguishable in the infrared spectrum of XXI, appearing at 4.48 and 4.58 μ, respectively.



The stereochemistry of XX cannot be assigned with confidence at this time. The formation of colored complexes with cupric and cobaltous ions indicates that at least one oxime function is *anti* to the carbonyl group. The single maximum at 263 mμ in the ultraviolet spectrum of XX is retained in a basic solution in which, however, two new peaks appear at 221 mμ and 345 mμ. This observation suggests the presence of one *anti* oximino group and one *syn* oximino group in the molecule. This conclusion is valid, of course, only if the two oximino groups in XX behave as spectrally independent units. On the other hand, the formation

(10) (a) A. F. Ferris, G. S. Johnson, F. E. Gould, and H. K. Latourette, *J. Am. Chem. Soc.*, **25**, 492 (1960); (b) A. F. Ferris, G. S. Johnson, and F. E. Gould, *ibid.*, **25**, 496 (1960); (c) A. F. Ferris, G. S. Johnson, F. E. Gould, and H. Stange, *ibid.*, **25**, 1302 (1960); (d) A. F. Ferris, G. S. Johnson, and F. E. Gould, *ibid.*, **25**, 1813 (1960).

(11) R. W. Wagner and H. D. Zook, "Synthetic Organic Chemistry," John Wiley and Sons, Inc., New York, N. Y., 1953, p 598.

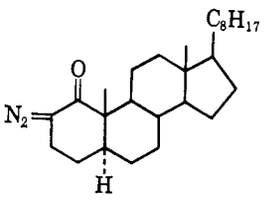
(12) The formation of glutaronitrile from 2,6-dioximinocyclohexanone, benzenesulfonyl chloride and base has been noted, but details have not been described.[10a]

(13) H. Rapport and J. Lavigne, *J. Am. Chem. Soc.*, **75**, 5329 (1953).

of a dinitrile (XXI) by the Beckmann rearrangement of XX is mechanistically more reasonable if both of the oximino groups of XX have the *anti* configuration.

The bisoximino ketones described above all reacted with chloramine to give diazo ketones, as evidenced by strong infrared absorption in the 4.8-μ region; only compounds V and VI gave pure crystalline products, namely 2,4-bisdiazo-5α-androstan-17β-ol-3-one (VII) and 2,4-bisdiazo-5β-androstan-17β-ol-3-one (VIII), respectively. Compounds VII and VIII, which are the first examples of steroidal α,α'-bisdiazo ketones, form bright yellow crystals which are remarkably stable at room temperature in the solid state.

A comparison of the infrared and ultraviolet spectra of the α,α'-bisdiazo ketone VII with those of a typical α-diazocyclohexanene, α-diazocholestan-1-one (XXII),[8c]



XXII

shows several interesting effects of the conjugation of a carbonyl with two diazo groups. Whereas the diazo group in the α-diazo ketone XXII absorbs in the infrared as a single band at 4.85 μ, the two diazo groups in the α,α'-bisdiazo ketone VII effect a splitting of this band into a doublet at 4.75 μ and 4.83 μ. Furthermore, the carbonyl absorption band in XXII appears at somewhat shorter wavelength (6.17 μ) than that of VII (6.29 μ), indicating an appreciably greater conjugation of the carbonyl in the bisdiazo ketone. The more pronounced conjugation of the α,α'-bisdiazo ketone system is even more apparent upon inspection of the ultraviolet absorption spectra of XXII and VII. The single absorption band at 276 mμ (ϵ 8800) in the spectrum of XXII is replaced in the spectrum of VII by a moderately intense band at 259 mμ (ϵ 3980) and a very intense band at 322 mμ (ϵ 25,400).

The ultraviolet irradiation of bisdiazo ketones VII and VIII in aqueous tetrahydrofuran solution afforded amorphous acidic fractions in 25–35% yields. These products were not investigated in detail since we were unable to resolve them into crystalline components either as the free acids or after treatment with diazomethane to form the corresponding methyl esters.

Experimental Section[14]

2,4-Bisoximinocholestan-3-one (IV).—Cholestan-3-one (22.5 g, 0.0582 mole) was dissolved in a stirred solution of potassium (7.5 g, 0.192 gram atom) in dry *t*-butyl alcohol (250 ml) kept under a nitrogen atmosphere. The solution was then treated with *n*-butyl nitrite (19.8 ml, 0.175 mole), added over a period of 10 min. After 3 hr, at room temperature, water (1 l.) was added and the resulting solution was extracted with two 200-ml portions of ether. The aqueous phase containing the soluble salt of the product was separated and then acidified with dilute hydrochloric acid. The resulting precipitate was filtered, washed well with water, and dried *in vacuo* to give 21.1 g (81.4% yield) of an amorphous solid, mp 212–215°. The product, which could not be recrystallized satisfactorily, was purified (mp 234–235° dec) by trituration with acetone: λ_{max} 3.17, 5.82, 6.18, 6.29 and 6.49 μ; $\lambda_{max}^{neutral}$ 248–250 mμ (ϵ 7480) and λ_{max}^{basic} 349 mμ (ϵ 14,490).

Anal. Calcd for $C_{27}H_{44}N_2O_3$: C, 72.93; H, 9.97; N, 6.30. Found: C, 72.50; H, 9.91; N, 5.97.

The value of $[\alpha]D$ was not determined because of the poor solubility of IV in the usual solvent.

The metal complexes of the bisoximino ketone were studied by adding 1 drop of a 5% aqueous solution of the metal cation [M(OAc)$_2$] to a solution (5 mg/ml) of IV in tetrahydrofuran. The following complexes were observed: Ni^{2+} (brown, precipitate), Cu^{2+} (green, precipitate), Co^{2+} (dark red).

2,4-Bisoximino-5α-androstan-17β-ol-3-one (V).—The procedure described above was followed using 5.00 g (0.0173 mole) of 5α-androstan-17β-ol-3-one[15] and proportional quantities of reagents. The precipitate of crude V was taken in ethyl acetate and the solution was washed with aqueous sodium bicarbonate before drying. Evaporation of the solution gave V as a yellow gum (2.90 g) which formed yellow crystals from acetone–petroleum ether (2.05 g, 34%). The crystals had no definite melting point, but puffed up at about 150° and then gradually darkened without melting on heating up to 300°; $[\alpha]^{29}D$ 17.8° (*c* 1.13, 95% EtOH); λ_{max} 2.91, 3.10, 5.78 and 6.25 μ; $\lambda_{max}^{neutral}$ 268 mμ (ϵ 8100) and λ_{max}^{basic} 348 mμ (ϵ 11,000).

Anal. Calcd for $C_{19}H_{28}N_2O_4$: C, 65.49; H, 8.10; N, 8.04. Found: C, 65.09; H, 8.53; N, 7.87. Using a solution (10 mg/ml) of V in ethanol, the following metal complexes were observed: Ni^{2+} (brown), Cu^{2+} (dark green), Co^{2+} (deep crimson), Fe^{2+} (deep blue, slowly becoming green).

2,4-Bisoximino-5β-androstan-17β-ol-3-one (VI).—The procedure described for V was followed using 10.00 g (0.0346 mole) of 5β-androstan-17β-ol-3-one[16] and proportional quantities of reagents. The crude amorphous product (8.70 g) crystallized from acetone–petroleum ether as pale yellow prisms (4.35 g, 36%) which had no definite melting point; as the temperature reached 130–150°, the crystals swelled and darkened gradually without melting up to 300°; $[\alpha]^{28}D$ 80.8° (*c* 1.12, 95% EtOH); λ_{max} 2.90, 3.05, 5.76 and 6.25 μ; $\lambda_{max}^{neutral}$ 264 mμ (ϵ 10,200) and λ_{max}^{basic} 333 mμ (ϵ 13,300).

Anal. Calcd for $C_{19}H_{28}N_2O_4$: C, 65.49; H, 8.10; N, 8.03. Found: C, 65.57; H, 8.44; N, 7.70.

This compound formed metal complexes of similar color to those formed by bisoximino ketone V.

2,4-Bisdiazo-5α-androstan-17β-ol-3-one (VII).—Uncrystallized 2,4-bisoximino-5α-androstan-17β-ol-3-one (2.00 g, 5.74 mmoles) was added in small portions to a stirred 5 *N* sodium hydroxide solution (10 ml), and complete dissolution was brought about by the addition of water (20 ml). Ether (250 ml) was then added while cooling to 0–5° in an ice–water bath. Concentrated ammonium hydroxide (20 ml) and a 5.25% solution of sodium hypochlorite (50 ml "Clorox") were added, and the two-phase system was stirred at 0–5° for 1 hr, and at room temperature for 2 hr longer. Chloroform (100 ml) was then added to dissolve some interfacial material, and the organic phase was separated, washed with water until the washings were neutral, dried, and concentrated to a yellow oil (0.45 g). The oil was taken up in chloroform and passed through a column containing 10 g of alumina. The eluent (100 ml, chloroform) was taken to dryness, leaving a crystalline residue, which was recrystallized from chloroform–ether to give pure VII as long yellow needles (0.360 g, 18%). The bisdiazo ketone had no definite melting point; it slowly decomposed with liberation of gas when heated above 150°; $[\alpha]^{30}D$ +81.9° (*c* 1.02); λ_{max} 2.88, 4.75 and 4.83 (doublet), 6.29 μ; λ_{max} 259 mμ (ϵ 3980) and 322 mμ (ϵ 25,400).

Anal. Calcd for $C_{19}H_{26}N_4O_2$: C, 66.64; H, 7.65; N, 16.36. Found: C, 67.00; H, 7.88; N, 16.47.

(14) All melting points were determined on a Fisher-Johns apparatus and are uncorrected. Infrared spectra were recorded on a Perkin-Elmer Model 237 spectrophotometer (potassium bromide disks). Ultraviolet absorption spectra were determined in 95% ethanol and with a Perkin-Elmer Model 4000 Spectracord; basic solutions were obtained by adding a few drops of 0.1 *N* aqueous sodium hydroxide to the neutral solutions. All optical rotations were measured in chloroform solution, unless otherwise indicated. Elemental analyses were performed by Midwest Microlab, Inc., Indianapolis, Ind., and by Dr. A. Bernhardt, Mülheim, Germany. (Only fair analytical results could be obtained for any of the bisoximino ketones, probably because of tenacious solvent retention, although many determinations were carried out.) The standard drying agent used was magnesium sulfate, and solvents were removed on a rotary evaporator. Woelm neutral alumina (activity III) was used in all chromatographic separations.

(15) Mp 179–180°; mp 178° reported by A. Butenandt, K. Tscherning, and G. Hanisch, *Ber.*, **68**, 2097 (1935).

(16) Mp 140–141°; mp 142–143° reported by R. B. Gabbard and A. Segaloff, *J. Org. Chem.*, **27**, 655 (1962).

2,4-Bisdiazo-5β-androstan-17β-ol-3-one (VIII).—The procedure described above was followed using 10.00 g (0.0287 mole) of uncrystallized 2,4-bisoximino-5β-androstan-17β-ol-3-one and proportional quantities of reagents. The crude crystalline product weighed 7.85 g before, and 7.10 g (72%) after chromatography. Recrystallization from chloroform–ether afforded shimmering yellow flakes (4.55 g, 46%) which were analytically pure, but which had no definite melting point; they slowly decomposed with liberation of gas when heated above 150°; $[\alpha]^{30}D$ 20.0° (*c* 1.03); λ_{max} 2.94, 4.77 and 4.85 (doublet), 6.40 μ; λ_{max} 259 mμ (ε 3520) and 322 mμ (ε 26,000).

Anal. Calcd for $C_{19}H_{26}N_4O_2$: C, 66.64; H, 7.65; N, 16.36. Found: C, 66.58; H, 7.72; N, 16.31.

2,3-Seco-A-norcholestane-2,3-dinitrile (IX).—A solution of 2,4-bisoximinocholestan-3-one (1.00 g, 2.25 mmoles) in acetic anhydride (5.4 ml) and dry pyridine (8 ml) was allowed to stand at room temperature overnight. Water (100 ml) was then added slowly, and the resulting precipitate was extracted from the warm mixture with four 50-ml portions of ether. The combined ether extracts were washed with dilute hydrochloric acid and then with water until neutral to blue litmus. Evaporation of the dried ether solution gave a residue which was taken up in benzene and then chromatographed on 40 g of alumina. The dinitrile, eluted with benzene (150 ml) formed crystals (0.249 g, 29%), mp 98–99°, from methanol. The analytical sample, mp 104–105°, was obtained from ether–methanol: $[\alpha]^{22}D$ 25.9° (*c* 0.3); λ_{max} 4.45 μ.

Anal. Calcd for $C_{26}H_{42}N_2$: C, 81.61; H, 11.05; N, 7.32. Found: C, 81.74; H, 11.24; N, 7.06.

17β-Acetoxy-2,3-seco-5α-A-norandrostane-2,3-dinitrile (X).—The procedure described above was followed using 3.00 g (8.60 mmoles) of 2,4-bisoximino-5α-androstan-17β-ol-3-one and proportional quantities of reagents except that the reaction period was 6 hr. On chromatography of the crude product (2.14 g) of 70 g of alumina, the first benzene fractions two 45-ml portions contained about 70 mg of yellow oil. Continued elution with benzene (820 ml, 6 fractions) gave 1.070 g (37%) of dinitrile as colorless crystals. Further elution with chloroform (200 ml) and ethanol (200 ml) gave residues which could not be crystallized. The analytical sample was obtained from benzene–petroleum ether as colorless needles: mp 185–186°; $[\alpha]^{28}D$ 2.80° (*c* 1.06); λ_{max} 4.47 and 5.79 μ.

Anal. Calcd for $C_{20}H_{28}N_2O_2$: C, 73.13; H, 8.59; N, 8.53. Found: C, 73.48; H, 8.35; N, 8.54.

17β-Acetoxy-2,3-seco-5β-A-norandrostane-2,3-dinitrile (XI).—The procedure described for IX was followed using 3.00 g (8.60 mmoles) of 2,4-bisoximino-5α-androstan-17β-ol-3-one and proportional quantities of reagents except that the reaction time was 6 hr. The crude product (2.03 g) was chromatographed on 70 g of alumina. The first benzene fractions (two 35-ml portions) contained about 25 mg of yellow oil. Further elution with benzene (900 ml, 8 fractions) gave 0.934 g (32%) of dinitrile as needles, mp 147–150°. The analytical sample was obtained by recrystallization from benzene–ether as colorless prisms: mp 150–151°; $[\alpha]^{29}D$ 56.5° (*c* 0.69); λ_{max} 4.45 and 4.47 (doublet), 5.79 μ.

Anal. Calcd for $C_{20}H_{28}N_2O_2$: C, 73.13; H, 8.59; N, 8.53. Found: C, 73.37; H, 8.37; N, 8.66.

17β-Tosyloxy-2,3-seco-5α-A-norandrostane-2,3-dinitrile (XII).—A solution of 2,4-bisoximino-5α-androstan-17β-ol-3-one (1.50 g, 4.30 mmoles) and *p*-toluenesulfonyl chloride (3.00 g) in dry pyridine (50 ml) was kept at room temperature overnight. The reaction was quenched and worked up as described for IX. The crude product (1.22 g) was dissolved in benzene and absorbed on 50 g of alumina. The early benzene fractions (six 50-ml portions) contained small amounts of yellow oil. Continued elution with benzene (850 ml, 5 fractions) afforded dinitrile XII as white needles (0.330 g, 17%). The analytical sample, mp 158–159°, was recrystallized from benzene–ether: $[\alpha]^{31}D$ 8.10° (*c* 0.99); λ_{max} 4.47, 6.25 and 6.68 μ.

Anal. Calcd for $C_{25}H_{32}N_2O_3S$: C, 68.15; H, 7.32; N, 6.36; S, 7.28. Found: C, 68.59; H, 7.40; N, 6.37; S, 7.56.

17β-Tosyloxy-2,3-seco-5β-A-norandrostane-2,3-dinitrile (XIII).—2,4-Bisoximino-5β-androstan-17β-ol-3-one (1.50 g, 4.30 mmoles) was treated and worked up exactly as described for the *trans* epimer XII. The crude product (1.28 g) was dissolved in benzene and adsorbed on 50 g of alumina. The first benzene fractions (four 25-ml portions) contained 0.245 g (13%) of dinitrile XIII as white needles. The analytical sample was obtained as colorless prisms, mp 168–169°, by recrystallization from benzene ether: $[\alpha]^{30}D$ 203.8° (*c* 1.05); λ_{max} 4.47, 6.25 and 6.69 μ.

Anal. Calcd for $C_{25}H_{32}N_2O_3S$: C, 68.15; H, 7.32; N, 6.36; S, 7.28. Found: C, 68.32; H, 7.38; N, 6.41; S, 7.54.

2,4-Bisoximinoandrost-5-en-17β-ol-3-one (XX).—Testosterone (50.0 g, 0.174 mole) was dissolved in a stirred solution of dry *t*-butyl alcohol (260 ml) containing potassium *t*-butoxide (39.3 g, 0.348 mole) kept under nitrogen. To this solution was added *n*-butyl nitrite (49.2 g, 0.348 mole). After 3 hr, the solution was diluted with water (2 l.) and worked up as described for IV to give 17.3 g (34%) of XX, dec p 235–240° without melting. Recrystallization from acetone gave material with the same decomposition range; λ_{max} 3.12–3.22, 5.87 and 6.23 μ; $\lambda_{max}^{neutral}$ 263 mμ (ε 10,200) and λ_{max}^{basic} 221 mμ (ε 7400), 263 mμ (ε 8100), and 345 mμ (ε 15,600).

The value of $[\alpha]D$ was not determined because of the poor solubility of XX in the usual solvents.

Anal. Calcd for $C_{19}H_{26}N_2O_4$: C, 65.87; H, 7.57; N, 8.09. Found: C, 65.45; H, 8.10; N, 8.02.

This compound formed metal complexes of similar color to those formed by V and VI, with the following exceptions: Cu^{2+} (dark green-brown), Co^{2+} (blood red).

17β-Acetoxy-2,3-seco-A-norandrost-5-ene-2,3-dinitrile (XXI).—To a solution of 2,4-bisoximinoandrost-5-en-17β-ol-3-one (0.466 g, 1.35 mmoles) in dry pyridine (4.0 ml) was added acetic anhydride (3.0 ml). After standing at room temperature for 4 hr, the dark solution was quenched and worked-up in the manner described for IX to give a yellow brown oil which was chromatographed on 20 g of alumina in chloroform. The eluants were concentrated to give an oil which, on addition of ether, afforded crystals of XXI (0.086 g, 20%), mp 187–193°. The analytical sample, mp 191–194°, was crystallized from acetone–hexane: $[\alpha]^{22}D$ −53.2 (*c* 0.20); λ_{max} 4.48, 4.58, 5.85 and 6.11 μ; λ_{max} 215 mμ (ε 7,400).

Anal. Calcd for $C_{20}H_{26}N_2O_2$: C, 73.58; H, 8.03; N, 8.58. Found: C, 73.80; H, 8.13; N, 8.57.

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