room temperature. The solvent was removed *in vacuo* and 5 ml of water was added to the residue. The aqueous solution was extracted twice with ether and the ethereal extract was washed with aqueous saturated sodium bicarbonate. The residue from the ether extract was preparatively chromatographed on silica gel G plates (10:1 benzene–acetone). A main band at R_f 0.50 yielded an oil (25 mg), which gave, after vacuum sublimation, fine needles (15 mg), mp 79–80°[8]; the material was identical with authentic (+)-β-eudesmol[2] by nmr, ir, and specific optical rotation.

Acid Hydrolysis of 1 to β-L-Arabinose.—A solution of 100 mg of 1 in 4 ml of methanol was mixed with 4 ml of 0.1 *N* sulfuric acid; the resultant solution was heated on a steam bath for 1 hr. The solution was concentrated *in vacuo* to *ca.* 3 ml and washed with $CHCl_3$ (two 5-ml portions).[9] The aqueous layer was neutralized with calcium carbonate (150 mg). After filtration, the aqueous solution was concentrated *in vacuo* to 2 ml. Again, the solution was filtered. The aqueous filtrate was concentrated to dryness to yield a thick syrup which was extracted with hot methanol (5 ml). The methanol extract yielded a clear syrup which grew long prisms on seeding with a small crystal of β-L-arabinose. The crude crystalline mass was recrystallized from methanol (0.5 ml) to yield 10 mg of prisms which were identical with authentic β-L-arabinose by ir, mixture melting point, and specific optical rotation.

Registry No.—**1**, 21615-76-9; **2**, 21615-77-0; **3**, 21615-78-1; **4**, 14520-32-2.

(8) (+)-β-Eudesmol was reported to have mp 75–76°: J. F. J. McQuillin and J. D. Panack, *J. Chem. Soc.*, 2973 (1956).

(9) Work-up of the chloroform extract from the acid hydrolysis of the glycoside gave β-eudesmol mixed with rearranged substances (by nmr).

Nitro Steroids. I. Synthesis and Proof of Structure of 2β-Nitro-3-ethoxyestra-3,5-dien-17β-ol Acetate

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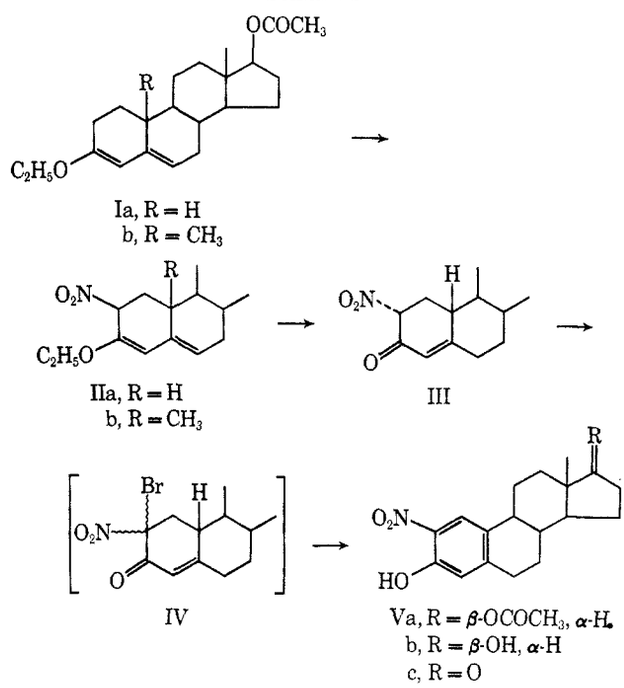
In the course of our researches in the field of estranes, we needed to prepare the compound 6-nitroestra-4-en-17β-ol-3-one as an intermediate. For this reason we repeated the reaction described in a British Patent,[1] using the 3-ethylenol ether of 19-nortestosterone acetate[2] (I) as starting material and carrying out the reaction with tetranitromethane in anhydrous ethyl ether. The nitro derivative (IIa) so obtained exhibited an infrared spectrum which was characteristic of a 3-ethoxy-$\Delta^{3,5}$ steroid (C=C bands at 1660 and 1635 cm^{-1}); however, the frequency of the NO_2 asymmetric vibration at 1550 cm^{-1} was indicative of a nitro group in a saturated position[3] and not in an unsaturated position as expected. The nmr spectrum showed two olefinic protons at *ca.* 4.47 (singlet and a doublet of doublets of which one signal fell under the singlet) assigned to C_4H and C_6H. These facts suggested that the nitro group was not in position 6, as postulated by Liisberg,[1] but probably in an allylic position, *i.e* position 2, 7, or 10.

In order to clarify the structure of IIa, the aromatization of ring A was performed as indicated in Scheme I.

SCHEME I



The enol ether IIa was hydrolyzed with concentrated hydrochloric acid in acetone to give III.[4] The nitro ketone III treated with bromine in ethyl ether afforded IV, the structure of which is only tentative and which was dehydrogenated directly with LiCl in dimethylformamide to give the nitroaromatic compound Va. Its infrared spectrum showed two aromatic bands at 1632 and 1575 cm^{-1} which were higher in frequency than the average and were typical of an aromatic nucleus substituted with a NO_2 group.[5] The nmr spectrum presented only two aromatic protons, one singlet (1H) at τ 2.02 assigned to C_1H and one singlet at τ 3.15 assigned to C_4H; these signals appeared slightly broadened by the weak coupling between *para* protons.

Acid hydrolysis of Va afforded Vb which by chromic acid oxidation gave the corresponding ketone Vc; chemical and spectral properties of Vb and Vc were in perfect agreement with those reported in the literature[6,7] for 2-nitroestradiol and 2-nitroestrone; hence, the structure of 2-nitro-3-ethoxyestra-3,5-dien-17β-ol acetate was assigned to IIa.

Information on the stereochemistry of the nitro group of IIa was furnished by the examination of its nmr spectrum. A doublet of doublets appeared at τ 5.0 (1 H) assigned to C_2H; this proton was coupled only with the C_1-methylene protons. The resonance peaks of the C_1H_e appeared as two triplets (1 H) at τ 7.47 and 7.25 (J_{gem} = 13 Hz; $J_{1,2}$ = 1.8 Hz; $J_{1,10}$ = 1.8 Hz), while the signals of the C_1H_a were hidden in the methylene envelope above τ 8.1. As the difference in chemical

(1) S. Liisberg, British Patent 883495 (1961); *Chem. Abstr.*, **57**, P3519c (1962).

(2) J. H. Zderik, H. Carpio, A. Bowers, and C. Djerassi, *Steroids*, **1**, 233 (1963).

(3) L. J. Bellamy, "The Infrared Spectra of Complex Molecules," Methuen and Co., London, 1958, p 298.

(4) As far as the stereochemistry of the nitrogroup in compound III is concerned, the nmr spectrum indicated the α configuration on the basis of coupling constants (doublet of doublets at τ 4.75 presented J = 14 and 5 Hz).

(5) Reference 3, p 71.

(6) T. L. Patton, *J. Org. Chem.*, **24**, 1795 (1959).

(7) H. Werbin, and C. Holoway, *J. Biol. Chem.*, **223**, 651 (1956).

shift between C_1H_e and C_1H_a was large,[8] the C_2H was treated as the X portion of an AMX system. The values of the coupling constants found for the signals at τ 5.0 were 1.8 and 4.5 Hz and indicated a β-axial configuration for the nitro group.[9]

The same reaction performed on the 3-ethyl enol ether of testosterone acetate[10] (Ib) gave a compound[11] (IIb) with spectral data closely similar to those of compound IIa; we therefore concluded that even in the case of the 19-CH_3 steroids the reaction afforded the 2-nitro derivative.[12]

Experimental Section[13]

2β-Nitro-3-ethoxyestra-3,5-dien-17β-ol Acetate (IIa).—To a suspension of 3-ethoxyestra-3,5-dien-17β-ol acetate[2] (Ia, 3.4 g) in anhydrous ethyl ether (30 cc), tetranitromethane (1.2 cc) was added dropwise within 10 min at room temperature. The steroid went rapidly into solution. After the solution had been allowed to stand for 1 hr, the crystalline material formed was filtered off and washed with ethyl ether–petroleum ether to give 2 g of IIa with mp 198–200°. Recrystallization from ethyl ether–petroleum ether afforded the analytical sample with mp 203–206°; $[\alpha]D$ −298°; uv max 246 mμ (ϵ 20,630); ir (KBr) 1730 (acetate), 1660 and 1635 (C=C enol ether), 1553 (NO_2) cm^{-1}; nmr τ 4.47 (s and dd, 2H, C_4H and C_6H), 5.00 (dd, 1 H, J = 4.5 and 1.8 Hz, C_2H), 5.38 (m, 1 H, $C_{17}H$), 6.12 (q, 2 H, J = 7 Hz, OCH_2CH_3), 7.97 (s, 3 H), 8.72 (t, 3 H, J = 7 Hz, CH_2CH_3), 9.18 (s, 3 H, angular CH_3).

Anal. Calcd for $C_{22}H_{31}NO_5$: C, 67.84; H, 8.02. Found: C, 67.98; H, 7.74.

2α-Nitroestr-4-en-17β-ol-3-one Acetate (III).—IIa (2.0 g) in acetone (40 cc) and concentrated hydrochloric acid (1 cc) were refluxed for 10 min, the solution was then cooled and diluted with water, and the steroid was extracted with ethyl acetate. The organic layers were washed with water, dried over anhydrous Na_2SO_4, and evaporated to dryness; the crude residue was crystallized from ethyl ether to give III (1.35 g) of mp 170–171°. An analytical sample obtained by recrystallization from ethyl ether had mp 170–172°; $[\alpha]D$ +89°; uv max 246 mμ (ϵ 15,300); nmr τ 4.05 (s, 1 H, C_4H), 4.75 (dd, 1 H, J = 5 and 14 Hz, C_2H), 5.37 (m, 1 H, $C_{17}H$), 7.98 (s, 3 H), 9.15 (s, 3 H, angular CH_3).

Anal. Calcd for $C_{20}H_{27}NO_5$: C, 66.46; H, 7.53; N, 3.88. Found: C, 66.22; H, 7.41; N, 4.00.

2-Nitroestra-1,3,5(10)-triene-3,17β-diol 17-Acetate (Va).—To an ice-cooled suspension of III (2.3 g) in anhydrous ethyl ether (75 cc) a few drops of a saturated solution of hydrobromic acid in acetic acid were added dropwise, followed by the addition, with stirring, of a solution of bromine (1.02 g) in acetic acid (10 cc). The reaction mixture was stirred at 0° for 15 min, and diluted with water. The steroid was extracted with ethyl acetate, and the organic layers were washed with diluted $NaHCO_3$ solution, and water, then dried over anhydrous Na_2SO_4, and evaporated to dryness. The crude residue (3.06 g) was dissolved in dimethylformamide (44 cc) and treated, under nitrogen, with anhydrous LiCl (1.15 g) for 2.5 hr on a steam bath. After cooling, the dark solution was diluted with water and the steroid extracted with ethyl acetate. After the usual work-up, the residue was crystallized from methanol to give Va (730 mg) with mp 192–195°. The analytical sample was recrystallized from the same solvent and afforded the pure compound with mp 195–197°; $[\alpha]D$ +66°; uv max 294 mμ (ϵ 8020); nmr τ −0.32 (s, 1 H, OH phenyl), 2.02 (s, 1 H, C_1H), 3.15 (s, 1 H, C_4H), 5.28 (m, 1 H, $C_{17}H$), 7.93 (s, 3 H), 9.15 (s, 3 H, angular CH_3).

Anal. Calcd for $C_{20}H_{25}NO_5$: C, 66.83; H, 7.01; N, 3.90. Found: C, 66.77; H, 7.03; N, 3.97.

2-Nitroestradiol (Vb).—Va (300 mg) in MeOH (30 cc) and H_2SO_4 (20%, 1 cc) was warmed for 2 hr on a steam bath. The solution was diluted with water and the steroid extracted with ethyl acetate. The organic layers were washed with water, dried over anhydrous Na_2SO_4, and evaporated to give a crude residue which, crystallized from methanol, afforded 2-nitroestradiol (Vb, 130 mg) with mp 168–170°; $[\alpha]D$ +125°; uv max 295 mμ (ϵ 8100) (lit.[6] mp 167–168°; uv max 293 mμ (ϵ 8100); ir (KBr) 3500 (17-OH), 3300 (3-OH), 1635 and 1575 (aromatic), 1520 (NO_2) cm;$^{-1}$ nmr τ −0.33 (s, 1 H, OH phenyl), 2.03 (s, 1 H, C_1H) 3.15 (s, 1 H, C_4H), 6.22 (m, 1 H, $C_{17}H$), 9.18 (s, 3 H, angular CH_3).

Chromic acid oxidation of Vb carried out in acetic acid at room temperature afforded the known[6,7] 2-nitroestrone (Vc).

2β-Nitro-3-ethoxyandrosta-3,5-dien-17β-ol Acetate (IIb).—To a solution of 3-ethoxyandrosta-3,5-dien-17β-ol acetate[10] (Ib, 1.67 g) in anhydrous ethyl ether (16.5 cc), tetranitromethane (0.72 cc) was added dropwise at room temperature in 10 min; after a few minutes a crystalline product was formed. The reaction mixture was allowed to stand at room temperature for 30 min; the crystals were filtered off and washed with ethyl ether–petroleum ether to give 800 mg of IIb with mp 195–197°. Recrystallizations from acetone afforded the analytical sample with mp 219–221°; $[\alpha]D$ −197°; uv max 247.5 mμ (ϵ 22,000); ir (KBr) 1730 (acetate), 1660 and 1635 (C=C enol ether), 1553 (NO_2) cm^{-1}; nmr τ 4.50 (s, 1 H), 4.58 (dd, 1 H, J = 7 and 1.8 Hz, C_2H), 5.38 (m, 1 H, $C_{17}H$), 6.10 (q, 2 H, J = 7 Hz, OCH_2CH_3), 7.97 (s, 3H), 8.68 (t, 3 H, J = 7 Hz, CH_2CH_3), 9.03 (s, 3 H, C_{19} protons), 9.18 (s, 3 H, C_{18} protons).

Anal. Calcd for $C_{23}H_{33}NO_5$: C, 68.46; H, 8.24; N, 3.47. Found: C, 68.56; H, 8.00; N, 3.44.

Registry No.—IIa, 21429-98-1; IIb, 21429-99-2; III, 21430-00-2; Va, 21430-01-3.

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(8) N. S. Bhacca and D. H. Williams, "Applications of Nmr Spectroscopy in Organic Chemistry," Holden-Day, Inc., San Francisco, Calif., 1964, p 47.

(9) Other 2β-substituted 3-ethoxy-$\Delta^{3,5}$ steroids have been reported: F. Mancini, and R. Sciaky, *Gazz. Chim. Ital.*, **97**, 431 (1967).

(10) S. K. Pradhan and H. J. Ringold, *J. Org. Chem.*, **29**, 601 (1964).

(11) This compound showed the same chemical and spectral data as reported by Liisberg[1] for the compound to which he assigned the structure of 3-ethyl enol ether of 6-nitrotestosterone acetate in the provisional specification of ref 1, p 5.

(12) Some examples of nitration by tetranitromethane have been reported: L. F. Fieser and M. Fieser, "Reagents for Organic Synthesis," John Wiley & Sons, Inc., New York, N. Y., 1967, p 1147.

(13) Melting points were determined with a Fisher-Johns apparatus and are uncorrected. The ultraviolet spectra were carried out in ethanolic solution. A Perkin-Elmer M 237 spectrophotometer was employed for the infrared spectra using KBr pellets. All rotations were measured in chloroform solution (c 1%) at the sodium D line. The nmr spectra were determined with a Varian A-60A spectrometer with TMS as internal standard and $CDCl_3$ as solvent.

Hydrogenation of Some Unsaturated Phosphines as Their Nickel Chloride Complexes[1]

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A number of unsaturated cyclic phosphines (phospholenes) are available from dehalogenation of diene–phosphonous dihalide adducts,[2] or reduction of the phosphine oxides formed on hydrolysis of these adducts.[3] We attempted to hydrogenate catalytically some of these phosphines to obtain the corresponding phospholanes. However, no consumption of hydrogen occurred at room temperature and atmospheric pressure with palladium as catalyst. Since a poisoning effect

(1) Supported in part by Public Health Service Research Grant CA-05507 from the National Cancer Institute.

(2) L. D. Quin in "1,4-Cycloaddition Reactions," J. Hamer, Ed., Academic Press Inc., New York, N. Y., 1967, Chapter 3.

(3) H. Fritzsche, U. Hasserodt, F. Korte, G. Friese, K. Adrian, and H. Arenz, *Chem. Ber.*, **98**, 1681 (1965).