in the explosive reaction. However, owing to the high temperature which must be present, a radical recombination is most likely.

The CF_3OF was identified by comparison of its spectroscopic and chromatographic properties with those of authentic CF_3OF. The infrared spectrum is in good agreement with that published previously,[3] as later corrected.[7] The F^{19} n.m.r. spectrum of the compound conforms very closely to the published n.m.r. spectrum of authentic CF_3OF.[7,12,13] The compound was also identified in a gas chromatogram using FC 75[14] as a liquid phase on a firebrick support. The column was cooled in Dry Ice–acetone. This column is capable of separating air, OF_2, CF_4, CHF_3, COF_2, and CF_3OF. The retention time of the product compound was the same as that of an authentic sample of CF_3OF.

Experimental Section

Reaction Vessel.—A 1-l. Pyrex bulb closed with a stopcock was employed as the reaction vessel. Two small holes (0.5 mm.) were made in the bulb at an angular separation of 180°. Pieces of no. 26 nichrome wire were passed through each hole until they almost touched in the center of the bulb (5 mm. separation). The wires were bent over and taped to the bulb at the exit points. Vacuum tight seals were made by dripping hot Apiezon W wax on the holes.

Pressure Measurements.—Since OF_2 and CF_3OF reacted rapidly with mercury, a nickel bellows pressure transducer (Giannini) was employed for pressure measurements.

Chromatographic Analysis.—A Loenco Model 15B gas chromatograph containing a hot-wire thermal conductivity detector was used for separation and analysis of the products. The chromatographic column employed was 0.25 in. × 6 ft. copper tube filled with 30% FC 75[14] on 60–80-mesh acid-washed firebrick. The column was cooled to −78° in an external Dry Ice–acetone bath, and helium was used as the carrier gas. The column could separate mixtures into the following components: O_2 + N_2, OF_2, CF_4, SiF_4, CHF_3, CO_2 + COF_2, and CF_3OF. Oxidizing compounds (OF_2, CF_3OF) could be detected by placing a moist starch–iodide test paper at the chromatograph outflow.

Spectroscopic Analysis.—Infrared adsorption spectra were obtained with a Perkin-Elmer 421 spectrophotometer. A 10-cm. monel-body gas cell was employed with NaCl windows.

N.m.r. spectra were made on Varian Model HR60 spectrometer operating at 56.4 Mc. Fluorotrichloromethane was used as a solvent and internal standard.

Trifluoromethane Reaction.—The reaction bulb was filled with a 50-mm. pressure equimolar mixture of CHF_3 and OF_2. One wire of the bulb was grounded and the other was attached to a high voltage vacuum leak detector. When the high voltage was turned on momentarily (<0.5 sec.) an orange flash and an audible detonation occurred. The contents of the bulb were transferred into an evacuated 100-ml. bulb cooled in liquid N_2. It was necessary to repeat the transfer several times since a noncondensible gas was present (probably O_2). Chromatographic analysis and infrared analysis gave the following results. A 12% yield of CF_3OF was observed and CO_2 and COF_2 were also seen. The ratio of CO_2 and COF_2 was highly variable. This is apparently due to the fact that COF_2 reacts with glass to give CO_2 and SiF_4, or with the water released by the reaction of HF on glass. The yield of the CO_2–COF_2 was about 70% with the remaining 8% made up by CF_4. The identity of the CF_3OF was confirmed by infrared and n.m.r. spectra. An authentic sample of CF_3OF was passed through the gas chromatograph and had the same retention time as the product compound (2.5 min.).

Methane Reaction.—The reaction bulb was filled with 2.5-mm. of CH_4 and 15 mm. of OF_2. A spark was discharged through the mixture resulting in a white flash and a detonation. The reaction mixture was worked up and analyzed by the above procedures. A yield of about 50% CF_3OF, 48% CO_2, 1% COF_2, and less than 0.5% CF_4 was found. When this reaction was performed in a metal system, CO_2 was still a major product; thus it does not entirely originate from COF_2 and glass or water.

(12) R. A. Ogg, Abstracts, 126th National Meeting of the American Chemical Society, New York, N. Y., Sept. 1954, p. 24M.

(13) G. H. Cady and C. I. Merrill, *J. Am. Chem. Soc.*, **84**, 2260 (1962).

(14) Trade name of the Minnesota Mining and Manufacturing Co. for a mixture of perfluoro C_8 cyclic ethers. The major component of this mixture is perfluoro-2-butyltetrahydrofuran.

Acknowledgments.—The author wishes to express thanks to Donald W. Moore and the U. S. Naval Ordnance Test Station, China Lake, California, for the n.m.r. analysis. We also would like to thank Dr. G. H. Cady of the University of Washington for supplying an authentic sample of CF_3OF.

The Mitomycin Antibiotics. Synthetic Studies. VIII. Nitration and O-Benzyl Rearrangement in the 7-Oxypyrroloindole System[1]

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During the course of an attempted preparation of 6-demethyl-7-methoxymitosene by a route essentially parallel to that employed in the synthesis of 7-methoxymitosene,[2] we sought to cleave the benzyloxy group of 7-benzyloxy-2,3-dihydro-9-formyl-1H-pyrrolo-[1,2-*a*]indole (I).[3] Concern for possible reduction of the 9-formyl group during hydrogenolysis with palladium catalyst[4] led us first to try cleavage with aluminum chloride.[5] However, when I was submitted to the latter reagent, it was found that the desired 7-hydroxy compound II was only the minor component of the resulting mixture.[6] The major component (III) was also a 7-hydroxy-9-formylpyrroloindole, but it contained a benzyl group (n.m.r.: five protons at 7.28 p.p.m. and two protons at 4.08 p.p.m.). That this group had entered the 6-position was apparent from its subsequent transformations.[7,8] Oxidation of III with potassium nitrosodisulfonate[2,9] gave a purple *o*-quinone VI which had ultraviolet absorption almost identical

(1) Paper VII: W. A. Remers, R. H. Roth, and M. J. Weiss, *J. Org. Chem.*, **30**, 2910 (1965).

(2) G. R. Allen, Jr., J. F. Poletto, and M. J. Weiss, *J. Am. Chem. Soc.*, **86**, 3877 (1964).

(3) W. A. Remers and M. J. Weiss, *J. Med. Chem.*, **8**, 700 (1965).

(4) See G. R. Allen, Jr., J. F. Poletto, and M. J. Weiss, *J. Am. Chem. Soc.*, **86**, 3878 (1964).

(5) This reagent successfully cleaved the 7-methoxy group of a related 9-formylpyrroloindole.[2]

(6) Separation of this mixture proved very difficult. Although a small portion of the major component (III) could be obtained pure by fractional crystallization from acetone, partition chromatography involving large eluent volumes was necessary to afford substantial amounts of both isomers.

(7) The n.m.r. spectrum of III supported this assignment, although superposition of phenyl-ring protons on one of the C-ring protons complicated the interpretation of this spectrum. A sharp singlet at 7.73 p.p.m. is assigned to the C-8 proton, since deshielding of this proton by the formyl group at C-9 should shift it downfield relative to the C-5 or C-6 proton [see W. A. Remers, *J. Am. Chem. Soc.*, **86**, 4610 (1964), footnote 9]. Since this peak appears unsplit by the other C-ring proton, the latter must be at the C-5 (*para*) position, rather than at the C-6 (*meta*) position.

(8) Zinc chloride catalyzed benzyl migration in benzyl phenyl ether (to give *p*-hydroxydiphenylmethane) was reported by J. van Alphen [*Rec. trav. chim.*, **46**, 799 (1927)]. In this paper a similar migration in diphenylmethyl phenyl ether was also noted. We wish to thank a referee for bringing this work to our attention.

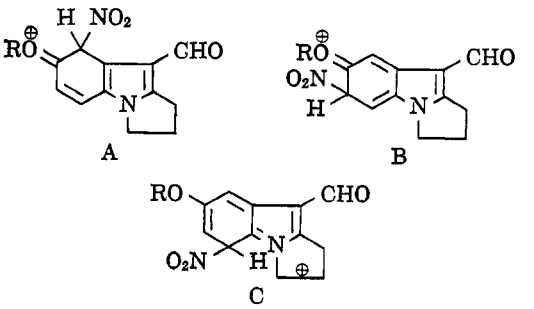
(9) H. J. Teuber and G. Thaler, *Chem. Ber.*, **91**, 2253 (1958), and previous papers.

with that of 9-formyl-6-methyl-7,8-pyrroloindoloquinone VII.[2] Thiele acetoxylation[2] of VI yielded triacetate XI, and treatment of the latter with sodium hydroxide followed by air oxidation afforded hydroxy-*p*-quinone VIII, almost identical in ultraviolet absorption spectrum with the corresponding 6-methyl analog IX[2] and possessing the indicator behavior (yellow in acid, blue in base) of this analog. Formation of such a hydroxy-*p*-quinone by the above route is possible only if the benzyl group is substituted at the 6-position; the corresponding 5- or 8-isomers might give *o*-quinones and triacetates, but the derived hydroxyquinones would be *ortho* and thus distinctly different in spectral properties from IX.

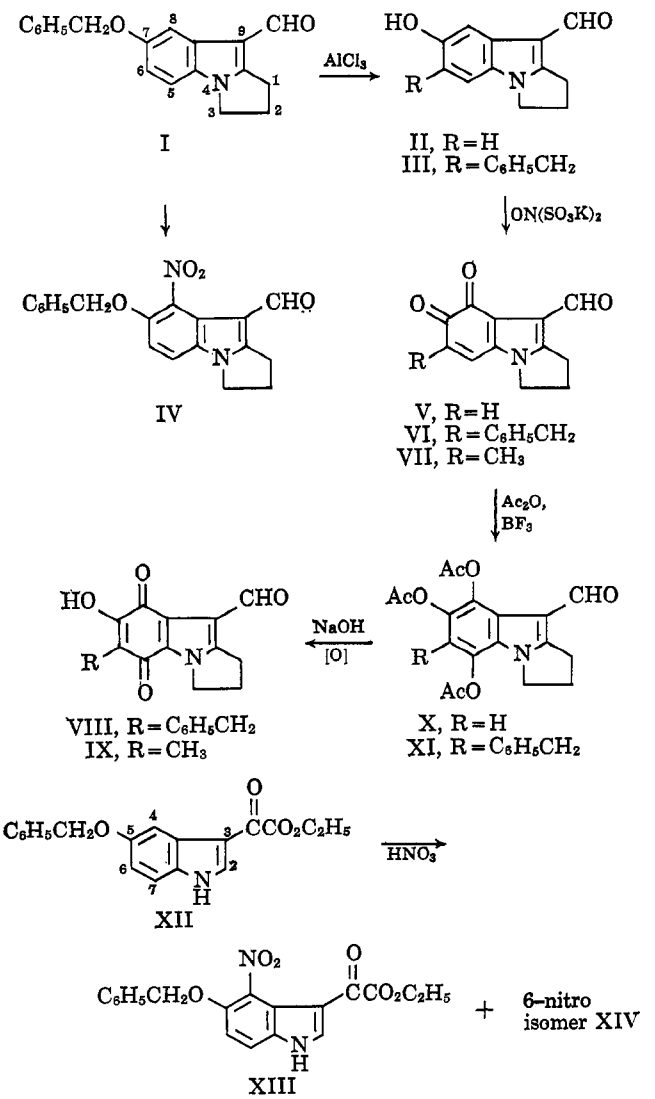
Returning to the problem of cleaving the benzyloxy group in I, we then attempted hydrogenolysis with palladium catalyst and found that in this particular case the desired cleavage occurred in high yield with no concommitant reduction of the formyl group. The hydrogenolysis product II was identical with the minor component obtained from the aluminum chloride cleavage. Proceeding by a route parallel to that of the 7-methoxymitosene synthesis[2] we converted II to *o*-quinone V. That a 7,8-quinone had been formed in preference to a 6,7-quinone is revealed by the n.m.r. spectrum of V which has a splitting pattern (two doublets, J = 10 c.p.s.) typical for *ortho* aromatic protons. Thiele acetoxylation of V yielded triacetate X. The location of the acetoxy group at C-5 (as opposed to C-6) has not been conclusively demonstrated. However, analogy to the Thiele acetoxylation of *o*-naphthoquinones[10,11] suggests this assignment. Unfortunately, in contrast to the corresponding 6-benzyl and 6-methyl[2] series, it was not possible to convert triacetate X to the corresponding hydroxy-*p*-quinone by the technique of alkaline hydrolysis followed by air oxidation.[12] Only an amorphous dark solid was obtained.

In an alternate route,[4] nitration of 7-benzyloxy-9-formylpyrroloindole I afforded in high yield 8-nitro derivative IV, the sole product isolated. Location of the nitro group at the 8-position is established by the presence in the n.m.r. spectrum of two doublets (J = 10 c.p.s.) typical of *ortho* aromatic protons.

The reason for nitration at the 8-position of I in preference to the 5- or 6-positions is probably related to the relative stabilities of the hypothetical intermediate cations, since, according to Hammond's postulate,[13] it follows that the transition state for aromatic substitution should closely resemble such an intermediate. The cation leading to electrophilic substitution at the 8-position is the only one that affords canonical resonance forms (*e.g.*, A) bearing the plus charge on the benzylic oxygen and at the same time maintaining the π-electron system in the pyrrole ring. The resonance contributor (B) bearing this charge on oxygen for the cation leading to substitution at C-6 has lost pyrrole-ring aromaticity. No reasonable cation with the positive charge on oxygen can be drawn for substitution at C-5, and the cation (C) bearing this charge on the indolic nitrogen has lost aromaticity in the pyrrole ring. Since contributors with the plus charge on carbon are undoubtedly less significant, the 8-substituted cation is the most stable and, hence, substitution at the 8-position is favored.[14]



It is possible that the preferential C-8 nitration observed in the formation of IV may be an example of a general phenomenon, wherein electrophilic substitution of 5-alkoxyindoles containing an electronegative group



(10) L. F. Fieser and M. Fieser, "Advanced Organic Chemistry," Reinhold Publishing Corp., New York, N. Y., 1961, p. 855.

(11) W. A. Remers, P. N. James, and M. J. Weiss, *J. Org. Chem.*, **28**, 1169 (1963).

(12) Other attempted methods[11] for the conversion of *o*-quinone V to a hydroxy-*p*-quinone, such as additon of aniline followed by acid hydrolysis, addition of *p*-toluenethiol followed by alkaline hydrolysis, and treatment with hydrogen chloride in methanol, were also unsuccessful.

(13) G. S. Hammond, *J. Am. Chem. Soc.*, **77**, 334 (1955).

(14) Similar reasoning was used by G. Buchi, R. E. Manning, and S. A. Monti [*ibid.*, **86**, 4635 (1964)] to explain the Mannich condensation at C-5 of a 6-hydroxytetrahydrocarbazole.

at the 3- (possibly 1- or 2-) position will be preferentially directed to the 4-position.[15] For example, it has been found that ethyl 5-benzyloxy-3-indoleglyoxylate (XII) undergoes nitration to give a mixture of 4- and 6-nitro derivatives (XIII and XIV, respectively) in a 4:1 ratio.[16]

Utilization of 8-nitropyrroloindole IV for the synthesis of 6-demethyl-7-methoxymitosene was not undertaken, since a demethyl analog in the corresponding 1-ethyl-2-methylindoloquinone carbamate series[4] was more readily prepared.[17]

Experimental Section

Melting points were determined on a Kofler hot-stage microscope and are corrected. Ultraviolet spectra were determined in methanol solution with a Cary recording spectrophotometer. Infrared spectra were determined in potassium bromide disks with a Perkin-Elmer Model 21 spectrophotometer. N.m.r. spectra were determined in dimethyl-d_6 sulfoxide, unless otherwise specified, with a Varian A-60 spectrometer. Solutions were dried over anhydrous magnesium sulfate and concentrated under reduced pressure on a rotary evaporator.

Cleavage of 7-Benzyloxy-2,3-dihydro-9-formyl-1H-pyrrolo[1,2-*a*]indole. A. With Aluminum Chloride.—A mixture of 2.86 g. (10 mmoles) of 7-benzyloxy-2,3-dihydro-9-formyl-1H-pyrrolo-[1,2-*a*]indole (I),[3] 2.00 g. (15 mmoles) of anhydrous aluminum chloride, and 45 ml. of dry benzene was stirred at reflux temperature for 1 hr., cooled, poured onto 100 g. of ice, and stirred overnight. The benzene was evaporated and the gray solid residue was washed with water and dried (yield 3.1 g.). Crystallization of a 100-mg. portion of this solid from acetone afforded a small amount of 6-benzyl-2,3-dihydro-9-formyl-7-hydroxy-1H-pyrrolo-[1,2-*a*]indole (III) as white needles: m.p. 243–255° dec.; λ_{max} 2.8, 3.1, 6.20, 13.7, 14.4 (benzyl) μ; λ_{max} 256 mμ (ϵ 27,000), 278 (21,000), 309 (18,000); n.m.r., 9.95 (CHO), 9.50 (OH), 7.73 (C-8 proton), 7.28 (six protons, phenyl and C-5 protons), 4.08 (four protons, benzylic and C-3 protons superimposed), 3.25 (apparent triplet, two C-1 protons), 2.80 (peaks obscured by dimethyl sulfoxide, C-2 protons) p.p.m. Satisfactory analyses could not be obtained.

Anal. Calcd. for $C_{19}H_{17}NO_2$ (291.33): C, 78.33; H, 5.88; N, 4.81. Found: C, 77.71; H, 5.90; N, 4.36.

The remainder of the solid (3.0 g.) was divided into three equal portions. Each portion was dissolved in 100 ml. of the lower phase of the system cyclohexane–ethyl acetate–dimethylformamide–water (125:100:40:5), mixed with 200 g. of Celite[18] diatomaceous earth, and packed atop a column prepared from 1500 g. of Celite diatomaceous earth and 750 ml. of the lower phase. This column was eluted with the upper phase and the effluent was passed through a recording spectrophotometer set at 260 mμ. Concentration of the eluate in the second hold-back volume (2800 ml./h.b.v.) gave 1.0 g. (combined from three columns) of 6-benzyl-2,3-dihydro-9-formyl-7-hydroxy-1H-pyrrolo[1,2-*a*]indole (III), identical in melting point and infrared spectrum with III obtained by crystallization of the crude product from acetone. Concentration of the eluate in the fourth h.b.v. afforded 430 mg. of 2,3-dihydro-9-formyl-7-hydroxy-1H-pyrrolo-[1,2-*a*]indole (II) as tan solid, dec. pt. 270°, identical in infrared spectrum with the sample of II prepared by hydrogenolysis of I (see part B).

B. With Hydrogen and Palladium.—A solution of 1.0 g. (3.4 mmoles) of 7-benzyloxy-2,3-dihydro-9-formyl-1H-pyrrolo-[1,2-*a*]indole in 200 ml. of hot ethanol containing 200 mg. of 10% palladium on charcoal was treated with hydrogen in a Parr apparatus at an initial pressure of 34 p.s.i. After 22 hr., the reaction mixture was filtered and the catalyst was washed with ethanol and acetone. The filtrate was concentrated at low temperature, affording 430 mg. (66.8%) of 2,3-dihydro-9-formyl-7-hydroxy-1H-pyrrolo[1,2-*a*]indole (II) as gray solid. After two recrystallizations from acetone, 166 mg. of white needles, m.p. 238–284°, was obtained: λ_{max} 2.8, 3.14, 6.18 μ; λ_{max} 214 mμ (ϵ 16,400), 255 (17,400), 279 (13,900), 309 (11,800); n.m.r., 7.67 (doublet, $J_{6,8}$ = 2 c.p.s., C-8 proton), 7.42 (doublet, $J_{5,6}$ = 9 c.p.s., C-5 proton), 6.82 (doubled doublet, $J_{5,6}$ = 9 c.p.s., $J_{6,8}$ = 2 c.p.s., C-6 proton), 4.13 (apparent triplet, C-3 protons), 3.25 (apparent triplet, C-1 protons), 2.67 (multiplet, C-2 protons) p.p.m.; identical in infrared spectrum with the sample of II prepared from aluminum chloride cleavage.

Anal. Calcd. for $C_{12}H_{11}NO_2$ (201.22): C, 71.62; H, 5.51; N, 6.96. Found: C, 71.62; H, 5.53; N, 6.86.

6-Benzyl-2,3-dihydro-7,8-dioxo-9-formyl-1H-pyrrolo[1,2-*a*]indole (VI).—To a solution of 2.90 g. (10.8 mmoles) of potassium nitrosodisulfonate in 180 ml. of $^1/_{18}$ *M* potassium dihydrogen phosphate was added a slurry of 366 mg. (1.8 mmoles) of 6-benzyl-2,3-dihydro-9-formyl-7-hydroxy-1H-pyrrolo[1,2-*a*]indole (III) in 300 ml. of hot acetone. The mixture was stirred for 90 min. and filtered. After dilution with 1200 ml. of water, the filtrate was extracted with methylene chloride and this extract was dried and concentrated. Recrystallization of the residue from methylene chloride–hexane gave 236 mg. (60%) of 6-benzyl-2,3-dihydro-7,8-dioxo-9-formyl-1H-pyrrolo[1,2-*a*]indole (VI) as purple granules: m.p. 194–195°; λ_{max} 6.01, 6.09, 14.3 μ; λ_{max} 225 mμ (ϵ 75,400), 281 (23,200), 345 (11,000), 525 (4100).

Anal. Calcd. for $C_{19}H_{15}NO_3$ (305.32): C, 74.74; H, 4.95; N, 4.59. Found: C, 74.23; H, 5.15; N, 4.63.

6-Benzyl-2,3-dihydro-9-formyl-5,7,8-triacetoxy-1H-pyrrolo-[1,2-*a*]indole (XI).—A suspension of 186 mg. of 6-benzyl-2,3-dihydro-7,8-dioxo-9-formyl-1H-pyrrolo[1,2-*a*]indole (VI) in 4 ml. of acetic anhydride was treated at room temperature with 0.07 ml. of boron trifluoride etherate. After 30 min. the white solid that formed was collected, triturated with water, and dissolved in methylene chloride. This solution was washed with 5% sodium bicarbonate, dried, and concentrated on a steam bath as hexane was added. Cooling the solution when the first crystals appeared gave 204 mg. (66%) of 6-benzyl-2,3-dihydro-9-formyl-5,7,8-triacetoxy-1H-pyrrolo[1,2-*a*]indole (XI) as white lances: m.p. 222–230°; λ_{max} 5.65, 6.02, 14.3 μ.

Anal. Calcd. for $C_{25}H_{23}NO_7$ (449.44): C, 66.81; H, 5.16; N, 3.12. Found: C, 66.10; H, 5.55; N, 3.13.

6-Benzyl-2,3-dihydro-5,8-dioxo-9-formyl-7-hydroxy-1H-pyrrolo[1,2-*a*]indole (VIII).—A suspension of 180 mg. of 6-benzyl-2,3-dihydro-9-formyl-5,7,8-triacetoxy-1H-pyrrolo[1,2-*a*]indole (XI) in a mixture of 10 ml. of ethanol and 12 ml. of 3% aqueous sodium hydroxide, under nitrogen, was warmed on a steam bath until a clear solution was obtained. This solution was cooled and air was bubbled through it for 1 hr. Treatment of the resulting blue solution with 3 *N* hydrochloric acid gave orange solid which was dissolved in methylene chloride. After being dried the latter solution was concentrated on a steam bath and hexane was added until the first crystals appeared. This procedure yielded 88 mg. (66%) of 6-benzyl-2,3-dihydro-5,8-dioxo-9-formyl-7-hydroxy-1H-pyrrolo[1,2-*a*]indole (VIII) as orange plates: m.p. 195–206° dec.; λ_{max} 3.0, 5.99, 6.10, 14.3 μ; λ_{max} 222 mμ (ϵ 23,400), 299 (12,700), 330 (8600), 475 (500); $\lambda_{max}^{0.1\ N\ NaOH}$ 240 mμ (ϵ 23,800), 301 (12,600), 335 (13,500), 550 (1270).

Anal. Calcd. for $C_{19}H_{15}NO_4$ (321.22): C, 71.02; H, 4.71; N, 4.36. Found: C, 71.13; H, 5.34; N, 4.40.

2,3-Dihydro-7,8-dioxo-9-formyl-1H-pyrrolo[1,2-*a*]indole (V).—Treatment of 2,3-dihydro-9-formyl-7-hydroxy-1H-pyrrolo-[1,2-*a*]indole (II) in the manner described in the preparation of VI afforded, after a second recrystallization from methylene chloride–hexane, a 29% yield of 2,3-dihydro-7,8-dioxo-9-formyl-1H-pyrrolo[1,2-*a*]indole (V) as purple needles: m.p. 167–170°; λ_{max} 5.94, 6.03 μ; λ_{max} 228 mμ (ϵ 75,200), 279 (23,100), 345 (11,000), 515 (4200); n.m.r., 10.25 (CHO), 7.62 (doublet, $J_{5,6}$ = 10 c.p.s., C-6 proton), 6.08 (doublet, $J_{5,6}$ = 10 c.p.s., C-5 proton), 4.17 (apparent triplet, C-3 protons), 2.50–3.30 (multiplets with superimposed dimethyl sulfoxide, C-1 and C-2 protons) p.p.m.

Anal. Calcd. for $C_{12}H_9NO_3$ (215.20): C, 66.97; H, 4.22; N, 6.51. Found: C, 66.71, 66.57; H, 4.30, 4.43; N, 6.40.

2,3-Dihydro-9-formyl-5,7,8-triacetoxy-1H-pyrrolo[1,2-*a*]indole (X).—Treatment of 2,3-dihydro-7,8-dioxo-9-formyl-1H-pyrrolo-[1,2-*a*]indole (V) in the manner described in the preparation of

(15) However, note that the aluminum chloride induced rearrangement of the benzyl group in I leads to electrophilic substitution at the 6-position.

(16) This experiment was performed by Mr. J. F. Poletto.

(17) W. A. Remers and M. J. Weiss, forthcoming publication.

(18) Celite is the trademark of Johns-Manville Corp. for diatomaceous earth products.

XI afforded, after adsorption chromatography on a Florisil[19] magnesia–silica gel column with methylene chloride containing 5% acetone as eluent and crystallization from methanol, a 33% yield of 2,3-dihydro-9-formyl-5,7,8-triacetoxy-1H-pyrrolo[1,2-*a*]-indole (X) as tan solid. Recrystallization of this solid from methanol gave nearly white needles: m.p. 234–238° dec.; λ_{max} 5.66, 6.02 μ; λ_{max} 219 mμ (ϵ 27,400), 247 (14,400), 304 (11,500).

Anal. Calcd. for $C_{18}H_{17}NO_7$ (359.32): C, 60.16; H, 4.77; N, 3.90. Found: C, 59.96; H, 4.60; N, 3.94.

7-Benzyloxy-2,3-dihydro-9-formyl-8-nitro-1H-pyrrolo[1,2-*a*]indole (IV).—A suspension of 1.02 g. (3.5 mmoles) of 7-benzyloxy-2,3-dihydro-9-formyl-1H-pyrrolo[1,2-*a*]indole (I) in 20 ml. of glacial acetic acid was treated with 1.4 ml. of yellow fuming nitric acid by dropwise addition. After 1 hr. at room temperature the mixture was poured into 50 ml. of ice–water and filtered. The solid that formed was washed with water and ether to give 1.115 g. (95%) of 7-benzyloxy-2,3-dihydro-9-formyl-8-nitro-1H-pyrrolo[1,2-*a*]indole (IV). Recrystallization from acetone afforded pale yellow crystals: m.p. 215–227°; λ_{max} 5.97, 6.52, 7.91 μ; λ_{max} 217 mμ (ϵ 36,300), 254 (18,200), 295 (10,800); n.m.r., 9.75 (CHO), 7.60 (doublet, $J_{5,6}$ = 9 c.p.s., C-5 proton), 7.42 (five protons, phenyl), 7.33 (doublet, $J_{5,6}$ = 9 c.p.s., C-6 proton), 5.30 (two protons, benzylic), 4.20 (apparent triplet, C-3 protons), 3.33 (peaks partially obscured by water, C-1 protons), 2.55 (peaks obscured by dimethyl sulfoxide, C-2 protons) p.p.m.

Anal. Calcd. for $C_{19}H_{16}N_2O_4$ (336.33): C, 67.85; H, 4.80; N, 8.33. Found: C, 67.75; H, 4.64; N, 8.42.

Ethyl 5-Benzyloxy-4-nitro-3-indoleglyoxylate (XIII) and Ethyl 5-Benzyloxy-6-nitro-3-indoleglyoxylate (XIV).[16]—A suspension of 2.46 g. of ethyl 5-benzyloxy-3-indoleglyoxylate (XII) in 61 ml. of acetic acid was treated with 2.03 ml. of yellow fuming nitric acid at room temperature. After 1 hr. the mixture was diluted with water, and the solid that formed was washed with water and ether and dried. A 1.3-g. sample of the resulting solid (2.64 g., m.p. 200–205°) was dissolved in 25 ml. of the lower phase of the system heptane–ethyl acetate–dimethylformamide–water, (100:100:40:5) mixed with 50 g. of Celite diatomaceous earth and packed atop a column prepared from 300 ml. of the lower phase and 600 g. of Celite diatomaceous earth. Elution with the upper phase produced two yellow bands on the column. Concentration of eluate from the first band (hold-back volumes 1–2.2, 830 ml./h.b.v.) afforded, after recrystallization from methanol, 92 mg. of ethyl 5-benzyloxy-6-nitro-3-indoleglyoxylate (XIV) as yellow crystals: m.p. 244–247°; λ_{max} 5.80, 6.15 (broad), 6.65, 7.55 μ; λ_{max} 260 mμ (ϵ 9200) (sh), 300 (13,300); n.m.r., 8.58 (C-2 proton), 8.10 (C-7 proton), 7.98 (C-4 proton), 6.92 (five protons, phenyl), 5.30 (two protons, benzylic), 4.35 (two-proton quartet, CH_2CH_3), 1.35 (three-proton triplet, CH_2CH_3) p.p.m.

Anal. Calcd. for $C_{19}H_{16}N_2O_6$ (368.33): C, 61.95; H, 4.38; N, 7.61. Found: C, 62.31; H, 4.36; N, 7.58.

Concentration of eluate from the second yellow band (hold-back volumes 3.5–4.4) afforded, after recrystallization from methanol, 786 mg. of ethyl 5-benzyloxy-4-nitro-3-indoleglyoxylate (XIII) as yellow crystals: m.p. 221–224°; λ_{max} 5.80, 6.10, 6.20, 6.53, 7.25 μ; λ_{max} 260 mμ (ϵ 12,500), 280 (12,000), 310 (10,000) (sh); n.m.r., 8.53 (C-2 proton), 7.70 (doublet, $J_{6,7}$ = 9 c.p.s., C-7 proton), 7.40 (doublet, $J_{6,7}$ = 9 c.p.s., C-6 proton), 7.37 (five protons, phenyl), 5.27 (two protons, benzylic), 4.33 (two-proton quartet, OCH_2CH_3), 1.33 (three-proton triplet, OCH_2CH_3) p.p.m.

Anal. Calcd. for $C_{19}H_{16}N_2O_6$ (368.33): C, 61.95; H, 4.38; N, 7.61. Found: C, 62.25; H, 4.75; N, 7.76.

Comparison of the relative areas of peaks in the n.m.r. spectrum of a sample of the mixture of XIII and XIV before partition chromatographic separation indicated that these two components were present in an approximate ratio of 4:1.

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(19) Florisil is the trademark of the Floridin Co. for a magnesia–silica gel adsorbent.

Some Transformation Products of 17-Keto Anthrasteroids

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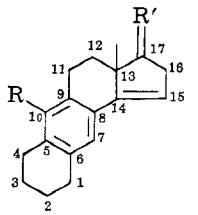
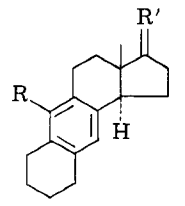
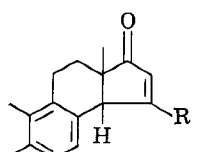
The formation of cyclopenteno-*s*-octahydroanthracenes of type I and VIa by acid-catalyzed elimination and rearrangement of steroidal 3β-hydroxy-5,7,9-(11)-trienes and their esters has been investigated extensively by Nes, Mosettig, and co-workers,[2] who have designated such products as anthrasteroids. In this paper, as an extension of the synthesis of 17-oxygenated anthrasteroids,[3] we report the preparation of several new anthrasteroids, along with the partial resolution of racemic 5,7,9,15-anthrastatetraene-15-carboxy-17-one (IIIb) and its conversion into *l*-5,7,9,14-anthrastatetraen-17β-ol (Id). We also record dehydrogenation studies leading to the dimethylcyclopentenoanthracene Va synthesized recently in a different manner by Nakazaki and co-workers.[4]



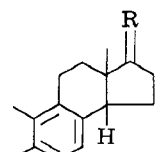
Ia, R = H; R′ = O
b, R = CH_3; R′ = O
c, R = H; R′ = OH
d, R = CH_3; R′ = OH



IIa, R = CH_3; R′ = O
b, R = H; R′ = OH
c, R = CH_3; R′ = OH
d, R = CH_3; R′ = CH_2
e, R = CH_3; R′ = CH_3



IIIa, R = H
b, R = COOH



IVa, R = O
b, R = H, OH

The three racemic 17-keto anthrasteroids Ia, Ib, and IIIa, prepared essentially as described previously,[3] but with certain improvements, were used as starting

(1) (a) Alfred P. Sloan Research Fellow, 1961–1964. (b) U. S. Public Health Service Predoctoral Fellow, 1961–1962. This work comprises part I of the Ph.D. Thesis of C. P. K., The University of Kansas, Aug. 1962, and was supported in part by Research Grant CY-4413 from the National Cancer Institute.

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