The sirup in tetrahydrofuran (125 ml.) was hydrogenated over 10% palladium-on-charcoal (1 g.) at 90° and 8.2 atm. until a pressure drop corresponding to 31.3 atm. had been recorded (calcd. 26.4 atm.). The catalyst was removed and the solution evaporated to leave methyl 2-*O*-ethyl-α,β-D-glucofuranoside (10.8 g., calcd. 9.7 g.). The sirupy product was hydrolyzed with 1 *N* sulfuric acid and the 2-*O*-ethyl-D-glucose recrystallized from ethanol; m.p. 185–186°, $[\alpha]^{25}D$ + 95.4° → + 62.6°, equil. (*c* 2, H_2O) (lit.[22] m.p. 191–195°, $[\alpha]^{25}D$ + 65°).

Anal. Calcd. for $C_8H_{16}O_6$: C, 46.12; H, 7.75. Found[14]: C, 46.41; H, 7.85.

Methyl 2-O-Ethyl-α-D-glucopyranoside (VII).—Methyl 2-*O*-vinyl-α-D-glucopyranoside (II) (2 g.) in methanol (75 ml.) containing a little ammonia was hydrogenated over 5% palladium-on-charcoal (0.1 g.) at 5.4 atm. for 1.5 hours at room temperature. The product was recrystallized from acetone to yield VII (1.07 g.), m.p. 136°, $[\alpha]^{25}D$ + 144° (*c* 2, H_2O).

Anal. Calcd. for $C_9H_{18}O_6$: C, 48.65; H, 8.18. Found[14]: C, 48.79; H, 7.96.

A sample of the product was hydrolyzed to 2-*O*-ethyl-D-glucose (VIII), m.p. 184–185°, mixed m.p. 185–186°, $[\alpha]^{25}D$ + 87.3° → + 61.0°, equil., (*c* 4, H_2O).

Methylation of the Methyl Mono-O-vinyl-α-D-glucopyranosides.—A portion of the second ether extract (10 g.) that contained the components of R_f 0.68 and 0.72 was methylated in tetrahydrofuran (200 ml.) with powdered sodium hydroxide (24 g.) and methyl sulfate (24 ml.). The product obtained by filtration and evaporation of solvent was dissolved in water (110 ml.) and glacial acetic acid (1 ml.) was added. After 36 hours at room temperature, the solution was evaporated to a sirup. Gas–liquid partition chromatography showed the presence of four methyl tri-*O*-methyl-α-D-glucopyranosides (Fig. 3).

(22) I. Croon and E. Flamm, *Svensk Papperstid.*, **61**, 963 (1958).

[CONTRIBUTION FROM THE CHEMICAL RESEARCH AND DEVELOPMENT DIVISION OF THE SCHERING CORP., BLOOMFIELD, N. J.]

Weak Acid-catalyzed Rearrangement of the Dihydroxyacetone Side Chain in Steroids

BY HERSHEL L. HERZOG, MARGARET JEVNIK GENTLES, HELEN MARSHALL AND E. B. HERSHBERG

RECEIVED MAY 4, 1961

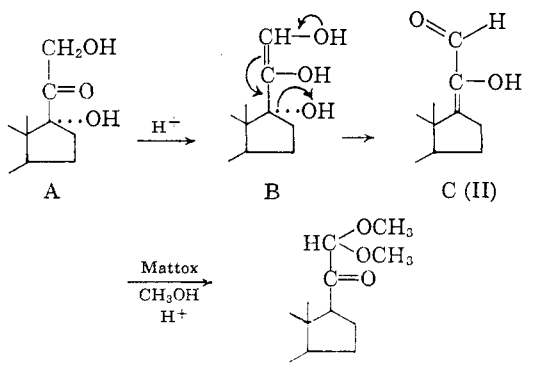
An enol aldehyde intermediate in the Mattox rearrangement of the steroidal dihydroxyacetone side-chain has been isolated and correlated with the proposed mechanism of Mattox. Proof is offered that the Norymberski reductive removal of the 17α-hydroxyl group in steroids bearing the dihydroxyacetone side-chain proceeds in its first stage *via* the Mattox rearrangement.

In the course of a study of microbiological 1-hydroxylation[1] of 4-pregnene-17α,21-diol-3,20-dione, evidence for the structure of the product was provided by the removal, by dehydration, of the 1-hydroxyl group in hot glacial acetic acid, which afforded 1,4-pregnadiene-17α,21-diol-3,20-dione (I). In this dehydration process, another, less polar product (II) was formed in minor amount. Compound II displayed an altered ultraviolet absorption spectrum in that, in addition to a peak at 246 mμ (ε 16,200) characteristic of the 1,4-diene-3-one, there was also a broad, flat peak between 260 and 280 mμ with an approximate maximum at 270 mμ (ε 14,000). The infrared spectrum of II showed bands at 2.94, 6.00, 6.16 and 6.23 μ from where the presence of 1,4-diene-3-one and hydroxyl was inferred. It was also noted that no evidence for a 20-carbonyl group remained since the customary band at about 5.85 μ was absent.

The same compound (II) was then prepared in about 40% yield by the action of refluxing glacial acetic acid on I for six hours, followed by chromatographic separation on Florisil. In addition to II, a smaller amount of the 21-acetate of I was formed. Compound II ($C_{21}H_{26}O_3$) contained one molecule of water less than I and gave a positive ferric chloride test. Acetylation with acetic anhydride in pyridine afforded a monoacetate (III) which, from its infrared spectrum, appeared free of hydroxyl groups and contained an enolic acetate (5.67 μ). The ultraviolet spectrum of III displayed no shoulder at 270 mμ, but the peak formerly at 245 mμ had shifted to 248 mμ, with a much enhanced intensity (ε 34,400). All these facts are consistent with the formulation of II as an enol aldehyde, as it is represented in the flow sheet.

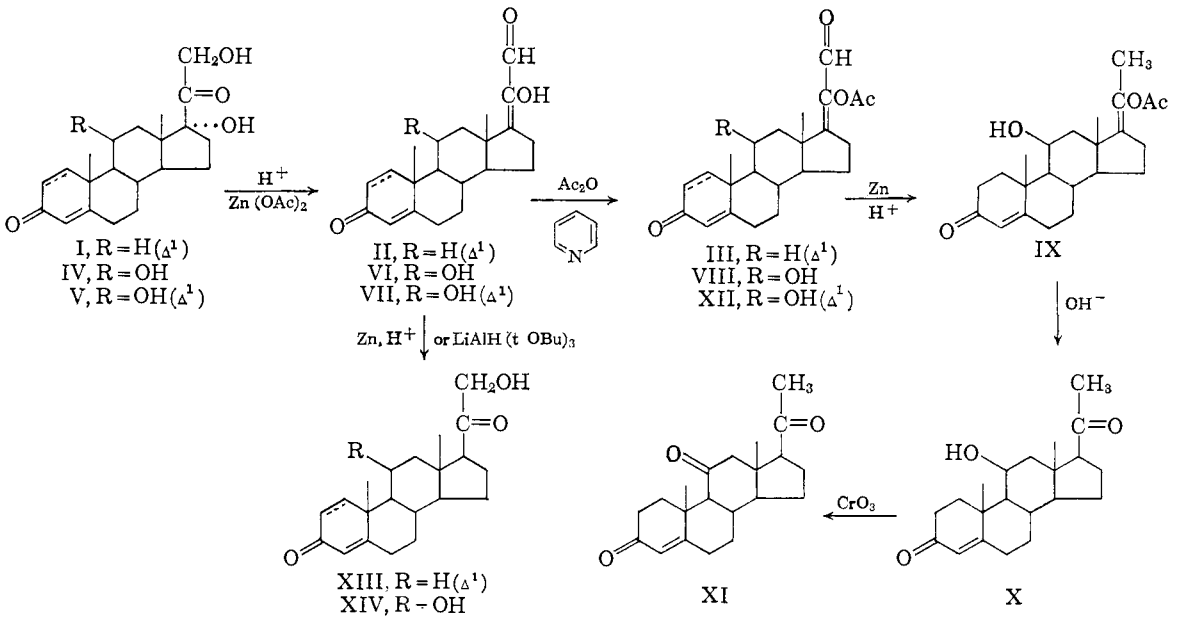
The rearrangement product II was converted in poor yield to 1-dehydrodesoxycorticosterone by the action of lithium aluminum tri-*t*-butoxyhydride and by reduction with zinc and acetic acid, which confirmed the structure assigned to II.

A compound of structure similar to II has been described by Mattox[2] as part of a study of the action of methanolic hydrogen chloride on steroids containing the dihydroxyacetone side chain. In the Mattox reaction with pregnane-3α,17α,21-triol-11,20-dione 3,21-diacetate the rearrangement product was isolated as the dimethyl acetal (21,21-dimethoxypregnan-3α-ol-11,20-dione). Bromination (1 mole) of the latter in the presence of excess hydrogen bromide followed by treatment with sodium iodide in acetic acid afforded 17(20)-pregnen-3α,20-diol-11-one-21-al, $\lambda_{max}^{ethanol}$ 284 mμ (ε 14,200). The shift of this peak to 270 mμ in



(1) G. Greenspan, C. P. Schaffner, W. Charney, H. L. Herzog and E. B. Hershberg, *J. Am. Chem. Soc.*, **79**, 3922 (1957).

(2) V. R. Mattox, *ibid.*, **74**, 1340 (1952).



the case of II may result in part from contributions from the A-ring dienone absorption. Mattox has presented a reasonable mechanism for the hydrogen chloride-catalyzed rearrangement which appears to apply equally well to the reaction we have observed. Under the milder conditions in acetic acid, intermediate C postulated by Mattox is stable and is isolated in good yield. By this mechanism the stability of the 21-acetate of I under our rearrangement conditions is explained since the transition from B to C requiring loss of a proton from the 21-oxygen cannot occur.

When 4-pregnene-11β,17α,21-triol-3,20-dione (IV) and 1,4-pregnadiene-11β,17α,21-triol-3,20-dione (V) were heated at reflux in acetic acid, little or none of the corresponding rearrangement products VI and VII were isolated, although ultraviolet spectra of the crude reaction products showed some evidence for the presence of the enol aldehyde absorption. It has been suggested by Slates and Wendler[3a] that the reaction of Norymberski[3b] for the reductive removal of the 17α-hydroxyl group from the dihydroxyacetone side chain with zinc and aqueous acetic acid probably proceeds *via* the enol aldehyde C of Mattox. In view of Norymberski's isolation of corticosterone in good yield from his procedure, we felt that an additional reagent generated in the Norymberski reaction was having a beneficial effect on the rearrangement step of the sequence. Accordingly, we added zinc acetate to the mixture of IV (and V) with acetic acid and carried out the reaction in the usual way. Thereby VI and VII were isolated in yields of 20–40%. The infrared and ultraviolet spectra and analyses were in good agreement with the assigned structures. The enolic hydroxyl groups were acetylated readily with acetic anhydride in pyridine affording the respective monoacetates VIII and XII which displayed the expected properties.

Reduction of VI with aqueous acetic acid and zinc *at room temperature* afforded corticosterone in good yield. From these results we infer that Slates and Wendler have postulated the course of the reaction of Norymberski correctly. The additional observation by Slates and Wendler and by Norymberski that acetylation at 21- prevents removal of the 17α-hydroxyl group is also fully in accord with the premise that the Norymberski reaction is a special case of the Mattox reaction; we have also confirmed that acetylation at 21- prevents the Mattox reaction from taking place in acetic acid (in the absence of zinc).

Recently Tsuda, Ohki and Suzuki[4] have isolated 17-isodesoxycorticosterone and 17-isoprogesterone from the Norymberski reaction on Reichstein's S. The formation of products isomeric at 17- is easily accommodated by the Mattox scheme since the 17(20)-enol may clearly reketonize to either configuration.

Beyler and Hoffman[5] have prepared a 21-aldehyde hydrate (the non-enolized, hydrated form of VI) by the oxidation of the 21-hydroxyl group of corticosterone with cupric acetate, which they characterized as a crystalline enol acetate, m.p. 213–217°, λ_{max}^{MeOH} 239 mμ. Our constants for VIII, to which we have ascribed the same structure as their enol acetate, are, m.p. 243–247°, λ_{max}^{MeOH} *245* mμ! The observed ultraviolet maxima for III and XII are consistent with that of VIII. The contribution of the enol acetate chromophore (in alcohol solution) according to Dorfman's review[6a] is at λ_{max} 253 mμ.; an average of this value with the contribution of the A-ring chromophore at λ_{max} 242 mμ[6b] gives a theoretical λ_{max} of about 247 mμ. This calculation assumes equal contributions from each chromophore, which is only approximately true; ϵ_{max} 16,000 for hydrocortisone,[6b] ϵ_{max} 14,300 for a 20-keto-21-al enolic acetate.[6a] The summa-

(3) (a) H. L. Slates and N. L. Wendler, *J. Org. Chem.*, **22**, 498 (1957); (b) J. K. Norymberski, *J. Chem. Soc.*, 517 (1956).

(4) K. Tsuda, E. Ohki and J. Suzuki, *Chem. Pharm. Bull. (Japan)*, **7**, 552 (1959).

(5) R. E. Beyler and F. Hoffman, *J. Am. Chem. Soc.*, **79**, 5297 (1957).

(6) (a) L. Dorfman, *Chem. Revs.*, **53**, 83 (1953); (b) R. H. Levin *et al.*, *J. Am. Chem. Soc.*, **75**, 502 (1953).

tion peak will be shifted slightly toward the lower wave length because of the greater value of ϵ for hydrocortisone.

Hence, our recorded value for VIII is more consistent with the summation of earlier experience than is the value noted by Beyler and Hoffman for their product. We cannot exclude the possibility that *cis–trans* isomerism at 17- is the origin of the difference between VIII and the Beyler–Hoffman compound.[7] The only pair of steroidal isomers *cis-trans* at 17-known to us was described by the Upjohn group.[8] This pair, *cis-* and *trans-*methyl 3,11-diketo-4,17 (20)-pregnadiene-21-oate has λ_{max} 233 mμ (*cis* in ethanol) and 230 mμ (*trans* in ethanol). Hence, significant differences can result from such isomerism.

The 20-acetate of VI (VIII) also was subjected to reduction with zinc and acetic acid at 30°. The principal product from the reaction (IX, $C_{23}H_{32}O_4$), isolated in 30% yield, had lost an oxygen atom with respect to the starting material, which contrasts with the results from the reduction of VI under the same conditions. Acetate carbonyl was still apparent in the infrared spectrum of IX, but the wave length of the band had shifted to 5.74 μ. Hydrolysis of acetate with methanolic potassium hydroxide regenerated a band for the 20-carbonyl group at 5.88 μ (X), from which it was clear that the enol acetate group is present in IX. The resulting 11β-hydroxyprogesterone (X) was oxidized with chromic acid to 11-ketoprogesterone (XI) which was identified by comparison with an authentic sample. The combined sequence IV → VI→ VIII → IX → X represents a method for simplifying side chain structure by removal of the 17- and 21-hydroxyl groups, which may have some use in structure problems arising from the microbiological transformation of steroids.

We are indebted to Dr. D. H. R. Barton for a valuable suggestion offered during the course of this work.

Experimental[9]

I into II.—A solution of 2.0 g. of I in 200 ml. of glacial acetic acid was heated at reflux for 6 hours. The mixture then was cooled to room temperature and concentrated to a residue. The residue was taken up in methylene chloride, washed free of acetic acid with water, dried and the resulting solution concentrated to a small volume. Chromatography of the solution over 50 g. of Florisil and elution with methylene chloride afforded 0.807 g. of crystalline solid, m.p. 226–238°. Recrystallization from acetone–hexane yielded 0.478 g. of 1,4,17(20)-pregnatrien-20-ol-21-al-3-one (II), m.p. 231–238°, $[\alpha]^{25}D$ + 163° (dioxane); λ_{max}^{MeOH} 246 mμ (ϵ 16,200), 270 mμ (ϵ 14,000); λ_{max}^{Nujol} 2.94 (OH), 6.00 (3- and 21-carbonyl), 6.17 and 6.23 μ ($\Delta^{1,4,17(20)}$).

Anal. Calcd. for $C_{21}H_{26}O_3$: C, 72.27; H, 8.03. Found: C, 72.57; H, 7.98.

Further elution of the chromatogram employed to separate II afforded minor amounts of the 21-acetate of I in the 0.5% methanol fraction (in methylene chloride).

Treatment of the 21-acetate of I in acetic acid under the same reaction conditions yielded only unreacted starting material.

II into III.—A solution of 0.100 g. of II in 1.0 ml. of pyridine was treated with 1.0 ml. of acetic anhydride and the resulting mixture was allowed to stand at room temperature for 64 hours. Excess water was added and the precipitated solid was removed by filtration. Recrystallization from ether–hexane afforded 0.047 g. of 1,4,17(20)-pregnatrien-20-ol-21-al-3-one acetate (III), m.p. 186–188°, $[\alpha]^{25}D$ +135° (dioxane); λ_{max}^{MeOH} 248 mμ (ϵ 34,400); λ_{max}^{Nujol} 5.67 (acetate carbonyl), 6.00 μ (3- and 21-carbonyl), 6.15 and 6.24 ($\Delta^{1,4,17(20)}$), 8.35 μ (C–O–C of acetate).

Anal. Calcd. for $C_{23}H_{28}O_4$: C, 74.97; H, 7.66. Found: C, 74.63; H, 7.24.

1-Dehydrodesoxycorticosterone (XIII).—To a solution of 0.040 g. of II in 10.0 ml. of anhydrous tetrahydrofuran at 0° was added 0.035 g. of lithium aluminum tri-*t*-butoxyhydride.[10] The mixture was agitated for 30 minutes at 0° and was allowed to warm to room temperature (10 minutes). Water then was added and the mixture was extracted with methylene chloride. The extracts were dried and concentrated to a residue, which was chromatographed on 3.0 g. of Florisil. From the 1% methanol–methylene chloride eluates 0.005 g. of crystalline 1-dehydrodesoxycorticosterone (XIII), m.p. 172–178°, was obtained. Recrystallization from acetone–ether raised the m.p. to 186–190°. Vischer, Meystre and Wettstein reported[11] m.p. 189–195°. An authentic sample prepared from desoxycorticosterone by the action of *B. sphaericus*[12] had an infrared spectrum identical with that prepared from II.

A solution of 0.08 g. of II in 4.0 ml. of acetic acid and 4.0 ml. of water was agitated with 0.8 g. of granular zinc at 50° for 4 hours. The reaction mixture then was decanted from the zinc and the zinc was washed with 50% aqueous acetic acid. The combined washings and decantate were concentrated to a residue which was leached thoroughly with methylene chloride. The extracts were washed with water, dried, concentrated and the residue (0.055 g.) was partitioned on 45 g. of Chromosorb-W (Johns-Manville) with the aid of the toluene–ligroin (1:1)–propylene glycol system. Elution with toluene–ligroin (1:1) saturated with propylene glycol afforded a series of fractions which contained one component with the same migration rate as authentic 1-dehydrodesoxycorticosterone. These fractions were combined (0.012 g.) and an infrared spectrum thereof in chloroform solution matched the spectrum of an authentic sample of 1-dehydrodesoxycorticosterone.

V into VII.—A solution of 9.95 g. of V in 400 ml. of glacial acetic acid containing 1.0 g. of zinc acetate dihydrate was heated at reflux for 2 hours. The mixture was processed by concentration, washing and chromatography as before and the product was eluted with ether. All solid fractions (5.0 g.) were combined and crystallized from acetone–hexane. There resulted 3.37 g. of 1,4,17(20)-pregnatriene-11β,20-diol-21-al-3-one (VII), m.p. 225–229°, $[\alpha]^{25}D$ +165° (dioxane); λ_{max}^{MeOH} 246 mμ (ϵ 15,500), 270 mμ (ϵ 14,900); λ_{max}^{Nujol} 2.92 and 3.05 (OH), 6.02 (3- and 21-carbonyl), 6.14 and 6.22 μ ($\Delta^{1,4,17(20)}$).

Anal. Calcd. for $C_{21}H_{26}O_4$: C, 73.66; H, 7.65. Found: C, 74.03; H, 7.61.

VII into XII.—A solution of 2.0 g. of VII in 20.0 ml. of pyridine and 20.0 ml. of acetic anhydride was stored at room temperature overnight. Excess water and ice were added and the solvents were removed in the air draft at room temperature. The residue was crystallized from acetone–hexane affording 1.78 g. of 1,4,17(20)-pregnatriene-11β,20-diol-21-al-3-one 20-acetate (XII), m.p. 246–250°, $[\alpha]^{25}D$ +117° (dioxane, corrected for half a mole of acetone of solvation); λ_{max}^{MeOH} 248 mμ (ϵ 30,600); λ_{max}^{Nujol} 3.02 (OH), 5.68 (acetate carbonyl), 5.85 (acetone of solvation), 5.96, 6.05 (3- and 21-carbonyl), 6.20 and 6.26 ($\Delta^{1,4,17(20)}$), 8.28 μ (C–O–C of acetate).

Anal. Calcd. for $(C_{23}H_{28}O_5)_2 \cdot C_3H_6O$: C, 71.16; H, 7.56. Found: C, 71.31; H, 7.31.

IV into VI.—A solution of 10.0 g. of IV in 400 ml. of glacial acetic acid containing 1.0 g. of zinc acetate dihydrate was heated at reflux for 2 hours. The reaction mixture was

(7) This possible explanation has been suggested to us by Dr. Beyler in correspondence.

(8) J. A. Hogg, *et al.*, *J. Am. Chem. Soc.*, **77**, 4436 (1955).

(9) Analyses and optical data measurements were carried out by members of the Physical Chemistry Department of the Schering Corp. We are indebted to Richard Wayne for the interpretation of the infrared spectra.

(10) H. C. Brown and B. C. S. Rao, *J. Am. Chem. Soc.*, **80**, 5377 (1958), and references cited therein.

(11) E. Vischer, C. Meystre and A. Wettstein, *Helv. Chim. Acta*, **38**, 835 (1955).

(12) T. H. Stoudt, *et al.*, *Arch. Biochem. and Biophys.*, **59**, 304 (1955).

then cooled, concentrated, extracted with methylene chloride and washed and the extract was chromatographed as noted previously. Elution with ether afforded 2.51 g. of 4,17(20)-pregnadiene-11β,20-diol-21-al-3-one (VI), m.p. 190–205°. Recrystallization from ether–hexane gave 1.066 g. of VI, m.p. 203–208°, and a second crop of 0.770 g., 197–203°, $[\alpha]^{25}D$ +161° (dioxane); λ_{max}^{MeOH} 242 mμ (ε 17,000), 285 mμ (ε 14,200); λ_{max}^{Nujol} 2.95 and 3.03 (OH), 5.98 (3- and 21-carbonyl), 6.12 ($\Delta^{4,17(20)}$).

Anal. Calcd. for $C_{21}H_{28}O_4$: C, 73.22; H, 8.19. Found: C, 73.77; H, 8.34.

On one occasion the reaction mixture from the action of acetic acid on IV was acetylated with acetic anhydride in pyridine solution and the steroidal mixture was isolated in the conventional way. From chromatography of the mixture over Florisil there was obtained, in addition to VIII, a small yield of 4-androstene-11β-ol-3,17-dione, which was identified by comparison of infrared spectrum with that from an authentic sample.

VI into VIII.—A solution of 0.500 g. of VI in 5.0 ml. of pyridine and 5.0 ml. of acetic anhydride was stored overnight at room temperature. The reaction mixture then was treated with ice and water and the precipitate which formed was separated by filtration. There resulted 0.50 g. of solid, m.p. 230–237°. Recrystallization from acetone–hexane afforded 0.360 g. of 4,17(20)-pregnadiene-11β,20-diol-21-al-3-one 20-acetate (VIII), m.p. 234–239° dec. The m.p. could be raised to 243–247° by repeated crystallization; $[\alpha]^{25}D$ +127.6° (dioxane); λ_{max}^{MeOH} 245 mμ (ε 28,600); λ_{max}^{Nujol} 2.96 (OH), 5.68 (acetate carbonyl), 5.96, 6.06 (3- and 21-carbonyl), 6.12 and 6.18 ($\Delta^{4,17(20)}$), 8.28 μ (C–O–C of acetate).

Anal. Calcd. for $C_{23}H_{30}O_5$: C, 71.48; H, 7.82. Found: C, 71.13; H, 7.82.

Corticosterone from VI.—To a solution of 1.0 g. of VI in 25.0 ml. of acetic acid was added 25.0 ml. of water and 10.0 g. of granular zinc. The reaction mixture was agitated for 4 hours at 30–35°. The zinc was removed by filtration and washed with 50% aqueous acetic acid. The combined filtrates were concentrated partially in an air draft and excess water was then added. Extraction of the aqueous with methylene chloride, washing, drying and concentration of the extracts afforded a residue which was crystallized from acetone–hexane. There was isolated thereby 0.642 g. of corticosterone (XIV), m.p. 171–182°, and 0.105 g. of a second crop, m.p. 153–172°. The infrared spectra of both fractions were identical with that of corticosterone and both fractions were homogeneous as measured by paper chromatography in toluene–propylene glycol.

VIII into IX.—To a solution of 0.325 g. of VIII in 15.0 ml. of acetic acid was added 15.0 ml. of water and 3.0 g. of zinc granules. The reaction mixture was agitated at 30–35° for 4 hours and the steroidal products were isolated as in the preceding experiment. The crude steroid mixture was dissolved in hexane containing a small amount of methylene chloride and chromatographed over 7 g. of Florisil. Recrystallization of solids collected in the 50% ether–hexane fractions afforded 0.113 g. of 4,17(20)-pregnadiene-11β,20-diol-3-one 20-acetate (IX), m.p. 155–157°, $[\alpha]^{25}D$ + 124° (dioxane); λ_{max}^{MeOH} 242 mμ (ε 16,200); λ_{max}^{Nujol} 2.98 (OH), 5.74 (enolic acetate carbonyl), 6.10 (3-carbonyl), 6.22 (Δ^4), 8.20 μ (C–O–C of acetate).

Anal. Calcd. for $C_{23}H_{32}O_4$: C, 74.16; H, 8.66. Found: C, 74.47; H, 8.73.

IX into X.—A solution of 0.090 g. of IX in 5.0 ml. of methanol and 1.0 ml. of 5% methanolic potassium hydroxide was stored at 27° for 1.5 hours. Thereupon the reaction mixture was made acid and diluted with water. Extraction of the aqueous with methylene chloride, and the usual washing and drying of the extracts, afforded, on concentration, a crystalline residue, which after recrystallization from acetone–hexane gave 0.068 g. of 11β-hydroxyprogesterone (X), m.p. 184–187°, $[\alpha]^{25}D$ + 200° (dioxane); λ_{max}^{Nujol} 2.95 (OH), 5.88 (20-carbonyl), 6.05 (3-carbonyl), 6.18 μ (Δ^4). Magerlein and Levin[13] report m.p. 186–188°, $[\alpha]^{25}D$ +212° (acetone).

X into XI.—To a solution of 0.050 g. of X in 2 ml. of acetic acid was added 0.011 g. of chromic acid in 0.5 ml. of water. After 3 hours storage at room temperature, the mixture was treated with excess water and then extracted with ether. The ethereal extracts were washed, dried, concentrated and crystallization was induced by the addition of hexane. There precipitated 0.035 g. of 11-ketoprogesterone (XI), m.p. 175–176°, $[\alpha]^{25}D$ +263° ($CHCl_3$). An authentic sample of XI prepared from 11α-hydroxyprogesterone (Upjohn) by chromic acid oxidation had m.p. 175–176°, $[\alpha]^{25}D$ +258° ($CHCl_3$), did not depress the melting point of XI on admixture and had the identical infrared spectrum. Peterson and co-workers[14] give m.p. 172–175°, $[\alpha]^{25}D$ +227° ($CHCl_3$). Fried and co-workers[15] give m.p. 170–172°, $[\alpha]^{23}D$ +276° ($CHCl_3$). Mancera and co-workers[16] give m.p. 170–172°, $[\alpha]^{30}D$ +238° ($CHCl_3$). The reason for the lack of agreement among the rotations reported is not apparent. Our results have been carefully checked and we believe them to be reliable.

(13) B. J. Magerlein and R. Levin, *J. Am. Chem. Soc.*, **75**, 3654 (1953).

(14) D. H. Peterson, *et al.*, *ibid.*, **74**, 5936 (1952).

(15) J. Fried, *et al.*, *ibid.*, **74**, 3962 (1952).

(16) O. Mancera, *et al.*, *J. Org. Chem.*, **17**, 1066 (1952).

[CONTRIBUTION FROM THE RESEARCH INSTITUTE FOR MEDICINE AND CHEMISTRY, CAMBRIDGE, MASS.]

A New Photochemical Reaction[1]

BY D. H. R. BARTON, J. M. BEATON, L. E. GELLER AND M. M. PECHET

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The photolysis of suitably constituted organic nitrites provokes an intramolecular exchange of the NO of the nitrite residue with a hydrogen atom attached to a carbon atom in the γ-position. The C-nitroso compounds thus formed can be isolated as the corresponding nitroso-dimers or, after isomerization, as the oximes. Adequate structural proof has been provided for several examples of the reaction. The mechanism of the process has been discussed and an interpretation of all the relevant facts presented.

The pyrolysis of organic nitrites is a reaction the mechanism of which has been thoroughly studied.[2] The primary step is the homolytic fission of the —O—(N=O) bond followed by disproportionation (or alternative fission) of the alkoxyl radicals thus derived.[2,3] For example,

$$RCH_2—O—N=O \longrightarrow RCH_2—O\cdot + NO;$$
$$2RCH_2—O\cdot \longrightarrow RCH=O + RCH_2—OH$$

Although the corresponding photolysis of organic nitrites has not received the same attention,[4]

(1) This paper is Communication No. 11 from the Research Institute for Medicine and Chemistry. For a preliminary report see D. H. R. Barton, J. M. Beaton, L. E. Geller and M. M. Pechet, *J. Am Chem. Soc.*, **82**, 2640 (1960).

(2) E. W. R. Steacie and G. T. Shaw, *J. Chem. Phys.*, **2**, 345 (1934), and many later papers by E. W. R. Steacie. See E. W. R. Steacie, "Atomic and Free Radical Reactions," Vol. I, Reinhold Publ. Corp., New York, N. Y., 2nd Ed., 1954, p. 239; see also P. Gray, P. Rathbone and A. H. Williams, *J. Chem. Soc.*, 3932 (1960)

(3) F. O. Rice and E. L. Radowskas, *J. Am. Chem. Soc.*, **56**, 214 (1935).

(4) C. H. Purkis and H. W. Thompson, *Trans. Faraday Soc.*, **32**,