toluene, reflux 3.5 hr). The crude product was chromatographed on 125 g of silica gel to elute 2.5 g of crystalline product with benzene–ethyl acetate (19:1). After two crystallizations from aqueous ethanol, there was obtained 1.43 g of product, mp 101–102°; ir ν_{max} 1665 cm^{-1}; λ_{max}^{EtOH} 240 mμ (ε 16,400); nmr δ 0.82 (s, 3H) and 1.27 (s, 3H).

The analytical sample was crystallized from aqueous ethanol: mp 102.5–103.0°, $[\alpha]^{25}D$ +64.0°.

Anal. Calcd for $C_{21}H_{32}O$ (mol wt 300.51): C, 83.94; H, 10.73. Found: C, 83.97; H, 10.81.

Registry No.—II, 21321-87-9; III, 21321-88-0; IV, 21321-89-1; V, 21321-90-4; VIII, 21321-91-5; IX, 1624-73-3; IX (hydrazone), 21321-93-7; X, 21321-94-8; XI, 21321-95-9; XII, 21321-96-0; XIII (hydrazone), 21321-97-1; XIV, 21321-98-2; XV, 21321-99-3; XVI, 21317-79-3; XVIII, 21317-80-6; XIX, 21317-81-7; XX, 21317-82-8; 3-methyl-20-iodo-19-norpregna-1,3,5(10),20-tetraene, 21339-87-7.

Acknowledgment.—We would like to thank Mr. S. Traiman, Dr. V. Toome, Dr. T. Williams, and Dr. F. Scheidl for the infrared spectra, ultraviolet spectra, nmr spectra, and microanalyses, respectively. We also acknowledge the cooperation of Dr. A. Boris and his staff for obtaining all of the endocrinological data. The technical assistance of Mr. Harold Lucas in the synthetic portions of this work is greatly appreciated.

Preparation and Properties of Steroidal 17,20- and 20,21-Acetonides Epimeric at C-20. I. Derivatives of 5β-Pregnan-3α-ol[1]

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Received March 26, 1969

Conditions optimal for the preparation and, in some cases, the hydrolysis of steroidal 17,20- and 20,21-acetonides epimeric at C-20 have been defined. Acetonides of the latter class are formed in good yield using *p*-toluenesulfonic acid as catalyst and undergo ready hydrolysis in 60–80% acetic acid at room temperature. Acetonides of the 17,20 variety are best prepared using perchloric acid as catalyst. Among members of this class 17,20α-acetonides are relatively resistant while their C-20 epimers are very resistant to hydrolysis with aqueous acetic acid. The use of both 17,20- and 20,21-acetonides in the preparation of 3-acetates of steroidal glycols and glycerols is described. It was noted that the bromine atom in the bromacetonides **15a** and **15b** resists substitution. In an investigation of the lithium aluminum hydride reduction of **15a** and **15b**, it was observed that the 20α epimer was more resistant to attack, although both bromoacetonides afforded their respective hydrogenolysis products. The differing reactivities of **15a** and **15b** toward this reagent as well as the observations relative to the ease of hydrolysis of epimeric 17,20-acetonides are correlated with the degree of steric hindrance. Reduction of **15a** and **15b** with sodium in *n*-propyl alcohol gave in both cases about equal amounts of the *trans*-pregnenol **17** and the pregnenediol **20**. A mechanism accounting for the formation of these substances is proposed. The principal bands of 17,20- and 20,21-acetonides in the infrared region are presented and their differentiation by this means is discussed.

Steroidal acetonides of the 20,21 variety have long been used as protecting groups,[2] but we are aware of only one earlier description of a 17,20-acetonide and in that instance the configuration at C-20 was not established.[3] The paucity of published information relative to these derivatives has prompted us to undertake a systematic investigation of the preparation and properties of epimeric pairs of both 17,20- and 20,21-acetonides derived from 5β-pregnan-3α-ol. We have studied the formation and, in some cases, the hydrolysis of these derivatives and have utilized both types in the preparation of partially acetylated polyhydroxypregnanes. Also included is a description of some novel reductive eliminations undergone by 17,20-acetonido-21-bromides.

To define optimal conditions for the preparation of both types of acetonides, a small-scale experiment was performed on eight pairs of C-20-epimeric glycols and glycerols[4] (Table I). These substrates were treated with the appropriate acid catalyst in acetone solution under standard conditions and, by means of thin layer chromatography of the reaction mixtures at intervals, the time required for a greater than 90% conversion into the acetonide was estimated. In keeping with the results of others, we observed that the relatively unhindered 20,21-glycols and glycerols (pairs I and II) readily form acetonides in the presence of *p*-toluenesulfonic acid (*p*-TSA). In contrast, acetonation of 17,20-glycols unsubstituted at C-21 (pair III) proceeds at only one-thirtieth this rate. The greater resistance to cyclization involving the 17α-hydroxyl group is increased still further by the introduction of various bulky substituents at C-21 (pairs IV–VIII). However, substitution of perchloric acid for *p*-TSA provides the 17,20-acetonides of all types in 15 min or less. The relative effectiveness of the two catalysts can best be assessed by comparing the reaction times in pair IV where both were used. These results show that perchloric acid promotes acetonation of the 21-acetates at a rate approximately 5000 times as great as that provided by *p*-TSA. For all examples no appreciable differences in reaction rates of C-20 epimers were noted.

The mildest conditions for the hydrolysis (cleavage) of acetonides were sought to exploit fully their utility as intermediates. The cleavage of both 20α,21- and 20β,-21-acetonides proceeds rapidly in 60–80% acetic acid at room temperature and is complete within 2 hr. Hydrolysis of 17,20α-acetonides unsubstituted at C-21 is notably slower under these conditions, but is complete within 24 hr. In striking contrast, the 20β epimers are virtually unchanged when so treated, but can be cleaved to 17,20β-glycols in good yield by brief

(1) This work was supported wholly by a research grant, AM 01255, from the National Institute of Arthritis and Metabolic Diseases, National Institutes of Health, U. S. Public Health Service.

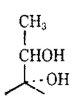
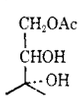
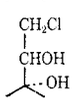
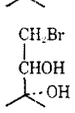
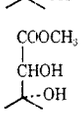
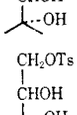
(2) C. Djerassi, "Steroid Reactions," Holden-Day, Inc., San Francisco, Calif., 1963, p 67.

(3) W. J. Adams, D. N. Kirk, D. K. Patel, V. Petrow, and I. A. Stuart-Webb, *J. Chem. Soc.*, 2298 (1954).

(4) M. L. Lewbart and J. J. Schneider, *J. Org. Chem.*, **33**, 1707 (1968).

TABLE I

CONDITIONS FOR FORMATION OF STEROIDAL ACETONIDES DERIVED FROM 5β-PREGNAN-3α-OL[a]

Pair no.	Type	Catalyst	Reaction time, min, 20α or 20β
I		*p*-TSA	10
II		*p*-TSA	10–15
III		*p*-TSA	360
IV		*p*-TSA $HClO_4$	5000[b] 1
V		$HClO_4$	5
VI		$HClO_4$	5–10
VII		$HClO_4$	15
VIII		$HClO_4$	15

[a] Each compound (1 mg) in 1 ml of acetone was treated with 0.25 mg of *p*-TSA or 2.5 μl of 70% $HClO_4$ at room temperature. The acetonide nature of the products was established in large-scale preparations either in the course of this work (acetonides from glycol pairs I, II, III, V, VI, and VIII) or in a previous publication (from pairs IV and VII).[5] [b] Less than 20% conversion into acetonide after 72 hr.

refluxing in 80% acetic acid. Introduction of an acetoxyl group at C-21 makes still more difficult the hydrolysis of 17,20-acetonides. Nevertheless, a 20α epimer (as the 3,21-diacetate) could be hydrolyzed in good yield by heating at 65° for 12 hr;[5] its 20β epimer was largely unaffected by this treatment.

Inspection of Dreiding models provides a possible explanation for the observed greater difficulty in cleaving 17,20β-acetonides. By restricting rotation between the C-17 and C-20 bond, the dioxolane ring fixes the position of the C-21 methyl group so as to hinder approach of the hydrolytic agent from the front and side of the molecule. In 17,20α-acetonides, however, the C-21 methyl group is fixed in the vicinity of the C-18 methyl group, and leaves the dioxolane ring far more open to attack. It is also possible that repulsive forces between these two methyl groups impose an additional strain in this ring system which is relieved by hydrolysis. These results may be regarded as an extreme expression of the well-known greater difficulty in hydrolyzing 20β-acetates.

The use of side-chain acetonides in the synthesis of partially acetylated pregnanes was first described by Sarett[6] who prepared the 3-acetates of the 3α,20α- and -20β,21-trihydroxy-5β-pregnan-11-ones *via* the 20,21-acetonides. Scheme I illustrates our use of acetonides as intemediates in the preparation of 3-acetates of steroidal glycols and glycerols in the 11-deoxy series. Treatment of an acetone solution of the triols **1a** and **1b** with *p*-TSA for 30 min gave the corresponding 20,21-acetonides **2a** and **2b** in excellent yields. Hydrolysis of their acetylation products **3a** and **3b** in 60% acetic acid at room temperature afforded in good yield the triol 3-acetates **4a** and **4b**. A similar sequence of reactions was carried out on the tetrols **5a** and **5b**. The acetonation products **6a** and **6b** were converted into the acetonide acetates **7a** and **7b** which, after treatment with 60% acetic acid at room temperature, provided the tetrol 3-acetates **8a** and **8b** in yields of 95 and 92%, respectively. The location of the acetoxyl group was established in each case by periodic acid oxidation to etiocholanolone acetate (**9**). Treatment of the triols **10a** and **10b** with *p*-TSA in acetone for 6 hr provided the 17,20-acetonides **11a** and **11b** in respective yields of 91 and 95%. Hydrolysis of the acetylation product (**12a**) of the 20α epimer was effected at room temperature in 60% acetic acid, furnishing the 3-acetate **13a** in a yield of 85%. Although cleavage of the epimeric acetonide **12b** did not occur under these conditions, the 3-acetate **13b** could be obtained in a yield of 78% after brief refluxing in 80% acetic acid. Periodic acid oxidation of the hydrolysis products **13a** and **13b** to etiocholanolone acetate (**9**) confirmed the location of the acetoxyl group.

The ready separation of a mixture of the pregnanetriols **10a** and **10b**, obtained by lithium aluminum hydride reduction of 17-hydroxypregnanolone, provides a further application. Sequential treatment with acetone–*p*-TSA and acetic anhydride–pyridine gave a mixture of the acetonide acetates **12a** and **12b**. Following exposure of this mixture to aqueous acetic acid at room temperature and chromatography on silica gel, the 20β-acetonide acetate **12b** and the 20α-triol 3-acetate **13a** were isolated in yields of 33 and 49%, respectively. These yields exceed slightly those obtained by other investigators who separated the triols as such[7] or as the diacetates.[8]

The bromoacetonides **15a** and **15b** (Scheme II) were prepared for use as intermediates in an alternate synthesis of 17,20-acetonido-21-ols.[5] Conversion of the bromotriols **14a** and **14b**[5] into the corresponding isopropylidene derivatives with acetone–perchloric acid occurred in excellent yield. Contrary to our expectations, however, the bromine atom in **15a** and **15b** showed great reluctance to undergo substitution reactions. Thus refluxing a solution of each epimer in 0.4 *N* aqueous methanolic sodium hydroxide for 4 hr was without effect. Neither compound was affected by refluxing for 1 hr with 5% silver nitrate in aqueous ethanol. (Under the same conditions the bromotriols **14a** and **14b** gave an almost immediate precipitate of silver bromide.) Even after prolonged refluxing with silver nitrate, the 20β-bromoacetonide **15b** was unchanged, but the 20α epimer **15a** afforded small amounts of more polar (less mobile) products. After refluxing with sodium iodide in acetone for 24 hr, both bromoacetonides were recovered intact.

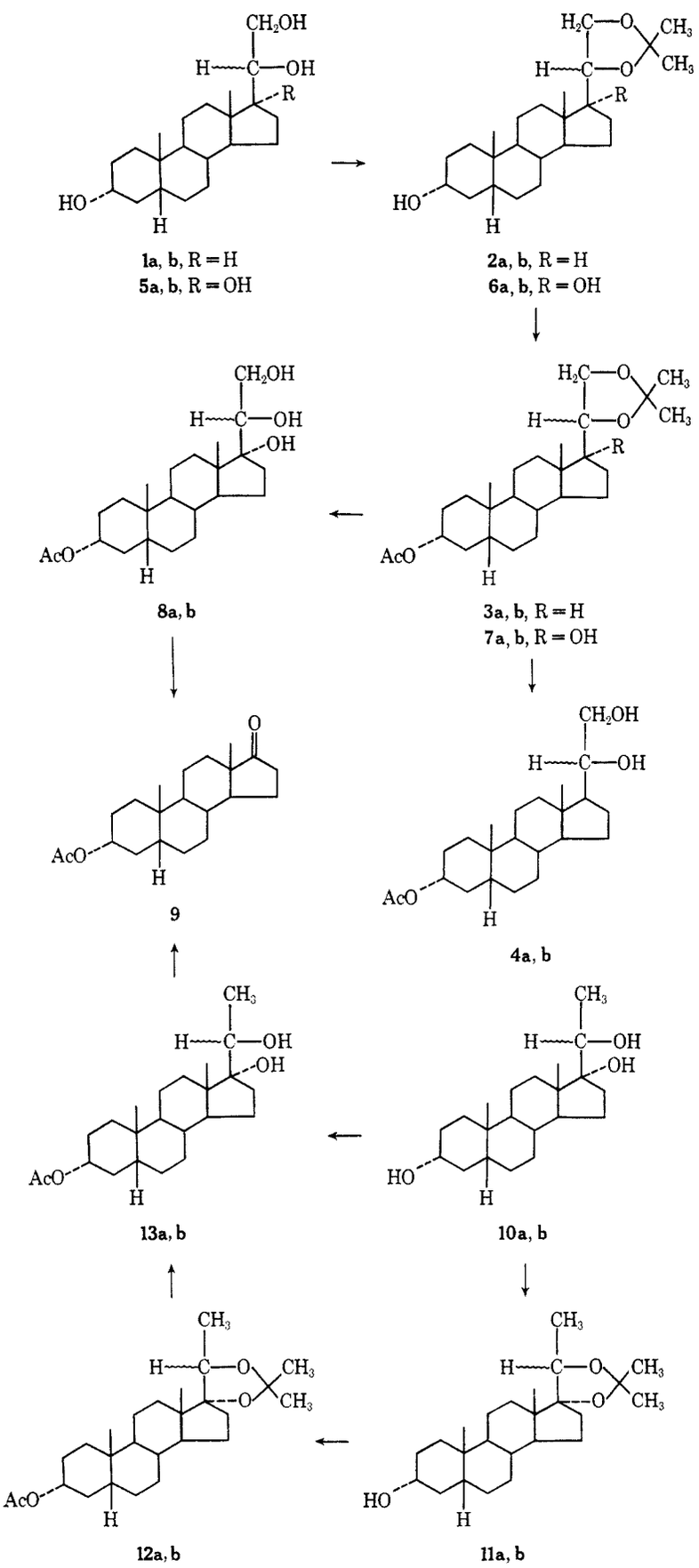
(5) M. L. Lewbart, *J. Org. Chem.*, **33**, 1695 (1968).

(6) L. H. Sarett, *J. Amer. Chem. Soc.*, **71**, 1165 (1949).

(7) C. B. Thornton, S. Rogers, and W. Klyne, *J. Endocrin.*, **32**, 231 (1965).

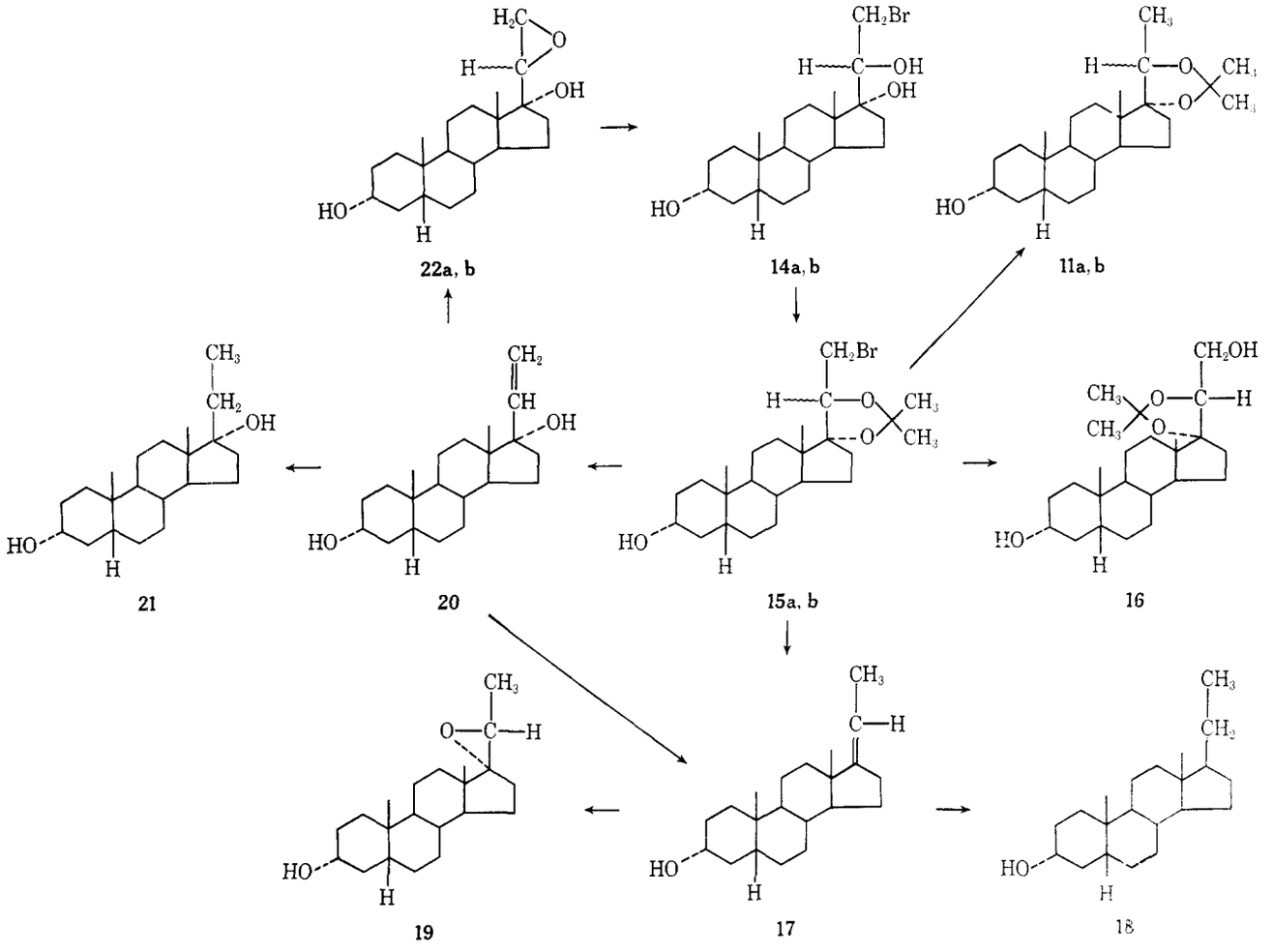
(8) D. K. Fukushima and E. D. Meyers, *J. Org. Chem.*, **23**, 174 (1958).

SCHEME I[a]



[a] In this scheme and in Scheme II the substituent at C-20 is α oriented in "a" compounds and β oriented in "b" compounds.

SCHEME II[a]



[a] See footnote *a*, Scheme I.

The action of various reducing agents was then investigated. Although sodium borohydride was without effect, lithium aluminum hydride slowly converted them into more polar products. After prolonged refluxing with this reagent in ether, the 20α epimer gave in 16% yield the hydrogenolysis product **11a**. Identical treatment of **15b** afforded both the hydrogenolysis product **11b** (42%) and the hydrolysis product **16** (22%). The greater reactivity of the 20β-bromoacetonide **15b** follows from the more exposed position of the bromine atom, but the generation of the 17,20-acetonido-21-ol under anhydrous conditions requires further explanation. It is possible that α elimination of hydrogen bromide occurs initially and that the resulting carbene intermediate undergoes ready addition of water in the course of the work-up.

In contrast to the notable differences in reactivity of the bromoacetonides toward lithium aluminum hydride, **15a** and **15b** afforded nearly identical reaction mixtures when treated with sodium in *n*-propyl alcohol. In addition to small amounts of the hydrogenolysis products **11a** and **11b**, each reaction mixture included roughly equal amounts of two unsaturated substances. The chromatographically more mobile of these was formed in a yield of 37% and was identified as the *trans*-pregnenol **17**[9] by means of its catalytic reduction to the known pregnanol **18**[4] and its epoxidation to the known 17,20β-epoxide **19**.[5] The less mobile of the two major products was recovered in a yield of 40% under these conditions, but could be obtained in over 60% yield by treating **15b** with sodium in aqueous dioxane. It was identified as the pregnenediol **20** primarily by means of its catalytic reduction to the known pregnanediol **21**.[4] Treatment of **20** with perbenzoic acid afforded a mixture of the 20α,21- and 20β,21-epoxides **22a** and **22b**.[5] Reaction of the epoxide mixture with hydrogen bromide, followed by column chromatography, provided the 20α- and 20β-bromotriols **14a** and **14b** in a roughly 3:1 ratio. The preparation of the 20α-bromotriol **14a** from the pregnenediol **20** in an over-all yield of 45% makes this route a useful one for the preparation of this generally inaccessible epimer. Since the olefin is most readily prepared from the 20β-bromotriol **14b** *via* **15b**, this mode of formation represents an example of inversion at C-20.

A plausible mechanism for the conversion of the bromoacetonides **15a** and **15b** (a in Scheme III) into the olefins **17** and **20** consists of an initial abstraction of bromine by sodium followed by a pair of electron shifts which results in rupture of the dioxolane ring and formation of the anion b. A second pair of electron shifts brings about liberation of acetone and generation of the anion c. Addition of a proton to c affords the 17-hydroxy-Δ^{20}-pregnene d. Subsequent attack at C-21

(9) H. Hirschmann, *J. Biol. Chem.*, **140**, 797 (1941).

TABLE II

CHARACTERISTIC INFRARED BANDS OF 20,21-ACETONIDES DERIVED FROM 5β-PREGNAN-3α-OL

C-17	Other substituents	1215–1205 cm⁻¹ 20α	1215–1205 cm⁻¹ 20β	1163–1155 cm⁻¹ 20α	1163–1155 cm⁻¹ 20β	866–850 cm⁻¹ 20α	866–850 cm⁻¹ 20β	Registry no. 20α	Registry no. 20β
H		1215 (vs)[a]	1215 (vs)	1162 (vs)	1162 (vs)	866 (s)	858 (vs)		
H	3-OAc	*b*	*b*	1162 (vs)	1158 (vs)	866 (vs)	853 (vs)		21337-71-3
H	6α-OH	1215 (vs)	1215 (vs)	1155 (s)	1155 (s)	860 (s)	853 (vs)	21337-72-4	21337-73-5
OH		1215 (s)	1210 (vs)	1158 (s)	1159 (vs)	858 (vs)	858 (vs)		
OH	3-OAc	1212 (s)	1210 (m)	1163 (vs)	1159 (vs)	865 (s)	858 (vs)		
OH	1α-OH		1210 (s)		1158 (s)		858 (vs)		16963-83-0
OH	1β-OH		1209 (m)		1158 (vs)		858 (vs)		16963-82-9
OH	11-one		1212 (s)		1158 (s)		850 (vs)		21337-80-4
OH	1β-OH, 11-one		1210 (s)		1158 (vs)		858 (vs)		16963-85-2
OH	1β-OH, 3-one		1212 (s)		1159 (s)		858 (vs)		21337-82-6
OH	1,11-dione		1210 (s)		1159 (s)		859 (vs)		16963-46-8
OH	Δ²-1,11-dione		1209 (s)		1160–1150 (br, s)		855 (vs)		21337-84-8
OH	Δ¹-3,11-dione		1215 (vs)		1157 (vs)		854 (vs)		21337-85-9
OH	Δ⁹-11-one		1205 (vs)		1156 (vs)		854 (vs)		21337-86-0
OH	1β-OH,3,11-dione		1210 (vs)		1159 (s)		858 (vs)		21337-87-1
OH	1,3,11-trione		1209 (sh, s)		1154 (s)		851 (vs)		21337-88-2

[a] vs, very strong; s, strong; m, medium; br, broad; sh, shoulder. [b] Characteristic band not observed owing to superimposed absorption by other groups.

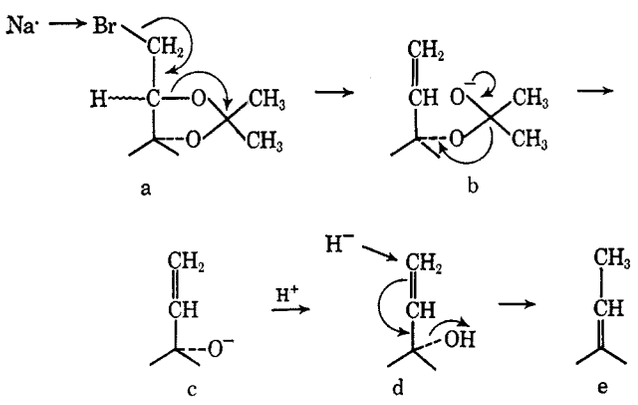
TABLE III

CHARACTERISTIC INFRARED BANDS OF 17,20-ACETONIDES DERIVED FROM 5β-PREGNAN-3α-OL

C-21	Other substituents	1250–1210 cm⁻¹ 20α	1250–1210 cm⁻¹ 20β	1170–1155 cm⁻¹ 20α	1170–1155 cm⁻¹ 20β	1000–990 cm⁻¹ 20α	1000–990 cm⁻¹ 20β	Registry no. 20α	Registry no. 20β
CH_3		1237 (vs), 1210 (vs)[a]	1249 (vs), 1214 (s)	1166 (m)	1169 (m)	999 (s)	1001 (s)		
CH_3	3-OAc	*b*, 1211 (s)	*b*, 1214 (m)	1165 (m)	1169 (sh, m)	1000 (m)	1001 (s)		
CH_3	11β-OH	1233 (s), 1209 (s)	1251 (vs), 1210 (s)	1159 (m)	1164 (s)	999 (s)	1000 (s)	21337-93-9	21337-94-0
CH_3	11-one	1235 (s), 1210 (s)	1248 (vs), 1211 (vs)	1154 (s)	1155 (vs)	999 (m)	998 (vs)	21337-95-1	21337-96-2
CH_2OH		1233 (vs), 1209 (s)	1248 (vs), 1213 (s)	1167 (s)	1168 (s)	995 (vs)	999 (s)	16109-62-9	
CH_2OH	3-OAc	*b*, 1208 (s)		1162 (s)		992 (s)		21371-78-8	
CH_2OH	6α-OH		1249 (s), 1214 (s)		1168 (s)		999 (s)		21337-99-5
CH_2OAc		*b*, 1205 (s)	*b*, *b*	1162 (s)	1162 (m)	994 (vs)	993 (s)	21338-00-1	16065-17-1
CH_2OAc	3-OAc	*b*, *b*	*b*, *b*	1165 (sh, m)	1162 (s)	993 (s)	999 (s)	16065-15-9	16065-16-0
$COOCH_3$		1235 (s), 1205 (br, vs)	1248 (s), 1211 (s)	1165 (sh, s)	1169 (s)	990 (s)	1000 (s)	21333-83-5	21333-84-6
$COOCH_3$	3-OAc	*b*, 1209 (s)	*b*, 1209 (s)	1165 (sh, s)	1171 (s)	990 (s)	1000 (s)	16109-60-7	16109-61-8
CH_2OTs		1232 (s), 1209 (m)	1245 (s), 1210 (m)	*b*	*b*	990 (m)	998 (m)	21333-87-9	21333-88-0
CH_2Cl		1235 (vs), 1212 (s)	1250 (s), 1211 (s)	1164 (s)	1165 (m)	992 (s)	997 (s)	21333-89-1	21333-90-4
CH_2Br		1238 (vs), 1212 (vs)	1247 (vs), 1211 (vs)	1162 (s)	1160 (m)	1002 (s)	998 (vs)		
CH_2Br	3-OAc	*b*, 1211 (vs)	*b*, 1212 (sh, s)	1162 (m)	1161 (m)	1002 (m)	1000 (m)		

[a,b] See footnotes *a* and *b* of Table II.

SCHEME III



by hydride ion induces a concerted shift in the double bond and elimination of the hydroxyl group, giving the Δ^{17}-pregnene e. That the formation of d precedes that of e was proven by treating both unsaturated compounds with sodium in *n*-propyl alcohol; appreciable amounts of e were obtained from d, but the reverse reaction did not occur.

The principal bands in the infrared region of the 17,20- and 20,21-acetonides described in this paper are presented in Tables II and III, respectively. Justification for these assignments is based upon the constant occurrence of certain bands in these derivatives together with their absence in the corresponding glycols. Absorption bands in the vicinity of 1210 and 1160 cm^{-1} are common to both types; specific differentiation rests upon the presence of an intense band at *ca.* 860 cm^{-1} in all 20,21-acetonides and a moderate to strong band at *ca.* 1000 cm^{-1} in all 17,20-acetonides. The location of these bands is not influenced by the nature of the substitutents adjacent to the dioxolane ring system. An additional band within the limits of 935–928 cm^{-1} was found in all 17-hydroxy-20,21-acetonides, but was absent in their 17-deoxy analogs. It is not possible to differentiate between 20α,21- and 20β,21-acetonides, but the presence of an intense band at *ca.* 1235 cm^{-1} in 17,20α-acetonides serves to distinguish them from 17,20β-acetonides which display this band at a significantly higher frequency (*ca.* 1250 cm^{-1}).

Experimental Section

Melting points were taken on a Fisher-Johns apparatus and are uncorrected. Optical rotations were determined at 365 and 589 (D line of sodium) in a Zeiss 0.005° photoelectric polarimeter. Measurements were made in methanol solution in a 0.5-dm tube at a concentration of about 1% and at a temperature of 26 ± 1°. Infrared (ir) spectra were determined as KBr pellets with a Beckman IR-8 instrument. A description of and references to the column, paper, and thin layer (tlc) chromatographic tech-

niques routinely employed in this laboratory appear in a previous paper.[10] The processing of reaction mixtures from acetylations and lithium aluminum hydride reductions has also been described earlier.[5] Elemental analyses were by August Peisker-Ritter, Brugg, Switzerland.

General Procedure for the Preparation and Hydrolysis of Acetonides.—To a solution of the steroid glycol in acetone (1–2 mg/ml) is added either *p*-TSA (0.25 mg/mg of glycol) or 70% perchloric acid (2.5 μl/mg of glycol). For compounds having low solubility in acetone, up to 5% of methanol can be added. Reaction mixtures are processed by addition of excess solid sodium bicarbonate and concentration *in vacuo* to a small volume. The residue is partitoned between methylene chloride and water, and the organic layer, after filtration through anhydrous sodium sulfate, is concentrated to dryness. Reaction mixtures from perchloric acid-catalyzed reactions frequently are oily in character, and require fractionation on silica gel columns.

For hydrolysis, a solution of steroidal acetonide in 60–80% aqueous acetic acid (1–2 mg/ml) is maintained at the temperature and for the time indicated in each case. (Higher concentrations of acetic acid are necessary where compounds have limited solubility in water, and prevent the hydrolysis of acetates which tends to occur at elevated temperatures.) The product is recovered by direct removal of the solvent *in vacuo*.

20α,21-Isopropylidenedioxy-5β-pregnan-3α-ol (2a) from 1a.—Treatment of 5β-pregnane-3α,20α,21-triol (50 mg) in acetone (75 ml) with *p*-TSA (10 mg) for 30 min at room temperature afforded a product which crystallized from acetone–*n*-hexane as needles (50 mg, mp 142–142.5°) in a yield of 89.5%: $[\alpha]_{365}$ 53.2°, $[\alpha]_D$ 19.4°.

Anal. Calcd for $C_{24}H_{40}O_3$: C, 76.55; H, 10.71. Found: C, 76.55; H, 10.66.

20α,21-Isopropylidenedioxy-5β-pregnan-3α-ol Acetate (3a).—Acetylation of 20α,21-isopropylidenedioxy-5β-pregnan-3α-ol with acetic anhydride–pyridine and crystallization of the product from methanol gave needles: mp 112–114°; $[\alpha]_{365}$ 110°, $[\alpha]_D$ 39.5°.

Anal. Calcd for $C_{26}H_{42}O_4$: C, 74.60; H, 10.13. Found: C, 74.62; H, 10.13.

5β-Pregnane-3α,20α,21-triol 3-Acetate (4a) from 3a.—A solution of 20α,21-isopropylidenedioxy-5β-pregnan-3α-ol acetate (60 mg) stood in 60% acetic acid (25 ml) for 4 hr at room temperature. The product crystallized from acetone as plates in a yield of 51 mg (95%): mp 166.5–167.5°; $[\alpha]_{365}$ 145°, $[\alpha]_D$ 50.7°; ν_{max} 1735, 1240, and 1027 cm^{-1} (3α-acetoxyl).

Anal. Calcd for $C_{23}H_{38}O_4$: C, 72.97; H, 10.12; CH_3CO, 11.37. Found: C, 72.95; H, 10.10; CH_3CO, 11.13.

20β,21-Isopropylidenedioxy-5β-pregnan-3α-ol (2b) from 1b.—Treatment of 5β-pregnane-3α,20β,21-triol (28 mg) in acetone (25 ml) with *p*-TSA (10 mg) provided 24.5 mg (78%) of hairy needles from acetone: mp 163–163.5°; $[\alpha]_{365}$ 111°, $[\alpha]_D$ 37.7°.

Anal. Calcd for $C_{24}H_{40}O_3$: C, 76.55; H, 10.71. Found: C, 76.42; H, 10.70.

20β,21-Isopropylidenedioxy-5β-pregnan-3α-ol Acetate (3b) from 2b.—The acetylation product of 20β,21-isopropylidenedioxy-5β-pregnan-3α-ol crystallized from methanol as platelets: mp 147–148°; $[\alpha]_{365}$ 169°, $[\alpha]_D$ 57.6°.

Anal. Calcd for $C_{26}H_{42}O_4$: C, 74.60; H, 10.11. Found: C, 74.80; H, 10.11.

5β-Pregnane-3α,20β,21-triol 3-Acetate (4b) from 3b.—Hydrolysis of 20β,21-isopropylidenedoxy-5β-pregnan-3α-ol acetate (20 mg) in 60% acetic acid (13 ml) for 4 hr at room temperature gave 17.5 mg (97%) of prismatic needles from methanol: mp 117–118.5°; $[\alpha]_{365}$ 143°, $[\alpha]_D$ 50.6°; ν_{max} 1735, 1240, and 1025 cm^{-1} (3α-acetoxyl).

Anal. Calcd for $C_{23}H_{38}O_4$: C, 72.97; H, 10.12; CH_3CO, 11.37. Found: C, 72.99; H, 9.98, CH_3CO, 11.59.

20α,21-Isopropylidenedioxy-5β-pregnane-3α,17-diol (6a) from 5a.—Treatment of 5β-pregnane-3α,17,20α,21-tetrol[5] (500 mg) in acetone (1 l.) with *p*-TSA (125 mg) for 30 min and crystallization of the product from acetone afforded prisms (529 mg, 95%): mp 214–214.5°; $[\alpha]_{365}$ −32.5°, $[\alpha]_D$ −9.7°.

Anal. Calcd for $C_{24}H_{40}O_4$: C, 73.43; H, 10.27. Found: C, 73.50; H, 10.40.

20α,21-Isopropylidenedioxy-5β-pregnane-3α,17-diol 3-Acetate (7a).—The acetylation product of 20α,21-isopropylidenedioxy-5β-pregnane-3α,17-diol crystallized from methanol as plates: mp 182.5–183.5°; $[\alpha]_{365}$ 32.0°, $[\alpha]_D$ 10.7°.

Anal. Calcd for $C_{26}H_{42}O_5$: C, 71.85; H, 9.74. Found: C, 72.02; H, 9.80.

5β-Pregnane-3α,17,20α,21-tetrol 3-Acetate (8a) from 7a.—Hydrolysis of 20α,21-isopropylidenedioxy-5β-pregnane-3α,17-diol 3-acetate (587 mg) in 60% acetic acid (250 ml) was carried out for 18 hr at room temperature. The product crystallized from acetone as leaflets (514 mg, 96.5%): mp 169.5–170.5°; $[\alpha]_{365}$ 80.4°, $[\alpha]_D$ 27.7°.

Anal. Calcd for $C_{23}H_{38}O_5$: C, 70.01; H, 9.71; CH_3CO, 10.91. Found: C, 70.24; H, 9.78; CH_3CO, 10.38.

20β,21-Isopropylidenedioxy-5β-pregnane-3α,17-diol (6b) from 5b.—Acetonation of 5β-pregnane-3α,17,20β,21-tetrol[5] (200 mg) by the standard procedure for 30 min furnished 206 mg (92.4%) of prismatic needles from acetone: mp 210.5°; $[\alpha]_{365}$ 68.5°, $[\alpha]_D$ 25.5°.

Anal. Calcd for $C_{24}H_{40}O_4$: C, 73.43; H, 10.27. Found: C, 73.63; H, 10.20.

20β,21-Isopropylidenedioxy-5β-pregnane-3α,17-diol 3-Acetate (7b).—Acetylation of 20β,21-isopropylidenedioxy-5β-pregnane-3α,17-diol afforded the acetonide acetate as fine needles from *n*-hexane: mp 120–120.5°; $[\alpha]_{365}$ 133°, $[\alpha]_D$ 47.0°.

Anal. Calcd for $C_{26}H_{42}O_5$: C, 71.85; H, 9.74. Found: C, 72.05; H, 9.88.

5β-Pregnane-3α,17,20β,21-tetrol 3-Acetate (8b) from 7b.—Hydrolysis of 20β,21-isopropylidenedioxy-5β-pregnane-3α,17-diol 3-acetate (30 mg) in 60% acetic acid (5 ml) for 5.5 hr at room temperature gave 25.5 mg (93%) of an amorphous product ($[\alpha]_{365}$ 102°, $[\alpha]_D$ 36°) which had an ir spectrum identical with that of the sodium borohydride reduction product of 3α-acetoxy-17,21-dihydroxy-5β-pregnan-20-one.[5]

17,20α-Isopropylidenedioxy-5β-pregnan-3α-ol (11a) from 10a.—Treatment of 5β-pregnane-3α,17,20α-triol (200 mg) in acetone (100 ml) with *p*-TSA (50 mg) for 17.5 hr at room temperature followed by purification on a silica gel column provided the acetonide as needles from acetone–*n*-hexane (224 mg, 90.5%): mp 148–149°; $[\alpha]_{365}$ −82.1°, $[\alpha]_D$ −27.5°.

Anal. Calcd for $C_{24}H_{40}O_3$: C, 76.55; H, 10.71. Found: C, 76.41; H, 10.66.

17,20α-Isopropylidenedioxy-5β-pregnan-3α-ol Acetate (12a) from 10a.—Treatment of 17,20α-isopropylidenedioxy-5β-pregnan-3α-ol with acetic anhydride–pyridine gave the acetonide acetate as needles from aqueous ethanol: mp 105–106.5°; $[\alpha]_{365}$ −7.58°, $[\alpha]_D$ −2.23°.

Anal. Calcd for $C_{26}H_{42}O_4$: C, 74.60; H, 10.11. Found: C, 74.20; H, 10.18.

5β-Pregnane-3α,17,20α-triol 3-Acetate (13a) from 12a.—Hydrolysis of 17,20α-isopropylidenedioxy-5β-pregnan-3α-ol (100 mg) in 60% acetic acid (50 ml) for 24 hr at room temperature provided needles from acetone–*n*-hexane (76 mg, 85%): mp 140°; $[\alpha]_{365}$ 60.7°, $[\alpha]_D$ 19.6°. The ir spectrum was indistinguishable from that of the minor sodium borohydride reduction product of 3α-acetoxy-17-hydroxy-5β-pregnan-20-one.[5]

17,20β-Isopropylidenedioxy-5β-pregnan-3α-ol (11b) from 10b.—Acetonation of 5β-pregnane-3α,17,20β-triol (200 mg) in the manner described for the preparation of **11a** from **10a** gave 236 mg (95%) of needles from *n*-hexane: mp 91–94° and 138–139°; $[\alpha]_{365}$ −14.4°, $[\alpha]_D$ −2.80°.

Anal. Calcd for $C_{24}H_{40}O_3$: C, 76.55; H, 10.71. Found: C, 76.50; H, 10.75.

17,20β-Isopropylidenedioxy-5β-pregnan-3α-ol Acetate (12b).—Acetylation of 17,20β-isopropylidenedioxy-5β-pregnan-3α-ol was carried out in the usual fashion. The product crystallized from methanol as needles: mp 150–151°; $[\alpha]_{365}$ 49.5°, $[\alpha]_D$ 18.5°.

Anal. Calcd for $C_{26}H_{42}O_4$: C, 74.60; H, 10.11. Found: C, 74.88; H, 10.05.

5β-Pregnane-3α,17,20β-triol 3-Acetate (13b) from 12b.—A solution of 17,20β-isopropylidenedioxy-5β-pregnan-3α-ol acetate (100 mg) in 80% acetic acid (40 ml) was refluxed for 30 min. Crystallization of the product from methanol gave needles (91 mg, 78%), mp 142–143°, which possessed an ir spectrum identical with that of the major sodium borohydride reduction product of 3α-acetoxy-17-hydroxy-5β-pregnan-20-one.[5]

3α-Acetoxy-5β-androstan-17-one (9) from 8a, 8b, 13a, and 13b.—To a solution of the 3-acetates (10 mg each) in ethanol (0.8 ml) was added periodic acid (10 mg) in water (0.2 ml). After 16 hr at room temperature, the products were recovered by extraction with methylene chloride. All four substrates afforded a common product (**9**) as confirmed by ir analysis.

Separation of the Pregnanetriol Acetonide Acetates 12a and 12b by Differential Hydrolysis.—A mixture of the 20α- and 20β-

(10) M. L. Lewbart and J. J. Schneider, *J. Org. Chem.*, **29**, 2559 (1964).

pregnanetriols **10a** and **10b** wss prepared by lithium aluminum hydride reduction of 3α,17-dihydroxy-5β-pregnan-20-one (2 g). After treatment in acetone (500 ml) with *p*-TSA (250 mg) for 24 hr at room temperature, the crude material was recovered and acetylated in the usual manner. The mixture of acetonide acetates (**12a** and **12b**) was dissolved in 80% acetic acid (500 ml). After 22 hr at room temperature the solvent was removed and the residue was chromatographed on a silica gel column in ethyl acetate–isooctane (1:1), affording the somewhat impure 20β-acetonide acetate **12b** (mp 141–143°) in a yield of 818 mg (32.6%) and the 20α-triol 3-acetate **12a** in a yield of 1106 mg (48.9%), mp 139.5°.

17,20α-Isopropylidenedioxy-21-bromo-5β-pregnan-3α-ol (15a) from 14a.—To a solution of 21-bromo-5β-pregnane-3α,17,20α-triol (300 mg) in acetone (120 ml) was added 70% perchloric acid (0.3 ml). After 1.5 hr at room temperature the product was recovered and purified on a 25 × 830 mm silica gel column in ethyl acetate–isooctane (1:1). Fractions (6 ml) were collected at 10-min intervals. From **fractions 47–80** were obtained hairy needles from aqueous acetone in a yield of 291 mg (88.4%), mp 173–174.5°. Recrystallization from acetone–*n*-hexane gave the analytical sample: mp 177–178°; $[\alpha]_{365}$ −145°, $[\alpha]_D$ −47.1°.

Anal. Calcd for $C_{24}H_{39}O_3Br$: C, 63.28; H, 8.63; Br, 17.54. Found: C, 63.32; H, 8.39; Br, 17.38.

Treatment of **15a** with acetic anhydride–pyridine and precipitation of the product from methanol solution with water gave **17,20α-isopropylidenedioxy-21-bromo-5β-pregnan-3α-ol acetate** as a white solid: mp 79–82°; $[\alpha]_{365}$ −71.0°, $[\alpha]_D$ −23.6°.

Anal. Calcd for $C_{26}H_{41}O_4Br$: C, 62.77; H, 8.31. Found: C, 62.84; H, 8.27.

17,20β-Isopropylidenedioxy-21-bromo-5β-pregnan-3α-ol (15b) from 14b.—Conversion of 21-bromo-5β-pregnane-3α,17,20β-triol (2 g) into the 17,20-acetonide was carried out with perchloric acid–acetone (2 ml/800 ml) for 90 min at room temperature. Successive crystallization of the product from aqueous methanol and methylene chloride–*n*-hexane supplied 2.01 g (91.8%) of needles, mp 148–149°. Data for the analytical sample follow: mp 152–152.5°; $[\alpha]_{365}$ 69.2°, $[\alpha]_D$ 26.3°.

Anal. Calcd for $C_{24}H_{39}O_3Br$: C, 63.28; H, 8.63; Br, 17.54. Found: C, 63.01; H, 8.60; Br, 17.36.

Acetylation of **15b** provided **17,20β-isopropylidenedioxy-21-bromo-5β-pregnan-3α-ol acetate** as a white solid from aqueous methanol: mp 76–78°; $[\alpha]_{365}$ −92.9°, $[\alpha]_D$ −34.0°.

Anal. Calcd for $C_{26}H_{41}O_4Br \cdot {}^1/_2H_2O$: C, 61.64; H, 8.36. Found: C, 61.30; H, 8.36.

17,20α-Isopropylidenedioxy-5β-pregnan-3α-ol (11a) from 15a.—A solution of 17,20α-isopropylidenedioxy-21-bromo-5β-pregnan-3α-ol (100 mg) and lithium aluminum hydride (200 mg) in ether (55 ml) was refluxed for 6 hr. After standing overnight at room temperature, the mixture was processed in the usual manner except for omission of the acid wash. The crude material (78 mg) was chromatographed on a 15 × 670 mm silica gel column in toluene–ethyl acetate (4:1). Fractions (2 ml) were collected every 15 min. After the emergence of fraction 180 the system was changed to toluene–ethyl acetate (3:2). From **fractions 66–106** was obtained 16.2 mg of starting material, mp 177–178.5°, as was shown by mixture melting point and ir comparisons.

17,20α-Isopropylidenedioxy-5β-pregnan-3α-ol (11a). Fractions 118–180.—The pooled material (15.5 mg) crystallized from acetone–*n*-hexane as needles, mp 177–178.5°. Its identity with the acetonation product of the 20α-triol **10a** was proven by ir analysis.

A succeeding fraction (tubes 251–291) weighed 8.3 mg. Analysis by ir spectroscopy and tlc showed it to be a mixture of 5β-pregn-20-ene-3α,17-diol (see below) and an unknown acetonide.

17,20β-Isopropylidenedioxy-5β-pregnan-3α-ol (11b) and 17,20β-isopropylidenedioxy-5β-pregnane-3α,21-diol (16) from 15b.—Treatment of 17,20β-isopropylidenedioxy-21-bromo-5β-pregnan-3α-ol (100 mg) with lithium aluminum hydride in ether and chromatography of the reaction mixture (81 mg) on a 15 × 620 mm silica gel column was carried out exactly as that to obtain **15a**. From **fractions 56–83** was obtained 4 mg of starting material.

17,20β-Isopropylidenedioxy-5β-pregnan-3α-ol. Fractions 88–181.—The residue (35.2 mg) crystallized from *n*-hexane as needles, mp 95–97.5° and 138.5–139.5°. Its ir spectrum was superimposable with that of the acetonation product of the 20β-triol **10b**.

A small intermediate fraction (7.6 mg) from tubes 228–273 crystallized from acetone as prisms, mp 178–181°. Its ir spectrum was identical with that of 5β-pregn-20-ene-3α,17-diol (see below).

17,20β-Isopropylidenedioxy-5β-pregnane-3α,21-diol. Fractions 295–361.—Crystallization of the residue (17.6 mg) from acetone–*n*-hexane gave needles, mp 178–178.5°. A mixture melting point with the reference compound[5] was 177.5–178.5° and their ir spectra were identical.

Reaction of 17,20α-Isopropylidenedioxy-21-bromo-5β-pregnan-3α-ol (15a) with Sodium in *n*-Propyl Alcohol.—To a solution of the 20α-bromoacetonide (100 mg) in *n*-propyl alcohol (25 ml) was added metallic sodium (2 g) in small pieces. After 10 min of spontaneous and 20 min of induced refluxing, ethyl acetate (25 ml) and water (25 ml) were cautiously added. The solution was diluted with an equal volume of ethyl acetate, washed twice with brine, and concentrated to dryness. The residue was chromatographed on a 16 × 680 mm silica gel column in isooctane–ethyl acetate (3:1). After the emergence of fraction 195 the system was changed to isooctane–ethyl acetate (1:1). A small initial fraction (tubes 35–51), which weighed 3.2 mg, had the same ir spectrum as **5β-pregn-20-ene-3α,17-diol 3-acetate** (see below).

5β-Pregn-17-en-3α-ol (17). Fractions 57–95.—Crystallization of the residue (23.6 mg, 35.5%) from *n*-hexane gave hairy needles, mp 127–128.5°. Data for the analytical sample follow: mp 130°; $[\alpha]_{365}$ 136°, $[\alpha]_D$ 45.0°; ν_{max} 3040, 1670, and 810 (trisubstituted ethylene) and 1040 cm^{-1} (3α-hydroxyl).

Anal. Calcd for $C_{21}H_{34}O$: C, 83.38; H, 11.33; O, 5.29. Found: C, 83.51; H, 10.96; O, 5.55.

A solution of **17** (25 mg) in a mixture of ethanol and cyclohexane was shaken for 1 hr in a hydrogen atmosphere in the presence of 5% palladium on carbon. The product crystallized from ethyl acetate as platelets (20 mg), mp 171–172°. It did not depress the melting point of **5β-pregnan-3α-ol**[4] and their ir spectra were identical.

A benzene solution of **17** (50 mg) was treated with slightly more than 1 equiv of perbenzoic acid for 1 hr at room temperature. The product was recovered and chromatographed on a 13 × 620 mm silica gel column in isooctane–ethyl acetate (3:2), from which 2-ml fractions were collected at 7.5-min intervals. Several crystallizations from ethyl acetate of the residue from **fractions 51–85** afforded platelets, mp 136.5–137.5°, which were identical with **17,20β-oxido-5β-pregnan-3α-ol.**[5]

Treatment of the pregnenol **17** with acetic anhydride–pyridine and crystallization of the product from methanol gave **5β-pregn-17-en-3α-ol acetate** as plates: mp 82.5–83.5°; $[\alpha]_{365}$ 207°, $[\alpha]_D$ 67.7°.

Anal. Calcd for $C_{23}H_{36}O_2$: C, 80.18; H, 10.53. Found: C, 80.14; H, 10.50.

17,20α-Isopropylidenedioxy-5β-pregnan-3α-ol. Fractions 126–186.—The residue weighed 6.4 mg (7.7%), mp 144–145°, and possessed an ir spectrum identical with that of **11a** prepared from **10a**.

5β-Pregn-20-ene-3α,17-diol (20). Fractions 262–351.—Crystallization of the pooled material (27.8 mg, 39.8%) from acetone gave plates: mp 185–187°; $[\alpha]_{365}$ −76.2°, $[\alpha]_D$ −18.8°; ν_{max} 3092, 1640, and 915 (terminal vinyl) and 1040 cm^{-1} (3α-hydroxyl).

Anal. Calcd for $C_{21}H_{34}O_2$: C, 79.19; H, 10.76. Found: C, 78.95; H, 10.73.

Catalytic hydrogenation of **20** (25 mg), as in the preparation of **18** from **17**, gave 21.5 mg of prisms mp 149–150.5°, from methanol, which were identical with **5β-pregnane-3α,17-diol.**[4]

Acetylation of **20** in the usual fashion furnished **5β-pregn-20-ene-3α,17-diol 3-acetate** as prisms from methanol: mp 133–134°; $[\alpha]_{365}$ 12.3°, $[\alpha]_D$ 9.5°.

Anal. Calcd for $C_{23}H_{36}O_3$: C, 76.62; H, 10.07. Found: C, 76.58; H, 10.01.

Reaction of 17,20β-Isopropylidenedioxy-21-bromo-5β-pregnan-3α-ol (15b) with Sodium in *n*-Propyl Alcohol.—The 20β-bromoacetonide (100 mg) was treated under the conditions used for its 20α epimer. The contents of fractions 34–55 weighed 2.7 mg (3.4%) and had an ir spectrum identical with that of **5β-pregn-20-ene-3α,17-diol 3-acetate.**

5β-Pregn-17-en-3α-ol. Fractions 60–100.—The residue (25.6 mg, 38.5%) gave needles from *n*-hexane: mp 129–130°.

17,20β-Isopropylidenedioxy-5β-pregnan-3α-ol (11b). Fractions 121–186.—From the pooled material (9.3 mg, 11.2%) was obtained needles from *n*-hexane: mp 94–97° and 137–138°. The ir spectrum was identical with that of the acetonation product of **10b**.

5β-Pregn-20-ene-3α,17-diol. Fractions 262–347.—The pooled contents (28.7 mg, 41%) crystallized from acetone as plates.

Reaction of 17,20β-Isopropylidenedioxy-21-bromo-5β-pregnan-3α-ol (15b) with Sodium in Aqueous Dioxane.—A solution of the bromoacetonide (1 g) in 60% aqueous dioxane (100 ml) was added dropwise to a refluxing, stirred suspension of sodium (20 g) in dioxane (50 ml) over a 2-hr period. More sodium (10 g) was introduced after approximately one-half the steroid had been added. Excess ethyl acetate and water was cautiously added to the cooled reaction mixture which, after further dilution with ethyl acetate, was washed twice with brine and concentrated to dryness. Since it has been found in earlier experiments that considerable alkali-catalyzed acetylation at C-3 occurs during the work-up, the residue was treated with aqueous methanolic sodium hydroxide. The saponified material was chromatographed on a 32 × 860 mm silica gel column in isooctane–ethyl acetate (3:1). After the emergence of fraction 281 the system was changed to isooctane–ethyl acetate (1:1). Fractions (8 ml) were collected at 10-min intervals.

5β-Pregn-17-en-3α-ol. Fractions 101–176.—Crystallization from aqueous acetone gave 115 mg (22%) of needles, mp 128–130°, whose ir spectrum was indistinguishable from that of the reference compound.

An intermediate fraction (tubes 201–280) weighed 80 mg and was shown by ir analysis to be a mixture of the hydrogenolysis product **11b** and starting material.

5β-Pregn-20-ene-3α,17-diol. Fractions 375–460.—Plates (443 mg, 63.5%) were obtained from acetone: mp 180–182°.

21-Bromo-5β-pregnane-3α,17,20α- and -20β-triols (14a and 14b) from 20 *via* 22a and 22b.—To a solution of the pregnenediol **20** (1.3 g, 4.09 mmol) in methylene chloride (95 ml) was added a benzene solution of perbenzoic acid (828 mg, 6 mmol). After 1 hr at room temperature tlc analysis showed an approximately 1:1 mixture of starting material and product. An equal amount of perbenzoic acid was added and the solution stood for 19 hr at room temperature. The mixture of epoxides was recovered and purified by chromatography on a 35 × 740 mm silica gel column in ethyl acetate–isooctane (2:1); 8-ml fractions were collected every 10 min.

The residue from fractions 181–317 was dissolved in chloroform (25 ml). To this solution was added 1 ml of 30% hydrogen bromide in acetic acid. After 15 min at room temperature the solution was diluted with an equal volume of chloroform, washed with 5% sodium bicarbonate solution and water, and concentrated to dryness. The bromotriol mixture was chromatographed on a 54 × 880 mm Celite column in toluene (50), isooctane (150), methanol (150), and 5% boric acid (50 ml) as described previously.[5] Fractions (12 ml) were collected every 10 min.

21-Bromo-5β-pregnane-3α,17,20β-triol. Fractions 211–321.—Several crystallizations from acetone gave 159 mg of prisms, mp 162.5–164.5°. The mother liquor residue was chromatographed on a 20 × 740 mm silica gel column in ethyl acetate–isooctane (1:1). From this column an additional 126 mg of 20β-bromotriol, mp 163–164°, was obtained. The total yield was 285 mg (16.8%). The ir spectrum was identical with that of the major sodium borohydride reduction product of 21-bromo-3α,17-dihydroxy-5β-pregnan-20-one.[5]

21-Bromo-5β-pregnane-3α,17,20α-triol. Fractions 501–715.—Crystallization from acetone gave a total of 755 mg of prisms, mp 174–175°. Silica gel chromatography of the mother liquor residue (97 mg) as above afforded an additional 14 mg of the 20α-bromotriol, mp 170.5°, raising the yield to 769 mg (45.4%).

17,20α-Isopropylidenedioxy-21-chloro-5β-pregnan-3α-ol.—Acetonation of 21-chloro-3α,17,20α-triol[11] (30 mg) by the general procedure provided 30 mg of needles from aqueous acetone: mp 166–169°; $[\alpha]_{365}$ −129°, $[\alpha]_D$ −43.2°.

Anal. Calcd for $C_{24}H_{39}O_3Cl$: C, 70.13; H, 9.56. Found: C, 70.01; H, 9.60.

17,20β-Isopropylidenedioxy-21-chloro-5β-pregnan-3α-ol.—Acetonation of 21-chloro-5β-pregnane-3α,17,20β-triol[12] (30 mg) gave 31.5 mg of needles from *n*-hexane: mp 168.5–169.5°; $[\alpha]_{365}$ 52.5°, $[\alpha]_D$ 20.6°.

Anal. Calcd for $C_{24}H_{39}O_3Cl$: C, 70.13; H, 9.56. Found: C, 69.95; H, 9.58.

17,20α-Isopropylidenedioxy-21-tosyloxy-5β-pregnan-3α-ol.—Reaction of 21-tosyloxy-5β-pregnane-3α,17,20α-triol[5] (25 mg) with acetone–perchloric acid followed by chromatography on silica gel furnished 17 mg of needles from methanol: mp 172.5–173.5° dec; $[\alpha]_{365}$ −100°, $[\alpha]_D$ −31.2°; ν_{max} 1597, 1491, 1363, 1188, 1173, 1091, 809, and 660 cm^{-1} (tosylate).[5]

Anal. Calcd for $C_{31}H_{46}O_6S$: C, 68.10; H, 8.48. Found: C, 68.21; H, 8.47.

17,20β-Isopropylidenedioxy-21-tosyloxy-5β-pregnan-3α-ol.—Acetonation of 21-tosyloxy-5β-pregnane-3α,17,20β-triol[5] (25 mg) gave 29 mg of an amorphous product which was obtained as a filterable solid from aqueous methanol: mp 84–86°; $[\alpha]_{365}$ −97.2°, $[\alpha]_D$ −36.1°; ν_{max} 1595, 1492, 1364, 1188, 1175, 1091, 810, and 661 cm^{-1} (tosylate).

Anal. Calcd for $C_{31}H_{46}O_6S$: C, 68.10; H, 8.48. Found: C, 67.87; H, 8.47.

Registry No.—**2a**, 21371-77-7; **2b**, 21337-69-9; **3a**, 21337-70-2; **4a**, 21338-06-7; **4b**, 21338-07-8; **6a**, 21337-74-6; **6b**, 21337-75-7; **7a**, 21337-76-8; **7b**, 21337-77-9; **8a**, 21338-08-9; **8b**, 16109-54-9; **10b**, 1165-28-2; **11a**, 21337-89-3; **11b**, 21337-90-6; **12a**, 21337-91-7; **12b**, 21337-92-8; **13a**, 16062-27-4; **13b**, 16062-26-3; **15a**, 21338-02-3; **15a** (acetate), 21338-04-5; **15b**, 21338-03-4; **15b** (acetate), 21338-05-6; **16**, 16109-63-0; **17**, 21338-13-6; **17** (acetate), 21338-14-7; **20**, 21338-15-8; **20** (acetate), 21338-16-9; 21-chloro-3α,11,20α-triol, 21333-91-5; 21-chloro-5β-pregnane-3α,-17,20β-triol, 21333-92-6.

(11) Unpublished synthesis by addition of hydrogen chloride to 20α,21-oxido-5β-pregnane-3α,17-diol[5] gave prisms from acetone: mp 195–196.5°; $[\alpha]_{365}$ 5.26°, $[\alpha]_D$ 2.63°. *Anal.* Calcd for $C_{21}H_{35}O_3Cl$: C, 67.99; H, 9.51. Found: C, 67.96; H, 9.46.

(12) Addition of hydrogen chloride to 20β,21-oxido-5β-pregnane-3α,17-diol[5] gave this compound as plates from ether: mp 174.5–175°; $[\alpha]_{365}$ 118°, $[\alpha]_D$ 43.4°. *Anal.* Calcd for $C_{21}H_{35}O_3Cl$: C, 67.99; H, 9.51. Found: C, 67.76; H, 9.49.