phthalate, the isolation of phthalans from the hydrogenolysis products of the esters of the coal acids cannot be regarded as unequivocal evidence for the presence of such heterocycles as nuclei of the coal acids.

Acknowledgment.—We wish to thank Messrs. D. T. Muth, T. R. Savich and J. B. Simsic for their assistance.

Experimental

Hydrogenolyses.—One kg. (7.26 equivalents) of dibutyl phthalate (No. D-30, Fisher Scientific Company), 100 g. of a copper-chromium oxide catalyst prepared as described previously,[4] and 125 atm. of hydrogen were charged to a stainless steel rocking autoclave and heated to 270° for six hours. After cooling, the bomb contents were filtered free of catalyst through a layer of Sil-O-Cel on a medium porosity fritted filter funnel. The catalyst and filter aid were extracted exhaustively in a soxhlet extractor with ether to remove adsorbed products, the ether was evaporated and the extract was combined with the main filtrate. The combined filtrate was then fractionated in a column of 30 theoretical plates until the still temperature reached 270°. The amount of ester present was determined by saponification of 1 g. of the still contents. The still contents were then subjected to the next stage of hydrogenolysis carried out in the same manner. Products from all four stages with the same boiling range were combined and refractionated in columns of 50 theoretical plates.

n-**Butyraldehyde.**—The combined fractions boiling up to 100° contained mainly butanol and *o*-xylene which had formed a ternary azeotrope with the readily separable water. *n*-Butyraldehyde, 0.5 g., b.p. 74° (740 mm.), was isolated and identified as its 2,4-dinitrophenylhydrazone, m.p. and mixture m.p. 122°.

o-**Xylene and Butanol.**—The fraction boiling 100–120° was a mixture of butanol and *o*-xylene which form a binary azeotrope[5]; no dimethylcyclohexanes were found. The *o*-xylene was freed of butanol by alternate distillation and washing with 10 volumes of water. The fractions boiling 120–144° consisted almost entirely of *o*-xylene with traces of dibutyl ether which boils close to the *o*-xylene and forms an azeotrope with it[5]; the dibutyl ether was readily removed by adsorption on silica gel. The total amount of *o*-xylene present in all fractions as determined by quantitative ultraviolet absorption spectra was 306 g. or a yield of 80.5%; the yield of butanol was not determined.

n-**Butyl** *n*-**Butyrate.**—The fraction boiling 144–170° contained 3 g. of *n*-butyl *n*-butyrate, b.p. 166° (740 mm.), n^{25}D 1.4052, sapn. equiv., 149. The infrared spectrum was identical with that of an authentic sample. The butyric acid was recovered from the saponification and converted to the *p*-phenyl phenacyl ester, m.p. and mixture m.p. 83°.

Hexahydrophthalan.—Redistillation of the fraction boiling 170–190° gave 7 g. of hexahydrophthalan, b.p. 179° (740 mm.), n^{25}D 1.4652, which readily forms an adduct with stannic chloride in pentane.

Anal. Calcd. for $C_8H_{14}O$: C, 76.14; H, 11.18; *MR*, 36.40. Found: C, 75.87; H, 11.21; *MR*, 36.10.

These data and the infrared spectra correspond closely with those recently published for authentic material.[6]

Phthalan and 2-Methylcyclohexanemethanol.—When the hexahydrophthalan was removed from the fraction boiling 170–190° there still remained a mixture of 8 g. of phthalan and 3 g. of 2-methylcyclohexanemethanol quantitatively characterized by comparison with refractive indices and the infrared spectra of authentic material.[6] The phthalan readily formed an adduct with stannic chloride, possessed the characteristic strong benzaldehyde odor, and on heating in air polymerized to a non-volatile red resin[6] from which the 2-methylcyclohexanemethanol was readily separated by distillation, b.p. 194°, n^{25}D 1.4615.

Anal. Calcd. for $C_8H_{16}O$: C, 74.94; H, 12.58; *MR*, 38.26. Found: C, 74.75; H, 12.52; *MR*, 38.49.

Residue.—The 20 g. of black viscous residue contained 0.08 equivalent of esters and 1.1 wt. % hydroxyl groups determined by saponification and acetylation, respectively, but was not investigated further.

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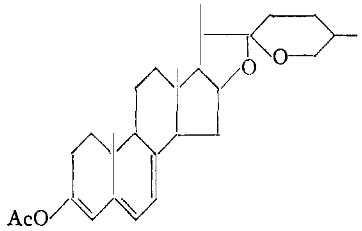
Steroidal Sapogenins. XIX.[1] Sodium Borohydride Reduction of 3-Acetoxy-$\Delta^{3,5,7}$-22-isospirostatriene and 3-Acetoxy-$\Delta^{3,5,7,9(11)}$-22-isospirostatetraene

BY HOWARD J. RINGOLD, G. ROSENKRANZ AND CARL DJERASSI[2]

RECEIVED DECEMBER 17, 1951

Three independent reports[3–5] have appeared recently on the sodium borohydride reduction of 3-acetoxy-$\Delta^{3,5}$-cholestadiene (Δ^4-cholesten-3-one enol acetate) to cholesterol in 60–75% yield. Since $\Delta^{5,7}$-3β-hydroxy steroids represent the starting materials for the introduction of a C-11 oxygen function into ring C unsubstituted steroids,[6] it seemed pertinent to investigate the applicability of the sodium borohydride reduction to the preparation of such dienes. In fact, Dauben, Eastham and Micheli[7] in a recent preliminary communication reported the formation of 70% of 7-dehydrocholesterol from 3-acetoxy-$\Delta^{3,5,7}$-cholestatriene by such a method. We have independently[8] investigated this procedure in the sapogenin series, where a two-step degradation[9] leads directly to the pregnane series, and would like to record briefly our results.



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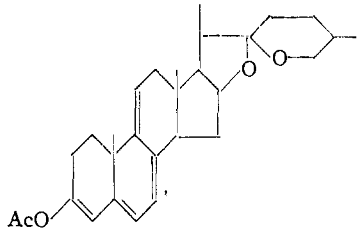

II

3-Acetoxy-$\Delta^{3,5,7}$-22-isospirostatriene[10] (I) be-

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(8) Mexican patent application No. 31855 (August 3, 1951).

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haved exactly like the cholestatriene analog[7] upon reduction with sodium borohydride. Thus at low temperature, the yield of pure $\Delta^{5,7}$-22-isospirostadien-3β-ol was *ca.* 70%, while at 80° the product was contaminated with an impurity absorbing at 242 mμ, most likely the $\Delta^{4,6}$-dien-3-ol. As shown by both Gallagher[4] and Dauben[5] the initial reaction appears to be hydrolysis of the enol acetate to the unconjugated ketone, which undergoes rapid reduction by the reagent to yield the unconjugated alcohol. Apparently, at higher temperature some isomerization of the unconjugated ketone to the $\Delta^{4,6}$-3-one occurs prior to reduction thus accounting for the formation of some of the $\Delta^{4,6}$-dien-3-ol. In this connection, it is of interest to note that the sodium borohydride reduction of 3-acetoxy-$\Delta^{3,5,7,9(11)}$-22-isospirostatetraene[10] (II) afforded $\Delta^{5,7,9(11)}$-22-isospirostatrien-3β-ol in essentially the same yield whether the reaction was carried out at 10° or at 80°. Evidently because of the longer conjugated triene system, the isomerization of the initially formed *un*conjugated ketone to the conjugated form is sufficiently slower so that reduction of the ketone predominates.

Experimental[11]

Sodium Borohydride Reduction of 3-Acetoxy-$\Delta^{3,5,7}$-22-isospirostatriene (I).—An ice-cold mixture of 1.0 g. of 3-acetoxy-$\Delta^{3,5,7}$-22-isospirostatriene (I)[10] in 40 cc. of dioxane and 60 cc. of methanol was added in one portion to a solution of 1.6 g. of sodium borohydride in 40 cc. of methanol and 3 cc. of water. After standing at 10° for 16 hours, the mixture was warmed for 30 minutes on the steam-bath, diluted with water and the solid was collected; yield 0.94 g., $\lambda_{\max}^{\mathrm{EtOH}}$ 270, 282 and 292 mμ, log ϵ 4.07, 4.09, 3.86. Two recrystallizations from ethyl acetate furnished 0.55 g. (60%) of **$\Delta^{5,7}$-22-isospirostadien-3β-ol** with m.p. 187–190°, $[\alpha]^{20}\mathrm{D}$ $-177°$, $\lambda_{\max}^{\mathrm{EtOH}}$ 270, 280 and 292 mμ, log ϵ 4.17, 4.19, 3.99, infrared spectrum identical with that of an authentic specimen[12] (reported: m.p. 188.5–190°, $[\alpha]^{20}\mathrm{D}$ $-174°$). Acetylation of the crystalline mother liquors afforded an additional 10–13% of **$\Delta^{5,7}$-22-isospirostadien-3β-ol acetate** with m.p. 201–203°, $[\alpha]^{20}\mathrm{D}$ $-122°$, the identity of which was confirmed by comparison of its infrared spectrum with that of an authentic sample[12] (reported: m.p. 202–205°, $[\alpha]^{20}\mathrm{D}$ $-127°$).

On carrying out the reaction as above but refluxing for 2 hours, the crude product (85% yield) exhibited m.p. 160–170°, $[\alpha]^{20}\mathrm{D}$ $-99°$, $\lambda_{\max}^{\mathrm{EtOH}}$ 242, 270, 280 and 292 mμ, log ϵ 3.52, 3.87, 3.89, 3.67.

Sodium Borohydride Reduction of 3-Acetoxy-$\Delta^{3,5,7,9(11)}$-22-isospirostatetraene (II).—One gram of the tetraene II[10] upon treatment with sodium borohydride as described above (10°) produced 0.635 g. (69%) of **$\Delta^{5,7,9(11)}$-22-isospirostatrien-3β-ol** with m.p. 187–190°, $[\alpha]^{20}\mathrm{D}$ $+121°$, $\lambda_{\max}^{\mathrm{EtOH}}$ 324 mμ, log ϵ 4.14 and inflections at 312 mμ (log ϵ 4.10) and 338 mμ (log ϵ 4.00); lit.,[13] m.p. 187–190°, $[\alpha]^{20}\mathrm{D}$ $+119°$, same ultraviolet absorption spectrum. **The acetate** showed m.p. 178–179°, $[\alpha]^{20}\mathrm{D}$ $+173°$ (reported[13]: m.p. 178–179°, $[\alpha]^{20}\mathrm{D}$ $+170°$). The infrared spectra of both compounds were identical with those of authentic[13] derivatives.

In this instance, the reduction could be carried out at 80° without any diminution in yield, which in addition to a shorter reaction time had the advantage that it was possible to work in more concentrated solution. Thus, when 0.8 g. of the tetraene II was refluxed for two hours with 1.6 g. of sodium borohydride in 30 cc. each of dioxane and ethanol containing 3 cc. of water, precipitation with water afforded 0.71 g. (97%) of crude $\Delta^{5,7,9(11)}$-trien-3β-ol with m.p. 173–178°, $[\alpha]^{20}\mathrm{D}$ $+113°$, $\lambda_{\max}^{\mathrm{EtOH}}$ 324 mμ, log ϵ 4.11. One recrystallization from methanol led to 0.5 g. (68%) of the pure trienol.

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[11] Melting points are uncorrected and were determined in a sulfuric acid bath. Rotations and infrared spectra were measured in chloroform and ultraviolet absorption spectra in 95% ethanol solution. We are grateful to Srta. Paquita Revaque and staff for these measurements. Thanks are due to Srta. Margarita Espinosa for technical assistance.

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Fatty Acid Amides. V.[1] Preparation of N-(2-Acetoxyethyl)-amides of Aliphatic Acids

BY EDWARD T. ROE, THOMAS D. MILES AND DANIEL SWERN

RECEIVED FEBRUARY 22, 1952

In a continuation of our studies on amides of fatty acids, we became interested in N-(2-acetoxyethyl)-amides. The only compound in this class previously described is N-(2-acetoxyethyl)-acetamide, prepared by treating ethanolamine with acetic anhydride[2] or with ketene.[3] When we attempted to prepare it by a slight modification of the former method we obtained diacetamide.

N-(2-Hydroxyethyl)-amides were acetylated (97–99%) by heating with a 100% excess of acetic anhydride for six hours. During the initial stages the temperature rose exothermically to 85–95° after which it was readily controlled at 75°. Careful control to prevent temperatures above 75° resulted in incomplete acetylation. Reactions carried out at 100° for three hours gave lower yields and undesirable side products.

Experimental

Starting Materials.—The N-(2-hydroxyethyl)-amides were prepared from pure fatty acids by refluxing 1 mole of the acid with 1.5 moles of ethanolamine for two to six hours.[4] N-(2-Hydroxyethyl)-acetamide, b.p. 145–146.7 (2.5 mm.) and $n^{25}\mathrm{D}$ 1.4709, was distilled through a 3-foot Vigreux column. N-(2-Hydroxyethyl)-caproamide was freed of excess ethanolamine by vacuum distillation and then crystallized from ethyl ether, 4 ml./g., at 0° until pure. N-(2-Hydroxyethyl)-lauramide, m.p. 88.0–88.5°, -palmitamide, m.p. 98°, and -stearamide, m.p. 102°, were crystallized directly from the crude reaction mixtures using 95% ethanol, 4 ml./g., at 0°, 10 ml./g. at 0°, and 8 ml./g. at 25°, respectively. N-(2-Hydroxyethyl)-oleamide has already been described.[4]

Preparation of N-(2-Acetoxyethyl)-amides.—These amides were prepared by heating one mole of the N-(2-hydroxyethyl)-amide with two moles of acetic anhydride for six hours in a nitrogen atmosphere. During the initial stages the temperature rose exothermically to 85–95° after which it was readily controlled at 75°.

After the acetylation of N-(2-hydroxyethyl)-acetamide, the reaction mixture was distilled at 100 mm. to remove excess acetic anhydride and acetic acid formed. The pressure was then lowered to 5 mm. and the N-(2-acetoxyethyl)-acetamide was distilled. The acetic anhydride and acetic acid were removed similarly from the N-(2-acetoxyethyl)-caproamide reaction mixture, but in this case the crude amide remaining was crystallized five times from a mixture of equal portions of ether and petroleum naphtha, 3 ml./g. at $-20°$.

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