78% yield; lit.[4b] m.p. 267–268.5°; 64% yield (based on material melting at 265–267°).

Bis-ethylene Ketal of Cortisone (Δ^5-Pregnene-17α,21-diol-3,11,20-trione 3,20-Bis-ethylene Ketal) (IIIa).—Chromic anhydride (150 mg.) was added to chilled pyridine (15 ml.), and the mixture was allowed to warm to room temperature. A solution of II (250 mg.) in pyridine (20 ml.) was added, and the mixture was allowed to stand at room temperature for 20 hours. It was poured into 50 ml. of water containing 0.7 g. of sodium bicarbonate. The mixture was steam-distilled for about 0.5 hour, and the product was extracted with ethyl acetate. The extract was washed with water, dried and evaporated under reduced pressure. This afforded 220 mg. (89% yield) of slightly impure IIIa, m.p. 230–237°, with previous softening. Recrystallization from acetone–petroleum ether (b.p. 64–66°) gave 80 mg., m.p. 241–245°. An additional 116 mg., m.p. 238–241°, was obtained from the mother liquor. Infrared analysis showed identity with an authentic sample of the bis-ethylene ketal of cortisone.

In another run the crude bis-ketal was exhaustively recrystallized from acetone–petroleum ether (Skellysolve B), and acetone. This gave pure IIIa; m.p. 245.5–248.5°, $[\alpha]^{24}D$ −8° (20.5 mg., chloroform, αD −0.085°). Infrared analysis showed complete identity with an authentic sample; lit.[4b] m.p. 234–238.5°, $[\alpha]^{26}D$ −8° (chloroform).

Anal.[20] Calcd. for $C_{25}H_{36}O_7$ (448.54): C, 66.94; H, 8.04. Found: C, 66.92; H, 7.77.

Bis-ethylene Ketal of Cortisone Acetate (Δ^5-Pregnene-17α,21-diol-3,11,20-trione 21-acetate 3,20-Bis-ethylene Ketal) (IIIb).—The free steroid (IIIa) (m.p. 245.5–248.5°) was acetylated in the usual manner; m.p. 226.5–228.5°; $[\alpha]^{24}D$ ±0° (21.6 mg., chloroform, αD −0.03°). Its infrared spectrum was identical with that of an authentic sample; lit.[4b] m.p. 226.5–228°; $[\alpha]^{31}D$ ±0° (chloroform).

Reduction of the Bis-ethylene Ketal IIIa of Cortisone with Sodium Borohydride.[21]—A mixture of 1.05 g. (0.0023 *M*) of IIIa, 1.25 g. (0.033 mole) sodium borohydride, 40 ml. of tetrahydrofuran, 3.5 ml. of 5% sodium hydroxide solution and 3.5 ml. of water was refluxed for 20 hours. With additional water, the mixture was refluxed for 0.5 hour more. The tetrahydrofuran was removed under reduced pressure, and the residual mixture was extracted with ethyl acetate. Evaporation under reduced pressure gave a glass which was dissolved in ether. Concentration gave a white powder; 653 mg., m.p. 186–215°. The mother liquor on evaporation afforded about 380 mg. of a glass.

Both fractions were combined, and acetylated at room temperature with 3 ml. of acetic anhydride and 5 ml. of pyridine. In this manner there was obtained 979 mg. of the acetate-bis-ketal IVb, m.p. 197–199°, 85% yield from cortisone bis-ketal (IIIa). Its infrared absorption spectrum was identical with that of an authentic sample.

Melting Point Determination of the Bis-ethylene Ketal IVa of Hydrocortisone.—Cortisone bis-ketal (IIIa) was reduced with sodium borohydride in the manner described above. In this run the product was extracted with chloroform. Evaporation gave a glass which on crystallization from acetone–petroleum ether afforded IVa, m.p. 186–210°. A portion of this material was recrystallized from methanol–ether, m.p. 211–214° with previous melt at 140–141°, and resolidification.

The remainder of IVa was acetylated. Recrystallization of the crude product from acetone–ether gave pure IVb, m.p. 207–209°; $[\alpha]^{25}D$ −27.1° (αD −0.33°, 24.36 mg., chloroform); lit.[5] m.p. 199–201°, $[\alpha]^{27}D$ −26° (chloroform).

A sample of the pure acetate IVb was saponified with 2% alcoholic potassium hydroxide, and the free steroid bis-ketal IVa was recrystallized once from acetone–ether, m.p. 170–200°.

In another hydrolysis, the free steroid bis-ketal IVa was recrystallized from acetone–petroleum ether, m.p. 181–183°.

Conversion of the Bis-ethylene Ketal IVa of Cortisone to Hydrocortisone (V).—A mixture of 1 g. (0.0022 mole) of cortisone bis-ketal (IIIa, m.p. 244–247°), 40 ml. of tetrahydrofuran, 0.50 g. (0.013 mole) of sodium borohydride, 3.5 ml. of 5% sodium hydroxide and 3.5 ml. of water was refluxed for 40 hours. The mixture was worked up in chloroform to yield 1.03 g. of a clear glass. This product in about 50 ml. of methanol was treated with 5 ml. of 8% (v./v.) sulfuric acid, and was refluxed for 50 minutes. Water (50 ml.) was added to the cooled mixture, and the methanol was removed under reduced pressure. The residual mixture was neutralized with 14 ml. of a saturated sodium bicarbonate solution, and was extracted with 500 ml. of chloroform. Evaporation gave a crystalline residue which melted at 207–210°. Recrystallization from acetone–petroleum ether afforded 514 mg. of hydrocortisone (V), m.p. 217.5–219°. An additional 65 mg. of V was obtained from the mother liquor, m.p. 212–215°; 72% yield from IIIa.

PEARL RIVER, NEW YORK

(20) We wish to thank Mr. Samuel S. Modes for the microanalysis.

(21) In another reduction with 3 g. of the bis-ketal IIIa, there was isolated 9 mg. of impure bis-ethylene ketal IIa of 11-*epi*-hydrocortisone, m.p. 266–270°. The identification of this material was confirmed by infrared analysis. It should be noted that the sample of IIIa employed here was obtained directly from cortisone prepared from "Merck" cortisone acetate. Hence the possibility of trace impurities of IIa in the starting material was eliminated.

[CONTRIBUTION FROM THE METCALF CHEMICAL LABORATORIES OF BROWN UNIVERSITY]

Application of the Favorskii Rearrangement to the Preparation of A-Norsteroids

BY BILL B. SMITH[1] AND HAROLD R. NACE

RECEIVED JULY 15, 1954

Treatment of 2α-bromocholestan-3-one with sodium ethoxide gave, in about 72% yield, a one-to-one mixture of 2- and 3-carbomethoxy-A-norcholestane, and in about 6% yield, dimethyl 2,3-*seco*-cholestane-2,3-dioate. Treatment of the esters with phenylmagnesium bromide, followed by dehydration, gave the corresponding diphenylethylenes. Ozonization of each of these gave 2- and 3-keto-A-norcholestane, respectively, thus establishing the structures of the rearrangement products.

Changes in the basic carbon skeleton of a steroid may cause striking changes in its physiological activity. For example, converting the A or D ring to the next higher homolog may result in increased or decreased activity.[2] It was therefore felt that the development of a method for the preparation of A-norsteroids, in high yield, would be of interest.

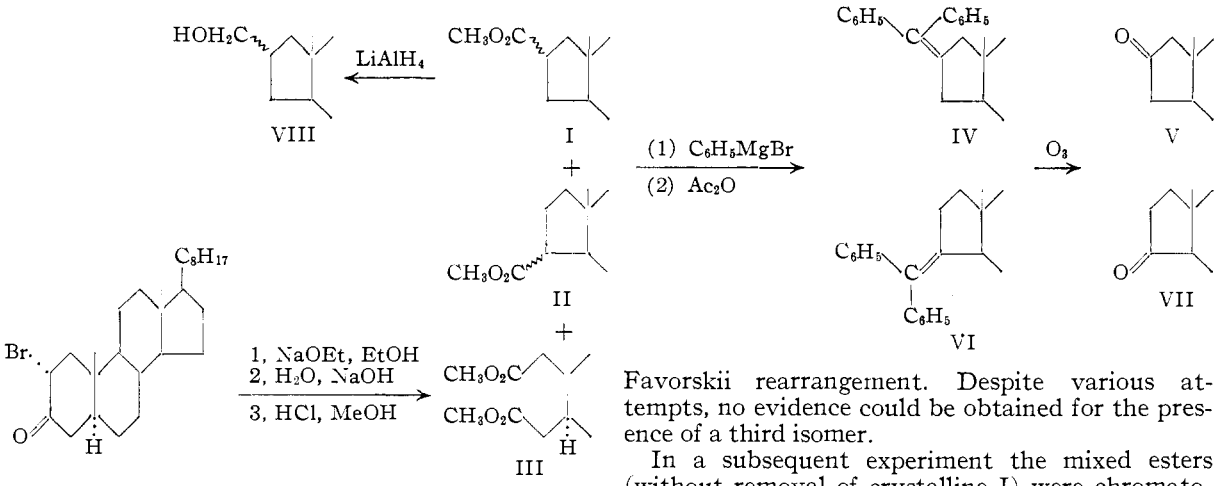
Among the various methods available for ring contraction, the Favorskii rearrangement appeared to offer interesting possibilities, especially since the required starting compound, 2α-bromocholestan-3-one, was readily available. Extension of the method to other steroids should be possible since α-bromoketo steroids are generally available.

Treatment of 2α-bromocholestan-3-one[3] with sodium ethoxide in refluxing ethanol yielded, after saponification of the reaction mixture, a mixture of acids, which was converted to a mixture of methyl esters for ease in handling.

(1) Abstracted from the Ph.D. Thesis of Bill B. Smith, Brown University, 1953. Research Corporation Fellow, 1951–1952; Brown University Fellow, 1952–1953.

(2) *Cf.* L. F. Fieser and M. Fieser, "The Chemistry of Natural Products Related to Phenanthrene," third edition, Reinhold Publishing Corp., New York, N. Y., 1949, Chap. 4.

(3) (a) A. Butenandt and A. Wolf, *Ber.*, **68B**, 2091 (1935); (b) E. J. Corey, THIS JOURNAL, **75**, 4832 (1953).



Treatment of the mixture with methanol yielded a crystalline product I, equivalent to about one-fourth of the esters, whose analysis was correct for a carbomethoxy A-norcholestane. When this material was chromatographed all of the resulting fractions had the same optical rotation and infrared spectrum. A sample was also reduced with lithium aluminum hydride to the corresponding alcohol VIII. Chromatography of this also gave fractions with identical infrared spectra and optical rotations. On the basis of this evidence it was felt that the crystalline material consisted of a single isomer.

The alcohol VIII was converted to the corresponding ethyl carbonate derivative, but pyrolysis[4] of this resulted in extensive decomposition and none of the desired olefin. Treatment of the methyl ester I with phenylmagnesium bromide and subsequent dehydration gave the diphenylethylene (IV) in 94% yield. No satisfactory conditions could be found for the oxidation of IV to V with chromic acid or potassium permanganate. However, ozonolysis gave the previously reported 2-keto-A-norcholestane (V),[5] thus establishing the structure of I as 2-carbomethoxy-A-norcholestane.

The material remaining after the removal of crystalline I was chromatographed and two main fractions (fraction I and fraction II) obtained.

Fraction I, as described in the Experimental section, was shown to be a mixture of I and 3-carbomethoxy-A-norcholestane (II), but it was not possible to obtain II free from I. However, when a sample of the mixed esters, rich in II, was converted to the diphenylethylenes as described above, the corresponding diphenylethylene (VI) could be obtained pure by fractional crystallization.[6] Ozonolysis of VI gave the known 3-keto-A-norcholestane (VII),[7] thus establishing the presence of 3-carbomethoxy-A-norcholestane in the ester mixture. The yield of fraction I was 50–62%, making the total yield of nor-esters 66–78%.

On the basis of the above evidence it seems likely that only two A-nor-esters were formed in the Favorskii rearrangement. Despite various attempts, no evidence could be obtained for the presence of a third isomer.

In a subsequent experiment the mixed esters (without removal of crystalline I) were chromatographed to separate fraction I (the A-nor-esters) and fraction II. Fraction I was then converted to the mixed diphenylethylenes. Assuming that only two isomers were formed, it was possible to calculate, from the rotations of the pure diphenylethylenes and the mixture of them, that the ratio of the isomers present was approximately one-to-one.

Fraction II was considerably more polar than the more easily eluted material (fraction I) and crystallized readily. Analysis established the empirical formula as $C_{29}H_{50}O_4$, and the infrared spectrum showed a strong ester carbonyl absorption at 5.80 μ. The compound was not completely saponified with strong alkali, but cleaved with hydrobromic acid in acetic acid to 2,3-*seco*-cholestane-2,3-dioic acid.[8] When an authentic sample of this acid was converted to the dimethyl ester it was identical with the reaction product III in all respects.

No precedent could be found in the literature for the formation of a diacid as a product of a Favorskii rearrangement. However, Stoll and Hulstkamp[9] have shown that acyloins react with sodium alkoxides in the presence of oxygen to form diacids. Thus the diacid isolated here could arise in this manner from 2-hydroxycholestan-3-one. This in turn could be formed from the reaction of 2α-bromocholestan-3-one with traces of sodium hydroxide present in the reaction mixture, although reasonable care was taken to exclude water from the reaction.

Acknowledgment.—We are indebted to the Research Corporation for funds in partial support of this work.

Experimental[10]

Cholestanone.—Cholestanol[12] was oxidized in the usual

(4) G. L. O'Connor and H. R. Nace, THIS JOURNAL, **74**, 5454 (1952).

(5) A. Windaus and O. Dalmer, *Ber.*, **52**, 162 (1919).

(6) It was possible to isolate IV from the mother liquors, but no evidence was obtained for the presence of any additional isomers.

(7) A. Windaus, *Ber.*, **52**, 170 (1919).

(8) A. Windaus and C. Uibrig, *ibid.*, **47**, 2384 (1914).

(9) M. Stoll and J. Hulstkamp, *Helv. Chim. Acta*, **30**, 1815 (1947).

(10) All melting points are corrected. Analyses by S. M. Nagy and Associates, Micro-chemical Laboratory, the Massachusetts Institute of Technology. The samples were crystallized until the melting points were constant. The optical rotations were measured in chloroform solution (1%). The infrared spectra were taken with a modified Perkin-Elmer model 1213 spectrometer described elsewhere.[11] Unless otherwise stated all spectra were run in 2% carbon disulfide solutions with a cell thickness of 1 mm. using a sodium chloride prism and windows of the same material.

(11) D. F. Hornig, G. E. Hyde and W. A. Adcock, *J. Opt. Soc. Am.*, **40**, 497 (1950).

(12) The authors wish to thank the Schering Corporation, Bloomfield, N. J., for a generous gift of cholestanol.

manner[13] to cholestanone. In order to assure the purity of the cholestanone, a sample was chromatographed on alumina (Merck and Co., Inc., "suitable for chromatographic analysis") and no change in properties was observed; m.p. 128–129°, $[\alpha]_D$ +40°; reported[14] m.p. 128°, $[\alpha]_D$ +41°.

2α-Bromocholestan-3-one.—This material was prepared by the method of Butenandt and Wolf.[3a] In order to assure its purity a sample was chromatographed on a mixture of three parts silica gel and two parts Hyflo Super-cel (Johns-Manville) made up in petroleum ether. The bromoketone was eluted (92% recovery) with 1:3 petroleum ether–benzene and had m.p. 168–169°, $[\alpha]_D$ +46° (reported[15] m.p. 167.5–168.0°, $[\alpha]_D$ +41°). It was subsequently found that the results of the following reaction were unchanged if the chromatography of the cholestanone and bromocholestanone were omitted.

Favorskii Rearrangement of 2α-Bromocholestan-3-one.—To a solution of 1.5 g. (65.2 millimoles) of sodium in 75 ml. of absolute ethanol in a 125-ml. erlenmeyer flask equipped with a condenser (drying tube) and magnetic stirrer was added 2.0 g. (4.3 millimoles) of 2α-bromocholestan-3-one. The resulting mixture was stirred overnight at room temperature. Longer periods of stirring did not increase the yield and heating decreased the yield. Maintaining a nitrogen atmosphere had no effect on the yield.

When reaction was complete 10 ml. of water was added and the resulting mixture was heated under reflux for two hours. The solution was then evaporated nearly to dryness and 300 ml. of warm water and 200 ml. of benzene added. The benzene layer was washed with additional portions of warm water until the water wash was clear. The combined aqueous washings were cooled, acidified with dilute hydrochloric acid and extracted with three 200-ml. portions of ether. The ether extract was dried over anhydrous sodium sulfate and the ether evaporated to yield 1.5–1.7 g. of steroid acids. This material was esterified by suspending it in a 3% solution of hydrogen chloride in methanol and allowing the mixture to stand overnight. The crude methyl esters weighed 1.5–1.7 g.

Crystallization from methanol gave 0.5 g. (28%) of I, m.p. 90–96°. The combined mother liquors (including those from recrystallization of I, as described below) were evaporated to dryness and the residue was taken up in petroleum ether (b.p. 30–60°) and chromatographed on 40 g. of alumina (Merck and Co., Inc., "suitable for chromatographic adsorption" grade was used in all cases where alumina is specified). Elution with 200 ml. of petroleum ether gave 0.9–1.1 g. (50–62%) of material designated as Fraction I, a mixture of compounds I and II. Elution with 6:4 petroleum ether–benzene gave 0.07–0.15 g. (3.5–7.5%) of material designated Fraction II, which proved to be dimethyl 2,3-*seco*-cholestane-2,3-dioate (III).

2-Carbomethoxy-A-norcholestane (I).—Three recrystallizations of the crude I gave 0.3 g. (16%) with m.p. 97.5–98.0°, $[\alpha]_D$ +29°, $\lambda_{max}^{CS_2}$ 5.85 μ.

Anal. Calcd. for $C_{28}H_{48}O_2$: C, 80.71; H, 11.61. Found: C, 80.75, 80.44; H, 11.56, 11.48.

To establish the purity of this material a sample was chromatographed on alumina. Six petroleum ether eluates were collected and each residue had $[\alpha]_D$ +28 ± 1°. The infrared spectra were identical.

Preparation of the Diphenylethylene of I.—To a solution of phenylmagnesium bromide, prepared from 270 mg. of magnesium and 1.4 ml. of bromobenzene in 20 ml. of anhydrous ether, was added a solution of 300 mg. of methyl ester I in 20 ml. of anhydrous benzene. The resulting mixture was heated under reflux for 3.5 hours, allowed to stand overnight at room temperature, and then poured into dilute iced hydrochloric acid. The benzene-ether layer was steam distilled to remove diphenyl and the residue extracted with benzene. The benzene was removed by distillation, the residue taken up in 20 ml. of acetic acid and 10 ml. of acetic anhydride, and then heated under reflux for two hours. The solvent was removed by distillation, the residue was taken up in petroleum ether, and chromatographed on alumina. Elution with petroleum ether gave 390 mg. (94%) of the diphenylethylene IV. Three recrystallizations from acetone–methanol gave material with m.p. 120.5–121°, $[\alpha]_D$ −143°; $\lambda_{max}^{solid\ film}$ 6.67, 6.81, 6.92 μ.

Anal. Calcd. for $C_{39}H_{54}$: C, 89.59; H, 10.41. Found: C, 89.50; H, 10.56.

The diphenylethylene IV did not decolorize a solution of bromine in carbon tetrachloride, or an acetone solution of potassium permanganate, even on heating.

Ozonolysis of the Diphenylethylene IV.—A solution of 100 mg. (0.19 millimoles) of the diphenylethylene IV in 75 ml. of chloroform was cooled in an ice-bath and ozonized oxygen bubbled through at such a rate that a 2.5 molar excess of ozone was added in 1.5 minutes. The solution was then kept in an ice-bath for 30 minutes and then the product decomposed by the addition of 10 ml. of acetic acid and 2 g. of zinc dust. After it had stood overnight the chloroform solution was washed with water, evaporated to dryness, and the residue taken up in petroleum ether and chromatographed on 5 g. of alumina.

The first two 30-ml. eluates (9:1 petroleum ether–benzene) gave 28 mg., $[\alpha]_D$ +104°, and 24 mg., $[\alpha]_D$ +140°.

The material with $[\alpha]_D$ +140° was recrystallized twice from methanol and then had m.p. 99.5–100°, mixture m.p. with an authentic sample[16] 98.0–100.5°.

The infrared spectra of the ketone V and the authentic sample were identical, $\lambda_{max}^{CS_2}$ 5.72 μ.

The ketone V with $[\alpha]_D$ +104° was converted to the oxime and after two recrystallizations from ethanol had m.p. 201.5–202.5°, mixture m.p. with an authentic sample[16] 199–200°.

Separation of the Mixed Nor esters in Fraction I.—Fraction I, obtained as described above, was taken up in petroleum ether and chromatographed over 30 g. of alumina. Eluates of 10 ml. were collected and all of the material was eluted after 20 fractions had been collected. The specific rotations of the various fractions decreased regularly from +13° for the first to +6° for the last eluate, with the majority of the material in the eluates of rotation +10 to +8°. The infrared spectra of all the fractions showed a strong band at 5.85 μ, but the spectra of the fractions with lower rotations differed markedly in the fingerprint region from the spectrum of ester I.

The fractions were combined into two groups having rotations above and below +10°, respectively. The two groups were rechromatographed several times and each time the new fractions were combined as above into groups having high and low rotations. In this fashion a group of fractions was obtained with rotation +4 to +6° which could be crystallized from acetone–methanol to constant m.p. 47–48°.

Anal. Calcd. for $C_{28}H_{48}O_2$: C, 80.71; H, 11.61. Found: C, 80.80; H, 11.51.

Preparation of the Diphenylethylene VI of Ester II.—To a solution of phenylmagnesium bromide, prepared by adding 1.4 ml. (13.3 millimoles) of bromobenzene to 270 mg. (11.1 millimoles) of magnesium in 30 ml. of anhydrous ether was added a solution of 219 mg. (0.52 millimole) of the ester of rotation +6 to +4°, just described, in 15 ml. of benzene. The resulting mixture was heated under reflux overnight and then worked up as described above. After chromatography over alumina the product had $[\alpha]_D$ +15°, yield 225 mg. Three recrystallizations from acetone–methanol gave m.p. 149.5–150°, yield 40–50%, constant $[\alpha]_D$ +107°; $\lambda_{max}^{solid\ film}$ 6.67, 6.81, 6.92 μ.

Anal. Calcd. for $C_{39}H_{54}$: C, 89.59; H, 10.41. Found: C, 89.98; H, 10.45.

The residue from the mother liquor had $[\alpha]_D$ −65°, and it was possible by further crystallizations to isolate the diphenylethylene IV from this material.

Ozonolysis of the Diphenylethylene VI.—A solution of 220 mg. (0.42 millimole) of the diphenylethylene VI in 30 ml. of chloroform was cooled to 0° and ozone was passed through at such a rate that 10 molar equivalents was added in 100 seconds. After the mixture was allowed to stand five minutes at 0°, 10 ml. of acetic acid and 3 g. of zinc dust were added, and this mixture was kept at 0° for five hours. It was then treated as in the previous ozonization and the product (220 mg.) was taken up in petroleum ether and chromatographed on 10 g. of alumina. Elution with 100

(13) "Organic Syntheses," Coll. Vol. II, John Wiley and Sons, Inc., New York, N. Y., 1943, p. 139.

(14) Reference 2, p. 95.

(15) C. Djerassi and C. R. Scholz, THIS JOURNAL, **69**, 2404 (1947).

(16) Prepared according to Windaus[5]; m.p. 100–100.5°, $[\alpha]_D$ +143°; oxime, m.p. 200–201°, also prepared according to Windaus.[5]

ml. of petroleum ether gave 75 mg. of starting material. Elution with 100 ml. of 9:1 petroleum ether–benzene gave 27 mg. of material, $[\alpha]D$ +105°. Two recrystallizations of this from methanol gave m.p. 73.5–74.5° (reported[7] for 3-keto-A-norcholestane, m.p. 73–74°), $\lambda_{max}^{CS_2}$ 5.76 μ.

The semicarbazone had m.p. 267–268° (reported[17] m.p. 268–270°).

Determination of the Ratio of Ester I to Ester II.—A sample of the mixed methyl esters from the Favorskii reaction, from which none of ester I had been removed by crystallization, was chromatographed to remove the diester III. The remaining combined esters I and II were then converted to the mixed diphenylethylenes as described above in 83% over-all yield. This material had $[\alpha]D$ −27° and from this and the rotations of the pure diphenylethylenes IV and VI it was calculated that the ratio of esters I and II was 54 to 46% respectively.

Identification of Methyl 2,3-*seco*-Cholestane-2,3-dioate (III).—The material from the original chromatogram designated as fraction II had $[\alpha]D$ +19°, $\lambda_{max}^{CS_2}$ 5.80 μ. Three recrystallizations from methanol gave m.p. 59–60°; two more recrystallizations gave m.p. 60–60.3°.

Anal. Calcd. for $C_{29}H_{50}O_4$: C, 75.28; H, 10.89. Found: C, 75.33, 75.57; H, 10.81, 11.16.

Heating the diester III with 0.04 *N* sodium hydroxide in ethylene glycol resulted in only partial saponification.

The diester III (70 mg.) in 10 ml. of acetic acid and 10 ml. of 48% hydrobromic acid was heated under reflux overnight, the resulting solution was then cooled, poured into water, and the resultant mixture extracted with an ether–benzene mixture. The ether and benzene were evaporated and the residue recrystallized from methanol–water and then petroleum ether–ether to give 10 mg., m.p. 196–197°, mixture m.p. with an authentic sample (reported[8] m.p. 196°) of 2,3-*seco*-cholestane-2,3-dioic acid, 196–197°.

A sample of the authentic acid was esterified with methanolic hydrogen chloride and the diester had m.p. 59–60°, $[\alpha]D$ +20° (reported[8] m.p. 67°). A mixture m.p. with the diester III was 59–60°, and the infrared spectra of the two samples were identical.

Reduction of 2-Carbomethoxy-A-norcholestane (I) to 2-Hydroxymethyl-A-norcholestane (VIII).—To a stirred slurry of 0.5 g. of lithium aluminum hydride in 25 ml. of anhydrous ether was added 200 mg. (0.48 millimole) of crystalline ester I. The mixture was stirred for 1.5 hours, the addition complex was then decomposed by the slow addition of dilute sulfuric acid, and the resulting mixture was extracted with benzene. The extract was washed with water, dried over anhydrous sodium sulfate, the benzene evaporated, and the residue (169 mg.) taken up in petroleum ether and chromatographed on 20 g. of alumina. Elution with benzene gave 158 mg. of alcohol VIII (85%), which, after four recrystallizations from 95% methanol, had m.p. 118–118.5°, $[\alpha]D$ +32°. $\lambda_{max}^{CS_2}$ 2.85 μ.

Anal. Calcd. for $C_{27}H_{48}O$: C, 83.43; H, 12.47. Found: C, 83.17; H, 12.60.

Cathylation of 2-Hydroxymethyl-A-norcholestane (VIII).—To a solution of 156 mg. (0.4 millimole) of the alcohol VIII in 5 ml. of pyridine cooled to 0° was added dropwise 0.5 ml. of ethyl chlorocarbonate. After the mixture had stood overnight at room temperature, it was diluted with 50 ml. of benzene, washed twice with water, twice with dilute hydrochloric acid, and twice with water, and then the benzene was evaporated. The residue was taken up in petroleum ether and passed over a column containing 5 g. of alumina to give 164 mg. (88%) of the cathylate. Two recrystallizations from acetone–ethanol gave material with m.p. 60.5–61.5°, $[\alpha]D$ +34°, $\lambda_{max}^{CS_2}$ 5.67 μ.

Anal. Calcd. for $C_{30}H_{52}O_3$: C, 78.20; H, 11.38. Found: C, 77.99; H, 11.37.

Pyrolysis of 85 mg. in a sealed evacuated Pyrex tube at 300° for 2.5 hours, followed by chromatography of the residue, gave 69 mg. of starting material, and intractable oils. Longer periods of heating and higher temperatures resulted in decomposition and only oils could be isolated.

(17) H. Lettre, *Z. physiol. Chem.*, **221**, 73 (1933).

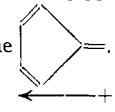
PROVIDENCE 12, R. I.

[CONTRIBUTION FROM THE CHEMICAL LABORATORIES OF THE POLYTECHNIC INSTITUTE OF BROOKLYN]

The Reaction of 1,2,3,4-Tetraphenylfulvene with Grignard Reagents

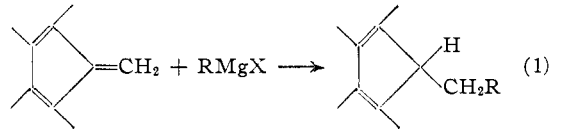
BY ANTHONY G. BONAGURA,[1] MARTIN B. MEYERS,[1] STANLEY J. STORFER[1] AND ERNEST I. BECKER[2]

RECEIVED JUNE 28, 1954

Ethyl-, *n*-propyl- and isopropylmagnesium halides have been newly added to 1,2,3,4-tetraphenylfulvene and the reported additions of benzyl-, *t*-butyl- and methylmagnesium halides have been verified to give the corresponding 5-(RCH_2)-1,2,3,4-tetraphenylcyclopentadienes. The dienes, where R = CH_3–, C_2H_5–, *n*-C_3H_7– and $(CH_3)_3C$–, have been synthesized by the addition of RCH_2– organometallic derivatives to tetracyclone and reducing the intermediates to the dienes. The correspondence of the dienes prepared by both routes is interpreted to be in accord with the dipolar character of fulvene  .

Recently Fuson and York[3] and Taber, *et al.*,[4] have reported that 1,2,3,4-tetraphenylfulvene (I) reacts with benzyl,[3] *t*-butyl[3] and methyl[4] Grignard reagents at the 6-position to give 5-alkyl-1,2,3,4,-tetraphenylcyclopentadienes. However, Taber, *et al.*, had raised a question concerning the course of the addition depending upon the purity of the magnesium. Elucidation of this point was of interest in connection with related studies here on the reactions of dipolar hydrocarbons.[4,5] This investigation was, therefore, designed to prove unequivocally the course of the reaction and to extend the reaction to other organometallic compounds.

The previously reported experiments were repeated using sublimed magnesium with essential accord in all important features. Then, the addi-



(1)

R = CH_3–, C_2H_5–, $(CH_3)_3C$–, $C_6H_5CH_2$–, *n*-C_3H_7–, *i*-C_3H_7–

(1) Taken from the theses of A.G.B., M.B.M. and S.J.S. presented to the Faculty of the Polytechnic Institute of Brooklyn in partial fulfillment of the requirements for the Bachelor of Science degree in Chemistry, 1954.

(2) To whom inquiries should be sent.

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