the isomer, m. p. 144–145°, described by Hoehn and Ungnade.[11]

Anal. Calcd. for $C_{18}H_{28}O_2$: C, 78.21; H, 10.21. Found: C, 78.08; H, 10.44.

Hydrogenation of *dl-m*-3-(4-Hydroxycyclohexyl)-4-(*p*-hydroxyphenyl)-hexane (I).—A solution of the octahydro compound (0.080 g.) in 100 cc. of methanol was reduced at 210° with 3 g. of Raney nickel by shaking for two and one-half hours at 3000 lb. The product (0.080 g.), isolated in the usual way, gave 0.050 g. of *meso*-3,4-di-(4-hydroxycyclohexyl)-hexane (II) melting at 166–167° after crystallization from ethyl acetate. The mixed melting point with authentic material was 166–167°.

***dl-m*-3-(4-Ketocyclohexyl)-4-(*p*-hydroxyphenyl)-hexane** (IV).—The crude phenolic material from the partial hydrogenation of *meso*-hexestrol (25 g.) was oxidized with 20 g. of aluminum *t*-butoxide and 185 cc. of acetone in 375 cc. of benzene. After refluxing for eight hours, the mixture was decomposed with 40 cc. of water and 100 cc. of 10% aqueous sulfuric acid, shaken and separated after addition of another 300-cc. portion of water. The benzene extract yielded 25 g. of glassy material. Separation of the crude product by means of Girard reagent[12] gave 3.74 g. of ketonic compounds. This mixture was further purified by adsorption on alumina from benzene solution. The benzene eluate (0.80 g.) was non-phenolic. The desired ketone was obtained from the acetone eluate, yield 1.60 g.

***dl-m*-3-(4-Hydroxycyclohexyl)-4-(*p*-hydroxyphenyl)-hexane** (III).—The above ketone (0.66 g.) dissolved in 50 cc. of methanol was reduced with 3 g. of Raney nickel at room temperature. Slightly more than the theoretical amount of hydrogen was taken up in four hours. The crude product (0.6 g.) was purified by adsorbing on aluminum oxide from benzene solution. The main product, a clear glass, (0.45 g.) was obtained from the acetone eluate.

Monobenzoate.—The alcohol (III) (0.45 g.) dissolved in 50 cc. of 5% aqueous sodium hydroxide was benzoylated with 0.4 cc. of benzoyl chloride. The crude product (0.6 g.) was adsorbed on alumina from benzene solution. The main product was obtained in the benzene eluate, yield 0.16 g.

The glassy alcohol (III) was regenerated from the benzoate by hydrolyzing with 0.1 *N* sodium ethoxide solution.

Anal. Calcd. for $C_{18}H_{28}O_2$: C, 78.20; H, 10.21. Found: C, 78.28; H, 10.32.

Absorption Spectra

The infrared absorption spectrum of the alcohol (I) has been found to differ from that of the previous octahydrostilbestrol compounds.[6,13]

Ultraviolet absorption spectra of the octahydro compounds (I) and (III), the specimen of Dr. Wilds and the compound prepared by Hoehn[11] have been determined and show a characteristic band at 280 mμ which can be used as a test for purity. The average molecular extinction of the octahydro compounds at this wave length is approximately half as large as the extinction of the dihydro compound (Figs. 1 and 3). The absorption curves of the two described benzoates nearly coincide (Fig. 2). The ultraviolet absorption spectra were determined in 95% alcohol at concentrations of around 0.00018 mole per liter with a Beckmann spectrophotometer. Readings were taken at 5 mμ intervals.[14]

Summary

A single pure isomer of *meso*-octahydrostilbestrol has been isolated from the products of the partial hydrogenation of *meso*-hexestrol. The catalytic reduction of the corresponding ketone yields a glassy substance which probably represents a mixture of *cis* and *trans* isomers. The compounds have been characterized by derivatives and absorption spectra.

(11) Hoehn and Ungnade, THIS JOURNAL, **67**, 1617 (1945).

(12) Girard and Sandulesco, *Helv. Chim. Acta*, **19**, 1095 (1936).

(13) Infrared absorption spectrum by Agatha Johnson and Foil Miller, University of Illinois.

(14) Ultraviolet absorption spectra by Dr. E. E. Pickett and P. W. Tucker, University of Missouri.

COLUMBIA, MISSOURI RECEIVED JULY 10, 1948

[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF NORTHWESTERN UNIVERSITY]

Derived Steroids. II. Structure of Products Derived from 3-Magnesio Halides[1]

BY ROBERT H. BAKER AND EDWARD N. SQUIRE[2]

Prior to our work, 3-cholesteryl Grignard reagents had been subjected only to carbonation and oxidation. Marker[3] referred to the acid so obtained as "*d,l*," and showed the oxidation product to be a mixture of α and β-forms of cholesterol. Since we have used the Grignard reagent extensively to make compounds of biological interest[4] in the cholestene[1] and 17-oxygenated androstene[5] series, it was of importance to investigate the stereochemical pattern of its reactions.

The ionic nature of the carbon–magnesium bond and the allylic nature of 3-cholesteryl derivatives offers the possibility of a particular derivative being either 3-α or β or 6-*i* or mixtures of these. Neither 5-cholestene-3-carboxylic acid nor any of its derivatives gives evidence of being a mixture. Extensive fractional crystallization and/or chromatography of the acid, the methyl ester or the series of amides reported herein demonstrate a striking homogeneity of each compound. Furthermore, only one compound, the anilide, has a positive rotation, 0.5°. Saturation of the double bond increased the positive rotation of both the anilide and the dipropylamide. Since a number of these compounds react with one equivalent of perbenzoic acid, the *i*-steroid structure is untenable.

The reaction of the cholesteryl Grignard with cholesteryl chloride is even more complex since both reagents are allyl-like and either 3-3′, 3-6′, or, less likely, 6-6′ linkages might be encountered. Although the product, bicholesteryl, has a specific rotation +30°, neither half of the molecule seems to have the *i*-steroid structure since it

(1) For the first paper see Baker and Squire, THIS JOURNAL, **70**, 1487 (1948).

(2) Junior Fellow of the National Institute of Health.

(3) Marker, Oakwood and Crooks, THIS JOURNAL, **58**, 481 (1936).

(4) Squire and Squire, *J. Bact.*, **55**, 766 (1948).

(5) Baker and Squire, forthcoming publication.

TABLE I

CHOLESTERYLAMIDES

Amine used	Formula	M. p., °C.	$[\alpha]^{24}D$	Concn. chloroform	Analyses, % Carbon Calcd.	Carbon Found	Hydrogen Calcd.	Hydrogen Found	Nitrogen Calcd.	Nitrogen Found
Ammonia	$C_{28}H_{47}NO$	227–228	−26	2.45	81.34	81.59	11.46	11.46	..	..
Diethyl	$C_{32}H_{55}NO$	146–147	−16	1.85	81.80	81.70	11.80	11.98	..	..
Dipropyl	$C_{34}H_{59}NO$	108–109	−14	3.30	82.01	81.52	11.96	12.01	2.81	2.95
Piperidine	$C_{33}H_{55}NO$	175–176	−20	1.47	82.26	82.04	11.51	11.33	..	..
Aniline	$C_{34}H_{51}NO$	229–231	+ 0.5	7.55	83.38	83.20	10.50	10.70	2.86	2.93
			DIHYDROCHOLESTERYLAMIDES							
Aniline	$C_{34}H_{53}NO$	236–237	+17	1.50	83.01	83.54	10.86	10.78	2.84	2.83
Dipropyl	$C_{34}H_{61}NO$	101–102	+23	1.90	81.70	81.17	12.33	12.08	2.80	2.96

rapidly takes up two molecules of bromine or two equivalents of oxygen.

The amides were prepared by reaction of an excess of the appropriate amine with the acid chloride. Refluxing of the amine solutions with 3-carbomethyl-5-cholestene for twenty-four hours failed to bring about ammonolysis.

Experimental[6]

Cholesteryl-3-carboxylic Acid.—This was prepared as previously described[1] and crystallized very slowly from benzene, m. p. 227–228° with softening at 224° and noticeable sublimation at 215°, $[\alpha]^{24}D$ −14, *c.* 0.95 in chloroform.

Bromination.—A solution of 0.414 g. (1.00×10^{-3} mole) of the acid in 75 ml. of chloroform was titrated with a standard solution of bromine in chloroform requiring 9.93 $\times 10^{-4}$ mole.

Oxidations.—The acid, 0.0100 g. (2.42×10^{-5} mole) was dissolved in 4 ml. of a chloroform solution containing 3.34×10^{-5} mole of perbenzoic acid. After standing sixty hours at 0°, iodometric titration showed the consumption of 2.50×10^{-5} equivalent of oxygen.

5-Cholesteryl-3-cholestene (Bicholesteryl).—Extensive crystallization produced a compound of slightly higher m. p., 272–273°, than previously encountered[1] but having the same rotation. Perbenzoic oxidation of 0.0100 g. (1.35×10^{-5} mole) in a manner similar to the acid showed the consumption of 2.7×10^{-2} equivalent of oxygen.

3-Cholesterylcarbonyl Chloride.—The crude compound previously described[1] was crystallized from benzene, m. p. 119–120°. Micro carbon and hydrogen analyses corresponded more closely to the acid, probably due to hydrolysis during handling. A macro sample was hydrolyzed and the halogen determined volumetrically.

Anal. Calcd. for $C_{28}H_{45}ClO$: Cl, 8.18. Found: Cl, 8.08.

Preparation of the Amides.—The compounds shown in Table I were prepared with slight variations as follows. 3-Cholesterylcarbonyl chloride, 0.2 g. (4.6×10^{-4} mole) was dissolved in 2 ml. of the amine at room temperature. After standing one day the amide had crystallized. The excess amine was removed *in vacuo* and the amide crystallized from ethanol; yield, 80–98%. Analytical samples were crystallized three to five times without greatly affecting the m. p.

Hydrogenations.—Two of the amides were reduced in acetic acid–acetic anhydride solution using platinum oxide and one atmosphere of hydrogen.

Summary

A series of cholesterylcarboxamides has been prepared. The structure and configurations of derivatives made from 3-cholesterylmagnesium halides are discussed.

EVANSTON, ILLINOIS RECEIVED JULY 15, 1948

(6) Microanalyses by Patricia Craig, Margaret Hines and Virginia Hobbs.

[CONTRIBUTION FROM BATTELLE MEMORIAL INSTITUTE]

Studies in the Methylcyclopentane Series. I. Preparation and Reactions of Methylcyclopentyl Monochlorides[1]

BY GARSON A. LUTZ, ARTHUR E. BEARSE, JOHN E. LEONARD[2] AND FRANK C. CROXTON

For several years there has been in progress in this Laboratory a study of methylcyclopentane and its derivatives. This hydrocarbon is one of the constituents of petroleum, and methods for its isolation have been developed.[3] This paper deals with the preparation and reactions of methylcyclopentyl chlorides.

Markownikoff[4] chlorinated methylcyclopentane but the products were not identified with certainty. The preparation of 1-chloro-1-methylcyclopentane from 1-methylcyclopentanol has been described by several investigators.[4,5]

Yarnall and Wallis[6] synthesized 1-chloro-2-methylcyclopentane, but 1-chloro-3-methylcyclopentane has, apparently, not been reported.

The chlorination of methylcyclopentane has been re-investigated, and methods of synthesizing

(1) Presented before the Division of Organic Chemistry at the 113th Meeting of the American Chemical Society, Chicago, Illinois, April, 1948.

(2) Present address: Charles F. Kettering Foundation for the Study of Chlorophyll and Photosynthesis, Antioch College, Yellow Springs, Ohio.

(3) (a) Bruun, *Bur. Standards, J. Research*, **7**, 799 (1931); (b) Tooke, U. S. Patent 2,368,050.

(4) Markownikoff, *Ann.*, **307**, 360 (1899).

(5) (a) Meerwein, *ibid.*, **405**, 171 (1914); (b) Chavanne, Miller and Cornet, *Bull. Soc. Chim. Belg.*, **40**, 673 (1931); (c) Hönel and Zinke, U. S. Patent 2,162,172.

(6) Yarnall and Wallis, *J. Org. Chem.*, **4**, 284 (1939).