dissolved to give a light yellow solution and within an hour the acidic product began to separate as an oil which subsequently solidified. After refluxing for thirty-four hours the mixture was diluted with water and extracted with ether. The product was then extracted into alkali and the solution was made nearly neutral, clarified with Norit (hot), and strongly acidified (Congo Red). The 3-(*o*-carboxyphenyl)-perinaphthane separated as an oil which changed to a granular solid on short boiling. Crystallization of the dried product (2.38 g.) from benzene–hexane, with recrystallization of the second crop, gave a total of 2.14 g. of satisfactory material, m. p. 181–182.5°*. The neutral fraction in the ether afforded 0.10 g. of nearly pure amide, whence the yield of acid was 86%.

2,1′-Trimethylene-1,9-benzanthrone (XI).—In a small platinum crucible 180 mg. of 3-(*o*-carboxyphenyl)-perinaphthane was covered with 5 cc. of anhydrous hydrogen fluoride. In a little over an hour the reagent had evaporated leaving a bright orange solid residue. This was crystallized from benzene–acetone, giving 90 mg. (53%) of flat, diamond-shaped orange leaves, m. p. 216–217.5°, corr. On a second crystallization the sample (62 mg.) melted at 217.2–218.4°, corr., and did not depress the m. p. (216.4–218°, corr.) of an authentic sample.[12]

4,4′-Trimethylene-2,3-benzfluorenone (XII).—One hundred milligrams of 1-(*o*-carboxyphenyl)-perinaphthane was cyclized with hydrogen fluoride (8 g.) as above, the residue left on evaporation of the reagent being a bright yellow solid. This was washed in benzene solution with bicarbonate, but no uncyclized material was present. After concentrating and adding hexane there crystallized 81 mg. (86.5%) of bright yellow prismatic blades, m. p. 196.5–197.5°*. The sample recrystallized for analysis exhibited polymorphism. When heated slowly it softened slightly at 187° and melted at 201–203°, corr. When heated rapidly it melted at 187–189°, corr., and when a sample was introduced to a bath at 190° it melted immediately to a clear liquid and then resolidified, remelting at 201–203°, corr.

Anal. Calcd. for $C_{20}H_{14}O$: C, 88.85; H, 5.23. Found: C, 88.77; H, 5.28.

Summary

A satisfactory method has been developed for the preparation of pure perinaphthanone-7 which consists in cyclization of β-(1-naphthyl)-propionic acid with hydrogen fluoride and separation of the main product (81%) from a trace of 4,5-benzhydrindone-1 (6%) by chromatographic adsorption and crystallization. On condensing perinaphthanone-7 with *o*-chlorophenylmagnesium bromide and applying the successive steps of dehydration, hydrogenation, conversion through the nitrile to the acid, and ring closure, the end products obtained are 2,1′-trimethylene-1′,9-benzanthrone-10 and 4,4′-trimethylene-2,3-benzfluorenone, in place of the expected 1′,9-dimethylene-1,2-benzanthracene. This is due to a rearrangement in the perinaphthane system, probably occurring in the course of dehydrating the carbinol, with the reformation of the naphthalenoid unit in both possible arrangements embodying conjugation with the substituent aryl radical.

CONVERSE MEMORIAL LABORATORY
CAMBRIDGE, MASSACHUSETTS RECEIVED JUNE 28, 1940

[CONTRIBUTION FROM THE SQUIBB INSTITUTE FOR MEDICAL RESEARCH, DIVISION OF ORGANIC CHEMISTRY]

On the Constitution of α-Spinasterol

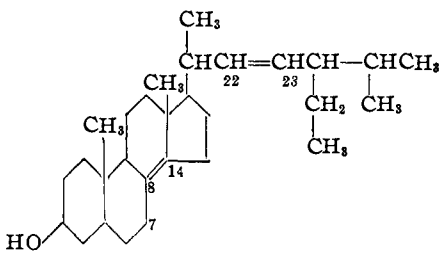
BY ERHARD FERNHOLZ AND WILLIAM L. RUIGH

α-Spinasterol has been isolated from spinach leaves, senega root, and alfalfa leaves and seeds. Since these plants are botanically unrelated, this sterol will in all probability eventually be found to be of rather widespread occurrence.

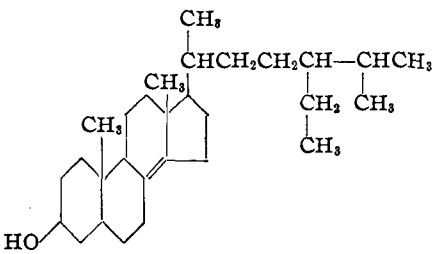
Larsen showed that α-spinasterol is an isomer of stigmasterol since saturation of its two double bonds led to the formation of stigmastanol.[1] With the nature of the carbon skeleton and the position of the hydroxyl group thus established, only the location of the two double bonds remained to be determined. Larsen and Heyl[2] reported that ozonization did not yield a volatile aldehyde, and thus concluded that there was no double bond in the side-chain. Our own results contradict their findings. We have obtained from α-spinasterol ethylisopropylacetaldehyde identical with the aldehyde from stigmasterol[3] in a yield of 22%, and have, therefore, demonstrated that one of the double bonds is between C-22 and C-23 in the side-chain. Of the two double bonds only one, that in the side-chain, is hydrogenated in neutral solvents. The hydrogenation stops after the formation of α-spinastenol, and in order to obtain complete saturation it is necessary first to isomerize α-spinastenol into β-spinastenol by means of acid.[2] This is strictly comparable to the case of α-dihydroergosterol, with which we compared

(1) C. D. Larsen, THIS JOURNAL, **60**, 2431 (1938).
(2) Larsen and Heyl, *ibid.*, **56**, 2663 (1934).
(3) A. Guiteras, *Z. physiol. Chem.*, **214**, 89 (1933).

α-spinasterol not long ago.[4] For the structure of α-spinasterol and α-spinastenol formulas I and II, respectively, can be proposed.

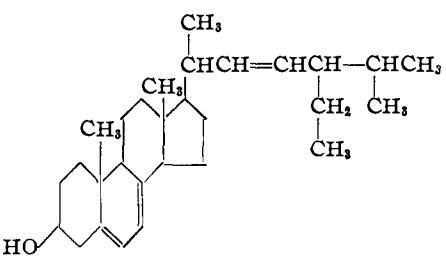


I, α-Spinasterol



II, α-Spinastenol (α-stigmastenol)

In order to prove that the second double bond is between C-8 and C-14 we have prepared α-stigmastenol (II) from stigmasterol for comparison with α-spinastenol. α-Stigmastenol was not known, but readily obtained by hydrogenation of 7-dehydrostigmasterol (III).



III, 7-Dehydrostigmasterol

When sterols of the ergosterol type are hydrogenated, a mono-unsaturated compound (α-ergostenol, α-cholestenol) is formed; the double bond at 7,8 shifts into the stable 8,14 position. Also in the case of 7-dehydrostigmasterol the hydrogenation stopped at that point, and there is little doubt that we obtained a compound of structure II, α-stigmastenol. This α-stigmastenol proved indeed to be identical with α-spinastenol. The structure of α-spinastenol has thus been fixed, but for α-spinasterol the possibility of the 7,8 position must still be considered as an alternative. The double bond in position 7,8 in the case of γ-ergostenol[5] and γ-cholestenol[6] shifts to the 8,14 position in the absence of hydrogen when a solution of these substances is shaken with a hydrogenating catalyst. However, α-spinasterol is unchanged by this treatment, and the double bond must already be in position 8,14. We believe that α-spinasterol is best represented by formula I.

(4) Fernholz and Moore, THIS JOURNAL, **61**, 2467 (1939).

Experimental

Ozonization of α-Spinasterol.—One gram of α-spinasterol suspended in 10 cc. of glacial acetic acid was ozonized for one and one-fourth hours without cooling. By the end of the period the temperature of the solution had risen to 45° and all but a few fragments of the solid had gone into solution. The solution with 5 cc. of acetic acid from rinsing the ozonizer tube was diluted with 50 cc. of water and the whole distilled through a preheated efficient fractionating column. The first 20 cc. of distillate contained large drops of an oily liquid and had the characteristic odor of ethylisopropylacetaldehyde. To the distillate was added 1 g. of semicarbazide hydrochloride, 1 g. of sodium acetate and then enough saturated potassium bicarbonate solution to make the liquid just alkaline to brom thymol blue. The solution was immediately made slightly acid with acetic acid and allowed to stand overnight. The solid semicarbazone was filtered, washed with water and sublimed in a high vacuum at about 100°. The sublimate crystallized from 10 cc. of hexane and yielded 90 mg. of needles of m. p. 128–129°. A mixed melting point with authentic ethyl isopropylacetaldehyde semicarbazone (m. p. 127.5–128°) from the ozonization of stigmasterol showed no depression. The rotation agreed with the value $[\alpha]^{20}D$ +9.13 given by Guiteras[3] and was found to be $[\alpha]^{24}D$ +9.3 (9.8 mg. in 1.01 cc. of absolute ethanol, $\alpha^{24}D$ −0.09, 1-dm. tube).

Anal. Calcd. for $C_8H_{17}ON_3$: N, 24.54. Found: N, 24.74.

Hydrogenation of 7-Dehydrostigmasteryl Benzoate.—The 7-dehydrostigmasteryl benzoate used in this experiment was prepared according to Linsert.[7] The benzoate (m. p. 181°, 0.639 g.) was suspended in 50 cc. of ether and shaken in an atmosphere of hydrogen at normal pressure in the presence of 0.5 g. of palladium black. The calculated amount of hydrogen, 2 mols, was taken up in a few hours, whereby the material gradually dissolved. The ether was evaporated and the residue crystallized from acetone–methanol. The substance appeared at first in the form of small leaflets, changing on standing into small prisms: very soluble in acetone, sparingly soluble in methanol and alcohol; m. p. 89°; $[\alpha]^{23}D$ +10.5 (15.2 mg., 2 cc. of chloroform, l = 1 dm., $\alpha^{23}D$ +0.08°).

Anal. Calcd. for $C_{36}H_{54}O_2$: C, 83.34; H, 10.49. Found: C, 83.61; H, 10.42.

Hydrogenation of α-Spinasteryl Benzoate.—This hydrogenation was carried out with 1 g. of α-spinasteryl benzoate, m. p. 200°, and 0.5 g. of palladium black in the way just described. The benzoate recrystallized from

(5) Windaus and Langer, *Ann.*, **508**, 105 (1933).
(6) Schenck, Buchholz and Wiese, *Ber.*, **69**, 2701 (1936).
(7) O. Linsert, *Z. physiol. Chem.*, **241**, 125 (1936).

acetone–methanol melted at 89°, and gave no depression with the above described α-stigmastenyl benzoate; $[\alpha]_D$ +11° (23.6 mg., 2 cc. of chloroform, l = 1 dm., $\alpha^{23}D$ +0.13°).

Anal. Calcd. for $C_{38}H_{54}O_2$, C.: C, 83.34; H, 10.49. Found: C, 83.01; H, 10.55.

α-Stigmastenol.—A sample (0.3 g.) of the first described benzoate was boiled with 30 cc. of a 5% solution of potassium hydroxide in alcohol for two hours. Water was then added in the sterol extracted with ether. It crystallized from methanol in big leaflets, containing solvent of crystallization. After drying in a vacuum at 80° it melted at 115°. Mixed with an authentic sample of α-spinastenol (m. p. 114°) there was no depression of the melting point; $[\alpha]^{23}D$ +24° (24.2 mg., 2 cc. of chloroform, l = 1 dm., $\alpha^{23}D$ +0.29°) in good agreement with the rotation reported for α-spinastenol ($[\alpha]_D$ +26).

Anal. Calcd. for $C_{29}H_{50}O$: C, 83.98; H, 12.16; Found: C, 84.05; H, 12.12.

α-Stigmastenyl Acetate.—Two-tenths gram of the α-stigmastenol just described was heated on the steam-bath with 10 cc. of acetic anhydride. On cooling the acetate came out in the form of big leaflets. It was recrystallized from benzene–alcohol: m. p. 118°, $[\alpha]^{23}D$ +16° (18.9 mg., 2 cc. of chloroform, l = 1 dm., $\alpha^{23}D$ +0.15°); no depression with α-spinastenyl acetate (m. p. 117°, $[\alpha]_D$ +15°).

Anal. Calcd. for $C_{31}H_{52}O_2$: C, 81.58; H, 11.48. Found: C, 82.02; H, 11.63.

Summary

Ozonization of α-spinasterol yields ethylisopropylacetaldehyde.

α-Spinastenol is identical with α-stigmastenol, the hydrogenation product of 7-dehydrostigmasterol.

In view of these experimental findings a structure formula, that of $\Delta^{8:14,22:23}$-stigmastadienol-3, is proposed for α-spinasterol.

NEW BRUNSWICK, N. J. RECEIVED JULY 5, 1940

[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF THE OHIO STATE UNIVERSITY]

Derivatives of the Aldehydrol Form of Sugars. III.[1] Carbon One Asymmetry

BY M. L. WOLFROM, M. KONIGSBERG AND F. B. MOODY

In continuation of our studies on derivatives of the aldehydrol form of sugar acetates, we wish to report on a number of such substances obtained in this Laboratory. Most of these compounds are new and those that are not have been prepared by methods that are novel or by methods that have not been applied previously to the derivatives in question.

The *aldehydo*-form of *d*-mannose pentaacetate has been reported[2] in the form of its crystalline ethyl hemiacetal (I).[3] The corresponding methyl hemiacetal was desired for further synthetic work and was obtainable readily in crystalline form. It was convertible on further acetylation into the *aldehydo-d*-mannose heptaacetate (II) recorded by Pirie.[4] These two hemiacetals of *aldehydo-d*-mannose pentaacetate showed a simple downward mutarotation in absolute chloroform and thus correspond to the α-isomer of the two isomeric ethyl hemiacetals of methyl *aldehydo-d*-galacturonate tetraacetate reported by Dimler and Link.[5] These authors have adopted the α and β prefixes for the two isomeric forms of these acyclic derivatives in which the isomerism is concerned only with the asymmetry of the aldehyde carbon atom. This designation is based on the usage proposed by Hudson,[6] in which that derivative in the cyclic *d*-series having the more positive rotation is assigned the prefix α. This nomenclature need lead to no confusion with the usual α,β cyclic sugar nomenclature, if the prefix *aldehydo* be included in the name. It will be adopted in the present communication.

Mild acetylation of this stable methyl hemiacetal of *aldehydo-d*-mannose pentaacetate produced one form of the 1-methoxy-*aldehydo-d*-mannose hexaacetate (III). The second form of this derivative was obtained by application of the interconversion conditions described by Hudson and co-workers[7] for the corresponding acyclic isomers of *d*-arabinose, obtained by them by the acetolysis of β-methyl-*d*-arabinoside.

Mild acetylation of the stable methyl hemi-

(1) Previous publications in this series: (a) M. L. Wolfrom, THIS JOURNAL, **57**, 2498 (1935); (b) M. L. Wolfrom and M. Konigsberg, *ibid.*, **60**, 288 (1938).

(2) M. L. Wolfrom and M. Konigsberg, *ibid.*, **61**, 574 (1939).

(3) The Roman numerals refer to the general type structures of these acyclic sugar derivatives as represented in Fig. 1.

(4) N. W. Pirie, *Biochem. J.*, **30**, 374 (1936).

(5) R. J. Dimler and K. P. Link, THIS JOURNAL, **62**, 1216 (1940).

(6) C. S. Hudson, *ibid.*, **31**, 66 (1909).

(7) Edna M. Montgomery, R. M. Hann and C. S. Hudson, *ibid.*, **59**, 1124 (1937).