

ether. The ether solution was washed with 5% sodium carbonate solution and evaporated to dryness. The residue was boiled with 5 cc. of ligroin (b. p. 60–70°), the solution decanted and concentrated to approximately 1 cc. Cooling gave needles, m. p. 196–205°. After three recrystallizations from acetone platelets were obtained melting at 211–214°. Neotigogenone when mixed with tigogenone, m. p. 201–207°, melted at 191–205°.

*Anal.* Calcd. for  $C_{27}H_{42}O_3$ : C, 78.21; H, 10.21. Found: C, 78.24; H, 9.90.

A solution of 0.0233 g. in 3 cc. of chloroform gave  $\alpha = -0.47^\circ$  in a 1-dm. tube;  $[\alpha]^{25}_D -60.6^\circ$ .

**Neotigogenone Oxime.**—A mixture of 23 mg. of neotigogenone, m. p. 205–210°, with 0.04 g. of hydroxylamine hydrochloride, 0.46 g. of sodium acetate, 1 cc. of water and 4 cc. of ethyl alcohol was boiled for one hour. Water was added and the mixture was filtered, dried, and recrystallized by dissolving in 7 cc. of acetone, concentrating to 1.5 cc. and allowing to cool slowly. This gave 12 mg. of fine needles which melted with decomposition at 224.5°. Repeated recrystallization from acetone raised the melting point to 231–232° with decomposition.

*Anal.* Calcd. for  $C_{27}H_{43}O_3N$ : C, 75.48; H, 10.09; N, 3.25. Found: C, 75.20; H, 9.87; N, 3.33.

**Attempted Isomerization of Tigogenin.**—One gram of tigogenin, m. p. 200–202.5°, was dissolved in 100 cc. of 95% ethyl alcohol and this was added to a mixture of 66 cc. of 95% ethyl alcohol and 30 cc. of concentrated hydrochloric acid. After heating for thirty-six hours the mixture was concentrated, cooled and filtered. On fractional crystallization from ethyl alcohol almost all of the material was separated into fractions which melted close to the melting point of tigogenin and gave no depression when mixed with tigogenin. However, about 5 mg. of material melting from 189.5–194.5° was obtained from the mother liquors. This gave no Beilstein test for halogen and a mixture with tigogenin, m. p. 206.5–209°, melted at 193–206°.

### Summary

A new steroid sapogenin has been obtained which is isomeric with tigogenin and has been named "neotigogenin." It has been isolated as the acetate and characterized by oxidation to a monoketone and conversion of the ketone into the oxime.

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[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF HARVARD UNIVERSITY]

## Saponins and Sapogenins. XII. The Product of Direct Oxidation of Echinocystic Acid with Dichromic Acid

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When methyl echinocystate is oxidized with dichromic acid in glacial acetic acid solution, a diketone ester is formed which on saponification loses carbon dioxide to give a diketone, norechinocystenedione.<sup>2</sup> However, if free echinocystic acid is oxidized under the same conditions, one obtains instead of the expected norechinocystenedione an isomeric compound which was believed to be an isomeric diketone and was named "isonorechinocystenedione."

In the hope that a clue would be provided as to the difference in structure of these two compounds we have determined their ultraviolet absorption spectra (Figs. 2 and 3) as well as that of the monoketone, norechinocystenone (Fig. 1). All three compounds contain a carbon-carbon double bond and the nature of the absorption precludes the possibility that this is conjugated with a carbonyl group since such a structure would give an intense absorption band with a maximum near 2350 Å. ( $\log E_m$  about 4.2) and a second band of lower in-

tensity with a maximum near 3200 Å.<sup>3</sup> An  $\alpha$ -diketone is excluded also since such a structure causes absorption in or near the visible region of the spectrum.

Norechinocystenone and norechinocystenedione gave typical carbonyl absorption bands in ethanol (Fig. 1 and Curve II, Fig. 2) with low-intensity maxima between 2900 and 3000 Å. This was not appreciably altered by the addition of alkali (Curve III, Fig. 2) or, in the case of the dione, by changing the solvent to ethyl ether (Curve I, Fig. 2). The second low-intensity maximum in the spectrum of the dione at 2450 to 2500 Å. cannot be attributed to simple carbonyl absorption and will be investigated further.

In the case of "isonorechinocystenedione" it was surprising to find no evidence of carbonyl absorption in ethyl ether (Curve I, Fig. 3). In absolute ethanol, however, it appeared as an inflection (Curve II) which developed in moist alcoholic sodium hydroxide solution into a clearly defined maximum at 2930 Å. (Curve III). This

(1) Commonwealth Fund Fellow.

(2) White and Noller, *THIS JOURNAL*, **61**, 983 (1939).

(3) Fieser, Fry and Jones, *ibid.*, **61**, 1849 (1939).

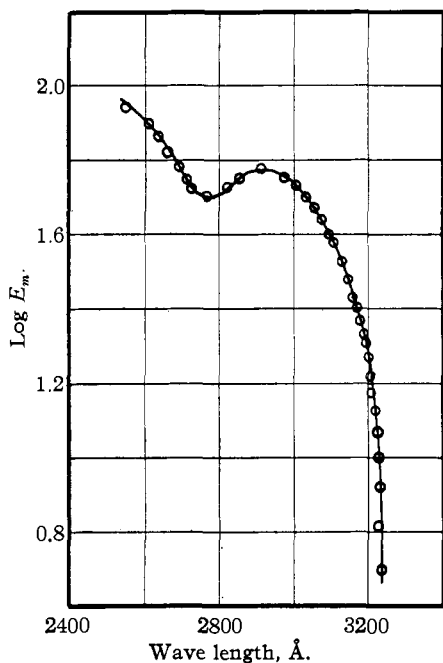


Fig. 1.—Absorption spectrum of norechinocystenone in ethanol.

abnormal behavior cannot be due to a keto-enol type of equilibrium since in the presence of the excess alkali (approximately eighteen moles) one

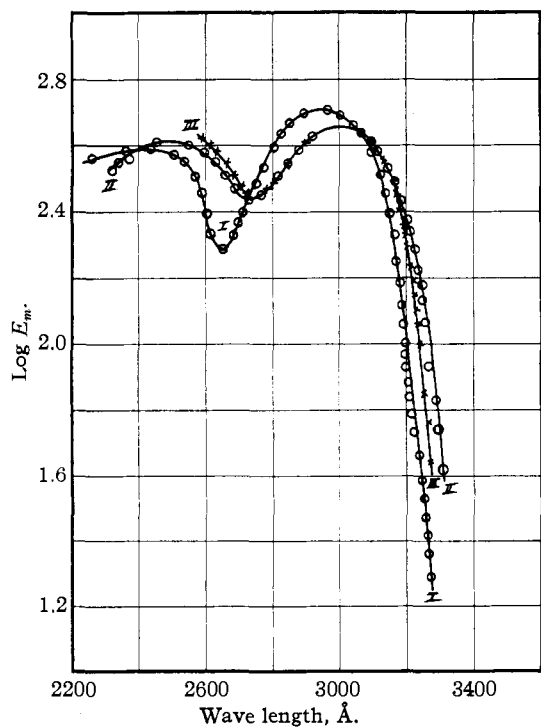


Fig. 2.—Absorption spectra of norechinocystenedione: Curve I in ether, II in ethanol, III in alkaline ethanol.

would expect the enolic form to predominate whereas alkali seems to favor the production of the keto form.

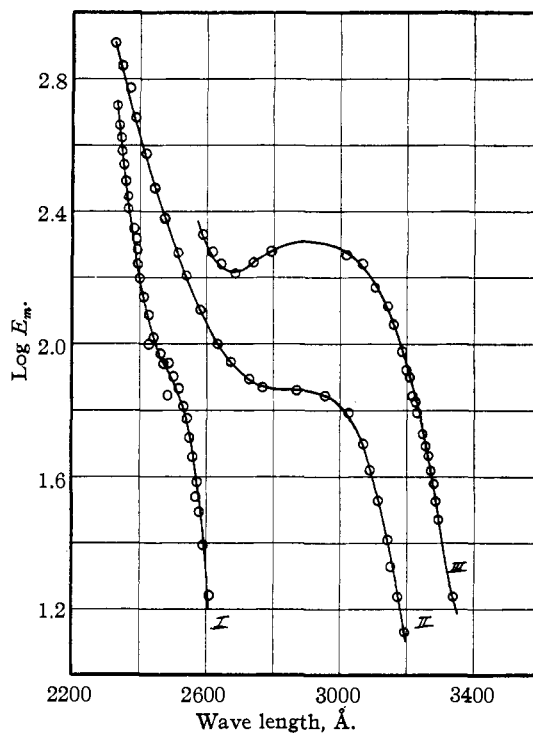


Fig. 3.—Absorption spectra of "isonorechinocystenedione": Curve I in ether, II in ethanol, III in alkaline ethanol.

The above observations led us to return to the chemical investigation of "isonorechinocystenedione." On boiling it with alcoholic potassium hydroxide, it was converted into norechinocystenedione as shown by melting point, mixed melting point and optical rotation. In spite of the spectrographic evidence against the presence of a carbonyl group, the "isodione" reacts with aqueous alcoholic hydroxylamine acidified with acetic acid to give a product the analysis of which is that of a monoxime. Norechinocystenedione and norechinocystenedione give the expected mono- and dioximes, respectively. While the results so far obtained are not sufficient to give a clear picture of the reactions involved, the conversion by alkali of a substance lacking a carbonyl group into a diketone suggests that the "isodione" may be a cyclic hemiacetal of a mono-enol form of the diketone. The reaction product with hydroxylamine in acid solution would then be formed by loss of water between hydroxylamine and the hydroxyl group of the cyclic hemiacetal. Such a structure

suggests a number of reactions that the "isodione" should undergo and the investigation will be continued at the first opportunity.

### Experimental

**Absorption Spectra.**—The spectra were taken with a Bausch and Lomb medium quartz spectrograph in conjunction with a Hilger Spekker photometer and a hydrogen discharge tube. The alkaline solutions of "isonorechinocystenedione" were prepared by adding to a solution of 7.1 mg. in 9 cc. of ethanol, 0.1 cc. of 3 *N* aqueous sodium hydroxide and allowing the solutions to stand for fifteen minutes before beginning the photographing of the spectra. In the case of norechinocystenedione, 0.1 cc. of 2 *N* sodium hydroxide in 90% ethanol was added to a solution of 3.9 mg. of the dione in 5 cc. of ethanol. The dilution effect of this addition of alkali was neglected in the calculation of the molecular extinction coefficients.

The preparation of a suitable alkaline solution of norechinocystenone was difficult because of the low solubility of this substance. A clear solution containing 0.1 ml. of a 2 *N* sodium hydroxide solution in 90% ethanol was finally obtained but as the precise concentration with respect to the ketone was uncertain, exact molecular extinction coefficients could not be calculated. The curve therefore is not reproduced although qualitatively it is similar to that obtained in the absence of alkali (maximum at 2930 Å.) and of the same order of intensity.

**Isomerization of "Isonorechinocystenedione."**—A solution of 0.5 g. of the "isodione" and 0.5 g. of potassium hydroxide in 50 cc. of 95% ethyl alcohol was refluxed for one and one-half hours. The solution became yellow in color and later a deep amber. It was poured into water, most of the alcohol removed by boiling and the precipitate filtered. The crude material after drying melted at 169–181° and after three crystallizations from methyl alcohol the melting point remained constant at 199–200°. A mixed melting point with norechinocystenedione, m. p. 200–203°, gave no depression. The specific rotation was  $[\alpha]_D^{25} -93.2^\circ$  in dioxane compared with the previously recorded value for norechinocystenedione<sup>2</sup> of  $-92.7^\circ$ .

**Monoxime of "Isonorechinocystenedione."**—A solution of 0.5 g. of the "isodione," 0.1 g. of fused sodium acetate and 0.5 g. of hydroxylamine hydrochloride in 75% aqueous ethyl alcohol was refluxed for two hours. Hot water then was added to turbidity and the solution cooled. The crude product weighed 0.44 g. and melted at 248–252° with

some decomposition. After four crystallizations from methyl alcohol the melting point remained constant at 254–257° when the bath was preheated to 240°.

*Anal.* Calcd. for  $C_{29}H_{46}O_2N$ : C, 79.21; H, 10.33; N, 3.18. Found: C, 79.12; H, 10.28; N, 3.33.

**Dioxime of Norechinocystenedione.**—To the alkali insoluble material from the saponification of 1 g. of the diketomethyl ester was added 5 g. of hydroxylamine hydrochloride in 10 cc. of water and 20 cc. of 1% sodium hydroxide solution and then methyl alcohol was added until complete solution had taken place at the boiling point. After refluxing for two hours, concentrating and cooling a product was obtained which after four crystallizations from methyl alcohol melted at 248–249°.

*Anal.* Calcd. for  $C_{29}H_{46}O_2N_2$ : C, 76.60; H, 10.20; N, 6.16. Found: C, 76.41; H, 9.89; N, 6.28.

**Oxime of Norechinocystenone.**—The oxime was prepared as above in methyl alcohol solution from 0.045 g. of norechinocystenone, 0.25 g. of hydroxylamine hydrochloride and 1 cc. of 1% sodium hydroxide. The crude product melted at 253–253.5° and the melting point was unchanged on recrystallization from methyl alcohol.

*Anal.* Calcd. for  $C_{29}H_{47}ON$ : C, 81.82; H, 11.13; N, 3.29. Found: C, 82.01; H, 10.62; N, 3.45.

### Summary

1. The ultraviolet absorption spectra of norechinocystenone and norechinocystenedione confirm the presence of isolated carbonyl groups. That of "isonorechinocystenedione" indicates the absence of carbonyl groups in ether solution but the presence of one or more carbonyl groups in alkaline ethyl alcohol solution.
2. Norechinocystenone and norechinocystenedione form a monoxime and dioxime, respectively, whereas "isonorechinocystenedione" forms only a monoxime.
3. On heating with alcoholic alkali "isonorechinocystenedione" is converted into norechinocystenedione. A possible interpretation of the isomerization is suggested.

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