ylglyoxylate consumed two moles of dinitrophenylhydrazine. The dinitrophenylhydrazones thus obtained were quite pure and not contaminated with ethyl phenylglyoxylate which could have been formed by transesterification. Hydrolysis was accomplished by refluxing with potassium bicarbonate in aqueous methanol. The dinitrophenylhydrazone of phenylglyoxylic acid and the free steroid alcohols which resulted from this fission were obtained in quantitative yields. The phenylglyoxylate dinitrophenylhydrazones of cholesterol, cholestane-3β-ol and (−)-neomenthol[4] showed a maximum at 387–388 mμ, that of dehydroepiandrosterone at 372 mμ.

Experimental[5]

Ethyl *d*-Camphor 10-Sulfonate Dinitrophenylhydrazone.—The crude product was chromatographed, eluted with mixtures of benzene and chloroform, and crystallized from chloroform–ethanol; m.p. 156–158°, λ Chf 362 mμ.

Anal. Calcd. for $C_{18}H_{24}O_7N_4S$: N, 12.72. Found: N, 12.82.

Cholesteryl *d*-Camphor 10-Sulfonate.—To a cooled solution of 64 mg. of cholesterol in 0.5 cc. of pyridine 71.4 mg. of *d*-camphor 10-sulfonyl chloride was added. The mixture was kept in the cold room overnight. After addition of ice and standing at room temperature for 1 hr., the crystals were filtered, washed with water, dried and recrystallized twice from ether–methanol. The ester formed white leaflets, m.p. 162–164.5°.

Anal. Calcd. for $C_{37}H_{60}O_4S$: S, 5.34. Found: S, 5.30.

Cholesteryl *d*-Camphor 10-Sulfonate Dinitrophenylhydrazone.—A solution of 45 mg. of cholesteryl *d*-camphor 10-sulfonate in 1 cc. of absolute ethanol and 0.5 cc. of chloroform was mixed with a solution of 15 mg. of dinitrophenylhydrazine in 1.8 cc. of absolute ethanol and 4 drops of concentrated hydrochloric acid. After standing at room temperature for 37 hours, the excess reagent was converted to pyruvic acid dinitrophenylhydrazone[6] which was removed by extraction with sodium carbonate. The neutral dinitrophenylhydrazone, crystallized from chloroform–ethanol, melted at 97–102°.

Anal. Calcd. for $C_{43}H_{64}O_7N_4S$: N, 7.18. Found: N, 6.77.

Cholestane-3β-yl Phenylglyoxylate Dinitrophenylhydrazone.—A solution of 27.4 mg. of dinitrophenylhydrazine in 3 cc. of absolute ethanol and 6 drops of concentrated hydrochloric acid was mixed with a solution of 29.6 mg. of cholestane-3β-yl phenylglyoxylate in 3 cc. of chloroform. The reagent utilized after 1 hr. amounted to 0.95 mole. The neutral dinitrophenylhydrazone was chromatographed and eluted with hexane–benzene (2:3 to 1:4). It crystallized from chloroform–ethanol in yellow granules, m.p. 244–246.5°, λ^{Chf} 387 mμ.

Anal. Calcd. for $C_{41}H_{56}O_6N_4$: N, 8.00. Found: N, 8.14.

The same derivative was obtained, when the reaction was carried out in chloroform–acetic acid.[6]

Hydrolysis was accomplished by refluxing 27.9 mg. of dinitrophenylhydrazone and 140 mg. of potassium bicarbonate in a mixture of 6 cc. of methanol and 3.2 cc. of water for 23 hr. The acidic material was separated and the hydrolysis repeated. The phenylglyoxylic acid dinitrophenylhydrazone isolated amounted to 13.0 mg. (calculated 13.15 mg.). After recrystallization from aqueous acetic acid, it melted at 202–203.5° (lit.[7] m.p. 196–197°). The neutral material weighed 15.2 mg. (calculated 15.5 mg.). After chromatography and recrystallization from 95% ethanol, cholestane-3β-ol, m.p. 143–144°, was obtained.

(5) Microanalyses by Huffman Microanalytical Laboratories, Wheatridge, Colo. All melting points were observed on a Kofler hot-stage. Acid-washed Alcoa aluminum oxide was used for chromatography. The ultraviolet spectra were taken in chloroform.

(6) H. Reich, K. F. Crane and S. J. Sanfilippo, *J. Org. Chem.*, **18**, 822 (1953).

(7) B. B. Corson, N. E. Sanborn and P. R. Van Ess, THIS JOURNAL, **52**, 1623 (1930).

Cholesteryl Phenylglyoxylate.—A mixture of 0.2 cc. of phenylglyoxylic acid chloride and 1 cc. of absolute benzene was added to a solution of 200 mg. of cholesterol in 1 cc. of absolute pyridine and 1.5 cc. of absolute benzene. After standing overnight, ice was added, followed by extraction with hexane. The solutions were washed to neutrality, dried and chromatographed. The fractions eluted with hexane and hexane–benzene (to 7:3) were crystallized from ether–methanol and gave white leaflets, m.p. 120–122°.

Anal. Calcd. for $C_{35}H_{50}O_3$: C, 81.03; H, 9.72. Found: C, 81.07; H, 9.81.

Cholesteryl Phenylglyoxylate Dinitrophenylhydrazone.—This compound was prepared in the same manner as the corresponding cholestanyl derivative. The dinitrophenylhydrazine utilized amounted to 0.94 mole. The dinitrophenylhydrazone, after chromatography (eluted with hexane–benzene 1:1 to 1:4) and crystallization from chloroform–ethanol, melted at 233–235°, λ^{Chf} 387 mμ.

Anal. Calcd. for $C_{41}H_{54}O_6N_4$: N, 8.02. Found: N, 8.20.

When the reaction was carried out in chloroform–acetic acid, more than the calculated amount of dinitrophenylhydrazine was utilized. The reaction product was contaminated with a red dinitrophenylhydrazone and difficult to purify.

Dehydroepiandrosteryl Phenylglyoxylate.—This ester was prepared from 150 mg. of dehydroepiandrosterone and 0.4 cc. of phenylglyoxylic acid chloride as described above. After chromatography (eluted with mixtures of hexane and benzene) and crystallization from chloroform–methanol, it melted at 186–187°.

Anal. Calcd. for $C_{27}H_{32}O_4$: C, 77.11; H, 7.67. Found: C, 76.63; H, 8.04.

Dehydroepiandrosteryl Phenylglyoxylate Bisdinitrophenylhydrazone.—A solution of 16.4 mg. of the phenylglyoxylate in 4 cc. of chloroform was added to a solution of 31.0 mg. of dinitrophenylhydrazine in 4 cc. of absolute ethanol and 8 drops of concentrated hydrochloric acid. The mixture was worked up as described above. The reagent utilized amounted to 1.88 moles. The dinitrophenylhydrazone was chromatographed, eluted with mixtures of benzene and chloroform, and crystallized from chloroform–ethanol. It melted at 264–266° dec., λ^{Chf} 372 mμ.

Anal. Calcd. for $C_{39}H_{40}O_{10}N_8$: N, 14.35. Found: N, 14.04.

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Furo-chromones and -Coumarins (X): On the Constitution of Prangenin

BY ALEXANDER SCHÖNBERG AND GAMIL AZIZ

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Pigulevskii and Kuznetsova[1] have isolated from *Prangos pabularia* a compound which they believe to be a substance of the constitution (Ia)[2] which they named prangenin.

Formula Ia shows a butyl ether of xanthotoxol and the aim of the investigation is to establish which of the four possible isomers, normal, iso, *sec-* or *t*-butyl ether is identical with prangenin, m.p. 97°.

Schönberg and Sina[3] have described the *n*-butyl ether, m.p. 83°; this therefore is not identical with prangenin.

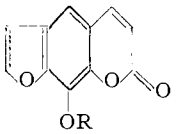
The authors allowed xanthotoxol (Ib) to react in acetone with *sec*-butyl iodide and with isobutyl io-

(1) G. V. Pigulevskiĭ and G. A. Kuznetsova, *Zhur. Obshchei Khim.*, **23**, (7), 1237 (1953).

(2) Unfortunately the abstract of the Russian paper (*C. A.*, **47**, 12341f (1953)) is not free from errors: in structure (I) "Bu" should be replaced by "C_4H_9" and "IV" next to the last line should read (II).

(3) A. Schönberg and A. Sina, THIS JOURNAL, **72**, 4826 (1950).

dide in the presence of potassium carbonate and obtained the secondary and isobutyl ethers, respectively (m.p. 62 and 59°). These two ethers, as well as the normal ether previously prepared, were dealkylated easily by the magnesium iodide method[4] to xanthotoxol (Ib); this establishes their constitution beyond doubt.



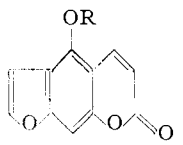
Ia, R = C_4H_9
b, R = H
c, R = $CH_2CH{=}C(CH_3)_2$

An analogous experiment carried out with *t*-butyl iodide did not lead to the isolation of *t*-butyl ether of xanthotoxol; *t*-butyl ethers are unlikely to be obtained by the action of *t*-butyl iodide on phenols.[5]

From the foregoing we conclude that provided there is no case of dimorphism, prangenin is neither the normal, the iso, nor the *sec*-butyl ether of xanthotoxol. It may, however, be the *t*-butyl ether. *t*-Butyl ethers of phenols are, however, very rare in nature.

Attention is drawn to the great similarity between prangenin (m.p. 97°) and imperatorin[6] (Ic). Both are colorless substances, insoluble in alkali, giving xanthotoxol on acid hydrolysis. The analytical values, apart from the values for carbon, show the similarity. Prangenin: Found: C, 70.00, 70.24; H, 5.28, 5.38, mol. wt., 244, 265. Calcd. for imperatorin: C, 71.1; H, 5.2; mol. wt., 270.

In this connection it should be mentioned that the authors succeeded in demethylating bergapten (IIa) to bergaptol (IIb) by the magnesium iodide method.[4] This substance seems not to have been prepared previously from this source. The identity of the bergaptol so obtained was proved by reconverting it into bergapten (methyl iodide–potassium method).



IIa, R = CH_3
b, R = H

Experimental

Butylation of Xanthoxol (Ib). *sec*-Butyl Ether.—A mixture of 1 g. of Ib, in 150 cc. of dry acetone, 3 cc. of *sec*-butyl iodide and 5 g. of potassium carbonate was refluxed for 36 hours and filtered while hot; the acetone was distilled off in a vacuum and the residue was crystallized from light petroleum (b.p. 50–70°) in colorless needles, m.p. 62°, insoluble in 10% sodium hydroxide, easily soluble in methyl alcohol; yield 0.42 g. *Anal.* Calcd. for $C_{15}H_{14}O_4$: C, 69.8; H, 5.5. Found: C, 69.6; H, 5.5.

The isobutyl ether was similarly prepared using isobutyl iodide; colorless needles, m.p. 59°, were obtained from light petroleum (b.p. 50–70°); the substance gave a strong depression in m.p. with the *sec*-butyl ether and was insoluble in 10% sodium hydroxide solution. *Anal.* Calcd. for $C_{15}H_{14}O_4$: C, 69.8; H, 5.4. Found: C, 69.6; H, 5.2.

Dealkylation of the *n*-Butyl Ether of Xanthotoxol (Ib).—0.4 g. of the ether was dissolved in 5 cc. of benzene (anhydrous), and magnesium iodide (prepared from 0.8 g. of iodine and 0.1 g. of magnesium) in 15 cc. of dry ether was added. The organic solvents were driven off in a vacuum and the residue was heated in an oil-bath at 160–170° (bath temperature) in a stream of dry carbon dioxide for 2 hours, allowed to cool and then decomposed with dilute sulfuric acid. The deposit was washed with water and then with aqueous sodium bisulfite. After crystallization from dioxane colorless crystals soluble in aqueous 10% sodium hydroxide were obtained; m.p. 246° not depressed by the addition of an authentic sample of xanthotoxol; yield 70–80%.

Dealkylation of the secondary and the isobutyl ethers was carried out in a similar manner yielding xanthotoxol in both cases (identified as previously).

Demethylation of Bergapten (IIa).—0.75 g. of bergapten was dissolved in 60 cc. of dry benzene and added to a solution of magnesium iodide (prepared from 2 g. of iodine and 0.25 g. of magnesium) in 20 cc. of dry ether; the solvents were distilled off in a vacuum and the residue dried at 120° for 15 minutes, after which the bath temperature was raised to 160–165°. After heating for 90 minutes, the reaction product was decomposed with dilute sulfuric acid and the deposit washed as in the case of the dealkylation of the *n*-butyl ether of xanthotoxol. The reaction product was crystallized from acetone–ether (1:1 by volume) and sublimed in vacuum (oil-pump) at 240–260° (bath temperature). Light yellow crystals were obtained, m.p. 276°.[7] IIb dissolves in 10% alkali with a yellow color. *Anal.* Calcd. for $C_{11}H_6O_4$: C, 65.3; H, 3.0. Found: C, 64.8; H, 3.1.

Bergapten from Bergaptol.—For further identification, bergaptol was transformed into bergapten. To 0.5 g. of bergaptol dissolved in 50 cc. of dry hot acetone, 4 g. of methyl iodide and 3 g. of potassium carbonate was added. After 32 hours refluxing, acetone was distilled off in vacuum and the residue purified by sublimation in vacuum (bath temperature 160°). Colorless needles insoluble in 10% sodium hydroxide were obtained; m.p. and mixed m.p. with an authentic sample 188°.

(4) A. Schönberg and R. Moubasher, *J. Chem. Soc.*, 462 (1944).

(5) E. W. Lewis, *ibid.*, **83**, 329 (1903).

(6) The m.p. of imperatorin (102°) is not quite definite in consequence of the thermal rearrangement into alloimperatorin (E. Späth and H. Holzen, *Ber.*, **68**, 1123 (1935)).

(7) E. Späth and L. Kahovec (*ibid.*, **66**, 1149 (1933)) gave m.p. 277°.

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The Preparation of *dl*-Alloisocitric Lactone

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The preparation of *dl*-isocitric lactone has been thoroughly studied.[1] This is the racemic lactone corresponding to the dextrorotatory isomer of isocitric acid which is found in plant tissues.[2] The diastereoisomeric racemate, *dl*-alloisocitric lactone, has not previously been prepared in a pure form, although Pucher and Vickery[1b] isolated a fraction rich in this material from the mother liquors of a preparation of *dl*-isocitric lactone by the method of Fittig and Miller.[1a]

A supply of *dl*-alloisocitric lactone was desired for stereochemical studies and for investigations of the biochemical activities of compounds related to the Krebs cycle. Attempts to isolate a pure substance from the impure material described by Pucher and Vickery were unsuccessful. Preparation of this pure racemate in a reasonable yield from *dl*-isocitric lactone proved feasible when the conditions used by Fisher[3] for epimerization of α-hydroxy acids of the sugar series were tried. An attempt to decide, through anhydride formation, which of these race-

(1) (a) R. Fittig and H. Miller, *Ann.*, **255**, 43 (1889); (b) G. W. Pucher and H. B. Vickery, *J. Biol. Chem.*, **163**, 169 (1946); (c) H. A. Krebs and L. V. Eggleston, *Biochem. J.*, **38**, 431 (1944); (d) H. P. Kato and S. R. Dickman in "Biochemical Preparations," Vol. 3, E. E. Snell, Ed., John Wiley and Sons, Inc., New York, N. Y., 1953, p. 52.

(2) G. W. Pucher and H. B. Vickery, *J. Biol. Chem.*, **145**, 525 (1942).

(3) E. Fisher, *Ber.*, **23**, 799 (1890).