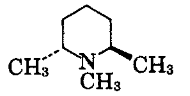
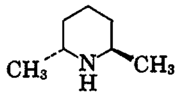
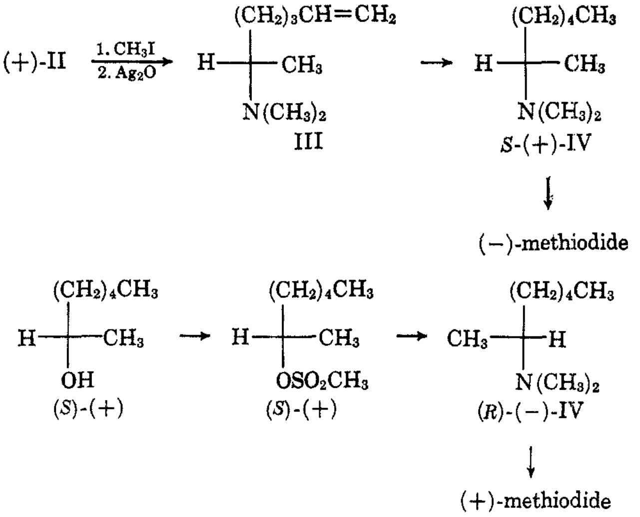
Repetition of the sequence with (−)-II gave (−)-IV.

To determine the absolute configuration of IV, (*S*)-(+)-2-heptanol[5] was converted to the mesylate and treated with dimethylamine to afford, *via* Walden inversion, (*R*)-(−)-IV.

These correlations establish the configuration of natural(−)-II as (2*R*:6*R*). Since Kuzovkov and Menshikov[2] showed that both *Nanophyton* bases belong to the same configurational series by methylating (−)-I to (−)-II, both levorotatory bases have the (*R*) configuration at both asymmetric centers, as shown.


(2*R*, 6*R*)-(−)-II


(2*R*, 6*R*)-(−)-I



Experimental Section

trans-**2,6-Dimethylpiperidine** (*dl*-I).—A mixture of *cis*- and *trans*-2,6-dimethylpiperidines was prepared by sodium–ethanol reduction of 2,6-lutidine, following the literature procedure.[3,6] Repeated distillation of the mixture through an 18-in. spinning-band column gave pure *trans*-I, bp 136–138° (lit. bp 133–134°, 136–137°). Vpc analysis showed the absence of the *cis* isomer.

The **hydrochloride** was recrystallized from ethyl acetate–ethanol and melted at 236–238° (lit.[3,6] mp 232–234°, 240–242°).

Anal. Calcd for $C_7H_{16}ClN$: C, 56.18; H, 10.78; N, 9.36. Found: C, 56.21; H, 10.82; N, 9.18.

trans-**1,2,6-Trimethylpiperidine** (*d,l*-II).—To a cooled solution of 30.4 g of 90% formic acid and 22.2 g of 37% aqueous formaldehyde solution was added 26.8 g of racemic I. The mixture was refluxed for 12 hr, treated with 20 ml of concentrated hydrochloric acid, and heated on the steam bath for several hours. The solution was made basic with 20% sodium hydroxide and extracted with ether. After drying, distillation gave 22.7 g of *dl*-II, bp 154–155° (lit.[2,4] bp 151.5°, 153–154°).

The **picrate** was recrystallized from water and melted at 255.5–257° dec (lit.[4] mp 244–245° dec).

Anal. Calcd for $C_{14}H_{20}N_4O_7$: C, 47.19; H, 5.66; N, 15.72. Found: C, 47.35; H, 5.75; N, 15.61.

The **methiodide**, after recrystallization from ethanol, melted at 324–325° dec (lit.[4] mp 313° dec).

Anal. Calcd for $C_9H_{20}IN$: C, 40.16; H, 7.49; N, 5.20. Found: C, 40.17; H, 7.67; N, 5.31.

Partial Resolution of *dl*-**II.**—To a nearly saturated solution of 23.6 g of *d*-tartaric acid in hot ethanol was added 20 g of *dl*-II and the resulting solution was cooled overnight. The salt obtained (26 g) was repeatedly recrystallized from ethyl acetate–ethanol until the weight dropped to 5 g. This salt was dissolved in water, made alkaline with 20% sodium hydroxide, and extracted with ether. Concentration of the dried ether solution gave 1.8 g of II, $[\alpha]^{23}_{\mathrm{D}}$ +7.7° (neat, 1-dm tube). Since the naturally occurring enantiomer has $[\alpha]_{\mathrm{D}}$ −43.02° (neat, 1-dm tube),[2] the partially resolved base is about 18% optically pure.

The **methiodide**, recrystallized from ethanol, melted at 318–320° dec.

Anal. Calcd for $C_9H_{20}IN$: C, 40.16; H, 7.49; N, 5.20. Found: C, 40.12; H, 7.46; N, 5.25.

Hofmann Elimination of (+)-**II. A.**—The Hofmann elimination was carried out as described[4] for *dl*-II. A suspension of silver oxide (from 1.63 g of silver nitrate) in 17.5 ml water was stirred with 1.35 g of the methiodide of (+)-II in the dark for 5 hr. The mixture was filtered, the filtrate was concentrated *in vacuo*, and the residue was heated at 100° at 18 mm. The distillate was treated with potassium carbonate and extracted with ether; concentration of the dried ether solution left 0.28 g of 2-dimethylaminohept-6-ene (III). This substance was not characterized, except for the infrared bands at 915 and 997 cm^{-1}, consistent with the structure assigned by Lukeš and Jizba.[4]

III was taken up in 5 ml of ethanol and 0.2 ml of concentrated hydrochloric acid and hydrogenated over 5% palladium–charcoal. Filtration and concentration of the filtrate gave 0.32 g of solid hydrochloride. Since repeated recrystallization of this hydrochloride did not give material with a satisfactory analysis, it was converted to the **methiodide of IV**, mp 195.5–196.5°, recrystallization from ethanol, $[\alpha]^{24}_{\mathrm{D}}$ −4.7° (*c* 1.3, chloroform).

Anal. Calcd for $C_{10}H_{24}IN$: C, 42.11; H, 8.48; N, 4.99. Found: C, 42.38; H, 8.81; N, 4.88.

B.—(−)-II was recovered from the mother liquors of the resolution, and the Hofmann elimination and subsequent hydrogenation were carried out as above on 2 g of II, $[\alpha]^{24}_{\mathrm{D}}$ −2.0° (neat, 1-dm tube). The 2-dimethylaminoheptane (IV) produced had $[\alpha]^{22}_{\mathrm{D}}$ −0.3° (neat, 1-dm tube), and an infrared spectrum identical with that of authentic IV.

Preparation of 2-Dimethylaminoheptane (IV) **from 2-Heptanol.**—2-Heptanol was resolved by the procedure of Kenyon and Walch,[7] giving material, bp 77–78° (24 mm), $[\alpha]^{25}_{\mathrm{D}}$ +7.3° (*c* 13.5, ethanol) [lit.[8] bp 73.5° (20 mm), $[\alpha]^{20}_{\mathrm{D}}$ +10.32°]. This was converted to the methanesulfonate, bp 75–76° (0.1 mm), $[\alpha]^{23}_{\mathrm{D}}$ +6.9° (neat, 1-dm tube) [lit.[9] bp 77–79° (1 mm), $[\alpha]^{25}_{\mathrm{D}}$ +20.96° (neat, 2-dm tube)].

The methanesulfonate (4.0 g) and dimethylamine (2.9 g) in 10 ml of benzene were heated in a pressure bottle at 90–100° for 12 hr. The reaction mixture was partitioned between benzene and dilute hydrochloric acid and the aqueous phase extracted several times with benzene. The aqueous layer was made basic with potassium carbonate and extracted with ether; after drying, distillation gave 1.3 g of 2-dimethylaminoheptane (IV), bp 56–58° (17 mm) (lit.[10] bp 160–163°), $[\alpha]^{22}_{\mathrm{D}}$ −2.6° (neat, 1-dm tube), $[\alpha]^{25}_{\mathrm{D}}$ +1.4° (*c* 0.75, ethanol, this rotation was obtained on a Cary 60 ord instrument).

The **methiodide**, after recrystallization from ethanol, melted at 195–196°, $[\alpha]^{24}_{\mathrm{D}}$ +11.5° (*c* 0.87, chloroform). The infrared spectrum was identical with that of the methiodide from Hofmann degradation of II.

Anal. Calcd for $C_{10}H_{24}IN$: C, 42.11; H, 8.48; N, 4.99. Found: C, 42.13; H, 8.74; N, 4.91.

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(6) A. Marcuse and R. Wolffenstein, *Ber.*, **32**, 2525 (1899).

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(9) H. R. Williams and H. S. Mosher, *J. Am. Chem. Soc.*, **76**, 3495 (1954).

(10) L. P. Friz and D. D. Bella, *Boll. Chim. Farm.*, **101**, 527 (1962): *Chem. Abstr.*, **59**, 1465 (1963).

Citrus Carotenoids. V. The Isolation of 8′-Hydroxy-8′,9′-dihydrocitranaxanthin

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In a previous communication,[2] we have described the isolation and structure determination of a new carot-

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[1] A laboratory of the Western Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

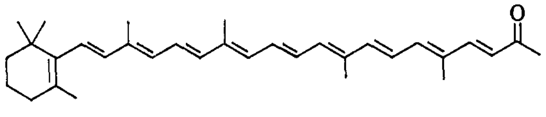
[2] H. Yokoyama and M. J. White, *J. Org. Chem.*, **30**, 2481 (1965).

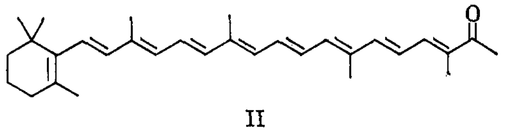
enoid ketone, citranaxanthin (I), whose unique feature is the terminal methyl ketone grouping in the side chain. This pigment was isolated from the flavedo of the trigeneric hybrid, Sinton citrangequat (*Citrus sinensis* × *Poncirus trifoliata* × *Fortunella margarita*).

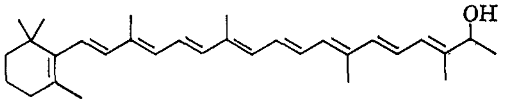
We wish to report herein a new carotenoid ketone containing the same carbon skeleton as citranaxanthin (I) but possessing an in-chain hydroxyl group at the 8′ position. Accordingly, we have designated this new carotenoid 8′-hydroxy-8′,9′-dihydrocitranaxanthin. This pigment was also isolated from the flavedo of the Sinton citrangequat.

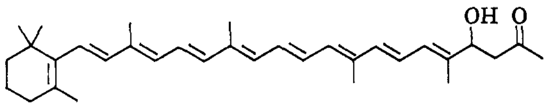
The seasonal variation in the amount of the carotenoid ketone sintaxanthin (II) present in the flavedo of the Sinton citrangequat was reported earlier.[3] Accompanying the increased amount of sintaxnathin found in the fruit collected in February 1965 was a significant amount of 8′-hydroxy-8′,9′-dihydrocitranaxanthin. This same distribution pattern was also observed in the fruit collected in late February 1966.

The visible spectrum (Figure 1) of 8′-hydroxy-8′,9′-dihydrocitranaxanthin recorded in *n*-hexane exhibited fine structure and indicated a nonaene chromophore similar to that of sintaxanthol (III).[3] The infrared spectrum showed the presence of a hydroxyl (3450 cm^{-1}) and a chelated carbonyl (1660 cm^{-1}) group.[4]


I


II


III


IV

The nmr spectrum exhibited singlets at τ 7.75 (Me α to a carbonyl group),[2,3] 8.03 (in-chain olefinic Me),[5] 8.15 (Me on C adjacent to a carbinol group),[3] 8.25 (Me attached to C=C in the cyclohexene ring),[5] and 8.97 (*gem*-Me$_2$).[5]

Treatment of IV with hydrogen chloride in chloroform resulted in a bathochromic shift in the absorption maxima and the isolated dehydration product was identical in every respect with citranaxanthin (I).

On the basis of the results described above, the structure of 8′-hydroxy-8′,9′-dihydrocitranaxanthin can be represented as IV. The structure of the compound was proved by synthesis from β-apo-8′-carotenal.

The structure of 8′-hydroxy-8′,9′-dihydrocitranaxanthin (IV) suggests that it might have a biogenetic relationship to sintaxanthin (II). The allylic hydroxyl group at the 8′ position can be readily oxidized (with MnO$_2$) to the ketone to give rise to a β-diketone, followed by deacetylation (base cleavage) of the β-diketone to afford sintaxanthin (II). Preliminary studies[6] indicate that in the ripening fruit there is an initial build-up of the decaenone carotenoid citranaxanthin (I). At full maturity there is accumulated a maximum amount of citranaxanthin. The maximum amount of sintaxanthin (II) appears subsequent to full maturity and is accompanied by a decrease in citranaxanthin. The validity of the postulated sequence must await biosynthetic experiments.

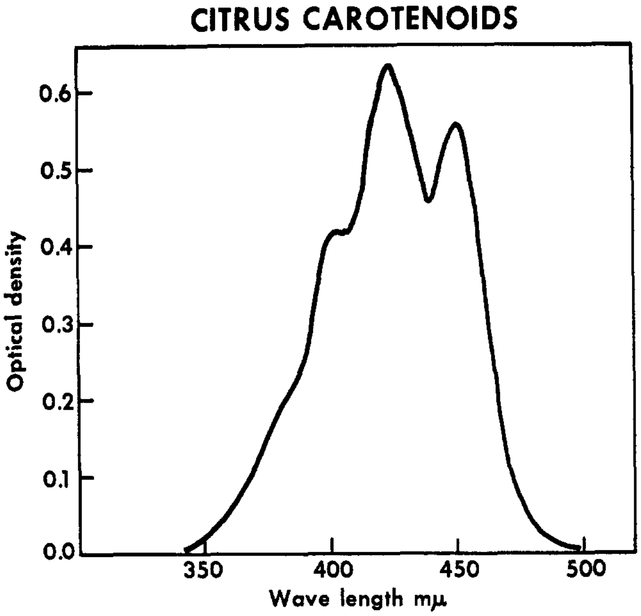


Figure 1.—Absorption spectrum of 8′-hydroxy-8′,9′-dihydrocitranaxanthin in *n*-hexane.

Experimental Section[7]

All melting point determinations were carried out in evacuated, sealed capillary tubes on an Electrothermal melting point apparatus and are uncorrected. Visible spectra were taken on a Cary Model 14 spectrophotometer. Infrared spectra were recorded in carbon tetrachloride and carbon disulfide or as KBr disks on Perkin-Elmer, Models 137 and 521, spectrophotometers. The nmr spectra were taken in carbon tetrachloride–deuteriochloroform on a Varian A-60 spectrometer, using tetramethylsilane as an internal standard. Relative areas of the peaks were consistent with assignments.

Isolation of 8′-Hydroxy-8′,9′-dihydrocitranaxanthin.—The fruit of the Sinton citrangequat was collected in late February 1966. The peel (15 kg) was separated from the endocarp and extracted with several portions of methanol. The mixture was transferred to ether, washed with water, dried over anhydrous magnesium sulfate, and evaporated to dryness *in vacuo*. The residue was taken up in methanol, and the pigment mixture was partitioned between 99% methanol and *n*-hexane. Chromatography of the hypophase on a column of Microcel C isolated the hydroxy ketone. Crystallization from peroxide-free ether–petroleum ether (bp 30–60°) afforded 60 mg of the pure hydroxy ketone: mp 146–147°; λ_{max} in *n*-hexane 402, 423, and 449 mμ; infrared bands at 3450 (hydroxyl), 1660 (chelated carbonyl), 1570 (conjugated C=C), and 965 cm^{-1} (*trans* CH=CH); nmr signals at τ 7.75, 8.03, 8.15, 8.25, and 8.97.

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[5] M. S. Barber, J. B. Davis, L. M. Jackman, and B. C. L. Weedon, *J. Chem. Soc.*, 2870 (1960).

[6] H. Yokoyama and M. J. White, unpublished data.

[7] Reference to a company or product does not imply approval or recommendation of the product by the U. S. Department of Agriculture to the exclusion of others that may be suitable.

Anal. Calcd for $C_{33}H_{46}O_2$: C, 83.47; H, 9.78. Found: C, 83.3; H, 9.81.

Dehydration of 8′-Hydroxy-8′,9′-dihydrocitranaxanthin.—A solution of 45 mg of the 8′-hydroxycitranaxanthin in 50 ml of chloroform was treated with 10 drops of chloroform–HCl reagent[8] allowed to stand for 20 min, and then diluted with petroleum ether. The mixture was then washed with sodium bicarbonate solution and water, and dried over anhydrous sodium sulfate. The solvents were removed *in vacuo*, and the residue was dissolved in *n*-hexane and chromatographed on a column of deactivated alumina developed and eluted with 40% ether in *n*-hexane. The zone corresponding to the dehydration product was isolated and crystallized from *n*-hexane, yielding 12 mg, mp 156–158°, undepressed on admixture of synthetic citranaxanthin; both samples exhibited the same thin layer chromatographic behavior. The nmr spectrum[2] [singlets at τ 7.72, 8.02, 8.25, and 8.93; doublet at 2.52 (J = 16 cps)] is in full accord with structure I. Further proof of identity with authentic sample of citranaxanthin was established by infrared and visible spectroscopy.

8′-Hydroxy-8′,9′-dihydrocitranaxanthin (IV).—A solution of 0.5 g of β-apo-8′-carotenal in 3 ml of acetone and 5 ml of ethanol was cooled to *ca.* 0° and added to a cold (*ca.* 0°) mixture of 0.5 ml of 0.1 N potassium hydroxide and 5 ml of ethanol. The reaction mixture was stirred, allowed to stand in the cold (*ca.* 0°) overnight, and then diluted with ether. The ethereal layer was washed with water and dried over anhydrous magnesium sulfate. The solvent was removed *in vacuo;* the residue was dissolved in 1% acetone–petroleum ether and was chromatographed on a column of Microcel C. IV was isolated and crystallized from peroxide-free ether–petroleum ether, yielding 80 mg, mp 145–147°. Both the synthetic and natural samples displayed the same thin layer chromatographic behavior. The nmr spectra (signals at τ 7.75, 8.03, 8.15, 8.25, and 8.97) is in full accord with structure IV. The infrared and visible spectra were superimposable on those of the natural sample.

Anal. Calcd for $C_{33}H_{46}O_2$: C, 83.47; H, 9.78. Found: C, 83.4; H, 9.71.

Acknowledgment.—The authors are indebted to Dr. David Dreyer for his helpful discussion and to Dr. R. J. Krukar of Hoffmann-LaRoche, Inc., Nutley, New Jersey, for generous samples of β-apo-8′-carotenal. The authors are also grateful to Dr. J. Furr, U. S. Department of Agriculture Date and Citrus Station, Indio, California; Dr. E. Olson, U. S. Department of Agriculture Crops Research Division, Weslaco, Texas; and Dr. P. Reece, U. S. Department of Agriculture Crops Research Division, Orlando, Florida, for fruit collections.

(8) L. Wallcave and L. Zechmeister, *J. Am. Chem. Soc.*, **75**, 4495 (1953).

Mechanism of the Reaction of Trialkylphosphine Dihalides with Alcohols. Isolation of an Alkoxytrialkylphosphonium Halide

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Received June 6, 1966

Wiley[1] recently described an extremely useful method for the conversion of alcohols to halides without isomerization. For example, a 91% yield of neopentyl bromide was obtained by treatment of neopentyl alcohol with tributylphosphine and bromine. As a result of a study of its stereochemistry and kinetics, Wiley[2] has proposed that the reaction probably proceeds by way of the rapid, irreversible formation of an alkoxytrialkylphosphonium intermediate followed by its slow decomposition to alkyl halide and trialkylphosphine oxide by way of an S_N2 displacement.

In the course of preparing 2,2,2-triphenylethyl bromide, which was needed in another study, from 2,2,2-triphenylethanol by use of Wiley's procedure we have isolated from the reaction mixture (2,2,2-triphenylethoxy)tributylphosphonium bromide.[3] We believe that this isolation and the characterization[4] of the proposed intermediate constitutes strong supporting evidence for Wiley's mechanism. Within the framework of this mechanism, the successful isolation of the proposed intermediate in this particular case may be explained in terms of the difficulty of S_N2 displacement at a center adjacent to a trityl group.

Experimental Section

2,2,2-Triphenylethanol (1.0 g, 0.0036 mole), prepared by lithium aluminum hydride reduction of triphenylacetic acid, and 1.0 ml (0.0040 mole) of tributylphosphine (Aldrich) in 3.4 ml of dimethylformamide (Matheson Coleman and Bell, stored over potassium hydroxide) were treated dropwise under nitrogen with 0.19 ml (0.0037 mole) of bromine, the temperature being maintained below 55°. The reaction mixture was poured into a mixture of 50 ml of water and 30 ml of ether. The aqueous phase was extracted with two 20-ml portions of ether and the combined organic phases washed with two 20-ml portions of water, dried with sodium sulfate, and evaporated under vacuum. Crystallization of the resulting 1.95 g of oil and solid from petroleum ether–benzene yielded 0.95 g[6] of (2,2,2-triphenylethoxy)tributylphosphonium bromide, mp 128–129°, whose nmr ($CDCl_3$) spectrum consisted of absorption at τ = 2.7–2.8, a poorly resolved doublet centered at τ = 4.66, very broad absorption centered at τ = 7.3 and complex absorption centered at τ = 8.6 and 9.1 ppm, with relative areas of 15, 1.9, 5.4, and 21, respectively.

Anal. Calcd for $C_{32}H_{44}BrOP$: C, 69.18; H, 7.98; Br, 14.38. Found: C, 68.94; H, 8.19; Br, 14.67.

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(1) G. A. Wiley, R. L. Hershkowitz, B. M. Rein, and B. C. Chung, *J. Am. Chem. Soc.*, **86**, 964 (1964).

(2) G. A. Wiley, B. M. Rein, and R. L. Hershkowitz, *Tetrahedron Letters*, 2509 (1964).

(3) By using this nomenclature we do not imply anything about the nature of the phosphorus–bromine bond.

(4) In the only previous report[5] of the preparation (from R_3POR and $R'I$) of an alkoxytrialkyl phosphonium halide, elemental analysis and the nature of the decomposition products were the basis of the assignment of structure.

(5) A. I. Razumov and N. N. Bankovskaya, *Dokl. Akad. Nauk S.S.S.R.*, **116**, 241 (1957).

(6) No attempt has been made to maximize the yield or to determine the total amount actually formed because the results reported here suffice to establish the principal point of this Note, that an alkoxytrialkylphosphonium halide is formed under the reaction conditions. It would of course be desirable, in addition to demonstrating the formation of the "salt" in the reaction mixture, to show that it is on the reaction path to product bromide. In view of the fact that this material is stable for many months at room temperature and melts without structural change at a temperature about 75° above the usual reaction temperature, we feel that the temperature necessary for the "salt" to decompose is sufficiently far from the reaction temperature so as to make any decomposition results inapplicable to the reaction as usually run.