The Constitution of Bronianone

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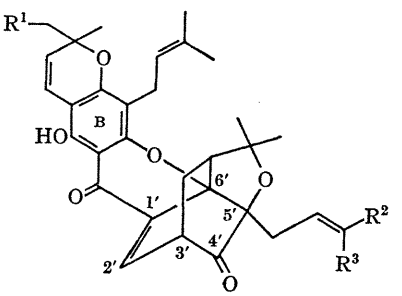
Summary Bronianone is shown to have the constitution (IV) and is considered to be biogenetically related to the polyisoprenylated xanthonoids (Ia—Ig).

A CLASS of structurally related xanthonoids has recently been recognised, and this group includes morellin (Ia),[1] isomorellin (Ib),[1] morellic acid (Ic),[2] isomorellic acid (Id),[2] deoxymorellin (Ie),[3] dihydroisomorellin (If),[3] and gambogic acid (Ig).[4–8] These natural products are phytochemically characteristic of several *Garcinia* species (*Guttiferae* family) and they may be regarded biogenetically[1,5a] as polyisoprenylated xanthones in which one of the benzene rings has been modified giving a bicyclo[2,2,2]octenone skeleton. Further examination of the *Guttiferae* has now provided a novel polyisoprenylated "benzophenone," bronianone, which is biogenetically related to the xanthonoid pigments (Ia—g).

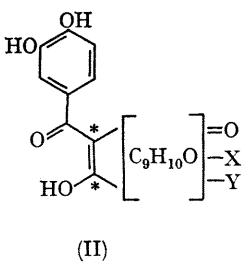
Bronianone, $C_{43}H_{58}O_6$, was obtained as an optically active, deep yellow oil† from the stem wood of *Garcinia hombroniana* Pierre. Its spectra indicated considerable conjugation [λ_{max} nm. (ϵ) 250 (10,350), 278 (7000), and 365 (6500)] and the presence of unconjugated (ν_{max} 1720 cm.$^{-1}$) and conjugated (ν_{max} 1660 cm.$^{-1}$) carbonyl groups. Methylation gave a trimethyl ether (ν_{max} 1720 and 1665 cm.$^{-1}$) whose n.m.r. spectrum showed an ABX system (τ_X 2·40, τ_A 2·74, τ_B 3·23; J_{AX} 2·0, J_{AB} 8·0, J_{BX} 0 Hz.) characteristic of a 3,4-dimethoxybenzoyl group; this was confirmed by permanganate oxidation of the trimethyl ether, which



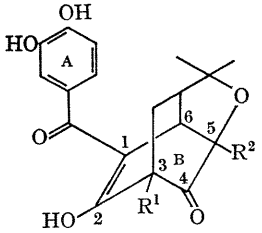
(I)	R¹	R²	R³
a	H	Me	CHO
b	H	CHO	Me
c	H	Me	CO_2H
d	H	CO_2H	Me
e	H	Me	Me
f	H (single bond at C-1′–C-2′)	CHO	Me
g	$Me_2CH{=}CHCH_2$	Me	CO_2H

† Bronianone and its derivatives were noncrystalline compounds, but their homogeneity was established chromatographically and they were fully characterised spectroscopically (u.v., i.r., and n.m.r. spectra and mass spectral fragmentation patterns). Molecular formulae were established by high-resolution mass spectrometry.

yielded 3,4-dimethoxybenzoic acid. Sodium borohydride reduction of bronianone trimethyl ether, $C_{46}H_{64}O_6$, gave a secondary alcohol, $C_{46}H_{66}O_6$ (ν_{max} 1665 cm.$^{-1}$). The alkaline hydrolysis of the trimethyl ether yielded the corresponding dimethyl ether, indicating[9] the presence of a vinylogous ester grouping derived from an enolised β-diketonic function present in bronianone which was associated with the carbonyl group of the 3,4-dihydroxybenzoyl residue. Accordingly, reaction of bronianone with phenylhydrazine gave an *N*-phenylpyrazole, $C_{49}H_{62}N_2O_4$, and copper(II) acetate gave a copper(II) co-ordination derivative.



(II)



(III) R^1=X, R^2=Y
(IV) R^1=Y, R^2=X

In formulae (II), (III) and (IV)
X=CH_2·CH:CMe·CH_2·CH_2·CH:CMe_2
Y=[CH_2·CH:CMe·CH_2]$_2$·CH_2·CH:CMe_2

The mass spectra of bronianone and its di- and trimethyl ethers showed an initial loss of a fragment, $C_{10}H_{17}$• *followed* by the loss of a $C_{14}H_{24}$ fragment either in a single process (−192 a.m.u.) or in a three-step sequence (−68, −68, −56 a.m.u.). The n.m.r. spectra of bronianone and its derivatives indicated *inter alia* the presence of seven olefinic methyl groups, sixteen allylic protons, and five vinylic protons. This combination of mass spectral and n.m.r. evidence suggested the existence (see II) of one geranyl and one farnesyl residue in bronianone, which was supported by catalytic hydrogenation experiments in which the five double bonds of the geranyl and farnesyl residues were reduced. The u.v. spectra of these decahydro-derivatives showed that the chromophore was unchanged and their n.m.r. spectra were as expected only for the transformations geranyl → tetrahydrogeranyl and farnesyl → hexahydrofarnesyl. The mass spectral fragmentations of these decahydro-derivatives showed *independent* cleavage patterns associated with (i) loss of the tetrahydrogeranyl residue as the radical, $C_{10}H_{21}$•, (ii) loss of the hexahydrofarnesyl residue as the olefin, $C_{15}H_{30}$ and (iii) loss of the 3,4-dioxygenated benzoyl residue.

The n.m.r. spectra of bronianone and its derivatives, coupled with the hydrogenation evidence, showed that the undefined $C_9H_{10}O$ residue (see II) could not contain any C=C double bonds and that the oxygen was ethereal. This $C_9H_{10}O$ residue plus the asterisked carbon atoms (see II) therefore formed a tricyclic system and the ten protons had to be associated with two methyl groups (s, τ 8·92 and 9·23) and four hydrogen atoms associated with high-field (τ 8·0—9·0) signals. It was clear that the isolated ketone group (ν_{max} 1720 cm.$^{-1}$) had to be either acyclic or in a ring that was at least six-membered and that none of the four high-field hydrogen atoms (τ 8·0—9·0) could be located α to this carbonyl function.[1,5,7]

Comparison of the u.v. spectra of bronianone and its derivatives with 2-(3,4-dimethoxybenzoylcyclohexanone) demanded more extensive conjugation than that shown in the partial formula (II). This requirement is met by the bicyclo[2,2,2]octenone system which permits a homoconjugative interaction associated with an enhancement of the $n \rightarrow \pi^*$ carbonyl transition;[10] this has been observed with a number of $\beta\gamma$-unsaturated ketones of the bicyclo-[2,2,2]octenone type. These considerations, coupled with the attractive biogenetic hypothesis that the $C_9H_{10}O$ residue contained an isoprenoid unit (–CH_2CH–CMe_2–), led to two possible constitutions [(III) and (IV)] for bronianone. A decision in favour of one of these (IV) was made possible by a detailed consideration of the mass spectra of bronianone and its derivatives, which will be discussed in detail in the full paper.

There is an interesting biogenetic relation (see rings labelled A and B) between the polyisoprenylated "benzophenone" structure now suggested for bronianone (IV) and the polyisoprenylated xanthonoids (Ia—g). This relation is relevant to current interest[11] in the biosynthesis of xanthones from benzophenone precursors.

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[1] G. Kartha, G. N. Ramachandran, H. B. Bhat, P. M. Nair, V. K. V. Raghavan, and K. Venkataraman, *Tetrahedron Letters*, 1963, 459; N. V. Bringi, K. H. Shah, and V. Venkataraman, *J. Sci. Ind. Res. (India)*, 1955, **14**, *B*, 135; N. V. Bringi, M. R. Padye, and K. Venkataraman, *ibid.*, 1956, **15**, *B*, 128.
[2] C. G. Karanjgaonkar, P. M. Nair, and K. Venkataraman, *Tetrahedron Letters*, 1966, 687.
[3] H. B. Bhat, P. M. Nair, and K. Venkataraman, *Indian J. Chem.*, 1964, **2**, 405.
[4] P. Yates, S. S. Karmarkar, D. Rosenthal, G. H. Stout, and V. F. Stout, *Tetrahedron Letters*, 1963, 1623.
[5] (a) W. D. Ollis, M. V. J. Ramsay, I. O. Sutherland, and S. Mongkolsuk, *Tetrahedron*, 1965, **21**, 1453; (*b*) W. D. Ollis, B. T. Redman, and I. O. Sutherland, *J. Chem. Soc.* (*C*), 1969, forthcoming.
[6] S. A. Ahmad, W. Rigby, and R. B. Taylor, *J. Chem. Soc.* (*C*), 1966, 772, B. J. Hunt and W. Rigby, *Chem. and Ind.*, 1967, 1790.
[7] M. Amorosa and G. Giovanninetti, *Ann. Chim.* (*Italy*), 1966, **56**, 232.
[8] G. Cardillo and L. Merlini, *Tetrahedron Letters*, 1967, 2529.
[9] J. F. Grove, J. MacMillan, T. P. C. Mulholland, and M. A. T. Rogers, *J. Chem. Soc.*, 1952, 3977; A. Brossi, M. Baumann, M. Gerecke, and E. Kyburz, *Helv. Chim. Acta*, 1960, **13**, 1444.
[10] S. F. Mason, *Quart. Rev.*, 1961, **15**, 287; 1963, **17**, 20; A. Moscowitz, K. Mislow, M. A. W. Glass, and C. Djerassi, *J. Amer. Chem. Soc.*, 1962, **84**, 1945; J. N. Murrell, "The Theory of the Electronic Spectra of Organic Molecules," Methuen, London, 1963, pp. 163—168; D. E. Bays, R. C. Cookson, and S. MacKenzie, *J. Chem. Soc.* (*B*), 1967, 215; D. E. Bays and R. C. Cookson, *ibid.*, p. 226.
[11] H.-G. Floss and A. Rettig, *Z. Naturforsch.*, 1964, **19b**, 1103; J. E. Atkinson, P. Gupta, and J. R. Lewis, *Chem. Comm.*, 1968, 1386; O. R. Gottlieb, *Phytochemistry*, 1968, **7**, 411.