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CELEBIXANTHONE

A COMBINED CHEMICAL AND CRYSTALLOGRAPHIC STRUCTURE PROOF[1]

G. H. STOUT, V. F. STOUT, and M. J. WELSH
Department of Chemistry, University of Washington, Seattle, Washington

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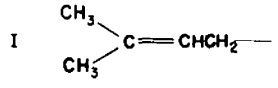
Abstract—Celebixanthone is shown by both chemical and crystallographic methods to be 3,4,8-trihydroxy-2-methoxy-1-(3-methyl-2-butenyl)-xanthone (VIIIa).

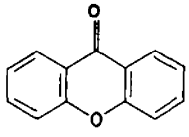
IN THE course of our search for new naturally occuring oxygen heterocycles, we have examined the extractives obtained from the bark of *Cratoxylon celebicum* Blume, a member of the Guttiferae found in the Philippine Islands. From this we have isolated in a yield of about 0·3% of the bark weight a new yellow, optically inactive substance to which we have assigned the formula $C_{19}H_{18}O_6$ and which we have named celebixanthone.

Chemical studies. Celebixanthone contains three phenolic hydroxyl groups as shown by its reaction with acetic anhydride and pyridine to form a triacetate with a single I.R. ester band at 5·59 μ. Reaction with a limited amount of diazomethane gives a monomethyl ether, which may be acetylated to a diacetate. The presence of one methoxyl group in the parent compound was shown by Zeisel determination.

The N.M.R. spectrum of celebixanthone triacetate showed, in addition to absorption corresponding to three acetoxyl and one methoxyl groups, two singlets at 8·20 and 8·32τ (3H each), a doublet at 6·03τ (2H), and a triplet at 4·86τ (1H). This family of peaks is highly characteristic of the isopentenyl side chain (I), an extremely



I



II

common substituent in the products isolated from the Guttiferae. No other non-aromatic protons could be observed and thus it appeared likely that the thirteen remaining carbon atoms were in the aromatic chromophore.

Examination of the U.V. spectra of celebixanthone triacetate and methyl ether diacetate showed that they were strikingly similar and nearly identical with that of xanthone (II) except for a small bathochromic shift (Table 1). Although the "removal" of phenolic groups from aromatic spectra by acetylation is well known,[2a,b] the

[1] Preliminary accounts of parts of this work have appeared previously: G. H. Stout, V. F. Stout, M. J. Welsh, and L. H. Jensen, *Tetrahedron Letters* No. 13, 541 (1962); G. H. Stout and L. H. Jensen, *Amer. Cryst. Assoc. Abstr.* 24 (1962).

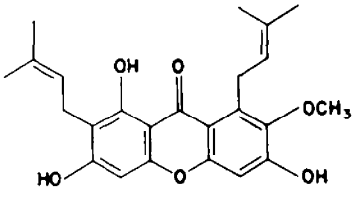
[2a] H. Brockmann, E. H. F. Falkenhausen, R. Neeff, A. Dorlars and G. Budde, *Chem. Ber.* 84, 865 (1951); [b] D. L. Dreyer, Ph.D. Thesis, University of Washington (1960).

TABLE 1

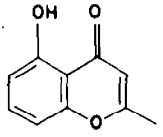
	mμ	ε	mμ	ε	mμ	ε	mμ	ε
Xanthone	239	42,800	260	12,500	288	4,400	336	7,000
Celebixanthone triacetate	247	38,000	272	12,000			345	7,800
Celebixanthone methyl ether diacetate	240	36,000	278	12,000			344	7,600
Cyclocelebixanthone triacetate	243 252 (sh)	33,600 29,400	276 (sh)	14,700			360	6,400
2-Methoxyanthone	237 249	35,000 31,000			301	4,200	360	6,200
Celebixanthone	240 (sh) 252	27,000 30,160	330	14,000			370 (sh)	5,400
1,5,6-Trihydroxyxanthone	250	34,300	331	12,700				

similarities in these spectra were so great as to suggest that the methoxyl groups were also not playing their usual roles in modifying the curves.[2b] The spectrum of celebixanthone itself, although consistent with a xanthone chromophore, was somewhat unusual and not immediately helpful.

The identification of the material as a xanthone accounted for all the remaining atoms and reduced our problem to that of locating the substituents properly around the rings. Consideration of the appearance of the side chain methylene signals at 6·03τ in the N.M.R. spectrum suggested that the chain was attached to an electron-poor ring atom, *ortho* or *para* to the carbonyl, while, conversely, the presence of the methoxyl signal at 6·24τ suggested attachment of this group to an electron-rich site. An excellent model for comparison was found in the closely related compound mangostin (III),[3] isolated from *Garcinia mangostana* (Guttiferae), in which the values found are: 2-CH_2, 6·68τ; 8-CH_2, 5·92; 7-OCH_3, 6·24τ.



III



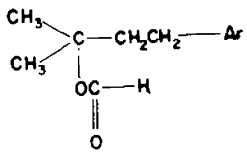
IV

Examination of the N.M.R. spectrum of celebixanthone in acetone showed the signals from the aromatic protons as doublets at 3·25 and 3·49τ together with a

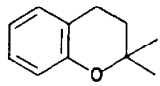
[3] P. Yates and G. H. Stout, *Chem. & Ind.* 1392 (1956); *J. Amer. Chem. Soc.* **80**, 1691 (1958).

triplet at 2·59τ. Such a spectrum requires that the three protons be adjacent and is strikingly similar to that of 2-methyl-5-hydroxy-chromone (IV), in both line positions and coupling constants.[4] Furthermore, under these conditions the hydroxyl protons appeared as two peaks, a sharp one at −3·16τ (1H) corresponding to a strongly hydrogen-bonded system and a very broad one centered at 1·28τ (2H) which reflected the presence of two other protons which were not chelated and which were undergoing exchange at a rate comparable to their separation.[5] The hydroxyl groups of mangostin showed the same separation into sharp chelated and broad non-chelated peaks. We could consequently say with certainty that of the three hydroxyl groups in celebixanthone one and only one was *ortho* to the carbonyl group.

When celebixanthone was heated briefly in 98% formic acid, a new compound was formed ($C_{20}H_{20}O_8$) whose acetate showed an added carbonyl band at 5·79 μ and a single new proton signal at 1·90τ, indicating that the elements of formic acid had added to the side chain double bond to produce the tertiary formate (V). As would be expected, the U.V. spectrum was unchanged from that of the starting material. This reaction has been found to occur only when the isopentenyl system is not



V



VI

adjacent to a free hydroxyl group; in the latter case cyclization occurs exclusively with the formation of a 2,2-dimethylchroman system (VI).[3]

When celebixanthone was demethylated with boiling hydriodic acid and the product isolated after acetylation, quite different results were obtained. The U.V. spectrum of the acetylated product showed a long wavelength band at 360 mμ and now strongly resembled 2-methoxyxanthone (Table 1). The N.M.R. spectrum showed the presence of only three acetyl groups and no methoxyl, while the appearance of triplets at 6·52 and 8·15τ (2H each) and the single methyl peak at 8·66τ (6H) indicated that addition to the double bond had occurred. The U.V. spectrum implied that an O-alkyl group was present at C_2, and so cyclization to a chroman had occurred following demethylation. Consequently, the side chain and the methoxyl group must be adjacent.

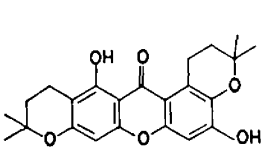
That a methoxyl group and a chroman ring at C_2 have such strikingly different effects on the U.V. spectra of their respective triacetates may be explained if there are additional substituents at C_1 andC_3. The result of this *o,o'*-disubstitution is to rotate the methoxyl group out of the plane of the aromatic system, decreasing the p-π overlap of the oxygen and the ring, and greatly diminishing its effect on the spectrum. In the chroman such rotation is no longer necessary or possible and the oxygen produces its usual spectral shifts. A very close analogy is again found in mangostin (III) which on demethylation gives VII. This on methylation gives the 6-methyl ether whose long wavelength band at 366 mμ is 16 mμ farther to the red than that of mangostin 3,6-dimethyl ether (350 mμ).[3]

[4] 3·35τ (d), 3·40τ (d), 2·60τ (t), J = 8 cps.

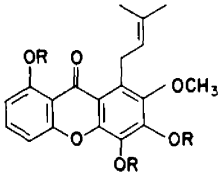
[5] J. A. Pople, W. G. Schneider, and H. J. Bernstein, *High-resolution Nuclear Magnetic Resonance*, McGraw-Hill, New York, N.Y. (1959).

The ready oxidation of celebixanthone by Tollens reagent suggested that two of its free hydroxyl groups were *ortho* or *para*, and the former was preferred since the compound gives a positive test for a catechol system when treated with GeO_2 and an indicator.[6]

If the side chain and the methoxyl group are adjacent, they cannot at the same time be in the ring with the three aromatic protons; so the other two positions must be occupied by hydroxyl groups. Only two such structures (VIIIa, IX) are possible which accommodate simultaneously the requirements that the side chain not be adjacent to a hydroxyl and that there be only one chelated —OH. Of these, only

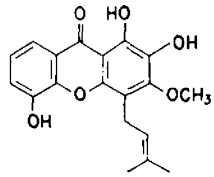


VII

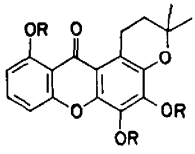


VIII a R=H

b R=$CH_3C(=O)$—

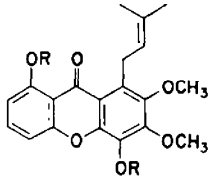


IX



Xa R=H

b R=$CH_3C(=O)$—



XI a R=H

b R=$CH_3C(=O)$—

VIIIa would give a demethylation product (Xa), the spectrum of whose acetate (Xb) would resemble that of 2-methoxyxanthone. Furthermore, comparison of the aromatic proton spectra of model compounds of the 2,6-dioxyphenylcarbonyl type as in VIII with those having 2,3-dioxyphenylcarbonyl substitution showed that the latter, because of their less symmetric nature, gave more complicated spectra than the former and in no way resembled celebixanthone.[7]

Comparison of the U.V. spectra of celebixanthone and 1,5,6-trihydroxyxanthone (Table 1) shows striking similarities which are in agreement with the correspondence in their structures. In particular, both show an unusual absorption band with $\epsilon >$ 10,000 at 330 mμ. The usual long wavelength band of xanthones, which appears only as a long tail in the model, is shifted enough toward the red by the addition of the 2-methoxyl group to be shown as a shoulder in celebixanthone.

[6] P. Berillard, *Bull. Soc. Chim. Fr.* 236 (1954).

[7] cf. for example J. N. Shoolery in *NMR and EPR Spectroscopy* p. 107. Pergamon Press, New York, N.Y. (1960).

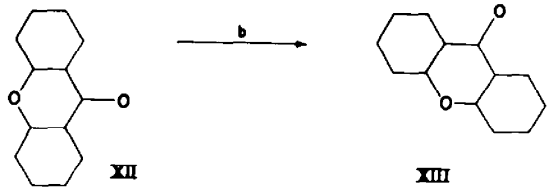
It is for these reasons, therefore, that we propose structure VIIIa for celebixanthone. The structure of the monomethyl ether formed on reaction with diazomethane has not been examined in detail, but we suggest that it is XIa for the following reasons: the —OH at C_3, being *para* to the carbonyl group, is normally the most acidic and therefore the most reactive toward diazomethane; the U.V. spectrum of the methyl ether diacetate (XIb) is almost identical with that of the parent triacetate (VIIIb), suggesting that the new methoxyl is also *o,o'*-disubstituted and is not contributing to the spectrum; what small spectral shift in the long wavelength band does occur is to the blue, characteristic of substitution at position 3, whereas a 4-OCH_3 derivative would be expected to cause a shift of 5–7 mμ toward the red.[2b]

X-ray studies. Concurrently with our chemical investigations, we began the study of the structure of celebixanthone by X-ray crystallographic methods. Crystals were grown from ethanol–water as monoclinic needles elongated along the *c* axis and were found to have the cell constants:

$$a = 15{\cdot}73\ \text{Å} \qquad b = 14{\cdot}65\ \text{Å} \qquad c = 7{\cdot}49\ \text{Å} \qquad \beta = 100{\cdot}0^\circ$$

Systematic extinctions required the space group to be $P2_1/c$. The appearance of a space group possessing a center of symmetry was positive assurance of the lack of optical activity of celebixanthone. Diffraction data was collected photometrically from integrated Weissenberg photographs[8] of levels 0 through 5 taken on a crystal rotating about the needle (*c*) axis. After the customary reduction of the intensity data to |F|rel, the levels were scaled together by means of 0kl data collected in the same fashion from a crystal rotating about the *a* axis. In all, 2540 reflections were included in the data, of which 1525 were actually observed and 8 were considered to be suffering from secondary extinction.

Examination of two- and three-dimensional Patterson functions calculated using these data confirmed the presence of a large aromatic system and indicated that the molecules were so oriented that two edges of each ring lay almost exactly parallel to the *b* axis. Attempts were made to obtain the phases of the intense reflections by application of the modified Sayre procedure which had been used on rubrofusarin,[9] but when the phases obtained were used in Fourier syntheses, reasonable molecules could not be fitted to the resulting electron density distributions. Consideration of several very strong reflections showed that most of the atoms had to be located (in projection on (001)) at positions selected from a set corresponding to the superposition of a number of regular hexagonal networks. As the number of possible points was much greater than the number of atoms to be placed, this information



XII XIII

[8] E. H. Wiebenga and D. W. Smits, *Acta Cryst.* **3**, 265 (1950).

[9] G. H. Stout, D. L. Dreyer, and L. H. Jensen, *Chem. & Ind.* 289 (1961); G. H. Stout and L. H. Jensen, *Acta Cryst.* **15**, 451 (1962).

was not of immediate value, but a special program was devised for the IBM 709 which would take a group of atomic coordinates corresponding to a hexagonal pattern (e.g. a xanthone skeleton) and shift this by increments which were the distances between vertices in the superimposed gridwork. In this manner the atoms were moved as a molecule from possible point to possible point, and at each resting place structure factors were calculated and compared with the observed hk0 data. Tests were carried out using the two structures XII, XIII, both of which satisfied the requirement that one ring bond be directed along the *b* axis, and on models derived from these by the addition of substituents in chemically reasonable positions around the ring system.

Using a model based on VIIIa, two molecular positions gave significantly better agreement between observed and calculated data than did the rest. Further tests using 0kl and hkl data showed one to be markedly preferable and led to a rough set of three dimensional coordinates for all atoms. Using these as a starting point, the structure was refined on an IBM 709 in standard fashion, first by three-dimensional Fourier methods and then by full-matrix[10] and block-diagonal[11] least squares. During the refinement, anisotropic temperature factors were introduced, and three-dimensional difference syntheses were used to locate all of the hydrogen atoms, which were then refined on position but not on temperature factors. The current value of the residual index R for the observed reflections is 8·2%.[12]

Fig. I shows a composite molecular projection on (001) of section through individual atoms in a three-dimensional Fourier synthesis. It is of interest to note that the methoxyl group is turned sharply out of the plane of the ring system as was suggested above on spectroscopic grounds. The ring oxygen atom is easily identified by its additional electron density, and the less regular nature of the heterocyclic ring is also clear.

Figs. II and III give the observed lengths and angles for the bonds between heavy atoms and between oxygen and hydrogen. The bond lengths are normal, with estimated errors of 0·01–0·02 Å, and the shorter bonds of the carbonyl group and the side chain double bond are clearly defined. Thus the correctness of the structure VIIIa is completely confirmed. The accuracy of the bonds to hydrogen is significantly less, about 0·1 Å, but the non-colinear nature of the intramolecular hydrogen bond system is unambigous and is in agreement with the results found by Cochran for salicylic acid using two-dimensional methods.[13] The geometry of the hydrogen bond system is also very similar to that which we have found in the naphthopyrone rubrofusarin.[14]

The C—H bonds, which are not shown, vary from 0·89 to 1·38 Å, with a mean of 1·09 Å. The extreme values occur on the methyl groups of the side chain, where the high thermal motion makes the location of the hydrogen atoms significantly

[10] W. R. Busing and H. A. Levy, *A Crystallographic Least Squares Refinement Program for the IBM 704*. Oak Ridge National Laboratories (1959).

[11] P. K. Gantzel, R. A. Sparks, and K. N. Trueblood, *A modified version of UCLALS1* University of California (1961).

[12] $R = \Sigma||F_o| - |F_c||/\Sigma|F_o|$ where F_o and F_c are the observed and calculated structure factors respectively.

[13] W. Cochran, *Acta Cryst.* **6**, 260 (1953).

[14] G. H. Stout and L. H. Jensen, unpublished results.

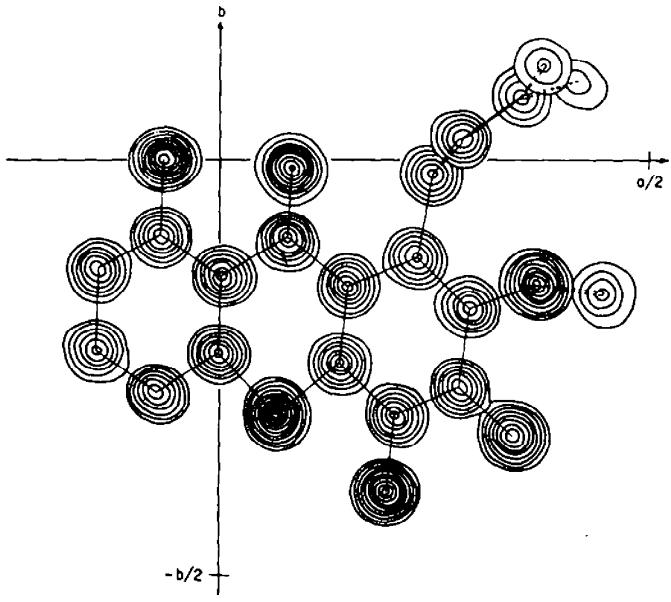


FIG. 1. Composite projection of celebixanthone on (001). Contours at 1e/A², starting at 2e/A².

more difficult.[15] The average, however, is in good agreement with the currently accepted value of 1·07 Å.[16]

Summary. In our study of the structure of celebixanthone, the role classically assigned to synthesis, that of providing confirmation of the deductions leading to a proposed structure, has instead been filled by a detailed crystallographic analysis. This analysis is no less independently certain in its results for having begun with a postulated structure than is a synthesis, and it may reasonably be argued that the mass of data to be fitted and the difference in kind between the deductive arguments and the diffraction evidence makes this approach the more certain.

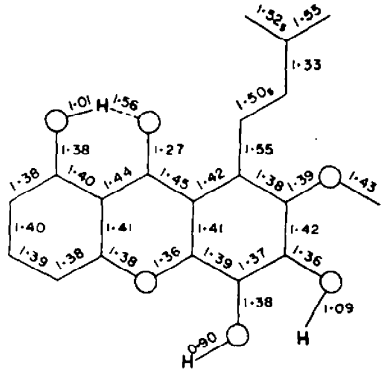


FIG. 2. Celebixanthone bond lengths

[15] The details of the X-ray analysis and of the crystal structure will be published in full elsewhere.
[16] L. H. Jensen in *The Encyclopedia of X-rays and γ-rays* Reinhold, New York, N.Y., to be published.

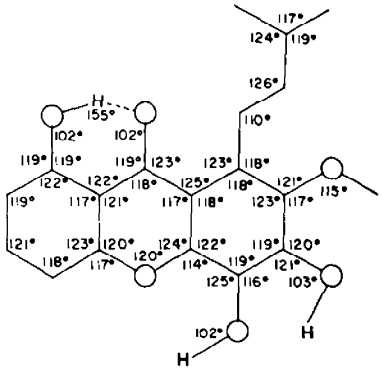


FIG. 3. Celebixanthone bond angles.

With regard to the structure itself, the very close relationship between celebixanthone and mangostin is of interest because although they are both products of the Guttiferae, they are obtained not only from different genera, but even from different sub-families.[17] What evidence existed previously suggested that the Hypericoideae,[18] the sub-family to which Cratoxylon belongs, might be characterized by anthracene derived pigments such as hypericin[2a] and harunganin,[19] while the remainder of the Guttiferae tended to produce xanthones[3,20,21] and coumarins.[22–24] It now appears that this assumption was overly optimistic and that much more data must be gathered before the correspondence between chemistry and taxonomy in this family becomes clear.

EXPERIMENTAL

All m.p.'s were taken on a Kofler micro hot stage and are corrected. N.M.R. spectra were taken at 60 mc. on a Varian spectrometer in $CHCl_3$ solution containing tetramethylsilane as a standard and are reported in τ units, followed in parentheses by relative areas. U.V. spectra are for ethanol solutions and were measured on a Cary Model 14.

Isolation of celebizanthone (VIIIa). Dried bark of *Cratoxylon celebicum*, collected in Laguna, P.I., was ground in a Wiley mill and extracted in a Soxhlet with 30–60° pet ether in batches of ca. 185 g for 160–300 hr. Despite the time, this method appeared the most successful, as more powerful solvents increased the amount of impurities to be removed in subsequent operations.

From 925 g of bark, the resulting dark brown powder (15·98 g) was washed repeatedly with benzene to leave a mustard-coloured product (7·46 g). The crude product (7·12 g) was extracted repeatedly at room temp with CH_2Cl_2 until the extracts were colourless. Crude celebixanthone (2·94 g) was obtained by concentrating the extracts and adding n-hexane. Sublimation at 150° and ca. 5×10^{-3} mm, followed by recrystallization from CH_2Cl_2–hexane and ethanol–water gave yellow needles m.p. 219–222° (dec). U.V.: see Table 1. N.M.R.: 8·33(3); 7·17(3); 6·03(2)—doub, J = 6 c.p.s.; 4·80(1)

[17] A. Engler and K. Prantle, *Die Naturlichen Pflanzenfamilien* Vol. 21. p. 169. Engelmann Verlag, Leipzig (1925).

[18] The Hypericoideae are often regarded as a separate family, the Hypericaceae. Cf. J. Hutchinson, *The Families of Flowering Plants* Vol. II. p. 297. Oxford University Press (1959).

[19] G. H. Stout, R. A. Alden, J. Kraut, and D. F. High, *J. Amer. Chem. Soc.* **84**, 2653 (1962).

[20] F. E. King, T. J. King, and L. C. Manning, *J. Chem. Soc.* 3932 (1952); 563 (1957).

[21] D. B. Spoelstra and M. J. van Royen, *Rec. Trav. Chim.* **48**, 370 (1929).

[22] J. Polonsky, *Bull. Soc. Chim. Fr.* 1079 (1957).

[23] C. Djerassi, E. J. Eisenbraun, R. A. Finnegan, and B. Gilbert, *Tetrahedron Letters* No. 1, 10 (1959).

[24] G. H. Stout and K. L. Stevens, unpublished results.

—trip, J = 6 c.p.s.; 3·49(1)—doub, J = 8 c.p.s.; 3·25(1)—doub, J = 8 c.p.s.; 2·59(1)—trip, J = 8 c.p.s.; 1·28(2)—v. broad; −3·16(1)—sharp. (Found: C, 66·37; H, 5·32; OCH_3, 8·7; Calc. for $C_{18}H_{15}O_5(OCH_3)$: C, 66·66; H, 5·30; OCH_3, 9·05%).

For crystallographic examination, crystals were grown by slow crystallization from ethanol–water as long monoclinic needles extended along the *c* axis. Measurements on rotation and Weissenberg photographs taken with Cu radiation (λ = 1·5418 Å) gave the cell constants:

$$a = 15{\cdot}73\ \text{Å} \qquad b = 14{\cdot}65\ \text{Å} \qquad c = 7{\cdot}49\ \text{Å} \qquad \beta = 100°0'$$

The density was determined by flotation in CCl_4–hexane mixtures to be 1·333, and corresponded to 4 molecules M.W. 341·1 per cell (Calc. 342·3).

Intensity data was collected from equi-inclination Weissenberg photographs taken for levels l = 0 to 5. The films were integrated unidimensionally using a Nonius camera and the resulting photographs were scanned photometrically in the cross direction. The resulting traces were planimetered and the areas taken as the integrated intensities. The structure factors were obtained in the usual fashion and were scaled level-to-level by comparison with 0kl data.

Celebixanthone triacetate (VIIIb). Celebixanthone (60 mg) was acetylated by heating 1 hr on the steam bath with acetic anhydride (1 ml) and pyridine (0·5 ml). The mixture was poured into water and the precipitate filtered off and crystallized from ethanol to give white needles m.p. 164–165°. U.V.: see Table 1. I.R.: 5·59, 6·00, 6·17, 6·25 μ. N.M.R.: 8·32(3); 8·20(3); 7·66, 7·61, 7·60(9); 6·26(3); 6·00(2)—doub; 4·86—trip (1). (Found: C, 63·82; H, 5·34; CH_2CO, 22·6; Calc. for $C_{18}H_{15}O_6(COCH_3)_2$: C, 64·10; H, 5·16; CH_2CO, 27·53%).

Methylcelebixanthone (XIa). Celebixanthone (87 mg, 0·25 mM) was dissolved in ether (10 ml) and treated with ethereal diazomethane solution (0·5 ml, 0·3 mM). The reaction was allowed to evaporate in the hood for 1–2 days and light yellow crystalline residue was recrystallized from benzene–hexane to give light yellow needles (34 mg) m.p. 164–169°, unchanged by further recrystallization. (Found: C, 67·06; H, 5·60; OCH_3, 16·0; Calc. for $C_{18}H_{14}O_4(OCH_3)_3$: C, 67·40; H, 5·66; OCH_3, 17·39%).

When larger amounts of diazomethane were used, the product was a yellow oil, which did not crystallize.

Methylcelebixanthone diacetate (XIb). Methylcelebixanthone (35 mg) was treated with acetic anhydride (15 ml) and pyridine (3 ml). After being heated on the steam bath for 40 min the mixture was poured into water (40 ml). A white flocculent precipitate appeared, and was filtered off after standing overnight. The crude product was crystallized repeatedly from hot n-hexane to give white needles (24 mg), m.p. 153–158°. U.V.: see Table 1. N.M.R.: 8·30(3); 8·17(3); 7·56(6); 6·20(3); 6·13, 6·03(5); 4·81(1). (Found: C, 65·27; H, 5·28; OCH_3, 13·83; CH_2CO, 15·99; Calc. for $C_{18}H_{12}O_4(OCH_3)_2(COCH_3)_2$: C, 65·44; H, 5·49; OCH_3, 14·07; CH_2CO, 19·52%).

Formoxydihydrocelebixanthone. Celebixanthone (125 mg) was dissolved in 98% formic acid (2 ml) with warming and heated on the steam bath for 10 min. The formic acid was removed under vacuum without further heating and the residue crystallized from benzene and twice from acetone–water to give 68 mg of yellow product, m.p. 182·5–185°. U.V.: 239 mμ (sh) (25,300), 254 mμ (31,500), 331 mμ (14,000), 370 mμ (sh) (5,600). (Found: C, 62·11; H, 5·23; Calc. for $C_{20}H_{20}O_8$: C, 61·85; H, 5·19%).

The NMR spectrum in formic acid of a sample of celebixanthone which had been dissolved with a minimum of heating showed only one C–Me peak; so the addition reaction apparently occurs immediately on solution and further heating is unnecessary.

Formoxydihydrocelebixanthone diacetate. Formoxydihydrocelebixanthone (50 mg) was treated with acetic anhydride (1·0 ml) and pyridine (0·5 ml) and heated on the steam bath for 30 min. Methanol and water were added to the cooled mixture and the colorless crystalline precipitate was filtered off and crystallized from chloroform–cyclohexane and acetone–water to give 35 mg of white needles m.p. 163–165°. U.V.: 240 mμ (sh) (36,800), 247 mμ (39,300), 273 mμ (14,700), 347 mμ (7,100). I.R.: 5·60, 5·79, 6·00, 6·16, 6·25 μ. NMR: 8·36(6); 7·90(2); 7·60(3); 6·66(2), 6·20(3); 1·90(1). (Found: C, 60·75; H, 5·32; Calc. for $C_{25}H_{26}O_{11}$: C, 60·70; H, 5·09%).

Cyclocelebixanthone triacetate (Xb). Celebixanthone (65 mg) was refluxed in a mixture of acetic anhydride (2 ml) and 48% hydriodic acid (1 ml) for 1 hr. The orange, homogeneous solution was poured into water and the resulting orange precipitate filtered off and dried.

The crude cyclocelebixanthone was treated with acetic anhydride (2 ml) and a few drops of pyridine, allowed to stand overnight, and finally heated on the steam bath for ½ hr. The reaction mixture

was poured into water, and the precipitate filtered off and dried (76 mg). The product was recrystallized from acetone–water, cyclohexane–dichloromethane and twice from methanol–dichloromethane to give off-white needles m.p. 219·5–222·5°. U.V.: see Table 1. N.M.R.: 8·66(6); 8·15(2)—trip, J = 6·5 c.p.s.; 7·65, 7·58, 7·56(9); 6·51(2)—trip, J = 6·5 cps. (Found: C, 63·43; H, 4·88; Calc. for $C_{16}H_{12}O_9$: C, 63·43; H, 4·88%).

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