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# EXTRACTIVES FROM GUTTIFERAE—VIII[1]

## THE ISOLATION OF 6-(3,3-DIMETHYLALLYL)-1,5-DIHYDROXY-XANTHONE AND TWO RELATED METABOLITES FROM *CALOPHYLLUM SCRIBLITIFOLIUM* HENDERSON AND WYATT-SMITH

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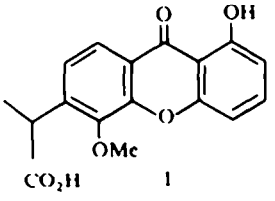
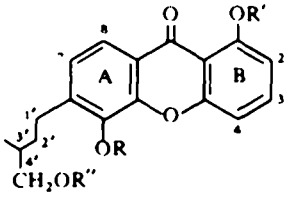
**Abstract**- The heartwood of *Calophyllum scriblitifolium* Henderson and Wyatt-Smith is shown to contain three new structurally related xanthones. These are 6-(4-hydroxy-3-methylbutanyl)1,5-dihydroxyxanthone, 6-(4-hydroxy-3-methylbut-2-enyl)1,5-dihydroxyxanthone and 6-(3,3-dimethylallyl)1,5-dihydroxyxanthone.

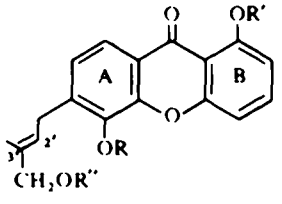
IN PARTS V[2] and VII[1] of this series we reported that a substance designated CS-1 occurred together with scriblitifolic acid (I) in the heartwood of *Calophyllum scriblitifolium* Henderson and Wyatt-Smith. Although CS-1 appeared to be a single substance from its melting properties and its resistance to chromatographic separation, it is shown now to be a mixture, in approximately equal parts, of the alcohols (IIa and IIIa).



I



IIa: R = R' = R'' = H
IIb: R = Me, R' = R'' = H
IIc: R = R' = Me, R'' = H
IId: R = R' = H, R'' = MeCO



IIIa: R = R' = R'' = H
IIIb: R = Me, R' = R'' = H
IIIc R = R' = Me, R'' = H
IIId: R = R' = H, R'' = MeCO

The mass spectrum of CS-1 (Fig. 1) showed a molecular ion at *m/e* 314 followed by a substantial peak at *m/e* 312. Corresponding dual fragment peaks were observed in the high mass region of the spectrum at *m/e* 296 and 294, and at 281 and 279. The best explanation for the appearance of these fragments seemed to be that CS-1 was a mixture of two similarly constituted compounds of mol wt 314 and 312, accurate

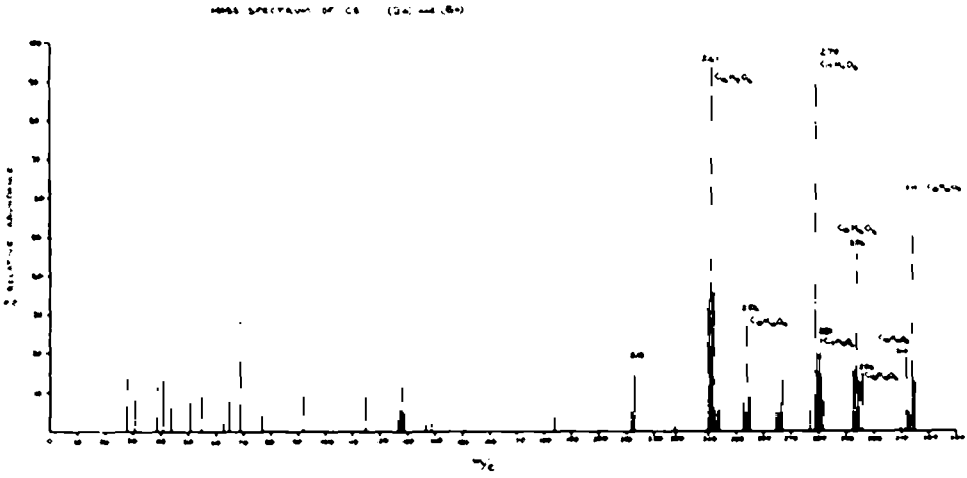


FIG. 1 Mass Spectrum of CS-1 (IIa and IIIa) recorded on an A.E.I. MS9 double focusing spectrometer at 70 eV.

TABLE 1. UV SPECTRA OF CS-1, ITS DERIVATIVES, AND SOME 1,5- AND 1,6-DIOXYGENATED XANTHONES

| | $\lambda_{max}$ (mμ) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | ($\varepsilon \times 10^{-3}$) | | | | | | |
| CS-1 (IIa and IIIa) | | | 252 | (41·4) | 317 | (10·3) | 372 | (2·9) |
| CS-1 Monomethyl ether (IIb and IIIb) | 235 | (27·7) | 245 | (29·2) | 296 | (9·2) | 363 | (4·6) |
| CS-1 Dimethyl ether (IIc and IIIc) | 247 | (44·4) | 285* | (11·2) | 296 | (11·2) | 348 | (6·4) |
| CS-1 Mono-acetate (IId and IIId) | 233* | (28·9) | 252 | (51·2) | 312 | (12·8) | 369 | (5·6) |
| Reduced CS-1 monomethyl ether (IIb) | 236 | (28·1) | 245 | (29·4) | 297 | (9·3) | 364 | (4·7) |
| 6-(3,3-Dimethylallyl)-1,5-dihydroxyxanthone (VI) | 234* | (25·9) | 249 | (44·4) | 313 | (10·6) | 365 | (3·0) |
| Scriblitifolic acid (I)[2] | 234 | (29·4) | 245 | (31·5) | 297† | (10·1) | 365 | (5·34) |
| 1,5-Dihydroxyxanthone[2] | 235* | (22·1) | 248 | (34·2) | 315 | (6·41) | 370 | (3·56) |
| 1-Hydroxy-5-methoxy-xanthone[2] | 235* | (32·6) | 247 | (44·2) | 310 | (10·6) | 370 | (6·8) |
| 1,5-Dimethoxyxanthone[2] | 235* | (34·8) | 244 | (44·4) | 303 | (8·4) | 350 | (5·6) |
| 6-Allyl-1-hydroxy-5-methoxyxanthone[2] | 234* | (32·2) | 245 | (33·0) | 298† | (10·1) | 364 | (5·73) |
| 6-Allyl-1,5-dimethoxy-xanthone[2] | 234* | (33·8) | 243 | (40·2) | 284* | (9·71) | 347 | (6·01) |
| | | | | | 297 | (10·2) | | |
| 6-Propyl-1,5-dimethoxy-xanthone[2] | 234* | (39·9) | 243 | (50·83) | 286* | (12·22) | 348 | (7·69) |
| | | | | | 296 | (13·5) | | |
| 1,6-Dihydroxyxanthone[2] | 230 | (28·14) | 248 | (17·46) | 265 | (9·62) | 305 | (10·33) |
| | | | | | 288* | (8·19) | 353 | (5·7) |
| 5-Propyl-1,6-dimethoxy-xanthone[2] | 234 | (50·83) | 240* | (39·8) | 286* | (12·17) | 305 | (16·01) |
| | | | | | | | 339 | (10·23) |

* Shoulder. † Flat peak.
All spectra were determined in MeOH soln.

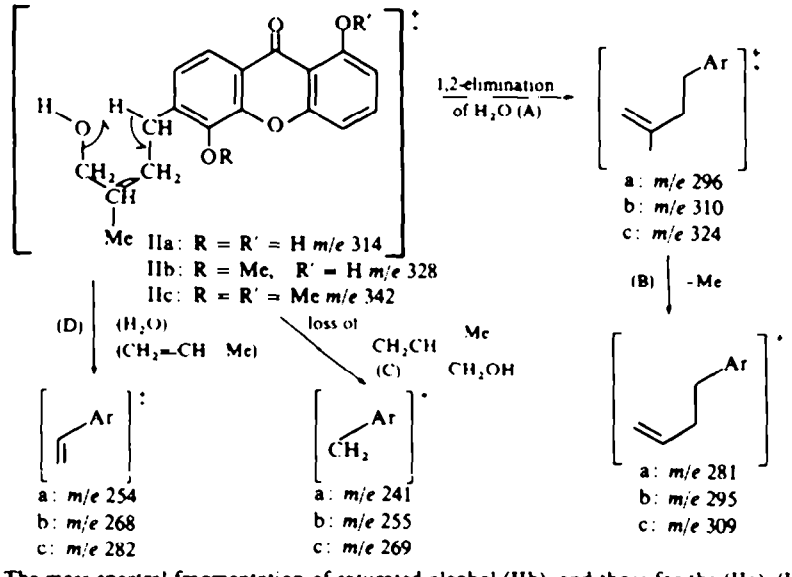
mass measurements showing them to have molecular formulae, $C_{18}H_{18}O_5$ (IIa) and $C_{18}H_{16}O_5$ (IIIa), and suggesting that the former might be the dihydro derivative of the latter. Both formulae were consistent with the results of the elemental analyses obtained earlier.

The structural elucidation of scriblitifolic acid (I) and the availability of several synthetic analogues[2] helped us to reinterpret earlier experimental work on CS-1. Since the UV spectra of CS-1 (IIa and IIIa) and scriblitifolic acid (I) (Table 1) were nearly identical, CS-1 could be recognized as a mixture of xanthones with the nuclear oxygenation pattern of scriblitifolic acid (I).

Methylation of CS-1 with diazomethane gave a mixture, shown by mass spectrometry to consist of the monomethyl ethers (IIb and IIIb). Methylation with dimethyl sulphate likewise gave a mixture of the dimethyl ethers (IIc and IIIc). The UV spectra (Table 1) of these mixtures of ethers were consistent with the structures assigned to them and the IR spectra showed the xanthone CO group at 1650 in the mono- and at 1655 $cm^{-1}$ in the dimethyl ethers. Even in the dimethyl ethers there was absorption in the region of 3300 $cm^{-1}$ suggesting that a residual unmethylated OH function had alcoholic rather than phenolic character.

In confirmation of these results, hydrogenation of the mixture of monomethyl ethers (IIb and IIIb) gave the single compound of structure IIb, the mass spectrum of which agreed exactly with the appropriate set of peaks from the mixture.

An analysis of the principal fragment ions appearing in the mass spectrum of the saturated alcohol IIb appears in Scheme 1, together with details of metastable peaks which confirm several of the steps.




SCHEME 1. The mass spectral fragmentation of saturated alcohol (IIb), and those for the (IIa), (IIb) and (IIc) components, respectively, in CS-1 and its ether derivatives.

Metastable peaks:

Fragmentation of (IIb): Step A: Found, 292·8, calculated, 293·0
Step C: Found, 198·5, calculated, 198·2
Step D: Found, 219·0, calculated, 219·0
Fragmentation of (IIc): Step A: Found, 306·8, calculated, 306·9

TABLE 2. PMR ABSORPTIONS OF SUBSTITUTED XANTHONES IN DEUTERIOCHLOROFORM: τ (PPM) USING TMS AS INTERNAL REFERENCE

| Compound | Aromatic protons C-1 | C-2 | C-3 | C-4 | C-5 | C-6 | C-7 | C-8 | Instrument |
|---|---|---|---|---|---|---|---|---|---|
| CS-1 Monomethyl ether (IIb and IIIb) | OH | 3·23 md | 2·43 t | 3·03 md | OMe | $-CH_2CH_2CH(Me)CH_2OH$ / $CH_2CH=C(Me)CH_2OH$ | 2·83 d | 2·09 d | N |
| CS-1 Dimethyl ether* (IIc and IIIc) | OMe | 3·20 md | 2·30 t | 2·91 md | OMe | $CH_2CH_2CH(Me)CH_2OH$ / $CH_2CH=C(Me)CH_2OH$ | 2·85 c | 1·97 d | M |
| CS-1 Mono-acetate (IId and IIId) | OH | 3·20 md | 2·46 t | 3·08 md | OH | $CH_2CH_2CH(Me)CH_2OCO\cdot Me$ / $CH_2CH=C(Me)CH_2OCO\cdot Me$ | 2·87 d | 2·26 d | M |
| Reduced CS-1 monomethyl ether (IIb) | OH | 3·22 md | 2·42 t | 3·03 md | OMe | $-CH_2CH_2CH(Me)CH_2OH$ | 2·83 d | 2·06 d | N |
| 6-(3,3-Dimethylallyl)-1,5-dihydroxyanthone (VI)† | OH | 3·23 md | 2·31 t | 2·96 md | OH | $CH_2CH=C(Me)Me$ | 2·79 d | 2·34 d | N |
| Scriblitifolic acid (I)[2] | OH | 3·20 md | 2·40 t | 3·02 md | OMe | $-CH_2CH_2CH(Me)CO_2H$ | 2·79 d | 2·04 d | M |
| 6-Propyl-1-hydroxy-5-methoxyxanthone[2] | OH | 3·26 md | 2·44 t | 3·05 md | OMe | $-CH_2CH_2CH_3$ | 2·85 d | 2·10 d | N |
| 6-Propyl-1,5-dimethoxy-xanthone[2] | OMe | 3·21 md | 2·40 t | 2·89 md | OMe | $CH_2CH_2CH_3$ | 2·87 d | 2·03 d | N |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 6-Allyl-1-hydroxy-5-methoxyxanthone[2] | OH | 3·27 md | 2·45 t | 3·07 md | OMe | $-CH_2CH=CH_2$ | 2·86 d | 2·12 d | N |
| 6-Allyl-1,5-dimethoxyxanthone[2] | OMe | 3·21 md | 2·40 t | 2·90 md | OMe | $-CH_2CH=CH_2$ | 2·86 d | 2·03 d | N |

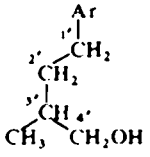
Ring substituent protons

| Compound | C-1 (OH) | Other OH | OMe | Ar–$CH_2$ | $-CH_3$ | —C Me | CH= | CH< | $-CH_2OH$ |
|---|---|---|---|---|---|---|---|---|---|
| IIb | −2·56 s | 8·45 bs | 5·99 s | 7·19 t | 8·30 c | 8·97 d | | 8·34 c | 6·46 c |
| IIIb | | | | 6·46 d | | 8·19 bs | 4·42 t | | 6·0 c |
| IIc | — | 7·8 | 5·90 s | 7·20 t | 8·20 | 8·95 d | | 8·20 | 6·43 |
| IIIc* | | | 5·92 s | 6·43 d | | 8·13 bs | 4·30 | | 5·90 |
| IId | − | 4·0 | $CH_3CO_2$ 7·93 s | 7·18 t | 8·30 | 8·95 d | | 8·30 | 6·01 d |
| IIId | | | | 6·44 d | | 8·20 bs | 4·30 | | 5·49 s |
| IIb | −2·62 s | 8·40 bs | 5·98 s | 7·18 t | 8·30 | 8·97 d | | 8·30 | 6·45 d |
| VI† | −2·74 s | | | 6·49 d | | = $CMe_2$ 8·27 bs | 4·61 t | — | — |
| I[2] | −2·61 bs | | 6·02 s | 7·20 t | 8·12 c | 8·75 d | | 7·5 c | |
| 6-Propyl-1-hydroxy-5-methoxyxanthone[2] | −2·62 s | | 6·00 s | 7·24 t | 8·3 c | 9·02 t | — | — | — |
| 6-Propyl-1,5-dimethoxyxanthone[2] | − | | 5·97 s 6·01 s | 7·25 t | 8·3 c | 9·02 t | | — | |
| 6-Allyl-1-hydroxy-5-methoxyxanthone[2] | −2·55 s | — | 6·02 s | 6·48 d | | | ~4·0 c | = $CH_2$ 4·8 5·08 c | |
| 6-Allyl-1,5-dimethoxyxanthone[2] | − | | 5·99 s | 6·48 d | | — | 4·2 c | = $CH_2$ 4·8–5·0 c | — |

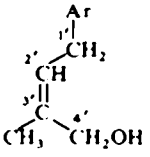
* Spectrum measured as a solution in $CCl_4$. † Spectrum measured as a solution in $(CD_3)_2CO$.

s = Singlet; d = doublet; bs = broad singlet; md = *ortho*-split doublet showing additional *meta*-splitting; c = complex; t = triplet. M = 100 Mc/s; N = 60 Mc/s. In all cases integrated areas supported the assignments.

In the NMR spectrum of the saturated alcohol IIb (Table 2) signals corresponding to 5 aromatic protons were observed, whose mode of coupling divided them into two groups. The lowest field resonance at 2·06 τ, which must be assigned to the highly deshielded proton at the C-8 position, was *ortho*-coupled to its C-7 neighbour ($J$ = 8·5 c/s) at 2·83 τ ($J$ = 8·5 c/s) in ring A. The three remaining protons appeared at higher fields as two sets of *ortho*- and *meta*-split quartets corresponding to protons at C-2 (3·22 τ, $J$ = 8·5 and 1·5 c/s) and C-4 (3·03 τ, $J$ = 8·5 and 1·5 c/s) leaving a symmetrically coupled triplet ($J$ = 8·5 c/s) at 2·43 τ due to the C-3 proton. This set of protons can be located only in ring B. The C-1 hydrogen bonded OH group appeared at −2·62 τ and the OMe group, attached at C-5 according to UV spectral evidence, appeared as a singlet at 5·98 τ. This pattern of signals corresponds well with those found for scriblitifolic acid (I) (Table 2).[2]




IV




V

The remaining signals in the NMR spectrum of the alcohol IIb belong to the side chain IV, whose point of attachment to the xanthone nucleus can only be at C-6. The side chain Me group at C-3′ appeared as a doublet at 8·97 τ ($J$ = 6 c/s). A triplet at 7·18 τ, showing slight long range coupling ($J$ = 7·0 and 2·0 c/s), was assigned to the C-1′ methylene group. The central C-2′ methylene group produced a complex signal with its centre at 8·30 τ, and the more deshielded C-4′ methylene group appeared as a doublet at 6·45 τ ($J$ = 6 c/s). A signal at 8·40 τ, which disappeared on addition of deuterium oxide, was assigned to the C-4′ OH group.

We next compared the NMR and mass spectra obtained for the mixture IIb and IIIb with the data for the saturated alcohol IIb. In both spectra the additional peaks produced by the second component were readily rationalized: they indicated that the unsaturated alcohol IIIb was present. Taking into consideration that the overlapping NMR signals of the aromatic protons must come from *both* components, the integrated areas for each set of side chain protons were consistent with an approximate 1:1 ratio of the two alcohols (IIb and IIIb). For the reason of the insolubility of CS-1 (IIa and IIIa) in common solvents, its NMR spectrum itself was not studied, but it is likely that the component xanthones are present in a similar ratio.

Detailed analysis of the NMR spectral data (Table 2) clearly indicates that the olefinic bond in components IIIb and IIIc of the mixed mono- and dimethyl ethers is between the C-2′ and C-3′ carbon atoms as indicated in the partial formula V.

Thus in the NMR spectrum of the mixed monomethyl ethers, IIb and IIIb, (Fig. 2) the signals attributed to the side chain V appeared as follows. The Me group attached at C-3′ was seen as a slightly broadened singlet at 8·19 τ, the benzylic C-1′ methylene group as a doublet at 6·46 τ ($J$ = 6·0 c/s), and the C-2′ methine proton as a triplet at 4·42 τ ($J$ = 8·0 c/s). The heavily deshielded C-4′ methylene group appeared as a singlet superimposed upon the C-5 OMe group signal at 5·99 τ. This pattern of signals can only be rationalized on the basis of the side chain structure V: alternative sitings of

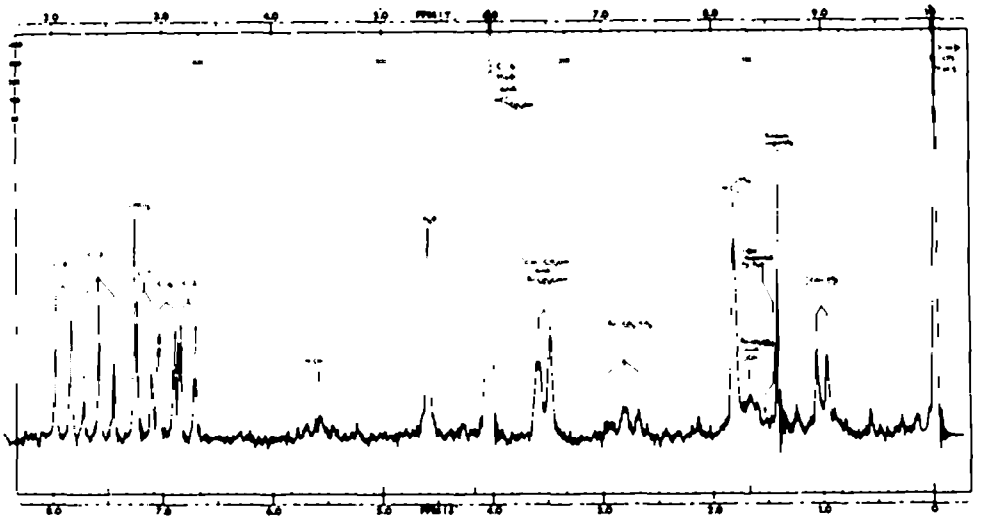


FIG. 2 Proton magnetic resonance spectrum of monomethyl ether of CS-1 (IIb and IIIb) in $CDCl_3$ ($+D_2O$) at 60 Mc/s using TMS as internal standard (sweep width 500 c/sec) (sweep offset showed signal at $-2{\cdot}58$ τ due H bonded OH).

the double bond would need to show *inter alia* either one or four sets of methylene protons instead of the two which are observed.

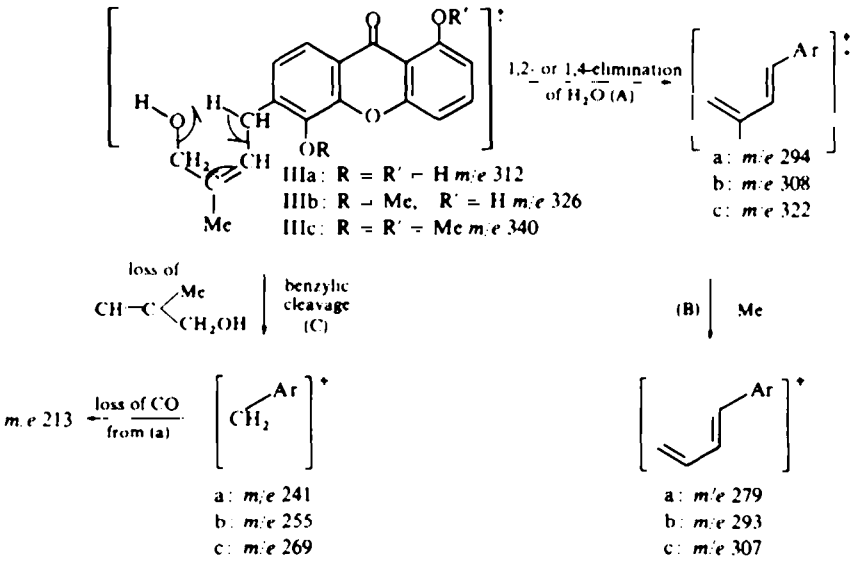
Unfortunately, because suitable model compounds were lacking, it was not possible to define the stereochemistry of the double bond substituents.

The resonance signals seen in the spectrum of the mixed dimethyl ethers IIc and IIIc (Table 2) provide further support for the conclusions reached above.

Exclusion of the mass spectral lines already attributed to the fragmentation of the saturated alcohol IIb (Scheme 1) leaves, in the spectrum of the mixed ethers IIb and IIIb, three major peaks at *m/e* 326, 308 and 293, which can be seen (Scheme 2) to arise logically from the fragmentation of the unsaturated component IIIb. The intense peak at *m/e* 255 is probably a fragment ion formed from either component IIb and IIIb, and from this point onwards fragmentation of the xanthone nucleus occurs. The mass spectrum of CS-1 itself (IIa and IIIa) (Fig. 1) and that for the derived mixture of dimethyl ethers (IIc and IIIc) both contain major peaks which can be rationalized in an exactly analogous manner (Schemes 1 and 2) to indicate the presence of xanthones with the side chains IV and V. The appearance of metastable peaks in these spectra again corroborated several of the fragmentations indicated, and in the case of CS-1, the major fragment ions were mass measured to confirm their molecular formulae.

An early attempt to record the NMR spectrum of CS-1 in trifluoroacetic acid* produced a spectrum which was seen to change rapidly with time, making any interpretation difficult. In order to simulate these highly acidic conditions, CS-1 (IIa and IIIa) was heated in acetic acid containing a catalytic quantity of sulphuric acid. Only the alcoholic groups were esterified giving the mixture of monoacetates (IId and IIId). The mass spectrum exhibited two molecular ions for the constituents

* We thank Dr. J. K. Becconsall and Mr. P. Hampson of I.C.I., Ltd., Dyestuffs Division, Blackley, Manchester, for this result.

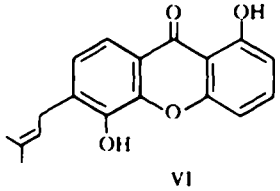



SCHEME 2. The mass spectral fragmentation of unsaturated alcohol components (IIIa), (IIIb) and (IIIc) in CS-1 and its ether derivatives.
Metastable peaks:

Fragmentation of (IIIa): Step (A): Found, 277·0, calculated, 277·1
Step (B): Found, 264·5, calculated, 264·8
Fragmentation of (IIIc): Step (B): Found, 292·5, calculated, 292·6

at *m/e* 356 and 354, each of which gave an ion at $(M-60)^+$ corresponding to the loss of acetic acid. This loss is typical of alkyl rather aryl acetates[3] and confirms the point of esterification. Furthermore, the UV spectrum of the monoacetates was similar to that of CS-1 itself, (Table 1) thus proving that the double bond in IIId had not moved into conjugation with the aromatic ring. The signals in the NMR spectrum of the mixture of monoacetates (IId and IIId) were also in accord with acetylation of the side chain hydroxyls (Table 2).

The isolation of CS-1 (IIa and IIIa) and our earlier isolation of scriblitifolic acid (I)[2] stimulated our search for their possible biogenetic precursor, 6-(3,3-dimethylallyl)1,5-dihydroxyxanthone (VI). This was found in small quantity in the mother liquors from CS-1 and, from its UV spectrum, the metabolite VI was recognized as a 6-alkyl-1,5-dihydroxyxanthone (Table 1)[2]. In agreement, the IR spectrum possessed OH and xanthone CO bands at 3300 and 1610 $cm^{-1}$, respectively. In the mass spectrum, the molecular ion at *m/e* 296 was mass measured and corresponded to $C_{18}H_{16}O_4$, the fragmentation being consistent with the breakdown of a 3,3-dimethylallyl side chain (loss of $[^{Me}_{Me}>C{=}CH]^+$)[4] which suggested the partial formula



VI

$C_{13}H_7O_4 \cdot C_5H_9$. The NMR spectrum, with signals at 4·61 τ (1H, triplet, $J$ = 8·0 c/s), 6·49 τ (2H, doublet, $J$ = 8·0 c/s) and 8·27 τ (6H, broad singlet), confirmed the presence of the 3,3-dimethylallyl group,[4,5] and the other signals were consistent with the presence of the 6-alkyl-1,5-dihydroxyxanthone nucleus (Table 2).

Earlier, we suggested[2] that scriblitifolic acid (I) could be produced in the plant by oxidation of the side chain of some dimethylallylxanthone derivative similar to VI. The isolation of this metabolite (VI) and the mixture of alcohols (IIa and IIIa) from the same heartwood supports this idea. Our other work on the Guttiferae heartwood constituents[4,5b,6] tends to indicate that the dimethylallyl side chain itself is introduced into a preformed hydroxylated xanthone nucleus, and we would expect this nucleus to arise from oxidative ring closure of a suitable hydroxylated benzophenone[6b] as in model experiments.[7] As yet, however, we have been unable to isolate any benzophenones from the heartwood of *C. scriblitifolium* Henderson and Wyatt-Smith.

## EXPERIMENTAL

Microanalyses were by Drs. Weiler and Strauss, Oxford. UV spectra (in MeOH) were measured on the Optika Spectrophotometer (No. CF 4 DRN1A) or the Unicam SP800. IR spectra, in Nujol unless otherwise stated, were measured on the Perkin–Elmer Infracord 137, and NMR spectra were measured on the Varian HR 100, HA 100 or A 60 instruments. Mass spectra were recorded on an A.E.I., MS 9 double focusing spectrometer at 70 eV. Analytical TLC, was on silica gel G by Stahl (Merck) and preparative TLC, on silica gel HF254 (Merck) unless otherwise stated.

### *Extraction of* Calophyllum scriblitifolium *Henderson and Wyatt-Smith*

A section of the heartwood of *Calophyllum scriblitifolium* Henderson and Wyatt-Smith (Herbarium numbers S 17580 and S 16170, Office of the Conservator of Forests, Kuching, Sarawak, Malaysia) was collected from the Setapok Forest Reserve. The wood was converted into powder (1·5 Kg) in an Apex cutter mill and then extracted with hot $CHCl_3$ in a Soxhlet apparatus for 5 days.

### *Isolation of CS-1,* IIa *and* IIIa

The dark brown solid (20·0 g) remaining after evaporation of the solvent from the above extract was dissolved in EtOAc and extracted with cold 4N NaOH. Neutralization of the alkaline extract with dil HCl gave a dark brown solid which was collected. After trituration with $CHCl_3$, the undissolved solid (10 g) was crystallized from MeOH to give crude CS-1. Crude CS-1 was dissolved in the minimum amount of EtOAc and chromatographed on a column of silica gel (500 g) made up with $CHCl_3$. The eluate (EtOAc $CHCl_3$, 3:20) was collected and evaporated to dryness, leaving a residue, which when crystallized from MeOH and finally acetone, gave *CS-1* (a mixture of IIa and IIIa), pale yellow plates (1·5 g), m.p. 219–222°, $R_f$ 0·5 (in EtOAc–$CHCl_3$, 2:3), $\nu_{max}$ 3300 (OH) and 1650 cm$^{-1}$ (xanthone C=O). (Found: C, 68·4; H, 5·5; M, 314·11546 and 312·0997 (mass spectrometry). $C_{18}H_{18}O_5$ requires:[8] C, 68·8; H, 5·8; M, 314·11541. $C_{18}H_{16}O_5$ requires:[8] C, 69·2; H, 5·2%; M, 312·0998)

### *Methylation of CS-1*

(a) *With diazomethane.* CS-1 (100 mg) was dissolved in EtOAc (50 ml) to which was added an excess of ethereal diazomethane. The reaction mixture was left overnight at 0°, after which removal of the solvent furnished a yellow solid (95 mg). Further purification by preparative TLC, gave *CS-1 monomethyl ether* (a mixture of IIb and IIIb) as pale yellow needles (50 mg) m.p. 89–99° from light petroleum (b.p. 60–80°), $R_f$ 0·5 (in EtOAc–$CHCl_3$, 1:1), $\nu_{max}$ 3300 (OH) and 1650 cm$^{-1}$ (xanthone C=O). (Found: M, 328 and 326 (mass spectrometry). $C_{19}H_{20}O_5$ requires: M, 328. $C_{19}H_{18}O_5$ requires: M, 326).

(b) *With dimethyl sulphate.* CS-1 (IIa and IIIa) (200 mg) was heated under reflux with $Me_2SO_4$ (2·6 ml), $K_2CO_3$ (1·0 g) and acetone (100 ml) for 4 hr. The suspension was filtered off, and the crude product obtained from the filtrate by evaporation, was purified using preparative TLC, (aluminium oxide H, Merck), $R_f$ 0·6 (in EtOAc–$CHCl_3$, 7:3). This product, crystallized from $CCl_4$, gave *CS-1 dimethyl ether* (a mixture of IIc and IIIc), colourless needles (50 mg), m.p. 100–103°, $\nu_{max}$ 3300 (OH) and 1655 cm$^{-1}$ (xanthone CO). (Found: C, 70·0; H, 6·2; M, 342 and 340 (mass spectrometry). $C_{20}H_{22}O_5$ requires: C, 70·2; H, 6·5; M, 342. $C_{20}H_{20}O_5$ requires: C, 70·6, H, 5·9%, M, 340).

*Reduction of CS-1 monomethyl ether*

CS-1 monomethyl ether (20 mg) was dissolved in benzene (30 ml) and agitated under $H_2$ in the presence of Raney Ni for 1 hr. The catalyst was collected and the filtrate evaporated, leaving a residue, which crystallized from light petroleum (b.p. 60–80°)–$CCl_4$ in pale yellow needles (8 mg) to give *6-(4-hydroxy-3-methylbutanyl)-1-hydroxy-5-methoxyxanthone* (IIb), m.p. 103–105°, $\nu_{max}$ 3300 (OH), and 1650 $cm^{-1}$ (xanthone C=O). (Found: M, 328 (mass spectrometry). $C_{19}H_{20}O_5$ requires: M, 328). There was no significant peak in the mass spectrum at *m/e* 326.

*Monoacetylation of CS-1*

CS-1 (IIa and IIIa) (100 mg) in AcOH (10 ml) containing $H_2SO_4$ (4 drops) was heated under reflux for 15 min, after which the reaction mixture was poured into water. The ppt was extracted into EtOAc and the extract washed with $NaHCO_3$ aq, then with water, and finally dried over $MgSO_4$. The solid obtained on evaporation of the solvent was purified by preparative TLC, $R_f$ 0·5 (in EtOAc–$CHCl_3$, 1:1), to give *CS-1 monoacetate* (a mixture of IId and IIId) as yellow needles (25 mg), m.p. 194–196° from $CHCl_3$–light petroleum (b.p. 60–80°), $\nu_{max}$ 3300 (OH), 1730 (ester C=O) and 1650 $cm^{-1}$ (xanthone C=O). (Found: C, 67·7; H, 5·4; M, 356 and 354 (mass spectrometry). $C_{20}H_{20}O_6$ requires: C, 67·4; H, 5·7%; M, 356. $C_{20}H_{18}O_6$ requires: C, 67·8; H, 5·1%; M, 354).

*Isolation of 6-(3,3-dimethylallyl)-1,5-dihydroxyxanthone* (VI)

From several combined extracts of *Calophyllum scriblitifolium* Henderson and Wyatt-Smith, the material of higher $R_f$ value than CS-1 (IIa and IIIa) was accumulated from the column chromatography of crude CS-1. Purification of the higher $R_f$ material using preparative TLC, gave a yellow solid, $R_f$ 0·85 (in benzene–$CHCl_3$, 1:4) which crystallized from $CCl_4$ in pale yellow plates (20 mg) giving *6-(3,3-dimethylallyl)-1,5-dihydroxyxanthone* (VI), m.p. 212–214°, $\nu_{max}$ 3300, (OH) and 1650 $cm^{-1}$ (xanthone C=O). (Found: M, 296·1041 (mass spectrometry). $C_{18}H_{16}O_4$ requires:[8] M, 296·1049)

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