Phytochemistry, 1970, Vol. 9, pp. 2537 to 2544. Pergamon Press. Printed in England.

XANTHONES FROM *KIELMEYERA SPECIOSA**†

O. R. GOTTLIEB, A. A. LINS MESQUITA, G. G. DE OLIVEIRA and M. TEIXEIRA DE MELO‡

Departamento de Química, Universidade Federal de Minas Gerais, Belo Horizonte, Brasil

(*Received* 3 *February* 1970)

Abstract—The trunk wood of *Kielmeyera speciosa* St. Hil. (Guttiferae) contains β-amyrin, 6-dehydroxyjacareubin (I), 2-hydroxyxanthone (IIa), 2-hydroxy-1-methoxyxanthone (IIb), 1,3,8-trihydroxy-7-methoxyxanthone (IIIa), 1,5-dihydroxy-3-methoxyxanthone (IVa), 5-hydroxy-1,3-dimethoxyxanthone (IVb), 4-hydroxy-2,3-dimethoxyxanthone (Va), 3-hydroxy-2,4-dimethoxyxanthone (Vd), 4-hydroxy-2,3-methylenedioxyxanthone (Vb), 3-hydroxy-1,2-dimethoxyxanthone (VIa) and 2,3-dihydroxy-1-methoxyxanthone (VIb).

RESULTS

Kielmeyera speciosa St. Hil. is a tree indigenous to the central Brazilian plateau. Its trunk wood, freed from bark, yielded a benzene extract which was fractionated by a combination of chemical and chromatographic methods. Among the twelve crystalline compounds isolated, β-amyrin and 6-dehydroxyjacareubin (I) were identified by direct comparison with authentic samples. 6-Dehydroxyjacareubin, whose constitution and presence in *K. speciosa* has been described previously,[1a,2] was subsequently located also in *K. ferruginea* A. P. Duarte,[3] *Calophyllum brasiliense* Camb.,[2] *C. scriblitifolium* Hend. & Wyatt-Smith,[4] *C. fragrans* Ridley[5] and *C. inophyllum* L.[6]

The derivation from a xanthone skeleton of the other aromatic constituents was apparent upon inspection of their u.v. spectra. In order to classify the substances into groups with identical oxygenation patterns, all were exhaustively methylated with dimethyl sulfate. The NMR spectra of the derivatives, which showed only substitution by methoxy groups and, in one case, by a methylenedioxy group, revealed that one of the compounds was mono-oxygenated, one was di-oxygenated and one was tetra-oxygenated, while seven were tri-oxygenated.

* Part XXVI in the series "The Chemistry of the Brazilian Guttiferae"; for Part XXV see: R. ALVES DE LIMA and O. R. GOTTLIEB, *Anais Acad. Brasil. Ciênc.* **41**, Supplement (1969).

† Taken, in part, from the Doctorate-Thesis submitted by G. G. DE OLIVEIRA to the Universidade Federal de Minas Gerais, Belo Horizonte, Brasil (1968). For preliminary communications see Ref. 1.

‡ MAURI TEIXEIRA DE MELO and two other young members of the Guttiferae team, ERBETI MARTINS DA SILVA (see Ref. 3) and SERGIO JANOT GONÇALVES (see Ref. 10) perished in a bus accident, 2 August 1969. This paper is dedicated to their memory.

[1] G. G. DE OLIVEIRA, A. A. LINS MESQUITA, O. R. GOTTLIEB and M. TAVEIRA MAGALHÃES, (a) *Anais Acad. Brasil. Ciênc.* **38**, 421 (1966); (b) **40**, 29 (1968).

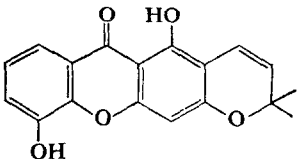
[2] O. R. GOTTLIEB, M. TAVEIRA MAGALHÃES, M. OTTONI DA SILVA PEREIRA, A. A. LINS MESQUITA, D. DE BARROS CORRÊA and G. G. DE OLIVEIRA, *Tetrahedron* **24**, 1601 (1968).

[3] O. R. GOTTLIEB, A. A. LINS MESQUITA, E. MARTINS DA SILVA and M. TEIXEIRA DE MELO, *Phytochem.* **8**, 665 (1969).

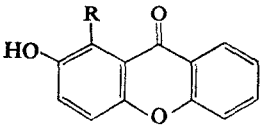
[4] B. JACKSON, H. D. LOCKSLEY and F. SCHEINMANN, *J. Chem. Soc.* (C) 2500 (1967).

[5] H. D. LOCKSLEY and I. G. MURRAY, *J. Chem. Soc.* (C) 1567 (1969).

[6] B. JACKSON, H. D. LOCKSLEY and F. SCHEINMANN, *Phytochem.* **8**, 927 (1969).

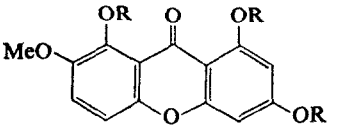


(I)



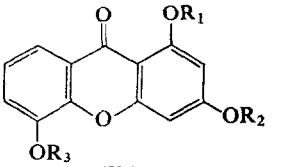
(II)

	R
a	H
b	OMe



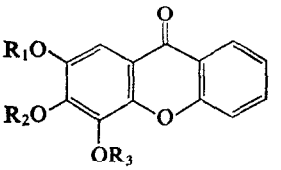
(III)

	R
a	H
b	Ac



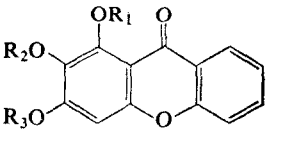
(IV)

	R_1	R_2	R_3
a	H	Me	H
b	Me	Me	H



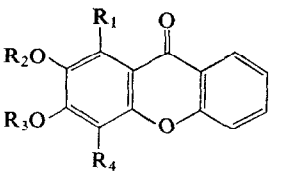
(V)

	R_1	R_2	R_3
a	Me	Me	H
b	—CH_2—		H
c	Me	Me	Me
d	Me	H	Me
e	Me	H	H
f	Me	Ac	Me



(VI)

	R_1	R_2	R_3
a	Me	Me	H
b	Me	H	H
c	Me	Me	Me
d	H	H	Me
e	Me	Me	Ac
f	Me	Ac	Ac



(VII)

	R_1	R_2	R_3	R_4
a	H	Me	Me	H
b	H	Me	H	H
c	H	Me	H	CHO
d	H	H	H	H
e	H	H	Me	H
f	CHO	H	Me	H

The Mono-, Di- and Tetra-oxygenated Xanthones

The mono-oxygenated xanthone was identified with 2-hydroxyxanthone by direct comparison with an authentic sample. This substance was first isolated from *Mammea americana* L.[7] and subsequently also from *K. excelsa* Camb.[8]

The di-oxygenated xanthone, however, proved to be a new natural compound. Its u.v. spectrum and the u.v. spectrum of 2-hydroxyxanthone underwent identical shifts in the presence of additives, revealing the presence of a hydroxyl at C-2. Hence, when the identity of the methyl ether of the natural compound with synthetic 1,2-dimethoxyxanthone[9] was demonstrated by direct comparison, the structure of 2-hydroxy-1-methoxyxanthone (IIb) was considered established. Indeed, not only were the m.ps of the isolate and of synthetic 2-hydroxy-1-methoxyxanthone[9] identical, but the mass spectrum showed the molecular ion at 242 a.m.u. and fragment ions compatible with such a structure. Appropriate "metastable peaks" were observed for transitions involving losses of 15, 18, 28, 29, and 30 mass units from the molecular ion. Excepting a further peak at M-15–28 a.m.u. no other prominent peaks were present. 2-Hydroxy-1-methoxyxanthone is the first natural xanthone with a 1,2-oxygenation pattern to be isolated. It has subsequently been found in *K. rupestris* A. P. Duarte[10] and *K. excelsa* Camb.[8] where it occurs accompanied by 1,2-methylenedioxyxanthone.

The mol. wt. 274, determined by mass spectrometry, revealed the tetra-oxygenated xanthone as a trihydroxy-monomethoxy derivative. Information regarding the localization of these substituents was obtained by u.v. spectrometry. Thus the shifts of the absorption maxima typical for the 1,3-dihydroxyxanthone system,[10,11] were observed in presence of $AlCl_3$, NaOH and NaOAc. The Gibbs test curve,[11] however, showed a maximum of much higher absorbance than would be expected for such a system. Since the wavelength of this maximum made the presence of a 5-OH-8-H system unlikely the remaining hydroxyl can only occupy position 8, *para* to an unsubstituted C-5. The aromatic region of the NMR spectrum showed the *meta* relationship of two protons, confirming the 1,3-oxygenation on one ring, and the *ortho* relationship of two others. A proton must, consequently, exist at C-6 and the methoxyl group should be located at the remaining position 7. Indeed, the identity of the natural isolate with 1,3,8-trihydroxy-7-methoxyxanthone (IIIa) was proved by direct comparison with synthetic material.[12]

The Tri-oxygenated Xanthones

Among the seven tri-oxygenated xanthones, four were identified by direct comparison with 1,5-dihydroxy-3-methoxyxanthone (IVa), 5-hydroxy-1,3-dimethoxyxanthone (IVb), 4-hydroxy-2,3-dimethoxyxanthone (Va) and 4-hydroxy-2,3-methylenedioxyxanthone (Vb) which all were originally isolated from *K. coriacea* Mart. and *K. corymbosa* (Spr.) Mart.[13,14] In later years the presence of 1,5-dihydroxy-3-methoxyxanthone in *Mesua ferrea* L. was

[7] R. A. Finnegan and P. L. Bachman, *J. Pharm. Sci.* **54**, 633 (1965).
[8] O. R. Gottlieb and G. M. Stefani, *Phytochem.* **9**, 453 (1970).
[9] J. S. H. Davies, F. Lamb and H. Suschitzky, *J. Chem. Soc.* 1790 (1958).
[10] D. de Barros Corrêa, L. G. Fonseca e Silva, O. R. Gottlieb and S. Janot Gonçalves, *Phytochem.* **9**, 447 (1970).
[11] A. A. Lins Mesquita, D. de Barros Corrêa, O. R. Gottlieb and M. Taveira Magalhães, *Anal. Chim. Acta* **42**, 311 (1968).
[12] K. R. Markham, *Tetrahedron* **20**, 991 (1964); **21**, 3687 (1965).
[13] A. Pimenta, A. A. Lins Mesquita, M. Camey, O. R. Gottlieb and M. Taveira Magalhães, *Anais Acad. Brasil. Ciênc.* **36**, 283 (1964); *Chem. Abs.* **63**, 4655 (1965).
[14] O. R. Gottlieb, M. Taveira Magalhães, M. Camey, A. A. Lins Mesquita and D. de Barros Corrêa, *Tetrahedron* **22**, 1777 (1966).

reported,[15] and the authors, unaware of the previous work, designated it mesuaxanthone A. The compound occurs also in *K. rupestris* A. P. Duarte[10] accompanied by 5-hydroxy-1,3-dimethoxyxanthone and 4-hydroxy-2,3-dimethoxyxanthone, while *K. ferruginea* A. P. Duarte[3] contains 5-hydroxy-1,3-dimethoxyxanthone and 4-hydroxy-2,3-dimethoxyxanthone.

The remaining three compounds were unknown. One of them, shown by mass spectrometry to be a hydroxydimethoxyxanthone, gave 2,3,4-trimethoxyxanthone (Vc) upon *O*-methylation. Since the 4-hydroxy-2,3-dimethoxy derivative (Va) is a known compound,[14] only two alternatives needed to be considered *a priori* for the natural isolate. The considerable acidity of the hydroxyl, as borne out by bathochromic and hyperchromic shifts of the u.v. maxima in presence of NaOAc,[11] however, makes the presence of this group at C-2 impossible. The mass spectrum was also in favour of the 3-hydroxy-2,4-dimethoxyxanthone structure (Vd), since it revealed the successive loss of two methyl groups by appropriate "metastable peaks". Fragmentation into methyl radicals is characteristic of methoxyl groups at C-2 and C-4 of the xanthone skeleton. Methoxyls at C-1 and C-3 are eliminated preferentially as the elements of formaldehyde after hydrogen rearrangement.[16]

The other two compounds, shown by mass spectrometry to be hydroxydimethoxy- and dihydroxymethoxyxanthones, gave an identical trimethoxyxanthone upon *O*-methylation. The NMR spectrum of this derivative contained the octet at relatively low field, indicative of a C-8 proton, *peri* to the carbonyl, on an unsubstituted xanthone ring.[17] From the four alternative structures which are in accord with this result, two could be ruled out when it was found that this methyl ether was not identical either with 2,3,4-trimethoxyxanthone[14] or with 1,3,4-trimethoxyxanthone[18] upon direct comparison with authentic samples. NMR spectrometry was not unequivocally helpful in deciding between the remaining 1,2,3- and 1,2,4-oxygenation patterns. Calculated and experimental values for the signals due to protons on highly substituted aromatic rings are usually not in good agreement.[17] The 1,2,4-pattern, however, cannot represent the correct alternative, since the hydroxyl of the hydroxydimethoxyxanthone can clearly be located only on C-3. Indeed, the u.v. spectrum of this compound showed the typical batho- and hyperchromic shifts of the K-band upon addition of NaOH and of NaOAc.[10] Its structure may, consequently, be defined as 3-hydroxy-1,2-dimethoxyxanthone (VIa).

The two hydroxyls of the dihydroxymethoxyxanthone are located at vicinal positions, since the u.v. maxima of this compound underwent characteristic shifts in presence of H_3BO_3 + NaOAc. The relatively high acidity of this xanthone precluded the possibility of the existence of the dihydroxy system at C-1,2. Besides, a 1,2-dihydroxyxanthone is very unstable in alkaline solution, suffering decomposition after a few minutes at room temp.[11] The compound under investigation being reasonably stable under these conditions, could only be assigned the structure of 2,3-dihydroxy-1-methoxyxanthone (VIb).

The analytical arguments put forward for these new xanthones were based on the assignment of the structure of 2,3,4-trimethoxyxanthone (Vc) and of 1,2,3-trimethoxyxanthone (VIc) to the derived methyl ethers. It was consequently deemed necessary to confirm the proposed structures of these ethers by synthesis.

[15] T. R. GOVINDACHARI, B. R. PAI, B. S. SUBRAMANIAN, U. R. RAO and M. MUTHUKUMARASWAMY, *Tetrahedron* **23**, 243 (1967).

[16] O. R. GOTTLIEB, *Métodos para a Investigação Estrutural de Xantonas*, pp. 83–94, D.Sc. Thesis, Universidade Federal Rural do Rio de Janeiro (1966).

[17] D. BARRACLOUGH, O. R. GOTTLIEB, H. D. LOCKSLEY, F. SCHEINMANN and M. TAVEIRA MAGALHÃES, *J. Chem. Soc.* (B) (in press).

[18] V. V. KANE, A. B. KULKARNI and R. C. SHAH, *J. Sci. Ind. Res., India*, **18B**, 75 (1959).

The known 2,3-dimethoxyxanthone (VIIa)[19] served as starting material in both cases. In one reaction sequence this compound was partially demethylated to 3-hydroxy-2-methoxyxanthone (VIIb). Duff formylation of this substance led to 3-hydroxy-2-methoxy-4-formylxanthone (VIIIc) whose oxidation according to Dakin afforded 3,4-dihydroxy-2-methoxyxanthone (Ve), identical with the natural product from *K. corymbosa* (Spr.) Mart.[14] Finally, etherification of Ve with dimethyl sulfate gave 2,3,4-trimethoxyxanthone (Vc), identical with the *O*-methyl derivatives of 3-hydroxy-2,4-dimethoxyxanthone (Vd) and 4-hydroxy-2,3-dimethoxyxanthone (Va) ex *K. speciosa* St. Hil.

In another reaction sequence, 2,3-dimethoxyxanthone (VIIa)[19] was fully demethylated. Partial methylation of the resulting 2,3-dihydroxyxanthone (VIId) with dimethyl sulfate yielded 2-hydroxy-3-methoxyxanthone (VIIe) whose formylation product, VIIf, was oxidized to 1,2-dihydroxy-3-methoxyxanthone (VId). Etherification of VId with dimethyl sulfate gave 1,2,3-trimethoxyxanthone (VIc), identical with the *O*-methyl derivatives of 3-hydroxy-1,2-dimethoxyxanthone (VIa) and 2,3-dihydroxy-1-methoxyxanthone (VIb) ex *K. speciosa* St. Hil.

EXPERIMENTAL

For experimental techniques see Ref. 2. The identification of all previously described substances was confirmed by direct comparison (co-chromatography, mixed m.ps and i.r. spectra) with authentic samples.

Isolation of the Constituents of Kielmeyera speciosa

The powdered wood (11·9 kg) was continuously extracted with hot benzene. Upon partial evaporation of the solvent precipitated a solid (*A*. 4·9 g) which was separated by filtration. The filtered benzene solution was evaporated and the residue (116 g) was treated with light petroleum.

A portion (3 g) of the insoluble part (30 g) was chromatographed on silica (90 g) yielding the following fractions with the indicated solvents: benzene–$CHCl_3$ (2:1) (B_1, B_2, B_3, B_4, B_5, in this order), benzene–$CHCl_3$ (1:1) (B_6).

The filtered light petroleum solution was washed successively with 10% aq. $NaHCO_3$, 10% aq. Na_2CO_3 and 3% aq. NaOH. The residual light petroleum solution was evaporated. Part (4 g) of the residue (44 g) was chromatographed on silica (120 g) yielding only one useful fraction (C_1) upon elution with benzene. The $NaHCO_3$, Na_2CO_3 and NaOH solutions were separately acidified (aq. HCl) and extracted with $CHCl_3$. Evaporation of the solvent yielded three residues, respectively *D*, *E* and *F*. Chromatography on silica (20 g) of *D* (0·5 g) yielded only one useful fraction (D_1) upon elution with benzene–$CHCl_3$ (1:1). Chromatography on silica (45 g) of *E* (1·5 g) yielded the following useful fractions with the indicated solvents: benzene (E_1), benzene–$CHCl_3$ (5:1) (E_2, E_3, in this order), benzene–$CHCl_3$ (2:1) (E_4), $CHCl_3$–MeOH (95:5) (E_5). Chromatography on silica (30 g) of *F* (0·9 g) led to the following useful fractions with the indicated solvents: benzene (F_1), benzene–$CHCl_3$ (2:1) (F_2, F_3, in this order), benzene–$CHCl_3$ (1:1) (F_4).

A (4·9 g) in $CHCl_3$ solution was extracted with 3% aq. NaOH. The alkaline solution was acidified (aq. HCl) and extracted with $CHCl_3$. The solvent was evaporated. The residue was recrystallized from EtOH yielding 5-hydroxy-1,3-dimethoxyxanthone (IVb, 302 mg).

B_1 (0·5 g) was washed with Et_2O and recrystallized several times from EtOH yielding 4-hydroxy-2,3-dimethoxyxanthone (Va, 186 mg). B_2 (0·1 g) was washed with Et_2O and recrystallized several times from EtOH yielding 1,5-dihydroxy-3-methoxyxanthone (IVa, 26 mg). B_3 (0·3 g) was recrystallized from EtOH yielding 3-hydroxy-1,2-dimethoxyxanthone (VIa, 108 mg). B_4 (0·1 g) in benzene–$CHCl_3$ solution was filtered through silica. The solvents were evaporated. The residue was recrystallized from EtOH yielding 1,3,8-trihydroxy-7-methoxyxanthone (IIIa, 12 mg). B_5 (0·2 g) was purified by the same procedure yielding 4-hydroxy-2,3-methylenedioxyxanthone (Vb, 8 mg). B_6 (0·5 g) was recrystallized several times from EtOH yielding 5-hydroxy-1,3-dimethoxyxanthone (IVb, 170 mg).

C_1 (0·1 g) in benzene solution was filtered through silica. The solvent was evaporated. The residue was crystallized from light petroleum yielding β-amyrin (23 mg).

D_1 (0·1 g) was purified by TLC yielding 3-hydroxy-2,4-dimethoxyxanthone (Vd, 4 mg).

E_1 (0·1 g) was recrystallized several times from benzene yielding 2,3-dihydroxy-1-methoxyxanthone (VIb, 42 mg). E_2 (0·1 g) was recrystallized several times from EtOH yielding 1,5-dihydroxy-3-methoxyxanthone (IVa, 22 mg). E_3 (0·5 g) in benzene solution was extracted with 10% aq. $NaHCO_3$. The benzene solution was

[19] C. H. Hassal and J. R. Lewis, *J. Chem. Soc.* 2312 (1961).

evaporated. The residue was recrystallized from EtOH yielding 4-hydroxy-2,3-dimethoxyxanthone (Va, 210 mg). The alkaline solution was acidified (aq. HCl) and extracted with $CHCl_3$. The solvent was evaporated and the residue recrystallized from EtOH yielding 3-hydroxy-2,4-dimethoxyxanthone (Vd, 18 mg). E_4 (0·4 g) was recrystallized from EtOH yielding 3-hydroxy-1,2-dimethoxyxanthone (VIa, 188 mg). E_5 (0·1 g) in $CHCl_3$ solution was filtered through silica. The solution was evaporated. The residue was recrystallized several times from EtOH yielding 1,3,8-trihydroxy-7-methoxyxanthone (IIIa, 9 mg).

F_1 (0·2 g) was recrystallized from benzene yielding 6-dehydroxyjacareubin (I, 97 mg). F_2 (0·1 g) was recrystallized several times from EtOH yielding 1,5-dihydroxy-3-methoxyxanthone (IVa, 28 mg). F_3 (0·2 g) in benzene–$CHCl_3$ solution was filtered through silica. The solvents were evaporated. The residue was recrystallized several times from benzene yielding 2-hydroxy-1-methoxyxanthone (IIb, 15 mg). F_4 (0·1 g) was recrystallized several times from EtOH–water (98:2) yielding 2-hydroxyxanthone (IIa, 18 mg).

Properties of K. speciosa *Constituents*

6-*Dehydroxyjacareubin* (*I*). M.p. found: 211–213°, required: 211–213°;[2] M found: 310, required: 310.

2-*Hydroxyxanthone* (*IIa*). M.p. found: 240–242°, required: 241–241·5°;[7] λ_{max}^{EtOH} (nm): 236, 250 sh, 302, 364 (ε resp. 27,300, 22,100, 2900, 4700), $\lambda_{max}^{EtOH+NaOH}$ (nm): 252, 275 sh, 310 sh (ε resp. 32,100, 21,300, 3400), no modification of the u.v. spectrum upon addition of NaOAc, $AlCl_3$; M found: 212, required: 212.

2-*Hydroxy*-1-*methoxyxanthone* (*IIb*). Yellow needles; m.p. found: 169–171°, required: 171°;[9] ν_{max}^{KBr} (cm^{-1}): 3500, 1640, 1625, 1605, 1585, 1495; λ_{max}^{EtOH} (nm): 239, 254, 275 sh, 369 (ε resp. 30,200, 27,000, 10,000, 5300), $\lambda_{max}^{EtOH+NaOH}$ (nm): 255, 274 (ε resp. 29,600, 24,700), no modification of the u.v. spectrum upon addition of NaOAc, $AlCl_3$; m.s. M 242 (100%), *m/e* (%) 227 (21), 224 (88), 213 (27), 212 (18), 199 (67), 196 (27), 168 (49).

1,5-*Dihydroxy*-3-*methoxyxanthone* (*IVa*). M.p. found: 268–270°, required: 269–271°;[14] M found: 258, required: 258.

5-*Hydroxy*-1,3-*dimethoxyxanthone* (*IVb*). M.p. found: 261–263°, required: 263–265°;[14] M found: 272, required: 272.

1,3,8-*Trihydroxy*-7-*methoxyxanthone* (*IIIa*). Yellow needles; m.p. found: 298–300°, required: 296–299°;[12] ν_{max}^{KBr} (cm^{-1}): 3350, 1637, 1605, 1575, 1505, 1275; λ_{max}^{EtOH} (nm): 237, 262, 336 (ε resp. 28,100, 32,300, 17,200), $\lambda_{max}^{EtOH+NaOH}$ (nm): 244, 265 sh, 279, 355 (ε resp. 30,600, 19,900, 15,000, 18,100), $\lambda_{max}^{EtOH+AlCl_3}$ (nm): 225, 241, 277, 328, 362 (ε resp. 20,700, 23,100, 28,400, 11,900, 16,400), $\lambda_{max}^{EtOH+NaOAc}$ (nm): 236, 260 sh, 269, 360 (ε resp. 36,200, 23,100, 24,900, 27,500); NMR ($(D_3C)_2SO$, τ): 6·23 (s, OCH_3), 3·86 (d, *J* 2·1 Hz, H-2), 3·72 (d, *J* 2·1 Hz, H-4), 3·12 (d, *J* 9·1 Hz, H-5), 2·58 (d, *J* 9·1 Hz, H-6), −1·94–1·54 (broad s, O*H*-1, O*H*-3, O*H*-8); m.s.: M 274 (100%), *m/e* (%) 259 (33), 256 (17), 231 (83).

4-*Hydroxy*-2,3-*dimethoxyxanthone* (*Va*). M.p. found: 217–219°, required: 218–219°;[14] M found: 272, required: 272.

4-*Hydroxy*-2,3-*methylenedioxyxanthone* (*Vb*). M.p. found: 294–296°, required: 298–299°;[14] M found: 256, required: 256.

3-*Hydroxy*-2,4-*dimethoxyxanthone* (*Vd*). White rectangular plates; m.p. 224–226°; ν_{max}^{KBr} (cm^{-1}): 3100, 1615, 1580, 1570, 1520, 1470; λ_{max}^{EtOH} (nm): 241, 274, 310, 352 (ε resp. 32,600, 7600, 12,200, 10,000), $\lambda_{max}^{EtOH+NaOH}$ (nm): 232, 270 sh, 375 (ε resp. 40,100, 9100, 22,300), $\lambda_{max}^{EtOH+NaOAc}$ (nm): 232, 270 sh, 375 (ε resp. 37,900, 8700, 21,300); m.s.: M 272 (56%), *m/e* (%) 257 (16), 242 (100), 227 (63), 213 (16), 199 (25), 171 (22).

2,3-*Dihydroxy*-1-*methoxyxanthone* (*VIb*). Yellow rectangular plates, m.p. 172–174°; ν_{max}^{KBr} (cm^{-1}): 3450, 1645, 1610, 1580, 1480; λ_{max}^{EtOH} (nm): 239, 255 sh, 313, 355 (ε resp. 29,500, 20,400, 14,300, 6100), $\lambda_{max}^{EtOH+NaOH}$ (nm): 231, 275, 354 (ε resp. 29,300, 11,200, 16,300), $\lambda_{max}^{EtOH+NaOAc}$ (nm): 235, 270 sh, 364 (ε resp. 34,400, 12,400, 19,600), $\lambda_{max}^{EtOH+H_3BO_3+NaOAc}$ (nm): 237, 315, 355 (ε resp. 29,600, 12,600, 7500), $\lambda_{max}^{EtOH+AlCl_3}$ (nm): 235, 260, 330 (ε resp. 24,300, 18,300, 17,800); NMR ($CDCl_3$, τ): 5·98 (s, OCH_3), 3·51 (s, H-4), 3·40 (broad s, O*H*-2), 2·80–2·25 (m, H-5, H-6, H-7), 1·77 (o, *J* 8·5 Hz, *J* 2·0 Hz, *J* indet., H-8), −1·41 (s, O*H*-3); m.s.: M 258 (100%), *m/e* (%) 243 (73), 228 (6), 215 (88), 131 (9), 121 (12).

3-*Hydroxy*-1,2-*dimethoxyxanthone* (*VIa*). Pale yellow rectangular plates, m.p. 236–238°; ν_{max}^{KBr} (cm^{-1}): 3150, 1640, 1615, 1580, 1465; λ_{max}^{EtOH} (nm): 241, 280, 305, 340 sh (ε resp. 35,200, 8700, 14,200, 7100), $\lambda_{max}^{EtOH+NaOH}$ (nm): 233, 280 sh, 356 (ε resp. 37,500, 6600, 20,200), $\lambda_{max}^{EtOH+NaOAc}$ (nm): 234, 280 sh, 356 (ε resp. 34,900, 6600, 20,100), $\lambda_{max}^{EtOH+AlCl_3}$ (nm): 241, 280, 305, 340 sh (ε resp. 36,600, 9000, 14,900, 6700); NMR (F_3CCO_2H, τ): 5·85 (s, OCH_3-2), 5·39 (s, OCH_3-1), 2·66 (s, H-4), 2·16 (m, *J* 7·5 Hz, *J* 6·5 Hz, *J* 1·5 Hz, H-7), 2·06 (q, *J* 8·5 Hz, *J* 1·5 Hz, H-5), 1·74 (m, *J* 8·5 Hz, *J* 6·5 Hz, *J* 1·8 Hz, H-6), 1·43 (o, *J* 7·5 Hz, *J* 1·8 Hz, *J* indet., H-8); m.s.: M 272 (33%), *m/e* (%) 257 (100), 242 (3), 230 (18).

Derivatives of K. speciosa *Constituents*

O-Acetyl and *O*-methyl derivatives of 6-dehydroxyjacareubin,[2] 2-hydroxyxanthone,[8] 2-hydroxy-1-methoxyxanthone,[9] 1,5-dihydroxy-3-methoxyxanthone,[14] 5-hydroxy-1,3-dimethoxyxanthone,[14] 4-hydroxy-2,3-dimethoxyxanthone,[14] 4-hydroxy-2,3-methylenedioxyxanthone,[14] 3-hydroxy-2,4-dimethoxyxanthone[14] were obtained and identified by direct comparison with authentic samples.

3-*Acetoxy*-2,4-*dimethoxyxanthone* (*Vf*). Was obtained from 3-hydroxy-2,4-dimethoxyxanthone as white rectangular plates (from EtOH), m.p. 184–186°; NMR ($CDCl_3$, τ): 2·72–2·38 (m, H-7, H-6, H-5), 2·26 (s, H-1), 1·73 (o, J 8·0 Hz, J 2·0 Hz, J indet., H-8).

1,2,3-*Trimethoxyxanthone* (*VIc*) was obtained from 3-hydroxy-1,2-dimethoxyxanthone as white rectangular plates (from $CHCl_3$–light petroleum), m.p. 128–129·5°; ν_{max}^{KBr} (cm^{-1}): 3000, 2930, 2830, 1655, 1600, 1470; λ_{max}^{EtOH} (nm): 243, 277, 300, 335 (ϵ resp. 41,800, 12,300, 16,500, 7500); NMR ($CDCl_3$, τ): 6·08 (s, OCH_3), 6·02 (s, OCH_3), 5·97 (s, OCH_3), 3·27 (s, H-4), 2·82–2·28 (m, H-7, H-6, H-5), 1·69 (o, J 8·0 Hz, J 2·0 Hz, J indet., H-8).

Methylation of 2,3-dihydroxy-1-methoxyxanthone (VIb) also afforded 1,2,3-trimethoxyxanthone.

3-*Acetoxy*-1,2-*dimethoxyxanthone* (*VIe*). Was obtained from 3-hydroxy-1,2-dimethoxyxanthone as white rectangular plates (from EtOH), m.p. 115–117°; ν_{max}^{KBr} (cm^{-1}): 2948, 1765, 1670, 1610, 1595, 1460; λ_{max}^{EtOH} (nm): 241, 270, 345 (ϵ resp. 45,200, 15,400, 7800).

2,3-*Diacetoxy*-1-*methoxyxanthone* (*VIf*). Was obtained from 2,3-dihydroxy-1-methoxyxanthone as white needles (from C_6H_6), m.p. 133–135°; ν_{max}^{KBr} (cm^{-1}): 2955, 1758, 1650, 1605, 1480; λ_{max}^{EtOH} (nm): 235 sh, 245, 270 sh, 295, 345 (ϵ resp. 26,300, 27,000, 10,000, 5500, 4500).

1,3,8-*Triacetoxy*-7-*methoxyxanthone* (*IIIb*). Was obtained from 1,3,8-trihydroxy-7-methoxyxanthone as white needles (from C_6H_6), m.p. 182–184°; ν_{max}^{EtOH} (nm): 244, 275 sh, 335, 346 (ϵ resp. 39,200, 9800, 11,600, 9600); NMR ($CDCl_3$, τ): 7·72 (s, CH_3COO), 7·63 (s, CH_3COO), 7·60 (s, CH_3COO), 6·18 (s, OCH_3), 3·29 (d, J 2·0 Hz, H-2), 2·88 (d, J 2·0 Hz, H-4), 2·79 (s, H-7, H-8).

Synthesis of 2,3,4- and 1,2,3-trimethoxyxanthone

3-*Hydroxy*-2-*methoxyxanthone* (*VIIb*). 2,3-Dimethoxyxanthone[19] (VIIa, 256 mg) and $AlCl_3$ (401 mg) in dry benzene (20 ml) were maintained at 70° during 40 min. After cooling to room temp., excess conc. HCl and water (200 ml) were added, and the mixture was extracted with ether. The ether–benzene layer was separated and extracted with 10% aq. Na_2CO_3. The organic layer was evaporated giving 2,3-dimethoxyxanthone (66 mg). The aqueous layer was neutralized with HCl and extracted with $CHCl_3$. The $CHCl_3$ solution was evaporated giving 3-hydroxy-2-methoxyxanthone (169 mg; 70%); m.p. 226–228°; λ_{max}^{EtOH} (nm): 225, 242, 277 sh, 313, 359 (ϵ resp. 28,100, 30,300, 19,400, 20,300, 20,100), $\lambda_{max}^{EtOH+NaOH}$ (nm): 239, 277 sh, 382 (ϵ resp. 31,900, 22,300, 27,600), $\lambda_{max}^{EtOH+NaOAc}$ (nm): 235, 275 sh, 380 (ϵ resp. 35,300, 22,300, 27,800); ν_{max}^{KBr} (cm^{-1}): 3410, 3000, 1638, 1610, 1587, 1570, 1518, 1480, 1470, 1440; m.s.: M 242 (100%), *m/e* (%) 241 (20), 228 (13), 227 (68), 213 (15), 199 (25), 171 (25), 121 (13), 115 (23).

2,3-*Dihydroxyxanthone* (*VIId*). 2,3-Dimethoxyxanthone[19] (VIIa, 800 mg) and $AlCl_3$ (4·172 g) in dry benzene (60 ml) were maintained at 70° during 2 hr. After cooling the mixture was worked up as above. The ether–benzene layer was evaporated and the residue chromatographed on a silica column. The fractions eluted with $CHCl_3$–MeOH (95:5) were recrystallized from EtOAc giving 2,3-dihydroxyxanthone (382 mg, 54%), slightly yellow needles, m.p. above 350°; λ_{max}^{EtOH} (nm): 235, 280 sh, 314, 369 (ϵ resp. 27,400, 15,000, 15,500, 18,500), $\lambda_{max}^{EtOH+NaOH}$ (nm): 242, 280 (ϵ resp. 29,600, 18,500), $\lambda_{max}^{EtOH+NaOAc}$ (nm): 235, 270 sh, 282 sh, 378 (ϵ resp. 30,100, 18,200, 16,600, 22,600), $\lambda_{max}^{EtOH+AlCl_3}$ (nm): 241, 315, 368 sh (ϵ resp. 27,400, 19,200, 18,200); ν_{max}^{KBr} (cm^{-1}): 3430, 3150, 1650, 1608, 1575, 1525, 1480, 1475; m.s.: M 228 (100%), *m/e* (%) 227 (5), 200 (7), 171 (10), 126 (16), 115 (11), 100 (15).

2-*Hydroxy*-3-*methoxyxanthone* (*VIIe*). 2,3-Dihydroxyxanthone (VIId, 363 mg) was methylated with Me_2SO_4 (0·073 ml)–K_2CO_3 (700 mg). The reaction product was purified by filtration through a silica column giving 2-hydroxy-3-methoxyxanthone (228 mg, 59%), white rectangular plates, m.p. 182–184°; λ_{max}^{EtOH} (nm): 220, 245, 277 sh, 309, 355 (ϵ resp. 26,400, 34,400, 20,600, 22,700, 19,800), $\lambda_{max}^{EtOH+NaOH}$ (nm): 234 sh, 257, 275 sh, 323 sh (ϵ resp. 25,200, 31,000, 29,800, 21,800), $\lambda_{max}^{EtOH+NaOAc}$ (nm): 226 sh, 245, 277 sh, 309, 354 (ϵ resp. 25,700, 32,400, 23,000, 23,200, 20,300); m.s.: M 242 (100%), *m/e* (%) 227 (27), 199 (23), 171 (19), 121 (7), 120 (5), 115 (15), 101 (7).

3-*Hydroxy*-2-*methoxy*-4-*formylxanthone* (*VIIc*). 3-Hydroxy-2-methoxyxanthone (VIIb, 169 mg) and hexamethylenetetramine (647 mg) in HOAc (15 ml) were maintained between 96 and 100° during 8 hr. After cooling, 15% aq. HCl (10 ml) were added and the mixture heated under reflux for 15 min. After cooling, the mixture was poured into ice flakes and kept for 8 hr. The precipitate was separated by filtration and purified by passage through a silica column giving 3-hydroxy-2-methoxy-4-formylxanthone (131 mg, 74%); yellow rectangular plates, m.p. 208–210°; λ_{max}^{EtOH} (nm): 233, 249, 278 sh, 312, 368 (ϵ resp. 31,100, 30,800, 13,000, 13,800, 14,300), $\lambda_{max}^{EtOH+NaOH}$ (nm): 233, 259 sh, 277 sh, 312, 370 (ϵ resp. 39,400, 21,900, 13,500, 15,100, 8400), $\lambda_{max}^{EtOH+NaOAc}$ (nm): 232, 259 sh, 285, 318, 363 (ϵ resp. 38,300, 18,600, 13,500, 13,800, 24,300), $\lambda_{max}^{EtOH+AlCl_3}$ (nm): 216, 239, 295, 320 (ϵ resp. 26,200, 31,100, 20,800, 21,300); ν_{max}^{KBr} (cm^{-1}): 1640, 1462, 1406, 1312; m.s. M 270 (100%), *m/e* (%) 269 (9), 241 (5), 239 (6), 228 (8), 227 (54), 225 (11), 224 (10), 199 (6), 171 (6); NMR ($CDCl_3$, τ): 6·02 (s, OCH_3), 2·63–2·21 (m, H-5, H-6, H-7), 2·17 (s, H-1), 1·69 (o, J 7·5 Hz, J 2·0 Hz, J indet., H-8), −3·00 (s, O*H*), −0·70 (s, C(=O)-*H*).

2-*Hydroxy*-3-*methoxy*-1-*formylxanthone* (*VIIf*). 2-Hydroxy-3-methoxyxanthone (VIIe, 220 mg) and hexamethylenetetramine (892 mg) in HOAc (10 ml) were treated as above, affording 2-hydroxy-3-methoxy-1-formylxanthone (124 mg, 51%), yellow rectangular plates, m.p. 212–214°; λ_{max}^{EtOH} (nm): 215, 244, 280 sh, 320 (ϵ resp. 39,700, 39,400, 8100, 11,600), $\lambda_{max}^{EtOH+NaOH}$ (nm): 258, 329 (ϵ resp. 24,800, 11,100), $\lambda_{max}^{EtOH+NaOAc}$ (nm): 242, 273 sh, 325 (ϵ resp. 32,900, 16,200, 11,300), $\lambda_{max}^{EtOH+AlCl_3}$ (nm): 235, 255, 310 (ϵ resp. 39,200, 39,400, 10,800); ν_{max}^{KBr} (cm^{-1}): 1636, 1594, 1475, 1440; m.s.: 270 (21%), *m/e* (%) 243 (16), 242 (100), 227 (28), 199 (16), 171 (11); NMR ($CDCl_3$, τ): 6·00 (s, OCH_3) 2·99 (s, H-4), 2·70–2·17 (m, H-5, H-6, H-7), 1·78 (o, *J* 7·0 Hz, *J* 2·0 Hz, *J* indet., H-8), −3·48 (s, O*H*), −1·58 (s, C—*H*).

3,4-*Dihydroxy*-2-*methoxyxanthone* (*Ve*). 3-Hydroxy-2-methoxy-4-formylxanthone (VIIc, 120 mg), pyridine (5 ml), 8% aq. NaOH (0·5 ml) and 6% aq. H_2O_2 (1·8 ml) were vigorously stirred during 5 min. After 30 min, 15% aq. HCl (25 ml) was added. The resulting precipitate was separated by filtration and recrystallized from ethanol giving 3,4-dihydroxy-2-methoxyxanthone (109 mg, 95%), white rectangular plates, m.p. found 242–244°, m.p. required[14] 243–245°.

1,2-*Dihydroxy*-3-*methoxyxanthone* (*VId*). 2-Hydroxy-3-methoxy-1-formylxanthone (VIIf, 120 mg) was oxidized as above giving 1,2-dihydroxy-3-methoxyxanthone (108 mg, 95%), yellow needles, m.p. 190–192°; λ_{max}^{EtOH} (nm): 248, 270 sh, 296, 315 (ϵ resp. 26,800, 12,400, 13,600, 15,200), $\lambda_{max}^{EtOH+NaOH}$ (nm): 238, 270 sh, 289, 298, 366 (ϵ resp. 21,600, 12,000, 10,800, 11,200, 13,600), $\lambda_{max}^{EtOH+NaOH+HCl}$ (nm): 246, 279 sh, 305 sh (ϵ resp. 18,000, 8000, 6000), $\lambda_{max}^{EtOH+NaOAc}$ (nm): 246, 295, 315 (ϵ resp. 25,200, 14,000, 14,800), $\lambda_{max}^{EtOH+AlCl_3}$ (nm): 256, 277, 310 sh, 336 (ϵ resp. 21,200, 13,200, 12,400, 19,600).

2,3,4-*Trimethoxyxanthone* (*Vc*). 3,4-Dihydroxy-2-methoxyxanthone (Ve, 9 mg) was methylated with Me_2SO_4–K_2CO_3. The reaction product was purified using preparative TLC, giving 2,3,4-trimethoxyxanthone (5 mg, 51%), white rectangular plates, m.p. found 152–154°, m.p. required[14] 153–155°.

1,2,3-*Trimethoxyxanthone* (*VIc*). 1,2-Dihydroxy-3-methoxyxanthone (VId, 10 mg) was methylated with Me_2SO_4–K_2CO_3. The reaction product was purified using preparative TLC, giving 1,2,3-trimethoxyxanthone (4 mg, 36%), white rectangular plates, m.p. found 128–130°, m.p. required (see above) 128–129·5°; ν_{max}^{KBr} (cm^{-1}): 3000, 2930, 2830, 1655, 1600, 1470; m.s.: M 286 (27%), *m/e* (%) 272 (15), 271 (100), 269 (5), 257 (6), 243 (14), 228 (13), 213 (11), 200 (6), 199 (5), 171 (6), 170 (7), 121 (26).

Acknowledgements—The authors are indebted to the Conselho Nacional de Pesquisas, Brazil, for financial aid. Professor W. D. Ollis's kindness in making available the mass spectra through the courtesy of Dr. C. P. Falshaw, The University, Sheffield, is also highly appreciated.