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SYNTHESIS OF 1,2,3,8-TETRAOXYGENATED XANTHONES

S. GIL, P. PALANCA, V. SANZ, and A. TORTAJADA*

Department of Organic Chemistry, University of Valencia, Doctor Moliner 50, 46100 Burjassot, Spain

ABSTRACT.—Nine 1,2,3,8-tetraoxygenated xanthones were synthesized. The structure of 1,2-dimethoxy-3,8-dihydroxyxanthone, isolated from *Calophyllum trapezifolium*, was confirmed. The structure of a xanthone, isolated from *Kielmeyera candidissima*, as 1,3-dihydroxy-2,8-dimethoxyxanthone was shown to be incorrect. The possibility of a 1,2,3,8-tetraoxygenation pattern for the new xanthones isolated from *Centaurium linarifolium* was discarded.

Xanthone isolation and characterization are of great importance in chemotaxonomic studies (1). In addition, in several cases the medical properties of some plants have been attributed to their xanthonic constituents, and several pharmacological studies have demonstrated that some xanthones show an analeptic effect in treatment of respiratory depression, as well as coanalgesic, cardiostimulant (2), tuberculostatic (3), and diuretic effects (4).

Preparation of xanthones for their chemotaxonomic and pharmacological interest also serves to confirm the structures of naturally occurring compounds.

Most of the naturally occurring xanthones of interest are tetraoxygenated. Three naturally occurring 1,2,3,8-tetraoxygenated xanthones have been reported in the literature: 1,2-dimethoxy-3,8-dihydroxyxanthone, isolated from the heartwood of *Calophyllum trapezifolium* Thw. (5); 1,3-dihydroxy-2,8-dimethoxyxanthone, isolated from *Kielmeyera candidissima* (6); and a 1,3,8-trihydroxy-2-methoxy or 1,3,8-trihydroxy-4-methoxyxanthone from *Centaurium linarifolium* (7). All these structures have been assigned mainly on the basis of spectral data.

However, some problems arose in these assignments. For example, there is no concordance between the reported data for the dimethylated derivatives of 1,2-dimethoxy-3,8-dihydroxy (5) and of 1,3-dihydroxy-2,8-dimethoxyxanthone (6). In other cases the spectral data are compatible with alternative structures (7). Besides, in order to elucidate the structure of corymbiferin (8) a mixture of 1,2,8-trihydroxy-3-methoxy- and 1,4,8-trihydroxy-3-methoxyxanthones was synthesized by reaction of 2,6-dihydroxybenzoic acid with 2,6-dimethoxyquinol. Although ambiguous and occurring in poor yield, this reaction led to assignment of the structure of corymbiferin as a 1,3,4,5,8-pentaoxygenated xanthone by comparison of its ^{1}H-nmr and uv spectral data with those of the synthetic xanthones.

Previous systematic studies on the ^{13}C nmr of xanthones have been reported (9). However we found that additive increments proposed by Frahm and Chaudhuri (10) give good agreement for monosubstituted or disubstituted rings, but important discrepancies are observed for rings with 3 or 4 substituents. On the other hand, we realized that the changes in the δ values produced when a methoxy group is substituted by an hydroxyl group are very difficult to evaluate. Thus, there is no agreement between Frahm and Chaudhuri (10) and Barraclough *et al.* (11) on the validity of additivity rules on assignment of carbon shifts for 1,3,6,7-tetramethoxy-, 1-hydroxy-3,6,7-trimethoxy-, 1,7-diallyloxy-3,6-dimethoxy-, and 2,8-diallyl-1,7-dihydroxy-3,6-dimethoxyxanthones. This fact might be due to the mesomeric interaction of the two rings A and C in the xanthone system, or to solvent (11) or other effects, which are difficult to evaluate. Further studies in this field are required before the ^{1}H and ^{13}C chemical shifts of xanthones can be evaluated.

In the present paper, continuing our work on xanthone synthesis (12–14), we de-

scribe the preparation of nine 1,2,3,8-tetraoxygenated xanthones, including those reported as naturally occurring, in an unambiguous way. A systematic study of their spectral data, summarized in Tables 1, 2, and 3, will be very valuable in the assignment of the correct structures of other 1,2,3,8-tetraoxygenated xanthones.

For unambiguous assignment of the ^{13}C-nmr signals from unsubstituted carbon atoms, ^{1}H-^{13}C correlation experiments were performed. This allowed the establishment of the ^{13}C-nmr signal for C-4, C-5, C-6, and C-7. The assignments were confirmed by the ^{1}H-^{13}C-coupled nmr spectra (J_{ipso} = 160 Hz). The rest of the aromatic ^{13}C signals were assigned by comparison with previous assignments for xanthones (9,10) and by their multiplicity and coupling constant values (J_{ortho} = 1–4 Hz, J_{meta} = 7–10 Hz, J_{para} is not observed).

TABLE 1. ^{1}H nmr of 1,2,3,8-Tetraoxygenated Xanthones.[a]

Compound (Solvent)	H-4	H-5	H-6	H-7	−OH	−OMe	MeOCO
5 (CDCl$_3$)	6.69	6.80 md	7.49 t	6.74 md	13.12	3.89 3.97 4.01	
5$_{Ac}$[b] (CDCl$_3$)	6.66	7.27 md	7.58 t	6.92 md	13.12	3.87 3.94 4.95	2.47
6 (CDCl$_3$)	6.46	6.85 md	7.55 t	6.76 md	11.86 (2H)	3.90 3.96	
7 (CDCl$_3$)	[c]	[c]	7.49 t	[c]	13.09	3.99 4.02	
7$_{Ac}$[b] (CDCl$_3$)	6.92	7.23 md	7.58 t	6.89 md		3.88 3.96	2.34 2.46
11 (CDCl$_3$)	6.63	6.92 md	7.49 t	6.74 md		3.87 3.93 3.96 4.01	
12 (DMSO-d_6)	6.82	7.01 md	7.69 t	6.79 md	8.79 11.42 11.89	3.94	
13 (CDCl$_3$)	6.37	6.95 md	7.55 t	6.76 md	13.12	3.88 3.93 4.00	
13$_{Ac}$[b] (CDCl$_3$)	6.74	6.94 md	7.51 t	6.76 md	13.12	3.82 3.96 (9H)	2.50
14 (CDCl$_3$)	6.43	6.99 md	7.58 t	6.78 md	6.52 13.47	3.96 4.01	
14 (DMSO-d_6)	6.35	7.00 md	7.66 t	6.91 md	13.39	3.72 3.86	
15 (DMSO-d_6)	6.51	6.86 md	7.55 t	6.76 md	6.62 11.85 12.18	4.02	
16 (CDCl$_3$)	[d]	6.92 md	7.49 t	[d]	6.46	3.98 4.00 (9H)	

[a]Chemical shifts are quoted in δ ppm, signals being denoted in the usual way: md, doublet (J = 8.3 Hz) split further narrowly (J = 0.7 Hz); t, triplet (J = 8.3 Hz). Singlets are unmarked. Unless marked otherwise OMe signals each integrated for 3 protons and the rest for one proton.

[b]Ac stands for the corresponding peracetylated derivative.

[c]6.71–6.82 m (3H).

[d]6.70–6.76 m (2H).

TABLE 2. ^{13}C nmr Data of 1,2,3,8-Tetraoxygenated Xanthones.[a]

Carbon	Compound								
	5	**6**	**7**	**11**	**12**	**13**	**14**	**15**	**16**
C-1	153,40	153,46	153,22	153,11	146,63	152,34	151,39	152,54	152,66
C-2	139,65	132,12	138,86	139,49	129,47	131,82	130,55	130,96	138,80
C-3	159,56	160,68	158,75	157,90	156,33	159,44	158,08	159,77	157,09
C-4	95,92	90,88	99,28	95,29	90,96	89,76	93,19	94,46	98,93
C-4a	154,54	153,69	153,78	153,40	149,65	154,64	154,46	153,44	153,27
C-4b	155,42	156,12	154,82	157,04	155,38	157,87	157,08	155,47	156,61
C-5	110,57	110.82	109,99	109,08	109,71	109,68	109,14	110,35	109,14
C-6	135,72	136,75	136,12	133,62	136,50	135,15	135,76	137,07	134,41
C-7	106,20	106,88	106,20	105,52	106,52	105,56	106,30	106,99	106,41
C-8	162,07	161,24	161,15	160,40	159,96	160,56	160,02	160,13	159,91
C-8a	109,25	107,43	107,93	113,00	106,52	109,68	109,58	106,54	112,43
C-8b	108,65	106,88	107,54	111,91	102,06	104,68	102,79	101,32	110,34
C=O	181,29	184,89	180,40	175,01	183,67	181,52	180,44	183,73	173,51

[a]Chemical shifts are quoted in δ ppm in $CDCl_3$ for compounds **5**, **6**, **11**, and **13** and DMSO-d_6 for compounds **7**, **12**, and **14–16**. In the ^{13}C-^{1}H coupled spectra the following multiplicities are observed: C-1 s, C-2 d (J_{meta}), C-3 d (J_{ortho}), C-4 d (J_{ipso}), C-4a d (J_{ortho}), C-4b dd ($J_{meta'}$ J_{ortho}), C-5 ddd ($J_{ipso'}$ $J_{meta'}$ J_{ortho}), C-6 dt ($J_{ipso'}$ J_{ortho}), C-7 ddd ($J_{ipso'}$ $J_{meta'}$ J_{ortho}), C-8 dd ($J_{meta'}$ J_{ortho}), C-8a t (J_{meta}), C-8b d (J_{meta}).

For example, C-1 appears as a singlet and C-8a as a triplet due to two meta ^{1}H-^{13}C coupling constants. Signals for C-4a and C-4b can be distinguished because C-4a is expected to appear as a doublet (J_{ortho}) and C-4b as a double doublet ($J_{ortho\text{-}meta}$) in agreement with found spectra.

RESULTS AND DISCUSSION

Most tetraoxygenated xanthones can be completely methylated. 1,2,3,8-Tetramethoxyxanthone can thus be considered as an essential compound for establishing the presence of a 1,2,3,8-tetraoxygenated xanthone system. Its preparation was, in consequence, our first objective.

We intended afterwards preparation of partially methylated hydroxyxanthones by demethylation of this tetramethoxy derivative. Unfortunately, there appeared to be no selectivity for monodemethylation when two methoxy groups are situated at similar positions (1, 8; 2, 7; 3, 6; or 4, 5) in the xanthone nucleus (15). However, previous protection of appropriately placed hydroxyl groups as benzyl ethers can circumvent this difficulty (16). In this study a combination of both methods has been used.

Our synthetic strategy consisted in the preparation of the conveniently substituted benzophenones by acylation of 3,4,5-trimethoxyphenol with 2,6-dihydroxybenzoic acids and cyclization of these benzophenones to the corresponding xanthones. The hydroxyl groups in these compounds had to be conveniently protected; otherwise, mixtures of 1,2,3,8- and 1,3,4,8-tetraoxygenated xanthones would be obtained (8). In Scheme 1, the benzyl ether was used as the protecting group for all the phenolic groups. The first step was the protection of 3,4,5-trimethoxyphenol (17) with benzyl bromide and K_2CO_3 in Me_2CO to give 1-benzyloxy-3,4,5-trimethoxybenzene [**1**] (18). Similar treatment of 2,6-dihydroxybenzoic acid followed by alkaline hydrolysis led to 2,6-dibenzyloxybenzoic acid [**2**]. Both synthons were condensed by means of trifluoroacetic anhydride (19) to give benzophenone **3**. Hydrogenolysis of **3** in EtOAc (20), using Pd/C as catalyst, gave, in quantitative yield, 2,2′,6′-trihydroxy-4,5,6-trimethoxybenzophenone [**4**] which, on heating with polyphosphoric acid (21) or Si

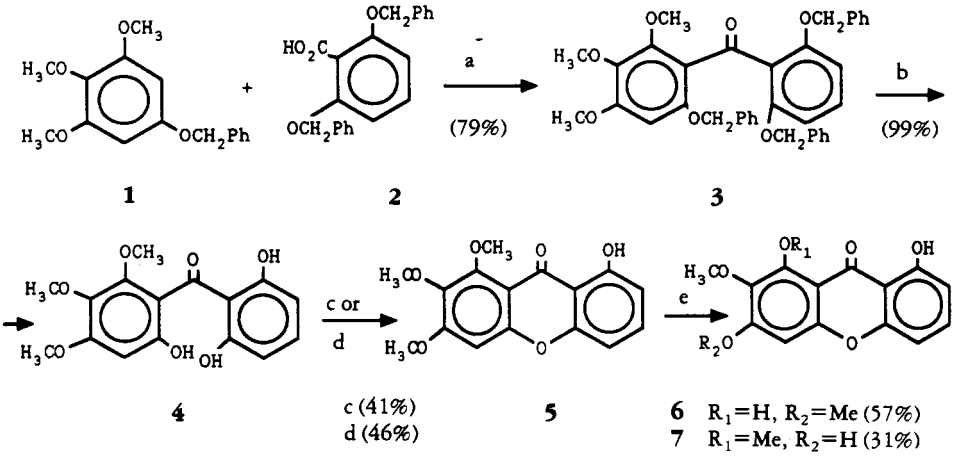
TABLE 3. Uv Data of 1,2,3,8-Tetraoxygenated Xanthones.[a]

Compound	Solvent	Absorbance (nm)
5	EtOH[b]	243 (3.82) 258 (3.85) 276 (3.70) 306 (3.62) 370 (3.28)
	EtOH + NaOMe	273 312 (sh) 398
	EtOH + $AlCl_3$[c]	263 281 324 422
6	EtOH	252 (3.19) 261 (sh) 269 (3.09) 308 (2.96) 325 (sh) 370 (2.46)
	EtOH + NaOMe	277 365
	EtOH + NaOAc[d]	252 261 (sh) 269 326 375
	EtOH + $AlCl_3$	259 268 277 (sh) 324 360 (sh)
	EtOH + $AlCl_3$ + HCl	262 270 281 325 360
7	EtOH	232 (3.08) 244 (sh) 256 (sh) 264 (sh) 303 (2.63) 361 (2.73)
	EtOH + NaOMe	234 260 (sh) 282 (sh) 368
	EtOH + NaOAc[c]	231 260 (sh) 366
	EtOH + $AlCl_3$	232 248 259 (sh) 277 325 415
	EtOH + $AlCl_3$ + HCl	232 260 278 325 415
11	OMeH[b,e]	247 266 (sh) 293 345
12	OMeH[b]	253 (4.33) 273 (4.13) 314 (4.13) 389 (3.57)
	OMeH + NaOMe	272 339 478
	OMeH + NaOAc + H_3BO_3	258 277 318 404
	OMeH + $AlCl_3$	251 262 285 345
	OMeH + $AlCl_3$ + HCl	251 284 336
	OMeH + $AlCl_3$ + HCl (20 min)	252 278 333
13	OMeH[b]	245 (4.46) 268 (sh) 317 (4.17) 354 (sh)
	OMeH + NaOMe	242 260 (inf) 268 (sh) 320 359
	OMeH + $AlCl_3$[c]	246 263 329 349
14	OMeH	218 (4.32) 243 (4.41) 322 (4.15) 356 (sh)
	OMeH + NaOMe	238 262 358
	OMeH + NaOAc[d]	238 261 359
	OMeH + $AlCl_3$	214 245 325
	OMeH + $AlCl_3$ + HCl	214 245 329

TABLE 3. Continued.

Compound	Solvent	Absorbance (nm)
15	EtOH	247 (3.92) 259 (sh) 268 (3.72) 332 (3.68) 365 (3.38)
	EtOH + NaOMe	262 (inf) 271 356 382 (inf)
	EtOH + NaOAc[d]	238 263 268 (sh) 366
	EtOH + $AlCl_3$	260 277 330 362
16	EtOH[e]	222 (4.55) 240 (sh) 247 (4.61) 263 (sh) 295 (4.25) 342 (4.05)
	EtOH + NaOMe	234 258 (sh) 292 (sh) 353
	EtOH + NaOAc	235 258 (sh) 292 (sh) 352

[a]λmax are quoted in nm (log ε); (sh) means a shoulder in the previous peak and (inf) an inflexion point.
[b]Uv spectrum showed no variation when NAOAc was added.
[c]Uv spectrum showed no variation when HCl was added.
[d]Uv spectrum was idential to that in OMeH or EtOH when H_3BO_3 was added.
[e]Uv spectrum showed no variation when $AlCl_3$ was added.



SCHEME 1. a: TFAA/CH_2Cl_2 (0°); b: H_2/Pd-C, EtOAc; c: P_2O_5/polyphosphoric acid; d: SiO_2 (40°); e: piperidine/H_2O (Δ).

gel, gave 8-hydroxy-1,2,3-trimethoxyxanthone [**5**] by elimination of H_2O. Although yields are moderate, dehydration on heating with Si gel allows easy recovery of unreacted starting material, and in consequence the overall yield can be improved.

When heated under reflux in aqueous piperidine (22) under optimized conditions (see Table 4), 8-hydroxy-1,2,3-trimethoxyxanthone [**5**] afforded a mixture of two dihydroxy-dimethoxyxanthones ($C_{15}H_{12}O_6$) which were separated by cc. The less polar xanthone was identified as 1,8-dihydroxy-2,3-dimethoxyxanthone [**6**] on the following evidence. Both hydroxyl groups appear at very low field in ^1H nmr (δ 11.86) due to double chelation with the carbonyl group. If only one hydroxyl group is chelated with the carbonyl group, as can be observed in Table 1, it appears at even lower field in ^1H nmr (δ 13). In addition, no hydroxylic absorption is observed in its ir spectrum due to this double chelation. Finally, uv maxima in MeOH did not change on addition of NaOAc or NaOAc + H_3BO_3 (see Table 3), but there were changes after addition of $AlCl_3$ (23).

The polar xanthone was identified as 3,8-dihydroxy-1,2-dimethoxyxanthone [**7**]. One hydroxyl group is placed at C-8 (confirmed by ^1H nmr δ 13.09) and the other is located at C-3 and not C-2 from the marked bathochromic uv shift when NaOAc is added (23,24). This is characteristic of xanthones with relatively strong acidic character due to a hydroxyl group in para situation to the carbonyl group. The rest of spectral data are in concordance with this assignment. Thus, ^1H nmr of the diacetylated derivative of **7**

TABLE 4. Demethylation of 1,2,3,8-Tetraoxygenated Xanthones with Aqueous Piperidine.

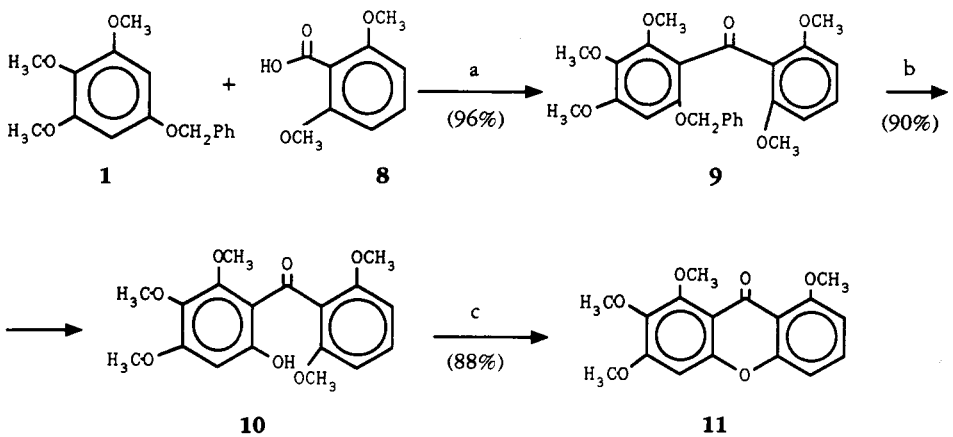
Xanthone	Piperidine (ml)	H_2O (ml)	Hours at room temperature	Percentage of Demethylation at:				
				C-1	C-3	C-1 and C-8	C-1 and C-3	C-3 and C-8
5	2.5	1	24	57	31			
13	2.5	1	110		56			38
11	1	1.5	24	42	15	4	10	
11	2	1	24	40	12	8	15	
11	4	1	24	38	11	10	21	

shows a characteristic shift for H-4 in agreement with its ortho relationship to the acetoxy group (25,26).

This result confirms that only methoxy groups at C-1 or C-3 are appreciably demethylated under weakly basic conditions (22).

The physical and spectral data of 3,8-dihydroxy-1,2-dimethoxyxanthone [**7**] were identical with those found for the naturally occurring xanthone from *Ca. trapezifolium* (5), thus confirming the formerly assigned structure.

Although 1,2,3,8-tetramethoxyxanthone [**11**] had been obtained from 8-hydroxy-1,2,3-trimethoxyxanthone [**5**] and 3,8-dihydroxy-1,2-dimethoxyxanthone [**7**] by methylation with Me_2SO_4 and K_2CO_3 in Me_2CO, the unambiguous procedure shown in Scheme 2 was developed in order to attain a better yield. As 1,2,3,8-tetramethoxyxanthone [**11**] has a methoxy group at C-8, commercial 2,6-dimethoxybenzoic acid [**8**] appears as the most convenient synthon. This was condensed with 1-benzyloxy-3,4,5-trimethoxybenzene [**1**] (18) by means of trifluoroacetic anhydride (19) to give 2-benzyloxy-2′,4,5,6,6′-pentamethoxybenzophenone [**9**]. Hydrogenolysis of benzophenone **9** (15,20) with Pd/C as catalyst led to 2-hydroxy-2′,4,5,6,6′-pentamethoxybenzophenone [**10**], which was cyclized on heating with aqueous tetramethylammonium hydroxide in pyridine (27) to give 1,2,3,8-tetramethoxyxanthone [**11**] with a 76% overall yield.



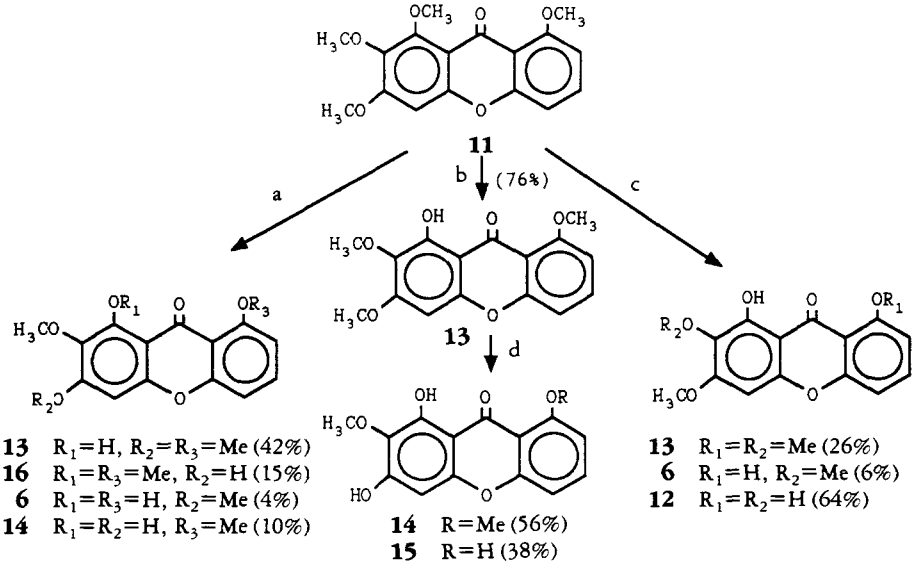
SCHEME 2. a: TFAA/CH_2Cl_2 (0°); b: H_2/Pd-C, EtOH (50°); c: Me_4NOH/pyridine/H_2O (Δ).

Physical and spectral data of this tetramethoxy xanthone were identical to those found for the permethylated product of the naturally occurring xanthone from *Ca. trapezifolium* (5), but quite different from those of the permethylated product resulting from the xanthone isolated from *K. candidissima* (6). This disproves the possibility of the 1,2,3,8-tetraoxygenation pattern for the latter xanthone. Besides, permethylation of all hydroxyxanthones included in Scheme 1 led to xanthone **11**.

As 1,2,3,8-tetramethoxyxanthone [**11**] can be obtained in good yield, it is an appropriate starting material for the preparation of a series of partially methylated 1,2,3,8-tetraoxygenated xanthones by selective demethylation.

Demethylations of 1,2,3,8-tetramethoxyxanthone [**11**] were performed with boron trichloride at different reaction times and concentrations of reagent. For short reaction time (0.5 h) (14) the main product (76%) was a monohydroxy-trimethoxyxanthone ($C_{16}H_{14}O_6$) identified as 1-hydroxy-2,3,8-trimethoxyxanthone [**13**] by the following evidence: the hydroxyl group must be placed at C-1 or C-8, because a signal is found at very low field in ^1H nmr (δ 13.12) due to chelation with the carbonyl group,

and no hydroxyl band is observed in the ir spectrum due to the same chelation. Besides, uv maxima in MeOH show a strong bathochromic shift on addition of $AlCl_3$, which is not destroyed by HCl (23,24). The ^{1}H-nmr data of the acetate derivative of this 1-hydroxy-2,3,8-trimethoxyxanthone [**13**] is consistent with a 1-acetoxy-2,3,8-trimethoxyxanthone (25,26): comparison of ^{1}H-nmr spectra of xanthone **13** and its acetate derivative shows no change for the ^{1}H-nmr signals of the monosubstituted ring. The signal for H-4 in compound **13** appears at δ 6.37 and at δ 6.74 in its acetylated derivative. This 0.4 ppm displacement is typical for a proton para to the acetoxy group (25,26). In addition, the hydroxyl group cannot be placed at C-8 as the physical and spectral data for 1-hydroxy2,3,8-trimethoxyxanthone [**13**] differ from those of 8-hydroxy-1,2,3-trimethoxyxanthone [**5**].



SCHEME 3. a: piperidine-H_2O (1:1.5) (Δ, 24 h); b: BCl_3/CH_2Cl_2 (−70°) 0.5 h; c: BCl_3/CH_2Cl_2 (−70°) 1.5 h; d: piperidine-H_2O (2.5:1) (Δ, 110 h).

Longer reaction time (1.5 h) led to 1,2,8-trihydroxy-3-methoxyxanthone [**12**] (64%) along with 1-hydroxy-2,3,8-trimethoxyxanthone [**13**] (26%). Eventually, traces of 1,8-dihydroxy-2,3-dimethoxyxanthone [**6**] (less than 10%) were obtained.

Compound **12** proved to be a trihydroxy-monomethoxyxanthone ($C_{14}H_{10}O_6$) and was identified as 1,2,8-trihydroxy-3-methoxyxanthone [**12**] by the following evidence: Two hydroxyl groups must be placed at C-1 and C-8 (^{1}H nmr δ 11.42 and 11.89). The third hydroxyl group is located at C-2 and not at C-3 because its uv spectrum in MeOH does not change when NaOAc is added, but it does change when NaOAc + H_3BO_3 is added. Besides, the uv spectrum suffers a variation with time after addition of $AlCl_3$ and HCl. Both facts are typical of compounds with two hydroxyl groups placed at ortho positions (23,24). Its physical and spectral data were identical with those previously described for 1,2,8-trihydroxy-3-methoxyxanthone [**12**] (8).

BCl_3 is generally used for the selective cleavage of methoxy groups in an ortho relationship to carbonyl groups (15, 28, 29) but for 1,2,8-trimethoxyxanthones the most sterically hindered and therefore basic methoxy group situated ortho to the xanthone carbonyl group undergoes selective demethylation (30). On the other hand, the obtention of 1,2,8-trihydroxy-3-methoxyxanthone [**12**] can be explained because hindered methoxy groups are shifted out of the aromatic plane and are basic enough (32) to co-

ordinate with BCl_3 and undergo demethylation even when no carbonyl group is present (31). In this case, more stringent conditions led to demethylation not only at C-1 and C-8 but at C-2 as well.

As shown in Scheme 1, demethylation of 8-hydroxy-1,2,3-trimethoxyxanthone [**5**] with aqueous piperidine led to a mixture of products from demethylation at C-1 or C-3 positions. Under weak basic conditions, demethylation of polymethoxyxanthones generally occurs at C-3 position (29,33), whereas C-1 or C-8 demethylated compounds are found as minor products (22). It seemed interesting to establish if, in this case, the high yield for C-1 demethylation came from anomalous behavior of the 1,2,3,8-oxygenation pattern, and/or from the reaction conditions.

Demethylation of 1-hydroxy-2,3,8-trimethoxyxanthone [**13**] with aqueous piperidine required a long reaction time, as unchanged xanthone **13** was recovered under the above conditions used for demethylation of 8-hydroxy-1,2,3-trimethoxyxanthone [**5**].

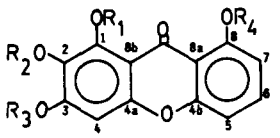
With piperidine-H_2O (5:2) and 110 h of reflux (Table 4), a mixture of 1,3-dihydroxy-2,8-dimethoxyxanthone [**14**] (56%), along with 1,3,8-trihydroxy-2-methoxyxanthone [**15**] (38%), was obtained.

Compound **14** was a dihydroxy-dimethoxyxanthone ($C_{15}H_{12}O_6$). A hydroxyl group must be placed at C-1 (confirmed by ^1H nmr δ 13.47). This xanthone showed a strong acidic character, and its uv spectrum in MeOH suffers a marked bathochromic shift when NaOAc is added, typical of a 1,3-dihydroxyxanthone (23). Besides, no ortho dihydroxy groups are present as its uv spectra in MeOH and MeOH + NaOAc + H_3BO_3 are identical (24).

Compound **15** was a trihydroxy-monomethoxyxanthone ($C_{14}H_{10}O_6$) with two hydroxyl groups placed at C-1 and C-8 (^1H nmr δ 11.85 and 12.18). Again its uv spectra were typical for a 1,3-dihydroxyxanthone without ortho hydroxyl groups (Table 3).

Both physical and spectral data of 1,3-dihydroxy-2,8-dimethoxyxanthone [**14**] differed from those described for a naturally occurring xanthone isolated from *K. candidissima* (6). The data cited for the naturally occurring xanthone isolated from *K. candidissima* (6) are quite similar to those described for the dihydroxy-dimethoxyxanthone isolated from *Ce. linarifolium* (7). These data are compatible with a 3,8-dihydroxy-1,4-dimethoxyxanthone structure, and additional work is being undertaken to confirm this possibility.

On the other hand, the physical and spectral data of 1,3,8-trihydroxy-2-methoxyxanthone [**15**] also differed from those described for the naturally occurring trihydroxy-monomethoxyxanthone isolated from *Ca. linarifolium* (7). The synthesis of



5 $R_1=R_2=R_3=Me$, $R_4=H$
6 $R_1=R_4=H$, $R_2=R_3=Me$
7 $R_1=R_2=Me$, $R_3=R_4=H$
11 $R_1=R_2=R_3=R_4=Me$
12 $R_1=R_2=R_4=H$, $R_3=Me$
13 $R_1=H$, $R_2=R_3=R_4=Me$
14 $R_1=R_3=H$, $R_2=R_4=Me$
15 $R_1=R_3=R_4=H$, $R_2=Me$
16 $R_1=R_2=R_4=Me$, $R_3=H$

1,3,8-trihydroxy-4-methoxyxanthone as an alternative structure is being undertaken.

These results thus clearly show that in fact, just one of the reported naturally occurring tetraoxygenated xanthones possesses the 1,2,3,8 substitution pattern, i.e., 3,8-dihydroxy-1,2-dimethoxyxanthone, isolated from the heartwood of *Ca. trapezifolium* (5).

When demethylations with aqueous piperidine were performed on 1,2,3,8-tetramethoxyxanthone [**11**] under different conditions, mixture of products were obtained, which could be compared with the xanthonic compounds previously obtained. This showed the presence of 1-hydroxy-2,3,8-trimethoxyxanthone [**13**] (demethylation at C-1) as the major component along with 1,8-dihydroxy-2,3-dimethoxyxanthone [**6**] (demethylation at C-1 and C-8), 1,3-dihydroxy-2,8-dimethoxyxanthone [**14**] (demethylation at C-1 and C-3) and a new xanthone identified as 3-hydroxy-1,2,8-trimethoxyxanthone [**16**] (demethylation at C-3), by the following evidence: it is a monohydroxy-trimethoxy xanthone ($C_{16}H_{14}O_6$). The hydroxyl group cannot be placed at C-1 or C-8 (^{1}H nmr δ 6.46). The physical and spectral data differ from those of compounds **5** and **13**. The hydroxyl group must be placed at C-3 because its uv maxima in MeOH suffer a strong bathochromic shift when NaOAc is added (23,29).

Under optimized conditions, 24 h reflux in 8.4 ml of piperidine and 14 ml of H_2O, 3-hydroxy-1,2,8-trimethoxyxanthone [**16**] was obtained in 15% yield. Higher piperidine-to-H_2O ratios led to higher yields of dihydroxylated components and to lower yields of monohydroxylated ones (Table 4).

Selective demethylation at C-3 or C-6, of polymethoxy xanthones, when heated under reflux in aqueous piperidine, has been described in the literature (22, 29, 33). This selectivity has been explained (29) because the oxygen atom para to a carbonyl group is the least electronegative. Jackson *et al.* (22) have also observed demethylation at C-1 or C-8, generally as by-products. Probably phenoxides at C-1 and C-3 are better leaving groups than at C-2 for the S_N2 substitution at the methyl group (29), as a consequence of their lower basicities. Another way to explain this selectivity implies acceptance of a nucleophilic attack on the ring. Methoxy groups at ortho or para position to the xanthone carbonyl group constitute vinylogues of an ester, and this probably accounts for their easier hydrolysis and for the selectivity of the demethylation under weakly basic conditions (22).

In our case, reflux in aqueous piperidine of 1,2,3,8-tetramethoxyxanthone [**11**] and 8-hydroxy-1,2,3-trimethoxyxanthone [**5**] led to mixtures of products by demethylation at C-1, C-3, and C-8, in a proportion which depends on the reaction conditions. In every case, demethylation at C-1 led always to the major product. But, as soon as C-1 has been demethylated, the normal trend in demethylation rates is followed (22) and demethylation at C-3 over C-8 is preferred. Thus, the major product in demethylation of 1-hydroxy-2,3,8-trimethoxyxanthone [**13**] is 1,3-dihydroxy-2,8-dimethoxyxanthone [**14**].

EXPERIMENTAL

GENERAL EXPERIMENTAL PROCEDURES.—All melting points were determined with a Reichert apparatus and are uncorrected. Uv spectra were determined with a Perkin-Elmer Lambda 9 spectrophotometer in MeOH or EtOH solution. Ir spectra were determined with a Perkin-Elmer model 281 recording spectrophotometer for KBr or NaCl pellets. ^{1}H-nmr spectra were recorded in the stated solvents with a Bruker AC-200 (200 MHz) instrument; chemical shifts are reported as δ values with TMS as internal standard. Low and high resolution mass spectra were taken with a Varian-166 mass spectrometer. Si gel Merck 60 (0.06–0.20 mm) was used for cc and Si gel 60 $HF_{254+360}$ for tlc.

PREPARATION OF 2,2′,6′-TRIBENZYLOXY-4,5,6-TRIMETHOXYBENZOPHENONE [**3**].—To a stirred solution of 2,6-dibenzyloxybenzoic acid [**2**] (1.27 g, 3.0 mmol) and 1-benzyloxy-3,4,5-trimethoxybenzene [**1**] (18) (0.82 g, 2.99 mmol) in dry CH_2Cl_2 (34 ml), under argon at 0°, trifluoroacetic anhydride (3.5 ml) was added (19). After 3 h at room temperature, the crude mixture was poured over ice

(50 g) and extracted with CH_2Cl_2 (4 × 25 ml). The combined extracts were washed with saturated $NaHCO_3$ solution and brine. After crystallization from hexane/CH_2Cl_2, 2,2',6'-tribenzyloxy-4,5,6-trimethoxybenzophenone [**3**] was obtained as colorless plates (1.4 g, 2.37 mmol, 79%): mp 157–159°, ir ν max (KBr) cm^{-1} 3200–2860, 1675, 1595, 1495, 1455, 1405, 1390, 1265, 1205, 1130, 1105, 830, 765, 750, 700; ^1H nmr ($CDCl_3$) δ 3.47, 3.71, and 3.82 (9H, 3s, 3 OMe), 4.66 (2H, s, OCH_2Ph), 4.88 (4H, s, 2 OCH_2Ph), 6.14 (1H, s, H-3), 6.51 (2H, d, J = 8.4 Hz, H-2' and H-5'), 7.10–7.21 (16H, m, aromatic protons 3 BzO + H-4'); hrms *m/z* (%) $[M]^+$ 590 (20) (found 590.229 ± 0.009, calcd for $C_{37}H_{34}O_7$, 590.230), 274 (20), 273 (29), 211 (19), 210 (34), 181 (13), 91 (100).

PREPARATION OF 2,2',6'-TRIHYDROXY-4,5,6-TRIMETHOXYBENZOPHENONE [**4**].—To a stirred solution of 2,2',6'-tribenzyloxy-4,5,6-trimethoxybenzophenone [**3**] (1.6 g, 2.69 mmol) in EtOAc (125 ml), concentrated HCl (0.5 ml) and 5% Pd/C (30 mg) were added (17,20). The mixture was hydrogenated at room temperature and 1 atm of pressure for 3 h. The catalyst was filtered off, and the solution was washed with H_2O until neutral. After crystallization from hexane/Et_2O, 2,2',6'-trihydroxy-4,5,6-trimethoxybenzophenone [**4**] (857 mg, 2.68 mmol, 99%) was obtained as orange-yellow prisms: mp 180–182°; ir ν max (KBr) cm^{-1} 3300, 3000–2800, 1615, 1575, 1490, 1470, 1450, 1400, 1350, 1285, 1260, 1210, 1140, 995, 940, 865, 810, 780, 735, 710; ^1H nmr ($CDCl_3$) δ 3.60, 3.73, and 3.90 (9H, 3s, 3 OMe), 6.30 (1H, s, H-2), 6.44 (2H, d, J = 8 Hz, H-2' and H-4'), 7.21 (1H, t, H-3'), 7.48 (2H, broad s, 2 OH), 10.73 (1H, s, OH); hrms *m/z* (%) $[M]^+$ 320 (36) (found 320.087 ± 0.004, calcd for $C_{16}H_{16}O_7$, 320.089), 289 (100), 228 (15), 210 (13), 184 (63), 169 (52), 137 (35).

PREPARATION OF 8-HYDROXY-1,2,3-TRIMETHOXYXANTHONE [**5**]—(*Method A*).—To a solution of 2,2',6'-trihydroxy-4,5,6-trimethoxybenzophenone [**4**] (300 mg, 0.94 mmol) in Me_2CO, Si gel (5 g) was added, and the solvent was allowed to evaporate. After heating the mixture at 40° for 14 h, it was purified by cc to give 8-hydroxy-1,2,3-trimethoxyxanthone [**5**] [hexane-Et_2O (8:2)] (130 mg, 43 mmol, 46%) as yellow needles (hexane/CH_2Cl_2): mp 137–139°); ir ν max (KBr) cm^{-1} 2940, 1645, 1605, 1480, 1465, 1430, 1270, 1245, 1235, 1210, 1140, 1100, 1070, 1005, 925, 825; hrms *m/z* (%) $[M]^+$ 302 (54) (found 302.080 ± 0.003, calcd for $C_{16}H_{14}O_6$, 302.0786), 303 (10), 287 (100), 285 (6), 284 (5), 288 (24), 273 (11), 229 (23), 137 (28). The most polar fractions yielded starting material **4** [hexane-Et_2O (5:5)] (120 mg, 0.38 mmol, 40%).

Method B.—To a mechanically stirred mixture of 2,2',6'-trihydroxy-4,5,6-trimethoxybenzophenone [**4**] (72 mg, 0.22 mmol) and polyphosphoric acid (2 ml), P_2O_5 (0.5 g) was added, and the mixture was heated at 40° for 5 h (21). The crude product was poured over ice, basified with K_2CO_3, and extracted with Et_2O (4 × 25 ml). After removal of the solvent an oil was obtained that was purified by cc to give 1-hydroxy-6,7,8-trimethoxyxanthone [hexane-Et_2O (8:2)] (27 mg, 0.09 mmol, 41%) and starting material **4** [hexane-Et_2O (5:5)] (17.1 mg, 0.05 mmol, 23%).

SYNTHESIS OF 1,8-DIHYDROXY-2,3-DIMETHOXYXANTHONE [**6**] AND 3,8-DIHYDROXY-1,2-DIMETHOXYXANTHONE [**7**].—A stirred solution of 8-hydroxy-1,2,3-trimethoxyxanthone [**5**] (84 mg, 0.277 mmol) in piperidine (10.8 ml) and H_2O (4.4 ml) was refluxed for 24 h (22). The crude solution was poured over ice-H_2O (50 ml), acidified with concentrated HCl (4 ml), and extracted with Et_2O (4 × 15 ml). The combined extracts were washed with $NaHCO_3$ solution and H_2O. The residue was purified by cc to give compounds **6** and **7**.

1,8-Dihydroxy-2,3-dimethoxyxanthone [**6**].—Compound **6** [hexane-Et_2O (8:2)] (46.1 mg, 0.16 mmol, 57%) was obtained as yellow needles (hexane/CH_2Cl_2): mp 188–192°; ir ν max (KBr) cm^{-1} 2970, 1660, 1635, 1605, 1500, 1460, 1290, 1240, 1210, 1150, 1100, 1060, 990, 820, 735, 715; hrms *m/z* (%) $[M]^+$ 288 (100), (found 288.061 ± 0.003, calcd for $C_{15}H_{12}O_6$, 288.063), 289 (10), 287 (11), 273 (79), 274 (12), 270 (31), 245 (62), 202 (22).

3,8-Dihydroxy-1,2-dimethoxyxanthone [**7**].—Compound **7** [hexane-Et_2O (6:4)] (24.5 mg, 0.09 mmol, 31%) was obtained as yellow needles (hexane/Me_2CO): mp 157–160°; found C 62.7, H 4.0, calcd for $C_{15}H_{12}O_6$, C 62.5, H 4.2%; ir ν max (KBr) cm^{-1} 3450–3250, 2920, 1640, 1605, 1480, 1465, 1430, 1270, 1240, 1160, 1095, 1060, 1015, 835, 820, 790, 760, 715. Its physical and spectral data are identical with those of a naturally occurring xanthone from *Ca. trapezifolium* (5) but differ with those of a naturally occurring xanthone from *Ce. linarifolium* (7).

PREPARATION OF 2-BENZYLOXY-2',4,5,6,6'-PENTAMETHOXYBENZOPHENONE [**9**].—To a stirred solution of 2,6-dimethoxybenzoic acid [**8**] (1.43 g, 7.9 mmol) and 1-benzyloxy-3,4,5-trimethoxybenzene [**1**] (2 g, 7.3 mmol) in dry CH_2Cl_2 (80 ml), under argon at 0°, trifluoroacetic anhydride (8 ml) was added. After 3 h at room temperature (19), the crude mixture was poured over ice (80 g). The phases were separated and the aqueous one was extracted with CH_2Cl_2 (3 × 35 ml). The combined extracts were washed with $NaHCO_3$ solution and H_2O. 2-Benzyloxy-2',4,5,6,6'-pentamethoxybenzophenone [**9**] was ob-

tained (3.06 g, 7 mmol, 96%) as prisms (hexane/CH_2Cl_2): mp 132–133°; ir ν max (KBr) cm^{-1} 2940, 1680, 1595, 1495, 1475, 1400, 1340, 1260, 1120, 1045, 840, 795, 740; ^1H nmr ($CDCl_3$) δ 3.57 (6H, 2s, 2 OMe), 3.72, 3.80, and 3.82 (9H, 3s, 3 OMe), 4.89 (2H, s, OCH_2Ph), 6.25 (1H, s, H-3), 6.47 (2H, d, $J = 8.4$ Hz, H-3′ and H-5′), 7.13–7.28 (6H, m, H-4′ + aromatic protons); ^{13}C nmr ($CDCl_3$) δ 54.5, 57.4, 59.5, 62.8, 71.3, 92.5, 95.7, 99.0, 103.0, 106.0, 125.8, 126.6, 129.0, 129.8, 132.2, 136.6, 153.5, 154.9, 158.1, 191.7; hrms *m/z* (%) $[M]^+$ 438 (44) (found 438.165 ± 0.004, calcd for $C_{25}H_{26}O_7$, 438.168), 439 (13), 407 (16), 348 (12), 347 (57), 211 (33), 210 (65), 195 (26), 165 (100), 150 (15), 91 (93).

PREPARATION OF 2-HYDROXY-2′,4,5,6,6′-PENTAMETHOXYBENZOPHENONE [**10**].—To a solution of 2-benzyloxy-2′,4,5,6,6′-pentamethoxybenzophenone [**9**] (2.8 g, 6.4 mmol) in EtOH (290 ml), 5% Pd/C (10 mg) was added, and the mixture was hydrogenated at 50° for 12 h (15). The catalyst was filtered off and the resulting solution concentrated. The residue was crystallized from EtOH/H_2O to give 2-hydroxy-2′,4,5,6,6′-pentamethoxybenzophenone [**10**] (1.99 g, 6.2 mmol, 90%) as light yellow needles: mp 150–151°, ir ν max (KBr) cm^{-1} 3000–2700, 1620, 1600, 1490, 1475, 1450, 1435, 1405, 1385, 1330, 1285, 1255, 1225, 1210, 1140, 1115, 1040, 995, 940, 930, 855, 820, 785, 745, 710, 650; ^1H nmr ($CDCl_3$) δ 3.33, 3.69, 3.73, 3.74, and 3.89 (15H, 5s, 5 OMe), 6.28 (1H, s, H-3), 6.59 (2H, d, $J = 8.4$ Hz, H-3′ and H-5′), 7.25 (1H, t, $J = 8.4$ Hz, H-4′), 13.33 (1H, s, OH); ^{13}C nmr ($CDCl_3$) δ 55.9, 56.0, 60.6, 60.8, 95.8, 103.9, 110.1, 121.9, 129.5, 134.6, 155.4, 156.4, 160.5, 162.2, 197.8; hrms *m/z* (%) $[M]^+$ 348 (45) (found 348.119 ± 0.004, calcd for $C_{18}H_{20}O_6$, 348.121), 318 (16), 317 (80), 287 (10), 210 (100), 195 (99), 167 (69).

PREPARATION OF 1,2,3,8-TETRAMETHOXYXANTHONE [**11**].—To a stirred solution of 2-hydroxy-2′,4,5,6,6′-pentamethoxybenzophenone [**10**] (1.77 g, 5 mmol) in pyridine (21.6 ml) under argon, H_2O (10.9 ml) and 10% aqueous tetramethylammonium hydroxide (8 ml) were added. The mixture was refluxed for 14 h (27), poured over ice (70 g), acidified with concentrated HCl, and extracted with Et_2O (4 × 35 ml). The combined extracts were washed with $NaHCO_3$ solution and H_2O. The crude residue was crystallized (hexane/Et_2O) to give 1,2,3,8-tetramethoxyxanthone [**11**] (1.41 g, 4.46 mmol, 88%) as white needles: mp 133–135°, ir ν max (KBr) cm^{-1} 2940, 1660, 1615, 1600, 1475, 1460, 1440, 1430, 1335, 1290, 1270, 1210, 1140, 1100, 1045, 1000, 975, 820, 790, 765; hrms *m/z* (%) $[M]^+$ 316 (29) (found 316.095 ± 0.003, calcd for $C_{17}H_{16}O_6$, 316.094), 301 (100), 258 (20), 151 (14). Its physical and spectral data were identical with those of the permethylated derivative of the naturally occurring xanthone from *Ca. trapezifolium* (5) but not with the one from *K. candidissima* (6).

PREPARATION OF 1,2,8-TRIHYDROXY-3-METHOXYXANTHONE [**12**].—To a stirred solution of 1,2,3,8-tetramethoxyxanthone [**11**] (150 mg, 0.472 mmol) in dry CH_2Cl_2 (30 ml) under argon at −70°, BCl_3 (1.0 ml) was added (28,29). After 1.5 h at room temperature, MeOH (1 ml) was added (to remove excess of reagent). The solution was poured over ice-NaOAc solution (50 ml), the phases were separated, and the aqueous one was extracted with EtOAc (4 × 25 ml). The combined extracts were washed with $NaHCO_3$ solution and H_2O. The residue was crystallized from Me_2CO/CH_2Cl_2 to give 1,2,8-trihydroxy-3-methoxyxanthone [**12**] (75 mg, 0.27 mmol, 64%) as orange-yellow prisms: mp 289–291° [lit. (8) 276–280°]; ir ν max (KBr) cm^{-1} 3540, 3495, 1665, 1630, 1605, 1500, 1470, 1335, 1300, 1280, 1235, 1210, 1140, 1090, 1055, 855, 820, 725, 680; hrms *m/z* (%) $[M]^+$ 274 (100) (found 274.045 ± 0.003, calcd for $C_{14}H_{10}O_6$, 274.0474), 275 (16), 245 (10), 228 (36), 137 (20). Its physical and spectral data were identical with those described (8) for 1,2,8-trihydroxy-3-methoxyxanthone.

The mother liquors from the above crystallization yielded 1-hydroxy-2,3,8-trimethoxyxanthone [**13**] (37 mg, 0.12 mmol, 26%).

PREPARATION OF 1-HYDROXY-2,3,8-TRIMETHOXYXANTHONE [**13**].—To a stirred solution of 1,2,3,8-tetramethoxyxanthone [**11**] (150 mg, 0.47 mmol) in dry CH_2Cl_2 (30 ml) under argon at −70°, BCl_3 (0.5 ml) was added (28,29). After 30 min at room temperature, MeOH (0.5 ml) was added (to remove excess of reagent). The solution was poured over ice-NaOAc solution (50 ml), the phases were separated, and the aqueous one was extracted with EtOAc (4 × 25 ml). The combined extracts were washed with $NaHCO_3$ solution and H_2O. The residue was purified by cc [hexane-Et_2O (5:5)] to give 1-hydroxy-2,3,8-trimethoxyxanthone [**13**] (108.7 mg, 36 mmol, 76%) as yellow prisms: mp 160–162°; ir ν max (KBr) cm^{-1} 3060, 3000, 2920, 1645, 1605, 1570, 1500, 1480, 1450, 1425, 1395, 1340, 1300, 1280, 1250, 1225, 1210, 1140, 1095, 1080, 1035, 990, 845, 830, 790, 730, 680; hrms *m/z* (%) $[M]^+$ 302 (100) (found 302.078 ± 0.003, calcd for $C_{16}H_{14}O_6$, 302.0786), 303 (17), 288 (86), 273 (49), 259 (40). Its physical and spectral data differ from those of the monomethylated derivative of a naturally occurring xanthone from *K. candidissima* (6).

PREPARATION OF 1,3,8-TRIHYDROXY-2-METHOXYXANTHONE [**15**] AND 1,3-DIHYDROXY-2,8-DIMETHOXYXANTHONE [**14**].—To a stirred solution of 1-hydroxy-2,3,8-trimethoxyxanthone [**13**]

(247 mg, 0.901 mmol) in piperidine (31.4 ml) under argon, H_2O (13 ml) was added, and the resulting solution was refluxed (22) for 110 h. The crude mixture was poured over ice (75 g), acidified with concentrated HCl, and extracted with CH_2Cl_2 (4 × 25 ml). The combined extracts were washed with $NaCO_3$ solution and H_2O. Elimination of the solvent yielded a solid that was purified by cc to give compounds **15** and **14**.

1,3,8-Trihydroxy-2-methoxyxanthone [**15**].—Compound **15** [hexane-Et_2O (7:3)] (83.8 mg, 0.31 mmol, 38%) was obtained as yellow needles (CH_2Cl_2): mp 227–230° found C 61.3, H 3.6, calcd for $C_{14}H_{10}O_6$, C 61.3, H 3.7%; ir ν max (KBr) cm^{-1} 3410, 1665, 1640, (C=O of xanthone), 1610, 1490, 1455, 1380, 1305, 1225, 1155, 1090, 1055, 975, 825, 815, 750, 705, 680. Its physical and spectral data differ from those of the naturally occurring xanthone from *Ce. linarifolium* (7).

1,3-Dihydroxy-2,8-dimethoxyxanthone [**14**].—Compound **14** [hexane-Et_2O (5:5)] (131 mg, 0.43 mmol, 56%) was obtained as yellow needles (CH_2Cl_2/hexane): ir ν max (KBr) cm^{-1} 3450, 3100, 2940, 1650, 1610, 1570, 1500, 1490, 1470, 1440, 1350, 1300, 1280, 1190, 1140, 1090, 1020, 975, 825, 790, 780, 690; hrms *m/z* (%) $[M]^+$ 288 (100) (found 288.062 ± 0.003, calcd for $C_{15}H_{12}O_6$, 288.063), 289 (17), 273 (65), 270 (21), 245 (80), 242 (15). Its physical and spectral data differ from those of the naturally occurring xanthone from *K. candidissima* (6).

PREPARATION OF 3-HYDROXY-1,2,8-TRIMETHOXYXANTHONE [**16**].—To a stirred solution of 1,2,3,8-tetramethoxyxanthone [**11**] (130 mg, 0.41 mmol) in piperidine (8.4 ml) under argon, H_2O (14 ml) was added, and the resulting solution was refluxed for 24 h (22). The crude mixture was poured over ice (75 g), acidified with concentrated HCl, and extracted with CH_2Cl_2 (4 × 25 ml). The combined extracts were washed with $NaHCO_3$ solution and H_2O. Elimination of the solvent yielded a solid that was purified by cc to give 1,8-dihydroxy-2,3-dimethoxyxanthone [**6**] [hexane-Et_2O (7:3)] (4.8 mg, 0.017 mmol, 4%), 1-hydroxy-2,3,8-trimethoxyxanthone [**13**] [hexane-Et_2O (6:4)] (52 mg, 0.17 mmol, 42%), 1,3-dihydroxy-2,8-dimethoxyxanthone [**14**] [hexane-Et_2O (5:5)] (13 mg, 0.04 mmol 10%), and 3-hydroxy-1,2,8-trimethoxyxanthone [**16**] [EtOAc-MeOH (9:1)] (18 mg, 0.06 mmol, 15%) as pale yellow needles (CH_2Cl_2/Me_2CO): mp 248–250°; found C 63.7, H 4.8, calcd for $C_{16}H_{14}O_6$, C 63.6, H 4.7%; ir ν max (KBr) cm^{-1} 3350–3050, 1635, 1610, 1600, 1580, 1475, 1385, 1340, 1295, 1270, 1200, 1140, 1095, 1025, 920, 890, 820, 790, 765.

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