

New Xanthone Derivatives from *Calophyllum caledonicum* (Clusiaceae)

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Received: 11 October 2024; in revised form 28 November 2024 / Accepted: 28 November 2024 /

Published: 31 January 2024

Abstract: *Calophyllum caledonicum* (Clusiaceae) yielded thirteen new hydroxylated and/or prenylated xanthone derivatives, namely 5-hydroxy-8-methoxyxanthone (**1**), 3,5-dihydroxy-1,2-dimethoxyxanthone (**2**), 1,8-dihydroxy-6,7-dimethoxyxanthone (**3**), 5,7-dihydroxy-2,6-dimethoxyxanthone (**4**), 6,8-dihydroxy-3,7-dimethoxy-xanthone (**5**), 2,5,6,7,8-pentahydroxyxanthone (**6**), 1,3,8-trihydroxy-5,7-dimethoxyxanthone (**7**) and according to a previously adopted nomenclature [3], caledonixanthone G-L. (**8-13**). The structural elucidation of **1-13** were mainly established on the basis of 1D and 2D NMR and HRMS spectroscopic analysis.

Key words: NMR, MS, xanthones, *Calophyllum caledonicum*, Guttiferae

Introduction

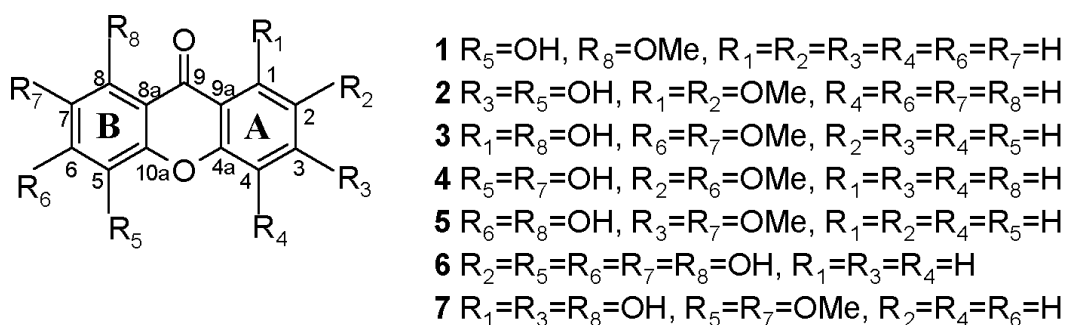
The genus *Calophyllum* (Guttiferae) is already known as a rich source of oxygenated and prenylated polyphenol derivatives belonging to the coumarin or the xanthone types of secondary metabolites [1-5]. Among 187 known species, *Calophyllum caledonicum* Vieill. is an endemic one restricted to

New-Caledonia where it is locally used by natives as a diuretic. We have already shown the presence of numerous xanthenes in *C. caledonicum* [3-5], some of them exhibiting quite interesting antifungal activities [4]. In our continuing search for novel biologically active compounds, we thus have carried on our phytochemical study of this species and we report hereafter on the isolation and the structure determination of new xanthenes **1-13** (Schemes 1 and 2).

Results and discussion

The molecular formula of **1** (C₁₄H₁₀O₄) was established by HRMS(EI) analysis of its molecular ion at *m/z* 242.0579 (Calcd. 242.0576). The UV spectrum of **1** showed maxima at 230, 256, 304 and 363 nm similar to those of hydroxylated xanthenes [6]. The ¹H-NMR spectrum (Table 1) showed the presence in the molecule of a 1,2-disubstituted benzene ring [δ_{H} 8.34 (1H, dd, *J* = 8.0, 1.5 Hz), 7.39 (1H, dd, *J* = 8.0, 8.0 Hz), 7.71 (1H, ddd, *J* = 8.5, 8.0, 1.5 Hz) and 7.46 ppm (1H, d, *J* = 8.5 Hz)], a methoxyl group (δ_{H} 3.99 ppm), a hydroxyl group (δ_{H} 5.51 ppm) and two *ortho*-coupled aromatic protons [δ_{H} 7.29 (1H, d, *J* = 9.0 Hz) and 6.74 ppm (1H, d, *J* = 9.0 Hz)]. The substitution pattern of the xanthone was finally deduced from the HMBC spectrum of **1**, which was thus identified as 5-hydroxy-8-methoxyxanthone. It should be noticed that though **1** has already been synthesized [7], this is the first report on the isolation of this compound from a natural source. Compounds **2-7** were then firmly identified from the same kind of spectroscopic data sets (see Experimental and Tables 1 & 2) since these xanthenes only differed from **1** in their number of hydroxyl or methoxyl groups and/or the substitution patterns of their aromatic rings.

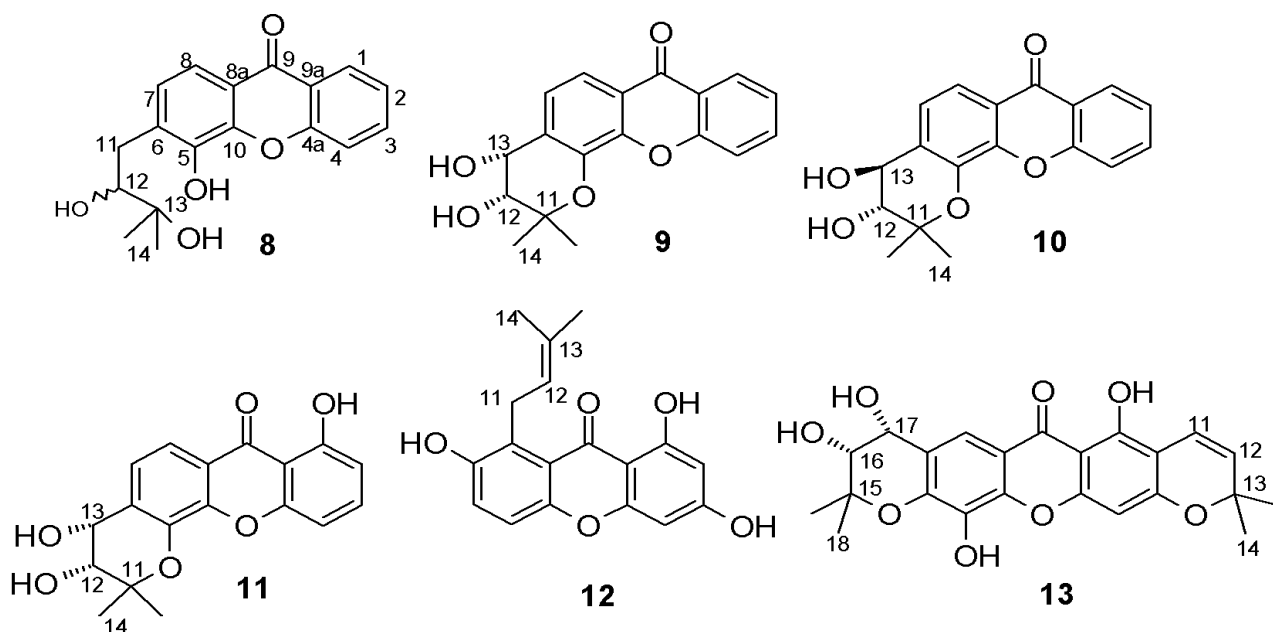
Scheme 1.



The HRMS(APCI) of **8** showed a [M-H₂O]⁺ ion at *m/z* 296.1027 which was consistent with a molecular formula of C₁₈H₁₈O₅. The ¹H-NMR spectrum showed the presence of a 1,2-disubstituted benzene ring [δ_{H} 8.23 (1H, dd, *J* = 8.0, 2.0 Hz), 7.43 (1H, dd, *J* = 8.0, 8.0 Hz), 7.81 (1H, ddd, *J* = 8.0, 8.0, 2.0 Hz) and 7.60 ppm (1H, d, *J* = 8.0 Hz)] whereas two *ortho*-coupled protons could be identified as two upfield doublets (*J* = 8.0 Hz) at δ_{H} 7.24 and 7.66 ppm. In the HMBC spectrum, a correlation between one of these *ortho*-coupled protons (δ_{H} 7.66 ppm) and the carbonyl at δ_{C} 176.9 ppm. then indicated that **8** was a 5,6-disubstituted xanthone. The ¹H-NMR spectrum of **8** also showed the

presence of two magnetically equivalent methyl groups [δ_{H} 1.26 ppm (6H, s)], an oxymethine proton [δ_{H} 3.75 (1H, dd, $J = 10.0, 2.0$ Hz)] and two methylene protons [δ_{H} 2.89 and 3.15 ppm (1H each, dd, $J = 10.0, 2.0$ Hz). These elements characterized the presence of a 2,3-dihydroxy-3-methyl-butyl chain in the molecule of **8**. Finally, on the addition of NaOMe, the UV spectrum (MeOH) of **8** exhibited a strong bathochromic shift demonstrating the presence of a hydroxyl group at C-5. The structure of caledonixanthone G, confirmed by its HMBC data was thus characterized as **8**.

Scheme 2.



The HRMS(EI) of **9** showed the molecular ion at m/z 312.1005 (Calcd. 312.0998) and the molecular formula to be $\text{C}_{18}\text{H}_{16}\text{O}_5$. As for **8**, the ^1H -NMR and HMBC spectra of **9** were indicative of a 5,6-disubstituted xanthone. The ^1H -NMR spectrum of **9** further showed the presence of a *gem*-dimethyl function [δ_{H} 1.35 and 1.40 ppm (3H each, s), H-12 and H-13] whereas the characteristic deshielded protons of a dihydrogenated dihydroxypyran ring resonated as two *cis* coupled doublets ($J = 5.0$ Hz) at δ_{H} 5.53 and 4.50 ppm. In the HMBC spectrum of **9**, the quaternary oxygen-bearing carbon of this pyran ring (δ_{C} 71.9 ppm) both correlated with H-12 and H-13 on one hand and the aforementioned *gem*-dimethyl protons on the other hand. These elements thus characterized a 3,4-dihydroxy-2,2-dimethyl chroman moiety and the structure of this xanthone which we have named caledonixanthone H (**9**) was further confirmed by long-range proton-carbon correlations. Compound **9** was here isolated as a racemate since neither optical rotation nor CD effects could be measured for this compound.

Caledonixanthone I (**10**) was then readily identified since this compound showed UV, NMR and MS data very similar to those of caledonixanthone H, **9**. The only significant differences in the ^1H - and ^{13}C -NMR spectra of **9** and **10** (Table 3) were observed for the signals assignable to the chroman ring.

Indeed, a coupling constant of 8.0 Hz between H-12 and H-13 there indicated that caledonixanthone I (**10**) was the *trans* isomer of **9**.

Compound **11** or caledonixanthone J had the molecular formula $C_{18}H_{16}O_6$ [HRMS(EI): M^+ at m/z 328.0958]. The UV spectrum of **11** showed absorptions at 252, 315 and 379 nm and the bathochromic shift observed upon addition of $AlCl_3$ indicated the presence of a chelated hydroxyl group at C-1. The 1H -NMR spectrum of **11** both showed the presence of two *ortho*-coupled protons [δ_H 7.38 and 7.78 ppm (1H each, d, $J = 8.0$ Hz)] and the existence of a 1,2,3-trisubstituted benzene ring [δ_H 6.76 (1H, d, $J = 8.0$ Hz), 7.63 (1H, dd, $J = 8.5, 8.0$ Hz) and 7.01 ppm (1H, d, $J = 8.5$ Hz)]. In the HMBC spectrum of **11**, one of these *ortho*-coupled protons (δ_H 7.78 ppm) was correlated to the carbonyl of the xanthone (C-9 at δ_C 183.5 ppm). These results indicated that **11** had a 1-hydroxy-5,6-disubstituted xanthone structure by comparison with **9**. The 1H -NMR and HMBC spectrum of **11** showed the presence 3,4-*cis*-dihydroxy-2,2-dimethylchroman in the molecule (Table 4). Further inspection of the HMBC data of **11** finally allowed us to firmly identify this compound as caledonixanthone J.

The HRMS(EI) revealed the molecular formula $C_{18}H_{16}O_5$ for **12** (M^+ at m/z 312.1013). The UV spectra of **12** (see Experimental) were those of a xanthone bearing hydroxyls at C-1 and either C-3 or C-6. The 1H -NMR spectrum of **12** showed two AB spins systems at δ_H 6.08 (1H, d, $J = 2.0$ Hz) and 6.17 ppm (1H, d, $J = 2.0$ Hz)] one the one hand and δ_H 7.13 (1H, d, $J = 9.0$ Hz) and 7.29 ppm (1H, d, $J = 9.0$ Hz) on the other hand. From these elements, ring A was then identified as a 1,3-dihydroxy benzene system, while it was established that ring B was disubstituted by one hydroxyl and had one other substituent at C-7 and C-8. Furthermore, typical signals of a prenyl group [δ_H 4.18 (2H, d, $J = 6.5$ Hz), 5.31 (1H, d, $J = 6.5$ Hz), 1.81 (3H, s) and 1.61 ppm (3H, s)] were also observed in the 1H -NMR spectrum of **12**. The relative location of this prenyl and the hydroxyl on ring B were then deduced by interlocking different HMBC correlations, *i. e.* the correlations observed between the aromatic proton at δ_H 7.29 ppm (H-7) and C-10a (δ_C 151.9 ppm) and C-8 (δ_C 128.8 ppm), as well as the ones existing between the methylene protons of the isoprenyl (δ_H 4.18 ppm) and C-7 (δ_C 152.1 ppm), C-8 (δ_C 128.8 ppm) and (C-8a δ_C 119.6 ppm) and. Accordingly, the hydroxyl the prenyl substituents of ring B were located at C-7 and C-8, respectively. This way, the structure of the so-called caledonixanthone K was concluded to be **12**.

Compound **13**, which we have named caledonixanthone L, showed in its HRMS(EI) the molecular ion at m/z 426.1328 (Calcd. 426.1315), corresponding to $C_{23}H_{22}O_8$. The UV spectra of **13** were indicative of a xanthone exhibiting one hydroxyl *peri* to the carbonyl of the heterocycle, *i. e.* at C-1 (δ_C 161.7 ppm). From the 1H -NMR spectrum of **13**, a 2,2-dimethylchromene ring [δ_H 1.47 (6H, s), 6.69 and 5.68 ppm (1H each, d, $J = 10.0$ Hz)], a 3,4-*cis*-dihydroxy-2,2-dimethylchroman moiety [δ_H 1.30 (3H, s), 1.32 (3H, s), 4.39 and 5.39 ppm (1H each, d, $J = 4.5$ Hz)] and two aromatic proton singlets [δ_H 7.66 and 6.44 ppm)] were firmly identified by direct comparison with the NMR data of caledonixanthonines G-K (**8-12**). In the HMBC spectrum of **13** the correlations observed between one of the aromatic protons (δ_H 7.66 ppm) and C-9 (δ_C 182.2 ppm), C-10a (δ_C 149.0 ppm), C-6 (δ_C 155.1 ppm) and an oxymethine carbon at δ_C 73.5 ppm indicated that ring B was substituted with an hydroxyl at C-5 and a 3,4-*cis*-dihydroxy-2,2-dimethylchroman moiety at C-6,7). Turning to ring A, one *cis*-

olefinic proton (δ_H 6.69 ppm, H-11) appeared to correlate with C-2 at δ_C 161.7 ppm and C-3 at δ_C 158.5 ppm. These results thus indicated that the dimethylchromene ring was located at C-2,3 and therefore, the structure of caledonixanthone L was established as **13**.

The antifungal activity of compounds **1-13** against the human pathogenic fungi *Candida albicans* and *Aspergillus fumigatus* was finally evaluated following a procedure already described [4]. Unfortunately, compounds **1-13** appeared to be inactive under these conditions ($IC_{80} > 250 \mu g.ml^{-1}$), when compared to our positive control (amphotericin B, $IC_{80} = 8 \mu g.ml^{-1}$).

Table 1. 1H NMR (270 MHz) data for compounds **1-7** [δ in ppm, (J) in Hz].

Proton	1 ^a	2 ^b	3 ^b	4 ^c	5 ^c	6 ^c	7 ^a
1	8.34 dd (8.0; 1.5)	-	-	7.49 d (3.5)	8.02 d (9.0)	7.42 d (2.0)	-
2	7.39 dd (8.0, 8.0)	-	6.80 d (8.0)	-	6.79 dd (9.0, 2.5)	-	6.02 d (2.0)
3	7.71 ddd (8.5, 8.0, 1.5)	-	7.58 dd (8.0, 7.5)	7.13 dd (9.0, 3.5)	-	7.36 dd (8.5, 2.0)	-
4	7.46 d (8.5)	6.73 s	6.88 d (7.5)	7.26 d (9.0)	6.71 d (2.5)	6.72 d (8.5)	6.21 d (2.0)
5	-	-	6.50 s	-	6.63 s	-	-
6	7.29 d (9.0)	7.18 d (7.5)	-	-	-	-	7.08 s
7	6.74 d (9.0)	7.13 dd (7.5, 7.5)	-	-	-	-	-
8	-	7.60 d (7.5)	-	6.41 s	-	-	-
1-OR	-	3.90 s	11.92 s	-	-	-	11.70 ^d s
2-OR	-	3.88 s	-	3.91 s	-	-	-
3-OR	-	-	-	-	3.93 s	-	-
5-OR	5.51 s	-	-	-	-	-	3.73 ^e s
6-OR	-	-	4.00 s	3.84 s	-	-	-
7-OR	-	-	3.94 s	-	3.87 s	-	3.67 ^d s
8-OR	3.99 s	-	11.91 s	-	-	-	11.15 ^f s

^a in $CDCl_3$; ^b in CD_3COCD_3 ; ^c in CD_3OD ; ^{e, f} Assignments may be interchanged in the same column

Table 2. ¹³C-NMR (67 MHz) data for compounds **1-7** (δ in ppm)

Carbon	1 ^a	2 ^b	3 ^b	4 ^c	5 ^c	6 ^c	7 ^c
1	127.2	154.0	157.3	110.1	128.5	117.8	163.2
2	124.4	141.3	110.8	154.6	114.2	145.3	98.4
3	134.4	163.1	136.8	123.5	154.3	123.1	167.5
4	116.9	100.7	106.9	119.2	102.3	115.3	94.2
4a	154.8	156.1	161.2	150.4	158.2	149.1	156.0
5	138.0	146.8	90.9	154.1 ^d	101.4	129.0 ^d	139.7
6	119.9	119.4	159.8	143.0	165.0	130.0 ^d	108.7
7	105.4	123.7	132.0	166.4 ^d	141.7	129.9 ^d	142.1
8	153.8	116.6	160.5	102.1	156.3	145.3 ^d	150.8
8a	112.5	123.8	111.1	106.5	108.2	127.0 ^d	109.7
9	175.1	174.5	184.9	176.6	177.8	175.3	184.8
9a	123.0	108.0	102.8	122.5	115.2	130.6	101.4
10a	145.0	145.0	153.6	157.6	156.0	149.1	148.0
1-OMe	-	61.1	-	-	-	-	-
2-OMe	-	61.8	-	62.0	-	-	-
3-OMe	-	-	-	-	61.9	-	-
5-OMe	-	-	-	-	-	-	56.9
6-OMe	-	-	56.4	61.2	-	-	-
7-OMe	-	-	60.9	-	61.2	-	56.9
8-OMe	56.6	-	-	-	-	-	-

^ain CDCl₃; ^bin CD₃COCD₃; ^cin CD₃OD; ^dAssignments may be interchanged in the same column.

Table 3. ¹H- (270 MHz, A) and ¹³C-NMR (67.5 MHz, B) data for compounds **8-10** (CD₃OD)

H or C N°	8		9		10	
	A	B	A	B	A	B
1	8.23 dd (8.0, 2.0)	127.0	8.30 d (8.0)	127.4	8.26 dd (8.0, 1.5)	127.2
2	7.43 dd (8.0, 8.0)	124.8	7.45 dd (8.0, 8.0)	125.5	7.45 dd (8.0, 8.0)	125.5
3	7.81 ddd (8.0, 8.0, 2.0)	135.7	7.78 dd (8.5, 8.0)	136.6	7.80 ddd (8.0, 8.0, 1.5)	136.6

4	7.60 d (8.0)	119.0	7.62 d (8.5)	119.3	7.67 d (8.0)	119.5
4a	-	156.8	-	157.4	-	157.6
5	-	145.5	-	149.6	-	143.0
6	-	134.5	-	137.5	-	132.0
7	7.24 d (8.0)	127.2	7.40 d (8.0)	121.5	7.52 d (8.5)	124.1
8	7.66 d (8.0)	116.4	7.80 d (8.0)	119.2	7.78 d (8.5)	117.3
8a	-	121.9	-	124.1	-	122.6 ^a
9	-	176.9	-	178.6	-	178.9
9a	-	122.3	-	122.7	-	122.7 ^a
10a	-	146.5	-	143.4	-	147.4
11	2.89, 3.15 dd (10.0, 2.0)	34.5	-	71.9	-	81.6
12	3.75 dd (10.0, 2.0)	80.2	4.50 d (5.0)	99.8	3.65 d (8.0)	76.2
13	-	72.8	5.53 d (5.0)	74.1	4.61 d (8.0)	69.9
14	1.26 s	25.4	1.35 s 1.40 s	25.7 25.3	1.32 s 1.60 s	19.6 26.9

^aAssignments may be interchanged in the same column.

Table 4. ¹H- (270 MHz, A) and ¹³C-NMR (67.5 MHz, B) data for compounds **11-13**

H or C N°	11^a		12^b		13^a	
	A	B	A	B	A	B
1	-	162.9	-	163.1	-	161.7
2	6.76 d (8.0)	111.5	6.08 d (2.0)	99.7	-	105.5
3	7.63 dd (8.5, 8.0)	138.1	-	145.8	-	158.5 ^c
4	7.01 d (8.5)	108.2	6.17 d (2.0)	94.5	6.44 s	96.0
4a	-	157.5	-	158.5	-	158.7 ^c
5	-	149.3	7.13 d (9.0)	116.5	-	163.8

6	-	136.8	7.29 d (9.0)	123.0	-	155.1
7	7.38 d (8.0)	121.5	-	152.1	-	129.4
8	7.78 d (8.0)	118.7	-	128.8	7.66 s	111.9
8a	-	123.0	-	119.6	-	116.7
9	-	183.5	-	183.0	-	182.2
9a	-	109.9	-	101.5	-	103.7
10a	-	143.2	-	151.9	-	149.0
11	-	71.8	4.18 d (6.5)	25.1	6.69 d (10.0)	116.2
12	4.45 d (5.5)	99.8	5.31 t (6.5)	124.8	5.68 d (10.0)	128.8
13	5.47 d (5.5)	74.1	-	130.9	-	79.3
14	1.30 s 1.34 s	25.2 25.8	1.61 s 1.81 s	18.2 25.2	1.47 s	28.6
15	-	-	-	-	-	71.9
16	-	-	-	-	4.39 d (4.5)	99.8
17	-	-	-	-	5.39 d (4.5)	73.5
18	-	-	-	-	1.30 s 1.32 s	25.3 25.5

^ain CD₃OD; ^bin CD₃COCD₃; ^cAssignments may be interchanged in the same column.

Experimental

General

Melting points were determined on a Electrothermal 8100 melting point apparatus and were uncorrected. Optical rotations were measured on a Schmidt-Haensch-polartronic-I polarimeter. UV spectra were taken on a Hitachi U-2000 spectrophotometer. HREIMS were recorded on Varian MAT 311 spectrometer at 70 eV for EI data and on a JMS-700 spectrometer with PEG matrix for APCI data. NMR spectra were recorded in CDCl₃ solutions on Jeol GSX 270 WB FT and Bruker AMX 500 (2-D experiments) instruments using TMS as internal standard. Si gel 60 (Macherey-Nagel, 230-400 mesh) was used for column chromatography, precoated Si gel plates (Macherey-Nagel, SIL G/UV254, 0.25 mm) were used for preparative TLC. The compounds were detected by UV at 254 and 366 nm.

Plant Material

The stem bark of *Calophyllum caledonicum* was collected from the “Rivière bleue” area, New Caledonia, during September 1997. A herbarium specimen is deposited at the Laboratoire des Plantes Medicinales, CNRS, Noumea, New Caledonia, under reference LIT 0315.

Extraction of *C. caledonicum* and isolation of compounds **1-13**

Air dried and powdered stem bark (1.8 kg) of *Calophyllum caledonicum* was successively extracted in a Soxhlet apparatus (72h) with hexane, dichloromethane, ethyl acetate and methanol. Concentration under reduced pressure gave 131.0 g (7.3%) of hexane-soluble, 29.7 g (1.65%) of dichloromethane-soluble, 23.4 g (1.3%) of ethyl acetate-soluble and 447.0 g (24.8%) of methanol-soluble extracts. 5.0 g of the EtOAc-soluble extract were subjected to column chromatography over 250 g of silica gel using a gradient of 100% CH₂Cl₂ to 20% CH₂Cl₂ - 80% EtOAc in 5% stepwise elutions (30 x 100 mL) and then 99% EtOAc - 1% MeOH to 80% EtOAc - 20% MeOH in 2% stepwise elutions (15 x 100 mL) which afforded 45 fractions (total elution volume : 4.5 L).

Fractions 7-10 (150 mg) were combined and chromatographed over 8 g of Si gel (elution with 85% CH₂Cl₂ - 15% EtOAc, 10 x 50 mL) to yield caledonixanthone K (**12**) (2 mg, 0.01%), 1,8-dihydroxy-6,7-dimethoxyxanthone (**3**) (4 mg, 0.02%). Fractions 11-14 (150 mg) were combined, then chromatographed over 7.5 g of Si gel (elution with 85% CH₂Cl₂ - 15% EtOAc, 10 x 40 mL) to yield 1,3,8-trihydroxy-5,7-dimethoxyxanthone (**7**) (9 mg, 0.04%), 5-hydroxy-8-methoxyxanthone (**1**) (2 mg, 0.01%). Fractions 15-25 (285 mg) were combined and chromatographed over 14 g of Si gel using 85% CH₂Cl₂ - 15 % EtOAc to 70% CH₂Cl₂ - 30% EtOAc in 5% stepwise elutions (18 x 50 mL) and yielded caledonixanthone L (**13**) (9 mg, 0.04%) and 3,5-dihydroxy-1,2-dimethoxyxanthone (**2**) (2 mg, 0.01%). Fractions 26-30 (350 mg) were mixed and chromatographed over 17 g of Si gel using 75% CH₂Cl₂ - 25% EtOAc to 50% CH₂Cl₂ - 50% EtOAc in 5% stepwise elutions (22 x 50 mL) and yielded 5,7-dihydroxy-2,6-dimethoxyxanthone (**4**) (8 mg, 0.03%) and 6,8-dihydroxy-3,7-dimethoxyxanthone (**5**) (5 mg, 0.02%).

Fraction 36 (705 mg) was chromatographed over 20 g of Si gel using 99% CH₂Cl₂ - 1% MeOH to 50% CH₂Cl₂ - 50% MeOH (8 x 50 mL) and yielded caledonixanthone J (**11**) (10 mg, 0.04%), caledonixanthone I (**10**) (8 mg, 0.03 %), caledonixanthone G (**8**) (7 mg, 0.03%) and caledonixanthone L (**13**) (4 mg, 0.02%). Fraction 37 (109 mg) was chromatographed over 6 g of Sephadex LH-20 using methanol as mobile phase and yielded caledonixanthone I (**10**) (4 mg, 0.02%), 2,5,6,7,8-pentahydroxyxanthone (**6**) (7 mg, 0.03%) and caledonixanthone H (**9**) (5 mg, 0.02%). Fractions 38 (205 mg) was chromatographed over 10 g of Sephadex using methanol and yielded caledonixanthone L (**13**) (5 mg, 0.02%). Fraction 39 (85 mg) was chromatographed over 8 g of Sephadex using methanol and yielded 2,5,6,7,8-pentahydroxyxanthone (**6**) (4 mg, 0.02%).

Spectral Data

5-Hydroxy-8-methoxyxanthone (1): Isolated as an amorphous solid; UV (MeOH): $\lambda_{\max}(\log\epsilon)$ 230 (3.76), 256 (3.72), 304 (3.26), 363 nm (3.11); MeOH + NaOMe: 215 (4.36), 268 (3.71), 303 nm (3.46); MeOH + AlCl₃ : 230 (3.87), 257 (3.76), 304 (3.37), 363 nm (3.22); MeOH + AlCl₃ + HCl: 230 (3.78), 256 (3.75), 298 (3.37), 363 nm (3.14); MeOH + NaOAc: 213 (4.31), 255 (3.69), 305 nm (3.27); MeOH + NaOAc + H₃BO₃ : 216 (4.36), 256 (3.73), 304 nm (3.27). IR $\nu_{\max}$ cm⁻¹ 3633, 1720, 1656, 1320, 1270, 1090, 758. NMR: see Tables 1 and 2. HRMS(EI): [M]⁺ 242.0576 (calcd. 242.0579 for C₁₄H₁₀O₄).

3,5-Dihydroxy-1,2-dimethoxyxanthone (2): Isolated as an amorphous solid; UV (MeOH): $\lambda_{\max}(\log\epsilon)$ 245 (4.15), 288 (3.74), 350 nm (3.80); MeOH + NaOMe: 216 (4.16), 256 (4.02), 293 (3.81), 349 nm (3.93); MeOH + AlCl₃ : 247 (4.16), 271 (3.84), 307 (3.76), 347 nm (3.49); MeOH + AlCl₃ + HCl: 248 (4.11), 272 (3.79), 308 (3.71), 349 nm (3.42); MeOH + NaOAc: 213 (4.11), 236 (4.14), 283 (3.72), 350 nm (3.94); MeOH + NaOAc + H₃BO₃ : 216 (4.15), 246 (4.15), 292 (3.74), 348 nm (3.72). IR $\nu_{\max}$ cm⁻¹ 3570, 1720, 1687, 1510. NMR: see Tables 1 and 2. HRMS(EI): [M]⁺ 288.0628 (calcd. 288.0634 for C₁₅H₁₂O₆).

1,8-Dihydroxy-6,7-dimethoxyxanthone (3): Isolated as an amorphous solid; UV (MeOH): $\lambda_{\max}(\log\epsilon)$ 213 (3.84), 249 (3.75), 303 (3.53), 375 nm (3.14); MeOH + NaOMe: 215 (4.72), 243 (3.99), 303 (3.71), 374 nm (3.47); MeOH + AlCl₃ : 236 (4.24), 272 (4.19), 328 (3.79), 348 nm (3.75); MeOH + AlCl₃ + HCl: 234 (4.17), 268 (4.21), 331 (3.72), 349 nm (3.47); MeOH + NaOAc: 212 (4.64), 249 (3.72), 298 (3.44), 375 nm (3.11); MeOH + NaOAc + H₃BO₃ : 216 (4.70), 255 (3.71), 310 (3.43), 373 nm (3.07). IR $\nu_{\max}$ cm⁻¹ 3633, 1722, 1657, 1498, 1283, 1236, 1145, 1098, 815. NMR: see Tables 1 and 2. HRMS(EI): [M]⁺ 288.0621 (calcd. 288.0634 for C₁₅H₁₂O₆).

5,7-Dihydroxy-2,6-dimethoxyxanthone (4): Isolated as an amorphous solid; UV (MeOH): $\lambda_{\max}(\log\epsilon)$ 238 (4.17), 315 (3.74), 350 (3.77), 379 nm (3.53); MeOH + NaOMe: 246 (4.12), 292 (3.68), 348 (3.89), 403 nm (3.36); MeOH + AlCl₃ : 239 (4.15), 286 (3.80), 314 (3.78), 358 nm (3.55); MeOH + AlCl₃ + HCl: 240 (4.10), 286 (3.75), 314 (3.73), 365 nm (3.41); MeOH + NaOAc: 235 (4.18), 290 (3.63), 352 (3.92), 385 nm (3.61); MeOH + NaOAc + H₃BO₃ : 240 (4.17), 284 (3.73), 316 (3.77), 365 nm (3.62). IR $\nu_{\max}$ cm⁻¹ 3570, 1704, 1656, 1510. NMR: see Tables 1 and 2. HRMS(EI): [M]⁺ 288.0623 (calcd. 288.0634 for C₁₅H₁₂O₆).

6,8-Dihydroxy-3,7-dimethoxyxanthone (5): Isolated as an amorphous solid; UV (MeOH): $\lambda_{\max}(\log\epsilon)$ 216 (3.94), 261 (3.40), 300 (3.18), 360 nm (3.38); MeOH + NaOMe: 240 (3.59), 308 (3.22), 350 (3.07), 375 nm (2.81); MeOH + AlCl₃ : 241 (3.64), 271 (3.35), 309 (3.31), 366 nm (2.85); MeOH + AlCl₃ + HCl: 241 (3.57), 271 (3.30), 307 (3.25), 360 nm (2.87); MeOH + NaOAc: 211 (3.83), 236 (3.59), 349 nm (3.32); MeOH + NaOAc + H₃BO₃ : 215 (3.93), 320 (3.23), 342 nm (3.60). IR $\nu_{\max}$ cm⁻¹

3500, 1703, 1656, 1562, 1254, 1049, 754. NMR: see Tables 1 and 2. HRMS(EI): $[M]^+$ 288.0642 (calcd. 288.0634 for $C_{15}H_{12}O_6$).

2,5,6,7,8-Pentahydroxyxanthone (6): Isolated as an amorphous solid; UV (MeOH): $\lambda_{\max}(\log\epsilon)$ 205 (4.14), 220 (3.95), 254 (3.64), 292 nm (3.20); MeOH + NaOMe: 206 (4.88), 275 (3.50), 299 nm (3.51); MeOH + $AlCl_3$: 236 (4.26), 277 (3.89), 315 nm (3.87); MeOH + $AlCl_3$ + HCl: 257 (3.89), 222 (3.97), 296 (3.92), 328 nm (3.62); MeOH + NaOAc: 215 (5.02), 256 (3.66), 289 nm (3.35); MeOH + NaOAc + H_3BO_3 : 216 (5.03), 263 (3.61), 298 nm (3.54). IR $\nu_{\max}$ cm^{-1} 3530, 1688, 1443, 1221, 759. NMR: see Tables 1 and 2. HRMS(EI): $[M]^+$ 276.0289 (calcd. 276.0270 for $C_{13}H_8O_7$).

1,3,8-Trihydroxy-5,7-dimethoxyxanthone (7): Isolated as an amorphous solid; UV (MeOH): $\lambda_{\max}(\log\epsilon)$ 213 (4.75), 249 (4.14), 271 (4.04), 358 nm (3.61); MeOH + NaOMe: 234 (4.02), 254 (3.98), 277 (3.90), 360 nm (3.91); MeOH + $AlCl_3$: 229 (4.23), 271 (4.08), 287 (4.05), 359 nm (3.72); MeOH + $AlCl_3$ + HCl: 235 (4.07), 251 (4.03), 288 (3.95), 359 nm (3.55); MeOH + NaOAc: 212 (4.69), 252 (3.99), 275 (3.91), 361 nm (3.81); MeOH + NaOAc + H_3BO_3 : 215 (4.75), 257 (4.00), 279 (3.92), 361 nm (3.65). IR $\nu_{\max}$ cm^{-1} 3570, 1704, 1656, 1510, 1254, 1090, 819. NMR: see Tables 1 and 2. HRMS(EI): $[M]^+$ 304.0588 (calcd. 304.0583 for $C_{15}H_{12}O_7$).

Caledonixanthone G (8): Isolated as orange prisms (MeOH); melting point 201°C; $[\alpha]_D^{25} -37^\circ$ ($c = 0.054$, MeOH); CD ($c = 0.11$, MeOH) $\lambda_{\max}$ 257 nm ($\Delta\epsilon = +3.6 \cdot 10^{-3}$); UV (MeOH): $\lambda_{\max}(\log\epsilon)$ 233 (4.20), 252 (4.36), 285 (3.75), 334 nm (3.45); MeOH + NaOMe: 236 (4.09), 270 (4.19), 299 (3.68), 371 nm (2.74); MeOH + $AlCl_3$: 235 (4.37), 251 (4.41), 288 (3.80), 330 nm (3.50); MeOH + $AlCl_3$ + HCl: 232 (4.30), 252 (4.24), 285 (3.75), 330 nm (3.50); MeOH + NaOAc: 257 (4.20), 298 nm (3.78); MeOH + NaOAc + H_3BO_3 : 255 (4.36), 289 (3.74), 338 nm (3.44). IR $\nu_{\max}$ cm^{-1} 3570, 1721, 1687, 1493, 1462, 1336, 1262, 1221. NMR: see Table 3. HRMS(APCI): $[M-H_2O]^+$ 296.1027 (calcd. 296.1048 for $C_{18}H_{16}O_4$).

Caledonixanthone H (9): Isolated as an amorphous solid; $[\alpha]_D^{25} 0^\circ$ ($c = 0.025$, MeOH); UV (MeOH): $\lambda_{\max}(\log\epsilon)$ 232 (4.42), 252 (4.53), 296 (3.96), 357 nm (3.72); MeOH + NaOMe: 212 (4.80), 252 (4.54), 295 (4.11), 343 nm (3.97); MeOH + $AlCl_3$: 234 (4.53), 252 (4.56), 300 (4.05), 358 nm (3.84); MeOH + $AlCl_3$ + HCl: 231 (4.41), 253 (4.49), 301 (3.98), 357 nm (3.74); MeOH + NaOAc: 211 (4.74), 252 (4.53), 295 (3.98), 337 nm (3.80); MeOH + NaOAc + H_3BO_3 : 214 (4.80), 252 (4.54), 295 (3.98), 342 nm (3.75). IR $\nu_{\max}$ cm^{-1} 3434, 1720, 1655, 1461, 1342, 1219, 757. NMR: see Table 3. HRMS(EI): $[M]^+$ 312.1005 (calcd. 312.0998 for $C_{18}H_{16}O_5$).

Caledonixanthone I (10): Isolated as an amorphous solid; $[\alpha]_D^{25} 0^\circ$ ($c = 0.025$, MeOH); UV (MeOH): $\lambda_{\max}(\log\epsilon)$ 234 (4.20), 253 (4.27), 284 (3.80), 360 nm (3.60); MeOH + NaOMe: 214 (4.52), 251 (4.24), 295 (3.84), 359 nm (3.73); MeOH + $AlCl_3$: 235 (4.27), 252 (4.28), 280 (3.95), 359 nm (3.69); MeOH + $AlCl_3$ + HCl: 234 (4.17), 253 (4.19), 297 (3.78), 359 nm (3.59); MeOH + NaOAc: 215 (4.53), 253 (4.27), 294 (3.80), 363 nm (3.68); MeOH + NaOAc + H_3BO_3 : 218 (4.55), 253 (4.27),

290 (3.80), 360 nm (3.66). IR $\nu_{\max}$ cm^{-1} 3434, 1721, 1654, 1461, 1342, 1219, 757. NMR: see Table 3. HRMS(EI): $[\text{M}]^+$ 312.0977 (calcd. 312.0998 for $\text{C}_{18}\text{H}_{16}\text{O}_5$).

Caledonixanthone J (**11**): Isolated as an amorphous solid; $[\alpha]_D^{25}$ 0° ($c = 0.025$, MeOH); UV (MeOH): $\lambda_{\max}(\log\epsilon)$ 252 (3.85), 315 (3.29), 379 nm (2.87); MeOH + NaOMe: 214 (4.54), 241 (3.78), 266 (3.55), 359 nm (3.39); MeOH + AlCl_3 : 237 (4.05), 278 (3.91), 328 (3.63), 368 nm (3.60); MeOH + AlCl_3 + HCl: 238 (3.80), 275 (3.69), 328 (3.50), 368 nm (3.43); MeOH + NaOAc: 212 (4.50), 252 (3.84), 327 (3.41), 359 nm (3.45); MeOH + NaOAc + H_3BO_3 : 214 (4.55), 252 (3.87), 328 (3.45), 359 nm (3.43). IR $\nu_{\max}$ cm^{-1} 3434, 1720, 1639, 1582, 1461, 1287, 1221, 1074, 759. NMR: see Table 4. HRMS(EI): $[\text{M}]^+$ 328.0958 (calcd. 328.0947 for $\text{C}_{18}\text{H}_{16}\text{O}_6$).

Caledonixanthone K (**12**): Isolated as an amorphous solid; UV (MeOH): $\lambda_{\max}(\log\epsilon)$ 238 (4.36), 261 (4.37), 313 (4.04), 360 nm (3.80); MeOH + NaOMe: 236 (4.38), 271 (4.27), 346 (4.17), 403 nm (3.76); MeOH + AlCl_3 : 235 (4.39), 277 (4.35), 328 (4.13), 439 nm (3.50); MeOH + AlCl_3 + HCl: 236 (4.26), 275 (4.23), 328 (4.01), 436 nm (3.35); MeOH + NaOAc: 234 (4.44), 263 (4.29), 345 (4.12), 400 nm (3.71); MeOH + NaOAc + H_3BO_3 : 236 (4.40), 262 (4.37), 309 (4.04), 389 nm (3.68). IR $\nu_{\max}$ cm^{-1} 3570, 1721, 1688, 1545, 1270, 1221, 1156, 758. NMR: see Table 4. HRMS(EI): $[\text{M}]^+$ 312.1013 (calcd. 312.0998 for $\text{C}_{18}\text{H}_{16}\text{O}_5$).

Caledonixanthone L (**13**): Isolated as an amorphous solid; UV (MeOH): $\lambda_{\max}(\log\epsilon)$ 254 (4.61), 281 (4.57), 327 (4.42), 370 nm (4.08); MeOH + NaOMe: 254 (4.86), 285 (4.84), 358 (4.74), 400 nm (4.64); MeOH + AlCl_3 : 272 (4.61), 295 (4.59), 370 (4.31), 392 nm (4.28); MeOH + AlCl_3 + HCl: 255 (4.50), 289 (4.04), 369 (4.21), 402 nm (3.68); MeOH + NaOAc: 254 (4.86), 285 (4.84), 358 (4.74), 400 nm (4.64); MeOH + NaOAc + H_3BO_3 : 255 (4.58), 282 (4.59), 327 (4.32), 371 nm (4.22). IR $\nu_{\max}$ cm^{-1} 3570, 1721, 1655, 1545, 1510, 1299, 1172, 1139, 1090, 1057. NMR: see Table 4. HRMS(EI): $[\text{M}]^+$ 426.1328 (calcd. 426.1315 for $\text{C}_{23}\text{H}_{22}\text{O}_8$).

References and Notes

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