Naphthopyranones from Rhizomes of *Paepalanthus diffissus*

José Gregorio Alvarado*, José Andrés Abad-Reyes, Roger Montealegre, Juan Manuel Amaro-Luis

Laboratorio de Productos Naturales. Departamento de Química. Facultad de Ciencias.
Universidad de Los Andes. Mérida 5101, Venezuela

(*) josealvarado@ula.ve

Recibido: 04/11/2013  Revisado: 06/12/2013  ACEPTADO: 08/12/2013

---

Resumen

Del extracto en diclorometano obtenido de los rizomas de *Paepalanthus diffissus* Moldenke (Eriocaulaceae) fueron aisladas las naftopiranonas bioactivas (+)-semi-vioxantina [3] y vioxantina [8]. Estos compuestos fueron caracterizados en base a estudios espectroscópicos, incluyendo experimentos de RMN unidimensional. La revisión de la literatura indica que estos metabolitos son encontrados frecuentemente en hongos y líquenes, pero son compuestos raros en plantas superiores. La presencia de (+)-semi-vioxantina en plantas con flores, es descrita aquí por primera vez.

**Palabras clave:** Eriocaulaceae; *Paepalanthus*; naftopiranonas; (+)-semi-vioxantina; vioxantina

**Abstract**

From a dichloromethane extract obtained of rhizomes of *Paepalanthus diffissus* Moldenke (Eriocaulaceae) were isolated the bioactive naphthopyranones (+)-semi-vioxanthin [3] and vioxanthin [8]. These compounds were characterized on the basis of spectroscopic studies, including 1D- and 2D-NMR experiments. The literature review indicated that these metabolites are frequently found in fungi and lichens, but they are rare compounds in higher plants. Presence of (+)-semi-vioxanthin in flowering plants is here described by first time.

**Keywords:** Eriocaulaceae; *Paepalanthus*; naphthopyranones; (+)-semi-vioxanthin; vioxanthin

---

**Introduction**

Eriocaulaceae is a small family of flowering plants, which contains about 1400 species grouped in 11 genera, although the most recent molecular studies tend to reduce the number of genera to ten. Most of the species included in this family are distributed in mountainous regions of South America, especially in the rocky savannas of Brazil and the felsen (table mountains) of Guyana and Venezuela; only a few species assembled in five genera, extend their habitat into temperate regions of North America and Europe, tropical Africa and eastern Asia. *Paepalanthus* represents the largest genus of the family, with over 450 species distributed disjunctly in neotropical South America, occidental Africa and Madagascar.

The genus *Paepalanthus* is well documented as a good source of secondary metabolites such as flavonoids, naphthopyranones, naphthoquinones and caffeic acid derivatives. Currently, some of these compounds possess a notable pharmacological interest due to their proven biological activity; for example, it has been reported that the naphthoquinone 5-methoxy-3,4-dehydroxanthomegnin [1].

---

**Keywords**

Eriocaulaceae; *Paepalanthus*; naphthopyranones; (+)-semi-vioxanthin; vioxanthin
In the light of the foregoing, as part of our continuing phytochemical studies on medicinal plants of Venezuela and Andean, in this paper we describe the isolation of two naphthopyranones from rhizomes of Paepalanthus diffissus Moldeke, a species found commonly in Andean moors. These naphthopyranones were identified as (+)-semi-vioxxanthin [3] and vioxxanthin [8], known antifungal antibiotics often isolated from fungi [27-29] and lichens [30]; presence of vioxxanthin in flowering plants is up to now limited to a few species of the genus Paepalanthus [31], but to the best of our knowledge, (+)-semi-vioxxanthin has so far not been found in higher plants.

Materials and methods

General

Melting points were determined using a Fisher-Johns apparatus and they are uncorrected. Optical rotations were measured on a 60Hz-Steeg & Reuter G.m.b.H. polarimeter using CHCl₃ as solvent. UV spectra were obtained in a Perkin-Elmer spectrophotometer, Lambda 3B, using quartz cells with 1cm thick and methanol (Merck-Uvasol) as solvent. IR measurements were obtained on a Perkin-Elmer FT-1725X spectrophotometer as KBr pellets. 1D and 2D NMR spectra in CDCl₃ were acquired using a Bruker-Avance DRX-400 instrument, operating at 400 MHz for ¹H and 100 MHz for ¹³C. Mass spectra were recorded on a Hewlett-Packard Mass Spectrometer, model 5890 (70 eV). TLC were developed on 0.25 mm layers of silica gel PF 254 (Merck); spots were visualized using UV light (254 and 365 nm) and subsequently by spraying with a mixture v/v CH₃COOH-H₂O-H₂SO₄ (20:4:1) and then heating with air flow at 100°C for few minutes. VCC was performed with silica gel Merck 60 (63-200 μm, 70-230 mesh). Size-exclusion chromatography columns were packed with Sigma Sephadex LH-20.

Plant material

Plant material (rhizomes) was collected at Páramo de San José de Acequias, Municipio Campo Elías, Estado Mérida, Venezuela. Species was identified as Paepalanthus diffissus Moldeke by Eng. Juan Antonio Carmona Arzola, Department of Pharmacognosy and Organic Medicaments, Faculty of Pharmacy and Bioanalysis, University of Los Andes (ULA); a voucher specimen (Amaro-Luis et al., N° 2342) was deposited at the Herbario MERV of this faculty.

Extraction

Rhizomes of Paepalanthus diffissus (ca 1.80 Kg) were air-dried, ground and exhaustively extracted with hexane and then with dichloromethane in a soxhlet. The solutions obtained were filtered and concentrated in vacuum on a rotary evaporator, to afford respectively, 54.8 g and 60.4 g of crude extracts.

Isolation and identification of the constituents

The dichloromethane extract was preadsorbed on silica gel and chromatographed (VLC) over silica gel 60, eluting with hexane, dichloromethane and EtOAc in mixtures of increasing polarity. Fifty-four (54) fractions of 500 mL were collected, concentrated in vacuum, and combined according to the TLC characteristics to afford twelve major fractions (A-L). (+)-Semi-vioxxanthin [3]: From combined fraction E [22-26, eluted with hexane-CH₂Cl₂ (7:3)] precipitated an apple green solid residue (≈ 5.8 g), which was partially purified by flash chromatography (hexane-EtOAc 4:1); crystallization from mixtures EtOAc/hexane provided
pure yellow needles (± 353 mg) detected in TLC plates as a homogeneous green-yellow spot, m.p. = 192-193°C, [α]D 20 [CHCl3]: +7.3° (CHCl3). UV, λmax (nm): 263, 379 (CH3OH); 228, 243, 404 (CH3OH + AlCl3). IR (KBr), vmax (cm−1): 3384 (OH), 2978-2850 (C=H), 1650 (C=O), 1582 (C=C), 1158 and 1124 (C-O), 844 and 598 (C=H). 1H NMR (Table 1). 13C NMR (Table 2). MS: m/z (%) 275 (60.12) [M+ +1], 274 (42.31) [M]+, 256 (47.31), 229 (27.72), 200 (15.81), 186 (23.18), 158 (16.03), 141 (22.20), 129 (41.63), 115 (49.82), 102 (33.64), 77 (32.95), 62 (22.31), 43 (37.75).

Vioxxanthin [8]: Combined fraction J [42-46, eluted with CH3Cl2-EtOAc (7:3)] was chromatographed on a Sephadex-LH20 column as eluent a mixture of hexane-CH3Cl2-CH3OH (0:5:4:0:5) which allowed to obtain twenty six fractions. From fraction N° 6 precipitated a crystalline solid as pale yellow needles (10.2 mg); m.p. = 196-198°C (decomposition); [α]D 20 + 4.6° (CHCl3). UV, λmax (nm): 270, 387 (CH3OH); 232, 276, 418 (CH3OH + AlCl3). IR (KBr), vmax (cm−1): 3398 (OH), 2976-2848 (C-H), 1632 (C=O), 1584 (C=C), 1128 and 1092 (C-O), 856 and 568 (C=H). 1H NMR (Table 1). 13C NMR (Table 2). EI-MS: m/z (%) 548 (4.25) [M]+2, 546 (18.42) [M]+, 531 (57.30), 517 (62.25).

Acetylation of (+)-semi-vioxxanthin [3]

Compound [3] (210 mg) was dissolved in pyridine (14 mL) and treated with Ac2O (35 mL) at room temperature overnight. Cold water was added to the reaction mixture and immediately it was extracted with CH2Cl2. The organic layer was washed in successive stages with aqueous solutions of HCl (10% v/v), NaHCO3 (2%) and water, dried on MgSO4 and evaporated to yield a solid residue (142 mg) that showed in TLC two spots. Separation was carried out on a silica gel column using as eluent hexane-CH2Cl2 (1:4) to furnish compounds [4] (36 mg) and [5] (22 mg).

(+)-Semi-vioxxanthin-9-monoacetate [4]: pale yellow flakes; m.p. = 186-188°C. IR (KBr), vmax (cm−1): 3424 (-OH), 1770 (C=O), 1648 (C=O), 1623 (C=C), 1210 (C-O), 858 (=C-H). 1H NMR (Table 1). 13C NMR (Table 2).

(+)-Semi-vioxxanthin-9,10-diacetate [5]: pale yellow needles; m.p. > 200°C. IR (KBr), vmax (cm−1): 1770 (C=O), 1716 (C=O), 1632 (C=O), 1580 (C=C), 1212 (C-O), 860 (=C-H). 1H NMR (Table 1). 13C NMR (Table 2).

Methylation of (+)-semi-vioxxanthin [3]

Compound [3] (124 mg) was treated with excess ethereal CH2N2 and solution was left standing overnight in a refrigerator at 4°C. Evaporation of ether yielded a colorless oil that was chromatographed on a silica gel column eluted with hexane-CH2Cl2 (1:4), to obtain pure TLC compounds [6] (4 mg) and [7] (23 mg).

(+)-Semi-vioxxanthin-9- methyl ether [6]: yellow solid; m.p. = 142-144°C. 1H NMR (Table 1).

(+)-Semi-vioxxanthin-10-methyl ether [7]: colorless oil. IR (KBr), vmax (cm−1): 3302 (-OH), 2848 (C-H), 1712 (C=O), 1642 and 1576 (C=C), 1123 (C-O). 1H NMR (Table 1). 13C NMR (Table 2).

Results and Discussion

(+)-Semi-vioxxanthin [3] was obtained as pale yellow needles [m.p. = 192-193 °C; [α]D 20 +7.3° (CHCl3)]. The presence in its EIMS of an ion molecular peak at m/z: 274 in conjuction with NMR data, allowed to establish the molecular formula C13H14O6. Its IR spectrum showed absorption bands of hydroxyl groups (3384 cm−1), a carbonyl group (1650 cm−1) and aromatic C-H bonds (1582, 844 and 598 cm−1). Its ultraviolet spectrum exhibited maxima at 263 and 379 nm. The 1H NMR spectrum of [3] (Table 1) indicated the presence in the molecule of three aromatic protons, a methoxyl group, dos hydroxyl protons and six aliphatic hydrogens that constitute a methylene, an oxymethene and a secondary methyl group. At the same time its 13C NMR (Table 2) shows, apart of ten signals typical of aromatic carbons, a peak assignable to a carbonyl group and four sp3 aliphatic carbons signals.

Comparing and contrasting the above information with the data derived from the analysis of the 2D-NMR spectra it was possible to conclude that [3] is a naphthopyranone with a lactone moiety, similar to paepalantine [2]. In effect, the naphthalene unit was identified by the presence of two aromatic Ï•meta-coupled protons [doublets at δH 6.54 and δH 6.51; J = 2.35 Hz (H-6 and H-8); HMBC: H-6 ↔ C-6 (δC 99.5, =CH); H-8 ↔ C-8 (δC 101.6, =CH); HMBC: C-7 ↔ H-6 ↔ C-8 and H-6 ↔ C-8], which characterize a 1,2,3,5-tetrasubstituted benzene ring [A] with two substituents identified as a hydroxyl on C-9 (acute singlet at δH 9.45, -OH) and a methoxyl group on C-7 [δH 3.87, s, (H-12)]; correlations in HMBC spectra (Fig 1) confirmed the ubication of these substituents [HMBC: C-8 ↔ OH ↔ C-9 (δC 158.6; =CH-O-)/C-9a ↔ H-8 and H-12 ↔ C-7 (δC 162.7; =CH-O-)]. The other two A-ring substitute carbons [δC 140.5; =C=C (C-5a) and δC 108.4; =C=C (C-9a)] conform the link between the second condensed pentasubstituted benzene ring [B], which also possesses two quaternary carbons bridge [δC 133.2; =C=C (C-4a) and δC 99.2; =C=C (C-10a)] that configure the fusion with a third aliphatic cycle [C]. The fifth substituent is a chelated hydroxyl group [δH 13.74, (-OH)] located at C-10.
Table 1: $^1$H-NMR (CDCl$_3$, 400 MHz) Chemical Shifts ($\delta_h$)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>H-3</td>
<td>4.73 (m)</td>
<td>4.71 (m)</td>
<td>4.74 (m)</td>
<td>4.70 (m)</td>
<td>4.62 (m)</td>
<td>4.75 (m)</td>
</tr>
<tr>
<td>H-4</td>
<td>2.96 (m)</td>
<td>2.95 (m)</td>
<td>2.96 (m)</td>
<td>2.97 (m)</td>
<td>2.97 (m)</td>
<td>3.01 (m)</td>
</tr>
<tr>
<td>H-5</td>
<td>6.85 (s)</td>
<td>6.93 (s)</td>
<td>7.44 (s)</td>
<td>6.85 (s)</td>
<td>7.20 (s)</td>
<td>6.95 (s)</td>
</tr>
<tr>
<td>H-6</td>
<td>6.54 (d)</td>
<td>6.87 (d)</td>
<td>6.95 (d)</td>
<td>6.57 (d)</td>
<td>6.60 (d)</td>
<td>6.70 (s)</td>
</tr>
<tr>
<td></td>
<td>J = 2.35</td>
<td>J = 2.40</td>
<td>J = 2.35</td>
<td>J = 2.33</td>
<td>J = 2.33</td>
<td></td>
</tr>
<tr>
<td>H-8</td>
<td>6.51 (d)</td>
<td>6.74 (d)</td>
<td>6.82 (d)</td>
<td>6.46 (d)</td>
<td>6.55 (d)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>J = 2.35</td>
<td>J = 2.40</td>
<td>J = 2.35</td>
<td>J = 2.33</td>
<td>J = 2.33</td>
<td></td>
</tr>
<tr>
<td>H-11</td>
<td>1.54 (d)</td>
<td>1.53 (d)</td>
<td>1.47 (d)</td>
<td>1.52 (d)</td>
<td>1.51 (d)</td>
<td>1.56 (d)</td>
</tr>
<tr>
<td>H-12</td>
<td>3.87 (s)</td>
<td>3.90 (s)</td>
<td>3.89 (s)</td>
<td>3.90 (s)</td>
<td>3.87 (s)</td>
<td>3.84 (s)</td>
</tr>
<tr>
<td>C-9 (OH)</td>
<td>9.45 (s)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>9.85 (s)</td>
<td>9.70 (s)</td>
</tr>
<tr>
<td>C-10 (OH)</td>
<td>13.74 (s)</td>
<td>12.90 (s)</td>
<td>-</td>
<td>13.20 (s)</td>
<td>-</td>
<td>13.79 (s)</td>
</tr>
<tr>
<td>H-10</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3.99 (s)</td>
<td>4.12 (s)</td>
<td>-</td>
</tr>
<tr>
<td>H-20</td>
<td>-</td>
<td>2.38 (s)</td>
<td>2.39 (s)</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>H-20</td>
<td>-</td>
<td>-</td>
<td>2.46 (s)</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

* Only shows $\delta_h$ of a monomer unit, since $\delta_h$ of second monomer unit are identical

Table 2: $^{13}$C-NMR (CDCl$_3$, 100 MHz) Chemical Shifts ($\delta_c$)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>C-1</td>
<td>171.6 (s)</td>
<td>170.3 (s)</td>
<td>169.9 (s)</td>
<td>162.8 (s)</td>
<td>171.1 (s)</td>
<td></td>
</tr>
<tr>
<td>C-3</td>
<td>76.5 (d)</td>
<td>76.1 (d)</td>
<td>74.6 (d)</td>
<td>74.5 (d)</td>
<td>76.0 (d)</td>
<td></td>
</tr>
<tr>
<td>C-4</td>
<td>34.7 (t)</td>
<td>35.1 (t)</td>
<td>35.9 (t)</td>
<td>36.3 (t)</td>
<td>34.2 (t)</td>
<td></td>
</tr>
<tr>
<td>C-4a</td>
<td>133.2 (s)</td>
<td>134.3 (s)</td>
<td>136.1 (s)</td>
<td>136.1 (s)</td>
<td>132.3 (s)</td>
<td></td>
</tr>
<tr>
<td>C-5</td>
<td>116.1 (d)</td>
<td>116.5 (d)</td>
<td>114.4 (d)</td>
<td>120.8 (d)</td>
<td>115.6 (d)</td>
<td></td>
</tr>
<tr>
<td>C-5a</td>
<td>140.5 (s)</td>
<td>140.8 (s)</td>
<td>139.5 (s)</td>
<td>139.7 (s)</td>
<td>134.5 (s)</td>
<td></td>
</tr>
<tr>
<td>C-6</td>
<td>99.5 (d)</td>
<td>104.9 (d)</td>
<td>104.5 (d)</td>
<td>98.6 (d)</td>
<td>97.5 (s)</td>
<td></td>
</tr>
<tr>
<td>C-7</td>
<td>162.7 (s)</td>
<td>162.2 (s)</td>
<td>159.9 (s)</td>
<td>162.0 (s)</td>
<td>162.3 (s)</td>
<td></td>
</tr>
<tr>
<td>C-8</td>
<td>101.6 (d)</td>
<td>111.8 (d)</td>
<td>122.9 (d)</td>
<td>102.6 (d)</td>
<td>107.7 (s)</td>
<td></td>
</tr>
<tr>
<td>C-9</td>
<td>158.6 (s)</td>
<td>150.0 (s)</td>
<td>148.0 (s)</td>
<td>157.4 (s)</td>
<td>154.9 (s)</td>
<td></td>
</tr>
<tr>
<td>C-9a</td>
<td>108.4 (s)</td>
<td>112.0 (s)</td>
<td>116.5 (s)</td>
<td>112.6 (s)</td>
<td>108.0 (s)</td>
<td></td>
</tr>
<tr>
<td>C-10</td>
<td>163.0 (s)</td>
<td>161.0 (s)</td>
<td>160.1 (s)</td>
<td>161.6 (s)</td>
<td>160.9 (s)</td>
<td></td>
</tr>
<tr>
<td>C-10a</td>
<td>99.2 (s)</td>
<td>101.5 (s)</td>
<td>113.2 (s)</td>
<td>109.5 (s)</td>
<td>98.8 (s)</td>
<td></td>
</tr>
<tr>
<td>C-11</td>
<td>20.8 (q)</td>
<td>20.8 (q)</td>
<td>20.7 (q)</td>
<td>20.7 (q)</td>
<td>20.2 (q)</td>
<td></td>
</tr>
<tr>
<td>C-12</td>
<td>55.9 (q)</td>
<td>55.7 (q)</td>
<td>55.8 (q)</td>
<td>55.5 (q)</td>
<td>55.4 (q)</td>
<td></td>
</tr>
<tr>
<td>C-10</td>
<td>-</td>
<td>171.2 (s)</td>
<td>169.2 (s)</td>
<td>64.4 (q)</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>C-20</td>
<td>-</td>
<td>21.3 (q)</td>
<td>21.2 (q)</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>C-20</td>
<td>-</td>
<td>-</td>
<td>169.6 (s)</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>C-20</td>
<td>-</td>
<td>-</td>
<td>21.6 (q)</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

* Only shows $\delta_c$ of a monomer unit, since $\delta_c$ of second monomer unit are identical
(cross peaks in HMBC among OH and C-10, C-9a and C-10a); the chelation requires that the lactone carboxy group in ring [C] is situated on C-1. The gross molecular structure is completed with the presence en ring [C] of a methylene group \( \delta_H 2.96, m, (H-4); \) HMQC: H-4 ↔ C-4 (\( \delta_C 34.7; >CH_2 \)) adjacent to a oxymethine \( \delta_H 4.73, m, (H-3); \) HMQC: H-3 ↔ C-3 (\( \delta_C 76.5; >CH-O-\)) that supports to the secondary methyl \( \delta_H 1.54; d, J = 6.32 \text{ Hz} \) (H-11); HMQC: H-11 ↔ C-11 (\( \delta_C 20.8; -CH_3 \)). Many other correlations in HMBC spectrum (Fig. 1) ensure the lineal condensation of the rings A/B/C and, unequivocally, confirm the position of substituents in [B] and [C] rings [HMBC: C-6 ↔ H-5 ↔ C-9a ↔ H-6 ↔ C-5 ↔ H-4 ↔ C-3 ↔ H-11 ↔ C-4 ↔ H-5 ↔ C-4a ↔ H-4 ↔ C-10a ↔ H-5 ↔ C-5a].

Fig. 1: HMBC Spectrum of (+)-Semivioxanthin [3]
The preceding analysis allows us to conclude that the structure of compound under study corresponds to 9,10-dihydroxy-7-methoxy-3-methyl-1-oxo-1H-naphto[2,3-c]pyran. This structure possesses a single chiral center (C-3) whose possible configurations (R or S) characterizes two enantiomeric molecules. Both molecules have been previously described as natural products: The levorotatory enantiomer, named (-)-semi-vioxanthin ([α]D -10.6°), possesses configuration 3β in C-3 and it was obtained from cultures of Cryptosporiopsis abietina32, a coelomycete endophytic fungus isolated from Chamaecyparis obtusa; this enantiomer exhibited abscisic activity against Hinoki cypress leaves and, in an antifungal test, inhibited spore germination of Cladosporum herbarum. The dextrorotatory isomer, (+)-semi-vioxanthin (configuration R in C-3) is a rare natural compound first isolated from the fungus Penicillium citreo-viride38 and subsequently also found in soil33 and marine-derived fungi.34 Its properties as an antifungal antibiotic and as a tumor necrosis factor-α regulator have been documented33-34. Compound described in this study is dextrorotatory and consequently its configuration in C-3 is R with the secondary methyl group α-oriented; it is obvious that the same was clearly identified as (+)-semi-vioxanthin [3].

Identification of (+)-semi-vioxanthin [3] was also confirmed by obtaining some derivatives. Thus, on acetylation with Ac2O/Py, compound [3] gave two acetyl derivatives, which were characterized by their spectroscopic data (Table 1) as monoacete [4] [IR, νmax: 1770 cm\(^{-1}\) (O=–C–O–)]; 1\(^{H}\) NMR: substitution of OH singlet at δ\(_H\) 9.45, by a new 3H singlet at δ\(_H\) 2.38, s, O=C-CH\(_3\) (H-2δ), 1\(^{3}\)C NMR: δ\(_C\) 171.2; O=C-CH\(_3\) (C-1δ) and δ\(_C\) 21.3; O=C-CH\(_3\) (C-2δ) and as diacetate [5] [IR, νmax: 1770 and 1716 cm\(^{-1}\) (O=–C–O–)]; 1\(^{H}\) NMR: substitution of both OH signals by two new singlets at δ\(_H\) 2.39 and δ\(_H\) 2.46, s, O=C-CH\(_3\) (H-2δ and H-2δ); 1\(^{3}\)C NMR: δ\(_C\) 169.2 and δ\(_C\) 169.6; O=C-CH\(_3\) (C-1δ and C-1δ) and δ\(_C\) 21.2 and δ\(_C\) 21.6; O=C-CH\(_3\) (C-2δ and C-2δ). Treatment of 3 with CH\(_2\)N\(_2\)/ether gave two dimethyl ether derivatives: (+)-Semi-vioxanthin-9 methyl ether [6] [δ\(_H\) 3.99; s, -OCH\(_3\); (H-1δ) and (+)-semivioxanthin-10-methyl ether [7] [δ\(_H\) 4.12; s, -OCH\(_3\); (H-1δ and δ\(_C\) 64.4; O=C-CH\(_3\)(C-1δ). Vioxanthin [8]: yellow needles observed in TLC plates as a orange spot; m.p. = 196-198°C (decomposition); [α]D + 4.6° (CHCl\(_3\)). Comparison of its 1\(^{H}\) NMR spectrum (Table 1) with that of (+)-semi-vioxanthin [3] revealed only two notable changes: The absence of singlet attributed to H-8 and the transformation of H-6 doublet in a sharp singlet [δ\(_H\) 6.70; s, (H-6/H-6δ)]; these changes indicate that C-8 is a quaternary carbon (=C<) and that ring A is pentasubstituted.

In accordance with the foregoing data, the 1\(^{3}\)C NMR spectrum (Table 2) displays, in the DEPT-90, only two peaks assignable to aromatic methines [δ\(_C\) 115.6 and δ\(_C\) 97.5; =CH (C-5 and C-6)], and consequently, it is also observed a new peak typical of a quaternary sp\(^{3}\) carbon [δ\(_C\) 107.7; =C< (C-8/8δ)]. The detection in its EI-MS of an ion molecular peak at \(m/z\) 546 [M\(^+\)] allows us to conclude that this compound is a symmetric dimer of (+)-semi-vioxanthin [3], with a bridge C-8/C-8δbetween the two monomer units; the symmetry of the structure justifies the not duplicity of the NMR signals. The above analysis led to the structure [8], named in the literature as vioxanthin. This naphthopyranone has been previously isolated of several fungti35-36 and lichens37 and also it has been found in other Paepalanthus species.38 Its wide range of biological activities is well documented in the literature14,20,35,36.

Acknowledgments

The authors are grateful to CDCHTA-ULA (C-1808-12-08-A) and to Venezuelan Ministry of Popular Power for Science, Technology and Innovation (MCTI), fScience Missiono Program (Grant N° 200800937), for financial support. Thank are also due to Eng. Juan Carmona Arzola, Department of Pharmacognosy and Organic Medicaments, Faculty of Pharmacy and Bioanalysis, University of Los Andes (ULA) for identification of plant material.

References


27. AS Ng, G Just, F Blank. Metabolites of pathogenic fungi. VII. Structure and stereochemistry of xanthomagnin, vioxanthin and viopurpurin, pigments from Phytomedicine, 12, 378-381 (2005).


