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CHIRALITY OF PERIDININ AND DINOXANTHIN*

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Abstract—Details are reported for the configurational assignment of peridinin as 3*S*, 5*R*, 6*R*, 3′*S*, 5′*R*, 6′*S* including ozonolytic degradation of its *p*-bromobenzoate to derivatives of known chirality obtained from fucoxanthin and violaxanthin. Details regarding derivatization and CD correlations in favour of the same chirality for dinoxanthin = neoxanthin 3-acetate are given.

INTRODUCTION

Peridinin is a unique C_{37}-skeletal carotenoid characteristic of dinoflagellates. Full details on the structural elucidation of peridinin have been published [1–3]. Studies leading to the absolute configuration of peridinin (**1**, Scheme 1) have been discussed in a symposium paper [4], and further details [5] are now reported.

RESULTS AND DISCUSSION

^{1}H NMR data, tabulated elsewhere [4] for peridinin (**1**) and for fucoxanthin (**2**), neoxanthin (**3**), natural violaxanthin (**4**) and semisynthetic violaxanthin (**5**, here prepared from zeaxanthin (**6**)) of known chirality [6, 7], supported the same relative configuration for the allenic end group of **1**, **2** and **3**. However, the relative stereochemistry of the epoxidic end group of peridinin (**1**) could not be deduced from ^{1}H NMR comparison with the models **2**, **3**, **4** and **5**.

Peridinin (**1**), as the *p*-bromobenzoate **1b**, upon ozonization provided the allenic ketone **7** and the *p*-bromobenzoate **8** (Scheme 1). The allenic ketone **7** was by spectral criteria, including ^{1}H NMR and CD (Fig. 1) found to be identical with **7**, previously obtained by ozonolysis of fucoxanthin (**2**) [8, 9]. The *p*-bromobenzoate **8** proved to be identical with **8** here obtained by ozonolysis of the di-*p*-bromobenzoate **4b** of natural violaxanthin (**4**). In the latter case also the *p*-bromobenzoate **9** was characterized as an ozonization product. The chirality of the alcohol corresponding to **9** obtained from natural violaxanthin (**4**) [10] has been confirmed by synthesis [11]. The chirality of peridinin was thus established as 3*S*, 5*R*, 6*R*, 3′*S*, 5′*R*, 6′*S*. The biosynthetic implications have been discussed elsewhere [4].

Details are further presented in support of dinoxanthin, a common minor carotenoid from dinoflagellates, previously shown to be neoxanthin 3-acetate [12], having 3*S*, 5*R*, 6*R*, 3′*S*, 5′*R*, 6′*S* chirality (**3b**).

The two C-8 epimeric dinochromes **10a** and **11a** (Scheme 2), formed by epoxide–furanoid rearrangement of dinoxanthin (**3b**) by known mechanism [13, 14], were subsequently hydrolysed to the C-8 epimeric triols **10b**, **11b** and silylated to the tri-(trimethyl)-silyl ethers **10c** and **11c** by reactions known to retain the stereochemistry of the chiral centres. Neoxanthin (**3**), isolated from maple leaves, was converted to **10c** and **11c** by the analogous reaction sequence given in Scheme 2. CD curves for the furanoxides **10c** and **11c** obtained from the two

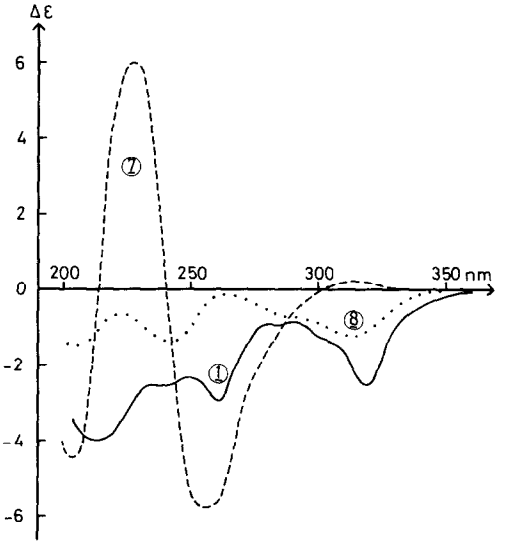

Fig. 1. CD spectra in EPA solution of peridinin (**1**) and its oxidative degradation products **7** and **8**.

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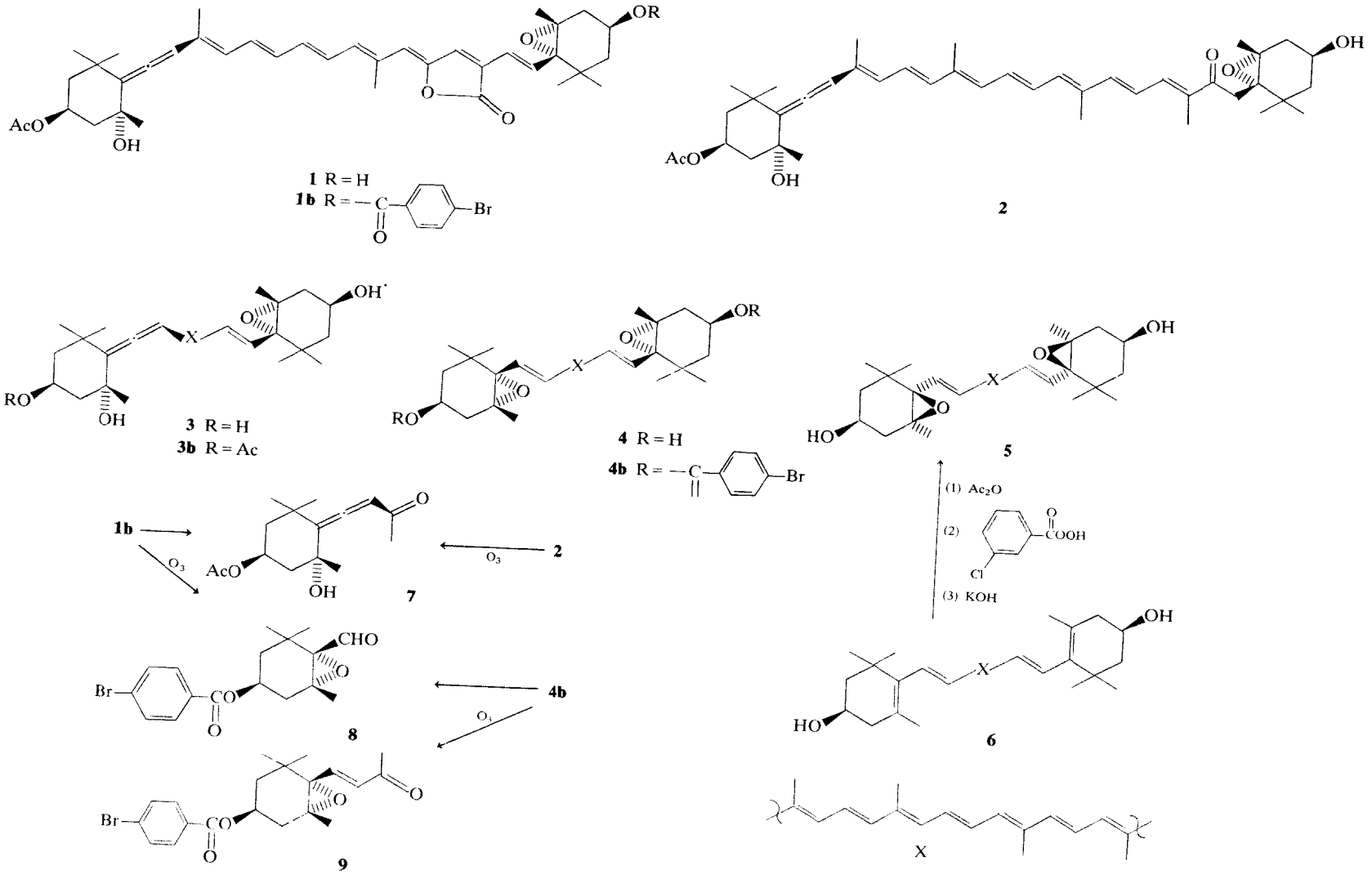
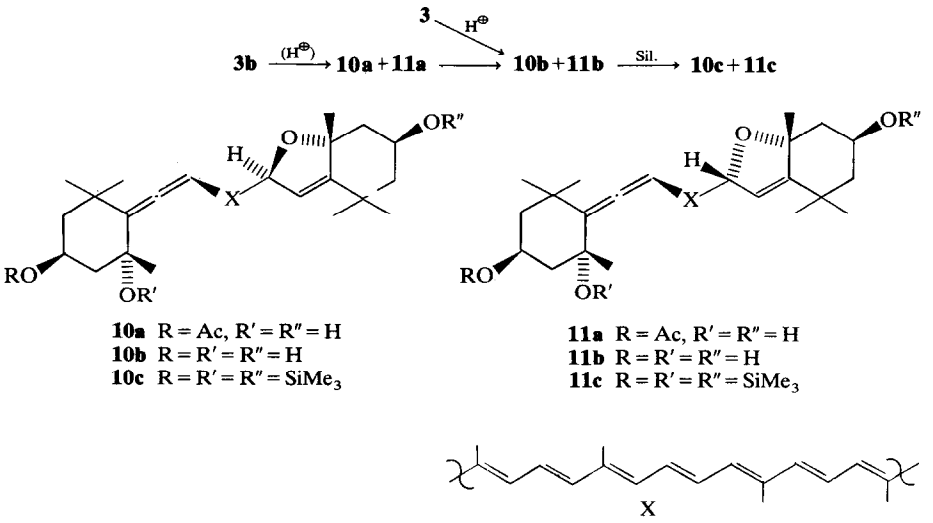

1 R = H
1b R = —C(=O)—C6H4—Br
2
3 R = H
3b R = Ac
4 R = H
4b R = —C(=O)—C6H4—Br
5
6
7
8
9
1b
2
4b
(1) Ac2O
(2)
(3) KOH
X

Scheme 1



10a R = Ac, R′ = R″ = H
10b R = R′ = R″ = H
10c R = R′ = R″ = $SiMe_3$

11a R = Ac, R′ = R″ = H
11b R = R′ = R″ = H
11c R = R′ = R″ = $SiMe_3$

Scheme 2

sources, published elsewhere [4], support the same chirality for neoxanthin (**3**) and dinoxanthin (**3b**), provided all chiral centres of the diastereomers **10c** and **11c** influence their Cotton effect and chromatographic behaviour.

EXPERIMENTAL

General. Methods were as commonly employed in the Norwegian laboratory [9, 15]. Further details are available [5]. Only diagnostically significant ^{1}H NMR (100 MHz) signals are cited. In order to facilitate comparisons carotenoid numbering is used also for the ozonization products. For electronic spectra the main abs. max. is italicized. TLC was generally performed on Si gel, using Me_2CO–hexane mixtures for development.

Peridinin (**1**). CD spectrum, Fig. 1.

Peridinin p-*bromobenzoate* (**1b**). Peridinin (**1**, 114 mg) was treated with *p*-bromobenzoyl chloride (350 g) in Py (8 ml) for 1.5 hr at 0°. Extraction and TLC provided **1b**; 132 mg (93%); $\lambda_{max}^{Me_2CO}$ nm: 466.

Ozonolysis of **1b**. **1b** (192 mg) in EtOAc (100 ml) was ozonized at −78° until complete decolourization (9 min). Usual work-up including TLC gave at least eleven products; the eight least polar ones were investigated. Seven of these contained *p*-bromobenzoyloxy groups according to ^{1}H NMR and MS.

3-p-*Bromobenzoyloxy*-5,6-*epoxy*-β-*cyclocitral* (**8**). Obtained from zone 2 from above TLC; yield 3 mg cryst.; λ_{max}^{MeOH} nm: 240, *244*, 249, 255 and 261; ^{1}H NMR ($CDCl_3$): δ1.16 (3H, *s*) and 1.35 (3H, *s*, *gem* dimethyl), 1.46 (3H, *s*, Me-5), 5.16 (1H, H-3), 9.77 (1H, *s*, H-7); MS (100° *m/e*: 368, 366 (M, 3.4%), 339 337 (M-29, 12.5%), 311, 309 (M-57, 1.6%), 279 (M-89, 87, 5.6%), 185, 183 (M-183, 98%) and 110 (100%); CD spectrum, Fig. 1.

Apo-9′-fucoxanthinone (**7**). Obtained from zone 7; yield 33.4 mg as an oil; λ_{max}^{MeOH} nm: 231; ν_{max}^{liquid} cm^{-1}: 3410 (s), 2965, 2930, 1938 (m), 1730, 1674 (s), 1367 (m), 1243 (s), 1164 (m), 1076 (w), 1033 (m), 959, 859, 831, and 758 (w); ^{1}H NMR ($CDCl_3$): δ 1.15 (3H, *s*) and 1.45 (3H, *s*, *gem.* dimethyl), 1.43 (3H, *s*, Me-5), 2.03 (2H, *s*, Ac), 2.18 (3H, *s*, Me-9), 5.37 (1H, H-3), 5.85 (1H, *s*, H-8). CD spectrum, Fig. 1, in agreement with **7** *ex* fucoxanthin [9].

Violaxanthin di-p-*bromobenzoate* (**4b**). Violaxanthin (**4**, 28 mg) was reacted with *p*-bromobenzoyl chloride as for **1** above, providing cryst. **4b**; $\lambda_{max}^{Et_2O}$: nm 411, *439* and 470.

Ozonolysis of **4b**. **4b** (*ca* 40 mg) in EtOAc was ozonized as for **1b** above. TLC showed five zones; the two major ones were investigated.

3-p-*Bromobenzoyloxy*-5,6-*epoxy*-β-*cyclocitral* (**8**). Obtained from zone 4 above; yield 6.7 mg; λ_{max}^{EPA} nm: 243; ^{1}H NMR ($CDCl_3$), MS *m/e* (120°) and CD (EPA) as for **8** *ex* **1b** above and inseparable from the latter.

3-p-*Bromobenzoyloxy*-5,6-*epoxy*-β-*ionone* (**9**). From zone 5, yield 20.5 mg, had λ_{max}^{EPA} nm: 232; ^{1}H NMR ($CDCl_3$): δ 1.04 (3H, *s*) and 1.23 (3H, *s*, *gem* dimethyl), 1.27 (3H, Me-5), 2.29 (3H, Me-9), 5.16 (1H, H-3), 7.06 (1H, *d*, H-7), 6.31 (1H, *d*, H-8, J_{7-8} = 16 Hz); MS (140°) *m/e*: 408, 406 (M, 1.0%), 185 (9.5%), 183 (10%) and 123 (100%); Δε (EPA) 200 (0), 228 (−1.4), 300 (0), 340 (+0.1), 365 (0) nm.

Semisynthetic violaxanthin (**5**). Zeaxanthin (**6**) diacetate, prepared from **6** (167 mg), was treated with *m*-chloroperbenzoic acid (0.17 g) at 0° in dry Et_2O (15 ml) for 18 hr. TLC provided 5-diacetate. Standard saponification and TLC gave **5**; 6.5 mg; $\lambda_{max}^{Et_2O}$ nm: 427, *439* and 469; ^{1}H NMR ($CDCl_3$): δ 1.01 (6H, *s*) and 1.15 (6H, *s*, *gem* dimethyl), 1.19 (6H, *s*, Me-5,5′), 1.92 (6H,*s*, Me-9,9′), 1.96 (6H, *s*, Me-13,13′), 3.84 (2H, H-3,3′).

Dinochromes (**10a** and **11a**). Isolated from an extract of *Amphidinium carterae* Plymouth 450 [12], where the original dinoxanthin (**3b**) had rearranged, were separated on TLC. **10a** and **11a** both exhibited $\lambda_{max}^{Me_2CO}$ nm: 401, *424* and 450.

Neochromes (**10b** and **11b**). The dinochromes (**10a** and **11a**) upon standard saponification and TLC gave **10b** and **11b**, in total 1 mg; λ_{max} as for **10a** and **11a** above.

Neochrome tri(*trimethylsilyl*) *ethers* (**10c** *and* **11c**) ex **3b**. The neochromes (**10b**+**11b**, 1 mg) were silylated by the standard method providing the all-*trans* C-8 epimers **10c** and **11c** (which is unknown), both with $\lambda_{max}^{Me_2CO}$ nm: 400, *423* and 451; Δε (EPA) epimer 1: 208 (+7.0), 232 (+0.4), 250 (+1.4), 263 (0), 300 (−2.4), 313 (−3.0), 350 (−0.2); epimer 2: 204 (−6.1), 235 (−2.1), 243 (−4.7), 278 (−1.8), 313 (−3.6), 350 (−0.2) nm.

Neochrome tri(*trimethylsilyl*) *ethers* (**10c** and **11c**) ex **3**. Neoxanthin (**3**) was isolated from leaves (360 g wet wt) of *Acer pseudoplatanus*, collected at NTH, Trondheim, August 1976. **3** comprised *ca* 10% of the total carotenoid in the saponified extract. TLC purification, furanoid rearrangement

in 0.01 N HCl in Et_2O–MeOH followed by silylation provided **10c** and **11c**, inseparable by TLC from **10c** and **11c** *ex* **3b** above ^1H NMR ($CDCl_3$) epimer 1. Allenic end group: δ1.01 (3H, *s*), 1.30 (3H, *s*) and 1.34 (3H, *s*, *gem*. dimethyl and Me-5), 1.76 (3H, *s*, Me-9), 1.95 (3H, *s*, Me-13), 4.2 (1H, H-3) and 5.95 (1H, *s*, H-8); furanoid end group: δ1.14 (3H, *s*) and 1.30 (3H, *s*, *gem* dimethyl), 1.58 (3H, *s*, Me-5′), 1.72 (3H, *s*, Me-9′), 1.95 (3H, *s*, Me-13′), 4.2 (1H, H-3′), 5.15 (1H, H-7′) and 5.21 (1H, H-8′). Epimer 2. Allenic end group: δ1.00 (3H, *s*), 1.29 (3H, *s*) and 1.32 (3H, *s*, *gem* dimethyl and Me-5), 1.75 (3H, *s*, Me-9), 1.93 (3H, *s*, Me-13) and 4.2 (1H, H-3); furanoid end group: δ1.14 (3H, *s*) and 1.24 (3H, *s*, *gem* dimethyl), 1.62 (3H, *s*, Me-5′), 1.78 (3H, *s*, Me-9′), 1.93 (3H, *s*, Me-13′), 4.2 (1H, H-3′), 5.02 (1H, *d*, H-7′) and 5.24 (1H, *d*, H-8′, J_{7-8} = 2Hz). $\Delta\varepsilon$ (EPA) Epimer 1: 208 (+6.7), 232 (+0.2), 250 (+1.2), 258 (0), 300 (−2.0), 313 (−2.4), 350 (−0.2); Epimer 2: 204 (−6.9), 230 (−3.0), 248 (−6.9), 278 (−0.2), 313 (−0.4), 350 (−0.2) nm.

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