m/z: 276 $[M]^+$. EIMS (probe, 70 eV) m/z (rel. int.): 276 $[M]^+$ (38), 179 (19), 110 (29), 98 (21), 94 (100).

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ISODEHYDROLEUCODIN AND ANOTHER NOVEL *CIS*-LACTONIZED GUAIANOLIDE FROM *MONTANOA IMBRICATA*

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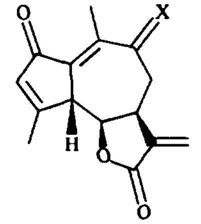
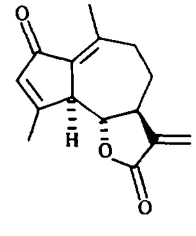
Key Word Index—*Montanoa imbricata*; Asteraceae; Heliantheae; sesquiterpene lactones; guaianolides.

Abstract—*Montanoa imbricata* yielded two guaianolides, isodehydroleucodin, which is the C-5,C-6-isomer of dehydroleucodin, and 9-oxo-isodehydroleucodin.

The less polar member (**1**) of a pair of guaianolides isolated from *Montanoa imbricata* V. A. Funk displayed spectral data (^{1}H NMR, Table 1; UV; MS) that approximated those of dehydroleucodin (**3**) previously isolated from *Lidbeckia pectinata* Berg. (Asteraceae, Anthemideae) [1]. Differences in the ^{1}H NMR coupling constants and chemical shifts between **1** and **3** suggested that they were stereoisomers. Stereochemical arguments are presented to support the proposal of opposite orientations of H-5 and H-6 in **1** relative to **3**. The second *M. imbricata* guaianolide (**2**) differs from **1** only in the presence of a keto function at C-9 in **2**.



1 X = H,H
2 X = O



3

Assuming an α-orientation for H-7 as in all sesquiterpene lactones reported from higher plants [2], difference NOE studies were conducted to establish the relationship between H-5, H-6 and H-7. Irradiation of H-5, H-6 and H-7 indicated a strong NOE between H-6 and H-7. No effects were observed between either H-5 and H-6 or H-5 and H-7. The results indicated that H-6 shares an α-orientation with H-7 and that H-5 most likely has an opposite β-orientation. These findings are in agreement with the J-values of **1**: the large $J_{5,6}$ (11.3 Hz) and smaller $J_{6,7}$ (7.8 Hz) are consistent with an antiperiplanar relationship (*Ca* 180° dihedral angle) between H-5 and H-6

Table 1. ^{1}H NMR spectral data of isodehydroleucodin (1) and 9-oxo-isodehydroleucodin (2) and the ^{13}C NMR data for 2

H	1	2	C	2
1	—	—	1	137.8*
2	—	—	2	200.2
3	6.15 ($J_{3,15} = 1.3$)	6.30 ($J_{3,15} = 1.3$)	3	135.0
4	—	—	4	168.5
5	3.72 *d* ($J_{5,6} = 11.3$)	3.76 *d* ($J_{5,6} = 10.4$)	5	38.4
6	4.44 *dd* ($J_{6,7} = 7.8$)	4.41 *dd* ($J_{6,7} = 7.2$)	6	79.8
7	3.17 *ddddd* ($J_{7,8a} = 2.9$, $J_{7,8b} \approx 10.0$)	3.41 *ddddd* ($J_{7,8a} = 2.3$, $J_{7,8b} = 13.3$)	7	49.8
8	1.75 (a) *dddd* ($J_{8a,8b} = 14.9$, $J_{8a,9a} = 5.1$, $J_{8a,9b} = 3.5$) 2.32 (b) *dddd* ($J_{8b,9a} = 12.0$, $J_{8b,9b} \approx 3.5$)	2.76 (a) *dd* ($J_{8a,8b} = 17.3$) 3.09 (b) *dd*	8	45.5
9	2.51 (a) *ddd* ($J_{9a,9b} = 19.7$)	—	9	196.0
10	—	—	10	141.4
11	—	—	11	137.1*
12	—	—	12	172.1
13	5.69 (a) *d* ($J_{7,13a} = 2.3$) 6.36 (b) *d* ($J_{7,13b} = 2.5$)	5.82 (a) *d* ($J_{7,13a} = 1.8$) 6.40 (b) *d* ($J_{7,13b} = 2.0$)	13	124.8
14	2.29* (3H)	2.38* (3H)	14	19.3
15	2.28* (3H)	2.35* (3H)	15	12.3

*These signals are interchangeable within each column. ^{1}H NMR spectrum recorded at 500 MHz in CDCl$_3$ with TMS as internal standard. ^{13}C NMR spectrum recorded at 22.6 MHz in CDCl$_3$ with TMS as internal standard. ^{13}C NMR results are compatible with the results of Attached Proton Test.

and a synperiplanar relationship (0–20° dihedral angle) between H-6 and H-7. If H-5 were α-oriented, the H-5/H-6 dihedral angle (*ca* 90°) would require a $J_{5,6}$ value approaching 0 Hz. The $J_{7,13a}$ (2.3 Hz) and $J_{7,13b}$ (2.5 Hz) values differ from the corresponding values (both J = 3.5 Hz) reported for 3 [1] and are in agreement with *cis*-lactonization. Results of 2D COSY ^{1}H NMR experiments confirm the signal assignments for 1.

^{1}H NMR data for 9-oxo-isodehydroleucodin (2) differed from those of 1 primarily in the absence of any H-9 signals and the simplification of the H-8 signals to doublets of doublets. Results of 2D COSY ^{1}H NMR experiments confirmed that the H-9 signals were absent from the spectrum of 2. The presence of two allylic ketone signals (δ 200.2 and 196.0) in the ^{13}C NMR spectrum and the EIMS results ([M]$^+$ at *m/z* 258) indicate that 2 differs from 1 by the presence of a keto function at C-9 in 2.

A final argument for the configurations H-5β and H-6α in 1 and 2 is based on biogenetic considerations. The common occurrence of *cis*-6,12-lactonic [$_{15}$D^5, ^{1}D$_{14}$]-germacradienolides in *Montanoa* [3–6] suggests that transannular cyclization involving the above germacradienolide conformation (or its epoxide) generates a guaianolide skeleton with a configuration H-5β. Compound 1 was also isolated from four populations of *Montanoa hexagona* Robins. et Greenm.

EXPERIMENTAL

For general procedures see ref. [7]. *Montanoa imbricata* was collected in Guerrero, Mexico at the junction of Hwy 95 and the road to Acahuizotla (FGe 2332) and near Xaltignaguis (FGe 2344) on 14 Nov 1977. Vouchers are deposited at the Ohio State University herbarium (OS). Dried leaves of FGe 2332 (55 g) and FGe 2344 (47.3 g) were extracted in CH$_2$Cl$_2$ (× 2) for two minutes and worked up in the usual fashion [7] to yield 1.3 g and 0.9 g of crude syrup, respectively. The combined syrups were chromatographed over Sephadex LH-20 (cyclohexane–CH$_2$Cl$_2$–MeOH, 7:4:1) to yield 50 mg 1 (fractions 14–25) and 35 mg 2 (fractions 35–42).

Montanoa hexagona (Fl 2920, 50 g) was collected in Quiche, Guatemala 0.5 miles S. of Zunil on 29 Nov 1978. The leaves were extracted and worked up as described above. The crude syrup (0.19 g) was separated by prep. TLC (silica gel G, CHCl$_3$–Me$_2$CO, 19:1) yielding a band containing 22 mg 1. Other *M. hexagona* collections containing 1 were FL 2909 (Guatemala, Quiche: above Nebáj on road to Sacapulas, 28 Nov 1978), FL 2910 (Guatemala, Quiche: outskirts of Nebáj, 28 Nov 1978) and FL 2948 (Guatemala, San Marcos, 6 Dec 1978). All vouchers deposited at OS.

Isodehydroleucodin (1). C$_{15}$H$_{16}$O$_3$, oil; UV $\lambda_{\max}^{\mathrm{MeOH}}$ nm: 200, last reading (ε 7.3 × 10^3), 252 (ε 5.6 × 10^3); IR $\nu_{\max}^{\mathrm{CHCl_3}}$ cm^{-1}: 1750 (γ-lactone), 1670 (cyclopentenone), 1600 (cisoid double bond); MS (probe) 70 eV, *m/z* (rel. int.): 244 [M]$^+$ (100), 229 [M − Me]$^+$ (10.5), 216 [M − CO]$^+$ (6.6), 201 [M − CO − Me] (17.3), 183 (32.4) and 91 (92.7). (Calc. for C$_{15}$H$_{16}$O$_3$: 24.1099. Found: (MS) 24.1004.)

9-Oxo-isodehydroleucodin (2). C$_{15}$H$_{14}$O$_4$, oil; UV $\lambda_{\max}^{\mathrm{MeOH}}$ nm: 270 (ε 9.2 × 10^3); IR $\nu_{\max}^{\mathrm{CHCl_3}}$ cm^{-1}: 2900, 1730, 1630, 1590, 1565, 1380; MS (probe) 70 eV, *m/z* (rel. int.): 258 [M]$^+$ (68.2), 230 [M − CO]$^+$ (4.1), 212 (43.1), 121 (40.5) and 91 (100.0).

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