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THE MOLECULAR STRUCTURES OF BROWNIINE PERCHLORATE AND DICTYOCARPINE-ACETONE COMPLEX

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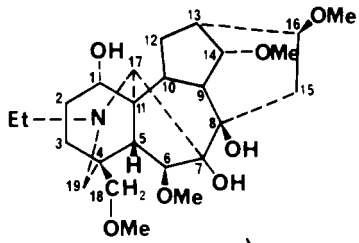
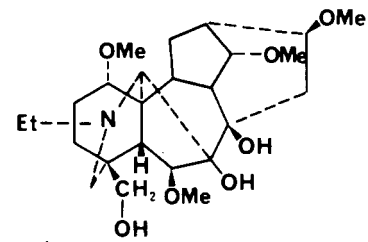
ABSTRACT.—Browniine perchlorate crystallizes in the monoclinic space group $P2_1$. The structure was solved by multisolution methods and refined to an R of 0.078 for 2766 observed reflections. Dictyocarpine crystallizes from acetone as an acetone complex. The crystals are orthorhombic, space group $P2_12_12_1$. The structure was solved by multisolution methods and refined to an R of 0.085 for 2483 observed reflections. These structural results require the configuration of the C(1)-methoxyl group in all C_{19}-diterpenoid alkaloids related to lycoctonine to be revised from β to α.

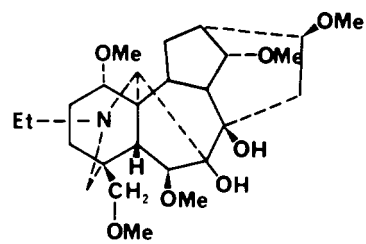
Recently, we described the methylation of delsoline (**1**) with methyl iodide and sodium hydride to give the known alkaloid dephatine (**2**) (1). Because the α-configuration of the C(*1*)-hydroxyl group in delsoline is well established by chemical (2) and spectral data (3), we pointed out that delphatine must also bear a C(*1*)-α-methoxyl



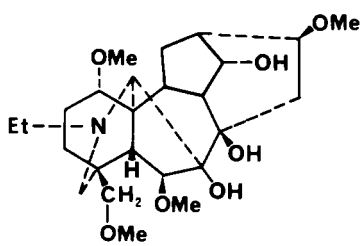
Delsoline, **1**



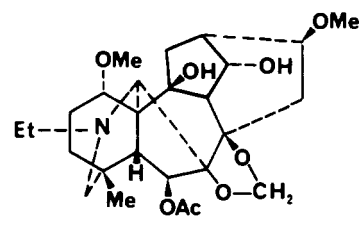
Lycoctonine, **3**



Delphatine, **2**



Browniine, **4**



Dictyocarpine, **5**

group (1). Inasmuch as we have converted lycoctonine (**3**) (4) and browniine (**4**) (1) to delphatine (**2**) by treatment with methyl iodide and sodium hydride, the structures of these two alkaloids must also bear a 1 α-methoxyl group (1, 5, 6). To confirm this revised structure (**4**) for browniine, and X-ray analysis of browniine perchlorate has been carried out.

Because the structure of the alkaloid dicytocarpine (**5**) (7, 8) depends on correlation with lycoctonine via a long sequence involving dictyocarpinine, 6,10-dimethyldeltamine, deltamine, delatine, delpheline, 6-*O*-methyldelpheline, and deoxylycoctonine (9, 10), we have confirmed the structure and stereochemistry of dictyocarpine by an X-ray analysis of its acetone complex. Both browniine and dictyocarpine possess a 1 α-methoxyl group.

Browniine perchlorate was crystallized from a mixture of EtOAc and Et_2O. Repeated trials over a longer period of time were required to obtain crystals suitable for X-ray structure determination. The crystals of brownine perchorate belonged to the monoclinic space group $P2_1$ with a=10.178(4)Å, b=10.649(10), c=12.584(4), β=102.76(4), and z=2.

The intensity data for 2886 unique reflections were measured using a CAD-4 diffractometer by ω scan (CuKα; λ=1.5418Å). The reflections had a fairly high mosaic spread, and the peaks were scanned for (0.90+0.14 tan θ) and 25% on either side for the background. The structure was solved using multisolution methods (11). Of the 2886 unique reflections measured, 120 had $|F_0| \leq 1.4\sigma$ (F), and they were excluded from the least squares refinement. Twenty-four hydrogen atoms were located stereochemically and were included in the structure factor calculations and refinement. The structure was refined by block diagonal least squares, and the final R and Rw are 0.078 and 0.076, respectively. The weights were assigned from the counting statistics. An ORTEP drawing of the structure of browniine is shown in Figure 1.

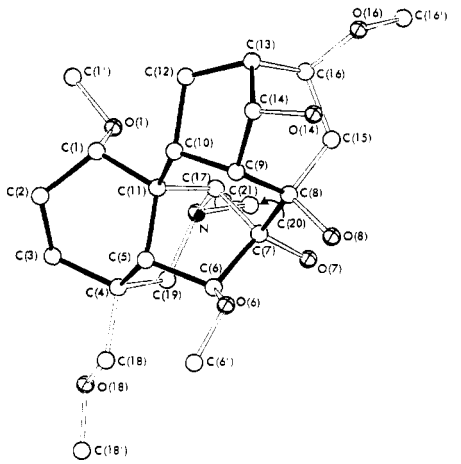


FIGURE 1. An ORTEP drawing of browniine (**4**). The A, B, and C rings are shaded for clarity. The thermal ellipsoids for carbons, nitrogen and oxygens are drawn differently.

The coordinates and thermal parameters of the nonhydrogen atoms are listed in Table 1. The bond lengths and angles of nonhydrogen atoms, the coordinates of the hydrogen atoms, the anisotropic thermal parameters, and a list of observed and calculated structure factors are available from the corresponding author.

TABLE 1. Coordinates and Thermal Parameters for Nonhydrogen Atoms in Browniine Perchlorate[a]

N	CODE	X/A	Y/B	Z/C	Beq
1.	CL	6590(1)	8010(1)	4032(1)	3.9
2.	O(*1L*)	7367(3)	7125(4)	3530(3)	6.1
3.	O(*2L*)	5391(6)	8207(11)	3363(12)	11.3
4.	O(*3L*)	7211(8)	9159(8)	4184(9)	14.9
5.	O(*4L*)	6205(10)	7349(10)	4891(6)	18.9
6.	O(*1*)	2998(2)	−770(2)	4549(1)	2.7
7.	O(6)	−1433(2)	−2023(2)	1042(2)	3.0
8.	O(7)	1412(2)	−993(2)	458(1)	2.7
9.	O(*8*)	202(3)	−3351(2)	118(2)	3.2
10.	O(*14*)	946(3)	−5867(2)	1339(2)	3.9
11.	O(*16*)	4048(2)	−5232(2)	1634(2)	3.9
12.	O(*18*)	−954(2)	2492(2)	2685(2)	3.7
13.	N	2356(2)	69(2)	2593(2)	2.4
14.	C(*1*)	1722(3)	−1356(3)	4473(2)	2.6
15.	C(*2*)	743(3)	−535(3)	4903(2)	3.1
16.	C(3)	414(3)	678(3)	4247(2)	3.4
17.	C(*4*)	61(2)	447(3)	2996(2)	2.3
18.	C(5)	−183(2)	−971(3)	2729(2)	2.2
19.	C(*6*)	−386(2)	−1178(3)	1486(2)	2.3
20.	C(7)	1019(2)	−1630(2)	1336(2)	2.2
21.	C(8)	1066(3)	−3084(3)	1169(2)	2.4
22.	C(9)	531(3)	−3760(3)	2064(2)	2.6
23.	C(*10*)	991(3)	−3136(3)	3206(2)	2.6
24.	C(*11*)	1135(2)	−1694(2)	3229(2)	1.9
25.	C(*12*)	2375(3)	−3815(3)	3714(2)	2.9
26.	C(*13*)	2582(3)	−4788(3)	2846(2)	2.8
27.	C(*14*)	1127(4)	−5070(3)	2295(3)	3.1
28.	C(*15*)	2466(3)	−3529(3)	1072(2)	3.4
29.	C(*16*)	3370(3)	−4198(3)	2050(2)	3.0
30.	C(*17*)	1976(3)	−1315(3)	2435(2)	2.5
31.	C(*18*)	−1231(3)	1190(3)	2509(2)	3.0
32.	C(*19*)	1150(2)	928(3)	2430(2)	2.6
33.	C(*20*)	3423(3)	483(3)	1973(3)	3.8
34.	C(*21*)	4205(4)	1567(5)	2519(5)	6.5
35.	C(1′)	3882(4)	−759(5)	5626(2)	3.7
36.	C(6′)	−2753(3)	−1543(4)	967(3)	3.9
37.	C(*16′*)	5128(4)	−4836(5)	1169(4)	5.1
38.	C(*18′*)	−2068(3)	3211(4)	2135(3)	4.0

[a]Positional parameters are multiplied; by 10^4. Beq is the isotropic equivalent of the anisotropic thermal parameters and is calculated as:

$$Beq = \frac{8\pi^2}{3}\left[\frac{U_{11}}{Sin^2\beta} + U_{22} + \frac{U_{33}}{Sin^2\beta} + 2U_{13}\frac{Cos\beta}{Sin^2\beta}\right]$$

The numbering of the atoms is given on the ORTEP drawing. The standard deviations in bond lengths vary from 0.003 to 0.005Å, and the standard deviations in bond angles vary from 0.4 to 0.5° for the browniine molecule.

Dictyocarpine crystallized from Me_2CO as an acetone complex. The crystals were orthorhombic, space group $P2_12_12_1$ with a=8.382(4)Å, b=17.568(3), c=19.323(3), and z=4. The intensity data were measured using a CAD-4 diffractometer ($2\theta < 150°$) by $\omega/2\theta$ scan with CuKα (λ=1.5418Å) radiation. The crystal disintegrated during the measurement of intensity, and the intensity of the control reflections fell by the end of the measurement to about 60% of the original value. The decrease in intensity of the control reflections were rather small in the beginning but became more rapid toward the end of the data collection. Three reflections were used to monitor the changes in in-

tensity; the rates of decrease in intensity for the three reflections were similar. A decay correction was applied to all the reflections as a function of time. The structure was solved by multisolution methods (11). Of the 2749 unique reflections measured, 266 of them had $|F_0| \leq 1.4\sigma(F)$ and were considered unobserved. Twenty-two hydrogens were located from stereochemical considerations and were also included in the block diagonal least squares refinement, and the R and R_w for 2483 reflections used in the least squares are 0.085 and 0.079, respectively.

The coordinates and thermal parameters of the nonhydrogen atoms are listed in Table 2. The bond lengths and angles of nonhydrogen atoms, the coordinates of the hy-

TABLE 2. Coordinates and Thermal Parameters for Nonhydrogen Atoms in Dictyocarpine-Acetone Complex[a]

N	CODE	X/A	Y/B	Z/C	Beq
1.	O(*1*)	3193(4)	5607(1)	4280(1)	4.4
2.	O(*6*)	733(3)	3435(1)	6285(1)	3.5
3.	O(*7*)	−1967(3)	4673(1)	5746(2)	4.3
4.	O(*8*)	−1888(3)	3406(1)	5407(1)	4.1
5.	O(*10*)	3647(3)	3563(1)	4806(1)	3.3
6.	O(*14*)	−791(4)	2527(1)	4087(1)	4.4
7.	O(*16*)	−1879(8)	3886(2)	3099(2)	10.3
8.	O(*6'*)	−635(7)	3594(2)	7259(1)	7.1
9.	N	722(4)	5842(1)	5540(2)	4.0
10.	C(*1*)	3639(4)	5226(1)	4901(1)	3.6
11.	C(*2*)	4236(5)	5842(2)	5393(2)	4.2
12.	C(*3*)	4336(5)	5575(2)	6140(2)	4.7
13.	C(*4*)	2687(5)	5245(2)	6369(2)	4.1
14.	C(*5*)	2364(4)	4520(1)	5941(1)	2.9
15.	C(*6*)	679(4)	4230(1)	6123(1)	3.2
16.	C(*7*)	−358(4)	4469(1)	5510(2)	3.5
17.	C(*8*)	−749(4)	3852(1)	4988(2)	3.5
18.	C(*9*)	747(4)	3404(1)	4827(1)	3.0
19.	C(*10*)	2159(4)	3966(1)	4704(1)	2.9
20.	C(*11*)	2235(4)	4723(1)	5159(1)	2.9
21.	C(*12*)	2064(6)	4140(2)	3910(1)	3.9
22.	C(*13*)	688(6)	3670(2)	3621(1)	4.3
23.	C(*14*)	652(5)	2992(1)	4123(1)	3.7
24.	C(*15*)	−1712(6)	4115(2)	4346(2)	5.2
25.	C(*16*)	−847(7)	4143(2)	3650(2)	5.8
26.	C(*17*)	558(4)	5122(1)	5169(2)	3.2
27.	C(*18*)	2801(7)	5038(2)	7161(2)	5.0
28.	C(*19*)	1295(5)	5807(2)	6261(2)	4.6
29.	C(*20*)	−724(6)	6322(2)	5477(3)	5.8
30.	C(*21*)	−290(11)	7168(3)	5474(6)	8.1
31.	C(*1'*)	4539(9)	5757(3)	3829(3)	7.3
32.	C(*6'*)	−21(5)	3176(2)	6854(2)	4.5
33.	C(*7',8'*)	−2837(5)	3950(2)	5744(3)	4.8
34.	C(*16'*)	−2502(9)	4383(4)	2695(3)	7.8
35.	C(*6''*)	28(7)	2318(2)	6893(2)	5.9
36.	O(*A*)	9777(15)	1902(4)	2732(2)	7.6
37.	C(*1A*)	9776(11)	1964(3)	2136(3)	8.0
38.	C(*2A*)	11184(21)	1661(14)	1659(9)	16.3
39.	C(*3A*)	8609(23)	2335(10)	1735(11)	15.2

[a]Atoms 36 to 39 belong to the acetone molecule. The positional parameters are multiplied by 10_4. Beq is calculated as:

$$Beq = \frac{8\pi^2}{3}\left[U_{11} + U_{22} + U_{33}\right]$$

drogen atoms, anisotropic thermal parameters, and structure factors are available as supplementary material.

The conformation of dictyocarpine is seen in Figure 2. It is noteworthy that the configuration of the O-CH_3 group at C(*1*) is α. Although the ring system in C_{19}-diterpenoid alkaloids is rather rigid, C(*2*) can be located either *cis*- or *trans*- to C(*5*) with reference to the plane passing through C(*1*), C(*3*), C(*4*), and C(*11*), thus permitting the *A* ring to assume either a boat or chair conformation. In the case of browniine perchlorate, the *A* ring has a boat conformation, whereas in dictyocarpine, the *A* ring has a chair conformation.

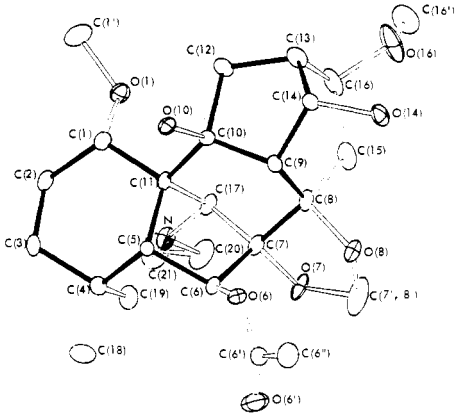


FIGURE 2. An ORTEP drawing of dictyocarpine (**5**).

The oxygen of the acetone molecule appears to be hydrogen bonded to O(*14*) with an O- - -O distance of 2.880Å.

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