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X-RAY STRUCTURE ANALYSIS OF TRIACETYLLAGOCHILIN AND LAGOCHILIN TETRAFORMATE

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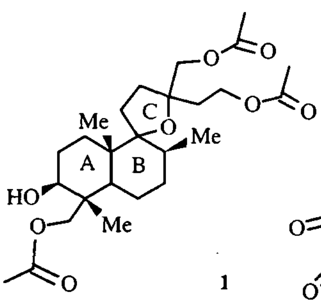
The molecular structures of two diterpene lagochilins, triacetyllagochilin and lagochilin tetraformate, are determined by x-ray structure analysis.

Key words: triacetyllagochilin, lagochilin tetraformate, crystal structure, x-ray structure analysis.

The principal components of extracts of plants from the *Lagochilus* genus are diterpenes [1]. More than 20 diterpenes have been isolated from plants of this genus. These can be subdivided into the following subgroups: isopropylidenelagochilins, acetyllagochilins, and diterpene lactones [2]. The structure and proposed configuration of the isolated diterpenes have been established mainly by chemical transformations using PMR and mass-spectrometric data. Full x-ray structure analysis, which would reveal features of the molecular structure, has been performed only for two crystalline forms of lagochilin [3, 4] and the dimer lagohirsin [5]. The x-ray structure analyses of two more diterpenes of the lagochilin group, triacetyllagochilin (1) and lagochilin tetraformate (2), are reported in the present article. The former was isolated from *Lagochilus pubescens* [6]. The latter was prepared by chemical modification of the starting lagochilin.



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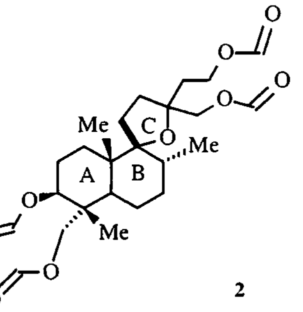

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The molecular structures of **1** and **2** are shown in Fig. 1. Rings A and B in **1** and **2** are *trans*-fused and have a distorted chair conformation with asymmetry parameters $\Delta C_S(2) = 2.1°$ and $\Delta C_S(6) = 0.3°$ for **1** and $\Delta C_S(2) = 2.0°$ and $\Delta C_S(7) = 1.3°$ for **2** (asymmetry parameters were calculated using the RING program [9]). The hydroxyl group on C(3) and the methyl group on C(8) in **1** are in equatorial positions whereas the methyl group on C(10) is axial. This orientation is retained in **2**.

The five-membered heterocycle C has the envelope conformation with $\Delta C_2(O1) = 0.7$ and 2.7° for **1** and **2**, respectively. Atoms C(9), C(11), C(13), and O(1) are coplanar with maximal deviations from the least-squares plane of 0.04 and 0.03 Å for **1** and **2**, respectively. Atom C(12) is deviated from plane on 0.44 and 0.41 Å , respectively.

The acetyl groups on C(15), C(16), and C(18) in **1** give the molecule a claw shape with distances O(1)...O(5), 4.57; O(1)...O(6), 4.90; O(1)...O(7), 4.95; O(5)...O(6), 5.45; O(6)...O(7), 6.39; O(5)...O(7), 7.20 Å. The flexibility of the acetyl groups and the distance between the acetyl O atoms and O1 suggest that this compound might be used as a ligand for metals.

The crystal structure of **1** contains spiral chains of **1** molecules bonded through O(2)–H(I)...O(6)(II) interactions (2.76 Å) that extend along the c axis (Fig. 2). The crystal structure of **2** contains van-der-Waals interactions.

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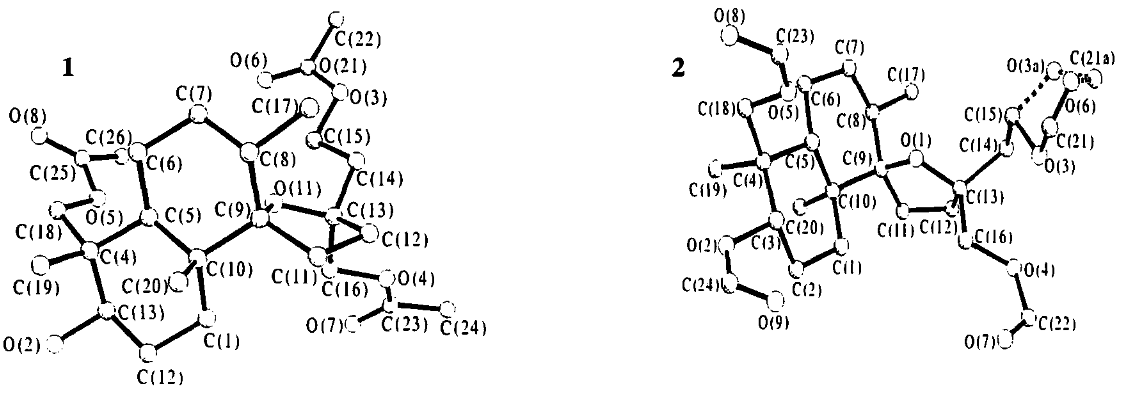

Fig. 1. Molecular structures of **1** and **2**.

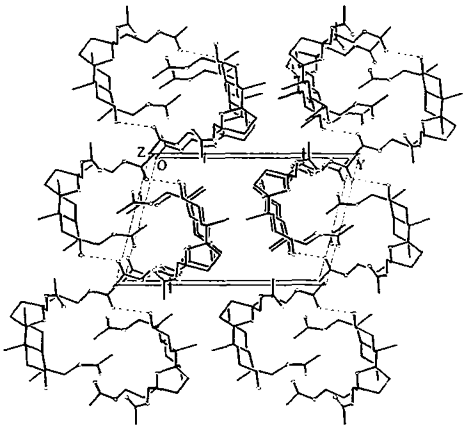

Fig. 2. Crystal structure of **1**.

EXPERIMENTAL

The preparation and physicochemical properties of **1** have been reported [6].

Lagochilin Tetraformate. Lagochilin (2 g, 5.6 mmoles) was treated with formic acid (10 ml, 0.26 moles) and reacted for 15 h. The solution was treated with distilled water (30 ml) and extracted with ether (3×80 ml). The ether extracts were combined, washed with distilled water, and dried over anhydrous Na_2SO_4. The solvent was evaporated. The solid was recrystallized from ether. Drying produced a white crystalline substance, $C_{24}H_{36}O_9$, mp 124-125°C. Yield 2.225 g, 85% of theoretical based on lagochilin.

IR spectrum (cm^{-1}): 2980-2910, 1715, 1460, 1375, 1185.

PMR spectrum ($CHCl_3$): 0.79 (s, 3H-20), 0.80 (d, J = 6 Hz, 3H-17), 0.89 (s, 3H-19), 3.71 (d, J = 12 Hz, H-18), 3.91 (d, J = 12 Hz, H-18), 4.09 (s, 2H-16), 4.29 (t, J = 6 Hz, 2H-15), 4.85 (m, H-3), 7.94, 7.97, 8.60, 8.03 (s, 4H–C=O).

Mass spectrum (*m/z*): 4.68 (M^+), 439, 421, 385, 375, 254, 253, 242, 241, 228, 227, 213, 201, 195, 167, 149, 136, 135, 133, 123, 121, 119, 109, 107, 106.

Crystallographic parameters of single crystals of **1** and **2** were determined and refined using 15 reflections on a four-circle Syntex $P2_1$ diffractometer. Unit-cell constants for **1** are $a = 11.675(2)$ Å, $b = 14.384(3)$ Å, $c = 8.2030(4)$ Å, $\gamma = 101.75(2)°$, $V = 1348.7(8)$ Å^3, $Z = 4$, $\rho = 1.19$ g/cm^3, monoclinic, space group $P2_1$; for **2**, $a = 17.221(2)$ Å, $b = 17.221(2)$ Å, $c = 16.645(3)$ Å, $V = 4936.3(12)$ Å^3, $Z = 8$, $\rho = 1.26$ g/cm^3, tetragonal, space group $P4_32_12_1$.

Integrated intensities were measured by $\Theta/2\Theta$-scanning using Cu Kα-radiation and a graphite monochromator at room temperature. Lorentz and polarization corrections were made. Weak reflections with $I < 2\sigma$ (**1**) were discarded. The data sets consisted of 1861 (**1**) and 2547 (**2**) reflections. The structures were refined by direct methods using the SHELXS-86 programs [7] and refined using full-matrix least-squares methods and the SHELX-76 programs [8]. All H atoms were located in a difference Fourier electron-density map. The discrepancy factors after the final refinement cycle of positional and anisotropic thermal parameters were $R = 0.059$ (**1**) and 0.087 (**2**). The atomic coordinates are listed in Table 1.

TABLE 1. Coordinates of Nonhydrogen Atoms ($\times 10^4$) in **1** and **2**

1				**2**			
Atom	*x/a*	*y/b*	*z/c*	Atom	*x/a*	*y/b*	*z/c*
O(1)	-7239(4)	-2988(3)	-3733(5)	O(1)	7182	2580	264
O(2)	-2316(4)	-1931(3)	-6067(5)	O(1)	6590(4)	3830(5)	1250(4)
O(3)	-9486(5)	-1238(4)	-2426(4)	C(4)	6731(5)	4582(4)	1691(4)
O(4)	-9278(4)	-2973(5)	-7094(5)	C(3)	7538(5)	4899(5)	1488(5)
O(5)	-3847(5)	-769(4)	-3253(4)	C(4)	7611(5)	5053(5)	596(4)
O(6)	-8121(5)	467(5)	-1993(4)	C(5)	7436(5)	4275(5)	148(4)
O(7)	-8581(5)	-1925(4)	-9009(5)	C(6)	7581(6)	4339(7)	-751(5)
O(8)	-2949(4)	-288(3)	-1484(4)	C(7)	7476(7)	3573(9)	-1137(6)
C(1)	-537(6)	-3411(5)	-5796(7)	C(8)	6725(7)	3129(7)	-985(5)
C(2)	-4099(5)	-3103(3)	-6368(6)	C(9)	6578(5)	3056(6)	-64(5)
C(3)	-3501(4)	-2217(4)	-5480(6)	C(10)	6628(5)	3906(5)	344(4)
C(4)	-3505(5)	-2356(4)	-3599(5)	C(11)	5836(5)	2622(5)	132(5)
C(5)	-4773(6)	-2758(6)	-3028(7)	C(12)	6040(5)	1805(6)	266(6)
C(6)	-4869(5)	-2904(5)	-1181(7)	C(13)	6887(6)	1855(5)	559(5)
C(7)	-6150(6)	-3164(6)	-631(6)	C(16)	6923(6)	1900(5)	1460(5)
C(8)	-6837(5)	-4010(5)	-1521(5)	O(2)	6705(4)	1128(4)	1780(5)
C(9)	-6784(6)	-3842(5)	-3380(6)	C(22)	6727(6)	1047(7)	2586(8)
C(10)	-5463(5)	-3644(6)	-3955(7)	O(7)	6951(5)	1537(5)	3025(4)
C(11)	-7592(5)	-4632(5)	-4320(6)	C(17)	6636(8)	2377(7)	-1447(6)
C(12)	-8759(6)	-4273(6)	-4539(6)	C(18)	8467(5)	5322(6)	447(6)
C(13)	-8352(5)	-3194(6)	-4565(6)	O(5)	9001(4)	4728(4)	666(4)
C(14)	-9190(6)	-2671(5)	-3646(5)	C(23)	9734(7)	4881(8)	797(10)
C(15)	-8597(5)	-1645(6)	-3286(5)	O(8)	9945(7)	5543(7)	668(6)
C(16)	-8127(6)	-2817(6)	-6306(6)	C(19)	7133(6)	5768(5)	321(6)
C(17)	-8072(7)	-4314(6)	-783(5)	C(20)	5916(5)	4388(6)	69(6)
C(18)	-3038(6)	-1383(7)	-2826(6)	O(2)	7661(4)	5628(3)	1936(4)
C(19)	-2599(5)	-2968(5)	-3100(7)	C(24)	7937(7)	5597(7)	2667(6)
C(20)	-4979(7)	-4559(6)	-3657(5)	O(9)	8050(5)	4992(4)	3015(4)
C(21)	-9082(6)	-372(5)	-1831(7)	C(14)	7352(7)	1116(7)	251(8)
C(22)	-10044(9)	20(12)	-893(9)	C(15)	8213(9)	1225(8)	425(15)
C(23)	-9397(11)	-2464(10)	-8394(13)	O(6)	9371(16)	676(19)	890(20)
C(24)	-10617(9)	-2691(12)	-9050(12)	O(3)	8380(20)	990(20)	1222(18)
C(25)	-3723(13)	65(14)	-2454(13)	C(21)	9180(30)	1070(30)	1450(30)
C(26)	-4549(12)	648(10)	-3087(15)	C(21A)	9050(20)	149(19)	550(20)
				O(3A)	8601(15)	556(13)	-6(15)

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