

THE ISOLATION AND STRUCTURE OF TRICYCLOSOLIDAGOLACTONE, A NEW DITERPENE FROM SOLIDAGO ALTISSIMA L.

Shosuke Yamamura, Masatoki Ito, Masatake Niwa,\* Izumi Hasegawa,\* Shigeru Ohba,† and Yoshihiko Saito\*

Department of Chemistry, Faculty of Engineering, Keio University, Hiyoshi, Yokohama, Japan

\* Faculty of Pharmacy, Meijo University, Tempaku-ku, Nagoya, Japan

† The Institute for Solid State Physics, The University of Tokyo, Roppongi 7, Minato, Tokyo, Japan

**Summary:** Tricyclosolidagolactone has been isolated from the leaves of *Solidago altissima* L., and its structure also been elucidated on the basis of its spectral data coupled with an X-ray crystallographic analysis of the corresponding trihydroxy compound produced on  $\text{LiAlH}_4$  reduction.

From a view point of biological activity, many structural studies have been made on the group of clerodane-type diterpenes. Previously, Kusumoto and his co-workers examined the bitter principles of roots of the plant *Solidago altissima* L. and isolated several *trans*-clerodanes.<sup>1</sup> However, any *cis*-clerodane-type diterpene has not yet been found in this plant. In connection with germacrene-D having a sexual stimulant activity similar to that of periplanone-B,<sup>2</sup> we also examined chemical constituents of the leaves of the same plant and could isolate a new type of diterpene, named tricyclosolidagolactone (1), as a main component. In the present paper, we wish to describe the isolation and structure of this new lactone.

The fresh leaves of the above plant (7 Kg) were immersed in benzene at room temperature, and then the benzene extract was chromatographed on alumina (Nakarai Chemicals, 300 mesh). After elution of germacrene-D using benzene as an eluent,<sup>2</sup> further elution with  $\text{CHCl}_3$  - EtOAc (10 : 1) afforded a crude oil, which was further separated by a combination of different column chromatographies [1) Silica gel (Mallinckrodt, 100 mesh),  $\text{CHCl}_3$  - EtOAc (10 : 1); 2) Alumina (Nakarai Chemicals, 300 mesh),  $\text{CHCl}_3$  - EtOAc (10 : 1)] and repeated preparative TLC [Kieselgel PF<sub>254</sub>;  $\text{CHCl}_3$  - EtOAc (10 : 1)] to afford tricyclosolidagolactone (1) (ca. 300 mg) as colorless needles [mp 184 - 185 °C (from benzene - hexane);  $[\alpha]_D^{25}$  -109° (c = 2.68 in  $\text{CHCl}_3$ );  $\text{C}_{20}\text{H}_{28}\text{O}_3$  (m/e 316(M<sup>+</sup>), 206, and 109);  $\nu_{\text{max}}$  (Nujol) 3450, 1760, and 1620  $\text{cm}^{-1}$ ;  $^1\text{H}$  NMR ( $\text{CDCl}_3$ ):  $\delta$  0.80(3H, s), 0.84(3H, d, J= 7Hz), 1.24(3H, s), 1.88(3H, br.s), 3.04(1H, br.t, J= 9Hz), 4.69(1H, dd, J= 17, 2Hz), 5.04(1H, dd, J= 17, 2Hz), 5.52(1H, br.s), and 5.94(1H, q, J= 2Hz);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ ):  $\delta$  16.4(q), 20.3(q), 20.7(t), 21.2(q), 23.2(t), 23.8(q), 32.1(d), 34.4(s), 37.2(t), 37.8(t), 38.8(d), 43.8(s), 49.2(d), 75.3(t), 76.5(s), 116.7(d), 125.9(d), 139.5(s), 173.8(s), and 174.6(s)].

From these IR and NMR spectral data, clearly, tricyclosolidagolactone (1) has an  $\alpha,\beta$ -unsaturated butenolide ring with a methine substituent at  $\beta$ -position [ $\nu_{\text{max}}$  1760 and 1620  $\text{cm}^{-1}$ ;  $^1\text{H}$  NMR:  $\delta$  3.04, 4.69, 5.04, and 5.94;  $^{13}\text{C}$  NMR:  $\delta$  49.2, 75.3, 116.7, 173.8, and 174.6]. Furthermore, the spectral data of 1 also indicate the presence of a tri-substituted double bond with

one Me group ( $\delta$  1.88 and 5.52), one tertiary OH group ( $\nu_{\max}$  3450  $\text{cm}^{-1}$  and  $\delta$  76.5) and three Me groups ( $\delta$  0.80, 0.84, and 1.24).

On treatment with excess  $\text{LiAlH}_4$  in THF (room temp., overnight), tricyclosolidagolactone was readily converted into a trihydroxy compound (**2**) as colorless plates [mp 155 - 156  $^\circ\text{C}$  (from ether);  $\text{C}_{20}\text{H}_{34}\text{O}_3$  (m/e 322( $\text{M}^+$ ));  $\nu_{\max}$  (Nujol) 3300 and 3250  $\text{cm}^{-1}$ ], in ca. 50% yield. The stereostructure of this reduction product was directly determined by means of an X-ray crystallographic analysis, as follows.

**CRYSTAL DATA:**  $\text{C}_{20}\text{H}_{34}\text{O}_3$ , MW 322.5, orthorhombic,  $\text{P}2_12_12_1$ ,  $a = 9.135(2)$ ,  $b = 28.555(3)$ ,  $c = 7.081(1)$   $\text{\AA}$ ,  $Z = 4$ ,  $V = 1847.2(5)$   $\text{\AA}^3$ ,  $D_x = 1.16$   $\text{g}\cdot\text{cm}^{-3}$ ,  $D_o = 1.16$   $\text{g}\cdot\text{cm}^{-3}$ .

A total of 1223 non-zero independent reflections with  $2\theta < 55^\circ$  was measured on a Rigaku-automated four-circle diffractometer using  $2\theta - \omega$  scan technique and graphite monochromated Mo  $\text{K}\alpha$  radiation. The structure was solved by direct method using MULTAN program.<sup>3</sup> Block-diagonal least-squares refinements with anisotropic nonhydrogen atoms and isotropic hydrogens reduced R to 0.048.<sup>4</sup> The figure is a computer generated ORTEP drawing of the molecule (50% ellipsoids). Accordingly, the stereostructure of tricyclosolidagolactone should be represented by **1**.

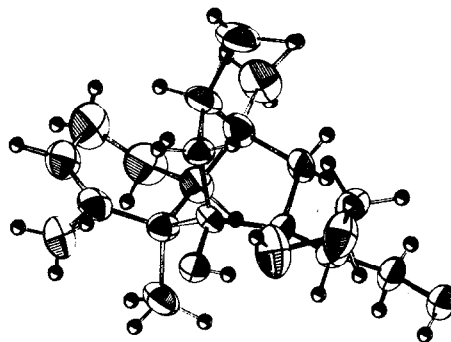
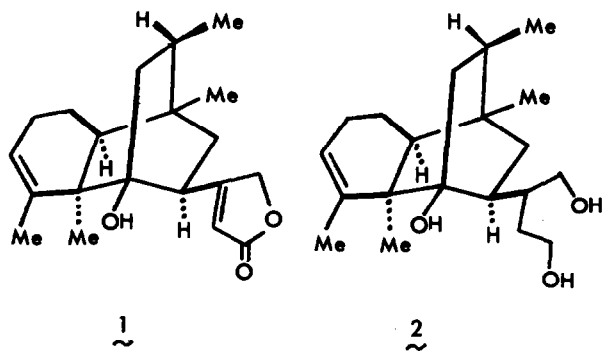


Fig. A computer generated ORTEP drawing of the molecule **2**

#### REFERENCES AND FOOTNOTES

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2. M. Niwa, M. Iguchi, and S. Yamamura, *Chem. Pharm. Bull.*, **28**, 997 (1980) and references cited therein.
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4. The atomic coordinates, the bond lengths and angles between inter- and intra-molecule, and some details will be published elsewhere.

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