1, H-2), 4.2 (q, 2, J = 7 Hz, OCH_2CH_3), 4.15 (s, 2, CH_2OH), 2.65 (s, 1, OH), 2.35 (s, 3. C-3 CH_3), 1.0 (s, 6, C-6 CH_3).

This material was dissolved in a mixture of ether (25 mL) and ethyl vinyl ether (25 mL); treated with *p*-toluenesulfonic acid (500 mg) with ice cooling, treated, after 10 min at room temperature, with more ether (500 mL), washed (saturated aqueous $NaHCO_3$, brine), dried ($MgSO_4$), and concentrated. The crude product (18 g) was dissolved in a mixture of methanol (100 mL), water (100 mL), and potassium hydroxide (10 g, 0.179 mol) and heated at reflux for 10 min. The mixture was then cooled to 10 °C, poured onto ice (750 g), and acidified with acetic acid (10 mL). The organic materials were then extracted into ethyl acetate, and the extracts were washed (brine), dried ($MgSO_4$), and concentrated to yield the impure acid **21**. Crystallization from hexane furnished pure **21**: 9.4 g (60%); mp 118-119 °C; ^1H NMR ($CDCl_3$) δ 11.0 (s, 1, CO_2H), 7.0 (dd, 1, J = 15, 11 Hz, H-5), 6.3 (d, 1, J = 15 Hz, H-4), 6.2 (s, 2, H-8, H-9), 6.1 (d, 1, J = 11 Hz, H-6), 4.7 (q, 1, J = 6 Hz, $OCHCH_3$), 4.0 (s, 2, CH_2O), 3.55 (m, 2, OCH_2CH_3), 2.35 (s, 3, C-3 CH_3), 2.0 (s, 3, C-7 CH_3), 1.35, 1.25 (dd, 3, J = 6 Hz, $OCHCH_3$), 1.05 (s, 6, C-6 CH_3). Anal. Calcd for $C_{24}H_{36}O_4$: C, 74.19; H, 9.34. Found: C, 74.43; H, 9.32.

A solution of **21** (3.88 g, 10 mmol) in acetone (70 mL) was treated with aqueous sulfuric acid solution (10 mL, 1 M), treated, after 30 min at room temperature, with water until turbid, and then seeded with **1**. The solids were filtered off, dried (3.1 g, mp 179-85 °C), and recrystallized from aqueous acetone to yield pure **1**: 2.5 g (79%); mp 187-189 °C dec.

Acknowledgment. We thank the personnel of the Physical Chemistry Department, Hoffmann-La Roche Inc., Nutley, NJ, for supplying most of the spectroscopic data and all of the microanalytical data. We also thank Dr. Beverly A. Pawson for her continual support and encouragement throughout this work.

Registry No. **1**, 63531-93-1; **2**, 81121-38-2; **3**, 81121-39-3; **4**, 80704-19-4; **5**, 49816-69-5; **6**, 70143-17-8; **7**, 81121-40-6; **8**, 81121-41-7; (±)-**9**, 24965-84-2; (±)-**10**, 81121-42-8; (±)-**11**, 81121-43-9; **12**, 65519-73-5; **13**, 72008-25-4; (±)-**14**, 81121-44-0; (±)-**15**, 81121-45-1; (±)-**16**, 81121-46-2; **17**, 81121-47-3; 4-*cis*-**18**, 81121-48-4; 4-*trans*-**18**, 81176-71-8; (4*E*)-**19**, 81121-49-5; **20**, 81121-50-8; **21**, 81121-51-9; **22**, 81132-94-7; **23**, 81121-52-0; ethyl (*E*)-β-formylcrotonate, 62054-49-3; (4*Z*)-**19**, 81176-72-9.

Crystal Structure and Stereochemistry of Verbesindiol[1]

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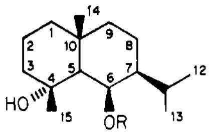
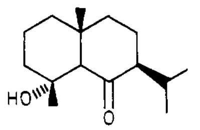
Received December 1, 1981

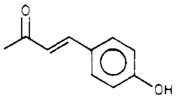
In the course of our search for biologically active lactones in Compositae, we recently described isolation from *Verbesina virginica* of the *p*-coumaryl ester **1a**.[2] The stereochemistry assigned to the parent diol **1d** which we named verbesindiol (4α,6β-dihydroxyeudesmane) was based primarily on ^1H NMR data. Coupling constants involving H-5 and H-6, chemical shift changes accompanying the conversion of **1a** to **1d** and thence to **2**, and the failure of **1d** to form an acetonide indicated that the isopropyl group was equatorial and that the C-6 hydroxyl and the two methyl groups were axial. This was supported by the demonstration of an appreciable NOE between the two methyl groups of **2** and $Eu(fod)_3$-induced shifts in the two methyl signals of **1d**. The absolute configuration was established by conversion of **1d** to (+)-selinene and (−)-selina-3,5-diene.





2

1a, R =



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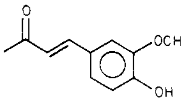

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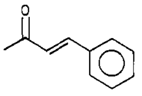
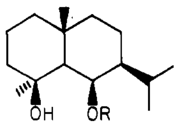
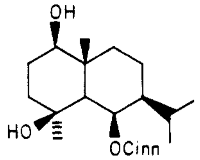


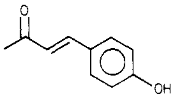
d, R = H





4

3a, R =



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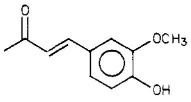

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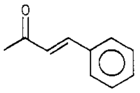

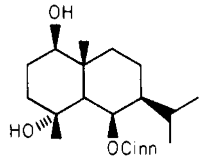

5

While our article was in press, Bohlmann and co workers[3] reported isolation of a substance **3a** and the corresponding ferulate **3b** from *Verbesina macrophylla*. The stereochemistry assigned by them to these compounds was based on the similarity of their ^1H NMR spectra to the spectrum of a cinnamate ester **3c**, earlier thought to be **1c**, from *V. eggersii* and *V. luetzelburgii*. The revision in stereochemistry from **1c** to **3c** hinged on a comparison[3] of its ^{13}C NMR spectrum with the ^{13}C NMR spectra of two related cinnamates ascribed formulas **4** (from *V. glabrata* and *V. luetzelburgii*)[3] and **5** (from *V. eggersii*).[4]

The ^1H NMR spectra of our **1a**[2] and the Berlin workers' **3a** and **3b**[3] were essentially superimposable as were the ^{13}C NMR spectra of our **1a**[2] and the presumed **3c**[3,5] if allowance is made for the extra aromatic hydroxyl in **1a**. This clearly indicated that the stereochemistries of all of these compounds were the same and required that our **1a** and the presumed **3a** were identical.

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[1] Work at the Florida State University was supported in part by a grant from the U.S. Public Health Service (CA-13121) through the National Cancer Institute.

[2] Herz, W.; Kumar, N. *Phytochemistry* **1981**, *20*, 247.

[3] Bohlmann, F.; Grenz, M.; Gupta, R. K.; Dhar, A. K.; Ahmed, M.; King, R. M.; Robinson, H. *Phytochemistry* **1980**, *19*, 2391.

[4] Bohlmann, F.; Lonitz, F. *Chem. Ber.* **1978**, *111*, 254.

0022-3263/82/1947-1785$01.25/0

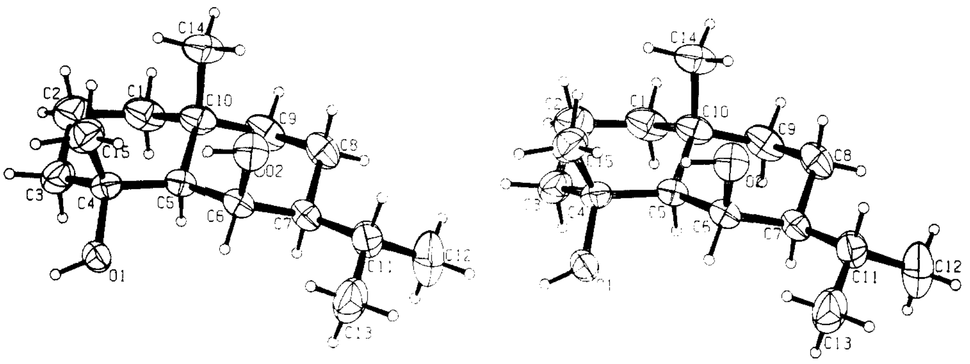

Figure 1. Stereoscopic view of **1d** molecule. Hydrogen atoms are shown as spheres and other atoms as 50% probability ellipsoids.

Table VI. Probable Intermolecular Hydrogen Bonds

hydrogen bond	O···O distance, Å
O(1)A-H···O(1)B	2.76
O(2)A-H···O(2)C	2.94
O(1)B-H···O(1)C	2.84
O(2)B-H···O(10)	2.75
O(1)C-H···O(1)A	2.97
O(1)D-H···O(1)C	2.93
O(2)D-H···O(2)B	2.83
O(10)-H···O(2)A	2.83
O(10)-H···O(1)D	2.82

To resolve the disagreement concerning the stereochemistry of these compounds, an X-ray analysis of verbesindiol was undertaken. Crystal data are given in the Experimental Section. The crystal contained four independent molecules of verbesindiol plus one independent molecule of water. The conformations of the four independent molecules (designated "A", "B", "C", and "D") were nearly the same. Figure 1 is a stereoscopic drawing of molecule "C" which shows that our formula **1d** for verbesindiol is correct. It follows that the 4-hydroxy-6-(acyloxy)eudesmanes so far isolated from *Verbesina* species are **1a** (as proposed by us earlier[2]), **1b**, and **1c** and not **3a**, **3b**, and **3c**. The assignments for the compounds thought[3] to be **4** and **5** may have to be interchanged also.

Tables I–V listing final atomic and final anisotropic thermal parameters, bond lengths, bond angles, and selected torsion angles for the four independent molecules of **1d** are available as supplementary material. Table VI, in which O(10) is the oxygen atom of the water molecule, indicates the proposed intermolecular hydrogen bonds which were used to calculate the positions of the hydroxyl and water hydrogen atoms. The approximate position of four of these hydrogen atoms were determined from a difference map calculated after anisotropic refinement of the nonhydrogen atoms (including contributions from the hydrogen atoms other than those of the hydroxyl and water molecule).

Experimental Section

Single crystals of verbesindiol[2] were obtained by slow crystallization from benzene. They were orthorhombic, space group $P2_12_12_1$, with $a = 9.917$ (2) Å, $b = 23.081$ (6) Å, $c = 26.535$ (5) Å, and $d_{\text{calcd}} = 1.071$ g cm^{-3} for $Z = 16$ ($C_{15}H_{28}O_2{\cdot}1/4H_2O$, $M_r = 244.89$). The intensity data were measured on a Hilger-Watts diffractometer (Ni-filtered Cu Kα radiation, θ–2θ scans, pulse-height discrimination). The size of the crystal used for data collection was approximately 0.12 × 0.35 × 0.55 mm. A total of 4581 independent reflections were measured for $\theta < 57°$, of which 3718 were considered to be observed $[I > 2.5\sigma(I)]$. The structure was solved by a multiple-solution procedure[6] and was refined by block-diagonal least squares in which the matrix was partitioned into two blocks. Two reflections which were strongly affected by extinction were excluded from the final refinement and difference map. In the final refinement, anisotropic thermal parameters were used for the nonhydrogen atoms and isotropic temperature factors were used for the hydrogen atoms. The hydrogen atoms were included in the structure factor calculations but their parameters were not refined. The final discrepancy indices are $R = 0.045$ for the remaining 3716 observed reflections. The final difference map has no peaks greater than ±0.2 e Å^{-3}.

Registry No. 1d, 35932-60-6.

Supplementary Material Available: Tables I–V giving final atomic parameters, final anisotropic thermal parameters, bond lengths, bond angles, and selected torsion angles for the four independent molecules of **1d** (9 pages). Ordering information is given on any current masthead page.

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[5] The ^{13}C NMR spectra of "**3a**" and "**3b**" were not reported in ref 3.

[6] Germain, G.; Main, P.; Woolfson, M. M. *Acta Crystallogr., Sect. A.* *27*, 368.