the double doublet at δ 5.26 was irradiated. The chemical shift of the latter indicated that we were dealing with the proton under the angelate residue while the signal at δ 3.45 obviously had to be assigned to the proton under the hydroxyl group. Thus the whole sequence H-1 through H-9 was established.

The stereochemistry followed from the observed couplings. The angelate residue at C-1 was equatorial while the hydroxyl group at C-9 was axial as the couplings $J_{8,9}$ were both small. The presence of a hydrogen bridge between the hydroxyl group and the ester group led to an unusual double doublet for the hydroxy proton (δ 4.04). Spin decoupling showed that this signal was coupled with H-9 and H-8β. Inspection of a model showed that $J_{8\beta,OH}$ was a *W* coupling. Also the small coupling $J_{9,OH}$ agreed with the angle which was revealed by the model. It is interesting that the stereochemistry at C-1 is different in the two lactones. The ^{1}H NMR data of **2** are presented in Table 1. The nature of the chemical constituents of this species indicated that it cannot be placed in the genus *Conyza*, as no sesquiterpene lactones have been reported from this genus [5].

EXPERIMENTAL

The aerial parts (4 kg) of the plant collected near Alexandria were extracted by percolation with petrol (40–60°) and the extract was dissolved in 2 l. EtOH (95%). The soln was separated from insoluble waxy material and the solvent evaporated. The residue was dissolved in 0.5 l. EtOH and gradually treated with 0.5 l. H_2O. Filtration gave 60 g insoluble material which was separated by CC (Si gel). Elution with EtOAc–petrol (1:5) gave 1.1 g **1**. The soln in EtOH–H_2O (1:1) was extracted with petrol and $CHCl_3$. The $CHCl_3$ soln after evaporation and recrystallization afforded 2.1 g **2**.

1β-Angeloyloxy-9α-hydroxy-α-cyclocostunolide (**1**). Colourless crystals, mp 122–123° (MeOH–petrol), IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 3480 (OH, hydrogen bonded), 1775 (γ-lactone), 1700, 1650 (C=CCO_2R, hydrogen bonded); MS *m/z* (rel. int.): 328.168 $[M-H_2O]^+$ (0.3) ($C_{20}H_{24}O_4$), 246 $[M-AngOH]^+$ (31), 228 $[246-H_2O]^+$ (11), 213 $[228-Me]^+$ (14), 83 $[C_4H_7CO]^+$ (58), 55 $[83-CO]^+$ (100).

$$[\alpha]_{24^\circ}^{\lambda} = \frac{589 \quad 578 \quad 546 \quad 436\,nm}{+190 \quad +200 \quad +229 \quad +406}\ (CHCl_3;\ c\ 1.67).$$

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TETRAHYDROLIGULARENOLIDE AND RELATED EREMOPHILANES FROM *SENECIO AUREUS*

RONALD J. NACHMAN

Western Regional Research Center, Agricultural Research Service, U.S. Department of Agriculture, Berkeley, CA 94710, U.S.A.

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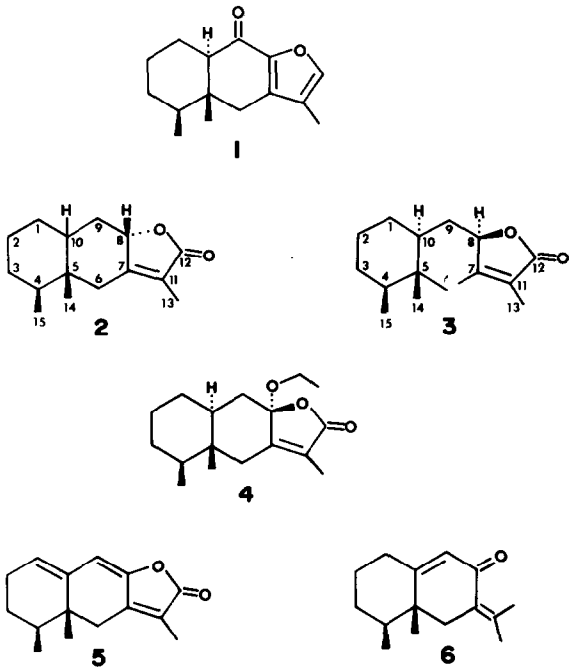
Key Word Index—*Senecio aureus*; Compositae; liferoot; eremophilanes; tetrahydroligularenolide; *trans*-9-oxofuranoeremophilane; ligularenolide; dehydrofukinone.

Abstract—An investigation of the eremophilane constituents of the medicinal herb, *Senecio aureus*, led to the isolation of tetrahydroligularenolide, furanoeremophilane, ligularenolide, and dehydrofukinone. Tetrahydroligularenolide has not been previously isolated as a natural product. While ligularenolide and dehydrofukinone are known compounds, they have not been previously reported as constituents of *S. aureus*.

Senecio aureus L. (golden ragweed, liferoot, squawweed), a perennial of the family Compositae, has been utilized as a pectoral, emmenagogue and a vulnerary by the peoples of Appalachia [1] and by Catawba Indian women to hasten labour during childbirth [2]. Despite the purported beneficial effects of this medicinal herb, a variety of toxic furanoeremophilanes [3] have been isolated from many species of the genus *Senecio*. Previous investigations [3, 4] of the eremophilane sesquiterpene constituents of *S. aureus* uncovered several furanoeremophilanes, analogues of which have been found by Jennings [5] to be hepatotoxic agents in *Tetradymia glabrata*, a range plant toxic to livestock. The two groups of furanoeremophilanes reported are, however, completely exclusive. This



disparity in results, and our interest in further defining the nature of the eremophilane constituents of this medicinal herb, prompted us to reinvestigate *S. aureus*.

In particular, we chose to investigate liferoot herb actually available on the market that had been identified as *S. aureus*. Extraction of the dried plant material, consisting of the above-ground parts of *S. aureus*, followed by chromatography of the extract afforded two crystalline materials and two chromatographically pure oils: compound A, mp 76.5–79°; compound B, mp 91–92°; compound C; and compound D. Compound A, found to be identical to an authentic sample of *trans*-9-oxofuranoeremophilane (**1**) (^{1}H NMR, MS, GC, IR), was also isolated by Zalkow *et al.* [4] from *S. aureus*.

Compound B, with a parent ion at *m/z* 232 and a base peak at *m/z* 123 in the mass spectrum revealed absorptions at 1760 and 1680 cm^{-1} in the IR spectrum and a methyl signal at δ 1.85 in the ^{1}H NMR spectrum that suggested an α-methylbutenolide moiety. A methyl doublet at δ 0.90 (J = 5.7 Hz) and a singlet at δ 0.58 further suggested that compound B was structurally related to the eremophilane α-methylbutenolide, eremophilenolide (**2**). Whereas the mass spectra of eremophilenolide (**2**) and compound B were very similar, with identical parent and base peaks at *m/z* 234 and 123, respectively, the ^{1}H NMR spectrum of **2** revealed a C-4 methyl doublet at δ 0.80 (J = 6.0 Hz) and a C-5 methyl singlet at δ 1.04. This suggested a *trans*-fused ring system, as found in tetrahydroligularenolide (**3**) [6], rather than the *cis*-fused ring system of **2**. A comparison of compound B with a synthetic sample of tetrahydroligularenolide (**3**) demonstrated that the two were identical by ^{1}H NMR, MS, IR and mp. In addition the two materials cochromatographed on a capillary GC column as a single peak of retention time different from that of an authentic sample of eremophilenolide. A similar α-methylbutenolide also containing a *trans* ring system, 8α-ethoxy-10α*H*-eremophilenolide (**4**), was isolated from an ethanol extract of *S. aureus* by Zalkow *et al.* [4]. These workers, however, suggested that compound **4** was an artifact arising from the ethanol extraction procedure used on *S. aureus*. Tetrahydroligularenolide (**3**) has not been previously reported as a natural product.

Spectroscopic data (MS, IR, ^{1}H NMR) for compound C were found to be virtually identical to the corresponding data reported for ligularenolide (**5**) isolated from *Ligularia sibirica* by Tanahashi *et al.* [6, 7]. Finally, a comparison of spectroscopic data obtained from compound D with data reported for dehydrofukinone (**6**), isolated from *Cacalia hastata* [8] and *Arctium lappa* [9], proved virtually identical. Dehydrofukinone (**6**) has also been recently isolated from *S. humillimus* by Bohlmann [10].

While several compounds were isolated in this study that have not been previously reported to occur in *S. aureus*, the eremophilane constituents of liferoot available on the market in the U.S.A. bear a resemblance to those found by Zalkow *et al.* [4] in *S. aureus* plants collected in Virginia. These North American samples, however, differ markedly in eremophilane content from the European sample of *S. aureus* that Bohlmann *et al.* [3] chose to investigate.

EXPERIMENTAL

The air-dried liferoot plant material (above-ground parts) was collected during June 1981 and received in bale form from the Wilcox Drug Co., Boone, North Carolina. A sample of the herb was identified as *Senecio aureus* by Dr. John Strother of the University of California, Berkeley Herbarium. A portion of this material (500 g) was ground in a hammermill, exhaustively extracted in a Soxhlet apparatus with Skelly F–Et_2O (2:1) and the resulting extract (16 g) partitioned by CC (Si gel, 0.05–0.2 mm,

EM reagents) with Skelly F–Et_2O–C_6H_6 (6:3:1) as eluent and further separated by repeated prep. TLC (Si gel, E. Merck). The herb sample afforded 125 mg **1**, 9 mg **3**, 5 mg **5** and 7 mg **6**. GC was carried out on a Hewlett–Packard 5830A chromatograph with a 18 m 30% SE-30 capillary column at 160° with N_2 flow rate of 30 ml/min.

Tetrahydroligularenolide (**3**). Isolated as colourless crystals; mp 91–92°; EIMS (probe) 70 eV, *m/z* (rel. int.): 234 $[M]^+$ (23), 125 $[M-109]^+$ (45), 123 $[M-111]^+$ (100), 112 $[M-122]^+$ (42), 110 $[M-124]^+$ (39); IR ν_{max} (film) cm^{-1}: 1735 (C=O), 1685 (C=C); ^1H NMR (200 MHz): δ 0.58 (3H, *s*, H-14), 0.90 (3H, *d*, $J_{15,4}$ = 5.7 Hz, H-15), 1.78 (3H, *m*, H-13), 2.76(1H, *d*, $J_{6\beta,6\alpha}$ = 14.0 Hz, H-6β), 4.62(1H, *m*, H-8). This material cochromatographed (GC) with a synthetic sample of **3** (R_f 1.00) and displayed a R_f different from eremophilenolide (**2**) (R_f 1.01). The above spectroscopic data was found to match values obtained with the synthetic sample of **3** and lit. values [6, 7, 11].

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A SESQUITERPENOID LACTONE FROM *AMBROSIA CUMANENSIS**

JUAN BORGES-DEL-CASTILLO, ANTONIO BRADLEY-DELSO, MA. TERESA MANRESA-FERRERO, PURIFICACIÓN VÁZQUEZ-BUENO and FRANCISCO RODRÍGUEZ-LUIS

Departamento de Química Orgánica, Facultad de Ciencias, Universidad Autónoma de Madrid, Canto Blanco, Madrid-34, Spain; Departamento de Química Orgánica, Facultad de Ciencias, Universidad de Cádiz, Cádiz, Spain

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Key Word Index—*Ambrosia cumanensis*; Heliantheae; Compositae; bark; sesquiterpenoid lactone; psilostachyinolides; 10α-hydroxyisopsilostachyin C; coniferaldehyde; syringaldehyde.

Abstract—A new psilostachyinolide, 10α-hydroxyisopsilostachyin C, and the phenols coniferaldehyde and syringaldehyde have been isolated from the bark of *Ambrosia cumanensis*.

INTRODUCTION

Continuing our studies of the family Compositae from El Salvador [1, 2], especially the aerial parts of *Ambrosia cumanensis* [3–5], we now report the isolation and structure of a major compound isolated from the bark of this species. The aim of this work was to explore possible relationships between the components of the bark and the sesquiterpenoid lactones obtained from the aerial parts. In previous work [3–5] we reported seven psilostachyinolides from the aerial parts of *A. cumanensis*. These sesquiterpenoid lactones show remarkable differences according to the geographical location of the botanic samples [6]. Ambrosanolides and psilostachyinolides are isolated as the major components.

RESULTS AND DISCUSSION

Compound **1**, $C_{15}H_{20}O_5$, was obtained from a petrol extract of the bark of *A. cumanensis* as a viscous oil. The

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