Phytochemistry, Vol. 20, No. 10, pp. 2389–2391, 1981.
Printed in Great Britain.

0031–9422/81/102389–03 $02.00/0

FURANOEREMOPHILANES FROM *SENECIO SMITHII**

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(*Received* 28 *January* 1981)

Key Word Index—*Senecio smithii*; Compositae; sesquiterpenes; furanoeremophilanes; bisabolone derivatives.

Abstract—The investigation of *Senecio smithii* afforded 17 furanoeremophilanes, six of them being isolated for the first time. Furthermore, two new bisabolone derivatives were present. The structures were elucidated by spectroscopic methods and a few chemical transformations. The chemotaxonomic situation is discussed briefly.

INTRODUCTION

The large cosmopolitan genus *Senecio* obviously is not very homogeneous [1]. We have therefore studied the chemistry of many representatives of this genus and of related ones [2]. In continuation of this programme we now have studied the constituents of a species from Ecuador, *Senecio smithii* DC. Again, this plant contains mainly furanoeremophilanes, which are widespread in the Senecioneae. Six of these compounds were not isolated before, all belonging to the 9-keto series. Furthermore, two bisabolones were present.

RESULTS AND DISCUSSION

The aerial parts afforded β-farnesene, eupatene (**22**) [3] and the furanoeremophilanes **1** [4], **3** [5], **4** [6], **9** [5], **10** [6], **11** [8], **12** [9], **15** [6] and **16** [6] as well as the carbinol **21** [10]. Furthermore, six additional furanoeremophilones were present, the senecioates **2** and **6**, the angelate **7**, the isobutyrate **8**, the alcohol **14** as well as the diketone **17**. The structures could be deduced from the ^{1}H NMR data (Table 1). In the spectrum of **2** the presence of a 3α-senecioyloxy residue followed from the three-fold doublet at 4.76 ppm and the typical signals of the ester group. Irradiation at 4.75 ppm allowed the assignment of H-2 and H-4, as the latter was coupled with the methyl doublet at 0.94 ppm. By further decouplings all other signals could be assigned too. The couplings of H-10 showed the presence of a *trans*-decalin system. The data observed were similar to those of known euryopsonol esters [5]. The additional 1α-hydroxy group in **6** clearly followed from the ^{1}H NMR data too. While most signals were similar to those of **2**, an additional three-fold doublet at 4.24 ppm and missing couplings for H-2 and H-10 showed the presence of a 1-hydroxy group, its stereochemistry being deduced from the couplings $J_{1,2}$ and $J_{1,10}$. Since in the spectra of **7** and **8** only the signals of the senecioate residue were replaced by those of an angelate and an isobutyrate group respectively, their structures could be directly assigned. The same is true for **14**, its ^{1}H NMR spectrum being very similar to that of the known acetate **15** [6], only the H-6β signal being shifted up-field and split by coupling with the hydroxy proton (2.38 *d*). All other signals could be assigned by spin decoupling. The spectroscopic data of **17**, molecular formula $C_{15}H_{16}O_4$, showed that this furan must be a 6,9-diketone with a 1,10β-epoxide group, as could be deduced from the chemical shifts of H-14 and H-15. Furthermore, **17** was obtained by manganese dioxide oxidation of **14**.

The less polar fractions further contained the bisabolone derivatives **18** and **19**. Their structures followed from the ^{1}H NMR data, which were close to those of bisabolone [11] and the corresponding 12-oic methyl ester [12]. The stereochemistry of the 10,11 double in **19** directly followed from the chemical shifts of H-10 and H-12. Since saponification of **18** gave **20**, which on oxidation led to **19**, the stereochemistry of the 10,11 double bond of the acetate was established. The stereochemistry at C-6 and C-7 followed from the couplings observed and by comparison with the spectrum of bisabolone with known stereochemistry and established absolute configuration [13]. As the sign of the optical rotation of **18** and **19** was also negative, the absolute configurations should be the same.

The roots also afforded β-farnesene, eupatene (**22**), **6–9**, **15** and **13**, its stereochemistry at C-1 being assigned previously [14], supporting the proposed stereochemistry of the other epoxides.

The compounds isolated from *S. smithii* indicate a relationship to the woody cacoloid group [14]. However, so far only a few South American species have been investigated chemically; more species need to be investigated before chemotaxonomic conclusion can be drawn.

EXPERIMENTAL

The air-dried plant material (voucher RMK 7481; US National Herbarium, Washington) was extracted with Et_2O–petrol (1:2) and the resulting extracts were separated first by CC (Si gel) and further by repeated TLC (Si gel) and partly by HPLC (reversed phase, RP2, MeOH–H_2O, 3:2). Known

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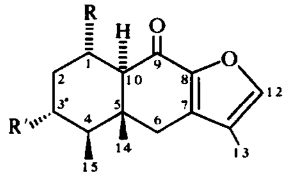
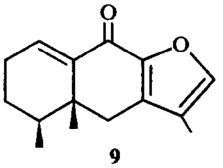
*Part 370 in the series "Naturally Occurring Terpene Derivatives". For Part 369 see Bohlmann, F., Jakupovic, J., Ahmed, M., Robinson, H. and King, R. M. (1981) *Phytochemistry* **20**, 2383.



	1	2	3	4	5	6	7	8
R	H	H	H	H	H	OH	OH	OH
R'	H	OSen	OAng	OiBu	OH	OSen	OAng	OiBu



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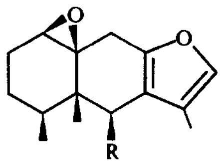
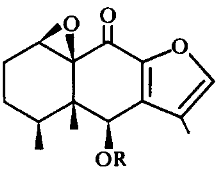
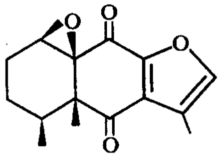


	10	11	12	13
R	OAc	OiBu	OSen	H



	14	15	16
R	H	Ac	Ang



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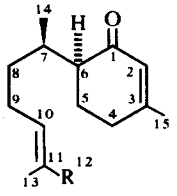
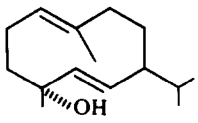


	18	19	20
R	CH_2OAc	CHO	CH_2OH



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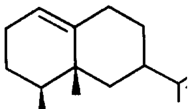

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Table 1. ^{1}H NMR spectral data of compounds **2**, **6–8**, **14** and **17** (400 MHz, $CDCl_3$, TMS as internal standard)

	2	**6**	**7**	**8**	**14***	**17**
H-1α	2.28 *dddd*	—	—	—	3.34 *br d*	3.48 *dd*
H-1β	1.53 *dddd*	4.24 *br ddd*	4.26 *br ddd*	4.24 *br ddd*	—	—
H-2α	1.33 *dddd*	1.48 *ddd*	1.51 *ddd*	1.45 *ddd*	1.87 *dddd*	1.84 *dddd*
H-2β	2.19 *dddd*	2.43 *ddd*	2.47 *ddd*	2.40 *ddd*	2.06 *ddd*	2.11 *dddd*
H-3α	—	—	—	—	1.70 *dddd*	1.51 *dddd*
H-3β	4.75 *ddd*	4.87 *ddd*	4.92 *ddd*	4.80 *ddd*	1.49 *dddd*	1.28 *dddd*
H-4	1.74 *dq*	1.89 *dq*	1.86 *dq*	1.81 *dq*	2.06 *ddq*	2.35 *ddq*
H-6	2.74 *d*	2.71 *d*	2.73 *d*	2.71 *d*	5.23 *d*	—
H-6'	2.47 *d*	2.52 *d*	2.53 *d*	2.52 *d*		—
H-10	2.41 *dd*	2.42 *d*	2.44 *d*	2.42 *d*	—	—
H-12	7.36 *br s*	7.42 *br s*	7.43 *br s*	7.42 *br s*	7.46 *q*	7.54 *br s*
H-13	1.98 *br s*	2.00 *br s*	2.01 *br s*	2.01 *br s*	2.19 *br s*	2.30 *br s*
H-14	0.84 *s*	0.87 *s*	0.89 *s*	0.86 *s*	1.16 *s*	1.37 *s*
H-15	0.94 *d*	0.96 *d*	0.98 *d*	0.95 *d*	1.08 *d*	1.13 *d*
OCOR	5.68 *br s*	5.69 *br s*	6.07 *qq*	2.56 *qq*	—	—
	2.17 *br s*	2.18 *br s*	1.98 *dq*	1.18 *d*	—	—
	1.89 *br s*	1.91 *br s*	1.91 *dq*	1.17 *d*	—	—

J (Hz): compound **2**: 1α,2α = 1α,2β = 3; 1α,10 = 3.5; 1α,1β = 1β,2α = 12; 1β,2β = 3.5; 1β,10 = 2α,2β = 12; 2α,3β = 11; 2β,3β = 4.5; 3β,4α = 11; 6,6' = 16.5; 4,15 = 7; compounds **6–8**: 1β,2α = 11.5; 1β,2β = 5; 1β,10 = 11; 2α,2β = 12; 2α,3β = 11; 2β,3β = 5; 3β,4α = 11; 4,15 = 7; 6,6' = 17; compound **14**: 1α,2α = 4.5; 2α,2β = 15; 2α,3α = 3.5; 2α,3β = 7; 2β,3α ~ 10; 2β,3β ~ 4; 3α,3β ~ 15; 3α,4α ~ 3; 3β,4α = 11; 4α,15 = 7; 6α,OH = 9; compound **17**: 1α,2α = 3; 1α,2β = 1.5; 2α,2β = 15; 2α,3α = 5; 2α,3β = 8; 2β,3α = 7.5; 2β,3β = 5; 3α,3β = 13; 3α,4α = 4.5; 3β,4α = 9; 4α,15 = 7; OAng: 3'4' = 7; 3',5' = 4',5' = 1.5; OiBu: 2',3' = 7.

*OH 2.38 *d*.

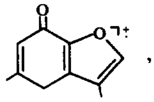
Table 2. ^1H NMR spectral data of compounds **18**–**20** (400 MHz, $CDCl_3$, TMS as internal standard)

	18	**19**	**20**
H-2	5.86 *q*	5.87 *q*	5.86 *q*
H-4	2.31 *m*	2.33 *m*	2.31 *m*
H-5	1.32 *m*	1.48 *m*	1.32 *m*
H-5′	1.78 *dddd*	1.81 *dddd*	1.78 *dddd*
H-6	2.14 *ddd*	2.16 *ddd*	2.15 *ddd*
H-7	2.31 *m*	2.33 *m*	2.31 *m*
H-8	1.32 *m*	1.48 *m*	1.32 *m*
H-9	2.00 *m*	2.40 *m* 2.00 *m*	2.00 *m*
H-10	5.46 *br t*	6.50 *br t*	5.40 *br t*
H-12	4.43 *br s*	9.39 *s*	3.99 *br s*
H-13	1.64 *br s*	1.75 *br s*	1.66 *br s*
H-14	0.80 *d*	0.85 *d*	0.79 *d*
H-15	1.93 *br s*	1.95 *br d*	1.93 *br s*
OAc	2.07 *s*	—	—

J (Hz): 2,15 = 1; 5,6 = 11; 5′,6 = 6,7 = 4.3; 5,5′ = 15; 7,14 = 6.5; 9,10 = 7.

compounds were identified by comparing the IR and ^1H NMR spectra with those of authentic material.

The aerial parts (830 g) afforded 5 mg β-farnesene, 15 mg **1**, 40 mg **2** (Et_2O–petrol, 1:1), 10 mg **3**, 5 mg **4**, 10 mg **5**, 25 mg **5** (Et_2O–petrol, 3:1), 10 mg **7** and 5 mg **8** (Et_2O–petrol, 3:1, separated by HPLC), 5 mg **9**, 15 mg **10**, 30 mg **11**, 5 mg **12**, 25 mg **14** (Et_2O–petrol, 3:1, separated from **5** by HPLC), 60 mg **15**, 10 mg **16**, 30 mg **17** (Et_2O–petrol, 1:1), 30 mg **18** (Et_2O–petrol, 1:1), 10 mg **19** (Et_2O–petrol, 1:1), 20 mg **21** and 5 mg **22**, while the roots (150 g) gave 5 mg β-farnesene, 3 mg **6**, 3 mg **7**, 2 mg **8**, 2 mg **9**, 5 mg **13**, 10 mg **15** and 5 mg **22**.

Euryopsonol senecioate (**2**). Colourless crystals, mp 195° (Et_2O), IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 1715 ($C{=}CCO_2R$), 1680 ($C{=}O$); MS *m/z* (rel. int.): 330.183 (M^+, 10) ($C_{20}H_{26}O_4$), 230 ($M - RCO_2H$, 41), 215 (230 − Me, 28), 162 ( , 44), 83 ($C_4H_7CO^+$, 100), 55 (83 − CO, 74).

$$[\alpha]^{\lambda}_{24^\circ} = \frac{589 \quad 578 \quad 546 \quad 436 \quad 365\,\text{nm}}{-61.8 \quad -65.0 \quad -76.7 \quad -159.0 \quad -206.3}$$

($c = 0.6$, $CHCl_3$).

1α-*Hydroxyeuryopsonol senicioate* (**6**). Colourless crystals, mp 194° (Et_2O), IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 3520 (OH), 1720 ($C{=}CCO_2R$), 1670, 1540 (α-furan ketone); MS *m/z* (rel. int.): 346.178 (M^+, 3) ($C_{20}H_{26}O_5$), 246 ($M - RCO_2H$, 13), 228 (246 − H_2O, 20), 213 (228 − Me, 24), 163 ($C_{10}H_{11}O_2$, 100), 83 ($C_4H_7CO^+$,49), 55 (83 − CO, 48).

$$[\alpha]^{\lambda}_{24^\circ} = \frac{589 \quad 578 \quad 546 \quad 336 \quad 365\,\text{nm}}{0 \quad 0 \quad -2.3 \quad -24.6 \quad -123.7}$$

($c = 0.35$, $CHCl_3$).

1α-*Hydroxyeuryopsonol angelate* (**7**). Colourless crystals, mp 150° (Et_2O–petrol), IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 3520 (OH), 1715 ($C{=}CCO_2R$), 1670, 1545 (α-furan ketone); MS *m/z* (rel. int.): 346.178 (M^+, 3) ($C_{20}H_{26}O_5$), 246 ($M - RCO_2H$, 6), 228 (246 − H_2O, 8), 213 (228 − Me), 163 ($C_{10}H_{11}O_2$, 100), 83 ($C_4H_7CO^+$, 26), 55 (83 − CO, 62).

$$[\alpha]^{\lambda}_{24^\circ} = \frac{589 \quad 578 \quad 546 \quad 436 \quad 365\,\text{nm}}{-0.8 \quad -1.3 \quad -3.4 \quad -28.0 \quad -149.1}$$

($c = 0.95$, $CHCl_3$).

1α-*Hydroxyeuryopsonol isobutyrate* (**8**). Colourless gum, IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 3520 (OH), 1730 (CO_2R), 1665, 1540 (α-furan ketone); MS *m/z* (rel. int.): 334.178 (M^+, 2) ($C_{19}H_{26}O_5$), 246 ($M - RCO_2H$, 4), 228 (246 − H_2O, 14), 213 (228 − Me, 21), 163 ($C_{10}H_{11}O_2$, 100), 71 ($C_3H_7CO^+$, 8).

6β-Hydroxy-1β,10β-epoxyfuranoeremophil-9-one (**14**). Colourless crystals, mp 183° (Et_2O–petrol), IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 3610 (OH), 1690, 1540 (α-furan ketone); MS *m/z* (rel. int.): 262.120 (M^+, 58) ($C_{15}H_{18}O_4$), 244 ($M - H_2O$, 10), 205 ($M - C_4H_9$, 100), 177 (205 − CO, 85). 5 mg **14** in 3 ml Et_2O was stirred for 2 hr with 50 mg MnO_2. TLC (Et_2O–petrol, 1:1) afforded 3 mg **17**, identical with the natural diketone.

6,9-*Dioxo*-1β,10β-*epoxyfuranoeremophilane* (**17**). Colourless crystals, mp 104° (Et_2O–petrol), IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1700 (CO), 1685, 1530 (α-furan ketone); MS *m/z* (rel. int.): 260.105 (M^+, 100) ($C_{15}H_{16}O_4$), 245 (M − Me, 28), 227 (245 − H_2O, 23), 217 (245 − CO, 53), 189 (217 − CO, 25).

$$[\alpha]^{\lambda}_{24^\circ} = \frac{589 \quad 578 \quad 546 \quad 436\,\text{nm}}{-26.7 \quad -30.0 \quad -37.5 \quad -99.2}\ (c = 0.12,\ CHCl_3).$$

12-*Acetoxybisabol*-1-*one* (**18**). Colourless oil, IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1750, 1250 (OAc), 1680, 1640 ($C{=}C{-}C{=}O$); MS *m/z* (rel. int.): 278 (M^+, 0.1), 218.167 (M − AcOH, 13) ($C_{15}H_{22}O$), 110 ($C_7H_{10}O$, 100, McLafferty), 95 (110 − Me, 18), 82 (110 − CO, 9); CI (isobutane): 279 (M + 1, 18), 219 (279 − AcOH, 100).

$$[\alpha]^{\lambda}_{24^\circ} = \frac{589 \quad 578 \quad 546 \quad 436 \quad 365\,\text{nm}}{-17.7 \quad -18.8 \quad -23.0 \quad -55.7 \quad -271.3}$$

($c = 0.6$, $CHCl_3$).

10 mg **18** in 1 ml MeOH were heated for 5 min with 100 mg KOH in 0.5 ml H_2O. TLC (Et_2O–petrol, 1:1) afforded 6 mg **20** (^1H NMR see Table 2), which on stirring with 100 mg MnO_2 in 2 ml Et_2O (2 hr) gave 3 mg **19**, identical with the natural compound (^1H NMR).

1-*Oxo-bisabol*-12-*al* (**19**). Colourless oil, IR $\nu_{max}^{CCl_4}$ cm^{-1}: 2740, 1735 (CHO), 1680 ($C{=}CC{=}O$); MS *m/z* (rel. int.): 234.162 (M^+, 4) ($C_{15}H_{22}O_2$), 206 (M − CO, 2), 110 ($C_7H_{10}O$, 100, McLafferty), 95 (110 − Me, 33), 82 (110 − CO, 43).

Acknowledgement—We thank the Deutsche Forschungsgemeinschaft for financial support.

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