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BISABOLENE DERIVATIVES AND ACETYLENIC COMPOUNDS FROM PERUVIAN *COREOPSIS* SPECIES

FERDINAND BOHLMANN, SHANTA BANERJEE, JASMIN JAKUPOVIC, ROBERT M. KING* and HAROLD ROBINSON*

Institute for Organic Chemistry, Technical University of Berlin, D-1000 Berlin 12, West Germany; *Smithsonian Institution, Department of Botany, Washington, DC 20560, U.S.A.

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Key Word Index—*Coreopsis microlepis*; *C. woytkowskii*; *C. senaria*; Compositae; sesquiterpenes; perezone derivatives; pipitzol-like compound; acetylenes.

Abstract—The investigation of three Peruvian *Coreopsis* species afforded, in addition to compounds isolated previously from this genus, two new tetraynenes and five sesquiterpenes all related to perezone, including a tricyclic ketone with a cedrane skeleton closely related to pipitzol. The structure were elucidated by spectroscopic methods.

INTRODUCTION

In continuation of our chemical investigations of the genus *Coreopsis* (Compositae, tribe Heliantheae, subtribe Coreopsidinae) [1] we have now studied three Peruvian species. Again acetylenic compounds and bisabolene derivatives were isolated. The results are discussed in this paper.

RESULTS AND DISCUSSION

The aerial parts of *Coreopsis microlepis* Blake et Sherff. afforded the tetraynene derivatives **1** and **2**. The UV spectrum of **1** was chracteristic of a tetraynene [2] and the ^{1}H NMR spectral data (Table 1) clearly showed that one side of the chromophore was substituted by a methyl, while the other side was flanked by $CH(OH)CH_2OCOCHMe_2$. The coupling of H-4 indicated an *E*-configuration for the double bond. Accordingly, the structure of **1** was settled. The ^{1}H NMR spectrum of **2** (Table 1), as well as the mass spectrum, showed that the compounds differed only in the nature of the ester group. Therefore in the ^{1}H NMR spectrum only the isobutyrate signals were replaced by those of an isovalerate.

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

	1	**2**
H-1	4.19 *dd*	4.20 *dd*
H-1′	4.04 *dd*	4.03 *dd*
H-2	4.48 *br t*	4.48 *br t*
H-3	6.37 *dd*	6.37 *dd*
H-4	5.91 *dd*	5.92 *dd*
H-13	1.99 *s*	2.00 *s*
OCOR	2.57 *qq*	2.23 *d*
	1.16 *d*	2.10 *m*
		0.94 *d*

J (Hz): 1, 1′ = 11.5; 1, 2 = 3.5; 1′, 2 = 6.5; 2, 3 = 5; 2, 4 = 1.5; 3, 4 = 16; OiBu: 2′, 3′ = 2′, 4′ = 7; OiVal: 2′, 3′ = 3′, 4′ = 3′, 5′ = 7.

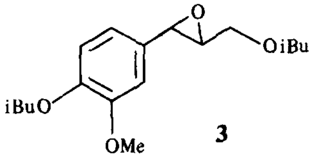
The aerial parts of *Coreopsis woytkowskii* Sherff. gave 11*E*- and 11*Z*-trideca-1,11-dien-3,5,7,9-tetrayne and phenylhepta-1,3-diyn-5-ene present in many *Coreopsis* species [2], while the roots afforded the phenylpropane derivatives **3** [3], **4** [3], cinnamyl alcohol and its acetate as well as sesquiphellandrene.

The aerial parts of *Coreopsis senaria* Blake et Sherff. gave caryophyllene, the cinnamate **5** [4], nerolidol, the isomeric perezone derivatives **8** [1] and **9**, **10** and perezone (**11**) [5], as well as perezone methyl ether [6] and the quinols **6** and **7**.

The structures of the latter two could be deduced from the ^{1}H NMR spectra and those of the oxidation products **8** and **10** (Table 2). The relative position of the acetoxyl group in the quinones clearly followed from the splitting of the H-2 or H-5 signal. **9** differs from perezone only in the position of the hydroxyl group. Again the position followed from the changed splitting of the corresponding olefinic proton.

In addition to these compounds, a further compound was isolated, which turned out to be the pipitzol-like ketone **13**. The mass spectrum of compound **13** led to the molecular formula $C_{15}H_{22}O_3$ and the IR spectrum showed the presence of an α,β-unsaturated carbonyl function. The ^{1}H NMR spectrum (see Experimental) showed a signal of an olefinic proton, similar to that of perezone. There were two OH signals (exchangeable with D_2O), one of which was a singlet and the other a doublet. Two double-bond methyl signals of perezone were replaced by two sharp singlets at δ0.94 and 1.15. The C-7 methyl doublet now appeared at lower field and the signal of the olefinic C-10 proton of perezone was absent. These facts suggested that we were dealing with a cyclized product of perezone involving C-6, C-10, C-11 and either C-4 or C-5, forming a tricyclic ketone. The participation of C-5 in ring formation could be excluded by NOE

$\overset{13}{Me}[C\equiv C]_4\overset{4}{CH}=\overset{3}{CH}-\overset{2}{CH}(OH)\overset{1}{CH_2}OR$ **1** R = iBu **2** R = iVal



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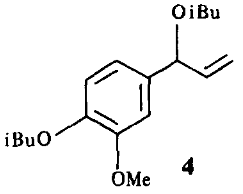

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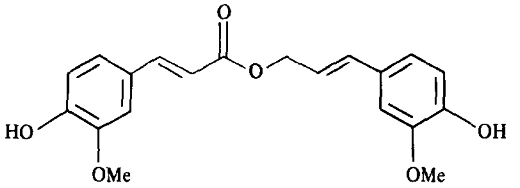

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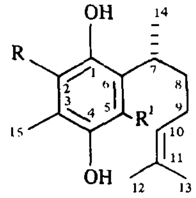
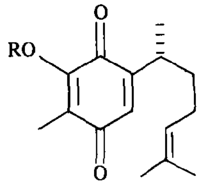
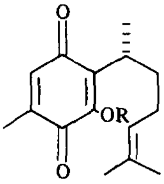


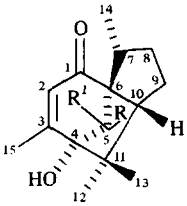
	6	**7**
R	H	OAc
R¹	OAc	H



8 R = Ac
9 R = H



10 R = Ac
11 R = H



12*R, R¹ = O
13 R = OH, R¹ = H

* Numbering as in **6** – **11**

Table 2. ^1H NMR spectral data of **6**, **7**, **9** and **10** (400 MHz, $CDCl_3$, TMS as internal standard)

	6	7	9	10
H-2	6.16 *s*	—	—	6.55 *q*
H-5	—	6.28 *s*	6.43 *d*	—
H-7	3.19 *m*	3.18 *m*	2.89 *m*	2.97 *m*
H-10	5.10 *br t*	5.05 *br t*	5.03 *br t*	5.03 *br t*
H-12	1.51 *br s*	1.52 *br s*	1.53 *br s*	1.52 *br s*
H-13	1.65 *br s*	1.66 *br s*	1.64 *br s*	1.64 *br s*
H-14	1.30 *d*	1.12 *d*	1.12 *d*	1.17 *d*
H-15	2.03 *s*	2.11 *s*	1.94 *s*	2.05 *s*
OAc	2.31 *s*	2.34 *s*	—	2.34 *s*

J (Hz): 7,14 = 9,10 = 7.

difference spectroscopy, which together with spin decoupling led to the structure **13**. The proposed configuration at C-5 was also very likely, if the biogenesis was considered. Perhaps perezone could react as a 1,3-dipole (formed by intramolecular H-shift followed by electron pair shifts). Thus the formation of **13** could be explained as an intramolecular 1,3-dipolar addition giving **12**. Inspection of a model shows that the formation of **13** would be favoured in the reduction of the C-5 carbonyl group. Thus the formation of **13** is an additional pathway from perezone to tricyclic compounds like the pipitzols [7]. We have named this cedrane derivative coreosenarione.

EXPERIMENTAL

The air-dried plant material (collected in January 1983 in Peru) was extracted with Et_2O–petrol–MeOH (1 : 1 : 1) and worked up in the usual fashion [8]. The CC fraction (Et_2O–petrol, 1 : 1) obtained from the extract of 210 g of aerial parts from *Coreopsis microlepis* (voucher RMK 9141) was separated by TLC (Et_2O–petrol, 1 : 1), affording 15 mg **1** (R_f 0.55) and 8 mg **2** (R_f 0.50). The combined CC fractions (Et_2O–petrol, 1 : 10 and 1 : 1) obtained from the extract of 50 g roots of *C. woytkowskii* (voucher RMK 9242) were separated by TLC (Et_2O–petrol, 1 : 1) to give 10 mg sesquiphellandrene (R_f 0.9), 12 mg **4** (R_f 0.8), a mixture (III, R_f 0.7), 10 mg **3** (R_f 0.6) and 5 mg cinnamyl alcohol. Repeated TLC of III (Et_2O–petrol, 3 : 7) gave 5 mg cinnamyl acetate. The extract of the aerial parts gave a CC fraction with petrol, which by TLC (Et_2O–petrol, 1 : 9) afforded 18 mg 11*E*- and 11*Z*-trideca-1,11-dien-3,5,7,9-tetrayne (R_f 0.75) and 20 mg 1-phenylhept-5*E*-en-1,3-diyne (R_f 0.65). The extract of aerial parts of *C. senaria* (voucher RMK 9121) gave CC fractions as follows: 1 (petrol), 2 (Et_2O–petrol, 1 : 4), 3 (Et_2O–petrol, 1 : 1) and 4 (Et_2O). TLC (petrol) of fraction 1 gave 15 mg caryophyllene; TLC (Et_2O–petrol, 1 : 10) of fraction 2 afforded 42 mg **11** (R_f 0.5), 15 mg perezone methyl ether (R_f 0.4), 7 mg nerolidol (R_f 0.3) and 18 mg **9** (R_f 0.25). TLC (Et_2O–petrol, 3 : 7) of fraction 3 gave 10 mg **10** (R_f 0.7), 28 mg **6** (R_f 0.55), 5 mg **7** (R_f 0.4), 15 mg **11** and 9 mg **13** (R_f 0.2). TLC of fraction 4 (Et_2O–petrol, 1 : 1) gave 40 mg **5** (R_f 0.6). Known compounds were identified by comparing the 400 MHz ^1H NMR spectra with those of authentic material and by co-TLC. The new compounds showed no impurities in the ^1H NMR spectra or by TLC in different solvent mixtures.

1-*Isobutyryloxy-tridec*-3E-*en*-5,7,9,11-*tetrayn*-2-*ol* (**1**). Yellow, unstable oil; UV $\lambda_{max}^{Et_2O}$ nm: 376, 345, 324, 306; MS *m/z* (rel. int.): 180.057 $[M - RCO_2H]^+$ (100) (calc. for $C_{13}H_8O$: 180.057), 167 $[M - CH_2OCOR]^+$ (18), 139 $[167 - CO]^+$ (27), 71 $[C_3H_7CO]^+$ (62).

1-*Isovaleryloxy-tridec*-3E-*en*-5,7,9,11-*tetrayn*-2-*ol* (**2**). Yellow, unstable oil; UV $\lambda_{max}^{Et_2O}$ nm: 376, 345, 324, 306; MS *m/z* (rel. int.): 180.057 $[M - RCO_2H]^+$ (100) (calc. for $C_{13}H_8O$: 180.057), 167 $[M - CH_2OCOR]^+$ (20), 139 $[167 - CO]^+$ (29), 85 $[C_4H_9CO]^+$ (45).

5-*Acetoxycurcuquinol* (**6**). Colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3500 (OH), 1770 (PhOAc); MS *m/z* (rel. int.): 292.167 $[M]^+$ (20) (calc. for $C_{17}H_{24}O_4$: 292.167), 250 $[M - \text{ketene}]^+$ (60), 167 $[250 - C_6H_{11}]^+$ (100), 166 $[250 - C_6H_{12}]^+$ (54).

2-*Acetoxycurcuquinol* (**7**). Colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3500 (OH), 1770 (PhOAc); MS *m/z* (rel. int.): 292.167 $[M]^+$ (24) (calc. for $C_{17}H_{24}O_4$: 292.167), 250 $[M - \text{ketene}]^+$ (65), 167 $[250 - C_6H_{11}]^+$ (100), 166 $[250 - C_6H_{12}]^+$ (50). Both **6** and **7** on standing in soln in the presence of air gave **8** and **10**, respectively, after purification by TLC.

1-*Hydroxycurcuquinone* (**9**). Yellow needles (Et_2O–petrol), mp 106°; IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 3400 (OH), 1665, 1655, 1640 (quinone); MS *m/z* (rel. int.): 248.141 $[M]^+$ (23) (calc. for $C_{15}H_{20}O_3$: 248.141), 167 $[M - C_6H_9]^+$ (100), 166 $[M - C_6H_{10}, \text{McLafferty}]^+$ (62), 138 $[166 - CO]^+$ (40).

Perezone acetate (**10**). Yellow oil; IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 1785 (OAc), 1670, 1655, 1610 (quinone); MS *m/z* (rel. int.): 290.152 $[M]^+$ (10) (calc. for $C_{17}H_{22}O_4$: 290.152), 248 $[M - \text{ketene}]^+$ (40), 166 $[248 - C_6H_{10}]^+$ (100).

Coreosenarione (**15**). Colourless crystals, mp 179° (Et_2O–petrol); IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 3400 (OH), 1675 (C=CC=O); MS *m/z* (rel. int.): 250.157 $[M]^+$ (42) (calc. for $C_{15}H_{22}O_3$: 250.157), 232 $[M - H_2O]^+$ (70), 217 $[232 - Me]^+$ (22), 192 (44), 167 (32), 151 (100), 137 (38); ^{13}C NMR ($CDCl_3$, 67.9 MHz) (C-1–C-15); 201.9 *s*, 125.8 *d*, 165.6 *s*, 88.8 *s*, 80.5 *d*, 66.3 *s*, 33.8 *d*, 37.3 *t*, 28.0 *t*, 59.2 *d*, 44.0 *s*, 28.0 *q*, 19.4 *q*, 14.4 *q*, 20.4 *q*; ^1H NMR ($CDCl_3$, 400 MHz): δ 5.71 *q* (H-2, $J = 1.5$ Hz), 3.38 *ddq* (H-7, $J = 7, 7, 7$ Hz), 1.93 *m* (H-8), 1.56 *m* (H-8′), 1.96 *m* (H-9), 1.50 *m* (H-9′), 1.95 *dd* (H-10, $J = 11, 6$ Hz), 0.94 *s* (H-12), 1.15 *s* (H-13), 1.31 *d* (H-14, $J = 7$ Hz), 2.03 *d* (H-15, $J = 1.5$ Hz), 2.71 *s* (C-4, OH), 2.33 *br d* (C-5, OH, $J = 7$ Hz).

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REFERENCES

1. Bohlmann, F., Ahmed, M., Grenz, M., King, R. M. and Robinson, H. (1983) *Phytochemistry* **22**, 2858.
2. Bohlmann, F., Burkhardt, T. and Zdero, C. (1973) *Naturally Occurring Acetylenes*. Academic Press, London.
3. Bohlmann, F. and Zdero, C. (1968) *Chem. Ber.* **101**, 3242.
4. Bohlmann, F. and Zdero, C. (1977) *Chem. Ber.* **110**, 468.
5. Archer, D. A. and Thompson, R. H. (1965) *Chem. Commun.* 354.
6. Anderson, L. A. P., de Kock, W. T., Pachler, K. G. R. and Brink, C. V. d. M. (1967) *Tetrahedron* **23**, 4153.
7. Walls, F., Padilla, J., Joseph-Nathan, P., Giral, F. and Romo, J. (1965) *Tetrahedron Letters* 1577.
8. Bohlmann, E., Zdero, C., King, R. M. and Robinson, H. (1984) *Phytochemistry* **23**, 1979.