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DITERPENES FROM *EUPATORIUM TURBINATUM*

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Key Word Index—*Eupatorium turbinatum*; Compositae; diterpenes; clerodane; abietane; friedolabdane.

Abstract—The aerial parts of *Eupatorium turbinatum* afforded three diterpenes, a known clerodane derivative, an unusual abietane derivative and a friedolabdane, liliolide, β-farnesene and the flavonol pachypodol. The structures were elucidated by highfield NMR spectroscopy. The chemotaxonomy is discussed briefly.

INTRODUCTION

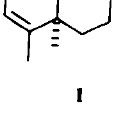
Eupatorium turbinatum Gray is very close to *Chromolaena bigelovii* (= *Eupatorium bigelovii*) but the former have never transferred to *Chromolaena* or any of the other new genera which have been separated from the old genus *Eupatorium*. We therefore have studied the chemistry which may give an idea of its proper placement. The results are discussed in this paper.

RESULTS AND DISCUSSION

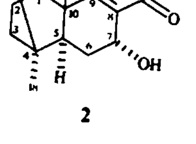
The aerial parts of *Eupatorium turbinatum* Gray afforded β-farnesene, liliolide [1], pachypodol [2], the clerodane (**1**) [3], the quinone **2** and the friedolabdane **3**.

The molecular formula of **2** was $C_{20}H_{26}O_6$ and the ^{13}C NMR spectrum (Experimental) indicated the presence of a fully substituted *p*-quinone by the singlets at δ188.8, 183.9, 150.9, 145.1, 142.5 and 124.7. Furthermore, three oxygen bearing carbons must be assumed, one being an acetal carbon (95.3 *d*). The ^1H NMR spectrum (Experimental) supported this proposal. In the low field region a pair of double doublets at δ3.88 and 3.34, a double doublet at 4.83 and a singlet at 5.60 were visible. Furthermore, a hydroxyl proton (7.18 *s*) was present. A pair of doublets at δ1.20 and 1.19 (each 3H) and a quartet of quartets at 3.18 were due to an isopropyl group. These data agreed with the presence of a derivative of the abietane quinone royleanone [4] where two of the tertiary methyl groups must be oxygenated as only one methyl singlet was present. The chemical shift (δ4.83) required an allylic position for the secondary hydroxyl. Spin decoupling allowed the assignment of two sequences. Together with the isolated CH_2OR group and the proton of an acetal carbon all data agreed with the proposed structure. The stereochemistry was supported by NOE difference spectroscopy. Thus clear effects were obtained between H-18, H-19, H-5 and H-6α, between H-6β, H-19, H-6α and H-7 as well as between H-20 and H-1β. These effects required an axial orientation of C-19 and C-20 and a 7α-hydroxy group as the NOE was observed with both protons at C-6. Most likely the semiacetal hydroxy group was hydrogen bonded with the quinone carbonyl group. This would explain the definite orientation of H-20 which showed a NOE with H-1β. The chemical shift and the couplings of the 7α-hydroxy derivative horminone agreed with those of **2** while the values of the β-isomer differed very significantly [5]. We have named compound **2** turbinatone.

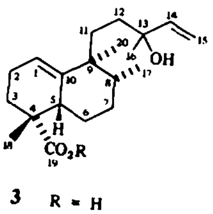
The structure of **3** clearly followed from the ^1H NMR and ^{13}C NMR spectra (Experimental). The nature of the side chain was deduced from the typical signals. Spin decoupling further gave a clear sequence of all protons at C-1–C-3 and C-5–C-8. As, however, H-5 showed an allylic coupling with H-1 and a homoallylic coupling with H-2 the whole sequence was established, excluding a labdane with a 5(6)-double bond. The stereochemistry was determined by NOE difference spectroscopy. Thus, in deuterobenzene clear effects were obtained between H-18, H-5 and H-6β, between H-7β, H-5 and H-11, between H-20, H-12, H-12′, H-11′ and H-1, between H-17 and H-7α as well as between H-16, H-15t and H-14. These effects required the proposed stereochemistry with a conformation where C-11, C-17 and CO_2R are axial. This is



1



2



3 R = H
3a R = Me

further supported by a W-coupling of H-11 with H-20. All data therefore nicely agreed with the presence of a friedolabdane derivative (**3**) which we have named friedolabdaturbinic acid. The absolute configurations of **2** and **3** were not determined.

Eupatorium turbinatum is closely related to *Chromolaena bigelovii* (Gray) King et Robins. The former species, however, has not been transferred into *Chromolaena*, perhaps as it was considered to be synonymous with *Chr. bigelovii*. However, *E. turbinatum* is specifically distinct from the latter [B. L. Turner, personal communication]. *Chr. bigelovii* as well as *Chr. collina* [6] belong to a small group of species placed in the subgenus *Osmiella* which have smooth coralla lobes, flat receptacles and loosely imbricate phyllaries. So far species of this group differ clearly in the chemistry [7, 8] from the other *Chromolaena* species where special cadinene derivatives predominate [9]. The isolation of rearranged diterpenes like **1** and **3** from *E. turbinatum* may be an indication that this group is more related to parts of the subtribe Critoniinae as similar diterpenes are reported from *Koanophyllon* [10]. *Osmiella* share more characters with elements of Critoniinae than with *Chromolaena* which they resemble only in their universally deciduous phyllaries. Further morphological and chemical studies are necessary to get a clear picture of the relationship of these taxa.

EXPERIMENTAL

Eupatorium turbinatum was collected in Nuevo Leon, 3.5 miles S of Montemorelus, Mexico (voucher B. L. Turner, 80-14MA, deposited in the Herbarium of the University of Texas at Austin). The air dried aerial parts (170 g) were extracted with MeOH–Et_2O–petrol (1:1:1) and the extract was worked-up as reported previously [11]. CC (silica gel) gave four crude fractions [(1) petrol; (2) Et_2O–petrol, 1:1; (3) Et_2O and (4) Et_2O–MeOH, 9:1]. Preparative TLC (silica gel, PF 254, petrol) of fraction 1 gave 22 mg β-farnesene. Fraction 2 gave crude **3** which was transformed to the methyl ester **3a** by addition of CH_2N_2. Preparative TLC (Et_2O–petrol, 1:2, three developments) gave 135 mg **3a** (R_f 0.5). Preparative TLC of fraction 3 (Et_2O) gave crude **2** which was purified by repeated preparative TLC (Et_2O–petrol, 1:1) affording 2.5 mg **2** (R_f 0.3). Preparative TLC of fraction 4 (toluene–Et_2O–CH_2Cl_2, 1:1:1) gave 15 mg liliolide and a mixture which gave by preparative TLC (Et_2O–petrol, 1:1, two developments) 3 mg pachypodol, 10 mg of a mixture of the latter with **1** and 4 mg **1** (R_f 0.3). Known compounds were identified by comparing the 400 MHz ^1H NMR spectra with those of authentic material.

Turbinatone (**2**). Yellow coloured oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3600, 3360 (OH), 1650, 1635 (quinone); EIMS *m/z* (rel. int.): 362 (8) $[M]^+$ ($C_{20}H_{26}O_6$), 344 $[M-H_2O]^+$ (100), 298 (73), 262 (50), 203 (68); CIMS *m/z* (rel. int.): 363 $[M+1]^+$ (7), 345 $[M+1-H_2O]^+$ (100), 317 $[345-CO]^+$ (17), 175 (48); ^1H NMR (400 MHz, $CDCl_3$): 1.29 (*ddd*, H-1α), 2.55 (*br dd*, H-1β), 1.59 (*br dd*, H-2α), 2.42 (*ddddd*, H-2β), 1.46 (*dddd*, H-3α), 1.74 (*dd*, H-3β), 1.70 (*br d*, H-5), 1.87 (*br d*, H-6α), 2.29 (*ddd*, H-6β), 4.83 (*dd*, H-7), 3.18 (*qq*, H-15), 1.19 (*d*, H-16), 1.20 (*d*, H-17), 0.79 (*s*, H-18), 3.88 and 3.34 (*dd*, H-19), 5.60 (*s*, H-20); OH: 7.18 *s*; [*J* (Hz): 1α,1β = 1α,2β = 2α,2β = 2β,3 = 3α,3β = 5,6β = 6,6β = 14; 1α,2α = 2α,3α = 6.5; 1β,2β = 2β,3β = 6; 3α,19 = 2; 5,19′ = 1.5; 6α,7 = 1.5; 6β,7 = 4.5; 15,16 = 15,17 = 7; 19,19′ = 11.5]; ^{13}C NMR (67.9 MHz, $CDCl_3$, C-1–C-20): 34.9 *t*, 21.1 *t*, 39.9 *t*, 32.5 *s*, 40.0 *d*, 26.2 *t*, 62.2 *d*, 142.5 *s*, 145.1 *s*, 41.6 *s*, 183.9 *s*, 150.9 *s*, 124.7 *s*, 188.8 *s*, 24.1 *d*, 19.8 *q*, 19.9 *q*, 23.6 *q*, 66.2 *t*, 95.3 *d*.

Methyl friedolabdaturbinoate (**3a**). Colourless oil; IR $\nu_{max}^{CCl_4}$ cm^{-1}: 3520 (OH), 1740 (CO_2R); EIMS *m/z* (rel. int.): 316.240 $[M-H_2O]^+$ (4) ($C_{21}H_{32}O_2$: 316.240), 301 $[316-Me]^+$ (1), 257 $[316-CO_2Me]^+$ (6.5), 235 $[M-CH_2CH_2C(OH)(Me)CH{=}CH_2]^+$ (92), 175 $[235-HCO_2Me]^+$ (100); $[\alpha]_D^{24°} = -47$ ($CHCl_3$; *c* 7.44); ^1H NMR (400 MHz, $CDCl_3$): 5.23 (*br dd*, H-1), 2.00 (*m*, H-2), (in C_6D_6 2.06 *br dd* and 1.86 *br d*), 1.80 (*ddd*, H-3α), 1.4 (*m*, H-3β), 2.67 (*br dd*, H-5), 1.40 (*m*, H-6), 1.40 (*m*, H-7α), 2.11 (*dddd*, H-7β), 1.52 (*m*, H-8), 2.20 (*br dd*, H-11), 0.99 (*m*, H-11′), 1.40 (*m*, H-12), 5.80 (*dd*, H-14), 5.19 (*d*, H-15*t*), 4.99 (*d*, H-15*c*), 1.25 (*s*, H-16), 0.74 (*d*, H-17), 1.07 (*s*, H-18), 0.79 (*s*, H-20); OMe: 3.63 *s*; [*J* (Hz): 1,2 = 4; 2α,3α = 2β,3α = 5; 2β,3α = 3α,3β = 13; 5,6α = 12; 5,6β = 4; 6α,7β = 7α,7β = 13; 6β,7β = 7β,8β = 4; 8,17 = 7; 11,11′ = 11,12 = 13; 11,20 ~ 0.5; 14,15c = 11; 14,15t = 17.5]; ^{13}C NMR (67.9 MHz, $CDCl_3$, 2D ^{13}C–^1H-correlated, C-1–C-20): δ 119.7 *d*, 23.3 *t*, 28.8 *t*, 44.9 *s*, 37.8 *d*, 23.7 *t*, 28.7 *t*, 39.6 *d*, 43.2 *s*, 141.8 *s*, 32.1 *t*, 36.6 *t*, 72.6 *s*, 144.3 *d*, 111.4 *t*, 29.7 *q*, 15.5 *q*, 22.4 *q*, 178.9 *s*, 22.0 *q*; OMe: 51.8 *q*.

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