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CAROTANE DERIVATIVES FROM *FERULA JAESCHKEANA*

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Key Word Index—*Ferula jaeschkeana*; Umbelliferae; rhizomes; sesquiterpene; γ-lactone of carotane derivative.

Abstract—The petrol extract of *Ferula jaeschkeana* rhizomes afforded, in addition to jaeschkeanadiol, 5α-(4-hydroxybenzoyl)-jaeschkeanadiol, and 5α-(3-methoxy-4-hydroxybenzoyl)-jaeschkeanadiol, a new carotane derivative having a γ-lactone moiety. The structures were elucidated by spectroscopic studies.

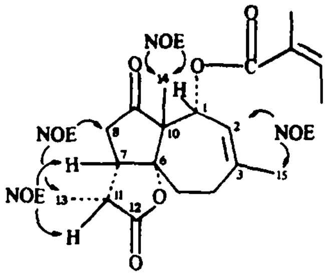
INTRODUCTION

Two groups of workers have examined organic solvent (petrol and acetone) extracts of *Ferula jaeschkeana* Vatke rhizomes. Thus Sukh Dev and co-workers [1] reported on the structure and stereochemistry of jaeschkeanadiol while Malikov and co-workers [2] reported on the structure of yeshferin, a sesquiterpene ester. In this paper, we describe the isolation and structure elucidation of a new carotane γ-lactone and of 5α-(3-methoxy-4-hydroxybenzoyl)- and 5α-(4-hydroxybenzoyl)-jaeschkeanadiol. This is the first report of the isolation of the last two compounds from this plant.

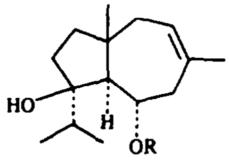
RESULTS AND DISCUSSION

The petrol extract of powdered dry rhizomes on repeated column chromatography yielded a new carotane γ-lactone, tentatively named feruginin (**1**), as well as jaeschkeanadiol (**2**) [1], 5α-(3-methoxy-4-hydroxybenzoyl)-jaeschkeanadiol (**3**) [3, 4] and 5α-(4-hydroxybenzoyl)-jaeschkeanadiol (**4**) [5, 6].

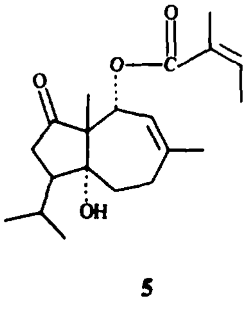
The structure of feruginin (**1**), a sesquiterpene lactone, $C_{20}H_{26}O_5$ (high-resolution mass spectrometry), followed from the UV, IR and ^1H NMR and ^{13}C NMR data, which were found to be very close to those of the angelate **5** [7]. The IR spectrum of **1** exhibited strong absorption for a γ-lactone at 1780 cm^{-1}, in addition to absorption bands at 1755 cm^{-1} for a five-membered ring ketone and 1725 cm^{-1} for an α,β-unsaturated ester. Its mass spectrum contained fragments at m/z 246, 83 and 55 due to loss of angelic acid. On saponification with alcoholic potassium hydroxide it gave angelic acid as one of the reaction products, confirming feruginin to be an angelic acid ester. The relative position of this ester group as 1α



1



2 R = H
3 R = Vanillyl
4 R = *p*-Hydroxy benzoyl



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was established on the basis of the coupling constant $J_{1,2} = 7.5$ Hz and by direct comparison with the chemical shift data for **5**.

The ^{13}C NMR spectrum of **1** showed the presence of one lactone carbonyl (δ177.29) and two oxygen bearing carbons [δ93.02 (*s*) [8] and 75.70 (*d*)] assigned as C-6 and C-1, respectively. An upfield signal due to a single secondary methyl group [11.01 (*q*)] [9] instead of two secondary methyl groups as in **5** was also present. This suggested that feruginin (**1**) was a γ-lactone in which ring closure involved a C-12 oxygen atom and O-6. Further, as expected [10], C-11 was also shifted downfield by δ11.9 (δ26.4–38.29) compared with **5**. Its ^{1}H NMR spectrum also supported structure **1** (see Experimental) since the single methyl signal at δ1.26 (*d*, $J = 7$ Hz) was δ0.25 downfield. This shift can be easily explained if there is a γ-lactone system as given in structure **1**. The C-7 methine appeared as a *ddd* at δ2.91 ($J = 11, 9, 7$ Hz) and H-11 at δ3.12 as a *dq* ($J = 7$ Hz). The latter on irradiation changed the *ddd* at δ2.91 into a *dd* ($J = 11, 9$ Hz), indicating that C-7 is β. Other signals were assigned on the basis of the chemical shifts of **5** and decoupling experiments. The stereochemistry at C-1, C-2, C-7 and C-11 was established by significant difference NOEs between βH-1–H$_3$-14; H$_3$-14–H-4; βH-7–βH-11; βH-8–H$_3$-13; H$_3$-15–αH-4; H$_3$-15–βH-4.

EXPERIMENTAL

Mps: uncorr; ^{1}H NMR and ^{13}C NMR: 400 MHz, CDCl$_3$ with TMS as internal standard; MS: 70 eV, direct inlet. Assignment of ^{1}H NMR was based on spin–spin decoupling expts. ^{13}C NMR chemical shifts were made with the aid of off-resonance and noise-decoupled spectra.

F. jaeschkeana rhizomes, collected from Gulmarg (Kashmir) in September 1980, were air-dried (1.6 kg), powdered and extracted with petrol (60–80°) in a Soxhlet apparatus. The solvent was removed *in vacuo* to give an oily mass (yield, 12.5%), which on repeated CC over silica gel with petrol–Me$_2$CO mixtures afforded the following four compounds: feruginin, jaeschkeanadiol, 5α-(3-methoxy-4-hydroxybenzoyl)-jaeschkeanadiol (ferutin) and 5α-(4-hydroxybenzoyl)-jaeschkeanadiol (ferutinin). The CC was monitored by TLC (silica gel, CHCl$_3$–MeOH, 49:1); the R_fs for the four compounds were 0.62, 0.41, 0.34 and 0.30, respectively.

Feruginin (**1**). Colourless needles (Me$_2$CO), mp 90° (50 mg). $[\alpha]_D^{35} - 466°$ (c 0.6: CHCl$_3$); UV $\lambda_{\max}^{\text{MeOH}}$ nm: 216; IR $\nu_{\max}^{\text{KBr}}$ cm^{-1}: 2900–2860, 1780, 1755, 1725, 1660, 1460, 1380, 1170, 1050, 985, 925, 900, 825; ^{1}H NMR (400 MHz, CDCl$_3$): δ1.16 (3H, *s*, H-14), 1.26 (3H, *d*, $J = 7$ Hz, H-12), 1.77 (3H, *s* (*br*), H-15), 1.82 (3H, *dq*, $J = 1.5$ Hz, H-19), 1.97 (3H, *dq*, $J = 7$ and 1.5 Hz, H-20), 2.12 (2H, *m*, H-5 and H-5′), 2.24 (1H, *dd*, $J = 18$ and 9 Hz, H-8′), 2.45 (1H, *dd*, $J = 18$ and 9 Hz, H-8), 2.57–2.7 (2H, *m*, H-4 and H-4′), 2.91 (1H, *ddd*, $J = 11, 9$ and 7 Hz, H-7), 3.12 (1H, *dq*, $J = 7$ Hz, H-11), 5.28 (1H, *d*, $J = 7.5$ Hz, H-1), 5.71 (1H, *dq*(*br*), $J = 7.5$ Hz, H-2) and 6.06 (1H, *qq*, $J = 7$ and 1.5 Hz, H-18); ^{13}C NMR (100 MHz, CDCl$_3$): δ217.0 (*s*, C-9), 177.29 (*s*, C-13), 165.81 (*s*, C-1′), 146.74 (*s*, C-3), 139.58 (*d*, C-3′), 126.56 (*s*, C-2′), 119.02 (*d*, C-2), 93.02 (*s*, C-6), 75.70 (*d*, C-1), 59.08 (*s*, C-10), 45.38 (*d*, C-7), 38.29 (*d*, C-11), 37.48 (*t*, C-4), 34.60 (*t*, C-8), 29.60 (*t*, C-5), 26.02 (*q*, C-14), 20.63 (*q*, C-4′), 18.57 (*q*, C-15), 15.67 (*q*, C-5′), 11.01 (*q*, C-12); MS *m/z* (rel. int.): 346.178 ($C_{20}H_{26}O_5$) $[M]^+$ (2), 331 (0.2), 318 $[346 - CO]^+$ (0.3), 284 (1.5), 264 (10), 263 $[346 - C_5H_7O]^+$ (36), 247 $[346 - \text{OAng}]^+$ (16), 246 [346 – angelic acid]$^+$ (7), 219 $[247 - CO]^+$ (3), 201 (5), 191 (5), 173 (12), 163 (4), 145 (5), 135 (5), 119 (6), 107 (6), 84 (7), 83 [MeCH=C(Me)C=O]$^+$ (100), 82 (7), 74 (10), 59 (20), 55 $[83 - CO]^+$ (80).

Hydrolysis of feruginin. A mixture of feruginin (20 mg) and 4% methanolic aq. KOH (2.5 ml) was refluxed for 2 hr and then worked up for the acidic fraction. The acidic fraction, R_f 0.85 (C_6H_6–MeOH–MeCO$_2$H, 45:8:4), was crystallized as colourless needles, mp 44°, which were found to be identical with an authentic sample of angelic acid.

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