THE STRUCTURE OF ULOPTEROL

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Khimiya Prirodnykh Soedinenii, Vol. 6, No. 3, pp. 300-304, 1970

UDC 577.15/17:582.89

In an investigation of the coumarin composition of the roots and fruit of Prangos uloptera D. C. (family Umbelliferae), we isolated a substance I, which we called "ulopterol"* with the properties characteristic for coumarin derivatives. The substance possesses a bright violet fluorescence in UV light, gives a color reaction with diazotized p-nitroaniline, and is readily soluble in organic solvents and is insoluble in water. It was reported previously [1] that ulopterol has the chemical composition $C_{20}H_{24}O_6$ and is a new dihydrofurocoumarin. However, on continuing our study of the structure of this compound it was found that its elementary formula is $C_{15}H_{18}O_5$ and that it is a 6,7-disubstituted coumarin. This is shown by its UV spectrum (Fig. 1), with a deep minimum in the 262-mμ region (log ε 2.38) and a small maximum in the 252-mμ region (log ε 2.87). The most intensive absorption is found at 330-334 mμ (log ε 3.36).

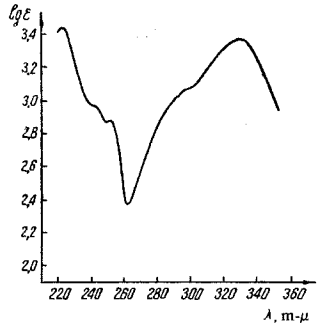


Fig. 1. UV spectrum of ulopterol.

The IR spectrum of I (Fig. 2a) taken in paraffin oil, shows a broad absorption band at 3300 cm^{-1} in the region of OH bonds, which shows the presence of one or more hydroxyl groups in the molecule. In the region of the stretching vibrations of C=O bonds there is a band at 1735 cm^{-1} (C=O of an α-pyrone ring) and also bands at 1622, 1565, 1505 (aromatic nucleus), 1382, and 1362 cm^{-1} (gem-dimethyl grouping).

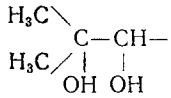
The acetylation of I gives mainly a monoacetyl derivative II and a small amount of a diacetyl derivative III, which shows the presence of two hydroxyl groups in the molecule. This is confirmed by the IR spectrum of II (Fig. 2b) in which, in addition to the absorption bands of the C = O bond of an α-pyrone ring (1700 cm^{-1}) and the C = O group of the ester (1745 cm^{-1}), there is a narrow hydroxyl band (3410 cm^{-1}). The appearance of only a small amount of III, in whose IR spectrum (Fig. 2c) there is no absorption band for an hydroxyl, is apparently explained by the fact that one of the hydroxyl groups is tertiary, since tertiary hydroxyl groups are very difficult to acetylate.

In the NMR spectrum of I in the region of the signals of aromatic protons there are two doublets with chemical shifts of δ 6.20 and 7.59 ppm (J = 9 Hz) and two singlets with δ 6.77 and 7.30 ppm (the relative intensity of each signal corresponds to one proton unit). The first signals are due to the 3- and 4-protons and the second to the 5- and 8-protons of the coumarin ring [2] (the latter assignment is based on the singlet nature of the signals). Thus, the NMR spectra show that I is a 6,7-disubstituted coumarin.

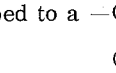
In the δ 3.89-ppm region of the NMR spectrum there is a singlet (three proton units) corresponding to a OCH_3

*Given as "ulopterole" in the translation of [1]. Now that the substance has been shown to contain hydroxyl groups the English spelling has been changed accordingly [Translator].

group bound to an aromatic ring. The methoxy group is one of the substituents of the initial coumarin, and from biogenetic considerations it probably occupies position 7. This is also shown by the presence of a strong band in the 330–334 mμ region in the UV spectrum (see Fig. 1). The presence of the strongest maximum in this region is characteristic for 7-methoxy- or 7-hydroxycoumarins [3]. The second substituent is probably a fragment of the type



, which agrees satisfactorily with the features of the NMR spectrum: two CH_3 groups attached to a carbon atom with a hydroxyl group give singlets with chemical shifts of δ 1.26 and 1.31 ppm (relative intensity of each signal three proton units); in the 2.9–3.70-ppm region there is a multiplet which may be ascribed to a



group (three proton units). This substituent is evidently in position 6. This structure is confirmed by the mass spectra (Fig. 3).

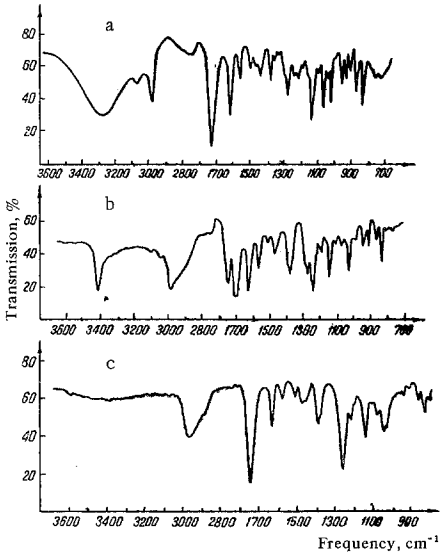


Fig. 2. IR spectrum of a) ulopterol, b) ulopterol monoacetate, and c) ulopterol diacetate.

The molecular weight of I found from the mass spectra is 278, which corresponds to the proposed formula $C_{15}H_{18}O_5$. This value agrees with the m/e figure for M^+ for the monoacetate of I, which is 320. A comparison of the spectrum of I with the spectrum of meranzin hydrate (Fig. 3a and 3b), which has the structure IV [4], gives grounds for assuming that I is a geometric isomer of meranzin hydrate. This is shown not only by their identical molecular weights but also by the practically identical fragmentation of the two compounds. The mass spectra of both substances have peaks at 260 m/e due to the splitting out of water ($M^+ - H_2O$). The strongest peaks correspond to fragments obtained by the stepwise elimination of the side chain from the molecular ion and from the ion ($M^+ - H_2O$) (see Fig. 3).

The mass spectrum of the monoacetate of I (Fig. 3c) is complex. Since one of the first steps of the main route of this degradation is the elimination of H_2O and the acetyl group CH_3CO with the migration of hydrogen to the oxygen of the resulting fragment, an ion with a mass number of 260 m/e is obtained, which obviously has the same structure as the product of the dehydration of I. The further degradation of this fragment, confirmed by the existence of metastable peaks, is practically the same in the spectra of all the compounds studied.

It must be mentioned that the spectrum of the monoacetate of I does not have the peaks for a fragment with m/e 220, nor for an ion with m/e 177 which would be formed by its decomposition, although these peaks are very strong in the spectra of I and IV. This is explained by the fact that the fragment with m/e 220 is obtained directly in the degradation of the molecular ion with m/e 278, which is barely found in the spectrum of the monoacetate of I.

The presence in the spectra of both I and its monoacetate of peaks corresponding to the splitting out of water ($M^+ - H_2O$) and of a hydroxyl group ($M^+ - OH$) from the molecular ion shows the presence of two hydroxyl groups in the molecule of I.

Thus, the combination of all the results permits the structure of 6-(2',3'-dihydroxy-3'-methylbutyl)-7-methoxycoumarin to be proposed for I.

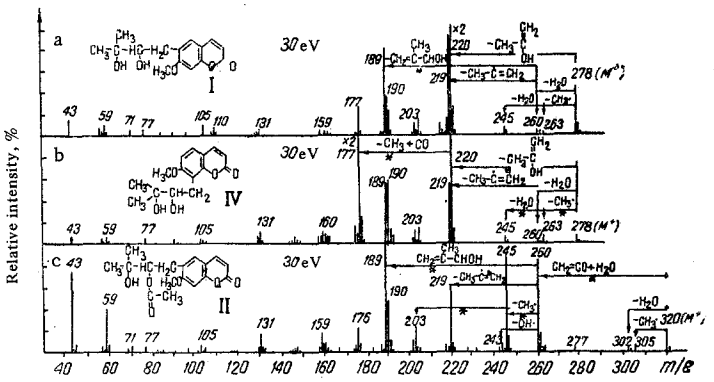


Fig. 3. Mass spectra of a) ulopterol, b) meranzin hydrate, and c) ulopterol monoacetate.

This structure corresponds to that of the methyl ether of peucedanol (V) [5], obtained by the methylation of peucedanol. However, the melting point of I differs from that of V. Compounds I and V are evidently optical isomers.

EXPERIMENTAL

Isolation of ulopterol (I). The resin, 10 g, was chromatographed on a column (1.5 × 40 cm) of alumina (50 g, activity grade II). Elution was carried out with petroleum ether (for fractions 1–7), a mixture of petroleum ether and chloroform (3 : 1) (for fractions 8–10), chloroform (for fractions 11–16), and methanol (for fractions 17–20). The volume of each fraction was 50 ml. After the solvent had been distilled off, the chlorofrom fractions yielded I, $C_{15}H_{18}O_5$, mp 141.5–142.5° C (from benzene), R_f 0.19 (Al_2O_3, activity grade III, ethyl acetate). Yield 0.45 g. Found, %: C 64.66; H 6.27. Calculated for $C_{15}H_{18}O_5$, %: C 64.74; H 6.47.

Acetylation of I. A mixture of 0.0117 g of I, 0.06 g of freshly fused sodium acetate, and 1 ml of acetic anhydride was heated in a water bath for 4 hr. After cooling, it was diluted with water (5 ml) and extracted with ether (4 × 5 ml). The ethereal extract was washed with water and dried over anhydrous sodium sulfate. Then the ether was distilled off under vacuum and the residue was separated preparatively in a thin layer of alumina. This gave 0.0062 g of II, $C_{17}H_{20}O_6$, mp 141.5–142.5° C (from petroleum ether), R_f 0.45 [Al_2O_3 of activity grade II, benzene–ethyl acetate (4 : 6)], and 0.004 g of III, $C_{19}H_{22}O_7$, mp 118–120° C (from petroleum ether), R_f 0.89 [Al_2O_3 of activity grade II, benzene–ethyl acetate (4 : 6)]. A mixture of II with an authentic sample of I gave a depression of the melting point.

The IR spectra were taken on a UR-20 spectrometer (mulls in paraffin oil) the UV spectra on an SF-4 spectrophotometer (solutions in ethanol), the NMR spectra on a JNM-4H-100 spectrometer, and the mass spectra on a MKh-1303 instrument. The melting points were determined on a Kofler instrument.

CONCLUSIONS

A new coumarin $C_{15}H_{18}O_5$ with mp 141.5–142.5° C (from benzene) has been isolated from the roots and fruit of Prangos uloptera D. C., and it has been called "ulopterol." On the basis of UV, IR, NMR, and mass spectra it has been found to have the structure of 6-(2',3'-dihydroxy-3'-methylbutyl)-7-methoxy-coumarin and is a geometrical isomer of meranzin hydrate.

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