THE STRUCTURE OF DRUPANOL – A NEW PHENOL FROM Psoralea drupaceae

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Psoralea drupaceae (drupe scurfpea) is a well studied plant; the furocoumarins psoralen and angelicin have been isolated from its fruit and roots [1] and the phytoestrogen drupatsin [drupacin] from the fruit [2].

From the fruit of the plant we have isolated a fraction of phenolic compounds consisting, according to a preliminary evaluation, of six substances with R_f 0.22, 0.36, 0.4, 0.55, 0.77, and 0.8.

By repeated column chromatography on silica gel and vacuum distillation we obtained an individual component (I) with the composition $C_{18}H_{24}O$, bp 189-190°C/10 mm Hg, $[\alpha]_D^{20}$ +27° (c 1.0; ethanol), d_4^{20} 0.96105, $[n]_D^{20}$ 1.5480, which we have called drupanol. It is readily soluble in benzene, carbon tetrachloride, ether, and ethanol, and is soluble in water. Its UV spectrum has a maximum at 263.5 nm (log ε 4.23), which shows the presence of a substituted benzene ring. In the presence of alkali, this maximum undergoes a bathochromic shift by 25.5 nm, with a simultaneous increase in intensity (log ε 4.35), showing the presence of a phenolic hydroxyl.

The IR spectrum of (I) (Fig. 1) shows absorption bands at 1610, 1520, and 820 cm^{-1} (1,4-substituted aromatic nucleus), 3380-3420 and 1240 cm^{-1} (phenolic hydroxyl), 840 cm^{-1} (β-isoprenyl group), and 920 and 980 cm^{-1} (vinyl group).

The substance has a neutral character, decolorizes solutions of bromine and $KMnO_4$, forms a brown coloration with diazotized sulfanilamide, and gives no reactions with 2,4-dinitrophenylhydrazine and with ferric chloride. It is readily soluble in a 40% aqueous methanolic solution of caustic potash and on subsequent acidification separates out unchanged. These properties and also its special characteristics show that the oxygen atom is present in the molecule of (I) in the form of a phenolic hydroxyl.

The aceylation of (I) with acetic anhydride in the presence of fused sodium acetate gave an acetate with the composition $C_{20}H_{26}O_2$ in the IR spectrum of which the absorption band of the hydroxy group had disappeared while maxima had appeared at 1770 and 1240 cm^{-1} of a CH_3COO group attached to an aromatic nucleus.

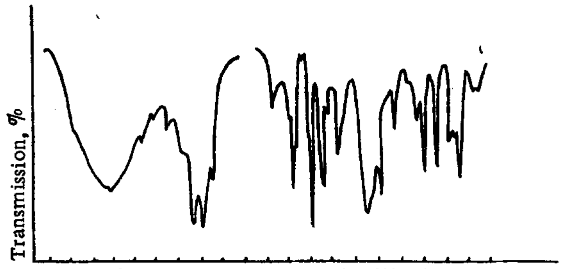

Fig. 1. IR spectrum of drupanol ($CHCl_3$).

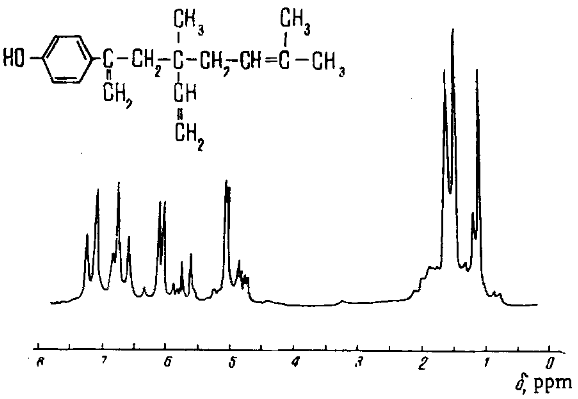

Fig. 2. NMR spectrum of drupanol (CCl_4).

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The catalytic hydrogenation of the acetate of (I) formed its hexahydro derivative, $C_{20}H_{32}O_2$, with bp 204-205°C/10 mm Hg.

In the NMR spectrum of (I) (Fig. 2), in the weak field there is a quadruplet with an intensity of 4 H at 7.06 and 6.58 ppm, J 9.0 Hz, due to two pairs of aromatic protons present in ortho positions. A broadened singlet at 6.75 ppm is due to the presence of the phenolic hydroxyl. In the spectrum of the acetate, the singlet disappears and the doublet at 6.58 ppm is shifted downfield by 0.23 ppm. These facts unambiguously show that the aromatic part of the molecule of (I) consists of a p-hydroxyphenyl radical $HO-C_6H_4-$. This is attached to a substituent with the composition $C_{12}H_{19}$ having a terpenoid nature, as is shown by the signals of vinyl and olefinic protons in the 4.70-6.14-ppm region and signals of methyl groups at 1.12-1.53 ppm. Two one-proton singlets at 6.11 and 6.14 ppm are due to the protons of a vinyl group attached to a quaternary carbon atom $CH_2=C\begin{smallmatrix}\diagup C\\ \diagdown C\end{smallmatrix}$. A group of peaks in the 4.70-5.03-ppm region (2H) and the 5.55-6.02-ppm region (1H) is caused by two vinyl protons interacting with an olefinic proton $CH_2=CH-C\begin{smallmatrix}\diagup C\\ \diagdown C\end{smallmatrix}-C$. The nature of the multiplicity of these signals corresponds to an AB_2 three-spin system with calculated values of δ of 5.72 and 4.92 ppm for A and B, respectively. Two singlets at 1.49 and 1.77 ppm (3H each) and a signal in the 5.0-ppm region superposed on the multiplet of the vinyl protons are due to gem-dimethyl groups at a double bond and to the olefinic protons in a $C-CH=C\begin{smallmatrix}\diagup CH_3\\ \diagdown CH_3\end{smallmatrix}$ grouping; a singlet at 1.10 ppm (3H) is due to a methyl group on a tertiary carbon atom $CH_3-C\begin{smallmatrix}\diagup C\\ -C.\\ \diagdown C\end{smallmatrix}$

In the NMR spectrum of the hexahydroacetate of (I), the signals of the five protons on double bonds have disappeared, and in the strong-field region a doublet at 0.85 ppm, J 7 Hz (6H) and a triplet at 0.77 ppm, J 4.5 Hz (3H) have appeared which are due to the protons of two methyl groups on a secondary carbon atom and one on a primary carbon atom.

In the spectrum of the acetate (I), in addition to downfield shifts of the signals of the aromatic protons by 0.13 and 0.17 ppm, the bands of the protons of the vinyl group $CH_2=C\begin{smallmatrix}\diagup C\\ \diagdown C\end{smallmatrix}$ have also shifted, from which it follows that the double bond of the latter is conjugated with the aromatic nucleus $HO-C_6H_4-\overset{\diagup}{C}=CH_2$.

In view of the above discussions, it may be concluded that the side chain of the molecule of (I) must include the artemisane skeleton and that drupanol itself has the structure of 4-(3,6-dimethyl-1-methylene-3-vinylhept-5-enyl)phenol.

The presence of the conjugated vinyl group in (I) and the resulting difficulty in the formation of a quinoid structure explains certain chemical features of the substance isolated – its insolubility in dilute solutions of caustic alkalis and the absence of a reaction with ferric chloride.

EXPERIMENTAL

The IR spectra were taken on a UR-20 spectrophotometer ($CHCl_3$); the NMR spectra on a JNM-4H-100/100 MHz instrument (CCl_4), the chemical shifts being given in the δ scale from the signal of HMDS taken as 0; the UV spectra on a Hitachi instrument (in ethanol); and the mass spectra on an MKh-1303 instrument. The purities of the substances were determined and the reactions were monitored by the TLC method using a fixed layer of KSK silica gel in the n-hexane–benzene–methanol (5 : 4 : 1) system, the spots being revealed with iodine vapor and with a 1% solution of vanillin in conc. sulfuric acid (brown coloration). The elementary analyses corresponded to the calculated figures.

Isolation of Drupanol. The comminuted fruit (4 kg) was extracted with methanol. The extract was evaporated to small volume, diluted with a twofold amount of water, and treated with benzene. The benzene was distilled off to leave 650 g of a viscous resinous residue. Of this, 50 g was distilled in vacuum, and a fraction was collected at 170-200°C/10 mm Hg. The light brownish oily distillate obtained (26 g) was triturated with 10% caustic potash solution with heating on the water bath, and then the mixture was cooled and was treated with ether. The extract was evaporated to dryness and the residue was chromatographed twice on a column of silica gel with benzene elution. The fraction obtained after the evaporation of the solvent was redistilled in vacuum at 180-192°C/10 mm Hg. This gave 6 g (1.65% of the weight of the raw material) of a yellowish substance of oily consistency with bp 189-190°C/10 mm, M^+ 256, R_f 0.55.

The acetylation of drupanol was performed by a known method by heating it with acetic anhydride in the presence of fused sodium acetate for 3.5 h. The oily product was chromatographed on silica gel twice, with elution by petroleum ether. This gave 0.6 g of a yellowish oil with M^+ 298, R_f 0.7.

Hydrogenation of Drupanol Acetate. A solution of 0.38 g of drupanol acetate in 6 ml of acetic acid was hydrogenated in the presence of 0.032 g of PtO_2. After the catalyst had been separated off, the reaction mixture was diluted, the reaction product was extracted with ether, and the extract was washed with sodium carbonate solution and with water and was dried. Distillation of the ether gave 0.25 g of an almost colorless oily product with M^+ 304, bp 204-205°C/10 mm Hg.

SUMMARY

A new phenol $C_{18}H_{24}O$ which has been given the name drupanol has been isolated from the fruit of *Psoralea drupaceae.* On the basis of the NMR and IR spectra of the substance itself and its acetate and the hexahydro derivative of the acetate it has been established that drupanol is 4-(3,6-dimethyl-1-methylene-3-vinylhept-5-enyl)phenol.

LITERATURE CITED

1. N. K. Abubakirov and U. V. Khalmurzaev, Khim. Prirodn. Soedin., 137 (1967).
2. V. G. Shimanov, "The chemical and pharmacological properties of *Psoralea drupaceae,*" Tr. In-ta Karakulevodstva UzANSKhI, **10**, 299 (1960).