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Abstract

Full Text

Chemistry

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N.M.R. Spectra of the Genins of Ginseng Glycosides

(*Panax ginseng* C. A. Mey)

As was previously reported ([1,2]), several physiologically active glycosides having genins of unknown structure have been isolated from ginseng roots*. From the products of acid hydrolysis of ginseng glycosides, several crystalline substances have been isolated, including the triterpene diol panaxgenin B ([3]), the structure of which was recently established by Shibata and co-workers ([4]), who named this substance panaxadiol. The same authors showed ([5]) that panaxadiol is not a native genin, but is a product of transformation of the latter under hydrolysis conditions.

In the present work we give the results of an investigation, by the nuclear magnetic resonance (N.M.R.) method, of four individual crystalline substances obtained upon hydrolysis of panacoside A and called genins A_1, A_2, A_5, and A_6, with empirical formulas $C_{30-31}H_{50-54}O_{4-6}$**. Taking into account the fact that the structure of these substances has not been chemically proved and that their N.M.R. spectra are rather complex, we draw conclusions only about individual fragments of the structure on the basis of comparison of their N.M.R. spectra with the known spectrum of panaxadiol.

The N.M.R. spectra were recorded on a JNM-3 spectrometer at a resonance frequency of 40 Mc/s. Chemical shifts were measured in parts per million (ppm) from tetramethylsilane, which served as the internal standard. The accuracy of the measurements was 0.05 ppm. Samples of 50 mg of substance dissolved in 0.5 cm^3 of solvent were investigated. Deuterochloroform (panaxadiol, A_5, and A_6) and pyridine (A_1, A_2) were used as solvents. In the case of solutions in deuterochloroform, the weak line at 7.27 ppm is due to a small impurity of $CHCl_3$.

In the N.M.R. spectrum of panaxadiol (Fig. 1, A), signals 1-4 (0.84-1.12 ppm) belong to methyl groups, with the number of methyl groups in each corresponding to 1-2-2-3 ([6]). These groups have been studied in detail in papers ([8–10]).

The unresolved signals 5 and 6 (1.42 and 1.72 ppm) belong to skeletal CH_2 and

Fig. 1. NMR spectra of panaxadiol (A), genin A_5 (B), genin A_2 (V)

Figure 1: Fig. 1. NMR spectra of panaxadiol (A), genin A_5 (B), genin A_2 (V)

CH groups. In the same region lies the signal of the hydroxyl at C_3. The broad signal 7 (3.20 ppm) is given by two protons located in the α-position to the hydroxyl groups at C_3 and C_{12} ([9]). The broadening of this signal is explained by spin-spin interaction with neighboring methylene groups of the skeleton.

Of greatest interest is the singlet line 8 (6.22 ppm), the intensity of which corresponds to one proton. It is natural to assign it to the hydroxyl group at C_{12}, with an intramolecular hydrogen bond to an ether oxygen. This signal makes it possible to judge easily whether the hydroxyl is in a hydrogen bond with ether oxygen, i.e., also the presence of the ether oxygen itself in the genin.

In the spectrum of the least polar genin A_6, there appeared lines which, in form and position, were analogous to the lines of the spectrum of panaxadiol (Fig. 1). From

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* G. B. Elyakov, N. I. Uvarova, R. N. Gorshkova, and N. K. Kochetkov (unpublished).
** Their isolation and chemical properties have been described by G. B. Elyakov, L. I. Strigina, and N. K. Kochetkov (unpublished).

From comparison of the spectra it may be said that the structures of A_6 and panaxadiol are close and that at C_{17}* there is a ring with ether oxygen. The hydroxy–

Fig. 1. NMR spectra of panaxadiol (A), genin A_5 (B), genin A_2 (V)

–acid with an intramolecular hydrogen bond (6.22 m.d.) at C_{12} in the acetate of this genin is retained. Hence it may be concluded that only the hydroxyl at C_3 is acetylated.

* The numbering of the skeletal atoms of the genins studied is taken to be the same as in the triterpenes of the dammarane series.

The NMR spectrum of genin A_5 (Fig. 1,) does not contain the signal of a hydroxyl bound by a hydrogen bond to ether oxygen ($\sim$ 6 ppm), but a narrow peak appears at 3.02 ppm. This signal is superimposed on the broadened signal from protons in the α-position to the hydroxyl groups at C_3 and C_{12}. Apparently, this signal is due to two hydroxyl groups at C_{12} and C_{18}, bound to one another by hydrogen bonds:

{ [[structural formula: two hydroxyl groups hydrogen-bonded, labeled C_{12} and C_{18}]] }

Here it must be assumed that such hydrogen bonds lead to a smaller shift than a hydrogen bond to ether oxygen. In the spectrum of genin A_5 acetate, only one acetoxy group is observed, and the intensity of line 7 does not change. This may be regarded as an indication that hydroxyls bound by a hydrogen bond are not acetylated, as in the case of genin A_6.

In the NMR spectrum of genin A_2 (Fig. 1,), which is more polar than A_6 and A_5, a new line 9 appears at 4.92 ppm. In intensity and position it corresponds to a CH_2 group at a double bond, which permits the following structure to be proposed:

{ [[structural formula: fragment bearing $2OH$, hydrogen-bonded hydroxyls, and an exocyclic CH_2 at C_{22}]] }

As confirmation of this conclusion, one should note the signal at 1.68 ppm, which by its position corresponds to a CH_3 group at a double bond. Signal 8 (3.08 ppm), by analogy with the spectrum of genin A_5, should be assigned to two hydroxyls with a hydrogen bond at C_{12} and C_{18}.

Signals 5, 6, and 7 are difficult to assign to definite groups. 3 (1.37 ppm) is a skeletal signal; 1 and 2 are methyl groups.

The spectrum of the most polar genin A_1 does not contain hydroxyls with a hydrogen bond. Evidently the side chain at C_{17} is arranged in such a way that the formation of a hydrogen bond is hindered.

On the basis of the NMR spectra, it may be concluded that in going from the most polar genin A_1 to the least polar A_6, the side chain at C_{17} closes into a ring with ether oxygen (with the formation of hydrogen bonds in A_2, A_5, A_6).

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Note: Figure translations are in progress. See original paper for figures.