CONVERSION OF ASCORBIGEN AND ITS DERIVATIVES TO SUBSTITUTED
1-DEOXY-1-(INDOLYL-3)-α-L-SORBOPYRANOSE

I. L. Plikhtyak, I. V. Yartseva, N. A. Klyuev, and M. N. Preobrazhenskaya

A new reaction involving L-ascorbic acid have been found. Under the action of alkali, ascorbigen and its N-alkyl derivatives undergo cleavage of the lactone ring, decarboxylation, and rearrangement to give 1-deoxy-1-(indolyl-3)-α-L-sorbopyranose and its N-alkyl derivatives. The structures of the compounds obtained were confirmed by mass-spectroscopy and PMR spectroscopy.

Ascorbigen -- 2-C-[(indolyl-3)methyl]-β-L-threo-L-glycero-3-hexulofuranosono-1,4-lactone (Ia) -- is formed in leafy plants from ascorbic acid and indole derivatives. Synthetic ascorbigen and its analogs have been obtained by the reaction of L-ascorbic acid. With 3-hydroxymethylindole and its derivatives [1]. We have studied the conversion of ascorbigen in aqueous alkali and have found that the lactone Ia undergoes ring opening, decarboxylation, and rearrangement to give 1-deoxy-1-(indolyl-3)-α-L-sorbopyranose (IIa) in about 30% yield. Similar changes occurred with 1-methyl- (Ib), 1-allyl- (Ic), and 1-butylascorbigens (Id).

A possible intermediate in the reaction is the ion II. A reaction of this type has been described for the lactone 2-C-benzyl-3-ketohexulonic acid, obtained from the reaction between sodium ascorbate and benzyl chloride in acetone. The product of the alkaline treatment of the C-benzyl derivative was assigned the structure 1-deoxy-1-C-phenyl-2-hexulose, the stereochemistry of which is not known [2].

Mass-spectroscopy using a secondary ionization source (bombardment with high-speed atoms [3]) was used to confirm the structure of the deoxysorboses IIIa-d and to study their fragmentation path. The mass spectra of compounds IIIb-d (see Experimental part) contain peaks from the protonated molecular ion MH⁺, the ion M⁺ itself, and the ion fragment [M – H]⁺. Peaks from the ion Φ, which is of maximum intensity in the spectra of all the compounds, together with the peaks from the ion Φ, indicate the presence of an indole group in the

molecule IIlb-d. These are formed by the specific cleavage of bonds $ to the indole nucleus, followed by ring expansion to give a quinoline cation [4]. Also in the mass spectra of compounds IIlb-d, there are ion peaks arising from the cleavage of the alkyl substituent $ from the ions $ and $, with m/z 129 and 130 respectively. The appearance of the ion with m/z 103 is explained by the absence of substituents at position 2 of the indole nucleus [4]; it is formed by the ejection of a particle of HCN from the ion fragment ($ - R$)$^+$. The spectrum of the allyl derivative IIlc has peaks from ions formed by splitting off CH=CH$_2$ from $ and $, and the spectrum of the butyl derivative IIId has peaks from ions formed as a result of the elimination of CH$_3$, C$_2$H$_5$, and C$_3$H$_7$ radicals from the n-butyl substituent.

Thus the indole part of the molecule IIlb-d is adequately confirmed by mass spectroscopic data. In contrast to this, the carbohydrate part of compounds IIlb-d is not seen in the mass spectra (calculated mass 150 amu). The mass spectra contain peaks corresponding to the ion fragments [M - H, -H$_2$O]$^+$, [M - H, -C$_2$H$_4$O$_2$]$^+$ and [M - H, -H$_2$O]$^+$, which are characteristic for sugars [5].

The IR spectra of compounds IIla-d contain no carbonyl-group absorptions.

In the PMR spectra of the sorboses IIla-d, the protons of the indole part of the molecule can be clearly seen. An increase in the coupling constants $J_{1,1'}$ for compounds IIla-d in comparison with $\alpha$-L-sorbopyranose (IV) indicates conjugation of the methylene group with the indole ring. In the region where carbohydrate protons absorb the spectrum is very similar to that of $\alpha$-L-sorbopyranose (IV) (see Table 1). Based on the values of the constants $J_{3,4}$, $J_{4,5}$, and $J_{5,6}$, which correspond to trans-diaxial interaction of the protons, compounds IIla-d, and also compound IV, have the conformation $^2C_5$. The $\alpha$-configuration of compounds IIla-d is confirmed by a comparison of the PMR spectra of compounds IIla-d and IV. For compounds IIla-d, signals of the 3-H and 5-H atoms show an upfield shift ($\Delta \delta \approx 0.2$ ppm) in comparison with those of the sorbopyranose IV, but the 4-H and 6a-H signals are unchanged, suggesting that in all cases the hydroxyl group at atom C(2) is in the axial position, i.e., the $\alpha$-configuration.

Acetylation of compounds IIla-d in pyridine with acetic anhydride at 0°C gave a complex mixture of compounds, which could not be separated. It appears that the conversion of the tautomeric forms of deoxysorbose IIla-d and their partially acetylated derivatives occurs very readily. Acetylation of the ketose usually gives a mixture of isomers, however, for D-fructose it was shown that if the acetylation is carried out at low temperatures then primarily $\beta$-D-fructopyranose derivatives are formed [6]. We succeeded in obtaining the individual 3,4,5-tri-O-acetate $\alpha$-L-sorbopyranose (V) by dissolving compound IIId in pyridine at $-40^\circ$C and then adding acetic anhydride at the same temperature; the reaction mixture is maintained at a temperature below $-20^\circ$C. Under these conditions the hydroxyl group at atom C(2) is not acetylated. This can be seen from a comparison of the PMR spectra of the tri-O-acetate V and the starting compound IIId. The spectrum of compound V shows a characteristic downfield displacement ($\Delta \delta \approx 2.00$ ppm) of protons on carbon atoms of acetoxy groups.

It is impossible to exclude the possibility of formation of 1-deoxy-1-(indolyl-3)-$\alpha$-L-sorbopyranose from ascorbic acid in living organisms via the formation of ascrobigen.

**EXPERIMENTAL**

The IR spectra of the compounds in KBr pellets were taken on a Perkin Elmer IR-283. PMR spectra were obtained on a Bruker WH-360 spectrometer with a working frequency of 360 MHz, internal standard, tetramethylsilane. Signals were assigned using the double resonance method. Mass spectra of bombardment with high-speed atoms were obtained on a Varian MAT-331A with an attachment developed by AMD. The compounds were dissolved in dimethylsulfoxide and introduced mixed with glycerin. Bombardment was with Xe$^+$ ions. The power of the Xe$^+$ beam was 0.3-3.4 W, accelerating voltage of the Xe$^+$ ions was 2-4 kV, the current of the bombarding ions 0.2-1.0 mA; accelerating voltage for the secondary ions was 3 kV. For the mass-spectra of compounds IIlb-d, the background spectrum was subtracted (background + DMSO + glycerin).

TLC was carried out using Silufol UV-254 plates, preparative chromatography on silica gel LSL 5/40 μm from Chemapol. Chromatography was carried out on plates (20 x 20 cm) with a mobile layer of silica gel of thickness 1.0 mm, chromatograms were view in UV light or sprayed (silufol) with Ehrlich's reagent. The following solvent systems were used: chloroform-methanol; 8:1 (A), ethyl acetate-acetone, 2:1 (B), and chloroform-ethyl acetate, 5:1 (C).