CARDIAC GLYCOSIDES OF CHEIRANTHUS ALLIONI

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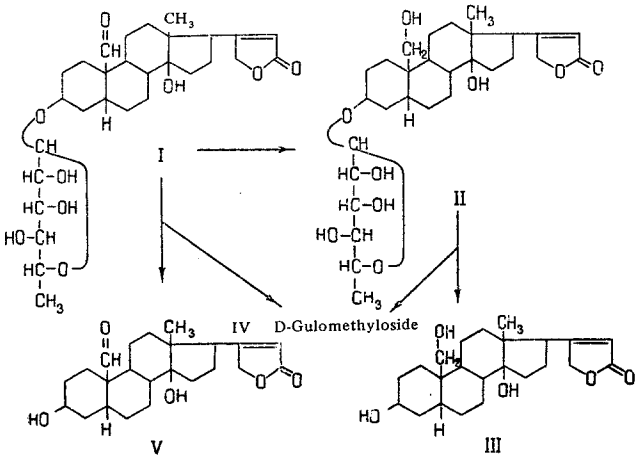
As already reported [1–3], the seeds of Cheiranthus allioni Hort. (Erysimum asperum, plains erysimum) has yielded a number of cardiac glycosides: erysimin, desglucoerycordin, glucodigifucoside, erysimoside, erycordin, alliside, and alliotoxin. Maksyutina [4] has also isolated allionin and violin. Continuing our study of the seeds of this plant, we have isolated four more glycosides (of the group of cardenolides of "moderate" polarity [1]). Three of them have been identified as helveticosol [5], erysimosol [6–8], and desglucocheirotoxin [9]. The fourth cardenolide, which we have called "cheiranthoside" is new. A sample of allionin kindly given to us by N. P. Maksyutina proved, according to its paper-chromatographic behavior, mixed melting point, and color reactions with H_2SO_4, to be identical with glucodigifucoside [10, 11].

Cheiranthoside has the composition $C_{29}H_{42}O_9$, which corresponds to that of a steroid monoglycoside. Its UV spectrum shows two absorption maxima: $\lambda_{max}^{C_2H_5OH}$ 217 and 296 mμ (log ε 4.19 and 1.73). The first of them is due to a butenolide ring and the second to an aldehyde group. The presence of an aldehyde group was confirmed by the formation of an acid on oxidation with potassium permanganate. The glycoside was very readily oxidized in solution by atmospheric oxygen, which complicated the determination of its structure. Consequently it was converted, by reduction with sodium borohydride, into the more stable compound II. The melting point of the latter, a mixed melting point test, the results of paper chromatography, and the IR spectrum (taken by I. P. Kovalev) showed its identity with desglucoerycordin, which is cannogenol 3-β-D-gulomethylopyranoside (II) [12].



When compound II was hydrolyzed by the Mannich-Siewert method [13], the aglycone and a monosaccharide were obtained in the pure state and were identified, respectively, as cannogenol (III) and D-gulomethylose (IV). On this basis, it was concluded that cheiranthoside is cannogenin 3-β-D-gulomethylopyranoside (I). The hydrolysis of the glycoside (I) carried out on a micro scale and an investigation of the hydrolysis products by paper chromatography confirmed that the aglycone of cheiranthoside is cannogenin (V) (a sample of cannogenin was kindly given to us by Prof. N. K. Abubakirov) and the sugar component is D-gulomethylose. Thus, cheiranthoside (I) can be characterized as 3β-(O-β-D-gulomethylopyranosyl-14β-hydroxy-19-oxo-5β-H-card-20(22)-enolide.

EXPERIMENTAL

The following solvent systems were used to identify the cardenolides by paper chromatography: toluene–butan-

1-ol (2.5 : 1)/water, tetrahydrofuran–chloroform (1 : 1)/formamide, and m-xylene–methyl ethyl ketone (1 : 1)/formamide. The monosaccharides were chromatographed on paper in a butan-1-ol–methyl ethyl ketone–borate buffer (1 : 1 : 2) system. The borate buffer consisted of equal volumes of 0.1 M aqueous H_3BO_3 and of 0.1 M aqueous $Na_2B_4O_7$. The cardiac glycosides were purified and separated by the method described previously [1].

Helveticosol. The glycoside crystallized from acetone, gave a positive Keller-Kiliani reaction, melted at 166–171° C, and had $[\alpha]_D^{26}$ +27.1 ± 3° (*c* 0.78, methanol). A solution of 60 mg of the glycoside in 20 ml of 0.05 N H_2SO_4 was heated at 80° C for 45 min. The aglycone was extracted from the solution with an ethanol–chloroform mixture (1 : 3, 4 × 20 ml). The ethanol–chloroform extract was treated with 5 ml of 2 N sodium carbonate solution and water (3 × 5 ml), and then evaporated in vacuo. The residue was crystallized from acetone. The aglycone melted at 140–144° C, and on paper chromatography had the same R_f values as strophanthidol. A mixture melted at 140–146° C. The aqueous solution, free from the aglycone, was neutralized with barium carbonate, filtered, and evaporated. The residue, which consisted of the sugar component of the glycoside, was identified as D-digitoxose by paper chromatography.

Desglucocheirotoxin. The substance crystallized from aqueous solution, mp 188–192° C, $[\alpha]_D^{25}$ −4.2 ± 3° (*c* 0.84, methanol). With conc H_2SO_4 it formed colors which changed with time: 0 min) yellow, 130 min) brown, 240 min) red. The UV spectrum showed two absorption maxima: $\lambda_{max}^{C_2H_5OH}$ 219 and 305 mμ (log ε 4.22 and 1.51). A mixture with desglucocheirotoxin (sample kindly given to us by N. F. Komissarenko) gave no depression of the melting point (188–192° C).

Erysimosol. The glycoside had mp 172–176° C (from acetone) and $[\alpha]_D^{24}$ +21.6 ± 3° (*c* 0.95, methanol). The cardenolide, 40 mg, was hydrolyzed by a known method [14] with an enzyme preparation obtained from the grape snail. The resulting monoglycoside and monosaccharide were identified by paper chromatography as helveticosol and D-glucose. A mixture of the diglycoside with erysimosol melted at 172–176° C.

Cheiranthoside. The cardenolide crystallized from water. It melted at 154–156° C and $[\alpha]_D^{22}$ −41.3 ± 3° (*c* 1.12, methanol). With conc H_2SO_4 it formed colors which changed with time: 30 sec) yellow, 20 min) yellow-orange, 60 min) orange, 240 min) red.

Found, %: C 64.89; H 7.84. Mol wt 538.2. Calculated for $C_{29}H_{42}O_9$, %: C 65.15; H 7.92. Mol wt 534.6.

During 25 min, 0.35 g of sodium borohydride was added to a solution of 0.25 g of cheiranthoside (I) in 30 ml of 80% dioxane. The solution was mixed with 250 ml of ethanol–chloroform (1 : 2), 0.5 g of mannitol was added, and it was treated with water (4 × 10 ml) and evaporated. The residue was dissolved in ethanol–chloroform (1 : 4) and purified with alumina (activity grade III). It was crystallized from acetone. The resulting glycoside (140 mg) melted at 160–164° C, and $[\alpha]_D^{26}$ −22.6 ± 2° (*c* 1.23, methanol). With conc H_2SO_4 it formed colors which changed with time: 0 min) yellow, 130 min) brown, 240 min) red. On paper chromatography, it showed the same R_f values as desglucoerycordin (II). The IR spectra (obtained on a UR-10 spectrometer with LiF and NaCl prisms in tablets of potassium bromide) of reduced cheiranthoside and of desglucoerycordin were identical.

When 110 mg of reduced cheiranthoside was hydrolyzed by the Mannich-Siewert method [13], the aglycone and a monosaccharide were obtained. The aglycone (cannogenol) had mp 236–239° C, and $[\alpha]_D^{26}$ +29.1 ± 2° (*c* 0.98, methanol). The monosaccharide (D-gulomethylose) melted at 124–129° C, and its phenylosazone melted at 181–182° C.

Cheiranthoside (I) (10 mg) was hydrolyzed by the Mannich-Siewert method [13] for 3 days; the aglycone moiety and the sugar component were separated in the usual way (see above). Paper chromatography of the hydrolysis products showed that they contained the aglycone cannogenin and the monosaccharide D-gulomethylose.

CONCLUSIONS

Four more glycosides have been isolated from the seeds of Cheiranthus allioni Hort. Three of them were identified as helveticosol, desglucocheirotoxin, and erysimosol. The fourth glycoside, which we have called "cheiranthoside," is new and has the structure of cannogenin 3-β-D-gulomethylopyranoside.

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