NECIC ACIDS

IV. Saponification of the Chlorodilactone with Aqueous Alkali*

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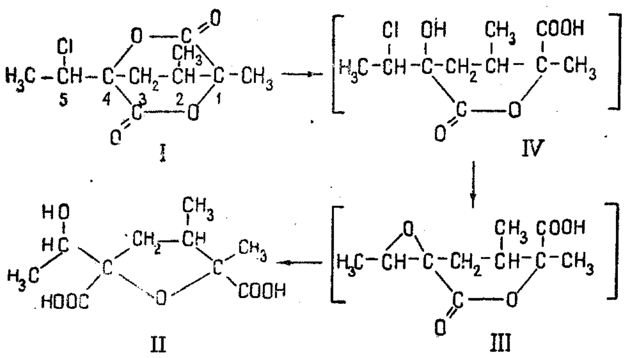
The saponification of the chlorodilactone from epoxy-jaconecic acid [1] with aqueous alkali has not been elucidated in detail in the literature. However, the course of this reaction is unusual and its discussion offers interest.

In preceding communications [2, 3] we have put forward the hypothesis that the action of alkaline reagents on the chlorodilactone (I) not only saponifies the lactone rings but also eliminates halogen from C_5 and hydrogen from the hydroxyl on C_1 with the formation of an oxygen-containing ring. In this case, the reaction product must be expected to be an acid having a tetrahydropyran structure. However, the saponification of the chlorodilactone with aqueous alkali gives an almost quantitative yield of jaconecic acid (II) [4, 5], which contains a tetrahydrofuran ring. Only by saponifying the chlorodilactone with alcoholic alkali did Bradbury and Willis [6] obtain isojaconecic acid with the tetrahydropyran structure in addition to jaconecic acid. The pseudojakonecic acid that we obtained by saponifying the dilactone of the bromohydrin of trans-senecic acid [2] also apparently has the tetrahydrofuran structure. This is indicated by the fact that the triol formed by the lithium aluminum hydride reduction of the dimethyl ester of this acid is not oxidized by periodic acid, i.e., it does not contain an α-glycol group.

Thus to explain the course of the saponification of the halogenodilactones, it is necessary to assume the formation during the reaction of intermediates capable of yielding a tetrahydrofuran ring. Since it is known that the saponification with aqueous alkali of the acetoxydilactone of jacolinecic acid leads to unchanged jacolinecic acid [7], there is a strong presumption that the halogen atom is replaced by hydroxyl in one of the first stages of the reaction considered. Consequently, it appeared to us to be most probable that the lactone of epoxy-jaconecic acid (III) is formed as the intermediate in the saponification of the chlorodilactone with aqueous alkali. This lactone was obtained previously by the action of moist silver oxide on the chlorodilactone; its structure has been demonstrated [1]. The lactone of epoxy-jaconecic acid is saponified to jaconecic acid in high yield.

It is possible that only one lactone ring of the chlorodilactone is saponified in the first stage of the reaction under consideration. The monolactone so obtained (IV), which has the structure of a chlorohydrin, undergoes ring closure in an alkaline medium to form an epoxide bridge and yield the lactone of epoxy-jaconecic acid (III). The further action of alkali leads to the saponification of the lactone of epoxy-jaconecic acid, which takes place with the simultaneous cleavage of the epoxide bridge at C_4 and the formation of the tetrahydrofuran ring.

It has been found that the lactone rings of the dilactone of sceleranecic acid also have different stabilities. This compound absorbs one mole of alkali at room temperature and a second mole on heating with an excess of alkali [8]. Moreover, the ease of conversion of the chlorohydrin structure into the epoxide structure and conversely is confirmed by the interconversion of the alkaloids jaconine and jacobine under mild conditions [9, 6].



Experimental

Reduction of dimethyl pseudojaconecate with $LiAlH_4$. A solution of 2.0 g of dimethyl pseudojaconecate in 50 ml of absolute ether was added in drops to a suspension of 2.0 g of $LiAlH_4$ in 100 ml of absolute ether. The reaction mixture was boiled for 6 hr, cooled, and acidified with 100 ml of 10% hydrochloric acid. The aqueous layer was evaporated in vacuum, and the residue was mixed with powdered calcined calcium sulphate and extracted with ether in a Soxhlet apparatus for 10 hr. The residue from the ether was dried in a vacuum desiccator. Weight 1.67 g, $[\alpha]_D^{18}$ + 13.0° C (c 1.3; alcohol). The oxidation of 1 mole of the substance obtained consumed 0.001 mole of periodic acid.

Tri-p-nitrobenzoyl derivative. A mixture of 1.53 g of the reduction product and 7.0 g of p-nitrobenzoyl chloride in 10 ml of pyridine was left for 16 hr at 20° C. Then it was diluted with 50 ml of water and extracted with chloroform. The chloroform solution was washed with 10% sulfuric acid, with water, and with sodium hydrogen carbonate solution, and was dried over sodium sulfate. This gave 3.0 g of a crystalline residue with mp 161°–163° C from a mixture of chloroform and anhydrous alcohol (2 : 1).

Found, %: C 57.38; H 4.50; N 6.58. Calculated for $C_{31}H_{29}N_3O_{13}$, %: C 57.14; H 4.49; N 6.45.

Saponification of the chlorodilactone from epoxy-jaconecic acid with aqueous alkali. A mixture of 2.0 g of the chlorodilactone from epoxy-jaconecic acid and 2.24 g of caustic soda in 11.2 ml of water was boiled for 1 hr. The cooled solution was acidified with H_3PO_4 and extracted with ether. The ethereal extract was dried over sodium sulfate. The ether was evaporated off to leave a crystalline residue, 1.80 g (90%), R_f 0.55 in the butanol – 5% acetic acid (1:1) system; mp 182°–183° C (from ethyl acetate), $[\alpha]_D^{20}$ + 28.0° (c 1.0; alcohol). The substance gave no depression of the melting point in admixture with authentic jaconecic acid.

Saponification of the lactone of epoxy-jaconecic acid with aqueous alkali. A mixture of 0.27 g of the lactone of epoxy-jaconecic acid and 10 ml of 10% caustic soda was heated in a boiling water bath for 2 hr. The reaction mixture was cooled, acidified with hydrochloric acid, and extracted with ether. The ethereal extract was dried over sodium sulfate and the solvent was evaporated. The residue amounted to 0.22 g (88%), R_f 0.56, mp 180°–182° C (from ethyl acetate). It gave no depression of the melting point in admixture with jaconecic acid.

Summary

A reaction mechanism for the saponification of the chlorodilactone from epoxy-jaconecic acid with aqueous alkali has been proposed.

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