Academician **I. N. Nazarov**, V. F. Kucherov, V. M. Andreev, and G. M. Segal’

1958

SovietRxiv

Abstract

Full Text

Chemistry

Academician **I. N. Nazarov**, V. F. Kucherov, V. M. Andreev, and G. M. Segal'

Stereochemistry of the Diene Condensation of 1-α-Acetoxyvinyl-Δ^1-cyclohexene with Maleic Anhydride

As was shown in one of the preceding communications (1), the condensation of 1-α-acetoxyvinyl-Δ^1-cyclohexene with maleic anhydride in boiling benzene gives a liquid adduct I, on saponification of which with water, in a yield of up to 85%, an individual anti-cis-4-acetoxy-Δ^4-octalin-1,2-dicarboxylic acid II is formed. Its configuration was proved by conversion into the trans-anti-cis-4-keto acid III, which on Clemmensen reduction gave the known trans-anti-cis-decalin-1,2-dicarboxylic acid IV.

I II III IV

On the basis of these data it was concluded that the liquid adduct I formed has the anti-cis configuration and that the diene condensation under these conditions proceeds mainly contrary to the rule of accumulation of unsaturation. A more detailed investigation showed that the liquid adduct I is not individual and contains a small amount of the isomeric syn-cis-4-acetoxy anhydride V, which English chemists (2) recently succeeded in obtaining in the condensation of 1-α-acetoxyvinyl-Δ^1-cyclohexene with maleic anhydride at room temperature. It was found that, on acid saponification of the crystalline mixture remaining after isolation of anti-cis-4-acetoxy acid II, the isomeric trans-syn-cis-4-keto acid VI, m.p. 177–178°, can be obtained in 8% yield and characterized in the form of the crystalline diester VII. This diester is readily isomerized by sodium methoxide into the known trans-anti-trans-4-keto diester IX (1) and, on Clemmensen reduction, gives the previously described trans-syn-cis-decalin-1,2-dicarboxylic acid X (3).

This same trans-syn-cis-4-keto acid VI can be isolated, in a yield of up to 10-15%, from the products of acid saponification of the individual anti-cis-4-acetoxy acid II. The latter fact proved rather unexpected and indicates that either the starting anti-cis-4-acetoxy acid II is not completely individual, or the saponification of the epolacetate group is not stereospecific. Since the individuality of the anti-cis-4-acetoxy acid II apparently leaves no doubt, it seems probable to us to accept the second supposition, all the more so since some cases of anomalous isomerization in transformations of cyclic compounds have been described in reaction scheme: formation and transformations of compounds II–XII

Figure 1: reaction scheme: formation and transformations of compounds II–XII

the literature (4). If the saponification of anti-cis-4-acetoxy acid II does indeed proceed with formation of both trans compounds (III and IV), then, taking into account the possibility of the same isomerization during acid saponification of the liquid adduct I, it should be considered that the content in it of the isomeric syn-cis anhydride V apparently does not exceed 5–6%.

The trans-syn-cis-4-keto acid VI obtained by us and its diester VII proved to differ in their constants from those described by the English authors (2), which required special proof of their configuration. For this purpose, the syn-cis anhydride XI was oxidized with osmium anhydride, and, after decomposition of the complex and treatment of the hydroxylation product with diazomethane, the ester of the cis-glycol XII was isolated; its configuration corresponds to addition of osmium anhydride from the side opposite to the carboxyl groups (5). This glycol, owing to the axial position

of the tertiary hydroxyl group, proved capable of being dehydrated very readily on heating with *p*-toluenesulfonic acid and gave the trans-syn-4-keto diester VII described above.

Since such a transformation does not directly affect the centers of asymmetry at C_2, C_2 and C_9 and leads to trans fusion of the rings, it may be considered that the keto ester formed in this reaction as the main product indeed has the trans-syn-cis configuration, which is a sufficiently unambiguous confirmation of the configuration of the 4-keto acid VI and its diester VII obtained in the diene synthesis.

The fact that the crystalline syn-cis anhydride V, obtained by the English investigators, gave saponification products different from those described by us shows that saponification of this anhydride is apparently accompanied by side isomerization reactions, which did not allow these authors to isolate the trans-syn-cis-4-keto acid and its diester in sufficiently pure form.

Experimental Part*

Isolation of trans-syn-cis-4-ketodecalin-1,2-dicarboxylic acid VI and its diester VII. A mixture of 10 g of liquid anhydride, obtained by the condensation of 1-α-acetoxyvinyl-Δ^1-cyclohexene with maleic anhydride in boiling benzene (1), and 45 ml of water was boiled until complete dissolution (10–15 min). The crystalline product that separated on slow cooling (after 3 h) was filtered off—

* All melting-point values are corrected.

filtered and 9 g of the previously described anti-cis-4-acetoxy acid II with m.p.

209–211° was obtained.

From the mother liquor, on further standing, an additional 1.2 g of crystalline product with m.p. 150–180° was isolated; this was saponified by boiling with 6 ml of 0.05% hydrochloric acid, and the resulting solution was evaporated to one-half. On cooling, 0.8 g of trans-syn-cis-ketodecalin-1,2-dicarboxylic acid VI separated as a crystalline hydrate with m.p. 136–139°, which after two recrystallizations from water and drying in air melted with decomposition at 142–144°.

Found, %: C 55.84; 55.95; H 6.98; 7.03
$C_{12}H_{16}O_5 \cdot H_2O$. Calculated, %: C 55.80; H 7.02

On drying in vacuum at 80° over calcium chloride, anhydrous trans-syn-cis-4-ketodecalin-1,2-dicarboxylic acid VI with m.p. 177–178° was obtained.

Found, %: C 59.83; 59.96; H 6.85; 6.72
$C_{12}H_{16}O_5$. Calculated, %: C 59.99; H 6.71

Found M 241.2 (by titration with NaOH); calculated M 240.2. On treatment of trans-syn-cis-4-keto acid VI with an ethereal solution of diazomethane, trans-syn-cis-4-keto diester VII was obtained in quantitative yield; after crystallization from a mixture of ether and petroleum ether it had the constant m.p. 93–94° and gave a sharp depression with the isomeric keto diesters VIII and IX.

Found, %: C 62.46; 62.42; H 7.36; 7.47
$C_{14}H_{20}O_5$. Calculated, %: C 62.67; H 7.51

The 2,4-dinitrophenylhydrazone obtained from trans-syn-cis-4-keto diester VII, after crystallization from a mixture of alcohol and chloroform, melted at 208–209° and gave a depression (180–190°) with the dinitrophenylhydrazone of the isomeric trans-anti-cis-4-keto diester VIII.

Found, %: C 53.59; 53.34; H 5.41; 5.45; N 12.67; 12.58
$C_{20}H_{24}O_8N_4$. Calculated, %: C 53.52; H 5.39; N 12.49

Saponification of anti-cis-4-acetoxy-Δ^4-octalin-1,2-dicarboxylic acid II. A mixture of 8 g of anti-cis-4-acetoxy dicarboxylic acid II with m.p. 210–212°, 50 ml of water, and 10 ml of 3% hydrochloric acid was boiled for 15 min, after which the solution was evaporated to one-third of its original volume. On standing, 6.8 g of a mixture of monohydrates of the isomeric keto acids III and VI with m.p. 108–115° gradually separated. Crystallization of this mixture from 32 ml of water gave 4.6 g of material with m.p. 115–118°; repeated crystallization of this from water gave 3.7 g of pure crystalline hydrate of trans-anti-cis-4-keto acid III with decomp. 121–123°, which gave no depression with the material described earlier (^{1}).

From the mother liquor from the first crystallization, after standing for 2 days, 2 g of crystalline product with m.p. 122–129° separated. After three crystallizations of this product from water, 1 g of trans-syn-cis-4-keto acid VI was isolated as a monohydrate with m.p. 142–144°; on drying it in vacuum, pure trans-syn-cis-4-ketodecalin-1,2-dicarboxylic acid VI with m.p. 176–177° was obtained, which gave no depression with the specimen described above.

Preparation of cis-glycol XII and its dehydration. To a solution of 3 g of syn-cis-anhydride XI in 200 ml of absolute ether, 4 g of osmium anhydride was added, and the mixture was left for 5 days at room temperature. The ether was distilled off, the residue was dissolved in 200 ml of alcohol, a solution of 28 g of sodium sulfite in 150 ml of water was added, and the mixture was boiled for 4 h. The precipitate that separated was filtered off, and the mother liquor was evaporated to a volume

25–30 ml; the crystalline hydroxylation product was filtered off and treated with an excess of an ethereal solution of diazomethane. After removal of the ether, 3.2 g of the ester of the cis-glycol XII was obtained, which, after crystallization from a mixture of ether and methanol (5 : 1), had a constant m.p. of 122–123°.

Found, %: C 58.76; 58.60; H 7.78; 7.71
$C_{14}H_{22}O_6$. Calculated, %: C 58.73; H 7.74;

For dehydration, a mixture of 1.4 g of cis-glycol XII and 0.1 g of *p*-toluenesulfonic acid was heated at 120–130° and a vacuum of 100 mm for 10 min. The reaction product was extracted with ether; the ethereal solution was washed with water and dried over sodium sulfate, and the ether was distilled off. The liquid residue gradually crystallizes on standing with dilute hydrochloric acid (1 : 1). Thus 0.9 g of trans-syn-cis-4-keto diester VII was obtained, which, after crystallization from a mixture of ether and petroleum ether, had m.p. 92–94° and did not give a depression with the sample obtained above.

On reduction of keto diester VII by the Clemmensen method, trans-syn-cis acid X was obtained in good yield, with m.p. 173–175° (^{3}).

Conclusions. It has been shown that the liquid adduct formed in the condensation of 1-α-acetoxyvinyl-Δ^1-cyclohexene with maleic anhydride in boiling benzene, along with the principal anti-cis-4-acetoxyanhydride I, contains a small amount (5–6%) of the isomeric syn-cis adduct V. The presence of this isomer, formed as a result of the reaction proceeding in accordance with the Alder principle, was demonstrated by obtaining the corresponding trans-syn-4-keto acid VI and diester VII, the configuration of which was proved by dehydration of cis-glycol XII.

Institute of Organic Chemistry named after N. D. Zelinsky
Academy of Sciences of the USSR

Received
21 XII 1957

REFERENCES

[1] I. N. Nazarov, V. F. Kucherov, V. M. Andreev, *Izv. AN SSSR, OKhN*, **1957**, 331.
[2] M. Ansell, G. Brooks, *J. Chem. Soc.*, **1956**, 4518.
[3] I. N. Nazarov, V. F. Kucherov, V. M. Andreev, *Izv. AN SSSR, OKhN*, **1957**, 471.
[4] P. A. Robins, J. Walker, *J. Chem. Soc.*, **1954**, 3960.
[5] V. F. Kucherov, G. M. Segal, I. N. Nazarov, *Izv. AN SSSR, OKhN*, **1957**, 367.

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