A Novel Transannular Cyclisation in the Solid State

By W. Heggie and J. K. Sutherland*
(*Chemistry Department, The University, Manchester* M13 9PL)

Summary The epoxy-alcohol (**12**) is stable when dissolved in organic solvents and 0·25N-sulphuric acid but, after crystallisation, it undergoes transannular cyclisation to form (**14**) and (**19**).

It has been reported[1] that the dimerisation of isoprene using a nickel based catalyst yields a dimethylcyclo-octadiene and two cyclohexene derivatives. We have confirmed that (**1**), (**2**), and (**3**) are formed in the ratio 78:8:14 and shown, by oxidative degradation, that the cyclo-octadiene is > 95% head-to-tail dimer. Treatment of the crude dimer mixture† with dibromocarbene[2] from KOBu^t–CHBr$_3$) yields the mono-adduct (**4**) which on solvolysis with silver acetate–acetic acid yielded the acetates (**5**) and (**7**) in an 8:3 ratio (60% yield). *trans*-Stereochemistry is assigned to the newly generated double bonds on a mechanistic basis[3] and by analogy with related work.[4] Mild hydrolysis (Na$_2$CO$_3$–MeOH–H$_2$O at 25°) converted the secondary acetate into (**8**). Prolonged alkaline hydrolysis of the mixture gave (**8**) and the alcohol (**6**). The same products (8:2 ratio) could be obtained directly from (**4**) by treatment with silver perchlorate in aqueous acetone.[5] The alcohol (**6**) is a mixture of isomers, probably due to a high energy barrier to ring inversion.‡

Treatment of the acetate (**7**) with *m*-chloroperbenzoic acid gave the stable crystalline oxide (**11**), τ (CDCl$_3$) 4·47 (1H, m), 7·94 (3H, s), 7·98 (3H, s), 8·58 (3H, s). When (**8**) was treated with the peracid in the presence of sodium carbonate a stable ethereal solution of (**12**), τ (CDCl$_3$) 5·35 (1H, m), 7·05 (1H, m), 8·05 (3H, s), 8·60 (3H, s), was obtained. On acetylation (**12**) gave (**11**). Concentration of the ethereal solution gave crystals which, if immediately

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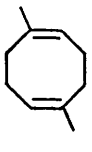
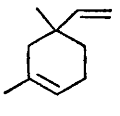
† Pure cyclo-octadiene can be obtained by distillation using a spinning-band column. However, for preparation of the cyclononadienes, dibromocarbene adducts from the hydrocarbon mixture can be used since the cyclohexene adducts are not solvolysed.

‡ Similar diastereoisomerism was observed in related compounds by Reese and Shaw.[5,6]

redissolved, gave the n.m.r. spectrum of (**12**). However, on standing, the crystals liquefied to a mixture which, after acetylation, yielded (**13**) (28%) τ ($CDCl_3$) 5·1 (1H, m), 6·15 (1H, m), 8·0 (3H, s), 8·74 (3H, s), 8·91 (3H, s), and (**18**) (24%) which was hydrolysed to (**19**), τ ($CDCl_3$) 6·26 (1H, m), 7·96 (3H, s), 8·87 (3H, s); ν_{max} (CCl_4) 3620, 3480, 1715, 1643 cm^{-1}; λ_{max} (EtOH) 255 nm (ϵ 10,000),§ characterised as its crystalline 3,5-dinitrobenzoate, τ ($CDCl_3$) 4·45 (1H, m). Hydrolysis of (**13**) yielded (**14**) which was oxidized by Jones' reagent to (**15**). Reduction with zinc in acetic acid converted (**15**) into (**16**). When (**16**) was heated under reflux with acetic anhydride in benzene containing toluene-*p*-sulphonic acid, (**17**)¶ was formed. Hydrolysis of (**17**) yielded (**19**). Spectroscopic data allow the part-structure (**20**) to be deduced for (**14**) and the structure can be completed if it is accepted that an 'anti-Bredt' enone would not survive the variety of conditions under which (**19**) is formed.


(1)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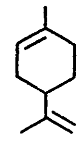
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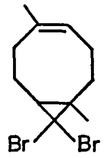
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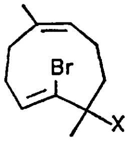
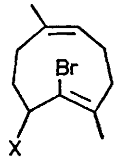
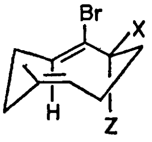


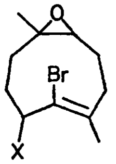
(5) X = OAc
(6) X = OH



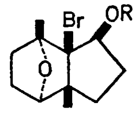
(7) X = OAc
(8) X = OH



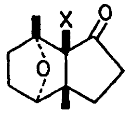
(9) Z = OH, X = Me
(10) Z = Me, X = OH



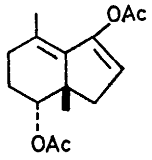
(11) X = OAc
(12) X = OH



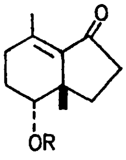
(13) R = Ac
(14) R = H



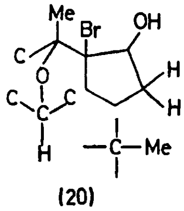
(15) X = Br
(16) X = H



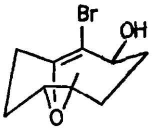
(17)



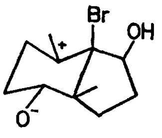
(18) R = Ac
(19) R = H



(20)



(21)



(22)

The cyclisation appears to be a genuine solid-state reaction and the oxide (**12**) is stable in t-butyl alcohol (25°, 5 h), 0·25N-sulphuric acid–water–acetone (15 min), and ether (37°, overnight). The decomposition of the dry crystals is quite rapid but their reaction when covered with ether is much slower. Hydrogen bromide is eliminated in forming (**19**) and it may be that there is an acid catalysed process also occurring;** in the presence of solvent this process may be slowed down by the dissolution of the decomposition products in the solvent. It is not possible to give a detailed mechanism for the decomposition but in light of the stability of the oxide acetate (**11**) the hydroxy-group must play an important part, presumably by hydrogen bonding with the oxide ring. On the basis of previous work[7] (**21**) is a reasonable conformation for the alcohol which could cyclise to the intermediate (**22**) thence generating the observed products; stereochemistry has been assigned on this basis. We can offer no convincing explanation of why the acid catalysed process in homogeneous solution is less facile than the solid state reaction.

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§ The u.v. and i.r. spectra are characteristic of a cisoid-enone.

¶ The chemical shift of the vinyl proton is consistent with this structure rather than that of the isomer.

** Treatment of (12) with HBr–AcOH in Et_2O leads to (14) and (19) but the product mixture is much more complex.

[1] L. I. Zakharin and G. G. Zhigareva, *Izvest. Akad. Nauk. S.S.S.R., Ser. khim.*, 1968, 168.
[2] P. S. Skell and A. Y. Garner, *J. Amer. Chem. Soc.*, 1956, **78**, 3409.
[3] C. H. dePuy, L. G. Schnack, and J. W. Hausser, *J. Amer. Chem. Soc.*, 1966, **88**, 3343.
[4] D. Duffin and J. K. Sutherland, *Chem. Comm.*, 1970, 626.
[5] C. B. Reese and A. Shaw, *J. Amer. Chem. Soc.*, 1970, **92**, 2568.
[6] C. B. Reese and A. Shaw, *Chem. Comm.*, 1970, 1365.
[7] D. Duffin and J. K. Sutherland, *Chem. Comm.*, 1970, 627.