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REASSIGNMENT OF CONFIGURATIONS FOR 5-BROMO-2,3-DIOXABICYCLO[2.2.1]HEPTANES AND ITS MECHANISTIC IMPLICATIONS

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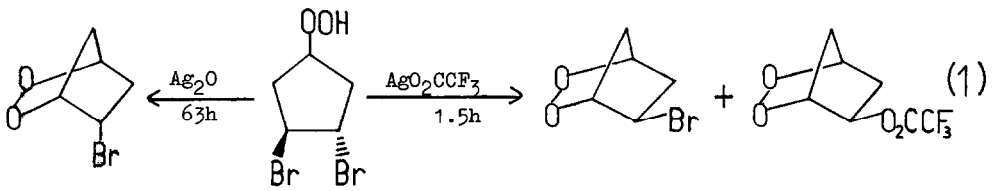
Summary. The configuration of the 5-bromo-2,3-dioxabicyclo[2.2.1]heptane obtained by treating 3,4-dibromocyclopentyl hydroperoxide with AgO_2CCF_3 and that of the isomer obtained using Ag_2O have been reassigned after identifying which 4-bromocyclopentane-1,3-diol is obtained from each upon catalytic hydrogenation. This implies a bromonium ion mechanism for the AgO_2CCF_3-induced dioxabicyclization in contrast to the S_N2-type displacements found for related compounds.

Recently we described the synthesis of the first simple 2,3-dioxabicyclo-[2.2.1]heptanes to carry a substituent at the 5-position[1]. These were obtained by the silver-salt-assisted dioxabicyclization of 3,4-dibromocyclopentyl hydroperoxide 1, which was prepared by trans-bromination of 3-cyclopentenyl hydroperoxide. Treatment of 1 with AgO_2CCF_3 afforded a 5-bromo-2,3-dioxabicyclo-[2.2.1]heptane 2 and a 5-trifluoroacetoxy-2,3-dioxabicyclo[2.2.1]heptane 3, and it was shown independently that 2 is rapidly converted into 3 by reaction with AgO_2CCF_3. Treatment of 1 with Ag_2O, on the other hand, slowly yielded an isomeric 5-bromo-2,3-dioxabicyclo[2.2.1]heptane 4.

On the basis of the known preference for displacement of a trans-3-bromine in the silver-acetate-based synthesis of 2,3-dioxabicyclo[2.2.1]heptane[2] and of the exclusive formation of cis-7-bromo-2,3-dioxabicyclo[2.2.1]heptane in the closely related dioxabicyclization of 2,3-dibromocyclopentyl hydroperoxide[3],

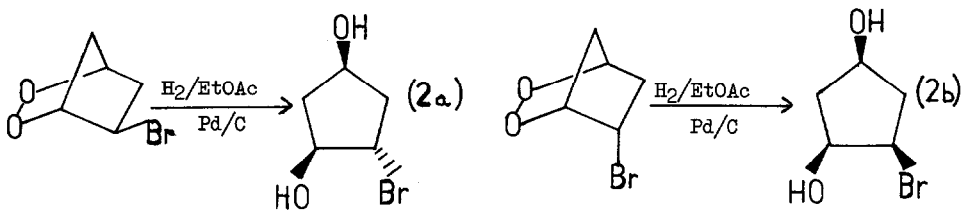
we assigned the endo configuration to 2 and hence the exo configuration to 4, suggesting that the latter was a product of equilibrium control. We have now obtained evidence (given below) that clearly shows that the original[1] configurational assignments for 2 and 4 must be reversed. The reactions with the products correctly assigned are given in equation (1).



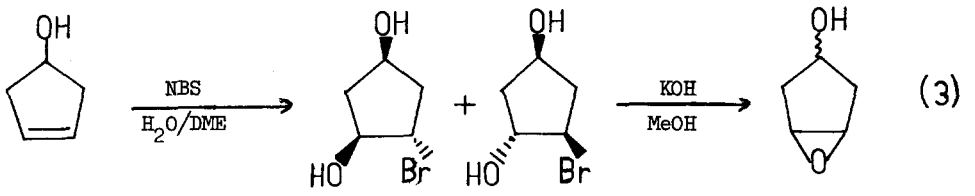
(1)

4 1 2 3

The new assignments for 2 and 4 are based on identifying which 4-bromocyclopentane-1,3-diol is obtained from each upon catalytic hydrogenation. It is assumed that this reduction will afford a cis-1,3-diol, as with 2,3-dioxabicyclo[2.2.1]heptane itself[4], and that the stereochemistry at the carbon bearing bromine will be unaffected. The AgO_2CCF_3-derived endoperoxide 2 gave a diol (equation 2a) that was identical (^{13}C NMR) with one of the two diols obtained by reaction of cyclopent-3-en-1-ol with N-bromosuccinimide and water, and the trans nature of the hydroxybromination was confirmed by ready conversion of the bromohydrins 5 and 7 into the known[5] 3,4-epoxycyclopentanols 8 (equation 3). The diol derived from 2 must therefore have structure 5 which in turn shows that 2 contains an exo-bromine[6]. Catalytic hydrogenation of the Ag_2O-derived endoperoxide was consistent with the endo configuration 4, giving a third 4-bromocyclopentane-1,3-diol 6 that did not epoxidise with methanolic KOH (equation 2b).



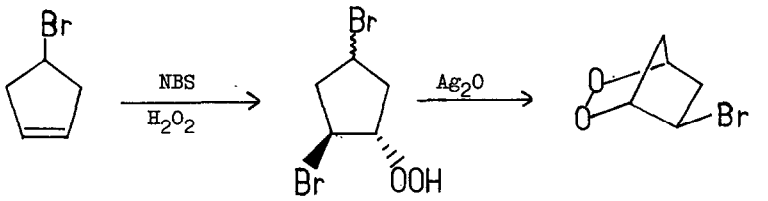
2 5 4 6



(3)

5 7 8

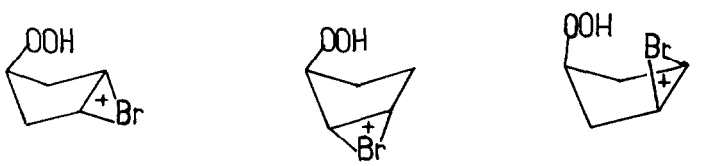
Further evidence for the structure of 2 came from an independent synthesis of it by reaction of Ag_2O with the 2,4-dibromocyclopentyl hydroperoxides 9 obtained by hydroperoxybromination of 3-cyclopentenyl bromide (equation 4). The exo-disposition of the bromine in 2 then follows if formation of 9 involves the expected trans addition. This represents a better route to 2 than that from 1 since it is not complicated by concurrent formation of 3; an 11% yield was achieved.



(4)

9 2

The possibility that 2 and 3 were derived from 1 via 4 was eliminated by the observation that 4 did not react with AgO_2CCF_3 or with $AgBr/HO_2CCF_3$ during 24h. It must be concluded, therefore, that in contradistinction to the reactions with 3-bromocyclopentyl[2] and 2,3-dibromocyclopentyl[3] hydroperoxides, the AgO_2CCF_3-induced dioxabicyclization of 3,4-dibromocyclopentyl hydroperoxide 1 involves preferential displacement of the cis-3-bromine. It seems highly probable that this process is assisted by the vicinal bromine, i.e. that the trans bromonium ion 10 is an intermediate.



10 11 12

Such a mechanism is not available to 3-bromocyclopentyl hydroperoxide and formation of a [2.2.1]-endoperoxide from 2,3-dibromocyclopentyl hydroperoxide via the corresponding species 11 would require a disfavoured[7] 5-endo mode of ring closure.

The proposal of a bromonium ion mechanism suggests that it may be possible to prepare 2 by generating 10 in other ways. Of course 10 is a likely intermediate in the bromination of 3-cyclopentenyl hydroperoxide to give 1, yet no 2 was detected in the crude product. Since this result could simply reflect a preference for 10 to be captured by bromide, we investigated the reaction of 3-cyclopentenyl hydroperoxide with other sources of electrophilic bromine. However treatment with N-bromosuccinimide and with 1,3-dibromo-5,5-dimethylhydantoin again failed to yield 2, possibly because complexation with the electrophile favours formation of the cis bromonium ion 12.

Acknowledgement. We thank the S.R C. for financial support.

References and Notes.

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4. W. Adam and H.J. Eggelte, J. Org. Chem., 42 (1977) 3987.

5. R. Steyn and H.Z. Sable, Tetrahedron, 25 (1969) 3579; 27 (1971) 4429.

6. The exo-disposition of the trifluoroacetate group in 3 was confirmed by catalytic hydrogenation followed by hydrolysis with aqueous K_2CO_3. This yielded a cyclopentane-1,2,4-triol (analogous to 5) that had a 5-line ^{13}C NMR spectrum whereas the endo isomer would give the all-cis triol (analogous to 6) with a 3-line ^{13}C NMR spectrum.

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