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THE REACTION OF OZONE WITH HIGHLY STRAINED BICYCLO[n.1.0]ALKANES[**]

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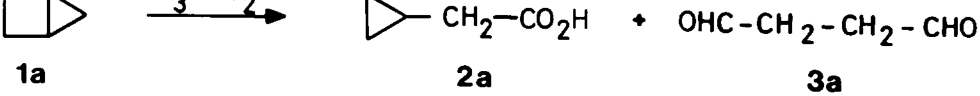
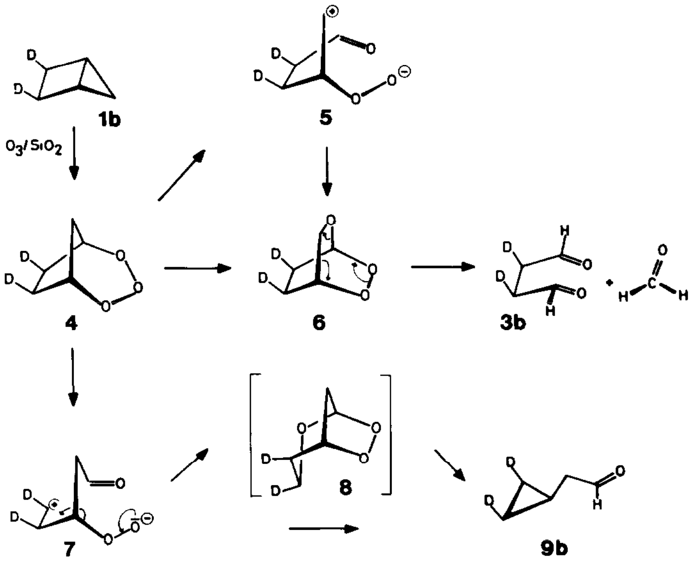
Although the cyclopropane ring and the olefinic double bond bear many similarities in their physical and chemical properties, a cyclopropane ring in contrast to a double bond is in general stable towards ozone. This has recently been confirmed by the observation, that ozone preferrentially attacks C-H-bonds in the α-position of a cyclopropyl group¹⁾, giving rise to a new method for the α-functionalization of cyclopropyl hydrocarbons[1,2].

In the homologous series of bicyclo[n.1.0]alkanes, however, the highly strained bicyclo[2.1.0]pentane (**1**) behaves exceptionally. Treatment of **1a** with ozone adsorbed on silica gel in the usual way³⁾ gives a mixture (2:5) of cyclopropylacetic acid (**2a**)⁴⁾ and succindialdehyde (**3a**). The actual reaction between **1a** and ozone starts to occur between -50° and -30°C. In order to gain some insight into the mechanism of this reaction, the ozonisation was applied to the 2,3-dideuterio **1b**⁵⁾ and the 2-methyl derivatives **10a**/**10b**.



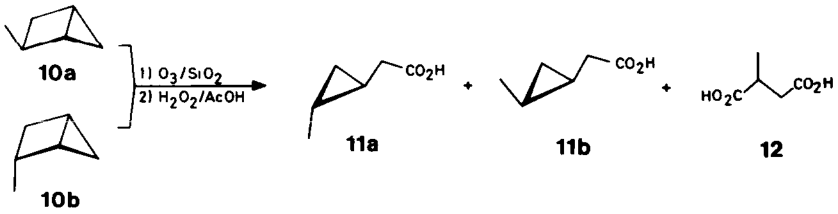
The two products obtained from **1b**⁵⁾ after oxidative work-up with hydrogen peroxide in acetic acid were 2',3'-dideuterio-cyclopropylacetic acid (**2b**)⁴⁾

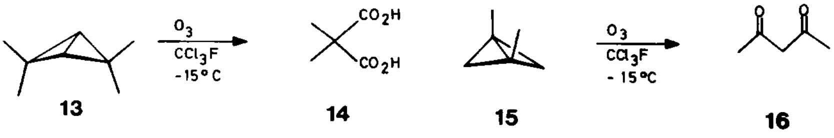
(mixture of *cis*,*cis*- and *trans*,*trans*-stereoisomers in the approximate ratio of 1:1) and *meso*-2,3-dideuteriosuccinic acid4). This result unequivocally excludes the conceivable possibility, that ozone initially attacks one of the C-H-bonds in the 2(3)-position of 1. It is, however, consistent with a mechanism in which the first step is the cycloaddition of ozone across the central σ-bond6) in 1 to yield the 1,2,3-trioxane derivative 4. The latter corresponds to the 1,2,3-trioxolane formed as the so-called primary ozonide from an olefin according to the well established *Criegee* mechanism7). Like a 1,2,3-trioxolane, 4 most probably can undergo a cycloreversion followed by an intramolecular 1,4-dipolar cycloaddition of the zwitterionic carbonyl species 5 to yield the 1,2,4-trioxane derivative 6. Formation of 6 from 4 can also be envisaged as a concerted dyotropic reaction8). A [2+2+2]-cycloreversion of 6 as indicated would then lead to *meso*-[2,3-D_2]-succindialdehyde (3b) and formaldehyde.



The [2',3'-D_2]-cyclopropylacetic acid (2b) can only be formed from 4 by a second mode of reaction, in which its 1,2,3-trioxacycloheptane feature is involved. Cycloreversion of this ring in 4 would lead to the zwitterionic carbonyl species 7, which could directly cleave into cyclopropylacetaldehyde 9b and oxygen. An intramolecular 1,5-dipolar cycloaddition in 7 yielding the bridged 1,2,4-trioxacycloheptane 8 is less likely although this possibility cannot be rigorously excluded. But the observation, that the product mixture, when isolated without further oxidation, always consists of cyclopropylacetic acid 2 and succindialdehyde, indicates a substantial stability difference for the two direct precursors of 3 and cyclopropylacetaldehyde 9. The conditions under which 9 is formed from its precursor must be such, that it can be further oxidized to the corresponding acid by excessive ozone, whereas the intermediate 6 leading to 3 seems to be stable up to higher temperatures, at which the excessive ozone has been completely desorbed from the silica gel[9]. Since 7, but not 8, undoubtedly should be less stable than 6, its direct cleavage to 9 is the more probable of the two pathways.

The products obtained from the *exo*- (10a) and *endo*-2-methylbicyclo[2.1.0]-pentane (10b)[5] are consistent with the mechanism suggested above. The ozonisation of a 1:1.15 mixture of 10a and 10b, followed by an oxidative work-up, gave a mixture of *trans*- (11a), *cis*-(2'-methylcyclopropyl)-acetic acid (11b)[4,10] and 2-methylsuccinic acid (12)[4] (ratios: 1.6:1:3.5). The ratio 11a:11b = 1.6:1 thus obtained corresponds exactly to the ratios observed, i.e. 1.35:1 and 1.9:1 respectively, when the pure stereoisomers 10a and 10b were ozonized. Although this indicates a certain stereoselectivity, at least one of the steps in the sequence to 11 must lack complete stereospecificity.





Since bicyclo[1.1.0]butane is even more strained than **1**, it is not surprising that it reacts with ozone, too. The 2,2,4,4-tetramethyl (**13**) and 1,3-dimethyl (**15**) derivatives were ozonized at -15°C in trichlorofluoromethane because they proved to be unstable on silica gel. The main product in each case, i.e. dimethylmalonic acid (**14**)$^{4)}$ (21%) from **13** and acetylacetone (**16**) (14%) from **15**, can be rationalized on the basis of the above mechanism assuming initial attack of ozone at the central σ-bond.

References and Footnotes.

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4) Characterized as its methyl ester after esterification with diazomethane.

5) W.R. Roth and M. Martin, *Liebigs Ann. Chem.* **702**, 1 (1967). The ratio of *exo,exo*- and *endo,endo*-[2,3-D_2]-bicyclo[2.1.0]pentane in the mixture used in our experiment was 2.6:1.

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