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OZONOLYSIS; INTRAMOLECULAR TRAPPING OF THE "CRIEGEE INTERMEDIATE". X-RAY ANALYSIS AND ANOMERIC EFFECT IN A 6-HYDROXY-3-METHOXY-1,2-DIOXANE

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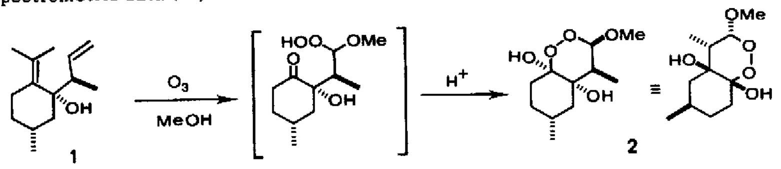
Summary : Ozonolysis of (1-methyl-2-propen-yl)-pulegol in methanol solution gives an endoperoxide bearing the 6-hydroxy-3-methoxy-1,2-dioxane ring. X-Ray analysis reveals the presence of endo- and exo-anomeric effect.

A three-step mechanism was formulated by R. Criegee over the period 1949-1957 to describe the ozonolysis of alkenes in solution (1). This proposal involves the formation of a relatively unstable primary ozonide, which cleaves into an aldehyde (or ketone) and a carbonyl oxide often called the Criegee intermediate. These fragments can then combine to give the normal ozonide.

The Criegee intermediate was thought to exist as a zwitterion in solution, but it is probably a diradical or dioxirane in the gas phase (2). The zwitterion may react with the solvent to give other products; for example, a gem-methoxyhydroperoxide has been found in presence of methanol (3). We have trapped such an intermediate as endoperoxide compound.

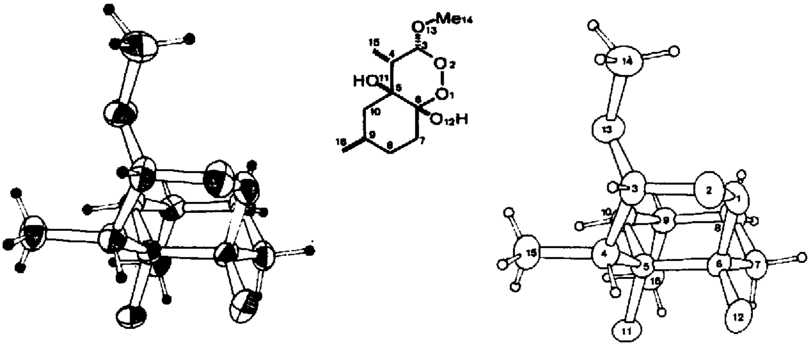
During the course of studies concerning the addition of allyl-magnesium halides on (R)-(+)-pulegone, ozonolysis of the (1-methyl-2-propen-yl)-pulegol 1 in methanol solution was performed. After acidic work up, a crystalline product was isolated (mp : 133 °C)(55-60 % yield)(4). This compound was submitted to the X-ray crystallography, which revealed an endoperoxide structure 2 in accordance with the spectrometric data (IR, ^1H and ^{13}C NMR spectra, mass analysis)(5).



Compound 2 results from the reversible intramolecular addition of the gem-methoxyhydroperoxide to the carbonyl group.

The endoperoxide 2 presents methoxy and hydroxy groups in axial position in the 1,2-dioxane ring. Compound 2 is obtained by a reversible process (cyclization in acidic medium) and, we can assume that it results from a thermodynamic control. Consequently, the axial position of these two groups indicates the presence of an anomeric effect. This effect consists in the tendency of C-O-C-O-C moiety to assume "gauche" conformation about the C-O-C-O bonds of a tetrahydropyran-type molecule (7).

In the chair conformation of 1,2-dioxane ring, gauche conformation of the methoxy group (torsional angle $O_{(13)}$-$C_{(3)}$-$O_{(2)}$-$O_{(1)}$: -68.00 °) and the hydroxy group (torsional angle $O_{(12)}$-$C_{(6)}$-$O_{(1)}$-$O_{(2)}$: -50.79 °) are in accordance with an anomeric effect (7b). In addition, an



ORTEP Stereodrawings of Endoperoxide 2 (m.p. 133 °C)

exo-anomeric interaction involving the methoxy oxygen non-bonded electrons and the $C_{(3)}$-$O_{(2)}$ bond is observed (torsional angle $C_{(14)}$-$O_{(13)}$-$C_{(3)}$-O-$_{(2)}$: -62.39 °). These effects can be correlated with the bond length $C_{(3)}$-$O_{(13)}$ (1.386 (6) Å) and $C_{(6)}$-$O_{(12)}$ (1.364 (5) Å) which are shorter than a "normal" C-O bond (1,407 Å)(7a). In contrast, the O-O bond presents a previously value ($O_{(1)}$-$O_{(2)}$: 1.467 (4) Å)(8).

The oxygen atoms of the endoperoxide linkage are weak donors of non-bonded electrons. Consequently, the major anomeric effect is the exo one involving non-bonded electrons of the methoxy or the hydroxy group (the same observation can result from the X-ray diffraction of the trans-3,6-dimethoxy-1,2,4,5 tetroxane (8c)). In valence bond terms of double bond-no bond resonance, we can proposed this relation :

References and Notes.

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(5) This material of composition $C_{11}H_{20}O_5$ crystallized (CCl_4) in monoclinic system, space group $P2_1$ with a = 8.281 Å , b = 6.634 Å , c = 10.360 Å, β = 100.07 °. The intensities are collected on a CAD4 Enraf-Nonius diffractometer (MoK$_\alpha$, λ= 0.7107 Å). The structure was solved by direct methods (Multan), current R = 0.037 for 726 independant reflections with $I > 3\sigma(I)$. Details on the structure can be obtained on request.

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