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SYNTHESIS OF 8,9-OXAZA[5.3.3]PROPELL-9-EN-2-ONES VIA 1,3-DIPOLAR CYCLOADDITION OF NITRILE OXIDES TO BICYCLO[5.3.0]DEC-1(7)-EN-2-ONE

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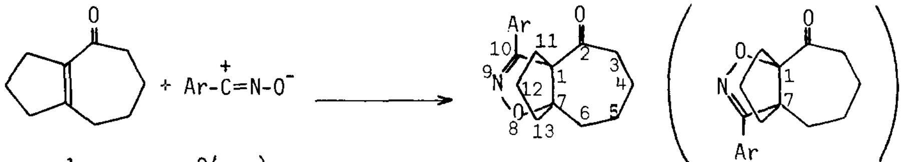
Summary: The synthesis of the title heterocyclic propellanes is described. The cycloaddition is also examined on the basis of frontier molecular orbitals (FMO) of the reacting species.

Although the synthesis of several propellanes[1] was achieved by Diels-Alder type reactions and photochemical cycloadditions, very little is known, with the exception of the reaction of phenyl azide with a condensed norbornene derivative[2], on the 1,3-dipolar cycloadditions as a possible synthetic route to propellanes. A limitation to this approach should be, however, the very low reactivity[3] of tetrasubstituted ethylene double bond towards 1,3-dipoles.

In connection with our previous work on 1,3-dipolar cycloadditions with cyclic enones[4] and on the oxidation[5] of aroylhydrazones, the bicyclo[5.3.0]dec-1(7)-en-2-one 1 was chosen as a dipolarophile in cycloadditions with nitrile oxides for the synthesis of heterocyclic propellanes. The system 1 has already been used for the synthesis of propellanes through photocycloaddition with alkenes[6,7,8] and it should show an increased dipolarophilicity because of conjugation of the ethylene double bond with the carbonyl group.

The cycloaddition of 1 with various nitrile oxides 2(a-c) gave as cycloadducts 10-aryl-8,9-oxaza[5.3.3]propell-9-en-2-ones 3(a-c) in moderate yields (25-32%). In all cases studied only one of the two possible regioisomers, 3 or 4, was isolated and the present experimental and theoretical data agree with the proposed structure 3.



1 2(a-c) 3(a-c) 4

(a): Ar=C_6H_5- ; (b): Ar=2,4,6-$(CH_3)_3$-C_6H_2- ; (c): Ar=2,6-Cl_2-C_6H_3-

The reactions took place by refluxing a chloroform solution of 1 with an excess of nitrile oxide for 48 h and the propellanes were separated by column chromatography and recrystallised from ether (m.p.s.: 3a 80-83°; 3b 115-117°; 3c 135-137°). In the case of the nitrile oxide 2a the reaction took place in ether solution by standing at room temperature for 70 h.

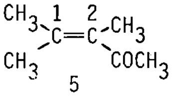
In contrast to the enone 1, which shows a moderate dipolarophilic activity, $\Delta^{9,10}$-octaline in unreactive with nitrile oxides. Thus, although an 1,4-cycloaddition with $\Delta^{9,10}$-octaline and an α-chloro-aldonitrone has been reported[9], no reaction product was isolated from this alkene and nitrile oxide 2b under the same conditions, even when a solution of nitrile oxide 2b was refluxed in excess of octaline at 195°.

The isolated propellanones give satisfactory elemental analyses and spectroscopic data (IR, NMR, MS) for the proposed structure. Thus, in IR they give the carbonyl absorption at 1700-1710 cm^{-1}, whereas in the mass spectra they give peaks corresponding to the molecular ions and in the case of 3b and 3c also peaks corresponding to retro- 1,3-dipolar cycloaddition fragments. In the ^{13}C-NMR spectrum[10] of 3b the C-1 and C-7 resonate at 98.7 and 79.1 ppm respectively. If, however, the cycloadduct had the regioisomeric structure 4, the C-7 should resonate at 50-60 ppm, whereas C-1 at 110 ppm according to the shifts of some other analogous compounds[8,11,12].

Besides the above data the structure characterization of the isolated cycloadducts was also based on reported data in analogous 1,3-dipolar cycloadditions and on FMO considerations. Thus, in the cycloaddition of nitrile oxides with cyclopentadienones the regioisomer analogous to 3 was only isolated[4]. Furthermore, in the reaction of cycloalkenones with nitrile oxides the 4-acyl-isoxazolines are mainly formed[13].

Because the exact geometry of enone 1 is unknown CNDO/2 calculations (CNINDO program, QCPE 141) were carried out on the model compound 5 in a coplanar conformation, using standard values for bond angles and lengths[14]. In Table I the orbital coefficients for HOMO and LUMO orbitals are given and using the corresponding orbital data for benzonitrile oxide[15], we observe that cycloaddition should be LUMO-dipole controlled leading to the regioisomer 3. If, however, the reaction was HOMO-dipole controlled the same regioisomer should be also formed.

Table I. FMO of benzonitrile oxide[15] and enone 5 from CNDO/2 calculations

	HOMO coefficients		E/eV	LUMO coefficients		E/eV
PhCNO	c_C=-0.438	c_O=0.602	-10	c_C=0.326	c_O=0.253	-1
 5	c_1=-0.491	c_2=-0.523	-11.82	c_1=0.569	c_2=-0.385	2.31

Further cycloadditions with other 1,3-dipoles are in progress.

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