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# AN UNUSUAL EXAMPLE OF A 1,1-CYCLOADDITION REACTION OF A DIAZOALKANE

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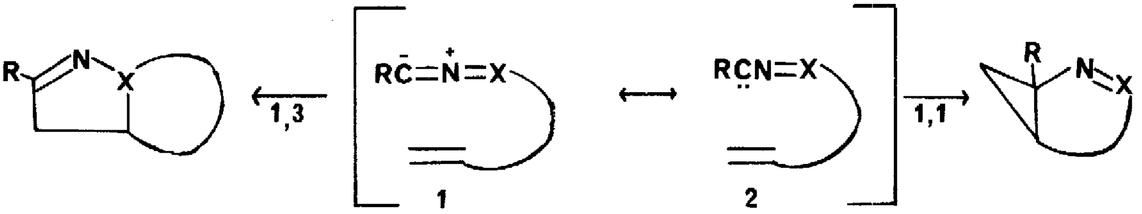
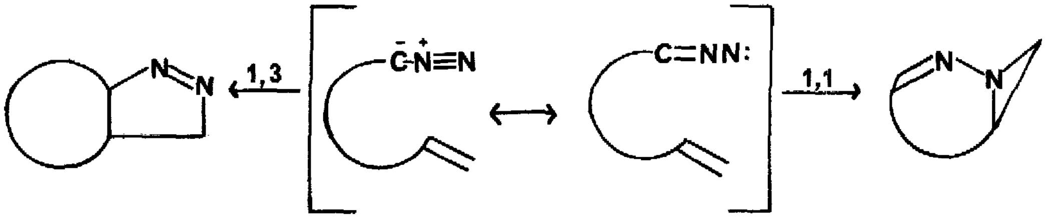
Abstract: Thermolysis of the sodium salt of E-1,4-diphenyl-3-buten-1-one N-tosylhydrazone gave rise to the corresponding diazoalkane which undergoes a subsequent 1,1-cycloaddition reaction to produce 3,6-diphenyl-1,2-diazabicyclo[3.1.0]hex-2-ene.

The cycloaddition of 1,3-dipoles has become an important method for the preparation of five-membered heterocyclic rings[1,2] and has recently had a significant impact on the synthesis of natural products[3]. Numerous possibilities for variation are available by changing the structure of both the dipole and dipolarophile. Recent work from our laboratory has shown that intramolecular 1,1-cycloaddition of nitrile ylides[4,5] as well as nitrile imines[6,7] can compete with the normal 1,3-addition when certain geometric constraints are imposed[8]. In these cases, the reactions can be formulated in terms of the carbene form (2) of the dipole. As a further consequence of our interest in this area, we thought it worthwhile to determine whether additional examples of 1,1-cycloaddition behavior of 1,3-dipoles could be uncovered.



The additions of diazoalkanes to olefins are amongst the most thoroughly studied 1,3-dipolar cycloadditions[1,9]. In spite of the copious literature dealing with bimolecular cycloaddition reactions of diazoalkanes, intramolecular examples have received only a minimum of attention[8].

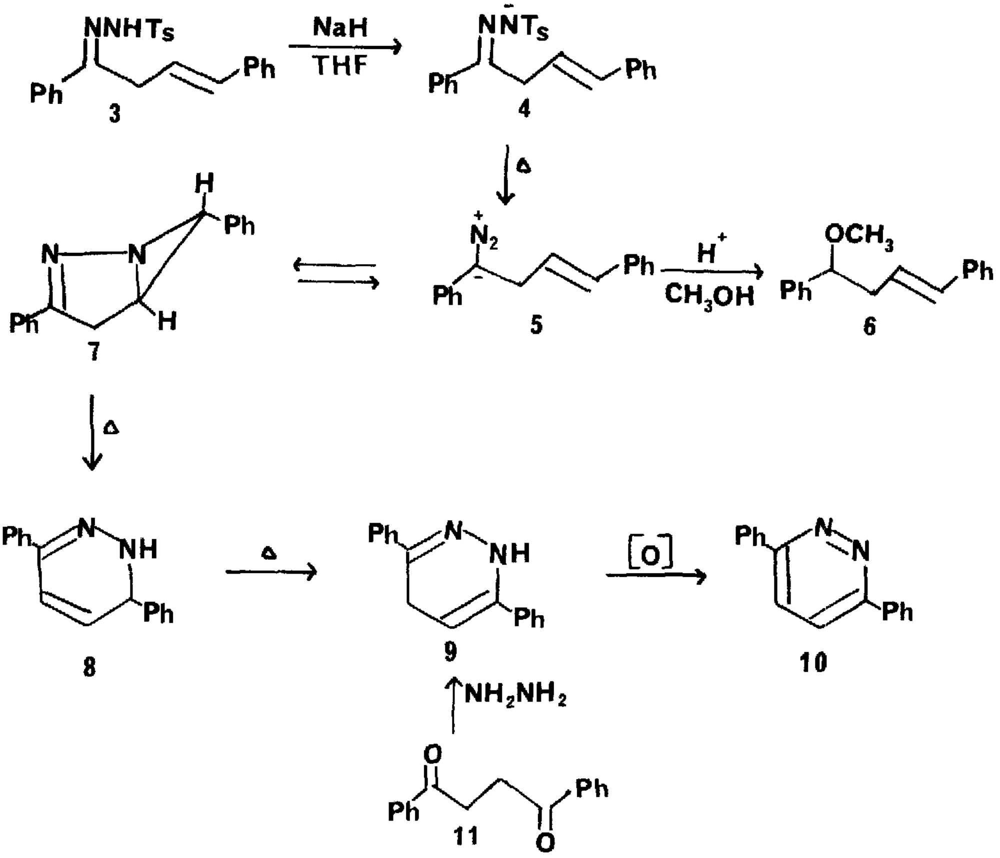
Among the possible geometric forms of a diazoalkane, a nitrene structure can be envisaged which makes conceivable a 1,1-cycloaddition of this 1,3-dipole. In this communication we wish to report the first example of a formal nitrene type cycloaddition of a diazoalkane[10].



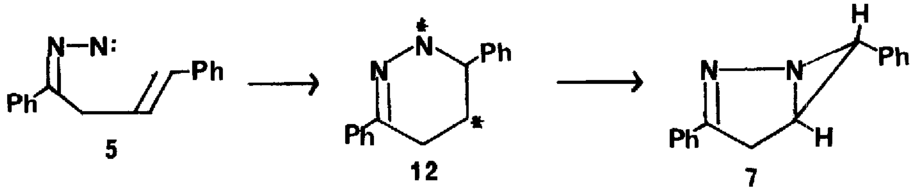
Thermolysis of the sodium salt of E-1,4-diphenyl-3-buten-1-one N-tosylhydrazone (4) at 80°C in benzene for 20 min resulted in a deep red coloration which gradually faded on extended heating. The initially formed diazo compound 5 was characterized by a strong band in the ir spectrum at 1984 $cm^{-1}$ and by NMR absorptions at δ3.58 (d,2H,J=5.0Hz) for the methylene protons and 6.44 (dt,1H,J=16.0 and 5.0Hz) and 6.84 (d,1H,J=16.0Hz) for the vinyl protons. This assignment was confirmed by treatment of the red solution with methanolic hydrochloric acid, which resulted in the isolation of 1,4-diphenyl-1-methoxy-3-butene (6). The structure of 6 was unambiguously established by comparison with an independently synthesized sample.

When a solution of the diazo compound 5 in benzene was allowed to stand at room temperature for 48 hours, a single product (7), mp 145-146°C, whose molecular formula corresponds to $C_{16}H_{14}N_2$, could be isolated by careful fraction crystallization. This material exhibits a band in the infrared at 1558 $cm^{-1}$ (C=N). The assignment of the 3,6-diphenyl-1,2-diazabicyclo[3.1.0]-hexene structure to compound 7 is supported by its ultraviolet spectrum ($\lambda_{max}$ 257 nm (ε 11,400)) which is similar to that reported for related azabicyclo[3.1.0]hexenes[4] and its NMR spectrum ($CDCl_3$, 400 MHz) δ 2.44 (d, 1H, J=4.4Hz), 3.05 (ddd, 1H, J=7.2, 4.4 and 2.0 Hz), 3.50 (dd, 1H, J=18.0 and 7.0 Hz), 3.58 (dd, 1H, J=18.0 and 2.0 Hz), 7.2-8.16 (m, 10H).

The reversibility of the 1,1-cycloaddition between 5 and 7 was directly observed by NMR analysis. Thus, heating a solution of 7 in $CDCl_3$ at 80°C for 15 min in a NMR tube gave rise to diazoalkene 5. The absorptions due to 5 disappeared upon cooling to room temperature cleanly reproducing the spectrum of 7. When the thermolysis of 7 was carried out in benzene at 80°C for 12 hr it was initially converted to 8 (NMR ($CDCl_3$,60MHz) δ 6.02 (dd,1H,J=10.0 and 4.0Hz), 6.34 (s,1H), 6.52 (dd,1H,J=10.0 and 2.0Hz) 6.75 (dd,1H,J=4.0 and 2.0Hz) and 7.0-8.0 (m,10H). Further heating of **8** resulted in the formation of **9** (NMR ($CDCl_3$, 60MHz) $\delta$ 3.35 (*d*,2H,J=4.0Hz), 4.95 (*dt*,1H,J=4.0 and 2.0Hz) and 7.4-8.1 (*m*,10H)). This structure was supported by comparison with an independently synthesized sample prepared by treating 1,2-dibenzoylethane with hydrazine. Finally, compound **9** was slowly oxidized to 3,6-diphenylpyridazine (**11**) on heating in the presence of oxygen.



The possibility that the 1,3-dipolar cycloaddition reaction of a diazoalkane with a dipolarophile actually proceeds via a 1,1-cycloaddition followed by ring expansion has been discounted by Huisgen and coworkers[11]. These workers were able to show that three-membered rings are not primary products in the cycloaddition reactions leading to five-membered heterocycles with diazoalkanes. For concerted 1,3-dipolar cycloaddition to take place, the atoms of the dipolarophile should be arranged in such a way as to allow their *p*-orbitals to lie in a plane parallel to the plane of the diazoalkane[1]. Inspection of molecular models of the allyl-substituted diazoalkane **5** indicates that the normal "two-plane" orientation approach of the diazo group and allyl π-system is impossible as a result of the geometric restrictions imposed on the system. Consequently, the normal mode of 1,3-dipolar addition does not occur here. Instead, attack of the terminal nitrogen atom of the diazo group on the neighboring double bond occurs to generate a six-membered ring dipole (**12**). Collapse of this species results in the formation of the observed diazabicyclohexene ring system[12]. The results described herein provide the first example of a 1,1-cycloaddition of a diazo compound. We are continuing to explore the scope and mechanistic details of this novel reaction.



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(10) A similar reaction has been independently uncovered by Y. Nishizawa, T. Miyashi and T. Mukai. We wish to thank Dr. Miyashi for informing us of his results.
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(12) The exclusive formation of **7** rather than the isomeric 2,3-diazabicyclo[3.1.0]hex-2-ene can be attributed to the stronger set of bonds and lesser strain energy of the system.

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