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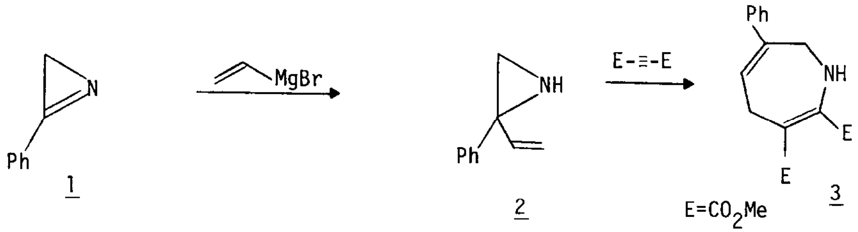
CYCLOADDITION OF VINYL AZIRIDINES WITH UNSATURATED SUBSTRATES. A NOVEL REARRANGEMENT OF AN UNSATURATED NITRO COMPOUND.[1]

Alfred Hassner*, Rosario D'Costa
Department of Chemistry, State University of New York at Binghamton, N.Y. 13901
Andrew T. McPhail
Department of Chemistry, Duke University, Durham, N.C. 27706
William Butler
Department of Chemistry, The University of Michigan, Ann Arbor, Michigan 48104

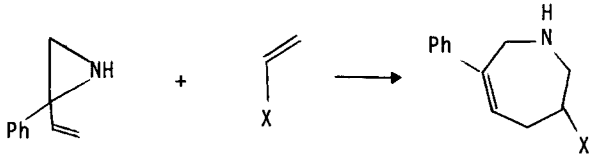
Abstract: Vinylaziridine 2 undergoes reaction with electrophilic acetylenes and olefins to produce 7-membered azepine derivatives. With β-nitro-styrene however, a novel rearrangement occurs, presumably via an ene reaction to form 10, the structure of which is definitively shown by x-ray diffraction.

Cis-1,2-Divinylcyclopropanes are known to undergo thermal electrocyclic ring closure to seven membered rings.[2] Scattered examples for the analogous formation of azepine derivatives have been reported, although the intermediate divinyl aziridines can usually not be isolated.[3] Our interest in aziridine and azepine chemistry[4] led us to investigate the cycloaddition of vinyl aziridine 2, readily prepared from azirine 1 by vinyllithium or Grignard addition,[5] with various unsaturated substrates.

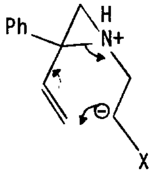
Reaction of 2 with acetylene dicarboxylate proceeds rapidly even at -20° and leads to dihydroazepine 3, mp 122-3°, in 95% yield. A vinyl pyrroline structure was ruled out on the basis of nmr, which showed a vinyl proton triplet at δ6.2 and two broad methylene doublets at 4.3 and 3.5, with the latter collapsing to a singlet on D_2O exchange (NH at 5.35 disappears with D_2O). The formation of 3 has analogy in the reaction of a related vinylaziridine with acetylene phosphonium salts.[3b] No divinyl aziridine intermediate was isolable even when the reaction was carried out in the presence of protic solvent (methanol).



We found that vinylaziridine 2 also reacts with electrophilic olefins, albeit slower than with acetylene dicarboxylate, to form tetrahydroazepines 6.



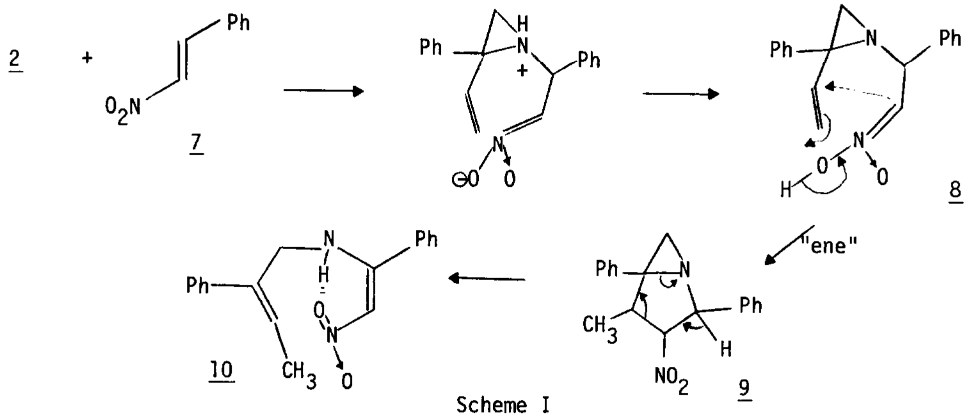
2 4 6



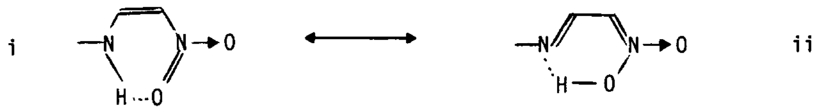
5

Thus, heating of 2 with acrylonitrile 4a (X:C≡N) in refluxing benzene for 6 days produces 6a in 70% yield. Other examples are shown in Table 1. Whether the cycloaddition occurs concertedly or via anion 5 has not been established, but no five membered ring cyclization products nor N-substituted vinylaziridines (derived from 5) have been detected.

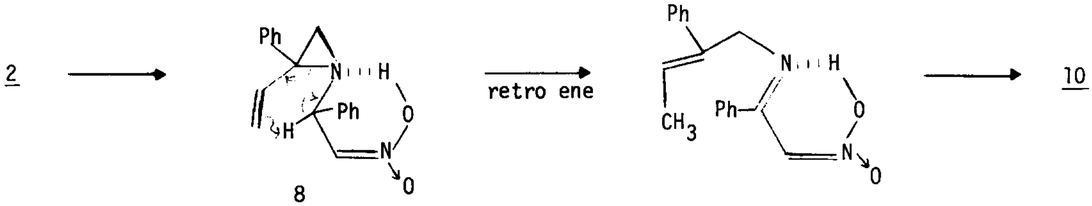
When 2 was heated with β-nitrostyrene (7), a product was isolated in good yield (80%). However, the presence of a methyl doublet in the H-nmr spectrum: doublet at δ1.8(3H), doublet at 4.3(2H), which broadens on D_2O exchange, quartet at 5.9(1H), singlet at 6.5(1H), multiplet at 7.4 (10H) and broad absorption at 10(1H, which diminishes in the presence of D_2O), ruled out structure 6. The 1:1 adduct (mass spec, elemental analysis) was assigned structure 10, which was confirmed by an x-ray diffraction analysis as shown in Figure 1. Strong hydrogen bonding in 10 between the NH and NO_2 group is indicated by the nmr, ir and x-ray data. The compound belongs to space group $P2_{1/c}$ with Z=4, a=10.430(2), b=7.597(1), c=20.039(5)Å, β=93.917(2)°, V=1584.1(5)Å^3, d(calc)=1.23g/ml.[6] Some bond lengths that illustrate the conjugation in the nitroenamine moiety (i and ii) are included in Figure 1.



Scheme I



Substituent effects in sigmatropic rearrangements can have important effects in vinyl aziridine cyclizations,[8] but the formation of 10 necessitates proton transfer to the non-activated vinyl group of 2 to form a methyl derivative. A logical pathway is indicated in Scheme I and involves an ene reaction between an acinitro and an olefinic group (see 8 → 9). Ring opening of the fused aziridine 9 to 10 completes the reaction sequence. Alternatively a retro-ene reaction of 8 can lead directly to 10 (see Scheme II).



Scheme II

The "ene reaction" is well established, including examples of hetero atom analogs, but these reactions usually require temperatures above 200°.[7] The example 2 → 10 proceeds below 100° and apparently represents the first case of an intramolecular ene reaction involving a nitro group. Further studies to exploit this chemistry are under way.

Table 1

Formation of 6 to the Thermal Cycloaddition[a] of 2 to 4.

6	X	m.p.	Yield
a	C≡N	70-1°	70%
b	CO_2Me	56-7°	55%
c	SO_2Ph	105-6°	50%

[a] Refluxing in benzene for 6 days.

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5. Another route to vinylaziridines as described by R. Chaabouni and A. Laurent, Synthesis, 464 (1975) does not work well for 2.
6. Diffraction data (a total of 3194 reflections having 2θ (MoK_α)<55 deg) were collected on a Syntex $P2_1$ automatic diffractometer using graphite monochromated MoK_α radiation. Computations were carried out on an Amdahl 470-V8 computer. The structure was solved by direct methods using the MULTAN 78 crystallographic program. Least-squares refinement using anisotropic thermal parameters for all nonhydrogen atoms gave R1=0.087 and R2=0.103. Difference maps revealed all of the hydrogen atoms. Refinement to convergence gave R1=0.049 and R2=0.054.
7. (a) H.M.R. Hoffman, Angew. Chem. Intern. Ed., 8, 556 (1969); (b) W. Oppolzer and V. Snieckus, ibid., 17, 476 (1978).
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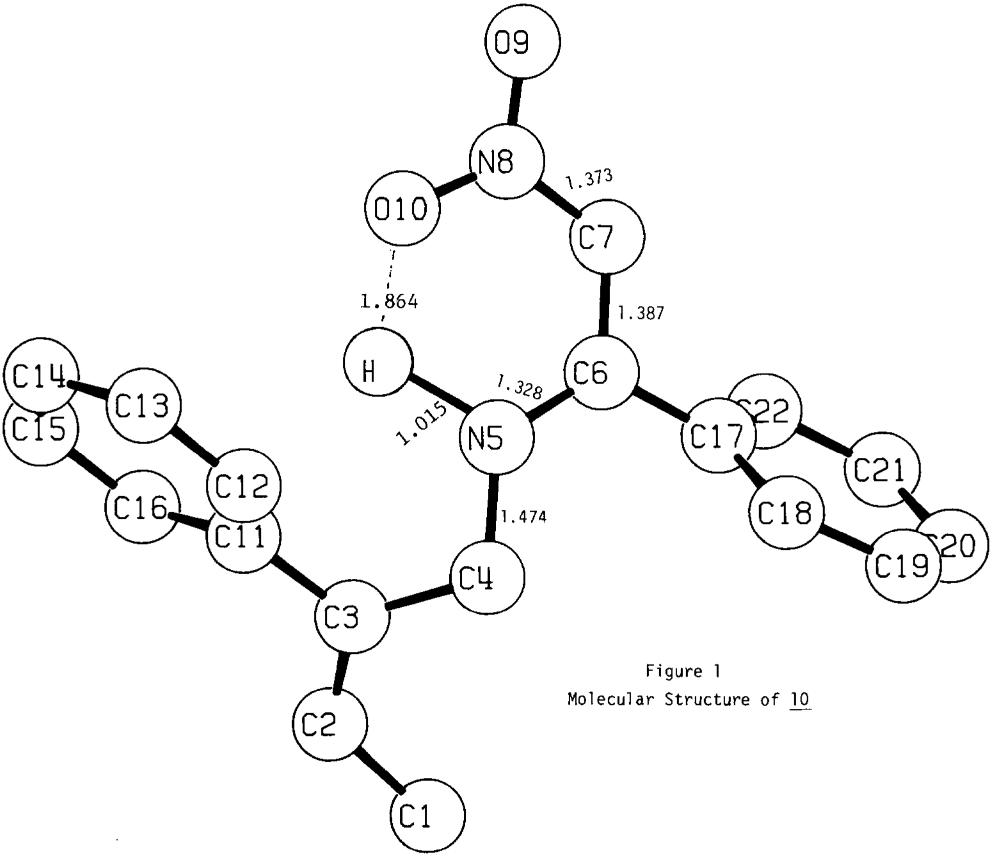

Figure 1
Molecular Structure of 10

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