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On the Mechanism and Scope of a Novel Nitroolefin Rearrangement[1]

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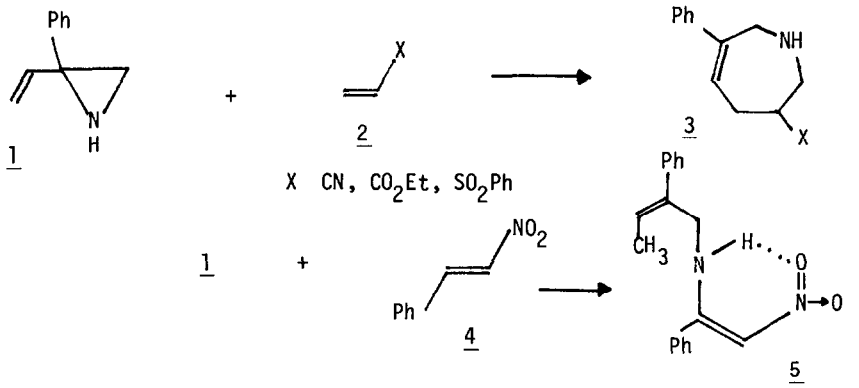
Abstract D-Labelling permits differentiation between three plausible mechanistic pathways in the novel transformation of vinylaziridine 1 with β-nitrostyrene 4 to nitro enamino olefin 5 The results are consistent with a retro-ene reaction proceeding under mild conditions (80°). Choice of proper substituents can guide the reaction toward formation of azepines or substituted enamines

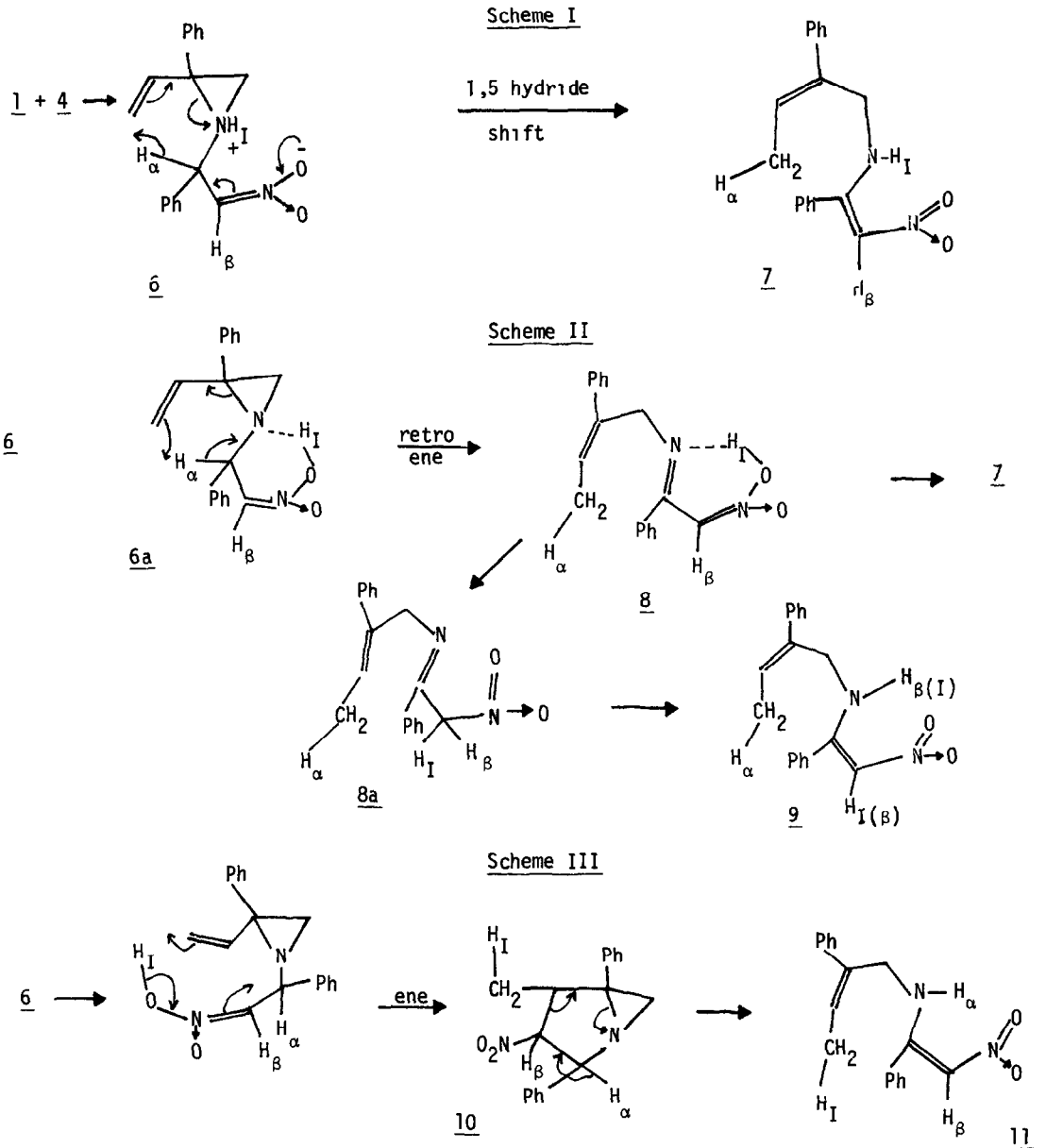
During a recent study[2] of the addition of 2-vinylaziridine 1 to unsaturated substrates 2, which led to formation of tetrahydroazepines 3, we discovered an unusual rearrangement When the nitroolefin 4 was used as a substrate instead of 2, and heated with 1 at 80°, the product isolated in over 90% yield was unexpectedly the unsaturated nitro enamine 5 The structure of the latter was proved by spectra and x-ray diffraction



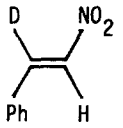
An examination of the scope and mechanism of these transformations has led to consideration of 3 pathways, Schemes I-III, for this novel rearrangement One involves an anion-mediated 1,5-hydride shift (Scheme I) Scheme II involves a prototropic shift followed by a retro-ene reaction (also a 1,5-shift) The third scheme proceeds with ring closure to a 5-membered ring 10 (ene reaction on a nitronic acid)[3] followed by ring opening of 10 to 11 It is clear that labelling of H_α should permit differentiation between Scheme III and the other two, while labelling of H_I or H_β may differentiate between Scheme I and II, provided

that these hydrogens do not exchange in the product.

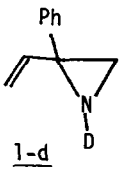
We prepared 4-d and found that its reaction product (96% yield) with vinylaziridine 1 possessed structure 7 (H_α=D), as evidenced by its nmr spectrum (vinyl triplet at δ5.83 ppm,



NH at 9 95 disappears on D_2O exchange and CH_2 doublet at 4 24 which collapses to a singlet with D_2O) This excludes Scheme III as a reaction pathway



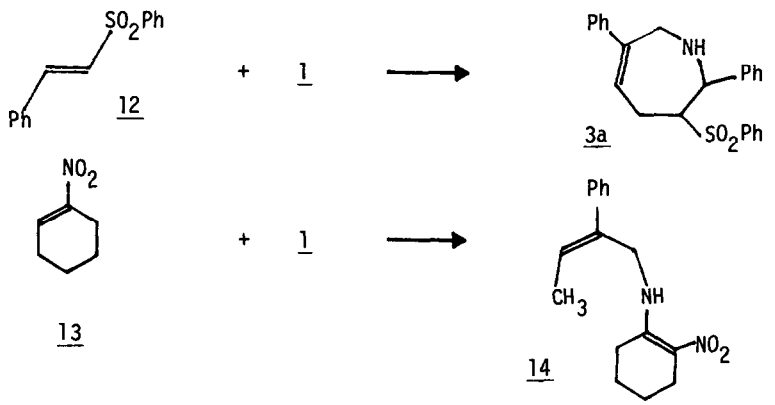
4-d



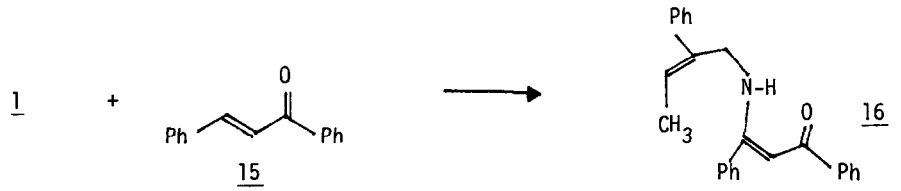
1-d

Treatment of the N-deuterated 1-d with 4 leads to isolation of 9 (H_I or H_β=D) with deuterium distributed on N and C in a ratio of 2·1, as determined by nmr integration of the NH at δ9,95 ppm and the vinyl H_β singlet at δ6.45 ppm. The product 7 exchanges only H_I with D_2O under reaction conditions (80°) Hence, an equilibration 7 ⇄ 8 ⇄ 9, that would scramble the deuterium in the product from nitrogen to carbon, is ruled out. Tautomerism of 8a to 9 (H_I or H_β=D) should occur with preferential proton over deuteron transfer to nitrogen, by virtue of the primary isotope effect. The observed 2 1 ratio of N-D to C-D in 9 is consistent with Scheme II in which a dual pathway (8 → 7 and 8 → 9) is operating or alternatively, both Scheme I and II may be operating in this rearrangement

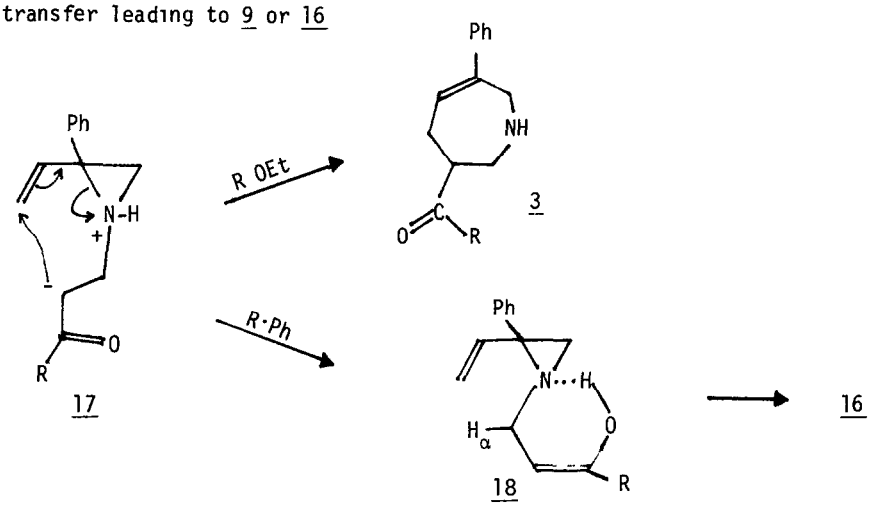
To establish the effect of substituents in the olefin substrate 2 upon the course of the reaction, we examined the phenyl substituted unsaturated sulfone 12 (presence of Ph but SO_2Ph instead of NO_2 as compared to 4), and 1-nitrocyclohexene 13 (presence of NO_2 but absence of Ph) The former reacted with 1 to produce the phenyl substituted tetrahydroazepine 3a, whereas 13



led to rearranged product 14. This indicates the importance of the nitro substituent on the olefin substrate However, the presence of a nitro group is not essential, since ketone 15 also leads to rearrangement (see 16)



We conclude that, for the rearrangement to occur, a well enolizable group (NO_2 or keto C=O) is required. In such cases the intermediate 6 or 17, instead of ring closing to a 7-membered ring 3, will undergo a prototropic shift to 6a or 18 followed by a retro-ene reaction and proton transfer leading to 9 or 16



These results shed light on the mechanism of the novel transformation 1 + 4 ⟶ 5 and allow one, by choice of proper substituents, to guide the reaction to azepine 3 or to rearranged products (of type 5, 14, 16) In these cases the retro-ene reaction proceeds under relatively mild conditions (80° instead of the usual 200-350°) apparently because of relief of strain by breaking of the aziridine ring[4] and may be applicable to other strained ring systems

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3 Examples of both the ene reaction and the retro-ene reaction have been studied but they usually require higher temperature conditions (200-500°), (a) H M R Hoffman, Angew. Chem Internat Ed , 8, 556 (1969), (b) W Oppolzer and V. Snieckus, ibid , 17, 476 (1978)

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