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CYCLOADDITIONS OF ORGANIC AZIDES TO CYCLOPENTADIENONES[1a]

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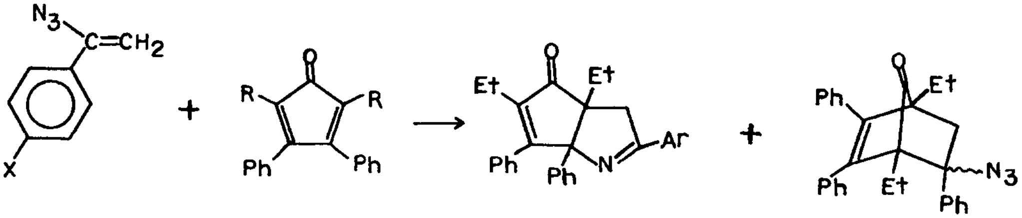
Organic azides, in particular, vinyl azides, have elicited recent interest not only as precursors to nitrenes but also as potential partners in dipolar cycloadditions.[2] The multiplicity of pathways that can a priori be predicted for the thermal addition of vinyl azides 1 to cyclopentadienones 2 includes cycloaddition of 1 via the azide group, the vinyl nitrene moiety or the olefinic double bond with 2 acting as the 2π- or 4π-electron component. Some vinyl azides have been shown to react thermally with 2 via prior transformation to azirines which add in a Diels-Alder fashion to produce azepines 5.[3]

We now report the thermal cycloaddition of several types of organic azides with 2 which affords novel heterocycles such as azabicyclo[3.3.0]octanes, azabicyclo[3.2.1]octanones, azabicyclo[3.1.0]hexanones, as well as azidobicyclo[2.2.1]heptanones and pyridones, depending on the structure of the azide substrate.[4]

For instance, vinyl azide 1a reacts with 2b in refluxing chloroform to produce 3 (52%) together with a minor amount (2%) of Diels-Alder adduct 4 (ir 1767 cm^{-1}). An 88% yield of 3a was realized by allowing a benzene solution of 1a (1.5 eq) and 2b to stand at 25° for 4 days.



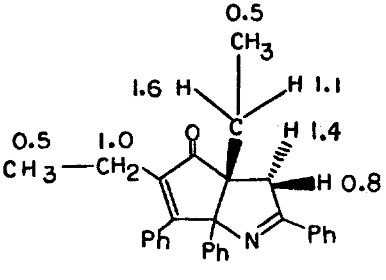
1a, X: H
1b, X: NO_2
1c, X: OCH_3

2a, R: Me
2b, R: Et

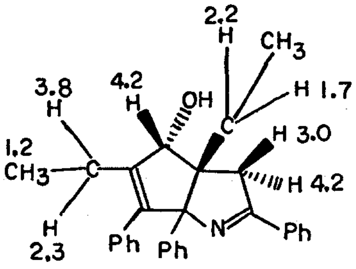
3a, Ar: Ph
3b, Ar: $C_6H_4NO_2$
3c, Ar: $C_6H_4OCH_3$

4

The structure of 3 follows from ir, H nmr, europium shift studies, ^{13}C nmr and mass spectra. 3a shows a C=O absorption at 1695 cm^{-1}.



3a



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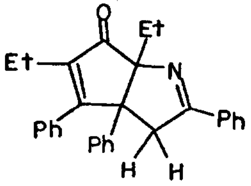
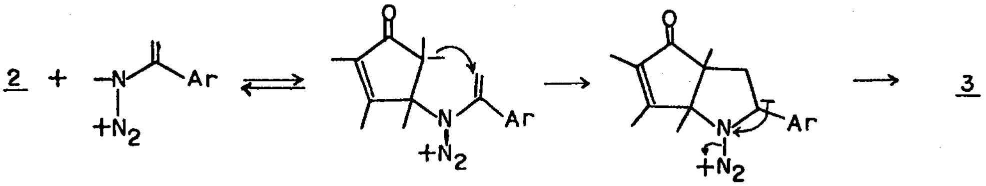


7

Downfield shifts in ppm on Eu(fod)$_3$ complexation

Complexation of the oxygen in ketone 3a and in its borohydride reduction product 6 with Eu(fod)$_3$ causes a much larger downfield shift for the β-protons (especially those located syn to the oxygen) than for the γ-protons. This excludes the regioisomeric structure 7. The cycloaddition of 1 to 2 is highly sensitive to steric and electronic factors leading to recovery of starting materials with β-substituted styryl azides. Electron withdrawing substituents X speed up the reaction, the relative rates of 1b:1a:1c being approximately 6:3:1.

This suggests stabilization of a negative charge in the transition state leading to 3 and is in direct contrast to the relative rate order which we observed for the reaction of vinyl azides with triazolinediones.[5] In the latter case the vinyl azide attacked the unsaturated system via the β-carbon. Our data are in consonance with the pathway shown in reaction scheme 1.

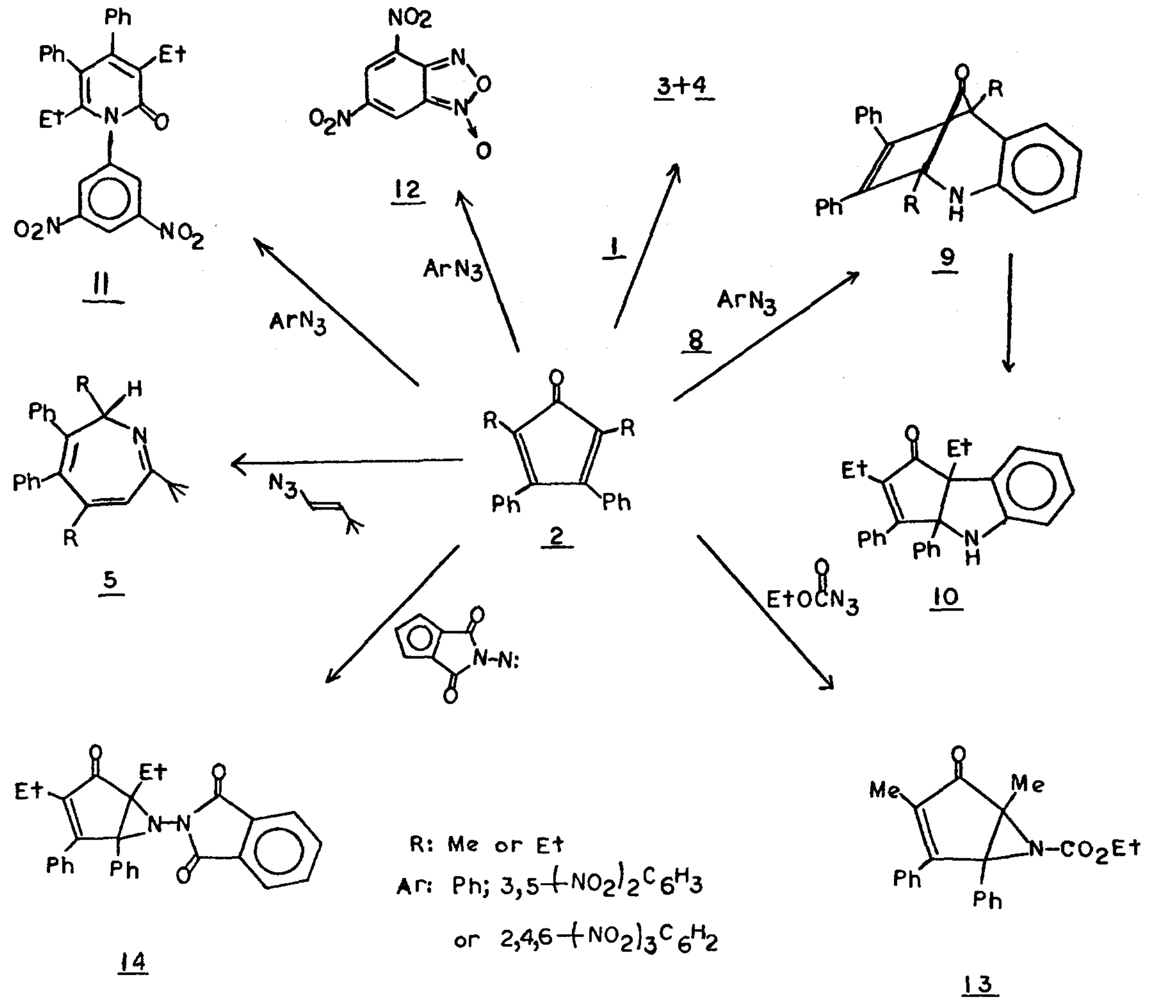


Scheme I

By comparison, diazoethane adds to tetraphenylcyclopentadienone at the carbonyl group as well as at one of the double bonds to produce a dihydropyrazole.[6]

Phenyl azide (8) reacts slowly with 2 in refluxing toluene (no reaction at 60°) to produce the bridged ketones 9 in ca. 70% yield. Apparently, decomposition of 8 is not a fast step in the reaction but is dependent on the presence of 2 since phenyl azide 8 remains largely unchanged upon refluxing in toluene in the presence of the 2,3-dihydro derivative of 2b. Furthermore, phenyl nitrene generated from nitrobenzene and tributylphosphine did not react with 2b. Ketone 9b is stable at 200° but rearranges by a 1,3-shift to the indoline 10 upon photochemical irradiation at 350 nm.

Reaction of 3,5-dinitrophenylazide with 2b to give the α-pyridone 11 (33%) and this is analogous to the behavior of sulfonyl azides with tetracyclone.[7] Under these conditions picryl azide forms the furazan-N-oxide 12. Nitrene addition to cyclopentadienone, 2 was achieved using ethyl azidoformate at 115° and via oxidation of N-amino phthalimide.[8] In this manner the fused aziridines 13 and 14 were formed in 64% and 100% yield, respectively. Efforts are underway to determine the reaction mechanisms in these transformations and the various factors that influence the pathway chosen.



Acknowledgment

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