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REGIOSPECIFIC FORMATION AND DECARBOXYLATIVE REARRANGEMENT OF A CYCLOADDUCT FROM α-PYRONE AND MONO-*trans* 3-BENZAZONINE

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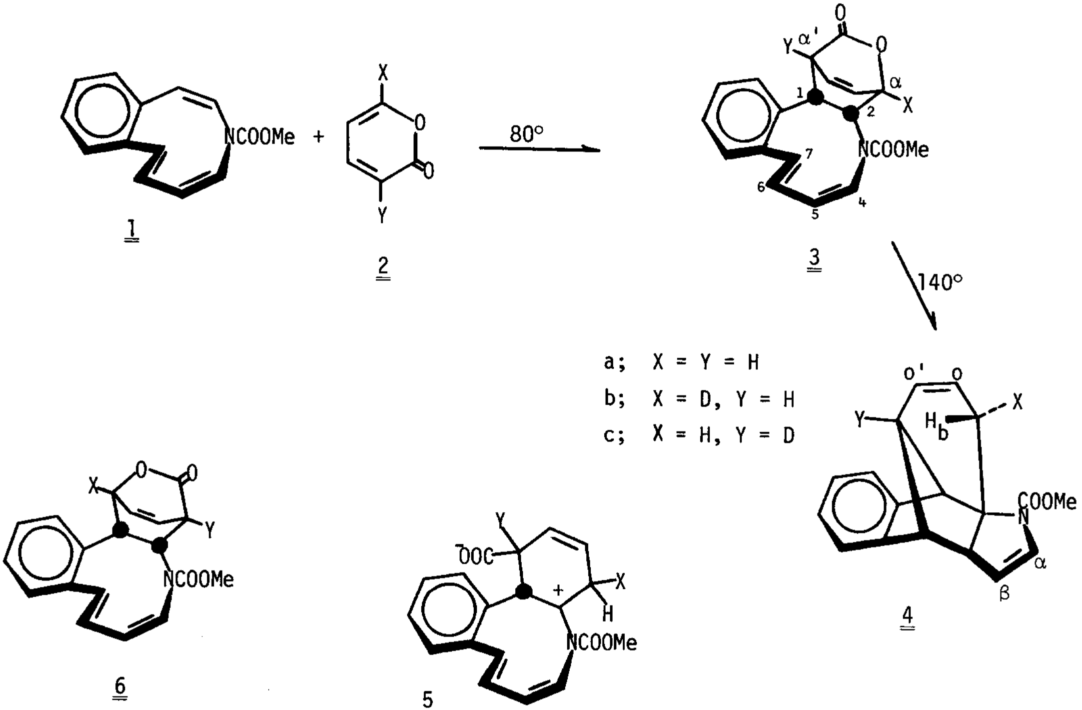
When properly utilized α-pyrone cycloaddition offers a unique method for realizing two-step C_4H_4 homologation with overall attachment of a 1,3-cyclohexadiene function.[1] In the present report we describe a rare instance where the final step in the procedure, *i.e.*, CO_2 extrusion, triggers major skeletal reorganization with interesting mechanistic implications.

Prolonged exposure (5 days) of *trans* benzazonine 1[2] to α-pyrone (2a) in hot (80°) xylene containing a few drops of triethylamine leads in *ca*. 30% yield to the 1:1 cycloadduct[3] shown in 3a[4] [white crystals, mp 153.5-154.5°; pmr (100 MHz, $CDC\ell$) τ 2.6-3.0 (4H, m, benzenoid), 3.15 (2H, *pseudo* t, ethylenic), 3.28 (1H, d, H_7, $J_{7,6}$ = 13.5 Hz), 3.9-4.3 (3H, m, $H_4 + H_5 + H_6$), 4.83 (1H, dt, H_α, J = 4.0, 2.5 Hz), 5.85 (1H, dd, H_2, $J_{2,1}$ = 8.5 Hz, $J_{2,\alpha}$ = 2.5 Hz), 6.28 (3H, s, methoxy), 6.3-6.6 (2H, m, $H_1 + H_{\alpha'}$); ms (70 eV) m/e 323 (P^+; 8.4%)]. Besides being entirely consistent with all available spectroscopic information, the structural assignment depicted in 3a receives unequivocal confirmation from work dealing with specifically labeled analogs (*vide infra*). 2.5-hr. thermolysis of a vacuum-sealed solution of 3a in benzene at *ca*. 140° effects loss of CO_2 with the formation of a single product (48%) formulated as 4a[4] [white crystals, mp 120-121°; pmr (100 MHz, $CDC\ell_3$) τ 2.6-3.1 (4H, m, benzenoid), 3.24 (1H, dd, H_α, $J_{\alpha,\beta}$ = 4.5 Hz, J = 1.5 Hz), 4.23 (1H, dd, H_o, $J_{o,o'}$ = 10 Hz, $J_{o,b}$ = 5 Hz), 4.50 (1H, *bdd*, $H_{o'}$, $J_{o',o}$ = 10 Hz, $J_{o',y}$ = 3.5 Hz), 4.65 (1H, dd, H_β, $J_{\beta,\alpha}$ = 4.5 Hz, J = 2.0 Hz), 6.1-6.6 (3H, m), 6.26 (3H, s, methoxy), 6.68 (1H, d), 7.06 (1H, *bs*), 7.76 (1H, dd, H_b, $J_{b,x}$ = 17 Hz, $J_{b,o}$ = 5 Hz); ms (70 eV) m/e 279 (P^+; 70%)]. This structural assignment draws primarily from the nmr (^1H, ^{13}C) information[5] which demands that the molecule incorporate (i) a five-membered heterocyclic moiety, as indicated by the relatively small value of $J_{\alpha,\beta}$ (4.5 Hz), (ii) a methylene function, as required by the large value of $J_{H_b,x}$ (17 Hz) and also the fact that one of the "aliphatic" singlets present in the proton-decoupled cmr spectrum changes to a clean triplet in the proton-coupled spectrum, and (iii) an isolated -CH=CH-function which is directly linked to the methylene group as indicated by the presence of coupling (5 Hz) between H_b and H_o.



a; X = Y = H
b; X = D, Y = H
c; X = H, Y = D

Operationally, the conversion of 3 to 4 is best accommodated through a sequence initiated by heterolytic XC-O bond rupture[7] followed by 1,2 hydride shift to 5 and concluded by decarboxylative internal bridging across the frame's *trans* double bond. Significantly, this mechanistic interpretation is supported by the results of experiments utilizing specifically labeled α-pyrone.

In brief, we find that exposure of 1 to α-pyrone-6-d (2b)[8] under conditions similar to those employed with 2a leads to a monodeuterated cycloadduct (m/e 324) specifically formulated as 3b on the basis of its pmr spectrum which closely resembles that of 3a but lacks the signal attributed to X of 3a while showing greatly simplified resonances (loss of secondary coupling) for H_2 as well as the protons attached to the ethylene bridge. In keeping with our mechanistic interpretation of the 3 to 4 transformation, pyrolytic extrusion of CO_2 from 3b at 140° produced the specifically deuterated (m/e 280) substance depicted in 4b and characterized by a pmr spectrum which is closely analogous to that of the protioanalog 4a except that now H_b appears as a broad singlet ($W_{\frac{1}{2}}$~10 Hz) instead of a geminally coupled doublet of doublets and the region between τ 6.0 and τ 6.3 integrates to five protons instead of the original six. In further confirmation of the structural and mechanistic interpretations presented in this report we find that reaction of 1 with yet another specifically labeled α-pyrone, namely 2c,[8] produces 3c (ms, pmr) which, in turn, yields 4c (ms, pmr) on thermolysis.

In closing, it is worth noting that conventional FMO analysis of the direction of cycloaddition between 1 and 2, i.e., formation of 3 instead of its position isomer 6[9] suggests that the 1,2 bond of 1 operates in its π2s capacity chiefly under the influence of the benzene appendage rather than the urethane function. The situation is depicted graphically in the Figure.[10]

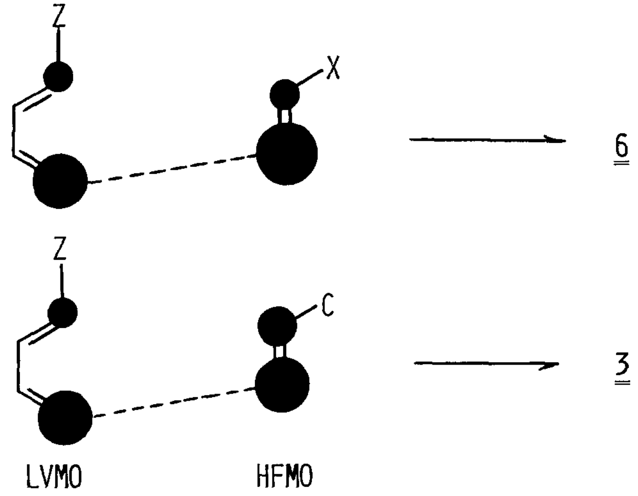


Figure.[a] FMO-Controlled Interaction Between 1 and 2

[a] Z represents the C= O group of 2, C denotes the phenyl appendage of 1 and X stands for the NCOOMe function of 1.

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REFERENCES AND REMARKS

(1) For a review on the subject see: A. G. Anastassiou, Accounts Chem. Res. 9, 453 (1976).

(2) A. G. Anastassiou and E. Reichmanis, Chem. Commun., 149 (1975).

(3) Similar processing of the all-*cis* counterpart of 1 failed to yield a cycloadduct.

(4) Fully consistent ir, uv and cmr spectra and correct elemental analysis were obtained for this substance.

(5) In several instances proton assignments required the use of double irradiation.

(6) The specific assignment of this signal to H_b, *i.e.*, the methylene proton which is coupled to its olefinic neighbour H_o follows from an examination of "Dreiding" molecular models which reveal the following dihedral angles: H_o-X~90°, H_o-H_b~50°.

(7) Our preference for heterolytic over homolytic XC-O bond cleavage derives from the nature of the subsequent step, *i.e.*, the 1,2 hydrogen shift which is generally known to occur only in cases where the migration terminus is positively charged.

(8) This substance was prepared as described by W. H. Pirkle and M. Dines, J. Amer. Chem. Soc., 90, 2318 (1968).

(9) It is notable that loss of CO_2 from 6 by a mechanism similar to that proposed in the case of 3 should lead to a substance whose structure does not entirely accomodate the available spectroscopic information.

(10) For an extensive analysis of the FMO procedure as applied to cycloaddition reactions see: I. Fleming, "Frontier Orbitals and Organic Chemical Reactions" Wiley, New York, New York, 1976, pp 110-181.