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A MASKED [$_{\pi}8$ + $_{\pi}2$] CYCLOADDITION REACTION INVOLVING THE 1,3,4,6-TETRAAZAPENTALENE RING SYSTEM

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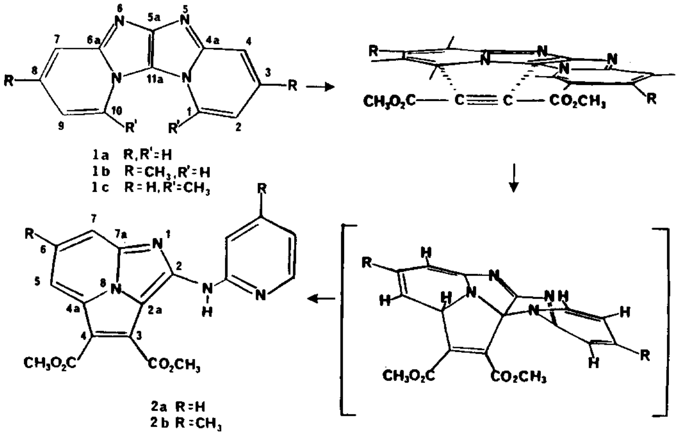
Abstract: Dipyrido[1,2-a:2',1'-f]-1,3,4,6-tetraazapentalene (1a) undergoes an [$_{\pi}8$ + $_{\pi}2$] cycloaddition reaction with dimethyl acetylenedicarboxylate to give, upon C-N bond cleavage, a substituted 1-azacycl[3.2.2]azine (2a).

The chemistry of compound 1a[1] is of interest since it contains the rare 10π-electron 1,3,4,6-tetraazapentalene ring system.[2] Single-crystal x-ray analysis of 1a has shown that the carbon-carbon bonds in the periphery of the 6-membered rings are of alternating length.[3] To test the conjugated double-bond character and possible dienophilic behavior of these terminal rings, compound 1a was caused to react with dimethyl acetylenedicarboxylate (DMAD) in refluxing benzene. From the complex mixture that resulted, a highly fluorescent yellow compound was isolated by column chromatography. Elemental microanalysis and mass spectrometry indicated this to be a 1:1 adduct with a molecular formula of $C_{16}H_{14}N_4O_4$. The enhanced color and fluorescence of the product ruled against its being the result of a [$_{\pi}4$ + $_{\pi}2$] cycloaddition. The observations of an intense peak at m/z 78 (e.g., $C_5H_4N^+$) in the mass spectrum and of an exchangeable proton at a chemical shift of 9.67 ppm in the ^{1}H NMR spectrum led to the conclusion that C-N bond cleavage had occurred. Such an event can be depicted formally as in Scheme I: [$_{\pi}8$ + $_{\pi}2$] cycloaddition of DMAD across the 10, 11a (or 1, 11a) positions of 1a to form an adduct that can undergo tautomerization and C-N bond cleavage to the substituted 1-azacycl-

Scheme I



[3.2.2]azine 2a. Proton and ^{13}C NMR spectra, including proton decoupling experiments, supported the conclusion that the structure of the product was dimethyl 2-(*N*-2-pyridinylamino)imidazo[2.1.5-*cd*]indolizine-3,4-dicarboxylate (2a) and excluded other possibilities.[4]

Recognition that acid might promote cleavage of the C-N bond prompted us to add a catalytic amount of 48% HBr to the reaction solution in methanol. The highest yield (*ca.* 30% based on unrecovered 1a) was achieved when a slight excess of DMAD was added dropwise to a refluxing methanolic solution of 1a containing a catalytic amount of 48% HBr. Under the same reaction conditions, the 3,8-dimethyl homolog 1b[5] gave 2b[6] (22%). By contrast, its 1,10-dimethyl isomer 1c, in which positions 1 and 10 are blocked and where no C-H bond in a presumed intermediate would be staged for cleavage, did not react with DMAD. Although the yields of 2a and 2b are low, they are reasonable when compared with the yields reported previously in Boekelheide reactions leading to 1-azacycl[3.2.2]azines and related 10π systems and proceeding via [8 + 2] cycloaddition.[7]

The [8 + 2] cycloaddition reactions between dimethyl acetylenedicarboxylate and either indolizines or azaindolizines normally require palladium-on-carbon as a dehydrogenating agent in refluxing toluene to afford the aromatic cycl[3.2.2]azines and azacycl[3.2.2]azines.[7,8] Flitsch and Heinrich[9] have reported that indolizines (8π compounds) with a substituted hydrazine as a leaving group on the 3-position yielded, inter alia, an aromatic cycl[3.2.2]azine when treated with DMAD in refluxing benzene without the need of Pd/C. In our example, the A and B rings of compound 1a can act similarly as an 8π component, i.e., a masked 1-azaindolizine, substituted on its "3"-position with the nitrogen of ring D. The latter can serve as a leaving group which does not actually depart from the scene but remains joined to the A/B ring system as an N-2-pyridylamino group at the 2-position (as in 2a). The idea of the occurrence of masked [$_\pi 8 + _\pi 2$] cycloaddition reactions may be applicable to other ring systems in which a hetero atom is attached internally to the terminus of an 8π electron component.

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3. M. P. Groziak, S. R. Wilson, G. L. Clauson, and N. J. Leonard, J. Am. Chem. Soc., submitted.
4. M.p. of 2a: 168-169 °C (methanol); R_f silicagel (CH_3OH-$CHCl_3$, 1:4, v/v) 0.70; ^1H NMR ($CDCl_3$) δ (ppm): 9.67 (s, 1, exchangeable), 8.62 (d, 1), 8.36 (d, 1), 7.87 (d, 1), 7.72 (m, 2), 7.37 (d, 1), 7.00 (dd, 1), 4.12 (s, 3), 3.99 (s, 3); ^{13}C NMR ($CDCl_3$) δ (ppm): 164.5 (s), 163.3 (s), 151.7 (s), 150.4 (s), 148.1 (d), 140.6 (s), 138.3 (d), 130.4 (s), 129.0 (d), 119.7 (s), 118.9 (s), 118.5 (d), 114.5 (d), 113.1 (s), 112.9 (d), 107.0 (d), 53.1 (q), 51.8 (q); EI mass spectrum (70 eV), m/z (rel.

intensity): 350 (M^+, 100), 317 (89), 286 (21), 260 (72), 232 (100), 154 (16), 78 (100); (CH_3OH) λ_{max}, nm ($\epsilon \times 10^4$): 208 (1.8), 244 (3.6), 286 (2.7), 340 (0.9), 394 (2.7); fluorescence (CH_3OH) λ^{ex}_{max} 395, λ^{em}_{max} *ca.* 484 nm. Anal. calcd for $C_{18}H_{14}N_4O_4$: C, 61.71; H, 4.03; N, 16.00. Found: C, 61.45; H, 3.91; N, 15.81.

5. We thank Gary L. Clauson for samples of **1b** and **1c**, the syntheses of which will be described shortly.
6. M.p. of **2b**: 188–189.5 °C (methanol); R_f silicagel (CH_3OH-$CHCl_3$, 1:4, v/v) 0.67; ^1H NMR ($CDCl_3$) δ (ppm): 9.71 (s, 1, exchangeable), 8.53 (s, 1), 8.25 (d, 1), 7.85 (s, 1), 7.39 (s, 1), 6.87 (d, 1), 4.14 (s, 3), 4.03 (s, 3), 2.74 (s, 3), 2.48 (s, 3); ^{13}C NMR ($CDCl_3$) δ (ppm): 164.5 (s), 163.5 (s), 151.8 (s), 150.5 (s), 149.5 (s), 147.8 (d), 140.7 (d), 140.4 (s), 129.9 (s), 119.7 (d), 119.6 (s), 118.5 (s), 114.1 (d), 113.1 (d), 111.5 (s), 108.4 (s), 52.9 (q), 51.6 (q), 22.9 (q), 21.5 (q); EI mass spectrum (70 eV) *m/z* (rel. intensity): 378 (M^+, 100), 346 (28), 288 (15), 260 (70), 173 (12), 92 (12); UV (CH_3OH) λ_{max}, nm ($\epsilon \times 10^4$): 208 (3.4), 250 (4.0), 264 (3.4), 349 (0.9), 400 (2.6); fluorescence (CH_3OH) λ^{ex}_{max} 395, λ^{em}_{max} *ca.* 486 nm. Anal. calcd for $C_{20}H_{18}N_4O_4$: C, 63.48; H, 4.80; N, 14.81. Found: C, 63.21; H, 4.62; N, 14.75.
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