THE REACTION OF ALIPHATIC DIAZO COMPOUNDS WITH HIGHLY ELECTROPHILIC ETHYLENE DERIVATIVES

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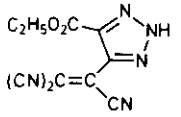
Dedicated to Professor Gilbert Stork on the Occasion of His 65th Birthday

Abstract — The cycloadditions of diazoacetic ester and diazomethane to tetracyanoethylene and ethylenetetracarboxylic ester, as well as reactions of the pyrazolines formed were investigated. In contrast to an earlier report, diazoacetic ester adds to the CC double bond of tetracyanoethylene.

α,β-Unsaturated nitriles accept diazoalkanes at the CC double bond.[1] However, the structure of the triazole 1 was assigned to the 1:1-adduct of tetracyanoethylene (TCNE) and ethyl diazoacetate by Scribner, Sausen, and Prichard [2] on the basis of IR evidence. Diazomethane combines with activated nitriles R-CN, R = CO_2CH_3, CN, Ts, Hal, OC_6H_5 to yield 1,2,3-triazoles;[1] phenyl cyanate slowly adds ethyl diazoacetate.[3]



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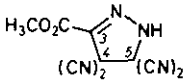

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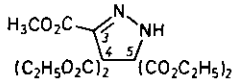

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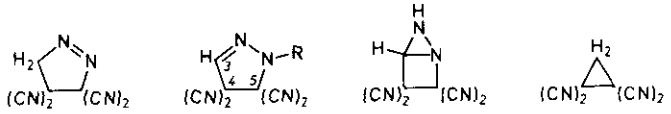
In fact, diazoacetic ester does *not* constitute an exception to the rule. The addition of *methyl diazoacetate* to *TCNE* in THF at 25°C (3 h) furnished 97% of 2-pyrazoline 2 in yellow crystals, mp 120-121°C.[4] The IR spectrum (KBr) shows N-H at 3370 (st, free) and 3120 (broad, ass.), C≡N at 2250 (w), C=O at 1745 (st, shoulder 1720), and C=N at 1596 cm^{-1} (st). The ^{13}C NMR shifts ([D_6]acetone/$CDCl_3$ 1:1) decide against a triazole formula and in favor of the 2-pyrazoline 2: 2s at δ 52.2 and 64.0 for C-4

and C-5, 2 s at 108.0 and 109.5 for 4 CN groups, s at 132.2 for C-3 and s at 158.4 for CO. The mass spectrum with m/z 228 (M^+, 6%), 201 (M^+ - HCN, 9%), 135 (16%, $H_3CO_2C-C=C(CN)_2^+$), and 128 ($TCNE^+$, 15%) is consistent with 2, but not with 1.

Tetraethyl ethylenetetracarboxylate is a less active dipolarophile than TCNE due to steric hindrance of resonance. Its reaction with *methyl diazoacetate* (3 d at 80°C without solvent) afforded 98% of the colorless 2-pyrazoline 3, mp 80°C. The ^1H NMR spectrum ($CDCl_3$) exhibits four identical OCH_2CH_3 at δ 1.26 (t) and 4.26 (q), by coincidence, whereas the ^{13}C-NMR signals indicate pairwise different ester CH_2 groups at δ 62.6 and 63.0 (2 t), and 4 CH_3 groups absorb at 13.7 (q). C-4 and C-5, δ 73.3 and 80.7 (2 s), appear in 3 at higher field than in 2, in accordance with known substituent increments;[5] $CO_2C_2H_5$ deshields more strongly than CN. The C-3 (δ 138.9) differs less, and the ^{13}C NMR spectra of 2 and 3 underline the structural analogy.



4 **5** R = H **7** **8**

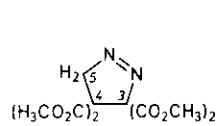
6 R = $COCH_3$

Scribner et al.[2] observed N_2 evolution when ethereal diazomethane was added to TCNE in THF; 38% of tetracyanocyclopropane (8) were isolated. On the other hand, Bastús and Castells [6] quoted IR-spectroscopic arguments for the occurrence of three monoadducts of TCNE and diazomethane to which structures 4, 5, and 7 were assigned. The crystals of the 1-pyrazoline 4 were stated to lose N_2 *in 16 d at 25°C to give 8*; allegedly, the bicyclic compound 7 isomerized to the 2-pyrazoline 5 under the influence of TCNE in ether and reverted to 7 in the presence of a trace of HCl. In our hands, only the 2-pyrazoline 5 was obtained as a pure product.

We added 1 equiv of *diazomethane* in THF to the suspension of *TCNE* in dry THF stirred at -78°C; the yellow color was rapidly consumed resembling a titration. The brown-yellow 5 precipitated from the clear solution at room temperature in 63% yield, when four volumes of pentane and some acetic acid were added. 2-Pyrazoline 5, mp 125-127°C (dec., 126°C [6]) after recrystallization from ether, showed ^1H NMR singlets ([D_6]acetone) at δ 7.65 (3-H) and 9.40 (br., NH) as well as ^{13}C NMR signals at δ 108.0 and 110.0 (equal intensity) for 2 x 2 CN, 132.9 (dd, C-3, splitting by NH, d with D_2O), 62.7 (s, C-5), and 52.8 (s, C-4).

When 5 was dissolved in [D_6]DMSO, the solution turned dark-brown and slow N_2 evolution started. After 72 h, the ^{1}H NMR spectrum indicated only the cyclopropane 8 (s, δ 3.50); isolation and sublimation at 130-140°C/0.1 Torr afforded 87% of light-yellow 8, mp 212-213°C (dec., 223-225°C [2]). Probably an equilibrium with the 1-pyrazoline 4 is established with the latter eliminating N_2. Interestingly enough, 30 min after dissolving 5 in DMSO, new ^{1}H NMR signals which disappeared later, suggest a reversible HCN elimination (s 6.23) from 4 or 5.

Acetic anhydride and a catalytic amount of pyridine converted 5 into the *N*-acetyl derivative 6, mp 220°C (dec.) after sublimation at 160°C/0.1 Torr. ^{1}H NMR singlets in [D_6]DMSO occurred at δ 8.86 (3-H) and 2.63 (CH_3), whereas IR (KBr) bands appeared at 2260 (w, C≡N) and 1715 cm^{-1} (st, C=O).



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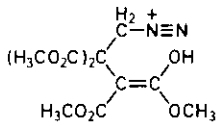

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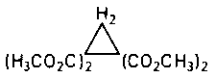

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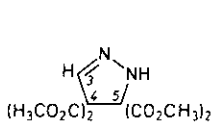

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The reaction of *tetramethyl ethylenetetracarboxylate* with *diazomethane* in ether at 20°C provided 79% of the colorless 1-pyrazoline 9, mp 86-88°C. The NMR ($CDCl_3$) data confirm a plane of symmetry. ^{1}H NMR: δ 5.15 (s, 5-H_2), 3.80 and 3.68 (2s, 2 x 2 OCH_3); ^{13}C NMR: δ 167.9 and 164.5 (2s, 2 x 2 CO), 106.3 (s, C-3), 85.8 (t, C-5), 61.7 (s, C-4). 9 evolved N_2 at 140°C in bromobenzene with $t_{1/2}$ = 39 min; the cyclopropane 11 appeared to the extent of 60% in the multi-product mixture. Steric hindrance of resonance is probably responsible for this astonishing stability of the 1-pyrazoline 9 with respect to N_2 elimination. The incipient trimethylene species does not sufficiently profit from the resonance with the twisted ester groups.

In 0.090 M trifluoroacetic acid in 1,1,2,2-tetrachloroethane at 25°C, the N_2 evolution from 9 followed the first order with a half-life of 31.3 h; $10^5 k_2$ amounted to 6.8 $M^{-1}s^{-1}$. After removal of acid and solvent, 95% of tetramethyl cyclopropane-1,1,2,2-tetracarboxylate (11) distilled at 100-110°C/0.001 Torr; from ether/pentane, mp 69.5-70.5°C. ^{1}H NMR ($CDCl_3$): δ 2.15 (s, 3-H_2), 3.70 (s, 4 OCH_3). The acid-catalyzed extrusion of N_2 from 1-pyrazolines has occasionally been applied to the preparation of steroidal cyclopropanes; $HClO_4$ in acetone [7] or BF_3 etherate in acetone [8] served as catalysts. A cationic chain reaction of 9 via 10 is conceivable.

The tautomerization of 1- to 2-pyrazolines, forbidden by orbital control as a concerted sigmatropic process, takes place by deprotonation via an anionic intermediate or through *N*-protonation. Whereas the tautomerization 4 → 5 proceeded in situ, we attribute the resistance of 1-pyrazoline 9 to the steric shielding of 5-CH_2 by two 4-CO_2CH_3. The interaction of 9 with a catalytic amount of aqueous conc. HCl in [D_6]DMSO, however, lead in 90 min to 84% of 12 and in 24 h to a 98% yield. The colorless 2-pyrazoline 12, mp 113-115°C (dec.), showed ^{1}H NMR ($CDCl_3$) singlets at δ 6.78 (3-H) and 6.61 (br., NH); those of 2 x 2 OCH_3 coincided at 3.78. The ^{13}C NMR shifts distinguish between the ester groups in 4- and 5-position: δ 165.5, 167.0 (2s, 2 x 2 CO), 139.2 (d, C-3), 78.2 (s, C-5), 74.1 (s, C-4). Strangely enough, 9 was resistant to trifluoroacetic acid in DMSO.

Thus, the cycloadditions of diazomethane to TCNE and ethylenetetracarboxylic ester proceed *normally*, i.e., at the CC double bond. The addition of diazomethane to dimethyl 2,3-dicyanofumarate, the "mixed dipolarophile", likewise starts with pyrazoline formation, but is followed by a surprising sequence of events.[9]

ACKNOWLEDGMENT

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