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Received July 5, 1987

The 1,3-dipolar cycloadditions of aryl nitrilimines to 1,2-diacetylene gave along with the 1,2-diaryl-4,5-diacetyl-4,5-dihydropyrazoles **5** and the corresponding dehydrogenated pyrazoles **6**, the unexpected 1,3-diaryl-4-acetylpyrazoles **7**. As for tetrasubstituted alkenes, whereas 1,2-diacetyl-1,2-dicarboethoxyethylene gave a stable cycloadduct **8**, 1,2,3,4-tetraacetylene yielded a mixture of pyrazoles **6** and **7**.

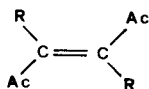
*J. Heterocyclic Chem.*, **25**, 249 (1988).

## Introduction.

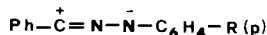
During our research on the reactivity of ethylenic systems with electron-withdrawing groups [1] we became interested in their behavior towards 1,3-dipoles, since the 1,3-dipolar cycloaddition of olefins is a versatile method for the stereoselective and regioselective synthesis of penta-atomic heterocycles.

In a previous paper [2] we reported the behavior of ethylenic systems of type 1-3 towards nitrile oxides.

### Scheme 1



- 1 R = H  
2 R = Ac  
3 R = COOEt



- 4 a R = H  
b R = Cl  
c R = Me

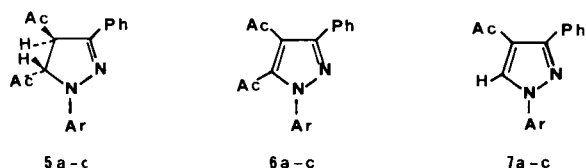
In order to obtain substituted pyrazole rings which could be condensed to yield polycycles, we extended the cycloaddition reactions of these systems to nitrilimines.

## Results and Discussion.

The cycloadditions between **1** and the diaryl nitrilimines **4**, prepared from hydrazoneyl chlorides in the presence of triethylamine, were carried out in benzene at room temperature.

According to the results obtained with nitrile oxides, the most peculiar feature of the reaction was that the diacylpyrazolines **5a-c**, which were the first products of the reaction of compound **1**, are unstable. By oxidation and by loss of an acetyl group they converted to a mixture of 1,2-diaryl-4,5-diacetyl-1*H*-pyrazoles **6** and 1,3-diaryl-4-acetyl-1*H*-pyrazoles **7**. The three products were already detectable (tlc and pmr spectra) in the reaction mixture, but during the chromatographic separation the conversion of **5** went on and only in some cases it was possible to separate compounds **5**, at a low purity grade.

### Scheme 2



The structures of compounds **5**, **6** and **7** were easily established by pmr spectroscopy. Thus the expected 1,3-dipolar cycloadducts **5** show the presence of two doublets for H-4 and H-5 protons, whose coupling constants ( $J = 4.2\text{-}4.7$  Hz) are in agreement with the *trans* stereochemistry.

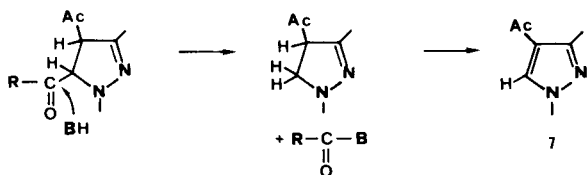
The spectra of the aromatized pyrazoles **6** show, beside the aromatic protons, only the methyl signal of the acetyl groups, while those of the mono acetylpyrazoles **7** are characterized by the presence of a singlet at  $\delta$  8.4, diagnostic of 5-unsubstituted pyrazoles.

The literature reported only another analogous behavior concerning the reaction of 1,2-dibenzoylene with *p*-nitrophenylnitrilimine. From this reaction a mixture of benzoylpyrazoles of type **5**, **6** and **7** was isolated [3]. Yet the lability of the acetyl groups seems much higher.

The presence of the pyrazoles **6a-c** can be easily explained keeping in mind that the 2-pyrazolines aromatize under different conditions, even in absence of oxygen [4,5], though the mechanism is not completely clear. The formation of 4-acylpyrazoles **7** is more difficult to explain. There is evidence that they come directly from the pyrazoles **5**, because 3,4-diacetylpyrazoles **6** are stable under the reaction conditions. The formation of acetamide when the reaction mixture was treated with primary amines, the enhancing of the decomposition rate in the presence of aqueous bases pointed out that the acyl loss was due to a nucleophilic attack on the carbonyl group linked at position 5 of the ring, which results the only one attacked. In fact no traces of the product desacetylated at position 4 were ever observed. However, the presence of an acetyl group at position 4 seems necessary in order to

have the desacetalation, since the 5-acylpyrazoles are by far more stable [3].

Scheme 3

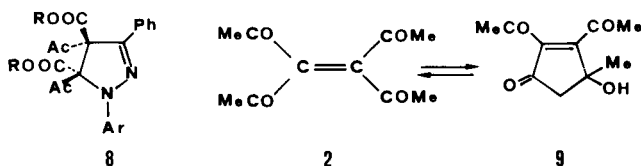


Notwithstanding the well known stereospecificity of cycloaddition reactions of *cis* and *trans* olefins with nitrilimines [6], even the reaction with *cis*-diacetylene led to the same mixture of products where was present only the *trans*-pyrazolines **5a-c**, beside the pyrazoles **6a-c** and **7a-c**. In some cases the simultaneous presence of the two pyrazolines *cis* and *trans* was attributed to the isomerisation of the *cis*-olefin under the basic conditions [7-9]. In our case we are more inclined to think that the isomerisation implies preferentially the *cis*-pyrazolines, since under the reaction conditions the isomerisation of diacetylene was much slower than the formation rate of the cycloadduct.

Unlike the behavior with nitrile oxides [2], the alkenes **2** and **3** reacted with aryl nitrilimines to close a pyrazole ring, but, whereas the alkene **3** gave rise to the 2-pyrazoline **8**, the alkene **2** yielded a reaction mixture, from which we isolated the acetylpyrazoles **6** and **7** in 75% overall yield.

According to the behavior of other tetrasubstituted alkenes [10], we believe that also in this case a cycloadduct like **8** was formed, but as a consequence of its instability it lost two or three acetyl groups converting into 4,5-diacetyl-**6a-c** and 4-acetyl-pyrazoles **7a-c**.

Scheme 4



We extended the reaction to the cyclopentenone **9**, derived from the alkene **2** by internal aldolic cyclization under basic conditions [11]. Though this compound resulted inert towards nitrile oxides, it reacted with diphenylnitrilimine **4a**; from the reaction mixture we isolated the pyrazoles **6a** and **7a** in a ratio 43.5:5.5. We never detected any derivative with the cyclopentenone moiety. This behavior indicates that under the reaction conditions the cyclopentenone **9** could exist in equilibrium with the open form **2** and this one reacted with the aryl nitrilimine.

## EXPERIMENTAL

Melting points were taken on a Kofler melting point apparatus and are uncorrected. The pmr spectra were recorded for deuteriochloroform solutions with a Hitachi-Perkin-Elmer R-600 instrument; chemical shifts ( $\delta$  in Hz) are reported downfield from internal tetramethylsilane. The ir spectra were recorded on a Perkin-Elmer 782 spectrophotometer using samples in potassium bromide pellets. Silica gel plates (Merck F<sub>254</sub>) and silica gel 60 (Merck 70-230 mesh) were used for analytical and preparative tlc and for column chromatography, respectively. Extracts were dried over sodium sulphate and solvents were evaporated *in vacuo*.

## Materials.

The *N*-aryldiazonoyl chlorides were prepared by the method of Huisgen [4]. The following compounds were prepared by the literature procedure cited: *cis* and *trans*-diacetylene [12], tetracetylene [13] and 2,3-diacetylfumarate [14].

General Procedure of the Reaction of Diaryl Nitrilimines **4a-c** with Alkene **1**.

To a solution of diazonoyl chloride (4.0 mmoles) in anhydrous benzene (15 ml) was added triethylamine (4.0 mmoles), followed by the alkene **1** (2.0 mmoles). The mixture was stirred at room temperature for 48 hours. The precipitated triethylamine hydrochloride was filtered off, and the filtrate was evaporated to dryness. Column chromatography of the residue and elution with ether-petroleum ether mixture (1:1) gave at first the diacetylpyrazoles **6**, then the dihydropyrazoles **5**, and at last the mono-acetylpyrazoles **7**.

1,3-Diphenyl-4,5-diacetylpyrazole (**6a**).

This compound was obtained in a yield of 41% as white needles, mp 120-121° (from cyclohexane); ir: 1690 (CO), 1655 cm<sup>-1</sup> (CO); pmr:  $\delta$  2.19 (3H, s, Me), 2.42 (3H, s, Me), 7.51 (10H, bs, 2 x Ar).

*Anal.* Calcd. for C<sub>17</sub>H<sub>16</sub>N<sub>2</sub>O<sub>2</sub>: C, 75.0; H, 5.26; N, 9.21. Found: C, 74.84; H, 5.24; N, 9.28.

1,3-Diphenyl-4,5-diacetyl-4,5-dihydropyrazole (**5a**).

This compound was obtained in a yield of 5.5%; attempts to purify this compound led to a mixture of **6a** and **7a**; pmr:  $\delta$  2.12 (3H, s, Me), 2.17 (3H, s, Me), 4.32 (1H, d, CH, J = 4.7), 4.85 (1H, d, CH, J = 4.7), 7.48 (10H, m, 2 x Ar).

1,3-Diphenyl-4-acetylpyrazole (**7a**).

This compound was obtained in a yield of 43% as white crystals, mp 99-101° (from diluted acetic acid); ir: 1680 cm<sup>-1</sup> (CO); pmr:  $\delta$  2.33 (3H, s, Me), 7.43 (10H, m, 2 x Ar), 8.40 (1H, s, CH).

*Anal.* Calcd. for C<sub>17</sub>H<sub>14</sub>N<sub>2</sub>O: C, 77.86; H, 5.34; N, 10.69. Found: C, 77.72; H, 5.46; N, 10.84.

1-(4-Chlorophenyl)-3-phenyl-4,5-diacetylpyrazole (**6b**).

This compound was obtained in a yield of 37% as white crystals, mp 116-110° (from cyclohexane); ir: 1710 (CO), 1670 cm<sup>-1</sup> (CO); pmr:  $\delta$  2.20 (3H, s, Me), 2.44 (3H, s, Me), 7.44 (5H, s, Ar), 7.50 (4H, bs, Ar).

*Anal.* Calcd. for C<sub>19</sub>H<sub>15</sub>ClN<sub>2</sub>O<sub>2</sub>: C, 67.36; H, 4.43; Cl, 10.46; N, 8.27. Found: C, 67.66; H, 4.22; Cl, 10.05; N, 8.09.

1-(4-Chlorophenyl)-3-phenyl-4-acetylpyrazole (**7b**).

This compound was obtained in a yield of 39% as white crystals, mp 72-74° (from diluted acetic acid); ir: 1670 cm<sup>-1</sup> (CO); pmr:  $\delta$  2.36 (3H, s, Me), 7.37-7.80 (9H, m, 2 x Ar).

*Anal.* Calcd. for C<sub>17</sub>H<sub>13</sub>ClN<sub>2</sub>O: C, 68.80; H, 4.38; Cl, 11.97; N, 9.44. Found: C, 68.92; H, 4.55; Cl, 11.47; N, 9.04.

1-(4-Chlorophenyl)-3-phenyl-4,5-diacetyl-4,5-dihydropyrazole (**5b**).

This compound was obtained in a yield of 3.2%; attempts to purify this compound led to a mixture of **6b** and **7b**; pmr:  $\delta$  2.10 (3H, s, Me), 2.16 (3H, s, Me), 4.32 (1H, d, CH, J = 4.2), 4.82 (1H, d, CH, J = 4.2), 7.50 (9H, m, 2 x Ar).

1-(4-Methylphenyl)-3-phenyl-4,5-diacetylpyrazole (**6c**).

This compound was obtained in a yield of 45% as white crystals, mp 130-133° (from cyclohexane); ir: 1710 (CO), 1665 cm<sup>-1</sup> (CO); pmr: δ 2.20 (3H, s, Me), 2.39 (3H, s, Me), 2.41 (3H, s, Me), 7.28-7.43 (9H, m, 2 x Ar).

*Anal.* Calcd. for C<sub>20</sub>H<sub>18</sub>N<sub>2</sub>O<sub>2</sub>: C, 75.47; H, 5.66; N, 8.81. Found: C, 75.24; H, 5.59; N, 8.65.

1-(4-Methylphenyl)-3-phenyl-4-acetylpyrazole (**7c**).

This compound was obtained in a yield of 45% as white crystals, mp 108-110° (from diluted acetic acid); ir: 1680 cm<sup>-1</sup> (CO); pmr: δ 2.38 (3H, s, Me), 2.41 (3H, s, Me), 7.14-7.89 (9H, m, 2 x Ar), 8.41 (1H, s, CH).

*Anal.* Calcd. for C<sub>18</sub>H<sub>16</sub>N<sub>2</sub>O: C, 78.26; H, 5.80; N, 10.15. Found: C, 79.45; H, 5.90; N, 10.38.

Reaction of Diaryl Nitrilimines **4a-c** with Alkene **2**.

Following the same procedure as described above for the reaction of diarylnitrilimines **4a-c** with alkene **1**, the alkene **2** gave the diacetylpyrazoles **6a,b,c** and the monoacetylpyrazoles **7a,b,c** in the ratio **6a:7a** = 43:34, **6a:7b** = 40:29, **6c:7c** = 35:30, respectively.

1,3-Diphenyl-4,5-diacetyl-4,5-diethoxycarbonylpyrazole (**8**).

To a solution of hydrazonoyl chloride (0.54 g, 2.3 mmoles) in anhydrous benzene (8 ml) was added triethylamine (0.32 ml, 2.3 mmoles) followed by diethyl 2,3-diacetylbutendioate (**3**) (0.3 g, 1.17 mmoles). The mixture was stirred at room temperature for 4 hours. The precipitated triethylamine hydrochloride was filtered off and the filtrate was evaporated to dryness. The residue was crystallized from cyclohexane to give 1,3-diphenyl-4,5-diacetyl-4,5-diethoxycarbonylpyrazole (**8**), as yellow crystals, mp 110-112°, in a yield of 76%; ir: 1750 (CO), 1740 (CO), 1720 cm<sup>-1</sup> (CO); pmr: δ 1.17 (3H, t, Me, J = 7.0), 1.21 (3H, t, Me, J = 7.0), 2.18 (3H, s, Me-4), 2.33 (3H, s, Me-5), 4.19 (2H, q, CH<sub>2</sub>, J = 7.0), 4.23 (2H, q, CH<sub>2</sub>, J = 7.0).

*Anal.* Calcd. for C<sub>26</sub>H<sub>26</sub>N<sub>2</sub>O: C, 66.66; H, 5.82; N, 6.22. Found: C, 66.64; H, 5.82; N, 6.63.

## Acknowledgement.

This work was financially supported by the Consiglio Nazionale delle Ricerche, Rome.

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