REACTIONS OF TETRAFLUOROETHENE OLIGOMERS. PART XII [1]
CYCLOADDITION REACTIONS OF 3,3,4,4,4-PENTAFLUORO-2-PENTAFLUOROETHYL-2-
TRIFLUOROMETHYLDIAZOBUTANE. A NOVEL SYNTHESIS OF PYRAZOLES

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SUMMARY

The title diazoalkane (1) reacts smoothly with a variety of electron
deficient alkenes to give, unexpectedly, the corresponding pyrazole
derivatives. Thus, reaction with methyl or ethyl propenoate affords the
methyl and ethyl esters of pyrazole-3-carboxylic acid (2) and (3). Reaction
with diethyl maleate yields 3,4-bis-(ethoxycarbonyl)pyrazole (4), and
dimethyl maleate gives the corresponding dimethyl ester (5). Treatment of
(1) with propenonitrile afforded 3-cyanopyrazole (6), and with propenoic
acid the corresponding pyrazole-3-carboxylic acid (7) was obtained. In all
of these reactions two side products were isolated, namely perfluoro-(3-
methylpent-2-ene) (8) and 3H-3-trifluoromethyldecafluoropentane (9). A
mechanistic rationale for these unusual and potentially useful reactions
is given.

INTRODUCTION

Although the cycloaddition of diazoalkanes to alkenes has been known for
many years, it was with the now classical work of Huisgen in the 1960 s

[2,3] that the ideas of dipolar cycloadditions were formulated. Studies of these additions have attracted considerable interest from a mechanistic viewpoint and this has been comprehensively reviewed [4]. The reactions are now classified as 3+2 additions and provide a convenient route to five membered ring systems. For example, diazomethane yields, on reaction with suitable olefins, a wide range of pyrazolines [4]. The reactivity of the diazoalkane is reported to be reduced by the introduction of electron withdrawing groups and increased by the presence of electron donating groups [5]. Further the reaction only works well when the alkene is part of a strained ring system or is conjugated to an electron attracting group [4].

In the fluorinated field, where relatively little work has been done, due to the lack of suitable poly- and perfluoro- diazoalkanes, cycloadditions have been observed. For example, reaction of perfluoro-2-diazopropane with propenonitrile gives the corresponding pyrazoline which readily rearranges to a more stable isomer [6,7].
Fluorinated pyrazolines and related compounds have been obtained from reaction of diazomethane with polyfluoroazaalkenes [8] and more recently with fluoroalkenes [9]. In all of these reactions it should be noted that the product is not the aromatic material and often further dehydrogenation is difficult to achieve [10].

RESULTS AND DISCUSSION

Although the implication from earlier studies was that electron deficient diazoalkanes did not readily participate in cycloaddition reactions, we had shown from other reactions [11] that (1) had such unusual properties, that its use in this type of reaction should nevertheless be explored. Thus, we treated (1) with methyl propenoate in the absence of solvent. In a slow reaction, the loss of the intense yellow colour of (1) is a good measure of the way that the reaction is proceeding; we found that after five days at room temperature a solid was being precipitated and the colour was fading. To ensure complete reaction the mixture was left for twenty days, when the colour had disappeared, as had the strong i.r. band for the diazoalkane.
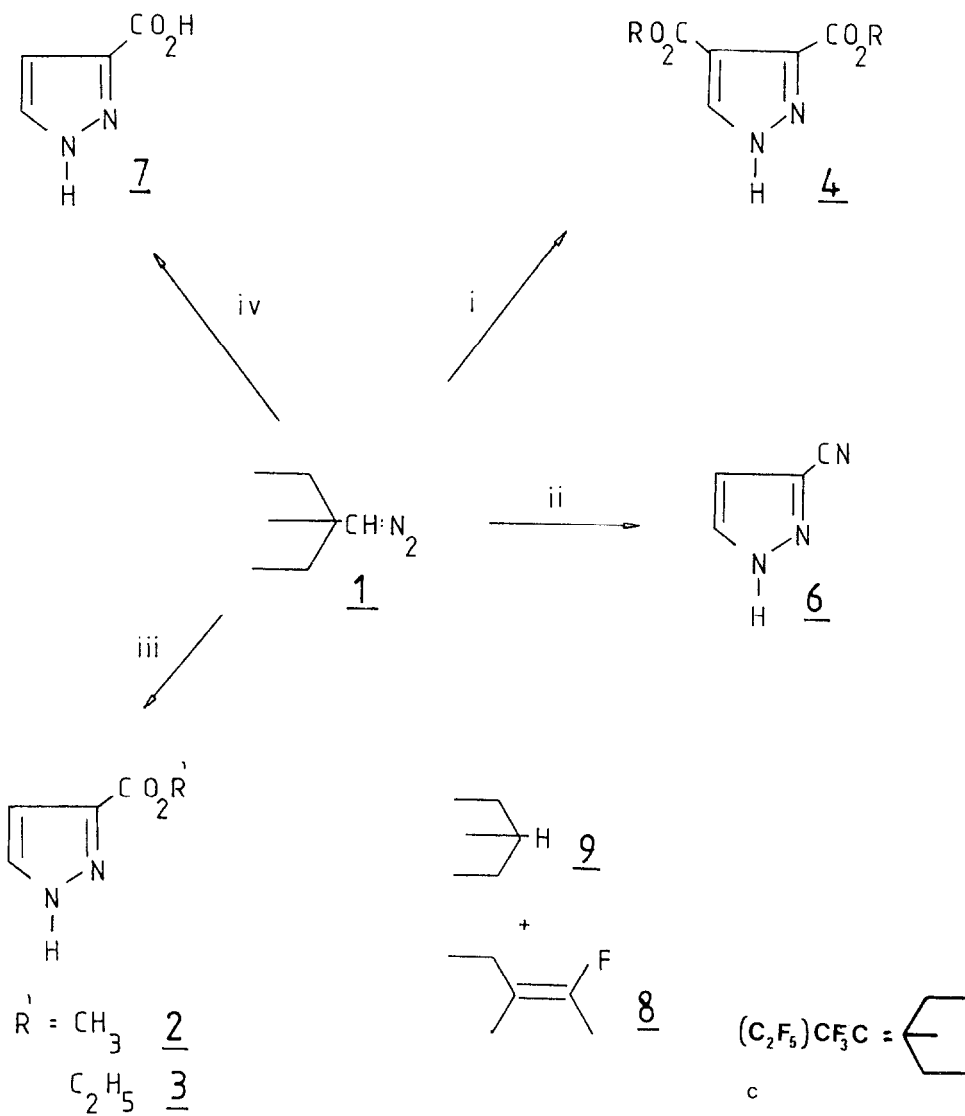
The solid was filtered from excess methyl propenoate and dried in vacuo; examination of its ^{19}F n.m.r. spectrum gave a total surprise since it showed the complete absence of fluorine in the molecule. The ^1H n.m.r. spectrum showed signals for a methyl group, two aromatic protons and an NH. The i.r. spectrum showed bands at 3110 cm^{-1} and 1730 cm^{-1} corresponding to NH and CO respectively. The mass spectrum gave the expected band (M = 126) for the product to be methyl pyrazole-3-carboxylate (2). Examination of the liquid fraction from this reaction showed two major components to be present; these were separated and readily identified as perfluoro-3-methylpent-2-ene (8) and 3H-3-trifluoromethyldecafluoropentane (9), both of which had been prepared previously. [12].

In a similar experiment, but using the ethyl ester, the corresponding ethyl pyrazole-3-carboxylate (3) was obtained, as well as the fluorocompounds (8) and (9).
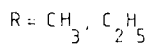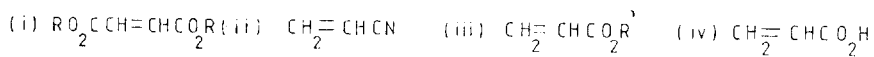
When (1) was treated with diethyl maleate the reaction was very slow, taking 60 days to go to completion to give a good yield of a white crystalline solid, which again contained no fluorine. The spectral data and elemental analysis clearly indicated that the product was 3,4-bis(ethoxycarbonyl)-pyrazole (4); again (8) and (9) were isolated from the mother liquors. The reaction was repeated but this time using the methyl ester and with Freon 113 as the solvent. In this case the reaction was much faster, being complete in 10 days to afford the corresponding ester (5) in similar yield; again (8) and (9) were isolated from the residue.

Thus, the pattern of reaction was well established and was further confirmed by reactions with propenonitrile and propenoic acid to give the expected nitrile (6) and the acid (7) respectively. These reactions are summarised in Scheme 1
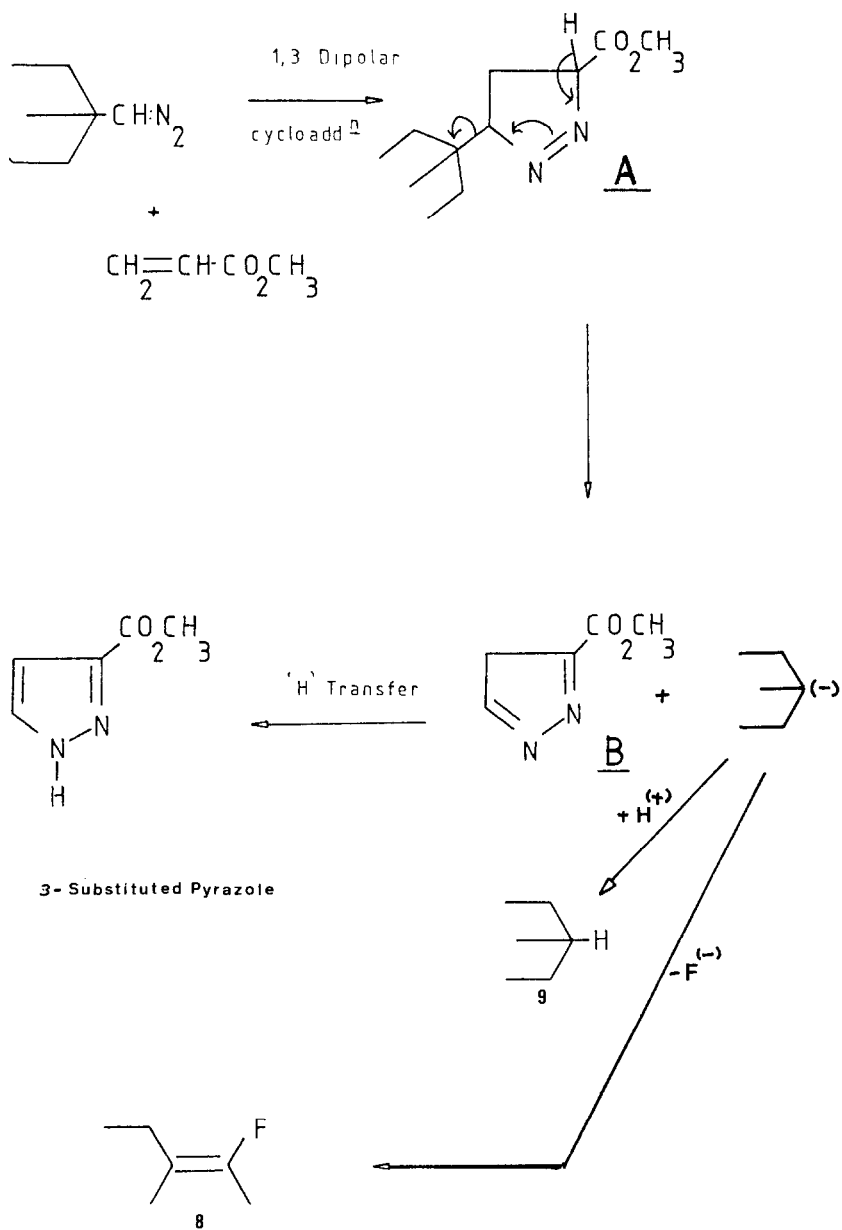
We believe that these interesting reactions initially follow the pattern expected for the dipolar addition of a diazoalkane to an olefin i.e. to form the intermediate (A) (Scheme 2) . In the hydrocarbon series there is now no simple pathway to the aromatic product and so the reaction stops at the pyrazoline (A). In our reaction however the formation of an aromatic

Scheme 1

$-CH:N_2$

1,3 Dipolar

cycloadd$^{\underline{n}}$

$+$

$CH_2=CH\cdot CO_2CH_3$

A

CO_2CH_3

B

$+$ (−)

$+H^{(+)}$

$-F^{(-)}$

'H' Transfer

CO_2CH_3

N
N
H
H

3- Substituted Pyrazole

H

9

F

8

Scheme 2

species is greatly facilitated by the ready loss of the $(C_2F_5)CF_2C$ group in a 1,4 elimination to give intermediate (B) (Scheme 2) which then affords the product isolated by a simple proton rearrangement step. This occurs due to the excellent leaving ability of the fluorocarbon function as we have observed previously [11].

We feel this simple, efficient reaction, represents an excellent route to pyrazoles and other five membered heterocycles. Extension of this work is currently in progress.

EXPERIMENTAL

Methyl pyrazole-3-carboxylate (2)

3,3,4,4,4-Pentafluoro-2-pentafluoroethyl-2-trifluoromethyldiazobutane (1) (5g.) and methyl propenoate (1.72g.) were sealed in a Carius tube and left to stand in the dark for 5 days, when a solid began to form but when the yellow colour of (1) still persisted. After a further 15 days when the colour had been discharged the tube was opened, the solid was filtered off and recrystallised from n-hexane to yield methyl pyrazole-3-carboxylate (2) (1.0 g, 57%) m.p. 135-137°C cited 139°C [13]   (Found: C, 47.0; H, 4.8; N, 21.9%. Calc for $C_5H_6N_2O_2$ C, 47.6; H, 4.8; N, 22.2%);   i.r. 3110 cm^{-1} (NH), 1730 cm^{-1} (CO) M.S. m/e 126 (M$^+$).

A portion (1.2 g,)of the mother liquors (3.6g.) from the reaction was separated by glc (D.N.P./Celite 1:3 10m x.96cm. 70°C) to yield (i) perfluoro-3-methylpent-2-ene (8) (0.25g.) and (ii) 3H-3-trifluoromethyldecafluoropentane (9) (0.54g.) both identified by comparison with authenticated samples [12].

Ethyl pyrazole-3-carboxylate (3)

In a similar experiment to the above but using ethyl pentenoate (2.0 g.), there was obtained after 10 days, on recrystallisation from water, ethyl pyrazole-3-carboxylate (0.96 g. 49%) m.p. 157-159°C cited [14] 158-159°C

(Found; C, 51.2; H, 5.7; N, 19.7 %. $C_6H_8N_2O_2$ requires C, 51.4; H, 5.7; N, 20.0%);   i.r. 3220 cm^{-1} (NH), 1695 cm^{-1} (CO),   M.S. m/e 140 (M$^+$).

The mother liquors were shown by ^{19}F n.m.r. spectroscopy to contain the fluorocarbons (8) and (9).

3,4-Bis-(ethoxycarbonyl) pyrazole (4)

In a similar experiment to the above the diazoalkane (1) (5.0 g.) and diethyl maleate (3.0 g.) afforded after 60 days, on recrystallisation from propanone, 3,4- bis-(ethoxycarbonyl) pyrazole (4) (1.72 g, 58%) m.p. 68-69°C cited 69-70°C [15] (Found; C, 50.8; H, 5.5; N, 13.0%. $C_9H_{12}N_2O_4$ requires C, 50.9; H, 5.7; N, 13.2 %); i.r. 3110 cm^{-1} (NH), 1745 and 1720 cm^{-1} (CO),   M.S. m/e 212 (M$^+$).

Again the fluorocarbons (8) and (9) were detected in the mother liquors.

3,4-Bis-(methoxycarbonyl) pyrazole (5)

In a similar experiment to the above (1) (5.0g.) and dimethyl maleate (1.44g.) in Freon 113 (2.0 cm^3) gave after 10 days and on recrystallisation from water, 3,4-bis-(methoxycarbonyl) pyrazole (5) (0.65g 25%) m.p. 135-138°C cited 140-141°C [16] (Found: C, 45.5; H, 4.4; N, 14.9%. Calc for $C_7H_8N_2O_4$ C, 45.7; H, 4.4; N, 15.2%);   i.r. 3110 cm^{-1} (NH), 1745 cm^{-1} and 1720 cm^{-1} (CO);   M.S. m/e 184 (M$^+$).

3-Cyanopyrazole (6)

In a similar experiment to the above the diazoalkane (5.0 g) and propenonitrile (2.0g) afforded after 10 days a crystalline solid which on recrystallisation from water gave 3-cyanopyrazole(6) (0.61 g, 47%) m.p. 73-73°C cited [15] 76-77°C; i.r 3340cm^{-1} (NH), and 2300 cm^{-1} (CN);   M.S. m/e 93 (M$^+$).

Pyrazole-3-carboxylic acid (7)

In a similar way to the previous experiments, treatment of the diazoalkane
(3.0 g) with propenoic acid (0.72 g) gave after 7 days a solid which on
recrystallisation from water gave pyrazole-3-carboxylic acid (7) (0.25 g,
27%) m.p. 208-210°C cited [17] 210-211°C;   i.r. 1700 cm⁻¹ (CO);   M.S. m/e
112 (M⁺);   U.V. λ max 214 (e 396).

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