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HIGH PRESSURE ADDITION REACTIONS OF SOME 3a,6a-DIAZAPENTALENES[1]

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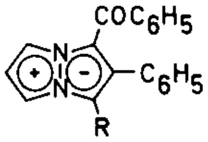
Abstract—Azacyclazine derivatives were obtained from 1-benzoyl-2-phenyl-3a,6a-diazapentalene with methyl propiolate and alcohols, and from 1,3-dibenzoyl-2-phenyl-3a,6a-diazapentalene with dimethyl acetylenedicarboxylate. The former diazapentalene with diphenylcyclopropenone yielded a pyrazole. These reactions only proceeded at 10 kbar pressure and the products were identified mainly from their ^{1}H and ^{13}C nmr spectra.

Mesoionic heteropentalenes have attracted considerable attention in recent years because of their intriguing chemical properties.[2] Most of these compounds behave as bicycloimmonium ylids and undergo formal 1,3-dipolar cycloadditions with electron deficient acetylenes to give novel types of heterocycles such as cyclazines.[3] 3a,6a-Diazapentalenes with dimethyl acetylenedicarboxylate (DMAD) give corresponding 2a-azacycl[2.2.2]azine in the presence of palladium on charcoal,[4] or rearranged adducts[5] in its absence. 3a,6a-Diazapentalene and its derivatives are usually sensitive to heat, and because of this attempted cycloaddition reactions with some electrophilic acetylenes have been unsuccessful under conventional thermal conditions. For example 1-benzoyl-2-phenyl-3a,6a-diazapentalene (1) was hardly affected by methyl propiolate under atmospheric pressure. We now describe the products obtained from these and similar reactions subjected to high pressures.[6,7]

This diazapentalene (1) with methyl propiolate in dichloromethane at 10 kbar pressure for 1 week at room temperature, followed by treatment with ethanol, gave a 1:2-molar adduct (5) which had incorporated 1 mole of ethanol (methanol yielded the analogue) in 61 % yield. M.p. 149-150 °C; m/z 500 (M^+), 471 ($M^+-CH_2CH_3$), 455 ($M^+-OCH_2CH_3$), 427 ($M^+-CH_2CO_2CH_3$), 395 ($M^+-COC_6H_5$); i.r. (KBr) 1668, 1720, 1745 cm^{-1}; ^1H nmr ($CDCl_3$) 1.13 (t, $CH_2C\underline{H}_3$, J=7.5 Hz), 2.95 (d, $C\underline{H}_2CO_2CH_3$, 7.5 Hz), 3.25 (dd, $OC\underline{H}H$, J=10, 7.5 Hz), 3.70 and 3.78 (each s, 2 × $OC\underline{H}_3$, overlapping $OCH\underline{H}$), 4.81 (m, H-4a), 5.00 (t, $C\underline{H}OCH_2CH_3$, J=7.5 Hz), 5.92 (dd, H-5, J=7.5, 4 Hz), 6.33 (d, further weakly coupled, H-6, J=7.5 Hz), 6.47 (d, H-3, J=2 Hz), 6.9-7.8 (m, 10H); ^{13}C nmr ($CDCl_3$) 15.6 (q, $CH_2\underline{C}H_3$), 36.5 (t, $\underline{C}H_2CO_2CH_3$), 51.8 (q, $O\underline{C}H_3$), 51.9 (q, $O\underline{C}H_3$), 57.7 (s, C-2a), 57.8 (d, C-4a), 58.4 (t, $O\underline{C}H_2$), 66.7 (d, $\underline{C}HOCH_2CH_3$), 99.6 (s), 124.1 (d), 127.4 (d, $\underline{C}$ × 3), 128.1 (d, $\underline{C}$ × 2), 129.5 (d, $\underline{C}$ × 2), 130.6 (d, $\underline{C}$ × 2), 133.0 (d), 134.2 (s), 135.2 (s), 135.8 (s), 139.5 (d), 140.3 (d), 148.3 (s), 162.9 (s, $\underline{C}$=O), 170.8 (s, $\underline{C}$=O), 192.9 (s, $\underline{C}OC_6H_5$). The methylene protons of the ethoxy group are diastereoscopic and the ^1H nmr spectrum shows three olefinic protons and one weakly coupled $sp^3C-\underline{H}$ at 4.81. These features are confirmed by the ^{13}C spectrum in which all the resonances are clearly resolved with the exception of the singlet at 57.7 which overlapped adjacent resonances. The positions of the two high field carbon doublets preclude their being due to sp^2C atoms. This data, and the loss of fragments corresponding to C_6H_5CO and $CH_2CO_2CH_3$ from the molecular ion in the mass spectrometer exclude most alternative structures such as (6) and (7) for (5) and suggest that the isomer with the 1 and 2a substituents interchanged is less likely. Attempts to isolate crystalline adducts, without the inclusion of alcohols, from these reactions failed. Compounds (5) could be formed from (1) via Michael type additions, yielding (3), then (4) followed by cycloaddition.

1,3-Dibenzoyl-2-phenyl-3a,6a-diazapentalene (2) reacts slowly with DMAD at 1 bar, but after 12 h at 10 kbar at room temperature a 1:2-molar adduct (6) was obtained almost quantitatively, m.p. 179-180 °C; m/z 674 (M^+), 615 ($M^+-CO_2CH_3$), 569 ($M^+-COC_6H_5$); i.r. (KBr) 1665, 1715, 1740 cm^{-1}; ^1H nmr ($CDCl_3$) 3.16 (s, $OC\underline{H}_3$), 3.40 (s, $OC\underline{H}_3$), 3.82 (s, 2 × $OC\underline{H}_3$), 4.35 (dd, H-4b, J=4, 2 Hz), 4.96 (d, H-4a, J=2 Hz), 5.28 (d,H-6a, J=4 Hz), 6.95 (s, $C_6\underline{H}_5$), 7.2-7.7 (m, 6H), 7.94 (m, 2H, ortho-H to C=O), 8.40 (m, 2H, ortho-H to C=O); ^{13}C nmr ($CDCl_3$) 51.8 (q, 2 × $O\underline{C}H_3$), 52.5 (q, $O\underline{C}H_3$), 55.7 (d, C-4b), 62.6 (d, C-4a), 73.0 (d, C-6a), 96.8 (s), 117.4 (s), 127.4, 127.9, 128.6 (br), 128.7 (d), 128.8 (d), 129.8 (d), 130.0 (d), 130.6, 133.4 (d), 134.3

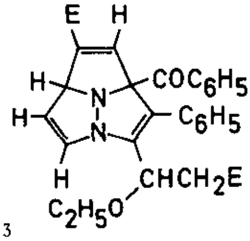


(1) R= H

(2) R= COC_6H_5

(3) R= $CH=CHCO_2CH_3$

(4) R= $CH(OCH_2CH_3)CH_2CO_2CH_3$



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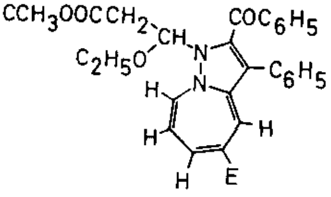

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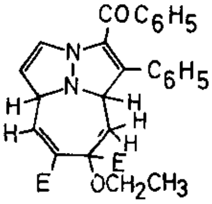

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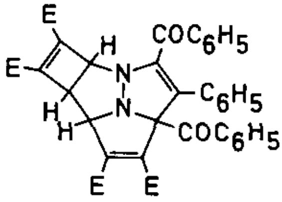

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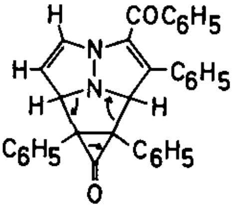

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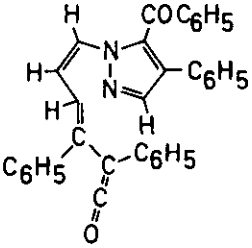

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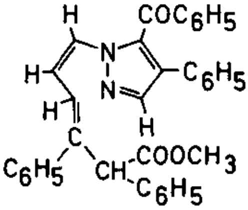

(11)

(d), 135.6 (s), 136.0 (s), 140.3 (s), 142.4 (s), 143.5 (s), 144.2 (s), 159.6 (s, $\underline{C}$=O), 160.6 (s, $\underline{C}$=O), 163.1 (s, $\underline{C}$=O), 163.3 (s, $\underline{C}$=O), 191.4 (s, $\underline{C}OC_6H_5$), 195.7 (s, $\underline{C}OC_6H_5$). The ^1H nmr spectrum shows three spin coupled mid-field protons which also appear in the ^{13}C spectrum in the sp^3C region. This greatly restricts the structural possibilities for this compound, which appears to be best represented by (8). It could be formed from an intermediate similar to (5) by cyclobutene formation in the usual way from the enamine system. All the carbon atoms were not clearly resolved in the ^{13}C spectrum.

The dipolarophilic capacity of the carbon-carbon double bond is considerable in diphenylcyclopropenone (DPP) which behaves often as a reactive form of diphenylacetylene.[8,9] DPP did not combine with the diazapentalene (1) significantly at 1 bar but 10 kbar at room temperature and subsequent methanol treatment gave the pyrazole derivative (11) (26 % yield), m.p. 117-118 °C; m/z 524 (M^+), 455 (M^+-OCH_3), 413 ($M^+-CH_2CO_2CH_3$), 381 ($M^+-COC_6H_5$); i.r. (KBr) 1640, 1725 cm^{-1}; ^1H nmr ($CDCl_3$) 3.63 (s, 3H), 5.29 (s, 1H), 6.12 (dd, J=12, 10 Hz, 1H), 6.92 (d, J=10 Hz, 1H), 7.0-8.2 (m, 22H); ^{13}C nmr ($CDCl_3$) 52.3 (q), 52.9 (d), 115.6 (d), 123.9 (d), 126.0-142.3 (cmplex), 172.7 (s), 188.4 (s). It could be formed by a concerted or otherwise stepwise, cycloaddition to give (9), ring opening to (10) and addition of methanol. DPP and diphenylcyclopropenethione are well known for their reactions with immonium, sulphonium, and phosphonium ylids.[8,] Methylphenylcyclopropenone, normally less reactive than DPP, was almost inert to (1) even at 15 kbar.

In contrast to the 3a, 6a-diazapentalenes, dibenzo-1,3a,6,6a-tetraazapentalene did not react with DMAD at 15 kbar and 70 °C.

The use of high pressures is clearly valuable in assisting combination between heat sensitive heterocycles such as diazapentalene where raising the temperature does not induce the desired reaction.

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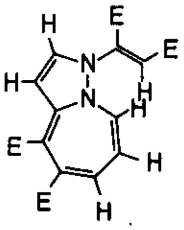
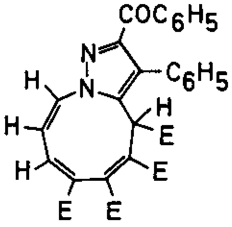


(A)



(B)

6. For a review on the synthesis and reactions of heterocycles under high pressures : K. Matsumoto, T. Uchida, and R.M. Acheson, Heterocycles, 16, 1367 (1981).
7. A typical procedure: Diazapentalene (2 mmol) and methylpropiolate (4 mmol) or DPP(2 mmol) or DMAD (4 mmol) diluted with CH_2Cl_2 in a 10 ml capsule is kept at 10-15 kbar for stated time and worked up as usual. Satisfactory elemental analyses were obtained for all new compounds.
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