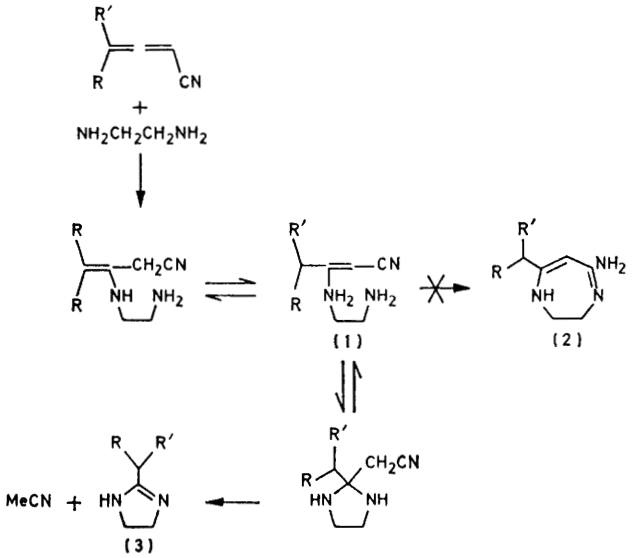
Allenes. Part 39.[1] The Synthesis of 3-Alkyl-5-aminopyrazoles and 3*H*-Indoles from Allenic or Acetylenic Nitriles

By **Z. Tanee Fomum**, Department of Organic Chemistry, University of Yaounde, Cameroon
Stephen R. Landor * and **Phyllis D. Landor**, Chemistry Department, University of the West Indies, Kingston, Jamaica
George W. P. Mpango, University of Calabar, Nigeria

Hydrazine adds to allenic or acetylenic nitriles to give 3-alkyl-substituted 5-aminopyrazoles in excellent yields. Conjugated and unconjugated enaminic nitriles may be isolated from the Michael addition of phenylhydrazine to allenic nitriles and ring-closed to give 3-alkyl-5-amino-*N*-phenylpyrazoles and 3*H*-indoles.

IMIDAZOLINES (3) and benzimidazoles have recently been shown to arise from a double Michael addition of 1,2-diamines to allenic or acetylenic nitriles followed by elimination of the acetonitrile (Scheme 1).[1,2] Although



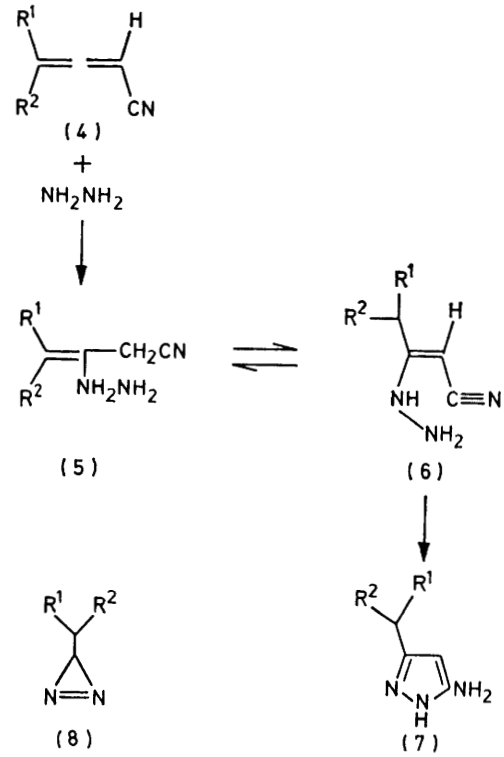
SCHEME 1

attack of the amino-group in the conjugated adducts (1) on the carbon of the nitrile group to give the seven-membered ring of the diazepines (2) is a possibility, further work has since shown that, under the conditions used to effect ring closure to the imidazolines, the diazepines are not stable and, even under mild conditions favourable to their formation, the diazepines could not be isolated or detected.

In contrast, double Michael addition of hydrazine followed by elimination of acetonitrile to give the diaziridines (8) did not occur, but nucleophilic attack of the amino-group of the enaminic nitriles (6) on the carbon of the nitrile proceeded smoothly to give the 3-alkyl-5-aminopyrazoles (7a)—(7e) in excellent yields [3,†] (*cf.* Table 1). The ring-closure step was fast and the intermediate enamic nitriles (5) and (6) could not be isolated.

† The addition of hydrazine to a mixture of prop-2-ynyl cyanide and buta-2,3-dienenitrile was reported to have given 5-amino-3-methylpyrazole (P. Kurtz, H. Gold, and H. Disselnkotter, *Liebigs Ann. Chem.*, 1959, **624**, 1).

It is known that both the *E*- and *Z*-isomers are present in the conjugated enaminic nitriles [4,5] and that the *E*-form usually predominates. The fact that the aminopyrazoles were obtained in near quantitative yields may be explained by the establishment of a labile equilibrium as the adducts were heated, with lowering of the rotational barriers by a

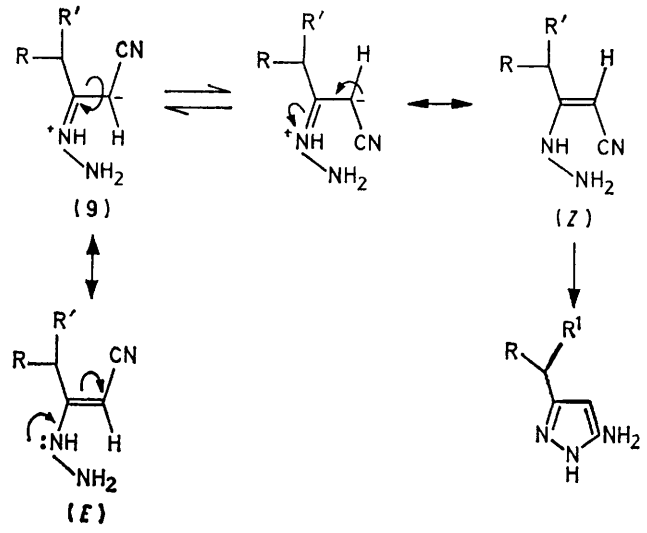


a; $R^1 = R^2 = Me$
b; $R^1 = Et$, $R^2 = Me$
c; $R^1 = R^2 = Et$
d; $R^1 = Pr^n$, $R^2 = H$
e; $R^1 = Bu^t$, $R^2 = Me$

SCHEME 2

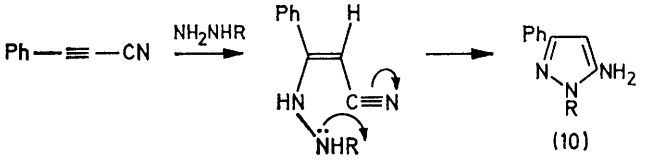
substantial contribution from the dipolar forms (9) and continuous displacement of the equilibrium through cyclisation (Scheme 3). Phenylpropynenitrile with hydrazine similarly gave 5-amino-3-phenylpyrazole (10a) (*cf.* Table 1, Scheme 4).

The pyrazoles (7) had maximum absorption in the u.v. spectra at λ 204—207 nm (ε 3 300—7 000) and the 5-



SCHEME 3

amino-3-phenylpyrazole (10a) showed a shift to λ 216 nm (ε 14 200). The i.r. spectra showed a broad band for the NH-stretching centred on ν 3 200 cm^{-1} and NH deformation bands at ν 1 625 and 1 590 cm^{-1}. The ^1H n.m.r. spectra gave signals for a strongly shielded proton for =CH near τ 4.6 in the pyrazoles (7) and at τ 4.13 in the 3-phenylpyrazole (10a), and three exchangeable hydrogens (*cf.* Table 2).

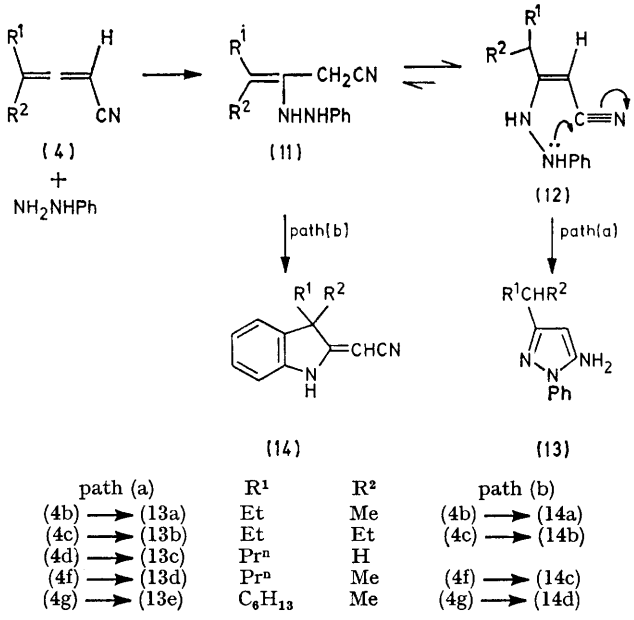


a; R = H
b; R = Ph

SCHEME 4

Phenylhydrazine and the allenic nitrile, when mixed at 0 °C, allowed to warm to room temperature and left for several days (the reaction was monitored by i.r. spectroscopy), gave, initially, the unconjugated adducts 11); after 7 days at room temperature, however, these adducts had almost completely isomerised to the conjugated adducts (12). The enaminic nitriles were then heated and cyclisation to the respective 3-substituted 5-amino-1-phenylpyrazoles (13) occurred in excellent yield [6] [*cf.* Table 1, Scheme 5, path (a)]. The crude product sometimes contained up to 5% of an impurity (by g.l.c.) which corresponded to the 3*H*-indoles (14) described below. The structure of the intermediate, conjugated enaminic nitrile (12; R^1 = Me, R^2 = Et) was shown by the presence of a C≡N stretch at ν 2 190 cm^{-1}, a maximum in the u.v. spectrum at λ 268 nm (ε 15 700), and two separate signals in the ^1H n.m.r. spectrum for protons attached to the nitrogen atoms (NH–C=C τ *ca.* 3 and N*H*Ph τ *ca.* 6.8) which exchanged with deuterium; thus phenylhydrazine reacted only at the primary amino-group. There were two signals of *ca.* equal intensity at τ 6.83 and 6.80, for =CHCN of the *E*- and *Z*-isomers. The pyrazoles (13) had a signal for =CH at τ *ca.* 4.8 for the alkyl-substituted pyrazoles, and at τ 4.07 for 5-amino-1,3-diphenylpyrazole (10b) (Scheme 4), and two exchangeable hydrogens.

However, when phenylhydrazine and the allenic nitrile were mixed at room temperature and the unconjugated adduct (11) heated to 80 °C for 3 min, an exothermic reaction occurred to give a mixture of the respective pyrazoles (13) and 3-dialkyl-2-cyanomethylene-3*H*-indoles (14), which were readily separated by chromatography [Scheme 5, paths (a) and (b)]. We have



path (a)	R^1	R^2	path (b)
(4b) → (13a)	Et	Me	(4b) → (14a)
(4c) → (13b)	Et	Et	(4c) → (14b)
(4d) → (13c)	Pr^n	H	
(4f) → (13d)	Pr^n	Me	(4f) → (14c)
(4g) → (13e)	C_6H_{13}	Me	(4g) → (14d)

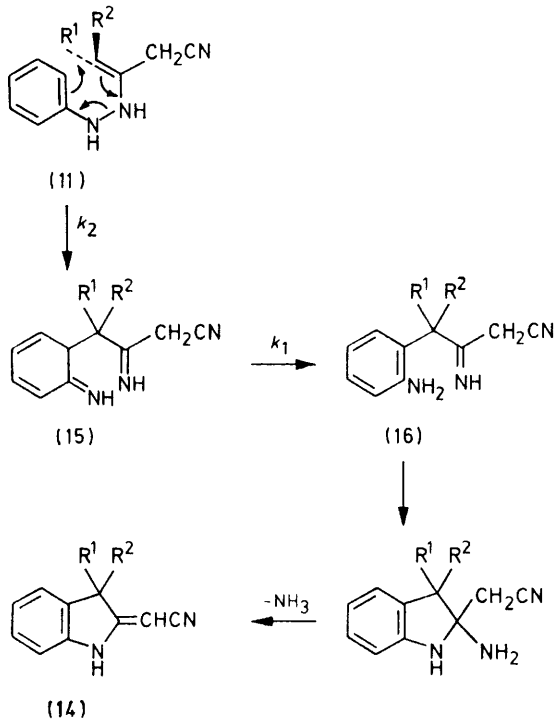
SCHEME 5

shown that the pyrazoles arise from the cyclisation of the conjugated adduct and, indeed, they were the only products formed from the addition of hydrazines to propynenitriles, which can only form conjugated enaminic nitriles. We therefore reasoned that the 3*H*-indoles (14) were derived from unconjugated adducts (11) by a Fischer–Indole-type reaction sequence which consisted of a [3,3] sigmatropic rearrangement [(11) → (15)], a prototropic rearrangement to the 2-substituted aniline [(15)→(16)], followed by nucleophilic cyclisation on the carbon of the imine and elimination of ammonia [(16)→(14)] (Scheme 6).

The 3*H*-indoles (14) have characteristic maxima in their u.v. spectra at λ 219—222 and 290—292 nm with a shoulder at λ *ca.* 310 nm; their i.r. spectra show absorption at ν 3 260—3 300 (NH) and 2 190—2 195 cm^{-1} for conjugated C≡N; and a shielded enaminic proton (=CHCN) signal at τ 5.95—6.15 is present in their ^1H n.m.r. spectra.

The yield of the 3*H*-indoles from 3,3-dialkyl-1-cyanoallenes was usually 40—50%, the rest of the product being the pyrazole. In order to maximise yields of the 3*H*-indoles, the 1,3-proton shift from unconjugated to

conjugated adduct has to be suppressed as the ratio of 3*H*-indole to pyrazole is determined by the ratio of the relative rates of reaction of the sigmatropic (k_2) to prototropic (k_1) rearrangement of the unconjugated adduct (11). Unfortunately, the energy of activation of the non-concerted prototropic shift is likely to be low (estimated as *ca.* 30 kJ from preliminary data for the rearrangement of the unconjugated to conjugated butylamino-adduct [7]) and it is difficult to find suitable conditions to inhibit this shift. Strictly aprotic conditions,



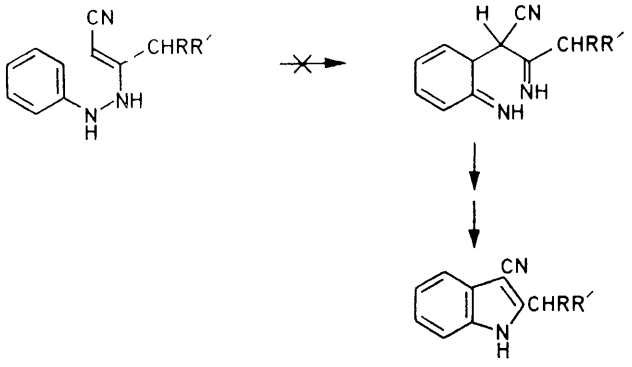
SCHEME 6

such as dry dichlorobenzene at reflux gave mainly the dimer [8] of the allenic nitrile, but the ratio of 3*H*-indole to the pyrazole was little changed. This suggests an intramolecular proton-abstraction by one of the nitrogen atoms of the adduct as the rate-determining step. Fischer–Indole catalysts such as proton and Lewis acids tend to decrease, rather than increase, the ratio of 3*H*-indole to pyrazole, which clearly shows that they catalyse the prototropic rearrangement to a greater extent than the sigmatropic rearrangement.

The unconjugated adducts (11; $R^1 = H$) formed from 3-monoalkyl-1-cyanoallenes were relatively less stable than those formed from the 3,3-dialkylcyanoallenes and isomerised so fast to conjugated adducts that only the pyrazoles and no 3*H*-indoles were obtained with phenylhydrazine.†

† During the course of this work I. Tamnefors, A. Claesson, and M. Karlsson, *Acta Pharm. Suec*, 1975, **12**, 435, reported the formation of pyrazoles from 1,4- and 1,2-additions of phenyl- and methyl-hydrazines to 2-methylhexa-4,5-dien-3-one. No indole was isolated from the adduct with phenylhydrazine, no doubt because of the fast rearrangement of unconjugated to conjugated adduct.

An alternative sigmatropic rearrangement of the conjugated adduct to give a 2-alkyl-3-cyanoindole did not compete with the ring-closure reaction which gave pyrazoles, and must therefore be energetically unfavourable (Scheme 7).



SCHEME 7

EXPERIMENTAL

I.r. spectra were determined on liquid films or solid melts with Perkin-Elmer 257 or 137 spectrophotometers. U.v. spectra were obtained for ethanolic solutions with a Pye-Unicam SP 1800 spectrometer. ^{1}H n.m.r. spectra were determined with a Varian T60 spectrometer for solutions in deuteriochloroform, with tetramethylsilane as internal standard. Ethereal solutions were dried over magnesium sulphate. The allenic nitriles were prepared as previously reported.[9] The m.p.s, yields, u.v. spectra, and analytical data for the 5-aminopyrazoles are given in Table 1; the ^{1}H n.m.r. data are given in Table 2.

5-*Amino*-3-(1-*methyl*)*propylpyrazole* (7b).—4-Methylhexa-2,3-dienenitrile (4b) (5.3 g, 50 mmol), dissolved in dichloromethane (50 ml), was added as drops to stirred and redistilled hydrazine hydrate (1.6 g, 50 mmol) in dichloromethane (30 ml) under reflux. The mixture was stirred under reflux for 14 h after which the solvent was removed and the residue, a mixture of 3-hydrazino-4-methylhex-3-enenitrile (5b) and 3-hydrazino-4-methylhex-2-enenitrile (6b), was heated at 100 °C for 5 min to give the crude aminopyrazole. Purification by column chromatography (alumina, activity V) and elution with chloroform–light petroleum (b.p. 40—60 °C) (4 : 1) gave the 5-*aminopyrazole* (7b) (5.85 g, 98%); ν 3 200 (NH) and 1 580 cm^{-1} (NH deform.). The other aminopyrazoles were prepared as above except where indicated below.

5-*Amino*-3-*isopropylpyrazole* (7a).—The dichloromethane was allowed to evaporate at which the temperature rose to 80 °C; it was held at this temperature for 20 min to give the crude *product* (7a) in quantitative yield.

5-*Amino*-3-(1-*ethylpropyl*)*pyrazole* (7c).—The nitrile (4c) was added at room temperature and the mixture was refluxed for 1 h. The solvent was removed and the residue was heated at 80 °C for 10 min. The crude product was dissolved in chloroform, washed with water and dried, and the solvent was removed to give the *pyrazole* (7c) in quantitative yield.

5-*Amino*-3-*butylpyrazole* (7d).—The mixture was refluxed for 1 h after which the solvent was removed and the residue was heated at 120 °C for 10 min.

5-*Amino*-3-(1,2,2-*trimethylpropyl*)*pyrazole* (7e).—The re-

TABLE 1

Preparation of 5-aminopyrazoles

Compound	M.p. (°C)	Yield (%)	λ_{max}/nm	ϵ	λ_{max}/nm	ϵ	Found (%) C	H	N	Required (%) C	H	N
(7a)	*a*	96 [b]	205	5 300	221	4 100	57.7	8.4	33.7	57.6	8.8	33.6
(7b)	*a*	98 [b]	207	4 000	225	4 100	60.6	9.4	30.0	60.4	9.4	30.2
(7c)	*a*	*ca.* 100	206	3 300	223	3 100		(*m/e* 153)			(*m/e* 153)	
(7d)	*a*	96 [b]	204	5 200	224	4 200	60.2	9.3	30.0	60.4	9.4	30.2
(7e)	101	80 [c]	206	7 000	223	6 200	64.6	10.1	25.3	64.7	10.2	25.2
(10a)	102	95 [d]	216	14 200	250	12 500	67.9 [h]	5.9	26.2	67.9	5.7	26.4
(13a)	(b.p. 223 °C/1 mmHg)	94	205	10 300	244	6 700	72.4	7.8	19.5	72.6	7.9	19.5
(13b)	65	88 [c]	205	10 700	243	6 200	73.4	8.4	18.0	73.4	8.3	18.3
(13c)	*a*	*ca.* 100 [f]	206	11 000	245	6 900	72.5	7.7	19.6	72.6	7.9	19.5
(10b)	129	88 [g]	204	39 100	258	11 800	76.8 [i]	5.5	18.4	76.6	5.5	17.9

[a] Liquids. [b] Purified by column chromatography (alumina); light petroleum–chloroform as eluant. [c] Recrystallised from chloroform–light petroleum. [d] Recrystallised from chloroform. [e] Recrystallised from carbon tetrachloride–pentane. [f] G.l.c. gave R_t 14.5 min (96%) on 3% O.V.-1 silicone at 150 °C. [g] Recrystallised from pentane–chloroform. [h] *M/e* 159. $C_9H_9N_3$ requires M^+ 159. [i] *M/e* 235. $C_{15}H_{13}N_3$ requires M^+ 235.

agents were mixed without solvent and the temperature rose to 90 °C; the mixture was then heated at 100 °C for 30 min. The crude product was dissolved in chloroform, dried, and the solvent was evaporated to give the *aminopyrazole* (7e) as an oil which solidified, with time, at 0 °C.

TABLE 2

^{1}H N.m.r. data for 5-aminopyrazoles (τ values)

Compound	
(7a)	8.77 (6 H, d, *Me*$_2$CH), 7.12 (1 H, m, C*H*Me$_2$), 4.57 (1 H, s, =CH), and 4.25 (3 H, s br, NH and NH$_2$) [a]
(7b)	9.17 (3 H, t, *Me*CH$_2$), 8.83 (3 H, d, *Me*CH), 8.47 (2 H, m, MeC*H*$_2$), 7.38 (1 H, sextet, CH$_2$C*H*Me), 4.60 (1 H, s, =CH), and 3.43 (3 H, s br, NH and NH$_2$)
(7c)	9.17 [6 H, t, (*Me*CH$_2$)$_2$CH], 8.43 [4 H, m, (MeC*H*$_2$)$_2$CH], 7.85—7.4 (1 H, m, CH$_2$C*H*CH$_2$), 4.82 (3 H, sbr, NH and NH$_2$),[a] and 4.60 (1 H, s, =CH)
(7d)	9.07 (3 H, t, *Me*CH$_2$), 8.83—8.17 (4 H, m, CH$_2$CH$_2$), 7.50 (2 H, t, CH$_2$C=), 4.60 (1 H, s, =CH), and 3.80 (3 H, sbr, NH and NH$_2$) [a]
(7e)	9.10 (9 H, s, *Me*$_2$CH), 8.83 (3 H, d, *Me*CH), 7.70—7.27 (1 H, m, C*H*Me), 5.33—4.67 (3 H, sbr, NH and NH$_2$),[a] and 4.55 (1 H, s, =CH)
(10a)	4.40 (3 H, sbr, NH and NH$_2$),[a] 4.13 (1 H, s, =CH), and 2.70—2.37 (5 H, m, Ph)
(13a)	9.12 (3 H, t, *Me*CH$_2$), 8.83 (3 H, d, *Me*CH), 8.68—8.07 (2 H, m, MeC*H*$_2$), 7.43 (1 H, sextet, CH$_2$C*H*Me), 6.13 (2 H, sbr, NH$_2$),[b] 4.80 (1 H, s, =CH), and 3.17—2.43 (5 H, m, Ph)
(13b)	9.13 [6 H, t, (*Me*CH$_2$)$_2$CH], 8.42 [4 H, m, (MeC*H*$_2$)$_2$CH], 7.87—7.53 (1 H, m, CH$_2$C*H*CH$_2$), 6.33 (2 H, sbr, NH$_2$),[b] 4.8 (1 H, s, =CH), and 2.90—2.37 (5 H, m, Ph)
(13c)	9.10 (3 H, t, *Me*CH$_2$), 8.85—8.20 (4 H, m, MeC*H*$_2$C*H*$_2$), 7.80—7.30 (2 H, m, CH$_2$C*H*$_2$C=N), 6.22 (2 H, sbr, NH$_2$),[b] 4.62 (1 H, s, =CH), and 2.82—2.56 (5 H, m, Ph)
(10b)	6.33 (2 H, sbr, NH$_2$),[b] 4.07 (1 H, s, =CH), and 2.73—2.10 (10 H, m, Ph)

[a] 3 H exchange with D_2O. [b] 2 H exchange with D_2O.

5-*Amino*-3-*phenylpyrazole* (10a).—Redistilled hydrazine hydrate (0.6 g, 10 mmol) in dichloromethane (10 ml) was added as drops to phenylpropynenitrile [1] (1.27 g, 10 mmol) in dichloromethane (20 ml). No apparent reaction occurred even on warming to 40 °C. The solvent was removed whereupon the reaction took place immediately. It was completed when the mixture was heated at 80 °C for 20 min. The crude product solidified at room temperature.

5-*Amino*-3-(1-*methylpropyl*)-1-*phenylpyrazole* (13a).—4-Methylhexa-2,3-dienenitrile (4b) (2.14 g, 20 mmol) was added as drops to phenylhydrazine (2.16 g, 20 mmol) at 0 °C and left for 4 h at 0 °C The reaction was monitored by i.r. spectroscopy and after 7 d at room temperature the crude product was mainly 4-methyl-3-(2-phenylhydrazino)-hex-2-enenitrile (12a) [but contained less than 5% of 4-methyl-3-(2-phenylhydrazino)hex-3-enenitrile (11a) by n.m.r. spectroscopy]; $\nu_{max.}$ 3 300 (NH), 2 260 (C≡N, unconj.), 2 190 (C≡N, conj.) 1 650 (C=C), 1 580 (NH deform.), and no 1 950 cm^{-1} band (C=C=C); $\lambda_{max.}$ (EtOH) 205 (ε 23 600) and 268 nm (15 700); τ(CCl_4) 9.07 (3 H, t, *Me*CH$_2$), 8.87 (3 H, d, CH*Me*), 8.77—8.13 (2 H, m, MeC*H*$_2$), 7.83—7.23 (1 H, m, C*H*Me), 6.83 and 6.80 (1 H, s, =CHCN), 7.00—6.50 (1 H, s br, N*H*Ph, disappears on deuteriation), 3.50—2.57 (5 H, m, Ph), and 2.98 (1 H, s br, =C–NH, disappears on deuteriation).

The enenitrile (12a) (4.1 g) was heated to 120—130 °C for 20 min and the crude aminopyrazole was purified by distillation to give the *phenylpyrazole* (13a) (3.9 g, 94%); $\nu_{max.}$ 3 250 (NH) and 1 580 cm^{-1} (N*H* deform.).

5-*Amino*-3-(1-*ethylpropyl*)-1-*phenylpyrazole* (13b).—This compound was prepared as for compound (13a) above, but left for 5 d at room temperature. The crude enenitrile (12b) was heated at 110 °C for 2 min when an exothermic reaction took place and the temperature rose to 180 °C.

5-*Amino*-3-*butyl*-1-*phenylpyrazole* (13c).—The nitrile (4d) and phenylhydrazine were mixed at room temperature; an exothermic reaction took place and the temperature rose to 150 °C and gave the *aminopyrazole* (13c) in quantitative yield.

5-*Amino*-1,3-*diphenylpyrazole* (10b).—Phenylpropynenitrile [1] was added as drops to phenylhydrazine at room temperature and the product was warmed to 80 °C for 5 min.

2-*Cyanomethylene*-3-*ethyl*-1,2-*dihydro*-3-*methyl*-3H-*indole* (14a) *and the* 5-*Aminopyrazole* (13a).—Phenylhydrazine (2.16 g, 20 mmol) was added slowly to 4-methylhexa-2,3-dienenitrile (4 b) (2.14 g, 10 mmol) at room temperature and the mixture was warmed to 80 °C when a very vigorous exothermic reaction occurred and the temperature rose to 185 °C. This gave a mixture of the indole (14a) and the 5-aminopyrazole (13a) [g.l.c (SE30, programmed for 80—140 °C at 4 °C per min) gave R_t 12 min (40%) and R_t 13.5 min (60%); g.c.–m.s. gave R_t 12 min, *m/e* 198, and R_t 13.5 min, *m/e* 215]. The crude mixture (4.0 g) on column chromatography (alumina 'H', activity III) and elution with

ether–isohexane (20%) gave the *indole* (14a) (1.5 g, 37%), m.p. 64—66 °C (Found: C, 78.8; H, 7.1; N, 14.1. $C_{13}H_{14}N_2$ requires C, 78.8; H, 7.1; N, 14.1%); $\nu_{max.}$ 3 300 (NH), 2 190 (C≡), 1 640 (C=C), and 1 520 cm^{-1} (Ar); $\lambda_{max.}$ (EtOH) 219 (ε, 10 600) and 290 nm (ε, 15 400); τ(CCl_4) 9.40 (3 H, t, *Me*CH_2), 8.67 (3 H, s, EtC*Me*), 8.50—8.15 (2 H, q, MeCH_2-C), 6.12 (1 H, s, =CHCN), 3.33—2.73 (4 H, m, Ph), and 0.60 (1 H, s, NH, disappears on deuteriation); *m/e* 198 (M^+; $C_{13}H_{14}N_2$ requires *M* 198). Elution with ether–isohexane (60%) gave the pyrazole (13a) (2.5 g, 60%).

2-*Cyanomethylene*-3,3-*diethyl*-1,2-*dihydro*-3*H*-*indole* (14b) *and the* 5-*Aminopyrazole* (13b).—(*a*) 4-Ethylhexa-2,3-dienenitrile (4c) (1.21 g, 10 mmol) was added slowly to redistilled phenylhydrazine (1.08 g, 10 mmol) at room temperature. The mixture was warmed to 80 °C which triggered an exothermic reaction. The temperature rose to 175 °C and gave, as the crude products, the indole (14b) (33%) and the pyrazole (13b) (67%) (g.l.c. gave R_t 15 min, *m/e* 212, and R_t 27 min, *m/e* 229).

The crude mixture on column chromatography (alumina 'H', activity III) and elution with ether–pentane (20%) gave the *indole* (14b) (0.46 g, 22%) (Found: C, 78.8; H, 7.8; N, 13.3. $C_{14}H_{16}N_2$ requires C, 79.2; H, 7.6; N, 13.2%); $\nu_{max.}$ 3 200 (NH), 2 190 (C≡), 1 640 (C=C), and 1 520 cm^{-1} (Ar-C=C); $\lambda_{max.}$ (EtOH) 218 nm (ε, 14 500); τ(CCl_4) 9.43 [6 H, t, (*Me*CH_2)$_2$C], 8.78—7.95 [4 H, m, (MeCH_2)$_2$C], 6.17 (1 H, s, =CHCN), 3.23—2.90 (4 H, m, Ph), and 0.93 (1 H, s, NH, disappears on deuteriation). This was followed by the pyrazole (13b) (1.2 g, 52%).

(*b*) 4-Ethylhexa-2,3-dienenitrile (4c) (1.21 g, 10 mmol) was added as drops to boiling, dry, redistilled *o*-dichlorobenzene (100 ml); redistilled phenylhydrazine (1.08 g, 10 mmol) was added as drops at the same rate as the nitrile. When addition of the reagents was completed, the mixture was heated under reflux for 10 min, cooled, and the dichlorobenzene distilled off under reduced pressure to give a mixture of 3-cyanomethylene-2,2-diethyl-4-(1-ethylpropylidene)-cyclobutanecarbonitrile (74%),[8] the pyrazole (13b) (16%), and the indole (14b) (10%).

(*c*) Anhydrous zinc chloride (1.0 g) was stirred in dry benzene (50 ml) for 2 min at room temperature. Redistilled phenylhydrazine (1.08 g, 10 mmol) was added to the mixture followed immediately by 4-ethylhexa-2,3-dienenitrile (4c) (1.21 g, 10 mmol). The mixture was stirred under reflux for 90 min after which the zinc chloride was filtered off; most of the benzene was then distilled off and the residue was removed under reduced pressure to give a mixture of the pyrazole (13b) (67%) and the indole (14b) (33%).

5-*Amino*-3-(1-*methylbutyl*)-1-*phenylpyrazole* (13d) and 2-*cyanomethylene*-1,2-*dihydro*-3-*methyl*-3-*propyl*-3H-*indole* (14c).—Redistilled phenylhydrazine (2.16 g, 20 mmol) was added slowly to 4-methylhepta-2,3-dienenitrile (4f) (2.42 g, 20 mmol), and the mixture was heated to 80 °C for 3 min when an exothermic reaction took place and the temperature rose to 208 °C to give a mixture of the pyrazole (13d) (61%) and the indole (14c) (39%) (g.l.c. (3% OVI; 168 °C) gave R_t 9.0 min (39%) and R_t 13.0 min (61%)]. The mixture (4 g) on column chromatography on alumina (Merck neutral 3) and elution with ether–hexane (40%) gave the *indole* (14c) (1.45 g), m.p. 114 °C (Found: C, 79.0; H, 7.7; N, 13.3. $C_{14}H_{16}N_2$ requires C, 79.2; H, 7.6; N, 13.2%); $\nu_{max.}$ 3 260 (NH), 2 195 (C≡N), 1 620 (C=C), 1 560 (Ar), and 1 500 cm^{-1} (NH deform.); $\lambda_{max.}$ (EtOH), 220 (ε 11 400), 292 (ε 16 000), and λ_{sh} 310 nm (ε 13 000); τ($CDCl_3$) 9.22 (3 H, t, *Me*CH_2), 8.67 (3 H, s, CMe), 8.50—8.00 (4 H, m, MeCH_2CH_2), 3 30—2,65 (4 H, m, Ar), and 1.42 (1 H, s, NH, disappears on deuteriation); *m/e* 212 (M^+). Elution with ether–hexane (80%) gave the *pyrazole* (13d) (2.2 g) (Found: C, 73.3; H, 8.5; N, 18.2. $C_{14}H_{19}N_3$ requires C, 73.3; H, 8.3; N, 18.4%); $\nu_{max.}$ 3 300, 3 190 (NH_2), 1 605, 1 595, and 1 560 cm^{-1} (C=N, C=C); $\lambda_{max.}$ (EtOH) 206 (ε 11 500) and 245 nm (ε 7 500); τ($CDCl_3$) 9.12 (3 H, t, *Me*CH_2), 8.78 (3 H, d, *Me*CH), 8.56—8.18 (4 H, m, MeCH_2CH_2), 7.50—6.90 (1 H, CH_2C*H*Me), 6.24 (2 H, s, NH_2, disappears on deuteriation), 4.57 (1 H, s, =CH), and 2.83—2.36 (5 H, m, Ar); *m/e* 229 (M^+).

5-*Amino*-3-(1-*methylheptyl*)-1-*phenylpyrazole* (13e) *and* 2-*cyanomethylene*-3-*hexyl*-1,2-*dihydro*-3-*methyl*-3H-*indole* (14d).—Redistilled phenylhydrazine (2.16 g, 20 mmol) was added slowly to 4-methyldeca-2,3-dienenitrile (4g) (3.26 g, 20 mmol) and the mixture was heated to 80 °C for 3 min when an exothermic reaction took place and the temperature rose to 212 °C to give a mixture of the pyrazole (13e) (48%) and the indole (14d) (52%) [g.l.c. (3% OVI, 140 °C), gave R_t 25.0 min (52%) and 39.7 min (48%)]. The mixture (4 g) on column chromatography gave the *indole* (14d) (2.02 g), m.p. 86 °C (Found: C, 80.0; H, 8.4; N, 11.2. $C_{17}H_{22}N_2$ requires C, 80.3; H, 8.6; N, 11.1%); $\nu_{max.}$ 3 260 (NH), 2 200 (C≡N), 1 610 (C=C), 1 560 (Ar C=C), and 1 500 cm^{-1} (NH deform.); $\lambda_{max.}$ (EtOH) 221 (ε 12 000), 292 (ε 16 500), and λ_{sh} 310 nm (ε 13 200); τ($CDCl_3$) 9.20 (3 H, t, *Me*[CH_2]$_2$-CH_2), 8.84—8.65 (8 H, m, Me[CH_2]$_4$CH_2), 8.58 (3 H, s, CH*Me*), 8.45—7.80 (2 H, m, Me[CH_2]$_4$CH_2], 5.96 (1 H, s, =CHCN), 3.25—2.65 (4 H, m, Ar), 1.66 (1 H, s, NH, disappears on deuteriation); *m/e* 254 (M^+); and the *pyrazole* (13e) (2.0 g) (Found: C, 75.5; H, 9.0; N, 15.4. $C_{17}H_{25}N_3$ requires C, 75.3; H, 9.2; N, 15.5%); $\nu_{max.}$ 3 300, 3 190 (NH_2), 1 610, 1 595, and 1 550 cm^{-1} (C=N, C=C); $\lambda_{max.}$ (EtOH) 206 (ε 12 000) and 247 nm (ε 8 000); τ($CDCl_3$) 9.10 (3 H, t, *Me*CH_2), 8.75—8.00 (13 H, m, *Me*CH, Me-[CH_2]$_5$), 7.60—6.90 (1 H, m, CH_2C*H*Me), 6.20 (2 H, s, NH_2, disappears on deuteriation), 4.52 (1 H, s, =CH), and 2.75—2.32 (5 H, m, Ar); *m/e* 271 (M^+).

[1/088 *Received*, 20*th January*, 1981]

REFERENCES

[1] Part 38, S. R. Landor, P. D. Landor, Z. T. Fomum, and G. W. Mpango, *J. Chem. Soc., Perkin Trans. 1*, 1979, 2289.
[2] Z. T. Fomum, P. D. Landor, and S. R. Landor, *J. Chem. Soc., Chem. Commun.*, 1974, 706.
[3] For a preliminary account of part of this work see Z. T. Fomum, P. D. Landor, S. R. Landor, and G. W. Mpango, *Tetrahedron Lett.*, 1975, 1101.
[4] Z. T. Fomum, P. M. Greaves, P. D. Landor, and S. R. Landor, *J. Chem. Soc., Perkin Trans. 1*, 1973, 1108.
[5] J-C. Chalchat, F. Theron, and R. Vessiere, *Bull. Soc. Chim. Fr.*, 1970, 711.
[6] S. R. Landor, P. D. Landor, Z. T. Fomum, and G. M. Mpango, *Tetrahedron Lett.*, 1977, 3743.
[7] Z. T. Fomum and S. R. Landor, unpublished work.
[8] C. W. N. Cumper, Z. T. Fomum, P. M. Greaves, and S. R. Landor, *J. Chem. Soc., Perkin Trans. 2*, 1973, 885.