Synthesis of Some Pyrrolobenzothiazepines *via* *N*-Aryl-2-thiocyanatopyrroles (1)

G. W. H. Cheeseman* and A. A. Hawi

Chemistry Department, Queen Elizabeth College, University of London, Campden Hill, London W8 7AH, England

Received August 16, 1982

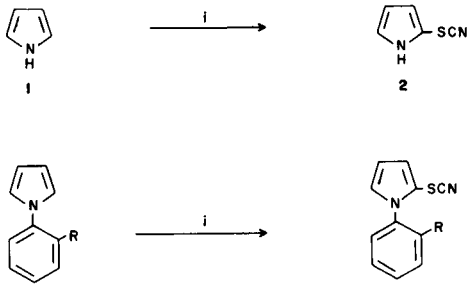
Pyrrolo[1,2-*a*][3,1]benzothiazepines were successfully synthesised from alkylthiopyrroles. The latter compounds were prepared from the appropriate *N*-aryl-2-thiocyanatopyrroles. 2,3-Dihydro-3-oxo-4-phenylthieno-[3,2-*b*]pyrrole (**29**) was obtained from acid treatment of the 2-pyrrolylthioacetic acid **28**.

J. Heterocyclic Chem., **20**, 585 (1983).

Despite fairly intensive research in the synthesis of thiazepines, very few 1,3-benzothiozepines are known and little work has been done on the chemistry of pyrrolobenzothiazepines (2).

In the present investigation novel pyrrolo[1,2-*a*][3,1]-benzothiazepines have been prepared by the cyclisation of pyrrolylsulphides. In view of the instability of the pyrrolylthiols (3), the required thiols were generated *in situ* by the reduction or alkali treatment of the corresponding thiocyanatopyrroles prior to conversion into the requisite pyrrolylsulphides.

Scheme I



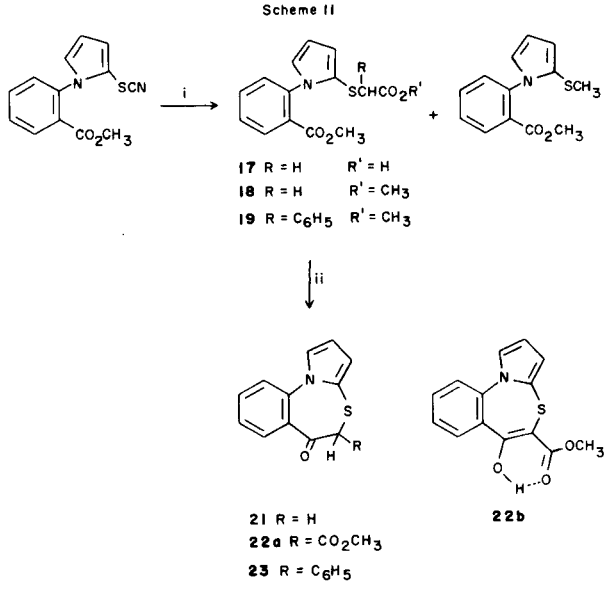
3, R = H — 10
4, R = CO_2CH_3 — 11
5, R = CN — 12
6, R = NO_2 — 13
7, R = $NHCOCH_3$ — 14
8, R = $NHCOC_6H_5$ — 15
9, R = $NHCOCH_2Cl$ — 16

i) $Cu(SCN)_2$, solvent at ~0°C

Thiocyanation of *N*-Arylpyrroles.

Matteson and Snyder (4) obtained a monothiocyanatopyrrole from the reaction of pyrrole (**1**) with cupric thiocyanate. Although some confusion regarding the position of thiocyanation existed at first, nmr studies (5) and chemical evidence (6) were later presented to show that the product was 2-thiocyanatopyrrole (2) and not the 3-isomer as originally believed. The *N*-arylpyrroles **3-9** similarly underwent electrophilic substitution on the pyrrole ring when reacted with excess cupric thiocyanate at 0° and the corresponding 2-thiocyanatopyrroles **10-16** were obtained

Scheme II



i, $NaBH_4$ and/or KOH, alkylating agent;
ii, $KOBu^t$, toluene

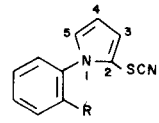
in yields ranging from 50-80% (Scheme I) (Table I). The thiocyanatopyrroles **10-16** showed a SCN absorption band around 2150 cm^{-1} of medium intensity in their ir spectra. In their nmr spectra the three pyrrolic hydrogens appeared as three sets of double doublets at about δ 6.4, 6.8 and 7.0 attributed to H − 4, H − 3 and H − 5. The values of coupling constants $J_{3,4} \cong 3.8$ Hz, $J_{4,5} \cong 2.9$ Hz and $J_{3,5} \cong 1.7$ Hz, fall within the ranges of values quoted for α-substituted pyrroles (5). It is worth noting that no β-isomer, if produced, was detected in any of the above reactions.

Synthesis of Pyrrolo[1,2-*a*][3,1]benzothiazepines.

Reduction of organic thiocyanates produces generally the corresponding thiols (7). Although produced in the reduction process, pyrrolylthiols are rarely isolated. Their high reactivity and readiness to oxidize in air to the disulphide has made their isolation impracticable (3). However pyrrolylthiols, generated *in situ*, are readily alkylated and acylated under alkaline conditions to give

Table I

N-Aryl-2-thiocyanatopyrroles



Compound	R	Reaction time (hours)	Mp°	Yield %	Recrystallisation Solvent	Molecular Formula	Analyses Calculated C	H	N	Found C	H	N
10	H	2	94-96	65	chloroform-petroleum ether (bp below 40°)	$C_{11}H_8N_2S$	65.97	4.03	13.99	65.60	4.05	13.84
11	CO_2CH_3	48	56-57	53	pentane	$C_{13}H_{10}N_2O_2S$	60.45	3.90	10.84	60.68	4.00	10.90
12	CN	12	95-97	50	petroleum ether (bp below 40°)	$C_{12}H_7N_2S$	63.98	3.13	18.65	63.19	2.88	18.67
13	NO_2	24	77-79	50	petroleum ether (bp 40-60°)	$C_{11}H_7N_3O_2S$	53.86	2.89	17.13	53.35	2.88	17.07
14	$NHCOCH_3$	16	126-127	70	benzene-petroleum ether (bp 60-80°)	$C_{13}H_{11}N_3OS$	60.68	4.31	16.33	60.34	4.27	16.06
15	$NHCOC_6H_5$	16	115-117	80	petroleum ether (bp 40-60°)	$C_{18}H_{13}N_3OS$	67.69	4.10	13.16	67.41	4.13	13.36
16	$NHCOCH_2Cl$	16 (a)	113-114	72	ethyl acetate-petroleum ether (bp 60-80°)	$C_{13}H_{10}N_3OSCl$	53.51	3.45	14.40	53.78	3.71	14.50

NMR of *N*-Aryl-2-thiocyanatopyrroles

Compound	δ (Deuteriochloroform) (b)
10	6.35 (dd, H − 4), 6.80 (dd, H − 3), 7.08 (dd, H − 5), 7.3 (s, benzenoid)
11	3.65 (s, CH_3), 6.35 (dd, H − 4), 6.80 (dd, H − 3), 6.95 (dd, H − 5), 7.3-8.2 (m, benzenoid)
12	6.30 (dd, H − 4), 6.70 (dd, H − 3), 6.9 (dd, H − 5), 7.3-7.7 (m, benzenoid)
13	6.41 (dd, H − 4), 6.85 (dd, H − 3), 7.00 (dd, H − 5), 7.47-8.21 (m, benzenoid)
14	1.96 (s, CH_3), 6.43 (dd, H − 4), 6.84 (dd, H − 3), 7.00 (dd, H − 5), 7.20-7.64 (m, benzenoid and NH); 8.22 (dd, benzenoid)
15	6.49 (dd, H − 4), 6.92 (dd, H − 3), 7.10 (dd, H − 5), 7.25-7.63 (m, benzenoid and NH), 8.5 (m, benzenoid)
16	4.10 (s, CH_2), 6.41 (dd, H − 4), 6.92 (dd, H − 3), 7.19 (dd, H − 5), 7.32-7.85 (m, benzenoid), 9.38 (s, NH)

(a) Starting material in this preparation suspended in ethanol. (b) All signals integrated for the correct number of protons.

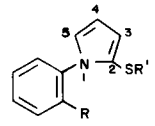
the corresponding sulphides. These sulphides have proved to be reliable and useful intermediates in the synthesis of heterocyclic compounds (3).

Reaction of the thiol derived from methoxycarbonylphenylthiocyanatopyrrole **11** with bromoacetic acid, methyl bromoacetate, and methyl α-bromophenylacetate (8) afforded the corresponding pyrrolylsulphides **17-19**. These compounds were obtained in moderate yields (Table II). Methylthiopyrrole **20**, a side product observed in all of the above reactions was identified by comparison with an authentic sample. The formation of methylthiopyrrole **20** is best explained by analogy to the observation made by Olsen and Snyder (9) that methylthioethers can be obtained from the reaction of thiocyanates with aqueous methanol in the presence of base.

Pyrrolylsulphides **17-19** were subjected to Dieckmann

Table II

N-Aryl-2-pyrrolylsulphides



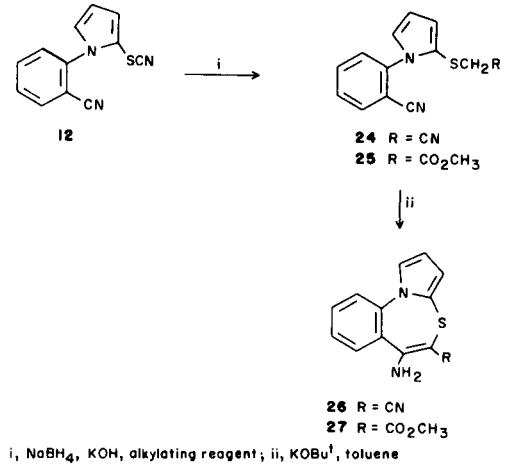
Compound	R	R'	Method	Mp°	Yield %	Recrystallization Solvent	Molecular Formula	Analyses Calculated C	H	N	Found C	H	N
17	CO_2CH_3	CH_2CO_2H	A	148-149	78	ethanol	$C_{14}H_{13}NO_4S$	57.72	4.49	4.81	57.84	4.55	4.55
18	CO_2CH_3	$CH_2CO_2CH_3$	B	58-60	33	petroleum ether (bp 40-60°)	$C_{15}H_{15}NO_4S$	58.99	4.95	4.58	59.01	4.91	4.59
20	CO_2CH_3	CH_3	(a)	bp 133-134 0.7 mm Hg	80	—	$C_{13}H_{13}NO_2S$	63.13	5.30	5.66	62.86	5.23	5.08
28	H	CH_2CO_2H	A	91-92	100	chloroform-petroleum ether (bp below 40°)	$C_{12}H_{11}NO_2S$	61.78	4.75	6.00	61.28	4.87	5.99

NMR of *N*-Aryl-2-pyrrolylsulphides

Compound	δ (Deuteriochloroform) (b)
17	3.07 (s, SCH_2), 3.68 (s, CO_2CH_3), 6.27 (dd, H – 4), 6.60 (dd, H – 3), 6.87 (dd, H – 5), 7.25-8.0 (m, benzenoid)
18	3.0 (s, SCH_2), 3.5 (s, $SCH_2CO_2CH_3$), 3.6 (s, CO_2CH_3), 6.25 (dd, H – 4), 6.55 (dd, H – 3), 6.9 (dd, H – 5) 7.2-8.0 (m, benzenoid)
20	1.9 (s, SCH_3), 3.60 (s, CO_2CH_3), 6.25 (t, H – 4), 6.5 (dd, H – 3), 6.8 (dd, H – 5), 7.25-8.20 (m, benzenoid)
28	3.02 (s, SCH_2), 6.25 (t, H – 4), 6.70 (dd, H – 3), 6.9 (dd, H – 5), 7.38 (s, benzenoid)

(a) See experimental (b) All signals integrated for the correct number of protons.

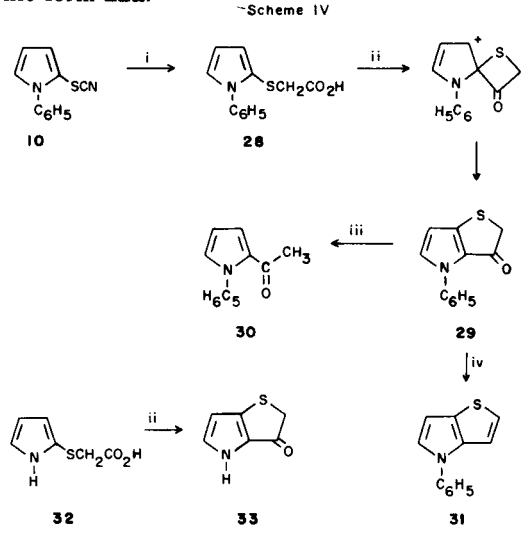
Scheme III



i, $NaBH_4$, KOH, alkylating reagent; ii, $KOBu^t$, toluene

condensation conditions (10) and on treatment with potassium tertiary butoxide ($KOBu^t$) in hot toluene followed by acidification produced the benzothiazepines **21-23** (Scheme II). The use of sodium hydride in refluxing toluene afforded the desired products in moderate yields. There was no tendency for benzothiazepine **22** to undergo decarboxymethylation, a reaction frequently observed in Dieckmann cyclisations, under the reaction conditions. Moreover study of the spectral data showed that compound **22** existed in its enolic form **22b** and not in its ketonic form **22a**.

Scheme IV



i, KOH, $BrCH_2CO_2H$; ii, PPA; iii, Raney Ni; iv, $NaBH_4$

Thorpe-Ziegler condensation (11), in principle only a modification of the Deickmann condensation, has been shown to be effective in the formation of seven- or eight-membered rings. Hence we decided to investigate its application to the synthesis of pyrrolobenzothiazepines. The dinitrile precursor **24** obtained in rather low yield from the reaction of cyanophenylthiocyanatopyrrole **12** with chloroacetonitrile in the presence of base afforded the expected benzothiazepine **26** when reacted in toluene with potassium tertiary butoxide at room temperature (Scheme II). In a related reaction, pyrrolylsulphide **25** prepared from thiocyanatopyrrole **12** and methyl bromoacetate, was cyclized with potassium tertiary butoxide and benzothiazepine **27** was thus obtained (Scheme III).

Synthesis of 2,3-dihydro-3-oxo-4-phenylthieno[3,2-*b*]-pyrrole (**29**).

Cyclodehydration of the pyrrolylacetic acid **28**, obtained from thiocyanatopyrrole **10** and bromoacetic acid, with polyphosphoric acid was attempted. It was hoped that under acidic conditions attack on the benzene ring would be promoted and that a benzothiazepine would be formed. This is the case in the nitration of *N*-phenylpyrrole in concentrated sulphuric acid which is reported to give *N*-(p-nitrophenyl)pyrrole as the sole product (3). However the thieno[3,2-*b*]pyrrole **29** was the only product isolated from the above reaction. Compound **29** was identified by spectral methods, in particular the pyrrolic hydrogens appeared as doublets (J = 2.7 Hz) at δ 6.28 and 7.32 in the nmr spectrum, thus confirming that substitution had occurred on the 3-position of the pyrrole ring. Chemical evidence for the proposed structure was provided by desulphurisation of the thienopyrrole **29** with Raney nickel catalyst to the 2-acetylpyrrole **30** while its reduction with sodium borohydride afforded the thienopyrrole **31**. It is evident that a rearrangement, analogous to the one observed by Gronowitz *et al* (5) in the synthesis of thienopyrrole **33** from 2-pyrrolylthioacetic acid (**32**) had occurred and a similar cyclic concerted mechanism could be operating (Scheme IV). It is worth noting however that rearrangement is not always observed in similar cyclisation reactions (12).

EXPERIMENTAL

The ir spectra of solids were taken as potassium bromide discs and liquids as thin films between sodium chloride plates. Nmr spectra were measured at 60 MHz in deuterochloroform on either a Perkin-Elmer R12B or a Brücker WP 60 spectrometer unless otherwise stated. Mass spectral measurements were recorded on a Kratos MS 25 machine equipped with a DS50S data system.

N-Phenyl- (13), -(2-methoxycarbonylphenyl) (14), -(2-cyanophenyl) (15), -(2-nitrophenyl) (15), -(2-acetamidophenyl) (16), -(2-benzamidophenyl) (16) and -(2-chloroacetamidophenyl)pyrrole (17) were prepared by the published literature procedures.

All of the compounds tabulated in Tables I and II showed the expected molecular ions.

Thiocyanation of *N*-Arylpyrroles.

To a stirred methanolic solution of *N*-arylpyrrole (0.04 mole in 200 ml of methanol or ethanol) cooled to 0-2° in an ice-bath and kept under nitrogen, freshly prepared cupric thiocyanate (18) (0.12 mole) was added in portions. The reaction mixture was then left to stir at 4° until the black suspension turned white. The white cuprous thiocyanate was filtered off, washed with methanol and the filtrate poured on ice. The thiocyanated purrole that had precipitated was filtered and air dried. It was usually obtained in a sufficiently pure form to be used in subsequent reactions without any further purification. The thiocyanates prepared by this procedure are listed in Table I.

Conversion of Thiocyanatopyrroles into Alkylthiopyrroles.

(a) With Bromoacid. General Procedure A.

A solution of *N*-arylthiocyanatopyrrole (0.002 mole) and bromoacid (0.0025 mole) in methanol (40 ml) was cooled to below −60° in a Dry ice-methanol bath, and stirred while 85% potassium hydroxide (0.0075 mole) in 50% aqueous methanol (10 ml) was added dropwise. Stirring was continued for about two hours while the reaction mixture warmed up to room temperature. It was then diluted with water (10 ml) and extracted with chloroform (4 × 30 ml) to remove non-acidic products. The aqueous layer was acidified with 2*N* hydrochloric acid and the product extracted with chloroform (4 × 30 ml). The chloroform extracts were dried over magnesium sulphate, filtered and the solvent removed. The thick oily product thus obtained usually solidified upon trituration with petroleum ether (bp below 40°).

(b) With Bromoester or Bromonitrile. General Procedure B.

To a solution of *N*-arylthiocyanatopyrrole (0.005 mole) in methanol (50 ml), kept under nitrogen, sodium borohydride (0.0075 mole) was added in portions and the mixture stirred at room temperature for 45 minutes. Potassium hydroxide (85%) (0.0075 mole) in methanol (10 ml) was added to the dark reaction mixture, followed by the bromoester (0.0075 mole). The reaction mixture was then allowed to reflux gently for 1.5 hours, after which it was cooled, diluted with brine solution (50 ml) and extracted with chloroform (4 × 40 ml). The chloroform extracts were dried over magnesium sulphate, filtered and the solvent removed. The residue was passed through a silica gel column, and the product eluted with chloroform, usually as the main fraction. The chromatographically pure product was used for the cyclisation step. The alkylthiopyrroles prepared by these procedures are listed in Table II.

N-(2-Methoxycarbonylphenyl)-2-methylthiopyrrole (**20**).

A stirred solution of *N*-arylthiocyanatopyrrole **11** (0.01 mole) and methyl iodide (0.015 mole) in methanol (50 ml) was kept under a nitrogen atmosphere and cooled to below 0° in an ice-salt bath. Potassium hydroxide (85%) (0.03 mole) in water (20 ml) was added dropwise. The cooling bath was removed and stirring was continued for one hour. The reaction mixture was then acidified with 2*N* hydrochloric acid, diluted with brine solution (50 ml) and extracted with chloroform (4 × 40 ml). the chloroform extracts were dried over magnesium sulphate, filtered and the solvent removed to give the crude methylthiopyrrole **20** which was purified by vaccum distillation (see Table II).

Synthesis of Pyrrolobenzothiazepines,

To a stirred suspension of commercially available potassium *t*-butoxide (0.002 mole) in dry toluene (35 ml) kept under a continuous stream of dry nitrogen, *N*-arylpyrrole (0.001 mole) in dry toluene (4-6 ml) was added. The suspension, which turned dark in colour upon addition of the pyrrole, was either left to stir at room temperature or heated gently at 80-100° for 1-4 hours. After cooling to room temperature (where appropriate), the reaction mixture was poured onto ice-water and acidified with 2*N* hydrochloric acid. The organic layer was separated and the aqueous layer extracted with chloroform (3 × 30 ml). The combined organic layers were dried over magnesium sulphate and the solvent removed. The residue, which consisted mainly of the cyclised product,

was chromatographed on a silica gel column. The cyclised product, the most mobile component of the reaction mixture, was eluted with chloroform.

5,6-Dihydro-6-oxo-pyrrolo[1,2-*a*][3,1]benzothiazepine (**21**).

[*N*-2-Methoxycarbonylphenyl)-2-pyrrolylthio]acetic acid (**17**) was reacted with a three-fold excess of potassium *t*-butoxide as described above for 1.5 hours at 70-90°, to give the crude product as a thick oil in 60% yield. A sample for analysis was purified by preparative thick layer chromatography (chloroform); ir: 1675 cm^{-1} (C=O); nmr δ 3.76 (s, 2H, methylene), 6.30 (dd, 1H, H-4, $J_{4,3}$ = 3.5 Hz, $J_{4,5}$ = 2.93 Hz), 6.51 (dd, 1H, H-3, $J_{3,5}$ = 1.85 Hz), 7.08 (dd, 1H, H-5), 7.22-7.85 (m, 4H, benzenoid); ms: 215 (M^+).

Anal. Calcd. for $C_{12}H_9NOS$: C, 66.95; H, 4.21; N, 6.50. Found: C, 67.41; H, 4.61; N, 6.24.

5-Methoxycarbonyl-6-hydroxy-pyrrolo[1,2-*a*][3,1]benzothiazepine (**22**).

Methyl [*N*-2-methoxycarbonylphenyl)-2-pyrrolylthio]acetate (**18**) was reacted with potassium *t*-butoxide as described above for 1.5 hours at 80-90° to give the crude product in 75% yield. An analytical sample of mp 108-109.5° was obtained as pale yellow crystals by crystallisation from ether; ir: 3400-2500 cm^{-1} (very broad, OH); 1640 (β-ketoester C=O); nmr: δ 3.90 (s, 3H, OCH_3), 6.34 (m, 2H, H-3 and H-4), 7.05 (dd, 1H, H-5, $J_{5,3}$ = 2.2 Hz, $J_{5,4}$ = 2.6 Hz), 7.24-7.96 (m, 4H, benzenoid), 13.1 (s, 1H, OH deuterium oxide exchangeable); ms: 273 (M^+).

Anal. Calcd. for $C_{14}H_{11}NO_3$: C, 61.52; H, 4.05; N, 5.12. Found: C, 61.37; H, 4.06; N, 4.79.

5-Phenyl-6-oxopyrrolo[1,2-*a*][3,1]benzothiazepine (**23**).

Methyl [*N*-(2-methoxycarbonylphenyl)-2-pyrrolylthio]phenylacetate (**19**) was prepared in 53% yield from methoxycarbonylphenylthiocyanatopyrrole (**11**) and methyl α bromophenylacetate by alkylation procedure B. It was isolated as a thick oil; nmr: δ 3.55 (s, 3H, $SCH(C_6H_5)CO_2CH_3$), 3.65 (s, 3H, CO_2CH_3), 4.35 (s, 1H, SCH), 6.25 (dd, 1H, H-4), 6.50 (dd, 1H, H-3), 6.80 (dd, 1H, H-5), 7.0-8.2 (m, 9H, benzenoid H) and was reacted with potassium *t*-butoxide as described above for 4 hours at 100-110° to give the crude product in 20% yield. An analytical sample of mp 133-134° was obtained as white needles by crystallisation from ether; ir: 1670 cm^{-1} (C=O); nmr δ 5.05 (s, 1H, methine); 6.29 (dd, 1H, H-4, $J_{4,3}$ = 3.7 Hz, $J_{4,5}$ = 2.9 Hz); 6.51 (dd, 1H, H-3, $J_{3,5}$ = 1.8 Hz); 7.10 (dd, 1H, H-5); 7.17-7.60 (m, 9H, benzenoid); ms: 291 (M^+).

Anal. Calcd. for $C_{18}H_{13}NOS$: C, 74.20; H, 4.49; N, 4.80. Found: C, 73.73; H, 4.41; N, 4.80.

5-Cyano-6-aminopyrrolo[1,2-*a*][3,1]benzothiazepine (**26**).

[*N*-(2-Cyanophenyl)-2-pyrrolylthio]acetonitrile (**24**) was prepared in 35% yield from cyanophenylthiocyanatopyrrole (**12**) and chloroacetonitrile by alkylation procedure B. It was isolated as a thick oil ; nmr: δ 3.15 (s, 2H, SCH_2), 6.45 (t, 1H, H-4), 6.85 (dd, 1H, H-3), 7.10 (dd, 1H, H-5), 7.35-8.0 (m, 4H, benzenoid H) and was reacted with potassium *t*-butoxide as described above for 1 hour at room temperature to give the crude product in 40% yield. An analytical sample of mp 182-184° dec was obtained as tan crystals by crystallisation from ether; ir: 3400, 3300 cm^{-1} (NH_2), 2150 (C≡N), 1630 (C=C); nmr: δ 5.0 (s, br, 2H, NH_2, deuterium oxide exchangeable), 6.34 (m, 2H, H-4 and H-3), 7.05 (dd, 1H, H-5, $J_{5,3}$ = 2.0 Hz, $J_{5,4}$ = 2.75 Hz), 7.25-7.8 (m, 4H, benzenoid); ms: 239 (M^+).

Anal Calcd. for $C_{13}H_9N_3S$: C, 65.24; H, 3.79; N, 17.56. Found: C, 65.54; H, 3.96; N, 17.12.

5-Methoxycarbonyl-6-aminopyrrolo[1,2-*a*][3,1]benzothiazepine (**27**).

Methyl [*N*-(2-cyanophenyl)-2-pyrrolylthio]acetate (**25**) was prepared in 23% yield from cyanophenylthiocyanatopyrrole (**12**) and methyl bromoacetate by alkylation procedure B. It was isolated as a thick oil; nmr: δ 3.10 (s, 2H, SCH_2), 3.52 (s, 3H, CO_2CH_3), 6.35 (t, 1H, H-4), 6.65 (dd, 1H, H-3), 7.03 (dd, 1H, H-5), 7.3-8.0 (m, 4H, benzenoid H) was reacted with potassium *t*-butoxide as described above for 4.5 hours at 50-70° to give the crude product in 37% yield. An analytical sample of mp 182-184° dec was obtained as tan needles by crystallisation from petroleum ether (bp below 40°); ir: 3400, 3300 cm^{-1} (NH_2), 1640 (C=O); nmr (200 MHz): δ 3.79 (s, 3H, CH_3), 6.30 (t, 1H, H-4); 6.36 (dd, 1H, H-3, $J_{3,4}$ = 3.5 Hz, $J_{3,5}$ = 1.8 Hz), 7.08 (dd, 1H, H-5, $J_{5,4}$ = 3.1 Hz), 7.36-7.73 (m, 6H, benzenoid and NH_2); ms: 272 (M^+).

Anal. Calcd. for $C_{14}H_{12}N_2O_2S$: C, 61.74; H, 4.44; N, 10.28. Found: C, 61.45; H, 4.52; N, 10.08.

2,3-Dihydro-3-oxo-4-phenylthieno[3,2-*b*]pyrrole (**29**).

N-Phenyl-2-pyrrolylthioacetic acid (**28**) (2.33 g, 0.01 mole) was added to a stirred solution of polyphosphoric acid (12 g) and dry xylene (30 ml) heated at 70-80°. The temperature was raised to 100-115° and the reaction mixture kept at this temperature for 45 minutes. After cooling and dilution with water (40 ml), the organic layer was separated and the aqueous layer extracted with chloroform. the organic layers were combined, washed twice with water, dried over magnesium sulphate and the solvent removed. The residue was then put on a silica gel column and the product eluted in the first fraction with chloroform. The thieno[3,2-*b*]-pyrrole **29** (0.5 g, 23%) was obtained as a white solid, mp 123-124°, after crystallisation from methanol; ir: 1660 cm^{-1} (C=O); nmr: δ 4.03 (s, 2H, methylene), 6.28 (d, 1H, H-6, $J_{6,5}$ = 2.7 Hz). 7.32 (d, 1H, H-5), 7.45 (s, 5H, benzenoid); ms: 215 (M^+).

Anal. Calcd. for $C_{12}H_9NOS$: C, 66.95; H, 4.27; N, 6.50. Found: C, 67.24; H, 4.18; N, 6.48.

N-Phenyl-2-acetylpyrrole (**30**).

A suspension of 2,3-dihydro-3-oxo-4-phenylthieno[3,2-*b*]pyrrole (**29**) (0.215 g, 0.001 mole) and Raney nickel (2.0 g) in 95% ethanol (40 ml) was heated under reflux for about one hour. The reaction mixture was filtered while hot, the catalyst washed with boiling ethanol (100 ml) and the combined filtrate and washings evaporated under reduced pressure. Fairly pure *N*-phenyl-2-acetylpyrrole (**30**) was thus obtained as a white solid (0.120 g, 65%). An analytical sample of mp 52-53° was obtained by low temperature recrystallisation from petroleum ether (bp below 40°); ir: 1660 cm^{-1} (C=O); nmr: δ 2.37 (s, 3H, CH_3), 6.24 (dd, 1H, H-4, $J_{4,3}$ = 4.0 Hz, $J_{4,5}$ = 2.75 Hz), 6.88 (dd, 1H, H-5, $J_{5,3}$ = 1.65 Hz), 7.05 (dd, 1H, H-3), 7.18-7.34 (m, 5H, benzenoid); ms: 185 (M^+).

Anal. Calcd. for $C_{12}H_{11}NO$: C, 77.81; H, 5.86; N, 7.56. Found: C, 77.54; H, 6.12; N, 7.44.

N-Phenylthieno[3,2-*b*]pyrrole (**31**).

Sodium borohydride (0.117 g, 0.0031 mole) was added in portions to a stirred suspension of 2,3-dihydro-3-oxo-4-phenylthieno[3,2-*b*]pyrrole (**29**) (0.260 g, 0.0012 mole) in ethanol (30 ml) and kept under a continuous stream of nitrogen. The suspension was heated under reflux for 1.5 hours. The clear solution thus obtained was cooled, diluted with water and the product extracted with chloroform. The chloroform extracts were combined, dried over magnesium sulphate, filtered and the solvent removed. The crude liquid product was obtained in 90% yield (0.215 g). It was purified by preparative thick layer chromatography (silica gel, chloroform). *N*-Phenylthieno[3,2-*b*]pyrrole, the most mobile component, was extracted with chloroform, dried over magnesium sulphate, filtered and the chloroform evaporated. The colourless liquid product darkened upon standing; ir: absence of C=O; nmr: (acetone-d_6, 200 MHz): δ 6.63 (d, 1H, H-6, $J_{6,5}$ = 3.1 Hz), 7.25-7.30 (m, 2H, H-2 and H-3), 7.31-7.37 (m, 1H, benzenoid H), 7.43 (dd, 1H, H-5, $J_{5,2}$ = 1.1 Hz), 7.50-7.65 (m, 4H, benzenoid H); ms: 199 (M^+).

Anal. Calcd. for $C_{12}H_9NS$: C, 72.36; H, 4.55; N, 7.03. Found: C, 72.16; H, 4.71; N, 7.00.

Acknowledgements.

We thank the British Council for the award of a scholarship to A. A. Hawi, J. Cobb for his assistance with the nmr measurements and W. Gunn and A. Cakebread for mass spectra which were obtained on a machine funded by the University of London Intercollegiate Research Services Scheme.

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