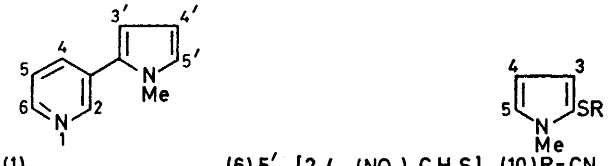
Identification of the Product from Nicotine and Sulphur as Bis-1-methyl-2-(3-pyridyl)pyrrol-3-yl Disulphide

By **R. Morrin Acheson** * and **Michael J. Ferris**, Department of Biochemistry, South Parks Road, Oxford OX1 3QU
Stephen R. Critchley and **David J. Watkin**,* Chemical Crystallography Laboratory, 9 Parks Road, Oxford OX1 3PD

Dithiodinicotyrine, obtained from nicotine and sulphur, has been identified as bis-1-methyl-2-(3-pyridyl)pyrrol-3-yl disulphide (9) from its spectra, reactions, and *X*-ray crystal structure. Its mode of formation is considered.

In 1885 Cahours and Étard[1] heated nicotine (3) with sulphur and obtained a product (thiotetrapyridine) for which they reported a molecular formula of $C_{20}H_{18}N_4S$ from analytical and molecular-weight data. Morton and Horovitz[2] obtained the same substance when toluene was the reaction solvent and described the compound as ' thiodinicotyrine ' (7) on the basis of their molecular weight measurements and the now known structure for nicotine. Subsequently three independent investigations[3-5] established the presence of an additional sulphur atom in the molecule and agreed on the single structure (8) for ' dithiodinicotyrine '. Chemical evidence in support of this was the copper powder[4] and Raney nickel[5] desulphurisations to nicotyrine (1), but we have not been able to confirm the reported[4] zinc and acetic acid reduction leading to the hydrochloride of (5) and the dinitrophenyl derivative (6). The mass spectrum[4,5] showed the molecular ion and the base peak at half this *m/e* value consistent with the presence of a disulphide link, but no evidence for the position of this link was put forward.



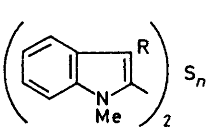
(1)
(2) 4',5' - H_2
(3) 2',3',4',5'-H_4
(4) 5'-*p*-$NO_2C_6H_4N_2$-
(5) 5'-SH
(6) 5'-[2,4-$(NO_2)_2C_6H_4S$]
(7) bis-5'-sulphide
(8) bis-5'-disulphide
(9) bis-3'-disulphide
(10) R=CN
(11) R=Me

The ^{1}H n.m.r. spectrum for ' dithiodinicotyrine ' includes[4,5] doublets at τ 3.68 and 3.32 with a coupling constant of *ca.* 3 Hz which were assigned to the pyrrole ring protons. The relatively simple spectrum showed conclusively that the sulphur atoms were attached to the same positions of the pyrrole rings. Coupling between the 2,3- and 3,4-protons for pyrroles is usually in the 2.37—3.1 and 3.4—4.2 Hz range,[6] while an even higher value (4.5 Hz) was observed for the azo-compound (4) prepared from nicotyrine and 4-nitrobenzenediazonium sulphate.[5] This suggested the ' dithiodinicotyrine ' might actually be the 3',3'-disulphide (9), so accurate coupling constants were obtained and the structural conclusion confirmed by a comparison with those for the compounds shown in Table 1. The position of the sulphur atoms could not be deduced unambiguously from the chemical shifts of the residual pyrrolic protons by comparison with the data for the few available model compounds. Confirmation of the position of the sulphur atoms was now sought by desulphurization with deuteriated Raney nickel under conditions which replace the sulphur atom of penicillin esters stereospecifically by deuterium.[7] The ^{1}H n.m.r. spectrum of the resulting nicotyrine, using the *N*-methyl resonance as a standard, was compared with that of a pure specimen of nicotyrine treated under the same conditions. Although the 2,6-protons of the pyridine rings for both samples had virtually completely exchanged, and some exchange had taken place at other positions, incorporation of deuterium at positions 3' and 4' (which could not be resolved at 60 M Hz) was far more (32%) for the product (9) than for the unlabelled nicotyrine (<5%) while exchange at positions 5' was about the same (36 and 30% respectively). Attempts were made to synthesize the 5'-disulphide (8) from nicotyrine and sulphur monochloride on the assumption that attack would occur at the 5'-position of the pyrrole; 3-substituted-1-methylindoles yield[8] mainly compounds of type (12; $n = 2$), contaminated with type (12; $n = 1$ and 3) with these conditions, while uracils yield mainly the bis-5-pyrimidinyl sulphides.[9] The crystalline product, of much higher m.p. than (9), gave a ^{1}H n.m.r. spectrum ($J_{3',4}$

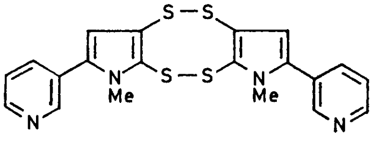
TABLE 1

Proton coupling constants for the pyrrole ring

	J/Hz		
Compound	3,4	4,5	3,5
(1)	3.4	2.7	2.1
(4)	4.4		
(8)	3.7		
(9)		2.9	
(10)	4.0	2.8	1.9
(11)	3.7	2.7	1.9



(12)



(13)

3.7 Hz) consistent with its assumed structure, but good analytical data could not be obtained owing to contamination with the corresponding monosulphide. Although the evidence assembled supported our structure for ' dithiodinicotyrine ' it was not considered sufficient and an X-ray crystal structure determination was carried out.

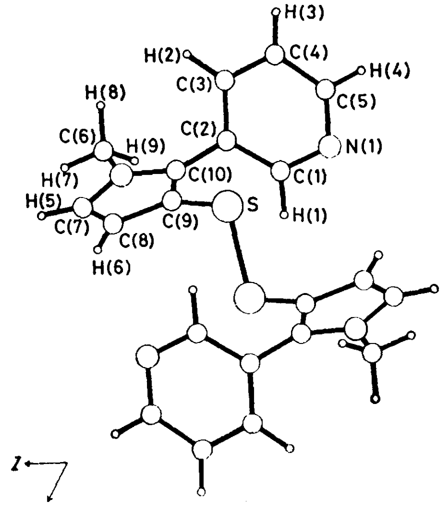


FIGURE 1 Projection of the disulphide (14) on the xz plane; the crystallographic atom numbering system is shown

The results confirmed that ' dithiodinicotyrine ' has structure (9). Figure 1 is a projection of the molecule showing the crystallographic atom numbering system, and the positions of the molecules in the unit cell are shown in Figure 2. The atom parameters are shown in Table 2, and molecular parameters in Table 3. Bond lengths and angles have not been corrected for thermal motion but are well within the normal ranges expected for a molecule of this type. The pyridine and pyrrole rings are essentially planar (maximum atom deviations being 0.004 and 0.010 Å respectively) and are mutually inclined at 55.5°. It is therefore clear that even small differences in ^{1}H coupling constants in the pyrrole series can be a valuable guide to the positions of substituents.

TABLE 2

Atom co-ordinates ($\times 10^5$; for H $\times$ 10^3) for compound (14), with estimated standard deviations in parentheses

Atom	x/a	y/b	z/c
S(1)	6 477(2)	4 746(5)	20 409(2)
N(1)	14 470(10)	−50 138(30)	29 901(9)
N(2)	11 361(8)	−39 410(20)	4 116(8)
C(1)	11 200(10)	−42 460(20)	25 071(9)
C(2)	15 806(8)	−39 830(20)	15 848(8)
C(3)	24 287(9)	−45 840(20)	11 460(10)
C(4)	27 740(10)	−54 020(30)	16 380(10)
C(5)	22 620(10)	−55 730(30)	25 480(10)
C(6)	14 860(10)	−58 330(30)	200(10)
C(7)	6 910(10)	−27 720(30)	1 300(10)
C(8)	4 480(10)	−11 290(20)	6 390(9)
C(9)	7 516(8)	−12 920(20)	12 621(8)
C(10)	11 726(8)	−30 640(20)	11 127(8)
H(1)	52(1)	−389(3)	286(1)
H(2)	281(1)	−446(3)	47(1)
H(3)	334(1)	−587(3)	139(1)
H(4)	248(2)	−602(4)	286(2)
H(5)	61(1)	−319(3)	−34(1)
H(6)	10(1)	−3(3)	61(1)
H(7)	134(2)	−674(4)	48(2)
H(8)	214(2)	−576(4)	−34(2)
H(9)	124(2)	−621(4)	−35(2)

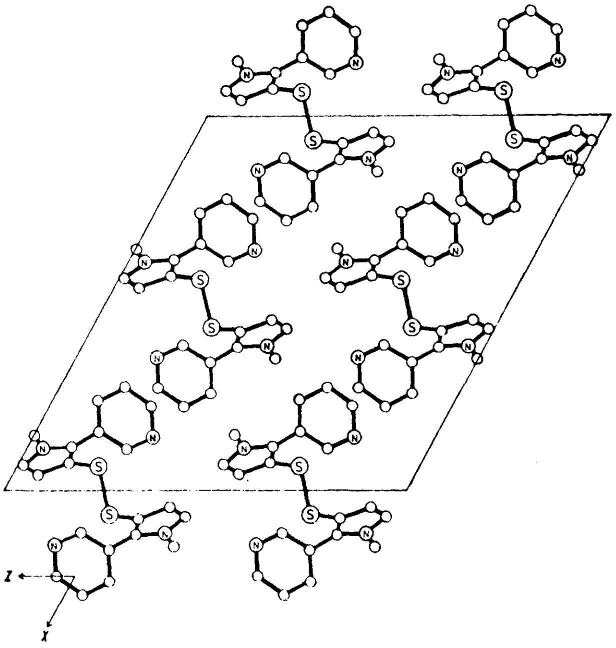


FIGURE 2 Arrangement of the molecules of the disulphide (14) within the unit cell

The mode of formation of the disulphide (9) from nicotine (3) is unlikely to involve initial dehydrogenation to nicotyrine (1) as nicotyrine with sulphur yields a different compound [3] which has been given [3] structure (13). Other isomeric formulations are possible, but our new spectral data (see Experimental section and Table

TABLE 3

Interatomic distances and interbond angles for (14), with estimated standard deviations in parentheses

(a) Bond lengths (Å)

S(1)–S(1)	2.079(1)	C(9)–C(10)	1.390(3)
C(1)–N(1)	1.337(2)	C(9)–S(1)	1.749(1)
C(1)–C(2)	1.397(2)	C(10)–N(2)	1.377(2)
C(2)–C(3)	1.392(2)	C(1)–H(1)	0.976(21)
C(2)–C(10)	1.474(2)	C(3)–H(2)	1.030(20)
C(3)–C(4)	1.387(2)	C(4)–H(3)	0.938(23)
C(4)–C(5)	1.380(3)	C(5)–H(4)	0.865(28)
C(5)–N(1)	1.335(2)	C(6)–H(7)	0.937(31)
C(6)–N(2)	1.459(2)	C(6)–H(8)	1.021(30)
C(7)–N(2)	1.377(2)	C(6)–H(9)	0.974(29)
C(7)–C(8)	1.364(2)	C(7)–H(5)	0.931(20)
C(8)–C(9)	1.423(2)	C(8)–H(6)	0.993(22)

(b) Bond angles (°)

N(1)–C(1)–C(2)	124.0(2)	N(2)–C(7)–C(8)	108.6(2)
C(1)–C(2)–C(3)	117.6(2)	C(7)–C(8)–C(9)	107.2(2)
C(1)–C(2)–C(10)	120.1(2)	C(8)–C(9)–S(1)	125.7(1)
C(2)–C(3)–C(4)	119.1(2)	C(8)–C(9)–C(10)	107.7(2)
C(3)–C(4)–C(5)	118.5(2)	C(9)–C(10)–N(2)	107.0(2)
C(4)–C(5)–N(1)	124.1(2)	C(9)–C(10)–C(2)	130.2(2)
C(5)–N(1)–C(1)	116.8(2)	C(3)–C(2)–C(10)	122.3(2)
C(6)–N(2)–C(7)	123.5(2)	C(10)–C(9)–S(1)	126.6(1)
C(6)–N(2)–C(10)	126.9(2)	C(9)–S(1)–S(1′)	104.1(1)

4), on a specimen of the compound prepared as described did not resolve the position and a satisfactory crystal for *X*-ray studies could not be obtained. The possibility that nicotine is first dehydrogenated to (2), that this reacts at position 3 with the sulphur to yield a disulphide, followed by dehydrogenation at the 4′,5′-positions to give (9) is consistent with the results obtained on heating (2) with sulphur. The 3′,3′-disulphide was obtained in 40% yield, along with 10% of (13) which could have been obtained *via* (1) formed by dehydrogenation of (2).

TABLE 4

^{13}C N.m.r. spectra (δ/p.p.m.) measured at 22.63 MHz from internal tetramethylsilane

(*a*) Resonance and position assignments * for the pyrrole ring

Cpd.	2 (or 5′)	3 (or 4′)	4 (or 3′)	5 (or 2′)	NMe
1-Methylpyrrole	121.1	107.8	107.8	121.1	35.8
(1)	125.2	108.6	110.2	129.7	35.3
(9)	122.8	114.5	114.0	134.7	35.5
(10)	112.2 † 107.1 †	120.8	109.5	128.4	34.4
(11)	123.0	115.9	107.9	124.4	33.6
					21.0 ‡
(13)	128.0	122.2	111.1	134.3	33.0

(*b*) Resonance and position assignments for the pyridine ring

	2	3	4	5	6
(1)	149.6	131.1	135.7	123.6	148.0
(9)	150.9	127.0	138.2	123.6	148.5
(13)	149.0	130.4	135.8	123.1	148.7

* All assignments are in conformity with proton double resonance experiments, but in a number of cases are not unambiguous.
† One of these is due to *C*N.
‡ S*C*H$_3$ resonance.

EXPERIMENTAL

The instruments employed have been noted [10] except that the 270 MHz ^{1}H n.m.r. spectra were recorded on the Oxford Enzyme Group's instrument. N.m.r. spectra were determined in CDCl$_3$ with internal tetramethylsilane as standard and are recorded in τ (*J* in Hz). Spence grade H alumina (100—200 mesh) for column chromatography was deactivated by shaking with 5% (v/v) 10% aqueous acetic acid. MN Polygram Sil N-HR/UV$_{254}$ (Machery-Nagel, Duren) precoated plastic sheets were employed for t.l.c. and were developed in chloroform–methanol–triethylamine (95 : 5 : 1 v/v/v). Nicotine (British Nicotine Ltd.) was always slowly distilled at 118—120 °C and 17 mmHg under nitrogen before use. Organic extracts were dried (MgSO$_4$).

Bis-1-*methyl*-2-(3-*pyridyl*)*pyrrol*-3-*yl Disulphide* (9). 1-Methyl-2-(3-pyridyl)pyrrolidine (50.0 g), sulphur (25.0 g), and toluene (350 ml) were heated under reflux under nitrogen for 72 h. After cooling, the basic material was collected with aqueous 2M-hydrochloric acid (250 ml), the toluene being discarded, and after washing with ether (2 × 200 ml) and basifying with ammonia the product was extracted into chloroform (3 × 250 ml). Evaporation of the dried extracts gave the yellow disulphide (9) which was crystallised twice from ethanol and once from toluene to give poorly developed rhomboids, m.p. 155 °C (lit.,[2] 153—156 °C) (8.5 g, 14.5%).

Most of the crystals were twinned but a tedious photographic examination led to a single crystal.

Crystal data.—$C_{20}H_{18}N_4S_2$, $M = 378.5$. Monoclinic, $a = 17.95(2)$, $b = 6.88(1)$, $c = 17.18(2)$ Å, $\alpha = \gamma = 90°$, $\beta = 60.86 \pm 0.03°$, $U = 1\,853.4$ Å^3, $D_m = 1.37$ g ml^{-1}, $Z = 4$, $D_c = 1.36$ g ml^{-1}. Space group $C2/c$ (C_{2h}^6, No. 15) Mo-K_α radiation, $\lambda = 0.710\,7$ Å; μ(Mo-K_α) = 2.9 cm^{-1}.

Approximate cell dimensions were determined from preliminary oscillation and Weissenberg photographs. A crystal of dimensions *ca*. 0.75 × 0.70 × 0.45 mm was selected for intensity measurements and was set up on an Hilger and Watts PDP 8 controlled four-circle diffractometer. Accurate cell dimensions and an orientation matrix were obtained by a least-squares fit [11] to the setting angles of fourteen reflections. The intensities of all independent reflections with $0 < 2\theta \leqslant 60°$ were measured by use of an ω—2θ scan and the ordinate analysis method [12] with 60 steps of 0.02°. The 30 consecutive steps giving the highest total count were treated as peak and the remaining 30 as background. The count time at each step was 0.7 s. Graphite-monochromated Mo-K_α radiation was used. Reflections with an intensity $I < 3\sigma(I)$ where σ is the standard deviation derived from simple counting statistics, or whose apparent centre was >0.2° from the predicted position, were not included in the subsequent calculations. Lorentz and polarisation corrections, and an empirical absorption correction [13] were applied, leading to a final set of 2 356 independent structure amplitudes.

The structure was solved by Patterson and Fourier techniques; hydrogen atoms were located from a difference synthesis. Refinement was by the full-matrix least-squares method. In the final cycles non-hydrogen atoms were permitted anisotropic temperature factors whilst the hydrogen atoms were refined isotropically. Each reflection was assigned a weight according to the expression: $w = 1/\sum_{r=1}^{n} ArTr^*\,(x)$, where n is the number of coefficients, Ar, for a Chebyshev series, Tr^* is the polynomial function, and x is F_o/F_o (max). The coefficients were chosen to minimise the variation of mean $w\,(|F_o| - |F_c|)^2$ with $|F_o|$. Initially a four-term series was used and the structure was refined to convergence at *R* 4.9%. Examination of the $|F_o|$ and $|F_c|$ data at this stage showed that reflections with low $\sin\theta/\lambda$ values had $|F_o| \ll |F_c|$ which suggested that extinction was occurring. A Larson secondary-extinction correction,[14] using a Gaussian distribution, was applied and the weighting scheme was recalculated (final coefficients were $A[0] = 296.6$, $A[1] = 422.9$, $A[2] = 145.3$, $A[3] = 12.9$). The structure was refined to a final *R* value of 3.85%.

A difference Fourier at this stage showed no structurally significant peaks. The equations for the mean planes for the ring atoms of the pyridine and pyrrole rings are respectively $-7.134x + 6.249y - 5.270z = 0.529$, and $-11.098x - 3.063y + 4.545z = 0.139$.

All calculations were carried out on the Oxford University ICL 1906A computer using the CRYSTALS system.[15] Results are given in Tables 2 and 3. The observed structure amplitudes and structure factors calculated from these final atom parameters together with thermal parameters are contained in Supplementary Publication No. SUP 22644 (26 pp., 1 microfiche).* Atomic scattering factors were taken from ref. 16.

1-*Methyl*-2-(3-*pyridyl*)*pyrrole* (1).—Bis-1-methyl-2-(3-pyridyl)pyrrol-3-yl disulphide (0.83 g) in tetrahydrofuran (20 ml) was added to Raney nickel [from nickel–aluminium alloy (4.0 g) and 10% sodium hydroxide (40 ml)] in tetrahydrofuran (50 ml), and the mixture was heated under reflux for 2 h. After filtration and evaporation, a chloroform extract of the residue was washed with water, dried, and distilled to give 1-methyl-2-(3-pyridyl)pyrrole (1) (0.6 g, 87%) as an oil, b.p. 140—142 °C/12 mmHg (lit.[17] 150—152 °C/16 mmHg). N.m.r. (τ values, J in Hz; 270 MHz) 1′-CH_3, 6.40s; 3′-H, 3.74dd; 4′-H, 3.81dd; 5′-H, 3.29dd; $J_{3',4'}$ 3.4; $J_{3',5'}$ 2.1; $J_{4',5'}$ 2.7; 2-H, 1.35d; 4-H, 2.37dt; 5-H, 2.75dd; 6-H, 1.52dd; $J_{2,4}$ 1.2; $J_{4,5}$ 8.9; $J_{4,6}$ 1.1; $J_{5,6}$ 4.8. The observed spectrum was matched, within experimental error, by a theoretical spectrum calculated by LAOCOON 1968 from the S.R.C. Atlas Computing laboratory on the Oxford University ICL 1906A computer.

1-*Methyl*-2-*thiocyanatopyrrole* (10).—Cupric thiocyanate (36.0 g) was added in portions under nitrogen to a stirred solution of 1-methylpyrrole (8.1 g) (lit.[18] for pyrrole) in methanol (75 ml) below 0 °C. The mixture was left at room temperature overnight, filtered, and the filtrate and methanol washings poured over ice (300 g). Sodium chloride (100 g) was added and the dried chloroform (3 × 100 ml) extracts distilled under nitrogen to give 1-*methyl*-2-*thiocyanatopyrrole* (10), b.p. 118—120 °C/18 mmHg (3.7 g, 27%), as a colourless oil (Found C, 52.4; H, 4.5; N, 20.2. $C_6H_6N_2S$ requires C, 52.2; H, 4.4; N, 20.3%). N.m.r. (270 MHz) 1-CH$_3$, 6.32s; 3-H, 3.44dd; 4-H, 3.89dd; 5-H, 3.15dd; $J_{3,4}$ 4.0; $J_{3,5}$ 1.9; $J_{4,5}$ 2.8. I.r. (liquid film): 2 160s (CN) and 1 298s cm^{-1}.

1-*Methyl*-2-(*methylthio*)*pyrrole* (11).—Methyl iodide (4.26 g) was added dropwise to a stirred solution of (10) (3.4 g) in methanol (25 ml) under nitrogen. After cooling to 0 °C, potassium hydroxide (3.36 g) in water (10 ml) and methanol (10 ml) was added over 10 min. After warming to room temperature, the methanol was evaporated and the aqueous residue extracted with chloroform (3 × 25 ml). Distillation of the dried extract under nitrogen gave 1-*methyl*-2-*methylthiopyrrole*, b.p. 81—84 °C/20 mmHg (1.57 g, 51%), as a colourless mobile liquid (Found C, 56.4; H, 7.2; N, 11.1. C_6H_9NS requires C, 56.7; H, 7.1; N, 11.0%). N.m.r. (270 MHz) 1-CH$_3$, 6.33s; 2-SCH$_3$, 7.71s; 3-H, 3.36dd; 4-H, 3.97dd; 5-H, 3.71dd; $J_{3,4}$ 3.7; $J_{3,5}$ 1.9; $J_{4,5}$ 2.7. I.r. (liquid film): 1 298 cm^{-1}.

Bis-1-*methyl*-2-(3-*pyridyl*)*pyrrol*-5-*yl Disulphide* (8).—Sulphur monochloride (0.57 g) in dichloromethane (10 ml) was added to a stirred solution of nicotyrine (1) (1.0 g) in dichloromethane (20 ml) at room temperature. The green precipitate was collected after 4 h, but oiled rapidly on exposure to air. It was dissolved in chloroform (50 ml), washed with saturated aqueous sodium hydrogencarbonate (2 × 50 ml), dried, and the solvent evaporated. Recrystallisation of the residue from chloroform–light petroleum (b.p. 40—60 °C) gave a crystalline solid (1.2 g) which after preparative t.l.c. on silica gel gave a substance of m.p. 190—195 °C. Attempts at further purification to obtain a sample giving a satisfactory analysis failed and this appeared to be due to the presence of a small quantity of the corresponding monosulphide (7). N.m.r.: 1′-CH$_3$, 6.50s; 3′-H, 3.58d; 4′-H, 3.76d; $J_{3,4}$ 3.7; 2,6-H$_2$, 1.46m; 4-H, 2.36m; 5-H, 2.73m.

Bis-1-*methyl*-5-(4-*nitrophenylazo*)-2-(3-*pyridyl*)*pyrrol*-3-*yl Disulphide*.—The disulphide (9) (0.81 g) in tetrahydrofuran (25 ml) and sodium acetate (1.5 g) in water were added simultaneously with stirring at 0 °C to a solution of 4-nitroaniline (0.6 g) in water (20 ml) and concentrated hydrochloric acid (1.5 ml) which had been diazotised previously with sodium nitrite (0.345 g) in water (10 ml). The *azo-compound* precipitated and recrystallised from ethanol as red needles, m.p. 163—164 °C (Found, C, 56.8; H, 3.6; N, 20.3. $C_{32}H_{24}N_{10}O_4S_2$ requires C, 56.8; H, 3.5; N, 20.7%). $\lambda_{max.}$ (MeOH): 207 ($\varepsilon \times 10^{-4}$ 0.43), 246 (infl.) (0.35), 297 (infl.) (0.26), and 452 (0.46); ^{1}H n.m.r. (90 MHz) (CDCl$_3$), 2-H, 1.48m; 4-H 2.43m; 5-H, 2.71m; 1′-CH$_3$, 6.18; 4′-H, 3.17; Ar-H$_2$ (*ortho* to NO$_2$) 1.72d, Ar-H$_2$, 2.16d, J 9.

We thank the Imperial Group Ltd. for a scholarship (to M. J. F.), Dr. I. D. Campbell and the Oxford Enzyme Group for the 270 MHz ^{1}H n.m.r. spectra, the University of Oregon for facilities, and the University of Oxford for leave (to R. M. A.) during which this work was completed.

[8/2213 *Received*, 28*th December*, 1978]

REFERENCES

[1] A. Cahours and A. Étard, *Bull. Soc. chim. France*, 1880, **34**, 449.

[2] A. A. Morton and D. Horovitz, *J. Amer. Chem. Soc.*, 1935, **57**, 1860.

[3] S. Wawzonek and G. R. Hanson, *J. Org. Chem.*, 1966, **31**, 3580.

[4] W. Auterhoff and W. Huth, *Arch. Pharm.*, 1971, **304**, 289.

[5] N. Sinclair, D. Phil. Thesis, Oxford, 1972.

[6] S. Gronowitz, A. Hörnfeldt, B. Gostblom, and R. A. Hofmann, *Arkiv Kemi*, 1961, **18**, 133; *J. Org. Chem.*, 1961, **26**, 2615; T. J. Batterham, 'N.M.R. Spectra of Simple Heterocycles,' Wiley, New York, 1973, pp. 150—152.

[7] S. Wolfe and S. K. Hasan, *Chem. Comm.*, 1970, 833.

[8] T. Hino, T. Suzuki, S. Takeda, N. Kano, T. Ishii, A. Sasaki. and M. Nakagawa, *Chem Pharm. Bull.*, 1973, **21**, 2739.

[9] R. J. Badger, D. J. Brown, and N. J. Khromou-Borisov, *Austral. J. Chem.*, 1972, **25**, 2275.

[10] R. M. Acheson, S. J. Hodgson, and R. G. McR. Wright, *J.C.S. Perkin I*, 1976, 1911.

[11] M. Dobler and B. Duerr, personal communication.

[12] H. C. Watson, D. M. Shotton, J. M. Cox, and H. Muirhead, *Nature*, 1970, **225**, 806.

[13] A. T. North, D. C. Phillips, and F. S. Matthews, *Acta Cryst.*, 1968, **A24**, 351.

[14] A. C. Larson, *Acta Cryst.*, 1967, **23**, 664.

[15] J. R. Carruthers, CRYSTALS User Manual, Oxford University Computing Laboratory, Oxford, 1975.

[16] 'International Tables for *X*-Ray Crystallography,' vol. III, Kynoch Press, Birmingham, 1962.

[17] R. L. Frank, R. W. Holley, and D. M. Wikholm, *J. Amer. Chem. Soc.*, 1942, **64**, 2835.

[18] S. Gronowitz, A. B. Hörnfeldt, B. Gostblom, and R. A. Hoffman, *Arkiv Kemi*, 1961, **18**, 151.

---

* See Notice to Authors No. 7, in *J.C.S. Perkin II* 1979, Index issue.