THE PREPARATION OF 2-FLUORO-5-NITROBENZONITRILE AND THE PROTON MAGNETIC RESONANCE SPECTRA OF SOME COMPOUNDS CONTAINING THE *N*-(2-CYANO-4-NITROPHENYL) GROUP

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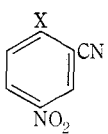
Summary

2-Fluoro-5-nitrobenzonitrile, an analogue of 1-fluoro-2,4-dinitrobenzene, in which the 2-nitro group has been replaced by a cyano group, has been prepared and made to react with several amines, amino acids, and NH-heteroaromatic compounds. The proton magnetic resonance spectra of some of the resultant *N*-(2-cyano-4-nitrophenyl) derivatives were compared with the spectra of the corresponding *N*-(2,4-dinitrophenyl) derivatives and furnish further evidence that the *ortho* nitro group of the latter derivatives is rotated out of the plane of the aromatic nucleus.

INTRODUCTION

1-Fluoro-2,4-dinitrobenzene (FDNB)† has occupied a distinguished place in protein chemistry since its use by Sanger[1] for the determination of the free amino groups of insulin and its fragments. FDNB also behaves as a reactive dye for fibrous proteins (wool is dyed bright yellow), although its use in this regard is probably limited because of its toxicity and the instability of the DNP residue to light (exemplified by the photochemical breakdown of DNP-amino acids to, *inter alia*, 2-nitroso-4-nitroaniline[2]). Since the formation of the latter product implicates the nitro group *ortho* to the amino acid residue in the photochemical breakdown, it was of interest to prepare and to study the reactions of an analogue of FDNB with the *ortho* nitro group replaced by another electron-withdrawing group and, to this end, 2-fluoro-5-nitrobenzonitrile (FNBN) (I) was prepared. Baudet[3] has studied the reaction of the corresponding chloro compound (II) with a variety of nucleophiles and, since he found that it was about one-fifth as reactive as 1-chloro-2,4-dinitrobenzene to sodium methoxide, it was expected that FNBN would have a similar order of reactivity vis-à-vis FDNB.



(I) X = F
(II) X = Cl
(III) X = NR^1R^2

The reaction of 2-fluoro-5-nitrobenzonitrile (I) with several amines, amino acids, and NH-heteroaromatic compounds was also studied. The proton magnetic

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† Abbreviations used: FDNB, 1-fluoro-2,4-dinitrobenzene; DNP, *N*-(2,4-dinitrophenyl); FNBN, 2-fluoro-5-nitrobenzonitrile; CNP, *N*-(2-cyano-4-nitrophenyl).

[1] Sanger, F., *Biochem. J.*, 1945, **39**, 507.

[2] Russell, D. W., *J. chem. Soc.*, 1963, 894.

[3] Baudet, H. P., *Recl Trav. chim. Pays-Bas Belg.*, 1924, **43**, 707.

resonance (p.m.r.) spectra of some of the resultant CNP derivatives (as in (III)) were measured and compared with the p.m.r. spectra of the corresponding DNP derivatives, as it was of interest to study the effect on the proton chemical shifts of the latter derivatives of replacing the *ortho* nitro group by the cyano group.

Results

2-Fluoro-5-nitrobenzonitrile was prepared in 73% yield by the reaction of the corresponding chloro compound (II) with anhydrous potassium fluoride in dimethyl sulphoxide. FNBN reacted readily in dimethyl sulphoxide with several secondary

Table 1

CNP derivatives of some NH-containing compounds

Compound No.	Parent Compound[a]	M.P. of CNP Derivative	Yield (%)	Solvent[b]
(1)	Dimethylamine	108–110°[c]	91	A
(2)	Pyrrolidine	135–137	98	A
(3)	Imidazole	176–178	94	B
(4)	Pyrazole	117–119	86	B
(5)	1,2,4-Triazole[d]	147–149	71	B
(6)	Benzimidazole	160–162	95	B
(7)	4,5-Diphenylimidazole	206–208	75	A
(8)	Glycine	179–181	76	A
(9)	L-Alanine	163–165	57	A
(10)	DL-Alanine	195–197	77	A

[a] The reaction of 2-fluoro-5-benzonitrile with ammonia gave 2-cyano-4-nitroaniline (m.p. 210–212°) in 86% yield (Found N, 26·1. $C_7H_5N_3O_2$ requires N, 25·8%). Baudet[3] gives m.p. 209°.

[b] Recrystallization solvent: A, aqueous ethanol; B, hexane/methylene chloride.

[c] Baudet[3] gives m.p. 110°.

[d] 1-CNP-1,2,4-triazole.

amines (excess amine as base), and some NH-heteroaromatic compounds (triethylamine as base). Reaction with amino acids was very slow in aqueous ethanol containing sodium bicarbonate but was readily accomplished in aqueous dimethyl sulphoxide containing triethylamine. All the CNP derivatives prepared in this investigation (see Tables 1 and 2) exhibited the expected infrared absorption peaks at 2210–2260 (CN), 1525–1560 (NO_2), and 1325–1340 cm^{-1} (NO_2).

CNP-L-alanine in 1% sodium bicarbonate solution was unexpectedly unstable to light. The photochemical reaction is under investigation and will be discussed elsewhere.

Proton Magnetic Resonance Spectra

In order to obtain a direct comparison with the p.m.r. spectra of the corresponding DNP derivatives,[4] the chemical shifts (at 60 Mc/s) of the CNP derivatives

[4] Wilshire, J. F. K., *Aust. J. Chem.*, 1966, **19**, 1935.

TABLE 2
ANALYTICAL DATA FOR CNP DERIVATIVES

Compound No.	Molecular Formula	Found (%)			Calc. (%)		
		C	H	N	C	H	N
(1)	$C_9H_9N_3O_2$			21·9			22·0
(2)	$C_{11}H_{11}N_3O_2$	61·0	5·1	19·2	60·8	5·1	19·4
(3)	$C_{10}H_6N_4O_2$	56·2	3·0	26·2	56·1	2·8	16·2
(4)	$C_{10}H_6N_4O_2$	56·3	2·8	26·1	56·1	2·8	26·2
(5)	$C_9H_5N_5O_2$	50·2	2·3	32·6	50·2	2·3	32·6
(6)	$C_{14}H_8N_4O_2$	63·5	3·2	20·9	63·6	3·1	21·2
(7)	$C_{22}H_{14}N_4O_2$	72·2	4·0	15·2	72·1	3·9	15·3
(8)	$C_9H_7N_3O_4$	48·9	3·2	18·9	48·9	3·2	19·0
(9)	$C_{10}H_9N_3O_4$	51·3	4·0	17·7	51·1	3·9	17·9
(10)	$C_{10}H_9N_3O_4$	51·0	3·8	18·0	61·1	3·9	17·9

TABLE 3
CHEMICAL SHIFTS (60 Mc/s) OF RING PROTONS OF THE 2-CYANO-4-NITROPHENYL RESIDUES OF SOME CNP DERIVATIVES

Chemical shifts in c/s ex tetramethylsilane for 0·4M solutions (dimethyl sulphoxide unless otherwise stated). Some DNP derivatives are included for comparison

Compound	H 3′[a]		$\Delta\nu$[b]	H 5′[a]		$\Delta\nu$[b]	H 6′[a]		$\Delta\nu$[b]
2-Cyano-4-nitroaniline[c]		499	−26		485	−2		411	−13
CNP-Imidazole	(36)[d]	535	− 2	(32)[d]	517	−3	(67)[d]	478	− 1
CNP-Pyrazole	(30)	529	2	(31)	516	2	(76)	487	2
1-CNP-1,2,4-Triazole	(37)	536	2	(37)	522	0	(81)	492	− 1
CNP-Benzimidazole	(43)	542	1	(38)	523	−1	(76)	487	− 2
CNP-4,5-Diphenylimidazole	(24)	523	− 2	(28)	513	−2	(59)	470	− 9
CNP-Dimethylamine	(2)	501	−11	(3)	488	−2	(10)	421	−13
CNP-Pyrrolidine	(−2)	497	−13	(−1)	484	−4	(−2)	409	−17
DNP-Dimethylamine	(−13)[e]	512	—	(3)[e]	490	—	(10)[e]	434	—
DNP-Pyrrolidine	(−15)[e]	510	—	(1)[e]	488	—	(2)[e]	426	—
CNP-Pyrazole[f]		520	0		513	2		488	17
DNP-Pyrazole[f]		520			511			471	
CNP-Dimethylamine[f]		503	−17		490	−1		409	−12
DNP-Dimethylamine[f]		520[g]	—		491[g]	—		421[g]	—
CNP-Pyrrolidine[f]		502	−15		487	−3		399	−15
DNP-Pyrrolidine[f]		517	—		490	—		414	—

[a] Only the positions of the centres of the multiplets are quoted. The CNP-ring protons exhibit the same pattern as described in the DNP series, namely, H 3′ (doublet), H 5′ (quartet), and H 6′ (doublet) (J_o 8·8–9·6; J_m 2·4–2·8 c/s) with occasional *para*-coupling ($J_{3,6}$ 0·8 c/s).

[b] $\Delta\nu$(CN–NO_2) (in c/s), see footnote to text.

[c] NH_2 signal occurs at 442 c/s (removed by the addition of D_2O).

[d] Figures in brackets are chemical shifts (in c/s) downfield with respect to the corresponding proton of 2-cyano-4-nitroaniline.

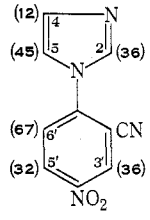
[e] Chemical shift downfield with respect to the corresponding proton of 2,4-dinitroaniline.

[f] 0·4M solutions in $CDCl_3$.

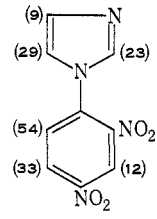
[g] The corresponding values (for 5% solution) given by Rae[6] are: 518 (H 3′); 490 (H 5′); 424 (H 6′).

(see Table 3) were recorded for 0·4M solutions in dimethyl sulphoxide. Several comparisons were also made for 0·4M solutions in deuterochloroform.

As expected, the various heteroaromatic substituents of the CNP-heteroaromatic derivatives exert a marked deshielding* effect on the CNP-ring protons, but the extent ($6'>5'\simeq3'$) to which these protons are deshielded differs from that ($6'>5'>3'$) found for the DNP-heteroaromatic derivatives[4] [for comparison, the deshielding values* (figures in brackets are c/s) for these and the remaining protons are shown schematically for CNP-imidazole (IV) and DNP-imidazole (V)].



(IV)



(V)

The fact that the 3′- and 5′- protons of the CNP derivatives are deshielded to practically the same extent indicates that the cyano group lies in the plane of the CNP ring (assuming of course that the cyano group of 2-cyano-4-nitroaniline (in dimethyl sulphoxide solution) is coplanar†). If however the deshielding in the CNP series (Table 3) is compared with the deshielding in the DNP series (ref.[4], Table 3), it will be seen that the 5′-proton is deshielded to the same extent in both series, but that the 3′-proton in the DNP series is deshielded to a lesser extent (by 24–28 c/s)‡ than the 3′-proton in the CNP series. The decreased deshielding of the 3′-proton in the DNP series can be attributed to the rotation of the 2′-nitro group out of the plane of the DNP-ring§ (such rotation lowers both the anisotropic and electronic effects of the nitro group on the adjacent 3′-proton).

* In the discussion which follows, deshielding (or shielding) refers to deshielding (or shielding) *relative* to the corresponding proton of 2-cyano-4-nitroaniline (CNP series), of 2,4-dinitroaniline (DNP series) (primed numerals are used to identify the protons of the CNP and DNP rings), or of the parent NH-heteroaromatic compound.

† A search of the literature revealed no aromatic nitriles in which the cyano group has been shown to be non-coplanar with the nucleus. If the cyano group of 2-cyano-4-nitroaniline were forced out of plane by the amino group, it would be expected that it would be forced even further out of plane by the bulky substituent(s) on the nitrogen atom. No such increased rotation (revealed by decreased deshielding of the 3′-proton) was observed for the CNP derivatives.

‡ Since it has been suggested[5] that the 2-nitro group of 2,4-dinitroaniline (in dimethyl sulphoxide solution but not in deuterochloroform) is already rotated out of the plane of the aromatic ring, shielding or decreased deshielding in the DNP series may be a measure of *additional* out-of-plane rotation caused by the bulky substituent(s) on the nitrogen atom.

§ Decreased deshielding (or shielding) of protons *ortho* to or in the neighbourhood of rotated nitro groups have been reported by several groups of workers[6–8] including ourselves.[4]

[5] Rae, I. D., *Chem. Commun.*, 1966, 519.
[6] Rae, I. D., *Aust. J. Chem.*, 1965, **18**, 1807.
[7] Wells, P. R., *Aust. J. Chem.*, 1964, **17**, 967.
[8] Heidberg, J., Weil, J. A., Janusonis, G. A., and Anderson, J. K., *J. chem. Phys.*, 1964, **41**, 1033.

Table 3 also reveals that, as in the DNP series, the deshielding of the 6′-proton of the CNP-heteroaromatic derivatives increases along the series imidazole<pyrazole <1,2,4-triazole, although a comparison between the two series shows that such deshielding is significantly smaller (by 12–16 c/s) in the DNP series. The smaller deshielding in the DNP series is presumably a further consequence of the rotation of the 2′-nitro group out of the plane of the DNP ring. The deshielding of the 6′-proton was discussed previously in terms of (1) the anisotropy of the adjacent nitrogen present, for example, in pyrazole and in 1,2,4-triazole, and (2) the ring current of the adjacent heterocyclic ring.[4] In addition to these two factors, Murrell *et al.*[9] in their p.m.r. studies of azabiphenyls have discussed two others, namely (3) changes in π-electron density and (4) the possibility that a CH . . . N interaction is less repulsive than the corresponding CH . . . CH interaction. The latter possibility, if applied to our results for the CNP (or DNP)-heteroaromatic derivatives, would suggest the following series of preferred conformations with planarities increasing in the order CNP (or DNP)-imidazole < CNP (or DNP)-pyrazole < 1-CNP (or DNP)-1,2,4-triazole. However, the differences in the chemical shifts of the 6′-protons, although significant, are small and do not necessarily reflect only differences in the dihedral angle between the two rings.

A comparison of the chemical shifts of 2-cyano-4-nitroaniline and 2,4-dinitroaniline in dimethyl sulphoxide shows that the 3′-proton ($\Delta\nu$(CN–NO_2)* −26 c/s) and 6′-proton ($\Delta\nu$(CN–NO_2) −13 c/s) of the former compound occur at a higher field and indicates (as expected[10]) that the aromatic cyano group has a smaller deshielding effect than the aromatic nitro group. Negative values for $\Delta\nu$(CN–NO_2) (somewhat less negative in the case of the 3′-proton because of the out-of-plane rotation of the 2′-nitro group of the DNP derivatives) were also found for the derivatives of pyrrolidine and dimethylamine in dimethyl sulphoxide and in deuterochloroform (the $\Delta\nu$(CN–NO_2) values were almost independent of the nature of the solvent). Except for the 6′-proton of CNP-4,5-diphenylimidazole where the effect of the neighbouring 5-phenyl group is presumably important, the values of $\Delta\nu$(CN–NO_2) for the heteroaromatic derivatives, which are even smaller ($\pm$3 c/s), are a further indication that the 2′-nitro group of the DNP-heteroaromatic compounds is rotated out of plane.

The coplanarity of the cyano group of CNP-pyrrolidine and CNP-dimethylamine is shown by the fact that practically no shielding of the 3′-protons was observed. On the other hand, the 3′-proton of the corresponding DNP-derivatives is shielded (by 13–15 c/s†) because the 2′-nitro group is rotated out of the plane of the DNP

* The term $\Delta\nu$(CN–NO_2) is used to denote the difference (in c/s) between the chemical shifts of a given proton of a CNP derivative and the same proton of the corresponding DNP derivative. A negative sign for $\Delta\nu$(CN–NO_2) indicates that the former proton occurs at a higher field.

† The value of this shielding (13 c/s) for DNP-dimethylamine (*N*,*N*-dimethyl-2,4-dinitroaniline) is less than that found in methylene chloride (0·2M solution)[8] and deuterochloroform (5% solution)[6] (25 and 33 c/s respectively), and therefore appears to be solvent-dependent. However, since 2,4-dinitroaniline is very sparingly soluble in the last two solvents, measurements could not be made at the same solute concentration (0·4M) and therefore accurate comparison is not possible.

[9] Murrell, J. N., Gil, V. M. S., and van Dingneveldt, F. B., *Recl Trav. chim. Pays-Bas Belg.*, 1965, **84**, 1399.

[10] Martin, J. S., and Dailey, P. S., *J. chem. Phys.*, 1963, **39**, 1722.

ring. This shielding is significantly less than the decreased deshielding (24–28 c/s) found for the corresponding DNP-heteroaromatic derivatives (see above), and suggests that the 2′-nitro group is rotated further out of the plane of the DNP ring in the latter derivatives. Such a molecular picture is not inappropriate since the rigid heteroaromatic substituents would be expected to force the 2′-nitro group further out of the plane of the DNP ring than would similarly located but less rigid methyl or methylene groups. In this connection, the *deshielding* of the 6′-proton both of the DNP- and of CNP-dimethylamine (but not of the corresponding pyrrolidine derivatives) is of interest and probably arises from a reduction in mesomeric donation by the bulky methyl groups as they are forced from the plane of the aromatic ring.

TABLE 4

CHEMICAL SHIFTS (60 Mc/s) OF METHYL, METHYLENE, AND HETEROCYCLIC RING PROTONS OF SOME CNP DERIVATIVES

Chemical shifts in c/s ex tetramethylsilane for 0·4M solutions (dimethyl sulphoxide unless otherwise stated). Some DNP derivatives are included for comparison. s, Singlet; d, doublet; dq, doublet partly resolved into quartet; pd, pair of doublets; m, multiplet. Coupling constants as for DNP series

Compound	H 2	$\Delta\nu$[a]	H 3	$\Delta\nu$[a]	H 4	$\Delta\nu$[a]	H 5	$\Delta\nu$[a]	Others	$\Delta\nu$[a]
CNP-Imidazole	bs 494	13			bs 433	3	bs 466	16		
CNP-Pyrazole			dq 479	9	q 404	6	pd 517	9		
1-CNP-1,2,4-Triazole			s 506	5			s 561	2		
CNP-Benzimidazole	s 521	11								
CNP-Pyrrolidine[b]									*N*-CH_2, m 226	25
									CH_2, m 126	2
DNP-Pyrrolidine[b]									*N*-CH_2, m 201	—
									CH_2, m 124	—
CNP-Dimethylamine[b]									CH_3, s 200	16
DNP-Dimethylamine[b]									CH_3, s 184[c]	—
CNP-Pyrazole[b]			dq 474	7	q 399	4	dq 505	36		
DNP-Pyrazole[b]			dq 467[d,e]	—	q 395[d]	—	dq 469[d,e]	—		
CNP-4,5-Diphenylimidazole	s 496	8								

[a] $\Delta\nu$(CN–NO_2) (in c/s), see footnote to text.

[b] 0·4M solutions in $CDCl_3$.

[c] Heidberg *et al.*[8] report this signal at 182 c/s (for a 0·2M solution).

[d] Elguero, J., Imbach, J.-L., and Jacquier, R. (*J. Chim. phys.*, 1965, **62**, 643) give the following values (expressed here in c/s) for $CDCl_3$ solution (concentration unspecified): DNP-pyrazole: 467 (H 3); 396 (H 4); 473 (H 5).

[e] These values are arbitrarily assigned to H 3 and H 5 but the assignments could be reversed.

The chemical shifts of the heterocyclic ring, and methyl and methylene protons of a number of CNP derivatives are collected in Table 4. For all compounds studied, $\Delta\nu$(CN–NO_2) is positive and therefore replacement of an *ortho* nitro group by a cyano group is accompanied by increased deshielding. The result, which is the reverse of what might have been expected,* can be readily understood if a *rotated ortho* nitro

* For example, in the pyrene series, the 1-nitro group deshields the adjacent H 2 (*ortho*) and H 10 (*peri*) protons much more than does the 1-cyano group.[11] In some cases, however, the deshielding effect of the aromatic cyano group on the adjacent *ortho* protons is anomalous.[10,12]

[11] Martin, R. H., Flammang, R., and Arbaoui, M., *Bull. Soc. chim. Belg.*, 1965, **74**, 418.

[12] Jackman, L. M., "Applications of Nuclear Magnetic Resonance Spectroscopy in Organic Chemistry." p. 63. (Pergamon Press: Oxford 1959.)

group has been replaced by a *coplanar* cyano group. Whether increased deshielding would result would depend on at least three interdependent factors: (1) the resultant CNP group is a stronger electron-withdrawing group than the original DNP group, (2) the coplanar cyano group exerts a greater anisotropic deshielding effect than the rotated nitro group on the adjacent methyl, methylene, or heteroaromatic ring protons, and (3) the dihedral angle between the two rings is less for the CNP-heteroaromatic derivatives. The values of $\Delta\nu(CN-NO_2)$ for the 5- and 6′-protons of CNP-pyrazole were also positive in deuterochloroform but were much larger than in dimethyl sulphoxide. The reason for the different solvent–solute interactions at these protons is not clear and, until measurements in other solvents have been made, further discussion is not warranted at the present time.

Experimental

Reagent grade potassium fluoride was heated in an oven to 120°, powdered, and kept at 120° for at least 24 hr before use. All melting points are uncorrected. The elementary analyses were carried out by the Australian Microanalytical Service, Melbourne. All analytical samples were dried under vacuum over P_2O_5 at 60° for 4 hr. Infrared spectra were measured on a Perkin–Elmer 137 instrument. Proton magnetic resonance spectra were obtained on a Varian A60 spectrometer operating at 60 Mc/s (tetramethylsilane as internal standard). With dimethyl sulphoxide as solvent, the ^{13}C–H satellite signal at 221 c/s (low field) was utilized as a secondary internal standard.

(*a*) *Preparation of 2-Fluoro-5-nitrobenzonitrile*

(i) *Preparation of 2-Chloro-5-nitrobenzonitrile*

The following procedure gave this compound in reproducibly high yield. Fuming nitric acid (*d* 1·5; 100 ml) was cooled to −20° in a dry ice/brine bath and *ortho*-chlorobenzonitrile (29 g) was added portionwise so that the temperature did not rise above −15°. The cooling bath was removed and the pale yellow solution allowed to stand at room temperature for 2 hr before being poured onto ice. The solid product was filtered, washed throughly with water, dried, and distilled under vacuum. The major fraction, (33·6 g; 87% yield), had b.p. 119–122°/0·6 mm and m.p. 105–107°. A portion recrystallized from hexane/methylene chloride had m.p. 107–109° (lit.[8] m.p. 108–109°). The distillation residue (0·6 g) had m.p. 103–105° and was identical (mixed m.p.) with the major product.

(ii) *Preparation of 2-Fluoro-5-nitrobenzonitrile*

2-Chloro-5-nitrobenzonitrile (33·6 g) was stirred in dimethyl sulphoxide (44 ml) with powdered anhydrous potassium fluoride (22 g) for 27 hr on the steam-bath. The reaction mixture was poured onto ice and the solid product filtered, washed thoroughly with water, dried in air, and taken up in benzene/ether (1 : 1; 200 ml). The organic extract was washed successively with water, with 1M sodium bicarbonate (3 × 100 ml), and finally with water (3 × 100 ml) before being dried over anhydrous sodium sulphate. Removal of the solvent left a solid which was fractionally distilled under vacuum. The major fraction, *2-fluoro-5-nitrobenzonitrile* (22·4 g; 73% yield), had b.p. 94°/0·5 mm and m.p. 73–75°. The analytical sample (from hexane/methylene chloride) had m.p. 74–75° (Found: C, 50·7; H, 1·9; N, 16·8. $C_7H_3FN_2O_2$ requires C, 50·6; H, 1·8; N, 16·9%).

The distillation residue was extracted with boiling chloroform to give a solid (0·5 g; m.p. 226–270°) which was not investigated further.

(*b*) *Reactions of 2-Fluoro-5-nitrobenzonitrile*

(i) *With Amines*

The reactions of concentrated ammonia (to give 2-cyano-4-nitroaniline), pyrrolidine, and dimethylamine (33% solution in ethanol) with 2-fluoro-5-nitrobenzonitrile (4 mmole) were carried

out at room temperature in dimethyl sulphoxide (15 ml) with the amine in excess (16 mmole). After 1 hr, water was added and the solid product filtered, washed, and dried.

(ii) *With NH-Heteroaromatic Compounds*

As in (i) except that the reaction was carried out on the steam-bath for 4 hr and with triethylamine (1·5 × calculated quantity) as base.

(iii) *With* L-*Alanine*

L-Alanine (356 mg; 4 mmole), 2-fluoro-5-nitrobenzonitrile (664 mg; 4 mmole), and triethylamine (1·12 ml; 8 mmole) were dissolved in a mixture of dimethyl sulphoxide (15 ml) and water (10 ml), and the solution stirred (magnetically) at room temperature for 2 hr. Water (25 ml) was added and the yellow solution was extracted with ether (2 × 25 ml). The alkaline layer was acidified cautiously with 1N hydrochloric acid to give N-(*2-cyano-4-nitrophenyl*)-L-*alanine* (533 mg; 57% yield), m.p. 159–162°. The analytical sample (pale yellow plates from aqueous ethanol) had m.p. 163–165°.

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