

*Acta Cryst.* (1974). B30, 2921**Isonicotinic Acid Hydrazide – a Reinvestigation**

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**Abstract.**  $C_6H_7N_3O$ , orthorhombic,  $P2_12_12_1$ ,  $a=14.915$  (15),  $b=11.400$  (10),  $c=3.835$  (5) Å,  $D_m=1.417$  (7),  $D_c=1.395$  g cm<sup>-3</sup> and  $Z=4$ . The structure was refined by the least-squares method to an  $R$  of 0.072 for 699 observed reflexions. The angle between the mean planes of the pyridine ring and the acid hydrazide moiety is 18.1°. The molecules are held together in the crystal by a network of N–H...N hydrogen bonds.

**Introduction.** Isonicotinic acid hydrazide (INH) is the most widely used antitubercular drug. Its crystal structure has been solved by Jensen (1954) with projection data. The present study was undertaken to obtain more accurate dimensions, especially those involving hydrogen atoms, of this important drug molecule.

The unit-cell dimensions and the space group of the crystal were determined from oscillation and Weissenberg photographs and the density was measured by flotation in a mixture of benzene and carbon tetrachloride. The X-ray data were recorded on equi-inclination Weissenberg photographs corresponding to reciprocal levels  $hkl$ ,  $l=0$  through 3, with Cu  $K\alpha$  radiation from a nearly cylindrical specimen grown along the  $c$  axis. The intensities were estimated visually. Out of the total number of 916 independent reflexions in the copper sphere, 831 were recorded of which 699 were in the measurable range. The data were corrected for Lorentz-polarization effects, but not for absorption ( $\mu_r=0.25$ ). Data from each level were put on absolute scale by Wilson's procedure.

The structure was redetermined by the non-centrosymmetric symbolic addition procedure followed by tangent formula refinement of the phase angles. The atomic parameters were refined, first isotropically and then anisotropically, by a block-diagonal S.F.L.S.

program originally written for the IBM 1130 computer by R. Shiono and modified by B. Swaminatha Reddy for the IBM 360/44 system. Anisotropic thermal parameters were of the form  $\exp[-(b_{11}h^2 + b_{22}k^2 + b_{33}l^2 + 2b_{12}hk + 2b_{23}kl + 2b_{13}hl)]$ . The positional parameters, obtained from a difference Fourier synthesis, and the isotropic temperature factors of the hydrogen atoms were also refined in the final least-squares cycles. The form factors of the non-hydrogen atoms and that of hydrogen were taken from Cromer & Waber (1965) and Stewart, Davidson & Simpson (1965) respectively. The final positional and thermal parameters of the non-hydrogen atoms and hydrogen atoms are given in Tables 1 and 2 respectively.\*

Table 2. *Final positional coordinates ( $\times 10^3$ ) and isotropic temperature factors for hydrogen atoms*

The estimated standard deviations are given in parentheses.

	$x$	$y$	$z$	$B$
H(2)	563 (3)	-38 (4)	-36 (16)	3 (1)
H(3)	702 (3)	36 (4)	245 (15)	3 (1)
H(5)	586 (3)	368 (5)	237 (18)	5 (1)
H(6)	452 (3)	280 (4)	-55 (18)	4 (1)
H(9)	723 (2)	423 (3)	262 (13)	2 (1)
H(101)	886 (4)	430 (5)	340 (21)	6 (2)
H(102)	848 (4)	388 (6)	703 (20)	8 (2)

**Discussion.** The bond lengths and angles are given in Fig. 1. They differ significantly from those obtained earlier by Jensen (1954), the maximum differences in

\* A list of structure factors has been deposited with the British Library Lending Division as Supplementary Publication No. SUP 30651 (5 pp.). Copies may be obtained through The Executive Secretary, International Union of Crystallography, 13 White Friars, Chester CH1 1NZ, England, or from the authors on request.

Table 1. *Final positional coordinates and anisotropic thermal parameters (all  $\times 10^4$ ) of the non-hydrogen atoms*

The standard deviations are given in parentheses.

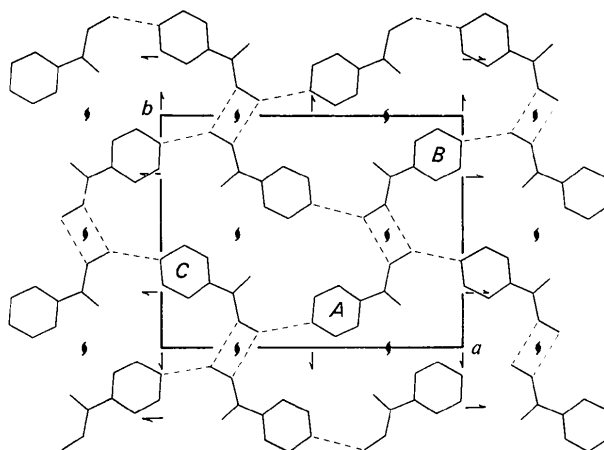
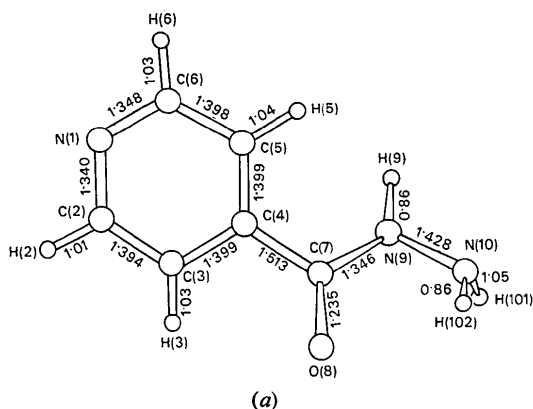
	$x$	$y$	$z$	$b_{11}$	$b_{22}$	$b_{33}$	$b_{12}$	$b_{13}$	$b_{23}$
N(1)	4985 (2)	1137 (3)	-460 (10)	32 (1)	78 (3)	369 (29)	-14 (1)	-4 (6)	-20 (8)
C(2)	5705 (3)	475 (4)	234 (13)	33 (2)	64 (3)	372 (34)	-11 (2)	-9 (7)	-30 (9)
C(3)	6509 (3)	902 (3)	1589 (14)	30 (2)	44 (2)	418 (35)	-4 (2)	0 (6)	-25 (8)
C(4)	6583 (2)	2105 (3)	2250 (10)	22 (1)	45 (2)	131 (29)	-3 (2)	-6 (4)	3 (6)
C(5)	5840 (2)	2814 (3)	1525 (14)	25 (1)	51 (2)	497 (35)	-1 (2)	-20 (6)	9 (9)
C(6)	5066 (2)	2296 (4)	161 (14)	25 (1)	69 (3)	571 (37)	-2 (2)	-29 (8)	31 (10)
C(7)	7455 (2)	2555 (3)	3756 (10)	22 (1)	39 (2)	260 (32)	3 (1)	-7 (5)	14 (7)
O(8)	8000 (2)	1897 (2)	5191 (10)	34 (1)	43 (2)	740 (30)	6 (1)	-53 (6)	26 (7)
N(9)	7587 (2)	3721 (2)	3538 (10)	21 (1)	36 (2)	405 (27)	2 (1)	-29 (5)	12 (6)
N(10)	8336 (2)	4266 (3)	5203 (10)	24 (1)	46 (2)	330 (30)	-2 (1)	-4 (5)	35 (7)

Table 3. *Hydrogen-bond parameters*

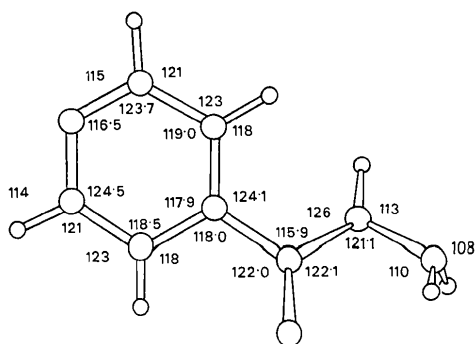
N(9)A...N(10)B	2.967 (4) Å	N(10)B...N(9)A—H(9)A	12 (3)°
N(10)C...N(1)A	3.094 (5)	N(1)A...N(10)C—H(10)C	12 (4)

(A)  $x, y, z$ ; (B)  $\frac{1}{2} - x + 1, -y + 1, \frac{1}{2} + z - 1$ ; (C)  $\frac{1}{2} + x - 1, \frac{1}{2} - y, -z$ .

bond lengths and angles involving non-hydrogen atoms being 0.028 Å and 1.4° respectively. Much larger differences are observed in those values involving hydrogen atoms, the positions of which were not refined in Jensen's analysis. The dimensions of the pyridine ring are comparable to those obtained in similar compounds. The C(4)–C(7) bond, which connects the six-membered ring and the acid hydrazide group, and the N(9)–N(10) bond have lengths corresponding to the appropriate single bonds. The C(7)–N(9) and C(7)–O(8) bonds, however, have partial double-bond character (Curl, 1959; Donohue, Lavine & Rollett, 1956; Marsh, Bierstedt & Eichhorn, 1962). Their lengths indicate that the acid hydrazide group can be considered as a resonance hybrid of a neutral form

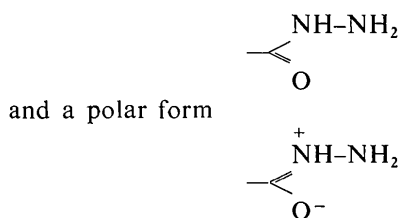
Fig. 2. Crystal structure viewed along the  $c$  axis.

(a)



(b)

Fig. 1. (a) Bond lengths (Å), (b) bond angles (°) in the molecule. (Angle H(101)–N(10)–H(102) = 112.) Mean standard deviations for the bond lengths are: (C–C) = 0.006, (C–N) = 0.005, (C–O) = 0.004, (N–N) = 0.005, (C–H) = 0.05, (N–H) = 0.08 Å. The e.s.d.'s of bond angles involving non-hydrogen atoms vary between 0.2 and 0.4°, whereas the mean e.s.d.'s of C–C–H (or N–C–H or N–N–H) and H–N–H are 2.5° and 4° respectively.



and a polar form

with the former making a larger contribution. The non-hydrogen atoms in the acid hydrazide group lie in a plane which makes an angle of 18.1° with that of the pyridine ring. An examination of non-bonded interatomic distances indicates that the mutual orientation of the two groups is determined essentially by steric considerations.

The arrangement of molecules in the crystal is shown in Fig. 2. The crystal structure is stabilized by a network of N–H...N hydrogen bonds, the parameters of which are given in Table 3.

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