

# The Crystal and Molecular Structure of Sulfapyridine

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(Received 17 September 1979)

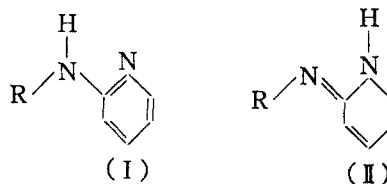
**Abstract** □ The crystal structure of sulfapyridine,  $C_{11}H_{11}N_3O_2S$ , has been determined by X-ray diffraction method. The compound crystallizes in the monoclinic space group  $C2/c$  with  $a=12.80(4)$ ,  $b=11.72(4)$ ,  $c=15.36(5)\text{\AA}$ ,  $\beta=94(3)^\circ$  and  $Z=8$ . A total of 1133 observed reflections were collected by the Weissenberg method with  $CuK\alpha$  radiation. Structure was solved by the heavy atom method and refined by isotropic block-diagonal least-squares method to the R value of 0.14.

The nitrogen in the pyridine ring of sulfapyridine is associated with an extra-annular hydrogen. The C (benzene ring)-S-N-C(pyridine ring) group adopts the gauche form with a conformational angle of  $71^\circ$ . The benzene ring are inclined at angle of  $84^\circ$  to the pyridine ring plane. Sulfapyridine shows three different hydrogen bonding in the crystal. They are two N-H...O hydrogen bonds with the distance of 2.90 and 2.98 Å respectively, and one N-H...N with the distance of 3.06 Å.

**Keywords** □ Sulfamines—Sulfapyridine—Crystal structure—X-ray diffraction method—Weissenberg method—heavy atom method—isotropic block-diagonal least-square method—Three hydrogen bonds in the crystal.

There has been some interest in our laboratories on the structure of sulphur-containing compounds which have biological activities. A systematic investigation of the conformation, hydrogen-bonding scheme and chemical bonding of sulfanilamide derivatives<sup>1-5</sup>) has been undertaken. The structure deter-

mination of sulfapyridine has been attempted to compare its structure with those of other sulfanilamide derivatives. It is also of interest to study the electronic structure of pyridine ring since it is expected that the pyridine ring in sulfapyridine may be able to exist in forms (I) and (II).



## EXPERIMENTAL

Transparent prismatic crystal of sulfapyridine were obtained by slow evaporation of a methanol solution of sulfapyridine sodium monohydrate which absorbs  $CO_2$  with the liberation of sulfapyridine and becomes incompletely soluble in water<sup>6</sup>).

Oscillation and Weissenberg photographs indicated the monoclinic space group  $C2/c$ . Unit cell parameters were measured from  $h0l$  and  $hk0$  Weissenberg photographs calibrated with superimposed NaCl powder as standard using  $CuK\alpha$  radiation. The density of single crystals was measured by the floatation method in a mixture of benzene and

Table I: The crystal data of sulfapyridine

Sulfapyridine (4-Amino-N-2-pyridinylbenzenesulfonamide), $C_{11}H_{11}N_3O_2S$ M.W.: 249.29 M.P.: 192°C
Unit cell parameters: $a=12.80(3)$ Å $b=11.72(3)$ $c=15.36(4)$ $\beta=94.0(3)$ $z=8$
Space group: $C2/c$ , from systematic absences $h00$ for $h=2n+1$ $0k0$ for $k=2n+1$ $hk0$ for $h+k=2n+1$
Density: calculated value $1.44g.cm^{-3}$ measured value $1.43g.cm^{-3}$

carbon tetrachloride.

Intensity data were collected from equi-inclination Weissenberg photographs taken with  $CuK\alpha$  radiation by use of the multiple-film method. The approximate sizes of the crystals used for the data collection for the  $a$ ,  $b$  and  $c$  axes were  $0.2 \times 0.3 \times 0.5$ ,  $0.3 \times 0.3 \times 0.5$  and  $0.2 \times 0.2 \times 0.3$  mm respectively.

The relative intensities were visually estimated by comparison with a calibrated film strip. The intensities were corrected for spot-shape, Lorentz and polarization effects, and reduced to structure factors. No absorption correction was made. The structure factors for various layers were placed on a common scale by interlayer scaling constants calculated from common equivalent reflections and put on an absolute scale by Wilson's method<sup>7</sup>. A total of 1133 observed independent structure factors were thus prepared for use in the structure analysis.

## STRUCTURE DETERMINATION AND REFINEMENT

After the structure factors were converted into the normalized structure factors, a three-dimensional sharpened Patterson synthesis was computed using all the observed reflections. A Patterson synthesis showed the

Table II: Fractional atomic coordinates and isotropic thermal parameters for sulfapyridine.

Atom	x	y	z	B
S	0.2036(5)	0.0434(6)	0.0622(5)	2.02(9)
O(1)	0.202(2)	0.132(2)	-0.003(1)	2.7(4)
O(2)	0.135(2)	-0.050(2)	0.043(1)	2.9(4)
N(1)	0.320(2)	-0.012(2)	0.082(1)	3.1(3)
N(2)	0.127(2)	0.234(2)	0.408(2)	3.3(5)
N(3)	0.407(2)	0.169(2)	0.075(1)	2.7(4)
C(1)	0.171(2)	0.103(2)	0.158(2)	2.4(5)
C(2)	0.145(2)	0.031(2)	0.228(2)	3.2(4)
C(3)	0.130(2)	0.073(2)	0.309(2)	2.6(5)
C(4)	0.136(2)	0.192(3)	0.325(2)	2.8(5)
C(5)	0.161(2)	0.263(3)	0.255(2)	2.8(5)
C(6)	0.177(2)	0.219(2)	0.173(2)	2.8(4)
C(7)	0.403(2)	0.056(2)	0.094(2)	2.6(4)
C(8)	0.500(3)	0.002(3)	0.122(2)	3.7(6)
C(9)	0.590(3)	0.070(4)	0.136(3)	5.0(8)
C(10)	0.587(3)	0.191(4)	0.123(3)	3.7(8)
C(11)	0.493(2)	0.238(3)	0.089(2)	3.3(6)
H(N2)	0.12	0.31	0.42	
H'(N2)	0.13	0.18	0.44	
H(N3)	0.36	0.19	0.05	
H(C2)	0.12	-0.07	0.21	
H(C3)	0.10	0.02	0.35	
H(C5)	0.17	0.34	0.26	
H(C6)	0.19	0.28	0.14	
H(C9)	0.65	0.01	0.16	
H(C10)	0.65	0.23	0.13	
H(C11)	0.48	0.32	0.07	

Key to atomic numbering is given in Fig. 1. The estimated standard deviations given in parentheses refer to the last decimal positions.

Table III: Observed and Calculated Structure Factor. Columns are: Index,  $|F_{obs}|$ ,  $|F_{cal}|$ .

0 0 2	61.24	69.42	1 3 2	43.98	39.63	-1 5 8	22.16	19.21	2 10 1	8.60	12.63
0 0 4	65.80	57.75	1 3 3	10.81	5.44	-1 5 9	17.20	14.68	2 10 2	15.59	14.70
0 0 6	59.08	55.79	1 3 4	31.55	26.52	-1 5 10	13.04	11.66	2 10 4	20.39	16.13
0 0 8	37.16	36.42	1 3 5	26.62	20.61	-1 5 12	5.51	6.99	2 10 6	9.89	11.06
0 0 12	25.75	33.99	1 3 6	59.85	53.54	-1 7 1	22.41	22.31	2 10 7	15.96	19.94
0 0 16	12.36	15.32	1 3 7	8.83	9.74	-1 7 3	30.25	27.31	2 10 10	14.75	11.95
0 2 0	50.02	6.93	1 3 9	9.73	7.94	-1 7 5	34.03	26.45	2 10 11	11.44	11.06
0 2 2	92.12	103.68	1 3 10	5.24	2.74	-1 7 6	12.49	12.18	2 10 12	16.05	15.40
0 2 2	54.14	51.71	1 3 12	5.48	9.11	-1 7 7	52.35	44.10	2 12 0	24.27	19.54
0 2 3	62.92	59.30	1 5 0	24.95	28.63	-1 7 12	7.46	5.99	2 12 2	29.63	25.52
0 2 5	33.55	23.29	1 5 2	18.24	20.62	-1 9 1	15.77	18.77	2 12 4	12.55	11.94
0 2 6	19.32	23.41	1 5 3	23.36	24.76	-1 9 2	11.85	7.46	2 12 5	7.37	9.23
0 2 8	25.73	29.24	1 5 6	9.98	9.12	-1 9 4	58.58	42.40	2 12 6	7.96	8.14
0 2 9	20.08	26.71	1 5 7	35.67	29.00	-1 9 6	8.35	8.41	2 12 8	14.78	11.29
0 2 10	18.07	26.13	1 5 8	4.96	6.56	-1 9 9	9.92	9.22	2 12 10	14.81	14.24
0 2 11	15.03	21.76	1 5 9	40.63	31.13	-1 9 10	10.94	6.83	2 14 0	6.97	6.32
0 2 12	16.67	21.85	1 5 11	25.23	20.68	-1 9 12	23.21	15.84	2 14 2	7.69	8.65
0 4 0	88.33	78.93	1 5 12	7.13	7.89	-1 11 2	25.23	24.32	2 14 5	13.23	10.22
0 4 1	19.62	13.41	1 7 0	12.95	13.63	-1 11 3	11.60	10.43	2 14 7	25.04	26.64
0 4 3	16.14	15.49	1 7 4	5.20	9.73	-1 11 4	8.04	5.81	2 14 8	10.27	60.44
0 4 4	42.36	27.42	1 7 5	21.20	16.57	-1 11 6	14.97	10.36	2 14 8	83.65	85.21
0 4 5	14.16	15.57	1 7 6	8.61	6.47	-1 11 10	16.88	9.46	2 14 10	45.90	50.94
0 4 6	78.04	70.93	1 7 7	32.88	32.14	-1 11 12	17.61	12.37	2 14 12	43.05	48.04
0 4 7	5.98	6.31	1 7 8	33.16	28.50	-1 13 1	8.58	8.64	2 14 14	27.89	30.26
0 4 8	17.48	17.34	1 7 9	11.91	7.47	-1 13 2	11.40	9.32	2 14 16	21.79	30.45
0 4 10	9.42	8.83	1 7 11	16.35	13.62	-1 13 4	15.50	11.60	2 14 19	8.09	11.11
0 4 11	16.18	14.35	1 9 1	23.06	24.99	2 0 0	59.66	52.31	2 2 2	5.54	1.53
0 6 0	14.69	10.58	1 9 3	9.51	8.46	2 0 2	22.31	21.05	2 2 2	10.83	21.16
0 6 1	24.30	44.21	1 9 4	27.34	23.11	2 0 4	93.82	51.40	2 2 3	9.51	9.79
0 6 2	23.17	19.09	1 9 5	25.60	20.38	2 0 6	20.74	25.66	2 2 4	47.11	34.56
0 6 3	45.99	41.35	1 9 6	18.22	16.44	2 0 8	17.95	16.59	2 2 5	11.74	14.15
0 6 5	12.98	10.73	1 9 7	19.63	15.13	2 0 10	5.21	6.42	2 2 6	95.58	74.08
0 6 6	6.91	6.86	1 11 0	13.75	11.70	2 0 12	11.20	15.51	2 2 7	59.63	56.94
0 6 9	23.02	22.32	1 11 1	10.59	12.52	2 0 16	11.96	14.48	2 2 8	43.73	43.05
0 6 11	17.54	12.14	1 11 4	5.82	7.22	2 2 0	37.44	41.14	2 2 10	10.47	12.92
0 8 0	18.07	15.65	1 11 5	11.55	12.68	2 2 2	69.32	63.33	2 2 11	37.62	27.12
0 8 4	8.71	8.99	1 11 6	26.93	21.18	2 2 4	46.85	38.50	2 2 12	24.39	28.14
0 8 5	48.79	36.87	1 11 11	13.54	11.36	2 2 6	7.35	17.67	2 2 4	37.04	23.83
0 8 7	10.38	10.10	1 11 12	3.61	5.06	2 2 7	15.15	12.41	2 2 4	30.24	17.26
0 8 8	32.51	25.23	1 13 0	11.28	11.37	2 2 8	39.42	32.01	2 2 4	13.57	13.99
0 9 0	15.22	12.67	1 13 4	13.48	10.91	2 2 9	15.06	11.41	2 2 4	16.18	19.42
0 8 11	17.79	14.68	1 13 6	16.58	15.15	2 2 14	5.10	7.34	2 2 4	67.07	50.39
0 6 12	15.60	10.52	-1 1 2	51.73	166.83	2 2 12	16.05	18.65	2 2 4	7	14.20
0 13 0	31.43	22.89	-1 1 3	42.06	83.28	2 4 2	23.92	20.01	2 2 4	51.29	40.79
0 10 2	25.35	22.99	-1 1 4	102.40	153.65	2 4 3	37.53	37.64	2 2 4	28.76	21.53
0 10 4	17.98	12.81	-1 1 5	29.94	29.04	2 4 5	55.86	45.89	2 2 4	10	27.95
0 10 6	30.40	22.15	-1 1 6	73.95	71.18	2 4 7	14.69	13.31	2 2 4	11	23.28
0 10 8	11.31	11.44	-1 1 8	38.62	36.04	2 4 8	21.04	19.60	2 2 4	12	6.26
0 12 0	15.37	12.89	-1 1 9	5.14	5.88	2 4 9	9.92	6.16	2 2 6	1	8.03
0 12 2	14.96	11.35	-1 1 10	34.53	38.10	2 4 10	15.40	14.96	2 2 6	7	29.01
0 12 3	11.50	11.37	-1 1 11	9.73	13.70	2 4 11	14.90	11.11	2 2 6	4	15.13
0 12 4	10.16	12.74	-1 1 12	32.57	36.21	2 4 12	6.57	4.67	2 2 6	5	15.57
0 12 9	19.18	14.01	-1 1 15	14.20	15.23	2 6 1	15.62	13.45	2 2 6	8	16.39
0 12 8	11.72	7.22	-1 1 18	9.33	14.20	2 6 3	19.24	18.25	2 2 6	9	15.12
0 12 10	15.56	10.88	-1 3 1	56.16	52.27	2 6 5	41.81	26.65	2 2 6	11	36.66
0 14 0	10.19	7.93	-1 3 2	60.28	57.09	2 6 6	7.55	18.71	2 2 6	12	5.14
0 14 5	5.70	4.73	-1 3 3	30.62	28.32	2 6 7	37.47	34.59	2 2 6	1	8.24
0 14 6	13.98	8.47	-1 3 4	50.16	69.10	2 6 8	18.47	18.82	2 2 6	5	24.42
1 1 2	72.30	119.58	-1 3 5	21.54	19.70	2 6 10	22.93	21.27	2 2 6	4	42.12
1 1 3	31.64	31.39	-1 3 7	20.67	19.22	2 6 12	16.96	14.52	2 2 6	5	24.33
1 1 4	24.98	23.69	-1 3 8	21.44	20.13	2 8 2	2.35	6.14	2 2 6	6	10.07
1 1 5	11.68	3.25	-1 3 9	15.59	15.51	2 8 4	21.54	18.88	2 2 6	7	17.66
1 1 6	24.72	21.31	-1 3 10	26.98	16.32	2 8 5	29.72	23.28	2 2 6	8	14.56
1 1 7	28.05	23.35	-1 3 12	18.04	18.63	2 8 6	0.71	6.10	2 2 6	10	20.83
1 1 8	14.74	15.10	-1 5 1	23.93	15.94	2 8 7	16.21	12.73	2 2 8	11	12.86
1 1 9	6.32	5.61	-1 5 4	41.25	22.35	2 8 8	11.15	9.81	2 2 10	1	18.58
1 1 12	24.72	29.91	-1 5 5	40.47	26.31	2 8 9	8.21	7.96	2 2 10	5	15.98
1 1 13	17.66	22.94	-1 5 6	39.58	29.23	2 8 12	73.35	18.94	2 2 10	8	28.17
1 3 1	39.05	35.23	-1 5 7	29.63	26.25	2 10 0	13.98	11.96	2 2 10	8	9.46







position of the sulfur atom and four atoms around it.

A Fourier synthesis based on the positions of the five atoms showed the remaining non-hydrogen atoms of a sulfapyridine. Refinement was performed by several cycles of isotropic structure factor calculations using the block-diagonal least-squares program<sup>8</sup> for the IBM 1130, and gave a final R value of 0.14 for all the observed reflections. At this stage a three-dimensional difference Fourier synthesis was computed using only low-order reflections with  $\sin \theta/\lambda \leq 0.35$ . The subsequent map showed peaks for the 10 hydrogen atoms in plausible positions except the one associated to the carbon atom in the pyridyl group, whose peak seemed to be very far placed from the expected position. This uncertain appearance may be a likely result under the present accuracy of the structure analysis.

The weighting scheme proposed by Cruickshank was used<sup>9</sup>. The atomic scattering factors were taken from International Tables for X-ray Crystallography<sup>10</sup>.

The final positional and thermal parameters are given in Table II with their estimated standard deviations. The observed and calculated structure factors are listed in Table III.

## DISCUSSION

The bond lengths and angles are given in Table IV and Fig. 1 with atomic numbering.

The benzene ring is planar within experimental error while the substituent S and N(2) atoms are markedly out of this plane. The C-C bond lengths in the benzene ring vary

Table IV: Bond lengths and angles in sulfapyridine.

Bond length (Å)		Bond angle (°)	
S—O(1)	1.44(4)	C(1)—S—O(1)	108(3)
S—O(2)	1.42(5)	C(1)—S—O(2)	108(3)
S—C(1)	1.71(5)	C(1)—S—N(1)	106(3)
S—N(1)	1.63(5)	N(1)—S—O(1)	112(3)
C(1)—C(2)	1.41(3)	N(1)—S—O(2)	106(3)
C(1)—C(6)	1.39(4)	O(1)—S—O(2)	115(3)
C(2)—C(3)	1.36(4)	S—C(1)—C(2)	120(2)
C(3)—C(4)	1.41(4)	S—C(1)—C(6)	122(2)
C(4)—C(5)	1.41(4)	C(2)—C(1)—C(6)	118(2)
C(4)—N(2)	1.39(4)	C(1)—C(2)—C(3)	121(2)
C(5)—C(6)	1.39(4)	C(2)—C(3)—C(4)	120(2)
C(7)—N(1)	1.32(3)	C(3)—C(4)—C(5)	118(3)
C(7)—N(3)	1.36(4)	C(3)—C(4)—N(2)	120(2)
C(7)—C(8)	1.43(4)	C(5)—C(4)—N(2)	122(3)
C(8)—C(9)	1.40(5)	C(4)—C(5)—C(6)	121(3)
C(9)—C(10)	1.43(5)	C(5)—C(6)—C(1)	120(3)
C(10)—C(11)	1.39(5)	N(1)—C(7)—N(3)	126(2)
C(11)—N(3)	1.37(4)	N(1)—C(7)—C(8)	117(2)
		N(3)—C(7)—C(8)	117(2)
		C(7)—C(8)—C(9)	118(3)
		C(8)—C(9)—C(10)	122(4)
		C(9)—C(10)—C(11)	118(3)
		C(10)—C(11)—N(3)	119(3)
		S—N(1)—C(7)	120(2)
		C(7)—N(3)—C(11)	126(3)

The estimated standard deviations are shown in parentheses.

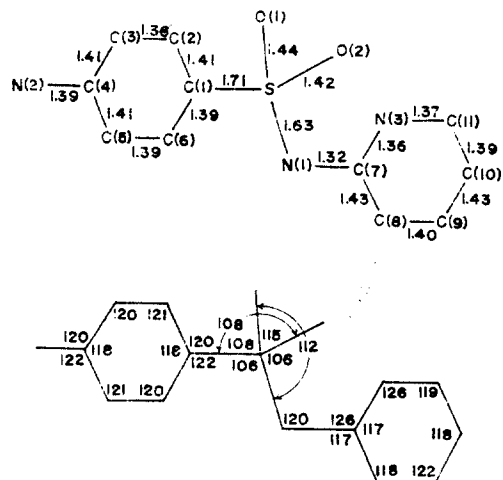


Fig. 1: Bond lengths(Å) and angles(°) in sulfapyridine.

from 1.36 to 1.41 with a mean value of 1.39Å, which shows good agreement with the value of 1.395Å quoted for the mean aromatic C-C bond length. Here some C-C bond lengths varying significantly from 1.395 Å in benzene may show the resonance effect expected in a benzene ring with an electron-donating group and an electron-withdrawing group para to one another. Also it has been pointed out by many authors, Klug<sup>11</sup>, Arona and Sundaralingam<sup>12</sup>, Kruger and Gafner<sup>13</sup>, that there is a tendency of stabilization of p-substituted benzene ring through the distortion from regular hexagonal symmetry. The C(4)-N(2) bond length of 1.39Å, which is significantly shorter than the corresponding normal single bond length, 1.44Å and in good agreement with the values reported in sulfanilamids<sup>14~16</sup>, shows an appreciable amount of double-bond character.

Bonding around the sulfur atom is slightly distorted from the ideal tetrahedral. The bond lengths reported for related compounds have been tabulated in Table V. The S-C(1) bond length of 1.71Å agrees with the value reported in  $\alpha$ -sulfanilamide<sup>14</sup>) and 2'-hydroxymethane sulfonamide<sup>17</sup>). The S-O bond lengths, 1.44 and 1.42Å are in good agreement with the values found in related compounds. The S-N(1) bond lengths of 1.63Å, which is distinctly shorter than the single S-N bond length of 1.764Å in sulfamic acid<sup>18</sup>) but in good agreement with the value of related compounds, show a considerable amount of double-bond character. Cruickshank<sup>19</sup>) has shown that there is strong  $\pi$ -bonding in  $XY_4^{n-}$  moieties (X=Si, P, S, Cl; Y=O, N) because of overlap between

**Table V: A comparison of bond length(Å) in sulfapyridine and related compounds.**

	H <sub>2</sub> N(2)-C (ring)	C-S	S-O	S-N	N(1)-C (ring)
Sulfapyridine	1.39	1.71	1.44 1.42	1.63	1.32
Sulfaguanidine monohydrate <sup>1</sup>	1.41	1.78	1.44 1.42	1.62	
Sufadiazine <sup>2</sup>	1.43	1.78	1.42 1.41	1.66	1.38
Sulfadimethoxine <sup>3</sup>	1.33	1.74	1.45 1.44	1.67	1.37
Sulfisoxazole <sup>4</sup>	1.35	1.77	1.42 1.41	1.69	1.39
Sodium sulfisoxazole hexahydrate <sup>5</sup>	1.42	1.78	1.48 1.47	1.61	1.39
$\alpha$ -sulfanilamide <sup>14</sup>	1.40	1.74	1.41 1.47	1.41	1.61
$\beta$ -sulfanilamide <sup>15</sup>	1.385	1.750	1.454 1.448	1.620	
$\gamma$ -sulfanilamide <sup>16</sup>	1.38	1.75	1.44 1.44	1.63	
Sulfathiazole polymorph I <sup>23</sup>	1.375	1.749	1.434 1.427	1.614	1.306
Sulfathiazole polymorph II <sup>13</sup>	1.401	1.759	1.444 1.435	1.589	1.312
Sulfathiazole polymorph III <sup>23</sup>	1.411	1.757	1.445 1.441	1.606	1.319

$3d_{x^2-y^2}$  and  $3d_{z^2}$  orbitals of X and  $2p_x$  orbitals of Y.

The C(7)-N(1) bond length of 1.32Å, which is significantly shorter than the corresponding normal single bond length of 1.47Å, indicates 50% double-bond character by Wheatley's order/length curve<sup>20</sup>) for C-N bonds. This double-bond character seems to be due to the conjugation of  $p_x$  electrons on the nitrogen atom with the  $\pi$ -system of the pyridyl group.

The pyridine ring is approximately planar. Bonding of the nitrogen atom in the pyridine ring is interesting. In sulfapyridine the crystal structure shows that the pyridyl group takes a form (II) in the crystalline state. An evidence



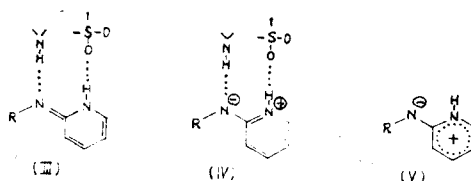
Table VI: Least-squares best planes in sulfapyridine.

Atoms included in plane	Atoms not included in plane	Distance from best plane(A)	Constant
<b>A. Benzene ring</b>			
C(8)		0.01	A = 0.958
C(3)		-0.01	B = -0.099
C(3)		0.01	C = 0.202
C(4)		-0.01	D = 2.455
C(5)		0.00	
C(6)		0.00	
	N(2)	0.09	
	S	0.18	
<b>B. pyridine ring</b>			
N(3)		-0.03	A = -0.294
C(7)		0.04	B = 0.165
C(8)		-0.02	C = 0.959
C(9)		-0.01	D = -0.065
C(10)		0.03	
C(11)		-0.02	
	N(1)	0.04	

Equation for planes :  $Ax + By + Cz = D$ , where  $x, y, z$  are in Å

which a form (II) appears to be quite conclusive is the location of the hydrogen atom revealed by the difference Fourier map. This hydrogen atom should be part of an N-H...O hydrogen bond of length 2.90Å. The N-H...O angle of 137° supports the assignment of the hydrogen position. Chater Singh<sup>21</sup> has proposed an indirect test for the presence of an extra-annular hydrogen attached to nitrogen by noting that the internal bond angle at nitrogen atoms with an extra-annular hydrogen is significantly greater (more than 120°) than at nitrogen atoms without an attachment (where the angle is generally less than 120°). The bond angle at nitrogen in sulfapyridine is 126°, a value similar to the angle of 125.1° in  $\alpha$ -pyridone<sup>22</sup>, where the

hydrogen atom is clearly associated with the nitrogen. The C(7)-N(1) bond length would also be expected to be sensitive to the position of the hydrogen. As can be seen in Table V, the C(7)-N(1) bond length of 1.32Å in sulfapyridine agrees well with that in sulfathiazole polymorphs<sup>13, 23</sup> where a hydrogen is not associated with the N(1) atom of the amide group but with the nitrogen in the thiazole ring, while the corresponding values for other related compounds where a hydrogen atom is associated to the nitrogen of amide group instead of the one in heterocyclic ring are considerably larger. Bond lengths on the pyridine ring which takes the short-long-short pattern in the C=C-C=C portion show an appreciable degree of  $\pi$ -bond localization supporting a form (II) when compared to corresponding values in pyridine<sup>24</sup>. Thus, the C(7)-C(8) and C(9)-C(10) bond lengths of 1.43 Å approach the accepted value 1.44 Å for  $C_{sp^2}$ - $C_{sp^2}$  single bonds. The C(7)-N(3) and C(11)-N(3) bond lengths of 1.36 and 1.37 Å, are also significantly longer than the corresponding bonds in pyridine<sup>24</sup>. A difference between the C-N bond lengths in the pyridine ring, the longer C(7)-N(1) than the corresponding normal double bond, and the hydrogen bonding scheme in sulfapyridine as shown in (III) provides a mechanism for stabilization of dipolar resonance form (IV). However the



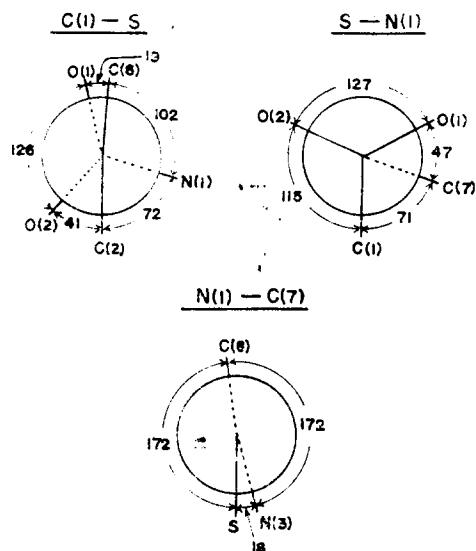


Fig. 2: Conformational angles in degree in sulfapyridine.

comparatively long C(7)-N(3), C(8)-C(9) and C(10)-C(11) to classify as pure double bond reflect an considerable contribution of the delocalized form (V).

The detailed conformational angles are given in Fig. 2. The conformation around the S-N(1) bond is very similar to related compounds. As expected, C(1)-S-N(1)-C(7) group in sulfapyridine adopts the gauche form with a conformational angle of  $71^\circ$ . The benzene ring plane are inclined at angle of  $84^\circ$  to pyridine ring. The conformational angles formed by the S-C(1) bond with that of N(1)-C(7), when the projection is taken along the S-N(1) in related compounds are compared in Table 7 with the angles between the two aromatic planar rings in these molecules. Small differences of the conformational and interplanar angles may be attributed to different hydrogen bonding schemes and

Table VII: A comparison of the conformational angles formed by the S-C(1) bond with that of N(1)-C(7) when the projection is taken along the S-N(1), and the angles between two aromatic planar rings in related compounds.

	Conformational angle( $^\circ$ ) about the S-N(1) bond	Angle( $^\circ$ ) between two aromatic planar rings
Sulfapyridine	71	84
Sulfaguanidine monohydrate <sup>1</sup>	76	
Sulfadiazine <sup>2</sup>	77	76
Sulfadimethoxine <sup>3</sup>	61	77.6
Sulfisoxazole <sup>4</sup>	54	69
Sodium sulfisoxazole hexahydrate <sup>5</sup>	73	60

Table VIII: Intermolecular contacts less than 3.5 Å

Hydrogen bonds			
N(2) .....	O(1)a	2.98 Å	
N(2) .....	N(1)d	3.06	
N(3) .....	O(1)c	2.90	
Other shortest contacts			
N(2) .....	C(9)e	3.38	
N(2) .....	C(10)e	3.43	
C(9) .....	O(1)c	3.13	
C(9) .....	O(2)b	3.19	
C(10) .....	O(2)b	3.35	
O(1) .....	O(6)c	3.02	
Symmetry code:			
	X,	Y,	Z.
a	X,	-Y,	$\frac{1}{2}+Z$ .
b	$\frac{1}{2}+X$ ,	$\frac{1}{2}+Y$ ,	Z.
c	$\frac{1}{2}-X$ ,	$\frac{1}{2}-Y$ ,	-Z.
d	$\frac{1}{2}-X$ ,	$\frac{1}{2}+Y$ ,	$\frac{1}{2}-Z$ .
e	$\frac{1}{2}+X$ ,	$\frac{1}{2}-Y$ ,	$\frac{1}{2}+Z$ .
f	-X,	Y,	$\frac{1}{2}-Z$ .

different molecular environment. Reference to Table VII has drawn a conclusion that the molecule in these compounds maintains a gauche form.

The crystal structure of sulfapyridine projected along the a and b axes is shown in

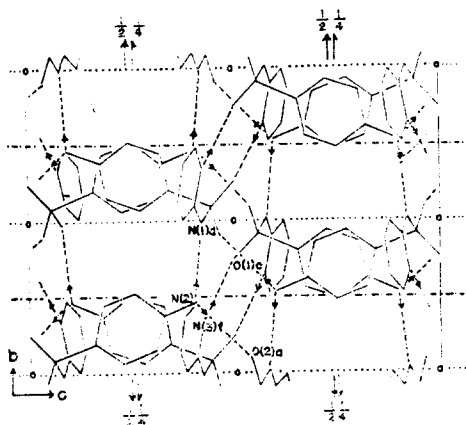


Fig. 3: The crystal structure of sulfapyridine viewed down the a axis.

Dashed lines are hydrogen bonds; arrows indicate donor direction.

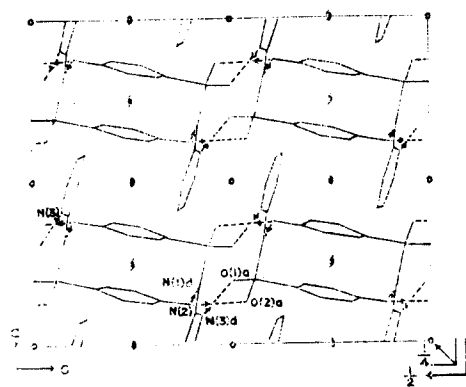


Fig. 4: The crystal structure of sulfapyridine viewed down the b axis.

Dashed lines are hydrogen bonds; arrows indicate donor direction.

Fig. 3 and Fig. 4.

An examination for interatomic and intermolecular contacts revealed that sulfapyridine has three different hydrogen bonds. As above mentioned, the N(3) atom with an extra-annular hydrogen forms a hydrogen bond to the O(1) atom of the sulfon group with N·····O distance of 2.90 Å. The N(2) atom of the aniline group participates in two

hydrogen bonds as donor, one is N-H·····O with N·····O distance of 2.98 Å and the other is N-H·····N with N-N distance of 3.06 Å. Interatomic contacts below 3.5 Å are summarized in Table 8. The short contacts of 3.13 Å for C(9)·····O(1)c and 3.19 Å for C(9)·····O(2)b could be explained by the strong van der Waals interaction. The tight contacts between the carbon atom in the pyridine ring and the oxygen atoms in neighbouring molecules might slightly support a contribution of the form(V) to the structure of sulfapyridine.

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