−6·5°. The χ_N deformation is remarkably large, being exceeded only in molecules where the non-planarity of the amide group is enforced by severe ring-fusion constraints (van der Helm, Ealick & Washecheck, 1975) – which is certainly not the case here. The value of χ_N depends heavily on the amide H position; however, the observed displacement of this atom from the OC′N plane amounts to 0·24 Å or about 8 e.s.d.'s, so we believe the deformation to be real. In one experiment, the amide H was placed at a trial position in the mean plane of the other amide group atoms, but it moved back, close to the reported position, on least-squares refinement.

The out-of-plane displacement of the amide H may be required by the contingencies of optimal hydrogen bonding, but it may also be due to interaction between the filled p orbital of the N atom and the antibonding (σ^*) orbital of the adjacent C(3)–O(2) bond. Interaction between lone-pair and 'superjacent' σ^* orbitals has been invoked for the interpretation of the anomeric effect (Altona, 1964; David, Eisenstein, Hehre, Salem & Hoffmann, 1973). By analogy, the σ^* orbital of the electronegative C–O bond could be said to induce some degree of pyramidalization of the N atom in the interests of optimal overlap – a kind of 'reverse anomeric effect'. In this connexion, it should be noted that the H atom is displaced to the *opposite* side of the amide plane from the hydroxyl group, so the developing lone pair is on the *same* side as this group, leading to a more *syn* than *anti* orientation. The inverted displacement would tend to make the developing lone pair orthogonal to the C–O bond.

The remaining structural features merit no special comment. Analysis of the vibrational ellipsoids in terms of rigid-body motion (Schomaker & Trueblood, 1968) leads to quite satisfactory agreement between observed and calculated U_{ij} values $[\langle \Delta^2(U_{ij})\rangle^{1/2} = 0{\cdot}0021$ Å^2, $\langle \sigma^2(U_{ij})\rangle^{1/2} = 0{\cdot}0016$ Å$^2]$. Librational corrections to bond lengths amount to 0·006–0·012 Å (see Fig. 2); angle corrections are negligible.

The crystal packing (Fig. 3) is dominated by hydrogen bonding. Pairs of molecules related by inversion centres are linked into dimers by N–H···O(2) bonds of length 3·05 Å, and chains of molecules related by the c glide operation are linked by O(2)–H···O(1) bonds of length 2·69 Å.

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2′-Hydroxy-5′-[1-hydroxy-2-(3″-pentylamino)propyl]fluoromethanesulfonanilide Hydrochloride

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Abstract. $C_{15}H_{26}FN_2O_4ClS$, M_r = 384·90, triclinic, $P\bar{1}$, a = 8·538 (5), b = 8·810 (5), c = 13·874 (8) Å, α = 93·76 (5), β = 108·06 (4), γ = 103·15 (4), V = 955·6 (9) Å^3, Z = 2, D_x = 1·338, D_m = 1·334 g cm^{-3}. The final R was 0·075 for the 1712 reflections used in the analysis. The OH of the side chain is *trans* to the amino N, a conformation not found in any of the active bronchodilators.

Introduction. Preliminary Weissenberg and precession photographs indicated triclinic symmetry, space group $P1$ or $P\bar{1}$. A second crystal, 0·31 × 0·18 × 0·18 mm, was used for the intensity measurements and the determination of the cell constants. The intensity data were measured with a Syntex $P\bar{1}$ diffractometer by the variable-speed θ–2θ scan method. Graphite-monochromatized Mo radiation was used for all the measurements. 2520 reflections were measured, of which 1712 had I(intensity) $\geq$ 1·8$\sigma(I)$ and were used in the analysis. μ for Mo $K\alpha$ is 3·4 cm^{-1}, and no absorption corrections were deemed necessary. The structure was solved by the heavy-atom method with Fourier syntheses to locate the other atoms. However, instead of one large peak for the F atom of the fluoromethyl group, two smaller peaks appeared at an early stage. Eventually, two half-F atoms were assigned to these peaks and the refinement proceeded smoothly. The R value ($R = \Sigma \Delta F / \Sigma F_o$) was reduced to 0·13 after three cycles with individual isotropic thermal parameters. After three additional cycles, during which anisotropic thermal parameters were used, R was reduced to 0·095. The H atoms were located in a difference Fourier synthesis and their contributions were included in the structure factor calculation but their parameters were not varied. R was reduced to 0·078, with the goodness-of-fit parameter being 0·83. Three additional least-squares cycles were calculated with the block approximation, in which all the parameters were varied, and R was lowered to 0·075. While R was not lowered significantly, we have found that the distances and angles involving the H atoms improved with the refinement.

Table 1. *Final positional parameters* (×10^4)

	x	y	z
Cl	2442 (2)	1178 (2)	726 (1)
S(1)	2592 (3)	4058 (3)	5360 (2)
O(1)	2775 (7)	4364 (6)	4408 (4)
O(2)	1159 (7)	2909 (8)	5374 (5)
O(3)	6042 (7)	5893 (5)	7669 (3)
O(4)	3816 (6)	−1326 (5)	7898 (4)
N(1)	4309 (7)	3637 (6)	6040 (4)
N(2)	412 (7)	296 (6)	8273 (4)
C(1)	4472 (8)	3284 (7)	7065 (5)
C(2)	5357 (9)	4479 (8)	7888 (5)
C(3)	5552 (9)	4124 (8)	8872 (5)
C(4)	4825 (8)	2618 (8)	9021 (5)
C(5)	3909 (8)	1428 (7)	8192 (5)
C(6)	3758 (8)	1764 (7)	7216 (5)
C(7)	2436 (14)	5905 (11)	5950 (8)
C(8)	3185 (8)	−236 (7)	8357 (5)
C(9)	1278 (8)	−834 (7)	7920 (5)
C(10)	−377 (9)	1248 (8)	7478 (5)
C(11)	−2037 (14)	38 (12)	6682 (6)
C(12)	−2632 (18)	641 (15)	5793 (10)
C(13)	−959 (13)	2476 (10)	7986 (7)
C(14)	248 (16)	3598 (10)	8791 (8)
C(15)	596 (9)	−2453 (8)	8193 (7)
F(1)	3987 (15)	7115 (12)	5797 (8)
F(2)	1491 (20)	5126 (15)	6626 (10)

Table 2. *Hydrogen atom positions*

The hydrogen atom is given followed by the atom to which it is bonded, the bond distance in Å, the positional parameters ×10^3 and the isotropic thermal parameter obtained from the least-squares refinement.

	Distance	x	y	z	B (Å^2)
H(1)–O(3)	0·81 (6)	640 (8)	652 (7)	819 (5)	7 (2)
H(2)–O(4)	1·10 (7)	517 (8)	−115 (7)	799 (5)	7 (2)
H(3)–N(1)	1·03 (7)	533 (7)	432 (7)	589 (5)	7 (2)
H(4)–N(2)	1·01 (6)	−054 (7)	−030 (6)	849 (4)	6 (2)
H(5)–N(2)	0·88 (5)	115 (7)	083 (6)	886 (4)	5 (1)
H(6)–C(3)	1·03 (6)	625 (7)	501 (7)	948 (5)	6 (2)
H(7)–C(4)	1·04 (5)	508 (7)	245 (6)	979 (4)	5 (1)
H(8)–C(6)	1·06 (6)	303 (7)	084 (6)	661 (4)	6 (1)
H(9)–C(8)	1·10 (5)	370 (7)	−051 (6)	913 (4)	4 (1)
H(10)–C(9)	1·08 (5)	085 (7)	−086 (6)	710 (4)	4 (1)
H(11)–C(10)	1·13 (7)	082 (7)	165 (7)	727 (4)	6 (2)
H(12)–C(11)	0·98 (8)	−186 (10)	−102 (9)	661 (6)	11 (2)
H(13)–C(11)	1·09 (8)	−306 (9)	−032 (8)	700 (6)	11 (2)
H(14)–C(12)	1·00 (8)	−276 (10)	171 (9)	599 (6)	11 (2)
H(15)–C(12)	0·98 (8)	−330 (10)	−022 (9)	522 (6)	13 (3)
H(16)–C(12)	1·20 (9)	−149 (10)	125 (9)	550 (6)	14 (3)
H(17)–C(13)	1·15 (8)	−188 (10)	213 (9)	844 (6)	12 (2)
H(18)–C(13)	0·98 (8)	−161 (9)	298 (8)	745 (6)	9 (2)
H(19)–C(14)	1·04 (10)	143 (10)	345 (10)	880 (6)	14 (3)
H(20)–C(14)	0·73 (7)	027 (9)	441 (8)	896 (6)	10 (2)
H(21)–C(14)	1·04 (7)	056 (9)	311 (8)	946 (6)	9 (2)
H(22)–C(15)	1·15 (6)	−088 (7)	−285 (7)	791 (4)	5 (2)
H(23)–C(15)	1·17 (7)	121 (8)	−205 (8)	908 (5)	8 (2)
H(24)–C(15)	1·00 (8)	149 (9)	−293 (8)	807 (5)	9 (2)

The quantity minimized in the least-squares calculations was $\Sigma\, w(|F_o| - |F_c|)^2$, where $w = (F_o/16{\cdot}0)^2$ if $F_o < 16{\cdot}0$, $w = 1$ if $16{\cdot}0 \leq F_o \leq 32{\cdot}0$ and $w = (32{\cdot}0/F_o)^2$ if $F_o > 32{\cdot}0$. The scattering factor for Cl$^-$ was from Doyle & Turner (1968) and for H from Stewart, Davidson & Simpson (1965); all others were from Hanson, Herman, Lea & Skillman (1964). The final positional parameters for the non-hydrogen atoms are given in Table 1, the H-atom parameters in Table 2.*

Discussion. The title compound (I) was one of a series of monofluoromethanesulfonamides prepared by Banitt, Coyne, McGurran & Robertson (1974) as possible new bronchodilators. Although several of the compounds compared favorably in all respects with known bronchodilators, (I) [No. 27 in the paper by Banitt *et al.* (1974) and hereinafter Riker-27] was considerably less potent. We determined the crystal structure of Riker-27 for comparison with active bronchodilators. We are attempting to obtain suitable single crystals of the more potent compounds Nos. 22 and 35 in the paper by Banitt *et al.* (1974).

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* Lists of structure factors and anisotropic thermal parameters have been deposited with the British Library Lending Division as Supplementary Publication No. SUP 33126 (13 pp.). Copies may be obtained through The Executive Secretary, International Union of Crystallography, 13 White Friars, Chester CH1 1NZ, England.

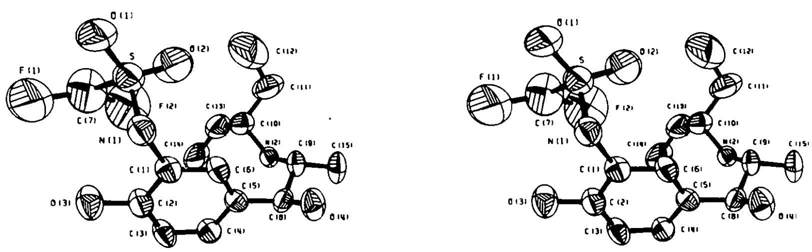


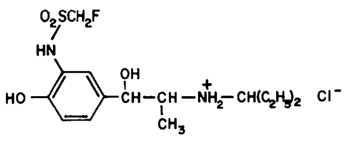
Fig. 1. An *ORTEP* stereoillustration of the title cation, showing the atomic numbering. The thermal ellipsoids are at the 50% probability level and the hydrogen atoms have been omitted for clarity. The atoms F(1) and F(2) are half atoms representing the disordered CH_2F group (see text).

Table 3. *Bond distances* (Å)

C(1)–C(2)	1·389 (9)	C(1)–N(1)	1·446 (8)
C(2)–C(3)	1·388 (9)	N(1)–S	1·616 (6)
C(3)–C(4)	1·390 (10)	S–O(1)	1·414 (5)
C(4)–C(5)	1·394 (9)	S–O(2)	1·405 (7)
C(5)–C(6)	1·378 (9)	S–C(7)	1·824 (10)
C(6)–C(1)	1·397 (9)	C(7)–F(1)	1·580 (16)
C(2)–O(3)	1·348 (8)	C(7)–F(2)	1·518 (19)
C(5)–C(8)	1·519 (9)	C(8)–O(4)	1·409 (9)
C(8)–C(9)	1·501 (10)	C(9)–C(15)	1·532 (9)
C(9)–N(2)	1·508 (9)	N(2)–C(10)	1·514 (9)
C(10)–C(11)	1·598 (12)	C(10)–C(13)	1·508 (12)
C(11)–C(12)	1·372 (16)	C(13)–C(14)	1·401 (14)

Table 4. *Intermolecular bond angles* (°)

C(1)–C(2)–C(3)	118·5 (6)	S–C(7)–F(1)	101·0 (7)
C(2)–C(3)–C(4)	120·4 (7)	S–C(7)–F(2)	94·4 (8)
C(3)–C(4)–C(5)	120·9 (6)	F(1)–C(7)–F(2)	151·7 (10)
C(4)–C(5)–C(6)	118·8 (6)	C(4)–C(5)–C(8)	120·9 (6)
C(5)–C(6)–C(1)	120·3 (6)	C(6)–C(5)–C(8)	120·2 (6)
C(6)–C(1)–C(2)	121·0 (6)	C(5)–C(8)–O(4)	111·0 (5)
C(1)–C(2)–O(3)	116·8 (6)	C(5)–C(8)–C(9)	115·2 (6)
C(3)–C(2)–O(3)	124·6 (6)	O(4)–C(8)–C(9)	105·3 (5)
C(2)–C(1)–N(1)	118·7 (6)	C(8)–C(9)–N(2)	111·4 (5)
C(6)–C(1)–N(1)	120·3 (6)	C(8)–C(9)–C(15)	113·3 (6)
C(1)–N(1)–S	119·3 (4)	N(2)–C(9)–C(15)	108·0 (6)
N(1)–S–C(7)	109·7 (4)	C(9)–N(2)–C(10)	115·5 (5)
N(1)–S–O(1)	107·6 (3)	N(2)–C(10)–C(11)	105·6 (6)
N(1)–S–O(2)	109·4 (4)	N(2)–C(10)–C(13)	109·0 (6)
O(1)–S–O(2)	119·2 (4)	C(11)–C(10)–C(13)	107·7 (7)
O(1)–S–C(7)	105·3 (4)	C(10)–C(11)–C(12)	111·4 (9)
O(2)–S–C(7)	105·4 (5)	C(10)–C(13)–C(14)	119·0 (9)



(I)

The atomic numbering and thermal ellipsoids for Riker-27 are shown in Fig. 1. The distances and angles are given in Tables 3 and 4 and are not unusual. The benzene ring is planar (as expected) with deviations from planarity of +0·011 to −0·012 Å. The C–C distances and the C–C–C angles average 1·389 (3) Å and 120·0 (4)° respectively. The average S–O distances, 1·410 Å, are not significantly different from the average value of 1·424 (3) Å found by Gadret, Goursolle, Leger, Colleter & Carpy (1976) in a similar methanesulfonanilide. The dimensions of various sulfonamides have been tabulated by Alléaume, Gulko, Herbstein, Kapon & Marsh (1976) and Mathew & Palenik (1974) and can be compared with our present results.

The most interesting feature of Riker-27 is its molecular conformation compared with other biologically active amines. The conformations of a number

Table 5. *Dihedral angles in some sympathomimetic amines* (°)

The angles τ_1, τ_2 and τ_3 are defined by Carlström, Bergin & Falkenberg (1973) and ω and χ by Hearn, Freeman & Bugg (1973). These angles are also defined in the text with respect to the present numbering system.

Compound		τ_1	τ_2	τ_3	ω	χ	Reference
Adrenaline hydrogen tartrate		−3	−179	−125	−58	−173	(1)
Adrenaline free base		80	172	−38	−65	158	(2)
Ephedrine hydrochloride		−81	164	160	−71	−170	(3)
Isoproterenol	*A*	102	175	−19	−62	−156	(4)
sulfate*	*B*	107	177	−129	50	−172	
Dichloroisoproterenol hydrochloride		−78	175	160	−60	89	(5)
Sotalol hydrochloride†		−100	174	134 54	−59 25	172	(6)
Pronethanol hydrochloride		−65	−167	56	73	−175	(7)
Riker-27		118	−52	−122	−175	106	(8)

References: (1) Carlström (1973). (2) Andersen (1975). (3) Bergin (1971). (4) Mathew & Palenik (1971). (5) Gadret, Goursolle, Leger & Colleter (1975*a*). (6) Gadret, Goursolle, Leger, Colleter & Carpy (1976). (7) Gadret, Goursolle, Leger & Colleter (1975*b*). (8) Present study.

* There are two molecules (*A* and *B*) in the asymmetric unit.

† The oxygen of the OH group is disordered and two values of τ_3 and ω are possible.

Table 6. *Hydrogen bonds*

D–H···A	Position of A	H···A (Å)	D···A (Å)	∠D–H···A(°)	∠H–D···A(°)
O(3)–H(1)···Cl	$1-x, 1-y, 1-z$	2·26 (6)	3·038 (5)	161 (6)	14 (4)
O(4)–H(2)···Cl	$1-x, 1-y, 1-z$	2·26 (7)	3·140 (6)	136 (5)	30 (3)
N(1)–H(3)···O(1)	$1-x, 1-y, 1-z$	1·93 (7)	2·966 (8)	179 (5)	1 (3)
N(2)–H(4)···Cl	$-x, -y, 1-z$	2·24 (6)	3·233 (6)	167 (5)	9 (3)
N(2)–H(5)···Cl	$x, y, 1+z$	2·45 (5)	3·251 (5)	152 (5)	21 (4)

of biogenic amines have been discussed in terms of the torsion angles τ_1, τ_2, τ_3 and τ_4 (Carlström, Bergin & Falkenberg, 1973) and ω, χ, τ and ψ (Hearn, Freeman & Bugg, 1973). The angle τ_1 is the torsion angle of C(4)–C(5)–C(8)–C(9); τ_2 is C(5)–C(8)–C(9)–N; τ_3, identical with τ, is C(4)–C(5)–C(8)–C(9); ω is O(4)–C(8)–C(9)–N; and χ is C(8)–C(9)–N(2)–C(10). The two angles τ_4 and ψ are of less general interest and will not be considered. The torsion angles τ_1, τ_2, τ_3, ω and χ for Riker-27 and several other similar amines have been tabulated in Table 5. The absolute value of τ_1 is usually about 90° (range 65–118°), with the exception of adrenaline hydrogen tartrate where τ_1 is −3°. The coplanarity in the latter was considered by Carlström (1973) to be a crystal-packing effect and presumably does not represent the favored conformation for biogenic amines. The value of τ_2 of −52° for Riker-27 is in marked contrast to the usual value of 180° (range +164 to −167°) which is required for a fully extended conformation. A second striking difference occurs in the ω angle where Riker-27 has the *trans* conformation ($\omega = -175°$). The other amines have a *gauche* arrangement so that the hydroxyl group is in close proximity to the amine N. Finally, the χ angle is about 180° (range −156 to +158°) for amines which are α or α,β-agonists, while for dichloroisoproterenol hydrochloride (β-antagonist) $\chi = 89°$, and for the inactive Riker-27 the angle is 106°. Consequently, we see that the conformation of the inactive Riker-27 is markedly different from that of other active amines although the bond distances and angles are not particularly unusual. Since the hydroxyl group on C(8) and the amine N(2) are essential features of bronchodilators, we consider that the *gauche* conformation is required for biological activity; hence, Riker-27, with a *trans* conformation, is inactive. However, the interdependence and relative importance of the torsion angles χ and τ_2 on biological activity will require further studies.

There are no unusual intermolecular contacts in the crystal and the packing involves a number of hydrogen bonds. All of the five H atoms bonded to O or N participate in the hydrogen-bonding network. The dimensions of the various hydrogen bonds are summarized in Table 6. Four of the five hydrogen bonds involve the Cl^- ion and the various distances are normal for either N–H···Cl or O–H···Cl bonds. The fifth hydrogen bond is N(4)–H(4)···O(1) and again is similar to other N–H···O hydrogen bonds. In summary, the crystal packing involves no unusual distances or angles which might influence the biological activity.

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