locked in a rigid conformation mainly by the aforementioned short contacts involving the carboxylate groups, as well as by the torsional barriers imposed on the ring system by the unsaturated bonds of the naphthalene rings. Indeed, *ortho* substitution brings O(1) in close proximity to C(11), at a distance 2·974 (4) Å, with a minimal torsion of 6° about the unsaturated C(1)–C(2) bond. Fig. 2 shows the molecule viewed down **c**.

There are no noticeable short intermolecular contacts.

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Structure of 4-Methyl-5-(2-pyrazinyl)-3*H*-1,2-dithiol-3-one: an Oltipraz Analog*

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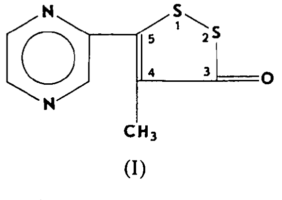
Abstract. $C_8H_6N_2OS_2$, $M_r = 210·278$, monoclinic, $P2_1/a$, $a = 11·863$ (3), $b = 19·873$ (5), $c = 7·552$ (3) Å, $\beta = 96·01$ (2)°, $V = 1770·6$ Å^3, $Z = 8$, $D_m = 1·59$ (2), $D_x = 1·577$ g cm^{-3}, $\lambda(\text{Mo } K\alpha_1) = 0·7093$ Å, $\mu = 5·57$ cm^{-1}, $F(000) = 864$, $T = 296$ (1) K, final $R(F) = 0·048$ for 2664 counter data with $F_o^2 \geq 2\sigma(F_o^2)$. As in the case of oltipraz, the two crystallographically independent molecules have corresponding molecular parameters closely resembling each other. Individual six- and five-membered rings are nearly planar to within 0·011 (2) Å, and the angle between plane normals of the six- and five-membered rings is 4·6 (1)° for one molecule and 9·6 (1)° for the other. Bond distances and angles agree well with those found in oltipraz except, of course, for the exocyclic C–O bond distances [av. 1·214 (6) Å].

Introduction. The antischistosomidal drug 4-methyl-5-(2-pyrazinyl)-3*H*-1,2-dithiole-3-thione (oltipraz) acts slowly on mice infected with *Schistosoma mansoni*, and eventually attains parasitological cures by a reduction of the glutathione stores of the parasite (Bueding, Dolan & Leroy, 1982). In their studies, Bueding *et al.* (1982) also used several other drugs, structurally similar to oltipraz, to test and compare their chemotherapeutic values.

As part of our health-related program to provide information regarding structure–function relationships, we have undertaken X-ray structural investigation on drugs of this class containing 3*H*-1,2-dithiole-3-thione as a basic building unit, and the structures of oltipraz (Wei, 1983), 5-(*p*-methoxyphenyl)-3*H*-1,2-dithiole-3-thione (Wang, Lin & Wei, 1985), and 3*H*-1,2-dithiole-3-thione (Wei, 1985) have been elucidated. The title compound (I) possesses a chemical formula closely resembling that of oltipraz but with the thione S replaced by an O. This simple modification of the chemical formula, however, renders the title compound therapeutically inactive. It is informative, therefore, to compare the structure of the title compound with that of oltipraz.



(I)

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Experimental. Yellow crystals obtained from a tetrahydrofuran solution of the specimen, kindly furnished by Professor Ernest Bueding of The Johns Hopkins University. Crystal density determined by flotation in mixtures of α-bromopropionic acid and bromobenzene. Space group and approximate unit-cell parameters established from Weissenberg and precession photographs. Data from a crystal of trapezoidal prism shape (0·23 × 0·12 × 0·62 mm) mounted on a Picker four-circle diffractometer with **c** approximately parallel to φ axis of the diffractometer. Lattice parameters refined by least-squares method from angle measurements of 18 strong reflections in 2θ range 41–46° (Busing, Ellison, Levy, King & Roseberry, 1968). The crystal diffracted very weakly; intensity data collected up to $2\theta = 55°$ by θ–2θ step scans ($-15 \leq h \leq 15$, $0 \leq k \leq 25$, $0 \leq l \leq 9$). Of the 3651 unique nonzero reflections, only 2664 with $F_o^2 \geq 2\sigma(F_o^2)$ used for the final refinement. Absorption corrections applied by the method of Busing & Levy (1957), transmission range 0·849 to 0·933. No extinction correction applied. Maximum mosaic spread of the crystal used estimed to be 0·5°. 2 standard reflections, variation <1%. Structure solved by the program *MULTAN* (Germain, Main & Woolfson, 1971) using intensity data only up to $2\theta = 40°$. By iterative least-squares refinements [by the program *ORXFLS*4 (Busing, Martin & Levy, 1962)] and difference-Fourier syntheses [by the program *ORFFP*3 (Levy, 1977)] all atoms including 12 H atoms finally located and refined. Scattering factors were those of Cromer & Waber (1974); anomalous-scattering corrections for S ($f' = 0{\cdot}110$, $f'' = 0{\cdot}124$) from Cromer (1974). The least-squares refinement was carried out until Δ/σ for non-H atoms became negligible and $(\Delta/\sigma)_{\max}$ for H parameters was down to 0·012. Final $R(F) = 0{\cdot}048$, $R(F^2) = 0{\cdot}058$, $wR(F^2) = 0{\cdot}095$, and $S = 1{\cdot}297$. Weights used in the refinement were reciprocals of $\sigma^2(F_o^2) + (0{\cdot}04F_o^2)^2$. The final difference Fourier map showed maximum $\Delta\rho$ 0·36 e Å^{-3}. With all 3651 unique nonzero reflections included, $R(F) = 0{\cdot}072$.

Discussion. Positional and isotropic temperature factors (or their equivalents) are listed in Table 1.*

There are two independent molecules in an asymmetric unit. The arrangement of these two molecules in the chosen positions of the unit cell is shown in a stereoscopic pair viewed perpendicular to the *ab* plane (Fig. 1). The structure is made up of these molecules held together by van der Waals forces. The closest intermolecular contact between nonhydrogen atoms is 3·128 (3) Å for S(12)···O(12);* the closest such contact between nonhydrogen and H atoms is 2·49 (4) Å for O(11)···H(31).

Table 1. *Positional and isotropic thermal parameters*

The e.s.d.'s are given in parentheses in all tables and in the text. The digits in parentheses correspond to the least significant digits of the parameters. The equivalent isotropic temperature factors for C, N, O and S atoms were calculated from the corresponding anisotropic thermal parameters and unit-cell parameters by the relation $B_{\text{eq}} = \frac{4}{3}(\beta_{11}b^2 + \beta_{22}b^2 + \beta_{33}c^2 + 2\beta_{13}ac\cos\beta)$ (Hamilton, 1959).

	x	y	z	B_{eq} or B(Å^2)
S(11)	0·94540 (7)	0·07176 (4)	0·3377 (1)	3·90 (2)
S(21)	0·98625 (9)	0·17096 (5)	0·3645 (1)	5·18 (3)
O(11)	0·8344 (3)	0·2583 (1)	0·4412 (4)	7·07 (11)
N(11)	0·8061 (2)	−0·0340 (1)	0·3167 (4)	3·86 (7)
C(11)	0·7433 (2)	0·0177 (2)	0·3659 (4)	3·09 (8)
C(21)	0·6343 (3)	0·0064 (2)	0·4045 (6)	4·39 (11)
N(21)	0·5856 (2)	−0·0541 (2)	0·3939 (4)	4·84 (9)
C(31)	0·6481 (3)	−0·1044 (2)	0·3442 (5)	4·19 (10)
C(41)	0·7577 (3)	−0·0939 (2)	0·3088 (5)	4·22 (10)
C(51)	0·8507 (4)	0·1992 (2)	0·4121 (5)	4·82 (11)
C(61)	0·7666 (3)	0·1449 (2)	0·4122 (4)	3·79 (9)
C(71)	0·8042 (3)	0·0825 (2)	0·3767 (4)	3·22 (8)
C(81)	0·6505 (4)	0·1659 (2)	0·4471 (8)	5·19 (14)
S(12)	0·37312 (6)	−0·14829 (4)	0·0510 (1)	3·47 (2)
S(22)	0·30708 (7)	−0·24288 (4)	0·0257 (1)	4·52 (3)
O(12)	0·0936 (2)	−0·2651 (1)	0·0565 (4)	5·43 (8)
N(12)	0·3596 (2)	−0·0136 (1)	0·0838 (4)	3·87 (8)
C(12)	0·2591 (2)	−0·0377 (1)	0·1192 (4)	2·84 (7)
C(22)	0·1805 (3)	0·0046 (2)	0·1818 (6)	4·77 (11)
N(22)	0·1991 (3)	0·0701 (1)	0·2102 (5)	5·01 (10)
C(32)	0·2991 (3)	0·0926 (2)	0·1758 (5)	4·27 (10)
C(42)	0·3779 (3)	0·0512 (2)	0·1115 (5)	4·56 (11)
C(52)	0·1659 (3)	−0·2218 (2)	0·0620 (5)	3·70 (9)
C(62)	0·1522 (2)	0·1499 (2)	0·0971 (4)	3·08 (7)
C(72)	0·2452 (2)	0·1109 (1)	0·0914 (4)	2·82 (7)
C(82)	0·0357 (3)	0·1281 (2)	0·1332 (7)	4·62 (12)
H(21)*	0·590 (3)	0·037 (2)	0·447 (5)	5·7 (10)
H(31)	0·617 (3)	−0·148 (2)	0·346 (5)	6·3 (10)
H(41)	0·799 (3)	0·130 (2)	0·274 (4)	4·5 (8)
H(8*a*1)	0·652 (4)	0·206 (3)	0·483 (6)	8·4 (15)
H(8*b*1)	0·592 (3)	0·159 (2)	0·360 (5)	4·6 (10)
H(8*c*1)	0·620 (3)	0·141 (2)	0·536 (5)	6·0 (11)
H(22)	0·103 (3)	0·010 (2)	0·205 (4)	5·1 (8)
H(32)	0·313 (3)	0·134 (2)	0·198 (5)	5·2 (9)
H(42)	0·447 (3)	0·064 (2)	0·090 (5)	5·7 (10)
H(8*a*2)	0·010 (4)	0·160 (3)	0·113 (6)	8·7 (15)
H(8*b*2)	0·032 (3)	−0·110 (2)	0·234 (5)	5·3 (11)
H(8*c*2)	0·002 (4)	−0·090 (2)	0·051 (5)	6·8 (11)

* H atoms are numbered according to the C atoms to which they are attached.

The chemical formula of the title compound is analogous to that of oltipraz (Wei, 1983) in that a pyrazine ring and a 4-methyl-1,2-dithiol-3-one ring are linked *via* the C(1)—C(7) bond, as shown in Fig. 2. Bond lengths, bond angles and their corresponding e.s.d.'s, shown in the figure, were calculated by the program *ORFFE*4 (Busing, Martin & Levy, 1964). The corresponding bond lengths and angles for the two crystallographically independent molecules are similar, the maximum difference in bond lengths and angles (not including H atoms) being 0·011 (7) Å for C(6)—C(8) and 1·1 (4)° for C(7)—C(1)—C(2).

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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 42334 (8 pp.). Copies may be obtained through The Executive Secretary, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

* The first number in parentheses designates the atom number; the second number, 1 or 2, represents either molecule (1) or molecule (2). When only one number is given in parentheses, it implies that particular atom in both molecule (1) and molecule (2).

Molecular parameters for the pyrazine and the five-membered heterocyclic ring systems for oltipraz have been compared with other related compounds in some detail (Wei, 1983). Since the title compound is analogous to oltipraz, many of those comparisons remain valid. For the pyrazine rings in the present compound, the angles at the N atoms are all less than 120°, ranging from 115·9 (3) to 116·9 (3)°. The average of the four C—N—C angles is 116·3 (2)°, in close agreement with the 116·7 (1)° observed for oltipraz. In contrast, the angles at the C atoms for the pyrazine rings are all larger than 120° [with one exception of 119·8 (3)° for N(11)—C(11)—C(21)], the average of eight being 121·7 (1)°, again in excellent agreement with the 121·6 (1)° found for oltipraz.

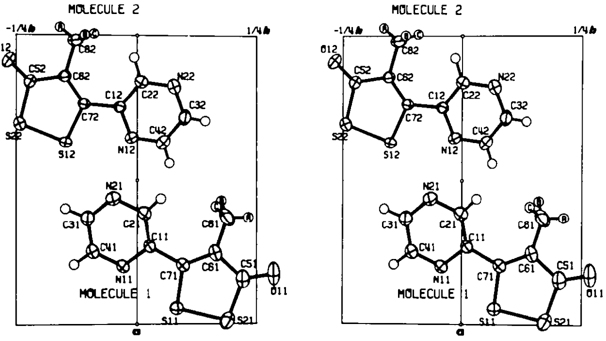

Fig. 1. Numbering scheme and arrangement of the two independent molecules in an asymmetric unit shown in a stereoscopic pair viewed perpendicular to the *ab* plane. Figs. 1 and 2 were prepared with the program *ORTEP*II (Johnson, 1976).

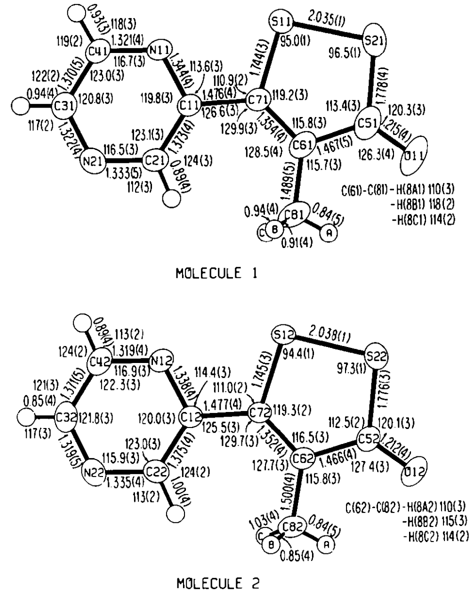

Fig. 2. Bond lengths (Å) and bond angles (°) for the two independent molecules.

For the five-membered heterocyclic ring system, the S(11)—S(21) and S(12)—S(22) bond lengths of 2·035 (1) and 2·038 (1) Å are shorter than the corresponding values of 2·049 (1) and 2·041 (1) Å reported for oltipraz. The average value of 2·037 (1) Å for S(1)—S(2) in the title compound, however, still lies in the range [1·999 (5) Å for tetraethylthiuram disulfide (Karle, Estlin & Britts, 1967) to 2·083 (6) Å for 3,3′-trithiodi(2,4-pentanedione) (Power & Jones, 1971)] reported for many other S—S bond lengths for noncyclic structures. It is understood that this S—S bond length depends upon different degrees of double-bond character arising from overlap of the $p\pi$ electron pairs of one divalent S atom with available $3d$ orbitals of a bond partner (Foss & Tjomsland, 1958). The double-bond characters for C(61)—C(71) and C(62)—C(72) are evidenced by the bond lengths of 1·354 (4) and 1·352 (4) Å in molecule (1) and molecule (2), respectively.

The endocyclic S(11)—C(71) and S(12)—C(72) bond lengths of 1·744 (3) and 1·745 (3) Å are close to the 1·741 (2) and 1·738 (2) Å observed in oltipraz. However, it is of interest to note that the S(21)—C(51) and S(22)—C(52) bond lengths of 1·778 (4) and 1·776 (3) Å are longer than S(11)—C(71) and S(12)—C(72), respectively, while in the structure of oltipraz the corresponding S(1)—C(7) values of 1·719 (2) and 1·717 (2) Å are shorter than those for S(2)—C(5). Presumably this disagreement is due to the fact that an O atom is attached to C(5) in the title compound while it is an S atom that is bonded to C(5) in the case of oltipraz. To the extent the O atom is more strongly bonded to C(5) than is the S atom, a longer S(2)—C(3) bond in the title compound than in oltipraz is expected.

The C(51)—O(11) and C(52)—O(12) distances of 1·215 (4) and 1·212 (4) Å are slightly shorter than the ordinary double bond of 1·23 (1) Å quoted for aldehydes, ketones, carboxylic acids, and esters, and are suggestive of shortened (partial triple bond) double-bond character (Kennard, 1962).

As expected, the central C—C single-bond length [1·476 (4) and 1·477 (4) Å] is shorter than the normal value of 1·544 Å due to conjugated environments, a fact also observed for oltipraz.

The bonding of C(6)—C(8) as well as the arrangements of all H atoms appear normal. The intramolecular separations H(2)···C(8) are 2·65 (4) Å in molecule (1) and 2·52 (4) Å in molecule (2). The rotation of three methyl H atoms around the C(6)—C(8) bonds results in H(21)···H(8*b*1) and H(21)···H(8*c*1) distances of 2·50 (5) and 2·18 (5) Å in molecule (1); the corresponding separations are 2·17 (5) and 2·24 (5) Å in molecule (2).

In each molecule the five- and six-membered rings are essentially planar, as can be seen in Table 2. Among these four molecular planes, the maximum deviation is that of C(62) in plane (*c*), being −0·011 (2) Å. In order

Table 2. *Equations of best molecular planes, and distances* (Å) *of atoms from these planes*

Root-mean-square deviations of the fitted atoms for planes (*a*), (*b*), (*c*) and (*d*) are 0·005 (1), 0·006 (2), 0·007 (1) and 0·004 (2), respectively. Calculations were performed with program *ORFFE*4 (Busing, Martin & Levy, 1964). *X*, *Y* and *Z* represent direct-axis coordinates expressed in Å.

$$(a)\quad 0{\cdot}1576X - 0{\cdot}1430Y + 0{\cdot}9552Z = 3{\cdot}9926$$
$$(b)\quad 0{\cdot}2313X - 0{\cdot}1688Y + 0{\cdot}9287Z = 4{\cdot}5501$$
$$(c)\quad -0{\cdot}1261X + 0{\cdot}1509Y - 0{\cdot}9619Z = -1{\cdot}3714$$
$$(d)\quad -0{\cdot}2816X + 0{\cdot}1991Y - 0{\cdot}9040Z = -2{\cdot}0470$$

	(*a*)		(*b*)		(*c*)		(*d*)
S(11)	0·007 (1)	N(11)	−0·003 (2)	S(12)	−0·002 (1)	N(12)	−0·001 (2)
S(21)	−0·006 (2)	C(11)	−0·004 (3)	S(22)	−0·003 (1)	C(12)	−0·002 (2)
C(51)	0·004 (2)	C(21)	0·005 (3)	C(52)	0·008 (2)	C(22)	0·000 (3)
C(61)	0·002 (2)	N(21)	0·001 (3)	C(62)	−0·011 (2)	N(22)	0·004 (3)
C(71)	−0·007 (2)	C(31)	−0·008 (3)	C(72)	0·008 (2)	C(32)	−0·007 (3)
O(11)*	0·016 (5)	C(41)	0·009 (3)	O(12*	0·026 (5)	C(42)	0·005 (3)
C(81)*	−0·023 (7)	C(71)*	0·021 (5)	C(82)*	−0·034 (7)	C(72)*	−0·056 (5)
C(11)*	−0·014 (5)	H(21)*	0·08 (4)	C(12)*	0·005 (5)	H(22)*	0·04 (3)
H(8*a*1)*	0·12 (5)	H(31)*	0·06 (4)	H(8*a*2)*	0·09 (5)	H(32)*	−0·04 (4)
H(8*b*1)*	−0·74 (4)	H(41)*	0·00 (3)	H(8*b*2)*	−0·70 (4)	H(42)*	−0·03 (4)
H(8*c*1)*	0·63 (4)			H(8*c*2)*	0·73 (4)		

* Atoms not included in the calculation of the least-squares plane.

to alleviate in part the intramolecular strain, the five- and six-membered rings in each molecule are twisted away from each other by a rotation around the C(1)—C(7) bonds, resulting in an angle of 4·6 (1)° between the plane normals for molecule (1), while the corresponding value for molecule (2) is 9·6 (1)°. The difference of 5·0 (1)° in these two dihedral angles is noticeable, as is the difference between the two independent molecules of oltipraz [5·2 (1)°]. The measure of this twist between the pyrazine ring and the 1,2-dithiole ring can also be expressed in terms of the torsion angles S(1)—C(7)—C(1)—N(1). For molecules (1) and (2), these values are −4·4 (4) and 8·9 (3)°, respectively. It should be noted that the signs of these values change for the inverted molecules.

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Structure of 8-Benzyl-4-thia-1,8-diazabicyclo[4.3.0]nonane-2,7,9-trione*

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Abstract. $C_{13}H_{12}N_2O_3S$, $M_r = 276{\cdot}3$, orthorhombic, *Pcab* (non-standard setting of *Pbca*). $a = 8{\cdot}851$ (2), $b = 12{\cdot}035$ (2), $c = 23{\cdot}506$ (3) Å, $V = 2504$ Å^3, $Z = 8$, $D_m = 1{\cdot}458$, $D_x = 1{\cdot}466$ Mg m^{-3}, λ(Mo $K\alpha$) = 0·7107 Å, $\mu = 0{\cdot}256$ mm^{-1}, $F(000) = 1152$, $T = 293$ K. $R = 0{\cdot}067$ for 1491 observed reflections. The hydantoin ring is planar while the thiazine ring adopts a

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