Table 2. *Selected geometric parameters* (Å, °)

S1—O1	1.410 (3)	C2—C3	1.521 (4)
S1—O2	1.413 (2)	C2—C4	1.534 (5)
S1—O3	1.549 (2)	C2—C5	1.580 (4)
S1—O4	1.549 (2)	C5—C6	1.534 (5)
O3—C1	1.486 (4)	C5—C7	1.533 (5)
O4—C3	1.478 (4)	C5—C8	1.537 (5)
C1—C2	1.521 (4)		
O1—S1—O2	119.9 (2)	C1—C2—C4	109.1 (3)
O1—S1—O3	106.85 (14)	C3—C2—C5	109.3 (2)
O2—S1—O3	110.14 (14)	C1—C2—C5	109.3 (2)
O1—S1—O4	106.66 (15)	C4—C2—C5	112.4 (3)
O2—S1—O4	109.82 (14)	O4—C3—C2	111.1 (2)
O3—S1—O4	101.97 (11)	C6—C5—C7	108.3 (3)
C1—O3—S1	115.8 (2)	C6—C5—C8	108.0 (3)
C3—O4—S1	114.7 (2)	C7—C5—C8	107.8 (4)
O3—C1—C2	110.9 (3)	C6—C5—C2	110.1 (3)
C3—C2—C1	108.3 (3)	C7—C5—C2	110.2 (3)
C3—C2—C4	108.4 (3)	C8—C5—C2	112.3 (3)

Table 3. *Comparison of selected geometric parameters* (Å, °) *for* (1) *and* (2)

	(1)	(2)
S1—O1	1.409	1.412
S1—O2	1.409	1.415
S1—O3	1.548	1.552
S1—O4	1.549	1.551
C3—O4	1.473	1.481
C1—O3	1.485	1.482
C2—C3	1.523	1.494
C1—C2	1.527	1.513
C2—C5 (Cα—Cβ)	1.575	-
O1—S1—O2	120.1	119.50
O3—S1—O4	101.9	102.60
O4—C3—C2	111.3	109.40
O3—C1—C2	110.7	109.00
O1—S1—O3	106.8	107.10
O2—S1—O4	109.7	109.50

The data were collected with scan rate of 1.3–5.9 min^{-1}, ω scan width of $(0.85 + 0.35\tan\theta)^\circ$ and aperture setting of 4 mm. The structure was solved by direct methods. All non-H atoms were located in the best *E* map. A subsequent difference map revealed the H-atom positions. Refinement was by least squares, with non-H atoms anisotropic and H atoms isotropic. The calculations were performed on a PC (IBM, AT-compatible).

Data collection: CAD-4/PC diffractometer software. Cell refinement: CAD-4/PC diffractometer software. Data reduction: CAD-4/PC diffractometer software. Program(s) used to solve structure: *SHELXS*86 (Sheldrick, 1990). Program(s) used to refine structure: *SHELXL*93 (Sheldrick, 1993). Molecular graphics: *PLUTON* (Spek, 1993). Software used to prepare material for publication: *SHELXL*93.

Lists of structure factors, anisotropic displacement parameters, H-atom coordinates and complete geometry have been deposited with the IUCr (Reference: HU1071). Copies may be obtained through The Managing Editor, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

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Scalaradial, a Sesterterpenoid Metabolite from the Marine Sponge *Cacospongia mollior*

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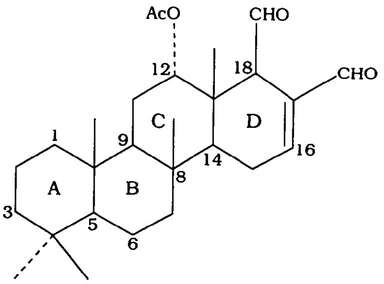
Abstract

The X-ray study of scalaradial [Cimino, De Stefano & Minale (1974). *Experientia*, **30**, 846–847], the major secondary metabolite from the marine sponge *Cacospongia mollior*, is reported. In the crystal of 12-(acetyloxy)-4,4,8-trimethyl-D-homoandrost-16-ene-17,17a-dicarboxaldehyde, $C_{27}H_{40}O_4$, the asymmetric unit comprises two molecules which display high geometrical and conformational similarity. All the saturated rings are in chair conformations, whereas the cyclohexene ring adopts a half-chair form. The molecule is highly bent in a direction normal to the average skeletal plane, with rings *A* and *C* forming an angle of about 30°. The four axial iso-oriented methyl groups in the tetracyclic system produce distortions of the skeletal geometry similar to those observed in other molecules with analogous sequences of axial substituents, and are probably responsible for the remarkable bend of the skeleton.

Comment

Among marine organisms, sponges are a particularly rich source of sesterterpenoids (Faulkner, 1994, and references therein). These substances often display multiple biological activities or are interesting as potential chemotherapeutic agents. In the course of our studies concerning structural elucidations and biological features of marine natural products, we were interested in crystal studies of new minor metabolites from the widespread sponge *Cacospongia mollior*, such as the cacospongionolide acetyl derivative (Puliti, De Rosa, Mattia & Mazzarella, 1990) and 12-deacetoxyscalaradial (De Rosa, Puliti, Crispino, De Giulio, Mattia & Mazzarella, 1994). These sesterterpenes have an important ecological role in preventing predation, as they develop an antifeedant effect in fish. For comparison with the strictly correlated 12-deacetoxyscalaradial (De Rosa *et al.*, 1994) and similar molecules, we have performed the X-ray analysis of scalaradial, the main metabolite from the sponge *C. mollior*. Scalaradial, (I), first studied by Cimino, De Stefano & Minale (1974), is a tetracyclic scalarane-type sesterterpene which has two vicinal aldehydic functions adjacent to an endocyclic unsaturation. Studies have shown that the biological activity of these sesqui- and sesterterpenoid dialdehydes is closely dependent on the stereochemistry of the vicinal aldehyde groups and also on the distance between the carbonyl groups (Cimino, Sodano & Spinella, 1987; Caprioli, Cimino, Colle, Gavagnin, Sodano & Spinella, 1987).



(I)

In the scalaradial crystal, the asymmetric unit is formed by two molecules which exhibit a high degree of geometrical and conformational similarity. They are related by a pseudo-translation of nearly **a**/2 + **b**/4, coupled to a 10° rotation about an axis roughly perpendicular to the skeletal plane. On superposition, the r.m.s. deviation of the corresponding atoms in the two molecules is only 0.15 Å, the largest differences (< 0.43 Å) being associated with hetero-methyl substituents.

A view of one molecule, approximately on the average plane through the rings, with the atomic labelling is shown in Fig. 1; labels for the second molecule have been increased by fifty. In the absence of atoms having strong anomalous scattering, the absolute stereochemistry was not determined and the configuration shown was chosen in accordance with that of the scalarane skeleton (Kazlauskas, Murphy, Wells & Daly, 1980; Cimino, De Rosa, De Stefano, Puliti, Strazzullo, Mattia & Mazzarella, 1987). On this basis, the relative configurations at the C12 and C18 chiral centres were fixed by the present analysis as S^* and R^*, respectively. The molecule is characterized by a tetracarbocyclic scalarane-type skeleton, which displays, as well as the methyl substituents (three of which are in axial β orientations at atoms C8, C10 and C13, respectively), an α-oriented acetoxy group at C12 and two aldehydic functions at C17 and C18 adjacent to the intracycle unsaturation, C16=C17. The β orientation of the equatorial aldehyde group at C18 has been correlated to biological activity (De Rosa *et al.*, 1994, and references therein).

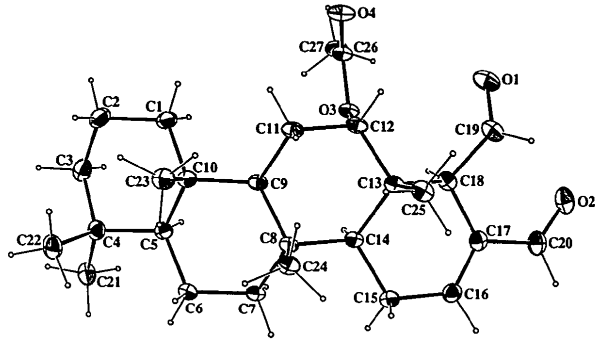


Fig. 1. View of the scalaradial molecule approximately on the average ring plane, with the atomic labelling for non-H atoms. Displacement ellipsoids are drawn at the 30% probability level.

The differences between the corresponding geometrical values in the two independent molecules are within experimental error. The presence of four axial iso-oriented methyl groups in the tetracyclic system gives rise to distortions in the skeletal geometry similar to those observed in other molecules with analogous sequences of axial substituents (Mattia, Mazzarella, Puliti, Riccio & Minale, 1988; Cimino *et al.*, 1987; Croft, Ghisalberti, Skelton & White, 1983). In particular, the lengthening of C—C bond distances within the central core of the molecule, from atoms C4 to C18, and the widening of angles C4—C5—C10, C8—C9—C10 and C8—C14—C13 (Table 2) are similar to those found in 12-deacetoxyscalaradial (De Rosa *et al.*, 1994).

All the saturated rings are in chair conformations, whereas the cyclohexene ring adopts a half-chair form that is distorted in the first molecule towards a half boat. Conformational details for each ring are reported in the supplementary material, together with puckering parameters (Cremer & Pople, 1975), which show the distortion from the ideal form. The acetoxy groups are strictly planar with the carbonyl O atoms *cis* to ring atoms C12 and C62. With respect to 12-deacetoxyscalaradial, the presence in (I) of an acetoxy substituent in the 12 position, does not affect the orientation of the β-axial aldehyde group, determined by the intramolecular contacts with the adjacent substituents.

The title molecule presents a remarkable bend in the skeleton approximately normal to the mean molecular plane (Fig. 2). This bending can be quantified by the angle between the average planes of rings *A* and *C*, which is close to 30° in both molecules. Similar bending has been observed for 12-deacetoxyscalaradial, indicating that it is the result of the short contacts between the axial methyl groups [C—C distances $\geq 3.137(4)$ Å] rather than the crystal packing (Fig. 3), which is governed only by normal van der Waals interactions.

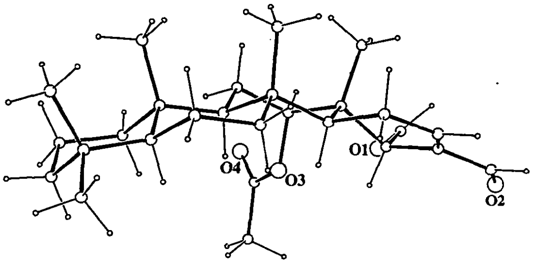


Fig. 2. View of the scalaradial molecule approximately normal to the average molecular plane, showing the bending of the skeleton.

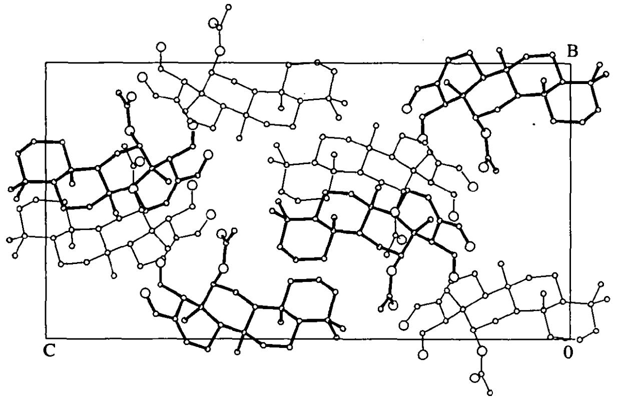


Fig. 3. The crystal packing projected onto the *bc* plane. Fine and thick lines indicate the two independent molecules in the asymmetric unit.

Experimental

Crystals of scalaradial were obtained by slow evaporation of an ethanol–ethyl ether solution of the compound.

Crystal data

$C_{27}H_{40}O_4$
$M_r = 428.58$
Orthorhombic
$P2_12_12_1$
$a = 12.139(3)$ Å
$b = 14.635(3)$ Å
$c = 27.951(7)$ Å
$V = 4966(2)$ Å^3
$Z = 8$
$D_x = 1.15$ Mg m^{-3}

Cu *Kα* radiation
$\lambda = 1.5418$ Å
Cell parameters from 25 reflections
$\theta = 24$–$28°$
$\mu = 0.559$ mm^{-1}
$T = 293$ K
Prism
0.8 × 0.4 × 0.3 mm
Colourless

Data collection

Enraf–Nonius CAD-4F diffractometer
ω–2θ scans
Absorption correction: refined from ΔF (*DIFABS*; Walker & Stuart, 1983)
$T_{\min} = 0.798$, $T_{\max} = 1.000$
5739 measured reflections

5739 independent reflections
5031 observed reflections [$I \geq 2\sigma(I)$]
$\theta_{\max} = 76°$
$h = 0 \rightarrow 16$
$k = 0 \rightarrow 19$
$l = 0 \rightarrow 35$
3 standard reflections
frequency: 240 min
intensity decay: 3%

Refinement

Refinement on *F*
$R = 0.040$
$wR = 0.039$
$S = 0.89$
5031 reflections
560 parameters
H-atom parameters not refined
$w = 1/[\sigma^2(F_o) + (0.01F_o)^2 + 0.6]$ (Killean & Lawrence, 1969)

$(\Delta/\sigma)_{\max} = 0.01$
$\Delta\rho_{\max} = 0.15$ e Å^{-3}
$\Delta\rho_{\min} = -0.10$ e Å^{-3}
Extinction correction: Stout & Jensen (1968)
Extinction coefficient: $9.2(1) \times 10^{-7}$
Atomic scattering factors from *International Tables for X-ray Crystallography* (1974, Vol. IV)

Table 1. *Fractional atomic coordinates and equivalent isotropic displacement parameters* (Å^2)

$$B_{\rm eq} = (1/3)\Sigma_i\Sigma_j B_{ij}a_i^*a_j^*\mathbf{a}_i.\mathbf{a}_j.$$

	x	*y*	*z*	$B_{\rm eq}$
O1	0.9464 (3)	0.4437 (2)	0.22115 (9)	12.42 (8)
O2	1.1818 (2)	0.5508 (2)	0.18438 (7)	8.42 (6)
O3	0.9306 (1)	0.45801 (9)	0.33294 (6)	4.79 (3)
O4	0.7917 (2)	0.3602 (1)	0.31987 (8)	7.68 (5)
C1	0.7789 (2)	0.5075 (2)	0.4643 (1)	6.26 (7)
C2	0.7465 (3)	0.4984 (2)	0.5169 (1)	7.86 (8)
C3	0.8386 (3)	0.5314 (2)	0.5495 (1)	7.47 (8)
C4	0.8760 (2)	0.6292 (2)	0.54024 (9)	5.82 (6)
C5	0.9027 (2)	0.6376 (2)	0.48583 (9)	4.92 (5)
C6	0.9505 (2)	0.7297 (2)	0.47089 (9)	5.45 (5)
C7	1.0050 (2)	0.7234 (2)	0.42192 (9)	5.14 (5)
C8	0.9265 (2)	0.6905 (2)	0.38221 (8)	4.63 (5)
C9	0.8674 (2)	0.6025 (1)	0.39979 (8)	4.45 (5)
C10	0.8121 (2)	0.6057 (2)	0.45017 (9)	5.06 (5)
C11	0.7933 (2)	0.5653 (2)	0.35951 (9)	5.23 (5)
C12	0.8620 (2)	0.5346 (2)	0.31716 (9)	5.01 (5)
C13	0.9379 (2)	0.6097 (2)	0.29715 (8)	4.79 (5)
C14	0.9989 (2)	0.6599 (2)	0.33872 (8)	4.62 (5)
C15	1.0733 (2)	0.7365 (2)	0.31953 (9)	5.97 (6)
C16	1.1329 (2)	0.7115 (2)	0.27551 (9)	5.91 (6)
C17	1.1146 (2)	0.6356 (2)	0.25054 (9)	5.43 (5)
C18	1.0283 (2)	0.5661 (2)	0.26470 (9)	5.33 (5)
C19	0.9762 (3)	0.5210 (2)	0.2212 (1)	7.64 (8)
C20	1.1861 (3)	0.6181 (2)	0.20966 (9)	6.74 (7)
C21	0.9820 (3)	0.6454 (2)	0.5694 (1)	7.52 (8)
C22	0.7895 (3)	0.6982 (2)	0.5582 (1)	7.74 (8)
C23	0.7071 (2)	0.6654 (2)	0.4494 (1)	6.51 (7)
C24	0.8483 (2)	0.7708 (2)	0.3699 (1)	6.15 (6)
C25	0.8661 (2)	0.6744 (2)	0.26655 (9)	5.99 (6)
C26	0.8840 (2)	0.3745 (2)	0.33179 (9)	5.41 (5)
C27	0.9642 (2)	0.3038 (2)	0.3485 (1)	6.38 (7)
O51	0.4154 (2)	0.2252 (1)	0.22041 (8)	8.95 (6)
O52	0.6549 (2)	0.3350 (1)	0.18975 (7)	7.54 (5)
O53	0.4341 (1)	0.24608 (9)	0.34007 (6)	4.92 (3)
O54	0.3269 (2)	0.1218 (1)	0.33599 (7)	7.54 (5)
C51	0.2589 (3)	0.2907 (2)	0.4685 (1)	6.86 (7)
C52	0.2286 (3)	0.2864 (2)	0.5218 (1)	8.21 (8)
C53	0.3166 (3)	0.3313 (2)	0.5524 (1)	8.12 (8)
C54	0.3423 (2)	0.4316 (2)	0.53911 (9)	6.34 (7)

C55	0.3665 (2)	0.4345 (2)	0.48443 (9)	5.19 (5)
C56	0.3995 (2)	0.5287 (2)	0.46590 (9)	5.90 (6)
C57	0.4515 (2)	0.5228 (2)	0.41641 (9)	5.51 (6)
C58	0.3771 (2)	0.4759 (2)	0.37886 (8)	4.48 (5)
C59	0.3357 (2)	0.3844 (2)	0.40050 (8)	4.44 (5)
C60	0.2799 (2)	0.3896 (2)	0.45077 (9)	5.08 (5)
C61	0.2713 (2)	0.3307 (2)	0.36266 (9)	5.02 (5)
C62	0.3452 (2)	0.3031 (2)	0.32131 (8)	4.72 (5)
C63	0.3997 (2)	0.3852 (2)	0.29663 (8)	4.42 (5)
C64	0.4507 (2)	0.4509 (1)	0.33460 (8)	4.41 (4)
C65	0.5010 (2)	0.5352 (2)	0.30984 (9)	5.46 (5)
C66	0.5703 (2)	0.5099 (2)	0.26861 (9)	5.47 (5)
C67	0.5688 (2)	0.4280 (2)	0.24769 (8)	5.08 (5)
C68	0.4949 (2)	0.3516 (2)	0.26310 (8)	4.79 (5)
C69	0.4460 (3)	0.3029 (2)	0.2201 (1)	6.37 (6)
C70	0.6482 (2)	0.4088 (2)	0.2099 (1)	6.39 (6)
C71	0.4466 (3)	0.4604 (3)	0.5669 (1)	8.9 (1)
C72	0.2480 (3)	0.4942 (2)	0.5555 (1)	7.49 (7)
C73	0.1677 (2)	0.4385 (2)	0.4491 (1)	6.60 (7)
C74	0.2845 (2)	0.5446 (2)	0.3658 (1)	6.00 (6)
C75	0.3116 (2)	0.4321 (2)	0.26550 (9)	5.62 (6)
C76	0.4155 (3)	0.1562 (2)	0.34416 (9)	5.65 (6)
C77	0.5168 (3)	0.1082 (2)	0.3592 (1)	7.93 (8)

Table 2. *Selected geometric parameters* (Å, °)

O1—C19	1.187 (4)	O51—C69	1.196 (3)
O2—C20	1.214 (4)	O52—C70	1.221 (4)
O3—C12	1.465 (3)	O53—C62	1.461 (3)
O3—C26	1.347 (3)	O53—C76	1.340 (3)
O4—C26	1.187 (3)	O54—C76	1.209 (4)
C1—C2	1.528 (5)	C51—C52	1.536 (4)
C1—C10	1.544 (4)	C51—C60	1.551 (4)
C2—C3	1.520 (5)	C52—C53	1.519 (5)
C3—C4	1.524 (4)	C53—C54	1.546 (4)
C4—C5	1.560 (4)	C54—C55	1.557 (4)
C4—C21	1.542 (4)	C54—C71	1.545 (4)
C4—C22	1.541 (4)	C54—C72	1.536 (4)
C5—C6	1.526 (3)	C55—C56	1.527 (4)
C5—C10	1.556 (3)	C55—C60	1.557 (3)
C6—C7	1.523 (4)	C56—C57	1.523 (4)
C7—C8	1.540 (3)	C57—C58	1.546 (3)
C8—C9	1.555 (3)	C58—C59	1.552 (3)
C8—C14	1.565 (3)	C58—C64	1.570 (3)
C8—C24	1.551 (3)	C58—C74	1.551 (3)
C9—C10	1.561 (3)	C59—C60	1.562 (3)
C9—C11	1.540 (3)	C59—C61	1.532 (3)
C10—C23	1.545 (3)	C60—C73	1.539 (4)
C11—C12	1.516 (3)	C61—C62	1.518 (3)
C12—C13	1.539 (3)	C62—C63	1.535 (3)
C13—C14	1.562 (3)	C63—C64	1.560 (3)
C13—C18	1.561 (3)	C63—C68	1.567 (3)
C13—C25	1.545 (4)	C63—C75	1.540 (3)
C14—C15	1.536 (3)	C64—C65	1.540 (3)
C15—C16	1.474 (4)	C65—C66	1.474 (4)
C16—C17	1.331 (4)	C66—C67	1.333 (3)
C17—C18	1.513 (4)	C67—C68	1.497 (3)
C17—C20	1.458 (4)	C67—C70	1.458 (4)
C18—C19	1.521 (4)	C68—C69	1.519 (4)
C26—C27	1.495 (4)	C76—C77	1.477 (4)
C12—O3—C26	116.6 (2)	C62—O53—C76	117.8 (2)
C2—C1—C10	113.2 (2)	C52—C51—C60	112.8 (2)
C1—C2—C3	111.1 (3)	C51—C52—C53	111.2 (3)
C2—C3—C4	114.6 (3)	C52—C53—C54	114.6 (3)
C3—C4—C5	107.6 (2)	C53—C54—C55	107.5 (2)
C3—C4—C21	107.7 (2)	C53—C54—C71	107.7 (3)
C3—C4—C22	110.9 (2)	C53—C54—C72	110.2 (3)
C5—C4—C21	109.3 (2)	C55—C54—C71	109.3 (2)
C5—C4—C22	114.0 (2)	C55—C54—C72	114.7 (2)
C21—C4—C22	107.2 (2)	C71—C54—C72	107.3 (2)
C4—C5—C6	114.6 (2)	C54—C55—C56	114.0 (2)
C4—C5—C10	117.0 (2)	C54—C55—C60	117.0 (2)
C6—C5—C10	111.0 (2)	C56—C55—C60	110.7 (2)
C5—C6—C7	110.9 (2)	C55—C56—C57	111.4 (2)
C6—C7—C8	113.5 (2)	C56—C57—C58	113.6 (2)
C7—C8—C9	108.5 (2)	C57—C58—C59	107.9 (2)
C7—C8—C14	107.6 (2)	C57—C58—C64	107.8 (2)
C7—C8—C24	107.5 (2)	C57—C58—C74	107.2 (2)
C9—C8—C14	105.6 (2)	C59—C58—C64	106.9 (2)
C9—C8—C24	114.6 (2)	C59—C58—C74	114.6 (2)
C14—C8—C24	112.8 (2)	C64—C58—C74	112.2 (2)
C8—C9—C10	117.3 (2)	C58—C59—C60	116.7 (2)
C8—C9—C11	109.3 (2)	C58—C59—C61	109.8 (2)
C10—C9—C11	114.8 (2)	C60—C59—C61	115.1 (2)
C1—C10—C5	107.5 (2)	C51—C60—C55	108.2 (2)
C1—C10—C9	108.4 (2)	C51—C60—C59	108.3 (2)
C1—C10—C23	108.4 (2)	C51—C60—C73	107.4 (2)
C5—C10—C9	106.4 (2)	C55—C60—C59	105.7 (2)
C5—C10—C23	114.9 (2)	C55—C60—C73	114.8 (2)
C9—C10—C23	111.0 (2)	C59—C60—C73	112.3 (2)
C9—C11—C12	110.8 (2)	C59—C61—C62	111.1 (2)
O3—C12—C11	107.7 (2)	O53—C62—C61	108.4 (2)
O3—C12—C13	108.4 (2)	O53—C62—C63	106.9 (2)
C11—C12—C13	113.6 (2)	C61—C62—C63	112.9 (2)
C12—C13—C14	110.5 (2)	C62—C63—C64	110.3 (2)
C12—C13—C18	109.9 (2)	C62—C63—C68	110.0 (2)
C12—C13—C25	107.5 (2)	C62—C63—C75	107.7 (2)
C14—C13—C18	106.9 (2)	C64—C63—C68	107.9 (2)
C14—C13—C25	113.0 (2)	C64—C63—C75	112.6 (2)
C18—C13—C25	109.0 (2)	C68—C63—C75	108.3 (2)
C8—C14—C13	116.5 (2)	C58—C64—C63	117.0 (2)
C8—C14—C15	113.1 (2)	C58—C64—C65	113.2 (2)
C13—C14—C15	111.3 (2)	C63—C64—C65	110.2 (2)
C14—C15—C16	113.5 (2)	C64—C65—C66	112.1 (2)
C15—C16—C17	124.3 (2)	C65—C66—C67	124.1 (2)
C16—C17—C18	122.7 (2)	C66—C67—C68	123.6 (2)
C16—C17—C20	117.2 (2)	C66—C67—C70	118.8 (2)
C18—C17—C20	120.0 (2)	C68—C67—C70	117.4 (2)
C13—C18—C17	111.3 (2)	C63—C68—C67	112.3 (2)
C13—C18—C19	110.5 (2)	C63—C68—C69	109.4 (2)
C17—C18—C19	111.7 (2)	C67—C68—C69	110.9 (2)
O1—C19—C18	122.7 (3)	O51—C69—C68	124.1 (3)
O2—C20—C17	124.9 (3)	O52—C70—C67	123.3 (3)
O3—C26—O4	124.3 (2)	O53—C76—O54	122.8 (2)
O3—C26—C27	110.3 (2)	O53—C76—C77	110.5 (2)
O4—C26—C27	125.5 (2)	O54—C76—C77	126.6 (2)
C26—O3—C12—C13	−152.0 (2)	C76—O53—C62—C63	−151.5 (2)
C12—O3—C26—O4	−1.5 (4)	C62—O53—C76—O54	−4.9 (3)
C21—C4—C5—C10	168.8 (2)	C71—C54—C55—C60	168.2 (2)
C22—C4—C5—C10	−71.3 (3)	C72—C54—C55—C60	−71.2 (3)
C6—C5—C10—C23	−66.2 (3)	C56—C55—C60—C73	−65.9 (3)
C24—C8—C9—C10	−70.0 (3)	C74—C58—C59—C60	−66.7 (3)
C25—C13—C14—C8	73.4 (3)	C75—C63—C64—C58	73.9 (2)
C15—C16—C17—C18	0.6 (4)	C65—C66—C67—C68	0.9 (4)
C16—C17—C20—O2	177.7 (3)	C66—C67—C70—O52	177.8 (3)
C17—C18—C19—O1	146.4 (3)	C67—C68—C69—O51	154.5 (3)

H atoms were placed on the basis of geometric considerations and ΔF map suggestions (for hydroxyl and methyl groups). All H atoms were included as fixed atoms in the final refinement, with isotropic displacement parameters set equal to B_{eq} of the parent atoms.

The structure was solved by means of the *SIR*88 package (Burla *et al.*, 1989). For the crystallographic data, the equipment of the CIMCF of the University 'Federico II' of Naples was used. All calculations were performed using Enraf–Nonius *SDP* software (B. A. Frenz & Associates, Inc., 1985) on a MicroVAX 3100 computer.

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Lists of structure factors, anisotropic displacement parameters, H-atom coordinates and conformational details for each ring, including puckering parameters, have been deposited with the IUCr (Reference: NA1154). Copies may be obtained through The Managing Editor, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

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Salicylaldehyde Semicarbazone–Acetic Acid Hydrogen-Bonded Complex

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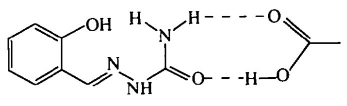
Abstract

The crystals of $C_8H_9N_3O_2.C_2H_4O_2$ consist of a one-to-one ratio of salicylaldehyde semicarbazone and acetic acid. Each molecule of salicylaldehyde semicarbazone is joined to an acetic acid molecule by a double hydrogen bond. This arrangement is very similar to the typical carboxylic acid dimer. The crystal structure exhibits a three-dimensional network of hydrogen bonds involving all of the possible hydrogen-bond donors and acceptors in both molecules.

Comment

The use of semicarbazones and thiosemicarbazones as anti-cancer and anti-viral agents has been known for many years (West *et al.*, 1993; Padhye & Kauffman, 1985). In 1956, the activity of pyridine-2-carboxaldehyde thiosemicarbazone in the lymphoid-leukaemia-1210 test was reported (Ali & Livingstone, 1974). In 1990, the compounds 2-acetylpyridine semicarbazone and thiosemicarbazone were reported to show activity against type-2 herpes simplex viral infections (Sidwell, Huffman, Schafer & Shipman, 1990). While these semicarbazones and thiosemicarbazones were shown to be effective while acting alone, the carcinostatic activity of kethoxal bis(thiosemicarbazone) was enhanced by the presence of Cu and Zn ions (Ali & Livingstone, 1974).

Bismuth drugs have been well documented for hundreds of years and several bismuth complexes, including the subsalicylate and citrate, are currently used to treat gastric disorders (Baxter, 1992). The synthesis of bismuth complexes with semicarbazone ligands seems a natural progression given their well noted activities. Crystals obtained in an unsuccessful attempt to synthesize a bismuth complex with salicylaldehyde semicarbazone (SASC) yielded a unique crystal structure of this ligand with a single molecule of acetic acid (HAc). This arrangement displays a high degree of hydrogen bonding involving SASC in a conformation that is stable enough to prevent the formation of the metal complex.



SASC–HAc

A displacement-ellipsoid drawing (*SHELXTL-Plus*; Sheldrick, 1991) of the molecules with the atom-labelling scheme is presented in Fig. 1. The structure of SASC has been determined previously (Valdés-Martínez, Toscano, Salcedo, Cea-Olivares & Meléndez, 1990). We report the crystal structure of the title compound SASC–HAc, crystallized in a 1:1 ratio. All of the structural features of SASC are similar to those of the previously reported structure. The carbonyl group is in the *anti* conformation with respect to N7, a conformation observed in similar compounds (Soriano-García, Valdés-Martínez & Toscano, 1988; Chattopadhyay, Mazumdar, Banerjee, Ghosh & Mak, 1988; Soriano-García, Valdés-Martinez, Toscano, Gomez-Lara & Villalobos-Penalosa, 1986; Naik & Palenik, 1974; Nardelli, Fava & Giraldi, 1965). Bond lengths and angles of the C1–C8 chain suggest π-electron delocalization along the chain. This delocalization is also supported by the torsion angles along the chain: C2—C1—C7—N7 = −2.3 (4), C1—C7—N7—N8 = −179.5 (3), C7—N7—N8—C8 = 172.0 (2), N7—N8—C8—N8*b* = 7.4 (4) and N7—N8—C8—O8*a* = −172.1 (2)°. The least-squares plane of the semicar-