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Structure of Methyl (1*R*,2*R*,9*R*)-12-Isopropyl-9-methyl-10,13-dioxo-7-phenylthio-tricyclo[7.4.0.0^{2,6}]trideca-6,11-diene-1-carboxylate

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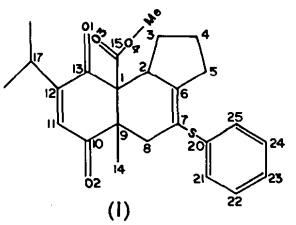
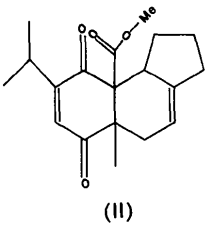
Abstract. $C_{25}H_{28}O_4S$, $M_r = 424{\cdot}56$, monoclinic, $P2_1/n$, $a = 10{\cdot}338\ (2)$, $b = 14{\cdot}538\ (3)$, $c = 15{\cdot}829\ (2)$ Å, $\beta = 106{\cdot}54\ (1)°$, $V = 2281\ (1)$ Å^3, $Z = 4$, $D_x = 1{\cdot}236$ g cm^{-3}, λ(Mo $K\alpha$) = 0·71073 Å, $\mu = 1{\cdot}61$ cm^{-1}, $F(000) = 904$, $T = 298$ K, $R = 0{\cdot}050$ for 2029 observed reflections. The five-membered ring is in an envelope conformation with C(3) out of the plane, the cyclohexene ring in a half-chair conformation with C(1) and C(9) out of the plane, and the cyclohexenedione is in a sofa conformation with C(1) out of the plane. The basic tricyclic system adopts an overall hemispherical conformation.

Introduction. The title compound (I) was prepared by a Diels–Alder reaction (Catani & Brocksom, 1989). The crystal structure determination was carried out in order to investigate the influence of the bulky —S—Ph substituent on the overall conformation of the molecule; in particular we were interested in a comparison between (I) and (II) (Zukerman-Schpector, Castellano, De Simone, Brocksom & Catani, 1990). Knowledge of the molecular conformation helps in the prediction of the steric course of subsequent reactions (Trost, 1983) and in the prediction of the orientation of similar Diels–Alder reactions (Woodward & Hoffman, 1970).



(I)



(II)

Experimental. A single colourless crystal of (I) with approximate dimensions 0·15 × 0·28 × 0·30 mm was used for data collection and cell determination on an Enraf–Nonius CAD-4 diffractometer with graphite-monochromatized Mo $K\alpha$ radiation. Unit-cell parameters were obtained from a least-squares refinement of the setting angles of 25 reflections in the θ range 8 to 24°. Intensity data were collected in the $\theta/2\theta$ scan mode up to $\theta_{max} = 25°$; 4087 reflections were measured of which 3935 were independent ($R_{int} = 0{\cdot}016$; $-12 < h < 11$, $0 < k < 17$, $0 < l < 18$) and 2029 with $I > 3\sigma(I)$ were employed in the refinement procedure. Data were corrected for Lorentz and polarization effects. The intensities of two standard reflections (800 and 080) were essentially constant throughout the experiment.

The structure was solved using standard direct methods and difference Fourier techniques. In the final cycles of full-matrix least-squares refinement ($Q = 7{\cdot}46$), all non-H atoms were treated anisotropically. H atoms were included at positions found in difference synthesis, all with a common isotropic temperature factor that refined to $U = 0{\cdot}12$ Å^2. The function minimized was $\sum w(|F_o| - |F_c|)^2$, where $w^{-1} = \sigma^2(F_o) + 0{\cdot}0005F_o^2$ resulting in $R = 0{\cdot}050$, $wR = 0{\cdot}053$ and $S = 1{\cdot}63$. Maximum shift to e.s.d. ratio 0·001 and maximum and minimum electron density in final difference map 0·28 and $-0{\cdot}19$ e Å^{-3}. Scattering factors for non-H atoms were taken from Cromer & Mann (1968) with corrections for anomalous dispersion from Cromer & Liberman (1970); for H atoms from Stewart, Davidson & Simpson (1965). Programs used: *SHELX*76 (Sheldrick, 1976) and *ORTEP* (Johnson, 1965).

Discussion. The final atomic parameters are given in Table 1,* bond distances and angles in Table 2. A

* Lists of H-atom positions, anisotropic thermal parameters and structure factors have been deposited with the British Library Document Supply Centre as Supplementary Publication No. SUP 53222 (23 pp.). Copies may be obtained through The Technical Editor, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

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Table 1. *Final atomic coordinates and isotropic temperature factors* (Å^2)

	x	*y*	*z*	B_{iso}*
S	0·4189 (1)	0·1287 (1)	−0·0835 (1)	5·27 (4)
O(1)	0·1445 (3)	0·1790 (2)	0·0961 (2)	5·0 (1)
O(2)	0·1237 (3)	0·4770 (2)	−0·0909 (2)	5·3 (1)
O(3)	0·2368 (3)	0·4813 (2)	0·1392 (2)	5·0 (1)
O(4)	0·1990 (3)	0·3646 (2)	0·2198 (2)	5·9 (1)
C(1)	0·2580 (4)	0·3238 (3)	0·0925 (3)	3·4 (1)
C(2)	0·3939 (4)	0·2764 (3)	0·1343 (3)	3·9 (1)
C(3)	0·4225 (5)	0·2227 (3)	0·2231 (3)	5·5 (2)
C(4)	0·5468 (5)	0·1666 (3)	0·2214 (3)	6·0 (2)
C(5)	0·5167 (4)	0·1337 (3)	0·1262 (3)	5·1 (2)
C(6)	0·4268 (4)	0·2072 (3)	0·0729 (3)	3·6 (1)
C(7)	0·3731 (4)	0·2107 (3)	−0·0144 (3)	3·7 (1)
C(8)	0·2720 (4)	0·2820 (3)	−0·0594 (3)	3·9 (1)
C(9)	0·2623 (4)	0·3637 (3)	0·0018 (2)	3·4 (1)
C(10)	0·1296 (4)	0·4121 (3)	−0·0414 (3)	3·9 (1)
C(11)	0·0063 (4)	0·3732 (3)	−0·0280 (3)	4·6 (1)
C(12)	0·0050 (4)	0·3010 (3)	0·0243 (3)	4·3 (1)
C(13)	0·1365 (4)	0·2590 (3)	0·0737 (3)	3·8 (1)
C(14)	0·3830 (4)	0·4283 (3)	0·0086 (3)	4·5 (1)
C(15)	0·2312 (4)	0·4004 (3)	0·1515 (3)	4·0 (1)
C(16)	0·1652 (6)	0·4299 (4)	0·2797 (3)	7·4 (2)
C(17)	−0·1205 (5)	0·2564 (3)	0·0350 (4)	6·5 (2)
C(18)	−0·1348 (7)	0·2786 (4)	0·1248 (5)	10·0 (3)
C(19)	−0·2466 (6)	0·2855 (5)	−0·0355 (6)	10·7 (3)
C(20)	0·2652 (4)	0·0702 (3)	−0·1294 (3)	4·0 (1)
C(21)	0·1785 (5)	0·0484 (3)	−0·0798 (3)	5·0 (2)
C(22)	0·0618 (5)	−0·0017 (3)	−0·1175 (4)	6·2 (2)
C(23)	0·0318 (6)	−0·0311 (4)	−0·2017 (4)	6·6 (2)
C(24)	0·1174 (6)	−0·0107 (4)	−0·2515 (3)	6·6 (2)
C(25)	0·2334 (5)	0·0411 (3)	−0·2166 (3)	5·4 (2)

$*B_{iso} = 4/3\sum_i\sum_j B_{ij}\mathbf{a}_i.\mathbf{a}_j$.

Table 2. *Interatomic bond distances* (Å) *and angles* (°)

S—C(7)	1·771 (4)	S—C(20)	1·766 (4)
O(1)—C(13)	1·212 (5)	O(2)—C(10)	1·217 (5)
O(3)—C(15)	1·196 (5)	O(4)—C(15)	1·325 (5)
O(4)—C(16)	1·453 (6)	C(1)—C(2)	1·535 (6)
C(1)—C(9)	1·561 (5)	C(1)—C(13)	1·530 (6)
C(1)—C(15)	1·529 (6)	C(2)—C(3)	1·561 (6)
C(2)—C(6)	1·504 (6)	C(3)—C(4)	1·529 (7)
C(4)—C(5)	1·526 (7)	C(5)—C(6)	1·507 (6)
C(6)—C(7)	1·335 (6)	C(7)—C(8)	1·500 (6)
C(8)—C(9)	1·554 (5)	C(9)—C(10)	1·520 (6)
C(9)—C(14)	1·541 (6)	C(10)—C(11)	1·464 (6)
C(11)—C(12)	1·339 (6)	C(12)—C(13)	1·492 (6)
C(12)—C(17)	1·503 (7)	C(17)—C(18)	1·51 (1)
C(17)—C(19)	1·51 (1)	C(20)—C(21)	1·386 (7)
C(20)—C(25)	1·391 (6)	C(21)—C(22)	1·390 (7)
C(22)—C(23)	1·349 (8)	C(23)—C(24)	1·375 (9)
C(24)—C(25)	1·390 (8)		

C(7)—S—C(20)	102·2 (2)	C(15)—O(4)—C(16)	116·0 (4)
C(2)—C(1)—C(9)	107·5 (3)	C(2)—C(1)—C(13)	114·0 (3)
C(2)—C(1)—C(15)	111·5 (3)	C(9)—C(1)—C(13)	106·7 (3)
C(9)—C(1)—C(15)	110·4 (3)	C(13)—C(1)—C(15)	106·6 (3)
C(1)—C(2)—C(3)	121·9 (3)	C(1)—C(2)—C(6)	111·7 (3)
C(3)—C(2)—C(6)	103·2 (3)	C(2)—C(3)—C(4)	101·3 (4)
C(3)—C(4)—C(5)	104·4 (4)	C(4)—C(5)—C(6)	104·5 (4)
C(2)—C(6)—C(5)	109·2 (3)	C(2)—C(6)—C(7)	122·6 (4)
C(5)—C(6)—C(7)	127·9 (4)	S—C(7)—C(6)	120·5 (3)
S—C(7)—C(8)	116·4 (3)	C(6)—C(7)—C(8)	123·1 (4)
C(7)—C(8)—C(9)	113·1 (3)	C(1)—C(9)—C(8)	108·2 (3)
C(1)—C(9)—C(10)	109·1 (3)	C(1)—C(9)—C(14)	113·4 (3)
C(8)—C(9)—C(10)	106·5 (3)	C(8)—C(9)—C(14)	108·3 (3)
C(10)—C(9)—C(14)	111·0 (3)	O(2)—C(10)—C(9)	121·5 (4)
O(2)—C(10)—C(11)	120·4 (4)	C(9)—C(10)—C(11)	117·9 (4)
C(10)—C(11)—C(12)	123·7 (4)	C(11)—C(12)—C(13)	118·5 (4)
C(11)—C(12)—C(17)	124·7 (4)	C(13)—C(12)—C(17)	116·8 (4)
O(1)—C(13)—C(1)	123·4 (4)	O(1)—C(13)—C(12)	121·5 (4)
C(1)—C(13)—C(12)	115·1 (4)	O(3)—C(15)—O(4)	123·6 (4)
O(3)—C(15)—C(1)	126·2 (4)	O(4)—C(15)—C(1)	110·1 (3)
C(12)—C(17)—C(18)	109·5 (5)	C(12)—C(17)—C(19)	112·7 (5)
C(18)—C(17)—C(19)	109·9 (5)	S—C(10)—C(21)	121·9 (3)
S—C(20)—C(25)	119·1 (3)	C(21)—C(20)—C(25)	119·0 (4)
C(20)—C(21)—C(22)	119·9 (4)	C(21)—C(22)—C(23)	121·2 (5)
C(22)—C(23)—C(24)	119·6 (5)	C(23)—C(24)—C(25)	120·8 (5)
C(20)—C(25)—C(24)	119·5 (5)		

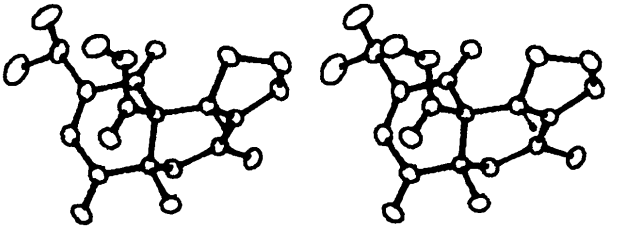

Fig. 1. Stereoscopic projection of the molecule; the phenyl ring has been omitted for clarity.

stereoscopic projection of compound (I) is shown in Fig. 1 where the phenyl ring has been omitted for clarity.

The main result of the present communication is that the basic tricyclic system adopts, as in the case of (II), an overall hemispherical conformation: a least-squares fit (Kabsch, 1976) between equivalent atoms of the tricyclic systems gives a mean deviation of 0·044 Å and a root-mean-square deviation of 0·051 Å, showing that the —S—Ph substituent has virtually no conformational influence.

The five-membered ring is in an envelope conformation with C(3) 0·624 (5) Å out of the plane defined by the other four atoms. The cyclohexenedione ring conformation is close to that of a sofa with C(1) 0·709 (4) Å out of the plane defined by the other five atoms. The cyclohexene ring is in an essentially half-chair conformation with C(1) 0·517 (4) Å above and C(9) 0·308 (4) Å below the plane defined by the other four atoms. The phenyl ring is planar to within experimental accuracy (σ_{av} = 0·007 Å).

The C(15)—O(3) carbonyl bond length of 1·196 (5) Å is in the range normally observed in esters (Allen, Kennard, Watson, Brammer, Orpen & Taylor, 1987).

The intermolecular distances are in the expected range for non-bonded contacts: C(6)···O(2)($-x$, $1-y$, $-z$) = 3·396 (5), C(6)···O(3)($-x$, $1-y$, $-z$) = 3·372 (5) Å.

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Structure of a Modified β-Lactam Antibiotic

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Abstract. 1-Phenoxy-9b-phenyl-1,4,5,9b-tetrahydro-2*H*-azeto[1,2-*a*]isoquinolin-2-one, $C_{23}H_{19}NO_2$, is a carbocyclic analogue of cephalosporin. The crystals are monoclinic, $M_r = 341$, $C2/c$, $a = 23{\cdot}054$ (1), $b = 7{\cdot}315$ (2), $c = 23{\cdot}713$ (4) Å, $\beta = 115{\cdot}08$ (6)°, $V = 3621{\cdot}9$ Å^3, $Z = 8$, $D_m = 1{\cdot}24$, $D_x = 1{\cdot}25$ g cm^{-3}, λ(Cu $K\alpha$) = 1·5418 Å, $\mu = 5{\cdot}96$ cm^{-1}, $F(000) = 1440$, $T = 288$ K, final $R = 0{\cdot}071$ for 2450 observed reflections. The β-lactam N atom, N(7), is 0·229 Å away from mean plane containing C(11), C(5) and C(25). From the plane N(7)–C(5)–C(11)–C(3), atoms O(2) and O(1) are in the *trans* position whereas O(1) and C(8) are in the *cis* position. The crystal structure is stabilized by base–base interactions about the center of inversion.

Introduction. A large family of antibiotics is known whose single common structural feature is a β-lactam ring. As a class, they consist of penicillins, the cephalosporins and non-classical β-lactam antibiotics. The penicillins and cephalosporins show bactericidal reactions by interfering with bacterial cell-wall synthesis and inhibiting the enzymes that catalyse the cross-linking reaction of D-alanyl peptides on peptidoglycan strands of the growing cell wall (Blumberg & Strominger, 1974). Several penicillins and cephalosporin antibiotics inhibit the synthesis of bacterial cell walls.

Since the β-lactam ring plays a key role in the biological activity of β-lactam antibiotics, its activity can be influenced by substituents or fused rings (Takasuka, Nishikawa & Tori, 1982).

The compound reported here is a carbocyclic analogue of cephalosporin (Sharma, Mehra & Gupta, 1978; Bose, Amin, Kapur & Manhas, 1976) the structure of which was sought as a part of an investigation into the geometrical features which provide significant stereochemical information on the lability of the β-lactam amide bonds and on the conformation of the antibiotic in the region of the

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