

Experimental

Crystals were obtained by isothermic evaporation of solvent from a solution of (1) in hexane.

Crystal data

C ₁₈ H ₁₂ N ₂ O	Mo K α radiation
$M_r = 272.30$	$\lambda = 0.71073 \text{ \AA}$
Monoclinic	Cell parameters from 24 reflections
$P2_1/c$	$\theta = 10\text{--}11^\circ$
$a = 11.662 (5) \text{ \AA}$	$\mu = 0.079 \text{ mm}^{-1}$
$b = 14.323 (7) \text{ \AA}$	$T = 293 (2) \text{ K}$
$c = 8.700 (4) \text{ \AA}$	Needle
$\beta = 94.57 (4)^\circ$	$0.60 \times 0.25 \times 0.20 \text{ mm}$
$V = 1448.5 (11) \text{ \AA}^3$	Yellow
$Z = 4$	
$D_x = 1.249 \text{ Mg m}^{-3}$	
D_m not measured	

Data collection

Siemens P3/PC diffractometer	$R_{\text{int}} = 0.03$
$\theta/2\theta$ scans	$\theta_{\text{max}} = 27.06^\circ$
Absorption correction: none	$h = -14 \rightarrow 14$
3381 measured reflections	$k = -18 \rightarrow 0$
3171 independent reflections	$l = 0 \rightarrow 11$
1683 reflections with $I > 2\sigma(I)$	2 standard reflections every 98 reflections
	intensity decay: 5%

Refinement

Refinement on F^2	$w = 1/[\sigma^2(F_o^2) + (0.0762P)^2]$
$R[F^2 > 2\sigma(F^2)] = 0.049$	where $P = (F_o^2 + 2F_c^2)/3$
$wR(F^2) = 0.113$	$(\Delta/\sigma)_{\text{max}} = -0.001$
$S = 1.092$	$\Delta\rho_{\text{max}} = 0.21 \text{ e \AA}^{-3}$
3113 reflections	$\Delta\rho_{\text{min}} = -0.15 \text{ e \AA}^{-3}$
226 parameters	Extinction correction: none
All H-atom parameters refined	Scattering factors from <i>International Tables for Crystallography</i> (Vol. C)

Table 1. Selected geometric parameters (\AA , $^\circ$)

N1—C6	1.144 (2)	C2—C3	1.342 (3)
N2—C1	1.352 (2)	C2—C6	1.421 (3)
N2—C13	1.424 (2)	C3—C4	1.414 (3)
O1—C1	1.214 (2)	C4—C5	1.189 (2)
C1—C2	1.498 (2)	C5—C7	1.439 (2)
C1—N2—C13	123.19 (15)	C6—C2—C1	122.0 (2)
O1—C1—N2	124.08 (15)	C2—C3—C4	125.0 (2)
O1—C1—C2	119.8 (2)	C5—C4—C3	176.3 (2)
N2—C1—C2	116.05 (15)	C4—C5—C7	179.5 (2)
C3—C2—C6	120.0 (2)	N1—C6—C2	177.9 (2)
C3—C2—C1	117.9 (2)	C1—N2—C13—C14	40.55 (8)

Table 2. Hydrogen-bonding geometry (\AA , $^\circ$)

$D\text{---}H\text{---}A$	$D\text{---}H$	$H\text{---}A$	$D\text{---}A$	$D\text{---}H\text{---}A$
N2—H2 \cdots O1'	0.93 (2)	2.14 (2)	2.985 (2)	152 (2)

Symmetry code: (i) $x, \frac{1}{2} - y, z - \frac{1}{2}$.

Data collection: P3 (Siemens, 1989). Cell refinement: P3. Data reduction: SHELXTL (Sheldrick, 1994). Program(s) used to solve structure: SHELXTL. Program(s) used to refine structure: SHELXTL. Molecular graphics: SHELXTL. Software used to prepare material for publication: SHELXTL.

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Supplementary data for this paper are available from the IUCr electronic archives (Reference: BM1318). Services for accessing these data are described at the back of the journal.

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Study of a diastereoisomeric dihydrothiophene derivative at 150 K

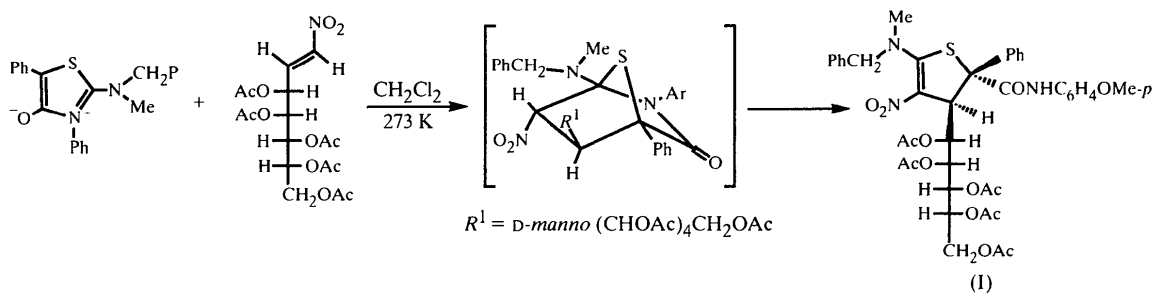
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Abstract

The crystal and molecular structure of (4*R*,5*R*)-4-(1',2',3',4',5'-penta-*O*-acetyl-D-manno-pentitol-1-yl)-5-[*N*-(4-methoxyphenyl)carbamoyl]-2-(*N*-methylbenzylamino)-3-nitro-5-phenyl-4,5-dihydrothiophene {IUPAC name: 1-(2*R*,3*R*)-5-(*N*-benzyl-*N*-methylamino)-2-[*N*-(4-methoxyphenyl)carbamoyl]-4-nitro-2-phenyl-2,3-dihydro-3-thienyl]-1,2,3,4,5-penta-*O*-acetyl-D-manno-pentitol}, C₄₁H₄₅N₃O₁₄S, has been investigated at 150 K. The analysis of the crystal structure allows the definition of the absolute configuration of the products of the cycloaddition reaction between 3,5-diphenyl-2-(*N*-methylbenzylamine)-1,3-thiazolium-7-olate



and (*E*)-3,4,5,6,7-penta-*O*-acetyl-1,2-dideoxy-1-*C*-nitro-*D*-manno-hept-1-enitol, where only one of the two diastereoisomeric dihydrothiophenes could be isolated. The configurations at the new C4 and C5 stereocentres, with respect to that known at C6, are *R,R*. Except for a slight overall contraction and a slightly altered geometry of the terminal acetyl group, the structure is virtually the same as at room temperature.

Comment

Mesoionic heterocycles currently receive considerable attention as synthons in modern organic synthesis. They are five-membered aromatic heterocycles that cannot be represented by Lewis forms not involving charge separation. Their attractiveness arises from the fact that mesoionics behave as masked 1,3-dipoles and therefore readily participate in cycloadditive processes (Potts, 1984; Osterhout *et al.*, 1994; Avalos *et al.*, 1995). Isomünchnones and thioisomünchnones are among the most widely used mesoionic rings in the synthesis of a variety of functionalized heterocycles, including natural products (Marino *et al.*, 1995). The current interest in the 1,3 thiazoline-4-olate (thioisomünchnones) sys-

tem prompted us to investigate the synthesis of molecules of this type *via* reaction of thioureido derivatives. In the course of this work, the molecular and crystal structure of 1-(2*R*,3*R*)-5-(*N*-benzyl-*N*-methylamino)-2-[*N*-(4-methoxyphenyl)carbamoyl]-4-nitro-2-phenyl-2,3-dihydro-3-thienyl]-1,2,3,4,5-penta-*O*-acetyl-*D*-mannopentitol, (I), was determined by X-ray diffraction and, based on the present conformational and configurational studies, its structure was unequivocally established, fully clarifying this type of reaction.

The structure of (I) was determined first at room temperature and then at 150 K, to reduce the dynamical disorder affecting the terminal acetoxy group. The isotropic equivalent displacement parameters at 150 K are almost half of those computed at room temperature, excluding atoms O101, O102, C101 and C102, for which the isotropic equivalent displacement parameters are three or four times smaller. Fig. 1 shows an *ORTEP*II view (Johnson, 1976) of the molecule at 150 K viewed along the *z* axis, together with the atomic numbering scheme. Significant differences have been observed between the anisotropic displacement parameters for the atoms of the terminal acetoxy group when compared with the room temperature results.

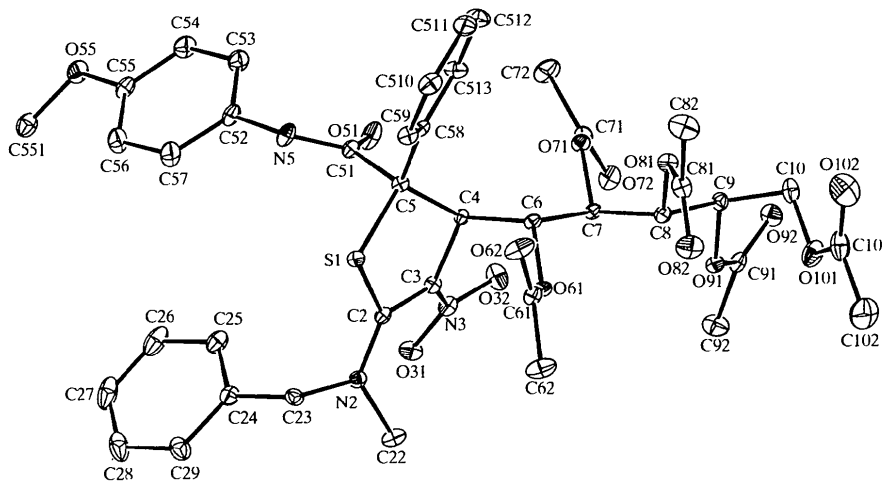


Fig. 1. *ORTEP*II (Johnson, 1976) plot of the molecule of (I) at 150 K, showing 30% probability displacement ellipsoids and the atom-numbering scheme. H atoms are omitted for clarity.

The two bond lengths involving sulfur, namely, S1—C2 and S1—C5, are unequal (see Table 1), the shorter one being that involved in π -conjugation with the C2=C3—N2 system. The mean values for the bond lengths are C—C (phenyl) 1.391 (5), C—C (sugar chain) 1.527 (3), C—C (acetyl group) 1.491 (4) [excluding C101—C102, which has a value of 1.487 (6)], C=O (acetyl) 1.200 (3) [excluding C101=O102, which has a value of 1.203 (5)], C—O (acetyl) 1.360 (3) [excluding C101—O101, which has a value of 1.340 (4)] and O—C (chain) 1.444 (3) Å. The (C52—C57) methoxy phenyl group deviates significantly from planarity [C52 and C55 are 0.010 (3) and 0.012 (3) Å out of the least-squares plane, respectively] while the other phenyls are planar. The sugar chain is not planar.

The dihydrothiophene ring adopts a conformation intermediate between envelope and twist ⁴T₃. The Cremer & Pople (1975) puckering parameters are $Q = 0.365$ (2) Å and $\varphi = 133.3$ (3)°. The smallest asymmetry parameters (Nardelli, 1983a) are $\Delta C_2(C2) = 0.017$ (1) and $\Delta C_5(C5) = 0.060$ (1). The atoms C6 and C58 are on the same side with respect to the best plane through the dihydrothiophene ring, at 1.725 (2) and 0.356 (2) Å, respectively, and N3, C51 and N2 are on the opposite side, at -0.566 (2), -1.820 (2) and -0.070 (2) Å, respectively.

The chiralities of the two new centres at C4 and C5 are *R,R*, as determined with respect to that known at C6 from the reagent used in the synthesis. The Newman projections for the molecule along the C5—C4 and C4—C6 bonds are shown in Fig. 2. The molecules are joined in chains running along [001] by an N—H...O hydrogen bond whose geometry is given in Table 2; here also a number of C—H...O contacts are quoted.

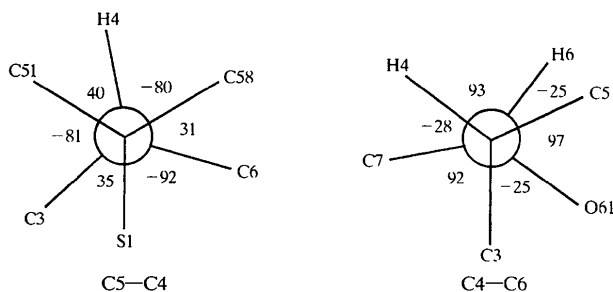


Fig. 2. Some Newman projections for (I) at 150 K.

Experimental

Crystals of (I) were prepared by reaction of 3,5-diphenyl-2-(*N*-methylbenzylamine)-1,3-thiazolium-4-olate with (*E*)-3,4,5,6,7-penta-*O*-acetyl-1,2-dideoxy-1-*C*-nitro-*D*-manno-hept-1-enitol in dichloromethane at room temperature and subsequent recrystallization from ethoxyethane. The reaction gave a mixture of two diastereoisomeric dihydrothiophenes, where only the compound with an *R,R* configuration could be isolated.

Crystal data

C₄₁H₄₅N₃O₁₄S

$M_r = 835.88$

Monoclinic

$P2_1$

$a = 15.670$ (4) Å

$b = 10.556$ (2) Å

$c = 12.258$ (4) Å

$\beta = 96.10$ (1)°

$V = 2016.2$ (9) Å³

$Z = 2$

$D_x = 1.3769$ Mg m⁻³

D_m not measured

Mo $K\alpha$ radiation

$\lambda = 0.71073$ Å

Cell parameters from 25

reflections

$\theta = 5-11$ °

$\mu = 0.153$ mm⁻¹

$T = 150$ (1) K

Prism

0.40 × 0.28 × 0.24 mm

Yellow

Data collection

Enraf-Nonius CAD-4

diffractometer

$\omega/2\theta$ scans

Absorption correction: none

6093 measured reflections

6093 independent reflections

5603 reflections with

$I > 2\sigma(I)$

$\theta_{\max} = 29.83$ °

$h = 0 \rightarrow 21$

$k = 0 \rightarrow 14$

$l = -17 \rightarrow 17$

3 standard reflections

frequency: 120 min

intensity decay: none

Refinement

Refinement on F^2

$R(F) = 0.042$

$wR(F^2) = 0.119$

$S = 1.054$

6093 reflections

712 parameters

H atoms not refined

$w = 1/[\sigma^2(F_o^2) + (0.0983P)^2 + 0.0069P]$

where $P = (F_o^2 + 2F_c^2)/3$

$(\Delta/\sigma)_{\max} = 0.019$

$\Delta\rho_{\max} = 0.744$ e Å⁻³

$\Delta\rho_{\min} = -0.412$ e Å⁻³

Extinction correction: none

Scattering factors from *International Tables for X-ray*

Crystallography (Vol. IV)

Table 1. Selected geometric parameters (Å, °)

S1—C5	1.841 (2)	N2—C2	1.336 (3)
S1—C2	1.765 (2)	N2—C22	1.463 (3)
O32—N3	1.251 (3)	N2—C23	1.464 (3)
N3—O31	1.253 (3)	N5—C51	1.359 (3)
N3—C3	1.392 (3)	N5—C52	1.430 (3)
C5—S1—C2	92.4 (1)	N5—C51—C5	115.8 (2)
O32—N3—O31	121.0 (2)	S1—C2—N2	118.4 (2)
O32—N3—C3	117.9 (2)	S1—C2—C3	110.9 (2)
O31—N3—C3	121.0 (2)	N2—C2—C3	130.6 (2)
C2—N2—C22	122.7 (2)	N3—C3—C4	119.3 (2)
C2—N2—C23	121.1 (2)	N3—C3—C2	124.1 (2)
C22—N2—C23	116.1 (2)	N5—C52—C53	122.7 (2)
C51—N5—C52	122.3 (2)	N5—C52—C57	118.0 (2)
S1—C5—C4	104.8 (1)	N2—C23—C24	114.0 (2)
O51—C51—N5	123.2 (2)		

Table 2. Hydrogen-bonding and short-contact geometry (Å, °)

$D-H \cdots A$	$D-H$	$H \cdots A$	$D \cdots A$	$D-H \cdots A$
C4—H4...O71	1.00	2.16	2.797 (3)	120
C4—H4...O51	1.00	2.32	2.717 (3)	102
C8—H8...O82	1.00	2.23	2.687 (3)	106
C6—H6...O62	1.00	2.32	2.709 (3)	102
C10—H10A...O102	1.00	2.26	2.665 (4)	102
C7—H7...O32	1.00	2.42	3.089 (3)	124
C9—H9...O72	1.02	2.70	3.157 (3)	107
C22—H22A...O31	1.02	1.80	2.677 (4)	142
C53—H53...O51	1.01	2.66	2.956 (3)	97

C513—H513 ···O62	1.00	2.96	3.050 (3)	86
N5—H5 ···O92'	1.00	2.00	2.969 (3)	162
C9—H9 ···O102''	1.02	2.38	3.297 (4)	150
C23—H23A ···O31'''	1.00	2.44	3.233 (3)	136
C23—H23B ···O55''''	1.01	2.55	3.354 (3)	137
C510—H510 ···O62''	1.01	2.61	3.189 (4)	117

Symmetry codes: (i) $x, y, 1+z$; (ii) $-x, y - \frac{1}{2}, -1-z$; (iii) $1-x, \frac{1}{2}+y, -z$; (iv) $x, 1+y, z$; (v) $-x, y - \frac{1}{2}, -z$.

The absolute configuration was assigned on the basis of the known chirality of the *D-manno* used in the synthesis. Since compound (I) crystallizes in a polar space group, polar axis restraints were applied by the method of Flack & Schwarzenbach (1988) and the absolute structure was established as described by Flack (1983). The H atoms were included at geometrically calculated positions. The displacement factors at room temperature are rather high and refinement of the terminal atoms gave the shift/s.u. greater than the normal values. It was in order to overcome these difficulties that the structure was studied at low temperature.

Data collection: *CAD-4 Software* (Enraf–Nonius, 1989). Cell refinement: *SET4* (Boer & Duisenberg, 1984) and *CELDIM* in *CAD-4 Software*. Data reduction: *XRAY76 System* (Stewart *et al.*, 1976). Program(s) used to solve structure: *SIR92* (Altomare *et al.*, 1994). Program(s) used to refine structure: *XRAY76 System*. Molecular graphics: *PLATON94* (Spek, 1994). Software used to prepare material for publication: *PARST* (Nardelli, 1983*b*) and *PARSTCIF* (Nardelli, 1991).

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Supplementary data for this paper are available from the IUCr electronic archives (Reference: NA1392). Services for accessing these data are described at the back of the journal.

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N-tert-Butoxycarbonyl-*N,N'*-ethylene-bridged (*S*)-tyrosyl-(*S*)-tyrosine methyl ester

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Abstract

The title compound, a pseudopeptide, methyl (2*S*)-3-(4-hydroxyphenyl)-2-[(3*S*)-4-(*tert*-butoxycarbonyl)-3-(4-hydroxybenzyl)-2-oxopiperazin-1-yl]propionate, C₂₆H₃₂N₂O₇, was crystallized from an H₂O/methanol solution. The two N-substituted chains on the piperazin-2-one (MKP) ring lie in the quasi-equatorial position and the third chain lies in the quasi-axial position. Each side chain on the tyrosines is located opposite the MKP ring. The MKP ring has a pseudo-chair form.

Comment

Peptides which are conformationally restricted through short-range cyclizations have been synthesized with the aim of clarifying the relationship between their biological activities, their conformations and their functionalities (Toniolo, 1990). The present authors have also prepared a series of structurally reinforced dipeptides containing *N,N'*-ethylene bridging and have studied their opiate activities (Takenaka *et al.*, 1993; Yamashita *et al.*, 1997). Although we have reported solid and solution structures of this series of oligo-pseudopeptides (Yamashita *et al.*, 1989; Kojima *et al.*, 1991) and macrocyclic pseudopeptides (Miyake *et al.*, 1996; Kojima *et al.*, 1995) which showed ionophorous (Kojima *et al.*, 1992) and enantioselective transport (Miyake *et al.*, 1993) properties, we have never obtained a crystal of a linear oligopseudopeptide containing a functional group on the side chains. This is the first paper describing the crystal structure of a pseudopeptide constructed from tyrosines, Boc-eYY-OMe,