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

$U_{eq} = \frac{1}{3}\sum_i\sum_j U_{ij}a_i^*a_j^*\mathbf{a}_i.\mathbf{a}_j$.

	x	y	z	U_{eq}
C1	0.2041 (7)	0.5124 (5)	0.5631 (5)	0.042 (2)
C2	0.2238 (8)	0.6072 (5)	0.6148 (5)	0.051 (3)
C3	0.0936 (8)	0.6019 (5)	0.6634 (5)	0.052 (3)
C4	−0.0607 (7)	0.5028 (5)	0.6640 (5)	0.047 (3)
C5	−0.0784 (8)	0.4061 (5)	0.6137 (5)	0.050 (3)
C6	0.0489 (7)	0.4109 (5)	0.5648 (5)	0.048 (3)
C7	0.5353 (8)	0.5460 (7)	0.5240 (5)	0.056 (3)
C8	0.6302 (8)	0.6238 (6)	0.4702 (5)	0.059 (3)
C9	0.5940 (7)	0.5436 (5)	0.4098 (5)	0.049 (2)
C10	0.3798 (8)	0.5148 (6)	0.4012 (5)	0.050 (3)
C11	0.2882 (9)	0.4400 (6)	0.4573 (5)	0.051 (3)
C12	−0.2007 (9)	0.5061 (6)	0.7159 (5)	0.058 (3)
C13	−0.363 (1)	0.393 (1)	0.7184 (6)	0.093 (6)
C14	0.8275 (9)	0.5534 (7)	0.3331 (5)	0.067 (4)
C15	0.797 (1)	0.3956 (6)	0.3524 (6)	0.066 (3)
N1	0.3269 (6)	0.5263 (4)	0.5132 (5)	0.046 (2)
O1	0.6643 (6)	0.6275 (4)	0.3589 (5)	0.062 (2)
O2	0.7031 (6)	0.4087 (4)	0.4104 (5)	0.067 (2)
O3	−0.1877 (8)	0.5990 (6)	0.7558 (5)	0.083 (3)

The starting materials *p*-fluoroacetophenone (1) and 1,4-dioxa-8-azaspiro[4.5]decane (2) were purchased from Aldrich Chemical Company, Inc. A mixture of (1) (47 ml, 0.39 mol), (2) (50 g, 0.35 mol) and potassium carbonate (70 g, 0.51 mol) in dimethyl sulfoxide (150 ml) was stirred vigorously with heating at 323 K for 30 h. Then, the reaction mixture was extracted with ethyl acetate and the organic layer was washed with water. Evaporation of the extract gave a pale-yellow solid. This was recrystallized from ethyl acetate. The single crystals for the X-ray measurements were obtained from slow evaporation of acetone solution at room temperature. ^{1}H NMR($CDCl_3$): δ 7.86 (*d*, 9.4 Hz, 2H), 6.88 (*d*, 9.4 Hz, 2H), 4.00 (*s*, 4H), 3.51 (*dd*, 7.7 Hz, 3.9 Hz, 4H), 2.52 (*s*, 3H), 1.80 (*dd*, 7.7 Hz, 3.9 Hz, 4H). $\lambda_{max}(CH_2Cl_2)$ = 326 nm ($\varepsilon = 4.46\times10^4$). Elemental analysis for $C_{15}H_{19}NO_3$: found C 69.0, H 7.52, N 5.44%; calculated C 68.9, H 7.33, N 5.36%. M.p. 396–397 K.

The powder SHG efficiency was measured by the techinique of Kurtz & Perry (1968) using a 1064 nm *Q*-switched Nd^{3+}:YAG laser (10 Hz, 8 ns pulse duration).

Lists of structure factors, anisotropic thermal parameters, H-atom coordinates and complete geometry have been deposited with the British Library Document Supply Centre as Supplementary Publication No. SUP 71525 (19 pp.). Copies may be obtained through The Technical Editor, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England. [CIF reference: HL1039]

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Structure Analysis of Monoamine Oxidase Inhibitors, (*R*)-5-Hydroxymethyl- and (*R*)-5-Methoxymethyl-3-(4-methoxyphenyl)-oxazolidin-2-one

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Abstract

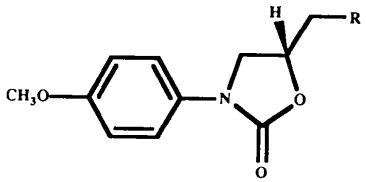
X-ray single-crystal structures of two recently synthesized inhibitors of monoamine oxidase (MAO) belonging to the aryloxazolidinone family are reported. The first compound is (*R*)-5-hydroxymethyl-3-(4-methoxyphenyl)oxazolidin-2-one, $C_{11}H_{13}NO_4$ (I) and the second is (*R*)-5-methoxymethyl-3-(4-methoxyphenyl)oxazolidin-2-one, $C_{12}H_{15}NO_4$ (II). Both compounds show coplanarity between the phenyl and oxazolidinone rings and electronic delocalization between the heteroatoms of the oxazolidinone moiety as indicated by the bond lengths. The crystal packing is assumed to be by van der Waals interactions. Cohesion is increased in the structure of (I) by the presence of hydrogen bonds.

Comment

This communication is part of a more general study on the structural properties of monoamine oxidase inhibitors (MAOIs) of the oxazolidinone family. Some of these compounds have an antidepressant activity and are therapeutic agents. The selectivity and the reversibility of these inhibitors towards the A and B forms of the enzyme depend on the nature of the substituents (Wouters *et al.*, 1992).

In this study, we have considered the (*R*)-5-hydroxymethyl- (I) and the (*R*)-5-methoxymethyl-3-(4-methoxyphenyl)oxazolidin-2-one (II). Compounds

(I) and (II) were provided by the Delalande Research Center – groupe Synthélabo (Rueil Malmaison, France) and single crystals were obtained by slow evaporation of solutions of toluene at room temperature.



(I) R = OH

(II) R = OCH_3

The final atomic coordinates and temperature factors are given in Tables 1 and 3. The atomic numbering scheme, bond lengths and valence angles are presented in Fig. 1 and stereoviews of the crystal packing are depicted in Fig. 2. Geometric parameters are also reported in Tables 2 and 4.

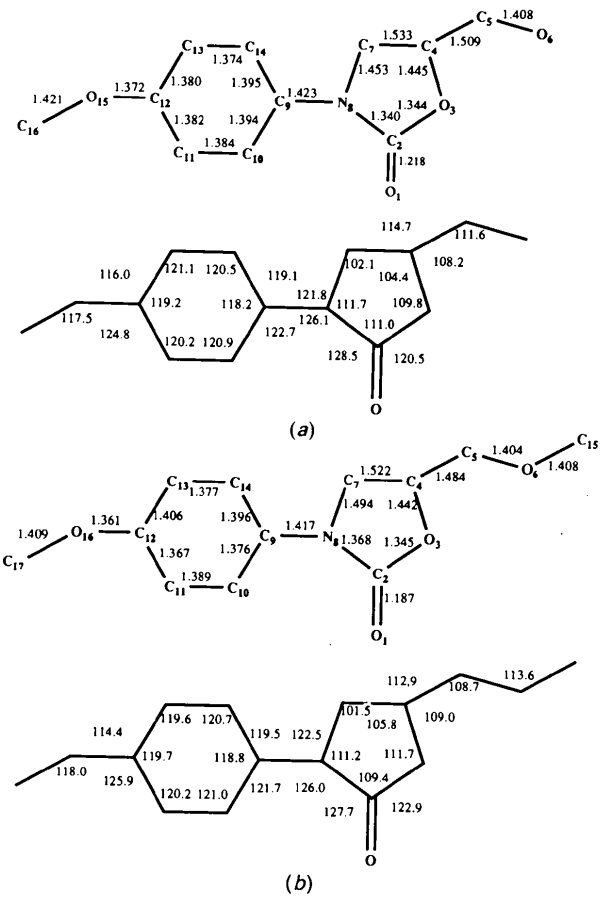


Fig. 1. Atomic numbering, bond lengths (Å) and angles (°) for (*a*) (*R*)-5-hydroxymethyl-3-(4-methoxyphenyl)oxazolidin-2-one (e.s.d.'s are smaller than 0.005 Å and 0.3°), and (*b*) (*R*)-5-methoxymethyl-3-(4-methoxyphenyl)oxazolidin-2-one (e.s.d.'s are smaller than 0.005 Å and 0.8°).

In both MAOIs, the oxazolidinone moiety shows C(2)—N(8) and C(2)—O(3) bond lengths shorter [1.340 (4), 1.344 (3) and 1.368 (8), 1.345 (8) Å for (I) and (II), respectively] than single C_{sp^3}—N

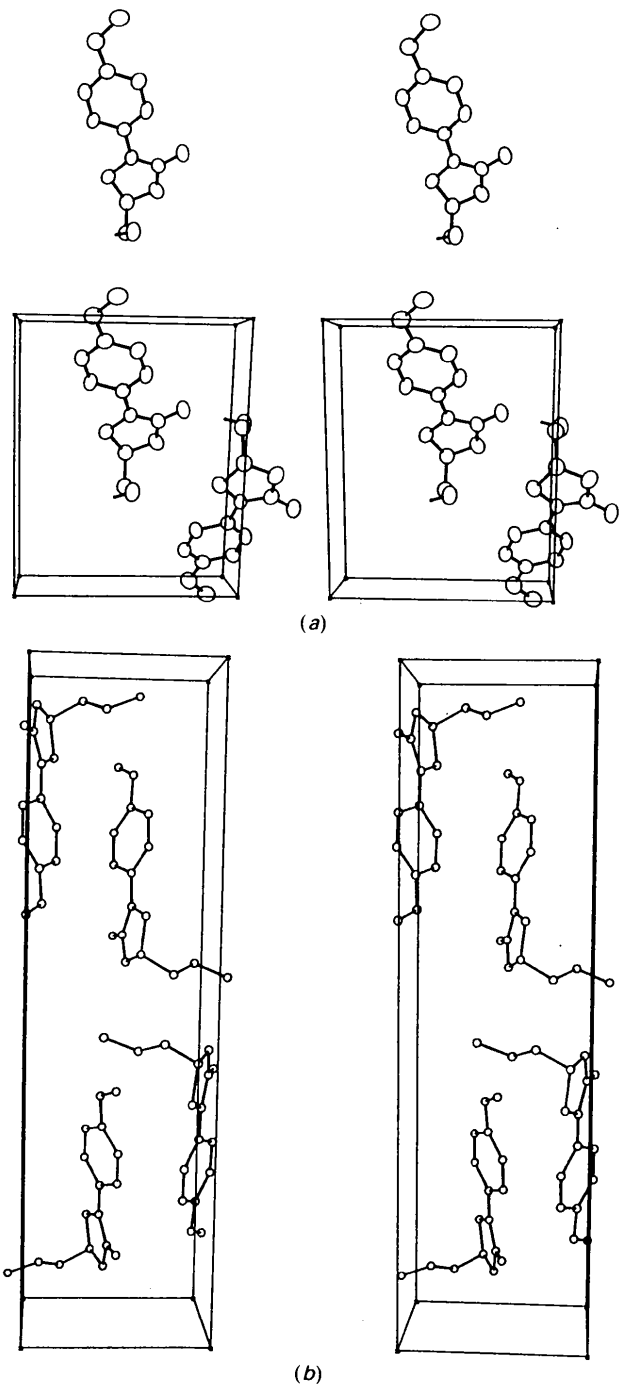


Fig. 2. Stereoviews of the molecular conformation and crystal packing of (*a*) (*R*)-5-hydroxymethyl-3-(4-methoxyphenyl)-oxazolidin-2-one, and (*b*) (*R*)-5-methoxymethyl-3-(4-methoxyphenyl)oxazolidin-2-one.

[1.469 (10) Å] and C_{sp^3}—O [1.432 (13) Å] bond lengths (Allen *et al.*, 1987), indicating electronic delocalization through N(8)—C(2)—O(3). The phenyl and oxazolidinone rings are nearly coplanar as indicated by the torsion angles C(10)—C(9)—N(8)—C(2) [14.0 (4) and 17.4 (9)° for (I) and (II), respectively] tending towards 0°. These observations are consistent with results obtained previously for toloxatone where the torsion angle is 2.4 (3)° (Moureau *et al.*, 1992).

There are no π–π type interactions between the rings in either (I) or (II) in the crystal packing, in contrast with observations made for toloxatone. The crystal packing is assumed to be by van der Waals interactions. Cohesion is increased in (I) by a hydrogen bond between the O(1) atom of one molecule and the O(6) hydroxyl function of another (Table 2).

Table 1. *Fractional atomic coordinates and equivalent isotropic thermal parameters* (Å^2) *for compound* (I)

U_{eq} = 1/3(trace of the orthogonalized U_{ij} matrix).

	x	y	z	U_{eq}
O(1)	0.3184 (2)	0.2550 (3)	0.2936 (5)	0.0580 (6)
O(3)	0.4493 (1)	0.1441 (3)	0.0911 (3)	0.0510 (6)
O(6)	0.6317 (2)	0.0238 (3)	0.5054 (3)	0.0540 (6)
O(15)	−0.0059 (2)	−0.1732 (3)	0.8804 (4)	0.0571 (6)
N(8)	0.3414 (2)	0.0105	0.3161 (4)	0.0392 (6)
C(2)	0.3648 (2)	0.1438 (4)	0.2437 (5)	0.0428 (7)
C(4)	0.4933 (2)	−0.0003 (4)	0.0704 (5)	0.0446 (8)
C(5)	0.6207 (2)	−0.0049 (3)	0.2205 (5)	0.0476 (8)
C(7)	0.4093 (2)	−0.0947 (4)	0.1971 (5)	0.0437 (8)
C(9)	0.2521 (2)	−0.0301 (3)	0.4627 (4)	0.0358 (7)
C(10)	0.1936 (2)	0.0682 (3)	0.6002 (5)	0.0449 (8)
C(11)	0.1081 (2)	0.0242 (4)	0.7430 (5)	0.0455 (7)
C(12)	0.0786 (2)	−0.1187 (3)	0.7488 (5)	0.0423 (8)
C(13)	0.1373 (2)	−0.2168 (3)	0.6162 (6)	0.0465 (8)
C(14)	0.2231 (2)	−0.1743 (3)	0.4759 (5)	0.0413 (7)
C(16)	−0.0708 (2)	−0.0747 (4)	1.0115 (6)	0.0582 (10)

Table 2. *Geometric parameters* (Å, °) *for compound* (I)

O(1)—C(2)	1.218 (4)	C(4)—C(5)	1.509 (3)
O(3)—C(2)	1.344 (3)	C(4)—C(7)	1.533 (4)
O(3)—C(4)	1.455 (5)	C(9)—C(10)	1.394 (4)
O(6)—C(5)	1.408 (3)	C(9)—C(14)	1.395 (4)
O(15)—C(12)	1.372 (3)	C(10)—C(11)	1.384 (4)
O(15)—C(16)	1.421 (4)	C(11)—C(12)	1.382 (5)
N(8)—C(2)	1.340 (4)	C(12)—C(13)	1.380 (4)
N(8)—C(7)	1.453 (4)	C(13)—C(14)	1.374 (4)
N(8)—C(9)	1.423 (3)		
C(2)—O(3)—C(4)	109.8 (3)	N(8)—C(7)—C(4)	102.1 (3)
C(12)—O(15)—C(16)	117.5 (3)	N(8)—C(9)—C(10)	122.7 (2)
C(2)—N(8)—C(7)	111.7 (2)	N(8)—C(9)—C(14)	119.1 (2)
C(2)—N(8)—C(9)	126.1 (2)	C(10)—C(9)—C(14)	118.2 (2)
C(7)—N(8)—C(9)	121.8 (2)	C(9)—C(10)—C(11)	120.9 (3)
O(1)—C(2)—O(3)	120.5 (3)	C(10)—C(11)—C(12)	120.2 (3)
O(1)—C(2)—N(8)	128.5 (2)	O(15)—C(12)—C(11)	124.8 (2)
O(3)—C(2)—N(8)	111.0 (3)	O(15)—C(12)—C(13)	116.0 (3)
O(3)—C(4)—C(5)	108.2 (2)	C(11)—C(12)—C(13)	119.2 (2)
O(3)—C(4)—C(7)	104.4 (2)	C(12)—C(13)—C(14)	121.1 (3)
C(5)—C(4)—C(7)	114.7 (2)	C(9)—C(14)—C(13)	120.5 (2)
O(6)—C(5)—C(4)	111.6 (2)		

D—H···*A*	*D*—H	H···*A*	*D*—H···*A*
O(6)—H(61)···O(1^{i})	0.848	1.876	175.9

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

Experimental

Compound (I)

Crystal data

$C_{11}H_{13}NO_4$
M_r = 223
Monoclinic
$P2_1$
a = 11.546 (6) Å
b = 9.360 (2) Å
c = 4.922 (3) Å
β = 101.5 (2)°
V = 521.1 (4) Å^3
Z = 2
D_x = 1.423 Mg m^{-3}
Mo $K\alpha$ radiation
λ = 0.71073 Å
Cell parameters from 25 reflections
θ = 8-13°
μ = 0.102 mm^{-1}
T = 295 K
Platelet
0.32 × 0.21 × 0.13 mm
Colourless

Data collection

Enraf-Nonius CAD-4 diffractometer
ω-θ scans
Absorption correction: none
1666 measured reflections
1560 independent reflections
1405 observed reflections [$I \geq 2.0\sigma(I)$]
R_{int} = 0.008
θ_{max} = 25°
h = −13 → 13
k = −9 → 11
l = 0 → 5
3 standard reflections
frequency: 60 min
intensity variation: none

Refinement

R = 0.0334
wR = 0.0401
S = 1.07
1405 reflections
144 parameters
Isotropic H atom refined using [U = U(carrier atom) + 0.02 Å^2]
$w = 1/[\sigma^2(F) + 0.002F^2]$
$(\Delta/\sigma)_{max}$ = 0.158 [N(8) x coordinate]
$\Delta\rho_{max}$ = 0.193 e Å^{-3}
$\Delta\rho_{min}$ = −0.233 e Å^{-3}
Extinction correction: none
Atomic scattering factors from *SHELX*76

Compound (II)

Crystal data

$C_{12}H_{15}NO_4$
M_r = 237
Orthorhombic
$P2_12_12_1$
a = 7.295 (3) Å
b = 25.553 (5) Å
c = 6.321 (2) Å
V = 1183 Å^3
Z = 4
D_x = 1.332 Mg m^{-3}
Mo $K\alpha$ radiation
λ = 0.71073 Å
Cell parameters from 25 reflections
θ = 8-13°
μ = 0.09 mm^{-1}
T = 295 K
Platelet
0.29 × 0.14 × 0.04 mm
Colourless

Data collection

Enraf-Nonius CAD-4 diffractometer
ω-θ scans
Absorption correction: none
R_{int} = 0.013
θ_{max} = 22°
h = −7 → 7
k = 0 → 27
l = 0 → 6

1770 measured reflections
1443 independent reflections
930 observed reflections [$I \geq 2.0\sigma(I)$]
3 standard reflections
frequency: 60 min
intensity variation: 6%

Refinement

$R = 0.0478$
$wR = 0.0545$
$S = 1.22$
930 reflections
154 parameters
Isotropic H atom refined using [U = U(carrier atoms) + 0.02 Å^2]
$w = 1.0/[\sigma^2(F) + 0.002F^2]$
Extinction correction: none
$(\Delta/\sigma)_{max} = 0.487$ [C(2) U_{33}]
$\Delta\rho_{max} = 0.234$ e Å^{-3}
$\Delta\rho_{min} = -0.217$ e Å^{-3}
Atomic scattering factors from *SHELX*76

Table 3. *Fractional atomic coordinates and equivalent isotropic thermal parameters* (Å^2) *for compound* (II)

U_{eq} = 1/3(trace of the orthogonalized U_{ij} matrix).

	x	y	z	U_{eq}
O(1)	0.5181 (7)	0.0983 (2)	0.3856 (7)	0.071 (2)
O(3)	0.4599 (5)	0.0603 (2)	0.0763 (7)	0.054 (2)
O(6)	0.0867 (6)	0.0610 (2)	−0.0054 (8)	0.073 (2)
O(16)	0.4184 (6)	0.3500 (2)	0.3925 (7)	0.060 (2)
N(8)	0.4305 (6)	0.1461 (2)	0.0959 (7)	0.043 (2)
C(2)	0.4743 (9)	0.1018 (2)	0.2053 (11)	0.050 (2)
C(4)	0.3869 (10)	0.0746 (3)	−0.1276 (10)	0.056 (2)
C(5)	0.2123 (10)	0.0462 (3)	−0.1627 (11)	0.062 (3)
C(7)	0.3621 (10)	0.1335 (2)	−0.1210 (10)	0.060 (3)
C(9)	0.4303 (8)	0.1975 (2)	0.1780 (9)	0.042 (2)
C(10)	0.5203 (8)	0.2099 (2)	0.3626 (9)	0.047 (2)
C(11)	0.5191 (8)	0.2605 (2)	0.4407 (8)	0.046 (2)
C(12)	0.4327 (8)	0.2993 (2)	0.3310 (9)	0.043 (2)
C(13)	0.3443 (9)	0.2877 (2)	0.1391 (10)	0.051 (3)
C(14)	0.3431 (8)	0.2372 (3)	0.0653 (9)	0.044 (2)
C(15)	−0.0908 (11)	0.0409 (3)	−0.0372 (15)	0.089 (3)
C(17)	0.4951 (11)	0.3643 (3)	0.5887 (11)	0.069 (3)

Table 4. *Geometric parameters* (Å, °) *for compound* (II)

O(1)—C(2)	1.187 (8)	N(8)—C(9)	1.417 (7)
O(3)—C(2)	1.345 (8)	C(4)—C(5)	1.484 (10)
O(3)—C(4)	1.442 (8)	C(4)—C(7)	1.522 (9)
O(6)—C(5)	1.404 (9)	C(9)—C(10)	1.376 (8)
O(6)—C(15)	1.408 (9)	C(9)—C(14)	1.396 (9)
O(16)—C(12)	1.361 (7)	C(11)—C(10)	1.389 (7)
O(16)—C(17)	1.409 (8)	C(12)—C(11)	1.367 (8)
N(8)—C(2)	1.368 (8)	C(13)—C(12)	1.406 (9)
N(8)—C(7)	1.494 (8)	C(14)—C(13)	1.377 (9)
C(2)—O(3)—C(4)	111.7 (5)	O(6)—C(5)—C(4)	108.7 (6)
C(5)—O(6)—C(15)	113.6 (6)	N(8)—C(7)—C(4)	101.5 (5)
C(12)—O(16)—C(17)	118.0 (5)	N(8)—C(9)—C(14)	119.5 (5)
C(2)—N(8)—C(7)	111.2 (5)	N(8)—C(9)—C(10)	121.7 (5)
C(2)—N(8)—C(9)	126.0 (5)	C(10)—C(9)—C(14)	118.8 (5)
C(7)—N(8)—C(9)	122.5 (5)	C(9)—C(10)—C(11)	121.0 (5)
O(1)—C(2)—O(3)	122.9 (5)	C(10)—C(11)—C(12)	120.2 (5)
O(1)—C(2)—N(8)	127.7 (6)	C(11)—C(12)—O(16)	125.9 (5)
O(3)—C(2)—N(8)	109.4 (6)	C(13)—C(12)—O(16)	114.4 (5)
O(3)—C(4)—C(5)	109.0 (6)	C(11)—C(12)—C(13)	119.7 (5)
O(3)—C(4)—C(7)	105.8 (5)	C(12)—C(13)—C(14)	119.6 (5)
C(5)—C(4)—C(7)	112.9 (6)	C(9)—C(14)—C(13)	120.7 (5)

The structures were solved with *SHELXS*86 (Sheldrick, 1985) and refined with *SHELX*76 (Sheldrick, 1976) by full-matrix least squares. The *XRAY*76 program (Stewart *et al.*, 1976) was used for geometry analysis. The *ORTEP* program (Johnson, 1965) was used to obtain the stereoscopic representations of the molecules and crystal packing.

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Lists of structure factors, anisotropic thermal parameters, H-atom coordinates and complete geometry have been deposited with the British Library Document Supply Centre as Supplementary Publication No. SUP 71392 (19 pp.). Copies may be obtained through The Technical Editor, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England. [CIF reference: DU1028]

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Structure of *cyclo*-(L-Threonyl-D-valyl-L-prolyl-sarcosyl-*N*-methyl-L-valyl-O_{Thr}) at 153 K

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Abstract

The crystal structure of *cyclo*-(L-Thr-D-Val-L-Pro-Sar-*N*-L-MeVal-O_{Thr}), $C_{23}H_{39}N_5O_6.HCl.MeOH.H_2O$ is reported. This cyclic pentapeptide lactone represents one