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Crystal Structures of Chiral and Racemic 4-Methyl-5-phenyl-1,3-oxazolidine-2-thione

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(4*S*,5*R*)- and (*rac*)-4-Methyl-5-phenyl-1,3-oxazolidine-2-thione (MPOT) crystallize in the orthorhombic $P2_12_12$ and monoclinic $C2/c$, respectively, with eight molecules in a unit cell. In (*rac*)-MPOT crystals, the thioamide groups of the enantiomeric (4*S*,5*R*)- and (4*R*,5*S*)-MPOT pairs are hydrogen-bonded around a center of symmetry to form a planar cyclic dimer. On the other hand, a cyclic dimer through the hydrogen bonding is formed between the two independent molecules (molecules A and B) and its geometry is considerably distorted in (4*S*,5*R*)-MPOT crystals.

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Homochiral 1,3-oxazolidine- and 1,3-thiazolidine-2-thiones have been used as versatile and efficient auxiliaries in asymmetric synthesis.[1,2] We have been studying the optical resolution of 1,3-oxazolidine-2-thiones through crystallization. Knowledge of the chiral and racemic crystal structures is a prerequisite for designing the crystallization condition. Previously, we analyzed the X-ray structures of chiral and racemic 4-phenyl-1,3-oxazolidine-2-thione (4-POT) and 4-phenyl-1,3-thiazolidine-2-thione (4-PTT) crystals.[3,4] As an extension of our research, we determined the crystal structures of chiral and racemic 4-methyl-5-phenyl-1,3-oxazolidine-2-thione (MPOT) in this work (Fig. 1).

(4*S*,5*R*)-MPOT and (4*R*,5*S*)-MPOT were synthesized using (1*R*,2*S*)-(–)- and (1S,2R)-(+)-norephedrine, respectively, according to a reported procedure.[5] (*rac*)-MPOT was prepared by dissolving equimolar of (4*S*,5*R*)-MPOT and (4*R*,5*S*)-MPOT in acetone and subsequently evaporating the solvent. (4*S*,5*R*)-MPOT and (*rac*)-MPOT crystals suitable for X-ray diffraction analysis were obtained by crystallization from a diethylether/hexane solution at room temperature.

Table 1 gives the crystal and experimental data. All non-hydrogen atoms were refined anisotropically by full-matrix least-squares methods, and all hydrogen atoms were refined isotropically. The final fractional atomic coordinates and equivalent isotropic thermal parameters for non-hydrogen atoms are given in Table 2. Selected bond distances, bond angles and torsion angles are listed in Table 3.

(4*S*,5*R*)-MPOT and (*rac*)-MPOT were crystallized in the orthorhombic and monoclinic forms, respectively, with eight molecules in a unit cell. As shown in Fig. 2, there are two independent molecules (A and B) per asymmetric unit in (4*S*,5*R*)-MPOT crystals, whereas (*rac*)-MPOT contains a unique molecule. The bond lengths and bond angles of (4*S*,5*R*)-MPOT and (*rac*)-MPOT are very similar to each other and fall within the normal ranges of non-substituted 1,3-oxazolidine-2-thione[6] and 4-POT.[3]

For both (*rac*)-MPOT and (4*S*,5*R*)-MPOT crystals, a pair of

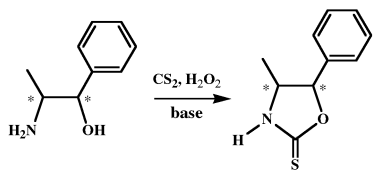

Fig. 1 Preparation scheme of MPOT.

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Table 1 Crystal and experimental data

(4*S*,5*R*)-MPOT	(*rac*)-MPOT
Chemical formula: $C_{10}H_{11}NOS$	$C_{10}H_{11}NOS$
Formula weight = 193.26	193.26
Crystal system: orthorhombic	monoclinic
Space group: $P2_12_12$ (#18) $Z = 8$	$C2/c$ (#15) $Z = 8$
a = 10.104(2)Å	a = 27.238(4)Å
b = 32.447(1)Å	b = 6.0517(8)A β = 99.433(1)°
c = 6.014(1)A	c = 11.726(3)Å
V = 1971.7(5)Å^3	V = 1906.7(6)Å^3
D_{calc} = 1.302 g cm^{-3}	D_{calc} = 1.346 g cm^{-3}
μ (Mo K_α) = 2.86 cm^{-1}	μ(Mo K_α) = 2.96 cm^{-1}
Temperature: 123 K	123 K
Radiation: 0.71069Å(MoK_α)	
$2\theta_{max}$ = 55.0°	$2\theta_{max}$ = 55.0°
No. of unique reflections measured: 2518	2096
No. of reflections used: 2414 [$I > 1.20\sigma(I)$]	1765 [$I > 1.20\sigma(I)$]
No. of parameters: 324	162
R, Rw = 0.028, 0.040	R, Rw = 0.030, 0.034
Goodness of fit: 1.12	0.93
$(\Delta/\sigma)_{max}$ = 0.001	$(\Delta/\sigma)_{max}$ = 0.001
$(\Delta\rho)_{max}$ = 0.14 eÅ^{-3}	$(\Delta\rho)_{max}$ = 0.27 eÅ^{-3}
$(\Delta\rho)_{min}$ = –0.10 eA^{-3}	$(\Delta\rho)_{min}$ = –0.15 eÅ^{-3}
Measurement: Rigaku / MSC Mercury CCD	
Program system: teXsan	
Structure determination: direct method (MITHRIL90)	direct method (MITHRIL90)
Refinement: full-matrix least-squares	

Table 2 Fractional atomic coordinates and equivalent isotropic thermal parameters of non-hydrogen atoms

	x	*y*	*z*	B_{eq}/Å^2
(4*S*,5*R*)-MPOT moleculeA				
S(1A)	0.02684(5)	0.37822(1)	0.95014(8)	2.096(9)
O(1A)	0.0458(2)	0.30292(4)	0.7925(2)	2.20(3)
N(1A)	0.0856(2)	0.35023(5)	0.5406(3)	2.00(3)
C(1A)	0.0541(2)	0.34394(5)	0.7502(3)	1.77(3)
C(2A)	0.1179(2)	0.31241(5)	0.4189(3)	1.92(3)
C(3A)	0.0559(2)	0.28048(5)	0.5818(3)	1.87(3)
C(4A)	0.2657(2)	0.30891(7)	0.3784(4)	2.61(4)
C(5A)	0.1312(2)	0.24108(5)	0.6150(3)	1.84(3)
C(6A)	0.1267(2)	0.21121(6)	0.4483(4)	2.36(4)
C(7A)	0.1975(2)	0.17452(6)	0.4729(4)	2.61(4)
C(8A)	0.2701(2)	0.16741(6)	0.6626(4)	2.48(4)
C(9A)	0.2737(2)	0.19662(7)	0.8296(4)	2.78(4)
C(10A)	0.2048(2)	0.23360(6)	0.8061(4)	2.41(4)
moleculeB				
S(1B)	0.09851(5)	0.44542(1)	–0.63999(8)	1.889(8)
O(1B)	0.2110(1)	0.51306(4)	–0.4849(2)	1.75(2)
N(1B)	0.1375(2)	0.47237(5)	–0.2223(3)	1.64(3)
C(1B)	0.1496(2)	0.47706(5)	–0.4380(3)	1.61(3)
C(2B)	0.2052(2)	0.50428(5)	–0.0941(3)	1.56(3)
C(3B)	0.2169(2)	0.53711(5)	–0.2791(3)	1.58(3)
C(4B)	0.3362(2)	0.48814(6)	–0.0049(3)	1.80(3)
C(5B)	0.3397(2)	0.56344(5)	–0.2708(3)	1.65(3)
C(6B)	0.3585(2)	0.58804(6)	–0.0833(3)	1.98(3)
C(7B)	0.4726(2)	0.61176(6)	–0.0609(4)	2.38(4)
C(8B)	0.5673(2)	0.61145(6)	–0.2271(4)	2.45(4)
C(9B)	0.5473(2)	0.58795(6)	–0.4165(4)	2.38(4)
C(10B)	0.4345(2)	0.56376(5)	–0.4386(3)	1.95(3)
(*rac*)-MPOT				
S(1)	0.47541(1)	0.19665(6)	0.06028(3)	2.048(7)
O(1)	0.42012(3)	0.3229(2)	0.21174(8)	1.86(2)
N(1)	0.45340(4)	0.6025(2)	0.1329(1)	1.81(2)
C(1)	0.44953(4)	0.3849(2)	0.1354(1)	1.70(2)
C(2)	0.41972(5)	0.7130(2)	0.2008(1)	1.69(2)
C(3)	0.41173(5)	0.5176(2)	0.2803(1)	1.71(2)
C(4)	0.37326(5)	0.7964(3)	0.1230(1)	2.03(3)
C(5)	0.36193(5)	0.4990(2)	0.3200(1)	1.64(2)
C(6)	0.34871(5)	0.6625(2)	0.3932(1)	1.99(3)
C(7)	0.30426(5)	0.6459(3)	0.4361(1)	2.30(3)
C(8)	0.27307(5)	0.4668(3)	0.4074(1)	2.12(3)
C(9)	0.28574(5)	0.3056(3)	0.3341(1)	2.20(3)
C(10)	0.33011(5)	0.3219(2)	0.2902(1)	2.04(3)

$B_{eq} = (8/3)\pi^2(U_{11}(aa^*)^2 + U_{22}(bb^*)^2 + U_{33}(cc^*)^2 + 2U_{12}aa^*bb^*\cos\gamma + 2U_{13}aa^*cc^*\cos\beta + 2U_{23}bb^*cc^*\cos\alpha)$.

Table 3 Selected bond lengths(Å), bond angles (˚) and torsion angles (˚)

Atom	Atom	Atom	Atom	(4*S*,5*R*)-MPOT (A)	(4*S*,5*R*)-MPOT (B)	(*rac*)-MPOT
S(1)	C(1)			1.661(2)	1.673(2)	1.666(1)
O(1)	C(1)			1.357(2)	1.352(2)	1.349(2)
O(1)	C(3)			1.465(2)	1.464(2)	1.465(2)
N(1)	C(1)			1.316(3)	1.312(3)	1.322(2)
N(1)	C(2)			1.466(3)	1.461(3)	1.471(2)
C(2)	C(3)			1.558(3)	1.545(3)	1.543(2)
C(1)	O(1)	C(3)		108.7(1)	107.6(1)	107.65(10)
C(1)	N(1)	C(2)		113.7(2)	113.3(2)	112.5(1)
S(1)	C(1)	O(1)		120.7(2)	121.4(2)	120.6(1)
S(1)	C(1)	N(1)		129.0(1)	128.2(2)	128.85(10)
O(1)	C(1)	N(1)		110.2(2)	110.5(2)	110.5(1)
N(1)	C(2)	C(3)		98.8(2)	98.3(1)	98.1(1)
O(1)	C(3)	C(2)		104.0(1)	103.8(1)	103.61(10)
S(1)	C(1)	O(1)	C(3)	172.1(1)	168.0(1)	168.41(9)
S(1)	C(1)	N(1)	C(2)	172.9(2)	174.4(1)	172.5(1)
O(1)	C(3)	C(2)	N(1)	–20.1(2)	–24.1(2)	–26.2(1)

Estimated standard deviations in the least significant figure are given in parentheses.

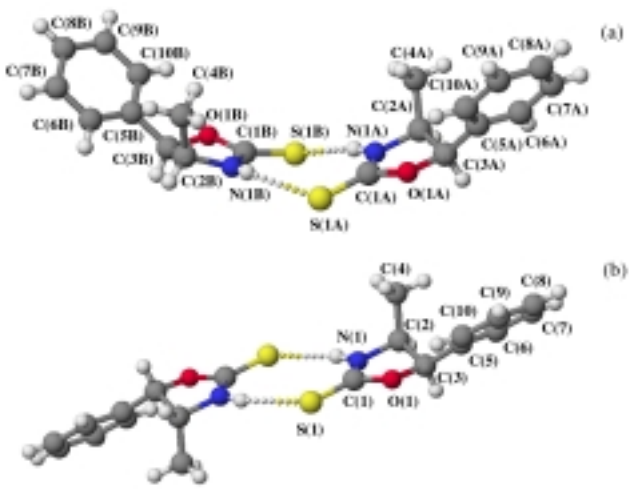

Fig. 2 Moleculer structures of (a) (4*S*,5*R*)-MPOT and (b) (*rac*)-MPOT with the atom numbering.

MPOT molecules forms a cyclic dimer through intermolecular N–H··S hydrogen bonds from the N–H group of one molecule to the C=S group of an adjacent molecule. However, the hydrogen bonding geometry is quite different from each other. In (*rac*)-MPOT crystals, an enantiomeric pair is hydrogen-bonded around a center of symmetry [N(1)··S(1)$^{(i)}$ 3.436(1)Å, N(1)–H··S(1)$^{(i)}$ 170(1)˚; symmetry code: (i) –*x* + 1, –*y* + 1, –*z*]. On the other hand, in (4*S*,5*R*)-MPOT crystals a cyclic dimer is formed between the two independent molecules (molecules A and B) and its geometry is considerably distorted [N(1A)··S(1B)$^{(ii)}$ 3.277(2)Å, N(1A)–H··S(1B)$^{(ii)}$ 168(3)˚; N(1B)··S(1A)$^{(iii)}$ 3.414(2)Å, N(1B)–H··S(1A)$^{(iii)}$ 172(3)˚; symmetry code: (ii) *x*, *y*, *z* + 1; (iii) *x*, *y*, *z* – 1]. In view of the averaged values of the D··A distance, the D–H··A angle, (4*S*,5*R*)-MPOT crystals may have slightly stronger hydrogen bonding than (*rac*)-MPOT crystals. There is a melting-point difference of about 10 K between chiral and racemic crystals of MPOT [81 – 82˚C for (4*S*,5*R*)-MPOT, 91 – 92˚C for (*rac*)-MPOT]. This difference in the melting temperature is much smaller than the 4-POT case (46 K).[3] The densities of (*rac*)-MPOT and (4*S*,5*R*)-MPOT were calculated to be 1.346 and 1.302 g cm^{-3}, respectively. Thus, the difference in the melting-point may be attributed to a difference in the crystal packing efficiency in the two crystals.

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