Structure and conformational features of tetrahydrothienothiepinoisoxazole as a novel heterocyclic system

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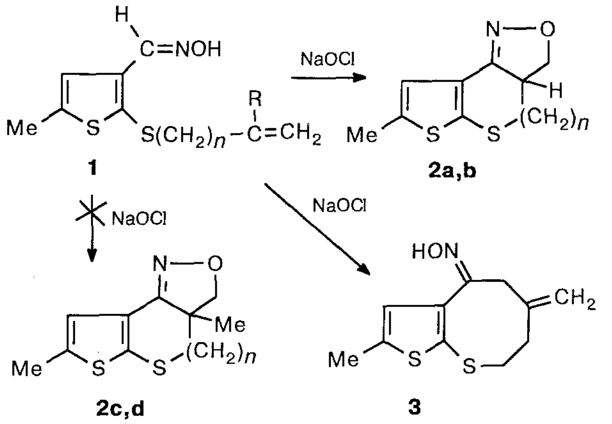
The crystal and molecular structure of a novel heterocyclic system, 8-methyl-3,3a,4,5-tetrahydrothieno[3′,2:6,7]thiepino[4,5-*c*]isoxazole, has been determined by X-ray analysis. The seven-membered ring has the boat conformation (B), while the isoxazoline cycle has the flat chair conformation ($_3$E). There are strong steric strains between the vicinal protons at the C(3a), C(3), and C(4) atoms.

Key words: 8-methyl-3,3a,4,5-tetrahydrothieno[3′,2′6,7]thiepino[4,5-*c*]isoxazole, X-ray analysis, conformation.

Earlier,[1] we reported that the oximes of the thiophene series of type **1** (R = H) can be easily cyclized by interaction with NaOCl to yield tricyclic compounds **2**. Using IR spectroscopy and synthetic methods, it was found that the corresponding thiophenylcarbonyltrioxides are formed during oxidation.[1] The anomalous intramolecular cyclization of 3-thiophenylcarbonyltrioxides with substituent containing methallyl fragments in the 2 position of the heterocycle were also reported. Thus, the reaction of oxime **1c** with NaOCl gave only polymer mixtures of unknown nature,[2] and the oxidation of **1d** resulted in thiocyne **3** instead of the expected thiepine **2d** (see Ref. 3).



a: n = 1, R = H; **b**: n = 2, R = H;
c: n = 1, R = Me; **d**: n = 2, R = Me

It should be noted that there are examples about the successful intramolecular cyclization of the aliphatic[4] and polycyclic[5] nitriloxides containing methallyl groups.

Table 1. Coordinates of the atoms in molecule **2b** ($\times 10^4$, for the H atoms $\times 10^3$)

Atom	*x*	*y*	*z*	U_{iso}
N(1)	4739(5)	3072(3)	3551(9)	5.56
O(2)	6163(5)	2872(4)	3463(8)	6.50
C(3)	6250(7)	1889(6)	3872(11)	6.43
C(3a)	4831(7)	1458(5)	4012(9)	6.02
C(4)	4954(5)	0701(3)	2547(7)	6.02
C(5)	3544(4)	0353(3)	2339(6)	5.87
S(6)	2019(1)	0415(0)	4279(1)	6.17
C(6a)	1632(4)	1618(3)	4196(6)	5.78
S(7)	−0060(1)	1954(0)	4330(1)	5.94
C(8)	0345(4)	3129(3)	4097(6)	5.98
C(9)	1803(4)	3254(3)	3934(6)	5.83
C(9a)	2539(4)	2393(3)	3916(6)	5.44
C(9b)	4041(7)	2324(5)	3800(9)	6.05
C(10)	−0686(5)	3889(3)	4148(7)	7.01
H(3)	644(6)	197(4)	479(8)	
H(3′)	708(5)	162(4)	266(7)	
H(3a)	434(8)	133(6)	514(10)	
H(4)	513(7)	034(5)	311(8)	
H(4′)	535(9)	106(7)	135(12)	
H(5)	329(6)	071(5)	144(8)	
H(5′)	357(3)	−030(2)	187(4)	
H(9)	209(5)	383(4)	382(7)	
H(10)	−072(9)	399(7)	319(13)	
H(10′)	027(6)	450(4)	412(8)	
H(10′′)	−197(9)	407(7)	503(13)	

To explain these anomalies in the reactions of intramolecular cycloaddition (IMCA), earlier[2,6] we investigated the structures of the starting oxime **1d** and the cyclization product, tetrahydrothienothiopyranoisoxazole **2a**, by X-ray analysis. It was suggested that the absence of cyclization or an unusual direction in the course of the latter is caused by either an unfavorable orientation

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Table 2. Bond lengths (*d*) in molecule **2b**

Bond	*d*/Å	Bond	*d*/Å
N(1)—O(2)	1.404(4)	S(6)—C(6a)	1.793(4)
N(1)—C(9b)	1.242(5)	C(6a)—C(9a)	1.386(6)
O(2)—C(3)	1.493(5)	C(6a)—S(7)	1.706(4)
C(3)—C(3a)	1.495(6)	S(7)—C(8)	1.697(4)
C(3a)—C(9b)	1.479(11)	C(8)—C(9)	1.416(6)
C(3a)—C(4)	1.535(7)	C(8)—C(10)	1.466(7)
C(4)—C(5)	1.522(7)	C(9)—C(9a)	1.409(6)
C(5)—S(6)	1.801(4)	C(9a)—C(9b)	1.459(8)

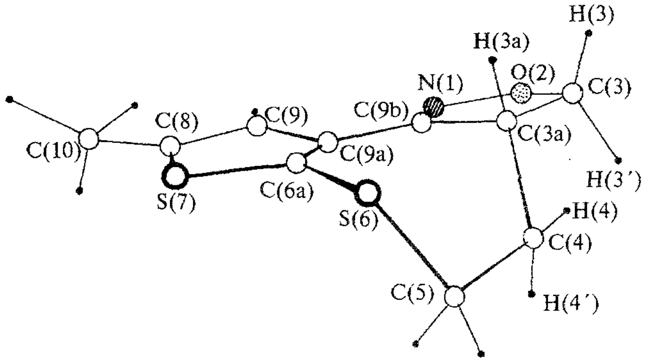

Fig. 1. Structure and conformation of molecule **2b**.

of the dipole and dipolarophile to each other, or the considerable steric hindrances that should arise during the formation of **2c,d**.

In the present work, we consider the molecular and crystal structure of 8-methyl-3,3a,4,5-tetrahydrothieno[3′,2′6,7]thiepino[4,5-*c*]isoxazole **2b**. The conformational features of this compound might give additional information for elucidating the reasons for the abnormal cyclization of **1c** and **1d**.

The structure of molecule **2b** is shown in Fig. 1. The atom coordinates, the bond lengths, and the bond angles in molecule **2b** as well as the torsion angles in the thiepine cycle are given in Tables 1—3.

In molecule **2b**, the thiophene cycle **A** is flat within ±0.02 Å, and the thiepine cycle **B** has the boat conformation (the angle of inflection along the S(6)—C(3a) line is 68.8°). The isoxazoline cycle **C** in **2b** has the strongly flattened chair conformation ($_3$E): the inflection angle of the C(3a)—O(2) line is 5.9°, *i.e.*, this cycle is notably flatter than that found in molecule **2a** (the corresponding dihedral angle is 13°).[6]

The bond lengths and the bond angles in molecule **2b** are close to the corresponding values in **2a**.

In molecule **2b**, as well as in **2a**, there are significant steric strains between the vicinal protons at the C(3a), C(3), and C(4) atoms: the bond angles at these atoms are strongly distorted, and, in addition, the intramolecular contacts H(3a)...H(3) (2.19 Å) and H(3a)...H(4) (2.08 Å) are notably smaller than the sum of the van der Waals radiuses of the hydrogen atoms (2.4 Å). These facts confirm our previous suggestion that, when the reagents containing the methallyl group are used, the direction of the IMCA reaction is changed due to the steric hindrances towards the introduction of the methyl group at the C(3a) atom in the case of the strongly flattened isoxazoline cycle.[6]

Experimental

The crystals of 8-methyl-3,3a,4,5-tetrahydrothieno[3′,2′6,7]thiepino[4,5-*c*]isoxazole **2b** grown from hexane as four-sided prisms, are monoclinic, $C_{10}H_{11}NOS_2$, a = 9.842(1), b = 14.058(2), c = 7.746(1) Å, β = 73.61(1)°, Z = 4, the space group $P2_1/c$. The parameters of the unit cell and the intensities of 983 reflections with $I > 2\sigma(I)$ were obtained on a four-circle automatic difractometer RED-4 (λ(Mo-Kα), $\theta/2\theta$-scanning, graphite monochromator, $\theta < 30°$).

The structure was solved by the direct method, the coordinates of non-hydrogen atoms were refined by the least squares method using the anisotropic approximation, and the coordinates of the H atoms were improved using the isotropic approximation. The resulting R value is 0.083.

Table 3. Bond (ω) and torsion* angles (φ) in molecule **2b**

Angle	ω/deg	Angle	ω/deg	Angle	φ/deg
C(9b)—N(1)—O(2)	109.7(10)	S(7)—C(8)—C(9)	109.4(6)	S(6)—C(6a)—C(9a)—C(9b)	5.7
N(1)—O(2)—C(3)	107.7(8)	S(7)—C(8)—C(10)	124.5(4)	C(6a)—C(9a)—C(9b)—C(3)	3.2
O(2)—C(3)—C(3a)	107.2(8)	C(9)—C(8)—C(10)	126.8(10)	C(9a)—C(9b)—C(3a)—C(4)	66.6
C(3)—C(3a)—C(9b)	99.6(10)	C(8)—C(9)—C(9a)	113.5(7)	C(9b)—C(3a)—C(4)—C(5)	57.5
C(3)—C(3a)—C(4)	110.4(6)	C(6a)—C(9a)—C(9)	111.6(4)	C(3a)—C(4)—C(5)—S(6)	26.8
C(4)—C(3a)—C(9b)	115.0(5)	C(6a)—S(7)—C(8)	93.9(3)	C(4)—C(5)—S(6)—C(6a)	79.1
C(3a)—C(4)—C(5)	114.6(4)	C(9)—C(9a)—C(9b)	124.5(8)	C(5)—S(6)—C(6a)—C(9a)	45.2
C(4)—C(5)—S(6)	117.8(2)	C(6a)—C(9a)—C(9b)	123.7(8)		
C(5)—S(6)—C(6a)	99.0(3)	N(1)—C(9b)—C(3a)	115.4(6)		
S(6)—C(6a)—C(9a)	129.2(4)	C(9a)—C(9b)—N(1)	117.5(10		
S(6)—C(6a)—S(7)	119.2(4)	C(9a)—C(9b)—C(3a)	127.1(9)		
S(7)—C(6a)—C(9a)	111.5(6)	S(7)—C(8)—C(9)	109.4(6)		

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* In the thiepine cycle.

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